



CanGas Solutions Ltd.

Unit C-587





UNIT C-587 MANUAL INDEX

PRINTED INFORMATION

Package Drawings

Process & Instrumentation
Utility & Instrumentation.....
General Arrangement
Bill of Material

Performance

Runs.....

Control Panel

Vendor Drawings

General

Compressor Balance & Lubrication Sheets.....
Cooler Data Sheet.....
Pressure Safety Valve Test Reports.....
Compressor Valve Tailor.....

DIGITAL INFORMATION

*All printed information is also included in digital format

Operating Manuals

Compressor Operating Manual
Compressor Parts Book.....
Driver Manual.....
Control Panel Manual.....
Cooler Manual.....

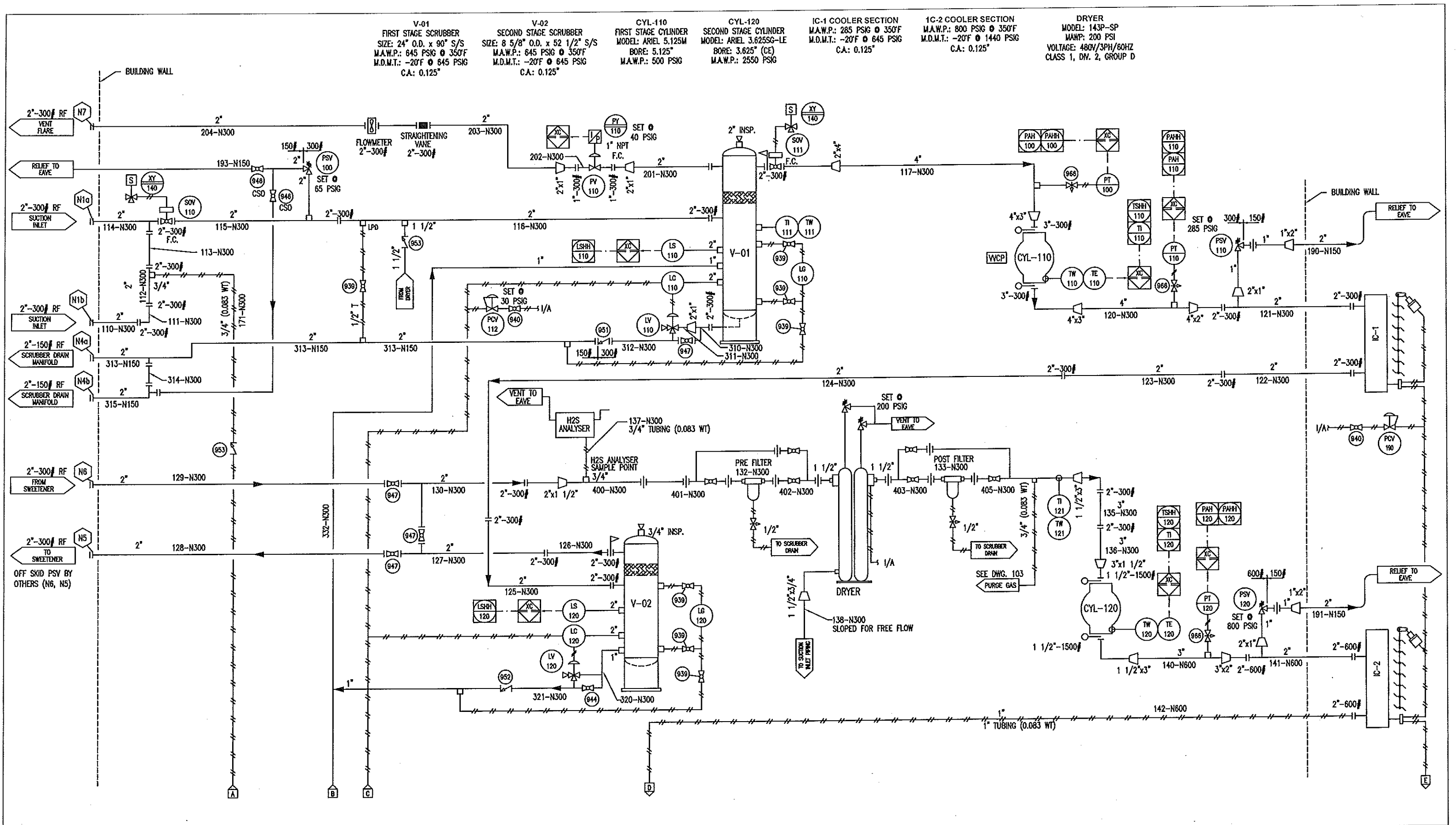
Quality Assurance

Quality Assurance Data Book.....
Piping AB-83.....
Vessel Nameplate Facsimilie
Line List.....
Cooler U1A.....
Vessels U1A.....
Five Star Fabrication Books.....



Unit C-587
Package Drawings





GENERAL NOTES
 FLANGED RELIEF VALVE NOZZLES TO BE GUSSETED TO PIPE STRAP TYPE PIPE CLAMPING AS STANDARD
 ALL PROCESS GASKETS TO BE 316SS FLEXITALLIC TYPE
 ALL STUDS TO BE SA-193-B7
 ALL NUTS TO BE SA-194-2H
 ALL CAPSCREWS TO BE PLATED GRADE 8
 PANEL TO BE POWERED BY OTHERS
 TUBING RUNS IN TRAFFIC AREAS TO BE PROTECTED WITH REMOVABLE COVER
 INSTRUMENT MEDIUM TO BE CLEAN DRY AIR, PURGE MEDIUM TO BE CLEAN DRY GAS.

PROCESS PIPING
 DESIGNED IN ACCORDANCE WITH ASME B31.3 2010 EDITION
 CORROSION ALLOWANCE: 1/8"
 RADIOGRAPHY: 100%
 STRESS RELIEF: NO
 PICKLE & OIL: NO

VESSELS
 DESIGNED IN ACCORDANCE WITH ASME SECTION VIII, DIV. 1
 CORROSION ALLOWANCE: 1/8"
 RADIOGRAPHY: V-01 TO V-04 (RT-1)
 STRESS RELIEF: YES
 PICKLE & OIL: YES
 VESSEL/COOLER REG.: AB, BC, SK, MB U STAMP

INSTRUMENT TUBING
 TUBING: 316SS
 FITTINGS: 316SS
 PROCESS: 316SS
 INSTRUMENT: 316SS
 FRAME INTERNALS: 316SS

PAINT
 PIPING & FITTINGS: RUSTOLEUM WARM GREY
 STRUCTURAL STEEL: RUSTOLEUM WARM GREY
 GRATING: SEMI GLOSS BLACK

REV.	DESCRIPTION	DATE	BY
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

COMPASS COMPRESSION SERVICES LTD.
 1537 - 9TH AVENUE S.E. CALGARY, AB T2G 5N4
 PHONE: (403) 262-2487 FAX: (403) 262-2480

MODEL: EM60-RAA2-3 UNIT #: C587
 SERVICE: SOUR H₂S: 2% CO₂: 0%
 DRN. BY: BG DATE: 05-09-11
 CHK. BY: DATE:
 APR. BY: DATE:

CANGAS SOLUTIONS LTD.
 C/O O'ROURKE ENG.
 SITE: VARIOUS LOCATIONS

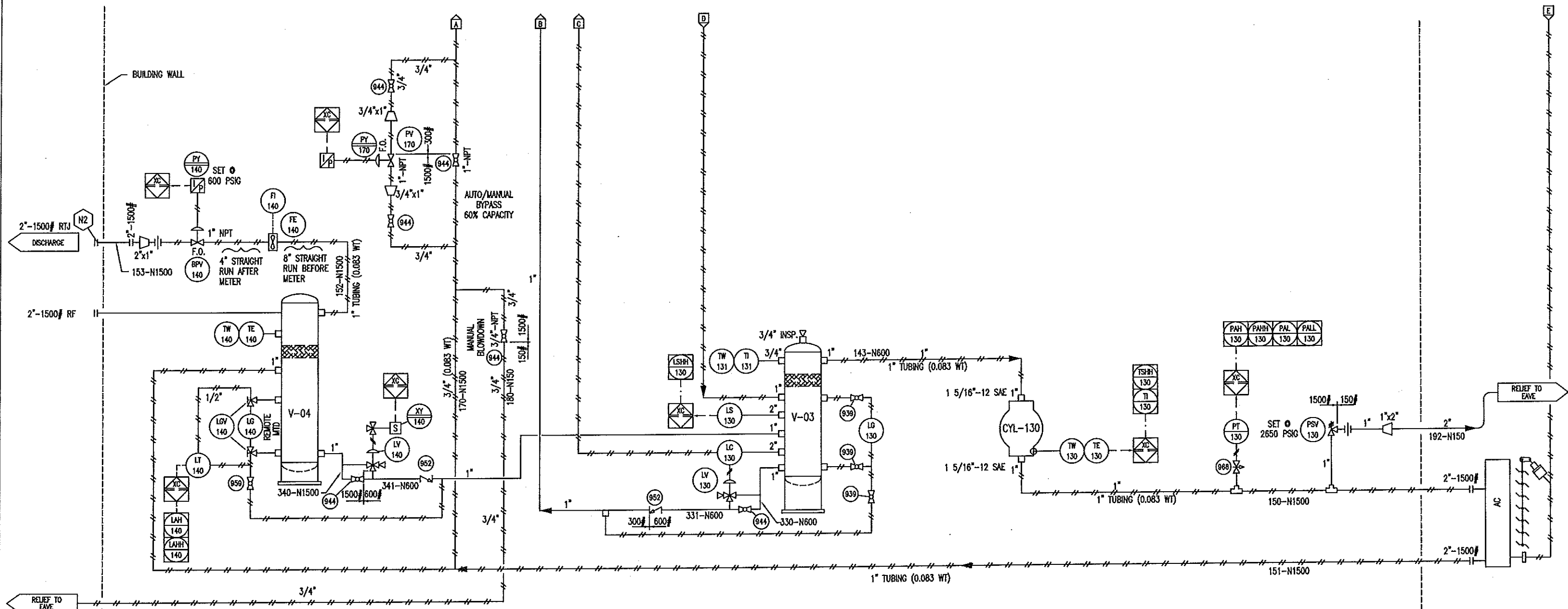
DWG. #: C587-101A REV. #: 0

V-03
 THIRD STAGE SCRUBBER
 SIZE: 8 5/8" O.D. x 52 1/2" S/S
 M.A.W.P.: 1287 PSIG @ 350°F
 M.D.M.T.: -20°F @ 1287 PSIG
 C.A.: 0.125"

V-04
 DISCHARGE SCRUBBER
 SIZE: 8 5/8" O.D. x 48" S/S
 M.A.W.P.: 2650 PSIG @ 300°F
 M.D.M.T.: -20°F @ 2650 PSIG
 C.A.: 0.125"

CYL-130
 THIRD STAGE CYLINDER
 MODEL: ARIEL 1.75SG-HE
 BORE: 1.5" (HE)
 M.A.W.P.: 6100 PSIG

AC COOLER SECTION
 M.A.W.P.: 2900 PSIG @ 350°F
 M.D.M.T.: -20°F @ 1440 PSIG
 C.A.: 0.125"



GENERAL NOTES
 FLANGED RELIEF VALVE NOZZLES TO BE GUSSETED TO PIPE
 STRAP TYPE PIPE CLAMPING AS STANDARD
 ALL PROCESS GASKETS TO BE 316SS FLEXITALLIC TYPE
 ALL STUDS TO BE SA-193-B7
 ALL NUTS TO BE SA-194-2H
 ALL CAPSCREWS TO BE PLATED GRADE 8
 PANEL TO BE POWERED BY OTHERS
 TUBING RUNS IN TRAFFIC AREAS TO BE PROTECTED WITH REMOVABLE COVER
 INSTRUMENT MEDIUM TO BE CLEAN DRY AIR, PURGE MEDIUM TO BE CLEAN DRY GAS.

PROCESS PIPING
 DESIGNED IN ACCORDANCE WITH ASME B31.3 2010 EDITION
 CORROSION ALLOWANCE: 1/8"
 RADIOGRAPHY: 100%
 STRESS RELIEF: NO
 PICKLE & OIL: NO

VESSELS
 DESIGNED IN ACCORDANCE WITH ASME SECTION VIII, DIV. 1
 CORROSION ALLOWANCE: 1/8"
 RADIOGRAPHY: V-01 TO V-04 (RT-1)
 STRESS RELIEF: YES
 PICKLE & OIL: YES
 VESSEL/COOLER REG.: AB, BC, SK, MB U STAMP

INSTRUMENT TUBING
 TUBING 316SS
 PROCESS 316SS
 INSTRUMENT 316SS
 FRAME INTERVALS 316SS

FITTINGS
 316SS
 316SS
 316SS

PAINT
 PIPING & FITTINGS RUSTOLEUM WARM GREY
 STRUCTURAL STEEL RUSTOLEUM WARM GREY
 GRATING SEMI GLOSS BLACK

REV.	DESCRIPTION	DATE	BY
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COMPASS COMPRESSION SERVICES LTD.
 1537 - 9TH AVENUE S.E. CALGARY, AB T2G 5N4
 PHONE: (403) 262-2487 FAX: (403) 262-2480

MODEL: EM60-RAA2-3 UNIT #: C587
 SERVICE: SOUR H₂S: 2% CO₂: 0%
 DRN. BY: BC DATE: 05-09-11
 CHK. BY: DATE:
 APR. BY: DATE:

CANGAS SOLUTIONS LTD.
 C/O O'ROURKE ENG.
 SITE: VARIOUS LOCATIONS

DWG. #: C587-1018 REV. #: 0

EM-01
ELECTRIC DRIVER
MAKE: TECO
MODEL: PDH06004TE2M
HP RATING: 60 HP @ 1800 RPM
VOLTAGE: 460V/3PH/60Hz

EM-02
ELECTRIC DRIVER
HP RATING: 2HP @ 1200 RPM
VOLTAGE: 460V/3PH/60Hz
TEFC, VFD COMPATIBLE

AIR COMPRESSOR
MAKE: EAGLE
MODEL: PVO2A
RATING: 2HP @ 1800 RPM
VOLTAGE: 208-230/460V/3PH/60Hz

C-01
AIR COOLER
MAKE: AIR-X-LIMITED
MODEL: 32V
REQ'D HP: 1.44HP @ 1170 RPM

C-02
OIL COOLER
MAKE: THERMAL TRANSFER
MODEL: AO-15-3PH
MOTOR VOLTAGE: 460V/3PH/60Hz
MOTOR RATING: 1/4 HP

CR-01
COMPRESSOR FRAME
MAKE: ARBEL
MODEL: JGA/2
STROKE: 3.0"
HP PER THROW: 140

CP-01
CONTROL PANEL
MAKE: ALLEN-BRADLEY
MODEL: MICROLOGIX 1400

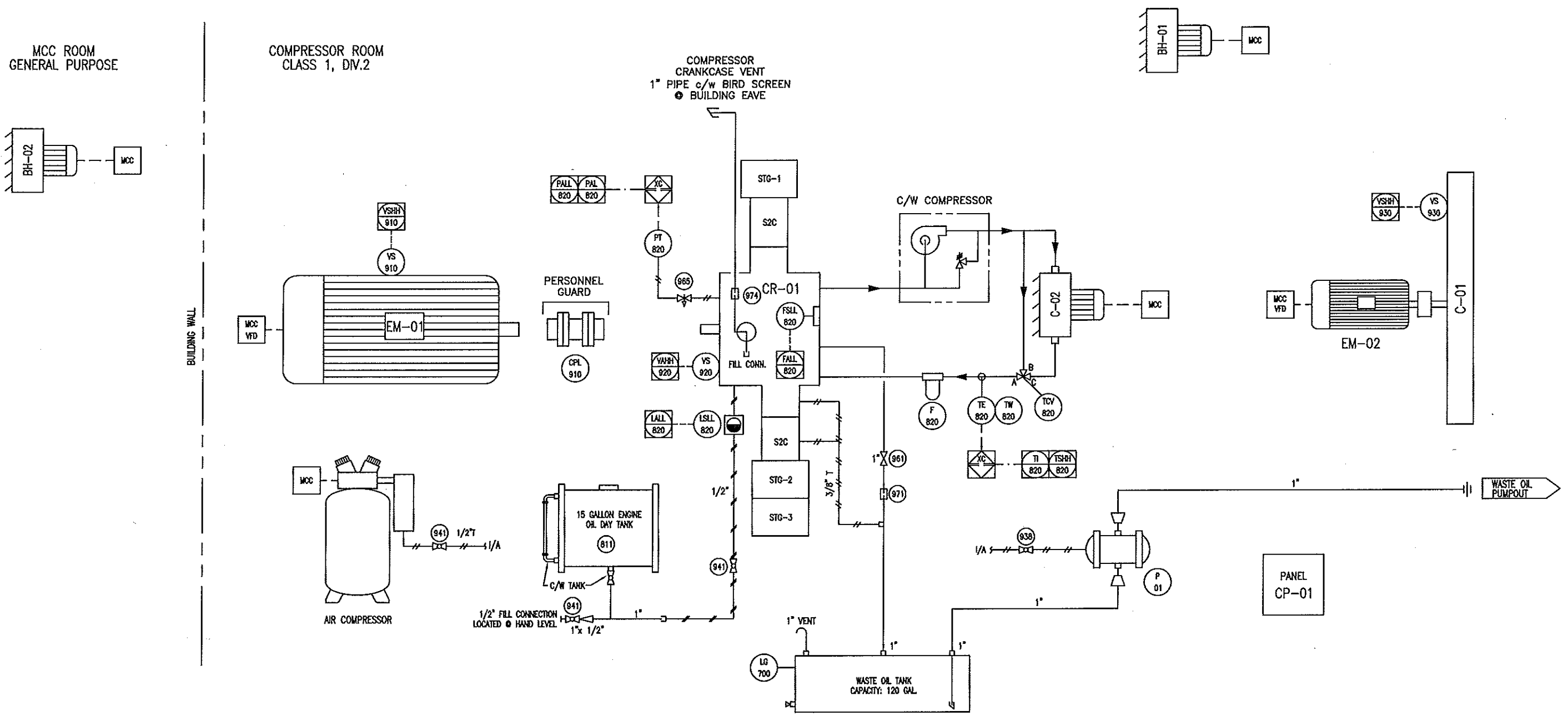
BH-01
BUILDING HEATER
MAKE: HAZLOC
MODEL: XEUI-12-100-480360-B-T
VOLTAGE: 480VAC/3PH/60HZ
OUTPUT: 34,100 BTU/HR (10 KW)
CLASS 1, ZONES 1&2

BH-02
BUILDING HEATER
MAKE: HAZLOC
MODEL: XEUI-12-050-480360-B-T
VOLTAGE: 480VAC/3PH/60HZ
OUTPUT: 17,050 BTU/HR (5 KW)
CLASS 1, ZONES 1&2

MCC ROOM
GENERAL PURPOSE

COMPRESSOR ROOM
CLASS 1, DIV.2

COMPRESSOR
CRANKCASE VENT
1" PIPE c/w BIRD SCREEN
@ BUILDING EAVE



GENERAL NOTES
 FLANGED RELIEF VALVE NOZZLES TO BE GUSSETED TO PIPE
 STRAP TYPE PIPE CLAMPING AS STANDARD
 ALL PROCESS GASKETS TO BE 316SS FLEXITALLIC TYPE
 ALL STUDS TO BE SA-193-87
 ALL NUTS TO BE SA-194-2H
 ALL CAPSCREWS TO BE PLATED GRADE 8
 PANEL TO BE MAGNETO POWERED
 TUBING RUNS IN TRAFFIC AREAS TO BE PROTECTED WITH REMOVABLE COVER
 INSTRUMENT & PURGE MEDIUM TO BE CLEAN DRY GAS

PROCESS PIPING
 DESIGNED IN ACCORDANCE WITH
 ASME B31.3 2010 EDITION
 CORROSION ALLOWANCE: 1/8"
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 STRESS RELIEF: NO
 PICKLE & OIL: NO

VESSELS
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 RADIOGRAPHY: V-01 TO V-04 (RT-1)
 STRESS RELIEF: YES
 PICKLE & OIL: YES
 VESSEL/COOLER REG.: AB, BC, SK, MB
 U STAMP

INSTRUMENT TUBING
 PROCESS TUBING 304SS
 INSTRUMENT TUBING 304SS
 FRAME INTERNALS 304SS
 PAINT: RUSTOLEUM WARM GREY
 PIPING & FITTINGS: RUSTOLEUM WARM GREY
 STRUCTURAL STEEL: RUSTOLEUM WARM GREY
 GRATING: SEMI GLOSS BLACK

TUBING	FITTINGS
304SS	316SS
304SS	316SS
304SS	316SS

REV.	DESCRIPTION	DATE	BY
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STAMP:
 09/12/11 NSP

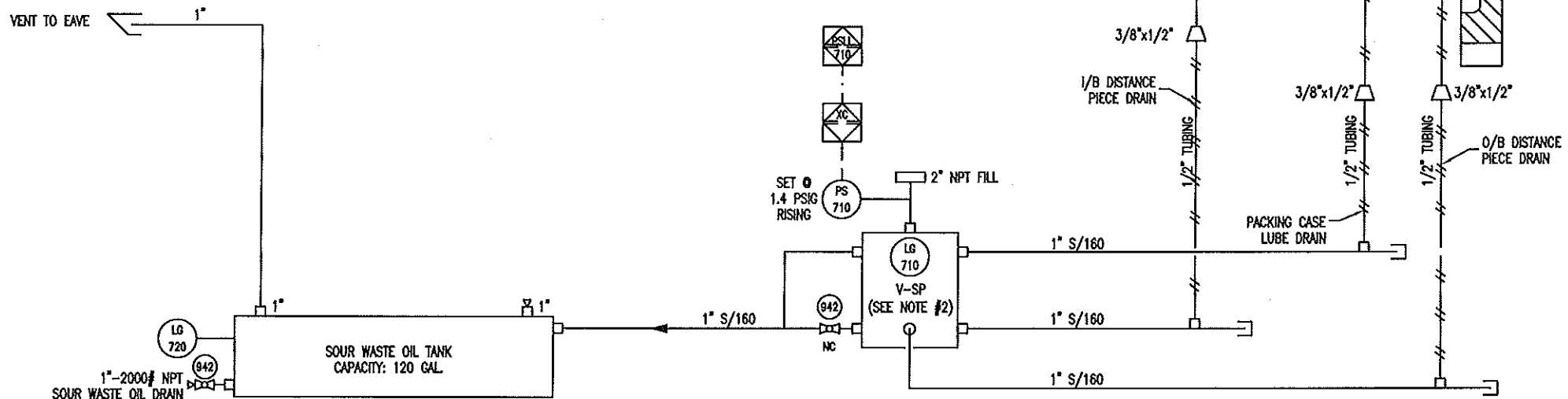
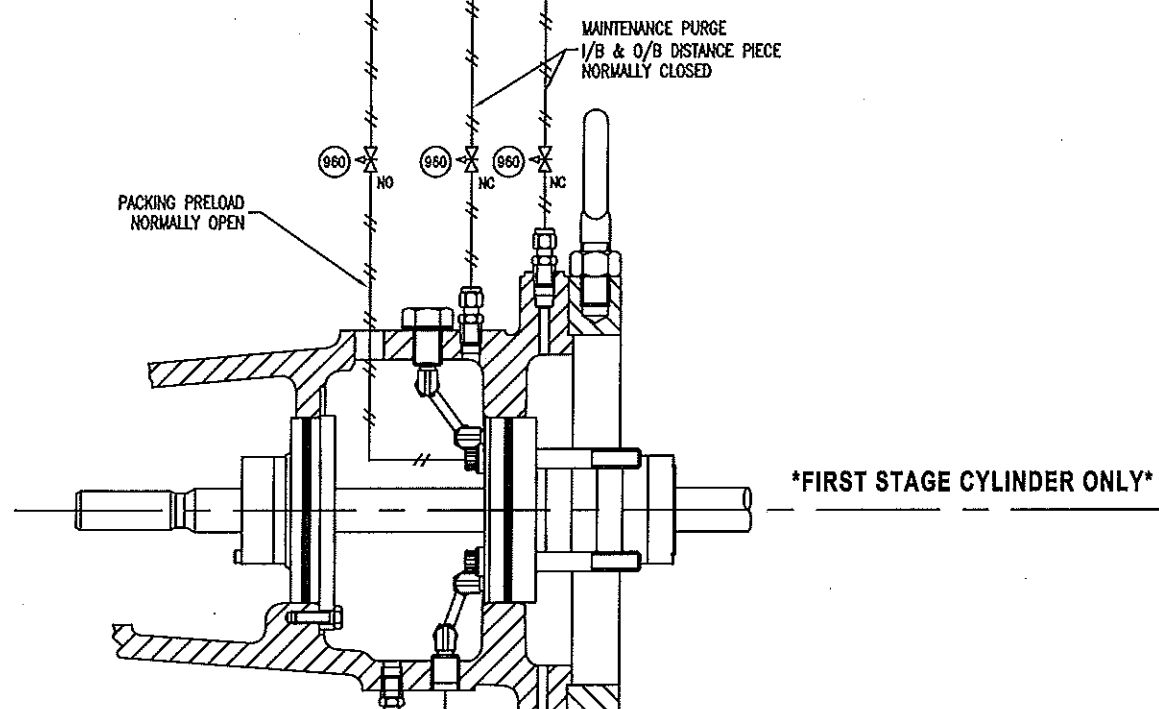
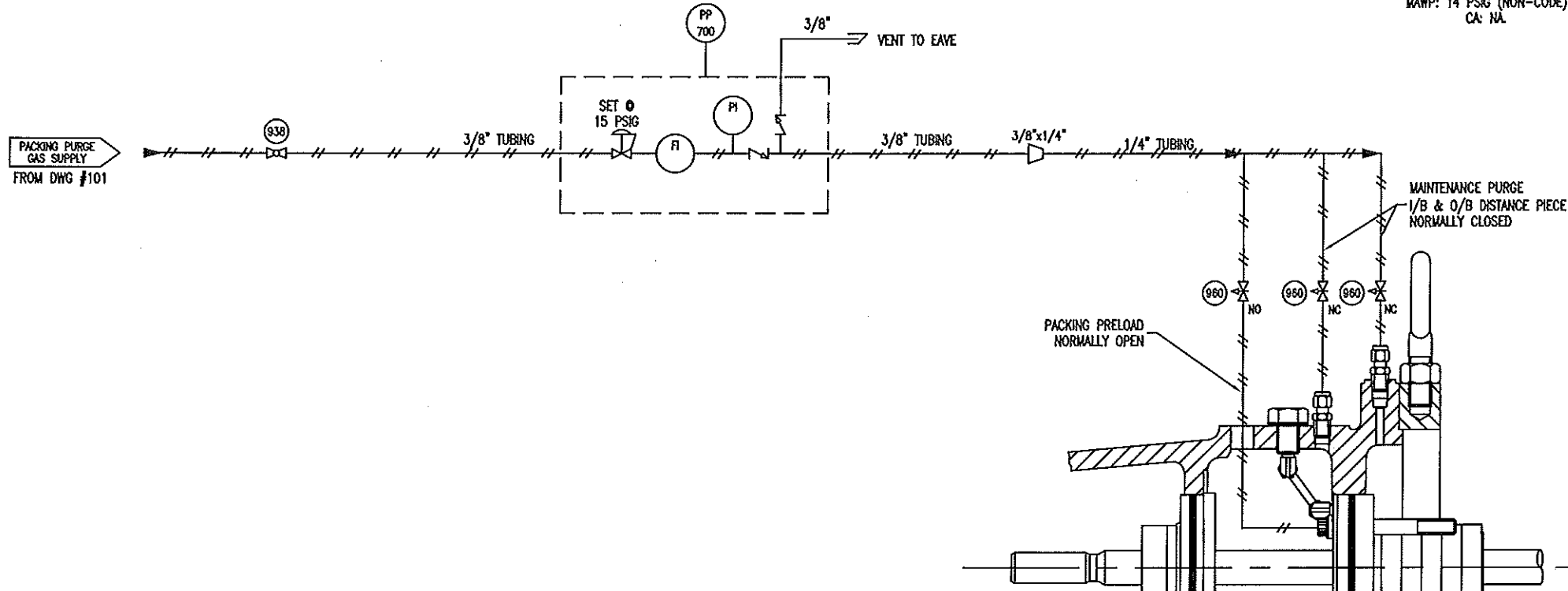
COMPASS COMPRESSION SERVICES LTD.
 1537 - 9TH AVENUE S.E. CALGARY, AB T2G 5N4
 PHONE: (403) 262-2487 FAX: (403) 262-2480

MODEL: EM60-RAA2-3	UNIT #: C587
SERVICE: SOUR	H ₂ S: 2% CO ₂ : 0%
DRN. BY: BC	DATE: 05-09-11
CHK. BY:	DATE:
APR. BY:	DATE:

CANGAS SOLUTIONS LTD.
 C/O O'ROURKE ENG.
 SITE: VARIOUS LOCATIONS

DWG. #: C587-102 REV. #: 0

V-SP
SEAL POT
SIZE: 6" HSS X 14" LG
MAWP: 14 PSIG (NON-CODE)
CA: NA



- NOTES
- ON APPLICATIONS w/o VACUUM PUMP, VACUUM PORT IS TO BE PLUGGED, AND SOUR WASTE OIL TANK TO BE VENTED TO EAVE.
 - SLOPE ALL HEADERS DOWN TO SEAL POT AND SLOPE SEAL POT DRAIN TO WASTE OIL TANK.

GENERAL NOTES
 FLANGED RELIEF VALVE NOZZLES TO BE GUSSETED TO PIPE
 STRAP TYPE PIPE CLAMPING AS STANDARD
 ALL PROCESS GASKETS TO BE 316SS FLEXITALLIC TYPE
 ALL STUDS TO BE SA-193-B7
 ALL NUTS TO BE SA-194-2H
 ALL CAPSCREWS TO BE PLATED GRADE 8
 PANEL TO BE MAGNETO POWERED
 TUBING RUNS IN TRAFFIC AREAS TO BE PROTECTED WITH REMOVABLE COVER
 INSTRUMENT & PURGE MEDIUM TO BE CLEAN DRY GAS

PROCESS PIPING
 DESIGNED IN ACCORDANCE WITH
 ASME B31.3 2010 EDITION
 CORROSION ALLOWANCE: 1/8"
 RADIOGRAPHY: 100%
 STRESS RELIEF: NO
 PICKLE & OIL: NO

VESSELS
 DESIGNED IN ACCORDANCE WITH
 ASME SECTION VIII, DIV. 1
 CORROSION ALLOWANCE: 1/8"
 RADIOGRAPHY: V-01 TO V-04 (RT-1)
 STRESS RELIEF: YES
 PICKLE & OIL: YES
 VESSEL/COOLER REG.: AB, BC, SK, MB
 U STAMP

INSTRUMENT TUBING
 PROCESS TUBING 304SS
 INSTRUMENT TUBING 304SS
 FRAME INTERNALS 304SS
 PAINT PIPING & FITTINGS RUSTOLEUM WARM GREY
 STRUCTURAL STEEL SEMI GLOSS BLACK
 GRATING

TUBING 304SS
 FITTINGS 316SS
 304SS
 316SS
 304SS
 316SS

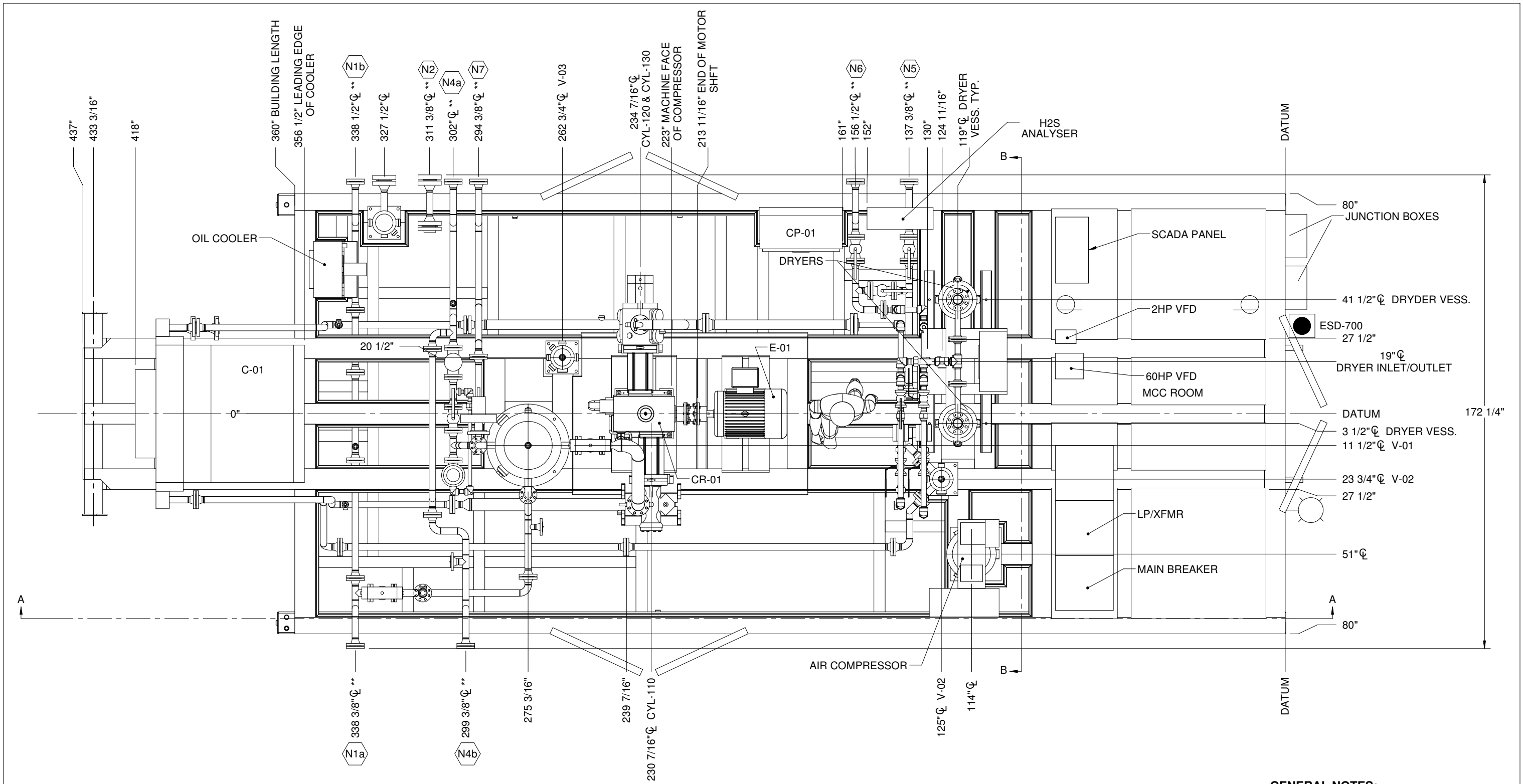
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0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

COMPASS COMPRESSION SERVICES LTD.
 1537 - 9TH AVENUE S.E. CALGARY, AB T2G 5N4
 PHONE: (403) 262-2487 FAX: (403) 262-2480

MODEL: EM60-RAA2-3 UNIT #: C587
 SERVICE: SOUR H₂S: 2% CO₂: 0%
 DRN. BY: BC DATE: 05-09-11
 CHK. BY: DATE:
 APR. BY: DATE: DWG. #: C587-103 REV. #: 0

CANGAS SOLUTIONS LTD.
 C/O O'ROURKE ENG.
 SITE: VARIOUS LOCATIONS



PLAN VIEW
SCALE 1:35

GENERAL NOTES:
 1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

CUSTOMER CONNECTIONS					
NO.	DESCRIPTION	SIZE	RATING	ELEVATION	PROJECTION
N1A	UNIT INLET	2"	300# RF	6 1/2"***	84 1/8"***
N1B	UNIT INLET	2"	300# RF	6"***	85 3/8"***
N2	FINAL DISCHARGE	2"	1500#	6"***	85 1/2"***
N4a	INLET SEPARATOR DRAIN	2"	150# RF	6"***	85 1/2"***
N4b	INLET SEPARATOR DRAIN	2"	150# RF	6 1/2"***	84"***
N5	DISCHARGE TO SWEETENER	2"	300# RF	5 7/8"***	85"***
N6	INLET FROM SWEETENER	2"	300# RF	6"***	84 3/4"***
N7	VENT TO FLARE	2"	300# RF	5 3/4"***	85 1/4"***

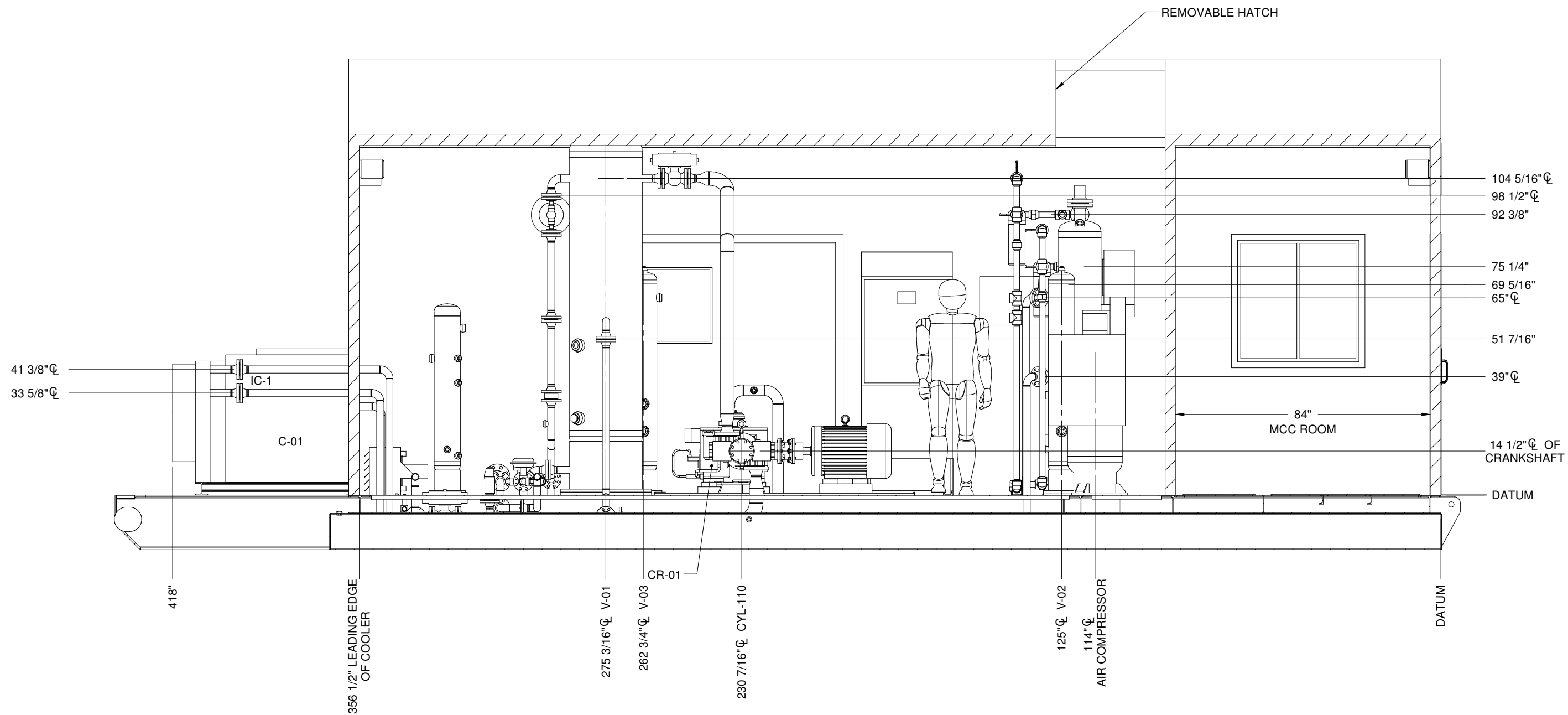
REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

COMPASS
COMPRESSION

1537 - 9th Ave. S.E.
 Calgary, Alberta
 Canada T2G 5N4
 P 403-262-2487
 F 403-262-2480

EQUIPMENT: EM60-RAA2-3		CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS	
PROJECT: C587			
SCALE: AS NOTED		GENERAL ARRANGEMENT	
DWN BY: NSP	DATE: 06/14/11		
APP BY:	DATE:	DWG: C587-200	REV: 1



SECTION A-A
SCALE 1 : 35

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

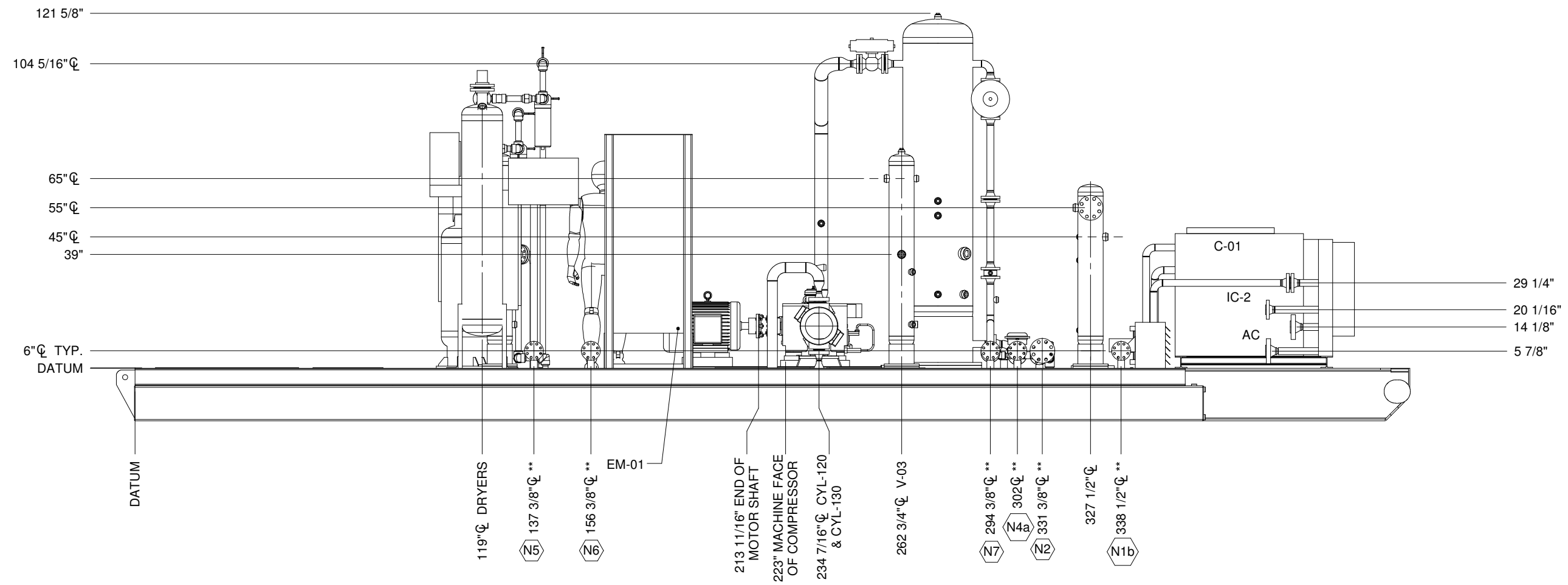
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0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:



1537 - 9th Ave. S.E.
Calgary, Alberta
Canada T2G 5N4
P 403-262-2487
F 403-262-2480

EQUIPMENT: EM60-RAA2-3		CANGAS SOLUTIONS LTD.	
PROJECT: C587		C/O O'ROURKE ENG.	
SCALE: AS NOTED		SITE: VARIOUS LOCATIONS	
DWN BY: NSP	DATE: 06/14/11	GENERAL ARRANGEMENT	
APP BY:	DATE:	DWG: C587-201	REV: 1




RIGHT SIDE ELEVATION VIEW
SCALE 1:40

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

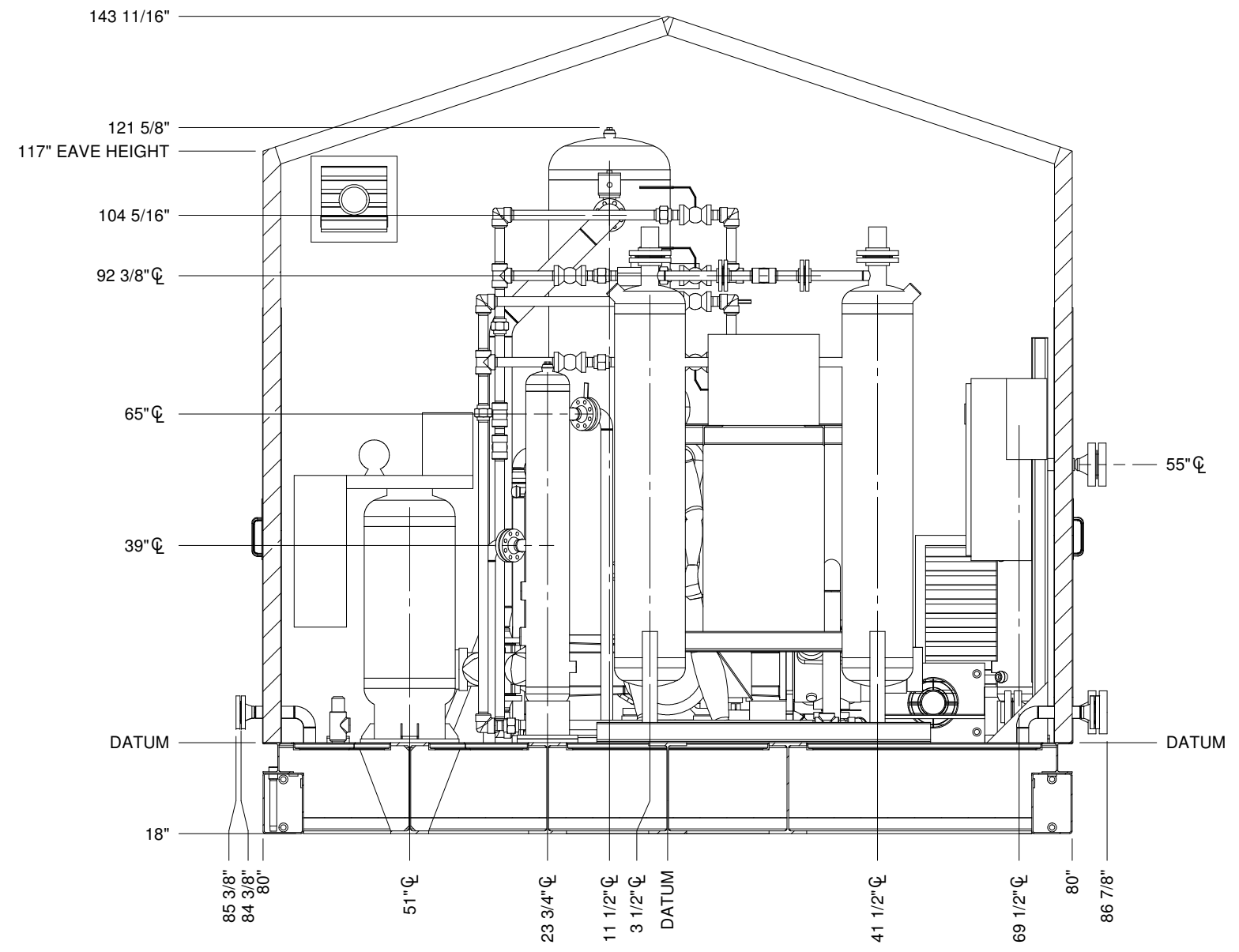
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**COMPASS
COMPRESSION**

1537 - 9th Ave. S.E.
Calgary, Alberta
Canada T2G 5N4
P 403-262-2487
F 403-262-2480

EQUIPMENT: EM60-RAA2-3		CANGAS SOLUTIONS LTD.	
PROJECT: C587			
SCALE: AS NOTED		C/O O'ROURKE ENG.	
DWN BY: NSP		SITE: VARIOUS LOCATIONS	
DATE: 06/14/11		GENERAL ARRANGEMENT	
APP BY:	DATE:	DWG: C587-202	REV: 1




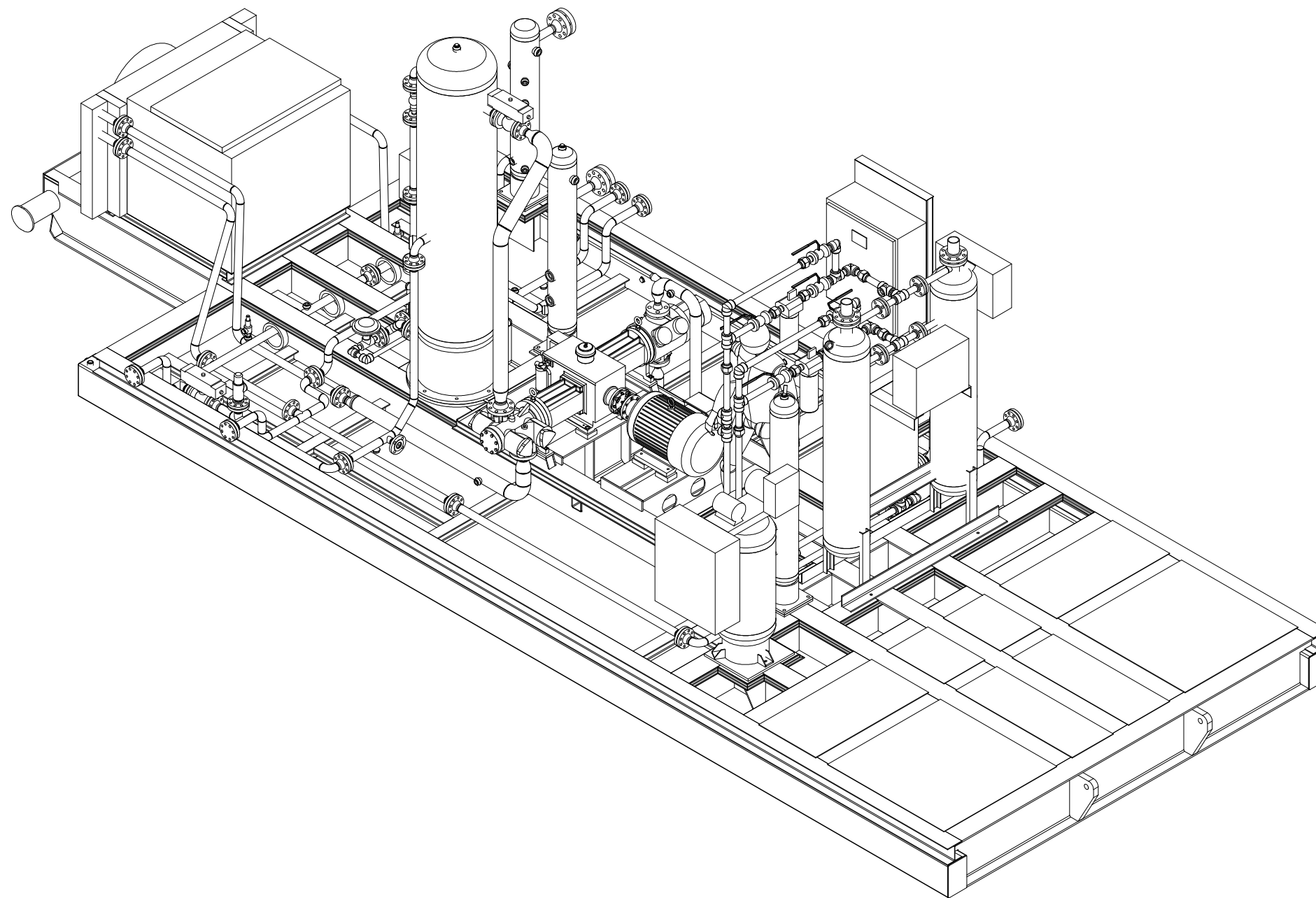
SECTION B-B
SCALE 1 : 30

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION	1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
	EQUIPMENT: EM60-RAA2-3 PROJECT: C587 SCALE: AS NOTED DWN BY: NSP APP BY:	DATE: 06/14/11 DATE:




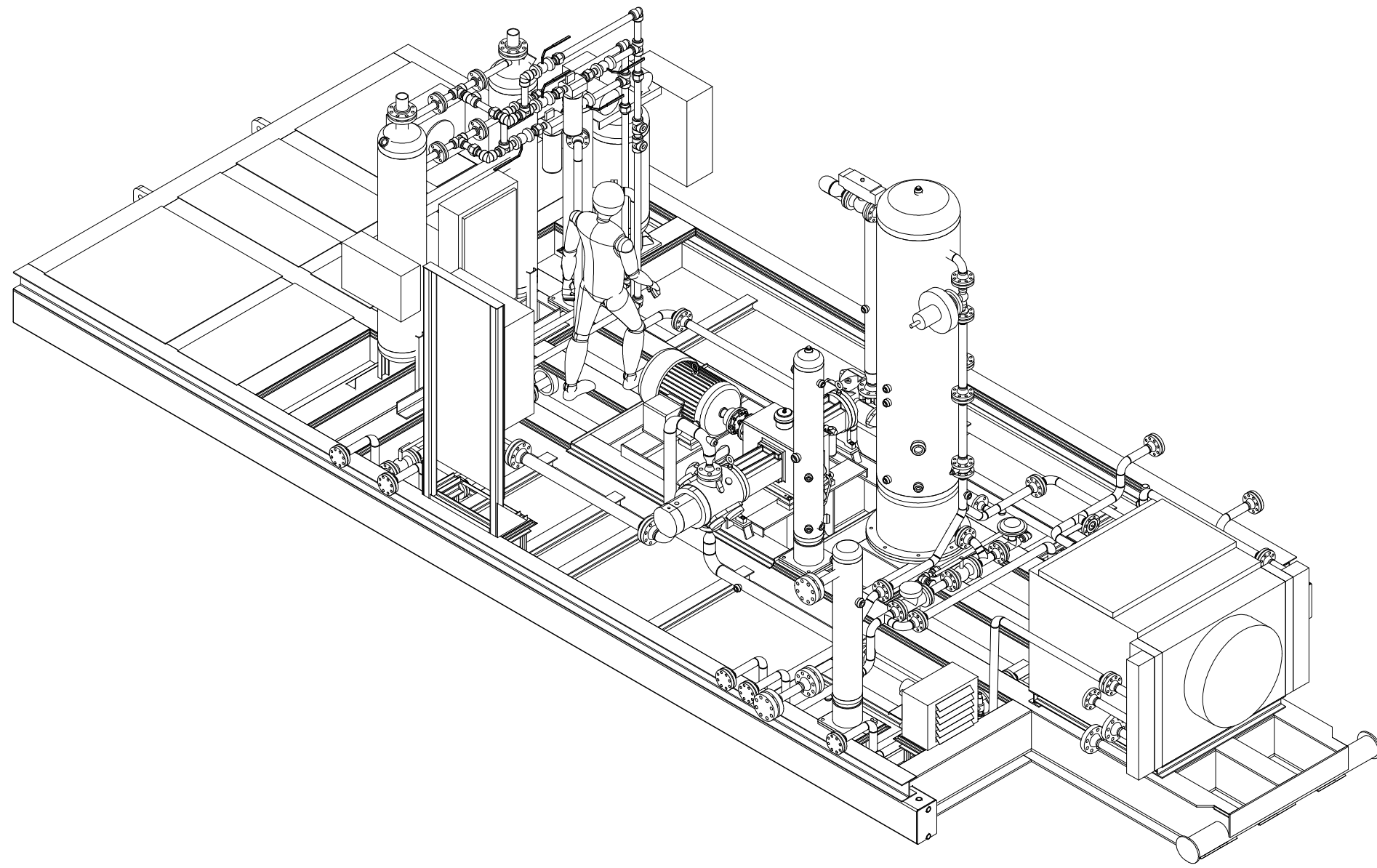
ISO VIEW
SCALE 1:40

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION	1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
	EQUIPMENT: EM60-RAA2-3 PROJECT: C587 SCALE: AS NOTED DWN BY: NSP DATE: 06/14/11 APP BY: DATE:	CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS GENERAL ARRANGEMENT DWG: C587-204 REV: 1




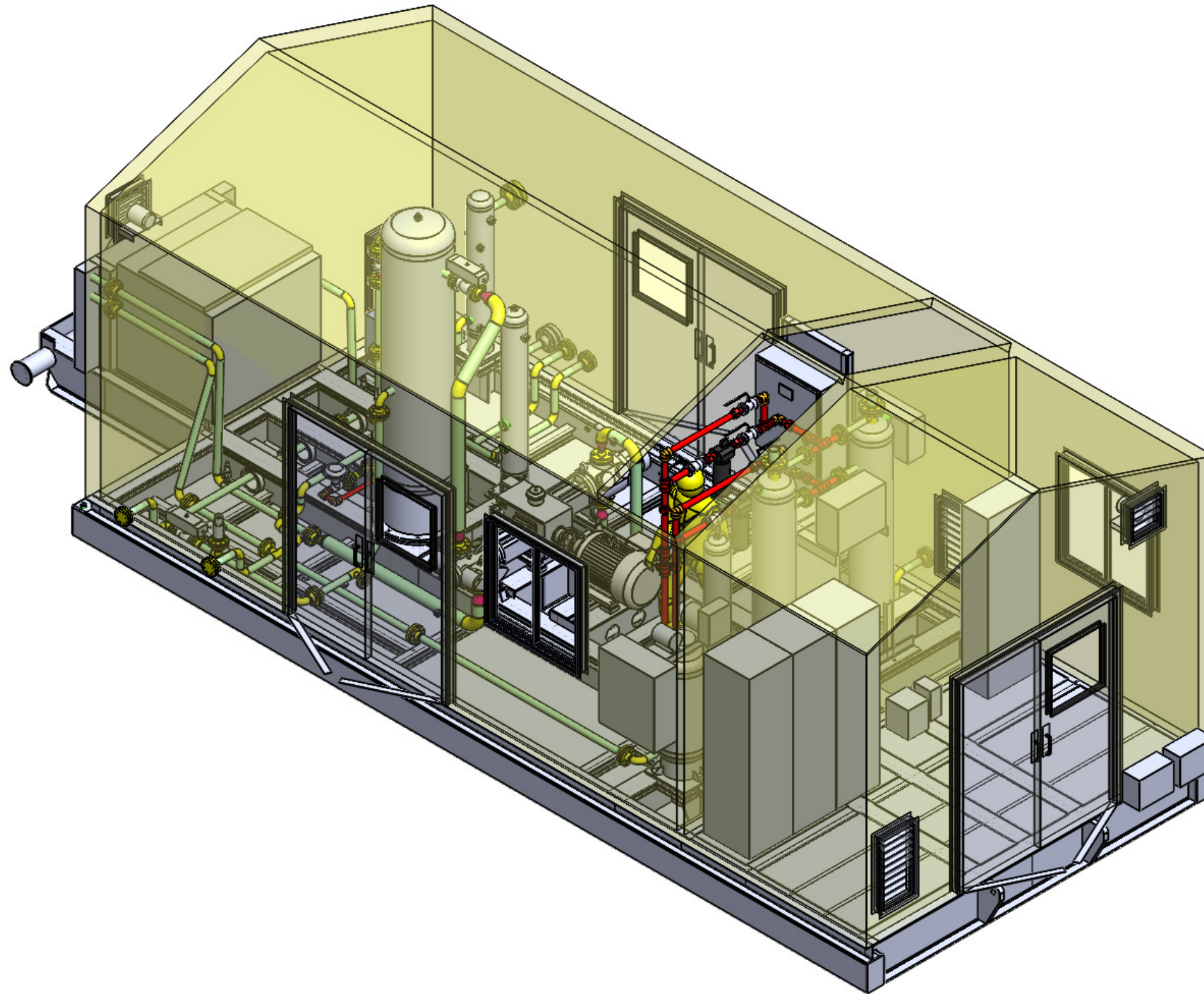
ISO VIEW
SCALE 1:40

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
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0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION		1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
		CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS	
EQUIPMENT: EM60-RAA2-3		PROJECT: C587	
SCALE: AS NOTED		DWN BY: NSP	
APP BY:		DATE: 06/14/11	
DWG: C587-205		REV: 1	




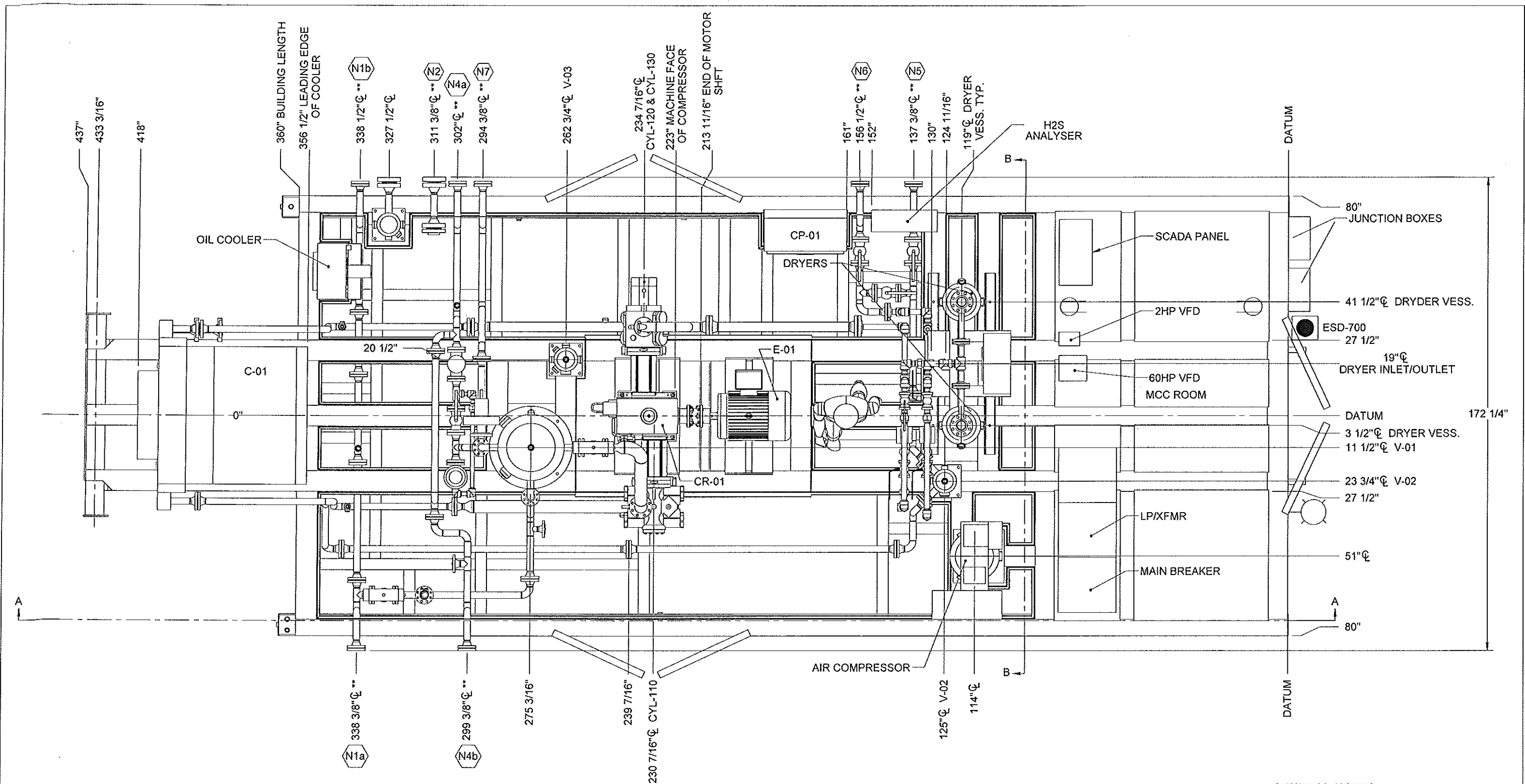
ISO VIEW
SCALE 1:40

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION		1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
		CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS	
EQUIPMENT: EM60-RAA2-3		PROJECT: C587	
SCALE: AS NOTED		DWN BY: NSP	
DATE: 06/14/11		DATE:	
APP BY:		DWG: C587-206	
REV: 1		REV: 1	



PLAN VIEW
SCALE 1:35

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

CUSTOMER CONNECTIONS

NO.	DESCRIPTION	SIZE	RATING	ELEVATION	PROJECTION
N1A	UNIT INLET	2"	300# RF	6 1/2"***	84 1/8"***
N1B	UNIT INLET	2"	300# RF	6"***	85 3/8"***
N2	FINAL DISCHARGE	2"	1500#	6"***	85 1/2"***
N4a	INLET SEPARATOR DRAIN	2"	150# RF	6"***	85 1/2"***
N4b	INLET SEPARATOR DRAIN	2"	150# RF	6 1/2"***	84"***
N5	DISCHARGE TO SWEETENER	2"	300# RF	5 7/8"***	85"***
N6	INLET FROM SWEETENER	2"	300# RF	6"***	84 3/4"***
N7	VENT TO FLARE	2"	300# RF	5 3/4"***	85 1/4"***

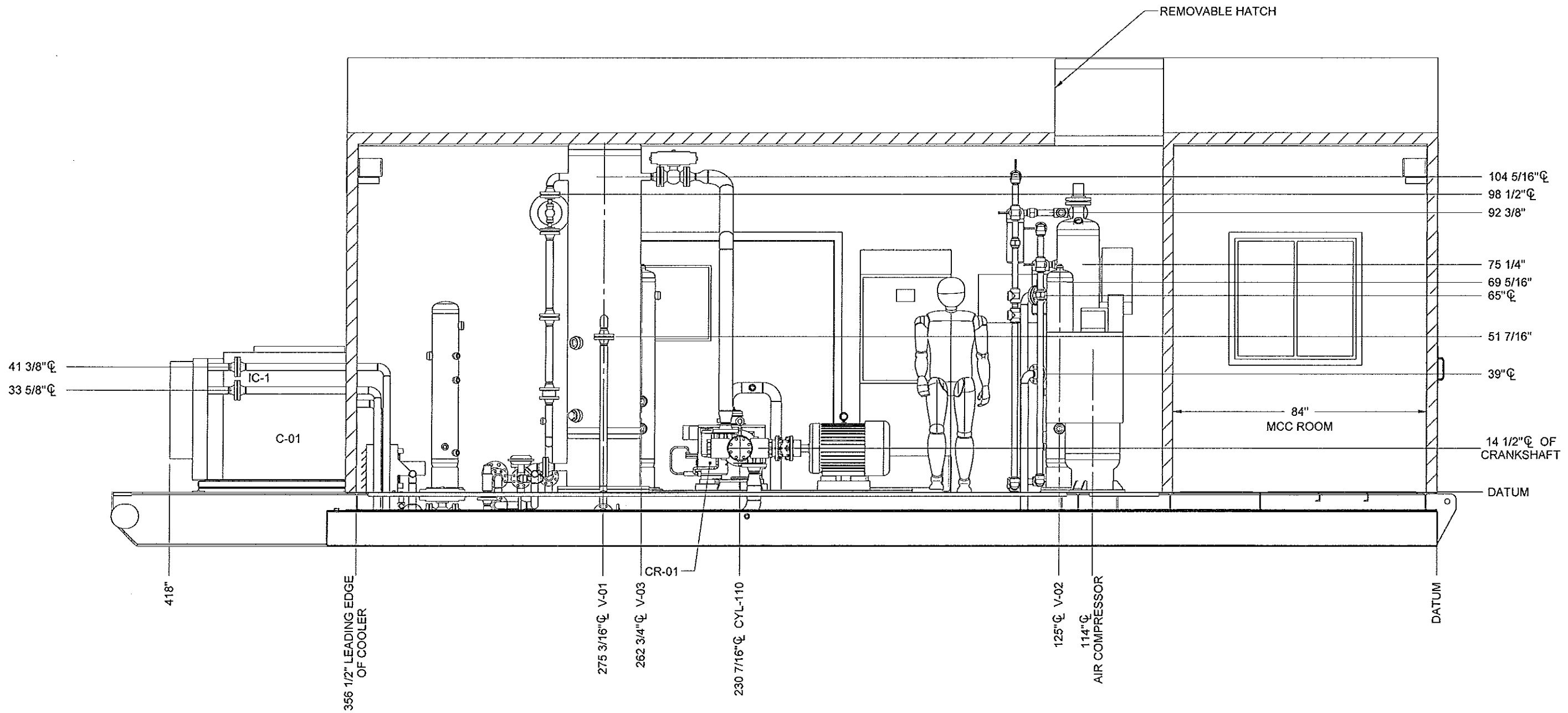
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COMPASS
COMPRESSION

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Calgary, Alberta
Canada T2G 5N4
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F 403-262-2480

EQUIPMENT: EM60-RAA2-3	CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS
PROJECT: C587	
SCALE: AS NOTED	GENERAL ARRANGEMENT
DWN BY: NSP DATE: 06/14/11	DWG: C587-200
APP BY: <i>[Signature]</i> DATE: <i>[Signature]</i>	REV: 1

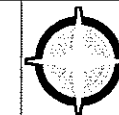


SECTION A-A
SCALE 1 : 35

- GENERAL NOTES:**
 1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
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0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:



**COMPASS
COMPRESSION**

1537 - 9th Ave. S.E.
 Calgary, Alberta
 Canada T2G 5N4
 P 403-262-2497
 F 403-262-2480

EQUIPMENT: EM60-RAA2-3

PROJECT: C587

SCALE: AS NOTED

DWN BY: NSP

APP BY:

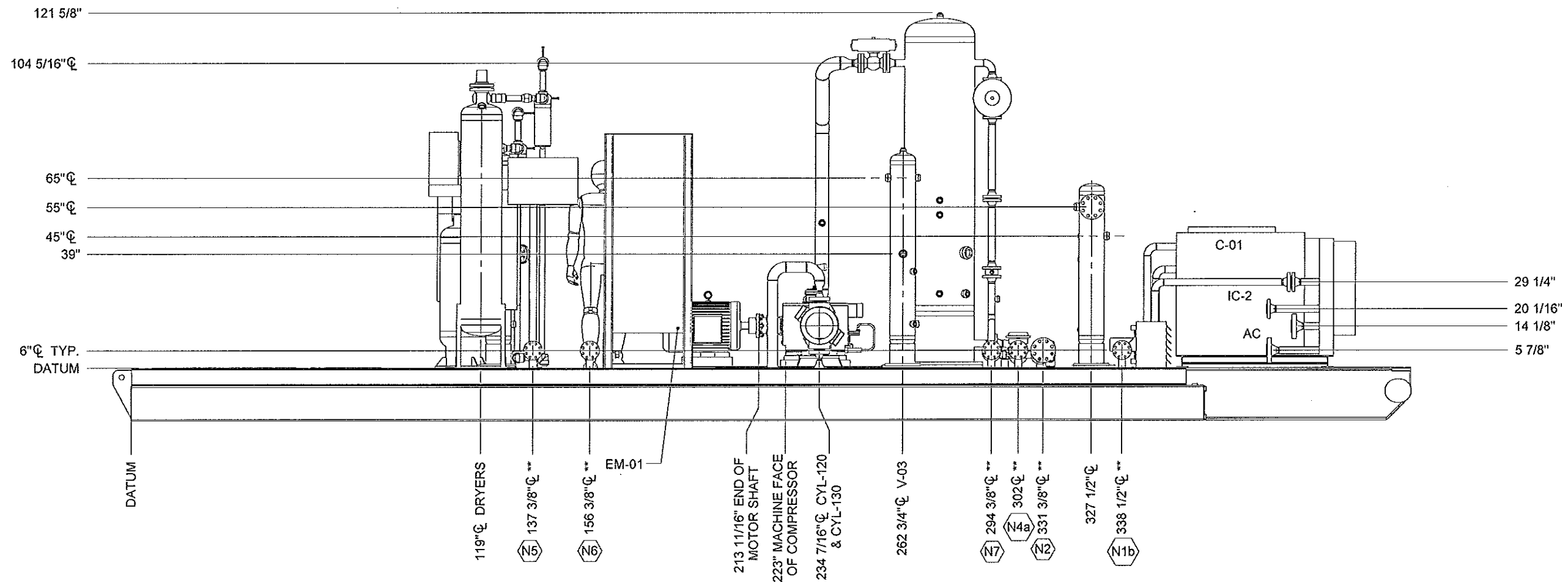
DATE: 06/14/11

DATE: 9/20/11

CANGAS SOLUTIONS
 LTD.
 C/O O'ROURKE ENG.
 SITE: VARIOUS LOCATIONS

GENERAL ARRANGEMENT

DWG: C587-201 REV: 1



RIGHT SIDE ELEVATION VIEW
SCALE 1:40

- GENERAL NOTES:
 1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

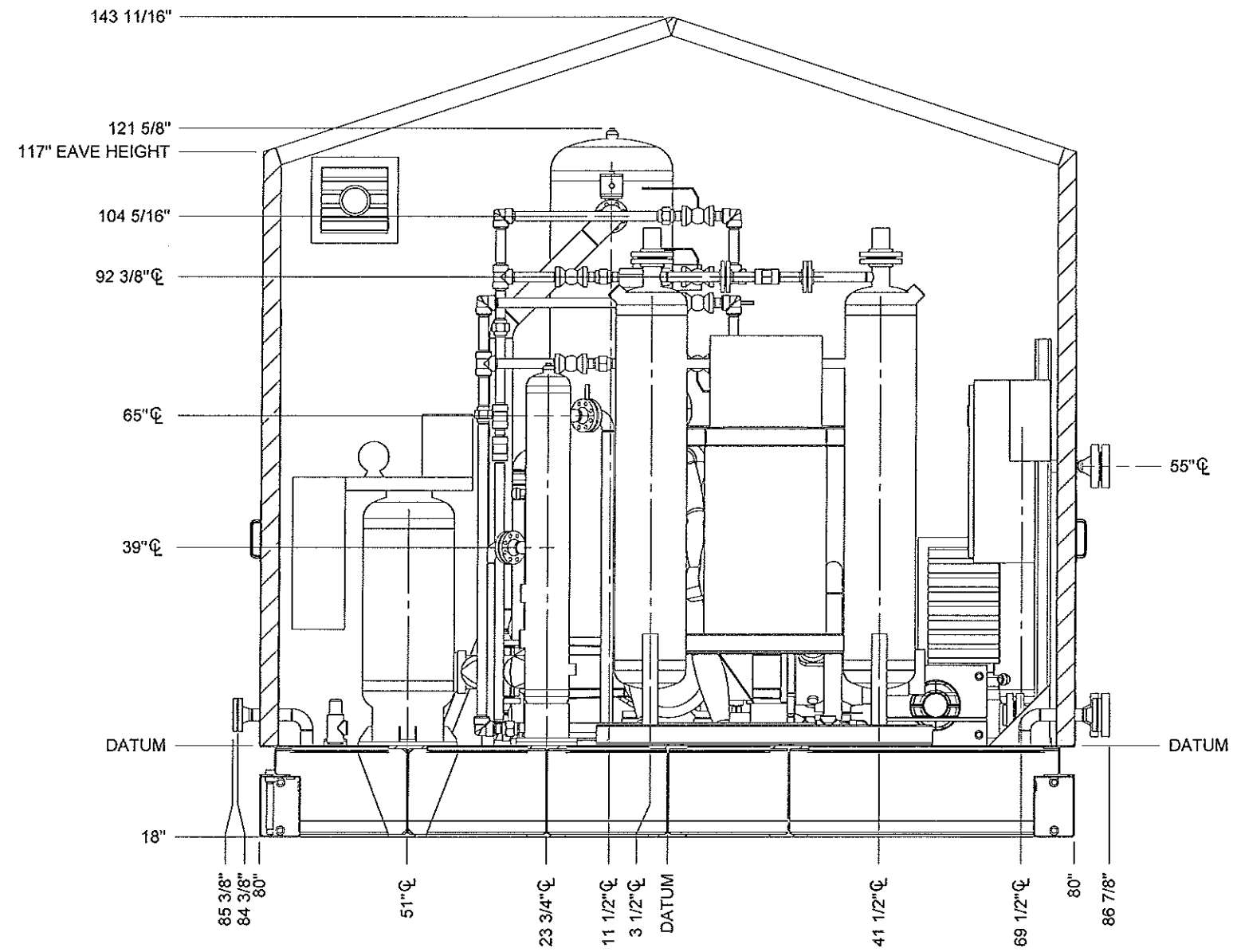
STAMP:



COMPASS
COMPRESSION

1537 - 9th Ave. S.E.
 Calgary, Alberta
 Canada T2G 5N4
 P 403-262-2487
 F 403-262-2480

EQUIPMENT: EM60-RAA2-3	CANGAS SOLUTIONS LTD.
PROJECT: C587	C/O O'ROURKE ENG.
SCALE: AS NOTED	SITE: VARIOUS LOCATIONS
DWN BY: NSP	DATE: 06/14/11
APP BY: <i>[Signature]</i>	DATE: 9/24/11
DWG: C587-202	REV: 1




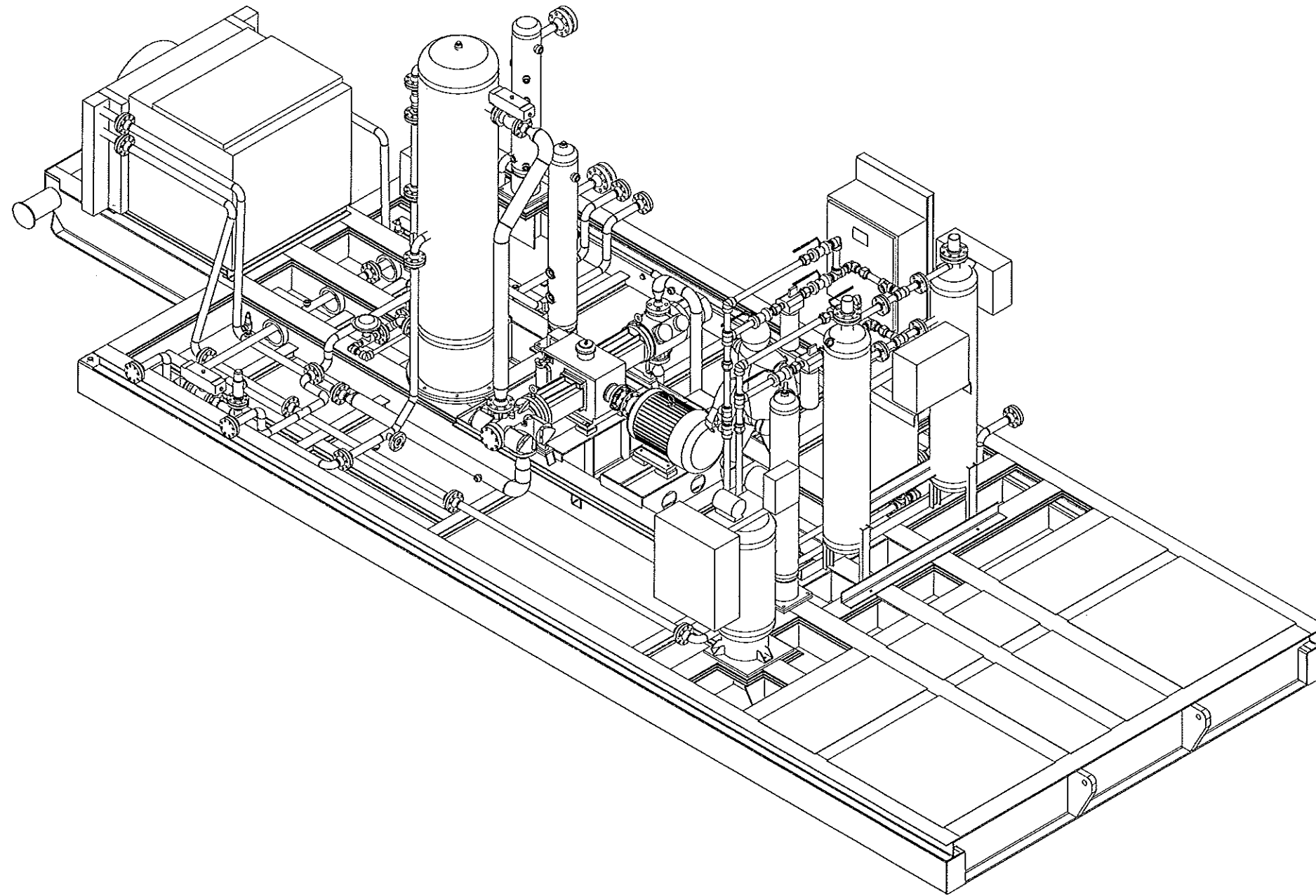
SECTION B-B
SCALE 1 : 30

- GENERAL NOTES:**
 1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION	1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
	EQUIPMENT: EM60-RAA2-3 PROJECT: C587 SCALE: AS NOTED DWN BY: NSP APP BY: <i>[Signature]</i>	CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS GENERAL ARRANGEMENT




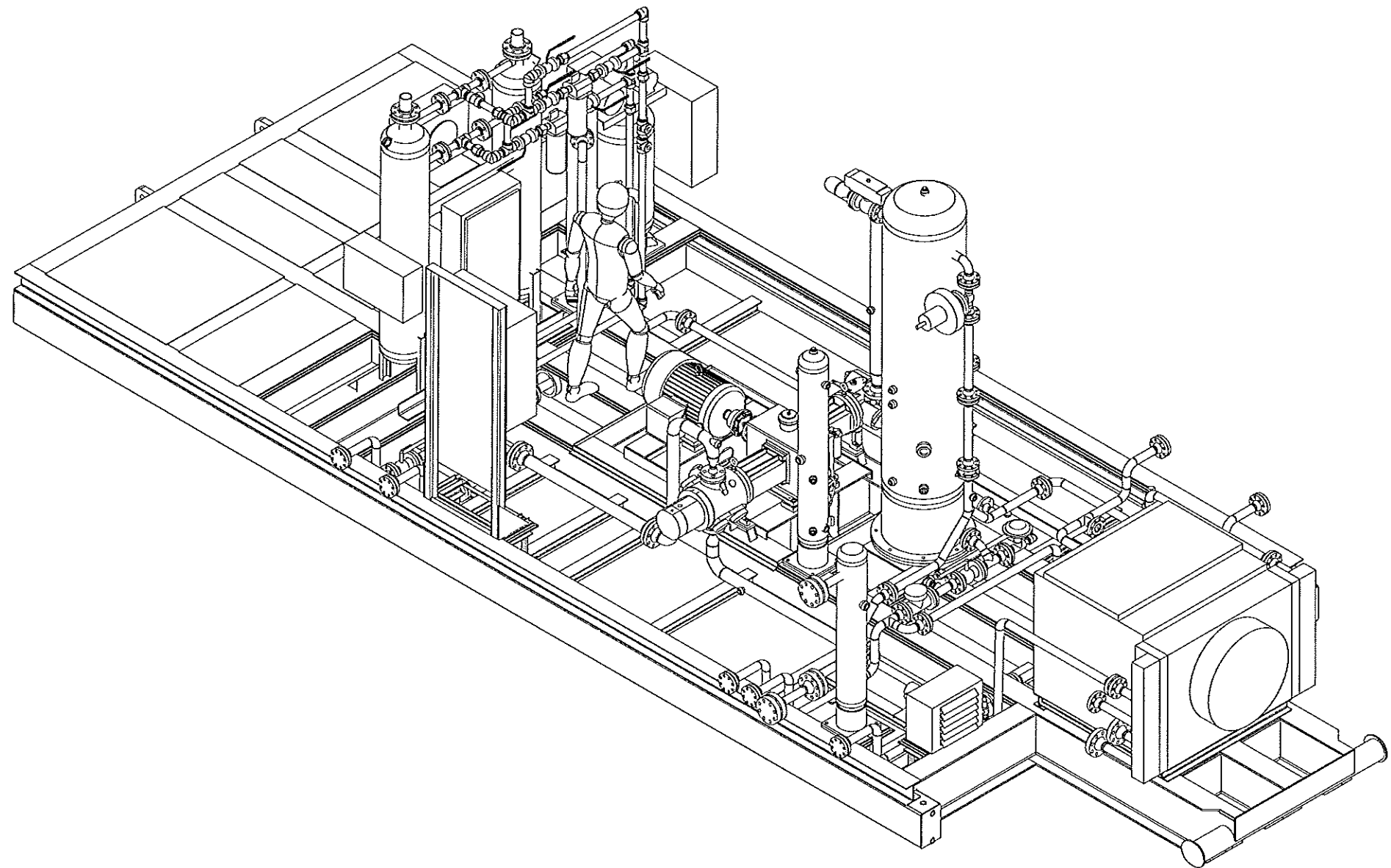
ISO VIEW
SCALE 1:40

- GENERAL NOTES:**
 1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION	1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
	EQUIPMENT: EM60-RAA2-3 PROJECT: C587 SCALE: AS NOTED DWN BY: NSP DATE: 06/14/11 APP BY: <i>[Signature]</i> DATE: <i>9/16/11</i>	CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS GENERAL ARRANGEMENT DWG: C587-204 REV: 1



ISO VIEW
SCALE 1:40

GENERAL NOTES:
 1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

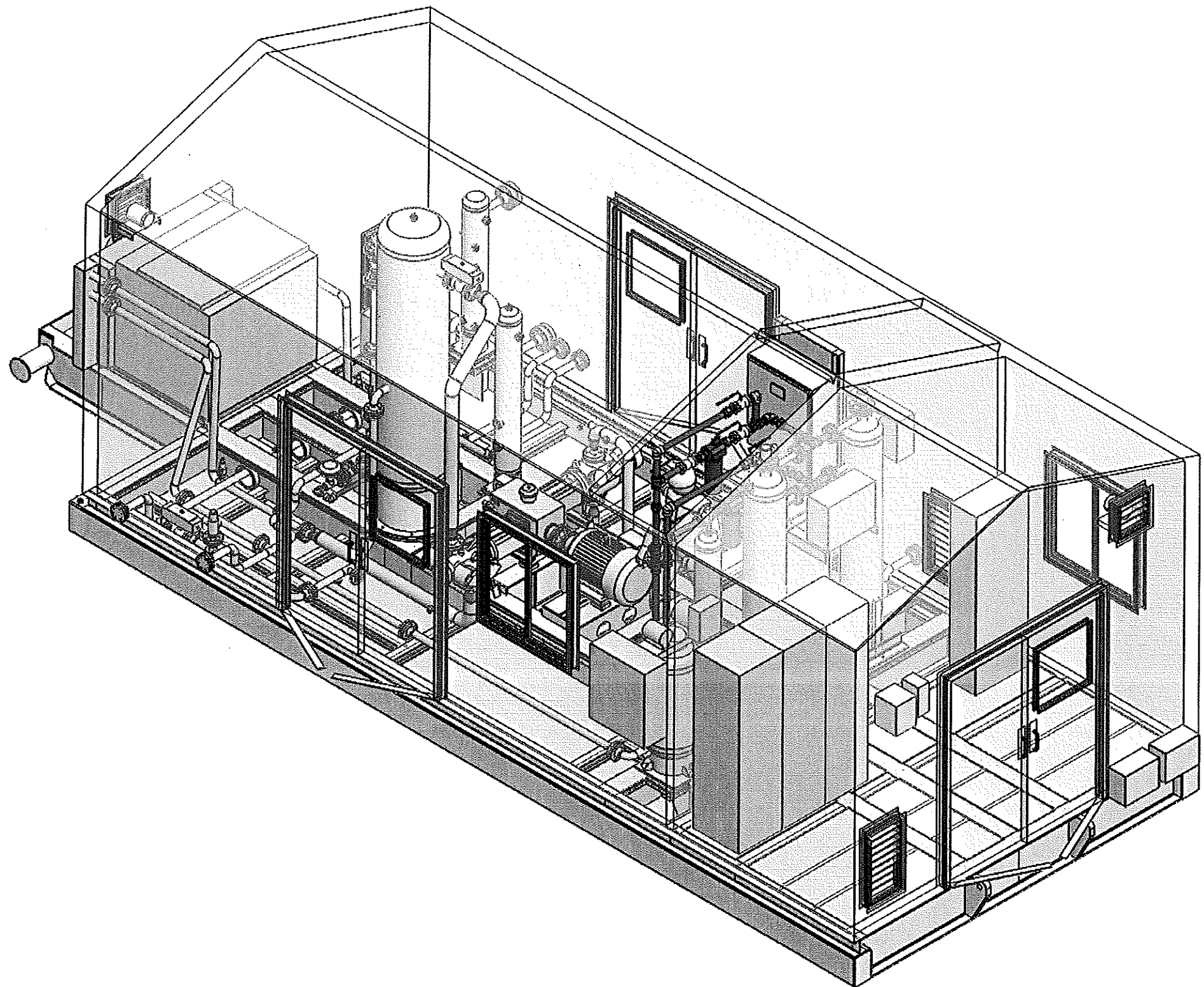
REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

**COMPASS
COMPRESSION**
LTD.

1537 - 9th Ave. S.E.
 Calgary, Alberta
 Canada T2G 5N4
 P 403-262-2487
 F 403-262-2480

EQUIPMENT: EM60-RAA2-3	CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS
PROJECT: C587	
SCALE: AS NOTED	GENERAL ARRANGEMENT
DWN BY: NSP	DATE: 06/14/11
APP BY: <i>[Signature]</i>	DATE: 9/20/11
DWG: C587-205	REV: 1




ISO VIEW
SCALE 1:40

- GENERAL NOTES:**
1. ALL ORDINATE DIMENSIONS FROM DATUM.
 2. ALL DIMENSIONS ARE IN INCHES.
 3. ALL PIPING MUST BE SELF SUPPORTING BEYOND UNIT CONNECTIONS.

REV	DESCRIPTION	DATE	BY
1	AS BUILT	09/16/11	NSP
0	ISSUED FOR CONSTRUCTION	09/12/11	NSP

STAMP:

 COMPASS COMPRESSION	1537 - 9th Ave. S.E. Calgary, Alberta Canada T2G 5N4 P 403-262-2487 F 403-262-2480	
	EQUIPMENT: EM60-RAA2-3 PROJECT: C587 SCALE: AS NOTED DWN BY: NSP APP BY: <i>[Signature]</i>	CANGAS SOLUTIONS LTD. C/O O'ROURKE ENG. SITE: VARIOUS LOCATIONS GENERAL ARRANGEMENT
DWG: C587-206		REV: 1



Bill of Materials - Client Summary

Client Name: CanGas Solutions Ltd.
Unit Number: C587
Model: EM60-RAA2-3

Revision: 0
Date Released: Issued: 08/06/2011 10:39:14 AM nhu
Date Required: August 5, 2011
Project Engineer: Nick Hu

Rev.	(All)
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Quantity								
Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total	
AP	1	Air Compressor	Eagle	IAC2	IAC2 Instrument air compressor -Eagle PV02A, two cylinder, V-style, cast iron, splash lubricated, single stage air compressor c/w intake filter, "cooling fan" type flywheel and "easy view" oil level sightglass. - 2 HP, 3 phase, 208-230/460 volts, 60 Hz, 1	-	1	
				DMD4-4	DMD4-4 Deltech permeable membrane dryer complete with 3-valve bypass using 2000# regular port Trueline ball valves, galvanized schedule 80 piping with forged steel alvanized 3000# fittings. No electrical hook-up is required, no desiccant to change, no mov	-	1	
BH	1	Heater, electrical	HAZLOC Heaters	XEU1-12-100-480360-B-T	XEU1-12-100-480360-B-T Explosion-Proof Electric Unit Heater, 10 kW 12 in. fan diameter, 480 volts, 3 phase, 60 hertz, Explosion-proof motor Class I & II, Div. 1 & 2; Groups C, D, F & G Temp Code T3B Class I, Zones 1 & 2, Groups IIA & IIB, T3 B 24V intern	-	1	
	2	Heater, electrical	HAZLOC Heaters	XEU1-12-050-480360-B-T	XEU1-12-050-480360-B-T Explosion-Proof Electric Unit Heater, 5 kW, 12 in. fan diameter, 480 volts, 3 phase, 60 hertz, Explosion-proof motor Class I & II, Div. 1 & 2; Groups C, D, F & G Temp Code T3B Class I, Zones 1 & 2, Groups IIA & IIB, T3 B 24V intern	-	1	
BPV	140	Discharge Back Pressure Control Valve	Fisher	NPS 1 - D4 FO	Fisher D4 Control Valve - 1" NPT LCC Steel - 1/4 " Micro-Form 416 SST-HT - ENVIRO-SEAL PTFE packing - Complies to NACE MR0175/ISO 15156 - Integral size 40 actuator, Fail Open - Maximum differential 4250 psi - Operating Range:0-33 psi - Face to Face:6.12	(blank)	1	
C	1	Air-Cooled Heat Exchanger	Air-X-Limited	36VI	Induced draft cooler: Fan: (1) MW 52L, 4 bladeS, 30 degree PA, 1.6 hp @ 1170 rpm (Design). SA179 STEEL Tubes, A105 STEEL Header w/ 0.125 C.A. CRN: AB/BC/SK/MB AUTO LOUVERS C587	S/N 117551A	1	

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
C	2	Oil Cooler	Thermal Transfer	AO-15-3PH	Oil Cooler, AO-15, 1"-NPT connections, motor: 1/4HP @ 1725 RPM, 208-230, 460V / 3ph / 60Hz TEFC suitable for service in hazardous areas	-	1
CP	1	Control Panel	PIC	MicroLogix 1400	Allen-Bradley, programmable and scalable control system	Serial No.:	1
CPL	910	Compressor Coupling	Rexnord	AMR-312	Hub Spacer Hub Type, Supplied with Rough Stock Bore Hubs, Steel Hubs, Stainless Steel Disc Packs.	-	1
CR	1	Compressor	Ariel	JGA/2	Ariel JGA/2 compressor frame. Strok = 3.0" Rating per throw: 140 Hp	Serial No.: F-35740	1
CYL	110	Cylinder	Ariel	5-1/8" M	Stage 1 cylinder 5.125" bore, 3.0 in stroke, 3"-300# FF connections. C/W VVCP Rating: 865 psig	Serial No:C-123344	1
	120	Cylinder	Ariel	3-5/8" SG-CE	Stage 2 cylinder 3.625" bore, 3.0 in stroke, 1-1/2" 1500# FF connections. Rating: 2550 psig	Serial No:C-123345	1
	130	Cylinder	Ariel	1-3/4" SG-HE	Stage 3 cylinder 1.5" bore, 3.0 in stroke, 1" SAE fitting connections. Rating: 6100 psig	Serial No:C-123346	1
EM	1	Electric Motor	TECO-Westinghouse	PDH05004TE2M	60 HP, 1800 RPM, 230/460 VAC, 3 PH, 60 HZ, 364T Frame, 1.15 SF, Class F Insulation, NEMA design B, TEFC Enclosure, Certified for Class 1, Div 2, Group B, C & D, Inverter duty 10:1 CT / 20:1 VT, 2.375" Diameter 4140 Steel Keyless Shaft, Oversize Main Condu	Serial No.: JTP7088323001	1
F	820	Oil Filter	Ariel	A-0661	Compressor Oil Filter	-	1
FE	140	Flow Meter	Cameron	7486 Turbine Meter	7400 Barton Turbine Meter configuration: 7400-A-A-E-D-A-2-A-1-A-A-A 3/4" NPT connection, 316 SS body and internal, 430 STST rotor, Bearing: 440C STST ball 1 pick off coil boss	-	1
FI	140	Scanner	Cameron	9A-SCANNER-CA	2000 NuFlo Scanner Micro-EFM 2000-X-X1-A-LP-3040-0-1-00-00S-0C-A-00-BU-X-M Model 2000 Enclosure:[X] Explosion Proof, Certification:[X1] CSA Div 1 XP, Div 2 Transducer:[X1] MVT, CRN-Encl Type 4, MVT Material:[A] STD-SS Covwer & Dia, CS Bolts,	-	1
FSL	820	Flow Switch	Trabon/Whitlock	DNFT-TO-LED-PS-3MIN	Stainless steel and aluminum construction, factory default 3-minute alarm, N.O./N.C. contacts, installs on Dropsa, Lincoln, SBCO and Lubriquip devider blocks. Rating: -40 F to 185 F, 2.5VA/250 VDC, CSAus Ex II 2G EEx md IIC T4	-	1
LC							

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
LC	110	Level Controller	SOR	1540C-G2A-C-J0-PS-CV	1540 = SIDE MOUNTED, FLOAT OPERATED	-	2
	120				C = 316SS CONSTRUCTION		
	130				G = SIDE INTEGRAL PROCESS CONNECTION 2 = 2 INCH A = NPT (M) C = 316/316LSS FLOAT J0 = THREE WAY PNEUMATIC VALVE, NON-BLEED, 30 PSIG MAX SUPPLY PS = PNEUMATIC LEVEL SWITCH THREE 1/4"NPT(F) AIR CONN		
LG	110	Level Gauge	Penberthy	2RL-9	1/2" FNPT process connections, carbon steel reflex glass, double section, 26-3/4" visible length, 28-1/4" OAL. Rating: 1800 psig at 100 F	-	1
	140	Level Gauge	Penberthy	1RH-7	1/2" FNPT process connections, carbon steel reflex glass, single section, 10-1/4" visible length, 11-3/4" OAL. Rating: 4000 psig at 100 F	-	1
	120	Level Gauge	Penberthy	1RM-9	1/2" FNPT process connections, carbon steel reflex glass, single section, 12-5/8" visible length, 14-1/8" OAL. Rating: 2250 psig at 100 F	-	2
	130						
	700	Level Gauge	Unknown	LSP-5109	Liquid Level Gauge	1-866-922-9347	3
710				2" NPT Lube Sight Check	Shawn Robson		
720							
LGV	140	Level Gauge Valve Set	Penberthy	330J	3/4" process connection, 1/2" gauge connection, carbon steel, stainless steel ball check, off-set pattern Rating: 4000 psi at 100 F	-	1
LICS	820	Level Controller	Murphy	15000238	Pipe bracket mounting kit, 7/8" diameter hole to fit a 1/2" pipe, two 1/4 UNC set screw holes..	-	1
		Level Controller Kit	Murphy	LM2000-E	1/2" FNPT inlet, 3/4" FNPT outlet, 1/2" FNPT vent, aluminum housing, polycarbonate lens, brass float, viton inlet seal, removable inlet screen, 1/2" FNPT conduit connection, SPDT switch. Rating: 9.5 psig inlet, 15 psig casing, 10 A at 30 VDC.	-	1
LS	110	Level Switch	Murphy	MLS-020	<ul style="list-style-type: none"> Clean Magnet Design virtually eliminates iron filing accumulation onto the magnet Seal-Free Construction ANSI/ISA 12.27.01 compliant (Single Seal) Operates in 0.50 specific gravity or heavier fluids Designed for harsh gas compressor scrubber app 	-	4
120							
130							
LT	140	Level Transmitter	Rosemount	2051CD2A02A1AS5K6	Rosemount Level Systems: Pressure Transmitter c/w Manifold 2051C: Transmitter Type: Pressure Transmitter for Liquid Level Control D: Measurement Type - Differential 2: Pressure Upper Range Limit: CD/CG: 250" H2O (623mbar) A: Transmitter Output 4-20ma with	Discharge Scrubber	1
LV							

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
LV	140	Control Valve	Fisher	1" D4 NPT FC	Fisher D4 Control Valve - 1" NPT LCC Steel - 1/2 " Micro-Form 17-4PH SST - ENVIRO-SEAL PTFE packing - Complies to NACE MR0175/ISO 15156 - Integral size 40 actuator, Fail Closed - Maximum differential 4180 psi - Operating Range:0-33 psi - Face to Face:6.12	-	1
	110 120 130	Control Valve	Fisher	1" D2 NPT FC	1" FNPT, 1/2" trim, adjustable travel, globe style SA352 LCC body, 316 SS trim, FAIL CLOSED reversilbe actuator, PTFE packing, Rating: 2250 in process, 40 psig in actuator, NACE MR-0175	-	3
	P	1	Diaphragm Pump	Yamada	NDP-20BAN-CSA	Diaphragm pump. 3/4" NPT inlet/outlet, aluminum housing, buna diaphragms, balls, o-rings, 1/4" FNPT instrument supply, 3/4" FNPT instrument vent. Rating: 28 usgpm, 100 psig, 180 F.	-
PCV	112	Pressure Regulator	Bellofram	962-418-006	Type 50 filter regulator, 1/4" FNPT connections, aluminum body, steel and brass trim, Buna-N and polyester diaphragm, 0 to 60 psig spring range, 1/4" FNPT tapped bonnet vent. Rating: 250 psig (inlet), 0 F to 160 F	Set at 30 psig	1
	140 170 190	Pressure Regulator	Bellofram	962-418-006	Type 50 filter regulator, 1/4" FNPT connections, aluminum body, steel and brass trim, Buna-N and polyester diaphragm, 0 to 60 psig spring range, 1/4" FNPT tapped bonnet vent. Rating: 250 psig (inlet), 0 F to 160 F	Set at 35 psig	3
PP	700	Purge Panel	Prominent	Purge Panel	PURGE PANEL 1 - Fisher Regulator, 67C, c/w Handwheel, 0-20psig spring, set @ 15psig 1 - Flow Indicator, MUIS, 9-96 SCFH Natural Gas Scale, 1/8" NPT SS Connections Viton O-rings 1 - Pressure Gauge Model WIKA-253.33, 0-30psig, BM 1 - Swagelok Needle Valve M	-	1
PS	710	Pressure Switch	CCS	604GZJ1-7011	Dual Snap Switch, 1.4 PSIG to 16 PSIG.	Set at 1.4 PSIG Rising	1
PSV	110	Pressure Relief Valve	Mercer	91-17D51T09EN1	1" MNPT x 1" FNPT, D-orifice, 9100 Series WCB CS body & inlet base, Teflon seat, 316 SS disk & nozzle Inconel X750 spring, SOUR gas Service Spring range 231-400 PSIG Set @ 285 psi 600 SCFM air, Temp: 350 F	1st Stage Discharge PSV. Set at 285 psig	1

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
PSV	120	Pressure Relief Valve	Mercer	91-17C51T09N1	1" MNPT x 1" FNPT, C-orifice, 9100 Series WCB CS body & inlet base, Teflon seat, 316 SS disk & nozzle Inconel X750 spring, SOUR gas Service Spring range 401-800 PSIG Set @ 800 psi 832 SCFM air, Temp: 350 F	2nd Stage Discharge PSV. Set at 800 psig	1
	130	Pressure Relief Valve	Mercer	91-17C61P14N1	1" MNPT x 1" FNPT, C-orifice, 9100 Series WCB CS body & inlet base, Peek seat, 316 SS disk & nozzle Inconel X750 spring, SOUR gas Service Spring range 2501-2999 PSIG Set @ 2650 psi 2724 SCFM air, Temp: 350 F	3rd Stage Discharge PSV. Set at 2650 psig	1
	100	Pressure Relief Valve	Mercer	81-43251V07N11	2" MNPT x 2" FNPT, G-orifice, 8100 Series WCB CS body & inlet base, Viton seat, 304 SS disk & 316 SS nozzle Inconel X750 spring, SOUR gas Service Spring range 41-60 PSIG Set @ 45 psi 463 SCFM air, Temp: 120 F	Suction PSV Set @ 45 psig	1
PT	820	Pressure Transmitter	Rosemount	2088G-2-S22A1C6	Gauge pressure transmitter, -14.7 to 150 psig range, 4-20 mA output, HART protocol, 316SS wetted parts, silicone filled diaphragm, 1/4" FNPT process connection. Rating: 1600 psig, -40 to 250 F, NACE, CSA XP, IS and non-incendive.	-	1
	110	Pressure Transmitter	Rosemount	2088G-3-S22A1C6	Gauge pressure transmitter, -14.7 to 800 psig range, 4-20 mA output, HART protocol, 316SS wetted parts, silicone filled diaphragm, 1/4" FNPT process connection. Rating: 1600 psig, -40 to 250 F, NACE, CSA XP, IS and non-incendive.	Calibrated to 0 to 300 psig	1
	120	Pressure Transmitter	Rosemount	2088G-3-S22A1C6	Gauge pressure transmitter, -14.7 to 800 psig range, 4-20 mA output, HART protocol, 316SS wetted parts, silicone filled diaphragm, 1/4" FNPT process connection. Rating: 1600 psig, -40 to 250 F, NACE, CSA XP, IS and non-incendive.	Calibrated to to 800 psig	1
	130	Pressure Transmitter	Rosemount	2088G-4-S22A1C6	Gauge pressure transmitter, -14.7 to 4000 psig range, 4-20 mA output, HART protocol, 316SS wetted parts, silicone filled diaphragm, 1/4" FNPT process connection. Rating: 8000 psig, -40 to 250 F, NACE, CSA XP, IS and non-incendive.	Calibrated to 0 to 3000 psig	1
	100	Pressure Transmitter	Rosemount	2088G-2-S22A1C6	Gauge pressure transmitter, -14.7 to 150 psig range, 4-20 mA output, HART protocol, 316SS wetted parts, silicone filled diaphragm, 1/4" FNPT process connection. Rating: 300 psig, -40 to 250 F, NACE, CSA XP, IS and non-incendive.	Calibrated to 0 to 60 psig	1
PV							

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
PV	110	Suction Pressure Vent Valve	Fisher	NPS 1 - D4 FC	Fisher D4 Control Valve - 1" NPT LCC Steel - 3/4 " Micro-Form 416 SST-HT - ENVIRO-SEAL PTFE packing - Complies to NACE MR0175/ISO 15156 - Integral size 40 actuator, Fail Closed - Maximum differential 1785 psi - Operating Range:0-33 psi - Face to Face:6.12	(blank)	1
	170	By-Pass Control Valve	Fisher	1" NPT 657-D FC	1" NPT Fisher 657-D Control Valve Tag: 60 % Capacity bypass - 1" 3600 NPT LCC steel body - 1/4 Micro-Flute 3 Flute 316 SST Alloy 6 Trim - Nitronic 50 SST Stem, Double TFE packing - B7M/2HM packing box studs and nuts - Complies to NACE MR-01-75 (2002) - Fa	-	1
PY	110	Electro-Pneumatic Transducer	Fisher	I2P-X3B	4-20mA input, 3 to 15 psig or 6 to 30 psig user-configurable output, sealed dual compartment, polyurethane painted low-copper aluminum housing, nitril seals. Rating: CSA<Class 1, Div 1, XP, IS, NEMA 3R,	(blank)	1
	170	Electro-Pneumatic Transducer	Fisher	I2P-X3B	4-20 mA input, 3 to 15 psig or 6 to 30 psig user configurable output, sealed dual compartment, polyurethane painted low-copper aluminum housing, nitril seals. Rating: CSA Class 1, Div. 1, XP, IS, NEMA 3R, natural gas approved, 50 psig.	-	1
SOV	110	Shut-Off Valve	Meridian	FB2R20R03NHBEAA	2"-CL300RF Meridian Split Body Floating Ball Valve, RP, A216 WCB Body, A182 F316 (blank) Ball & Stem, TFM 1700/MPTFE Seat, TFE/Graphite Seals, NACE MR0175/ISO 15166 Rev 2005, Meets CSA Z245.15, API 6D, API607, API608 and B16.34. Operated by DW40-SR-LT Meridian P	(blank)	1
	111	Shut-Off Valve	Meridian	FB2R20R03NHBEAA	2"-CL300RF Meridian Split Body Floating Ball Valve, RP, A216 WCB Body, A182 F316 (blank) Ball & Stem, TFM 1700/MPTFE Seat, TFE/Graphite Seals, NACE MR0175/ISO 15166 Rev 2005, Meets CSA Z245.15, API 6D, API607, API608 and B16.34. Operated by DW40-SR-LT Meridian P	(blank)	1
TCV	820	Temperature Control Valve	Fluid Power	D-1210V-160	FPE Model D-1210V-160 1/2" NPT, ductile iron body, 160F	-	1
TE	820	Thermocouple	Power Ignition Controls	2008-16-K-300	Type 'K' thermocouple, 1/4" diameter 316 stainless steel probe, 90 deg. bend, 6" max insertion, 25' flex wire, bare wire ends.	Compressor frame oil temp	1
	140	Thermocouple	Power Ignition Controls	2008-16-K-120	Type 'K' thermocouple, 1/4" diameter 316 stainless steel probe, 90 deg. bend, 6" max insertion, 10' flex wire, bare wire ends.	Final discharge	1
	120	Thermocouple	Power Ignition Controls	2008-16-K-300	Type 'K' thermocouple, 1/4" diameter 316 stainless steel probe, 90 deg. bend, 6" max insertion, 25' flex wire, bare wire ends.	Stg 2, 3 Discharge	2
	130	Thermocouple	Power Ignition Controls	2008-16-K-300	Type 'K' thermocouple, 1/4" diameter 316 stainless steel probe, 90 deg. bend, 6" max insertion, 25' flex wire, bare wire ends.	Stg 1 discharge	1
	110	Thermocouple	Power Ignition Controls	2008-16-K-360	Type 'K' thermocouple, 1/4" diameter 316 stainless steel probe, 90 deg. bend, 6" max insertion, 30' flex wire, bare wire ends.	Stg 1 discharge	1
TI	111	Temperature Indicator	Winters	TBM30090-B8	0 to 250 F temperature range, 9.0" stem length 'A', 1/2" MNPT centre back process connection, 3" dial, 304 stainless steel housing. Rating: 125 psig, IP65.	Stg 1 suction	1

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
TI	121	Temperature Indicator	Winters	TBM30040-B8	0 to 250 F temperature range, 4.0" stem length 'A', 1/2" MNPT centre back process connection, 3" dial, 304 stainless steel housing. Rating: 125 psig, IP65.	Stg 2 suction	1
	131	Temperature Indicator	Winters	TBM30025-B8	0 to 250 F temperature range, 2.5" stem length 'A', 1/2" MNPT centre back process connection, 3" dial, 304 stainless steel housing. Rating: 125 psig, IP65.	Stg 3 suction	1
TW	820	Thermowell	Murphy	PTW-610	3/4" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260" bore, 1.0" insertion length 'U', 2.5" stem length 'A'.	Compressor frame oil	1
	110	Thermowell	Murphy	PTW-420	1/2" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260" bore, 2.0" insertion length 'U', 5.5" stem length 'A'.	Stg 1 cylinder discharge	1
	120	Thermowell	Murphy	PTW-425	1/2" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260" bore, 2.5" insertion length 'U', 4.0" stem length 'A'.	Stg 2 cylinder discharge	1
	111	Thermowell	Murphy	PTW-675	3/4" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260 bore, 7.5" insertion length 'U', 9.0" stem length 'A'.	Stg 1 suction	1
	121	Thermowell	Murphy	PTW-625	3/4" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260 bore, 2.5" insertion length 'U', 4.0" stem length 'A'.	Stg 2 suction	1
	130	Thermowell	Murphy	PTW-440	1/2" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260" bore, 4.0" insertion length 'U', 5.5" stem length 'A'.	Stg 3 cylinder discharge	1
	131	Thermowell	Murphy	PTW-610	3/4" MNPT process connection, 1/2" FNPT instrument connection, 304 stainless steel, .260 bore, 1.0" insertion length 'U', 2.5" stem length 'A'.	Stg 3 suction	1
V	1	Vessel, Suction Scrubber	CADO Industries	2011-040-301	24" OD x 90" S/S shell length in Carbon Steel, mesh pad in 316SS. Rating: 645 psig, -20 to 350 F, 1/8" C.A., RT-1 radiography, PWHT, OIL & PICKLE CRN AB, BC, SK, MB, U-Stamp	Serial No	1
	2	Vessel, Suction Scrubber	CADO Industries	2011-040-302	8.625" OD x 52.5" S/S shell length in Carbon Steel, mesh pad in 316SS. Rating: 645 psig, -20 to 350 F, 1/8" C.A., RT-1 radiography, PWHT, OIL & PICKLE CRN AB, BC, SK, MB, U-Stamp	Serial No:	1
	3	Vessel, Suction Scrubber	CADO Industries	2011-040-303	8.625" OD x 52.5" S/S shell length in Carbon Steel, mesh pad in 316SS. Rating: 1287 psig, -20 to 350 F, 1/8" C.A., RT-1 radiography, PWHT, OIL & PICKLE CRN AB, BC, SK, MB, U-Stamp	Serial No:	1
	4	Vessel, Suction Scrubber	CADO Industries	2011-040-304	8.625" OD x 52.5" S/S shell length in Carbon Steel, mesh pad in 316SS. Rating: 2650 psig, -20 to 350 F, 1/8" C.A., RT-1 radiography, PWHT, OIL & PICKLE CRN AB, BC, SK, MB, U-Stamp	Serial No:	1
VS	910 920 930	Vibration Switch	Murphy	VS2-E	Base mount vibration switch, SPDT switch, adjustable sensitivity, local reset. Rating: 1A at 30 VDC, NEMA 3R, QPS approved Class 1, Div.2 non-incendive	-	3
XY	140	Solenoid Valve	Asco	EF-8320G202-24	1/4" FNPT connections, 303 SS body, 3-way normally closed, spring return. Rating: 225 psig, -20 to 200 F, 115 psi max dP, CSA approved XP.	-	1
(blank)	811	Oil Day Tank	Midwestern Compressor	2011	15 usg capacity, sight glass with volume gauge, 2" fill with vent cap, 1/2" ball valve supply.	-	1
	940	Ball Valve	Meridian	MAC2CF-1/4	Meridian MAC2CF-1/4, 2000 WOG, 2 Piece, Full Port 1/4" NPT, NACE	-	4
	952	Check Valve, Swing	NEWCO	38T-FS4/3	1"NPT Swing Check, Forged carbon steel Body. 316SS internals,	-	3

Func. I.D.	Loop I.D	Item Group	Manufacturer	Part Number	Description	Notes	Total
(blank)	999	Building	Warwick Industries	NA	Self-framing, gable style, metal building, 4:12 roof slope 13'-4" wide x 30'-0" long x 9'-9" eave (exterior wall dimensions) Exterior walls and roof: 22ga, pre-painted, color TBD. Exterior doors and trim: 22ga, pre-painted, color TBD. Insulation - walls a	-	1
	941	Ball Valve	Meridian	MAC2CF-1/2"	1/2" FNPT connection, carbon steel body, stainless steel trim, PTFE seal and packing, locking handle. Rating: 2000 WOG, 1100 psig at 250 F, NACE	-	3
	942	Ball Valve	Meridian	MAC2CF-1"	1" FNPT connection, carbon steel body, stainless steel trim, PTFE seal and packing, locking handle. Rating: 2000 WOG, 1100 psig at 250 F, NACE	-	2
	944	Ball Valve	Nutron	NTR-T3-R10S30S	1" FNPT connections, 3-piece threaded, A105 carbon steel body, Teflon Seats,NACE trim, reduced port. Rating: 3000 WOG	-	8
	951	Check Valve, Swing	Stream-Flo	14100	2"-300# Swing Check, Forged carbon steel Body. 316SS internals,	-	1
	961	Gate Valve	MTC	T-62T-05	1" FNPT connections, brass body, non-rising stem. Rating: 200 WOG.	-	1
	965	Needle Valve	Century	CM2-3-M22T-BV	1/4" MNPT x 1/4" FNPT connections, carbon steel body, carbon steel trim, Viton o-ring, needle tipped stem end. Rating: 6000 psig at 200 F.	-	1
	966	Needle Valve	Century	CM21M64TDT	3/4" MNPT x 1/2" FNPT, 6000 PSIG, 316SS Body/Trim, Teflon Adjustable Packing, Rotating Ball Tipped Stem End	-	4
	922	Ariel mountingi blocks	Anglo Precision Machining	C581-JGA2-MB	According to issued drawings	-	4
	924	Motor mountingi blocks	Anglo Precision Machining	C581-MOTOR-MB	According to issued drawings	-	4
	938	Ball Valve	Meridian	MAC2CF-3/8"	3/8" FNPT connection, carbon steel body, stainless steel trim, PTFE seal and packing, locking handle. Rating: 2000 WOG, 1100 psig at 250 F, NACE	Purge isolation	2
	939	Ball Valve	Meridian	MAC2SF-1/2	1/2" FNPT connection, 316SS body, 316SS trim, PTFE seal and packing, locking handle. Rating: 2000 WOG, 1100 psig at 250 F, NACE	Scrubber LG & drain valve	10
	946	Ball Valve	Nutron	NTR-T3-R20S30S	2" FNPT connections, 3-piece threaded, A105 carbon steel body, Teflon Seats,NACE trim, reduced port. Rating: 3000 WOG	-	2
	947	Ball Valve	Nutron	NTR-T3-R20R03S	2"-300# RF connections, 3-piece threaded, A105 carbon steel body, Teflon Seats,NACE trim, reduced port. Rating: ANSI class 300	-	4
	953	Check Valve, Swing	NEWCO	38T-FS4/3	3/4"NPT Swing Check, Forged carbon steel body. 316SS internals	(blank)	2
		Spring load Check Valve	Swagelok	SS-8CPA2-350	1/2" NPTM connections, Adjustable cracking pressure: 350 - 600 psig Set @ 550 PSIG	Set to 550 psig	1
	960	Needle Valve	Swagelok	SS-1RS4	1/4" tube connections, 316SS, Regulator Tip	-	3
	974	Dresser Coupling	Aeroquip	NH1600C100B0288	1" NPS I.D., Buna-N gaskets, plated carbon steel sleeve, 2.88" joint length. Rating: 200 psig, -25 to 180 F.	-	1



Unit C- 587

Performance





Ariel Performance



Company: Ariel Corporation
 Quote: 1103-074
 Case 1: 50 mscfd

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions

Compressor Data:

Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,°F:	100.00
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0
Calc RPM:	<u>458.4</u>	BHP:	12	Calc PS FPM:	229.2

Driver Data:

Type:	<u>VFD</u>
Mfg:	TECO
Model:	TEFC-PDH
BHP:	15
Avail:	15 (0)

Pseudo Q

Services

Service 1

Gas Model

VMG

Stage Data:

1

2

3

Target Flow, MMSCFD	0.050	0.050	0.050
Flow Calc, MMSCFD	0.050	0.050	0.046
BHP per Stage	4.1	3.4	3.3
Specific Gravity	0.9965	0.9972	0.9407
Ratio of Sp Ht (N)	1.1786	1.1883	1.2226
Comp Suct (Zs)	0.9835	0.9384	0.7998
Comp Disch (Zd)	0.9621	0.8894	0.8202
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	140.31	537.10
Pres Disch Flg, psig	144.48	547.10	2424.13
Pres Disch Line, psig	N/A	N/A	2400.00
Pres Ratio F/F	<u>4.727</u>	3.646	4.428
Temp Suct, °F	68.00	110.00	110.00
Temp Clr Disch, °F	110.00	110.00	110.00

Cylinder Data:

Throw 2

Throw 1

Throw 1

Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	32.0	7.4	1.4
Pres Suct Intl, psig	19.75	139.39	535.96
Temp Suct Intl, °F	72	114	114
Pres Disch Intl, psig	145.68	551.43	2430.52
Temp Disch Intl, °F	215	246	293
HE Suct Gas Vel, FPM	2287	N/A	1128
HE Disch Gas Vel, FPM	2131	N/A	1227
HE Spcrs Used/Max	0/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	15.14	N/A	17.00
HE Total Clr, %	15.14	N/A	17.00
CE Suct Gas Vel, FPM	2177	2017	N/A
CE Disch Gas Vel, FPM	2029	2062	N/A
CE Spcrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	16.31	22.12	N/A
CE Total Clr, %	16.31	22.12	N/A
Suct Vol Eff HE/CE, %	49.6/46.4	N/A/46.3	53.4/N/A
Disch Event HE/CE, ms	14.2/16.4	N/A/18.5	15.6/N/A
Suct Pseudo-Q HE/CE	0.9/0.8	N/A/0.7	<u>0.3</u> /N/A
Gas Rod Ld Comp, %	23.8 C	38.1 C	38.1 C
Gas Rod Ld Tens, %	24.5 T	30.0 T	30.0 T
Gas Rod Ld Total, %	25.4	35.9	35.9
Xhd Pin Deg/%Rvrsl lbf	173/94.0	162/70.5	162/70.5
Flow Calc, MMSCFD	0.050	0.050	0.046
Cyl BHP	4.1	3.4	3.3



Ariel Performance



Company: Ariel Corporation
 Quote: 1103-074
 Case 2: 120 mscfd

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions

Compressor Data:

Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,°F:	100.00
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0
Calc RPM:	1100.7	BHP:	31	Calc PS FPM:	550.3

Driver Data:

Type:	<u>VFD</u>
Mfg:	TECO
Model:	TEFC-PDH
BHP:	37
Avail:	37 (0)

Services

Gas Model

Service 1

VMG

Stage Data:

1

2

3

Target Flow, MMSCFD	0.120	0.120	0.120
Flow Calc, MMSCFD	0.120	0.120	0.109
BHP per Stage	10.4	8.7	8.0
Specific Gravity	0.9965	0.9972	0.9407
Ratio of Sp Ht (N)	1.1786	1.1883	1.2226
Comp Suct (Zs)	0.9835	0.9384	0.7998
Comp Disch (Zd)	0.9621	0.8894	0.8202
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	140.30	537.07
Pres Disch Flg, psig	144.48	547.07	2424.13
Pres Disch Line, psig	N/A	N/A	2400.00
Pres Ratio F/F	<u>4.727</u>	3.646	4.428
Temp Suct, °F	68.00	110.00	110.00
Temp Clr Disch, °F	110.00	110.00	110.00

Cylinder Data:

Throw 2

Throw 1

Throw 1

Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	76.9	17.8	3.4
Pres Suct Intl, psig	18.55	135.00	530.50
Temp Suct Intl, °F	73	114	114
Pres Disch Intl, psig	151.31	571.75	2460.81
Temp Disch Intl, °F	223	253	297
HE Suct Gas Vel, FPM	5490	N/A	2708
HE Disch Gas Vel, FPM	5117	N/A	2946
HE Spcrs Used/Max	0/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	15.14	N/A	17.00
HE Total Clr, %	15.14	N/A	17.00
CE Suct Gas Vel, FPM	5226	4844	N/A
CE Disch Gas Vel, FPM	4871	4950	N/A
CE Spcrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	16.31	22.12	N/A
CE Total Clr, %	16.31	22.12	N/A
Suct Vol Eff HE/CE, %	49.6/46.4	N/A/46.3	53.4/N/A
Disch Event HE/CE, ms	6.1/6.8	N/A/7.7	6.5/N/A
Suct Pseudo-Q HE/CE	5.3/4.8	N/A/4.1	1.9/N/A
Gas Rod Ld Comp, %	25.1 C	39.0 C	39.0 C
Gas Rod Ld Tens, %	25.8 T	31.9 T	31.9 T
Gas Rod Ld Total, %	26.7	37.4	37.4
Xhd Pin Deg/%RvrsI lbf	167/99.2	151/67.3	151/67.3
Flow Calc, MMSCFD	0.120	0.120	0.109
Cyl BHP	10.4	8.7	8.0



Gas Analysis Data



Company: Ariel Corporation
 Quote: 1103-074
 Case 2: 120 mscfd

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions

7.6.5.1

Services	Service							
Gas Model	VMG							
Stage	# 1	# 1	# 2	# 2	# 3	# 3	# 3	Final
Stream	Main	Vapor	Liq1	Vapor	Liq1	Liq2	Vapor	Vapor
Suction Press, psig	20.00	20.00		140.30			537.02	
Disch Press, psig		144.47		547.02			2424.13	2400.00
Suction Temp, °F	68.00	68.00		110.00			110.00	110.00
Disch Temp, °F		222.86		253.19			296.59	110.00
Flow, MMSCFD	0.120	0.120	0.000	0.120	0.010	0.001	0.109	0.109
Flow, lb/h	380.3	380.3	0.4	379.9	51.4	1.4	327.1	327.1
Flow, GPM			0.001		0.207	0.003		
Dropout, %			0.179		8.131	0.582		
Specific Gravity	0.9965	0.9965		0.9972			0.9407	0.9407
Ratio of Sp Ht (N)		1.1786		1.1883			1.2226	
Comp Suct (Zs)		0.9835		0.9384			0.7998	0.5791
Comp Disch (Zd)		0.9621		0.8894			0.8203	
Comp @ Std (Zstd)		0.9924		0.9924			0.9924	0.9932
Mole Weight		28.86		28.88			27.25	27.25
Density, lb/ft3		0.173		0.774			3.077	18.802
Density @ Std, lb/ft3		0.076		0.076			0.072	0.072
Enthalpy, Btu/lb		174.23		187.46			173.49	91.44
Entropy, Btu/lb-F		1.6078		1.5293			1.4891	1.2773
Speed of Sound (Suct), ft/s		1025.87		1027.65			972.39	1418.10
Pseudo-Pc, psig		660.103		655.586			646.033	646.033
Pseudo-Tc, °F		29.58		28.37			8.12	8.12
Cp, Btu/lb.°F		0.4443		0.4801			0.5709	0.8322
NHV Mass, BTU/ft3		1492.44		1495.11			1415.80	1415.80
Speed of Sound (Disch), ft/s		1124.04		1097.93			1292.62	1407.89
Viscosity, lb/ft-s		8.17e-006		8.50e-006			9.11e-006	7.23e-006
Thermal Cond., Btu/ft-h.°F		2.19e-002		2.35e-002			2.64e-002	1.79e-002
Heat Load, BTU/h		1.91e+004		2.61e+004			3.48e+004	0.00e+000
Humidity	100.00	100.00						
HYDROGEN	0.02000	0.01980		0.01984	0.00141		0.02160	0.02160
HELIUM-3	0.10000	0.09901		0.09919	0.01310	0.00001	0.10749	0.10749
NITROGEN	2.27000	2.24751	0.00021	2.25153	0.25112	0.00086	2.44404	2.44404
CARBON DIOXIDE	0.64000	0.63366	0.00250	0.63479	0.27709	0.00828	0.67064	0.67064
HYDROGEN SULFIDE	0.00001	0.00001		0.00001	0.00001		0.00001	0.00001
METHANE	50.92000	50.41552		50.50568	12.54473	0.00002	54.20852	54.20852
ETHANE	17.41000	17.23751		17.26834	13.58238		17.70666	17.70666
PROPANE	17.72000	17.54444		17.57582	30.08213		16.57391	16.57391
ISOBUTANE	1.95000	1.93068		1.93413	5.67487		1.61328	1.61328
n-BUTANE	6.40000	6.33659		6.34793	21.64420		5.02598	5.02598
ISOPENTANE	0.92000	0.91089		0.91251	4.70407		0.58063	0.58063
n-PENTANE	1.04000	1.02970		1.03154	5.62128		0.62932	0.62932
n-HEXANE	0.32000	0.31683		0.31740	2.63970		0.11258	0.11258
n-HEPTANE	0.29000	0.28713		0.28764	2.86598		0.05983	0.05983
WATER	0.99073	0.99073	99.99728	0.81366	0.09792	99.99083	0.24552	0.24552



Gas Analysis Data



Company: Ariel Corporation
Quote: 1103-074
7.6.5.1 Case 2: 120 mscfd

Customer: O'Rourke
Inquiry:
Project: CanGas Solutions



Ariel Performance



Company: Ariel Corporation
 Quote: 1103-074
 Case 3: Full Flow

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions

Compressor Data:

Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,°F:	100.00
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0
Calc RPM:	1800.0	BHP:	54	Calc PS FPM:	900.0

Driver Data:

Type:	<u>VFD</u>
Mfg:	TECO
Model:	TEFC-PDH
BHP:	60
Avail:	60 (0)

Disch Temp

Services

Service 1

Gas Model

VMG

Stage Data:

1

2

3

Target Flow, MMSCFD	0.120	0.120	0.120
Flow Calc, MMSCFD	0.191	0.191	0.185
BHP per Stage	18.6	15.8	14.0
Specific Gravity	0.9965	0.9965	0.9785
Ratio of Sp Ht (N)	1.1784	1.1854	1.2127
Comp Suct (Zs)	0.9835	0.9408	0.7965
Comp Disch (Zd)	0.9617	0.8935	0.8154
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	143.63	558.71
Pres Disch Flg, psig	147.81	568.71	2424.13
Pres Disch Line, psig	N/A	N/A	2400.00
Pres Ratio F/F	<u>4.827</u>	3.707	4.261
Temp Suct, °F	68.00	121.10	128.70
Temp Clr Disch, °F	121.10	128.70	115.30

Cylinder Data:

Throw 2

Throw 1

Throw 1

Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	125.8	29.1	5.5
Pres Suct Intl, psig	16.13	129.47	540.24
Temp Suct Intl, °F	73	125	133
Pres Disch Intl, psig	166.00	634.30	2524.40
Temp Disch Intl, °F	241	282	<u>314</u>
HE Suct Gas Vel, FPM	8979	N/A	4429
HE Disch Gas Vel, FPM	8369	N/A	4819
HE Spcrs Used/Max	0/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	15.14	N/A	17.00
HE Total Clr, %	15.14	N/A	17.00
CE Suct Gas Vel, FPM	8546	7921	N/A
CE Disch Gas Vel, FPM	7966	8094	N/A
CE Spcrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	16.31	22.12	N/A
CE Total Clr, %	16.31	22.12	N/A
Suct Vol Eff HE/CE, %	48.5/45.2	N/A/45.3	54.7/N/A
Disch Event HE/CE, ms	3.6/4.1	N/A/4.6	<u>4.1</u> /N/A
Suct Pseudo-Q HE/CE	14.1/12.8	N/A/10.8	5.0/N/A
Gas Rod Ld Comp, %	28.4 C	40.7 C	40.7 C
Gas Rod Ld Tens, %	29.1 T	37.3 T	37.3 T
Gas Rod Ld Total, %	30.2	41.1	41.1
Xhd Pin Deg/%Rvrsl lbf	155/78.5	136/61.1	136/61.1
Flow Calc, MMSCFD	0.191	0.191	0.185
Cyl BHP	18.6	15.8	14.0



Ariel Performance



Company: Ariel Corporation
 Quote: 1103-074
 Remarks:

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions

7.6.5.1

Compressor Data:

Elevat'n,ft:	50.00	Barmtr,psia:	14.669	Ambient,°F:	100.00
Frame:	JGA/2	Stroke,in:	3.00	Rod Dia,in:	1.125
Max RL Tot,lbf:	20000	Max RL Tens,lbf:	10000	Max RL Comp,lbf:	11000
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0
Calc RPM:	1800.0	Calc BHP:	59	Calc PS FPM:	900.0

Driver Data:

Type: Electric
 Mfg: TW
 Model: PDH
 BHP: 60
 Avail: 60 (0)

Deactivated

Service

Stage Data

	1	2	3
Flow Req'd, MMSCFD	0.120		
Flow Calc, MMSCFD	0.490	0.490	<i>BlowThru</i>
Cyl BHP per Stage	31.4	21.6	0.0
Specific Gravity	0.9986	0.9986	0.9976
Ratio of Sp Ht (N)	1.1885	1.1960	1.1801
Comp Suct (Zs)	0.9626	0.9132	0.8405
Comp Disch (Zd)	0.9329	0.8837	0.8423
Pres Suct Line, psig	60.00	N/A	N/A
Pres Suct Flg, psig	60.00	213.26	416.89
Pres Disch Flg, psig	217.23	421.89	408.29
Pres Disch Line, psig	N/A	N/A	400.00
Pres Ratio F/F	3.106	1.915	0.980
Temp Suct, °F	68.00	121.10	128.70
Temp Clr Disch, °F	121.10	128.70	115.30

Cylinder Data

	Throw 2	Throw 1	Throw 1
Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore,in	4.750	3.625	1.500
Cyl RDP (API),psig	454.5	2318.2	5545.5
Cyl MAWP,psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	107.6	29.1	5.5
Pres Suct Intl, psig	54.86	191.98	413.47
Temp Suct Intl, °F	72	124	129
Suct Zsph	0.9633	0.9144	0.8405
Pres Disch Intl, psig	233.38	476.84	413.47
Temp Disch Intl, °F	190	213	129
HE Suct Gas Vel, FPM	6852	N/A	4429
HE Disch Gas Vel, FPM	6256	N/A	4819
HE Spcrs Used/Max	0/2	N/A	1/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
HE Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	18.54	N/A	17.00
HE Total Clr, %	18.54	N/A	34.60
CE Suct Gas Vel, FPM	6467	7921	N/A
CE Disch Gas Vel, FPM	5905	8094	N/A
CE Spcrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	20.11	22.12	N/A
CE Total Clr, %	20.11	22.12	N/A
Suct Vol Eff HE/CE, %	62.5/60.0	N/A/77.3	N/A/N/A
Disch Event HE/CE, ms	5.1/5.7	N/A/8.2	N/A/N/A
Suct Pseudo-Q HE/CE	7.6/6.8	N/A/11.2	N/A/N/A
Gas Rod Ld Comp, %	29.4	6.9	N/A
Gas Rod Ld Tens, %	29.2	18.9	N/A
Gas Rod Ld Total, %	30.8	13.3	N/A
Xhd Pin Deg/%Rvrsl	174/92.9	178/68.7	178/68.7
Flow Calc, MMSCFD	0.490	0.490	<i>BlowThru</i>
Cyl BHP	31.4	21.6	

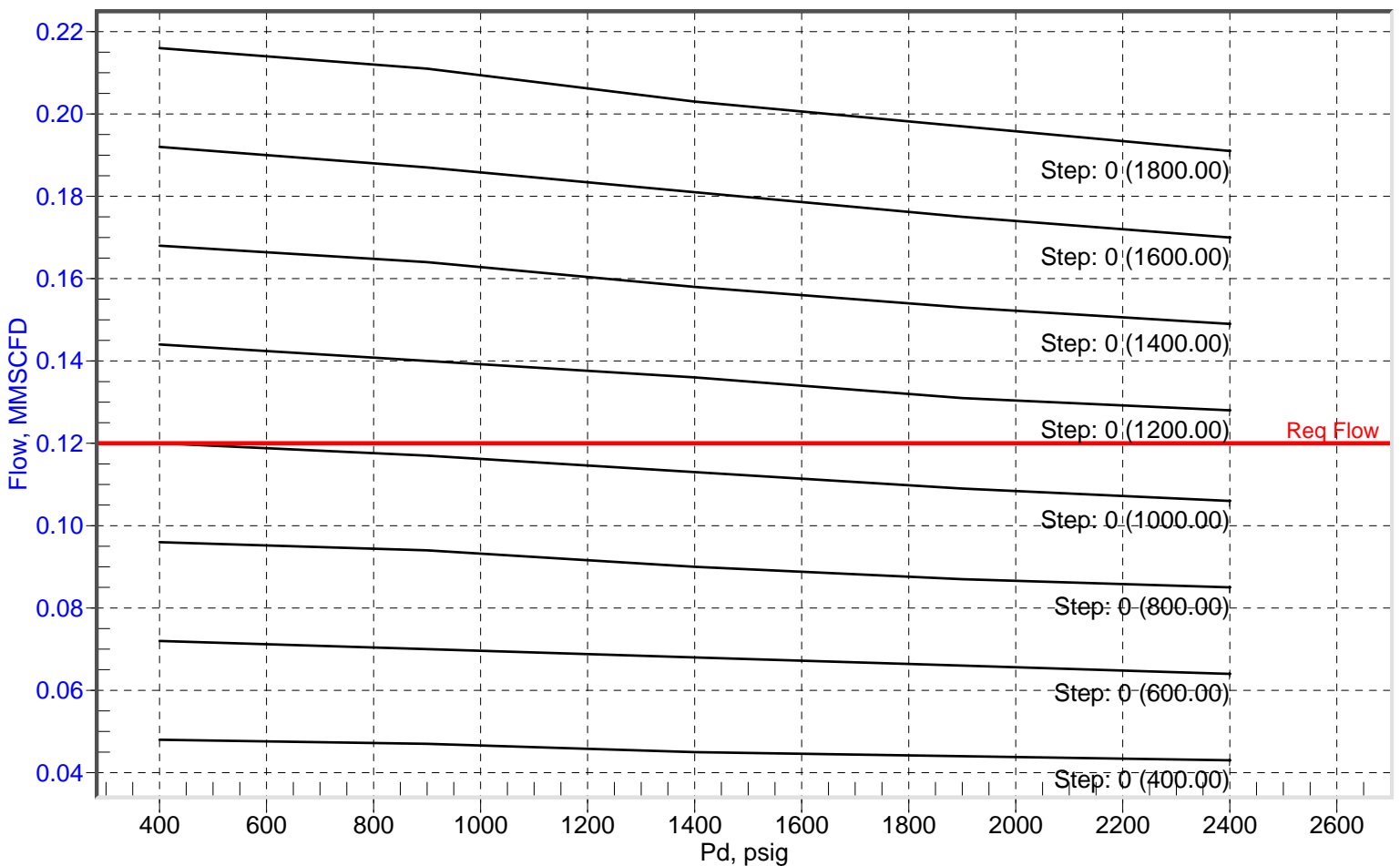
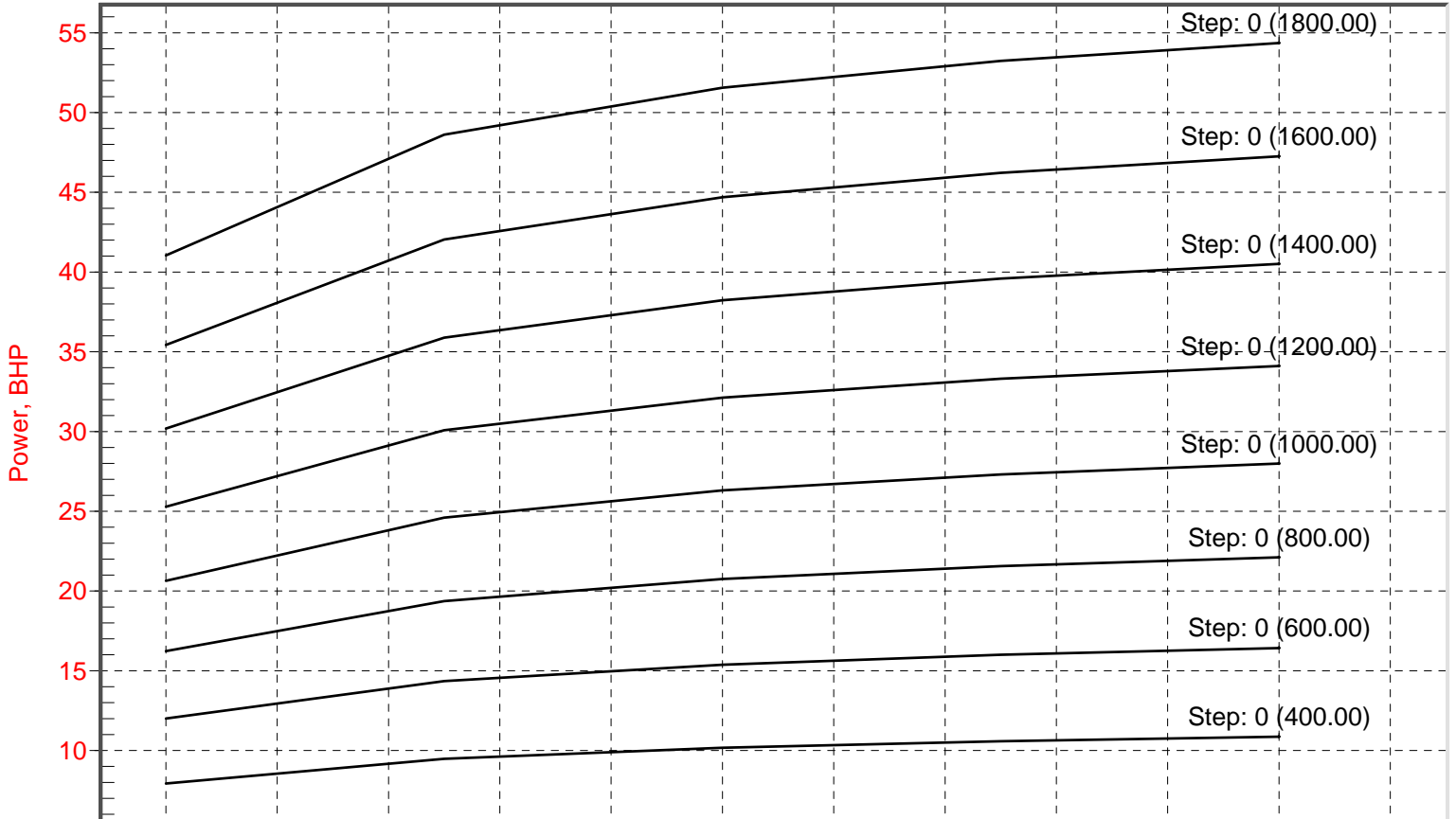
Step: 0 - Default Cfg

CanGas Solutions

Ps, psig: 20.00, RPM: 400.00 - 1800.00

Driver: TECO Model: TEFC-PDH
Frame: JGA/2MMSCFD at 14.70 psia, 60.0 °F
Thw2: 5-1/8M (5.125) Stage: 1, Service: Service 1, SG: 0.9965, Suct Temp (°F): 68.00
Thw1CE: 3-5/8SG-CE (3.625) Stage: 2
Thw1HE: 1-3/4SG-FS-HE (1.500) Stage: 3

Ariel 7.6.5.1 MRV 1.11
1103-074 CanGas EM60-RAA2-3 PER01
1103-074 CanGas RAA_MR 5_125.csv

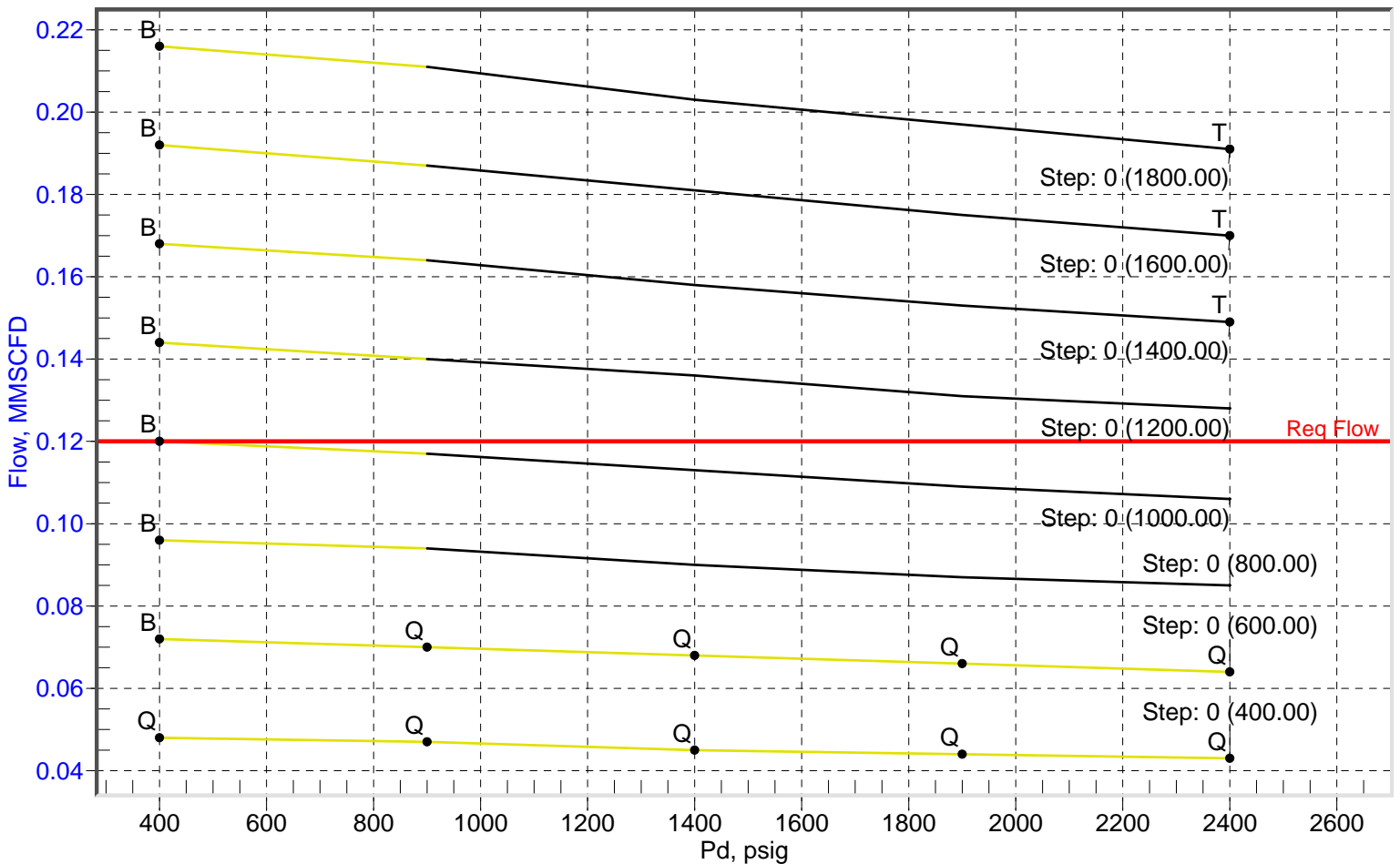
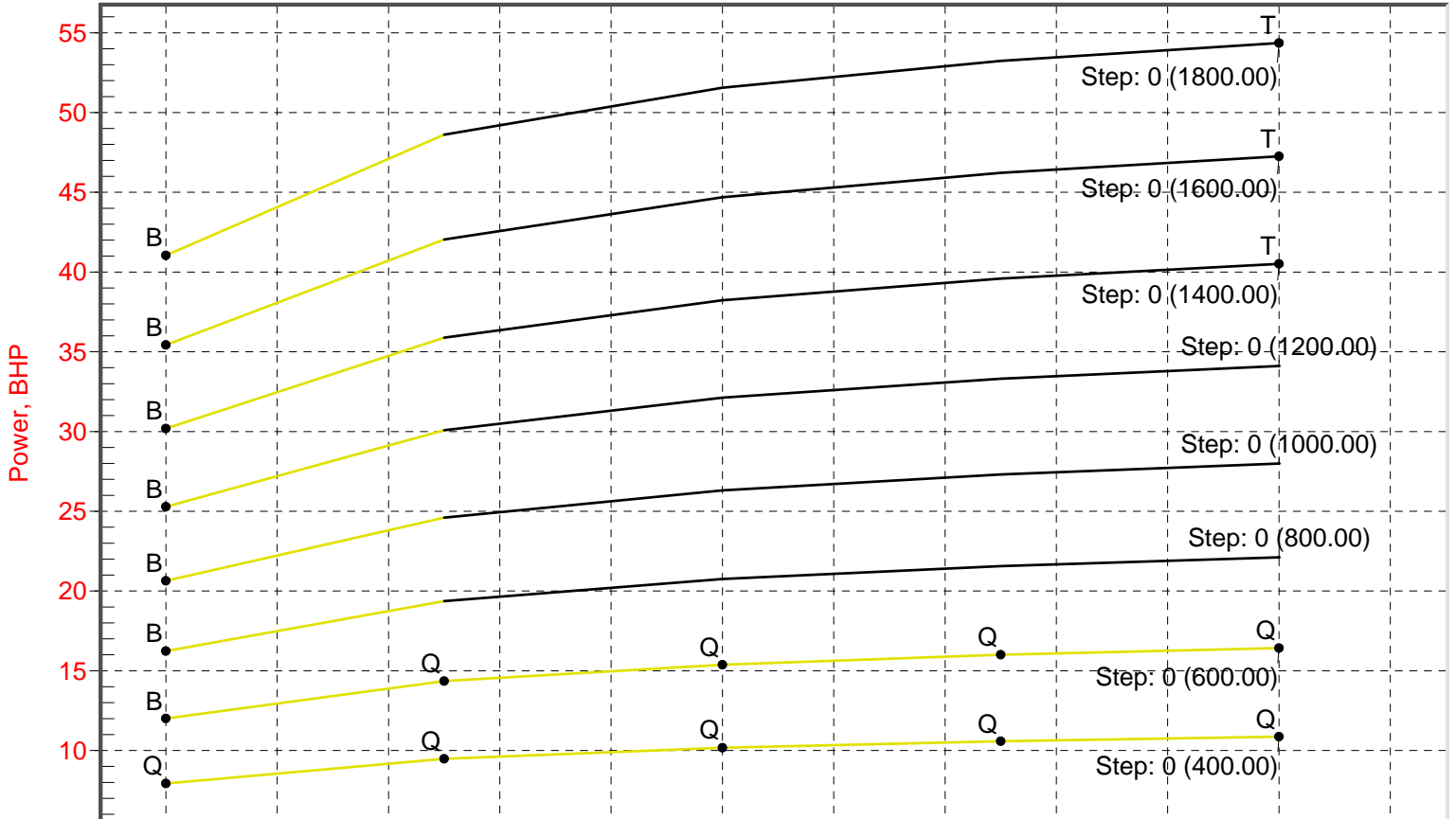


CanGas Solutions

Ps, psig: 20.00, RPM: 400.00 - 1800.00

Driver: TECO Model: TEFC-PDH
 Frame: JGA/2MMSCFD at 14.70 psia, 60.0 °F
 Thw2: 5-1/8M (5.125) Stage: 1, Service: Service 1, SG: 0.9965, Suct Temp (°F): 68.00
 Thw1CE: 3-5/8SG-CE (3.625) Stage: 2
 Thw1HE: 1-3/4SG-FS-HE (1.500) Stage: 3

Ariel 7.6.5.1 MRV 1.11
 1103-074 CanGas EM60-RAA2-3 PER01
 1103-074 CanGas RAA_MR 5_125.csv

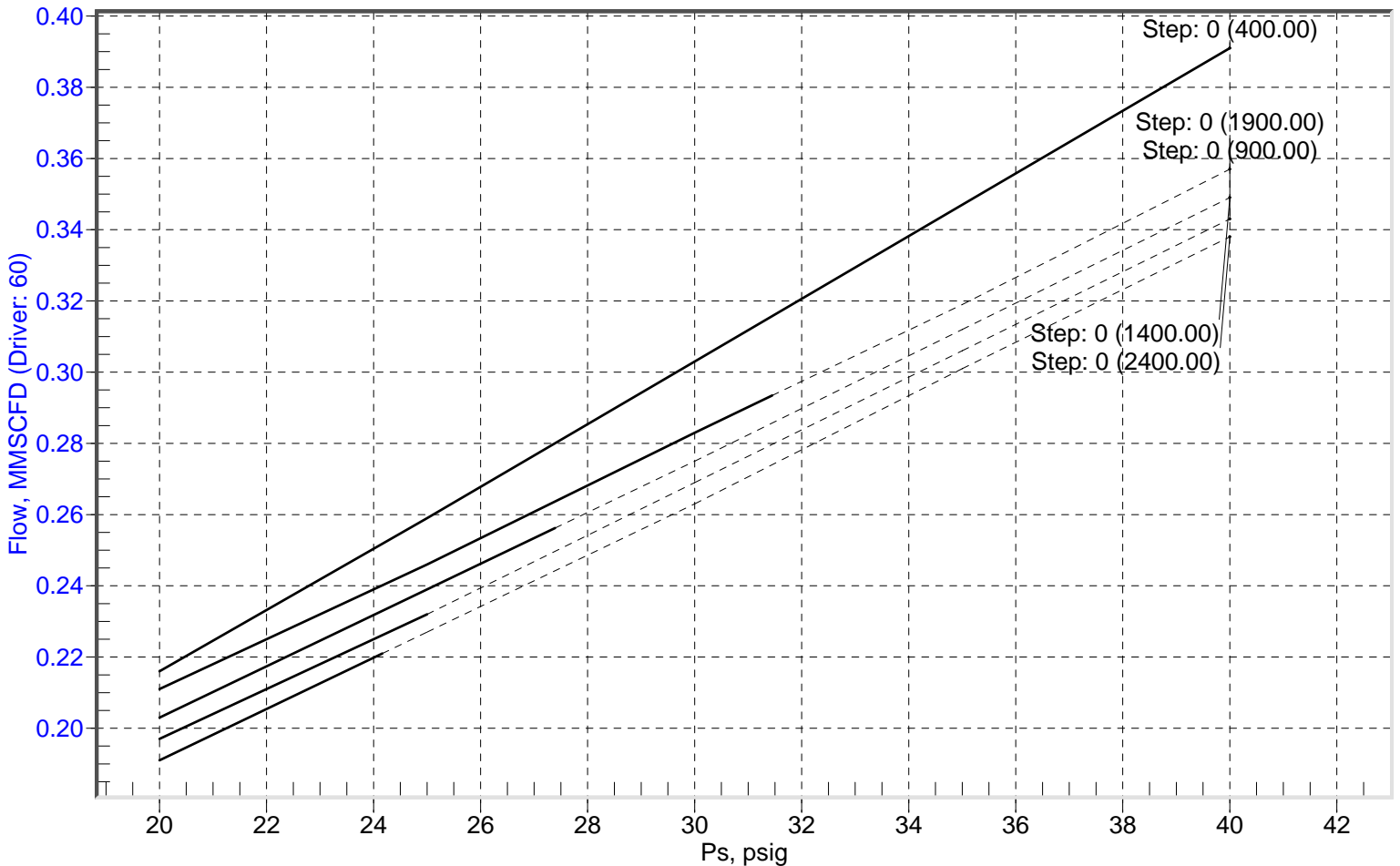
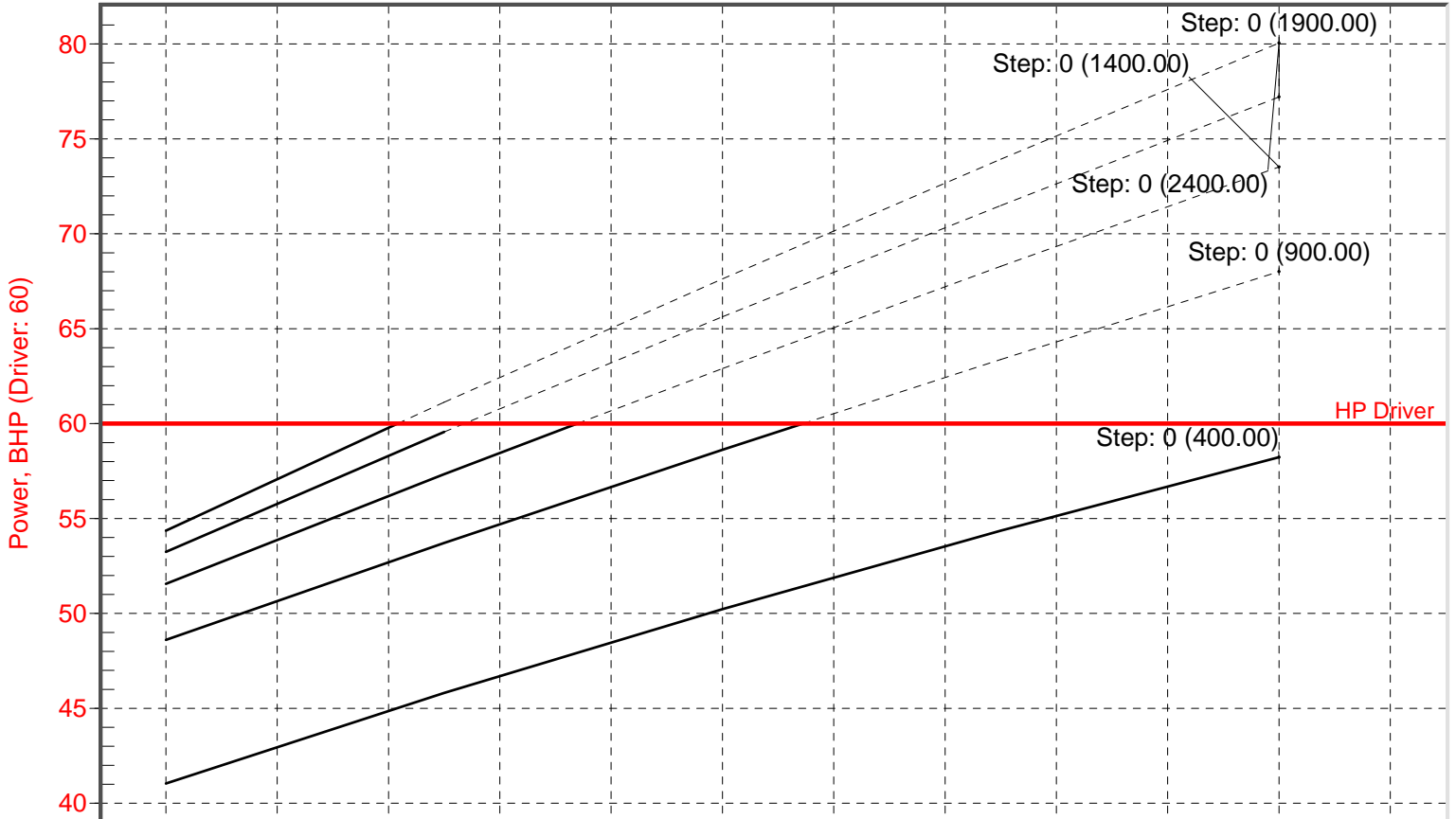


CanGas Solutions

RPM: 1800.0, Pd, psig: 400.00 - 2400.00

Driver: TECO Model: TEFC-PDH
Frame: JGA/2MMSCFD at 14.70 psia, 60.0 °F
Thw2: 5-1/8M (5.125) Stage: 1, Service: Service 1, SG: 0.9965, Suct Temp (°F): 68.00
Thw1CE: 3-5/8SG-CE (3.625) Stage: 2
Thw1HE: 1-3/4SG-FS-HE (1.500) Stage: 3

Ariel 7.6.5.1 MRV 1.11
1103-074 CanGas EM60-RAA2-3 PER01
1103-074 CanGas RAA_MR 5_125.csv

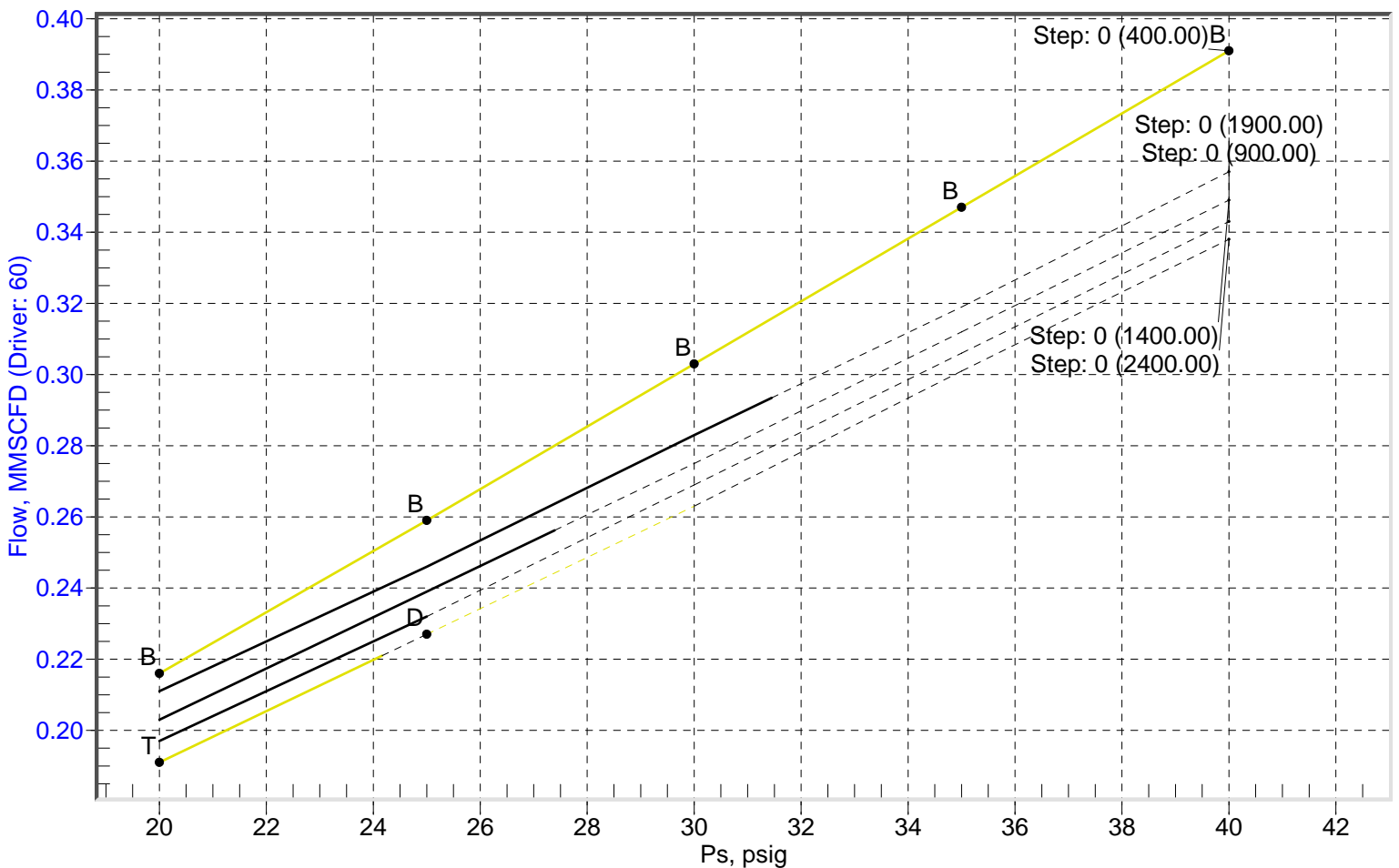
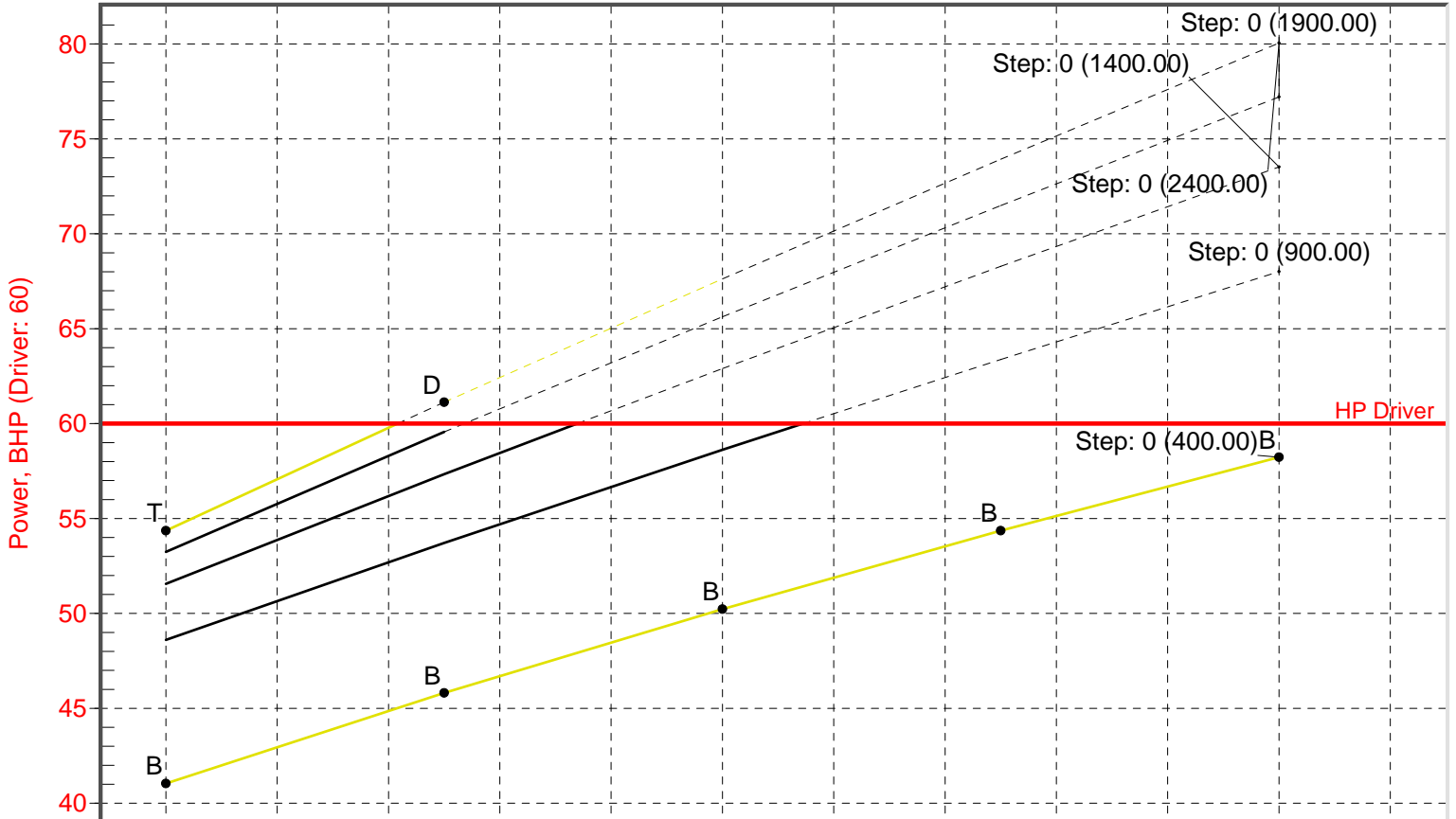


CanGas Solutions

RPM: 1800.0, Pd, psig: 400.00 - 2400.00

Driver: TECO Model: TEFC-PDH
 Frame: JGA/2MMSCFD at 14.70 psia, 60.0 °F
 Thw2: 5-1/8M (5.125) Stage: 1, Service: Service 1, SG: 0.9965, Suct Temp (°F): 68.00
 Thw1CE: 3-5/8SG-CE (3.625) Stage: 2
 Thw1HE: 1-3/4SG-FS-HE (1.500) Stage: 3

Ariel 7.6.5.1 MRV 1.11
 1103-074 CanGas EM60-RAA2-3 PER01
 1103-074 CanGas RAA_MR 5_125.csv





Company: Ariel Corporation
 Project #: AP021437 Rev:8
 Case 1: Pd=600

Gas Analysis Data

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions



Services	Service							
Gas Model	VMG							
Stage	# 1	# 1	# 2	# 3	# 3	# 3	Final	Final
Stream	Main	Vapor	Vapor	Liq1	Liq2	Vapor	Liq1	Liq2
Suction Press, psig	20.00	20.00	109.99			362.64		
Disch Press, psig		112.64	367.64			610.00		
Suction Temp, °F	68.00	68.00	110.00			110.00		
Disch Temp, °F		196.66	228.91			168.31		
Flow, MMSCFD	0.095	0.095	0.095	0.002	0.001	0.092	0.006	0.000
Flow, lb/h	300.9	300.9	300.9	13.0	1.2	286.7	30.8	0.2
Flow, GPM				0.048	0.002		0.128	0.000
Dropout, %				2.266	0.649		6.632	0.135
Specific Gravity	0.9965	0.9965	0.9965			0.9781		
Ratio of Sp Ht (N)		1.1800	1.1847			1.2208		
Comp Suct (Zs)		0.9835	0.9508			0.8520		
Comp Disch (Zd)		0.9663	0.9150			0.8223		
Comp @ Std (Zstd)		0.9924	0.9924			0.9924		
Mole Weight		28.86	28.86			28.33		
Density, lb/ft3		0.173	0.613			2.049		
Density @ Std, lb/ft3		0.076	0.076			0.075		
Enthalpy, Btu/lb		174.23	189.01			178.02		
Entropy, Btu/lb·F		1.6078	1.5476			1.4760		
Speed of Sound (Suct), ft/s		1025.87	1037.25			978.61		
Pseudo-Pc, psig		660.103	660.103			645.657		
Pseudo-Tc, °F		29.58	29.58			19.76		
Cp, Btu/lb·°F		0.4443	0.4753			0.5255		
NHV Mass, BTU/ft3		1492.44	1492.44			1471.15		
Speed of Sound (Disch), ft/s		1110.56	1098.50			1008.62		
Viscosity, lb/ft·s		7.94e-006	8.29e-006			7.75e-006		
Thermal Cond., Btu/ft·h·°F		2.09e-002	2.25e-002			2.01e-002		
Heat Load, BTU/h		1.16e+004	1.70e+004			8.79e+003		
Humidity	100.00	100.00						
HYDROGEN	0.02000	0.01980	0.01980	0.00072		0.02038	0.00173	
HELIUM-3	0.10000	0.09901	0.09901	0.00745	0.00001	0.10181	0.01547	0.00001
NITROGEN	2.27000	2.24751	2.24751	0.13784	0.00054	2.31179	0.30069	0.00098
CARBON DIOXIDE	0.64000	0.63366	0.63366	0.18683	0.00577	0.64829	0.30756	0.00906
HYDROGEN SULFIDE	0.00001	0.00001	0.00001	0.00001		0.00001	0.00001	
METHANE	50.92000	50.41552	50.41552	7.69138	0.00001	51.75016	14.40354	0.00002
ETHANE	17.41000	17.23751	17.23751	9.99911		17.52180	14.65896	
PROPANE	17.72000	17.54444	17.54444	25.91330		17.46642	31.06188	
ISOBUTANE	1.95000	1.93068	1.93068	5.74401		1.85457	5.61972	
n-BUTANE	6.40000	6.33659	6.33659	23.43685		5.97977	21.02064	
ISOPENTANE	0.92000	0.91089	0.91089	6.31475		0.79082	4.25323	
n-PENTANE	1.04000	1.02970	1.02970	7.89383		0.87634	4.98752	
n-HEXANE	0.32000	0.31683	0.31683	5.27902		0.20310	1.85132	
n-HEPTANE	0.29000	0.28713	0.28713	7.29311		0.12549	1.42082	
WATER	0.99073	0.99073	0.99073	0.10178	99.99367	0.34925	0.09691	99.98993



Company: Ariel Corporation
 Project #: AP021437 Rev:8
 Case 1: Pd=600

Gas Analysis Data

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions



Services	Service
Gas Model	VMG
Stage	Final
Stream	Vapor
Suction Press, psig	
Disch Press, psig	600.00
Suction Temp, °F	110.00
Disch Temp, °F	110.00
Flow, MMSCFD	0.086
Flow, lb/h	255.7
Flow, GPM	
Dropout, %	
Specific Gravity	0.9356
Ratio of Sp Ht (N)	
Comp Suct (Zs)	0.7754
Comp Disch (Zd)	
Comp @ Std (Zstd)	0.9927
Mole Weight	27.10
Density, lb/ft3	3.579
Density @ Std, lb/ft3	0.071
Enthalpy, Btu/lb	170.10
Entropy, Btu/lb·F	1.4817
Speed of Sound (Suct), ft/s	963.05
Pseudo-Pc, psig	645.923
Pseudo-Tc, °F	6.60
Cp, Btu/lb·°F	0.5944
NHV Mass, BTU/ft3	1408.50
Speed of Sound (Disch), ft/s	964.17
Viscosity, lb/ft·s	7.22e-006
Thermal Cond., Btu/ft·h·°F	1.78e-002
Heat Load, BTU/h	0.00e+000
Humidity	
HYDROGEN	0.02174
HELIUM-3	0.10810
NITROGEN	2.45819
CARBON DIOXIDE	0.67345
HYDROGEN SULFIDE	0.00001
METHANE	54.48168
ETHANE	17.75079
PROPANE	16.52456
ISOBUTANE	1.58942
n-BUTANE	4.91847
ISOPENTANE	0.54567
n-PENTANE	0.58515
n-HEXANE	0.08615
n-HEPTANE	0.03353
WATER	0.22311



Unit C-587

Control Panel



DRAWING INDEX		
SPARTAN DWG No.	DESCRIPTION	REV.
DE-27490-AB-010-00	DRAWING INDEX	0
DE-27490-AB-100-00	EXTERNAL CABINET LAYOUT AND DETAILS	0
DE-27490-AB-100-01	INTERNAL CABINET LAYOUT AND DETAILS	0
DE-27490-AB-200-00	PNEUMATIC LOGIC AND BILL OF MATERIALS	0
DE-27490-AB-500-00	POWER DISTRIBUTION	0
DE-27490-AB-500-01	PLC RACK LAYOUT AND WIRING DETAILS	0
DE-27490-AB-610-00	DISCRETE INPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-620-00	DISCRETE OUTPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-630-00	ANALOG INPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-630-01	ANALOG INPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-640-00	ANALOG OUTPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-640-01	ANALOG OUTPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-650-00	THERMOCOUPLE INPUT MODULE WIRING DIAGRAM	0
DE-27490-AB-650-01	THERMOCOUPLE INPUT MODULE WIRING DIAGRAM	0



SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

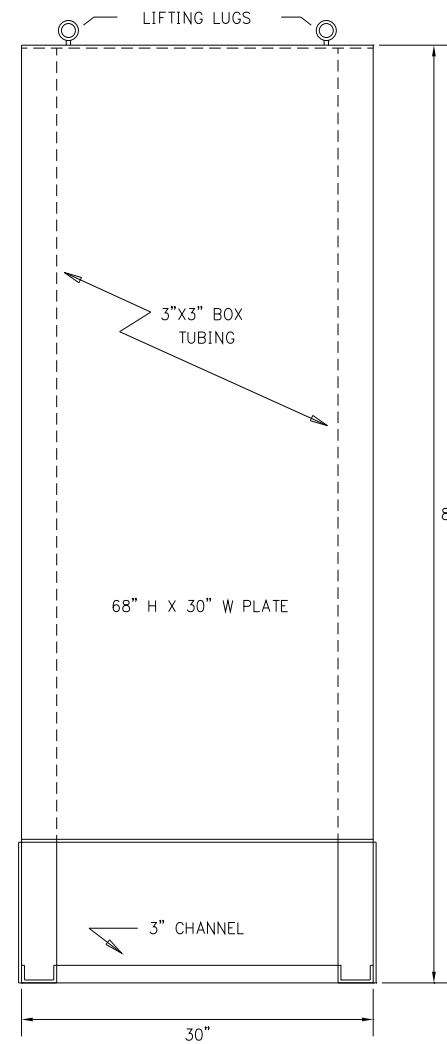
COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
DRAWING INDEX

LSD: PROJECT No. PN27490 SCALE: NTS DRAWING No. DE-27490-AB-010-00 REV. 0
UNIT# C-587 P.O. #C14606-C586

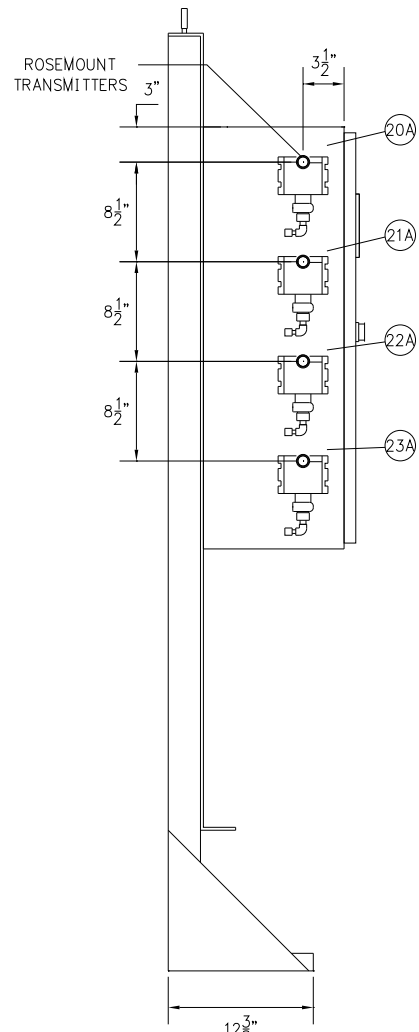
July 21, 2011 1:21pm

DRAWING No.	REFERENCE DRAWINGS	REV.	DESCRIPTION	DATE	DRAWN	CHK	DESIGN	APP
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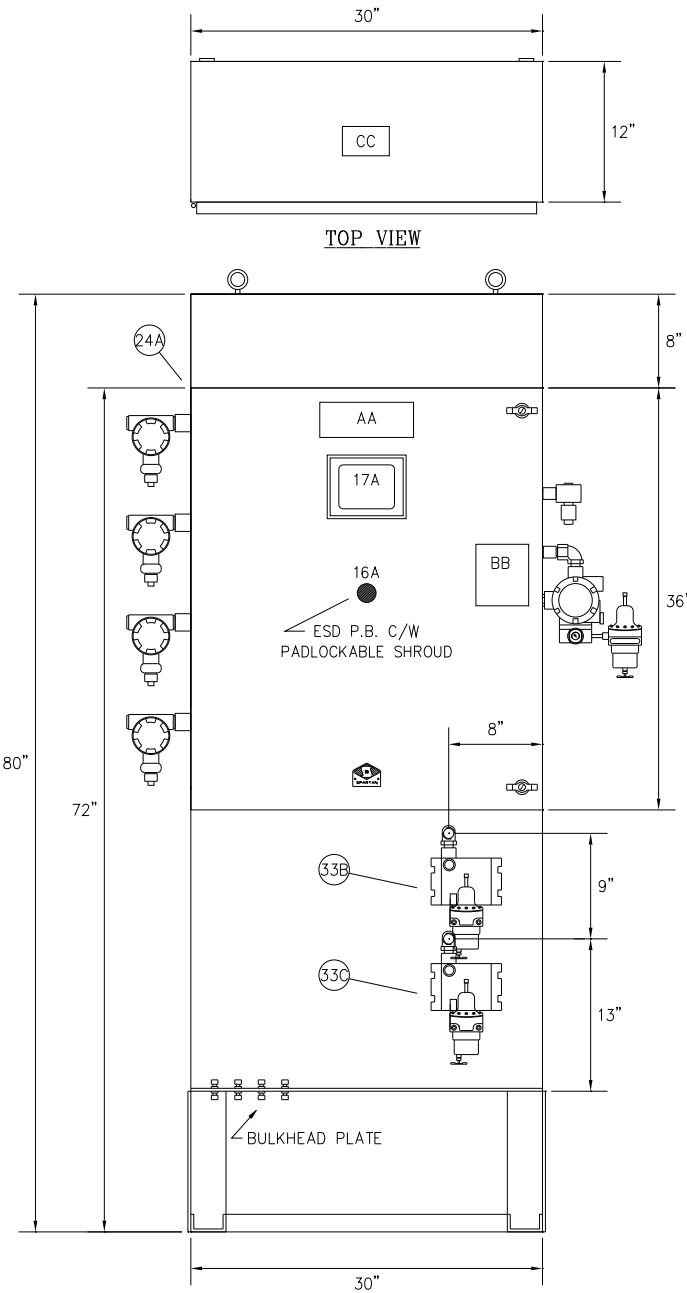
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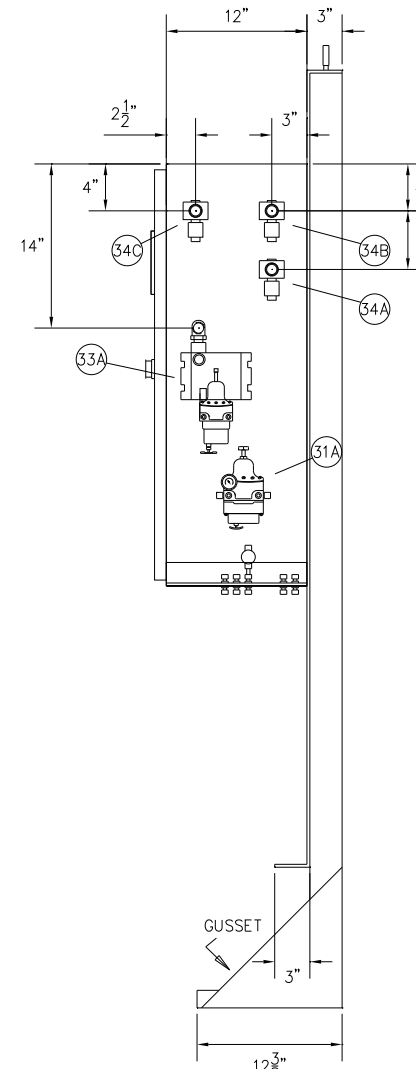
RACK DETAIL-FRONT VIEW



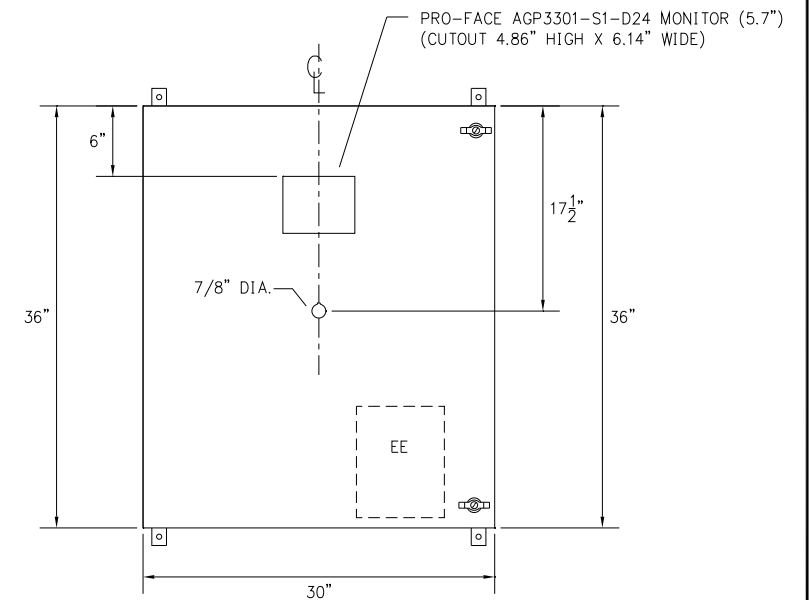
LEFT SIDE VIEW



FRONT VIEW



RIGHT SIDE VIEW



CUTOUT DETAIL

ITEM	LAMACOID TAG	SIZE	COLOUR
EE	GROUNDING INSTRUCTIONS	9.5x7.5	WHITE
16A	USD	1x3	RED

LAMACOID TAG 'CC'

LAMACOID SIZE: 1.25x3, COLOUR: RED
(FASTENED WITH 2 SIDE TAPE ONLY)

WARNING
INTERNAL PANEL COMPONENTS
MUST BE COVERED PRIOR TO
DRILLING ANY HOLES INTO
THIS ENCLOSURE

LAMACOID TAG 'BB'
(LAMACOID SIZE: 4.5x5.25, COLOUR: RED)

WARNING
MORE THAN ONE LIVE
CIRCUIT (see wiring diagram).
ENSURE THERE IS NO GAS PRESENT AND
DISCONNECT POWER BEFORE SERVICING,
OPERATING DISCONNECT TERMINALS,
TEST JUMPERS AND/OR REMOVING FUSES.

USE OF CERAMIC OR SAND FILLED
FUSES IS RECOMMENDED.
DO NOT EXCEED FUSE RATINGS.

ALL EQUIPMENT INSTALLED IN THIS PANEL
MUST BE SUITABLE FOR CL.I DIV.2.
SUBSTITUTION OF EQUIPMENT MAY
IMPAIR SUITABILITY FOR CL.I DIV.2
HAZARDOUS LOCATIONS

LAMACOID TAG 'AA'

CANGAS SOLUTIONS
UNIT# C-587
DRIVER: 60 HP ELECTRIC MOTOR
COMPRESSOR: ARIEL JGA/2
MANUFACTURED BY:
COMPASS COMPRESSION

DRIVER: 60 HP ELECTRIC MOTOR
COMPRESSOR: ARIEL JGA/2

NOTES:

- 1 CABINET TO BE 36" H X 30" W X 12" D C/W SINGLE FRONT ACCESS DOOR.
- 2 PAINT COLOUR: ASA-61 GREY.
- 3 ENCLOSURE RATING : NEMA 12.
- 4 ALL TUBING BY CUSTOMER.
- 5 ALL DISCRETE END DEVICES NOT WIRED TO NON-INCENDIVE BARRIERS TO BE SUITABLE FOR CLASS I, DIV 2 APPLICATION WITH 24VDC POWER.
- 6 ALL WIRING FOR TRANSMITTERS PENETRATING THROUGH ENCLOSURE TO BE RUN IN CLASS I DIV. 2 CONNECTORS.
- 7 PANEL CERTIFIED TO: CSA, CLASS I, DIVISION 2, GROUPS C&D, TEMP CODE T2D.



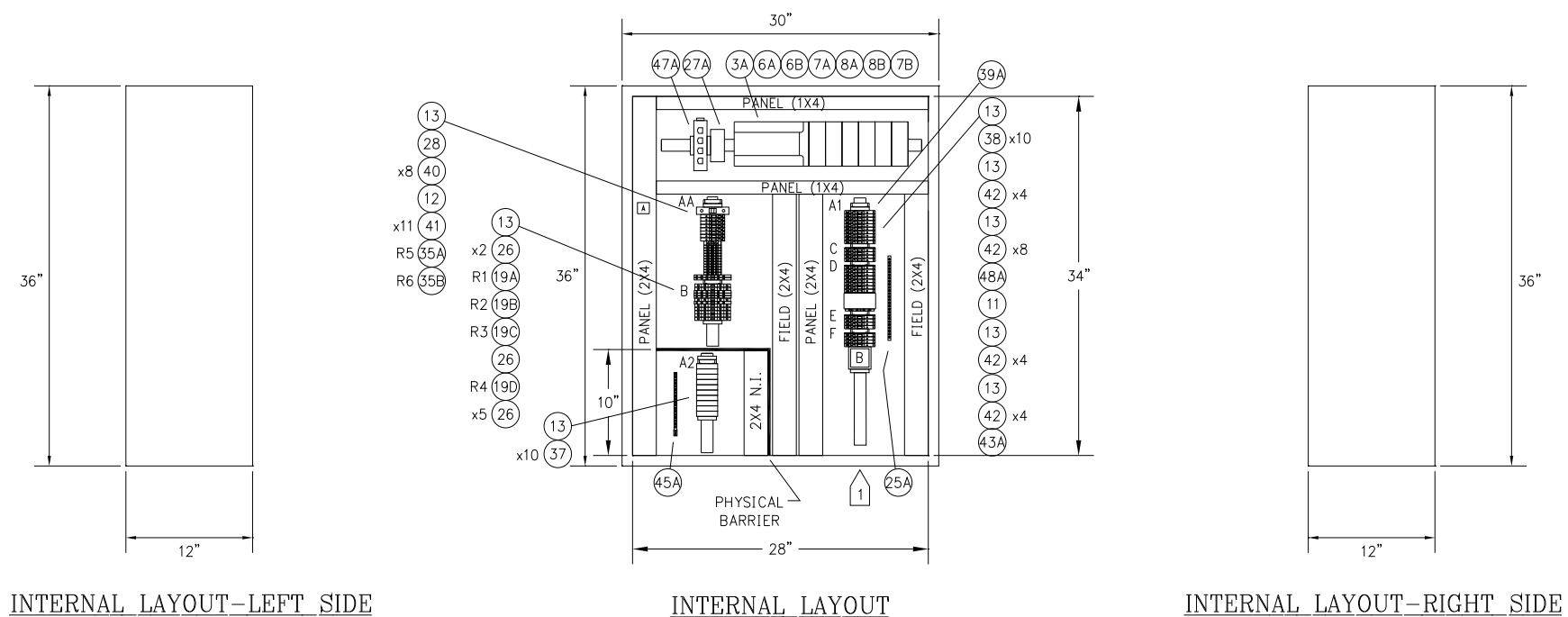
SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
EXTERNAL CABINET LAYOUT AND DETAILS

LSD:	UNIT# C-587	P.O. #C14606-C586
PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-100-00
REV. 0		

ITEM	LAMACOID TAG	SIZE	COLOUR
A	PANEL POWER →	1.125x1.125	WHITE
B	SPARE FUSES	2x2	WHITE



ITEM	TERMINAL STRIP IDENTIFIER
AA	DC POWER DISTRIBUTION
A1	TS 1 (D.I. TERMINALS) ALL FUSES 50mA
A2	TS 1 (D.I. BARRIERS)
B	TS 2 (D.O. TERMINALS) ALL FUSES 1A
C	TS 3 (A.I. TERMINALS) ALL FUSES 50mA
D	TS 4 (A.I. TERMINALS)
E	TS 5 (A.O. TERMINALS) ALL FUSES 250mA
F	TS 5 (A.O. TERMINALS) ALL FUSES 250mA

NOTES:

- 1 DIN RAIL TO BE ISOLATED FROM SUBPLATE AND GROUNDED TO THE GROUND BUS BAR.



SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

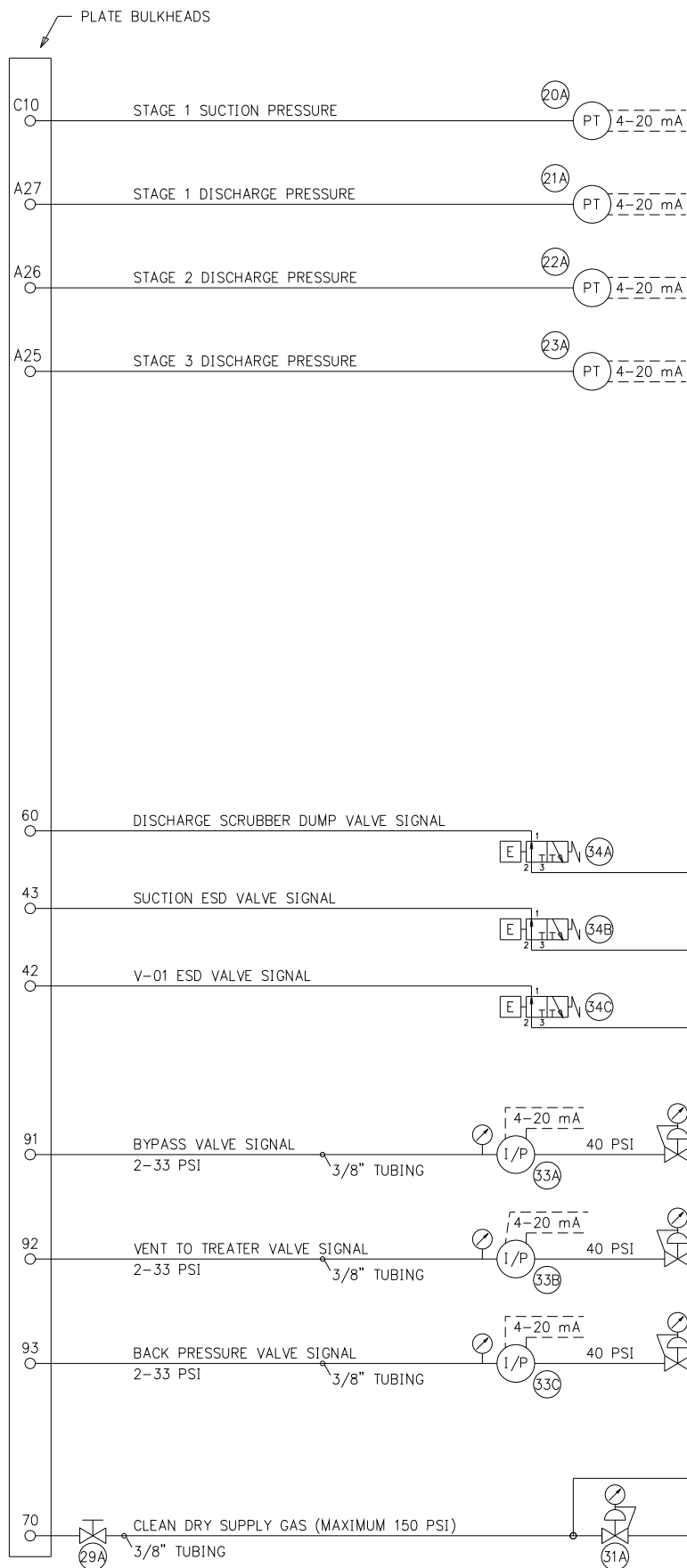
COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
INTERNAL CABINET LAYOUT AND DETAILS

LSD:	UNIT# C-587	P.O. #C14606-C586
PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-100-01
REV. 0		

July 21, 2011 1:21pm

DRAWING No.	REFERENCE DRAWINGS	REV.	DESCRIPTION	DATE	DRAWN	CHK	DESIGN	APP
		0	SPARTAN AS BUILT	21 JUL 11	RDW	JMK	JMK	JMK

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BILL OF MATERIALS				
ITEM	QTY.	PART NUMBER	DESCRIPTION	INSTRUCTIONS
45A	1	0000083	6" LONG ILSCO BAR	-
	1	GROUND LUG MEDIUM	GROUND LUG 2/0-14 GA.	-
	2	GL 2165-1A	1" GLASTIC INSULATOR	BY MFG.
46A	-	-	-	-
47A	1	2891152	PHOENIX ETHERNET SWITCH/DIN RAIL MOUNT/5 PORTS	-
48A	1	MCR-F-U1-DC	PHOENIX CONTACT FREQUENCY/CURRENT CONVERTER	-

BILL OF MATERIALS				
ITEM	QTY.	PART NUMBER	DESCRIPTION	INSTRUCTIONS
1A	-	-	-	-
2A	-	-	-	-
3A	1	1766-L32BXBA	ALLEN-BRADLEY MICROLOGIX CONTROLLER (20D1,12D0,4V1,2VO,ETHERNET)	-
4A	-	-	-	-
5A	-	-	-	-
6A-B	2	1762-IF4	ALLEN-BRADLEY ANALOG INPUT MODULE/4 PTS	-
7A-B	2	1762-OF4	ALLEN-BRADLEY ANALOG OUTPUT MODULE/4 PTS	-
8A-B	2	1762-IT4	ALLEN-BRADLEY THERMOCOUPLE INPUT MODULE/4 PTS	-
9A	-	-	-	-
10A	-	-	-	-
11	4	10215.0	WEIDMULLER DUAL STACK TERMINAL BLOCK/WDK2.5	-
12	2	4437.6	WEIDMULLER TERMINAL BLOCK/SAK10/TS35	-
13	7	16319.3	WEIDMULLER CARRIER TAG SHT5S	-
14A	-	-	-	-
15A	-	-	-	-
16A	1	ZB4BS54	TELEMECANIQUE PUSHBUTTON, RED, MUSHROOM HEAD, MAINTAINED	-
	1	ZB4BZ102	TELEMECANIQUE CONTACTS, 1 NC	-
	1	ZBZ1604	TELEMECANIQUE PROTECTIVE GUARD/METAL/RED/PADLOCKABLE	-
17A	1	10-0582	PRO-FACE CONTROLLER AGP3301-SI-D24/5.7" TFT COLOUR LCD/24VDC	-
	1	HMI STYLUS	HMI STYLUS (SHIPPED ON BACK SIDE OF PANEL DOOR)	-
18A	1	-	PRO-FACE GRAPHIC CONTROLLER TO MICROLOGIX CONTROLLER CABLE	BY MFG.
19A-D	4	80.010.4000.0	WIELAND TERMINAL BLOCK RELAY/24VDC/6A AC/2A DC	-
20A	1	2088G2S22A1C6	ROSEMOUNT PRESSURE TRANSMITTER/316SS/0-60 PSI	-
21A	1	2088G3S22A1C6	ROSEMOUNT PRESSURE TRANSMITTER/316SS/0-300 PSI	-
22A	1	2088G3S22A1C6	ROSEMOUNT PRESSURE TRANSMITTER/316SS/0-800 PSI	-
23A	1	2088G4S22A1C6	ROSEMOUNT PRESSURE TRANSMITTER/316SS/0-3000 PSI	-
24A	1	541ES363012	EUROBEX ENCLOSURE/NEMA 4	-
	1	885ESMF1	EUROBEX MOUNTING FEET (PACKAGE OF 4)	-
	1	0000094	SPARTAN LOGO	-
	2	880SCQ4-WN	EUROBEX KEY LOCK WING HANDLE	-
	1	0002705	CUSTOM STEEL RACK/80" H X 30" W	-
25A	1	0000075	12" LONG ILSCO BAR (CUT AT 8")	-
	2	GL 2165-1A	1" GLASTIC INSULATOR	BY MFG.
26	8	5532777	PHOENIX FUSED TERMINAL (DUAL) BLOCK WITH INTERNAL DIODE	-
	8	GDA 1A	BUSS 1 AMP CERAMIC FUSE	-
27A	1	1763-NC01	COMM'S CABLE	-
28	2	USM1	FERRAZ SHAWMUT FUSED TERMINAL BLOCK/TS35	-
	1	KTK 15A	BUS KTK 15A FUSE	-
29A	1	SS-43GS6	SWAGELOK 3/8" BALL VALVE/316SS	-
30	1	-	1300 OHM RESISTOR	BY MFG.
31	1	67CF-1663-352560	FISHER REGULATOR/35-125 PSI/VENTED BONNET	-
	1	11B8579X042	FISHER 2" GAUGE/0-160 PSI	-
32	3	-	500 OHM RESISTOR	BY MFG.
33A-C	3	12P-X3B	FISHER I/P TRANSDUCER/2-33 PSI	-
	3	PEM1405	WINTER 2" DRY GAUGE/0-60 PSI	-
	3	67CF-1663-329150	FISHER REGULATOR/0-60 PSI/VENTED BONNET	-
	3	PEM1405	WINTER 2" DRY GAUGE/0-60 PSI	-
	3	MF90-1	KILLARK 1/2" CONDUIT ELBOW	-
34A-C	3	EF8320G202-24	ASCO SOLENOID VALVE/24VDC	-
35A-B	2	80.010.4005.0	WIELAND TERMINAL BLOCK RELAY/24VDC/20 mA	-
36A	1	2088G2S22A1C6	ROSEMOUNT PRESSURE TRANSMITTER/316SS/0-150 PSI	SHIPPED LOOSE
	1	02088-0071-0001	ROSEMOUNT MOUNTING BRACKET	SHIPPED LOOSE
37	10	WT-57.867.0000.0010	WIELAND DISCRETE NON-INCENDIVE BARRIER	-
38	10	95033.5	WEIDMULLER FUSED TERMINAL BLOCK/KDKS1 EN	-
	10	GDA 50mA	BUSS 50mA CERAMIC FUSE	-
39A	1	21.311.1253.0	WIELAND 6 EDS TERMINAL STRIP/12 POLE	-
40	8	2227.6	WEIDMULLER FUSED TERMINAL BLOCK/ASK1 LD	-
	1	GDA 500mA	BUSS 1/2 mA CERAMIC FUSE	-
	4	GDA 1A	BUSS 1 AMP CERAMIC FUSE	-
	1	GDA 2A	BUSS 2 AMP CERAMIC FUSE	-
	2	GDA 5A	BUSS 5 AMP CERAMIC FUSE	-
41	12	4674.6	WEIDMULLER TERMINAL BLOCK/SAK4 EN	-
42	20	9532450000	WEIDMULLER FUSED TERMINAL BLOCK WITH GND/KDKS1/PE	-
	12	GDA 50 mA	BUSS 50 mA CERAMIC FUSE	-
	8	GDA 250mA	BUSS 1/4 mA CERAMIC FUSE	-
43A	1	7914760001	WEIDMULLER FUSE CONTAINER/DIN RAIL MOUNT	-
44A	1	0003125	FUSE KIT PLC	-



SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
PNEUMATIC LOGIC AND BILL OF MATERIALS

LSD:	UNIT# C-587	P.O. #C14606-C586
PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-200-00
REV. 0		

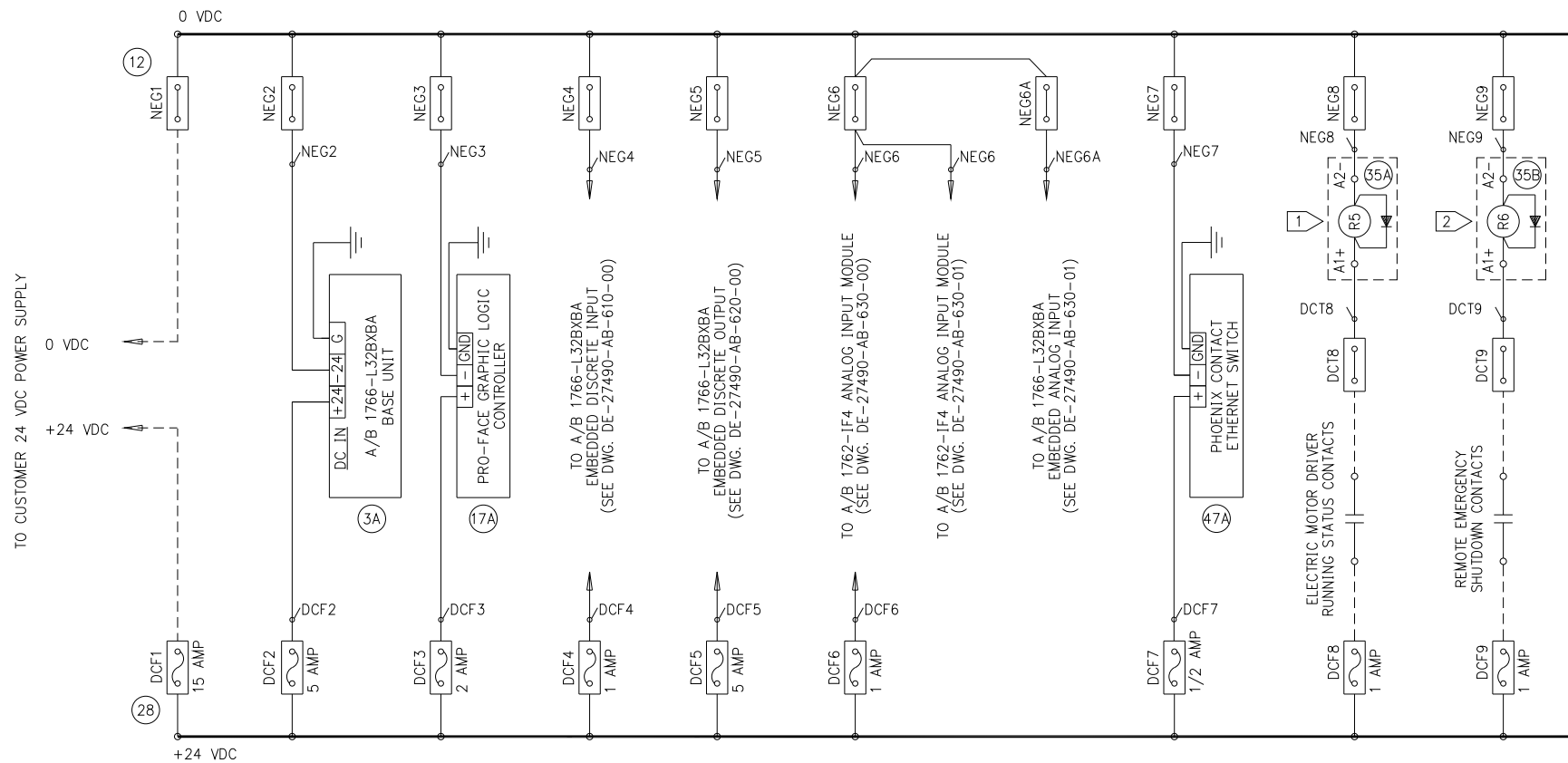
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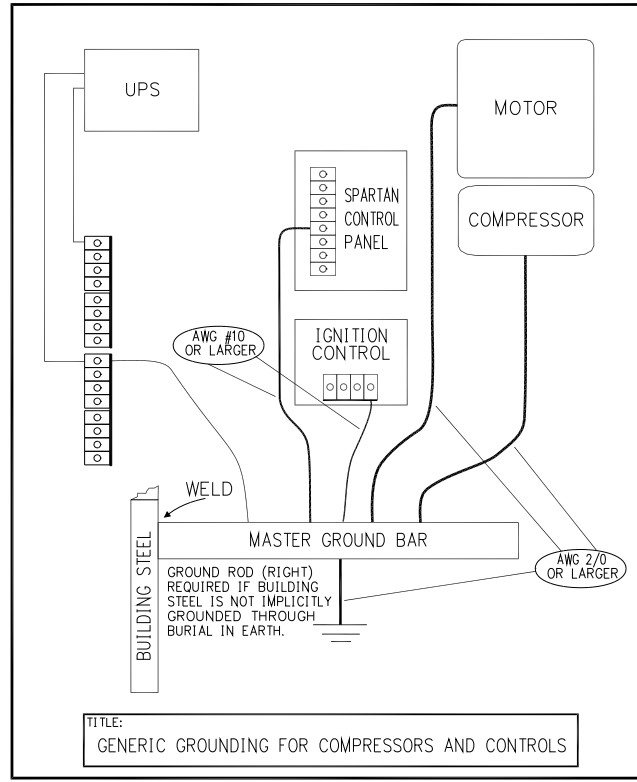
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DC POWER DISTRIBUTION

VOLTAGE INPUT RANGE : 20VDC MIN./28VDC MAX.
 NOTE: RECOMMEND USE OF 24V LOW VOLTAGE DISCONNECT TO REDUCE POSSIBILITY OF BROWN-OUTS AND DATA CORRUPTION.
 POWER WIRE SIZING CALCULATIONS SHOULD BE COMPLETED BASED ON SPECIFIC SITE CONDITIONS.
 POWER WIRE SMALLER THAN 10AWG SHOULD NOT BE USED. IF PANEL CURRENT CONSUMPTION CALCULATIONS ARE REQUIRED CONTACT SPARTAN CONTROLS.



GROUNDING



WIRE COLOUR CODE	
GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE
0 VDC SWITCHED	MEDIUM BLUE

WIRE LEGEND	
PANEL WIRE	—————
FIELD WIRE	- - - - -

- NOTES:
- 1 FOR RELAY CONTACTS R5-1 SEE DWG. DE-27490-AB-610-00.
 - 2 FOR RELAY CONTACTS R6-1 SEE DWG. DE-27490-AB-610-00.

- LEGEND:
- WEIDMULLER ASK1 EN FUSED TERMINAL BLOCK
 - WEIDMULLER SAK4 EN FEED-THROUGH TERMINAL BLOCK (UNLESS NOTED OTHERWISE)

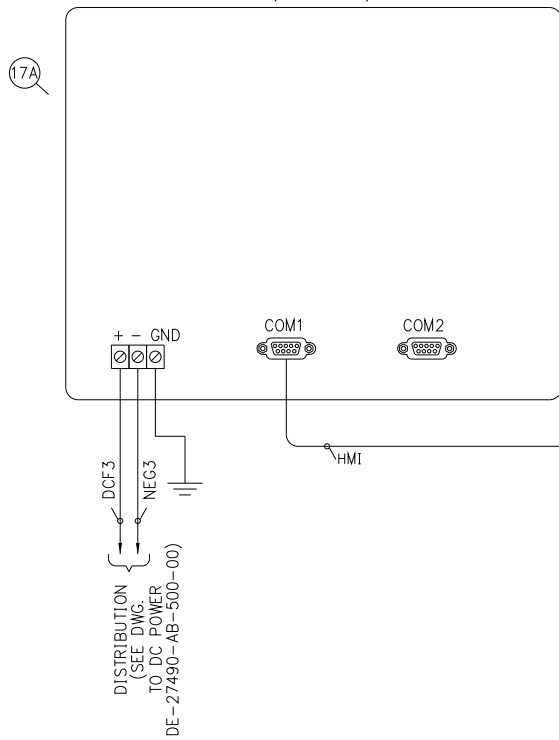


COMPASS COMPRESSION
 CANGAS SOLUTIONS
 -
 COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
 POWER DISTRIBUTION
 UNIT# C-587 P.O. #C14606-C586
 LSD: PROJECT No. PN27490 SCALE: NTS DRAWING No. DE-27490-AB-500-00 REV: 0

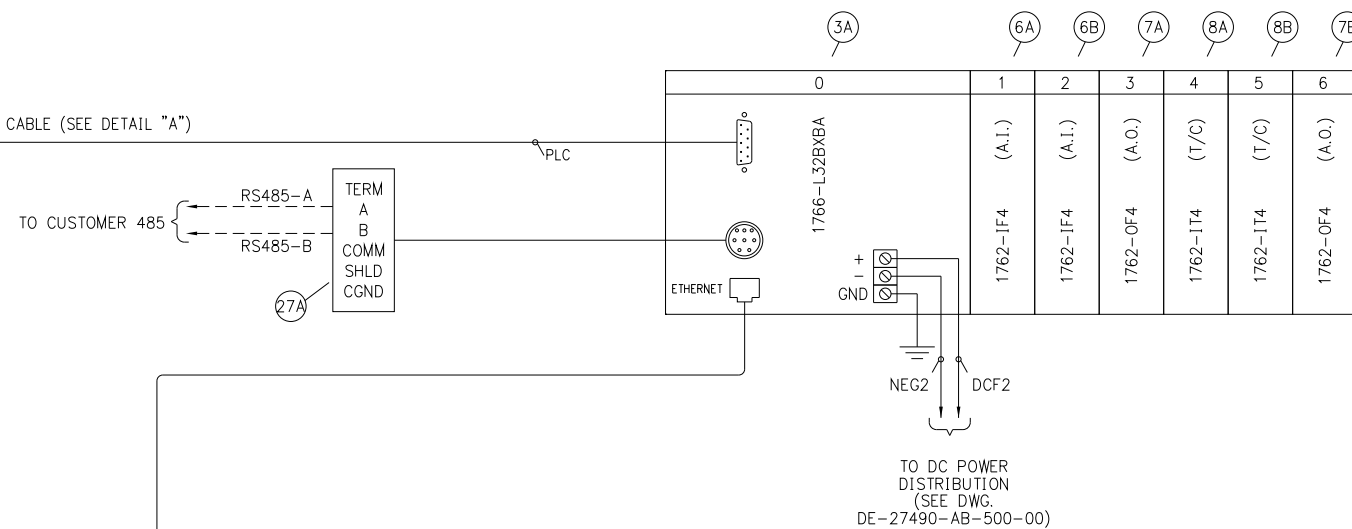
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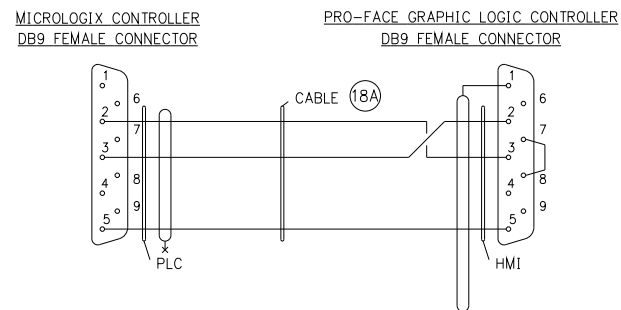
PRO-FACE GRAPHIC LOGIC CONTROLLER
(REAR VIEW)



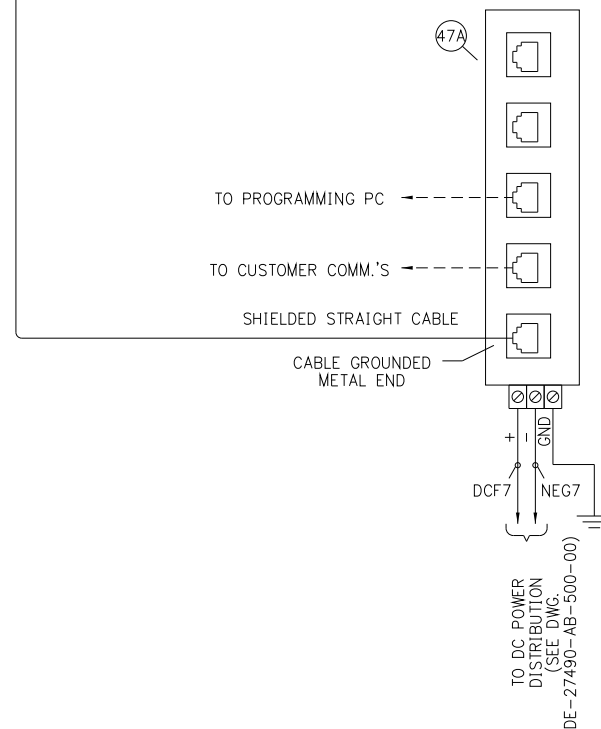
ALLEN-BRADLEY MICROLOGIX 1400 PLC PHYSICAL LAYOUT



CABLE DETAIL "A"



ETHERNET SWITCH



SPARTAN CONTROLS

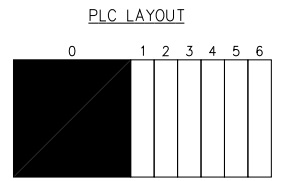
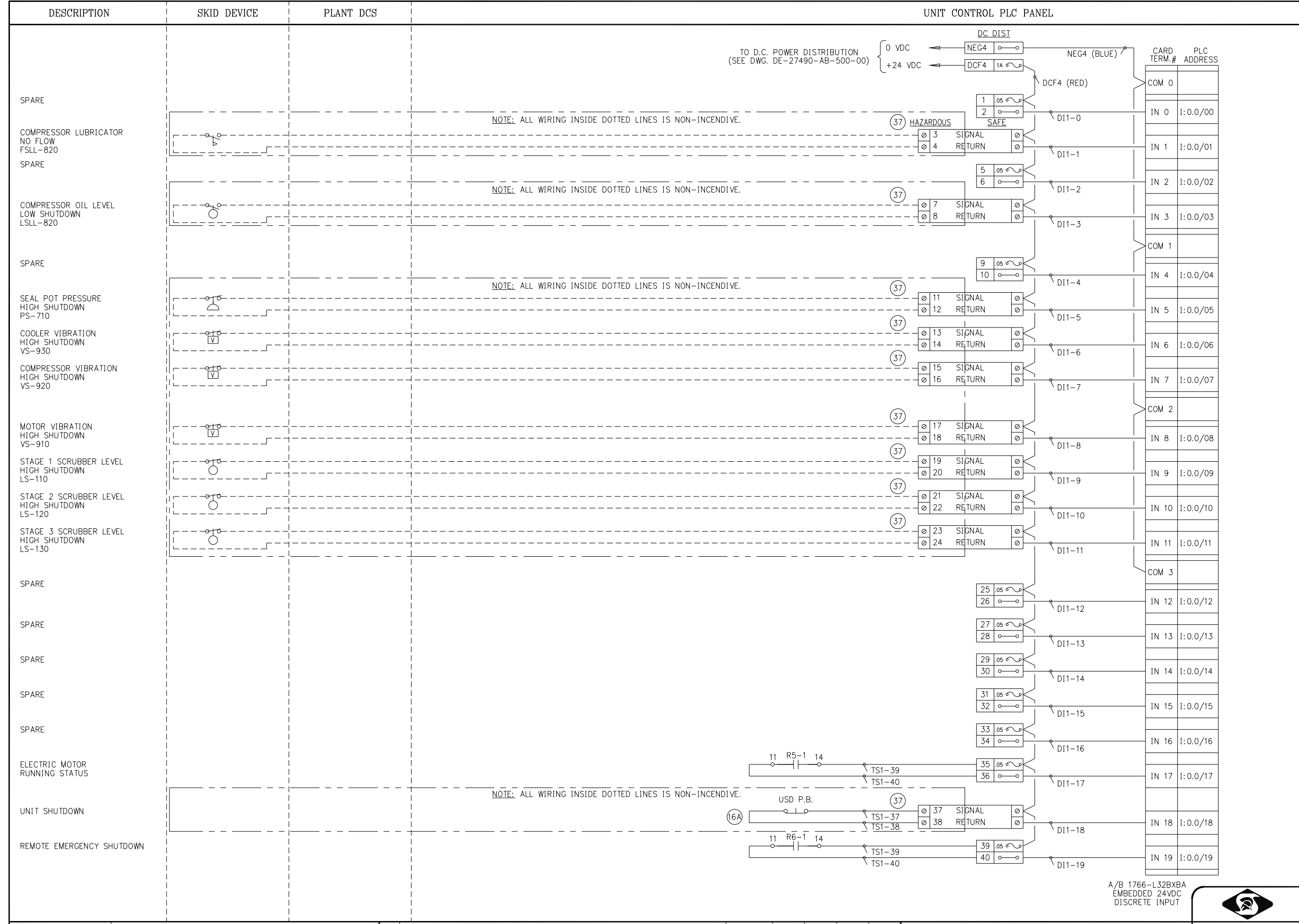
COMPASS COMPRESSION
CANGAS SOLUTIONS
-
COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
PLC RACK LAYOUT AND WIRING DETAILS
UNIT# C-587 P.O. #C14606-C586

PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-500-01	REV. 0
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July 21, 2011 1:21pm

DRAWING No.	REFERENCE DRAWINGS	REV.	DESCRIPTION	DATE	DRAWN	CHK	DESIGN	APP
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WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

PANEL WIRE	—————
FIELD WIRE	- - - - -



A/B 1766-L32BXBA
EMBEDDED 24VDC
DISCRETE INPUT



SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS
COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
DISCRETE INPUT MODULE WIRING DIAGRAM
UNIT# C-587 P.O. #C14606-C586

LSD:	PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-610-00	REV: 0
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July 21, 2011 1:21pm

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UNIT CONTROL PLC PANEL

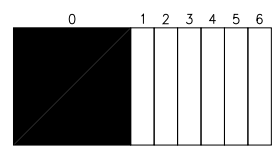
PLANT DCS

MCC

SKID DEVICE

DESCRIPTION

PLC LAYOUT

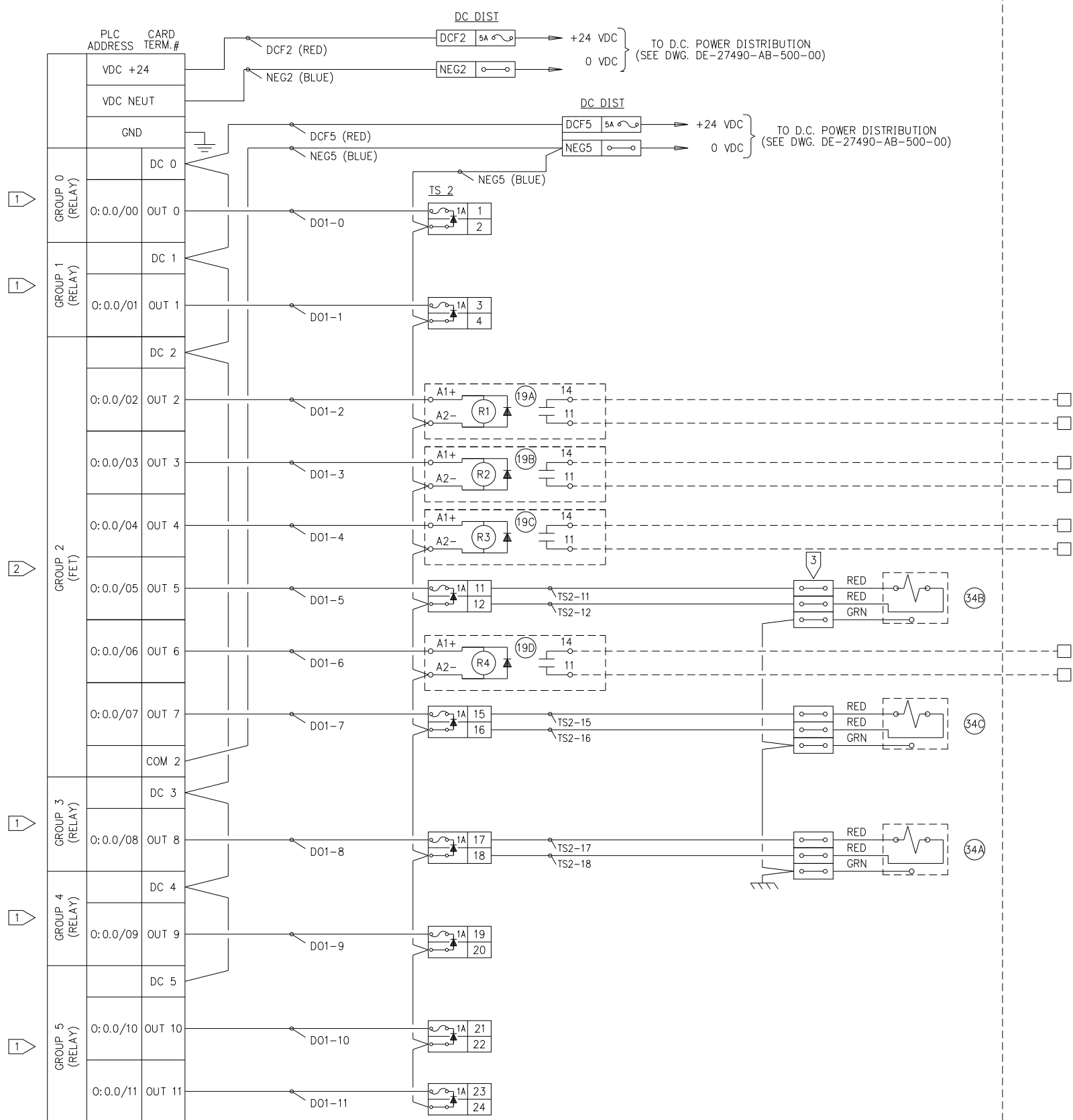


WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

PANEL WIRE	—————
FIELD WIRE	- - - - -



SPARE

SPARE

COOLER FAN MOTOR (START/STOP) EM-02

COMPRESSOR OIL COOLER FAN MOTOR

ELECTRIC MOTOR DRIVER (START/STOP) EM-01

SUCTION ESD VALVE SOLENOID

REMOTE RUN STATUS

V-01 ESD VALVE SOLENOID

DISCHARGE SCRUBBER DUMP VALVE SOLENOID LV-140

SPARE

SPARE

SPARE

- NOTES:**
- 1 GROUPS 0,1,3,4,5,6 RATED FOR 2.5 AMP MAXIMUM PER CHANNEL.
 - 2 GROUP 2 RATED FOR 0.75 AMP MAXIMUM PER CHANNEL AND 3 AMP TOTAL FOR GROUP.
 - 3 6 EDS TERMINAL STRIP LOCATED INSIDE 2X2 PANDUIT FASTENED ON THE RIGHT SIDE OF THE ENCLOSURE.

LEGEND:

	PHOENIX 5532777 DUAL STACKED FUSED/FEED-THROUGH TERMINAL BLOCK WITH INTERNAL REVERSE (1N4007) DIODES
	WEIDMULLER WDK2.5 DUAL STACK

A/B 1766-L32BXBA
EMBEDDED 24VDC
DISCRETE OUTPUT



COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
DISCRETE OUTPUT MODULE WIRING DIAGRAM

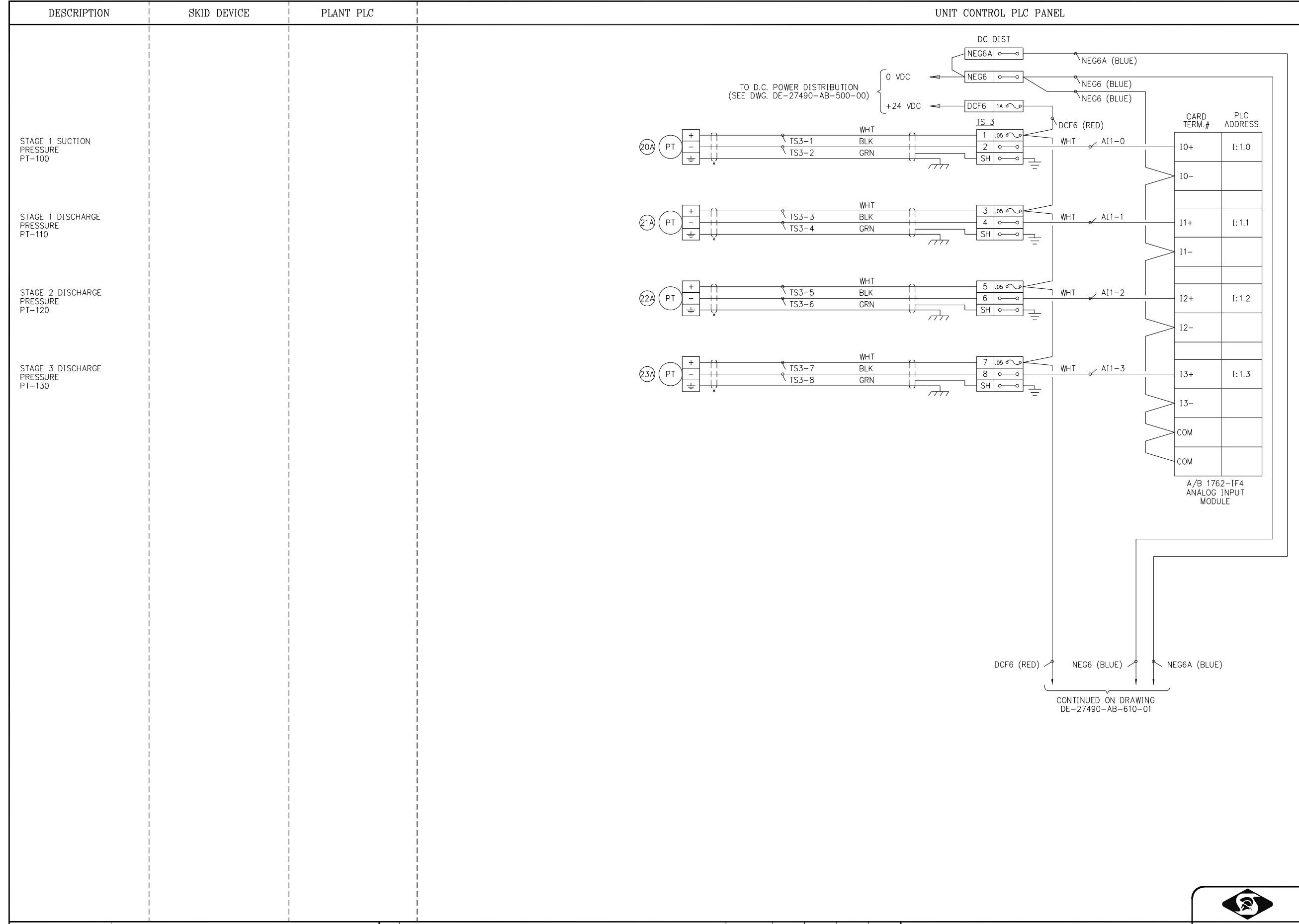
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PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-620-00	REV. 0
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July 21, 2011 1:21pm

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PLC LAYOUT

0	1	2	3	4	5	6
---	---	---	---	---	---	---

WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

PANEL WIRE —————

FIELD WIRE - - - - -

1762-IF4 DIP SWITCH DETAIL

CH0	CH1	OFF	CH2	CH3	OFF
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	ON	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	ON

LEGEND:

	WEIDMULLER KDKS1/PE DUAL STACKED FUSED/FEED-THROUGH TERMINAL BLOCK WITH GROUND
--	--

July 21, 2011 1:21pm

REV.	DESCRIPTION	DATE	DRAWN	CHK	DESIGN	APP
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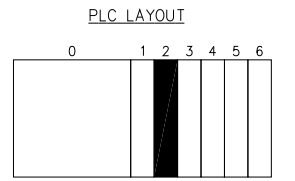
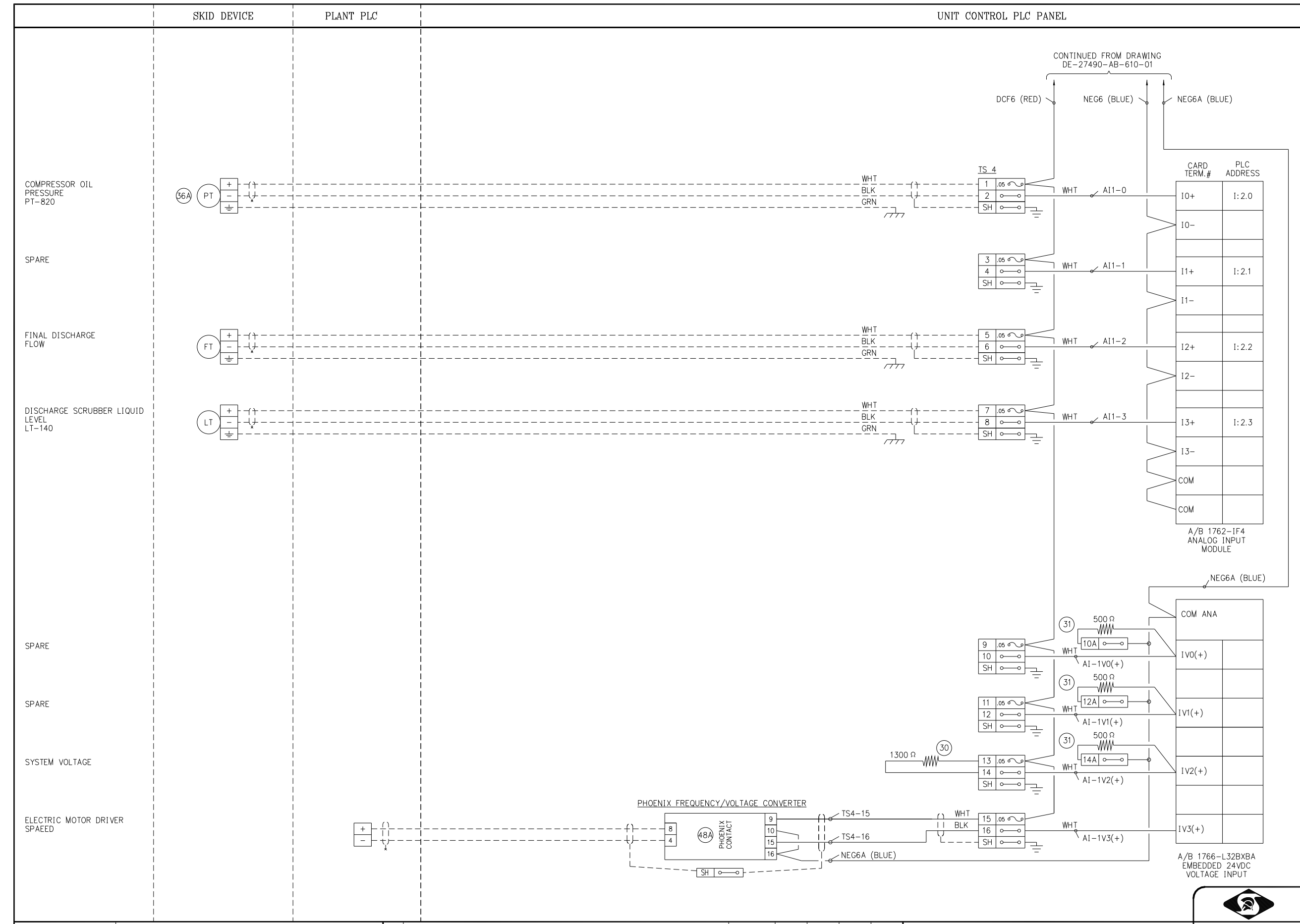
SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
ANALOG INPUT MODULE WIRING DIAGRAM

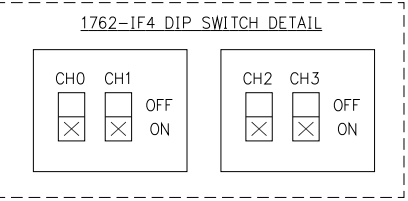
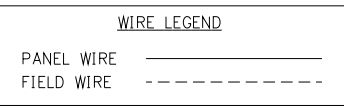
LSD: UNIT# C-587 P.O. #C14606-C586

PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-630-00	REV. 0
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WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE



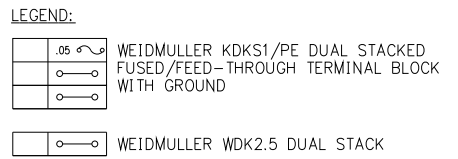
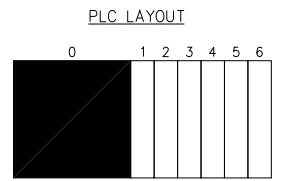
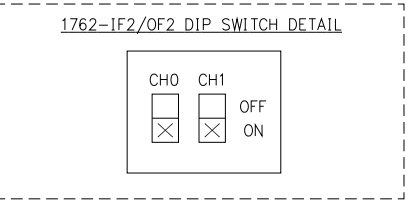
PHOENIX CURRENT/VOLTAGE CONVERTER
CONFIGURATION

ZERO INPUT	0 mA
FULL SCALE INPUT	20 mA
ANALOG OUTPUT	0-10 V
DIGITAL OUTPUT	N/A
LOW SETPOINT	N/A
HIGH SETPOINT	N/A

- EXTENDED MODE CONFIGURATION

+
 (PUSH BOTH BOTTOMS SIMULTANEOUSLY)

NO INPUT	0 V
----------	-----



SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
ANALOG INPUT MODULE WIRING DIAGRAM

LSD:	PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-630-01	REV. 0
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July 21, 2011 1:21pm

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UNIT CONTROL PLC PANEL

MCC

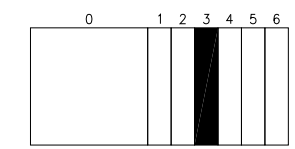
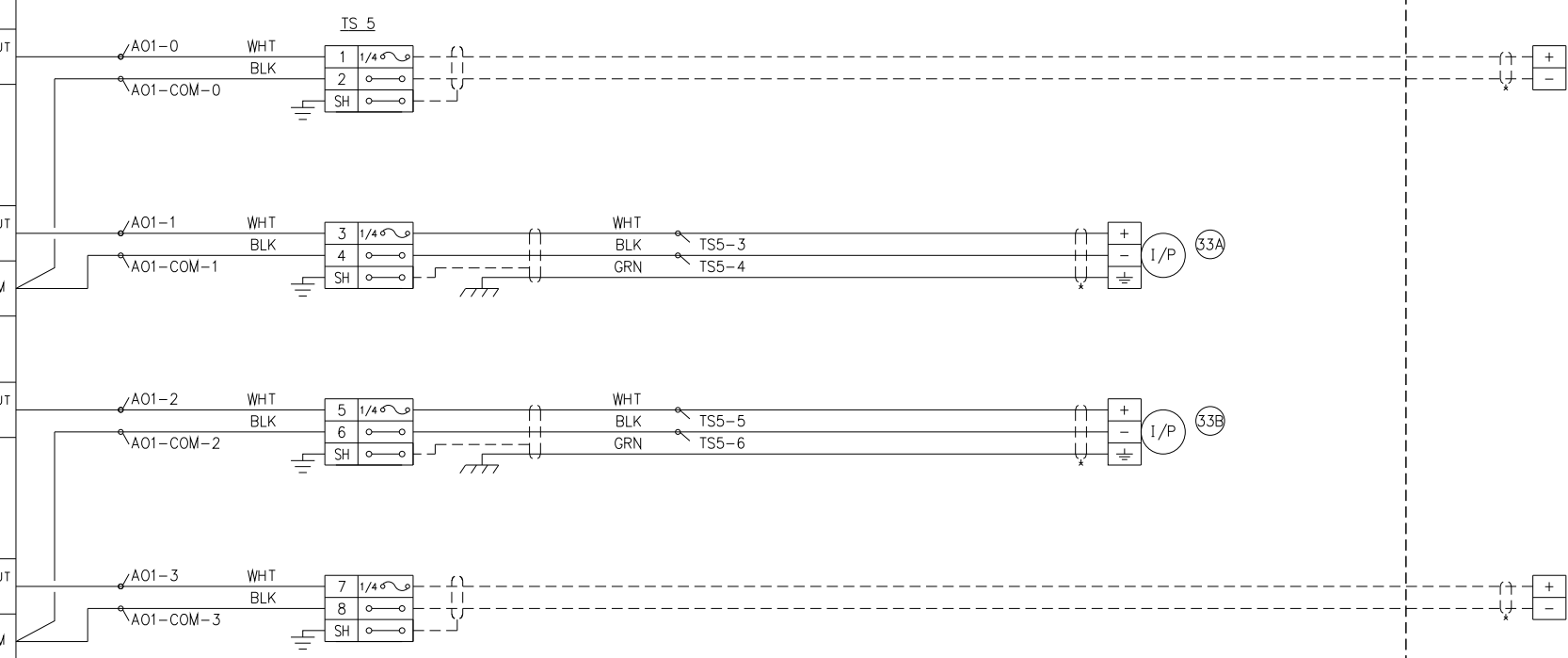
SKID DEVICE

DESCRIPTION

PLC LAYOUT

PLC ADDRESS	CARD TERM.#
O: 3.0	I OUT 0+
O: 3.1	I OUT 1+
	COM
O: 3.2	I OUT 2+
O: 3.3	I OUT 3+
	COM

A/B 1762-OF4
ANALOG OUTPUT
MODULE



WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

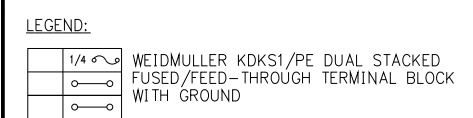
PANEL WIRE	—————
FIELD WIRE	- - - - -

ELECTRIC MOTOR DRIVER
SPEED CONTROL

BYPASS VALVE
CONTROL
PV-170

VENT TO TREATER VALVE
CONTROL

COOLER FAN MOTOR SPEED
CONTROL



SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
ANALOG OUTPUT MODULE WIRING DIAGRAM

LSD: UNIT# C-587 P.O. #C14606-C586

July 21, 2011 1:21pm

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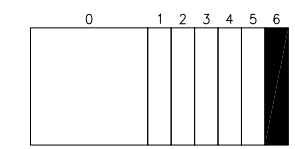
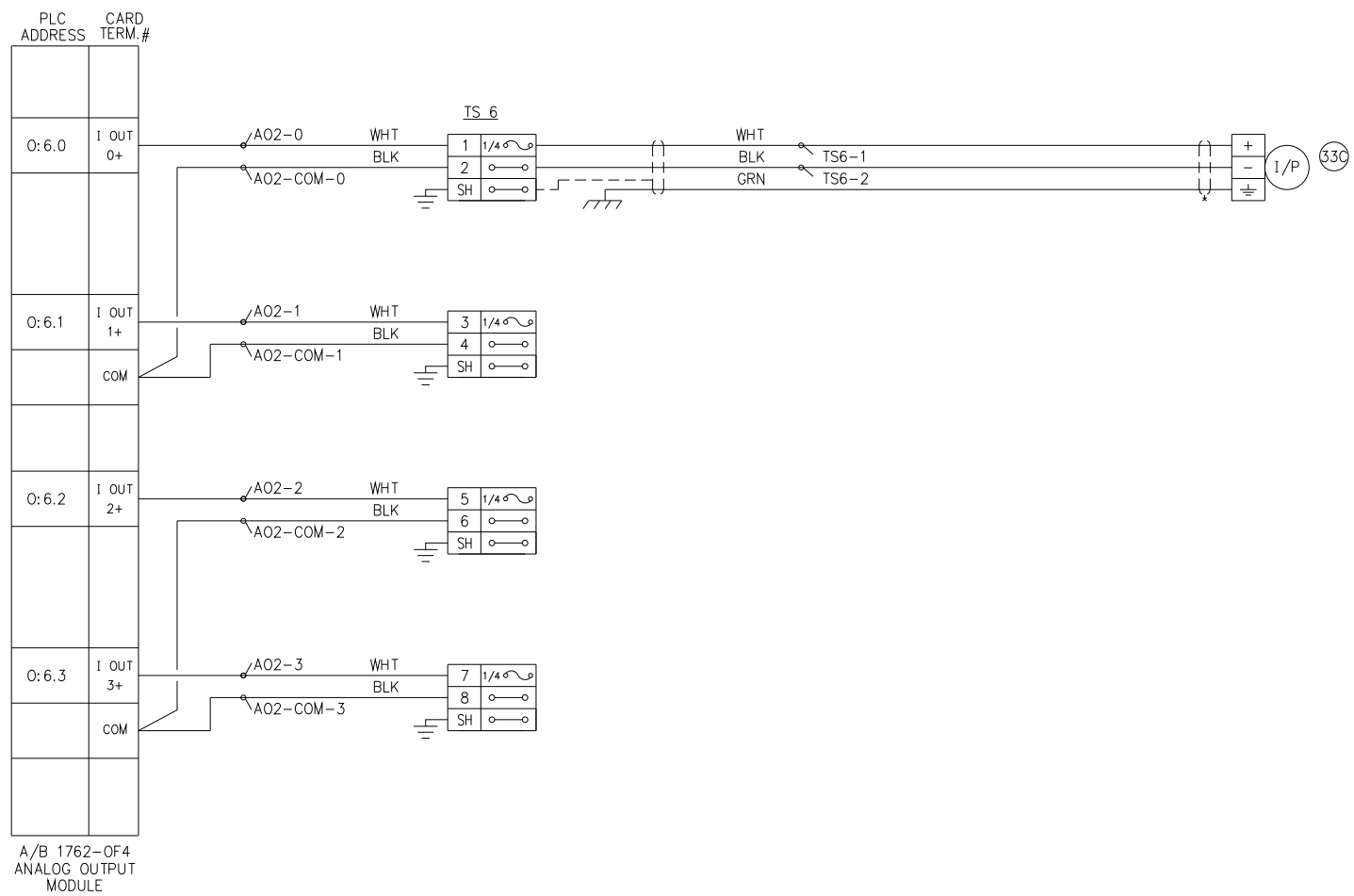
PROJECT No.	PN27490	SCALE:	NTS	DRAWING No.	DE-27490-AB-640-00	REV.	0
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UNIT CONTROL PLC PANEL

SKID DEVICE

DESCRIPTION

PLC LAYOUT



WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

PANEL WIRE	—————
FIELD WIRE	- - - - -

BACK PRESSURE VALVE CONTROL

SPARE

SPARE

SPARE

LEGEND:

	1/4	WEIDMULLER KDKS1/PE DUAL STACKED FUSED/FEED-THROUGH TERMINAL BLOCK WITH GROUND



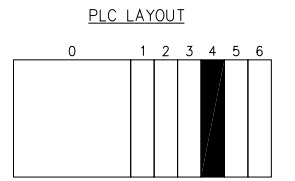
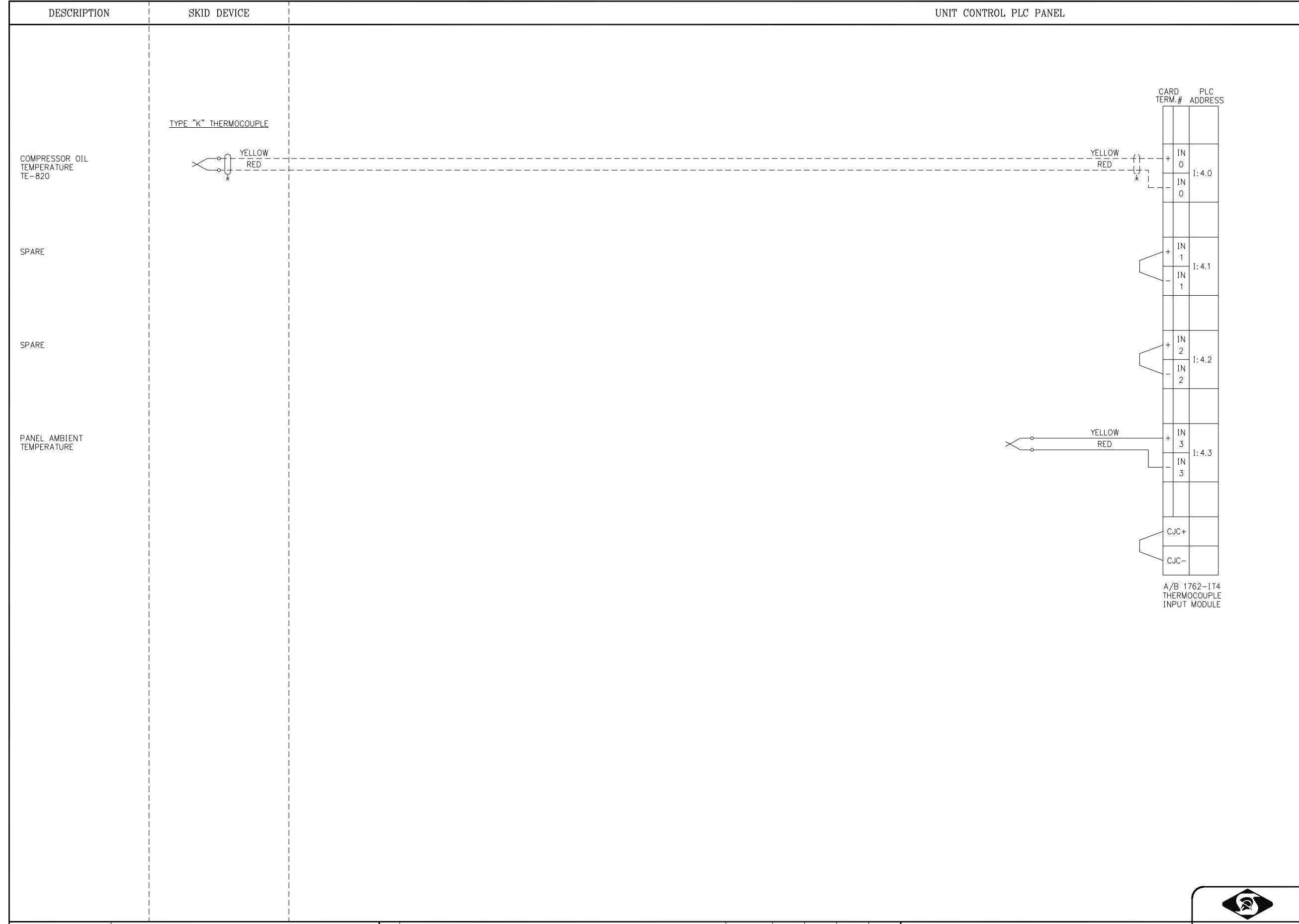
SPARTAN CONTROLS

COMPASS COMPRESSION
CANGAS SOLUTIONS
-
COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
ANALOG OUTPUT MODULE WIRING DIAGRAM

LSD:	UNIT# C-587	P.O. #C14606-C586
PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-640-01
REV. 0	DESCRIPTION	REV. 0

July 21, 2011 1:21pm



DRAWING No.	REFERENCE DRAWINGS	REV.	DESCRIPTION	DATE	DRAWN	CHK	DESIGN	APP
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WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

PANEL WIRE	
FIELD WIRE	



COMPASS COMPRESSION
CANGAS SOLUTIONS

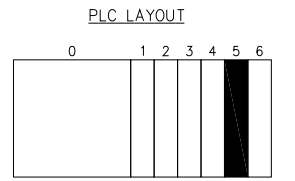
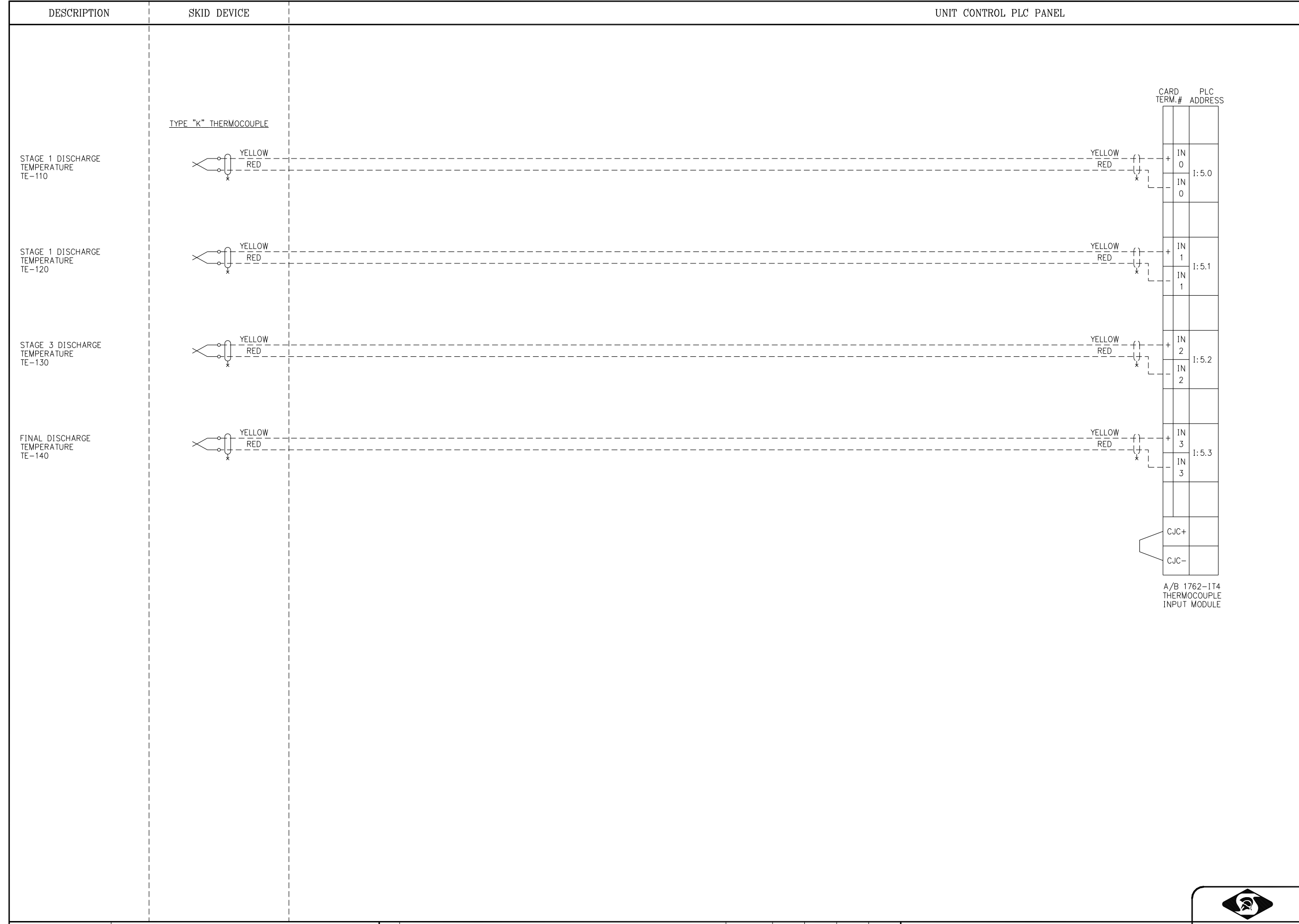
COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
THERMOCOUPLE INPUT MODULE WIRING DIAGRAM

LSD: UNIT# C-587 P.O. #C14606-C586

PROJECT No. PN27490	SCALE: NTS	DRAWING No. DE-27490-AB-650-00	REV. 0
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July 21, 2011 1:21pm



WIRE COLOUR CODE

GROUND	GREEN
+24 VDC	RED
24 VDC SWITCHED	ORANGE
0 VDC	BLUE

WIRE LEGEND

PANEL WIRE	—————
FIELD WIRE	- - - - -



COMPASS COMPRESSION
CANGAS SOLUTIONS

COMPRESSOR UNIT CONTROL PANEL (MICROLOGIX 1400)
THERMOCOUPLE INPUT MODULE WIRING DIAGRAM

LSD: UNIT# C-587 P.O. #C14606-C586

PROJECT No. PN27490 SCALE: NTS DRAWING No. DE-27490-AB-650-01 REV. 0

REV.	DESCRIPTION	DATE	DRAWN	CHK	DESIGN	APP
0	SPARTAN AS BUILT	21 JUL 11	RDW	JMK	JMK	JMK

DRAWING No. REFERENCE DRAWINGS

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July 21, 2011 1:21pm

Spartan Controls Ltd.	Compass Compression	Date: June 3, 2011
Project: PN27490-AA/AB	Unit # C-586 & C-587	Revision 0
	CanGas	Page 1



Spartan Controls
MicroLogix Compressor Control Panel
Operating Philosophy

Location:

Customer references: UNIT # C-586 & C-587

Vendor: Spartan Controls Ltd.

Vendor document: Operating Philosophy

Vendor project: PN27490AA/AB

Revision	0					
Date	June 3, 2011					
Check	MXP					
Review						

DOCUMENT ACCEPTANCE & APPROVAL

Certification of acceptance and approval of this document.

Customer name signature: _____ Date: _____

Spartan Controls Ltd. signature: _____ Date: _____

Spartan Controls Ltd.

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<p>Spartan Controls Ltd.</p> <p>Project: PN27490-AA/AB</p>	<p>Compass Compression</p> <p>Unit # C-586 & C-587</p> <p>CanGas</p>	<p>Date: June 3, 2011</p> <p>Revision 0</p> <p style="text-align: right;">Page 2</p>
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1. INTRODUCTION

1.1 General

This document outlines the **MicroLogix** compressor control panel operating philosophy for **Compass Compression**. A **MicroLogix 1400** control system will be programmed to safely start, stop, and automatically sequence a **recipricating** compressor with an **electric** drive. The automatic sequence has been designed based on practices and recommendations from **Compass Compression** for control of an electric motor, and an **Arial JGA/2 recipricating** compressor.

A Proface 5.7" colour touch-screen display mounted in the control panel door serves as the HMI (Human Machine Interface). The interface displays first-in shutdowns, an alarm history, sequencing messages and all process real-time data. A separate pushbutton mounted on the door is provided for USD (Unit Shutdown).

This document covers both the standard base system, and several options summarized in the next sections.

1.2 Standard Base System

The base system control logic functionality is listed below. These are covered in greater detail in later sections.

- Automatic speed / recycle valve control with high Discharge Pressure override and low Suction Pressure override.
- Cooler VFD Speed Control
- Cooldown stop sequencing.
- Compressor differential pressure alarm & shutdown logic.
- Low class C discharge Logic.
- Shutdown Bypass Logic.

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2. START-UP / SHUTDOWN SEQUENCING

The operator must ensure that all shutdowns have been cleared before a start can be attempted. This may be confirmed by viewing the HMI 'Main' screen. Once all shutdowns have been cleared, a "READY FOR LOCAL START" message is displayed. A "READY FOR REMOTE START" will be displayed if the *Local / Remote* selector is in the remote position.

2.1 Start-Up Sequencing (Electric Driver Motor)

Item	Step	Description
1	Press 'Start' softkey on HMI 'Start-up' screen.	<p>Initiates a start attempt. The Load/Unload Control and Motor Speed Control outputs are reset to 0% (Recycle Control Valve fully open and Driver Motor Speed Control at minimum output signal).</p> <p>Each step through the start sequence will be displayed on the HMI 'Start-Up' screen in the 'UNIT STATUS' box. When a shutdown occurs, the status will display "SHUTDOWN". The flashing 'Alarms' softkey can be pressed to go directly to the 'Active Alarms/Shutdowns' screen for details.</p> <p>The setpoint and timer parameters discussed in this section can be accessed from the HMI 'Sequence Parameters' screens.</p>
2	Start Positions	<ul style="list-style-type: none"> The Recycle Control Valve will adjust to the Recycle Valve Fully Open Startup Position. (HMI configurable)
3	Start Delay	<p>The start sequence will initiate the Start Delay Timer.</p> <ul style="list-style-type: none"> A 10 seconds Start Delay Timer will start (HMI adjustable).
4	Driver Motor Run Command	<p>Following the completion of the Start Delay Timer, the Driver Motor Run Command relay is energized.</p> <ul style="list-style-type: none"> The Driver Failed to Start Timer is started. If the speed does not exceed the Driver Running Speed Permit setting before the Driver Failed to Start Timer expires, the start sequence will abort on a "DRIVER FAILED TO START SHUTDOWN".
5	Driver Motor Running	<ul style="list-style-type: none"> If the start attempt is successful, the motor will accelerate to its' Idle Speed setpoint. The Class 'C' channels are enabled. The 120-second 'B' Timer starts. The 20-second 'b' Timer starts. The Remote Run Status relay is energized. The Cooler Fan Motor relay is energized. The Compressor Oil Cooler Fan Motor is energized. Refer to Appendix A for Class A/B/b/C definitions.

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6	Compressor Warm-up	<p>Automatic loading of the unit is not permitted until the compressor is warmed up.</p> <ul style="list-style-type: none"> • When the 120-second 'B' Timer expires, the Compressor Oil temperature is monitored. Once the temperature reaches the 'Load Temperature' permissive set point, the unit is ready to be loaded. A "READY TO LOAD" message will be displayed on the HMI 'Start-Up' screen. • Automatic loading can be initiated by pressing the 'Load' soft key on the HMI. Refer to Section 3 (Automatic Loading Control).
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2.1.1 Cooldown & Stop (Electric Driver Motor)

If the 'Stop' softkey on the HMI is pressed a Cooldown Stop sequence is initiated. On a Unit Cooldown and Stop, the Cooldown Timer will commence. The Cooldown Timer is adjustable from the HMI 'Sequence Parameters' screen. During the Cooldown cycle, the Cooldown Timer will be displayed on the HMI 'Start-Up' screen.

On a normal stop, the Load/Unload Control output will slowly ramp down to 0%. This will reduce the motor to its 'Minimum Load Speed', and the Recycle Control Valve will ramp open. The motor will then slow down to the 'Motor Idle Speed'.

When the Cooldown Timer expires, the Driver Motor Run Command will de-energize thus stopping the motor. Both the Cooler Fan and the Compressor Oil Cooler Fan motors will de-energize stopping the motors.

The 'Stop' softkey can be pressed a second time (at least three-seconds into the Cooldown Cycle) to stop the unit immediately. The 'Load' softkey can be pressed to cancel the Cooldown Cycle, and load the unit.

2.1.2 Alarm Initiated Cooldown Stop (Electric Driver Motor)

Each analog transmitter, TC, or RTD (if applicable) can be configured from the HMI to automatically initiate a cooldown stop if the low or high alarm is tripped. The setpoint screens include a button for each point to enable (YES) or disable (NO) this option.

A high shutdown will shut the unit down immediately, regardless of the option selection (YES or NO).

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2.1.3 Shutdown (Electric Driver Motor)

A shutdown is initiated if a discrete shutdown switch trips, an analog shutdown setpoint is exceeded, or an analog input sensor fails. On a shutdown, the Driver Motor Run Command relay will de-energize thus stopping the motor. The Driver Speed output is reset to 0% and the Recycle Control Valve will open (HMI configurable). The Cooler Fan and the Compressor Oil Cooler Fan relay's are de-energized stopping the motors.

On the HMI 'Start-Up' screen, the 'UNIT STATUS' will display "SHUTDOWN". The flashing 'Alarms' softkey can be pressed to go directly to the 'Active Alarm' screen to view the details of the shutdown.

2.1.4 Emergency Shutdown (ESD)

A Unit Emergency Shutdown (ESD) is initiated by any of the following:

- Remote ESD (hard-wired from Station Control System)
- Panel 'USD' pushbutton

On an ESD condition, the Driver Motor Run Command relay is de-energized thus stopping the motor. The Driver Speed output is reset to 0% and the Recycle Control Valve will open. The Cooler Fan and the Compressor Oil Cooler Fan relay's are de-energized stopping the motors.

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3. AUTOMATIC LOADING CONTROL

When the unit is ready to be loaded, a “UNIT READY TO LOAD” status is displayed on the HMI ‘Start-Up’ screen. Loading can be initiated by pressing the ‘Load’ softkey on the HMI (Local Mode), or ‘Remote Load’ from the Station Control System (Remote Mode).

When automatic loading is initiated, the driver speed will ramp up to the ‘Minimum Load Speed’. Once the driver speed reaches the ‘Minimum Load Speed’, the ‘Load/Unload Control’ will begin to increase from zero to 100% at an adjustable rate. If no override conditions exist Suction & Discharge Pressure Override PIDs will track the ‘Load/Unload Control’. Loading can be monitored from the HMI ‘Control Overview’ screen.

The lowest output signal (Low Select) from the Suction Override PID, Discharge Override PID or Load/Unload Control is split-ranged and sent to the Recycle Control Valve and the Driver Speed Control.

As the Low Select signal goes from 0-100%, the Recycle Control Valve ramps from fully open to fully closed, the Driver Speed signal changes from the ‘Minimum Load Speed’ to ‘Maximum Load Speed’. For example, with split range settings of 50-100% for speed and 0-25% for Bypass Valve, the driver speed setpoint changes from the *Minimum Load Speed* to *Maximum Load Speed* with a 50-100% signal from the PID output, the Bypass Valve ramps from fully open to fully closed with a 0-25% signal from the PID output. The split-range settings and the ‘Minimum / Maximum Load Speed’ settings can be accessed from the HMI ‘Sequence Parameters’ screen.

The Bypass Valve will stop opening, and switch to differential pressure control if the Discharge/Suction differential pressure drops to the control setpoint during unloading.

If the Suction Pressure drops below setpoint the Suction Override PID will stop tracking and start controlling.

If the Discharge Pressure rises above setpoint the Discharge Override PID will stop tracking and start controlling.

The ‘Unload’ softkey on the HMI ‘Start-Up’ screen can be pressed to automatically unload the unit. The Load/Unload Control output is ramped to zero. The unit is unloaded according to the split-range settings.

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3.1 Low Suction Pressure Override Control

The Suction Override PID can be accessed from the HMI 'Process Control' screen. If at anytime the Suction Pressure drops below the Suction Override PID setpoint, the PID will stop tracking and start controlling, its output will decrease. The unit will unload by reducing the driver speed and opening the recycle control valve. The split-range settings determine how the unit will unload.

Access to PID setpoint adjustment & tuning parameters is available via the HMI.

3.2 High Discharge Pressure Override Control

The Discharge Override PID can be accessed from the HMI 'Process Control' screen. If at anytime the Discharge Pressure rises above the Discharge Override PID setpoint, the PID will stop tracking and its output will decrease. The unit will unload by reducing the driver speed and opening the recycle control valve. The split-range settings determine how the unit will unload.

The PID controllers have the feature to limit the output, and to prevent the integral term from becoming excessive when the output reaches the limit (a reset windup situation). The PID controllers should be tuned to quickly respond to the pressure changes.

Since pressure and flow control is a fast process, dynamic by nature, the PID controllers should only use Proportional-Integral (PI) functions.

Access to PID setpoint adjustment & tuning parameters is available via the HMI.

3.3 Load/Unload Control

The Load/Unload Control can be accessed from the HMI 'Control Overview' screen. This control default mode is automatic. After loading is initiated & 'Minimum Load Speed' is reached the 'Load/Unload Control' can be switched to manual and adjusted as required by the operator.

When loading, the Load/Unload control signal will ramp from zero to 100%. Provided the override pressures are within the override PID setpoint limits the override PIDs will track 5% (HMI adjustable) above this output. When the Unload button is pressed the Load/Unload Control signal is ramped to zero. The unit will unload by reducing the driver speed and opening the recycle control valve. The split-range settings determine how the unit will unload.

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4. MANUAL LOADING CONTROL

4.1 Manual Bypass Valve Control

The *Bypass Valve* analog output can be placed in manual mode from the HMI 'Speed/Bypass Control' screen. The *Bypass Valve* will remain at its present position until ramped open or closed via the *Increase / Decrease* buttons on the screen. The manual position adjustment (0-100% output), control setpoint (0-100% output), and current position (0-100% open) are displayed.

The *Suction Override PID* and *Discharge Override PID* controllers continue to operate when the *Bypass Valve* is in manual mode. When the output is returned to automatic mode the *Bypass Valve* will ramp back to the position specified by the automatic control logic.

The *Bypass Valve* AO Scaling option can be used to specify a specific output percentage of the analog output relating to the actual valve position. These settings can be adjusted from the 'Sequence Parameters' screen. For example, if the *Bypass Valve* is closed when the analog output is at 80% the '*Bypass Valve Fully Closed @ ___%*' setpoint can be changed to 80%. The logic will automatically rescale to operate at a range of 0-80%. The HMI indicators will continue to display the full 0-100% range. As the valve closes and the signal reaches 80% it will automatically be forced to 0% to ensure the valve is fully closed.

4.2 Manual Driver Speed Control

The *Driver Speed Control* analog output can be placed in manual mode from the HMI 'Speed/Bypass Control' or 'Setpoint Control' screens. The output will remain at its present position until the *Increase / Decrease* buttons are activated. The desired position can also be directly entered. The appropriate speed control output (0-100% output), driver speed (RPM), and control setpoint (RPM) are displayed.

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5. COOLER VFD CONTROL

The *Cooler VFD PID* controller controls the speed of the Cooler VFD and is used to maintain a desired final discharge temperature. The output signal from the PID is sent to the *Cooler VFD* analog output. If at anytime the Final Discharge Temperature rises above the *Cooler VFD PID Setpoint* the output will begin to increase the cooler fan speed.

Standard PID screens with a real time trend, auto/manual selection & tuning capability are provided on the HMI.

6. DISCHARGE SCRUBBER LEVEL CONTROL

Analog Input: Discharge Scrubber Level (Control) (LT-120)
Discrete Outputs: Discharge Scrubber Dump Valve (LV-140)

The Discharge Scrubber has a Scrubber Level Transmitter (LT-120) sensing the liquid level in the vessel. The Scrubber Level control is only active while the unit is running.

If the liquid level rises above the '*Discharge Scrubber Drain Initiate*' setpoint, the Discharge Scrubber Dump Valve will open to drain the liquid. The Scrubber Drain Fault Timer is started. The Discharge Scrubber Dump Valve will close when the liquid level decreases to the '*Discharge Scrubber Drain Stop*' setpoint.

If the Discharge Scrubber Dump Valve remains open longer than the Discharge Scrubber Drain Fault Timer (typically 120s / HMI adjustable), the unit will alarm and close the valve. The Scrubber Drain Fault can be configured from the HMI sequence parameters screen as an alarm or a shutdown.

7. DIFFERENTIAL PRESSURE MONITORING

The unit will be shut down if any differential pressure exceeds its HMI adjustable setpoint. The differential values are internally calculated by the **MicroLogix**.

Stage 1 Discharge / Stage 1 Suction Differential = Compressor St1 Discharge – Compressor Suction

Stage 2 Discharge / Stage 1 Discharge Differential = Compressor St2 Discharge – Compressor St1 Discharge

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8. LOW CLASS C DISCHARGE LOGIC

Low class C discharge logic is provided for the compressor discharge pressure. The setpoint is monitored when loading is initiated. The discharge pressures can be unstable during loading. A timer is used to temporarily bypass the logic. The timer is started when the pressure initially rises above the setpoint. Once the timer has expired, a shutdown will occur if the pressure drops back below the setpoint.

The low shutdown/alarm logic is enabled when auto loading is initiated, and disabled when unload or cooldown is initiated.

9. SHUTDOWN BYPASS LOGIC

Occasionally, it is necessary to work on an end device while the unit is running. A channel *Shutdown Bypass* mode is provided for this purpose. Each channel can be individually bypassed from the HMI 'Shutdown Bypass' screens. Only one channel can be bypassed at any time. **Only the setpoint shutdown logic is bypassed. All other program functions related to the input remain active while the channel is bypassed. A complete review of the control implications should be considered before bypassing any input.**

If the *Driver Speed* input is bypassed the *Overspeed Setpoint* will be reduced by 10% for the duration of the bypass. This allows the operator to test the overspeed function without taking the unit into a true overspeed condition.

The bypass function will bypass the channel for 5 minutes. The time remaining in the bypass will be indicated on the HMI 'Shutdown Bypass' screen. The *Shutdown Bypass Timer* can be restarted at any time during the bypass by pressing the *Reset Bypass Timer* button. An individual bypass can be manually cancelled at any time by pressing the *Remove All Bypass* button. If a channel is in an unhealthy state when the bypass ends (either manually cancelled, or timer expired) the unit will be shut down.

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10. MISCELLANEOUS

10.1 Password Protection

The following HMI screens are password protected.

- 'Analog Input Setpoints'
- 'TC / RTD Setpoints'
- 'Sequence Parameter Setpoints'
- 'Differential and RPM Setpoints'
- 'Analog Input Transmitter Ranges'
- 'DI/AI/TC/RTD Shutdown Bypass'

The operator user ID is 'O' and the operator password will be set to a value of '1' when the panel ships. The user ID and password can be changed to a site specific number using the HMI software.

Screens that do not require password entry are provided for viewing the motor/compressor/sequence parameters. Alarm setpoints, and certain sequence parameters can be adjusted from these screens.

10.2 Verify Discrete Input

The open /closed status of each discrete input can be viewed from the HMI 'Verify Discrete Input' screen.

10.3 Force Discrete Output

When the unit is not running & there is no ESD active, any discrete output (DO) can be manually forced on/off from the HMI 'Discrete Output Control' screens. This manual logic is disabled when a start is initiated. The operator must not run the unit manually as this is unsafe. It is the responsibility of the operator to perform a hazop and have the required permits & lockouts in place to protect personnel & equipment from damage due to manual operation of any DO.

10.4 Run Time Hours / Number Of Start Attempts

The Unit *Run Time Hours* and *Number Of Start Attempts* can be viewed from the HMI 'RUNTIME HOURS' screen.

10.5 Maintenance

The control system will calculate based on runtime hours and operator setpoint, the next required oil change.

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10.6 Local Mode

Remote Start, Stop and Reset communications commands are ignored. Remote setpoints are automatically reset to the local setpoint values. The Remote Stop discrete input is monitored.

10.7 Remote Mode

Local Stop remains active. The local Start and Reset commands are ignored. Local setpoints are automatically reset to the remote setpoint values.

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APPENDIX A

Input/Output List

See I/O list provided separately.

APPENDIX B

Definitions

Table B-1: Alarm/Shutdown Classification Definitions

Class	Description
Class A	Class A alarm/shutdown functions are always enabled. All Class A shutdowns must be cleared before the unit can be started. Examples: Cylinder Discharge Temperature
Class B	Class B alarm/shutdown functions are disabled until the B Timer is started. Class B functions are bypassed until the B Timer expires. Examples:
Class b	Class b alarm/shutdown functions are disabled until the b Timer is started. Class b functions are bypassed until the b Timer expires. Examples: Compressor Oil Pressures
Class C	Class C alarm/shutdown functions are disabled until the unit is running. Class C functions are then individually monitored. When a Class C function becomes healthy it is enabled, and will cause an alarm/shutdown if it then goes unhealthy.

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PLEASE APPROVE AND RETURN.

Comments: _____

Approved by: _____ Approval date: _____

END DOCUMENT

Spartan Controls PN-27490 PLC Communications Map

Compass Compression

C-586 & C-587

Modbus Comm Notes:

Node address: **C-586=2 C-587=3** (range is 1-247) / 9600baud / 8 data bits / 1 stop bit / Micrologix 1400 - channel '0' used for modbus / maximum single poll is 123 words
 N100 data file is directly mapped to Modbus Table / polls cannot exceed the size of N100 data file(126words)

WRITE TAGS

				AB Database Address	Modbus Address
Remote Start				N100:80	40081
Remote Stop				N100:81	40082
Remote Reset				N100:82	40083
					40084
Remote Load				N100:84	40085
Remote Unload				N100:85	40086
Above Remote Commands-pulse a (1) for 2 seconds.					
Remote Max Load Speed Setpoint				N100:90	40091
Remote Suction Override Pid Setpoint				N100:91	40092
Remote Discharge Override Pid Setpoint				N100:92	40093
Remote Suction Valve PID Setpoint				N100:93	40094
Remote Spare Override PID Setpoint				N100:94	40095
Remote Temperature PID Setpoint				N100:95	40096
Remote Diff Pressure PID Setpoint				N100:96	40097
Remote Backpressure PID Setpoint				N100:97	40098

READ TAGS

GENERAL INFORMATION

Tag Number	Description			AB Database Address	Modbus Address
	Firstout State - See FIRSTOUT STATE column in Shutdowns sections			N100:0	40001
	Sequence State - See Sequence States Below			N100:1	40002
	Sequence Timer			N100:2	40003
	Start Attempts			N100:3	40004
	Runtime Hours - Total Runtime Hours is (N100:4*1000)+N100:5			N100:4	40005
				N100:5	40006

SEQUENCE STATES

HMI MESSAGE	STATE				
	0				
SHUTDOWN	1				
READY FOR REMOTE START	2				
READY FOR LOCAL START	3				
OIL PERMISSIVE	4				
START DELAY	5				
MOTOR RUN COMMAND	6				
ENGINE PURGE	7				
IGNITION	8				
IGNITION/FUEL	9				
B TIMER	10				
BLOWING DOWN	11				
WARM-UP	12				
READY TO LOAD	13				
LOADING INITIATED	14				
COOLDOWN-LOAD TO CANCEL	15				
POSTLUBE	16				
SPARE	17				
FULLY LOADED	18				
B TIMER-LUBE NO FLOW	19				
MOTOR RUN STATUS CLOSED	20				
SPARE	21				
SPARE	22				
SPARE	23				
	24				
	25				
	26				
	27				
	28				

DISCRETE INPUT STATUS						
Tag Number	Discrete Inputs - 0=Open 1=Closed		AB Database Address	BIT	Modbus Address	BIT
DI-0	Spare Discrete Input		N100:6	0	40007	0
DI-1	Compressor Lubricator No-Flow SD			1		1
DI-2	Spare Discrete Input			2		2
DI-3	Compressor Oil Level Low SD			3		3
DI-4	Spare Discrete Input			4		4
DI-5	Seal Pot Pressure High SD			5		5
DI-6	Cooler Vibration High SD			6		6
DI-7	Compression Vibration High SD			7		7
DI-8	Motor Vibration High SD			8		8
DI-9	Stage 1 Scrubber Level High SD			9		9
DI-10	Stage 2 Scrubber Level High SD			10		10
DI-11	Stage 3 Scrubber Level High SD			11		11
DI-12	Spare Discrete Input			12		12
DI-13	Spare Discrete Input			13		13
DI-14	Spare Discrete Input			14		14
DI-15	Spare Discrete Input			15		15
DI-16	Spare Discrete Input		N100:7	0	40008	0
DI-17	Motor Run Status			1		1
DI-18	Panel USD SD			2		2
DI-19	Remote Emergency SD			3		3
DI-20	Spare Discrete Input			4		4
DI-21	Spare Discrete Input			5		5
DI-22	Spare Discrete Input			6		6
DI-23	Spare Discrete Input			7		7
DI-24	Spare Discrete Input			8		8
DI-25	Spare Discrete Input			9		9
DI-26	Spare Discrete Input			10		10
DI-27	Spare Discrete Input			11		11
DI-28	Spare Discrete Input			12		12
DI-29	Spare Discrete Input			13		13
DI-30	Spare Discrete Input			14		14
DI-31	Spare Discrete Input			15		15

DISCRETE OUTPUT STATUS						
Tag Number	Discrete Outputs - 0=Off 1=On		AB Database Address	BIT	Modbus Address	BIT
DO-0	Spare Discrete Output		N100:8	0	40009	0
DO-1	Spare Discrete Output			1		1
DO-2	Cooler Fan Motor Relay			2		2
DO-3	Compressor Oil Cooler Fan Motor Relay			3		3
DO-4	Electric Motor Driver Command Relay			4		4
DO-5	Suction ESD Valve Solenoid			5		5
DO-6	Remote Run Status Relay			6		6
DO-7	V-01 ESD Valve Solenoid			7		7
DO-8	Discharge Scrubber Dump Valve Solenoid			8		8
DO-9	Spare Discrete Output			9		9
DO-10	Spare Discrete Output			10		10
DO-11	Spare Discrete Output			11		11
DO-12	Spare Discrete Output			12		12
DO-13	Spare Discrete Output			13		13
DO-14	Spare Discrete Output			14		14
DO-15	Spare Discrete Output			15		15

ANALOG INPUT READINGS						
Tag Number	Analog Input	UNITS	AB Database Address	Modbus Address		
			Int		Int	
AI/0	Stage 1 Suction Pressure		N100:20		40021	
AI/1	Stage 1 Discharge Pressure		N100:21		40022	
AI/2	Stage 2 Discharge Pressure		N100:22		40023	
AI/3	Stage 3 Discharge Pressure		N100:23		40024	
AI/4	Compressor Oil Pressure		N100:24		40025	
AI/5	Spare Analog Input		N100:25		40026	
AI/6	Final Discharge Flow		N100:26		40027	
AI/7	Discharge Scrubber Liquid Level		N100:27		40028	
AI/8	Spare Analog Input		N100:28		40029	
AI/9	Spare Analog Input		N100:29		40030	
AI/10	Spare Analog Input		N100:30		40031	
AI/11	Spare Analog Input		N100:31		40032	
AI/12	Spare Voltage Input 1400		N100:32		40033	
AI/13	Spare Voltage Input 1400		N100:33		40034	
AI/14	System Voltage		N100:34		40035	
AI/15	Driver Speed		N100:35		40036	

ANALOG OUTPUT READINGS						
Tag Number	Analog Input		AB Database Address		Modbus Address	
			Int		Int	
AO/0	Driver Speed		N100:60		40061	
AO/1	Bypass Control Valve		N100:61		40062	
AO/2	Vent to Treater Valve		N100:62		40063	
AO/3	Cooler Fan Motor Speed		N100:63		40064	
AO/4	Backpressure Control Valve		N100:64		40065	
AO/5	Spare Analog Output		N100:65		40066	
AO/6	Spare Analog Output		N100:66		40067	
AO/7	Spare Analog Output		N100:67		40068	
TEMPERATURE INPUT READINGS						
Tag Number	Temperature Input Readings	UNITS	AB Database Address		Modbus Address	
			Int		Int	
TEMP/0	Compressor Oil Temp		N100:40		40041	
TEMP/1	Spare Temp		N100:41		40042	
TEMP/2	Spare Temp		N100:42		40043	
TEMP/3	Panel Ambient Temp		N100:43		40044	
TEMP/4	Stage 1 Discharge Temp		N100:44		40045	
TEMP/5	Stage 2 Discharge Temp		N100:45		40046	
TEMP/6	Stage 3 Discharge Temp		N100:46		40047	
TEMP/7	Final Discharge Temp		N100:47		40048	
TEMP/8	Spare Temp		N100:48		40049	
TEMP/9	Spare Temp		N100:49		40050	
TEMP/10	Spare Temp		N100:50		40051	
TEMP/11	Spare Temp		N100:51		40052	
TEMP/12	Spare Temp		N100:52		40053	
TEMP/13	Spare Temp		N100:53		40054	
TEMP/14	Spare Temp		N100:54		40055	
TEMP/15	Spare Temp		N100:55		40056	
PACKED SHUTDOWN / ALARM STATUS BITS - 0=NO SHUTDOWN/ALARM 1=SHUTDOWN/ALARM						
DISCRETE INPUT SHUTDOWNS						
Tag Number	0=Healthy 1=Shutdown	FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	DISCRETE SHUTDOWNS	FIRSTOUT	SHUTDOWN		SHUTDOWN	BIT
DI-0	Spare Discrete Input	1	N100:100	0	40101	0
DI-1	Compressor Lubricator No-Flow SD	2		1		1
DI-2	Spare Discrete Input	3		2		2
DI-3	Compressor Oil Level Low SD	4		3		3
DI-4	Spare Discrete Input	5		4		4
DI-5	Seal Pot Pressure High SD	6		5		5
DI-6	Cooler Vibration High SD	7		6		6
DI-7	Compression Vibration High SD	8		7		7
DI-8	Motor Vibration High SD	9		8		8
DI-9	Stage 1 Scrubber Level High SD	10		9		9
DI-10	Stage 2 Scrubber Level High SD	11		10		10
DI-11	Stage 3 Scrubber Level High SD	12		11		11
DI-12	Spare Discrete Input	13		12		12
DI-13	Spare Discrete Input	14		13		13
DI-14	Spare Discrete Input	15		14		14
DI-15	Spare Discrete Input	16		15		15
DI-16	Spare Discrete Input	17	N100:101	0	40102	0
DI-17	Motor Run Status	18		1		1
DI-18	Panel USD SD	19		2		2
DI-19	Remote Emergency SD	20		3		3
DI-20	Spare Discrete Input	21		4		4
DI-21	Spare Discrete Input	22		5		5
DI-22	Spare Discrete Input	23		6		6
DI-23	Spare Discrete Input	24		7		7
DI-24	Spare Discrete Input	25		8		8
DI-25	Spare Discrete Input	26		9		9
DI-26	Spare Discrete Input	27		10		10
DI-27	Spare Discrete Input	28		11		11
DI-28	Spare Discrete Input	29		12		12
DI-29	Spare Discrete Input	30		13		13
DI-30	Spare Discrete Input	31		14		14
DI-31	Spare Discrete Input	32		15		15

DISCRETE INPUT ALARMS

Tag Number	0=Healthy 1=Alarm	FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	DISCRETE ALARMS	Not Applicable	ALARM		ALARM	BIT
DI-0	Spare Discrete Input		N100:113	0	40114	0
DI-1	Compressor Lubricator No-Flow SD			1		1
DI-2	Spare Discrete Input			2		2
DI-3	Compressor Oil Level Low SD			3		3
DI-4	Spare Discrete Input			4		4
DI-5	Seal Pot Pressure High SD			5		5
DI-6	Cooler Vibration High SD			6		6
DI-7	Compression Vibration High SD			7		7
DI-8	Motor Vibration High SD			8		8
DI-9	Stage 1 Scrubber Level High SD			9		9
DI-10	Stage 2 Scrubber Level High SD			10		10
DI-11	Stage 3 Scrubber Level High SD			11		11
DI-12	Spare Discrete Input			12		12
DI-13	Spare Discrete Input			13		13
DI-14	Spare Discrete Input			14		14
DI-15	Spare Discrete Input			15		15
DI-16	Spare Discrete Input		N100:114	0	40115	0
DI-17	Motor Run Status			1		1
DI-18	Panel USD SD			2		2
DI-19	Remote Emergency SD			3		3
DI-20	Spare Discrete Input			4		4
DI-21	Spare Discrete Input			5		5
DI-22	Spare Discrete Input			6		6
DI-23	Spare Discrete Input			7		7
DI-24	Spare Discrete Input			8		8
DI-25	Spare Discrete Input			9		9
DI-26	Spare Discrete Input			10		10
DI-27	Spare Discrete Input			11		11
DI-28	Spare Discrete Input			12		12
DI-29	Spare Discrete Input			13		13
DI-30	Spare Discrete Input			14		14
DI-31	Spare Discrete Input			15		15

ANALOG INPUT SHUTDOWNS

Tag Number	0=Healthy 1=Shutdown	FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	ANALOG INPUT	Fault Type	FIRSTOUT	SHUTDOWN	SHUTDOWN	BIT
AI/0	Stage 1 Suction Pressure	LOW	49	N100:103	0	40104
		HIGH	50		1	1
		SENSOR FAIL	51		2	2
AI/1	Stage 1 Discharge Pressure	LOW	52		3	3
		HIGH	53		4	4
		SENSOR FAIL	54		5	5
AI/2	Stage 2 Discharge Pressure	LOW	55		6	6
		HIGH	56		7	7
		SENSOR FAIL	57		8	8
AI/3	Stage 3 Discharge Pressure	LOW	58		9	9
		HIGH	59		10	10
		SENSOR FAIL	60		11	11
AI/4	Compressor Oil Pressure	LOW	61		12	12
		HIGH	62		13	13
		SENSOR FAIL	63		14	14
AI/5	Spare Analog Input	LOW	64		15	15
		HIGH	65	N100:104	0	40105
		SENSOR FAIL	66		1	1
AI/6	Final Discharge Flow	LOW	67		2	2
		HIGH	68		3	3
		SENSOR FAIL	69		4	4
AI/7	Discharge Scrubber Liquid Level	LOW	70		5	5
		HIGH	71		6	6
		SENSOR FAIL	72		7	7
AI/8	Spare Analog Input	LOW	73		8	8
		HIGH	74		9	9
		SENSOR FAIL	75		10	10
AI/9	Spare Analog Input	LOW	76		11	11
		HIGH	77		12	12
		SENSOR FAIL	78		13	13
AI/10	Spare Analog Input	LOW	79		14	14
		HIGH	80		15	15
		SENSOR FAIL	81	N100:105	0	40106
AI/11	Spare Analog Input	LOW	82		1	1
		HIGH	83		2	2
		SENSOR FAIL	84		3	3
AI/12	Spare Voltage Input 1400	LOW	85		4	4
		HIGH	86		5	5
		SENSOR FAIL	87		6	6
AI/13	Spare Voltage Input 1400	LOW	88		7	7
		HIGH	89		8	8
		SENSOR FAIL	90		9	9
AI/14	System Voltage	LOW	91		10	10
		HIGH	92		11	11
		SENSOR FAIL	93		12	12
AI/15	Driver Speed	LOW	94		13	13
		HIGH	95		14	14
		SENSOR FAIL	96		15	15

ANALOG INPUT ALARMS

Tag Number	0=Healthy 1=Alarm		FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	ANALOG INPUT	Fault Type	Not Applicable	ALARM		ALARM	BIT
AI/0	Stage 1 Suction Pressure	LOW		N100:116	0	40117	0
		HIGH			1		1
		SENSOR FAIL			2		2
AI/1	Stage 1 Discharge Pressure	LOW			3		3
		HIGH			4		4
		SENSOR FAIL			5		5
AI/2	Stage 2 Discharge Pressure	LOW			6		6
		HIGH			7		7
		SENSOR FAIL			8		8
AI/3	Stage 3 Discharge Pressure	LOW			9		9
		HIGH			10		10
		SENSOR FAIL			11		11
AI/4	Compressor Oil Pressure	LOW			12		12
		HIGH			13		13
		SENSOR FAIL			14		14
AI/5	Spare Analog Input	LOW			15		15
		HIGH		N100:117	0	40118	0
		SENSOR FAIL			1		1
AI/6	Final Discharge Flow	LOW			2		2
		HIGH			3		3
		SENSOR FAIL			4		4
AI/7	Discharge Scrubber Liquid Level	LOW			5		5
		HIGH			6		6
		SENSOR FAIL			7		7
AI/8	Spare Analog Input	LOW			8		8
		HIGH			9		9
		SENSOR FAIL			10		10
AI/9	Spare Analog Input	LOW			11		11
		HIGH			12		12
		SENSOR FAIL			13		13
AI/10	Spare Analog Input	LOW			14		14
		HIGH			15		15
		SENSOR FAIL		N100:118	0	40119	0
AI/11	Spare Analog Input	LOW			1		1
		HIGH			2		2
		SENSOR FAIL			3		3
AI/12	Spare Voltage Input 1400	LOW			4		4
		HIGH			5		5
		SENSOR FAIL			6		6
AI/13	Spare Voltage Input 1400	LOW			7		7
		HIGH			8		8
		SENSOR FAIL			9		9
AI/14	System Voltage	LOW			10		10
		HIGH			11		11
		SENSOR FAIL			12		12
AI/15	Driver Speed	LOW			13		13
		HIGH			14		14
		SENSOR FAIL			15		15

TEMPERATURE INPUT SHUTDOWNS

Tag Number	0=Healthy 1=Shutdown		FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	TEMPERATURE INPUT	Fault Type	FIRSTOUT	SHUTDOWN		SHUTDOWN	BIT
TEMP/0	Compressor Oil Temp	LOW	121	N100:107	0	40108	0
		HIGH	122		1		1
		SENSOR FAIL	123		2		2
TEMP/1	Spare Temp	LOW	124		3		3
		HIGH	125		4		4
		SENSOR FAIL	126		5		5
TEMP/2	Spare Temp	LOW	127		6		6
		HIGH	128		7		7
		SENSOR FAIL	129		8		8
TEMP/3	Panel Ambient Temp	LOW	130		9		9
		HIGH	131		10		10
		SENSOR FAIL	132		11		11
TEMP/4	Stage 1 Discharge Temp	LOW	133		12		12
		HIGH	134		13		13
		SENSOR FAIL	135		14		14
TEMP/5	Stage 2 Discharge Temp	LOW	136		15		15
		HIGH	137	N100:108	0	40109	0
		SENSOR FAIL	138		1		1
TEMP/6	Stage 3 Discharge Temp	LOW	139		2		2
		HIGH	140		3		3
		SENSOR FAIL	141		4		4
TEMP/7	Final Discharge Temp	LOW	142		5		5
		HIGH	143		6		6
		SENSOR FAIL	144		7		7
TEMP/8	Spare Temp	LOW	145		8		8
		HIGH	146		9		9
		SENSOR FAIL	147		10		10
TEMP/9	Spare Temp	LOW	148		11		11
		HIGH	149		12		12
		SENSOR FAIL	150		13		13
TEMP/10	Spare Temp	LOW	151		14		14
		HIGH	152		15		15
		SENSOR FAIL	153	N100:109	0	40110	0
TEMP/11	Spare Temp	LOW	154		1		1
		HIGH	155		2		2
		SENSOR FAIL	156		3		3
TEMP/12	Spare Temp	LOW	157		4		4
		HIGH	158		5		5
		SENSOR FAIL	159		6		6
TEMP/13	Spare Temp	LOW	160		7		7
		HIGH	161		8		8
		SENSOR FAIL	162		9		9
TEMP/14	Spare Temp	LOW	163		10		10
		HIGH	164		11		11
		SENSOR FAIL	165		12		12
TEMP/15	Spare Temp	LOW	166		13		13
		HIGH	167		14		14
		SENSOR FAIL	168		15		15

TEMPERATURE INPUT ALARMS							
Tag Number	0=Healthy 1=Alarm		FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	TEMPERATURE INPUT	Fault Type	Not Applicable	ALARM		ALARM	BIT
TEMP/0	Compressor Oil Temp	LOW		N100:120	0	40121	0
		HIGH			1		1
		SENSOR FAIL			2		2
TEMP/1	Spare Temp	LOW			3		3
		HIGH			4		4
		SENSOR FAIL			5		5
TEMP/2	Spare Temp	LOW			6		6
		HIGH			7		7
		SENSOR FAIL			8		8
TEMP/3	Panel Ambient Temp	LOW			9		9
		HIGH			10		10
		SENSOR FAIL			11		11
TEMP/4	Stage 1 Discharge Temp	LOW			12		12
		HIGH			13		13
		SENSOR FAIL			14		14
TEMP/5	Stage 2 Discharge Temp	LOW		N100:121	15	40122	15
		HIGH			0		0
		SENSOR FAIL			1		1
TEMP/6	Stage 3 Discharge Temp	LOW			2		2
		HIGH			3		3
		SENSOR FAIL			4		4
TEMP/7	Final Discharge Temp	LOW			5		5
		HIGH			6		6
		SENSOR FAIL			7		7
TEMP/8	Spare Temp	LOW			8		8
		HIGH			9		9
		SENSOR FAIL			10		10
TEMP/9	Spare Temp	LOW			11		11
		HIGH			12		12
		SENSOR FAIL			13		13
TEMP/10	Spare Temp	LOW			14		14
		HIGH			15		15
		SENSOR FAIL		N100:122	0	40123	0
TEMP/11	Spare Temp	LOW			1		1
		HIGH			2		2
		SENSOR FAIL			3		3
TEMP/12	Spare Temp	LOW			4		4
		HIGH			5		5
		SENSOR FAIL			6		6
TEMP/13	Spare Temp	LOW			7		7
		HIGH			8		8
		SENSOR FAIL			9		9
TEMP/14	Spare Temp	LOW			10		10
		HIGH			11		11
		SENSOR FAIL			12		12
TEMP/15	Spare Temp	LOW			13		13
		HIGH			14		14
		SENSOR FAIL			15		15
LOGIC BASED SHUTDOWNS							
	0=Healthy 1=Shutdown		FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	LOGIC SHUTDOWNS		FIRSTOUT	SHUTDOWN		SHUTDOWN	BIT
	COMP OIL PERMISSIVE SD		217	N100:111	0	40112	0
	ENGINE OIL PERMISSIVE SD		218		1		1
	DRIVER FAILED TO START SD		219		2		2
	ENGINE FAILED TO CRANK SD		220		3		3
	COMP ST1 DIFF PRESS HIGH SD		221		4		4
	COMP ST2 DIFF PRESS HIGH SD		222		5		5
	COMP ST3 DIFF PRESS HIGH SD		223		6		6
	MAG PICKUP FAULT SD		224		7		7
	COMPRESSOR BLOWDOWN FAULT SD		225		8		8
	SUCTION SCRUBBER DRAIN FAULT SD		226		9		9
	COMP ST1 DIFF PRESS LOW SD		227		10		10
	COMP ST2 DIFF PRESS LOW SD		228		11		11
	COMP ST3 DIFF PRESS LOW SD		229		12		12
	SPARE LOGIC SD		230		13		13
	SPARE LOGIC SD		231		14		14
	SPARE LOGIC SD		232		15		15
	SPARE		233	N100:112	0	40113	0
	SPARE		234		1		1
	SPARE		235		2		2
	SPARE		236		3		3
	SPARE		237		4		4
	SPARE		238		5		5
	SPARE		239		6		6
	SPARE		240		7		7
	SPARE		241		8		8
	SPARE		242		9		9
	SPARE		243		10		10
	SPARE		244		11		11
	SPARE		245		12		12
	SPARE		246		13		13
	SPARE		247		14		14
	SPARE		248		15		15

LOGIC BASED ALARMS

Tag Number	0=Healthy 1=Alarm	FIRSTOUT	AB Database Address	BIT	Modbus Address	BIT
	LOGIC ALARMS	Not Applicable	ALARM		ALARM	BIT
	COMP ST1 DIFF PRESS HIGH AL		N100:124	0	40125	0
	COMP ST2 DIFF PRESS HIGH AL			1		1
	COMP ST3 DIFF PRESS HIGH AL			2		2
	ALARM INITIATED COOLDOWN			3		3
	MAINTENANCE HOURS AL			4		4
	POWER FAIL / PROGRAM RESTART AL			5		5
	COMP ST1 DIFF PRESS LOW AL			6		6
	COMP ST2 DIFF PRESS LOW AL			7		7
	COMP ST3 DIFF PRESS LOW AL			8		8
	SUCTION SCRUBBER DRAIN FAULT AL			9		9
	SPARE LOGIC AL			10		10
	SPARE LOGIC AL			11		11
	SPARE LOGIC AL			12		12
	SPARE LOGIC AL			13		13
	PROCESSOR BATTERY FAULT AL			14		14
	LOGIC MATH OVERFLOW FAULT AL			15		15
	SPARE		N100:125	0	40126	0
	SPARE			1		1
	SPARE			2		2
	SPARE			3		3
	SPARE			4		4
	SPARE			5		5
	SPARE			6		6
	SPARE			7		7
	SPARE			8		8
	SPARE			9		9
	SPARE			10		10
	SPARE			11		11
	SPARE			12		12
	SPARE			13		13
	SPARE			14		14
	SPARE			15		15



Unit C-587

General





Company: Ariel Corporation
 Order #: 56400 (AP021437)
 Case 1:

Ariel Compressor Balancing Record

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions



7.6.5.0

Balance By: Completed: 03/06/2011 Frame: **JGA/2** Frame S/N: **F35740** Operating RPM: **900.0**
 Stroke, in: **3.00**

Parts Group	Throw #1		Throw #2							
	5.125M		3.625SG-CE							
	SN: C123344		CE SN: C123345							
			1.500SG-FS-HE							
		HE SN: C123346								
	P/N	LB	P/N	LB						
Connecting Rod with Bushing, bolts and bearing shells	AD-1043	14.40	AD-1043	14.40						
Piston(s) with rings, rod, collar & nut or stub shaft	C-0778	23.70	C-6081	18.90						
	C-0564									
Crosshead with bushings	D-3284	8.10	D-3284	8.10						
Crosshead nut with setscrews	B-0015	0.70	A-0052	4.50						
Total Recip Weight Max: 103.20	46.90		45.90							
Imbalance Max: 1.00	1.00									



Ariel Lubrication Sheet

Company: Ariel Corporation
 Order #: 56400 (AP021437)
 Case 2:

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions



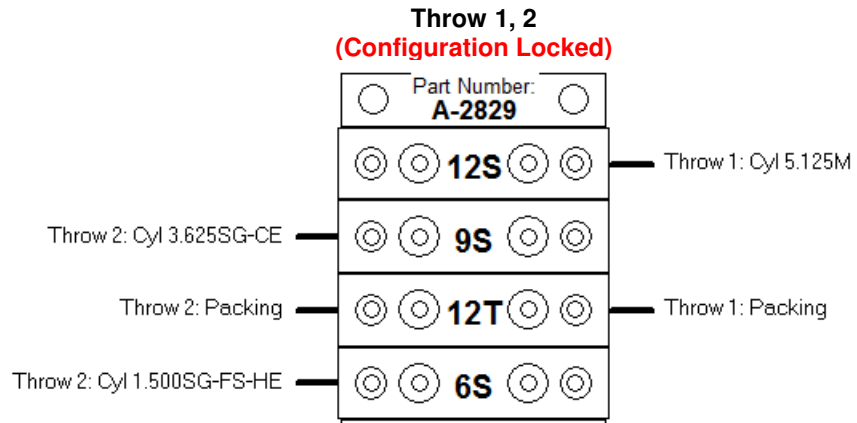
Frame: JGA/2 **Stroke, in:** 3.00 **Rod Dia, in:** 1.125 **Frame S/N:** F35740
Gas Stream: Natural Gas (Water Saturated and/or Heavy hydrocarbons)

Throw	Cylinder Model	MAWP psig	Service	Stage #	Suct Press psig	Disch Press psig	Serial No.
1	5.125M	500.0	Service 1	1	20.00	124.11	C123344
2	3.625SG-CE	2550.0	Service 1	2	120.18	481.48	C123345
	1.500SG-FS-HE	6100.0	Service 1	3	471.48	2020.13	C123346

Applied Speed, RPM **1800**
 Cycle Time at Applied Speed, sec **40.0** (see chart, lower right)
 Break-In Cycle Time, sec **23.0** (For period of 200 hours)
 Recommended lubricant (mineral oil) for application and pressures *Cylinder Oil (ISO 460-680) w/ Compounding*

Rupture Disc **Blue** 7300.00 psig, 0.125 in hole dia.
 Lubricator Pump Diameter **3/16"** (0.1875 in)
 Qty of Pumps feeding this block **1**
 Recommended base feed rate **0.30** Pints/day/in of bore diameter

High mawp requires thick walled tubing on this pump system per Customer Tech Bulletin#137



Lube Point Description	Base Rate Multiplier	Recommended Pints/day	Delivered Pints/day	Del/Rec
Throw 1: Cylinder 5.125M	1.25	1.92	1.80	93%
Throw 2: Cylinder 3.625SG-CE	1.25	1.36	1.35	99%
Throw 2: Packing	1.25	0.84	0.90	106%
Throw 1: Packing	1.25	0.84	0.90	106%
Throw 2: Cylinder 1.500SG-FS-HE	2.00	0.90	0.90	100%

RPM	Cycle Time, sec		Pints/day	
	Normal	Break-In	Normal	Break-In
1800	40.0	23.0	5.8	10.1
1700	42.4	24.4	5.5	9.5
1600	45.0	25.9	5.2	9.0
1500	48.0	27.6	4.8	8.4
1400	51.4	29.6	4.5	7.9
1300	55.4	31.8	4.2	7.3
1200	60.0	34.5	3.9	6.7
1100	65.5	37.6	3.5	6.2
1000	72.0	41.4	3.2	5.6
900	80.0	46.0	2.9	5.1

****NOTE:** Ariel suggests that delivered/recommended amount for cylinders and packings be within 90 - 125%. These recommendations are general guidelines. If the lubricants or flow rates do not appear to work adequately, flow rates and/or lubricant types may need to be changed. Please contact the lubricant supplier for specific lubricant recommendations. [See Section 6.0 of the Ariel Packager Standards for more information.](#)



Company: Ariel Corporation
 Order #: 56400 (AP021437)
 Case 2:

Ariel Lubrication Sheet

Customer: O'Rourke
 Inquiry:
 Project: CanGas Solutions



7.6.5.0

Special Oil Recommendation

Frame: F35740

Model: JGA/2

This notice is to alert the customer that this unit has a special oil recommendation that may require that the force feed lubricator, which supplies lubricating oil to the compressor cylinders and piston rod packings, have an independent oil supply.

This oil recommendation is based on the gas composition and operating conditions provided. Please refer to the ARIEL CORPORATION Lubrication Sheet(s) for the details of the above frame including the correct cylinder bore sizes and throw positions.

Some synthetic oils are not compatible with the mineral oil normally used during the factory test run. If the compressor is going to use a synthetic oil, please advise Ariel. It may be possible to test run the compressor with a compatible oil if necessary.

The following information should be reviewed regarding Independent Oil Supply in [Section 6.0 Lubrication](#) of the Reciprocating Packager's Standards within Ariel's Application Manual.

Paragraphs:

- 6.5.1.2 Independent Oil Supply
- 6.5.1.3 Independent Force Feed Lubricator Systems
- 6.5.9.1 Lubrication Recommendation Guidelines
- 6.5.9.2 Warranty of Component Failure

Contact Ariel

Contact	Telephone	FAX	E-Mail
Ariel Response Center	888-397-7766	740-397-1060	arc@arielcorp.com
Spare Parts	(toll free USA-Canada) or	740-393-5054	spareparts@arielcorp.com
Order Entry	740-397-3602 (International)	740-397-6450	----
Ariel World Headquarters	740-397-0311	740-397-3856	info@arielcorp.com
Technical Field Service			fieldservice@arielcorp.com



Unit C-587

Operating Manuals



ARIEL Heavy Duty Balanced Opposed Compressors

TECHNICAL MANUAL
For Models:

JG and JGA



ARIEL CORPORATION
35 BLACKJACK ROAD, MOUNT VERNON, OHIO 43050
TELEPHONE: 740-397-0311 FAX: 740-397-3856 (Also see page 7-10)
VISIT OUR WEB SITE: www.arielcorp.com

REV: 11/01

CAUTION

GAS COMPRESSOR UNITS ARE COMPLICATED AND DANGEROUS PIECES OF EQUIPMENT, IF YOU ARE NOT FULLY TRAINED AND FAMILIAR WITH THEIR OPERATION.

BEFORE STARTING THIS UNIT:

FAMILIARIZE YOURSELF WITH THE UNIT.

READ AND STUDY START-UP AND SHUT-DOWN INFORMATION FOR BOTH PACKAGE AND COMPRESSOR CAREFULLY!

A GAS/AIR MIXTURE UNDER PRESSURE CAN EXPLODE! YOU CAN BE SEVERELY INJURED OR KILLED. MAKE SURE THE COMPRESSOR IS SUFFICIENTLY PURGED OF ANY EXPLOSIVE MIXTURE BEFORE LOADING.

AFTER COMPLETING THE ABOVE, BEGIN PROPER STARTING PROCEDURE.



CAUTION

DO NOT ATTEMPT TO START-UP UNIT WITHOUT REFERRING TO THIS MANUAL SECTION 3: START-UP. IT IS ALSO ESSENTIAL TO REFER TO THE PACKAGER'S OPERATING MANUAL.

CAUTION

THIS MANUAL EDITION IS BASED ON THE CURRENT DESIGN AND BUILD PRACTICES FOR ARIEL COMPRESSORS AT THE TIME OF THE COVER PAGE DATE OF ISSUE. IT IS ROUTINELY UPDATED AND MAY BE CHANGED WITHOUT NOTICE. IN THE CASE OF CONFLICT OR OMISSION BETWEEN THIS MANUAL AND THE ASSEMBLY DRAWINGS, PARTS LIST, PHYSICAL EQUIPMENT, ETC., CONTACT ARIEL FOR INFORMATION. IT MAY NOT APPLY TO EQUIPMENT BUILT PRIOR TO THE COVER ISSUE DATE OR TO EQUIPMENT WITH CUSTOMER CHANGES IN CONFIGURATION. CONTACT ARIEL WITH ANY QUESTIONS, ESPECIALLY REGARDING CRITICAL SPECIFICATIONS, REFER TO THE "Ariel Telephone, Fax, E-Mail and Web Site Numbers" ON PAGE 7-10.

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SECTION 1 - DESIGN SPECIFICATIONS & DATA

General

Ariel compressors are designed for ease of operation and maintenance. Experience has shown that an Ariel compressor will normally provide years of satisfactory performance with minimal maintenance.

While Ariel compressors share many similarities, each model has aspects that are unique to the particular type. If you as an operator are familiar with Ariel compressors, it is still important to review this manual to determine the differences. If you are new to Ariel compressors it is critical that you become very familiar with this manual prior to operating the compressor.

This manual is designed to provide information on installation, start up, operation and maintenance of a JG or JGA compressor. If you have any questions please contact your packager. If they are unable to provide resolution, they will refer your concerns to Ariel Corporation. If you prefer, you may always contact Ariel directly.

This manual provides design specifications for standard current production equipment at publication date. Do not exceed information plate ratings for a particular compressor.

The location of the throws and the data shown on the Information Plates is very important when communicating questions concerning an Ariel compressor.

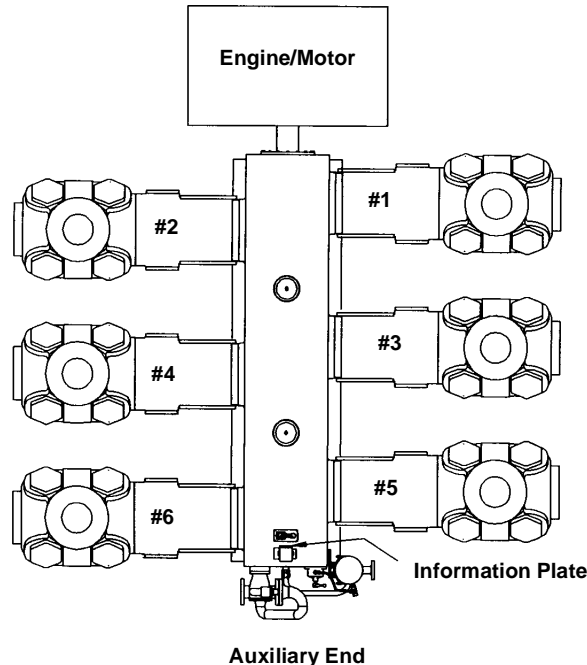


FIGURE 1-1: TYPICAL COMPRESSOR THROW NUMBERING AND INFORMATION PLATE LOCATION

Specifications

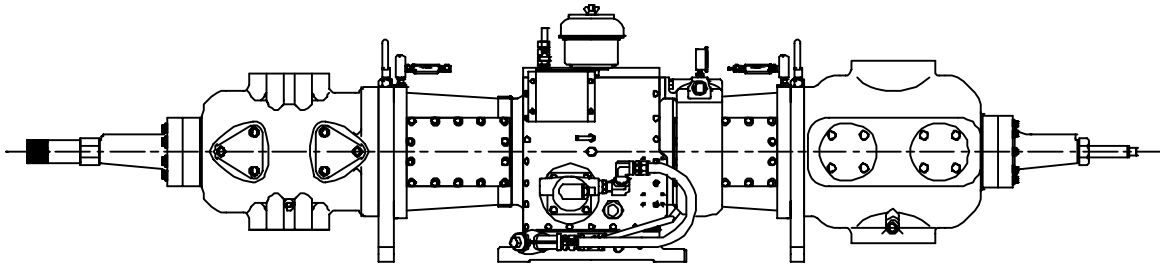


FIGURE 1-2: AUXILIARY END VIEW

Table 1-1: JG/JGA FRAME SPECIFICATIONS^a

MODEL	JG/2	JG/4	JGA/2	JGA/4	JGA/6
Stroke, inches (mm), Nominal	3.5 (89)	3.5 (89)	3 (76)	3 (76)	3 (76)
Speed, RPM	750 To 1500	750 To 1500	900 To 1800	900 To 1800	900 To 1800
Piston Speed, FPM (m/s)	To 875 (4.45)	To 875 (4.45)	To 900 (4.57)	To 900 (4.57)	To 900 (4.57)
Number of Throws	2	4	2	4	6
Horsepower (kW)	To 252 (188)	To 504 (376)	To 280 (209)	To 560 (418)	To 840 (626)
Height - Bottom to Crankshaft \varnothing , in. (mm)	10.25 (260) - Nominal				
Connecting Rod \varnothing To \varnothing , in. (mm)	8.25 (210) - Nominal				
Maximum Width, in. (mm)	80 (2030)	80 (2030)	80 (2030)	80 (2030)	80 (2030)
Maximum Length, in. (mm)	35 (890)	61 (1550)	35 (890)	61 (1550)	89 (2260)
Approximate Weight with Cylinders, lb. (kg)	2200 (1000)	4700 (2100)	2200 (1000)	4700 (2100)	7400 (3400)
Frame Oil Flow Rate @ Max. Rated Speed & 180°F (82°C), GPM (L/s)	2.0 (0.13)	5.0 (0.32)	2.0 (0.13)	5.0 (0.32)	7.5 (0.47)
Oil Heat Rejection, BTU/hr. (kW)	4000 (1.2)	7000 (2.1)	5000 (1.5)	8000 (2.3)	11,000 (3.2)
Oil Sump Volume, US gallons (L)	4 (15)	10 (38)	4 (15)	10 (38)	16 (61)
Piston Rod Diameter, in. (mm)	1.125 (29) - Nominal				
Internal Rod Load - Double Acting:					
Compression + Tension, lbf. (kN)	18,000 (80)	18,000 (80)	20,000 (89)	20,000 (89)	20,000 (89)
Tension, lbf. (kN)	9000 (40)	9000 (40)	10,000 (44)	10,000 (44)	10,000 (44)
Compression, lbf. (kN)	10,000 (44)	10,000 (44)	11,000 (49)	11,000 (49)	11,000 (49)
Internal Rod Load - Single Acting:					
Tension, lbf. (kN)	9000 (40)	9000 (40)	10,000 (44)	10,000 (44)	10,000 (44)

a. For more details see Ariel Databook.

Product Information and Safety Plates

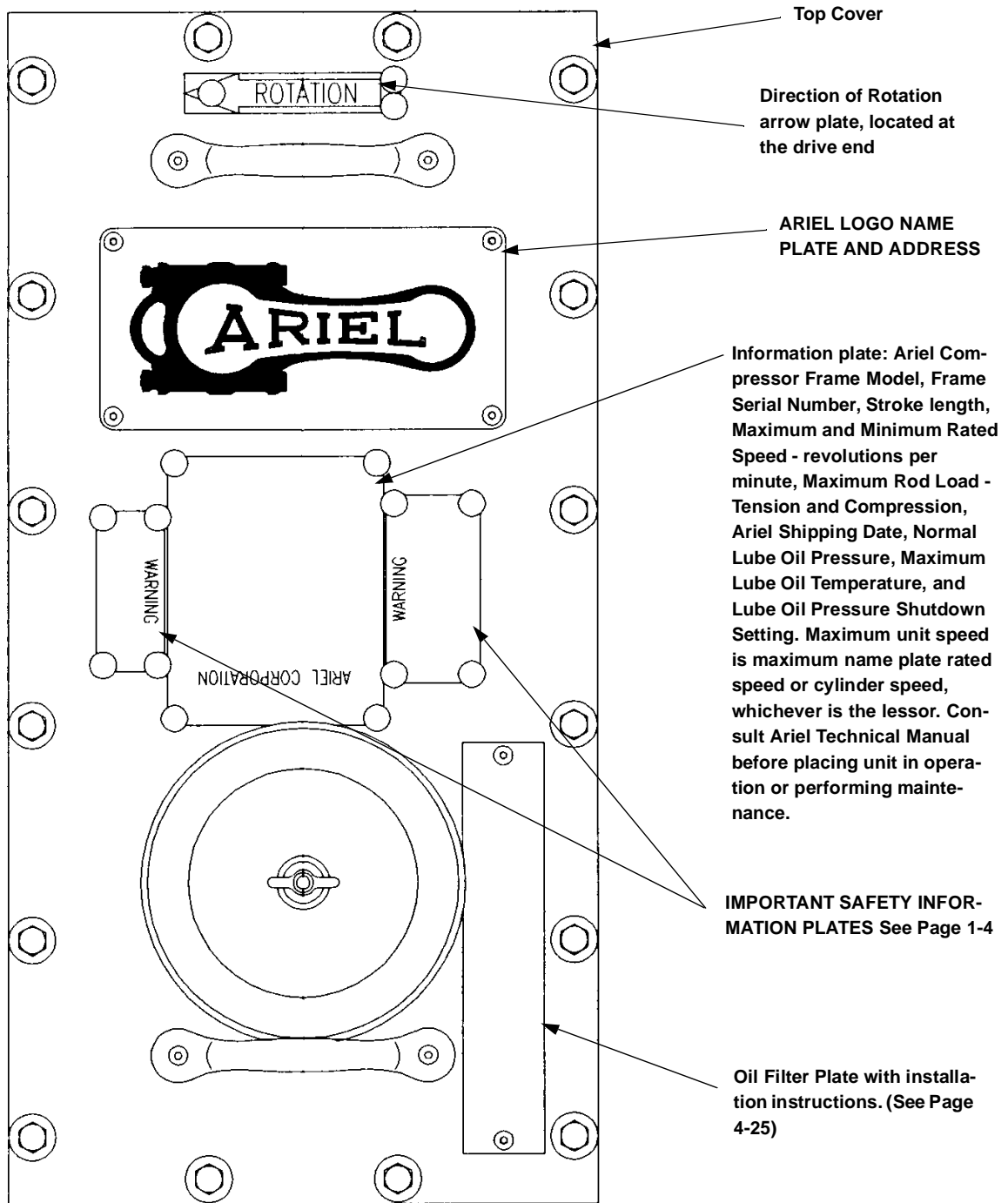


FIGURE 1-3: TOP COVER

Important Safety Information

 **CAUTION**

SEVERE PERSONAL INJURY AND PROPERTY DAMAGE CAN RESULT IF PRESSURE SYSTEM IS NOT COMPLETELY VENTED BEFORE LOOSENING THE BOLTS ON FLANGES, HEADS, VALVE CAPS, OR PACKING. CONSULT ARIEL TECHNICAL MANUAL BEFORE PERFORMING ANY MAINTENANCE.

 **CAUTION**

SEVERE PERSONAL INJURY AND PROPERTY DAMAGE WILL RESULT IF SUCTION AND DISCHARGE VALVES ARE NOT INSTALLED IN THEIR PROPER LOCATION.

 **CAUTION**

NOISE GENERATED BY RECIPROCATING MACHINERY CAN BE A SOURCE FOR HEARING INJURY. SEE PACKAGER'S INFORMATION FOR ANY SPECIFIC RECOMMENDATIONS. WEAR HEARING PROTECTION WHEN UNIT IS RUNNING.

 **CAUTION**

HOT GAS TEMPERATURES ESPECIALLY THE CYLINDER DISCHARGE AREAS, 190°F (88°C) OIL AND HIGH FRICTION AREAS CAN BE A SOURCE FOR BURNS. WEAR PROPER INSULATION WHEN WORKING AROUND THESE AREAS. SHUT DOWN UNIT AND ALLOW TO COOL BEFORE DOING MAINTENANCE IN THESE AREAS.

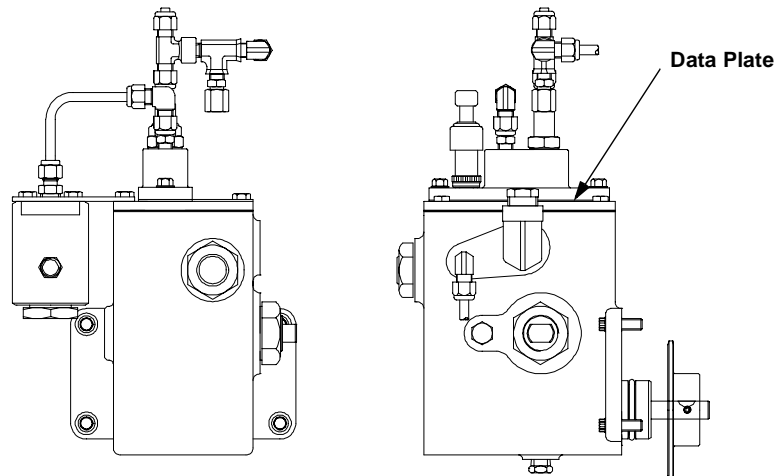


FIGURE 1-4: FORCE FEED LUBRICATOR PUMP - TYPICAL

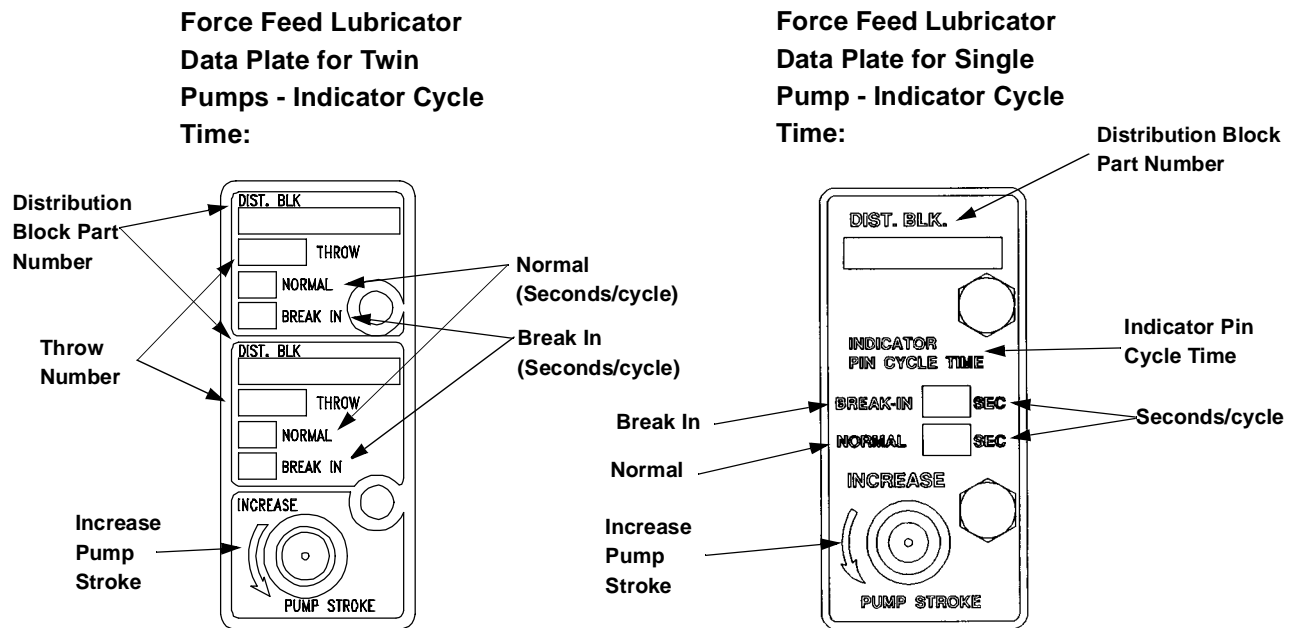


FIGURE 1-5: FORCE FEED LUBRICATOR DATA PLATES

The Force Feed Lubricator provides oil to the piston rod packing and the compressor pistons. The Lubricator Plate gives directions for adjusting the flow of oil. If this plate is missing, please contact Ariel Corporation, Mount Vernon, Ohio for a replacement or directions.

NOTE: THE FORCE FEED LUBRICATOR BOX CONTAINS APPROXIMATELY 1/3 GALLONS (1 L) OF LUBRICANT.

Unloader Identification Plate:
Customer Work Order Number, Hydrotest Pressure and Tester's Personal Stamp are stamped near this plate on top of the Unloader body.

Frame Serial Number:
stamped on machined surface above the Mechanical Inspector's Plate. On drive end throw #2 side.

Cylinder Identification Plate - See Figure 1-7: on page 1-7

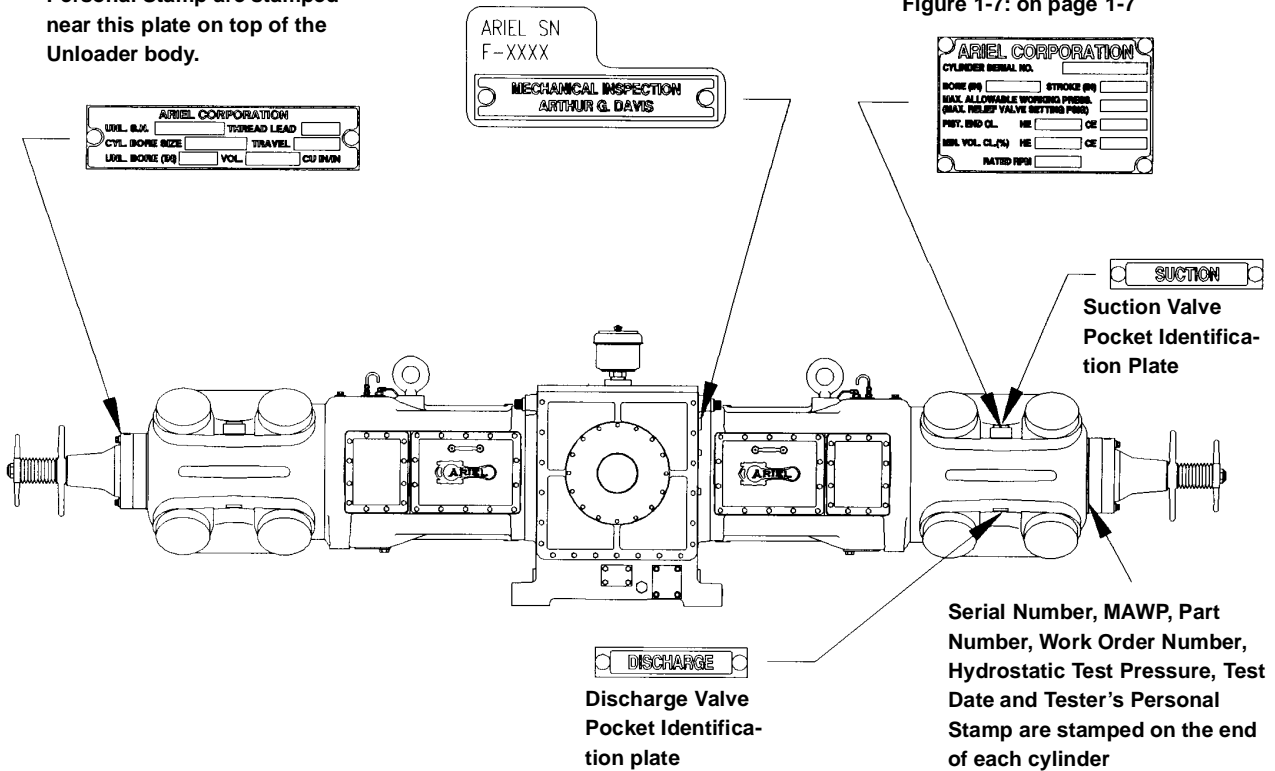
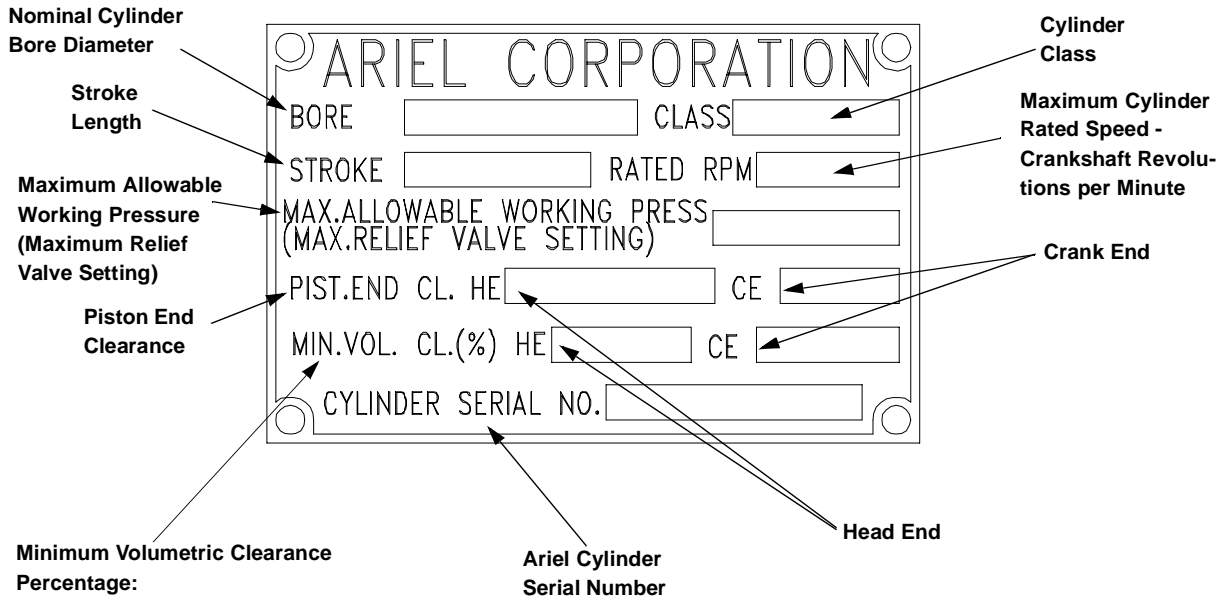


FIGURE 1-6: IDENTIFICATION PLATES - TYPICAL

Cylinder Identification Plates appear on each cylinder. The serial number is also stamped on the end of each cylinder. If any plate is missing, please contact Ariel Corporation, Mount Vernon, Ohio for a replacement or specific directions.

NOTE: USE THE CYLINDER AND FRAME SERIAL NUMBERS IN ALL CORRESPONDENCE.

CYLINDER IDENTIFICATION PLATE:



UNLOADER IDENTIFICATION PLATE:

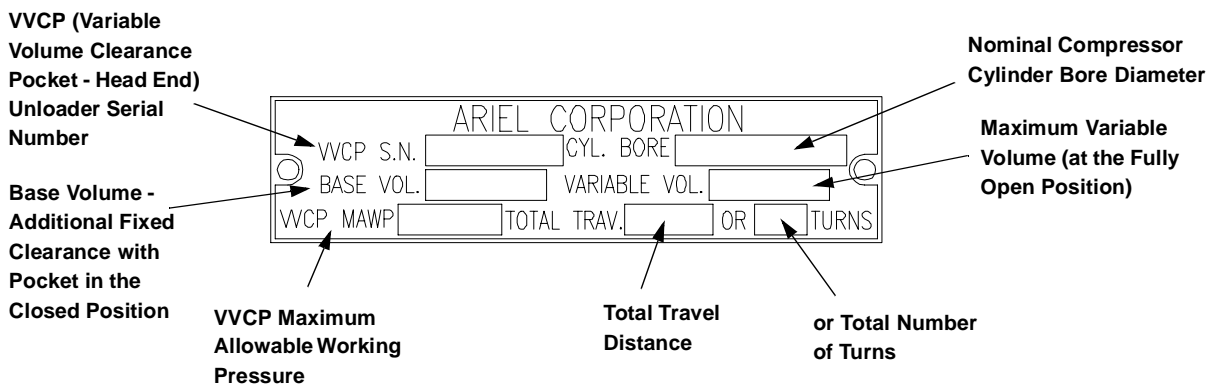


FIGURE 1-7: CYLINDER AND UNLOADER IDENTIFICATION PLATES

Clearances

TABLE 1-2: CLEARANCES

DESCRIPTION	CLEARANCE, IN.	CLEARANCE, (mm)	
Crankshaft Dust Seal (Feeler Gauge - Centered)	0.008 to 0.010	(0.20 to 0.25)	
Crankshaft Thrust (End)	0.0035 to 0.011	(0.089 to 0.28)	
Crankshaft Journal Bearing (Jack)	0.0005 to 0.0035	(0.013 to 0.089)	
Crankshaft Pin to Connecting Rod Bearing (Jack)	0.0015 to 0.0040	(0.038 to 0.102)	
Connecting Rod Thrust (Side)	0.007 to 0.016	(0.18 to 0.41)	
Connecting Rod Bushing to Crosshead Pin	0.0014 to 0.0031	(0.036 to 0.079)	
Crosshead Bushing to Crosshead Pin	0.0014 to 0.0036	(0.036 to 0.091)	
Crosshead (Bronze) to Crosshead Pin	0.0015 to 0.0025	(0.038 to 0.064)	
Crosshead (Babbitted Ductile Iron) to Guide - (Feeler Gauge ^a)	0.004 to 0.008	(0.10 to 0.20)	
Crosshead (Babbitted Bronze) to Guide (Feeler Gauge ^a)	0.006 to 0.010	(0.15 to 0.25)	
Total Piston End Clearance - Double Acting ^b	0.090 to 0.145	(2.29 to 3.68)	
Piston End Clearance - Crank End - Double Acting ^b	0.035	(0.89)	
Piston End Clearance - Head End - Double Acting ^b	0.055 to 0.110	(1.40 to 2.79)	
Total Piston End Clearance - Tandem ^{b,c}	0.090 to 0.180	(2.29 to 4.57)	
Piston End Clearance - Crank End Tandem ^{b,c}	0.035	(0.89)	
Piston End Clearance - Head End Tandem ^{b,c}	0.055 to 0.145	(1.40 to 3.68)	
Maximum Acceptable Piston Rod Run Out Readings ^d	Vertical	0.0010	(0.025)
	Horizontal	0.0005	(0.013)

- a. Crosshead guide to crosshead clearance at the top is to be checked by inserting a standard 0.5 inch (13 mm) wide feeler stock from one side edge of the crosshead across to the opposite side. This is to be done at both ends. The bottom clearance is to be checked with 0.0015 inch (0.038 mm) feeler stock at the 4 corners. If the feeler can be inserted more than 0.5 inches (13 mm), the assembly is not acceptable.
- b. If piston end clearance is not within table tolerance, crank end + head end, contact Packager or Ariel.
- c. For 2-1/4P-CE cylinders, it is not practical to use CE clearance tool to set piston clearance. See "Piston and Rod - Installation" on page 5-20.
- d. See "Piston Rod Run Out" on page 5-21.

NOTE: MEASURED CLEARANCES WILL NOT NECESSARILY AGREE BECAUSE OF OIL FILMS, ASSEMBLY TOLERANCES, WEAR, ETC. PLASTIGAGES, SOLDER, ETC. ARE NOT TO BE USED.

Piston Ring and Packing Ring Side Clearance, Inches (mm)

The standard side clearance in inches (mm) for JG and JGA compressor piston rings and packing rings when new are as follows:

TABLE 1-3: NEW CONVENTIONAL PISTON RING SIDE CLEARANCE, INCHES (mm)

NOMINAL WIDTH	ACTUAL GROOVE WIDTH	NON-METALLIC	BRONZE
3/16 (4.76)	0.187 to 0.189 (4.75 to 4.80)	0.005 to 0.009 (0.13 to 0.23)	0.004 to 0.008 (0.10 to 0.20)
1/4 (6.35)	0.250 to 0.252 (6.35 to 6.40)	0.005 to 0.009 (0.13 to 0.23)	0.004 to 0.008 (0.10 to 0.20)
5/16 (7.94)	0.312 to 0.314 (7.92 to 7.98)	0.006 to 0.010 (0.15 to 0.25)	0.004 to 0.008 (0.10 to 0.20)
3/8 (9.53)	0.375 to 0.377 (9.53 to 9.58)	0.007 to 0.011 (0.18 to 0.28)	0.004 to 0.008 (0.10 to 0.20)
3/4 (19.05)	0.750 to 0.752 (19.05 to 19.10)	0.014 to 0.019 (0.36 to 0.48)	0.006 to 0.010 (0.15 to 0.25)

TABLE 1-4: NEW RIDER RING SIDE CLEARANCE, INCHES (mm)

NOMINAL WIDTH	ACTUAL GROOVE WIDTH
3/16 (4.76)	0.187 to 0.189 (4.75 to 4.80)
1/4 (6.35)	0.250 to 0.252 (6.35 to 6.40)
3/8 (9.53)	0.375 to 0.377 (9.53 to 9.58)
1/2 (12.70)	0.500 to 0.502 (12.70 to 12.75)

TABLE 1-5: PACKING RING SIDE CLEARANCE, INCHES (mm)

ACTUAL GROOVE WIDTH	1 - RING/ GROOVE NON-METAL OR CI	2 - RINGS/ GROOVE NON-METAL OR CI	3 - RINGS/ GROOVE NON-METAL & CI	BRONZE
0.375 to 0.377 (9.53 to 9.58)	0.011 to 0.014 (0.28 to 0.36)	0.011 to 0.015 (0.28 to 0.38)	N/A	0.006 to 0.008 (0.15 to 0.20)
0.447 to 0.449 (11.35 to 11.41)	N/A	N/A	0.013 to 0.018 (0.33 to 0.46)	
0.562 to 0.564 (14.28 to 14.33)	N/A	N/A	0.017 to 0.022 (0.43 to 0.56)	
0.936 to 0.938 (23.77 to 23.82)	N/A	Zero (0) ^a		N/A

a. Side loaded "AL" (5) ring type

TABLE 1-6: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP, INCHES (mm) - LUBRICATED M, P & SP CLASS CYLINDERS

BORE DIAMETER ^A	PISTON TO BORE CLEARANCE	PISTON RING END GAP - NON-METALLIC	
		NEW	MAXIMUM
2.0625 (52)	0.007 to 0.011 (0.18 to 0.28)	0.025 to 0.030 (0.64 to 0.76)	0.120 (3.05)
2.25 (57)	0.007 to 0.011 (0.18 to 0.28)	0.027 to 0.032 (0.69 to 0.81)	0.128 (3.18)
2.5 (64)	0.007 to 0.011 (0.18 to 0.28)	0.030 to 0.036 (0.76 to 0.91)	0.144 (3.66)
2.75 (70)	0.007 to 0.011 (0.18 to 0.28)	0.033 to 0.040 (0.84 to 1.02)	0.160 (3.71)
3 (76)	0.007 to 0.011 (0.18 to 0.28)	0.036 to 0.044 (0.91 to 1.12)	0.176 (4.47)
3.25 (83))	0.009 to 0.013 (0.23 to 0.33)	0.039 to 0.047 (0.99 to 1.19)	0.188 (4.76)
3.5 (89)	0.009 to 0.013 (0.23 to 0.33)	0.042 to 0.052 (1.07 to 1.30)	0.208 (5.28)
3.75 (95)	0.010 to 0.014 (0.25 to 0.36)	0.046 to 0.056 (0.17 to 1.42)	0.224 (5.69)
3.875 (98)	0.010 to 0.014 (0.25 to 0.36)	0.047 to 0.057 (0.19 to 1.45)	0.228 (5.79)
4.125 (105)	0.010 to 0.014 (0.25 to 0.36)	0.049 to 0.060 (1.24 to 1.52)	0.240 (6.10)
4.375 (111)	0.011 to 0.015 (0.28 to 0.38)	0.052 to 0.064 (1.32 to 1.63)	0.255 (6.48)
4.75 (121)	0.012 to 0.017 (0.30 to (0.43)	0.057 to 0.077 (1.45 to 1.96)	0.308 (7.82)
5.125 (130)	0.012 to 0.017 (0.30 to 0.43)	0.061 to 0.081 (1.55 to 2.06)	0.324 (8.23)
5.5 (140)	0.013 to 0.018 (0.33 to 0.46)	0.065 to 0.085 (1.65 to 2.16)	0.340 (8.64)
5.75 (146)	0.013 to 0.018 (0.33 to 0.46)	0.068 to 0.088 (1.73 to 2.24)	0.352 (8.94)
6.125 (156)	0.014 to 0.020 (0.36 to 0.51)	0.073 to 0.093 (1.85 to 2.36)	0.372 (9.45)
6.5 (165)	0.014 to 0.020 (0.36 to 0.51)	0.077 to 0.097 (1.96 to 2.46)	0.388 (9.86)
7.5 (191)	0.016 to 0.022 (0.41 to 0.56)	0.089 to 0.109 (2.26 to 2.77)	0.430 (10.92)
8 (203)	0.016 to 0.022 (0.41 to 0.56)	0.095 to 0.115 (2.41 to 2.87)	0.460 (11.68)

a. Conventional piston rings are standard for all M, P and SP Class Cylinders, except for 1-3/4M-FS Class Cylinder with bore diameters of 1.625" (41mm) and 1.75" (44) where piston/rider rings are standard. Piston/rider rings are optional for all other lubricated M, P and SP Class Cylinders. See Table 1-8.

Table 1-7: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP, INCHES (mm) - NON-LUBE^a M & P CLASS CYLINDERS

BORE DIAMETER	PISTON TO BORE CLEARANCE	PISTON RING END GAP - NON-METALLIC	
		NEW	MAXIMUM
2.75 (70)	0.057 to 0.064 (1.45 to 1.63)	0.033 to 0.045 (0.84 to 1.14)	0.180 (4.57)

a. With Wear Bands.

TABLE 1-8: PISTON TO BORE CLEARANCE AND PISTON/RIDER RING END GAP, INCHES (mm) - LUBRICATED M, P & SP CLASS CYLINDERS.

BORE DIAMETER ^a	PISTON TO BORE CLEARANCE	PISTON/RIDER RING END GAP	
		NEW	MAXIMUM
1.625 (41)	0.090 to 0.096 (2.29 to 2.44)		
1.75 (44)	0.090 to 0.096 (2.29 to 2.44)	0.016 to 0.032 (0.41 to 0.81)	0.128 (3.25)
2.0625 (52)	0.090 to 0.096 (2.29 to 2.44)	0.020 to 0.036 (0.51 to 0.91)	0.144 (3.66)
2.25 (57)	0.090 to 0.096 (2.29 to 2.44)	0.023 to 0.039 (0.58 to 0.99)	0.156 (3.96)
2.5 (64)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
2.75 (70)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3 (76)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.25 (83))	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.5 (89)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.75 (95)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.875 (98)	0.090 to 0.096 (2.29 to 2.44)	0.045 to 0.061 (1.14 to 1.55)	0.244 (6.20)
4.125 (105)	0.090 to 0.096 (2.29 to 2.44)	0.049 to 0.065 (1.24 to 1.65)	0.260 (6.60)
4.375 (111)	0.090 to 0.096 (2.29 to 2.44)	0.052 to 0.068 (1.32 to 1.73)	0.272 (6.91)
4.75 (121)	0.090 to 0.096 (2.29 to 2.44)	0.057 to 0.073 (1.45 to 1.85)	0.292 (7.42)
5.125 (130)	0.090 to 0.096 (2.29 to 2.44)	0.062 to 0.078 (1.57 to 1.98)	0.312 (7.93)
5.5 (140)	0.090 to 0.096 (2.29 to 2.44)	0.068 to 0.084 (1.73 to 2.13)	0.336 (8.53)
5.75 (146)	0.090 to 0.096 (2.29 to 2.44)	0.071 to 0.087 (1.80 to 2.21)	0.348 (8.84)
6.125 (156)	0.090 to 0.096 (2.29 to 2.44)	0.069 to 0.099 (1.75 to 2.51)	0.396 (10.06)
6.5 (165)	0.090 to 0.096 (2.29 to 2.44)	0.074 to 0.104 (1.88 to 2.64)	0.416 (10.57)
7.5 (191)	0.090 to 0.096 (2.29 to 2.44)	b	b
8 (203)	0.090 to 0.096 (2.29 to 2.44)	b	b

a. Conventional piston rings are standard for all M, P and SP Class Cylinders, except for 1-3/4M-FS Class Cylinder with bore diameters of 1.625" (41mm) and 1.75" (44) where piston/rider rings are standard. Piston/rider rings are optional for all other lubricated M, P and SP Class Cylinders.

b. 8M x 3-1/2" (88.9 mm) stroke & 8SP-HE class cylinders, w/ 7.5" (191) bore: end gap, new is 0.099" to 0.129" (2.51 to 3.53), maximum is 0.516" (13.11).

8M x 3" (76.2) stroke, w/ 7.5" (191) bore: new 0.088" to 0.118" (2.24 to 3.00), maximum 0.472" (11.99).

8M x 3-1/2" (88.9) & 8SP-HE, w/ 8" (203) bore: new 0.106" to 0.136" (2.69 to 3.43), maximum 0.544" (14.07).

8M x 3" (76.2) w/ 8" (203) bore: new 0.095" to 0.125" (2.41 to 3.18), maximum 0.500" (12.70).

TABLE 1-9: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP (ANGULAR-CUT & SEAL-JOINT), INCHES (mm) - LUBRICATED JG CLASS CYLINDERS

BORE DIAMETER a	PISTON TO BORE CLEARANCE	PISTON RING END GAP - NON-METALLIC ^b	
		NEW	MAXIMUM
1.25 (32) ^c	0.025 to 0.033 (0.64 to 0.84)	0.018 to 0.028 (0.46 to 0.71)	0.112 (2.85)
1.5 (38) ^b	0.030 to 0.038 (0.76 to 0.97)	0.021 to 0.031 (0.51 to 0.79)	0.124 (3.15)
1.625 (41) ^b	0.030 to 0.038 (0.76 to 0.97)	0.023 to 0.033 (0.58 to 0.84)	0.132 (3.35)
1.75 (44) ^b	0.030 to 0.038 (0.76 to 0.97)	0.025 to 0.035 (0.64 to 0.89)	0.140 (3.55)
2.75 (70)	0.009 to 0.014 (0.23 to 0.36)	0.028 to 0.040 (0.71 to 1.02)	0.160 (4.06)
3 (76)	0.009 to 0.014 (0.23 to 0.36)	0.030 to 0.036 (0.76 to 0.91)	0.144 (3.66)
3.375 (86)	0.010 to 0.015 (0.25 to 0.38)	0.034 to 0.041 (0.88 to 1.04)	0.164 (4.17)
3.625 (92)	0.010 to 0.015 (0.25 to 0.38)	0.036 to 0.044 (0.91 to 1.12)	0.176 (4.47)
3.875 (98)	0.011 to 0.016 (0.28 to 0.41)	0.039 to 0.057 (0.99 to 1.30)	0.228 (5.79)
4.125 (105)	0.011 to 0.016 (0.28 to 0.41)	0.041 to 0.050 (1.04 to 1.27)	0.200 (5.08)
4.75 (121)	0.012 to 0.018 (0.30 to 0.46)	0.057 to 0.077 (1.45 to 1.96)	0.308 (7.82)
5.125 (130)	0.012 to 0.018 (0.30 to 0.46)	0.061 to 0.081 (1.55 to 2.06)	0.324 (8.23)
6.125 (156)	0.013 to 0.019 (0.33 to 0.48)	0.073 to 0.093 (1.85 to 2.36)	0.372 (9.45)
6.5 (165)	0.014 to 0.020 (0.36 to 0.51)	0.077 to 0.097 (1.96 to 2.46)	0.388 (9.86)
7.125 (181)	0.015 to 0.021 (0.38 to 0.53)	0.085 to 0.105 (2.16 to 2.67)	0.409 (10.4)
7.5 (191)	0.015 to 0.021 (0.38 to 0.53) ^d	0.089 to 0.109 (2.26 to 2.77)	0.430 (10.9)
8.5 (216)	0.017 to 0.023 (0.43 to 0.58)	0.102 to 0.122 (2.59 to 3.10)	0.488 (12.4)
8.875 (225)	0.018 to 0.024 (0.46 to 0.61)	0.106 to 0.126 (2.69 to 3.20)	0.504 (12.8)
10.5 (267)	0.022 to 0.027 (0.56 to 0.69)	0.125 to 0.145 (3.18 to 3.68)	0.580 (14.7)
11 (279)	0.022 to 0.028 (0.56 to 0.71)	0.131 to 0.151 (3.33 to 3.84)	0.604 (15.3)

- a. Conventional piston rings are standard for JG Class Cylinders, except 2-1/2JG-FS-HE Class cylinders with bore diameters of 2.25" (57mm) & 2.5" (64); 3JG-CE, 2.75" (70) & 3" (76); 3-5/8JG-CE, 3.375" (86) & 3.625" (92); and 13-12JG, 13" (330) & 13.5" (343), which use piston/rider rings. Piston/rider rings are optional for other lubricated JG Cylinders, except for the 1-3/4JG-FS-HE class, which uses conventional type rings but with seal-joint (see Figure 5-12: on page 5-23) and wear band.
- b. Seal-Joint piston rings are standard for JG Class high-pressure tandem cylinders.
- c. The 1-3/4JG-FS-HE class bore diameter sizes use conventional type seal-ring piston rings and wear band, see Table 1-11 for wear band values.
- d. The the 7.5" (191 mm) bore with a heavy piston, the piston to bore clearance is 0.085 to 0.098" (2.16 to 2.49 mm).

TABLE 1-10: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP, INCHES (mm) - NON-LUBE JG CLASS CYLINDERS

BORE DIAMETER	PISTON TO BORE CLEARANCE	PISTON RING END GAP - NON-METALLIC	
		NEW	MAXIMUM
3.375 (86)	0.075 to 0.083 (1.91 to 2.110)	0.044 to 0.056 (1.12 to 1.42)	0.224 (5.68)
6.125 (156)	0.084 to 0.097 (2.13 to 2.46)	0.073 to 0.093 (1.85 to 2.36)	0.373 (9.44)
7.5 (191)	0.085 to 0.098 (2.16 to 2.49)	0.098 to 0.118 (2.49 to 3.00)	0.472 (12.00)

TABLE 1-11: WEAR BAND END GAP, RADIAL PROJECTION & SIDE CLEARANCE (NEW) - LUBRICATED 1-3/4JG-FS-HE & 7-1/2JG (WITH HEAVY PISTON) CLASS, INCHES (mm)

BORE DIAMETER	END GAP MINIMUM	RADIAL PROJECTION ^a	SIDE CLEARANCE
1.25 (32)	0.039 (0.99)	0.005 to 0.012 (0.13 to 0.30)	0.010 to 0.014 (0.25 to 0.36)
1.5 (38)	0.049 (1.24)	0.0075 to 0.0145 (0.19 to 0.37)	0.010 to 0.014 (0.25 to 0.36)
1.625 (41)	0.052 (1.32)	0.0075 to 0.0135 (0.19 to 0.34)	0.010 to 0.014 (0.25 to 0.36)
1.75 (44)	0.058 (1.47)	0.0075 to 0.0145 (0.19 to 0.37)	0.010 to 0.014 (0.25 to 0.36)
7.5 (191)	0.210 (5.33)	0.028 to 0.039 (0.71 to 0.99)	0.011 to 0.016 (0.28 to 0.41)

a. Replace wear band before piston contacts the cylinder bore.

TABLE 1-12: WEAR BAND END GAP, RADIAL PROJECTION & SIDE CLEARANCE (NEW) - NON-LUBE, INCHES (mm)

BORE DIAMETER	END GAP MINIMUM	RADIAL PROJECTION ^a	SIDE CLEARANCE
2.75 (70))	0.088 (0.224)	0.036 to 0.050 (0.91 to 1.27)	0.010 to 0.014 (0.25 to 0.36)
3.375 (86)	0.085 (2.16)	0.027 to 0.034 (0.69 to 0.86)	0.010 to 0.014 (0.25 to 0.36)
6.125 (156)	0.201 (5.11)	0.028 to 0.039 (0.71 to 0.99)	0.010 to 0.014 (0.25 to 0.36)
7.5 (191)	0.164 (4.17)	0.028 to 0.039 (0.71 to 0.99)	0.011 to 0.016 (0.28 to 0.41)

a. Replace wear band before piston contacts the cylinder bore.

TABLE 1-13: PISTON TO BORE CLEARANCE AND PISTON/RIDER RING END GAP (ANGULAR-CUT), INCHES (mm) - LUBRICATED JG CLASS CYLINDERS

BORE DIAMETER ^a	PISTON TO BORE CLEARANCE	PISTON/RIDER RING END GAP	
		NEW	MAXIMUM
2.25 (57)	0.090 to 0.096 (2.29 to 2.44)	0.023 to 0.039 (0.58 to 0.99)	0.156 (3.96)
2.5 (64)	0.090 to 0.096 (2.29 to 2.44)	0.030 to 0.046 (0.76 to 1.17)	0.184 (4.67)
2.75 (70)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3 (76)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.375 (86)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.625 (92)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.240 (6.10)
3.875 (98)	0.090 to 0.096 (2.29 to 2.44)	0.051 to 0.067 (1.30 to 1.70)	0.268 (6.81)
4.125 (105)	0.090 to 0.096 (2.29 to 2.44)	0.055 to 0.071 (1.40 to 1.80)	0.284 (7.21)
4.75 (121)	0.090 to 0.096 (2.29 to 2.44)	0.057 to 0.073 (1.45 to 1.85)	0.292 (7.42)
5.125 (130)	0.090 to 0.096 (2.29 to 2.44)	0.062 to 0.078 (1.57 to 1.98)	0.312 (7.93)
6.125 (156)	0.090 to 0.096 (2.29 to 2.44)	0.069 to 0.099 (1.75 to 2.51)	0.396 (10.1)
6.5 (165)	0.090 to 0.096 (2.29 to 2.44)	0.074 to 0.104 (1.88 to 2.64)	0.416 (10.6)
7.125 (181)	0.090 to 0.096 (2.29 to 2.44)	0.083 to 0.113 (2.11 to 2.87)	0.452 (11.5)
7.5 (191)	0.090 to 0.096 (2.29 to 2.44)	0.088 to 0.118 (2.24 to 3.00)	0.472 (12.0)
8.5 (216)	0.090 to 0.096 (2.29 to 2.44)	0.114 to 0.144 (2.90 to 3.66)	0.576 (14.6)
8.875 (225)	0.090 to 0.096 (2.29 to 2.44)	0.120 to 0.150 (3.05 to 3.81)	0.600 (15.2)
10.5 (267)	0.090 to 0.096 (2.29 to 2.44)	0.144 to 0.174 (3.66 to 4.42)	0.696 (17.7)
11 (279)	0.090 to 0.096 (2.29 to 2.44)	0.152 to 0.182 (3.86 to 4.62)	0.728 (18.5)
13 (330)	0.090 to 0.096 (2.29 to 2.44)	0.182 to 0.212 (4.62 to 5.38)	0.848 (21.5)
13.5 (343)	0.090 to 0.096 (2.29 to 2.44)	0.190 to 0.220 (4.83 to 5.59)	0.880 (22.4)

a. Conventional piston rings are standard for JG Class Cylinders, except 2-1/2JG-FS-HE Class cylinders with bore diameters of 2.25" (57mm) & 2.5" (64); 3JG-CE, 2.75" (70) & 3" (76); 3-5/8JG-CE, 3.375" (86) & 3.625" (92); and 13-12JG, 13" (330) & 13.5" (343), which use piston/rider rings. Piston/rider rings are optional for other lubricated JG Cylinders, except for the 1-3/4JG-FS-HE class, which uses conventional type seal-joint rings and wear band.

Table 1-14: PISTON TO BORE CLEARANCE AND PISTON/RIDER RING END GAP (SEAL-JOINT^a), INCHES (mm) - LUBRICATED JG CLASS CYLINDERS

BORE DIAMETER	PISTON TO BORE CLEARANCE	PISTON/RIDER RING END GAP	
		NEW	MAXIMUM
2.75 (70)	0.090 to 0.096 (2.29 to 2.44)	0.047 to 0.059 (1.19 to 1.50)	0.177 (4.50)
3 (76)	0.090 to 0.096 (2.29 to 2.44)	0.051 to 0.063 (1.30 to 1.60)	0.189 (4.80)

a. Seal-Joint piston rings are standard for JG Class high-pressure Tandem Cylinders. See Figure 5-12: on page 5-23

Fastener Tightening Torque

Listed in the following tables are fastener tightening torque values required for proper assembly of Ariel JG and JGA compressors. Refer to the section concerning a subject component for detailed assembly procedures.

Threads must be clean and free of burrs.

Torque values are based on the use of petroleum type lubricants on both the threads and seating surfaces. Use lubricating oil or Lubriplate 630, except for compressor rods-piston end, piston nuts and crosshead nuts use Never-Seez (by Bostik, Boston St., Middleton, MA 01949, phone: 508-777-0100). Molybdenum disulfide lubricants and Never-Seez are not otherwise to be used for fastener lubrication, unless specified, or excessive stresses can result with the listed values.

TABLE 1-15: FASTENER TIGHTENING VALUES (for latest available information see ER-63 at www.arielcorp.com)

FASTENER	NOMINAL SIZE, INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Main Bearing Cap - Cap Screw	1/2 - 13	12 Point - Grade 8	58 (79)
Connecting Rod Cap - Cap Screw	1/2 - 20	12 Point - Grade 8	67 (91)
Crosshead Pin Thru Bolt - Lock Nut	3/8 - 24	Hex - Prevailing	25 (34)
Spacer Bar - Cap Screw	5/8 - 18	Hex Grade 9	92 (125)
Crosshead Guide to Frame	1/2 - 13	12 Point	48 (65)
Distance Piece to Crosshead Guide - Cap Screw	12 - 13	12 Point	57 (77)
Distance Piece to Crosshead Guide (11JG) - Cap Screw	3/8 - 16	Socket Head	18 (24)
Crosshead Guide to Cylinder - Cap Screw	1/2 - 13	12 Point	48 (65)
Eccentric Vernier Cap - Cap Screw	5/16 - 18	Hex - Grade 8	Hand Wrench Tight
Idler Sprocket Thru Bolt - Lock Nut	1/2 - 20	Hex - Prevailing	41 (55)
Rod Packing - Cap Screw	1/2 - 13	12 Point - Grade 8	35 (48)
Piston Nut	7/8 - 12	Ariel Design	222 (300)
Crosshead-Balance Nut	1 - 12	Ariel Design	255 (345)

TABLE 1-15: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE, INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Piston Rod Oil Slinger - Lock Nut	1/4 - 28	Jam Nut - Prevailing	96 lb x in. (11)
Rupture Disk - Blow-Out Fitting Cap	1/4 Nom. Tube	Hex - Tube Fitting	36 lb x in. (4.1)
Frame Foot Hold Down	3/4 - 10	Hex Stud-Nut	175 ^a (235)
Crosshead Guide Support Foot Hold Down	5/8 - 11	Hex Stud-Nut	90 ^a (120)
Valve Cap/Cylinder Head/Gas Passage/ Unloader - Cap Screw ^b	3/8 - 16	Hex - Grade 8 or 9 or 12 Point - Grade B7M or 8	193 lb x in. (22)
	7/16 - 14		26 (35)
	1/2 - 13		40 (54)
	5/8 - 11		79 (105)
	3/4 - 10		140 (190)
	7/8 - 9		230 (310)
	7/8 - 14		260 (350)
	1 - 8		345 (465)
Tandem Cylinder to Cylinder - Cap Screw ^b	1/2 - 13	Hex - Grade 8 or 9 or 12 Point - Grade 8	44 (60)
	5/8 - 11		88 (120)
	3/4 - 10		160 (215)
Seating Studs in Cylinder	3/8 - 16	Dog Point	107 lb x in. (12)
	7/16 - 14		172 lb x in. (19)
	1/2 - 13		22 (30)
	9/16 - 12		32 (43)
	5/8 - 11		44 (60)
	3/4 - 10		79 (105)
	7/8 - 9		130 (170)
	1 - 8		190 (260)
Distribution Block Tie Rod - Nut	1/4 - 28	Hex	68 lb x in. (7.7)
Distribution Block Divider Valve - Screw	1/4 - 28	Socket Head	109 lb x in. (12)
Grade 5 - Hex Cap Screw	All	Hex - Grade 5	Hand Wrench Tight

- a. Minimum torque for recommended hold down stud size to provide stress in stud of 55,000 psi (380 MPa). Stud must have an ultimate strength of 100,000 psi (690 MPa) or greater. If greater, increase torque to stress stud to about 55% of ultimate strength of stud material, as specified by packager.
- b. When studs are specified for cylinder applications, tighten stud-nuts to the same values as cap screws in similar applications. Reference Figure 1-8:

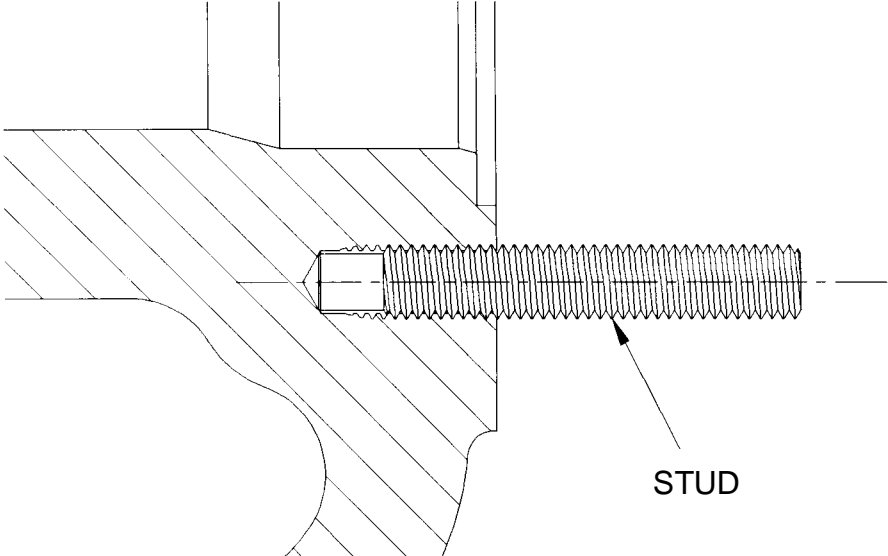


FIGURE 1-8: DOG POINT STUDS

TABLE 1-16: HOERBIGER VALVE ASSEMBLY FASTENERS - TIGHTENING VALUES

FASTENER	NOMINAL SIZE INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Center Cap Screw ^{a b}	5/16 - 24	12 Point - Steel Grade 8	26 (35)
	3/8 - 24		45 (61)
	7/16 - 20		62 (83)
	5/16 - 24	12 Point- Steel Grade 5	18 (24)
	3/8 - 24		32 (43)
	7/16 - 20		50 (68)
	5/16 - 24	12 Point - Grade B8M - Stainless Steel	120 lb x in. (13.6)
	3/8 - 24		192 lb x in. (21.7)
	7/16 - 20		24 (33)
Center Stud - Drake Lock Nut	1/4 - 28	Bottom Half	103 lb x in. (11.6)
		Top Half	66 lb x in. (7.5)
	5/16 - 24	Bottom Half	168 lb x in. (18.9)
		Top Half	96 lb x in. (10.8)
	3/8 - 24	Bottom Half	192 lb x in. (21.7)
		Top Half	96 lb x in. (10.8)
	1/2 - 20	Bottom Half	36 (49) ^c
		Top Half	20 (27)
	5/8 - 18	Bottom Half	73 (99)
		Top Half	40 (54)
	3/4 - 16	Bottom Half	130 (176)
		Top Half	70 (95)
Peripheral Cap Screws	10 - 32	Hex Socket Head	25 lb x in. (2.8)
	12 - 28		43 lb x in. (4.9)
	1/4 - 20		110 lb x in. (12.4)
	5/16 - 18		176 lb x in. (19.9)
	3/8 - 16		21 (28)

- a. 12 Point Cap Screw Center Fasteners in Valve Assemblies not marked SPL (Spirallock Threads), must be cleaned with Loctite Safety solvent and locked with one to two drops of Loctite #272. Do not use petroleum thread lubricants.
- b. 12 Point Cap Screws in Valve Assemblies with Spirallock Threads and marked SPL (see Figure 1-9:) are lubricated, both threads and seating surfaces, with a petroleum type lubricant only.
- c. 29 lb x ft (39 N·m) for 1/2 - 20 Bottom Half - Drake Lock Nut with non-metallic Plates in Liftwasher Type Valves.

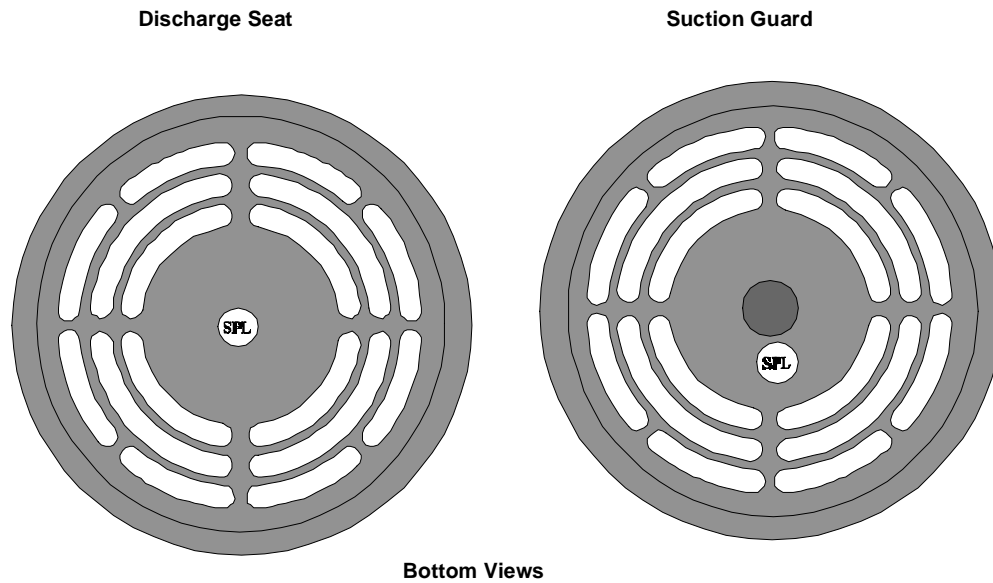


FIGURE 1-9: SPIRALOCK THREADED VALVE ASSEMBLY - MARKED SPL

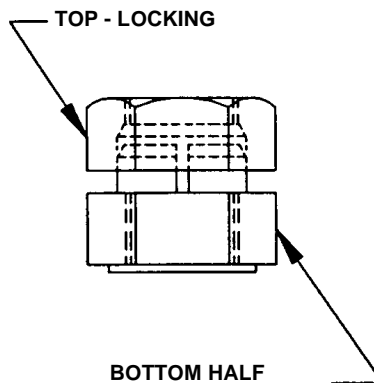


FIGURE 1-10: DRAKE LOCK NUT

Tightening Torque Procedures

Listed below are some procedures which make fastener tightening more accurate and will help ensure that the proper torque is being applied.

1. Ensure that the torque wrench is properly calibrated and used by qualified personnel to achieve the required fastener tightening torque for all critical parts, except for the crosshead balance/lock nut which may be tightened using the “tried and true” slugging procedure.
2. Always check to determine over what range the torque wrench is accurate since most torque wrenches are not accurate over their entire range.

3. Always apply a steady slow force to a torque wrench, do not jerk it. When a torque wrench is jerked the amount of torque applied can be as much as one and a half times the amount set on the wrench. For example, if a wrench is set at 80 lb x ft but is jerked, 120 lb x ft torque can be applied.
4. Always do the final tightening with a torque wrench. Do not tighten the fastener with a ratchet or impact wrench and then "check" the torque with a torque wrench.
5. Do not double tap a torque wrench. Rapidly double tapping a torque wrench will make the torque on the bolt more than what is set by a significant amount. If it is desired to check the setting release all pressure on the wrench and then slowly apply a steady force until the click is felt.
6. Always reset the torque wrench to its lowest setting when the job is complete. If the torque wrench is left in a high setting the spring in it is stressed and will become inaccurate with time. If the torque wrench is put back to its lowest setting the spring will relax and retain its accuracy.
7. Do not use a torque wrench to break fasteners loose as it may overload the torque wrench and/or cause loss of calibration.
8. For applications requiring the use of a boxed end or crowsfoot adapter with a torque wrench to reach not readily accessible fasteners, the torque wrench setting will not be the actual torque applied to the fastener.¹
9. The ratio of actual torque at the fastener with that on the wrench scale is a function of the adapter's length and its position in relation to the torque wrench beam and the location on that at which the force is applied (see Figure 1-11:).

$$T_w = T_a \left(\frac{L}{L + A} \right)$$

T_w = Torque wrench setting, lb x ft

T_a = Torque required at fastener, lb x ft

L = Length of wrench, ft (from square drive end to center point of force on handle)

A = Length of adapter, ft (measured through end of adapter on a line parallel to the center line of the wrench)

These are general guidelines to assist in the proper use of torque wrenches. Consult with your torque wrench dealer for more detailed information.

1. The exception is when the adapter is 90° to the torque wrench. The torque will be the same as on the wrench scale (see Figure 1-12:).

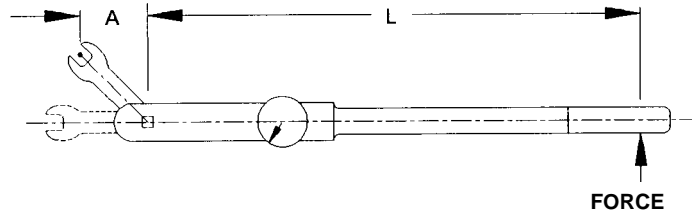


FIGURE 1-11: TORQUE WRENCH WITH ADAPTOR AT ANY ANGLE

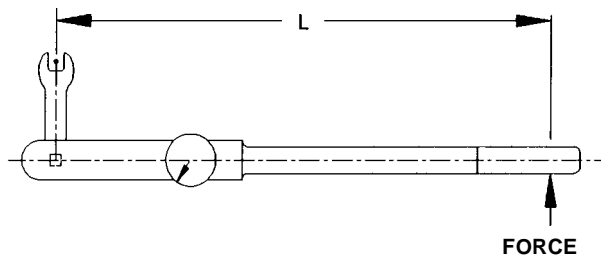
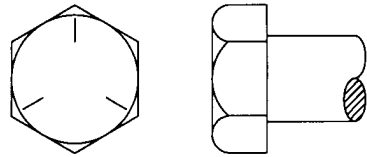


FIGURE 1-12: TORQUE WRENCH WITH ADAPTOR AT RIGHT ANGLE

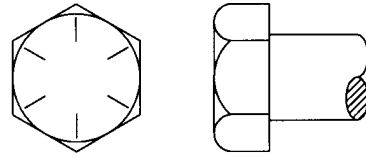
Ariel Bolting

Bolts have been selected that meet Ariel's strength, elongation, sealing and locking requirements. Proper bolting must be used and tightened to the values listed in Table 1-15 on page 1-15. Figure 1-13: is provided to assist in the identification of bolts used in an Ariel compressor.

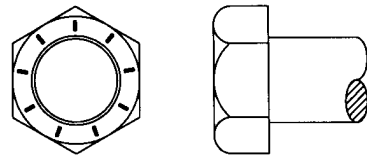
Connecting rod, valve cap and suction/discharge nozzle-Ariel supplied specialized companion flange-bolting is modified to prevent fatigue and cannot be replaced with standard bolts. If attempting to replace other bolting with standard bolts and there is any question, contact your packager or Ariel. Ariel supplied replacement bolting is recommended.



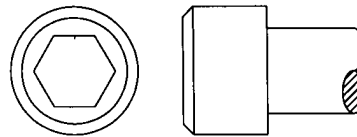
Hex head Grade 5



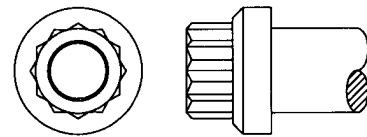
Hex head Grade 8



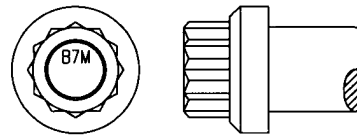
Hex head Grade 9



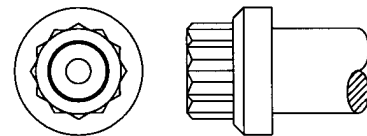
Hex Socket Head Grade 8



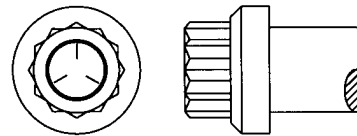
12 Point Grade 8



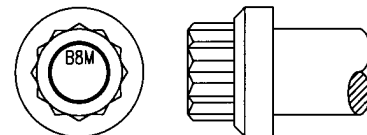
12 Point Grade B7M (NACE)



12 Point Interim Grade 5



12 Point Grade 5



12 Point Stainless Steel Grade B8M

CAUTION: WHEN RE-ASSEMBLING OR REPLACING BOLTING, SEE THE PARTS LIST TO DETERMINE THE PROPER FASTENER GRADE AND PART NUMBER. DO NOT USE A LESSER OR GREATER MATERIAL GRADE. ALL SPECIAL FASTENERS AND ALL BOLTING THAT HAS BEEN MACHINED TO REDUCE THE BODY DIAMETER, FOR FATIGUE RESISTANCE, MUST BE REPLACED WITH ARIEL PARTS.

FIGURE 1-13: BOLT IDENTIFICATION

Optional Main Bearing Temperature Instrumentation - Alarm & Shutdown

Eutectic Temperature Valve

This eutectic alloy device is selected to melt at 228°F (109°C) to vent control pressure and to provide a shutdown signal. Upon melting, the fuse rod must be replaced. To ensure proper operation of the detector, replace the fuse rod every five years.

Electrical Instrumentation Setting

Set within 10% of normal operating temperature, to a maximum of 220°F (104°C) alarm and 230°F (110°C) shutdown.

NOTES

SECTION 2 - INSTALLATION

General

The installation of the compressor with the associated driver and piping must be done with care and precision. This section does not attempt to address all of the concerns that can arise during installation. This section addresses some of the more critical installation considerations and requirements.

Procedure For Setting and Aligning

The following points deserve special attention during the setting and alignment of the compressor:

1. The skid design should:
 - Transmit compressor and driver reaction forces to the foundation.
 - Ensure that there is a proper mismatch between the shaking forces and the natural frequency of the skid.
 - Have sufficient stiffness and strength so that the compressor can be mounted flat with no bending or twisting of the compressor frame, crosshead guides or cylinder. This can be accomplished by careful shimming or grouting.
 - Have enough stiffness and mass to resist vibration induced by the maximum unbalanced couples as specified in the **Ariel Application Data Book**.
2. The feet on the crosshead guides must be supported in a fashion that not only provides vertical support but also prevents horizontal movement perpendicular to the piston rod and capable of carrying the combined weight of the cylinders, bottles and piping.
3. The compressor frame oil piping system and components are to be free of foreign matter including, but not limited to dirt, sand, rust, mill scale, metal chips, weld spatter, grease and paint. It is recommended that a commercial pipe cleaning service be used to clean the oil piping system. If that is not practical, proper cleaning procedures using cleaners, acids, and/or mechanical cleaning are to be used to meet the cleanliness requirements. Cleaning by-products are to be properly disposed; a disposal service is recommended. It is also recommended that all oil-piping systems be flushed using an electric or pneumatic driven pump and filtered clean production oil. All compressor frame cavities are thoroughly cleaned prior to assembly at the Ariel factory. Then each unit is put through a test run with a filtered closed lube loop.
4. Compressor cylinders that have water-cooled packing are to be connected to water cooling unless prior approval is obtained from Ariel Field Service. Refer to "Water Cooled Compressor Rod Packing" on page 3-11.

Setting

1. Move the compressor into place onto the skid. With the compressor cylinders mounted but unsupported and with no piping or pulsation damping bottles attached, tighten the frame hold down bolting to skid at full fastener torque. Then loosen each hold down bolt individually while checking the frame foot to skid deflection with a dial indicator. Shim any foot clearance that is more than 0.002 inches (0.05 mm). Re-torque the hold down bolt and repeat at each frame to skid bolt.
2. With the guides and cylinders unsupported, measure the clearance at a cross-head guide support foot to skid support. completely fill with shim stock. Tighten the crosshead guide support to skid hold down bolting to full fastener torque. Loosen the bolting while checking with a dial indicator to ensure that the clearance is completely filled and there is no deflection. Re-tighten the crosshead hold down bolting. Repeat for each crosshead guide support.
3. Proper compressor to skid hold down bolting torque values are to be determined by the packager based on the bolt size and the bolting material being used. The packager should see Ariel Corporation reference document ER-26 to determine proper hold down bolting torque values

Alignment

Proper alignment is necessary for satisfactory performance. A flexible coupling will not make up for poor alignment. Misalignment can result in:

- High bending moment on the crankshaft
- Large axial forces
- Excessive wear to the bearings
- And if severe, probable damage to various components

An Ariel compressor may be aligned by any of a number of acceptable methods such as:

- Face/peripheral
- Reverse indicator
- Across the disc pack
- Optical
- Laser
- Mechanical direct to computer

When aligning a unit some procedural concerns are:

- Soft foot (compressor and driver are not laying flat)
- Repeatable readings
- Which way indicator moves (plus or minus)
- Thermal growth
- Indicator sag

When properly aligned, the forces on the connected equipment will be at a minimum. This will result in long bearing life and a smooth running unit. Consult Packager's information for alignment requirements.

Vents and Drains¹

It is critical, for the safe operation of the compressor, to ensure that all vents and drains are open, functional and, if necessary, tubed off of the skid or out of the building. Depending upon your climate and insect population it can be necessary to install screens over the vents and drains to ensure that they do not become blocked. This can be essential if the compressor is shutdown for a long period of time.

Some other points are:

1. A vent should be provided to safely relieve pressure from the system.
2. Adequate vents and drains are to be provided for the distance pieces, primary packing vents and crankcase. Primary vents and drains must be independently vented from the secondary vents and drains. All vents and drains must be installed in such a manner as to prevent the collection of liquids that could cause the build up of either gas or liquid. When a heavier than air gas is involved, vent and drain design must be accommodating.

1. Also see Section 4.

NOTES

SECTION 3 - START UP

General

To ensure proper start up, it is important to carefully follow the Start Up Check List provided in this section. It is also important that the operator be thoroughly familiar with this manual and with the Packager's Operating Manual.

CAUTION

BEFORE STARTING A NEW COMPRESSOR, OR AFTER RE-LOCATING OR RE-APPLYING A COMPRESSOR, OR AFTER MAJOR OVERHAUL, BE SURE TO COMPLETE AND CHECK OFF ALL THE ITEMS ON THE START UP CHECK LIST ON PAGES 3-2 THROUGH 3-5. THIS LIST IS DESIGNED TO ENSURE MAXIMUM SAFETY IN STARTING AND OPERATING THE COMPRESSOR

CAUTION

FOR SAFE OPERATION, DO NOT ATTEMPT TO START-UP THE UNIT WITHOUT BEING COMPLETELY KNOWLEGABLE ON THE INFORMATION CONTAINED IN THIS SECTION. IT IS ALSO ESSENTIAL TO REFER TO THE PACKAGER'S OPERATING MANUAL.

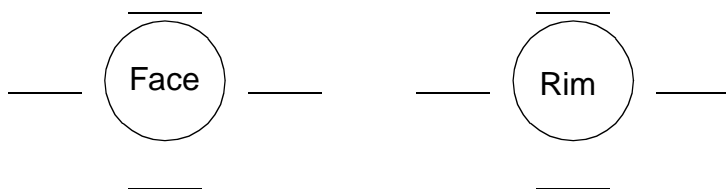
Start-Up Check List (see www.arielcorp.com for latest, ER-10.4.0)

Compressor Model _____ Serial No. F- _____
 Cylinder S/N C- _____ C- _____ C- _____ C- _____ C- _____ C- _____
 Driver _____ Rated Speed _____
 Packager _____ Packager Unit No. _____
 Date Packager Shipped _____ Start Up Date _____
 Serviceman _____ Customer _____
 Location _____ Field Contact _____
 Field Telephone No. _____ Unit Location _____
 Frame Oil - Make/Grade _____
 Cylinder Oil - Make/Grade _____

Check List - Prior To Starting

YES NO

1. Are the correct Ariel parts book, technical manual, special tools, and spares available? _____
2. Have the design limitations for the compressor model such as rod load, maximum and minimum speed, discharge temperature been checked? _____
3. Have the design operating conditions been determined?
 Pressure, PSIG (kPa): Suction _____ Discharge _____
 Temperature, °F (°C): Suction _____ Discharge _____
 Maximum RPM _____ Minimum RPM _____
4. Soft Foot Check: Have the compressor feet and crosshead guide supports been shimmed so the machine is not twisted or bent? _____
5. Have bottom crosshead clearances on all corners been checked? _____
 Maximum 0.0015" (0.038 mm) feeler inserted to 1/2" (12.7 mm) maximum depth
6. Record top crosshead minimum feeler clearance below. Throw #
 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____
7. Have the piping and supports been checked to be sure they do not bend or stress compressor? _____
8. Have coupling bolt torque values been rechecked? _____
9. Has the compressor to driver alignment been checked? _____
 Maximum allowable 0.005 inches (0.13 mm) TIR
10. Record coupling dial indicator readings in inches at the 3, 6, 9 & 12 o'clock positions on lines provided:



11. Has the crankshaft thrust clearance been checked? _____
 Record crankcase thrust clearance here: _____ inches (mm)

Compressor Model _____ Serial No. F- _____

	YES	NO
12. Have piston end clearances been checked with feeler gauges? Record below:	_____	_____
Throw #1 #2 #3 #4 #5 #6		
HE _____		
CE _____		
13. Has the crankcase been filled with oil to the proper level?	_____	_____
14. Has proper oil been installed if extreme ambient conditions exist or special gases are compressed?	_____	_____
15. Is the compressor crankcase oil level control working and set at the proper level?	_____	_____
16. Is the crankcase oil supply isolation valve open?	_____	_____
17. Does the crankcase low level shutdown work?	_____	_____
18. Have the recommended oil filter elements been installed?	_____	_____
19. Are the oil filter element and all lube oil piping primed with oil?	_____	_____
20. Is the low oil pressure shutdown installed and tubed correctly to the downstream side of the oil filter?	_____	_____
21. Does the low oil pressure shutdown work?	_____	_____
22. Oil cooler? Compressor inlet oil temperature is 190°F (88°C) max.	_____	_____
23. Is the crankcase oil temperature shutdown installed, set and working?	_____	_____
24. If oil is cooled, is there a temperature control valve?	_____	_____
25. Is the crankcase breather element clean?	_____	_____
26. Is the force feed lubricator box filled with proper oil?	_____	_____
27. Is the force feed lubrication system primed/purged?	_____	_____
28. Is the force feed lubrication system no flow shutdown installed and working?	_____	_____
29. Is the force feed blow out assembly installed? Check rupture disc for color? Purple is standard = 3250 PSIG (22 400 kPa).	_____	_____
30. Has the lubricator instruction plate or "Parts Book" Cylinder Lubrication Sheet been checked for proper lube feed rate?	_____	_____
31. Is there a working vibration shutdown mounted on compressor?	_____	_____
32. Are the primary and secondary packing vents and the distance piece vents open, and when necessary, tubed off of the skid or out of the building?	_____	_____
33. Is there some method of suction pressure control?	_____	_____
34. Are the suction pressure, interstage pressure and discharge pressure shutdowns set and working?	_____	_____
35. Are the safety relief valves installed and working to protect cylinders and piping for each stage of compression?	_____	_____

Compressor Model _____ Serial No. F-_____

- | | YES | NO |
|---|------------|-----------|
| 36. Are the gas discharge temperature shutdowns installed, set and working? | _____ | _____ |
| 37. Have the gas suction lines been blown out to remove water, slag, dirt, etc.? | _____ | _____ |
| 38. Have temporary screens been installed at cylinder suction? | _____ | _____ |
| 39. Was compressor prelubed prior to starting? For electric motor driven units, compressor must have prelube pump. | _____ | _____ |
| 40. For engine driven units, has the machine been rolled with the starter to make sure it is free? The oil pressure should come up noticeably while rolling on the starter. | _____ | _____ |
| 41. For other drivers, has the machine been barred over by hand to ensure it is rolling free? | _____ | _____ |
| 42. Does the driver rotation match the compressor rotation arrow? | _____ | _____ |
| 43. For machines compressing a combustible gas, have the piping and compressor been purged to remove all air? | _____ | _____ |
| 44. Have start-up instructions for other package equipment been followed? | _____ | _____ |
| 45. Has the Packager's representative done the required review of the Packager's Start-Up and Operating Instructions for the unit with the unit operator? | _____ | _____ |
| 46. Has piston rod runout been checked? | _____ | _____ |

Check List - After Starting

- | | YES | NO |
|--|------------|-----------|
| 1. Did the oil pressure come up immediately? | _____ | _____ |
| 2. Are the oil filter and force feed pump pressure gauges working? | _____ | _____ |
| 3. Oil filter diff. pressure <10 psi (69 kPa), unless otherwise specified? | _____ | _____ |
| 4. Any strange noises or shaking in the compressor or piping? | _____ | _____ |
| 5. Is low oil pressure shutdown set at 35 psi (240 kPa)? | _____ | _____ |
| 6. Are the high discharge gas temperature shutdowns set at approx 10% above normal discharge temperature? 375°F (190°C) max. | _____ | _____ |
| 7. Is the distribution block indicator pin moving, and have you set lubricator for proper break-in flow rate? | _____ | _____ |
| 8. Are there any oil leaks? If so, where? | _____ | _____ |
| 9. Are the scrubber dumps and high level shutdowns working? | _____ | _____ |
| 10. Are the scrubbers removing all liquids from the gas?
How often do they dump? (___ minutes) | _____ | _____ |
| 11. Are there sands or oxides in the gas? | _____ | _____ |
| 12. Is the overspeed shutdown set? | _____ | _____ |
| 13. Are rod packings sealing properly? | _____ | _____ |

Compressor Model _____ Serial No. F-_____

- | | YES | NO |
|--|------------|-----------|
| 14. Have all safety functions been tested to ensure shutdown of unit upon malfunction? | _____ | _____ |
| 15. Has Ariel's "Compressor Warranty Notification and Installation List Data" form been completed and mailed or faxed to Ariel? | _____ | _____ |
| 16. Has a copy of this completed "Start-up Checklist" been mailed to Ariel at Ariel Corporation, 35 Blackjack Road, Mount Vernon, OH 43050, USA, Attention: Administrative Assistant - Sales or faxed to Ariel at 740-397-3856, Attention: Administrative Assistant - Sales? | _____ | _____ |

Maximum Allowable Working Pressure

All Ariel Compressor Cylinders have a "Maximum Allowable Working Pressure (MAWP)." The MAWP, the hydrostatic test pressure, and the test date are stamped on the end of every Ariel Cylinder (see Figure 1-6: on page 1-6).



API Specification 11P, Second Edition, November 1989, Paragraph 1.10.4 defines "Maximum Allowable Working Pressure" as follows:

"Maximum allowable working pressure (MAWP) is the maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred), when handling the specified fluid at the maximum specified temperature."

API SPEC 11P, paragraph 2.5.1.1 defines "Maximum Allowable Working Pressure" for Compressor Cylinders as follows:

"The maximum allowable working pressure of the cylinder shall exceed the rated discharge pressure by at least 10 percent or 25 psig¹, whichever is greater."

API SPEC 11P, paragraph 1.10.5 defines the rated discharge pressure as follows:

"Rated discharge pressure is the highest pressure required to meet the conditions specified by the purchaser for the intended service."

1. (172 kPa)

Relief Valve Settings

It is the responsibility of the packager to provide relief valves for every stage of compression in compliance with API SPEC 11P, paragraph 7.20.3, as follows:

"Relief valve setting shall take into consideration all possible types of equipment failure and the protection of the lowest pressure rated component in any continuous system. Relief valves shall be set to operate at not more than the maximum allowable working pressures but not less than the values following:

System Discharge Pressure psig (kPa)	Relief Valve Margin Above System Discharge Pressure
-14.7 to 150 (-101 to 1034)	15 PSI (100 kPa)
151 to 2500 (1035 to 17 237)	10%
2501 to 3500 (17 238 to 24 132)	8%
3501 to 5000 (24 133 to 34 474)	6%

NOTE: For rated discharge pressures above 5000 psig (34 474 kPa), the relief valve setting shall be agreed upon between the purchaser and the vendor."

CAUTION

WHEN A BYPASS IS FURNISHED, A RELIEF VALVE MUST BE INSTALLED IMMEDIATELY DOWNSTREAM OF THE BYPASS VALVE OR ON THE INLET SCRUBBER OF THE DOWNSTREAM CYLINDER. THIS RELIEF VALVE MUST BE SET FOR THE MAXIMUM ALLOWABLE WORKING PRESSURE OF THE CYLINDER WHICH HAS THE LOWEST MAWP OF THOSE IN THE BYPASS CIRCUIT. THIS IS TO PROTECT AGAINST DISCHARGE-CHECK VALVE FAILURE WHEN OPERATING ON BYPASS. (SEE ARIEL PACKAGER'S STANDARDS, SECTION 4.4 "RELIEF VALVES").

Filling Sump & Priming a Main Oil Lube Oil System - Before Starting

Filling The Sump

1. Remove breather and fill compressor sump through top cover.
2. Check sight glass on auxiliary end. Oil level at start-up should be near the top of the glass. **DO NOT OVERFILL SUMP.** The crankshaft will dip into the oil, causing aeration and foaming, and making it difficult to pump and to control the proper level. After the machine is running, it may be necessary to add oil to bring up oil level to one-half the height of the sight glass; but it must never exceed two-thirds height, while running.
3. When the sump is filled to the proper level, replace and snug up the breather cap by hand, to facilitate later removal.

Priming - Main Lube Oil System

NOTE: BE SURE THE OIL SYSTEM FROM THE LUBE OIL PUMP THRU THE COOLER AND OIL FILTER IS FILLED WITH OIL.

JG, and JGA frames should be equipped with a manual lube oil priming pump. It is important to prime the unit until the bearings receive oil. Five strokes of the pump, after the pressure gauge at the oil filter outlet indicates pressure, is sufficient. If the unit is equipped with a motor-driven pre-lube pump, the pump should run at pressure for a minimum of fifteen seconds before starting the unit.

All electric motor driven compressors and all unattended start compressors with any type driver must have a separate motor-driven prelube pump to ensure oil flow prior to start-up. The prelube pump flow rate should be 50% of the flow rate of the compressor frame lube oil pump. A start permissive for these applications is to be used to disable the startup sequence if oil pressure is below 15 psig (1.0 bar_g).

NOTE: IF THE CRANKSHAFT SPEED IS LESS THAN 50% OF MAXIMUM RATED FRAME SPEED (SEE TABLE 1-1 ON PAGE 1-2), THERE WILL NOT BE ENOUGH FLOW THRU THE PUMP TO MAINTAIN PROPER LUBE OIL PRESSURE TO THE FRAME. AN AUXILIARY OR A LARGER LUBE OIL PUMP WILL BE REQUIRED.

Force Feed Lubricator Adjustment

Ensure that the force feed lubricator is set at the break-in rate shown on the force feed lubricator plate (see Figure 1-5: on page 1-5). The break-in and normal lube timing rates that are stamped on the lubricator box information plate are calculated according to the Ariel Lube Specifications to match the gas operation conditions as supplied to Ariel with the compressor order. The lube sheets supplied in the Ariel Parts Book state gas conditions and list the base rate multiplier at each lube point. When gas conditions are not supplied, the rates are

calculated for clean, dry, 0.65 specific gravity, sweet gas at rated speed and discharge pressures.

Priming/Purging the Force Feed System

All trapped air and/or gas must be purged from the force feed lube system so that it will operate properly. Purging should be done prior to initial start-up, after maintenance that involves the force feed system and after prolonged shutdown. Failure to purge can result in alarm, shutdown and or premature failure of parts. A high-pressure hand priming pump is available from Ariel (see "Ariel Optional Tools" on page 7-1).

Purge the force feed lube system as follows:

1. The force feed lube system should be purged with a proper high-pressure hand pump purge gun using clean service injection oil. **DO NOT USE ANY OTHER FLUIDS FOR PURGING!**
2. Fill the hand pump with clean force feed service injection oil used in the system being purged. Holding in the vertical position, operate hand pump to purge air or other fluids from the pump hose without it being connected.
3. Loosen the tubing nuts at the inlet of the master divider valve blocks, active balance valves, cylinders and packing cases (at crosshead guide connections). If there are secondary (slave) divider blocks, loosen the inlet connections.
4. Remove the tubing caps at the top of the tee tube fittings on the discharge side of the force feed pumps. Connect the high-pressure hand pump to the top purge connection at the tee fitting.
5. Holding the purge gun in the vertical position, operate hand pump until bubbles stop flowing at the tubing connection at the inlet of the master divider valve block. Using a hand wrench re-tighten the tubing nut while oil is still flowing. Rotate the nut to its original position, an increase in resistance will be encountered near the original position. Then tighten slightly.
6. Continue to operate the pump. When bubbles stop, re-tighten the tubing nuts at the secondary divider blocks, active balance valves, cylinder, and packing case guide connections. Repeat for each pump system on the compressor. When active balance valves are present, purge gun pressure will exceed balance valve setting during purging.
7. Remove the hand pump and replace the tee fittings cap nuts. Drain the hand pump and purge hose before using with a different lubricant. Clean hand pump if lubricants are not compatible.

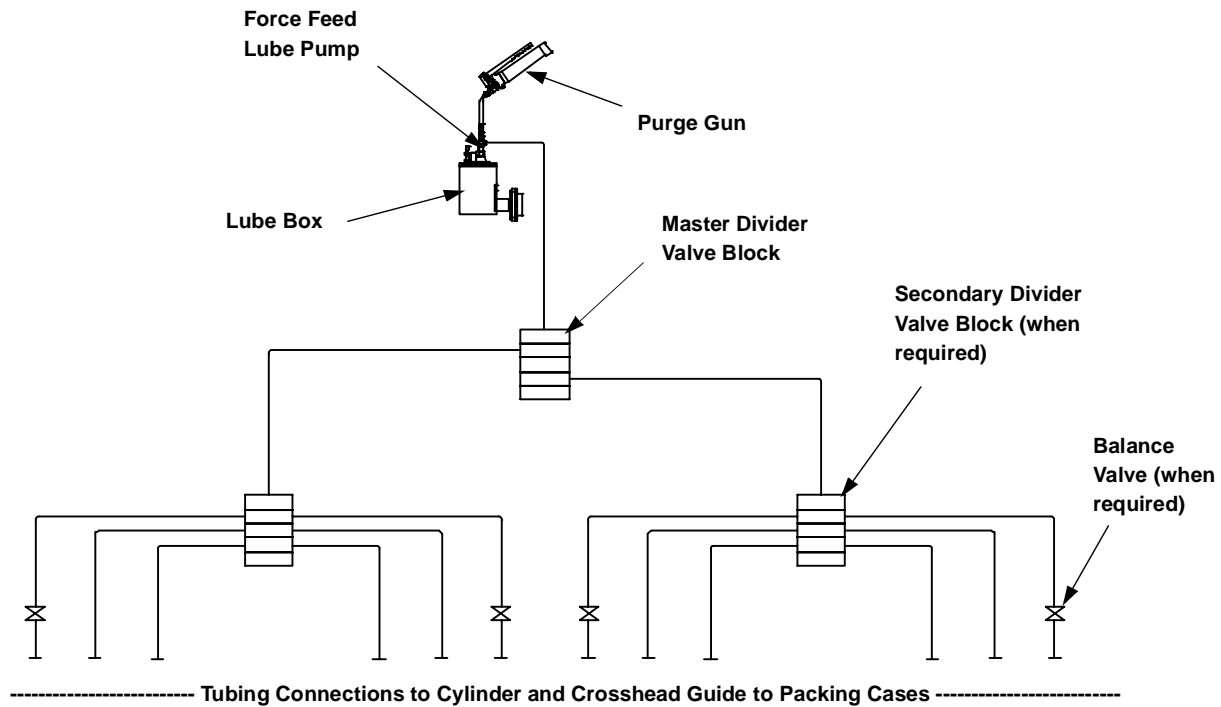


FIGURE 3-1: FORCE FEED PURGING DIAGRAM

Force Feed Setting

An indicator on the distributor block shows the rate at which the block is cycling. Adjust lubricator pump stroke until the indicator strokes at the proper rate. Run at this setting for 200 hours of operation. The lubricator adjustment may then be reduced to the normal operating rate (see Figure 1-5: on page 1-5).

When compressor location or operating conditions change, the lubrication rates should be changed according to the Ariel Lube Specifications shown in Table 4-1 on page 4-8.

When two or more force-feed lubricator pumps are manifolded into one distribution block, the following procedure is recommended to adjust pump rates:

- 1 Start with each pump adjusted to full open.
- 2 Adjust the pumps in equal increments until the break-in cycle time is properly set. The pumps should be stroking at approximately the same rate.
- 3 After break-in, the pumps should be readjusted using the same technique until the prescribed cycle time is set. At this rate, the pumps should be operating with a stroke at least 20% of maximum. Pump stroke below 20% of maximum results in unreliable pump output. If necessary, stop one of the pumps and readjust the remaining pump(s) for desired cycle time.

Water Cooled Compressor Rod Packing

Water cooled packing cases may be applied for higher piston speeds, higher pressure or temperature and/or for certain gas combinations. When water cooled packing is supplied approval from Ariel Field Service is required if water cooling is not connected.

Cooling water quality and treatment is to be maintained to prevent corrosion and mineral or other deposits. Cooling water must be treated with an appropriate antifreeze if subject to freezing.

The coolant flow is to be the number of packing cases x 1 US gallon per minute, minimum for each inch of piston rod diameter (cases x 0.149 L/mm of rod diameter). The cooler should be sized for the number of cases x 20 BTU/minute/inch of rod diameter (cases x 831 J/minute/mm of rod diameter). The coolant into the packing case is not to exceed 130°F maximum (54°C max.). A cooler water temperature is better in high pressure applications. Refer to "Water-Cooled Compressor Rod Packing" on page 5-37.

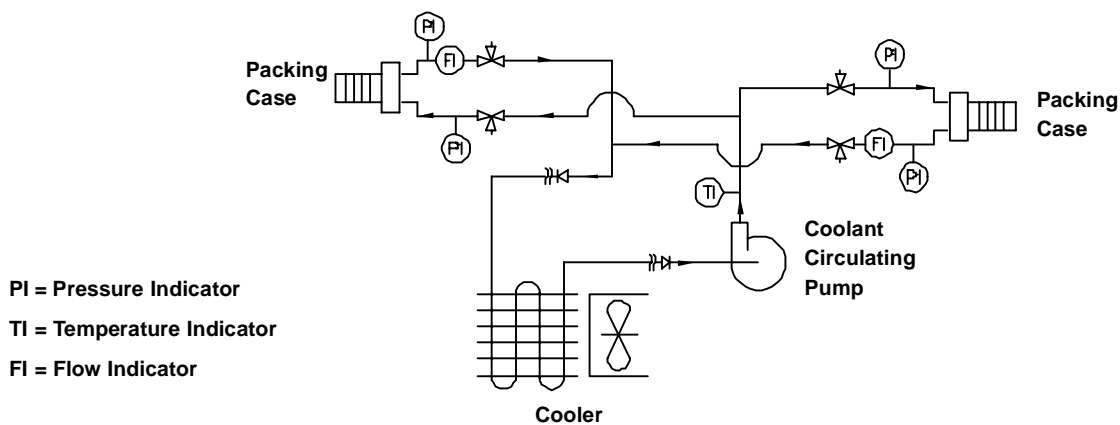


FIGURE 3-2: TYPICAL PACKING COOLING SYSTEM

Oil System Cleanliness

The compressor frame oil piping system and components are to be free of foreign matter including, but not limited to dirt, sand, rust, mill scale, metal chips, weld spatter, grease and paint. If the Ariel supplied piping is disturbed or additional piping is added, it must be cleaned. It is recommended that a commercial pipe cleaning service be used to clean the oil piping system prior to initial start-up or after major re-application. If that is not practical, proper cleaning procedures using cleaners, acids, and/or mechanical cleaning are to be used to meet cleanliness requirements. Cleaning by-products are to be properly disposed, a disposal service is recommended. It is also recommended that all oil piping systems be flushed using an electric or pneumatic driven pump and filtered clean production oil. All compressor frame cavities are thoroughly cleaned prior to assembly and compressors are test run with a filtered closed loop lube system at the Ariel factory.

Compressor Re-Application

NOTE: IF ANY OF THE CONDITIONS LISTED BELOW CHANGE, CONSULT YOUR PACKAGER AND/OR ARIEL FOR ANY HARDWARE AND/OR DOCUMENTATION CHANGES THAT ARE REQUIRED. PERFORMANCE, OPERATING PRESSURES AND LUBE RATE MUST BE RE-CALCULATED.

- 1 GAS PRESSURES, TEMPERATURES OR FLOW REQUIREMENTS
- 2 GAS PROPERTIES
- 3 DRIVER TYPE, SPEED OR TORQUE
- 4 RE-LOCATION OF COMPRESSOR TO A DIFFERENT SITE
- 5 CYLINDER RE-CONFIGURATION
- 6 CHANGE OF CYLINDER AND PACKING LUBRICANT TYPE

SECTION 4 - LUBRICATION AND VENTING

General

Lubrication performs at least six functions in a compressor:

1. Reduce friction - decreasing friction decreases energy requirement and heat buildup.
2. Reduce wear - decreasing wear increases equipment life expectancy and decreases maintenance costs.
3. Cool rubbing surfaces - cooling of rubbing parts maintains working tolerances, extends oil life, and removes heat from the system.
4. Prevent corrosion - minimization of surface corrosion decreases friction, heat, and component wear. Generally provided by additives rather than the base lubricant.
5. Seal and reduce contaminant buildup - improves gas seal on piston rings and packing rings, and flushes away contaminants from moving parts.
6. Dampen shock - shock loads are cushioned, thereby reducing vibration and noise, and increasing component life.

Lubrication is vital for successful operation of a compressor and deserves special attention in the package design.

Oil Cooler

All compressors must have an oil cooler. Maximum allowable oil temperature into the compressor frame is 190°F (88°C). The packager is responsible for sizing a proper oil cooler. Operating conditions which must be taken into account are; the cooling medium, cooling medium temperature, cooling medium flow rate, lube oil temperature, and lube oil flow rate. Oil heat rejection data for each frame are shown in the Ariel Data Book in the Frame Details section (contact your Packager or Ariel when you need this information). The cooler should be mounted as close to the compressor as possible, with piping of adequate size to minimize pressure drop of both the lubricating oil and the cooling medium.

1. For proper operation of the recommended thermostatic valve, provided as an option by Ariel, the maximum differential pressure between the hot oil supply line (point B) and the cooled oil return line (point C) is 10 psi (0.7 bar). Refer to Figure 4-11: Lube Oil System Schematic - Typical.
2. Ariel recommends installation of the thermostatic valve in the mixing mode.

Cold Starting

If a compressor is exposed to cold ambient temperatures, the oil system must be designed so the unit may be safely started with adequate oil flow to the main bearings. Temperature controlled cooler by-pass valves, oil heaters, cooler louvers and even buildings may be needed to ensure successful operation. Cold weather installations may use multi-viscosity oils in the compressor frame if the oil supplier can certify that the oil is shear stable. The viscosity of shear stable oil does not degrade through use. Multi-viscosity oils are subject to a shorter oil life than single grade oils by 30% to 50%.

Compressor Prelube Pump

All electric motor driven compressors and all unattended start compressors with any type of driver must have an electric or pneumatic driven prelube pump to ensure oil flow prior to start-up. A start permissive should disable the start-up sequence if oil pressure is below 10 psig (0.7 bar_g). Motor driven prelube pumps should be sized at 30 psig (2.0 bar_g) and a flow rate equal to half the flow rate of the compressor frame lube oil pump (see Table 1-1 on page 1-2). A compressor prelube cycle is strongly recommended for all compressors to extend bearing life.

Lubricants

Liquid lubricants commonly used in compressors include petroleum based oils and synthetic fluids. Lubricant additives are used to improve the viscosity index, inhibit oxidation, depress the lubricant pour point, inhibit rust formation, improve detergency, provide anti-wear protection, provide extreme pressure protection, improve “lubricity”, decrease effects of gas dilution, increase “wetability”, and resist “washing” of the lubricant due to water, wet or saturated gas, or diluent properties of the gas stream.

- *Viscosity index* is a measure of the ability of an oil to resist the thinning effect caused by increasing the oil temperature.
- *Lubricity* is the “slipperiness” or ability of a lubricant to decrease friction.
- *Wetability* is a measure of the ability of the lubricant to adhere to metal surfaces. An increase in wetability increases the lubricants’ resistance to “washing” effects.

Petroleum Based Oils - also referred to as mineral oils:

Paraffinic - higher wax content, better resistance to thinning at higher operating temperatures than naphthenic.

Naphthenic - (as compared to paraffinic) lower wax content, better flowability at low temperatures for cold start-ups, lower resistance to thinning at higher operating temperatures, better solvency, lower life/oxidation stability. Naphthenic oils leave softer carbon deposits/residues on discharge valves, etc.

Compounded Cylinder Oil Additives

Cylinder oils are specially compounded lubricants designed for use in steam cylinders and/or compressor cylinders. Compounded lubricants can be petroleum or synthetic base. Additives can be animal, vegetable, or synthetic base. These lubricants are formulated to enhance oil film strength to counter the affects of water, wet gases, solvents, etc. present in the gas.

Animal Fats

Generally acidless tallow used as a compounding additive to petroleum lubricants to improve “slipperiness” at higher pressures and resist dilution in wet or saturated gases. They can solidify at low or high temperatures. Oils with these additives should not be used in the compressor frame.

Vegetable Oils

Rapeseed oil is an example. Used as a compounding additive in petroleum lubricants to improve “slipperiness” at higher pressures and resist dilution in wet or saturated gases. These additives are not high temperature oxidation stable and therefore additive life decreases rapidly above 170°F (77°C). Oils with these additives should not be used in the compressor frame.

Synthetic Lubricants

Man-made materials with more consistent, controlled chemical structures than petroleum lubricants. This improves predictability of viscosity and thermal stability. Synthetic lubricants can be designed with better oxidation resistance, better lubricity, better film strength, natural detergency, lower volatility, and results in decreased operating temperatures. These attributes can help to decrease cylinder feed rate requirements. Justification for the use of synthetic lubricants is based on energy savings, reduced lubricant usage, increased component life, decreased equipment downtime, and reduced maintenance/labor. Some synthetic lubricants can be used in the compressor frame. Consult with the lubricant supplier before using these lubricants in the compressor frame.

- Synthesized Hydrocarbons - polyalphaolefins (PAO) can be used as compressor lubricants:
 1. Compatible with mineral oils.
 2. Requires additives to improve detergent action and improve seal compatibility.
 3. Soluble in some gases. Verify application with lubricant supplier.
- Organic Esters - diesters and polyolesters:
 1. Compatible with mineral oils
 2. Incompatible with some rubbers (O-rings), plastics, and paints. Compatible with Viton.
 3. Primarily used in air compressors.
- Polyglycols - polyalkylene glycols (PAG), polyethers, polyglycolethers, and polyalky-

lene glycol ethers:

1. Not compatible with mineral oils, some plastics and paints.
2. Requires complete system flush when changing to or from polyglycols.
3. Compatible with Viton and HNBR - Buna N (high end acrylonitrile-butadiene).
4. Resistant to hydrocarbon gas dilution. Excellent wetability.
5. Can be water soluble - must verify application with lubricant supplier.
6. Poor inherent oxidation stability and corrosion protection - requires additives.
7. Not recommended for air compressors.

Compressor Frame Lubricants

Ariel recommends, for use in the compressor frame, a good quality mineral oil which provides proper lubrication and heat removal, as well as oxidation inhibition, rust and corrosion inhibition, and anti-wear properties.

The minimum viscosity at operating temperature is 60 SUS (10 cSt).

For clean, dry, pipeline quality gas, the oil used in the natural gas fueled engine should be satisfactory. SAE 40 weight (ISO 150 grade) oil is recommended for normal operation.

Low ash or no ash oils are recommended as high ash oils can increase maintenance requirements.

Additives must not be corrosive to lead or copper based bearing materials.

The compressor frame driven lube oil pumps maintain oil pressure with a spring loaded regulating valve within the pump head. Lube system pressure can be raised or lowered by adjusting this valve. Normal pressure on the discharge side of the lube oil filter is factory set for 60 psig (4.1 bar_g). If the lube oil pressure drops below 50 psig (3.4 bar_g), the cause should be found. A low lube oil pressure shutdown, set at 35 psig (2.4 bar_g), is required for protection of the compressor.

The maximum viscosity of the lube oil for cold ambient temperature starting is 15,000 SUS (3300 cSt), typically 40°F (4°C) for SAE 30 weight (ISO 100 grade) oil, or 55°F (13°C) for SAE 40 weight (ISO 150 grade) oil.

The minimum lube oil operating temperature is 150°F (66°C). This is the minimum temperature required to drive off water vapor.

When frame lube oil immersion heaters are used, the watt density of the heater element should not exceed 8 watts per square inch (1.2 W/cm²) for systems without circulating pumps. Oil coking will occur at the element with higher wattage heaters if a circulating pump is not used. When high wattage heaters are required, the heaters must be interlocked with an oil circulation pump to ensure that coking of the oil will not occur. Coked oil will form deposits which can "insulate" the system and decrease heat removal. The deposits can also break loose and act as abrasives in the lubricating system.

JG and JGA compressors are equipped with simplex, spin-on, resin-impregnated type filters as standard. Pressure gauges are provided for monitoring pressure drop across the filter.

Compressor frame lubricating oil should be changed at regular maintenance intervals (6 months or 4,000 hours), when oil filter differential pressure exceeds 10 psi (0.7 bar) or when oil sample results indicate the need. A more frequent oil change interval may be required if operating in an extremely dirty environment or if the oil supplier recommends it.

Oil sampling should be performed on a regular basis to verify suitability of oil for continued service. Degradation to the next lower viscosity grade below the original viscosity or an increase in viscosity to the next higher grade requires a complete oil change. Viscosity testing should be performed at 212°F (100°C).

Cylinder And Packing Lubrication Requirements

Cylinder lubrication requirements will vary with the operating conditions and the composition of the gas to be compressed. Careful consideration must be given to proper cylinder lubrication selection. The degree of cylinder oil lubrication dilution/saturation by the process gas stream is influenced by the following factors:

1. Process gas composition/Specific Gravity (SG) - usually the higher the SG, the greater the oil dilution.
2. Discharge gas pressure - the higher the pressure, the greater the oil dilution.
3. Discharge gas temperature - the higher the cylinder discharge temperature, the less the oil dilution.
4. Lubricant selection - some types of oil are more prone to dilution than others.

Please refer to Table 4-1 on page 4-8 for lubrication recommendations for various gas compositions and various operating conditions. Note that lubrication rates can change with operating conditions. Lubricating oil type will also vary with the composition of the gas which is to be compressed.

Common Oil Supply - When process gas composition and cylinder operating conditions allow compressor frame lubricating oil to be used for cylinder and packing lubrication, the resulting force feed lube systems are installed as shown in Figure 4-8: on page 4-18.

Independent Oil Supply - When process gas composition and cylinder operating conditions require an independent cylinder oil supply, the resulting separate force feed lube systems require an oil supply as shown in Figure 4-9: on page 4-20. Lubricator oil is supplied under pressure from an elevated tank. To ensure that the compressor frame oil is not contaminated, be sure that the force feed lubricator box over flow does not drain into the crankcase. This over flow tubing must be disconnected from the compressor frame and directed to an appropriate drain system.

Independent force feed lube systems require oil with a viscosity below 5000 SUS (1100 cSt) at the lubricator pump inlet. Measures which may be necessary to make sure that the force feed pump is filled with oil during the suction stroke include; appropriate pipe and fitting size from the tank to the force feed pump, heating the oil, and pressurizing the supply tank. An in-line oil filter or fine screen is required between the supply tank and the force feed lubricator pumps. Recommended filtration is 20 micron nominal.

Inadequate (under) lubrication results in a “mini-lube” condition. This condition results in extremely rapid breakdown of Teflon and PEEK piston and packing ring materials. Black,

gummy deposits which can be found in the distance piece, packing case, cylinder and valves are indicators of under lubrication.

Excessive (over) lubrication can result in excessive oil carryover into the gas stream, and increased quantities of deposits in the valves and gas passages. Valve plate breakage and packing failure are also symptoms of over lubrication. The packing case will “hydraulic”, which forces the packing rings to lift off of the rod enough to form a leak path. Increased gas leakage then results in packing and rod overheating. A rod and packing case can turn blue even though the lubrication appears sufficient.

Even when the proper rate and lubricating medium are in use, dirt and foreign matter in the gas will prevent the lubricant from performing properly. Inlet gas debris screens with a maximum 50 micron opening are recommended. Proper maintenance of the inlet screens is required.

To check cylinders for the proper lubrication rates, the cigarette paper test method can provide a practical indication. Relieve and vent all pressure from all cylinders. Remove a head end suction valve and position piston at inner center, for the cylinder to be checked. “Lock out” so that crankshaft can not be accidentally turned; see the “CAUTION” in “General Introduction” on page 5-1 and refer to the Packager’s Operation Manual for details. Use two layers of regular unwaxed commercial cigarette paper, together. Wipe the cylinder bore at top with both papers using light pressure in circumferential motion through about 20°. The paper next to the bore should be stained (wetted with oil), but the second paper should not be soaked through.

Repeat the test at both sides of the bore at about 90° from the top, using two new clean papers for each side. When the paper next to the bore is not stained through, it may be an indication of under lubrication. When both papers are stained through, it may be an indication of over lubrication. In either case, it is normally recommended that the lubrication rate be changed accordingly and that all cigarette paper tests be repeated until passed. Repeat for all cylinders. If a reduction or increase of the lubrication rate is indicated for a cylinder, change in 5% increments by adjusting cycle time at the force feed lube pump as discussed in “Force Feed Lubricator Adjustment” on page 3-8. Repeat oil film testing, for the cylinders affected, after 24 hours of operation.

NOTE: THE CIGARETTE PAPER TEST ONLY GIVES AN INDICATION OF OIL FILM QUANTITY. IT DOES NOT GIVE AN INDICATION OF VISCOSITY QUALITY. OILS DILUTED WITH WATER, HYDROCARBONS OR OTHER CONSTITUENTS MAY PRODUCE WHAT APPEARS TO BE AN ADEQUATE FILM. BUT THE OIL FILM MAY NOT HAVE THE REQUIRED LOAD-CARRYING CAPABILITY DUE TO THE DILUTION.

When observed symptoms indicate lack of lubrication; first verify that the force feed lubricator pumps are operating properly. Confirm that the distribution block cycle time matches the lube sheet or lubrication box information plate provided by Ariel, and double check that all tubing and fittings are tight and no leaks are present. Do not overlook the fittings inside the cylinder gas passages.

The lubricant flow rates (measured in seconds per cycle) are generally so low that all of the required flow to a lube point may be observed as a drip at a fitting. The break-in and normal lube timing rates which are stamped on the lubricator box information plate are calculated according to the Ariel Lube Specifications to match the gas operation conditions as supplied to Ariel with the compressor order. The lube sheets supplied in the Ariel Parts Book state

gas conditions and list the base rate multiplier at each lube point. If gas conditions were not supplied, the rates are for clean, dry, 0.65 specific gravity, sweet gas at rated speed and discharge pressures. If the compressor operating conditions change (such as gas properties, gas pressures, temperatures or flow requirements or cylinder reconfiguration) the lubrication rates must be recalculated and hardware changes may be necessary to the force-feed lubrication system. Consult the following table and your Packager or Ariel.

To set the proper force-feed lubricator pump flow rate, the cycle time indicator on the distribution block is to be observed. To determine cycle time, time the cycle from flash to flash for a digital no-flow timer switch (DNFT); or time the cycle from initial movement of the indicator pin at the fully retracted position, to the time when the pin returns to the fully retracted position and begins to move back out again for a magnetic cycle indicator assembly.

NOTE: WHEN ADJUSTING THE FORCE FEED LUBRICATION PUMP SETTING FOR THE APPROPRIATE CYCLE TIME, DO NOT SET THE FLOW RATE TOO LOW. THE PUMPS CAN BECOME INCONSISTENT WHEN SET TOO LOW.

The force feed lubrication pumps should be capable of delivering 150% minimum of the “normal” required lube rate for the break in period (set as close as possible to twice the “normal” rate for 200 hours). Please contact Ariel for assistance if the existing pump is not capable of the minimum flow rate required.

Used engine oil may be used as long as the new oil specifications meet the listed requirements, and the oil is appropriately filtered (i.e. 20 micron nominal). Oil viscosity must be monitored and tested, as follows, for serviceability.

Oil should be changed at regular maintenance intervals (6 months or 4,000 hours), when oil filter differential pressure exceeds 10 psi (0.7 Bar) for spin-on filters or when oil sample results indicate the need. A more frequent oil change interval may be required if operating in an extremely dirty environment or if the oil supplier recommends it. Oil sampling should be performed on a regular basis to verify suitability of oil for continued service. Degradation to the next lower viscosity grade below the original viscosity or an increase in viscosity to the next higher grade requires a complete oil change. Viscosity testing should be performed at 212°F (100°C).

The use of higher viscosity lubricants or specially compounded lubricants can compensate somewhat for the presence of liquids in the gas stream.

NOTE: WHEN THERE ARE LIQUIDS PRESENT IN THE GAS, THE MOST EFFECTIVE LUBRICATION OF CYLINDERS AND PACKING REQUIRES REMOVAL OF THE LIQUIDS BEFORE THE GAS ENTERS THE COMPRESSOR.

THESE LUBRICATION RECOMMENDATIONS ARE GENERAL GUIDELINES. IF THE RECOMMENDED LUBRICANTS OR FLOW RATES DO NOT APPEAR TO WORK ADEQUATELY, FLOW RATES AND/OR LUBRICANT TYPES MAY NEED TO BE CHANGED. PLEASE CONTACT THE LUBRICANT SUPPLIER FOR SPECIFIC LUBRICANT RECOMMENDATIONS.

WARRANTY OF COMPONENT FAILURES WHICH OCCUR WHILE USING LUBRICANTS WHICH DO NOT MEET THESE SPECIFICATIONS WILL BE SUBJECT TO REVIEW ON A CASE BY CASE BASIS.

TABLE 4-1: CYLINDER/PACKING LUBE OIL RECOMMENDATIONS FOR VARIOUS GAS STREAM COMPONENTS

GAS STREAM	CYLINDER DISCHARGE PRESSURE				
	< 1000 psig < (70 bar _g)	1000 to 2000 psig (70 to 140 bar _g)	2000 to 3500 psig (140 to 240 bar _g) ^a	3500 to 5000 psig (240 to 345 bar _g) ^a	> 5000 psig > (345 bar _g) ^a
Pipeline Quality Natural Gas Including CNG (Dry)	SAE 40 wt. ISO 150 Base Rate or Various Synthetics Base Rate	SAE 40-50 wt. ISO 150 - 220 1.25 x Base Rate or Various Synthetics Base Rate	SAE 50 wt. ISO 220 w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 x Base Rate	Cylinder Oil ISO 320 - 460 w/ Compounding 2 x Base Rate or Synthetic - Diester/Polyglycol 1.5 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 3 x Base Rate or Synthetic - Polyglycol 2 x Base Rate
Natural Gas with Water and/or Heavy hydrocarbons ^b Methane <90% Propane >8% SG >0.7	SAE 40 - 50 wt. ISO 150 - 220 1.25 x Base Rate or Various Synthetics Base Rate	SAE 50 - 60 wt. ISO 220 - 320 or SAE 40 wt. ISO 150 w/ Compounding 1.5 x Base Rate or Var. Synthetics 1.25 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 2 x Base Rate or Various Synthetics 1.5 x Base Rate	Cylinder Oil ISO 680 w/ Compounding 3 x Base Rate or Synthetic - Diester/Polyglycol 2 x Base Rate	Contact Lubricant Supplier
Natural Gas with Water and Carbon Dioxide >2% to 10%	SAE 40 - 50 wt. ISO 150 - 220 1.25 x Base Rate or Various Synthetics Base Rate	SAE 50 - 60 wt. ISO 220 - 320 or SAE 40 wt. ISO 150 w/ Compounding 1.5 x Base Rate or Var. Synthetics 1.25 x Base Rate	Cylinder Oil ISO 460-680 w/ Compounding 2 x Base Rate or Synthetic PAG 1.5 x Base Rate	Cylinder Oil ISO 680 w/ Compounding 3 x Base Rate or Synthetic PAG 2 x Base Rate	Contact Lubricant Supplier
Natural Gas with Water and Carbon Dioxide ≥10%	SAE 40 - 50 wt. ISO 150 - 220 1.50 x Base Rate or Various Synthetics 1.25 Base Rate	SAE 50 - 60 wt. ISO 220 - 320 or SAE 40 weight ISO 150 w/ Compounding 2 x Base Rate or Var. Synthetics 1.5 x Base Rate	Cylinder Oil ISO 460-680 w/ Compounding 3 x Base Rate or Synthetic PAG 2 x Base Rate	Cylinder Oil ISO 680 w/ Compounding 4 x Base Rate or Synthetic PAG 3 x Base Rate	Contact Lubricant Supplier
Natural Gas with Water and H ₂ S >2% to 30%	SAE 40 wt. ISO 150 w/ Compounding 1.25 x Base Rate or Various Synthetics Base Rate	SAE 40 - 50 wt. ISO 150 - 220 w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 x Base Rate	SAE 50 wt. ISO 220 w/ Compounding 2 x Base Rate or Various Synthetics 1.5 x Base Rate	SAE 60 wt. ISO 320 w/ Compounding 3 x Base Rate or Various Synthetics 2 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 4 x Base Rate or Various Synthetics 3 x Base Rate

TABLE 4-1: CYLINDER/PACKING LUBE OIL RECOMMENDATIONS FOR VARIOUS GAS STREAM COMPONENTS

GAS STREAM	CYLINDER DISCHARGE PRESSURE				
	< 1000 psig < (70 bar _g)	1000 to 2000 psig (70 to 140 bar _g)	2000 to 3500 psig (140 to 240 bar _g) ^a	3500 to 5000 psig (240 to 345 bar _g) ^a	> 5000 psig > (345 bar _g) ^a
Natural Gas with Water and H ₂ S ≥30%	SAE 40 wt. ISO 150 w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 Base Rate	SAE 40 - 50 wt. ISO 150 - 220 w/ Compounding 2 x Base Rate or Various Synthetics 1.5 x Base Rate	SAE 50 wt. ISO 220 w/ Compounding 2.5 x Base Rate or Various Synthetics 2 x Base Rate	SAE 60 wt. ISO 320 w/ Compounding 3.5 x Base Rate or Various Synthetics 2.5 x Base Rate	Cylinder Oil ISO 460 - 680 w/ Compounding 5 x Base Rate or Various Synthetics 3 x Base Rate
Air	SAE 40 wt. ISO 150 Air Compressor Oil Base Rate or Various Synthetics Base Rate	SAE 50 wt. ISO 220 Air Compressor Oil w/ Compounding 1.5 x Base Rate or Various Synthetics 1.25 x Base Rate	Synthetic - Diester 1.5 x Base Rate	Contact Lubricant Supplier	Contact Lubricant Supplier
Wet Air (Water Saturated)	SAE 40 - 50 wt. ISO 150 - 220 Air Compressor Oil w/ Compounding Base Rate or Various Synthetics Base Rate	Synthetic - Diester 1.5 x Base Rate	Synthetic - Diester 2 x Base Rate	Contact Lubricant Supplier	Contact Lubricant Supplier
Nitrogen (Bone Dry - Contact Ariel)	SAE 40 wt. ISO 150 Base Rate or Various Synthetics Base Rate	SAE 40 - 50 wt. ISO 150 - 220 Base Rate or Various Synthetics Base Rate	SAE 50 wt. ISO 220 Base Rate or Various Synthetics Base Rate	SAE 60 wt. ISO 320 Base Rate or Various Synthetics Base Rate	Cylinder Oil ISO 460 - 680 Base Rate or Various Synthetics Base Rate
Propane ^c (Refrigerant)	SAE 40 wt. ISO 150 or Refrigerant Oil 0.5 x Base Rate or Various Synthetics 0.5 x Base Rate	SAE 40 wt. ISO 150 or Refrigerant Oil Base Rate or Various Synthetics Base Rate	Refrigerant Oil Contact Lubricant Supplier	Refrigerant Oil Contact Lubricant Supplier	Refrigerant Oil Contact Lubricant Supplier

a. Also requires water cooled packing.

b. Lean burn engine oils contain detergents, dispersants and ash additives, which hold water in suspension. This suspension does not provide adequate lubrication in the cylinder and packings.

c. Verify oil pour point temperature is below inlet gas temperature.

NOTE: BASE RATE REFERRED TO ABOVE IS AS FOLLOWS:

0.3 PINTS/DAY/INCH BORE (0.0056 L/DAY/mm BORE) FOR JG AND JGA FRAMES.

PISTON ROD DIAMETER IS DOUBLED AND TREATED LIKE A CYLINDER FOR CALCULATING PACKING LUBE RATE.

CYLINDERS HAVE ONE POINT BORE LUBE AS STANDARD, EXCEPT FOR 1-3/4JG-HE and 13-1/3JG CLASS CYLINDERS WHICH HAVE MULTI-PORT LUBE AS STANDARD. TOP AND BOTTOM BORE LUBE IS AVAILABLE AS AN ORIGINAL PURCHASE OPTION. PISTON ROD PACKINGS FOR HIGH-PRESSURE CYLINDERS HAVE TWO POINT LUBE. FOR MULTIPLE LUBE POINTS, THE REQUIRED LUBRICANT FOR THE CYLINDER OR PACKING IS DIVIDED EQUALLY AMONG THE LUBE POINTS.

BREAK-IN LUBE RATE SHOULD BE TWICE THE RECOMMENDED DAILY RATE (150% MINIMUM); I.E. THE BREAK-IN CYCLE TIME SHOULD BE APPROXIMATELY ONE-HALF THE NORMAL CYCLE TIME (67% MAXIMUM) TO INCREASE LUBE RATE. BREAK-IN RATE SHOULD BE MAINTAINED FOR 200 HOURS OF OPERATION.

THE RECOMMENDED LUBE RATES FOR BREAK-IN OR NORMAL OPERATION, IN CYCLES PER SECOND (AS STAMPED ON THE LUBRICATOR BOX INFORMATION PLATE), ARE CALCULATED AT MAXIMUM COMPRESSOR SPEED (AS STAMPED ON THE COMPRESSOR INFORMATION PLATE). THE LUBE RATE MAY BE REDUCED WITH SPEED, (AS COMPRESSOR SPEED IS REDUCED, CYCLE TIME INCREASES TO REDUCE LUBE RATE):

$$(RPM_{MAX} \div RPM_{RUNNING}) \times CYCLE\ TIME\ SEC_{LUBE\ PLATE} = CYCLE\ TIME\ SEC_{RUNNING}$$

REFERENCE THE LUBRICATION SHEETS IN THE ARIEL "PARTS BOOK" FOR THE CYCLE TIME (SECONDS) VS. RPM (COMPRESSOR SPEED) TABLE AT VARIOUS RUNNING SPEEDS FOR YOUR UNIT, AT THE STATED GAS OPERATING CONDITIONS AND LUBRICANT.

SPECIAL LUBRICANT FORMULATIONS ARE AVAILABLE FROM LUBRICANT SUPPLIERS FOR SPECIFIC APPLICATIONS. SUPPLIERS WHO WILL CERTIFY SUITABILITY OF THE FORMULATION FOR SITE CONDITIONS SHOULD PROVIDE APPROPRIATE DOCUMENTATION. CONTACT ARIEL FOR VERIFICATION OF WARRANTY COVERAGE.

Force Feed Lubrication System - Description

The force feed lubrication system provides oil to the compressor cylinders and the piston rod packings. Refer to Figure 4-8: on page 4-18.

All cylinders have both top and bottom lubrication injection points available as an original order option, except for the 1-3/4JG-HE and 13-1/2JG class cylinders where “both top and bottom” is provided.

Oil is supplied to the 150 micron sintered bronze filter on the suction side of the force feed lubricator pump directly from the pressure side of the frame lube oil system, or from an over-head tank (see Figure 4-9: on page 4-20). The filter, that prevents large particles from entering the pump, is mounted on the lubricator box using a bracket. The filter inlet is on the side of the filter housing and is provided with a 1/4 inch tube fitting connection.

The lubricator box has its own oil reservoir to lubricate the worm gear and cam. The reservoir is self-contained and is not directly fed by the lube oil system. Lubricator pump overflow spills into the lubricator box reservoir. A drain prevents the reservoir from overflowing. A sight glass on the lubricator will show the oil level in the lubricator reservoir. Refer to Figure 5-10: on page 5-17.

There are 1/4 inch tube fitting connections in the discharge line near the force feed lubricator pump through which the force feed lubricator system may be primed. See “Priming/Purging the Force Feed System” on page 3-9.

Next in the discharge line is a blow-out disc. If there is a blockage in the system, the pressure build-up will fracture the disc. Venting the system through the blow-out disc causes the no-flow shutdown switch to close.

The oil then travels to the distribution block. It is here that the lubricating oil is apportioned to provide the exact amounts to the cylinders and packings. The pistons in the intermediate sections of the distribution block move back and forth in a continuous cycle, forcing lubricant successively through the several outlets as long as lubricant is supplied under pressure at the inlet. Each outlet has a check valve to prevent oil from backing up in the block. An indicator on the block shows the rate at which the block is cycling. A pressure gauge is provided at each distribution block inlet to show system pressure.

From the distribution block, oil travels to the cylinders and packings.

Check valves are located at each injection point where 1 inch minimum (25mm) of head is provided to ensure reliable check valve operation and to lengthen check valve life. At lube points where 1 inch of head is not feasible, an oil trap fitting is installed (refer to Figure 4-7: on page 4-18).

Some of the oil to the packing travels through to the cylinders, but the bulk of it is drained out through the pressure vent/drain fitting on the bottom of the crosshead guide and through the atmospheric drain also in the bottom of the guide.

An oil level control valve, supplied by the packager and mounted on the skid, maintains proper level in the crankcase sump to replace oil used in cylinder lubrication.

Force Feed Pumps

The force feed pumps are attached to and driven by the lube box. Pump features include a one piece steel pump body, modular cast iron cylinder (barrel and plunger) assembly, hardened steel roller rocker arm, weatherproof construction and is suitable with mineral or synthetic lubricants.

If the barrel and plunger fail on a force feed pump, replace the entire pump assembly. Do not repair a pump, except for replacement of external parts, such as spring, spring retainer, snap ring, outlet check valve and seal washer, rubber boot and or pump assembly to lube box.

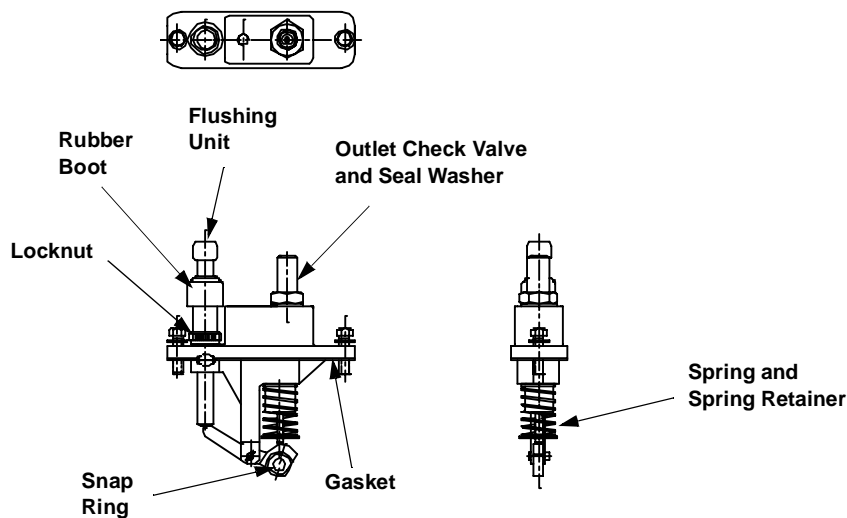


FIGURE 4-1: FORCE FEED PUMP

Force Feed Lubricator Adjustment

See instructions “Force Feed Lubricator Adjustment” on page 3-8 and see Figure 5-10:.

NOTE: THE FORCE FEED SYSTEM MUST HAVE A BLOW-OUT DISC BETWEEN THE FORCE FEED LUBRICATOR PUMP AND THE NO-FLOW SHUTDOWN. THE FORCE FEED SYSTEM MUST HAVE A WORKING NO-FLOW SHUTDOWN SET TO ACTUATE WITHIN THREE TO FIVE MINUTES AFTER INTERRUPTION OF THE LUBRICATOR OIL FLOW.

Blow-Out Fittings and Rupture Disks

TABLE 4-2: BLOW-OUT FITTING ASSEMBLIES AND REPLACEMENT RUPTURE DISKS

SUPPLIER	BLOW-OUT FITTING ASSEMBLY			REPLACEMENT RUPTURE DISK ^a			
				ARIEL P/N	COLOR	THICKNESS	
	ARIEL P/N	RATED PSI	RATED MPa			INCHES	mm
Lincoln	A-0080	3250	22.4	A-0124	Purple	0.0225	0.57
Lubriquip	A-3531	3700	26	A-3536	Yellow	0.010	0.28
Lubriquip	A-3532	4600	32	A-3537	Red	0.012	0.30
Lubriquip	A-3533	5500	38	A-3538	Orange	0.014	0.36
Lubriquip	A-3534	6400	44	A-3539	Aluminum	0.016	0.41
Lubriquip	A-3535	7300	50	A-3540	Blue	0.020	0.51

a. Do not use a Lincoln replacement rupture disk in a Lubriquip blow-out fitting assembly, nor a Lubriquip disk in a Lincoln fitting. See Figure 1-15 on page 1-15 for blow-out fitting cap tightening torque. Do not over tighten cap or blow-out pressure can be reduced.

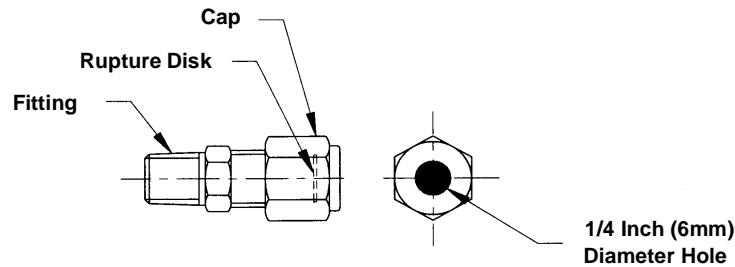


FIGURE 4-2: LINCOLN ST. LOUIS BLOW-OUT FITTING ASSEMBLY (P/N A-0080 ONLY)

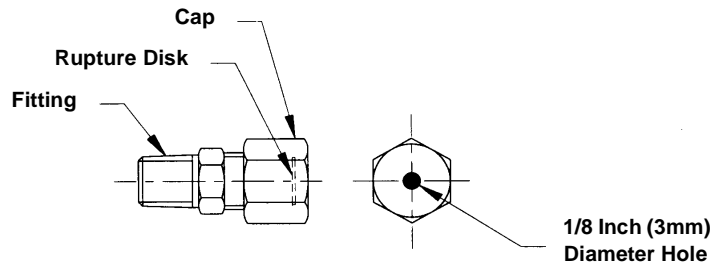


FIGURE 4-3: LUBRIQUIP BLOW-OUT FITTING ASSEMBLY

Divider Valves

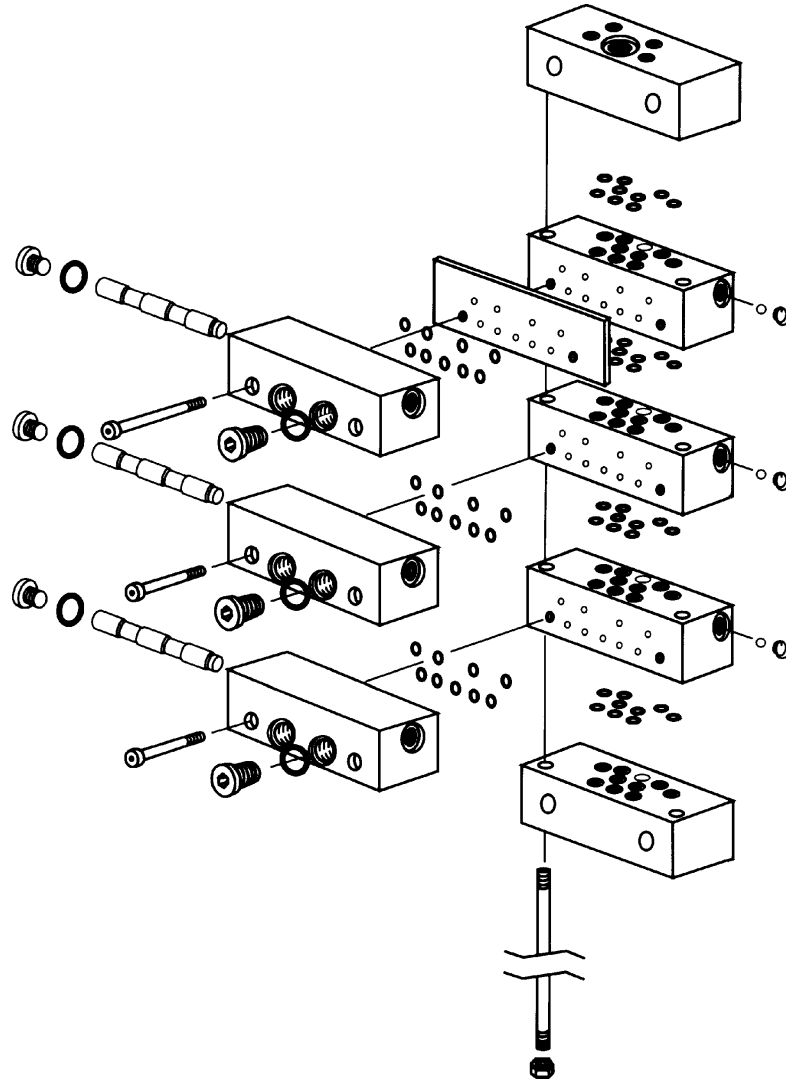


FIGURE 4-4: DIVIDER VALVE; DISTRIBUTION BLOCK - TYPICAL

NOTE: REFER TO THE PARTS BOOK FOR THE FRAME BEING SERVICED FOR ASSEMBLY DRAWINGS, PARTS LIST AND REPAIR KITS THAT ARE AVAILABLE FOR DIVIDER VALVES. DIVIDER VALVES AND THEIR PISTONS ARE MATCHED SETS AND CAN NOT BE INTERCHANGED. IF A DIVIDER VALVE FAILS, REPLACE IT. DO NOT ATTEMPT REPAIR, EXCEPT FOR REPLACING O-RINGS.

Description

Divider valves are comprised of three to eight valve blocks fastened to a segmented baseplate. O-rings are used to seal between the valve blocks and the baseplate and between the baseplate segments. These divider valves are used in a single line, progressive lubrication system and can be used for dispensing oil or grease. Valves and baseplate segments are normally supplied with Buna-N O-rings.

Check valves are installed at the inlets of all lube points.

Valve blocks containing metering pistons discharge a predetermined amount of lubricant with each cycle. Valve blocks can be single or twin and can be externally singled or cross-ported. Outlets not to be used when singling or crossporting must be plugged.

A by-pass block can be used in any position on the baseplate. The use of a by-pass block allows the addition or deletion of lubrication points without disturbing existing tubing. Both outlets under a by-pass block must be plugged.

The valve blocks and by-pass blocks are fastened to a baseplate mounted on the machine to be lubricated. The baseplate contains the divider valve's inlet and outlet connections, interrelated passageways and built-in check valves. All piping of lubricant to and from the divider valve is connected to the baseplate.

The baseplate consists of one inlet block, three to eight intermediate blocks, one end block and three tie rods. Gasket plate seals are included with the baseplate segments. The valve block capacity of each baseplate is dependent upon the number of intermediate blocks in the baseplate. There must be a minimum of three working valves on each valve and baseplate assembly.

Standard Electronic-Lubricator Digital No-Flow Timer Switch - DNFT

The DNFT is a microprocessor-based switch used to sense no-flow or slow-flow conditions in the compressor cylinder lubrication system to facilitate alarm and/or shutdown. The DNFT also contains an amber light-emitting diode (LED) cycle indicator to provide a positive visual indication of system operation. The Ariel DNFT includes a proximity switch. The standard DNFT is factory set for (3) three minutes from no-flow to alarm/shutdown signal and is not adjustable. Optional programmable models are available. Introduced in September of 1996, the DNFT replaced the traditional mechanical no-flow switch and is standard on all new units. Since its introduction, the DNFT has undergone a series of design enhancements and several versions are in service. The current DNFT is shown in Figure 4-5:

The DNFT works thru a magnetic pin which cycles back and forth as the divider valve piston moves, flashing the amber LED and indicating a complete cycle of the divider valve. The DNFT operates on a field-replaceable lithium battery. If battery voltage drops below normal operating levels, the DNFT goes into shutdown mode and compressor can not be re-started until battery is replaced.

Replacing the (field-replaceable) battery in the DNFT:

1. Shut down the compressor

- 2 Disconnect wiring and loosen set screws. Remove DNFT housing to a safe atmosphere.
- 3 Use 3/8 inch ratchet wrench to remove the pipe plug.
- 4 Remove battery from the DNFT and disconnect from the polarized connector.
- 5 Connect the new battery (Ariel part number A-10807 or Radio Shack 960-0418) to the attached polarized plug.
- 6 Reinsert the battery and reinstall pipe plug.
- 7 Replace DNFT control housing on the magnet housing to original position and tighten set screws. Reattach wiring and conduit.
- 8 Verify the DNFT is working by pre-lubing the system and check for LED blink

See the Ariel web site - vendor literature - Whitlock for more details on DNFT's.

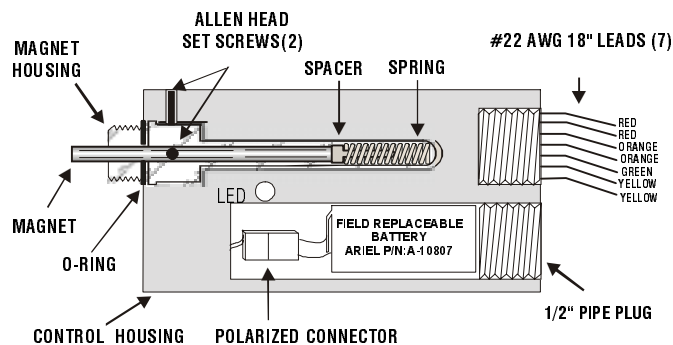


FIGURE 4-5: DIGITAL NO-FLOW TIMER SWITCH - (DNFT)

Assembly Instructions For Divider Valves

NOTE: THE CENTER TIE ROD IN THE BASEPLATE IS OFFSET SO THAT THE INTERMEDIATE BLOCKS CANNOT BE ASSEMBLED BACKWARDS. IF EXCESSIVE FORCE IS ENCOUNTERED DURING ASSEMBLY, MAKE SURE BLOCK IS NOT BACKWARDS.

1. Screw three tie rods into inlet block until ends are flush with surface of block.
2. Slide inlet gasket onto tie rods.
3. Alternately slide an intermediate block and an intermediate gasket plate onto the tie rods until the last intermediate block is in place.
4. Discard remaining intermediate gasket plate.
5. Slide end gasket plate and end block onto tie rods.
6. Lay baseplate assembly on flat surface and tightening nuts to 72 lb-in. (8.1 N·m), torque.
7. Mount divider valves with gasket plates onto baseplate and tightening mounting screws to 108 lb-in. (12.2 N·m), torque.

Operation

The inlet passageway is connected to all piston chambers at all times with only one piston free to move at any one time. With all pistons at the far right, lubricant from the inlet flows against the right end of piston 1. (See Figure 4-6: illustration 1)

Lubricant flow shifts piston 1 from right to left dispensing piston lube through connecting passages to outlet 1. Piston 1 shift directs flow against right side of piston 2. (See Figure 4-6: illustration 2)

Lubricant flow shifts piston 2 from right to left dispensing lube through valve ports of piston 1 and through outlet 2. Piston 2 shift directs lubricant flow against right side of piston 3. (See Figure 4-6: illustration 3)

Lubricant flow shifts piston 3 from right to left dispensing lube through valve ports of piston 2 and through outlet 3. Piston 3 shift directs lubricant through connecting passage to the left side of piston 1. (See Figure 4-6: illustration 4)

Lubricant flow against left side of piston 1 begins the second half-cycle which shifts pistons from left to right dispensing lubricant through outlets 4, 5 and 6 of the divider valve.

If pistons refuse to move, check for air lock in one or more valve ports by manually shifting a piston from right to left.

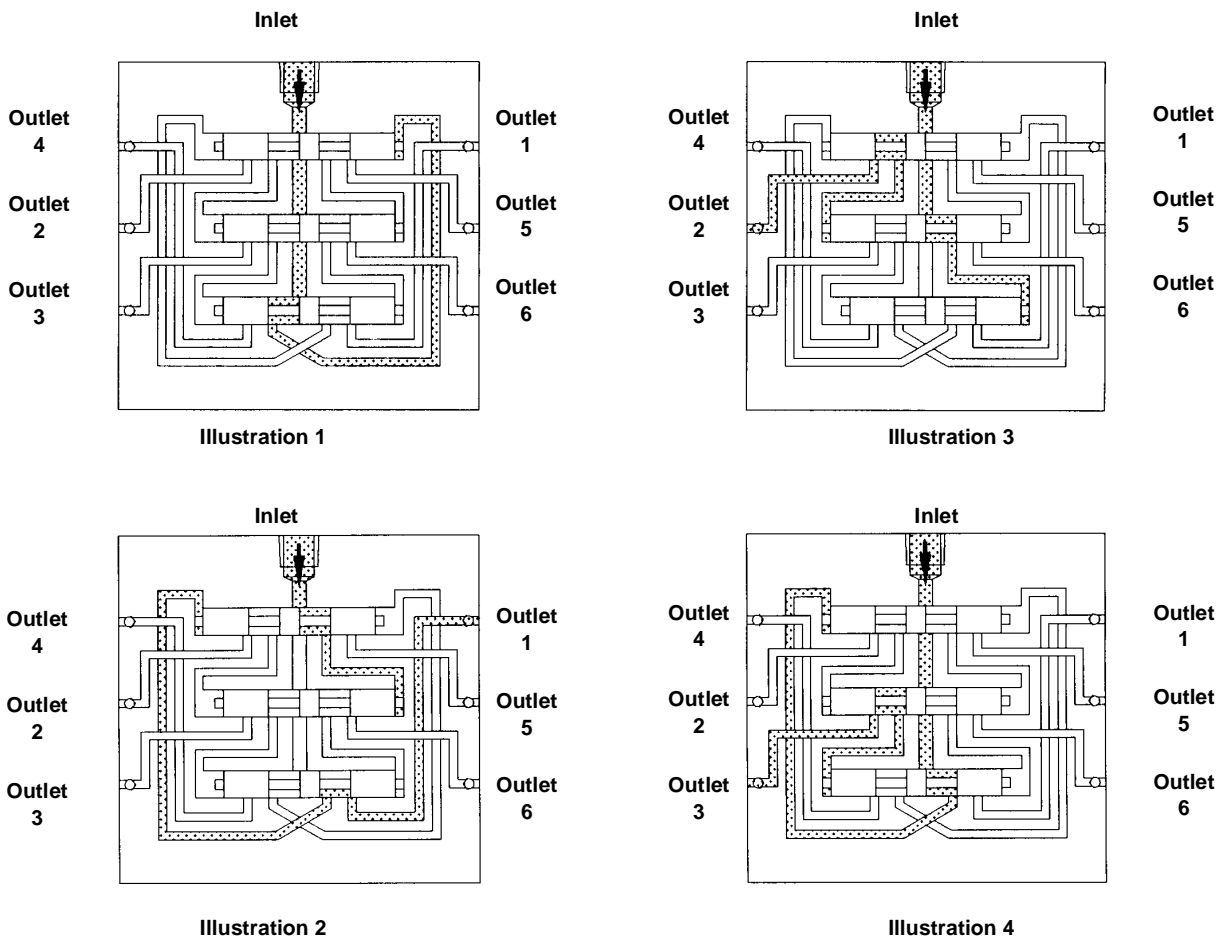


FIGURE 4-6: DIVIDER VALVE OPERATION SCHEMATIC

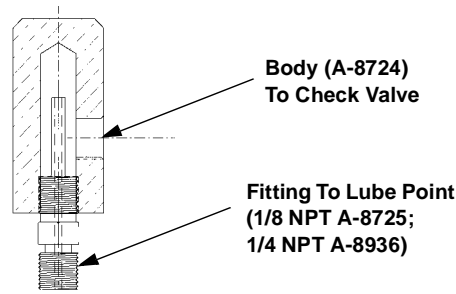


FIGURE 4-7: OIL HEAD TRAP FITTING

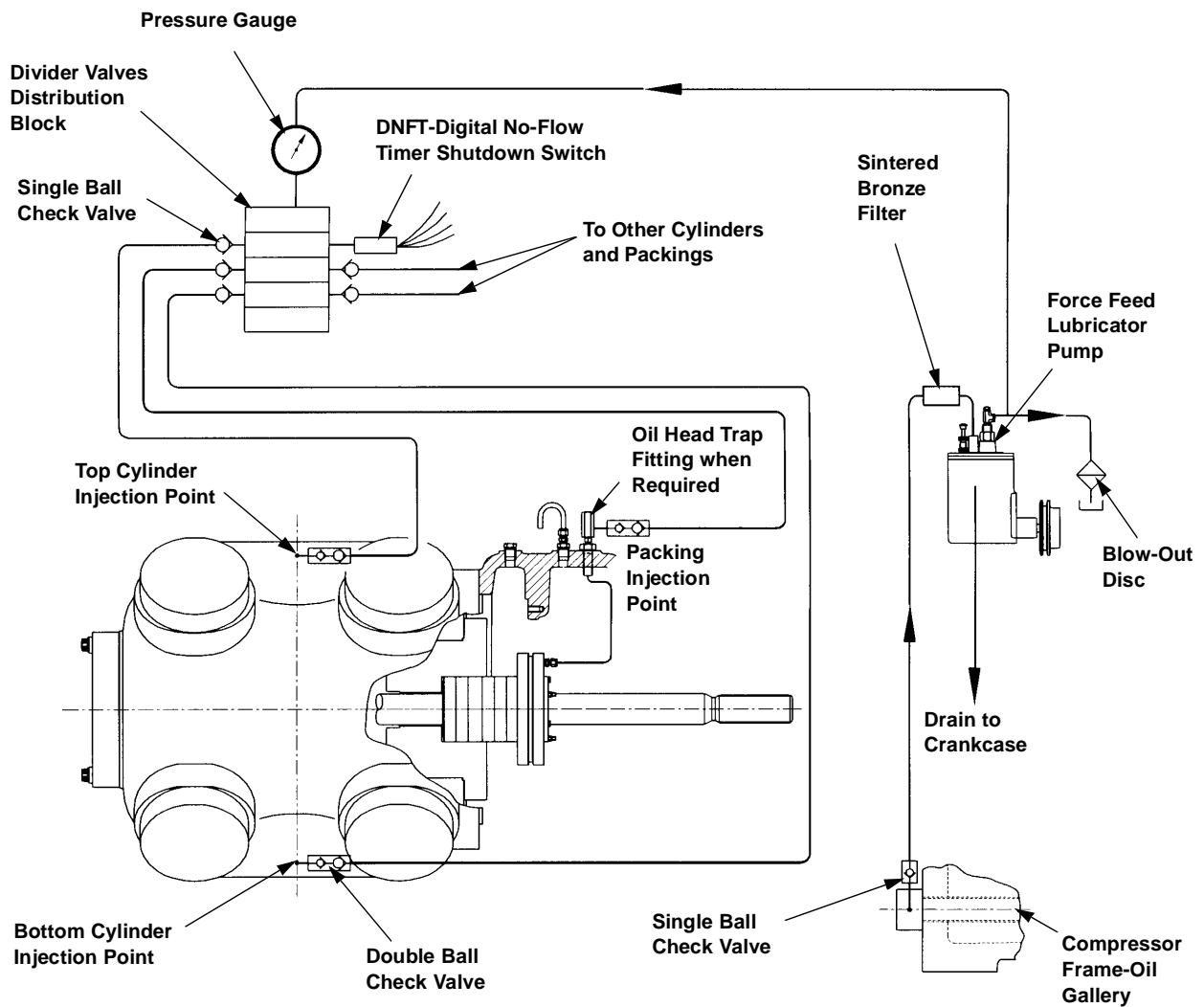


FIGURE 4-8: FORCE FEED LUBRICATION SYSTEM SCHEMATIC - TYPICAL

NOTE: PRESSURE IN FORCE FEED LUBE LINES IS, AS A MINIMUM, 110% OF THE CYLINDER SUCTION GAS PRESSURE.

Force Feed Lubrication System and Running Conditions

Force Feed Lubrication System

1. Check sight glass on lubricator reservoir to make sure it is properly filled with oil. The oil in the reservoir is used to lubricate the worm gear and cam; it does not flow through the system. The reservoir also catches lube pump overflow. Oil is added only if it becomes necessary to raise the reservoir oil level. When replacing lubricator reservoir oil, use new frame oil, except with an independent force feed supply, then use cylinder oil. If a synthetic oil is used, drain and clean reservoir before re-filling.
2. The system has been filled with mineral oil at the factory, and unless the piping has been disturbed, it is ready for operation. If piping has been removed, or if the system has been drained, it can be filled and primed through a 1/8 inch plug on the discharge end of the lubricator pump. Priming the force feed lubrication system requires the use of a priming pump (G-7162); refer to "Ariel Optional Tools" on page 7-1 and "Priming/Purging the Force Feed System" on page 4-9.
3. If the unit has been overhauled, adjust the lubricator for maximum delivery. Refer to Figure 5-10:. Loosen the adjusting screw locknut. Turn the plunger stroke adjustment screw to the full up position. Tighten the adjusting screw locknut. Proper feed rate may be set after the machine is started.

Running Conditions

When the machine is running, make sure that the oil level in the lubricator reservoir is at least one-half way up the sight level, but does not exceed two-thirds.

See your packager's specific data to determine the normal operating conditions, the cylinder working pressures, and the rated speed.

System Design Considerations and Operating Parameters

To optimize force-feed lubrication system operation, Ariel uses the following general guidelines:

1. Minimal use of "master/slave" distribution blocks in favor of lubricator pumps dedicated to an individual distribution block.
2. Maintain lube ratios within prescribed limits and cycle times as low as possible (10 sec minimum) to provide each point with lubrication as frequently as possible.
3. Multiple pumps with manifolding are used to ensure that 150% of the normal lubrication rate can be provided during break-in.
4. Pumps are not allowed to operate below 20% of full stroke, the point at which they become unreliable.
5. In some applications, to optimize operation of the lubrication system, a single twin divider output is used to deliver lubrication to both a packing and a cylinder.
6. In some applications, cross-porting of divider valves is used to deliver the proper

proportion of lubricant to a given point.

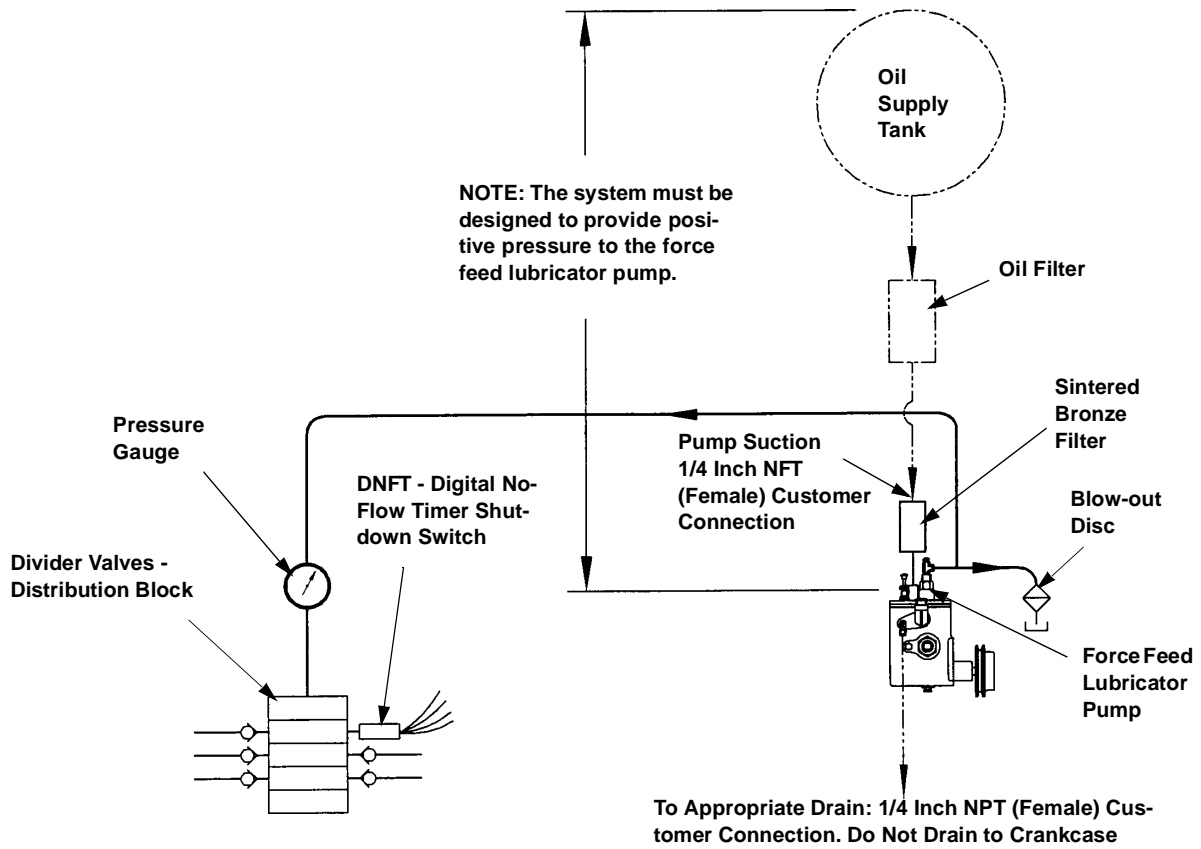


FIGURE 4-9: FORCE FEED LUBRICATION SYSTEM - INDEPENDENT OIL SUPPLY

Force Feed Balance Valves

Balance Valves are used in high differential-pressure distribution-block applications to reduce system problems such as bypassing, no-flow switch errors or blown rupture discs. A force feed balance valve is shown in Figure 4-10:.

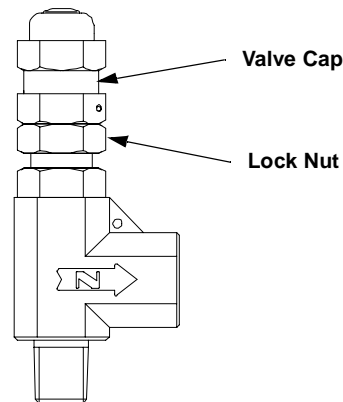


FIGURE 4-10: FORCE FEED BALANCE VALVE

Setting and Maintaining Balance Valves

Balance valves cannot be set prior to operating the unit. Ensure that all fittings are tight and any known leaks have been fixed.

Purge the force feed lube system with a high-pressure hand pump, using the same injection oil that is used in service, to remove any trapped air or gas in the system. **DO NOT USE ANY OTHER FLUIDS FOR PURGING!**

Start up the compressor and bring up to normal operating pressure. After the operating pressures have stabilized, adjust the cap on the top of the balance valve if necessary. Loosen the locking nut on the top of the balance valve directly under the cap. Turn the cap clockwise to increase the pressure and counter clockwise to decrease the pressure. Retighten the locking nut against the cap.

Set the balance valves and maintain at approximately same pressure on each pressure gauge in the injection lines of the pump system affected. A system should be set and maintained within 500 psi (3400 kPa) total or less. The closer the individual line pressures are maintained, the more reliable the system will become.

Once the balance valves have been set, they should be checked 4 to 6 hours later to ensure the pressures have not changed and caused another imbalance. If readjustment is necessary the gauges should be checked again in 4 to 6 hours. If a pressure gauge in a line with a balance valve is reading more than 500 psi (3400 kPa) higher than the others, try to reduce the pressure on that particular injection line. If reducing the balancing pressure on the balance valve does not drop the pressure, then the other balance valves will need to be adjusted to match the highest pressure.

To set balance valves equipped with a distribution block inlet gauge only:

1. Start up the compressor and bring up to normal operating pressure. After the operating pressures have stabilized, with all balance valves backed off (zero spring load), note the highest gauge pressure reached in a complete block cycle.
2. Slowly increase the spring load on one balance valve, being careful to not exceed rupture disc rated pressure. Watch the gauge and if the maximum pressure increases, reduce the spring load until the highest pressure falls to the pressure noted in step 1, above. Tighten the lock nut against the cap, hand wrench tight.
- 3 Repeat step 2, for the remaining valve(s).

Maintain the system by recording the pressures and cycle times of the lubrication system at least once a day.

Checking/Adjusting Balance Valves on Subsequent Start-up

Ensure that all fittings are tight and any known leaks have been fixed. Purge the force feed system.

Start the compressor and bring up to normal operating pressure. After the operating pressures have stabilized, check the pressure gauges to ensure the system is still balanced. If one or more line pressures are out of balance, wait for 2 to 3 hours to see if they become balanced. DO NOT adjust the balancing valves immediately. It is possible that some lube points will increase in injection pressure after a short period of run time and the system will become balanced if it is not balanced on start up.

If a balance valve(s) was installed, but is not required, leave (or set) the spring adjustment at zero. If back-pressure on an unused balance valve is high enough, it may eventually begin to leak oil. In this case, replace the balance valve internal assembly with a plug assembly, Ariel Part Number A-10330. DO NOT RUN UNIT WITH LEAKY BALANCE VALVES. A valve seal repair kit, Ariel Part Number A-8005-K, is available.

Maintain the system by recording the pressures and cycle times of the lubrication system at least once a day. Readjust valves as required to keep pump systems pressure balanced for best results.

Frame Lubricating System - Description

The frame lubricating system supplies oil to the internal frame running gear. The cylinders are supplied with lubrication by the force feed system (see "Force Feed Lubrication System - Description" on page 4-11). An oil level regulator outside the crankcase should be used to maintain the proper oil level in the sump.

Frame lubrication is drawn from the sump through the suction strainer into the oil pump that is mounted on the crankcase auxiliary end cover. The pump's discharge is piped to an oil cooler mounted on the compressor skid and is temperature controlled with a thermostatic control valve. Oil returns from the cooler to the oil filter mounted on the auxiliary end of the crankcase. Pressure gauges are provided on the filter inlet and outlet. Normal pressure drop thru a clean filter is 2 to 6 PSI (15 to 40 kPa), at normal operating temperature.

From the filter, oil travels to an oil gallery cast in the crankcase and running the length of the crankcase.

Drilled holes from the gallery thru the bearing saddles deliver oil to the crankshaft bearings.

Passages drilled diagonally thru the crankshaft from the crank journals to the crank pins deliver oil to the connecting rod bearings.

Holes drilled through the length of the connecting rods deliver oil to the connecting rod bushing.

Oil travels from the bushings thru holes drilled in the middle of the crosshead pin to the hollow crosshead pins, and from there to the crosshead bushing.

Drilled passages from the oil gallery deliver oil at full system pressure thru the tubing to lubricate the top and bottom of each crosshead. Run-off from the shoes, crosshead, and connecting rod bushings collects in the crosshead guide and drains back to the sump (see Figure 4-11: Lube Oil System Schematic - Typical).

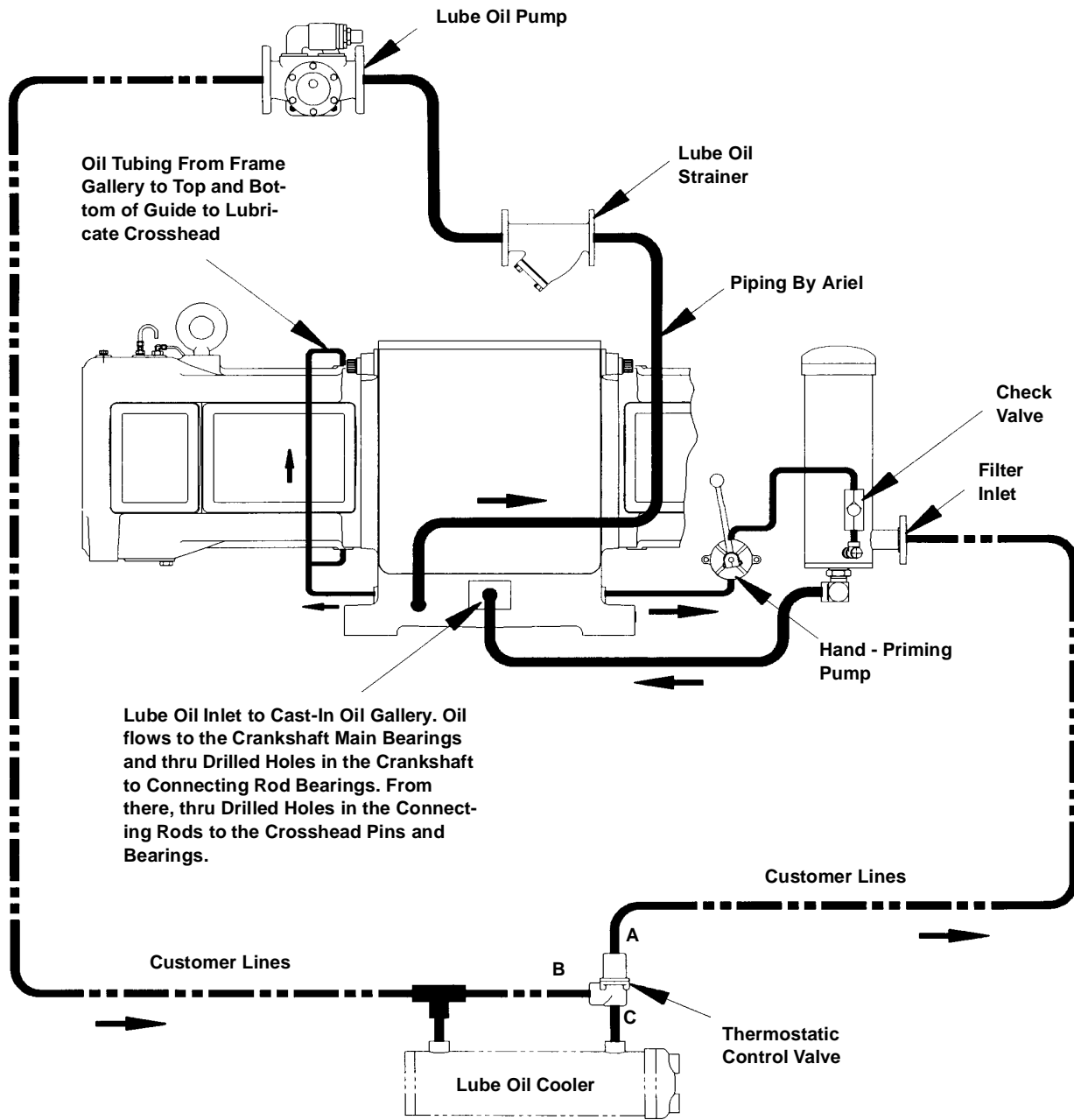


FIGURE 4-11: LUBE OIL SYSTEM SCHEMATIC - TYPICAL

Lube Oil Strainer, Filter & Filter Installation Instructions

Lube Oil Strainer

The strainer is located on the auxiliary end of the crankcase below the oil level. The strainer basket should be taken out and washed in an appropriate solvent whenever the lubricating oil is changed.

Lube Oil Filter

Ariel recommends replacing filter element when differential pressure reaches approximately 10 PSI (70 kPa) across the filter at normal operating temperatures or at six month intervals.

Filter Element Installation Instructions

1. Clean filter base surface, and be certain old gasket is removed.
2. Fill filter with clean oil using the same grade oil as in the crankcase.
3. Apply clean lube oil to the filter gasket.
4. After the filter gasket contacts the base, tighten one turn.
5. After starting the unit, check for leaks, and retighten if necessary.
6. Do not run unit with a damaged filter can. It can fracture or leak. Replace only with an Ariel approved filter.

NOTE: FAILURE TO FILL FILTER VESSEL WITH OIL, PRIOR TO STARTING, CAN CAUSE SEVERE DAMAGE TO THE COMPRESSOR.

Lube Oil Pump & Lube Oil Pressure

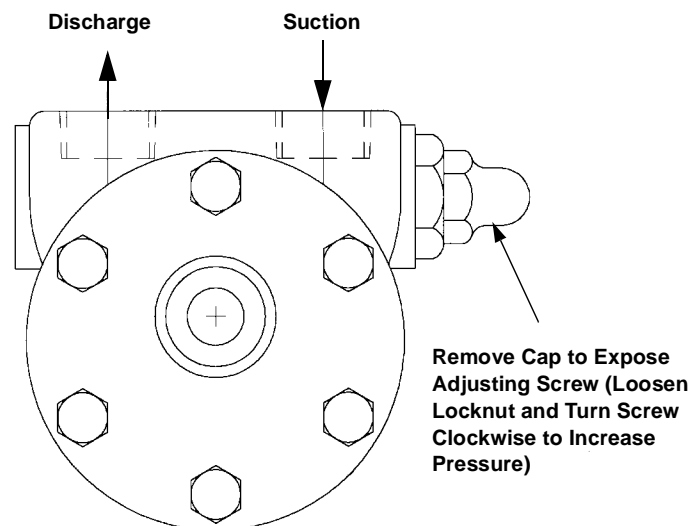


FIGURE 4-12: LUBE OIL PUMP - JG:A/2

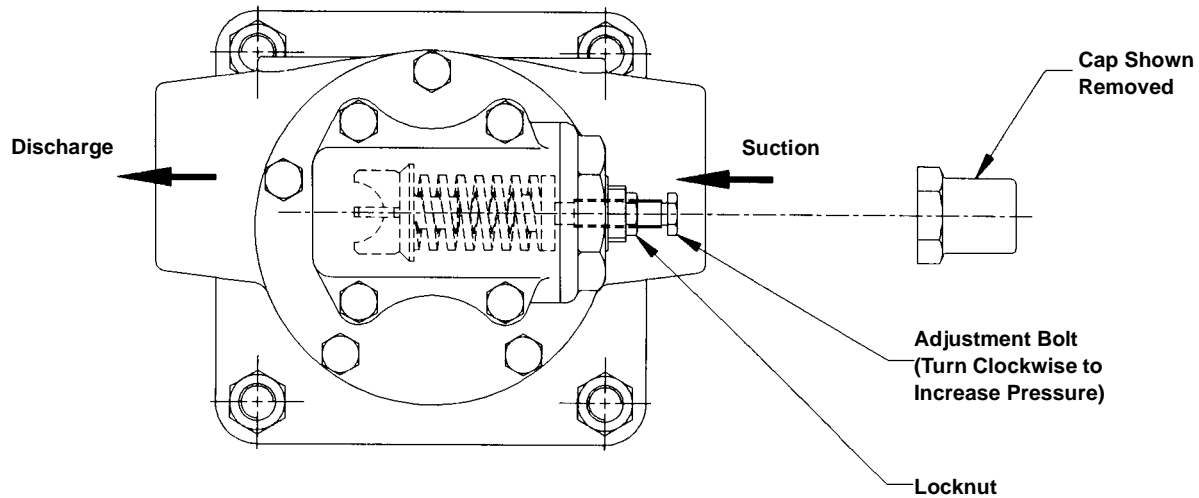


FIGURE 4-13: LUBE OIL PUMP - JG:A/4 & JGA/6

Description & Adjustment

Oil pump discharge pressure is held nearly constant by a spring loaded regulating valve within the pump head. Lube system pressure can be raised or lowered by adjusting this valve (see Figure 4-13:).

Lube Oil Pressure

NOTE: NORMAL PRESSURE ON THE DISCHARGE SIDE OF THE LUBE OIL FILTER IS SET AT THE FACTORY AT 60 PSI (414 kPa) WHEN CRANKSHAFT SPEED EQUALS OR EXCEEDS 750 RPM FOR THE JG AND 900 RPM FOR JGA. IF OIL PRESSURE DROPS BELOW 50 PSI (350 kPa), THE CAUSE MUST BE FOUND AND CORRECTED.

Low Oil Pressure Shutdown

The low oil pressure shutdown is normally mounted by the packager and is supplied to customer specifications. Ariel provides an oil pressure pickup fitting on the oil gallery located after the cooler and filter. The electric or pneumatic oil pressure switch is to be set to actuate when oil pressure falls below 35 PSIG (240 kPa).

NOTE:

1. **THE COMPRESSOR MUST HAVE A WORKING LOW OIL PRESSURE SHUT-DOWN.**

2. DO NOT ATTEMPT TO ADD OIL TO THE CRANKCASE THROUGH THE BREATHER HOLE WHILE THE UNIT IS RUNNING. THIS WILL CAUSE OIL FOAMING AND UNNECESSARY NO FLOW SHUTDOWNS IN THE FORCE FEED LUBRICATION SYSTEM.
3. SINCE THE FORCE FEED LUBRICATION SYSTEM IS CONSTANTLY USING OIL FROM THE CRANKCASE, A WORKING CRANKCASE OIL LEVEL CONTROLLER IS NECESSARY. THIS MUST BE DESIGNED TO ALLOW OIL TO FLOW INTO THE CRANKCASE FROM AN OVERHEAD TANK AT ALL AMBI-ENT TEMPERATURE CONDITIONS.

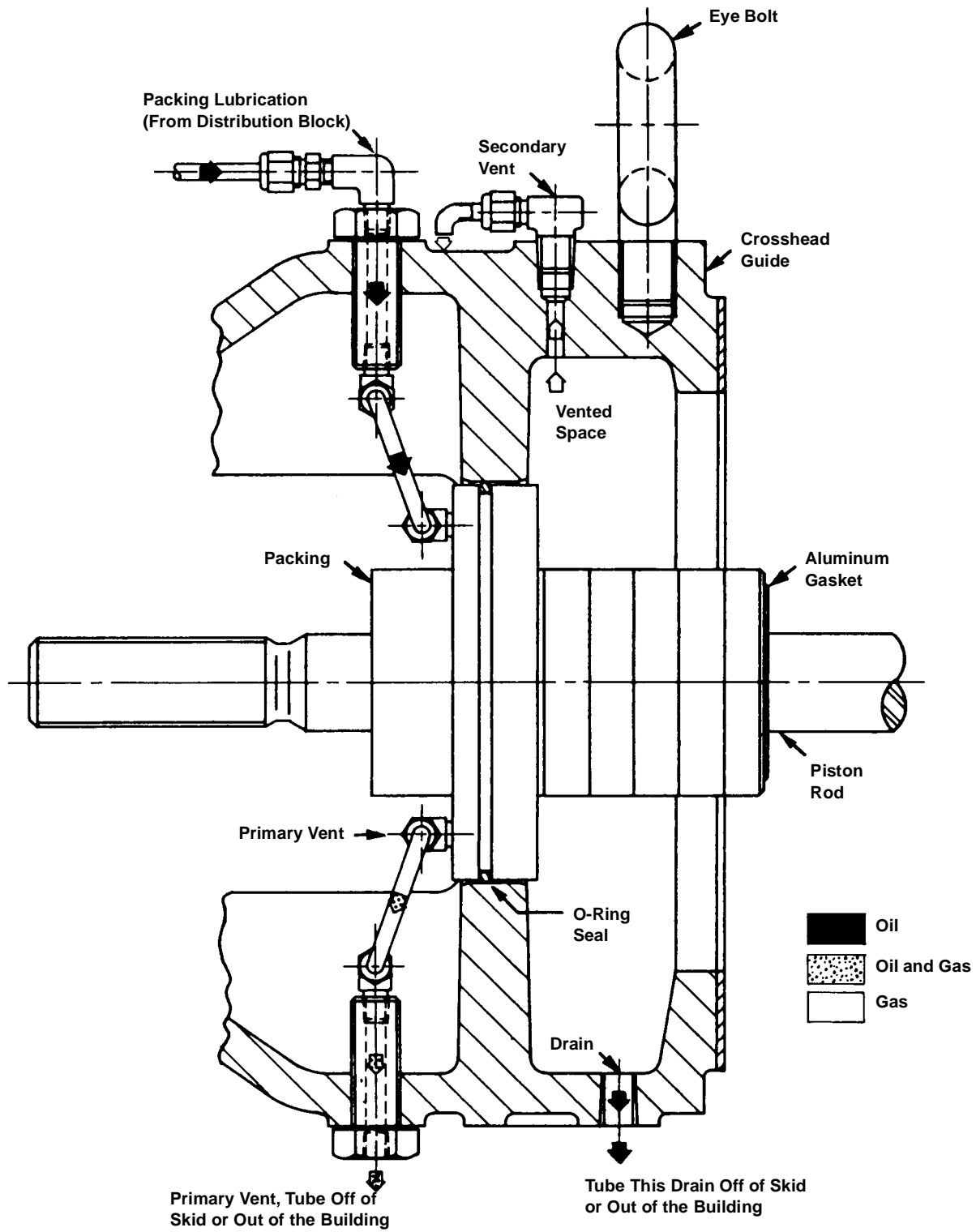


FIGURE 4-14: PACKING, TUBING AND DISTANCE PIECE VENTING

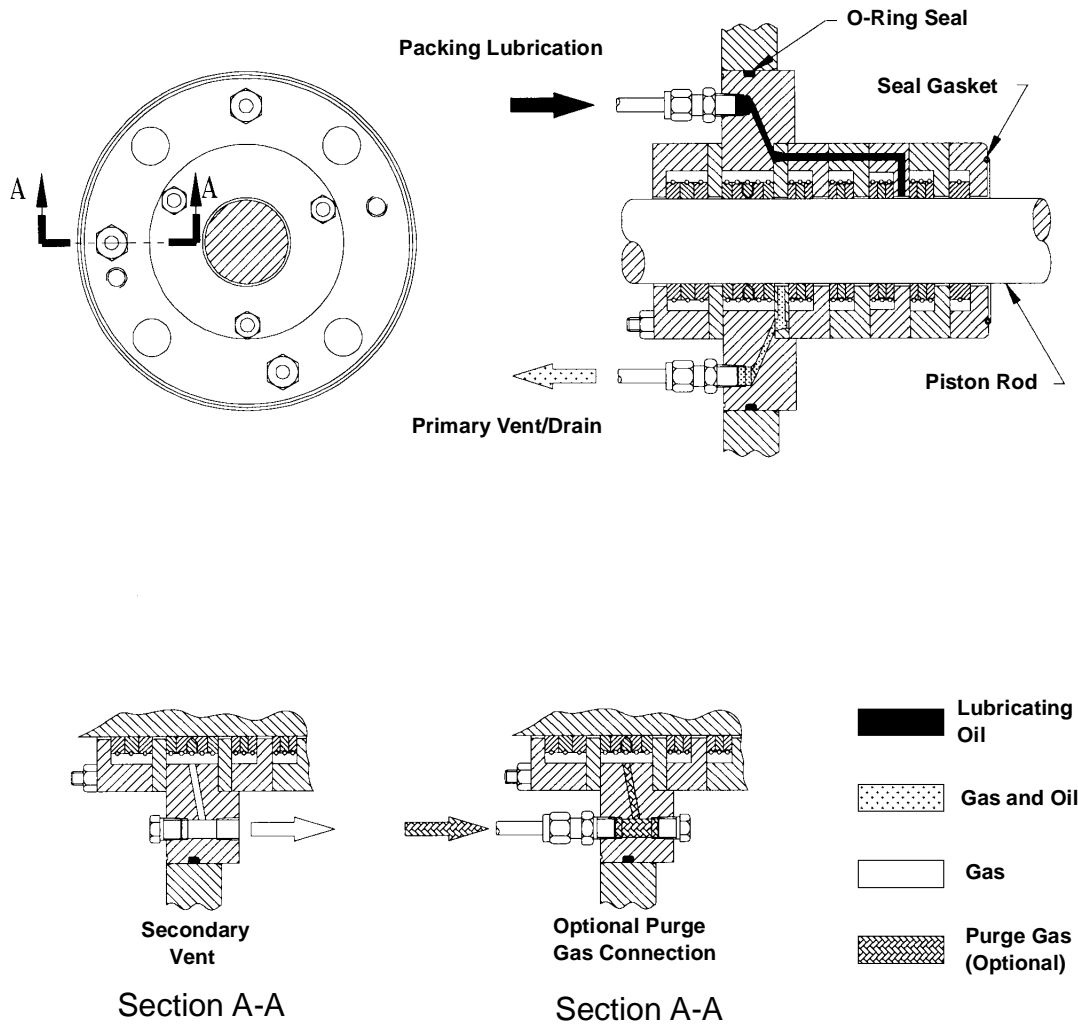


FIGURE 4-15: PACKING LUBRICATION AND VENTING

NOTES

SECTION 5 - MAINTENANCE

General Introduction

The major components of the frame assembly are the crankcase, crankshaft and bearings, connecting rods, chain drive system, crossheads and guides, and distance pieces.

A cast-in oil gallery runs the length of the crankcase. Drilled oil passages feed lubricating oil to the running gear.

Removable end covers, a top cover, and crosshead guide side covers provide generous access for inspecting and removing internal components. The top cover is made of aluminum for easy handling.

Absolute cleanliness, including the use of lint-free wiping cloths, is a necessity during any maintenance on the compressor. When access covers have been removed, keep the frame covered to protect the interior from dust except when actually working on the unit. Any components that have been removed should be protected from falling objects that might mar or chip running surfaces.

Whenever the machine is dismantled, gaskets at non-pressure positions are to be carefully inspected before reuse. Damaged gaskets must be replaced. Gaskets at pressure locations should be replaced. Always apply an anti-seize lubricant to both sides of the gaskets for easy removal at a later date. During major overhauls, drain and flush the crankcase.

When opposed throw compressor cylinders are exchanged side to side on a given unit, all reciprocating components, except the connecting rods, must be exchanged. When re-applying to a throw other than opposed or when reapplying to a different size or class cylinder, the weight balance must be re-calculated. Contact your packager and/or Ariel Field Service for more information. To contact Ariel, refer to "Ariel Telephone, Fax, E-Mail and Web Site Numbers" on page 7-10.

 **CAUTION**

TO PREVENT PERSONAL INJURY, ENSURE THAT COMPRESSOR CRANKSHAFT CANNOT BE TURNED BY THE DRIVER OR COMPRESSOR CYLINDER GAS PRESSURE DURING MAINTENANCE: -- ON ENGINE-DRIVEN COMPRESSORS, REMOVE THE CENTER COUPLING OR LOCK THE FLYWHEEL. -- ON ELECTRIC MOTOR-DRIVEN COMPRESSORS, IF IT IS INCONVENIENT TO DETACH THE DRIVER FROM THE COMPRESSOR, THE DRIVER SWITCH GEAR MUST BE LOCKED OUT DURING MAINTENANCE.

BEFORE STARTING ANY MAINTENANCE OR REMOVING ANY COMPONENTS, RELIEVE ALL PRESSURE FROM THE COMPRESSOR CYLINDERS. SEE PACKAGER'S INSTRUCTIONS FOR COMPLETELY VENTING THE SYSTEM.

 **CAUTION**

AFTER PERFORMING ANY MAINTENANCE, THE ENTIRE SYSTEM MUST BE PURGED WITH GAS PRIOR TO OPERATION, TO AVOID A POTENTIALLY EXPLOSIVE AIR/GAS MIXTURE.

Connecting Rod - Removal

1. Remove the top cover from the crankcase and the side covers from the crosshead guides.
2. Remove the middle spacer bar on a 2-throw frame and the middle bar of each set of three on a 4- or 6- throw frame.
3. Move the throw to the outer dead center position and remove the locknut, bolt, end plates, and crosshead pin from the crosshead.
4. Remove the crosshead as described in "Crosshead - Removal" on page 5-5. Before removing the crosshead, refer to the "CAUTION" on page 5-5.

CAUTION: CROSSHEADS ARE HEAVY. CARE MUST BE TAKEN WHEN HANDLING TO AVOID PERSONAL INJURY. THE WEIGHT OF EACH CROSSHEAD IS LISTED IN THE BALANCE SHEET THAT COMES IN THE MANUAL WITH EACH COMPRESSOR.

5. Turn the crankshaft until the throw is at its highest point. Remove the top two connecting rod bolts and the rod bearing cap. The bottom two bolts remain in the cap while the cap is being removed.
6. Half of the bearing shell will come out with the cap. The other half can be removed by sliding it out.
7. Turn the crankshaft until the rod can be taken out through the top opening of the crankcase.
8. After the removal of the connecting rods, be sure to protect the crank pins from being nicked or scratched.

NOTE: IF ALL CONNECTING RODS ARE TO BE REMOVED, IT MAY BE MORE EXPEDIENT TO REMOVE THE CRANKSHAFT PRIOR TO REMOVING THE RODS.

Crank Pin Bearing & Connecting Rod Bushing Removal & Installation

Crank Pin Bearing

This is a tri-metal (steel, bronze, and babbitt with a tin flash) precision split bearing. A visual inspection should be sufficient to determine if the bearing is serviceable. Any appreciable wear of the babbitt would expose the bronze underneath. Such exposure indicates the need for bearing replacement. It is recommended that the bearings be replaced any time a bearing cap is removed.

There are notches in the rod and rod cap for the bearing tabs in order to position and maintain the position of the bearing halves.

Connecting Rod Bushing

Check crosshead pin to bushing clearance (see Table 1-2 on page 1-8 for recommended clearance.) Wear on the pin can be determined by a visual inspection. Replace the pin if necessary.

If a replacement bushing is needed, the existing bushing should be filed or hack-sawed to within 1/32 inches (1 mm) of its thickness. It can then be easily drifted out.

A press would be helpful to install the new bushing. Do not use a hammer to force the bushing into place as this will distort the bushing's bore. Lay the connecting rod on the press surface so that the chamfered edge of the rod bushing hole is on top. Be sure to locate the bushing oil hole at the connecting rod oil passage before pressing it in. The bushing has an annular groove around its outer surface in line with the oil hole; therefore, if the bushing should shift circumferentially during operation, oil can still travel to its inner surface and to the crosshead pin. However, during installation of a new bushing, no more than 1/3 of the oil passage hole in the rod should be covered by the bushing.

The bushing must be installed into the connecting rod by cooling the bushing in a dry ice and alcohol solution. The bushing needs to be left in the solution long enough to reach the same temperature as the solution, about -120°F (-85°C). DO NOT TOUCH COLD SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.

NOTE: ABSOLUTE CLEANLINESS IS REQUIRED OF BOTH THE BUSHING AND THE CONNECTING ROD TO PREVENT DIRT FROM ACCUMULATING BETWEEN THE BUSHING AND CONNECTING ROD.

Connecting Rod - Installation

1. Snap the half bearing shell into the rod with the bearing tab properly located in the notch on the rod. With the crankcase top cover off, turn the throw to the inner dead center position and slide the rod into the crosshead guide space.

NOTE: THE CAPS AND RODS ARE NUMBERED BY THROW BEGINNING WITH NUMBER ONE AT THE DRIVE END. ALWAYS INSTALL RODS WITH THE NUMBERS UP. BE SURE TO PROTECT CRANK PIN AT ALL TIMES.

2. Fit the connecting rod to the crank pin and turn to the highest position. Replace the cap, the half bearing shell properly located in the notch, and the bolts. Snug up all bolts. Do not tighten bolts to full torque at this point.
3. Reconnect the rod and the crosshead with the pin. Install the end plates, the thru bolt and lock nut. Tighten the lock nut to the value listed in Table 1-15 on page 1-15.
4. Tighten the connecting rod bolts in 25% increments to full torque to the values listed in Table 1-15 using a crisscross pattern.
5. Measure each crankshaft to connecting rod bearing jack clearance, with a dial indicator and magnetic stand, to the values listed in Table 1-2 on page 1-8. Turn the crankshaft pin up and mount the indicator stand on an adjacent web with the stem of the indicator on the rod above the centerline of the pin. Push down on the rod, set indicator to zero, then pry up on the head of the connecting rod bolt with a bar, observe and record reading

Note: Install Throw Marking and Joint Match Marks Up

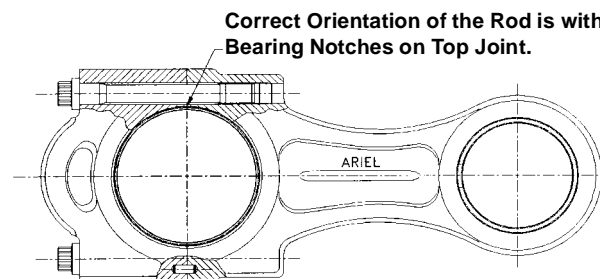


FIGURE 5-1: CONNECTING ROD - TYPICAL

6. Reinstall the spacer bars. All spacer bars are match-marked for proper location. They must be reinstalled in their original location. Tighten all spacer bar bolts to the value listed in Table 1-15 on page 1-15.

7. Examine the removed top cover and side cover gaskets. If there is any doubt about their condition, install new gaskets. Before installing old or new gaskets, apply an anti-seize lubricant to both sides to aid in their easy removal at a later date. Replace the top cover and crosshead guide cover. Tighten all capscrews.

Crosshead - Removal

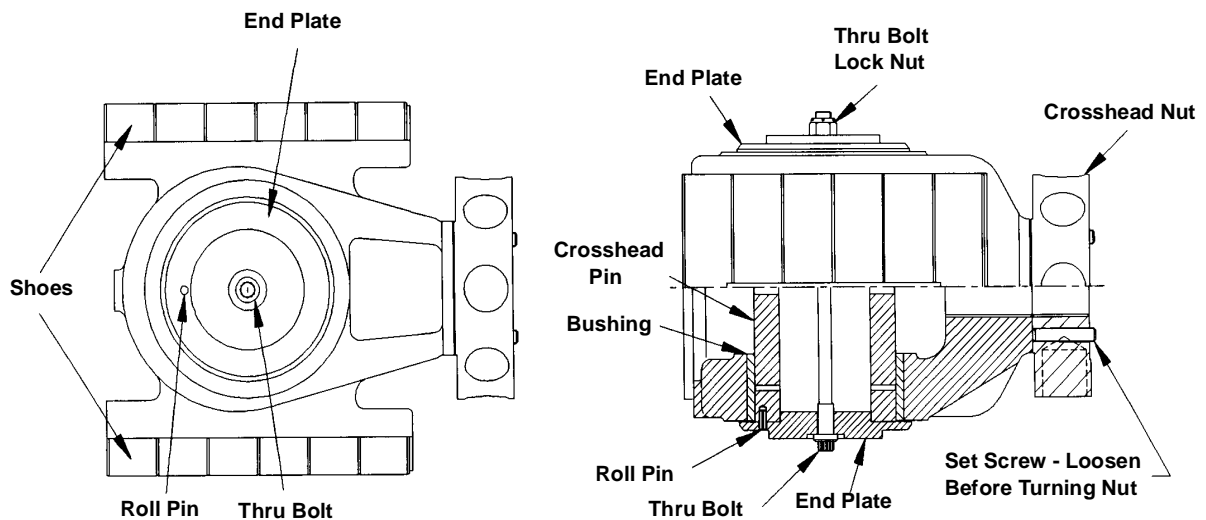


FIGURE 5-2: CROSSHEAD - TYPICAL

CAUTION

BEFORE REMOVING THE CYLINDER HEAD, BACK OFF ALL CAPSCREWS TO 1/8 INCHES (3 mm). MAKE SURE THAT THE HEAD IS LOOSE AND THE CYLINDER IS VENTED. SEE IMPORTANT SAFETY INFORMATION PLATES ON UNIT TOP COVER, (REFERENCE FIGURE 1-3: ON PAGE 1-3 FOR LOCATION.)

 **CAUTION**

CROSSHEADS ARE HEAVY. CARE MUST BE TAKEN WHEN HANDLING TO AVOID PERSONAL INJURY. THE WEIGHT OF EACH CROSSHEAD IS LISTED IN THE BALANCE SHEET THAT COMES IN THE MANUAL WITH EACH COMPRESSOR.

1. Remove crosshead guide side covers and cylinder head.
2. Move the crosshead to its inner dead center position and back off, but do not remove, the crosshead nut set screws. Loosen the crosshead nut with the special slugging Peg or Open End Wrench shown in Figure 7-1: on page 7-3, depending on nut style, and a babbitt or plastic-faced slugging hammer.
3. Use the Piston Nut Spanner (Torquing Adaptor) shown in Figure 7-1: and a speed wrench to screw the piston rod out of the crosshead. The two dowels on the Adapter fit holes in the piston nut. Turn the crosshead nut off the piston rod. Push the rod end forward to the edge of the packing to provide a clearance for crosshead removal.
4. With the crosshead in its outer dead center position, remove the crosshead pin thru bolt, lock nut, end-plates and pin.
5. Turn the crankshaft to its inner dead center position. Move the crosshead to its outer dead center position to be free of the connecting rod. Make sure the connecting rod does not drop and damage the crosshead guide surface.
6. Roll the crosshead 90 degrees and remove it through the guide opening.
7. Check the crosshead pin to bushing clearance. (See Table 1-2 on page 1-8.) Wear on the pin can be determined by a visual inspection. Replace the pin if necessary. If the bushings need to be replaced, hacksaw or file to within 1/32 inches (1 mm) of their thickness. They can be easily drifted out. A press will be needed to install new bushings. The bushing can be installed in the crosshead by cooling the bushing in a dry ice and alcohol solution. The bushing needs to be left in the solution long enough to reach the same temperature as the solution, about -120° F (-85°C). **DO NOT TOUCH COLD SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.** Bronze crossheads do not have bushings; if the crosshead pin bearing area is worn, these crossheads should be replaced.

NOTE: THE SIDE OF THE CROSSHEAD RECEIVING THE NEW BUSHING SHOULD BE SUPPORTED DIRECTLY TO PREVENT POSSIBLE CRUSHING OF THE CROSSHEAD BY THE PRESS. (SEE FIGURE 5-3:)

ABSOLUTE CLEANLINESS IS REQUIRED OF BOTH BUSHING AND CROSSHEAD TO PREVENT DIRT FROM ACCUMULATING BETWEEN THE BUSHING AND CROSSHEAD BORE.

8. Visually inspect the shoe surfaces for scoring. Since they are constantly lubricated under pressure during operation, there should be virtually no wear.

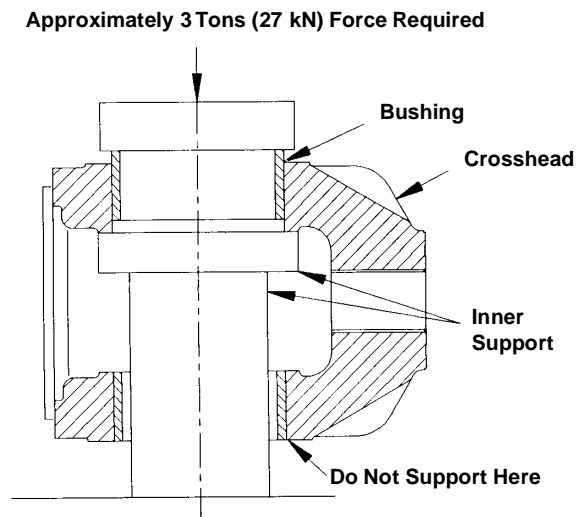


FIGURE 5-3: CROSSHEAD BUSHING REPLACEMENT

Crosshead - Installation

NOTE: BE SURE CROSSHEADS ARE RETURNED TO THEIR ORIGINAL THROW LOCATION.

1. With the crosshead on its side, slip it in the crosshead guide. Once inside, it can be rolled upright. Make sure it does not become cocked. Should the crosshead become wedged, do not force it. ease it off and start again. Be careful not to damage the crosshead shoe surface during installation.
2. Turn the crankshaft to its outer dead center position to locate the connecting rod in position and insert the crosshead pin. Install the end plates, thru bolt and locknut. Tighten the locknut to the torque value listed in Table 1-15.
3. Reinstall the crosshead nut on the piston rod. Be sure to have setscrew cup points on the crosshead side of the nut. Screw the piston/rod assembly into the crosshead using the Piston Nut Spanner and a speed wrench. Make sure all threads are well lubricated with clean fresh oil to ensure smooth installation.

NOTE PISTON END CLEARANCE MUST NOW BE SET OR SERIOUS DAMAGE COULD OCCUR. REFER TO TABLE 1-2 ON PAGE 1-8 FOR PISTON END CLEARANCE SETTINGS.

4. Tighten the crosshead nut using the special slugging Peg Wrench or Open End Wrench shown in Figure 7-1: on page 7-3 and a slugging hammer.
5. Before installing the side covers, apply an anti-seize lubricant to the gaskets. This will aid to ease removal at a later date.
6. Replace the crosshead guide side covers; tighten all capscrews.

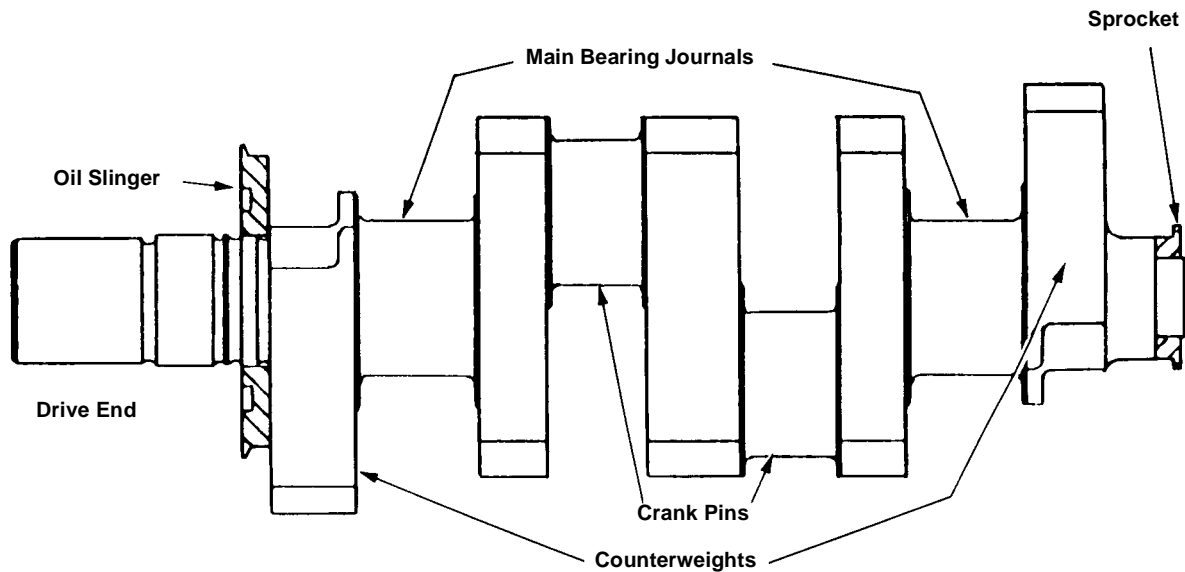


FIGURE 5-4: CRANKSHAFT WITH SLINGER AND SPROCKET - TYPICAL

Crankshaft - Removal

1. Remove the coupling shim pack. Remove the coupling hub. (In order to remove the coupling hub it may be necessary to heat it. Use insulated gloves to protect hands.) If the coupling hub is not removed, the drive end cover cannot be removed and will need to be lifted out with the crankshaft.
2. Remove the top cover, spacer bars and drive end cover (if the coupling hub has been removed). Tip: If the spacer bar bolts are difficult to remove, use a 12 point hammer wrench.
3. Be careful not to damage the sharp corners on each end of the top of the crankcase. These corners form the junction between the end covers, top cover, and base; thus they must be kept sharp and unmarred to prevent oil leaks.
4. Detach the connecting rods. (See "Connecting Rod - Removal" on page 5-2.) Move the rods to their full outer position.
5. Remove the capscrews on the chain adjustment cap. Turn the cap to loosen the chain. Slip the chain off the crankshaft sprocket.
6. Remove the capscrews from the bearing caps. Pull the caps straight up to prevent damage to the dowel fit. If the cap is tight, use a Bearing Cap Puller as illustrated in Figure 5-5:

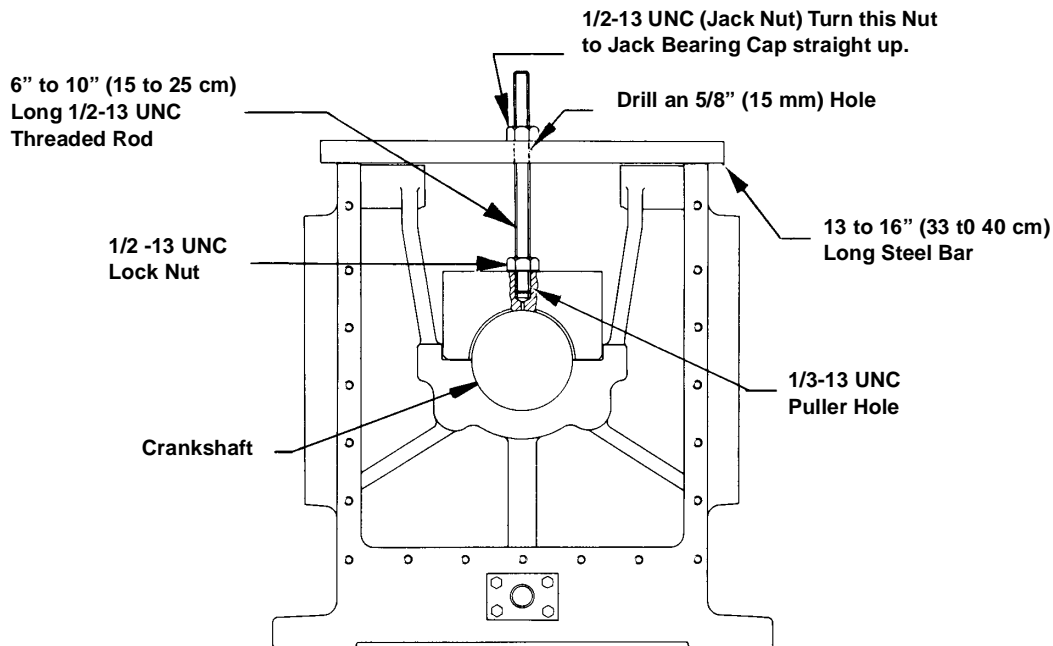


FIGURE 5-5: BEARING CAP PULLER

7. Before removing the crankshaft from the crankcase, wooden saddles or a notched wooden crate with sides high enough to prevent the webs or oil slinger from touching bottom should be prepared in order to store the crankshaft during maintenance - even though it may be out for only a short time. In addition, the crankshaft should be adequately protected from above so that dropped tools or equipment cannot mar the surface of pins and journals.
8. Turn the crankshaft so that sling lifting point(s) are above the center of gravity of the shaft, so that it does not want to rotate when lifted. Lift straight up with the ends of the crankshaft parallel to the frame. Two persons will be needed to safely remove the crankshaft as well as a crane or lift due to the weight of the crankshaft. Appropriately sized nylon slings should be used during this operation to avoid marring of the running surface of the crankshaft. Great care must be taken during this operation since the shaft could bind and become damaged.

NOTE: THE LOWER HALF BEARING SHELLS SOMETIMES HAVE A TENDENCY TO STICK TO THE SHAFT JOURNALS BECAUSE OF THE CLOSE FITTING OILY SURFACES OF THE TWO PARTS. THEREFORE, WHEN THE SHAFT HAS BEEN LIFTED CLEAR OF THE SADDLES, APPROXIMATELY 1/4 INCHES OR 6 mm, CHECK TO MAKE SURE THAT THE LOWER HALF BEARING SHELLS HAVE NOT COME OUT WITH THE SHAFT. IF SO, THE BEARING SHELLS SHOULD BE TAPPED BACK ONTO THE SADDLES BEFORE LIFTING THE SHAFT ANY FURTHER.

9. While one person operates the crane, raising it very slowly, the second person must grasp the crankshaft at the drive end with one hand on the counterweight or one of the throws and the other hand on the end of the shaft to keep the

crankshaft level. Wear gloves to avoid being cut by the slinger and to achieve a good grip. The gloves should be clean to avoid marring of the running surface. As the shaft is being slowly raised, the drive and auxiliary ends should be lifted at the same rate. Again, care must be taken to avoid marring the crankshaft surfaces by carefully guiding the crankshaft.

Crankshaft - Oil Slinger

Removal

Although the slinger should last indefinitely with proper care, it can become nicked. Should it need replacement, suspend the crankshaft on a sling(s) as in "" on page 5-8 and heat the slinger to 400° F (240°C). It will attain a yellow glow at this temperature. When it has expanded it should fall off by itself. **DO NOT TOUCH HOT SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.**

Installation

Put a rod at least 1/2 inches (13 mm) in diameter through the slinger. (Special care should be exercised when handling the slinger, not only to keep its surfaces unmarred, but to avoid being cut by the outer sharp edge.) After the slinger is suspended heat it with a small torch. When it has attained a yellow glow, approximately 400° F (240°C), it can be slipped over the drive end of the crankshaft. Hold the slinger in position with high temperature gloves or two pieces of clean wood, rotating it slightly to make sure it is square, until it has cooled enough to shrink onto the crankshaft. **DO NOT TOUCH HOT SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY.**

Crankshaft - Chain Sprocket

Removal

Examine the sprocket carefully for signs of wear. If it has been in operation for five years or more, it may be convenient to replace it if the crankshaft is removed from the frame.

Drill a hole in the sprocket hub. This hole should be parallel to the shaft centerline and big enough that it removes most of the hub cross section. (See Figure 5-6:) Be careful not to touch the shaft with the drill. Mark the drill with tape so you do not drill through the sprocket and into the crankshaft face.

The drilled hole will relieve most of the shrink, and a couple of good radial hits with a hammer and chisel will open the sprocket enough so it can be easily removed.

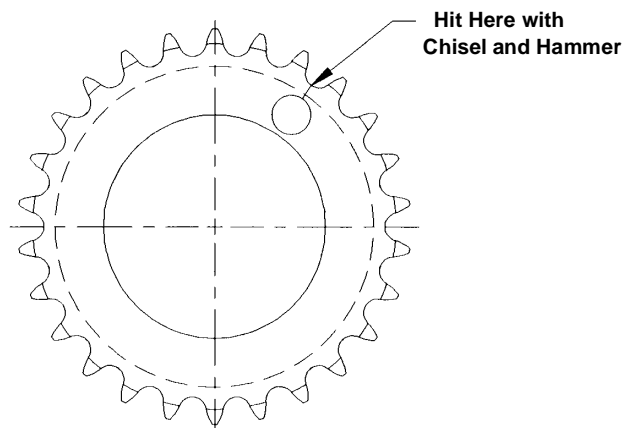


FIGURE 5-6: CRANKSHAFT - CHAIN SPROCKET

Installation

Encircle the sprocket with wire. Suspend the sprocket from the wire and heat it with a small propane torch. When it has attained a yellow glow, approximately 400°F (240°C), it can be slipped over the auxiliary end of the crankshaft. Hold the sprocket in position with high temperature gloves or two pieces of clean wood, rotating it slightly to make sure it is square, until it has cooled enough to shrink on the crankshaft. **DO NOT TOUCH HOT SURFACES WITHOUT PROPER INSULATION TO PREVENT INJURY**

Main Bearings - Removal and Installation

Bearings must be replaced if they show signs of wear or scoring. Wear will be indicated by the bronze showing through the babbitted surface. It is recommended that bearing be replaced any time the bearing caps are removed.

If replacement bearings are needed, the old bearing halves can easily be slid out, new bearings slid in (untabbed end first), and snapped into place. Locate tabs in the notches in the bearing saddles and bearing caps. It is recommended that the bearings be replaced any time that the bearing caps are removed.

Crankshaft - Installation

1. Move the connecting rods to their full outer position. While the crankshaft is being lowered very slowly into the crankcase (if suspended by a crane with a nylon sling), one person should grasp the drive end and slowly maneuver the

drive end and auxiliary end straight down into the crankcase, wearing clean gloves as during removal. Both drive end and auxiliary end journals should touch the bearing saddles at the same time.

2. When the crankshaft is resting on the bearing saddles, attach the bearing caps with the capscrews lightly snugged. Then, starting at the thrust end, tighten the bolts in a crisscross pattern in 25% increments to the recommended torque value in Table 1-15 on page 1-15. Bearing caps are match-marked to correspond with the spacer bar and spacer bar bosses on the frame.
3. Be sure the dowels in the bearing caps are aligned with the holes in the crankcase base. A set screw on top of each dowel prevents it from backing out.
4. Measure each crankshaft journal bearing jack clearance, with a dial indicator and magnetic stand to Table 1-2 on page 1-8. To measure main bearing clearance, turn the adjacent crankshaft pin up and mount the indicator stand on the main bearing cap, with the indicator stem touching the web of the crank adjacent to the bearing cap. Push down on the crank, set indicator to zero, pry up, observe and record reading. This is best done before the connecting rods are installed by pulling a clean lifting strap around the adjacent pin and pulling up on the crankshaft with a crane or bar on the strap.
5. Reattach the connecting rods (See "Connecting Rod - Installation" on page 5-4), packing diaphragms, and unloaders/head end heads.
6. Reinstall the chain drive. (See "Chain Drive System" on page 5-12).
7. Replace the spacer bars. Locate the match mark on the spacer bar. Install the spacer bar so that the match mark is up and next to the spacer bar boss with the same marking. Tighten bolts to the value in Table 1-15 on page 1-15.
8. Install new end cover gaskets. Examine the top cover gasket. If there is any doubt that it is not in good usable condition, install a new gasket. Before installing gaskets, apply an antiseize lubricant to all gaskets or to the metal surfaces on which they will seat. This will aid in their easy removal at a later date. Trim the excess from the new end cover gaskets flush to the base with a knife after end covers have been re-bolted.
9. Reinstall the drive end cover and the top cover. Replace and tighten bolts.

Chain Drive System

Description

The chain drive system is crankshaft-driven at the auxiliary end of the frame. The chain runs the lube oil pump and force feed lubricator. Chain tightness is controlled by an idler sprocket attached to the eccentric adjustment cap. The chain dips into the crankcase oil and, as a result, is constantly lubricated. See Figure 5-7:, for the auxiliary end components and chain drive system.

Replacement of any parts that can change the position of the drive sprocket on the crankshaft (i.e. crankshaft, drive sprocket), and/or loss of the as built sprocket position of driven components, can require repositioning the lube oil pump and force feed lubricator sprockets. Center crankshaft in end play. With a good straight edge, check to see that sprockets are aligned within 1/32 inch (1mm). Or measure the distance between the inside face of the aux-

iliary end cover to the near faces of the drive sprockets on the crankshaft with a good machinist rule. Check the driven sprockets in the chain drive system against the measured dimensions at crankshaft drive sprockets. Adjust the driven sprockets to the drive sprocket measurements to be aligned within 1/32 inch (1mm).

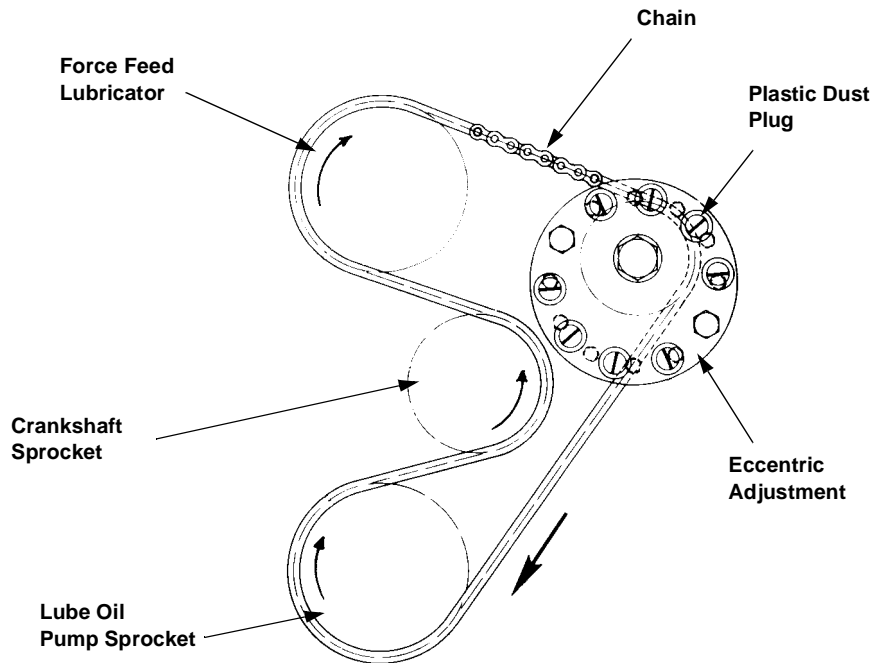


FIGURE 5-7: CHAIN DRIVE SYSTEM - TYPICAL

Chain Adjustment

1. Roll machine to the tightest position of the chain. This prevents snugging up on the chain at a slack position and breaking rollers or ruining the pump and lubricator bearings when the chain goes through its tightest position.
2. Remove the two capscrews and eight plugs from the eccentric adjustment cap. Rotate the cap 6 degrees clockwise facing cap from outside to line up two new capscrew holes. If this makes the chain too tight, try turning the cap around in a counterclockwise direction for a different hole lineup.
3. Tighten the two capscrews and roll the machine to check the tightness in a number of positions. At its tightest position, the chain should be adjusted so that the deflection of the most accessible span is within the chain deflection limits shown in Table 5-1. This deflection can be measured from a straight edge held on the chain wrapped over the two sprockets. The allowable deflection is measured at the center of the span, while a force of 2 to 10 lb (9 to 45 N) finger pressure is applied to chain.

TABLE 5-1: CHAIN DEFLECTION LIMITS

COMPRESSOR MODEL	DEFLECTION LIMITS
	FORCE FEED LUBRICATOR TO IDLER, INCHES (mm)
JG/2, JG/4, JGA/2, JGA/4	0.05 to 0.08 (1.3 to 2.0)
JGA/6	0.03 to 0.05 (0.8 to 1.3)

4. Replace the dust plugs in the eccentric adjustment cap to keep dirt out of the unused holes in the end cover.

Chain and Sprocket Replacement

The chain should be replaced if the elongation exceeds 0.084 inches (2.13 mm) over a 10 pitch length. The section of chain to be measured should be stretched tight, in place, in the compressor and measured with vernier calipers. A reading made outside of the rollers at 10 pitches should be added to a reading between the inside of the same rollers and then be divided by two. If this calculation exceeds 3.834 inches (97.38 mm) for 3/8 pitch, the chain should be replaced. Any sprocket showing any undercutting should be replaced.

Eccentric Vernier - Chain Idler Sprocket Replacement

1. A typical chain idler sprocket is shown in Figure 5-8: on Page 5-15.
2. Remove the frame top cover. Remove the dust plugs and the two capscrews that hold the eccentric adjustment cap to the end cover. Rotate the eccentric cap to loosen the chain for removal. After dropping the chain off the idler sprocket, the entire assembly can be removed from the end cover.
3. With a good machinist rule, measure the exact distance from the outer face of the chain sprocket to the closest face of the eccentric cap. Note the measurement for the proper positioning of the new sprocket.
4. Remove the locknut, capscrew, sprocket and Stat-O-Seal washer. Discard these items since they must be replaced with new parts. Remove and discard the cap O-ring.
5. Reassemble all parts using a new capscrew, Stat-O-Seal washer, sprocket, and locknut. Compare the sprocket to cap measurement to the measurement previously taken. If necessary, shim between the cap and the idler spacer to make the measurements equal. Tighten the idler locknut to the recommended torque shown in Table 1-15 on page 1-15.
6. Install the assembly on the end cover. Do not install the chain. First check the alignment to the crankshaft drive sprocket, with crankshaft centered in end play, using a straight edge.
7. If not in alignment within 1/32 inch (1 mm), shim as necessary, see Figure 5-8:.
8. When the alignment is within 1/32 inch (1 mm), remove the entire assembly again. Apply oil and install a new O-ring. Install the assembly and adjust the chain according to the instructions given in "Chain Adjustment" on page 5-13.

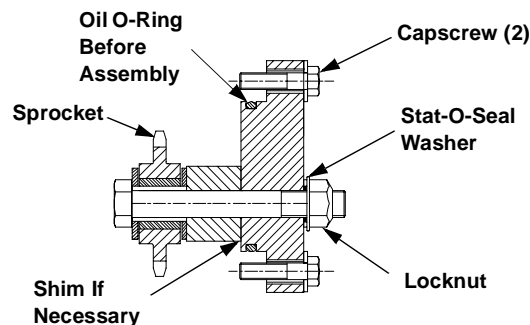


FIGURE 5-8: ECCENTRIC VERNIER - CHAIN IDLER SPROCKET (SELF-ALIGNING SPROCKET) - TYPICAL

Lube Oil Pump Chain Sprocket Replacement

1. Refer to Figure 5-9:.
2. Remove all piping from the pump. Remove fasteners from pump mounting flange and the pump with sprocket will come free through the hole in the end cover after the removal of the chain.
3. With a good machinist rule, measure the exact distance from the sprocket drive face to the pump mounting flange face, in order to position the new sprocket. Note this measurement for future reference.
4. With the oil pump on a bench, use an Allen Wrench to remove the sprocket set screws; then, pull the sprocket from its shaft.
5. Remove the Woodruff No. 204 or square key, 3/16 x 1 inches (4.8 x 25 mm) long, from the shaft and file the shaft to smooth out any burrs raised by the cup point of the set screw.
6. Install a new key, a No. 204 Woodruff for 2- & 4-throw units or a square 3/16 x 1 inches (4.8 x 25 mm) long for 6-throw units, after first checking to make sure the key will fit into the new sprocket. If the key is too thick, it can be polished with an emery cloth on a flat surface until it can easily slide into the notch. It may also be a little high and require filing of the top edge.
7. Install a new sprocket to the original measurement between the sprocket drive face and the pump mounting flange face. When it is in position, tighten the set screws.
8. Install new gaskets. Before reinstalling the pump, apply an anti-seize lubricant to the gasket surfaces. This will aid in easy removal at a later date.
9. Reinstall the pump onto the end cover. Check the alignment to crankshaft drive sprocket, with crankshaft centered in end play, using a straight edge to within 1/32 inch (1 mm). If not in alignment, adjust sprocket position as necessary.

10. Re-install and adjust the chain according to the instructions in "Chain Adjustment" on page 5-13.
11. Reinstall all tubing to the pump.

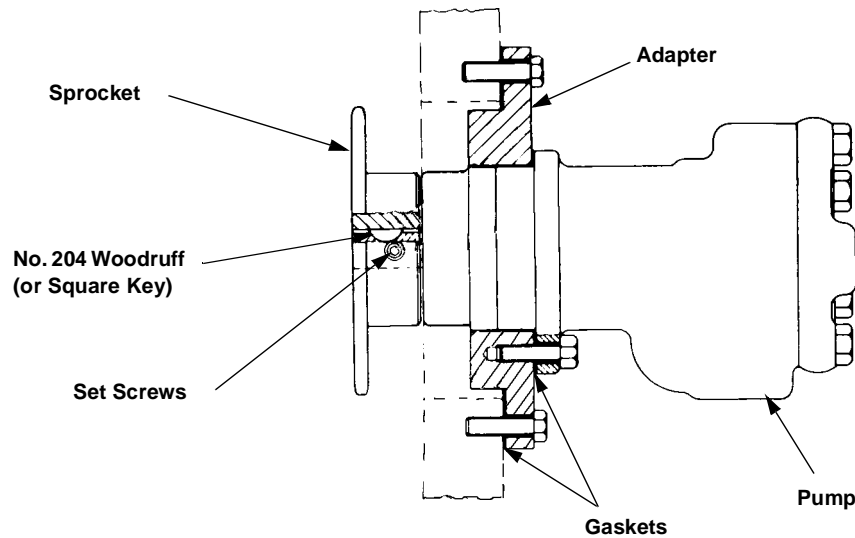


FIGURE 5-9: LUBE OIL PUMP AND SPROCKET - TYPICAL

Force Feed Lubricator Chain Sprocket Replacement

1. Refer to Figure 5-10: on page 5-17.
2. With a good machinist rule, measure the exact distance from the inside face of the auxiliary end cover to the near face of the lubricator sprocket. Note the measurement for proper positioning of the new sprocket. Remove chain.
3. Remove the sprocket set screw and sprocket. Detach all tubing to the lubricator.
4. Remove the four mounting bracket capscrews and remove the lubricator.
5. With the lubricator on the bench, remove the Woodruff Key from the shaft and file the shaft to remove any burrs raised by the cup point of the set screw. Install a new O-ring.
6. Install a new No. 204 Woodruff Key after first checking to make sure the key will fit into the new sprocket. If it is too thick, it can be polished with an emery cloth on a flat surface until it can easily slide into the notch. It may also be a little high and require filing of the top edge.
7. After the new key has been installed and it has been determined that the new sprocket will fit, oil the new O-ring and remount the lubricator to the end cover.
8. Put the new sprocket onto the shaft and set to measured dimension. Tighten the set screw.
9. Check alignment to the crankshaft drive sprocket with crankshaft centered in end play, using a straight edge, to within 1/32 inch (1mm).
10. Install chain and adjust using the instructions given in "Chain Adjustment" on page 5-13.

11. Re-attach all tubing to the lubricator.

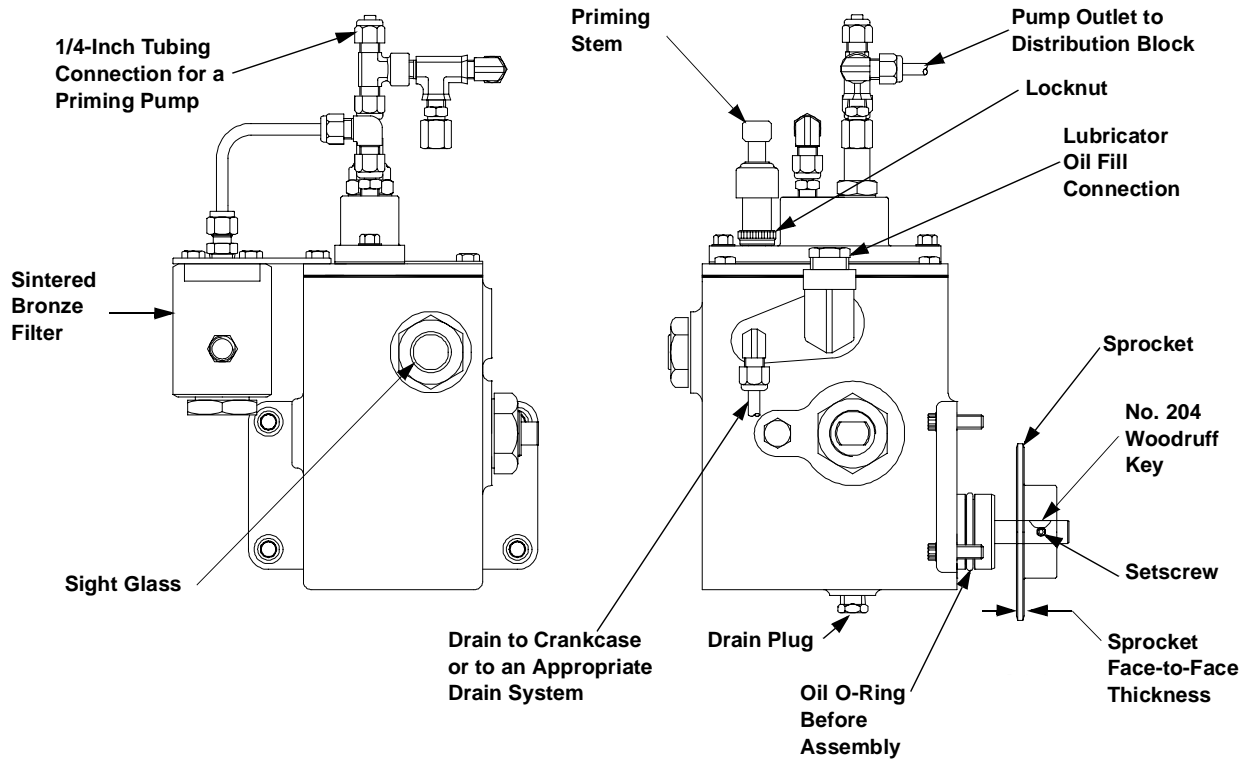


FIGURE 5-10: FORCE FEED LUBRICATOR AND SPROCKET - TYPICAL

Piston and Rod - Removal

CAUTION

TO PREVENT PERSONAL INJURY, ENSURE THAT COMPRESSOR CRANKSHAFT CANNOT BE TURNED BY THE DRIVER OR COMPRESSOR CYLINDER GAS PRESSURE DURING MAINTENANCE: -- ON ENGINE-DRIVEN COMPRESSORS, REMOVE THE CENTER COUPLING OR LOCK THE FLYWHEEL. -- ON ELECTRIC MOTOR-DRIVEN COMPRESSORS, IF IT IS INCONVENIENT TO DETACH THE DRIVER FROM THE COMPRESSOR, THE DRIVER SWITCH GEAR MUST BE LOCKED OUT DURING MAINTENANCE.

BEFORE PERFORMING ANY MAINTENANCE, COMPLETELY VENT SYSTEM. BEFORE REMOVING A CYLINDER HEAD, BACK OFF ALL CAPSCREWS 1/8" (3 mm). MAKE SURE THE HEAD IS LOOSE AND THE CYLINDER IS COMPLETELY VENTED.

1. Remove the crosshead guide side covers and the cylinder head. The cylinder head is to be loosened first to the Caution! instructions above.
2. Move the crosshead to its inner dead center position. Back off, but do not remove, the crosshead nut set screws. Loosen the crosshead nut with the special slugging wrench, (see Figure 7-1: on page 7-3) and a slugging hammer. Use the open-end wrench for hex nuts and the peg wrench for round nuts.
3. Remove the cylinder head. In the case of tandem cylinders where the outboard cylinder bore is smaller than the inboard bore, it is necessary to remove the outboard cylinder. Support such cylinders during removal and installation, as to not put excessive weight on the piston and rod assembly which might cause bending.
4. Use the Piston Nut Spanner and speed wrench to screw the piston and rod assembly out of the crosshead. The two dowels on the Piston Nut Spanner fit the holes in the piston nut. Turn the crosshead nut off the piston rod.
5. As the piston leaves the cylinder, be careful in handling the piston rings. Despite their toughness in service, rings are fragile with regard to removal. Always handle them with clean tools and hands protecting the rings from nicks, marring, and bending. Move the piston out of the cylinder until a fraction of the first ring clears the cylinder. Encircle the ring by hand (use a band for larger sizes) until it is clear and remove it. Use this same procedure to remove the succeeding rings and wear band.
6. Slide the piston rod assembly out of the head end. The threaded crosshead end of the rod is 1/8 inches (3 mm) smaller in diameter than the inside diameter of the packing. Using extreme care, slowly slide the piston rod through the packing to avoid damaging the rod threads or the packing rings.

Piston and Rod - Disassembly and Reassembly

Disassembly

The Piston and Rod Clamping Fixture shown in Figure 5-11: on page 5-19 will be useful for the piston and rod disassembly and reassembly operations. This fixture may be purchased from Ariel.

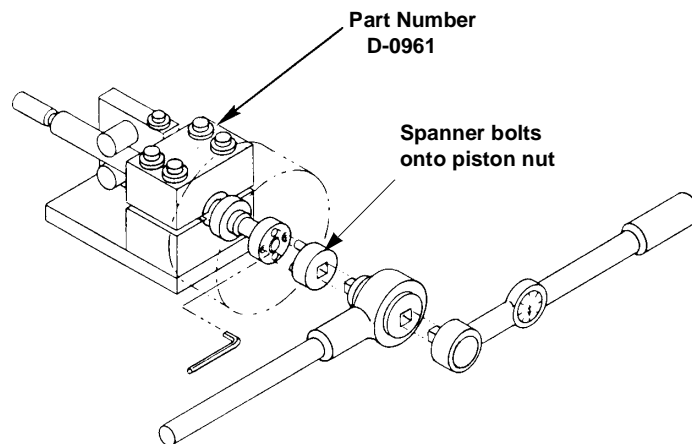


FIGURE 5-11: PISTON AND ROD CLAMPING FIXTURE

1. Clamp the piston and rod assembly in the special Clamping Fixture (D-0961), using the bushing for a 1-1/8" rod size (see Figure 5-11:). Tighten the four 12-point cap screws to prevent the rod from turning. The fixture will properly hold the piston rod to prevent damage to the parts and promote safety during disassembly and reassembly. The Clamping Fixture must be securely bolted down to prevent it from turning with the piston rod. It should be at a convenient height of approximately three feet or 0.9 meters. Remove the setscrews from the piston nut. Although the piston nut has been staked to lock the setscrews, they can be forced out, by turning with an Allen wrench, past the small lip that has been formed.
2. Remove piston nut using piston nut spanner (see Figure 7-1: on page 7-3).

NOTE: A SMALL AMOUNT OF GAS PRESSURE CAN BUILD UP WITHIN THE PISTON DURING OPERATION. THIS WILL VENT WHEN THE PISTON NUT IS LOOSENED.

3. After the piston nut has been removed, the piston and collar will slip off the end of the rod.

Reassembly

1. Clean all piston and rod assembly parts thoroughly. Be sure piston is internally clean and dry.
2. Inspect parts for nicks, burrs or scratches and dress surfaces with a fine grit stone as required.
3. Inspect the piston rod threads and collar shoulder. Threads should be clean and free of burrs. Install the collar and nut into the piston to verify that the outside diameter fits and rotates freely. Install the collar and nut onto the piston rod to verify that the inside diameter fits and rotates freely. Run the piston nut down by hand until the rod threads protrude to verify freedom of thread engagement. Remove nut and collar.
4. Check piston rings and wear band (when used) to determine wear (see "Determining Ring Wear:" on page 5-23 and "Determining Wear Band Wear:" on page 5-24). Replace piston rings and wear bands as required.
5. Secure the piston rod in Torque Fixture D-0961.
6. Apply a thin coat of Never-Seez to piston rod shoulder and rod collar locating band, and collar face in contact with the piston, then slide collar onto rod.
7. Apply a thin coat of Never-Seez to the piston rod threads at the piston end, then slide piston onto rod and collar.

NOTE: ONE END OF SINGLE PIECE PISTONS ARE MACHINED 0.002" (0.05 mm) UNDERSIZE ACROSS A 3/4 INCH (20 MM) WIDE BAND FOR MANUFACTURING PURPOSES. THIS IS THE HEAD END OF THE PISTON.

8. Apply a thin coat of Never-Seez to the piston nut threads and piston mating face. Install nut and hand tighten to make up the piston and rod assembly.
9. Tighten the piston nut to the recommended torque in Table 1-12 on page 1-16.
10. After tightening nut, the piston rod should not protrude more than 0.010 in. (0.25mm) past the piston face.
11. Apply a thin coat of Never-Seez to two new Allen set screws. Two new Allen wrenches are also required per nut at each tightening and are discarded after their one time destructive use. Install the set screws and tighten so that the Allen wrench is permanently deformed by tightening past its yield point (twisted thru a 15° arc).
12. Prick-punch the piston nut, within 1/16 in. (1.5mm) of the set screw threads, to lock the set screws in place. Prick-punch marks should deform nut screw threads to lock the set screws in place.
13. Weigh the piston rod assembly with piston rings included. Stamp the weight on the piston head end. Flatten any raised lips to avoid clearance measurement errors. Record this weight for future reference.

Piston and Rod - Installation

1. Install the piston/rod assembly with piston rings, and wear band when applicable, into the cylinder. The threaded crosshead end of the rod is 1/8 inches (3 mm) smaller than the inside diameter of the packing. It is not necessary to use an entering sleeve if reasonable care is taken, but a sleeve may be helpful.

Using a non-metallic sleeve from the crosshead side will help ensure that packing rings are not damaged. An optional piston rod entering sleeve, Part Number A-8561, is available from Ariel (refer to Figure 7-3: on page 7-3).

2. Screw the crosshead nut onto the piston rod. Make sure all threads and nut seating surfaces are well lubricated with clean, fresh oil to ensure proper assembly. Position the crankshaft in the inner dead center position. Remove a crank end discharge valve. Determine the required piston crank end clearance as shown on the cylinder identification plate. Refer to Table 1-2 on page 1-8. Insert a feeler gage, equal to the required crank end clearance, thru the discharge valve pocket. A special feeler gauge is provided with 2-3/4M, 3M, 2-3/4P-CE and 3-1/4P-CE class cylinders only (refer to Figure 7-2: on page 7-3). Use the Piston Nut Spanner and a speed wrench to screw the piston rod into the crosshead until piston is snug against the feeler gage. (For the 2-1/4P-CE class cylinder, it is not possible to use a crank end feeler gauge. For this class, with crankshaft in the inner dead center position, screw piston rod assembly hand tight against the crank end head, then turn out, loosen, 1/2 turn.) Snug the crosshead nut, but do not tighten. Remove the feeler gage.
3. Ensure that the Piston Turning Tool has been removed. Replace the cylinder head and gasket. Tighten all cylinder head bolts evenly to the proper torque value listed in Table 1-15 on page 1-15.
4. Remove a head end suction valve. Determine the required piston head end clearance as shown on the cylinder identification plate. Refer to Table 1-2 on page 1-8. Rotate the crankshaft 180° to the outer dead center position, and using the feeler gages thru the valve pocket, check the head end clearance. Determine that measured clearance is within the required clearance limits.
5. Tighten the crosshead nut to the proper torque value listed in Table 1-15 on page 1-15.
6. Tighten set screws in the crosshead nut.
7. Before installing the side covers, apply an anti-seize lubricant to the gaskets. This will aid removal at a later date.
8. Replace the crosshead guide side covers; tighten all capscrews.
9. Replace the valve assemblies, tighten all valve cap bolts evenly to the proper torque value listed in Table 1-15 on page 1-15.

Piston Rod Run Out

Check piston rod run out after installing a new unit, after relocating a unit or after any maintenance that could affect rod run out.

Verify that the crosshead guides are properly shimmed to level. Refer to See “Procedure For Setting and Aligning” on Page 2-1. Verify that the crossheads are in direct contact with the bottom guide. A 0.0015 inches (0.04 mm) feeler stock should not be able to be inserted more than 1/2 inches (13 mm) at all four corners of the crosshead.

Position the dial indicator¹ stem against the piston rod, close to the packing case. Set the indicator to zero with the piston toward the crank end. Readings are to be taken in both the

1. Use a 0.0001 inches (0.001 mm) increment dial indicator.

vertical and horizontal directions. When measuring vertical rod moment, upward movement will be recorded as positive, downward movement will be recorded as negative. When measuring horizontal rod movement, rod movement toward the auxiliary end of the frame, will be recorded as a positive reading, movement toward the drive end of the frame will be recorded as a negative reading. Copy Table 5-2 to record readings. Bar over crankshaft by hand and record readings at mid-stroke and with piston at the head end.

TABLE 5-2: PISTON ROD RUN OUT

THROW NUMBER:		1	2	3	4	5	6
VERTICAL	Piston @ CE	0	0	0	0	0	0
	Mid-Stroke						
	Piston @ HE						
HORIZONTAL	Piston @ CE	0	0	0	0	0	0
	Mid-Stroke						
	Piston @ HE						

Compare readings to Table 5-3.

TABLE 5-3: MAXIMUM ACCEPTABLE PISTON ROD RUN OUT READINGS

DIRECTION	JG & JGA	
	INCHES	(mm)
Vertical	0.0010	(0.025)
Horizontal	0.0005	(0.013)

If a vertical reading is greater than the maximum acceptable reading, the following procedure is used to determine acceptability: With the piston at the head end, use feeler gages to determine clearance at the top of the piston. On wear band pistons this clearance is over the band. Feeler top clearance is divided by (÷) 2 and then the following amount is subtracted: (-)0.003 inches (0.08 mm). Place a feeler of this calculated thickness under the bottom of the piston. Place the feeler under the wear band on wear band pistons. This feeler should be long enough to stay under the piston as the piston is moved throughout its stroke. Re-measure vertical run out and compare to acceptable limits in the table above. The horizontal readings, taken without the use of feelers are to be used for acceptance. Copy Table 5-4 and record calculations and readings.

TABLE 5-4: FEELER THICKNESS TO CORRECT FOR PISTON WEIGHT

LINE	THROW NUMBER:	1	2	3	4	5	6
1	Top Feeler Clearance						
2	Line 1 (÷2)						
3	Line 2 - 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)					
4	Bottom Feeler Thickness						
5	Vertical~Piston @ CE	0	0	0	0	0	0
6	Vertical~Piston @ HE						

If readings are not within acceptable limits after replacing worn parts and correcting any piping misalignment, the piston rod assembly should be replaced.

Piston Rings

All JG and JGA cylinders use one-piece angle-cut filled Teflon piston rings, excepting tandem cylinders classes which use stepped seal-joint piston rings (refer to Figure 5-12:), and very small cylinder and rider rings which use two-piece rings.

Stepped seal-joint rings are standard for high-pressure tandem cylinders. Seal-joint piston rings are directional and must be installed properly.

To utilize the seal-joint rings in double acting cylinders, in place of angle cut rings, contact Ariel for new part numbers.



FIGURE 5-12: SEAL-JOINT RINGS

Determining Ring Wear:

Ariel recommends replacing rings when the end gap has increased three times the new dimension. To measure the end gaps, insert the rings in the cylinders without pistons. (See Table 1-6 on page 1-10, through Table 1-10; Table 1-13 and Table 1-14 for new end gap dimensions.)

Removal:

See paragraph 4 at "Piston and Rod - Removal" on page 5-18 for piston ring removal.

Wear Bands

1-3/4JG-FS-HE Class pistons use one, one-piece angle cut filled Teflon wear band.

Determining Wear Band Wear:

Since the wear band does not work as a sealing ring, maximum end gap is not critical. The amount of wear band projection beyond the outer diameter of the piston is important. Wear band projection can be checked by measuring piston to cylinder bore clearance at the bottom of the bore. This can be done without removing the piston from the cylinder. Replace the wear band before it has worn enough to allow the piston to touch the cylinder bore.

Piston Rings - Installation

1. Place the rings over the grooves in the piston. Compress the Teflon one-piece rings by hand.
2. With the rings fully compressed in the grooves, insert the rod and piston into the cylinder. Make sure the rings stay in place while inserting the piston and rod.

NOTE: RING GAPS ARE TO BE STAGGERED AROUND THE PISTON, RATHER THAN IN LINE.

3. Follow the steps under "Piston and Rod - Installation" on page 5-20.

Wear Band - Installation

Install the wear band as if it was another piston ring as above.

Piston Rod Pressure Packing - Removal

1. Remove the piston and piston rod. See "Piston and Rod - Removal" on page 5-18.
2. Remove packing diaphragm and oil wiper packing.
3. Disconnect the lube oil tube and/or coolant connections from the top of the packing gland and the primary vent tube from the bottom of the gland. Remove the twelve point capscrews that hold the pressure packing gland to the cylinder.
4. At this point do not remove the small nuts from the studs. These studs hold the entire packing case together so it can be removed as an assembly.
5. Screw two short 3/8-16 UNC capscrews into the two tapped holes provided in the crank end face of the packing gland. A screwdriver or pry bar under the heads of the capscrews can be used to pull the entire pressure packing out into the crosshead guide. It will then come out through the side opening of the guide. The pressure packing may now be taken to a clean place for disassembly.
6. Set the pressure packing on a clean surface on its nose cup or cylinder end. Three long tie studs hold the pressure packing together. The stud holes are not

equally spaced. This prevents the stack of parts from being aligned incorrectly. Remove the stud nuts and the pressure packing can be un-stacked. Replace these nuts each time the pressure packing is serviced.

7. Ring wear can be determined by placing the assembled rings, (note match-marks), on the piston rod. Check end gap clearance. If the ends butt, or nearly butt, they should be replaced by new rings.
8. Fins or wire edges on the rings due to wear should be carefully filed off so that all matching edges will be square.
9. The metal gasket on the end cup can be pried loose with a sharp awl. Be careful not to scratch the sides of the gasket groove.
10. Before reassembly be certain all parts are perfectly clean.

Piston Rod Packing - Reassembly

1. Be sure to refer to the pressure packing assembly in your parts book. Please contact your distributor if you do not have a parts book. A pressure packing assembly drawing also is packaged with each pressure packing re-build kit.
2. If installing a new set of rod rings in an existing packing case, the case parts need to be inspected for wear. Cups should be smooth and flat on the back side where the rod rings must seal. If the cups or grooves have worn concave or tapered, they should be reground or relapped. It is rarely necessary to alter the crosshead side of the cups, however, if this is found necessary, care must be taken so that the correct side clearance for the renewal rings is not destroyed.

NOTE: IF PREMATURE WEAR IS SUSPECTED, REFER TO THE ARIEL See “Cylinder And Packing Lubrication Requirements” on page 4-5.

3. Before a packing case is installed, it should always be disassembled and thoroughly cleaned in an appropriate solvent for the intended service.
4. Make sure that each rod ring and cup is properly positioned and that rings are liberally coated with a clean lubricant before reassembly. Examine all parts for unusual nicks or burrs which might interfere with the free floating of the rod ring in the cups. Particular care should be taken with rod rings made of soft materials, such as bronze or TFE, and it is extremely important that wiper rings be handled and installed so as to prevent damage to the scraping edges.
5. Parts should be laid out on a work bench so that they can be installed progressively with each in its correct position and the rod rings with their proper faces toward the pressure. Note that all rod ring segments are carefully lettered and must be assembled accordingly. This is most important in order to ensure proper sealing. After the tie stud nuts are tightened, all rings should be free to “float” radially in each cup.
6. For new installations, care must be given to the cleaning of all accumulated dirt in the lines and compressor because foreign material will lodge in the packing to become destructively abrasive.
7. Prior to installing the packing case into the cylinder, the end cup gasket must be inspected for nicks and damage that would cause it to leak in service. When in doubt, replace the gasket with a new one.

8. Before installing the packing case into the cylinder, be sure the gasket surface in the packing counter bore on the crank end of the cylinder is clean and not scratched.
9. Reinstall the complete packing case assembly with the oil supply point on top. Using the rod packing bolts, pull the packing into place.
10. Reinstall the packing diaphragm and wiper packing.
11. Reinstall the piston and rod. Follow the steps under "Piston and Rod - Installation" on page 5-20.
12. After the crosshead nut has been tightened, tighten the rod packing bolts evenly to the recommended torque in Table 1-15 on page 1-15. This procedure will ensure that the pressure packing comes up square on its nose gasket. Alignment is readily accomplished by the use of feelers to maintain a uniform clearance all around between the case bore and the rod.
13. Retighten the small tie stud nuts. Reinstall the tubing connections for the oil supply, primary vent and/or coolant. Take care not to cross-thread the tubing nuts. Tubing nuts must be tight.

NOTE: AFTER INSTALLING THE NEW PRESSURE PACKING RINGS, REFER TO "Force Feed Lubrication System and Running Conditions" on Page 4-19 FOR INSTRUCTIONS FOR PRIMING THE FORCE FEED LUBE SYSTEM. PRIMING SHOULD BE REPEATED EACH TIME A COMPRESSOR IS STARTED BECAUSE OIL LINES MAY HAVE BEEN BLED DURING DOWN TIME. FOLLOW INSTRUCTIONS IN THE NOTE on page 4-10 AND Table 4-1 on page 4-8 FOR LUBRICATION RATES THAT ARE RECOMMENDED FOR BREAK-IN OF A NEW MACHINE. BREAK-IN LUBE RATES ARE TWICE THE NORMAL RATES - OR ONE-HALF THE NORMAL INDICATOR CYCLE TIME.

Types of Piston Rod Packing Rings

Type "P" Pressure Breaker

This is a single ring. It is cut radially into three equal segments. Total end clearance for the ring is 0.022 to 0.028 inches (0.56 to 0.71 mm) for PEEK rings and 0.011 to 0.017 inches (0.28 to 0.43 mm) for bronze and cast iron rings. This ring breaks down or slows the gas flow without sealing it completely. This end gap should be maintained by adjusting the ring gap or replacing the ring. See Figure 5-13:.

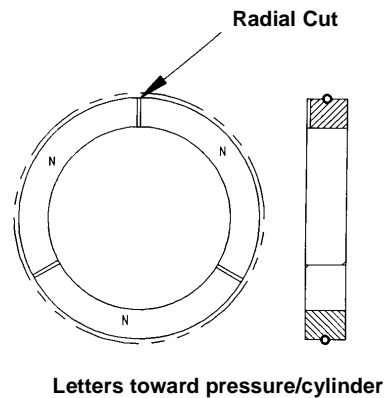


FIGURE 5-13: TYPE "P" PRESSURE BREAKER

Type "BTR" Single Acting Seal Set

This set is made up of three rings. It seals in one direction only. The first ring (pressure side) is radially cut. The installed total end gap is 0.046 to 0.078 inches (1.17 to 1.98 mm) for Teflon and 0.093 to 0.125 inches (2.36 to 3.18 mm) for bronze and Polyimide. The second ring is a tangentially step cut ring. The first two rings are doweled so the cuts are staggered from one ring to the other. The third ring is called a back-up ring and is radially cut. The bore in this ring is larger than the rod diameter. This allows the radial joints to be tight together forming a gas seal. No dowel is necessary for this ring. See Figure 5-14:

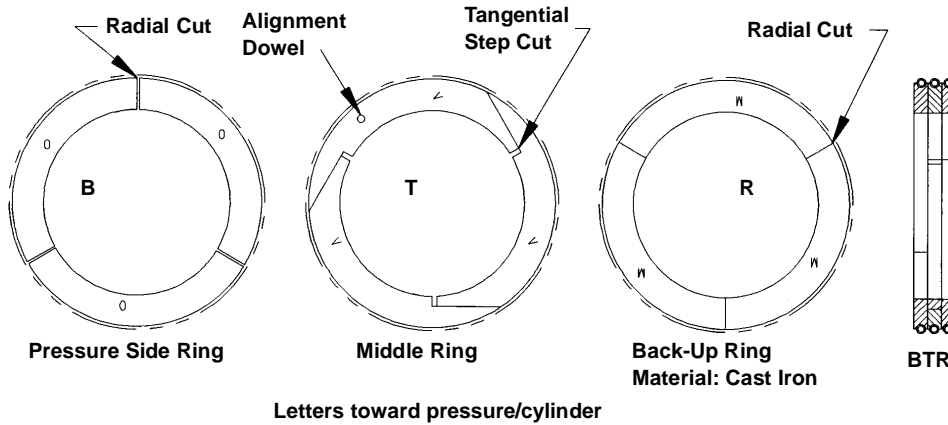


FIGURE 5-14: TYPE "BTR" SINGLE ACTING SEAL SET

Type "AL" Double Acting Seal Set

This set is made up of five rings. The center three are radial cut and the two outboard rings are step-tangent cut. The last two rings on each end are doweled together to stagger the cuts. The center ring, along with the two adjacent rings, form a wedge that overcomes rod friction and forces the set to have constant contact against both groove faces during either direction of rod travel. The installed total end gap is 0.062 to 0.093 (1.57 to 2.34 mm). This ring set is designed for gas purge applications. See Figure 5-15:.

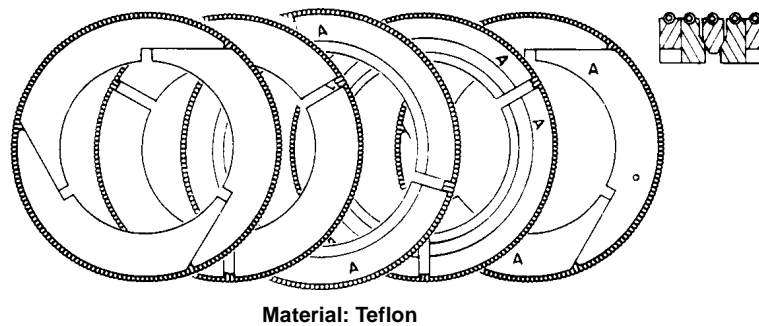


FIGURE 5-15: TYPE "AL" DOUBLE ACTING

Type "BD" Double Acting Seal Set

This set consists of two tangentially step cut rings. The rings are doweled so the tangential cuts are staggered from one ring to the other. The installed total end gap is 0.046 to 0.078 inches (1.17 to 1.98 mm) for Teflon and 0.093 to 0.125 inches (2.36 to 3.18 mm) for bronze and Polyimide. The set is double acting in that it will seal in either direction. It is used in cylinders operating near atmospheric pressure to prevent air from entering the cylinder. Install with the match mark letters facing the pressure. See Figure 5-16:

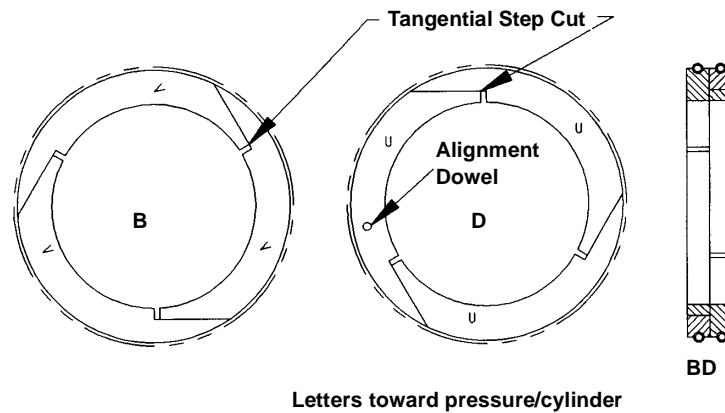


FIGURE 5-16: TYPE "BD" DOUBLE ACTING

Type "3RWS" Oil Wiper Set

This set uses three radial cut rings. They are doweled to provide a staggered arrangement. Their purpose is to keep crankcase oil out of the packing and cylinder. Assemble with the blank face towards the oil (crankcase) and the slotted side towards the pressure packing. See Figure 5-17:

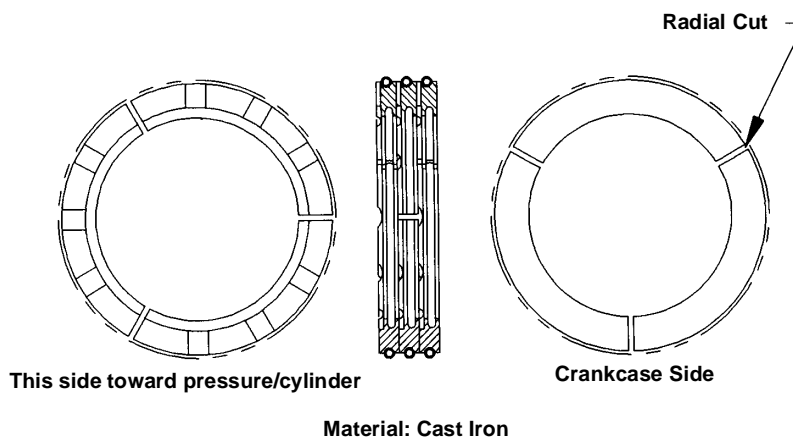
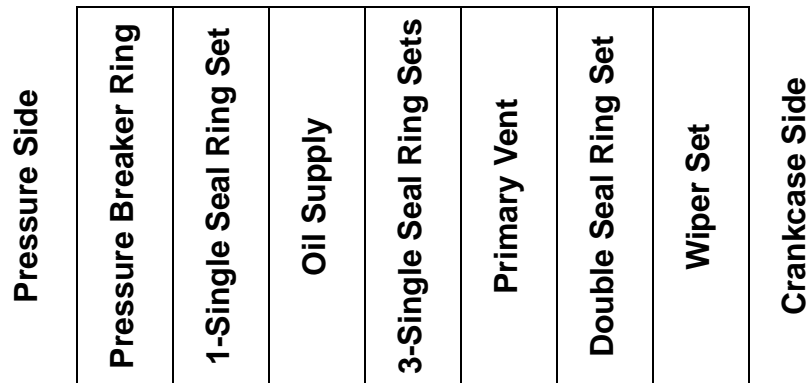


FIGURE 5-17: TYPE "3RWS" WIPER SET

Typical Arrangement of Piston Rod Packing Rings

The general arrangement of the oil supply, seal ring and vent locations is shown below:



The oil wiper rings and a seal ring set are carried on a separate diaphragm in the crosshead guide when a “two compartment distance piece” is supplied.

NOTE: REFER TO THE PACKING ASSEMBLY IN YOUR PARTS BOOK. SEE PAGE 4-21 FOR PACKING TUBING AND DISTANCE PIECE VENTING AND PAGE 4-22 FOR PACKING LUBRICATION AND VENTING.

Piston Rod Packing Ring Material

In the past, bronze was the standard material for Ariel packing rings. Bronze, however, is unsatisfactory for sour gas service, (hydrogen sulfide in the gas). PEEK, cast iron and Teflon provide outstanding service with sour gas, and since they perform equally well with sweet gas, they are now the standard materials.

A typical packing will have a PEEK pressure breaker, Teflon/cast iron single acting rings, all Teflon double acting rings, and a cast iron wiper set. The Teflon is glass reinforced and impregnated with molybdenum disulfide. This provides a strong, slick material to reduce friction and wear.

Valves

CAUTION

BEFORE ATTEMPTING TO REMOVE ANY VALVE CAP, BE CERTAIN THAT ALL PRESSURE HAS BEEN VENTED FROM THE COMPRESSOR CYLINDER. THE PRESSURE MUST BE COMPLETELY VENTED FROM BOTH THE SUCTION AND DISCHARGE PASSAGES OF THE CYLINDER. SEE FIGURE 1-3: ON PAGE 1-3 FOR LOCATION OF IMPORTANT SAFETY INFORMATION PLATES.

Valves - Removal

1. Slightly loosen all of the bolts on each valve cap. With all the bolts loose, the cap should stay in its original position. If it pushes out on its own accord-stop! Take steps to completely vent the cylinder. See Caution above. A typical valve assembly is shown in Figure 5-18: on Page 5-33.
2. After all the above safety checks, remove the valve cap bolts. A pair of prybars (or screwdrivers), one on each side of the cap, will help pry it loose. With the retainer still in place, screw a valve tool over the valve center bolt. See Figure 7-1: on page 7-3. Now the valve and retainer can be pulled out together. For cylinder class 1-3/4JG-FS-HE and 2-1/2JG-FS-HE tandem cylinders, the suction and discharge piping and cylinder head must be removed to gain access to the concentric valve. A concentric valve combines the suction and discharge valves in one assembly. See Caution at "Piston and Rod - Removal" on page 5-18.
3. In most cases the flat metal gasket will remain in the pocket. It is difficult to see. A flashlight and a small mirror on an adjustable rod are the best tools to see the gasket clearly. On cylinders with horizontal valves, the gasket may fall into the gas passage. A small magnet on a flexible extension rod will help fish it out. This gasket should be replaced after several uses.

Valves - Maintenance

Ariel uses valves manufactured by Hoerbiger Corporation. Before servicing any valve refer to the correct valve assembly drawing and parts list and Hoerbiger's literature in the Parts Book. On the valve assembly drawing you will notice that valves have different springing for different pressure levels. The cylinder cover sheet in the Parts Book lists the valve originally supplied with each cylinder. If different operating pressures are encountered, then different springs may be required.

The suction valve must be selected on the basis of operating suction pressure and the discharge valve for operating discharge pressure. Proper valve spring selection is also based

upon the operating speed (RPM), gas specific gravity and the suction temperature of the gas.

Contact Ariel in Mount Vernon, for assistance in valve selection.

Valves - Reassembly

1. The 1/32 inches (0.8 mm) thick soft metallic flat gasket should be coated with an anti-seize lubricant. It can then be either inserted into the valve pocket or stuck onto the valve. In either case, care must be taken to keep this gasket from falling into the gas passage.
2. The retainer keeper is a plastic thumb screw in a threaded hole in the bottom valve retainers. This should be screwed through just far enough to provide friction so that bottom retainers will not fall out while the cap is being installed.
3. Using the Valve Tool illustrated in Figure 7-1: on page 7-3, the valve and the retainer may be inserted into the pocket together. When installed correctly, the distance from the outer retainer face to the surface of the valve boss on the cylinder will be 1/8 inches (3 mm) shorter than the length of the nose on the valve cap.
4. Inspect the valve cap O-ring for cuts or gashes and replace it if necessary. Lubricate the O-ring and the nose of the valve cap. Some high pressure cylinders use a soft metallic wire gasket in lieu of the O-ring design. Insert the cap and tighten the bolts evenly to the recommended torque in Table 1-15 on page 1-15. See "Bolt Tightening for Valve Caps" on page 5-33. If the assembly is correct, the distance from the underside of the cap to the valve boss surface on the cylinder will be 1/8 inches (3 mm).

NOTE: BE CERTAIN ALL PARTS, GASKET FACES, AND MATING SURFACES ARE ABSOLUTELY CLEAN AND ALWAYS USE CLEAN, FRESH OIL ON THE THREADS BEFORE REINSTALLING BOLTS.

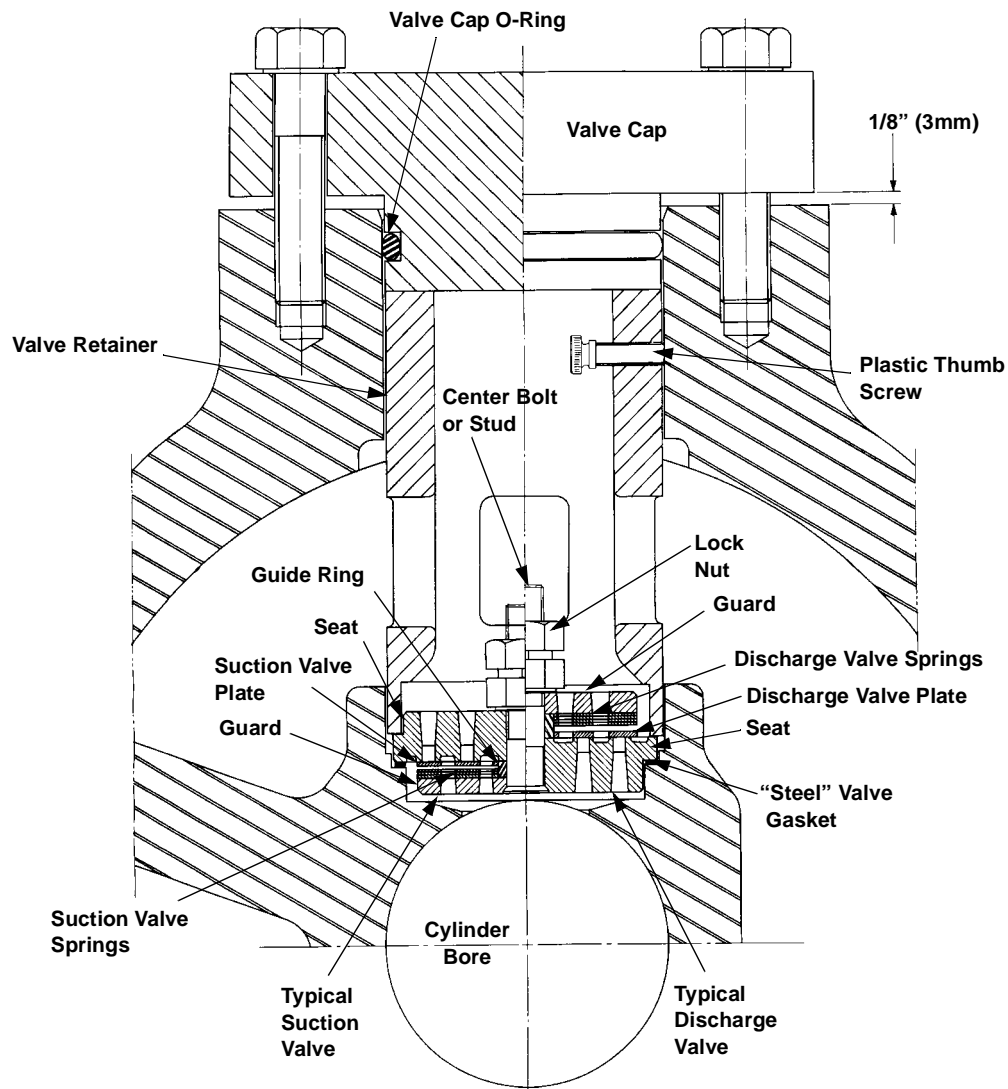


FIGURE 5-18: TYPICAL VALVE ASSEMBLIES

Bolt Tightening for Valve Caps

Proper fastener tightening technique is essential for sealing of valve caps with soft metallic wire gaskets used in some high pressure cylinders. It is important to draw up bolting to full torque in even and gradual steps. Do not allow the valve cap to be tightened with bias on one bolt or to become cocked in the bore. Such bias or cocking can cause uneven crush of the gasket, which could cause a leak and could also cause bolt failure. This step tightening procedure is also recommended for all valve caps.

Install the valve assembly (and high clearance spacer, when applicable), with the flat gas-kets) and valve retainer, in the valve pocket. See "Valves - Reassembly" on page 5-32. For

high pressure applications, place a new, proper, soft metallic wire gasket on the retainer and install the valve cap. Be careful not to gouge the bore, distort or damage the wire gasket. Always use a new metallic wire gasket; wire gaskets are not reusable.

Lubricate threads and bolt seating surfaces with petroleum type lubricant, and install bolts. Do not use anti-seize compounds on valve cap bolting. Tighten each bolt until snug using a criss-cross pattern. Next, tighten each bolt to 25% of full torque, moving across from bolt to bolt, in a criss-cross pattern. See Figure 5-19: 1-2-3-4-5. Repeat this step for 50%, 75% and 100% of full torque.

Proper tightening and torquing is important for all valve caps, but is especially important for high pressure valve cap assemblies. High pressure applications have caution plates on the cylinder which are stamped with proper torque values:

⚠ CAUTION

SEVERE PERSONAL INJURY AND PROPERTY DAMAGE CAN RESULT IF VALVE CAP BOLTING IS NOT INSTALLED TO PROPER TORQUE OF _____ FT. LBS. _____ N-m.

REFER TO TECHNICAL MANUAL FOR PROPER TORQUING PROCEDURE.

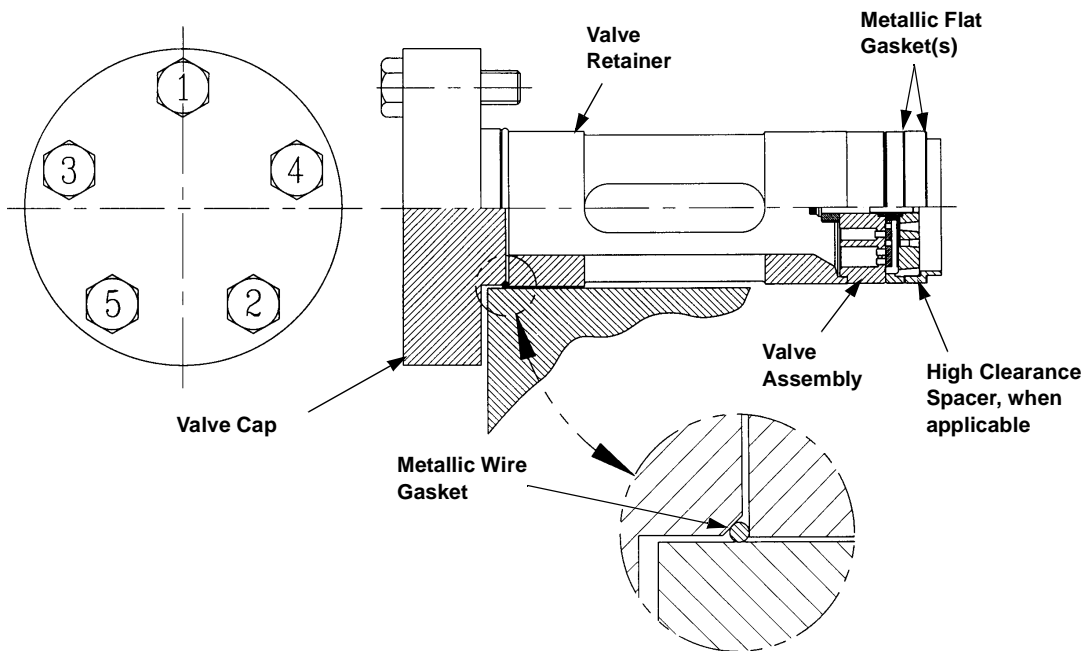


FIGURE 5-19: HIGH PRESSURE VALVE CAP ASSEMBLY

VVCP - Variable Volume Clearance Pocket Head End Unloader

Removal

Disconnect the VVCP packing vent. Remove the VVCP from the cylinder using similar procedures as when removing a cylinder head. The approximate weights of VVCP's for handling purposes can be found in the Ariel Data Book.

Disassembly

Unsnap the thread protector bellows from the slot in the hand wheel. With the locking handle locked, remove locknut and hand wheel. A hammer or puller may be required to break hand wheel to stem tapered fit. Loosen locking handle and unscrew to remove handle. Remove socket head screws at inside of bolt flange and separate the halves of the VVCP. Unscrew the VVCP stem and piston assembly to remove.



CAUTION

TRAPPED GAS PRESSURE CAN PRESENT A PERSONAL SAFETY HAZARD WHEN SERVICING THE VVCP. WORK IN A WELL VENTILATED, NON SPARKING AREA. DO NOT BREATHE GAS OMMITTED FROM VVCP WHEN VENTING TRAPPED GAS.

Maintenance

To replace or clean the VVCP packing, remove the bolts and flange that hold the packing in place and remove the packing. Replace the VVCP packing when excessive leakage is noted at the vent. Remove the VVCP piston ring; replace as necessary.

Clean all parts to remove all debris, rust, etc. The stem and piston are permanently pinned, do not attempt to disassemble.

Reassemble the VVCP in reverse order, using a new O-ring at the bolt flange. While the torque used for the socket head bolting is not critical, these bolts must be sufficiently tight to prevent loosening during service. Be sure that thread protector bellows are properly aligned when installing hand wheel. Lubricate stem with 3-4 pumps of all-purpose petroleum grease with a hand pump grease gun at the grease fitting.

To re-install the VVCP on the cylinder, use a new head gasket. Lubricate threads and bolting seating surfaces with petroleum type lubricant and install bolting. Tighten each cap

screw until snug using a criss-cross pattern. Next tighten each cap screw to 25% of full torque, moving from cap screw to cap screw in a criss-cross pattern. Repeat this step for 50%, 75% and 100% of full torque. See Table 1-15 on page 1-15 for tightening torque value. Reconnect VVCP packing vent. When installing a new VVCP, check total piston end clearance and re-set crank end/head end feeler clearances with VVCP completely closed. See Table 1-2 on page 1-8 for clearances.

Adjustment

VVCP clearance volume may be changed with the compressor running or stopped. Consult the Packager's instructions regarding where to set the VVCP. Also reference the VVCP data sheet in the Ariel Technical Manual Parts Book.

The VVCP piston ring is designed not to be gas tight, to allow a nearly balanced gas pressure for ease of VVCP adjustment with the cylinder pressurized. Gas pressure behind the VVCP piston normally vents when cylinder is vented. Process debris or rust around the piston ring can make a seal that takes some time to vent. If gas is trapped behind the piston, the VVCP can be adjusted when the cylinder is pressurized, but difficult to turn when the cylinder is vented. This problem is corrected by disassembling the VVCP and cleaning.

To adjust the volume, loosen the stem locking handle, so that stem is free to turn. Turn the stem by use of the hand wheel on the outboard end of the shaft. Turn hand wheel clockwise to load; counterclockwise to unload. Re-tighten the stem locking handle to 150 lbs-ft (203 Nm) torque.

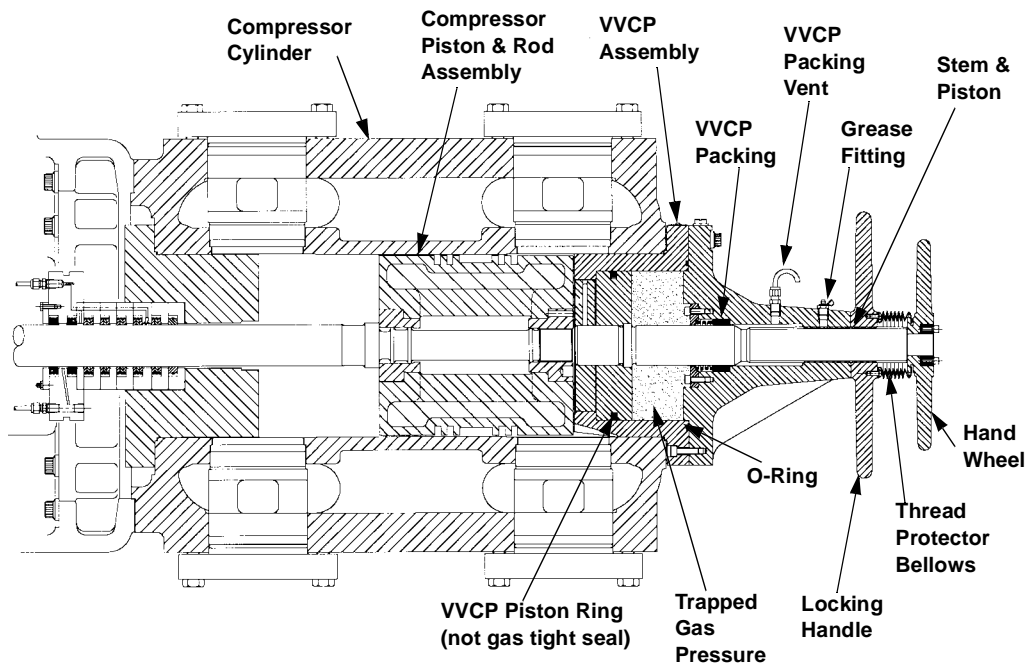


FIGURE 5-20: CYLINDER WITH VVCP - TYPICAL

Water-Cooled Compressor Rod Packing

When any disassembly of water-cooled rod packing cases is required, proper re-assembly and testing is required. This is to ensure that the cases do not leak.

Re-assembly

Cases are lapped, and care must be taken to prevent scratching of the mating surfaces of the cups. Scratches can cause significant leakage problems.

The cups are numbered on the outside diameter and are to be assembled in consecutive order, starting with the end cup. The studs are offset so the cups will only fit one way.

Make sure the tie studs are completely screwed into the end cup. Put the proper ring in the groove and facing the proper direction. Be careful when sliding parts onto the tie studs to ensure that no scratching occurs to the lapped faces.

Install second cup next, put the rings into place, and make sure the two (2) small O-rings are in place around the coolant holes.

Continue assembling the remaining parts in the proper configuration to the packing case drawing. In consecutive order, by repeating the above step.

Install tie stud-nuts and tighten to the values given in Table 1-15 on page 1-15. Using fingers, make sure that all rings move freely, radially, in their grooves. Side loaded AL rings will be snug, but should still move using fingers.

Testing

100% verification of function is required for all internal passages.

The passages are to be checked by blowing compressed air thru the connection taps on the flange and verifying that air is exiting at the proper holes. When air is applied to the connection tap stamped "Coolant In", air should be exiting the connection tap stamped "Coolant Out", or if air is applied to the tap stamped "Lube", air should be exiting at the appropriate cup on the inside diameter of the case.

Pressure leak test packing cases as follows:

- 1 Plug the "Coolant Out" connection>
- 2 Apply 60 to 100 psi (400 to 700 kPa) dry, compressed air pressure to the "Coolant In" connection. For water cooled rod packing cases in non-lube service, compressed air is to be oil free. Air should exit at connection tap "Coolant Out". Air applied to the tap stamped "Lube" should exit at the appropriate cup on the inside diameter of the case.
- 3 Plug the "Coolant Out" connection and apply 60 to 100 psi (400 to 700 kPa) dry, compressed air pressure to the "Coolant In" connection through a ball valve with a calibrated pressure gauge located between the ball valve and packing case. Close the ball valve and disconnect the air supply. There should be no pressure drop for 5 minutes minimum.
- 4 If water cooled packing cases are used in lubricated applications, leak testing may be done by submersing the packing case in oil with 10 to 100 psig (400 to 700 kPa) test air pressure. After the air trapped in the ring grooves has been

released, there should be no continuous stream of bubbles coming from the pressurized case.

- 5 Cases which fail this testing procedure are to be disassembled, inspected, repaired, re-assembled and re-tested. Packing cases may be bolted into place in a cylinder head to aid sealing, using proper bolting and tightening torques.

All cylinders with water-cooled packing must be connected to a circulating water cooling system that will provide the required flow, pressure drop, inlet temperature and heat rejection, unless prior approval is obtained from Ariel to leave it unconnected.

Ethylene Glycol Contamination

Ethylene glycol contamination of a compressor can result from water-cooled compressor rod packing or oil cooler.

Ethylene glycol anti-freeze coolant mixture leaking into the compressor frame crankcase oil can cause crankshaft seizure due to lack of adequate lubrication. Crankcase oil should be changed as recommended in "Recommended Maintenance Intervals" on Page 6-1 Also, crankcase oil should be routinely sampled and analyzed by a qualified laboratory to verify suitability for continued use, including checking for ethylene glycol contamination.

Even small quantities of ethylene glycol in the oil can be detrimental. If contamination is less than 5%, drain oil, replace filters and flush oil system with a 50-50 mixture of butoxyethanol (Dow Chemical Company Dowanol EB or equivalent) and 10W oil using a motor driven pump. Flushing should be done on a warm compressor. Bearings should be continuously flushed for 1/2 hour while barring over compressor. All surfaces that come in contact with crankcase oil are to be flushed, including spraying all interior surfaces in the crankcase. Completely drain cleaning mixture, being sure to drain all components of the oil system. Repeat flushing operation using a 60/40 mixture of 10W oil and kerosene or fuel oil. Completely drain the system, install new filters and fill the crankcase with proper oil. The source of the coolant leak must be found and repaired.

If sampling indicates ethylene glycol contamination greater than 5% or if the compressor has seized due to contamination, the unit must be disassembled, cleaned with 100% butoxyethanol, flushed with kerosene or fuel oil and repaired as required. All surfaces that come in contact with crankcase oil must be cleaned with butoxyethanol, including all passages and piping, and then flushed with kerosene or fuel oil. Oil and filters must be changed. The source of the coolant leak must be found and repaired.

Butoxyethanol presents health and safety hazards. Use proper eye and shin protection and adequate ventilation. Do not use near open flame or sparks. See manufacturer's Material Safety Data Sheet for complete details.

Ethylene glycol, butoxyethanol, contaminated oils and solvents must be properly disposed. A qualified chemical disposal service should be used.

Cleaning Non-Lube Compressor Cylinder Components

Complete non-lube cylinders ordered and shipped from Ariel are provided cleaned and protected to non-lube service requirements. Internal parts shipped loose, contaminated internal surfaces and all repair parts are to be cleaned prior to installation, thus providing long life of non-lube compressors and extending life of rings.

Clean the cylinder bore thoroughly with denatured alcohol until a clean, alcohol soaked, white "Bounty" paper towel does not remove any more debris. This includes all surfaces of the bore, counter bore, valve pockets, etc.... Do not use Never-Seize on the crank-end-head steel gasket. Very lightly oil valve cap, crank end and head end threaded bolt-holes; prevent oil from getting inside the cylinder. If the cylinder in an O-ring seal, apply only a very light film of oil to the cylinder seating surface to seal the O-ring.

Denatured alcohol presents health and safety hazards. Keep away from heat, sparks, flame and all other ignition sources. Use adequate ventilation, neoprene or butyl gloves, mono-goggles or face-mask and impermeable apron. Denatured alcohol contains methyl alcohol which is poisonous if ingested. Avoid eye contact. Materials resulting from clean-up are to be handled and disposed in a proper manner. See manufacturer's Material Safety Data Sheet for more information.

Use very small amounts of Never-Seize on the nut and collar when assembling the piston assembly.

Thoroughly clean the piston with denatured alcohol until a clean, alcohol soaked towel does not remove any more debris. This includes cleaning the ring grooves exceptionally well.

Disassemble the packing case, wipe all surfaces clean with denatured alcohol and re-assemble. When the packing case is water-cooled, re-assemble and test to "Water-Cooled Compressor Rod Packing" on page 5-37. Thoroughly dry packing case with warm air, such as with a hair dryer. Handle cleaned parts with new or clean "rubber" or new white cotton gloves.

Before installing the piston rod into the unit, wipe the piston rod with denatured alcohol. Be careful not to leave any fingerprints on the rod before it contacts the packing case rings.

Make sure the piston rod is wiped down with denatured alcohol after the rod is installed.

Clean the head end head or unloader components with denatured alcohol. Use small amounts of oil for the bolt holes to make sure the oil does not run down into the cylinder. Also install the head end steel gasket without Never-Seize.

The valves should be disassembled, cleaned with denatured alcohol, re-assembled, wiped down again, and installed. Clean the retainers and high clearance assemblies with denatured alcohol. Use only a thin film of oil for the valve cap O-rings and bolt holes. Do not lubricate valve steel-gaskets.

Cleaned parts are to be assembled immediately to avoid contamination and corrosion. If cylinder is not to be put into immediate service, contact Ariel (see "Ariel Telephone, Fax, E-Mail and Web Site Numbers" on page 7-10.) for preservation instructions to ER-34.

Use a small amount of Loctite 565 Pipe Sealant on male threads when installing pipe plugs.

NOTES

SECTION 6 - TECHNICAL ASSISTANCE

Recommended Maintenance Intervals

Like all equipment, Ariel compressors do require maintenance. The frequency of maintenance is dictated by the environment in which the compressor is placed, the loads the user imposes on the compressor and the cleanliness of the gas.

First and foremost on the preventative maintenance list is the completion and compliance with the Ariel Corporation Packagers Standard and Compressor Start Up Check List. All items must be adhered to, both before and after start up.

The following is a guide only and, as stated above, may vary due to operating conditions. The time intervals start from the start up date of the unit. If your oil supplier's recommended oil service changes are more frequent than the Ariel recommendation, the supplier's intervals should be followed. Regular oil analysis is recommended. If problems develop, the oil should be changed immediately and the cause of the problem determined and corrected.

A log book should be kept with each unit. Every maintenance item can be recorded with exacting detail in order that records will be available for tracking maintenance cost per unit and for trouble-shooting.

Operator logs should be reviewed by qualified personnel to determine trends in compressor performance and/or maintenance.

Daily (see www.arielcorp.com for latest Recommended Maintenance Intervals, ER-8.2)

1. Check frame oil pressure. It should be 50-60 PSIG (350-420 kPa) when at operating temperature. Compressor inlet oil temperature is 190°F (88°C) maximum.
2. Check frame oil level. Oil should be visible at approximately mid-level in the sight glass when the compressor is running. If not, determine and correct the problem. Do not overfill. Check oil makeup tank for sufficient oil supply.
3. Check lubricator block cycle movement indicator. Refer to information plate on top of lubricator box for correct cycle time. Very dirty or wet gas may require a more frequent cycle time than normal.
4. Check primary and secondary packing vents for blowing. If blowing, determine cause and, if necessary, replace packing internal parts.
5. Check and correct any gas leaks.
6. Check and correct any oil leaks.
7. Check operating pressure and temperatures. If not normal, determine cause of abnormality. It is recommended that a daily log of operating temperatures and pressure be kept for reference.
8. Check shutdown set points.

9. Low oil pressure shutdown is 35 psi (240 kPa) minimum.
10. High temperature shutdown to be set within 25°F (14C) of actual operating temperature.
11. High-low pressure shutdowns set as close as practical. Consideration should be given to rod load capacity of machine.
12. Check lubricator box oil level.
13. Check for unusual noises or vibrations.
14. If balance valves are used in the force feed lube system, readjust as required to keep pump systems pressure balanced (refer to “Force Feed Balance Valves” on page 4-21).

Monthly (in addition to Daily Requirements)

1. Check and confirm safety shutdown functions.
2. For cylinders rated greater than 3500 psi (24 000 kPa), remove cylinder heads and check cylinder for oil presence to verify lubrication is adequate.

Every 6 Months or 4,000 Hours (plus Daily/Monthly)

1. Drain and replace lubricator box oil.
2. Change oil filter or when differential pressure exceeds 10 psi (70 kPa).
3. Change oil. A more frequent oil change interval may be required if operating in an extremely dirty environment or if the oil supplier recommends it or if an oil analysis dictates it. A less frequent oil change interval may be allowed if the oil is replenished on a regular basis due to force feed lubricator usage.
4. Clean the sintered element in the small oil filter supplied on the force feed lubrication system. This filter should also be cleaned every time the main oil filter is changed.
5. Clean oil strainer when oil is changed.
6. Open frame when oil is changed and visually inspect for foreign material. Disassembly is not recommended unless a reason for it is identified.
7. Re-tighten hold down stud-nuts to proper torque values and perform a soft foot check. More than 0.002 inches (0.05 mm) pull down requires re-shimming. If re-shimming is required, realign if necessary to hold coupling alignment within 0.005 inches (0.13 mm) TIR.
8. For cylinders rated greater than 3500 psi (24 000 kPa), inspect piston ring end gap, and when applicable wear band end gap and radial projection. Replace piston rings and wear bands that are outside the maximum limit listed in Table 1-6, Table 1-8, Table 1-9, Table 1-11 and Table 1-13 and before piston contacts the cylinder bore.

Yearly or 8,000 Hours (plus Daily/Monthly/6 Months)

1. Check main bearing clearance, connecting rod bearing clearance, and crank thrust clearance with a bar and indicator. If outside the limits listed in Table 1-2 on page 1-8, replace the affected bearings.
2. Check crosshead guide clearance with feelers, and if outside the limits listed in Table 1-2 on page 1-8, replace the affected parts.

3. Inspect valves for broken plates and loose center bolts, replace broken parts and tighten center bolts to torque values listed in Table 1-16 on page 1-18.
4. Inspect cylinder bores for damage or wear. If gouged, so that the total cross sectional area of the gouges is greater than 0.001 square inches per inch of cylinder circumference ($0.025 \text{ mm}^2/\text{mm}$ of cylinder circumference), cylinder should be replaced or re-bored to a maximum of 0.020 inches (0.50 mm) oversize. The cylinder should also be replaced or re-bored if the bore is more than 0.001 inches per inch of cylinder diameter ($0.001\text{m}/\text{m}$ of cylinder diameter) out of round or tapered.

NOTE: REBORING REMOVES NITRIDED SURFACE OF CYLINDER BORE. CONTACT ARIEL FOR RE-NITRIDING.

5. Inspect piston ring end gap. Replace piston rings that are outside the maximum limit listed in Table 1-6, Table 1-8, Table 1-9 and Table 1-13.
6. Inspect piston rods for damage and excessive wear. If gouged or scratched, replace the rod. If the rod is more than 0.005 inches (0.13 mm) under size, out of round more than 0.001 inches (0.03 mm), or tapered more than 0.002 inches (0.05 mm), replace the rod.
7. Rebuild cylinder packing cases.
8. Inspect for frame twist or bending by checking shimming of compressor feet.
9. Realign if necessary to hold coupling alignment within 0.005 inches (0.13 mm) TIR.
10. Check and re-calibrate all temperature and pressure gauges.
11. Check and record compressor rod run out.
12. Grease VVCP unloader stem threads at grease fitting, with 2 to 3 pumps of multi-purpose grease using a standard hand pump grease gun.
13. Clean crankcase breather filter.
14. Adjust drive chains.
15. Pressure test the force feed lubrication distribution block(s).

Every 2 Years or 16,000 Hours (plus Daily/Monthly/6 months/yearly)

1. Check auxiliary end chain drive for sprocket teeth undercutting and chain for excessive stretching.
2. Rebuild oil wiper cases.

Every 4 Years or 32,000 Hours (plus Daily/Monthly/6 Months/1/2 Years)

1. Check main and connecting rod bearing clearances by using an indicator and a pry bar. Disassembly to check clearances is not recommended. Disassembly should be performed if the pry bar check indicates excessive clearance.
2. Check crosshead guide clearances with feeler gauges.
3. Check crosshead pin to crosshead pin bore and connecting rod bushing bore by removing crosshead pins.
4. Check for excessive wear in the auxiliary end drive chain tightener.

5. Check for excessive ring groove wear in pistons.

Every 6 Years or 48,000 Hours (plus Daily/Monthly/6 Months/1/2/4 Years

1. Replace main and connecting rod bearing shells and bushings.
2. Replace lubricator distribution blocks.
3. Replace crosshead bushings.
4. Replace DNFT.

Trouble Shooting

Minor problems can be expected during the routine operation of an Ariel compressor. These troubles are most often traced to liquid, dirt, improper adjustment or to operating personnel being unfamiliar with Ariel compressors. Difficulties of this type can usually be corrected by cleaning, proper adjustment, elimination of an adverse condition, replacement of a relatively minor part or proper training of the operating personnel.

Major problems can usually be traced to long periods of operation with unsuitable lubrication, careless operation, lack of routine maintenance or the use of the compressor for purposes for which it was not intended.

Recording of the interstage pressures and temperatures on multistage units is valuable because any variation, when operating at a given load point, indicates trouble in one of the stages. Normally, if the interstage pressure drops the trouble is in the lower pressure cylinder. If it rises, the problem is normally in the higher pressure cylinder.

While it would be impossible to compile a complete list of every possible problem, listed below are some of the more common ones with their possible causes.

Problem	Possible Causes
Low Oil Pressure	Oil pump failure. Oil foaming from counterweights striking oil surface (oil level too high). Cold oil. Dirty oil filter. Interior frame oil leaks. Excessive leakage at bearings. Improper low oil pressure switch setting. Oil pump relief valve set too low. Defective pressure gauge. Plugged oil sump strainer. Improper end clearance in oil pump.

Problem	Possible Causes
Noise in Cylinder	Loose piston. Piston hitting cylinder head end head or crank end head. Loose crosshead balance nut. Broken or leaking valve(s). Worn or broken piston rings or wear bands. Valve improperly seated or damaged seat gasket. Liquids in cylinder.
Excessive Packing Leakage	Worn packing rings. Improper lube oil and or insufficient lube rate. Dirt in packing. Packing rings assembled incorrectly. Improper ring side or end gap clearance. Plugged packing vent system. Scored, tapered or out of round piston rod. Excessive piston rod run-out. Packing not seated or properly run in.
Packing Over Heating	Lubrication failure. Improper lube oil and/or insufficient lube rate. Worn packing rings. Dirt in packing. Improper ring side or end gap clearance. Scored, tapered or out of round piston rod. Excessive piston rod runout.
Excessive Carbon on Valves	Excessive lube oil. Improper lube oil. Oil carry-over from inlet system or previous stage. Broken or leaking valves causing high temperature. Excessive temperature due to high pressure ratio across cylinders.
Relief Valve Popping	Faulty relief valve. Leaking suction valves or rings on next higher stage. Obstruction, bind or valve closed in discharge line.
High Discharge Temperature	Excessive ratio across cylinder due to leaking inlet valves or rings on next higher stage. Fouled intercooler piping. Leaking discharge valves or piston rings. High inlet temperature. Improper lube oil and or lube rate.
Frame Knocks	Loose crosshead pin or pin caps. Loose or worn main, crankpin or crosshead bearings. Low oil pressure. Cold oil. Incorrect oil. Knock is actually from cylinder end. Low fluid level in damper.
Drive End of Crankshaft Oil Leak	Clogged vent or vent piping. Excessive cylinder packing leakage.

Problem	Possible Causes
Piston Rod Oil Wiper Leaks	Worn wiper rings. Wipers incorrectly assembled. Worn/scored rod. Improper fit of rings to rod/side clearance.
Force Feed Lube No-Flow Shutdown	Blockage causing blow-out disk to vent. Force feed filter(s) dirty. Force feed pump failure. Distributor block failure. Loss of force feed oil supply to pump. DNFT failure. Oil injection point check valve failure.

SECTION 7 - APPENDICES

Ariel Tools

Ariel Furnished Tools

Ariel provides one tool box with each unit with tools included in the box as listed below (see Figure 7-1:).

- Peg Wrench for Round Crosshead Nuts 3/4" Diameter (A-0076)
- Open End Wrench for Hex Crosshead Nuts 2" (B-0016)
- Ratchet Extension Support (B-1240)
- 1/4" x 3/8" UNF Valve Tool for Installing or Removing Valves (A-0409)
- 5/16" x 1/2" UNF Valve Tool for Installing or Removing Valves (A-0135)
- Piston Nut Spanner for 3/4" Square Drive Ratchet (A-0279)
- Piston Turning Tool for 9/16" socket (A-1678) provided with small tandem cylinders only
- Crank End Clearance Setting Tool 0.035" (0.89 mm) special tool provided for 2-3/4M, 3M, 2-3/4P-CE and 3-14P-CE class cylinders only (A-8159)
- Torque Chart (D-2159)

Ariel provides these tools with every compressor. Please contact your Distributor if you do not have these tools.

These tools are specifically designed for use on Ariel units. Clean all tools before use. Ensure that the tool and the part being removed or installed are fully engaged during the process. If a tool is missing, worn or broken, please call your distributor for a replacement. Do not use substitute, worn or broken tools.

Also included in the tool box are standard commercial tools as follows:

- Allen Wrenches: 3/32", 1/8", 9/64", 5/32", 3/16", 1/4", 5/16" & 3/8"

Ariel Optional Tools

- Piston and Rod Clamping Fixture (D-0961) (see Figure 5-11: on page 5-19)
- Force Feed Lubricator Bearing Housing Spanner Wrench (A-8158)
- Force Feed Lubrication Hand Purge Pump (G-7162)
- Piston Rod Entering Sleeve (A-8561)

Minimum Hand Tools Required

The following hand tools are normally all that is required to work on Ariel JG and JGA compressors. These are in addition to the Ariel furnished and optional tools listed above. Please contact Ariel if you have any questions about tools for Ariel units.

- 3/8" Square Drive Ratchet Wrench
- 1/2" Square Drive Ratchet Wrench
- 2" and 6" Extensions for above Ratchet
- 3/8" Square Drive Breaker Bar
- 1/2" Drive Speed Wrench
- 1/2" Female x 3/4" Male Adaptor
- 3/8" Square Drive Universal Joint
- 3/8" Square Drive Torque Wrenches (10 LB-IN to 250 LB-IN)
- 1/2" Square Drive Torque Wrenches (15 LB-FT to 250 LB-FT)
- Set of 12 Point Sockets for a 3/8" Square Drive
- Set of 12 Point Sockets for a 1/2" Square Drive
- 3/8" Hex Key and 1/4" Hex Key (Allen) Sockets for a Square Drive Ratchet Wrench
- 5/16" - 12 Point Box Wrench
- 1/2" x 9/16" Open End Wrench
- 3/8" x 7/16" Open End Wrench
- 12" Adjustable Wrench
- 2 - Medium Size Screw Drivers
- Babbitt or Plastic-Faced Slugging Hammer
- Feeler Gage Pack
- Awl

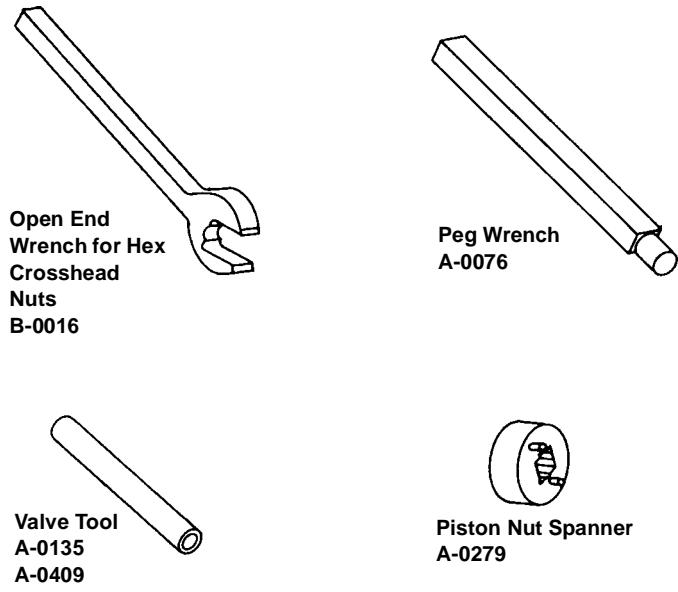


FIGURE 7-1: ARIEL TOOLS

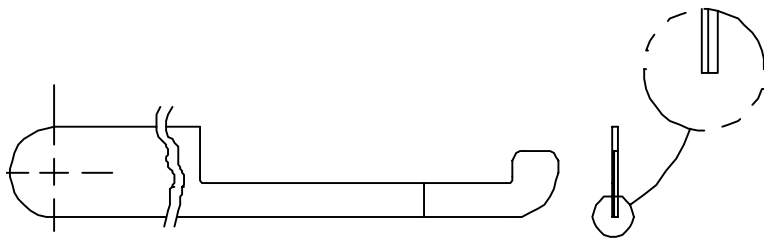


FIGURE 7-2: CRANK END SETTING TOOL 0.035 IN. (0.89 mm) (A-8561)

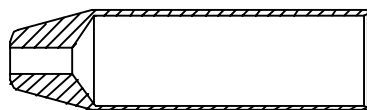


FIGURE 7-3: OPTIONAL PISTON ROD ENTERING SLEEVE (A-8561)

Terms, Abbreviations¹ and Conversion to SI Metric²

Area

in² or square inch x 0.00064516 = meter², or m²

in² or square inch x 6.4516 = centimeter², or cm²

Flow - Gas

MMSCFD or million standard cubic feet per day (at 14.696 psia & 60°F) x 0.310 = normal meter³/second (at 1.01325 bar & 0°C), or m_n³/s

SCFM or standard cubic feet per minute (at 14.696 psia & 60°F) x 1.607 = normal meter³/hour (at 1.01325 bar & 0°C), or m_n³/h

Flow - Liquid

GPM or US gallons per minute x 0.0630902 = liter/second, or L/s = dm³/s

GPM or US gallons per minute x 0.227125 = meter³/hour, or m³/h

Force

lbf or pound (force) x 4.44822 = Newton, or N

Heat

BTU or British Thermal Units x 1.05506 = kilojoule, or kJ

Length

in. or " or inches x 25.4000 = millimeters, or mm

ft or feet x 0.304800 = meter, or m

Mass

lb or pound (mass) x 0.453592 = kilogram, or kg

-
1. US units of measure can appear abbreviated in upper or lower case.
 2. Maintain upper and lower case letters in SI Metric as shown.

Moment or Torque

LB x FT or pound-foot (force) x 1.35583 = Newton-meter, or N·m

LB x IN or pound-inch (force) x 0.112985 = Newton-meter, or N·m

Power¹

HP or Horsepower x 0.745700 = kilowatt, or kW

Pressure² or Stress

psi x 6894.757 = Pascal, or Pa

Pa x 0.000145 = psi

psi x 6.894757 = kiloPascal, or kPa

kPa x 0.145 = psi

bar x 100 000 = Pascal, or Pa

Pa x 0.00001 = bar

bar x 100 = kPa

kPa x 0.01 = bar

psi x 68.94757 = mbar or millibar

mbar x 0.0145 = psi

psi x 0.06894757 = bar

bar x 14.5 = psi

Speed

FPM or feet per minute x 0.005080 = meter per second, or m/s

RPM or r/min or revolutions per minute x 60 = revolutions per second, or rev/s

Temperature

°F or degrees Fahrenheit. $(°F - 32)/1.8 = \text{degrees Celsius, or } °C$

1. Horsepower based on 550 ft-lb/sec

2. G suffix (PSIG) indicates gauge pressure, A indicates absolute

Time

sec = second, or s

min or minute x 60 = second, or s

hr or h or hour x 3600 = second, or s

Viscosity

SSU, SUS or Saybolt Universal seconds x 0.22 - (180/SSU) = mm²/s = centistoke, or cSt
(for a range of 33 thru 200,000 SUS)

Volume

gal or gallons (US liquid) x 3.78541 = liter, or L

Other Abbreviations

CE = Crank End

CI = Cast Iron

CL. = Clearance

CU = Cubic

CYL = Cylinder

⌀ = Centerline

DNFT = Digital No-Flow Timer Switch

ESNA = Registered Trade Mark of Elastic Stop Nut Division, Harvard Industries

HE = Head End

HEX = Hexagon

MAWP = Maximum Allowable Working Pressure

MAX. = Maximum

MIN. = Minimum

N/A = Not Applicable

NO. = Number

NPT = National Pipe Thread

PEEK = Poly-Ether-Ether-Ketone plastic material

% = Percent

PIST = Piston

P/N = Part Number

SAE = Society of Automotive Engineers

SG = Specific Gravity

SI = International System, as applied to the modern metric system

S. N. or S/N = Serial Number

TFE = Teflon

THD = Thread

TIR = Total Indicator Reading

TPI = Threads Per Inch

TRAV = Travel

UNC = Unified (Inch) National Coarse Screw Threads

UNF = Unified (Inch) National Fine Screw Threads

UNL = Unloader

VOL = Volume

W/ = With

Gas Analysis Common Abbreviations

TABLE 7-1: GAS ANALYSIS COMMON ABBREVIATIONS

COMMON ABBREVIATION	COMPONENT NAME (SYNONYM)	CHEMICAL FORMULA
C1	Methane	CH ₄
C2	Ethane	C ₂ H ₆
C3	Propane	C ₃ H ₈
IC4	Iso-Butane (2-Methyl Propane)	C ₄ H ₁₀
NC4	N-Butane	C ₄ H ₁₀
IC5	Iso-Pentane (2-Methyl Butane)	C ₅ H ₁₂
NC5	N-Pentane	C ₅ H ₁₂
NEOC5	Neopentane	C ₅ H ₁₂
NC6	Hexane	C ₆ H ₁₄
NC7	Heptane	C ₇ H ₁₆
NC8	Octane	C ₈ H ₁₈
NC9	Nonane	C ₉ H ₂₀
NC10	N-Decane	C ₁₀ H ₂₂

TABLE 7-1: GAS ANALYSIS COMMON ABBREVIATIONS

COMMON ABBREVIATION	COMPONENT NAME (SYNONYM)	CHEMICAL FORMULA
NC11	N-Undecane (Hendecane)	C ₁₁ H ₂₄
NC12	N-Dodecane	C ₁₂ H ₂₆
C2-	Ethylene (Ethene)	C ₂ H ₄
C3-	Propane (Propylene)	C ₃ H ₆
BENZ	Benzene	C ₆ H ₆
TOL	Toluene	C ₇ H ₈
EBNZ	Ethylbenzene	C ₈ H ₁₀
CO	Carbon Monoxide	CO
CO2	Carbon Dioxide	CO ₂
H ₂ S	Hydrogen Sulfide	H ₂ S
H ₂	Hydrogen	H ₂
O ₂	Oxygen	O ₂
N ₂	Nitrogen	N ₂
H ₂ O	Water	H ₂ O
He	Helium	He
Ar	Argon	Ar
---	Air	---

TABLE 7-2: USEFUL SI METRIC MULTIPLE AND SUB-MULTIPLE FACTORS

MULTIPLICATION FACTOR	PREFIX	SI SYMBOL ^a
1 000 000 = 10^6	mega	M
1 000 = 10^3	kilo	k
100 = 10^2	hecto ^b	h
10 = 10^1	deka ^b	da
.1 = 10^{-1}	deci ^b	d
.01 = 10^{-2}	centi ^b	c
.001 = 10^{-3}	milli	m
.000 001 = 10^{-6}	micro	:

a. Maintain upper and lower case letters as shown.

b. Not Recommended, but occasionally used.

Technical and Service Schools on Ariel Compressors

Ariel schedules several in plant schools each year, which include classroom and hands on training. Ariel can also arrange to send a representative to provide a customized training school at your location. Contact Ariel for details.

Ariel Customer Technical Bulletins (Formerly Ariel Newsletters)

Ariel Customer Technical Bulletins provide important technical information including changes, corrections and/or additions to the Technical Manual for Packagers and End Users. Be sure to refer to this material before operating or servicing the equipment.

A complete listing of these Bulletins is available at the Ariel Website (www.arielcorp.com), selected Bulletins are available at the Web site, or copies may be obtained from the Packager or from Ariel.

Vender Literature

When available, vendor literature on purchased parts used in Ariel Compressors is provided on the Ariel Website (www.arielcorp.com), or copies may be obtained from the Packager or from Ariel.

Ariel Telephone, Fax, E-Mail and Web Site Numbers

TABLE 7-3: ARIEL CONTACT NUMBERS

CONTACT	TELEPHONE	FAX	EMAIL
Ariel Response Center	888-397-7766 (toll free USA & Canada) or 740-397-3602 (International)	740-397-1060	arc@arielcorp.com
Spare Parts		740-393-5054	spareparts@arielcorp.com
Order Entry		740-397-6450	---
Ariel World Headquarters	740-397-0311	740-397-3856	info@arielcorp.com
Technical Field Service			fieldservice@arielcorp.com
Web Site: www.arielcorp.com			

- Ariel Response Center Technicians or Switchboard Operators will answer telephones during Ariel business hours, Eastern Time - USA or after hours by voice mail.
- The after Hours Telephone Emergency System works as follows:
 1. Follow automated instructions to Field Service Emergency Technical Assistance or Spare Parts Emergency Service.
 2. Calls are answered by voice mail.
 3. Leave Message: caller's name, telephone number, serial number of equipment in question (frame, cylinder, unloader) and brief description of emergency.
 4. Your voice message is routed to an on-call representative, who will respond as soon as possible.
- Users must order all parts through Authorized Distributors.



ARIEL CORPORATION
Recommended Spares Start-Up

Thu Oct 20 09:55:53 EDT 2011

Project:

U86848

QTY	Part Number	Description	Your Price	Net Amount
		VVCP, 5-1/8JG:A:M:P		
1	A-0093	STL GASKET, 5.480 X 5.230 X 60	\$0.0000	\$0.00
1	A-0015	O-RING,VT, 5.020 O.D. X .210	\$0.0000	\$0.00
		Sub Total		\$0.00
		Start-Up Grand Total		\$0.00



ARIEL CORPORATION
Recommended Spares Consumables

Thu Oct 20 09:55:53 EDT 2011

Project:

U86848

QTY	Part Number	Description	Your Price	Net Amount
		VVCP, 5-1/8JG:A:M:P		
1	A-0093	STL GASKET, 5.480 X 5.230 X 60	\$0.0000	\$0.00
1	A-0015	O-RING,VT, 5.020 O.D. X .210	\$0.0000	\$0.00
		Sub Total		\$0.00
		Consumables Grand Total		\$0.00



ARIEL CORPORATION
Recommended Spares Insurance

Thu Oct 20 09:55:53 EDT 2011

Project:

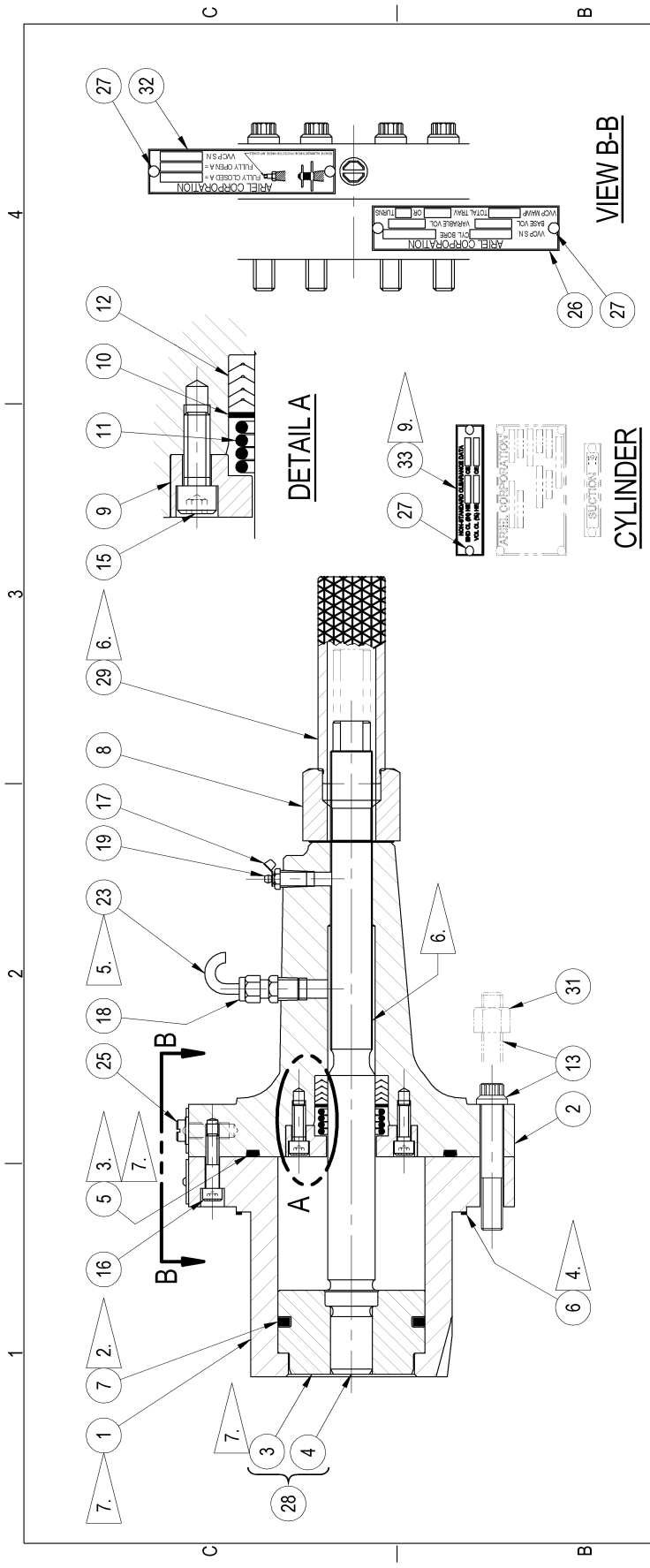
U86848

QTY	Part Number	Description	Your Price	Net Amount
VVCP, 5-1/8JG:A:M:P				
1	A-0015	O-RING,VT, 5.020 O.D. X .210	\$0.0000	\$0.00
1	A-0487	UNL.PISTON RING, 3-1/2 O.D.	\$0.0000	\$0.00
1	A-0501	V PACKING, UNL	\$0.0000	\$0.00
			Sub Total	\$0.00
			Insurance Grand Total	\$0.00

All amounts are in US dollars and price is subject to change at any time.

ARIEL CORPORATION, 35 BLACKJACK ROAD, MOUNT VERNON, OHIO 43050 USA
 PHONE: 740-397-0311 FAX: 740-397-3856

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NOTES:

- 1.- LOOSEN OR TIGHTEN ALL FASTENERS PER RECOMMENDED PROCEDURES AND TORQUE VALUES IN MANUAL.
2. LIGHTLY OIL BORE AND RING BEFORE INSTALLING.
3. OIL O-RING BEFORE INSTALLING.
4. APPLY AN ANTI-SEIZE LUBRICANT TO GASKET SURFACES.
5. VENT TUBE TO BE POINTED DOWN.
6. APPLY AN ANTI-SEIZE LUBRICANT TO STEM THREADS BEFORE ASSEMBLING.
7. CAUTION: FOR NON-LUBE APPLICATIONS REFER TO TECHNICAL MANUAL FOR SPECIAL PROCEDURES FOR THESE ITEMS.
- 8.- THIS ASSEMBLY DRAWING IS FOR ILLUSTRATION PURPOSES ONLY AND MAY NOT NECESSARILY REPRESENT THE EXACT ITEMS PERTAINING TO THE UNIT ORDERED. REFER TO PARTS LIST FOR ITEMS (AND QUANTITIES OF EACH) REQUIRED FOR YOUR PARTICULAR ASSEMBLY.
9. WHERE APPLICABLE, MOUNT ADDED FIXED CLEARANCE TAG AS CLOSE TO CYLINDER DATA TAG AS POSSIBLE.

ARIEL CORPORATION
 35 BLACKJACK ROAD
 MOUNT VERNON, OHIO 43050

REV	DESCRIPTION	INITIALS	DATE

ASSEMBLY DWG. NO.	A-17451		
SCALE	NONE		
DRAWN	CPM 10/14/10	CHECKED	DLI 10/20/10
REV	EON	REV	EON
0	16628	0	16628

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REV	DESCRIPTION	INITIALS	DATE

10/18/11

ARIEL CORPORATION
SALES ORDER COVER SHEET

C/N: 001

RHCOVP02

SERIAL #: U86848

PART: G-18500 DESCRIPTION: VVCP, 5-1/8JG:A:M:P

5-1/8" JG:A:M:P UNLOADER ASSEMBLY WITH PART NO. G-18500
STAINLESS STEEL TUBING AND FITTINGS. REF DRAWING A-17451

ITEM	PART NUMBER	QTY	DESCRIPTION
1	C-0273	1	UNL.HEAD, 5-1/8JGU:WU
2	C-0270	1	ADAPTER, HEAD END UNLOADER, 5-1/8JG:M:P:W
3	B-0393	0	UNL PIST, 5-1/8JG:M
4	C-3734	0	UNL.STEM,3-5/8,5-1/8JGU CL.
5	A-0015	1	O-RING, VT, 5.020 OD X .210, 75/85 DUROMETER
6	A-0093	1	STEEL GASKET, 05.480 OD X 05.230 ID X .060, HEAD
7	A-0487	1	UNL.PISTON RING, 3-1/2 O.D.
8	B-0754	1	UNL HEX NUT,1"-12UNF
9	B-0388	1	SPRING RETAINER,4-1/8JG:JG-HE:M,5-1/8JG:M:P:P10, 4-3/8P-HE
10	A-0519	1	BACK-UP RING, PACKING
11	A-0499	1	COMPRESSION SPRING, UNLOADER
12	A-0501	1	V PACKING, UNL
13	FC0120GP	8	12-POINT CAPSCREW, 1/2-13 X 3-1/4, G8
15	FC0110DF	4	SOCKET HEAD CAPSCREW, 5/16-18 X 7/8, G8
16	FC0110DH	3	SOCKET HEAD CAPSCREW, 5/16-18 X 1-1/4, G8
17	A-0500	1	GREASE FITTING CAP, PLASTIC
18	A-0938	1	MALE CONNECTOR, SS, 1/4 TUBE X 1/4 NPT
19	PZ0230BA	1	GREASE FITTING, STRAIGHT, 1/4-18
23	PT0201CD	5."	TUBING, 316 SS, 1/4 OD X .065 WALL
25	A-0256	1	MACHINE SCREW PLUG, PLASTIC, 1/2-13
26	A-0755	1	DATA PLATE, UNLOADER HEAD SPECIFICATION

10/18/11

SALES ORDER COVER SHEET

27	FR0571CC	4	DRIVE SCREW, TYPE U, SS, #6 X 1/4
28	AC-3735	1	UNL PIST ASSY, 5-1/8JG
29	B-0753	1	STEM GUARD CAP
32	A-12927	1	DATA PLATE, UNLOADER ADAPTER SPECIFICATION

VARIABLE VOLUME CLEARANCE POCKET (Headend Unloader) DATA SHEET

5-1/8M Class Cylinder

Stroke: 3.00 in 76 mm

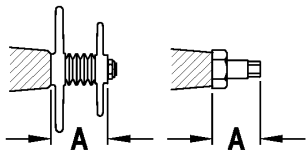
Bore: 5.125 in 130 mm

MAWP: 500 psig 34.5 barg 3447 kPa(g) 35.2 kg/cm2(g)

General Data for VVCP (independent of cylinder):

*Note: If VVCP services another cylinder, it may have a higher MAWP than the above

MAWP*:	865	59.6 barg	5964 kPa(g)
VVCP piston diameter:	3.5 in	89 mm	
Stem thread lead (pitch):	0.083333 in	2 mm	
Total travel:	2.9 in	7.5 cm	
Number of turns from closed to fully open:			35



A distance - see diagram

- closed:	2-7/8 in	7.3 cm
- open:	5-3/4 in	14.8 cm

Minimum added fixed clearance:	0.6 in3	10.2 cm3
Additional added clearance when fully open:	28 in3	459 cm3
Total added clearance when fully open:	28.6 in3	469.1 cm3
Clearance volume change per turn:	0.8 in3	13.0 cm3
Clearance volume change per change in travel:	9.5 in3/in	61.5 cm3/cm

Clearance Data for VVCP alone, in percent of swept volume of above cylinder:

Minimum added fixed clearance:	1.0%
Additional added clearance when fully open:	45.2%
Total added clearance when fully open:	46.3%
Head end clearance change per turn:	1.3%
Head end clearance change per change in travel:	15.4% /in 6.1% /cm

Clearance Data with VVCP installed on above cylinder with standard valves, in percent of swept volume:

Minimum fixed head end clearance:	17.1%
Total head end clearance when fully open:	62.4%

PLEASE NOTE: It is important to understand that the percent clearance figures for the variable volume clearance pocket above include the cylinder headend clearance. However, any valve spacers or other non-standard added clearances on the unit must be accounted for.



For Further Information, Call Us:

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EAST: 1-800-268-4770

OPTIM® HE PLUS PREMIUM



OPTIM® HE PLUS PREMIUM

PREMIUM EFFICIENCY TEFC SEVERE DUTY

NEMA Standard 3-Phase Motors

60Hz, 230V/460V (Usable on 208V) or 575V

NEMA Design B or C, Continuous Duty

Class F Insulation, 40°C Ambient, 1.15 S.F.

1-300HP CSA Certified for Division 2 Locations (up to 449T Frame)

CSA Certified for Inverter Duty Operation (up to 449T Frame)

HPE™ Wire



PDH06004TE2N

CATALOGUE NUMBER	HP	RPM	VOLTS	PHASE	Hz
PDH06004TE2N	60	1800	230 / 460	3	60
ENCLOSURE	FRAME	F/L EFF.	LIST PRICE		
TEFC	364T	95.0	-		

NOTE: 1. Prices subject to change without notice.

2. Ratings over 125HP are single voltage rated (460 or 575V).

3. For 50Hz, please contact a TWMI representative.

4. For ratings meeting NEMA Design C, please contact a TWMI representative.

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1. INTRODUCTION

This and the following instructions address the more common situations encountered in motor installation, operation and maintenance. For the TECO motor warranty to be and to remain in effect, the motor must be installed and operated in strict accordance with the outline drawing, motor nameplates and these instructions and must not be altered or modified in any unauthorized manner.

During these installations and operation of motors in heavy industrial applications there is a danger of live electrical parts and rotating parts. Therefore to prevent injury and/or damage the basic planning work for installation, transport, assembly, operation, etc.... needs to be done and checked by authorized and competent personnel only.

Since these instructions cannot cover every eventuality of installation, operation and maintenance, the following points should however be considered and checked.

- The technical data and information on permissible use such as assembly, connection, ambient and operating conditions given in the related catalogue, operating instructions, nameplates and other production documentation.
- The general erection and safety regulations.
- The local and plant-specific specifications and requirements.
- The proper use of transport, lifting devices and tools.
- The use of personal protective equipment.

Following indications should be observed when reading these instructions.

Safety instructions are marked as follows :



Warning of electric hazards for personnel.



Warning of dangers for personnel.

ATTENTION !

Warning of damage for the motor or installation.

2. ACCEPTING, INSPECTION, STORAGE, TRANSPORTATION

2.1 Inspection upon receipt

Check the following points upon receipt :

- Are the nameplate ratings identical with what you ordered ?
- Are dimensions and color in compliance with your specifications ?
- Are the nameplate ratings for heater, thermal protector, temperature detector, etc. identical with what you ordered ?
- Is there any damage ?
- Are all accessories and accompanying instruction manuals in good order ?
- Please ensure that the arrowhead indicator really indicates direction of revolution.
- If there are any specific requirements, please ensure they are in conformity with your specification.

2.2 Storage

When motors are not in operation, the following precautionary measures should be undertaken to assure best performance.

2.2.1 Place

- (a) High and dry, well-ventilated without direct sun, dust or corrosive gas.
- (b) Not located near to a boiler or freezer.
- (c) Entirely free from vibration and easy for movements.
- (d) Motors should be put on pallets to prevent moisture.

2.2.2

Motors should be well shielded from dust, but under well-ventilated circumstances.

2.2.3 Moisture prevention

Since moisture can be very detrimental to electrical components, the motor temperature should be maintained about 3°C above the dew point temperature by providing either external or internal heat. If the motor is equipped with space heaters, they should be energized at the voltage shown by the space heater nameplate attached to the motor. Incandescent light bulbs can be placed within the motor to provide heat. However, if used, they must not be allowed to come in contact with any parts of the motor because of the concentrated hot spot that could result.

2.2.4

Even during storage, the insulation resistance should be kept above the specified values.

- (a) For measurement of insulation resistance and acceptable standard values, please refer to measures stated in 4.1.2 "Measurement of insulation resistance".
- (b) Insulation resistance test should be performed once every three months.

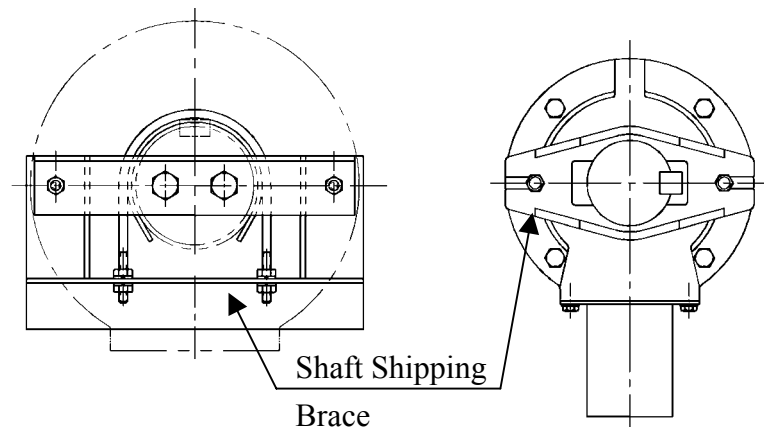
2.2.5

If the motor is not in operation for a long period (one week and above) after installation or has been in operation but stopped for a period of time, the following precautions must be taken.

- (a) Protect the motor as measures stated in 2.2.3.
- (b) Insulation resistance test should be performed as stated in 2.2.4.
- (c) Operation test should be performed once every three months.

2.2.6 Bearing protection

- (a) If the motor has been provided with a shaft shipping brace to prevent shaft movement during transit, it must be removed before operating the motor. It is very important that this brace be reinstalled exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported. This prevents axial rotor movement that might damage the bearings.



- (b) Motors equipped with sleeve bearings are shipped from the factory with the bearing oil reservoirs drained. In storage, the oil reservoirs should be properly filled to the center of the oil level gauge with a good grade of rust inhibiting oil. To keep the bearing journals well oiled and to prevent rusting, the motor shaft should be rotated several revolutions about every month ensuring the shaft does not come to rest in its original position. While the shaft is rotating, it should be pushed to both extremes of the endplay.
- (c) Motors with anti-friction bearings are properly lubricated with the correct grade of grease at the factory and no further greasing is required in storage. The shaft should be rotated several revolutions about every month to maintain proper distribution of the grease within the bearings.
- (d) Tilt-pad bearings are a type of sleeve bearing used in special design applications. Due to the nature of this bearing, a loose oil ring for delivering lubricant cannot be provided. Therefore, during the storage interval, oil must be periodically manually introduced into the pads and housing to prevent the occurrence of oxidation of the precision machined components.
 - (1) Remove the pipe plug from the bearing cap located above the tilt-bearing shell.
 - (2) Pour in approximately one cup of oil every month and rotate the shaft a few revolutions about every two (2) weeks.

For long periods of storage, the oil that accumulates in the housing should be removed.

(e) The bearing assembly parts of motors with oil mist lubrication are put on with anti-rust oil, so they can be preserved for several months in good conditions. The motor should be stored indoor & well-ventilated environment and prevent to contact with contaminated or corrosive air. The following points should be noted :

- (1) During preservation, the Inpro seal can not prevent the moisture to go through into the bearings. Please use the oil mist to lubricate the bearings every two (2) weeks.
- (2) If the color of flow out oil is changed, the bearing should be rusted or having contamination in it. Please contact with us.
- (3) Avoid using grease as it will plug the vent/drain.
- (4) All assembly surfaces are painted with seal bonds, don't disassemble them anytime.
- (5) Don't remove the plugs in vent/drain to prevent the moisture.
- (6) Don't apply any force on the Inpro seal to prevent damage.
- (7) The Inpro seal is a labyrinth type seal. Therefore it can not contain a pressure differential.

2.2.7

ATTENTION !

Cares should be taken to keep parts such as fitting surface, key, shaft extension and axial central hole from any collision with foreign matters. Grease should also be generously applied to prevent rusting.

2.3 Transportation

ATTENTION !

To keep the rotating parts of motors from moving, thus preventing damage and scratching during transportation, they should be held securely with a locking device. Remove all transit clamps before operating the motor. It is very important that this device be reinstalled exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported.

The vertical mounting type motors should be transported in the vertical position.



Do not use the hoisting hook/eyebolts to lift more that the motor itself. They are designed to support the motor only.

Make sure the hoisting hook is correctly attached to the eyebolt(s) or lug(s) of the motor and that the eyebolt(s)/lug(s) are fully screwed in before hoisting. Also note such parts as fan cover, ventilation box, bracket, slip-ring, etc. may have their own hoisting lugs which can only carry their own weight. Nothing extra should be attached while hoisting.

Do not twist the steel wires and make sure the eyebolts have been firmly screwed and the sling angle is correct.

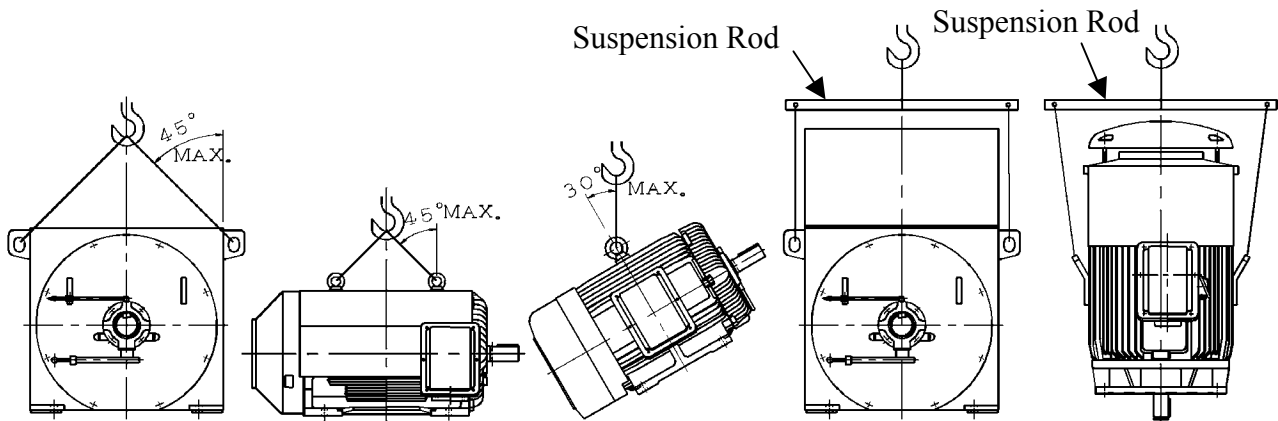


Fig. 1

3. INSTALLATION

3.1 Site and environment for motor installation

3.1.1

Standard environment and site conditions for the installation of motors are usually set as follows :

- (a) Ambient temperature : -20 ~ +40 °C
- (b) Humidity : Relative humidity below 95%RH for totally-enclosed types, and below 80%RH for semi-enclosed types.
- (c) Elevation : below 1000 meters.
- (d) Harmful gases, liquids, dusts, high moisture should be absent.
- (e) Foundations should be strong and free of vibration.

If there are any special environmental conditions, please inform us upon ordering.

3.1.2 Ventilation and space

- (a) Installation area should be well-ventilated.
- (b) The installation space should be large enough to facilitate heat dissipation and maintenance.

3.2 Foundation

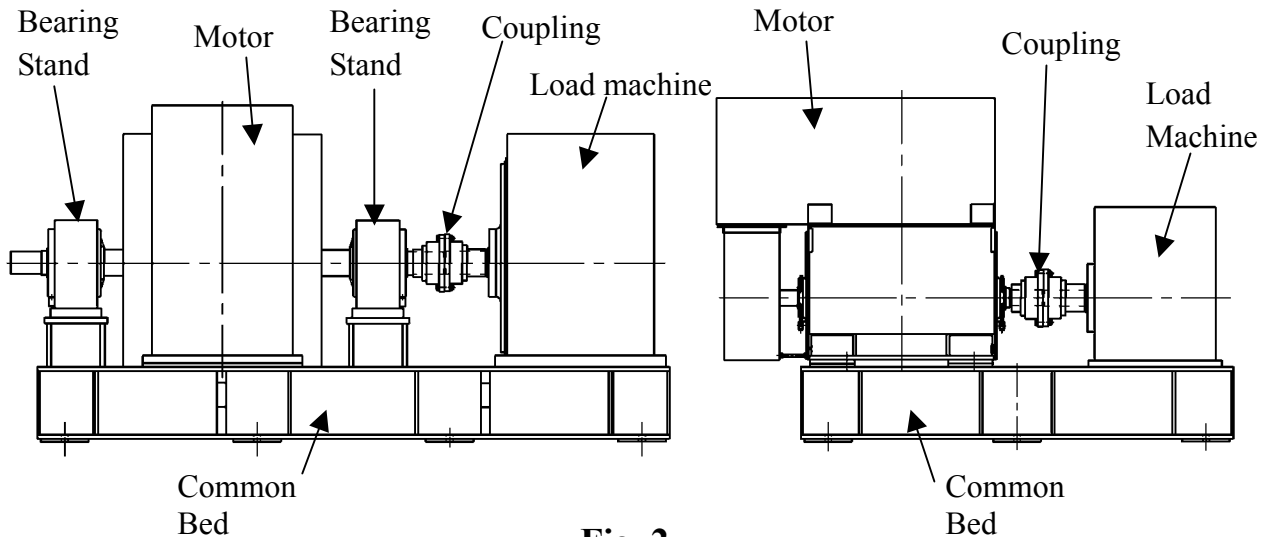
3.2.1 Soleplate & common bed

Use rigid and solid soleplate or common bed as foundation.

ATTENTION !

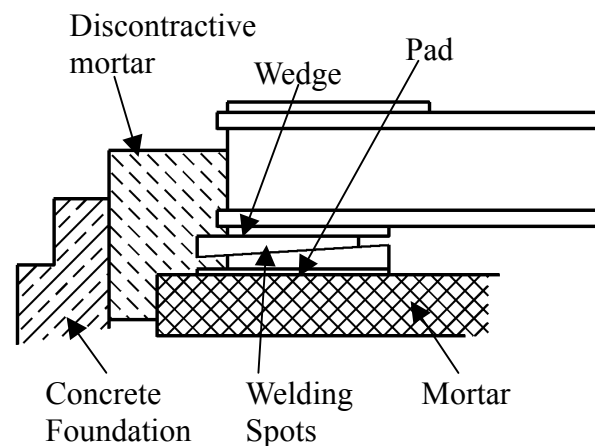
For best motor performance, it is advisable to use a soleplate or common bed, particularly when using a shaft coupling.

If the soleplate or common bed doesn't have enough stiffness, the critical speed of motors or equipment will then be changed. This change may cause a large vibration (resonance) and decrease the life of machines.



3.2.2 Installation

- Select an appropriate foundation surface for the soleplate or common bed which will be considered the ultimate level.
- Align the position of the common bed with reference to that level.
- Align the level accuracy at least at four points such as bearing mounting, shaft extension etc. The accuracy should be within 0.04mm.
- Soleplate or common bed should be embedded in concrete foundation as illustrated in Fig.3. Stiff pads should also be installed beneath the wedges which are welded together at various spots about 400-500mm apart etc., to enable foundation to carry evenly the weight of the whole motor.



- (e) The base should be sturdy and rigid to keep it flat and level.
- (f) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, then set the motor on the mounting foundation.
- (g) Accurately install shaft couplings, belt sheaves etc., then weld the wedges solid to prevent untoward change in position.

3.2.3 The foundation of vertical induction motor (Also the foundation of pump)

- (a) Foundation of motor/pump must be rigid and secure to provide adequate support. There must be no vibration, twisting, misalignment etc. due to inadequate foundations.
- (b) A massive concrete foundation is preferred in order to minimize vibration. Rigidity and stability are enhanced by prop plate and foundation bolt. As shown in Fig.4 and Fig.5.

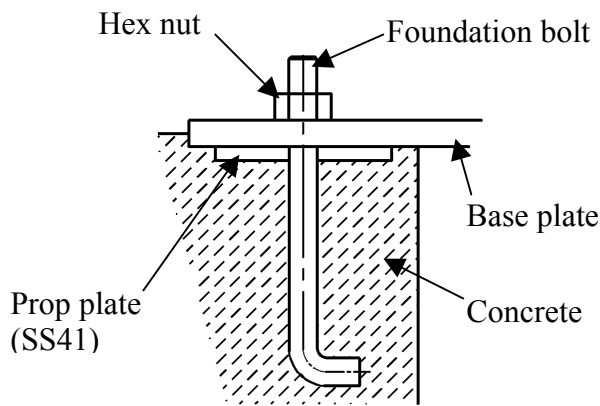


Fig. 4

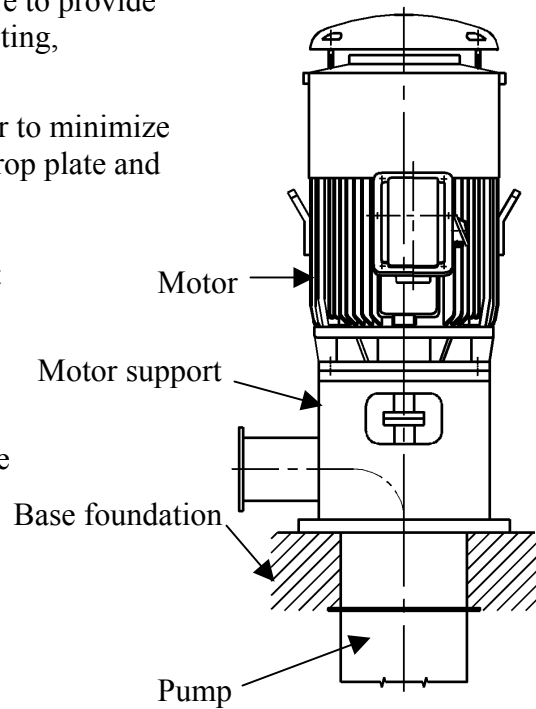


Fig. 5

3.2.4 Installation of vertical motor

- (a) All mounting surfaces must be clean and level.
- (b) Foundation must be leveled at least at 4 points and guaranteed to be below 0.04mm flat and level.
- (c) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, then set the motor on the mounting foundation.
- (d) Accurately install shaft couplings.

3.3 Installation of shaft coupling

3.3.1

ATTENTION !

Motors must always be accurately aligned, and this applies especially where they are directly coupled.

Incorrect alignment can lead to bearing failure, vibration and even shaft fracture. As soon as bearing failure or vibration is detected, the alignment should be checked.

3.3.2

Field application of a coupling to the motor shaft should follow the procedures recommended by the coupling manufacturer. The motor shaft extension must not be subjected to either extreme heat or cold during coupling installation.

3.3.3

ATTENTION !

Basically, the coupling should be heated and pushed onto the shaft extension with slight axial force. Do not hammer coupling to prevent bearing damage.

3.3.4

Although the sleeve bearings are equipped with thrust faces, these are intended only to provide momentary axial restraint of rotor movement either during start-up or when operating the motor disconnected from the driven equipment. They must not be operated under a constant thrust load unless they were originally designed for this condition.

Motors with either sleeve or anti-friction bearings are suitable for connection to the driven load through a flexible coupling. Coupling solidly to the load is not acceptable. With sleeve bearings, the flexible coupling should be of the limited end float type to prevent the possibility of any end thrust from the load being transmitted to the motor bearings, which could cause bearing damage.

The recommended limits of end float for couplings are as follows :

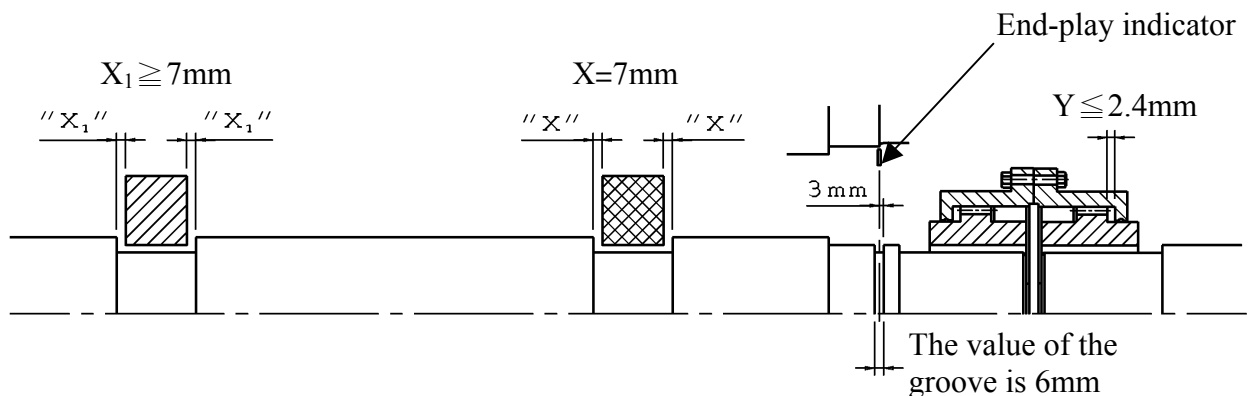


Fig. 6

- When the motor is in operation after installation, be sure that the end-play indicator is within the 6mm of the groove on the shaft or aligned to the shaft shoulder immediately outboard of the drive-end bearing to assure there is low friction between shaft and bearing.
- Unless otherwise specified, the designed end-play value X of the groove for TECO motors in general is within 7mm as illustrated in Fig. 6. In essence, the end-play indicator is adjusted to point at the center of the groove or the drive-end shaft shoulder; thus X equals to $7 \pm 1\text{mm}$ or so, and the end-play value (Y) of the couplings should equal or be smaller than 2.4mm.
- If the desired value Y is greater than 3mm caused for instance by a thrust load and/or load machine with large end-play, please inform us when ordering.

3.3.5

In aligning the motor (and rotor) axially with the driven equipment, consideration should be given not only to the end-play indicator position but also to axial shaft expansion and increase in shaft centerline height due to thermal effects. In general, the axial shaft growth for motors can be disregarded since neither bearing is fixed and any shaft growth due to temperature increase will produce an elongation away from the coupling.

Shaft height growth (change in shaft centerline elevation) for TEFC machines can be calculated as follows :

$$\Delta = (0.0005) \times (\text{motor foot to shaft centerline dimension})$$

For non-TEFC machines, divide this number by 2.

3.3.6

It is desirable, in normal operation, that the motor operate on its magnetic center, so that no axial force is exerted on the coupling.

The motor shaft and the driven shaft should be aligned within the following tolerances in both angular and parallel alignment :

Unit : mm

TIR	Range of rotating speed	Solid coupling	Flexible coupling
C	2500rpm and above	0.03	0.03
	Below 2500rpm	0.04	0.05
A	2500rpm and above	0.03	0.03
	Below 2500rpm	0.03	0.04

Angular misalignment is the amount by which the centerlines of driver and driven shaft are skewed. It can be measured using a dial indicator set up as shown in Fig.7. The couplings are rotated together through 360 degrees so that the indicator does not measure run out of the coupling hub face. The shafts should be forced against either the in or out extreme of their end float while being rotated.

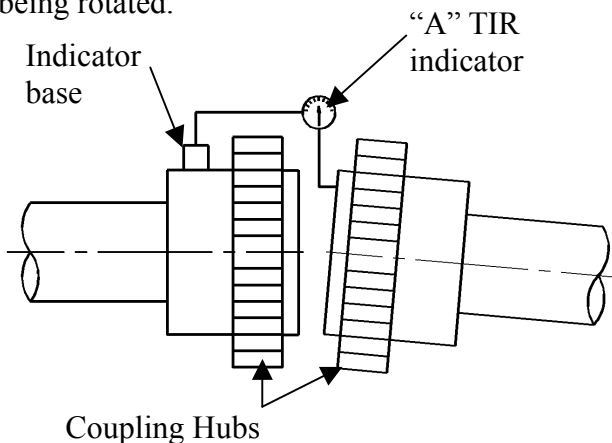


Fig. 7

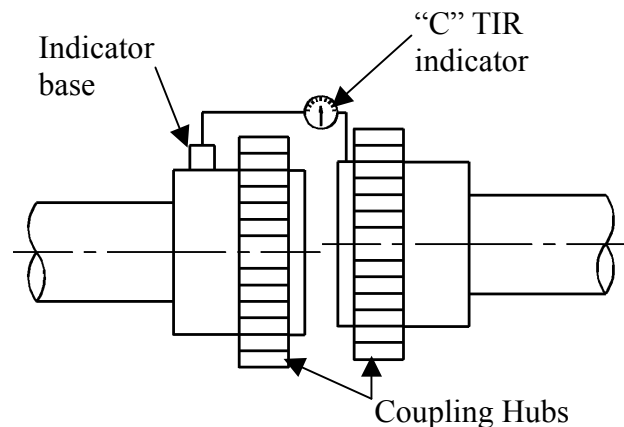


Fig. 8

Parallel misalignment is the amount by which the centerlines of the driver and driven shafts are out of parallel. It can be measured using a dial indicator set up as shown in Fig.8. Again, the couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub outside diameter.

TIR = Total indicator reading (by dial indicator)

3.3.7

After the motor has been properly aligned with the driven equipment and the hold-down bolts have been installed and tightened, for motors with fabricated frame, at least two dowel pins should be installed in two diagonally opposite motor feet.

3.3.8 Installation of shaft coupling (Vertical hollow shaft motor only)

Bolted coupling as Fig.9

- (a) Bearings are provided to absorb some upward shaft thrust when the coupling is fitted.
- (b) The coupling is fastened with bolts.
- (c) This coupling type is not auto-release type.

Note : Standard high thrust motors can absorb momentary upthrust load up to 30% of the standard downthrust load. If the upthrust is long duration (over 10 seconds) and/or exceeds 30% of the standard high thrust rating, special design arrangements are required and a standard motor is not suitable.

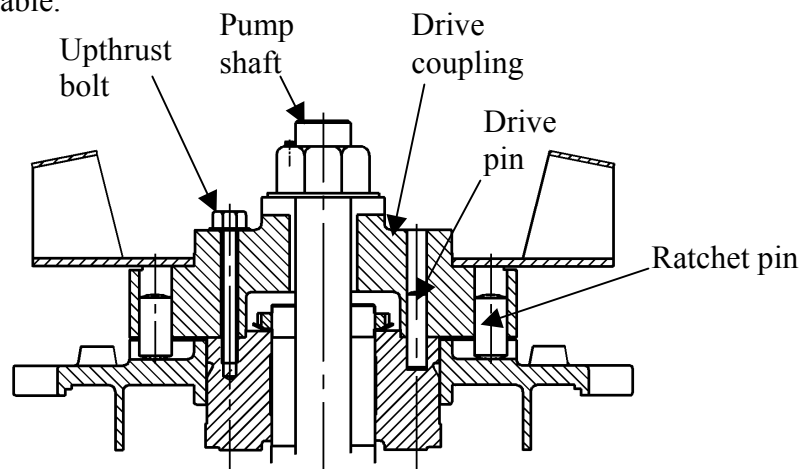


Fig. 9

3.3.9 Non-reverse ratchet/coupling, as Fig.9 (If necessary)

The non-reverse coupling is also a bolted type and,

- (a) It prevents the pump and motor from rotating in the reverse direction.
- (b) It also prevents damage from over speeding and damage to pump shaft and bearings.
- (c) The ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed.
- (d) When power is removed, speed decreases, and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.
- (e) When installing the non-reverse coupling, do not use lubricant. Lubrication will interfere with proper operation. The top half of the coupling should seat solidly on the lower half and the pins should touch the bottom of the pockets between the teeth in the plate.
- (f) As with the bolted coupling, the upthrust capabilities are 30% of the standard high thrust rating for downthrust.

ATTENTION !

Do not apply non-reverse ratchets on applications in which the pump reversal time from shutdown (the instant the stop button is pressed) to zero speed is less than one second.

3.3.10 Removal of redundant shaft key

When the length of coupling hub is different from the length of shaft key, the motor may have a high vibration level due to this unbalance condition. The removal of redundant shaft key is necessary, shown as Fig.10.

Method (1) :

After installing the coupling, use a grinding wheel to remove the redundant key (hatch area).

Method (2) :

Before installing the coupling, calculate the different length between coupling hub and shaft key, then cut the half of this different value (hatch area) to achieve approximate-balance condition.

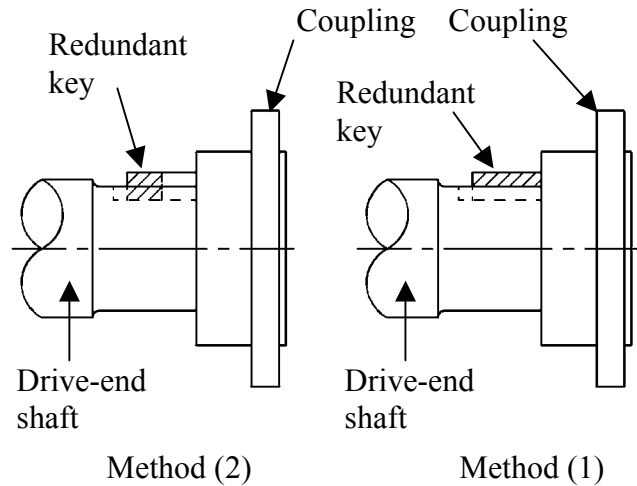


Fig. 10

3.4 Installation for belt drive

In general, power transmission through direct flexible coupling is appropriate for large motors. Such motors are not suitable for belt, chain or gear connection unless specially designed for such service. However, for small and medium motors of which outputs within the ranges shown on table below, it is acceptable to use belt transmission as indicated. Beyond these ranges, do not apply belt sheaves unless specially designed.

3.4.1

The diameter ratio between conveyance sheaves should not be greater than 5 to 1 for flat belts, and 8 to 1 for V-belt. It is also advisable to limit the belt velocity to under 35 m/sec to limit belt abrasion and vibration. The smaller the outer diameter of the V-belt sheave, the greater the shaft bending stress will be. If the bending stress is in excess of the shaft fatigue stress, the shaft may break. Therefore, please inform us when you have decided the size of the sheaves and the length of the belts upon ordering.

ATTENTION !

Place the sheave and belt as close as possible to the motor body (it is advisable to make x as shown in Fig.11 equal to 0) to reduce the bending moment and improve shaft life.

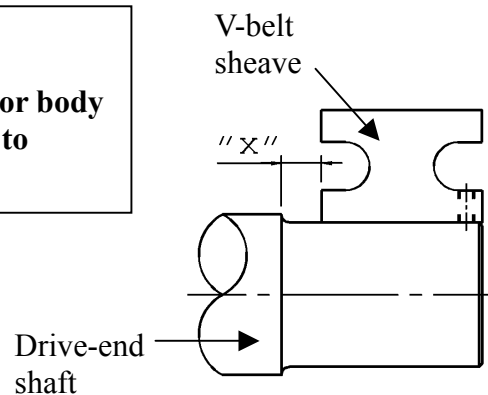


Fig. 11

3.4.2 Table of belt-sheave application for general electric motors

Output (KW)			V-Belt Sheave							
			Conventional V-Belt				Narrow V-Belt			
4P	6P	8P	V-Belt Type	Number of Belts	Min. PCD (mm)	Max. Width (mm)	V-Belt Type	Number of Belts	Min. PCD (mm)	Max. Width (mm)
11	--	--	B	4	160	82	3V	4	125	48
--	11	--	B	5	170	101	3V	5	140	59
--	--	11	B	5	190	101	3V	6	160	69
15	--	--	B	5	170	101	3V	6	125	69
--	15	--	B	5	224	101	3V	6	160	69
--	--	15	C	4	224	111	5V	3	180	60
18.5	--	--	B	5	200	101	3V	6	140	69
--	18.5	--	C	4	224	111	5V	3	180	60
--	--	18.5	C	5	224	136	5V	4	180	78
22	--	--	B	5	224	101	3V	6	160	69
--	22	--	C	5	224	136	5V	4	180	78
--	--	22	C	5	250	136	5V	4	200	78
30	--	--	C	5	224	136	5V	4	180	78
--	30	--	C	5	265	136	5V	4	224	78
--	--	30	C	6	265	162	5V	5	224	95
37	--	--	C	6	224	162	5V	4	200	78
--	37	--	C	6	265	162	5V	4	224	78
--	--	37	C	7	280	187	5V	5	250	95
45	--	--	C	6	265	162	5V	4	224	78
--	45	--	C	7	280	187	5V	5	224	95
--	--	45	C	7	315	187	5V	6	250	113
55	--	--	C	7	265	187	5V	5	224	95
--	55	--	C	8	300	213	5V	6	250	113
--	--	55	D	5	355	196	5V	6	280	113
75	--	--	C	8	315	213	5V	6	250	113
--	75	--	D	6	355	233	5V	6	315	113
--	--	75	D	6	400	233	5V	6	355	113
--	90	--	D	6	400	233	5V	6	355	113
--	--	90	D	6	425	233	8V	4	355	124
--	110	--	D	7	400	270	8V	4	355	124
--	132	110	D	7	450	270	8V	4	400	124
--	160	132	D	9	450	344	8V	4	450	124

3.5 Conveyance with chain or gear

3.5.1

Make sure the loading capacity of shaft and bearings is appropriate for the size and installation position (overhung) of chain and gear. If necessary, please contact us to ensure the shaft and bearings will meet your requirements.

3.5.2

Pay close attention to ensure the parallelism of shafts.

3.5.3

The teeth of couplings should be correctly and precisely matched; the force conveyance centers should lie on the same line.

3.5.4

There should be no skip, jumping, vibration or unusual noises.

ATTENTION !

Do not hammer the conveyance devices such as couplings, belt sheaves, chain wheels, gears etc. onto the shaft. Those shaft fitments should be fitted and removed only by means of suitable devices. Heat shrinking may be a better alternative to avoid damaging bearings and other components.



The exposed rotating parts should be covered to prevent accidents.

3.6 Electrical connections

All interconnecting wiring for controls and grounding should be in strict accordance with local requirements such as the USA National Electrical Code and UK IEE wiring regulations.

Wiring of motor and control, overload protection and grounding should follow the instructions of connection diagrams attached.

3.6.1 Power

The rated conditions of operation for the motor are as shown on the nameplate. Within the limits, given below, of voltage and frequency variation from the nameplate values, the motor will continue to operate but with performance characteristics that may differ from those at the rated conditions :

+/- 10% of rated voltage

+/- 5% of rated frequency

+/- 10% combined voltage and frequency variation so long as frequency variation is no more than +/- 5% of rated

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage to or failure of the motor.

3.6.2

The main lead box furnished with the motor has been sized to provide adequate space for the make-up of the connections between the motor lead cables and the incoming power cables.



The bolted joints between the motor lead and the power cables must be made and insulated in a workman-like manner following the best trade practices.

3.6.3

Either fabricated motors or fan cooled cast frame motors are all provided with grounding pads or bolts.



The motor must be grounded by a proper connection to the electrical system ground.

3.6.4

The rotation direction of the motor will be as shown by either a nameplate on the motor or the outline drawing. The required phase rotation of the incoming power for this motor rotation may also be stated. If either is unknown, the correct sequence can be determined in the following manner : While the motor is uncoupled from the load, start the motor and observe the direction of rotation. Allow the motor to achieve full speed before disconnecting it from the power source. Refer to the operation section of these instructions for information concerning initial start-up. If resulting rotation is incorrect, it can be reversed by interchanging any two (2) incoming cables.

3.6.5 Auxiliary devices

Auxiliary devices such as resistance temperature detectors, thermocouples, thermoguards, etc., will generally terminate on terminal blocks located in the auxiliary terminal box on the motor. Other devices may terminate in their own enclosures elsewhere on the motor. Such information can be obtained by referring to the outline drawing. Information regarding terminal designation and the connection of auxiliary devices can be obtained from auxiliary drawings or attached nameplates.

If the motor is provided with internal space heaters, the incoming voltage supplied to them must be exactly as shown by either a nameplate on the motor or the outline drawing for proper heater operation.



Caution must be exercised anytime contact is made with the incoming space heater circuit as space heater voltage is often automatically applied when the motor is shutdown.

4. OPERATION

4.1 Examination before start

4.1.1

When motors are installed in good manner, ensure the wiring is according to the diagram. Also, the following points should be noted :

- (a) Make sure all wiring is correct.
- (b) Ensure the sizes of cable wires are appropriate and all connections are well made for the currents they will carry.

- (c) Ensure all connections are properly insulated for the voltage and temperature they will experience.
- (d) Ensure the capacity of fuse, switches, magnetic switches and thermo relays etc. are appropriate and the contactors are in good condition.
- (e) Make sure that frame and terminal box are grounded.
- (f) Make sure that the starting method is correct.
- (g) Make sure switches and starters are set at their right positions.
- (h) Motor heaters must be switched off when the motor is running.

4.1.2 Measurement of insulation resistance



During and immediately after measuring, the terminals must not be touched as they may carry residual dangerous voltages. Furthermore, if power cables are connected, make sure that the power supplies are clearly disconnected and there are no moving parts.

- (a) For rated voltage below 1000V, measured with a 500VDC megger.
For rated voltage above 1000V, measured with a 1000VDC megger.
- (b) In accordance with IEEE 43, clause 9.3, the following formula should be applied :

$$R \geq \frac{\text{Rated voltage (v)}}{1000} + 1 \quad (\text{M}\Omega)$$

- (c) On a new winding, where the contaminant causing low insulation resistance is generally moisture, drying the winding through the proper application of heat will normally increase the insulation resistance to an acceptable level. The following are several accepted methods for applying heat to a winding :
 - (1) If the motor is equipped with space heaters, they can be energized to heat the winding.
 - (2) Direct current (as from a welder) can be passed through the winding. The total current should not exceed approximately 20% of rated full load current. If the motor has only three leads, two must be connected together to form one circuit through the winding. In this case, one phase will carry the full applied current and each of the others, one-half each. If the motor has six leads (3 mains and 3 neutrals), the three phased should be connected into one series circuit.



Ensure there is adequate guarding so live parts cannot be touched.

- (3) Heated air can be either blown directly into the motor or into a temporary enclosure surrounding the motor. The source of heated air should preferably be electrical as opposed to fueled (such as kerosene) where a malfunction of the fuel burner could result in carbon entering the motor.

ATTENTION !

Caution must be exercised, when heating the motor with any source of heat other than self contained space heaters, to raise the winding temperature at a gradual rate to allow any entrapped moisture to vaporize and escape without rupturing the insulation. The entire heating cycle should extend over 15-20 hours.

Insulation resistance measurements can be made while the winding is being heated. However, they must be corrected to 40°C for evaluation since the actual insulation resistance will decrease with increasing temperature. As an approximation for a new winding, the insulation resistance will approximately halve for each 10°C increase in insulation temperature above the dew point temperature.

- (d) Should the resistance fail to attain the specified value even after drying, careful examination should be undertaken to eliminate all other possible causes, if any.

4.1.3 Power source

- (a) Ensure the capacity of the power source is sufficient.
- (b) Ensure the supply voltage and frequency ratings are identical to those on the nameplate.
- (c) Voltage variation should be confined to within $\pm 10\%$ of the rated value and the phase to phase voltages should be balanced.

4.1.4 Bearing lubrication

- (a) For sleeve bearing motors, the oil reservoir must be filled with oil to the correct level. On self-lubricated bearings, the standstill oil level will be at the center of the oil gauge. The proper oil is a rust and oxidation inhibited, turbine grade oil. Refer to the lubrication nameplate for the recommended viscosity.
- (b) Motors which are supplied with provision for flood lubrication have an inlet orifice to meter the oil flow to the bearing. Refer to the outline drawing for these values. If the supply pressure does not match that stated on the outline, the orifice size must be adjusted to produce the specified flow rate. The drain adapter (also provided) has a weir plate fixed to the inside of the pipe to permit the establishment of the proper oil level. This weir plate must be located at the bottom of the pipe and must be parallel to the plane of the motor feet. To ensure optimum flow, the drain line should be vented to the atmosphere.

Oil inlet temperature : Normal below 50°C

Alarm 60°C

Trip 65°C

- (c) If the motor is in storage for over three (3) months, refilling of some new oil should be undertaken before operation to prevent bearing damage due to dry friction. The oil level should be kept at the center of the oil gauge. If necessary, drain some oil after refilling.
- (d) Grease lubricant type
- (1) The bearings have been well greased at factory before delivery. However, regreasing is required if a significant period has elapsed between manufacture and use or in storage. Fill new grease until it overflows and the old grease is entirely replaced.
- (2) Unless otherwise specified, SHELL Alvania R3 is the standard applied to TECO motors.

4.1.5 Oil-mist lubrication motors

(a) Before operation :

Please check the rotor & stator parts of the Inpro seal, and make sure that they don't contact with each other. The 0.03mm thickness gap gauge is suggested to inspect the gap between rotor and stator as shown in Fig.12. If they are touched in one side, it means that this seal is in the wrong position. You can use a wooden or rubber hammer to adjust this seal gently. If this can't be done, this seal may be failed and have to be checked. Please contact with us.

(b) Lubricant :

Please use ISO VG68 or the same viscosity oil except lubrication nameplate specified others.

(c) About the oil mist lubrication generation system :

The users have to prepare an oil mist lubrication system, and apply suitable inlet oil quantity and pressure. Please follow the instruction of oil mist lubrication system what you used. Avoid high oil pressure going into the inside of the motor to damage the insulation or oil leakage.

(d) Operation :

Before first operation or long time without running, please turn on the oil mist lubrication system at least 5 hours to lubricate the bearings. If you use the central control system, the mist system shall operate continuously for a minimum of 48 hours. After making sure that the pressure is stable and flow out oil is in good conditions, then you could operate this motor.

(e) Appendix :

Fitting or reclassifier of oil-mist lubrication system :

Reclassifiers or fittings are devices which convert small particle-size dry mist to larger particle sizes which can lubricate bearings. Please use correct fittings or reclassifiers.

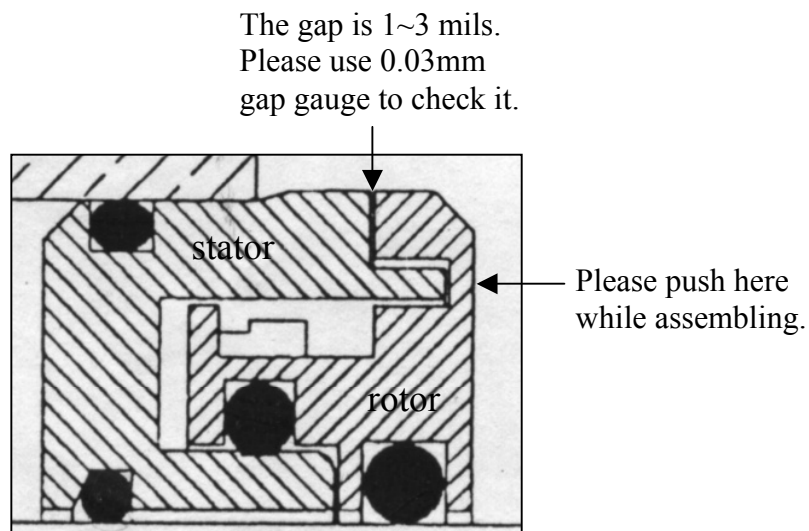


Fig. 12

4.1.6 Cooling water for the cooler on water-cooled motors

Make sure the quality, volume and inlet temperature of cooling water for the motors are normal before the machine is in operation.

Water : General tower water or industrial water

Volume : Please see outline drawing

Inlet temperature : Normal below 30°C

Alarm 35°C

Trip 40°C

Special temperature settings will be noted in outline drawings.

4.1.7

ATTENTION !

Make sure all locks which fasten the movable parts of the motors during transportation are dismantled and the shaft can rotate freely.

4.1.8

ATTENTION !

Ensure there are no foreign matters or tools inside the motors before starting motors.

4.1.9

Make sure the transmission system, including belts, screws, bolts, nuts and set pins are in good condition.



The keys fitted to the shaft extensions are held by plastic tape only to prevent them falling out during transportation or handling. The shaft key shall be removed to avoid flying out, when the motor is operated prior to the couplings etc. being fitted to the shaft extension.

4.1.10

Make sure the items above are examined. Test the motor running with or without load. Record and check according to "Maintenance" at 15 minutes intervals during the first three hours of operation. Then regular examinations should take place at longer intervals. If all goes well the motor can be classified as "in good order".

4.2 Starting operation

4.2.1 Starting load

Initially run the motor unloaded prior to coupling to other machines. Unless otherwise specified, a motor usually starts with light load which is then gradually increased proportional to the square of speed and at last reach 100% load at full load speed.

4.2.2 Starting

Too frequent starts can harm the motors. The following restrictions should be observed :

- (a) Motor can be restarted should the initial start fail. Two starts are generally permissible when the motor is cold.
- (b) Motor can be started only once when it is at normal running temperature.
- (c) Should additional starts be necessary beyond the conditions stated above, the following restrictions should be noted :
 - (1) Let the motor cool down for 60 minutes before restarting, fully loaded.
 - (2) Let the motor cool down for 30 minutes before restarting, unloaded.
 - (3) Two inching starts can be regarded as one normal start.

(d)

ATTENTION !

If the motor rotor fails to start turning within one or two seconds, shut off the power supply immediately.

Investigate thoroughly and take corrective action before attempting a restart.

Possible reasons for not starting are :

- (1) Too low a voltage at the motor terminals.
- (2) The load is too much for the rotor to accelerate.
- (3) The load is frozen up mechanically.
- (4) All electrical connections have not been made.
- (5) Single phase power has been applied.
- (6) Any combination of the above.

4.2.3 Rotating direction

- (a) Most TECO motors are bi-directional. However, when some special types, such as high speed 2P, certain large capacity motors, those with a non-reverse ratchet etc. should rotate in one direction, please ensure the rotation is in conformity with the directional arrow-mark shown on the attached nameplate.
- (b) To reverse a bi-directional motor, cut the power and wait until the motor stops. Then interchange any two of the three phases.

4.2.4 Power source, Voltage, Current

- (a) Ensure the voltage and frequency of the power source are identical to the ratings shown on the nameplate.
- (b) Voltage variation should be confined to within $\pm 10\%$ of the rating and the three phase voltages should be in full balanced.
- (c) Ensure the motor phase currents, when without load, are within $\pm 5\%$ of the average values.

4.2.5

Frequency variation should be confined to within $\pm 5\%$ of the rating. The aggregate variation of voltage and frequency should be confined to within $\pm 10\%$ of the absolute value of the ratings.

4.2.6 Starting time and unusual noises

ATTENTION !

Starting time is longer for the motors with large inertia. However, if starting time is longer than usual or if there is difficulty in starting, or there is abnormal noise, do not run the motor and refer to TECO.

4.2.7 Sleeve bearing oil rings (sleeve bearing types only)

As the oil ring is used to carry lubricant to sleeve bearings, frequently check to ensure the oil ring is in motion.

4.2.8 Bearing temperature rise

Following the initial start-up, the bearing temperatures should be closely monitored. The rate of rise in bearing temperature is more indicative of impending trouble than is the actual temperature.

ATTENTION !

If the rate of rise in temperature is excessive or if the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

If the bearing temperature rise and motor operation appear to be normal, operation should continue until the bearing temperatures stabilize.

Recommended limits on bearing temperature are as follows :

Sleeve Bearings.	Alarm temperature.	Trip temperature
• By permanently installed detector	90°C	95°C
Anti-Friction Bearings.		
• By permanently installed detector	90°C	95°C

ATTENTION ! (For sleeve bearing)

- (1) It must be noted that when operating flood lubricated sleeve bearings without outside lubrication supplied, the bearing temperature must not be allowed to exceed 85°C total temperature.**
- (2) Under normal condition, for the self-lube bearing, the rate of temperature rise should be from 11°C to 14°C for the first ten (10) minutes after starting up and approximately 22°C at thirty (30) minutes. The rate of bearing temperature rise is a function of the natural ventilation and operating conditions.**
- (3) When the rate of bearing temperature rise is less than 1°C per half hour, the bearing temperature is considered to be stabilized.**
- (4) If the total bearing temperature exceeds 95°C, the motor should be shut down immediately.**

4.2.9 Noise and Vibration

ATTENTION !

Any abnormal noise or vibration should be immediately investigated and corrected. Increased vibration can be indicative of a change in balance due to mechanical failure of a rotor part, a stator winding problem or a change in motor alignment.

5. MAINTENANCE

5.1 Major points in regular inspection and maintenance



For safety, maintenance and repairs must only be carried out by properly trained personnel.



Some testing, such as insulation resistance, usually requires the motor to be stopped and isolated from power supply(ies).

Routine inspection and maintenance are usually performed by looking, listening, smelling and simple meters.



High temperature may arise under operating conditions on the motor surfaces, so that touching should be prevented or avoided.

Keep away from moving and live parts.

Unless deemed necessary, do not remove guards whilst assessing the motor.

Timely replacement of worn parts can assure longevity and prevent breakdown.

Routine inspection and regular inspection and maintenance are important in preventing breakdown and lengthening service life.

Owing to the varied time and circumstances, motors are used, it is difficult to set the items and periods for regular inspection and maintenance. However, as a guide it is recommended to be performed periodically according to factory maintenance program. Generally, the inspection scope determined by the following factors :

- (a) Ambient temperature.
- (b) Starting and stopping frequency.
- (c) Troublesome parts usually affecting motor functions.
- (d) Easily abraded parts.
- (e) The important position of motor in the operational system of a factory should be duly recognized. Therefore, its health and wellbeing should be fully protected, especially when it is operating in severe conditions.

5.2 Motor windings

- (a) Measurement of insulation resistance and standards to determine quality of insulation resistance, please refer to measures stated in 4.1.2 "Measurement of insulation resistance".
- (b) Inspection of coil-ends :
 - (1) Grease and dust accumulated on coils may cause insulation deterioration and poor cooling effect.
 - (2) Moisture must not accumulate. Keep coils warm when motor is not in use if moisture can be seen.
 - (3) Discoloring. This is mainly caused by overheat.
- (c) Ensure no untoward change of wedges from original position.
- (d) Ensure the binding at the coil end is in its normal position.

5.3 Clean the interior of the motor

- (a) After a motor is in operation for some time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage. Regular cleaning and examination is necessary to assure top performance.
- (b) Points to note during cleaning :
 - (1) If using compressed air or a blower :
 - a) Compressed air should be free of moisture.
 - b) Maintain air pressure at 4 kg/cm², since high pressure can cause damage to coils.
 - (2) Vacuum

Vacuum cleaning can be used, both before and after other methods of cleaning, to remove loose dirt and debris. It is a very effective way to remove loose surface contamination from the winding without scattering. Vacuum cleaning tools should be non-metallic to avoid any damage to the winding insulation.
 - (3) Wiping

Surface contamination on the winding can be removed by wiping using a soft, lint-free wiping material. If the contamination is oily, the wiping material can be moistened (not dripping wet) with a safety type petroleum solvent.

In hazardous locations, a solvent such as inhibited methyl chloroform may be used, but must be used sparingly and immediately removed. While this solvent is non-flammable under ordinary conditions, it is toxic and proper health and safety precautions should be followed while using it.

ATTENTION !

Solvents of any type should never be used on windings provided with abrasion protection. Abrasion protection is a gray, rubber-like coating applied to the winding end-turns.



Adequate ventilation must always be provided in any area where solvents are being used to avoid the danger of fire, explosion or health hazards. In confined areas (such as pits) each operator should be provided with an air line respirator, a hose mask or a self-contained breathing apparatus. Operators should wear goggles, aprons and suitable gloves. Solvents and their vapors should never be exposed to open flames or sparks and should always be stored in approved safety containers.

- (4) Keep core ducts completely clean. The difference in temperature rise could be around 10°C before and after cleaning.

5.4 Clean the exterior of the motor

- (a) On open ventilated motors, screens and louvers over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air movement.

ATTENTION !

Screens and louvers should never be cleaned or disturbed while the motor is in operation because any dislodged dirt or debris can be drawn directly into the motor.

- (b) If the motor is equipped with air filters, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions. It is better to replace or recondition filters too often than not often enough.
- (c) Totally enclosed air-to-air cooled and totally enclosed fan cooled motors require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up not removed can lead to unbalance and vibration. All of the tubes of the air-to-air heat exchanger should be cleaned using a suitable tube brush having synthetic fiber bristles (not wire of any type).

5.5 Maintenance of anti-friction bearing

5.5.1 Frequency of relubrication

The life of grease varies greatly as a result of types of model, revolution speed, temperature, operational conditions etc. It is, therefore, impossible to be precise about replenishment intervals. However, for normal direct coupling transmission, the periods shown as Table 1 may be used as a guide.

Remarks :

- (a) The periods shown in Table 1 should be halved where bearings are used for belt drive and/or in dirty, or high ambient temperature or high humidity environments.
- (b) Please refer to the lubrication nameplate, if attached to the motor.
- (c) For bearing numbers outside the range of Table 1, please contact TECO.
- (d) If the periods referred to Table 1 for drive-end bearing and opposite drive-end bearing are different, for the convenience of maintenance operation, please take the shorter one the required grease replenishment period of these bearings.

TABLE 1

Bearing number		600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM	3000 RPM	3600 RPM
62XX 63XX 72XX 73XX	6210										
	12									2000Hrs	
	13										
	14									1000Hrs	
	15										
	16									720 Hrs	
	17									2000Hrs	
	18	3000Hrs									
	20										
	22										
	24									1500Hrs	
	26										
	28									2000Hrs	
	30									1000Hrs	
	32									500 Hrs	
	34									1500Hrs	
36											
38									2000Hrs		
										1000Hrs	

Bearing number		600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM		
NU2XX NU3XX	NU214										
	15									2000Hrs	
	16										
	17										
	18	3000Hrs								1500Hrs	
	20										
	22									1000Hrs	
	24										
	26									2000Hrs	
	28									500 Hrs	
	30										
	32										
	34									2000Hrs	
	36									1000Hrs	
	38	2000Hrs									
	40										
44									1000Hrs		
48	1000Hrs										

Bearing number		600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM		
222XX 223XX	22220									300Hrs	
	22										
	24	1000Hrs								500 Hrs	
	26										
	28										
	30									300 Hrs	
	32									500 Hrs	
	34										
	36										
	38	500 Hrs									
	40									300 Hrs	
44											
48	300 Hrs										

5.5.2 Kinds of grease

SHELL Alvania R3 grease is standard for TECO motors except some special models for which special grease will be shown on the lubrication nameplate. Please use identical grease or its equivalents when maintaining.

ATTENTION !

Do not mix different kinds of grease.

Mixing grease with different type of thickeners may destroy its composition and physical properties. Even if the thickeners are of the same type, possible differences in the additive may cause detrimental effects.

5.5.3 Grease quantity

The amount of grease per replenishment depends on the type, size and construction of the bearings. The maximum amount of one replenishment for each bearing is shown in Table 2.

TABLE 2

Bearing No.		Amount of replenishment	Bearing No.		Amount of replenishment
62XX	6210	30g	63XX	6310	40g
72XX	6212	40	73XX	6312	60
NU2XX	6213	50	NU3XX	6313	80
222XX	6214	50	223XX	6314	80
	6215	60		6315	100
	6216	60		6316	100
	6217	80		6317	120
	6218	80		6318	120
	6220	100		6320	160
	6222	120		6322	220
	6224	120		6324	270
	6226	140		6326	300
	6228	160		6328	400
	6230	180		6330	450
	6232	200		6332	500
	6234	250		6334	600
	6236	300		6336	700
	6238	350		6338	800
	6240	400		6340	900
	6244	450		6344	900
6248	500	6348	900		

* Fill new grease until it overflows and the old grease is entirely replaced.

5.5.4 Re-greasing



If relubrication is to be performed when the motor is running, stay clear of rotating parts.

It is advisable to re-grease when the motor is running to allow the new grease to be evenly distributed inside the bearing.

Before re-greasing, the inlet fitting should be thoroughly cleaned to prevent any accumulated dirt from being carried into the bearing with the new grease. The outlet of grease drainage should be opened to allow the proper venting of old grease.

Use a grease gun to pump grease through grease nipple into bearings. After re-greasing, operate the motor for 10-30 minutes to allow any excess grease to vent out.

5.5.5 Oil relubrication (For oil lubrication types only)

Maintain proper lubrication by checking the oil level periodically and adding oil when necessary. Because of the initial clearing action of the bearing and the expansion of the oil as it comes up operating temperature, the oil level will be higher after the motor has been in operation for a while than it is with the motor at standstill.

Overfilling should be avoided not only because of the possibility that expansion may force the oil over the oil sleeve and on to the rotor, but also because too high an operating oil level prevents the bearing from clearing itself of excess oil. The resultant churning can cause extra loss, high temperatures, and oxidized oil. If, during operation, the oil level goes above the maximum shown on the sight gauge, drain enough oil to bring the level back within the recommended operating range.

Do not permit the operating level to fall below the minimum shown on the gauge.

ATTENTION !

Should it ever become necessary to add excessive amount of make-up oil, investigate immediately for oil leaks.

Change the oil at regular intervals. The time between oil changes depends upon the severity of operating conditions and, hence, must be determined by the motor user. Two or three changes a year is typical, but special conditions, such as high ambient temperature, may require more frequent changes. Avoid operating the motor with oxidized oil.

Use only good grade, oxidation-corrosion-inhibited turbine oils produced by reputable oil companies. The viscosity of the oil to be used depends upon the type and size of the bearing, its load and speed, the ambient temperature, and the amount and temperature of the cooling water (if used). The lubrication nameplate or instructions with each motor specifies the viscosity range of oil suitable for average conditions. The usual oil viscosity recommendations are summarized in Table 3 and Table 4. Operation in ambient temperatures that are near or below freezing may require preheating the oil or the use of special oil. Whenever the motor is disassembled for general cleaning and reconditioning, the bearing housing may be washed out with a suitable cleaning solvent. Be sure that the oil metering hole is clear, and then dry the housing thoroughly before reassembly, and ensure all traces of cleaning solvent have been removed.

Table 3 oil viscosity for vertical motors**

Bearing Type	Oil viscosity	Range of pole
Angular contact ball (72XX , 73XX)	ISO VG32 (150 SSU/100°F)	2 pole
	ISO VG68 (300 SSU/100°F)	4 pole and above
Spherical roller (293XX , 294XX)	ISO VG68 (300 SSU/100°F)	4 pole
	ISO VG150 (700 SSU/100°F)	6 pole and above
RENK Vertical Bearing Inserts Type EV or Kingsbury Type	ISO VG68 (300 SSU/100°F)	4 pole and above

Table 4 oil viscosity for horizontal motors**

Bearing Type	Oil viscosity	Range of pole
Sleeve bearing	ISO VG32 (150 SSU/100°F)	2 pole
	ISO VG46 (200 SSU/100°F)	4 pole
	ISO VG68 (300 SSU/100°F)	6 pole and above

**Remark: When a lubrication nameplate attached to the motor, use lubrication oil it stipulates.

5.5.6 Cleaning and installation of bearings

(a) Apply the proper amount of grease to disassembled parts of the bearing after they have been thoroughly cleaned with high quality cleaning oil. Then protect them from contamination before and during assembly.

(b) Bearing installation

ATTENTION !

Before installing the bearings, make sure that the shaft mounted parts inside the bearings are in place before installation.

Since the bearing is a high precision component, it is important to avoid ingress of dust and foreign matter, and hammering during cleaning and installation. Use extreme care and ensure clean conditions during installation and assembly.

ATTENTION !

The best way for bearing installation is heat shrinking. Knocking and hammering during installation should be avoided absolutely.

The bearing should be heated in a bath of clean oil at temperature of approx. 80°C. After warming, slide the bearings in place quickly and nimbly so that it has not shrunk before being fully in position.

Grease the bearing after the temperature returns to normal, and then reassemble the motor.

5.6 Maintenance of sleeve bearing

5.6.1 Daily inspections

- (a) Ensure the volume and quality of lubricating oil are in compliance with specifications.

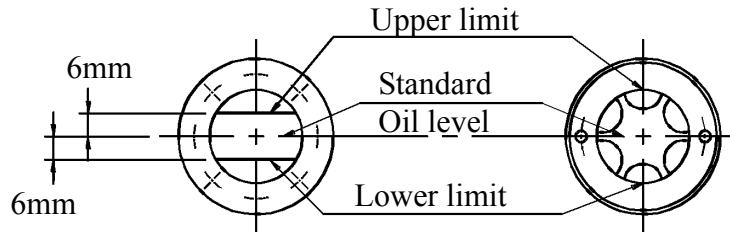


Fig. 13

- (b) Ensure there is motion of the oil ring and it is not clamped.
- (c) The indicator of the shaft endplay should be restricted within the specified range of the red groove of the shaft or the $\pm 3\text{mm}$ range of the drive-end shaft shoulder, or the bearing may be damaged.

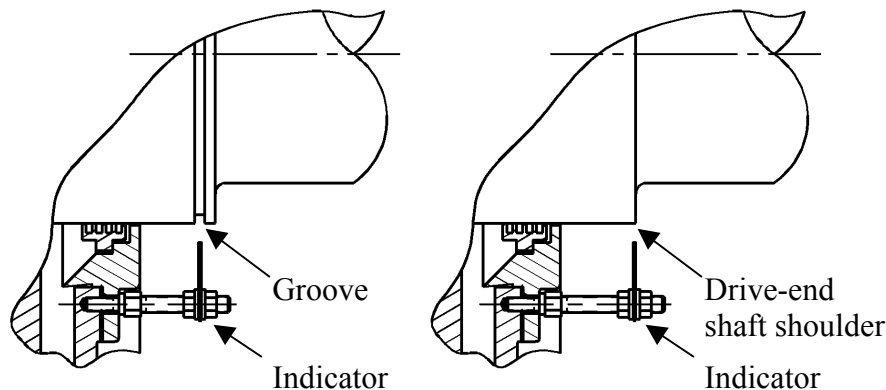


Fig. 14

5.6.2 Regular examination

- (a) Periodical change of oil

The oil reservoirs of self (not flood) lubricated bearings should be drained and refilled about every six (6) months. More frequent changes may be needed on high-speed (3600-rpm) motors or if severe oil discoloration or contamination occurs. In conditions where contamination does occur, it may be advisable to flush the reservoir with kerosene to remove any sediment before new oil is added. Proper care must be taken to thoroughly drain the reservoir of the flushing material before refilling with the new oil.

Refill the reservoir to the center of oil sight glass with a rust and oxidation inhibited turbine grade oil. Refer to the outline and lubrication nameplate for the correct viscosity.

- (b) Quantity of lubrication oil

Please refer to the lubrication nameplate for oil quantity.

(c) Oil viscosity

ISO	Equivalents		Viscosity	
	ESSO	MOBIL	cSt , 40°C	SUS/100°F
VG32	ESSO TERESSO 32	MOBIL DTE OIL LIGHT	32	150
VG46	ESSO TERESSO 46	MOBIL DTE OIL MEDIUM	46	200
VG68	ESSO TERESSO 68	MOBIL OIL HEAVY MEDIUM	68	300
VG150	ESSO NUTO 150	MOBIL DTE OIL EXTRA HEAVY	150	700

5.6.3 Disassembly



Prior to disassembling, ensure the power supplies are disconnected and there are no moving parts.

The bearing sleeve is of the spherically seated, self-aligning type. The opposite drive end bearing is normally insulated for larger motors (or when specified). On some motors, the insulation is bonded to the spherical seat of the bearing housing.

ATTENTION !

Extreme care must be exercised in removing the bearing sleeve from the insulated support to avoid damaging this insulation.

The following is the recommended procedure for removing the bearing sleeve:

- (a) Remove the oil drain plug in the housing bottom and drain the oil sump.
- (b) Remove all instrumentation sensors that are in contact with the bearing sleeve. These would include resistance temperature detectors, thermocouples, thermometers, etc.
- (c) Remove the socket head bolts holding the bearing cap and the inner air seal. The end cover plate must also be removed if the non-drive end bearing is being disassembled. Remove the bearing cap and top half of the inner air seal. Place them on a clean, dry surface to avoid damage to the parting surfaces.
- (d) Remove the top half of the bearing sleeve using suitable eyebolts in the tapped holes provided. Lift the bearing top straight up and avoid any contact with the shoulders of the shaft journals that might damage the thrust faces of the bearing. Place on a clean, dry surface taking care to prevent damage to either the parting surfaces or the locating pins that are captive in the top bearing half.
- (e) Remove the screws at the partings in the oil ring and dismantle the ring by gently tapping the dowel pin ends with a soft face mallet. Remove the ring halves and immediately reassemble them to avoid any mix up in parts or damage to the surface at the partings.
- (f) Pulls up on the garter spring surrounding the floating labyrinth seal and carefully slip out the top half. Rotate the garter spring until the lock is visible. Twist counter-clockwise to disengage the lock, remove the garter spring, and then rotate the lower half of the seal out of the groove in the bearing housing. Note the condition of these floating labyrinth seals. If they are cracked or chipped, they must be replaced. Do not attempt to reuse a damaged seal.
- (g) To remove the bottom bearing half, the shaft must be raised a slight amount to relieve pressure on the bearing. On the drive end, this can be done by jacking or lifting on the shaft

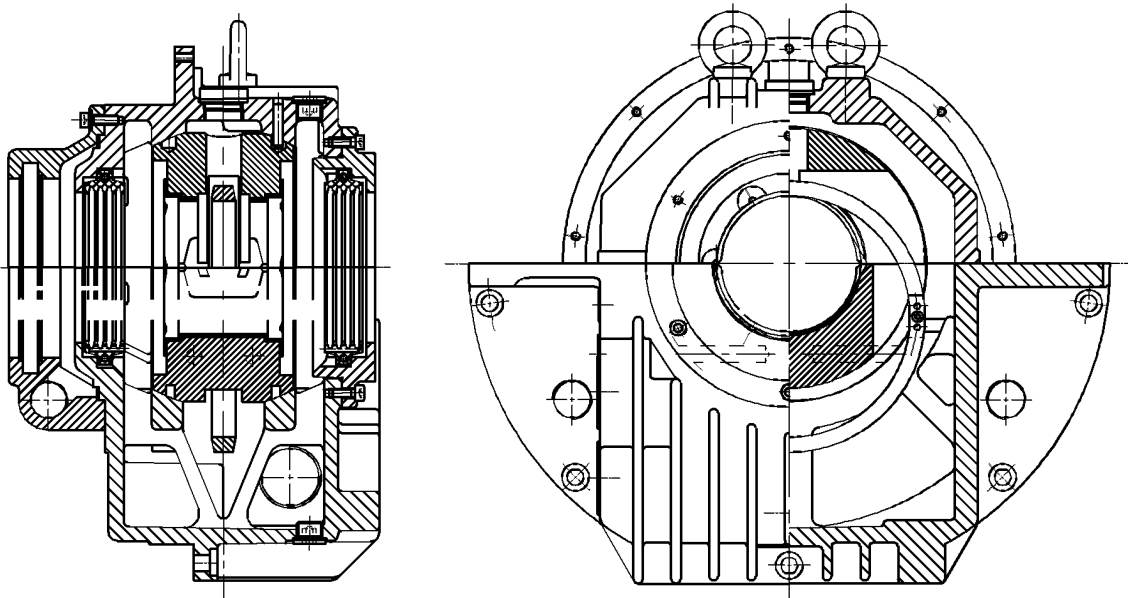
extension. Protect the shaft. On the non-drive end, jacking or lifting can be done using bolts threaded into the tapped holes provided in the shaft end.

- (h) Roll the bottom bearing half to the top of the shaft journal and then lift it using suitable eyebolts threaded into the holes provided. Again avoid any contact with the shaft shoulders that could damage the bearing thrust faces. Place the lower bearing half on a clean, dry surface to protect the parting surfaces.



Use extreme care when rolling out the lower bearing half. Keep the hands and fingers well clear of any position where they might be caught by the bearing half if it were accidentally released and rotated back to its bottom position. Serious personal injury could result.

- (i) Protect the shaft journal by wrapping it with clean, heavy paper or cardboard.



5.6.4 Reassembly

Bearing reassembly is basically a reverse of the disassembly procedures outlined above, with the following suggestion:

- (a) The interior of the bearing housing should be cleaned and then flushed with clean oil or kerosene.
- (b) The bearing halves and the shaft journal should be wiped clean using lint-free cloth soaked with clean oil.
- (c) All parts should be carefully inspected for nicks, scratches, etc., in any contact surfaces. Such imperfections should be removed by an appropriate method such as stoning, scraping, filing, etc., followed by thorough cleaning.
- (d) Before installing the floating labyrinth seal halves, observe their condition. Do not attempt to use a cracked or chipped seal. The bottom half seal has a set of drilled holes in its side face. These must be placed at the bottom toward the inside of the bearing so that accumulating oil may drain back into the housing.
- (e) Put a bead of Curil-T around the seal half O.D.'s on both sides adjacent to the garter spring groove. This will prevent oil by-passing the seal around its outside.

- (f) Place the bottom seal half on top of the shaft and roll it into position. Install the top half and insert the garter spring pulling up on both ends to permit engaging the lock. Run a bead of Curil-T around the O.D.'s on both sides adjacent to the garter spring groove on this half also.
- (g) Carefully reassemble the two oil ring halves. Inspect the dowel pins for burrs and straightness and make any corrections required. Do not force the ring halves together. Excessive force may alter the roundness or flatness of the oil ring which can change its oil delivery performance.
- (h) Some of the pipe plugs in the housing are metric thread type. These are identified as those which have a copper, lead, or similar material washer. If these plugs are removed, be careful not to lose the washers. Before reassembly, inspect the washers and replace them as required.
- (i) Before installing the bearing cap, observe the position of the floating labyrinth seal. The "tab" must be on top to engage the pocket. Failure to position the seal properly will result in damage when the cap is assembled.

ATTENTION !

- (1) Curil-T is the only approved compound for use in the assembly of the bearings on this motor. Other products may harden and impede the operation.**
- (2) During the reassembly of the bearing parts, a thin layer of Curil-T should be applied to all gaskets and machined interface surface. This suggestion does not apply to the machined surfaces of the bearing liner halves.**
- (3) When seating the bearing shell, apply a thin layer of lube oil at the spherical surface of the liner. Slowly roll the lower bearing liner into the bearing housing making sure that splitted surface of the liner and the housing are flush. Gradually lower the shaft onto the bearing. The weight of the shaft will help rotate the bearing liner so that the babbitt surface of the liner will match the slope of the journal. Sometimes it is required to use a rubber mallet to tap lightly on the bearing housing while slowly rolling the shaft to help this seating operation.**

5.7 Maintenance of slip ring (For Wound Rotor only)



Ensure motor is disconnected from power supplies and there are no accessible moving parts before maintenance operation.

5.7.1 Adjustment of carbon brush

(a) Brush pressure for normal operation :

- Electro-graphite brush... $200 \text{ g/cm}^2 \pm 10\%$

When frequent vibrations are evident or the brush is small (area below 0.5 cm^2), the pressure should be greater than as shown.

(b) Adjustment of brush pressure :

The brush pressure should be adjusted to keep normal operation as it wears.

- The brush pressure may be reduced after use, so it is necessary to re-adjust. For adjustment, please turn adjusting screw, pressure adjusting pin or pressure adjusting plate as shown in Fig.15 to obtain the correct tension ($=0.23 \times \text{brush cross sectional area in cm}^2 \pm 10\%$ kg).

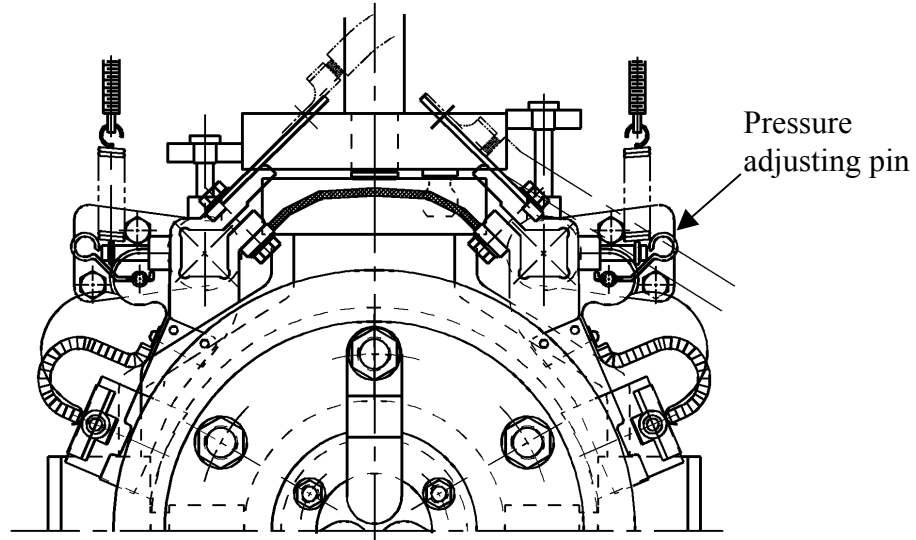


Fig. 15

(c) Brush pressure need not be adjusted if constant force spring is used as shown in Fig.16 and Fig. 17.

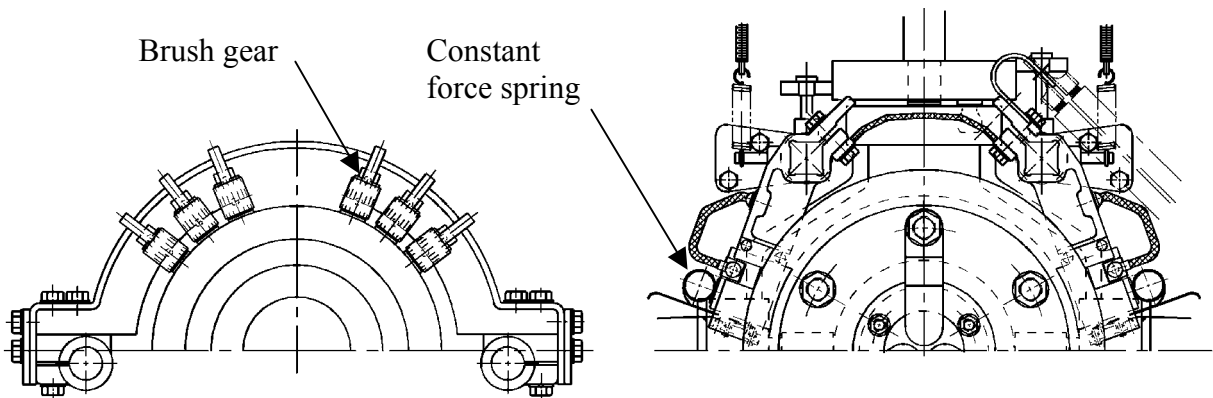


Fig. 16

Fig. 17

5.7.2 Brush replacement

The carbon brush is a part of the equipment which easily worn away, replace it after it is worn to 1/2~3/5 of original size.

(a) Brush material

The brush material is important to the performance of the motor. Only the most appropriate materials are chosen by TECO, and are listed on the nameplate of motor. It is important to know this when you replace the brush, so a recommended type is used.

(b) Dimensions

Brush, holder and gap between them, please refer to CNS 2322 C4051 or JIS C2802.

ATTENTION !

The gap between a brush and its holder is important for good performance and safety of the motor.

(c) Adjustment of new brushes (Shown in Fig.18)

- (1) Polish the new brush with a file until it assumes the appropriate contour of the slip ring which it touches.
- (2) Place sandpaper (JIS R6252 NO.40.....50) on the slip ring with the abrasive face of the paper against the brush to induce a closer contact by rubbing against each other.
- (3) Repeat item 2 with fine sand-paper (JIS R6252 NO. 100 to 200) until the contact surface between brush and slip ring exceeds 80%.
- (4) Finally, clean the contaminated slip ring and brush with clean cloth or compressed air.

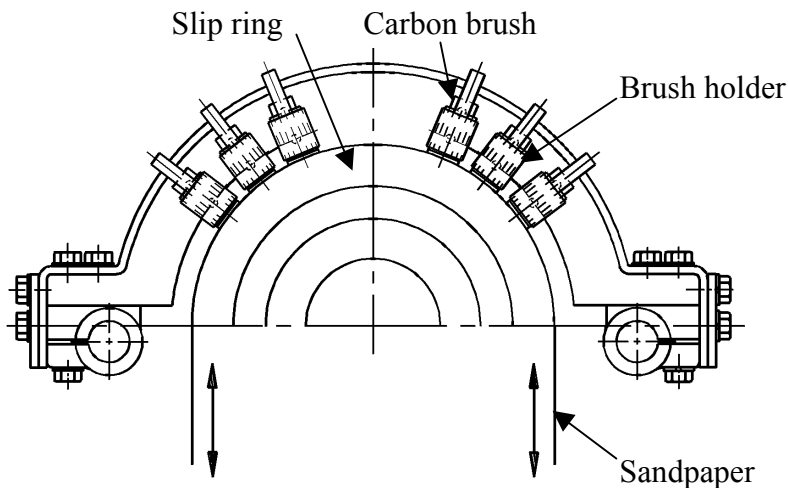


Fig. 18

5.8 Maintenance of non-reverse ratchet mechanism (For Vertical high Thrust Motor only)

5.8.1

In the pump piping system, a check valve and a stop valve should be installed in the discharge line. The check valve, placed between the pump and the stop valve, is to protect the pump from reverse flow and excessive back pressure. The stop valve is used in priming, starting and when shutting down the pump. It is advisable to close the stop valve before stopping the pump. This is especially important when the pump is operated against a high static head.

TECO vertical high thrust motors are equipped with non-reverse ratchet (N.R.R.) mechanism only when requested by the pump manufacturer. Typical construction of N.R.R. mechanism is shown as Fig.19 below.

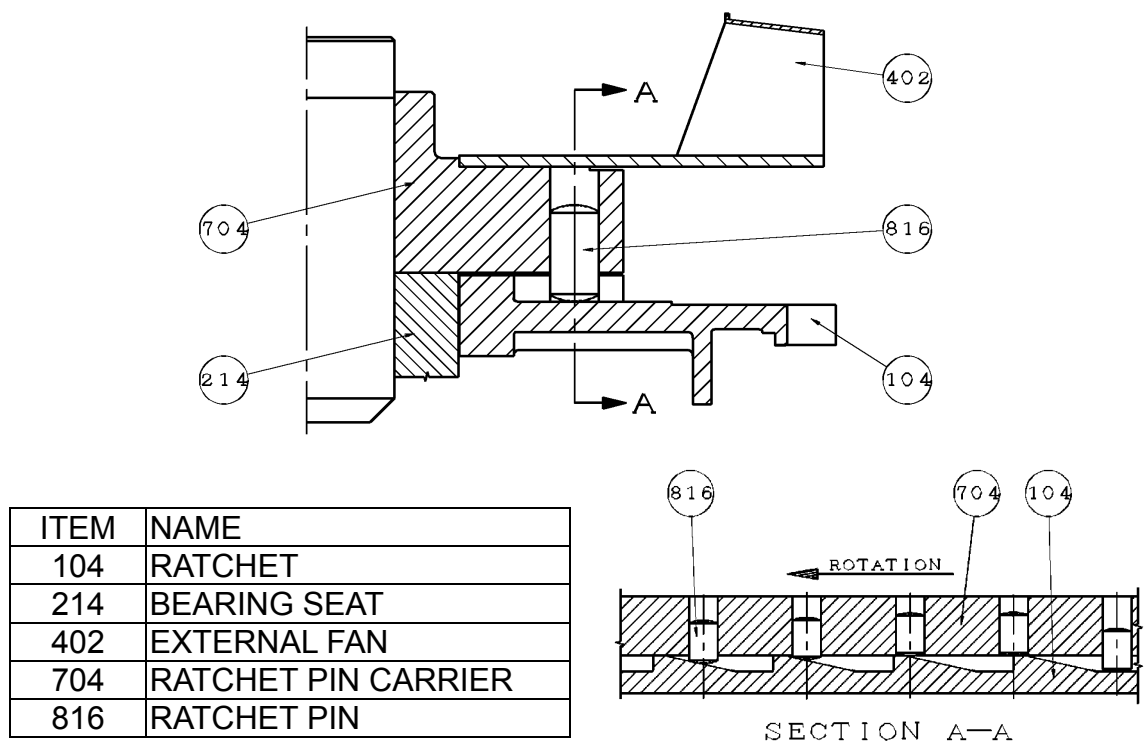


Fig. 19

The N.R.R. mechanism keeps the pump and motor from rotating in the reverse direction. Thus prevents damage from over speeding and damage to water-lubricated pump shaft bearings when, on shutdown, the falling water column tends to drive the pump in the reverse direction.

In normal operation, the ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed. When power is removed, the speed decreases and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.

5.8.2

The service life of ratchet pins depends not only on the reverse shock load between the pin and ratchet tooth when pump stopped but also the frequency of pump starting and stop in application.

Provided that the pins are deformed due to thus reverse shock load, then the up and down motion of ratchet pins could be sluggish or jammed and that unusual noises shall arise.

The recommended replacement period for these ratchet pins is every three (3) years. If the reverse shock load is greater than 30% of motor rated torque or the starting frequency is more than twice per day, then the replacement period is to be halved.

ATTENTION !

The check valve and stop valve in the discharge line should be regularly inspected and maintained to assure the normal function of these valves. This is important to protect the pump and motor from damage and increase the service life of N.R.R. mechanism.

6. FAULT FINDING AND RECOGNITION

Kinds of Breakdown	Symptoms	Possible causes	Remedies
Fail to start without load	Motionless and soundless	Power-off	Consult power company
		Switch-off	Switch-on
		No fuse	Install fuse
		Broken wiring	Check wiring and repair
		Broken lead	Check wiring and repair
		Broken windings	Check windings and repair
	Fuse blowing. (Automatic switch trips off, slow start with electromagnetic noise)	Short circuit of circuit switches	Check circuit switches and replace
		Incorrect wiring	Check wiring according to nameplate
		Poor contact at terminals	Lock tightly
		Windings grounded	Factory repair
		Broken windings	Factory repair
		Poor contact of circuit switches	Check and repair
		Broken wiring	Check and repair
		Poor contact of starting switches	Check and repair
Loading after start	Fuse blowing. Fail to restart due to trip-off of automatic switch	Insufficient capacity of fuse	Replace fuse if wiring permits
		Overload	Lighten load
		High load at low voltage	Check circuit capacity and reduce load
	Overheating motor	Overload or intermittent overload	Lighten load
		Under-voltage	Check circuit capacity and power source
		Over-voltage	Check power source
		Ventilation duct clogged	Remove the foreign matter in the duct
		Ambient temperature exceeds 40°C	Correct insulation class to B or F, or lower ambient temperature.
		Friction between rotor and stator	Factory repair
		Fuse blown (Single-phase rotating)	Install the specified fuse
	Poor contact of circuit switches	Check and repair	
	Poor contact of circuit starting switches	Check and repair	
	Unbalanced three-phase voltage	Check circuit or consult power company	

Kinds of Breakdown	Symptoms	Possible causes	Remedies
Loading after start	Speed falls sharply	Voltage drop	Check circuit and power source
		Sudden overload	Check machine
		Single-phase rotating	Check circuit and repair
	Switch overheat	Insufficient capacity of switch	Replace switch
		High load	Lighten load
	Bearing overheating	High belt tension	Adjust belt tension
		Slack belt tension	Adjust belt tension
		Misalignment between motor and machine shafts	Re-align
		Over speed of bearing outer-ring	Adjust bracket
		High bearing noise	Replace the damaged bearing
Noise	Electromagnetic noise induced by electricity	Occurrence from its first operation	May be normal
		Sudden sharp noise and smoking	Short circuit of windings Should be repaired at factory
	Bearing noise	Noise of low shishi or Thru-Thru	May be normal
		Kala-Kala as result of poor lubrication	Grease
		Kulo-Kulo as a result of deteriorated grease	Clean bearing and grease
		Sa-Sa or larger noise	Replace the damaged bearing
	Mechanical noise caused by machinery	Loose belt sheave	Adjust key and lock the screw
		Loose coupling or skip	Adjust the position of couplings, lock key and screw
		Loose screw on fan cover	Lock fan cover screw tightly
		Fan rubbing	Adjust fan position
		Rubbing as a result of ingress of foreign matters	Clean motor interior and ventilation ducts
		Wind noise	Noise induced by air flowing through ventilation ducts
		Induced by conveyance machine	Repair machine
Vibration	Electromagnetic vibration	Short circuit of windings	Factory repair
		Open circuit of rotor	Factory repair
	Mechanical vibration	Unbalanced rotor	Factory repair
		Unbalanced fan	Factory repair
		Broken fan blade	Replace fan
		Unsymmetrical centers between belt sheaves	Align central points
		Central points of couplings do not lie on the same level	Adjust the central points of couplings to the same level
		Improper mounting installation	Lock the mounting screws
		Motor mounting bed is not strong enough	Reinforce mounting bed
		Mounting bed vibration caused by near machines	Eliminate the vibration source near motor

Remarks:

- (1) Circuit switches: These include knife switches, electromagnetic switches, fuse and other connection switch etc.
- (2) Starting switches: These include Delta-Star starters, compensate starters, reactance starters, resistor starters, starting controllers etc.

DRV

Consulting Inc.

May 19, 2011
Document: 110402B

Torsional Vibration Analysis

for

O'Rourke

Customer: Compass Compression
Project: CanGas Solutions
Requestor: Nick Hu

Reported by:



Rodney R. Varty, P.Eng



Apegga Permit P11290

Summary

System Description

A 60 HP electric induction motor is coupled to a three-stage, two-throw reciprocating compressor through a Rexnord Thomas AMR 312 coupling. Compass Compression has provided five operating conditions for the compressor. A vibration analysis has been performed for these operating conditions plus a no load condition to ensure torsional compatibility of the system. Upset single acting conditions have also been evaluated.

Conclusion

Failure of the chain driven lube system at the auxiliary end of the compressor is predicted below 900 RPM. The lube system must be removed and replaced with a remote driven lube system. Please consult Ariel for their expertise regarding this modification. If the chain driven lube system is desired, do not run the compressor below 900 RPM.

Otherwise, the following analysis indicates the system is free of serious torsional vibration for the normal, no load and upset single acting operating conditions described. Analysis results indicate torsional vibration levels in the crankshaft and in the coupling are within manufacturer's acceptable levels. Predicted motor shaft vibration levels are also within allowable limits with a conservative assumption for shaft strength.

The maximum shaft/coupling hub torque is 1297 Nm or 11,479 lb-in. Confirm appropriate interference fits with the coupling manufacturer.

For compressor loading conditions other than those analyzed in this report, DRV strongly recommends another vibration analysis be performed to verify torsional compatibility of the drive train.

System Data

Motor: Teco Westinghouse 364T Frame, 31301W115 DWG, Solid Core Rotor, Keyless Drive Stub, Rated 60 BHP @ 1775 RPM, Operating @ 600-1800 RPM
Coupling: Rexnord Thomas AMR 312
(leave machined steel hubs at standard length to allow for bolt removal)
Compressor: Ariel JGA/2 - with tandem cylinders for stages 2 and 3

Recommended Limits

Torsional vibration limits are as follows:

Alternating Stress in motor shaft: +/- 45.94 MPa for combined orders
Based on an endurance limit of 202 MPa, stress concentration factor of 2.2 and safety factor of 2.0
Amplitude at compressor Auxiliary End: +/- 1.00 degrees for 1.0 order
+/- 0.50 degrees for 2.0 order
+/- 0.25 degrees for orders above 2.0
Alternating Torque in compressor shaft: +/- 2700 N-m for combined orders

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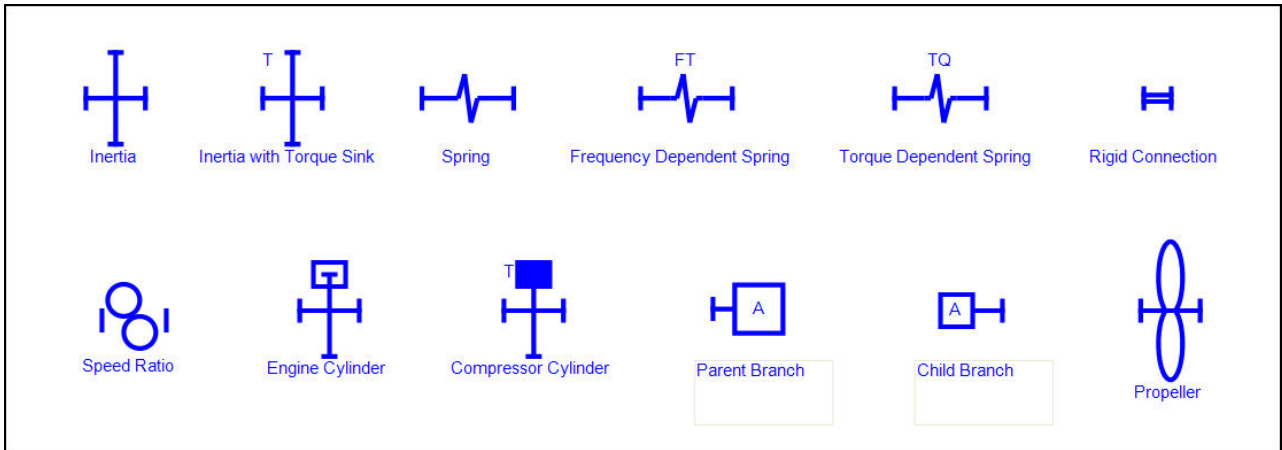
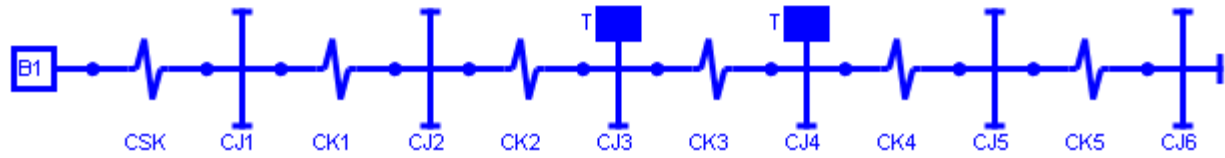
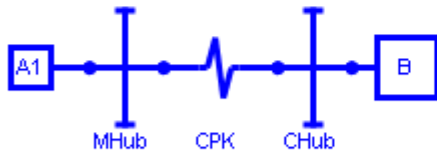
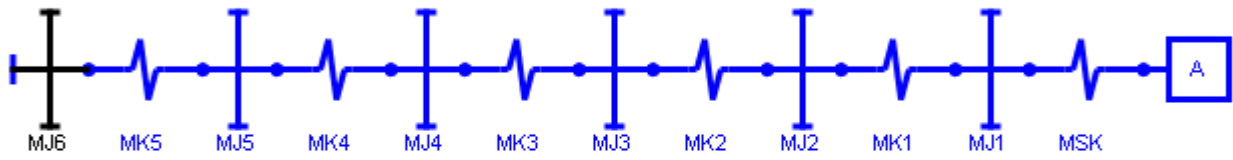
Modal Analysis

Mass-Elastic System

Rated Speed: 1775 rev/min
Rated Power: 60 HP
Speed Sweep: 540 - 1890 rev/min
Misfire: Off

Motor

Config



Mass Elastic Inertia Data

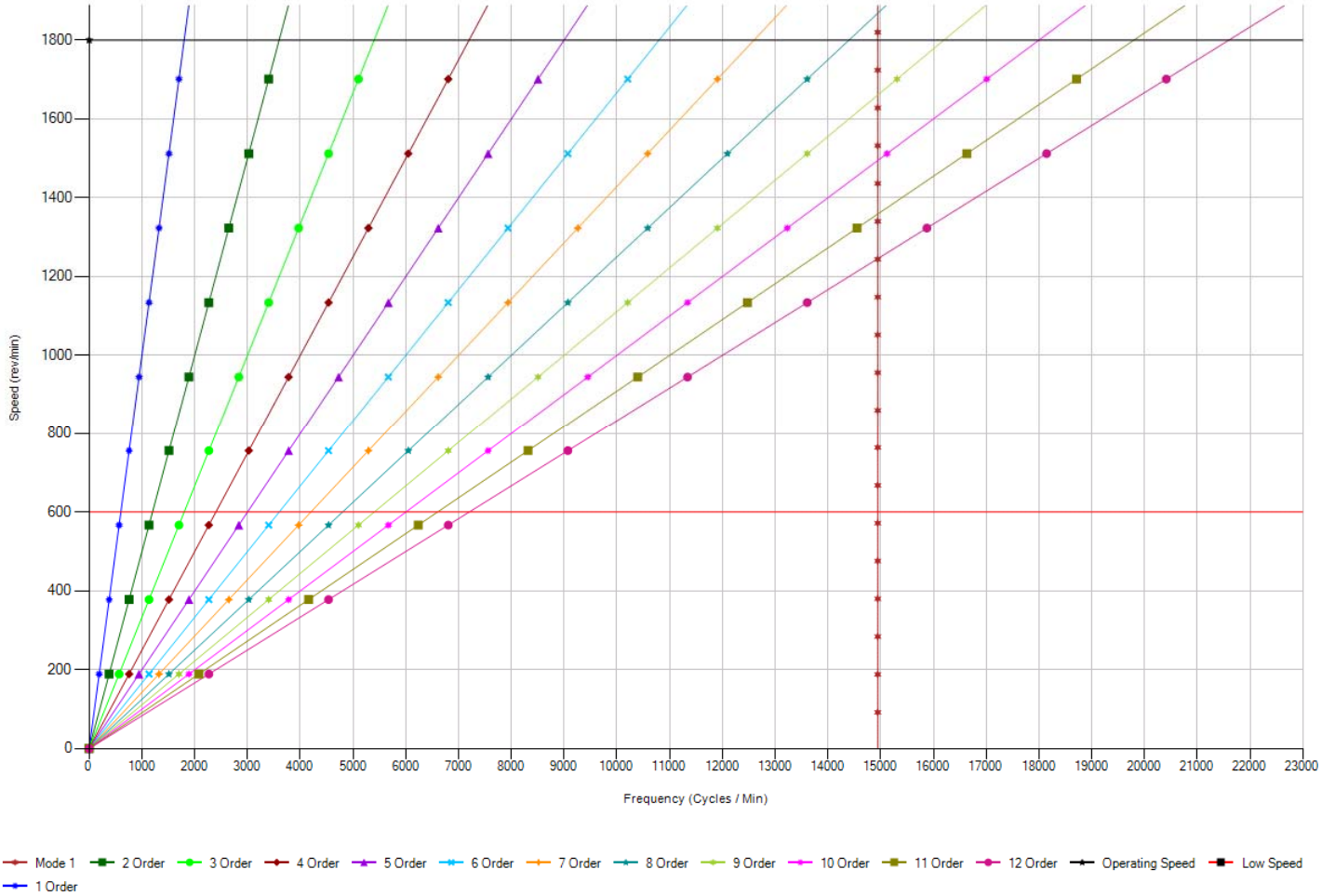
Mass ID	Description	Inertia Value (Nms ²)	Damping Value (Nms/rad)
MJ6	Core End	0.5215	15
MJ5	Core Start	0.0088	
MJ4	Step 3	0.0040	
MJ3	Step 2	0.0032	
MJ2	Step 1	0.0029	
MJ1	Stub	0.0030	
MHub	Motor Hub	0.0589	
CHub	Comp Hub	0.0594	
CJ1	Shoulder Stop	0.0163	
CJ2	Main #1 CL	0.0209	
CJ3	Throw #1 CL (stg 1)	0.0445	50
CJ4	Throw #2 CL (tandem stg 2&3)	0.0442	50
CJ5	Main #2 CL	0.0209	
CJ6	Aux Drive End	0.0101	

Mass Elastic Spring Data

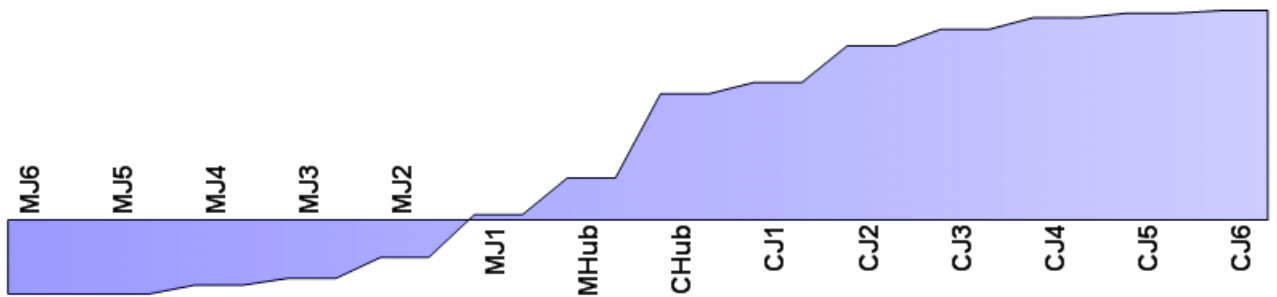
Spring ID	Description	Spring Rate (MNm/rad)	Diameter (mm)
MK5	Motor	10,000.0000	90.000
MK4	Motor	10.9144	99.000
MK3	Motor	14.3959	95.000
MK2	Motor	4.5737	85.000
MK1	Motor	2.2979	73.025
MSK	Motor Stub	2.6384	73.025
CPK	Coupling	1.0847	
CSK	Comp Stub	6.3750	66.675
CK1	Compressor	1.8473	66.675
CK2	Compressor	3.5308	66.675
CK3	Compressor	3.1941	66.675
CK4	Compressor	3.5308	66.675
CK5	Compressor	2.0089	66.675

Undamped Frequency Results

Resonant Speed Diagram



First Natural Frequency Occurs at 14,944 CPM



Forced Response Results

Forced Response Summary

Highlighted vibration levels and safety factors represent worst cases. Highlighted operating conditions are presented in forced response highlights and are based on worst cases. Vibration levels that are above limits and indicate failure are flagged red.

		Operating Conditions									
Condition		1	2	3	4	5	5	5	5	no load	
Case		2	4	6	7	Alt 1	SACE1	SACE2-IB	SACE2-OB		
Component	Limits	Min SF	Maximum Motor Combined Order Vibratory Stress (MPa)								
MK5	24.75	4.03	3.784	3.844	3.601	3.777	4.306	5.815	4.361	4.653	6.144
MK4	44.74	9.53	2.892	2.937	2.751	2.886	3.290	4.443	3.331	3.555	4.694
MK3	64.04	11.96	3.297	3.349	3.136	3.290	3.751	5.065	3.798	4.053	5.352
MK2	45.11	6.00	4.630	4.703	4.404	4.620	5.268	7.113	5.334	5.692	7.515
MK1	45.94	3.86	7.340	7.456	6.981	7.323	8.352	11.275	8.456	9.023	11.912
MSK	45.94	3.84	7.377	7.495	7.015	7.359	8.396	11.332	8.499	9.070	11.972

Component	Limits	Min SF	Minimum/Maximum Coupling Combined Order Vibratory Torque (Nm)								
CPK SS	2672	8.68	145	144	154	236	308	308	308	308	0
CPK Min	-1004	1.02	-610	-624	-555	-600	-732	-973	-719	-763	-988
CPK Max	1281	1.26	624	635	616	624	678	921	706	760	1014

Component	Limits	Min SF	Maximum Compressor Combined Order Vibratory Torque (Nm)								
CSK	2700	2.51	666	684	628	652	763	1017	768	824	1076
CK1	2700	2.47	680	698	639	663	779	1036	783	840	1095
CK2	2700	2.42	696	717	652	676	798	1058	802	861	1118
CK3	2700	4.74	325	329	322	323	493	465	519	570	537
CK4	2700	87.10	28	27	31	28	27	30	28	29	31
CK5	2700	270.00	9	9	10	9	9	10	9	9	10

Component	CJ6	Limit	Min SF	Maximum Compressor Individual Order Amplitude (deg)								
Order 1.000	1.00	0.77	0.785	0.714	0.915	0.929	0.344	0.392	1.181	1.304	0.139	
Order 2.000	0.50	0.38	1.156	1.105	1.326	1.318	1.201	0.370	0.688	1.170	0.390	
Order 3.000	0.25	2.17	0.031	0.033	0.054	0.035	0.112	0.115	0.032	0.112	0.048	
Order 4.000	0.25	3.57	0.052	0.047	0.070	0.069	0.022	0.014	0.033	0.022	0.002	
Order 5.000	0.25	10.00	0.015	0.014	0.015	0.016	0.025	0.013	0.012	0.025	0	
Order 6.000	0.25	31.25	0.007	0.007	0.008	0.007	0.006	0.004	0.005	0.006	0	
Order 7.000	0.25	50.00	0.003	0.002	0.003	0.003	0.005	0.002	0.003	0.005	0	
Order 8.000	0.25	41.67	0.004	0.004	0.006	0.005	0.001	0.002	0.003	0.001	0	
Order 9.000	0.25	83.33	0.002	0.001	0.003	0.002	0.002	0.001	0.002	0.002	0	
Order 10.000	0.25	125.00	0.002	0.002	0.002	0.002	0.001	0.002	0	0.001	0	
Order 11.000	0.25	125.00	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0	
Order 12.000	0.25	250.00	0.001	0.001	0.001	0.001	0.001	0.001	0	0.001	0	

Condition Three

Forced Response Highlights

Model Symbol	Component	Measured	Units	Order	Predicted Value	Limit	Comments
MSK	Motor	Vibratory Stress	MPa	Combined	7.02	45.94	Acceptable
CPK	Coupling	Nominal Torque	Nm	Combined	154	2672	Acceptable
		Minimum Torque	Nm	Combined	-555	-1036	Acceptable
		Maximum Torque	Nm	Combined	616	1389	Acceptable
CK2	Compressor Crankshaft	Vibratory Torque	Nm	Combined	652	2700	Acceptable
CJ6	Aux End	Absolute Amplitude	deg	1.0	0.915	1.000	Acceptable
				2.0	1.326	0.500	See Note
				4.0	0.070	0.250	Acceptable

Note: This level indicates certain aux end failure. The chain driven lube system must be removed and replaced by a remote driven lube system or the compressor must not be operated below 900 RPM.

Speed Range

The compressor can be loaded from 600-1800 RPM. The torsional response has been analyzed from 90% (540 RPM) to 105% (1890 RPM) of operating speed.

Motor Shaft Stresses

The predicted motor shaft stresses are within allowable limits.

Coupling Torques

The predicted vibratory torque for the AMR 312 coupling is within the manufacturer's allowable limits.

Compressor Crankshaft

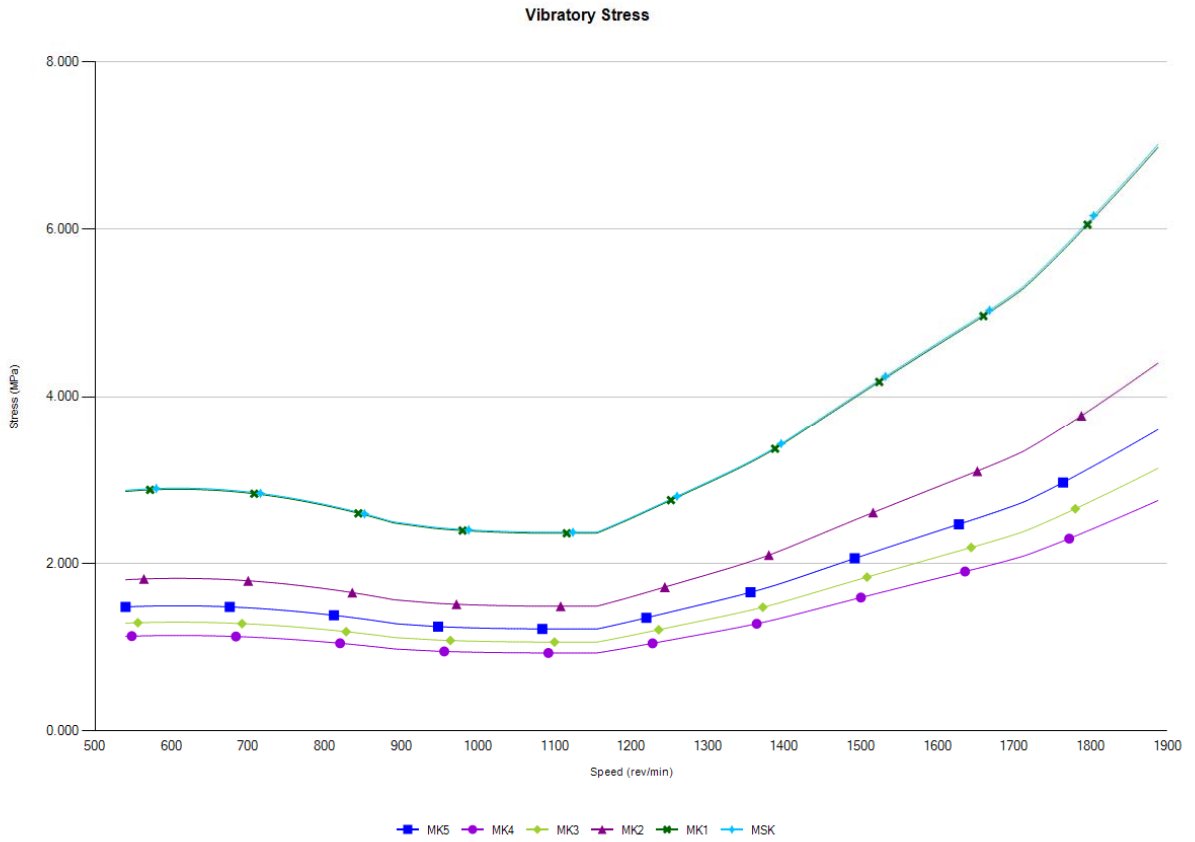
The predicted alternating torque for the JGA/2 is within the compressor manufacturer's allowable limits.

Compressor Auxiliary End Amplitudes

The predicted vibratory amplitudes at the auxiliary end of the compressor crankshaft exceed the manufacturer's allowable limits.

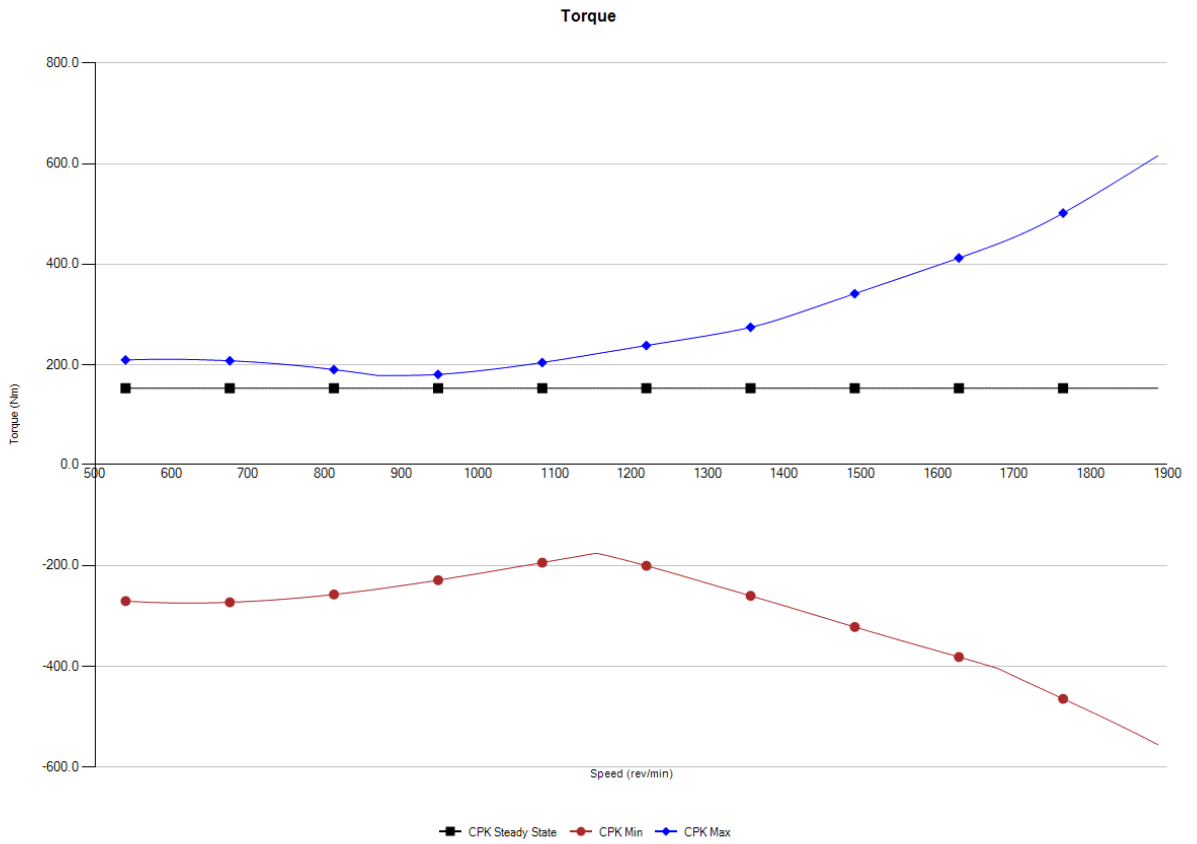
Forced Response Results

Motor Shaft Combined Order Vibratory Stress



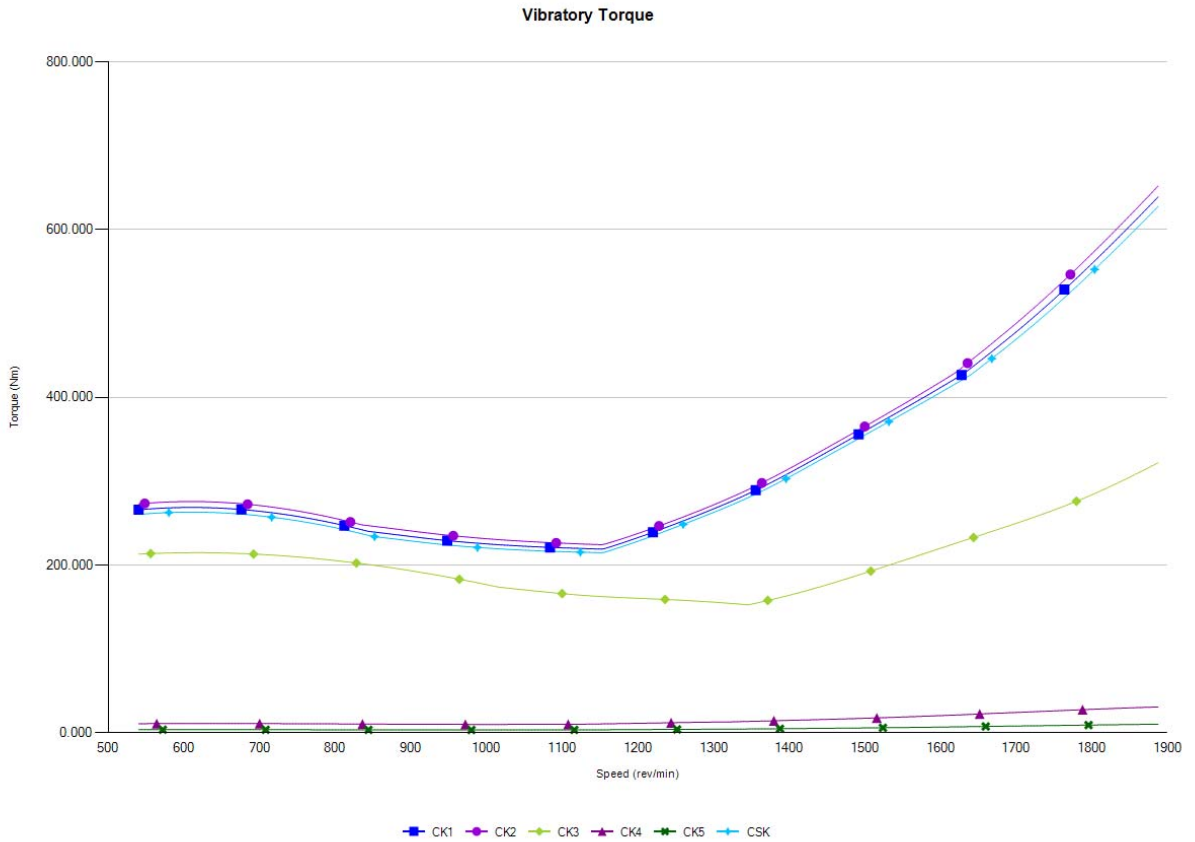
Component	Max Vibratory Stress (MPa)
MK5	3.601
MK4	2.751
MK3	3.136
MK2	4.404
MK1	6.981
MSK	7.015

Coupling Combined Order Torque



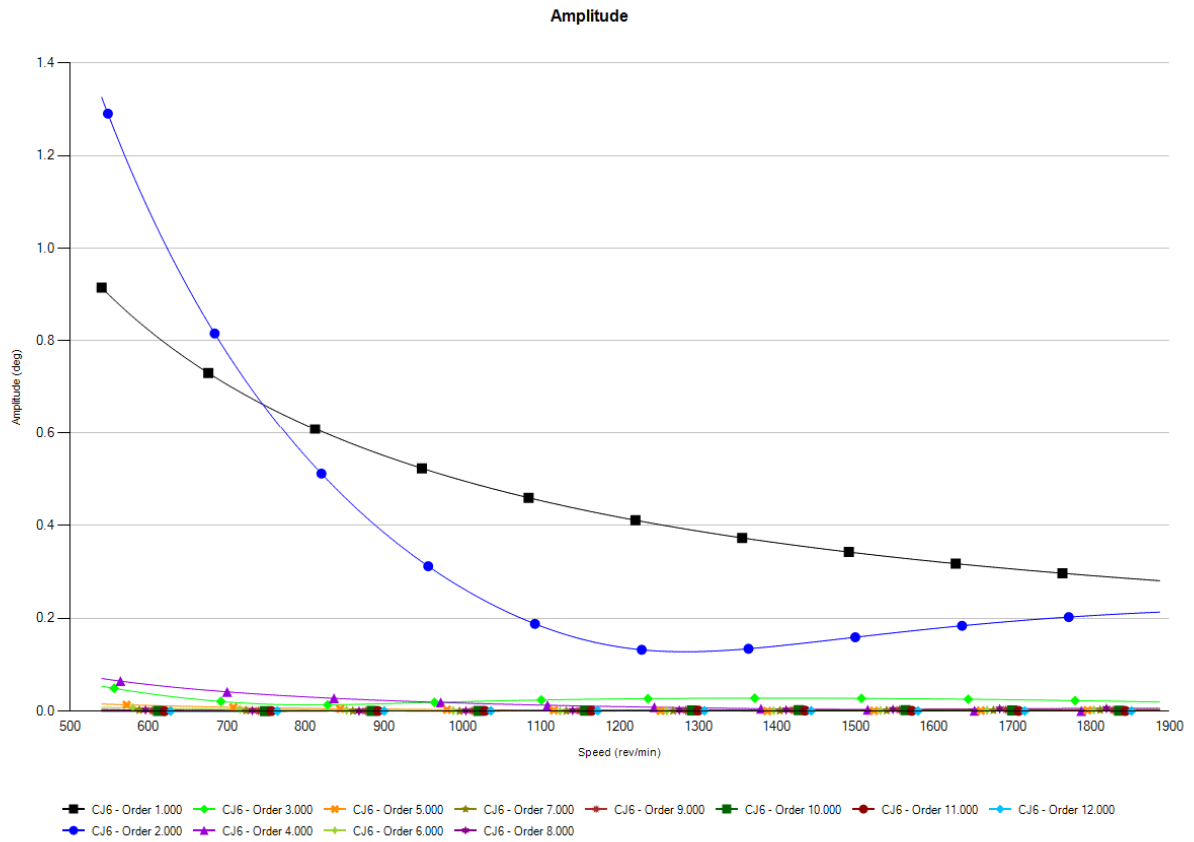
Component	Torque (Nm)
CPK Nominal	154
CPK Min	-555
CPK Max	616

Compressor Shaft Combined Order Vibratory Torque



Component	Max Vibratory Torque (Nm)
CSK	628
CK1	639
CK2	652
CK3	322
CK4	31
CK5	10

Compressor Aux End Amplitude



Component	Max Amplitude (deg)
CJ6 - Order 1.000	0.915
CJ6 - Order 2.000	1.326
CJ6 - Order 3.000	0.054
CJ6 - Order 4.000	0.070
CJ6 - Order 5.000	0.015
CJ6 - Order 6.000	0.008
CJ6 - Order 7.000	0.003
CJ6 - Order 8.000	0.006
CJ6 - Order 9.000	0.003
CJ6 - Order 10.000	0.002
CJ6 - Order 11.000	0.001
CJ6 - Order 12.000	0.001

Condition Five

Forced Response Highlights

Model Symbol	Component	Measured	Units	Order	Predicted Value	Limit	Comments
MSK	Motor	Vibratory Stress	MPa	Combined	8.40	45.94	Acceptable
CPK	Coupling	Nominal Torque	Nm	Combined	308	2672	Acceptable
		Minimum Torque	Nm	Combined	-732	-1004	Acceptable
		Maximum Torque	Nm	Combined	678	1281	Acceptable
CK2	Compressor Crankshaft	Vibratory Torque	Nm	Combined	798	2700	Acceptable
CJ6	Aux End	Absolute Amplitude	deg	1.0	0.344	1.000	Acceptable
				2.0	1.201	0.500	See Note
				3.0	0.112	0.250	Acceptable

Note: This level indicates certain aux end failure. The chain driven lube system must be removed and replaced by a remote driven lube system or the compressor must not be operated below 900 RPM.

Speed Range

The compressor can be loaded from 600-1800 RPM. The torsional response has been analyzed from 90% (540 RPM) to 105% (1890 RPM) of operating speed.

Motor Shaft Stresses

The predicted motor shaft stresses are within allowable limits.

Coupling Torques

The predicted vibratory torque for the AMR 312 coupling is within the manufacturer's allowable limits.

Compressor Crankshaft

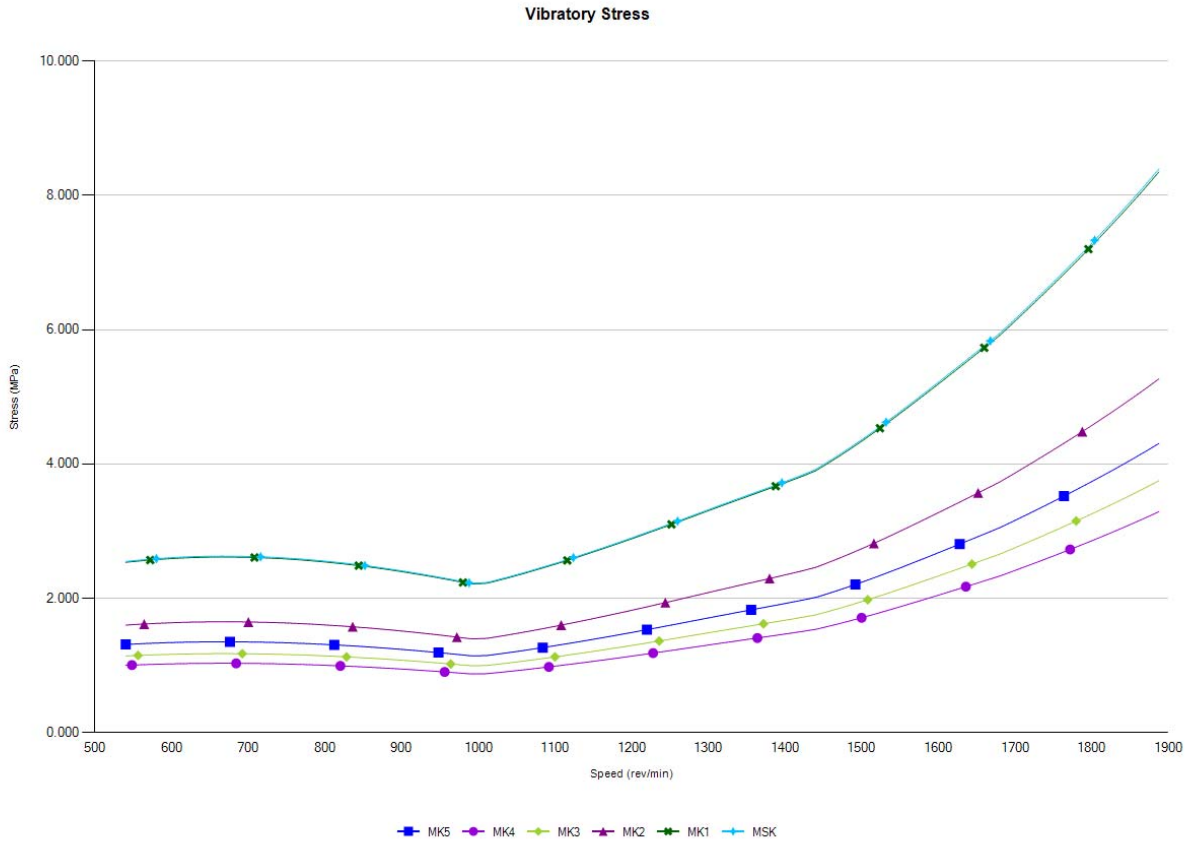
The predicted alternating torque for the JGA/2 is within the compressor manufacturer's allowable limits.

Compressor Auxiliary End Amplitudes

The predicted vibratory amplitudes at the auxiliary end of the compressor crankshaft exceed the manufacturer's allowable limits.

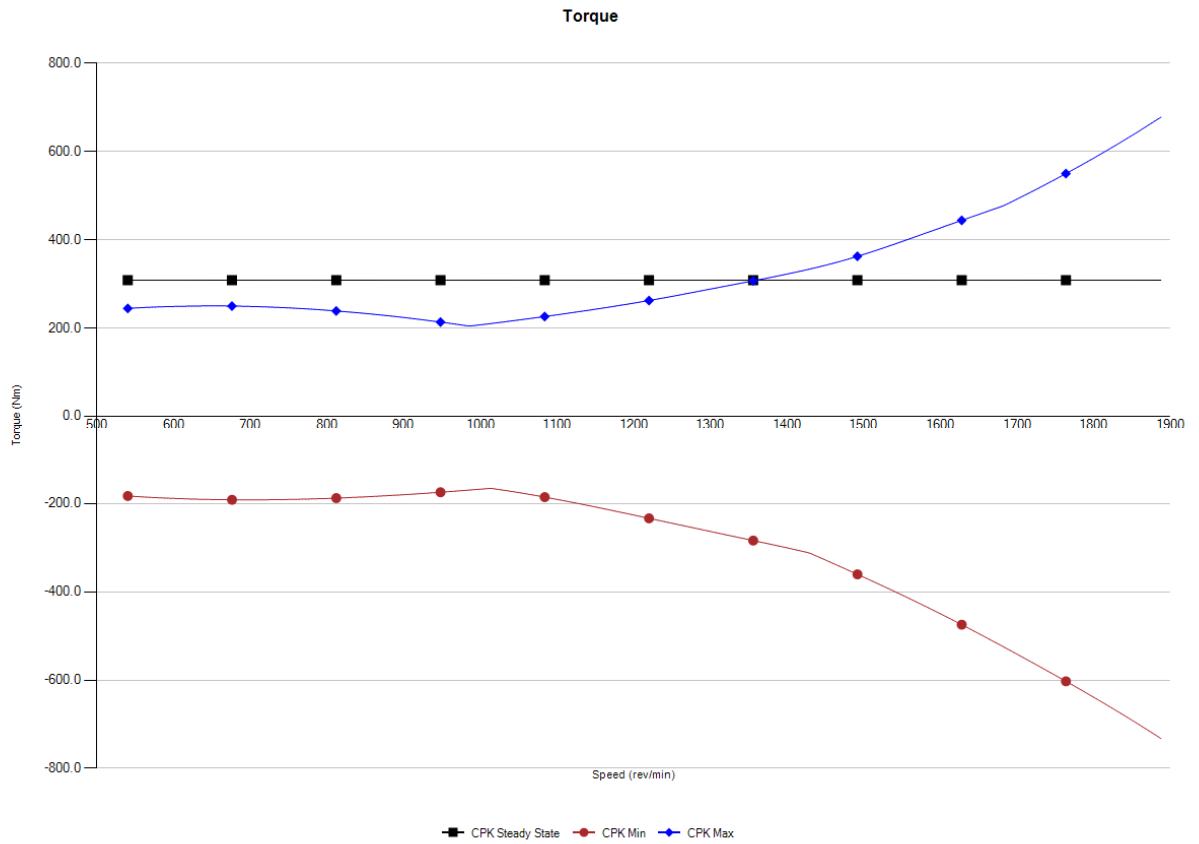
Forced Response Results

Motor Shaft Combined Order Vibratory Stress



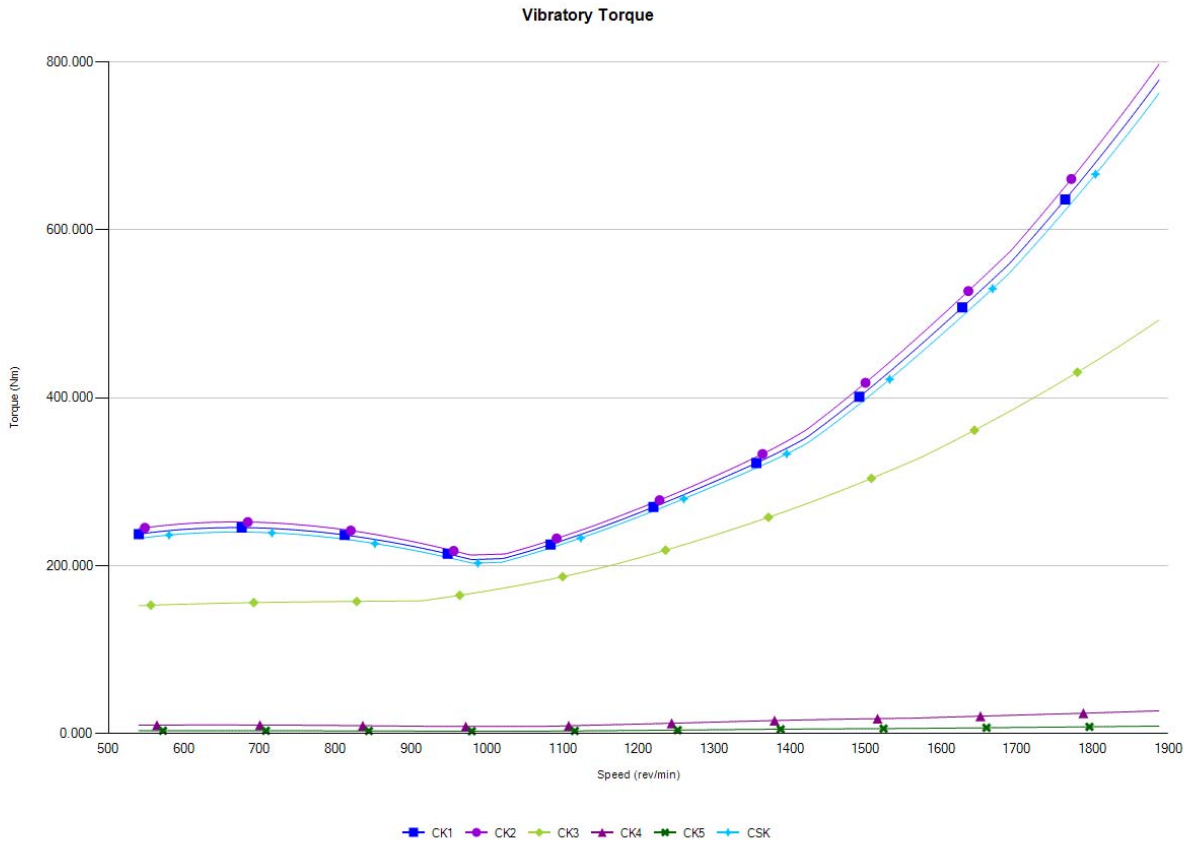
Component	Max Vibratory Stress (MPa)
MK5	4.306
MK4	3.290
MK3	3.751
MK2	5.268
MK1	8.352
MSK	8.396

Coupling Combined Order Torque



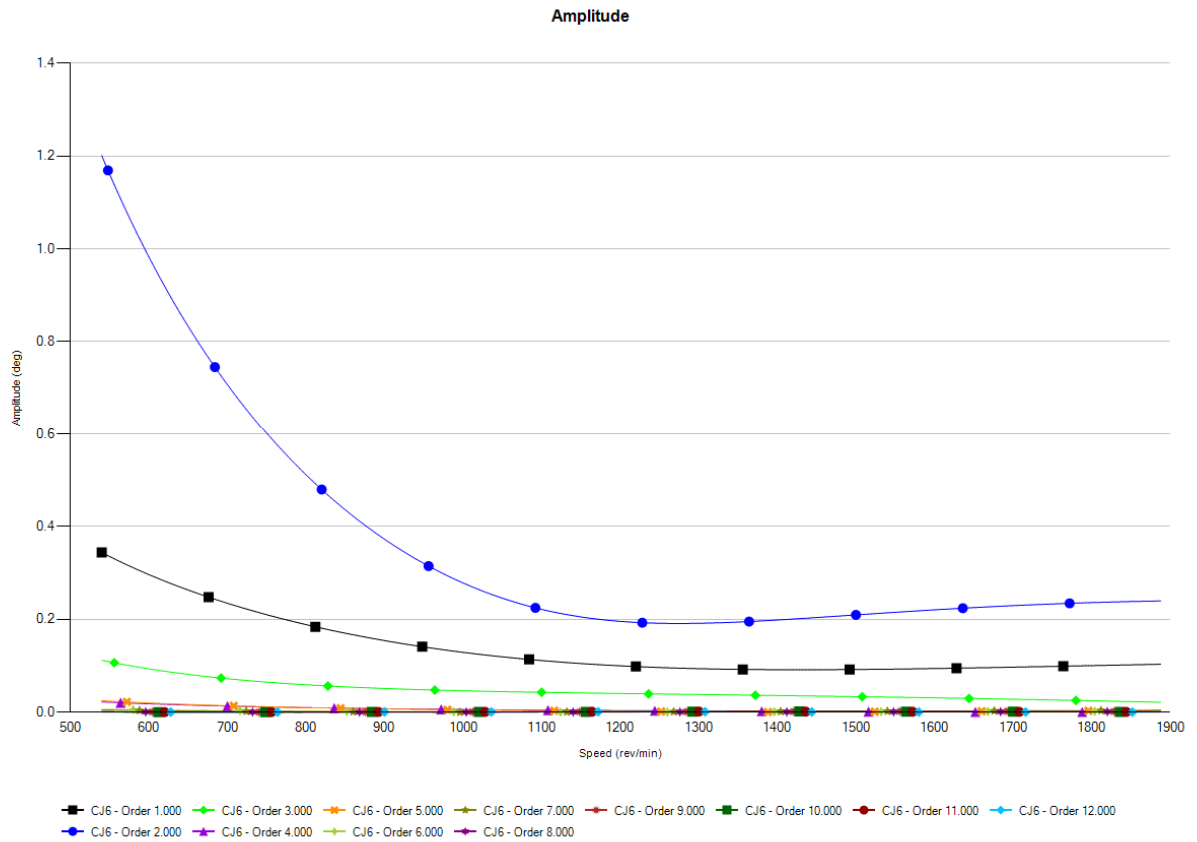
Component	Torque (Nm)
CPK Nominal	308
CPK Min	-732
CPK Max	678

Compressor Shaft Combined Order Vibratory Torque



Component	Max Vibratory Torque (Nm)
CSK	763
CK1	779
CK2	798
CK3	493
CK4	27
CK5	9

Compressor Aux End Amplitude



Component	Max Amplitude (deg)
CJ6 - Order 1.000	0.344
CJ6 - Order 2.000	1.201
CJ6 - Order 3.000	0.112
CJ6 - Order 4.000	0.022
CJ6 - Order 5.000	0.025
CJ6 - Order 6.000	0.006
CJ6 - Order 7.000	0.005
CJ6 - Order 8.000	0.001
CJ6 - Order 9.000	0.002
CJ6 - Order 10.000	0.001
CJ6 - Order 11.000	0.001
CJ6 - Order 12.000	0.001

Condition Five with Upset SACE Cylinder One

Forced Response Highlights

Model Symbol	Component	Measured	Units	Order	Predicted Value	Limit	Comments
MSK	Motor	Vibratory Stress	MPa	Combined	11.33	45.94	Acceptable
CPK	Coupling	Nominal Torque	Nm	Combined	308	2672	Acceptable
		Minimum Torque	Nm	Combined	-973	-1004	Acceptable
		Maximum Torque	Nm	Combined	921	1281	Acceptable
CK2	Compressor Crankshaft	Vibratory Torque	Nm	Combined	1058	2700	Acceptable
CJ6	Aux End	Absolute Amplitude	deg	1.0	0.392	1.000	Acceptable
				2.0	0.370	0.500	Acceptable
				3.0	0.115	0.250	Acceptable

Speed Range

The compressor can be loaded from 600-1800 RPM. The torsional response has been analyzed from 90% (540 RPM) to 105% (1890 RPM) of operating speed.

Motor Shaft Stresses

The predicted motor shaft stresses are within allowable limits.

Coupling Torques

The predicted vibratory torque for the AMR 312 coupling is within the manufacturer's allowable limits.

Compressor Crankshaft

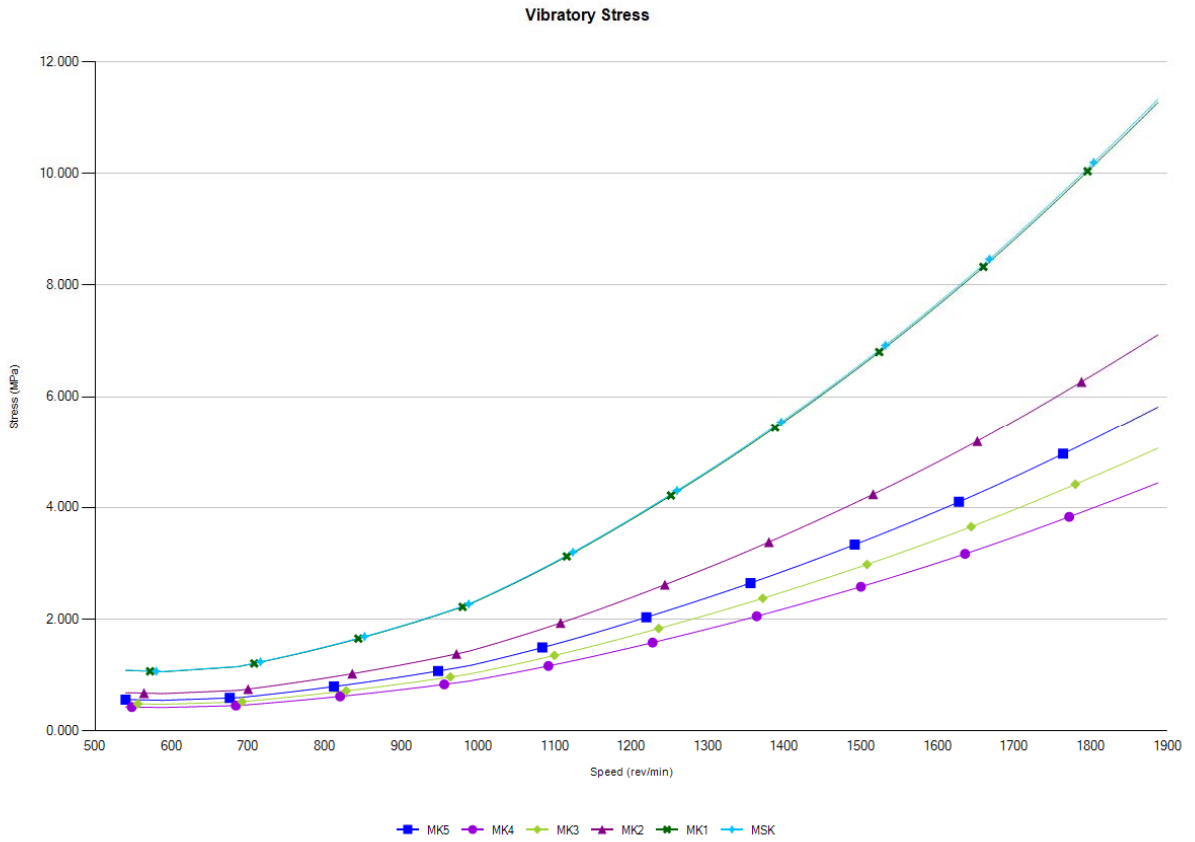
The predicted alternating torque for the JGA/2 is within the compressor manufacturer's allowable limits.

Compressor Auxiliary End Amplitudes

The predicted vibratory amplitudes at the auxiliary end of the compressor crankshaft are within the manufacturer's allowable limits.

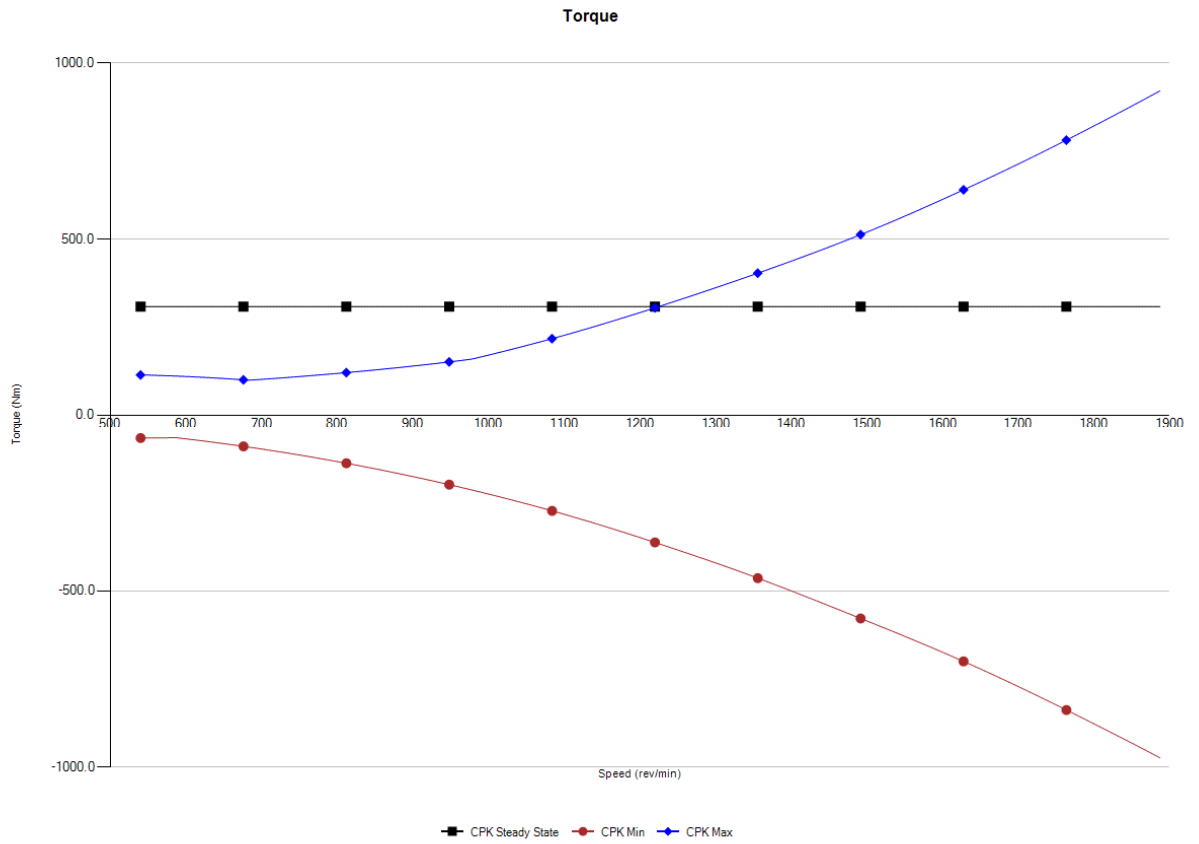
Forced Response Results

Motor Shaft Combined Order Vibratory Stress



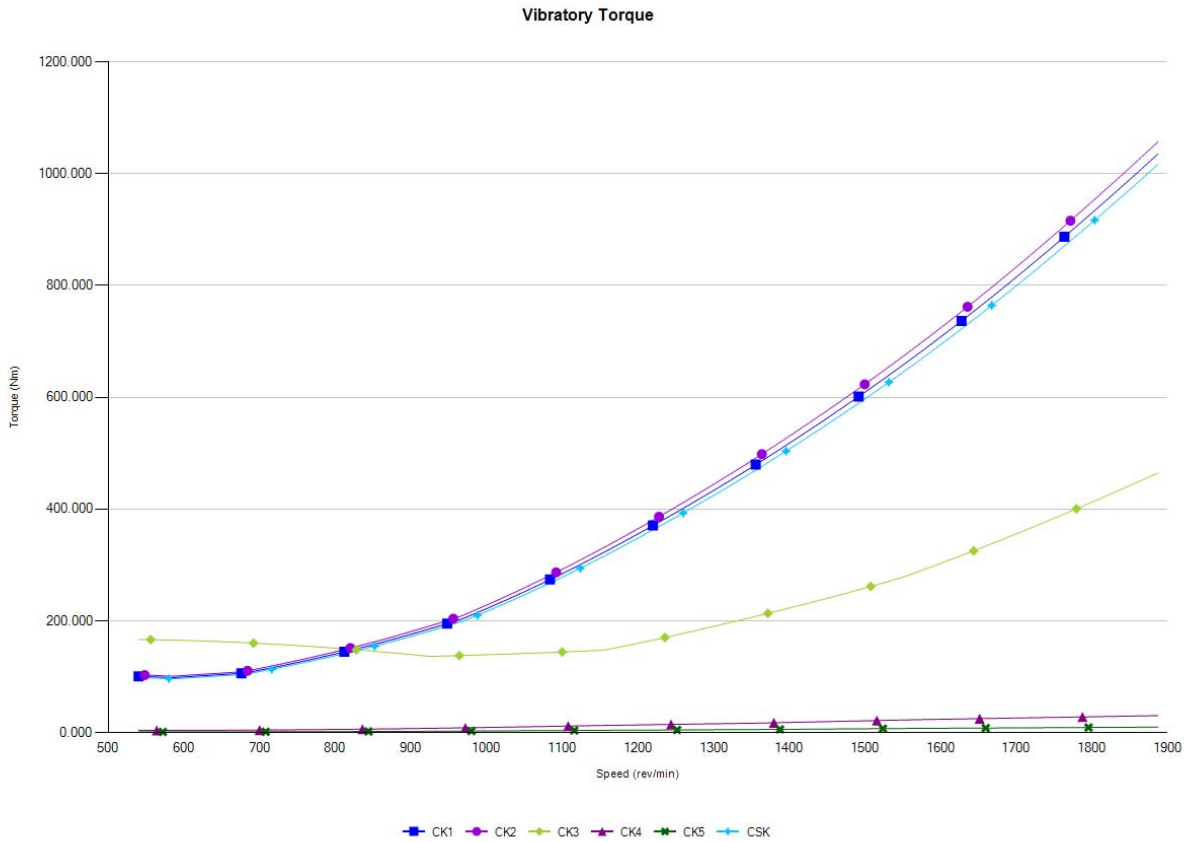
Component	Max Vibratory Stress (MPa)
MK5	5.815
MK4	4.443
MK3	5.065
MK2	7.113
MK1	11.275
MSK	11.332

Coupling Combined Order Torque



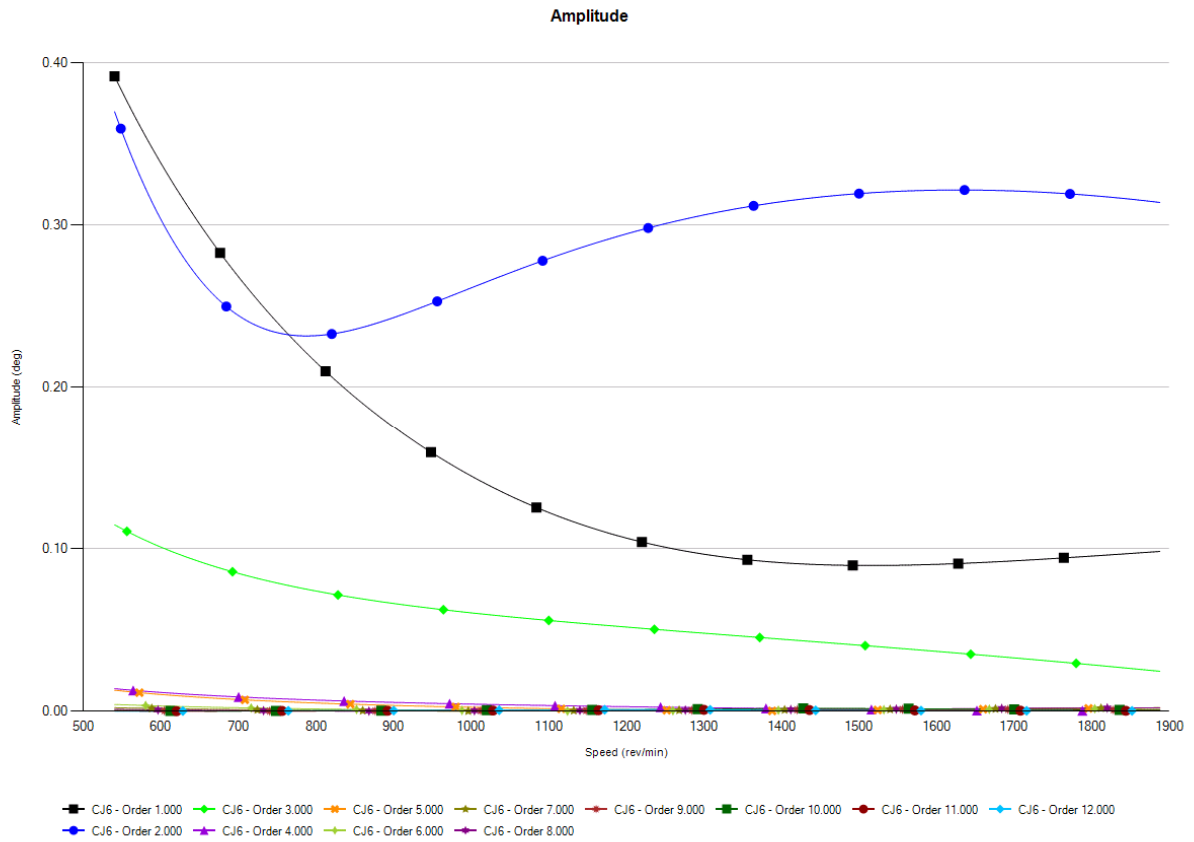
Component	Torque (Nm)
CPK Nominal	308
CPK Min	-973
CPK Max	921

Compressor Shaft Combined Order Vibratory Torque



Component	Max Vibratory Torque (Nm)
CSK	1017
CK1	1036
CK2	1058
CK3	465
CK4	30
CK5	10

Compressor Aux End Amplitude



Component	Max Amplitude (deg)
CJ6 - Order 1.000	0.392
CJ6 - Order 2.000	0.370
CJ6 - Order 3.000	0.115
CJ6 - Order 4.000	0.014
CJ6 - Order 5.000	0.013
CJ6 - Order 6.000	0.004
CJ6 - Order 7.000	0.002
CJ6 - Order 8.000	0.002
CJ6 - Order 9.000	0.001
CJ6 - Order 10.000	0.002
CJ6 - Order 11.000	0.001
CJ6 - Order 12.000	0.001

No Load Condition

Forced Response Highlights

Model Symbol	Component	Measured	Units	Order	Predicted Value	Limit	Comments
MSK	Motor	Vibratory Stress	MPa	Combined	11.97	45.94	Acceptable
CPK	Coupling	Nominal Torque	Nm	Combined	0	2672	Acceptable
		Minimum Torque	Nm	Combined	-988	-1069	Acceptable
		Maximum Torque	Nm	Combined	1014	1496	Acceptable
CK2	Compressor Crankshaft	Vibratory Torque	Nm	Combined	1118	2700	Acceptable
CJ6	Aux End	Absolute Amplitude	deg	1.0	0.139	1.000	Acceptable
				2.0	0.390	0.500	Acceptable
				3.0	0.048	0.250	Acceptable

Speed Range

No Load analysis is used to determine the system response during startup. The torsional response of the system has been analyzed with no compression loading through the operating speed range of 0 RPM to 105% (1890 RPM) of maximum speed.

Motor Shaft Stresses

The predicted motor shaft stresses are within allowable limits.

Coupling Torques

The predicted vibratory torque for the AMR 312 coupling is within the manufacturer's allowable limits.

Compressor Crankshaft

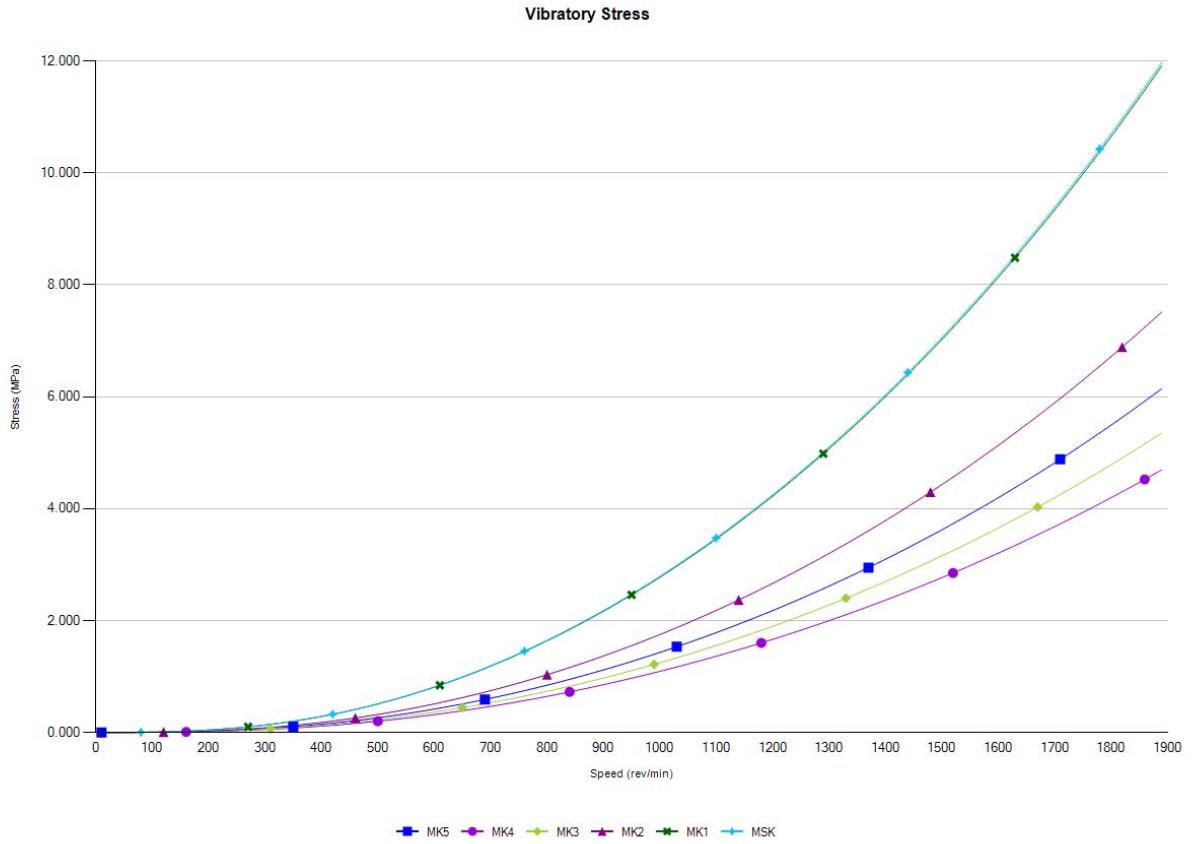
The predicted alternating torque for the JGA/2 is within the compressor manufacturer's allowable limits.

Compressor Auxiliary End Amplitudes

The predicted vibratory amplitudes at the auxiliary end of the compressor crankshaft exceed the manufacturer's allowable limits.

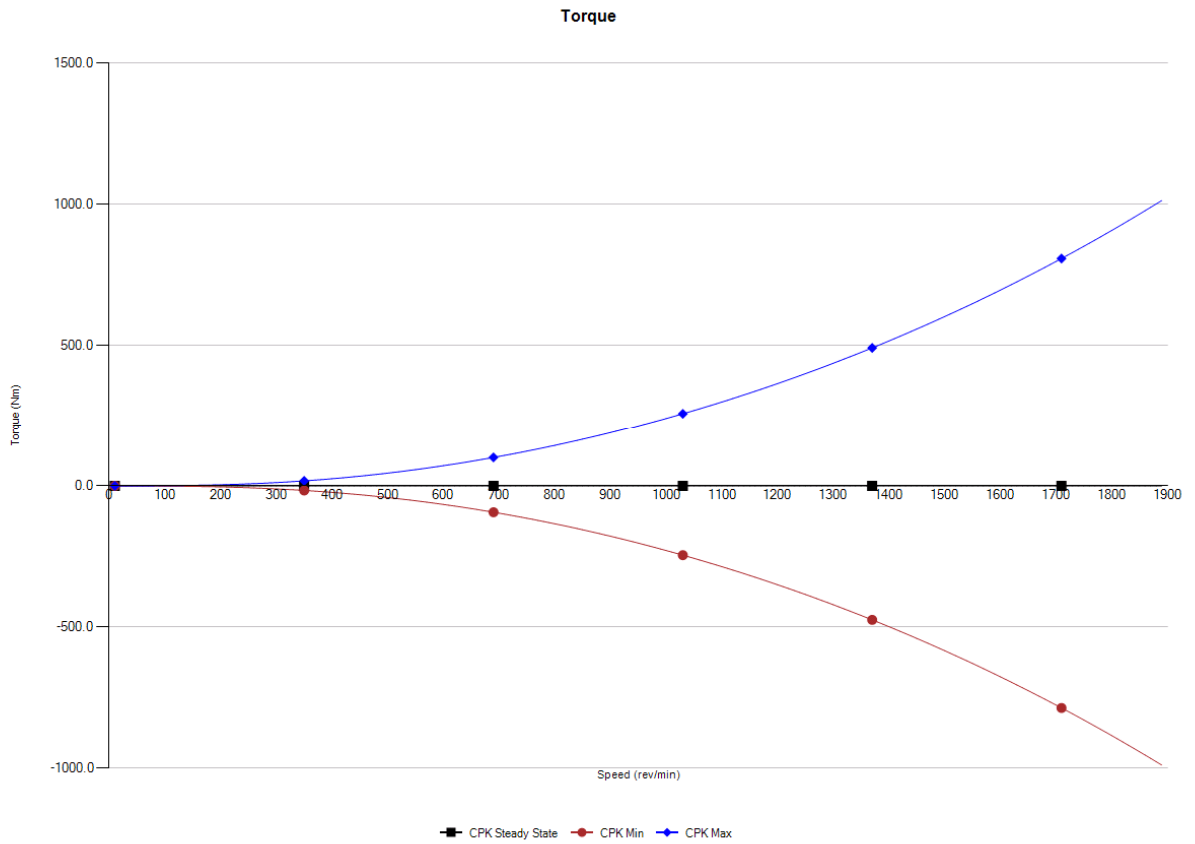
Forced Response Results

Motor Shaft Combined Order Vibratory Stress



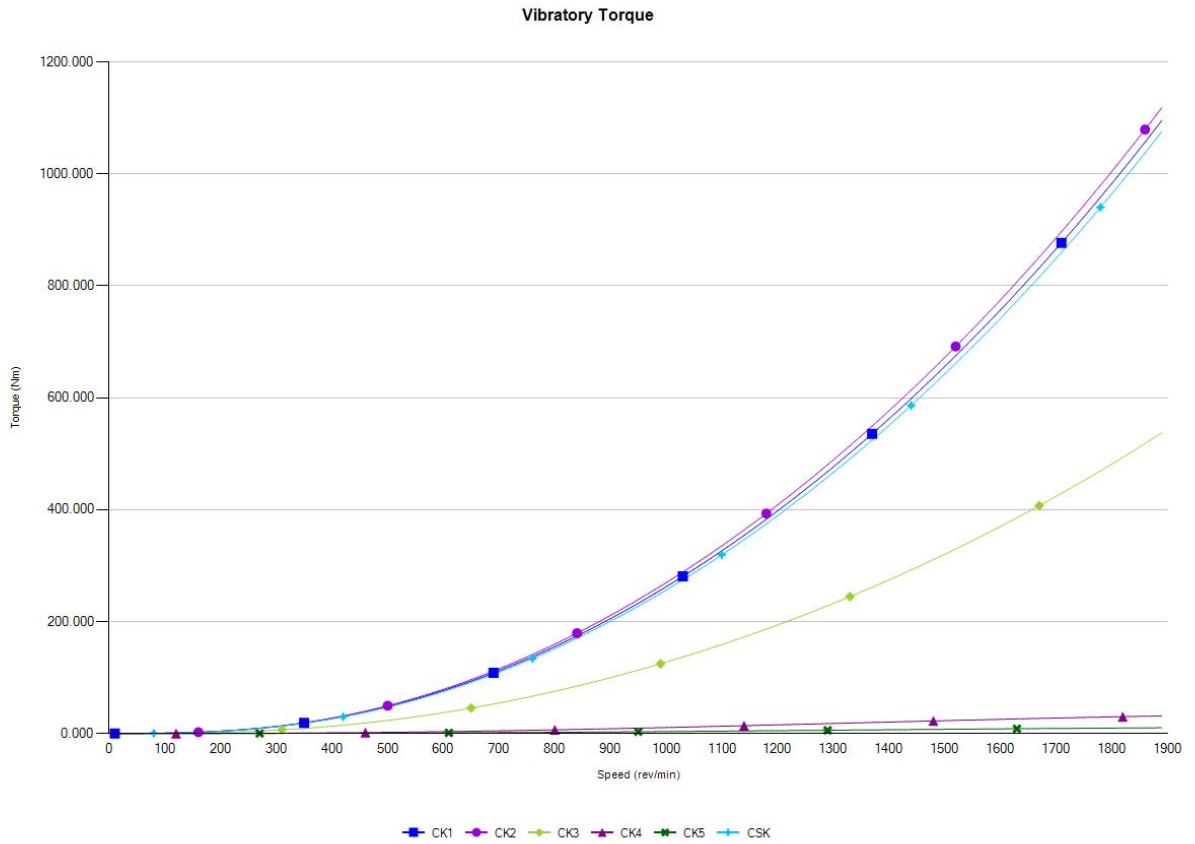
Component	Max Vibratory Stress (MPa)
MK5	6.144
MK4	4.694
MK3	5.352
MK2	7.515
MK1	11.912
MSK	11.972

Coupling Combined Order Torque



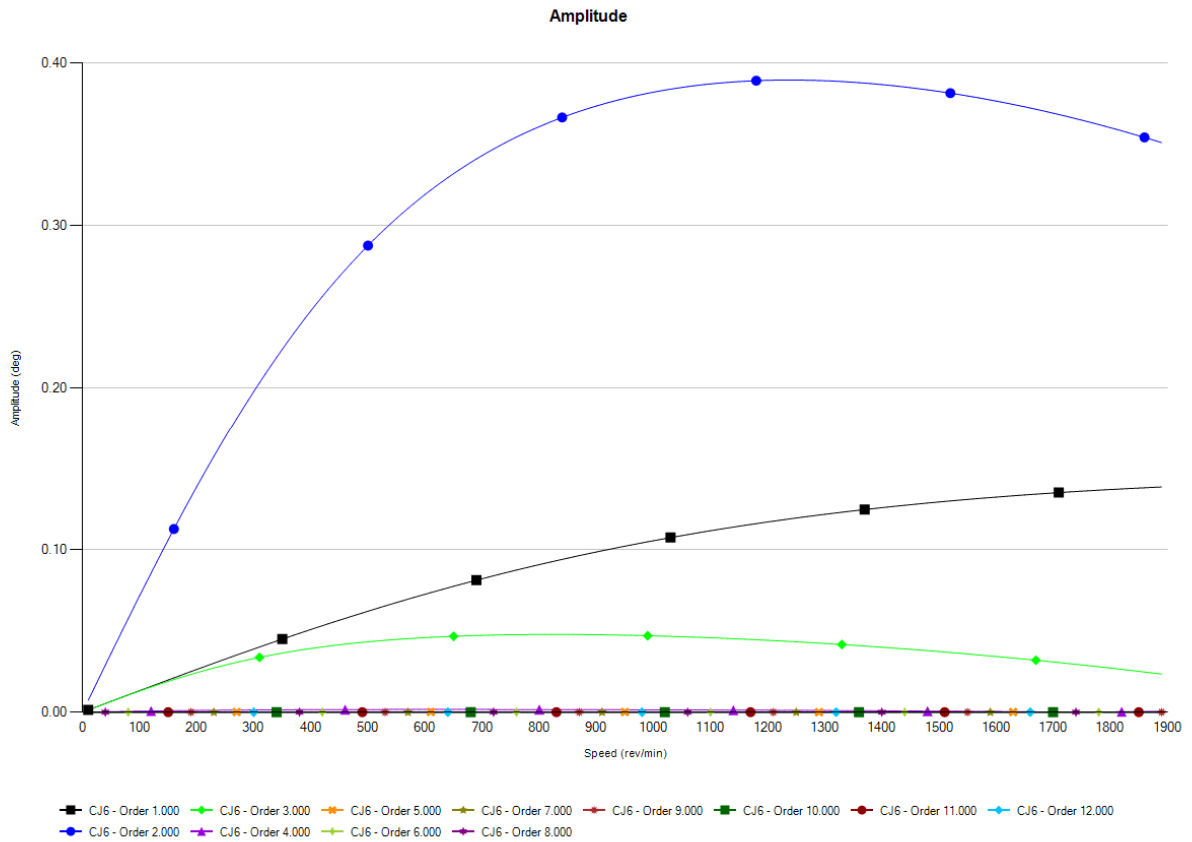
Component	Torque (Nm)
CPK Nominal	0
CPK Min	-988
CPK Max	1014

Compressor Shaft Combined Order Vibratory Torque



Component	Max Vibratory Torque (Nm)
CSK	1076
CK1	1095
CK2	1118
CK3	537
CK4	31
CK5	10

Compressor Aux End Amplitude



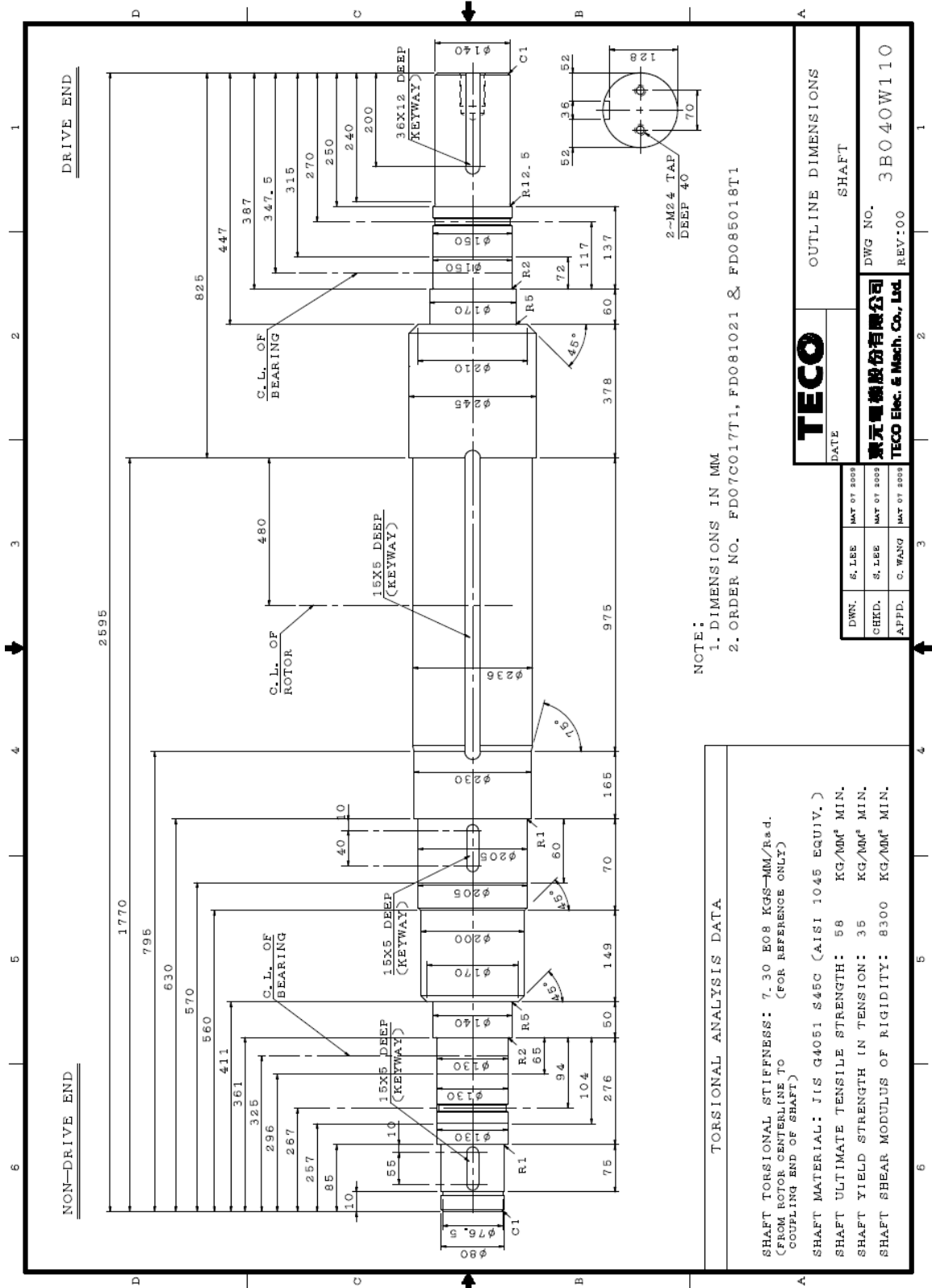
Component	Max Amplitude (deg)
CJ6 - Order 1.000	0.139
CJ6 - Order 2.000	0.390
CJ6 - Order 3.000	0.048
CJ6 - Order 4.000	0.002
CJ6 - Order 5.000	0
CJ6 - Order 6.000	0
CJ6 - Order 7.000	0
CJ6 - Order 8.000	0
CJ6 - Order 9.000	0
CJ6 - Order 10.000	0
CJ6 - Order 11.000	0
CJ6 - Order 12.000	0

Notes

1. The analysis is based upon information provided by the customer and other manufacturers. DRV is in no way responsible for the accuracy of that information. DRV warrants this analysis to be free from errors in calculations. Any damages arising out of an alleged error by DRV in this report shall be limited to free replacement of services as provided herein, to correct any defect. This warranty is expressly in lieu of any other warranties, expressed or implied, including any warranty of merchantability or fitness for a particular purpose. Remedies under this warranty are limited to free replacement of services as specified above. DRV is not responsible for incidental or consequential damages.
2. Satisfactory system operation also depends on factors other than torsional vibration. This report should not be used as a guarantee of a successful system installation.
3. Combined order results include single orders from 0 through 12. Vibratory amplitudes, stresses and torque's are single amplitude, which means they are +/- from zero.
4. System mass-elastic data values are actual values. Mass-elastic values for components driven through a gearbox are not adjusted to engine speed. Forced response peak amplitudes may appear at speeds that do not correspond to those reported on the Resonant Speed Diagram due to the effects of frequency and torque dependent components or the variation of mean load as a function of speed.
5. This report contains information from two different analysis methods that produce complementary results. The natural frequency tables and the resonant speed diagram contain no damping or excitation. The forced response results shown in the report include system damping and excitation.



Appendix

Motor Shaft Drawing
Shaft Will be Keyless with 4140 Material



Operating Conditions



Condition 1 – Case 2

Ariel Performance	
 Company: Ariel Corporation Project #: AP021437 Rev:8 Case 2:	 Customer: O'Rourke Inquiry: Project: CanGas Solutions

Compressor Data:				Driver Data:	
Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,*F:	100.00
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0
Calc RPM:	1200.0	BHP:	29	Calc PS FPM:	600.0
				Type:	VFD
				Mfg:	TECO
				Model:	TEFC-PDH
				BHP:	40
				Avail:	40 (0)

Services	Service 1		
Gas Model	VMG		
Stage Data:	1	2	3
Target Flow, MMSCFD	0.120	0.120	0.120
Flow Calc, MMSCFD	0.111	0.111	0.104
BHP per Stage	8.8	8.3	7.4
Specific Gravity	0.9965	0.9968	0.9535
Ratio of Sp Ht (N)	1.1795	1.1854	1.2213
Comp Suct (Zs)	0.9835	0.9466	0.8184
Comp Disch (Zd)	0.9647	0.9016	0.8068
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	120.19	471.52
Pres Disch Flg, psig	124.12	481.52	2020.13
Pres Disch Line, psig	N/A	N/A	2000.00
Pres Ratio F/F	4.117	3.705	4.194
Temp Suct, *F	68.00	110.00	110.00
Temp Clr Disch, *F	110.00	110.00	110.00
Cylinder Data:	Throw 1	Throw 2	Throw 2
Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	83.9	19.4	3.7
Pres Suct Intl, psig	18.40	114.76	464.71
Temp Suct Intl, *F	72	114	114
Pres Disch Intl, psig	130.70	507.02	2058.01
Temp Disch Intl, *F	210	255	289
HE Suct Gas Vel, FPM	5762	N/A	2953
HE Disch Gas Vel, FPM	5339	N/A	3212
HE Spcrrs Used/Max	1/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	16.59	N/A	17.00
HE Total Clr, %	25.86	N/A	17.00
CE Suct Gas Vel, FPM	5484	5281	N/A
CE Disch Gas Vel, FPM	5081	5396	N/A
CE Spcrrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	17.84	22.02	N/A
CE Total Clr, %	17.84	22.02	N/A
Suct Vol Eff HE/CE, %	31.6/50.4	N/A/45.7	53.9/N/A
Disch Event HE/CE, ms	4.6/6.9	N/A/6.9	6.3/N/A
Suct Pseudo-Q HE/CE	5.1/5.1	N/A/4.9	2.2/N/A
Gas Rod Ld Comp, %	21.3 C	32.7 C	32.7 C
Gas Rod Ld Tens, %	21.8 T	28.8 T	28.8 T
Gas Rod Ld Total, %	22.6	32.4	32.4
Xhd Pin Deg/%Rvrsl lbf	140/89.3	167/69.1	167/69.1
Flow Calc, MMSCFD	0.111	0.111	0.104
Cyl BHP	8.8	8.3	7.4

Condition 2 – Case 4

Ariel Performance			
	Company: Ariel Corporation	Customer: O'Rourke	
	Project #: AP021437 Rev:8	Inquiry:	
7.6.5.1	Case 4:	Project: CanGas Solutions	

Compressor Data:

Elevation,ft: 2500.00
 Frame: JGA/2
 Max RL Tot, lbf: 20000
 Rated RPM: 1800
 Calc RPM: 1200.0

Barmtr,psia: 13.400
 Stroke, in: 3.00
 Max RL Tens, lbf: 10000
 Rated BHP: 280.0
 BHP: 28

Ambient, °F: 100.00
 Rod Dia, in: 1.125
 Max RL Comp, lbf: 11000
 Rated PS FPM: 900.0
 Calc PS FPM: 600.0

Driver Data:

Type: VFD
 Mfg: TECO
 Model: TEFC-PDH
 BHP: 40
 Avail: 40 (0)

Services

Gas Model



Service 1

VMG

Stage Data:

	1	2	3
Target Flow, MMSCFD	0.120	0.120	0.120
Flow Calc, MMSCFD	0.113	0.113	0.106
BHP per Stage	8.9	8.3	7.1
Specific Gravity	0.9965	0.9967	0.9564
Ratio of Sp Ht (N)	1.1795	1.1853	1.2220
Comp Suct (Zs)	0.9835	0.9471	0.8224
Comp Disch (Zd)	0.9649	0.9031	0.7997
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	118.94	458.05
Pres Disch Flg, psig	122.73	467.63	1818.13
Pres Disch Line, psig	N/A	N/A	1800.00
Pres Ratio F/F	4.076	3.635	3.885
Temp Suct, °F	68.00	110.00	110.00
Temp Clr Disch, °F	110.00	110.00	110.00
Cylinder Data:	Throw 1	Throw 2	Throw 2
Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	83.9	19.4	3.7
Pres Suct Intl, psig	18.40	113.56	451.43
Temp Suct Intl, °F	72	114	114
Pres Disch Intl, psig	129.26	492.45	1853.12
Temp Disch Intl, °F	209	252	279
HE Suct Gas Vel, FPM	5762	N/A	2953
HE Disch Gas Vel, FPM	5339	N/A	3212
HE Spcra Used/Max	1/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	16.59	N/A	17.00
HE Total Clr, %	25.86	N/A	17.00
CE Suct Gas Vel, FPM	5484	5281	N/A
CE Disch Gas Vel, FPM	5081	5396	N/A
CE Spcra Used/Max	0/2	0/2	N/A
CE Min Clr, %	17.84	22.02	N/A
CE Total Clr, %	17.84	22.02	N/A
Suct Vol Eff HE/CE, %	32.4/50.9	N/A/46.9	56.9/N/A
Disch Event HE/CE, ms	4.7/6.9	N/A/7.1	6.7/N/A
Suct Pseudo-Q HE/CE	5.1/5.1	N/A/4.9	2.2/N/A
Gas Rod Ld Comp, %	21.0 C	29.4 C	29.4 C
Gas Rod Ld Tens, %	21.5 T	27.8 T	27.8 T
Gas Rod Ld Total, %	22.3	30.0	30.0
Xhd Pin Deg/%RvrsI lbf	140/87.4	176/73.4	176/73.4
Flow Calc, MMSCFD	0.113	0.113	0.106
Cyl BHP	8.9	8.3	7.1



Condition 3 – Case 6

Ariel Performance			
	Company: Ariel Corporation	Customer: O'Rourke	
	Project #: AP021437 Rev:8	Inquiry:	
7.6.5.1	Case 6: 120 mscfd	Project: CanGas Solutions	

Compressor Data:			Driver Data:		
Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,°F:	100.00
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0
Calc RPM:	1100.7	BHP:	30	Calc PS FPM:	550.3
				Type:	VFD
				Mfg:	TECO
				Model:	TEFC-PDH
				BHP:	37
				Avail:	37 (0)

Services	Service 1		
Gas Model	VMG		
Stage Data:	1	2	3
Target Flow, MMSCFD	0.120	0.120	0.120
Flow Calc, MMSCFD	0.114	0.114	0.105
BHP per Stage	9.7	8.4	7.8
Specific Gravity	0.9965	0.9971	0.9426
Ratio of Sp Ht (N)	1.1788	1.1876	1.2219
Comp Suct (Zs)	0.9835	0.9404	0.8027
Comp Disch (Zd)	0.9627	0.8919	0.8214
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	135.46	526.62
Pres Disch Flg, psig	139.64	536.62	2424.13
Pres Disch Line, psig	N/A	N/A	2400.00
Pres Ratio F/F	4.582	3.695	4.514
Temp Suct, °F	68.00	110.00	110.00
Temp Clr Disch, °F	110.00	110.00	110.00
Cylinder Data:	Throw 1	Throw 2	Throw 2
Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	76.9	17.8	3.4
Pres Suct Intl, psig	18.66	130.34	520.19
Temp Suct Intl, °F	73	114	114
Pres Disch Intl, psig	145.73	560.74	2460.73
Temp Disch Intl, °F	219	254	299
HE Suct Gas Vel, FPM	5285	N/A	2708
HE Disch Gas Vel, FPM	4897	N/A	2946
HE Spcrrs Used/Max	0/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
HE Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	16.59	N/A	17.00
HE Total Clr, %	16.59	N/A	17.00
CE Suct Gas Vel, FPM	5030	4844	N/A
CE Disch Gas Vel, FPM	4661	4950	N/A
CE Spcrrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	17.84	22.02	N/A
CE Total Clr, %	17.84	22.02	N/A
Suct Vol Eff HE/CE, %	47.4/44.1	N/A/45.7	52.3/N/A
Disch Event HE/CE, ms	5.9/6.8	N/A/7.6	6.5/N/A
Suct Pseudo-Q HE/CE	4.7/4.3	N/A/4.1	1.9/N/A
Gas Rod Ld Comp, %	24.0 C	39.0 C	39.0 C
Gas Rod Ld Tens, %	24.7 T	31.5 T	31.5 T
Gas Rod Ld Total, %	25.6	37.2	37.2
Xhd Pin Deg/%Rvrsl lbf	166/99.4	149/66.2	149/66.2
Flow Calc, MMSCFD	0.114	0.114	0.105
Cyl BHP	9.7	8.4	7.8

Condition 4 – Case 7

Ariel Performance			
	Company: Ariel Corporation	Customer: O'Rourke	
7.6.5.1	Project #: AP021437 Rev:8	Inquiry:	
Case 7:	Full Flow	Project: CanGas Solutions	



Compressor Data:				Driver Data:			
Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,*F:	100.00	Type:	<u>VFD</u>
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125	Mfg:	TECO
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000	Model:	TEFC-PDH
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0	BHP:	60
Calc RPM:	1800.0	BHP:	46	Calc PS FPM:	900.0	Avail:	60 (0)

Disch Temp

Services

	Service 1		
Gas Model	VMG		
Stage Data:	1	2	3
Target Flow, MMSCFD	0.120	0.120	0.120
Flow Calc, MMSCFD	0.157	0.157	0.153
BHP per Stage	13.9	13.5	12.4
Specific Gravity	0.9965	0.9965	0.9844
Ratio of Sp Ht (N)	1.1792	1.1827	1.2100
Comp Suct (Zs)	0.9835	0.9480	0.8100
Comp Disch (Zd)	0.9641	0.9029	0.8216
Pres Suct Line, psig	20.00	N/A	N/A
Pres Suct Flg, psig	20.00	124.80	514.00
Pres Disch Flg, psig	128.97	524.00	2424.13
Pres Disch Line, psig	N/A	N/A	2400.00
Pres Ratio F/F	4.263	3.889	<u>4.622</u>
Temp Suct, °F	68.00	121.10	128.70
Temp Clr Disch, °F	121.10	128.70	115.30
Cylinder Data:	Throw 1	Throw 2	Throw 2
Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	125.8	29.1	5.5
Pres Suct Intl, psig	16.41	112.44	497.16
Temp Suct Intl, °F	73	126	133
Pres Disch Intl, psig	143.96	583.67	2523.10
Temp Disch Intl, °F	226	285	<u>323</u>
HE Suct Gas Vel, FPM	8643	N/A	4429
HE Disch Gas Vel, FPM	8008	N/A	4819
HE Spcrrs Used/Max	1/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	16.59	N/A	17.00
HE Total Clr, %	25.86	N/A	17.00
CE Suct Gas Vel, FPM	8227	7921	N/A
CE Disch Gas Vel, FPM	7622	8094	N/A
CE Spcrrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	17.84	22.02	N/A
CE Total Clr, %	17.84	22.02	N/A
Suct Vol Eff HE/CE, %	28.8/48.4	N/A/42.5	49.9/N/A
Disch Event HE/CE, ms	2.9/4.4	N/A/4.4	<u>3.8</u> /N/A
Suct Pseudo-Q HE/CE	11.0/11.5	N/A/10.7	4.9/N/A
Gas Rod Ld Comp, %	24.2 C	40.7 C	40.7 C
Gas Rod Ld Tens, %	24.8 T	35.0 T	35.0 T
Gas Rod Ld Total, %	25.7	39.9	39.9
Xhd Pin Deg/%RvrsI lbf	154/77.5	118/61.5	118/61.5
Flow Calc, MMSCFD	0.157	0.157	0.153
Cyl BHP	13.9	13.5	12.4

Condition 5 – Alternate Case 1 (50 mscfd)

		Ariel Performance			
	Company: Ariel Corporation			Customer: O'Rourke	
	Quote: 1103-074			Inquiry:	
7.6.5.1	Case 1: 50 mscfd			Project: CanGas Solutions	



Compressor Data:				Driver Data:			
Elevation,ft:	2500.00	Barmtr,psia:	13.400	Ambient,°F:	100.00	Type:	<u>VFD</u>
Frame:	JGA/2	Stroke, in:	3.00	Rod Dia, in:	1.125	Mfg:	TECO
Max RL Tot, lbf:	20000	Max RL Tens, lbf:	10000	Max RL Comp, lbf:	11000	Model:	TEFC-PDH
Rated RPM:	1800	Rated BHP:	280.0	Rated PS FPM:	900.0	BHP:	60
Calc RPM:	1800.0	BHP:	58	Calc PS FPM:	900.0	Avail:	60 (0)

Deactivated

Services

	Service 1		
Gas Model	VMG		
Stage Data:	1	2	3
Target Flow, MMSCFD	0.050	0.050	0.050
Flow Calc, MMSCFD	0.375	0.375	<u>Blow Thru</u>
BHP per Stage	29.5	22.5	0.0
Specific Gravity	0.9981	0.9981	0.9451
Ratio of Sp Ht (N)	1.1848	1.1964	1.1823
Comp Suct (Zs)	0.9708	0.9167	0.8044
Comp Disch (Zd)	0.9432	0.8731	0.8063
Pres Suct Line, psig	45.00	N/A	N/A
Pres Suct Flg, psig	45.00	192.80	518.62
Pres Disch Flg, psig	196.41	523.62	510.00
Pres Disch Line, psig	N/A	N/A	500.00
Pres Ratio F/F	3.593	2.604	0.984
Temp Suct, °F	68.00	110.00	110.00
Temp Clr Disch, °F	110.00	110.00	110.00
Cylinder Data:	Throw 1	Throw 2	Throw 2
Cyl Model	5-1/8M	3-5/8SG-CE	1-3/4SG-FS-HE
Cyl Bore, in	5.125	3.625	1.500
Cyl RDP (API), psig	454.5	2318.2	5545.5
Cyl MAWP, psig	500.0	2550.0	6100.0
Cyl Action	DBL	CE	HE
Cyl Disp, CFM	125.8	29.1	5.5
Pres Suct Intl, psig	38.12	173.28	515.34
Temp Suct Intl, °F	72	113	110
Pres Disch Intl, psig	221.53	589.79	515.34
Temp Disch Intl, °F	214	235	110
HE Suct Gas Vel, FPM	8979	N/A	4429
HE Disch Gas Vel, FPM	8369	N/A	4819
HE Spcrrs Used/Max	1/2	N/A	0/2
HE Vol Pkt Avail, %	No Pkt	N/A	No Pkt
Vol Pkt Used, %	No Pkt	N/A	No Pkt
HE Min Clr, %	15.14	N/A	17.00
HE Total Clr, %	24.41	N/A	17.00
CE Suct Gas Vel, FPM	8546	7921	N/A
CE Disch Gas Vel, FPM	7966	8094	N/A
CE Spcrrs Used/Max	0/2	0/2	N/A
CE Min Clr, %	16.31	22.12	N/A
CE Total Clr, %	16.31	22.12	N/A
Suct Vol Eff HE/CE, %	44.0/60.1	N/A/64.6	N/A/N/A
Disch Event HE/CE, ms	3.9/5.4	N/A/6.5	N/A/N/A
Suct Pseudo-Q HE/CE	14.1/13.0	N/A/11.3	N/A/N/A
Gas Rod Ld Comp, %	34.9 C	8.6 C	N/A
Gas Rod Ld Tens, %	35.5 T	29.4 T	N/A
Gas Rod Ld Total, %	36.9	19.4	N/A
Xhd Pin Deg/%Rvrsl lbf	171/95.8	162/62.3	162/62.3
Flow Calc, MMSCFD	0.375	0.375	<u>Blow Thru</u>
Cyl BHP	29.5	22.5	

Compressor Mass Elastic

Mass Elastic Data			
	Company: Ariel Corporation	Customer: O'Rourke	
	Project #: AP021437 Rev:8	Inquiry:	
7.6.5.1	Case 1:	Project: CanGas Solutions	

Frame: JGA/2 Stroke: 3.00 in Conrod Center Dist: 8.25 in Rotation: Clockwise

Throw #:	1	2
Cylinder Model:	5-1/8M	3-5/8SG-CE
Cylinder Bore, in:	5.125	3.625
WEIGHTS, lbs:		
Conrod Large End:	9.09	9.09
Conrod Small End:	5.31	5.31
Piston & Rod Assembly:	23.70	18.90
X-Head:	8.10	8.10
X-Head Pin Assembly:	4.87	4.87
Balance Nut:	0.70	4.50
Recip Weight, lbs	42.68	41.68

THROW INERTIA:		
Crankpin, lb-in ² :	83.240	83.240
Conrod Large End, lb-in ² :	20.444	20.444
Recip Weight, lb-in ² :	48.416	47.282
Total, lb-in ² :	152.100	150.966

MASS ELASTIC DATA

Location	Station (in)	Symbol	Inertia (lb-in ²)	Internal Flywheel (lb-in ²)	Symbol	Stiffness (in-lbs/RAD x 10E6)
Shoulder Stop	0.000	I1	55.670		K1	16.350
Main #1 CL	5.438	I2	71.550		K2	31.250
Throw #1 CL	9.188	I3	152.100		K3	28.270
Throw #2 CL	13.188	I4	150.966		K4	31.250
Main #2 CL	16.938	I5	71.550		K5	17.780
Aux Drive End	21.625	I6	34.580			
Total:			536.416	0.000		

Crankshaft Material:

Material: ASTM A668 Class DH/AISI 1045 (Forged Carbon Steel)
 Yield, psi: 45000
 Tensile, psi: 90000

NOTES:

1. Inertia and Stiffness of the drive stub forward of the stop shoulder are not included in this table.
2. Throw Inertias include inertia for the crankshaft, as well as the connecting rod, crosshead, balance nut and piston and rod assembly for that throw.
3. Drive stub stiffness must be calculated appropriately depending upon coupling or flanged hub connection.
4. Mass elastic data listed does not include the added inertia from any optional flywheels or detuners.
5. Refer to the [Ariel Packager Standards, section 5 \(ER-56.05\)](#), for additional information regarding the compressor drive system and the torsional analysis requirements.
6. Inertia is for bare compressor only. If an internal auxiliary end flywheel is selected it will show above. Does not include driver, coupling, external flywheel, or internal detuners (donuts).
7. For inertia units of lb-in-sec², divide the value of lb-in² by 386.1 in/sec².

ALLOWABLE CRANKSHAFT TORQUE AND AUXILIARY END TORSIONAL VIBRATION AMPLITUDE LIMITS FOR ARIEL FRAMES



NOTES:

- These limits include appropriate design safety factors, endurance limit modifying factors, stress concentrations factors, and specific shaft diameters.
- Apply these torque limits to combined order torque predictions (not individual orders).
- Torque limits are for torsional (shear) loading only. Unique applications that demand significant bending or axial stresses require additional investigation.
- If the mode shape indicates peak vibratory torque amplitudes at locals other than at the "critical section", higher torque levels may be acceptable if properly analyzed and discussed with Ariel.

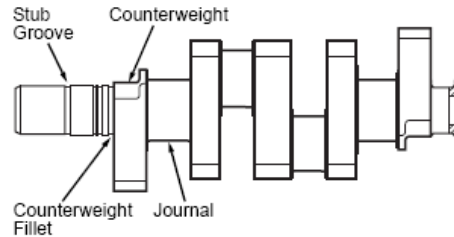


FIGURE 1-1 Crankshaft - Typical

TABLE 1-1 Allowable Crankshaft Torque for Ariel Frames

STANDARD MATERIAL				
Frame	Throws	Material	Critical Section	Alternating Torque (P) = (max-min ÷ 2) in-lbf (kN·m)
JGM:P:N:Q:G:A	1,2	1045	Counterweight Fillet	23,200 (2.7)
JG, JGA	4	1045	Counterweight Fillet	23,700 (2.7)
JGA	6	1045	Journal	29,400 (3.3)
JGR, JGJ	2,4	1045	Counterweight Fillet	62,700 (7.1)
JGJ	6	1045	Journal	78,300 (8.8)
JGH:E:K:T	2,4	1045	Counterweight Fillet	150,900 (17.0)
JGE:K:T	6	4140	Journal	277,400 (31.3)
JGC, JGD	2,4	1045	Counterweight Fillet	318,100 (35.9)
JGC, JGD	6	4140	Counterweight Fillet	575,000 (65.0)
JGZ, JGU	2	1045	Stub Groove	430,800 (48.7)
JGZ, JGU	4	1045	Journal	528,000 (59.7)
JGZ, JGU	6	4140	Journal	765,200 (86.5)
JGB:V, KBB:V	4,6	4140	Journal	1,272,000 (143.7)
ALTERNATE MATERIAL				
JGJ	6	4140	Journal	118,300 (13.4)
JGE:K:T	2,4	4140	Counterweight Fillet	228,900 (25.9)
JGC, JGD	2,4	4140	Counterweight Fillet	481,600 (54.4)
JGZ, JGU	2	4140	Stub Groove	647,600 (73.2)
JGZ, JGU	4	4140	Journal	794,700 (89.8)

0						
REV	DESCRIPTION	0	014090	1-17-07		
		REV	EC	DATE	REV	EC
						DATE

Auxiliary-End Torsional Vibration Amplitude Limits

The following limits are for any individual harmonic. If more than one significant individual harmonic exists at a single speed with amplitude levels near the limit, an overall level should be examined and discussed with Ariel Corporation's Field Service Department.

Ariel Corporation Dec 1, 2006

Compressor Auxiliary-End Drive Design	Ariel Compressor Frames Included	Acceptable Compressor Auxiliary End Vibration Limits (degrees 0-peak)
Single Chain	<ul style="list-style-type: none"> All single throw frames All 2 & 4 throw frames in classes JG:A:M:P:N:Q:W:R:J:H:E:K:T:C:D JGA/6 & JGJ/6 Older 6 throw JGC:D frames shipped <u>before Sept. 16, 2002</u> (approximate frame serial number F18137) 	<p>1 degree for first harmonic (1X)</p> <p>1 degree for <u>engine induced 1/2 orders</u> from 1/2 to 1-1/2X</p> <p>1/2 degree for second harmonic (2X)</p> <p>1/4 degree for harmonics above second (>2X)</p> <p>1/4 degree for <u>engine induced 1/2 orders</u> greater than 2X</p>
Dual Chain	<ul style="list-style-type: none"> All 2 throw frames in classes JGZ:U All 4 throw frames in classes JGZ:U:B:V:KBB:KBV 6 throw JGE:K:T:Z:U:B:V:KBB:KBV Newer 6 throw JGC:D frames shipped <u>after Sept. 16, 2002</u> (approximate frame serial number F18137) 	<p>2 degree for first harmonic (1X)</p> <p>2 degree for <u>engine induced 1/2 orders</u> from 1/2 to 1-1/2X</p> <p>1 degree for second harmonic (2X)</p> <p>1/2 degree for harmonics above second (>2X)</p> <p>1/2 degree for <u>engine induced 1/2 orders</u> greater than 2X</p>



Allen-Bradley

MicroLogix 1400 Embedded Web Server

Bulletin 1766 Controllers

User Manual

**Rockwell
Automation**

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication [SGI-1.1](#) available from your local Rockwell Automation sales office or online at <http://literature.rockwellautomation.com>) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.





In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

<p>WARNING</p> 	<p>Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.</p>
<p>IMPORTANT</p>	<p>Identifies information that is critical for successful application and understanding of the product.</p>
<p>ATTENTION</p> 	<p>Identifies information about practices or circumstances that can lead to: personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence</p>
<p>SHOCK HAZARD</p> 	<p>Labels may be on or inside the equipment, such as a drive or motor, to alert people that dangerous voltage may be present.</p>
<p>BURN HAZARD</p> 	<p>Labels may be on or inside the equipment, such as a drive or motor, to alert people that surfaces may reach dangerous temperatures.</p>

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Notes:

MicroLogix 1400 Embedded Web Server

How to Use This Chapter

Rockwell Automation offers enhanced MicroLogix 1400 controllers for your EtherNet/IP control systems so you can monitor data remotely via web pages.

This chapter shows how you can use a MicroLogix 1400 controller in your control system.

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Typical Applications

With the MicroLogix 1400 controller, you can access controller and control system data with different and remote access applications. With a web browser, you can easily monitor live MicroLogix 1400 controller data remotely.

With the MicroLogix 1400 controller, you can access Simple web page view, and custom-designed User Provided page views. Simple web pages use only HTML tags and are useful in limited-communication environments where radio modems are used.

Browser Requirements

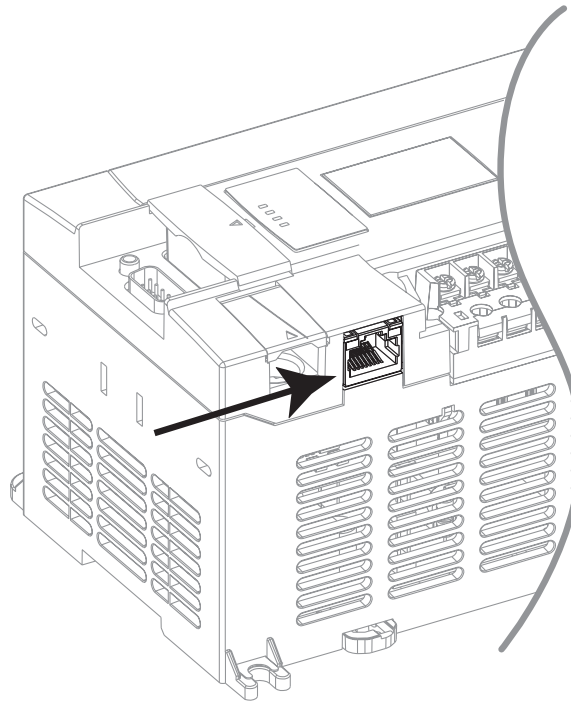
You can access the MicroLogix 1400 controllers only with Internet Explorer 6.0, Opera 9.23 , FireFox 2.0.0.14, or Safari 3.0.4, or higher . To access data view pages, the browser requires Javascript and XML support.

The supported display sizes start from 640 x 480. Smaller display sizes also work but require scrolling to view the information.

Connect the MicroLogix 1400 controller to the Network

1. Connect the module to the network.

Connect the MicroLogix 1400 controller to the Ethernet network. The RJ-45 connector is on the left-hand side of the module.



44592

2. Obtain an IP address.

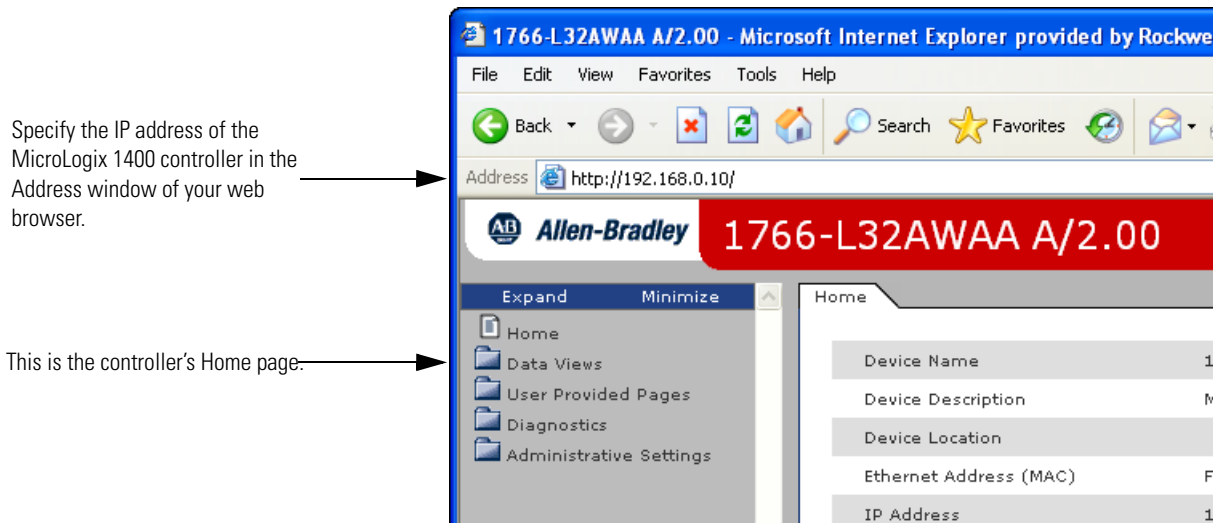
*For more information, see
MicroLogix1400 Programmable
Controllers User Manual
[1766-UM001](#).*

By default, the MicroLogix 1400 controller is BOOTP enabled. If you connect the MicroLogix 1400 controller to a network that has a BOOTP server, that server will assign an IP address to the MicroLogix 1400 controller and the LCD screen of the MicroLogix 1400 controller will display BOOTP IP address.

If your network does not have a BOOTP server, use one of the methods described in the MicroLogix 1400 Programmable Controllers User Manual [1766-UM001](#) to assign an IP address to the MicroLogix 1400 controller.

3. Access the Home page of the web server.

In your web browser's Address box, enter the IP address of the MicroLogix 1400 controller. The Home page is displayed.



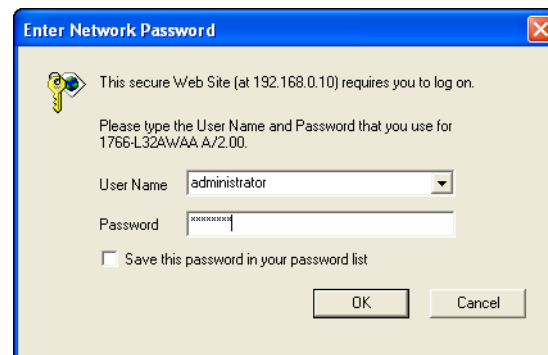
4. Log into the web server.

Many of the features of the MicroLogix 1400 controller require you to log in with appropriate access. If you select a feature, such as Data Views, the MicroLogix 1400 controller prompts you to enter your user name and password. The user name is either administrator or guest. The password is ml1400 for administrator and guest for guest.

Default Access

User Name: administrator or guest
(case sensitive)

Password:
(ml1400 for administrator, guest for guest)



You can set up as many as 10 user accounts. Each account can have read, write, or administrator access. For more information, see User Management on page 23.

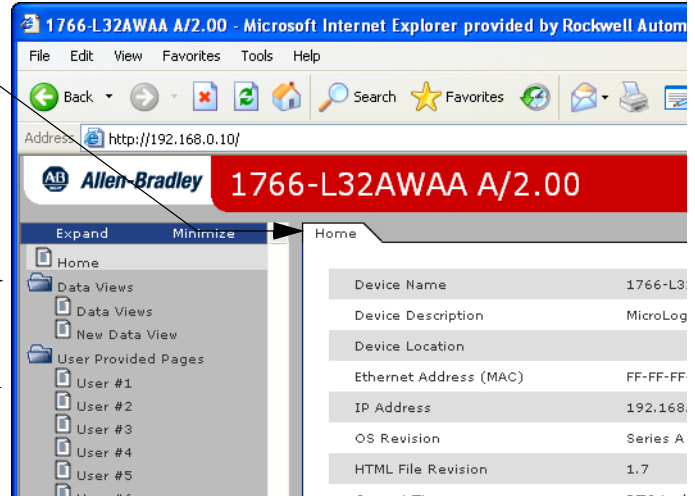
Navigate the MicroLogix 1400 Controller

You navigate the web server's web pages by using the navigation panel on the left of the screen. There are also tabs across the top you can click to navigate the folders containing documents.

Tabs across the top match the documents within a folder, as shown in the left navigation panel.

Click folders to open and close additional levels of information.

Click a document to display a web page showing specific information.



Use Data Views to Access Controller Data

How to Use This Chapter

The MicroLogix 1400 controller provides access to the controller data table files. This chapter shows you how to set up views of data table files.

Topic	Page
Overview of Data Views	7
Change an Access Group	8
Monitor Data Views and Data Table File	9
Change Data Table Files	10
Disable Web View	12

Overview of Data Views

Data views give you the ability to read controller data via a browser interface. The MicroLogix 1400 controller provides web pages that let you configure a set of files (a data view) that can be read.

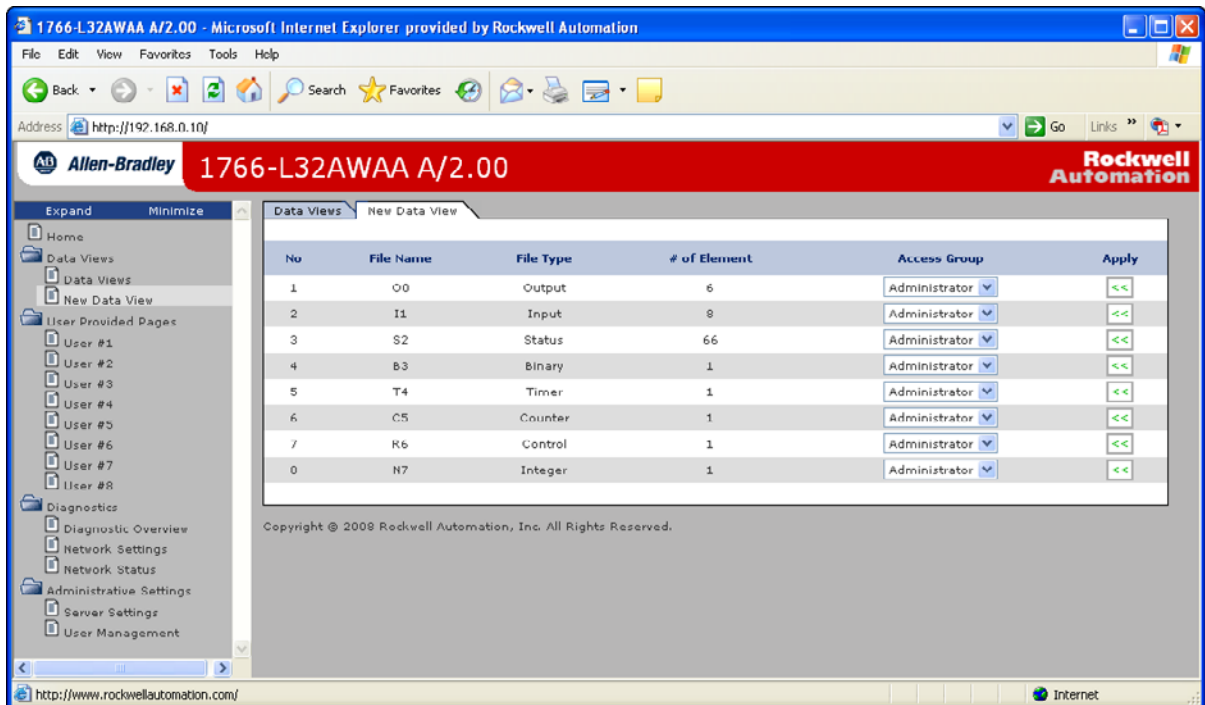
A data view consists of an HTML file and an XML file with data file information. The HTML file is in a readable ASCII format. It contains the File Name, File Type, # of Element, and Access Group.


Change an Access Group

Each data view contains a group of files that you want to monitor. Each MicroLogix 1400 controller can support multiple data views. One browser supports only one data view, so if you want to look at many data views, you need to run a corresponding number of browsers.

You change an access group from the Data Views → New Data View page.

- From the Access Group pull-down menu of the given data table file, choose one of the following access group types:
 - Administrator (all access)
 - Write (read/write access only)
 - Read (read access only)
- Choose Administrator, Write, or Read from the Access Group pull-down menu to change a file's access group.



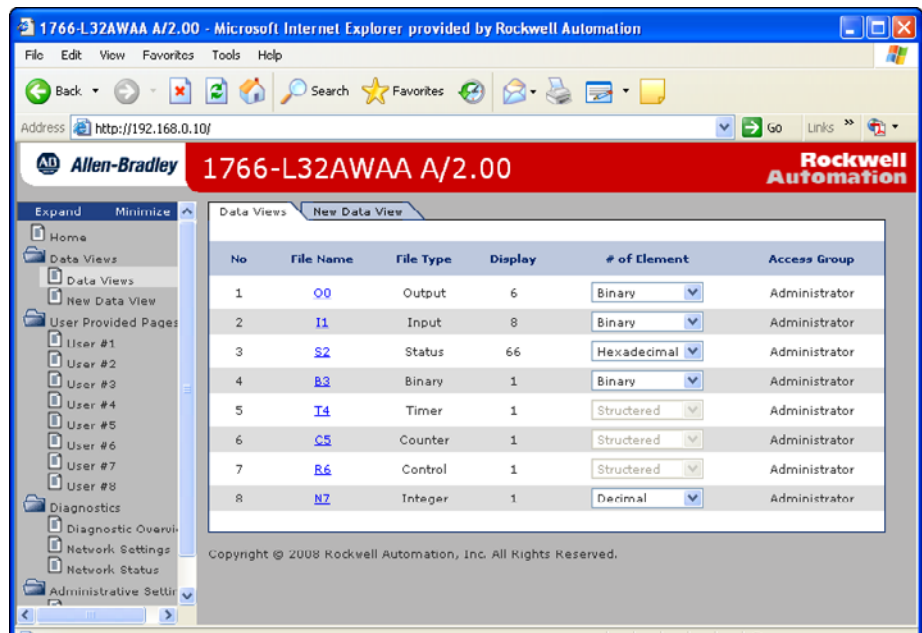
- Click Apply  to change an access group for the data table file you specified.

Monitor Data Views and Data Table File

Use the Data Views → Data Views page to view existing data table files. Click the file name to view the data within a data table file.

Data View Page

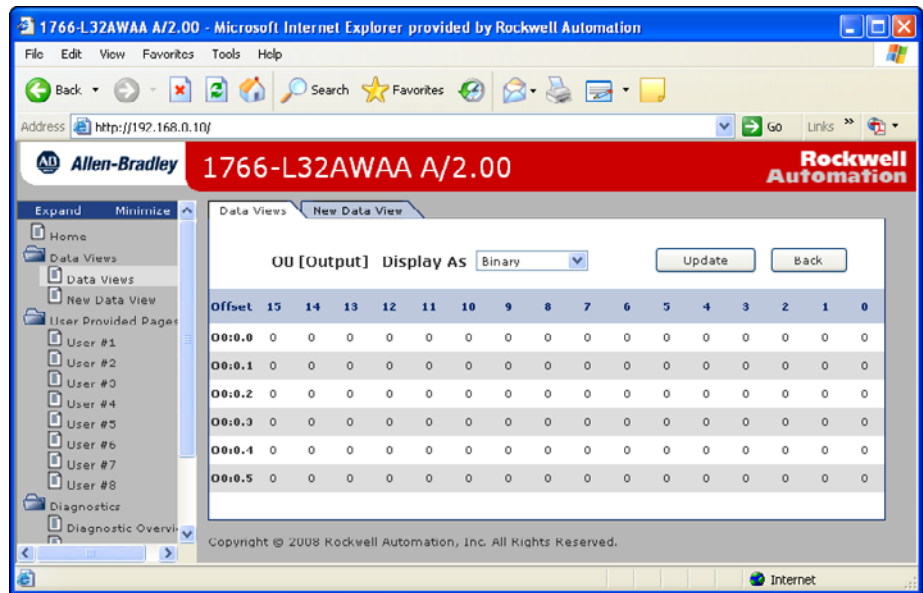
The Data Views page displays a list of the data table files, their type, and size in elements for a connected MicroLogix 1400, as shown in the following example.



No	File Name	File Type	Display	# of Element	Access Group
1	O0	Output	6	Binary	Administrator
2	I1	Input	8	Binary	Administrator
3	S2	Status	66	Hexadecimal	Administrator
4	B3	Binary	1	Binary	Administrator
5	T4	Timer	1	Structured	Administrator
6	C5	Counter	1	Structured	Administrator
7	R6	Control	1	Structured	Administrator
8	N7	Integer	1	Decimal	Administrator

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Each file contains a hyperlink that takes you to the specific Data Views page for that file. When you click a particular file, the Data Views page appears, displaying the contents of the data table file you selected.

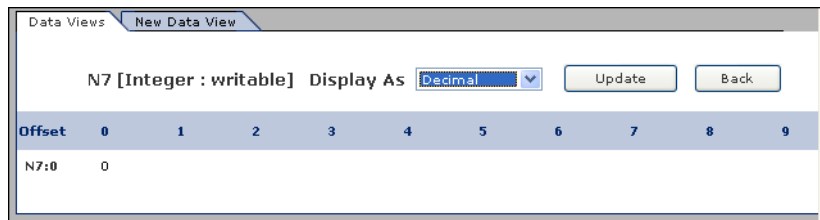


The available and default display formats depend on the data type of the file.

Click Back to display the previous page. To refresh the data view, click Update.

Change Data Table Files

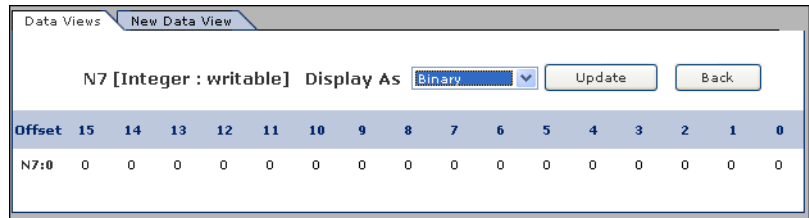
The data in the Data File Types such as Binary, Integer, Long, Float, and String can be changed. The Binary, Integer, and Long types support all the Display formats. You can edit Binary types by bit, and the Octal, Decimal, and Hexadecimal types by element. A user account with either Write or Administrator access level can change the Data Table Files. When you click N7 in Data Views, Data Writable appears beside a Data File Type (Integer here) as shown below.



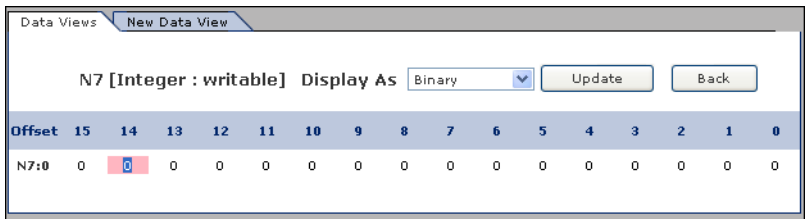
How to Change a Data File Type

In the steps that follow, a Binary type is assumed.

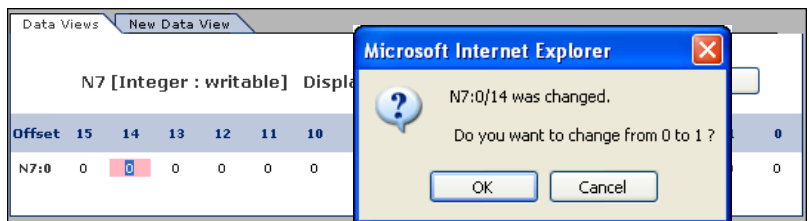
1. Change Display As to Binary, then the following screen appears.



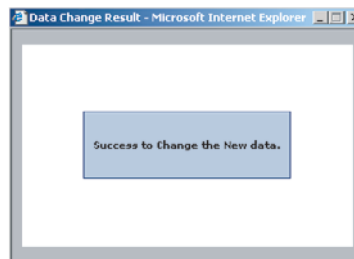
2. Double-click the data you want to change, then the background color turns pink.



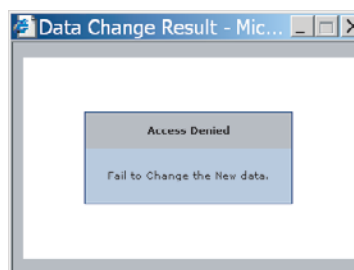
3. Enter a value and either press Enter or click an area in the screen, then a confirmation window appears.



4. Click OK to change the value.
The following screen appears when the value is successfully saved into the server.



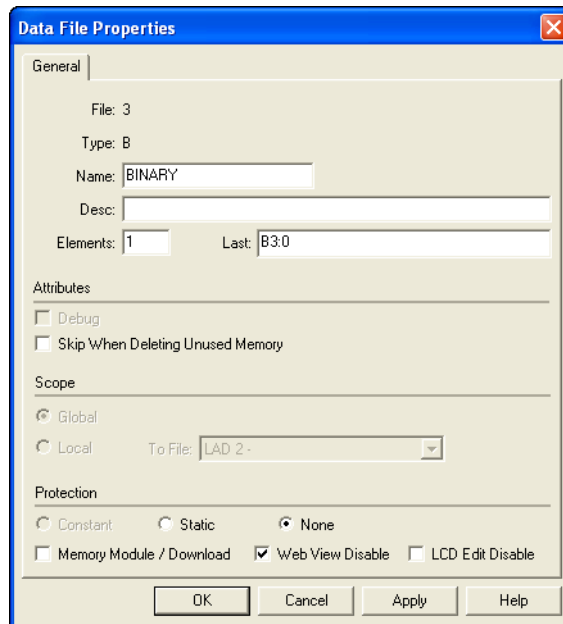
If the following screen appears, the value is not saved and the value returns to the original value.



If you want to change the data in Decimal, click the pull-down menu to change the Display As to Decimal and follow the steps described. The steps also apply to the String type.

Disable Web View

Using RSLogix 500/RSLogix Micro V8.10 or higher, you can disable individual data files from being viewed via any web browser by selecting the data file's properties page and checking the Web View Disable checkbox as shown below. Any data file property changes must be made offline and downloaded to the processor or later.



The image shows a 'Data File Properties' dialog box with a blue title bar and a close button in the top right corner. The dialog is divided into several sections: 'General', 'Attributes', 'Scope', and 'Protection'. In the 'General' section, 'File' is 3, 'Type' is B, 'Name' is 'BINARY', 'Desc' is empty, 'Elements' is 1, and 'Last' is 'B3:0'. The 'Attributes' section has two unchecked checkboxes: 'Debug' and 'Skip When Deleting Unused Memory'. The 'Scope' section has 'Global' selected with a radio button, and 'Local' is unselected. A 'To File' dropdown menu is set to 'LAD 2-'. The 'Protection' section has three radio buttons: 'Constant' (unchecked), 'Static' (unchecked), and 'None' (selected). There are also three checkboxes: 'Memory Module / Download' (unchecked), 'Web View Disable' (checked), and 'LCD Edit Disable' (unchecked). At the bottom, there are four buttons: 'OK', 'Cancel', 'Apply', and 'Help'.

Data File Properties

General

File: 3
Type: B
Name: BINARY
Desc:
Elements: 1 Last: B3:0

Attributes

Debug
 Skip When Deleting Unused Memory

Scope

Global
 Local To File: LAD 2-

Protection

Constant Static None
 Memory Module / Download Web View Disable LCD Edit Disable

OK Cancel Apply Help

Notes:

Monitor Diagnostics

How to Use This Chapter

This chapter describes the diagnostics presented on the user-oriented diagnostic pages.

Topic	Page
MicroLogix 1400 Controller Diagnostics	15
Diagnostic Overview	16
Network Settings	17
Network Status	18

MicroLogix 1400 Controller Diagnostics

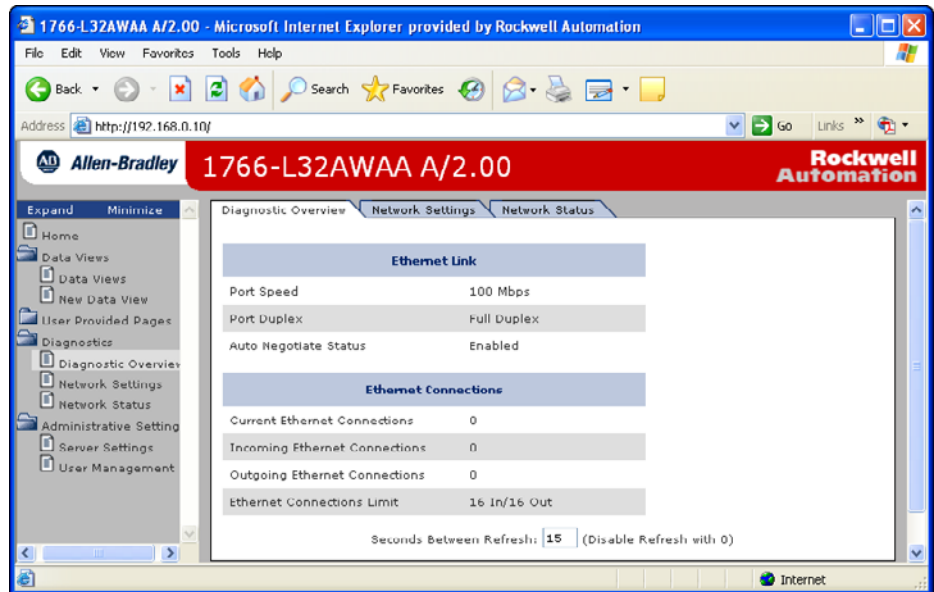
The MicroLogix 1400 controller provides four diagnostic pages of user-oriented diagnostics.

Topic	Web page
Overview of the current configuration of the MicroLogix 1400 controller	Diagnostics → Diagnostic Overview
Summary of the network settings configured for the MicroLogix 1400 controller	Diagnostics → Network Settings
Ethernet statistics	Diagnostics → Network Status

Diagnostic Overview

The Diagnostics → Diagnostic Overview page presents a summary of the current configuration and overall status of the MicroLogix 1400 controller. This summary includes:

- Ethernet link.
- Ethernet Connections.

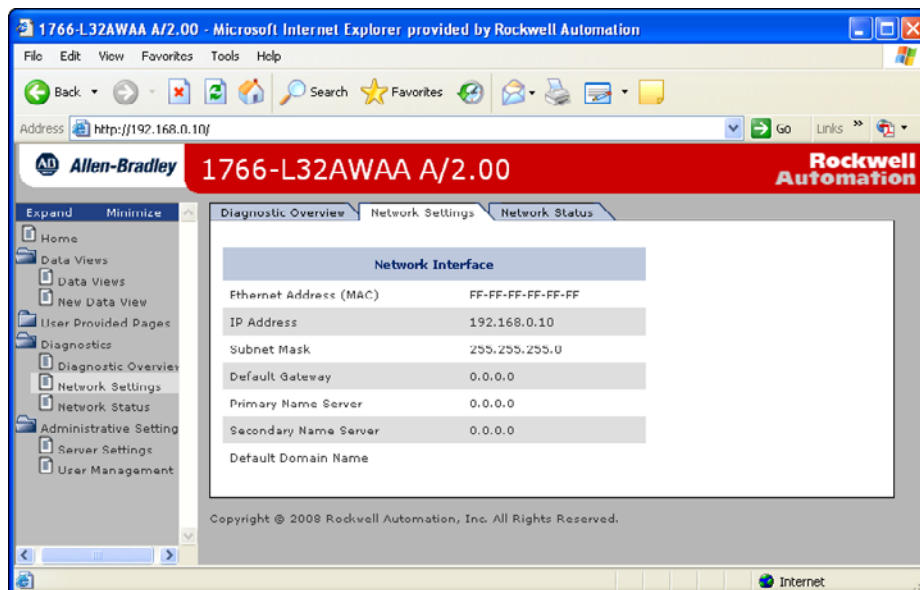


This field	Specifies
Ethernet Link	
Port Speed	whether the Ethernet port is operating at 10 Mbps or 100 Mbps
Port Duplex	whether the Ethernet port is operating at half duplex or full duplex
Auto negotiate Status	whether the port speed and duplex mode were determined via autonegotiation or whether they were manually configured
Ethernet Connections	
Current Ethernet Connections	current number of active connections
Incoming Ethernet Connections	current number of incoming connections
Outgoing Ethernet Connections	current number of outgoing ethernet connections
Ethernet Connection Limit	maximum number of Ethernet incoming/outgoing connections

Network Settings

The Diagnostics → Network Settings page presents a summary of the current Ethernet configuration for MicroLogix 1400. This summary includes:

- Ethernet address details.



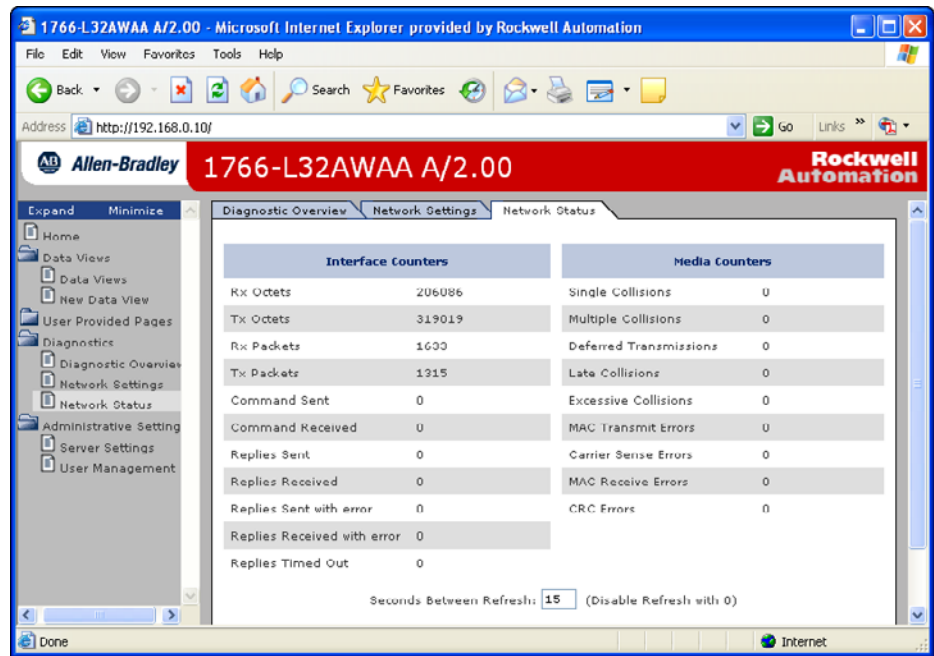
Any fields not configured remain blank.

This field	Specifies
Network Interface	
Ethernet Address (MAC)	Ethernet (MAC) address of the controller
IP Address	IP address for the controller
Subnet Mask	subnet mask for the controller
Default Gateway	gateway address for the controller
Primary Server Name	DNS server names, if using DNS addressing
Secondary Server Name	
Domain Name	domain name for the web server module, if using DNS addressing

Network Status

The Diagnostics → Network Status page presents a summary of the status of communication activity on the Ethernet network. This summary includes:

- Ethernet network configuration.
- packets sent and received over the Ethernet network.
- frames sent and received over the Ethernet network.



This field	Specifies
Interface Counters	
Rx Octets	Octets received on the Ethernet interface
Tx Octets	Octets sent on the Ethernet interface
Rx Packets	Packets received on the Ethernet interface
Tx Packets	Packets sent on the Ethernet interface
Command Sent	Command sent on the Ethernet interface
Command Received	Command received on the Ethernet interface
Replies Sent	Replies sent on the Ethernet interface
Replies Received	Replies received on the Ethernet interface
Replies Sent with error	Outbound packets that contain errors
Replies Received with error	Inbound packets that contain errors
Replies Timed Out	No reply within a specified time period
Media Counters	
Single Collisions	Successfully transmitted frames which experienced exactly one collision

This field	Specifies
Multiple Collisions	Successfully transmitted frames which experienced more than one collision
Deferred Transmissions	Frames for which first transmission attempt is delayed because the medium is busy
Late Collisions	Number of times a collision is detected later than 512 bit-times into the transmission of a packet
Excessive Collisions	Frames for which transmission fails due to excessive collisions
MAC Transmit Errors	Frames for which transmission fails due to an internal MAC sublayer transmit error
Carrier Sense Errors	Times that the carrier sense condition was lost or never asserted when attempting to transmit a frame
MAC Receive Errors	Frames for which reception on the Ethernet interface failed due to an internal MAC sublayer receive error
CRC Errors	Frames for which CRC error is detected

Notes:

Administrative Settings

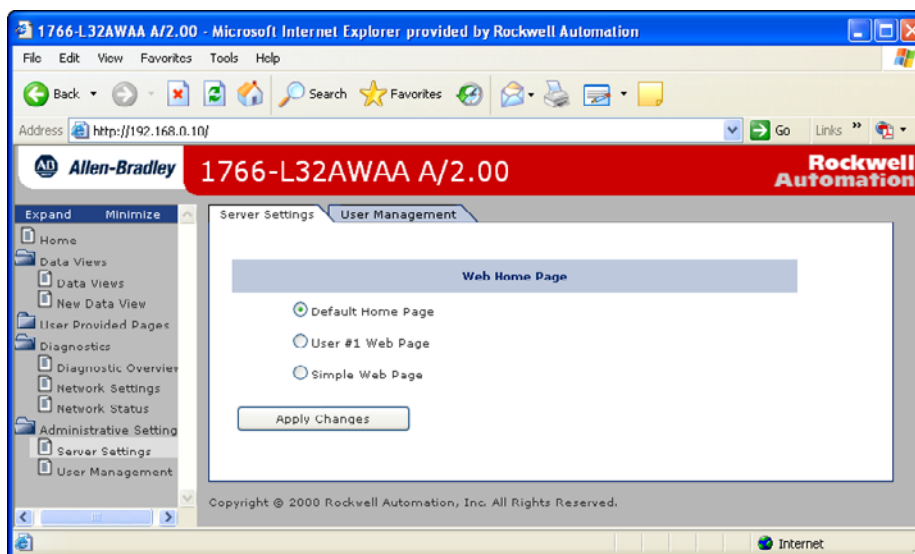
Server Settings

Select Administrative Settings > Server Settings to customize some of the server settings of the module, as well as back up the file system on the web server module. You can:

- customize server settings, including web home page.

Customize Server Settings

Select Administrative Settings > Server Settings to customize the web home page.



In The Field	Take This Action
Web Home Page	<p>Select a home page of MicroLogix 1400 controller.</p> <p>If Default Home Page is selected, the current web page is shown. If User #1 Web Page is selected, the first user provided page is shown. For information, see User Provided Pages on page 33. If Simple Web Page is selected, the simple web page is shown.</p> <p>For default home page, enter the IP address in the URL address bar, for example, http://192.168.0.10/index.htm.</p>

Notes:

User Management

How to Use This Chapter

This chapter describes how to configure user access levels to different information on the module.

Topic	Page
User Accounts and Privilege Classes	23
Configure Access Limits for Web Pages	24
Create User Accounts	25
Recover with Unknown Password	26

By assigning user accounts with different access levels, you can manage which users have access to view network configuration or have access to view and change data views.

Several pages on the MicroLogix 1400 controller, such as diagnostics pages and data views pages, have default access protection. Before accessing these pages, you must authenticate your access by entering a user name and password. The module displays the log-in box when you access these web pages.

IMPORTANT

Once authenticated, you do not have to re-enter a user name or password when accessing subsequent pages. You **must** close your browser to log out.

The default user name is administrator with password 'ml1400' or guest with password 'guest'.

IMPORTANT

It is strongly recommended that you change the password for the default Administrator account.

User Accounts and Privilege Classes

The MicroLogix 1400 controller supports multiple user accounts, each with a user name and password. Each user account is configured for one of these access levels:

- Administrator (all access)
- Write (read/write access only)
- Read (read access only)

The access level determines which web pages the user can access. You configure access limits for individual web pages.

Configure Access Limits for Web Pages

Each page in the MicroLogix 1400 controller has one of these protection levels:

- Administrator
- Write
- Read

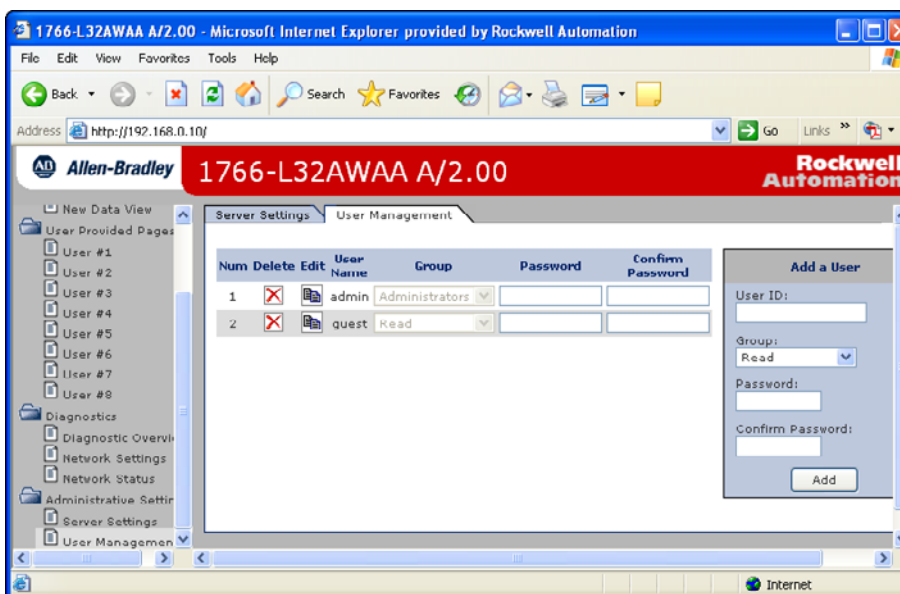
The protection levels are hierarchical. Administrator users can access Read protected pages.

These pre-defined pages (those web pages that come with the MicroLogix 1400 controller) in the MicroLogix 1400 controller have these default access levels. You can change the Data View access group, if needed, with administrator privilege

Web Page	Default Protection Level
Home page	no protection
Diagnostics pages	Read protection
Data Views	Read protection
New Data View	Administrator protection
Server Setting page	Administrator protection
User Management page	Administrator protection

Create User Accounts

You need Administrator access to create and modify user accounts. You can create as many as 10 individual accounts. You manage accounts from the Administrative Settings → User Management → Edit Users page.



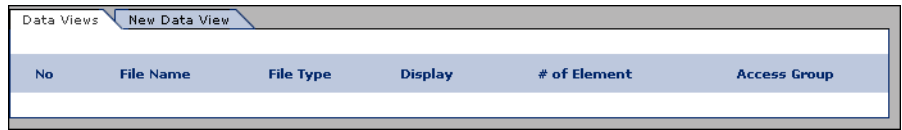
In this field	Do this
User ID	enter the user name for the account 20 characters maximum can contain these characters: A-Z, a-z, 0-9, underscore (_), and dash (-)
Group	select Administrator, Write, or Read access for the user account
Password	enter the password for the account 10 characters maximum
Confirm Password	re-enter the same password for the account

IMPORTANT

If you use Internet Explorer, the number of characters allowed for a user ID or password depends on how many characters “fit in the box.” Larger characters (such as “W”) take more room and reduce the total number of allowed characters.

A user account with a specific privilege can access the Data corresponding to the specific access level, i.e. a user account with Read access level can not access the Data belonging to Write or

Administrator access group. The following screen, which shows only Read Access Group, appears when you log in with the guest account.



No	File Name	File Type	Display	# of Element	Access Group
----	-----------	-----------	---------	--------------	--------------

Recover with Unknown Password

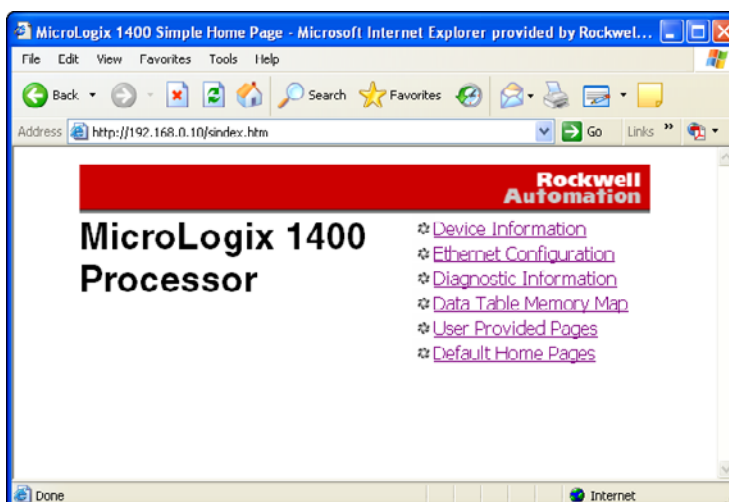
Update the firmware using ControlFlash to initialize both user accounts and the access level of data view.

Simple Web Pages

MicroLogix 1400 controllers can supply Simple Web Pages in environments where communications status is an issue. These type of web pages only support HTML tags without graphic files. You can only monitor Ethernet configurations and data tables with these type of web pages.

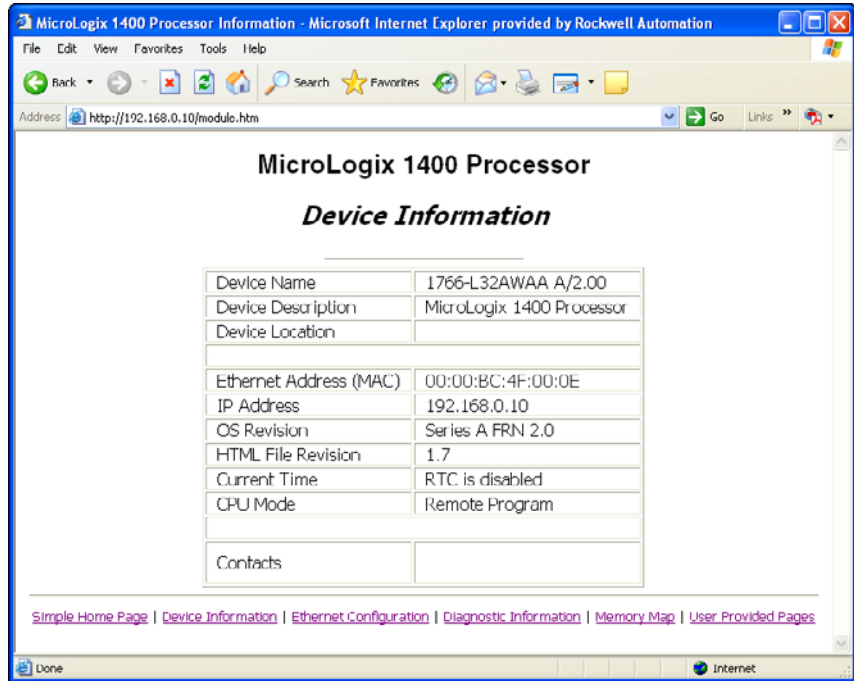
The following topics appear on the home page main menu, as shown below:

- Module Information
- Ethernet Configuration
- Diagnostic Information
- Data Table Memory Map
- User Provided Pages



Device Information

The device information page displays a table with information about the Micrologix 1400 controller. The specific information displayed includes the controller model, series/revision and mode of the controller.



Ethernet Configuration

This page displays a table with information about the current Ethernet configuration parameters. Included are the module's IP address, the subnet mask, gateway address, the Ethernet hardware address and whether BOOTP is enabled. Also included are the name server,

secondary name server and the default domain name parameters, if configured.

The screenshot shows a web browser window titled "MicroLogix 1400 Ethernet Configuration - Microsoft Internet Explorer provided by Rockwell Automation". The address bar shows "http://192.168.0.10/tcpcfg.htm". The main content area displays the following configuration data:

TCP/IP Configuration	
Ethernet Address (MAC)	00:00:BC:4F:00:0E
IP Address	192.168.0.10
Subnet Mask	255.255.255.0
Gateway Address	0.0.0.0
Name Server	0.0.0.0
Secondary Name Server	0.0.0.0
Default Domain Name	

Protocol Control	Current
Port Speed	100 Mbps
Port Duplex	Full Duplex
Auto Negotiate Status	Enabled

Ethernet Connection	value
Current Connections	0
Incoming Connections	0
Outgoing Connections	0
Connections Limit	16 In/16 Out

At the bottom of the page, there are navigation links: [Simple Home Page](#) | [Device Information](#) | [Ethernet Configuration](#) | [Diagnostic Information](#) | [Memory Map](#) | [User Provided Pages](#). The browser status bar shows "Done" and "Internet".

Diagnostic Information

This section gives you access to the various diagnostic information screens that are available.

The diagnostic screens automatically refresh using a time which is configurable by the user and defaults to 15 seconds.

MicroLogix 1400 Processor
Diagnostic Information

Rx Octets	174376	Single Collisions	0
Tx Octets	231429	Multiple Collisions	0
Rx Packets	1313	Deferred Transmissions	0
Tx Packets	1057	Late Collisions	0
Command Sent	0	Excessive Collisions	0
Command Received	0	MAC Transmit Errors	0
Replies Sent	0	MAC Receive Errors	0
Replies Received	0	Carrier Sense Errors	0
Replies Sent with error	0	CRC Errors	0
Replies Received with error	0		
Replies Timed Out	0		

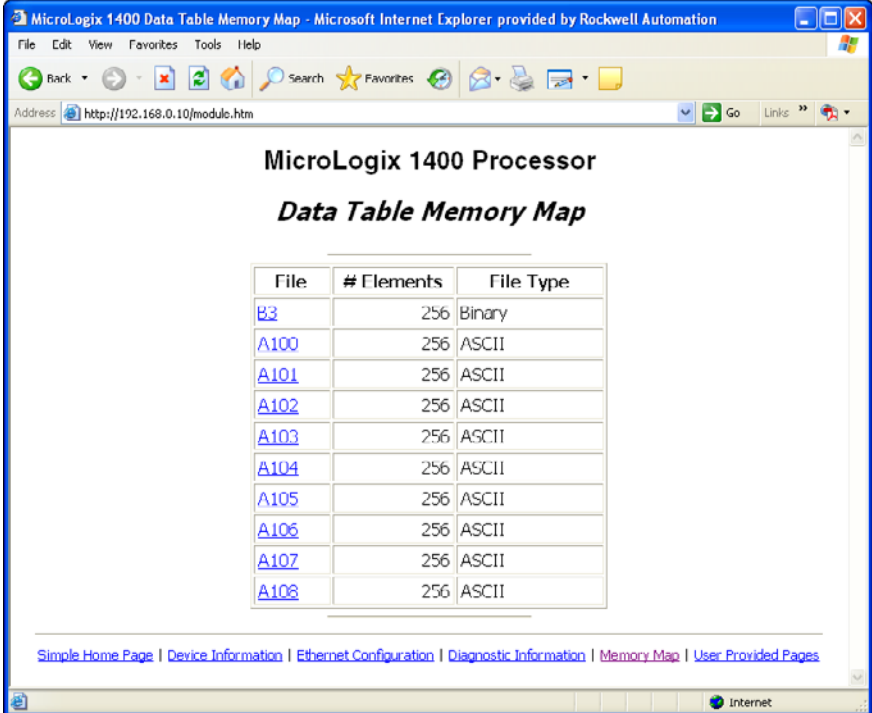
Refresh counters every seconds.

[Simple Home Page](#) | [Device Information](#) | [Ethernet Configuration](#) | [Diagnostic Information](#) | [Memory Map](#) | [User Provided Pages](#)

Data Table Memory Map

The Data Table Memory Map page displays a list of the data table files, their type, and size in elements for a connected MicroLogix 1400

controller. To view memory maps, login with a Read access group user account.



MicroLogix 1400 Processor
Data Table Memory Map

File	# Elements	File Type
B3	256	Binary
A100	256	ASCII
A101	256	ASCII
A102	256	ASCII
A103	256	ASCII
A104	256	ASCII
A105	256	ASCII
A106	256	ASCII
A107	256	ASCII
A108	256	ASCII

[Simple Home Page](#) | [Device Information](#) | [Ethernet Configuration](#) | [Diagnostic Information](#) | [Memory Map](#) | [User Provided Pages](#)

Each file contains a hyperlink that takes you to the specific Data Table Monitor page for that file. When you click on a particular file, the Data

Table Monitor page appears, displaying the contents of the data table file you selected.

MicroLoix 1400 Processor
Data Table Monitor

Address	0	1	2	3	4	5	6	7	8	9
B3:0	1023	-31745	16415	8192	4096	2048	1024	512	256	128
B3:10	64	32	16	8	4	2	1	2	4	8
B3:20	16	32	64	0	0	0	0	0	0	0
B3:30	0	0	0	0	0	0	0	0	0	0
B3:40	0	0	0	0	0	0	0	0	0	0
B3:50	0	0	0	0	0	0	0	0	0	0
B3:60	0	0	0	0	0	0	0	0	0	0
B3:70	0	0	0	0	0	0	0	0	0	0
B3:80	0	0	0	0	0	0	0	0	0	0
B3:90	0	0	0	0	0	0	0	0	0	0
B3:100	0	0	0	0	0	0	0	0	0	0
B3:110	0	0	0	0	0	0	0	0	0	0
B3:120	0	0	0	0	0	0	0	0	0	0
B3:130	0	0	0	0	0	0	0	0	0	0
B3:140	0	0	0	0	0	0	0	0	0	0
B3:150	0	0	0	0	0	0	0	0	0	0
B3:160	0	0	0	0	0	0	0	0	0	0
B3:170	0	0	0	0	0	0	0	0	0	0
B3:180	0	0	0	0	0	0	0	0	0	0
B3:190	0	0	0	0	0	0	0	0	0	0
B3:200	0	0	0	0	0	0	0	0	0	0
B3:210	0	0	0	0	0	0	0	0	0	0
B3:220	0	0	0	0	0	0	0	0	0	0
B3:230	0	0	0	0	0	0	0	0	0	0
B3:240	U	U	U	U	U	U	U	U	U	U
B3:250	U	U	U	U	U	U				

Display format:
 Refresh data every seconds.

[Simple Home Page](#) | [Device Information](#) | [Ethernet Configuration](#) | [Diagnostic Information](#) | [Memory Map](#) | [User Provided Pages](#)

The available and default display formats depend on the data type of the file.

You can change the *Display format* and *Refresh data every xx seconds* fields by entering data in the text boxes and clicking the Change Parameters button.

To change the refresh data function back to the default of 15 seconds, click the *Default* field. To disable the refresh data function, click the *Disable* button.

User Provided Pages

You can use a text editor to generate up to 8 user-provided web pages. Each page is stored in four consecutive ASCII files of the MicroLogix 1400 controller. The channel configuration feature of RSLogix 500/RSLogix Micro (version 8.10 or later) allows you to select the starting file number and the number of user pages to be stored, as shown in the following example:

RSLogix 500/RSLogix Micro (version 8.10 or later) also allows you to import an HTML file from your PC to specified ASCII files in the MicroLogix 1400 controller. See page 36 for details.

HTML Pages

Referencing Other Pages/Servers - following are some basic considerations when referencing other pages or servers:

- reference User Specified Pages in the MicroLogix 1400 controller by using the names *user1.htm* through *user8.htm*

- to reference a page on the same controller, specify a URL such as */user2.htm*
- to reference a page on another processor, specify a URL such as *http://www.xxx.yyy.zzz/user2.htm*, where *www.xxx.yyy.zzz* is the IP address of the controller
- you can reference other WWW servers and display images from other sources without affecting your usage of data table memory (except for the size of the HTTP reference)

Referencing Data Table Memory - reference data table memory locations by placing custom tags into your HTML source which specify the data table location and optional formatting information. Use the following format for the custom tag:

```
<!ABDTR-file_type{file_number};{file_element}[,#elements][%format]>
```

The items surrounded by {} are sometimes optional. The items surrounded by [] are always optional.

You must always specify the basic file reference. Depending on which file is being referenced, *file_number* or *file_element* may be defaulted. If the *file_type* is I, O or S, the *file_number* does not need to be specified, but the *file_element* must be specified. If the *file_type* is not one of the three special files, the *file_number* must be specified and the *file_element* may default to zero (the input, output and status files have fixed file numbers).

When defining your custom tag, consider the following:

Tag Item	Description
#elements	If not specified, this defaults to one. If it is less than one, it also defaults to one. Each element is output using the same format (whether specified with %format or defaulted).
%format	Legal values are %d for decimal and %x for hexadecimal. The following file types allow the format to be specified <ul style="list-style-type: none"> • Input • Output • Status • Integer • Timer • Counter • Control • Long
Display format defaults	Input and Output file elements are output in decimal format. Status file elements are output in hexadecimal format with a leading 0x. Integer file elements are output in decimal format. Complex data types (Timer, Counter, Control, or other data types) are output as a table with bits and important words specified.
Fixed display formats	Float files are always output in floating point format ("C"%g format). ASCII and SString files are always output as a null terminated text string. Binary files are always output as two binary bytes.

HTML Examples - the following example shows an HTML code segment with a short description of what you would see on a web browser:

Examples	HTML Code	Web Browser Displays
Input image word I:0	<!ABDTR-I:0>	the value of the first word of the input image table in the default format of decimal with bold type
Timer T4:0	<!ABDTR-T4:0>	the values of the timer in T4:0 in the default format of a table
Timer T4:0	<!ABDTR-T4:0%d>	the values of the three words comprising timer T4:0 in decimal with bold type
N24:0 to N24:3	<!ABDTR-N24:0,4>	the values of the four words in N24:0 through N24:3 in decimal with bold type
S:21 to S:23	<!ABDTR-S:21, 3%d>	the values of the three words in S:21 through S:23 in decimal with bold type

Generating Custom Data Table Monitor Pages

You can generate Custom Data Table Monitor pages with your text editor then download them to the MicroLogix 1400 controller using RSLogix 500/RSLogix Micro version 8.10 or later. **The first element of the file must contain a special tag** as shown here:

```
<!ABCDM-xx>
```

where **xx** is the automatic refresh rate in seconds (01 to 99).

A value outside the range defaults to a “snapshot” display. You can modify the refresh rate three different ways:

- enter the desired refresh rate and press the *Change* button
- select the *Default* button for a 15 second refresh
- disable the refresh by selecting the *Disable* button

Referencing Data Table Memory - the Data Table locations in the Custom Data Table Monitor are referenced by placing custom tags into the ASCII file of the processor. The format of the custom tag is:

```
<!ABDTR-file_type[file_number]:[file_element][,#elements][%format]
[!comment]>
```

The items surrounded with {} are sometimes optional, whereas the items surrounded by [] are always optional.

You must always specify the basic file reference. Depending on which file is being referenced, *file_number* or *file_element* may be defaulted. If the *file_type* is I, O or S, the *file_number* does not need to be specified, but the *file_element* must be specified. If the *file_type* is not one of the three special files, the *file_number* must be specified and the *file_element* may default to zero (because the input, output and status files have fixed numbers).

When defining your custom tag, consider the following:

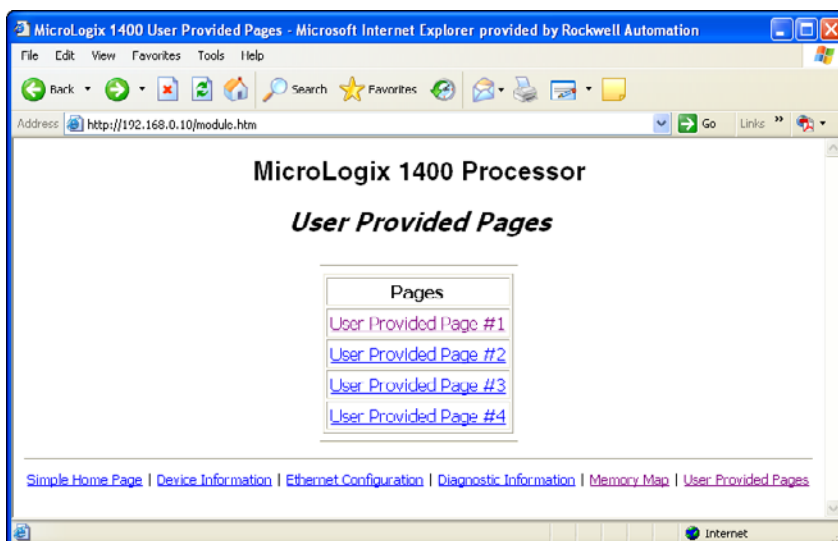
Tag Item	Description
#elements	If not specified, this defaults to one. If it is less than one, also defaults to one. Each element is output using the same format (whether specified with %format or defaulted). Any associated comment is displayed only for the first element.
%format	Legal values are %b for binary, %d for decimal, %O for octal and %x for hexadecimal. The following file types allow the format to be specified: <ul style="list-style-type: none"> • Input • Output • Status • Integer All other file types are displayed in an appropriate format.
!comment	Data after the exclamation point and up to the closing > is displayed in the Comment column of the monitor.
Fixed display formats	Float files are always output in floating point format ("C"%g format). String files are always output as a null terminated text string. Binary files are always output as four binary nibbles. Complex data types (Timer, Counter, Control or other data files) are output as a table with bits and important words specified.

Importing User Page Files to the MicroLogix 1400 Controller

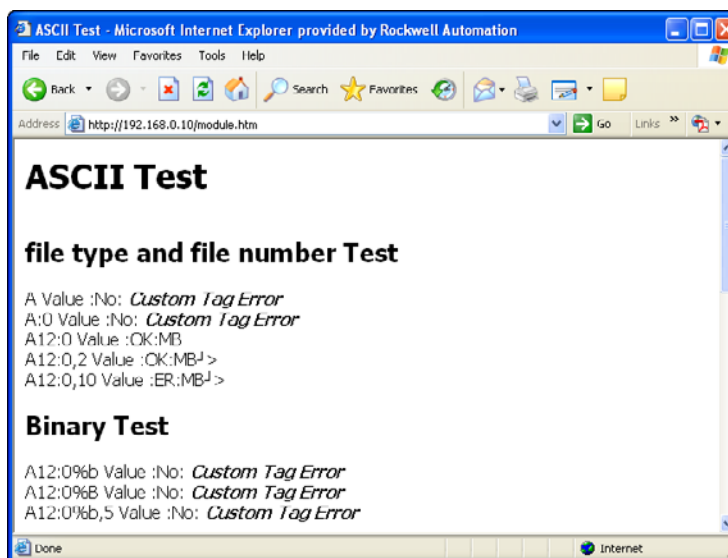
Use RSLogix 500/RSLogix Micro to import user page files to the MicroLogix 1400 controller ASCII files:

1. In the Project folder (under the Data Files folder), right-click on the first of the block of four consecutive ASCII files where you will import the user page HTML file.
2. Click on *Properties*.
3. Click on *Import HTML*.
4. Use the browser to locate the user page HTML file you want to import.
5. Double-click on the file to select it.
6. Click *OK*.

7. Repeat this process for each user page file.
8. When all user page files have been imported, go online with your MicroLogix 1400 controller processor.
9. Select the *User Provided Pages* link to view the User Provided Pages menu, as shown in the following example:



Click on the *User Provided Page #X* to display that specific page.



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Cat. No. Bulletin 1766 Controllers Pub. No. 1766-UM002A-EN-P Pub. Date November 2008 Part No. _____

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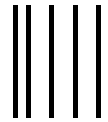
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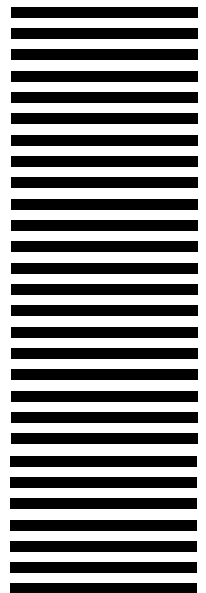
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Notes:

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Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products. At <http://support.rockwellautomation.com>, you can find technical manuals, a knowledge base of FAQs, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools.

For an additional level of technical phone support for installation, configuration and troubleshooting, we offer TechConnect Support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit <http://support.rockwellautomation.com>.

Installation Assistance

If you experience a problem with a hardware module within the first 24 hours of installation, please review the information that's contained in this manual. You can also contact a special Customer Support number for initial help in getting your module up and running:

United States	1.440.646.3434 Monday – Friday, 8am – 5pm EST
Outside United States	Please contact your local Rockwell Automation representative for any technical support issues.

New Product Satisfaction Return

Rockwell tests all of its products to ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned:

United States	Contact your distributor. You must provide a Customer Support case number (see phone number above to obtain one) to your distributor in order to complete the return process.
Outside United States	Please contact your local Rockwell Automation representative for return procedure.

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444

Europe/Middle East/Africa: Rockwell Automation, Vorstlaan/Boulevard du Souverain 36, 1170 Brussels, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640

Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846



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AXH Job: 117551AB

Ref: C14078-C586, C14079-C587

Model: 36VI

Tag: C586, C587

End User: CanGas

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- Stress Relieve Charts
- X-Ray Test Reports
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- Dye Penetrate/Magnetic Particle Test Reports
- Hydrostatic Test Certification Reports

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AXH air-coolers

401 East Lowry Road, Claremore, Oklahoma 74017
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www.axh.com

INTRODUCTION

This manual has been prepared for the purpose of providing general information and recommendations for the operation and maintenance of your air-cooled heat exchanger in order to insure that it will continue to provide you maximum performance in future years under a variety of operating conditions.

Normal maintenance items and light repairs as outlined can be achieved with basic mechanics tools. These include adjusting v-belt tension, checking and adjusting fan blade pitch angle, lubrication of bearings, setting of vibration switches and the periodic cleaning of fin tubes, both externally and internally. For more specific and detailed information please refer to the individual manufacturer's maintenance instructions for the specific item or component in questions (i.e. motors, fans, bearings, and controls). The Table of Contents indicates the appropriate section where this information is contained.

Naturally, prudent judgment should always be exercised when repairing, replacing or particularly modifying any original parts to make certain that they are equivalent to the original design. **AXH air-coolers** stocks most standard parts and components and are available within a 24 hour emergency basis if necessary.

RECEIPT OF EQUIPMENT & SITING

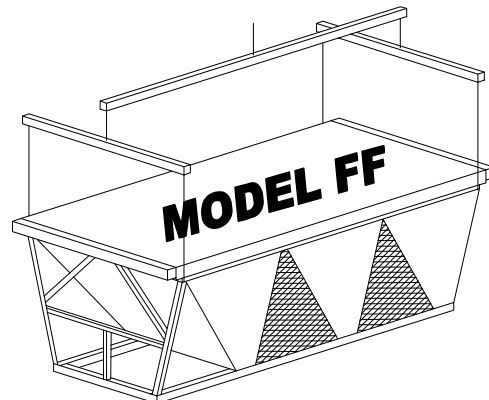
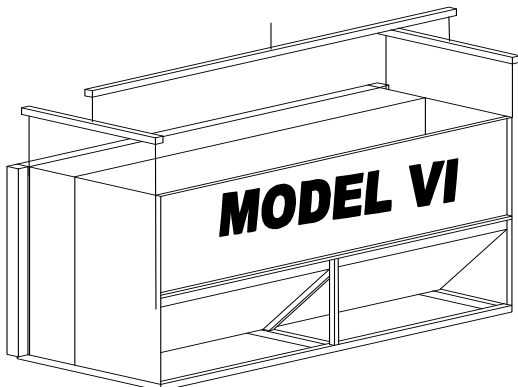
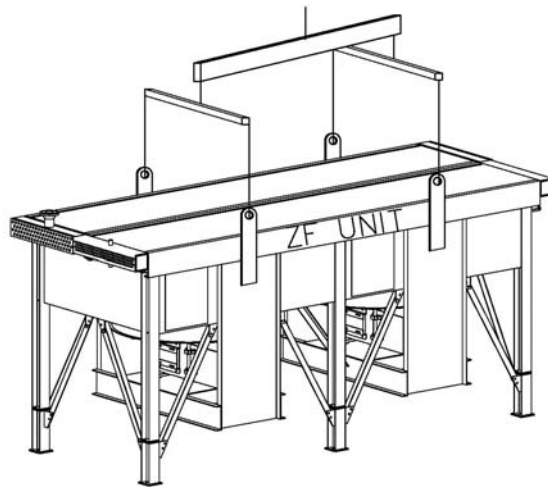
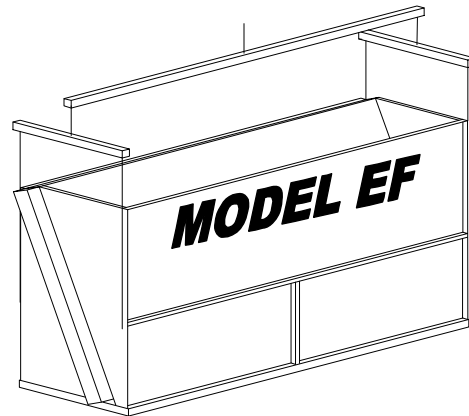
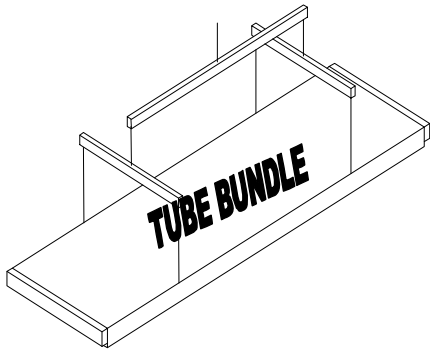
Upon arrival at site, the cooler should be inspected thoroughly by receiving personnel. Damage in transit could be the result of dropping or being struck by heavy objects or equipment. Observe the sub-skid, flanges, plenum side panels and coil sections for any apparent physical damage. Dents, bent flanges, crushed fins, damaged controls are among other items that should be described on the bill of lading document and presented by the carrier. Prompt reporting will expedite filing of claims and will expedite resolution and compensation from the responsible party.

Installation of the cooler(s) is the responsibility of the purchaser or contractor who must insure that the cooler intake areas are free from obstructions and provide adequate airflow. Spacing of air coolers should be adequate to avoid hot air re-circulation (and the affects of other coolers). The impact of grouping coolers closely together may be compensated for by either elevating and/or separating them.

The cooler is normally completely shop assembled and no field assembly at the job-site is required. However, occasionally optional or special accessories may require disassembly to meet transportation height or width limitations. In the event some assembly of the unit is required, the appropriate assembly instructions will accompany the shipment. The packing list should be checked carefully to see that all parts shipped with the cooler are on hand. These parts may be shipped separately, secured to the skid base (if so designed) or inside the plenum area.

UNLOADING & HANDLING COOLERS

Spreader bars should be used for lifting when the cooler width is over eight (8) feet. The cooler is normally supplied with multiple lifting points to be used for off loading from carrier. Lifting by any other point may cause damage to the cooler. Following are some recommended ways of lifting. Please refer to the illustration below that resembles the type of **AXH air-coolers** cooler to be handled and use it as a guide on how to unload and handle the cooler properly. (See unit name plate for unit type i.e. EF, VI, FF, ZF, etc.)



PRIOR TO RUN-IN & START UP

HYDROSTATIC TEST

AXH air-coolers tube bundles (sections) are hydrostatically tested to 1.3 times the design pressure as required by ASME before being released for shipment. To ensure that no damage has been done during shipment and/or installation, it is good practice to hydro test the entire system, including piping, heat exchangers, pumps, etc., prior to start up.

BEARINGS

Check bearings for lubrication. **Caution: DO NOT OVER GREASE.** The manufacturer has greased the bearings and no additional grease is necessary at start up. Remote lubrication lines, when provided, should be loosened at the bearing end, and checked to be sure they are filled with grease from the fitting end. This will ensure that the lube lines are full of grease and free of air and any debris. During high-speed operation too much grease will cause overheating. When dust and water are present bearings should contain as much grease as the operating speed will permit since a full bearing with very slight leakage is the best protection against the entrance of foreign material. Under normal conditions refer to the following table as a general guideline, although certain conditions may require a change of lubrication periods other than those described. Bearing mounting bolts and set screws should be checked for tightness. See bearing manufacturer recommended lubrication chart for recommended maintenance schedule and type of grease.

FANS

Check fan blade bolts and hub bushing set screws for tightness. Rotate fan by hand to insure that shaft, speed reducer, and driver turn freely. The fan blades should be checked for adequate tip clearance and blade pitch angle. To measure this, first move all blades past a fixed point on the inside of the fan ring and observe which blade has the least amount of clearance at that point. Then move the blade selected 360 degrees to the point of minimum clearance. Refer to the section on fans. If the fan is found not to be centered in the fan ring, slight adjustment of the tip clearance can be made by loosening the fan shaft bearing bolts and moving the complete fan and fan shaft assembly until it is centered in the fan ring. To check the fan blade angle, use a level bubble protractor (this can be obtained from **AXH air-coolers**). Loosen the nuts on the bolts and place the protractor on the angle setting mark or the clevis. Refer to fan manufactures information for proper location and air-x-hemphill parts list for design angle. Using a mallet, tap on the shank end of the blade to adjust the angle. Tighten fan blade bolts to the proper torque (refer to manufactures maintenance instructions) making sure to tighten evenly. Recheck blade angle. Occasionally coolers may be equipped with an auto-variable type fan. These fans have blade angles controlled by varying the air supply pressure. Air pressure should be applied to the fan before starting to check for proper operation. **Before starting, any electric motor should be “bumped” to check for proper direction of fan rotation and air flow.** This will also insure that the motor is in proper working order.

LOUVERS/SHUTTERS

Check all mounting brackets and bolts for tightness. To insure that the linkage is adjusted properly on manually operated louvers, operate blades from a fully open to a fully closed position. On automatic louvers with air motors (optional) air should be applied to actuator to check for proper linkage adjustment, free operation, and sufficient air supply. For further information on air motors see attached manufacture maintenance instructions.

CAUTION: DO NOT WALK ON LOUVERS OR USE THEM AS A LADDER

V-BELT DRIVES

Check V-Belt tension in accordance with V-Belt tensioning section of this manual.

GEAR BOX

When supplied, check gearbox for oil. Gears are shipped without oil and must be filled and serviced in accordance with the instructions contained later in this operating manual.

VIBRATION SWITCH (OPTIONAL)

For Murphy switches, after the switch has been installed, adjust it by turning the adjustment screw in a clockwise direction until the starting torque does not trip the vibration switch. For other brands see the specific manufacture's information.

PROCESS START-UP

The process start-up should be conducted in a manner that will minimize thermal shock of the tube bundles. Over cooling of fluids during periods of low ambient temperature and/or low heat load duty should also be avoided, especially during start up.

HEADER ACCESS PLUGS

Header plugs opposite each tube are installed at room temperature. To correct any minor leaking, it may be necessary to tighten the plugs when the bundle is at operating temperature. **WARNING: DO NOT tighten plugs while bundle is under pressure.** If any plugs are removed, the soft iron gasket (shoulder plugs only) should always be replaced. Replacement gaskets are in stock and may be ordered from **AXH air-coolers**. When installing the plugs, a thread lubricant and/or anti-galling compound should be used.

LONG TERM MAINTENANCE

FIN CLEANING

Fins should be kept free of dirt and lint. Bug and lint screens are an available option that will greatly assist in keeping tube bundles clean. Fin tubes can be cleaned by directing compressed air perpendicular to the tubes in a direction OPPOSITE to the normal airflow. Caution should be taken when using steam or chemicals to clean fins. DO NOT clean or spray water when the section/bundle is hot.

TUBE CLEANING

The internal cleaning of tubes can be done in several different ways:

1. **Mechanical Cleaning** - This consists of using a drill, (or wire brushes), on long rods, and rotating them with air or electric motors. This is normally followed by a treated water or chemical wash or air purge.
2. **Chemical Cleaning** - This consists of circulating chemical solutions through the tubes. The solution should contain inhibitors to avoid corrosion of the tube walls.
3. **High Pressure Water Sprays** - This consists of placing a high-pressure water jet head at the end of hollow rods and pushing through the individual tubes.

NOTE: The last two processes will not work on tubes that have been “plugged” with sealing pins.

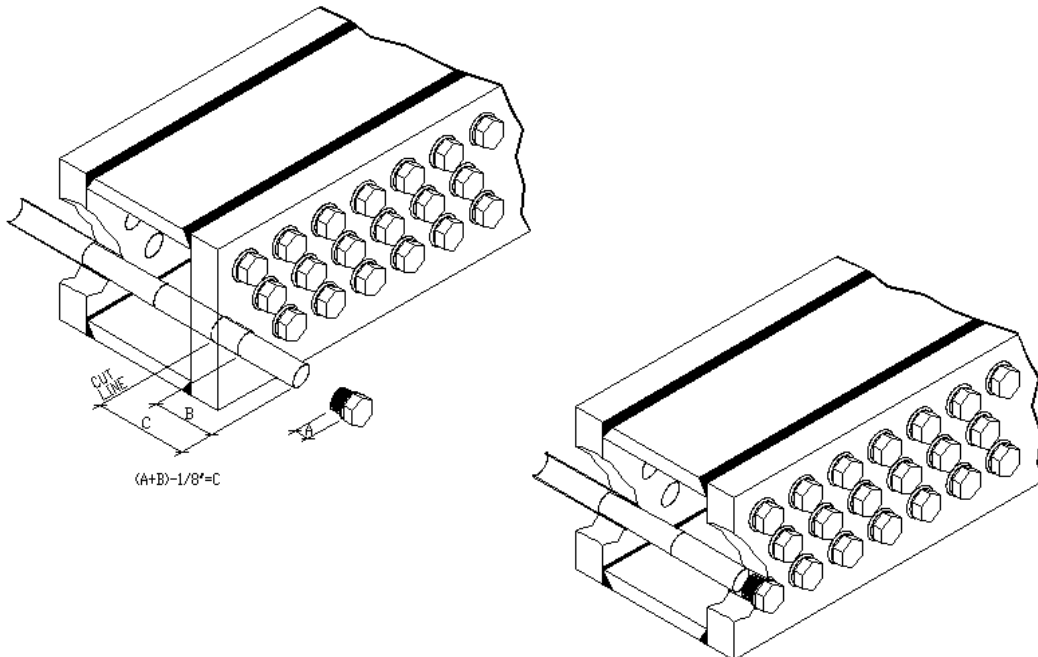
LEAKING TUBES

Tube leaks are generally of two types: 1) leaks through the tube wall itself, and more commonly 2) leaks in the tube end attachment in the header (tube sheet). In the first case it is desirable to plug both ends of the tube. Only a limited number of tubes can be sealed off in this manner before performance is adversely affected and will vary with each specific application. When cooling performance falls below acceptable limits, the tube bundle may be re-tubed. If leaks develop in the tube end attachment at the tube sheet, re-rolling of the tube may be necessary. Care must be taken in selecting the proper tube expander for the tube size (diameter) and gauge of tube to be rolled. When rolling a tube, excess or “over-rolling” must be avoided. Consult the factory for further information on taper sealing pins to plug the tubes and tube roller sizes.

INSTRUCTIONS FOR USING TAPER PINS FOR SEALING TUBES

- 1.) Remove header access plug from one end of leaking tube (do not switch plugs in holes) and replace with new gaskets whenever possible.
- 2.) Insert taper sealing pin through plug hole into tube and tap lightly with hammer until seated firmly, but not too tight to be removed.
- 3.) Measure plug to determine the depth it was originally screwed into header plug sheet. (Dimension A)
- 4.) Measure the distance that the taper pin protrudes from the header plug sheet in "seated" position. (Dimension B)
- 3.) Add the distance measured in Steps 3 and 4 and subtract 1/8". This will be the length which should be cut off the large end of the taper sealing pin. ($A+B-1/8"$ = Dimension C)
- 4.) Remove the taper pin from the end of the tube.
- 5.) Cut the end off the large end of the taper pin to the length calculated in Step 5. CAUTION: Do not cut the pin too short.
- 6.) Re-insert the taper sealing pin in the tube and drive securely into place.
- 7.) Lubricate the access plug and replace it in plug sheet and run in tightly. The plug should now seat tightly and hold taper pin in place.
- 8.) Repeat operation on other end of tube.
- 9.) Hydro-test section to insure proper pressure seal without leaks.

NOTE: If the access plug that was removed does not seal properly, replace it along with the gasket if it is a shoulder type plug.



INSPECTION

TUBES

Tubes should be inspected for internal and external corrosion and/or erosion periodically. This depends on the severity and type of service and atmosphere that the tubes are operating in. Inspection of the tubes should be performed every six months to one year intervals. Tube wall thickness can be checked externally using an ultrasonic technique.

FANS

Fans should be inspected for wear or loose bolts (cracks, pitting and corrosion) on all surfaces. These inspections should be performed every six months. In addition to surface inspections, all bolts and nuts must be checked for proper torque. (See the fan section of the manual).

BEARINGS

In addition to checking bearings as recommended by the manufacture, the mounting bolts should be checked for proper torque and alignment. These checks should be done at least every six months.

STRUCTURE

A general inspection of the structure should be performed every six months to a year. This inspection should include checks for corrosion, damaged members, sheeting guards and for loose bolts.

HEADERS

Headers should be inspected for corrosion periodically. This corrosion should not be allowed to proceed past the stated corrosion allowance as stated on the individual job specification data sheet.

RECOMMENDED SPARE PARTS

We suggest that one each of the parts that are identified as recommended spare parts on the Table of Contents page, be kept in stock or be readily available. The down time caused by waiting for delivery of a replacement part may cost far more in lost production or service than the cost of the item itself.

Spare parts orders should be specified in accordance with the parts list description and always include the corresponding *AXH air-coolers'* model and job number.

WARRANTY

AXH air-coolers warrants that the equipment it *manufactures* is free of defects in material and workmanship, when operated in accordance with conditions stated, for a period of one (1) year after start-up not to exceed fifteen (15) months from shipment. Such warranty shall not apply to any equipment that has been altered or repaired by other than the Company's personnel. The Company's obligation under this warranty is limited, however, to repairing or, if in the Company's judgment it seems more appropriate, to furnishing without charge, F.O.B. the Company's factory, a similar part to replace any part which after examination shall, to its own satisfaction be determined to have been defective at the time it was shipped. This warranty applies only if the Company received an immediate written notice upon discovery of such defect. The Company makes no warranties covering deterioration or failure due to corrosion, erosion or fouling or due to improper installation or operation. EXCEPT AS SPECIFICALLY STATED ABOVE, AXH AIR-COOLERS HEREBY DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WHETHER OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE.

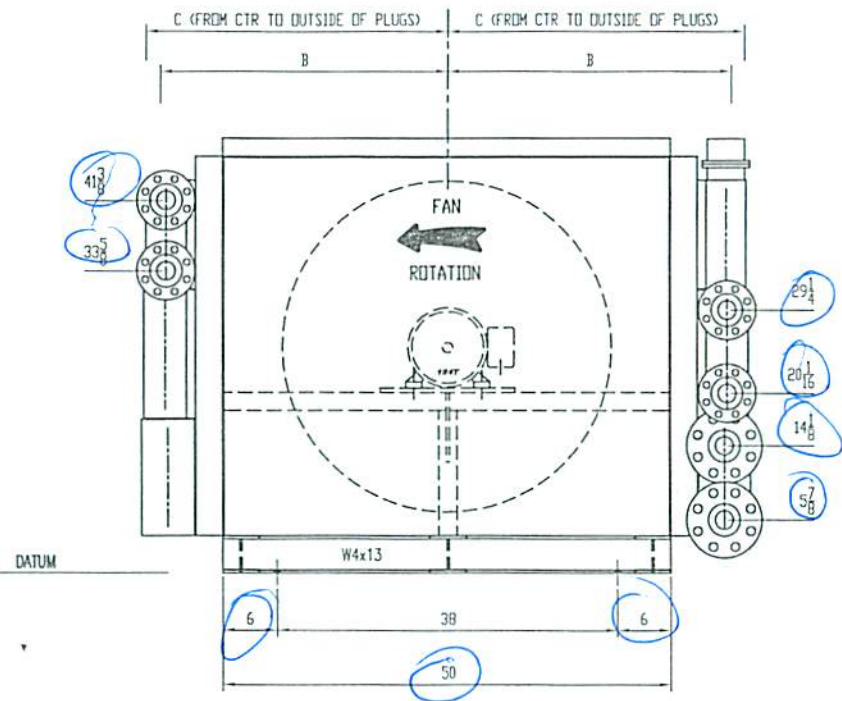
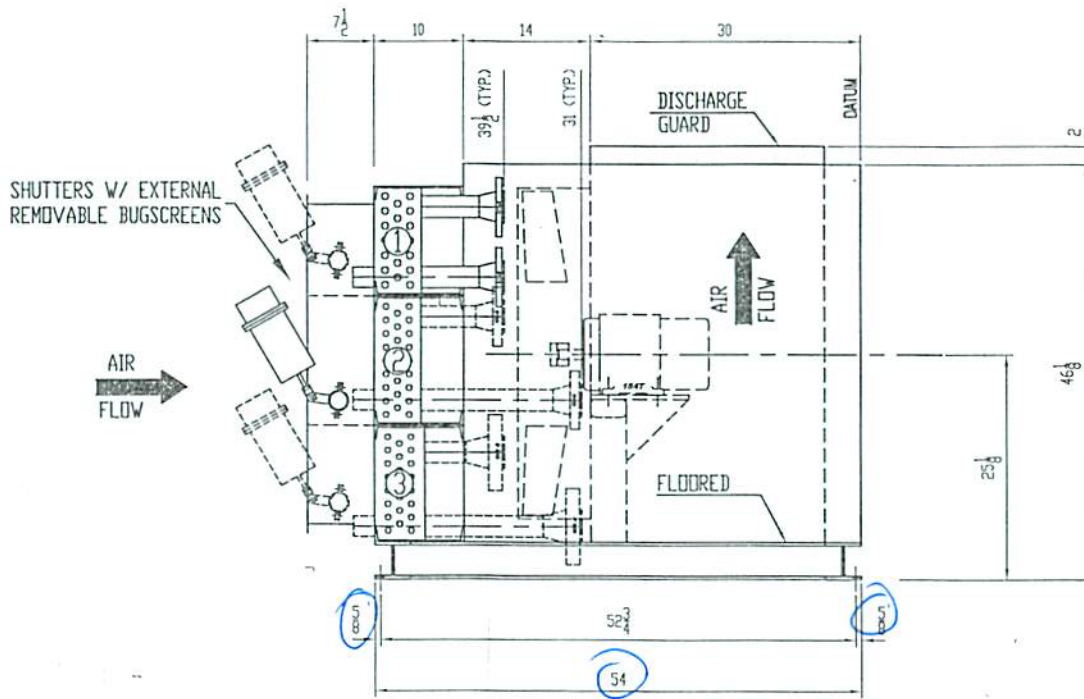
LIMITATION OF LIABILITY

The remedies set forth herein are exclusive. AXH air-coolers shall not be liable, in excess of the purchase price of the equipment, for any damages, whether in contract, in tort or on any other basis, sustained by the customer or any other person arising from or related to the delivery, use or failure of the equipment or for any delay, special, incidental, consequential, indirect or commercial damages whether due to lost profits or otherwise resulting from the delivery, use or failure of the equipment. If it is ever necessary to contact our plant for service or replacement parts, it is essential that our job number and other identifying data be obtained from the metal nameplate attached to the cooler, or the nameplate attached to the tube bundle header box, which also contains the design pressure, temperature, and serial number.


AXH air-coolers

401 East Lowry Road, Claremore, Oklahoma 74017
(918) 283-9200 Fax (918) 283-9229
www.axh.com

ITEM	SERVICE	MAWP	CODE	NOZZLES		COUPLING TEMP	REF. DIMENSION		LOUVERS	BUG SCREEN	DRIVE	FAN	FINISH
				INLET	OUTLET		B	C					
1	IC-1	285 PSI @ 350/-20F	ASME	2-300 RFWN	2-300 RFWN	1-6000	31.25	34.5	AUTO	YES (SOFT)	DIRECT DRIVE BY 2HP, 1200 RPM, 460V, 60HZ, 3P, TEFC, VFD COMP. MOTOR (CSA)	36" MULTI-WING 5ZL PAG 4-BLADE 30" PA LH ROTATION 1170 RPM @ 1.6 HP REQ'D	STRUCTURE STD. PRIMER W/WARM GRAY ENAMEL TOP COAT
2	IC-2	800 PSI @ 350/-20F	ASME	2-600 RFWN	2-600 RFWN	1-6000	31.375	34.625	AUTO				
3	AC	2900 PSI @ 350/-20F	ASME	2-1500 RFWN	2-1500 RFWN	1-6000	31.0625	35.3125	AUTO				



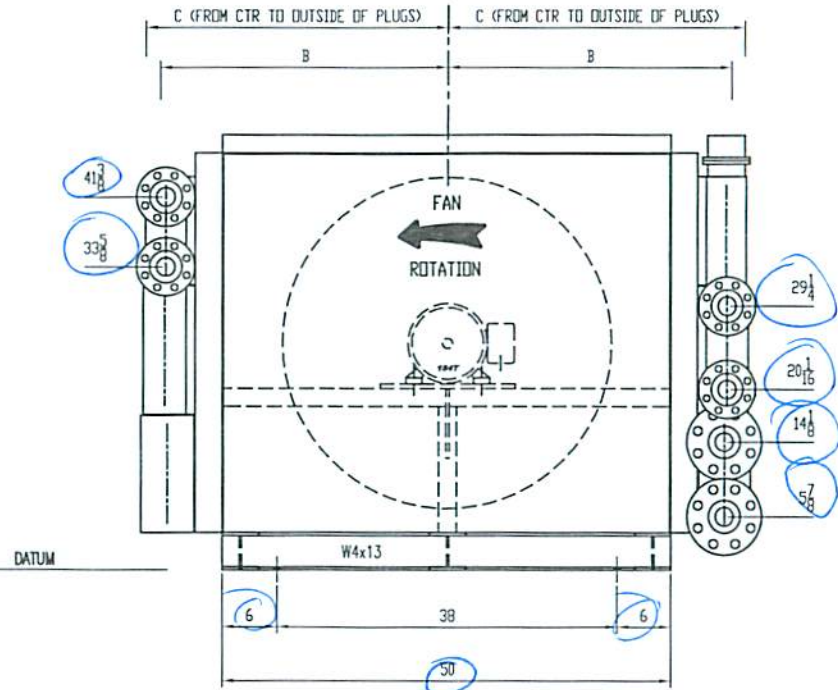
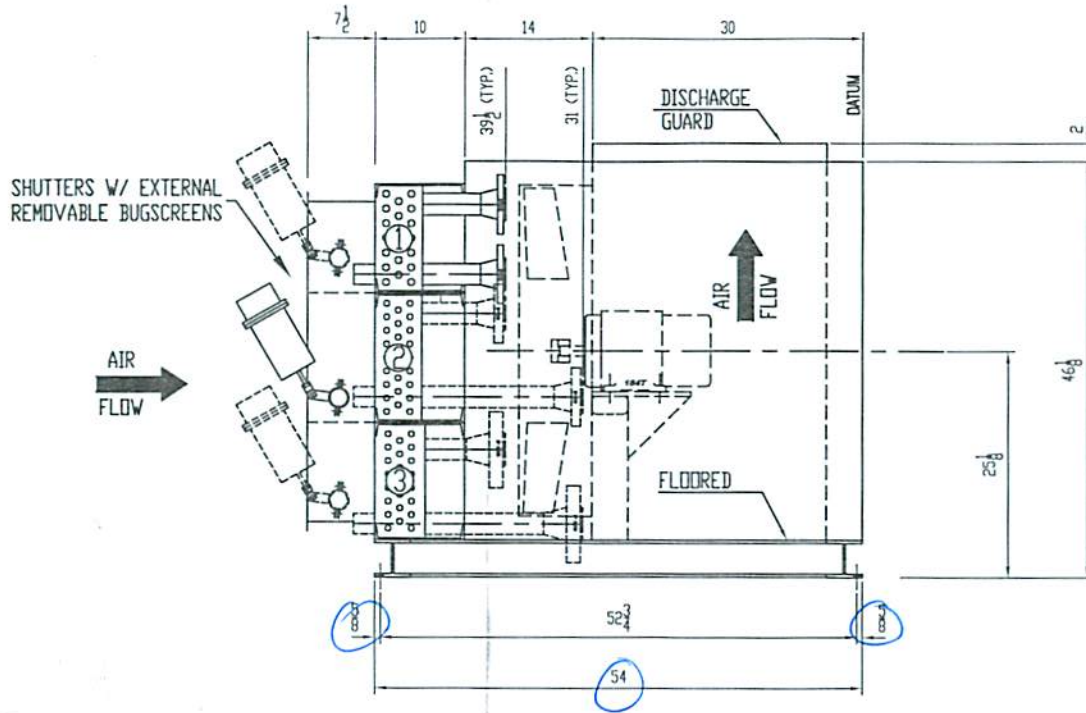
RELEASED
FABRICATION OF THIS
ORDER HAS BEGUN

				FOR: COMPASS COMPRESSION	ESTIMATED DRY WEIGHT 2,600#	
				P.O. NO: C14078-C586, C14079-C587	 AXH air-coolers	
				TAG NUM: C585, C587		
				USER: CANGAS	CERTIFIED DRAWING FOR:	
				JOB SITE: -	MODEL 36VI QUANTITY: 2	
				JOB NO: 117551	- DWG. NO. 117551-CRT	
2			DC	BY	05/20/11	WORK ORDER NO:
1			DC	BY	05/05/11	DR: D.C. DATE: 04/27/11
REV			BY	CK	DATE	CK: B.V. DATE: 04/27/11
						SCALE: FULL DATE: 04/27/11
						REV 2


Lay Report 6-30-11

(A)

ITEM	SERVICE	MAWP	CODE	NOZZLES		COUPLING	REF. DIMENSION		LOUVERS	BUG SCREEN	DRIVE	FAN	FINISH
				INLET	OUTLET	TEMP	B	C					
1	IC-1	285 PSI @ 350/-20F	ASME	2-300 RFWN	2-300 RFWN	1-6000	31.25	34.5	AUTO	YES (SOFT)	DIRECT DRIVE BY 2HP, 1200 RPM, 460V, 60HZ, 3P, TEFC, VFD COMP. MOTOR (CSA)	36" MULTI-WING 5ZL PAG 4-BLADE 30" PA LH ROTATION 1170 RPM @ 1.6 HP REQ'D Ø1.125" BORE WITH .25 x .125 KWY.	STRUCTURE STD. PRIMER W/WARM GRAY ENAMEL TOP COAT HAIL GUARD GALVANIZED
2	IC-2	800 PSI @ 350/-20F	ASME	2-600 RFWN	2-600 RFWN	1-6000	31.375	34.625	AUTO				
3	AC	2900 PSI @ 350/-20F	ASME	2-1500 RFWN	2-1500 RFWN	1-6000	31.0625	35.3125	AUTO				



RELEASED
FABRICATION OF THIS
ORDER HAS BEGUN

					FOR: COMPASS COMPRESSION	ESTIMATED DRY WEIGHT 2,600#
					P.O. NO: C14078-C586, C14079-C587	
					TAG NUM: C586, C587	
					USER: CANCAS	CERTIFIED DRAWING FOR:
					JOB SITE: -	MODEL 36VI QUANTITY: 2
					JOB NO: 117551	- DWG. NO. 117551-CRT
2	REPERATED & REVISED PER CUSTOMER REQUEST	DC	BV	05/20/11	WORK ORDER NO:	SCALE: FULL
1	MIRROR NOZZLES	DC	BV	05/05/11	DR: D.C. DATE: 04/27/11	DATE: 04/27/11
REV	REVISION DESCRIPTION	BY	CK	DATE	CK: B.V. DATE: 04/27/11	REV 2

Jay Lyant
6.30.11

B



AXH air-coolers

401 E. Lowry Road, Claremore, Oklahoma 74017
 (918) 283-9200 Fax (918) 283- 9229
 www.axh.com

Job number: 117551A-B
 Customer: COMPASS COMPRESSION SERVICES
 Quantity: 1.00
 Model: 36-VI

Parts List

Note: Quantity Shown is for One Unit Only

Revision	Engineer	Date	Description
0	CG	05/12/2011	Released Parts List
1	CG	05/17/2011	Revised Fan per rearate, Tube length changed from 4' to 5'

QUANTITY

DESCRIPTION OF PARTS

** 1.00 Electric-Motor EA Item for Attached Notes

Make: TECO Westinghouse
 Horsepower: 2
 RPM: 1200
 V/P/HZ: 460/3/60
 Frame: 184T
 Enclosure: TEFC
 Shaft: Horizontal
 Mounting: F-1
 Special Notes: Single winding, variable torque, VFD compatable. CSA

** 1.00 FAN EA FAN

Make: Multi-Wing
 Model: 36/4-12/30°/PAG/5ZL/SD 1.125"/BR

1.00 LOUVERS EA LOUVERS

Auto over each gas service to include (3) pivot mounts

3.00 AM-G501-6-630 EA Air Motor Garzo Model 501-6 - 6/30# Spring

3.00 TC-T-12 EA Temp. Controller Kimray T-12

3.00 TC-PROBE-SS-12SS EA TC PROBE 1 IN W/SEPERABLE SOCKET MODEL SS-12SS

1.00 REG-F67CFR-224 EA Regulator Fisher 67CFR-224

** = RECOMMENDED SPARE PART



#1, 12181 44TH STREET S.E. CALGARY ALBERTA PH:403-215-6961

**AUTHORIZED BLUE TAG ASSEMBLER
CALIBRATION REPORT**

DATE July 22, 2011
CUSTOMER: Compass Compression Services Ltd
ADDRESS 1537 - 9th Ave SE
Calgary, AB T2G 5N4

SERIAL NUMBER 711670
PRODUCT NUMBER 81-43251V09N11
INLET AND OUTLET 2" MNPT X 2" FNPT "G" Orifice
SERIES SAFETY RELIEF VALVE 8100
SET PRESSURE 65 PSI
LEAK TEST 0 BPM @ 58.5 PSI
CAPACITY 622 SCFM AIR
BACK PRESSURE
TEMPERATURE 120 F
COLD SET
TRIM SOUR GAS
CANADIAN REGISTRATION # 0G8841.5C
QUOTE ORDER NUMBER 2097821 REV.1
WORK ORDER NUMBER 215013
CUSTOMER P.O. NUMBER C15140-C586
LOCATION: SUCTION PSV-100
CUSTOMER ID#:
CUSTOMER REFERENCE:

inlet

THE VALVES PURCHASED ON THE ABOVE WORK ORDER NUMBER WERE BUILT PER SECTION VIII, DIVISION 1 OF THE ASME BOILER AND PRESSURE VESSEL CODE.


CERTIFIED INDIVIDUAL
QUALITY CONTROL

JUL 27 2011

81 C-586



MERCER VALVE CANADA LTD.

#1, 12181 44TH STREET S.E. CALGARY ALBERTA PH:403-215-6961


AUTHORIZED BLUE TAG ASSEMBLER CALIBRATION REPORT

DATE July 22, 2011
 CUSTOMER: Compass Compression Services Ltd
 ADDRESS 1537 - 9th Ave SE
 Calgary, AB T2G 5N4

*1st stage / Dis.
P.S.*

SERIAL NUMBER 711672
 PRODUCT NUMBER 91-17D51T09EN1
 INLET AND OUTLET 1" MNPT X 1" FNPT "D" Orifice
 SERIES SAFETY RELIEF VALVE 9100
 SET PRESSURE 285 PSI
 LEAK TEST 0 BPM @ 273.6 PSI
 CAPACITY 600 SCFM AIR
 BACK PRESSURE
 TEMPERATURE 350 F
 COLD SET 288 PSI
 TRIM SOUR GAS
 CANADIAN REGISTRATION # 0G8841.5C
 QUOTE ORDER NUMBER 2097821 REV.1
 WORK ORDER NUMBER 215013
 CUSTOMER P.O. NUMBER C15140-C586
 LOCATION: STG 1 DISCHARGE PSV-110
 CUSTOMER ID#:
 CUSTOMER REFERENCE:

THE VALVES PURCHASED ON THE ABOVE WORK ORDER NUMBER WERE BUILT PER SECTION VIII, DIVISION 1 OF THE ASME BOILER AND PRESSURE VESSEL CODE.



 CERTIFIED INDIVIDUAL
 QUALITY CONTROL

JUL 27 2011

SH C586



MERCER VALVE CANADA LTD.

#1, 12181 44TH STREET S.E. CALGARY ALBERTA PH:403-215-6961

AUTHORIZED BLUE TAG ASSEMBLER CALIBRATION REPORT

DATE July 22, 2011
 CUSTOMER: Compass Compression Services Ltd
 ADDRESS 1537 - 9th Ave SE
 Calgary, AB T2G 5N4

Second Stage

SERIAL NUMBER 711674
 PRODUCT NUMBER 91-17C51T09N1
 INLET AND OUTLET 1" MNPT X 1" FNPT "C" Orifice
 SERIES SAFETY RELIEF VALVE 9100
 SET PRESSURE 800 PSI
 LEAK TEST 0 BPM @ 767.6 PSI
 CAPACITY 832 SCFM AIR
 BACK PRESSURE
 TEMPERATURE 350 F
 COLD SET 808 PSI
 TRIM SOUR GAS
 CANADIAN REGISTRATION # 0G8841.5C
 QUOTE ORDER NUMBER 2097821 REV.1
 WORK ORDER NUMBER 215013
 CUSTOMER P.O. NUMBER C16140-C586
 LOCATION: STG 2 DISCHARGE PSV-120
 CUSTOMER ID#:
 CUSTOMER REFERENCE:

THE VALVES PURCHASED ON THE ABOVE WORK ORDER NUMBER WERE BUILT PER SECTION VIII, DIVISION 1 OF THE ASME BOILER AND PRESSURE VESSEL CODE.

CERTIFIED INDIVIDUAL
QUALITY CONTROL

JUL 27 2011

SH C-586



MERCER VALVE CANADA LTD.

#1, 12181 44TH STREET S.E. CALGARY ALBERTA PH:403-215-6961

AUTHORIZED BLUE TAG ASSEMBLER


CALIBRATION REPORT

DATE July 22, 2011
CUSTOMER: Compass Compression Services Ltd
ADDRESS 1537 - 9th Ave SE
Calgary, AB T2G 5N4

Third stage.

SERIAL NUMBER 711676
PRODUCT NUMBER 91-17C61P14N1
INLET AND OUTLET 1" MNPT X 1" FNPT "C" Orifice
SERIES SAFETY RELIEF VALVE 9100
SET PRESSURE 2650 PSI
LEAK TEST 0 BPM @ 2,542.2 PSI
CAPACITY 2,724 SCFM AIR
BACK PRESSURE
TEMPERATURE 350 F
COLD SET 2676 PSI
TRIM SOUR GAS
CANADIAN REGISTRATION # 0G8841.5C
QUOTE ORDER NUMBER 2097821 REV.1
WORK ORDER NUMBER 215013
CUSTOMER P.O. NUMBER C15140-C586
LOCATION: STG 3 DISCHARGE PSV-130
CUSTOMER ID#:
CUSTOMER REFERENCE:

THE VALVES PURCHASED ON THE ABOVE WORK ORDER NUMBER WERE BUILT PER SECTION VIII, DIVISION 1 OF THE ASME BOILER AND PRESSURE VESSEL CODE.


CERTIFIED INDIVIDUAL
QUALITY CONTROL

JUL 27 2011

SH C-586



AXH air-coolers
air-x-limited

401 E. Lowry Road Phone (918) 283-9200
Claremore, OK 74017 Fax (918) 283-9229
info@axh.com www.axh.com

Proposal / Job No. 117551D
Date 5/16/2011
Page 1 OF 1

1	Purchaser	COMPASS COMPRESSION	Ultimate User	CANGAS
2	Inquiry / PO#	1103-074	Destination	
3	# Units	1	Model	36VI
4	Assembly	PACKAGED	Draft	INDUCED
			Reference	EMD - JGA/2
			Overall Size, Ft	
			Est Wt	2300 LBS

THERMAL & MECHANICAL DESIGN

5	Service	IC1	IC2	AC
6	Flow	.169MMSCFD	.169MMSCFD	.159MMSCFD
7	Fluid	.9967SPGR	.9967SPGR	.9963SPGR
8	Temp. In / Out, °F	210.0 / 110.0	265.0 / 110.0	284.0 / 110.0
9	Pressure, PSI	123PSIG	468PSIG	1818PSIG
10	Pressure Drop, PSI	1.5	1.1	.3
11	Heat Load, BTU/HR	29690	53801	67276
12	True LMTD	35.0	47.4	50.0
13	Overall Rate, U	49.9	65.2	76.7
14	Fouling Factor	.0020	.0020	.0020
15	Surface, Tube / Total, Sq Ft	19 / 278	20 / 321	18 / 284
16	Sections, #	(1)	(1)	(1)
17	Design Temp, °F Max / Min	350 / -20	350 / -20	350 / -20
18	MWP / Test Press, PSIG	285 / 371	800 / 1040	2900 / 3770
19	Pass Arrangement	CROSSFLOW	CROSSFLOW	CROSSFLOW
20	# Tube Rows	3	3	3
21	# Tube Passes	4	4	4
22	Tubes, OD x BWG	3/4X16	5/8X16	5/8X16
23	Material	SA179 STEEL	SA179 STEEL	SA179 STEEL
24	# Per Section / Length, Ft	20 / 5	26 / 5	23 / 5
25	Turbulators			
26	Accelerators	.250	.250	.250
27	Fins, Type	HI-EFF	HI-EFF	HI-EFF
28	Material	AL	AL	AL
29	Nozzles, Rating / Type	300RF	600RF	1500RF
30	Material	SA105	SA105	SA105
31	#-Inlets / Size In	(1) 2	(1) 2	(1) 2
32	#-Outlets / Size In	(1) 2	(1) 2	(1) 2
33	Headers, Type	BOX	BOX	BOX
34	Material	SA516-70	SA516-70	SA516-70
35	Corrosion Allow, In	.1250	.1250	.1250
36	Grooved Tubesheet	DBL	DBL	DBL
37	Plugs, Type	SHOULDER	SHOULDER	SHOULDER
38	Plugs Material	A105 STEEL	A105 STEEL	A105 STEEL
39	PWHT	YES	YES	YES
40	ASME Code & Nat'l Board	YES	YES	YES
41	CRN	AB/BC/SK/MB	AB/BC/SK/MB	AB/BC/SK/MB
42	Add'l Specs & Options			
43	API			
44	Louvers / Hail Screen	AUTO /	AUTO /	AUTO /
45	Inspection / NDT	BX, UT	BX, UT	BX, UT

FX= 100% X-Ray of all header seam, attachment & nozzle butt welds. **SX=** Spot X-Ray of 1 long seam & 1 end closure, per header
BX= 100% X-Ray of all nozzle butt welds. **UT =** 100% UT of all header seam, attachment & nozzle butt welds. **H =** Hardness testing.

AIR-SIDE PERFORMANCE		FAN DATA		DRIVER DATA		STRUCTURAL	
46	Ambient Air Temp, In °F	100	Fan(s)	(1) MW 5ZL	Type	Guards	
47	Elevation, Ft	2500	Blade Material	PAG	DIRECT DRIVE BY (1) 2HP,		SOFT BUG SCREENS
48	Air Flow, SCFM	8,603	HP / Fan	1.6	1200RPM, 460/60/3, TEFC, VFD		DISCHARGE GUARD
49	Outlet Air Temp, °F	116.2	Dia, In / # Blades	36 / 4	COMP. MOTOR (CSA)		
50	Min Air Temp, °F	-20	RPM	1170			
51			Tipspeed, FPM	11026			
52	Est. Noise Data:	82 dBA @ 1m, 63 dBA @ 15m	Pitch, Deg	30			
53	Additional Info.						
54							
55							
56							
57							
58							

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(ALTERNATIVE FORM FOR SINGLE CHAMBER, COMPLETELY SHOP OR FIELD FABRICATED VESSELS ONLY)
AS REQUIRED BY THE PROVISIONS OF THE ASME CODE RULES, SECTION VIII, DIVISION 1

1. Manufactured and certified by: AXH air-coolers, LLC - 401 EAST LOWRY ROAD - CLAREMORE, OKLAHOMA 74017
(Name and address of manufacturer)

2. Manufactured for: COMPASS COMPRESSION SERVICES LTD., 1537 - 9TH AVENUE SOUTHEAST, CALGARY, ALBERTA, CANADA T2G 5N4

3. Location of installation: UNKNOWN
(Name and address)

4. Type HORZ. H. EXCHANGER 117551A-B.1 R1519.2134 117551 IC-1 R0 & 26696-CRN3 R0 18168-18169 2011
(Horiz. Or vert., tank) (Mfr's serial No.) (CRN) (Drawing No.(s)) (Natl Bd No) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL
CODE. The design, construction and workmanship conform to ASME Rules, Section VIII, Division 1. 2010 EDITION
Year

to: NO ADDENDA - -
Addenda (Date) Code Case Nos. Special Service per UG-120 (d)

6. Shell: TUBE&PLUG: SA-516 70 FR & BK 7/8" .125 FR & BK 0' 5 5/16" 1' 0"
Matl (Spec. No., Grade) Nom. Thk. (in.) Corr. Allow. (in.) (Inner diameter) Length (overall)

7. Seams: CORNER JOINT SEE REMARKS 1.0 1150° 1 - - 2
(Long. welded, dbl, Sngl., Lap, Butt) R.T. (Spot or Full) Eff. (%) H.T. Temp (F) Time (hr.) Girth (Welded, Dbl R.T. (Spot, Parbal. Eff. (%) No. of Courses of Full)

8. Heads: (a) Material WRAPPERS: SA-516 70 (b) Material ENDS: SA-516 70
(Spec. No., Grade) (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
a	WRAPPERS	1/2"	.125"	-	-	-	-	-	**	FLAT
b	ENDS	1/2"	.125"	-	-	-	-	-	***	FLAT

If removable, bolts used (describe other fastenings) (Material Spec. No., Gr., Size, No.)

9. MAWP 285 psi N/A at max. temp 350 °F N/A
(Internal) (External) (Internal) (External)

Min. design metal temp. -20 °F at 285 psi Hydro. ~~test~~ test pressure 371 psi

Proof Test NONE

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diam. or Size	Type	Material	Nom. Thk.	Reinforcement Material	How Attached	Location (Header)
INLET/OUTLET	2	2"-300#	PIPE / RFWN	SA-106-B / SA-105	S/160	NONE	UW-16(a)	HEADER
INSTRUMENT	1	1"	CPLG	SA-105	6000#	NONE	UW-16(a)	HEADER
PLUGS	40	7/8"-14	UNF	SA-105	-	-	-	HEADER

11. Supports: Skirts NO LUGS N/A LEGS N/A OTHER N/A STRUCTURE BOLTED Attached: BOLTED
(Yes or no) (No) (No) (Describe) (Where and How)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:
(Name of part, item number, Mfr's. name, and identifying stamp)

*2 HEADERS, ONE AT EACH END. **WRAPPERS FLAT DIA. 2 3/4" X 1' 0". ***ENDS FLAT DIA. 2 3/4" X 4 5/16".
20 TUBES SA-179 3/4" O.D. X .065 MW 5' 0" LG. RADIOGRAPH PER CUSTOMER SPECIFICATIONS.
IMPACTS EXEMPT PER UG-20(f). PRESSURE RELIEF DEVICE BY OTHERS. CONSTRUCTED IN ACCORDANCE WITH APPENDIX 28.

CERTIFICATE OF SHOP / FIELD COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section V111, Division 1. "U" Certificate of Authorization No. 34, 950 expires 02/07/2014

Date: 7.6.11 Co. name: AXH air-coolers, LLC. Signed Renee Weeks
(Manufacturer) (Representative)

CERTIFICATE OF SHOP / FIELD INSPECTION

Vessel constructed by AXH air-coolers, LLC. at 401 E. LOWRY ROAD - CLAREMORE, OKLAHOMA 74017

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and / or the State or Province of OKLAHOMA and employed by SENECA INSURANCE COMPANY OF TEXAS

have inspected the component described in this Manufacturer's Data Report on 6-29-11 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date: 7-6-11 Signed: [Signature] Commissioner NB12461A OK883
(Authorized Inspector) (Natl Board (incl. endorsements,) State, Prov. and No.)

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(ALTERNATIVE FORM FOR SINGLE CHAMBER, COMPLETELY SHOP OR FIELD FABRICATED VESSELS ONLY)
AS REQUIRED BY THE PROVISIONS OF THE ASME CODE RULES, SECTION VIII, DIVISION 1

1. Manufactured and certified by: AXH air-coolers, LLC - 401 EAST LOWRY ROAD - CLAREMORE, OKLAHOMA 74017
(Name and address of manufacturer)

2. Manufactured for: COMPASS COMPRESSION SERVICES LTD., 1537 - 9TH AVENUE SOUTHEAST, CALGARY, ALBERTA, CANADA T2G 5N4

3. Location of installation: UNKNOWN
(Name and address)

4. Type HORZ. H. EXCHANGER 117551A-B.2 R4810.2134 117551 IC-2 R0 & 37905-CRN2 R0 18170-18171 2011
(Horz. Or vert., tank) (Mfg's serial No.) (CRN) (Drawing No.(s)) (Nat'l Bd. No.) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL
CODE. The design, construction and workmanship conform to ASME Rules, Section VIII, Division 1. 2010 EDITION
Year

to: NO ADDENDA - -
Addenda (Date) Code Case Nos. Special Service per UG-120 (d)

6. Shell: TUBE&PLUG: SA-516 70 FR & BK 7/8" .125 FR & BK 0' 5 1/4" 1' 2 1/4"
Mat'l (Spec. No., Grade) Nom. Thk. (in.) Corr. Allow. (in.) (Inner diameter) Length (overall)

7. Seams: CORNER JOINT SEE REMARKS 1.0 1150° 1 - - 2
(Long (welded, dbl, Sngl., Lap, Butt)) R.T. (Spot or Full) Eff. (%) H.T. Temp. (F) Time (hr.) Girth (Welded, Dbl, R.T. (Spot, Partial, Eff. (%) No. of Sngl., Lap, Butt) of Full) Courses

8. Heads: (a) Material WRAPPERS: SA-516 70 (b) Material ENDS: SA-516 70
(Spec. No., Grade) (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
a	WRAPPERS	5/8"	.125"	-	-	-	-	-	**	FLAT
b	ENDS	5/8"	.125"	-	-	-	-	-	***	FLAT

If removable, bolts used (describe other fastenings) _____
(Material Spec No., Gr., Size, No)

9. MAWP 800 psi N/A at max. temp 350 °F N/A
(Internal) (External) (Internal) (External)

Min. design metal temp. -20 °F at 800 psi Hydro. ~~press. or comb.~~ test pressure 1040 psi

Proof Test NONE

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No	Diam. or Size	Type	Material	Nom. Thk	Reinforcement Material	How Attached	Location (Header)
INLET/OUTLET	2	2"-600#	PIPE / RFWN	SA-106-B / SA-105	S/160	NONE	UW-16(a)	HEADER
INSTRUMENT	1	1"	CPLG	SA-105	6000#	NONE	UW-16(a)	HEADER
PLUGS	52	3/4"-16	UNF	SA-105	-	-	-	HEADER

11. Supports: Skirts NO LUGS N/A LEGS N/A OTHER STRUCTURE Attached: BOLTED
(Yes or no) (No.) (No.) (Describe) (Where and How)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:
(Name of part, item number, Mfg's name, and identifying stamp)

*2 HEADERS, ONE AT EACH END. **WRAPPERS FLAT DIA. 3" X 1' 2 1/4". ***ENDS FLAT DIA. 3" X 4".
26 TUBES SA-179 5/8" O.D. X .065 MW 5' 0" LG. RADIOGRAPH PER CUSTOMER SPECIFICATIONS.
IMPACTS EXEMPT PER UG-20(f). PRESSURE RELIEF DEVICE BY OTHERS. CONSTRUCTED IN ACCORDANCE WITH APPENDIX 28.

CERTIFICATE OF SHOP / FIELD COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section V111, Division 1. "U" Certificate of Authorization No. 34, 950
 expires 02/07/2014
 Date: 7-6-11 Co. name: AXH air-coolers, LLC. Signed Renee LeBecks
(Manufacturer) (Representative)

CERTIFICATE OF SHOP / FIELD INSPECTION

Vessel constructed by AXH air-coolers, LLC. at 401 E. LOWRY ROAD - CLAREMORE, OKLAHOMA 74017
 I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and / or the State or Province of OKLAHOMA and employed by SENECA INSURANCE COMPANY OF TEXAS
 have inspected the component described in this Manufacturer's Data Report on 6-29-11 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.
 Date: 7-6-11 Signed: [Signature] Commissioner NB12461A OK883
(Authorized Inspector) (Nat'l Board (incl. endorsements,) State, Prov. and No.)

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(ALTERNATIVE FORM FOR SINGLE CHAMBER, COMPLETELY SHOP OR FIELD FABRICATED VESSELS ONLY)
AS REQUIRED BY THE PROVISIONS OF THE ASME CODE RULES, SECTION VIII, DIVISION 1

1. Manufactured and certified by: AXH air-coolers, LLC - 401 EAST LOWRY ROAD - CLAREMORE, OKLAHOMA 74017
(Name and address of manufacturer)

2. Manufactured for: COMPASS COMPRESSION SERVICES LTD., 1537 - 9TH AVENUE SOUTHEAST, CALGARY, ALBERTA, CANADA T2G 5N4

3. Location of installation: UNKNOWN
(Name and address)

4. Type HORZ. H. EXCHANGER 117551A-B.3 V4821.2134 117551 AC R0 & 117551-CR2 R0 18172-18173 2011
(Horiz. Or vert., tank) (Mfr's serial No.) (CRN) (Drawing No (s)) (Nat'l Bd. No.) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL
CODE. The design, construction and workmanship conform to ASME Rules, Section VIII, Division 1. 2010 EDITION
Year

to: NO ADDENDA
Addenda (Date) Code Case Nos. Special Service per UG-120 (d)

6. Shell: TUBE&PLUG: SA-516 70N FR & BK 1 3/4" .125 FR & BK 0' 5 5/8" 1' 1"
Mat'l (Spec. No., Grade) Nom. Thk. (in.) Corr. Allow. (in.) (Inner diameter) Length (overall)

7. Seams: CORNER JOINT SEE REMARKS 1.0 1150° 1 - - 2
[Long (welded, dbl, Sngl., Lap, Butt)] R.T. (Spot or Full) Eff. (%) H.T. Temp. (F) Time (hr.) Girth (Welded, Dbl, R.T. (Spot, Partial, Eff. (%) No. of Courses

8. Heads: (a) Material WRAPPERS: SA-516 70N (b) Material ENDS: SA-516 70N
(Spec. No., Grade) (Spec. No., Grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
a	WRAPPERS	7/8"	.125"	-	-	-	-	-	**	FLAT
b	ENDS	3/4"	.125"	-	-	-	-	-	***	FLAT

If removable, bolts used (describe other fastenings) _____

9. MAWP 2900 psi N/A at max. temp 350 °F N/A
(Internal) (External) (Internal) (External)

Min. design metal temp. -20 °F at 2900 psi Hydro. ~~press. or comb.~~ test pressure 3770 psi

Proof Test NONE

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain)	No.	Diam. or Size	Type	Material	Nom. Thk.	Reinforcement Material	How Attached	Location (Header)
INLET/OUTLET	2	2"-1500#	PIPE / RFWN	SA-106-B / SA-105	S/XXH	NONE	UW-16(a)	HEADER
INSTRUMENT	1	1"	CPLG	SA-105	6000#	NONE	UW-16(a)	HEADER
PLUGS	46	3/4"-16	UNF	SA-105	-	-	-	HEADER

11. Supports: Skirts NO LUGS N/A LEGS N/A OTHER STRUCTURE Attached: BOLTED
(Yes or no) (No.) (No.) (Describe) (Where and How)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:
(Name of part, item number, Mfr's name, and identifying stamp)

*2 HEADERS, ONE AT EACH END. **WRAPPERS FLAT DIA. 2 3/8" X 1' 1". ***ENDS FLAT DIA. 2 3/8" X 3 7/8".
23 TUBES SA-179 5/8" O.D. X .065 MW 5' 0" LG. RADIOGRAPH PER CUSTOMER SPECIFICATIONS.
IMPACTS EXEMPT PER UG-20(f). PRESSURE RELIEF DEVICE BY OTHERS. CONSTRUCTED IN ACCORDANCE WITH APPENDIX 28.

CERTIFICATE OF SHOP / FIELD COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section V111, Division 1. "U"Certificate of Authorization No. 34,950
 expires 02/07/2014
 Date: 7.6.11 Co. name: AXH air-coolers, LLC. Signed Renee Weeks
(Manufacturer) (Representative)

CERTIFICATE OF SHOP / FIELD INSPECTION

Vessel constructed by AXH air-coolers, LLC. at 401 E. LOWRY ROAD - CLAREMORE, OKLAHOMA 74017
 I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and / or the State or Province of OKLAHOMA and employed by SENECA INSURANCE COMPANY OF TEXAS
 have inspected the component described in this Manufacturer's Data Report on 6-29-11 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.
 Date: 7-6-11 Signed: [Signature] Commissioner NB12461A OK883
(Authorized Inspector) (Nat'l Board (incl. endorsements.) State, Prov. and No.)



NB 18168

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA IC-1

W
HT

MAX. ALLOWABLE WORKING PRESSURE 285 PSI @ 350 °F
MIN. DESIGN METAL TEMP. -20 °F @ 285 PSI
SER. NO. 117551A.1 CRN. R1519.2134
YEAR 2011 HYDRO. 371 PSIG SERVICE



NB 18170

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA IC-2

W
HT

MAX. ALLOWABLE WORKING PRESSURE 800 PSI @ 350 °F
MIN. DESIGN METAL TEMP. -20 °F @ 800 PSI
SER. NO. 117551A.2 CRN. R4810.2134
YEAR 2011 HYDRO. 1040 PSIG SERVICE



NB 18172

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA AC

W
HT

MAX. ALLOWABLE WORKING PRESSURE 2900 PSI @ 350 °F
MIN. DESIGN METAL TEMP. -20 °F @ 2900 PSI
SER. NO. 117551A.3 CRN. V4821.2134
YEAR 2011 HYDRO. 3770 PSIG SERVICE



NB 18169

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA IC-1

W
HT

MAX. ALLOWABLE WORKING PRESSURE 285 PSI @ 350 °F
MIN. DESIGN METAL TEMP. -20 °F @ 285 PSI
SER. NO. 117551B.1 CRN. R1519.2134
YEAR 2011 HYDRO. 371 PSIG SERVICE



NB 18171

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA IC-2

W
HT

MAX. ALLOWABLE WORKING PRESSURE 800 PSI @ 350 °F
MIN. DESIGN METAL TEMP. -20 °F @ 800 PSI
SER. NO. 117551B.2 CRN. R4810.2134
YEAR 2011 HYDRO. 1040 PSIG SERVICE



NB 18173

CERTIFIED BY **AXH air-coolers, LLC**

CLAREMORE, OKLAHOMA AC

W
HT

MAX. ALLOWABLE WORKING PRESSURE 2900 PSI @ 350 °F
MIN. DESIGN METAL TEMP. -20 °F @ 2900 PSI
SER. NO. 117551B.3 CRN. V4821.2134
YEAR 2011 HYDRO. 3770 PSIG SERVICE



RW 6.28.11

**FINAL IN PROCESS
INSPECTION CHECKLIST**



CUSTOMER:

JOB / MODEL NUMBER:

UNIT:

DATE:

COMPASS COMPRESSION				117551 / 36VI				A				6/11/2011			
ASSEMBLY	CHECK	Q.C.	CUST.					ASSEMBLY	CHECK	Q.C.	CUST.				
FLANGE ARRANGEMENT AND FACING	MIS 6-30-11	LD 6-30-11	X					MANUAL AND/OR AIR MOTORS	AL 6-30-11	LD 6-30-11	X				
RUST PREVENTION OF NOZZLES / HEADERS	JP 6-30-11	LD 6-30-11	X					SHUTTERS OPERATE CORRECTLY	AL 6-30-11	LD 6-30-11	X				
RUST PREVENTION OF SHAFTS	G.C 6-28-11	LD 6-28-11	X					CUT IN PAINT	PS 6-27-11	LD 6-30-11	X				
DIMENSIONAL INSPECTION OF SUB COLUMNS	/	/						FINAL FINISH AVG. MIL. 4.9	ZS 6-30-11	LD 6-30-11	X				
DIMENSIONAL INSPECTION OF BASE	J.G 6/24/11	LD 6-28-11	X					GALVANIZED PARTS CLEAN GALVANIZING	J.L 6-30-11	LD 6-30-11	X				
FAN BLADE CLEARANCE & TORQUEING OF FAN/SHAFT	J.G 6/24/11	LD 6-28-11	X					HAIL GUARD, FAN GUARD AND/OR BUG SCREENS	AL 6-30-11	LD 6-30-11	X				
FAN BLADE PITCH CHECKED 30°	J.G 6/24/11	LD 6-28-11	X					UNIT NAME PLATE INSP. AND ATTACHMENT	G.C 6-30-11	LD 6-30-11	X				
CPLG, BUSHING, AND BEARING SECURED	J.G 6/24/11	LD 6-28-11	X					PARTS SHIPPING LOOSE	AL 6-30-11	LD 6-30-11	X				
BEARINGS AND/OR UNIVERSAL GREASED		N/A	X												
IDLER ALIGNMENT															
ELECTRIC MOTOR	J.G 6/24/11	LD 6-28-11	X												
LIFTING LUG ATTACHMENT								QUALITY CONTROL							
								VIBRATION SWITCH							
								RUN TEST AND/OR VIBRATION CHECK	JKS 6-30-11	LD 6-30-11	X				

Q.C. REVIEW:

RW

Q.C. RELEASE FOR SHIPMENT:

Larry August 6-30-11

COMMENTS: Took pictures of shutters 6-30-11

**FINAL IN PROCESS
INSPECTION CHECKLIST**



CUSTOMER:

JOB / MODEL NUMBER:

UNIT:

DATE:

COMPASS COMPRESSION				117551 / 36VI				B				6/11/2011			
ASSEMBLY	CHECK	Q.C.	CUST.					ASSEMBLY	CHECK	Q.C.	CUST.				
FLANGE ARRANGEMENT AND FACING	BC 6-30-11	LD 6-30-11	X					MANUAL AND/OR AIR MOTORS	AL 6-30-11	LD 6-30-11	X				
RUST PREVENTION OF NOZZLES / HEADERS	J.P 6-30-11	LD 6-30-11	X					SHUTTERS OPERATE CORRECTLY	AL 6-30-11	LD 6-30-11	X				
RUST PREVENTION OF SHAFTS	J.L 6-28-11	LD 6-28-11	X					CUT IN PAINT	Z.S. 6-28-11	LD 6-30-11	X				
DIMENSIONAL INSPECTION OF SUB COLUMNS								FINAL FINISH AVG. MIL. 5.0	B.S. 6-30-11	LD 6-30-11	X				
DIMENSIONAL INSPECTION OF BASE	J.L 6-28-11	LD 6-28-11	X					GALVANIZED PARTS CLEAN GALVANIZING	J.L 6-30-11	LD 6-30-11	X				
FAN BLADE CLEARANCE & TORQUEING OF FAN/SHAFT	J.L 6-28-11	LD 6-28-11	X					HAIL GUARD, FAN GUARD AND/OR BUG SCREENS	AL 6-30-11	LD 6-30-11	X				
FAN BLADE PITCH CHECKED 30 <small>Fixed blades</small>	J.L 6-28-11	LD 6-28-11	X					UNIT NAME PLATE INSP. AND ATTACHMENT	G.C 6-30-11	LD 6-30-11	X				
CPLG, BUSHING, AND BEARING SECURED	J.L 6-28-11	LD 6-28-11	X					PARTS SHIPPING LOOSE	AL 6-30-11	LD 6-30-11	X				
BEARINGS AND/OR UNIVERSAL GREASED		NA	X												
IDLER ALIGNMENT															
ELECTRIC MOTOR	J.L 6-28-11	LD 6-28-11	X												
LIFTING LUG ATTACHMENT								QUALITY CONTROL							
								VIBRATION SWITCH							
								RUN TEST AND/OR VIBRATION CHECK	QWS 6-30-11	LD 6-30-11	X				
Q.C. REVIEW: RW								Q.C. RELEASE FOR SHIPMENT: Tony Ayuda 6-30-11							

COMMENTS: Took pictures of shutters LD 6-30-11

Customer Information

Your PO#:500594

Part #:117551a.1IC-1 FR

117551A.2 IC-2 BK

117551A.3AC BK,

TSI Heat Treating Certification

Thermal Specialties Information

Date Processed: 06-24-2011

TSI SO#: 164676

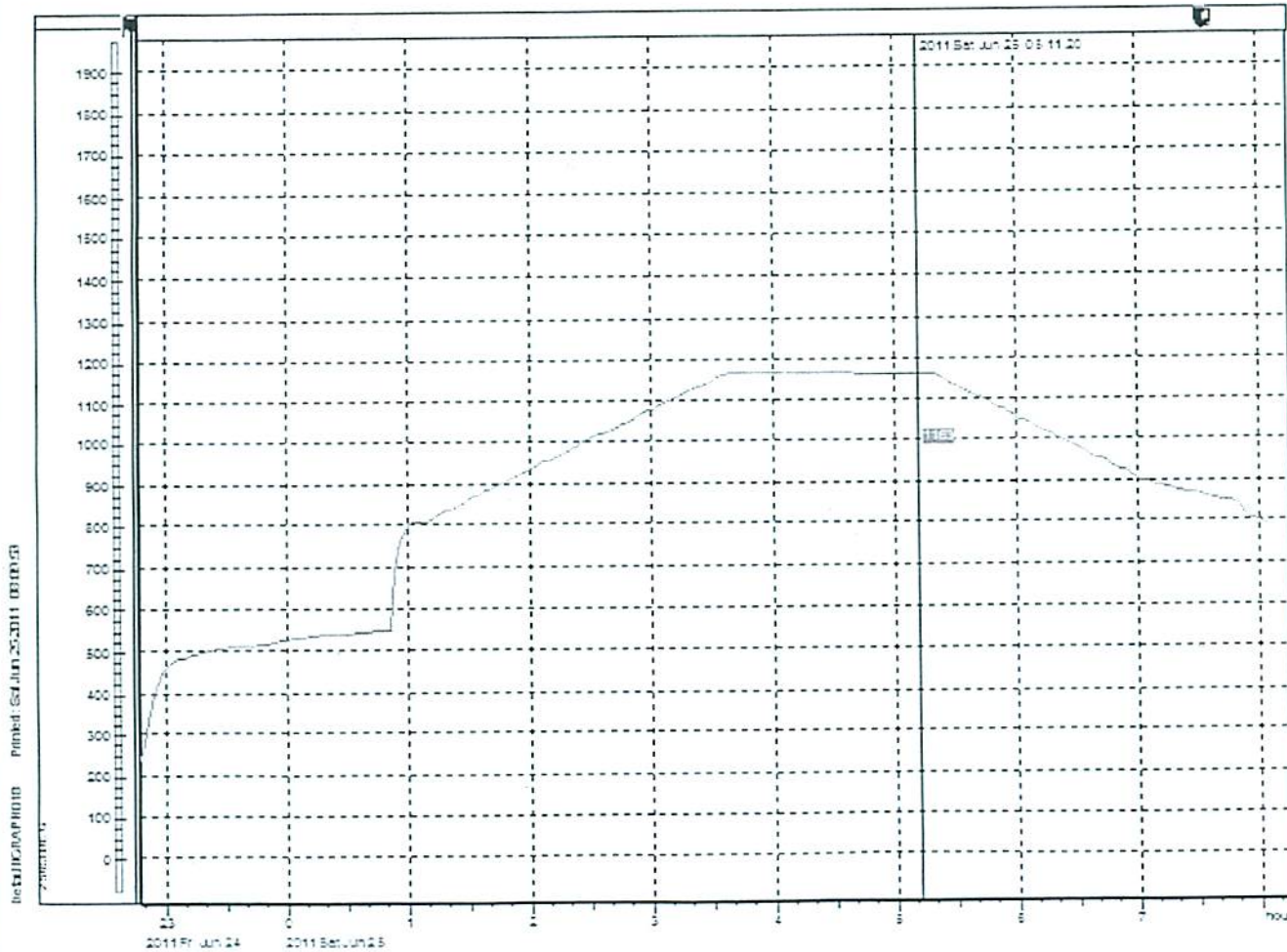
Furnace#: 25

Calibration Date: 05/09/2011

Thermocouple Type K

Approved by: MY

Description:



Vo
6-27-11

Thermal Specialties certifies that the item has been processed in accordance with customer's requirements. Processes were obtained through standard approved methods and in accordance with Thermal Specialties quality assurance manual

Shipment: 55-49110

Shipment



Shipment: 55-49110

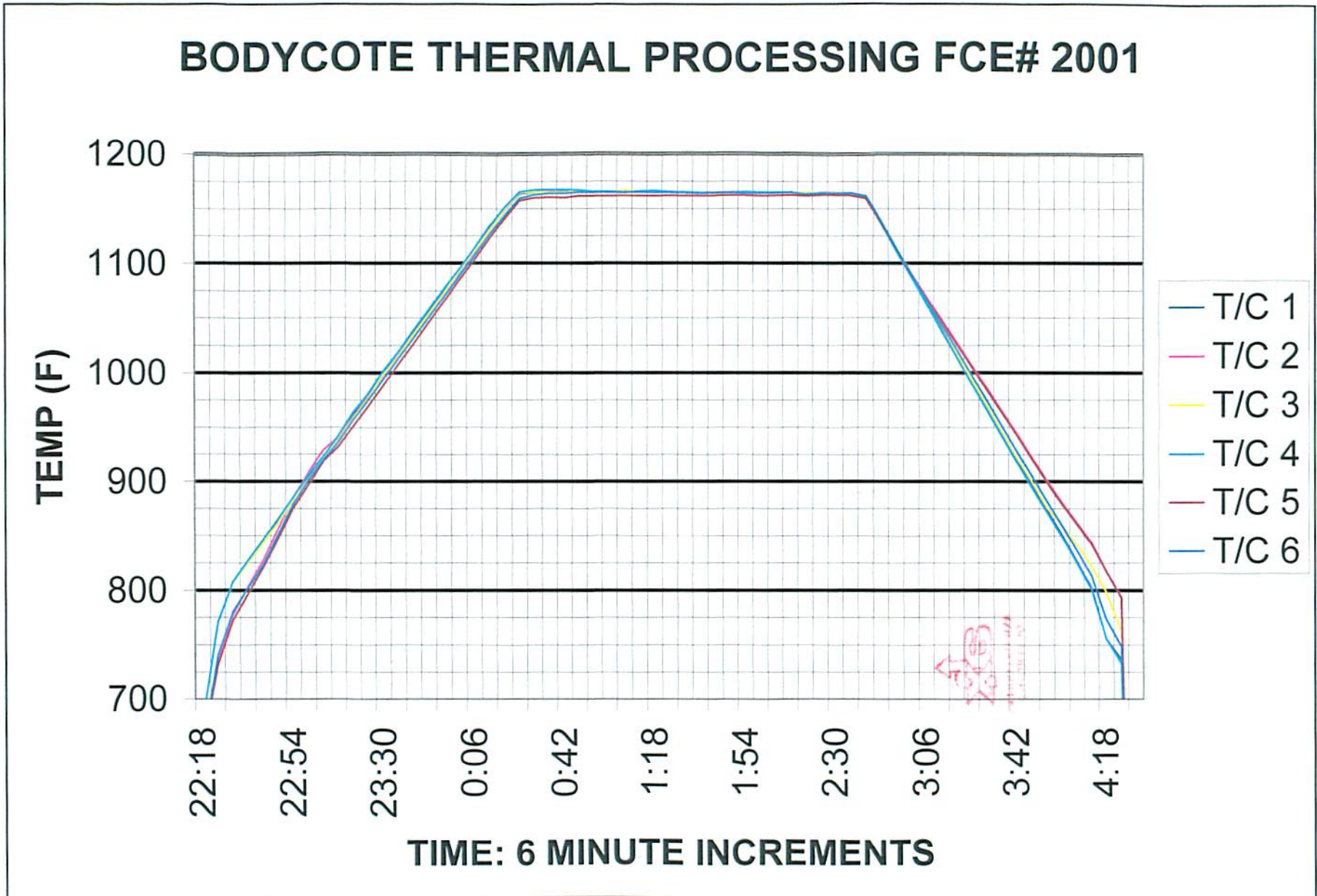


From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200</small>	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200</small>
Ship Date 6/24/2011 7:12:12 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =	STRESS RELIEVE 1150F +/-25F	
Container(s) =	WP	

Order No. 48209 P.O. No. 117551A Recv'd 6/23/2011 8:06:22 PM Shipment COMPLETE			
Qty 1	Part Number 117551A.1 IC-1 BK <small>Material and Description</small> Low Carbon Steel	Part Name HEADER	Wgt 42
Totals...			
Ttl Qty 1	Signed For By / Date <hr/>		Ttl Wgt 42

VA 6-24-11







Shipment: 55-49111



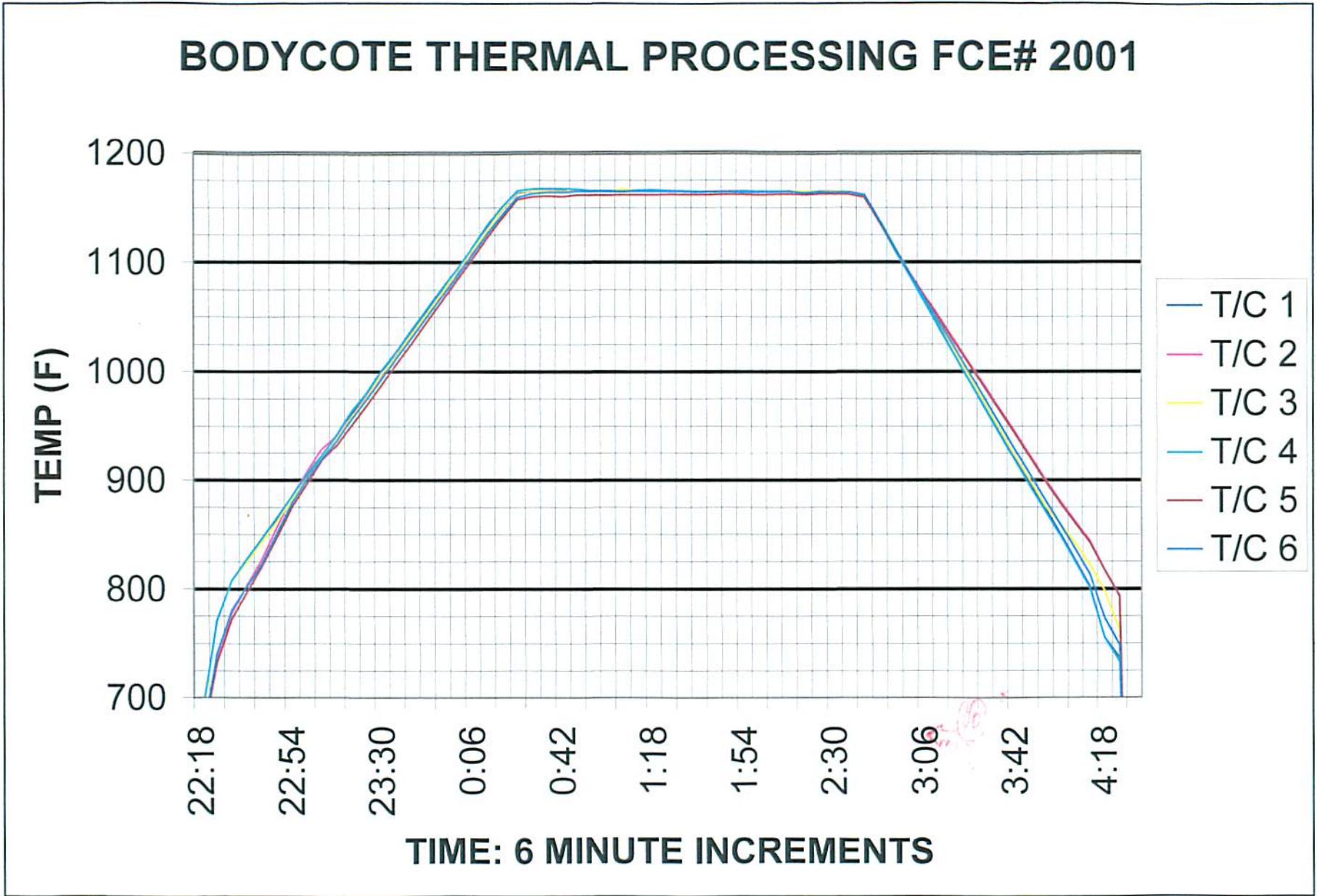
From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200
Ship Date 6/24/2011 7:13:39 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =	STRESS RELIEVE 1150F +/-25F	
Container(s) =	WP	

Order No. 48210 P.O. No. 117551A Recv'd 6/23/2011 8:08:06 PM Shipment COMPLETE

Qty	Part Number	Part Name	Wgt
1	117551A.2 IC-2 FR Material and Description Low Carbon Steel	HEADER	54
Totals...			
Ttl Qty 1	Signed For By / Date		Ttl Wgt 54

VJ 6-24-11







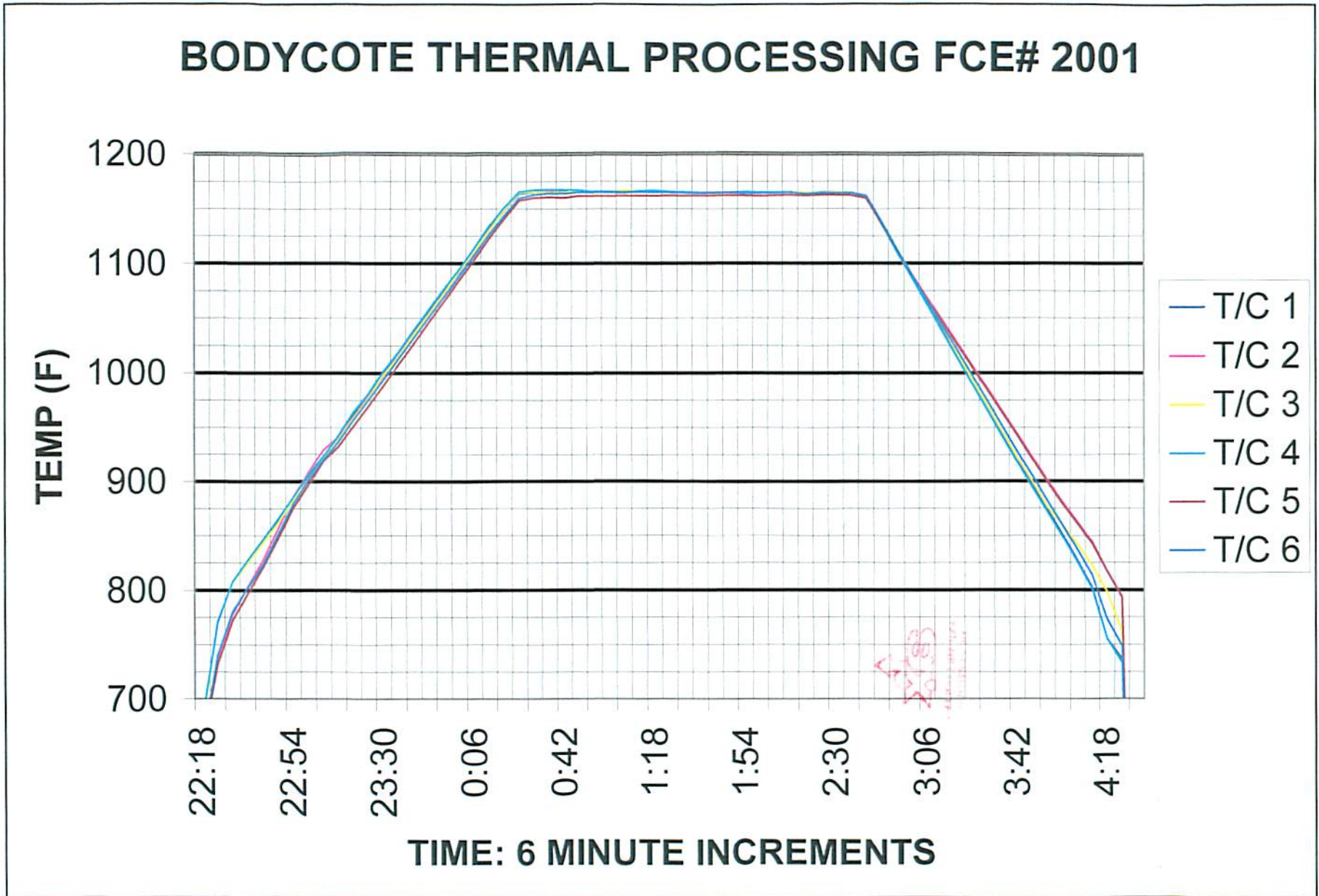
Shipment: 55-49116

From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200
Ship Date 6/24/2011 7:53:45 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =	STRESS RELIEVE 1150F +/-25F	
Container(s) =	WP	

Order No. 48215 P.O. No. 117551A Recv'd 6/23/2011 8:18:22 PM Shipment COMPLETE			
Qty 1	Part Number 117551A.3 AC FR Material and Description Low Carbon Steel	Part Name HEADER	Wgt 96
Totals...			
Ttl Qty 1	Signed For By / Date <hr/>		Ttl Wgt 96

WJ 6-24-11





John Winkle

Customer Information

Your PO#: 500594

Part #:

117551B.1 IC-1 FR

TSI Heat Treating Certification

Thermal Specialties Information

Date Processed: 06-24-2011

TSI SO#: 164676

Furnace#: 25

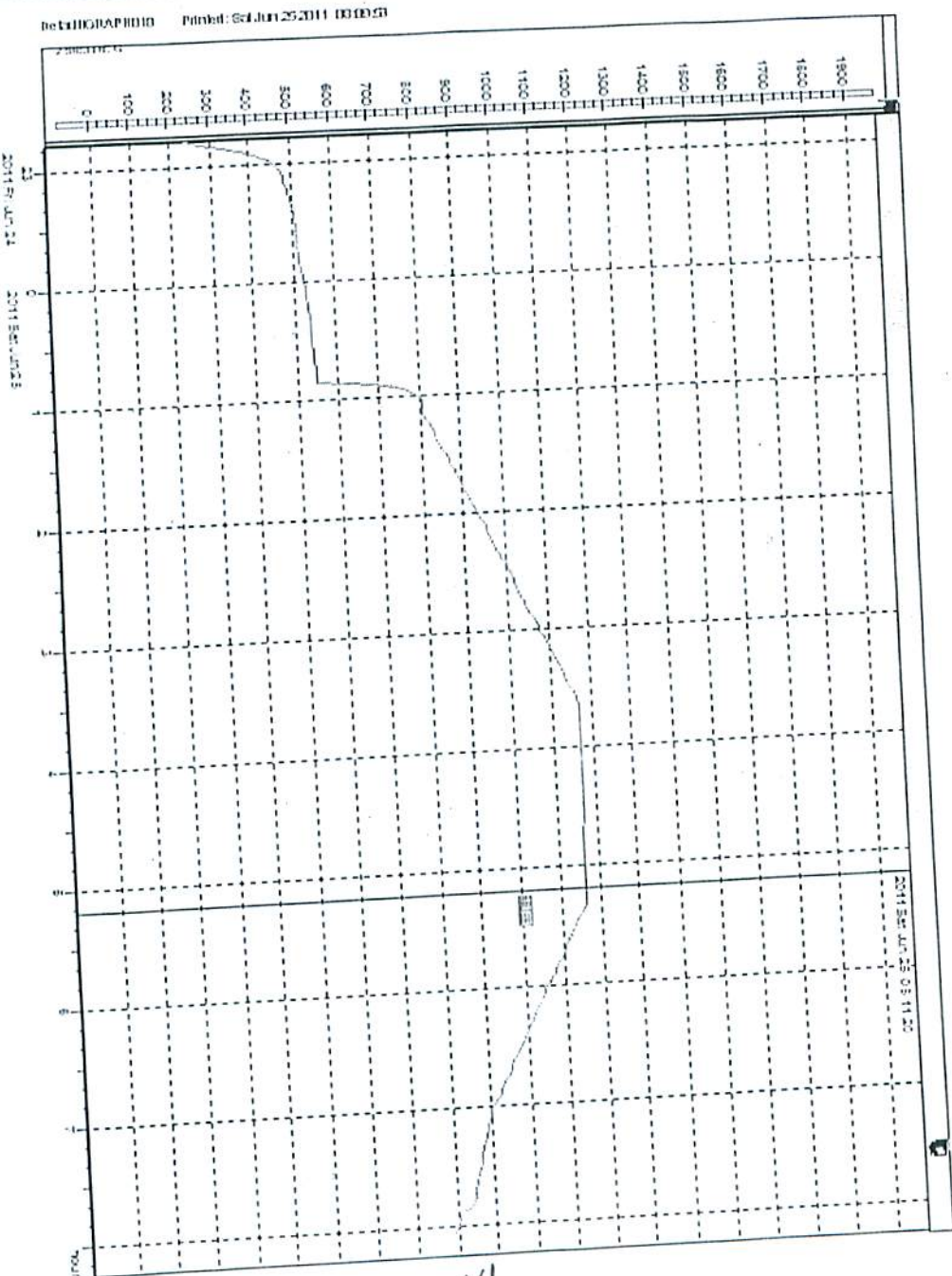
Calibration Date: 05/09/2011

Thermocouple Type K

Approved by: _____ MY

117551B.3 AC BK

Description:




VA 6-27-11



Thermal Specialties certifies that the item has been processed in accordance with customer's requirements. Processes were obtained through standard approved methods and in accordance with Thermal Specialties quality assurance manual

Shipment: 55-49115

Shipment 



Shipment: 55-49115



From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200</small>	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200</small>
Ship Date 6/24/2011 7:52:56 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =	STRESS RELIEVE 1150F +/-25F	
Container(s) =	WP	

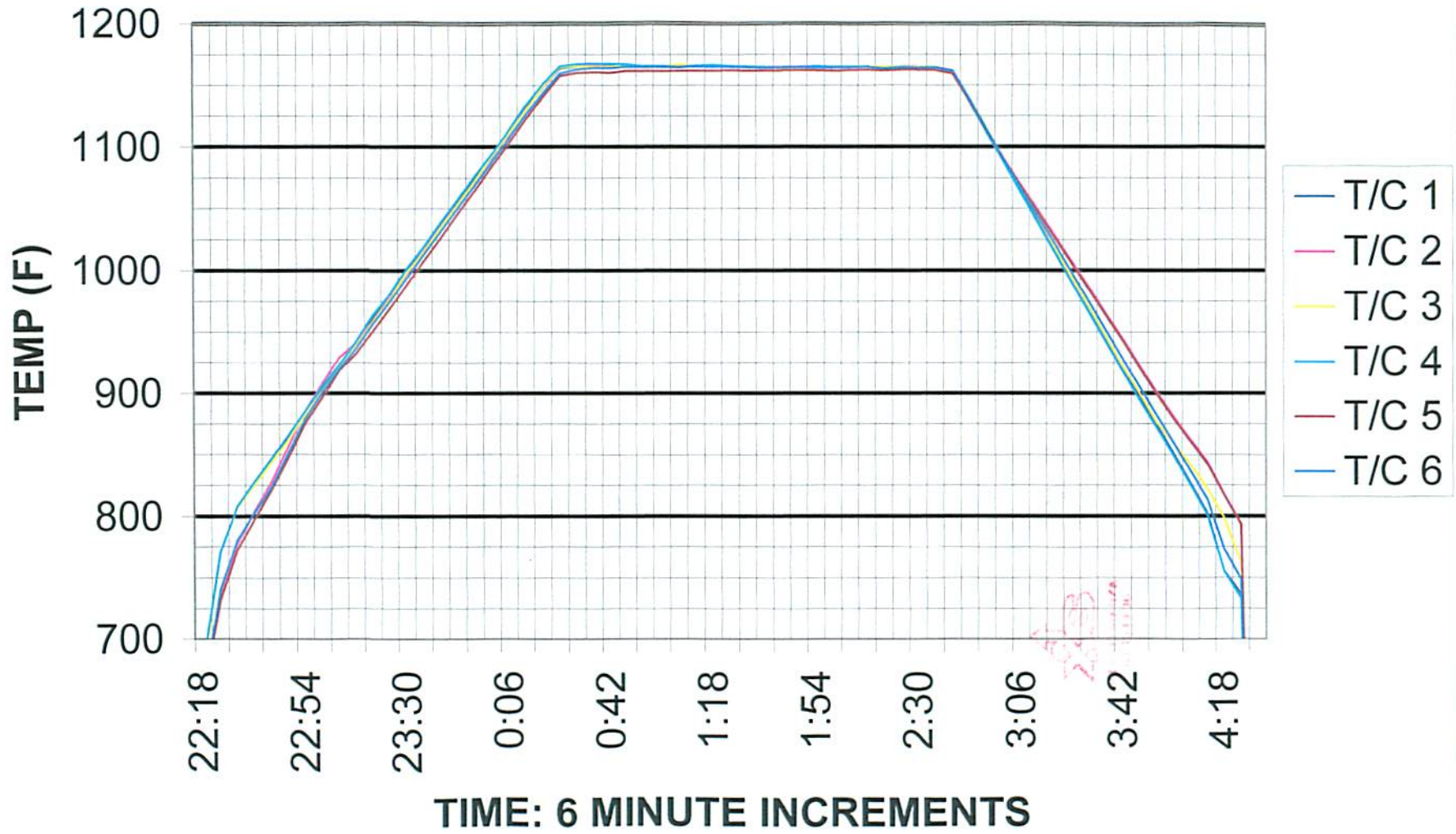
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Qty	Part Number	Part Name	Wgt
1	117551B.1 IC-1 BK Material and Description Low Carbon Steel	HEADER	56
Totals...			
Ttl Qty 1	Signed For By / Date		Ttl Wgt 56

WS
6-24-11



BODYCOTE THERMAL PROCESSING FCE# 2001



2011
6/24/11

Shipment: 55-49113

Shipment 



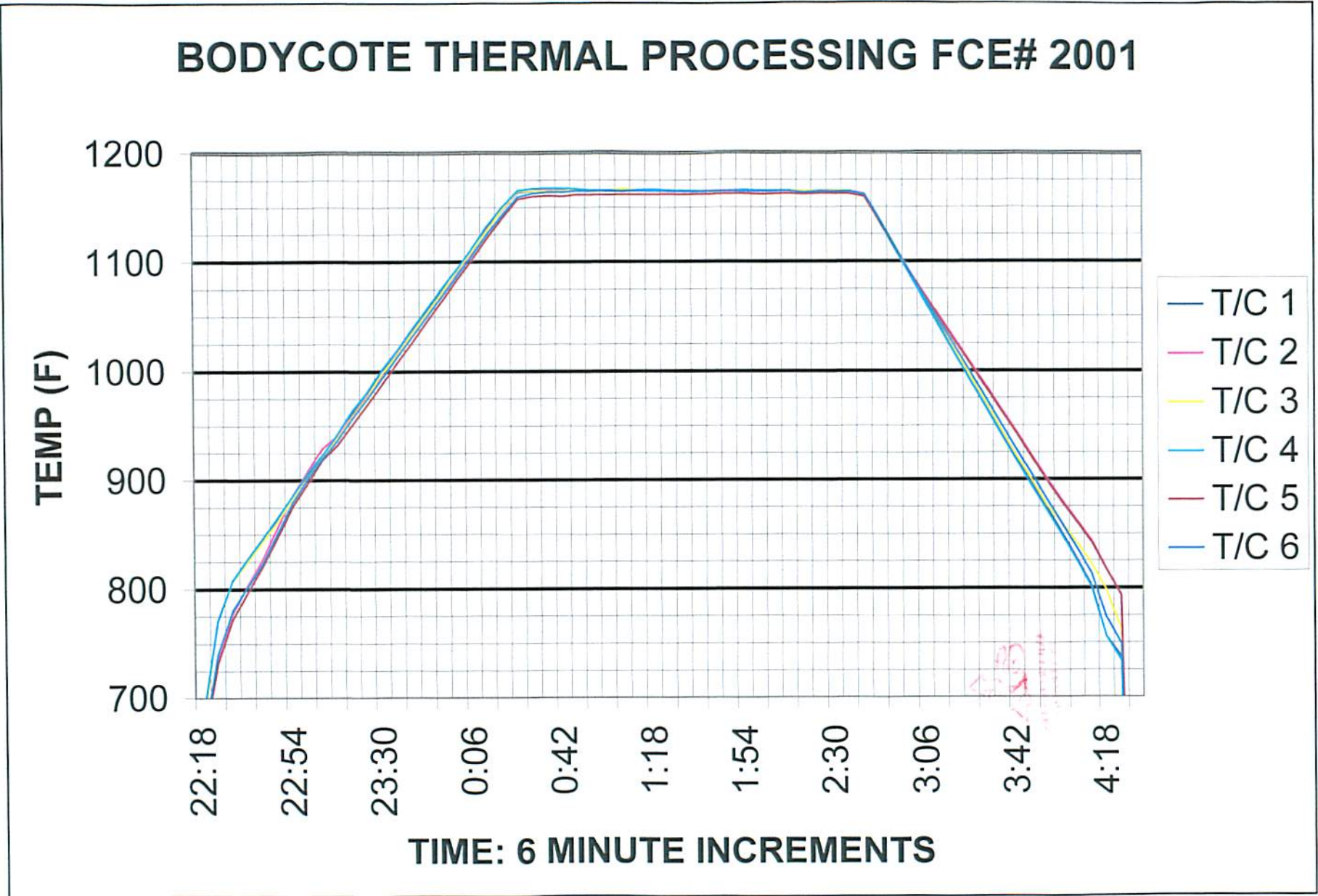
Shipment: 55-49113

From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200
Ship Date 6/24/2011 7:48:07 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =	STRESS RELIEVE 1150F +/-25F	
Container(s) =	WP	

Order No. 48212 P.O. No. 117551B Recv'd 6/23/2011 8:11:59 PM Shipment COMPLETE			
Qty 1	Part Number 117551B.2 IC-2 FR Material and Description Low Carbon Steel	Part Name HEADER	Wgt 56
Totals...			
Ttl Qty 1	Signed For By / Date <hr/>		Ttl Wgt 56

WJ
6-24-11





Shipment: 55-49114

Shipment



Shipment: 55-49114

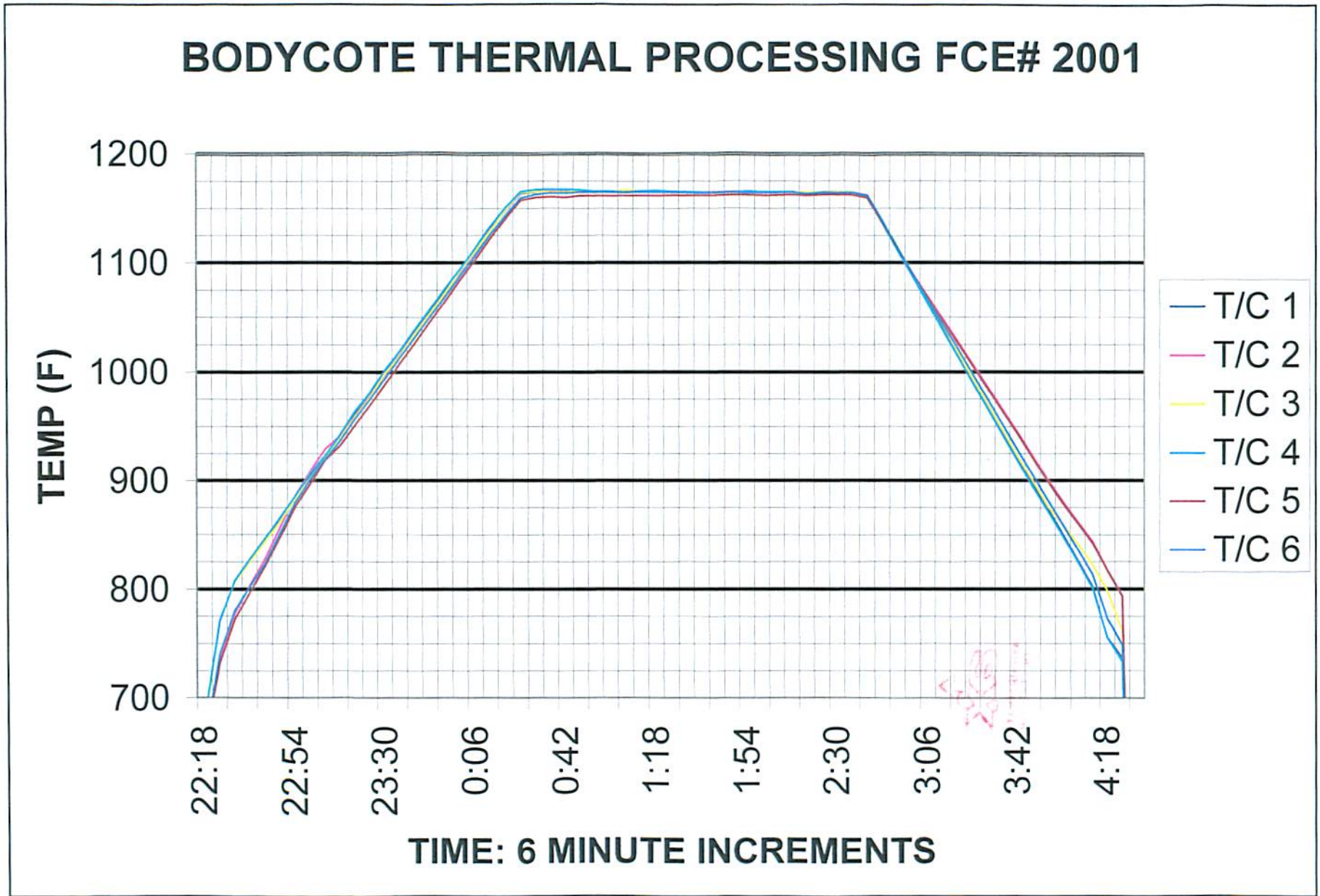
From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200</small>	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233 (Voice) 1 (918) 283-9200</small>
Ship Date 6/24/2011 7:52:28 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =	STRESS RELIEVE 1150F +/-25F	
Container(s) =	WP	

Order No. 48213 P.O. No. 117551B Recv'd 6/23/2011 8:14:13 PM Shipment COMPLETE

Qty	Part Number	Part Name	Wgt
1	117551B.2 IC-2 BK Material and Description Low Carbon Steel	HEADER	42
Totals...			
Ttl Qty 1	Signed For By / Date		Ttl Wgt 42

WS
6-24-11





Shipment: 55-49112

Shipment #5



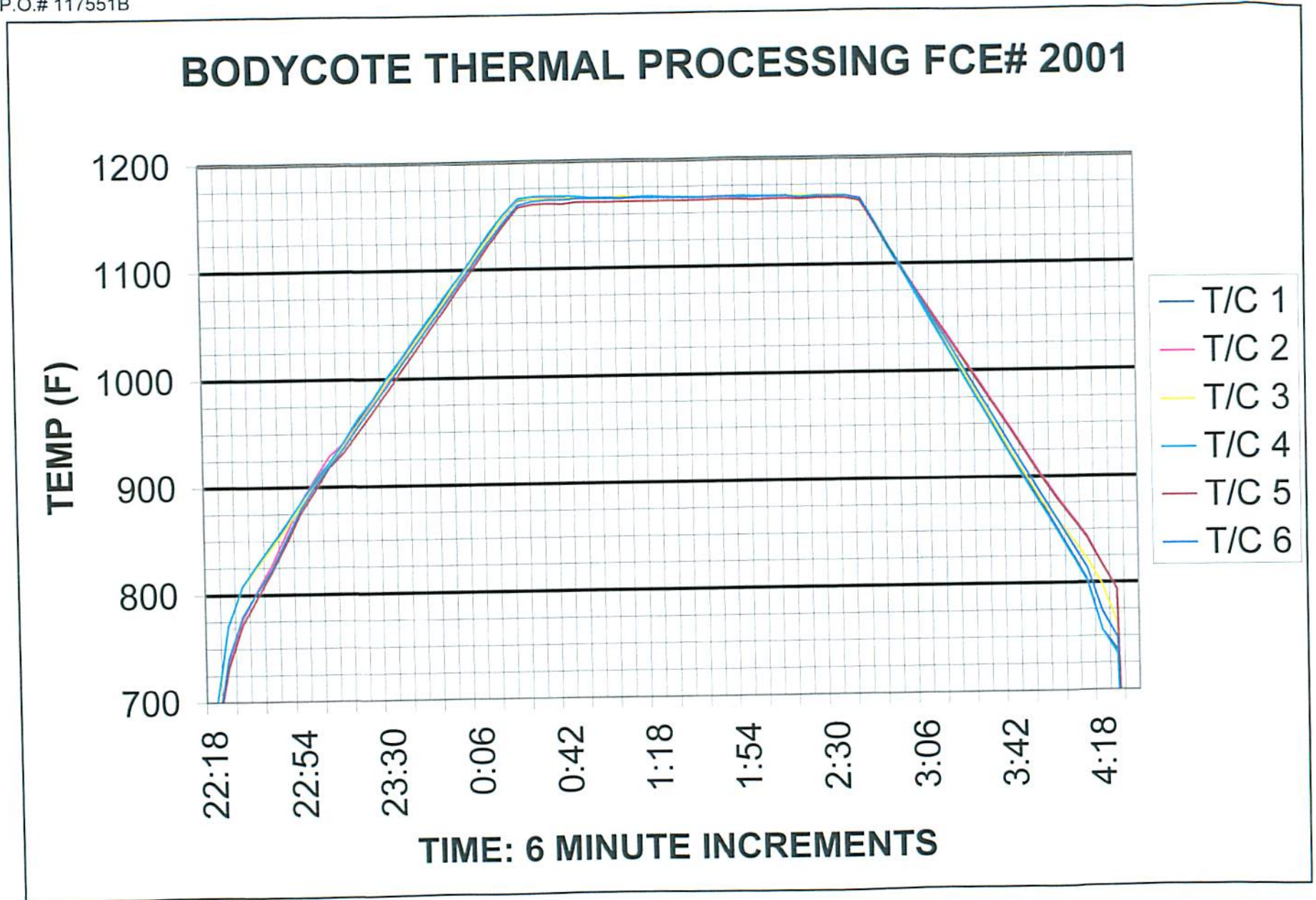
Shipment: 55-49112



From: Division: 55 Bodycote Thermal Processing - Pine 1520 North 170th East Avenue Tulsa, OK 74116	Sold To: Customer: 55-1602 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233</small> <small>(Voice) 1 (918) 283-9200</small>	Shipped To: Ship To: 55-1602-1 AXH Air-Coolers, LLC 401 East Lowry Road Claremore, OK 74017 <small>AP FAX (Judy) (Fax) 1 (918) 283-9233</small> <small>(Voice) 1 (918) 283-9200</small>
Ship Date 6/24/2011 7:15:21 AM		Bill Of Lading
Shipment Method OUR TRUCK		
Message		
Required Process =		STRESS RELIEVE 1150F +/-25F
Container(s) =		WP

Order No. 48211 P.O. No. 117551B Recv'd 6/23/2011 8:10:37 PM Shipment COMPLETE			
Qty 1	Part Number 117551B.3 AC FR <small>Material and Description</small> Low Carbon Steel	Part Name HEADER	Wgt 44
Totals...			
Ttl Qty 1	Signed For By / Date <hr/>		Ttl Wgt 44

VP 6-24-11



CUSTOMER: AXH IRISNDT#: 129967 DATE: 6-20-11
 LOCATION: Clearmore JOB#: 117551.1A P.O.#: _____ PART#: _____
 MATERIAL: C/S CODE: ASME ORIG. FILM / REPAIR FILM _____

TESTING VARIABLES

Ir₁₉₂ Co₆₀ X-Ray : Ci 68 kV _____ mA _____ EFSS: .149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2+
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	OFD Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	W1E	17F 1/8		.394	16"	394	2-4	RT5	2"		✓	
2											✓	
3											✓	
4	N2E									Too DARK		X
5										{		X
6										{		X
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												

IRISNDT Procedure:
 RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D.

TERMS AND ABBREVIATIONS
 AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IQI - Image Quality Indicator (Penetrator)
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: J. Seber
 Interpretation by: _____ ASNT SNT-TC-1A
 (Print) _____
 (Signature) AG-20-11-LULT CERT. # _____
 Client Representative: _____

CUSTOMER: AXH IRISNDT#: 129992 DATE: 6-21-11
 LOCATION: Claremore JOB#: 117551.1A P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASME ORIG. FILM ✓ REPAIR FILM _____

TESTING VARIABLES

Ir₁₉₂ Co₆₀ X-Ray : Ci 49 KV _____ mA _____ EFSS: 1149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2H
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	OFD Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	NA	E	17F	18	344	16.9	344	2-4	RS	2"	✓	
2											✓	
3											✓	
4												
5												
6												
7												
8												
9												
10												
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30												

IRISNDT Procedure:

RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D

TERMS AND ABBREVIATIONS

AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam
 IQI - Image Quality Indicator (Penetrator)

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: J. G. [Signature]

Interpretation by: _____
 ASNT SNT-TC-1A
 (Print) 6-21-11 LVLCP (Signature)
 CERT. # _____
 Client Representative: _____

CUSTOMER: AXH IRISNDT#: 129967 DATE: 6-20-11
 LOCATION: Claremore JOB#: 117551.2A P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASME ORIG. FILM REPAIR FILM _____

TESTING VARIABLES

Ir₁₉₂ Co₆₀ X-Ray : Ci 68 kV _____ mA _____ EFSS: .149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2+
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	O.F.D. Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	N1 E	17F	1/8	.394	16"	.394	2-4	RT5	2"		✓	
2											✓	
3											✓	
4	N2 E										✓	
5											✓	
6											✓	
7												
8												
9												
10												
11												
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30												

IRISNDT Procedure:

RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D

TERMS AND ABBREVIATIONS

AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IQI - Image Quality Indicator (Penetrameter)
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: J. Wolf, J. Sake

Interpretation by: _____
 ASNT SNT-TC-1A
LA 6-20-11 LUCA
 (Print) (Signature)
 CERT. # _____
 Client Representative: _____


CUSTOMER: AXH IRISNDT#: 129967 DATE: 6-20-11
 LOCATION: Clearmont JOB#: 1175513A P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASME ORIG. FILM REPAIR FILM _____

TESTING VARIABLES

Ir₁₉₂ Co₆₀ X-Ray : Ci 68 kV _____ mA _____ EFSS: 149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2+
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	O.F.D. Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	NI E	17F	1/8	.436	16"	.436	2.4	RTS	2"		✓	
2											✓	
3											✓	
4	NI E										✓	
5											✓	
6											✓	
7												
8												
9												
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IRISNDT Procedure:
 RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D.

TERMS AND ABBREVIATIONS
 AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IQI - Image Quality Indicator (Penetrameter)
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: Joseph Lake

Interpretation by: _____
 ASNT SNT-TC-1A
 (Print) 6-20-11 (Signature) LVL CERT. # ex
 Client Representative: _____

CUSTOMER: AXH IRISNDT#: 129967 DATE: 6-20-11
 LOCATION: Clearmore JOB#: 117551-1B P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASME ORIG. FILM REPAIR FILM _____

TESTING VARIABLES
 Ir₁₉₂ Co₆₀ X-Ray Ci 68 kV _____ mA _____ EFSS: 149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2+
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	OFD Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	N1 E	17F	1/8	.436	16"	436	2.4	RTS	2"		✓	
2											✓	
3											✓	
4	N2 E										✓	
5											✓	
6											✓	
7												
8												
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IRISNDT Procedure:
 RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D.

TERMS AND ABBREVIATIONS
 AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IQI - Image Quality Indicator (Penetrameter)
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: J. Lopez, J. E. [Signature]

Interpretation by: _____
 ASNT SNT-TC-1A (Level) _____
 (Print) 6-20-11 LVL [Signature] CERT. # _____
 (Signature)
 Client Representative: _____



CUSTOMER: AXH IRISNDT#: 129967 DATE: 6-20-11
 LOCATION: Claremore JOB#: 117551.2B P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASME ORIG. FILM REPAIR FILM _____

TESTING VARIABLES
 Ir₁₉₂ Co₆₀ X-Ray : Ci 68 kV _____ mA _____ EFSS: .149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2+
 FILM USAGE: 3½ x 8½ 3½ x 10 _____ 3½ x 17 _____ 4½ x 10 _____ 4½ x 17 _____ 14 x 17 _____
 7 x 8½ _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____


FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	O.F.D. Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	N1 E	1/8	1/8	.394	16"	34"	2-4	RES	2"		✓	
2											✓	
3											✓	
4	N2 E										✓	
5											✓	
6											✓	
7											✓	
8												
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IRISNDT Procedure:
 RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D

TERMS AND ABBREVIATIONS

AB - Arc Burns	EUC - External Undercut	IC - Internal Concavity	P - Porosity
BT - Burn Through	IUC - Internal Undercut	LF - Lack of Fusion	S - Slag
CK - Crack	HB - Hollow Bead	LC - Low Cover	RS - Round Seam
EP - Excessive Penetration	IP - Incomplete Penetration	MA - Misalignment	LS - Long Seam
	IQI - Image Quality Indicator (Penetrator)		

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: Joseph J. Sabo

Interpretation by: _____
 ASNT
 SNT-TC-1A
VA 6-20-11 LVL# (Print)
 (Signature)
 CERT. # EX
 Client Representative: _____


CUSTOMER: AXH IRISNDT#: 129967 DATE: 6-20-11
 LOCATION: Claremore JOB#: 117551.3B P.O.#: _____ PART#: _____
 MATERIAL: CS CODE: ASme ORIG. FILM REPAIR FILM _____

TESTING VARIABLES

Ir₁₉₂ Co₆₀ X-Ray : Ci 68 kV _____ mA _____ EFSS: .149
 PROCESSING: MANUAL AUTOMATIC SINGLE FILM COMPOSITE FILM
 EXPOSURE: DWE/SWV DWE/DWV SWE/SWV
 FILM: TYPE F-80 CLASS 1 SENSITIVITY 2-2+
 FILM USAGE: 3 1/2 x 8 1/2 3 1/2 x 10 _____ 3 1/2 x 17 _____ 4 1/2 x 10 _____ 4 1/2 x 17 _____ 14 x 17 _____
 7 x 8 1/2 _____ 7 x 17 _____ 8 x 10 _____ 70mm _____ Other _____

FILM I.D.	INTERVAL	I.Q.I.	SHIM	MAT'L THK	SOD Inches	OFD Inches	DENSITY	IRISNDT Proc.	DIA.	DISCONTINUITIES	ACCEPT	REJECT
1	N1 E	17F	1/8	.436	16"	.436	2.4	RES	2"		<input checked="" type="checkbox"/>	
2											<input checked="" type="checkbox"/>	
3											<input checked="" type="checkbox"/>	
4	N2 E										<input checked="" type="checkbox"/>	
5											<input checked="" type="checkbox"/>	
6											<input checked="" type="checkbox"/>	
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IRISNDT Procedure:

RT 1, 2, 2A, 6, 7 - Single Wall Exposure
 RT 3, 3A, 4, 5, 8, - Double Wall Exposure
 S.O.D. = Source-to-object distance
 O.F.D. = Object-to-film distance
 S.O.D. + O.F.D. = S.F.D

TERMS AND ABBREVIATIONS

AB - Arc Burns
 BT - Burn Through
 CK - Crack
 EP - Excessive Penetration
 EUC - External Undercut
 IUC - Internal Undercut
 HB - Hollow Bead
 IP - Incomplete Penetration
 IQI - Image Quality Indicator (Penetrator)
 IC - Internal Concavity
 LF - Lack of Fusion
 LC - Low Cover
 MA - Misalignment
 P - Porosity
 S - Slag
 RS - Round Seam
 LS - Long Seam

Unit # _____ Miles: _____
 In _____ Out _____ Hrs. _____
 In _____ Out _____ Hrs. _____
 Personnel: Jeffrey J. Salas

Interpretation by: _____
 ASNT SNT-TC-1A 
VA 6-20-11 LULA (Print)
 (Signature)
 CERT. # AXH AIR COOLEY'S QC CERTIFIED
 Client Representative: _____

JOB # 117551 Page 1 of 1
 PO # _____ Date 06/24/11

Client: AXH Air Coolers Item Inspected: Box Header Seams IRISNDT# 130106
 Location: CLAREMORE, OK Nozzel Attachments
 Code: ASME Sec. V ART. 4
ASME VIII DIV I APP. 12 Heat Treatment: B.P.W.H.T.

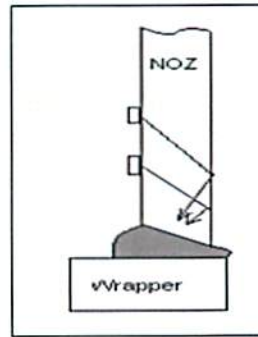
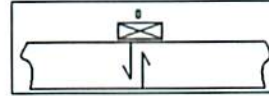
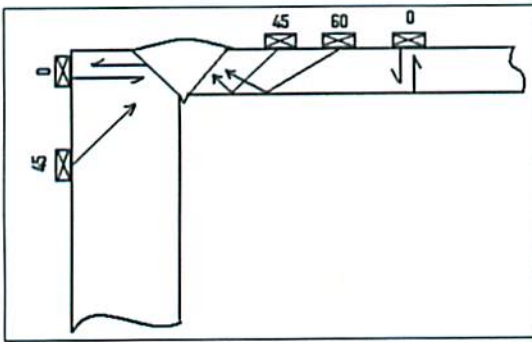
Procedure: 4.0 U.T. Surface Condition: As Welded Material: c/s
 UT Equipment: EPOCH XT IRISNDT# 101371412 Cal Date: 2/14/2011

Calibration Block: <u>IIW</u> Probes:	Angle:(degrees)	<u>0</u>	<u>60</u>	<u>45</u>	<u>60</u>		
Test Piece: <u>ASME 3/4" Basic</u>	Frequency:(mhz)	<u>5</u>	<u>2.25</u>	<u>5</u>	<u>5</u>		
Distance/Amp Cal: <u>2/4 to 6/4T</u>	Crystal Size:(inches)	<u>1/2"</u>	<u>1/2"</u>	<u>1/4"</u>	<u>1/4"</u>		

Transfer Loss Cal: Direct Comparison Scan Gain: +6dB Couplant: Echo Gel Batch # 09247
 Ref. Flaw Size: 3/32" SDH Primary Reference Level: 80% FSH
 Scan Method: Contact TOF Lamination: x Thickness: x Shear Wave: x

Scope: UT Inspection Performed On All Accessible Areas Of Box Header Weldments
 Long Seams, End Blocks, And Nozzle Attachment Welds

Results: 117551.1A FR - Accept
117551.2A BK - Accept
117551.3A BK - Accept



UT Revealed No Rejectable Indications
 All Welds Are Acceptable Per Code



Unit: <u>455</u>	Miles:	Hrs.:	Consumables:	Technician: <u>Mark Rake</u> (print)
In:	Out:		Minimum	Technician: <u>Mark Rake</u> (sign)
In:	Out:			SNT-TC -1A Level: <u>II</u> cert# <u>522</u>
				I am in full agreement with report contents:
				Client Representative: <u>116-24-11</u>

Tulsa, Oklahoma
 1115 West 41st Street
 Phone: 918-446-8773 Fax: 918-446-8777

JOB # 117551 Page 1 of 1
 PO # _____ Date 06/23/11

Client: AXH Air Coolers Item Inspected: Box Header Seams IRISNDT# 130069
 Location: CLAREMORE, OK
 Code: ASME Sec. V ART. 4
ASME VIII DIV I APP. 12 Heat Treatment: B.P.W.H.T.

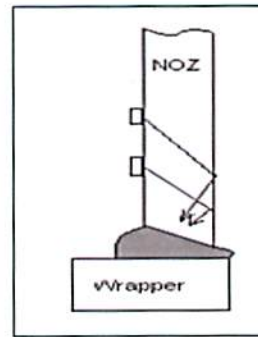
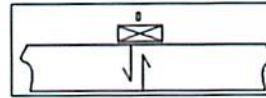
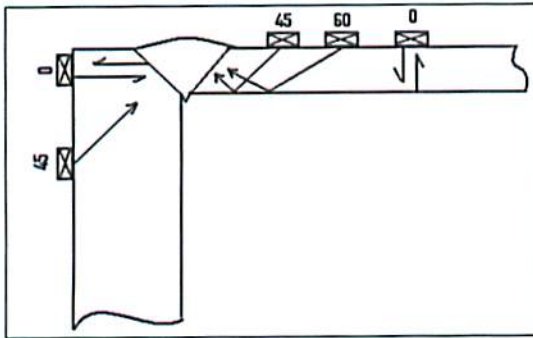
Procedure: 4.0 U.T. Surface Condition: As Welded Material: c/s
 UT Equipment: EPOCH XT IRISNDT# 101371412 Cal Date: 2/14/2011

Calibration Block: <u>IIW</u>	Probes:	Angle:(degrees)	<u>0</u>	<u>60</u>	<u>45</u>	<u>60</u>			
Test Piece: <u>ASME 3/4" Basic</u>		Frequency:(mhz)	<u>5</u>	<u>2.25</u>	<u>5</u>	<u>5</u>			
Distance/Amp Cal: <u>2/4 to 6/4T</u>		Crystal Size:(inches)	<u>1/2"</u>	<u>1/2"</u>	<u>1/4"</u>	<u>1/4"</u>			

Transfer Loss Cal: Direct Comparison Scan Gain: +6dB Couplant: Echo Gel Batch # 09247
 Ref. Flaw Size: 3/32" SDH Primary Reference Level: 80% FSH
 Scan Method: Contact TOF Lamination: X Thickness: X Shear Wave: X

Scope: UT Inspection Performed On All Accessible Areas Of Box Header Weldments
 Long Seams And End Blocks

Results:
 117551.1A BK - **Accept**
 117551.2A FR - **Accept**
 117551.3A FR - **Accept**



UT Revealed No Rejectable Indications
 All Welds Are Acceptable Per Code



Unit: <u>455</u>	Miles:	Hrs.:	Consumables:	Technician: <u>Mark Rake</u> (print)
In:	Out:		Minimum	Technician: <u>Mark Rake</u> (sign)
In:	Out:			SNT-TC -1A Level: <u>II</u> cert# <u>522</u>
				I am in full agreement with report contents:
				Client Representative: <u>6-23-11</u>

Tulsa, Oklahoma
 1115 West 41st Street
 Phone: 918-446-8773 Fax: 918-446-8777

JOB # 117551 Page 1 of 1
 PO # _____ Date 06/24/11

Client: AXH Air Coolers Item Inspected: Box Header Seams IRISNDT# 130106
 Location: CLAREMORE, OK Nozzel Attachments
 Code: ASME Sec. V ART. 4
ASME VIII DIV I APP. 12 Heat Treatment: B.P.W.H.T.

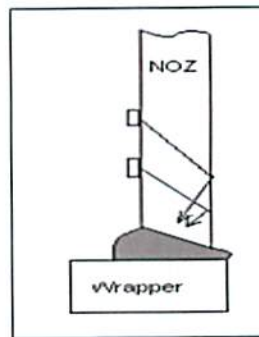
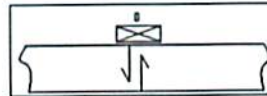
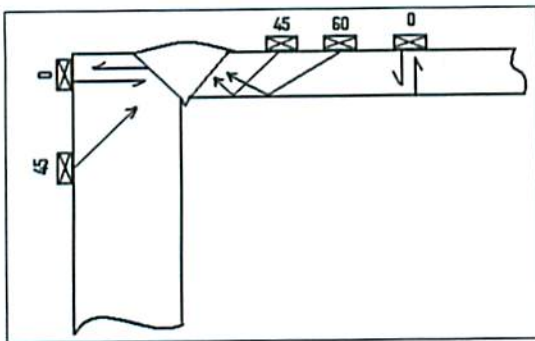
Procedure: 4.0 U.T. Surface Condition: As Welded Material: c/s
 UT Equipment: EPOCH XT IRISNDT# 101371412 Cal Date: 2/14/2011

Probes:	Angle:(degrees)	0	60	45	60			
	Frequency:(mhz)	5	2.25	5	5			
	Crystal Size:(inches)	1/2"	1/2"	1/4"	1/4"			

Calibration Block: IIW Probes: _____
 Test Piece: ASME 3/4" Basic Frequency: _____
 Distance/Amp Cal: 2/4 to 6/4T Crystal Size: _____
 Transfer Loss Cal: Direct Comparison Scan Gain: +6dB Couplant: Echo Gel Batch # 09247
 Ref. Flaw Size: 3/32" SDH Primary Reference Level: 80% FSH
 Scan Method: Contact TOF Lamination: X Thickness: X Shear Wave: X

Scope: UT Inspection Performed On All Accessible Areas Of Box Header Weldments
 Long Seams, End Blocks, And Nozzle Attachment Welds

Results: 117551.1B FR - Accept
117551.3B BK - Accept



UT Revealed No Rejectable Indications
 All Welds Are Acceptable Per Code

Unit: 455	Miles:	Hrs.:	Consumables:	Technician: Mark Rake (print)
In:	Out:		Minimum	Technician: Mark Rake (sign)
In:	Out:			SNT-TC -1A Level: II cert# 522
				I am in full agreement with report contents:
				Client Representative: <u>118 6-24-11</u>

Tulsa, Oklahoma
 1115 West 41st Street
 Phone: 918-446-8773 Fax: 918-446-8777

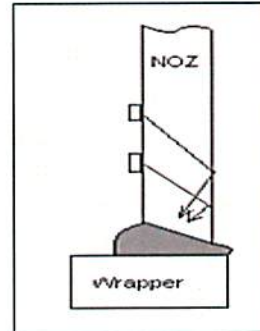
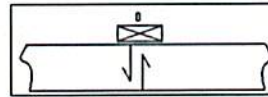
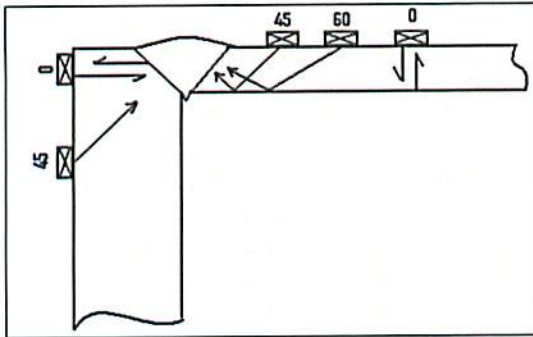
JOB # 117551 Page 1 of 1
 PO # _____ Date 06/23/11

Client: AXH Air Coolers Item Inspected: Box Header Seams IRISNDT# 130069
 Location: CLAREMORE,OK Attachments _____
 Code: ASME Sec. V ART. 4 Heat Treatment: B.P.W.H.T.
ASME VIII DIV I APP. 12

Procedure: 4.0 U.T. Surface Condition: As Welded Material: c/s
 UT Equipment: EPOCH XT IRISNDT# 101371412 Cal Date: 2/14/2011
 Calibration Block: IIW Probes: Angle:(degrees) 0 60 45 60
 Test Piece: ASME 3/4" Basic Frequency:(mhz) 5 2.25 5 5
 Distance/Amp Cal: 2/4 to 6/4T Crystal Size:(inches) 1/2" 1/2" 1/4" 1/4"
 Transfer Loss Cal: Direct Comparison Scan Gain: +6dB Couplant: Echo Gel Batch # 09247
 Ref. Flaw Size: 3/32" SDH Primary Reference Level: 80% FSH
 Scan Method: Contact TOF Lamination: X Thickness: X Shear Wave: X

Scope: UT Inspection Performed On All Accessible Areas Of Box Header Weldments
 Long Seams , End Blocks , And Attachment welds

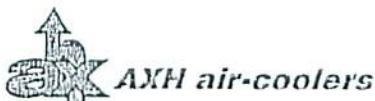
Results:
 117551.1B BK - **Accept**
 117551.2B FR/BK - **Accept**
 117551.3B FR - **Accept**



UT Revealed No Rejectable Indications
 All Welds Are Acceptable Per Code

Unit: 455	Miles:	Hrs.:	Consumables:	Technician: Mark Rake (print)
In.	Out:		Minimum	Technician: Mark Rake (sign)
In:	Out:			SNT-TC -1A Level: II cert# 522
				I am in full agreement with report contents:
				Client Representative: <u>6-23-11</u>

Tulsa, Oklahoma
 1115 West 41st Street
 Phone: 918-446-8773 Fax: 918-446-8777



REPORT OF NONDESTRUCTIVE TESTING
MAGNETIC PARTICLE EXAMINATION RECORD

REFERENCE STANDARD: ASME SECT.V, ASME SECT. VIII DIV.1, APPENDIX 6
AXH AIR-COOLERS STANDARD MS-20.0 REVISION: 0

EXAMINATION EQUIPMENT & METHOD

MAGNETIZING EQUIPMENT: Parker Research Contour Probe SERIAL #: 3663

CURRENT TYPE: AC DC

MT TYPE: WET DRY FLOURESCENT VISIBLE

LIGHTING EQUIPMENT: FLOURESCENT LIGHT
 WHITE LIGHT USING PARKER RESEARCH Y300 OR Y400 PROBE LIGHTING
 FLASHLIGHT # OF BATTERIES TYPE: _____ CELL _____
 MAXIMUM DISTANCE FROM OBJECT: _____ FEET _____
 OTHER _____

MINIMUM LIGHT INTENSITY ON SURFACE TO BE EXAMINED: 100 FOOT CANDLES

EXAMINATION RESULTS

IDENTIFICATION:

CUSTOMER: Compass Compression Services DATE: 6-24-11

JOB #: 117551A ITEM #: 1, 2, 3 FR/BK (EXAMPLE: .1, .2, .3)

MATERIAL TYPE: SAS16-70/SAS16-70N MATERIAL THICKNESS: _____

EXAMINATION PERFORMED:

- PLATE EDGES BEFORE WELDING (WRAPPERS, END PLATES, TUBE AND PLUG SHEETS WHICH HAVE BEEN BEVELED) AND AFTER WELDING (PERIPHERAL EDGE OF TUBE AND PLUG SHEETS) PER ASME SECTION VIII, DIV. 1, UG-93
BEFORE 6-22-11 AFTER 6-24-11
- ALL WELDED SEAMS WHERE ACCESSIBLE
- ALL FINAL WELD SEAMS, NOZZLES, & COUPLINGS WHERE ACCESSIBLE
- ALL NOZZLE & COUPLING ROOT PASSES WHERE ACCESSIBLE
- OTHER _____

EXAMINATION RESULTS:

ACCEPT

REJECT

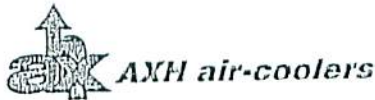
DESCRIPTION AND/OR MAP OF INDICATIONS FOUND



W. Smith

EXAMINER

QUALIFICATION LEVEL



REPORT OF NONDESTRUCTIVE TESTING
MAGNETIC PARTICLE EXAMINATION RECORD

REFERENCE STANDARD: ASME SECT.V, ASME SECT. VIII DIV.1, APPENDIX 6
AXH AIR-COOLERS STANDARD MS-20.0 REVISION: 0

EXAMINATION EQUIPMENT & METHOD

MAGNETIZING EQUIPMENT: Parker Research Contour Probe SERIAL #: 3563

CURRENT TYPE: AC DC

MT TYPE: WET DRY FLOURESCENT VISIBLE

LIGHTING EQUIPMENT: FLOURESCENT LIGHT
 WHITE LIGHT USING PARKER RESEARCH Y300 OR Y400 PROBE LIGHTING
 FLASHLIGHT # OF BATTERIES _____ TYPE: _____ CELL _____
 MAXIMUM DISTANCE FROM OBJECT: _____ FEET
 OTHER _____

MINIMUM LIGHT INTENSITY ON SURFACE TO BE EXAMINED: 100 FOOT CANDLES

EXAMINATION RESULTS

IDENTIFICATION:

CUSTOMER: COMPASS COMPRESSION SERVICES DATE: 6-24-11

JOB #: 117551B ITEM #: 1, 2, 3 FR/BK (EXAMPLE: .1, .2, .3)

MATERIAL TYPE: SA516-70/SA516-70N MATERIAL THICKNESS: _____

EXAMINATION PERFORMED:

- PLATE EDGES BEFORE WELDING (WRAPPERS, END PLATES, TUBE AND PLUG SHEETS WHICH HAVE BEEN BEVELED) AND AFTER WELDING (PERIPHERAL EDGE OF TUBE AND PLUG SHEETS) PER ASME SECTION VIII, DIV. 1, UG-93
BEFORE 6-22-11 AFTER 6-24-11
- ALL WELDED SEAMS WHERE ACCESSIBLE
- ALL FINAL WELD SEAMS, NOZZLES, & COUPLINGS WHERE ACCESSIBLE
- ALL NOZZLE & COUPLING ROOT PASSES WHERE ACCESSIBLE
- OTHER _____

EXAMINATION RESULTS:

ACCEPT REJECT

DESCRIPTION AND/OR MAP OF INDICATIONS FOUND



U Smith

EXAMINER

QUALIFICATION LEVEL



HYDROSTATIC TEST REPORT

MANUFACTURED FOR COMPASS COMPRESSION

AXH JOB NUMBER 117551A-B

VESSEL TESTED 117551A-B.1 IC-1

TEST PRESSURE 371 PSI

HYDRO TEST HELD FOR 1 HR.

THIS REPORT IS TO CERTIFY THAT THE AFOREMENTIONED
VESSEL (OR) VESSELS WERE HYDROSTATIC TESTED IN
ACCORDANCE WITH ASME SECTION VIII DIV 1.

CUSTOMER WITNESS _____

DATE 6.29.11 BY Renee Weeks

QUALITY CONTROL DEPARTMENT



HYDROSTATIC TEST REPORT

MANUFACTURED FOR COMPASS COMPRESSION

AXH JOB NUMBER 117551A-B

VESSEL TESTED 117551A-B.2 IC-2

TEST PRESSURE 1040 PSI

HYDRO TEST HELD FOR 1 HR.

**THIS REPORT IS TO CERTIFY THAT THE AFOREMENTIONED
VESSEL (OR) VESSELS WERE HYDROSTATIC TESTED IN
ACCORDANCE WITH ASME SECTION VIII DIV 1.**

CUSTOMER WITNESS _____

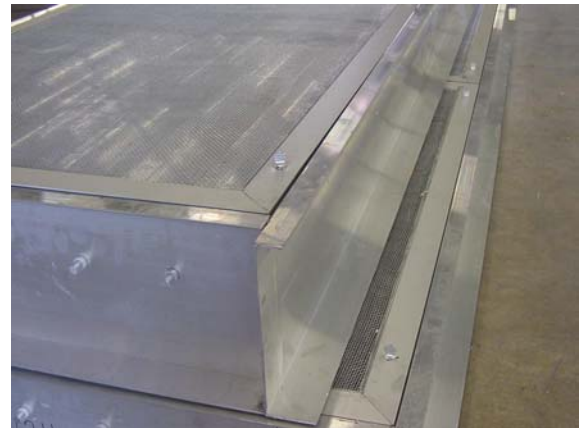
DATE 6.29.11 BY Renee Weeks
QUALITY CONTROL DEPARTMENT

Duraflow Industrial Louvers

- Aluminum or Galvanized Steel Construction
- Built to Heavy Duty Airtech Standards
- Optional API 661 Compliance
- Bolted or Welded Construction
- Internal Mechanism / Actuation



- Bug Screens & Hail Guards
 - Wire Cloth
 - Expanded Metal
 - Vinyl
- Fan Guards
- Recirc Doors with Frames



- Short Lead Times
- Built to Customer Specifications
- Competitive Pricing
- Domestic or Export Crating

AIRTECH Products, Inc.

P.O. Box 790

Sand Springs, OK 74063

Phone: 918-241-0264

Fax: 918-241-0270

Email: info@airtechinc.biz

Technical Information / Standard Configurations

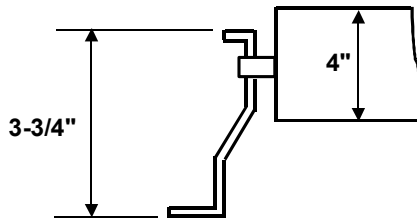
Aluminum Frame (extrusion):	6063-T5
Aluminum Frame (folded sheet):	3003-H14
Galvanized Steel Frame:	A653-G90 Carbon Steel (Mechanical Galvanized Finish)
Blades:	6063-T6 Aluminum
Blade Pins:	
Aluminum:	6061-T6 Aluminum
Stainless Steel:	303 Stainless Steel
Torque Tube:	6063-T6 Aluminum
Actuator Rod:	6063-T6 Aluminum
Actuator Lever Arm:	6061-T6 Aluminum
Clevis:	1018 Carbon Steel
Clevis to Arm Connecting Link:	6061-T6 Aluminum

Assembly Hardware:

Cap Screws:	ANSI/ASME 18.2.1 Grade 5, Zinc Plate
Nuts:	Locking nut, Performance Spec IFI/100, MIL/N/25027, Light Hex, Standard Height, Zinc Plate
Bearings:	Glass Filled Nylon, (Per API Specification 661)

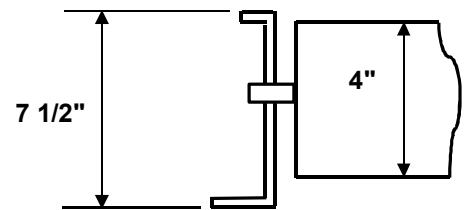
Series 300

- 3 3/4" Frame
- 4" Blade



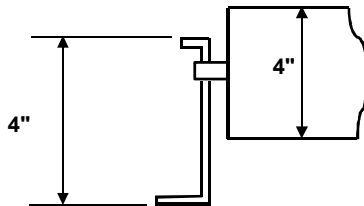
Series 740

- 7 1/2" Frame
- 4" Blade



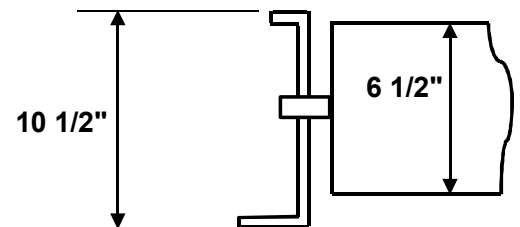
Series 400

- 4" Frame
- 4" Blade



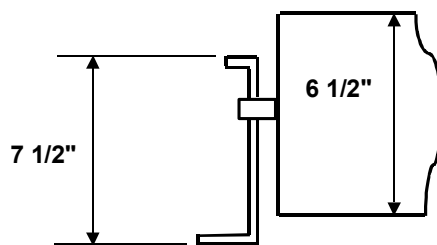
Series 1000

- 10 1/2" Frame
- 6 1/2" Blade



Series 700

- 7 1/2" Frame
- 6 1/2" Blade



Airtech Products, Inc., P.O. Box 790, Sand Springs, OK 74063
Phone: 918-241-0264, Fax: 918-241-0270
Email: info@airtechinc.biz

AIRTECH PRODUCTS, INC.

P.O. Box 790
8101 West 16th Street
Sand Springs, OK 74063
Email: info@airtechinc.biz

918-241-0264 (Phone)

918-241-0270 (Fax)

Duraflow Industrial Louvers

Installation and Maintenance Instructions

PRE-INSTALLATION ACTIVITIES:

1. With the louver crate resting firmly on either saw horses or a smooth and level area at grade, remove packing crate top and sides.
2. Make a visual inspection of the louver frame, blades and all linkages/drive mechanisms to ensure there was no shipping damage.
3. Various small parts needed to connect the drive linkages are shipped in a separate and smaller cardboard box. Keep this box at hand but out of the way and in a safe place.
4. Inspect the mounting surface of the cooler giving particular attention to ensure it provides uniform support of the louver perimeter and that it is structurally adequate to support all static and dynamic loadings.
 - a. If the louver is to be mounted in a horizontal configuration, it is **CRITICALLY IMPORTANT** to ensure the mounting surface is uniform and level to +/- .25" over 20'. Airtech louvers are manufactured to precise tolerances and bolting to an off-level surface will cause binding in the moving parts. This will result in inconsistent operation, shorten product life and can cause permanent damage that voids the manufacturers warranty.
 - b. If the louver is to be mounted in a vertical configuration, the installer must confirm there will be uniform support / attachment to the mounting surface at spacing not greater than 18" centers on the louver perimeter flange. Failure to do so may result in bending of the louver frame and inconsistent operation, a shortened product life and can cause damage that voids the manufacturers warranty.
5. Take a moment to visualize the installation and plan the placement of individual louver sub-assemblies. Although all louver installations involve essentially the same procedure, any given application will have some unique characteristics. Some projects will require louver sections to link together at the side via torque tube connectors while others may link together at the ends via end links on the actuator rod. Small projects may require neither type of connection while large projects will require both.
6. Open the cardboard box of small parts and confirm all the necessary pieces are at hand. Depending on the application, this could be torque tube couplings, actuator rod end links, grade level operator components, clevises, etc. Please note, unless the louvers are to be attached via angle clips, the actual attachment hardware won't be included in the louver shipment.
7. Most of the time, louver installation is easiest done using self-drilling speed screws, ¼" x 1¼" long, fine thread. Ensure a screw is in place on all corners and not greater than 18" centers around the louver perimeter. Simply drill through the louver flange into the host structure making sure the screw is completely pulled down tight. If retaining clips is your preferred method of attachment, please review to "Reference A" for instructions on use and installation.

MOUNTING & ATTACHMENT

1. Hoist the louver (or first louver sub-section) into place making sure the lift is well supported around the perimeter. DO NOT ALLOW THE LOUVER TO RACK or excessively bend during the lifting process.
 - a. **For horizontal applications**, set the louver onto the mounting surface and visually confirm 100% of the perimeter is supported and resting flat upon the top of the cooler. Make sure the operating mechanism travels freely through the entire range of motion and there is no interference from complete shut to complete open. If the louver is supplied in multiple sections, install the section with the operator first and perform the motion/operation test noted above. Square the louver to the cooler as best you can but above all, be sure the louver remains square – do not force to the louver out of square to accommodate the cooler. THE LOUVER MUST BE SQUARE to operate properly. After confirming the louver is properly placed relative to the mounting surface (and to other subsequent sections, if applicable), install a self-drilling screw at each corner and at no greater than 18” centers along all flanges. If applicable, hoist subsequent sections into place and following the above instructions, attach each to the host structure. DO NOT STEP ON LOUVER BLADES AT ANY TIME. If you must step out onto the louver, use dimension lumber or plywood as a walking surface.
 - b. **For vertical applications**, hoist the louver (or first louver section) into place and after checking for clearance on moving parts, attach to the cooler with a self drilling screw at each corner and at no greater than 18” spaces along all flanges. Install all attachment screws before releasing hoist cables or hoisting device to ensure the louver is fully attached and there is no deflection in the louver frame. If applicable, hoist subsequent sections into place and following the above instructions, attach each to the host structure.
2. If the louver is supplied in multiple sections, remove the connecting links / couplers from the shipping box and install them as required at the ends of actuator rods and torque tubes. End link installation instructions are detailed as attached “Reference B” and Torque Tube coupling installation instructions are detailed as attached “Reference C”.
3. When all sections are installed and connected, test the drive mechanism to ensure it moves freely, without binding or interference. On very large louvers with multiple sections, this may require use of a lever. Small to average size louvers should easily operate by hand strength on the torque tube.
4. Complete the installation by attaching any remaining components such as pneumatic actuator or grade level operators. Detailed installation instructions for actuator can be found in its shipping carton. For instructions on grade level operators, see attached “Reference D”.
5. After installing any remaining operators, complete the installation process by cycling the louver several times to ensure it moves freely, without interference and isn’t binding at any location. Some adjustment of end links may be required to ensure all louver blades open and shut consistently down the entire length of the louver.
6. Check all attachment fasteners to ensure all are properly tightened and completely engaged to the louver flange.
7. If applicable, check all end link connections and torque tube couplers to ensure they are properly tightened and fasteners are completely engaged.

MAINTENANCE INSTRUCTIONS (Annual)

1. Visually inspect all blade pins to ensure the pin bearings are in place and do not have unacceptable wear.
2. Visually inspect all connections between blade horns and actuator rod to confirm all connecting bearing, bolts and nuts are in place and not showing unacceptable wear.
3. Visually inspect all attachment screws to ensure none have backed off or are missing.
4. If dirt or grease buildup is excessive, clean louver blades and operating mechanisms with high pressure clear water wash.
5. Operate any manual levers or grade level operators to confirm all are in good working order and move freely without binding or interference.
6. If actuators are installed, visually inspect the mounting bolts to ensure all are tight and in place. Visually inspect the condition of all connecting links, the clevis and clevis pin.
7. Visually inspect all actuator rod end links and torque tube connectors to confirm all are in place and properly engaged.
8. Remove any leaves or other debris that may have collected in corners or between the louver blades and integral hailguards.

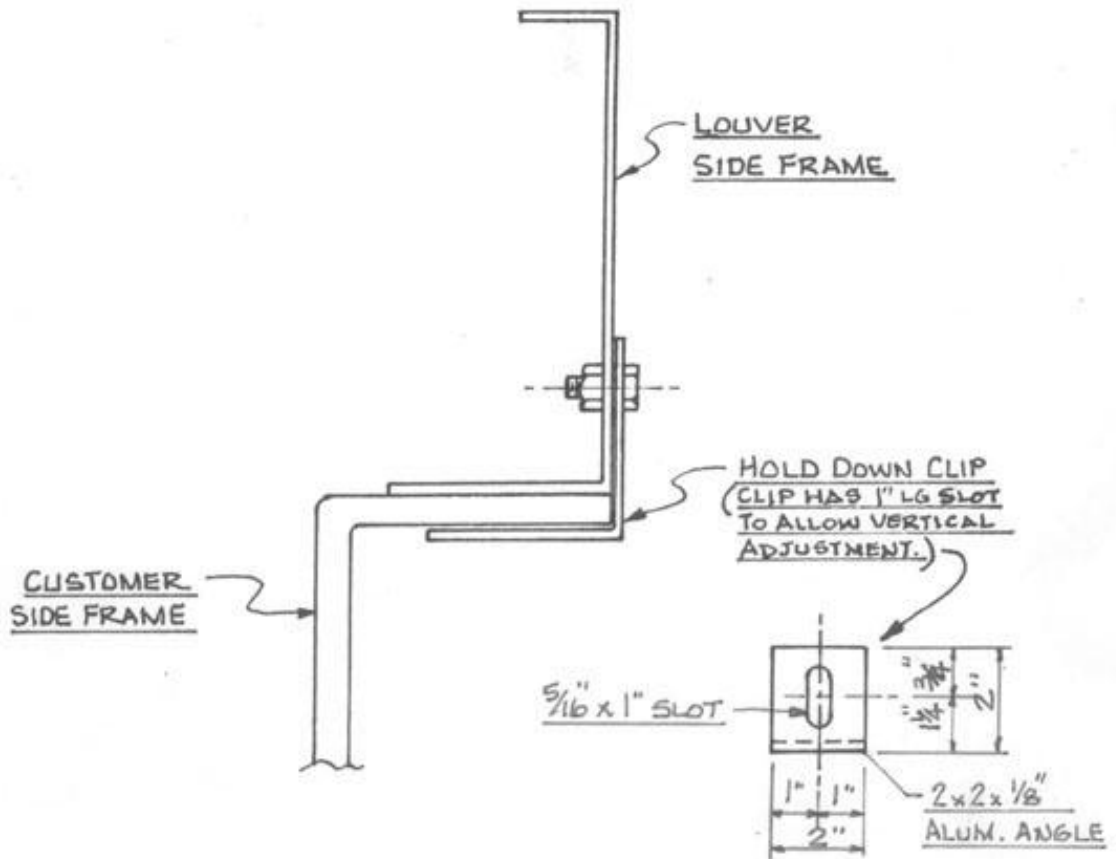
RECOMMENDED SPARE PARTS LIST

Item Description	Suggested Quantity
1. Blade horn bearing, bolt and nut kit	1 per 5 Ft ² louver area
2. Actuator rod end link kit	1 per 2 connections
3. Torque Tube couplings	1 per 2 torque tube connections
4. Blade Pin and Pin Bearing kits	5 per 10 Ft ² louver area
5. Manual handle kits	1

AIRTECH Products Inc.

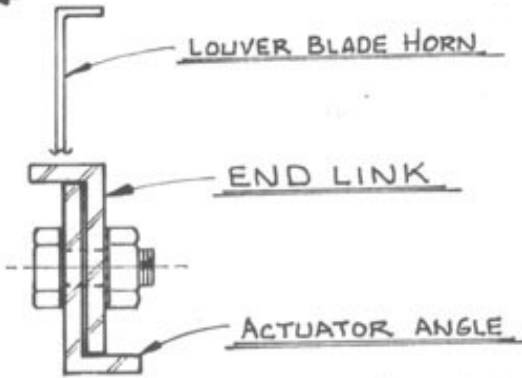
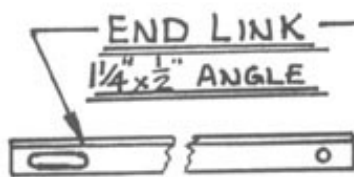
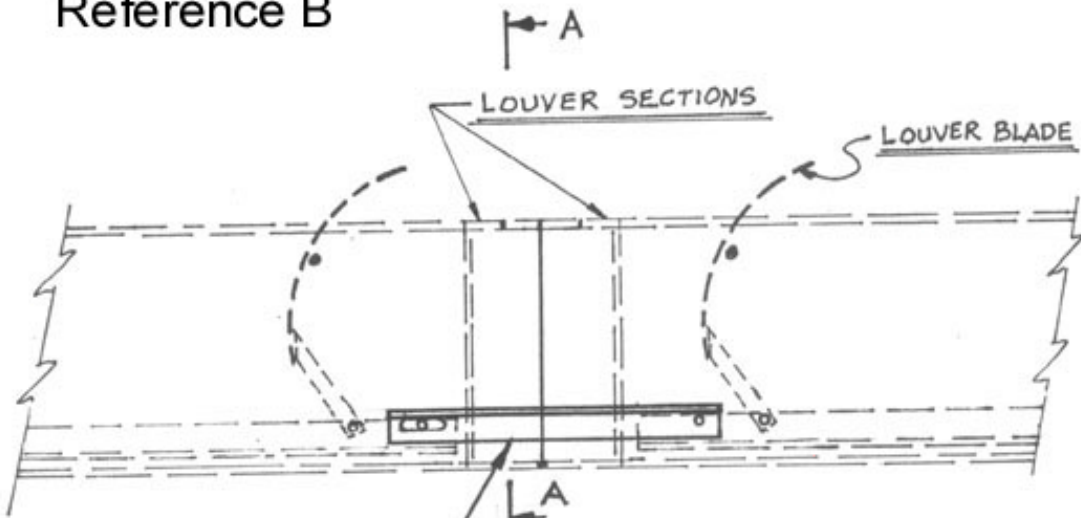
Reference A

MOUNTING CLIP DETAIL



P.O. BOX 790
SAND SPRINGS, OK 74063
(918) 241-0264

Reference B



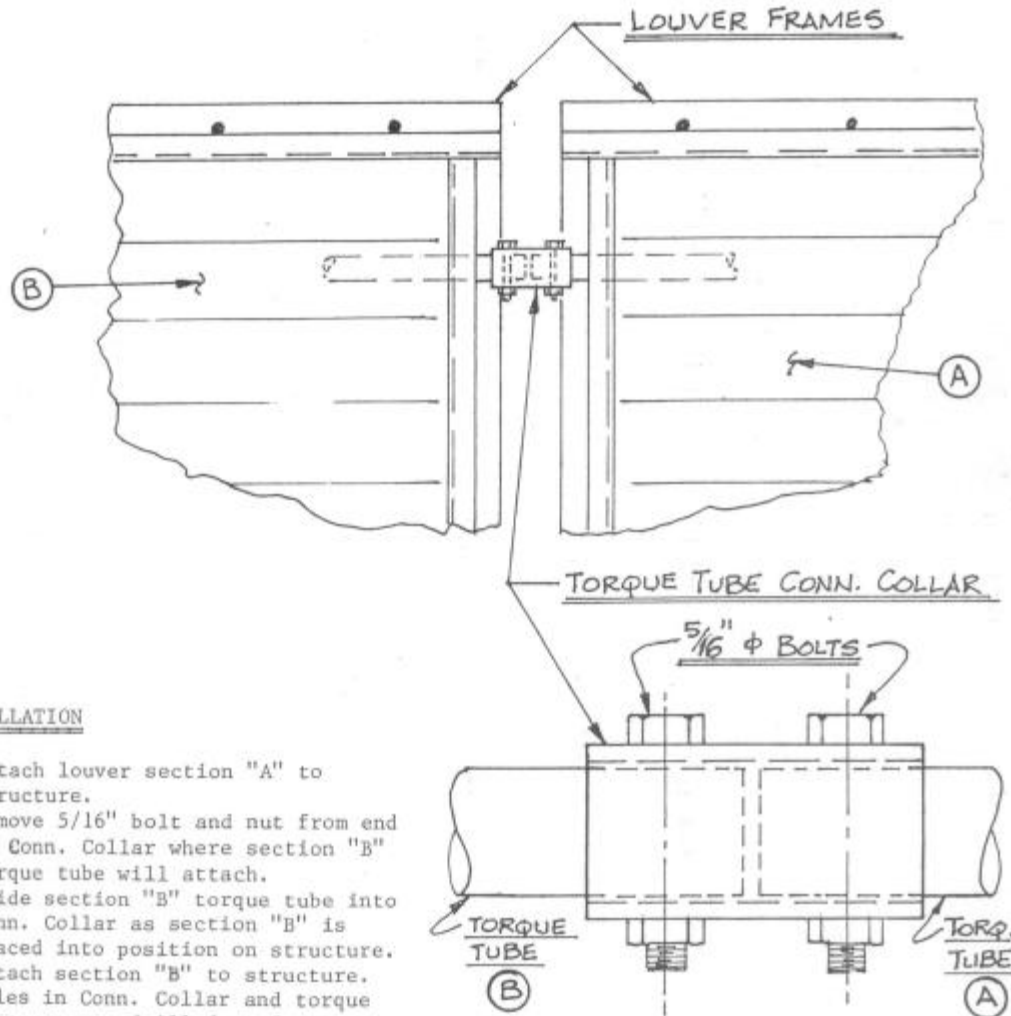
INSTALLATION

1. Position blades in each louver section to same percent of opening.
2. Insert End Link through slots in louver section end frames.
3. Install End Link by attaching to louver actuator rods using the 1/4" bolts and locknuts provided.

END LINKS ARE \$3.25 each including bolts & nuts.

AIRTECH	
INDUSTRIAL SHUTTERS	
END LINK INSTALLATION	
Cust. _____	Dwg. 700-4
Date _____	

Reference C



INSTALLATION

1. Attach louver section "A" to structure.
2. Remove 5/16" bolt and nut from end of Conn. Collar where section "B" torque tube will attach.
3. Slide section "B" torque tube into Conn. Collar as section "B" is placed into position on structure.
4. Attach section "B" to structure.
5. Holes in Conn. Collar and torque tube are pre-drilled at factory to assure proper opening and closing of louver blades. Be sure all louver blades are in same percent of opening before replacing 5/16" bolt and nut to Conn. Collar and section "B" torque tube.

AIRTECH

INDUSTRIAL SHUTTERS

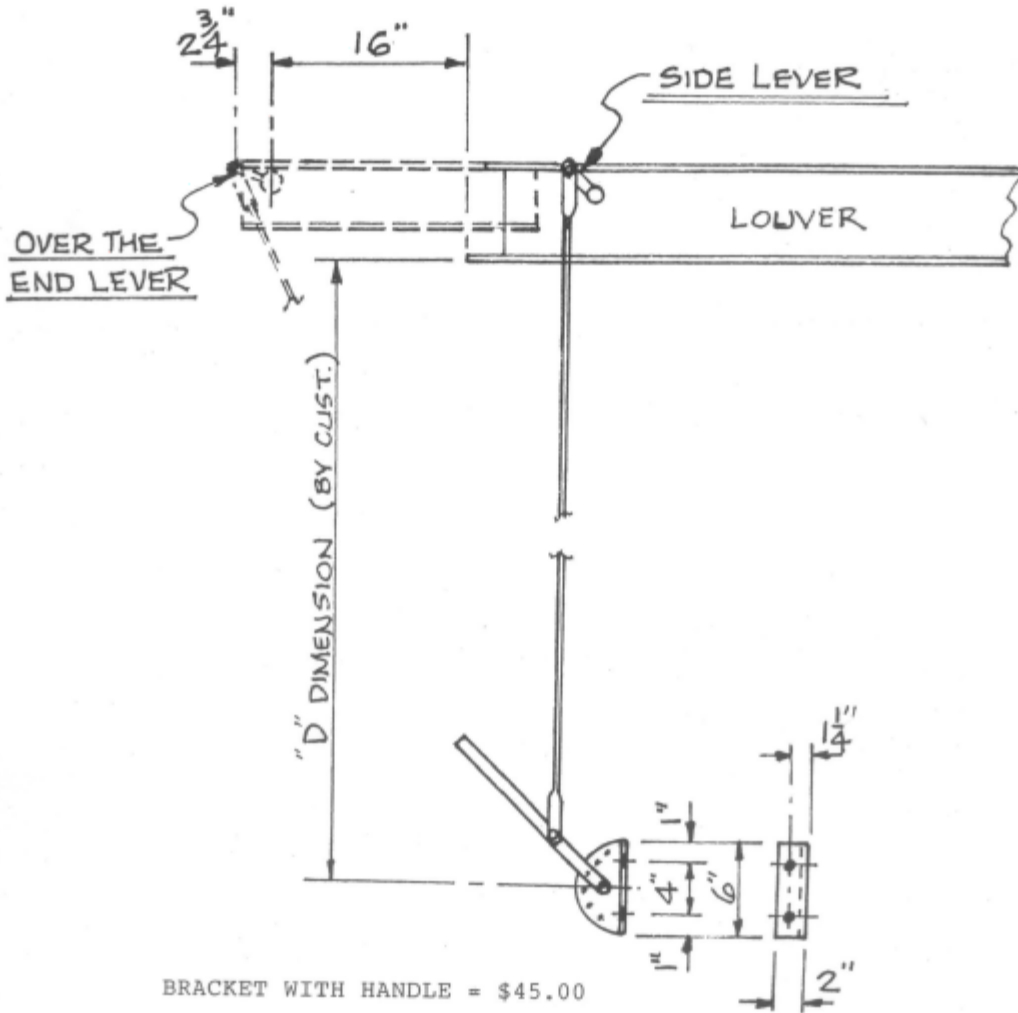
Connecting Collar Installation

Cust.

Date

DWG. 700-4

Reference D



AIRTECH

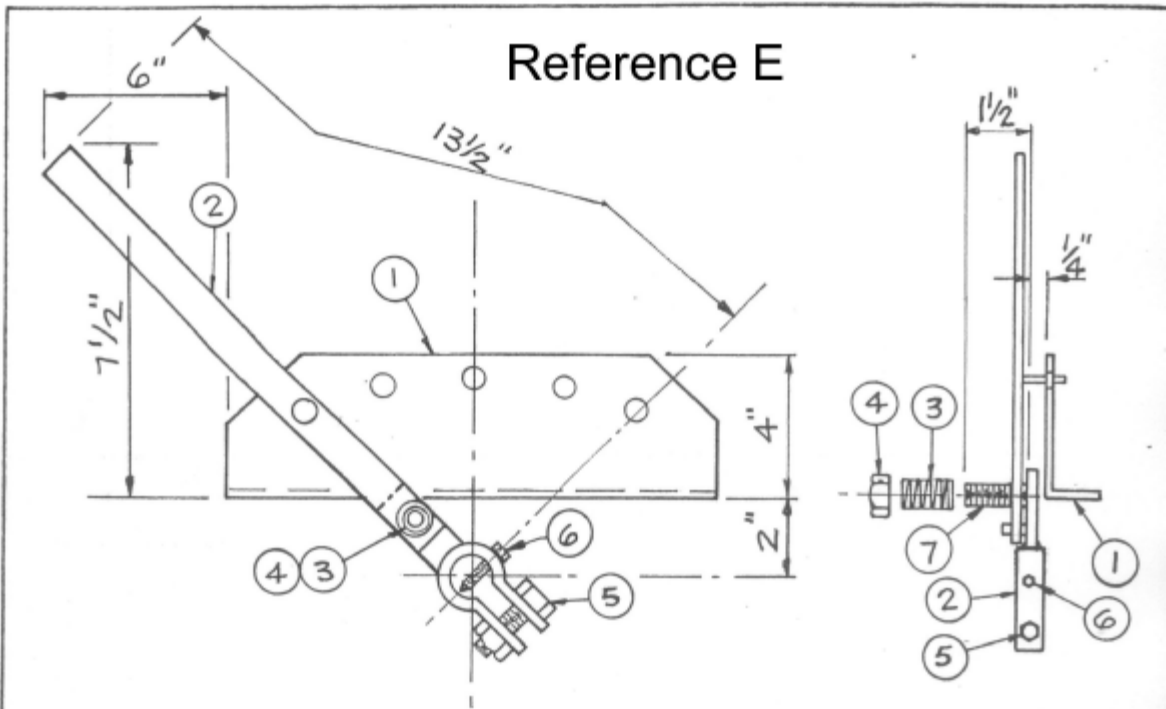
INDUSTRIAL SHUTTERS

MANUAL GRADE LEVEL OPERATOR

Cust.

Date

Dwg. 700-5



Reference E

MANUAL OPERATOR DETAIL

- (1) = Manual Operator Bracket.
- (2) = Manual Operator Handle.
- (3) = Manual Operator Handle Spring.
- (4) = Manual Handle Nut.
- (5) = Manual Handle Clamp Bolt & Nut.
- (6) = Set Screw
- (7) = 3/8" dia. all-thread.

AIRTECH	
INDUSTRIAL SHUTTERS	
MANUAL OPERATOR PARTS	
Cust.	
Date	Dwg. 700 - 3

Reference F

AIRTECH PRODUCTS, INC.

P.O. Box 790
8101 West 16th Street
Sand Springs, OK 74063

918-241-0264 (Phone)
918-241-0270 (Fax)

Louver Materials of Construction

Aluminum Frame (extrusion):	6063 T5
Aluminum Frame (folded sheet):	3003 H14
Galvanized Steel Frame:	A653-G90 10 Ga. Carbon Steel (Mechanical Galvanized Finish)
Blades:	6063-T6 Aluminum
Blade Pins:	
Aluminum:	6061-T6 Aluminum
Stainless Steel:	303 Stainless Steel
Torque Tube:	6063-T6 Aluminum
Actuator Rod:	6063-T6 Aluminum
Actuator Lever Arm:	6061-T6 Aluminum
Clevis:	1018 Carbon Steel
Clevis to Arm Connecting Link:	6061-T6 Aluminum
Assembly Hardware:	
Cap Screws:	ANSI/ASME 18.2.1 ¼-20, Grade 5, Zinc Plate
Nuts:	Nylon Insert lock nut, Performance Spec IFI/100, MIL/N/25027, Light Hex, Standard Height, Zinc Plate
Bearings:	Glass Filled Nylatron, (Per API Specification 661)

Airtech Products, Inc.

P.O. Box 790

8101 West 16th Street

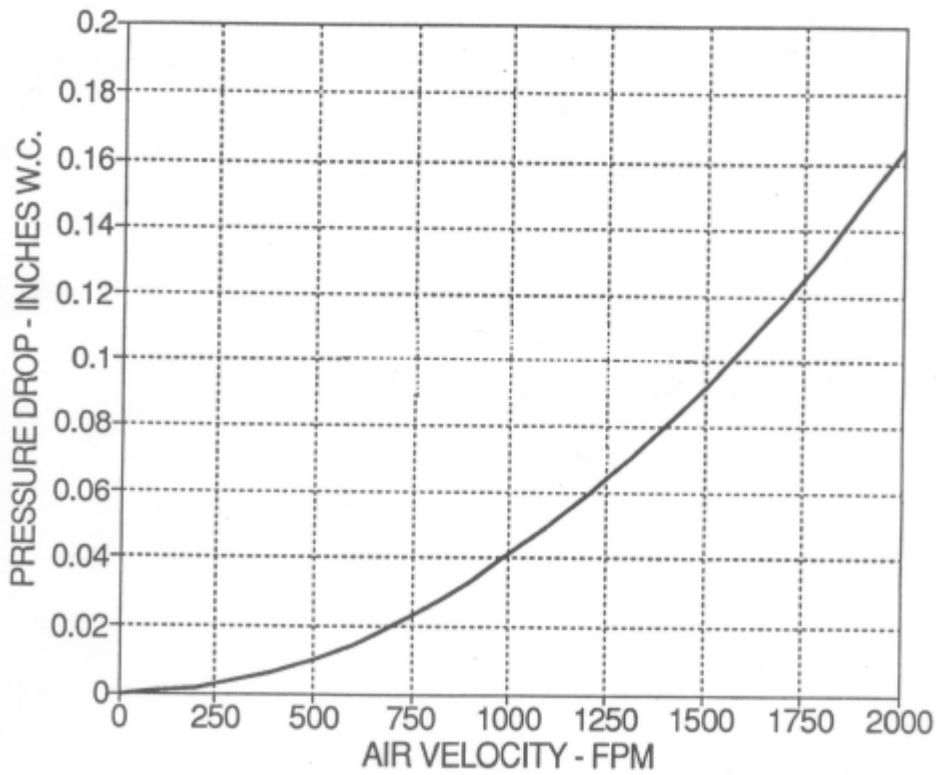
Sand Springs, OK 74063

Reference G

918-241-0264 Phone

918-241-0270 Fax

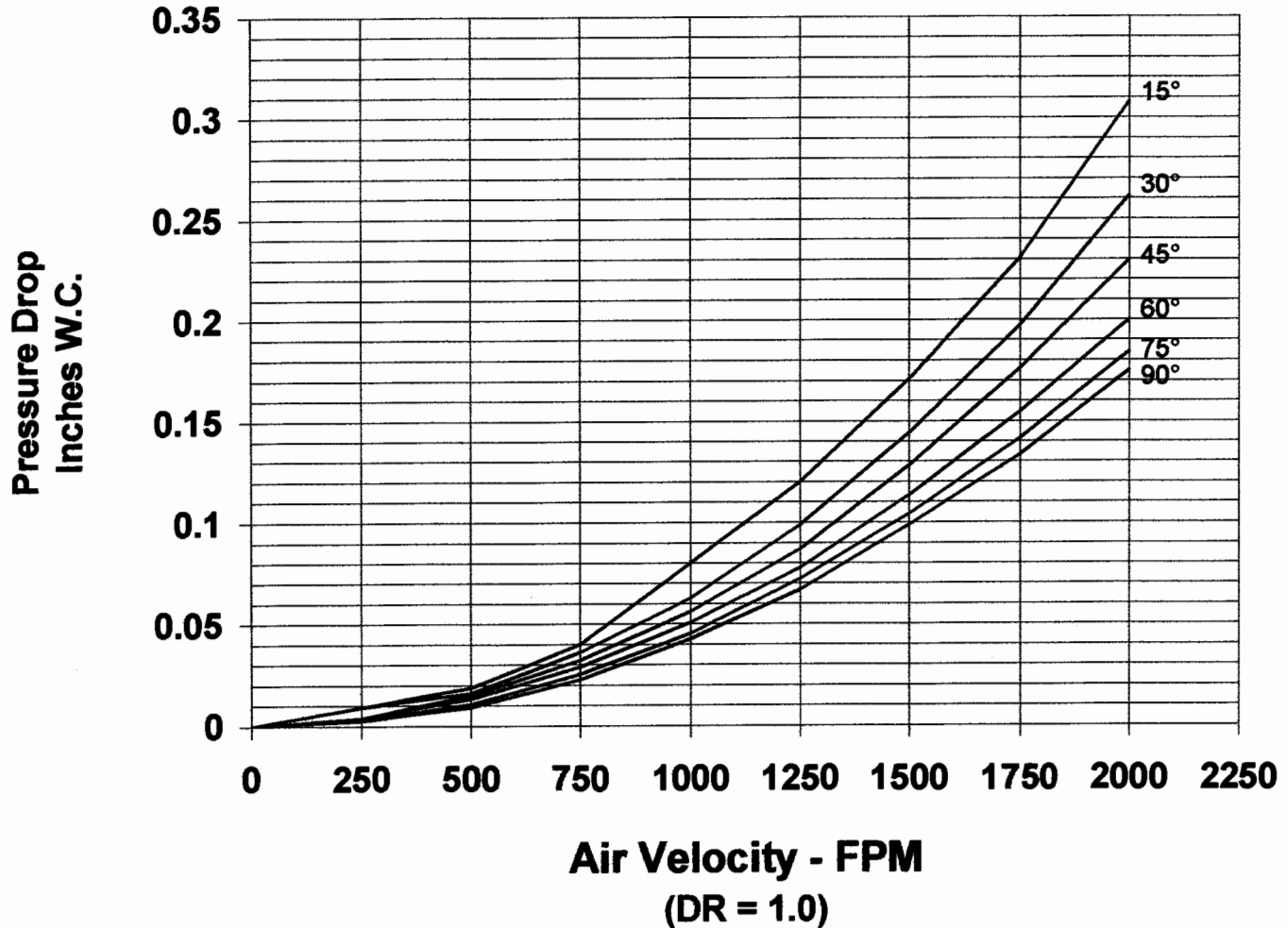
LOUVER PRESSURE DROP CURVE



DENSITY RATIO = 1.0

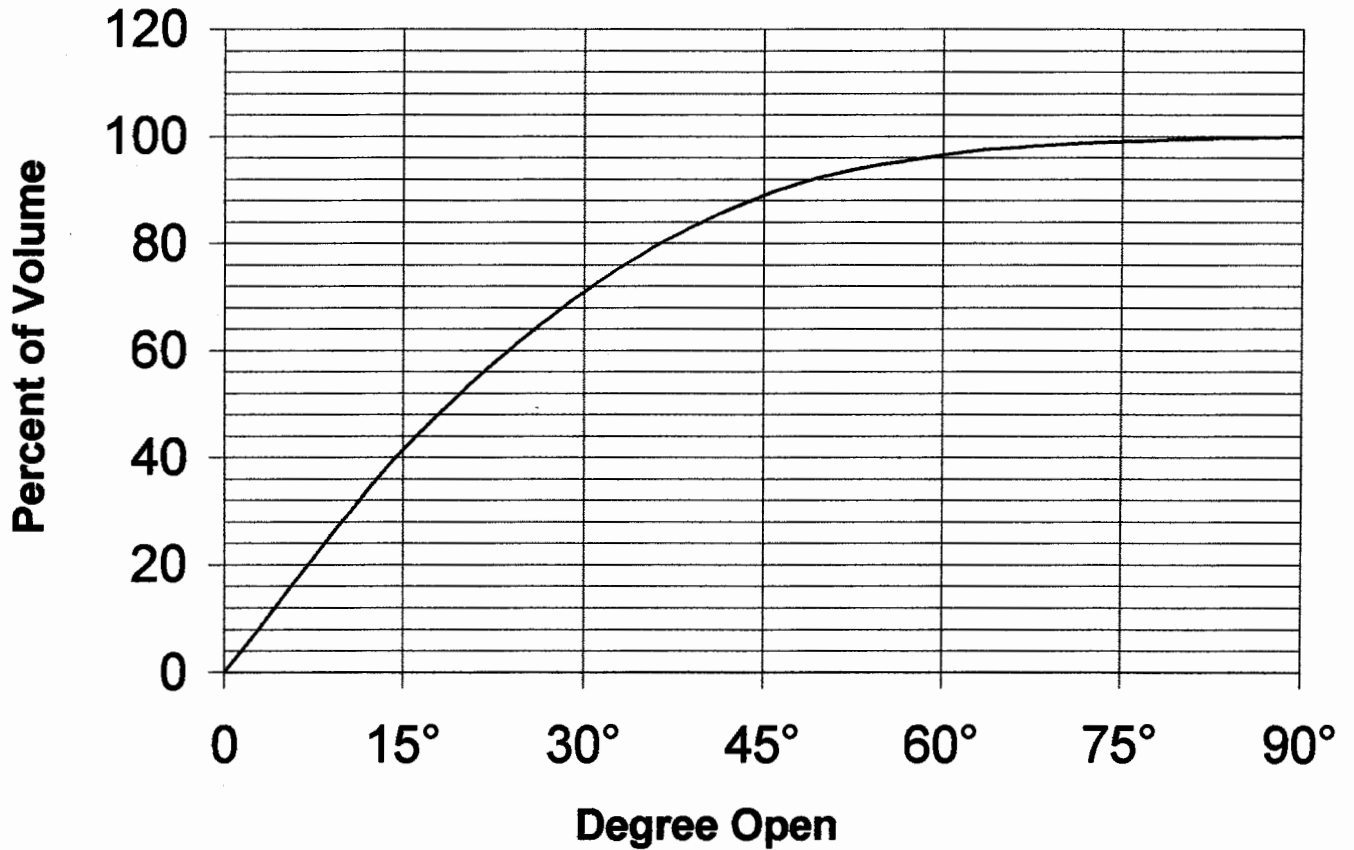
Corrected Pressure Drop Across The Louvers As A
Function of Air Speed Within The Wind Tunnel.

Pressure Drop vs Degree of Opening





Percent of Volume Per Degree Open



Multi-Wing® Z Series Fans.

Outstanding performance.

Multi-Wing Z Series Fans feature a unique airfoil profile blade design that produces a most efficient combination of high air volume, low power consumption and low noise.

Strong, lightweight components.

Injection molded engineered thermoplastic or cast aluminum blades and pressure die cast aluminum hubs are strong and lightweight—resulting in less wear and stress on motors and bearings.

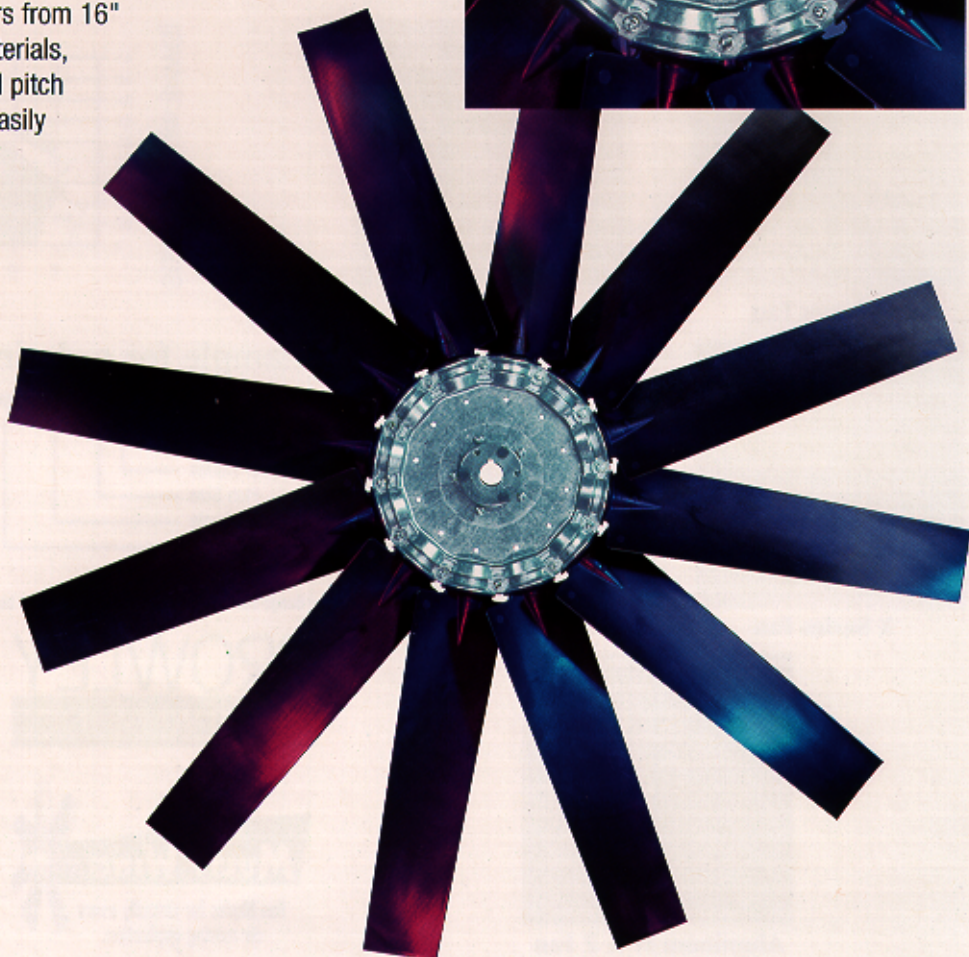
Z Series applications include:

- HVAC
- Engine cooling
- Heat exchangers
- Evaporators
- Cooling towers

Flexible choices.

Z Series Fans are available in diameters from 16" to 49", 5 corrosion-resistant blade materials, configurations from 3 to 16 blades and pitch angles from 20° to 50°, making them easily customized to your application.

Exceptional efficiency by design.



MULTI-WING®

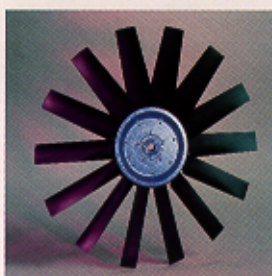
Fan blades for virtually every air-moving application.

Multi-Wing® Z Series Fans.

Put application specific, budget friendly Z Series Fans together with short lead times, emergency service, engineering support and no restrictions on minimum order size, and you've got the whole package. Contact us for all the details.

The Multi-Wing System Design Matrix

Fan Series	H	Z	X	6Z	Aluminum
Blade Profile	twisted airfoil	twisted airfoil	twisted airfoil	increasing arc	twisted airfoil
Blades	2-14	3-16	3-10	3-16	2-16
Diameter	7"-29"	16"-49"	36"-78"	24"-49"	7"-49"
Angles	fixed pitch 25°-50°	adjustable pitch 20°-50°	adjustable pitch 22.5°-50°	adjustable pitch 20°-35°	adjustable or fixed pitch 20°-50°
Application	all	all	all	off highway	all



H Series Fan



Z Series Fan



X Series Fan

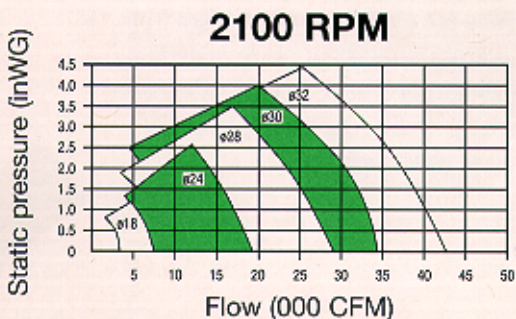
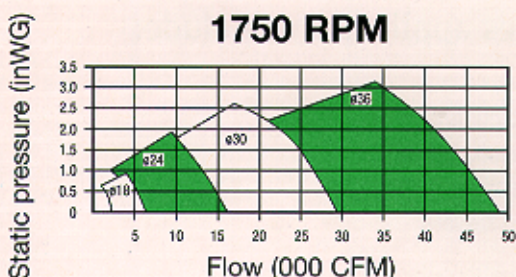
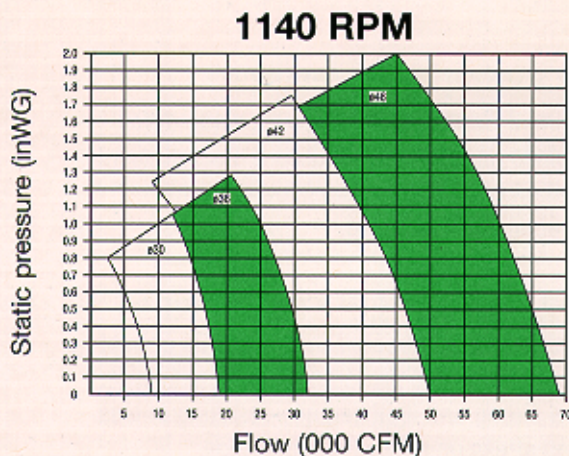


6Z Series Fan

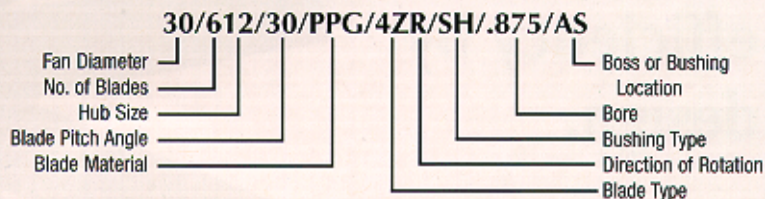


Aluminum H & Z Fan

Selection Guide



Example for ordering



For flange mounting, specify bolt pattern (pilot hole diameter, number of bolts, bolt hole size, bolt circle diameter).

CROWLEY
COMPANY, INC.

P.O. Box 425
15030 Berkshire Industrial Parkway
Burton, Ohio 44021
Phone: 440-834-9400
Toll Free: 800-311-8465
Fax: 440-834-0449
Web Site: www.crowleyfans.com
E-Mail: engineering@crowleyfans.com



Note: Specifications subject to change without notice.

CROWLEY COMPANY

Multi-Wing[®] Z Series Fans.

Features:

- High efficiency
- Low noise
- Lightweight
- High strength
- Corrosion resistant
- Flexibility to customize
- Diameters from 16" to 49"

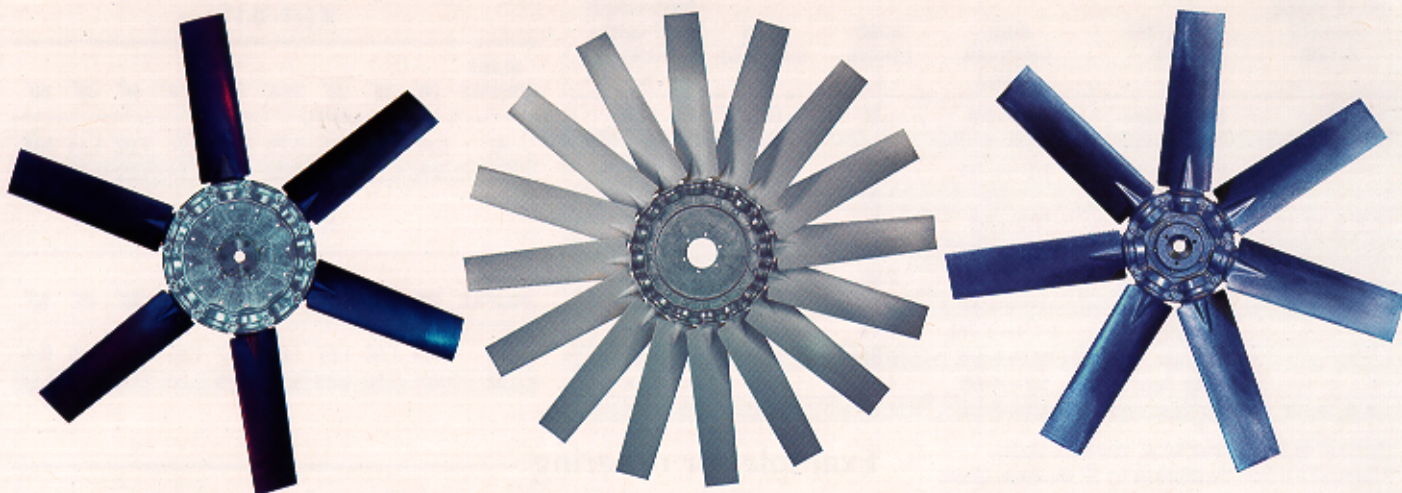


Z Series Fan Specifications

Blade Material	Symbol	Temperature Range	Maximum Tip Speed	Application Duty
Glass Reinforced Polypropylene	PPG	-40° F to +185° F	320 ft/sec	Standard Material
Glass Reinforced Nylon	PAG	-50° F to +250° F	395 ft/sec	Heavy Duty, Engine Driven
"Super Tuff" Nylon	PAGST	-50° F to +250° F	395 ft/sec	Extreme Vibration
Electro Anti-Static Nylon	PAGAS	-40° F to +250° F	395 ft/sec	Hazardous Conditions
Die Cast Aluminum	AL	-60° F to +300° F	275 ft/sec	Temperature Extremes

All materials are corrosion resistant and spark proof on impact.

PAGAS blades are suitable for underground mining, oil and gas platforms, chemical processing plants, or any application where there is potential for an explosion.



From 3 blades to 16 blades, 16" in diameter to 49", there's a Crowley Z Series Fan to fit your HVAC, engine cooling, chemical duty or severe duty application.

CROWLEY
COMPANY, INC.

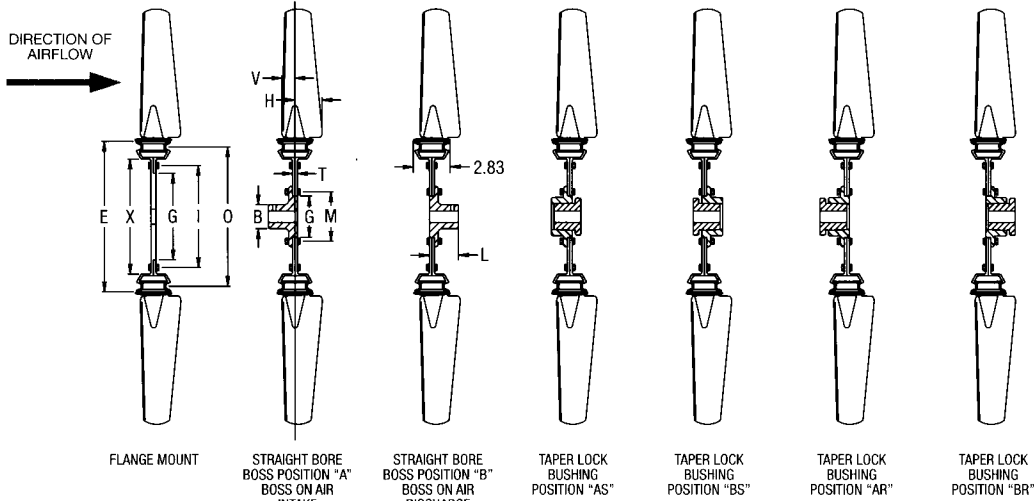
P.O. Box 425 • 15030 Berkshire Industrial Parkway • Burton, Ohio 44021
Phone: 440-834-9400 • Toll Free: 800-311-8465 • Fax: 440-834-0449
Web Site: www.crowleyfans.com • E-Mail: engineering@crowleyfans.com

MULTI-WING

Fan blades for virtually every
air-moving application.



Multi-Wing[®] Z Series Fan Specifications



Hub Dimensions

NO. OF BLADE SOCKETS IN HUB	MOUNTING TYPE	BORE DIAMETER (Inches)	MAXIMUM FAN DIAMETER 4Z*	MAXIMUM FAN DIAMETER 5Z**	HUB DIAMETER E	RETAINER PILOT G	HUB THICKNESS T	MAXIMUM SPACER DIAMETER X	INSIDE BOLT CIRCLE DIAMETER I	OUTSIDE BOLT CIRCLE DIAMETER O
5	Shaft Mount	1/2—1-1/4	30.0	40.6	5.69	2.17	0.25	2.88	N/A	5.47
	Shaft Mount	1-3/8	30.0	40.6	5.69	2.17	0.25	2.88	2.50	5.47
	Flange Mount	Custom	30.0	40.6	5.69	2.17	0.25	2.88	N/A	5.47
7	Shaft Mount	1/2—1-7/8	31.5	42.2	7.32	2.95	0.27	4.62	N/A	6.85
	Flange Mount	Custom	31.5	42.2	7.32	2.95	0.27	4.62	N/A	6.85
8	Shaft Mount	1/2—1-7/8	34.7	45.3	10.49	2.95	0.27	7.60	6.93	9.84
	Flange Mount	Custom	34.7	45.3	10.49	2.95	0.27	7.60	6.93	9.84
9	Shaft Mount	1/2—1-7/8	32.1	42.9	7.87	2.95	0.27	5.20	N/A	7.44
	Flange Mount	Custom	32.1	42.9	7.87	3.74	0.27	5.20	N/A	7.44
12	Shaft Mount	1/2—1-7/8	35.3	46.0	11.02	2.95	0.35	8.20	7.28	10.45
	Flange Mount	Custom	35.3	46.0	11.02	6.69	0.35	8.20	7.28	10.45
16	Shaft Mount	1/2—1-7/8	39.0	49.7	14.76	2.95	0.31	12.00	11.02	14.21
	Shaft Mount	1/2—2-1/4	39.0	49.7	14.76	3.54	0.31	12.00	11.02	14.21
	Flange Mount	Custom	39.0	49.7	14.76	9.45	0.31	12.00	11.02	14.21

Shaft Mounting Boss Dimensions

NO. OF BLADE SOCKETS IN HUB	MOUNTING TYPE	BORE DIAMETER (Inches)	BOSS LENGTH L	BOSS DIAMETER B	BOSS MOUNT BOLT CIRCLE DIAMETER M
5	Straight Bore	5/8—7/8	1.65	1.73	N/A
	Straight Bore	15/16—1-1/8	2.44	2.05	N/A
	JA Taper Lock	1/2—1-1/4	0.75	2.13	N/A
	H Taper Lock	1-3/8	1.00	2.88	2.50
7, 8, 9, 12, 16	Straight Bore	1/2—5/8	1.22	1.10	3.54
	Straight Bore	5/8—3/4	1.65	1.57	3.54
	Straight Bore	7/8	2.05	1.77	3.54
	Straight Bore	1—1-3/16	2.44	2.01	3.54
	Straight Bore	1-1/4—1-7/8	2.44	2.87	3.54
	G/JA Taper Lock	1/2—1-1/4	0.91	2.87	3.54
	SH/P1/SD Taper Lock	1/2—1-7/8	1.50	3.23	3.54
8, 9, 12, 16	SK/SF Taper Lock	1/2—2-1/4	1.77	5.00	4.33

* Add 0.9" to the diameter for 4Z aluminum blades.

** Subtract 0.5 from the diameter for 5Z aluminum blades.

For severe duty corrosive applications, aluminum hubs can be supplied with protective coatings and stainless steel fasteners. Contact factory for available coatings. Shaft surfaces should be clean before installation.

Metric bore and shaft sizes also available. Contact factory for availability.

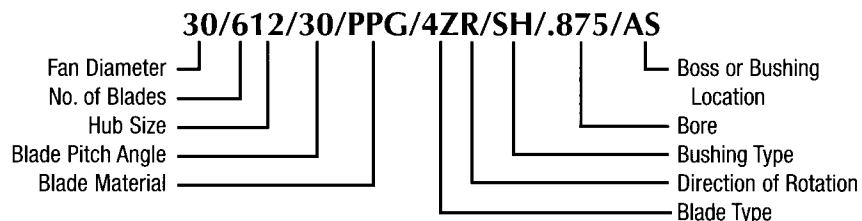
All specifications are subject to change without notice. Please contact the factory for the latest specifications.

Blade Dimensions

		V (+/- 0.1")								
BLADE PROFILE		20°	25°	30°	32.5°	35°	37.5°	40°	45°	50°
4Z		0.47	0.59	0.75	0.79	0.87	0.94	1.02	1.14	N/A
5Z		N/A	0.67	0.87	0.98	1.06	1.14	1.22	1.34	1.50

		H (+/- 0.1")								
BLADE PROFILE		20°	25°	30°	32.5°	35°	37.5°	40°	45°	50°
4Z		1.14	1.38	1.57	1.69	1.77	1.85	1.93	2.05	N/A
5Z		N/A	1.65	1.89	2.01	2.09	2.20	2.32	2.48	2.64

Example for ordering



For flange mounting, specify bolt pattern (pilot hole diameter, number of bolts, bolt hole size, bolt circle diameter).

Multi-Wing Z Series Fans
Blade Pitch Angle Setting Instructions

Before You Begin:

To maintain balance of fan:

- Mark the hub castings across a joint, so the fan hub can be reassembled in the same orientation.
- Mark the location of any balancing weight. Balancing weight will be on the outer bolt circle, in the form of washers, and/or longer bolts, or an additional balancing nut.
- Number the blades and blade sockets, so that they are replaced into their original position.

If possible, note the location of the pitch setting pin in the blade socket, and whether pin is located in the Hub or Retainer half of the fan (see step 7 for detailed definition).

Step 1 – Determine Blade Type: “4Z”, “5Z”, or “6Z”

If the blade is wider at the tip than at the base near the hub, then you have a 6Z.

Otherwise, look for 4Z or 5Z markings on blade which are in one of two places:

Look on cone section at base of blade (visible when fan is assembled), or

Look inside the bottom of the socket (blade must be removed from hub).

Alternatively, measure the width of the blade at the widest portion at base of blade:

4Z blade is approximately 4-1/2 inches

5Z blade is approximately 5-1/4 inches.

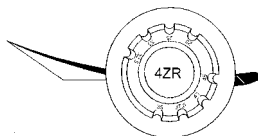
Step 2 – Determine Rotation Code: “L” or “R”

For all fans, if the fan rotates clockwise facing air discharge, it is an R rotation. Otherwise, it is an L rotation.

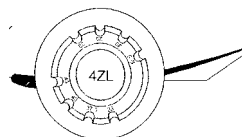
For 4Z and 5Z blades, the rotation code is molded into the blade. The location of the rotation code is either on the cone section at base of blade, or inside bottom of the socket. It is the letter R or L after the 4Z or 5Z molded into the blade.

Example drawings are below for 4Z blades, and 5Z is similar. Viewing socket end of blade, rotation is:

R, or clockwise



L, or counterclockwise





Step 3 – Determine Boss location code: “A” or “B”

The boss is the center section of the hub through which the fan is mounted to the shaft, and typically contains either setscrews or a center-tapered hole where the bushing inserts.

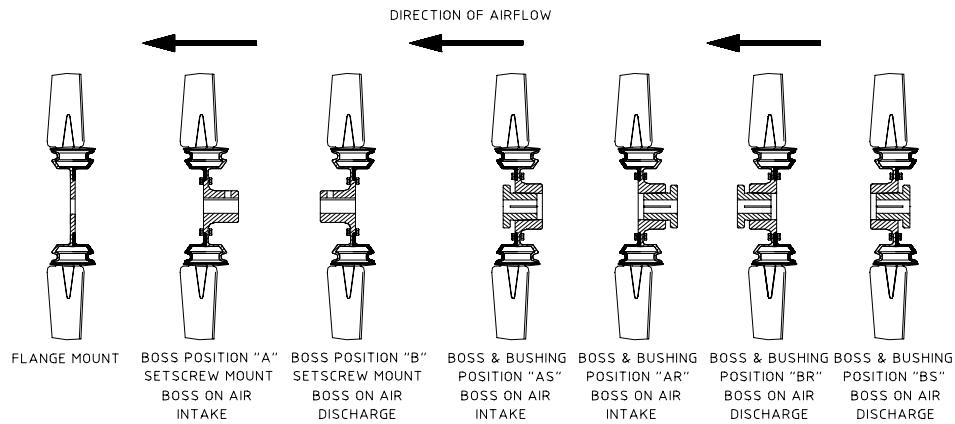
Select boss location A or B:

A is the boss on air inlet, including A, AR, and AS configurations.

B is the boss on air discharge, including B, BR, and BS.

See examples in drawing below.

For flange mounted (engine) fans, use boss location A for R rotation fans, and boss location B for L rotation fans.



Step 4 – Find Blade Pitch Angle: 20, 25, 27.5, 30, 32.5, 35, 37.5, 40, 45, or 50

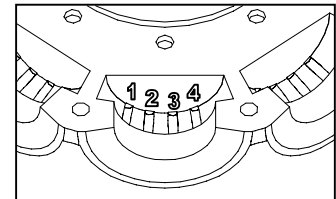
The blade pitch angle can be found several ways:

First, by knowledge of the Multi-Wing fan part number.

The pitch angle precedes the blade material code in the part number. For example, the pitch angle is 30 degrees in this part number: 36/9-9/30/PPG/5ZR/AS SH 1-3/8.

Second, by careful disassembly with this method:

- Disassemble fan on flat surface, and note in which groove the pin is located. See number code in picture to the right.
- Using pictures in step 7 on next page, determine if the pin was in the hub (HUB) or retainer side (RET) of fan.
- Using table in step 6 below, find the possible blade pitch.
- Using table in step 5 below, select your blade angle based on whether your pin was in the HUB or RET.



Third, by calling a sales engineer at Crowley Company for assistance in selecting a blade pitch angle for your application.



Step 5 – Determine Hub/Retainer Code: “HUB” or “RET”

Find “HUB” or “RET” in chart below:

Type	Rotation	Boss Pos.	Blade Pitch Angle									
			20°	25°	27.5°	30°	32.5°	35°	37.5°	40°	45°	50°
4Z	R or L	A	RET	RET	-	RET	RET	HUB	HUB	HUB	HUB	-
4Z	R or L	B	HUB	HUB	-	HUB	HUB	RET	RET	RET	RET	-
5Z	R or L	A	-	RET	-	RET	RET	RET	HUB	HUB	HUB	HUB
5Z	R or L	B	-	HUB	-	HUB	HUB	HUB	RET	RET	RET	RET
6Z	R	A	RET	RET	HUB	RET	HUB	RET	-	-	-	-
6Z	R	B	HUB	HUB	RET	HUB	RET	HUB	-	-	-	-
6Z	L	A	HUB	HUB	RET	HUB	RET	HUB	-	-	-	-
6Z	L	B	RET	RET	HUB	RET	HUB	RET	-	-	-	-

Step 6 – Determine Groove Number: 1 or 2 or 3 or 4

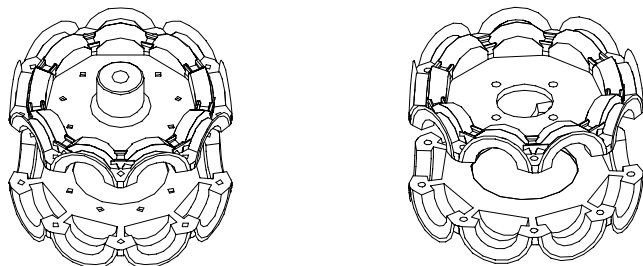
Find the groove number in chart below:

Type	Rotation	Blade Pitch Angle									
		20°	25°	27.5°	30°	32.5°	35°	37.5°	40°	45°	50°
4Z	R	4	3	-	2	1	4	3	2	1	-
4Z	L	1	2	-	3	4	1	2	3	4	-
5Z	R	-	4	-	3	2	1	4	3	2	1
5Z	L	-	1	-	2	3	4	1	2	3	4
6Z	R	1	2	1	3	2	4	-	-	-	-
6Z	L	1	2	4	3	3	4	-	-	-	-

Step 7 – Final Assembly

Definition of HUB and RET for purposes of these instructions:

For 2-piece hubset like below:

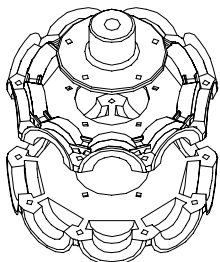


Top half is the HUB, and bottom half is the RET or retainer ring.



Step 7 – Final Assembly continued

For 3-piece hubset as below:



Top two pieces together are considered the HUB, and bottom piece is considered the RET or retainer ring.

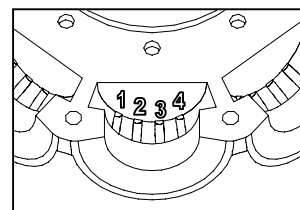
Using the HUB or RET code found in Step 5:

If code is HUB, place the hub down on work surface first (one or two pieces, depending on above).
If code is RET, place one retainer ring only down on the work surface first.

A weighted coffee can could be used to elevate the fan from the work surface.

Using the Groove Number found in Step 6:

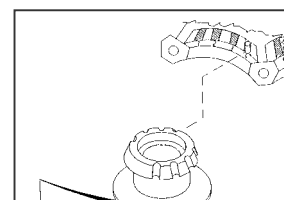
Using picture to right, place the locking pin in the groove number that you found in Step 6 above.



Finally, Insert Blades:

- Place the blade over the pin in the hub/retainer blade socket, so that the pin also fits into the appropriate pitch angle groove in the blade. See example picture to the right.

For 6Z fans, use the pitch angle groove in the blade marked with your rotation (R or L) and pitch angle. Example: L35 is “L” rotation and 35-degree pitch angle.



- Repeat for all blades.
- Assemble hubset together, aligning the match marks you made.
- Replace any balancing weight to its original position.
- To finish, tighten the bolts in a cross pattern to 5 to 6 foot-pounds of torque.

*GARZO spring opposed
linear diaphragm operators*



*Your
solution
for
friction-free
cylinders.*



Quality Products since 1939

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HOUSTON, TX 77041
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March



HOME OIL LEVEL REGULATORS LINEAR DIAPHRAGM OPERATORS LOW FLOW METERS PRODUCT REGISTRATION

MODELS 501-4 501-6 501-12 501-25

CO

MODEL 501-6 LINEAR DIAPHRAGM OPERATOR

GARZO Linear Diaphragm Operators are small diameter spring opposed rolling diaphragm operators suitable for gas compressor applications. The series 501 operators are designed specifically to be used in various industrial applications. The rolling diaphragm creates the perfect seal for friction free cylinders. It is a durable, flexible membrane shaped like a top hat with the peak of the hat resting against the end of the piston and the brim clamped between the forward and rear cylinders. Inside the cylinder this forms a long-lasting frictionless sealed cushion of air between the piston head and the cylinder wall. The fabric reinforced elastomer rolling diaphragms are produced exclusively for GARZO to our exacting standards. Standard diaphragm material design allows for operation of the cylinders in temperatures from -31°F to 248°F. Custom diaphragm material design allows for operation of the cylinders in temperatures from -121°F to 500°F.

The operators are designed to withstand many corrosive elements. The piston and body of the operators are made from 100% aluminum castings which resist galvanic corrosion and eliminate the need for painting. The diaphragm is a Dacron fabric, Buna-n impregnated, molded rolling diaphragm. The diaphragms are designed and manufactured to withstand repeated use in industrial applications, and the fabric prevents the elastomer from stretching in over pressure conditions. The spring has been electro zinc plated. The piston rod is a large diameter 300 series stainless steel. All other parts are either plated or stainless steel, making the operator suitable for offshore salt water, natural gas, and sour gas service.



GARZO linear diaphragm operators are designed using INSTRUMENT SOCIETY of AMERICA recognized spring rates. The GARZO operators have strokes that follow a true linear progression. A properly sized GARZO spring opposed diaphragm operator has as much force on the forward stroke as it does on the return stroke.

FEATURES

- Super Sensitivity
- Absolutely No Lubrication Required
- Low Hysteresis
- No Blow-By Leakage - 100% Leak Testing
- Solid Aluminum Construction
- Ease of Maintenance
- Wide Temperature Variations
- Designed For Use With Air or Sour Gas

SPECIFICATIONS

- Cylinders 100% Cast Aluminum
- Piston 100% Cast Aluminum
- Rod 303 Stainless Steel
- Diaphragm Buna-N with Dacron Fabric
- Spring Zink Plated

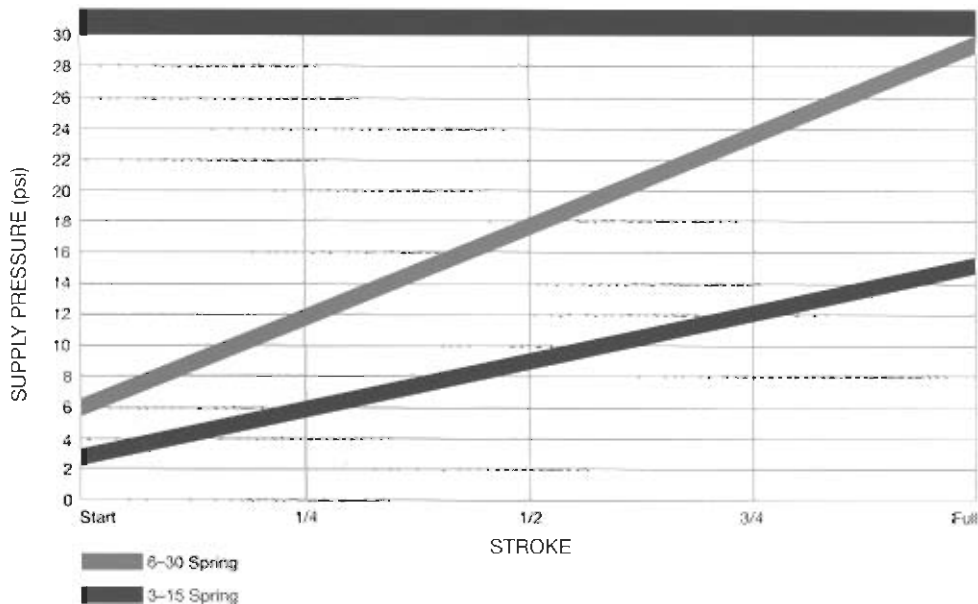
Features

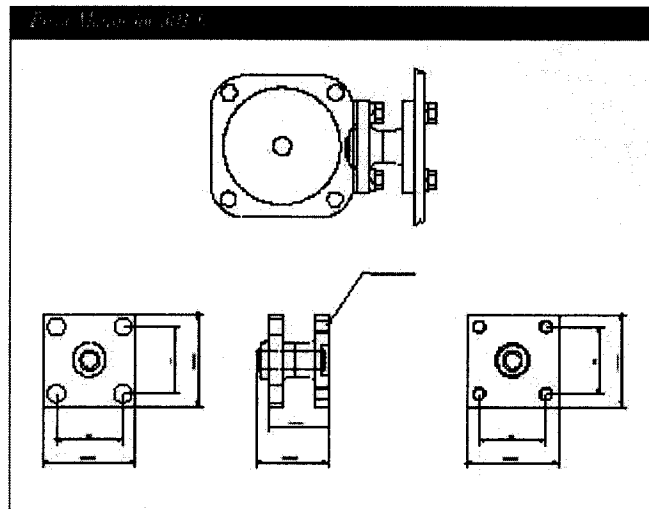
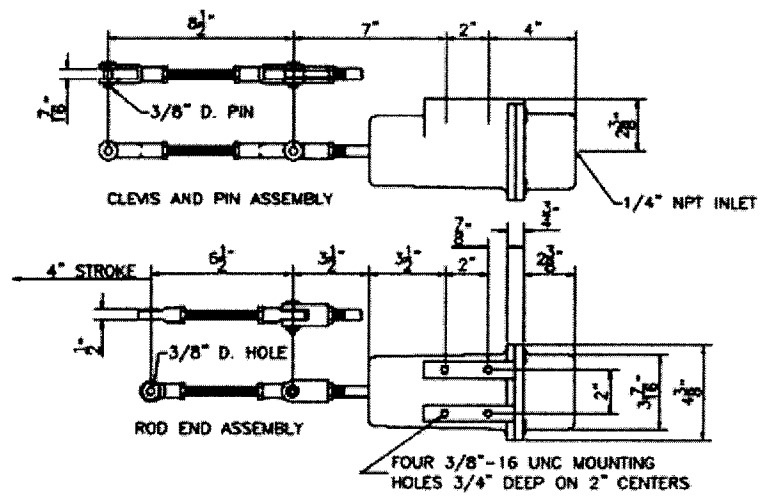
- Super Sensitivity
- Absolutely No Lubrication Required
- Low Hysteresis
- No Blow-By Leakage—100% Leak Testing
- Solid Aluminum Construction
- Ease of Maintenance
- Wide Temperature Variations
- Designed For Use With Air or Sour Gas

Specifications

- Cylinders
100% Cast Aluminum
- Piston
100% Cast Aluminum
- Rod
303 Stainless Steel
- Diaphragm
Buna-N with Dacron Fabric
- Spring
Zink Plated

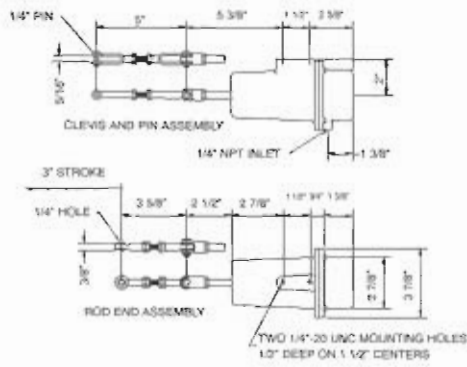
MODEL NUMBER	EFFECTIVE AREA (IN ²)	STROKE (IN)	FORCE AVAILABLE (LB)	NOMINAL SUPPLY PRESSURE	MAXIMUM SUPPLY PRESSURE
501-4-315	4	3	12	20	100
501-4-630	4	3	24	40	100
501-6-315	6	4	18	20	100
501-6-630	6	4	36	40	100
501-12-315	12	6	36	20	100
501-12-630	12	6	72	40	100
501-25-315	25	10	75	20	100
501-25-630	25	10	150	40	100



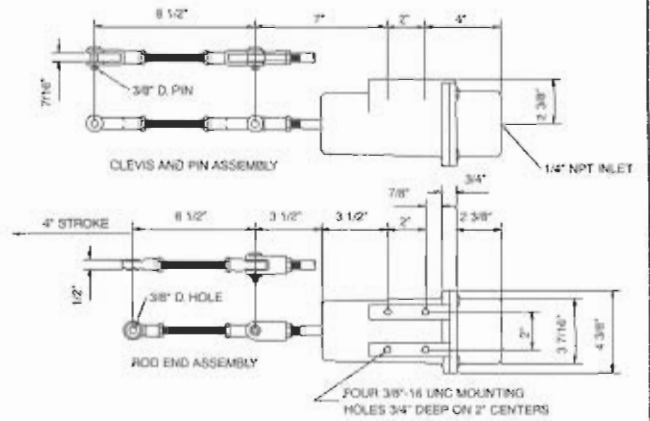


MODEL NUMBER	EFFECTIVE AREA (IN ²)	STROKE (IN)	FORCE AVAILABLE (LBS)	NOMINAL SUPPLY PRESSURE	MAXIMUM SUPPLY PRESSURE
501-6-315	6	4	18	20	100
501-6-630	6	4	36	40	100

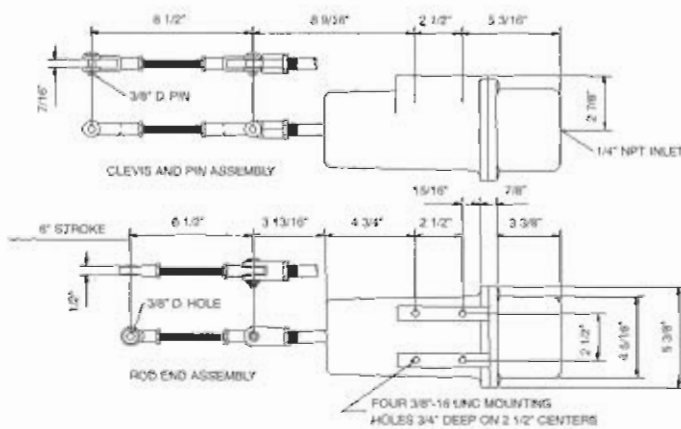
501-4



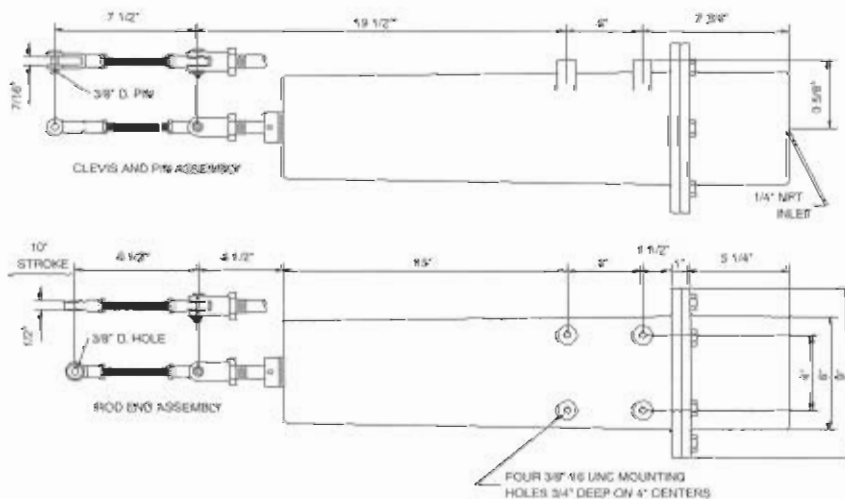
501-6



501-12



501-25





How to order.

Series _____ **501-4-315-SUR-P-SIL**

Model _____

Spring Range _____

315-3 to 15 psig

630-6 to 30 psig

Mounting _____

SUR-Surface Mounting Bracket

PVT-Pivot Mounting Bracket

Positioner _____

O-Without Positioner

P-With Top Mounted Positioner

Diaphragm Temperature Range _____

Buna-N Diaphragm (Standard) -35°C to 120°C (-31°F to 248°F)

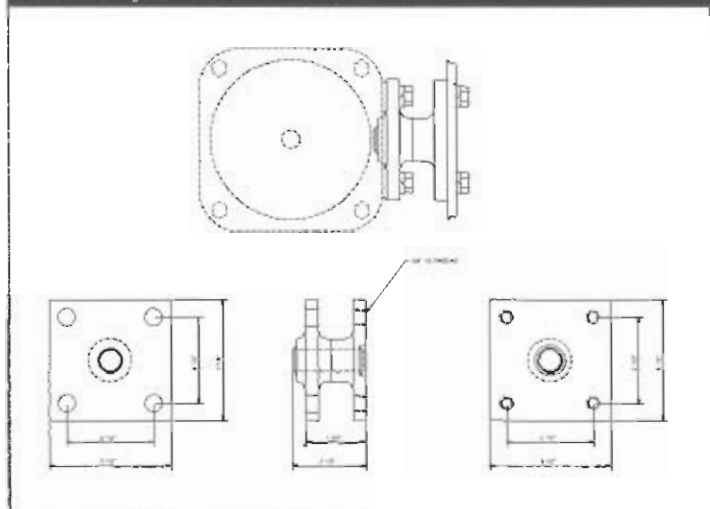
Silicone Diaphragm -85°C to 260°C (-121°F to 500°F)

Connector Assembly

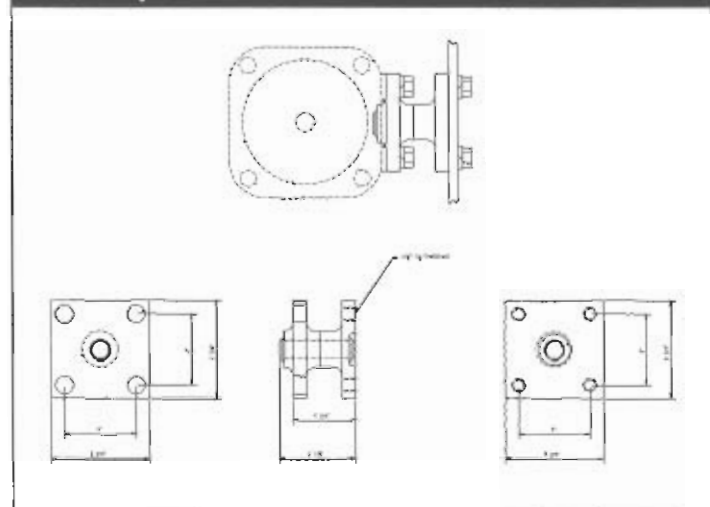
Clevis & Pin Assembly (Standard)

Rod End Assembly

Pivot mount for 501-12



Pivot Mount for 501-6



June 2003

67C Series Instrument Supply Regulators



Figure 1. Typical 67C Series Regulators

Introduction

Scope of Manual

This manual provides instructions and parts lists for 67C Series instrument supply regulators. Instructions and parts lists for other equipment mentioned in this instruction manual, as well as for other 67 Series regulators, are found in separate manuals.

Product Descriptions

The 67C Series direct-operated regulators are typically used to provide constantly controlled, reduced pressures to pneumatic and electropneumatic controllers and other instruments. They are suitable for most air or gas applications. Other applications include providing reduced pressures to air chucks, air jets, and spray guns.

The Type 67C is the standard instrument supply regulator without a filter or internal relief.

The Type 67CF and 67CFS are equipped with a filter for removing particles from the supply gas.

The Type 67CR has an internal relief valve with a soft seat for reliable shutoff with no discernible leakage.

The Type 67CFR and 67CFSR have a filter and internal relief valve with a soft seat for reliable shutoff with no discernible leakage.

Specifications

Some general 67C Series ratings and other specifications are given on page 2. A label on the spring case gives the control spring range for a given regulator as it comes from the factory.



www.FISHERregulators.com



67C Series

Specifications

Body Size, Inlet and Outlets Connection Style

1/4-inch NPT

Maximum Inlet Pressure (Body Rating)⁽¹⁾

250 psig (17,2 bar)

Outlet Pressure Ranges

See table 1

Maximum Emergency Outlet Pressure⁽¹⁾

50 psi (3,4 bar) over outlet pressure setting

Accuracy

Inlet Sensitivity: Less than 0.2 psig (0,014 bar) change in outlet pressure for every 25 psig (1,72 bar) change in inlet pressure

Repeatability: 0.1 psig (0,0069 bar)⁽²⁾

Air Consumption: testing repeatedly shows no discernible leakage

Type 67CR, 67CFR, and 67CFSR Internal Relief Performance

Low capacity for minor seat leakage only; other overpressure protection must be provided if inlet pressure can exceed the maximum pressure rating of downstream equipment or exceeds maximum outlet pressure rating of the regulator.

Regulator Temperature Capabilities

With Nitrile (NBR)

Standard Bolting: -20 to 180°F (-29 to 82°C)

Stainless Steel Bolting: -40 to 180°F (-40 to 82°C)

With Fluoroelastomer (FKM):

0 to 300°F (-18 to 149°C)

With Silicone (VMQ)⁽³⁾ Diaphragm and Low

Temperature bolting: -60 to 180°F (-51 to 82°C)

With Gauges: -20 to 180°F (-29 to 82°C)

Type 67CF, 67CFR, 67CFS, and 67CFSR Filter Capabilities

Free Area: 12 times pipe area

Micron Rating: *Cellulose Element:* 40 microns

Glass Fiber Element: 10 microns

Stainless Steel Element: 40 microns

Drain Valve and Spring Case Vent Location

Aligned with inlet standard, other positions optional

Pressure Registration

Internal

Options

All Types

- Handwheel adjusting screw
- Inlet screen
- NACE MR0175 or NACE MR0103 construction
- Panel mount (includes spring case with 1/4-inch vent, handwheel, and panel mounting nut)
- Closing cap (available on spring case with 1/4-inch NPT vent)
- Fluoroelastomer (FKM) elastomers for high temperatures and/or corrosive chemicals
- Silicone (VMQ) elastomers for cold temperatures
- Fixed Bleed Restriction
- Triple scale outlet pressure gauge (brass or stainless steel)
- Stainless steel stem on the valve plug
- Tire valve or pipe plug in second outlet

Types 67C, 67CF, and 67CFS only

- Ammonia service construction

Types 67CF and 67CFR only

- Aluminum or stainless steel drain valve

1. The pressure/temperature limits in this manual and any applicable standard or code limitation should not be exceeded.

2. Repeatability is the measure of the regulator's ability to return to setpoint consistently when traveling from steady state to transient to steady state.

3. Silicone is not compatible with hydrocarbon gas.

Table 1. Outlet Pressure Ranges and Control Spring Data

Type	OUTLET PRESSURE RANGES, PSIG (bar)	CONTROL SPRING DATA			
		Color	Material	Part Number	Wire Diameter, Inch (mm)
67C, 67CR, 67CF, 67CFR	0 to 20 (0 to 1,4)	green stripe	Music Wire	T14130T0012	0.135 (3,43)
	0 to 35 (0 to 2,4)	silver		T14059T0012	0.156 (3,96)
	0 to 60 (0 to 4,1)	blue stripe		T14058T0012	0.170 (4,32)
	0 to 125 (0 to 8,6)	red stripe		T14060T0012	0.207 (5,26)
	0 to 35 (0 to 2,4)	silver stripe	Inconel	T14113T0012	0.156 (3,96)
	0 to 60 (0 to 4,1)	blue		T14114T0012	0.172 (4,37)
0 to 125 (0 to 8,6)	red	T14115T0012		0.207 (5,26)	
67CFS, 67CFSR	0 to 20 (0 to 1,4)	green	Inconel	10C1729X012	0.135 (3,43)
	0 to 35 (0 to 2,4)	silver stripe		T14113T0012	0.156 (3,96)
	0 to 60 (0 to 4,1)	blue		T14114T0012	0.172 (4,37)
	0 to 125 (0 to 8,6)	red		T14115T0012	0.207 (5,26)
	0 to 150 (0 to 10,3)	black		10C1730X012	0.250 (6,35)

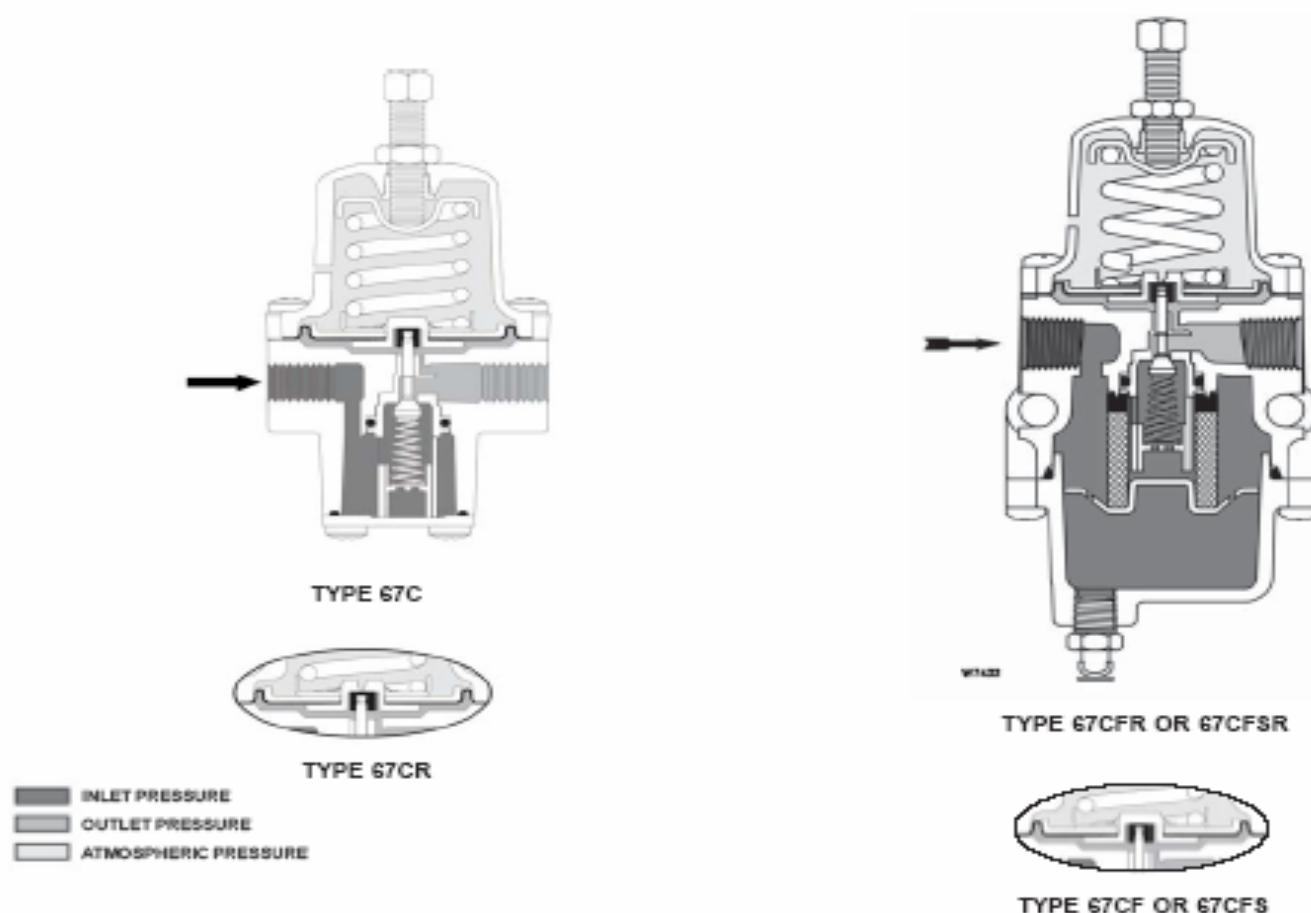


Figure 2. 67C Series Operational Schematics

Principle of Operation

Downstream pressure is registered internally on the lower side of the diaphragm. When the downstream pressure is at or above the set pressure, the valve plug is held against the orifice and there is no flow through the regulator. When demand increases, downstream pressure drops slightly allowing the spring to extend, moving the stem down and the valve plug away from the orifice. This allows flow through the regulator.

Internal Relief (67CR, 67CFR, 67CFSR)

If for some reason, outside of normal operating conditions, the downstream pressure exceeds the set point of the regulator, the force created by the downstream pressure will lift the diaphragm until the diaphragm is lifted off the relief seat. This allows flow through the token relief. The relief valve on the Type 67CR, 67CFR, or 67CFSR is an elastomer plug that prevents leakage of air from the downstream to atmosphere during normal operation, thereby conserving

plant air. In some cases, it is desired to have a small amount of flow or a fixed bleed from the outlet chamber during normal operation. The fixed bleed option is used in these applications. For example, if the regulator is installed on equipment that at times has no flow demand but is expected to backflow on loss of inlet pressure, then the fixed bleed would be used.

Overpressure Protection

The 67C Series regulators have maximum outlet pressure ratings that are lower than their maximum inlet pressure ratings. A pressure relieving or pressure limiting device is needed if inlet pressure can exceed the maximum outlet pressure rating.

Types 67CR, 67CFR, 67CFSR have a low capacity internal relief valve for minor seat leakage only. Other overpressure protection must be provided if the maximum inlet pressure can exceed the maximum pressure rating of the downstream equipment or exceeds the maximum outlet pressure rating of the regulator.

67C Series

Installation

Note

If the regulator is shipped mounted on another unit, install that unit according to the appropriate instruction manual.



WARNING

Personal injury, property damage, equipment damage, or leakage due to escaping gas or bursting of pressure-containing parts may result if this regulator is over-pressured or is installed where service conditions could exceed the limits given in the specifications, or where conditions exceed any ratings of the adjacent piping or piping connections. To avoid such injury or damage, provide pressure-relieving or pressure-limiting devices (as required by the appropriate code, regulation, or standard) to prevent service conditions from exceeding those limits.



WARNING

The internal relief valve of the Type 67CR, 67CFR, or 67CFSR does not provide full overpressure protection. The internal relief valve is designed for minor seat leakage only. If maximum inlet pressure to the regulator exceeds maximum pressure ratings of the downstream equipment or exceeds maximum allowable outlet pressure of the regulator, additional overpressure protection is required.



WARNING

A regulator may vent some gas to the atmosphere. In hazardous or flammable gas service, vented gas may accumulate and cause personal injury, death, or property damage due to fire or explosion. Vent a regulator in hazardous gas service to a remote, safe location away from air intakes or any hazardous area. The vent line or stack opening must be protected against condensation or clogging.

Before installing a Type 67C, 67CR, 67CF, 67CFR, 67CFS, or 67CFSR regulator, be sure the installation complies with the following installation guidelines:

1. Regulator operation within ratings does not preclude the possibility of damage from debris in the lines or from external sources. Regulators should be inspected for damage periodically and after any overpressure condition.
2. Only personnel qualified through training and experience should install, operate, and maintain a regulator. Make sure that there is no damage to or foreign material in the regulator. Also ensure that all tubing and piping is free of debris.
3. Install the regulator so that flow is from the IN to the OUT connection as marked on the regulator body.
4. For best drainage, orient the drain valve (key 2) to the lowest possible point on the dripwell (key 5). This orientation may be improved by rotating the dripwell with respect to the body (key 1).
5. A clogged spring case vent hole may cause the regulator to function improperly. To keep this vent hole from being plugged (and to keep the spring case from collecting moisture, corrosive chemicals, or other foreign material) orient the vent to the lowest possible point on the spring case or otherwise protect it.

Inspect the vent hole regularly to make sure it is not plugged. Spring case vent hole orientation may be changed by rotating the spring case with respect to the body. A 1/4-inch NPT spring case vent may be remotely vented by installing obstruction-free tubing or piping into the vent. Protect the remote vent by installing a screened vent cap on the remote end of the vent pipe.
6. For use in regulator shutdown, install upstream block and vent valves and downstream block and vent valves (if required), or provide some other suitable means of properly venting the regulator inlet and outlet pressures. Install a pressure gauge to monitor instruments on startup.
7. Apply a good grade of pipe compound to the male pipe threads before making connections, making sure not to get the pipe compound inside the regulator.
8. Install tubing fitting or piping into the 1/4-inch NPT inlet connection on the body (key 1) and into the 1/4-inch NPT body outlet connection.
9. The second 1/4-inch NPT outlet can be used for a gauge or other use. If not used, it must be plugged.

Installing a 67CF Series Regulator in an Existing Installation

When installing a 67CF Series regulator in an existing installation, it may be necessary to use spacers (key 34, figure 9) to adapt the installation. If the mounting bolts are too long, place a spacer on the bolt (see figure 9). To be sure the regulator is secure, the bolts should have at least two full threads of engagement.

Startup and Adjustment

Key numbers are referenced in figure 3, 4, or 5.

1. With proper installation completed and downstream equipment properly adjusted, slowly open the upstream and downstream shutoff valve (when used) while using pressure gauges to monitor pressure.



WARNING

To avoid personal injury, property damage, or equipment damage caused by bursting of pressure containing parts or explosion of accumulated gas, never adjust the control spring to produce an outlet pressure higher than the upper limit of the outlet pressure range for that particular spring. If the desired outlet pressure is not within the range of the control spring, install a spring of the proper range according to the diaphragm parts maintenance procedure.

2. If outlet pressure adjustment is necessary, monitor outlet pressure with a gauge during the adjustment procedure. The regulator is adjusted by loosening the locknut (key 19), if used, and turning the adjusting screw or handwheel (key 18) clockwise to increase or counterclockwise to decrease the outlet pressure setting. Retighten the locknut to maintain the adjustment position.

Shutdown

First, close the nearest upstream block valve and then close the nearest downstream block valve (when used). Next, open the downstream vent valve. Since the regulator remains open in response to the

decreasing downstream pressure, pressure between the closed block valves will be released through the open vent valve.

Maintenance

Regulator parts are subject to normal wear and must be inspected and replaced as necessary. The frequency of inspection and replacement of parts depends on the severity of service conditions and applicable codes and government regulations. Open the Type 67CF, 67CFR, 67CFS, or 67CFSR drain valve (key 2) regularly to empty accumulated liquid from the dripwell (key 5).

Note

If sufficient clearance exists, the body (key 1) may remain mounted on other equipment or in a line or panel during maintenance unless the entire regulator will be replaced.



WARNING

To avoid personal injury, property damage, or equipment damage caused by sudden release of pressure or explosion of accumulated gas, do not attempt any maintenance or disassembly without first isolating the regulator from system pressure and relieving all internal pressure from the regulator.

Type 67C and 67CR

Trim Maintenance

Key numbers are referenced in figures 3 and 8.

1. Remove four bottom plate screws (key 3) from the bottom plate (key 39) and separate the bottom plate and O-ring (key 4) from the body (key 1).

2. Inspect the removed parts for damage and debris. Replace any damaged parts.

3. To remove the valve cartridge assembly, grasp the end of cartridge and pull it straight out of body (key 1). Replace with new cartridge assembly. The cartridge assembly may be disassembled and parts may be cleaned or replaced. If the soft seat (key 15) was

67C Series

removed, make sure it is properly snapped into place before installing the valve cartridge assembly.

4. Check O-ring (key 14) for wear and replace, if necessary. Apply lubricant to the O-ring and place in the body. Align cartridge key to keyway in body and insert. Reinstall the O-ring (key 4), secure the bottom plate (key 39) with screws (key 3), and torque to 15 to 30 inch-pounds (1,9 to 3,9 N·m).

Diaphragm Maintenance

Key numbers are referenced in figure 3.

1. Back out the adjusting screw or handwheel (key 18) until compression is removed from the spring (key 17).

2. Remove the spring case screws (key 3) to separate the spring case (key 7) from the body (key 1). Remove the upper spring seat (key 20) and spring (key 17).

3. Remove the diaphragm assembly (key 16), inspect the diaphragm, and replace the assembly, if necessary.

4. Place the diaphragm assembly (key 16) on the body (key 1) as shown in figure 5. Push down on the diaphragm assembly to make sure the valve plug (key 11) strokes smoothly and approximately 1/16-inch (2 mm).

Note

In step 5, if installing a control spring of a different range, be sure to delete the spring range originally appearing on the label and indicate the new spring range.

5. Stack the control spring (key 17) and upper spring seat (key 20) onto the diaphragm assembly (key 16).

6. Install the spring case (key 7) on the body (key 1) with the vent oriented to prevent clogging or entrance of moisture. Install the six spring case screws (key 3) using a crisscross pattern and torque to 15 to 30 inch-pounds (1,9 to 3,9 N·m).

7. When all maintenance is complete, refer to the Startup and Adjustment section to put the regulator back into operation and adjust the pressure setting. Tighten the locknut (key 19) if used, and install the closing cap if used.

Types 67CF, 67CFR, 67CFS, and 67CFSR

Filter Element and Trim Maintenance

Key numbers are referenced in figures 4, 5, and 8.

1. Remove four dripwell screws (key 3) from the dripwell (key 5) and separate the dripwell and O-ring (key 4) from the body (key 1). The filter retainer (key 9), filter element (key 6), and gasket (key 26) may come off with dripwell. If not, remove these parts.

2. Inspect the removed parts for damage and debris. Replace any damaged parts. If a replacement is not available, the filter element may be cleaned.

3. To remove the valve cartridge assembly, grasp the end of cartridge and pull it straight out of body (key 1). Replace with new cartridge assembly. The cartridge assembly may be disassembled and parts may be cleaned or replaced. If the soft seat (key 15) was removed, make sure it is properly snapped into place before installing the valve cartridge assembly.

4. Check O-ring (key 14) for wear and replace, if necessary. Apply lubricant to the O-ring (key 14), then align cartridge key to keyway in body and insert. Reinstall the gasket (key 26), filter (key 6), and filter retainer (key 9). Reinstall the O-ring (key 4), secure the dripwell with screws (key 3), and torque to 15 to 30 inch-pounds (1,9 to 3,9 N·m).

Diaphragm Maintenance

Key numbers are referenced in figure 4.

1. Back out the adjusting screw or handwheel (key 18) until compression is removed from the spring (key 17).

2. Remove the six spring case screws (key 3) to separate the spring case (key 7) from the body (key 1). Remove the upper spring seat (key 20) and spring (key 17).

3. Remove the diaphragm assembly (key 16), inspect the diaphragm, and replace the assembly, if necessary.

4. Place the diaphragm assembly (key 16) on the body (key 1) as shown in figure 4. Push down on the diaphragm assembly to make sure the valve plug (key 11) strokes smoothly and approximately 1/16-inch (2 mm).

Note

In step 5, if installing a control spring of a different range, be sure to delete the spring range originally appearing on the label and indicate the new spring range.

5. Stack the control spring (key 17) and upper spring seat (key 20) onto the diaphragm assembly (key 16).

6. Install the spring case (key 7) on the body (key 1) with the vent oriented to prevent clogging or entrance of moisture. Install the six spring case screws (key 3) using a crisscross pattern and torque to 15 to 30 inch-pounds (1,9 to 3,9 N·m).

Note

On Types 67CFS and 67CFSR, lubricate the adjusting screw (key 18) thread to reduce galling of stainless steel.

7. When all maintenance is complete, refer to the Startup and Adjustment section to put the regulator back into operation and adjust the pressure setting. Tighten the locknut (key 19) if used, and install the closing cap if used.

Parts Ordering

When corresponding with the Fisher Sales Office or Sales Representative about this regulator, include the type number and all other pertinent information printed on the label. Specify the eleven-character part number when ordering new parts from the following parts list.

Parts List

Key	Description	Part Number
Parts Kits		
	Types 67C and 67CR - Includes valve cartridge assembly (contains keys 10, 11, 12, 13, 14, and 15), O-ring (key 4), diaphragm assembly (key 16), and four screws (key 3)	
	Type 67C (without relief)	
	Brass stem with nitrile plug	R67CX000012
	Aluminum stem with nitrile plug (NACE)	R67CX000N12
	Type 67CR (with relief)	
	Brass stem with nitrile plug	R67CRX00012
	Aluminum stem with nitrile plug (NACE)	R67CRX000N12
	Types 67CF, 67CFR, and 67CFSR - Includes valve cartridge assembly (contains keys 10, 11, 12, 13, 14, and 15), diaphragm assembly (key 16), O-ring (key 4), filter element (key 6), filter gasket (key 25), and four screws (key 3)	
	Type 67CF (without relief)	
	Brass stem with nitrile plug	R67CFX00012
	Aluminum stem with nitrile plug (NACE)	R67CFX000N12
	Type 67CFR (with relief)	
	Brass stem with nitrile plug	R67CFRX00012
	Aluminum stem with nitrile plug (NACE)	R67CFRX000N12
	Type 67CFSR (with relief)	
	Stainless steel stem with nitrile plug (NACE)	R67CFSRX0012
	Valve Cartridge Assembly Only	
	Type 67C, 67CR, 67CF, or 67CFR	
	Brass stem	
	With nitrile plug	T14121T0012
	With fluoroelastomer plug	T14121T0022

Key	Description	Part Number
Parts Kits (continued)		
Valve Cartridge Assembly Only (continued)		
Type 67C, 67CR, 67CF, or 67CFR (continued)		
	Aluminum stem	
	with nitrile plug	T14121T0042
	with nitrile plug (NACE)	T14121T0052
	Type 67CFS or 67CFSR	
	316 Stainless steel stem	
	with nitrile plug and O-rings (NACE)	T14121T0092
	with Fluoroelastomer plug and O-rings	T14121T0102
	with nitrile plug and Silicone O-rings	T14121T0112
1	Body	
	Type 67C or 67CR, Aluminum	T40643T0012
	Type 67CF or 67CFR, Aluminum	T80432T0012
	Type 67CFS or 67CFSR, Stainless steel	40C1867X012
2	Drain Valve	
	Type 67CF or 67CFR	
	Brass	1K418918992
	Aluminum	1K4189000B2
	18-8 Stainless steel	AH3946X0012
	Type 67CFS or 67CFSR	
	316 Stainless steel	AH3946X0032
3	Flange Screw	
	Type 67C, 67CR, 67CF, or 67CFR	
	Standard spring case and spring case with 1/4-inch NPT vent (10 required)	T13526T0012
	For wire seal	
	Flange Screw (9 required)	T13526T0012
	Flange Screw (1 required)	14B3987X012
	Type 67CFS or 67CFSR (10 required)	T13526T0042
4 ¹⁾	O-Ring	
	Type 67C or 67CR	
	Nitrile (NBR)	T14380T0012
	Fluoroelastomer (FKM)	T14380T0022
	Silicone (VMQ)	T14380T0032
	Type 67CF, 67CFR, 67CFS, or 67CFSR	
	Nitrile (NBR)	T14057T0012
	Fluoroelastomer (FKM)	T14057T0022
	Silicone (VMQ)	T14057T0032
5	Dripwell	
	Type 67CF or 67CFR	T21040T0012
	Type 67CFS or 67CFSR	20C1726X012
6 ¹⁾	Filter Element (Type 67CF, 67CFR, 67CFS, 67CFSR)	
	Cellulose(40 microns)(67CF, 67CFR Standard)	1F257706992
	Glass fiber (10 microns)	17A1457X012
	Stainless steel (40 microns)	
	(67CFS, 67CFSR Standard)	15A5967X022
7	Spring Case	
	Type 67C, 67CR, 67CF, or 67CFR, Aluminum	
	Drilled hole vent (standard)	T14070T0012
	1/4-inch NPT vent	T14070T0022
	Type 67CFS or 67CFSR, Stainless steel	20C1727X012
9	Filter Retainer	
	Type 67CF or 67CFR	T14052T0012
	Type 67CFS or 67CFSR	T14052T0022
10 ¹⁾ *	Valve Cartridge	T80434T0012
11 ¹⁾ *	Valve Plug	
	Type 67C, 67CR, 67CF, or 67CFR	
	Brass stem, nitrile plug	T14053T0012
	Aluminum stem, fluoroelastomer plug	T14053T0022
	Aluminum stem, nitrile plug	T14053T0032
	Type 67CFS or 67CFSR	
	Stainless steel stem, nitrile plug	T14053T0042
	Stainless steel stem, fluoroelastomer plug	T14053T0052

1. Recommended Spare Part

2. Valve cartridge assembly includes keys 10, 11, 12, 13, 14, and 15.

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Key	Description	Part Number
12 ^{a, 9}	Valve Spring Type 67C, 67CR, 67CF, or 67CFR Stainless steel Inconel (NACE) Type 67CFS or 67CFSR, Inconel (NACE)	T14105T0012 T14116T0012 T14116T0012 T14071T0012
13 ^{a, 9}	Valve Retainer	T14071T0012
14 ^{a, 9}	O-Ring Nitrile (NBR) Fluoroelastomer (FKM) Silicone (VMQ)	T14063T0012 T14063T0022 T14063T0032
15 ^{a, 9}	Soft Seat Nitrile (NBR) Fluoroelastomer (FKM)	T14055T0012 T14055T0022
16 ^(b)	Diaphragm Assembly Type 67C or 67CF (without relief) Nitrile (NBR) Fluoroelastomer (FKM) Type 67CR or 67CFR (with relief) Nitrile (NBR) Fluoroelastomer (FKM) Silicone (VMQ) Type 67CFS (without relief) Nitrile (NBR) Fluoroelastomer (FKM) Type 67CFSR (with relief) Nitrile (NBR) Fluoroelastomer (FKM) Silicone (VMQ)	T14119T0022 T14119T0042 T14119T0012 T14119T0032 T14119T0052 T14119T0062 T14119T0072 T14119T0082 T14119T0092 T14119T0102
17	Spring Type 67C, 67CR, 67CF, or 67CFR, Plated steel (standard) 0 to 20 psig (0 to 1,4 bar), Green stripe 0 to 35 psig (0 to 2,4 bar), Silver 0 to 60 psig (0 to 4,1 bar), Blue stripe 0 to 125 psig (0 to 8,6 bar), Red stripe Type 67CR or 67CFR (NACE), Inconel (NACE) 0 to 35 psig (0 to 2,4 bar), Silver stripe 0 to 60 psig (0 to 4,1 bar), Blue 0 to 125 psig (0 to 8,6 bar), Red Type 67CFS or 67CFSR, Inconel (NACE) 0 to 20 psig (0 to 1,4 bar), Green 0 to 35 psig (0 to 2,4 bar), Silver stripe 0 to 60 psig (0 to 4,1 bar), Blue 0 to 125 psig (0 to 8,6 bar), Red 0 to 150 psig (0 to bar), Black	T14130T0012 T14059T0012 T14058T0012 T14060T0012 T14113T0012 T14114T0012 T14115T0012 10C1729X012 T14113T0012 T14114T0012 T14115T0012 10C1730X012
18	Adjusting Screw Type 67C, 67CR, 67CF, or 67CFR For standard spring case Square head (standard) Handwheel Wire seal (not shown) For spring case with 1/4-inch NPT vent Square head for closing cap Handwheel Wire seal (not shown) Type 67CFS or 67CFSR Square head with or without closing cap Handwheel	T14061T0012 T14102T0012 T14104T0012 T14101T0012 T14103T0012 T14198T0012 T14101T0022 T14103T0012
19	Locknut Type 67C, 67CR, 67CF, or 67CFR Type 67CFS or 67CFSR	1A946324122 1A9463X0042
20	Upper Spring Seat Type 67C, 67CR, 67CF, or 67CFR Type 67CFS or 67CFSR	T14051T0012 10C1725X012
22	Pressure Gauge (not shown) Brass 0 to 30 psig/0 to 2 bar/0 to 0,2 MPa 0 to 60 psig/0 to 4 bar/0 to 0,4 MPa 0 to 160 psig/0 to 11 bar/0 to 1,1 MPa	11B8579X022 11B8579X032 11B8579X042

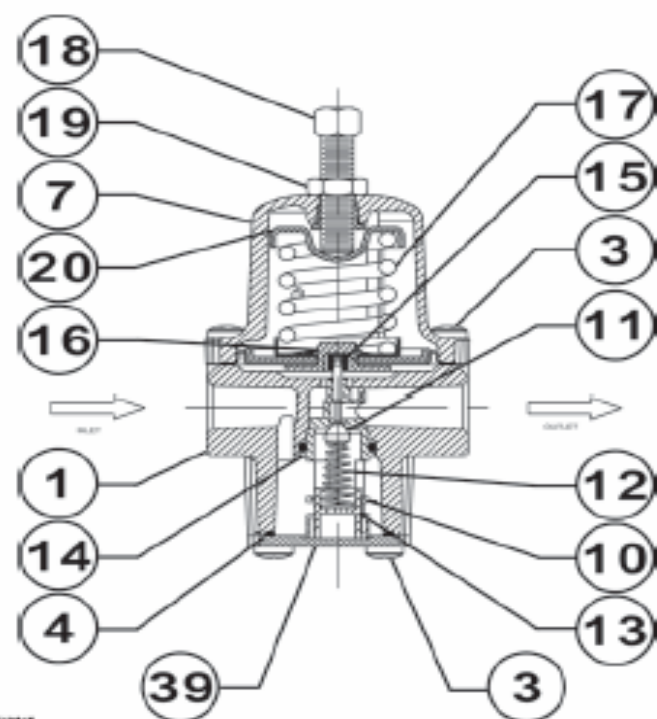
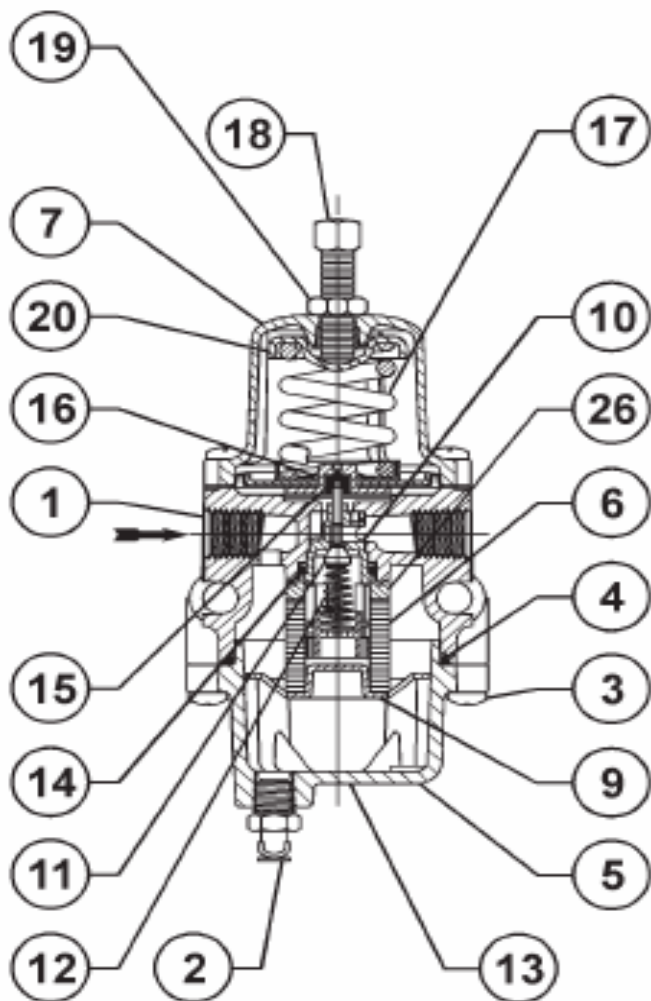


Figure 3. Type 67C or 67CR Assembly Drawing

Key	Description	Part Number
22	Pressure Gauge (not shown) (continued) Stainless Steel 0 to 30 psig/0 to 2 bar/0 to 0,2 MPa 0 to 60 psig/0 to 4 bar/0 to 0,4 MPa 0 to 160 psig/0 to 11 bar/0 to 1,1 MPa	11B9639X012 11B9639X022 11B9639X032
23	1/4-inch Pipe Plug (not shown) Socket head, steel Hex head, stainless steel	1C333528992 1A767535072
24	Tire Valve (not shown)	1H447099022
25	Information Label	-----
26 ^(b)	Filter Gasket Nitrile (NBR) Fluoroelastomer (FKM)	T14081T0012 T14081T0022
30	NACE Tag (not shown)	19A6034X012
31	Panel Mounting Nut	10B2657X012
32	Wire Seal (not shown)	1U7581000A2
33	Closing Cap, resin	23B9152X012
34	Spacer (2 required) (figure 9) Type 67C, 67CR, 67CF, or 67CFR Type 67CFS or 67CFSR	T14123T0012 T14123T0022
37	Thrust Washer (Type 67CF, 67CFR, 67CFS, or 67CFSR) Nitrile (NBR) Fluoroelastomer (FKM)	T14196T0012 T14196T0022
39	Bottom Plate Standard construction NACE construction	T14341T0012 T14341T0032
45	Screen Vent	0L078343062

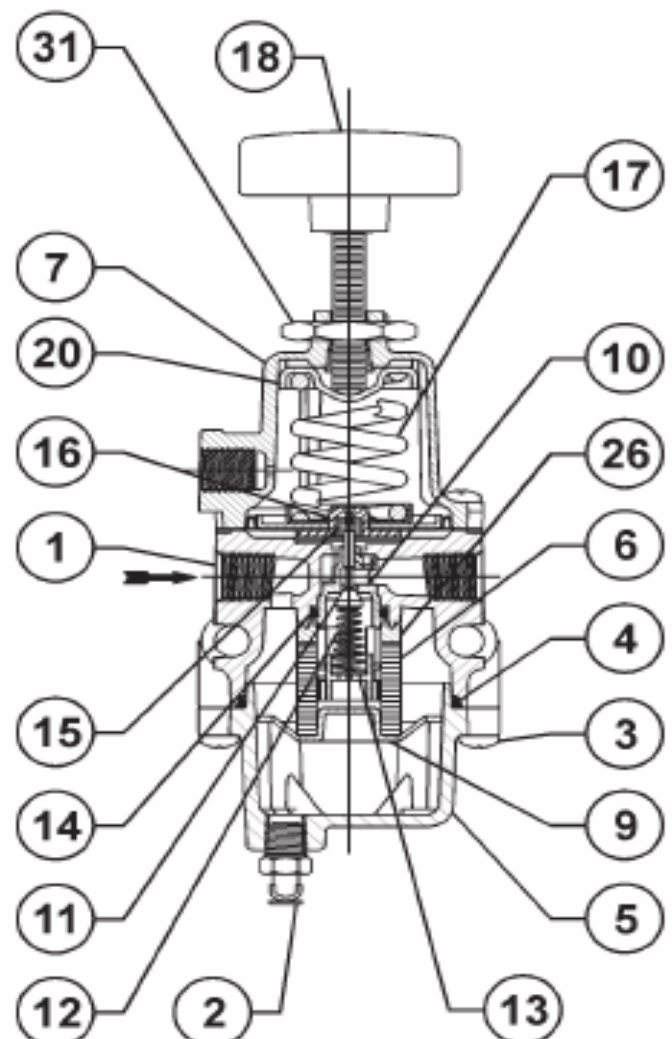
Parts for Mounting on Fisher 2500 Series Controller

35	Mounting adaptor plate (not shown)	T21043T0012
36	O-ring (not shown)	1E591406992
38	Gasket (not shown)	1C898603012



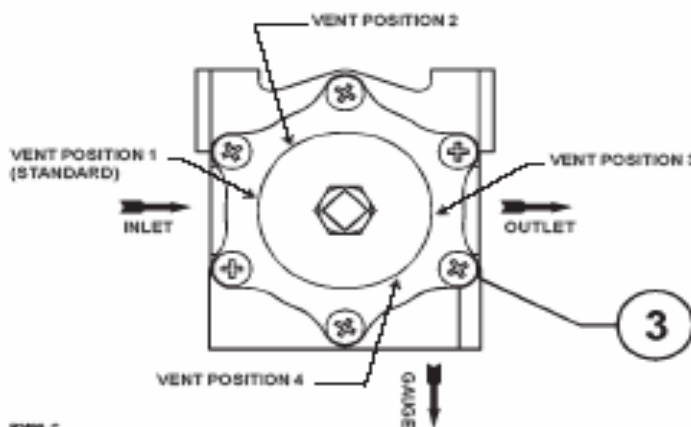
K099

STANDARD CONSTRUCTION



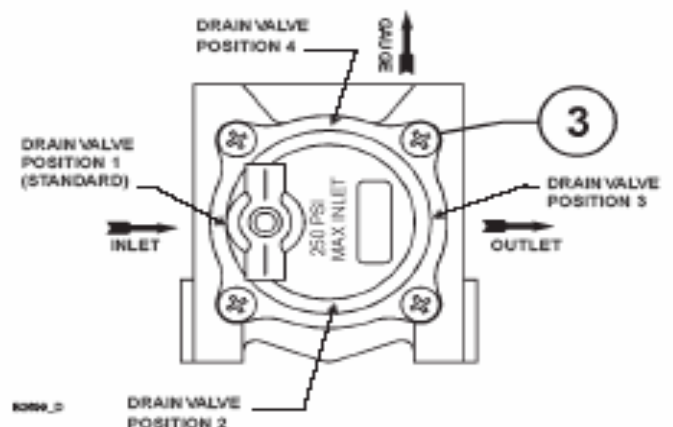
K100

PANEL MOUNT OPTION
(INCLUDES HANDWHEEL, MOUNTING NUT,
AND 1/4-INCH NPT SPRING CASE VENT)



K099_C

SPRING CASE VENT POSITIONS



K099_D

DRAIN VALVE POSITIONS

Figure 4. Type 67CF or 67CFR Assembly Drawings

67C Series

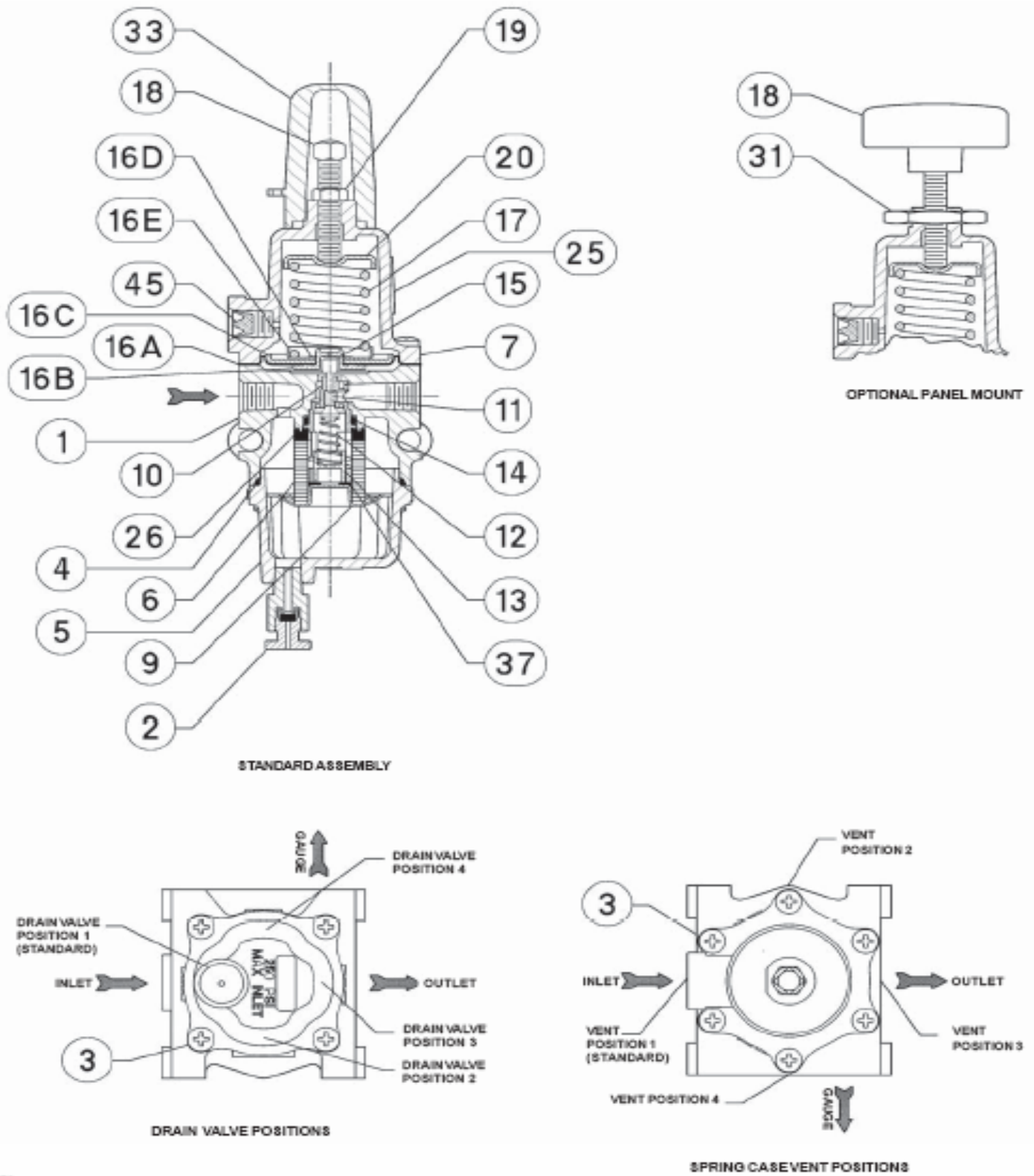


Figure 5. Type 67CFS or 67CF SR Assembly Drawing

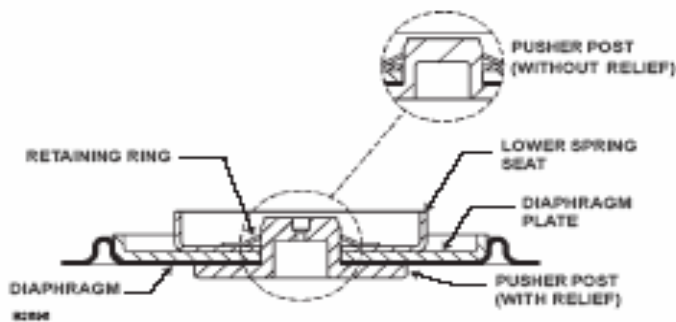


Figure 6. Diaphragm Assembly (Key 16)

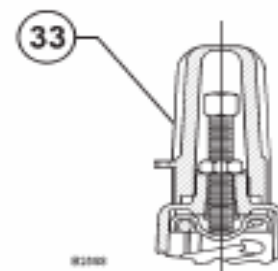
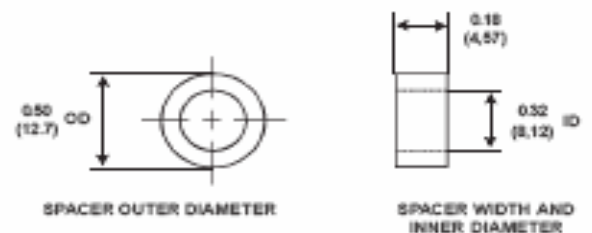


Figure 7. Optional Closing Cap
(Only Available with the 1/4-inch Spring Case Vent)



SPACER OUTER DIAMETER

SPACER WIDTH AND INNER DIAMETER

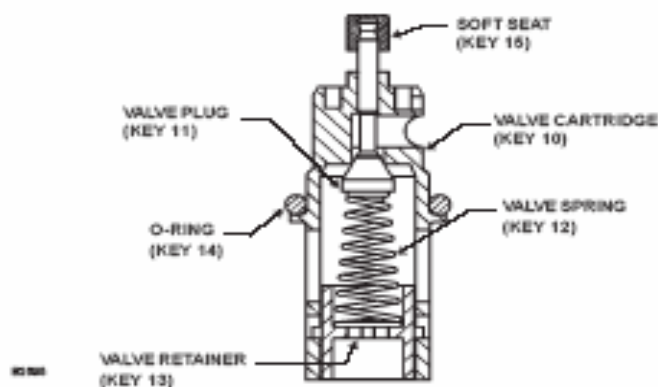


Figure 8. Valve Cartridge Assembly

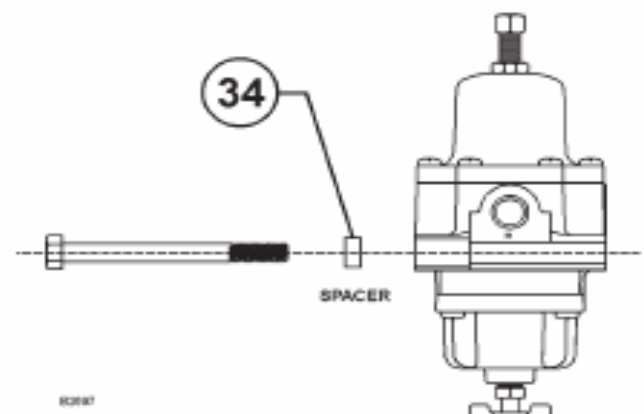


Figure 8. Spacer Diameter and Assembly
(For Installing in an Existing Installation
if the Mounting Bolts are too Long)

67C Series

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Singapore 128461



BASE ASSEMBLIES

ACTION:

Indirect throttle; Pilot Output Pressure (Yellow) decreases with temperature rise.

WORKING PRESSURE (sensing element):

psi	kg/cm ²	
500	35.15	max. without Separable Socket
4000	281.22	max. with Separable Socket
10000	703.77	max. with Special Separable Socket

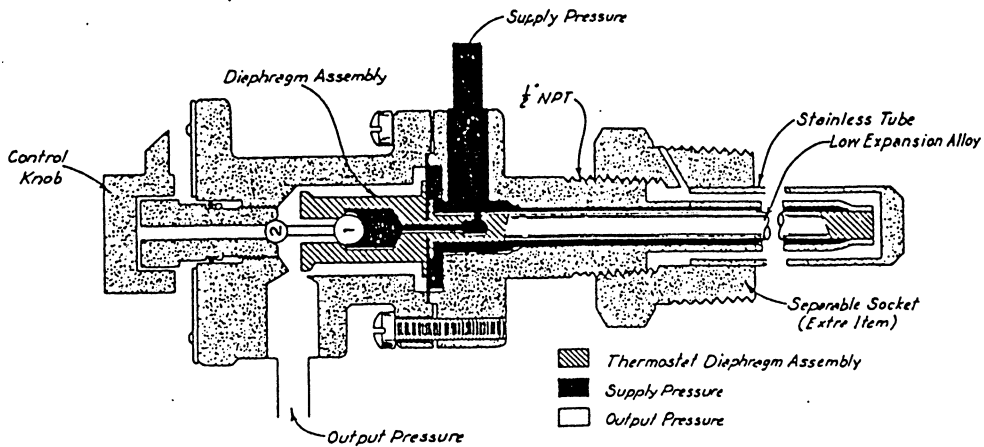
Separable Socket is an extra price item and must be specified on order, if desired. See page 6 for available sockets.

THROTTLING RANGE:

- T12—1¾ lbs./°F, .22 kg/cm²/°C
- T18—2½ lbs./°F, .31 kg/cm²/°C
- HT12—2½ lbs./°F, .31 kg/cm²/°C
- HT18—3¾ lbs./°F, .47 kg/cm²/°C

SUPPLY PRESSURE:

- 5 lb. min. to 30 lb. max.
- .35 kg/cm² to 2.11 kg/cm² max.



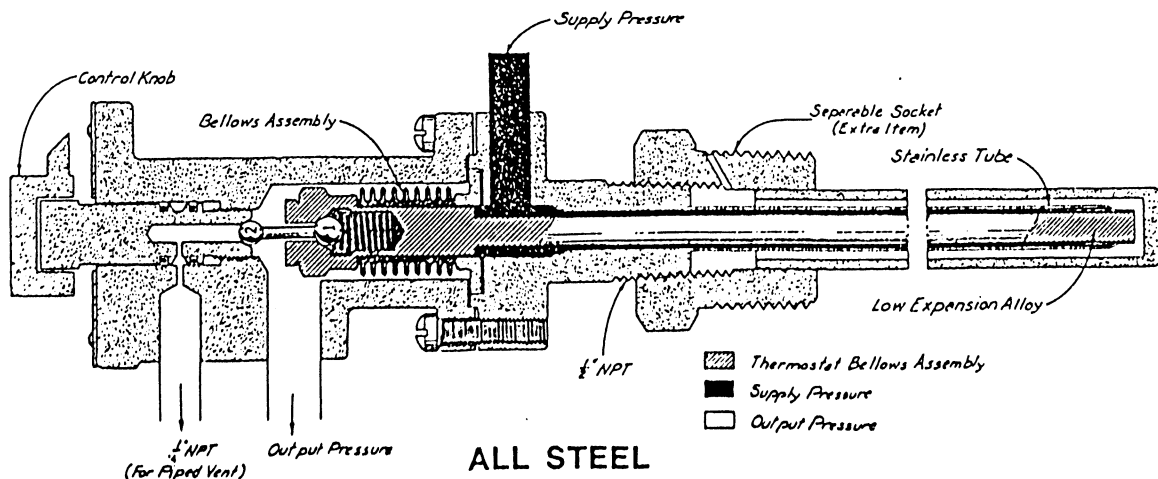
T12 or T18 BASE ASSEMBLY (for temperatures -30°F to 400°F, -34°C to 240 °C)

OPERATION (Either Assembly):

Assume the set temperature of the Thermostat is above that of the system. The Vent at Ball 2 is closed and the Inlet at Ball 1 is open. Output Pressure (Yellow) is being sent to any Pilot or Motor Valve.

As the temperature rises in the system, the Stainless Tube increases in length to move the Thermostat Diaphragm (or Bellows) Assembly in a direction to first close the seat at Ball 1 (Red to Yellow) and open the seat at Ball 2 (Yellow to Atmosphere). Output Pressure (Yellow) decreases to cause the desired Pilot or Motor Valve action.

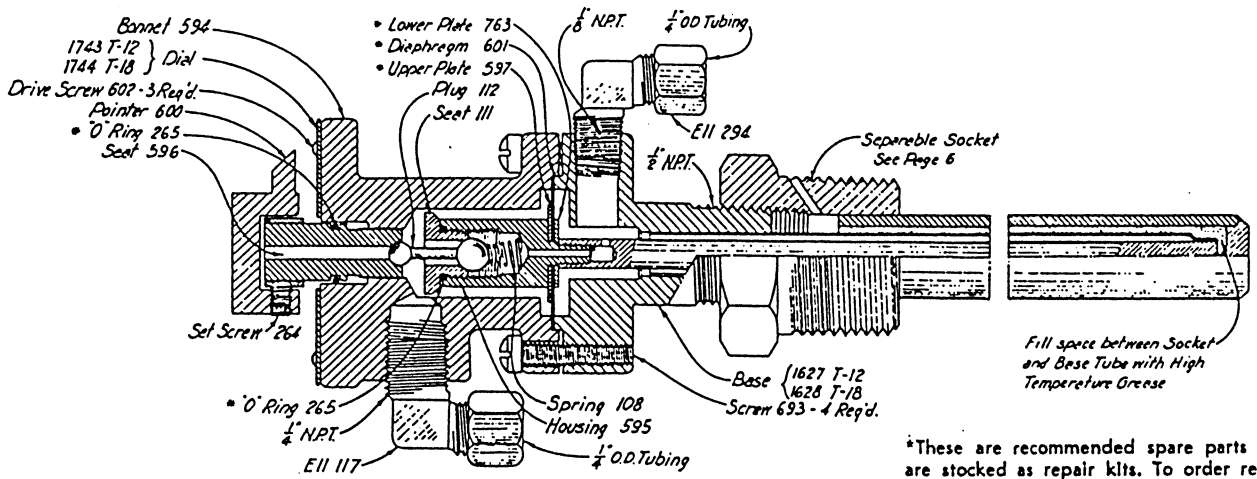
As the temperature decreases, the action is reversed to increase Output Pressure (Yellow).



ALL STEEL

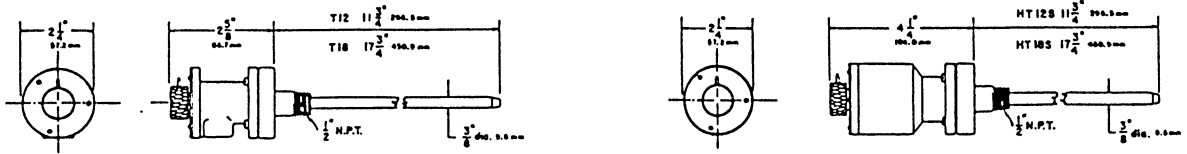
HT12 or HT18 BASE ASSEMBLY (for temperatures -30°F to 750°F, -34°C to 399°C)

PARTS REFERENCE



*These are recommended spare parts and are stocked as repair kits. To order repair kit specify, "T12B Repair Kit."

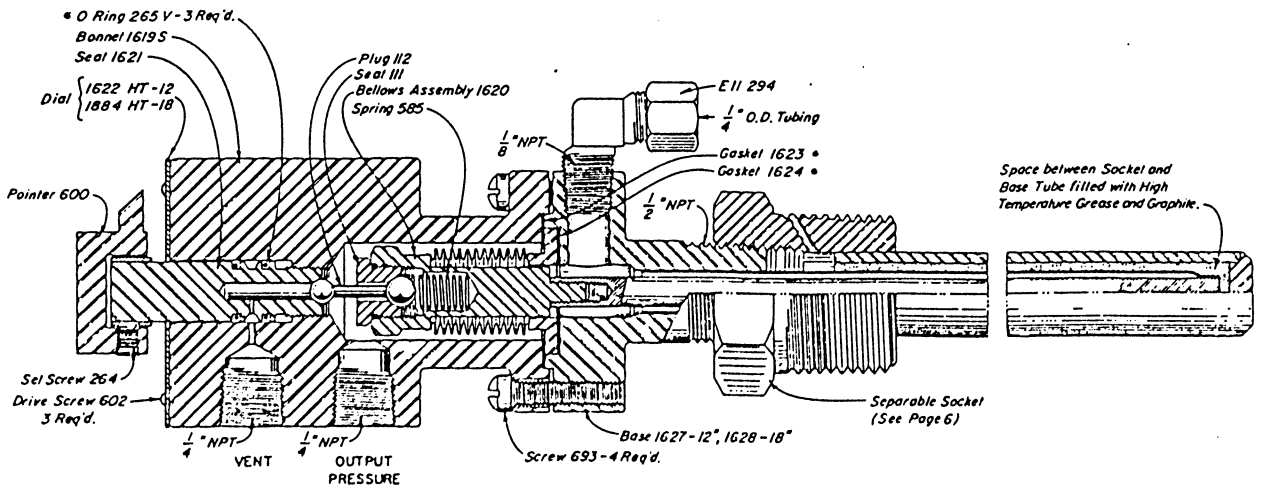
T12 or T18 BASE ASSEMBLY



T12 & T18

HT12 & HT18

BASE ASSEMBLY DIMENSIONS



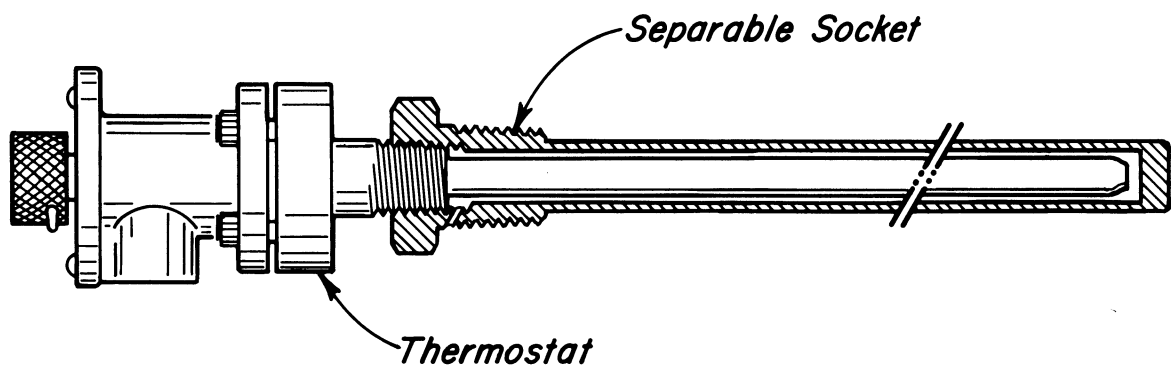
* These are recommended spare parts and are stocked as repair kits. To order, Specify, "HT" Repair Kit.

ALL STEEL

HT12 or HT18 BASE ASSEMBLY

APPLICATION:

Increases working pressure of Thermostat Sensing Element. All Separable Sockets are filled with high temperature grease. Allows Thermostat removal without losing vessel pressure.



SEPARABLE SOCKETS AVAILABLE:

CAT. NO.	MALE THD. SIZE, NPT	MODEL NUMBER	MATERIAL	W.P. p.s.i.g.	W.P. kg/cm ²
HCA	1"	SS- 4	STL	4,000	281.23
HCB	1"	SS- 6	STL	4,000	281.23
HCC	1"	SS- 12	STL	4,000	281.23
HCD	1"	SS- 18	STL	4,000	281.23
HCE	1"	SS- 12SS	SS6	4,000	281.23
HCF	1"	SS- 18SS	SS6	4,000	281.23
HCG	1"	S-SS- 12SS	SS6	7,000	492.15
HCH	3/4"	3/4SS- 12	STL	4,000	281.23
HCI	3/4"	3/4SS- 18	STL	4,000	281.23
H CJ	3/4"	3/4SS- 12SS	SS6	4,000	281.23
HCK	3/4"	3/4SS- 18SS	SS6	4,000	281.23
HCL	3/4"	3/4SS- 4	STL	4,000	281.23
HCM	3/4"	3/4SS- 6	STL	4,000	281.23
H CN	1"	SS- 6SS	SS6	4,000	281.23
HCP	3/4"	SS- 4SS	SS6	4,000	281.23
HCR	3/4"	S-SS- 12SS	SS6	5,000	351.53
HCS	1"	S-SS -6SS	SS6	7,000	492.15

ACTION

Indirect throttle; Pilot Output Pressure (Yellow) decreases with temperature rise.

APPLICATION:

Used to control a set temperature in indirect heaters, emulsion treaters, reboilers, steam generators, heat exchangers, cooler shutter controls, and salt bath heaters.

WORKING PRESSURE (sensing element):

psig	kg/cm ²
500	35.15 max. without Separable Socket.
4000	281.23 max. with Separable Socket.
7000	492.15 max. with Special Separable Socket.

Separable Socket is an extra price item and must be ordered separately, if desired. To order Separable Sockets refer to Table of Contents

TEMPERATURE RANGE:

T 12, T 18	-30°F minimum TO 400°F maximum
	-34°C minimum to 204°C maximum
HT 12, HT 18	-30°F minimum to 750°F maximum
	-34°C minimum to 399°F maximum

OPERATION:

These Thermostat Base Assemblies consist of a STAINLESS TUBE for monitoring the changing temperature, which is connected by a Low Expansion Alloy Rod to a DIAPHRAGM or BELLOWS ASSEMBLY. The differential pressure across the Diaphragm or Bellows combined with changes in the length of the STAINLESS TUBE throttle a PILOT PLUG seat. The PILOT PLUG consists of two stainless balls rigidly connected together. The seat at BALL 1 is the Supply Pressure inlet (Violet to Yellow). The seat at BALL 2 is the pressure vent (Yellow to Atmosphere).

Assume the temperature of the Thermostat is above that of the system. The vent at BALL 2 is closed and the inlet at BALL 1 is open. Output Pressure (Yellow) is being sent to any Pilot or Motor Valve.

As the temperature rises in the system, the STAINLESS TUBE increases in length to move the Thermostat Diaphragm (or Bellows) Assembly in a direction to first close the seat at BALL 1 (Violet to Yellow) and open the seat at BALL 2 (Yellow to Atmosphere). Output Pressure (Yellow) decreases to cause the desired Pilot or Motor Valve action.

As the temperature decreases, the action is reversed to increase Output Pressure (Yellow).

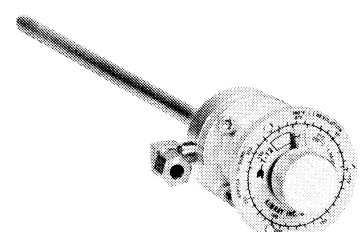
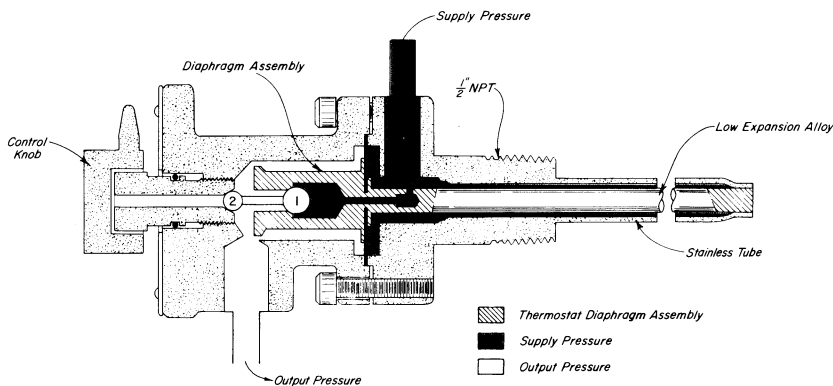
SUPPLY PRESSURE:

5 to 30 psig
.35 to 2.11 kg/cm²

RESPONSE RANGE:

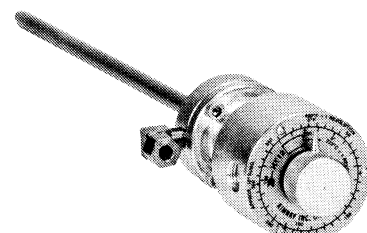
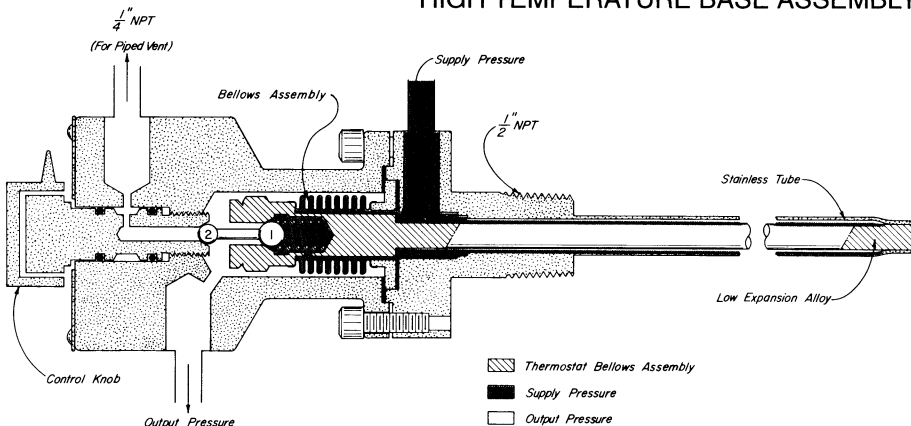
T 12	- 1.75 psig/°F, .22 kg/cm ² /°C
T 18	- 2.50 psig/°F, .31 kg/cm ² /°C
HT 12	- 2.50 psig/°F, .31 kg/cm ² /°C
HT 18	- 3.75 psig/°F, .47 kg/cm ² /°C

LOW TEMPERATURE BASE ASSEMBLY



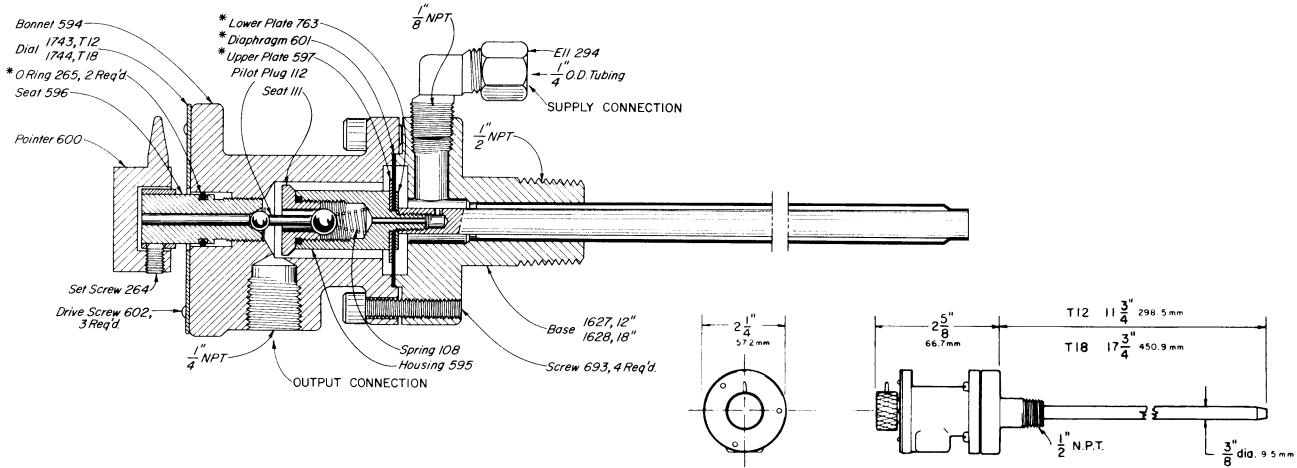
T 12

HIGH TEMPERATURE BASE ASSEMBLY



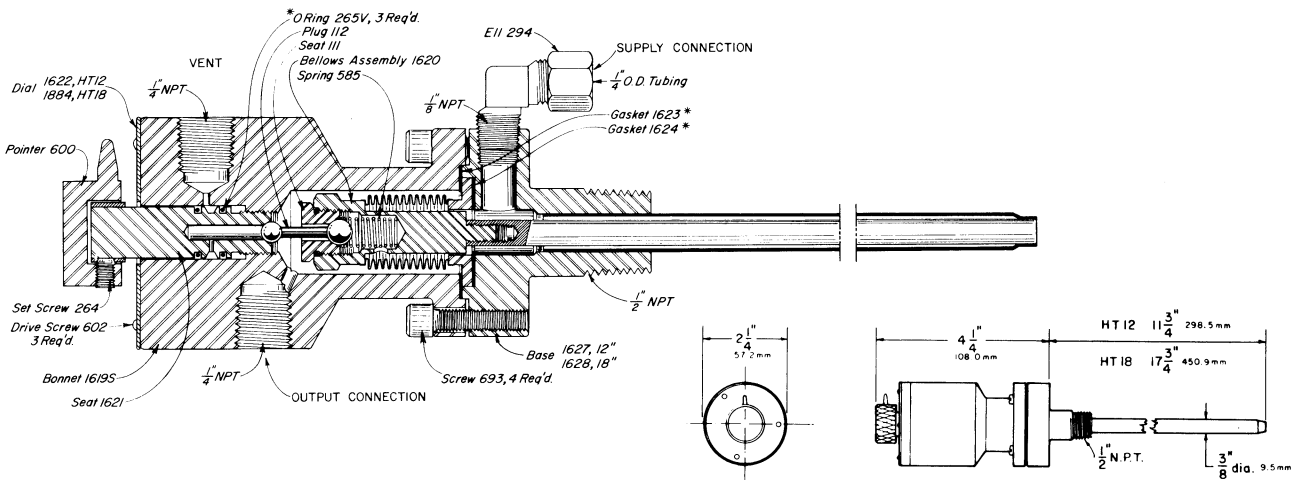
HT 12

T 12/18
DUCTILE
500 lbs. W.P.
-30°F to 400°F, -34°C to 204°C



T 12 & T 18 DIMENSIONS

HT 12/18
STEEL
500 lbs. W.P.
-30°F to 750°F, -34°C to 399°C



HT 12 & T 18 DIMENSIONS

INDIRECT BASE ASSEMBLIES AVAILABLE:
DUCTILE or STEEL

CAT. NO.	BASE ASSEMBLY	MAX. TEMP. °F	MAX. TEMP. °C
HAA	T 12	400	204
HAB	T 18	400	204
HBA	HT 12	750	399
HBB	HT 18	750	399

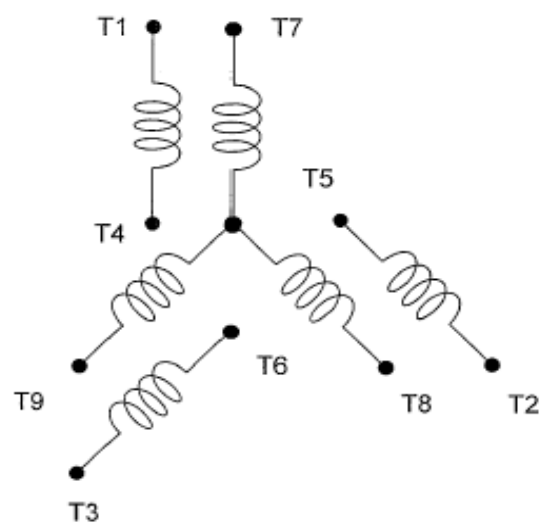
*These are recommended spare parts and are stocked as repair kits. To order repair kit, specify; "T12BRepair Kit, RLB" or; "HT Repair Kit, RLQ."

Separable Sockets are available at extra cost, refer to Table of Contents for ordering.

DATE:
June 17, 2005

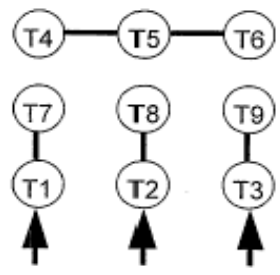
CONNECTION DIAGRAM

CATALOG NO.:
EP0026

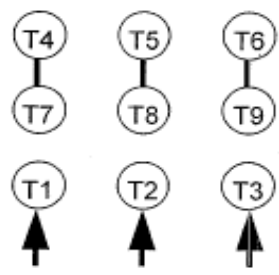


SCHEMATIC - 2Y/Y CONNECTION

ACROSS THE LINE CONNECTION



**LINE
230 VOLT CONNECTION**



**LINE
460 VOLT CONNECTION**



OPERATION
&
MAINTENANCE
MANUAL
FOR
THREE PHASE
INDUCTION
MOTORS

TECO-Westinghouse Motor Company
5100 North IH-35
Round Rock, Tx. 78681

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1. INTRODUCTION

This and the following instruction address the more common situations encountered in motor installation, operation and maintenance. For the TWMC motor warranty to be and to remain in effect, the motor must be installed and operated in strict accordance with the outline drawing, motor nameplates and these instructions and must not be altered or modified in any unauthorized manner.

During the installation and operation of motors in heavy industrial applications there is a danger of live electrical parts and rotating parts. Therefore to prevent injury and/or damage the basic planning work for installation, transportation, assembly, operation, etc... needs to be done and checked by authorized and competent personnel only.

Since these instructions cannot cover every eventuality of installation, operation and maintenance, the following points should be considered and checked.

- The technical data and information on permissible use such as assembly, connection, ambient and operating conditions given in the related catalogue, operating instructions, nameplates and other production documentation.
- The general erection and safety regulations.
- The local and plant-specific specifications and requirements.
- The proper use of transport, lifting devices and tools.
- The use of personal protective equipment.

Following indications should be observed when reading these instructions.

Safety instructions are marked as follows:



Warning of electric hazards for personnel.



Warning of dangers for personnel.

ATTENTION! Warning of damage for the motor or installation.
--

2. ACCEPTING, INSPECTION, STORAGE, TRANSPORTATION

Inspection upon receipt

Check to following points upon receipt:

- Are the nameplate ratings identical with what you ordered?
- Are dimensions and color in compliance with your specifications?
- Are the nameplate ratings for space heater, thermal protector, temperature detector, etc. identical with what you ordered?
- Is there any damage?
- Are all accessories and accompanying instruction manuals in good order?
- Please ensure that the arrow head indicator really indicates direction of rotation.
- If there are any specific requirements, please ensure they are in conformity with your specifications.

2.1 Storage

When motors are not in operation, the following precautionary measures should be undertaken to assure best performance.

2.2 Place

- (a) High and dry, well ventilated without direct sun, dust or corrosive gas.
- (b) Not located near to a boiler or freezer.
- (c) Entirely free from vibration and easy for movements.
- (d) Motors should be put on pallets to prevent moisture.

2.3 Moisture prevention

Since moisture can be very detrimental to electrical components, the motor temperature should be maintained about 3°C above the dew point temperature by providing either external or internal heat. If the motor is equipped with space heaters, they should be energized at the voltage shown by the space heater nameplate attached to the motor. Incandescent light bulbs can be placed within the motor to provide heat. However, if used, they must not be allowed to come in contact with any parts of the motor because of the concentrated hot spot that could result.

2.4

Even during storage, the insulation resistance should be kept above the specified values.

- (a) For measurement of insulation resistance and acceptable standard values, please refer to measures stated in 3.1.2 "Measurement of insulation resistance".
- (b) Insulation resistance test should be performed once every three months.

2.5

If the motor is not in operation for a long period (one week and above) after installation or has been in operation but stopped for a period of time, the following precautions must be taken.

- (a) Protect the motor as measures stated in 2.2.3.
- (b) Insulation resistance test should be performed as stated in 2.2.4.

2.6 Bearing protection

- (a) If the motor has been provided with a shaft shipping brace to prevent shaft movement during transit, it must be removed before operating the motor. It is very important that this brace be re-installed exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported. This prevents axial rotor movement that might damage the bearings.
- (b) Motors equipped with sleeve bearings are shipped from the factory with the bearing oil reservoirs drained. In storage, the oil reservoirs should be properly filled to the center of the oil level gauge with a good grade of rust inhibiting oil. To keep the bearing journals well oiled and to prevent rusting, the motor shaft should be rotated several revolutions about every month ensuring the shaft does not come to rest in its original position. While the shaft is rotating, it should be pushed to both extremes of the endplay.
- (c) Motors with anti-friction bearings are properly lubricated with the correct grade of grease at the factory and no further greasing is required in storage. The shaft should be rotated several revolutions about every month to maintain proper distribution of the grease within the bearings.
- (d) Tilt-pad bearings are a type of sleeve bearing used in special design applications. Due to the nature of this bearing, a loose oil ring for delivering lubricant cannot be provided. Therefore, during the storage interval, oil must be periodically manually introduced into the pads and housing to prevent the occurrence of oxidation of the precision machined components.
 - (1) Remove the pipe plug from the bearing cap located above the tilt-bearing shell.
 - (2) Pour in approximately one cup of oil every month and rotate the shaft a few revolutions about every two (2) weeks.
 - (3) For long periods of storage, the oil that accumulates in the housing should be removed.

ATTENTION!

Care should be taken to keep parts such as fitting surfaces, key, shaft extension and axial central hole from any collision with foreign matter. Grease should also be generously applied to prevent rusting.

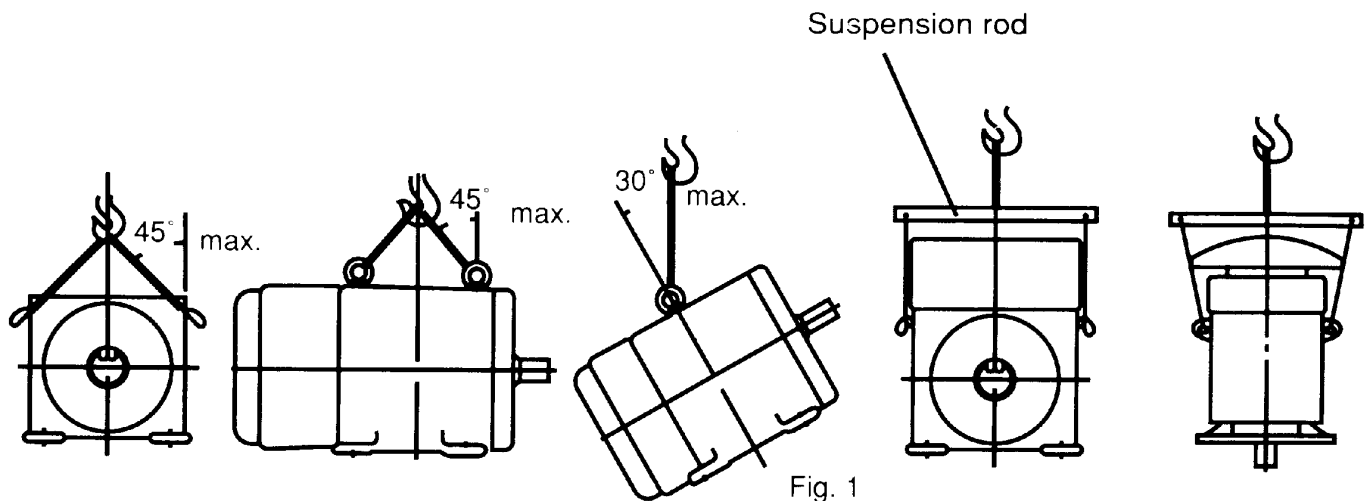
2.7 Transportation

To keep the rotating parts of motors from moving, thus preventing damage and scratching during transportation, they should be held securely with a locking device. Remove all transit clamps before operating the motor. It is very important that this device be reinstalled exactly as it was originally, before the motor is moved from storage or any time when the motor is being transported. The vertical mounting type motors should be transported in the vertical position.



Do not use the hoisting hook/eyebolts to lift more than the motor itself. They are designed to support the motor only. Make sure the hoisting hook is correctly attached to the eyebolt(s)/lug(s) are fully screwed in before hoisting. Also note such parts as fan cover, ventilation box, bracket, slip-ring, etc. may have their own hoisting lugs which can only carry their own weight. Nothing extra should be attached while hoisting.

Do not twist the steel wires and make sure the eyebolts have been firmly screwed and the sling angle is correct.



3 INSTALLATION

Site and environment for motor installation

3.1.1

Standard environment and site conditions for the installation of motors are usually set as follows:

- Ambient temperature: $-10\sim 40^{\circ}\text{C}$
- Humidity: Relative humidity below 90%RH for totally enclosed types, and below 80%RH for semi-enclosed types.
- Elevation: below 1000 meters or 3300 feet.
- Harmful gases, liquids, dusts, high moisture should be absent.
- Foundations should be strong and free of vibration.

If there are any special environmental conditions, please inform TWMC prior to ordering.

3.1.2 Ventilation and space

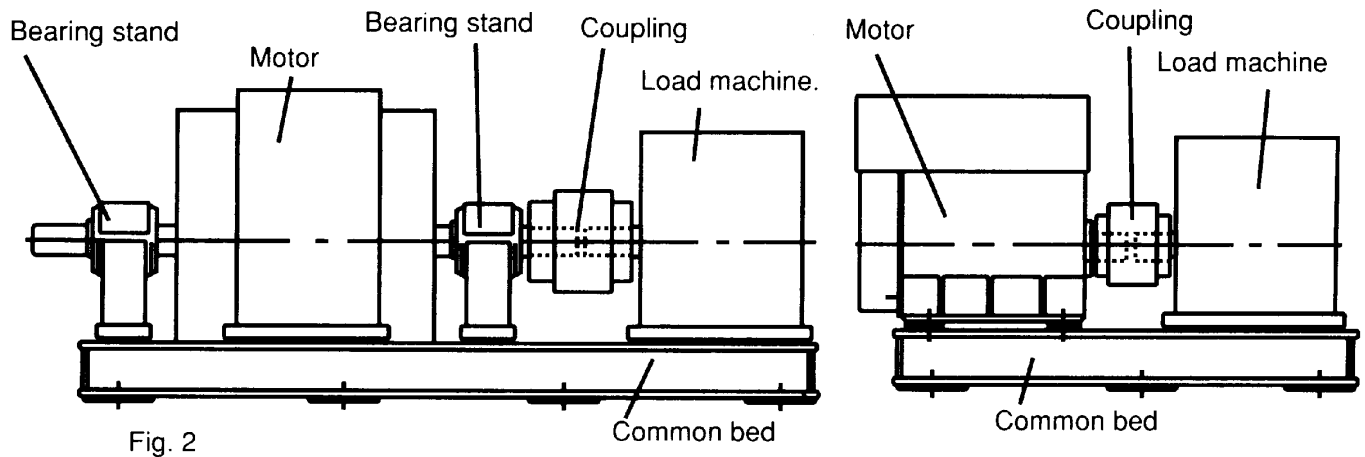
- Installation area should be well ventilated.
- The installation space should be large enough to facilitate heat dissipation and maintenance.

3.2 Foundation

3.2.1

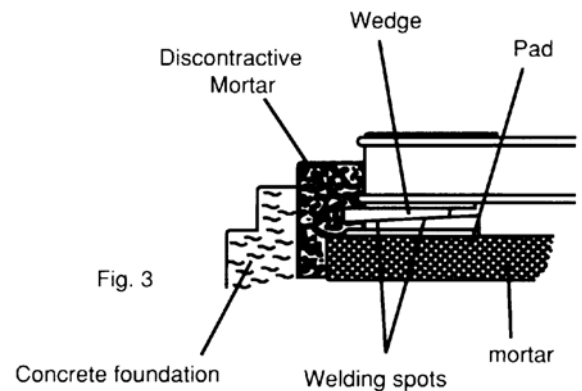
Use rigid and solid sole plate or common bed as foundation.

For best motor performance, it is advisable to use a sole plate or common bed, particularly when using a shaft coupling.



3.2.2 Installation

- Select an appropriate foundation surface for the sole plate or common bed, which will be, considered the ultimate level.
- Align the position of the common bed with reference to that level.
- Align the level accuracy at least at four points such as bearing mounting, shaft extension etc. The accuracy should be within 0.04mm or .0015 inches
- Sole plate or common bed should be embedded in concrete foundation as illustrated in Fig. 3. Stiff pads should also be installed beneath the wedges, which are welded together at various spots about 400-500mm (15.75-19.70 inches) apart etc., to enable the foundation to carry evenly the weight of the whole motor.
- The base should be sturdy and rigid to keep it flat and level.
- Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, and then set the motor on the mounting foundation.
- Accurately install shaft couplings, belt sheaves etc., then weld the wedges solid to prevent untoward change in position.



3.2.3 The foundation of vertical induction motors: (Also the foundation of pump)

- Foundation of motor/pump must be rigid and secure to provide adequate support. There must be no vibration, twisting, misalignment etc. due to inadequate foundations.
- A massive concrete foundation is preferred in order to minimize vibration. Rigidity and stability are enhanced by prop plate and foundation bolt. As shown in Fig. 4.

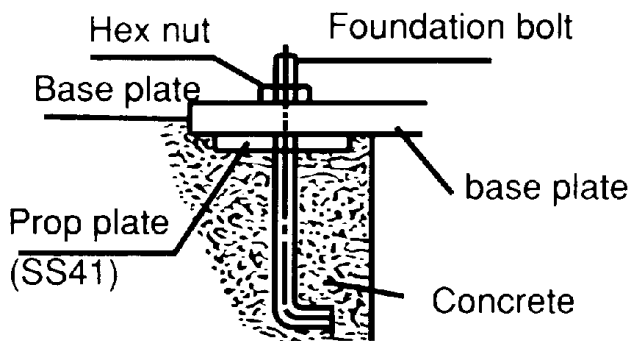


Fig. 4

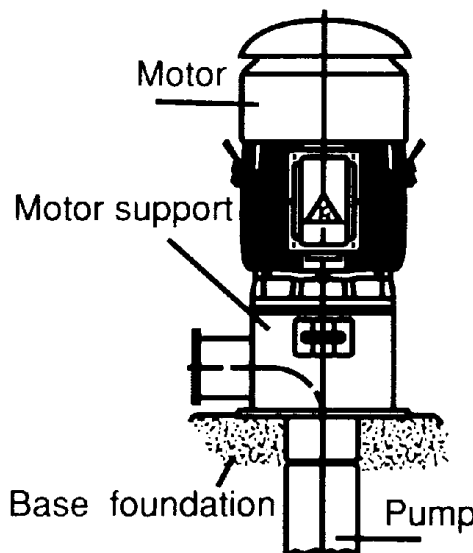


Fig. 5

3.2.4 Installation of vertical motors:

- (a) All mounting surfaces must be clean and level.
- (b) Foundation must be leveled at least at 4 points and guaranteed to be below 0.04mm (.0015 in.) flat and level.
- (c) Make sure the mortar and concrete are completely dry, and the precision of the level is acceptable, and then set the motor on the mounting foundation.
- (d) Accurately install shaft couplings.

3.3 Installation of shaft coupling

ATTENTION!

Motors must always be accurately aligned, and this applies especially where they are directly coupled.

Incorrect alignment can lead to bearing failure, vibration and even shaft fracture. As soon as bearing failure or vibration is detected, the alignment should be checked.

3.3.1

Field application of a coupling to the motor shaft should follow the procedures recommended by the coupling manufacturer. The motor shaft extension must not be subjected to either extreme heat or cold during coupling installation.

ATTENTION!

Basically, the coupling should be heated and pushed onto the shaft extension with slight axial force. Do not hammer coupling to prevent bearing damage.

3.3.2

Although the sleeve bearings are equipped with thrust faces, these are intended only to provide momentary axial restraint of rotor movement either during start-up or when operating the motor disconnected from the driven equipment. They must not be operated under a constant thrust load unless they were originally designed for this condition.

Motors with either sleeve or anti-friction bearings are suitable for connection to the driven load through a flexible coupling. Coupling solidly to the load is not acceptable. With sleeve bearings, the flexible coupling should be of the limited end float type to prevent the possibility of any end thrust from load being transmitted to the motor bearings, which could cause bearing damage. The recommended limits of end float are as follows:

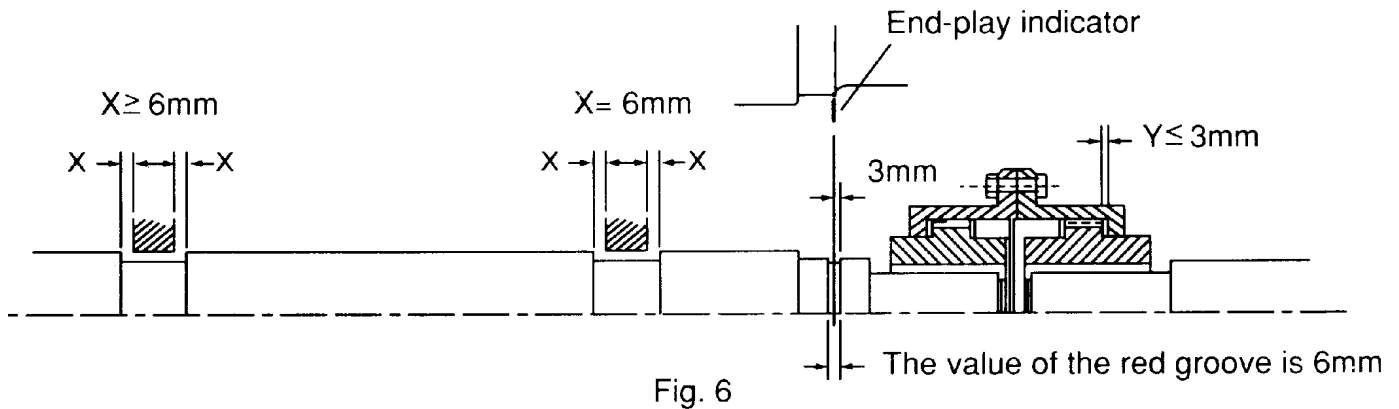


Fig. 6

- When the motor is in operation after installation, be sure that the end-play indicator is within the 6mm (.236 in.) of the groove on the shaft or aligned to the shaft shoulder immediately outboard of the drive-end bearing to assure there is low friction between shaft and bearing.
- Unless otherwise specified, the designed end-play value X of the groove for TWMC motors in general is within 6mm (.236 in.) as illustrated in Fig. 6. In essence, the endplay indicator is adjusted to point at the center of the groove or the drive-end shaft shoulder; thus X equals to $6 \pm 1\text{mm}$ or so, and the endplay value (Y) of the couplings should equal or be smaller than 3mm (.118 in.).
- If the desired value Y is greater than 3mm (.118 in.) caused for instance by a thrust load and/or load machine with large end-play, please inform TWMC prior to entering an order.

3.3.3

In aligning the motor (and rotor) axially with the driven equipment, consideration should be given not only to the endplay indicator position but also to axial shaft expansion and increase in shaft centerline height due to thermal effects. In general, the axial shaft growth for motors can be disregarded since neither bearing is fixed and any shaft growth due to temperature increase will produce an elongation away from the coupling.

Shaft height growth (change in shaft centerline elevation) for TEFC machines can be calculated as follows:

$$\Delta = (0.0005") \times (\text{motor foot to shaft } \text{£} \text{ dimension})$$

For non-TEFC machines, divide the number by 2.

3.3.4

It is desirable, in normal operation that the motor operates on its magnetic center, so that no axial force is exerted on the coupling.

The motor shaft and the driven shaft should be aligned within the following tolerances in both angular and parallel alignment:

Unit: mm

TIR	Range of rotating speed	Solid coupling	Flexible coupling
C	2500 rpm and above	0.03	0.03
	Below 2500 rpm	0.04	0.05
A	2500 rpm and above	0.03	0.03
	Below 2500 rpm	0.03	0.04

Angular misalignment is the amount by which the centerlines of driver and driven shafts are skewed. It can be measured using a dial indicator set up as shown in Fig. 7. The couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub face. The shafts should be forced against either the in or out extreme of their end float while being rotated.

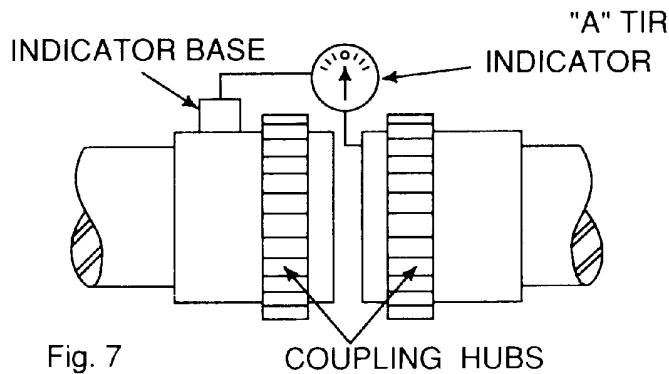


Fig. 7
TIR=Total indicator reading (by dial indicator)

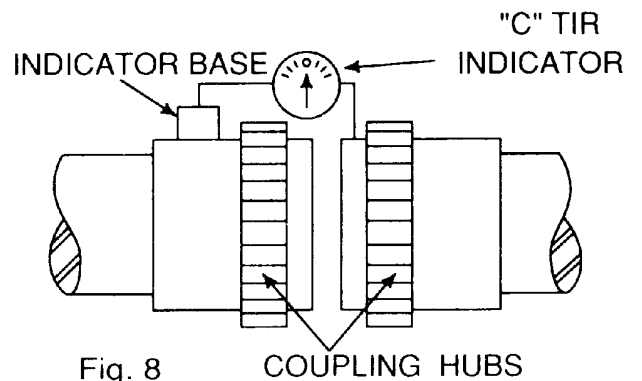


Fig. 8

Parallel misalignment is the amount by which the centerlines of the driver and driven shafts are out of parallel. It can be measured using a dial indicator set up as shown in Fig. 8. Again, the couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub outside diameter.

3.3.5

After the motor has been properly aligned with the driven equipment and the hold-down bolts have been installed and tightened, for motors with fabricated frames, at least two dowel pins should be installed in two diagonally opposite motor feet.

3.3.6 Installation of shaft coupling: (Vertical hollow shaft motor only)

Bolted Coupling as shown in Fig. 9

- Bearings are provided to absorb some upward shaft thrust when the coupling is fitted.
- The coupling is fastened with bolts.
- This coupling type is not auto-release type.

Note: Standard high thrust motors can absorb momentary up-thrust load up to 30% of the standard down thrust load. If the up-thrust is long in duration (over 10 Seconds) and/or exceeds 30% of the standard high thrust rating, special design arrangements are required and standard motor is not suitable.

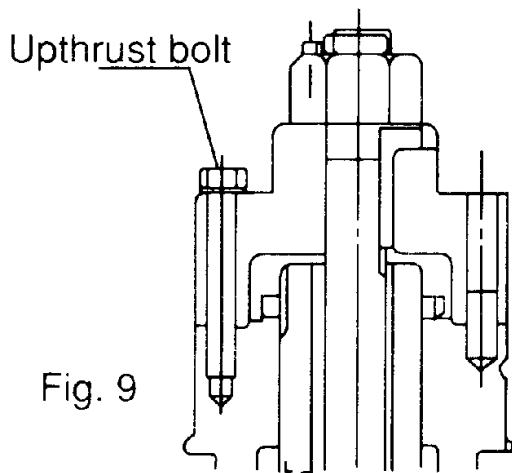


Fig. 9

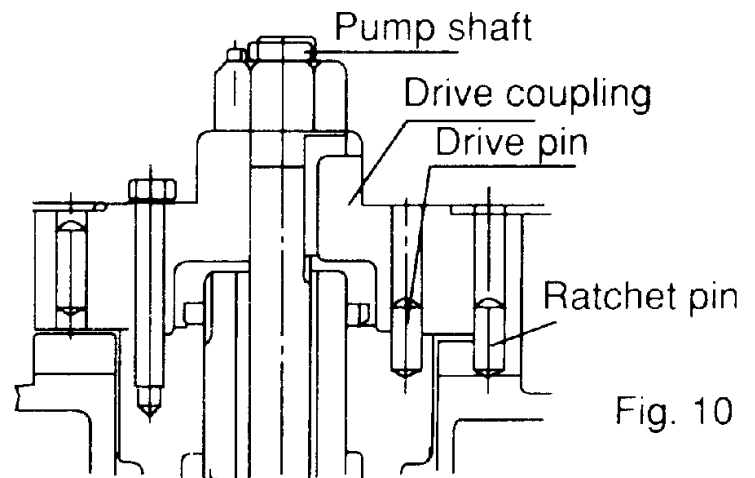


Fig. 10

3.3.7 Non-reverse ratchet/coupling, as Fig. 10 (If necessary)

The non-reverse coupling is also a bolted type and,

- (a) It prevents the pump and motor from rotating in the reverse direction.
- (b) It also prevents damage form over speeding and damage to pump shaft and bearings.
- (c) The ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed.
- (d) When power is removed, speed decreases, and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.
- (e) When installing the non-reverse coupling, do not use lubricant. Lubricant will interfere with proper operation. The top half of the coupling should seat solidly on the lower half and the pins should touch the bottom of the pockets between the teeth in the plate.
- (f) As with the bolted coupling, the up-thrust capabilities are 30% of the standard high thrust rating for down thrust.

ATTENTION!

Do not apply non-reverse ratchets on applications in which the pump reversal time from shutdown (the instant the stop button is pressed) to zero speed is less than one second.

3.4 Installation for belt drive

In general, power transmission though direct flexible coupling is appropriate for large motors. Such motors are not suitable for belt, chain or gear connection unless specially designed for such service. However, for small and medium motors of which outputs within the ranges shown on table below, it is acceptable to use belt transmission as indicated. Beyond these ranges, do not apply belt sheaves unless specially designed.

3.4.1

The diameter ratio between conveyance sheaves should not be greater than 5 to 1 for flat belts, and 8 to 1 for V-belts. It is also advisable to limit the belt velocity to under 35m/sec (115 ft/sec) to limit belt abrasion and vibration. The smaller the outer diameter of the V-belt sheave, the greater the shaft bending stress will be. If the bending stress is in excess of the shaft fatigue stress, the shaft may break. Therefore, please inform TWMC when you have decided the size of the sheaves and the length of the belts upon ordering.

ATTENTION!

Place the sheave and belt as close as possible to the motor body (it is advisable to make x as shown in Fig. 11 equal to 0) to reduce the bending moment and improve shaft life.

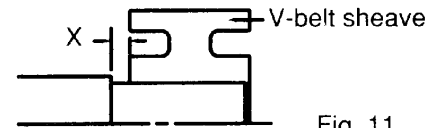


Fig. 11

3.4.2 Table of belt-sheave application for general electric motors

Output (KW/HP)			V-Belt Sheave							
4P	6P	8P	Conventional V-Belts				Narrow V-Belts			
			V-Belt Type	Number Of Belts	Min. PCD (mm)	Max Width (mm)	V-Belt Type	Number Of Belts	Min. PCD (mm)	Max Width (mm)
11/15	-	-	B	4	160	82	3V	4	125	48
-	11/15	-	B	5	170	101	3V	5	140	59
-	-	11/15	B	5	190	101	3V	6	160	69
15/20	-	-	B	5	170	101	3V	6	125	69
-	15/20	-	B	5	224	101	3V	6	160	69
-	-	15/20	C	4	224	111	5V	3	180	60
18.5/25	-	-	B	5	200	101	3V	6	140	69
-	18.5/25	-	C	4	224	111	5V	3	180	60
-	-	18.5/25	C	5	224	136	5V	4	180	78
22/30	-	-	B	5	224	101	5V	6	160	69
-	22/30	-	C	5	224	136	3V	4	180	78
-	-	22/30	C	5	250	136	5V	4	200	78
30/40	-	-	C	5	224	136	5V	4	180	78
-	30/40	-	C	5	265	136	5V	4	224	78
-	-	30/40	C	6	265	162	5V	5	224	95
37/50	-	-	C	6	224	162	5V	4	200	78
-	37/50	-	C	6	265	162	5V	4	224	78
-	-	37/50	C	7	280	187	5V	5	250	95
45/60	-	-	C	6	265	162	5V	4	224	78
-	45/60	-	C	7	280	187	5V	5	224	95
-	-	45/60	C	7	315	187	5V	6	250	113
55/75	-	-	C	7	265	187	5V	5	224	95
-	55/75	-	C	8	300	213	5V	6	250	113
-	-	55/75	D	5	355	196	5V	6	280	113
75/100	-	-	C	8	315	213	5V	6	250	113
-	75/100	-	D	6	355	233	5V	6	315	113
-	-	75/100	D	6	400	233	5V	6	355	113
-	90/120	-	D	6	400	233	5V	6	355	113
-	-	90/120	D	6	425	233	8V	4	355	124
-	110/150	-	D	7	400	270	8V	4	355	124
-	132/175	110/150	D	7	450	270	8V	4	400	124
-	160/200	132/175	D	9	450	344	8V	4	450	124

3.5 Conveyance with chain or gear**3.5.1**

Make sure the loading capacity of shaft and bearings is appropriate for the size and installation position (overhung) of chain and gear. If necessary, please contact us to ensure the shaft and bearings will meet your requirements.

3.5.2

Pay close attention to ensure the parallelism of shafts.

3.5.3

The teeth of couplings should be correctly and precisely matched; the force conveyance centers should lie on the same line.

3.5.4

There should be no skip, jumping, vibration or unusual noises.

ATTENTION!

Do not hammer the conveyance devices such as couplings, belt sheaves, chain wheels, gears etc. onto the shaft. Those shaft fitments should be fitted and removed only by means of suitable devices. Heat shrinking may be a better alternative to avoid damaging bearings and components.



The exposed rotating parts should be covered to prevent accidents.

3.6 Electrical connections

All interconnecting wiring for controls and grounding should be in strict accordance with local requirements such as the USA National Electrical Code and UK IEE wiring regulations. Wiring of motor and control, overload protection and grounding should follow the instructions of connection diagrams attached to the motor.

3.6.1 Power

The rated conditions of operation for the motor are as shown on the nameplate. Within the limits, given below, of voltage and frequency variation from the nameplate values, the motor will continue to operate but with performance characteristics that may differ from those at rated conditions:

±10% of rated voltage

±5% of rated frequency

±10% combined voltage and frequency variation so long as frequency variation is no more than ±5% of rated.

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage to or failure of the motor.

3.6.2

The main lead box furnished with the motor has been sized to provide adequate space for the make-up of the connections between the motor lead cables and the incoming power cables.



The bolted joints between the motor lead and the power cables must be made and insulated in a workman-like manner following the best trade practices.

3.6.3

Either fabricated motors or fan cooled cast frame, motors are all provided with grounding pads or bolts.



The motor must be grounded by proper connection to the electrical system ground.

3.6.4

The rotation direction of the motor will be as shown by either a nameplate on the motor or the outline drawing. The required phase rotation of the incoming power for this motor rotation may also be stated. If either is unknown, the correct sequence can be determined in the following manner: While the motor is uncoupled from the load, start the motor and observe the direction of rotation. Allow the motor to achieve full speed before disconnecting it from the power source. Refer to the operation section of these instructions for information concerning initial start-up. If resulting rotation is incorrect, it can be reversed by interchanging any two (2) incoming cables.

3.6.5 Auxiliary devices

Auxiliary devices such as resistance temperature detectors, thermocouples, thermoguards, etc., will generally terminate on terminal blocks located in the auxiliary terminal box on the motor. Other devices may terminate in their own enclosures elsewhere on the motor. Such information can be obtained by referring to the outline drawing. Information regarding terminal designation and the connection of auxiliary devices can be obtained from auxiliary drawings or attached nameplates.

If the motor is provided with internal space heaters, the incoming voltage supplied to them must be exactly as shown by either a nameplate on the motor or the outline drawing for proper heater operation.



Caution must be exercised anytime contact is made with the incoming space heater circuit as space heater voltage is often automatically applied when the motor is shutdown.

4. OPERATION

4.1 Examination before start

4.1.1

When motors are installed in good manner, ensure the wiring is according to the diagram. Also, the following points should be noted:

- (a) Make sure all wiring is correct.
- (b) Ensure the sizes of cable wires are appropriate and all connections are well made for the currents they will carry.
- (c) Ensure all connections are properly insulated for the voltage and temperature they will experience.
- (d) Ensure the capacity of fuses, switches, magnetic switches and thermo relays etc. are appropriate and the contactors are in good condition.
- (e) Make sure the frame and terminal box are grounded.
- (f) Make sure that the starting method is correct.
- (g) Make sure switches and starters are set at their right positions.
- (h) Motor heaters must be switched off when the motor is running.

4.1.2 Measurement of insulation resistance



During and immediately after measuring, the terminals must not be touched as they may carry residual dangerous voltages. Furthermore, if power cables are connected, make sure that the power supplies are clearly disconnected and there are no moving parts.

- (a) For rated voltage below 1000V, measured with a 500VDC megger.
- (b) For rated voltage above 1000V, measured with a 1000VDC megger.
- (c) In accordance with IEEE 43, clause 9.3, the following formula should be applied:

$$R \geq \left(\frac{\text{Rated voltage (v)}}{1000} + 1 \right) \times 10(\text{M}\Omega)$$

- (d) On a new winding, where the contaminant causing low insulation resistance is generally moisture, drying the winding through the proper application of heat will normally increase the insulation resistance to an acceptable level. The following are several accepted methods for applying heat to the winding:
 - (1) If the motor is equipped with space heaters, they can be energized to heat the winding.
 - (2) Direct current (as from a welder) can be passed through the winding. The total current should not exceed approximately 50% of rated full load current. If the motor has only three leads, two must be connected together to form one circuit through the winding. In this case, one phase will carry the fully applied current and each of the others, one-half each. If the motor has six leads (3 mains and 3 neutrals), the three phases should be connected into one series circuit.



Ensure there is adequate guarding so live parts cannot be touched.

- (3) Heated air can either be blown directly into the motor or into a temporary enclosure surrounding the motor. The source of heated air should preferably be electrical as opposed to fueled (such as kerosene) where a malfunction of the fuel burner could result in carbon entering the motor.

ATTENTION!

Caution must be exercised, when heating the motor with any source of heat other than self contained space heaters, to raise the winding temperature at a gradual rate to allow any entrapped moisture to vaporize and escape without rupturing the insulation. The entire heating cycle should extend over 15-20 hours.

Insulation resistance measurements can be made while the winding is being heated. However, they must be corrected to 40°C for evaluation since the actual insulation resistance will decrease with increasing temperature. As an approximation for a new winding, the insulation resistance will approximately halve for each 10°C increase in insulation temperature above the dew point temperature.

- (e) Should the resistance fail to attain the specified value even after drying, careful examination should be undertaken to eliminate all other possible causes, if any.

4.1.3 Power Source

- (a) Ensure the capacity of the power source is sufficient.
- (b) Ensure the supply voltage and frequency ratings are identical to those on the nameplate.
- (c) Voltage variation should be confined to within ±10% of the rated value and the phase to phase voltages should be balanced.

4.1.4 Bearing lubrication

- (a) For sleeve bearing motors, the oil reservoir must be filled with oil to the correct level. On self-lubricated bearings, the standstill oil level will be at the center of the oil gauge. The proper oil is a rust and oxidation inhibited, turbine grade oil. Refer to the lubrication nameplate for the recommended viscosity.
- (b) Motors, which are supplied with provision for flood lubrication, have an inlet orifice to meter the oil flow to the bearing. Refer to the outline drawing for these values. If the supply pressure does not match that stated on the outline, the orifice size must be adjusted to produce the specified flow rate. The drain adapter (also provided) has a weir plate fixed to the inside of the pipe to permit the establishment of the proper oil level. This weir plate must be located at the bottom of the pipe and must be parallel to the plane of the motor feet. To ensure optimum flow, the drain line should be vented to the atmosphere.

Oil inlet temperature: Normal below 50°C
 Alarm 60°C
 Trip 65°C

- (c) If the motor is in storage for over three (3) months, refilling of some new oil should be undertaken before operation to prevent bearing damage due to dry friction. The oil level should be kept at the center of the oil gauge. If necessary, drain some oil after refilling.
- (d) Motors that have been designed with anti-friction bearings for use with an oil mist lubrication system have been packed at the factory with a small amount of grease for short test runs. Continuous running should not be considered unless the oil mist system is installed and operating.
- (e) Grease lubricant type
 - (1) The bearings have been well greased at the factory before delivery. However, regreasing is required if a significant period has elapsed between manufacture and use or in storage
 - (2) **All motors with ZZ bearings will have SHELL Alvania R3 (Lithium base grease).** All motors with open bearings will have Polyrex EM (polyurea base grease).

4.1.5 Cooling water for the cooler on water-cooled motors

Make sure the quality, volume and inlet temperature of cooling water for the motors are normal before the machine is in operation.

Water: General tower water or industrial water.

Volume: Please see outline drawing

Inlet temperature: Normal below 30°C
 Alarm 35°C
 Trip 40°C

ATTENTION!

Make sure all locks, which fasten the movable parts of the motors during transportation, are dismantled and the shaft can rotate freely.

ATTENTION!

Ensure there is no foreign matter or tools inside the motors before starting motors.

4.1.6

Make sure the transmission system, including belts, screws, bolts, nuts and set pins are in good condition.



The keys fitted to the shaft extensions are held by plastic tape only to prevent them from falling out during transportation or handling. The shaft key shall be removed to avoid flying out, when the motor is operated prior to the couplings etc. being fitted to the shaft extension.

4.1.7

Make sure the items above are examined. Test the motor running with or without load. Record and check according to "Maintenance" at 15-minute intervals during the first three hours of operation. Then regular examinations should take place at longer intervals. If all goes well the motor can be classified as "in good order".

4.2 Starting operation

4.2.1 Starting load

Initially run the motor unloaded prior to coupling to other machines. Unless otherwise specified, a motor usually starts with light load, which is then gradually increased, proportional to the square of the speed and at last reaches 100% load at full load speed.

4.2.2 Starting

Too frequent starts can be harmful to the motors. The following restrictions should be observed:

- (a) Motor can be restarted should the initial start fail. Two starts are generally permissible when the motor is cold.
- (b) Motor can be started only once when it is at normal running temperature.
- (c) Should additional starts be necessary beyond the conditions stated above, the following restrictions should be noted:
 - (1) Let the motor cool down for 60 minutes before restarting, fully loaded.
 - (2) Let the motor cool down for 30 minutes before restarting, unloaded.
 - (3) Two inching starts can be regarded as one normal start.

ATTENTION!

**If the motor rotor fails to start turning within one or two seconds, shut off the power supply immediately.
Investigate thoroughly and take corrective action before attempting a restart.**

Possible reasons for not starting are:

- (1) Too low a voltage at the motor terminals.
- (2) The load is too much for the rotor to accelerate.
- (3) The load is frozen up mechanically.
- (4) All electrical connections have not been made.
- (5) Single-phase power has been applied.
- (6) Any combination of the above.

4.2.3 Rotating direction

- (a) Most TWMC motors are bi-directional. However, when some special types, such as high speed 2-Pole, certain large capacity motors, those with a non-reversing ratchet etc., should rotate in one direction, please ensure the rotation is in conformity with the directional arrow-mark shown on the attached nameplate.
- (b) To reverse a bi-directional motor, cut the power and wait until the motor stops. Then interchange any two of the three phases.

4.2.4 Power source, Voltage, Current

- (a) Ensure the voltage and frequency of the power source are identical to the ratings shown on the nameplate.
- (b) Voltage variation should be confined to within $\pm 10\%$ of the rating and the three phase voltages should be in full balance
- (c) Ensure the motor phase currents, when without load, are within $\pm 5\%$ of the average values.

4.2.5

Frequency variation should be confined to within $\pm 5\%$ of the rating. The aggregate variation of voltage and frequency should be confined to within $\pm 10\%$ of the absolute value of the ratings.

Starting time and unusual noises

ATTENTION!

Starting time is longer for the motors with large inertia. However, if starting time is longer than usual or if there is difficulty in starting, or there is abnormal noise, do not run the motor and refer to TWMC Service representative.

4.2.6 Sleeve bearing oil rings (sleeve bearing types only)

As the oil ring is used to carry lubricant to sleeve bearings, frequently check to ensure the oil ring is in motion.

4.2.7 Bearing temperature rise

Following the initial start-up, the bearing temperatures should be closely monitored. The rate of rise in bearing temperature is more indicative of impending trouble than is the actual temperature.

ATTENTION!

If the rate of rise in temperature is excessive or if the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

If the bearing temperature rise and motor operation appear to be normal, operation should continue until the bearing temperature stabilizes.

Recommended limits on bearing temperature are as follows:

Sleeve Bearings	Total measured temperature
• By permanently installed detector	90°C
• By temporary detector on top of the bearing sleeve near the oil ring	85°C

Anti-Friction Bearings

- By permanently installed detector
- By temporary detector measuring the outside of the bearing housing

Total measured temperature

100°C
95°C

ATTENTION! (For sleeve bearing)

- (1) It must be noted that when operating flood lubricated sleeve bearings without outside lubrication supplied, the bearing temperature must not be allowed to exceed 85°C total temperature
- (2) Under normal condition, for the self-lube bearing, the rate of temperature rise should be from 11 to 14°C for the first ten (10) minutes after starting up and approximately 22°C at thirty (30) minutes. The rate of bearing temperature rise is a function of the natural ventilation and operating conditions.
- (3) When the rate of bearing temperature rise is less than 1°C per half-hour, the bearing temperature is considered to be stabilized.
- (4) If the total bearing temperature exceeds 95°C, the motor should be shut down immediately.

Noise and Vibration

ATTENTION!

Any abnormal noise or vibration should be immediately investigated and corrected. Increased vibration can be indicative of a change in balance due to mechanical failure of a rotor part, a stator winding problem or a change in motor alignment.

5. MAINTENANCE

5.1 Major points in regular inspections and maintenance.



For safety, maintenance and repairs must only be carried out by properly trained personnel.



Some testing, such as insulation resistance, usually requires the motor to be stopped and isolated from power supply(ies).

Routine inspection and maintenance are usually performed by looking, listening, smelling and simple meters.



High temperature may arise under operating conditions on the motor surfaces, so that touching should be prevented or avoided. Keep away from moving and live parts. Unless deemed necessary, do not remove guards whilst assessing the motor.

Timely replacement of worn parts can assure longevity and prevent breakdown.

Routine inspection and regular inspection and maintenance are important in preventing breakdown and lengthening service life.

Owing to the varied time and circumstances, motors are used, it is difficult to set the items and periods for regular inspection and maintenance. However, as a guide it is recommended to be performed periodically according to factory maintenance program. Generally, the inspection scope determined by the following factors:

- (a) Ambient temperature.
- (b) Starting and stopping frequency.
- (c) Troublesome parts usually affecting motor functions.
- (d) Easily abraded parts.
- (e) The important position of motor in the operational system of a factory should be duly recognized. Therefore, its health and wellbeing should be fully protected especially when it is operating in severe conditions.

5.2 Motor windings:

- (a) Measurement of insulation resistance and standards to determine quality of insulation resistance, please refer to measures stated in 3.1.2 "Measurement of insulation resistance".
- (b) Inspection of coil-ends:
 - (1) Grease and dust accumulated on coils may cause insulation deterioration and poor cooling effect.
 - (2) Moisture must not accumulate. Keep coils warm when motor is not in use if moisture can be seen.
 - (3) Discoloring. This is mainly caused by overheating.
- (c) Ensure no untoward change of wedges from original position.
- (d) Ensure the binding at the coil end is in its normal position.

5.3 Clean the interior of the motor:

- (a) After a motor is in operation for some time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage. Regular cleaning and examination is necessary to assure top performance.
- (b) Points to note during cleaning:
 - (1) If using compressed air or blower:
 - (a) Compressed air should be free of moisture.
 - (b) Maintain air pressure at 4 kg/cm², since high pressure can cause damage to coils.
 - (2) Vacuum
Vacuum cleaning can be used, both before and after other methods of cleaning, to remove loose dirt and debris. It is a very effective way to remove loose surface contamination from the winding without scattering. Vacuum cleaning tools should be non-metallic to avoid any damage to the winding insulation
 - (3) Wiping
Surface contamination on the winding can be removed by wiping using a soft, lint-free wiping material. If the contamination is oily, the wiping material can be moistened (not dripping wet) with a safety type petroleum solvent. In hazardous locations, a solvent such as inhibited methyl chloroform may be used, but must be used sparingly and immediately removed. While this solvent is non-flammable under ordinary conditions, it is toxic and proper health and safety precautions should be followed while using it.

ATTENTION!

Solvents of any type should never be used on windings provided with abrasion protection. Abrasion protection is a gray, rubber-like coating applied to the winding end-turns.



Adequate ventilation must always be provided in any area where solvents are being used to avoid the danger of fire, explosion or health hazards. In confined areas (such as pits) each operator should be provided with an airline respirator, a hose mask or a self-contained breathing apparatus. Operators should wear goggles, aprons and suitable gloves. Solvents and their vapors should never be exposed to open flames or sparks and should always be stored in approved safety containers.

- (4) Keep core ducts completely clean. The difference in temperature rise could be around 10°C before and after cleaning

5.4 Clean the exterior of the motor:

- (a) On open ventilated motors, screens and louvers over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air movement.

ATTENTION!

Screens and louvers should never be cleaned or disturbed while the motor is in operation because any dislodged dirt or debris can be drawn directly into the motor.

- (b) If the motor is equipped with air filters, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions. It is better to replace or recondition filters too often than not often enough.
- (c) Totally enclosed air to air cooled and totally enclosed fan cooled motors require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up not removed can lead to unbalance and vibration. All of the tubes of the air-to-air heat exchanger should be cleaned using a suitable tube brush having synthetic fiber bristles (not wire of any type).

5.5 Maintenance of anti-friction bearings**5.5.1 Frequency of re-lubrication:**

The life of grease varies greatly as a result of types of model, revolution speed, temperature, operational conditions etc. It is, therefore, impossible to be precise about replenishment intervals. However, for normal direct coupling transmission, the periods shown as Table 1 may be used as a guide.

Remarks:

- (a) The periods shown in Table 1 should be halved where bearings are used for belt drive and/or in dirty or high ambient temperature or high humidity environments.
- (b) Please refer to the lubrication nameplate, if attached to the motor.
- (c) For bearing numbers outside the range of Table 1, please contact TWMC

- (d) If the periods referred to in Table 1 for drive-end bearing and opposite drive-end are different, for the convenience of maintenance operation, please take the shorter one the required grease replenishment period of these bearings.

5.5.1 Kinds of grease:

All motors with ZZ bearings will have SHELL Alvania R3 (lithium base grease). All motors with open bearings will have Polyrex EM (polyurea base grease).

Certain T-frame models will utilize special grease and will be noted on the lubrication nameplate. Please use identical grease or its equivalents when maintaining lubrication schedule.

ATTENTION!

Do not mix different kinds of grease.

Mixing grease with different type of thickeners may destroy its composition and physical properties. Even if the thickeners are of the same type, possible differences in the additive may cause detrimental effects.

5.5.2 Grease quantity

The amount of grease per replenishment depends on the type, size and construction of the bearings. The maximum amount of one replenishment for each bearing is shown in Table 2.

5.5.3 Re-greasing



If re-lubrication is to be performed when the motor is running, stay clear of rotating parts.

It is advisable to re-grease when the motor is running to allow the new grease to be evenly distributed inside the bearing.

Before re-greasing, the inlet fitting should be thoroughly cleaned to prevent any accumulated dirt from being carried into the bearing with the new grease. The outlet of grease drainage should be opened to allow the proper venting of old grease.

Use a grease gun to pump grease through grease nipple into the bearings. After re-greasing, operate the motor for 10-30 minutes to allow any excess grease to vent out.

TABLE 1.

Bearing Number	600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM	3000 RPM	3600 RPM
62XX 63XX 72XX 73XX	6210									
	12								2000 Hrs.	
	13									
	14								1000 Hrs.	
	15									
	16								720 Hrs.	
	17							2000 Hrs.		
	18			3000 Hrs.						
	20									
	22									
	24							1500 Hrs.		
	26									
	28					2000 Hrs.		1000 Hrs.		
	30									
	32							500 Hrs.		
	34					1500 Hrs.				
36										
38			2000 Hrs.		1000 Hrs.					

Bearing Number	600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM
NU2XX NU3XX	NU214							
	15						2000 Hrs.	
	16							
	17							
	18			3000 Hrs.			1500 Hrs.	
	20							
	22						1000 Hrs.	
	24							
	26					2000 Hrs.		
	28						500 Hrs.	
	30							
	32							
	34			2000 Hrs.		1000 Hrs.		
	36							
	38	2000 Hrs.						
	40							
44			1000 Hrs.					
48	1000 Hrs.							

Bearing Number	600 RPM	720 RPM	750 RPM	900 RPM	1000 RPM	1200 RPM	1500 RPM	1800 RPM
222XX 223XX	22220						300 Hrs.	
	22							
	24			1000 Hrs.		500 Hrs.		
	26							
	28							
	30					300 Hrs.		
	32			500 Hrs.				
	34							
	36							
	38	500 Hrs.						
	40			300 Hrs.				
	44							
48	300 Hrs.							

TABLE 2.

Bearing No.	Amount of replenishment
6210	30 g
6212	40
6213	50
6214	50
6215	60
6216	60
6217	80
6218	80
6220	100
6222	120
6224	120
6226	140
6228	160
6230	180
6232	200
6234	250
6236	300
6238	350
6240	400
6244	450
6248	500

Bearing No.	Amount of replenishment
6310	40 g
6312	60
6313	80
6314	80
6315	100
6316	100
6317	120
6318	120
6320	160
6322	220
6324	270
6326	300
6328	400
6330	450
6332	500
6334	600
6336	700
6338	800
6340	900
6344	900
6348	900

*Fill new grease until it overflows and the old grease is entirely replaced.

5.5.4 Oil re-lubrication (For oil lubrication types only)

Maintain proper lubrication by checking the oil level periodically and adding oil when necessary. Because of the initial clearing action of the bearing and the expansion of the oil as it comes up to operating temperature, the oil level will be higher after the motor has been in operation for a while than it is with the motor at standstill.

Overfilling should be avoided not only because of the possibility that expansion may force the oil over the oil sleeve and on to the rotor, but also because too high an operating oil level prevents the bearing from clearing itself of excess oil. The resultant churning can cause extra loss, high temperatures, and oxidized oil. If, during operation, the oil level goes above the maximum shown on the sight gauge, drain enough oil to bring the level back within the recommended operating range. **Do not permit the operating level to fall below the minimum shown on the gauge.**

ATTENTION!

Should it ever become necessary to add excessive amount of make-up oil, investigate immediately for oil leaks.

Change the oil at regular intervals. The time between oil changes depends upon the severity of operating conditions and, hence, must be determined by the motor user. Two or three changes a year is typical, but special conditions, such as high ambient temperature, may require more frequent changes. Avoid operating the motor with oxidized oil.

Use only good grade, oxidation-corrosion-inhibited turbine oils produced by reputable oil companies.

The viscosity of the oil to be used depends upon the type and size of the bearings, its load and speed, the ambient temperature, and the amount and temperature of the cooling water (if used)). The lubrication nameplate or instructions with each motor specifies the viscosity range of oil suitable for average conditions. The usual oil viscosity range of oil suitable for average conditions. The usual oil viscosity recommendations are summarized in Table 3. Operation in ambient temperatures that are near or below freezing may require preheating the oil or the use of special oil. Whenever the motor is disassembled for general cleaning and reconditioning, the bearing housing may be washed out with a suitable cleaning solvent. Be sure that the oil-metering hole is clear, and then dry the housing thoroughly before re-assembly, and ensure all traces of cleaning solvent have been removed.

TABLE 3 Oil Viscosity**

Bearing function and location	Bearing Type	Oil Viscosity - SSU	
		@ 100°F	@ 200°F
Thrust Bearing	72XX, 73XX Angular contact ball And/or (62XX, 63XX)	150	45
	Spherical roller	300	53
	Plate (Kingsbury Type)	300	53

**Remark: When a lubrication nameplate attached to the motor, use lubrication oil it stipulates.

5.5.5 Cleaning and installation of bearings

- (a) Apply the proper amount of grease to the disassembled parts of the bearing after they have been thoroughly cleaned with high quality cleaning oil. Then protect them from contamination before and during assembly.
- (b) Bearing installation

ATTENTION!

Before installing the bearings, make sure that the shaft mounted parts inside the bearings are in place before installation.

Since the bearing is a high precision component, it is important to avoid ingress of dust and foreign matter, and hammering during cleaning and installation. Use extreme care and insure clean conditions during installation and assembly.

ATTENTION!

The best way for bearing installation is heat shrinking. Knocking and hammering during installation should be avoided absolutely.

The bearing should be heated in a bath of clean oil at a temperature of approximately 80°C. After warming, slide the bearings in place quickly and nimbly so that it has not shrunk before being fully in position. Grease the bearing after the temperature returns to normal, and then reassemble the motor.

5.6 Maintenance of sleeve bearings

5.6.1 Daily inspections

- (a) Ensure the volume and quality of lubrication oil are in compliance with specifications.

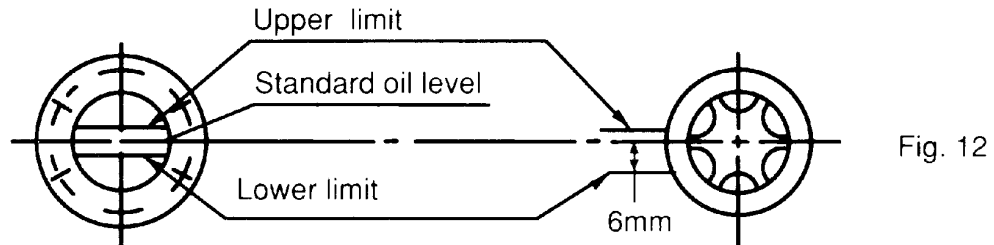


Fig. 12

- (b) Ensure there is motion of the oil ring and it is not clamped.
 (c) The indicator of the shaft endplay should be restricted within the specified range of the red groove of the shaft or the $\pm 3\text{mm}$ (.118 in.) range of the drive-end shaft shoulder, or the bearing may be damaged.

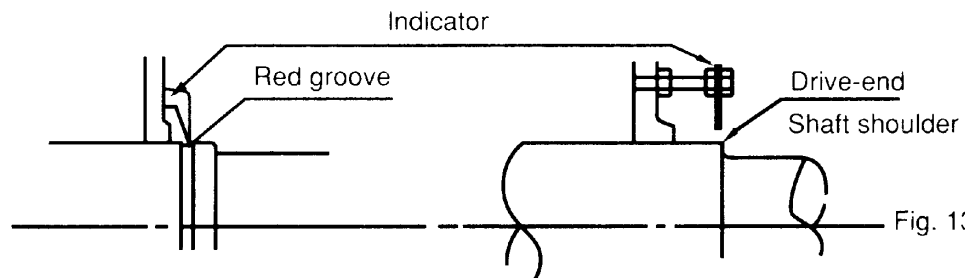


Fig. 13

5.6.2 Regular examination

- (a) Periodical change of oil

The oil reservoirs of self (not flood) lubricated bearings should be drained and refilled about every six (6) months. More frequent changes may be needed on high speed (3600 rpm) motors or if severe oil discoloration or contamination occurs. In conditions where contamination does occur, it may be advisable to flush the reservoir with kerosene to remove any sediment before new oil is added. Proper care must be taken to thoroughly drain the reservoir of the flushing material before refilling with the new oil.

Refill the reservoir to the center of oil sight glass with a rust and oxidation inhibited turbine grade oil. Refer to the outline and lubrication nameplate for the correct viscosity.

- (b) Quantity of lubrication oil
 Please refer to the lubrication nameplate for oil quantity.
 (c) Oil viscosity
 (d)

ISO	Equivalents	Viscosity (SUS/100°F)
VG32	Esso Teresso 32	150
VG46	Esso Teresso 46	200
VG68	Esso Teresso 68	300

5.6.3 Disassembly



Prior to disassembling, ensure the power supplies are disconnected and there are no moving parts.

The bearing sleeve is of the spherically seated, self-aligning type. The opposite drive end bearing is normally insulated for larger motors (or when specified). On some motors, the insulation is bonded to the spherical seat of the bearing housing.

ATTENTION!

Extreme care must be exercised in removing the bearing sleeve from the insulated support to avoid damaging this insulation.

The following is the recommended procedure for removing the bearing sleeve:

- (a) Remove the oil drain plug in the housing bottom and drain the oil sump.
- (b) Remove all instrumentation sensors that are in contact with the bearing sleeve. These would include resistance temperature detectors, thermocouples, thermometers, etc..
- (c) Remove the socket head bolts holding the bearing cap and the inner air seal. The end cover plate must also be removed if the non-drive end bearing is being disassembled. Remove the bearing cap and top half of the inner air seal. Place them on a clean, dry surface to avoid damage to the parting surfaces.
- (d) Remove the top half of the bearing sleeve using suitable eyebolts in the tapped holes provided. Lift the bearing top straight up and avoid any contact with the shoulders of the shaft journals that might damage the thrust faces of the bearing. Place on a clean, dry surface taking care to prevent damage to either the parting surfaces or the locating pins that are captive in the top bearing half.
- (e) Remove the screws at the partings in the oil ring and dismantle the ring by gently tapping the dowel pin ends with a soft face mallet. Remove the ring halves and immediately reassemble them to avoid any mix up of parts or damage to the surfaces at the partings.
- (f) Pull up on the garter spring surrounding the floating labyrinth seal and carefully slip out the top half. Rotate the garter spring until the lock is visible. Twist counter-clockwise to disengage the lock, remove the garter spring then rotate the lower half of the seal out of the groove in the bearing housing. Note the condition of these floating labyrinth seals. If they are cracked or chipped, they must be replaced. Do not attempt to reuse a damaged seal.
- (g) To remove the bottom bearing half, the shaft must be raised a slight amount to relieve pressure on the bearing. On the drive end, this can be done by jacking or lifting on the shaft extension. Protect the shaft. On the non-drive, jacking or lifting can be done using bolts threaded into the tapped holes provided in the shaft end.

- (h) Roll the bottom bearing half to the top of the shaft journal and then lift it using suitable eyebolts threaded into the holes provided. Again avoid any contact with the shaft shoulders that could damage the bearing thrust faces. Place the lower bearing half on a clean, dry surface to protect the parting surfaces.



Use extreme care when rolling out the lower bearing half. Keep the hands and fingers well clear of any position where they might be caught by the bearing half if it were accidentally released and rotated back to its bottom position. Serious personal injury could result.

- (i) Protect the shaft journal by wrapping it with clean, heavy paper or cardboard.

5.6.4 Re-assembly

Bearing re-assembly is basically a reverse of the disassembly procedures outlined above, with the following suggestions:

- (a) The interior of the bearing housing should be cleaned and then flushed with clean oil or kerosene.
- (b) The bearing halves and the shaft journal should be wiped clean using lint-free cloth soaked with clean oil.
- (c) All parts should be carefully inspected for nicks, scratches, etc., in any contact surfaces. Such imperfections should be removed by an appropriate method such as stoning, scraping, filling, etc., followed by thorough cleaning.
- (d) Before installing the floating labyrinth seal halves, observe their condition. Do not attempt to use a cracked or chipped seal. The bottom half seal has a set of drilled holes in its side face. These must be placed at the bottom toward the inside of the bearing so that accumulating oil may drain back into the housing.
- (e) Put a bead of Curil-T around the seal half O.D.'s on both sides adjacent to the garter spring groove. This will prevent oil by-passing the seal around its outside.
- (f) Place the bottom seal half on top of the shaft and roll it into position. Install the top half and insert the garter spring pulling up on both ends to permit engaging the lock. Run a bead of Curil-T around the O.D.'s on both sides adjacent to the garter spring groove on this half also.
- (g) Carefully reassemble the two oil ring halves. Inspect the dowel pins for burrs and straightness and make any corrections required. Do not force the ring halves together. Excessive force may alter the roundness or flatness of the oil ring which can change its oil delivery performance.
- (h) Some of the pipe plugs in the housing are metric thread type. These are identified as those, which have a copper, lead, or similar material washer. If these plugs are removed,

be careful not to lose the washers. Before re-assembly, inspect the washers and replace them as required.

- (i) Before installing the bearing cap, observe the position of the floating labyrinth seal. The “tab” must be on top to engage the pocket. Failure to position the seal properly will result in damage when the cap is assembled.

ATTENTION!

- (1) Curil-T is the only approved compound for use in the assembly of the bearings on this motor. Other products may harden and impede the operation.**
- (2) During the re-assembly of the bearing parts, a thin layer of Curil-T should be applied to all gaskets and machined interface surfaces. This suggestion does not apply to the machined surfaces of the bearing liner halves.**
- (3) When seating the bearing shell, apply a thin layer of lube oil at the spherical surface of the liner. Slowly roll the lower bearing liner into the bearing housing making sure that the splinted surface of the liner and the housing are flush. Gradually lower the shaft onto the bearing. The weight of the shaft will help rotate the bearing liner so that the babbitt surface of the liner will match the slope of the journal. Sometimes it is required to use a rubber mallet to tap lightly on the bearing housing while slowly rolling the shaft to help this seating operation.**

5.7 Maintenance of slip ring (For Wound Rotor Motors only)



Ensure motor is disconnected from power supplies and there are no accessible moving parts before maintenance operation.

5.7.1 Adjustment of carbon brush

- (a) Brush pressure for normal operation:
 - Electro-graphite brush.....0.2~0.25 kg/cm²
When frequent vibrations are evident or the brush is small (area below 0.5 cm²), the pressure should be greater than as shown.
- (b) Adjustment of brush pressure:
The brush pressure should be adjusted to keep normal operation as it wears.
 - The brush pressure may be reduced after use, so it is necessary to re-adjust. For adjustment, please turn adjusting screw, pressure adjusting pin or pressure adjusting plate as shown in Fig. 14 to obtain the correct tension (=0.23 x brush cross sectional area in cm²) ±10% kg.
- (c) Brush pressure need not be adjusted if constant force spring is used as shown in Fig. 15 and Fig. 16.

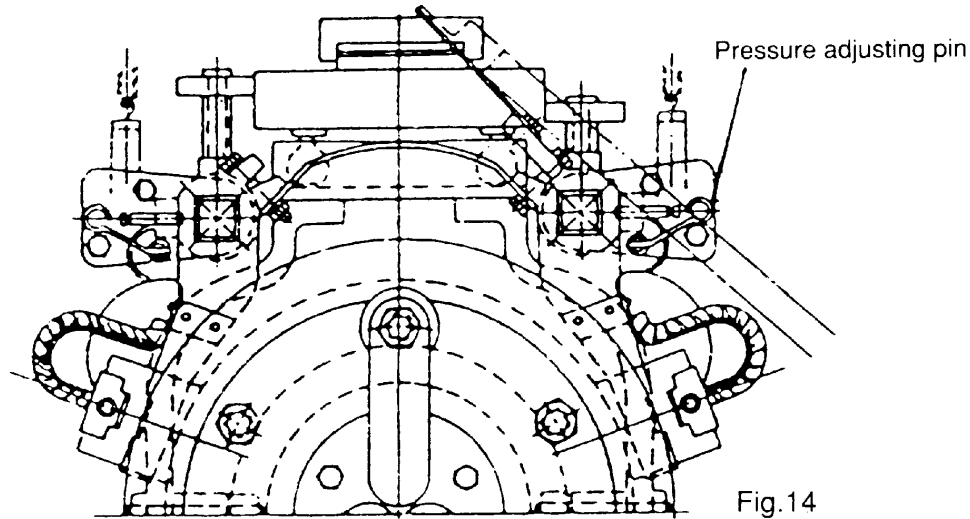


Fig.14

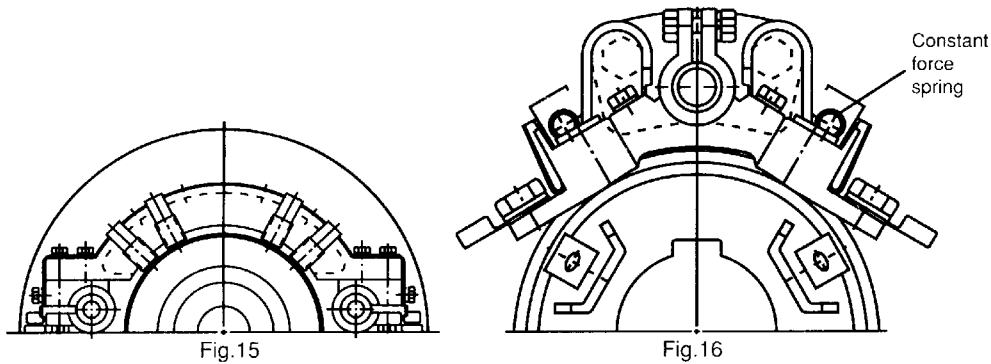


Fig.15

Fig.16

5.7.2 Brush replacement

The carbon brush is a part of the equipment which is easily worn away, replace it after it is worn to $\frac{1}{2} \sim \frac{3}{4}$ of original size.

(a) Brush material

The brush material is important to the performance of the motor. Only the most appropriate materials are chosen by TWMC, and are listed on the nameplate of the motor. It is important to know this when you replace the brush, so a recommended type is used.

(b) Dimensions

Brush, holder and gap between them, please refer to CNS 2322 C4051 or JIS C2802.

ATTENTION!

The gap between a brush and it holder is important for good performance and safety of the motor.

(c) Adjustment of new brushes (Shown in Fig. 17)

- (1) Polish the new brush with a file until it assumes the appropriate contour of the slip ring which it touches.

- (2) Place sand-paper (JIS R6252 No. 40...50) on the slip ring with the abrasive face of the paper against the brush to induce a closer contact by rubbing against each other.
- (3) Repeat item 2 with fine sand –paper (JIS R6252 No. 100 to 200) until the contact surface between brush and slip ring exceeds 80%.
- (4) Finally, clean the contaminated slip ring and brush with clean cloth or compressed air.

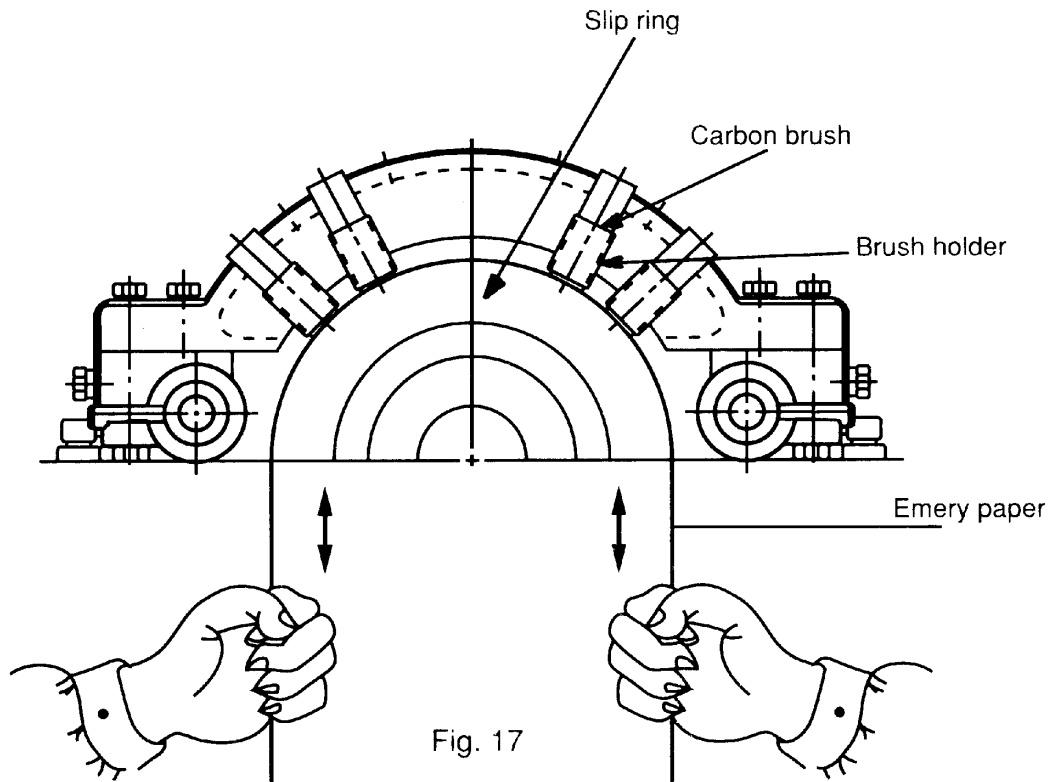


Fig. 17

5.8 Maintenance of non-reverse ratchet mechanism (For Vertical high Thrust Motor only)

5.8.1

In the pump piping system, a check valve and a stop valve should be installed in the discharge line. The check valve, placed between the pump and the stop valve, is to protect the pump from reverse flow and excessive backpressure. The stop valve is used in priming, starting and when shutting down the pump. It is advisable to close the stop valve before stopping the pump. This is especially important when the pump is operated against a high static head.

TWMC vertical high thrust motors are equipped with non-reverse ratchet (N.R.R.) mechanism only when requested by the pump manufacturer. Typical construction of the N.R.R. mechanism is shown as Fig 18 below.

The N.R.R. mechanism keeps the pump and motor from rotating in the reverse direction. Thus prevents damage from over-speeding and damage to water-lubricated pump shaft bearings

when, on shutdown, the falling water column tends to drive the pump in the reverse direction. In normal operation, the ratchet pins are lifted by the ratchet teeth and are held clear by centrifugal force and friction as the motor comes up to speed. When power is removed, the speed decreases and the pins fall. At the instant of reversal, a pin will catch in a ratchet tooth and prevent backward rotation.

5.8.2

The service life of ratchet pins depends not only on the reverse shock load between the pin and ratchet tooth when pump stopped but also the frequency of pump starting and stopping while in service. Provided that the pins are deformed due to this reverse shock load, then the up and down motion of the ratchet pins could be sluggish or jammed and that unusual noises shall arise.

The recommended replacement period for these ratchet pins is every three (3) years. If the reverse shock load is greater than 30% of motor rated torque or the starting frequency is more than twice per day, then the replacement period should be halved.

ATTENTION!
The check valve and stop valve in the discharge line should be regularly inspected and maintained to assure the normal function of these valves. This is important to protect the pump and motor from damage and increase the service life of the N.R.R. mechanism.

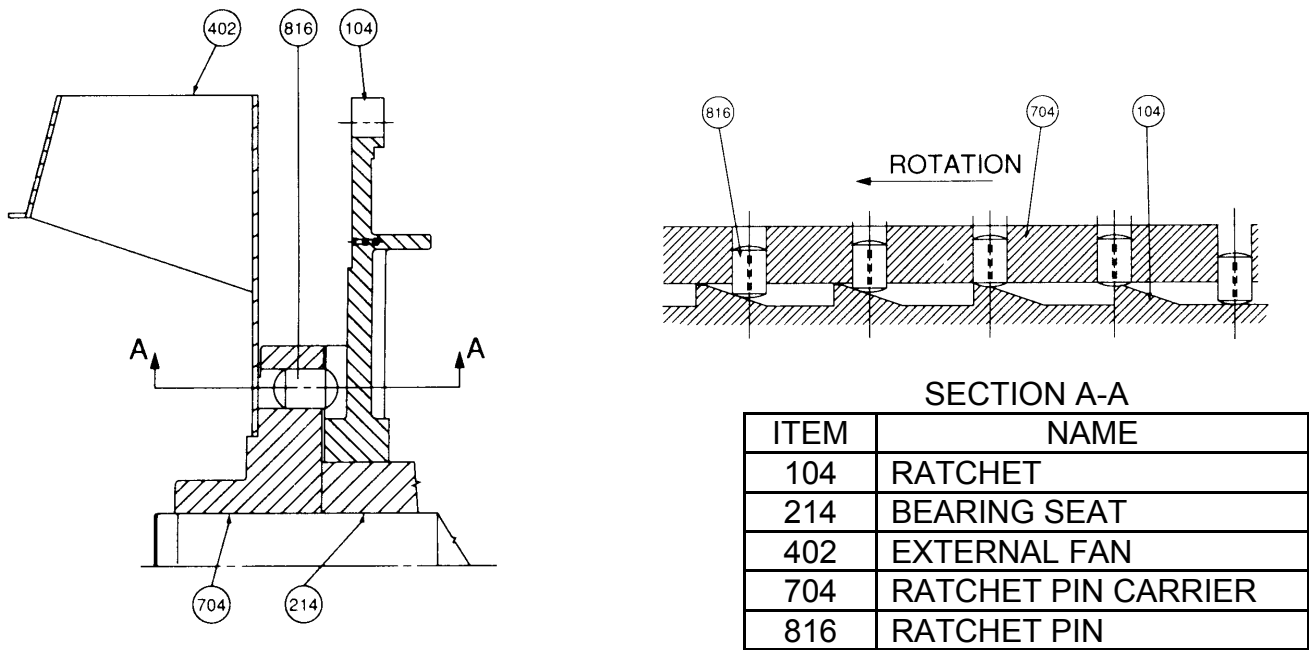


Fig. 18

6. FAULT FINDING AND RECOGNITION

Kinds of Breakdown	Symptoms	Possible Causes	Remedies
Fail to start without load	Motionless and soundless	Power-off	Consult power company
		Switch-off	Switch-on
		No fuse	Install fuse
		Broken wiring	Check wiring and repair
		Broken lead	Check wiring and repair
		Broken windings	Check windings and repair
	Fuse blowing. (Automatic switch trips off, slow start with electromagnetic noise)	Short circuit of circuit switches	Check circuit switches and replace
		Incorrect wiring	Check wiring according to nameplate
		Poor contact at terminal	Lock tightly
		Windings grounded	Factory repair
		Broken windings	Factory repair
		Poor contact of circuit switches	Check and repair
		Broken wiring	Check and repair
		Poor contact of starting switches	Check and repair
Short circuit of starting switches	Check and repair		
Incorrect connections of starting switches	Connect according to nameplate		
Loading after start	Fuse blowing. Fail to restart due to trip-off of automatic switch	Insufficient capacity of fuse	Replace fuse if wiring permits
		Overload	Lighten load
		High load at low voltage	Check circuit capacity and reduce load
	Overheating motor	Overload or intermittent overload	Lighten load
		Under-voltage	Check circuit capacity and power source
		Over-voltage	Check power source
		Ventilation duct clogged	Remove the foreign matter in the duct
		Ambient temperature exceeds 40°C	Correct insulation class to B or F, or lower ambient temperature
		Friction between rotor and stator	Factory repair
		Fuse blown (Single-phase rotating)	Install the specified fuse
		Poor contact of circuit switches	Check and repair
		Poor contact of circuit starting switches	Check and repair
		Unbalance three-phase voltage	Check circuit or consult power company

Kinds of Breakdown	Symptoms	Possible Causes	Remedies
Loading after start	Speed falls sharply	Voltage drop	Check circuit and powers source
		Sudden overload	Check machine
		Single-phase rotating	Check circuit and repair
	Switch overheating	Insufficient capacity of switch	Replace switch
		High load	Lighten load
	Bearing over-heating	High belt tension	Adjust belt tension
		Slack belt tension	Adjust belt tension
		Misalignment between motor and machine shafts	Re-align
		Over speed of bearing outer-ring	Adjust bracket
		High bearing noise	Replace the damaged bearing
Noise	Electromagnetic noise induced by electricity	Occurrence from its first operation	May be normal
		Sudden sharp noise and smoking	Short circuit of windings should be repaired at the factory
	Bearing noise	Noise of low shishi or Thru-Thru	May be normal
		Kala-Kala as a result of poor lubrication	Grease
		Kulo-Kulo as a result of poor lubrication	Clean bearing and grease
		Sa-Sa or larger noise	Replace the damaged bearing
	Mechanical noise caused by machinery	Loose belt sheave	Adjust key and lock the screw
		Loose coupling or skip	Adjust the position of couplings, lock key and screw
		Loose screw on fan cover	Lock fan cover screw tightly
		Fan rubbing	Adjust fan position
		Rubbing as a result of ingress of foreign matter	Clean motor interior and ventilation ducts
		Wind noise	Noise induced by air flowing through ventilation ducts
		Induced by conveyance machine	Repair machine
	Vibration	Electromagnetic vibration	Short circuit of winding
Open circuit of rotor			Factory repair
Mechanical vibration		Unbalanced rotor	Factory repair
		Unbalanced fan	Factory repair
		Broken fan blade	Replace fan
		Unsymmetric centers between belt sheaves	Align central points
		Central points of couplings do not lie on the same level	Adjust the central points of couplings to the same level
		Improper mounting installation	Lock the mounting screws
		Motor mounting bed is not strong enough	Reinforce mounting bed
Remarks:			
(1) Circuit switches: These include knife switches, electromagnetic switches, fuse and other connection switches etc.			
(2) Starting switches: These include Delta-Star starters, compensate starters, reactance starters, resistor starters, starting controller's etc.			

DATE
Sept. 8, 2005
CAT. #: EP0026

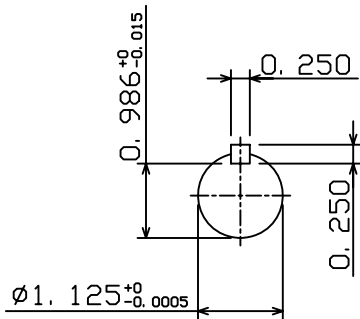
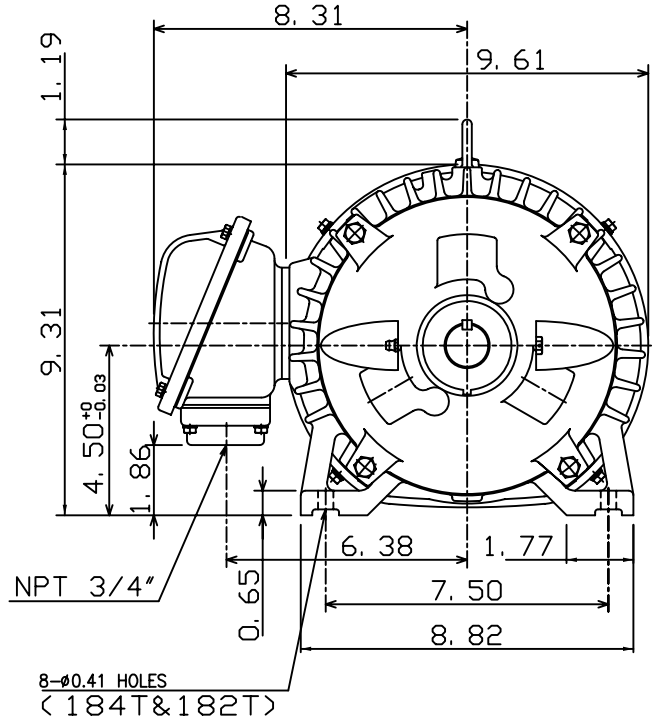
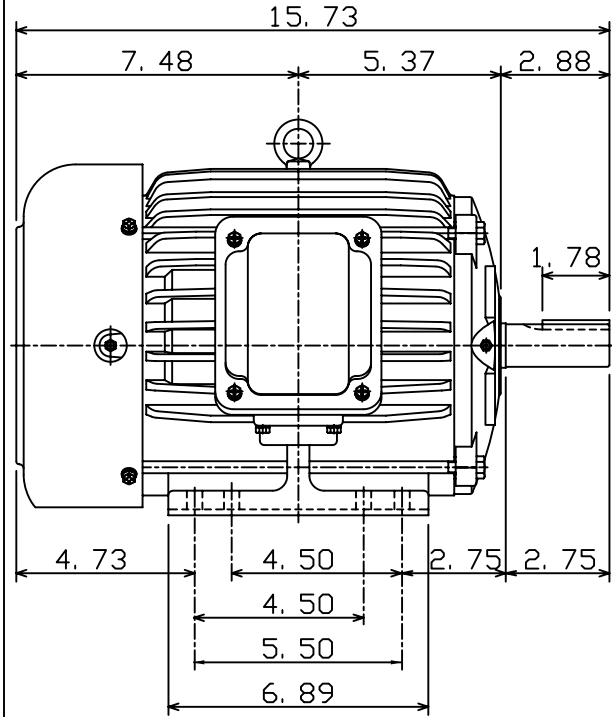
OUTLINE DIMENSIONS
3-PHASE INDUCTION MOTOR

MOTOR TYPE:
AEHH8N
FRAME NO. 184T

Pole	HP	kW	Hz	VOLT	Syn. Speed r/min(rpm)
6	2	1.5	60	230/460	1200

Ins	Rating	Dimension in	Approx Weight	Bearings
F	CONT.	inch	114 lbs.	DE: 6306ZZ NDE: 6306ZZ

Totally Enclosed Fan-Cooled Type, Squirrel-Cage Rotor.



DWN.	C. S. LO	12-22-04
CHKD.	C. S. LO	12-27-04
APPD.	M. C. TSAI	12-27-04

TEC Westinghouse

DWG NO.
31057H354030

TECO Westinghouse

ISSUED 5/5/2006	PERFORMANCE DATA 3-PHASE INDUCTION MOTOR	ENCLOSURE TEFC
TYPE AEHH8N		CATALOG# EP0026

NAMEPLATE INFORMATION

OUTPUT HP	KW	POLE	FRAME SIZE	VOLTAGE	HZ	RATED AMBIENT	INS. CLASS	NEMA DESIGN	TIME RATING	SERVICE FACTOR
2	1.49	6	184T	230/460	60	40°C	F	B	CONT.	1.15

VARIABLE FREQUENCY DRIVE SERVICE

VARIABLE TORQUE				OHMS/PHASE EQUIVALENT WYE CIRCUIT (AT RATED OPERATING TEMPERATURE 25°C)				
HZ	HP	RPM	TORQUE (lb-ft)	R1	R2	X1	X2	X _m
3-60	0.0003~2	60~1200	0.027~8.975	2.4842	3.3568	10.221	14.587	146.93

CONSTANT TORQUE				CONSTANT HORSEPOWER			
HZ	HP	RPM	TORQUE (lb-ft)	HZ	HP	RPM	TORQUE (lb-ft)
6-60	.2~2	120~1200	8.975	60~120	2	1200~2400	8.975~4.488

TYPICAL PERFORMANCE

FULL LOAD RPM	EFFICIENCY				POWER FACTOR			SOUND PRESSURE LEVEL @ 3 FT Db(A)
	FULL LOAD		3/4 LOAD %	1/2 LOAD %	FULL LOAD %	3/4 LOAD %	1/2 LOAD %	
	MIN.%	NOM.%						
1170	86.5	88.5	88.5	86.5	70.5	63	50.5	53

CURRENTS									NEMA KVA CODE LETTER	SAFE STALL TIME IN SECONDS	
NO LOAD			FULL LOAD			LOCKED ROTOR				COLD	HOT
AT 208 VOLT	AT 230 VOLT	AT 460 VOLT	AT 208 VOLT	AT 230 VOLT	AT 460 VOLT	AT 208 VOLT	AT 230 VOLT	AT 460 VOLT			
3.73	3.38	1.69	6.63	6.00	3.00	55.0	50.0	25	L	95	67

TORQUE				INERTIA			ACCEL TIME (DOL)		ALLOWABLE STARTS PER HOUR	
FULL LOAD (lb-ft)	LOCKED ROTOR %FLT	PULL UP %FLT	BREAK DOWN %FLT	ROTOR WR ² (lb-ft ²)	NEMA LOAD WK ² (lb-ft ²)	MAX ALLOWABLE WK ² (lb-ft ²)	NEMA LOAD WK ² Sec	MAX ALLOWABLE WR ² Sec	COLD	HOT
8.98	180	150	270	0.423	30	219	6.08	27.72	2	1

APPROVED:	M. PRATER	DRAWING NO.	31057EP0026	REVISION:	0
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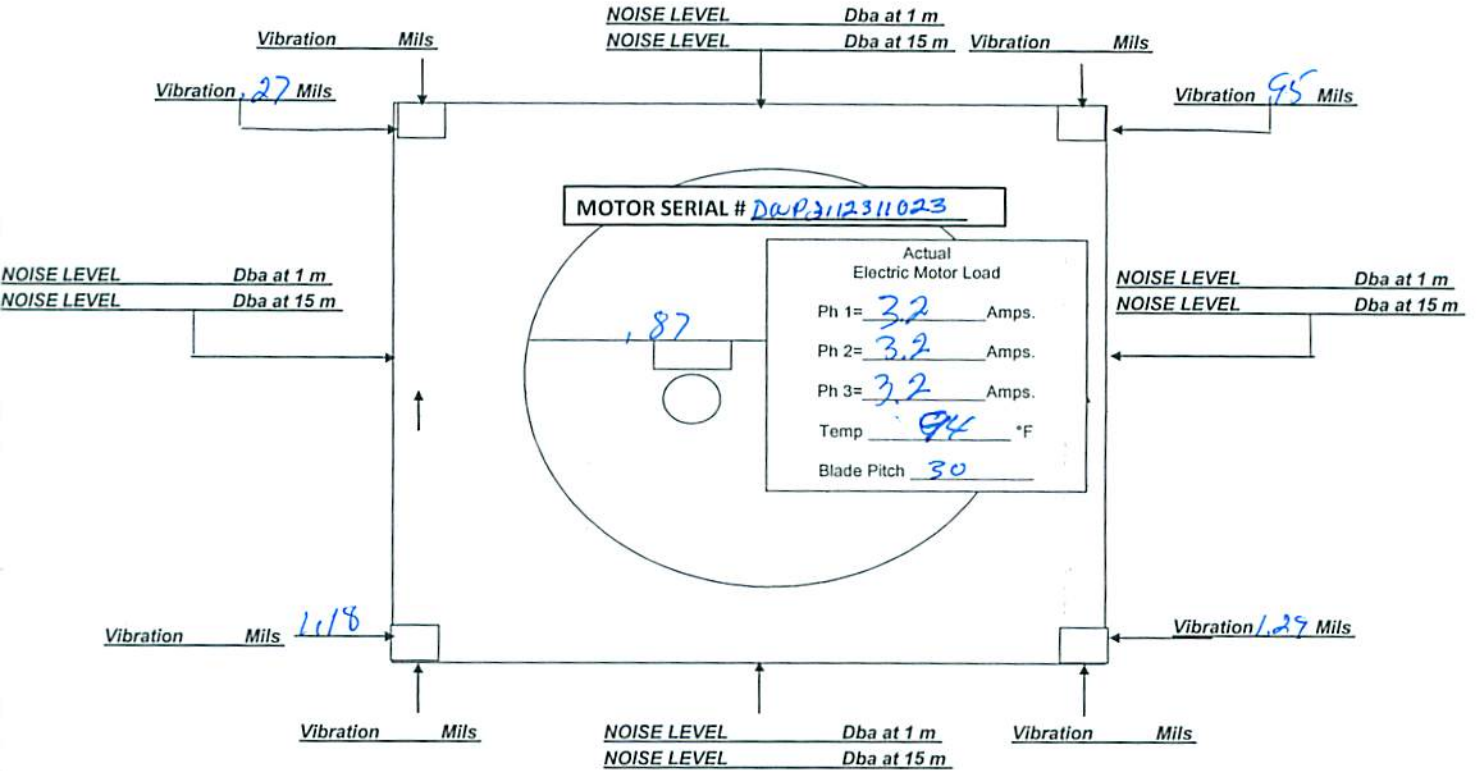
AXH air-coolers

401 East Lowery Rd. - Claremore, Ok. 74017
918-283-9200 - fax: 918-283-9229
www.axh.com

JOB NUMBER(S): 117551A
CUSTOMER: COMPASS COMPRESSION
QUANTITY: 1 MOTOR
MODEL: 36VI
Date: 6-30-11

RUN-IN & NOISE TESTING

BACK HEADER END



FRONT HEADER END

TESTING PERFORMED

1. Vibration Displacement in Mils. Peak to peak
 2. Vibration Meter: Balmac Model 205
 3. Noise Meter: Extech Model 407764
- ANSI S1.4-1983 Type 2, IEC 651

AXH air-coolers

Tested By: LARRY DRYWATER
 Date Tested: 6-30-11
 Time Tested: 3:30 am/pm

(A)



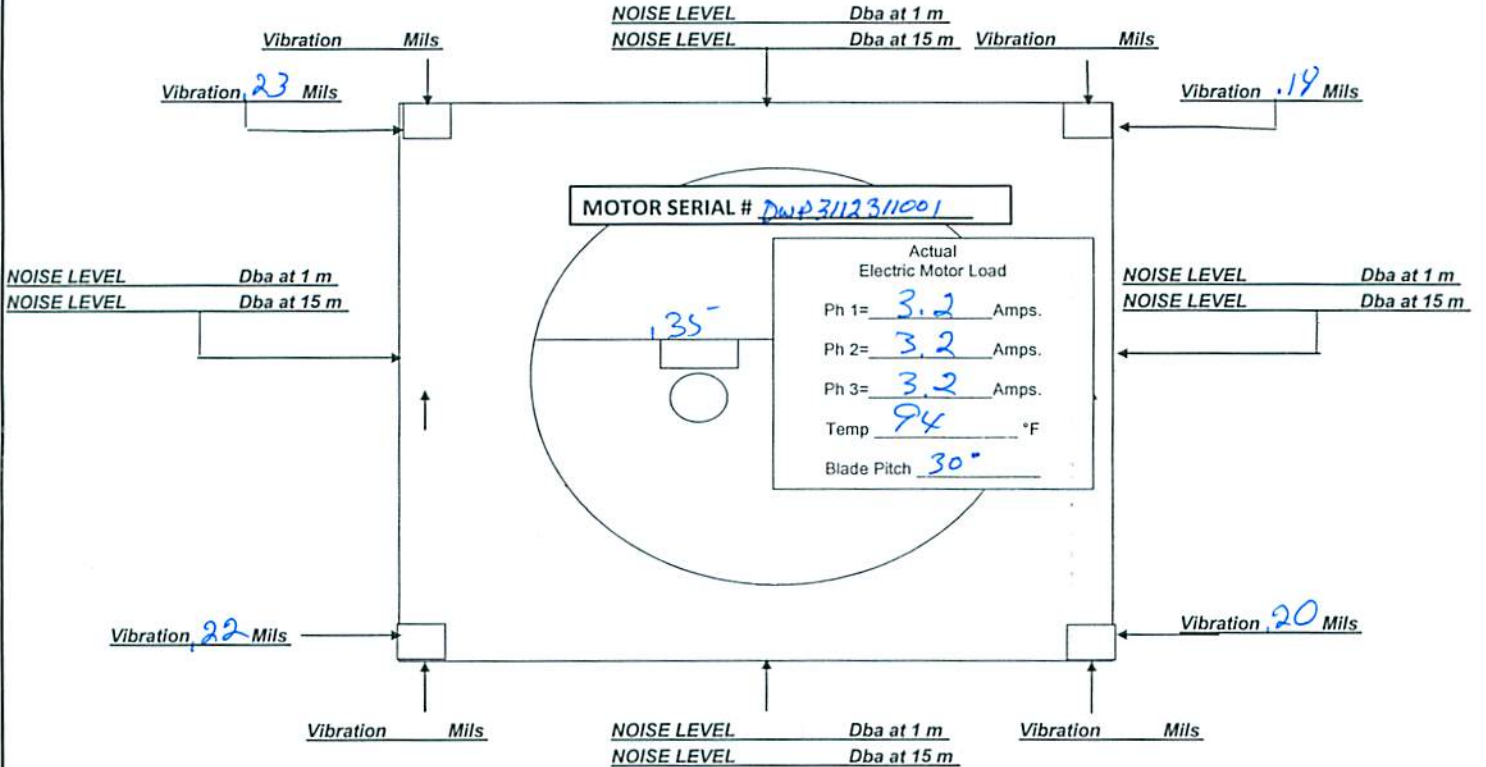
AXH air-coolers

401 East Lowery Rd. - Claremore, Ok. 74017
918-283-9200 - fax: 918-283-9229
www.axh.com

JOB NUMBER(S): 117551B
CUSTOMER: COMPASS COMPRESSION
QUANTITY: 1 MOTOR
MODEL: 36VI
Date: 6-30-11

RUN-IN & NOISE TESTING

BACK HEADER END



FRONT HEADER END

TESTING PERFORMED

1. Vibration Displacement in Mils. Peak to peak
 2. Vibration Meter: Balmac Model 205
 3. Noise Meter: Extech Model 407764
- ANSI S1.4-1983 Type 2, IEC 651

AXH air-coolers

Tested By: LARRY Drywater
 Date Tested: 6-30-11
 Time Tested: 2:50 am/pm

(B)









ax air-coolers
MODEL: SWA
JOB NO.: 117851A
TAG NO.: C496
REF NO.: C1407C-506

DANGER
LOCK OUT
EQUIPMENT
BEFORE ENTERING

TOYOTA



AXH air-coolers
Columbus, Oklahoma
918.225.8200
www.axh.com

MODEL	36VI
JOB NO.	117551A
TAG NO.	C588
REF NO.	CT4078-C588

DANGER
LOCK OUT
EQUIPMENT
BEFORE ENTERING

AXH air-coolers, LLC
Columbus, Oklahoma
918.225.8200
www.axh.com

NO ENTRY
NO TRIPASSING

NO TRIPASSING





AXH air-coolers

Only the name is new... AXH air-coolers

...combines 40 years of leadership experience in the air-cooled heat exchanger industry that encompasses the entire spectrum of air-coolers from initial thermal application and mechanical engineering, through design drafting, project management and after market support. To meet the growing market demands and customer expectations Air-x-hemphill was merged into AXH air-coolers in early 2005 in conjunction with a major expansion of both physical facilities and personnel.

Capabilities

AXH air-coolers' offers an unparalleled level of experience and technical expertise throughout the entire organization, coupled with the largest manufacturing facility in the industry. A complete range of air-cooler models, types and sizes can be provided to fit any standard or custom application. Importantly we have the capability to design, supply and duplicate virtually any replacement cooler or section as well as support the reapplication of existing coolers.

Reliability

We have manufactured thousands of air-coolers for the natural gas compression and process industries and have an established reputation for meeting delivery requirements. Foremost we are committed to quality assurance and on time shipment.

Integrity

AXH air-coolers' objective and commitment is to consistently provide customers with the highest quality air-coolers and support at a competitive price.



Corporate and sales office

Facilities



A new 161,000 square feet plant is located on 12 acres outside Tulsa and adjacent to Route 66 in Claremore, Oklahoma.



Capabilities



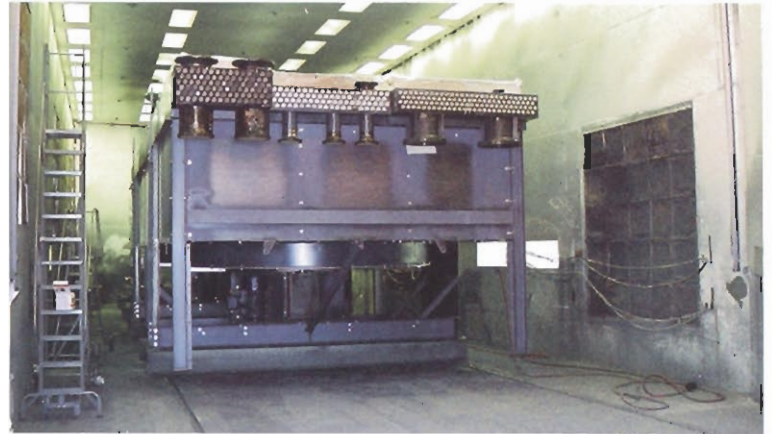
Finning area in 750 foot long East bay



5,000 sq. ft. parts warehouse



400 ton, 3/4" X 22' press brake



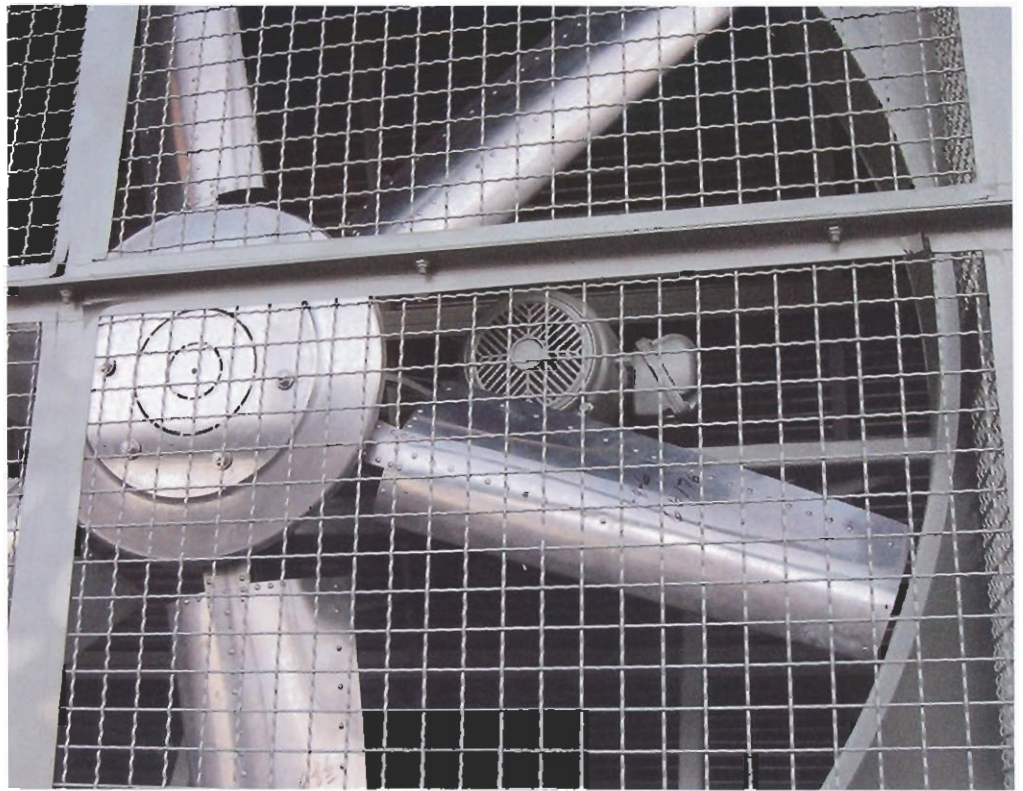
Larger of two paint booths - 1,900 sq. ft.



East bay final assembly area



(46) ASME code welding stations providing Stick, MIG, TIG & sub-arc procedures



Model 120EF with internal electric motor drive



Type HF incorporating evaporative inlet cooling



EF Models departing with warm air recirculation

Reliability



EF coolers ready for shipment

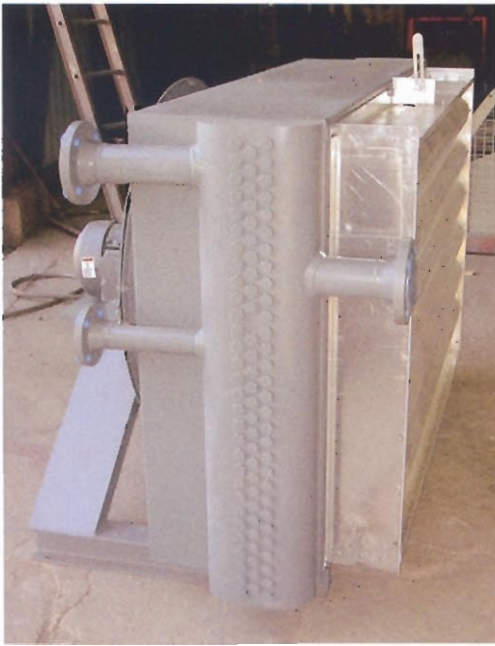


Type EF fan guard and "soft" bug screen frame



Induced Draft - Type VI's





Model VV with Obround headers



Model 180-2ZF destined for overseas



Direct Drive Model 36VF's



Model 60HF



Packaged two-fan, Model 120FF2



Galvanized Model 108FF2

Integrity



Air Cooled Heat Exchangers



Fully equipped for field service



AXH air-coolers

401 East Lowry, Claremore, Oklahoma 74017

(918) 283-9200 Fax (918) 283-9229

www.axh.com

Model 1010

Three-Way Thermostatic Valve

1010	1" NPT
1110	3/4" NPT
1210	1/2" NPT
1010J8	1/2" SAE O-Ring
1010J12	3/4" SAE O-Ring
1010J16	1" SAE O-Ring

Fluid Power Energy (FPE) Thermostatic Valves utilize the principle of expanding wax, which in the semi-liquid state undergoes large expansion rates within a relatively narrow temperature range. The self-contained element activates a stainless steel sleeve, which directs flow. All FPE Thermostatic Valves are factory set at predetermined temperatures: no further adjustments are necessary. A wide range of temperatures are available for water and oil temperature control applications.

When used in a diverting application, on start-up the total fluid flow is routed back to the main system. As fluid temperature rises to the control range, some fluid is diverted to the cooling system. As fluid temperature continues to increase, more flow is diverted. When the thermostat is in a fully stroked condition, all fluid flow is directed to the cooling system. FPE Thermostatic Valves may also be used in a mixing application.

In a mixing application, hot fluid enters the "B" port and colder fluid enters the "C" port. The flows mix and the thermostat adjusts to reach the desired temperature, exiting the "A" port.

Standard FPE thermostatic valve housings are made from aluminum and grey iron castings, however, ductile iron, bronze, steel and stainless steel housings are available.

Optional 1010 features: High over temperature element, plated element. Other options available upon request.



Features

Wide Range of Temperatures

Heavy Duty

Self-Contained

Replaceable Element

Non-Adjustable

Rugged Construction

Tamper-Proof

Operate in Any Position

Available for Refrigeration Service



FLUID POWER ENERGY, INC.

W229 N591 Foster Court • Waukesha, WI 53186

262 • 548 • 6220 Fax 262 • 548 • 6239

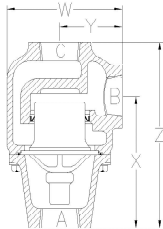
www.fpevalves.com



Model 1010

MODEL NUMBER	BODY MATERIAL (*)	NOMINAL PIPE SIZE	PRINCIPAL DIMENSIONS (UNITS in. & (mm))				MAX WIDTH IN THE OTHER PLANE	FLANGE DRILLING			NO. OF ELEMENTS	APPROX. SHIPPING WEIGHT	NOTES OR NUMBERED ENDNOTES
			"X"	"Y"	"W"	"Z"		NO. OF HOLES	DIA. OF HOLES	BOLT CIRCLE			
*1010	A, AL, B, D, S, SS	1" NPT	4 1/4 (107.95)	2 (50.80)	3 5/8 (92.08)	6 (152.40)	3 3/8 (85.73)	N/A	N/A	N/A	1	A=6.5#, AL=3# B=8.5#, D=6.5# S & SS=7#	
*1110	A, AL, B, D, S, SS	3/4" NPT	4 1/4 (107.95)	2 (50.80)	3 5/8 (92.08)	6 (152.40)	3 3/8 (85.73)	N/A	N/A	N/A	1	A=6.5#, AL=3# B=8.5#, D=6.5# S & SS=7#	
*1210	A, AL, B, D, S, SS	1/2" NPT	4 1/4 (107.95)	2 (50.80)	3 5/8 (92.08)	6 (152.40)	3 3/8 (85.73)	N/A	N/A	N/A	1	A=6.5#, AL=3# B=8.5#, D=6.5# S & SS=7#	
*1010J8	A, AL, B, D, S, SS	SAE 8 1/2"	4 13/32 (111.92)	2 3/16 (55.56)	3 7/8 (98.43)	6 11/32 (161.13)	3 3/8 (85.73)	N/A	N/A	N/A	1	A=6.5#, AL=3# B=8.5#, D=6.5# S & SS=7#	
*1010J12	A, AL, B, D, S, SS	SAE 12 3/4"	4 13/32 (111.92)	2 3/16 (55.56)	3 7/8 (98.43)	6 11/32 (161.13)	3 3/8 (85.73)	N/A	N/A	N/A	1	A=6.5#, AL=3# B=8.5#, D=6.5# S & SS=7#	
*1010J16	A, AL, B, D, S, SS	SAE 16 1"	4 13/32 (111.92)	2 3/16 (55.56)	3 7/8 (98.43)	6 11/32 (161.13)	3 3/8 (85.73)	N/A	N/A	N/A	1	A=6.5#, AL=3# B=8.5#, D=6.5# S & SS=7#	

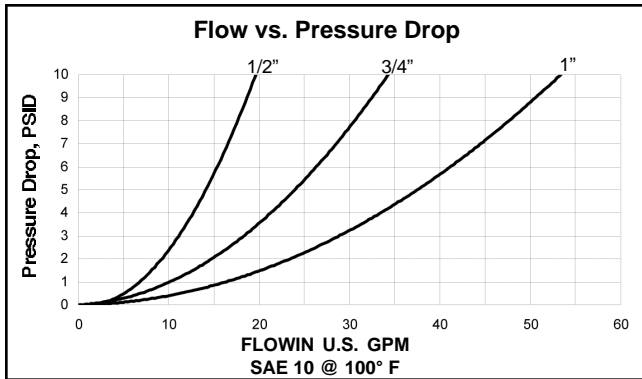
* (Replace * with body material type; A=Cast Iron, AL=Aluminum, B=Bronze, D=Ductile Iron, S=Steel, SS=Stainless Steel)



All models

PRESSURE RATINGS	
MATERIAL	PSI
A, AL, B	150
D	250
S, SS	500

For port sizes not shown consult factory



Recommended Pressure Drop is 2 to 7 PSI

PART #	DESCRIPTION
*1010	VALVE BODY (*See table for material)
*1020	VALVE COVER (*See table for material)
1080	GASKET (Older than 1979)
1572**	O-RING (Standard material is Buna-N)
1071	LIP SEAL
1060-Temp	THERMOSTAT (Temp to follow dash)
1600	HEX BOLT
1601	LOCK WASHER
1590	NAMEPLATE

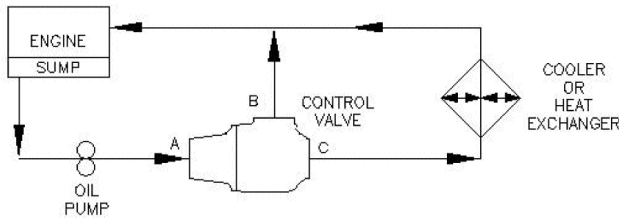
FPE Model 1000* Replacement Kit (Includes the following:)

1572**	O-RING (Standard material is Buna-N)
1071	LIP SEAL
1060-Temp	THERMOSTAT (Temp to follow dash)

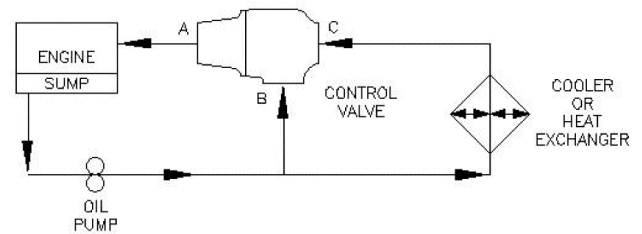
(For Viton® (V) or Neoprene (E) O-Ring material, replace ** with V or E)

Viton® is a registered trademark of Dupont Dow Elastomers

APPLICATION CHARTS



DIVERTING SYSTEM



MIXING SYSTEM

To Order

Specify Model Number, nominal temperature desired, and housing material. For Model coding information, visit our website or consult your factory representative.



FLUID POWER ENERGY, INC.

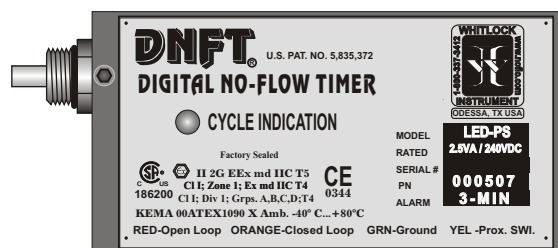
W229 N591 Foster Court • Waukesha, WI 53186

262•548•6220 Fax 262•548•6239

www.fpevalves.com

DNFT-LED-PS

P/N: 000507



DNFT-LED-PS



- **MONITORS MOVEMENT OF DIVIDER VALVE PISTON FOR DEPENDABLE "TIMED" SHUTDOWN PROTECTION**
- **CLOSED LOOP OR OPEN LOOP OPERATION**
- **INSTALLS DIRECTLY TO DIVIDER VALVE**
- **NOT AFFECTED BY TEMPERATURE OR OIL VISCOSITY**
- **REQUIRES NO EXTERNAL POWER**
- **LED INDICATOR - CYCLE INDICATION**
- **DEDICATED SWITCH CLOSURE TO MONITOR EACH DIVIDER VALVE CYCLE (PS OPTION)**
- **FIELD REPLACEABLE BATTERY**

Distributed by:

SPECIFICATIONS

Material.....Stainless Steel, Aluminum
Temperature Range..... -40° F to +185°F
Switch Rating.....2.5VA/240 VDC
Epoxy Encapsulated.....UL LISTED EL-CAST VFR 641
Alarm/Shutdown..... Factory default for 3 minute alarm
Power.....Field Replaceable - Lithium Battery
Battery..... P/N 000505
Alternate Battery.....Radio Shack 960-0418
Divider Block Application.....Dropsa/Lincoln/SBCO/
Lubriquip
Warranty.....2.5 Years

RATINGS

  **II 2G EEx md IIC T5**
CE
186200 **0344**
CI I; Zone 1; Ex md IIC T4
CI I; Div 1; Grps. A,B,C,D;T4
KEMA 00ATEX1090 X Amb. -40° C...+80°C

DESCRIPTION

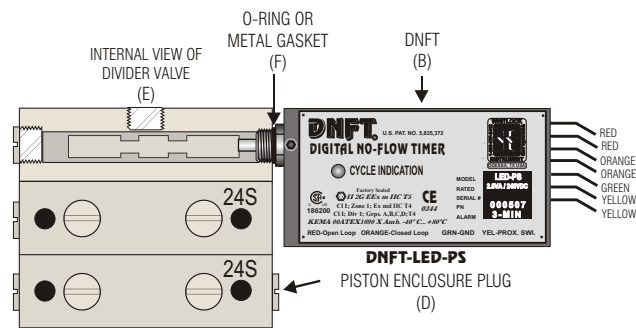
The DNFT-LED is a totally enclosed electronic device, combining the latest technology in microprocessor and transistor components for detecting Slow-Flow and No-Flow of divider block lubrication systems. The DNFT incorporates an oscillating crystal to accurately monitor the cycle time of the lubrication system to enable precision timed shutdown capability. The magnet assembly and control housing mount directly to the divider valve to become an integral part of the lubrication system. The DNFT operates on a field replaceable lithium battery. If battery voltage drops below normal operating levels the DNFT goes into alarm mode and the unit cannot be restarted. LED models utilize an LED to indicate each cycle of the divider valve. This enables the operator to easily set and monitor lubrication rates.

OPERATION

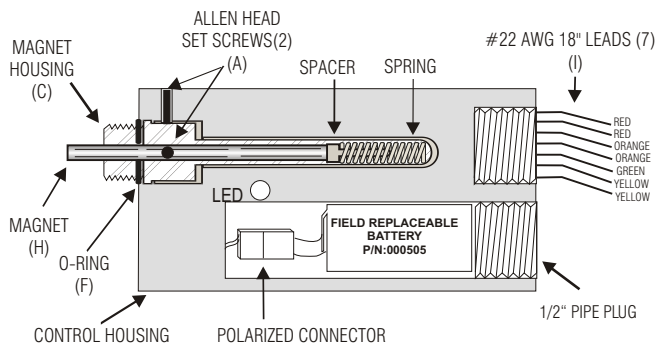
Lubricant flow through the divider valve assembly forces the pistons to cycle back and forth causing a lateral movement of a magnet linked to the piston. Movement is monitored by the microprocessor which resets the timer, lights the LED, and allows the unit to continue operation, this indicates one complete cycle of the lubrication system. The microprocessor must receive this cycle in a predetermined time or a shutdown will occur. The DNFT will automatically reset alarm circuit when normal operation of divider valve resumes.

P/N 000507 DNFT-LED-PS DIGITAL NO-FLOW TIMER WITH DEDICATED PROXIMITY SWITCH. INSTALL ON DROPSA/LINCOLN/SBCO/LUBRIQUIP DIVIDER BLOCK. SWITCH RATING 2.5VA 240VDC

- Loosen all Allen head set screws (A) on DNFT (B) and remove magnet housing (C). Do not remove magnet, spring or spacer from magnet housing.
 - Remove piston enclosure plug (D) from end of divider valve where DNFT will be installed. The DNFT does not have to be installed on the top divider valve. It may be installed on any convenient divider valve, top to bottom. (**Notice:** Do not install DNFT on Lincoln divider valves with cycle indicator pins or any Dropsa divider valve less than SMX 16.)
 - Be sure O-ring or metal gasket (F) is in place on magnet housing (C). Screw magnet housing (C) into end of divider valve (E). Torque to 15 foot pounds max.
 - Slide DNFT (B) all the way onto hex of magnet housing (C). Tighten set screws on hex of magnet housing. Torque 25 inch pounds max.
 - The LED on the DNFT indicates each divider valve cycle. This enables operator to adjust the lubricator pump for correct cycle time and oil consumption recommended by compressor manufacturer. If LED does not blink with compressor running or by manually pumping oil into divider valve, the DNFT must be adjusted. Normal cycle indication is a bright strobe type blink.
 - Before adjusting DNFT, divider valve must be cycling. This can be achieved with the compressor running or by manually pumping oil through the divider valve assembly with a hand priming pump.
 - Adjustment is made by sliding the DNFT (B) all the way on the hex of the magnet housing (C). Tighten set screws on hex of the magnet housing to 25 inch pounds max. Check for LED blink to confirm correct adjustment. If LED does not blink with divider valve cycling, adjust the DNFT back in 1/16" increments. Correct adjustment of the DNFT is confirmed by blinking LED.
 - All conduit and connections should be appropriate for area classification. **Notice:** Conduit and fittings must be supported to avoid bending magnet housing.
 - After installing magnet assembly and pre-compressor start-up, it is absolutely necessary to purge all air from divider block lubrication system. This can easily be accomplished with a lubrication system purge gun.**
 - DNFT must be installed with correct magnet assembly for each divider valve manufacturer.
 - Lincoln-7/16"-20 extended nose with O-ring
 - Trabon-1994 or earlier 7/16"-20 with metal crush gasket
 - Dropsa
 - SBCO & Trabon-1995 and up 7/16"-20 with O-ring
- Notice: When installing more than one DNFT, each DNFT must be wired to a separate alarm circuit of the control panel, annunciator or PLC to simplify troubleshooting the lubrication system and DNFT.



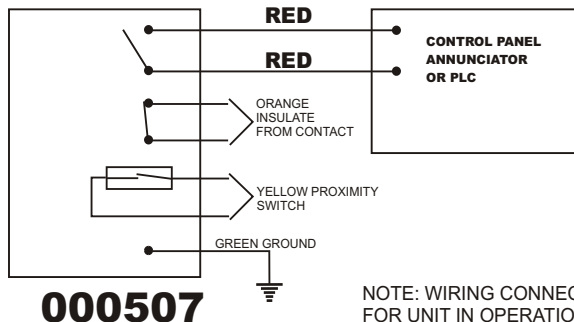
CAUTION: DISCONNECT ALL WIRING PRIOR TO WELDING ON COMPRESSOR OR SKID.



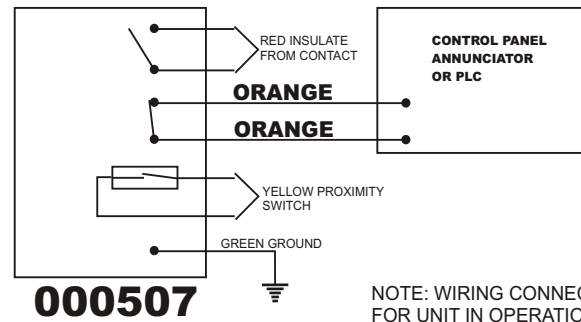
DNFT-LED-PS 000507

WIRING LEGEND
 RED.....NORMALLY OPEN OPERATION
 ORANGE.....NORMALLY CLOSED OPERATION
 GREEN.....CASE GROUND
 YELLOW.....DEDICATED PROX. SWITCH
 UNIT MUST BE SECURELY GROUNDED. DISCONNECT ALL WIRING PRIOR TO WELDING ON SKID.

OPEN LOOP MODE



CLOSED LOOP MODE



DNFT

DIGITAL NO-FLOW TIMER
U.S. PAT. NO. 5,835,372

WHITLOCK INSTRUMENT
1300 N. Texas
Odessa, TX 79761
432.3373412 Fax 432.335.5926
1.800.337.3412 www.noflo.com

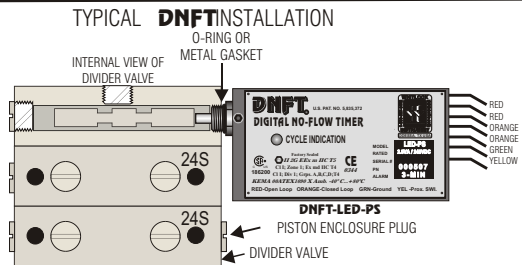
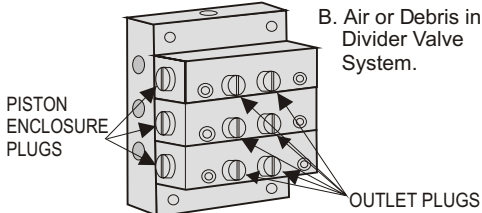
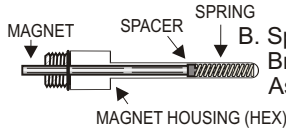


507LIT LED-PS-WI-3
06.05.01

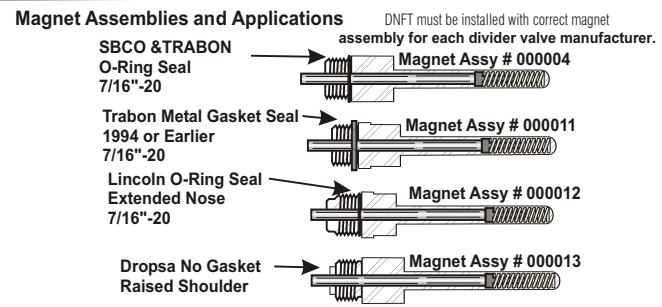
TROUBLESHOOTING DNFT-LED-PS

NOTICE: WHEN MORE THAN ONE DNFT IS INSTALLED ON THE COMPRESSOR OR ENGINE, EACH DNFT MUST BE WIRED TO A SEPARATE ALARM CIRCUIT ON THE CONTROL PANEL, ANNUNCIATOR OR PLC TO SIMPLIFY TROUBLESHOOTING THE LUBRICATION SYSTEM AND DNFT

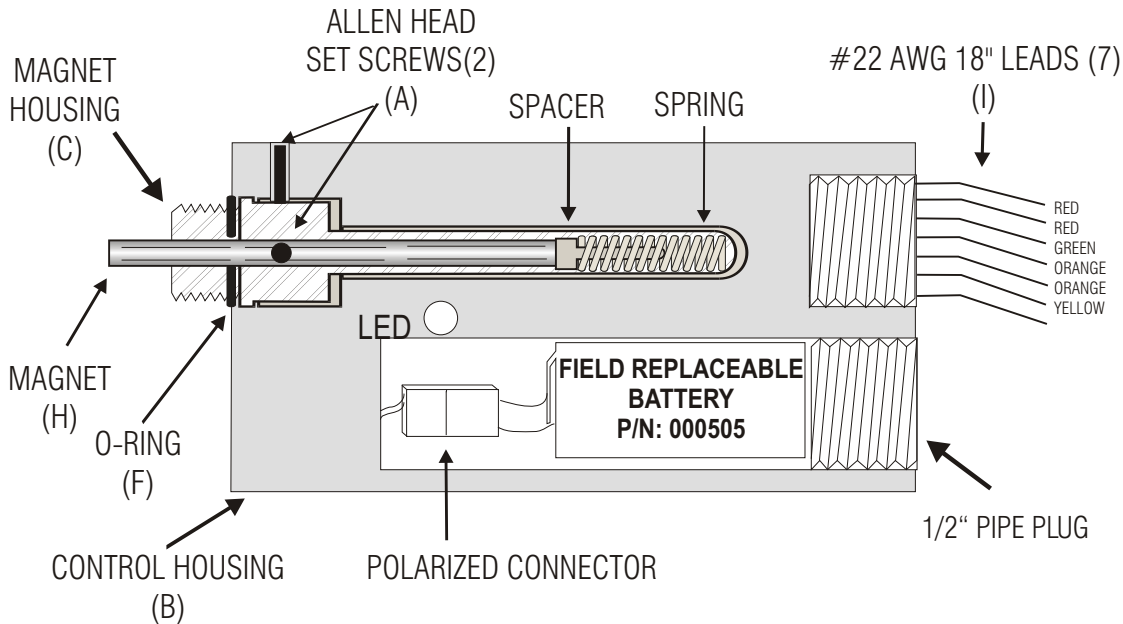
PROBLEM	POSSIBLE CAUSE	SERVICE PROCEDURE AND / OR CORRECTION
1. LED does Not Blink, Control Panel Indicates Lube No-Flow (See also, 3. Erratic shutdown)	A. Improperly Adjusted DNFT	Loosen set screws, slide DNFT all the way onto hex of magnet housing and torque to 25 inch pounds max. (Do not over tighten) Cycle divider valve by pumping clean oil through system with lubrication system purge gun or running compressor. If necessary, adjust DNFT 1/16" back until LED blinks with each cycle of divider valve.
	B. Spring or Magnet is Broken in Magnet Assembly	Loosen set screws, remove DNFT from magnet housing. Remove magnet assembly from divider valve. Remove magnet, spacer and spring. Check components for damage. Replace damaged spring and/or magnet and install on divider valve. If necessary, adjust DNFT, check for LED blink. Purge air from system with lubrication system purge gun.
	C. Low Battery voltage	Remove the battery from the DNFT per the attached instructions. Replace the battery if the voltage is below 2.5 volts using a factory recommended replacement battery.
	D. Bent Magnet Housing	Loosen set screws, remove DNFT from magnet housing. Check for damaged or bent magnet housing. Remove magnet assembly from divider valve. Replace magnet housing, magnet, spring and spacer. Re-install DNFT on magnet housing. If necessary, adjust DNFT, check for LED blink. Purge air from system with lubrication system purge gun.
2. After installation of DNFT, Rupture Disc is Blown and Divider Valve is Locked up.	A. Wrong Magnet Housing. Installed on Divider Valve (See magnet assy. Below)	Loosen set screws and remove DNFT from magnet housing. Check for correct magnet housing for divider valve manufacturer. Remove and replace with correct magnet housing. Replace DNFT on magnet housing. If necessary adjust DNFT, check for LED blink. Purge air from system with lubrication system purge gun.
	B. Air or Debris in Divider Valve System.	Check system pressure insure oil is flowing to divider valves. If necessary install pressure gauge to monitor operation of lubrication system. 1. Loosen outlet plugs in front of valve blocks. Fast purge the system with lubrication system purge gun until clean, clear, air free oil appears from plugs. 2. Loosen each piston enclosure plug individually to purge air from behind piston. Do not remove piston enclosure plugs. Tighten all divider valve plugs. Adjust DNFT. To insure proper operation of the divider block lubrication system, it is absolutely necessary that all tubing and components be filled with oil and free of air before start-up.
ELETRICAL TESTING OF DNFT ALARM CIRCUIT		1. NORMALLY OPEN - Attach ohmmeter to red wires. Meter should read 10 megaohms in operation and less than 10 ohms in alarm state. 2. NORMALLY CLOSED - Attach ohmmeter to orange wires. Meter should read less than 10 ohms in operation and infinity in alarm state.
Faulty Lube Pump		Check system pressure to insure oil is flowing to divider valves. If necessary, install pressure gauge to monitor operation of lubrication system. Check gauge to insure pump will build sufficient pressure to inject oil into cylinder. You cannot check for oil flow into cylinder by removing tubing from check valve and pumping oil to atmosphere. Replace pump.



CAUTION: DISCONNECT ALL WIRING PRIOR TO WELDING ON COMPRESSOR OR SKID.



DNFT BATTERY REPLACEMENT INSTRUCTIONS



Directions for replacing the battery in the Digital No Flow Timer.

1. Shut down the engine or set the bypass timer.
2. Use a 3/8" ratchet to remove the 1/2" NPT Pipe plug.
3. Remove the battery from the DNFT and disconnect from the polarized connector.
4. Connect the new battery to the attached polarized plug.
5. Reinsert the battery and reinstall 1/2" NPT Pipe plug.
6. Verify the DNFT is working by pre-lubing the system and check for LED blink.

ITEMS REQUIRED FOR REPLACING THE DNFT BATTERY:

- (1) P/N: 000505 BATTERY or RADIO SHACK P/N: 960-0418 (alternate replacement)
- (1) 3/8" RATCHET WRENCH (for removal of battery plug)

For any further information or questions, please contact:

WHITLOCK INSTRUMENT
1300 N. Texas
Odessa, TX 79761
432.3373412 Fax 432.335.5926
1.800.337.3412
www.noflo.com

THOMAS® FLEXIBLE DISC COUPLINGS

TYPE AMR

AMR couplings are used in heavy duty slow to medium speed applications, where high starting torque, shock loads, torque reversals or continuous alternating torque is present. The open lug type center member provides ample clearance for assembly while minimizing the space required for coupling installation.

Construction

Hubs: Cast Alloy Iron

Center Section: Sizes 162 – 750 are Cast Alloy Iron, Sizes 800 and above are Cast Steel

Bolts: Alloy Steel

Disc Packs: Tomaloy Tpack™ (225-750 Size)

Coatings Available: Black Oxide, Zinc, Cadmium

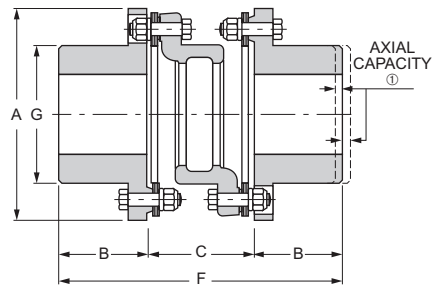
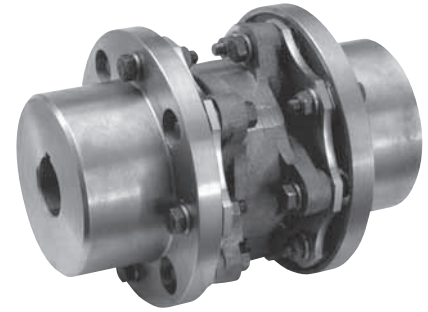
Other materials such as Stainless Steel, Monel and Inconel are available; please consult Rexnord Industries, Inc.

Misalignment: 1/8° per disc pack

****INCREASED TORQUE RATINGS****

General Dimensions (inch)

Cplg. Size	④ Rough Bore	⑥ Max Bore	A	B	C	F	G
162	—	1.62	4.56	1.75	2.62	6.12	2.75
200	—	2.00	5.75	2.12	3.00	7.25	3.62
225	—	2.25	6.00	2.50	3.00	8.00	3.88
262	—	2.62	6.88	2.88	3.50	9.25	4.50
312	—	3.12	8.12	3.38	4.12	10.88	5.44
350	—	3.50	9.12	3.75	4.56	12.06	6.00
375	—	3.75	10.06	4.00	5.12	13.12	6.50
425	—	4.25	11.00	4.25	5.56	14.06	7.00
450	—	4.50	11.88	4.50	5.94	14.94	7.44
500	2.69	5.00	13.44	5.00	6.81	16.81	8.38
550	2.69	5.50	15.00	5.50	7.69	18.69	9.44
600	3.69	6.00	16.75	6.00	8.44	20.44	10.31
700	4.25	7.00	18.94	7.00	9.62	23.62	11.75
750	4.94	7.50	20.62	7.25	10.50	25.00	12.62
800	5.19	8.00	22.38	7.75	11.38	26.88	13.75
850	5.44	8.50	23.75	8.25	12.12	28.62	14.50
925	5.94	9.25	25.75	9.00	13.25	31.25	15.88
1000	6.50	10.00	28.25	9.50	14.50	33.50	17.50
1100	7.00	11.00	30.25	10.25	15.50	36.00	18.50
1200	7.50	12.00	33.38	11.00	17.06	39.06	20.25
1300	8.00	13.00	36.00	12.00	18.31	42.31	22.50
1550	8.50	15.50	39.25	14.50	19.44	48.44	26.00



Engineering Data

Coupling Size	Max Horsepower Per 100 RPM	③ Max. RPM	Max. Continuous Torque (lb.-in.)	⑦ Peak Overload Torque (lb.-in.)	② Weight (lb.)	⑤ WR ² (lb.-in. ²)	① Axial Capacity (in.)
	Service Factor						
162	9.1	2,500	5,740	6,888	8	18	±0.036
200	17.5	2,500	11,030	13,236	16	57	±0.036
225	24.7	2,500	15,575	18,690	20	76	±0.036
262	33.4	2,500	21,038	25,245	32	162	±0.043
312	37.5	2,500	23,650	28,380	47	365	±0.051
350	83.8	2,300	52,800	63,360	71	659	±0.056
375	126	2,200	79,442	95,330	92	1,025	±0.062
425	140	2,000	88,000	105,600	117	1,590	±0.067
450	216	1,900	136,125	163,350	144	2,250	±0.072
500	319	1,800	200,750	240,900	212	4,240	±0.082
550	436	1,800	275,055	330,066	290	7,220	±0.092
600	569	1,800	358,875	430,650	389	12,000	±0.102
700	724	1,500	456,500	547,800	587	22,800	±0.115
750	1,023	1,500	644,930	773,916	722	33,900	±0.125
800	1,291	1,200	813,780	976,536	938	55,600	±0.136
850	1,426	1,100	898,700	1,078,440	1,150	75,600	±0.144
925	2,033	1,000	1,281,280	1,537,536	1,400	102,000	±0.156
1000	2,360	900	1,487,200	1,784,640	1,900	172,000	±0.172
1100	3,246	800	2,046,000	2,455,200	2,280	245,000	±0.183
1200	3,494	650	2,202,200	2,642,640	2,990	394,000	±0.203
1300	3,787	600	2,387,000	2,864,400	3,900	561,000	±0.218
1550	4,957	600	3,124,000	3,748,800	5,150	889,000	±0.242

For larger sizes, consult Rexnord. For ordering instructions, see Page 10-11.

① All Thomas disc couplings meet NEMA frame sleeve bearing motor specifications without modification or the addition of end-float restricting devices.

② Weight and WR² at maximum bore.

③ Consult Rexnord if balancing is required.

④ Consult Rexnord for minimum rough bore on sizes 162-450.

⑤ Special hub available for size 600 with 6 3/4 max. bore. Consult Rexnord.

⑥ Straight bores with no keyway require a steel hub. Consult Rexnord.

⑦ The Peak Overload Torque is not an alternating torque limit.

Note: Dimensions subject to change. Certified dimensions of ordered material furnished on request.

Integral-Bonnet Needle Valves



O, 1, 18, 20, and 26 Series

- Live-loaded packing system
- Compact design
- Working pressures up to 6000 psig (413 bar)
- Temperatures up to 600°F (315°C)

Features

Stem Designs

- Vee—all series
- Soft-seat—all series
- Regulating—O, 1, and 18 series

Orifice Sizes

- From 0.080 to 0.375 in. (2.0 to 9.5 mm)

Flow Coefficients (C_v)

- From 0.09 to 1.80

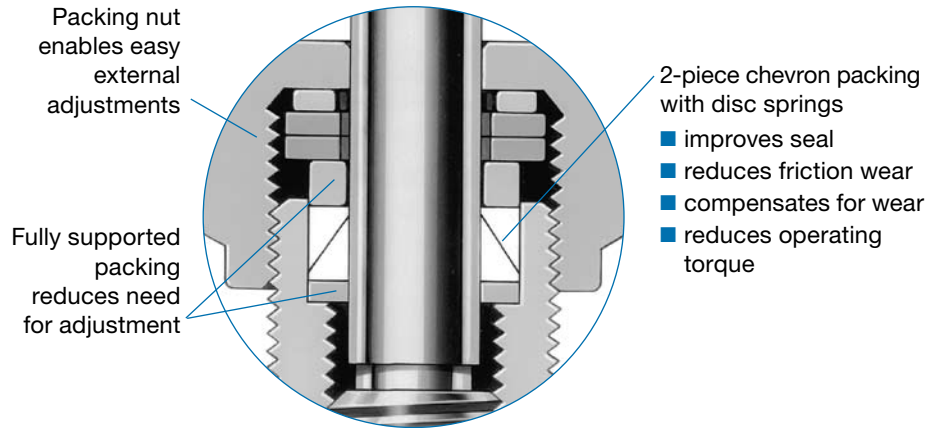
Flow Patterns

- Straight, angle, and cross patterns

Panel Mounting

- O, 1, and 18 series

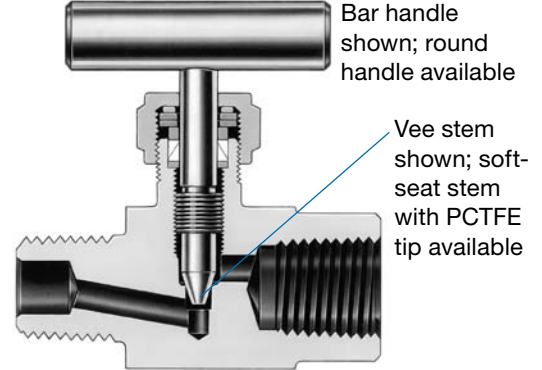
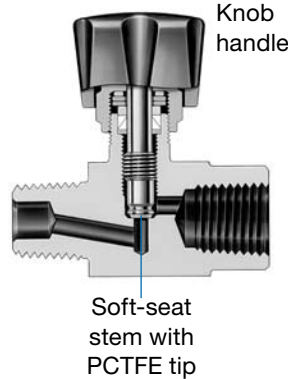
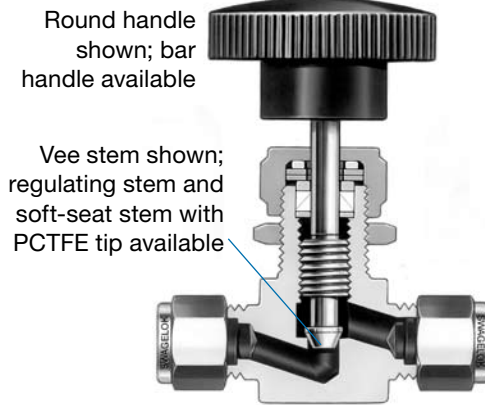
Live-Loaded Packing System



O, 1, and 18 Series

20K Series

20V and 26 Series



Pressure-Temperature Ratings

Ratings are limited to:

- 200°F (93°C) max with soft-seat stem with PCTFE stem tip.
- 250°F (121°C) max with UHMWPE packing.
- 450°F (232°C) max with PFA packing.
- 600°F (315°C) max with PEEK packing.

To order a valve with soft-seat stem and PCTFE stem tip, see **Ordering Information and Dimensions**, page 4 and 6.

To order a valve with UHMWPE or PEEK packing, see **Options and Accessories**, page 7.

O, 1, and 18 Series

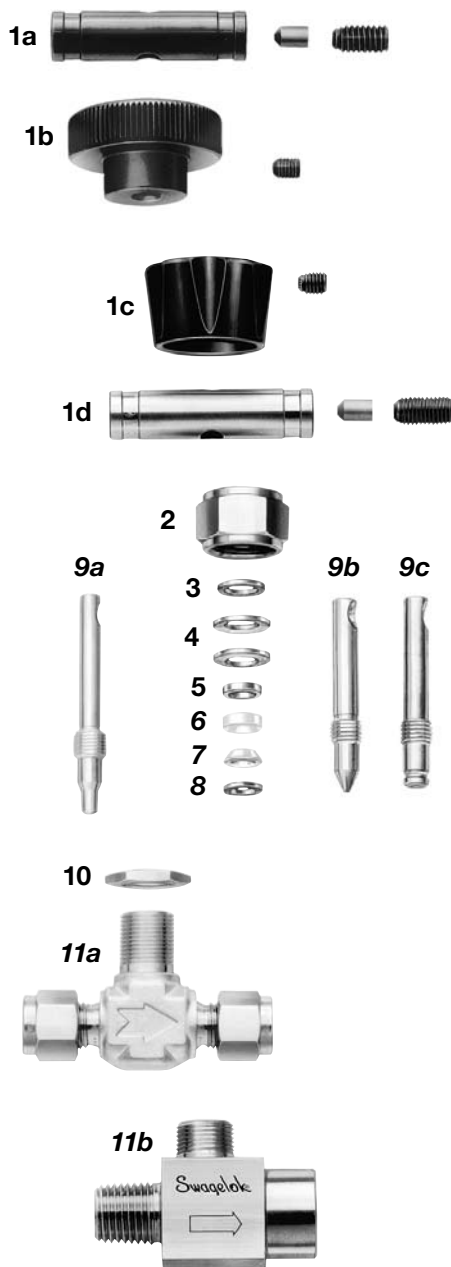
ASME Class	2080	N/A		1500
Material Group	2.2	N/A		3.4
Material Name	316 SS	Brass	Steel	Alloy 400
Temperature, °F (°C)	Working Pressure, psig (bar)			
-65 (-53) to -20 (-28)	5000 (344)	3000 (206)	—	3000 (206)
-20 (-28) to 100 (37)	5000 (344)	3000 (206)	3000 (206)	3000 (206)
200 (93)	4295 (295)	2350 (161)	2730 (188)	2640 (181)
250 (121)	4085 (281)	2200 (151)	2695 (185)	2555 (176)
300 (148)	3875 (266)	2050 (141)	2660 (183)	2470 (170)
350 (176)	3715 (255)	1470 (101)	2615 (180)	2430 (167)
400 (204)	3560 (245)	390 (26)	—	2390 (164)
450 (232)	3435 (236)	—	—	2380 (163)
500 (260)	3310 (228)	—	—	2375 (163)
600 (315)	3130 (215)	—	—	—

20 and 26 Series

ASME Class	2500
Material Group	2.2
Material Name	316 SS
Temperature °F (°C)	Working Pressure psig (bar)
-65 (-53) to 100 (37)	6000 (413)
200 (93)	5160 (355)
250 (121)	4910 (338)
300 (148)	4660 (321)
350 (176)	4470 (307)
400 (204)	4280 (294)
450 (232)	4130 (284)
500 (260)	3980 (274)
600 (315)	3760 (259)

For more information about pressure ratings of valves with tube fitting end connections, see Swagelok *Tubing Data*, MS-01-107.

Materials of Construction



Component	Series	Valve Body Materials			
		Material Grade/ASTM Specification			
		316 SS	Brass	Steel	Alloy 400
1a Bar handle Handle pin Set screw	18	Anodized aluminum 2024/B221 or A209			
		Steel/A108			
		Nickel cadmium-plated steel			
1b Round handle Set screw	O and 1	Phenolic with brass insert			
		Nickel cadmium-plated steel			
1c Knob handle Set screw	20K	Anodized aluminum 7129/B221	—		
		Nickel cadmium-plated steel	—		
1d Bar handle Handle pin, set screw	20V and 26	316 SS/A276	—		
		S17400/A564	—		
2 Packing nut	All	316 SS/A276	Brass 360/B16	12L14/A108	Alloy 400/B164
3 Gland	O, 1, ^① and 20	304 SS/A240, A167			
4 Packing springs	All ^②	S17700/A693			
5 Packing gland	All	316 SS/A240, A276, B783			
6 Upper packing	All	PFA/D3307			
7 Lower packing					
8 Lower gland	All	316 SS/A240			Alloy 400/B127
9a Regulating stem	O, 1, and 18	Chrome-plated ^③ 316 SS/A276	316 SS/A276		Alloy 400/B164
9b Vee stem	All				
9c Soft-seat stem Stem tip	All				
		PCTFE/D1430			
10 Panel nut	O, 1, and 18	316 SS	Brass 360/B16	316 SS	
11a Body	O, 1, and 18	316 SS/A182	Brass 377/B283	Cadmium-plated 11L17/A108	Alloy 400/B564
11b Body	20 and 26	316 SS/A479	—		
Lubricant	All	Tungsten disulfide- and fluorocarbon-based			

Wetted components listed in *italics*.

Valve series listed with standard handles. For handle options, see **Handles**, page 8.

① 1 series valves with orifice of 0.172 in. (4.4 mm).

② O, 20 and 1 series with orifice of 0.172 (4.4 mm)—2 springs; 18, 26, and 1 series with orifice of 0.250 (6.4 mm)—3 springs.

③ Regulating and vee stem tip and threads; soft-seat stem threads.

Testing

Every integral-bonnet needle valve is factory tested with nitrogen at 1000 psig (69 bar). Seats have a maximum allowable leak rate of 0.1 std cm³/min. Shell testing is performed to a requirement of no detectable leakage with a liquid leak detector.

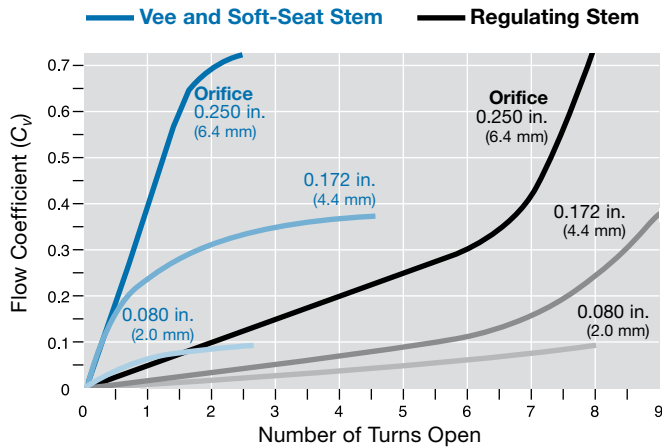
Cleaning and Packaging

All integral-bonnet needle valves are cleaned and packaged in accordance with Swagelok *Standard Cleaning and Packaging (SC-10)*, MS-06-62. Cleaning and packaging in accordance with Swagelok *Special Cleaning and Packaging (SC-11)*, MS-06-63, to ensure compliance with product cleanliness requirements stated in ASTM G93 Level C are available as an option.

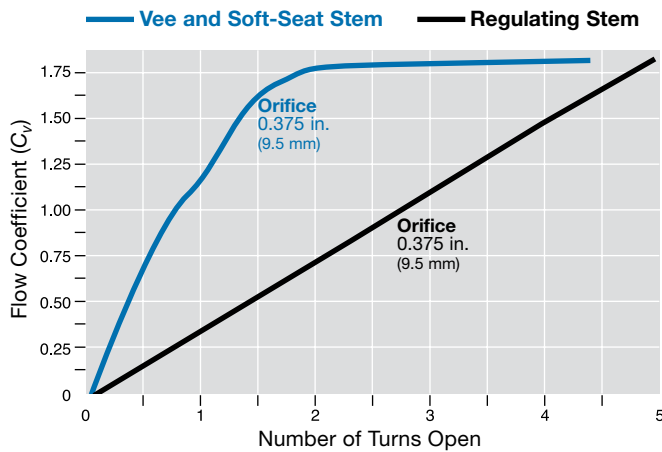
Flow Data at 100°F (37°C)

Flow Coefficient at Turns Open

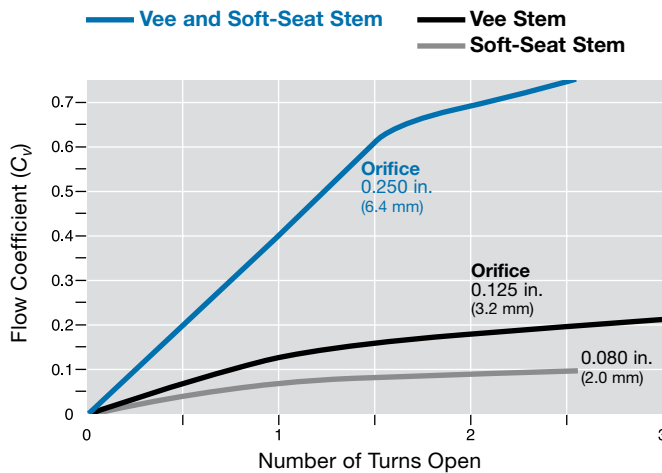
O and 1 Series



18 Series



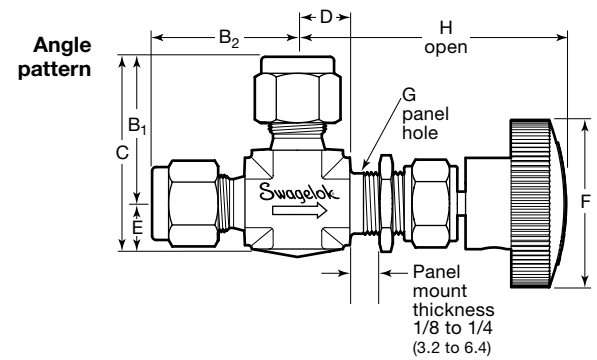
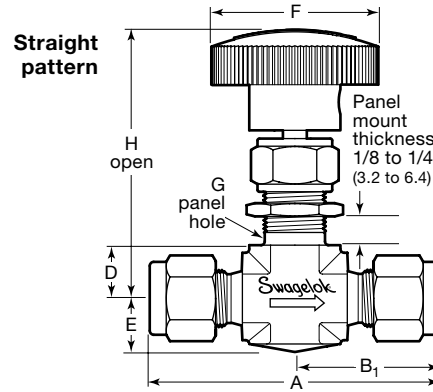
20 and 26 Series



Ordering Information and Dimensions

O, 1, and 18 Series

Dimensions, in inches (millimeters), are for reference only and are subject to change.



Stainless Steel Valves with Regulating Stems

Select an ordering number.

Alloy 400, Brass, and Steel Valves with Regulating Stems

Replace **SS** in the ordering number with a material designator.

Example: **M-ORS2**

Material	Designator
Alloy 400	M
Brass	B
Steel	S

Vee and Soft-Seat Stems

Replace **R** in the ordering number with **V** for a vee stem or **K** for a soft-seat stem with PCTFE stem tip.

Examples: **SS-OVS2**
SS-OKS2

Angle-Pattern Valves

Add **-A** to the ordering number.

Example: **SS-ORS2-A**

Cross-Pattern Valves

Certain 1 series valves are available with cross-pattern bodies, which provide continuous flow between the side ports and on-off or regulating flow through the bottom port. Contact your authorized Swagelok sales and service representative for more information.

End Connections		C _v	Orifice in. (mm)	Ordering Number	Dimensions, in. (mm)								
Inlet/Outlet	Size				A	B ₁	B ₂	C	D	E	F	G	H
Fractional Swagelok tube fittings	1/8 in.	0.09	0.080 (2.0)	SS-ORS2	1.94 (49.3)	0.98 (24.9)		1.29 (32.8)	0.44 (11.2)	0.31 (7.9)	1.00 (25.4)	0.47 (11.9)	2.28 (57.9)
	1/4 in.	0.37	0.172 (4.4)	SS-1RS4	2.27 (57.6)	1.13 (28.7)		1.51 (38.4)		0.38 (9.7)	1.38 (35.1)	0.53 (13.5)	2.50 (63.5)
	3/8 in.	0.73	0.250 (6.4)	SS-1RS6	2.58 (65.5)	1.29 (32.8)		1.79 (45.5)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	1/2 in.			SS-1RS8	2.80 (71.1)	1.40 (35.6)		1.90 (48.3)					
	1/2 in.	1.80	0.375 (9.5)	SS-18RS8	3.80 (96.5)	1.90 (48.3)		2.65 (67.3)	0.75 (19.1)		3.00 (76.2)	1.03 (26.2)	3.91 (99.3)
	3/4 in.			SS-18RS12									
Metric Swagelok tube fittings	3 mm	0.09	0.080 (2.0)	SS-ORS3MM	1.94 (49.3)	0.98 (24.9)		1.29 (32.8)	0.44 (11.2)	0.31 (7.9)	1.00 (25.4)	0.48 (12.2)	2.28 (57.9)
	6 mm	0.37	0.172 (4.4)	SS-1RS6MM	2.27 (57.6)	1.13 (28.7)		1.51 (38.4)		0.38 (9.7)	1.38 (35.1)	0.53 (13.5)	2.50 (63.5)
	8 mm			SS-1RS8MM	2.34 (59.4)	1.17 (29.7)		1.54 (39.1)					
	10 mm	0.73	0.250 (6.4)	SS-1RS10MM	2.60 (66.0)	1.30 (33.0)		1.80 (45.7)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	12 mm			SS-1RS12MM	2.80 (71.1)	1.40 (35.6)		1.90 (48.3)					
	12 mm	1.80	0.375 (9.5)	SS-18RS12MM	3.80 (96.5)	1.90 (48.3)		2.65 (67.3)	0.75 (19.1)		3.00 (76.2)	1.03 (26.2)	3.91 (99.3)
	18 mm			SS-18RS18MM									
Female NPT	1/8 in.	0.09	0.080 (2.0)	SS-ORF2	1.88 (47.8)	0.94 (23.9)		1.25 (31.8)	0.44 (11.2)	0.31 (7.9)	1.00 (25.4)	0.47 (11.9)	2.28 (57.9)
	1/8 in.	0.37	0.172 (4.4)	SS-1RF2	1.62 (41.1)	0.81 (20.6)		1.19 (30.2)		0.38 (9.7)	1.38 (35.1)	0.53 (13.5)	2.50 (63.5)
	1/4 in.	0.73	0.250 (6.4)	SS-1RF4	2.12 (53.8)	1.06 (26.9)		1.56 (39.6)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	3/8 in.	1.80	0.375 (9.5)	SS-18RF6	3.00 (76.2)	1.50 (38.1)		2.25 (57.2)	0.75 (19.1)		3.00 (76.2)	1.03 (26.2)	3.88 (98.6)
	1/2 in.			SS-18RF8									
Male NPT	1/8 in.	0.09	0.080 (2.0)	SS-ORM2	1.50 (38.1)	0.75 (19.1)		1.06 (26.9)	0.44 (11.2)	0.31 (7.9)	1.00 (25.4)	0.47 (11.9)	2.28 (57.9)
	1/8 in.	0.37	0.172 (4.4)	SS-1RM2	1.62 (41.1)	0.81 (20.6)		1.19 (30.2)		0.38 (9.7)	1.38 (35.1)	0.53 (13.5)	2.50 (63.5)
	1/4 in.			SS-1RM4	1.97 (50.0)	0.98 (24.9)		1.36 (34.5)					
	3/8 in.	0.73	0.250 (6.4)	SS-1RM6	2.25 (62.5)	1.12 (28.4)		1.62 (41.1)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	1/2 in.	1.80	0.375 (9.5)	SS-18RM8	3.00 (76.2)	1.50 (38.1)		2.25 (57.2)	0.75 (19.1)		3.00 (76.2)	1.03 (26.2)	3.88 (98.6)
Male NPT/ Swagelok tube fitting	1/8 in.	0.09	0.080 (2.0)	SS-ORM2-S2	1.73 (43.9)	0.98 (24.9)	0.75 (19.1)	1.29 (32.8)	0.44 (11.2)	0.31 (7.9)	1.00 (25.4)	0.47 (11.9)	2.28 (57.9)
	1/4 in.	0.37	0.172 (4.4)	SS-1RM4-S4	1.95 (49.5)	1.13 (28.7)	0.98 (24.9)	1.51 (38.4)		0.38 (9.7)	1.38 (35.1)	0.53 (13.5)	2.50 (63.5)
	1/4/ 3/8 in.	0.73	0.250 (6.4)	SS-1RM4-S6	2.42 (61.5)	1.29 (32.8)	1.12 (28.4)	1.79 (45.5)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	3/8 in.			SS-1RM6-S6		1.90 (48.3)							
	3/8/ 1/2 in.			SS-1RM6-S8	2.52 (64.0)	1.40 (35.6)							
Male/ female NPT	1/4 in.	0.73	0.250 (6.4)	SS-1RM4-F4	2.19 (55.6)	1.06 (26.9)	1.12 (28.4)	1.56 (39.6)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	1/2 in.	1.80	0.375 (9.5)	SS-18RM8-F8	3.00 (76.2)	1.50 (38.1)		2.25 (57.2)	0.75 (19.1)		3.00 (76.2)	1.03 (26.2)	3.88 (98.6)
Female ISO ^①	1/4 in.	0.73	0.250 (6.4)	SS-1RF4RT	2.12 (53.8)	1.06 (26.9)		1.56 (39.6)	0.55 (14.0)	0.50 (12.7)	1.88 (47.8)	0.78 (19.8)	2.97 (75.4)
	3/8 in.	1.80	0.375 (9.5)	SS-18RF6RT	3.00 (76.2)	1.50 (38.1)		2.25 (57.2)	0.75 (19.1)		3.00 (76.2)	1.03 (26.2)	3.88 (98.6)
	1/2 in.			SS-18RF8RT									

Dimensions determined using valves with regulating stems and standard handles. Dimensions are shown with Swagelok nuts finger-tight.

① See specifications ISO 7/1, BS EN 10226-1, DIN-2999, JIS B0203.

Ordering Information and Dimensions

20 and 26 Series

Dimensions are for reference only and are subject to change.

Select an ordering number.

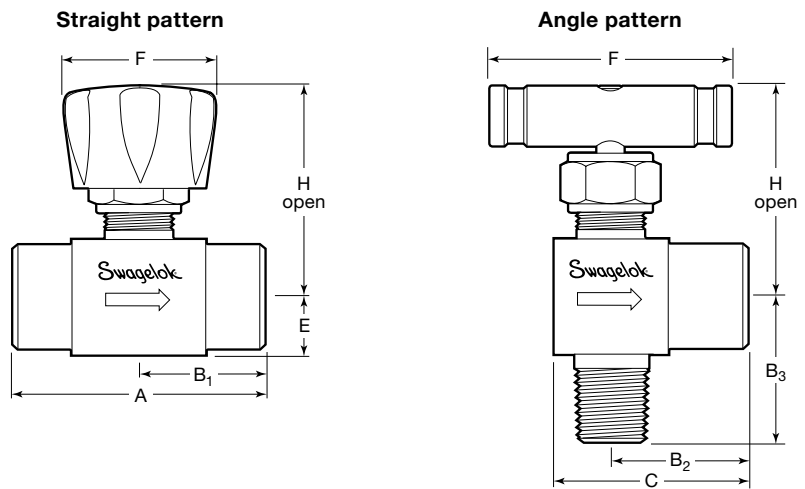
For soft-seat stems and PCTFE stem-tips in valves that are standard with vee stems, replace **V** with **K**.

Example: SS-20KS4

Angle-Pattern Valves

Angle-pattern bodies are available for valves with C dimensions listed. To order, add **-A** to the ordering number.

Example: SS-20KM4-F4-A



End Connections		C _v	Orifice in. (mm)	Ordering Number	Dimensions, in. (mm)									
Inlet/Outlet	Size				A	B ₁	B ₂	B ₃	C	E	F	H		
20 series with soft-seat stem and PCTFE stem tip														
Female NPT	1/4 in.	0.09	0.080 (2.0)	SS-20KF4	1.88 (47.8)	0.94 (23.9)	—	—	—	0.42 (10.7)	1.12 (28.4)	1.66 (42.2)		
Male NPT	1/4 in.			SS-20KM4	1.94 (49.3)	0.97 (24.6)	—	—	—					
Male/ female NPT	1/4 in.			SS-20KM4-F4	1.91 (48.5)	0.94 (23.9)	1.00 (25.4)	1.03 (26.2)	1.44 (36.6)					
20 and 26 series with vee stem														
Swagelok tube fittings	1/4 in.	0.21	0.125 (3.2)	SS-20VS4	2.46 (62.5)	1.23 (31.2)	1.13 (28.7)	1.16 (29.5)	1.57 (39.9)	0.42 (10.7)	1.75 (44.4)	1.66 (42.2)		
	3/8 in.	0.73	0.250 (6.4)	SS-26VS6	3.08 (78.2)	1.54 (39.1)	—	—	—	0.66 (16.8)	2.50 (63.5)	2.31 (58.7)		
	1/2 in.			SS-26VS8	3.30 (83.8)	1.65 (41.9)	—	—	—	—	—	—	—	
Female NPT	1/4 in.	0.21	0.125 (3.2)	SS-20VF4	1.88 (47.8)	0.94 (23.9)	1.00 (25.4)		1.44 (36.6)	0.42 (10.7)	1.75 (44.4)	1.66 (42.2)		
	3/8 in.	0.73	0.250 (6.4)	SS-26VF6	2.50 (63.5)	1.25 (31.8)	—	—	—	0.66 (16.8)	2.50 (63.5)	2.31 (58.7)		
	1/2 in.			SS-26VF8	2.50 (63.5)	1.25 (31.8)	1.41 (35.8)		2.06 (52.3)	—	—	—		
Male NPT	1/4 in.	0.21	0.125 (3.2)	SS-20VM4	1.94 (49.3)	0.97 (24.6)	—	—	—	0.42 (10.7)	1.75 (44.4)	1.66 (42.2)		
Male NPT/ Swagelok tube fittings	1/4 in.			SS-20VM4-S4	—	—	1.13 (28.7)	1.00 (25.4)	1.57 (39.9)	—				
Male/ female NPT	1/4 in.			SS-20VM4-F4	1.91 (48.5)	0.94 (23.9)	1.00 (25.4)	1.03 (26.2)	1.44 (36.6)	0.42 (10.7)			1.75 (44.4)	
	3/8 in.	0.73	0.250 (6.4)	SS-26VM6-F6	2.50 (63.5)	1.25 (31.8)	1.41 (35.8)	1.22 (31.0)	20.6 (52.3)	0.66 (16.8)	2.50 (63.5)	2.31 (58.7)		
	1/2 in.			SS-26VM8-F8	2.55 (64.8)	1.25 (31.8)	1.41 (35.8)						—	—
	3/4 to 1/2 in.			SS-26VM12-F8	2.50 (63.5)	1.25 (31.8)	—	—					—	—
Female ISO ^①	1/4 in.	0.21	0.125 (3.2)	SS-20VF4RT	1.88 (47.8)	0.94 (23.9)	—	—	—	0.42 (10.7)	1.75 (44.4)	1.66 (42.2)		
	1/2 in.	0.73	0.250 (6.4)	SS-26VF8RT	2.50 (63.5)	1.25 (31.8)	—	—	—	0.66 (16.8)	2.50 (63.5)	2.31 (58.7)		

Dimensions are shown with Swagelok nuts finger-tight.

① See specifications ISO 7/1, BS EN 10226-1, DIN-2999, JIS B0203.

Options and Accessories

Stem Packing Materials

Two-piece chevron-style PFA packing is standard. For an optional stem packing, add **-P** for UHMWPE or **-PK** for PEEK to the ordering number. See **Pressure-Temperature Ratings**, page 2, for ratings of valves with optional stem packings. See the table at right for lubricants used with optional stem packing materials.

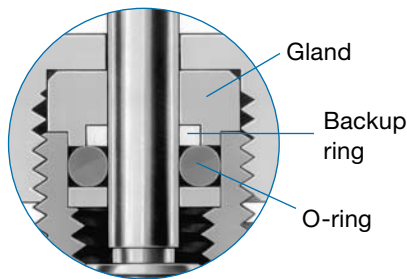
Examples: SS-ORS2-**P**
 SS-20KF4-**PK**

Stem Packing Kits

PFA, UHMWPE, and PEEK packing kits are available. Kits contain stem packings, springs, lubricant, and instructions.

Valve Series	Orifice in. (mm)	Stem Packing Material, Kit Ordering Number		
		PFA	UHMWPE	PEEK
O	All	PFA-91K-O	PE-91K-O	PK-91K-O
1	0.172 (4.4)	PFA-91K-14	PE-91K-14	PK-91K-14
	0.250 (6.4)	PFA-91K-16	PE-91K-16	PK-91K-16
18	All	PFA-91K-18	PE-91K-18	PK-91K-18
20	All	PFA-91K-20	PE-91K-20	PK-91K-20
26	All	PFA-91K-16	PE-91K-16	PK-91K-16
Lubricant		Tungsten disulfide and fluorocarbon based	Molybdenum disulfide and hydrocarbon based	Molybdenum disulfide, tungsten disulfide, and fluorocarbon based

O-Ring Stem Seals



O-ring stem seals include:

- 316 SS/ASTM A276 gland for 316 SS, steel, and alloy 400 valves, or brass 360 gland for brass valves
- PTFE/ASTM D1710 backup ring and silicone-based lubricant for all O-rings except ethylene propylene, which requires a polyethylene/ASTM D4020 backup ring, and molybdenum disulfide with hydrocarbon-based lubricant
- O-ring.

O-Ring Material	Temperature Rating °F (°C)	O-Ring Designator	Kit Designator	Kit Basic Ordering Number
Buna C	-65 to 250 (-53 to 121)	-BC	BC70	-9K-O (O and 20 series) -9K-14 (1 series, 0.172 in. orifice) -9K-16 (1 series, 0.250 in. orifice) -9K-18 (18 series)
Buna N	-20 to 250 (-28 to 121)	-B	BN70	
Ethylene propylene		-E	EP70	
Fluorocarbon FKM	-20 to 450 (-28 to 232)	-V	VA70	
Kalrez®		-KZ	KZ70	
Silicone	-20 to 250 (-28 to 121)	-SI	SI70	

Valves with O-Ring Stem Seals

Add an O-ring designator to the ordering number.

Examples: SS-ORS2-**BC**
 SS-20KF4-**B**

O-Ring Maintenance Kits

Maintenance kits contain O-ring, backup ring, lubricant, and instructions.

To order, add a kit designator to a kit basic ordering number.

Example: **BC70-9K-O**

Handles

- O and 1 series valves—black phenolic round handles are standard; colored phenolic, 316 SS bar, and anodized black aluminum bar handles are optional.
- 18 series valves—anodized black aluminum bar handles are standard; phenolic round and 316 SS bar handles are optional.

Valves with Optional Handles

Add a handle designator to the ordering number.

Handle	Designator (O and 1 Series)	Designator (18, 20, and 26 Series)	Kit Color Designator
Black phenolic	-BK	-BKP	-BK
Blue phenolic	-BL	-BLP	-BL
Green phenolic	-GR	-GRP	-GR
Orange phenolic	-OG	-OGP	-OG
Red phenolic	-RD	-RDP	-RD
Yellow phenolic	-YW	-YWP	-YW
316 SS bar	-SH	-SH	—
Anodized black aluminum bar	-BKB	-BKB	—

Examples:

SS-ORS2-**BL**

SS-20KF4-**SH**

Sour Gas Service

Integral-bonnet needle valves with female NPT, female ISO, and male NPT end connections are available for sour gas service. Stem and lower gland are alloy 400. Materials are selected in accordance with NACE MR0175/ISO 15156. See the NACE specification for information on stainless tube fitting requirements.

To order, add **-SG** to the ordering number.

Example: SS-ORF2-**SG**

Special Cleaning and Packaging (SC-11)

To order integral-bonnet needle valves cleaned and packaged in accordance with Swagelok *Special Cleaning and Packaging (SC-11)*, MS-06-63, to ensure compliance with product cleanliness requirements stated in ASTM G93 Level C, add **-SC11** to the valve ordering number.

Example: SS-ORS2-**SC11**

Safe Product Selection

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange parts with those of other manufacturers.

- 20K series valves—anodized black aluminum knob handles are standard; phenolic round, 316 SS bar, and anodized black aluminum bar handles are optional.
- 20V and 26 series valves—316 SS bar handles are standard; phenolic round and anodized black aluminum bar handles are optional.

Handle Kits

Handle kits contain handle and instructions. Select a handle kit ordering number.

For colored phenolic handles, replace **BK** in the ordering number with a kit color designator.

Valve Series	Orifice in. (mm)	Handle Kit Ordering Numbers		
		Black Phenolic	Black Aluminum Bar	316 SS Bar
O	All	PH-5K-OK-BK	A-5K-14B-BK	SS-5K-14B
1	0.172 (4.4)	PH-5K-14K-BK	A-5K-6NB-BK	SS-5K-6NB
	0.250 (6.4)	PH-5K-4K-BK	A-5K-6NB-BK	SS-5K-6NB
18	All	PH-5K-7K-BK	A-5K-18B-BK	SS-5K-7B
20	All	PH-5K-14K-BK	A-5K-14B-BK	SS-5K-14B
26	All	PH-5K-4K-BK	A-5K-6NB-BK	SS-5K-6NB

Example: PH-5K-OK-**BL**

To order an anodized black aluminum knob handle kit for the 20K series valve, use ordering number **A-5K-20K-BK**.

Oxygen Service Hazards

For more information about hazards and risks of oxygen-enriched systems, see the Swagelok *Oxygen System Safety* technical report, MS-06-13.

⚠ Packing adjustment may be required during the valve's service life.

⚠ Valves that have not been cycled for a period of time may have a higher initial actuation torque.

Warranty Information

Swagelok products are backed by The Swagelok Limited Lifetime Warranty. For a copy, visit swagelok.com or contact your authorized Swagelok representative.

Check Valves



C, CA, CH, CP, and CPA Series

- Working pressures up to 6000 psig (413 bar)
- Adjustable and fixed cracking pressures
- Variety of end connections
- 316 stainless steel and brass materials

Contents

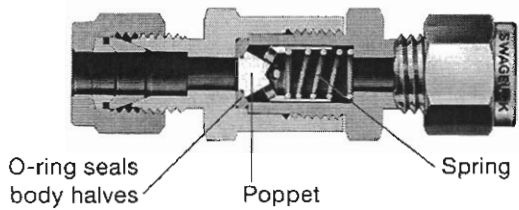
Features	2	Testing	10
Technical Data	3	Cleaning and Packaging	10
Pressure-Temperature Ratings	3	Ordering Information and Dimensions	11
Cracking and Reseal Pressures	4	Options and Accessories	14
Materials of Construction	5	Maintenance Kits	15
Flow Data	7		

Features

Fixed Cracking Pressures

From 1/3 to 25 psi (0.03 to 1.8 bar)

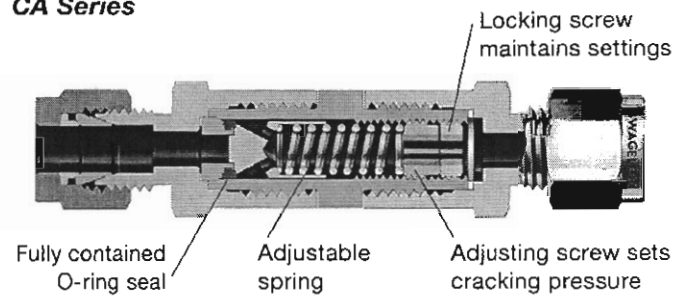
C Series



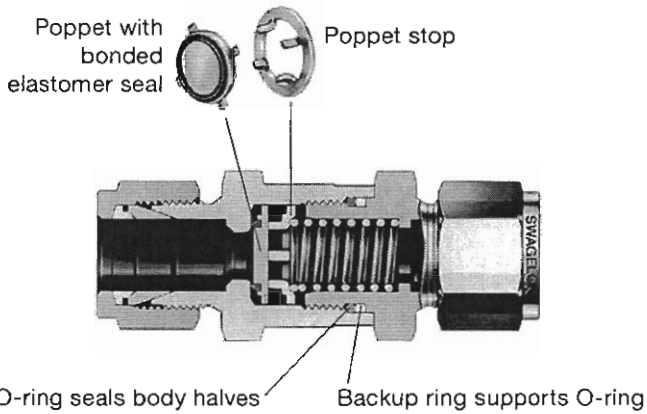
Adjustable Cracking Pressures

From 3 to 600 psi (0.21 to 41.4 bar)

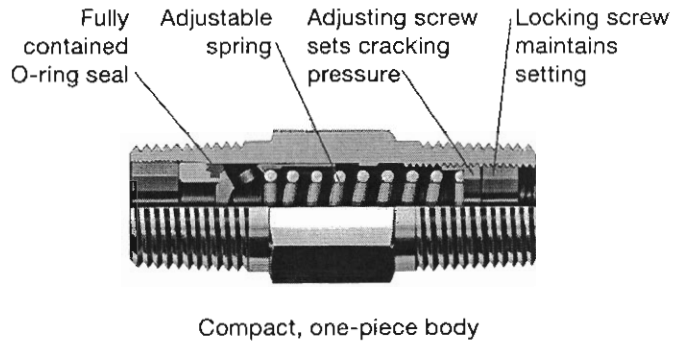
CA Series



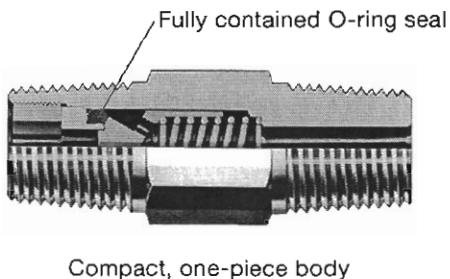
CH Series



CPA Series



CP Series



Technical Data

Cracking pressure—the upstream pressure at which the first indication of flow occurs.

Reseal pressure—the pressure at which there is no indication of flow.

⚠ For valves not actuated for a period of time, initial cracking pressure may be higher than the set cracking pressure.

Series	Maximum Flow Coefficient (C _v)	Nominal Cracking Pressure psi (bar)	Downstream Pressure at 70°F (20°C) psig (bar)
Fixed Cracking Pressure			
2C	0.10	1/3, 1, 10 and 25 (0.03, 0.07, 0.69, and 1.8)	1000 (68.9) ^①
4C	0.47		200 (13.7)
6C	1.47		
8C	1.68		
12C, 16C	4.48		
CH4	0.67	1/3, 1, 5, 10 and 25 (0.03, 0.07, 0.35, 0.69, and 1.8)	6000 (413)
CH8	1.8		5000 (344)
CH16	4.7		
4CP	0.35	1/3, 1, 10 and 25 (0.03, 0.07, 0.69, and 1.8)	3000 (206)
8CP	1.20		
Adjustable Cracking Pressure			
CA	0.37	3 to 50 (0.21 to 3.5) 50 to 150 (3.5 to 10.4) 150 to 350 (10.4 to 24.2) 350 to 600 (24.2 to 41.4)	3000 (206)
4CPA	0.35		
8CPA	1.20		

① For cracking pressure of 25 psi (1.8 bar), downstream pressure is 3000 psig (206 bar).

Pressure-Temperature Ratings

C (2C, 4C, 6C, and 8C), CA, CP, and CPA Series

Ratings based on fluorocarbon FKM O-rings in 316 stainless steel valves and Buna N O-rings in brass valves.

Material	316 SS	Brass
Temperature, °F (°C)	Working Pressure, psig (bar) ^①	
-10 (-23) to 100 (37)	3000 (206)	3000 (206)
200 (93)	2575 (177)	2600 (179)
250 (121)	2450 (168)	2405 (165)
300 (148)	2325 (160)	—
375 (190)	2185 (150)	—

① To reduce the possibility of dislodging the O-ring in systems where pressure surges, shock, or pulses occur, for all 2C and 4C series valves and for 6C and 8C series valves with cracking pressures lower than 50 psi (3.5 bar), an optional inlet gasket is available. See page 14 for ordering information. Cracking and reseal pressures may decrease slightly from the ranges listed in this catalog.

Alternatively, CH or CP series valves should be considered.

C Series (12C and 16C)

Ratings based on fluorocarbon FKM O-rings in 316 stainless steel valves and Buna N O-rings in brass valves.

Material	316 SS	Brass
Temperature, °F (°C)	Working Pressure, psig (bar)	
-10 (-23) to 100 (37)	2000 (137)	1500 (103)
200 (93)	1715 (118)	1300 (89.5)
250 (121)	1630 (112)	1200 (82.6)
300 (148)	1545 (106)	—
375 (190)	1450 (99.9)	—

CH Series

Ratings based on fluorocarbon FKM seals.

Material	316 SS	
Series	CH4, CH8	CH16
Temperature, °F (°C)	Working Pressure, psig (bar)	
-10 (-23) to 100 (37)	6000 (413)	5000 (344) ^①
200 (93)	5160 (355)	4290 (295)
250 (121)	4910 (338)	4080 (281)
300 (148)	4660 (321)	3875 (266)
400 (204)	4280 (294)	3560 (245)

For more information about pressure ratings of valves with tube fitting end connections, see Swagelok® *Tubing Data*, MS-01-107.

① Pressure ratings may be limited by the end connection. See Dimensions, page 12.

Cracking and Reseal Pressures at 70°F (20°C)

Cracking pressure—the upstream pressure at which the first indication of flow occurs.

Reseal pressure—the pressure at which there is no indication of flow.

⚠ For valves not actuated for a period of time, initial cracking pressure may be higher than the set cracking pressure.

C Series

Nominal Cracking Pressure psi (bar)	Cracking Pressure Range psi (bar)	Reseal Pressure psi (bar)
1/3 (0.03)	Up to 3 (0.21)	Up to 6 (0.42) downstream pressure
1 (0.07)	Up to 4 (0.28)	Up to 6 (0.42) downstream pressure
10 (0.69)	7 to 15 (0.49 to 1.1)	3 (0.21) or more upstream pressure
25 (1.8)	20 to 30 (1.4 to 2.1)	17 (1.2) or more upstream pressure

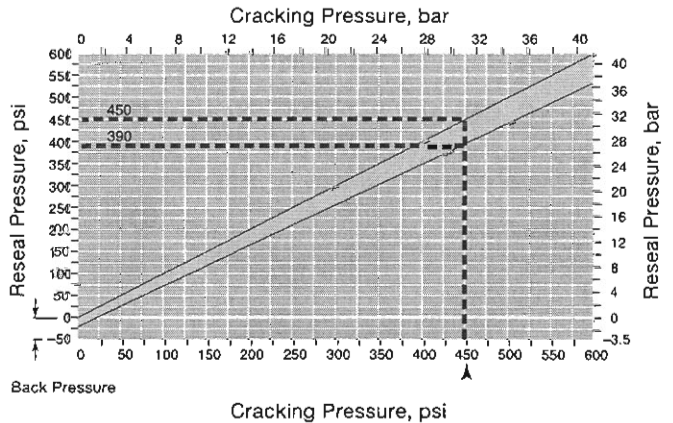
CH Series

Nominal Cracking Pressure psi (bar)	Cracking Pressure Range psi (bar)	Reseal Pressure psi (bar)
1/3 (0.03)	Up to 3 (0.21)	Up to 6 (0.42) back pressure
1 (0.07)	Up to 4 (0.28)	Up to 5 (0.35) back pressure
5 (0.35)	3 to 9 (0.21 to 0.63)	Up to 2 (0.14) back pressure
10 (0.69)	7 to 15 (0.49 to 1.1)	3 (0.21) or more upstream pressure
25 (1.8)	20 to 30 (1.4 to 2.1)	17 (1.2) or more upstream pressure

CP Series

Nominal Cracking Pressure psi (bar)	Cracking Pressure Range psi (bar)	Reseal Pressure psi (bar)
1/3 (0.03)	Up to 3 (0.21)	6 to 20 (0.42 to 1.4) downstream pressure
1 (0.07)	Up to 4 (0.28)	5 to 20 (0.35 to 1.4) downstream pressure
10 (0.69)	7 to 13 (0.49 to 0.90)	3 to 10 (0.21 to 0.69) downstream pressure
25 (1.8)	21 to 29 (1.5 to 2.0)	5 (0.35) or more upstream pressure

CA and CPA Series

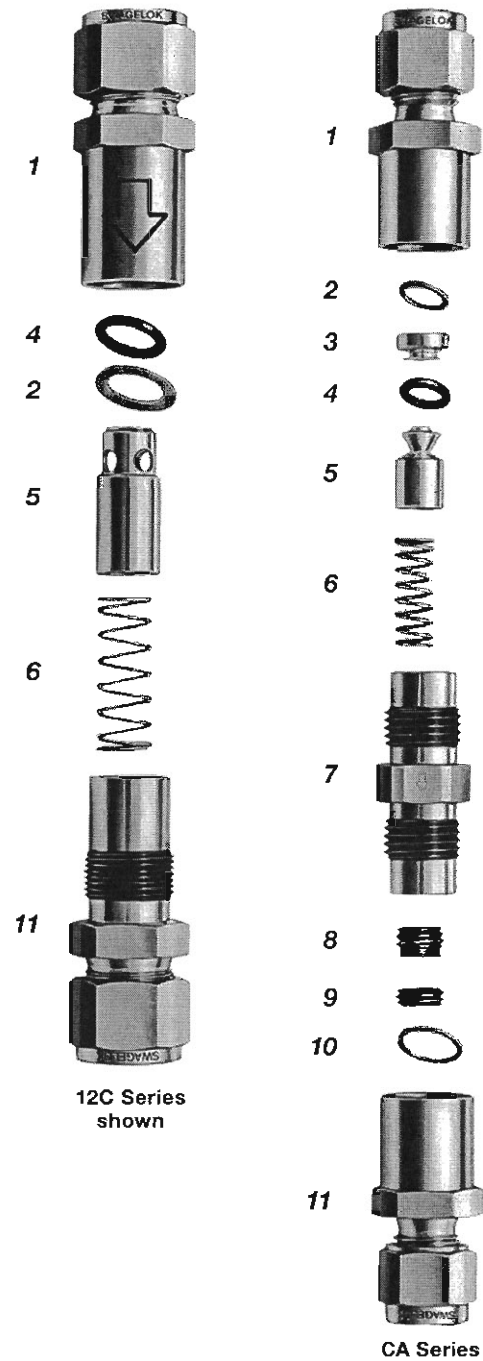


Materials of Construction

C and CA Series

Component	Valve Body Materials	
	316 SS	Brass
	Material Grade/ASTM Specification	
1 Inlet body	316 SS/A479	Brass 360/B16
2 Inlet gasket (CA series)	PTFE-coated 316 SS/A240	
<i>Inlet gasket (standard for 6C and 8C series with ≥ 50 psi [3.5 bar] spring; optional for 2C and 4C series and all other 6C and 8C series)</i>	PTFE-coated 316 SS/A240	
<i>Inlet gasket (12C and 16C series)</i>	PTFE-coated 316 SS/A240	PTFE-coated aluminum/B209
3 Insert (CA series)	316 SS/A479	Naval brass 485/B21
4 O-ring	Fluorocarbon FKM	Buna N
5 Poppet	316 SS/A479	Brass 360/B16
6 Spring	302 SS/A313	
7 Center body (CA series)	316 SS/A479	Brass 360/B16
8 Adjusting screw (CA series)	316 SS/A276	
9 Locking screw (CA series)		
10 Outlet gasket (CA series)	PTFE-coated 316 SS/A240	
11 Outlet body	316 SS/A479	Brass 360/B16
Lubricants	<i>Silicone-based and molybdenum disulfide-based (C series); PTFE-based and molybdenum disulfide-based (CA series)</i>	<i>Silicone-based (C series); PTFE-based (CA series)</i>

Wetted components listed in *italics*.

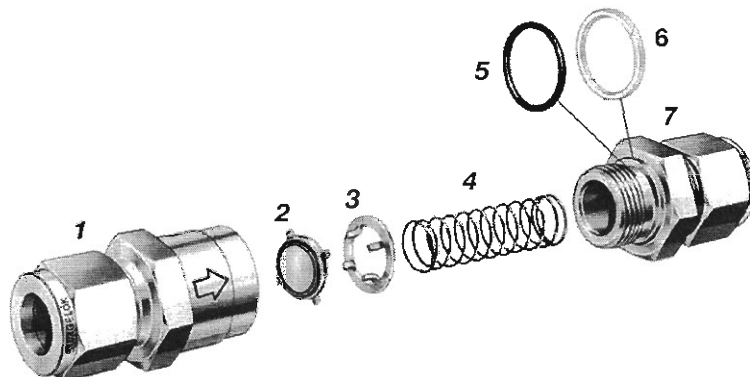


CH Series

Component	Material Grade/ASTM Specification
1 Inlet body	316 SS/A479
2 Poppet	Fluorocarbon FKM-bonded [Ⓢ] 316 SS/A479
3 Poppet stop	316 SS/A240
4 Spring	302 SS/A313
5 O-ring	Fluorocarbon FKM
6 Backup ring	PTFE/D1710
7 Outlet body	316 SS/A479
Lubricant	PTFE-based

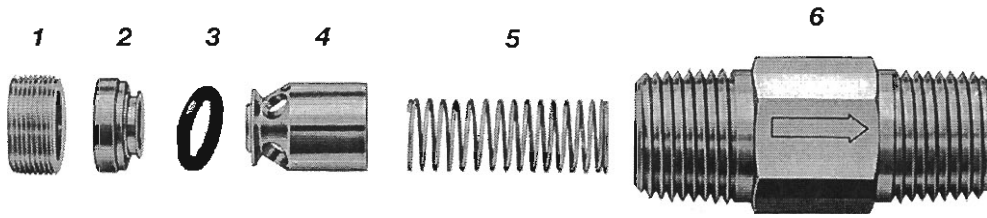
Wetted components listed in *italics*.

Ⓢ Material Safety Data Sheet for bonding agent available on request.

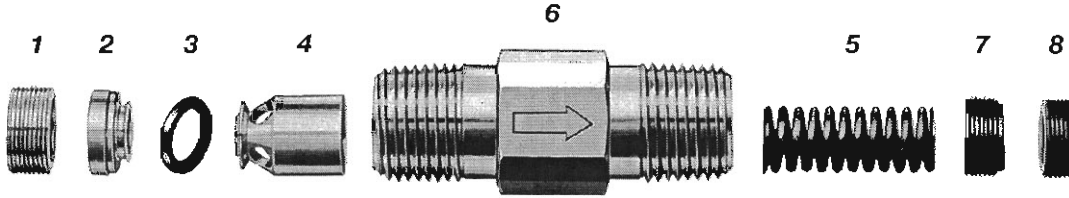


Materials of Construction

CP Series



CPA Series



Component	Valve Body Materials				
	316 SS	Brass			
		4CP	8CP	4CPA	8CPA
Material Grade/ASTM Specification					
1 Insert lock screw	316 SS/A276 or A479	Brass 485/ B21	Brass 360/ B16	Brass 485/ B21	Brass 360/ B16
2 Insert	316 SS/A479				
3 O-ring	Fluorocarbon FKM	Buna N			
4 Poppet	316 SS/A479	Brass 360/B16			
5 Spring	302 SS/A313				
6 Body	316 SS/A479	Brass 360/B16			
7 Adjusting screw (CPA series)	316 SS/A276	—		316 SS/A276	Brass 360 ^① / B16
8 Locking screw (CPA series)					
Lubricants	PTFE-based				

Wetted components listed in *italics*.

① Adjusting screw in valve with 150 or 350 psi (10.4 or 24.2 bar) spring is 316 SS.

Flow Data at 70°F (20°C)

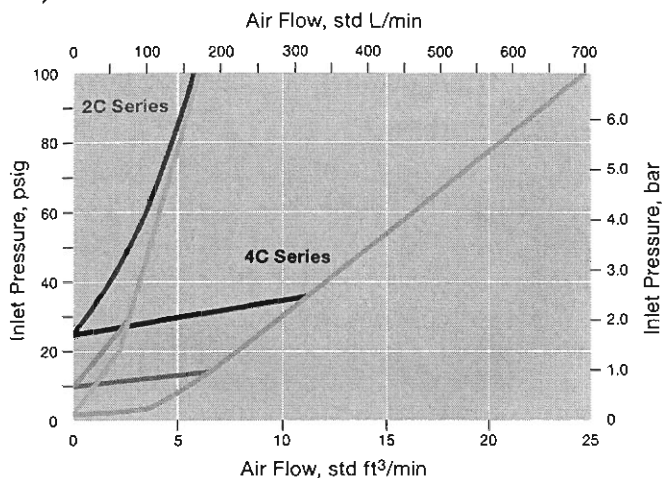
C Series

Nominal Cracking Pressures

- 2C, 6C, 16C Series 1 psi (0.07 bar) 10 psi (0.69 bar) 25 psi (1.8 bar)
- 4C, 8C Series 1 psi (0.07 bar) 10 psi (0.69 bar) 25 psi (1.8 bar)

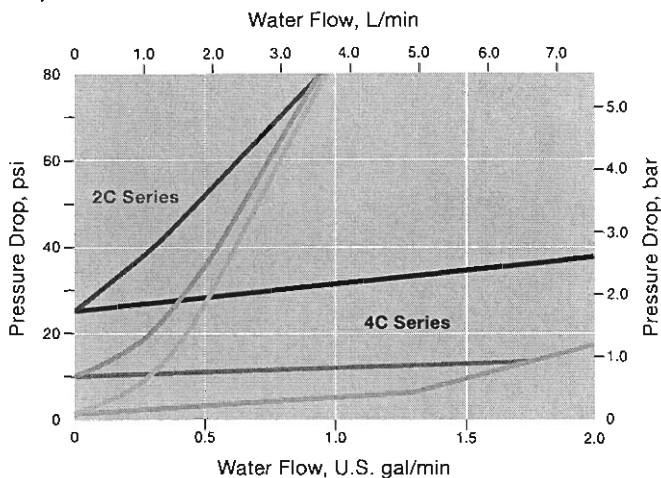
Air

2C, 4C Series

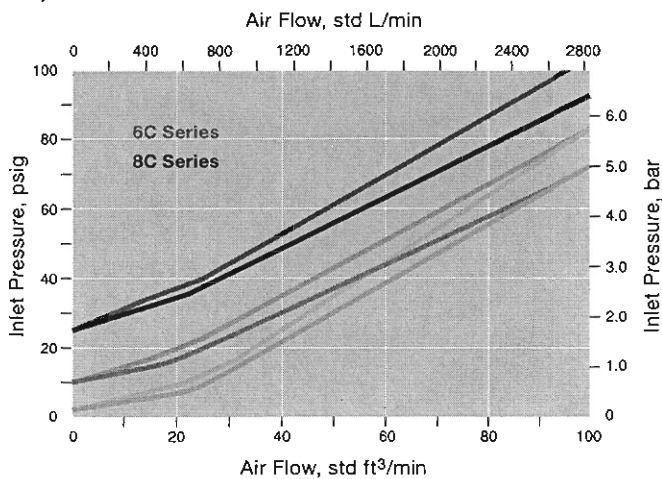


Water

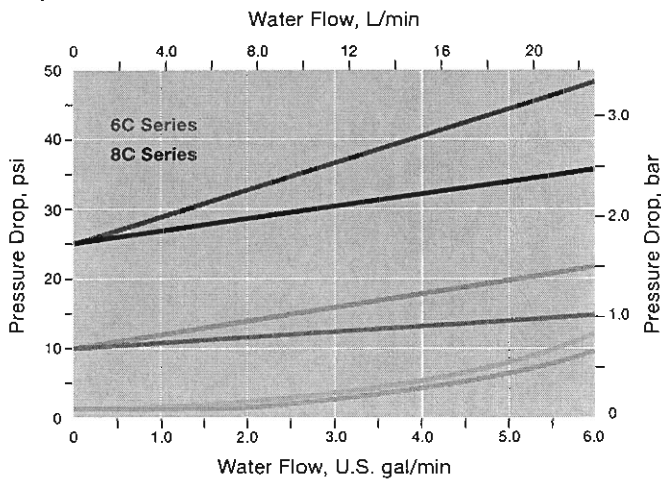
2C, 4C Series



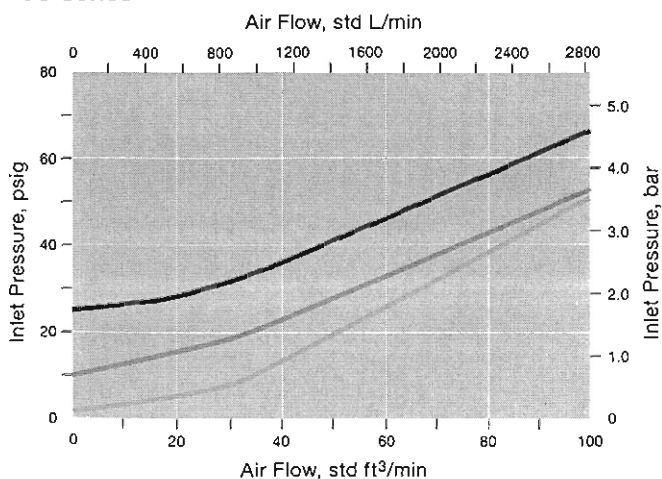
6C, 8C Series



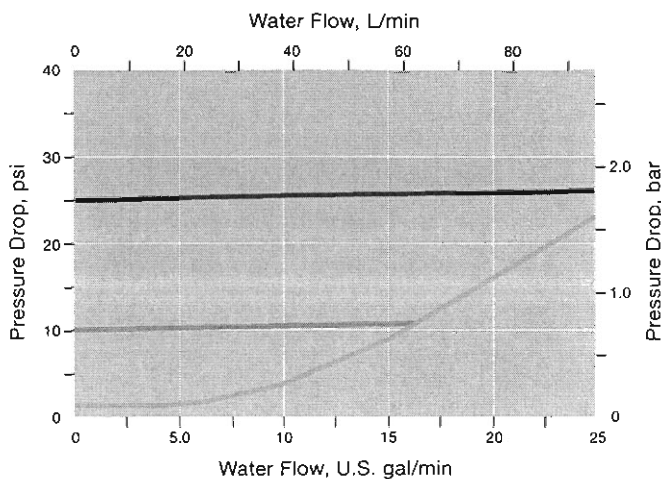
6C, 8C Series



16C Series



16C Series



Flow Data at 70°F (20°C)

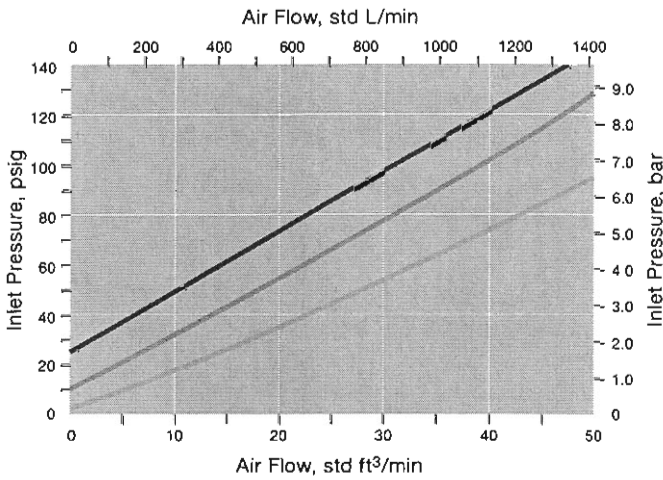
CH Series

Nominal Cracking Pressures

— 1 psi (0.07 bar) — 10 psi (0.69 bar) — 25 psi (1.8 bar)

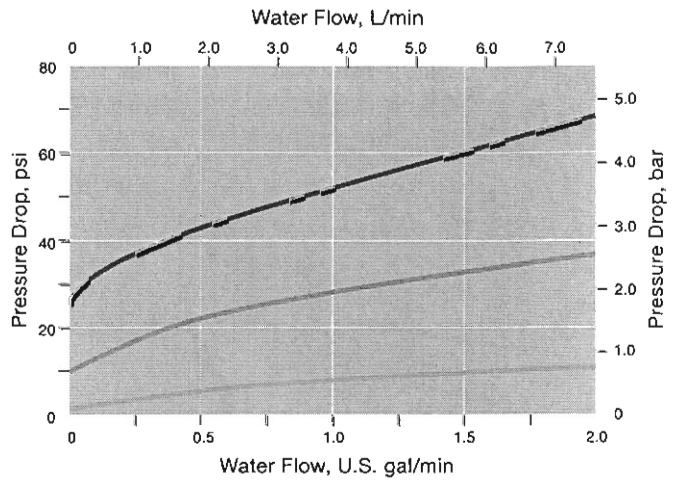
Air

CH4 Series

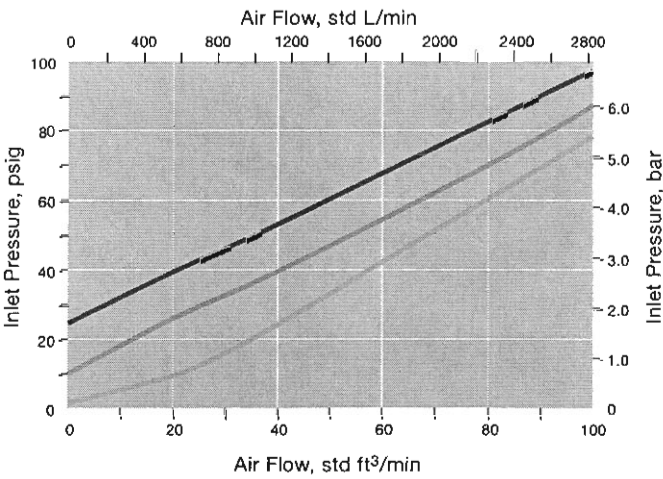


Water

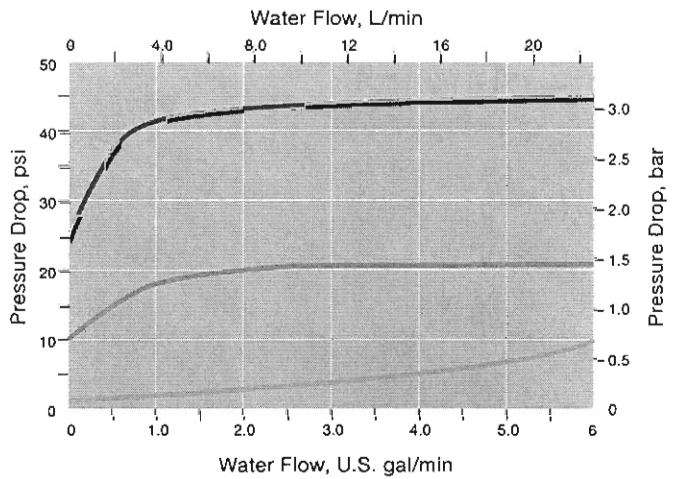
CH4 Series



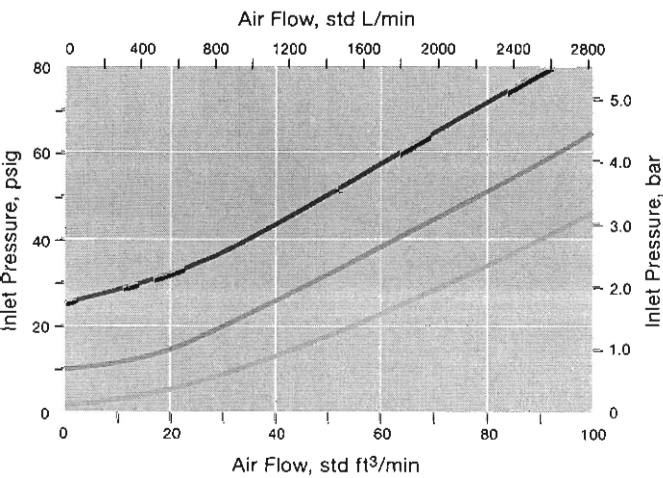
CH8 Series



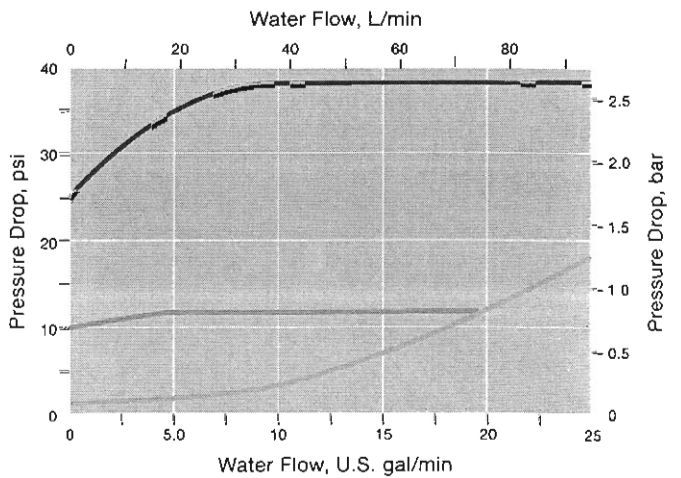
CH8 Series



CH16 Series



CH16 Series



Flow Data at 70°F (20°C)

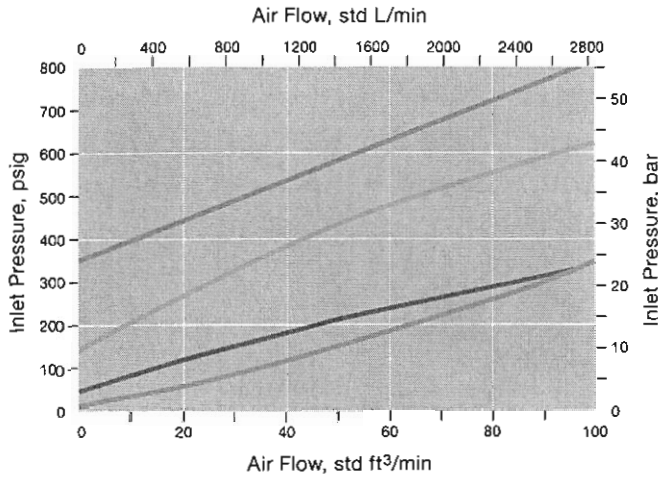
CA and CPA Series

Nominal Cracking Pressures

— 3 psi (0.21 bar) — 50 psi (3.5 bar) — 150 psi (10.4 bar) — 350 psi (24.2 bar)

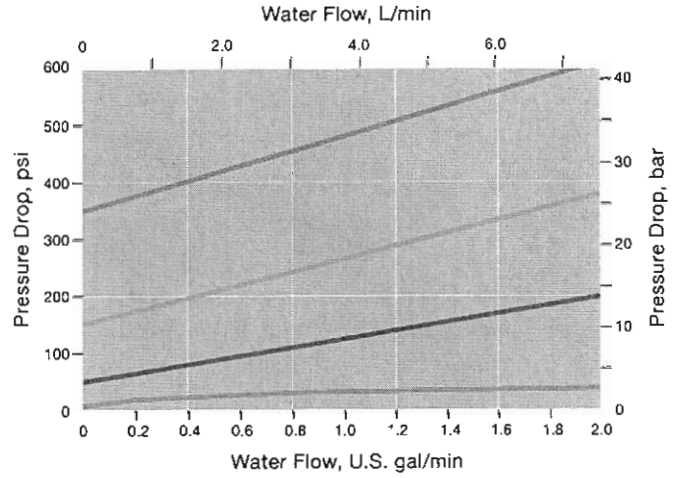
Air

CA Series

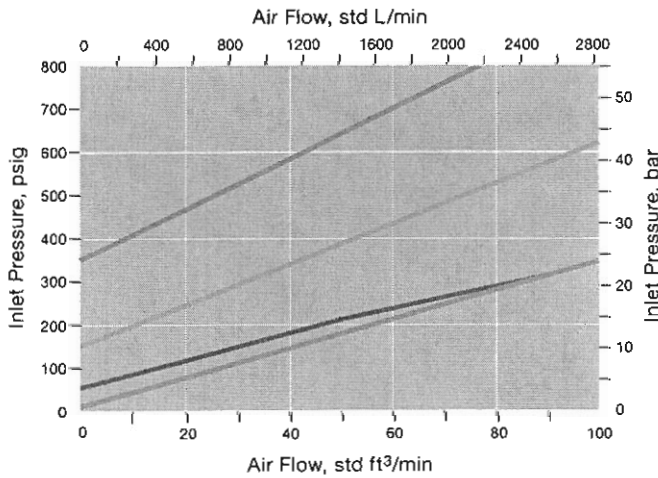


Water

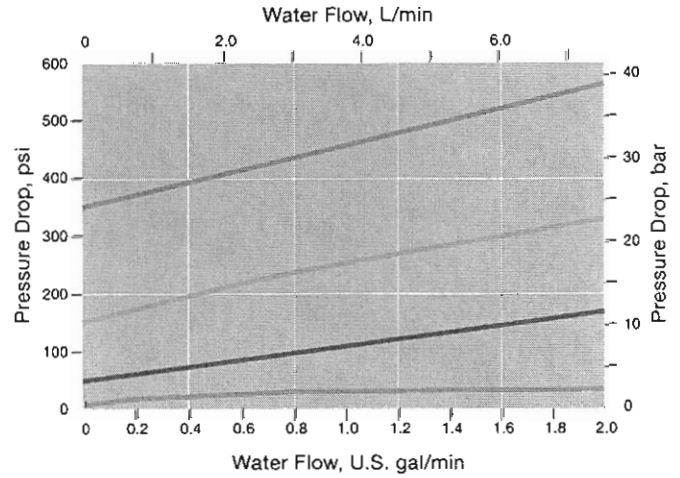
CA Series



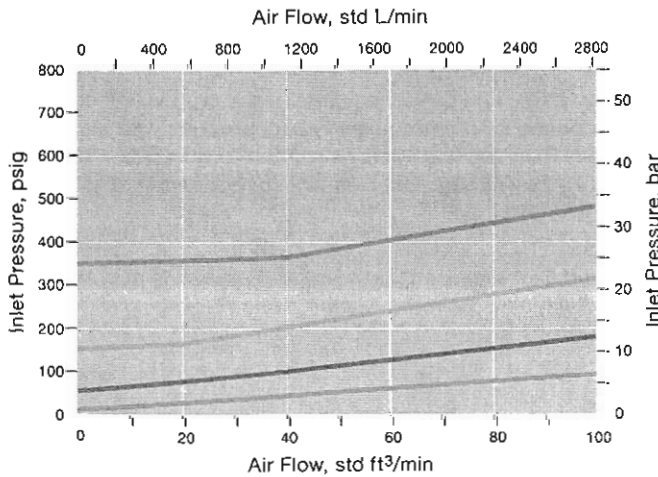
4CPA Series



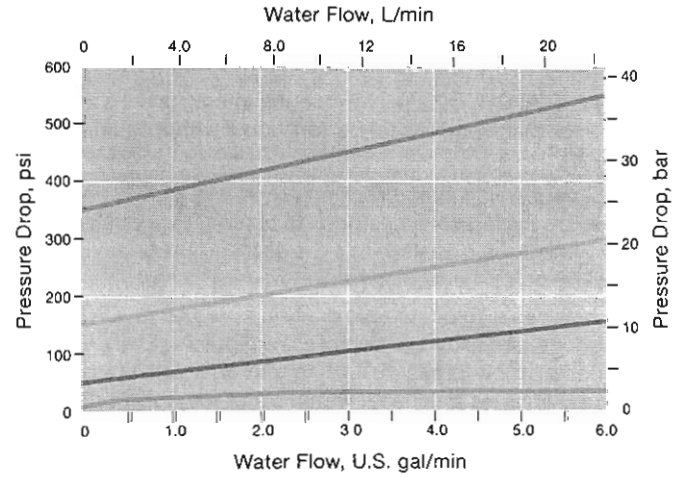
4CPA Series



8CPA Series



8CPA Series



Flow Data at 70°F (20°C)

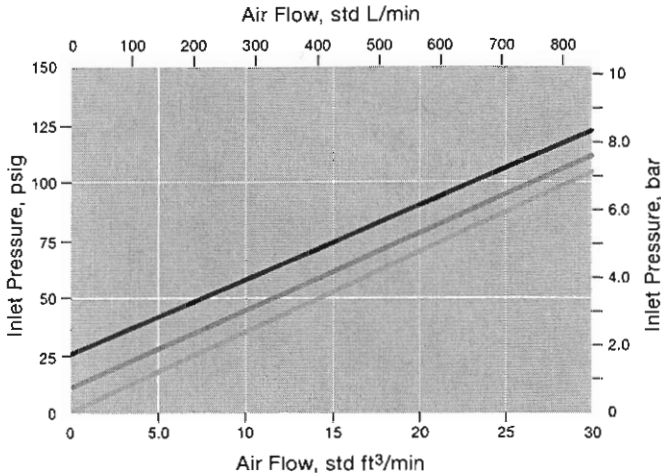
CP Series

Nominal Cracking Pressures

— 1 psi (0.07 bar) — 10 psi (0.69 bar) — 25 psi (1.8 bar)

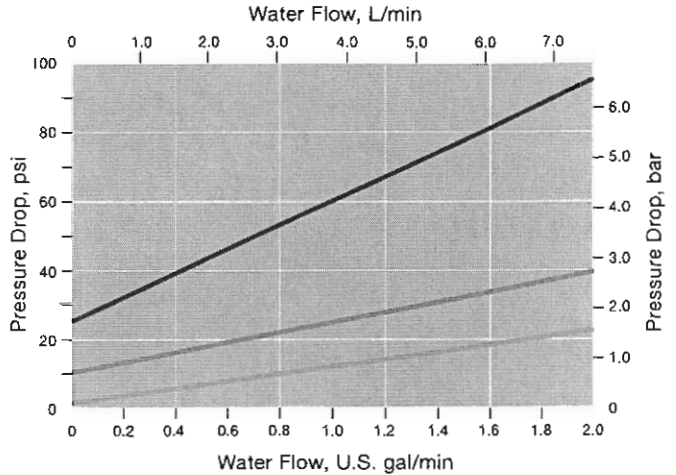
Air

4CP Series

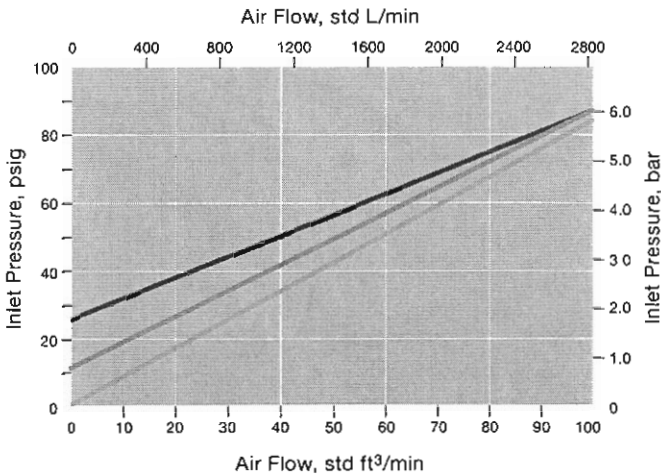


Water

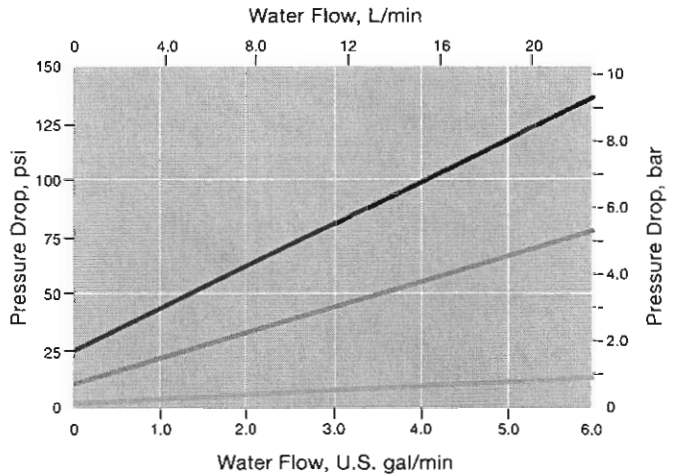
4CP Series



8CP Series



8CP Series



Testing

Every C, CA, CH, CP, and CPA series check valve is factory tested for crack and reseal performance with a liquid leak detector.

Check valves with fixed cracking pressures, C, CP, and CH series, are cycled six times prior to testing. Every valve is tested to ensure it seals within 5 s at the appropriate reseal pressure.

Check valves with adjustable cracking pressures, CA and CPA series, are tested at two pressure points. Every valve is tested at a low-pressure setting and at a high-pressure setting. All valves must seal within 5 s at the appropriate reseal pressure.

Cleaning and Packaging

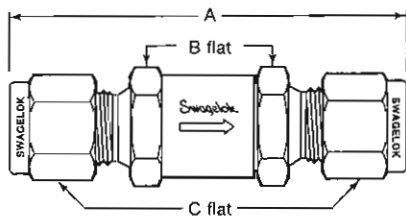
Every C, CA, and CH series check valve with VCR® or VCO® end connections is processed in accordance with Swagelok *Special Cleaning and Packaging (SC-11)*, MS-06-63, to ensure compliance with product cleanliness requirements as stated in ASTM G93 Level C.

All other C, CA, and CH series check valves, as well as every CP and CPA series check valve, are cleaned in accordance with Swagelok *Standard Cleaning and Packaging (SC-10)*, MS-06-62.

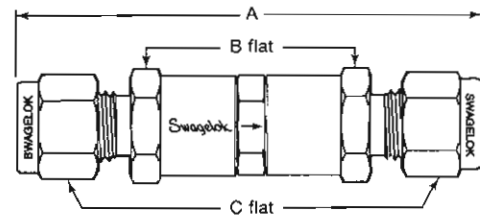
Dimensions

Dimensions, shown with Swagelok tube fitting nuts finger-tight, are for reference only and are subject to change.

C Series



CA Series



End Connections		Basic Ordering Number	Series	Dimensions, in. (mm)		
Inlet/Outlet	Size			A	B	C
Fixed Cracking Pressure, C Series						
Fractional Swagelok tube fittings	1/8 in.	SS-2C-	2C	2.14 (54.3)	5/8	7/16
	1/4 in.	SS-4C-	4C	2.35 (59.7)		9/16
	3/8 in.	SS-6C-	6C	3.17 (80.5)	7/8	11/16
	1/2 in.	SS-8C-	8C	3.42 (86.9)		7/8
	3/4 in.	SS-12C-	12C	4.32 (110)	1 1/4	1 1/8
	1 in.	SS-16C-	16C	4.74 (120)	1 3/8	1 1/2
Metric Swagelok tube fittings	6 mm	SS-6C-MM-	4C	2.36 (59.9)	5/8	(14)
	10 mm	SS-10C-MM-	8C	3.32 (84.3)	7/8	(19)
	12 mm	SS-12C-MM-		3.42 (86.9)		(22)
Female NPT	1/8 in.	SS-2C4-	2C	1.89 (48.0)	5/8	-
	1/4 in.	SS-4C4-	4C	2.15 (54.6)	3/4	
	3/8 in.	SS-6C4-	6C	2.98 (75.7)	7/8	
	1/2 in.	SS-8C4-	8C	3.58 (90.9)	1 1/16	
	3/4 in.	SS-12C4-	12C	4.08 (104)	1 1/4	
	1 in.	SS-16C4-	16C	4.84 (123)	1 5/8	
Male NPT	1/8 in.	SS-2C2-	2C	1.71 (43.4)	5/8	-
	1/4 in.	SS-4C2-	4C	2.09 (53.1)		
	3/8 in.	SS-6C2-	6C	2.78 (70.6)	7/8	
	1/2 in.	SS-8C2-	8C	3.16 (80.3)		
	3/4 in.	SS-12C2-	12C	4.08 (104)	1 1/4	
	1 in.	SS-16C2-	16C	4.52 (115)	1 5/8	
Male NPT/ Swagelok tube fitting	1/4 in.	SS-4C1-	4C	2.22 (56.4)	5/8	9/16
Male VCR fittings	1/4 in.	SS-4C-VCR-	4C	2.21 (56.1)	5/8	-
	1/2 in.	SS-8C-VCR-	8C	3.56 (90.4)	15/16	
	3/4 in.	SS-12C-VCR-	12C	4.64 (118)	1 5/8	
	1 in.	SS-16C-VCR-	16C	4.76 (121)		
Adjustable Cracking Pressure, CA Series						
Swagelok tube fittings	1/4 in.	SS-4CA-	CA	3.23 (82.0)	5/8	9/16
	6 mm	SS-6CA-MM-				(14)
	8 mm	SS-8CA-MM-				3.32 (84.3)
Male NPT/ Swagelok tube fitting	1/4 in.	SS-4CA1-		3.12 (79.2)		9/16
Male VCR fittings	1/4 in.	SS-4CA-VCR-		3.09 (78.5)		-

Ordering Information

Basic ordering numbers specify stainless steel material. To order brass, replace **SS** with **B** in the basic ordering number.

Example: **B-2C-**

C Series

To order, add a cracking pressure designator to the basic ordering number.

Cracking Pressure psi (bar)	Designator
1/3 (0.03)	1/3
1 (0.07)	1
10 (0.69)	10
25 (1.8)	25

Example: **SS-2C-1/3**

CA Series

To order, add a cracking pressure range designator to the basic ordering number.

Cracking Pressure psi (bar)	Designator
3 to 50 (0.21 to 3.5)	3
50 to 150 (3.5 to 10.4)	50
150 to 350 (10.4 to 24.2)	150
350 to 600 (24.2 to 41.4)	350

Example: **SS-4CA-3**

⚠ Check valves are designed for directional flow control only. Swagelok check valves should never be used as code safety relief devices.

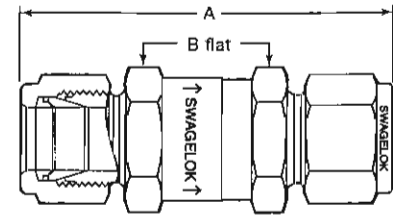
Dimensions

Dimensions, shown with Swagelok tube fitting nuts finger-tight, are for reference only and are subject to change.

End Connections		Pressure Rating at 100°F (37°C) psig (bar)	Basic Ordering Number	Series	Dimensions in. (mm)	
Type	Size				A	B
Fractional Swagelok tube fitting	1/8 in.	6000 (413)	SS-CHS2-	CH4	2.27 (57.7)	11/16
	1/4 in.		SS-CHS4-		2.43 (61.7)	
	3/8 in.		SS-CHS6-	CH8	2.75 (69.9)	
	1/2 in.		SS-CHS8-		2.96 (75.2)	
	3/4 in.	5000 (344)	SS-CHS12-	CH16	3.52 (89.4)	1 5/8
1 in.	4700 (323)	SS-CHS16-	3.88 (98.6)			
Metric Swagelok tube fitting	6 mm	6000 (413)	SS-CHS6MM-	CH4	2.43 (61.7)	11/16
	8 mm		SS-CHS8MM-		2.70 (68.6)	
	10 mm		SS-CHS10MM-	CH8	2.80 (71.1)	
	12 mm		SS-CHS12MM-		2.96 (75.2)	
	22 mm	4900 (337)	SS-CHS22MM-	CH16	3.48 (88.4)	1 5/8
25 mm	4600 (316)	SS-CHS25MM-	3.88 (98.6)			
Female NPT	1/4 in.	6000 (413)	SS-CHF4-	CH4	2.13 (54.1)	11/16
	3/8 in.	5300 (365)	SS-CHF6-	CH8	2.55 (64.8)	1
	1/2 in.	4900 (337)	SS-CHF8-		3.03 (77.0)	
	3/4 in.	4600 (316)	SS-CHF12-	CH16	3.23 (82.0)	1 5/8
	1 in.	4400 (303)	SS-CHF16-		3.83 (97.3)	
Male NPT	1/8 in.	6000 (413)	SS-CHM2-	CH4	1.79 (45.5)	11/16
	1/4 in.		SS-CHM4-		2.17 (55.1)	
	3/8 in.		SS-CHM6-	CH8	2.36 (59.9)	
	1/2 in.		SS-CHM8-		2.73 (69.3)	
	3/4 in.	5000 (344)	SS-CHM12-	CH16	3.29 (83.6)	1 5/8
1 in.	4400 (303)	SS-CHM16-	3.67 (93.2)			
Female ISO ^①	1/4 in.	6000 (413)	SS-CHF4RT-	CH4	2.28 (57.9)	11/16
	1/2 in.	5100 (351)	SS-CHF8RT-	CH8	3.29 (83.6)	1 1/16
	3/4 in.	4800 (330)	SS-CHF12RT-	CH16	3.55 (90.2)	1 5/8
	1 in.	4400 (303)	SS-CHF16RT-		3.83 (97.3)	
Male ISO ^①	1/4 in.	6000 (413)	SS-CHM4RT-	CH4	2.17 (55.1)	11/16
	1/2 in.		SS-CHM8RT-	CH8	2.73 (69.3)	1
	3/4 in.	5000 (344)	SS-CHM12RT-	CH16	3.35 (85.1)	1 5/8
	1 in.	4400 (303)	SS-CHM16RT-		3.67 (93.2)	
Female SAE/MS	1/2 in.	4600 (316)	SS-CHF8ST-	CH8	2.74 (69.6)	1
Male SAE/MS	1/2 in.	4600 (316)	SS-CHM8ST-		2.48 (63.0)	
Male VCO fitting	1/4 in.	6000 (413)	SS-CHVCO4-	CH4	1.98 (50.3)	11/16
	1/2 in.		SS-CHVCO8-	CH8	2.35 (59.7)	1
	3/4 in.	5000 (344)	SS-CHVCO12-	CH16	2.90 (73.7)	1 5/8
	1 in.	4400 (303)	SS-CHVCO16-			
Male VCR fitting	1/4 in.	6000 (413)	SS-CHVCR4-	CH4	2.28 (57.9)	11/16
	1/2 in.	4300 (296)	SS-CHVCR8-	CH8	2.73 (69.3)	1
	3/4 in.	3700 (254)	SS-CHVCR12-	CH16	3.78 (96.0)	1 5/8

① See specifications ISO 7/1, BS EN 10226-1, DIN 2999, JIS B0203.

CH Series



Ordering Information

To order, add a cracking pressure designator to the basic ordering number.

Cracking Pressure Psi (bar)	Designator
1/3 (0.03)	1/3
1 (0.07)	1
5 (0.35)	5
10 (0.69)	10
25 (1.8)	25

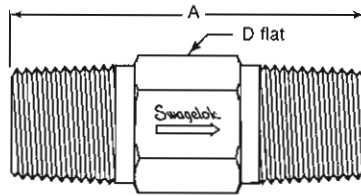
Example: SS-CHS2-1/3

⚠ Check valves are designed for directional flow control only. Swagelok check valves should never be used as code safety relief devices.

Dimensions

Dimensions, shown with Swagelok tube fitting nuts finger-tight, are for reference only and are subject to change.

CP and CPA Series



End Connections		Basic Ordering Number	Series	Dimensions, in. (mm)	
Inlet/Outlet	Size			A	D
Fixed Cracking Pressure, CP Series					
Female NPT	1/4 in.	SS-4CP4-	4CP	2.41 (61.2)	3/4
	1/2 in.	SS-8CP4-	8CP	3.71 (94.2)	1 1/16
Male NPT	1/4 in.	SS-4CP2-	4CP	1.62 (41.1)	9/16
	1/2 in.	SS-8CP2-	8CP	2.28 (57.9)	7/8
Female/male NPT	1/4 in.	SS-4CP6-	4CP	2.29 (58.2)	3/4
Male/female NPT	1/4 in.	SS-4CP5-		1.75 (44.4)	3/4
	1/2 in.	SS-8CP5-	8CP	2.83 (71.9)	1 1/16
Female ISO ^①	1/4 in.	SS-4CP4-RT-	4CP	2.54 (64.5)	3/4
Male ISO ^①	1/4 in.	SS-4CP2-RT-		1.62 (41.1)	9/16
Adjustable Cracking Pressure, CPA Series					
Female NPT	1/4 in.	SS-4CPA4-	4CPA	2.98 (75.7)	3/4
Male NPT	1/4 in.	SS-4CPA2-		1.62 (41.1)	9/16
	1/2 in.	SS-8CPA2-	8CPA	2.56 (65.0)	7/8
Male ISO ^①	1/4 in.	SS-4CPA2-RT-	4CPA	1.62 (41.1)	9/16
	1/2 in.	SS-8CPA2-RT-	8CPA	2.56 (65.0)	7/8

① See specifications ISO 7/1, BS EN 10226-1, DIN 2999, and JIS B0203.

Ordering Information

Basic ordering numbers specify stainless steel material. To order brass, replace **SS** with **B** in the basic ordering number.

Example: **B-4CP4-**

CP Series

To order, add a cracking pressure designator to the basic ordering number.

Cracking Pressure psi (bar)	Designator
1/3 (0.03)	1/3
1 (0.07)	1
10 (0.69)	10
25 (1.8)	25

Example: **B-4CP4-1/3**

CPA Series

To order, add a cracking pressure range designator to the basic ordering number.

Cracking Pressure psi (bar)	Designator
3 to 50 (0.21 to 3.5)	3
50 to 150 (3.5 to 10.4)	50
150 to 350 (10.4 to 24.2)	150
350 to 600 (24.2 to 41.4)	350

Example: **SS-4CPA4-3**

⚠ Check valves are designed for directional flow control only. Swagelok check valves should never be used as code safety relief devices.

Options and Accessories

Seal Materials (All Series)

Fluorocarbon FKM O-rings are standard in 316 stainless steel valves; Buna N O-rings are standard in brass valves. Other elastomer seals (poppet bonding material and O-ring) are available. To order, insert the seal material designator into the valve ordering number.

Seal Material	Designator	Temperature Rating °F (°C)
Buna N	-BU	-10 to 250 (-23 to 121)
Ethylene propylene	-EP	-50 to 300 (-45 to 148)
Fluorocarbon FKM	-VI	-10 to 375 (-23 to 190) [ⓐ]
Neoprene	-NE	-40 to 250 (-40 to 121)

[ⓐ] -10 to 400°F (-23 to 204°C) for CH series.

Example: B-2C-VI-1/3

Additional seal materials are available. Contact your authorized Swagelok sales and service representative for details.

Special Alloys (All Series)

Springs of alloy 400 or alloy C-276 are available in some sizes. Valve bodies of alloy 400, carbon steel, aluminum, or other alloys are available in some sizes. Contact your authorized Swagelok representative for more information.

PTFE-Coated Springs (C, CA, CP, and CPA Series)

Springs with PTFE coating are available in some sizes. Contact your authorized Swagelok representative for more information.

Inlet Gaskets (2C, 4C, 6C, and 8C Series)

PTFE-coated 316 stainless steel inlet gaskets are available for 2C, 4C, 6C, and 8C series valves to reduce the possibility of dislodging the O-ring in systems where pressure surges, shock, or pulses occur. Gaskets are standard in 6C and 8C series valves with cracking pressures greater than 50 psi (3.5 bar).

To order an inlet gasket, if it is not standard, insert -FG into the valve ordering number.

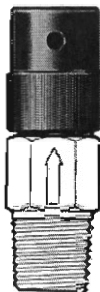
Example: SS-4C-FG -1

Deflector Cap (CP and CPA Series)

A polyethylene deflector cap is available for CP and CPA series valves with male NPT end connections. The deflector cap deflects flow from direct contact with personnel and prevents atmospheric contaminants from entering the valve. The deflector cap screws easily onto the male NPT outlet end of the valve. Maximum rating is 300 psig at 100°F (20.6 bar at 37°C).

To order, insert -DG for a green cap or -DR for a red cap into the ordering number.

Example: SS-4CPA2-DR-3



Sour Gas Valves (CH Series)

CH series valves are available for sour gas service. Materials are selected in accordance with NACE MR0175/ISO 15156.

Technical Data

Pressure Rating at 70°F (20°C)

5000 psig (344 bar)

Temperature Rating

-50 to 300°F (-45 to 148°C)

Nominal Cracking Pressures

1/3, 1, and 5 psi (0.03, 0.07, and 0.35 bar)

End Connections

1/4, 3/8, and 1/2 in. Swagelok tube fittings

Materials of Construction

Body, poppet—alloy 400/B164

Seals—ethylene propylene

Backup ring—PTFE

Spring—alloy X-750/AMS 5699

All other materials and lubricant same as standard product.

See **Materials of Construction**, page 5.

Ordering Information

To order, replace **SS** with **M** and insert -SG into the ordering number.

Example: M-CHS4-SG-1/3

Valves With ECE R110-Type Approval (CH Series)

Stainless steel CH series check valves with Buna C seals are available with ECE R110-type approval for use in alternative fuel service.

■ Temperature rating: -40 to 185°F (-40 to 85°C)

■ Pressure rating within the range: 3770 psig (260 bar)

To order, add -11670 to a standard valve ordering number.

Example: SS-CHS8-1/3-11670

Special Cleaning and Packaging (SC-11)

Every C, CA, and CH series check valve with VCR or VCO end connections is processed in accordance with Swagelok *Special Cleaning and Packaging (SC-11)*, MS-06-63, to ensure compliance with product cleanliness requirements stated in ASTM G93 Level C.

To order special cleaning and packaging for C, CA, and CH series check valves with other end connections, add -SC11 to the ordering number.

Example: SS-2C-1/3-SC11

Oxygen Service Hazards

For more information about hazards and risks of oxygen-enriched systems, see the Swagelok *Oxygen System Safety* technical report, MS-06-13.

Maintenance Kits



C, CP, CA, and CPA Series Seal Kits

Kits contain O-ring and instructions. Select a basic kit ordering number and add an O-ring material designator. Uniform O-ring size and durometer are provided for reference only.

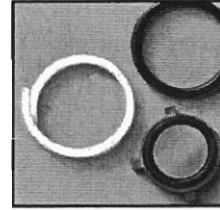
Example: VI70-4C-K4

Valve Series	Uniform O-ring Size	Durometer ^①	Basic Kit Ordering Number
Fixed Cracking Pressures: 1/3, 1, 10, and 25 psi (0.03, 0.07, 0.69, and 1.8 bar)			
2C, 4C, 4CP	009	70 ^②	70-4C-K4
6C, 8C	111		70-8C-K4
8CP	110		70-8CP-K4
12C, 16C	114		70-14C-K4
Adjustable Cracking Pressures: 3 to 150 psi (0.21 to 10.4 bar)			
CA, 4CPA	009	70 ^②	70-4C-K4
8CPA	110		70-8CP-K4
Adjustable Cracking Pressures: 150 to 600 psi (10.4 to 41.4 bar)			
CA, 4CPA	009	90 ^③	90-4C-K4
8CPA	110		90-8CP-K4

- ① Not applicable to PTFE O-rings. To order PTFE seal kits, omit the durometer number. Example: T-4C-K4
- ② Fluorocarbon FKM O-rings have a durometer of 75.
- ③ Silicone O-rings size 009 have a durometer of 80; silicone O-rings size 110 have a durometer of 70.

O-ring Material	Designator
Buna N	BU
Ethylene propylene	EP
Fluorocarbon FKM	VI
Neoprene	NEO

Additional seal materials are available. Contact your authorized Swagelok representative for details.



CH Series Seal Kits

Kits contain bonded poppet, body seal O-ring, PTFE backup ring, and instructions. Select a basic kit ordering number and add a seal material designator.

Example: SS-3K-CH4-VI

Valve Series	Valve Body Material	Basic Kit Ordering Number
CH4	316 SS	SS-3K-CH4-
	Alloy 400	M-3K-CH4-
CH8	316 SS	SS-3K-CH8-
	Alloy 400	M-3K-CH8-
CH16	316 SS	SS-3K-CH16-

Seal Material	Designator
Buna N	BN
Ethylene propylene	EP
Fluorocarbon FKM	VI
Neoprene	NE



CA, 8C, and 16C Series Metal Gasket Kits

Kits contain PTFE-coated gasket(s) and instructions. Select a basic kit ordering number and add a gasket material designator.

Example: SS-8C-K6

Valve Series	Basic Kit Ordering Number
2C, 4C (1 gasket) ^①	-4C-K6
6C, 8C (1 gasket) ^①	-8C-K6
12C, 16C (1 gasket)	-14C-K6
CA (1 inlet gasket, 1 outlet gasket)	-4CA-K6

Gasket Material	Designator
316 SS	SS
Alloy 400 ^①	M
Aluminum ^②	A

- ① Not available for 6C, 8C, and CA series valves.
- ② Not available for 2C, 4C, 6C, 8C, and CA series valves.

① Gasket is available for 2C, 4C, 6C, and 8C series valves for use in systems where pressure surges, shock, or pulses occur and is required in 6C and 8C series valves with 50 psi (3.5 bar) or higher spring cracking pressure.

Maintenance Kits



C, CP, CA, and CPA Series Spring Kits

Kits contain spring, two cracking pressure labels, and instructions. Select a basic kit ordering number and add a spring material designator.

Example: 302-4C-K2-1/3

To order a kit with a PTFE-coated spring, add T to the kit ordering number.

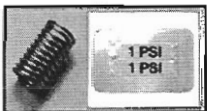
Example: 302-4C-K2-1/3T

Valve Series	Cracking Pressure psi (bar)	Basic Kit Ordering Number
2C, 4C 4CP	1/3 (0.03)	-4C-K2-1/3
	1 (0.07)	-4C-K2-1
	10 (0.69)	-4C-K2-10
	25 (1.8)	-4C-K2-25
6C, 8C, 8CP	1/3 (0.03)	-8C-K2-1/3
	1 (0.07)	-8C-K2-1
	10 (0.69)	-8C-K2-10
	25 (1.8)	-8C-K2-25
12C, 16C	1/3 (0.03)	-14C-K2-1/3
	1 (0.07)	-14C-K2-1
	10 (0.69)	-14C-K2-10
	25 (1.8)	-14C-K2-25

Valve Series	Cracking Pressure psi (bar)	Basic Kit Ordering Number
CA, 4CPA	3 to 50 (0.21 to 3.5)	-4CA-K2-3
	50 to 150 (3.5 to 10.4)	-4CA-K2-50
	150 to 350 (10.4 to 24.2)	-4CA-K2-150
	350 to 600 (24.2 to 41.4)	-4CA-K2-350
8CPA	3 to 50 (0.21 to 3.5)	-8CA-K2-3
	50 to 150 (3.5 to 10.4)	-8CA-K2-50
	150 to 350 (10.4 to 24.2)	-8CA-K2-150
	350 to 600 (24.2 to 41.4)	-8CA-K2-350

Spring Material	Designator
302 SS	302
Alloy 400 [Ⓛ]	M

[Ⓛ] Not available for CA or CPA series valves.



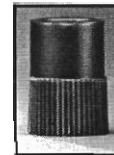
CH Series Spring Kits

Kits contain spring, two cracking pressure labels, and instructions. Select a basic kit ordering number and add a cracking pressure designator.

Example: 302-13K-CH4-1/3

Valve Series	Valve Body Material	Basic Kit Ordering Number
CH4	316 SS	302-13K-CH4-
	Alloy 400	M-13K-CH4-
CH8	316 SS	302-13K-CH8-
	Alloy 400	M-13K-CH8-
CH16	316 SS	302-13K-CH16-

Cracking Pressure psi (bar)	Designator
1/3 (0.03)	1/3
1 (0.07)	1
5 (0.35)	5
10 (0.69)	10
25 (1.8)	25



CP and CPA Series Deflector Cap Kits

Each kit contains five polyethylene deflector caps in red or green.

Male NPT	Kit Ordering Number	
	Red	Green
1/4 in.	P-4CP4-K12-RD	P-4CP4-K12-GR
1/2 in.	P-8CP4-K12-RD	P-8CP4-K12-GR

Safe Product Selection

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Caution: Do not mix or interchange parts with those of other manufacturers.

Warranty Information

Swagelok products are backed by The Swagelok Limited Lifetime Warranty. For a copy, visit swagelok.com or contact your authorized Swagelok representative.



Type 1540 Side-Mount Pneumatic Level Switch

Form 1337

Type 1540 is a horizontally mounted, float-operated level switch suitable for plant and OEM applications where pneumatic valve operation is required to signal presence or absence of liquid at a discrete level. The float arm moves a magnet which in turn moves a shuttle that either blocks or allows pilot pressure to pass and operate ancillary equipment. Actuation (deactuation) can be reversed by rotating the unit 180 degrees or switching inlet connections (see below).



The supply media must be filtered and oil free. Air is the usual media; however, any dry, filtered gas can be used.

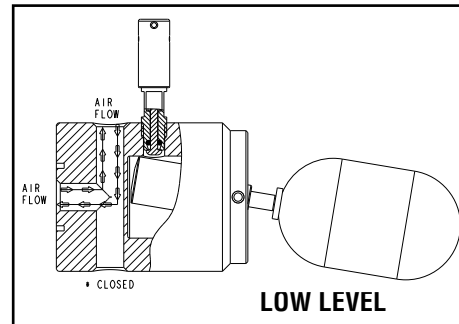
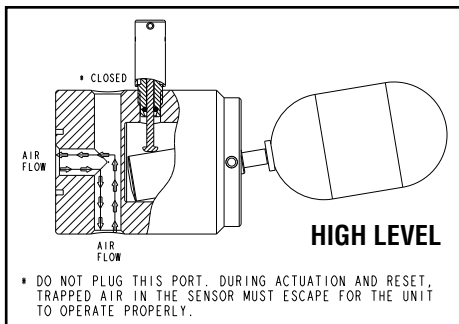
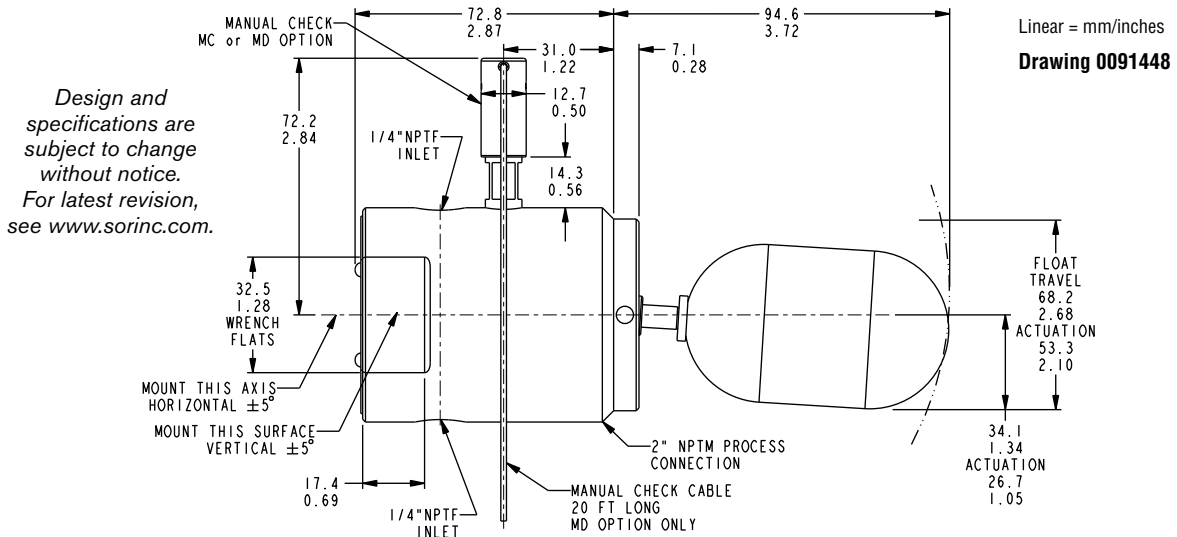
Product Specifications

Orientation	Horizontal mount only
Connection Size	2" NPT(M)
I/O Connection	1/4" NPT(F)
Output Pressure	0-30 psi (0-2 BAR)
Pilot (supply) Pressure	0-30 psi (0-2 BAR)
Flow Rate @ 30 psi Supply	60 SCFH (1.7 CMH)
Leak Rate @ 50 psi Supply	<0.5 SCFH (.01 CMH)
Maximum Process Pressure	1500 psi (100 BAR)
Minimum Specific Gravity	0.65
Weight	3.5 lbs. (2 kg)

SCFH - Standard cubic feet per hour
CMH - Cubic meter per hour

Dimensions

The drawings & illustrations below show the manual check (MC or MD) option.



Type 1540 Side-Mount Pneumatic Level Switch

How to Order

Select model number from table below. Accessory designator(s) may be added after PS if required.

Body Material	Float Material	Process Rating		Model Number
316SS	316SS	* -40 to 400°F (-40 to 204°C)	1500 psi (100 BAR)	1540C-G2A-C-J0-PS

* Manufacturer limits on Viton GLT are -40 to 400°F.

Optional Accessories

Add option designator(s) to end of model number.

Description	Designator
Wetted parts are cleaned for industrial oxygen service.	BB
Canadian Registration Number (CRN).	CV
ANSI B31.3 certificate of conformance.	CZ
Manual Check accessory (uses Viton GLT O-ring).	MC*
Manual Check accessory (uses Viton GLT O-ring) with 20' remote cable.	MD*
NACE construction - MR-01-75.	NC
Tag fiber. Attached with plastic wire to housing. Stamped with customer-specified tagging information.	PP
Stainless steel nameplate attached to housing with wire. Stamped with customer-specified tagging information. (2 lines, 18 characters and spaces per line.)	RR
Stainless steel nameplate permanently attached to housing. Stamped with customer-specified tagging information.	TT
Fungicidal varnish. Covers exterior except working parts.	VV
Epoxy coating on exterior only. Polyamide epoxy with 316SS pigment. (200 hours-salt spray)	YY

* Manufacturer limits on Viton GLT are -40 to 400°F.

Replacement Parts

Designator	Description
3130040	20' Remote Cable with two cable crimps**
3100152	Float
9227012	Float & Arm Assembly
9227024	Manual Check Accessory (uses Viton GLT O-ring) (MC)**
9227025	Manual Check Accessory with remote 20' cable (MD)**

**Unit must have originally been supplied with MC or MD option.

Limited Warranty

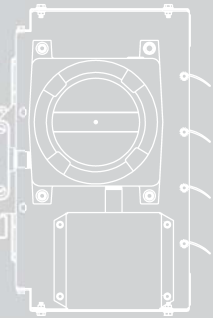
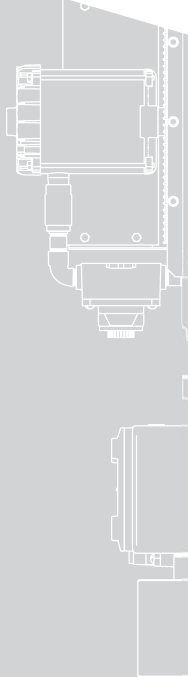
SOR® agrees to repair or replace any switch found to be defective in material or workmanship within five years from date of shipment. The limited warranty is valid only if the switch was installed in accordance with published factory installation instructions, operated within the design limitations stated on the nameplate, and returned to the factory for inspection, freight prepaid, within the warranty period. Contact the factory for return authorization. No claim for labor or consequential damages will be allowed.





Hazloc Heaters™

Safe heat when you need it!



Includes our
EXCaliber™
HEAT EXCHANGER CORE

XEU1

Explosion-Proof Electric Air Heater For Hazardous Locations

Class I, Divisions 1 & 2, Groups C & D
Class II, Divisions 1 & 2, Groups F & G
Temperature Code T3B

Class I, Zones 1 & 2, Groups IIA & IIB, T3

www.HazlocHeaters.com



Hazloc Heaters™ is a manufacturer of industrial-grade unit heaters suitable for hazardous and severe-duty locations.



The **XEU1** series of explosion-proof electric air heaters is designed to meet the most demanding requirements of heavy industry. The harsh operating conditions of this industry require heating equipment that is safe, reliable, dependable, and available when you need it. **XEU1** unit heaters are designed to provide primary or supplementary heating for comfort or freeze protection in areas that are classified as hazardous locations.

Designed for hazardous locations!

All **Hazloc Heaters™ XEU1** models are **designed to meet U.S. and Canadian certification standards**. The three sizes of **XEU1** heaters include our **ExCaliber™** high performance liquid-to-air heat-exchanger cores that are available in **27 model choices** of voltage and heat output combinations to meet your specific requirements.

The rugged and versatile **XEU1** heater incorporates a high quality immersion heater, high performance fan and motor assembly, a sturdy 14 GA steel cabinet with epoxy/polyester powder-coating for corrosion resistance, large control enclosure with an extra port for convenient wiring of an external room thermostat, and enclosure O-rings to minimize moisture ingress.



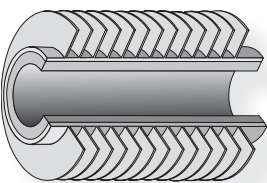
XEU1 heaters are suitable for a wide variety of applications that include but are not limited to oil & gas drilling rigs, petrochemical facilities, refineries, chemical storage and handling facilities, paint storage areas, sewage treatment plants, aircraft servicing areas, grain elevators, coal preparation areas, and areas containing metal dusts.



Rugged design, but easily maintained!

All **XEU1** heaters are designed for industrial applications with all features being heavy-duty to meet your most demanding environments and long-life expectations. Even with heavy-gauge steel construction used throughout the heater it does not inhibit maintenance of the product since the **XEU1** has been designed for easy field servicing with a removable heat exchanger core assembly, split fan guard, and replaceable automatic and manual reset high-limits. An added benefit is our 36-month heater warranty!

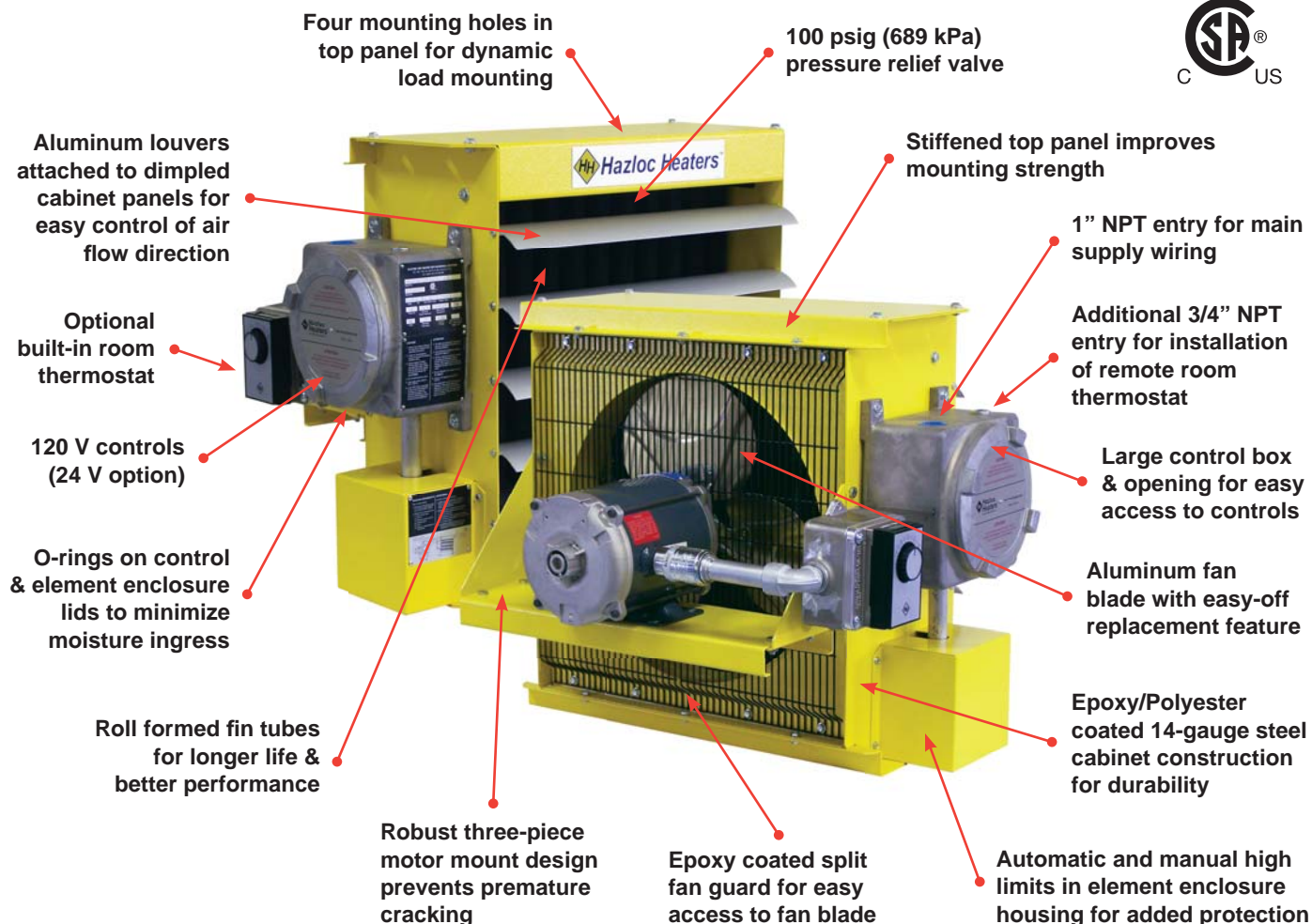
Maximum durability... rugged fin tubes!



All **XEU1 ExCaliber™** liquid-to-air heat-exchanger cores are evacuated & sealed and are constructed using rugged carbon-steel tubes with roll-formed aluminum fins to maximize heat transfer and carbon-steel headers for **maximum durability, resistance to corrosion, and longer life** in your demanding applications.

“Safe heat when you need it!”

Dedicated to Performance and Reliability!



NOTE: XEU1 heaters should not be exposed to rain or snow. This applies to both installed and stored heaters.

Suitable for the following hazardous location classifications:

- Class I, Divisions 1 & 2, Groups C & D, T3B
- Class II, Divisions 1 & 2, Groups F & G, T3B
- Class I, Zones 1 & 2, Groups IIA & IIB, T3

Limited 36-month Warranty

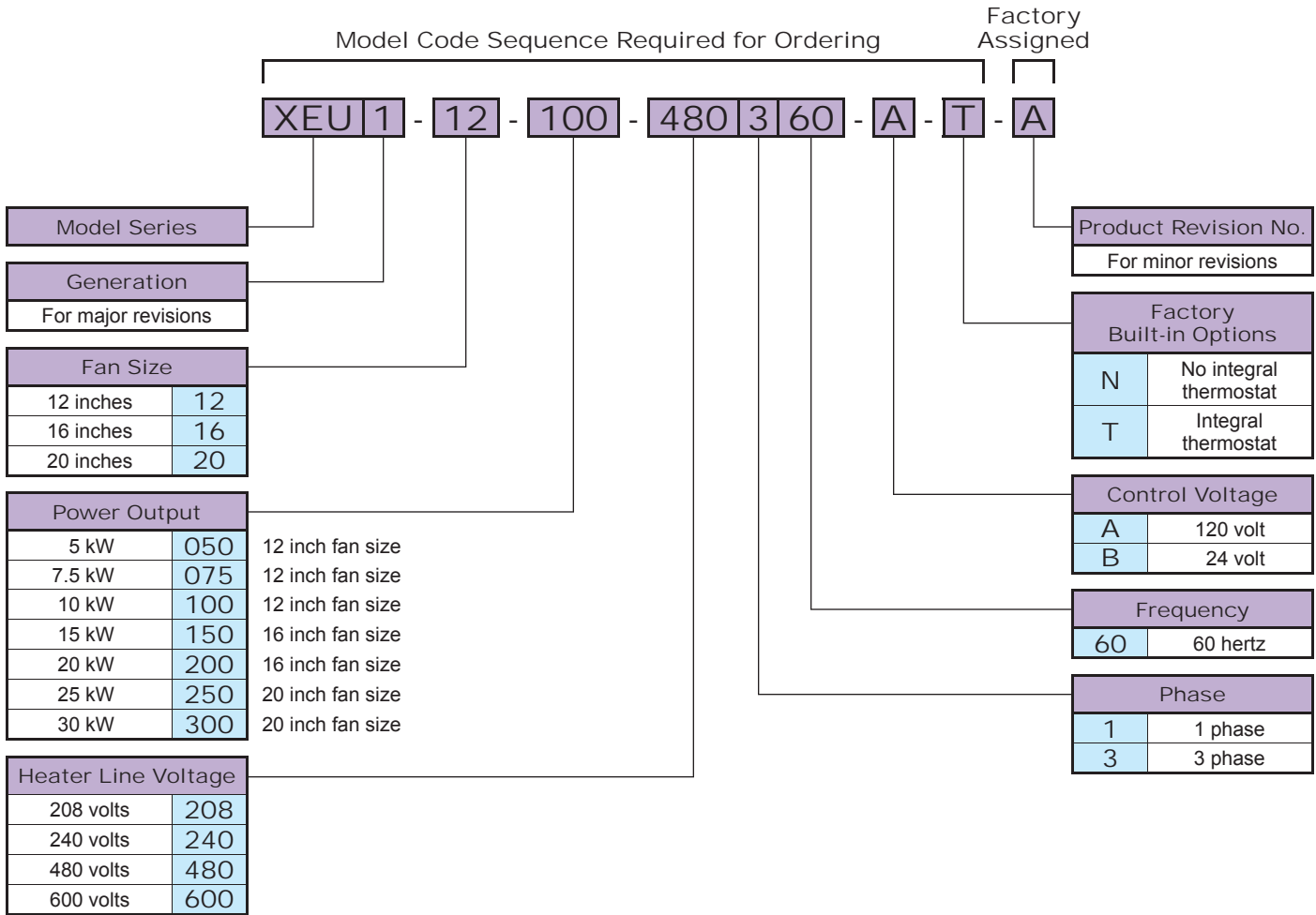


The **ExCaliber™** evacuated and sealed liquid-to-air heat exchanger core is constructed using rugged roll-formed aluminum fins and protected by a vent relief valve, automatic reset high limit, and a back-up manual reset high limit.

The **XEU1** heater has the highest air temperature rise, on average, in the industry across our complete kW range.

ExCaliber™ heat-exchanger core is easy to remove

XEU1 Model Coding



How to Order

When ordering refer to Page 7 and then please follow the **“Model Code Sequence Required for Ordering”** format above to specify base model, motor voltage, phase, frequency and also specify hazardous location area rating required (eg. suitable for Class I, Div.1, Group D; T3B or Class I, Zone 1, Group IIA; T3)

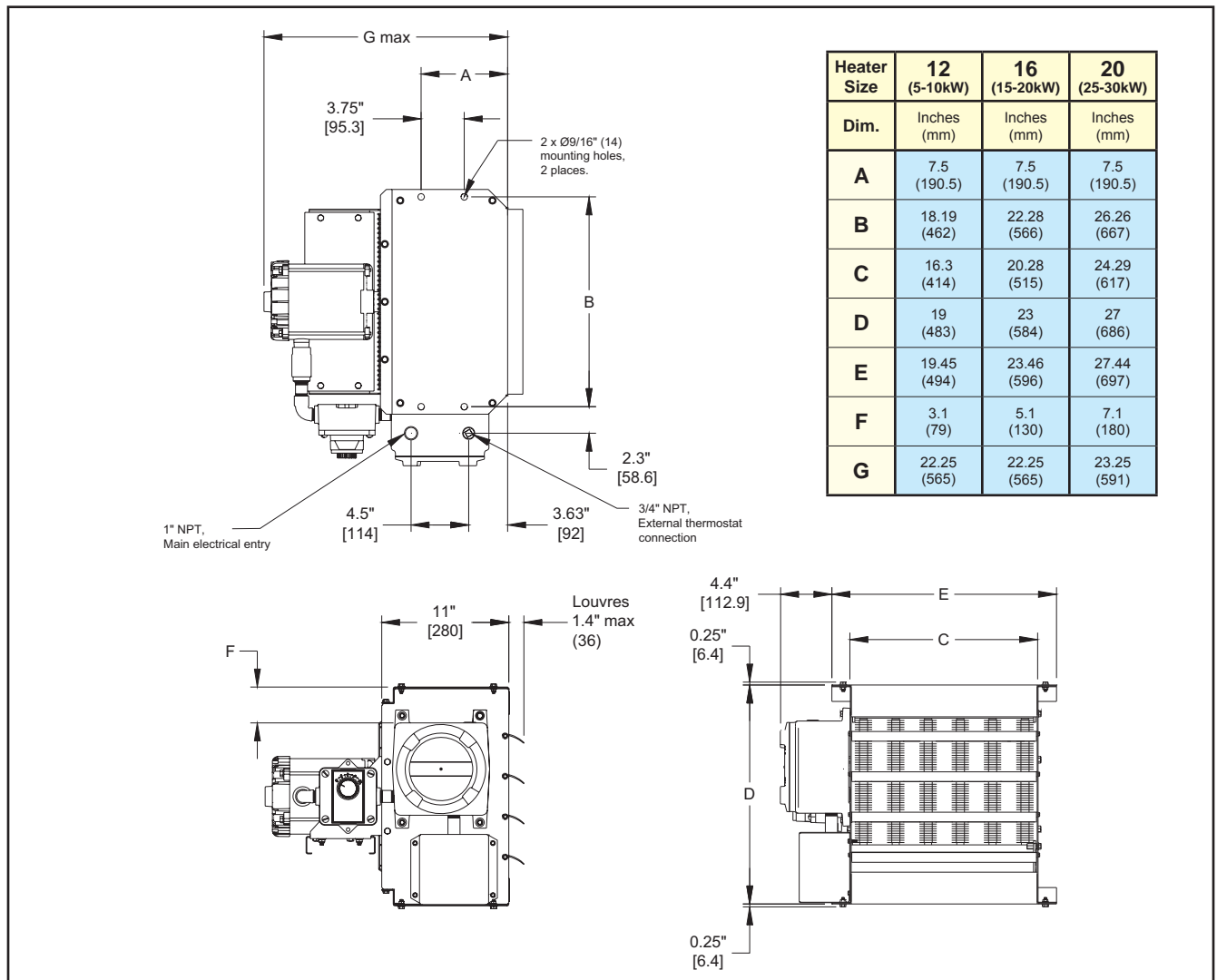
Example Model Code: XEU1-12-100-480360-A-T



XEU1 Specifications By Model Size

Model		XEU1-12			XEU1-16		XEU1-20	
Fan diameter	in (mm)	12 (304.8)			16 (406.4)		20 (508.0)	
Nominal kW		5	7.5	10	15	20	25	30
Air delivery	cfm	400	600	800	1200	1700	2100	3000
	m3/hr	680	1019	1359	2039	2888	3568	5097
Approx. air velocity	fpm	479	718	958	808	1145	916	1309
	m/s	2.4	3.6	4.9	4.1	5.8	4.6	6.6
Approx. horizontal air throw	ft	15	22	30	33	46	41	61
	m	4.6	6.7	9.1	10.1	14.0	12.5	18.6
Motor power	hp (watts)	¼ (186)			¼ (186)		½ (373)	
Max. mounting height (to underside of heater)	ft	7	7.5	9.5	10	11	12	15
	m	2.1	2.3	2.9	3.0	3.4	3.6	4.6
Approx. net weight	lbs (kg)	129 (58.5)		133 (60.3)	161 (73.0)		192 (87.1)	
Approx. shipping weight	lbs (kg)	203 (92.1)		207 (93.9)	235 (106.6)		286 (129.7)	

XEU1 Physical Dimensions



XEU1 Specifications By Model Size

	Certification	CSA _{C/US} - Certified to Canadian and U.S. standards
Approvals	North American Hazardous Location Classifications	Class I, Divisions 1 & 2, Groups C & D Class II, Divisions 1 & 2, Groups F & G T3B
	Temperature code	Class I, Zones 1 & 2, Groups IIA & IIB, T3 Division System - T3B 165°C (329°F); Zone System - T3 200°C (392°F)
Cabinet	Cabinet material	14-gauge (0.075 in.) (1.9 mm) steel. Yellow epoxy/polyester powder coated with five-stage pretreatment, including iron phosphate.
	Fan guard	Split design with close wire spacing. A 3/8 in. (9.5 mm) diameter probe will not enter. Black polyester powder coated.
	Louver blades	Anodized extruded aluminum.
	Conduit materials & fittings	Plated steel and aluminum alloy for corrosion resistance.
	Fasteners	Zinc plated steel for corrosion resistance.
	Enclosure	Cast aluminum (non-copper alloy) NEMA Type 7 & 9 with O-ring.
	Mounting holes	9/16" diameter holes – Four located on the top face of heater.
Motor/Fan	Motor type	Explosion-proof, thermally protected, 1725 RPM permanently lubricated ball bearing type with 56 frame and "easy-off" fan blade replacement feature.
	Fan	Three-blade aluminum, steel spider and hub with 5/8 in. bore.
Heat Exchanger	Heating elements	Long-life, low watt-density, high grade metal-sheathed
	Heat transfer fluid	Ethylene glycol and water including corrosion inhibitors.
	Header material	Carbon steel.
	ExCaliber™ Core	Carbon steel shells and carbon steel tubes with copper-free, roll-formed aluminum fins @ 10 fins per in. Evacuated and sealed. Sprayed with black, high heat enamel paint.
Protection	Temperature high limits	One automatic reset rated for 100,00 cycles, and one manual reset. Both are snap-action bimetal type, open on temperature rise.
	Pressure relief	Preset 100 psig (689 kPa) aluminum body pressure relief valve.
Controls	Control circuit	Built in 120 V control. Optional 24V control available.
	Control contactor	40 amp. Rated for 500,000 mechanical operations.
	Control transformer	Multitap primary, 120V or 24V secondary.
	Fuse protection	Thermal delay fuse (spare included).
	Room thermostat (optional)	Built in, TBX1 explosion-proof thermostat, 40°F to 80°F (5°C to 27°C)
Operating Limits	Ambient temperature	-49°F to 104°F (-45°C to 40°C).
	Maximum altitude ASL	10,000 ft (3048 m).

XEU1 Heater Performance Data

kW (btu/hr)	Line Volts	Ø	Fan Dia. in.	Model See page 4 to complete model coding	Total Amps A	Air Temp. Rise	
						°F	°C
5 (17060)	208	1	12	XEU1-12-050-208160 *	26.5	38.1	21.2
	240	1	12	XEU1-12-050-240160 *	23.3	38.1	21.2
	208	3	12	XEU1-12-050-208360 *	14.6	38.1	21.2
	240	3	12	XEU1-12-050-240360 *	12.7	38.1	21.2
	480	3	12	XEU1-12-050-480360 *	6.7	38.1	21.2
	600	3	12	XEU1-12-050-600360 *	5.5	38.1	21.2
7.5 (25590)	208	1	12	XEU1-12-075-208160 *	38.6	40.4	22.4
	240	1	12	XEU1-12-075-240160 *	33.8	40.4	22.4
	208	3	12	XEU1-12-075-208360 *	21.5	40.4	22.4
	240	3	12	XEU1-12-075-240360 *	18.7	40.4	22.4
	480	3	12	XEU1-12-075-480360 *	9.7	40.4	22.4
	600	3	12	XEU1-12-075-600360 *	7.9	40.4	22.4
10 (34120)	240	1	12	XEU1-12-100-240160 *	44.2	38.8	21.6
	208	3	12	XEU1-12-100-208360 *	28.5	38.8	21.6
	240	3	12	XEU1-12-100-240360 *	24.8	38.8	21.6
	480	3	12	XEU1-12-100-480360 *	12.7	38.8	21.6
	600	3	12	XEU1-12-100-600360 *	10.3	38.8	21.6
15 (51180)	208	3	16	XEU1-16-150-208360 *	42.3	39.1	21.7
	240	3	16	XEU1-16-150-240360 *	36.8	39.1	21.7
	480	3	16	XEU1-16-150-480360 *	18.7	39.1	21.7
	600	3	16	XEU1-16-150-600360 *	15.1	39.1	21.7
20 (68240)	480	3	16	XEU1-16-200-480360 *	24.8	37.3	20.7
	600	3	16	XEU1-16-200-600360 *	19.9	37.3	20.7
25 (85300)	480	3	20	XEU1-20-250-480360 *	31.1	37.5	20.8
	600	3	20	XEU1-20-250-600360 *	25.1	37.5	20.8
30 (102360)	480	3	20	XEU1-20-300-480360 *	37.1	31.5	17.5
	600	3	20	XEU1-20-300-600360 *	29.9	31.5	17.5

(*) Refer to page 4 for Control Voltage and Factory Built-in Option codes to complete entire model code for ordering.

Nomenclature/Useful Formulas/Conversions

cfm – Cubic feet per minute; **fpm** – Feet per minute; **btu** – British Thermal Unit

1 kW = 3,414 btu/hr; Final air temp. = Entering air temp. + Temp. rise; °C = 5/9 (°F - 32)

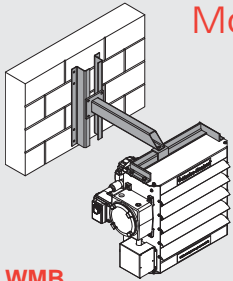
AC/DC Formulas			
To Find	Direct Current	AC - 1 phase	AC - 3 phase
Amps when horsepower is known	$\frac{HP \times 746}{E \times \text{Eff}}$	$\frac{HP \times 746}{E \times \text{Eff} \times \text{PF}}$	$\frac{HP \times 746}{1.73 \times E \times \text{Eff} \times \text{PF}}$
Amps when kilowatts is known	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times \text{PF}}$	$\frac{kW \times 1000}{1.73 \times E \times \text{PF}}$
Amps when kVA is known	$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{1.73 \times E}$
Kilowatts	$\frac{I \times E}{1000}$	$\frac{I \times E \times \text{PF}}{1000}$	$\frac{I \times E \times 1.73 \text{ PF}}{1000}$
Kilovolt-Amps	$\frac{I \times E}{1000}$	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$
Horsepower (output)	$\frac{I \times E \times \text{Eff}}{746}$	$\frac{I \times E \times \text{Eff} \times \text{PF}}{746}$	$\frac{I \times E \times \text{Eff} \times 1.73 \times \text{PF}}{746}$

Where **I** = amps; **E** = phase-to-phase volts; **Eff** = efficiency expressed as a decimal; **PF** = power factor expressed as a decimal; **kW** = kilowatts; **KVA** = kilovolt amperes; **HP** = horsepower.



Accessories

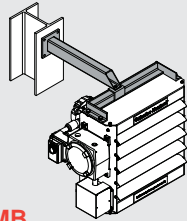
Mounting Brackets



WMB

Wall Mounting Bracket

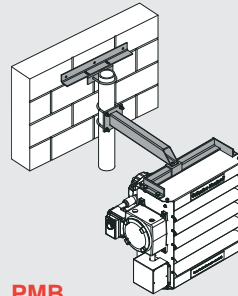
For use in buildings that have substantial walls. The Z sections provide additional support where necessary.



BMB

Basic Mounting Bracket

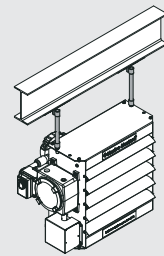
For applications where the support arm can be bolted or welded directly to structural steel or concrete.



PMB

Pipe Mounting Bracket

For buildings with insufficient strength to use other types of mounting brackets. Requires 3 in. pipe (3.5 in. O.D., min. Sch. 40, not supplied).



HMB

Hanging Mounting Bracket

Ideal and economical if adequate overhead structure exists. Requires 1/2 in. pipe, cut and threaded (min. Sch. 40 not supplied).

Note: When ordering mounting brackets, please specify the type of bracket preferred and the basic model code of the heater to be mounted.

Example, **PMB-XEU1-16**.

Mounting kits are made of steel with a black enamel paint finish.

Structural support of heater and bracket during transit is required.

Thermostat

TBX1 (SPDT)

Explosion-proof Thermostat - Class I, Groups C&D, Class II, Groups E, F & G

Temperature range: 40°F to 80°F (5°C to 27°C),

3/4" - NPT conduit opening on top and bottom.

22 Amps Resistive Load, 277 VAC Max; 3/4 HP@125 VAC; 1-1/2 HP@ 250/277 VAC

Overall dimensions - 6.4 in (16.2 cm) W x 5.6 in (14.3 cm) H x 4.4 in (11.1 cm) D

Ship wt - 5.3 lbs (2.4 kg)



XEU1 Engineering Specifications

1.0 General

- 1.1 The explosion-proof unit heater(s) shall be supplied and installed in accordance with the plans and specifications, with ratings as listed in the schedule of electrical heating equipment, and shall be Hazloc Heaters' XEU1 series.
- 1.2 The unit heater(s) shall be CSA_{C/US} certified for use in Class I, Divisions 1 & 2, Groups C & D; Class II, Divisions 1 & 2, Groups F & G; and Class I, Zones 1 & 2, Groups IIA & IIB Hazardous Locations and shall be rated for National Electric Code and Canadian Electric Code Temperature Code T3B, 165°C (329°F) for Division System and T3, 200°C (392°F) for Zone System.

2.0 Heat Exchanger

- 2.1 The Heat Exchanger shall be a liquid-to-air type consisting of steel tubes with integral aluminum fins @ 10 fins per inch and be evacuated, sealed and painted with black, high heat enamel.
- 2.2 The Heat Exchanger shall be protected by a preset 100 psig (689 kPa) pressure-relief valve, aluminum body, with no serviceable parts.
- 2.3 The Heat Exchanger shall be filled and sealed to design level with a custom-blended, long-life solution of ethylene-glycol and water including inhibitors to provide superior corrosion protection.
- 2.4 The Heat Exchanger shall include heavy-duty immersion heating elements brazed into a heavy steel flange. The elements shall consist of high-quality resistance wire embedded in a magnesium oxide refractory and sheathed in a metal tubing. The heater is to be protected by two snap-action bimetal temperature high-limit cutouts. The primary high-limit shall be an automatic reset type rated for 100,000 cycles, and the secondary high-limit a manual reset type and will shut off the heater if the fluid temperature rises due to a lack of heat dissipation. The high-limits shall not be effected by altitude or changes in atmospheric pressure.

3.0 Fan and Motor Assembly

- 3.1 The Fan Assembly shall include a ball bearing, permanently lubricated, thermally protected explosion-proof motor rated for continuous duty at 40°C (104°F). The motor shaft shall provide a method for easy field replacement of fan blade assembly without the use of special tools.
- 3.2 The Fan shall be aluminum to prevent sparking. The Fan shall be directly connected to the motor, dynamically balanced, and designed specifically for the heater application.
- 3.3 The Fan shall be shielded with a heavy-duty steel wire, polyester-coated guard. To provide easy maintenance and cleaning of the fan and motor, the fan guard shall be of a two piece construction. The guard shall not allow a 3/8 in. (9.5 mm) probe to enter.

XEU1 Engineering Specifications (continued)

4.0 Control Center

- 4.1 The Control Center shall be completely factory pre-wired and tested, and enclosed in a NEMA 7 and 9 explosion-proof control enclosure with O-ring and a large threaded cover for easy access.
- 4.2 The Control Center shall include a 40 amp magnetic contactor sized to handle the heater and motor current, and shall be rated for 500,000 cycles operation. The encapsulated severe-duty coil shall be rated 120V or 24V (specify one) and separately fuse protected.
- 4.3 The Control Center shall include a control voltage transformer, the primary voltage being the same as the heater voltage and the secondary to be 120V or 24V (specify one).
- 4.4 The Control Center shall include a terminal block for remote thermostat connection.
- 4.5 The Control Center shall include in-line thermal delay fuse protection on secondary side of transformer. The fuse holder shall be mounted on the printed circuit board and contain both an operating fuse and a spare fuse.

5.0 Cabinet Assembly

- 5.1 The Cabinet Assembly shall be fabricated from 14 gauge steel with a baked epoxy/polyester powder coating over a 5-stage pretreatment including iron phosphate, for protection from corrosive atmospheres.
- 5.2 The Cabinet shall include four 9/16 inch (14.3 mm) mounting holes located on top face of heater.
- 5.3 Louver blades shall be individually adjustable and made of anodized extruded aluminum.

6.0 Mounting Brackets

- 6.1 The heater shall be provided with a steel Mounting Bracket , with wet applied black enamel paint, specifically designed to bear the weight of the heater assembly.
- 6.2 The Mounting Bracket shall be - (select one):
 - Type WMB - Wall Mounting Bracket
 - Type BMB - Basic Mounting Bracket
 - Type PMB - Pipe Mounting Bracket
 - Type HMB - Hanging Mounting Bracket

7.0 Room Thermostat Options

- 7.1 The heater shall be supplied with (select one):
 - Integral TBX1 explosion-proof room thermostat mounted on the control enclosure side of the heater.
 - Field installed remote mount TBX1 explosion-proof thermostat.

Hazardous Location Definitions

Class I - Flammable Gases, Vapors or Liquids

Class I Area Classification

Division 1

Where ignitable concentrations of flammable gases, vapors or liquids can exist all of the time or some of the time under normal operating conditions.

Division 2

Where ignitable concentrations of flammable gases, vapors or liquids are not likely to exist under normal operating conditions

Zone 0

Where ignitable concentrations of flammable gases, vapors or liquids are present continuously or for long periods of time under normal operating conditions.

Zone 1

Where ignitable concentrations of flammable gases, vapors or liquids are likely to exist under normal operating conditions.

Zone 2

Where ignitable concentrations of flammable gases, vapors or liquids are not likely to exist under normal operating conditions.

Class I Groups (Typical Examples)

Division 1 & 2

- A (acetylene)
- B (hydrogen)
- C (ethylene)
- D (propane)

Zone 0, 1 & 2

- IIC (acetylene & hydrogen)
- IIB (ethylene)
- IIA (propane)

Class II - Combustible Dusts

Class II Area Classification

Division 1

Where ignitable concentrations of combustible dusts can exist all of the time or some of the time under normal operating conditions.

Division 2

Where ignitable concentrations of combustible dusts are not likely to exist under normal conditions.

Class II Groups

Division 1 & 2

- E (metals - Division 1 only)
- F (coal)
- G (grain)

Class III - Ignitable Fibers & Flyings

Class III Area Classification

Division 1

Where easily ignitable fibers or materials producing combustible flyings are handled, manufactured or used.

Division 2

Where easily ignitable fibers are stored or handled.

Class III Groups

Division 1 & 2

None.

Temperature Codes

Class I Temperature Code

Division 1 & 2

- T1 ($\leq 450^{\circ}\text{C}$)
- T2 ($\leq 300^{\circ}\text{C}$)
- T2A, T2B, T2C, T2D ($\leq 280^{\circ}\text{C}$, $\leq 260^{\circ}\text{C}$, $\leq 230^{\circ}\text{C}$, $\leq 215^{\circ}\text{C}$)
- T3 ($\leq 200^{\circ}\text{C}$)
- T3A, T3B, T3C ($\leq 180^{\circ}\text{C}$, $\leq 165^{\circ}\text{C}$, $\leq 160^{\circ}\text{C}$)
- T4 ($\leq 135^{\circ}\text{C}$)
- T4A ($\leq 120^{\circ}\text{C}$)
- T5 ($\leq 100^{\circ}\text{C}$)
- T6 ($\leq 85^{\circ}\text{C}$)

Zone 0, 1 & 2

- T1 ($\leq 450^{\circ}\text{C}$)
- T2 ($\leq 300^{\circ}\text{C}$)
- T3 ($\leq 200^{\circ}\text{C}$)
- T4 ($\leq 135^{\circ}\text{C}$)
- T5 ($\leq 100^{\circ}\text{C}$)
- T6 ($\leq 85^{\circ}\text{C}$)

Class II Temperature Codes

Division 1 & 2

- T1 ($\leq 450^{\circ}\text{C}$)
- T2 ($\leq 300^{\circ}\text{C}$)
- T2A, T2B, T2C, T2D ($\leq 280^{\circ}\text{C}$, $\leq 260^{\circ}\text{C}$, $\leq 230^{\circ}\text{C}$, $\leq 215^{\circ}\text{C}$)
- T3 ($\leq 200^{\circ}\text{C}$)
- T3A, T3B, T3C ($\leq 180^{\circ}\text{C}$, $\leq 165^{\circ}\text{C}$, $\leq 160^{\circ}\text{C}$)
- T4 ($\leq 135^{\circ}\text{C}$)
- T4A ($\leq 120^{\circ}\text{C}$)
- T5 ($\leq 100^{\circ}\text{C}$)
- T6 ($\leq 85^{\circ}\text{C}$)

Class III Temperature Codes

None.

Note: Article 503 of the NEC limits the maximum temperature for Class III equipment to 165°C for equipment not subject to overloading and to 120°C for equipment that may be overloaded.

Additional Products Available



SRH

The SRH series of heat-exchanger unit heaters is designed for steam applications on drilling rigs and is designed for pressures up to 100 psi. Meets ASME requirements with a CRN.



HUH

The HUH series of heat-exchanger unit heaters is designed for steam, hot water, glycol or other fluid circulating heating systems. Suitable for pressures and temperatures up to 400 psi and 550 °F respectively. Meets ASME requirements with a CRN.



HHP

The HHP high performance series of heat-exchanger unit heaters is designed for steam, hot water, glycol or other fluid circulating heating systems. Suitable for pressures and temperatures up to 450 psi and 550 °F respectively. Meets ASME requirements with a CRN.

XEC1

Explosion-proof electric convection heater

Coming Soon!

Hazloc Heaters™ “Safe heat when you need it!”

Hazloc Heaters™ is committed to a high standard of quality and on-time delivery performance. Upon acceptance of your order you can be assured your heater will ship when promised.

That is our commitment to you!

Limited 36-Month Warranty

Hazloc Heaters™ warrants all **XEU1** series of explosion-proof electric heaters against defects in materials and workmanship under normal conditions of use for a period of thirty-six (36) months from date of purchase based on the following terms:

1. The heater must not be modified in any way.
2. The heater must be stored, installed and used only in accordance with the owner's manual and attached data plate information.
3. Replacement parts will be provided free of charge as necessary to restore any unit to normal operating condition, provided that the defective parts be returned to us freight prepaid and that the replacement parts be accepted freight collect.
4. The complete heater may be returned to our manufacturing plant for repair or replacement (at our discretion), freight charges prepaid.
5. Contamination by dirt, dust, etc. or corrosion will not be considered as defects.
6. This warranty shall be limited to the actual equipment involved and, under no circumstances, shall include or extend to installation or removal costs, or to consequential damages or losses.

Hazloc Heaters™

Safe heat when you need it!

#1, 666 Goddard Ave. NE
Calgary, Alberta T2K 5X3 Canada
Tel.: +1-403-730-2488
Fax: +1-403-730-2482
Customer Toll Free (U.S. & Canada):
+1-866-701-Heat (4328)
www.HazlocHeaters.com

Available from:



MERCER VALVE CO., INC.
AUTO SEAT TECHNOLOGY®

8100 SERIES



MERCER VALVE

THINK...MERCER FIRST™

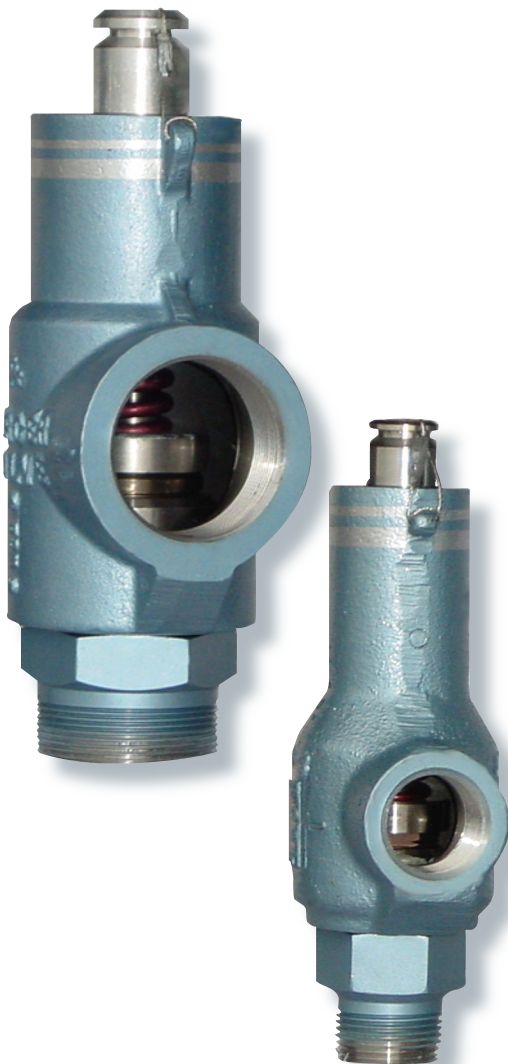




8100 Series Product Overview

The Mercer Valve 8100 Series Pressure Relief Valve is “State of the Art” in soft seat, high flow rate, pressure relieving devices. The 8100 Series spring operated valve was the first pressure relief valve to incorporate Mercer Valve’s patented **Auto Seat Technology®** into its design. Our **Auto Seat Technology®** incorporates a fully guided disk and low rate spring to ensure an accurate and repeatable set pressure. The low rated, guided spring will reduce stresses on the spring, giving you a consistent, repeatable set pressure, which will continually outlast the competition. The soft seated 8100 Series has a field-proven lip seal design, which allows for a tighter seal up to set pressure. This tight seal reduces leaks and limits product loss. Our non-rising stem allows us to produce a valve with a shorter bonnet, which will be lighter and fit in tighter confined spaces.

The 8100 Series is manufactured in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 for Air/Gas. The 8100 Series is well suited for compressors, separators, transmission, gathering lines, and other production processes.



8100 Series Features

- **Designed with Auto Seat Technology®.**
- **Consistent Set Pressures allowing repeatable uses without repair or resetting.**
- **Open, Close, Seat and Seal™.**
- **Fully guided disk keeps the disk properly aligned, opening and closing, helping to reseal the valve.**
- **Mechanical Stop prevents wear on parts and controls valve lift.**
- **Low rated and fully guided spring allows for more consistent set pressures from pop to pop.**
- **Pop Action relief allows valve to go to full lift at set pressure. Helps with DOT regulated applications.**
- **Built in accordance with the requirements of ASME Boiler and Pressure Vessel Code. Sec. VIII Div 1.**
- **Non-rising stems allowing valves to be installed in small areas.**



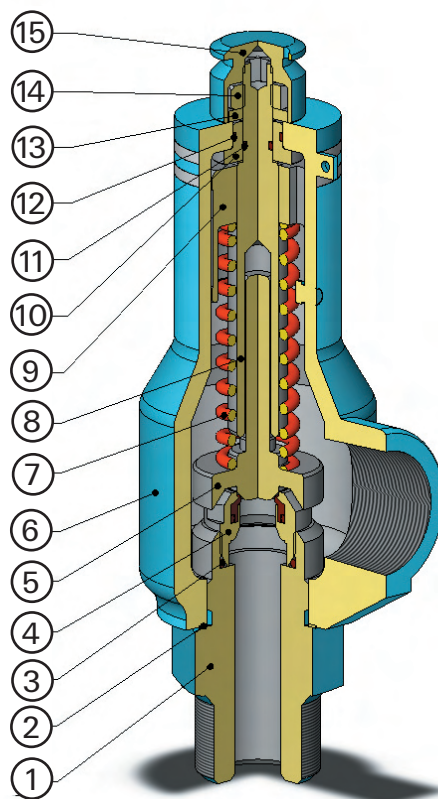
8100 Series Specifications

Basic Valve Size	1/2" Orifice	3/4" Orifice
Inlet Sizes Available	3/4" NPT 1" NPT	1 1/2" NPT 2" NPT
Outlet Sizes Available	1" NPT	2" NPT
Inlet and Outlet Connection Types Available	Male NPT x Female NPT Female NPT x Female NPT	
Orifice Diameter	.520 in.	.775 in.
Orifice Area	.212 in ²	.472 in ²
Equivalent API Letter	E	G
Pressure Ranges	15 to 2400 psi	15 to 2000 psi
Standard Temperature Range	-20°F to 400°F	-20°F to 400°F
ASME "Slope" (Gas)	3.10	7.21
Equivalent Flow Coefficient (Gas)	.800	.830
Approximate Weight	4.5 lbs.	10.0 lbs.

NOTE: Mercer Valve reserves the right to change product designs and specifications without notice.



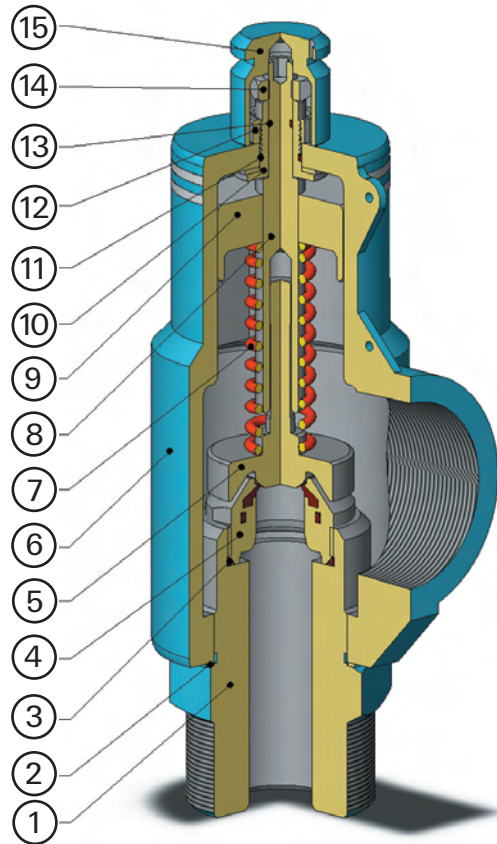
8100 Series Parts and Materials



8100 Series 1/2" Orifice

ITEM NO	PART NAME	STANDARD MATERIALS
1	INLET BASE	CARBON STEEL
2	BASE SEAL	SOFT STEEL
3	NOZZLE O-RING	VITON
4	NOZZLE SUBASSEMBLY	STAINLESS STEEL WITH SOFT SEAT
5	DISK SUBASSEMBLY	STAINLESS STEEL
6	BODY SUBASSEMBLY	CARBON STEEL
7	SET SPRING	STAINLESS STEEL
8	ADJUSTMENT SCREW	STAINLESS STEEL
9	ADJUSTMENT BUSHING	CARBON STEEL
10	CENTER BUSHING	CARBON STEEL
11	ADJUSTMENT SCREW O-RING	BUNA N
12	CENTER BUSHING O-RING	BUNA N
13	WASHER	CARBON STEEL
14	LOCKNUT	CARBON STEEL
15	CLOSED CAP	ALUMINUM

NOTE: Mercer Valve reserves the right to change product designs and specifications without notice.



8100 Series 3/4" Orifice

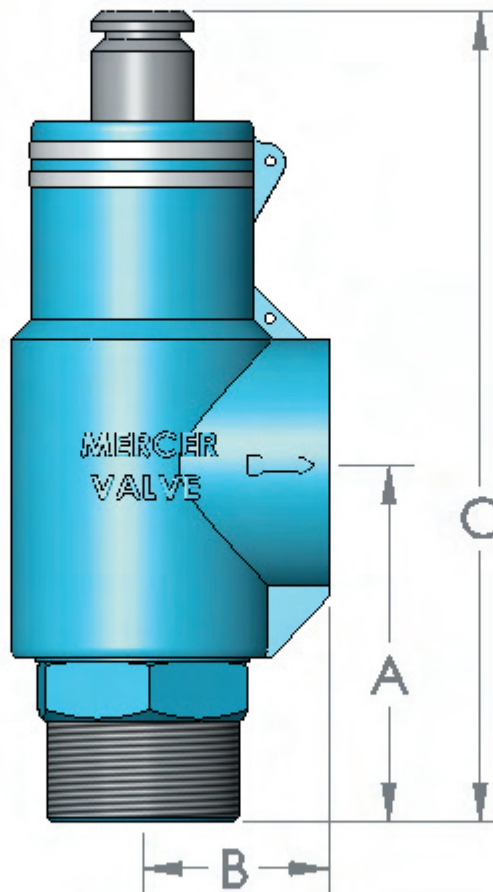
ITEM NO	PART NAME	STANDARD MATERIALS
1	INLET BASE	CARBON STEEL
2	BASE SEAL	SOFT STEEL
3	NOZZLE O-RING	VITON
4	NOZZLE SUBASSEMBLY	STAINLESS STEEL WITH SOFT SEAT
5	DISK SUBASSEMBLY	STAINLESS STEEL
6	BODY SUBASSEMBLY	CARBON STEEL
7	SET SPRING	STAINLESS STEEL
8	ADJUSTMENT SCREW	STAINLESS STEEL
9	ADJUSTMENT BUSHING	CARBON STEEL
10	CENTER BUSHING	CARBON STEEL
11	CENTER BUSHING O-RING	BUNA N
12	CENTERNUT	CARBON STEEL
13	ADJUSTMENT SCREW O-RING	BUNA N
14	LOCKNUT	CARBON STEEL
15	CLOSED CAP	ALUMINUM

NOTE: Mercer Valve reserves the right to change product designs and specifications without notice.

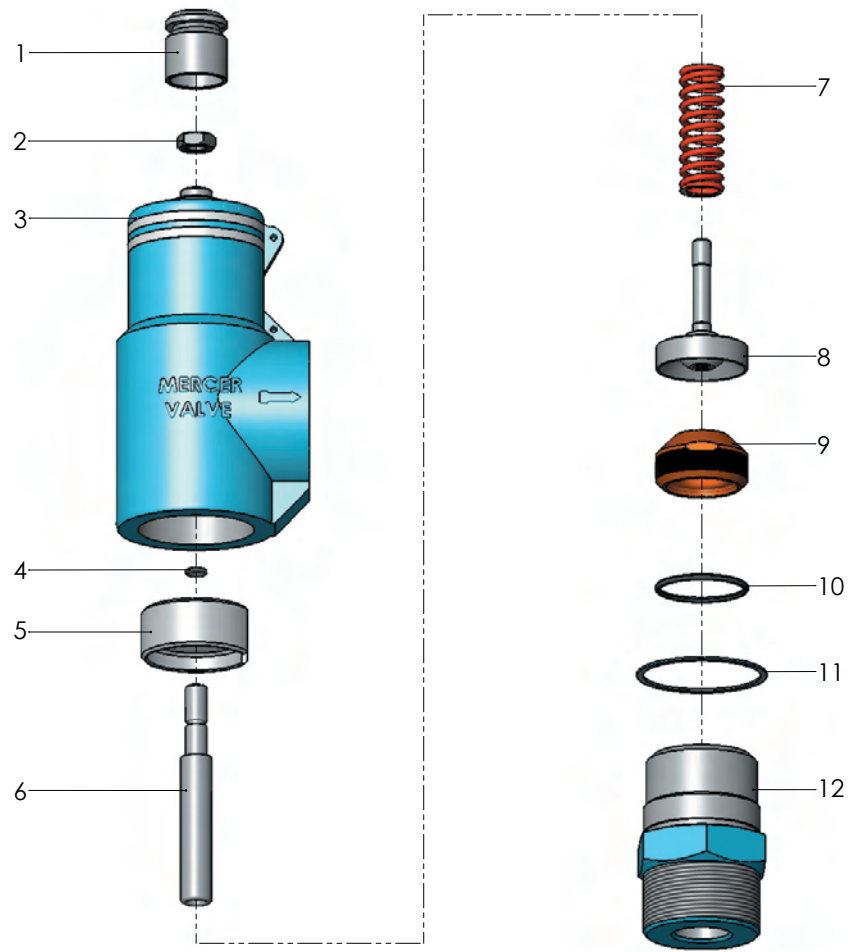


8100 Series Threaded Dimensions and Weights

Inlet and Outlet Code	Inlet and Outlet Size	Orifice Available	Pressure Limit (psi)	Dimensions "A" x "B" x "C" (in ±1/16)	Approx. Weight (lbs)
11	3/4" FNPT x 1" FNPT	1/2"	15 - 2400	2-1/4 x 1-7/8 x 7-1/16	4.5
12	3/4" MNPT x 1" FNPT	1/2"	15 - 2400	3-1/4 x 1-7/8 x 8	4.5
16	1" FNPT x 1" FNPT	1/2"	15 - 2400	3-1/4 x 1-7/8 x 8	4.5
17	1" MNPT x 1" FNPT	1/2"	15 - 2400	3-1/4 x 1-7/8 x 8	4.5
33	1 1/2" FNPT x 2" FNPT	3/4"	15 - 2000	4-5/8 x 2-3/8 x 10-5/16	11.5
34	1 1/2" MNPT x 2" FNPT	3/4"	15 - 2000	4-7/16 x 2-3/8 x 10-1/16	11
42	2" FNPT x 2" FNPT	3/4"	15 - 2000	4-5/8 x 2-3/8 x 10-5/16	12
43	2" MNPT x 2" FNPT	3/4"	15 - 2000	4-7/16 x 2-3/8 x 10-1/16	12



NOTE: Mercer Valve reserves the right to change product designs and specifications without notice.



8100 Series Exploded View

ITEM NO	PART NAME
1	CAP
2	LOCKNUT
3	BODY SUBASSEMBLY
4	ADJUSTMENT SCREW O-RING
5	ADJUSTMENT BUSHING
6	ADJUSTMENT SCREW
7	SET SPRING
8	DISK SUBASSEMBLY
9	NOZZLE SUBASSEMBLY
10	NOZZLE O-RING
11	BASE SEAL
12	INLET BASE

NOTE: Mercer Valve reserves the right to change product designs and specifications without notice.



8100 Series Capacity Chart

AIR CAPACITY AT 60°F AND STD ATMOSPHERIC CONDITIONS

Set Pressure (psi)	1/2" Orifice			3/4" Orifice		
	SCFM	MSCFH	MMSCFD	SCFM	MSCFH	MMSCFD
15	101	6.08	0.15	236	14.15	0.34
20	117	7.01	0.17	272	16.31	0.39
25	132	7.94	0.19	308	18.47	0.44
30	148	8.87	0.21	344	20.64	0.50
50	216	12.96	0.31	503	30.15	0.72
75	301	18.08	0.43	701	42.05	1.01
100	387	23.19	0.56	899	53.95	1.29
125	472	28.31	0.68	1097	65.84	1.58
150	557	33.42	0.80	1296	77.74	1.87
200	728	43.65	1.05	1692	101.53	2.44
300	1069	64.11	1.54	2485	149.12	3.58
400	1410	84.57	2.03	3278	196.70	4.72
500	1751	105.03	2.52	4071	244.29	5.86
600	2092	125.49	3.01	4865	291.88	7.01
700	2433	145.95	3.50	5658	339.46	8.15
800	2774	166.41	3.99	6451	387.05	9.29
900	3115	186.87	4.48	7244	434.63	10.43
1000	3456	207.33	4.98	8037	482.22	11.57
1100	3797	227.79	5.47	8830	529.81	12.72
1250	4308	258.48	6.20	10020	601.18	14.43
1500	5161	319.63	7.43	12002	720.15	17.28
2000	6866	411.93	9.89	15968	958.08	22.99
2400	8230	493.77	11.85			



0.6 SG NATURAL GAS CAPACITY AT 60°F AND STD ATMOSPHERIC CONDITIONS

Set Pressure (psi)	1/2" Orifice			3/4" Orifice		
	SCFM	MSCFH	MMSCFD	SCFM	MSCFH	MMSCFD
15	126	7.59	0.18	294	17.65	0.42
20	146	8.75	0.21	339	20.35	0.49
25	165	9.91	0.24	384	23.04	0.55
30	184	11.07	0.27	429	25.74	0.62
50	270	16.17	0.39	627	37.61	0.90
75	376	22.55	0.54	874	52.45	1.26
100	482	28.93	0.69	1122	67.30	1.62
125	589	35.32	0.85	1369	82.14	1.97
150	695	41.70	1.00	1616	96.98	2.33
200	908	54.46	1.31	2111	126.66	3.04
300	1333	79.98	1.92	3100	186.02	4.46
400	1758	105.50	2.53	4090	245.38	5.89
500	2184	131.03	3.14	5079	304.75	7.31
600	2609	156.55	3.76	6068	364.11	8.74
700	3035	182.07	4.37	7058	423.47	10.16
800	3460	207.60	4.98	8047	482.83	11.59
900	3885	233.12	5.59	9037	542.20	13.01
1000	4311	258.64	6.21	10026	601.56	14.44
1100	4736	284.17	6.82	11015	660.92	15.86
1250	5374	322.45	7.74	12499	749.96	18.00
1500	6438	386.26	9.27	14973	898.37	21.56
2000	8565	513.88	12.33	19920	1195.18	28.68
2400	10266	615.97	14.78			



8100 Series Product Numbering System

81 - 17 1 5 1

VALVE SERIES

81 – 8100 Series

INLET & OUTLET COMBINATION

- 11 – 3/4" FNPT x 1" FNPT
- 12 – 3/4" MNPT x 1" FNPT*
- 16 – 1" FNPT x 1" FNPT
- 17 – 1" MNPT x 1" FNPT*
- 33 – 1 1/2" FNPT x 2" FNPT
- 34 – 1 1/2" MNPT x 2" FNPT *
- 42 – 2" FNPT x 2" FNPT
- 43 – 2" MNPT x 2" FNPT*

ORIFICE SIZE

- 1 – 1/2" DIAMETER*
- 2 – 3/4" DIAMETER*

INLET BASE & BODY MATERIAL

- 5 – CARBON STEEL/WCB
CARBON STEEL*
- 6 – 316 STNLS STL/WCB
CARBON STEEL

CAP TYPE

- 1 – CLOSED CAP*
- 2 – OPEN LIFT LEVER
- 3 – CLOSED LIFT LEVER

NOTE: Mercer Valve reserves the right to change product designs and specifications without notice.



2 - DIGIT "SPECIAL" CODE
 (IF APPLICABLE ASSIGNED BY MERCER)

O-RING MATERIAL

1 - STANDARD O-RINGS*
 (VITON & BUNA-N)

TRIM CODES

G1 - GAS SERVICE (15-1225: 1/2" ORIFICE,
 15-520: 3/4" ORIFICE)*

G2 - GAS SERVICE (1226-2400: 1/2"
 ORIFICE, 521-2000: 3/4" ORIFICE)*

N1 - SOUR GAS SERVICE (15-1225: 1/2"
 ORIFICE, 15-520: 3/4" ORIFICE)*

N2 - SOUR GAS SERVICE (1226-2400: 1/2"
 ORIFICE, 521-2000: 3/4" ORIFICE)*

SPRING CODE*
 (ASSIGNED BY MERCER)

SEAT MATERIAL

V - VITON 90 DURO*

T - 15% GLASS FILLED TEFLON*

B - BUNA-N

P - VIRGIN PEEK*

*** = STANDARD MATERIALS**

Consult Factory for
 Additional Information



8100 SERIES CATALOG

CORPORATE HEADQUARTERS

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HOUSTON BRANCH OFFICE

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HOUSTON@MERCERVALVE.NET

CALGARY BRANCH OFFICE

#203, 2835 23rd St. NE
CALGARY, ALBERTA T2E 7A4
PHONE: (403) 250-5557, FAX: (403) 250-5661
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BRIDGEPORT, TX BRANCH OFFICE

5758 US Highway 380
BRIDGEPORT, TX 76426-6421
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(405) 495-3274

MERCER VALVE COMPANY, INC. 9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

INSTALLATION

The safety relief valve should always be installed on a tank or piping run in the vertical position with the valve outlet pointing in a horizontal direction. When screwing the valve into the inlet piping, always use the wrench flats on the inlet connection. Never put a wrench on the relief valve body.

One of the most common causes of early failure of relief valves is dirt trapped on the valve seat. Welding slag and/or piping Teflon tape are among the more common items that cause difficulty. It is recommended that all piping and tank systems be cleaned prior to installation of the relief valve.

A relief valve should be connected with the minimum amount of piping between the tank and valve. Further, all piping used must be equal or larger than the inlet pipe size of the relief valve, **never smaller**. Any restriction of the inlet to a relief valve may cause unusual valve chatter, which could result in **serious damage** to the valve. Piping restrictions can also cause the valve to not relieve its full capacity causing the valve not to be able to reduce the pressure increase. Outlet piping from the relief valve should be less than four (4) feet in length and never of a pipe size smaller than the outlet pipe size of the relief valve. Long runs of small diameter pipe on the outlet side of a relief valve will create valve chatter and a capacity reduction that can cause the system to not be protected.

Extreme caution is required in the outlet piping if installed where liquids, if present, could form an ice block in the piping of the relief valve body in below freezing conditions. Discharge lines must be "weathered capped" and provided with a drain hole to prevent any liquid collection in the relief valve body or outlet piping. This liquid can freeze and cause the valve to not open or reduce the capacity of the valve. If these precautions are not taken the valves will not protect the system.

Additional, important installation information is contained in Paragraph UG-135, Section VIII of the ASME Code.

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

OPERATION

For best performance in process work is usually obtained by setting the safety relief valve to open at least 15% above the operating pressure where possible. A greater margin is desirable. However, this setting must not exceed the maximum working pressure of the vessel. All Mercer 9100 Series Safety Relief Valves are checked for bubble-tight per API 527.

In Addition to checking the set pressure versus the maximum allowable working pressure of the vessel, also check to insure that back pressure and temperature limitations of the process are consistent with valve ratings. The fluid state, capacity, temperature, set pressure, and back pressure can all be found on the tag of the valve. Pressures and Temperatures outside the normal ranges require special materials. Further, carefully check the process fluid input capacities to insure that the relief valve capacity is **greater than** the process capacities.

DO NOT BREAK THE SEAL WIRE Breaking the seal wire invalidates the manufacture's warranty to repair or replace the valve. If resetting is required in a field emergency situation a qualified personnel with calibrated instrumentation should perform it. With a broken seal wire this valve will be considered a non ASME code valve until it has been repaired by a VR certified repair shop.

**MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES**

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

DISASSEMBLY: The following general procedure is recommended in disassembly inspection and cleaning of the relief valve:

1. Cut the wire seal and unscrew the cap to expose the adjustment screw.
2. Loosen the lock nut and relieve the tension on the spring by turning the adjustment screw counter clockwise. This will relieve the spring tension.
3. Secure the valve body so that it will not move
For orifice sizes C to G, unscrew and remove the inlet base
For orifice size of H, unscrew and remove the bonnet
For orifice sizes J and K, unbolt and remove the bonnet
4. Inspect the replaceable seat for cuts and abrasions. If there are only minor scratches or abrasions on the seat, polish the seat area lightly with Scotch-Brite #7447. Be careful not to damage the soft seat. If the seat is damaged with deep abrasions and cuts, replace the nozzle/seat subassembly.
5. Refer to Figure 1 and measure the diameter of Ds with a precision caliper. This diameter must be in the range of values listed in Table 1. If this is not the case, replace the nozzle/seat subassembly.

TABLE 1

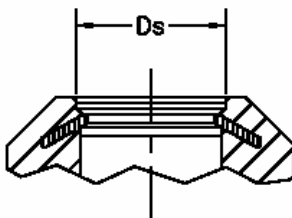


FIGURE 1

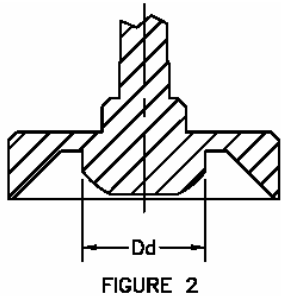
ORIFICE SIZE	DIAMETER Ds (INCHES)	
	MINIMUM	MAXIMUM
“C”	.335	.337
“D”	.480	.482
“E”	.620	.622
“F”	.778	.780
“G”	.914	.916
“H”	1.242	1.2465
“J”	1.599	1.6025
“K”	1.899	1.903

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

6. Remove and inspect the disk subassembly, especially the spherical surface portion that engages the seat. This surface must be clean and smooth. Polishing this surface with Scotch-Brite #7447 may restore the disk if it has only minor imperfections. If the spherical surface is damaged or scratched, replace the disk subassembly
7. Refer to Figure 2 and measure the diameter of Dd with a precision caliper. This diameter must be within the range of values listed in Table 2. If this is not the case, replace the disk subassembly.

TABLE 2



ORIFICE SIZE	DIAMETER Dd (INCHES)	
	MINIMUM	MAXIMUM
“C”	.331	.333
“D”	.474	.477
“E”	.614	.616
“F”	.768	.771
“G”	.904	.906
“H”	1.228	1.231
“J”	1.580	1.583
“K”	1.876	1.880

8. Check the disk stem of the disk subassembly to insure that the surface is smooth. Polish the stem if necessary with Scotch-Brite or fine emery. If the stem is galled, replace the disk subassembly.
9. Remove the spring and inspect for wear or damage. Clean and replace the spring if necessary. Be sure the spring is straight and square. If not replace the spring.
10. Remove the adjustment screw and guide bushing by tapping on the top of the adjustment screw with a “soft” drive rod. The guide bushing is designed to “slip fit” into the internal machined bore of the body. This “slip fit” must be maintained by cleaning the outside diameter of the guide bushing and internal bore of the valve body.
11. Replace the o-ring found on the adjustment screw stem.
12. **DO NOT REMOVE THE CENTER NUT OR INDEX BRACKET SUBASSEMBLY.** They are permanently installed at the factory. The purpose of the index bracket subassembly is to prevent rotation of the guide bushing. A body side pin is used in the 9100 “C” AND “D” orifices in place of the index bracket.
13. Lubricate the outside diameter of the adjustment screw thread, outside diameter of the guide bushing, the adjustment screw o-ring and the internal upper machined bore of the valve body with a good lubricating grease.

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

REASSEMBLY: The following general procedure is recommended in reassembly and setting of the valve:

1. Before reinstalling the adjustment screw and guide bushing, position the adjustment screw with the upper end of the thread protruding 1/8" from the end of the guide bushing. Carefully "slip fit" this assembly into the body, fitting the index bracket leg or body side pin into the slotted portion of the guide bushing. Note that the guide bushing must slip into the valve bore freely but with little radial play. Remove and reclean parts if the parts do not easy fit in. **DO NOT FORCE THE GUIDE BUSHING INTO THE VALVE BODY.** Forcing the parts may restrict valve lift and **cause serious malfunction.**
2. Swab out the internal bore of the adjustment screw to insure that is is clean and free from obstructions like dirt and grease.
3. Before reinstalling the spring, insert the disk subassembly into the bore of the adjustment screw and simulate the valve opening operation. The disk stem must slide freely within the bore of the adjustment screw.
4. Reinstall the spring and the disk subassembly. The spring should slide over the disk freely without sticking. Make sure the correct spring is installed.
5. Install the nozzle subassembly into the inlet base or body, for whichever applies.
6. For bottom entry valves reinstall the inlet base subassembly using a new base seal. Caution, the inlet base must be tight against the base seal and body.
For top entry valves reinstall the bonnet subassembly.
Make sure the disk and nozzle are aligned.
7. Check the lift of the valve by inhering a properly shaped drive rod in an arbor press into the internal bore of the inlet base and pressing on the nose of the disk subassembly. Apply a slight spring tension to the valve disk. Measure the "lift" of the valve with a dial indicator. The minimum lift can be found in NB-18 on the National Board website www.nationalboard.org.
8. Reinstall the lock nut and the valve is ready for setting. Valve setting at all pressures is dangerous. All eye and ear safety precautions should be observed.
9. Resetting should be performed using the correct fluid. Gas/Vapor valves should be set with air and liquid valves should be set using water. Mercer Valve recommends that for gas/vapor valves there be approximately (1) cubic foot capacity below the valve when setting. To see other valve characteristics a larger vessel may be required. The test gauges should be at least .25% accuracy and be currently calibrated using a dead weight tester.
10. Repeated "popping" at set pressure is recommended. The valve should be popped approximately five (5) to ten (10) times during the setting process allowing full blowdowns.
11. A slight audible warning action is to be expected, starting approximately 5% below the set pressure.
12. All valves should be bubble tight at 10% below set pressure in accordance with API 527.

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

13. When the valve is set, tighten the lock nut securely so at least 1/4" of the stem is exposed above the lock nut. The adjustment screw must not turn when the lock nut is tightened. This will affect the set pressure. Pop the valve once more after the lock nut is tightened to verify the set pressure.
14. Reinstall the cap and a new lockwire. Close the lockwire and crimp the lead seal.

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

BACK PRESSURE TESTING The purpose of back pressure testing Mercer Safety Relief Valves is to check for leaks in the secondary pressure zone (the outlet side of the relief valve). This includes the body, bonnet, outlet flange and all parts included in the upper valve assembly. This is best performed before the valve seal wire has been attached.

The back pressure test is performed after the valve has been assembled and set to the correct set pressure. The test is performed by attaching a pressure source to the outlet of the valve and submerging the valve in a solution of water treated with rust inhibitor. The pressure in the secondary pressure zone is then brought to 30 psig or to what the back pressure the valve will see. This is the pressure required by the ASME BOILER AND PRESSURE VESSEL CODE, SECTION VIII. PART UG-136(d) "Production Testing by Manufacturers and Assemblers". The valve is then visually inspected for any leaks by checking for bubbles coming from any part of the valve. If any part of the valve is producing bubbles, the valve is disassembled, repaired and the valve is reassembled and retested. If no leaks are detected, the valve is stamped with the appropriate set pressure, the valve then goes to the finishing department to be painted, tagged, and prepared for shipping.

IF YOU HAVE ANY QUESTIONS OR COMMENTS ABOUT THE PRECEDING PROCEDURES, FEEL FREE TO CONTACT THE FACTORY AT (405) 495-6533 or 800-833-6402. Phones are answered 24 hours a day.

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

“C”, “D”, AND “E” ORIFICE STANDARD BILL OF MATERIALS

“C” ORIFICE DIAMETER: .281 In.

“C” ORIFICE AREA: .062 Sq.In.

SET PRESSURE RANGE: 15-2999 PSI

“D” ORIFICE DIAMETER: .394 In.

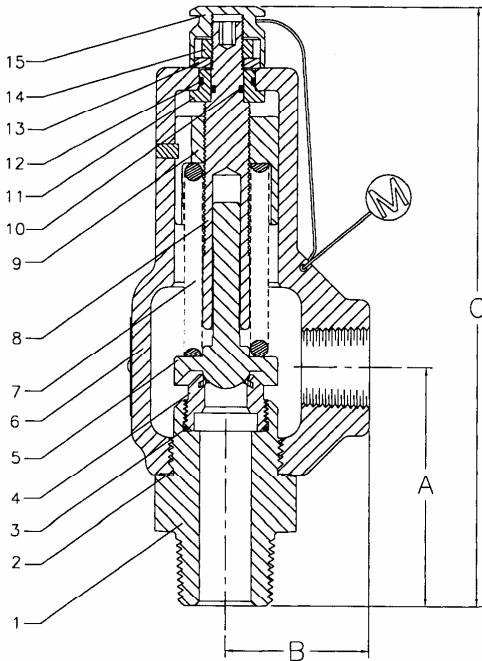
“D” ORIFICE AREA: .122 Sq.In.

SET PRESSURE RANGE: 15-2999 PSI

“E” ORIFICE DIAMETER: .520 In.

“E” ORIFICE AREA: .212 Sq.In.

SET PRESSURE RANGE: 15-2400 PSI



“C”, “D”, and “E” Orifice

“C”, “D”, AND “E” ORIFICE				
ITEM NO.	PART NAME	“C” ORIFICE STD MTRLS “C” TRIM CODE	“D” & “E” STD MTRLS “I” TRIM CODE	“C”, “D”, “E” OPTIONS “U”, “L”, “N”, OR “B” CODE
1	Inlet Base	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel
2	Base Seal	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel
3	O’Ring	Viton	Viton	Viton
4	Nozzle Subassy	17-4 Stainless Steel with Soft Seat	17-4 Stainless Steel with Soft Seat	316 Stainless Steel with Soft Seat
5	Disk Subassy	440C Stainless Steel	17-4 Stainless Steel	316 Stainless Steel
6	Body	WCB Carbon Steel or CF3M Stainless Steel	WCB Carbon Steel or CF3M Stainless Steel	WCB Carbon Steel or CF3M Stainless Steel
7	Spring	17-7 Stainless Steel	17-7 Stainless Steel	17-7 Stainless Steel or Inconel X-750 (NACE)
8	Adjustment Screw	300 Series Stainless Steel	300 Series Stainless Steel	300 Series Stainless Steel
9	Adjustment Bushing	300 Series Stainless Steel	300 Series Stainless Steel	300 Series Stainless Steel
10	O’Ring	Buna N	Buna N	Buna N
11	Center Bushing	300 Series Stainless Steel	300 Series Stainless Steel	300 Series Stainless Steel
12	O’Ring	Buna N	Buna N	Buna N
13	Washer	Carbon Steel	Carbon Steel	Carbon Steel
14	Lock Nut	Carbon Steel	Carbon Steel	Carbon Steel
15	Cap	Anodized Aluminum	Anodized Aluminum	Anodized Aluminum

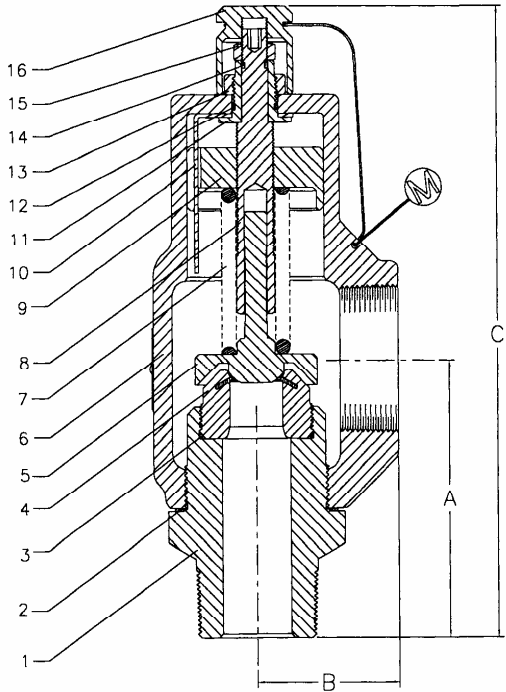
MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

“F” AND “G” ORIFICE STANDARD BILL OF MATERIALS

“F” ORIFICE DIAMETER: .655 In.
 “F” ORIFICE AREA: .337 Sq.In.
 SET PRESSURE RANGE: 15-2400 PSI

“G” ORIFICE DIAMETER: .775 In
 “G” ORIFICE AREA: .472 Sq.In.
 SET PRESSURE RANGE: 15-2000 PSI



“F” and “G” Orifice

“F” AND “G” ORIFICE			
ITEM	PART NAME	“F” AND “G” ORIFICE STD MTRLS “U”, “L”, “N”, OR “B” TRIM CODE	“F” AND “G” STD MTRLS “C” TRIM CODE (High Pressure)
1	Inlet Base	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel
2	Base Seal	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel
3	O’Ring	Viton	Viton
4	Nozzle Subassy	316 Stainless Steel with Soft Seat	17-4 Stainless Steel with Soft Seat
5	Disk Subassy	316 Stainless Steel	440C Stainless Steel
6	Body	WCB Carbon Steel or CF3M Stainless Steel	WCB Carbon Steel or CF3M Stainless Steel
7	Spring	17-7 Stainless Steel or Inconel X-750 (NACE)	17-7 Stainless Steel
8	Adjustment Screw	300 Series Stainless Steel	300 Series Stainless Steel
9	Adjustment Bushing	300 Series Stainless Steel	300 Series Stainless Steel
10	Index Bracket	300 Series Stainless Steel	300 Series Stainless Steel
11	Center Bushing	300 Series Stainless Steel	300 Series Stainless Steel
12	O’Ring	Buna N	Buna N
13	Center Nut	Carbon Steel	Carbon Steel
14	O’Ring	Buna N	Buna N
15	Lock Nut	Carbon Steel	Anodized Aluminum
16	Cap	Anodized Aluminum	Anodized Aluminum

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

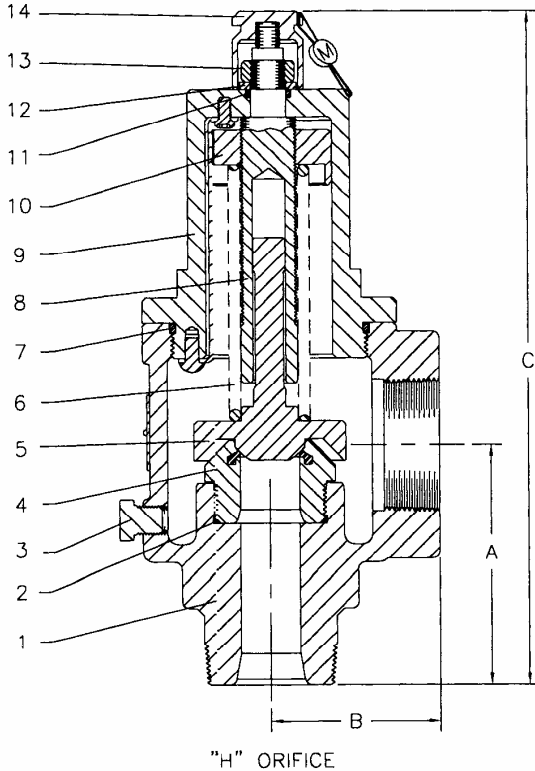
INSTALLATION, OPERATION AND MAINTENANCE MANUAL

“H” ORIFICE STANDARD BILL OF MATERIALS

“H” ORIFICE DIAMETER: 1.050 In.

“H” ORIFICE AREA: .865 Sq.In.

SET PRESSURE RANGE: 15-2000 PSI



“H” ORIFICE			
ITEM	PART NAME	“H” ORIFICE STD MTRLS “U”, “L”, “N”, OR “B” TRIM	“H” ORIFICE STD MTRLS “C” TRIM CODE (High
1	Body	WCB Carbon Steel or CF3M Stainless Steel	WCB Carbon Steel or CF3M Stainless Steel
2	O’Ring	Viton	Viton
3	Drain Plug	Carbon Steel or Stainless Steel	Carbon Steel or Stainless Steel
4	Nozzle Subassy	316 Stainless Steel with Soft Seat	17-4 Stainless Steel with Soft Seat
5	Disk Subassy	316 Stainless Steel	440C Stainless Steel
6	Spring	17-7 Stainless Steel or Inconel X-750 (NACE)	17-7 Stainless Steel
7	O’Ring	Buna N	Buna N
8	Adjustment Screw	300 Series Stainless Steel	300 Series Stainless Steel
9	Bonnet Subassy	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel
10	Adjustment Bushing	300 Series Stainless Steel	300 Series Stainless Steel
11	O’Ring	Buna N	Buna N
12	Washer	300 Series Stainless Steel	300 Series Stainless Steel
13	Lock Nut	18-8 Stainless Steel	18-8 Stainless Steel
14	Cap	Anodized Aluminum	Anodized Aluminum

MERCER VALVE COMPANY, INC.
9100 SERIES THREADED SAFETY RELIEF VALVES

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

“J” AND “K” ORIFICE STANDARD BILL OF MATERIALS

“J” ORIFICE DIAMETER: 1.350 In.

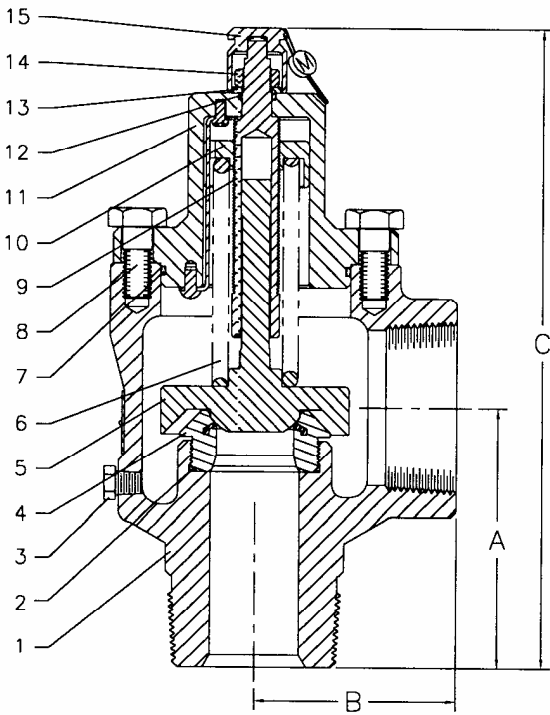
“J” ORIFICE AREA: 1.430 Sq.In.

SET PRESSURE RANGE: 15-1800 PSI

“K” ORIFICE DIAMETER: 1.625 In.

“K” ORIFICE AREA: 2.074 Sq.In.

SET PRESSURE RANGE: 15-1500 PSI



“J” and “K” Orifice

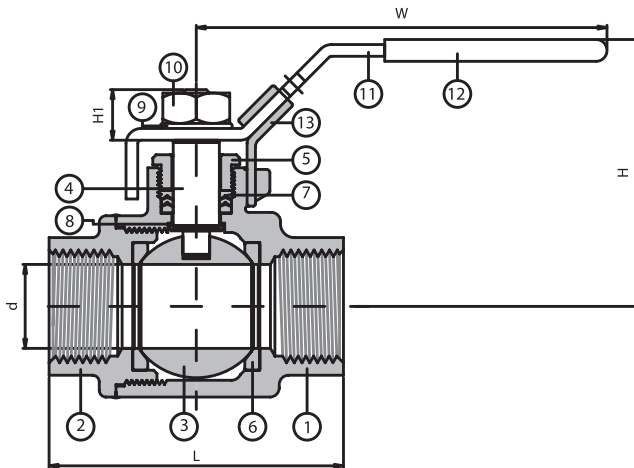
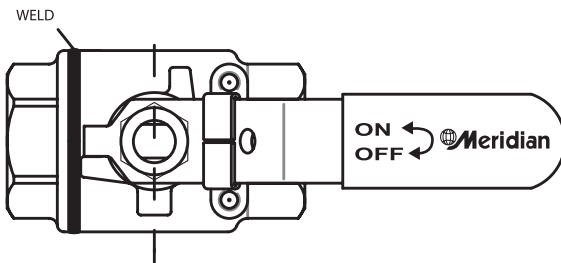
“J” AND “K” ORIFICE			
ITEM NO.	PART NAME	“J” AND “K” STD MTRLS “U”, “L”, “N”, OR “B” TRIM	“J” AND “K” STD MTRLS “C” TRIM CODE (High Pressure)
1	Body	WCB Carbon Steel or CF3M Stainless Steel	WCB Carbon Steel or CF3M Stainless Steel
2	O’Ring	Viton	Viton
3	Drain Plug	Carbon Steel or Stainless Steel	Carbon Steel or Stainless Steel
4	Nozzle Subassy	316 Stainless Steel with Soft Seat	17-4 Stainless Steel with Soft Seat
5	Disk Subassy	316 Stainless Steel	440C Stainless Steel
6	Spring	17-7 Stainless Steel or Inconel X-750 (NACE)	17-7 Stainless Steel
7	O’Ring	Buna N	Buna N
8	Bonnet Bolt	Alloy Steel B7 or Stainless Steel B8M	Alloy Steel B7 or Stainless Steel B8M
9	Adjustment Screw	300 Series Stainless Steel	300 Series Stainless Steel
10	Adjustment Bushing	300 Series Stainless Steel	300 Series Stainless Steel
11	Bonnet Subassy	Carbon Steel or 316 Stainless Steel	Carbon Steel or 316 Stainless Steel
12	O’Ring	Buna N	Buna N
13	Washer	300 Series Stainless Steel	300 Series Stainless Steel
14	Lock Nut	18-8 Stainless Steel	18-8 Stainless Steel
15	Can	Anodized Aluminum	Anodized Aluminum



Meridian™ Ball Valve

Model #: MAC2CF

2000 WOG 2-PIECE FULL BORE



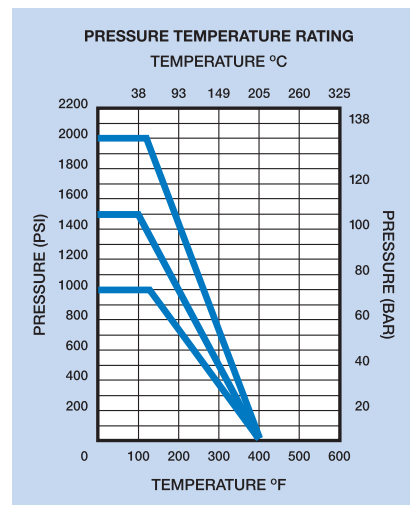
FEATURES

- ASME B16.34 design
- Threaded ends conform to ASME B1.20.1 (NPT)
- Seal welded body
- Investment casting
- Blow-out proof stem
- 2000 psi (1/4" to 1") CL 800
- 1500 psi (1 1/4" to 2") CL 600
- 1000 psi (2 1/2" to 3") CL 400
- Glassfibre filled PTFE seats
- PTFE packing
- Latch lock handle
- Mounting pad
- Sour / NACE Service

ITEM	PARTS	MATERIAL
1	BODY	ASTM A216-WCB
2	END CAP	ASTM A216-WCB
3	BALL	ASTM A351-CF8M
4	STEM	ASTM A276-316
5	GLAND RING	AISI 304
6	BALL SEAT	R-PTFE
7	PACKING	PTFE
8	THRUST WASHER	PTFE
9	SPRING WASHER	AISI 304
10	NUT	AISI 304
11	HANDLE	AISI 304
12	HANDLE SLEEVE	PVC
13	LOCK DEVICE	AISI 304

DN	d	L	H	H1	W	Cv
8	11.6	60.5	53.6	10.5	102	10
10	12.8	60.5	53.6	10.5	102	10
15	15	62.5	57	10.5	102	12
20	20.2	77	62.1	13.5	124	35
25	25.6	90	80	15.7	165	60
32	32	100	83.7	15.7	165	100
40	38	118.2	99	17	188	150
50	50.8	138	106.9	17	188	250
65	65.5	167	141.9	27.5	250	400
80	80	193	152.8	27.5	250	600

NPS	d	L	H	H1	W	Cv
1/4"	0.46	2.38	2.11	0.41	4.02	10
3/8"	0.50	2.38	2.11	0.41	4.02	10
1/2"	0.59	2.46	2.24	0.41	4.02	12
3/4"	0.80	3.03	2.44	0.53	4.88	35
1"	1.01	3.54	3.15	0.62	6.50	60
1-1/4"	1.26	3.94	3.30	0.62	6.50	100
1-1/2"	1.50	4.65	3.90	0.67	7.40	150
2"	2	5.43	4.21	0.67	7.40	250
2-1/2"	2.58	6.57	5.59	1.08	9.84	400
3"	3.15	7.6	6.02	1.08	9.84	600



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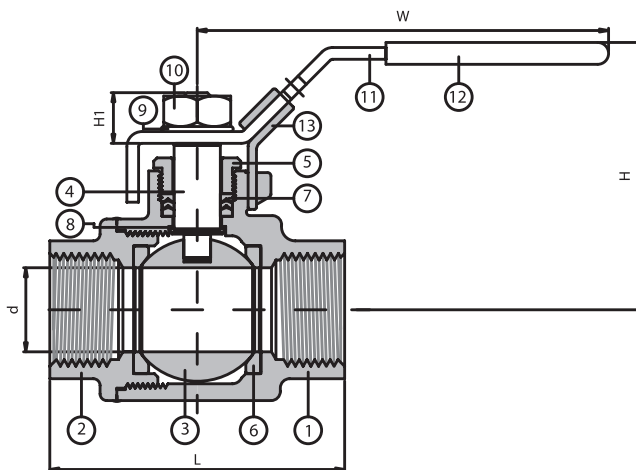
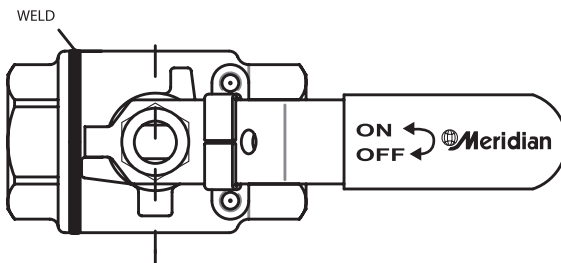
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Meridian™ Ball Valve

Model #: MAC2SF

2000 WOG 2-PIECE FULL BORE



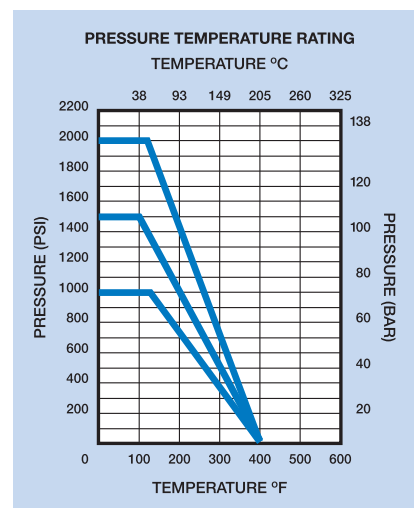
FEATURES

- ASME B16.34 design
- Threaded ends conform to ASME B1.20.1 (NPT)
- Seal welded body
- Investment casting
- Blow-out proof stem
- 2000 psi (1/4" to 1") CL 800
- 1500 psi (1 1/4" to 2") CL 600
- 1000 psi (2 1/2" to 3") CL 400
- Glassfibre filled PTFE seats
- PTFE packing
- Latch lock handle
- Mounting pad
- Sour / NACE Service

ITEM	PARTS	MATERIAL
1	BODY	ASTM A351-CF8M
2	END CAP	ASTM A351-CF8M
3	BALL	ASTM A351-CF8M
4	STEM	ASTM A276-316
5	GLAND RING	AISI 304
6	BALL SEAT	R-PTFE
7	PACKING	PTFE
8	THRUST WASHER	PTFE
9	SPRING WASHER	AISI 304
10	NUT	AISI 304
11	HANDLE	AISI 304
12	HANDLE SLEEVE	PVC
13	LOCK DEVICE	AISI 304

DN	d	L	H	H1	W	Cv
8	11.6	60.5	53.6	10.5	102	10
10	12.8	60.5	53.6	10.5	102	10
15	15	62.5	57	10.5	102	12
20	20.2	77	62.1	13.5	124	35
25	25.6	90	80	15.7	165	60
32	32	100	83.7	15.7	165	100
40	38	118.2	99	17	188	150
50	50.8	138	106.9	17	188	250
65	65.5	167	141.9	27.5	250	400
80	80	193	152.8	27.5	250	600

NPS	d	L	H	H1	W	Cv
1/4"	0.46	2.38	2.11	0.41	4.02	10
3/8"	0.50	2.38	2.11	0.41	4.02	10
1/2"	0.59	2.46	2.24	0.41	4.02	12
3/4"	0.80	3.03	2.44	0.53	4.88	35
1"	1.01	3.54	3.15	0.62	6.50	60
1-1/4"	1.26	3.94	3.30	0.62	6.50	100
1-1/2"	1.50	4.65	3.90	0.67	7.40	150
2"	2	5.43	4.21	0.67	7.40	250
2-1/2"	2.58	6.57	5.59	1.08	9.84	400
3"	3.15	7.6	6.02	1.08	9.84	600



Canada's Valve Specialist

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OPERATION AND MAINTENANCE MANUAL

NUTRON BALL VALVE

Model T3

1/2" FP – 4" RP 150# - 2500#

1/4" FP – 4" RP 1000 WOG – 6000 WOG

FLANGED, FNPT and WELD END

For technical questions, please contact the following:

Engineering Department

2125 - 64 Avenue

Edmonton, Alberta

T6P 1Z4

Phone: (780) 468-2732

Fax: (780) 450-1359

OPERATION

The Nutron Model T3 ball valve is a floating ball, quarter turn valve designed for shut off service. The ball valve construction is a three piece threaded design. The handle direction corresponds with the valve position. When the handle is inline with the body, the valve is open and if at a right angle to the body, the valve is closed. The valve should be operated until the capscrew head travel stop limits the handle's movement. Operating the valve in a partially open or partially closed position will damage and/or shorten the life of the valve seats.

Due to the critical nature of pressurized piping systems it is recommended that the compatibility to the service of the metallic and non-metallic components be confirmed prior to installation.

CAUTION

READ CAREFULLY BEFORE INSTALLING OR OPERATING THE VALVE

Hazards are inherent with the construction, operation and maintenance of high pressure piping systems. The following information and precautions are provided to minimize these hazards:

- 1. The valve's nameplate indicates maximum operating pressure, as well as minimum and maximum operating temperatures. The valve may be safely operated within these limits.*
- 2. The valve's end connections are provided in accordance with ASME flanged end, threaded end or weld end requirements.*
- 3. T3 valves are firesafe, and are in accordance with API 607 requirements.*
- 4. The valve has been factory pressure tested based on the nameplate maximum operating pressure.*
- 5. The valves may be lifted using slings. Fittings and other devices, which may be attached to the valve, are not intended to be used as lifting points. Always follow local safety regulations when lifting heavy valves.*
- 6. Nutron valves are designed, manufactured and tested under a certified quality system. Only quality parts and materials are used in the assembly of Nutron valves. Pressure containing components are suitable for the minimum temperature marked on the nameplate. Factory certification is available. (Note: Some NPT valves may be marked only with maximum temperature.)*
- 7. If the valve, in service, is exposed to hazards such as traffic, wind or earthquake loading contact the factory, if it is necessary, to confirm that the valve design is suitable for the application. The factory requires a complete description of the hazard before making any recommendations.*
- 8. If the valve, in service, is exposed to hazards such as excessive piping system reaction forces and moments contact the factory, if it is necessary, to confirm that the valve design is suitable for the application. The factory requires a complete description of the hazard before making any recommendations.*
- 9. If the valve, in service, is exposed to hazards such as corrosive or abrasive fluids or atmospheric conditions contact the factory, if it is necessary, to confirm that the valve design is suitable for the application. The factory requires a complete description of the hazard before making any recommendations.*
- 10. The valve has been designed and manufactured so that under normal operation conditions hazards such as material fatigue, brittle fracture, creep rupture or buckling*

will not occur. Do not operate the valve beyond the pressures and temperatures marked on the nameplate. The factory requires a complete description of the hazard before making any recommendations.

11. *The user is responsible for minimizing other hazards associated with the construction, operation and maintenance of high pressure piping systems, such as:*
 - a. *Possibility of decomposition of unstable fluids*
 - b. *Provisions for the release or blow off of pressure*
 - c. *Prevention of physical access to system under pressure*
 - d. *Prevention of physical access to surfaces at extreme temperature*
 - e. *Provisions for inspection*
 - f. *Provisions for draining and venting*
 - g. *Provisions for filling*
 - h. *Provision for equipment access*
 - i. *Prevention of over-pressurization, over-heating and over-filling*
 - j. *Provision for fault indication*
12. *The user is responsible for meeting applicable local safety regulations.*

INSTALLATION

All valves are shipped in the open position with protective covers on the end connections to prevent contaminants from entering the valve cavity and potentially damaging the ball or resilient seat surfaces during storage. The covers should be repaired or replaced if damaged and not removed until the valve is to be installed.

For handling the valve, proper slings and rigging procedures must be used. Attached fittings, gearboxes, actuators, handles and pipe handles are not to be used as lifting points. The valves should be rigged such that the slings safely clear all fittings, gearboxes, actuators, handles and pipe handles.

When installing the valve, it must remain in the fully open position to protect the seal surfaces of the ball from damage. Leave the valve in the open position and do not operate until the line has been thoroughly cleaned and flushed. Valves, which need to be positioned either fully opened or fully closed, can be locked in place with optional locking device.

The valve may be installed with flow in either direction. It may be positioned horizontally, vertically or at a gradient without impairing the operation of the valve.

Valves installed at the end of a line require that all appropriate and necessary safety practices be followed.

For actuated valves, please refer to the actuator manufacturer's specifications for the valve's orientation to ensure optimal performance.

If system hydrostatic tests are to be performed at pressures exceeding the rated working pressure of the valve, the ball should be left in the partially opened position. This prevents seats from experiencing these pressures while the body cavity can accept up to 150% rated working pressure.

After pressure tests, with the valve in the half open position and all test pressure relieved, the body cavity should be completely drained via the attached piping system to prevent corrosion. The valve may then be placed in the required operating position.

Flanged Connections

Care must be taken not to damage the flange seal faces and that they are clean for assembly. The end-user must provide gaskets and mating flanges of equal ratings to that of the valve for proper installation. When bolting the flanges together, bolt threads should be lubricated to obtain maximum loading on the bolts. The bolts should be tightened using a criss-cross pattern for even loading. When ring type joints are supplied the ring number is marked on the rim of the RTJ flange.

MAINTENANCE

CAUTION: *Safety practices for pressurized equipment must be followed and address hazards inherent in pressurized systems. Extreme caution and safety procedures are to be exercised whenever a valve, or fitting in a valve, are serviced or maintained.*

The valve requires no periodic maintenance. If the valve leaks by the stem seal (Key 9), tighten both capscrews (Key 13) equally to re-compress the stem packing.

TOOLS REQUIRED FOR DISASSEMBLY AND ASSEMBLY

List for all valve sizes:

Allen Keys: 5/32, 3/16, 1/4 or 5/16

Wrench sizes for handle nuts: 7/16, 1/2, 11/16 or 15/16

2-1/2" Chain Wrench or Vice

6" Screwdriver

20" Adjustable Wrench

Lubricant Jetlube KOPR-KOTE or equivalent

Loctite 549 or equivalent

DISASSEMBLY

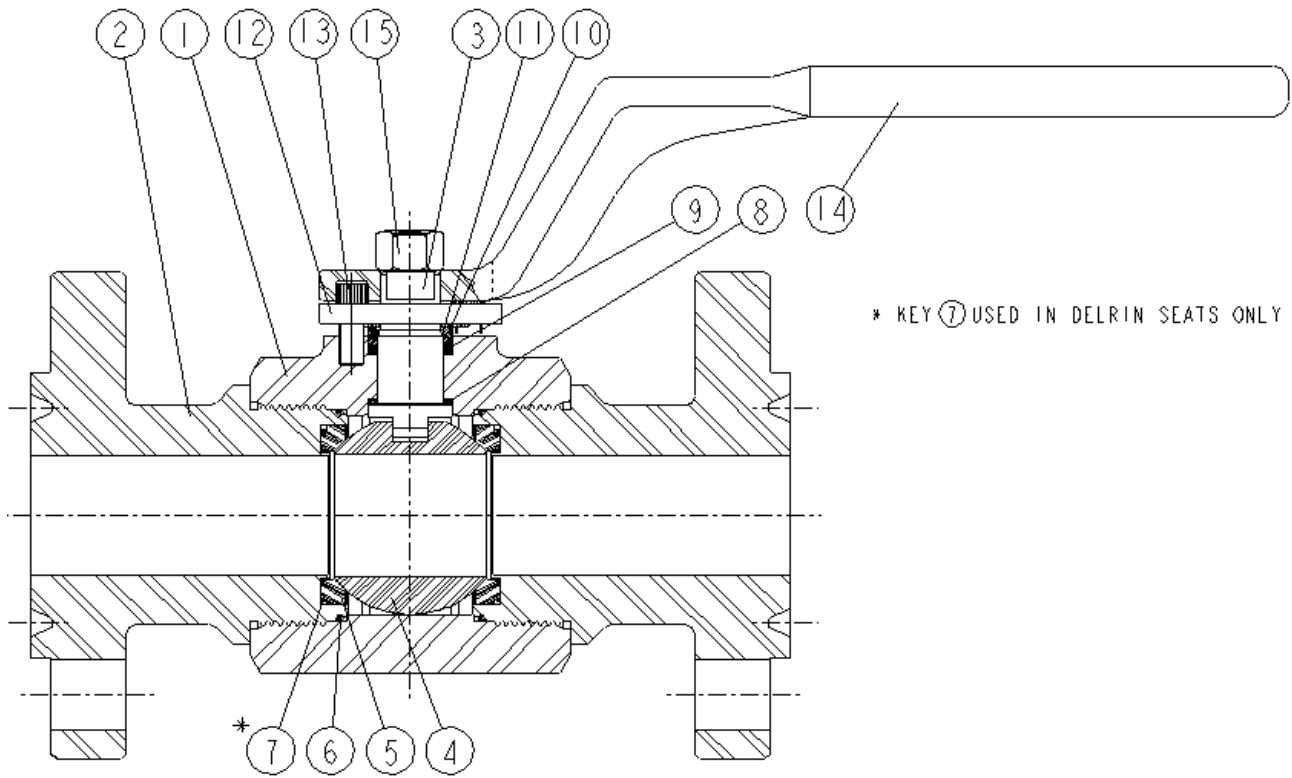
- 1. **CAUTION:** Before removal from the line and before disassembly isolate the valve from line pressure. With the valve in the half open position ensure all pressure is bled from the valve body via the attached piping system.*
- 2. Remove handle capscrew (Key 15) or nut followed by the handle (Key 14).*
- 3. Remove the gland flange capscrews (Key 13), gland flange (Key 12), belleville washer (Key 11), and packing follower (Key 10) from the valve.*
- 4. For flange connections, scribe line-up marks on the body and caps. Mark the caps to determine which side of the valve they are removed from. This ensures the caps are fully tightened upon reassembly and installed on proper side.*
- 5. Unscrew 1st cap (Key 2) from the body (Key 1). Remove the body seal (Key 6), seat (Key 5) and seat seal¹ (Key 7) from cap (Key 2). NOTE: Heat may be required to remove cap from body as Loctite was used in assembling the valve.*
- 6. Remove the ball (Key 4) from the valve. The ball must be in the closed position.*
- 7. Remove the stem (Key 3), stem packing (Key 9) and the stem thrust washer (Key 8) from the body (Key 1).*

8. *Clean and inspect all components for wear and/or damage:*
 - ~ *replace ball if it has nicks, pits, or scars in the sealing areas or if damage has occurred where the stem inserts into the ball*
 - ~ *replace seats if there are nicks, cuts, or deformation of the sealing surface*
 - ~ *inspect thrust washer (Key 8) for wear or damage*
 - ~ *remove all o-rings and replace if broken, nicked, stretched, swollen, hard, brittle or sticky*

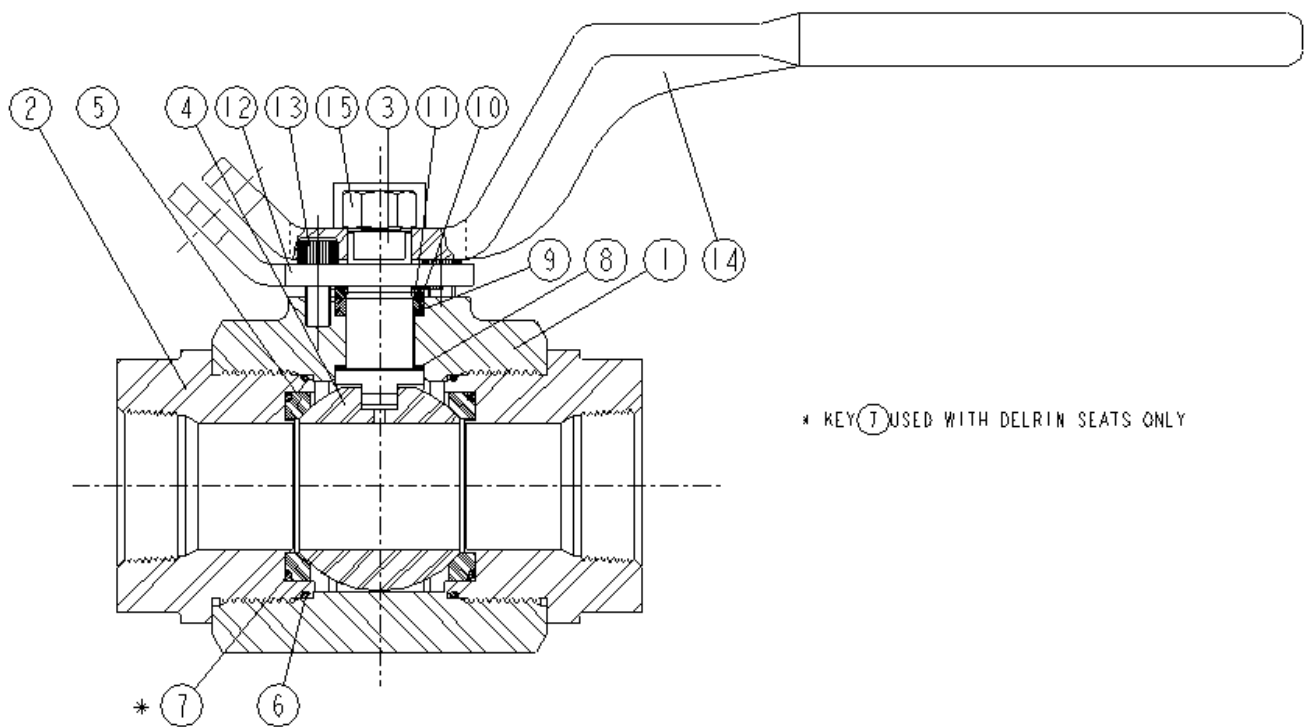
ASSEMBLY

1. *Ensure all components for the assembly are clean of dirt and contaminants. Install seats (Key 5) and seat seals¹ (Key 7), if required, on to the end connections. Ensure that the correct sealing surface of the seat is facing the ball. Apply a compatible light grease to the seat or seat/o-ring assembly, and its mating bore.*
2. *Install body seal (Key 6) onto 1st cap and apply grease to seal. Apply Loctite to the threads of the cap and screw cap fully into the valve body. Tighten with chain wrench, on flanged ends, until scribed line of body and cap are lined up.*
3. *Apply Jetlube KOPR-KOTE or equivalent to stem (Key 3). Place the thrust washer (Key 8) on the stem (Key 3) and insert into the valve body (Key 1).*
4. *Install the ball (Key 4) into the valve body. NOTE: Ball to be in closed position when tightening caps.*
5. *Install body seal (Key 6) on 2nd cap and grease the seal.*
6. *Screw the cap (Key 2) fully onto the valve body and tighten with a chain wrench, on flanged ends, until scribed line of body and cap line up.*
7. *Place the stem packing (Key 9) followed by the packing follower (Key 10) on the valve stem (Key 3).*
8. *Place the belleville washer (Key 11) on the valve stem. Ensure the washer is installed correctly.*
9. *Install the gland flange (Key 12) and capscrews (Key 13) and tighten equally until the belleville washer is flattened fully. Ensure that the gland flange is installed so that the valve closes clockwise. When necessary, gland flange may be turned 90 degrees to allow clockwise opening of the valve.*
10. *Place the handle (Key 14) on the valve stem and secure with the handle nut (Key 15).*
11. *Ensure valve operates properly and leave in the full open position.*
12. *Valve should be tested to the appropriate specifications.*

¹ *Only applicable in some Delrin Seated Valves*



Nutron - T3 Ball Valve – Flanged



Nutron - T3 Ball Valve – FNPT



The Reliable Source

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Product Line Technical Data



Corporate Headquarters Houston, Texas

1300 Gazin St.

Houston, TX 77020

Tel: 713.675.8631

Fax: 713.675.1589

Toll Free: 800.231.3505

www.NewmansValve.com

Manufacturer of

Newco

COOPER



QuadroSphere

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Newmans History

Newco Valves, L.P., a Texas limited partnership, dba Newmans, and its wholly owned subsidiary, Newmans Valves, LTD, manufactures, markets and sells Gate, Globe, Check, Ball, and Triple Offset valves ranging in sizes from 1/4" thru 120" ANSI Class 125 thru 4500 lbs. The valves are manufactured to ASME, API, and MSS specifications from Carbon (cast and forged), Stainless (cast and forged including Duplex and Super Duplex products), and other alloys (low alloy steels, Inconel, Hastelloy, and noble alloys). "Newco", "OIC", and "Cooper Valves" brand name valves are used in various applications from low pressure processes to specialty applications within the refining, petrochemical, power, pulp and paper, and marine industries. The companies provide both standard product and special designs for their focused industries.

Newmans, L.P., also offers value added services including modifications or actuations and installation of by-passes, bore changes and gear operators for its valves. Some of these modifications include various trim changes covering stems, packing and gaskets, new bolting or changes in the flange surface. In addition, Company operations include marketing, product design, quality control, vendor qualification and value-added services for its product lines.

Timeline

1936: The Company's primary focus was wholesale plumbing and field salvage.

1946: The Company was incorporated under the Newmans name. At that time the focus was changed to the PVF industry until acquired by the Jordan Group in 1989.

1976: Newmans opened its Canadian branch under the name of Newmans Valve Limited.

1984: Precision Actuation Services (PAS) was opened to perform valve modification and actuation services.

1996: Precision Castparts Corporation (PCC) acquired Newmans. The business was operated as a part of the PCC Flow Technologies Division.

1997: In March, Newmans acquired "OIC" and added this trade mark to its business.

2003: On December 26th the business was purchased by the current group of partners that included the original owners of Newmans.

2005: In June, Newco Valves, L.P., purchased the operations of Cooper Valves from Dresser, Inc., and added specialty alloys and materials to its valve products line.

2006: Newmans opened its Shanghai, China office for service to the Far East market, direct shipments globally and service to the Far East for global project management.

2007: Completed two foundry operations, two process centers, and one ball valve facility in the China. Newmans also opened Bergamo, Italy office.

2008: Opened Atlanta, GA branch and a sales office in Chicago, Ill. Newmans formed a manufacturing joint venture for the Trinity Series Triple Offset valves 3" to 120" - 150 to 600 class.

2009: Opened Stafford, TX Corporate Office and Projects branch and stocking warehouse.

Over the years Newmans has established an excellent reputation for providing a broad product offering from world wide sources at competitive prices and a high level of quality and customer service. The company maintains seven (7) stocking warehouse locations in North America and one (1) in Shanghai, China. Newmans also has a sales office in Bergamo, Italy.

Newmans services its markets through a network of distributors and direct sales personnel. The Companies utilize the Info Commerce@Work (C@W) information system. Commerce@Work is a fully integrated system allowing all Newmans' facilities to operate in an integrated and efficient manner.

Mission Statement

It is our goal to be known and respected in the Industry as "The Reliable Source" for our extensive knowledge and superior service. Measured by keeping our word, we will deliver quality products on time at a fair value.

We achieve the above dealing with integrity in an open and flexible environment allowing people access to valuable information to make good and timely decisions. We believe that all this can be accomplished yielding great rewards for all involved while maintaining a balance in life.

Company Profile

Newmans is recognized as a global valve manufacturing company providing product to the market on a world-wide basis. The NEWCO, OIC and COOPER trademarks are recognized and respected the world over for their high quality and ability to meet the industry's most exacting standards. Newmans manufactures and markets one of the industry's broadest product lines suitable for most applications and market segments. Newmans is fully committed to engineering excellence and product innovation supported by a highly qualified technical engineering staff. Superior customer service is backed by the inventories of finished valves shipped daily from the six divisions located strategically throughout North America.

Product Technology

Newmans manufactures Gate, Globe, Check, Stop Check, Tilting Disc, Floating Ball, Trunnion Ball, QuadroSphere™ Ball, and Trinity Series Triple Offset valves in a full range of materials, valve styles, and pressure classes. Cast carbon steel and low-alloys, forged valves, cast iron and ductile iron valves are manufactured under the NEWCO trademark. 300 series stainless steel and Alloy 20 are produced and marketed under the OIC trademark. Other exotic alloys are manufactured under the Cooper trademark.

Newmans manufactures and stocks valves in sizes from 1/4" to 120" in diameter and in pressure classes from 125 to 4500 lbs. Larger sizes are available on request.

Newmans facilities operate under ISO 9001-2000 & 14001-2004 series registration. All valves are compliant to the industry standards of API, ASTM, and ASME. Inspection and testing is maintained throughout the manufacturing process to verify compliance to these standards as well as any specific customer requirements.

Customer service is further enhanced by complete modification and actuation capabilities. This capability allows Newmans to provide rapid deliveries of special valve requirements to meet the customer's delivery needs.

Newmans' Complete Product Range

Brand	Type	Size	Class	Ends	Available Material**
Newco	Cast Carbon	* 2" to 48"	150 - 2500	RF, RTJ, BW	WCB, LCC
Newco	Cast Alloy	2" to 24"	150 - 2500	RF, RTJ, BW	C5, WC6, WC9, C12, C12A
Newco	Cast Iron	2" to 36"	125	FF	A126 - Cl. B
Newco	Ductile Iron	2" to 36"	150	RF	A395
Newco	Forged Carbon	1/4" to 3"	150 - 4500	FLGD, THRD, SW	A105N, LF2
Newco	Forged Alloy	1/4" to 2"	150 - 4500	FLGD, THRD, SW	F5, F9, F11, F22, F91, F51
Newco	Forged Stainless	1/4" to 2"	150 - 4500	FLGD, THRD, SW	304/L, 316/L, 317/L, 321, 347, A20
Newco	Pressure Seal	2" to 24"	600 - 4500	RF, RTJ, BW	Cast - all grades
Newco	Trunnion Ball & QuadroSphere	2" to 36"	150 - 2500	RF, BW	A105, LF2, F316, F51
Newco	Floating Ball	1/2" to 18"	150 - 600	RF	WCB, LCC, CF8M
Newco	Trinity Triple Offset	3" to 120"	150 - 600	WFR, LUG, FLGD, BW	WCB, 316, Monel, Hastelloy, NiAlBr
OIC	Cast Stainless	1/2" to 24"	150 - 2500	RF, RTJ, BW	304/L, 316/L, 317/L, 321, 347/H, A20
OIC	Forged Stainless	1/4" to 2"	150 - 4500	FLGD, THRD, SW	304/L, 316/L, 317/L, 321, 347, A20
Cooper	Cast Alloy	1/4" to 24"	150 - 1500	FLGD, THRD, SW, BW	Monel, Inconel, Hastelloy, Titanium, Zirconium, Duplex
Cooper	Forged Alloy	1/4" to 3"	800 - 1500	FLGD, THRD, SW, BW	Monel, Inconel, Hastelloy, Titanium, Zirconium, Duplex
Cooper	Ball Valves	1/4" to 3"	1500 PSI	THRD, SW, BW	Monel, Inconel, Hastelloy, Titanium, Zirconium, Duplex
Cooper	Ball Valves	1/2" to 12"	150 - 900 PSI	FLGD	Monel, Inconel, Hastelloy, Titanium, Zirconium, Duplex

*Larger sizes available upon request. **Other materials available upon request.

Products & Services

VALVES

NEWCO

- Full Line of Gate, Globe, & Check Valves in Forged & Cast Steel
- Floating Ball Valves
- Trunnion Mounted Ball Valves
- QuadroSphere® Trunnion Mounted Ball Valves

OIC

- Gate, Globe, and Check Valves in Stainless Steel

COOPER

- Gate, Globe, and Check Valves Flanged, Threaded, and Socket Weld in Cast and Forged Exotic Alloy, and Stainless Steel
- Flanged and 3-Piece Ball Valves in Exotic Alloy

Manual Operations

- Worm Gears, Spur Gears, Bevel Gears, and Reach Rods
- Field and Shop Installation Services
- Table Stands, Extension Systems, and Brackets

Valve Modification

- By Passes, Bore Changes, Mounting Plates, Stem Extensions, Limit Switches, Trim Changes, etc.

AUTOMATION

Valve & Damper Actuation

- Capabilities and Support for all Actuators including: **Limitorque, Rotork, Auma, EIM, Bettis, Automax, Fisher, Miller, and Hanna**
- Electric, Hydraulic, and Pneumatic Automation
- New Applications and Field Retrofits
- Multi-turn, Quarter-turn, and Linear

Automation Site Services

- Experienced Field Technicians
- Commissioning and Repair Services
- Actuator Installation, Setting, Calibration, Start-up
- Automation and Control Surveys

Automation Shop Services

- Experienced Shop Technicians
- Special Wiring Diagrams and Control Schematic
- Complete Automated Valve Assemblies
- Shop Acuator Repairs on **Limitorque, Rotork, Auma, & EIM**

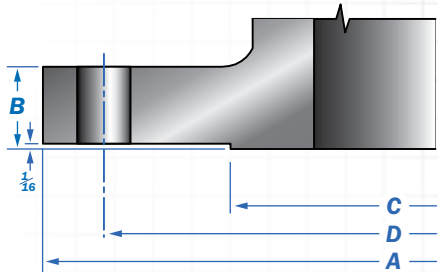
Controls & Digital Communications

- Pneumatic and Hydraulic Services
- Two-wire Integration, Field Bus, ModBus, ProfiBus, DeviceNet, EtherNet, Serial Communications, Network Control Systems
- Solenoid and Speed Control Valves; Limit Switches

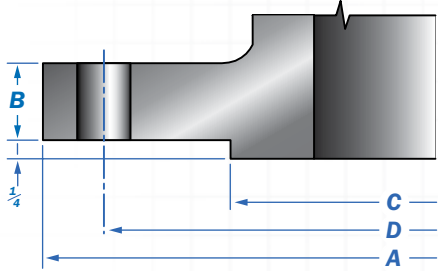
Specialists in Electric and Pneumatic Actuation - Authorized Limitorque Distributor and Service Center

Flange Dimensions - ASME B16.5

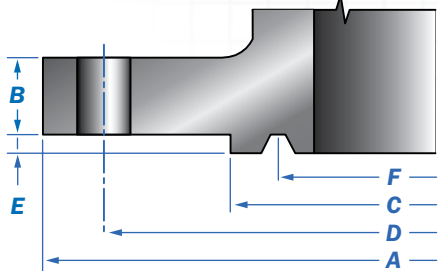
**Raised Face
Class 150 & 300**



**Raised Face
Class 600 thru 2500**



**RTJ
Class 600 thru 2500**



Flange Dimensions in Inches											
Class	Size in. mm	A	B	C	D	Ring Joint Facing			Ring No.	Bolt Holes	
						C	F	E		Size	No.
150	1/2	3.5	0.44	1.38	2.38	-	-	-	-	0.62	4
	15	89	11.58	34.9	60.3	-	-	-	-	16	4
	3/4	3.88	0.5	1.69	2.75	-	-	-	-	0.62	4
	20	98	13	42.9	69	-	-	-	-	16	4
	1	4.25	0.55	2	3.12	-	-	-	-	0.62	4
	25	108	14.5	50.8	79.4	-	-	-	-	16	4
	1-1/4	4.62	0.62	2.5	3.5	-	-	-	-	0.62	4
	32	117	16	68.5	88.9	-	-	-	-	16	4
	1-1/2	5	0.69	2.88	3.88	-	-	-	-	0.62	4
	40	127	17.5	73	98.4	-	-	-	-	16	4
300	2	6	0.75	3.62	4.75	-	-	-	-	0.75	4
	50	152	19.5	92.1	120.6	-	-	-	-	19	4
	1/2	3.75	0.56	1.38	2.62	-	-	-	-	0.62	4
	15	95	14.5	34.9	66.7	-	-	-	-	16	4
	3/4	4.62	0.62	1.69	3.25	-	-	-	-	0.75	4
	20	117	16	42.9	82.5	-	-	-	-	19	4
	1	4.88	0.69	2	3.5	-	-	-	-	0.75	4
	25	124	17.5	50.8	88.9	-	-	-	-	19	4
	1-1/4	5.25	0.75	2.5	3.88	-	-	-	-	0.75	4
	32	133	19.5	68.5	98.4	-	-	-	-	19	4
600	1-1/2	6.12	0.81	2.88	4.5	-	-	-	-	0.88	4
	40	156	21	73	114.3	-	-	-	-	22.5	4
	2	6.5	0.88	3.62	5	-	-	-	-	0.75	8
	50	165	22.5	92.1	127	-	-	-	-	19	8
	1/2	3.75	0.56	1.38	2.62	2	1.34	0.22	R 11	0.62	4
	15	95	14.5	34.9	66.7	51	34.14	5.6	R 11	16	4
	3/4	4.62	0.62	1.69	3.25	2.5	1.68	0.25	R 13	0.75	4
	20	117	16	42.9	82.5	63.5	42.88	6.3	R 13	19	4
	1	4.88	0.69	2	3.5	2.75	2	0.25	R 16	0.75	4
	25	124	17.5	50.8	88.9	70	50.8	6.3	R 16	19	4
1500	1-1/4	5.25	0.81	2.5	3.88	3.12	2.38	0.25	R 18	0.75	4
	32	133	21	63.5	98.4	79.5	60.32	6.3	R 18	19	4
	1-1/2	6.12	0.88	2.88	4.5	3.56	2.69	0.25	R 20	0.88	4
	40	156	22.5	73	114.3	90.5	68.28	6.3	R 20	22.5	4
	2	6.5	1	3.62	5	4.25	3.25	0.31	R 23	0.75	8
	50	165	25.5	92.1	127	108	82.55	7.9	R 23	19	8
	1/2	4.75	0.88	1.38	3.25	2.38	1.56	0.25	R 12	0.88	4
	15	121	22.5	34.9	82.5	60.5	39.67	6.3	R 12	22.5	4
	3/4	5.12	1	1.69	3.5	2.62	1.75	0.25	R 14	0.88	4
	20	130	22.5	42.9	88.9	66.5	44.45	6.3	R 14	22.5	4
2500	1	5.88	1.12	2	4	2.81	2	0.25	R 16	1	4
	25	149	29	50.8	101.6	71.5	50.8	6.3	R 16	25.5	4
	1-1/4	6.25	1.12	2.5	4.38	3.19	2.37	0.25	R 18	1	4
	32	159	29	63.5	111.1	81	60.32	6.3	R 18	25.5	4
	1-1/2	7	1.25	2.88	4.88	3.62	2.68	0.25	R 20	1.12	4
	40	178	32	73	123.8	92	68.28	6.3	R 20	28.5	4
	2	8.5	1.5	3.62	6.5	4.88	3.75	0.31	R 24	1	8
	50	216	38.5	92.1	165.1	124	95.25	7.9	R 24	25.5	8
	1/2	5.25	1.19	1.38	3.5	2.56	1.68	0.25	R 13	0.88	4
	15	133.5	30.5	34.9	88.9	65	42.88	6.3	R 13	22.5	4
3000	3/4	5.5	1.25	1.69	3.75	2.88	2	0.25	R 16	0.88	4
	20	139.5	32	42.9	95.3	73.2	50.8	6.3	R 16	22.5	4
	1	6.25	1.38	2	4.25	3.25	2.37	0.25	R 18	1	4
	25	159	35	50.8	108	82.5	60.32	6.3	R 18	25.5	4
	1-1/4	7.25	1.5	2.5	5.12	4	2.84	0.31	R 21	1.12	4
	32	184	38.5	63.5	130.2	101.6	72.24	7.9	R 21	28.5	4
	1-1/2	8	1.75	2.88	5.75	4.5	3.25	0.31	R 23	1.25	4
	40	203	44.5	73	146.1	114.3	82.55	7.9	R 23	32	4
	2	9.25	2	3.62	6.75	5.25	4	0.31	R 26	1.12	8
	50	235	51	92.1	171.5	133.4	101.6	7.9	R 26	28.5	8

“Reliable” is not just a word.

Edmonton, Alberta Barrie, Ontario
Carson, CA New Brunswick, NJ
Houston, TX Atlanta, GA Bergamo, Italy
Shanghai, China



In the pre-dawn hours of Saturday, September 13th our corporate headquarters in Houston, Texas took a direct hit from Hurricane Ike. The entire upper Texas Gulf coast was shut down in the wake of this storm... leaving homes and businesses in the dark. Newmans was prepared! Our modern Disaster Recovery Plan was in place - globally!

Our reputation as the Reliable Source was put to the test. Even though our Houston operation was momentarily crippled, seven of our eight locations, with 75% of our \$100 million inventory, were able to network seamlessly to maintain the

consistent high quality service to which our customers have been accustomed.

In the wake of the storm, Newmans proved once again that we are indeed **The Reliable Source!**

Newmans offers a complete line of valves in a full range of materials, sizes, styles, and pressure classes with complete actuation capabilities in sizes 1/4" thru 60" in classes ANSI 125 thru 4500 lbs.

For product details, visit our web site @ www.newmansvalve.com.



Newmans
The Reliable Source

Toll Free: 1.800.231.3505
www.NewmansValve.com

Gates • Globes • Checks • Stop Checks • Angles • Tilting Discs • Trunnion Balls • Floating Balls • QuadroSphere™ Balls

Newco[®]

FORGED STEEL

Gates • Globes • Checks



Newco Forged Steel Valves Product Applications

The sole purpose of a valve is to regulate flow throughout a fluid processing/transport system whether it is starting, stopping, throttling, or simply controlling flow rate. Gate, Globe, Angle Globe, Swing and Lift Check valve configurations are designed to perform different functions within a fluid system. This section is designed to help you determine which Newmans valve will best address your application(s).

Threaded, Socket Weld, & Butt Weld End Gate Valves

Sizes: 1/4" thru 3" **Class:** 800 thru 4500

Gate Valves are ideal for bidirectional, full flow and tight seal shut-off. Due to the flow characteristics of the wedge-to-seat design, gate valves should be operated in the full-open or full-close position. Gate valves are utilized in applications where minimum pressure drop is necessary.



Flanged End Gate Valves

Sizes: 1/2" thru 2" **Class:** 150 thru 2500

Newmans' Flanged Gate Valves are suited to bi-directional flow. They are ideal for on - off duties where tight shut-off is required. Many of our designs feature integral body forging. Newmans offers flanged gate valves for wide service conditions.

Extended Body Gate Valves

Sizes: 1/2" thru 2" **Class:** 800 thru 1500

These valves are available in a variety of connections. Extended Body Valves have a welded or threaded connection and are used for pressure vessels and header lines for vents, drains or takeoff lines and instrumentation.



Threaded, Socket Weld, & Butt Weld End Globe Valves

Sizes: 1/4" thru 2" **Class:** 800 thru 4500

Globe Valves are ideal for unidirectional, controlled flow. The flow characteristic of a Globe valve is repeatable, consistent, and easy to control at any open position, which makes the design suitable for throttling applications.





Flanged End Globe Valves

Sizes: 1/2" thru 2" **Class:** 150 thru 2500

Flanged End Globe Valves offer flow characteristics that are repeatable, consistent, and easy to control at any open position. This makes them ideal for unidirectional, controlled flow and suitable for throttling applications.

Threaded, Socket Weld, & Butt Weld End Swing & Lift Check Valves

Sizes: 1/4" thru 2" **Class:** 800 thru 4500

Swing and Lift Check valves are available for a variety of services, and where high pressure application is needed. Quality manufacturing ensures that the valve will prevent flow reversal. Newmans offers swing, piston, and ball configurations for these valves.



Flanged End Swing & Lift Check Valves

Sizes: 1/2" thru 2" **Class:** 150 thru 1500

Newco Flanged End Swing and Lift Check Valves are designed for use in multiple applications. These valves are ideal for applications where flow characteristics of fluids require pressure control.

Threaded, Socket Weld, & Butt Weld Y-Pattern Globe Valves

Sizes: 1/2" thru 2" **Class:** 800 thru 4500

Y-Pattern Globe Valves are designed much the same as Angle Globe Valves. They are designed for a variety of service conditions and are used commonly for high pressure applications.

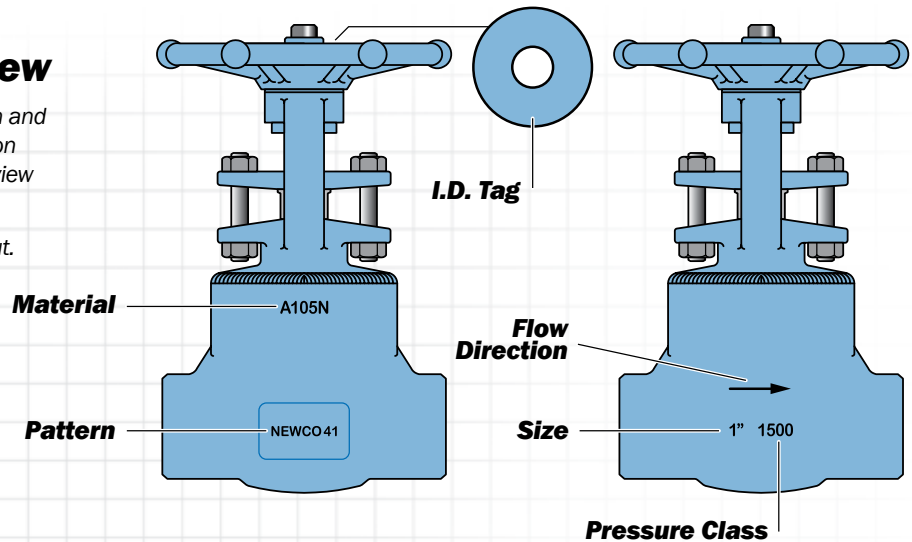


Valve & I.D. Tag Overview

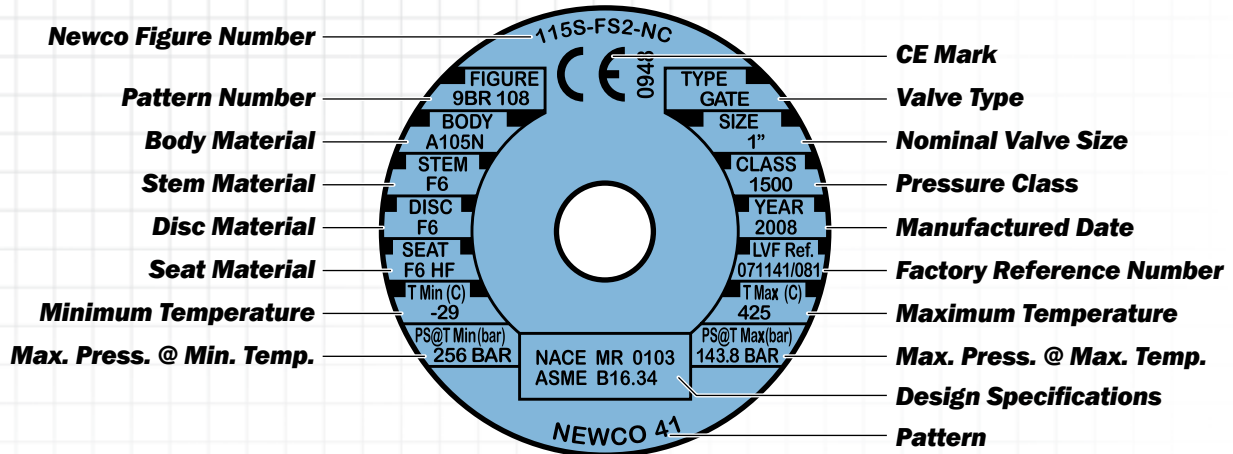
The identification tag displays all construction and tracking data regarding the respective valve on which it is attached. Below is a general overview of the identification tag components.

I.D. Tags are located under the handwheel nut.

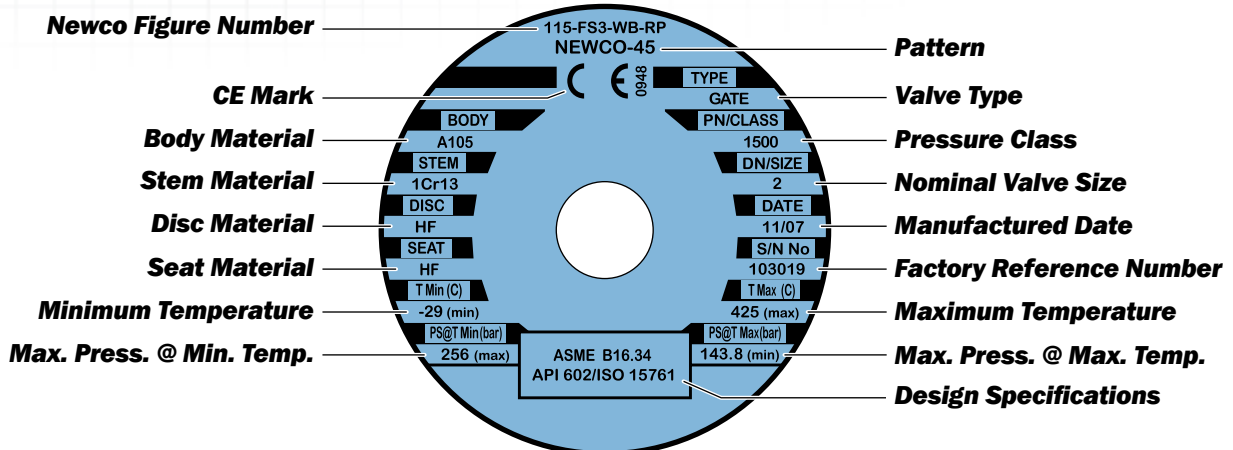
Globe and Check Valves will have a flow direction arrow on body for proper installation.



NEWCO 41 I.D. Tag



NEWCO 45 I.D. Tag



Body/Bonnet Materials

Newco forged steel valves are available in stock in a wide range of body/bonnet materials and optional trim materials. Listed below are some of the more popular materials. Additional materials are available. Please contact Newmans or your local distributor for details.

Newco Material Designation	Common Description	ASTM Specs.	Body/Bonnet Material Service Limitations *
FS	Carbon Steel	A105	Non-corrosive service water, oil, & gases at temperatures between -20° F & +800° F
LF2	Low Temp Carbon	A350	Low temperature service between -50° F & +800° F
F11	1.25% Chrome & .5% Moly	A182	Non-corrosive service water, oil, & gases at temperatures between -20° F & +1100° F
F22	2.25% Chrome & 1% Moly	A182	Non-corrosive service water, oil, & gases at temperatures between -20° F & +1100° F
F5	5% Chrome & .5% Moly	A182	Corrosive, non-corrosive, or erosive service at temperatures between -20° F & +1200° F
F9	9% Chrome & 1% Moly	A182	Corrosive, non-corrosive, or erosive service at temperatures between -20° F & +1200° F
F91	9% Chrome, 1% Moly, & V	A182	Corrosive, non-corrosive, or erosive service at temperatures between -20° F & +1200° F
F316	316	A182	Corrosive, cryogenic or high temperature service between -450° F & +1200° F

* Limitations are per 2004 Edition of ASME B16.34.

Trim Materials

The following are Newco's standard trim designations.

Newco Trim Number	Common Name	API 600 Trim No.	Seat Ring Facing (1)	Wedge or Disc Facing (1)	Stem	Other Trim Parts (2)	Service Limitations
1	13 Chrome	1	CR 13	CR 13	CR 13	CR 13	Non-corrosive applications. Steam, gas, & general service to 700° F. Oil & oil vapor to 900° F
2	Half Stellite	8	HF	CR 13	CR 13	CR 13	Steam, gas, & general service to 1000° F. Standard trim for gate valves
3	Full Stellite	5	HF	HF	CR 13	CR 13	Premium trim service to 1200° F. Excellent for high pressure water and steam service
4	316	10	316	316	316	316	Corrosive services to 850° F. Low temperature service standard for 316 SS valves
4/2	316/Half Stellite	12	HF	316	316	316	
4/3	316/Full Stellite	16	HF	HF	316	316	
5	Monel	9	NiCu	NiCu	NiCu	NiCu	Corrosive services to 750° F
5/2	Monel/Half Stellite	11	HF	NiCu	NiCu	NiCu	
5/3	Monel/Full Stellite	-	HF	HF	NiCu	NiCu	
6	Alloy 20	13	A20	A20	A20	A20	Corrosive services to 300° F
X	Special	Special	Special	Special	Special	Special	Customer to specify

(1) Facing is defined as the seating surface of a seat ring and wedge/disc

(2) Other trim parts are defined as small internal parts that are normally in contact with the service fluid. This includes the stem, etc. in gate and globe valves and the swing check disc nut

Newco Features and Benefits

- Material Test Reports
- International Organization for Standardization (ISO)
- Traceability
- Fugitive Emissions Tested
- API-598 Tested
- Major End-user Approved
- Ship from Multiple North American Locations
- Extensive Engineering Capabilities
- Excellent Customer Service
- Warranty
- Field Services for Start-up
- In-house Automation Capabilities

How to Order All Newco Products

Note: OIC and Cooper "How to Order" information can be found in their respective catalogs.

Figure Number

The figure number shown below identifies specific valve configuration details of Newco valves such as valve type, pressure class, end connections, body/bonnet & trim materials, and special features.

Please specify end connections, body materials, and trims not listed below.

When placing an order, please refer to the respective product section of the catalog for size availability. A detailed description must be included with any special orders.

Type	
1	= Gate, OS&Y
2	= Globe/Globe Stop Check, OS&Y
3	= Swing/Tilting Disc Check
4	= Piston Check
5	= Ball
6	= Gate, NRS
7	= Angle/Angle Stop Check, OS&Y

Pressure Class	
1	= 150
2	= 125
3	= 300
6	= 600
8	= 800
9	= 900
15	= 1500
16	= 1690
25	= 2500
26	= 2680
45	= 4500

End Connections	
F	= Flanged
J	= RTJ
S	= Socket Weld
T	= Threaded
W	= Butt Weld
X	= Threaded x Socket Weld

Trim Material	API Trim =
1 = CR13	1, 4, 8A
2 = CR13/HF**	8
3 = CR13/FHF**	5
4 = 316	10
4/2 = 316/HF**	12
4/3 = 316/FHF**	16
5 = Ni Cu (Monel***)	9
5/2 = Monel/HF**	11
6 = Alloy 20	13
7 = Bronze	N/A
A7 = Aluminum Bronze	N/A
8 = Iron	N/A
9 = Special (Customer to Specify)	

Fig. 18T-FS2__

Body/Bonnet Material	
A20 = ASTM A351, CN7M	= Cast Alloy 20
CB = ASTM A216, WCB	= Cast Carbon Steel
CC = ASTM A216, WCC	= Cast Carbon Steel
C5 = ASTM A217, C5	= Cast Alloy Steel (5% Chrome, .5% Moly)
C6 = ASTM A217, WC6	= Cast Alloy Steel (1.25% Chrome, .5% Moly)
C9 = ASTM A217, WC9	= Cast Alloy Steel (2.25% Chrome, 1% Moly)
C12 = ASTM A217, C12	= Cast Alloy Steel (9% Chrome, 1% Moly)
C12A = ASTM A217, C12A	= Cast Alloy Steel (9% Chrome, 1% Moly, V)
CF3 = ASTM A351, CF3	= Cast Stainless Steel
C3M = ASTM A351, CF3M	= Cast 316L Stainless Steel
CF8 = ASTM A351, CF8	= Cast 304 Stainless Steel
C7L = ASTM A351, CG3M	= Cast 317L Stainless Steel
C8M = ASTM A351, CF8M	= Cast 316 Stainless Steel
C8C = ASTM A351, CF8C	= Cast 347 Stainless Steel
CT = ASTM A351, CG8M	= Cast 317 Stainless Steel
DI = ASTM A395	= Cast Ductile Iron
FS = ASTM A105	= Forged Carbon Steel
F3M = ASTM A182, F316L	= Forged 316 Stainless Steel
F5 = ASTM A182, F5	= Forged Alloy Steel (5% Chrome, .5% Moly)
F7 = ASTM A182, 317	= Forged 317 Stainless Steel
F7L = ASTM A182, F317L	= Forged 317L Stainless Steel
F11 = ASTM A182, F11	= Forged Alloy Steel (1.25% Chrome, .5% Moly)
F22 = ASTM A182, F22	= Forged Alloy Steel (2.25% Chrome, 1% Moly)
F9 = ASTM A182, F9	= Forged Alloy Steel (9% Chrome, 1% Moly)
F91 = ASTM A182, F91	= Forged Alloy Steel (9% Chrome, 1% Moly, V)
F8 = ASTM A182, F304	= Forged 304 Stainless Steel
F8M = ASTM A182, F316	= Forged 316 Stainless Steel
F8C = ASTM A182, F321	= Forged 321 Stainless Steel
IB = ASTM A126, CLB	= Cast Iron
LCC = ASTM A352, LCC	= Cast Low Temperature Carbon Steel
LF2 = ASTM A350, LF2	= Forged Low Temperature Carbon Steel
MO = ASTM A414, M35	= Cast Ni Cu (Monel***)
SPL = Special (Customer to specify)	

Suffix Letters	
BP	= By Pass
BS	= Bellows Seal
CL	= Chlorine Service
CR	= Cryogenic Service
CW	= Chain Wheel
EB	= Extended Body
FP	= Full Port
FS	= Fire Safe
GI	= Grease Injection
GO	= Gear Operated
HB	= Horizontal Ball Check
HP	= Horizontal Piston Check
HO	= Hydraulic Operator
INT	= Integral Flanged
LD	= Locking Device
LL	= Locking Loop
LV	= Live Load Packing
MO	= Motor Operated
NC	= NACE MRO103 Compliant
OL	= Outside Weight & Lever
OX	= Oxygen Service
PO	= Pneumatic Operator
PS	= Pressure Seal Bonnet
PT	= PTFE Seats
QS	= QuadroSphere
RP	= Regular Port
SC	= Stop Check
SL	= Spring Loading
SPL	= Special (Customer to specify)
TD	= Tilting Disc Check
TF	= Teflon* Insert
TM	= Trunnion Mounted
VP	= Vertical Ball Check
VL	= Vertical Lift Check
VP	= V-Port Disc
VT	= Viton* Insert
WB	= Welded Bonnet
Y	= Y Pattern
*	= Viton and Teflon are registered trademarks of DuPont Company
**HF	= Hardfaced - AWS 5.13 Class C ₀ C ₁ A
***	= Monel is a registered trademark of International Nickel Company

Newco[®]

Forged Steel Bolted & Welded Bonnet Gate Valves

Manufactured by Newmans™

Sizes: 1/4" thru 3" • Pressure Class: 150 thru 4500



Typical Newco Forged Steel Bolted & Welded Bonnet Gate Valve Expanded View

1. Handwheel Nut: The handwheel nut secures the handwheel to the bonnet assembly.

2. Handwheel: The handwheel cycles the valve.

3. Stem Nut: The stem nut provides a precision guide for proper stem alignment.

4. & 11. Gland Bolts & Nuts: The gland bolt and nut allows for easy adjustments for packing compression.

5. Stuffing Box: The stuffing box contains the packing.

6. Bonnet Bolts: The bonnet bolts secure the bonnet to the body.

7. Yoke & Bonnet: Newco bonnet assemblies are built to the same standards as the bodies. Larger size gate valves utilize a multi-piece bonnet design.

8. Bonnet Gasket: The bonnet gasket creates a leakproof seal between the bonnet and body.

9. Body: Newco forged steel bodies provide low resistance flow and optimum strength and performance.

10. Seat Rings: To ensure a stable shutoff, seat rings are aligned and swaged into the valve, then precision ground for optimal seating.

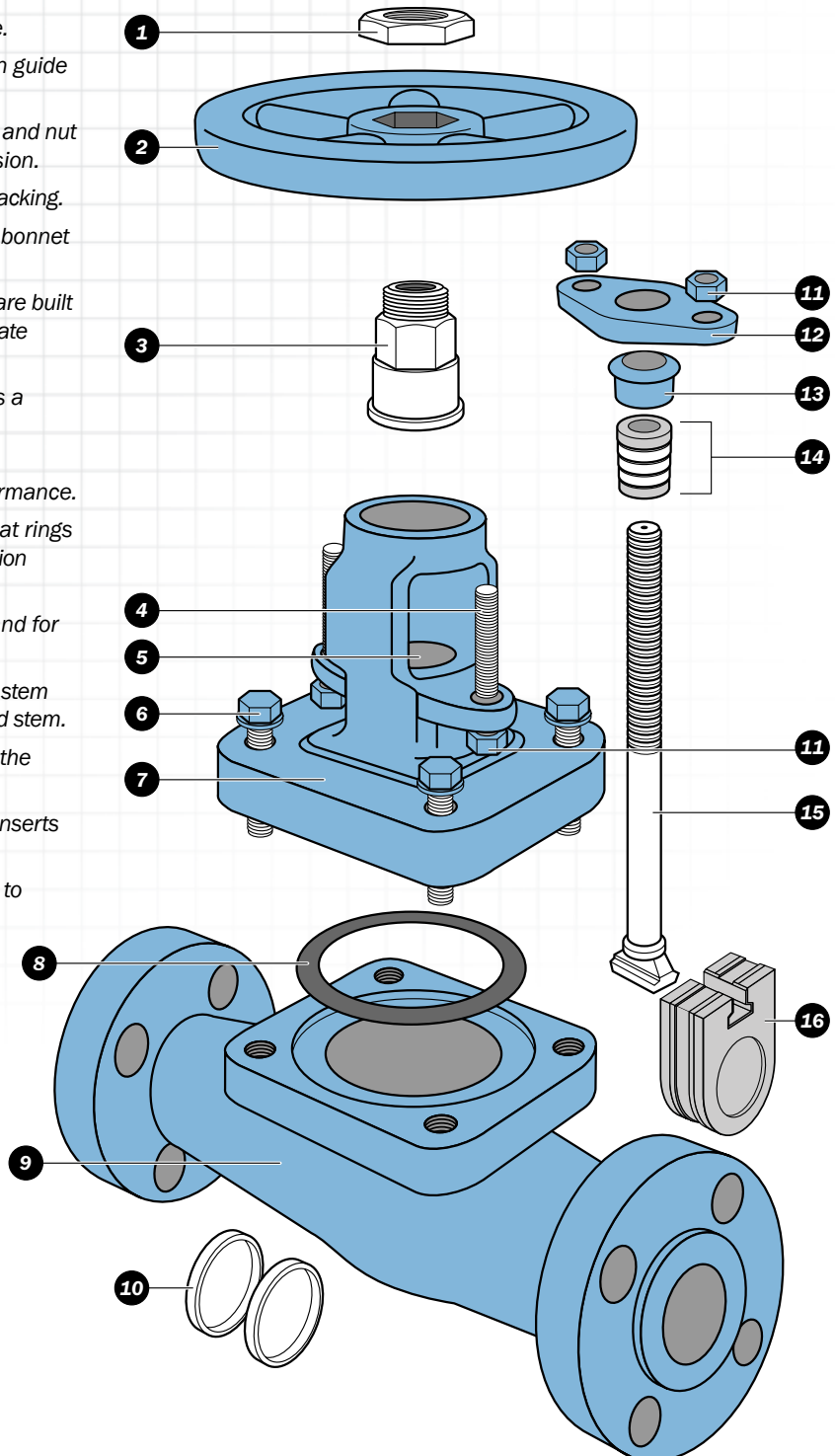
12. Gland Flange: Applies pressure to the gland for accurate packing adjustments.

13. Gland: Compresses the packing to create a stem seal above the back seat, between the bonnet and stem.

14. Packing: The packing creates a seal above the back seat, between the bonnet and stem.

15. Stem: The stem is precision machined and inserts into the horizontal channel in the disc.

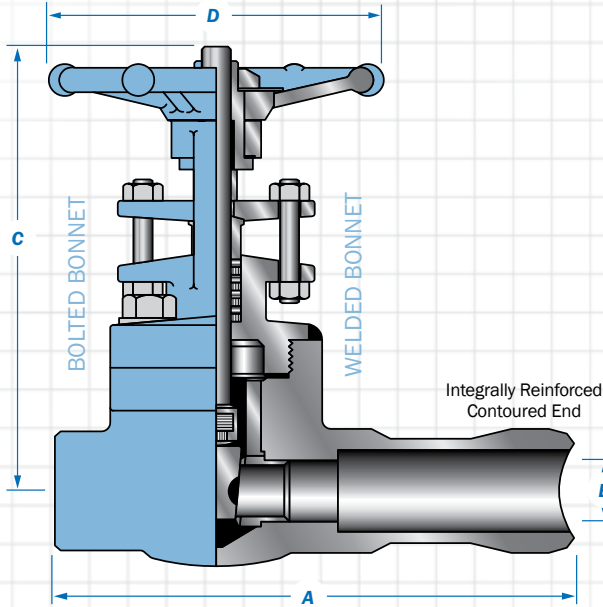
16. Wedge: Newmans solid wedge is machined to the tightest tolerances to ensure trouble free shutoff and cycling.



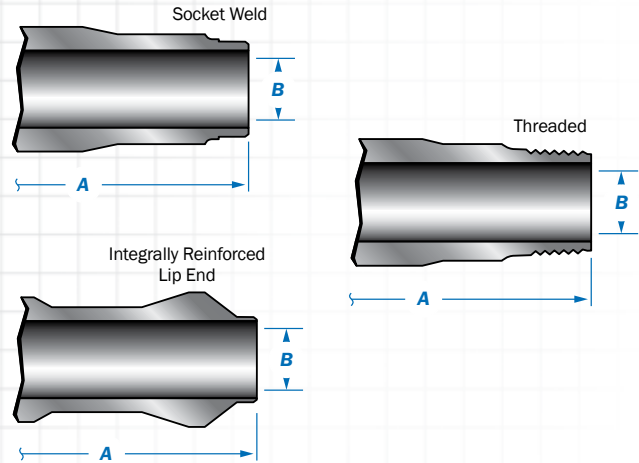
Forged Steel Extended Body Gates
Bolted & Welded Bonnet
Conventional Port
Class 800 thru 1500
Sizes: 1/2" thru 2"

Design and Manufacturing Standards

Valve Design: API 602
Pipe Threads, General Purpose, Inch: ASME B1.20.1
Socket Welding : ASME B16.11
Tested in Accordance with: API 598
Recommended Spare Parts*



Available Ends



Class 800 & 1500 Extended Body - Bolted & Welded Bonnet Gate

Size in. mm	Class 800 IR Contoured End					Class 800 IR - Lip End					Class 800 Threaded					Class 800 Socket Weld								
	A	B	C	D	Wt.	A	B	C	D	Wt.	A	B	C	D	Wt.	A	B	C	D	Wt.				
	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45
1/2	8.6	0.39	5.9	3.2	6	8.6	0.39	5.9	3.2	6	5.6	0.39	6.4	3.1	5.7	5.6	0.39	6.4	3.1	5.7				
15	207	9.9	150	81	3	207	9.9	150	81	3	141.5	10	162	80	2.6	141.5	10	162	80	2.6				
3/4	8.6	0.55	6.1	3.2	7	8.6	0.55	6.1	3.2	7	5.8	0.55	7.3	3.9	6.4	5.8	0.55	7.3	3.9	6.4				
20	218	13.9	155	81	3	218	13.9	155	81	3	146.5	14	185	100	2.9	146.5	14	185	100	2.9				
1	9.6	0.71	7.3	3.9	10	9.6	0.71	7.3	3.9	10	6.5	0.7	7.6	3.9	9.5	6.5	0.7	7.6	3.9	9.5				
25	245	18	185	99	5	245	18	185	99	5	166	18	192	100	4.3	166	18	192	100	4.3				
1-1/2	10.4	1.14	10.2	5.5	19	10.4	1.14	10.2	5.5	19	7.5	1.14	10	5.5	19.4	7.5	1.14	10	5.5	19.4				
40	263	28.9	259	140	9	263	28.9	259	140	9	191	29	255	140	8.8	191	29	255	140	8.8				
2	11.4	1.44	10.8	5.5	29	11.4	1.44	10.8	5.5	29	8.5	1.44	10.7	6.7	28.6	8.5	1.44	10.7	6.7	28.6				
50	289	36.6	274	140	13	289	36.6	274	140	13	216	36.5	273	170	13	216	36.5	273	170	13				
Size in. mm	Class 1500 Re-Out-Forced					Class 1500 Re-In Forced					Class 1500 Threaded					Class 1500 Socket Weld								
	A	B	C	D	Wt.	A	B	C	D	Wt.	A	B	C	D	Wt.	A	B	C	D	Wt.				
	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45	41	45
1/2	8.6	0.39	5.4	3.2	6	8.6	0.39	5.4	3.2	6	5.7	0.39	6.5	3.2	6.4	5.7	0.39	6.5	3.2	6.4				
15	218	9.9	138	80	3	218	9.9	138	80	3	146	10	165	80	2.9	146	10	165	80	2.9				
3/4	9.6	0.55	6.3	3.9	10	9.6	0.55	6.3	3.9	10	6.5	0.55	7.1	3.9	9.5	6.5	0.55	7.1	3.9	9.5				
20	245	13.9	161	100	5	245	13.9	161	100	5	166	14	180	100	4.3	166	14	180	100	4.3				
1	10.4	0.75	8.6	4.7	15	10.4	0.75	8.6	4.7	15	7.5	0.7	9.4	5.5	19.4	7.5	0.7	9.4	5.5	19.4				
25	264	19	218	120	7	264	19	218	120	7	191	18	240	140	8.8	191	18	240	140	8.8				
1-1/2	10.5	1.16	9.4	5.5	25	10.5	1.16	9.4	5.5	25	8.5	1.14	10.6	6.7	29.7	8.5	1.14	10.6	6.7	29.7				
40	267	29.5	238	140	11	267	29.5	238	140	11	216	29	270	170	13.5	216	29	270	170	13.5				
2	12.8	1.44	10.9	6.7	35	12.8	1.44	10.9	6.7	35	9.8	1.44	12.6	10.2	41.1	9.8	1.44	12.6	10.2	41.1				
50	325	36.6	276	170	16	325	36.6	276	170	16	250	36.5	320	260	18.7	250	36.5	320	260	18.7				

Typical Bill of Materials (See page 12 for available materials.)

Component	Material	ASTM Spec	Component	Material	ASTM Spec
Body	Carbon Steel	A105N	Handwheel Nut	Carbon Steel	Commercial
Bonnet	Carbon Steel	A105N	Nameplate	Aluminum	Commercial
* Packing	Graphite W/Braided Carbon Fiber End Rings		Handwheel	Carbon Steel	A105N
* Gasket	Stainless Steel 316 Graphite		Yoke Sleeve	Stainless Steel	AISI 416
Stem	Stainless Steel	A479-410	Gland Nuts	Carbon Steel	A194 2H
Wedge	Stainless Steel	13 Chrome	Gland Flange	Carbon Steel	A105N
Seat Rings	Stainless Steel	A479-410	Gland Studs	Stainless Steel	AISI 410
Bonnet Bolt	Alloy Steel	A193 B7	Packing Gland	Stainless Steel	A479-316

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Dimensions are subject to change without notice.

**Forged Steel Flanged End Gates
Bolted & Welded Bonnet
Conventional Port
Class 150 thru 1500
Sizes: 1/2" thru 2" (1/4" & 3/8" available upon request)**

Design and Manufacturing Standards

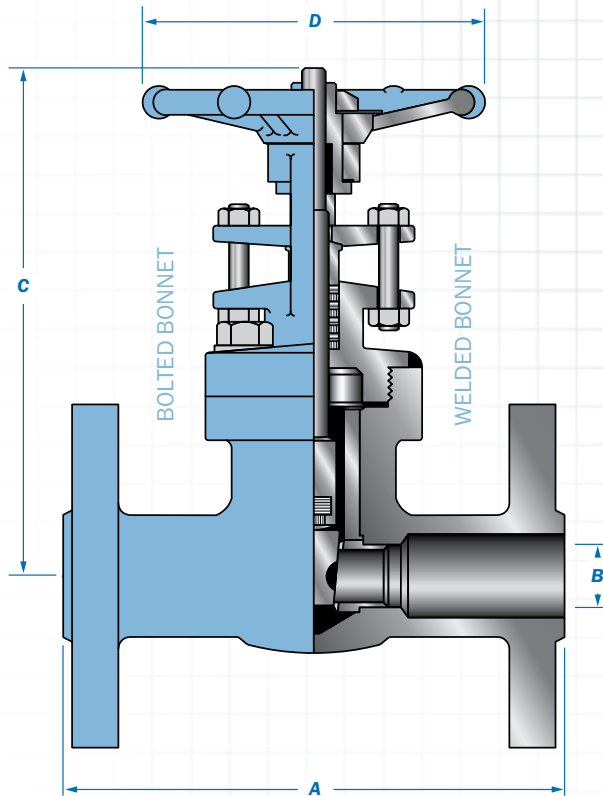
Valve Design: API 602

Flange Dimensions: ASME B16.5

Face-to-Face Dimensions: ASME B16.10

Tested in Accordance with: API 598

Recommended Spare Parts*



**Class 150 thru 1500
Bolted & Welded Bonnet Flanged Gates**

Size in. mm	Class 150 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	4.3	0.39	0.39	6.8	4.9	3.2	6.8	6.6		
15	108	10	10	173	125	80	3.1	3		
3/4	4.6	0.55	0.55	7.1	5.2	3.2	8.6	7.7		
20	118	14	14	180	132	80	4	3.5		
1	5.0	0.71	0.71	8.1	6.7	4.0	12.1	12.1		
25	127	18	18	205	170	100	5.7	5.5		
1-1/4	5.5	0.94	0.95	9.3	7.6	4.8	18.1	15		
32	140	24	24	235	193	120	8.2	6.8		
1-1/2	6.5	1.22	1.14	10.2	8.3	5.5	23.4	22.9		
40	165	30	29	260	211	140	10.5	10.4		
2	7.0	1.44	1.44	11.7	9.3	5.5	32.0	31.7		
50	178	37	37	296	236	170	15.4	14.4		
Size in. mm	Class 300 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	5.5	0.39	0.39	6.9	4.9	3.2	7.3	7.9		
15	140	10	10	174	125	80	4	3.6		
3/4	6.0	0.55	0.55	7.1	5.2	3.2	10.8	10.8		
20	153	14	14	180	132	80	5.4	4.9		
1	6.5	0.71	0.71	8.1	6.7	3.9	14.7	15.4		
25	165	18	18	205	170	100	6.5	7		
1-1/4	7.0	0.94	0.95	10.2	7.6	4.7	21.1	20.7		
32	178	24	24	260	193	140	12.5	9.4		
1-1/2	7.5	1.22	1.14	10.4	8.3	5.5	29.5	29.3		
40	191	30	29	265	211	140	13	13.3		
2	8.5	1.44	1.44	11.7	9.3	6.7	35.9	39.6		
50	216	37	37	296	236	170	17.5	18		
Size in. mm	Class 600 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	6.5	0.39	0.39	5.7	4.9	3.2	7.7	9.2		
15	165	10	10	145	125	80	4.2	4.2		
3/4	7.5	0.55	0.55	6.1	5.2	3.2	11.7	12.8		
20	191	14	14	155	132	80	5.6	5.8		
1	8.5	0.71	0.71	7.3	6.7	4.0	15.7	19.4		
25	216	18	18	185	170	100	7.2	8.8		
1-1/4	9.0	1.14	0.95	9.8	7.6	5.5	30.9	26.6		
32	229	29	24	248	193	140	14.5	12.1		
1-1/2	9.5	1.22	1.14	9.8	8.3	5.5	30.9	34.3		
40	241	30	29	248	211	140	14.5	15.6		
2	11.5	1.44	1.44	10.7	9.3	5.6	40.8	34.3		
50	292	37	37	273	236	170	18	19.5		
Size in. mm	Class 1500 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	8.5	0.55	0.55	8.3	7.8	3.9	22	9		
15	216	14	14	210	198	100	10	4		
3/4	9	0.71	0.55	10.0	7.8	4.7	33	9.5		
20	229	18	14	255	198	120	15	4.3		
1	10	0.94	0.71	10.8	8.6	5.5	37.4	13.5		
25	254	24	18	275	218	140	17	6		
1-1/4	-	-	0.95	-	9.3	-	-	19.2		
32	-	-	24	-	236	-	-	8.7		
1-1/2	12	1.44	1.14	15	10.8	6.8	77	26.9		
40	305	36.5	29	380	274	172	35	12		
2	14.5	1.57	1.44	15.3	12.6	10.2	121	39		
50	368	40	37	388	320	260	55	17.7		

Typical Bill of Materials (See page 12 for available materials.)

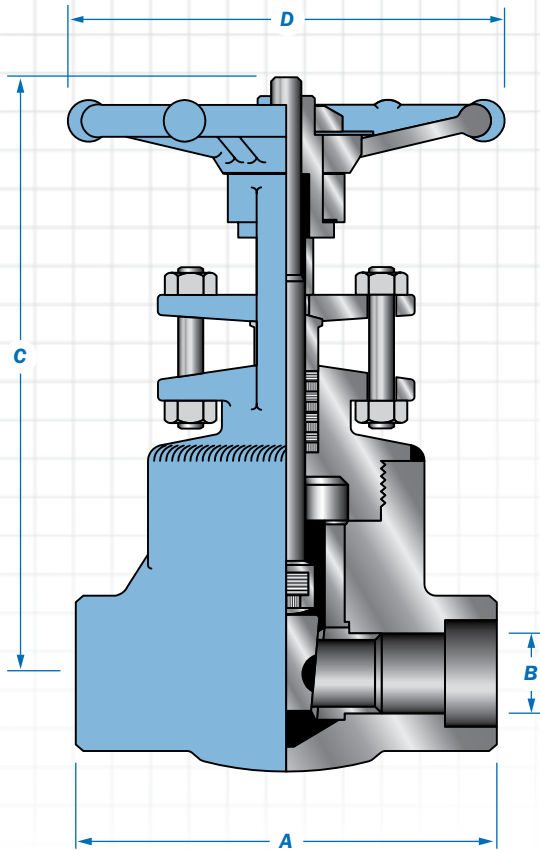
Component	Material	ASTM Spec
Body	Carbon Steel	A105N
Bonnet	Carbon Steel	A105N
* Packing	Graphite W/Braided Carbon Fiber End Rings	
* Gasket	Stainless Steel 316 Graphite	
Stem	Stainless Steel	A479-410
Wedge	Stainless Steel	13 Chrome
Seat Rings	Stainless Steel	A479-410
Bonnet Bolt	Alloy Steel	A193 B7
Handwheel Nut	Carbon Steel	Commercial
Nameplate	Aluminum	Commercial
Handwheel	Carbon Steel	A105N
Yoke Sleeve	Stainless Steel	AISI 416
Gland Nuts	Carbon Steel	A194 2H
Gland Flange	Carbon Steel	A105N
Gland Studs	Stainless Steel	AISI 410
Packing Gland	Stainless Steel	A479-316

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

**Forged Steel High Pressure
Welded Bonnet Gate
Conventional Port
Class 4500
Sizes: 1/2" thru 2"**

Design and Manufacturing Standards

Valve Design: ASME B16.34
Pipe Threads, General Purpose, Inch: ASME B1.20.1
Socket Welding: ASME B16.11
Tested in Accordance with: API 598
Recommended Spare Parts*



**Class 4500
Welded Bonnet Gate**

Size	A	B	C	D	Wt.
1/2	4.7	0.47	10.4	5.5	17.6
15	120	12	265	140	8
3/4	5.1	0.47	10.4	5.5	19.8
20	130	12	265	140	9
1	5.1	0.47	10.4	6.7	19.8
25	130	12	265	170	9
1-1/4	8.3	0.63	12.4	6.7	31.9
32	210	16	315	170	14.5
1-1/2	8.3	0.63	12.4	10.2	33
40	210	16	315	260	15
2	9.4	0.83	15.4	10.2	41.8
50	240	21	390	260	19

Typical Bill of Materials (See page 12 for available materials.)

Component	Material	ASTM Spec
Body	Carbon Steel	A105N
Bonnet	Carbon Steel	A105N
* Packing	Graphite W/Braided Carbon Fiber End Rings	
* Gasket	Stainless Steel 316 Graphite	
Stem	Stainless Steel	A479-410
Wedge	Stainless Steel	13 Chrome
Seat Rings	Stainless Steel	A479-410
Bonnet Bolt	Alloy Steel	A193 B7
Handwheel Nut	Carbon Steel	Commercial
Nameplate	Aluminum	Commercial
Handwheel	Carbon Steel	A105N
Yoke Sleeve	Stainless Steel	AISI 416
Gland Nuts	Carbon Steel	A194 2H
Gland Flange	Carbon Steel	A105N
Gland Studs	Stainless Steel	AISI 410
Packing Gland	Stainless Steel	A479-316

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

Newco[®]

Forged Steel Bolted & Welded Bonnet Globe Valves

Manufactured by Newmans™

Sizes: 1/2" thru 2" • Pressure Class: 150 thru 4500



Typical Newco Forged Steel Bolted & Welded Bonnet Globe Valve Expanded View

1. Handwheel Nut: The handwheel nut secures the handwheel to the bonnet assembly.

2. Handwheel Washer: The washer helps to prevent loosening.

3. Handwheel: The handwheel cycles the valve.

4. & 14. Gland Bolts & Nuts: The gland bolt and nut allows for easy adjustments for packing compression.

5. Gland Flange: Applies pressure to the gland for accurate packing compression.

6. Gland: Compresses the packing to create a stem seal above the back seat, between the bonnet and stem.

7. Packing: The packing creates a seal above the back seat, between the bonnet and stem.

8. Bonnet Bolts: The bonnet bolts secure the bonnet to the body.

9. Bonnet: Newco bonnet assemblies are built to the same standards as the bodies.

10. Bonnet Gasket: The bonnet gasket creates a leakproof seal between the bonnet and body.

11. Body: Newco forged steel bodies provide low resistance flow and optimum strength and performance

12. Seat Ring: To ensure a stable shutoff, the seat ring is aligned into the valve, then precision ground for optimal seating.

13. Stem Nut: The stem nut provides a precision guide for proper stem alignment.

15. Stuffing Box: The stuffing box contains the packing.

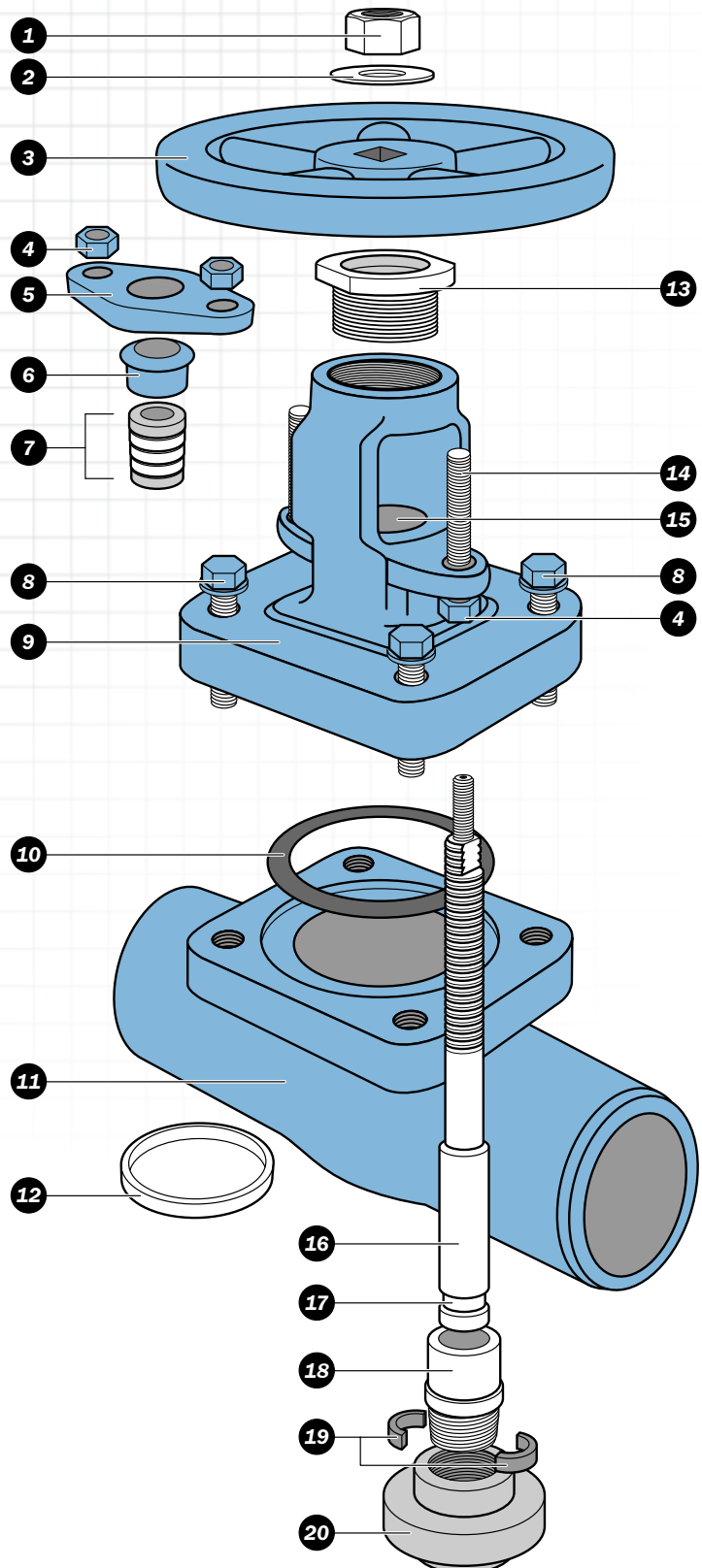
16. Stem: The stem inserts vertically into the disc.

17. Lock Groove: The lock groove receives the split lock ring which allows the disc nut to lift the disc during cycling.

18. Disc Nut: The disc nut, in conjunction with the split lock ring, secures the disc to the stem.

19. Split Ring: The split ring allows the disc nut to lift the disc during cycling.

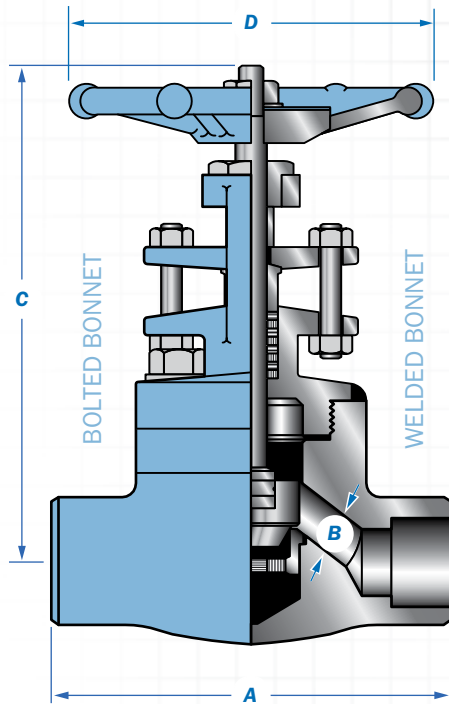
20. Disc: Newmans plug type disc is machined to the tightest tolerances to ensure trouble free shutoff and cycling.



Forged Steel Bolted & Welded Bonnet Globes
Threaded, Socket Weld & Buttweld Ends
Conventional Port
Class 800 thru 2500
Sizes: 1/2" thru 2" (1/4" & 3/8" available upon request)

Design and Manufacturing Standards

Valve Design: API 602
Pipe Threads, General Purpose, Inch: ASME B1.20.1
Socket Welding: ASME B16.11
Tested in Accordance with: API 598
Recommended Spare Parts*



Class 800 thru 1500
Bolted & Welded Bonnet Globes

Size in.	Class 800 WB						Class 800 BB													
	A	B	C	D	Wt.		A	B	C	D	Wt.									
1/2	3.2	3.1	0.35	6.3	5.2	3.2	3.3	4	2.9	3.2	3.1	0.35	6.3	5.2	3.2	3.3	4	2.9		
15	80	78.7	9	160	132.1	80	83.8	1.8	1.3	80	78.7	9	160	132.1	80	83.8	1.8	1.3		
3/4	3.5	3.6	0.49	6.7	5.4	3.2	3.3	4.4	3.7	3.5	3.6	0.49	6.7	5.4	3.2	3.3	4.4	3.7		
20	90	91.4	12.5	170	137.2	80	83.8	2	1.7	90	91.4	12.5	170	137.2	80	83.8	2	1.7		
1	4.3	4.4	0.68	7.9	7	3.9	4.7	7.3	6.4	4.3	4.4	0.68	7.9	7	3.9	4.7	7.3	6.4		
25	110	111.8	17.5	200	177.8	100	119.4	3.3	2.9	110	111.8	17.5	200	177.8	100	119.4	3.3	2.9		
1-1/4	5	4.7	0.88	9.3	8.3	4.7	5.9	11.9	15.9	5	4.7	0.88	9.3	8.3	4.7	5.9	11.9	15.9		
32	127	119.4	22.5	235	210.8	120	149.9	5.4	7.2	127	119.4	22.5	235	210.8	120	149.9	5.4	7.2		
1-1/2	6.1	6	1.14	9.3	8.4	5.5	5.9	17.4	14.9	6.1	6	1.14	9.3	8.4	5.5	5.9	17.4	14.9		
40	155	152.4	29	270	213.4	140	149.9	7.9	6.8	155	152.4	29	270	213.4	140	149.9	7.9	6.8		
2	6.7	6.8	1.37	11.4	10.3	6.7	6.7	23.8	23.4	6.7	6.8	1.37	11.4	10.3	6.7	6.7	23.8	23.4		
50	170	172.7	35	290	261.6	170	170.2	10.8	10.6	170	172.7	35	290	261.6	170	170.2	10.8	10.6		
Size in.	Class 1500 WB						Class 1500 BB													
	A	B	C	D	Wt.		A	B	C	D	Wt.									
1/2	3.5	4.4	0.35	0.39	6.5	8.1	3.2	4.9	4.2	4.4	3.5	4.4	0.35	0.39	6.5	8.1	3.2	4.9	4.4	4.4
15	90	111.8	9	9.9	165	205.7	80	124.5	1.9	2	90	111.8	9	9.9	165	205.7	80	124.5	2	2
3/4	4.3	4.4	0.43	0.51	7.7	8.1	4.7	4.9	7	8.4	4.3	4.4	0.43	0.51	7.7	8.1	4.7	4.9	7.3	8.4
20	110	111.8	11	12.95	195	205.7	120	124.5	3.2	3.8	110	111.8	11	12.95	195	205.7	120	124.5	3.3	3.8
1	4.7	5.1	0.57	0.66	9.3	9.4	5.5	6.2	12.1	9.3	4.7	5.1	0.57	0.66	9.1	9.4	5.5	6.2	12.1	9.3
25	120	129.5	14.5	16.76	235	238.8	140	157.5	5.5	4.2	120	129.5	14.5	16.76	230	238.8	140	157.5	5.5	4.2
1-1/4	5.1	5.9	0.75	0.9	10.4	10.2	5.5	6.2	17.6	17.6	5.1	5.9	0.75	0.9	10.2	10.2	5.5	6.2	19.8	17.6
32	130	149.9	19	22.86	265	259.1	140	157.5	8	8	130	149.9	19	22.86	260	259.1	140	157.5	9	8
1-1/2	6.7	6.8	1.06	1.18	11	11.4	6.7	6.2	24.2	29.1	6.7	6.8	1.06	1.18	11.2	11.4	6.7	6.2	26.4	29.1
40	170	172.7	27	29.97	280	289.6	170	157.5	11	13.2	170	172.7	27	29.97	285	289.6	170	157.5	12	13.2
2	8.3	8.7	1.22	1.49	13.2	13.3	6.7	7.1	39.6	37	8.3	8.7	1.22	1.49	13	13.3	6.7	7.1	39.6	37
50	210	220.9	31	37.85	335	337.8	170	180.3	18	16.8	210	220.9	31	37.85	330	337.8	170	180.3	18	16.8
Size in.	Class 2500 WB						Class 2500 BB													
	A	B	C	D	Wt.		A	B	C	D	Wt.									
1/2	4.3	0.43	7.7	4.7	8.6		4.3	0.43	10.6	4.7	11									
15	110	11	195	120	3.9		110	11	270	120	5									
3/4	4.7	0.55	8.9	5.5	14.1		4.7	0.55	10.8	5.5	17.6									
20	120	14	225	140	6.4		120	14	275	140	8									
1	5.1	0.75	10	5.5	19.9		5.1	0.75	11.4	5.5	23.5									
25	130	19	255	140	9		130	19	290	140	10.7									
1-1/4	8.3	0.94	12.8	6.7	44		8.3	0.94	15.4	6.7	52.8									
32	210	24	325	170	20		210	24	390	170	24									
1-1/2	8.3	1.1	13	6.7	48.4		8.3	1.1	16.3	10.2	70.4									
40	210	28	330	170	22		210	28	415	260	32									
2	9.5	1.42	14.6	10.2	61.6		9.5	1.42	16.7	10.2	81.4									
50	240	36	370	260	28		240	36	425	260	37									

Typical Bill of Materials (See page 12 for available materials.)

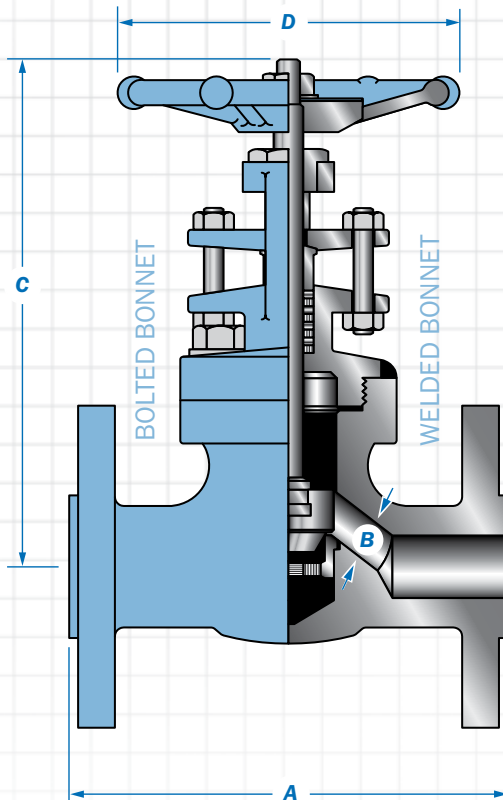
Component	Material	ASTM Spec	Component	Material	ASTM Spec
Body	Carbon Steel	A105N	Handwheel Nut	Carbon Steel	Commercial
Bonnet	Carbon Steel	A105N	Nameplate	Aluminum	Commercial
* Packing	Graphite W/Braided Carbon Fiber End Rings		Handwheel	Carbon Steel	Commercial
* Gasket	Stainless Steel 316 Graphite		Yoke Sleeve	Stainless Steel	AISI 416
Stem	Stainless Steel	A479-410	Gland Nuts	Carbon Steel	A194 2H
Disc	Stainless Steel	13 Chrome	Gland Flange	Carbon Steel	A105N
Seat Rings	Stainless Steel	A479-410	Gland Studs	Stainless Steel	AISI 410
Bonnet Bolt	Alloy Steel	A193 B7	Packing Gland	Stainless Steel	AISI 416
Washer	Carbon Steel	Commercial			

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

Forged Steel Flanged End Globes
Bolted & Welded Bonnet
Conventional Port
Class 150 thru 1500
Sizes: 1/2" thru 2" (1/4" & 3/8" available upon request)

Design and Manufacturing Standards

Valve Design: API 602
Flange Dimensions: ASME B16.5
Face-to-Face Dimensions: ASME B16.10
Tested in Accordance with: API 598
Recommended Spare Parts*



Class 150 thru 1500
Bolted & Welded Bonnet Flanged Globes

Size in. mm	Class 150 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	4.25	0.35	0.39	7.3	6.8	3.1	7	9.9		
15	108	9	9.9	185	173	80	3.1	4.5		
3/4	4.63	0.47	0.39	7.6	7.0	3.1	8	15.2		
20	118	12.5	9.9	192	178	80	4	6.9		
1	5.00	0.67	0.69	8.7	8.3	4.0	17	21.6		
25	127	17.5	17.5	220	211	100	5.7	9.8		
1-1/2	6.50	1.10	1.18	10.4	9.2	5.5	25	42.9		
40	165	29	30	265	234	140	10.6	19.5		
2	8.00	1.34	1.46	12.2	10.4	6.7	35	61.6		
50	203	35	37.1	310	264	170	15.4	28		
Size in. mm	Class 300 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	6.00	0.35	0.39	6.3	6.26	3.1	8	10.6		
15	152.5	9	9.9	160	159	80	3.5	4.8		
3/4	7.00	0.47	0.39	6.6	6.26	3.1	11	16.9		
20	178	12.5	9.9	168	159	80	4.8	7.7		
1	8.00	0.67	0.69	7.9	7.6	4.0	15	24.2		
25	203	17.5	17.5	200	193	100	7.2	11		
1-1/2	9.00	1.10	1.18	10.6	9.2	5.5	30	46.6		
40	229	29	30	268	234	140	14.5	21.2		
2	10.5	1.34	1.46	11.4	10.4	6.7	40	71.7		
50	267	35	37.1	290	264	170	18	32.6		
Size in. mm	Class 600 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	6.50	0.35	0.39	6.3	6.26	3.1	8.2	12.3		
15	165	9	9.9	160	159	80	3.7	5.6		
3/4	7.50	0.47	0.39	6.6	6.26	3.1	11.7	17.2		
20	190.5	12.5	9.9	168	159	80	5.3	7.8		
1	8.50	0.67	0.69	7.9	7.6	4.0	18.1	27.5		
25	216	17.5	17.5	200	193	100	8.2	12.5		
1-1/2	9.51	1.10	1.18	10.6	8.7	5.5	33.1	51.7		
40	241.5	29	30	268	221	140	15	23.5		
2	11.5	1.34	1.46	11.4	10.4	6.7	47.4	85.4		
50	292	35	37.1	290	264	170	21.5	38.8		
Size in. mm	Class 1500 BB & WB									
	A		B		C		D		Wt.	
	41	45	41	45	41	45	41	45	41	45
1/2	8.5	.43	0.5	8.86	8.1	4.72	3.93	22.0	17.6	
15	216	11	13	225	207	120	100	10.0	8.0	
3/4	9.0	.57	0.7	10.63	9.4	5.51	4.92	33.0	29.0	
20	229	14.5	18	270	240	140	125	15.0	13.2	
1	10.0	.75	0.9	11.22	10.2	5.51	6.29	37.4	38.3	
25	254	19	24	285	258	140	160	17.0	17.4	
1-1/4	11.0	-	1.1	-	11.4	-	6.29	-	42.0	
32	279	-	29	-	290	-	160	-	19.0	
1-1/2	12.0	1.22	1.4	15.75	13.3	6.69	7.08	79.2	54.0	
40	305	31	36.5	400	337	170	180	36.0	24.5	
2	14.5	1.48	1.8	16.54	14.0	10.24	9.45	121.0	68.2	
50	368	37.5	46.5	420	354	260	240	55.0	31.0	

Typical Bill of Materials (See page 12 for available materials.)

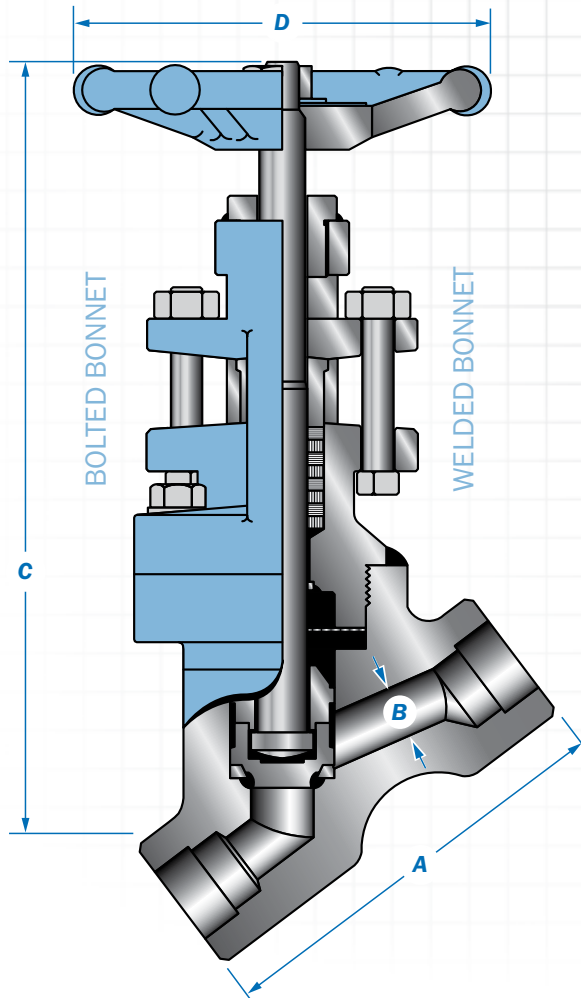
Component	Material	ASTM Spec
Body	Carbon Steel	A105N
Bonnet	Carbon Steel	A105N
* Packing	Graphite W/Braided Carbon Fiber End Rings	
* Gasket	Stainless Steel 316 Graphite	
Stem	Stainless Steel	A479-410
Disc	Stainless Steel	13 Chrome
Seat Rings	Stainless Steel	A479-410
Bonnet Bolts	Alloy Steel	A193 B7
Washer	Carbon Steel	Commercial
Handwheel Nut	Carbon Steel	Commercial
Nameplate	Aluminum	Commercial
Handwheel	Carbon Steel	Commercial
Yoke Sleeve	Stainless Steel	AISI 416
Gland Nuts	Carbon Steel	A194 2H
Gland Flange	Carbon Steel	A105N
Gland Studs	Stainless Steel	AISI 410
Packing Gland	Stainless Steel	AISI 416

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

**Forged Steel Y-Pattern
Bolted & Welded Bonnet Globe
Conventional Port
Class 800 thru 2680
Sizes: 1/2" thru 2" (1/4" & 3/8" available upon request)**

Design and Manufacturing Standards

Valve Design: ASME B16.34
Pipe Threads, General Purpose, Inch: ASME B1.20.1
Socket Welding: ASME B16.11
Tested in Accordance with: API 598
Recommended Spare Parts*



**Class 800
Bolted & Welded Bonnet Globe**

Size	A	B	C	D	Wt.
1/2	3.6	0.39	7.5	3.7	4.4
15	92	10	190	95	2
3/4	3.6	0.51	7.5	3.7	4.4
20	92	13	190	95	2
1	4.4	0.69	9.3	4.3	9
25	111	17.5	235	110	4.1
1-1/4	6	0.94	11.2	5.5	19.8
32	152	24	286	140	9
1-1/2	6	1.22	11.2	5.5	19.8
40	152	31	286	140	9
2	6.8	1.46	12.8	6.7	30.4
50	172	37	325	200	13.8

**Class 1500 & 1690
Welded Bonnet Globe**

Size	A	B	C	D	Wt.
1/2	3.9	0.51	7.3	3.9	6.6
15	100	13	185	100	3
3/4	4.3	0.69	9.1	5.5	8.8
20	110	17.5	230	140	4
1	4.9	0.89	9.4	5.5	11
25	125	22.5	240	140	5
1-1/4	5.9	1.1	12	6.7	20.9
32	150	28	305	170	9.5
1-1/2	6.3	1.38	13.4	7.9	24.2
40	160	35	340	200	11
2	7.5	1.73	15.7	10.2	37.4
50	190	44	400	260	17

**Class 2500 & 2680
Welded Bonnet Globe**

Size	A	B	C	D	Wt.
1/2	3.9	0.47	9.1	4.7	8.8
15	100	12	230	120	4
3/4	4.9	0.59	9.4	5.5	11
20	125	15	240	140	5
1	6.3	0.79	12	6.7	20.9
25	160	20	305	170	9.5
1-1/4	6.3	0.98	12	6.7	23.1
32	160	25	305	170	10.5
1-1/2	7.5	1.22	13.6	7.9	37.4
40	190	31	345	200	17
2	8.3	1.49	15.7	10.2	50.6
50	210	38	400	260	23

Typical Bill of Materials (See page 12 for available materials.)

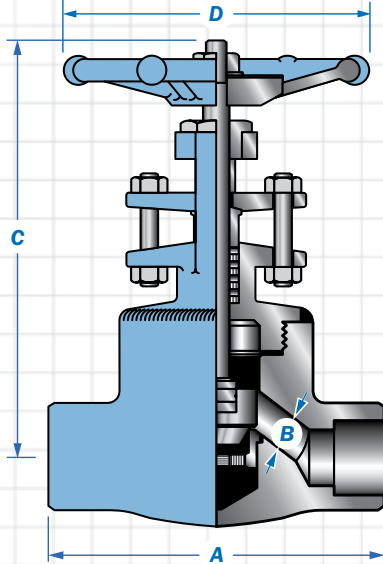
Component	Material	ASTM Spec	Component	Material	ASTM Spec
Body	Carbon Steel	A105N	Handwheel Nut	Carbon Steel	Commercial
Bonnet	Carbon Steel	A105N	Nameplate	Aluminum	Commercial
* Packing	Graphite W/Braided Carbon Fiber End Rings		Handwheel	Carbon Steel	Commercial
* Gasket	Stainless Steel 316 Graphite		Yoke Sleeve	Stainless Steel	AISI 416
Stem	Stainless Steel	A479-410	Gland Nuts	Carbon Steel	A194 2H
Disc	Stainless Steel	13 Chrome	Gland Flange	Carbon Steel	A105N
Seat Rings	Stainless Steel	A479-410	Gland Studs	Stainless Steel	AISI 410
Bonnet Bolts	Alloy Steel	A193 B7	Packing Gland	Stainless Steel	AISI 416
Washer	Carbon Steel	Commercial			

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

**Forged Steel High Pressure
Welded Bonnet Globe
Conventional Port
Class 4500
Sizes: 1/2" thru 2"**

Design and Manufacturing Standards

Valve Design: ASME B16.34
Pipe Threads, General Purpose, Inch: ASME B1.20.1
Socket Welding: ASME B16.11
Tested in Accordance with: API 598
Recommended Spare Parts*

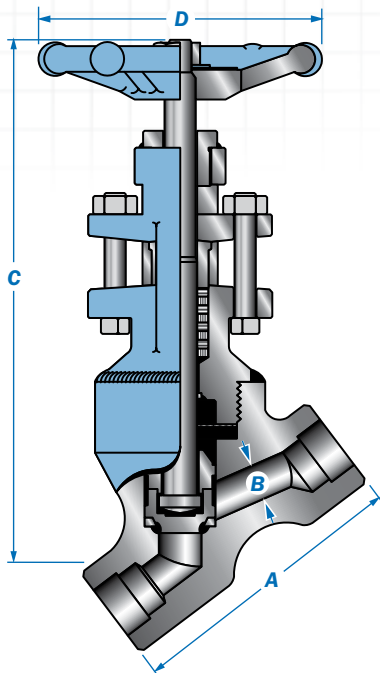


**Class 4500
Welded Bonnet Globe**

Size	A	B	C	D	Wt.
1/2	4.7	0.31	8.9	4.7	17.6
15	120	8	228	120	8
3/4	6.1	0.47	10.8	5.5	4
20	155	12	275	140	11
1	6.1	0.59	11	5.5	41.8
25	155	15	280	140	19
1-1/4	8.3	0.79	16.1	10.2	50.6
32	210	20	410	260	23
1-1/2	8.3	0.98	16.1	10.2	50.6
40	210	25	410	260	23
2	9.4	1.1	16.5	10.2	50.6
50	240	28	420	260	23

Typical Bill of Materials (See page 12 for available materials.)

Component	Material	ASTM Spec	Component	Material	ASTM Spec
Body	Carbon Steel	A105N	Handwheel Nut	Carbon Steel	Commercial
Bonnet	Carbon Steel	A105N	Nameplate	Aluminum	Commercial
* Packing	Graphite W/Braided Carbon Fiber End Rings		Handwheel	Carbon Steel	Commercial
* Gasket	Stainless Steel 316 Graphite		Yoke Sleeve	Stainless Steel	AISI 416
Stem	Stainless Steel	A479-410	Gland Nuts	Carbon Steel	A194 2H
Disc	Stainless Steel	13 Chrome	Gland Flange	Carbon Steel	A105N
Seat Rings	Stainless Steel	A479-410	Gland Studs	Stainless Steel	AISI 410
Bonnet Bolts	Alloy Steel	A193 B7	Packing Gland	Stainless Steel	AISI 416
Washer	Carbon Steel	Commercial			



**Class 4500
Welded Bonnet Y-Pattern Globe**

Size	A	B	C	D	Wt.
1/2	4.9	0.31	9.4	5.5	12.1
15	125	8	240	140	5.5
3/4	6.3	0.43	11.2	6.7	22
20	160	11	285	170	10
1	7.5	0.59	12.6	7.9	37.4
25	190	15	320	200	17
1-1/4	7.5	0.71	12.6	7.9	37.4
32	190	18	320	200	17
1-1/2	8.3	0.79	12.6	10.2	41.8
40	210	20	360	260	19
2	11	0.98	17.7	14.6	52.8
50	280	25	450	370	24

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

Rev: 042209

Newco[®]

Forged Steel Bolted & Welded Bonnet Check Valves

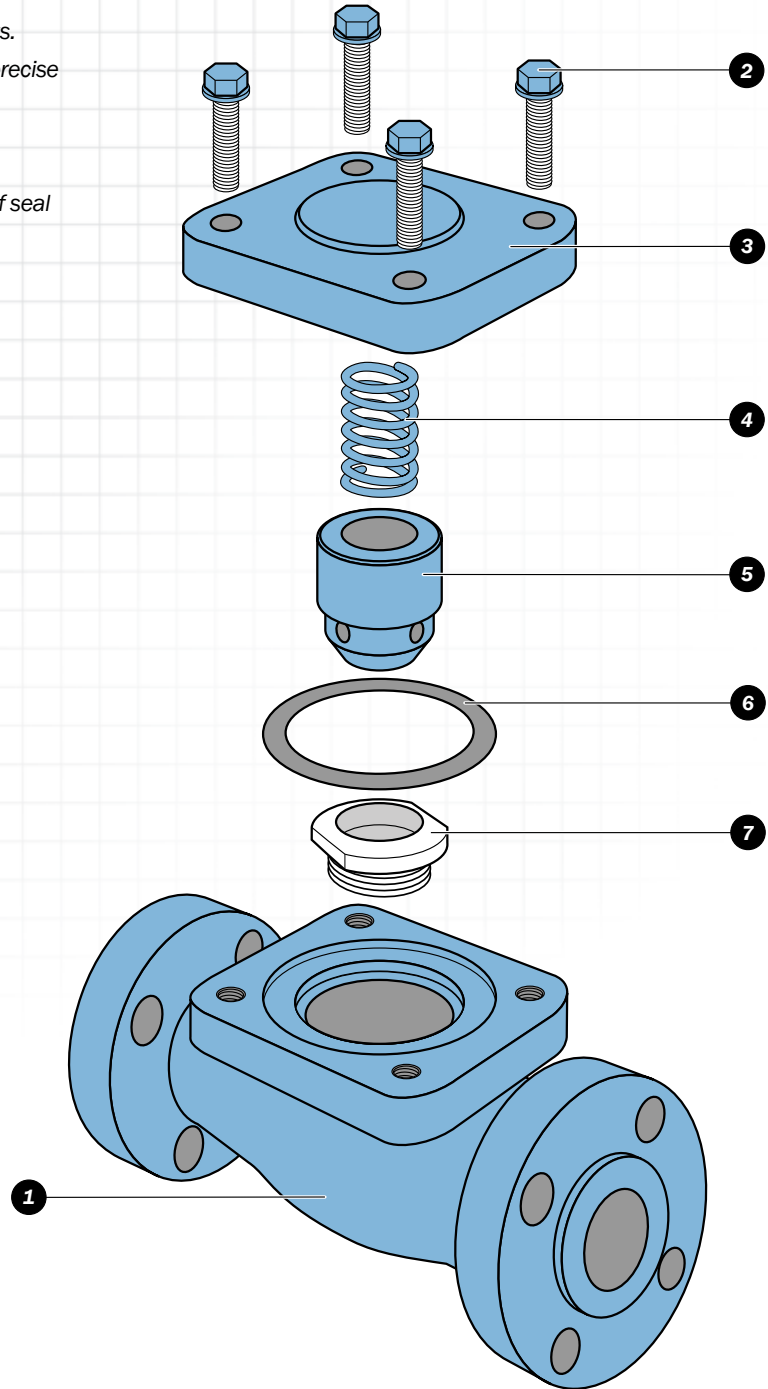
Manufactured by Newmans™

Sizes: 1/2" thru 2" • Pressure Class: 150 thru 1500



Typical Newco Forged Steel Bolted Check Valve Expanded View

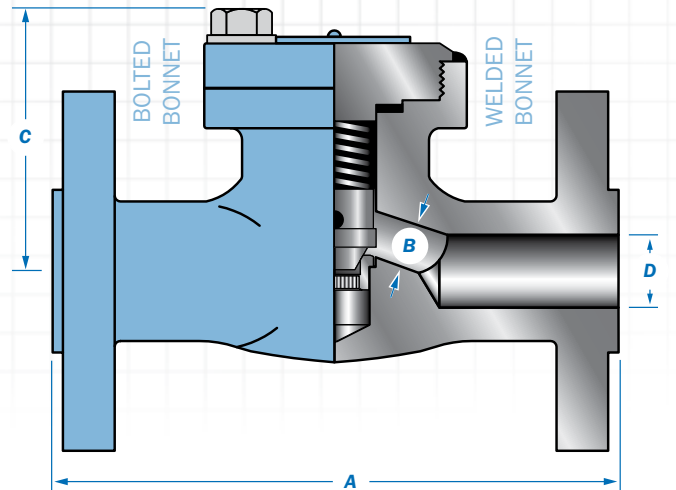
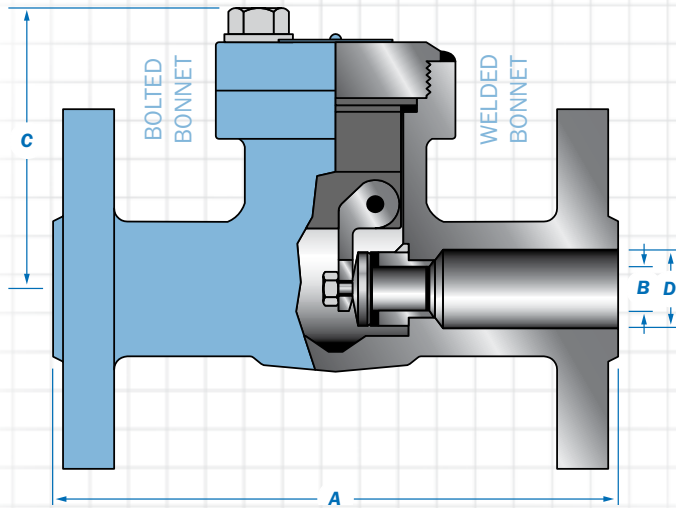
- 1. Body:** Newco forged steel bodies provide low resistance flow and optimum strength and performance.
- 2. Cover Studs:** The cover studs secure the bonnet to the body.
- 3. Cover:** The cover allows access to internal components.
- 4. Spring:** The spring is precision made and loaded for precise pressures.
- 5. Piston:** Newmans piston is machined to the tightest tolerances to ensure trouble free shutoff and cycling.
- 6. Cover Gasket:** The cover gasket creates a leak-proof seal between the bonnet and the body.
- 7. Seat:** The seat ensures a stable shutoff. The seat is precision ground for optimal seating.



Forged Steel Lift & Swing Checks
Bolted & Welded Cover
Conventional Port
Class 150 thru 1500
Sizes: 1/2" thru 2" (1/4" & 3/8" available upon request)

Design and Manufacturing Standards

Valve Design: ASME B16.34
Flange Dimensions: ASME B16.5
Face-to-Face Dimensions: ASME B16.10
Tested in Accordance with: API 598
Recommended Spare Parts*



Class 150 thru 1500
Bolted & Welded Bonnet - Lift & Swing Check

Size in. mm	Class 150										Wt.		
	A		B (lift)		B (swing)		C		D				
	41	45	41	45	41	45	41	45	41	45			
1/2	4.3		0.35		0.4		2.8	1.6	0.5	6.2			
15	108		9		10		70	40.6	12.7	2.8	3.4		
3/4	4.6		0.49		0.4		3.2	1.8	0.75	8.8			
20	118		12.5		10		80	45.7	19.1	4	4.4		
1	5		0.68		0.7		3.6	2.3	1	11.7			
25	127		17.5		18		92	58.4	25.4	5.3	8.2		
1-1/2	6.5		1.14		1.2		3.9	3.1	1.5	19.8			
40	165		29		29.5		100	78.7	38.1	9	12		
2	8		1.37		1.4		5.5	3.7	2	33			
50	203		35		36.5		140	94	50.8	15	14.3		
Size in. mm	Class 300										Wt.		
	A (lift)		A (swing)		B (lift)		B (swing)		C			D	
	41	45	41	45	41	45	41	45	41	45			
1/2	6		6		0.35		0.4		2	1.6	0.5	6.2	8.1
15	152.5		152.5		9		10		50	40.6	12.7	2.8	3.7
3/4	7		7		0.49		0.6		2.2	1.8	0.75	10.3	10.6
20	178		178		12.5		14		55	45.7	19.1	4.7	4.8
1	8		8.5		0.68		0.7		2.8	2.3	1	12.5	19.4
25	203		216		17.5		18		70	58.4	25.4	5.7	8.8
1-1/2	9		9.5		1.14		1.2		3.9	3.1	1.5	26	30.1
40	229		241		29		30		98	78.7	38.1	11.8	13.7
2	10.5		10.5		1.37		1.4		4.3	3.7	2	37.4	39.2
50	267		267		35		36.5		110	94	50.8	17	17.8
Size in. mm	Class 600										Wt.		
	A		B (lift)		B (swing)		C		D				
	41	45	41	45	41	45	41	45	41	45			
1/2	6.5		0.35		0.4		2	1.6	0.5	6.4	8.8		
15	165		9		10		50	40.6	12.7	2.9	4		
3/4	7.5		0.49		0.6		2.2	1.8	0.75	10.6	12.8		
20	191		12.5		14		55	45.7	19.1	4.8	5.8		
1	8.5		0.68		0.7		2.8	2.3	1	21.3	20.9		
25	216		17.5		18		70	58.4	25.4	9.7	9.5		
1-1/2	9.5		1.14		1.2		3.9	3.1	1.5	26.4	34.3		
40	241		29		30		98	78.7	38.1	12	15.6		
2	11.5		1.37		1.4		4.3	3.7	2	38.1	53.9		
50	292		35		36.5		110	94	50.8	17.3	24.5		
Size in. mm	Class 1500										Wt.		
	A		B (lift)		B (swing)		C		D				
	41	45	41	45	41	45	41	45	41	45			
1/2	8.5		0.43		0.6		3.5		0.5	16.7			
15	216		11		14		90		12.7	7.6			
3/4	9		0.57		0.7		4.1		0.69	23.8			
20	229		14.5		18		105		17.5	10.8			
1	10		0.74		0.9		4.7		0.87	31.9			
25	254		19		24		120		22.1	14.5			
1-1/2	12		1.22		1.4		6.3		1.37	68.2			
40	305		31		36		160		34.8	31			
2	14.5		1.48		1.6		6.7		1.87	94.6			
50	368		37.5		40		170		47.5	43			

Typical Bill of Materials

(See page 12 for available materials.)

Component	Material	ASTM Spec
Body	Carbon Steel	A105N
Seat Ring	Stainless Steel	A479-410
Piston	Stainless Steel	A479-410
Rivet	Brass	Commercial
Spring	Stainless Steel	A479-316
Nameplate	Aluminum	Commercial
* Gasket	Stainless Steel 316 W/Graphite Spiral Wound	
Cap	Carbon Steel	A105N
Cap Bolt	Alloy Steel	A193-B7

Note: Dimensions: Inches/Millimeters - Weights: Pounds/Kilograms. Larger sizes available on request. Dimensions are subject to change without notice.

Forged Steel Cv Values Gates, Globes, Checks

Newco Forged Steel Gate Valves Cv Values	NPS	150 - 800 Full Bore	150 - 800 Reduced Bore	1500 Full Bore	1500 Reduced Bore	2500 Full Bore
	1/2	12	6	13	6	5
	3/4	23	10	24	11	12
	1	43	26	44	27	23
	1-1/4	57	44	59	45	43
	1-1/2	98	65	100	66	56
	2	200	103	*	99	97

* 40mm = >155

Newco Forged Steel Globe Valves Cv Values	NPS	150 - 800 Full Bore	150 - 800 Reduced Bore	1500 Full Bore	1500 Reduced Bore
	1/2	3	2	3	2
	3/4	6	4	6	3
	1	12	6	12	6
	1-1/4	15	10	-	-
	1-1/2	21	18	20	16
	2	38	22	24	20

Newco Forged Steel Y-Pattern Globe Valves Cv Values	NPS	800	1500	2500
	1/2	5	5	3
	3/4	11	11	6
	1	14	15	12
	1-1/4	-	-	-
	1-1/2	37	35	27
	2	68	68	36

Newco Forged Steel Swing Check Valves Cv Values	NPS	150 - 800 Full Bore	150 - 800 Reduced Bore	1500 Full Bore	1500 Reduced Bore
	1/2	5	4	-	-
	3/4	12	6	-	-
	1	17	13	-	-
	1-1/4	26	18	-	-
	1-1/2	54	28	-	-
	2	101	55	-	-

Newco Forged Steel Lift Check Valves Cv Values	NPS	150 - 800 Full Bore	150 - 800 Reduced Bore	1500 Full Bore	1500 Reduced Bore
	1/2	3	1	3	2
	3/4	5	3	6	3
	1	11	6	11	5
	1-1/4	-	-	-	-
	1-1/2	18	15	19	11
	2	32	18	22	19

Table Applies to Both Piston and Ball Check Valves

Newco Forged Steel Y-Pattern Lift Check Valves Cv Values	NPS	800	1500	2500
	1/2	4	4	3
	3/4	11	11	6
	1	13	14	12
	1-1/4	-	-	-
	1-1/2	36	34	27
	2	67	67	36

Table Applies to Both Piston and Ball Check Valves

Limited Warranty

Newmans warrants to the original purchaser, for a period of one year from and after the date of delivery to the original customer, that its products will be free from defects in workmanship and materials, not caused or resulting from improper usage or application, improper installation, improper maintenance, repair modification or alterations.

In the event the original purchaser shall determine that a product purchased from Newmans shall be defective in workmanship or materials, the customer shall notify the Newmans Warranty Representative by telephone (713) 675-8631 within 24 hours from such determination, followed by written notice to such effect within 7 days therefrom, addressed to:

Newmans
1300 Gazin Street
Houston, Texas 77020

In the event Newmans shall determine that the product is defective as a result of factory workmanship, based upon such examination of the product which Newmans may deem appropriate, Newmans shall thereupon, at its sole option, (a) cause the defective product to be repaired, (b) replaced with a substantially identical product, or (c) accept the return of a defective product and refund the purchasing price to the original purchaser. Newmans shall bear all normal surface transportation costs to the original purchaser but shall in no event bear any installation, re-installation, engineering or other costs incurred in connection with repair or replacement.

Unless Newmans shall have provided engineering and/or suitability of application or installation services for a purchaser, for which a separate charge shall have been specifically identified and made, the selection, suitability, installation and fitness of all products sold by Newmans shall be deemed to have been determined exclusively by and within the sole discretion of the purchaser. Accordingly, Newmans disclaims any obligation, warranty or guarantee in any manner relating to or resulting from the selection, application, suitability, fitness or installation of its products.

The foregoing constitutes the sole obligation of Newmans with respect to defective products purchased from it and in no manner shall Newmans assume or be liable for any other expenses, incidental or consequential damages, losses, lost profits, down time or otherwise, whether directly or indirectly suffered, or in any other manner relating to or as the result of any defect or failure or any product that it may sell.

Except as otherwise provided herein, NEWMANS MAKES NO WARRANTIES OR REPRESENTATIONS, WHETHER EXPRESSED OR IMPLIED, OF ANY KIND WHATSOEVER WITH RESPECT TO GOODS AND PRODUCTS SOLD BY IT, INCLUDING WITHOUT LIMITATION, ANY WARRANTIES WITH RESPECT TO MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. NO PERSON IS AUTHORIZED TO GRANT OR EXTEND ANY WARRANTY OR REPRESENTATION ON BEHALF OF NEWMANS OTHER THAN AS SET FORTH HEREIN.

Industry Standards Typically Used in Valve Manufacturing

(For Reference Only)

ISO 9001: 2000
 RWTUV approved Newmans for design, manufacture, sales, & service of industrial valves under certificate registration number #08-1016
 ISO 14001: 2004

The Newmans/Yancheng Manufacturing Team has passed the TUV-USA ISO 14001:2004 Certification Audit. All facilities inclusive of two (2) Foundries (Lost Wax and Sand Cast), Ball Valve Factory, Final Processing Center and Warehouses 15 & 16.

American Petroleum Institute (API)

API RP 574 (1998) - Inspection practices for piping system components
 API 589 (1998) - Fire test for evaluation of valve stem packing
 API RP 591 (2003) - Process valve qualification procedure
 API 594 (2004) - Check valves-flanged, lug, wafer & buttwelding
 API 597 (1981) - Steel venturi gate valves, flanged, buttwelding ends
 API 598 (2004) - Valve inspection & testing
 API 599 (2002) - Metal plug valves - flanged, welding ends
 API 601 (1988) - Metallic gaskets for raised-face pipe flanges & flanged connections (double-jacketed corrugated & spiral wound)
 API 600 (2001) - Bolted bonnet steel gate valves for petroleum & natural gas industries "ISO adoption from ISO 10434"
 API 602 (2005) - Steel gate, globe, & check valves for sizes DN100 and smaller for the petroleum & natural gas industries
 API 603 (2001) - Corrosion-resistant, bolted bonnet gate valves-flanged & buttweld ends
 API 604 (1981) - Ductile iron gate valves, flanged ends
 API 605 (1988) - Large-diameter carbon steel flanges (nominal pipe sizes 26" through 60", classes 75, 150, 300, 400, 600, & 900 (replaced by ANSI/ASME B16.47)
 API 606 (1989) - Compact steel gate valves, extended body (included in API 602) fire test for soft-seated quarter-turn valves "ISO adoption from ISO 10497-5 2004"
 API 607 (2005) - Fire test for soft-seated quarter-turn valves "ISO adoption from ISO 10497-5 2004"
 API 608 (2002) - Metal ball valves, flanged, threaded, & welding ends
 API 609 (2004) - Butterfly valves-double flanged, lug- & wafer-type
 API RP 941 (2004) - Steel for hydrogen service at elevated temperatures & pressures in petroleum refineries & petrochemical plants
 API RP 520 (2000), Part 1 - Sizing, selection & installation of pressure relieving devices in refineries
 API RP 520 (2003), Part 2 - Sizing, selection & installation of pressure relieving devices in refineries devices in refineries
 API Spec 6A (2005) - Specification for wellhead & christmas tree equipment
 API Spec 6D (2005) - Specifications for pipeline valves
 API Spec 14D (1994) - Specifications for wellhead surface safety valves & underwater safety valves for offshore service
 API 5B (2004) - Threading, gauging thread inspection of coring, tubing, & line pipe threads
 API 6M (2003) - Material toughness
 API 6FA (1999) - Fire test for valves
 API 6FC (1999) - Fire test for valves with backseats
 API 6FD (1995) - Specification for fire test for check valves
 API Q1 (2003) - Specification for quality programs for the petroleum, petrochemical, & natural gas

American Society of Mechanical Engineers (ASME)

ASME Code (1997 addenda) - Boiler & pressure vessel code
 ASME A13.1 (1996) - Scheme for the identification of piping systems
 ASME B1.1 (2003) - Unified inch screw threads, UN, & UNR thread form
 ASME B1.5 (1997) - ACME screw threads
 ASME B1.7M (1984) - Nomenclature, definitions, & letter symbols for screw threads
 ASME B1.8 (1988) - Stub ACME screw threads
 ASME B1.12 (1987) - Class 5 interference - fit thread
 ASME B1.20.1 (1983) - Pipe threads, general purpose, inch
 ASME B1.20.3 (1976) - Dry-seal pipe threads, inch
 ANSI/ASME B16.1 (1998) - Cast iron pipe flanges & flanged fittings
 ANSI/ASME B16.5 (2003) - Pipe flanges & flanged fittings: NPS 1/2" through 24"
 ASME B16.9 (2003) - Factory made wrought steel buttwelding fittings
 ANSI/ASME B16.10 (2002) - Face-to-face & end-to-end dimensions of valves
 ASME B16.11 (2001) - Forged fittings, socket welding & threaded
 ASME B16.20 (1998) - Metallic gaskets for pipe flanges: ring joint spiral wound & jacketed
 ASME B16.21 (2005) - Non-metallic flat gaskets for pipe flanges
 ASME B16.25 (2003) - Buttwelding ends
 ANSI/ASME B16.33 (2002) - Manually operated metallic gas valves for use in gas piping systems up to 125 PSI (sizes NPS 1/2" through 2")
 ANSI/ASME B31.1 (2004) - Power piping
 ANSI/ASME B31.3 (2004) - Process piping
 ANSI/ASME B16.34 (2004) - Valves flanged, threaded & welding end
 ANSI/ASME B16.36 (1996) - Orifice flanges
 ANSI/ASME B16.38 (1985) - Large metallic valves for gas distribution (manually operated, NPS 2-1/2" through 12", 125 PSIG maximum)
 ANSI/ASME B16.42 (1998) - Ductile iron pipe flanges & flanged fittings: classes 150 & 300
 ANSI/ASME B16.47 (1996) - Large diameter steel flanges
 ANSI B17.1 (1967, R' 89) - Keys & keyseats
 ANSI B18.2.2 (1987) - Square & hex nuts
 ASME B31.4 (2002) - Pipeline transportation systems for liquid hydrocarbons & other ammonia & alcohols
 ANSI/ASME B31.8 (2003) - Gas transmission & distribution piping systems
 ANSI/ASME B36.10 (2004) - Welded & seamless wrought steel pipe
 ANSI/ASME B36.19 (2004) - Stainless steel pipe
 ANSI FC1-2 (1991) - Control valve seat leakage

American Society Non-destructive Test (ASNT)

ASNT-TC-1A (1996) - Recommended practice no. SNT-TC-1A 1996

American Society for Testing and Materials (ASTM)

British Standards Institute (BS)

BS 1414 (1975, R' 91) - Gate, wedge & double disk valves: steel
 BS 1868 (1975, R' 91) - Check valves: steel
 BS 1873 (1975, R' 91) - Globe & check valves: steel
 BS 2080 (1989) obsolete - Flanged & buttweld end steel valves
 BS 5146 - (withdrawn) Replaced by BS 6755 p.1 steel valves testing (1986) & BS 6755 p.2 (1984)
 BS 5152 (1974, R' 91) - Globe & check: cast iron
 BS 5153 (1974, R' 91) - Check: cast iron
 BS 5159 (1974, R' 91) - Ball: cast iron & carbon steel
 BS 5160 (1974, R' 91) - Globe & check: steel
 BS 5163 (1986, R' 91) - Gate, wedge & double disk: cast iron
 BS 5351 (1986, R' 91) - Ball: steel
 BS 5352 (1986, R' 91) - Globe & check: steel
 BS 5418 - (withdrawn) Replaced by BS EN 19 (1992) marking: general purpose industrial
 BS 5840 (1980, R' 91) - Valve mating details for actuator operation
 BS 6364 (1984, R' 91) - Cryogenic
 BS 6683 (1985, R' 91) - Guide: installation & use of valves
 BS 6755: Part 1 (1986, R' 91) - Specification for production pressure testing requirements
 BS 6755: Part 2 (1987) - Specification for fire type-testing requirements
 BS EN 19 (1992) - Marking of general purpose industrial valves

Canadian Standards Association

B51-97 - Boiler, pressure vessel, & pressure piping code
 Z245.15-96 - Steel valves
 CAN3-z299.4-85 (reaffirmed 1997) - Quality assurance program - Category 4
 CAN3-z299.3-85 (reaffirmed 1997) - Quality assurance program - Category 3

International Organization for Standardization

ISO 5211/1 (2001) - Industrial valves- part-turn actuator attachments
 ISO 5211/2 (2001) - Part-turn valve actuator attachment-flange & coupling performance characteristics
 ISO 5211/3 (2001) - Part-turn valve actuator attachment-dimensions of driving components
 ISO 5752 (1982) - Metal valves for use in flanged pipe systems face-to-face & center-to-face dimensions
 ISO 9000 (2005) - Quality management systems and fundamentals & vocabulary
 ISO 10012-1 (1992) - Quality assurance requirements for measuring equipment

Manufacturers Standardization Society

SP-6 (2001) - Standard finishes for contact faces of pipe flanges & connecting-end flanges of valves & fittings
 SP-9 (r2005) - Spot facing for bronze, iron & steel flanges
 SP-25 (1998) - Standard marking system for valves, fittings, flanges & unions
 SP-42 (2004) - Class 150 corrosion resistant gate, globe, angle, & check valves with flanged & buttweld ends
 SP-44 (2001) - Steel pipeline flanges
 SP-45 (2003) - Bypass & drain connections
 SP-51 (2003) - Class 150/w corrosion resistant cast flanges & flanged fittings
 SP-53 (2002) - Quality standard for steel castings & forgings for valves, flanges, & fittings & other piping components: magnetic particle exam method
 SP-54 (2002) - Quality standard for steel castings for valves, flanges, & fittings and other piping components: radiographic examination method
 SP-55 (2001) - Quality standard for steel castings for valves, flanges other piping components-visual method for evaluation of surface irregularities
 SP-60 (2004) - Connecting flange joint between tapping sleeves & tapping valves
 SP-61 (2003) - Pressure testing of steel valves
 SP-65 (2004) - High pressure chemical industry flanges & threaded stubs for use with lens gaskets
 SP-67 (2000A) - Butterfly valves
 SP-69 (2003) - ANSI/MSS edition pipe hangers & supports, selection & application
 SP-70 (1998) - Cast iron gate valves, flanged & threaded ends
 SP-71 (1997) - Gray iron swing check valves, flanged & threaded ends
 SP-72 (1999) - Ball valves with flanged or butt-welding ends for general service
 SP-79 (2004) - Socket-welding reducer inserts
 SP-81 (2001) - Stainless steel, bonnetless, flanged knife gate valves
 SP-82 (1992) - Valve pressure testing methods
 SP-84 (1990) - Valves - socket welding & threaded ends
 SP-85 (2002) - Cast iron globe & angle valves, flanged & threaded ends
 SP-86 (2002) - Guidelines for metric data in standards for valves, flanges, fittings & actuators
 SP-88 (r2001) - Diaphragm valves
 SP-91 (1992) - Guidelines for manual operation of valves
 SP-92 (1999) - MSS valve user guide
 SP-93 (r2004) - Quality standard for steel castings & forgings for valves, flanges & fittings & other piping components- liquid penetrant exam method
 SP-94 (r2004) - Quality standard for ferritic & martensitic steel castings for valves, flanges, & fittings and others piping components - ultrasonic exam method
 SP-96 (r2005) - Guidelines on terminology for valves & fittings
 SP-98 (2001) - Protective coatings for the interior of valves, hydrants, & fittings
 SP-99 (r2005) - Instrument valves
 SP-101 (r2001) - Part-turn valve actuator attachment-flange and driving component dimensions & performance characteristics
 SP-102 (r2001) - Multi-turn valve actuator attachment: flange and driving component dimensions & performance characteristics
 SP-110 (1996) - Ball valves threaded, socket-welding, solder joint, grooved, & flared ends
 SP-117 (2002) - Bellows seals for globe & gate valves
 SP-118 (2002) - Compact steel globe and check valves-flanged, flangeless, threaded & welding ends (chemical & petroleum refinery service)
 SP-120 (2002) - Flexible graphite packing system for rising stem steel valves (design requirements)
 SP-121 (R2002) - Qualification testing methods for stem packing for rising stem steel valves

National Association of Corrosion Engineers (NACE)

MR0175 (2005) - Sulfide stress cracking resistant metallic materials for oil field equipment
 MR0103 (2005) - Materials resistant to sulfide stress cracking in corrosive petroleum refining environments

Terms & Conditions

Definitions

1) Supplier

"Supplier" refers to NEWCO Valves LP dba NEWMANS, a Texas (USA) limited partnership, and all of its affiliated or related entities, including, but not limited to, its parent, subsidiary, affiliated companies, their officers, directors, employees and agents, individually and collectively.

2) Customer

"Customer," refers to all of the following:

- any party acting as agent for the Customer, the party ordering goods or services on behalf of himself, herself or itself and others;
- the person signing Supplier's credit application, service order, bill of lading, delivery receipt or ticket;
- the store, factory, warehouse, shipping company, accepting agent, contractor or subcontractor of the job site, store, warehouse, transportation company, accepting agent;
- the person accepting and/or ordering Supplier's goods and services acknowledges that he or she has the actual and apparent agency authority to bind the Customer and owner of the property the product will improve, to the terms and conditions of this agreement, all of whom are included in the term "Customer"; and
- the person paying the invoices of Supplier, signing Supplier's service orders, delivery tickets, bills of lading or other Supplier contracts, acknowledges that he or she is the agent of the Customer and/or any entity who is benefited by the Supplier's product, and that they are said person's agent.

3) Equipment

"Equipment" refers to any goods and service, item of supply or equipment or property ordered or purchased by Customer or the Customer's agent from Supplier or provided by Supplier, including, but not limited to: valves, pipe, fittings, product or general equipment, supplies, parts, materials, supplies and/or merchandise sold by Supplier or provided in connection with Supplier's provider capabilities or needed by Supplier to assist Supplier in the performance and delivery of its product to Customer, but "Equipment" excludes "Services" as defined below.

4) Services

"Service(s)" refers to all employees or agents furnished by Supplier as consultants and/or to perform any function, including the operation of equipment which performs any function, trucks or other merchandise necessary to perform any function when operated by Customer's employees or agents or the Supplier's employees or agents on Customer's job or to satisfy the Customer's order or orders.

5) Claims

"Claim(s)" refers to all of the following:

- any liability of Supplier to Customer; b) loss of equipment, time, money, or profit of Supplier; and c) claim, demand, cause of action, proceeding, damage to person, damage to personal or real property, damage and penalty, including attorney's fees, costs and expenses.

6) Price Book, Price List, Manual, & Credit Application

Customer agrees to be bound by all relevant provisions of the following:

- "Supplier's Price Book" and "Price Book" refer to the current book published by Supplier which may list the Supplier's contractual terms and conditions, lists prices for Equipment and Services offered by Supplier, including all amendments;
- "Supplier's Manual," "Manual" and "Employee Manual" refer to any manual of Supplier governing, which may contain its contractual terms and conditions, the procedures for pricing Equipment and Services of Supplier, or the manner in which Supplier is to provide goods or services plus all amendments and updates. Customer agrees to be bound by such terms and conditions, procedures; and
- "Supplier's Credit Application" and "Credit Application" refer to any application or request submitted by Customer to Supplier for the purpose of seeking the extension of credit by Supplier and which may contain the Supplier's terms and conditions all of which shall be binding on the Customer.

General Terms & Conditions

Customer acknowledges that it has reviewed and agrees to be bound by the above and following (Definitions, Terms and Conditions and all of the language contained herein and in related documents described elsewhere herein) whenever it or its employees, transportation and/or warehouse company, its customer or end user, and/or agent either: i) accepts the Equipment or Services of Supplier; or ii) signs a Credit Application, service order, delivery ticket, bill of lading or contract for goods or services; or iii) receives an invoice from Supplier and/or orders more Equipment or Services from Supplier.

1) Entire Contract

The Terms and Conditions herein, in the invoice, acknowledgement or acceptance of Customer's order, Price Book, Manual and Credit Application as defined above and elsewhere herein, the other documents aforementioned, all of which are incorporated herein by reference for all purposes, constitute the entire contract ("Contract") between the parties and may not be amended except in writing signed by Supplier's authorized representative.

2) Controlling Terms and Conditions

Equipment or Services furnished to Customer by Supplier or its agents will be controlled only by the Terms and Conditions contained herein and contained in the other documents of Supplier mentioned herein and these are the only terms and conditions to which these parties shall be bound. In the event that Customer writes any letters or uses any other document generated by Customer to order or accept Supplier's Equipment or Services, the Terms and Conditions contained herein shall control and this document does hereby serve as an objection thereto.

3) Failure of Any Party to Enforce

The failure of either party to enforce any provision hereof will not constitute a waiver or preclude subsequent enforcement thereof.

4) Invalidity of Any Term or Condition Contained Herein

No partial invalidity of this Contract will affect the remainder. In the event that any term or condition contained herein is found to be invalid, the parties agree that the remainder of Supplier's contract shall remain valid.

5) Jurisdiction and Venue; Construction of Terms and Conditions

The Parties hereto agree that the terms and conditions of Supplier's documents mentioned herein and the Terms and Conditions of this document shall be construed in accordance with the laws of the State of Texas or, if offshore, in accordance with General Maritime Law of the United States, without giving effect to respective conflicts of law principals, or Supplier at its exclusive option may choose the Jurisdiction to interpret the terms and conditions contained herein and in the other documents mentioned herein. In the event of litigation between Customer and Supplier, Customer hereby waives any claim it may have to any jurisdiction and venue other than that chosen by Supplier. Customer agrees that it is to perform its obligations herein in Houston, Harris County, Texas, non-exclusively to include payment. Canada: Whenever the facts of a particular contract would in the sole opinion of the Supplier be best litigated in Canada, the parties agree that Supplier can choose that jurisdiction and that Supplier can choose any venue it deems appropriate in Canada. All the other terms and conditions contained in this document shall then apply in Canada as if this agreement was in the United States of America.

6) Credit

Terms are cash in advance unless credit is approved in writing prior to the sale. If credit is approved, Customer must maintain credit satisfactory to Supplier. When Customer or its agent signs any of Supplier's documents in the process of ordering or receiving Equipment or Services from Supplier, it states for Supplier's reliance that it has the current ability to pay for the Equipment or Services ordered or accepted and it further agrees that Supplier reserves the right to require Customer to furnish security for performance of Customer's obligations. Payments shall be made in U.S. Dollars net 30 days at Supplier's address in Houston, Harris County, Texas. If credit terms are not met or Customer otherwise fails to follow the Terms and Conditions contained herein, in addition to its other legal rights, Supplier may and Customer hereby authorizes Supplier to: a) defer or cancel further shipments of Equipment or Services and/or otherwise decline to provide its product to Customer; b) enter upon any property or job site on which the Equipment of Supplier is located by taking any necessary action, including, but not limited to, opening gates, cutting locks, cutting chains; c) authorize any other company to remove its equipment from any location, to the extent needed for Supplier to be able to remove its equipment, and said company moving its equipment shall send its bill for the same to Customer or Supplier may pay said bill and include the same in its bill to Customer; d) take any action needed to remove its equipment from the job site; e) act as stated herein at the expense of Customer and Customer hereby indemnifies and holds harmless Supplier from any harm arising from said actions, including, but not limited to, environmental harm, harm to the real property and personal property and harm to the real and personal property of any third party; and f) charge Customer interest on any unpaid balance at the lesser of: i) eighteen percent (18%) per annum, or ii) the maximum rate permitted by applicable law.

7) Taxes

Customer shall be responsible for all customs fees, duties, and foreign, federal, state or local taxes (including, sales, use, excise or similar taxes and foreign withholding taxes).

8) Transportation

For Equipment sold, Customer may arrange shipment and will pay all crating, handling and shipping costs. Risk of loss passes to Customer at the time Customer and/or any carrier takes possession of the Equipment from Supplier. For Equipment sold where Customer does not timely furnish shipping instructions or requests that Supplier arrange shipment, such transportation shall be in a commercially reasonable manner at Customer's risk and invoiced to Customer at current freight rates, plus all handling incurred, or at the prevailing mileage rate for any vehicles used by Supplier's personnel. Risk of loss will then pass to Customer at the time the Equipment leaves Supplier's premises, warehouse or store. All claims for shortages, damages, corrections or deductions must be made in writing within 10 days from receipt of goods and if shipper fails to comply, it waives its right to make a claim.

9) Consequential and Incidental Damages

Supplier will not be responsible for consequential or incidental damages of any kind, which shall include, but not be limited to, loss of profits, use or business opportunity, damages for failure to meet deadlines, pollution damage and/or wreck or debris removal expense and Customer holds harmless and indemnifies Supplier from all harm arising from any claims made against Supplier from out of any of these things.

10) Force Majeure

Supplier will not be liable for any damages, including special and consequential damages, as stated above, caused by events of force majeure or any other occurrences beyond Supplier's reasonable control subject to all of the limitations contained herein. In such event, the time for performance will be extended automatically for such reasonable time as is necessary to permit performance hereof.

11) Disclaimer Of All Warranties Except Those Specifically Granted Herein Supplier hereby disclaims all warranties except those specifically granted and states as follows:

- Supplier makes no warranties of any kind regarding its equipment and/or services;
- technical information and any assistance in equipment installation or technical or engineering information concerning equipment or services provided by Supplier will be advisory only, at Customer's sole cost and on an "as is" basis;
- no warranty is given with respect to such services or information and Supplier will not be liable for any claims arising from its furnishing or Customer's use of such assistance or information;
- Supplier specifically disclaims all implied warranties, the warranty of merchantability, warranty of fitness for a particular purpose and any warranty that the equipment or service provided by Supplier will actually accomplish the goal(s) desired by Customer. Supplier grants to Customer only a limited warranty as follows: Supplier grants only to Customer only a 1-year warranty on material and workmanship on its new products commencing at date of shipment.

12) Insurance

The parties agree that the indemnities provided by Customer to Supplier herein shall be supported either by available insurance or that Customer shall voluntarily become self-insured, in whole or part and upon request of Supplier prove that Customer is good for the loss and that Customer is sufficiently self insured. In addition, Customer shall, at its expense, maintain adequate insurance to fully protect any Equipment or Services or personnel supplied by Supplier and shall supply to Supplier, upon request, satisfactory evidence of sufficient insurance coverage to protect Supplier, Supplier's property, Supplier's personnel and Supplier's liability.

13) Prices

All Supplier's, terms, conditions, prices, rates and charges are subject to change without notice.

14) Assignment

Customer may not assign any rights or obligations hereunder, without Supplier's prior written consent.

15) Amendment of Indemnities to Conform to Law

The indemnities provided by Customer herein shall be limited to the extent necessary for compliance with applicable state and federal laws.

16) Termination/Cancellation

Unless provided otherwise in writing herein, Customer cannot terminate or cancel any order once Supplier has accepted the order. No termination shall relieve Customer of any liability incurred and Customer's obligations shall survive such termination, including all hold harmless and all indemnities and all warranties & non-warranties contained herein which are made expressly for the benefit of Supplier.

- Termination Policy: No goods or products supplied pursuant hereto may be returned without Supplier's written permission. Supplier assumes no responsibility without Supplier's written permission. All returns shall be made freight prepaid. Supplier will charge to Customer a 25% Restocking Charge upon the return of goods by Customer.
- Special Orders: A special order is an order for any product of Supplier or which comes from Supplier's sources which is non standard requiring separate/additional manufacturing, engineering, modification, tooling and machining. If Supplier agrees in writing that a Special Order can be terminated, Special Orders cannot be cancelled unless Customer agrees in writing to pay for all work including engineering completed up to the time of cancellation.

17) Default

If Customer ever defaults on or breaches any Term or Condition contained herein or in any other document of Supplier mentioned above, all charges for all Equipment and Services provided by Supplier for Customer's benefit shall automatically accelerate and shall immediately become due and payable, notwithstanding any other provision which would afford Customer, under normal circumstances, any stated amount of time in which to pay for said charges. In addition, all discounts which may have been offered to Customer shall automatically and immediately be revoked and become fully due and owing with no action or notice from Supplier, notwithstanding any other provision to the contrary. If Customer ever disputes any charges of Supplier, Customer shall tender to Supplier all amounts for all charges which are not disputed by Customer. Customer hereby indemnifies and holds Supplier harmless for and agrees to reimburse Supplier for all costs of collections, including, but not limited to, actual attorney's fees and costs incurred in connection with the collection of past due amounts and defending against any counterclaims. Notwithstanding any other provision in this document or any other document or check, Customer agrees that all payments received by Supplier on Customer's account may be applied first to all outstanding interest and then to the oldest amounts owed by Customer to Supplier, and this provision is not waived by Supplier by accepting any check from Customer containing contrary language.

18) Customer Holds Harmless and Indemnifies Supplier

Customer shall hold harmless, defend, indemnify, release and hold Supplier harmless from and against any and all claims by Customer, Customer's customer, owner, or any other person or entity against Supplier of every kind or character, whatsoever, whether such claims are based on theories of contract law, tort law, or otherwise, direct or indirect, including incidental, special and consequential damages caused by Supplier arising out of delivery, pick-up, repair, use or operation of equipment or services relating to execution, completion or termination of this contract or on account of bodily injury or death or property damage, destruction or economic loss (including, but not limited to release of radioactive materials, contamination or damage to real property or personal property, land, buildings, vehicles, or property rights) because of purchase, delivery, installation, possession, operation, use, condition or return of goods, people, services and/or equipment used, purchased, or used during the term of this contract, or on account of infringement of any patent, design, copyright, or trade name or mark, whether by Supplier, Customer or otherwise, irrespective of whether Supplier was concurrently negligent or at fault for any such claims where the damage, injury or death was caused by the sole or partial negligence of Supplier.

19) Inspection

Customer's acceptance of delivery and signature of its representative on any delivery tickets or other Supplier documents is conclusive evidence that Customer found the Equipment to be suitable for its needs and in good condition and that the signor was the agent for Customer or Customer's Customer, building or land owner, contractor, sub contractor and operator. Customer also has a duty to inspect Equipment prior to use and to notify Supplier immediately of any defects and before use of the Supplier's product. SALE TERMS: The following are in addition to and a part of all other Terms and Conditions provided for herein.

20) Limited Liability/Disclaimer

- Supplier does warrant Equipment sold by Supplier to Customer to be free from defects in material or workmanship.
- In the event that a court finds that Supplier is liable for any breach of contract or any breach of warranty, Supplier's liability for said breach is expressly limited to the repair or replacement, at its sole option, of any Equipment which proves to be defective during any period declared by the court to be a period of warranty. All such Equipment shall be repaired or replaced F.O.B. Supplier's plant, warehouse, store or premises.
- In the event that a court finds that Supplier has an obligation to repair or replace equipment, said repair or replacement constitutes agreed and liquidated damages for any breach of Supplier's actual or court-declared warranty.
- The remedies stated above for any such breach thereof, shall be in lieu of all other

warranties, express or implied, including all other warranties for merchantability or fitness for any particular purpose which Supplier has specifically disclaimed herein, and in lieu of liability for Supplier's negligence or fault and Customer's rights and remedies under the Texas deceptive trade practices consumer protection act (chapter 17, Texas business and commerce code).

21) Prices

- Prices for standard equipment will be the sales price shown on Supplier's current product sales price list ("Price List") or Price Book, F.O.B. Supplier's plant, warehouse, district stock points, or premises.
- Requests for quotations for nonstandard Equipment should be sent to the appropriate Supplier office. Quoted prices are valid for 30 days after the date of the quotation, unless otherwise noted on the quotation or unless canceled by Supplier prior to Customer's acceptance.
- Cost of additional labor, materials or outside services for modification of such procedures or specifications requested by Customer will be charged to Customer at Supplier's prevailing rate.
- Services required to install Equipment will be based on the prevailing rates at the time of installation.

22) Delivery/Disclaimer

- Supplier will use its best efforts to have Equipment ready for shipment, subject to receipt of all necessary Customer information, including approved drawings. HOWEVER, SUPPLIER ASSUMES NO LIABILITY FOR DAMAGES INCURRED AS A RESULT OF ITS LATE DELIVERY OF EQUIPMENT, SUPPLIES, PRODUCT, PERSONAL PROPERTY, REGARDLESS OF CAUSE.
- Title and risk of loss will pass to Customer upon delivery of Equipment, F.O.B. Supplier's plant, warehouse or premises.
- If unable to deliver, Supplier may charge Customer its customary storage rates and Customer will maintain all-risk property insurance on Equipment, at its replacement value. Supplier will not be liable for deterioration of Equipment, personal property, product resulting from atmospheric conditions, acts of God, or other events regardless of whether they are within Supplier's reasonable control while in Supplier's possession or in transit to Customer's destination or location.

Service Terms

The following are in addition to and a part of all other Terms and Conditions provided for herein.

1) Limited Liability/Disclaimer

- Supplier will use its best efforts to ensure that all personnel furnished are competent and that Equipment, supplies, personal property or product furnished is in good condition; however, Customer agrees that the Equipment and personnel come without warranty or guarantee of any kind whatsoever except as provided herein.
- Supplier's personnel will attempt to perform the work requested by Customer; however, because of the nature of the work to be accomplished and because of the unpredictable conditions which always exist, such results as required by Customer or Customer's Customer cannot be and are not guaranteed or warranted and Customer agrees that Supplier makes no warranties of any kind and that Supplier does not guarantee any particular result as from furnishing people, goods, product, personal property, equipment or services.
- Supplier reserves the right not to do work if, in its sole discretion, job conditions render such action inadvisable for any reason or unsafe for any reason.
- Customer agrees that any employee(s) furnished by Supplier shall not be responsible for any final decision made on any job. Rather, Customer shall retain complete control and supervision of the job, building site, project and performance of operations in and about the job site.
- Customer shall pay Supplier for Equipment and Services regardless of whether the desired results are achieved without any deduction or offset of any kind, irrespective of any Claims which Customer may assert or allege against Supplier or any Supplier and/or manufacturer of Equipment and/or Services, at the rates indicated in the Customer's document, manual, delivery documents or Price Book in effect at the time of delivery.
- Customer will be invoiced at the sales rate or service rates in effect at the beginning of the invoice period.
- Supplier makes no warranty or representation of any kind, express or implied, as to the quality, performance or function of its people, as to the design, operation, condition or quality of the material or workmanship of equipment or performance of equipment delivered to Customer, it being agreed that all such risks as between Supplier and Customer are to be borne by Customer, regardless of whether such equipment is operated under Supplier's supervision, and all equipment, services and people are accepted by Customer "as is" except as provided elsewhere herein. Customers desiring different standards than those contained herein should, at Customer's expense, obtain an inspection of goods, services, equipment and people prior to use and the benefits of any and all implied warranties of Supplier are hereby waived by Customer except as elsewhere provided herein.

2) Charges

All charges are on a daily basis for a 24-hour day or any part stated therein.

- Services
 - all Services are on a daily or hourly basis, subject to any minimum charge, all of which are specified by Supplier in Supplier's documents mentioned herein;
 - charges begin when each Service person departs Supplier's store location where said person or Equipment is based and the charges shall continue until returned to that store;
 - Customer shall furnish quarters and meals for Supplier's personnel or reimburse Supplier for reasonable living expenses incurred at the prevailing rate from the time each Service person leaves the Supplier's location until return to Supplier's location;
 - if personnel and/or Equipment are dispatched at Customer's request, but are later canceled, Customer will be invoiced for a "dead call" as provided in the Price Book or other Supplier documents mentioned herein.
- Standby Charges: Standby rates may be applied under conditions specified in the Price Book.

3) Trade Discount

Trade discounts, if any, apply only to Equipment, goods, or services which are paid for within 30 days of the invoice date. In the event payment is not timely made, with time being deemed to be of the absolute essence, all discounts granted are automatically revoked and reversed on Customer's account and are fully due and owing.



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NDP-20 Specifications

3/4" Port Size (28 GPM Max. Capacity)

Port Dimensions

Intake & discharge connection:

Polypropylene (PPG)	3/4" Female NPT or 3/4" ANSI Flange B16.5 #150
Aluminum (ADC-12)	3/4" Female NPT
Stainless Steel (316)	3/4" Female NPT
Air inlet (incl. ball valve):	1/4" Female NPT
Air exhaust (incl. silencer):	3/4" Female NPT

Maximum Liquid Temperature*

Diaphragm Material	Temperature
Neoprene	180°F (82°C)
Buna N	180°F (82°C)
EPDM	212°F (100°C)
Hytrel	248°F (120°C)
Santoprene	225°F (107°C)
Viton	248°F (120°C)
Teflon (PTFE)	212°F (100°C)

*Polypropylene pumps have a maximum liquid temperature of 180°F (82°C) regardless of diaphragm material.

Air Supply Pressure (All Models)

20–100 PSI (1.4–7 kgf/cm)

Discharge Volume Per Cycle

Rubber diaphragm: 0.14 gallons (490 cc)
PTFE diaphragm: 0.10 gallons (290 cc)

Maximum Cycles Per Minute

Rubber diaphragm: 195
PTFE diaphragm: 195

Maximum Size Solid

1/16" (2.0 mm)

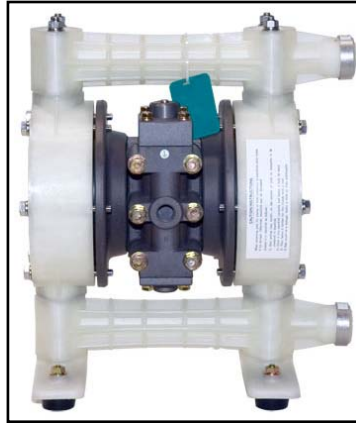
Maximum Dry Suction Lift

Rubber-fitted pump capability: 18-feet

Aluminum Air Motor—Standard

Optional: Epoxy-coated, Teflon-coated, or Electroless Nickel Plate

Notes: Hytrel-fitted pumps include Buna N check balls & wetted o-rings. Santoprene-fitted pumps include EPDM check balls & wetted o-rings.



Aluminum (NPT)

Dimensions:

9.80" W x 12.60" H

Net Wt.: 19.8 lbs. (9.0 kg)

Shipping Wt.: 23 lbs.

Polypropylene

ANSI Flange Dimensions:

12.44" W x 14.75" H

NPT Dimensions:

12.44" W x 14.50" H

Net Wt.: 29 lbs. (10.9 kg)

Shipping Wt.: 30 lbs.

Stainless Steel (NPT)

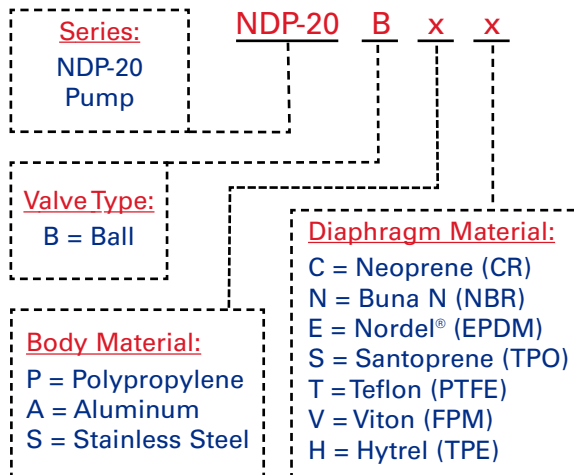
Dimensions:

9.80" W x 12.60" H

Net Wt.: 30.8 lbs. (13.9 kg)

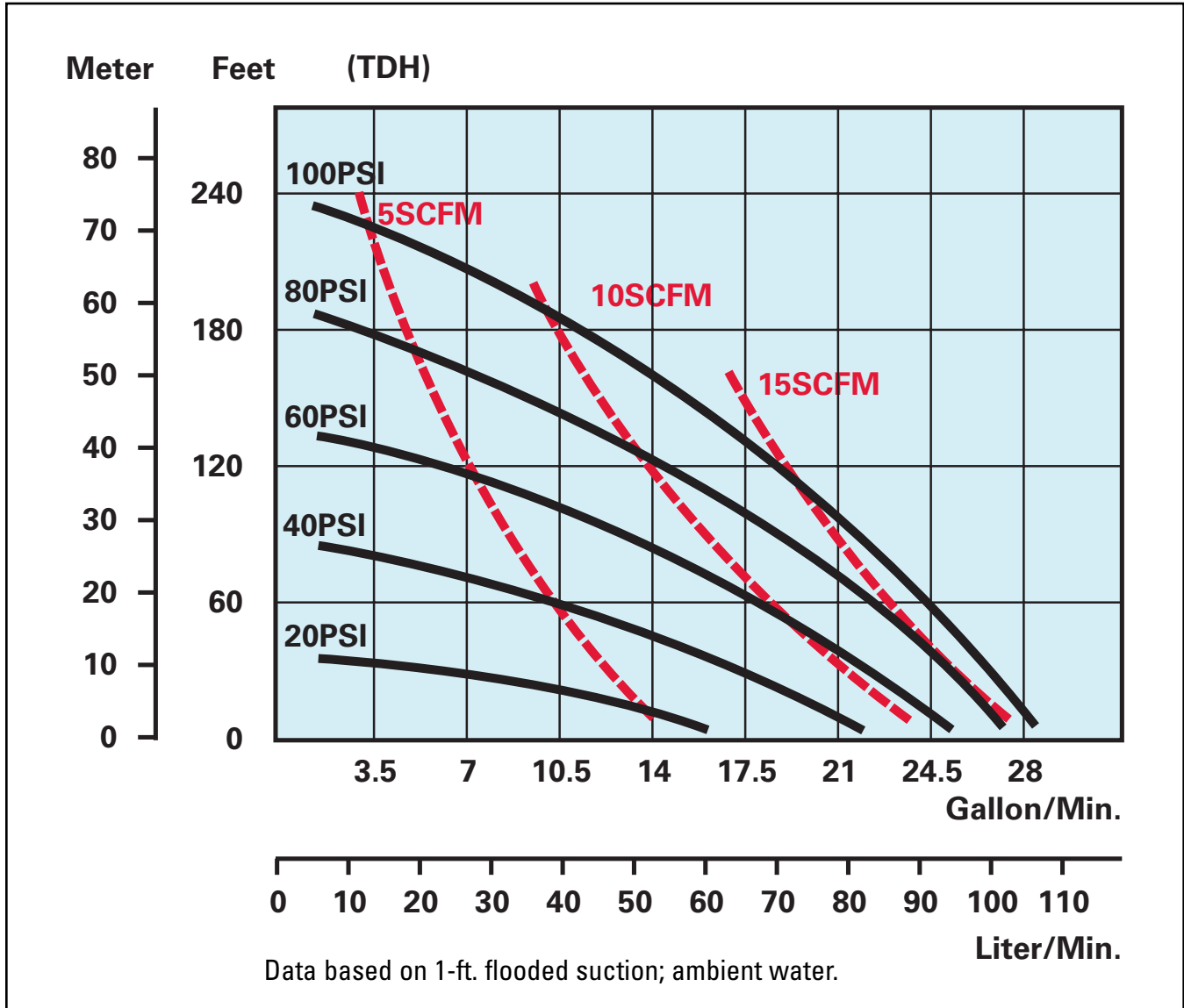
Shipping Wt.: 32 lbs.

Model Number Nomenclature



NDP-20 Performance Curve — Rubber

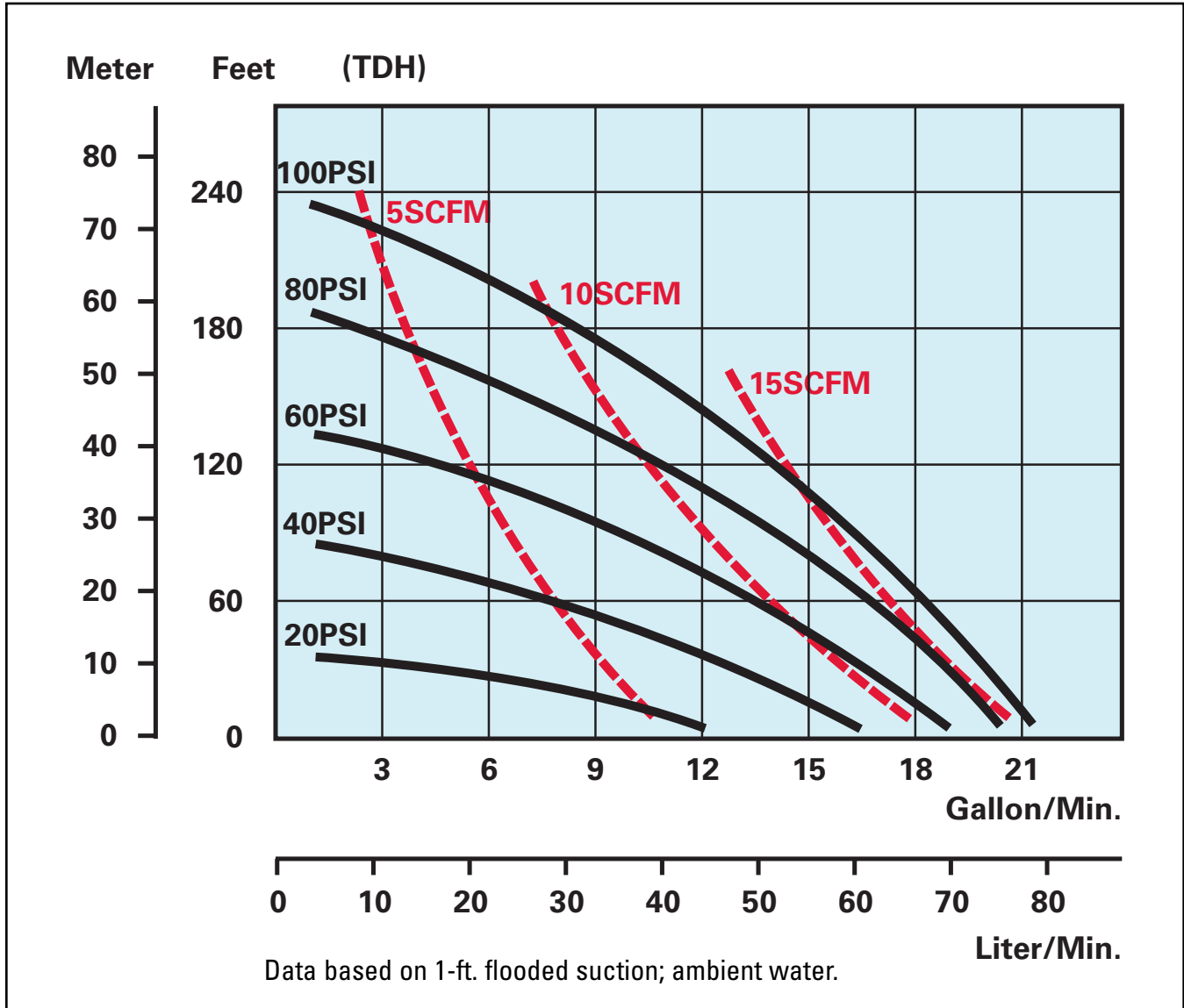
Rubber Diaphragm Performance Curve



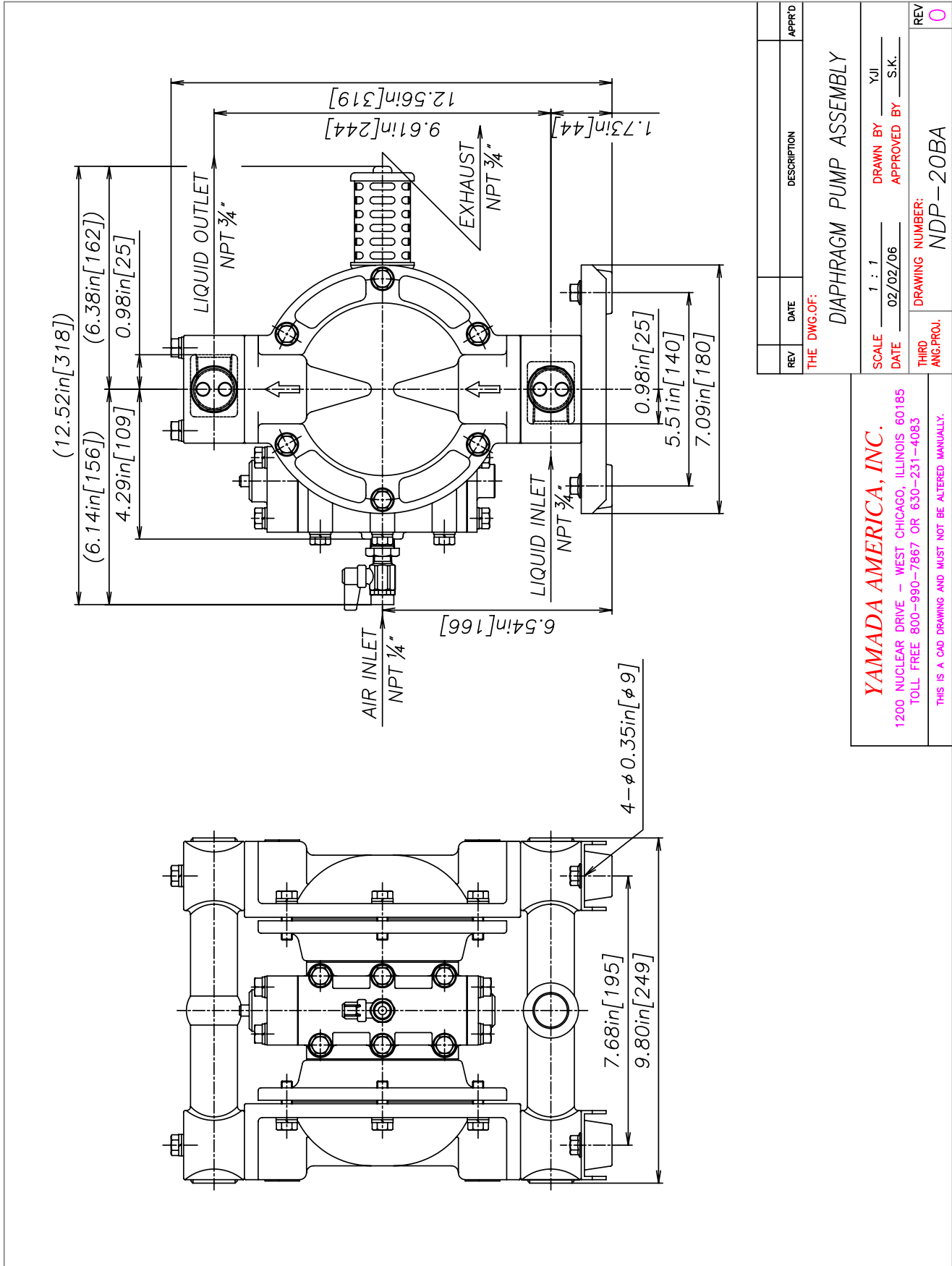
To calculate performance for Santoprene and Hytrel-fitted pumps, use Rubber Diaphragm Curve.

NDP-20 Performance Curve — PTFE

PTFE Diaphragm Performance Curve



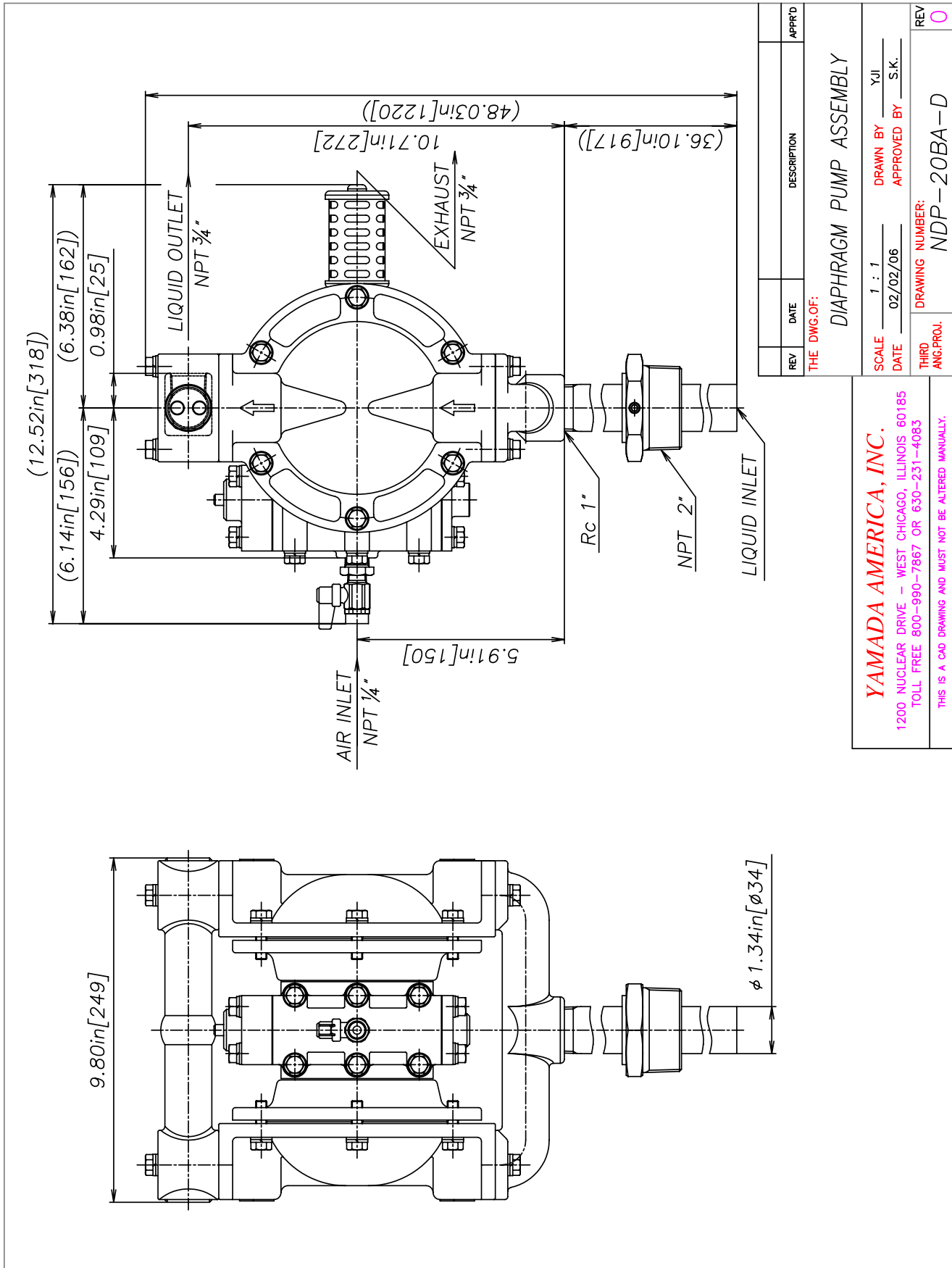
To calculate performance for Santoprene and Hytrel-fitted pumps, use Rubber Diaphragm Curve.



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DIAPHRAGM PUMP ASSEMBLY			
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DATE 02/02/06		APPROVED BY S.K.	
THIRD ANG.PROJ.	DRAWING NUMBER: NDP-20BA		REV 0

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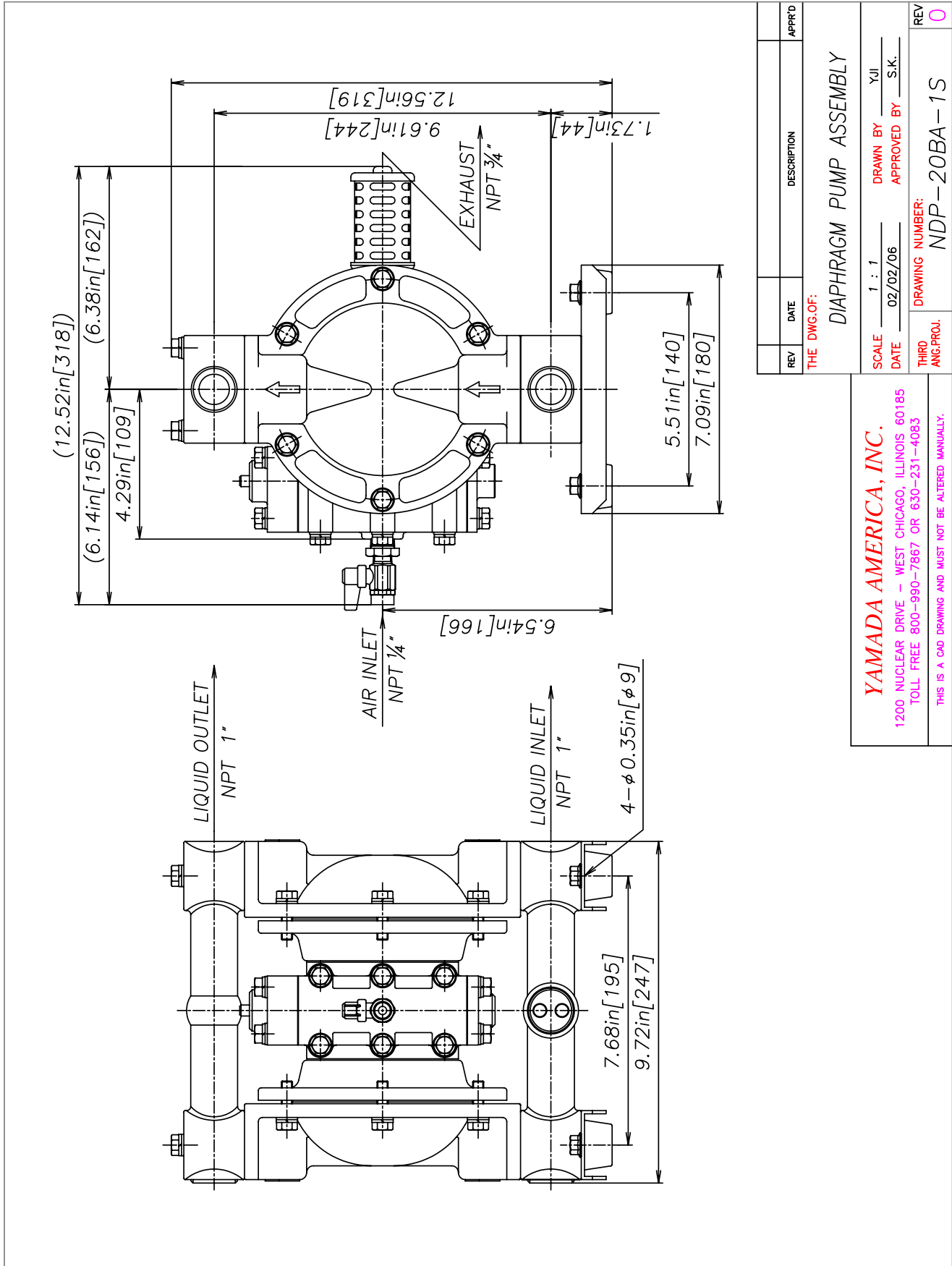


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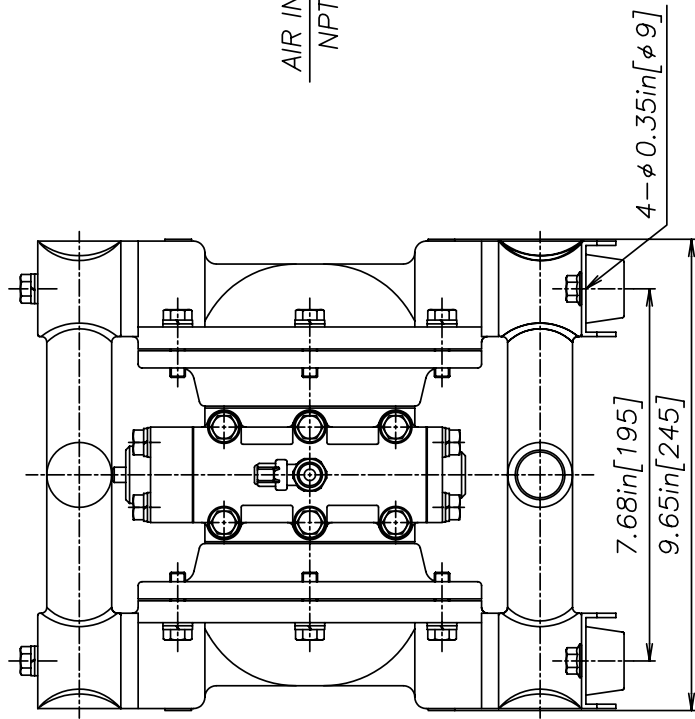
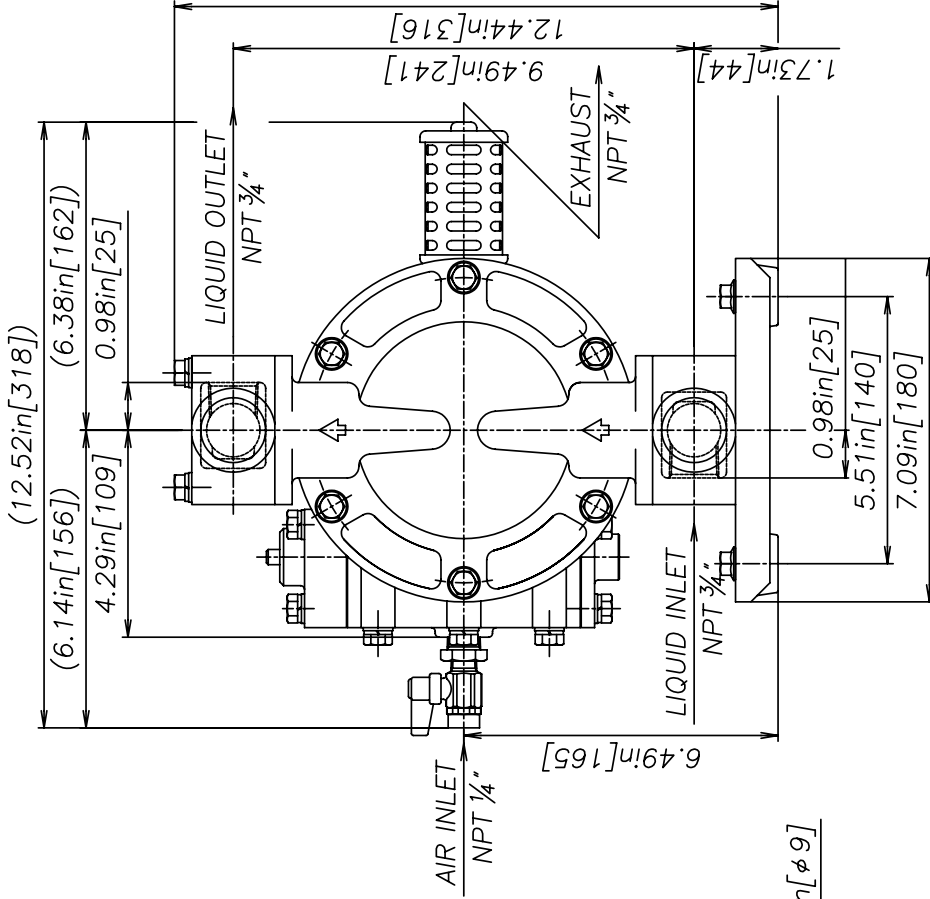




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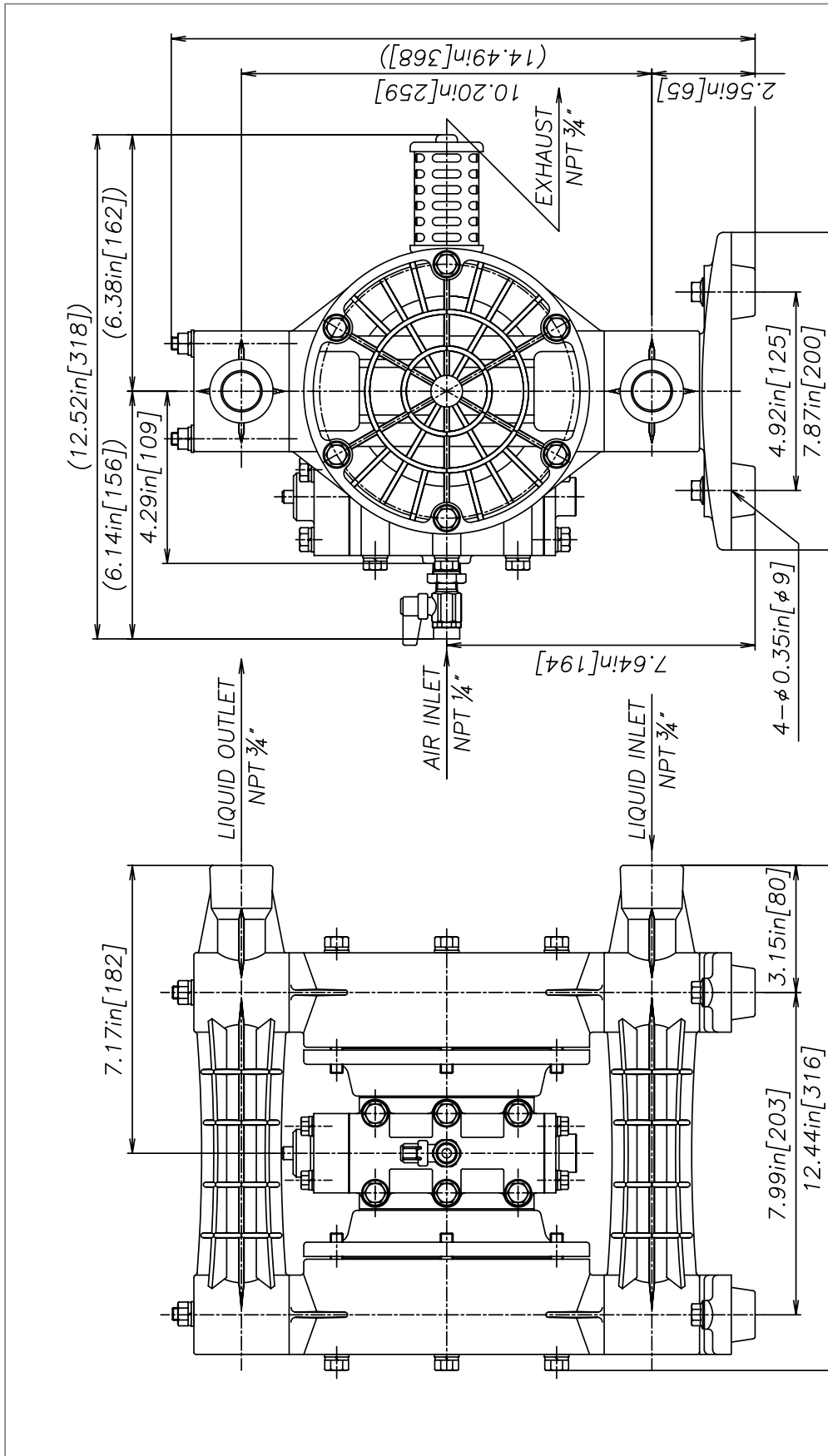
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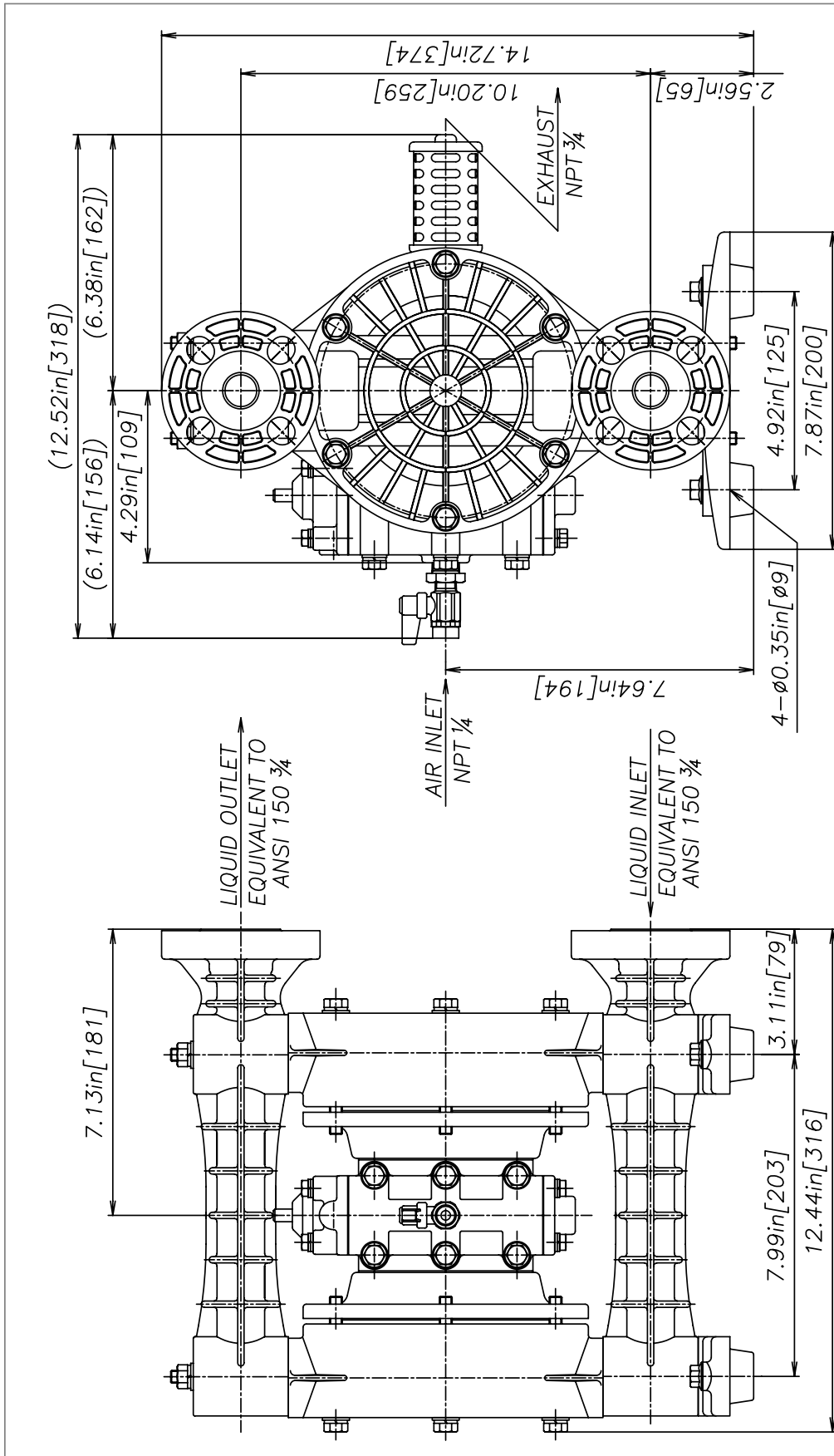
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Design D2 FloPro Control Valve

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W9235-1

Figure 1. Design D2 FloPro Control Valve

Introduction

Scope of Manual

This instruction manual provides installation, maintenance, and parts information for the NPS 1 Design D2 FloPro control valve and actuator **manufactured with lot numbers equal to and greater than 0410-xxxx.**

See Appendix A for information on packing constructions **manufactured with lot numbers less than 0410-xxxx.**

Do not install, operate, or maintain a Design D2 FloPro control valve without first • being fully trained and qualified in valve, actuator, and accessory installation, operation, and maintenance, and • carefully reading and understanding the contents of this manual. If you have any questions about these instructions, contact your Emerson Process Management™ sales office before proceeding.

Description

The Design D2 FloPro control valve (figure 1) is a compact, rugged valve designed for on-off control of a variety of fluids at pressures up to 155 bar (2250 psig). This valve is ideal for use as a dump valve on gas separators and scrubbers. It is also well suited for other high pressure applications in natural gas production, compression, and processing. The Design D2 FloPro valve has threaded end connections and is available in an NPS 1 globe style valve body.

Specifications

Table 1 lists specifications for the Design D2 FloPro control valve. Some of the specifications for a given control valve as it originally comes from the factory are stamped on a nameplate located on the upper diaphragm casing flange.



Table 1. Specifications

<p>Valve Assembly Pressure Class ASME B16.34 CL900</p> <p>Maximum Inlet Pressure and Temperature⁽¹⁾ 155 bar from -46 to 93°C, and 150 bar at 149°C. (2250 psig from -50 to 200°F, and 2185 psig at 300°F)</p> <p>Maximum Allowable Pressure Drop⁽¹⁾</p> <p>Flow Down⁽²⁾ <i>Maximum Inlet Pressure:</i> 155 bar (2250 psig) <i>Maximum Outlet Pressure:</i> 103 bar (1500 psig)</p> <p>Flow Up <i>Maximum Inlet Pressure:</i> 103 bar (1500 psig) <i>Maximum Outlet Pressure:</i> 103 bar (1500 psig)</p> <p>Shutoff Classification Class IV ANSI/FCI 70-2 and IEC 60534-4</p> <p>Construction Materials</p> <p>Valve Body and Bonnet: ASME SA 352 LCC Valve Plug and Seat: ■ R30006 (Alloy 6) or ■ S17400 double H1150 Valve Stem: S31600 O-Rings: HNBR (Hydrogenated Nitrile) Packing: PTFE/Carbon PTFE Packing Springs: N07718 Stem Bushing: PPS (polyphenylene sulfide) Actuator Diaphragm: Nitrile/Polyester Actuator Springs: Zinc-plated steel</p> <p>Flow Characteristic <i>FloPro</i> Characterized</p>	<p>Port Diameter 13 mm (0.5 inch)</p> <p>Maximum Travel 13 mm (0.5 inch)</p> <p>Approximate Weight 7.7 kg (17 lb)</p> <p>Material Temperature Capabilities</p> <p>Valve Body Assembly: -46 to 149°C (-50 to 300°F) Actuator Assembly: -46 to 93°C (-50 to 200°F)</p> <p>Bonnet/Body Connection Threaded with leakoff bleed</p> <p>Standard Actuator Configuration The <i>D2 FloPro</i> actuator is an on-off spring-and-diaphragm. Globe Valve Body: Supplied as either Air-to-Open or Air-to-Close.</p> <p>Maximum Actuator Casing Pressure 2.8 bar (40 psig)</p> <p>Minimum Required Actuator Casing Pressure 2.1 to 2.4 bar (30 to 35 psig)</p> <p>Actuator Diaphragm Effective Area 194 cm² (30 square inches)</p> <p>Actuator Pressure Connections 1/4 NPT internal</p>
---	--

1. The pressure or temperature limits in the referenced tables and any applicable ASME code limitations should not be exceeded.
2. Standard flow direction.

Note

Neither Emerson, Emerson Process Management, nor any of their affiliated entities assumes responsibility for the selection, use and maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

sure what these conditions are, you should contact your Emerson Process Management sales office for more complete specifications.

1. Before installing the valve, inspect it to be certain that the valve body cavity is free of foreign material. Clean out all pipelines to remove scale, welding slag, and other foreign materials.

2. The control valve assembly may be installed in any orientation unless limited by seismic criteria.

The standard flow direction is indicated by the arrow on the valve body.

3. Use accepted piping practices when installing the valve in the pipeline.

4. If continuous operation is required during inspection or maintenance, install a three-valve bypass around the control valve assembly.

Installation

 **WARNING**

Always wear protective gloves, clothing, and eyewear when performing any installation operations to avoid personal injury.

Personal injury or equipment damage caused by sudden release of pressure may result if the valve assembly is installed where service conditions could exceed the limits given in table 1 or on the appropriate nameplates. To avoid such injury or damage, provide a relief valve for overpressure protection as required by accepted industry or local, state, and Federal codes and good engineering practices.

Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

If installing into an existing application, also refer to the WARNING at the beginning of the Maintenance section in this instruction manual.

CAUTION

This valve is intended for a specific range of pressures, temperatures, and other service conditions (see table 1). Applying different pressure, temperature, and other conditions to the valve could result in parts damage, malfunction of the valve, or loss of control of the process. *Do not expose this valve to service conditions or variables other than those for which this valve is intended.* If you are not

Note

The NPS 1 Design D2 FloPro valve is equipped with ENVIRO-SEAL® D2 packing.

The actuator is available from the factory as either air-to-open or air-to-close.

Additionally, the actuator as shipped from the factory, has the FloPro flow adjuster set at a 0.375 inch port flow rate position. If some other flow rate is desired, see the Setting Valve FloPro Flow Adjuster section in this manual.

Setting Valve FloPro Flow Adjuster

Air-to-Open Actuator Action

1. To change the valve flow rate, loosen the flow adjuster socket head cap screws (key 29), and reposition the flow adjuster halves (key 14 and 15) to the desired flow rate position. See figure 2 for flow rate settings.

Air-to-Close Actuator Action

1. Attach a pressure line to the actuator. Supply pressure to the actuator to seat the plug in the seat ring.

2. To change the valve flow rate, loosen the flow adjuster socket head cap screws (key 29), and reposition the flow adjuster halves (key 14 and 15) to the desired flow rate position. See figure 2 for flow rate settings.

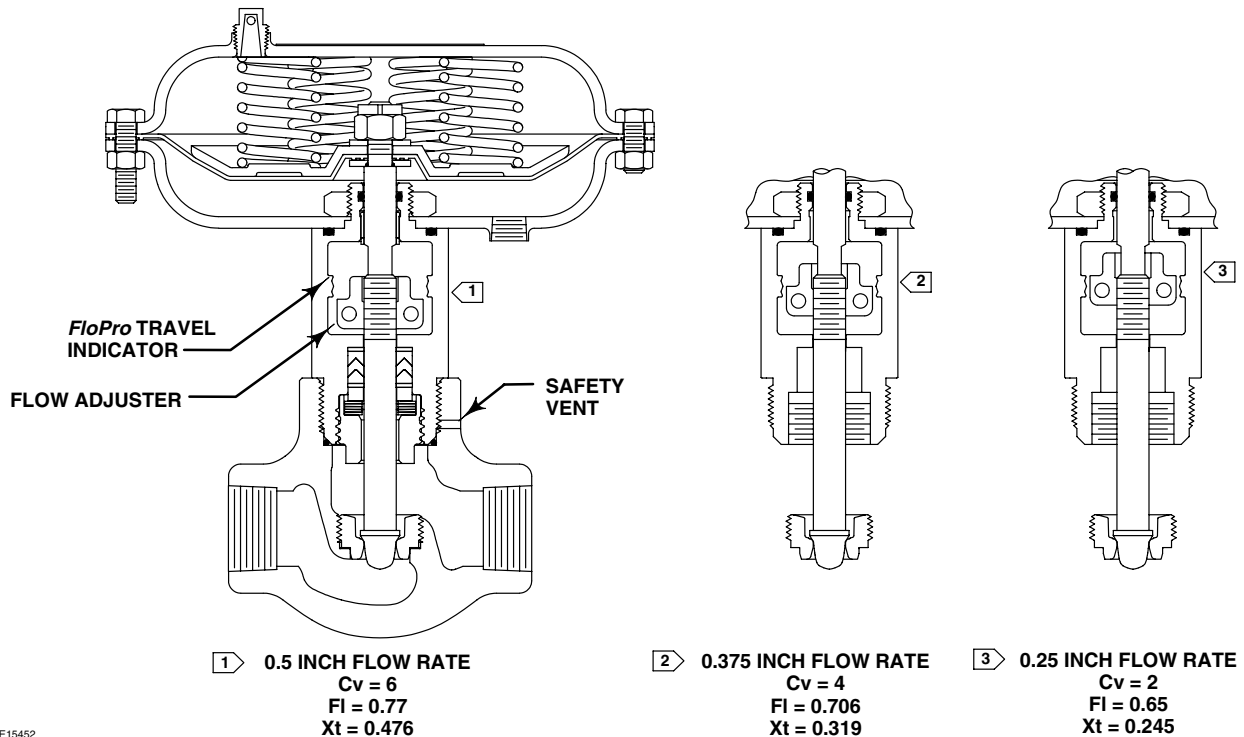


Figure 2. Flow Rate Adjustments

Changing Actuator Action from (Air-to-Open) to (Air-to-Close)

Key numbers are referenced in figures 6 and 7.

WARNING

To prevent possible personal injury or property damage from removing the casing cap screws in the wrong sequence, follow the procedure as outlined below for removing the upper casing.

1. Remove the six **short** actuator casing cap screws (key 22) first. Once these have been removed from the actuator assembly, remove the two **long** actuator cap screws (key 30) by alternating between them as you loosen them, to keep the upper casing (key 21) level during this procedure.

Note

Be aware as you loosen and remove the actuator cap screws that the

actuator springs are under compression.

2. Remove the upper casing (key 21) and the springs (key 27).
3. Do not turn the valve stem (key 4) while removing the diaphragm hex nut (key 26). Keep the stem from turning by using an open end wrench on the machined flats located on the valve stem above the flow adjuster for this procedure. Continue the actuator disassembly by removing the washer (key 24) diaphragm plate (key 25), diaphragm (key 19), washer (key 36), and O-ring (key 37). Inspect the diaphragm for any wear or damage. Replace with a new one if necessary.
4. Unscrew the socket head cap screws (key 29), and remove the flow adjuster halves (key 14 and 15). Position the stem (key 4) to its most upward position.
5. Place 2 of the springs (key 27) from the actuator into the bottom casing (key 20), equally spaced, 180 degrees apart. Place the washer (key 36) over the valve stem, as shown in view A of figure 7. Then place the O-ring (key 37) over the valve stem. Next install the diaphragm plate (key 25) and, using the

diaphragm plate, correctly position the actuator springs.

6. Place the diaphragm (key 19) over the stem, along with washer (key 24). Position the diaphragm so the holes in the diaphragm align with the holes in the bottom casing.

7. Insert a 1/8 inch diameter drift punch, or other suitable device through the 5/32 inch diameter hole in the valve stem located below the bottom of the previously removed flow adjuster. Install hex nut (key 26) and tighten to 10 N•m (90 lbf•in). Use the 1/8 inch drift punch or other holding device to turn the stem to align the holes of the diaphragm (key 19) to the lower casing (key 20).

8. Position the upper casing and install the two **long** cap screws (key 30) opposite one another. Install the six shorter cap screws (key 22) and the hex nuts, tightening the actuator casing cap screws evenly using a cross-tightening procedure. Torque to 10 N•m (8 lbf•ft).

9. Connect a pressure line to the top actuator pressure connection, and apply pressure to the actuator. Stroke the actuator until the valve plug is seated on the seat ring. Install the flow adjuster, positioning it to the desired travel. Tighten the flow adjuster socket head cap screws to 3 N•m (26 lbf•in).

10. Release the actuator pressure, and install the vent plug (key 28) into the bottom casing pressure connection.

Maintenance

Valve parts are subject to normal wear and must be inspected and replaced as necessary. Inspection and maintenance frequency depends on the severity of service conditions. This section includes instructions for packing and trim maintenance, and replacing actuator parts.

All maintenance operations can be performed with the valve in the line.

Note

Whenever a gasket seal or O-ring is disturbed by removing or shifting gasketed parts, a new gasket should be installed upon reassembly. This is necessary to ensure a good gasket seal, since the used gasket or O-ring will not seal properly.

WARNING

Avoid personal injury from sudden release of process pressure. Before performing any maintenance operations:

- **Always wear protective gloves, clothing, and eyewear when performing any maintenance operations to avoid personal injury.**

- **Disconnect any operating lines providing air pressure or a control signal to the actuator. Be sure the actuator cannot suddenly open or close the valve.**

- **Use bypass valves or completely shut off the process to isolate the valve from process pressure. Relieve process pressure on both sides of the valve. Drain the process media from both sides of the valve.**

- **Use lock-out procedures to be sure that the above measures stay in effect while you work on the equipment.**

- **The valve packing box may contain process fluids that are pressurized, even when the valve has been removed from the pipeline. Process fluids may spray out under pressure when removing the packing hardware or packing rings.**

- **Check with your process or safety engineer for any additional measures that must be taken to protect against process media.**

Valve Trim Maintenance

Note

The following maintenance procedures apply to both air-to-open and air-to-close actuator configurations, except for steps 2 and 8 as noted.

Key numbers are referenced in figures 6 and 7.

1. Isolate the control valve from the line pressure, release pressure from both sides of the valve body, and drain the process media from both sides of the valve.

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2. **For air-to-open actuator action only**, apply pressure to the actuator to fully stroke it open. This will raise the plug off its seat so that the valve stem serrations are visible inside the flow adjuster window (see figure 3). Loosen the socket head screws (key 29) and lower the flow adjuster (key 14 and 15) to its lowest position on the valve stem. Retighten the socket head screws (key 29) to 3 N•m (26 lbf•in). Relieve pressure to the actuator, shut off all pressure lines to the actuator, and disconnect. Use lockout procedures to be sure that the above measures stay in effect while you work on the equipment.

CAUTION

The preceding step is intended to prevent damage to the valve plug (key 3) and seat ring (key 5) during the removal of the bonnet and actuator.

3. Unscrew the bonnet from the valve body.



WARNING

Avoid personal injury from sudden release of process pressure. If the process media starts to escape from the safety vent (see figure 2) located in the bonnet neck of the valve body,

STOP DISASSEMBLY IMMEDIATELY!

The escape of process media indicates that the valve has NOT been isolated from the process media, or process pressure is trapped in the valve body.

Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

4. Once the bonnet has been removed from the valve body, inspect the seat ring (key 5) for wear or damage. If the seating surface has been damaged, remove it from the valve body. Also remove the seat ring gasket (key 6). Clean and inspect the valve body gasket surface for damage. Visually inspect the

valve body interior below the seat ring for erosion. Replace the valve body if necessary.

To replace the seat ring, first install a new seat ring gasket. Install the new seat ring and tighten to 230 N•m (170 lbf•ft).

Cover the opening in the valve body to prevent foreign material from getting into the valve body cavity.

5. Inspect the valve stem for scratches or wear, and valve plug for wear or damage. Replace if necessary.

6. If the valve plug requires replacement, use an open end wrench on the machined flats located on the valve stem above the flow adjuster and unscrew the valve plug from the valve stem. Replace it with a new valve plug. Screw the valve plug into the valve stem, being careful not to damage the plug seat or plug contour. Tighten to 18 N•m (13 lbf•ft).



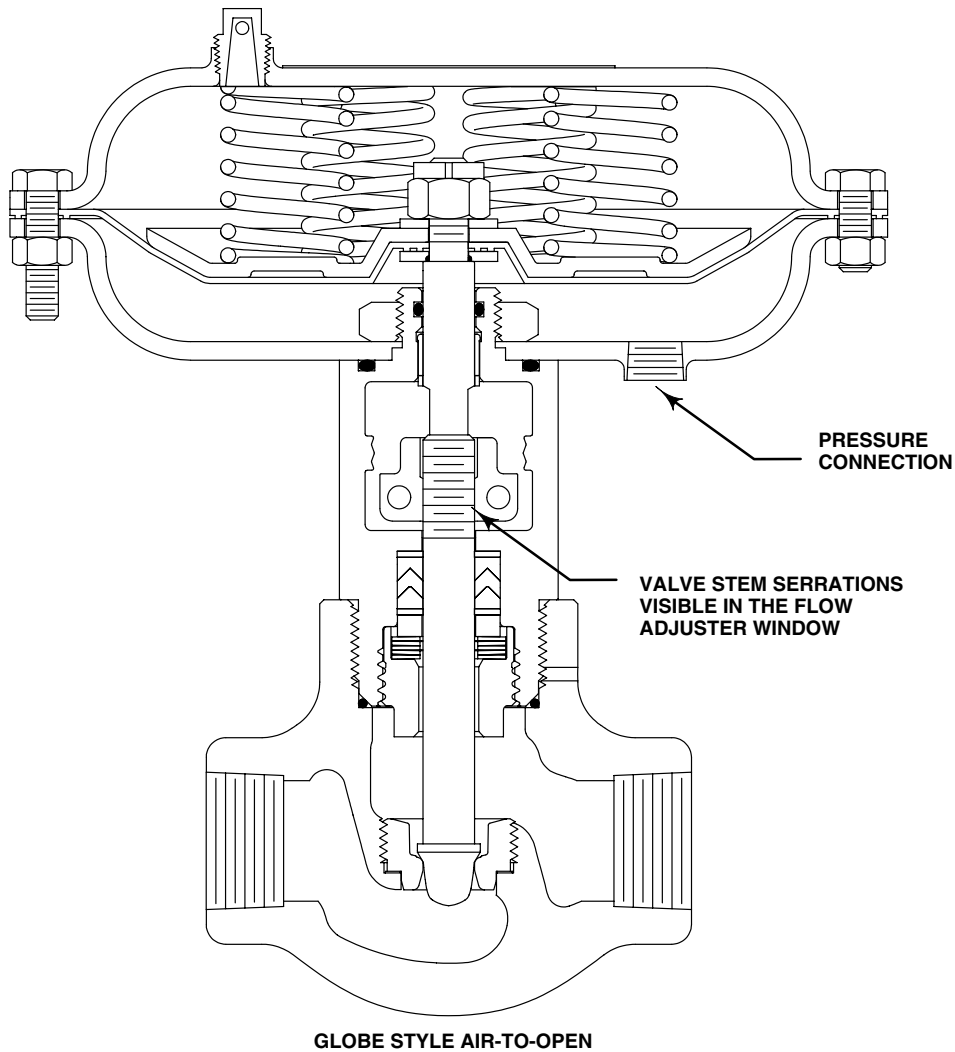
WARNING

Upon reassembly, ensure that no foreign material blocks the safety vent hole as shown in figure 2. If the safety vent hole is blocked or plugged, possible personal injury from the sudden release of process pressure during maintenance disassembly may occur.

7. Lubricate a new O-ring (key 13) with lithium grease and place it into the valve body as shown in figure 6 or 7. Ensure that no foreign material blocks the safety vent hole. Screw the bonnet into the valve body, and torque to a range of 542 to 678 N•m (400 to 500 lbf•ft).

8. **For air-to-open actuator action only**, attach the pressure line to the actuator, and supply pressure to the actuator. Loosen the socket head screws (key 29) and remove the flow adjuster (keys 14 and 15). Release the pressure to the actuator. This allows the plug to find its seated position.

9. Set the flow adjuster to the desired travel position (see figure 2), and tighten the flow adjuster socket head cap screws to 3 N•m (26 lbf•in).



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Figure 3. Design D2 FloPro Construction

Packing, Valve Trim, and Actuator Maintenance

Note

The following maintenance procedures apply to both air-to-open and air-to-close actuator configurations, except as noted.

Key numbers are referenced in figures 6 and 7.

Disassembly

1. Isolate the control valve from the line pressure, release pressure from both sides of the valve body, and drain the process media from both sides of the valve.
2. **For air-to-open actuator action only**, apply pressure to the actuator to fully stroke it open. This will raise the plug off its seat so that the valve stem serrations are visible inside the flow adjuster window (see figure 3). Loosen the socket head screws (key 29) and lower the flow adjuster (key 14 and 15) to its lowest position on the valve stem. Retighten the socket head screws (key 29) to 3 N•m (26 lbf•in). Relieve pressure to the actuator, shut off all pressure lines to actuator, and disconnect. Use

lockout procedures to be sure that the above measures stay in effect while you work on the equipment.

CAUTION

The preceding step is intended to prevent damage to the valve plug (key 3) and seat ring (key 5) during the removal of the bonnet and actuator.

3. Unscrew the bonnet from the valve body.

WARNING

Avoid personal injury from sudden release of process pressure. If the process media starts to escape from the safety vent (see figure 2) located in the bonnet neck of the valve body,

STOP DISASSEMBLY IMMEDIATELY!

The escape of process media indicates that the valve has NOT been isolated from the process media, or process pressure is trapped in the valve body.

Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

4. Once the bonnet has been removed from the valve body, inspect the valve seat (key 5) for wear or damage. If the seating surface has been damaged, remove it from the valve body. Also remove the seat ring gasket (key 6). Clean and inspect the valve body gasket surface for damage. Visually inspect the valve body interior below the seat ring for erosion. Replace the valve body if necessary.

To replace the seat ring, first install a new seat ring gasket. Install the new seat ring and tighten to 230 N•m (170 lbf•ft).

Cover the opening in the valve body to prevent foreign material from getting into the valve body cavity.

WARNING

To prevent possible personal injury or property damage from removing the casing cap screws in the wrong sequence, follow the procedure as outlined below for removing the upper casing.

5. Remove the six **short** actuator casing cap screws (key 22) first. Once these have been removed from the actuator assembly, remove the two **long** actuator cap screws (key 30) by alternating between them as you loosen them, to keep the upper casing (key 21) level during this procedure..

Note

Be aware as you loosen and remove the actuator cap screws that the actuator springs are under compression for the air-to-open configuration.

6. Remove the upper casing (key 21) and the springs (key 27).
7. Do not turn the valve stem (key 4) while removing the diaphragm hex nut (key 26). Keep the stem from turning by using an open end wrench on the machined flats located on the valve stem above the flow adjuster for this procedure. Continue the actuator disassembly by removing these parts: washer (key 24) diaphragm plate (key 25), diaphragm (key 19), washer (key 36), and O-ring (key 37). Inspect the diaphragm for any wear or damage. Replace with a new one if necessary.

If you wish to inspect/replace the bonnet to actuator casing O-ring (key 16), mark the orientation of the actuator pressure connection to the bonnet for later reference (see figure 3). Unscrew the hex nut (key 18) from the bonnet. Remove the bottom casing (key 20).

8. Unscrew the flow adjuster socket head cap screws (key 29), and remove the flow adjuster halves.
9. Unscrew the packing retainer (key 7) from the bonnet (key 2). After the packing retainer has been unscrewed from the bonnet, pull the valve stem and plug out of the bonnet.
10. Remove the five Belleville springs (key 9), packing spacer (key 10), packing (key 11), and two anti-extrusion rings (key 12) from the bonnet. See figure 4.

11. Clean and inspect the packing box wall to ensure that the packing surfaces are not damaged. If the surface condition is damaged, and cannot be improved by light sanding, replace the bonnet by contacting your Emerson Process Management sales office.

12. Inspect the valve stem for scratches or wear, and valve plug for wear or damage. Replace if necessary.

13. If the valve plug requires replacement, use an appropriate tool on the machined flats located on the valve stem above the flow adjuster and unscrew the valve plug from the valve stem. Replace it with a new valve plug. Screw the valve plug into the valve stem, being careful not to damage the plug seat or plug contour. Tighten to 18 N•m (13 lbf•ft).

14. Inspect the valve stem bushing (key 8) located in the upper end of the bonnet. If damaged, remove and replace it with new bushing (key 8). Replace the valve stem bushing by inserting the bushing, flange end first, into the bore located at the top of the bonnet flow adjuster window. Insert until the flange snaps into the groove provided for it.

15. Remove the O-ring (key 17) from the upper end of the bonnet. Replace it with a new one, and lubricate it with lithium grease.

Assembly

1. Use the packing spacer (key 10) and a tube to push the upper anti-extrusion washer (key 12) into place. Using the packing spacer in this manner will ensure the upper anti-extrusion washer is fully seated and flat when installed in the packing bore.

2. Remove the packing spacer from the packing bore.

CAUTION

All D2 FloPro packing kits include a single use packet of high performance fluorinated grease. This is the only acceptable D2 packing lubricant.

Note

In the following procedure, carefully install each packing ring individually over the valve stem and push completely into the packing box with a non-marring tube. A 12-inch length of 1/2 inch PVC pipe works well for this. It is recommended that the lubricated packing rings be installed individually rather than pushed in as a set.

3. Apply a 3mm (1/8 inch) bead of the supplied high performance fluorinated grease (key 38) around the groove of the female packing adaptor as shown in figure 5 and install over the valve stem.

4. Apply a 3mm (1/8 inch) bead of the supplied high performance fluorinated grease (key 38) around the groove of the packing ring as shown in figure 5 and install over the valve stem.

5. Install the male packing adaptor, lower anti-extrusion washer (key 12), and packing spacer over the valve stem as shown in figure 4.

6. Firmly press all packing parts into the packing bore with a tube.

7. Install the five Belleville springs (key 9) over the valve stem as shown in figure 4.

8. Lubricate the threads of the packing retainer with anti-seize and install into the bonnet using a 1-1/8 inch wrench. Make sure the Belleville springs are completely enclosed by the packing retainer as shown in figure 4.

9. Torque the packing retainer to 81 N•m (60 lbf•ft). The packing retainer has been installed correctly when a metal-to-metal contact has been made between the packing retainer end and the bonnet (key 2). The packing retainer threads should be flush with the bottom of the bonnet as shown in figure 4.

10. If the bottom casing (key 20) has been removed, place O-ring (key 16) into the groove provided in the top of the bonnet. Place the bottom casing on the bonnet, oriented in the same position as marked in step 7 on page 8. Screw the hex nut (key 18) onto the bonnet, and tighten to 203 N•m (150 lbf•ft).

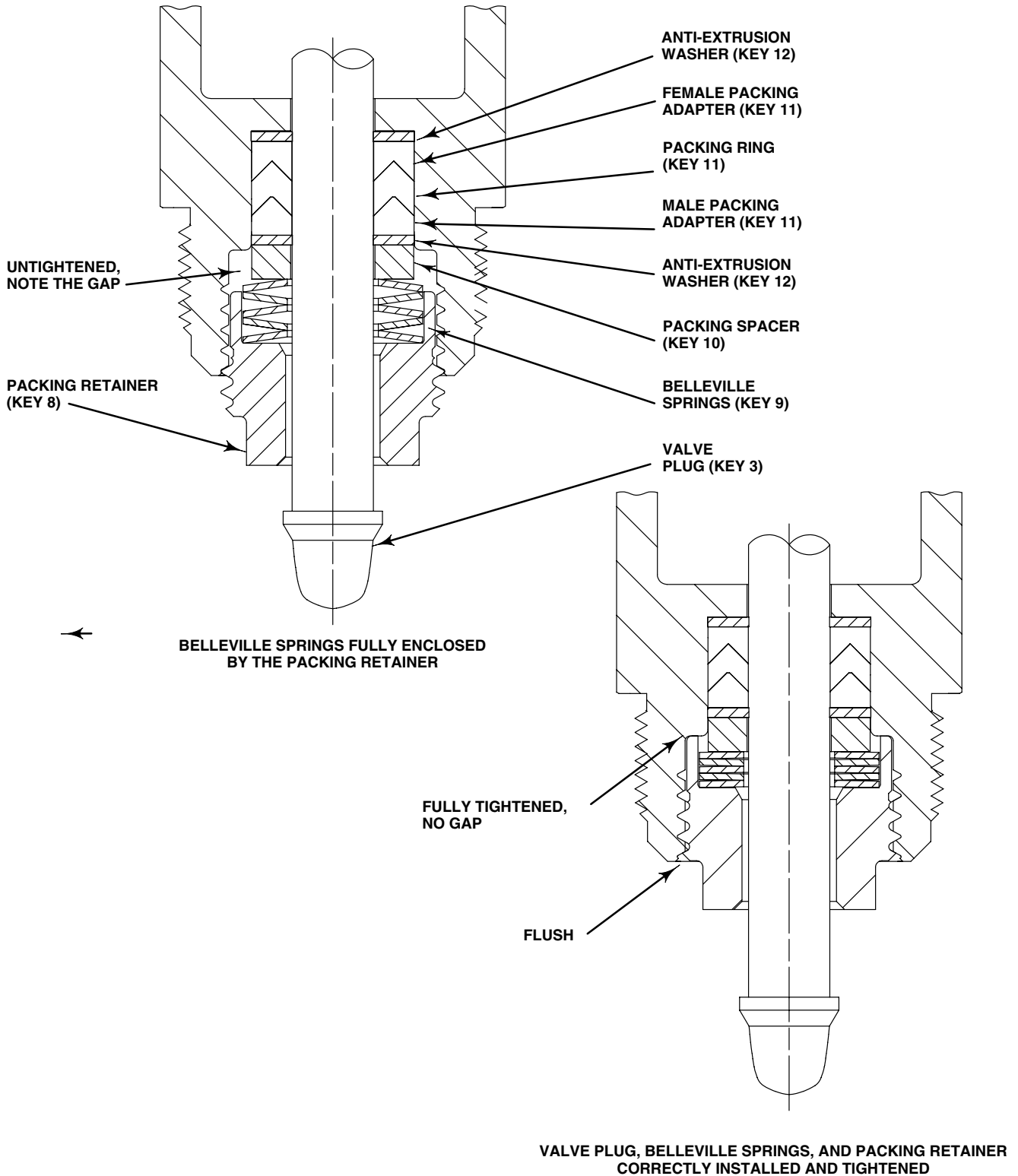


Figure 4. Packing and Belleville Spring Stacking Order

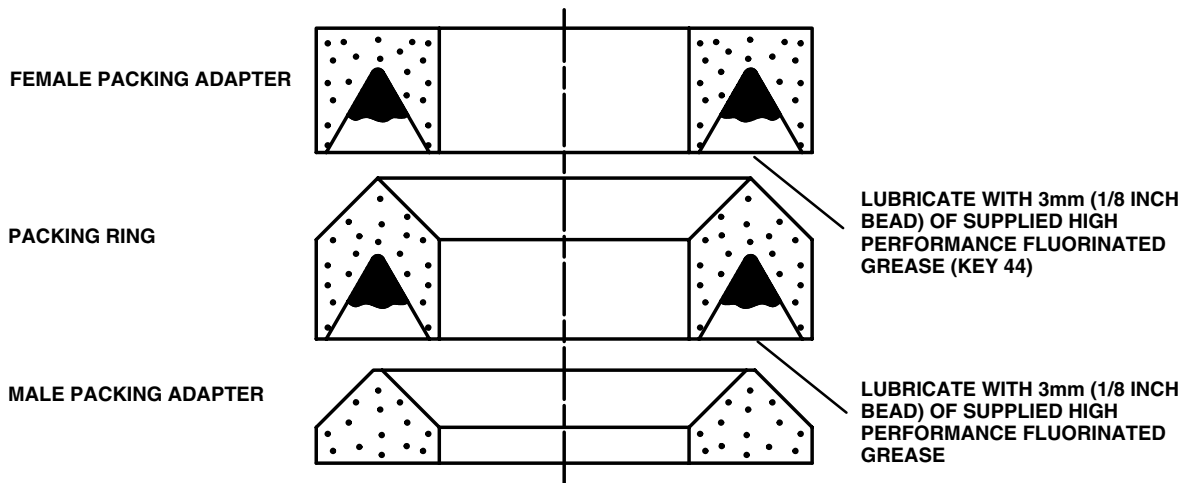


Figure 5. Lubrication Locations on Packing

11. **For air-to-open actuator action only (see figure 6)**, assemble the actuator by first placing the O-ring (key 37) over the valve stem. Then place the washer (key 36) over the valve stem. Place the diaphragm (key 19) over the valve stem, and position it so the holes in the diaphragm match the holes in the casing. Place the diaphragm plate (key 25) over the valve stem. Install the washer (key 24) and the diaphragm hex nut (key 26). Tighten the diaphragm hex nut to 10 N•m (90 lbf•in), while holding the stem by the flats. Install six springs (key 27) and attach the upper casing (key 21) by first installing the two **long** cap screws (key 30) opposite one another.

12. **For air-to-close actuator action only (see figure 7)**, assemble the actuator by first placing 2 of the springs (key 27) from the actuator into the bottom casing (key 20), equally spaced, 180 degrees apart. Place the washer (key 36) over the valve stem, as shown in view A of figure 7. Then place the O-ring (key 37) over the valve stem. Next install the diaphragm plate (key 25) and, using the diaphragm plate, correctly position the actuator springs.

a. Place the diaphragm (key 19) over the stem, along with the washer (key 24). Position the diaphragm so the holes in the diaphragm align with the holes in the bottom casing.

b. Insert a 1/8 inch diameter drift punch, or other suitable device through the 5/32 inch diameter hole in the valve stem located below the bottom of the previously removed flow adjuster. Install the hex nut (key 26) and tighten to 10 N•m (90

lbf•in). Use the 1/8 inch drift punch or other holding device to turn the stem to align the holes of the diaphragm (key 19) to the lower casing (key 20).

13. Position the upper casing and install the two **long** cap screws (key 30) opposite one another. Install the six shorter cap screws (key 22) and the hex nuts, tightening the actuator casing cap screws evenly using a cross-tightening procedure. Torque to 10 N•m (8 lbf•ft).

WARNING

Upon reassembly, ensure that no foreign material blocks the safety vent hole as shown in figure 2. If the safety vent hole is blocked or plugged, possible personal injury from the sudden release of process pressure during maintenance disassembly may occur.

14. Lubricate a new O-ring (key 13) with lithium grease and place it into the valve body as shown in figure 6 or 7. Ensure that no foreign material blocks the safety vent hole. Screw the bonnet into the valve body, and torque to a range of 542 to 678 N•m (400 to 500 lbf•ft).

15. **For air-to-open actuator action only**, attach the pressure line to the actuator, and supply pressure to the actuator. Loosen the socket head screws (key 29) and remove the flow adjuster (keys 14 and 15). Release the pressure to the actuator. This allows the plug to find its seated position.

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16. Set the flow adjuster to the desired travel position (see figure 2), and tighten the flow adjuster socket head cap screws to 3 N•m (26 lbf•in).
17. **For air-to-close actuator action only**, attach a pressure line to the actuator. Supply pressure to the actuator to seat the plug in the seat ring.
18. Set the flow adjuster to the desired travel position (see figure 2), and tighten the flow adjuster socket head cap screws to 3 N•m (26 lbf•in).

Parts Ordering



WARNING

Use only genuine Fisher® replacement parts. Components that are not supplied by Emerson Process Management should not, under any circumstances, be used in any Fisher valve, because they will void your warranty, might adversely affect the performance of the valve, and could give rise to personal injury and property damage.

Note

Neither Emerson, Emerson Process Management, nor any of their affiliated entities assumes responsibility for the selection, use and maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

Parts Kits

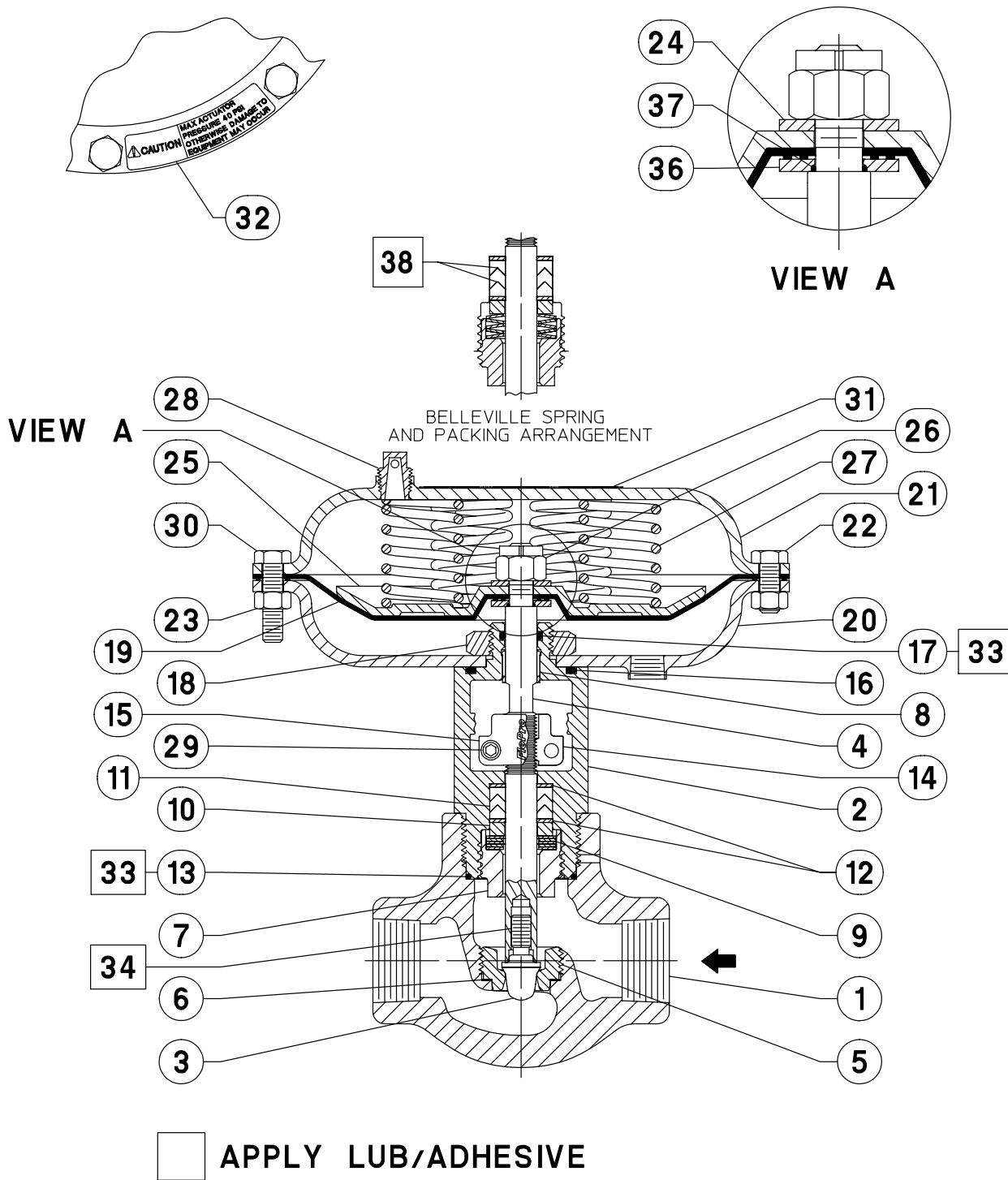
Description	Part Number
* Valve Trim Kit	
R30006 Valve Plug and Seat	
Includes key numbers 3, 5, 6, and 13	19B8485X012
S17400 double H1150 Valve Plug and Seat	
Includes key numbers 3, 5, 6, and 13	19B8485X022
* Valve Packing Kit	
Includes key numbers 8, 11, 12 (2 req'd), 13, 16, 17, and 38	19B8486X012

Parts List

Note

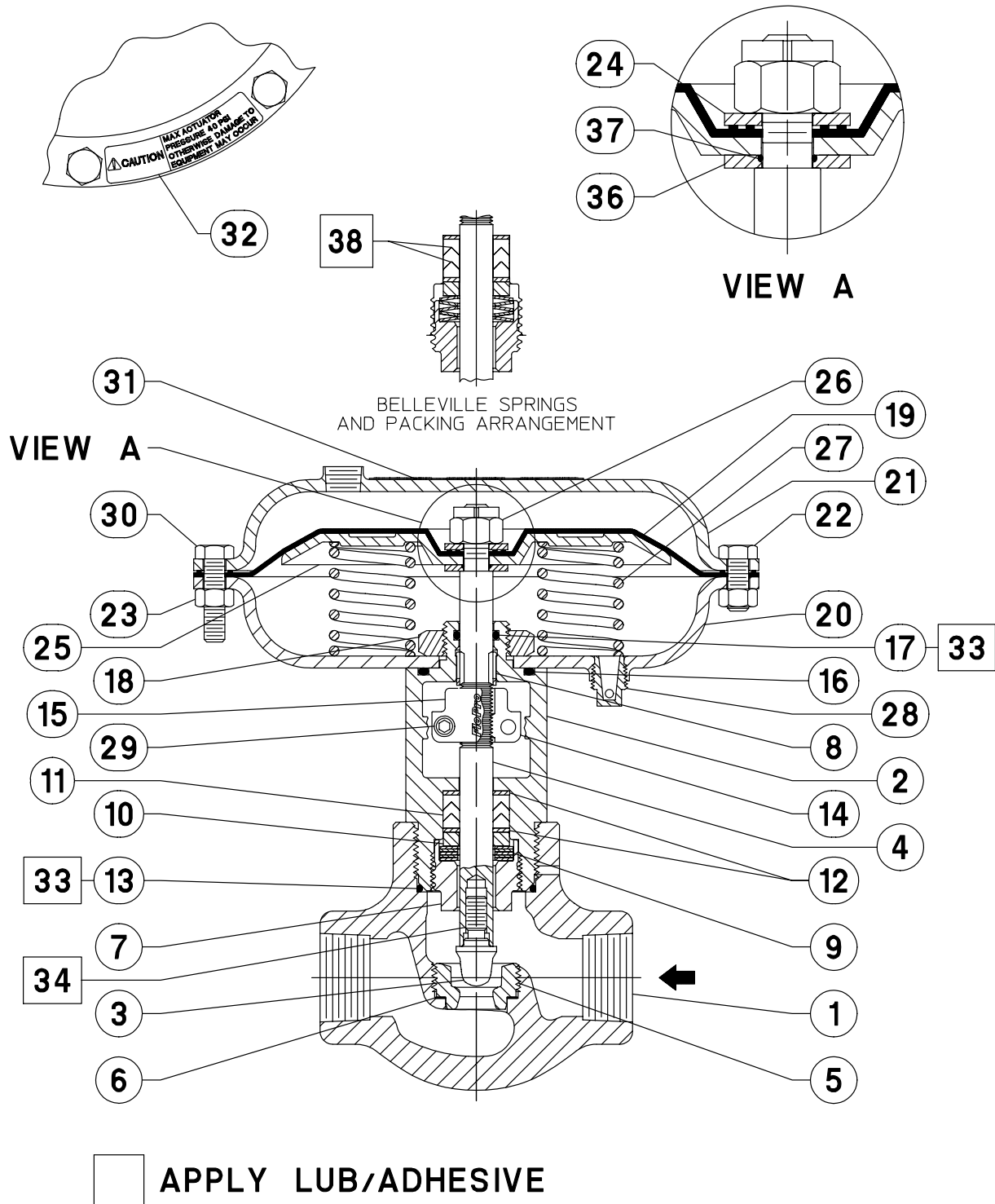
Part numbers are shown for recommended spares only. For part numbers not shown, contact your Emerson Process Management sales office.

Key	Description	Part Number
1	Valve Body	
2	Bonnet	
3	Valve Plug	
4*	Valve Stem	39B5914X012
5	Seat Ring	
6*	Seat Ring Gasket	19B5887X012
7	Packing Retainer	
8	Valve Stem Bushing	
9	Belleville Springs (3 req'd)	
10	Packing Spacer	
11	ENVIRO-SEAL D2 Packing Set	
12	Anti-Extrusion Ring (2 req'd)	
13	Valve Body O-ring	
14	Flow Adjuster Half	
15	Flow Adjuster Half	
16	Casing O-ring	
17	Valve Stem O-ring	
18	Hex Nut	
19*	Diaphragm	39B3849X012
20	Bottom Casing	
21	Upper Casing	
22	Short Actuator Casing Cap Screws (6 req'd)	
23	Nut	
24	Washer	
25	Diaphragm Plate	
26	Diaphragm Hex Nut	
27	Springs	
	Air-to-Open (use 6 springs)	
	Air-to-Close (use 2 springs)	
28	Vent Plug	
29	Flow Adjuster Socket Head Cap Screws (2 req'd)	
30	Long Actuator Casing Cap Screws (2 req'd)	
31	Nameplate	
32	Caution Label	
33	Lubricant, Lithium Grease	
36	Washer	
37*	O-ring	GE12527X012
38*	High Performance Fluorinated Grease Packing Lubricant	GE25891X012



39B5892-M

Figure 6. Design D2 FloPro Assembly—Air-to-Open



39B8450-M

Figure 7. Design D2 FloPro Assembly—Air-to-Close

Instruction Manual

Form 5738
February 2008

D2 FloPro Valve

D2 FloPro Valve

Appendix A (Packing Constructions with Lot Numbers Less Than 0410)

Appendix A provides information on packing constructions **manufactured with lot numbers less than 0410-xxxx**.

Packing and Valve Trim Maintenance (Appendix A)

Note

The following maintenance procedures apply to both air-to-open and air-to-close actuator configurations, except as noted.

Key numbers are referenced in figures 10 and 11.

1. Isolate the control valve from the line pressure, release pressure from both sides of the valve body, and drain the process media from both sides of the valve.
2. **For air-to-open actuator action only**, apply pressure to the actuator to fully stroke it open. This will raise the plug off its seat so that the valve stem serrations are visible inside the flow adjuster window (see figure 9). Loosen the socket head screws (key 29) and lower the flow adjuster (key 14 and 15) to its lowest position on the valve stem. Retighten the socket head screws (key 29) to 3 N•m (26 lbf•in). Relieve pressure to the actuator, shut off all pressure lines to actuator, and disconnect. Use lockout procedures to be sure that the above measures stay in effect while you work on the equipment.

CAUTION

The preceding step is intended to prevent damage to the valve plug (key 3) and seat ring (key 5) during the removal of the bonnet and actuator.

3. Unscrew the bonnet from the valve body.

WARNING

Avoid personal injury from sudden release of process pressure. If the process media starts to escape from the safety vent (see figure 2) located in the bonnet neck of the valve body,

STOP DISASSEMBLY IMMEDIATELY!

The escape of process media indicates that the valve has NOT been isolated from the process media, or process pressure is trapped in the valve body.

Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

4. Once the bonnet has been removed from the valve body, inspect the valve seat (key 5) for wear or damage. If the seating surface has been damaged, remove it from the valve body. Also remove the seat ring gasket (key 6). Clean and inspect the valve body gasket surface for damage. Visually inspect the valve body interior below the seat ring for erosion. Replace the valve body if necessary.

To replace the seat ring, first install a new seat ring gasket. Install the new seat ring and tighten to 230 N•m (170 lbf•ft).

Cover the opening in the valve body to prevent foreign material from getting into the valve body cavity.

WARNING

To prevent possible personal injury or property damage from removing the casing cap screws in the wrong sequence, follow the procedure as outlined below for removing the upper casing.

5. Remove the six **short** actuator casing cap screws (key 22) first. Once these have been removed from the actuator assembly, remove the two **long** actuator cap screws (key 30) by alternating between them as you loosen them, to keep the upper casing (key 21) level during this procedure..

Note

Be aware as you loosen and remove the actuator cap screws that the actuator springs are under compression for the air-to-open configuration.

6. Remove the upper casing (key 21) and the springs (key 27).
7. Do not turn the valve stem (key 4) while removing the diaphragm hex nut (key 26). Keep the stem from turning by using an open end wrench on the machined flats located on the valve stem above the flow adjuster for this procedure. Continue the actuator disassembly by removing these parts: washer (key 24) diaphragm plate (key 25), diaphragm (key 19), washer (key 36), and O-ring (key 37). Inspect the diaphragm for any wear or damage. Replace with a new one if necessary.

If you wish to inspect/replace the bonnet to actuator casing O-ring (key 16), mark the orientation of the actuator pressure connection to the bonnet for later reference (see figure 9). Unscrew the hex nut (key 18) from the bonnet. Remove the bottom casing (key 20).

8. Unscrew the flow adjuster socket head cap screws (key 29), and remove the flow adjuster halves.
9. Unscrew the packing retainer (key 7) from the bonnet (key 2). After the packing retainer has been unscrewed from the bonnet, pull the valve stem and plug out of the bonnet.
10. Remove the three Belleville springs (key 9), packing spacer (key 10), packing (key 11), and two anti-extrusion rings (key 12) from the bonnet. See figure 8.
11. Clean and inspect the packing box wall to ensure that the packing surfaces are not damaged. If the surface condition is damaged, and cannot be improved by light sanding, replace the bonnet by contacting your Emerson Process Management sales office.
12. Inspect the valve stem for scratches or wear, and valve plug for wear or damage. Replace if necessary.
13. If the valve plug requires replacement, use an appropriate tool on the machined flats located on the valve stem above the flow adjuster and unscrew the valve plug from the valve stem. Replace it with a new valve plug. Screw the valve plug into the valve stem, being careful not to damage the plug seat or plug contour. Tighten to 18 N•m (13 lbf•ft).

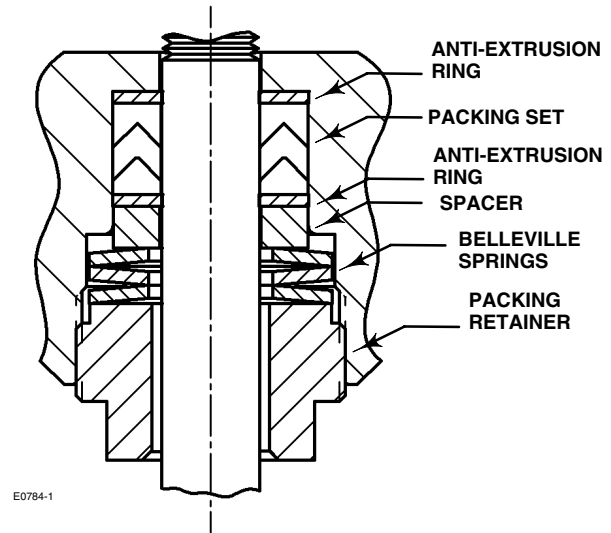


Figure 8. Packing and Belleville Spring Stacking Order (Appendix A)

14. Inspect the valve stem bushing (key 8) located in the upper end of the bonnet. If damaged, remove and replace it with new bushing (key 8). Replace the valve stem bushing by inserting the bushing, flange end first, into the bore located at the top of the bonnet flow adjuster window. Insert until the flange snaps into the groove provided for it.
15. Remove the O-ring (key 17) from the upper end of the bonnet. Replace it with a new one, and lubricate it with lithium grease.
16. Install new packing according to the packing arrangement shown in figure 8, Apply a light film of lithium grease to the threads of the packing retainer (key 7). Install the Belleville springs and packing retainer, as shown in figure 8, but do not tighten.
17. Apply a light film of lithium grease to the valve stem. Carefully slide the valve stem through the packing retainer and packing to a point where the serration extends completely into the flow adjuster window of the bonnet (see figure 9).
18. **Tighten the packing retainer to a range of 81 to 95 N•m (60 to 70 lbf•ft). Then loosen the packing retainer 30 degrees counter-clockwise. See figure 8.**
19. If the bottom casing (key 20) has been removed, place O-ring (key 16) into the groove provided in the top of the bonnet. Place the bottom casing on the bonnet, oriented in the same position as marked in step 7 on page 8. Screw the hex nut (key 18) onto the bonnet, and tighten to 203 N•m (150 lbf•ft).

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20. **For air-to-open actuator action only (see figure 10)**, assemble the actuator by first placing the O-ring (key 37) over the valve stem. Then place the washer (key 36) over the valve stem. Place the diaphragm (key 19) over the valve stem, and position it so the holes in the diaphragm match the holes in the casing. Place the diaphragm plate (key 25) over the valve stem. Install the washer (key 24), diaphragm hex nut (key 26). Tighten the diaphragm hex nut to 10 N•m (90 lbf•in), while holding the stem by the flats. Install six springs (key 27) and attach the upper casing (key 21) by first installing the two **long** cap screws (key 30) opposite one another.

21. **For air-to-close actuator action only (see figure 11)**, assemble the actuator by first placing 2 of the springs (key 27) from the actuator into the bottom casing (key 20), equally spaced, 180 degrees apart. Place the washer (key 36) over the valve stem, as shown in view A of figure 11. Then place the O-ring (key 37) over the valve stem. Next install the diaphragm plate (key 25) and, using the diaphragm plate, correctly position the actuator springs.

a. Place the diaphragm (key 19) over the stem, along with washer (key 24). Position the diaphragm so the holes in the diaphragm align with the holes in the bottom casing.

b. Insert a 1/8 inch diameter drift punch, or other suitable device through the 5/32 inch diameter hole in the valve stem located below the bottom of the previously removed flow adjuster. Install hex nut (key 26) and tighten to 10 N•m (90 lbf•in). Use the 1/8 inch drift punch or other holding device to turn the stem to align the holes of the diaphragm (key 19) to the lower casing (key 20).

22. Position the upper casing and install the two **long** cap screws (key 30) opposite one another.

Install the six shorter cap screws (key 22) and the hex nuts, tightening the actuator casing cap screws evenly using a cross-tightening procedure. Torque to 10 N•m (8 lbf•ft).

WARNING

Upon reassembly, ensure that no foreign material blocks the safety vent hole as shown in figure 2. If the safety vent hole is blocked or plugged, possible personal injury from the sudden release of process pressure during maintenance disassembly may occur.

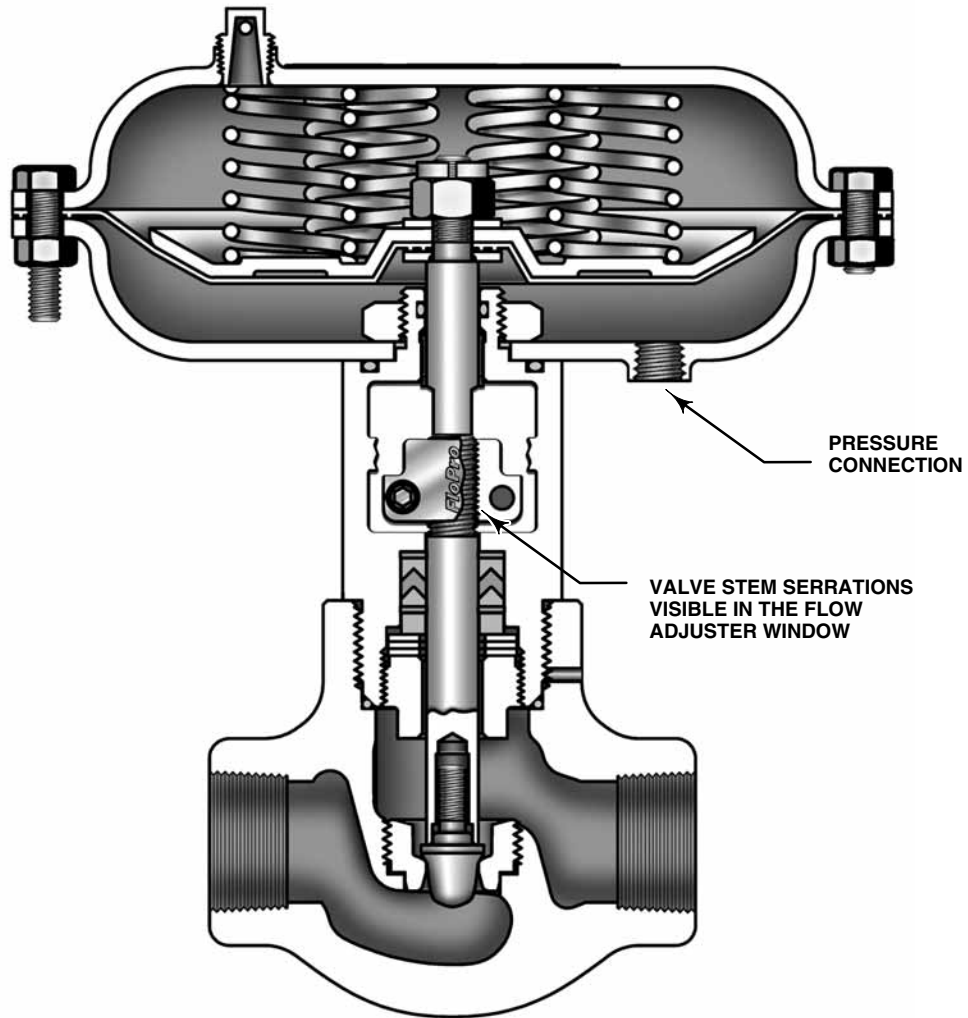
23. Lubricate a new O-ring (key 13) with lithium grease and place it into the valve body as shown in figure 10 or 11. Ensure that no foreign material blocks the safety vent hole. Screw the bonnet into the valve body, and torque to a range of 542 to 678 N•m (400 to 500 lbf•ft).

24. **For air-to-open actuator action only**, attach the pressure line to the actuator, and supply pressure to the actuator. Loosen the socket head screws (key 29) and remove the flow adjuster (keys 14 and 15). Release the pressure to the actuator. This allows the plug to find its seated position.

25. Set the flow adjuster to the desired travel position (see figure 2), and tighten the flow adjuster socket head cap screws to 3 N•m (26 lbf•in).

26. **For air-to-close actuator action only**, attach a pressure line to the actuator. Supply pressure to the actuator to seat the plug in the seat ring.

27. Set the flow adjuster to the desired travel position (see figure 2), and tighten the flow adjuster socket head cap screws to 3 N•m (26 lbf•in).



W9005-1

Figure 9. Design D2 FloPro Construction (Appendix A)

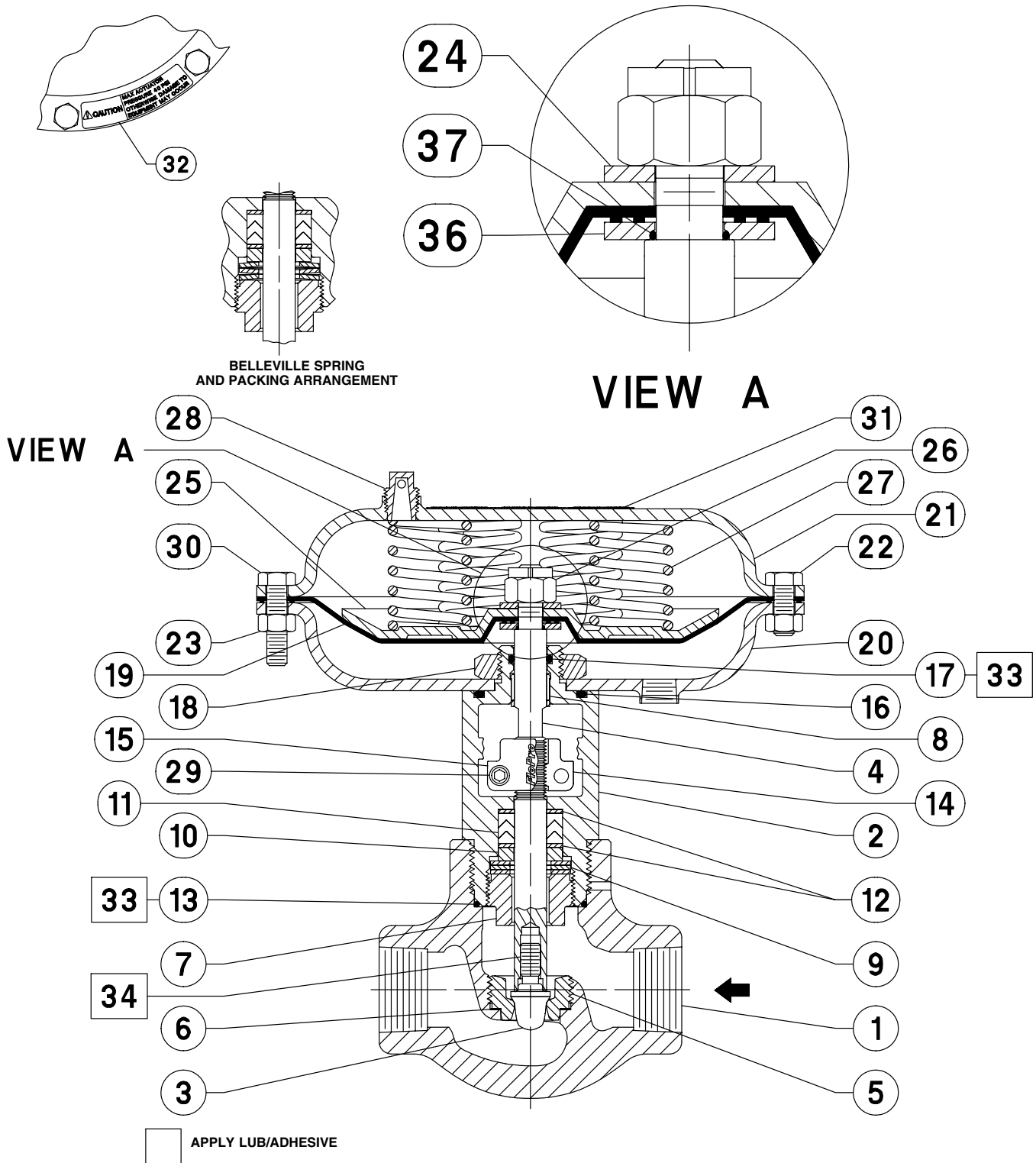


Figure 10. Design D2 FloPro Assembly—Air-to-Open (Appendix A)

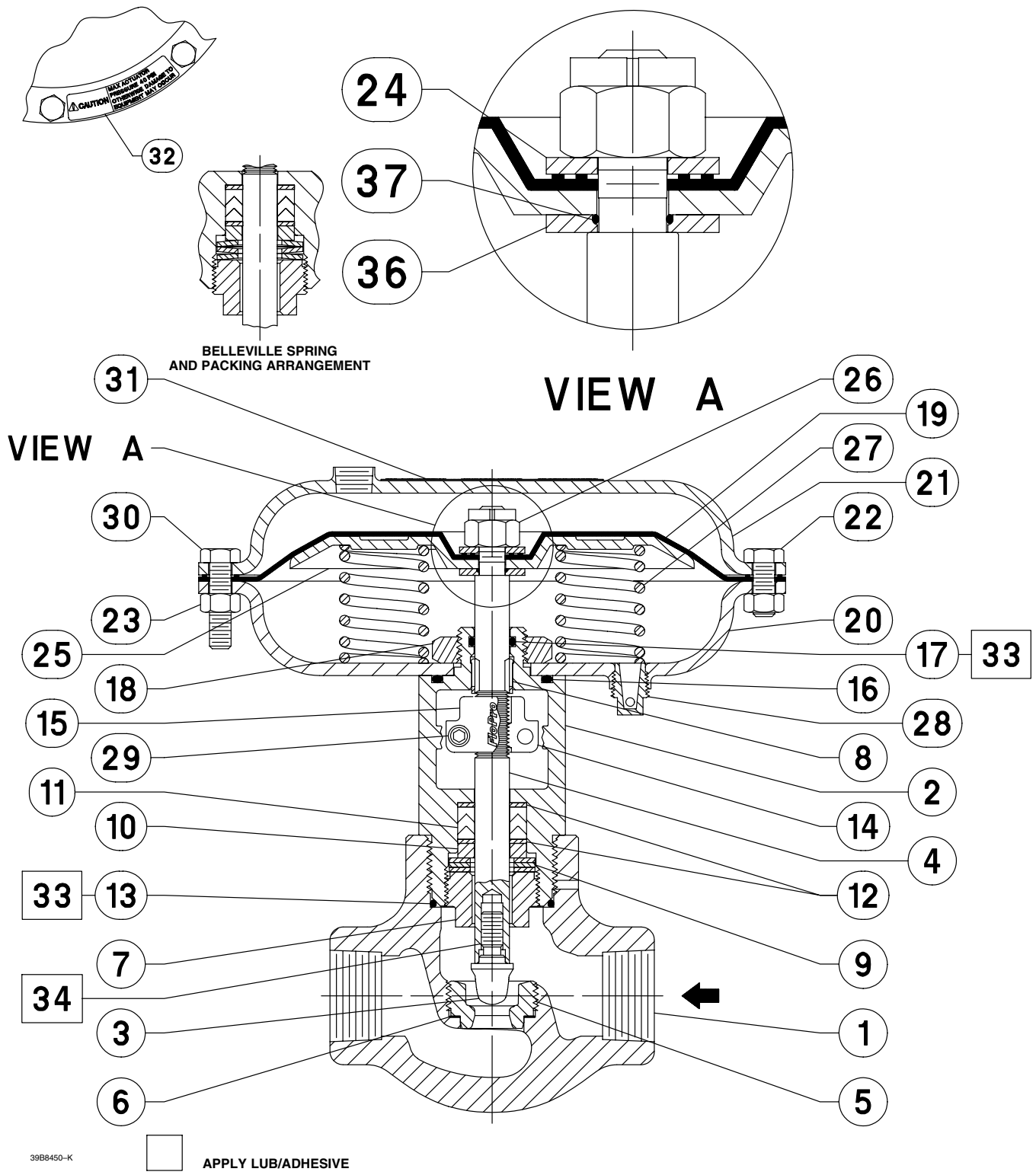


Figure 11. Design D2 FloPro Assembly—Air-to-Close (Appendix A)

D2 FloPro Valve

Parts Ordering (Appendix A)



WARNING

Use only genuine Fisher replacement parts. Components that are not supplied by Emerson Process Management should not, under any circumstances, be used in any Fisher valve, because they will void your warranty, might adversely affect the performance of the valve, and could give rise to personal injury and property damage.

Note

Neither Emerson, Emerson Process Management, nor any of their affiliated entities assumes responsibility for the selection, use and maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

Parts Kits (Appendix A)

Description	Part Number
* Valve Trim Kit	
R30006 Valve Plug and Seat	
Includes key numbers 3, 5, 6, and 13	19B8485X012
S17400 double H1150 Valve Plug and Seat	
Includes key numbers 3, 5, 6, and 13	19B8485X022
* Valve Packing Kit	
Includes key numbers 8, 11, 12 (2 req'd), 13, 16, and 17	19B8486X012

Parts List (Appendix A)

Note

Part numbers are shown for recommended spares only. For part numbers not shown, contact your Emerson Process Management sales office.

Key	Description	Part Number
1	Valve Body	
2	Bonnet	
3	Valve Plug	
4*	Valve Stem	39B5914X012
5	Seat Ring	
6*	Seat Ring Gasket	19B5887X012
7	Packing Retainer	
8	Valve Stem Bushing	
9	Belleville Springs (3 req'd)	
10	Packing Spacer	
11	ENVIRO-SEAL D2 Packing Set	
12	Anti-Extrusion Ring (2 req'd)	
13	Valve Body O-ring	
14	Flow Adjuster Half	
15	Flow Adjuster Half	
16	Casing O-ring	
17	Valve Stem O-ring	
18	Hex Nut	
19*	Diaphragm	39B3849X012
20	Bottom Casing	
21	Upper Casing	
22	Short Actuator Casing Cap Screws (6 req'd)	
23	Nut	
24	Washer	
25	Diaphragm Plate	
26	Diaphragm Hex Nut	
27	Springs	
	Air-to-Open (use 6 springs)	
	Air-to-Close (use 2 springs)	
28	Vent Plug	
29	Flow Adjuster Socket Head Cap Screws (2 req'd)	
30	Long Actuator Casing Cap Screws (2 req'd)	
31	Nameplate	
32	Caution Label	
33	Lubricant, Lithium Grease	
36	Washer	
37*	O-ring	GE12527X012

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Design D4 Control Valve Assembly

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Introduction

Scope of Manual

This instruction manual provides installation, maintenance, and parts information for the Design D4 control valve.

No person may install, operate, or maintain a Design D4 control valve without first (1) being fully trained and qualified in valve, actuator, and accessory installation, operation, and maintenance, and (2) carefully reading and understanding the contents of this manual. If you have any questions about these instructions, contact your Fisher sales office before proceeding.

Note

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W8531/IL

Figure 1. Design D4 Control Valve

Description

The Design D4 control valve is a compact, rugged valve designed primarily for high-pressure throttling applications. This valve is ideal for use on pressure and flow control applications within the oil and gas production industry. The Design D4 valve also makes an excellent dump valve for high-pressure separators and scrubbers.

Specifications

Table 1 lists specifications for the Design D4 control valve. Some of the specifications for a given control valve as it originally comes from the factory are stamped on a nameplate located on the actuator spring barrel.



D4 Valve

Table 1. Specifications

<p>Available Configurations Spring-to-Close Spring-to-Open</p> <p>Valve Body Sizes and End Connection Styles⁽¹⁾ See table 2</p> <p>Maximum Inlet Pressures and Temperatures⁽¹⁾ If the valve nameplate shows an ASME pressure-temperature class, maximum inlet pressure and temperature is consistent with the applicable class per ASME B16.34. If the nameplate does not show an ASME class, it will show a maximum cold working pressure at 38°C (100°F) (for example, 248 bar [3600 psi])</p> <p>Maximum Pressure Drops⁽¹⁾ See tables 3, 4, 5, and 6</p> <p>Input Signal to Actuator See tables 3, 4, 5, and 6</p> <p>Actuator Maximum Casing Pressure⁽¹⁾ 3.4 bar (50 psig)</p> <p>Shutoff Classification per ANSI/FCI 70-2 and IEC 60534-4 Class IV</p>	<p>Material Temperature Capabilities⁽¹⁾ Actuator Assembly: -40 to 93°C (-40 to 200°F) Valve Body Assembly: <i>Standard Bonnet O-Ring:</i> -46 to 149°C (-50 to 300°F) <i>Optional Fluoroelastomer Bonnet O-Ring:</i> -23 to 204°C (-10 to 400°F)</p> <p>Flow Characteristic Equal percentage</p> <p>Flow Direction Flow up only</p> <p>Port Diameters See table 2</p> <p>Valve Plug Travel 19 mm (3/4 inch)</p> <p>Valve Plug Style Micro-Form™ valve plug</p> <p>Actuator Diaphragm Effective Area 452 cm² (69 inches²)</p> <p>Actuator Pressure Connection Size 1/4 inch NPT female</p>
--	--

1. The pressure or temperature limits in the referenced tables and any applicable ASME code limitations should not be exceeded.

Table 2. Valve Sizes and Connection Styles

VALVE SIZE, INCHES	PORT DIAMETER, (INCHES)	SCREWED	RAISED FACE (RF) FLANGED				RING TYPE JOINT (RTJ) FLANGED	
		3600 psi	Class 150	Class 300	Class 600	Class 900 and 1500	Class 600	Class 900 and 1500
1	1/4, 3/8, 1/2, 3/4	X	X	X	X	X	X	X
2	1/4, 3/8, 1/2 3/4, 1, 1-1/4	X	X	X	X	X	X	X

X = Available construction.

*Table 3. Maximum Shutoff Pressure Drops⁽¹⁾ for Design D4 Control Valves (Spring-to-Close)
When Used with Typical Control Instrumentation⁽²⁾*

INPUT SIGNAL TO ACTUATOR		0 to 1.2 Bar (0 to 18 Psig)		0 to 1.4 Bar (0 to 20 Psig)		0 to 2.0 Bar (0 to 30 Psig)		0 to 2.3 Bar (0 to 33 Psig)		0 to 2.4 Bar (0 to 35 Psig)		0 to 3.4 Bar (0 to 50 Psig)	
SPRING		Light Rate						Heavy Rate					
INITIAL SPRING SETTING		0.77 Bar (11.2 Psig)		0.77 Bar (11.2 Psig)		0.85 Bar (12.4 Psig)		1.05 Bar (15.3 Psig)		1.18 Bar (17.1 Psig)		1.18 Bar (17.1 Psig)	
PORT DIAMETER		Maximum Pressure Drop											
mm	Inches	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi
6.4	1/4	259 ⁽³⁾	3750 ⁽³⁾	259 ⁽³⁾	3750 ⁽³⁾	259	3750	259	3750	259	3750	259	3750
9.5	3/8	259 ⁽³⁾	3750 ⁽³⁾	259 ⁽³⁾	3750 ⁽³⁾	259	3750	259	3750	259	3750	259	3750
12.7	1/2	191	2765	191	2765	219	3180	259	3750	259	3750	259	3750
19.1	3/4	80	1160	80	1160	92	1340	123	1785	143	2080	143	2080
25.4	1	42	610	42	610	49	715	67	965	78	1130	78	1130
31.8	1-1/4	25	365	25	365	30	430	41	590	48	700	48	700

1. The pressure or temperature limits in the referenced tables and any applicable ASME code limitations should not be exceeded.
 2. For example, use the column marked 0-1.4 bar (0-20 psig) for a 0.21-1.0 bar (3-15 psig) pneumatic controller with 1.4 bar (20 psig) supply pressure.
 3. For applications with downstream pressure in excess of 196 bar (2845 psig), use 196 bar (2845 psig) for Maximum Shutoff Pressure.

*Table 4. Maximum Shutoff Pressure Drops⁽¹⁾ for Design D4 Control Valves (Spring-to-Close)
When Used with Instrumentation with Restricted Output Range⁽²⁾*

INPUT SIGNAL TO ACTUATOR		0.2 to 1.0 Bar (3 to 15 Psig)				0.4 to 2.0 Bar (6 to 30 Psig)			
SPRING		Light Rate				Heavy Rate			
INITIAL SPRING SETTING		0.67 Bar (9.7 Psig)				0.97 Bar (14.0 Psig)			
PORT DIAMETER		Maximum Pressure Drop							
mm	Inches	Bar		Psi		Bar		Psi	
6.4	1/4	259 ⁽³⁾		3750 ⁽³⁾		259 ⁽⁴⁾		3750 ⁽⁴⁾	
9.5	3/8	152 ⁽³⁾		2205 ⁽³⁾		210 ⁽⁴⁾		3045 ⁽⁴⁾	
12.7	1/2	80		1160		113		1635	
19.1	3/4	31		445		45		655	
25.4	1	14		210		23		330	
31.8	1-1/4	7.6		110		13		185	

1. The pressure or temperature limits in the referenced tables and any applicable ASME code limitations should not be exceeded.
 2. For example, an Electro-Pneumatic Transducer calibrated for 0.21-1.0 bar (3-15 psig) output pressure.
 3. For applications with downstream pressure in excess of 85 bar (1240 psig), use 85 bar (1240 psig) for Maximum Shutoff Pressure.
 3. For applications with downstream pressure in excess of 118 bar (1715 psig), use 118 bar (1715 psig) for Maximum Shutoff Pressure.

Installation



WARNING

Always wear protective gloves, clothing, and eyewear when performing any installation operations to avoid personal injury.

To avoid personal injury or property damage caused by bursting of pressure-retaining parts or by uncontrolled process fluid, be certain the service conditions do not exceed the limits shown on the valve nameplate and in tables 1, 3, 4, 5, and 6. Use pressure-relieving devices required by government or accepted

industry codes and good engineering practices.

Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

CAUTION

When ordered, the valve configuration and construction materials were selected to meet particular pressure, temperature, pressure drop, and controlled fluid conditions. Responsibility for the safety of process media and compatibility of valve materials with process media rests solely with the purchaser and end-user. Since some body/trim

D4 Valve

Table 5. Maximum Shutoff Pressure Drops⁽¹⁾ for Design D4 Control Valves (Spring-to-Open) When Used with Typical Control Instrumentation⁽²⁾

INPUT SIGNAL TO ACTUATOR		0 to 1.2 Bar (0 to 18 Psig)		0 to 1.4 Bar (0 to 20 Psig)		0 to 2.0 Bar (0 to 30 Psig)		0 to 2.3 Bar (0 to 33 Psig)		0 to 2.4 Bar (0 to 35 Psig)		0 to 3.4 Bar (0 to 50 Psig)	
SPRING		Light Rate						Heavy Rate					
INITIAL SPRING SETTING		0.23 Bar (3.4 Psig)		0.23 Bar (3.4 Psig)		0.28 Bar (4.0 Psig)		0.28 Bar (4.0 Psig)		0.28 Bar (4.0 Psig)		0.28 Bar (4.0 Psig)	
PORT DIAMETER		Maximum Pressure Drop											
mm	Inches	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi	Bar	Psi
6.4	1/4	259 ⁽³⁾	3750 ⁽³⁾	259 ⁽³⁾	3750 ⁽³⁾	259	3750	259	3750	259	3750	259	3750
9.5	3/8	259 ⁽³⁾	3750 ⁽³⁾	259 ⁽³⁾	3750 ⁽³⁾	259	3750	259	3750	259	3750	259	3750
12.7	1/2	187	2715	233	3380	259	3750	259	3750	259	3750	259	3750
19.1	3/4	78	1135	99	1430	147	2130	178	2575	198	2875	259	3750
25.4	1	41	600	53	765	80	1160	97	1410	109	1575	195	2830
31.8	1-1/4	24	355	32	465	49	715	60	875	68	985	123	1785

1. The pressure or temperature limits in the referenced tables and any applicable ASME code limitations should not be exceeded.
 2. For example, use the column marked 0-1.4 bar (0-20 psig) for a 0.21-1.0 bar (3-15 psig) pneumatic controller with 1.4 bar (20 psig) supply pressure.
 3. For applications with downstream pressure in excess of 190 bar (2760 psig), use 190 bar (2760 psig) for Maximum Shutoff Pressure.

Table 6. Maximum Shutoff Pressure Drops⁽¹⁾ for Design D4 Control Valves (Spring-to-Open) When Used with Instrumentation with Restricted Output Range⁽²⁾

INPUT SIGNAL TO ACTUATOR		0.2 to 1.0 Bar (3 to 15 Psig)				0.4 to 2.0 Bar (6 to 30 Psig)			
SPRING		Light Rate				Heavy Rate			
INITIAL SPRING SETTING		0.43 Bar (6.2 Psig)				0.69 Bar (10.0 Psig)			
PORT DIAMETER		Maximum Pressure Drop							
mm	Inches	Bar		Psi		Bar		Psi	
6.4	1/4	226 ⁽³⁾		3275 ⁽³⁾		259 ⁽⁴⁾		3750 ⁽⁴⁾	
9.5	3/8	91 ⁽³⁾		1315 ⁽³⁾		259 ⁽⁴⁾		3750 ⁽⁴⁾	
12.7	1/2	46		660		196		2845	
19.1	3/4	15		220		82		1195	
25.4	1	---		---		43		630	
31.8	1-1/4	---		---		26		380	

1. The pressure or temperature limits in the referenced tables and any applicable ASME code limitations should not be exceeded.
 2. For example, an Electro-Pneumatic Transducer calibrated for 0.21-1.0 bar (3-15 psig) output pressure.
 3. For applications with downstream pressure in excess of 51 bar (740 psig), use 51 bar (740 psig) for Maximum Shutoff Pressure.
 4. For applications with downstream pressure in excess of 202 bar (2925 psig), use 202 bar (2925 psig) for Maximum Shutoff Pressure.

material combinations are limited in their pressure drop and temperature ranges, do not apply any other conditions to the valve without first contacting your Fisher sales office.

Fisher does not assume final responsibility for the selection, use, or maintenance of any product. Final responsibility for the selection, use, and maintenance of any Fisher product remains with the purchaser and end-user.

1. Before installing the control valve assembly, inspect it for any damage and for any foreign material that may have collected in the valve body.
2. Remove any pipe scale, welding slag, and other foreign material from the pipeline.

3. The control valve can be installed in any position, but normally the actuator is vertical above the valve. Install the valve so the flow direction arrow on the side of the valve indicates the direction of the process flow.

4. Install the valve following local and national piping codes when they apply to the application. For screwed connections, treat the male pipe threads with a good grade pipe compound. For flanged valves, use suitable gaskets between valve and pipeline flanges.

5. If continuous operation is required during maintenance and inspection, install a conventional three-valve bypass around the valve.

6. Connect loading pressure for the Spring-to-Open configuration to the 1/4-18 NPT connection in the upper casing assembly (key 23) as shown in figure 4. The Spring-to-Close configuration loading pressure

connection is in the lower casing assembly (key 39) as shown in figure 3.

frequency of inspection and maintenance depends on the severity of the service conditions.

Spring Adjustment

The spring has a fixed pressure span over which loading pressure will stroke the valve. Adjustment of the spring compression shifts the span so that more or less loading pressure is required to start travel. Since the span does not change, there will be a corresponding increase or decrease in the pressure requirements at the end of the valve stroke.

In order to maximize shutoff pressure drop values, the actuator spring must be accurately adjusted for each Input Signal Pressure Range. If the actuator has been disassembled or pressure conditions have changed, the spring may require adjustment. Refer to tables 2 and 3 to determine the Initial Spring Set values based on the Input Signal range that is available to the actuator. These values include packing friction.

Spring-to-Close

Refer to figure 3.

1. Loosen the adjusting screw nut (key 44).
2. Turn the adjusting screw (key 31) clockwise to compress the spring or counterclockwise to decrease spring compression.
3. After adjustment, tighten the adjusting screw nut (key 44).

Spring-to-Open

Refer to figure 4.

1. Unscrew the spring case assembly (key 27).
2. Turn the adjusting stem nut (key 44) clockwise to compress the spring or counterclockwise to decrease spring compression.
3. After adjustment, replace the spring case assembly (key 27).

Maintenance

Refer to figure 3.

Valve parts are subject to normal wear and must be inspected and replaced as necessary. The

WARNING

Avoid personal injury from sudden release of process pressure or bursting of parts. Before performing any maintenance operations:

- Always wear protective gloves, clothing, and eyewear when performing any maintenance operations to avoid personal injury.
- Disconnect any operating lines providing air pressure, electric power, or a control signal to the actuator. Be sure the actuator cannot suddenly open or close the valve.
- Use bypass valves or completely shut off the process to isolate the valve from process pressure. Relieve process pressure on both sides of the valve. Drain the process media from both sides of the valve.
- Vent the power actuator loading pressure and relieve any actuator spring precompression.
- Use lock-out procedures to be sure that the above measures stay in effect while you work on the equipment.
- The valve packing box may contain process fluids that are pressurized, *even when the valve has been removed from the pipeline.* Process fluids may spray out under pressure when removing the packing hardware or packing rings.
- Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

Valve Plug and Seat Ring

The Design D4 control valve is designed to allow easy access to the valve plug and seat ring without disturbing the packing. Refer to other sections of this instruction manual if additional maintenance is required.

D4 Valve

Disassembly

1. Remove the loading pressure tubing and any accessories that may hamper disassembly.
2. Break the hammer nut (key 6) loose with a hammer. Continue turning the hammer nut by using a hammer or a large adjustable wrench, tightened around one ear of the hammer nut. If the bonnet is stuck on the valve, continue to unscrew the hammer nut. The hammer nut will contact the spring pins (key 7) and will force the bonnet out of the valve. Carefully lift the actuator, bonnet, and valve plug assembly from the valve body.

Note

The spring pins must always be in place during valve operation. They provide a safeguard against injury when the unit is being disassembled.

3. Use a socket wrench to loosen the seat ring (key 3).
4. Remove the seat ring (key 3) and seat ring gasket (key 9) from the valve body.
5. Inspect parts for wear or damage that would prevent proper operation of the valve body. Carefully clean the seat ring gasket surfaces and seat ring threads.

CAUTION

Be careful to avoid damaging the seating surface on the valve plug or seat ring as damage in these areas will allow excessive leakage at shutoff. Avoid damaging the highly polished valve stem surface. A damaged valve stem could cut the packing and allow process fluid to leak to the atmosphere.

6. **For spring-to-close only:** To remove the valve plug (key 2), drive out the groove pin (key 4) and unscrew the valve plug from the stem (key 47).

If the valve plug cannot be easily unscrewed from the stem, use a punch to keep the stem from turning as the plug is removed.

7. **For spring-to-open only:** To remove the valve plug (key 2), first remove the spring case assembly (key 27). Remove the adjustment screw nut (key 44), the upper spring seat (key 29), and the spring (key 30). Push the adjustment stem (key 31) fully downward until the diaphragm plate (key 40)

contacts the cap screws (key 38), exposing the groove pin (key 4) in the plug. Drive out the groove pin (key 4) and unscrew the valve plug from the stem (key 47).

If the valve plug cannot be easily unscrewed from the stem, use a punch to keep the stem from turning as the plug is removed.

Table 7. Torque for Seat Ring (Key 3)

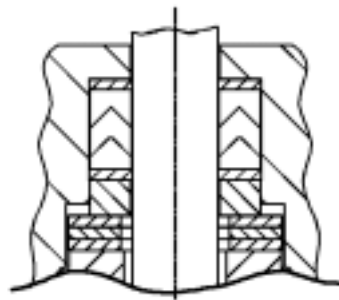
VALVE SIZE		RECOMMENDED TORQUE	
mm	Inches	N•m	Lbf•ft
25.4	1	407	300
50.8	2	698	515

Assembly

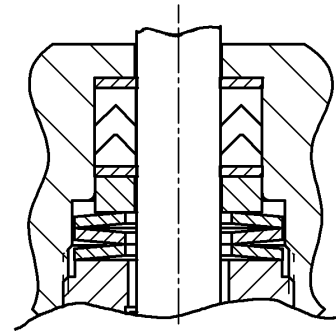
1. Make sure the bonnet O-ring (key 8) is on the bonnet and lubricated with Lubriplate Mag-1 or equivalent (key 49).
2. Install the plug (key 2) on the stem (key 47) and insert a new groove pin (key 4).
3. Thoroughly clean the seat ring and bonnet threads in the valve body (key 1). Also clean the valve body seat ring gasket surfaces.
4. Apply Never-Seez Nickel Special lubricant or equivalent (key 54) to the threads of the seat ring (key 3), and its mating threads in the valve body.
5. Apply Never-Seez Nickel Special lubricant or equivalent (key 54) to the seat ring gasket (key 9) and install into the valve body.
6. Screw the seat ring into the valve body. Use a socket wrench to tighten the seat ring to the torque values shown in table 7. Remove all excess lubricant after tightening.
7. Lubricate (key 54) the threads on the valve body and hammer nut and the contact surfaces of the bonnet and hammer nut flange. Install the bonnet and actuator assembly with pinned valve plug onto the valve body. Tighten the hammer nut using an adjustable wrench until the nut stops turning. A few hammer blows will be required to ensure that the assembly is tight.
8. See the actuator assembly and spring adjustment sections of this manual.

Valve Packing

The valve stem packing can only be accessed from within the valve body. If packing maintenance is required, first disassemble per steps 1, 2, and 6 or 7 in the Valve Plug and Seat Ring Disassembly section of this document.



BELLEVILLE SPRINGS REASONABLY
TIGHT TO SEAT THE PACKING



BELLEVILLE SPRINGS FINGER TIGHT, THEN
TIGHTEN 5/6 TURN (5 FLATS ON THE RETAINER)

E0862

Figure 2. Design D4 Belleville Spring Procedure

Disassembly

1. Loosen the packing retainer locknut (key 22) with a spanner wrench or with a punch and hammer.
2. Unscrew the packing retainer (key 10) from the bonnet (key 5).
3. Remove the three Belleville springs (key 11), packing spacer (key 14), packing (key 13), and two anti-extrusion rings (key 12) from the bonnet, using a formed wire hook.
4. Clean and inspect the packing box wall to ensure that the packing surfaces are not damaged. If the surface condition is damaged, and cannot be improved by light sanding, replace the bonnet by contacting your Fisher sales office.
5. Inspect the valve stem for scratches or wear, and valve plug for wear or damage. Replace if necessary.

Assembly

Refer to figures 2 and 3.

1. Install new packing and Belleville springs according to the packing arrangement shown in figure 2.
2. Apply a light film of lubricant (key 54) to the threads of the packing retainer (key 10).
3. Install the packing retainer into the bonnet and tighten until the Belleville springs (key 11) are reasonably tight to fully seat the packing and anti-extrusion rings.

4. Completely loosen the packing retainer to relieve all Belleville spring compression.
5. Retighten the packing retainer by hand until the packing retainer firmly contacts the Belleville springs.
6. Tighten the packing retainer clockwise 5/6 turn (5 flats on the retainer).
7. Lock the packing retainer (key 10) solidly in place by tightening the packing retainer locknut (key 22) using a spanner wrench, or a hammer with a punch or chisel.

Actuator (Spring-to-Close)

Refer to figure 3.

Before disassembling the actuator, disassemble the valve plug, seat ring, and packing according to instructions in this manual.

Disassembly

1. Loosen the adjusting screw nut (key 44) and turn the adjusting screw (key 31) counterclockwise to remove all spring compression.
2. Unscrew the casing cap screws and hex nuts (keys 45 and 46), and remove the upper casing assembly (key 23) from the lower casing (key 39).
3. Remove the spring seat (key 29) and actuator spring (key 30).
4. Lift out the diaphragm, diaphragm plate, and stem assembly. Remove the travel indicator (key 32)

D4 Valve

when the bottom of the stem enters the yoke window.

5. To replace the diaphragm (key 15), separate the diaphragm assembly by using a wrench on the hex nuts (key 42) to unscrew the assembly.
6. Separate the parts—diaphragm washer, actuator O-ring (keys 41 and 25), diaphragm, and diaphragm plate, (keys 15 and 40).
7. Inspect the diaphragm and the actuator O-ring for damage or deterioration, and replace if necessary. If the diaphragm is replaced, a new O-ring should also be installed.
8. Inspect the stem O-ring (key 19) and bonnet bushing (key 20); replace if necessary. To inspect the casing O-ring (key 18), remove the cap screws (key 38) and lift off the lower casing (key 39). Replace the O-ring if necessary.
9. If the hammer nut needs to be removed from the bonnet, the spring pins (key 7) can be removed with locking pliers.

Assembly

1. Before starting assembly, make sure all parts are clean and in good condition. There should be no burrs or sharp edges on any threads or surfaces that might cut or damage an O-ring, bushing, the packing, or the diaphragm. When replacing O-rings and bushings, be sure the O-ring or bushing groove is clean and undamaged. Using a general purpose lubricant (key 49), lubricate all bushings and O-rings and the threads of parts that have to pass through the bushings and O-rings.

CAUTION

The threads on factory-produced valve stems have been specially machined to avoid O-ring, bushing, or packing damage during trim maintenance. Use of other than a factory-produced valve stem may result in early stem O-ring, bushing, and packing failure.

Note

Do not lubricate cap screws (key 38) before inserting them in the following procedure.

2. Place the hammer nut and spring pins on the bonnet, if removed. Install the casing O-ring

(key 18), the stem O-ring (key 19), and the bonnet bushing (key 20). Position the lower casing (key 39) on the bonnet. Insert the nonlubricated cap screws (key 38), and torque to 49 N•m (36 lbf•ft).

Note

Spring pins must always be in place during valve operation, acting as a safeguard against injury when the unit is being disassembled.

3. Assemble the diaphragm plate assembly. Place the patterned side of the diaphragm (key 15) against the diaphragm plate (key 40). Be sure to turn the diaphragm washer (key 41) so that the side that is beveled on the inside diameter is against the O-ring (key 25). Also, make sure that it is assembled for installation with the diaphragm on the loading pressure side and the lockwasher (key 43) and lower spring seat (key 28) are on the spring side.
4. Fasten the diaphragm and diaphragm plate assembly on the stem with hex nuts (key 42). Place the diaphragm and diaphragm plate, and stem assembly into the lower casing and bonnet. Install the travel indicator (key 32) on the stem as the bottom of the stem enters the yoke window.

CAUTION

Over-tightening the diaphragm casing cap screws and nuts (keys 45 and 46) can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

5. Replace the spring (key 30) on the diaphragm plate (key 40). Replace the upper spring seat (key 29). Position the upper casing (key 23) on the lower casing (key 39). Insert the cap screws (key 45) and tighten the hex nuts (key 46). Torque the casing cap screws evenly to 27 N•m (20 lbf•ft) using a crisscross pattern.
6. Adjust the initial spring set per the Spring Adjustment section in this manual.

Actuator (Spring-to-Open)

Refer to figure 4.

Before disassembling the actuator, disassemble the valve plug, seat ring, and packing according to instructions in this manual.

Disassembly

1. Unscrew the spring case assembly (key 27). Turn the adjusting screw nut (key 44) counterclockwise to

remove all spring compression. Remove the adjusting screw nut, upper spring seat, and spring (keys 44, 29, and 30)

2. Unscrew the casing cap screws and hex nuts (keys 45 and 46), and remove the upper casing assembly (key 23) from the lower casing (key 39). Remove the cotter pin (key 36) and unscrew the adjusting stem (key 31).
3. Lift out the diaphragm (key 15), diaphragm plate (key 40), and stem assembly. Remove the travel indicator (key 32) when the bottom of the stem enters the yoke window.
4. To replace the diaphragm (key 15), separate the diaphragm assembly by using a wrench on the hex nuts (key 42) to unscrew the assembly.
5. Separate the parts—diaphragm washer, actuator O-ring (keys 41 and 25), diaphragm, and diaphragm plate, (keys 15 and 40).
6. Inspect the diaphragm and the actuator O-ring for damage or deterioration, and replace if necessary. If the diaphragm is replaced, a new O-ring should also be installed.
7. Inspect the stem O-ring (key 19) and bonnet bushing (key 20); replace if necessary. To inspect the casing O-ring (key 18), remove the cap screws (key 38) and lift off the lower casing (key 39). Replace the O-ring if necessary. Inspect the adjusting stem bushing (key 26) and actuator stem O-ring (key 53). Replace if necessary.
8. If the hammer nut needs to be removed from the bonnet, the spring pins (key 7) can be removed with locking pliers.

Assembly

1. Before starting assembly, make sure all parts are clean and in good condition. There should be no burrs or sharp edges on any threads or surfaces that might cut or damage an O-ring, bushing, the packing, or the diaphragm. When replacing O-rings and bushings, be sure the O-ring or bushing groove is clean and undamaged. Using a general purpose lubricant (key 49), lubricate all bushings and O-rings and the threads of parts that have to pass through the bushings and O-rings.

CAUTION

The threads on factory-produced valve stems have been specially machined to avoid O-ring, bushing, or packing

damage during trim maintenance. Use of other than a factory-produced valve stem may result in early stem O-ring, bushing, and packing failure.

Note

Do not lubricate cap screws (key 38) before inserting them in the following procedure.

2. Place the hammer nut and spring pins on the bonnet, if removed. Install the casing O-ring (key 18), the stem O-ring (key 19), and the bonnet bushing (key 20). Position the lower casing (key 39) on the bonnet. Insert the nonlubricated cap screws (key 38), and torque to 49 N•m (36 lbf•ft).
3. Assemble the diaphragm plate assembly. Place the patterned side of the diaphragm (key 15) against the diaphragm plate (key 40). Be sure to turn the diaphragm washer (key 41) so that the side that is beveled on the inside diameter is against the O-ring (key 25). Also, make sure that it is assembled for installation with the diaphragm on the loading pressure side and the lockwasher (key 43) and diaphragm washer (key 41) are on the upper side.

Note

Spring pins must always be in place during valve operation, acting as a safeguard against injury when the unit is being disassembled.

4. Fasten the diaphragm and diaphragm plate assembly on the stem with hex nuts (key 42). Place the diaphragm and diaphragm plate, and stem assembly into the lower casing and bonnet. Install the travel indicator (key 32) on the stem as the bottom of the stem enters the yoke window.
5. Screw the adjusting stem (key 31) onto the stem (key 47) and secure the cotter pin (key 36). Make sure the bushing and O-ring are in place in the upper casing.

CAUTION

Over-tightening the diaphragm casing cap screws and nuts (keys 45 and 46) can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

6. Position the upper casing (key 23) on the lower casing (key 39). Insert the cap screws (key 45) and tighten the hex nuts (key 46). Torque the casing cap

D4 Valve

screws evenly to 27 N•m (20 lbf•ft) using a crisscross pattern.

7. Replace the spring (key 30), spring seat (key 29), and adjusting stem nut (key 44) over the adjusting stem. Replace the spring case assembly (key 27).

8. Adjust the initial spring set per the Spring Adjustment section in this manual.

Parts Ordering

Each Design D4 control valve is assigned a serial number, which can be found on the nameplate. Refer to the number when contacting your Fisher representative for assistance or when ordering replacement parts.

Use only genuine Fisher replacement parts. Components that are not supplied by Fisher should not, under any circumstances, be used in any Fisher valve, because they will void your warranty, might adversely affect the performance of the valve, and might jeopardize worker and workplace safety.

Note

Fisher does not assume responsibility for the selection, use, or maintenance of any product. Responsibility for proper selection, use, and maintenance of any Fisher product remains solely with the purchaser and end-user.

Repair Kits

Note

All repair kits are supplied with hydrogenated nitrile bonnet O-ring. Viton bonnet O-ring must be ordered separately when required.

Description	Part Number
* Packing Repair Kit Includes key numbers 4, 8, 12 (2 req'd), and 13	RD4X0000012
* Actuator Repair Kit Includes key numbers 4, 8, 12 (2 req'd), 13, 15, 18, 19, 20, 25, 26, 36, and 53	RD4X0000022

Parts List

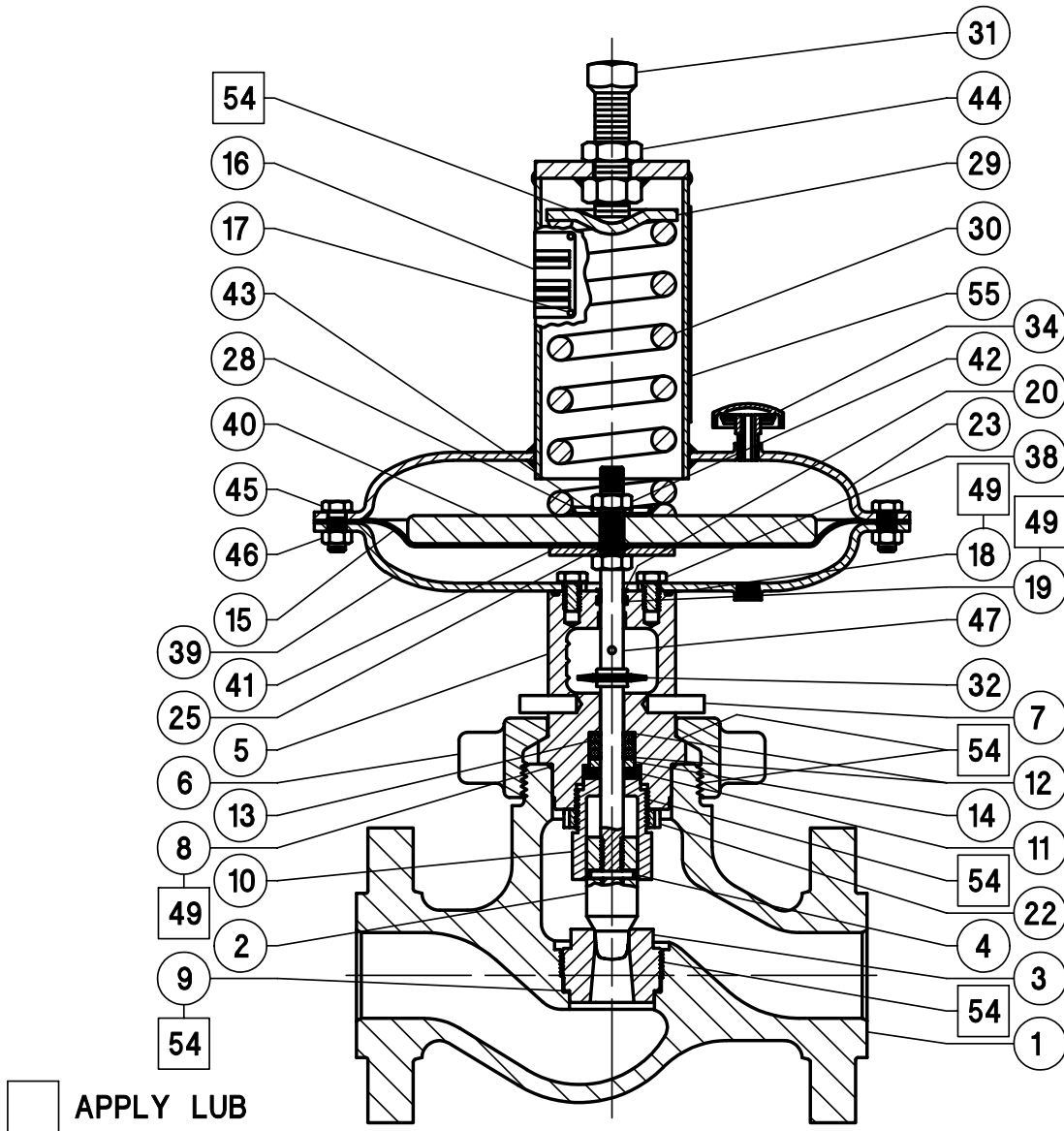
Key	Description	Part Number
1	Valve Body	
2*	Valve Plug	
	S41000 / S41600 HT	
	1-inch valve	
	1/4 inch port diameter	20C3692X012
	3/8 inch port diameter	20C3693X012
	1/2 inch port diameter	20C3694X012
	3/4 inch port diameter	GE01557X012
	2-inch valve	
	1/4 inch port diameter	GE00992X012
	3/8 inch port diameter	GE00993X012
	1/2 inch port diameter	GE00994X012
	3/4 inch port diameter	GE01558X012
	1-inch port diameter	GE01561X012
	1-1/4 inch port diameter	GE01555X012
	S17400 H1150 Dbl	
	1-inch valve	
	1/4 inch port diameter	20C3692X032
	3/8 inch port diameter	20C3693X032
	1/2 inch port diameter	20C3694X032
	3/4 inch port diameter	GE01557X032
	2-inch valve	
	1/4 inch port diameter	GE00992X032
	3/8 inch port diameter	GE00993X032
	1/2 inch port diameter	GE00994X032
	3/4 inch port diameter	GE01558X032
	1-inch port diameter	GE01561X032
	1-1/4 inch port diameter	GE01555X032
	Tungsten Carbide	
	1-inch valve	
	1/4 inch port diameter	20C3696X012
	3/8 inch port diameter	20C3697X012
	1/2 inch port diameter	20C3698X012
	3/4 inch port diameter	20C3699X012

Instruction Manual

Form 5755
May 2003

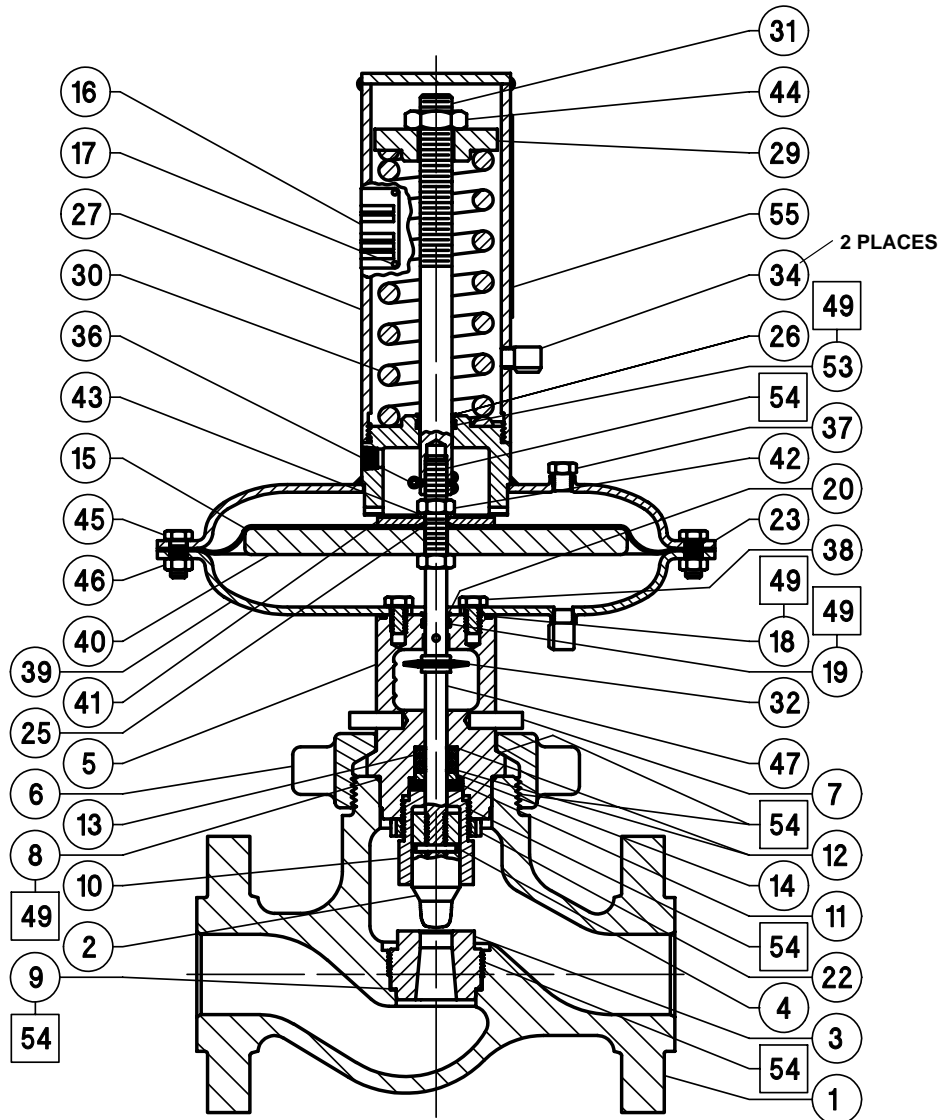
D4 Valve

Key	Description	Part Number	Key	Description	Part Number
2*	Valve Plug (continued)		10	Packing Retainer	
	Tungsten Carbide		11	Belleville Springs	
	2-inch valve		12*	Anti-Extrusion Washer, 2 req'd	12B6335X022
	1/4 inch port diameter	20C3682X012	13*	Packing Set	12B6667X012
	3/8 inch port diameter	20C3683X012	14	Packing Spacer	
	1/2 inch port diameter	20C3685X012	15*	Diaphragm	22B3521X012
	3/4 inch port diameter	20C3686X012	16	Nameplate	
	1-inch port diameter	20C3687X012	17	Drive Screw	
	1-1/4 inch port diameter	20C3688X012	18*	Casing O-ring	1F9141X0142
3*	Seat Ring		19*	Stem O-ring	1K7561X0072
	S17400 H1150 Dbl		20*	Bonnet Bushing	17A7112X012
	1-inch valve		22	Locknut	
	1/4 inch port diameter	GE00982X032	23	Upper Casing Assembly	
	3/8 inch port diameter	GE00983X032	25*	Actuator O-ring	1K7561X0072
	1/2 inch port diameter	GE00984X032	26*	Adjusting Stem Bushing (spring-to-open only)	17A4059X012
	3/4 inch port diameter	GE00985X032	27	Spring Case Assembly	
	2-inch valve		28	Lower Spring Seat	
	1/4 inch port diameter	GE00986X032	29	Upper Spring Seat	
	3/8 inch port diameter	GE00987X032	30	Spring	
	1/2 inch port diameter	GE00988X032		Spring-to-Close	
	3/4 inch port diameter	GE00989X032		Light Rate	1F176827092
	1-inch port diameter	GE00990X032		Heavy Rate	1E792427082
	1-1/4 inch port diameter	GE00991X032		Spring-to-Open	
	Tungsten Carbide			Light Rate	1F176727032
	1-inch valve			Heavy Rate	1F714327092
	1/4 inch port diameter	1J6886X0062	31	Adjustment Screw or Stem	
	3/8 inch port diameter	1J6887X0042	32	Travel Indicator	
	1/2 inch port diameter	1J6888X0052	34	Vent Assembly	
	3/4 inch port diameter	1J6889X0012	36*	Cotter Pin (spring-to-open only)	1C608035022
	2-inch valve		37	Pipe Plug	
	1/4 inch port diameter	1J6899X0032	38	Cap Screw	
	3/8 inch port diameter	1J8154X0052	39	Lower Casing	
	1/2 inch port diameter	1J8156X0062	40	Diaphragm Plate	
	3/4 inch port diameter	1J8158X0062	41	Diaphragm Washer	
	1-inch port diameter	1J8160X0012	42	Hex Nut	
	1-1/4 inch port diameter	1P7241X0072	43	Lockwasher	
		GE01163X012	44	Adjustment Screw Nut	
4*	Groove Pin		45	Cap Screw	
5	Bonnet		46	Hex Nut	
6	Hammer Nut		47	Valve Stem Assembly	
7	Spring Pin		49	Lubricant (Lubriplate MAG-1 or equivalent)	
8*	Bonnet O-ring		50	NACE Tag (not shown)	
	Hydrogenated Nitrile		51	Drive Screw	
	-46 to 149°C (-50 to 300°F)	10C3680X012	53*	Actuator Stem O-ring (spring-to-open only)	1C7821X0182
	Viton		54	Lubricant (Never-Seez or equivalent)	
	-23 to 204°C (-10 to 400°F)	10C3680X022	55	Spring Setting Label (not shown)	
9*	Seat Ring Gasket				
	For 1-inch valve	1B198636042			
	For 2-inch valve	1B198836042			



GE02332-A

Figure 3. Design D4 Valve Assembly (Spring-to-Close)



GE02334A

□ APPLY LUB

Figure 4. Design D4 Valve Assembly (Spring-to-Open)

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Fisher® 667 Diaphragm Actuator Sizes 30-76 and 87

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Figure 1. Fisher® 667 or 667-4 Actuator Mounted on easy-e® Valve

through 76 and size 87. The 667-4 actuator in sizes 70 and 87 is also covered. Refer to separate instruction manuals for information about the valve positioner and other accessories used with these actuators.

Do not install, operate, or maintain a 667 actuator (see figure 1) without first being fully trained and qualified in valve, actuator, and accessory installation, operation, and maintenance, and carefully reading and understanding the contents of this manual. If you have any questions about these instructions, contact your Emerson Process Management sales office before proceeding.

Introduction

Scope of Manual

This instruction manual provides information on installation, adjustment, maintenance, and parts ordering for the Fisher® 667 actuator in sizes 30



667 Size 30-76 and 87 Actuators

October 2008

Table 1. Specifications

SPECIFICATION ⁽¹⁾		ACTUATOR SIZE										
		30	34	40	45	46	50	60	70 ⁽¹⁾	76	87 ⁽¹⁾	
Nominal Effective Area	Sq cm	297	445	445	667	1006	677	1006	1419	1006	1419	
	Sq Inch	46	69	69	105	156	105	156	220	156	220	
Yoke Boss Diameter	mm	54	54	71	71	71	90	90	90	90	125	
	Inch	2-1/8	2-1/8	2-13/16	2-13/16	2-13/16	3-9/16	3-9/16	3-9/16	3-9/16	5	
Acceptable Valve Stem Diameter	mm	9.5	9.5	12.7	12.7	12.7	19.1	19.1	19.1	19.1	25.4	
	Inch	3/8	3/8	1/2	1/2	1/2	3/4	3/4	3/4	3/4	1	
Maximum Allowable Output Thrust ⁽⁴⁾	N	10,230	10,230	12,010	25,131	33,582	25,131	30,246	39,142	30,246	39,142	
	LB	2300	2300	2700	5650	7550	5650	6800	8800	6800	8800	
Maximum Travel ⁽²⁾	Standard	mm	19	29	38	51	51	51	51	76 ⁽³⁾	51	76 ⁽³⁾
		Inch	0.75	1.125	1.5	2	2	2	2	3 ⁽³⁾	2	3 ⁽³⁾
	Top-Loaded	mm	---	19	---	19	---	---	29	---	29	76
		Inch	---	0.75	---	0.75	---	---	1.125	---	1.125	3
Maximum Casing Pressure for Actuator Sizing ^(4,6)	Bar	3.8	4.8	4.8	4.5	3.5	4.5	3.5	3.4	3.4	3.4	
	Psig	55	70	70	65	55	65	55	50	50	50	
Maximum Excess Diaphragm Pressure ^(4,5)	Bar	3.9	1.4	1.4	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
	Psig	55	20	20	10	10	10	10	10	10	10	
Maximum Diaphragm Casing Pressure ^(4,6,7)	Bar	7.6	6.2	6.2	5.2	4.5	5.2	4.5	4.1	4.1	4.1	
	Psig	110	90	90	75	65	75	65	60	60	60	
Approximate Weight	Kg	15	22	23	41	55	43	55	115	86	118	
	Pounds	34	48	50	90	121	94	122	254	190	260	
Material Temperature Capabilities	Nitrile Elastomers	-40 to 82°C (-40 to 180°F)										
	Silicone Elastomers	-54 to 149°C (-65 to 300°F)										

1. These values also apply to the 667-4 actuator construction.
 2. Actuator travel may be less than the value listed after connected to the valve.
 3. Maximum actuator travel for 667-4 is 102 mm (4 inches).
 4. See also the Specification portion of the introduction section.
 5. Additional pressure may be added when the actuator is at full travel. If the Maximum Excess Diaphragm Pressure is exceeded, damage to the diaphragm or diaphragm casing might result. See the Maximum Pressure Limitation section.
 6. Maximum diaphragm casing pressure must not be exceeded and must not produce a force on the actuator stem greater than the maximum allowable actuator output thrust or the maximum allowable stem load. See the Maximum Pressure Limitation section.
 7. This maximum casing pressure is not to be used for normal operating pressure. Its purpose is to allow for typical regulator supply settings and/or relief valve tolerances.

Description

The 667 actuator (figure 1) and the 667-4 actuator are reverse-acting, spring-opposed diaphragm actuators. They provide automatic operation of control valves. The 667 actuator provides 76 mm (3 inches) maximum actuator travel. The 667-4 actuator provides 102 mm (4 inches) maximum actuator travel. Both actuators position the valve plug in response to varying pneumatic loading pressure on the diaphragm. Figure 2 shows the operation of these actuators.

A 667 or 667-4 actuator can be furnished with either

a top-mounted or a side-mounted handwheel assembly. A top-mounted handwheel assembly is normally used as an adjustable down travel stop. (A down travel stop limits actuator travel in the down direction [when the stem is traveling out of the actuator]. Travel in the up direction is when the stem is traveling into the actuator.) A side-mounted handwheel assembly is normally used as an auxiliary manual actuator. The side-mounted handwheel can also be used as an adjustable up or down travel stop. Casing-Mounted adjustable up or down travel stops are also available on this actuator.

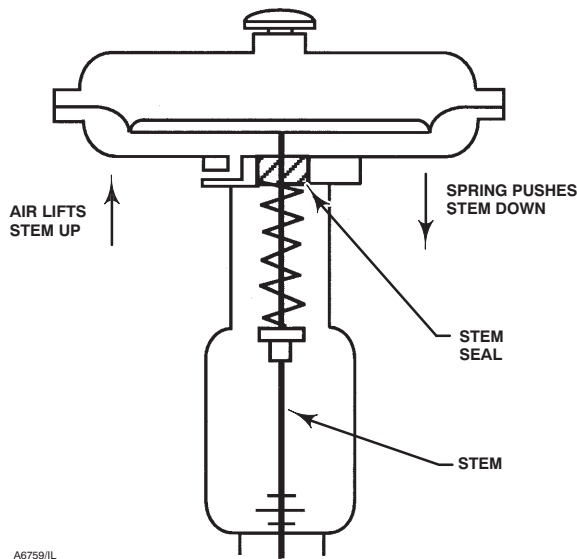


Figure 2. Schematic of Fisher® 667 and 667-4 Actuators

Note

If repeated or daily manual operation is expected, the actuator should be equipped with a side-mounted handwheel rather than a casing-mounted travel stop or top-mounted handwheel. The side-mounted handwheel is designed for more frequent use as a manual operator.

Specifications

Refer to table 1 for Specifications of the 667 and 667-4 actuators. See the actuator nameplate for specific information for your actuator.

WARNING

To avoid personal injury or damage to equipment that may result in the malfunction of the control valve or loss of control of the process caused by excessive pressure, do not exceed the Maximum Pressures listed in table 1. Refer to the Maximum Pressure Limitations section below.

Maximum Pressure Limitations

The casing and diaphragm of 667 actuators are pressure operated. This air pressure provides energy to compress the spring, to stroke the actuator, and to seat the valve. The following explanations describe the maximum pressure limits for an actuator. Refer to the nameplate or table 1 for maximum values for your actuator.

- **Maximum Casing Pressure for Actuator Sizing:** This is the maximum pressure that can be applied at less than full travel of the actuator. If this stroking pressure is exceeded before the upper diaphragm plate contacts the travel stop, damage to the stem or other parts might result.

- **Maximum Excess Diaphragm Pressure:** Additional pressure may be added when the actuator is at full travel. If the Maximum Excess Diaphragm Pressure is exceeded, damage to the diaphragm or diaphragm casing might result.

Because the actuator has traveled its specified travel, and the diaphragm head is physically stopped from movement, the energy from any additional air pressure is transmitted to the diaphragm and diaphragm casings. The amount of air pressure that can be added once the actuator has traveled to the stops is limited by the resultant adverse effects that may occur. Exceeding this limiting factor could result in leakage or casing fatigue due to the deformation of the upper diaphragm casing.

- **Maximum Diaphragm Casing Pressure:** If the Maximum Diaphragm Casing Pressure is exceeded, damage to the diaphragm, diaphragm casing, or actuator might result.

Installation

WARNING

Always wear protective gloves, clothing, and eyewear when performing any installation operations. Check with your process or safety engineer for any other hazards that may be present from exposure to process media.

If installing into an existing application, also refer to the **WARNING** at the beginning of the Maintenance section in this instruction manual.

667 Size 30-76 and 87 Actuators

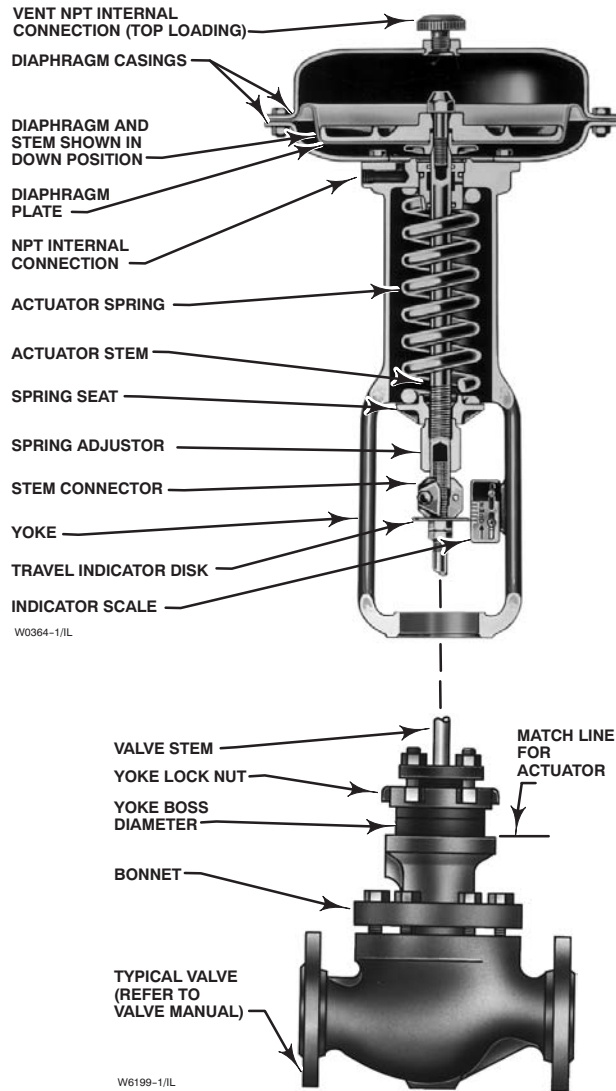


Figure 3. Actuator-Mounting Components for Size 30 through 70 Actuators

Key number locations are shown in figures 6, 7, and 8, unless otherwise noted. Also, refer to figure 3 for location of parts.

CAUTION

To avoid parts damage, do not use an operating pressure that exceeds the Maximum Diaphragm Casing Pressure (table 1) or produces a force on the actuator stem greater than the Maximum Allowable Output Thrust

(table 1) or the Maximum Allowable Valve Stem Load.

- **Valve/Actuator Assembly:** If the actuator and valve are shipped together as a control valve assembly, it has been adjusted at the factory, and may be installed in the pipeline. After installing the valve in the pipeline, refer to the Loading Connection procedures.

- **Actuator Mounting:** If the actuator is shipped separately or the actuator has been removed from the valve, it is necessary to mount the actuator on the valve before placing the valve in the pipeline. Refer to the following actuator mounting procedures before placing the valve in service. It is recommended that you perform the Bench Set Spring Adjustment procedures in this section to confirm that the actuator is adjusted correctly for the valve travel.

- **Positioner:** If a positioner is installed, or is to be installed on the actuator, refer to the positioner instruction manual for installation. During the adjustment procedures, it will be necessary to provide a temporary loading pressure to the actuator diaphragm.

- **Handwheel Cap:** If the handwheel cap (key 247, figures 9, 11, or 16) is not in place, install the cap by pushing it on by hand until it snaps into place.

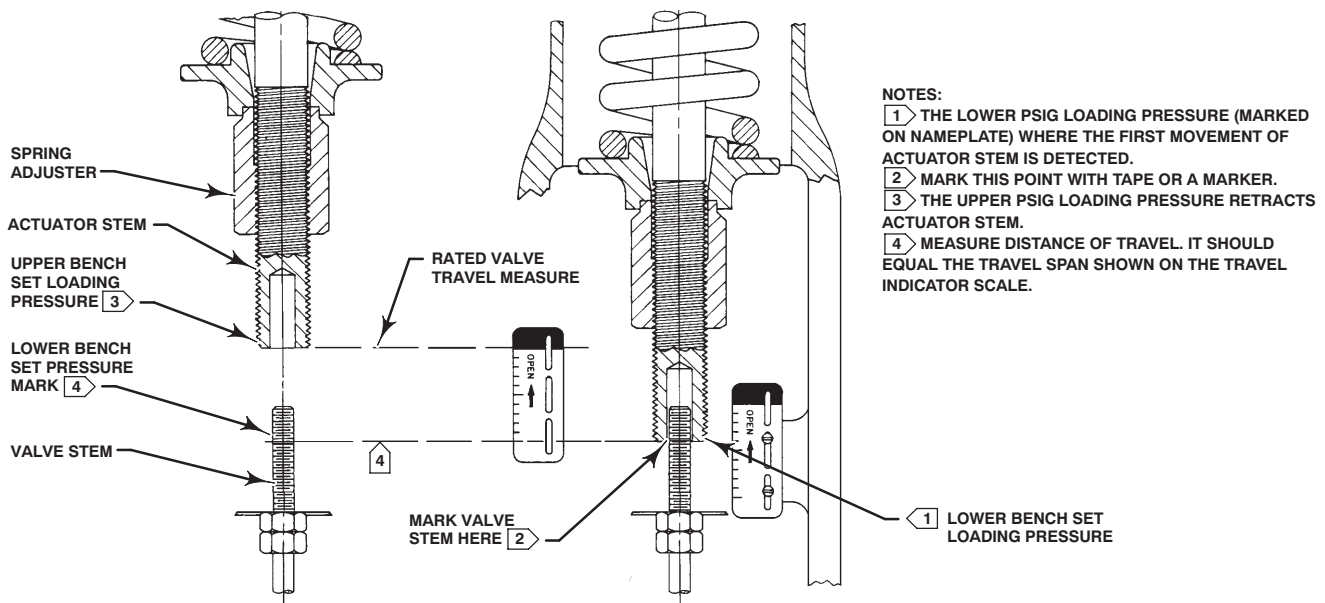
Mounting the Actuator on the Valve

CAUTION

The 667 actuator spring load pushes the stem down out of the actuator yoke (see figure 2), and it can come in contact with the valve stem during actuator mounting.

If the valve stem is allowed to remain in the up position (towards the actuator) during actuator mounting, it can interfere with the actuator stem during mounting. It is possible to damage valve stem threads or bend the valve stem. Be sure the valve stem is pushed down (into the valve body), away from the actuator while mounting.

It may be necessary to apply a temporary loading pressure to the actuator to move the actuator stem away from the valve during installation.



NOTES:
 1 THE LOWER PSIG LOADING PRESSURE (MARKED ON NAMEPLATE) WHERE THE FIRST MOVEMENT OF ACTUATOR STEM IS DETECTED.
 2 MARK THIS POINT WITH TAPE OR A MARKER.
 3 THE UPPER PSIG LOADING PRESSURE RETRACTS ACTUATOR STEM.
 4 MEASURE DISTANCE OF TRAVEL. IT SHOULD EQUAL THE TRAVEL SPAN SHOWN ON THE TRAVEL INDICATOR SCALE.

Figure 4. Bench Set Adjustment

If it is not possible to provide a temporary loading pressure, be very careful when lowering the actuator over the valve stem to prevent damage to valve stem and threads.

WARNING

When moving the actuator stem with loading pressure applied, exercise caution to keep hands and tools out of the actuator stem travel path. If the loading pressure is accidentally disconnected, personal injury and property damage may result if something is caught between the actuator stem and other control valve parts.

1. Provide a vise or some other method of supporting the valve and the weight of the actuator during assembly. For direct or reverse acting valves, push the valve stem down away from the actuator while mounting the actuator.
2. Screw the stem locknuts all the way onto the valve stem. With the concave side of the travel indicator disk (key 34) facing the valve, install the travel indicator disk on the valve stem. (Note: The travel indicator disk is not used with size 87 actuators.)

3. Lift or hoist the actuator onto the valve bonnet:

a. **For size 87 actuators:** Slowly lower the actuator down onto the valve while guiding the valve stem into the opening in the end of the actuator stem (see figure 4). Once the actuator is in place, insert the cap screws and tighten the hex nuts, securing the actuator to the bonnet.

b. **For all other size actuators:**

- Slowly lower the actuator down onto the valve. As the yoke passes over the end of the valve stem, place the yoke locknut over the valve stem. (Note: On small size actuators, it may be necessary to remove the indicator disk and re-install it while lowering the actuator onto the valve because the disk will not go through the actuator yoke opening).
- Continue to lower the actuator while guiding the valve stem into the opening in the end of the actuator stem until the actuator is in place (see figure 4).
- Screw the yoke locknut onto the valve bonnet and tighten the locknut.

4. Do not connect the actuator stem to the valve stem at this time. Whenever the actuator is installed on the valve, it is recommended that you perform the Bench Set Spring Adjustment procedures below, to verify that the actuator is still adjusted correctly.

667 Size 30-76 and 87 Actuators

Discussion of Bench Set

The bench set pressure range is used to adjust the initial compression of the actuator spring with the valve-actuator assembly “on the bench.” The correct initial compression ensures that the valve-actuator assembly will function properly when it is put into service and the proper actuator diaphragm operating pressure is applied.

The bench set range is established with the assumption that there is no packing friction. When attempting to adjust the spring in the field, it is very difficult to ensure that there is no friction being applied by “loose” packing.

Accurate adjustment to the bench set range can be made during the actuator mounting process by making the adjustment before the actuator is connected to the valve (see the Bench Set Spring Adjustment Procedure).

If you are attempting to adjust the bench set range after the actuator is connected to the valve and the packing tightened, you must take friction into account. Make the spring adjustment so full actuator travel occurs at the bench set range (a) plus the friction force divided by the effective diaphragm area with increasing diaphragm pressure or (b) minus the friction force divided by the effective diaphragm area with decreasing diaphragm pressure.

For an assembled valve-actuator assembly, the valve friction may be determined by following the procedure described below:

1. Install a pressure gauge in the actuator loading pressure line that connects to the actuator diaphragm casing.

Note

Steps 2 and 4 require that you read and record the pressure shown on the pressure gauge.

2. Increase the actuator diaphragm pressure and read the diaphragm pressure as the actuator reaches its mid-travel position.
3. Increase the actuator diaphragm pressure until the actuator is at a travel position greater than its mid-travel position.
4. Decrease the actuator diaphragm pressure and read the diaphragm pressure as the actuator reaches its mid-travel position.

The difference between the two diaphragm pressure readings is the change in the diaphragm pressure

required to overcome the friction forces in the two directions of travel.

5. Calculate the actual friction force:

$$\text{Friction Force, = 0.5} \left(\begin{array}{c} \text{Difference} \\ \text{in pressure} \\ \text{readings, psig} \end{array} \right) \times \left(\begin{array}{c} \text{Effective} \\ \text{diaphragm area,} \\ \text{inches}^2 \end{array} \right)$$

Refer to table 1 for the effective diaphragm area.

When determining valve friction, you can make diaphragm pressure readings at a travel position other than mid-travel if you desire. If you take readings at zero or at the full travel position, take extra care to ensure that the readings are taken when the travel just begins or just stops at the position selected.

It is difficult to rotate the spring adjustor (key 74, figure 6, 7, and 8) when the full actuator loading pressure is applied to the actuator. Release the actuator loading pressure before adjusting. Then re-apply loading pressure to check the adjustment.

Spring Verification

Ensure that the actuator diaphragm is at the bottom of its travel as shown in figure 4 and not connected to the valve. (Note: Some spring compression is required to move the diaphragm to the **bottom** of its travel.)

Also, provide a certified pressure gauge that will accurately read the diaphragm pressure from 0 through the upper bench set pressure marked on the nameplate. Apply loading pressure to the diaphragm.

Stroke the actuator a few times to ensure that the pressure gauge is working correctly, and that the actuator is functioning properly.

CAUTION

To prevent product damage, it is important to ensure that the actuator assembly is not binding or producing any friction on the actuator stem movement.

Key numbers are shown in figures 6, 7, and 8.

For Direct-Acting Valves (PDTC)

1. If not already accomplished, push the valve stem down away from the actuator to the closed position.

2. Set the diaphragm loading pressure to 0.3 bar (5 psig) over the upper bench set pressure. The upper travel stop should be contacting the diaphragm casing.
3. Slowly decrease the pressure towards the upper bench set pressure while checking for the **first** movement of the actuator stem.

Note

Before turning the spring adjuster on size 70, 76, or 87 actuators, assemble the stem connector around the actuator stem and the anti-rotating lug on the yoke. Mark the actuator stem as a visual reference to verify that stem rotation does not occur. Remove the stem connector before rechecking the bench set.

4. If movement occurs before or after the upper pressure is reached, adjust the spring adjuster (see figure 4). Thread the adjuster up or down on the actuator stem until the actuator stem movement is **first** detected at the upper bench set pressure. (Note: You may need to lower the loading pressure to reduce spring compression, allowing the spring adjuster to turn.)
5. Be sure the spring adjuster is adjusted to meet the requirements of step 4 above.
6. Apply the lower bench set loading pressure to the diaphragm. This will extend the actuator stem toward the valve. Mark the end of the actuator stem on a nearby surface using tape or some other method.
7. Slowly increase the diaphragm pressure until the upper bench set loading pressure is applied. Again, the travel stop should be against the diaphragm casing.
8. Measure the distance between the mark or tape to the end of the actuator stem. This distance should match the travel span shown on the travel indicator scale (key 32).
9. If the span of travel is correct, bench set is complete. Proceed to the Installing the Stem Connector Assembly subsection.
10. If the travel span is not exact, remember the free-length and load rate tolerances for the spring may produce a slightly different span than specified. Contact your Emerson Process Management sales office for assistance.

For Reverse-Acting Valves (PDTO)

1. If not already accomplished, push the valve stem down away from the actuator to the open position. Later, when installing the connector, pull up the valve stem to the closed position.
2. Set the diaphragm loading pressure to a value less than the lower bench set pressure (near zero). The down travel stop should be contacting the yoke.
3. Slowly increase the pressure towards the lower bench set pressure while checking for the **first** movement of the actuator stem.

Note

Before turning the spring adjuster on size 70, 76, or 87 actuators, assemble the stem connector around the actuator stem and the anti-rotating lug on the yoke. Mark the actuator stem as a visual reference to verify that stem rotation does not occur. Remove the stem connector before rechecking the bench set.

4. If movement occurs before or after the lower pressure is reached, adjust the spring adjuster (see figure 4). Thread the adjuster up or down on the actuator stem until the actuator stem movement is **first** detected at the lower bench set pressure.
5. Apply the upper bench set loading pressure to the diaphragm. This will retract the actuator stem away from the valve. Mark the end of the actuator stem on a nearby surface using tape or some other method.
6. Slowly decrease the diaphragm pressure until the lower bench set loading pressure is applied. Again, the down-stops should be against the yoke.
7. Measure the distance between the mark or tape to the end of the actuator stem. This distance should match the travel span shown on the travel indicator scale (key 32).
8. If the span of travel is correct, bench set is complete. Proceed to the Installing the Stem Connector Assembly subsection.
9. If the travel span is not exact, remember the free-length and load rate tolerances for the spring may produce a slightly different span than specified. Contact your Emerson Process Management sales office for assistance.

Installing the Stem Connector Assembly

When installing the stem connector assembly (key 31), the actuator and valve stem threads should

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engage the threads of the stem connector by a distance equal to the diameter of the stem.

Note

Replacement stem connectors are an assembly of two stem connector halves, cap screws, and a spacer between the connector halves. Remove the spacer and discard it, if present, before clamping the actuator and valve stems together.

1. If necessary, push the valve stem down so that the valve plug is touching the seat ring on direct-acting valves. For reverse-acting valves, pull the stem up to the closed position. Always start with the valve plug on the seat.
2. If necessary, screw the valve stem locknuts down, away from the connector location. For all actuators except size 87, ensure that the travel indicator disk (key 34) is on top of the locknuts.
3. Adjust the diaphragm pressure to the lower bench set pressure. (Or, the upper bench set pressure for reverse-acting valves.) This should be the same pressure used in the bench set steps, and it is marked on the nameplate.
4. Place the stem connector half with the threaded holes, approximately half way between the actuator and valve stems. Refer to figures 6, 7, and 8 to help locate the connector position.

Be sure that the actuator and valve stem threads are engaging the threads of the stem connector by a distance equal to one diameter of the stem.

CAUTION

Incomplete engagement of either the valve stem or actuator stem in the stem connector can result in stripped threads or improper operation. Be sure that the length of each stem clamped in the stem connector is equal to or greater than one diameter of that stem. Damage to threads on either stem or in

the stem connector can cause the parts to be replaced prematurely.

5. Install the other half of the stem connector and insert the cap screws and tighten them. If installing a positioner, also attach the feedback bracket at the same time.

CAUTION

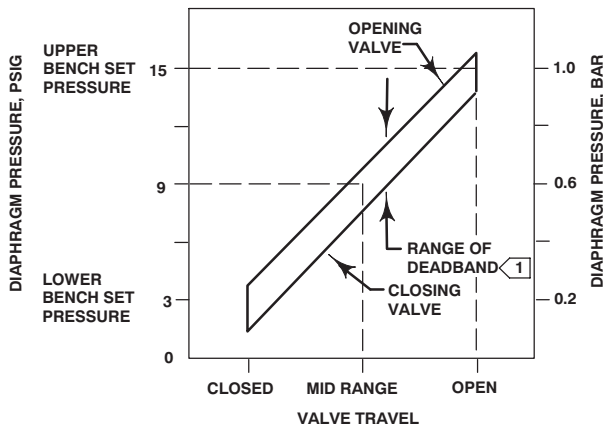
Over-tightening the valve stem locknuts can make disassembly difficult.

6. Screw the valve stem locknuts up until the indicator disk contacts the bottom of the stem connector, or for size 87 actuators, tighten the locknuts against the stem connector. Do not over-tighten the locknuts.
7. Slowly increase and then decrease pressure several times, stroking the valve from the lower bench set pressure to the upper pressure.

Be sure that the valve is in the closed position (up or down, depending on valve action). Loosen the screws on the travel scale, and align it with the travel indicator disk. Stroke the valve full travel to ensure that the travel matches the valve travel on the travel indicator plate. If valve travel is not correct, repeat the stem connector procedure.

Note

For push-down-to-close valves, the valve plug seat is the limit for downward travel and the actuator up-stop is the limit for upward (away from the valve) movement. For push-down-to-open valves, the actuator down-stop is the limit for downward movement, and the valve seat is the limit for upward (away from the valve) movement. For 667 actuators, a down-stop (key 77, figure 6) is installed to limit actuator diaphragm downward movement when the actuator provides the limit.



NOTE:
 1 DEADBAND IS CAUSED BY FRICTION.
 A6588-1 / IL

Figure 5. Typical Reverse-Acting Valve Response to Deadband

Deadband Measurement

Deadband is caused by packing friction, unbalanced forces, and other factors in the control valve assembly. Deadband is the range a measured signal can vary without initiating a response from the actuator (see figure 5). Each actuator spring has a fixed spring rate (force). You have verified that the right spring was installed in the actuator by completing the Bench Set Spring Adjustment steps.

Deadband is one factor that affects the control valve assembly operation during automatic loop control. The control loop tolerance for deadband varies widely depending on the loop response. Some common symptoms of the deadband being too wide are no movement, a “jump” movement, or oscillating movements of the actuator during automatic loop control. The following steps are provided to determine the span of deadband. The percent of deadband is helpful in troubleshooting problems with the process control loop.

1. Start at a pressure near the lower bench set pressure, slowly increase pressure until the valve is approximately at mid-travel. Note this pressure reading.
2. Slowly decrease pressure until movement of the valve stem is detected, and note this pressure.
3. The difference between these two pressures is deadband, in psi.
4. Calculate the percent of deadband by:
 Deadband, psi

$$\text{Deadband} = \frac{\text{Deadband, psi}}{\text{Bench Set Span, psi}} = nn \%$$

Loading Connection

Key number locations are shown in figures 6, 7, and 8, unless otherwise noted.

The loading pressure connections are made at the factory if the valve, actuator, and positioner come as a unit. Keep the length of tubing or piping as short as possible to avoid transmission lag in the control signal. If a volume booster, valve positioner or other accessory is used, be sure that it is properly connected to the actuator. Refer to the positioner instruction manual or other manuals as necessary. For actuators shipped separately or whenever the actuator pressure connections are installed, use the following steps:

1. Connect the loading pressure piping to the NPT internal connection in the side of the yoke (key 73).
2. For size 70 and 87 actuators, if necessary, remove the 1/4 NPT bushing if a 1/2 NPT internal connection is needed to increase connection size. The connection can be made with either piping or tubing.
3. Cycle the actuator several times to be sure that the valve stem travel is correct when the correct pressure ranges are applied to the diaphragm.
4. If valve stem travel appears to be incorrect, refer to the Bench Set Spring Adjustment procedures at the beginning of this section. Do not place the valve in service if it is not reacting correctly to diaphragm loading pressure changes.

Maintenance

Actuator parts are subject to normal wear and must be inspected regularly and replaced when necessary. The frequency of inspection and replacement depends on the severity of service conditions.

⚠ WARNING

Avoid personal injury or property damage from sudden release of process pressure or uncontrolled movement of parts. Before performing any maintenance operations:

- Always wear protective gloves, clothing, and eyewear when

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performing any maintenance operations to avoid personal injury.

- **Disconnect any operating lines providing air pressure, electric power, or a control signal to the actuator. Be sure the actuator cannot suddenly open or close the valve.**

- **Use bypass valves or completely shut off the process to isolate the valve from process pressure. Relieve process pressure from both sides of the valve. Drain the process media from both sides of the valve.**

- **Vent the power actuator loading pressure and relieve any actuator spring pre-compression.**

- **Use lock-out procedures to be sure that the above measures stay in effect while you work on the equipment.**

- **The valve packing box may contain process fluids that are pressurized, even when the valve has been removed from the pipeline. Process fluids may spray out under pressure when removing the packing hardware or packing rings, or when loosening the packing box pipe plug.**

- **Check with your process or safety engineer for any additional measures that must be taken to protect against process media.**

The maintenance instructions are divided into several sections: Actuator, Top-Mounted Handwheel Assembly (Adjustable Down Travel Stop), Side-Mounted Handwheel Assembly for Size 34 through 60 Actuators (Manual Actuator), Side-Mounted Handwheel Assembly for Size 70, 76 and 87 Actuators (Manual Actuator), and Casing-Mounted Travel Stops.

Actuator

This procedure describes how the actuator can be completely disassembled and assembled. When inspection or repairs are required, disassemble only those parts necessary to accomplish the job; then, start the assembly at the appropriate step.

Key numbers are shown in figures 6, 7, or 8, unless otherwise noted. Figure 6 shows the size 30 through

60 actuators, figure 7 shows the size 70 actuator, and figure 8 shows the size 87 actuator.

Actuator Disassembly

Isolate the control valve from the line pressure, release pressure from both sides of the valve body, and drain the process media from both sides of the valve. Also shut off all pressure lines to the power actuator, release all pressure from the actuator. Use lock-out procedures to be sure that the above measures stay in effect while you work on the equipment.

1. Remove the tubing or piping from the connection in the top of the yoke (key 73). For a top-loaded construction, also remove the piping or tubing from the connection in the upper diaphragm casing (key 1).

2. Turn the spring adjuster (key 74) counterclockwise (**toward the valve body**) until all spring compression is relieved.

WARNING

To avoid personal injury due to the sudden uncontrolled movement of parts, do not loosen the stem connector cap screws when the stem connector has spring force applied to it.

3. If necessary, remove the actuator from the valve body by separating the stem connector (key 31). Loosen the stem locknuts for the size 87 actuator, and remove the stem connector nuts. For all other sizes, separate the stem connector by loosening the stem locknuts (keys 69 and 75) and unscrewing the two stem connector cap screws.

4. Unscrew the spring adjuster (key 74) from the actuator stem (key 144). Also lift the spring seat and spring (key 19 and 18) out of the yoke.

5. Remove the diaphragm casing cap screws and nuts (keys 13 and 14), and lift off the upper diaphragm casing (key 1).

CAUTION

Be careful during disassembly to avoid damaging the O-rings (key 8).

6. Remove the following connected parts: the diaphragm (key 3), upper diaphragm plate (key 4), spacer (key 2), cap screw (key 12), lower diaphragm plate (key 71), and actuator stem (key 144). Be

careful when pulling the threads of the actuator stem through the seal bushing (key 7) to avoid damaging the O-rings (key 8).

7. Remove the cap screw (key 12) to separate the parts of this assembly.
8. To remove the seal bushing, remove the snap ring (key 72), and lift out the bushing. Inspect, and if necessary, replace O-rings (8 and 9).
9. Remove cap screws (key 30), and take off the lower diaphragm casing (key 64) and the gasket (key 70, size 30 through 60 and 76) or O-ring (key 70, size 70 or 87). If necessary, the down travel stops (key 77) can be removed.

Actuator Assembly

1. Coat the O-rings (key 70, sizes 70 and 87) with lithium grease (key 237), or, coat the gasket with lithium grease (key 237). Place a new gasket or O-ring (key 70) on the yoke (key 73). Position the lower diaphragm casing (key 64) on the yoke and align the holes. Insert the cap screws (key 30) and tighten evenly in a crisscross pattern to 41 N•m (30 lbf•ft) for size 30-60 and 76 actuators or 95 N•m (70 lbf•ft) for size 70 and 87 actuators. If down travel stops (key 77) were removed, insert and tighten them.
2. Coat the O-rings (keys 8 and 9) with lithium grease (key 237) and place the O-rings in the seal bushing (key 7).
3. Fill the seal bushing with lithium grease (key 237), slide the bushing into the yoke (key 73), and install the snap ring (key 72).

CAUTION

Be careful during assembly to avoid damaging the O-rings (key 8).

4. Assemble the actuator stem (key 144), lower diaphragm plate (key 71), diaphragm (key 3), upper diaphragm plate (key 4), and the travel stop cap screw and spacer (keys 12 and 2). Coat the cap screw threads with lithium grease (key 237). Tighten the cap screw (key 12) to 41 N•m (30 lbf•ft) torque for size 30 actuators, 68 N•m (50 lbf•ft) torque for size 34 and 40 actuators, or 183 N•m (135 lbf•ft) torque for size 45 to 76 and 87 actuators. Place this assembly in the actuator. Take care when pushing the actuator stem through the seal bushing so that the threads do not damage the O-rings.

Note

When you replace actuator diaphragms in the field, take care to ensure the diaphragm casing bolts are tightened to the proper load to prevent leakage, but not crush the material. Perform the following tightening sequence with a manual torque wrench for size 30-76 and 87 actuators.

CAUTION

Over-tightening the diaphragm cap screws and nuts (keys 13 and 14) can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

Note

Do not use lubricant on these bolts and nuts. Fasteners must be clean and dry.

5. Install the upper diaphragm casing (key 1), and install the cap screws and nuts (keys 13 and 14). Tighten the diaphragm cap screws and nuts in the following manner.
6. The first four bolts tightened should be diametrically opposed and 90 degrees apart. Tighten these four bolts to 13 N•m (10 lbf•ft).
7. Tighten the remaining bolts in a clockwise, criss-cross pattern to 13 N•m (10 lbf•ft).
8. Repeat this procedure by tightening four bolts, diametrically opposed and 90 degrees apart, to a torque of 27 N•m (20 lbf•ft).
9. Tighten the remaining bolts in a clockwise, criss-cross pattern to 27 N•m (20 lbf•ft).
10. After the last bolt is tightened to 27 N•m (20 lbf•ft), all of the bolts should be tightened again to 27 N•m (20 lbf•ft) in a circular pattern around the bolt circle.
11. Once completed, no more tightening is recommended.
12. Install the actuator spring (key 18) and spring seat (key 19). Apply anti-seize lubricant (key 239) to the threads of the actuator stem and to the surface of the spring adjuster (key 74) that contacts the spring seat. Thread the spring adjuster onto the actuator stem.

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13. Mount the actuator onto the valve in accordance with the procedures in the Installation section.

Top-Mounted Handwheel Assembly (Adjustable Down Travel Stop)

Actuator key numbers are shown in figures 6, 7, and 8. And, top-mounted handwheels are shown in figures 9, 11, and 12.

Note

If repeated or daily manual operation is expected, the actuator should be equipped with a side-mounted handwheel rather than a casing-mounted travel stop or top-mounted handwheel. The side-mounted handwheel is designed for more frequent use as a manual operator.

A top-mounted handwheel assembly (figures 9, 11, and 12) is usually used as an adjustable down travel stop to limit full extension of the actuator stem.

Turning the handwheel counterclockwise pulls the extension rod (key 150, figures 9, 11, and 12) up, retracting the actuator stem.

Instructions are given below for complete disassembly and assembly. Perform the disassembly only as far as necessary to accomplish the required maintenance; then, begin the assembly at the appropriate step.

Disassembly for Top-Mounted Handwheel

1. Bypass the control valve, reduce loading pressure to atmospheric, and remove the tubing or piping from the connection in the top of the yoke (key 73, figures 6, 7, and 8).
2. Turn the handwheel (key 58) clockwise so that the handwheel assembly is not causing any spring compression.
3. Turn the actuator spring adjuster (key 74) to relieve all the compression from the spring (key 18).
4. If servicing just the thrust bearing, races, and handwheel screw (keys 180, 181, and 160), use the following steps:

- Remove the cap and take out the cotter pin. Remove the castle nut, bearing retainer, thrust bearing, and races (keys 247, 167, 166, 180, and 181).

- Use the handwheel to remove the handwheel screw (key 160) from the handwheel body (key 148).

- If necessary, remove the extension rod (key 150) at this time. Most maintenance procedures do not require the rod to be removed.

- Clean and inspect all parts or replace parts as necessary. Upon re-assembly, lubricate handwheel threads, bearings, and races with anti-seize lubricant (key 239).

- Lubricate and re-install the handwheel screw into handwheel body (key 148). Lubricate and replace the races, bearing, and retainer (keys 181, 180, and 182). Replace the castle nut (key 166), tighten it, and insert the cotter pin (key 167). Replace the handwheel cap (key 247).

5. For size 30 through 60 and 76 actuator handwheels (figures 9 and 11):

- Remove the cap screws (key 161). Make sure that the guide plate can turn between the handwheel body and the mounting plate (keys 157, 148 and 158).

- Remove the cap (key 247) and cotter pin (key 167). Remove the castle nut (key 166) and, if necessary, unscrew the extension rod (key 150). Remove the rod, the handwheel body (key 148), and the attached parts.

- Remove the hex nuts and cap screws (keys 14 and 13, figures 6, 7, and 8) from the diaphragm casings. Lift off the upper diaphragm casing (key 1) and the mounting plate (key 158).

- Turn the handwheel (key 58) to remove the handwheel screw (key 160) from the handwheel body (key 148). Remove the retaining ring (key 60) if the handwheel (key 58) must be separated from the handwheel screw.

- If necessary, perform other actuator maintenance before returning to the following assembly steps.

6. For size 70 and 87 actuator handwheels (figure 12):

- Remove the cap (key 247). Take out the cotter pin (key 167) and remove the castle nut, the bearing retainer, and thrust bearing (keys 166, 182, 181, and 180). It is not necessary to remove the extension rod (key 150) at this time.

- Remove the hex nuts and cap screws (keys 14 and 13, figures 6, 7, and 8) from the diaphragm

casings. Lift off the upper diaphragm casing (key 1), handwheel body (key 148) and attached parts.

- If travel stops (key 152) are used, note and record their position relative to the cap screws (key 154) for use in assembly. Remove the travel stops and cap screws, and remove either the mounting plate (key 158, figure 12) or the handwheel body (key 148, figure 12) and attached parts.

- Turn the handwheel (key 58) to remove the handwheel screw (key 160) from the handwheel body (key 148). Remove the retaining ring (key 60) if the handwheel (key 58) must be separated from the handwheel screw.

- If necessary, perform other actuator maintenance before returning to the following assembly steps.

Assembly for Top-Mounted Handwheel

For size 30 through 60 and 76 actuator handwheels:

Refer to figures 9 and 11 for top-mounted handwheel assemblies.

1. If it was removed, slide the handwheel (key 58) onto the end of the handwheel screw (key 160), and snap the retaining ring (key 60) into place. Also, install the guide post (key 150) if it was removed.
2. Generously coat the threads of the handwheel screw (key 160) with anti-seize lubricant (key 239). Turn the screw into the handwheel body (key 148).
3. Install the mounting plate (key 158) to the diaphragm casing (key 1, figures 6, 7, and 8) with the cap screws (key 154). Finger tighten the screws.
4. If travel stops were used, install the travel stops to their original positions as recorded in the proceeding Disassembly steps. Tighten the screws and travel stops.

Note

When you replace actuator diaphragms in the field, take care to ensure the diaphragm casing bolts are tightened to the proper load to prevent leakage, but not crush the material. Perform the following tightening sequence with a manual torque wrench for size 30-76 and 87 actuators.

CAUTION

Over-tightening the diaphragm cap screws and nuts (keys 13 and 14) can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

Note

Do not use lubricant on these bolts and nuts. Fasteners must be clean and dry.

5. Position the diaphragm casing (key 1, figures 6, 7, and 8), mounting plate (key 158), travel stops (key 152), if used, and cap screws (key 154) on the diaphragm. Install the cap screws and hex nuts (keys 13 and 14, figures 6, 7, and 8) and tighten in the following manner.
6. The first four bolts tightened should be diametrically opposed and 90 degrees apart. Tighten these four bolts to 13 N•m (10 lbf•ft).
7. Tighten the remaining bolts in a clockwise, criss-cross pattern to 13 N•m (10 lbf•ft).
8. Repeat this procedure by tightening four bolts, diametrically opposed and 90 degrees apart, to a torque of 27 N•m (20 lbf•ft).
9. Tighten the remaining bolts in a clockwise, criss-cross pattern to 27 N•m (20 lbf•ft).
10. After the last bolt is tightened to 27 N•m (20 lbf•ft), all of the bolts should be tightened again to 27 N•m (20 lbf•ft) in a circular pattern around the bolt circle.
11. Once completed, no more tightening is recommended.
12. If necessary, screw the extension rod (key 150) into the connector (key 27). Slide the guide plate (key 157) onto the extension rod (key 150). For size 45 through 76, place the spacer (key 253) on top of the guide plate (key 157). If necessary, replace the extension rod (key 150). Slide the handwheel body (key 148) over the extension rod, position the handwheel body on the spacer (key 253), align the holes, and insert and tighten the cap screws (key 161).
13. Lubricate and install the thrust bearings (keys 181 and 180), install the bearing retainer (key 182), install the castle nut (key 166) on the extension rod. Do not overtighten the castle nut on

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the bearing. Install the cotter pin (key 167). Replace the cap (key 247).

14. Refer to the Assembly portion of the Actuator maintenance section.

For size 70 and 87 actuators handwheels (figure 12):

Refer to figure 12 for top-mounted handwheel assemblies.

1. If removed, slide the handwheel (key 58) onto the end of the handwheel screw (key 160), and snap the retaining ring (key 60) into place.
2. Generously coat the threads of the handwheel screw (key 160) with anti-seize lubricant (key 239). Turn the screw into the handwheel body (key 148).
3. If necessary, install the extension rod (key 150) into the connector (key 27) and tighten it. Position the handwheel body (key 148) on the diaphragm casing (key 1, figures 6, 7, and 8), and align the holes. Insert the cap screws (key 154). Finger tighten the screws.
4. If travel stops were used, return the travel stops to their original positions as recorded in the preceding Disassembly steps. Tighten the screws and travel stops.

Note

When you replace actuator diaphragms in the field, take care to ensure the diaphragm casing bolts are tightened to the proper load to prevent leakage, but not crush the material. Perform the following tightening sequence with a manual torque wrench for size 30-76 and 87 actuators.

CAUTION

Over-tightening the diaphragm cap screws and nuts (keys 13 and 14) can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

Note

Do not use lubricant on these bolts and nuts. Fasteners must be clean and dry.

5. Slide the extension rod (key 150) into the handwheel screw (key 160), and position the diaphragm casing (key 1, figures 6, 7, and 8) with

the attached parts on the diaphragm. Install the cap screws and hex nuts (keys 13 and 14, figures 6, 7, and 8) and tighten in the following manner.

6. The first four bolts tightened should be diametrically opposed and 90 degrees apart. Tighten these four bolts to 13 N•m (10 lbf•ft).
7. Tighten the remaining bolts in a clockwise, criss-cross pattern to 13 N•m (10 lbf•ft).
8. Repeat this procedure by tightening four bolts, diametrically opposed and 90 degrees apart, to a torque of 27 N•m (20 lbf•ft).
9. Tighten the remaining bolts in a clockwise, criss-cross pattern to 27 N•m (20 lbf•ft).
10. After the last bolt is tightened to 27 N•m (20 lbf•ft), all of the bolts should be tightened again to 27 N•m (20 lbf•ft) in a circular pattern around the bolt circle.
11. Once completed, no more tightening is recommended.

12. Lubricate and install the thrust bearings (keys 180 and 181), install the bearing retainer (key 182), install the castle nut (keys 166) on the extension rod. Do not overtighten the castle nut on the bearing. Install the cotter pin (key 167). Replace the cap (key 247).

13. Refer to the Assembly portion of the Actuator maintenance section.

Side-Mounted Handwheel Assembly for Size 34 through 60 Actuators

A side-mounted handwheel assembly (figures 13 and 14) is usually used as a manual actuator. This design is frequently used to drive the valve open or closed under loading conditions. Turning the handwheel clockwise past the neutral position always closes a push-down-to-close valve. A pair of levers (key 146, figure 13) on a handwheel assembly close the valve by moving the valve stem.

Instructions are given below for disassembly and assembly. Perform the disassembly only as far as necessary to accomplish the required maintenance; then begin the assembly at the appropriate step.

Disassembly for Side-Mounted Handwheel (34-60)

1. If desired, the handwheel assembly can be removed from the actuator yoke. To do this, remove

the nuts (keys 147 and 170) from the U-bolts (keys 166 and 143) that hold the assembly to the yoke.

2. Remove the retaining ring (key 154), and drive out the lever pivot pin (key 153).
3. Two screws (key 156) hold the right- and left-hand levers (key 146) together. Remove the screw from the top of the levers so that the levers will drop down out of the assembly. Disassemble further, if necessary, by removing the other screw.
4. Remove the screw (key 161) and pointer mounting bolt (key 159, not shown) located behind the pointer (key 160).
5. Remove the nut (key 54), lockwasher (key 150), and washer (key 149), and take off the handwheel (key 51). Be careful not to lose the small ball (key 55) and spring (key 56).
6. Unscrew the bearing retainer (key 136) after loosening the locking set screw (key 168, not shown).
7. Pull the screw assembly (key 145) out of the handwheel body. The operating nut (key 132) will come out with the screw. Also, remove the bushing (key 151) on sizes 34 and 40.
8. If required, remove the bearings (key 152), one from the bearing retainer and the other from the handwheel body.

Assembly for Side-Mounted Handwheel (Sizes 34-60)

1. Pack the bearings (key 152) with anti-seize lubricant (key 239). Insert one bearing and the bushing (key 151) in the handwheel body (key 142) as shown in figure 13 or 14. The bushing is not used in a handwheel assembly for size 45 through 60 actuators.
2. Coat the screw threads with anti-seize lubricant (key 239), and thread the operating nut onto the screw. Slide the second bearing (key 152) onto the screw, and insert the end of the screw into either the bushing (key 151) as shown in figure 13 or 14 or into the bearing.
3. Thread the bearing retainer (key 136) into the body (key 142). Completely tighten the bearing retainer, and then loosen it one-quarter turn. Tighten the set screw (key 168, not shown) to hold the bearing retainer in place.
4. Coat the groove in the handwheel body (key 142) with lithium grease (key 237). Insert the spring (key 56) and ball (key 55) into the handwheel (key 51). Holding the ball and spring in the handwheel, put the handwheel (key 51), the washer

(key 149), the lockwasher (key 150), and the hex nut (key 54) on the end of the screw (key 145). Tighten the hex nut.

5. Position the pointer mounting bolt (key 159, not shown) and the pointer (key 160) as shown in figure 13 or 14. Insert and tighten the screw (key 161).
6. Assemble the two levers (key 146) with the cap screws (key 156) for handwheel assemblies for size 45, 50, and 60 actuators or with the machine bolts (key 156) for handwheel assemblies on size 34 and 40 actuators.
7. If the handwheel assembly was removed from the yoke, remount the handjack assembly to the yoke using the dowel pins for alignment. Position the U-bolts (keys 166 and 143) on the yoke, and hand-tighten the hex nuts (keys 170 and 147) to hold the handwheel assembly in position. Cap screws (key 163) should be tight against the yoke legs to provide stability. Tighten nuts (key 144). Finish tightening the U-bolt nuts to 163 N•m [120 lbf•ft] (key 170) and 41 N•m [30 lbf•ft] (key 147). Be sure the handwheel assembly remains flat against the mounting pad and perpendicular to the yoke.
8. Position the levers (key 146) as shown in figure 13 or 14. Insert the lever pivot pin (key 153), and snap the retaining ring (key 154) onto the lever pivot pin.

Side-Mounted Handwheel Assembly for Size 70, 76, and 87 Actuators

A side-mounted handwheel assembly (figure 15) is usually used as a manual actuator. Turning the handwheel clockwise past the neutral position always closes the valve body. A sleeve (key 123, figure 15) on a handwheel assembly for a size 70, 76 or 87 actuator opens the valve body by moving the valve stem.

Instructions are given below for complete disassembly and assembly. Perform the disassembly only as far as necessary to accomplish the required maintenance; and then begin the assembly at the appropriate step.

Disassembly for Side-Mounted Handwheel (Sizes 70, 76, and 87)

1. Bypass the control valve. Reduce the loading pressure to atmospheric. Disconnect the loading pressure tubing or piping at the yoke.
2. Remove the cover band (key 87), and relieve spring compression by turning the spring adjuster (key 74) counterclockwise.
3. Remove the cap screws and nuts (keys 13 and 14) and lift off the upper diaphragm casing (key 1).

667 Size 30-76 and 87 Actuators

4. Remove the travel stop screw (key 12) and spacer (key 2), and take off the diaphragm plate (key 4), the diaphragm (key 3), and the lower diaphragm plate (key 71).
5. Unscrew the cap screws (key 90) and remove the following connected parts: the lower diaphragm casing (key 64), the O-ring (key 70), spring case adaptor (key 89), the seal bushing, O-rings, and snap ring (keys 7, 8, 9, and 72).
6. Remove the snap ring (key 72), and slide the seal bushing and O-rings (keys 7, 8, and 9) out of the spring case adaptor (key 89).
7. Take out the actuator spring (key 18).
8. Remove the stem connector (key 31) and stem connector cap screws.
9. Pull the actuator stem (key 144) up and out of the yoke. The spring seat (key 19), spring adjuster (key 74), thrust bearing (key 128), and the pinned adjusting screw (key 131) will come out with the actuator stem.
10. Turn the handwheel so that the lower sleeve (key 123) extends out of the bottom of the yoke. DO NOT move the neutral indicator scale (key 125).
11. Loosen two set screws (key 121), and unscrew the bearing retainer flange (key 45). Take out the worm gear and two thrust bearings (key 132), one on each side of the gear.
12. The worm shaft (key 51) and associated parts can be disassembled, if desired, by first removing the handwheel nut (key 127) and the handwheel (key 58). Do not lose the small ball (key 141) and spring (key 142).
13. Loosen the set screw (key 52) for each worm shaft retainer (keys 48 and 49). Unscrew the two worm retainers (keys 48 and 49). The ball bearings (key 50) will come out with the retainers.
3. Coat the worm shaft (key 51) threads with anti-seize lubricant (key 239), and slide the shaft into the yoke so that the end of the shaft fits snugly into the back bearing retainer.
4. Insert the bearing in the front bearing retainer (key 49), and thread the retainer and ball bearing into the yoke. Align the slot in the retainer with the hole in the yoke, insert the set screw (key 52), and tighten it.
5. Put the spring and ball (keys 141 and 142) in the handwheel (key 58). Slide the handwheel onto the worm shaft (key 51). Thread the hex nut (key 127) onto the worm shaft.
6. Pack the two needle bearings (key 132) and coat the worm gear (key 44) threads with anti-seize lubricant (key 239). Insert the key (key 122), the bearings, and the worm gear in the yoke (key 73) as shown in figure 15.
7. Slots are cut in the threads of the bearing retainer flange (key 45). Thread the flange into the yoke so that the slots and the holes for the set screws (key 121) align. Insert the screws, and tighten them.
8. The lower sleeve (key 123) has a milled groove in one end. Coat the sleeve threads with anti-seize lubricant (key 239), slide the end of the lower sleeve with the groove into the bearing retainer flange, turn the handwheel, and feed the sleeve through the worm gear so that the slot in the lower sleeve engages the key (key 122) in the yoke. Continue turning the handwheel until the lower sleeve protrudes 81 mm (3.19 inches) below the surface of the yoke. The bottom of the lower sleeve should be even with the bottom of the extension on the neutral indicator.
9. Pack the thrust bearing (key 128) with anti-seize lubricant (key 239). Slide the actuator stem (key 144) and the attached adjusting screw (key 131), pin (key 130), thrust bearing (key 128), spring seat (key 19), and spring adjuster (key 74) into the yoke. The lower end of the stem slides through the lower sleeve (key 123) and the lower sleeve slides into the adjusting screw (key 131), as shown in figure 15.

Assembly for Side-Mounted Handwheel (Sizes 70, 76, and 87)

1. The front and back worm retainers (keys 48 and 49) each have a slot in their threads for a set screw (key 52). Pack the ball bearings (key 50) with anti-seize lubricant (key 239), and insert one ball bearing in the back worm retainer (key 49) as shown in figure 15.
2. Thread the back bearing retainer and ball bearing (keys 49 and 50) into the yoke. Align the slot in the bearing retainer with the set screw hole in the yoke, insert the set screw (key 52), and tighten it.
10. Position the actuator stem (key 144) against the valve stem. Clamp both stems between the two halves of the stem connector (key 31), and be sure the threads are engaged properly on both stems. The stem connector should not be closer than 3.2 mm (1/8 inches) to the lower sleeve when the actuator stem is in the retracted position. This adjustment will provide approximately 3.2 mm (1/8 inches) of free travel of the lower sleeve in either direction for manual operation. Fasten the halves together with the cap screws.

11. Put the actuator spring (key 18) in the yoke on the spring seat (key 19).
12. Coat the O-rings (keys 8 and 9) with lithium grease (key 237), and insert them in the seal bushing (key 7). Slide the seal bushing and O-rings into the spring case adaptor (key 89).
13. Install the snap ring (key 72).
14. Slide the seal bushing and O-rings (keys 7, 8, and 9) over the actuator stem (key 144), and position the spring case adaptor (key 89), lower diaphragm casing (key 64), and O-ring (key 70) on the yoke.
15. Insert and tighten the cap screws (key 90).
16. Slide the lower diaphragm plate (key 71), the diaphragm (key 3) with the patterned side up, the diaphragm plate (key 4), the spacer (key 2), and the cap screw (key 12) on the actuator stem (key 144). Tighten the cap screw.
17. Put the diaphragm casing (key 1) on the diaphragm. Align the holes in the diaphragm (key 3) and the diaphragm casings (keys 1 and 64).

Note

When you replace actuator diaphragms in the field, take care to ensure the diaphragm casing bolts are tightened to the proper load to prevent leakage, but not crush the material. Perform the following tightening sequence with a manual torque wrench for size 30-76 and 87 actuators.

CAUTION

Over-tightening the diaphragm cap screws and nuts (keys 13 and 14) can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

Note

Do not use lubricant on these bolts and nuts. Fasteners must be clean and dry.

18. Install the cap screws and hex nuts (keys 13 and 14) and tighten in the following manner.
19. The first four bolts tightened should be diametrically opposed and 90 degrees apart. Tighten these four bolts to 13 N•m (10 lbf•ft).

20. Tighten the remaining bolts in a clockwise, criss-cross pattern to 13 N•m (10 lbf•ft).
21. Repeat this procedure by tightening four bolts, diametrically opposed and 90 degrees apart, to a torque of 27 N•m (20 lbf•ft).
22. Tighten the remaining bolts in a clockwise, criss-cross pattern to 27 N•m (20 lbf•ft).
23. After the last bolt is tightened to 27 N•m (20 lbf•ft), all of the bolts should be tightened again to 27 N•m (20 lbf•ft) in a circular pattern around the bolt circle.
24. Once completed, no more tightening is recommended.
25. Return the actuator to service after completing the Loading Connection procedure in the Installation section and the procedures in the Adjustments section.

Casing-Mounted Travel Stops

Note

If repeated or daily manual operation is expected, the actuator should be equipped with a side-mounted handwheel rather than a casing-mounted travel stop or top-mounted handwheel. The side-mounted handwheel is designed for more frequent use as manual operator.

Casing-mounted adjustable travel stops (shown in figures 16 through 20) are available to limit travel in the down direction (extending the actuator stem) or in the up direction (retracting the actuator stem). The travel stop in figure 16 is a down travel stop, the travel stop in figure 17 is an up and down travel stop, and the travel stops in figures 18, 19, and 20 are up travel stops.

Use the locknuts (key 151, figures 16 and 17), stem (key 150, figure 18), handwheel (key 58, figure 19) or cap screw (key 177, figure 20) to set the point at which the travel stop limits travel. Be sure to tighten the locknuts and replace the cap (key 149, figures 16 and 18; key 247, figure 17) after setting the travel stop.

Instructions are given below for disassembly and assembly. Perform the disassembly only as far as necessary to accomplish the required maintenance; then, begin the assembly at the appropriate step.

667 Size 30-76 and 87 Actuators

Key numbers are shown in figures 16 through 20.

1. Remove the cap (key 149 or 247) if the travel stop uses one. For down travel stops, loosen the locknuts (key 151, figures 16 and 17) so that the stop is not causing any spring compression.
2. Bypass the control valve, reduce loading pressure to atmospheric, and remove the tubing or piping from the connection on top of the yoke (key 73, figures 6, 7, and 8).
3. For down travel stops, turn the spring adjuster (key 74, figures 6, 7, and 8) out of the yoke toward the stem connector (key 31) to relieve all the compression in the spring (key 18).
4. **For style 11 travel stops (figure 17)**, unscrew the cap screws (key 161), and make sure that the guide plate (key 157) can turn between the handwheel body (key 148) and the mounting plate (key 158).
5. Use a wrench on the nuts (key 151) to unscrew the extension rod (key 150). Remove the rod, the handwheel body (key 148), and the attached parts.
6. Unscrew the hex nuts and cap screws (keys 14 and 13, figures 6, 7, and 8) from the diaphragm casings. Lift off the upper diaphragm casing (key 1, figures 6, 7, and 8) and, for the style 11 travel stop, the mounting plate (key 158). For styles 10, 12 and 13, the travel stop assembly will be removed with the casing.
7. Note and record the position of travel stops (key 152) relative to the cap screws (key 154) for use in assembly. Unscrew the travel stops and cap screws, and remove either the mounting plate (key 158) or the handwheel body (key 148) and attached parts.
8. Separate the stem (key 150) and screw (key 160, figure 17) from the handwheel body.
9. Before reassembling, lubricate parts indicated by key 239 in figures 16 through 20. Use anti-seize lubricant (key 239).
10. Reassemble parts in the reverse order of removal.
11. When replacing the cap screws (key 154) and, if used, the travel stops (key 152), be sure to return them to their original position as recorded in step 6.

CAUTION

Over-tightening the diaphragm cap screws and nuts (keys 13 and 14), figures 6, 7, and 8 can damage the diaphragm. Do not exceed 27 N•m (20 lbf•ft) torque.

12. Install the cap screws and nuts (keys 13 and 14, figures 6, 7, and 8) and finger tighten. Tighten the diaphragm cap screws and nuts to 27 N•m (20 lbf•ft) torque in a crisscross pattern.
13. Return the spring adjuster (key 74, figure 6, 7, and 8) to its original position. Re-adjust the travel stop.

Parts Ordering

Each actuator has a serial number stamped on the nameplate. Always mention this number when corresponding with your Emerson Process Management sales office regarding technical information or replacement parts. Also, reference the complete 11-character part number of each needed part as found in the following Parts Kits and Parts List sections.

WARNING

Use only genuine Fisher® replacement parts. Components that are not supplied by Emerson Process Management should not, under any circumstances, be used in any Fisher valve, because they may void your warranty, might adversely affect the performance of the valve, and could cause personal injury and property damage.

Note

Neither Emerson, Emerson Process Management, nor any of their affiliated entities assumes responsibility for the selection, use, or maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

Parts Kits

Side-Mounted Handwheels Retrofit Kits

Key	Description	Part Number
Retrofit Kit includes parts to add a Side-Mounted Handwheel.		
	Size 34 Push-Down-To-Close	30A8778X0E2
	Size 34 Push-Down-To-Open	30A8778X0F2
	Size 40 Push-Down-To-Close	30A8778X0G2
	Size 40 Push-Down-To-Open	30A8778X0H2
	Size 45 & 46 Push-Down-To-Close	40A8779X0A2
	Size 45 & 46 Push-Down-To-Open	40A8779X0B2
	Size 50 & 60 Push-Down-To-Close	40A8779X0C2
	Size 50 & 60 Push-Down-To-Open	40A8779X0D2

Top-Mounted Handwheels Retrofit Kits

Retrofit Kit includes parts to add a Top-Mounted Handwheel. Kit number 1 includes the handwheel assembly only. Kit number 2 includes Kit number 1 and a new diaphragm case that is required to mount the handwheel assembly.

Key	Description	Part Number
Kit 1		
	Size 30	30B3940X102
	Sizes 34	39B3940X022
	Size 40	39B3940X042
	Sizes 45 & 50	33B9224X012
	Sizes 46, 60, & 76	33B9224X012
	Sizes 70 & 87	CV8060X0012
Kit 2		
	Size 30	30B3940X052
	Size 34	30B3940X062
	Size 40	30B3940X092
	Sizes 45 & 50	33B9224X022
	Sizes 46, 60, & 76	33B9224X032
	Sizes 70 & 87	CV8060X0022

Actuator Repair Kits

Parts kit includes keys 8, 9, and 70. O-ring material is nitrile, and gasket material is composition.

Key	Description	Part Number
	Size 30	R667X000302
	Sizes 34 & 40	R667X000402
	Sizes 45 through 60	R667X000502
	Sizes 70 & 87	R667X000702
	Size 76	R667X000762

Parts List

Note

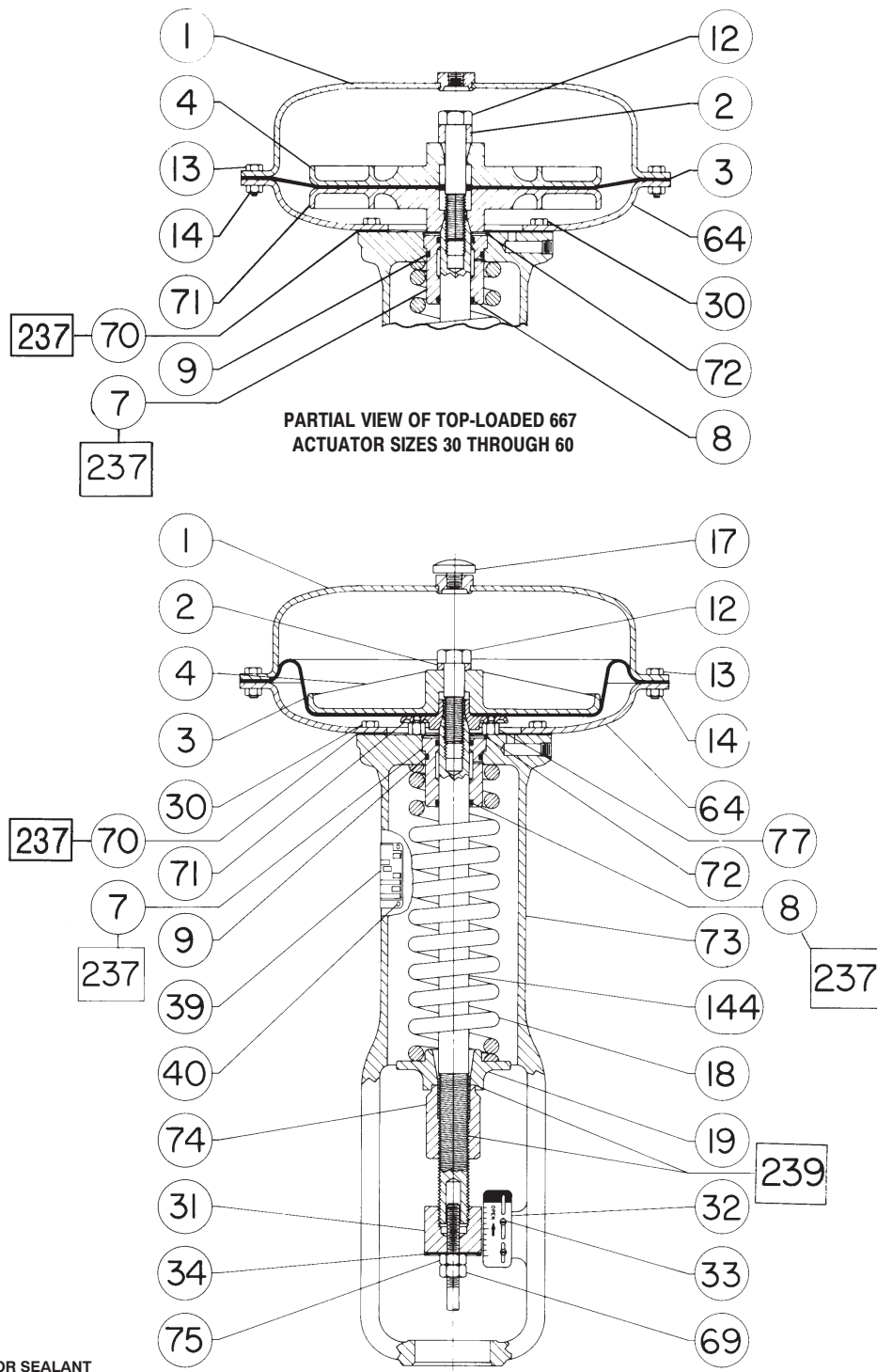
Part numbers are shown for recommended spares only. For part numbers not shown, contact your Emerson Process Management sales office.

Actuator Assembly

Key	Description	Part Number	Qty
1	Upper Diaphragm Casing		
2	Travel Stop Spacer		
3*	Diaphragm		
	Molded Nitrile/Nylon		
	Size 30	2E800002202	1
	Sizes 34 & 40	2E669902202	1
	Sizes 45 & 50	2E859602202	1
	Sizes 46, 60 & 76	2E859802202	1
	Sizes 70 & 87	2N130902202	1
	Molded Silicone/Polyester		
	Size 30	18B2713X012	1
	Sizes 34 & 40	18B2713X022	1
	Sizes 45 & 50	18B2713X032	1
	Sizes 46, 60 & 76	18B2713X042	1
	Sizes 70 & 87	18B2713X052	1
4	Upper Diaphragm Plate		
7*	Bushing, Seal		
	Brass		
	Size 30	1E791214012	1
	Sizes 34 & 40	1E682814012	1
	Sizes 45 through 60	1E845714012	1
	Sizes 70, 76 & 87	1N1316X0052	1
	S41600 [416 stainless steel (SST)]		
	Size 30	1E7912X0012	1
	Sizes 34 & 40	1E6828X0012	1
	Sizes 45 through 60	1E8457X0012	1
	PTFE w/25% Glass		
	Sizes 70, 76 & 87	1N1316X0042	1
8*	O-Ring		
	Nitrile		
	Size 30	1E5914X0052	2
	Sizes 34 & 40	1D237506992	2
	Sizes 45 through 60	1C5622X0022	2
	Sizes 70, 76 & 87	1E736906992	2
	Fluorocarbon		
	Size 30	1E5914X0062	2
	Sizes 34 & 40	1D237506382	2
	Sizes 45 through 60	1N285406382	2
	Sizes 70, 76, & 87	1N1633X0012	2
9*	O-Ring		
	Nitrile		
	Sizes 30 through 40	1C415706992	1
	Sizes 45 through 87	1E845806992	1
	Fluorocarbon		
	Sizes 30 through 40	1C4157X0032	1
	Sizes 45 through 87	1E8458X0022	1
12	Screw, Cap, hex hd		
13	Hex hd Cap Screw		
14	Hex Nut		
17	Vent Assembly		
18	Spring		
19	Seat, Lower Spring		
27	Extension Rod Conn		
30	Hex hd Cap Screw		
31	Stem Connector Assembly		
32	Travel Indicator Scale		
33	Screw, Self Tapping		
33	Screw, Mach, Fill hd		
34	Disk, Travel Indicator		
39	Nameplate		
40	Screw, Drive		
64	Lower Diaphragm Casing		

*Recommended spare parts

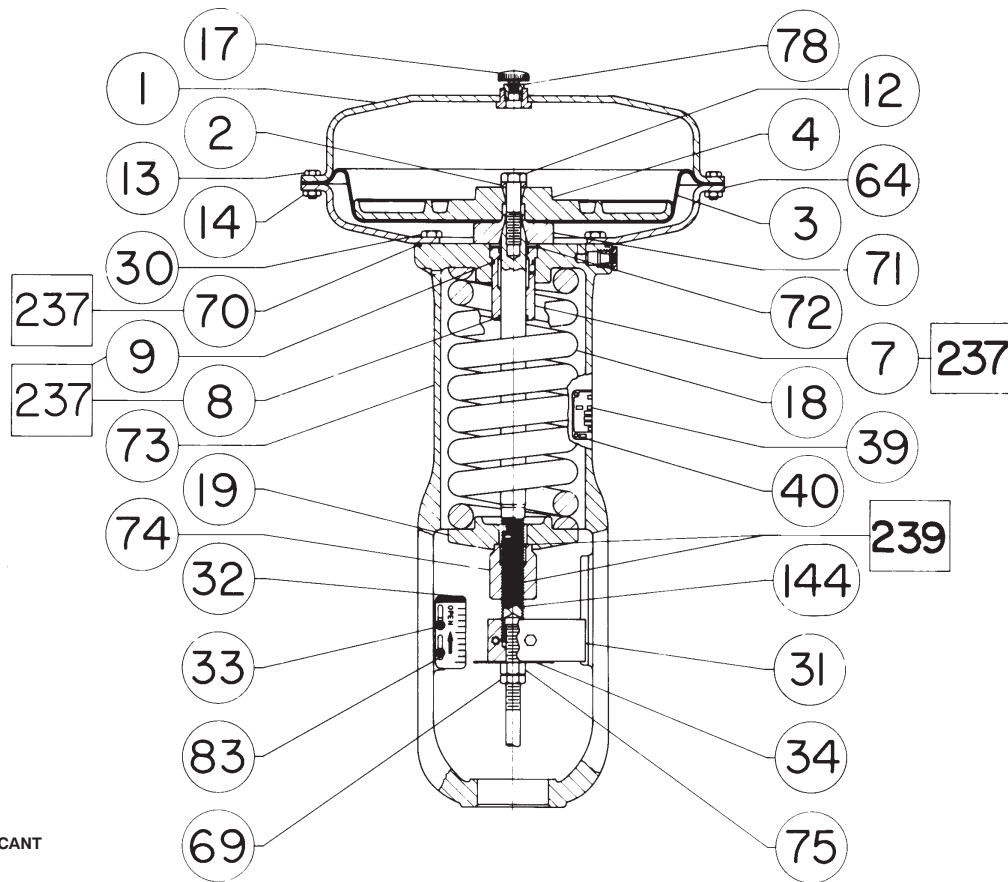
667 Size 30-76 and 87 Actuators



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50A8379-C/IL

Figure 6. Fisher® 667 Actuator Sizes 30 through 60



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Figure 7. Fisher® 667 Size 70 and 76 Actuator

Key	Description	Part Number	Qty
69	Nut, Hex, Jam		
70*	Gasket Composition [up to 232°C (450°F)] Sizes 30 through 40 Sizes 45 through 60 & 76	1E801204022 1E845404022	1 1
70*	O-Ring Nitrile Size 70 & 87	1D269106992	1
71	Lower Diaphragm Plate		
72	Ring, Snap		
73	Yoke		
74	Spring Adjuster		
75	Nut, Hex		
76	Nut, Speed, Twin		
77	Stop, Travel		
78	Bushing, Pipe, Hex		
79	Screw, Mach, Flat Hd		
81	Screw, Mach, Rd Hd		
82	Indicator, Travel, Adaptor		
83	Washer, Plain		
89	Spring Case Adaptor		
90	Screw, Cap		
102	Plug, Pipe, Hex Hd		

Key	Description	Part Number	Qty
144	Actuator Stem		
227	Washer, Plain		
228	Stem Disk Spacer		
237	Lubricant, lithium grease not furnished with actuator		
239	Lubricant, anti-seize not furnished with actuator		
254	Caution Nameplate		

**Top-Mounted Handwheel
(figures 9, 11, and 12)**

58	Handwheel
60	Retainer Ring
148	Handwheel Body
150	Extension Rod
152	Travel Stop
154	Cap Screw
156	Vent Assembly
157	Guide Plate
158	Mounting Plate

*Recommended spare parts

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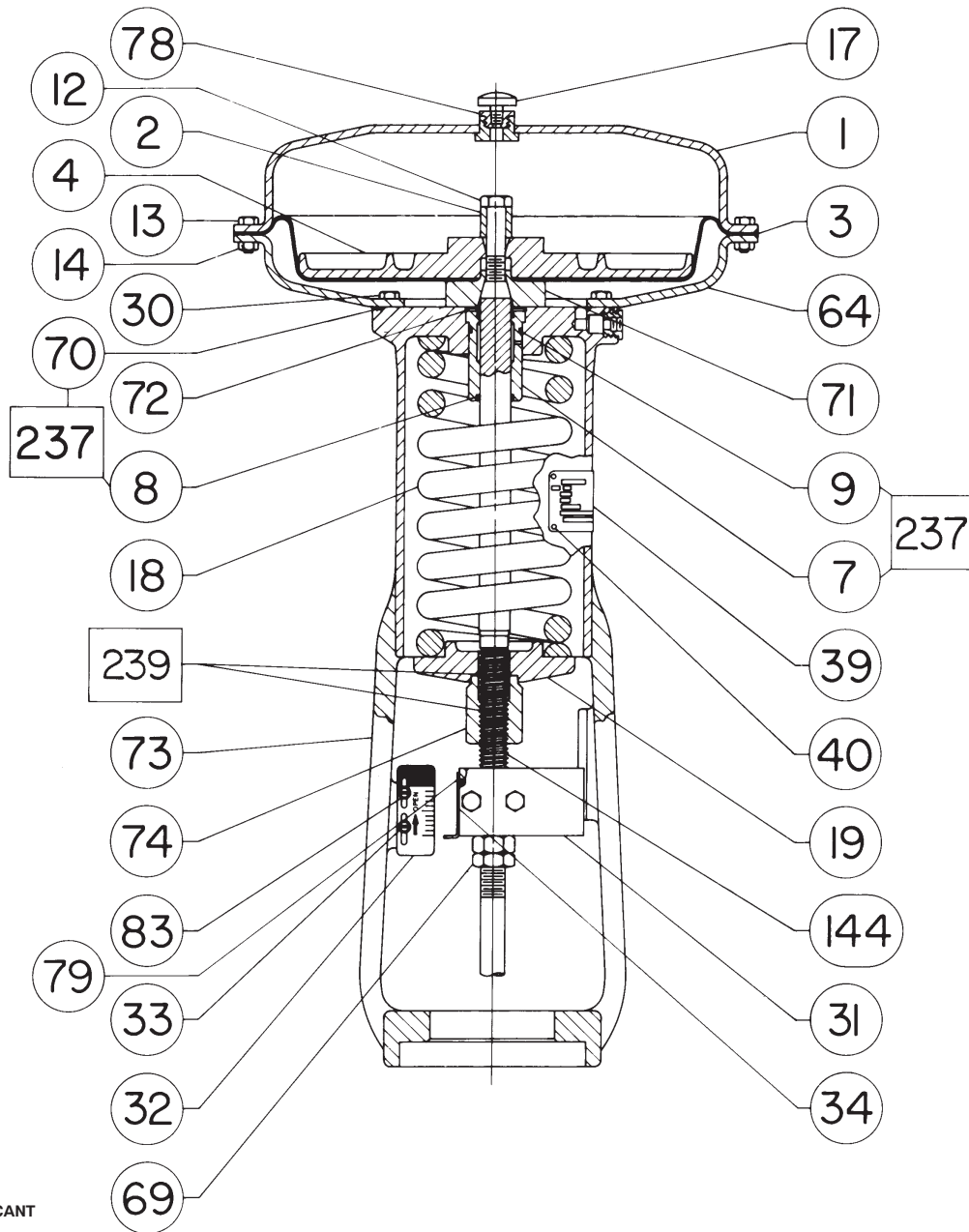
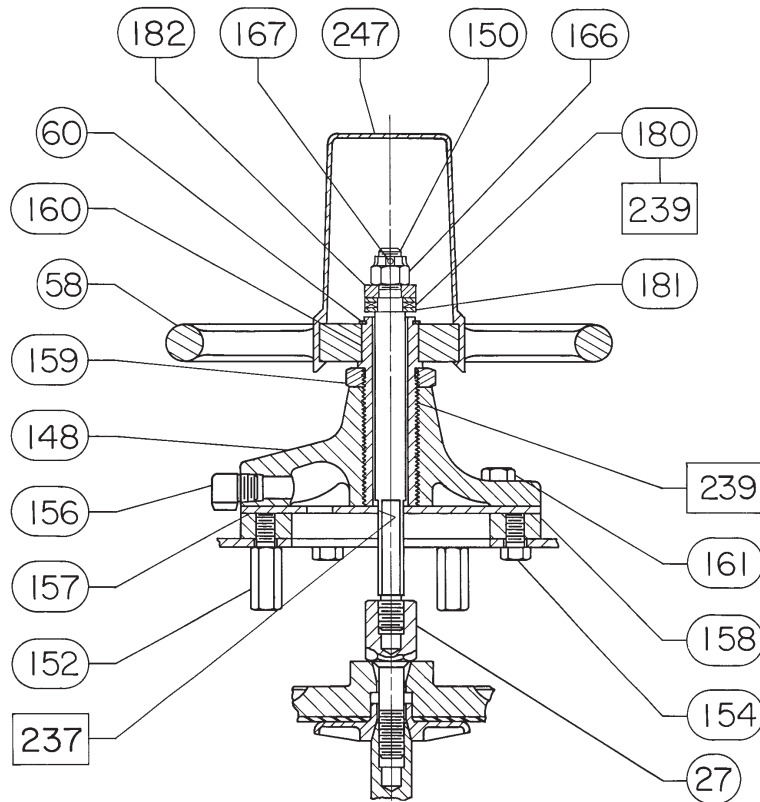


Figure 8. Fisher® 667 Size 87 Actuator

Key	Description	Part Number	Key	Description	Part Number
159	Lock Nut		180	Thrust Bearing	
160	Handwheel Screw		181	Thrust Race	
161	Cap Screw		182	Bearing Retainer	
166	Castle Nut		183	Pipe Nipple	
167	Cotter Pin		239	Lubricant, anti-seize not furnished with handwheel	
178	Machine Screw		247	Handwheel Cap	
179	Lockwasher		253	Spacer, Handjack	



□ APPLY LUBRICANT

NOTE:
THE TOP MOUNTED HANDWHEEL IS NOT DESIGNED FOR USE UNDER
HEAVY LOAD OR FREQUENT USE.

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Figure 9. Top-Mounted Handwheel Assembly for Size 30 through 40 Actuators

**Side-Mounted Handwheel,
Size 34-60 (figures 13 and 14)**

Key	Description	Part Number
51	Handwheel	
54	Hex Jam Nut	
55	Ball	
56	Spring	
132	Operating Nut	
136	Bearing Retainer	
142	Handwheel Body	
143	Mounting Bolts	
144	Hex Nut	
145	Handwheel Screw	
146	Lever & Pin Assembly	
147	Hex Jam Nut	
148	Dowel Pin	
149	Washer	
150	Lockwasher	
151	Bushing	
152	Ball Bearing	
153	Lever Pivot Pin	
154	Retaining Ring	
155	Spacer	
156	Screw	

Key	Description	Part Number
157	Lockwasher	
158	Hex Nut	
159	Pointer Mounting Bolt	
160	Pointer	
161	Machine Screw	
162	Indicator Plate (Aluminum)	
163	Cap Screw	
166	U-Bolt	
167	Guide Bolt	
168	Set Screw	
169	Grease Fitting	
170	Hex Nut	
177	Spring Cap	
178	Machine Screw	
241	Lubricant, lithium grease Not furnished with handwheel	
244	Lubricant, anti-seize Not furnished with handwheel	

**Side-Mounted Handwheel,
Size 70, 76 and 87 (figure 15)**

29	Handgrip
38	Handgrip Bolt

667 Size 30-76 and 87 Actuators

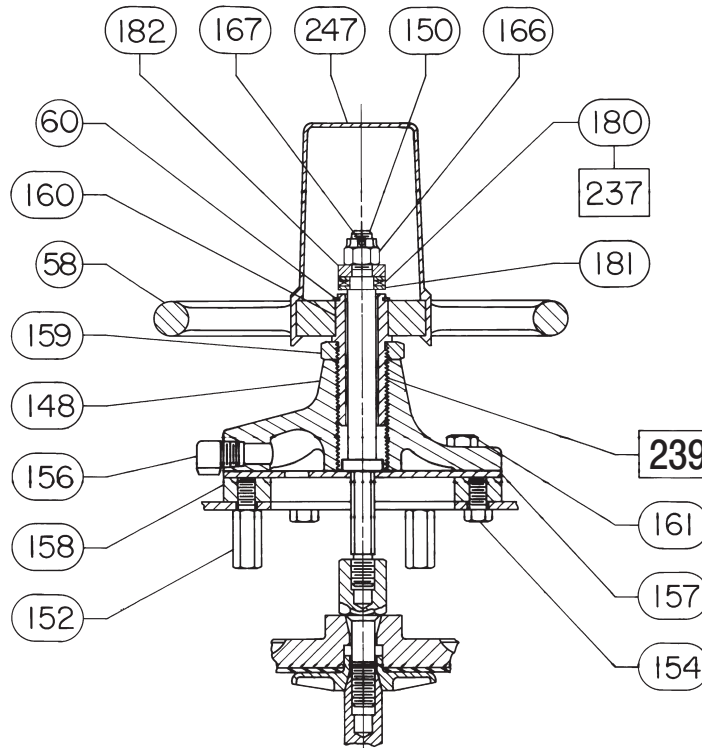


Figure 10. Top-Mounted Handwheel Assembly, Style P2 for Size 45, 50, 60, and 76 Actuators

Key	Description	Part Number	Key	Description	Part Number
44	Worm Gear		58	Handwheel	
45	Bearing Retainer Flange		102	Plug, Pipe	
48	Back Worm Retainer		127	Hex Nut	
49	Front Worm Retainer		148	Travel Stop Body	
50	Ball Bearing		149	Travel Stop Cap	
51	Worm Shaft		150	Extension Rod	
52	Set Screw		150	Travel Stop Stem	
57	Grease Fitting		151	Hex Jam Nut	
58	Handwheel		152	Travel Stop	
87	Cover Band Ass'y		153	Nut, Hex	
89	Spring Case Adaptor		154	Screw, Cap, Hex Hd	
90	Cap Screw		155	Washer, Lock, Split	
121	Set Screw		156	Vent	
122	Key		157	Guide Plate	
123	Lower Sleeve		158	Mounting Plate	
125	Handwheel Indicator		159	Nut, Travel Stop	
127	Handwheel Cap		160	Screw, Handwheel	
128	Needle Bearing		161	Screw, Cap, Hex Hd	
129	Needle Bearing Race		162	Washer	
130	Roll Pin		177	Travel Stop Screw	
131	Spring Adjusting Screw		184	Nipple, Pipe, NPT	
132	Needle Bearing		237	Lubricant, lithium grease	
133	Needle Bearing Race		239	Lubricant, anti-seize	
141	Ball		247	Travel Stop Cap	
142	Spring		248	Mounting Plate	
237	Lubricant, lithium grease Not Furnished with Handwheel				
239	Lubricant, anti-seize Not Furnished with Handwheel				
245	Yoke Extension				

Casing-Mounted Travel Stops (figures 16 through 20)

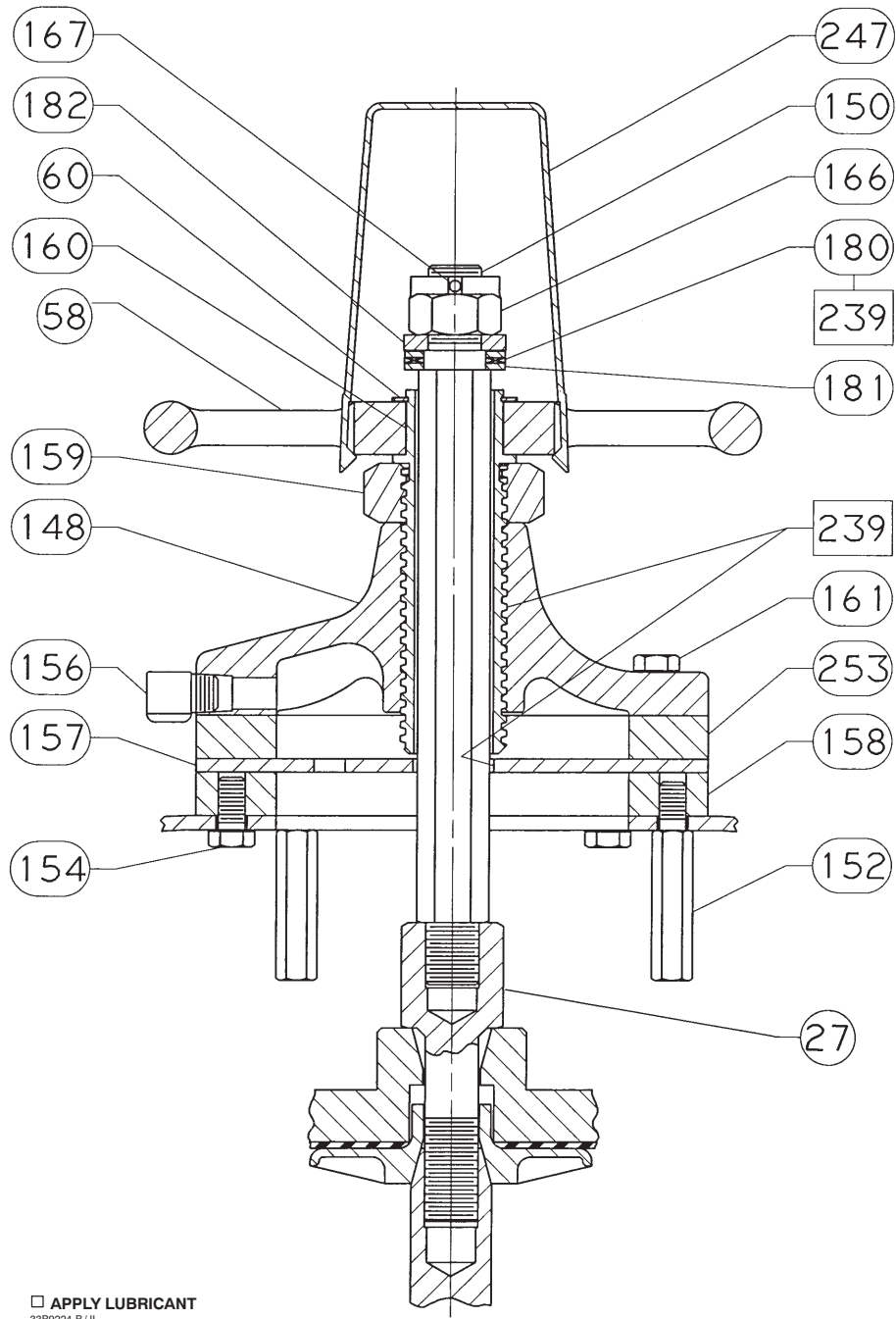


Figure 11. Top-Mounted Handwheel Assembly for Size 45-76 Actuators

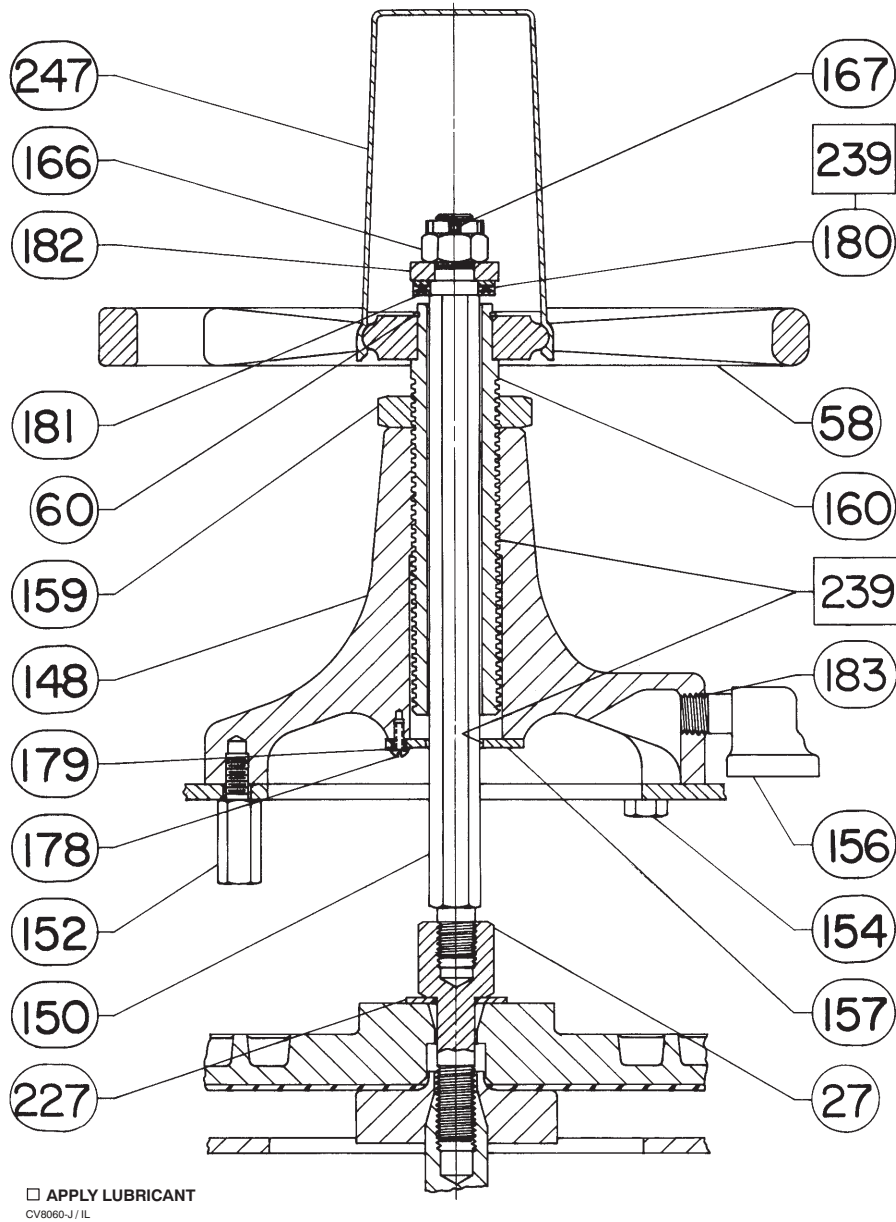
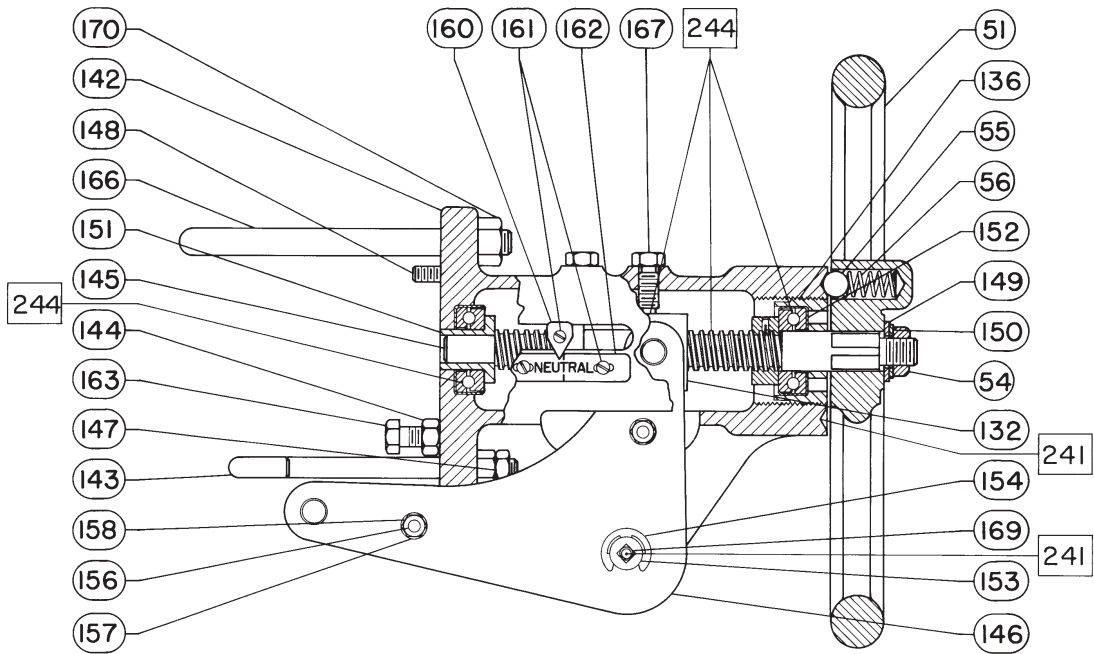
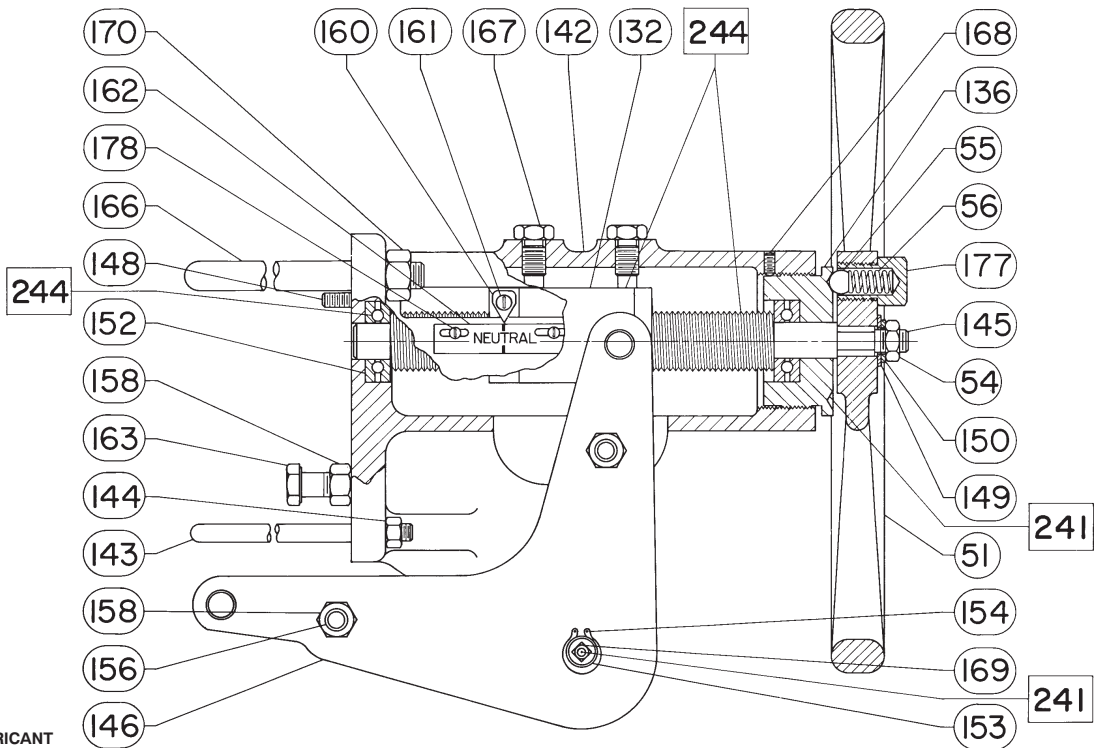


Figure 12. Top-Mounted Handwheel Assembly for Size 70 and 87 Actuators



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Figure 13. Side Mounted Handwheel Assembly for Size 34 and 40 Actuators

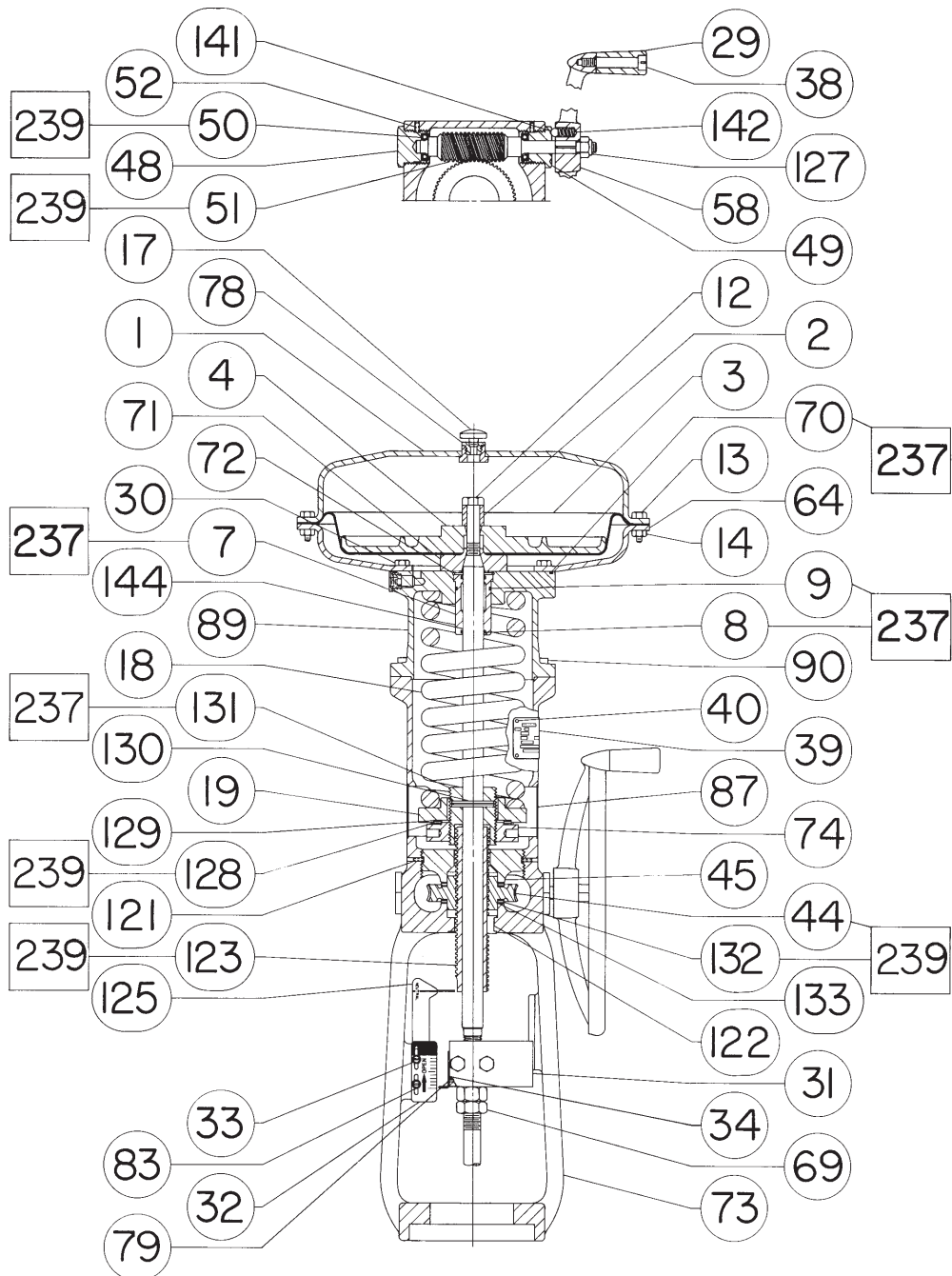


□ APPLY LUBRICANT
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Figure 14. Side-Mounted Handwheel Assembly for Size 45 through 60 Actuators

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Figure 15. Size 70, 76, and 87 Actuator with Side Mounted Handwheel Assembly

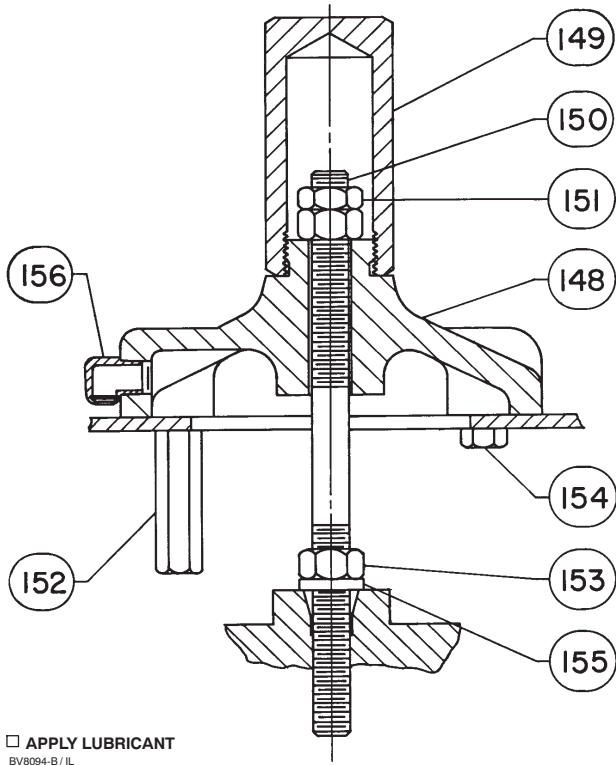


Figure 16. Style 10 Down Travel Stop (Casing Mounted)

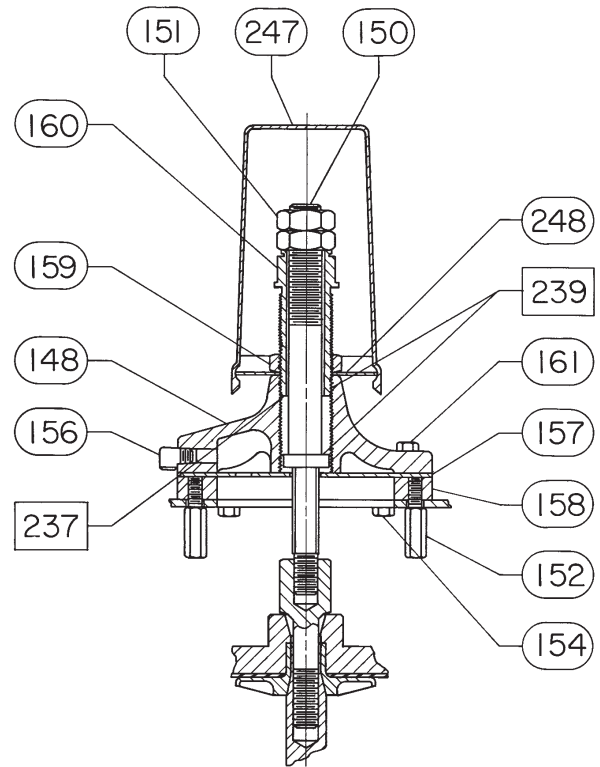
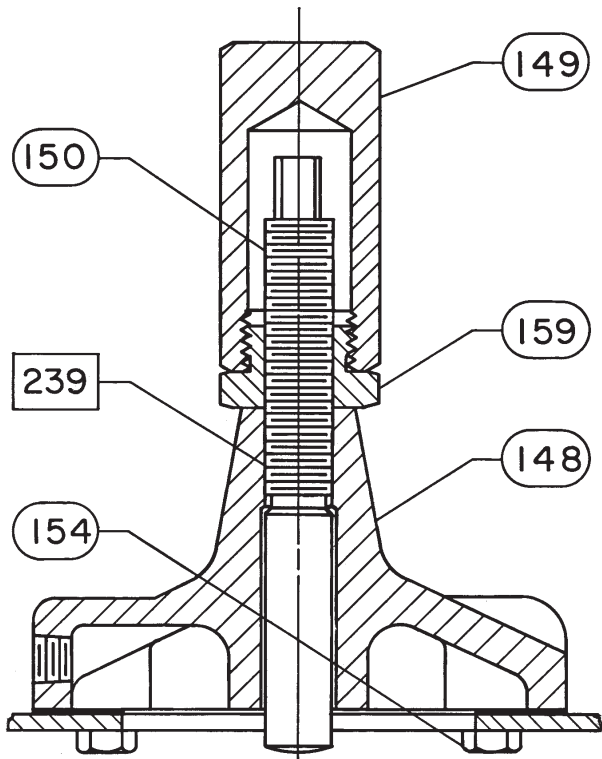


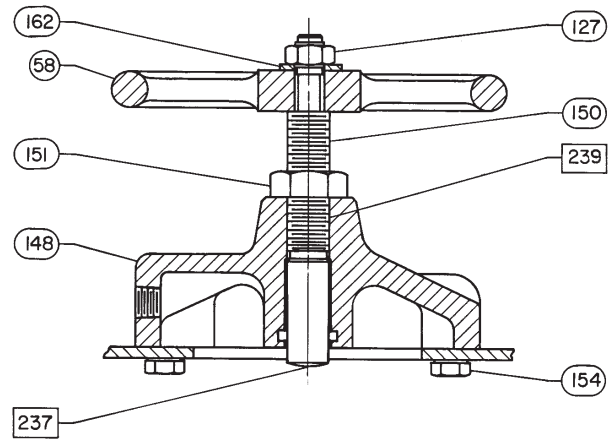
Figure 17. Style 11 Up Or Down Travel Stop (Casing Mounted)

667 Size 30-76 and 87 Actuators



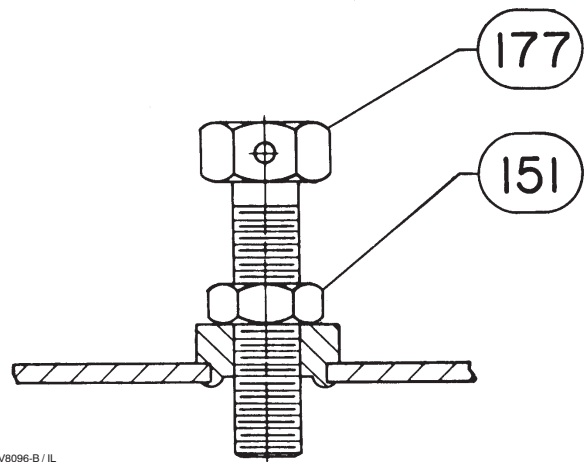
□ APPLY LUBRICANT
28A1208-B/IL

Figure 18. Style 12 Up Travel Stop (Casing Mounted)



□ APPLY LUBRICANT
28A1204-B/IL

Figure 19. Style 13 Up Travel Stop (Casing Mounted), size 30 shown



AV8096-B/IL

Figure 20. Style 14 Up Travel Stop (Casing Mounted)

667 Size 30-76 and 87 Actuators

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www.Fisher.com

Rosemount 2051 Pressure Transmitter

with 4-20 mA HART and 1-5 Vdc Low Power Protocol



ROSEMOUNT®

www.rosemount.com



EMERSON™
Process Management

Rosemount 2051 Pressure Transmitter

Read this manual before working with the product. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this product.

For technical assistance, contacts are listed below:

Customer Central

Technical support, quoting, and order-related questions.

United States - 1-800-999-9307 (7:00 am to 7:00 pm CST)

Asia Pacific- 65 777 8211

Europe/ Middle East/ Africa - 49 (8153) 9390

North American Response Center

Equipment service needs.

1-800-654-7768 (24 hours—including Canada)

Outside of these areas, contact your local Emerson Process Management representative.

⚠ CAUTION

The products described in this document are NOT designed for nuclear-qualified applications. Using non-nuclear qualified products in applications that require nuclear-qualified hardware or products may cause inaccurate readings.

For information on Rosemount nuclear-qualified products, contact your local Emerson Process Management Sales Representative.

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Section 1 Introduction

USING THIS MANUAL

The sections in this manual provide information on installing, operating, and maintaining Rosemount 2051 pressure transmitters with HART® protocol. The sections are organized as follows:

- **Section 2: Installation** contains mechanical and electrical installation instructions, and field upgrade options.
- **Section 3: Configuration** provides instruction on commissioning and operating Rosemount 2051 transmitters. Information on software functions, configuration parameters, and online variables is also included.
- **Section 4: Operation and Maintenance** contains operation and maintenance techniques.
- **Section 5: Troubleshooting** provides troubleshooting techniques for the most common operating problems.
- **Appendix A: Reference Data** supplies reference and specification data, as well as ordering information.
- **Appendix B: Approval Information** contains intrinsic safety approval information, European ATEX directive information, and approval drawings.
- **Appendix C: Glossary**

SERVICE SUPPORT

To expedite the return process outside of the United States, contact the nearest Emerson Process Management representative.

Within the United States, call the Emerson Process Management Instrument and Valves Response Center using the 1-800-654-RSMT (7768) toll-free number. This center, available 24 hours a day, will assist you with any needed information or materials.

The center will ask for product model and serial numbers, and will provide a Return Material Authorization (RMA) number. The center will also ask for the process material to which the product was last exposed.

⚠ CAUTION

Individuals who handle products exposed to a hazardous substance can avoid injury if they are informed of and understand the hazard. If the product being returned was exposed to a hazardous substance as defined by OSHA, a copy of the required Material Safety Data Sheet (MSDS) for each hazardous substance identified must be included with the returned goods.

Emerson Process Management Instrument and Valves Response Center representatives will explain the additional information and procedures necessary to return goods exposed to hazardous substances.

MODELS COVERED

The following Rosemount 2051 Pressure Transmitters are covered by this manual:

Rosemount 2051C Coplanar™ Pressure Transmitter

2051CD - Differential Pressure Transmitter

Measures differential pressure up to 2000 psi (137,9 bar)

2051CG - Gage Pressure Transmitter

Measures gage pressure up to 2000 psi (137,9 bar)

Rosemount 2051T In-Line Pressure Transmitter

2051TG - Gage Pressure Transmitter

Measures gage pressure up to 10000 psi (689,5 bar)

2051TA - Absolute Pressure Transmitter

Measures absolute pressure up to 10000 psi (689,5 bar)

Rosemount 2051L Liquid Level Pressure Transmitter

2051L - Flange-Mounted Liquid Level Transmitter

Provides precise level and specific gravity measurements up to 300 psi (20,7 bar) for a wide variety of tank configurations

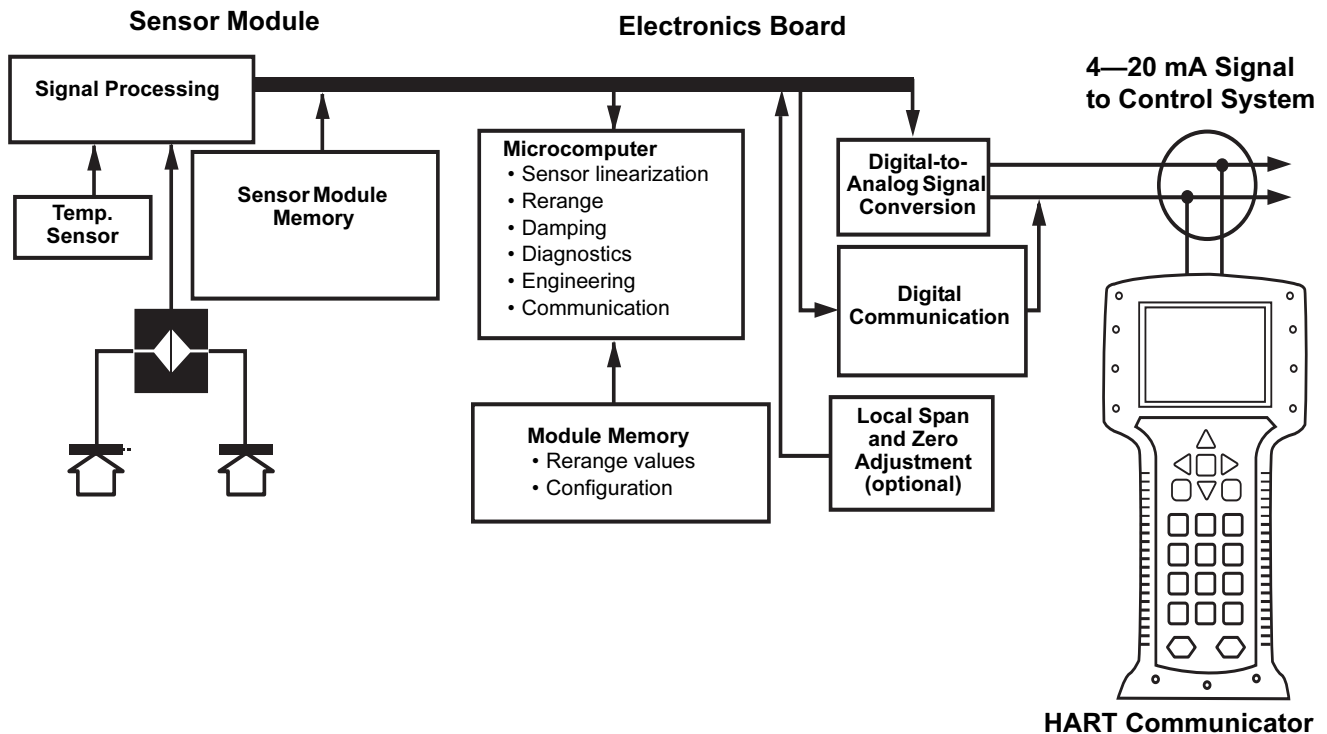
**TRANSMITTER
 OVERVIEW**

The Rosemount 2051C Coplanar design is offered for Differential Pressure (DP) and Gage Pressure (GP) measurements where it utilizes Emerson Process Management capacitance sensor technology. Piezoresistive sensor technology is utilized in the Rosemount 2051T measurements.

The major components of the Rosemount 2051C are the sensor module and the electronics housing. The sensor module contains the oil filled sensor system (isolating diaphragms, oil fill system, and sensor) and the sensor electronics. The sensor electronics are installed within the sensor module and include a temperature sensor (RTD), a memory module, and the capacitance to digital signal converter (C/D converter). The electrical signals from the sensor module are transmitted to the output electronics in the electronics housing. The electronics housing contains the output electronics board, the local zero and span buttons, and the terminal block. The basic block diagram of the Rosemount 2051CD is illustrated in Figure 1-1.

For the Rosemount 2051C design, pressure is applied to the isolating diaphragms, the oil deflects the center diaphragm, which then changes the capacitance. This capacitance signal is then changed to a digital signal in the C/D converter. The microprocessor then takes the signals from the RTD and C/D converter calculates the correct output of the transmitter. This signal is then sent to the D/A converter, which converts the signal back to an analog signal and superimposes the HART signal on the 4-20 mA output.

Figure 1-1. Block diagram of operation



Section 2 Installation

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OVERVIEW

The information in this section covers installation considerations for the Rosemount 2051 with HART protocols. A Quick Installation Guide for HART protocol (document number 00825-0100-4101) is shipped with every transmitter to describe basic pipe-fitting and wiring procedures for initial installation. Dimensional drawings for each 2051 variation and mounting configuration are included on page 2-5.

HART Communicator and AMS Device Manager instructions are given to perform configuration functions. For convenience, HART Communicator fast key sequences are labeled “Fast Keys” for each software function below the appropriate headings.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operation. Information that raises potential safety issues is indicated with a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

Warnings

WARNING

Explosions could result in death or serious injury:

Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 2051 reference manual for any restrictions associated with a safe installation.

- Before connecting a HART communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

WARNING

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals.

Process leaks could result in death or serious injury.

- Install and tighten all four flange bolts before applying pressure.
- Do not attempt to loosen or remove flange bolts while the transmitter is in service.

Replacement equipment or spare parts not approved by Emerson Process Management for use as spare parts could reduce the pressure retaining capabilities of the transmitter and may render the instrument dangerous.

- Use only bolts supplied or sold by Emerson Process Management as spare parts.
- Refer to page A-25 for a complete list of spare parts.

Improper assembly of manifolds to traditional flange can damage sensor module.

- For safe assembly of manifold to traditional flange, bolts must break back plane of flange web (i.e., bolt hole) but must not contact sensor module housing.

GENERAL CONSIDERATIONS

Measurement accuracy depends upon proper installation of the transmitter and impulse piping. Mount the transmitter close to the process and use a minimum of piping to achieve best accuracy. Also, consider the need for easy access, personnel safety, practical field calibration, and a suitable transmitter environment. Install the transmitter to minimize vibration, shock, and temperature fluctuation.

IMPORTANT

Install the enclosed pipe plug (found in the box) in unused conduit opening with a minimum of five threads engaged to comply with explosion-proof requirements.

For material compatibility considerations, see document number 00816-0100-3045 on www.emersonprocess.com/rosemount.

**MECHANICAL
CONSIDERATIONS**

NOTE

For steam service or for applications with process temperatures greater than the limits of the transmitter, do not blow down impulse piping through the transmitter. Flush lines with the blocking valves closed and refill lines with water before resuming measurement.

NOTE

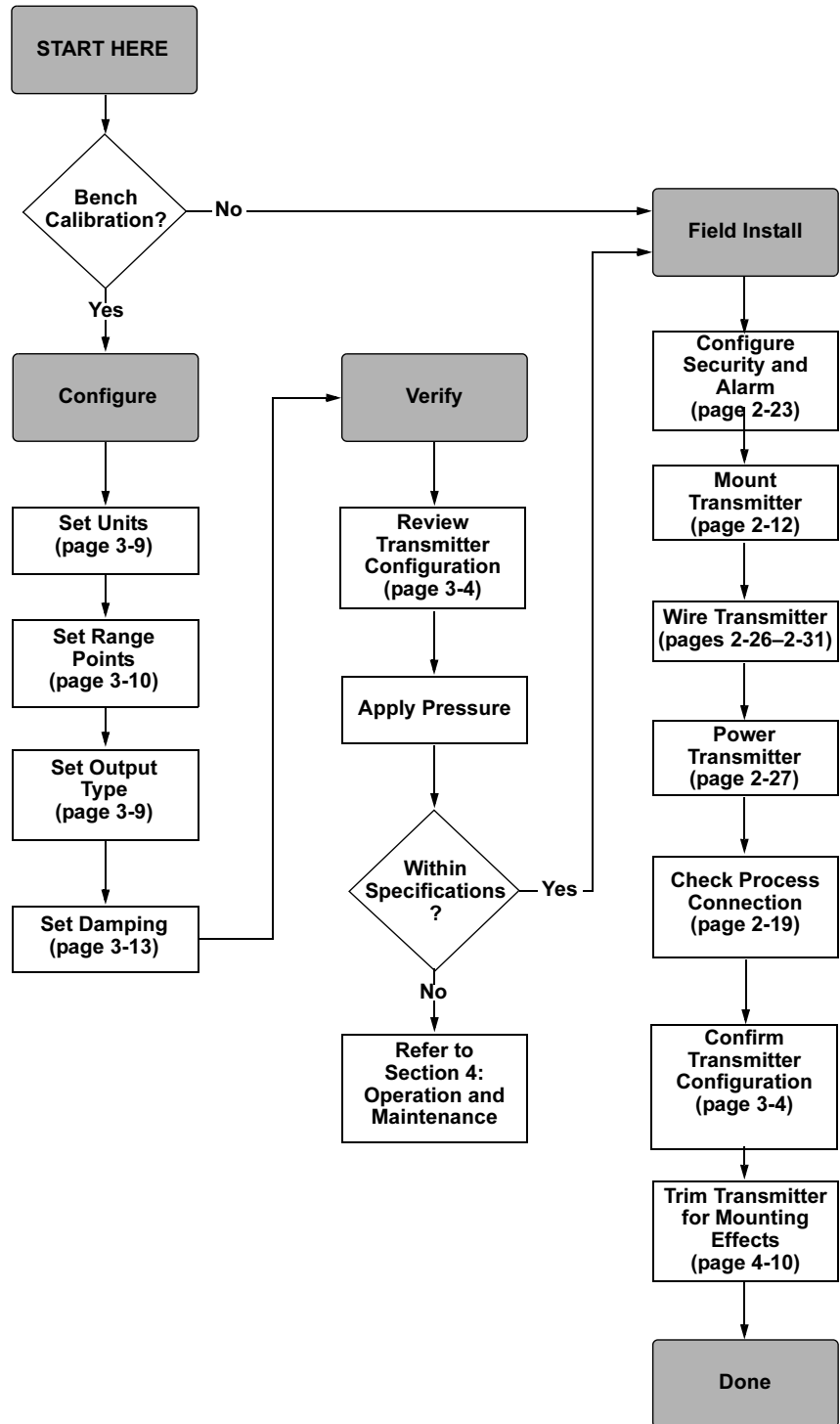
When the transmitter is mounted on its side, position the Coplanar flange to ensure proper venting or draining. Mount the flange as shown in Figure 2-8 on page 2-18, keeping drain/vent connections on the bottom for gas service and on the top for liquid service.

**ENVIRONMENTAL
CONSIDERATIONS**

Best practice is to mount the transmitter in an environment that has minimal ambient temperature change. The transmitter electronics temperature operating limits are -40 to 185 °F (-40 to 85 °C). Refer to Appendix A: Reference Data that lists the sensing element operating limits. Mount the transmitter so that it is not susceptible to vibration and mechanical shock and does not have external contact with corrosive materials.

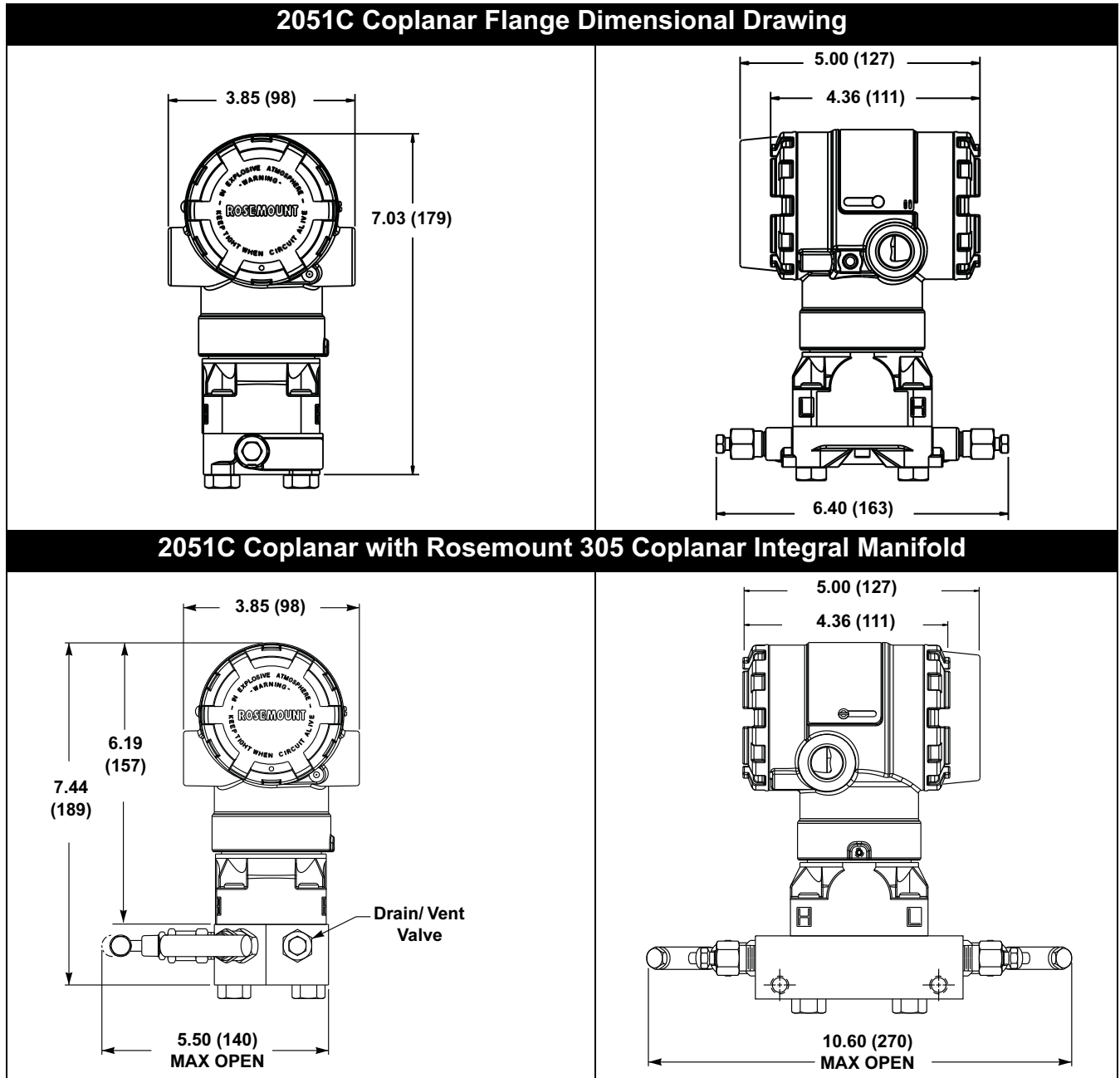
**HART INSTALLATION
FLOWCHART**

Figure 2-1. HART Installation Flowchart



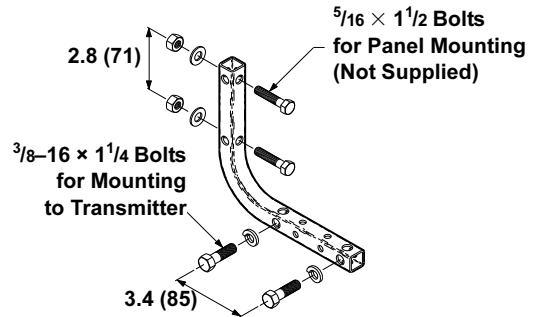
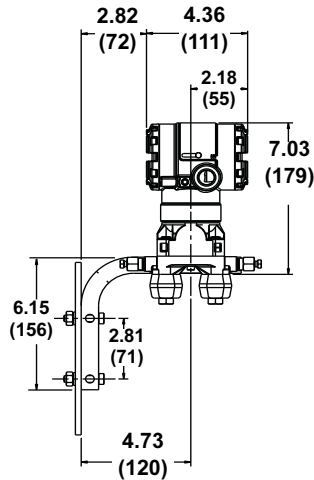
**INSTALLATION
 PROCEDURES**

Dimensional Drawings

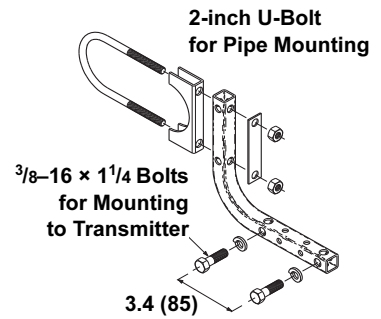
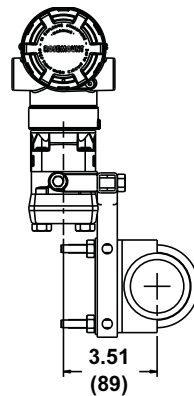
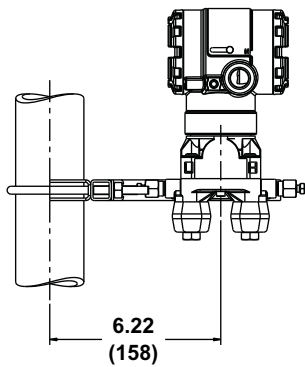


**Coplanar Flange Mounting Configurations with
 Optional Bracket (B4) for 2-in. Pipe or Panel Mounting**

PANEL MOUNTING

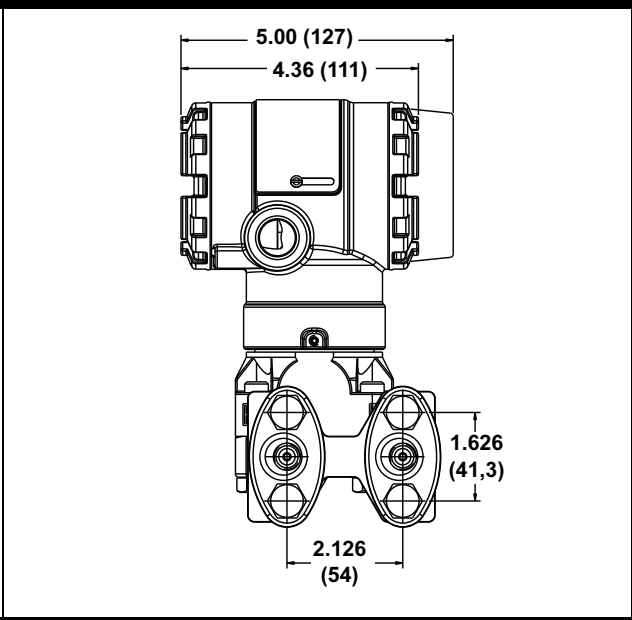
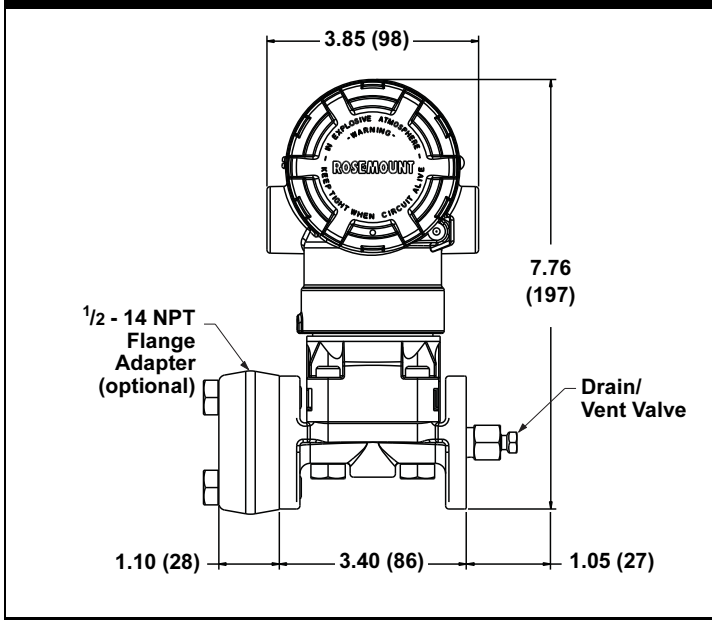


PIPE MOUNTING

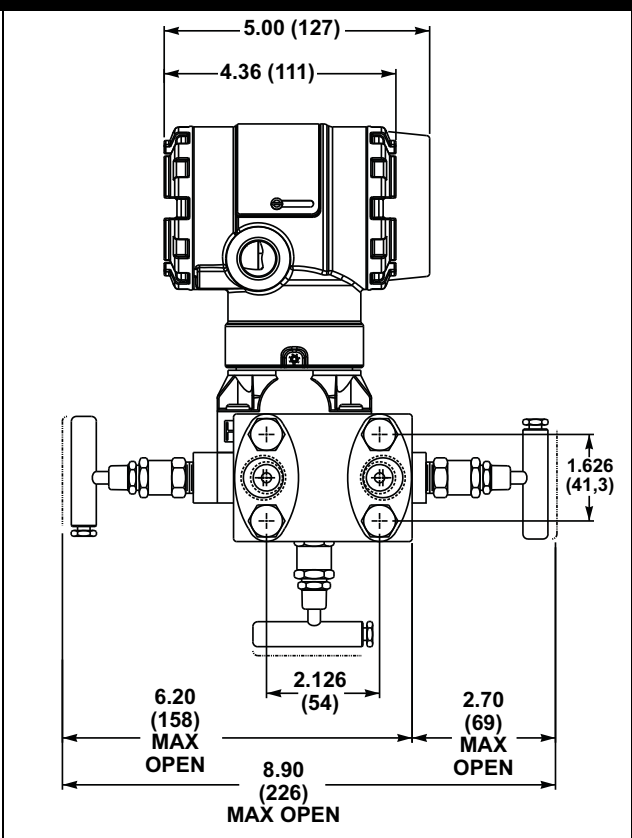
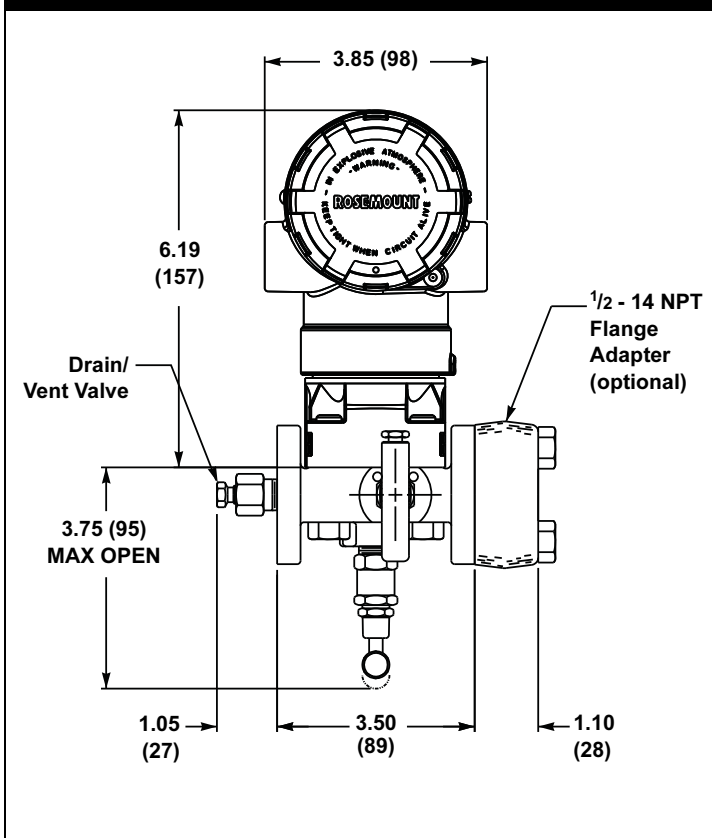


Dimensions are in inches (millimeters)

2051C Coplanar with Traditional Flange



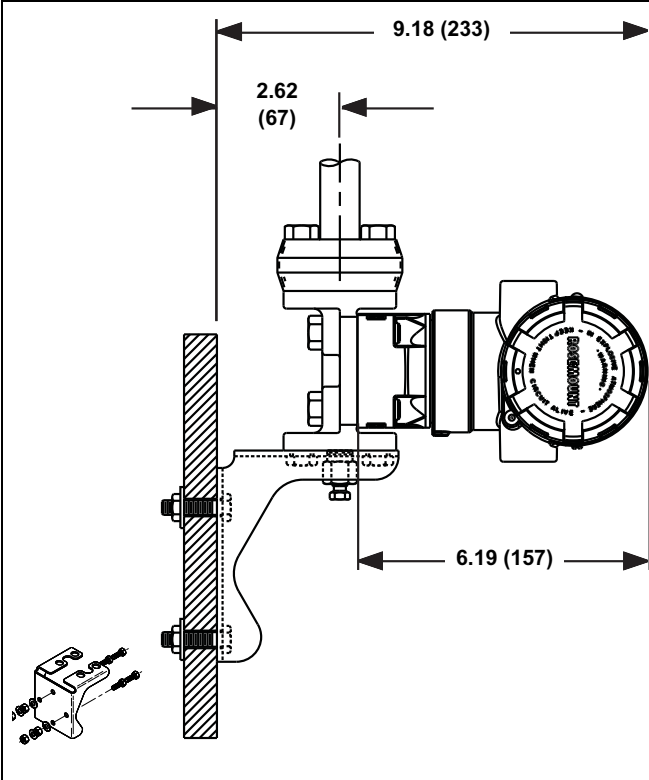
2051C Coplanar with Rosemount 305 Traditional Integral Manifold



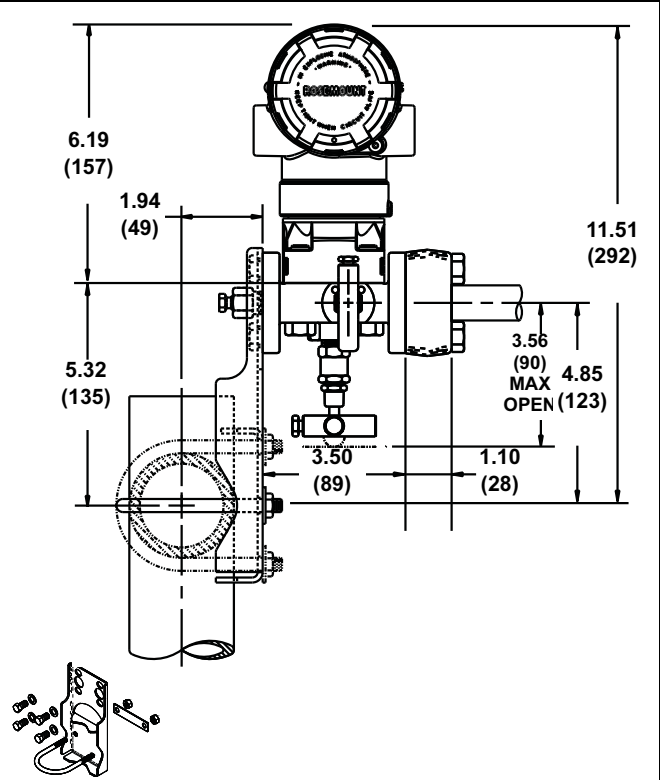
Rosemount 2051

Traditional Flange Mounting Configurations with Optional Brackets for 2-in. Pipe or Panel Mounting

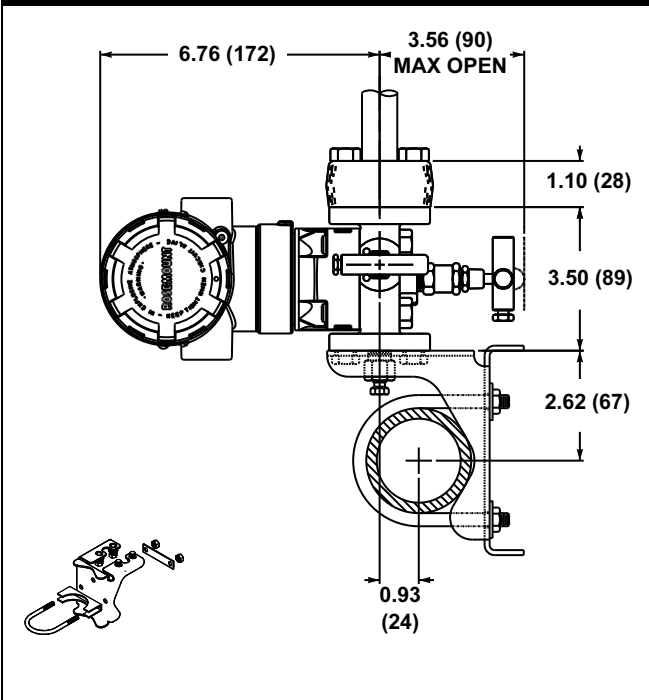
Panel Mount (Bracket Option B2 / B8)



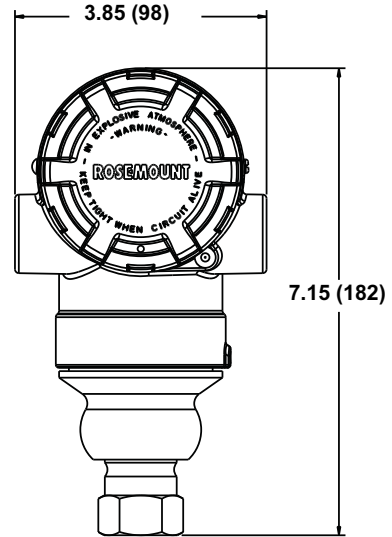
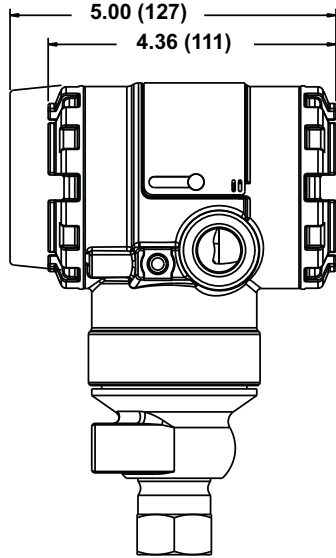
Pipe Mount (Bracket Option B3 / B9 / BC)



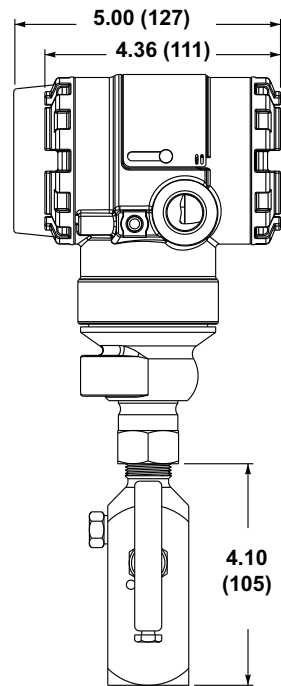
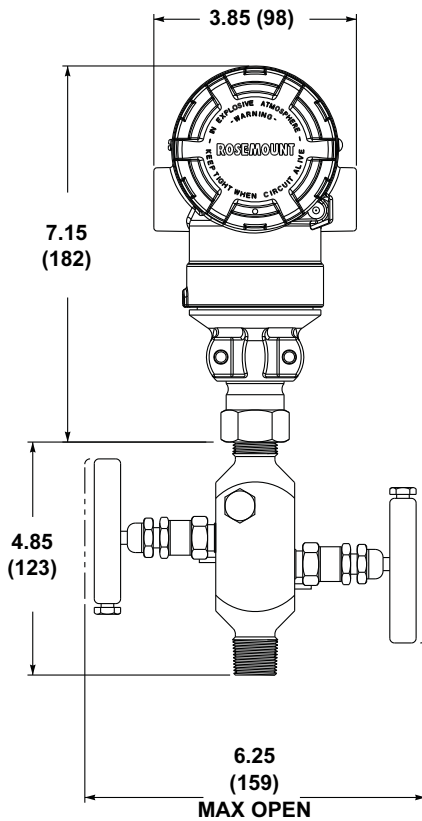
Pipe Mount (Bracket Option B1 / B7 / BA)

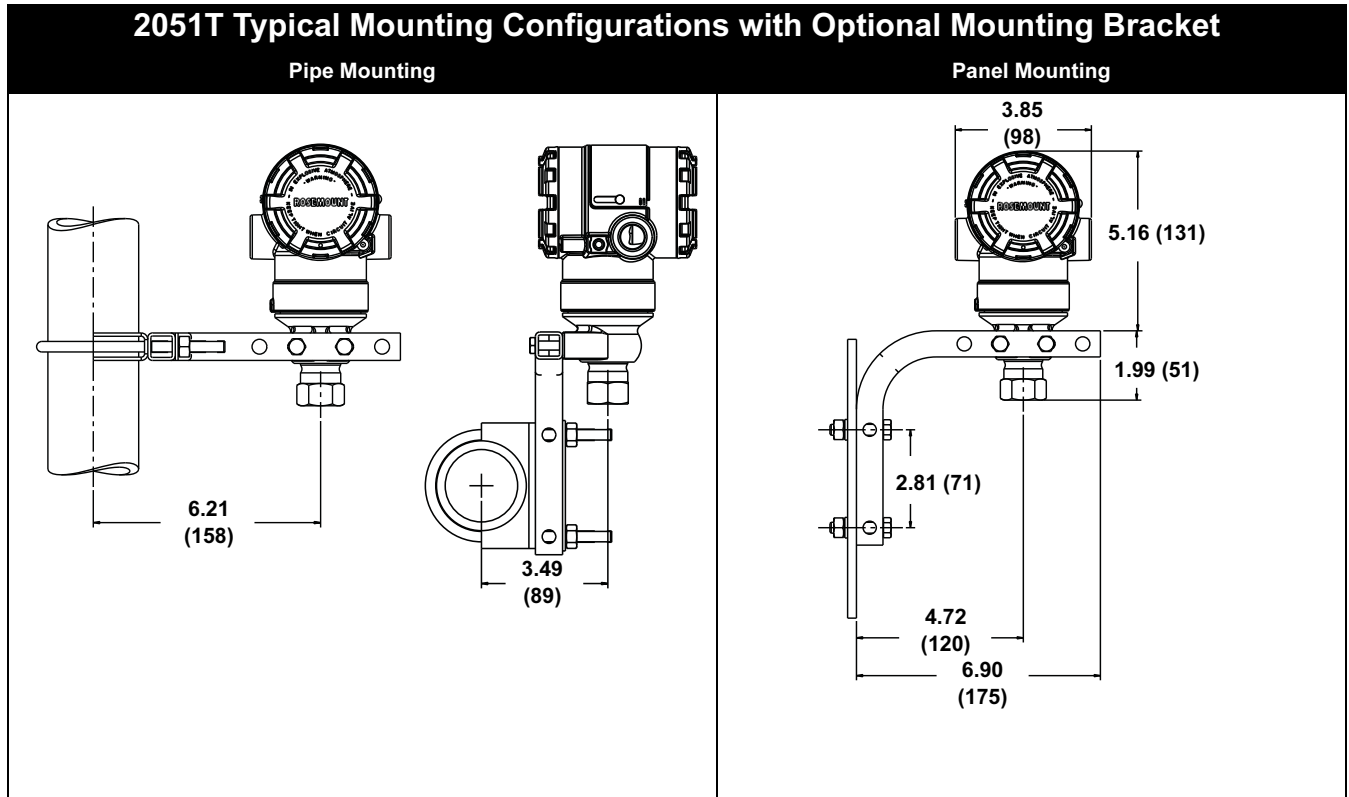


2051T Dimensional Drawings



2051T with Rosemount 306 Integral Manifold

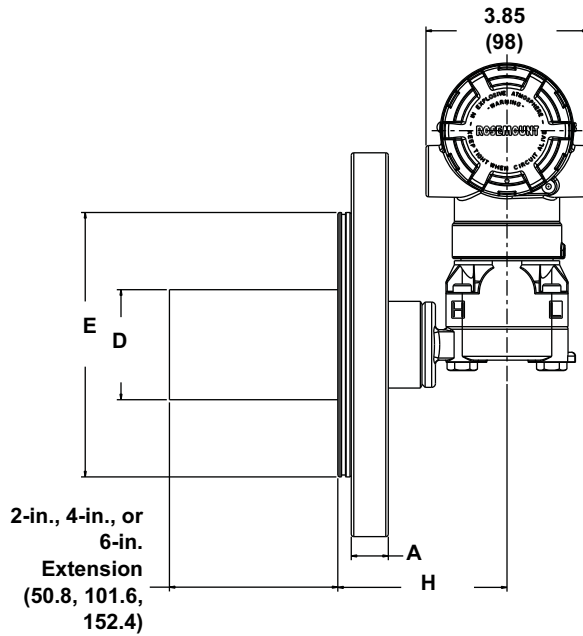
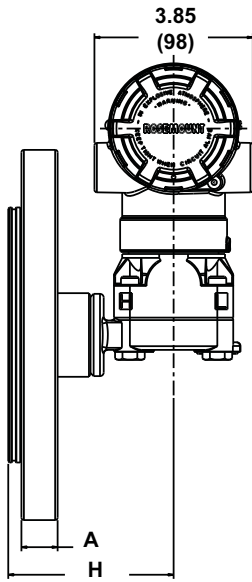




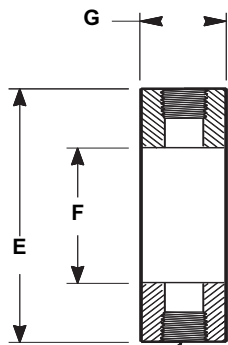
2051L Liquid Level

2-in. Flange Configuration (Flush Mount Only)

3- and 4-in. Flange Configuration



Optional Flushing Connection Ring (Lower Housing)



Flushing Connection

Diaphragm Assembly and Mounting Flange

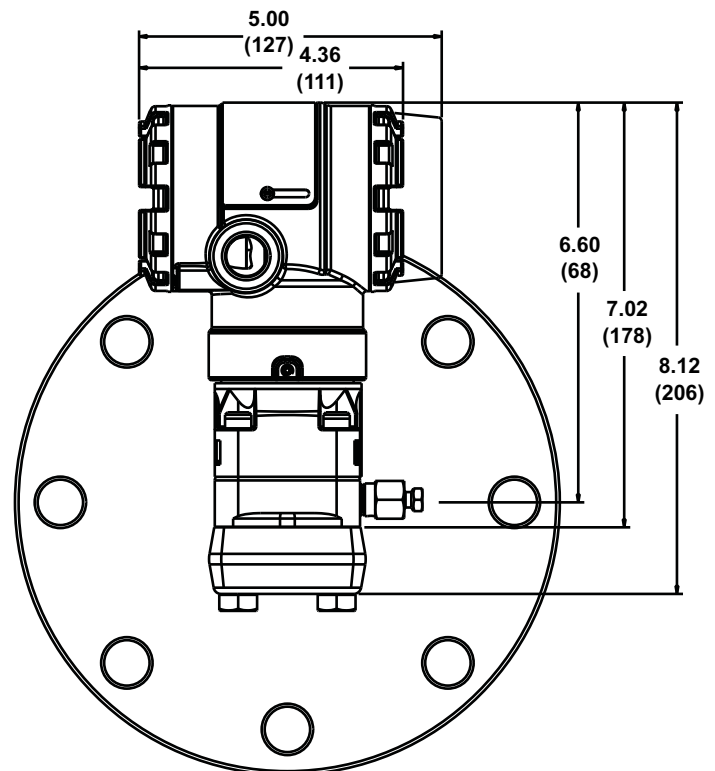
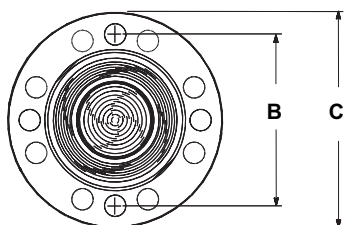


Table 2-1. 2051L Dimensional Specifications

Except where indicated, dimensions are in inches (millimeters).

Class	Pipe Size	Flange Thickness A	Bolt Circle Diameter B	Outside Diameter C	No. of Bolts	Bolt Hole Diameter	Extension Diameter ⁽¹⁾ D	O.D. Gasket Surface E
ASME B16.5 (ANSI) 150	2 (51)	0.69 (18)	4.75 (121)	6.0 (152)	4	0.75 (19)	NA	3.6 (92)
	3 (76)	0.88 (22)	6.0 (152)	7.5 (191)	4	0.75 (19)	2.58 (66)	5.0 (127)
	4 (102)	0.88 (22)	7.5 (191)	9.0 (229)	8	0.75 (19)	3.5 (89)	6.2 (158)
ASME B16.5 (ANSI) 300	2 (51)	0.82 (21)	5.0 (127)	6.5 (165)	8	0.75 (19)	NA	3.6 (92)
	3 (76)	1.06 (27)	6.62 (168)	8.25 (210)	8	0.88 (22)	2.58 (66)	5.0 (127)
	4 (102)	1.19 (30)	7.88 (200)	10.0 (254)	8	0.88 (22)	3.5 (89)	6.2 (158)
DIN 2501 PN 10–40	DN 50	20 mm	125 mm	165 mm	4	18 mm	NA	4.0 (102)
DIN 2501 PN 25/40	DN 80	24 mm	160 mm	200 mm	8	18 mm	65 mm	5.4 (138)
	DN 100	24 mm	190 mm	235 mm	8	22 mm	89 mm	6.2 (158)

Class	Pipe Size	Process Side F	Lower Housing G		H
			1/4 NPT	1/2 NPT	
ASME B16.5 (ANSI) 150	2 (51)	2.12 (54)	0.97 (25)	1.31 (33)	5.65 (143)
	3 (76)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
	4 (102)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
ASME B16.5 (ANSI) 300	2 (51)	2.12 (54)	0.97 (25)	1.31 (33)	5.65 (143)
	3 (76)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
	4 (102)	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
DIN 2501 PN 10–40	DN 50	2.4 (61)	0.97 (25)	1.31 (33)	5.65 (143)
DIN 2501 PN 25/40	DN 80	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)
	DN 100	3.6 (91)	0.97 (25)	1.31 (33)	5.65 (143)

(1) Tolerances are -0.020 and +0.040 (-0,51 and +1,02)

Mount the Transmitter

Process Flange Orientation

Mount the process flanges with sufficient clearance for process connections. For safety reasons, place the drain/vent valves so the process fluid is directed away from possible human contact when the vents are used. In addition, consider the accessibility for a testing or calibration input.

NOTE

Most transmitters are calibrated in the horizontal position. Mounting the transmitter in any other position will shift the zero point to the equivalent amount of liquid head pressure caused by the varied mounting position. To reset zero point, refer to “Sensor Trim” on page 4-5.

Terminal Side of Electronics Housing

Mount the transmitter so the terminal side is accessible. Clearance of 0.75-in. (19 mm) is required for cover removal. Use a conduit plug on the unused side of the conduit opening.

Circuit Side of Electronics Housing

Provide 0.75 in. (19 mm) of clearance for units without an LCD display. Provide 3 in. (76 mm) of clearance for units installed with LCD.

Cover Installation

Always ensure a proper seal by installing the electronics housing covers so that metal contacts metal. Use Rosemount o-rings.

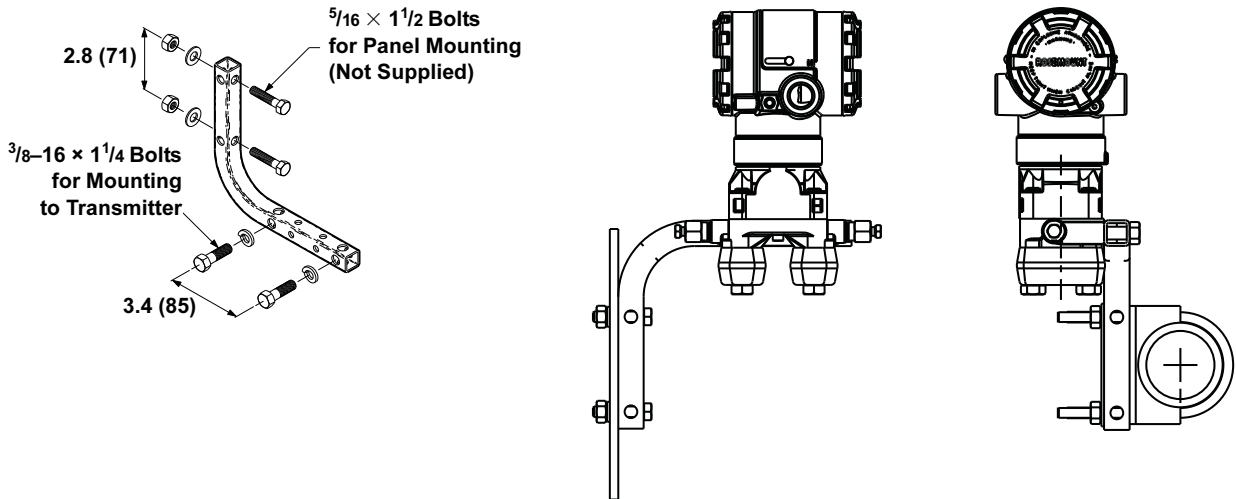
Mounting Brackets

Rosemount 2051 Transmitters may be panel-mounted or pipe-mounted through an optional mounting bracket. Refer to Table 2-2 for the complete offering and see Figure 2-2 through Figure 2-5 on pages 2-13 and 2-14 for dimensions and mounting configurations.

Table 2-2. Mounting Brackets

2051 Brackets										
Option Code	Process Connections			Mounting			Materials			
	Coplanar	In-Line	Traditional	Pipe Mount	Panel Mount	Flat Panel Mount	CS Bracket	SST Bracket	CS Bolts	SST Bolts
B4	X	X		X	X	X		X		X
B1			X	X			X		X	
B2			X		X		X		X	
B3			X			X	X		X	
B7			X	X			X			X
B8			X		X		X			X
B9			X			X	X			X
BA			X	X				X		X
BC			X			X		X		X

Figure 2-2. Mounting Bracket Option Code B4



Rosemount 2051

Figure 2-3. Mounting Bracket Option Codes B1, B7, and BA

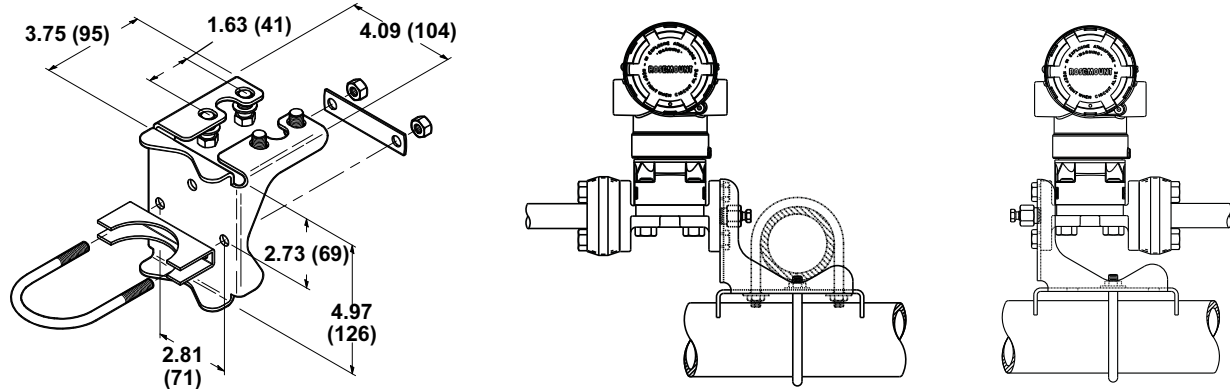


Figure 2-4. Panel Mounting Bracket Option Codes B2 and B8

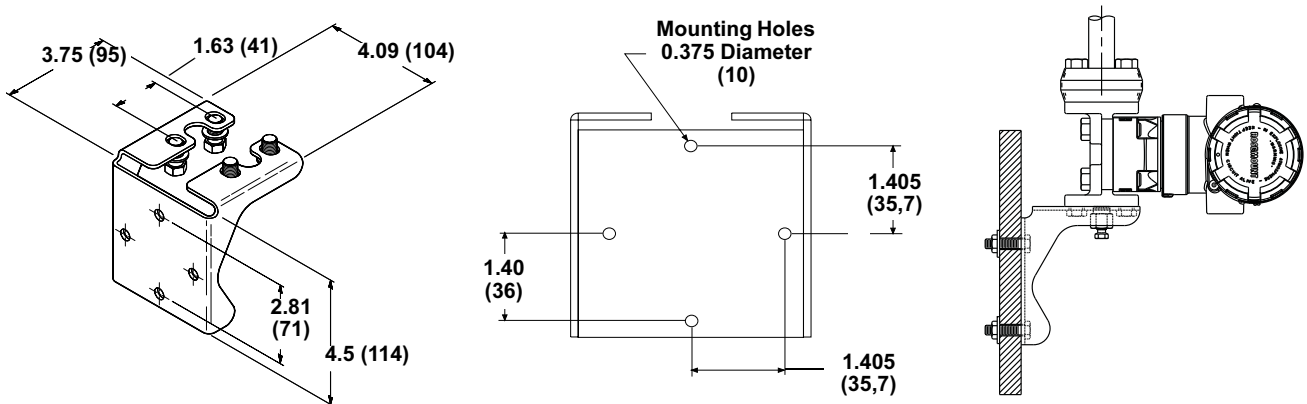
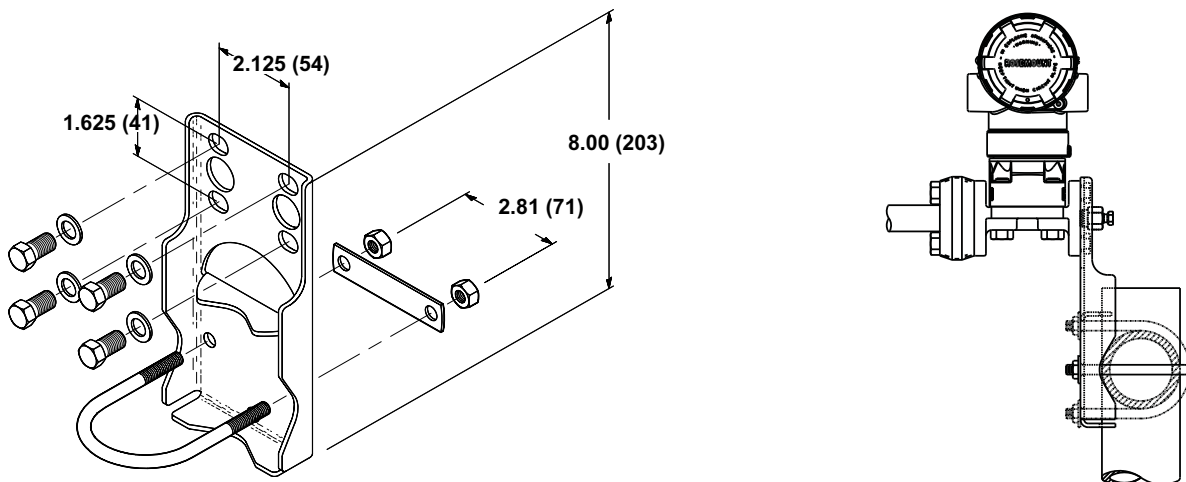


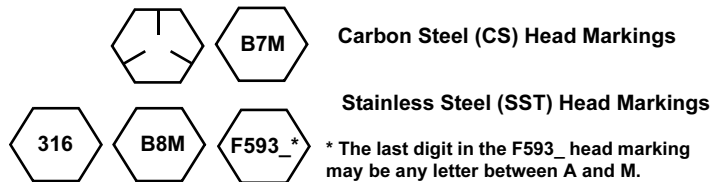
Figure 2-5. Flat Mounting Bracket Option Codes B3 and BC




NOTE
 Dimensions are in inches (millimeters).

Flange Bolts

The 2051 is shipped with a Coplanar flange installed with four 1.75-in. (44 mm) flange bolts. See Figure 2-6 and Figure 2-7 on pages 2-16 and 2-16. Stainless steel bolts are coated with a lubricant to ease installation. Carbon steel bolts do not require lubrication. No additional lubricant should be applied when installing either type of bolt. Bolts are identified by their head markings:



Bolt Installation

 Only use bolts supplied with the 2051 or provided by Emerson Process Management as spare parts. When installing the transmitter to one of the optional mounting brackets, torque the bolts to 125 in.-lb. (0,9 N-m). Use the following bolt installation procedure:

1. Finger-tighten the bolts.
2. Torque the bolts to the initial torque value using a crossing pattern.
3. Torque the bolts to the final torque value using the same crossing pattern.

Torque values for the flange and manifold adapter bolts are as follows:

Table 2-3. Bolt Installation Torque Values

Bolt Material	Initial Torque Value	Final Torque Value
CS-ASTM-A449 Standard	300 in.-lb (34 N-m)	650 in.-lb (73 N-m)
316 SST—Option L4	150 in.-lb (17 N-m)	300 in.-lb (34 N-m)
ASTM-A-193-B7M—Option L5	300 in.-lb (34 N-m)	650 in.-lb (73 N-m)
ASTM-A-193 Class 2, Grade B8M—Option L8	150 in.-lb (17 N-m)	300 in.-lb (34 N-m)

 See "Safety Messages" on page 2-1 for complete warning information.

Rosemount 2051

Figure 2-6. Traditional Flange Bolt Configurations

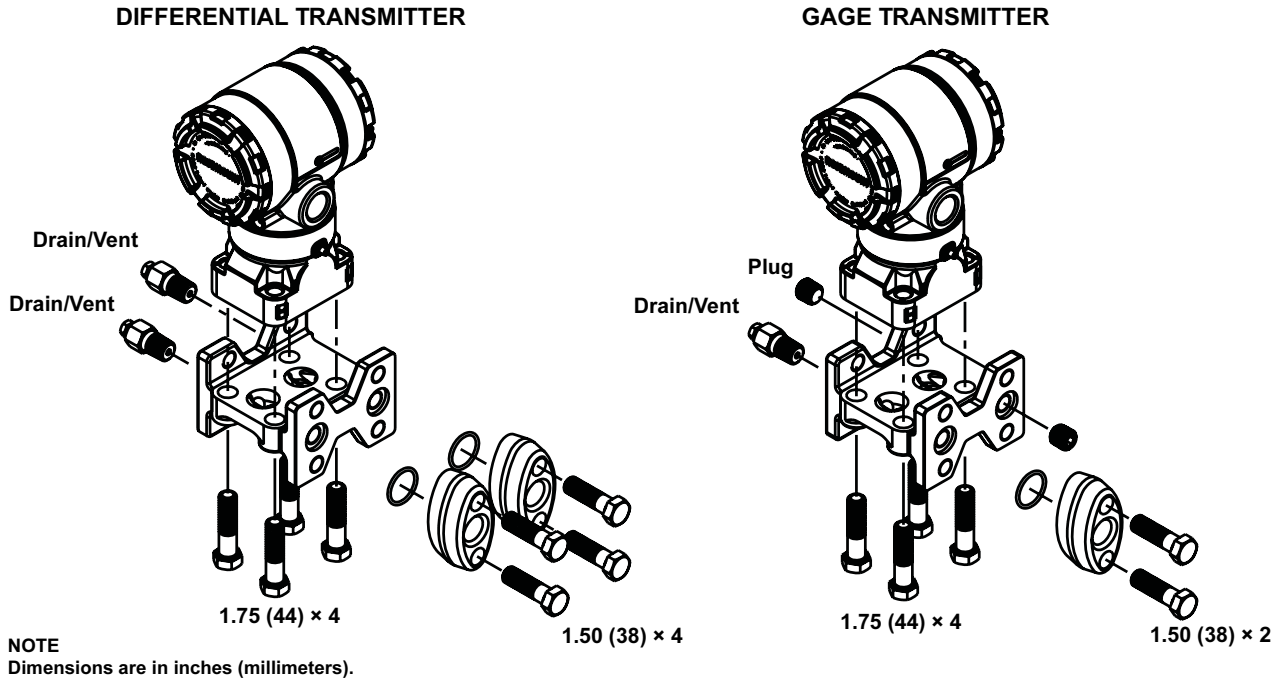
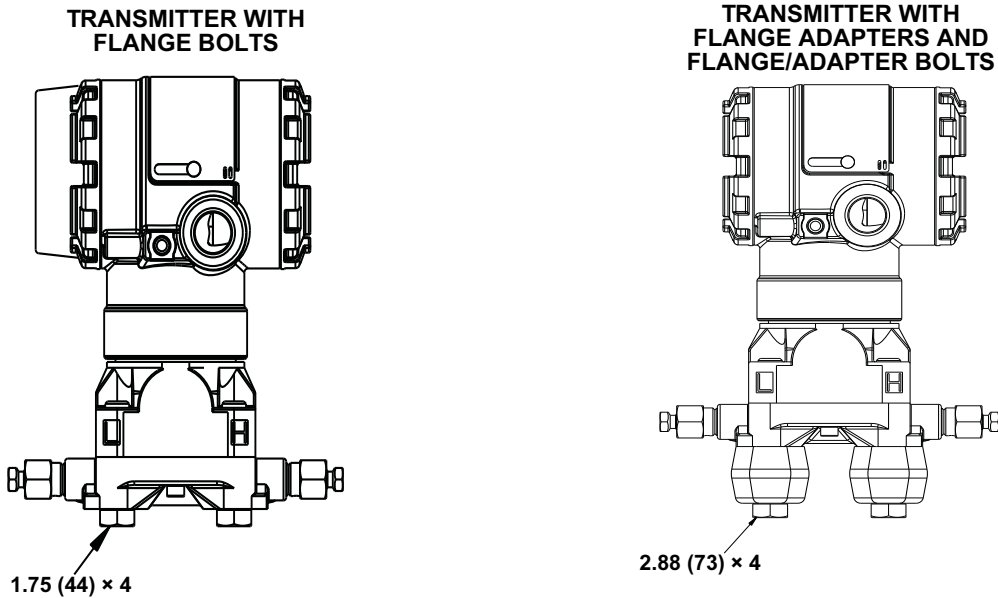


Figure 2-7. Mounting Bolts and Bolt Configurations for Coplanar Flange



Description	Size in. (mm)
Flange Bolts	1.75 (44)
Flange/Adapter Bolts	2.88 (73)
Manifold/Flange Bolts	2.25 (57)

Note: Rosemount 2051T transmitters are direct mount and do not require bolts for process connection.

NOTE
Dimensions are in inches (millimeters).

Impulse Piping

The piping between the process and the transmitter must accurately transfer the pressure to obtain accurate measurements. There are six possible sources of impulse piping error: pressure transfer, leaks, friction loss (particularly if purging is used), trapped gas in a liquid line, liquid in a gas line, and density variations between the legs.

The best location for the transmitter in relation to the process pipe is dependent on the process. Use the following guidelines to determine transmitter location and placement of impulse piping:

- Keep impulse piping as short as possible.
- For liquid service, slope the impulse piping at least 1 in./foot (8 cm/m) upward from the transmitter toward the process connection.
- For gas service, slope the impulse piping at least 1 in./foot (8 cm/m) downward from the transmitter toward the process connection.
- Avoid high points in liquid lines and low points in gas lines.
- Make sure both impulse legs are the same temperature.
- Use impulse piping large enough to avoid friction effects and blockage.
- Vent all gas from liquid piping legs.
- When using a sealing fluid, fill both piping legs to the same level.
- When purging, make the purge connection close to the process taps and purge through equal lengths of the same size pipe. Avoid purging through the transmitter.
- Keep corrosive or hot (above 250 °F [121 °C]) process material out of direct contact with the sensor module and flanges.
- Prevent sediment deposits in the impulse piping.
- Maintain equal leg of head pressure on both legs of the impulse piping.
- Avoid conditions that might allow process fluid to freeze within the process flange.

Mounting Requirements

Impulse piping configurations depend on specific measurement conditions. Refer to Figure 2-8 for examples of the following mounting configurations:

Liquid Flow Measurement

- Place taps to the side of the line to prevent sediment deposits on the process isolators.
- Mount the transmitter beside or below the taps so gases vent into the process line.
- Mount drain/vent valve upward to allow gases to vent.

Gas Flow Measurement

- Place taps in the top or side of the line.
- Mount the transmitter beside or above the taps so to drain liquid into the process line.

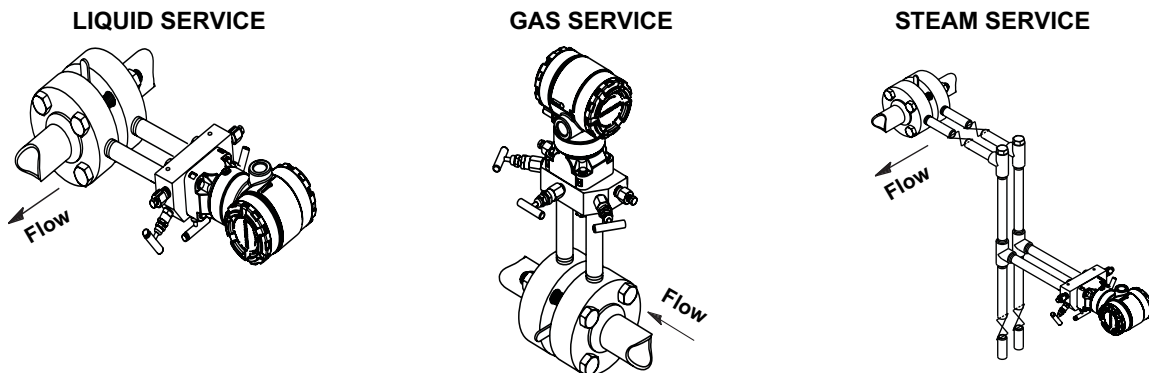
Steam Flow Measurement

- Place taps to the side of the line.
- Mount the transmitter below the taps to ensure that impulse piping will remain filled with condensate.
- In steam service above 250 °F (121 °C), fill impulse lines with water to prevent steam from contacting the transmitter directly and to ensure accurate measurement start-up.

NOTE

For steam or other elevated temperature services, it is important that temperatures at the process connection do not exceed the transmitter's process temperature limits. See "Process Temperature Limits" on page A-7 for details.

Figure 2-8. Installation Examples



Process Connections

Coplanar or Traditional Process Connection

⚠ Install and tighten all four flange bolts before applying pressure, or process leakage will result. When properly installed, the flange bolts will protrude through the top of the sensor module housing. Do not attempt to loosen or remove the flange bolts while the transmitter is in service.

⚠ Flange Adaptors:

Rosemount 2051DP and GP process connections on the transmitter flanges are 1/4–18 NPT. Flange adapters are available with standard 1/2–14 NPT Class 2 connections. The flange adapters allow users to disconnect from the process by removing the flange adapter bolts. Use plant-approved lubricant or sealant when making the process connections. Refer to Dimensional Drawings on page 2-5 for the distance between pressure connections. This distance may be varied $\pm 1/8$ in. (3.2 mm) by rotating one or both of the flange adapters.

To install adapters to a Coplanar flange, perform the following procedure:

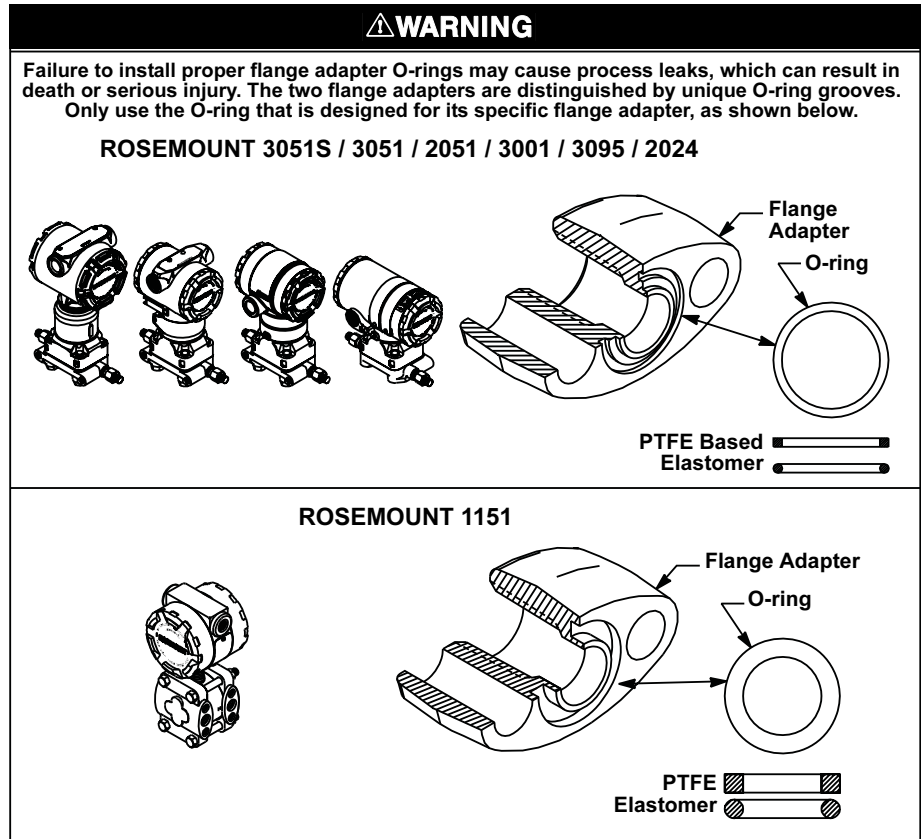
1. Remove the flange bolts.
2. Leaving the flange in place, move the adapters into position with the o-ring installed.
3. Clamp the adapters and the Coplanar flange to the transmitter sensor module using the larger of the bolts supplied.
4. Tighten the bolts. Refer to “Flange Bolts” on page 2-15 for torque specifications.

Whenever you remove flanges or adapters, visually inspect the PTFE o-rings. Replace with o-ring designed for Rosemount transmitter if there are any signs of damage, such as nicks or cuts. Undamaged o-rings may be reused. If you replace the o-rings, retorque the flange bolts after installation to compensate for cold flow. Refer to the process sensor body reassembly procedure in Section 5: Troubleshooting.

O-rings:

The two styles of Rosemount flange adapters (Rosemount 1151 and Rosemount 3051/2051/2024/3095) each require a unique O-ring (see Figure 2-9). Use only the O-ring designed for the corresponding flange adaptor.

Figure 2-9. O-Rings.



⚠ When compressed, PTFE O-rings tend to “cold flow,” which aids in their sealing capabilities.

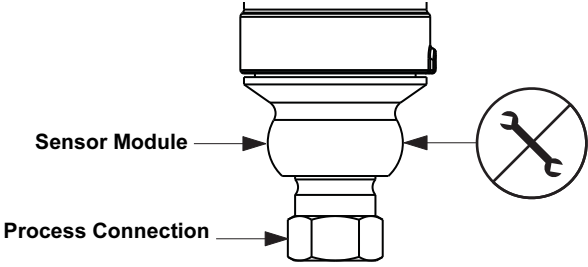
NOTE

PTFE O-rings should be replaced if the flange adaptor is removed.

Inline Process Connection

⚠ WARNING

Do not apply torque directly to the sensor module. Rotation between the sensor module and the process connection can damage the electronics. To avoid damage, apply torque only to the hex-shaped process connection.



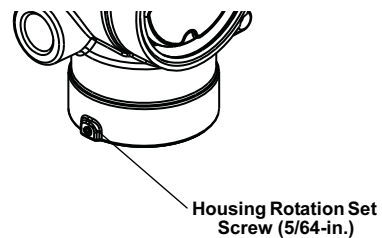
The diagram shows a cross-section of the sensor assembly. The top part is the sensor module, and the bottom part is the process connection, which has a hexagonal base. A warning symbol (a circle with a diagonal line through a crossed wrench and screwdriver) is positioned to the right of the sensor module, with an arrow pointing towards it. Labels 'Sensor Module' and 'Process Connection' have arrows pointing to their respective parts.

Housing Rotation

The electronics housing can be rotated up to 180 degrees in either direction to improve field access, or to better view the optional LCD display. To rotate the housing, perform the following procedure:

1. Loosen the housing rotation set screw using a $\frac{5}{64}$ -in. hex wrench.
2. Turn the housing left or right up to 180° from its original position. Over rotating will damage the transmitter.
3. Retighten the housing rotation set screw.

Figure 2-10. Housing Rotation

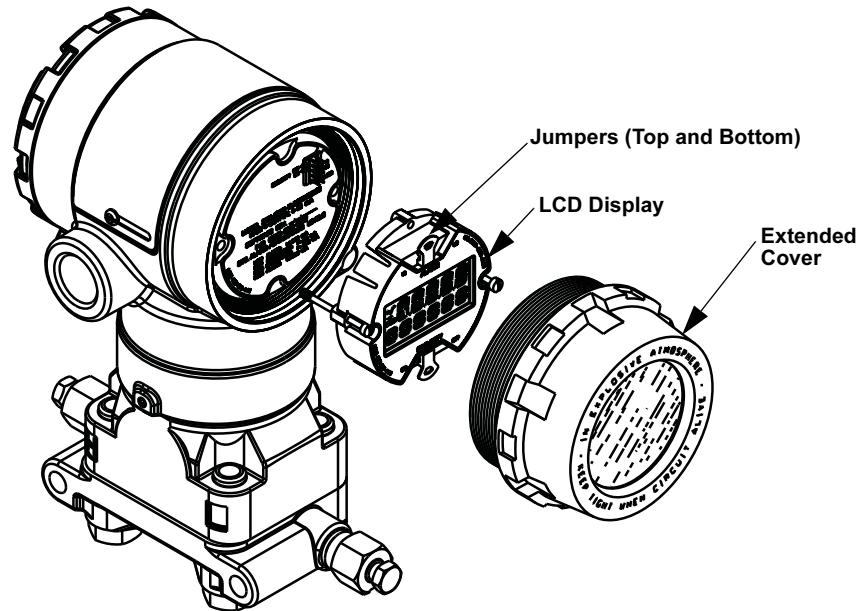


Rosemount 2051

LCD Display

Transmitters ordered with the LCD option are shipped with the display installed. Installing the display on an existing 2051 transmitter requires a small instrument screwdriver.

Figure 2-11. LCD Display



Configure Security and Alarm

Security (Write Protect)

There are three security methods with the Rosemount 2051 transmitter:

1. Security Jumper: prevents all writes to transmitter configuration.
2. Local Keys (Local Zero and Span) Software Lock Out: prevents changes to transmitter range points via local zero and span adjustment keys. With local keys security enabled, changes to configuration are possible via HART.
3. Physical Removal of Local Keys (Local Zero and Span) Magnetic Buttons: removes ability to use local keys to make transmitter range point adjustments. With local keys security enabled, changes to configuration are possible via HART.

NOTE

The Local Keys (Local Zero and Span Adjustments) are optional (option code D4 in model number). If the Adjustments are not ordered on the transmitter, options 2 and 3 above are not valid security method options.

You can prevent changes to the transmitter configuration data with the write protection jumper. Security is controlled by the security (write protect) jumper located on the electronics board or LCD display. Position the jumper on the transmitter circuit board in the "ON" position to prevent accidental or deliberate change of configuration data.

If the transmitter write protection jumper is in the “ON” position, the transmitter will not accept any “writes” to its memory. Configuration changes, such as digital trim and reranging, cannot take place when the transmitter security is on.

NOTE

If the security jumper is not installed, the transmitter will continue to operate in the security OFF configuration.

Configuring Transmitter Security and Alarm Jumper Procedure

To reposition the jumpers, follow the procedure described below.



1. Do not remove the transmitter covers in explosive atmospheres when the circuit is live. If the transmitter is live, set the loop to manual and remove power.
-  2. Remove the housing cover opposite the field terminal side. Do not remove the transmitter covers in explosive atmospheres when the circuit is live.
3. Reposition the jumpers as desired.
 - Figure 2-12 shows the jumper positions for the 4-20 mA HART Transmitter.
 - Figure 2-13 shows the jumper positions for the 1-5 HART Vdc Low Power Transmitter.
-  4. Reattach the transmitter cover. Always ensure a proper seal by installing the electronics housing covers so that metal contacts metal to meet explosion-proof requirements.

Figure 2-12. Electronics Board

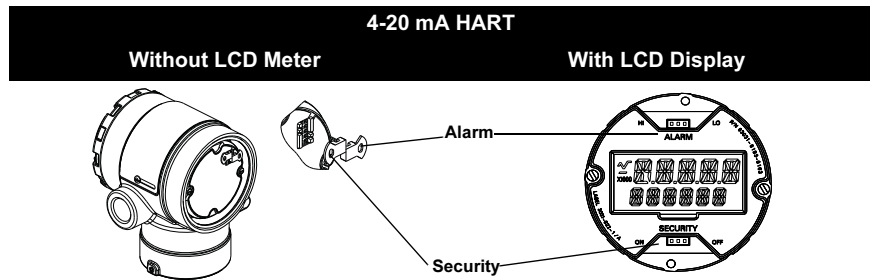
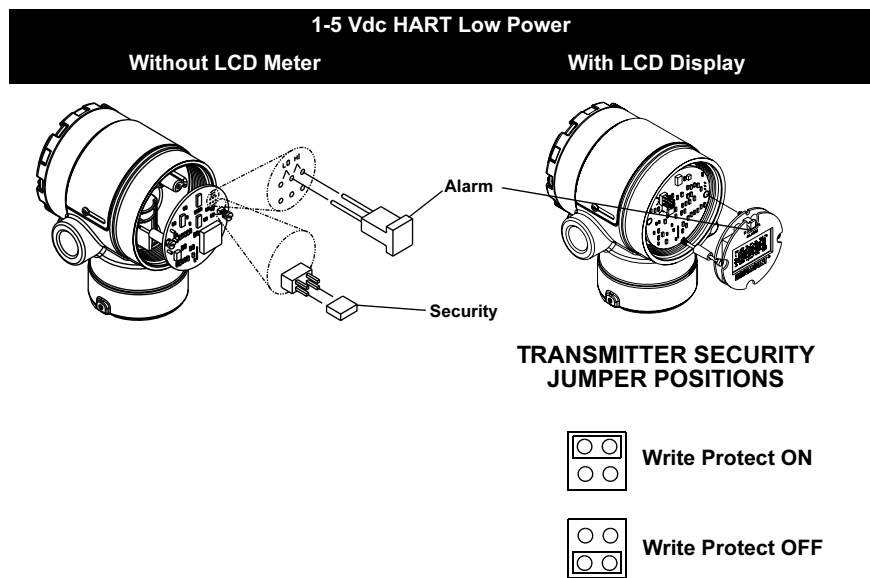


Figure 2-13. Low Power Transmitter Electronics Boards



NOTE
Security jumper not installed = Not Write Protected
Alarm jumper not installed = High Alarm

**ELECTRICAL
CONSIDERATIONS**

NOTE
Make sure all electrical installation is in accordance with national and local code requirements.

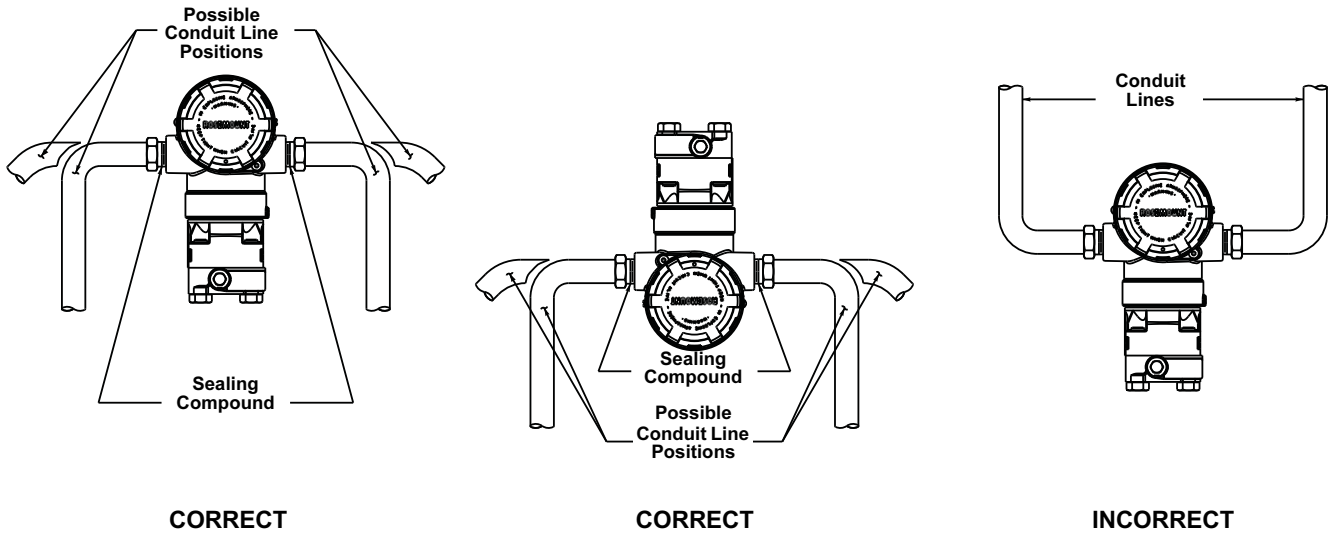
Conduit Installation

⚠ CAUTION

If all connections are not sealed, excess moisture accumulation can damage the transmitter. Make sure to mount the transmitter with the electrical housing positioned downward for drainage. To avoid moisture accumulation in the housing, install wiring with a drip loop, and ensure the bottom of the drip loop is mounted lower than the conduit connections or the transmitter housing.

Recommended conduit connections are shown in Figure 2-14.

Figure 2-14. Conduit Installation Diagrams.



Wiring

⚠ CAUTION

Do not connect the power signal wiring to the test terminals. Voltage may burn out the reverse-polarity protection diode in the test connection.

NOTE

Use shielded twisted pairs to yield best results. To ensure proper communication, use 24 AWG or larger wire, and do not exceed 5000 feet (1500 meters).

Figure 2-15. 4-20 mA HART wiring

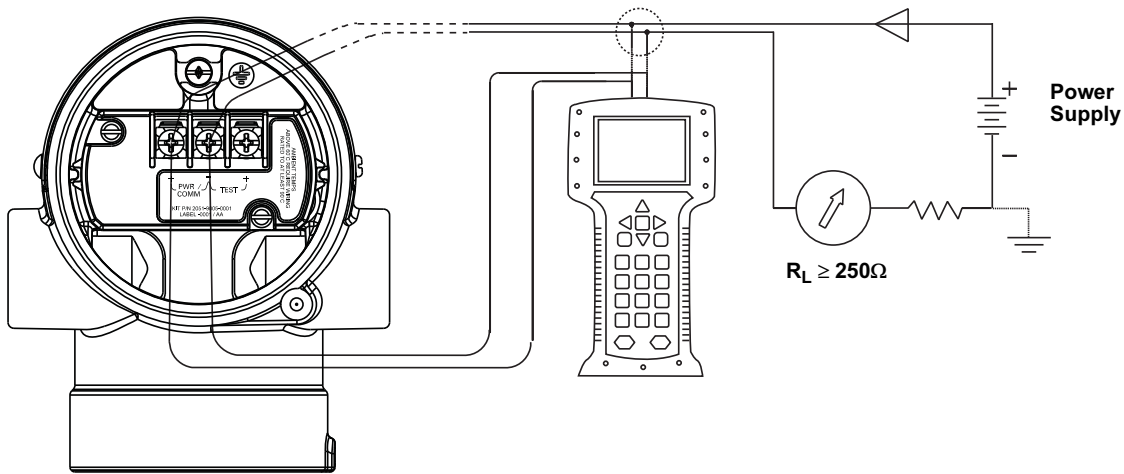
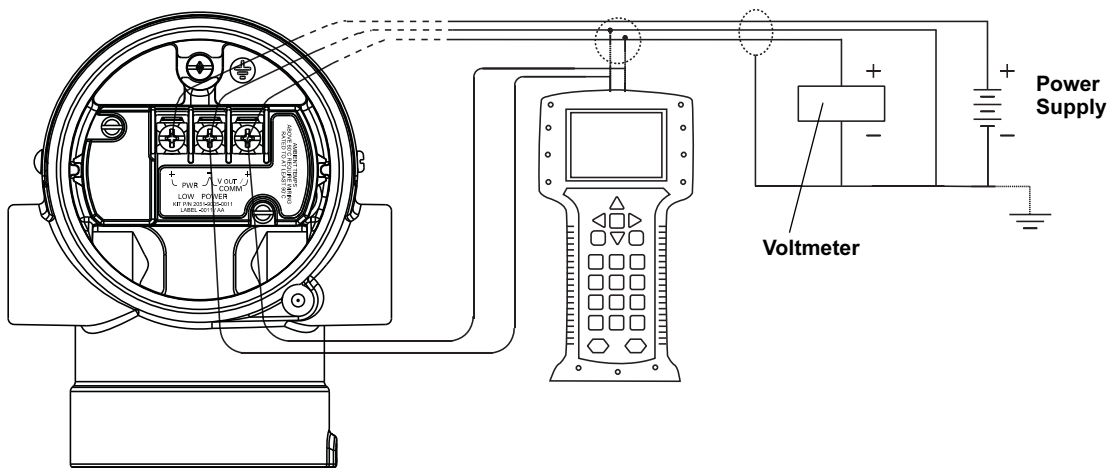


Figure 2-16. 1-5 Vdc Low Power wiring



Perform the following procedure to make wiring connections:

- ⚠ 1. Remove the housing cover on terminal compartment side. Do not remove the cover in explosive atmospheres when the circuit is live. Signal wiring supplies all power to the transmitter.
- ⚠ 2. a. For 4-20 mA HART output, connect the positive lead to the terminal marked (+) and the negative lead to the terminal marked (pwr/comm -). Do not connect powered signal wiring to the test terminals. Power could damage the test diode.

b. For 1-5 Vdc HART Low Power output, connect the positive lead to the terminal marked (+ pwr) and the negative lead to the terminal marked (pwr -). Connect signal lead to V_{out} / comm +.
3. Plug and seal unused conduit connection on the transmitter housing to avoid moisture accumulation in the terminal side. Install wiring with a drip loop. Arrange the drip loop so the bottom is lower than the conduit connections and the transmitter housing.

Power Supply for 4-20 mA HART

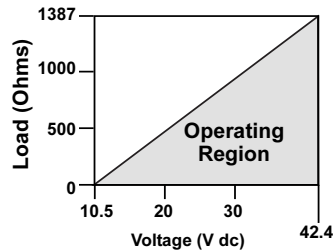
Transmitter operates on 10.5 - 42.4 Vdc. The dc power supply should provide power with less than two percent ripple.

NOTE

A minimum loop resistance of 250 ohms is required to communicate with a HART Communicator. If a single power supply is used to power more than one 2051 transmitter, the power supply used, and circuitry common to the transmitters, should not have more than 20 ohms of impedance at 1200 Hz.

Figure 2-17. Load Limitation

$$\text{Maximum Loop Resistance} = 43.5 * (\text{Power Supply Voltage} - 10.5)$$



The HART communicator requires a minimum loop resistance of 250Ω for communication.

The total resistance load is the sum of the resistance of the signal leads and the load resistance of the controller, indicator, and related pieces. Note that the resistance of intrinsic safety barriers, if used, must be included.

Power Supply for 1-5 Vdc HART Low Power

Low power transmitters operate on 9–28 Vdc. The dc power supply should provide power with less than two percent ripple. The V_{out} load should be 100 kΩ or greater.

⚠ See "Safety Messages" on page 2-1 for complete warning information.

Rosemount 2051

Transient Protection Terminal Block

The transmitter will withstand electrical transients of the energy level usually encountered in static discharges or induced switching transients. However, high-energy transients, such as those induced in wiring from nearby lightning strikes, can damage the transmitter.

The transient protection terminal block can be ordered as an installed option (Option Code T1 in the transmitter model number) or as a spare part to retrofit existing 2051 transmitters in the field. See "Spare Parts" on page A-38 for spare part numbers. The lightning bolt symbol shown in Figure 2-18 and Figure 2-19 identifies the transient protection terminal block.

Figure 2-18. 4-20 mA HART wiring with transient protection

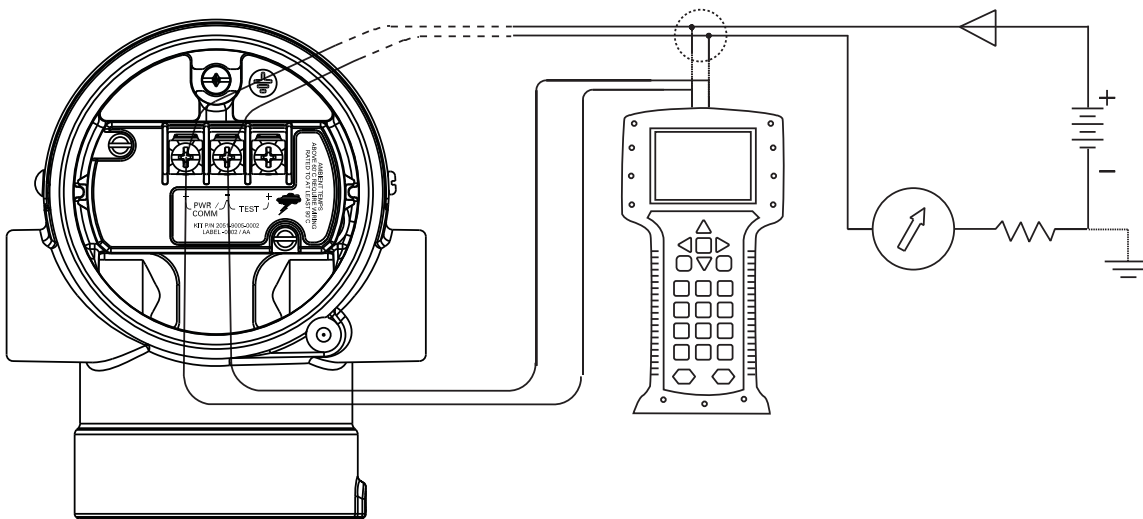
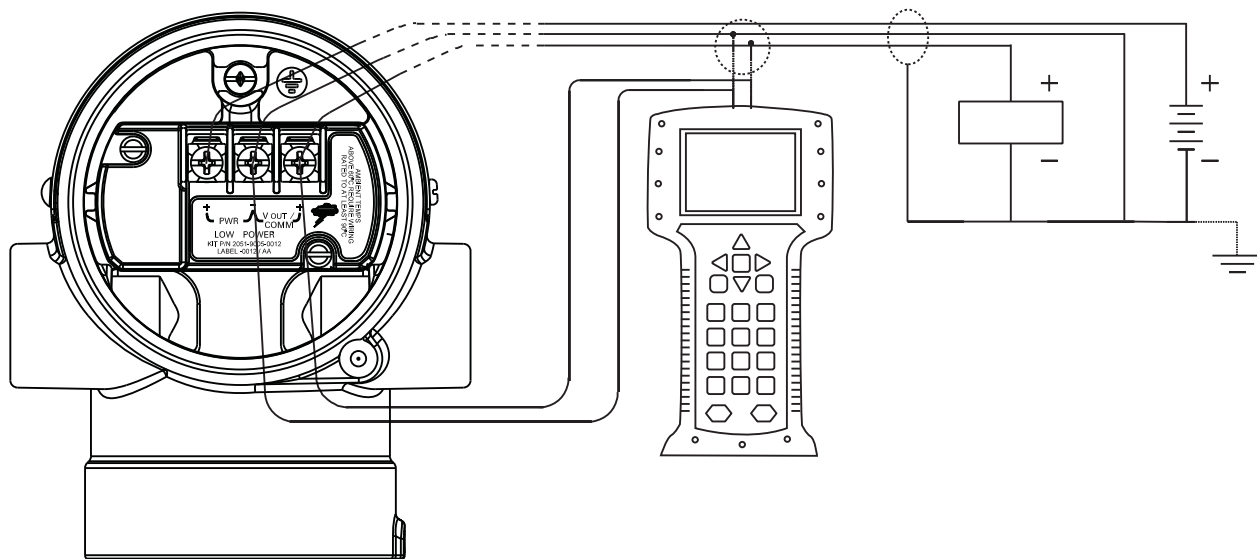


Figure 2-19. 1-5 Vdc Low Power wiring with transient protection



NOTE

The transient protection terminal block does not provide transient protection unless the transmitter case is properly grounded. Use the guidelines to ground the transmitter case. Refer to page 2-29.

Do not run the transient protection ground wire with signal wiring as the ground wire may carry excessive current if a lightning strike occurs.

Grounding

- ⚠ Use the following techniques to properly ground the transmitter signal wiring and case:

Signal Wiring

Do not run signal wiring in conduit or open trays with power wiring or near heavy electrical equipment. It is important that the instrument cable shield be:

- Trimmed close and insulated from touching the transmitter housing
- Connected to the next shield if cable is routed through a junction box
- Connected to a good earth ground at the power supply end

For 4-20 mA HART output, the signal wiring may be grounded at any one point on the signal loop or may be left ungrounded. The negative terminal of the power supply is a recommended grounding point.

For 1-5 Vdc HART Low Power output, the power wires may be grounded at only one point or left ungrounded. The negative terminal of the power supply is a recommended grounding point.

Transmitter Case

Always ground the transmitter case in accordance with national and local electrical codes. The most effective transmitter case grounding method is a direct connection to earth ground with minimal impedance. Methods for grounding the transmitter case include:

- **Internal Ground Connection:** The Internal Ground Connection screw is inside the FIELD TERMINALS side of the electronics housing. This screw is identified by a ground symbol (⊕). The ground connection screw is standard on all Rosemount 2051 transmitters. Refer to Figure 2-20.
- **External Ground Assembly:** This assembly is included with the optional transient protection terminal block (Option Code T1), and it is included with various hazardous location certifications. The External Ground Assembly can also be ordered with the transmitter (Option Code V5), or as a spare part. See "Spare Parts" on page A-38. Refer to Figure 2-21 for location of the External Ground Screw.

Figure 2-20. Internal Ground Screw

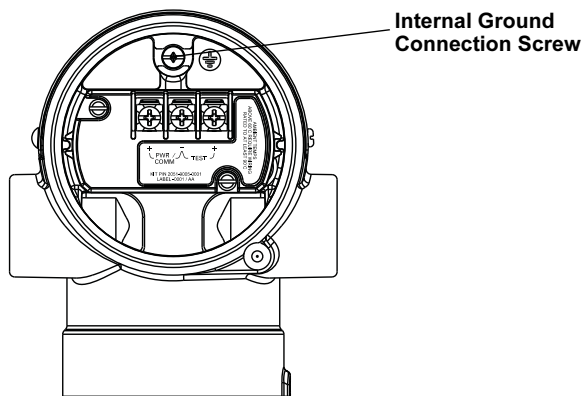
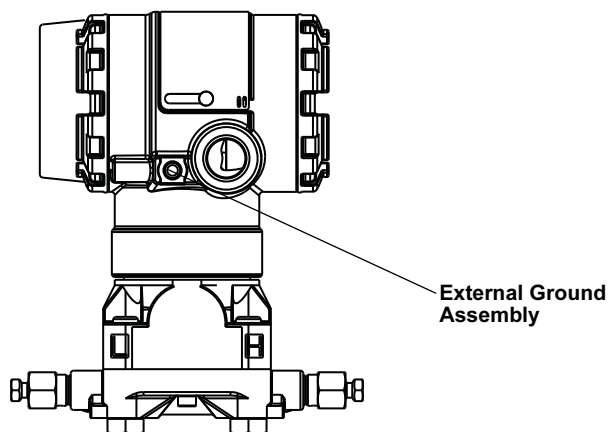


Figure 2-21. External Ground Assembly



NOTE

Grounding the transmitter case via threaded conduit connection may not provide sufficient ground continuity.

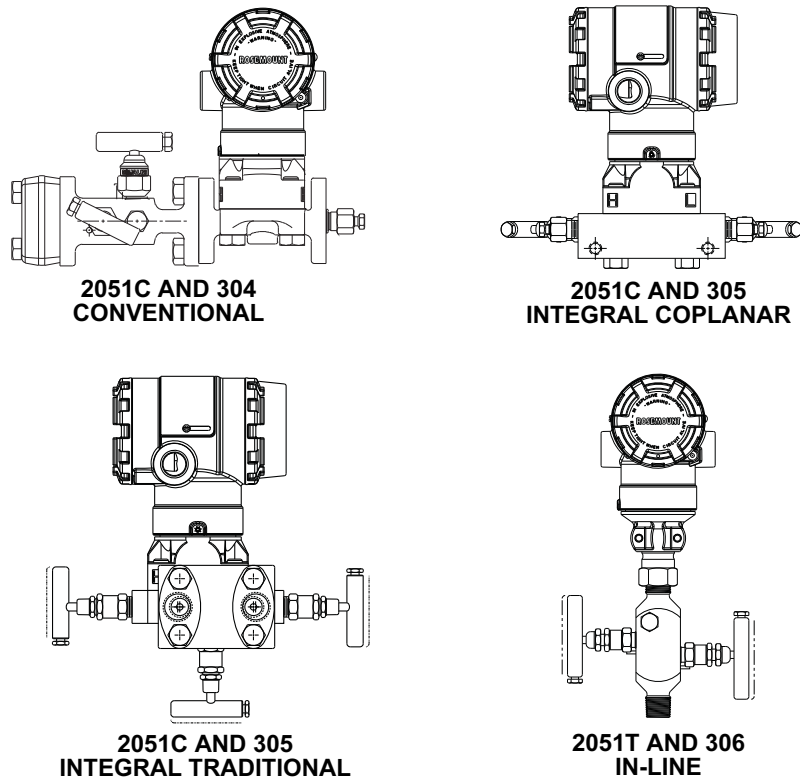
**HAZARDOUS
LOCATIONS
CERTIFICATIONS**

⚠ Individual transmitters are clearly marked with a tag indicating the approvals they carry. Transmitters must be installed in accordance with all applicable codes and standards to maintain these certified ratings. Refer to “Hazardous Locations Certifications” on page B-2 for information on these approvals.

**ROSEMOUNT 305, 306
AND 304 MANIFOLDS**

The 305 Integral Manifold is available in two designs: Traditional and Coplanar. The traditional 305 Integral Manifold can be mounted to most primary elements with mounting adapters in the market today. The 306 Integral Manifold is used with the 2051T in-line transmitters to provide block-and-bleed valve capabilities of up to 10000 psi (690 bar).

Figure 2-22. Manifolds



Rosemount 2051

Rosemount 305 Integral Manifold Installation Procedure

To install a 305 Integral Manifold to a 2051 transmitter:



1. Inspect the PTFE sensor module o-rings. Undamaged o-rings may be reused. If the o-rings are damaged (if they have nicks or cuts, for example), replace with o-rings designed for Rosemount transmitter.

IMPORTANT

If replacing the o-rings, take care not to scratch or deface the o-ring grooves or the surface of the isolating diaphragm while you remove the damaged o-rings.

2. Install the Integral Manifold on the sensor module. Use the four 2.25-in. manifold bolts for alignment. Finger tighten the bolts, then tighten the bolts incrementally in a cross pattern to final torque value. See “Flange Bolts” on page 2-15 for complete bolt installation information and torque values. When fully tightened, the bolts should extend through the top of the sensor module housing.
3. If the PTFE sensor module o-rings have been replaced, the flange bolts should be re-tightened after installation to compensate for cold flow of the o-rings.

NOTE

Always perform a zero trim on the transmitter/manifold assembly after installation to eliminate mounting effects.

Rosemount 306 Integral Manifold Installation Procedure

The 306 Manifold is for use only with a 2051T In-line transmitter.




- Assemble the 306 Manifold to the 2051T In-line transmitter with a thread sealant.

Rosemount 304 Conventional Manifold Installation Procedure

To install a 304 Conventional Manifold to a 2051 transmitter:

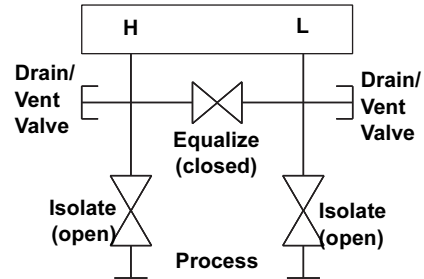
1. Align the Conventional Manifold with the transmitter flange. Use the four manifold bolts for alignment.
2. Finger tighten the bolts, then tighten the bolts incrementally in a cross pattern to final torque value. See “Flange Bolts” on page 2-6 for complete bolt installation information and torque values. When fully tightened, the bolts should extend through the top of the sensor module housing.
3. Leak-check assembly to maximum pressure range of transmitter.

 See “Safety Messages” on page 2-1 for complete warning information.

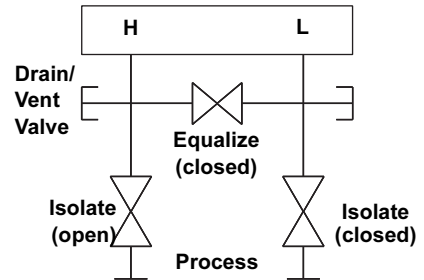
Integral Manifold Operation

Three-valve configuration shown.

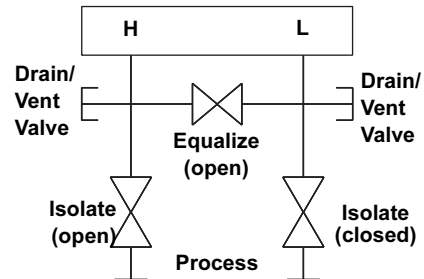
In normal operation the two isolate valves between the process and instrument ports will be open and the equalizing valve(s) will be closed.



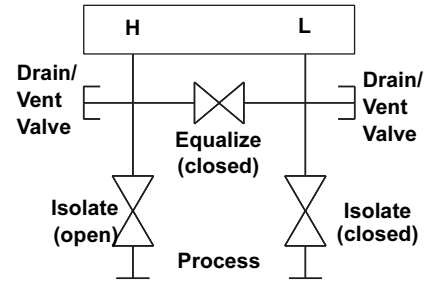
To zero the 2051, close the isolate valve to the low pressure (downstream side) of the transmitter first.



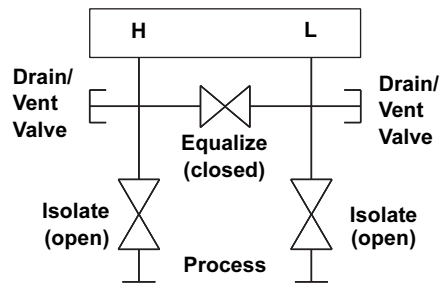
Next, open the center (equalize) valve(s) to equalize the pressure on both sides of the transmitter.



The manifold valves are now in the proper configuration for zeroing the transmitter. To return the transmitter to service, close the equalizing valve(s) first.



Next, open the isolate valve on the low pressure side of the transmitter.



LIQUID LEVEL MEASUREMENT

Differential pressure transmitters used for liquid level applications measure hydrostatic pressure head. Liquid level and specific gravity of a liquid are factors in determining pressure head. This pressure is equal to the liquid height above the tap multiplied by the specific gravity of the liquid. Pressure head is independent of volume or vessel shape.

Open Vessels

A pressure transmitter mounted near a tank bottom measures the pressure of the liquid above.

Make a connection to the high pressure side of the transmitter, and vent the low pressure side to the atmosphere. Pressure head equals the liquid's specific gravity multiplied by the liquid height above the tap.

Zero range suppression is required if the transmitter lies below the zero point of the desired level range. Figure 2-23 shows a liquid level measurement example.

Closed Vessels

Pressure above a liquid affects the pressure measured at the bottom of a closed vessel. The liquid specific gravity multiplied by the liquid height plus the vessel pressure equals the pressure at the bottom of the vessel.

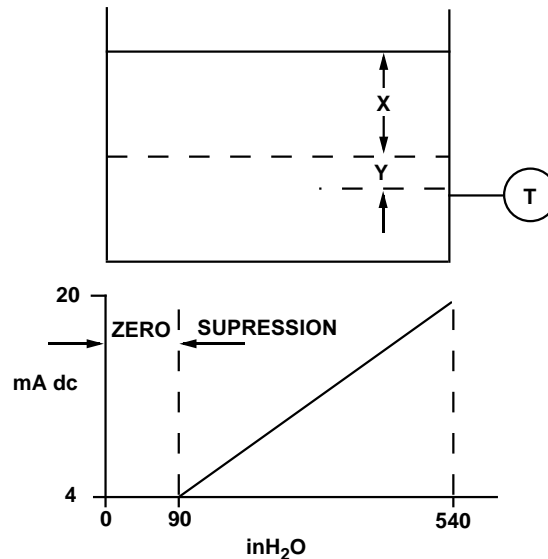
To measure true level, the vessel pressure must be subtracted from the vessel bottom pressure. To do this, make a pressure tap at the top of the vessel and connect this to the low side of the transmitter. Vessel pressure is then equally applied to both the high and low sides of the transmitter. The resulting differential pressure is proportional to liquid height multiplied by the liquid specific gravity.

Dry Leg Condition

Low-side transmitter piping will remain empty if gas above the liquid does not condense. This is a dry leg condition. Range determination calculations are the same as those described for bottom-mounted transmitters in open vessels, as shown in Figure 2-23.

Figure 2-23. Liquid Level Measurement Example.

- Let **X** equal the vertical distance between the minimum and maximum measurable levels (500 in.).
- Let **Y** equal the vertical distance between the transmitter datum line and the minimum measurable level (100 in.).
- Let **SG** equal the specific gravity of the fluid (0.9).
- Let **h** equal the maximum head pressure to be measured in inches of water.
- Let **e** equal head pressure produced by **Y** expressed in inches of water.
- Let **Range** equal **e** to **e + h**.
- Then $h = (X)(SG)$
 $= 500 \times 0.9$
 $= 450 \text{ inH}_2\text{O}$
- $e = (Y)(SG)$
 $= 100 \times 0.9$
 $= 90 \text{ inH}_2\text{O}$
- Range** = 90 to 540 inH₂O

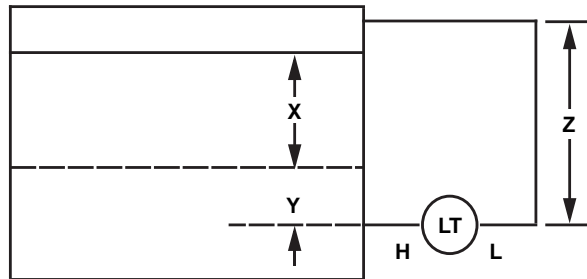


Wet Leg Condition

Condensation of the gas above the liquid slowly causes the low side of the transmitter piping to fill with liquid. The pipe is purposely filled with a convenient reference fluid to eliminate this potential error. This is a wet leg condition.

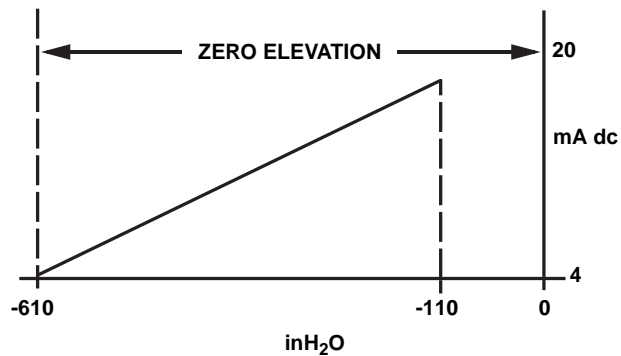
The reference fluid will exert a head pressure on the low side of the transmitter. Zero elevation of the range must then be made. See Figure 2-24

Figure 2-24. Wet Leg Example.



- Let **X** equal the vertical distance between the minimum and maximum measurable levels (500 in.).
- Let **Y** equal the vertical distance between the transmitter datum line and the minimum measurable level (50 in.).
- Let **z** equal the vertical distance between the top of the liquid in the wet leg and the transmitter datum line (600 in.).
- Let **SG₁** equal the specific gravity of the fluid (1.0).
- Let **SG₂** equal the specific gravity of the fluid in the wet leg (1.1).
- Let **h** equal the maximum head pressure to be measured in inches of water.
- Let **e** equal the head pressure produced by **Y** expressed in inches of water.
- Let **s** equal head pressure produced by **z** expressed in inches of water.
- Let **Range** equal **e - s to h + e - s**.

$$\begin{aligned}
 \text{Then } h &= (X)(SG_1) \\
 &= 500 \times 1.0 \\
 &= 500 \text{ in H}_2\text{O} \\
 e &= (Y)(SG_1) \\
 &= 50 \times 1.0 \\
 &= 50 \text{ inH}_2\text{O} \\
 s &= (z)(SG_2) \\
 &= 600 \times 1.1 \\
 &= 660 \text{ inH}_2\text{O} \\
 \text{Range} &= e - s \text{ to } h + e - s \\
 &= 50 - 660 \text{ to } 500 + 50 - 660 \\
 &= -610 \text{ to } -110 \text{ inH}_2\text{O}
 \end{aligned}$$

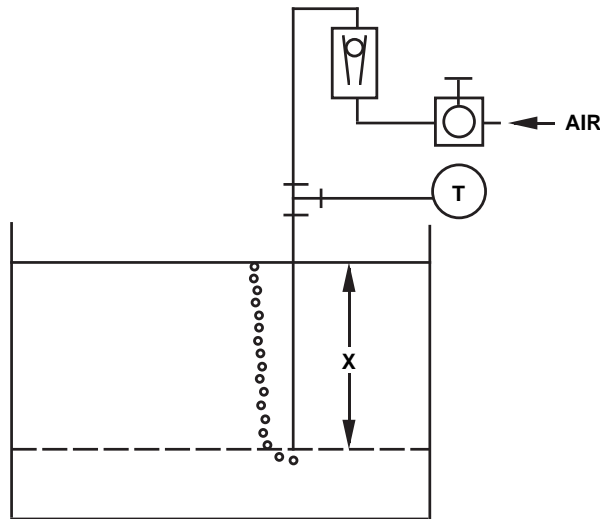


Bubbler System in Open Vessel

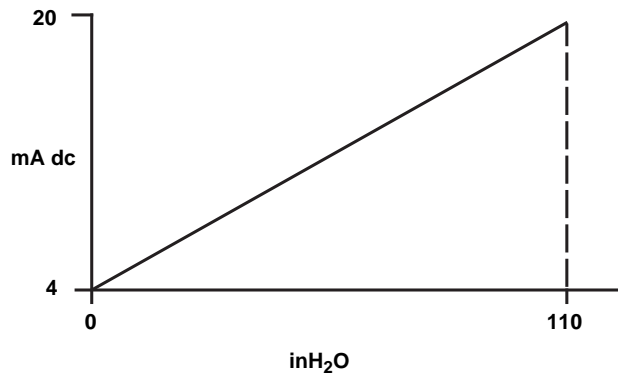
A bubbler system that has a top-mounted pressure transmitter can be used in open vessels. This system consists of an air supply, pressure regulator, constant flow meter, pressure transmitter, and a tube that extends down into the vessel.

Bubble air through the tube at a constant flow rate. The pressure required to maintain flow equals the liquid’s specific gravity multiplied by the vertical height of the liquid above the tube opening. Figure 2-25 shows a bubbler liquid level measurement example.

Figure 2-25. Bubbler Liquid Level Measurement Example.



Let **X** equal the vertical distance between the minimum and maximum measurable levels (100 in.).
 Let **SG** equal the specific gravity of the fluid (1.1).
 Let **h** equal the maximum head pressure to be measured in inches of water.
 Let **Range** equal **zero** to **h**.
 Then **h** = **(X)(SG)**
 = 100 x 1.1
 = 110 inH₂O
Range = 0 to 110 inH₂O



Section 3 Configuration

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OVERVIEW

This section contains information on commissioning and tasks that should be performed on the bench prior to installation.

HART Communicator and AMS Device Manager instructions are given to perform configuration functions. For convenience, HART Communicator fast key sequences are labeled “Fast Keys” for each software function below the appropriate headings.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

Warnings

⚠ WARNING

Explosions could result in death or serious injury:
Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 2051 reference manual for any restrictions associated with a safe installation.

- Before connecting a HART communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.


Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

Rosemount 2051

COMMISSIONING

Commissioning consists of testing the transmitter and verifying transmitter configuration data. The 2051 transmitters can be commissioned either before or after installation. Commissioning the transmitter on the bench before installation using a HART Communicator or AMS Device Manager ensures that all transmitter components are in working order.

 To commission on the bench, required equipment includes a power supply, a milliamp meter, and a HART Communicator or AMS Device Manager. Wire equipment as shown in Figure 3-1 and Figure 3-2. To ensure successful communication, a resistance of at least 250 ohms must be present between the HART Communicator loop connection and the power supply. Connect the HART Communicator leads to the terminals labeled “COMM” on the terminal block.

Set all transmitter hardware adjustments during commissioning to avoid exposing the transmitter electronics to the plant environment after installation.

When using a HART Communicator, any configuration changes made must be sent to the transmitter by using the “Send” key. AMS Device Manager configuration changes are implemented when the “Apply” button is clicked.

Setting the Loop to Manual

Whenever sending or requesting data that would disrupt the loop or change the output of the transmitter, set the process application loop to manual. The HART Communicator or AMS Device Manager will prompt you to set the loop to manual when necessary. Acknowledging this prompt does not set the loop to manual. The prompt is only a reminder; set the loop to manual as a separate operation.

Wiring Diagrams

Connect the equipment as shown in Figure 3-1 for 4-20 mA HART or Figure 3-2 for 1-5 Vdc HART Low Power. To ensure successful communication, a resistance of at least 250 ohms must be present between the HART Communicator loop connection and the power supply. The HART Communicator or AMS Device Manager may be connected at “COMM” on the transmitter terminal block or across the load resistor. Connecting across the “TEST” terminals will prevent successful communication for 4-20 mA HART output.

Turn on the HART Communicator by pressing the ON/OFF key or log into AMS Device Manager. The HART Communicator or AMS Device Manager will search for a HART-compatible device and indicate when the connection is made. If the HART Communicator or AMS Device Manager fail to connect, it indicates that no device was found. If this occurs, refer to Section 5: Troubleshooting.

Figure 3-1. 4–20 mA HART Transmitter Wiring Diagrams

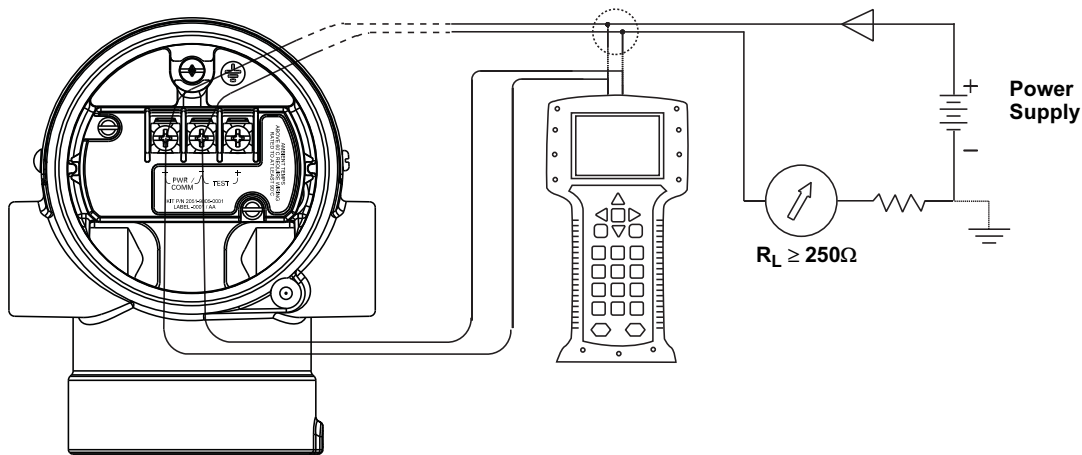
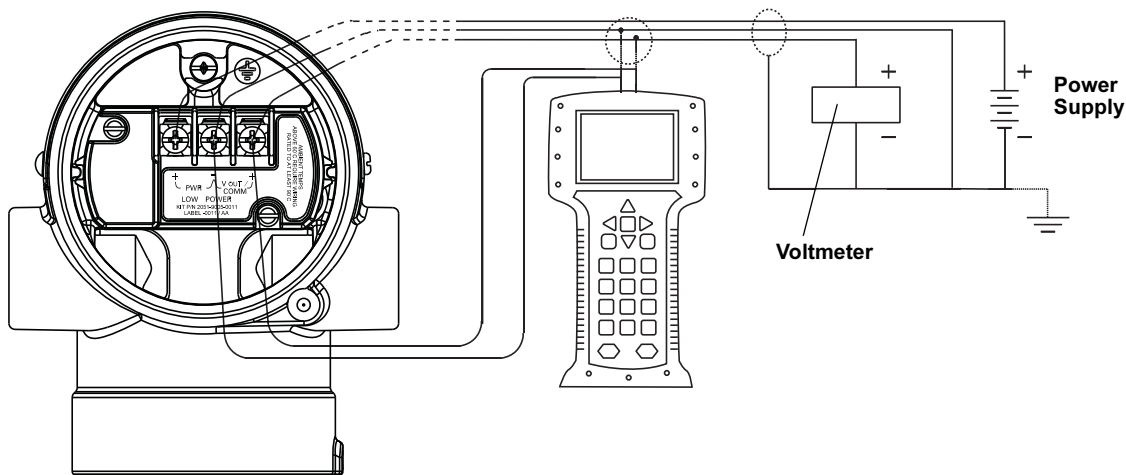


Figure 3-2. 1-5 Vdc HART Low Power Transmitter Wiring



CONFIGURATION DATA REVIEW

NOTE

Information and procedures in this section that make use of HART Communicator fast key sequences and AMS Device Manager assume that the transmitter and communication equipment are connected, powered, and operating correctly.

The following is a list of factory default configurations. These can be reviewed by using the HART Communicator or AMS Device Manager.

HART Communicator

4-20 mA Fast Keys	1, 5
1-5 Vdc Fast Keys	1, 5

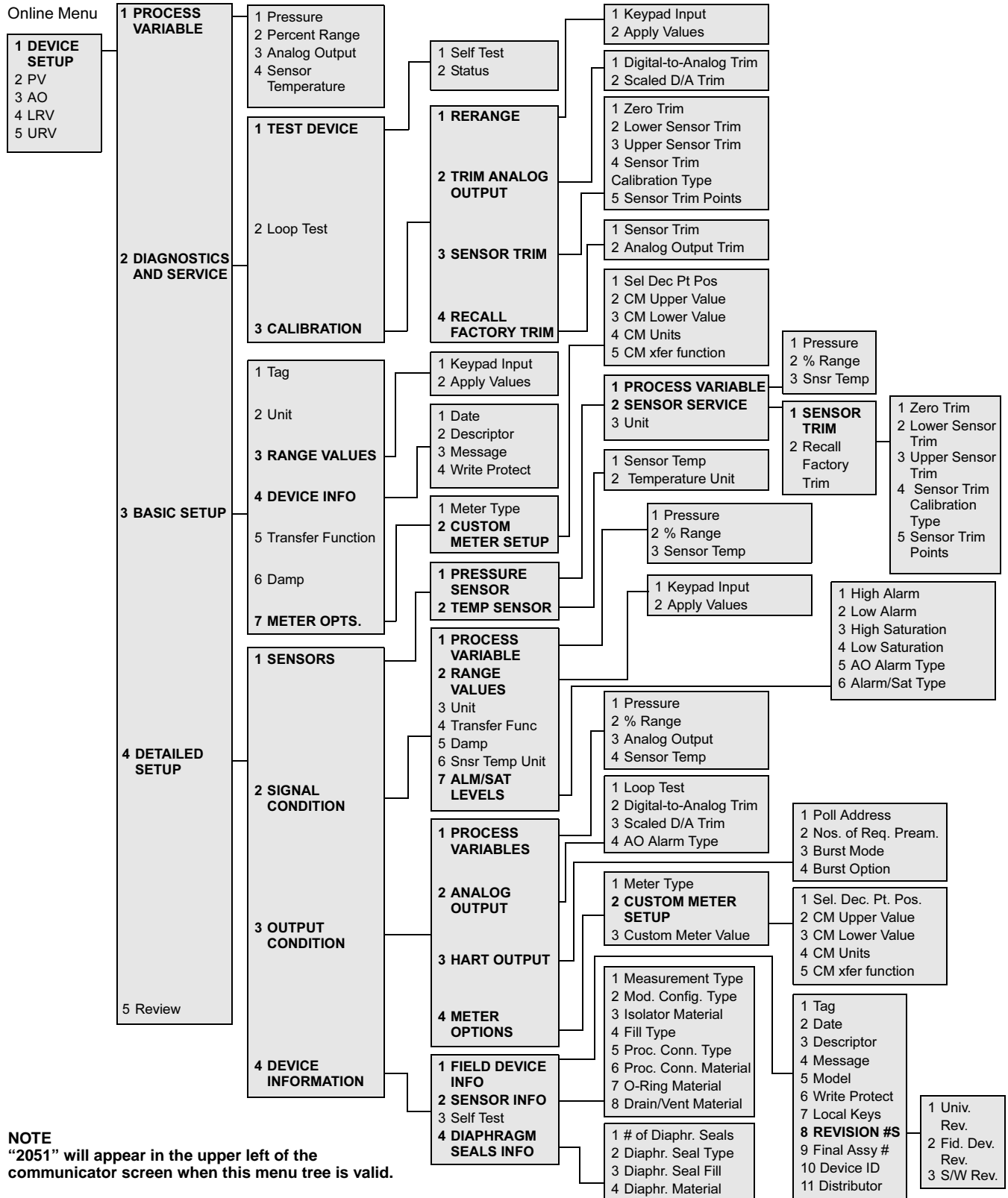
Enter the fast key sequence to view the configuration data.

Transmitter Model	Type
Tag	Range
Date	Descriptor
Message	Minimum and Maximum Sensor Limits
Minimum Span	Units
4 and 20 mA points	Output (linear or sq. root)
Damping	Alarm Setting (high, low)
Security Setting (on, off)	Local Zero/Span Keys (enabled, disabled)
Integral Display	Sensor Fill
Isolator Material	Flange (type, material)
O-Ring Material	Drain/Vent
Remote Seal (type, fill fluid, isolator material, number)	Transmitter S/N
Address	Sensor S/N

AMS Device Manager

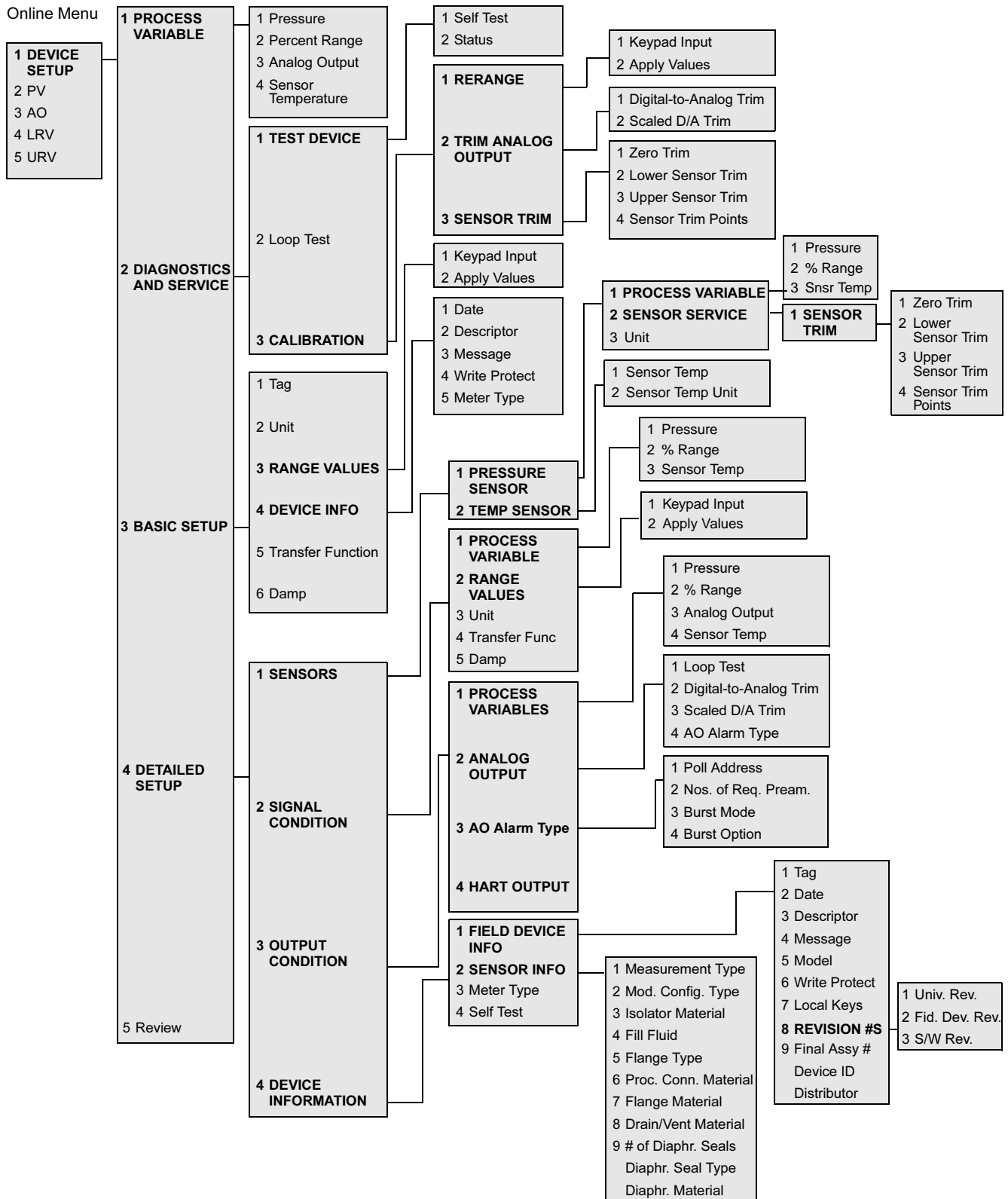
Right click on the device and select “Configuration Properties” from the menu. Select the tabs to review the transmitter configuration data.

HART COMMUNICATOR 2051 HART menu tree for 4-20 mA HART output MENU TREES



NOTE
 "2051" will appear in the upper left of the communicator screen when this menu tree is valid.

2051 HART menu tree for 1-5 Vdc HART Low Power



FAST KEY SEQUENCE

A check (✓) indicates the basic configuration parameters. At minimum, these parameters should be verified as part of the configuration and startup procedure.

Table 3-1. 2051 Fast Key Sequence

Function	4-20 mA HART	1-5 Vdc HART Low Power
✓ Alarm and Saturation Levels	1, 4, 2, 7	N/A
Analog Output Alarm Type	1, 4, 3, 2, 4	1, 4, 3, 2, 4
Burst Mode Control	1, 4, 3, 3, 3	1, 4, 3, 3, 3
Burst Operation	1, 4, 3, 3, 4	1, 4, 3, 3, 4
Custom Meter Configuration	1, 3, 7, 2	N/A
Custom Meter Value	1, 4, 3, 4, 3	N/A
✓ Damping	1, 3, 6	1, 3, 6
Date	1, 3, 4, 1	1, 3, 4, 1
Descriptor	1, 3, 4, 2	1, 3, 4, 2
Digital To Analog Trim (4-20 mA Output)	1, 2, 3, 2, 1	1, 2, 3, 2, 1
Disable Local Span/Zero Adjustment	1, 4, 4, 1, 7	1, 4, 4, 1, 7
Field Device Information	1, 4, 4, 1	1, 4, 4, 1
Full Trim	1, 2, 3, 3	1, 2, 3, 3
Keypad Input – Rerange	1, 2, 3, 1, 1	1, 2, 3, 1, 1
Local Zero and Span Control	1, 4, 4, 1, 7	1, 4, 4, 1, 7
Loop Test	1, 2, 2	1, 2, 2
Lower Sensor Trim	1, 2, 3, 3, 2	1, 2, 3, 3, 2
Message	1, 3, 4, 3	1, 3, 4, 3
Meter Options	1, 4, 3, 4	N/A
Number of Requested Preambles	1, 4, 3, 3, 2	1, 4, 3, 3, 2
Poll Address	1, 4, 3, 3, 1	1, 4, 3, 3, 1
Poll a Multidropped Transmitter	Left Arrow, 4, 1, 1	Left Arrow, 4, 1, 1
✓ Range Values	1, 3, 3	1, 3, 3
Rerange	1, 2, 3, 1	1, 2, 3, 1
Scaled D/A Trim (4–20 mA Output)	1, 2, 3, 2, 2	1, 2, 3, 2, 2
Self Test (Transmitter)	1, 2, 1, 1	1, 2, 1, 1
Sensor Info	1, 4, 4, 2	1, 4, 4, 2
Sensor Temperature	1, 1, 4	1, 1, 4
Sensor Trim Points	1, 2, 3, 3, 4	1, 2, 3, 3, 4
Status	1, 2, 1, 2	1, 2, 1, 2
✓ Tag	1, 3, 1	1, 3, 1
✓ Transfer Function (Setting Output Type)	1, 3, 5	1, 3, 5
Transmitter Security (Write Protect)	1, 3, 4, 4	1, 3, 4, 4
Trim Analog Output	1, 2, 3, 2	1, 2, 3, 2
✓ Units (Process Variable)	1, 3, 2	1, 3, 2
Upper Sensor Trim	1, 2, 3, 3, 3	1, 2, 3, 3, 3
Zero Trim	1, 2, 3, 3, 1	1, 2, 3, 3, 1

Rosemount 2051

CHECK OUTPUT

Before performing other transmitter on-line operations, review the digital output parameters to ensure that the transmitter is operating properly and is configured to the appropriate process variables.

Process Variables

The process variables for the 2051 provide transmitter output, and are continuously updated. The pressure reading in both engineering units and percent of range will continue to track with pressures outside of the defined range from the lower to the upper range limit of the sensor module.

HART Communicator

4-20 mA Fast Keys	1, 1
1-5 Vdc Fast Keys	1, 1

The process variable menu displays the following process variables:

- Pressure
- Percent of range
- Analog output

AMS Device Manager

Right click on the device and select “Process Variables...” from the menu. The process variable screen displays the following process variables:

- Pressure
- Percent of range
- Analog output

Sensor Temperature

The 2051 contains a temperature sensor near the pressure sensor in the sensor module. When reading this temperature, keep in mind the sensor is not a process temperature reading.

HART Communicator

4-20 mA Fast Keys	1, 1, 4
1-5 Vdc Fast Keys	1, 1, 4

Enter the fast key sequence “Sensor Temperature” to view the sensor temperature reading.

AMS Device Manager

Right click on the device and select “Process Variables...” from the menu. “Snsr Temp” is the sensor temperature reading.

BASIC SETUP

Set Process Variable Units

The PV Unit command sets the process variable units to allow you to monitor your process using the appropriate units of measure.

HART Communicator

4-20 mA Fast Keys	1, 3, 2
1-5 Vdc Fast Keys	1, 3, 2

Enter the fast key sequence "Set Process Variable Units." Select from the following engineering units:

- inH₂O
- inHg
- ftH₂O
- mmH₂O
- mmHg
- psi
- bar
- mbar
- g/cm²
- kg/cm²
- Pa
- kPa
- torr
- atm
- inH₂O at 4 °C
- mmH₂O at 4 °C

AMS Device Manager

Right click on the device and select "Configure" from the menu. In the Basic Setup tab, use "Unit" drop down menu to select units.

Set Output (Transfer function)

The 2051 has two output settings: Linear and Square Root. Activate the square root output option to make analog output proportional to flow. As input approaches zero, the 2051 automatically switches to linear output in order to ensure a more smooth, stable output near zero (see Figure 3-3).

For 4-20 mA HART output, the slope of the curve is unity ($y = x$) from 0 to 0.6 percent of the ranged pressure input. This allows accurate calibration near zero. Greater slopes would cause large changes in output (for small changes at input). From 0.6 percent to 0.8 percent, curve slope equals 42 ($y = 42x$) to achieve continuous transition from linear to square root at the transition point.

HART Communicator

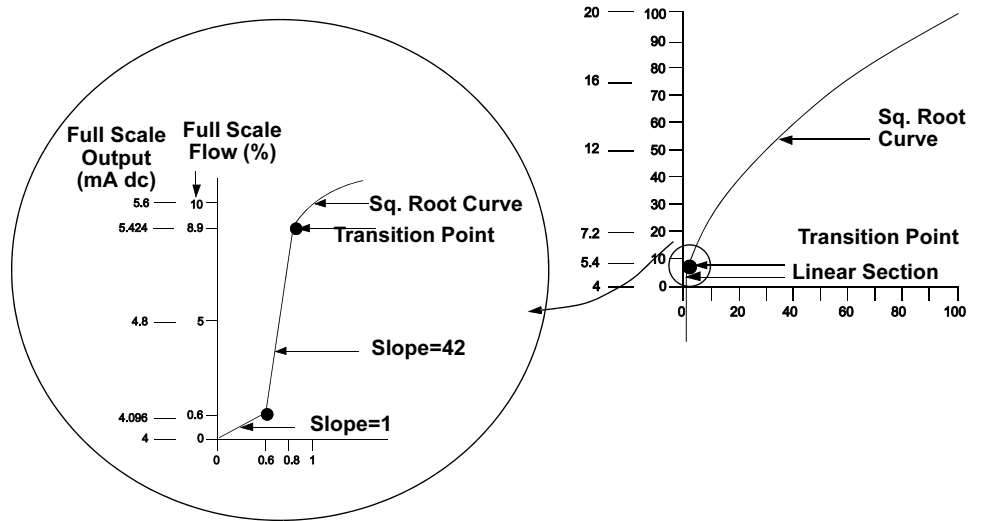
4-20 mA Fast Keys	1, 3, 5
1-5 Vdc Fast Keys	1, 3, 5

AMS Device Manager

Right click on the device and select "Configure" from the menu.

1. In the Basic Setup tab, use "Xfer fnctn" drop down menu to select output, click **Apply**.
2. After carefully reading the warning provided, select **yes**.

Figure 3-3. 4-20 mA HART
Square Root Output Transition
Point



NOTE
For a flow turndown of greater than 10:1 it is not recommended to perform a square root extraction in the transmitter. Instead, perform the square root extraction in the system.

Rerange

The Range Values command sets each of the lower and upper range analog values (4 and 20 mA points and 1 and 5 Vdc points) to a pressure. The lower range point represents 0% of range and the upper range point represents 100% of range. In practice, the transmitter range values may be changed as often as necessary to reflect changing process requirements. For a complete listing of Range & Sensor limits, refer to "Range and Sensor Limits" on page A-4.

NOTE
Transmitters are shipped from Emerson Process Management fully calibrated per request or by the factory default of full scale (zero to upper range limit).

NOTE
Regardless of the range points, the 2051 will measure and report all readings within the digital limits of the sensor. For example, if the 4 and 20 mA points are set to 0 and 10 inH₂O, and the transmitter detects a pressure of 25 inH₂O, it digitally outputs the 25 inH₂O reading and a 250% of range reading.

Select from one of the methods below to rerange the transmitter. Each method is unique; examine all options closely before deciding which method works best for your process.

- Rerange with a HART Communicator or AMS Device Manager only.
- Rerange with a pressure input source and a HART Communicator or AMS Device Manager.
- Rerange with a pressure input source and the local zero and span buttons (option D4).

NOTE

If the transmitter security switch is **ON**, adjustments to the zero and span will not be able to be made. Refer to “Configure Security and Alarm” on page 2-22 for security information.

Rerange with a HART Communicator or AMS Device Manager Only

The easiest and most popular way to rerange is to use the HART Communicator only. This method changes the range values of the analog 4 and 20 mA points (1 and 5 Vdc points) independently without a pressure input. This means that when you change either the 4 or 20 mA setting, you also change the span.

An example for the 4-20 mA HART output:

If the transmitter is ranged so that

$$\begin{aligned} 4 \text{ mA} &= 0 \text{ inH}_2\text{O}, \text{ and} \\ 20 \text{ mA} &= 100 \text{ inH}_2\text{O}, \end{aligned}$$

and you change the 4 mA setting to 50 inH₂O using the communicator only, the new settings are:

$$\begin{aligned} 4 \text{ mA} &= 50 \text{ inH}_2\text{O}, \text{ and} \\ 20 \text{ mA} &= 100 \text{ inH}_2\text{O}. \end{aligned}$$

Note that the span was also changed from 100 inH₂O to 50 inH₂O, while the 20 mA setpoint remained at 100 inH₂O.

To obtain reverse output, simply set the 4 mA point at a greater numerical value than the 20 mA point. Using the above example, setting the 4 mA point at 100 inH₂O and the 20 mA point at 0 inH₂O will result in reverse output.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 1
1-5 Vdc Fast Keys	1, 2, 3, 1

From the **HOME** screen, enter the fast key sequence “Rerange with a Communicator Only.”

AMS Device Manager

Right click on the device and select “Configure” from the menu. In the Basic Setup tab, locate the Analog Output box and perform the following procedure:

1. Enter the lower range value (LRV) and the upper range value (URV) in the fields provided. Click **Apply**.
2. After carefully reading the warning provided, select **yes**.

Rerange with a Pressure Input Source and a HART Communicator or AMS Device Manager

Reranging using the HART Communicator and applied pressure is a way of reranging the transmitter when specific 4 and 20 mA points (1 and 5 Vdc points) are not calculated.

NOTE

The span is maintained when the 4 mA point (1 Vdc point) is set. The span changes when the 20 mA point (5 Vdc point) is set. If the lower range point is set to a value that causes the upper range point to exceed the sensor limit, the upper range point is automatically set to the sensor limit, and the span is adjusted accordingly.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 1, 2
1-5 Vdc Fast Keys	1, 2, 3, 1, 2

From the **HOME** screen, enter the fast key sequence "Rerange with a Pressure Input Source and a HART Communicator or AMS Device Manager".

AMS Device Manager

Right click on the device, select "Calibrate", then "Apply values" from the menu.

1. Select **Next** after the control loop is set to manual.
2. From the "Apply Values" menu, follow the on-line instructions to configure lower and upper range values.
3. Select **Exit** to leave the "Apply Values" screen.
4. Select **Next** to acknowledge the loop can be returned to automatic control.
5. Select **Finish** to acknowledge the method is complete.

Rerange with a Pressure Input Source and the Local Zero and Span buttons (option D4)

Reranging using the local zero and span adjustments (see Figure 3-4 on page 3-13) and a pressure source is a way of reranging the transmitter when specific 4 and 20 mA (1 and 5 Vdc) points are not known and a communicator is not available.

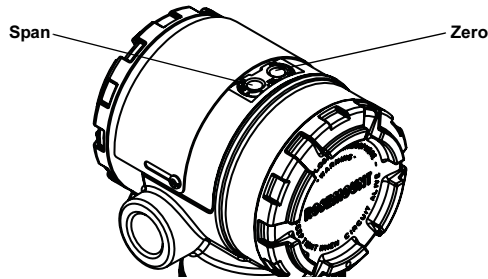
NOTE

When you set the 4 mA (1 Vdc) point the span is maintained; when you set the 20 mA (5 Vdc) point the span changes. If you set the lower range point to a value that causes the upper range point to exceed the sensor limit, the upper range point is automatically set to the sensor limit, and the span is adjusted accordingly.

To rerange the transmitter using the span and zero buttons, perform the following procedure:

1. Loosen the screw holding the certifications label on the side of the transmitter housing. Slide the label to expose the zero and span buttons. See Figure 3-4.
2. Apply the desired 4 mA (1 Vdc) pressure value to the transmitter. Push and hold the zero adjustment button for at least two seconds but no longer than ten seconds.
3. Apply the desired 20 mA (5 Vdc) pressure value to the transmitter. Push and hold the span adjustment button for at least two seconds but no longer than ten seconds.

Figure 3-4. Zero and Span buttons



NOTE

The span is maintained when the 4 mA point (1 Vdc point) is set. The span changes when the 20 mA point (5 Vdc point) is set. If the lower range point is set to a value that causes the upper range point to exceed the sensor limit, the upper range point is automatically set to the sensor limit, and the span is adjusted accordingly.

Damping

The “Damp” command introduces a delay in the micro-processing which increases the response time of the transmitter; smoothing variations in output readings caused by rapid input changes. Determine the appropriate damping setting based on the necessary response time, signal stability, and other requirements of the loop dynamics within your system. The default damping value is 0.4 seconds and it can be set to any of ten pre-configured damping values between 0 and 25.6 seconds. See list below.

- 0.00 seconds
- 0.05 seconds
- 0.10 seconds
- 0.20 seconds
- 0.40 seconds
- 0.80 seconds
- 1.60 seconds
- 3.20 seconds
- 6.40 seconds
- 12.8 seconds
- 25.6 seconds

The current damping value can be determined by executing the HART Communicator fast keys or going to "Configure" in AMS Device Manager.

HART Communicator

4-20 mA Fast Keys	1, 3, 6
1-5 Vdc Fast Keys	1, 3, 6

AMS Device Manager

Right click on the device and select “Configure” from the menu.

1. In the “Basic Setup” tab, enter the damping value in the “Damp” field, click **Apply**.
2. After carefully reading the warning provided, select **yes**.

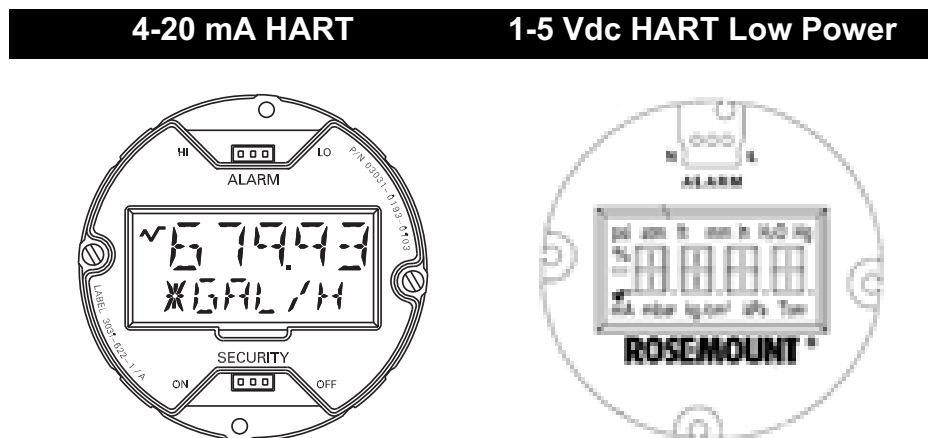
LCD DISPLAY

The LCD display connects directly to the interface board which maintains direct access to the signal terminals. The display indicates output and abbreviated diagnostic messages. A display cover is provided to accommodate the display.

For 4-20 mA HART output, the LCD display features a two-line display. The first line of five characters displays the actual measured value, the second line of six characters displays the engineering units. The LCD can also display diagnostic messages. Refer to Figure 3-5.

For 1-5 Vdc HART Low Power output, the LCD display features a single-line display with four characters that display the actual value. The LCD can also display diagnostic messages. Refer to Figure 3-5.

Figure 3-5.



LCD Display Configuration for 4-20 mA HART only

The factory default alternates are between Engineering Units and % of Range. The LCD Display Configuration command allows customization of the LCD display to suit application requirements. The LCD display will alternate between the selected items:

- Eng. Units only
- % of Range only
- Custom Display only
- Alternate Eng. Units & % of Range
- Alternate Eng. Units & Custom Display
- Alternate % of Range & Custom Display

HART Communicator

4-20 mA Fast Keys	1, 3, 7
-------------------	---------

To change the standard default to one of the above options, follow these steps:

1. From the communicators main menu select (1) Device Setup (3) Basic Setup, (7) Meter Options.
2. Select (1) Meter Type. Using the up or down arrows scroll up or down until the desired display has been highlighted. Press ENTER, SEND, and HOME.

AMS

Right click on the device and select "Configuration Properties" from the menu.

1. In the "Local Display" tab, locate the "Meter Type" area. Select the desired options to suit your application needs, click **Apply**.
2. An "Apply Parameter Modification" screen appears, enter desired information and click **OK**.
3. After carefully reading the warning provided, select **OK**.

Custom Display Configuration 4-20 mA HART only


The user-configurable scale is a feature that enables the LCD display to display flow, level, or custom pressure units. With this feature you can define the decimal point position, the upper range value, the lower range value, the engineering units, and the transfer function. The display can be configured using a HART Communicator or AMS.

The user-configurable scale feature can define:

- decimal point position
- upper range values
- lower range values
- engineering units
- transfer function

To configure the display with a HART communicator, perform the following procedure:

1. Change the Meter Type to "Custom Meter" by using the Fast Key sequence under "LCD Display Configuration for 4-20 mA HART only" on page 3-15.
2. Next from the **ONLINE** screen, *Select 1 Device Setup, 3 Basic Setup, 7 Meter Options, 2 Meter Options, 2 Custom Meter Setup*
3. To specify decimal point position:

 See "Safety Messages" on page 3-1 for complete warning information.

- a. Select *1 Sel dec pt pos*. Choose the decimal point representation that will provide the most accurate output for your application. For example, when outputting between 0 and 75 GPM, choose *XX.XXX* or use the decimal point examples below:

XXXXX
XXXX.X
XXX.XX
XX.XXX
X.XXXX

NOTE:

Make sure the selection has been sent and the decimal point has changed before proceeding to the next step.

- b. SEND
- 4. To specify a custom upper range value:
 - a. Select *2 CM Upper Value*. Type the value that you want the transmitter to read at the 20 mA point.
 - b. SEND
- 5. To specify a custom lower range value:
 - a. Select *3 CM Lower Value*. Type the value that you want the transmitter to read at the 4 mA point.
 - b. SEND
- 6. To define custom units:
 - a. Select *4 CM Units*. Enter the custom units (five characters maximum) that you want the display to display.
 - b. SEND
- 7. To choose the transmitter transfer function for the display:
 - a. Select *5 CM xfer fnct*. Enter the transmitter transfer function for the display. Select *sq root* to display flow units. The custom meter transfer function is independent of the analog output transfer function.
- 8. Select **SEND** to upload the configuration to the transmitter.

DETAILED SETUP

Failure Mode Alarm and Saturation

The 2051 transmitters automatically and continuously perform self-diagnostic routines. If the self-diagnostic routines detect a failure, the transmitter drives its output outside of the normal saturation values. The transmitter will drive its output low or high based on the position of the failure mode alarm jumper. See Table 3-2, Table 3-3, and Table 3-4 for failure mode and saturation output levels. To select alarm position, see "Configure Security and Alarm" on page 2-22.

Table 3-2. 4-20 mA HART Alarm and Saturation Values

Level	4–20 mA Saturation	4–20 mA Alarm
Low	3.9 mA	≤ 3.75 mA
High	20.8 mA	≥ 21.75 mA

Table 3-3. NAMUR-Compliant Alarm and Saturation Values

Level	4–20 mA Saturation	4–20 mA Alarm
Low	3.8 mA	≤ 3.6 mA
High	20.5 mA	≥ 22.5 mA

Table 3-4. 1-5 Vdc HART Low-Power Alarm and Saturation Values

Level	1–5 V Saturation	1–5 V Alarm
Low	0.97 V	≤ 0.95 V
High	5.20 V	≥ 5.4 V

CAUTION

Alarm level values will be affected by analog trim. Refer to “Analog Output Trim” on page 4-7.

NOTE

When a transmitter is in an alarm condition, the HART communicator indicates the analog output the transmitter would drive if the alarm condition did not exist. The transmitter will alarm high in the event of failure if the alarm jumper is removed.

Alarm and Saturation Levels for Burst Mode

Transmitters set to burst mode handle saturation and alarm conditions differently.

Alarm Conditions:

- Analog output switches to alarm value
- Primary variable is burst with a status bit set
- Percent of range follows primary variable
- Temperature is burst with a status bit set

Saturation:

- Analog output switches to saturation value
- Primary variable is burst normally
- Temperature is burst normally

Alarm and Saturation Values for Multidrop Mode

Transmitters set to multidrop mode handle saturation and alarm conditions differently.

Alarm Conditions:

- Primary variable is sent with a status bit set
- Percent of range follows primary variable
- Temperature is sent with a status bit set

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Saturation:

- Primary variable is sent normally
- Temperature is sent normally

Alarm Level Verification

If the transmitter electronics board, sensor module, or LCD display is repaired or replaced, verify the transmitter alarm level before returning the transmitter to service. This feature is also useful in testing the reaction of the control system to a transmitter in an alarm state. To verify the transmitter alarm values, perform a loop test and set the transmitter output to the alarm value (see Tables 3-2, 3-3, and 3-4 on page 3-16, and “Loop Test” on page 3-18).

DIAGNOSTICS AND SERVICE

Diagnostics and service functions listed below are primarily for use after field installation. The Transmitter Test feature is designed to verify that the transmitter is operating properly, and the Loop Test feature is designed to verify proper loop wiring and transmitter output.

Transmitter Test

The Transmitter Test command initiates a more extensive diagnostics routine than that performed continuously by the transmitter. The test routine can quickly identify potential electronics problems. If the test detects a problem, messages to indicate the source of the problem are displayed on the HART Communicator screen.

HART Communicator

4-20 mA Fast Keys	1, 2, 1, 1
1-5 Vdc Fast Keys	1, 2, 1, 1

AMS Device Manager

Right click on the device and select “Diagnostics and Test,” then “Self Test” from the menu.

1. Click **Next** to acknowledge test results.
2. Select **Finish** to acknowledge the method is complete.

Loop Test

The Loop Test command verifies the output of the transmitter, the integrity of the loop, and the operations of any recorders or similar devices installed in the loop.

HART Communicator

4-20 mA Fast Keys	1, 2, 2
1-5 Vdc Fast Keys	1, 2, 2

To initiate a loop test, perform the following procedure:

1. a. For 4-20 mA HART output, connect a reference meter to the transmitter by either connecting the meter to the test terminals on the terminal block, or shunting transmitter power through the meter at some point in the loop.
b. For 1-5 Vdc Low Power HART output, connect a reference meter to the V_{out} terminal.
2. From the **HOME** screen, enter the fast key sequence "Loop Test" to verify the output of the transmitter.
3. Select **OK** after the control loop is set to manual (see "Setting the Loop to Manual" on page 3-2).
4. Select a discrete milliamp level for the transmitter to output. At the **CHOOSE ANALOG OUTPUT** prompt select 1: 4mA (1 Vdc), select 2: 20mA (5 Vdc), or select 3: "Other" to manually input a value.
 - a. If you are performing a loop test to verify the output of a transmitter, enter a value between 4 and 20 mA (1 and 5 Vdc).
 - b. If you are performing a loop test to verify alarm levels, enter the value representing an alarm state (see Tables 3-2, 3-3, and 3-4 on page 3-16).
5. Check that the reference meter displays the commanded output value.
 - a. If the values match, the transmitter and the loop are configured and functioning properly.
 - b. If the values do not match, the meter may be attached to the wrong loop, there may be a fault in the wiring or power supply, the transmitter may require an output trim, or the reference meter may be malfunctioning.

After completing the test procedure, the display returns to the loop test screen to choose another output value or to end loop testing.

AMS Device Manager

Right click on the device and select "Diagnostics and Test," then "Loop test" from the menu.

1. a. For 4-20 mA HART output, connect a reference meter to the transmitter by either connecting the meter to the test terminals on the terminal block, or shunting transmitter power through the meter at some point in the loop.
b. For 1-5 Vdc Low Power HART output, connect a reference meter to the V_{out} terminal.
2. Click **Next** after setting the control loop to manual.
3. Select desired analog output level. Click **Next**.
4. Click **Next** to acknowledge output being set to desired level.
5. Check that the reference meter displays the commanded output value.
 - a. If the values match, the transmitter and the loop are configured and functioning properly.
 - b. If the values do not match, the meter may be attached to the wrong loop, there may be a fault in the wiring or power supply, the transmitter may require an output trim, or the reference meter may be malfunctioning.

After completing the test procedure, the display returns to the loop test screen to choose another output value or to end loop testing.

6. Select **End** and click **Next** to end loop testing.
7. Select **Next** to acknowledge the loop can be returned to automatic control.
8. Select **Finish** to acknowledge the method is complete.

ADVANCED FUNCTIONS

Saving, Recalling, and Cloning Configuration Data

Use the cloning feature of the HART Communicator or the AMS Device Manager “User Configuration” feature to configure several 2051 transmitters similarly. Cloning involves configuring a transmitter, saving the configuration data, then sending a copy of the data to a separate transmitter. Several possible procedures exist when saving, recalling, and cloning configuration data. For complete instructions refer to the HART Communicator manual (publication no. 00809-0100-4276) or AMS Device Manager on-line guides. One common method is as follows:

HART Communicator

4-20 mA Fast Keys	left arrow, 1, 2
1-5 Vdc Fast Keys	left arrow, 1, 2

1. Completely configure the first transmitter.
2. Save the configuration data:
 - a. Select **SAVE** from the HART Communicator **HOME/ONLINE** screen.
 - b. Ensure that the location to which the data will be saved is set to **MODULE**. If it is not, select 1: Location to set the save location to **MODULE**.
 - c. Select 2: Name, to name the configuration data. The default is the transmitter tag number.
 - d. Ensure that the data type is set to **STANDARD**. If the data type is **NOT STANDARD**, select 3: Data Type to set the data type to **STANDARD**.
 - e. Select **SAVE**.
3. Connect and power the receiving transmitter and HART Communicator.
4. Select the back arrow from the **HOME/ONLINE** screen. The HART Communicator menu appears.
5. Select 1: Offline, 2: Saved Configuration, 1: Module Contents to reach the **MODULE CONTENTS** menu.
6. Use the **DOWN ARROW** to scroll through the list of configurations in the memory module, and use the **RIGHT ARROW** to select and retrieve the required configuration.
7. Select 1: Edit.
8. Select 1: Mark All.
9. Select **SAVE**.
10. Use the **DOWN ARROW** to scroll through the list of configurations in the memory module, and use the **RIGHT ARROW** to select the configuration again.

11. Select 3: Send to download the configuration to the transmitter.
12. Select **OK** after the control loop is set to manual.
13. After the configuration has been sent, select **OK** to acknowledge that the loop can be returned to automatic control.

When finished, the HART Communicator informs you of the status. Repeat Steps 3 through 13 to configure another transmitter.

NOTE

The transmitter receiving cloned data must have the same software version (or later) as the original transmitter.

AMS Device Manager creating a Reusable Copy

To create a reusable copy of a configuration perform the following procedure:

1. Completely configure the first transmitter.
2. Select View then User Configuration View from the menu bar (or click the toolbar button).
3. In the User Configuration window, right click and select New from the context menu.
4. In the New window, select a device from the list of templates shown, and click **OK**.
5. The template is copied into the User Configurations window, with the tag name highlighted; rename it as appropriate and press **Enter**.

NOTE

A device icon can also be copied by dragging and dropping a device template or any other device icon from AMS Device Manager Explorer or Device Connection View into the User Configurations window.

The “Compare Configurations” window appears, showing the Current values of the copied device on one side and mostly blank fields on the other (User Configuration) side.

6. Transfer values from the current configuration to the user configuration as appropriate or enter values by typing the values into the available fields.
7. Click Apply to apply the values, or click **OK** to apply the values and close the window.

AMS Device Manager Applying a User Configuration

Any amount of user configurations can be created for the application. They can also be saved, and applied to connected devices or to devices in the Device List or Plant Database.

NOTE

When using AMS Device Manager Revision 6.0 or later, the device to which the user configuration is applied, must be the same model type as the one created in the user configuration. When using AMS Device Manager Revision 5.0 or earlier, the same model type and revision number are required.

To apply a user configuration perform the following procedure:

1. Select the desired user configuration in the User Configurations window.
2. Drag the icon onto a like device in AMS Device Manager Explorer or Device Connection View. The Compare Configurations window opens, showing the parameters of the target device on one side and the parameters of the user configuration on the other.
3. Transfer parameters from the user configuration to the target device as desired, Click **OK** to apply the configuration and close the window.

Burst Mode

When configured for burst mode, the 2051 provides faster digital communication from the transmitter to the control system by eliminating the time required for the control system to request information from the transmitter. Burst mode is compatible with the analog signal. Because the HART protocol features simultaneous digital and analog data transmission, the analog value can drive other equipment in the loop while the control system is receiving the digital information. Burst mode applies only to the transmission of dynamic data (pressure and temperature in engineering units, pressure in percent of range, and/or analog output), and does not affect the way other transmitter data is accessed.

Access to information other than dynamic transmitter data is obtained through the normal poll/response method of HART communication. A HART Communicator, AMS Device Manager or the control system may request any of the information that is normally available while the transmitter is in burst mode. Between each message sent by the transmitter, a short pause allows the HART Communicator, AMS Device Manager or a control system to initiate a request. The transmitter will receive the request, process the response message, and then continue “bursting” the data approximately three times per second.

HART Communicator

4-20 mA Fast Keys	1, 4, 3, 3, 3
1-5 Vdc Fast Keys	1, 4, 3, 3, 3

AMS Device Manager

Right click on the device and select “Configure” from the menu.

1. In the “HART” tab, use the drop down menu to select “Burst Mode ON or OFF.” For “Burst option” select the desired properties from the drop down menu. Burst options are as follows:
 - PV
 - % range/current
 - Process vars/crnt
 - Process variables
2. After selecting options click **Apply**.
3. After carefully reading the warning provided, select **yes**.

MULTIDROP COMMUNICATION

Multidropping transmitters refers to the connection of several transmitters to a single communications transmission line. Communication between the host and the transmitters takes place digitally with the analog output of the transmitters deactivated. With smart communications protocol, up to fifteen transmitters can be connected on a single twisted pair of wires, or over leased phone lines.

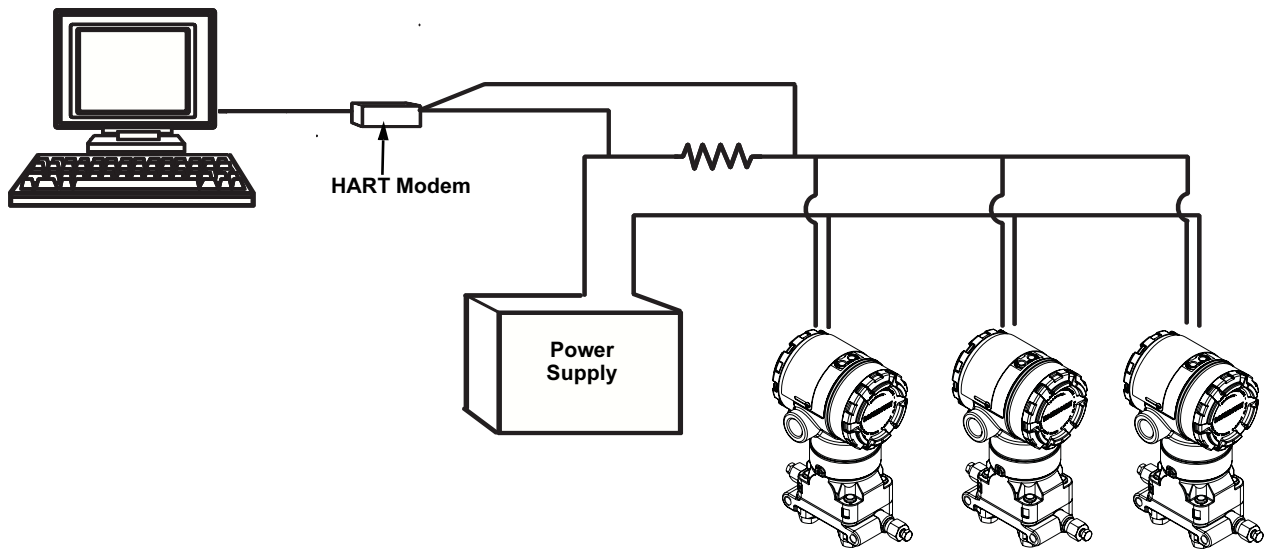
Multidrop installation requires consideration of the update rate necessary from each transmitter, the combination of transmitter models, and the length of the transmission line. Communication with transmitters can be accomplished with HART modems and a host implementing HART protocol. Each transmitter is identified by a unique address (1–15) and responds to the commands defined in the HART protocol. HART Communicators and AMS Device Manager can test, configure, and format a multidropped transmitter the same way as a transmitter in a standard point-to-point installation.

Figure 3-6 shows a typical multidrop network. This figure is not intended as an installation diagram.

NOTE

A transmitter in multidrop mode has the analog output fixed at 4 mA. If an LCD display is installed to a transmitter in multidrop mode, it will alternate the display between “current fixed” and the specified LCD display output(s).

Figure 3-6. Typical Multidrop Network



The 2051 is set to address zero (0) at the factory, which allows operation in the standard point-to-point manner with a 4–20 mA output signal. To activate multidrop communication, the transmitter address must be changed to a number from 1 to 15. This change deactivates the 4–20 mA analog output, sending it to 4 mA. It also disables the failure mode alarm signal, which is controlled by the upscale/downscale switch position. Failure signals in multidropped transmitters are communicated through HART messages.

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Changing a Transmitter Address

To activate multidrop communication, the transmitter poll address must be assigned a number from 1 to 15, and each transmitter in a multidropped loop must have a unique poll address.

HART Communicator

4-20 mA Fast Keys	1, 4, 3, 3, 1
1-5 Vdc Fast Keys	1, 4, 3, 3, 1

AMS Device Manager

Right click on the device and select "Configuration Properties" from the menu.

1. In the "HART" tab, in "ID" box, enter poll address located in the "Poll addr" box, click **Apply**.
2. After carefully reading the warning provided, select **yes**.

Communicating with a Multidropped Transmitter

HART Communicator

4-20 mA Fast Keys	1, 4, 3, 3, 2
1-5 Vdc Fast Keys	1, 4, 3, 3, 2

To communicate with a multidropped transmitter, configure the HART Communicator to poll for a non-zero address.

1. From the **HOME** screen, enter the fast key sequence "Communicating with a Multidropped Transmitter."
2. On the polling menu, scroll down and select "Digital Poll." In this mode, the HART Communicator automatically polls for devices at addresses 0-15 upon start up.

AMS Device Manager

Click on the HART modem icon and select "Scan All Devices."

Polling a Multidropped Transmitter

Polling a multidropped loop determines the model, address, and number of transmitters on the given loop.

HART Communicator

4-20 mA Fast Keys	Left arrow, 4, 1
1-5 Vdc Fast Keys	Left arrow, 4, 1

AMS Device Manager

Click on the HART modem icon and select "Scan All Devices."

Section 4 Operation and Maintenance

Overview	page 4-1
Safety Messages	page 4-1
Calibration Overview	page 4-2
Analog Output Trim	page 4-7
Sensor Trim	page 4-10

OVERVIEW

This section contains information on calibrating and diagnostics messages on the Rosemount 2051 Pressure Transmitters.

HART Communicator and AMS instructions are given to perform configuration functions. For convenience, HART Communicator fast key sequences are labeled "Fast Keys" for each software function below the appropriate headings.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

Warnings

⚠ WARNING

Explosions could result in death or serious injury:
Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 2051 reference manual for any restrictions associated with a safe installation.

- Before connecting a HART communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

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CALIBRATION OVERVIEW

Calibration is defined as the process required to optimize transmitter accuracy over a specific range by adjusting the factory sensor characterization curve located in the microprocessor. Possible procedures are:

- Reranging: Setting the lower and upper range points (4 and 20 mA or 1 and 5 Vdc) points at required pressures. Reranging does not change the factory sensor characterization curve. Refer to page 3-10.
- Analog Output Trim: Adjusts the transmitter's analog characterization curve to match the plant standard of the control loop. There are two types of digital-to-analog output trims. Refer to page 4-7.
 - Digital-to-Analog Output Trim on 4-20 mA HART output (page 4-7)
 - Digital-to-Analog Output Trim on 4-20 mA HART output Using Other Scale (page 4-8)
- Sensor Trim: Adjusts the position of the factory sensor characterization curve due to a change in the sensor characteristics over time or a change in test equipment. Trimming has two steps, zero and sensor trims. Refer to page 4-10 and page 4-11.
 - Zero Trim (page 4-10)
 - Sensor Trim (page 4-11)

Figure 4-1 on page 4-3 illustrates 2051 transmitter data flow. Data flow can be summarized in four major steps:

1. A change in pressure is measured by a change in the sensor output (Sensor Signal).
2. The sensor signal is converted to a digital format that is understood by the microprocessor (Analog-to-Digital Signal Conversion). Sensor trim functions affect this value. Select these options to alter the digital signal on the LCD or HART Communicator.
3. Corrections are performed in the microprocessor to obtain a digital representation of the process input (Digital PV).
4. The Digital PV is converted to an analog value (Digital-to-Analog Signal Conversion). Rerange and Analog trim functions affect this value. Select these options to change the range points (4-20 mA or 1-5 Vdc).

For a summary of recommended calibration procedures, refer to Table 4-1 on page 4-3. Also, Figure 4-1 on page 4-3 identifies the approximate transmitter location for each calibration task. Data flows from left to right and a parameter change affects all values to the right of the changed parameter.

Figure 4-1. Transmitter Data Flow with Calibration Options

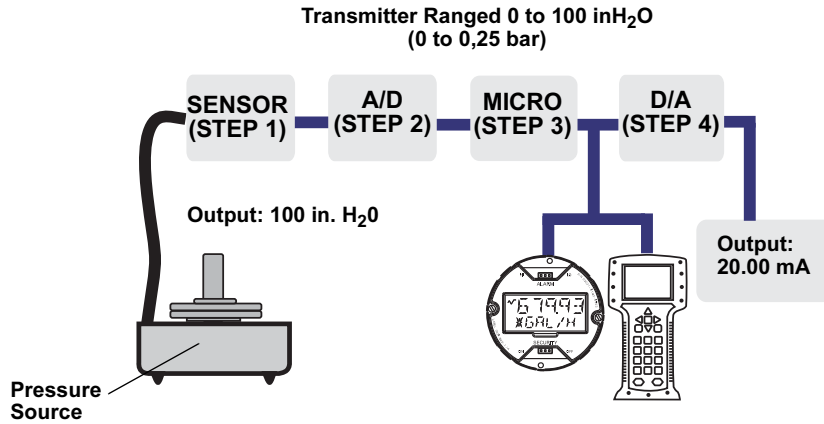


Table 4-1. Recommended Calibration Tasks

Transmitter	Bench Calibration Tasks	Field Calibration Tasks
2051CD 2051CG 2051L 2051TG, Range 1-4	<ol style="list-style-type: none"> 1. Set output configuration parameters: <ol style="list-style-type: none"> a. Set the range points. b. Set the output units. c. Set the output type. d. Set the damping value. 2. <i>Optional:</i> Perform a sensor trim. (Accurate pressure source required.) 	<ol style="list-style-type: none"> 1. Reconfigure parameters if necessary. 2. Zero trim the transmitter to compensate for mounting effects or static pressure effects. 3. <i>Optional:</i> Perform an analog output trim. (Accurate multimeter required)
2051TA 2051TG, Range 5	<ol style="list-style-type: none"> 1. Set output configuration parameters: <ol style="list-style-type: none"> a. Set the range points. b. Set the output units. c. Set the output type. d. Set the damping value. 2. <i>Optional:</i> Perform a sensor trim if equipment available (accurate absolute pressure source required), otherwise perform the low trim value section of the sensor trim procedure. 	<ol style="list-style-type: none"> 1. Reconfigure parameters if necessary. 2. Perform low trim value section of the sensor trim procedure to correct for mounting position effects. 3. <i>Optional:</i> Perform an analog output trim (Accurate multimeter required)

NOTE

The 2051 has been carefully calibrated at the factory. Trimming adjusts the position of the factory characterization curve. It is possible to degrade performance of the transmitter if any trim is done improperly or with inaccurate equipment.

NOTE

A HART communicator is required for all sensor and output trim procedures. Rosemount 2051C Range 4 and Range 5 transmitters require a special calibration procedure when used in differential pressure applications under high static line pressure (see “Compensating for Line Pressure” on page 4-13).

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Determining Calibration Frequency

Calibration frequency can vary greatly depending on the application, performance requirements, and process conditions. Use the following procedure to determine calibration frequency that meets the needs of your application.

1. Determine the performance required for your application.
2. Determine the operating conditions.
3. Calculate the Total Probable Error (TPE).
4. Calculate the stability per month.
5. Calculate the calibration frequency.

Sample Calculation For A Standard 2051C

Step 1: Determine the performance required for your application.

Required Performance: 0.30% of span

Step 2: Determine the operating conditions.

Transmitter: 2051CD, Range 2 [URL=250 inH₂O(623 mbar)]
 Calibrated Span: 150 inH₂O (374 mbar)
 Ambient Temperature Change: ± 50 °F (28 °C)
 Line Pressure: 500 psig (34,5 bar)

Step 3: Calculate total probable error (TPE).

$$TPE = \sqrt{(\text{Reference Accuracy})^2 + (\text{Temperature Effect})^2 + (\text{Static Pressure Effect})^2} = 0.189\% \text{ of span}$$

Where:

Reference Accuracy = ± 0.075% of span

Ambient Temperature Effect =

$$\pm \left(\frac{0.025 \times \text{URL}}{\text{Span}} + 0.125 \right) \text{ per } 50 \text{ }^\circ\text{F} = \pm 0.1666\% \text{ of span}$$

Span Static Pressure Effect⁽¹⁾ =

$$0.1\% \text{ reading per } 1000 \text{ psi (69 bar)} = \pm 0.05\% \text{ of span at maximum span}$$

(1) Zero static pressure effect removed by zero trimming at line pressure.

Step 4: Calculate the stability per month.

$$\text{Stability} = \pm \left[\frac{0.100 \times \text{URL}}{\text{Span}} \right] \% \text{ of span for 2 years} = \pm 0.0069\% \text{ of span per month}$$

Step 5: Calculate calibration frequency.

$$\text{Cal. Freq.} = \frac{(\text{Req. Performance} - \text{TPE})}{\text{Stability per Month}} = \frac{(0.3\% - 0.189\%)}{0.0069\%} = 16 \text{ months}$$

**Sample Calculation for 2051C with P8 option
(0.065% accuracy & 5-year stability)**

Step 1: Determine the performance required for your application.

Required Performance: 0.30% of span

Step 2: Determine the operating conditions.

Transmitter: 2051CD, Range 2 [URL=250 inH₂O(623 mbar)]

Calibrated Span: 150 inH₂O (374 mbar)

Ambient Temperature Change: ± 50 °F (28 °C)

Line Pressure: 500 psig (34,5 bar)

Step 3: Calculate total probable error (TPE).

$$\text{TPE} = \sqrt{(\text{ReferenceAccuracy})^2 + (\text{TemperatureEffect})^2 + (\text{StaticPressureEffect})^2} = 0.185\% \text{ of span}$$

Where:

Reference Accuracy = ± 0.065% of span

Ambient Temperature Effect =

$$\pm \left(\frac{0.025 \times \text{URL}}{\text{Span}} + 0.125 \right) \text{ per } 50 \text{ }^\circ\text{F} = \pm 0.1666\% \text{ of span}$$

Span Static Pressure Effect⁽¹⁾ =

0.1% reading per 1000 psi (69 bar) = ±0.05% of span at maximum span

(1) Zero static pressure effect removed by zero trimming at line pressure.

Step 4: Calculate the stability per month.

$$\text{Stability} = \pm \left[\frac{0.125 \times \text{URL}}{\text{Span}} \right] \% \text{ of span for 5 years} = \pm 0.0035\% \text{ of span per month}$$

Step 5: Calculate calibration frequency.

$$\text{Cal. Freq.} = \frac{(\text{Req. Performance} - \text{TPE})}{\text{Stability per Month}} = \frac{(0.3\% - 0.185\%)}{0.0035\%} = 32 \text{ months}$$

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Choosing a Trim Procedure

To decide which trim procedure to use, you must first determine whether the analog-to-digital section or the digital-to-analog section of the transmitter electronics need calibration. Refer to Figure 4-1 and perform the following procedure:

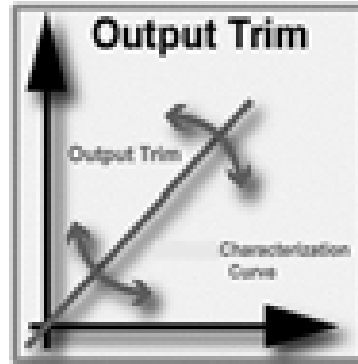
1. Connect a pressure source, a HART Communicator or AMS, and a digital readout device to the transmitter.
2. Establish communication between the transmitter and the HART Communicator.
3. Apply pressure equal to the upper range point pressure.
4. Compare the applied pressure to the pressure process variable value on the Process Variables menu on the HART Communicator or the Process Variables screen in AMS. For instructions on how to access process variables, see page 3-7 of Section 3: Configuration.
 - a. If the pressure reading does not match the applied pressure (with high-accuracy test equipment), perform a sensor trim. See “Sensor Trim Overview” on page 4-10 to determine which trim to perform.
5. Compare the Analog Output (AO) line, on the HART Communicator or AMS, to the digital readout device.

If the AO reading does not match the digital readout device (with high-accuracy test equipment), perform an analog output trim. See “Analog Output Trim” on page 4-7.

ANALOG OUTPUT TRIM

The Analog Output Trim commands allow you to adjust the transmitter’s current output at the 4 and 20 mA (1 and 5 Vdc) points to match the plant standards. This command adjusts the digital to analog signal conversion.

Figure 4-2. Output Trim



Digital-to-Analog Trim

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 2, 1
1-5 Vdc Fast Keys	1, 2, 3, 2, 1

To perform a digital-to-analog trim with a HART Communicator, perform the following procedure.

1. From the **HOME** screen, enter the fast key sequence “Digital-to-Analog Trim.” Select **OK** after setting the control loop to manual, see “Setting the Loop to Manual” on page 3-2.
2.
 - a. For 4-20 mA HART output, connect a reference meter to the transmitter by either connecting the meter to the test terminals on the terminal block, or shunting transmitter power through the meter at some point in the loop.
 - b. For 1-5 Vdc Low Power HART output, connect a reference meter to the V_{out} terminal.
3. Select **OK** after connecting the reference meter.
4. Select **OK** at the **SETTING FLD DEV OUTPUT TO 4 MA (1 Vdc)** prompt. The transmitter outputs 4.0 mA.
5. Record the actual value from the reference meter, and enter it at the **ENTER METER VALUE** prompt. The HART Communicator prompts you to verify whether or not the output value equals the value on the reference meter.
6. Select 1: Yes, if the reference meter value equals the transmitter output value, or 2: No if it does not.
 - a. If 1 is selected: Yes, proceed to Step 7.
 - b. If 2 is selected: No, repeat Step 5.
7. Select **OK** at the **SETTING FLD DEV OUTPUT TO 20 MA (5 Vdc)** prompt, and repeat Steps 5 and 6 until the reference meter value equals the transmitter output value.
8. Select **OK** after the control loop is returned to automatic control.

AMS

Right click on the device and select “Calibrate,” then “D/A Trim” from the menu.

1. Click **Next** after setting the control loop to manual.
2. Click **Next** after connecting the reference meter.
3. Click **Next** at the “Setting fld dev output to 4mA (1 Vdc)” screen.
4. Record the actual value from the reference meter, and enter it at the “Enter meter value” screen and click **Next**.
5. Select **Yes**, if the reference meter value equals the transmitter output value, or **No** if it does not. Click **Next**.
 - a. If Yes is selected, proceed to Step 6.
 - b. If No is selected, repeat Step 4.
6. Click **Next** at the “Setting fld dev output to 20mA (5 Vdc)” screen.
7. Repeat Step 4 - Step 5 until the reference meter equals the transmitter output value.
8. Select **Next** to acknowledge the loop can be returned to automatic control.
9. Select **Finish** to acknowledge the method is complete.

Digital-to-Analog Trim Using Other Scale

The Scaled D/A Trim command matches the 4 and 20 mA (1 and 5 Vdc) points to a user selectable reference scale other than 4 and 20 mA (for example, 2 to 10 volts if measuring across a 500 ohm load, or 0 to 100 percent if measuring from a Distributed Control System (DCS)). To perform a scaled D/A trim, connect an accurate reference meter to the transmitter and trim the output signal to scale, as outlined in the Output Trim procedure.

NOTE

Use a precision resistor for optimum accuracy. If you add a resistor to the loop, ensure that the power supply is sufficient to power the transmitter to a 20 mA output with additional loop resistance. Refer to “Power Supply for 4-20 mA HART” on page 2-27.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 2, 2
1-5 Vdc Fast Keys	1, 2, 3, 2, 2

AMS

Right click on the device and select “Calibrate,” then “Scaled D/A trim” from the menu.

1. Click **Next** after setting the control loop to manual.
2. Select **Change** to change scale, click **Next**.
3. Enter Set scale-Lo output value, click **Next**.
4. Enter Set scale-Hi output value, click **Next**.
5. Click **Next** to proceed with Trim.
6. Click **Next** after connecting the reference meter.
7. Click **Next** at the “Setting fld dev output to 4 mA” screen.
8. Record the actual value from the reference meter, and enter it at the “Enter meter value” screen and click **Next**.
9. Select **Yes**, if the reference meter value equals the transmitter output value, or **No** if it does not. Click **Next**.
 - a. If Yes is selected, proceed to Step 10.
 - b. If No is selected, repeat Step 8.
10. Click **Next** at the “Setting fld dev output to 20mA” screen.
11. Repeat Step 8 - Step 9 until the reference meter equals the transmitter output value.
12. Select **Next** to acknowledge the loop can be returned to automatic control.
13. Select **Finish** to acknowledge the method is complete.

Recall Factory Trim— Analog Output

The Recall Factory Trim—Analog Output command allows the restoration of the as-shipped factory settings of the analog output trim. This command can be useful for recovering from an inadvertent trim, incorrect Plant Standard or faulty meter. This command is only available with 4-20 mA output.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 4, 2
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AMS

Right click on the device and select “Calibrate,” then “Recall Factory Trim” from the menu.

1. Click **Next** after setting the control loop to manual.
2. Select “Analog output trim” under “Trim to recall” and click **Next**.
3. Click **Next** to acknowledge restoration of trim values is complete.
4. Select **Next** to acknowledge the loop can be returned to automatic control.
5. Select **Finish** to acknowledge the method is complete.

SENSOR TRIM

Sensor Trim Overview

Trim the sensor using either sensor or zero trim functions. Trim functions vary in complexity and are application-dependent. Both trim functions alter the transmitter's interpretation of the input signal.

Zero trim is a single-point offset adjustment. It is useful for compensating for mounting position effects and is most effective when performed with the transmitter installed in its final mounting position. Since this correction maintains the slope of the characterization curve, it should not be used in place of a sensor trim over the full sensor range.

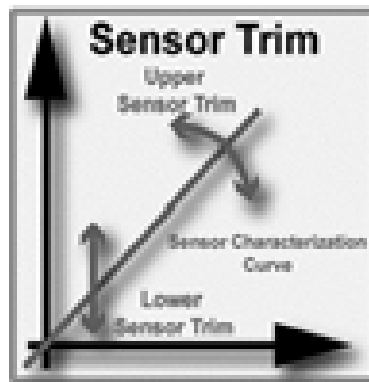
When performing a zero trim, ensure that the equalizing valve is open and all wet legs are filled to the correct levels.

NOTE

Do not perform a zero trim on Rosemount 2051T Absolute pressure transmitters. Zero trim is zero based, and absolute pressure transmitters reference absolute zero. To correct mounting position effects on a 2051T Absolute Pressure Transmitter, perform a low trim within the sensor trim function. The low trim function provides an offset correction similar to the zero trim function, but it does not require zero-based input.

Sensor trim is a two-point sensor calibration where two end-point pressures are applied, and all output is linearized between them. Always adjust the low trim value first to establish the correct offset. Adjustment of the high trim value provides a slope correction to the characterization curve based on the low trim value. The trim values allow you to optimize performance over your specified measuring range at the calibration temperature.

Figure 4-3. Sensor Trim



Zero Trim

NOTE

The transmitter must be within three percent of true zero (zero-based) in order to calibrate with zero trim function.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 3, 1
1-5 Vdc Fast Keys	1, 2, 3, 3, 1

Calibrate the sensor with a HART Communicator using the zero trim function as follows:

1. Vent the transmitter and attach a HART Communicator to the measurement loop.
2. From the **HOME** screen, follow the fast key sequence “Zero Trim.”
3. Follow the commands provided by the HART Communicator to complete the zero trim adjustment.

AMS

Right click on the device and select “Calibrate,” then “Zero trim” from the menu.

1. Click **Next** after setting the control loop to manual.
2. Click **Next** to acknowledge warning.
3. Click **Next** after applying appropriate pressure to sensor.
4. Select **Next** to acknowledge the loop can be returned to automatic control.
5. Select **Finish** to acknowledge the method is complete.

Sensor Trim

NOTE

Use a pressure input source that is at least three times more accurate than the transmitter, and allow the input pressure to stabilize for ten seconds before entering any values.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 3
1-5 Vdc Fast Keys	1, 2, 3, 3

To calibrate the sensor with a HART Communicator using the sensor trim function, perform the following procedure:

1. Assemble and power the entire calibration system including a transmitter, HART Communicator, power supply, pressure input source, and readout device.
2. From the **HOME** screen, enter the fast key sequence under “Sensor Trim.”
3. Select 2: Lower sensor trim. The lower sensor trim value should be the sensor trim point that is closest to zero.

Examples:

Calibration: 0 to 100 "H₂O - lower trim = 0, upper trim = 100

Calibration: -100 to 0 "H₂O - lower trim = 0, upper trim = -100

Calibration: -100 to 100 "H₂O - lower trim = -100 or 100,
 upper trim = -100 or 100

NOTE

Select pressure input values so that lower and upper values are equal to or outside the 4 and 20 mA (1 and 5 Vdc) points. Do not attempt to obtain reverse output by reversing the high and low points. This can be done by going to “Rerange” on page 3-9 of Section 3: Configuration. The transmitter allows approximately five percent deviation.

4. Follow the commands provided by the HART Communicator to complete the adjustment of the lower value.
5. Repeat the procedure for the upper value, replacing 2: Lower sensor trim with 3: Upper sensor trim in Step 3.

AMS

Right click on the device and select “Calibrate,” then “Sensor trim” from the menu.

1. Select “Lower sensor trim.” The lower sensor trim value should be the sensor trim point that is closest to zero.
2. Click **Next** after setting the control loop to manual.
3. Click **Next** after applying appropriate pressure to sensor.
4. Select **Next** to acknowledge the loop can be returned to automatic control.
5. Select **Finish** to acknowledge the method is complete.
6. Right click on the device and select “Calibrate,” select “Sensor trim” from the menu.
7. Select “Upper sensor trim” and repeat steps 2-5.

**Recall Factory Trim—
Sensor Trim**

The Recall Factory Trim—Sensor Trim command allows the restoration of the as-shipped factory settings of the sensor trim. This command can be useful for recovering from an inadvertent zero trim of an absolute pressure unit or inaccurate pressure source. This command is only available with 4-20 mA output.

HART Communicator

4-20 mA Fast Keys	1, 2, 3, 4, 1
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AMS

Right click on the device and select “Calibrate,” then “Recall Factory Trim” from the menu.

1. Click **Next** after setting the control loop to manual.
2. Select “Sensor trim” under “Trim to recall” and click **Next**.
3. Click **Next** to acknowledge restoration of trim values is complete.
4. Select **Next** to acknowledge the loop can be returned to automatic control.
5. Select **Finish** to acknowledge the method is complete.

Compensating for Line Pressure

Rosemount 2051 Range 4 and 5 pressure transmitters require a special calibration procedure when used in differential pressure applications. The purpose of this procedure is to optimize transmitter performance by reducing the effect of static line pressure in these applications. The 2051 differential pressure transmitters (Ranges 1, 2, and 3) do not require this procedure because optimization occurs in the sensor.

Applying high static pressure to 2051 Range 4 and Range 5 pressure transmitters causes a systematic shift in the output. This shift is linear with static pressure; correct it by performing the Sensor Trim procedure on page 4-11.

The following specifications show the static pressure effect for 2051 Range 4 and Range 5 transmitters used in differential pressure applications:

Zero Effect:

$\pm 0.1\%$ of the upper range limit per 1000 psi (69 bar) for line pressures from 0 to 2000 psi (0 to 138 bar)

For line pressures above 2000 psi (138 bar), the zero effect error is $\pm 0.2\%$ of the upper range limit plus an additional $\pm 0.2\%$ of upper range limit error for each 1000 psi (69 bar) of line pressure above 2000 psi (138 bar).

Example: Line pressure is 3000 psi (3 kpsi). Zero effect error calculation:

$\pm \{0.2 + 0.2 \times [3 \text{ kpsi} - 2 \text{ kpsi}]\} = \pm 0.4\%$ of the upper range limit

Span Effect:

Correctable to $\pm 0.2\%$ of reading per 1000 psi (69 bar) for line pressures from 0 to 3626 psi (0 to 250 bar)

The systematic span shift caused by the application of static line pressure is -1.00% of reading per 1000 psi (69 bar) for Range 4 transmitters, and -1.25% of reading per 1000 psi (69 bar) for Range 5 transmitters.

Use the following example to compute corrected input values.

Example

A Range 4 transmitter with model number 2051_CD4 will be used in a differential pressure application where the static line pressure is 1200 psi (83 bar). The transmitter output is ranged with 4 mA at 500 inH₂O (1,2 bar) and 20 mA at 1500 inH₂O (3,7 bar).

To correct for systematic error caused by high static line pressure, first use the following formulas to determine corrected values for the low trim and high trim.

Low Trim Value

$$LT = LRV - (S/100 \times P/1000 \times LRV)$$

Where:

LT =	Corrected Low Trim Value
LRV =	Lower Range Value
S =	Span shift per specification (as a percent of reading)
P =	Static Line Pressure in psi

In this example:

LRV =	500 inH ₂ O (1.24 bar)
S =	-1.00%
P =	1200 psi
LT =	500 inH ₂ O - (-1%/100 x 1200 psi/1000 x 500 inH ₂ O)
LT =	506 inH ₂ O

High Trim Value

$$HT = (URV - (S/100 \times P/1000 \times URV))$$

Where:

HT =	Corrected High Trim Value
URV =	Upper Range Value
S =	Span shift per specification (as a percent of reading)
P =	Static Line Pressure in psi

In this example:

URV =	1500 inH ₂ O (3.74 bar)
S =	-1.00%
P =	1200 psi
HT =	1500 - (-1%/100 x 1200 psi/1000 x 1500 inH ₂ O)
HT =	1518 inH ₂ O

Complete the Sensor Trim procedure as described on page 4-11. In the example above, at step 4, apply the nominal pressure value of 500 inH₂O. However, enter the calculated correct lower trim (LT) value of 506 inH₂O with the HART Communicator. Repeat the procedure for the upper value.

NOTE

The range values for the 4 and 20 mA (1 and 5 Vdc) points should be at the nominal URV and LRV. In the example above, the values are 1500 inH₂O and 500 inH₂O respectively. Confirm the values on the HOME screen on the HART Communicator. Modify, if needed, by following the steps in the Rerange section on page 3-10.

Section 5 Troubleshooting

Overview	page 5-1
Safety Messages	page 5-1
Diagnostic Messages	page 5-3
Disassembly Procedures	page 5-8
Reassembly Procedures	page 5-10

OVERVIEW

Table 5-1 provides summarized maintenance and troubleshooting suggestions for the most common operating problems.

If you suspect malfunction despite the absence of any diagnostic messages on the HART Communicator display, consider using Table 5-1 on page 5-2 to identify any potential problem.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

Warnings (⚠)

⚠ WARNING

Explosions could result in death or serious injury:
Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review the approvals section of the 2051 reference manual for any restrictions associated with a safe installation.

- Before connecting a HART communicator in an explosive atmosphere, ensure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

Rosemount 2051

Table 5-1. Rosemount 2051
Troubleshooting Table for 4-20
mA output

Symptom	Corrective Actions
Transmitter milliamp reading is zero	<ul style="list-style-type: none"> Verify power is applied to signal terminals Check power wires for reversed polarity Verify terminal voltage is 10.5 to 42.4 Vdc Check for open diode across test terminal
Transmitter Not Communicating with HART Communicator	<ul style="list-style-type: none"> Verify the output is between 4 and 20 mA or saturation levels Verify terminal voltage is 10.5 to 42.4 Vdc Verify clean DC Power to transmitter (Max AC noise 0.2 volts peak to peak) Check loop resistance, 250 Ω minimum (PS voltage -transmitter voltage/loop current) Have HART Communicator poll for all addresses
Transmitter milliamp reading is low or high	<ul style="list-style-type: none"> Verify applied pressure Verify 4 and 20 mA range points Verify output is not in alarm condition Verify if 4 – 20 mA output trim is required
Transmitter will not respond to changes in applied pressure	<ul style="list-style-type: none"> Check test equipment Check impulse piping or manifold for blockage Verify the transmitter is not in multidrop mode Verify applied pressure is between the 4 and 20 mA set points Verify output is not in alarm condition Verify transmitter is not in Loop Test mode
Digital Pressure Variable reading is low or high	<ul style="list-style-type: none"> Check test equipment (verify accuracy) Check impulse piping for blockage or low fill in wet leg Verify transmitter is calibrated properly Verify pressure calculations for application
Digital Pressure Variable reading is erratic	<ul style="list-style-type: none"> Check application for faulty equipment in pressure line Verify transmitter is not reacting directly to equipment turning on/off Verify damping is set properly for application
Milliamp reading is erratic	<ul style="list-style-type: none"> Verify power source to transmitter has adequate voltage and current Check for external electrical interference Verify transmitter is properly grounded Verify shield for twisted pair is only grounded at one end

DIAGNOSTIC MESSAGES

In addition to the output, the LCD meter displays abbreviated operation, error, and warning messages for troubleshooting the transmitter. Messages appear according to their priority, with normal operating messages appearing last. To determine the cause of a message, use a HART Communicator or AMS to further interrogate the transmitter. A description of each LCD diagnostic message follows.

Error

Error messages appear on the LCD display to inform you of serious problems affecting the operation of the transmitter. The LCD displays an error message until the error condition is corrected, and the analog output is driven to the specified alarm level. No other transmitter information is displayed during an alarm condition.

FAIL

The transmitter CPU board and the sensor module are incompatible. See “Disassembly Procedures” on page 5-8.

Fail Module

The sensor module is disconnected or is malfunctioning. Verify that the sensor module ribbon cable is connected to the back of the electronics board. If the ribbon cable is properly connected, there is a problem within the sensor module. Possible sources of problems include:

- Pressure or temperature updates are not being received in the sensor module.
- A non-volatile memory fault that will effect transmitter operation has been detected in the module by the memory verification routine.

Some non-volatile memory faults are user-repairable. Use a HART Communicator to diagnose the error and determine if it is repairable. Any error message that ends in “FACTORY” is not repairable. In cases of non user-repairable errors, you must replace the transmitter.

Fail Elect

The transmitter electronics board is malfunctioning due to an internal fault. Some of the FAIL ELECT errors are user-repairable. Use a 275 HART Communicator to diagnose the error and determine if it is repairable. Any error message that ends in “FACTORY” is not repairable. In cases of non user-repairable errors, you must replace the electronics board. See “Disassembly Procedures” on page 5-3.

Fail Config

A memory fault has been detected in a location that could effect transmitter operation, and is user-accessible. To correct this problem, use a HART Communicator to interrogate and reconfigure the appropriate portion of the transmitter memory.

Warnings

Warnings appear on the LCD display to alert you of user-repairable problems with the transmitter, or current transmitter operations. Warnings appear alternately with other transmitter information until the warning condition is corrected or the transmitter completes the operation that warrants the warning message.

Press Limit

The process variable read by the transmitter is outside of the transmitter's range.

Temp Limit

The secondary temperature variable read by the transmitter is outside of the transmitter's range.

Curr Fixed

The transmitter is in multidrop mode. The analog output is not tracking pressure changes.

Curr Saturd

The pressure read by the module is outside of the specified range, and the analog output has been driven to saturation levels.

Loop Test

A loop test is in progress. During a loop test or 4–20 mA trim, the analog output is set to a fixed value. The meter display alternates between the current selected in milliamps and "LOOP TEST."

Xmtr Info

A non-volatile memory fault has been detected in the transmitter memory by the memory verification routine. The memory fault is in a location containing transmitter information. To correct this problem, use a HART Communicator to interrogate and reconfigure the appropriate portion of the transmitter memory. This warning does not effect the transmitter operation.

Operation

Normal operation messages appear on the LCD meter to confirm actions or inform you of transmitter status. Operation messages are displayed with other transmitter information, and warrant no action to correct or alter the transmitter settings.

Zero Pass

The zero value, set with the local zero adjustment button, has been accepted by the transmitter, and the output should change to 4 mA (1 Vdc).

Zero Fail

The zero value, set with the local zero adjustment button, exceeds the maximum rangedown allowed for a particular range, or the pressure sensed by the transmitter exceeds the sensor limits.

Span Pass

The span value, set with the local span adjustment button, has been accepted by the transmitter, and the output should change to 20 mA (5 Vdc).

Span Fail

The span value, set with the local span adjustment button, exceeds the maximum rangedown allowed for a particular range, or the pressure sensed by the transmitter exceeds the sensor limits.

LOCAL DSBLD

This message appears during reranging with the integral zero and span buttons and indicates that the transmitter local zero and span adjustments have been disabled. The adjustments may have been disabled by the transmitter security jumper on the transmitter circuit board or through software commands from the HART Communicator. See “Security (Write Protect)” on page 2-14 for information on the position of the security jumper and information on software lockout.

Write Protect

This message appears if you attempt to change the transmitter configuration data while the security jumper is in the **ON** position. See “Security (Write Protect)” on page 2-14 for more information about the security jumper.

HART Communicator Diagnostics

Table 5-2 is a list of messages used by the HART Communicator (HC) and their corresponding descriptions.

Variable parameters within the text of a message are indicated with *<variable parameter>*.

Reference to the name of another message is identified by *[another message]*.

Table 5-2. HART Communicator Messages

Message	Description
1k snsr EEPROM error-factory ON	Replace the transmitter
1k snsr EEPROM error-user-no out ON	Use the HART communicator to reset the following parameters: remote seal isolator, remote seal fill fluid, flange material, o-ring material, transmitter type, remote seal type, flange type, meter type, number of remote seals.
1k snsr EEPROM error-user ON	Perform a full trim to recalibrate the transmitter.
4k micro EEPROM error-factory ON	Replace the electronics board.
4k micro EEPROM error-user-no out ON	Use the HART communicator to reset the message field.
4k micro EEPROM error-user ON	Use the HART communicator to reset the following parameters: units, range values, damping, analog output, transfer function, tag, scaled meter values. Perform a D/A trim to ensure that the error is corrected.
4k snsr EEPROM error-factory ON	Replace the transmitter.
4k snsr EEPROM error-user ON	Use the HART communicator to reset the temperature units and the calibration type.
Add item for ALL device types or only for this ONE device type.	Asks the user whether the hot key item being added should be added for all device types or only for the type of device that is connected.
Command Not Implemented	The connected device does not support this function.
Communication Error	The communicator and the device are not communicating correctly. Check all connections between the HART Communicator and the device and resend the information.


Message	Description
Configuration memory not compatible with connected device	The configuration stored in memory is incompatible with the device to which a transfer has been requested.
CPU board not initialized ON	The electronics board is not initialized. Replace the electronics board.
CPU EEPROM write failure ON	Message sent to electronics board from HART signal failed. Replace the electronics board.
Device Busy	The connected device is busy performing another task.
Device Disconnected	The device failed to respond to a command. Check all connections between the HART Communicator and the device and resend the command.
Device write protected	Device is in write-protect mode. Data can not be written.
Device write protected. Do you still want to shut off?	Device is in write-protect mode. Press YES to turn the HART communicator off and lose the unsent data.
Display value of variable on hotkey menu?	Asks whether the value of the variable should be displayed adjacent to its label on the hotkey menu if the item being added to the hotkey menu is a variable.
Download data from configuration memory to device	Press the SEND softkey to transfer information from the communicator memory to the device.
Exceed field width	Indicates that the field width for the current arithmetic variable exceeds the device-specified description edit format.
Exceed precision	Indicates that the precision for the current arithmetic variable exceeds the device-specified description edit format.
Ignore next 50 occurrences of status?	Select YES to ignore the next 50 occurrences of device status, or select no to display every occurrence.
Illegal character	An invalid character for the variable type was entered.
Illegal date	The day portion of the date is invalid.
Illegal month	The month portion of the date is invalid.
Illegal year	The year portion of the date is invalid.
Incompatible CPU board and module ON	Upgrade the electronics board or the sensor module to the current revision.
Incomplete exponent	The exponent of a scientific notation floating point variable is incomplete.
Incomplete field	The value entered is not complete for the variable type.
Looking for a device	Polling for multidropped devices at addresses 1–15.
Local buttons operator error ON	Illegal pressure applied during zero or span operation. Repeat the process after verifying the correct pressures.
Mark as read only variable on hotkey menu?	Asks whether the user should be allowed to edit the variable from the hotkey menu if the item being added to the hotkey menu is a variable.
Module EEPROM write failure ON	Message sent to the module from the HART signal failed. Replace the transmitter.
No device configuration in configuration memory	There is no configuration saved in memory available to re-configure off-line or transfer to a device.
No Device Found	Poll of address zero fails to find a device, or poll of all addresses fails to find a device if auto-poll is enabled.
No hotkey menu available for this device.	There is no menu named "hotkey" defined in the device description for this device.
No pressure updates ON	No pressure updates being received from the sensor module. Verify that the sensor module ribbon cable is attached correctly. Or replace the transmitter.
No offline devices available.	There are no device descriptions available to be used to configure a device offline.
No simulation devices available.	There are no device descriptions available to simulate a device.

Message	Description
No temperature updates ON	No temperature updates being received from the sensor module. Verify that the sensor module ribbon cable is attached correctly. Or replace the transmitter.
No UPLOAD_VARIABLES in ddl for this device	There is no menu named "upload_variables" defined in the device description for this device. This menu is required for offline configuration.
No Valid Items	The selected menu or edit display contains no valid items.
OFF KEY DISABLED	Appears when the user attempts to turn the HC off before sending modified data or before completing a method.
Online device disconnected with unsent data. RETRY or OK to lose data.	There is unsent data for a previously connected device. Press RETRY to send data, or press OK to disconnect and lose unsent data.
Out of memory for hotkey configuration. Delete unnecessary items.	There is no more memory available to store additional hotkey items. Unnecessary items should be deleted to make space available.
Overwrite existing configuration memory	Requests permission to overwrite existing configuration either by a device-to-memory transfer or by an offline configuration. User answers using the softkeys.
Press OK...	Press the OK softkey. This message usually appears after an error message from the application or as a result of HART communications.
Restore device value?	The edited value that was sent to a device was not properly implemented. Restoring the device value returns the variable to its original value.
ROM checksum error ON	Checksum of transmitter software has detected a fault. Replace the electronics board.
Save data from device to configuration memory	Prompts user to press SAVE softkey to initiate a device-to-memory transfer.
Saving data to configuration memory.	Data is being transferred from a device to configuration memory.
Sending data to device.	Data is being transferred from configuration memory to a device.
Sensor board not initialized ON	The sensor module electronics board is not initialized. Replace the transmitter.
There are write only variables which have not been edited. Please edit them.	There are write-only variables which have not been set by the user. These variables should be set or invalid values may be sent to the device.
There is unsent data. Send it before shutting off?	Press YES to send unsent data and turn the HC off. Press NO to turn the HC off and lose the unsent data.
Too few data bytes received	Command returns fewer data bytes than expected as determined by the device description.
Transmitter Fault	Device returns a command response indicating a fault with the connected device.
Units for <variable label> has changed. Unit must be sent before editing, or invalid data will be sent.	The engineering units for this variable have been edited. Send engineering units to the device before editing this variable.
Unsent data to online device. SEND or LOSE data	There is unsent data for a previously connected device which must be sent or thrown away before connecting to another device.
Upgrade 275 software to access XMTR function. Continue with old description?	The communicator does not contain the most recent 2051 Device Descriptors (DDs). Select YES to communicate using the existing DDs. Select NO to abort communication.
Use up/down arrows to change contrast. Press DONE when done.	Gives direction to change the contrast of the HC display.

Message	Description
Value out of range	The user-entered value is either not within the range for the given type and size of variable or not within the min/max specified by the device.
<message> occurred reading/writing <variable label>	Either a read/write command indicates too few data bytes received, transmitter fault, invalid response code, invalid response command, invalid reply data field, or failed pre- or post-read method; or a response code of any class other than SUCCESS is returned reading a particular variable.
<variable label> has an unknown value. Unit must be sent before editing, or invalid data will be sent.	A variable related to this variable has been edited. Send related variable to the device before editing this variable.

DISASSEMBLY PROCEDURES

Remove from Service

 Do not remove the instrument cover in explosive atmospheres when the circuit is live.


Follow these steps:

- Follow all plant safety rules and procedures.
- Isolate and vent the process from the transmitter before removing the transmitter from service.
- Remove all electrical leads and disconnect conduit.
- Remove the transmitter from the process connection.
 - The Rosemount 2051C transmitter is attached to the process connection by four bolts and two cap screws. Remove the bolts and separate the transmitter from the process connection. Leave the process connection in place and ready for re-installation.
 - The Rosemount 2051T transmitter is attached to the process by a single hex nut process connection. Loosen the hex nut to separate the transmitter from the process. Do not wrench on neck of transmitter.
- Do not scratch, puncture, or depress the isolating diaphragms.
- Clean isolating diaphragms with a soft rag and a mild cleaning solution, and rinse with clear water.
- For the 2051C, whenever you remove the process flange or flange adapters, visually inspect the PTFE o-rings. Replace the o-rings if they show any signs of damage, such as nicks or cuts. Undamaged o-rings may be reused.

Remove Terminal Block


Electrical connections are located on the terminal block in the compartment labeled "FIELD TERMINALS."

1. Remove the housing cover from the field terminal side.
2. Loosen the two small screws located on the assembly in the 9 o'clock and 3 o'clock positions.
3. Pull the entire terminal block out to remove it.

 See "Safety Messages" on page 5-1 for complete warning information.

Remove the Electronics Board

The transmitter electronics board is located in the compartment opposite the terminal side. To remove the electronics board perform the following procedure:

1. Remove the housing cover opposite the field terminal side.
2. If you are disassembling a transmitter with a LCD display, loosen the two captive screws that are visible on the right and left side of the meter display.
-  3. Loosen the two captive screws that anchor the board to the housing. The electronics board is electrostatically sensitive; observe handling precautions for static-sensitive components. Use caution when removing the LCD as there is an electronic pin connector that interfaces between the LCD and electronics board. The two screws anchor the LCD display to the electronics board and the electronics board to the housing.
4. Using the two captive screws, slowly pull the electronics board out of the housing. The sensor module ribbon cable holds the electronics board to the housing. Disengage the ribbon cable by pushing the connector release.

Remove the Sensor Module from the Electronics Housing

1. Remove the electronics board. Refer to "Remove the Electronics Board" on page 5-9.

IMPORTANT

To prevent damage to the sensor module ribbon cable, disconnect it from the electronics board before you remove the sensor module from the electrical housing.

2. Carefully tuck the cable connector completely inside of the internal black cap.

NOTE

Do not remove the housing until after you tuck the cable connector completely inside of the internal black cap. The black cap protects the ribbon cable from damage that can occur when you rotate the housing.


3. Loosen the housing rotation set screw with a $\frac{5}{64}$ -inch hex wrench, and loosen one full turn.
4. Unscrew the module from the housing, making sure the black cap and sensor cable do not catch on the housing.

REASSEMBLY PROCEDURES


1. Inspect all cover and housing (non-process wetted) O-rings and replace if necessary. Lightly grease with silicone lubricant to ensure a good seal.
2. Carefully tuck the cable connector completely inside the internal black cap. To do so, turn the black cap and cable counterclockwise one rotation to tighten the cable.
3. Lower the electronics housing onto the module. Guide the internal black cap and cable through the housing and into the external black cap.
4. Turn the module clockwise into the housing.

IMPORTANT

Make sure the sensor ribbon cable and internal black cap remain completely free of the housing as you rotate it. Damage can occur to the cable if the internal black cap and ribbon cable become hung up and rotate with the housing.

-  5. Thread the housing completely onto the sensor module. The housing must be no more than one full turn from flush with the sensor module to comply with explosion proof requirements.
6. Tighten the housing rotation set screw using a $\frac{5}{64}$ -inch hex wrench.

Attach the Electronics Board

1. Remove the cable connector from its position inside of the internal black cap and attach it to the electronics board.
2. Using the two captive screws as handles, insert the electronics board into the housing. Make sure the posts from the electronics housing properly engage the receptacles on the electronics board. Do not force. The electronics board should slide gently on the connections.
3. Tighten the captive mounting screws.
-  4. Replace the electronics housing cover. The transmitter covers must be engaged metal-to-metal to ensure a proper seal and to meet Explosion-Proof requirements.

Install the Terminal Block

1. Gently slide the terminal block into place, making sure the two posts from the electronics housing properly engage the receptacles on the terminal block.
2. Tighten the captive screws.
3. Replace the electronics housing cover. The transmitter covers must be fully engaged to meet Explosion-Proof requirements.

Reassemble the 2051C Process Flange

1. Inspect the sensor module PTFE o-rings. Undamaged o-rings may be reused. Replace o-rings that show any signs of damage, such as nicks, cuts, or general wear.

NOTE

If you are replacing the o-rings, be careful not to scratch the o-ring grooves or the surface of the isolating diaphragm when removing the damaged o-rings.

2. Install the process connection. Possible options include:

 See "Safety Messages" on page 5-1 for complete warning information.

- a. Coplanar Process Flange:
 - Hold the process flange in place by installing the two alignment screws to finger tightness (screws are not pressure retaining). Do not overtighten as this will affect module-to-flange alignment.
 - Install the four 1.75-in. flange bolts by finger tightening them to the flange.
 - b. Coplanar Process Flange with Flange Adapters:
 - Hold the process flange in place by installing the two alignment screws to finger tightness (screws are not pressure retaining). Do not overtighten as this will affect module-to-flange alignment.
 - Hold the flange adapters and adapter o-rings in place while installing the four configurations, use four 2.88-in. bolts. For gage pressure configurations, use two 2.88-in. bolts and two 1.75-in. bolts.
 - c. Manifold:
 - Contact the manifold manufacturer for the appropriate bolts and procedures.
3. Tighten the bolts to the initial torque value using a crossed pattern. See Table 5-3 for appropriate torque values.

Table 5-3. Bolt Installation Torque Values

Bolt Material	Initial Torque Value	Final Torque Value
CS-ASTM-A445 Standard	300 in.-lb. (34 N-m)	650 in.-lb. (73 N-m)
316 SST—Option L4	150 in.-lb. (17 N-m)	300 in.-lb. (34 N-m)
ASTM-A-193-B7M—Option L5	300 in.-lb. (34 N-m)	650 in.-lb. (73 N-m)
ASTM-A-193 Class 2, Grade B8M—Option L8	150 in.-lb (17 N-m)	300 in.-lb (34 N-m)

NOTE

If you replaced the PTFE sensor module o-rings, re-torque the flange bolts after installation to compensate for cold flow.

NOTE

After replacing o-rings on Range 1 transmitters and re-installing the process flange, expose the transmitter to a temperature of 185 °F (85 °C) for two hours. Then re-tighten the flange bolts in a cross pattern, and again expose the transmitter to a temperature of 185 °F (85 °C) for two hours before calibration.

Install the Drain/Vent Valve

1. Apply sealing tape to the threads on the seat. Starting at the base of the valve with the threaded end pointing toward the installer, apply two clockwise turns of sealing tape.
2. Tighten the drain/vent valve to 250 in.-lb. (28.25 N-m).
3. Take care to place the opening on the valve so that process fluid will drain toward the ground and away from human contact when the valve is opened.

Appendix A Reference Data

Performance Specifications	page A-1
Functional Specifications	page A-4
Physical Specifications	page A-9
Ordering Information	page A-12
Options	page A-22
Spare Parts	page A-25

PERFORMANCE SPECIFICATIONS

For zero based spans, reference conditions, silicone oil fill, SST materials, Coplanar flange (2051C) or 1/2 in. - 14 NPT (2051T) process connections, digital trim values range points. Applies to 4-20 mA HART output only unless otherwise noted.

Conformance To Specification ($\pm 3\sigma$ (Sigma))

Technology leadership, advanced manufacturing techniques and statistical process control ensure specification conformance to at least $\pm 3\sigma$.

Reference Accuracy⁽¹⁾

Models	Standard	Performance Option, P8
2051C		
Ranges 2-5	$\pm 0.075\%$ of span For spans less than 10:1, accuracy = $\pm \left[0.025 + 0.005 \left(\frac{URL}{Span} \right) \right] \% \text{ of Span}$	Ranges 2-5 High Accuracy Option, P8 $\pm 0.065\%$ of span For spans less than 10:1, accuracy = $\pm \left[0.015 + 0.005 \left(\frac{URL}{Span} \right) \right] \% \text{ of Span}$
Range 1	$\pm 0.10\%$ of span For spans less than 15:1, accuracy = $\pm \left[0.025 + 0.005 \left(\frac{URL}{Span} \right) \right] \% \text{ of Span}$	
2051T		
Ranges 1-4	$\pm 0.075\%$ of span For spans less than 10:1, accuracy = $\pm \left[0.0075 \left(\frac{URL}{Span} \right) \right] \% \text{ of Span}$	Ranges 1-4 High Accuracy Option, P8 $\pm 0.065\%$ of span For spans less than 10:1, accuracy = $\pm \left[0.0075 \left(\frac{URL}{Span} \right) \right] \% \text{ of Span}$
Range 5	$\pm 0.075\%$ of span for spans greater than 5:1	
2051L		
Ranges 2-4	$\pm 0.075\%$ of span For spans less than 10:1, accuracy = $\pm \left[0.025 + 0.005 \left(\frac{URL}{Span} \right) \right] \% \text{ of Span}$	

(1) For FOUNDATION fieldbus transmitters, use calibrated range in place of span.

Long Term Stability

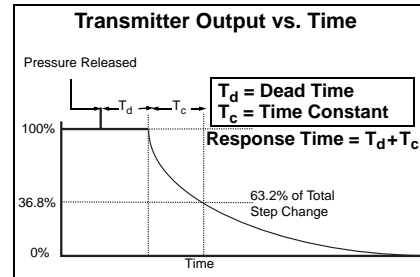
Models	Standard	Performance Option, P8
2051C ⁽¹⁾	Ranges 2-5 ±0.1% of URL for 2 years	±0.125% of URL for 5 years
2051CD	Range 1 ±0.2% of URL for 1 year	
2051T ⁽¹⁾	Ranges 1-5 ±0.1% of URL for 2 years	±0.125% of URL for 5 years

(1) Measured at reference conditions after exposure to temperature changes of up to ±50 °F (28 °C), and line pressure changes up to 1000 psi (6,9 mPa).

Dynamic Performance

	4 - 20 mA HART ⁽¹⁾ 1-5 Vdc HART Lower Power ⁽¹⁾	Fieldbus ⁽³⁾	Typical HART Transmitter Response Time
Total Response Time (T_d + T_c)⁽²⁾:			
2051C, Range 3-5:	115 milliseconds	152 milliseconds	
Range 1:	270 milliseconds	307 milliseconds	
Range 2:	130 milliseconds	152 milliseconds	
2051T:	100 milliseconds	152 milliseconds	
2051L:	See <i>Instrument Toolkit</i> [®]	See <i>Instrument Toolkit</i>	
Dead Time (T_d)	60 milliseconds (nominal)	97 milliseconds	
Update Rate	22 times per second	22 times per second	

(1) Dead time and update rate apply to all models and ranges; analog output only
 (2) Nominal total response time at 75 °F (24 °C) reference conditions.
 (3) Transmitter fieldbus output only, segment macro-cycle not included.



Line Pressure Effect per 1000 psi (6,9 MPa)

For line pressures above 2000 psi (13,7 MPa) and Ranges 4-5, see user manual (Rosemount publication number 00809-0100-4101).

Models	Line Pressure Effect
2051CD	Zero Error ⁽¹⁾
Ranges 2-3	±0.1% of URL/1000 psi (68,9 bar) for line pressures from 0 to 2000 psi (0 to 13,7 MPa)
Range 1	±0.5% of URL/1000 psi (68,9 bar)
	Span Error
Ranges 2-3	±0.1% of reading/1000 psi (68,9 bar)
Range 1	±0.4% of reading/1000 psi (68,9 bar)

(1) Can be calibrated out at line pressure.

Ambient Temperature Effect per 50°F (28°C)

Models	Ambient Temperature Effect
2051C	Ranges 2-5 $\pm(0.025\% \text{ URL} + 0.125\% \text{ span})$ from 1:1 to 5:1 $\pm(0.05\% \text{ URL} + 0.25\% \text{ span})$ from 5:1 to 100:1 Range 1 $\pm(0.2\% \text{ URL} + 0.5\% \text{ span})$ from 1:1 to 50:1
2051T	Range 2-4 $\pm(0.05\% \text{ URL} + 0.25\% \text{ span})$ from 1:1 to 30:1 $\pm(0.07\% \text{ URL} + 0.25\% \text{ span})$ from 30:1 to 100:1 Range 1 $\pm(0.05\% \text{ URL} + 0.25\% \text{ span})$ from 1:1 to 10:1 $\pm(0.10\% \text{ URL} + 0.25\% \text{ span})$ from 10:1 to 100:1 Range 5 $\pm(0.2\% \text{ URL} + 0.3\% \text{ span})$
2051L	See <i>Instrument Toolkit</i>

Mounting Position Effects

Models	Mounting Position Effects
2051C	Zero shifts up to $\pm 1.25 \text{ inH}_2\text{O}$ (3,1 mbar), which can be calibrated out. No span effect.
2051T	Zero shifts up to $\pm 2.5 \text{ inH}_2\text{O}$ (6,2 mbar), which can be calibrated out. No span effect.
2051L	With liquid level diaphragm in vertical plane, zero shift of up to $1 \text{ inH}_2\text{O}$ (2,49 mbar). With diaphragm in horizontal plane, zero shift of up to $5 \text{ inH}_2\text{O}$ (12,43 mbar) plus extension length on extended units. Zero shifts can be calibrated out. No span effect.

Vibration Effect

Less than $\pm 0.1\%$ of URL when tested per the requirements of IEC60770-1 field or pipeline with high vibration level (10-60 Hz 0.21mm displacement peak amplitude / 60-2000 Hz 3g).

Power Supply Effect

Less than $\pm 0.005\%$ of calibrated span per volt.

Electromagnetic Compatibility (EMC)

Meets all relevant requirements of EN 61326 and NAMUR NE-21.

Transient Protection (Option Code T1)

Meets IEEE C62.41, Category Location B
 6 kV crest (0.5 μs - 100 kHz)
 3 kV crest (8 \times 20 microseconds)
 6 kV crest (1.2 \times 50 microseconds)

FUNCTIONAL SPECIFICATIONS

Range and Sensor Limits

Range	2051CD, 2051CG, 2051L					
	Range and Sensor Limits					
	Minimum Span	Upper (URL)	Lower (LRL)			
2051C Differential			2051C Gage ⁽¹⁾	2051L Differential	2051L Gage ⁽¹⁾	
1	0.5 inH ₂ O (1,2 mbar)	25 inH ₂ O (62,3 mbar)	-25 inH ₂ O (-62,1 mbar)	-25 inH ₂ O (-62,1 mbar)	N/A	N/A
2	2.5 inH ₂ O (6,2 mbar)	250 inH ₂ O (0,62 bar)	-250 inH ₂ O (-0,62 bar)	-250 inH ₂ O (-0,62 bar)	-250 inH ₂ O (-0,62 bar)	-250 inH ₂ O (-0,62 bar)
3	10 inH ₂ O (24,9 mbar)	1000 inH ₂ O (2,49 bar)	-1000 inH ₂ O (-2,49 bar)	-393 inH ₂ O (-979 mbar)	-1000 inH ₂ O (-2,49 bar)	-393 inH ₂ O (-979 mbar)
4	3 psi (0,207 bar)	300 psi (20,6 bar)	-300 psi (-20,6 bar)	-14.2 psig (-979 mbar)	-300 psi (-20,7 bar)	-14.2 psig (-979 mbar)
5	20 psi (1,38 bar)	2000 psi (137,9 bar)	-2000 psi (-137,9 bar)	-14.2 psig (-979 mbar)	N/A	N/A

(1) Assumes atmospheric pressure of 14.7 psig.

Range	2051T			
	Range and Sensor Limits			
	Minimum Span	Upper (URL)	Lower (LRL) (Abs)	Lower ⁽¹⁾ (LRL) (Gage)
1	0.3 psi (20,6 mbar)	30 psi (2,06 bar)	0 psia (0 bar)	-14.7 psig (-1,01 bar)
2	1.5 psi (0,103 bar)	150 psi (10,3 bar)	0 psia (0 bar)	-14.7 psig (-1,01 bar)
3	8 psi (0,55 bar)	800 psi (55,2 bar)	0 psia (0 bar)	-14.7 psig (-1,01 bar)
4	40 psi (2,76 bar)	4000 psi (275,8 bar)	0 psia (0 bar)	-14.7 psig (-1,01 bar)
5	2000 psi (137,9 bar)	10000 psi (689,4 bar)	0 psia (0 bar)	-14.7 psig (-1,01 bar)

(1) Assumes atmospheric pressure of 14.7 psig.

Service

Liquid, gas, and vapor applications

Protocols

4–20 mA HART (Output Code A)

Output

Two-wire 4–20 mA, user-selectable for linear or square root output. Digital process variable superimposed on 4–20 mA signal, available to any host that conforms to the *HART* protocol.

Power Supply

External power supply required. Standard transmitter operates on 10.5 to 42.4 V dc with no load.

Turn-On Time

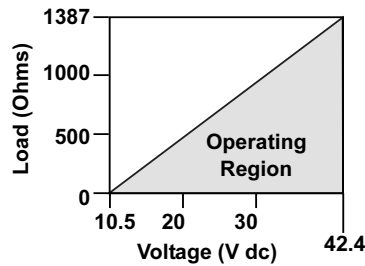
Performance within specifications less than 2.0 seconds after power is applied to the transmitter.

Load Limitations

Maximum loop resistance is determined by the voltage level of the external power supply, as described by:

Table A-1.

$$\text{Maximum Loop Resistance} = 43.5 * (\text{Power Supply Voltage} - 10.5)$$



The HART communicator requires a minimum loop resistance of 250Ω for communication.

FOUNDATION™ fieldbus (Output Code F)

Power Supply

External power supply required; transmitters operate on 9.0 to 32.0 V dc transmitter terminal voltage.

Current Draw

17.5 mA for all configurations (including LCD display option)

Turn-On Time

Performance within specifications less than 20.0 seconds after power is applied to the transmitter.

FOUNDATION fieldbus Function Block Execution Times

Block	Execution Time
Resource	-
Transducer	-
LCD Block	-
Analog Input 1, 2	30 milliseconds
PID	45 milliseconds

FOUNDATION fieldbus Parameters

Schedule Entries	7 (max.)
Links	20 (max.)
Virtual Communications Relationships (VCR)	12 (max.)

Standard Function Blocks

Resource Block

- Contains hardware, electronics, and diagnostic information.

Transducer Block

- Contains actual sensor measurement data including the sensor diagnostics and the ability to trim the pressure sensor or recall factory defaults.

LCD Block

- Configures the local display.

2 Analog Input Blocks

- Processes the measurements for input into other function blocks. The output value is in engineering units or custom and contains a status indicating measurement quality.

PID Block

- Contains all logic to perform PID control in the field including cascade and feedforward.

Backup Link Active Scheduler (LAS)

The transmitter can function as a Link Active Scheduler if the current link master device fails or is removed from the segment.

1-5 Vdc HART Low Power (Output Code M)

Output

Three wire 1–5 Vdc output, user-selectable for linear or square root output. Digital process variable superimposed on voltage signal, available to any host conforming to the *HART* protocol.

Power Supply

External power supply required. Standard transmitter operates on 9 to 28 Vdc with no load.

Power Consumption

3.0 mA, 27–84 mW

Output Load

100 k Ω or greater

Turn-On Time

Performance within specifications less than 2.0 seconds after power is applied to the transmitter.

Overpressure Limits

Transmitters withstand the following limits without damage:

2051C

- Ranges 2–5: 3626 psig (250 bar)
4500 psig (310,3 bar) for option code P9
- Range 1: 2000 psig (137,9 bar)

2051T

- Range 1: 750 psi (51,7 bar)
- Range 2: 1500 psi (103,4 bar)
- Range 3: 1600 psi (110,3 bar)
- Range 4: 6000 psi (413,7 bar)
- Range 5: 15000 psi (1034,2 bar)

2051L

Limit is flange rating or sensor rating, whichever is lower (see Table A-2).

Table A-2. 2051L Flange Rating

Standard	Type	CS Rating	SST Rating
ANSI/ASME	Class 150	285 psig	275 psig
ANSI/ASME	Class 300	740 psig	720 psig
<i>At 100 °F (38 °C), the rating decreases with increasing temperature.</i>			
DIN	PN 10-40	40 bar	40 bar
DIN	PN 10/16	16 bar	16 bar
<i>At 248 °F (120 °C), the rating decreases with increasing temperature.</i>			

Static Pressure Limit

2051CD

- Operates within specifications between static line pressures of -14.2 psig (0.034 bar) and 3626 psig (250 bar)
 - For Option Code P9, 4500 psig (310,3 bar)
- Range 1: 0.5 psia to 2000 psig (34 mbar and 137,9 bar)

Burst Pressure Limits

2051C Coplanar or traditional process flange

- 10000 psig (689,5 bar)

2051T

- Ranges 1-4: 11000 psi (758,4 bar)
- Range 5: 26000 psi (1792,64 bar)

Temperature Limits

Ambient

-40 to 185 °F (-40 to 85 °C)

With LCD display⁽¹⁾: -40 to 175 °F (-40 to 80 °C)

Storage

-50 to 230 °F (-46 to 110 °C)

With LCD display: -40 to 185 °F (-40 to 85 °C)

⁽¹⁾ LCD display may not be readable and LCD updates will be slower at temperatures below -4 °F (-20 °C).

Process Temperature Limits

At atmospheric pressures and above.

Table A-3. 2051 Process Temperature Limits

2051C	
Silicone Fill Sensor ⁽¹⁾	
with Coplanar Flange	-40 to 250 °F (-40 to 121 °C) ⁽²⁾
with Traditional Flange	-40 to 300 °F (-40 to 149 °C) ⁽²⁾
with Level Flange	-40 to 300 °F (-40 to 149 °C) ⁽²⁾
with 305 Integral Manifold	-40 to 300 °F (-40 to 149 °C) ⁽²⁾
Inert Fill Sensor ⁽¹⁾	0 to 185 °F (-18 to 85 °C) ⁽³⁾
2051T (Process Fill Fluid)	
Silicone Fill Sensor ⁽¹⁾	-40 to 250 °F (-40 to 121 °C) ⁽²⁾
Inert Fill Sensor ⁽¹⁾	-22 to 250 °F (-30 to 121 °C) ⁽²⁾
2051L Low-Side Temperature Limits	
Silicone Fill Sensor ⁽¹⁾	-40 to 250 °F (-40 to 121 °C) ⁽²⁾

Table A-3. 2051 Process Temperature Limits

Inert Fill Sensor⁽¹⁾ 0 to 185 °F (–18 to 85 °C)⁽²⁾

2051L High-Side Temperature Limits (Process Fill Fluid)

Syltherm® XLT	–100 to 300 °F (–73 to 149 °C)
D.C. Silicone 704®	32 to 400 °F (0 to 205 °C)
D.C. Silicone 200	–40 to 400 °F (–40 to 205 °C)
Inert	–50 to 350 °F (–45 to 177 °C)
Glycerin and Water	0 to 200 °F (–18 to 93 °C)
Neobee M-20®	0 to 400 °F (–18 to 205 °C)
Propylene Glycol and Water	0 to 200 °F (–18 to 93 °C)

- (1) Process temperatures above 185 °F (85 °C) require derating the ambient limits by a 1.5:1 ratio.
- (2) 220 °F (104 °C) limit in vacuum service; 130 °F (54 °C) for pressures below 0.5 psia.
- (3) 160 °F (71 °C) limit in vacuum service.

Humidity Limits

0–100% relative humidity

Volumetric Displacement

Less than 0.005 in³ (0,08 cm³)

Damping

Analog output response to a step input change is user-selectable from 0 to 25.6 seconds for one time constant. This software damping is in addition to sensor module response time.

Failure Mode Alarm

If self-diagnostics detect a sensor or microprocessor failure, the analog signal is driven either high or low to alert the user. High or low failure mode is user-selectable with a jumper on the transmitter. The values to which the transmitter drives its output in failure mode depend on whether it is factory-configured to *standard* or *NAMUR-compliant* operation. The values for each are as follows:

Standard Operation			
Output Code	Linear Output	Fail High	Fail Low
A	$3.9 \leq I \leq 20.8$	$I \geq 21.75 \text{ mA}$	$I \leq 3.75 \text{ mA}$
M	$0.97 \leq V \leq 5.2$	$V \geq 5.4 \text{ V}$	$V \leq 0.95 \text{ V}$

NAMUR-Compliant Operation			
Output Code	Linear Output	Fail High	Fail Low
A	$3.8 \leq I \leq 20.5$	$I \geq 22.5 \text{ mA}$	$I \leq 3.6 \text{ mA}$

Output Code F

If self-diagnostics detect a gross transmitter failure, that information gets passed as a status along with the process variable.

PHYSICAL SPECIFICATIONS

Electrical Connections

$\frac{1}{2}$ -14 NPT, G $\frac{1}{2}$, and M20 × 1.5 (CM20) conduit.

Process Connections

2051C

- $\frac{1}{4}$ -18 NPT on 2 $\frac{1}{8}$ -in. centers
- $\frac{1}{2}$ -14 NPT and RC $\frac{1}{2}$ on 2-in. (50.8mm), 2 $\frac{1}{8}$ -in. (54.0 mm), or 2 $\frac{1}{4}$ -in. (57.2mm) centers (process adapters)

2051T

- $\frac{1}{2}$ -14 NPT female
- G $\frac{1}{2}$ A DIN 16288 Male (available in SST for Range 1-4 transmitters only)
- Autoclave type F-250-C (Pressure relieved $\frac{9}{16}$ -18 gland thread; $\frac{1}{4}$ OD high pressure tube 60° cone; available in SST for Range 5 transmitters only)

2051L

- High pressure side: 2-in. (50.8mm), 3-in. (72 mm), or 4-in. (102mm), ASME B 16.5 (ANSI) Class 150 or 300 flange; 50, 80 or 100 mm, DIN 2501 PN 40 or 10/16 flange
- Low pressure side: $\frac{1}{4}$ -18 NPT on flange, $\frac{1}{2}$ -14 NPT on process adapter

2051C Process Wetted Parts

Drain/Vent Valves

316 SST or Alloy C-276

Process Flanges and Adapters

Plated carbon steel, SST CF-8M (cast version of 316 SST, material per ASTM-A743), or CW12MW (cast version of Alloy C-276)

Wetted O-rings

Glass-filled PTFE or Graphite-filled PTFE

Process Isolating Diaphragms

316L SST or Alloy C-276

2051T Process Wetted Parts

Process Connections

- 316L SST or Alloy C-276

Process Isolating Diaphragms

- 316L SST or Alloy C-276

2051L Process Wetted Parts

Flanged Process Connection (Transmitter High Side)

Process Diaphragms, Including Process Gasket Surface

- 316L SST or Alloy C-276

Extension

- CF-3M (Cast version of 316L SST, material per ASTM-A743), or Cast C-276. Fits schedule 40 and 80 pipe.

Mounting Flange

- Zinc-cobalt plated CS or SST

Reference Process Connection (Transmitter Low Side)

Isolating Diaphragms

- 316L SST or Alloy C-276

Reference Flange and Adapter

- CF-8M (Cast version of 316 SST, material per ASTM-A743)

Non-Wetted Parts for 2051C/T/L

Electronics Housing

Low-copper aluminum or CF-8M (Cast version of 316 SST). Enclosure Type 4X, IP 65, IP 66, IP68

Coplanar Sensor Module Housing

CF-3M (Cast version of 316L SST)

Bolts

ASTM A449, Type 1 (zinc-cobalt plated carbon steel)

ASTM F593G, Condition CW1 (Austenitic 316 SST)

ASTM A193, Grade B7M (zinc plated alloy steel)

Sensor Module Fill Fluid

Silicone oil (D.C. 200) or Fluorocarbon oil (Halocarbon or Fluorinert[®] FC-43 for 2051T)

Process Fill Fluid (2051L only)

Syltherm XLT, D.C. Silicone 704,

D.C. Silicone 200, inert, glycerin and water, Neobee M-20 or propylene glycol and water

Paint

Polyurethane

Cover O-rings

Buna-N

Shipping Weights

Table A-4. Transmitter Weights without Options

Transmitter	lb. (kg)
2051C	4.9 (2,2)
2051L	Table A-5 below
2051T	3.1 (1,4)

Table A-5. 2051L Weights without Options

Flange	Flush lb. (kg)	2-in. Ext. lb (kg)	4-in. Ext. lb (kg)	6-in. Ext. lb (kg)
2-in., 150	12.5 (5,7)	—	—	—
3-in., 150	17.5 (7,9)	19.5 (8,8)	20.5 (9,3)	21.5 (9,7)
4-in., 150	23.5 (10,7)	26.5 (12,0)	28.5 (12,9)	30.5 (13,8)
2-in., 300	17.5 (7,9)	—	—	—
3-in., 300	22.5 (10,2)	24.5 (11,1)	25.5 (11,6)	26.5 (12,0)
4-in., 300	32.5 (14,7)	35.5 (16,1)	37.5 (17,0)	39.5 (17,9)
DN 50/PN 40	13.8 (6,2)	—	—	—
DN 80/PN 40	19.5 (8,8)	21.5 (9,7)	22.5 (10,2)	23.5 (10,6)
DN 100/ PN 10/16	17.8 (8,1)	19.8 (9,0)	20.8 (9,5)	21.8 (9,9)
DN 100/ PN 40	23.2 (10,5)	25.2 (11,5)	26.2 (11,9)	27.2 (12,3)

Table A-6. Transmitter Options Weights

Code	Option	Add lb (kg)
J, K, L, M	Stainless Steel Housing	3.9 (1,8)
M5	LCD display for Aluminum Housing	0.5 (0,2)
B4	SST Mounting Bracket for Coplanar Flange	1.0 (0,5)
B1 B2 B3	Mounting Bracket for Traditional Flange	2.3 (1,0)
B7 B8 B9	Mounting Bracket for Traditional Flange	2.3 (1,0)
BA, BC	SST Bracket for Traditional Flange	2.3 (1,0)
H2	Traditional Flange	2.6 (1,2)
H3	Traditional Flange	3.0 (1,4)
H4	Traditional Flange	3.0 (1,4)
H7	Traditional Flange	2.7 (1,2)
FC	Level Flange—3 in., 150	12.7 (5,8)
FD	Level Flange—3 in., 300	15.9 (7,2)
FA	Level Flange—2 in., 150	8.0 (3,6)
FB	Level Flange—2 in., 300	8.4 (3,8)
FP	DIN Level Flange, SST, DN 50, PN 40	7.8 (3,5)
FQ	DIN Level Flange, SST, DN 80, PN 40	12.7 (5,8)

ORDERING INFORMATION

Model	Transmitter Type (Select One)	CD	CG		
2051C	Pressure Transmitter	•	•		
Model	Measurement Type	CD	CG		
D	Differential	•	—		
G	Gage	—	•		
Code	Pressure Ranges (Range/Min. Span)	CD	CG		
	2051CD 2051CG				
1	–25 to 25 inH ₂ O/0.5 inH ₂ O (–62,2 to 62,2 mbar/1,2 mbar)	•	•		
2	–250 to 250 inH ₂ O/2.5 inH ₂ O (–623 to 623 mbar/6,2 mbar)	•	•		
3	–1000 to 1000 inH ₂ O/10 inH ₂ O (–2,5 to 2,5 bar/25 mbar)	•	•		
4	–300 to 300 psi/3 psi (–20,7 to 20,7 bar/0,2 bar)	•	•		
5	–2000 to 2000 psi/20 psi (–137,9 to 137,9 bar/1,4 bar)	•	•		
	–25 to 25 inH ₂ O/0.5 inH ₂ O (–62,1 to 62,2 mbar/1,2 mbar)	•	•		
	–250 to 250 inH ₂ O/2.5 inH ₂ O (–623 to 623 mbar/6,2 mbar)	•	•		
	–393 to 1000 inH ₂ O/10 inH ₂ O (–0,98 to 2,5 bar/25 mbar)	•	•		
	–14.2 to 300 psi/3 psi (–0,98 to 20,7 bar/0,2 bar)	•	•		
	–14.2 to 2000 psig/20 psi (–0,98 to 137,9 bar/1,4 bar)	•	•		
Code	Output	CD	CG		
A	4–20 mA with Digital Signal Based on HART Protocol	•	•		
M	Low-Power, 1–5 V dc with Digital Signal Based on HART Protocol	•	•		
F	FOUNDATION fieldbus Protocol	•	•		
Code	Materials of Construction	CD	CG		
	Process Flange Type Flange Material Drain/Vent				
2	Coplanar	SST	SST	•	•
3 ⁽¹⁾	Coplanar	Cast C-276	Alloy C-276	•	•
5	Coplanar	Plated CS	SST	•	•
7 ⁽¹⁾	Coplanar	SST	Alloy C-276	•	•
8 ⁽¹⁾	Coplanar	Plated CS	Alloy C-276	•	•
0	Alternate Process Connection (Requires selecting Flange, Manifold, or Primary Element option code, see page A-13)			•	•
Code	Isolating Diaphragm	CD	CG		
2 ⁽¹⁾	316L SST	•	•		
3 ⁽¹⁾	Alloy C-276	•	•		
Code	O-ring	CD	CG		
A	Glass-filled PTFE	•	•		
B	Graphite-filled PTFE	•	•		
Code	Fill Fluid	CD	CG		
1	Silicone	•	•		
2	Inert fill (Halocarbon)	•	•		
Code	Housing Material	Conduit Entry Size	CD	CG	
A	Polyurethane-covered Aluminum	½–14 NPT	•	•	
B	Polyurethane-covered Aluminum	M20 × 1.5 (CM20)	•	•	
D	Polyurethane-covered Aluminum	G½	•	•	
J	SST (consult factory for availability)	½–14 NPT	•	•	
K	SST (consult factory for availability)	M20 × 1.5 (CM20)	•	•	
M	SST (consult factory for availability)	G½	•	•	

Code	Options	CD	CG
Alternate Process Connection: Flange⁽²⁾			
H2	Traditional Flange, 316 SST, SST Drain/Vent	•	•
H3 ⁽¹⁾	Traditional Flange, Cast C-276, Alloy C-276 Drain/Vent	•	•
H7 ⁽¹⁾	Traditional Flange, 316 SST, Alloy C-276 Drain/Vent	•	•
HJ	DIN Compliant Traditional Flange, SST, 7/16 in. Adapter/Manifold Bolting	•	•
HK ⁽³⁾	DIN Compliant Traditional Flange, SST, 10 mm Adapter/Manifold Bolting	•	•
HL	DIN Compliant Traditional Flange, SST, 12mm Adapter/Manifold Bolting	•	•
FA	Level Flange, SST, 2 in., ANSI Class 150, Vertical Mount	•	•
FB	Level Flange, SST, 2 in., ANSI Class 300, Vertical Mount	•	•
FC	Level Flange, SST, 3 in., ANSI Class 150, Vertical Mount	•	•
FD	Level Flange, SST, 3 in., ANSI Class 300, Vertical Mount	•	•
FP	DIN Level Flange, SST, DN 50, PN 40, Vertical Mount	•	•
FQ	DIN Level Flange, SST, DN 80, PN 40, Vertical Mount	•	•
Alternate Process Connection: Manifold⁽²⁾⁽⁴⁾			
S5	Assemble to Rosemount 305 Integral Manifold	•	•
S6	Assemble to Rosemount 304 Manifold or Connection System	•	•
Alternate Process Connection: Primary Element⁽²⁾⁽⁴⁾			
S4 ⁽⁵⁾	Assemble to Rosemount Primary Element	•	—
S3	Assemble to Rosemount 405 Primary Element	•	—
Diaphragm Seal Assemblies⁽⁴⁾			
S1 ⁽⁶⁾	Assemble to one Rosemount 1199 diaphragm seal	•	•
S2 ⁽⁷⁾	Assemble to two Rosemount 1199 diaphragm seals	•	—
Mounting Brackets			
B1 ⁽⁸⁾	Traditional Flange Bracket for 2-in. Pipe Mounting, CS Bolts	•	•
B2 ⁽⁸⁾	Traditional Flange Bracket for Panel Mounting, CS Bolts	•	•
B3 ⁽⁸⁾	Traditional Flange Flat Bracket for 2-in. Pipe Mounting, CS Bolts	•	•
B4 ⁽⁹⁾	Coplanar Flange Bracket for 2-in. Pipe or Panel Mounting, all SST	•	•
B7 ⁽⁸⁾	B1 Bracket with Series 300 SST Bolts	•	•
B8 ⁽⁸⁾	B2 Bracket with Series 300 SST Bolts	•	•
B9 ⁽⁸⁾	B3 Bracket with Series 300 SST Bolts	•	•
BA ⁽⁸⁾	SST B1 Bracket with Series 300 SST Bolts	•	•
BC ⁽⁸⁾	SST B3 Bracket with Series 300 SST Bolts	•	•
Product Certifications			
E1 ⁽¹⁰⁾	ATEX Flameproof	•	•
E2 ⁽¹⁰⁾	INMETRO Flameproof (consult factory for availability)	•	•
E3 ⁽¹⁰⁾	China Flameproof (consult factory for availability)	•	•
E4 ⁽¹⁰⁾	TIIS Flameproof (consult factory for availability)	•	•
E5	FM Explosion-proof, Dust Ignition-proof	•	•
E6	CSA Explosion-proof, Dust Ignition-proof, Division 2	•	•
E7	IECEX Flameproof	•	•
EP ⁽¹⁰⁾	Korea (KOSHA) Flameproof Approval (consult factory for availability)	•	•
EW ⁽¹⁰⁾	India (CCOE) Flameproof Approval (consult factory for availability)	•	•
EM ⁽¹⁰⁾	GOST Explosion-proof (consult factory for availability)	•	•
I1	ATEX Intrinsic Safety	•	•
I2 ⁽¹⁰⁾	INMETRO Intrinsic Safety (consult factory for availability)	•	•
I3 ⁽¹⁰⁾	China Intrinsic Safety (consult factory for availability)	•	•
I4 ⁽¹⁰⁾	TIIS Intrinsic Safety (consult factory for availability)	•	•
I5	FM Intrinsically Safe, Division 2	•	•
I6	CSA Intrinsically Safe	•	•
I7 ⁽¹⁰⁾	IECEX Intrinsic Safety	•	•
IA ⁽¹¹⁾	ATEX FISCO Intrinsic Safety	•	•
IB ⁽¹¹⁾	INMETRO FISCO Intrinsic Safety (consult factory for availability)	•	•
ID ⁽¹¹⁾	TIIS FISCO Intrinsic Safety (consult factory for availability)	•	•
IE ⁽¹¹⁾	FM FISCO Intrinsically Safe	•	•

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IF ⁽¹¹⁾	CSA FISCO Intrinsically Safe	.	.
IG ⁽¹¹⁾	IECEX FISCO Intrinsically Safe	.	.
IP ⁽¹⁰⁾	Korea (KOSHA) Intrinsic Safety (consult factory for availability)	.	.
IM ⁽¹⁰⁾	GOST Intrinsically Safe (consult factory for availability)	.	.
IW ⁽¹⁰⁾	India (CCOE) Intrinsic Safety Approval (consult factory for availability)	.	.
K1 ⁽¹⁰⁾	ATEX Flameproof, Intrinsic Safety, Type n, Dust	.	.
K2 ⁽¹⁰⁾	INMETRO Flameproof, Intrinsic Safety, Type n (consult factory for availability)	.	.
K4 ⁽¹⁰⁾	TIIS Flameproof, Intrinsic Safety (consult factory for availability)	.	.
K5	FM Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2	.	.
K6	CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2	.	.
K7 ⁽¹⁰⁾	IECEX Flameproof, Intrinsic Safety, Type n	.	.
KA	ATEX and CSA Flameproof, Intrinsically Safe, Division 2	.	.
KB	FM and CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2	.	.
KC	FM and ATEX Explosion-proof, Intrinsically Safe, Division 2	.	.
KD ⁽¹⁰⁾	FM, CSA, and ATEX Explosion-proof, Intrinsically Safe	.	.
N1 ⁽¹⁰⁾	ATEX Type n	.	.
N7 ⁽¹⁰⁾	IECEX Type n	.	.
ND	ATEX Dust	.	.
Bolting Configurations			
L4	Austenitic 316 SST Bolts	.	.
L5	ASTM A 193, Grade B7M Bolts	.	.
L8	ASTM A 193 Class 2, Grade B8M Bolts	.	.
Digital Display			
M5	LCD display	.	.
Special Configuration (Hardware)			
D4 ⁽¹²⁾	Zero and Span Hardware Adjustments	.	.
DF ⁽¹³⁾	1/2-14 NPT Flange Adapters	.	.
D9 ⁽¹⁴⁾	JIS Process Connection-RC 1/4 Flange with RC 1/2 Flange Adapter	.	.
V5 ⁽¹⁵⁾	External Ground Screw Assembly	.	.
Performance			
P8 ⁽¹⁶⁾	0.065% accuracy and 5 year stability	.	.
Terminal Blocks			
T1	Transient Protection Terminal Block	.	.
Special Configuration (Software)			
C1 ⁽¹⁷⁾	Custom Software Configuration (Requires completed Configuration Data Sheet)	.	.
C4 ⁽¹⁷⁾⁽¹⁸⁾	Analog Output Levels Compliant with NAMUR Recommendation NE 43, Alarm High	.	.
CN ⁽¹⁷⁾⁽¹⁸⁾	Analog Output Levels Compliant with NAMUR Recommendation NE 43 Alarm Low	.	.
Special Procedures			
P1	Hydrostatic Testing with Certificate	.	.
P2 ⁽¹⁹⁾	Cleaning for Special Service	.	.
P9	4500 psig (310 bar) static pressure limit (Ranges 2-5 only)	.	.
P3 ⁽¹⁹⁾	Cleaning for <1 PPM Chlorine/Fluorine	.	.
Special Certifications			
Q4	Calibration Certificate	.	.
Q8	Material Traceability Certification per EN 10204 3.1.B	.	.
QS ⁽¹⁷⁾	Prior-use certificate of FMEDA data	.	.
Q16 ⁽²⁰⁾	Surface finish certification for sanitary remote seals	.	.
QP	Calibration certification and tamper evident seal	.	.
QZ ⁽²⁰⁾	Remote Seal System Performance Calculation Report	.	.

Typical Model Number: 2051C D 2 A 2 2 A 1 A B4 M5

- (1) Materials of Construction comply with recommendations per NACE MR0175/ISO 15156 for sour oil field production environments. Environmental limits apply to certain materials. Consult latest standard for details. Selected materials also conform to NACE MR0103 for sour refining environments.
- (2) Requires 0 code in Materials of Construction for Alternate Process Connection.
- (3) Not valid with optional code P9 for 4500psi Static Pressure.
- (4) "Assemble-to" items are specified separately and require a completed model number.
- (5) Process Flange limited to Coplanar (codes 2, 3, 5, 7, 8) or Traditional (H2, H3, H7).

- (6) Not valid with optional code D9 for RC1/2 Adaptors.
- (7) Not valid with optional codes DF & D9 for Adaptors.
- (8) Requires option in the Alternate Process Connection: Flange section.
- (9) Requires Coplanar flange.
- (10) Not available with Low Power output code M.
- (11) Only valid with FOUNDATION fieldbus output code F.
- (12) Not available with FOUNDATION fieldbus output code F.
- (13) Not valid with Alternate Process Connection options S3, S4, S5, S6.
- (14) Not available with Alternate Process Connection: DIN Flanges and Level Flanges.
- (15) The V5 option is not needed with the T1 option; external ground screw assembly is included with the T1 option.
- (16) Available for HART 4-20mA output code A. Valid for Ranges 2-5 only.
- (17) Only available with HART 4-20mA output (output code A).
- (18) NAMUR-Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.
- (19) Not valid with Alternate Process Connections S5 & S6.
- (20) Requires one of the Diaphragm Seal Assemblies codes (S1 or S2).

Rosemount 2051

Model	Transmitter Type (Select One)	
2051T	In-Line Pressure Transmitter	
Model	Measurement Type	
G	Gage	
A	Absolute	
Code	Pressure Ranges (Ranges/ Min. Span)	
	2051TG	2051TA
1	-14.7 to 30 psi/0.3 psi (-1,01 to 2,1 bar/20,7 mbar)	0 to 30 psia/0.3 psia (0 to 2,1 bar/20,7 mbar)
2	-14.7 to 150 psi/1.5 psi (-1,01 to 10,3 bar/103,4 mbar)	0 to 150 psia/1.5 psia (0 to 10,3 bar/103,4 mbar)
3	-14.7 to 800 psi/8 psi (-1,01 to 55,2 bar/0,55 bar)	0 to 800 psia/8 psia (0 to 55,2 bar/0,55 bar)
4	-14.7 to 4000 psi/40 psi (-1,01 to 275,8 bar/2,8 bar)	0 to 4000 psia/40 psia (0 to 275,8 bar/2,8 bar)
5	-14.7 to 10000 psi/2000 psi (-1,01 to 689,5 bar/138 bar)	0 to 10000 psia/2000 psia (0 to 689,5 bar/138 bar)
Code	Output	
A	4–20 mA with Digital Signal Based on HART Protocol	
M	Low-Power, 1–5 V dc with Digital Signal Based on HART Protocol	
F	FOUNDATION fieldbus Protocol	
Code	Process Connection Style	
2B	1/2–14 NPT female	
2C	G1/2 A DIN 16288 male (Range 1-4 only)	
2F	Coned and Threaded, Compatible with Autoclave Type F-250-C (Includes Gland and Collar, Available in SST for Range 5 only)	
Code	Isolating Diaphragm	
2 ⁽¹⁾	316L SST	
3 ⁽¹⁾	Alloy C-276	
Code	Fill Fluid	
1	Silicone	
2	Inert fill (Fluorinert FC-43)	
Code	Housing Material	Conduit Entry Size
A	Polyurethane-covered Aluminum	1/2–14 NPT
B	Polyurethane-covered Aluminum	M20 × 1.5 (CM20)
D	Polyurethane-covered Aluminum	G1/2
J	SST (consult factory for availability)	1/2–14 NPT
K	SST (consult factory for availability)	M20 × 1.5 (CM20)
M	SST (consult factory for availability)	G1/2
Code	Options	
Manifold Assemblies		
S5 ⁽²⁾	Assemble to Rosemount 306 Integral Manifold	
Diaphragm Seal Assemblies		
S1 ⁽²⁾	Assemble to one Rosemount 1199 diaphragm seal	
Mounting Brackets		
B4	Bracket for 2-in. Pipe or Panel Mounting, all SST	
Product Certifications		
E1 ⁽³⁾	ATEX Flameproof	
E2 ⁽³⁾	INMETRO Flameproof (consult factory for availability)	
E3 ⁽³⁾	China Flameproof (consult factory for availability)	
E4 ⁽³⁾	TIIS Flameproof (consult factory for availability)	
E5	FM Explosion-proof, Dust Ignition-proof	
E6	CSA Explosion-proof, Dust Ignition-proof, Division 2	
E7	IECEx Flameproof	
EP ⁽³⁾	Korea (KOSHA) Flameproof Approval (consult factory for availability)	
EW ⁽³⁾	India (CCOE) Flameproof Approval (consult factory for availability)	
EM ⁽³⁾	GOST Explosion-proof (consult factory for availability)	

Reference Manual

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I1	ATEX Intrinsic Safety
I2 ⁽³⁾	INMETRO Intrinsic Safety (consult factory for availability)
I3 ⁽³⁾	China Intrinsic Safety (consult factory for availability)
I4 ⁽³⁾	TIIS Intrinsic Safety (consult factory for availability)
I5	FM Intrinsically Safe, Division 2
I6	CSA Intrinsically Safe
I7 ⁽³⁾	IECEx Intrinsic Safety
IA ⁽⁴⁾	ATEX FISCO Intrinsic Safety
IB ⁽⁴⁾	INMETRO FISCO Intrinsic Safety (consult factory for availability)
ID ⁽⁴⁾	TIIS FISCO Intrinsic Safety (consult factory for availability)
IE ⁽⁴⁾	FM FISCO Intrinsically Safe
IF ⁽⁴⁾	CSA FISCO Intrinsically Safe
IG ⁽⁴⁾	IECEx FISCO Intrinsically Safe
IP ⁽³⁾	Korea (KOSHA) Intrinsic Safety (consult factory for availability)
IM ⁽³⁾	GOST Intrinsically Safe (consult factory for availability)
IW ⁽³⁾	India (CCOE) Intrinsic Safety Approval (consult factory for availability)
K1 ⁽³⁾	ATEX Flameproof, Intrinsic Safety, Type n, Dust
K2 ⁽³⁾	INMETRO Flameproof, Intrinsic Safety, Type n (consult factory for availability)
K4 ⁽³⁾	TIIS Flameproof, Intrinsic Safety (consult factory for availability)
K5	FM Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2
K6	CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2
K7 ⁽³⁾	IECEx Flameproof, Intrinsic Safety, Type n
KA	ATEX and CSA Flameproof, Intrinsically Safe, Division 2
KB	FM and CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2
KC	FM and ATEX Explosion-proof, Intrinsically Safe, Division 2
KD ⁽³⁾	FM, CSA, and ATEX Explosion-proof, Intrinsically Safe
N1 ⁽³⁾	ATEX Type n
N7 ⁽³⁾	IECEx Type n
ND	ATEX Dust
Digital Display	
M5	LCD display
Special Configuration (Hardware)	
D4 ⁽⁵⁾	Zero and Span Hardware Adjustments
V5 ⁽⁶⁾	External Ground Screw Assembly
Performance	
P8 ⁽⁷⁾	0.065% accuracy and 5 year stability
Terminal Blocks	
T1	Transient Protection Terminal Block
Special Configuration (Software)	
C1 ⁽⁸⁾	Custom Software Configuration (Requires completed Configuration Data Sheet)
C4 ⁽⁸⁾⁽⁹⁾	Analog Output Levels Compliant with NAMUR Recommendation NE 43, Alarm High
CN ⁽⁸⁾⁽⁹⁾	Analog Output Levels Compliant with NAMUR Recommendation NE 43 Alarm Low
Special Procedures	
P1	Hydrostatic Testing with Certificate
P2 ⁽¹⁰⁾	Cleaning for Special Service
P3 ⁽¹⁰⁾	Cleaning for <1 PPM Chlorine/Fluorine

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Special Certifications

Q4	Calibration Certificate
Q8	Material Traceability Certification per EN 10204 3.1.B
QS ⁽⁸⁾	Prior-use certificate of FMEDA data
Q16 ⁽¹¹⁾	Surface finish certification for sanitary remote seals
QP	Calibration certification and tamper evident seal
QZ ⁽¹¹⁾	Remote Seal System Performance Calculation Report

Typical Model Number: 2051T G 3 A 2B 1 A B4 M5

- (1) *Materials of Construction comply with recommendations per NACE MR0175/ISO 15156 for sour oil field production environments. Environmental limits apply to certain materials. Consult latest standard for details. Selected materials also conform to NACE MR0103 for sour refining environments.*
- (2) *"Assemble-to" items are specified separately and require a completed model number.*
- (3) *Not available with Low Power output code M.*
- (4) *Only valid with FOUNDATION fieldbus output code F.*
- (5) *Not available with FOUNDATION fieldbus output code F.*
- (6) *The V5 option is not needed with the T1 option; external ground screw assembly is included with the T1 option.*
- (7) *Available for HART 4-20mA output code A. Valid for Ranges 1-4 only.*
- (8) *Only available with HART 4-20mA output (output code A).*
- (9) *NAMUR-Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.*
- (10) *Not valid with Alternate Process Connection S5.*
- (11) *Requires S1 Diaphragm Seal Assembly code.*

Model	Transmitter Type		
2051L	Flange-Mounted Liquid Level Transmitter		
Code	Pressure Ranges (Range/Minimum Span)		
2	-250 to 250 inH ₂ O/2.5 inH ₂ O (-0,6 to 0,6 bar/6,2 mbar)		
3	-1000 to 1000 inH ₂ O/10 inH ₂ O (-2,5 to 2,5 bar/25 mbar)		
4	-300 to 300 psi/3 psi (-20,7 to 20,7 bar/0,2 bar)		
Code	Output		
A	4-20 mA with Digital Signal Based on HART Protocol		
M	Low-Power, 1-5 V dc with Digital Signal Based on HART Protocol		
F	FOUNDATION fieldbus Protocol		
Code	High Pressure Side		
	Diaphragm Size	Material	Extension Length
G0	2 in./DN 50	316L SST	Flush Mount Only
H0	2 in./DN 50	Alloy C-276	Flush Mount Only
A0	3 in./DN 80	316L SST	Flush Mount
A2	3 in./DN 80	316L SST	2 in./50 mm
A4	3 in./DN 80	316L SST	4 in./100 mm
A6	3 in./DN 80	316L SST	6 in./150 mm
B0	4 in./DN 100	316L SST	Flush Mount
B2	4 in./DN 100	316L SST	2 in./50 mm
B4	4 in./DN 100	316L SST	4 in./100 mm
B6	4 in./DN 100	316L SST	6 in./150 mm
C0	3 in./DN 80	Alloy C-276	Flush Mount
C2	3 in./DN 80	Alloy C-276	2 in./50 mm
C4	3 in./DN 80	Alloy C-276	4 in./100 mm
C6	3 in./DN 80	Alloy C-276	6 in./150 mm
D0	4 in./DN 100	Alloy C-276	Flush Mount
D2	4 in./DN 100	Alloy C-276	2 in./50 mm
D4	4 in./DN 100	Alloy C-276	4 in./100 mm
D6	4 in./DN 100	Alloy C-276	6 in./150 mm
Code	Mounting Flange		
	Size	Rating	Material
M	2 in.	Class 150, ANSI	CS
A	3 in.	Class 150, ANSI	CS
B	4 in.	Class 150, ANSI	CS
N	2 in.	Class 300, ANSI	CS
C	3 in.	Class 300, ANSI	CS
D	4 in.	Class 300, ANSI	CS
X	2 in.	Class 150, ANSI	SST
F	3 in.	Class 150, ANSI	SST
G	4 in.	Class 150, ANSI	SST
Y	2 in.	Class 300, ANSI	SST
H	3 in.	Class 300, ANSI	SST
J	4 in.	Class 300, ANSI	SST
Q	DN50	PN 10-40, DIN	CS
R	DN80	PN 40, DIN	CS
K	DN50	PN 10-40, DIN	SST
T	DN80	PN 40, DIN	SST

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Code	Process Fill-High Pressure Side	Temperature Limits
A	Syltherm® XLT	-100 to 300 °F (-73 to 135 °C)
C	D.C. Silicone 704	60 to 400 °F (15 to 205 °C)
D	D.C. Silicone 200	-40 to 400 °F (-40 to 205 °C)
H	Inert (Halocarbon)	-50 to 350 °F (-45 to 177 °C)
G	Glycerin and Water	0 to 200 °F (-17 to 93 °C)
N	Neobee® M-20	0 to 400 °F (-17 to 205 °C)
P	Propylene Glycol and Water	0 to 200 °F (-17 to 93 °C)

Code	Low Pressure Side			
	Configuration	Flange Adapter	Diaphragm Material	Sensor Fill Fluid
11	Gage	SST	316L SST	Silicone
21	Differential	SST	316L SST	Silicone
22	Differential (SST Valve Seat)	SST	Alloy C-276	Silicone
2A	Differential	SST	316L SST	Inert (Halocarbon)
2B	Differential (SST Valve Seat)	SST	Alloy C-276	Inert (Halocarbon)
31	Remote Seal	SST	316L SST	Silicone

Code	O-ring
A	Glass-filled PTFE

Code	Housing Material	Conduit Entry Size
A	Polyurethane-covered Aluminum	½–14 NPT
B	Polyurethane-covered Aluminum	M20 × 1.5 (CM20)
D	Polyurethane-covered Aluminum	G½
J	SST (consult factory for availability)	½–14 NPT
K	SST (consult factory for availability)	M20 × 1.5 (CM20)
M	SST (consult factory for availability)	G½

Code	Options
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Diaphragm Seal Assembly

S1⁽¹⁾ Assemble to one Rosemount 1199 diaphragm seal

Product Certifications

E1⁽²⁾ ATEX Flameproof
 E2⁽²⁾ INMETRO Flameproof (consult factory for availability)
 E3⁽²⁾ China Flameproof (consult factory for availability)
 E4⁽²⁾ TIIS Flameproof (consult factory for availability)
 E5 FM Explosion-proof, Dust Ignition-proof
 E6 CSA Explosion-proof, Dust Ignition-proof, Division 2
 E7 IECEx Flameproof
 EP⁽²⁾ Korea (KOSHA) Flameproof Approval (consult factory for availability)
 EW⁽²⁾ India (CCOE) Flameproof Approval (consult factory for availability)
 EM⁽²⁾ GOST Explosion-proof (consult factory for availability)
 I1 ATEX Intrinsic Safety
 I2⁽²⁾ INMETRO Intrinsic Safety (consult factory for availability)
 I3⁽²⁾ China Intrinsic Safety (consult factory for availability)
 I4⁽²⁾ TIIS Intrinsic Safety (consult factory for availability)
 I5 FM Intrinsically Safe, Division 2
 I6 CSA Intrinsically Safe
 I7⁽²⁾ IECEx Intrinsic Safety
 IA⁽³⁾ ATEX FISCO Intrinsic Safety
 IB⁽³⁾ INMETRO FISCO Intrinsic Safety (consult factory for availability)
 ID⁽³⁾ TIIS FISCO Intrinsic Safety (consult factory for availability)
 IE⁽³⁾ FM FISCO Intrinsically Safe
 IF⁽³⁾ CSA FISCO Intrinsically Safe
 IG⁽³⁾ IECEx FISCO Intrinsically Safe
 IP⁽²⁾ Korea (KOSHA) Intrinsic Safety (consult factory for availability)
 IM⁽²⁾ GOST Intrinsically Safe (consult factory for availability)

IW ⁽²⁾	India (CCOE) Intrinsic Safety Approval (consult factory for availability)
K1 ⁽²⁾	ATEX Flameproof, Intrinsic Safety, Type n, Dust
K2 ⁽²⁾	INMETRO Flameproof, Intrinsic Safety, Type n (consult factory for availability)
K4 ⁽²⁾	TIIS Flameproof, Intrinsic Safety (consult factory for availability)
K5	FM Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2
K6	CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2
K7 ⁽²⁾	IECEX Flameproof, Intrinsic Safety, Type n
KA	ATEX and CSA Flameproof, Intrinsically Safe, Division 2
KB	FM and CSA Explosion-proof, Dust Ignition-proof, Intrinsically Safe, Division 2
KC	FM and ATEX Explosion-proof, Intrinsically Safe, Division 2
KD ⁽²⁾	FM, CSA, and ATEX Explosion-proof, Intrinsically Safe
N1 ⁽²⁾	ATEX Type n
N7 ⁽²⁾	IECEX Type n
ND	ATEX Dust

Digital Display

M5	LCD display
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Special Configuration (Hardware)

D4 ⁽⁴⁾	Zero and Span Hardware Adjustments
DF ⁽⁵⁾	1/2-14 NPT Flange Adapters
V5 ⁽⁶⁾	External Ground Screw Assembly

Terminal Blocks

T1	Transient Protection Terminal Block
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Special Configuration (Software)

C1 ⁽⁷⁾	Custom Software Configuration (Requires completed Configuration Data Sheet)
C4 ⁽⁷⁾⁽⁸⁾	Analog Output Levels Compliant with NAMUR Recommendation NE 43, Alarm High
CN ⁽⁷⁾⁽⁸⁾	Analog Output Levels Compliant with NAMUR Recommendation NE 43 Alarm Low

Special Certifications

Q4	Calibration Certificate
Q8	Material Traceability Certification per EN 10204 3.1.B
QS ⁽⁷⁾	Prior-use certificate of FMEDA data
Q16	Surface finish certification for sanitary remote seals
QP	Calibration certification and tamper evident seal

Flushing Connections

F1	One 1/4-inch Connector, SST Ring Material
F2	Two 1/4-inch Connectors, SST Ring Material
F3 ⁽⁹⁾	One 1/4-inch Connector, Cast C-276 Ring Material
F4 ⁽⁹⁾	Two 1/4-inch Connectors, Cast C-276 Ring Material
F7	One 1/2-inch Connector, SST Ring Material
F8	Two 1/2-inch Connectors, SST Ring Material
F9	One 1/2-inch Connector, Cast C-276 Ring Material
F0	Two 1/2-inch Connectors, Cast C-276 Ring Material

Typical Model Number: 2051L 2 A 2 2 A 1 A B4

- (1) "Assemble-to" items are specified separately and require a completed model number.
- (2) Not available with Low Power output code M.
- (3) Only valid with FOUNDATION fieldbus output code F.
- (4) Not valid with FOUNDATION fieldbus output code F.
- (5) Not available with Diaphragm Seal Assembly option S1.
- (6) The V5 option is not needed with the T1 option; external ground screw assembly is included with the T1 option.
- (7) Only available with HART 4-20mA output (output code A).
- (8) NAMUR-Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.
- (9) Not available with Option Codes A0, B0, and G0.

OPTIONS

Standard Configuration

Unless otherwise specified, transmitter is shipped as follows:

Engineering Units 2051C:	inH ₂ O (Ranges 1-3), psi (Ranges 4-5)
Engineering Units 2051T:	psi (all ranges)
Engineering Units 2051L:	inH ₂ O
4 mA (1 V dc)⁽¹⁾:	0 (engineering units above)
20 mA (5 V dc)⁽¹⁾:	Upper range limit
Output:	Linear
Flange type:	Specified model code option
Flange material:	Specified model code option
Drain/vent:	Specified model code option
Integral meter:	Installed or none
Alarm⁽¹⁾:	High
Software tag:	(Blank)

(1) Not applicable to fieldbus.

Tagging (3 options available)

- Standard SST hardware tag is permanently affixed on transmitter. Tag character height is 0.125 in. (3,18 mm), 140 characters maximum.
- Tag may be wired to the transmitter nameplate upon request, 85 characters maximum.
- Tag may be stored in transmitter memory (8 characters maximum). Software tag is left blank unless specified.

Commissioning tag (fieldbus only)

A temporary commissioning tag is attached to all transmitters. The tag indicates the device ID and allows an area for writing the location.

Optional Rosemount 304, 305 or 306 Integral Manifolds

Factory assembled to 2051C and 2051T transmitters. Refer to Product Data Sheet (document number 00813-0100-4839 for Rosemount 304 and 00813-0100-4733 for Rosemount 305 and 306) for additional information.

Optional Diaphragm and Sanitary Seals

Refer to Product Data Sheet (document number 00813-0100-4016 or 00813-0201-4016) for additional information.

Output Information

Output range points must be the same unit of measure. Available units of measure include:

inH ₂ O	inH ₂ O@4 °C ⁽¹⁾	psi	Pa
inHg	ftH ₂ O	bar	kPa
mmH ₂ O	mmH ₂ O@4 °C ⁽¹⁾	mbar	torr
mmHg	g/cm ²	kg/cm ²	atm

(1) Not available on low power.

Hardware Adjustments

D4 Local zero and span adjustments

- Alarm and security adjustments ship standard

LCD display

M5 Digital Meter

- 2-Line, 5-Digit LCD for 4-20 mA HART and FOUNDATION fieldbus
- 1-Line, 4-Digit LCD for 1-5 Vdc HART Low Power
- Direct reading of digital data for higher accuracy
- Displays user-defined flow, level, volume, or pressure units
- Displays diagnostic messages for local troubleshooting
- 90-degree rotation capability for easy viewing

Transient Protection

T1 Integral Transient Protection Terminal Block

Meets IEEE C62.41, Category Location B

- 6 kV crest (0.5 μ s - 100 kHz)
- 3 kV crest (8 \times 20 microseconds)
- 6 kV crest (1.2 \times 50 microseconds)

Bolts for Flanges and Adapters

- Standard material is plated carbon steel per ASTM A449, Type 1

L4 Austenitic 316 Stainless Steel Bolts

L5 ASTM A 193, Grade B7M Bolts

L8 ASTM A 193 Class 2, Grade B8M Bolts

Rosemount 2051C Coplanar Flange and 2051T Bracket Option

B4 Bracket for 2-in. Pipe or Panel Mounting

- For use with the standard Coplanar flange configuration
- Bracket for mounting of transmitter on 2-in. pipe or panel
- Stainless steel construction with stainless steel bolts

Rosemount 2051C Traditional Flange Bracket Options

B1 Bracket for 2-in. Pipe Mounting

- For use with the traditional flange option
- Bracket for mounting on 2-in. pipe
- Carbon steel construction with carbon steel bolts
- Coated with polyurethane paint

B2 Bracket for Panel Mounting

- For use with the traditional flange option
- Bracket for mounting transmitter on wall or panel
- Carbon steel construction with carbon steel bolts
- Coated with polyurethane paint

B3 Flat Bracket for 2-in. Pipe Mounting

- For use with the traditional flange option
- Bracket for vertical mounting of transmitter on 2-in. pipe
- Carbon steel construction with carbon steel bolts
- Coated with polyurethane paint

B7 B1 Bracket with SST Bolts

- Same bracket as the B1 option with Series 300 stainless steel bolts

B8 B2 Bracket with SST Bolts

- Same bracket as the B2 option with Series 300 stainless steel bolts

B9 B3 Bracket with SST Bolts

- Same bracket as the B3 option with Series 300 stainless steel bolts

BA Stainless Steel B1 Bracket with SST Bolts

- B1 bracket in stainless steel with Series 300 stainless steel bolts

BC Stainless Steel B3 Bracket with SST Bolts

- B3 bracket in stainless steel with Series 300 stainless steel bolts

SPARE PARTS

Terminal Block, HART	Part Number
4-20 mA HART Output	
Standard terminal block assembly	02051-9005-0001
Transient terminal block assembly (option T1)	02051-9005-0002
1-5 Vdc HART Low Power Output	
Standard terminal block assembly	02051-9005-0011
Transient terminal block assembly (option T1)	02051-9005-0012
Electronics Board, HART	Part Number
Assemblies for 4-20 mA HART	
4-20 mA HART for use without D4 option	02051-9001-0001
4-20 mA HART for use with D4 option	02051-9001-0002
4-20 mA HART NAMUR Compliant for use with or without D4 option	02051-9001-0012
Assembly for 1-5 Vdc HART Low Power	
1-5 Vdc HART	02051-9001-1001
LCD Display, HART	Part Number
LCD Display Kit⁽¹⁾	
4-20 mA with Aluminum Housing	03031-0193-0101
4-20 mA with SST Housing	03031-0193-0111
1-5 Vdc with Aluminum Housing	03031-0193-0001
1-5 Vdc with SST Housing	03031-0193-0011
LCD Displays Only⁽²⁾	
For 4-20 mA output	03031-0193-0103
For 1-5 Vdc Low Power output	03031-0193-0003
LCD Display Hardware, both 4-20 mA and 1-5 Vdc Low Power	
Aluminum Display Cover Assembly ⁽³⁾	03031-0193-0002
SST Display Cover Assembly ⁽³⁾	03031-0193-0012
O-ring package for electronics housing cover, pkg of 12	03031-0232-0001
Zero and Span Hardware Adjustments (D4 option)	
Zero and Span Kit for 4-20 mA HART⁽⁴⁾	
Zero and Span Kit for Aluminum Housing	02051-9010-0001
Zero and Span Kit for SST Housing	02051-9010-0002
Zero and Span Kit for 4-20 mA HART NAMUR Compliant (C4/CN) option⁽⁵⁾	
Zero and Span Kit for Aluminum Housing	02051-9010-1001
Zero and Span Kit for SST Housing	02051-9010-1002
Zero and Span Kit for 1-5 Vdc HART Low Power⁽⁵⁾	
Zero and Span Kit for Aluminum Housing	02051-9010-1001
Zero and Span Kit for SST Housing	02051-9010-1002
O-Ring Packages (package of 12)	Part Number
Electronic housing, cover (standard and meter)	03031-0232-0001
Electronics housing, module	03031-0233-0001
Process flange, glass-filled PTFE	03031-0234-0001
Process flange, graphite-filled PTFE	03031-0234-0002
Flange adapter, glass-filled PTFE	03031-0242-0001
Flange adapter, graphite-filled PTFE	03031-0242-0002

(1) Kit includes LCD display, captive mounting hardware, 10-pin interconnection header, cover assembly.
(2) Displays include LCD, captive mounting hardware, 10-pin interconnection header. No cover assembly.
(3) Display Cover Assembly includes the cover and o-ring only.
(4) Kit includes zero and span hardware adjustments and electronics board.
(5) Kit includes zero and span hardware adjustments only.

Flanges	Part Number
Differential Coplanar Flange	
Nickel-plated carbon steel	03031-0388-0025
316 SST	03031-0388-0022
Cast C-276	03031-0388-0023
Gage Coplanar Flange	
Nickel-plated carbon steel	03031-0388-1025
316 SST	03031-0388-1022
Cast C-276	03031-0388-1023
Coplanar Flange Alignment Screw (package of 12)	03031-0309-0001
Traditional Flange	
316 SST	03031-0320-0002
Cast C-276	03031-0320-0003
Level Flange, Vertical Mount	
2 in., class 150, SST	03031-0393-0221
2 in., class 300, SST	03031-0393-0222
3 in., class 150, SST	03031-0393-0231
3 in., class 300, SST	03031-0393-0232
DIN, DN 50, PN 40	03031-0393-1002
DIN, DN 80, PN 40	03031-0393-1012
Flange Adapter	Part Number
Nickel-plated carbon steel	02024-0069-0005
316 SST	02024-0069-0002
Cast C-276	02024-0069-0003
Drain/Vent Valve Kits (each kit contains parts for one transmitter)	Part Number
Differential Drain/Vent Kits	
316 SST stem and seat kit	01151-0028-0022
Alloy C-276 stem and seat kit	01151-0028-0023
316 SST ceramic ball drain/vent kit	03031-0378-0022
Alloy C-276 ceramic ball drain/vent kit	01151-0028-0123
Gage Drain/Vent Kits	
316 SST stem and seat kit	01151-0028-0012
Alloy C-276 stem and seat kit	01151-0028-0013
316 SST ceramic ball drain/vent kit	03031-0378-0012
Alloy C-276 ceramic ball drain/vent kit	01151-0028-0113
Mounting Brackets	
2051C and 2051L Coplanar Flange Bracket Kit	
B4 bracket, SST, 2-in. pipe mount, SST bolts	03031-0189-0003
2051T Bracket Kit	
B4 bracket, SST, 2-in. pipe mount, SST bolts	03031-0189-0004
2051C Traditional Flange Bracket Kits	
B1 bracket, 2-in. pipe mount, CS bolts	03031-0313-0001
B2 bracket, panel mount, CS bolts	03031-0313-0002
B3 flat bracket for 2-in. pipe mount, CS bolts	03031-0313-0003
B7 (B1 style bracket with SST bolts)	03031-0313-0007
B8 (B2 style bracket with SST bolts)	03031-0313-0008
B9 (B3 style bracket with SST bolts)	03031-0313-0009
BA (SST B1 bracket with SST bolts)	03031-0313-0011
BC (SST B3 bracket with SST bolts)	03031-0313-0013

Bolt Kits

COPLANAR FLANGE

Flange Bolt Kit {44 mm (1.75 in.)} (Set of 4)

Carbon steel	03031-0312-0001
316 SST	03031-0312-0002
ASTM A 193, Grade B7M	03031-0312-0003
ASTM A 193, Class 2, Grade B8M	03031-0312-0005

Flange/Adapter Bolt Kit {73 mm (2.88 in.)} (Set of 4)

Carbon steel	03031-0306-0001
316 SST	03031-0306-0002
ASTM A 193, Grade B7M	03031-0306-0003
ASTM A 193, Class 2, Grade B8M	03031-0306-0005

Manifold/Flange Kit {57 mm (2.25 in.)} (Set of 4)

Carbon steel	03031-0311-0001
316 SST	03031-0311-0002
ASTM A 193, Grade B7M	03031-0311-0003
ASTM A 193, Class 2, Grade B8M	03031-0311-0020

TRADITIONAL FLANGE

Differential Flange and Adapter Bolt Kit {44 mm (1.75 in.)} (Set of 8)

Carbon steel	03031-0307-0001
316 SST	03031-0307-0002
ASTM A 193, Grade B7M	03031-0307-0003
ASTM A 193, Class 2, Grade B8M	03031-0307-0005

Gage Flange and Adapter Bolt Kit (Set of 6)

Carbon steel	03031-0307-1001
316 SST	03031-0307-1002
ASTM A 193, Grade B7M	03031-0307-1003
ASTM A 193, Class 2, Grade B8M	03031-0307-1005

Manifold/Traditional Flange Bolts

Carbon steel	Use bolts supplied with manifold
316 SST	Use bolts supplied with manifold

LEVEL FLANGE, VERTICAL MOUNT

Flange Bolt Kit (Set of 4)

Carbon steel	03031-0395-0001
316 SST	03031-0395-0002

Covers

Aluminum field terminal cover + o-ring	03031-0292-0001 ⁽¹⁾
SST field terminal cover + o-ring	03031-0292-0002 ⁽¹⁾
Aluminum HART electronics cover: cover + o-ring	03031-0292-0001 ⁽¹⁾
316 SST HART electronics cover: cover + o-ring	03031-0292-0002 ⁽¹⁾
Aluminum Electronics / LCD Display Cover Assembly: cover + o-ring	03031-0193-0002
SST Electronics / LCD Display Cover Assembly: cover + o-ring	03031-0193-0012

Miscellaneous

External ground screw assembly (option V5)	03031-0398-0001
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(1) Covers are blind, not for use with LCD Display. Refer to LCD Display section for LCD covers.


Appendix B Approval Information

Overview	page B-1
Safety Messages	page B-1
Approval Drawings	page B-7


OVERVIEW

This Appendix contains information on Approved manufacturing locations, European directive information, Ordinary Location certification, Hazardous Locations Certifications and approval drawings for HART protocol.

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (). Refer to the following safety messages before performing an operation preceded by this symbol.

Warnings

 WARNING

Explosions could result in death or serious injury:

Installation of this transmitter in an explosive environment must be in accordance with the appropriate local, national, and international standards, codes, and practices. Please review this section of the Rosemount 2051 reference manual for any restrictions associated with a safe installation.

- Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- In an Explosion-Proof/Flameproof installation, do not remove the transmitter covers when power is applied to the unit.

Process leaks may cause harm or result in death.

- Install and tighten process connectors before applying pressure.

Electrical shock can result in death or serious injury.

- Avoid contact with the leads and terminals. High voltage that may be present on leads can cause electrical shock.

 WARNING

Cable gland and plug must comply with the requirements listed on the certificates.

Approved Manufacturing Locations

Rosemount Inc. — Chanhassen, Minnesota USA
Emerson Process Management GmbH & Co. — Wessling, Germany
Emerson Process Management Asia Pacific Private Limited — Singapore
Beijing Rosemount Far East Instrument Co., LTD — Beijing, China

Rosemount 2051

European Directive Information

The EC declaration of conformity for all applicable European directives for this product can be found on the Rosemount website at www.rosemount.com. A hard copy may be obtained by contacting an Emerson Process Management representative.

ATEX Directive (94/9/EC)

All 2051 transmitters comply with the ATEX Directive.

European Pressure Equipment Directive (PED) (97/23/EC)

2051CG2, 3, 4, 5; 2051CD2, 3, 4, 5 (also with P9 option)

— QS Certificate of Assessment - EC No. PED-H-100

Module H Conformity Assessment

All other 2051 Pressure Transmitters

— Sound Engineering Practice

Transmitter Attachments: Diaphragm Seal - Process Flange - Manifold

— Sound Engineering Practice

Electro Magnetic Compatibility (EMC) (2004/108/EC)

All 2051 Pressure Transmitters meet all of the requirements of IECEN61326:2006 and NAMUR NE-21.

Ordinary Location Certification for Factory Mutual

As standard, the transmitter has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

HART Protocol

Hazardous Locations Certifications

North American Certifications

FM Approvals

- E5** Explosion-Proof for Class I, Division 1, Groups B, C, and D.
Dust-Ignition-Proof for Class II, Division 1, Groups E, F, and G.
Dust-Ignition-Proof for Class III, Division 1.
T5 (Ta = 85 °C), Factory Sealed, Enclosure Type 4X
- I5** Intrinsically Safe for use in Class I, Division 1, Groups A, B, C, and D; Class II, Division 1, Groups E, F, and G; Class III, Division 1 when connected per Rosemount drawing 02051-1009; Non-incendive for Class I, Division 2, Groups A, B, C, and D.
Temperature Code: T4 (Ta = 40 °C), T3 (Ta = 85 °C),
Enclosure Type 4X
For input parameters see control drawing 02051-1009.

Canadian Standards Association (CSA)

- E6** Explosion-Proof for Class I, Division 1, Groups B, C, and D.
Dust-Ignition-Proof for Class II and Class III, Division 1, Groups E, F, and G. Suitable for Class I, Division 2 Groups A, B, C, and D for indoor and outdoor hazardous locations. Enclosure type 4X, factory sealed

- I6** Intrinsically safe approval. Intrinsically safe for Class I, Division 1, Groups A, B, C, and D when connected in accordance with Rosemount drawing 02051-1008. Temperature Code T3C.
Dust-Ignition-Proof for Class II and Class III, Division 1, Groups E, F, and G. Suitable for Class I, Division 2 Groups A, B, C, and D hazardous locations. Enclosure type 4X, factory sealed
For input parameters see control drawing 02051-1008.

European Certifications


- I1** ATEX Intrinsic Safety
Certification No. Baseefa08ATEX0129X  II 1 G
Ex ia IIC T4 ($-60 \leq T_a \leq +70 \text{ }^\circ\text{C}$)
IP66 IP68
cE 1180

Table B-1. Input Parameters

$U_i = 30\text{V}$


$I_i = 200\text{ mA}$

$P_i = 1.0\text{W}$

$C_i = 0.012\text{ }\mu\text{F}$

Special Conditions for Safe Use (X):

When the optional transient protection terminal block is installed, the apparatus is not capable of withstanding the 500V insulation test required by Clause 6.3.12 of EN60079-11. This must be taken into account when installing the apparatus.

- N1** ATEX Type n
Certification No. Baseefa08ATEX0130X  II 3 G
Ex nAnL IIC T4 ($-40 \leq T_a \leq +70 \text{ }^\circ\text{C}$)
 $U_i = 42.4\text{ Vdc max}$
IP66 IP68
cE

Special Conditions for Safe Use (X):

When the optional transient protection terminal block is installed, the apparatus is not capable of withstanding a 500V r.m.s. test to case. This must be taken into account on any installation in which it is used, for example by assuring that the supply to the apparatus is galvanically isolated.

Rosemount 2051

E1 ATEX Flame-Proof

Certification No. KEMA 08ATEX0090X G Ⓢ II 1/2 G

Ex d IIC T6 ($-50 \leq T_a \leq 65 \text{ }^\circ\text{C}$)

Ex d IIC T5 ($-50 \leq T_a \leq 80 \text{ }^\circ\text{C}$)

IP66 IP68

cE 1180

Vmax = 42.4 V dc

Special Conditions for Safe Use (X):

1. Appropriate ex d blanking plugs, cable glands, and wiring needs to be suitable for a temperature of 90 °C.
2. This device contains a thin wall diaphragm. Installation, maintenance and use shall take into account the environmental conditions to which the diaphragm will be subjected. The manufacturer's instructions for maintenance shall be followed in detail to assure safety during its expected lifetime.
3. The 2051 does not comply with the requirements of IEC 60079-1 Clause 5 for flameproof joints. Contact Emerson Process Management for information on the dimensions of flameproof joints.

ND ATEX Dust

Certification No. Baseefa08ATEX0182X Ⓢ II 1 D

Dust Rating: T80 °C ($-20 \leq T_a \leq 40 \text{ }^\circ\text{C}$) IP66 IP68

Vmax = 42.4 V dc

A = 22 mA

cE 1180

Special Conditions for Safe Use (X):

1. The user must ensure that the maximum rated voltage and current (42.4 volts, 22 milliamperes, DC) are not exceeded. All connections to other apparatus or associated apparatus shall have control over this voltage and current equivalent to a category "ib" circuit according to EN 60079-1.
2. Cable entries must be used which maintain the ingress protection of the enclosure to at least IP66.
3. Unused cable entries must be filled with suitable blanking plugs which maintain the ingress protection of the enclosure to at least IP66.
4. Cable entries and blanking plugs must be suitable for the ambient range of the apparatus and capable of withstanding a 7J impact test.

IECEX Certifications

I7 IECEX Intrinsic Safety

Certification No. IECEXBAS08.0045X Ⓢ II 1 GD

Ex ia IIC T4 ($-60 \leq T_a \leq +70 \text{ }^\circ\text{C}$)

Dust Rating: T80 °C ($-20 \leq T_a \leq 40 \text{ }^\circ\text{C}$) IP66 IP68

cE 1180

Table B-1. Input Parameters

$U_i = 30\text{V}$

$I_i = 200\text{ mA}$

$P_i = 1.0\text{W}$

$C_i = 0.012\text{ }\mu\text{F}$

Special Conditions for Safe Use (X):

When the optional transient protection terminal block is installed, the apparatus is not capable of withstanding the 500V insulation test required by Clause 6.3.12 of IEC60079-11. This must be taken into account when installing the apparatus.

- E7** IECEx Explosion-Proof (Flame-Proof)
Certification No. IECEx KEM 08.0020X Ⓢ II 1/2 G
Ex d IIC T6 ($-50 \leq T_a \leq 65 \text{ }^\circ\text{C}$)
Ex d IIC T5 ($-50 \leq T_a \leq 80 \text{ }^\circ\text{C}$)
cE 1180
Vmax = 42.4 V dc

Special Conditions for Safe Use (X):

1. Appropriate ex d blanking plugs, cable glands, and wiring needs to be suitable for a temperature of 90 °C.
2. This device contains a thin wall diaphragm. Installation, maintenance and use shall take into account the environmental conditions to which the diaphragm will be subjected. The manufacturer's instructions for maintenance shall be followed in detail to assure safety during its expected lifetime.
3. The 2051 does not comply with the requirements of IEC 60079-1 Clause 5 for flameproof joints. Contact Emerson Process Management for information on the dimensions of flameproof joints.

- N7** IECEx Type n
Certification No. IECExBAS08.0046X Ⓢ II 3 G
Ex nAnL IIC T4 ($-40 \leq T_a \leq +70 \text{ }^\circ\text{C}$)
U_i = 42.4 Vdc max
cE

Special Conditions for Safe Use (X):

When the optional transient protection terminal block is installed, the apparatus is not capable of withstanding a 500V r.m.s. test to case. This must be taken into account on any installation in which it is used, for example by assuring that the supply to the apparatus is galvanically isolated.

**TIIS Certifications
(consult factory for availability)**

- E4** TIIS Flame-Proof
Ex d IIC T6
- I4** TIIS Intrinsic Safety
Ex ia IIC T4

**INMETRO Certifications
(consult factory for availability)**

- E2** Flame-Proof
BR-Ex d IIC T6/T5
- I2** Intrinsic Safety
BR-Ex ia IIC T4

GOST Certifications
(consult factory for availability)

- IM** Intrinsic Safety
 Certificate Pending
- EM** Flame-Proof
 Certificate Pending

China (NEPSI) Certifications
(consult factory for availability)

- E3** Flame-Proof
 Ex d II B+H₂T3~T5
- I3** Intrinsic Safety
 Ex ia IIC T3/T4

KOSHA Certifications
(consult factory for availability)

- EP** Flame-Proof
 Ex d IIB+H₂ T5
- IP** Intrinsic Safety
 Ex ia IIC T3

CCoE Certifications
(consult factory for availability)

- IW** Intrinsic Safety
 Ex ia IIC T4
- EW** Flame-Proof
 Ex d IIC T5 or T6

Combinations of Certifications

Stainless steel certification tag is provided when optional approval is specified. Once a device labeled with multiple approval types is installed, it should not be reinstalled using any other approval types. Permanently mark the approval label to distinguish it from unused approval types.

- K1** **E1, I1, N1, and ND** combination
- K2** **E2 and I2** combination (consult factory for availability)
- K4** **E4 and I4** combination (consult factory for availability)
- K5** **E5 and I5** combination
- K6** **I6 and E6** combination
- K7** **E7, I7, and N7** combination
- KA** **E1, I1, E6, and I6** combination
- KB** **E5, I5, E6, and I6** combination
- KC** **E1, I1, E5, and I5** combination
- KD** **E1, I1, E5, I5, E6, and I6** combination

APPROVAL DRAWINGS

Factory Mutual (FM)

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	REV	DESCRIPTION	CHG. NO.	APP'D	DATE
	AA	NEW RELEASE	RTC1025889	J.G.K.	4/21/08


ENTITY APPROVALS FOR
 2051C
 2051L
 2051T

OUTPUT CODE A (4-20 mA HART) I.S. SEE SHEETS 2-5
 OUTPUT CODE M (LOW POWER) I.S. SEE SHEETS 6-7
 OUTPUT CODE F/W (FIELD BUS) I.S. SEE SHEETS 8-12
 ALL OUTPUT CODES NONINCENDIVE SEE SHEET 13

THE ROSEMOUNT TRANSMITTERS LISTED ABOVE ARE F.M. APPROVED AS INTRINSICALLY SAFE WHEN USED IN CIRCUIT WITH F.M. APPROVED BARRIERS WHICH MEET THE ENTITY PARAMETERS LISTED IN THE CLASS I, II, AND III, DIVISION 1 GROUPS INDICATED, TEMP CODE T4. ADDITIONALLY, THE ROSEMOUNT 751 FIELD SIGNAL INDICATOR IS F.M. APPROVED AS INTRINSICALLY SAFE WHEN CONNECTED IN CIRCUIT WITH ROSEMOUNT TRANSMITTERS (FROM ABOVE) AND F.M. APPROVED BARRIERS WHICH MEET THE ENTITY PARAMETERS LISTED FOR CLASS I, II, AND III, DIVISION 1, GROUPS INDICATED, TEMP CODE T4.

TO ASSURE AN INTRINSICALLY SAFE SYSTEM, THE TRANSMITTER AND BARRIER MUST BE WIRED IN ACCORDANCE WITH THE BARRIER MANUFACTURER'S FIELD WIRING INSTRUCTIONS AND THE APPLICABLE CIRCUIT DIAGRAM.

CAD MAINTAINED (MicroStation)

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES (mm). REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125 -TOLERANCE- .X ± .1 [2,5] .XX ± .02 [0,5] .XXX ± .010 [0,25] FRACTIONS ANGLES ± 1/32 ± 2° DO NOT SCALE PRINT	CONTRACT NO.	 ROSEMOUNT® 8200 Market Boulevard • Chanhassen, MN 55317 USA			
	DR. Myles Lee Miller 4/16/08			TITLE INDEX OF I.S. & NONINCENDIVE F.M. FOR 2051C/L/T	
	CHK'D	SIZE A	FSCM NO	DWG NO. 02051-1009	
	APP'D.	APP'D. GOVT.	SCALE N/A	WT. _____	SHEET 1 OF 13

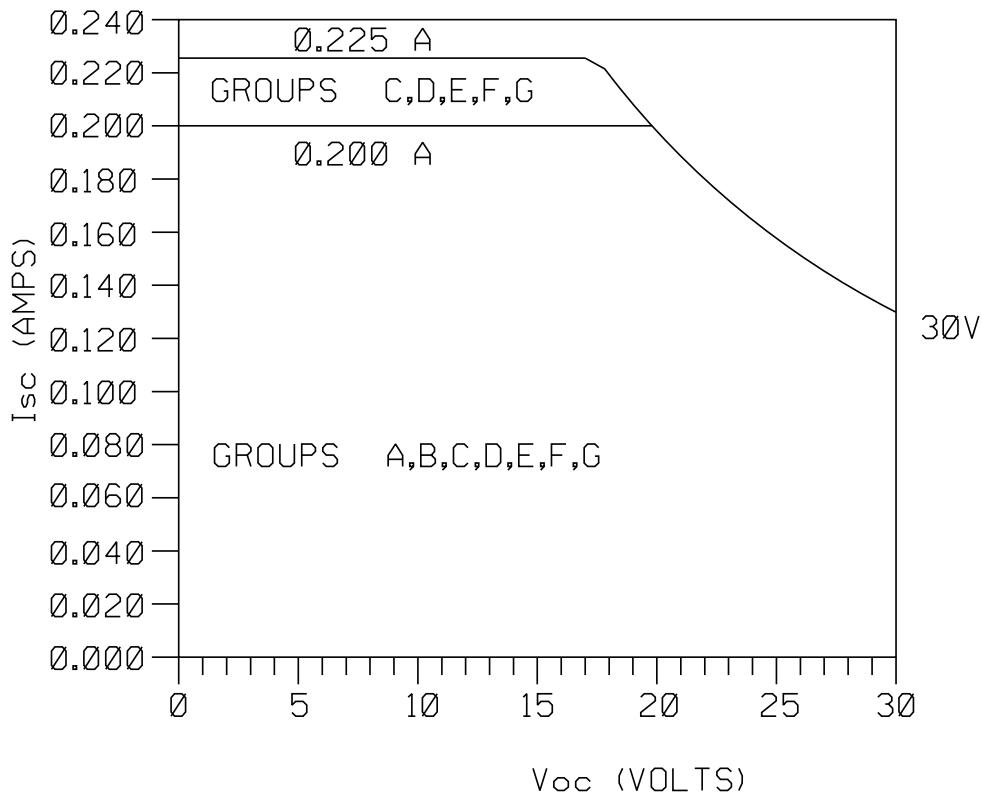
From Rev. d/c

Rosemount 2051

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

BARRIER PARAMETERS (APPLICABLE TO OUTPUT CODES A & M)

$P_{max} = 1WATT$



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 8200 Market Boulevard
 Chanhassen, MN 55317 USA

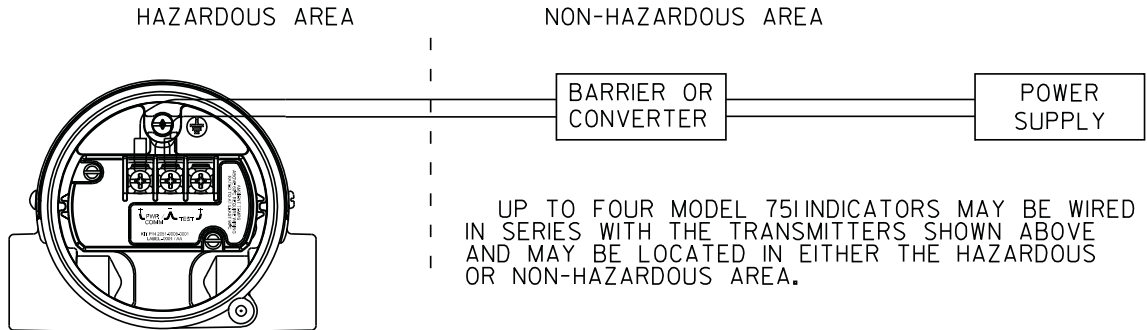
CAD MAINTAINED (MicroStation)

DR.	Myles Lee Miller	SIZE	A	FSCM NO		DWG NO.	02051-1009
ISSUED		SCALE	N/A	WT.		SHEET	2 OF 13

From Rev. AC

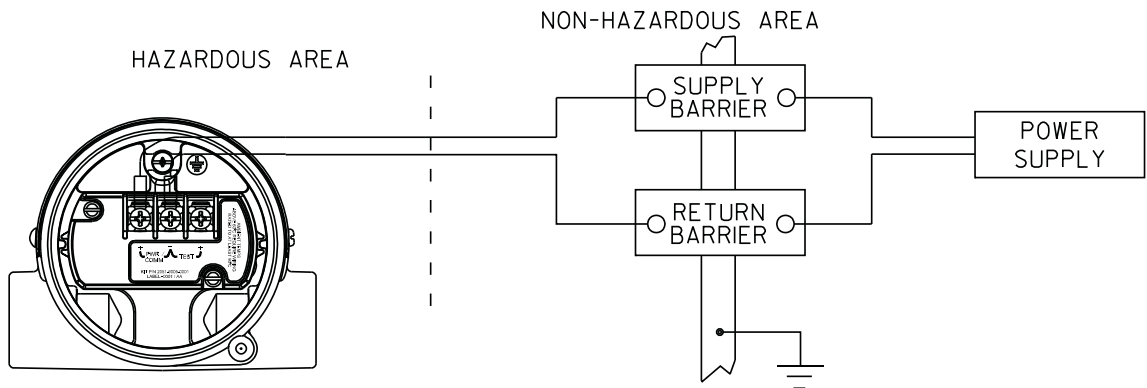
REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

CIRCUIT DIAGRAM 1
 ONE BARRIER OR CONVERTER:
 SINGLE OR DUAL CHANNEL



OUTPUT CODE A
MODELS INCLUDED
 2051C, L, T

CIRCUIT DIAGRAM 2
 SUPPLY AND RETURN BARRIERS
 (ONLY FOR USE WITH BARRIERS APPROVED IN THIS CONFIGURATION)



OUTPUT CODE A
MODELS INCLUDED
 2051C, L, T

Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA		CAD MAINTAINED (MicroStation)		
DR.	Myles Lee Miller	SIZE	FSCM NO	DWG NO. 02051-1009
ISSUED		SCALE	N/A	WT. ——— SHEET 3 OF 13

Form Rev. 4/02

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

ENTITY CONCEPT APPROVALS

THE ENTITY CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIFICALLY EXAMINED IN COMBINATION AS A SYSTEM. THE APPROVED VALUES OF MAX. OPEN CIRCUIT VOLTAGE (V_{OC} OR V_t) AND MAX. SHORT CIRCUIT CURRENT (I_{SC} OR I_t) AND MAX. POWER ($V_{OC} \times I_{SC}/4$) OR ($V_t \times I_t/4$), FOR THE ASSOCIATED APPARATUS MUST BE LESS THAN OR EQUAL TO THE MAXIMUM SAFE INPUT VOLTAGE (V_{MAX}), MAXIMUM SAFE INPUT CURRENT (I_{MAX}), AND MAXIMUM SAFE INPUT POWER (P_{MAX}) OF THE INTRINSICALLY SAFE APPARATUS. IN ADDITION, THE APPROVED MAX. ALLOWABLE CONNECTED CAPACITANCE (C_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE CAPACITANCE AND THE UNPROTECTED INTERNAL CAPACITANCE (C_i) OF THE INTRINSICALLY SAFE APPARATUS, AND THE APPROVED MAX. ALLOWABLE CONNECTED INDUCTANCE (L_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE INDUCTANCE AND THE UNPROTECTED INTERNAL INDUCTANCE (L_i) OF THE INTRINSICALLY SAFE APPARATUS.

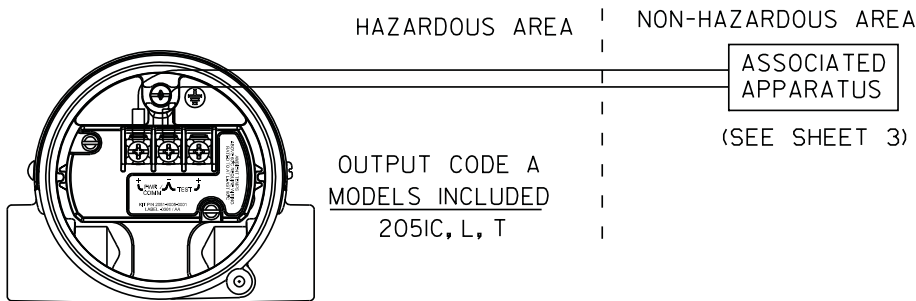
FOR OUTPUT CODE A NOTE: ENTITY PARAMETERS LISTED APPLY ONLY TO ASSOCIATED APPARATUS WITH LINEAR OUTPUT.

CLASS I, DIV. 1, GROUPS A AND B

$V_T = 30V$	V_T OR V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_T = 200mA$	I_T OR I_{SC} IS LESS THAN OR EQUAL TO 200mA
$P_{MAX} = 1 \text{ WATT}$	$(\frac{V_T \times I_T}{4})$ OR $(\frac{V_{OC} \times I_{SC}}{4})$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = .01\mu f$	C_A IS GREATER THAN $.01\mu f$
$L_I = 10\mu H$	L_A IS GREATER THAN $10\mu H$

CLASS I, DIV. 1, GROUPS C AND D

$V_T = 30V$	V_T OR V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_T = 225mA$	I_T OR I_{SC} IS LESS THAN OR EQUAL TO 225mA
$P_{MAX} = 1 \text{ WATT}$	$(\frac{V_T \times I_T}{4})$ OR $(\frac{V_{OC} \times I_{SC}}{4})$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = .01\mu f$	C_A IS GREATER THAN $.01\mu f$
$L_I = 10\mu H$	L_A IS GREATER THAN $10\mu H$



Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA		CAD MAINTAINED (MicroStation)		
DR. Myles Lee Miller	SIZE A	FSCM NO.	DWG NO. 02051-1009	
ISSUED	SCALE N/A	WT.	SHEET 4 OF 13	

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

FOR OUTPUT CODE M

CLASS I, DIV. 1, GROUPS A AND B

$V_{MAX} = 30V$	V_T OR V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 200mA$	I_T OR I_{SC} IS LESS THAN OR EQUAL TO 200mA
$P_{MAX} = 1 \text{ WATT}$	$(\frac{V_T \times I_T}{4})$ OR $(\frac{V_{oc} \times I_{sc}}{4})$ IS LESS THAN OR EQUAL TO 1 WATT
$C_T = .02\mu f$	C_A IS GREATER THAN $.02\mu f$
$L_T = 10\mu H$	L_A IS GREATER THAN $10\mu H$

*

FOR T1 OPTION:

$L_T = 0.75mH$	L_A IS GREATER THAN $0.75mH$
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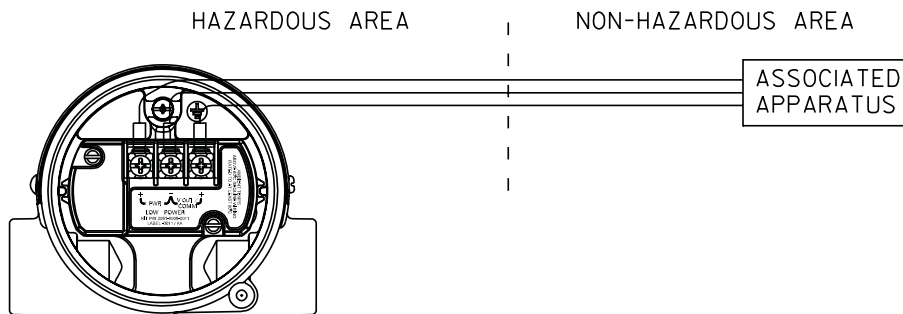
CLASS I, DIV. 1, GROUPS C AND D

$V_{MAX} = 30V$	V_T OR V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 225mA$	I_T OR I_{SC} IS LESS THAN OR EQUAL TO 225mA
$P_{MAX} = 1 \text{ WATT}$	$(\frac{V_T \times I_T}{4})$ OR $(\frac{V_{oc} \times I_{sc}}{4})$ IS LESS THAN OR EQUAL TO 1 WATT
$C_T = .02\mu f$	C_A IS GREATER THAN $.02\mu f$
$L_T = 10\mu H$	L_A IS GREATER THAN $10\mu H$

*

FOR T1 OPTION:

$L_T = 0.75mH$	L_A IS GREATER THAN $0.75mH$
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OUTPUT CODE M
 AVAILABLE FOR THE MODELS LISTED

205IC 205IT
 205IL

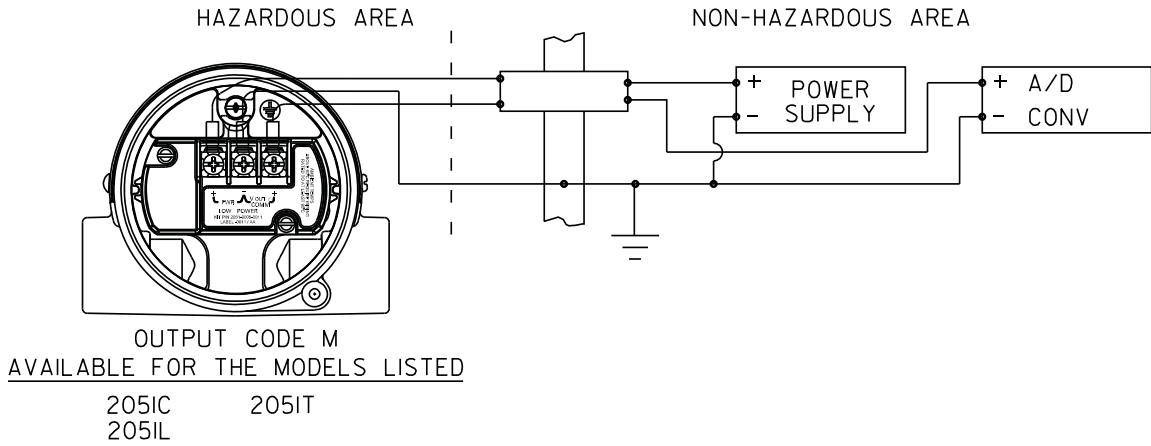
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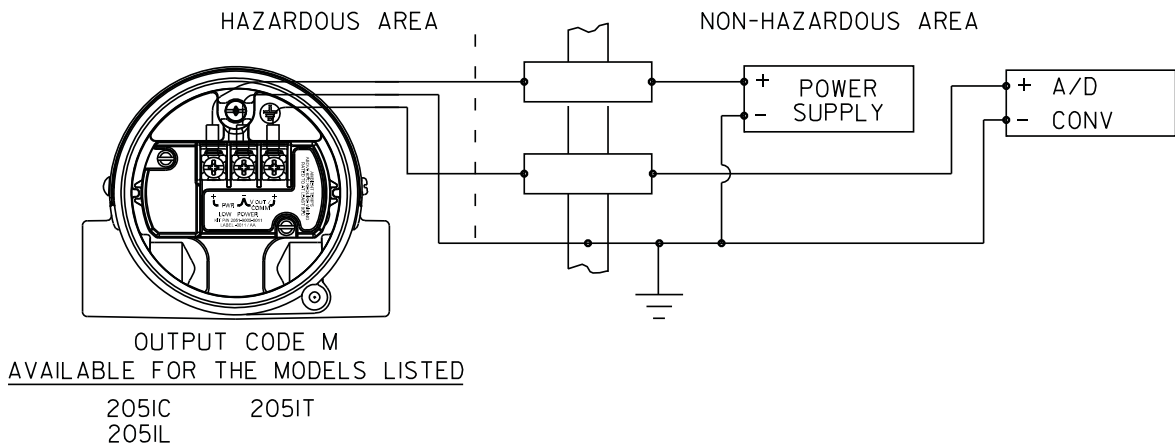
DR. Myles Lee Miller	SIZE A	FSCM NO.	DWG NO. 02051-1009
ISSUED	SCALE N/A	WT.	SHEET 5 OF 13

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

CIRCUIT DIAGRAM 3
ONE DUAL CHANNEL BARRIER



CIRCUIT DIAGRAM 4
TWO SINGLE CHANNEL BARRIERS
(ONLY FOR USE WITH BARRIERS APPROVED
IN THIS CONFIGURATION)



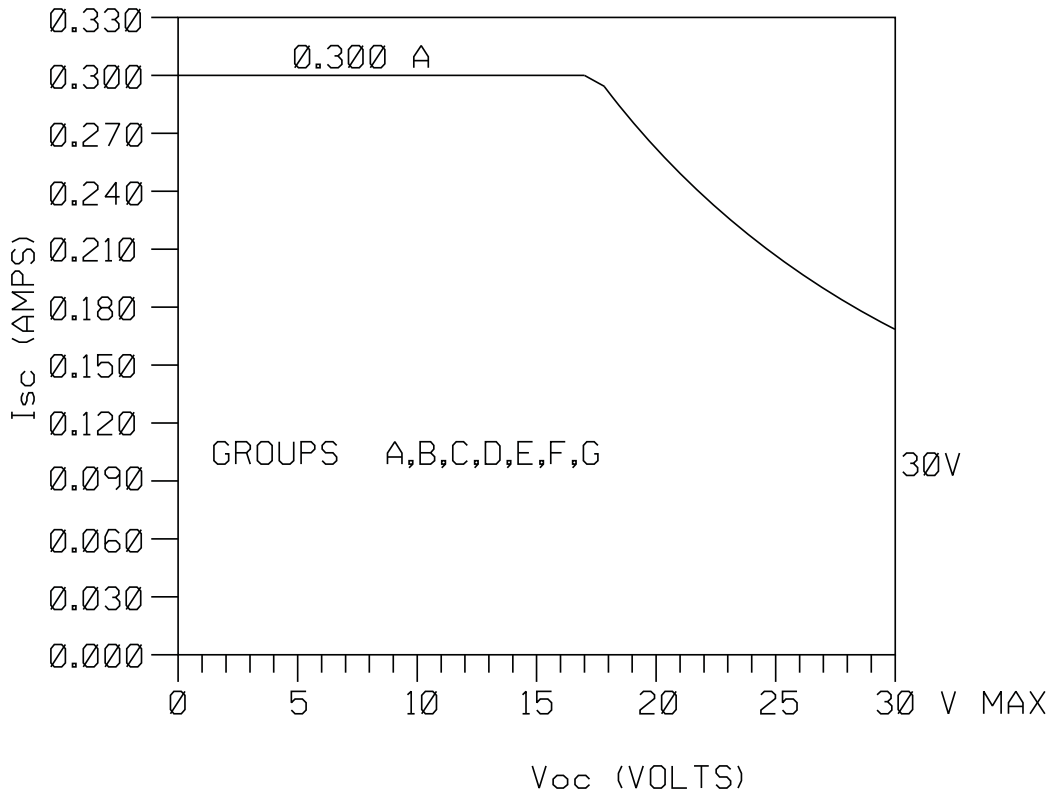
Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA		CAD MAINTAINED (MicroStation)		
DR. Mylee Lee Miller	SIZE A	FSCM NO	DWG NO.	02051-1009
ISSUED	SCALE	N/A	WT.	SHEET 6 OF 13

From Rev. AC

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

2051 WITH FOUNDATION FIELDBUS OR PROFIBUS.
 (OUTPUT CODE F OR W)

BARRIER PARAMETERS (APPLICABLE TO OUTPUT CODE F OR W)
 $P_{max} = 1.3 \text{ WATT}$



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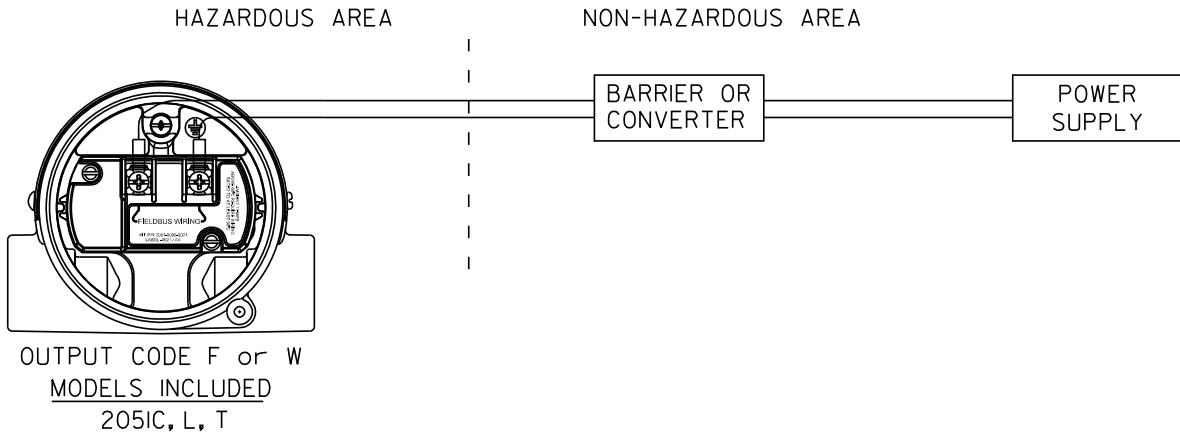
CAD MAINTAINED (MicroStation)

DR. Myles Lee Miller	SIZE A	FSCM NO.	DWG NO. 02051-1009
ISSUED	SCALE N/A	WT. ---	SHEET 7 OF 13

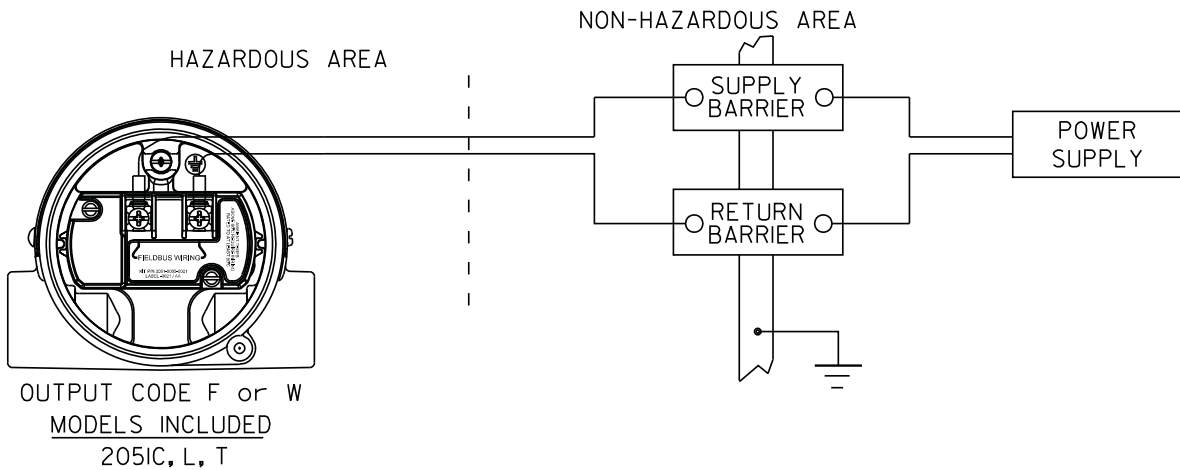
Form: Rev. 02

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

CIRCUIT DIAGRAM 1
ONE BARRIER OR CONVERTER:
SINGLE OR DUAL CHANNEL



CIRCUIT DIAGRAM 2
SUPPLY AND RETURN BARRIERS
(ONLY FOR USE WITH BARRIERS APPROVED IN THIS CONFIGURATION)



Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA		CAD MAINTAINED (MicroStation)		
DR. Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02051-1009	
ISSUED	SCALE N/A	WT.	SHEET 8 OF 13	

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REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

ENTITY CONCEPT APPROVALS

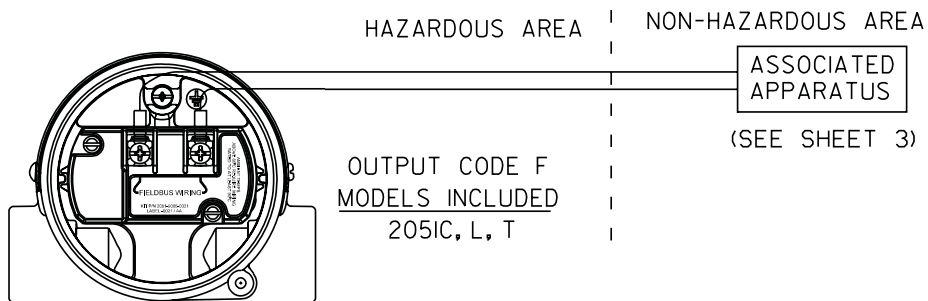
THE ENTITY CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIFICALLY EXAMINED IN COMBINATION AS A SYSTEM. THE APPROVED VALUES OF MAX. OPEN CIRCUIT VOLTAGE (V_{oc} OR V_t) AND MAX. SHORT CIRCUIT CURRENT (I_{sc} OR I_t) AND MAX. POWER ($V_{oc} \times I_{sc}/4$) OR ($V_t \times I_t/4$), FOR THE ASSOCIATED APPARATUS MUST BE LESS THAN OR EQUAL TO THE MAXIMUM SAFE INPUT VOLTAGE (V_{max}), MAXIMUM SAFE INPUT CURRENT (I_{max}), AND MAXIMUM SAFE INPUT POWER (P_{max}) OF THE INTRINSICALLY SAFE APPARATUS. IN ADDITION, THE APPROVED MAX. ALLOWABLE CONNECTED CAPACITANCE (C_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE CAPACITANCE AND THE UNPROTECTED INTERNAL CAPACITANCE (C_i) OF THE INTRINSICALLY SAFE APPARATUS, AND THE APPROVED MAX. ALLOWABLE CONNECTED INDUCTANCE (L_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE INDUCTANCE AND THE UNPROTECTED INTERNAL INDUCTANCE (L_i) OF THE INTRINSICALLY SAFE APPARATUS.

NOTE: ENTITY PARAMETERS LISTED APPLY ONLY TO ASSOCIATED APPARATUS WITH LINEAR OUTPUT.

FOR OUTPUT CODE F or W

CLASS I, DIV. 1, GROUPS A, B, C AND D

$V_{MAX} = 30V$	V_T OR V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 300mA$	I_T OR I_{SC} IS LESS THAN OR EQUAL TO 300mA
$P_{MAX} = 1.3 \text{ WATT}$	$(\frac{V_T \times I_T}{4})$ OR $(\frac{V_{oc} \times I_{sc}}{4})$ IS LESS THAN OR EQUAL TO 1.3 WATT
$C_I = 0\mu f$	C_A IS GREATER THAN $0\mu f$
$L_I = 0\mu H$	L_A IS GREATER THAN $0\mu H$



Rosemount Inc.
 8200 Market Boulevard
 Chanhassen, MN 55317 USA

CAD MAINTAINED (MicroStation)

DR. Myles Lee Miller	SIZE A	FSCM NO.	DWG NO. 02051-1009
ISSUED	SCALE N/A	WT.	SHEET 9 OF 13

Form: Rev. 02

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

FISCO CONCEPT APPROVALS

THE FISCO CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIALLY EXAMINED IN SUCH COMBINATION. FOR THIS INTERCONNECTION TO BE VALID THE VOLTAGE (U_1 or V_{max}), THE CURRENT (I_1 or I_{max}), AND THE POWER (P_1 or P_{ma}) THAT INTRINSICALLY SAFE APPARATUS CAN RECEIVE AND REMAIN INTRINSICALLY SAFE, INCLUDING FAULTS, MUST BE EQUAL OR GREATER THAN THE VOLTAGE (U_0 , V_{oc} , or V_t), THE CURRENT (I_0 , I_{sc} , or I_t), AND THE POWER (P_0 or P_{max}) LEVELS WHICH CAN BE DELIVERED BY THE ASSOCIATED APPARATUS, CONSIDERING FAULTS AND APPLICABLE FACTORS. ALSO, THE MAXIMUM UNPROTECTED CAPACITANCE (C_1) AND THE INDUCTANCE (L_1) OF EACH APPARATUS (BESIDES THE TERMINATION) CONNECTED TO THE FIELD BUS MUST BE LESS THAN OR EQUAL TO 5nF AND 10μH RESPECTIVELY. ONLY ONE ACTIVE DEVICE IN EACH SECTION (USUALLY THE ASSOCIATED APPARATUS) IS ALLOWED TO CONTRIBUTE THE DESIRED ENERGY FOR THE FIELD BUS SYSTEM. THE ASSOCIATED APPARATUS' VOLTAGE U_0 (or V_{oc} or V_t) IS LIMITED TO A RANGE OF 14V TO 24 V.D.C. ALL OTHER EQUIPMENT COMBINED IN THE BUS CABLE MUST BE PASSIVE (THEY CANNOT PROVIDE ENERGY TO THE SYSTEM, EXCEPT A LEAKAGE CURRENT OF 50 μA FOR EACH CONNECTED DEVICE) SEPARATELY POWERED EQUIPMENT REQUIRES A GALVANIC ISOLATION TO AFFIRM THAT THE INTRINSICALLY SAFE FIELD BUS CIRCUIT WILL REMAIN PASSIVE. THE PARAMETER OF THE CABLE USED TO INTERCONNECT THE DEVICES MUST BE IN THE FOLLOWING RANGE:

LOOP RESISTANCE R' : 15...150 OHM/km
 INDUCTANCE PER UNIT LENGTH L' : 0.4...1mH/KM
 CAPACITANCE PER UNLIT LENGTH C' : 80...200nF

$C' = C' \text{ LINE/LINE} + 0.5C' \text{ LINE/SCREEN}$, IF BOTH LINES ARE FLOATING, OR
 $C' = C' \text{ LINE/LINE} + C' \text{ LINE/SCREEN}$, IF THE SCREEN IS CONNECTED TO ONE LINE
 TRUNK CABLE LENGTH: ≤ 1000 m
 SPUR CABLE LENGTH: ≤ 30 m
 SPLICE LENGTH: ≤ 1 m

AN APPROVED INFALLIBLE LINE TERMINATION TO EACH END OF THE TRUNK CABLE, WITH THE FOLLOWING PARAMETERS IS APPROPRIATE:

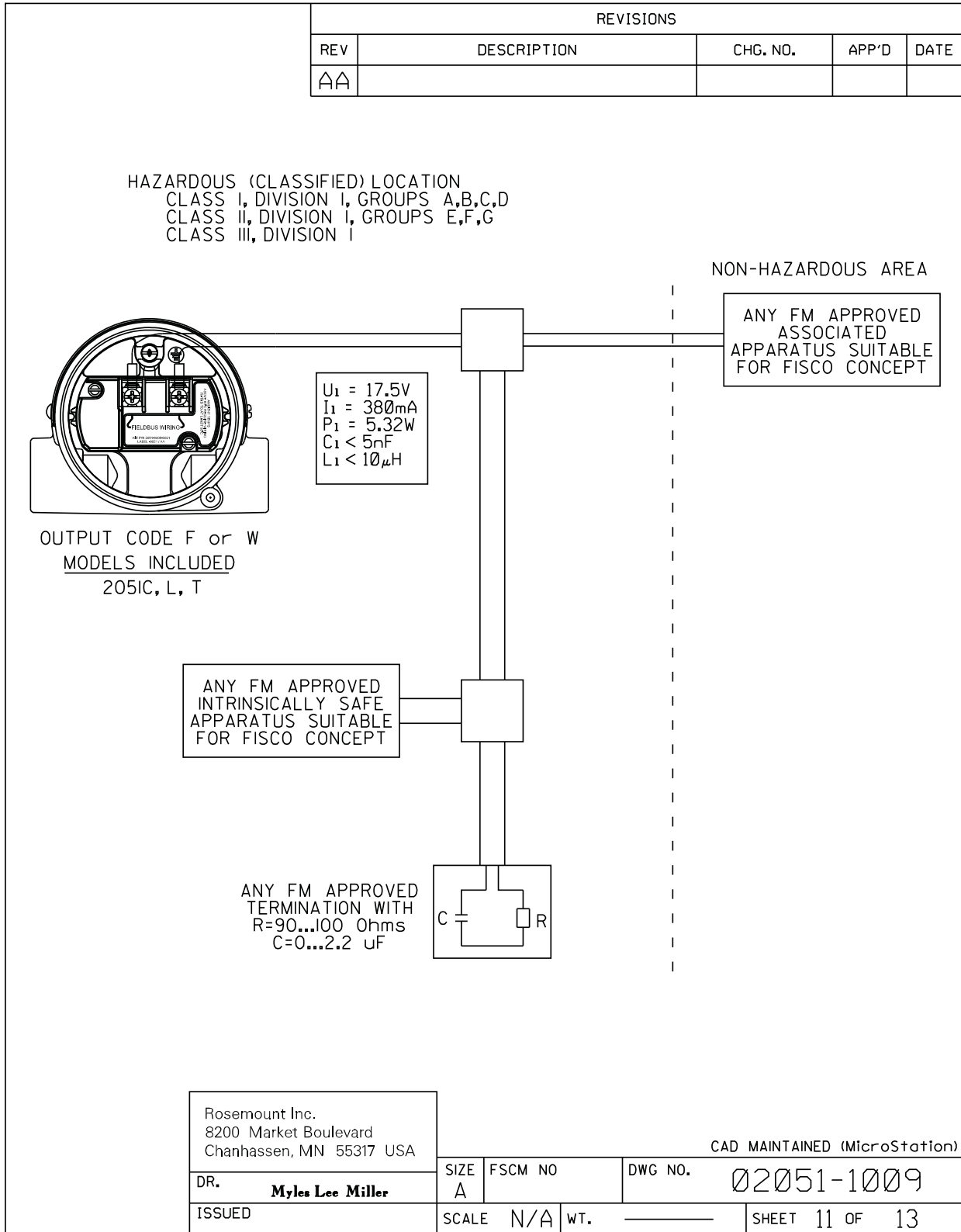
$R = 90...100 \text{ OHMS}$ $C = 2.2\mu F$

AN ALLOWED TERMINATION MIGHT ALREADY BE LINKED IN THE ASSOCIATED APPARATUS. DUE TO I.S. REASONS, THE NUMBER OF PASSIVE APPARATUS CONNECTED TO THE BUS SEGMENT IS NOT LIMITED. IF THE RULES ABOVE ARE FOLLOWED, UP TO A TOTAL LENGTH OF 1000 m (THE SUMMATION OF TRUNK AND ALL SPUR CABLES), THE INDUCTANCE AND THE CAPACITANCE OF THE CABLE WILL NOT DAMAGE THE INTRINSIC SAFETY OF THE SYSTEM.

NOTES:
 INTRINSICALLY SAFE CLASS I, DIV. 1, GROUPS A, B, C, D

1. THE MAXIMUM NON-HAZARDOUS AREA VOLTAGE MUST NOT EXCEED 250 V.
2. CAUTION: ONLY USE SUPPLY WIRES SUITABLE FOR 5°C ABOVE SURROUNDING TEMPERATURE.
3. WARNING: REPLACEMENT OF COMPONENTS MAY DAMAGE INTRINSIC SAFETY.

Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA	CAD MAINTAINED (MicroStation)		
DR. Myles Lee Miller	SIZE A	FSCM NO.	DWG NO. 02051-1009
ISSUED	SCALE N/A	WT. _____	SHEET 10 OF 13



Form Rev A/C

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

**NONINCENDIVE FIELD CIRCUIT
CLASS I, DIV. 2 LOCATIONS**

NON-HAZARDOUS
LOCATION

DIVISION 2 HAZARDOUS (CLASSIFIED) LOCATION

V_{max1}	V_{max2}	V_{max3}	V_{maxN}
C_{I1}	C_{I2}	C_{I3}	C_{IN}
L_{I1}	L_{I2}	L_{I3}	L_{IN}
I_{max1}	I_{max2}	I_{max3}	I_{maxN}

WIRING PER NEC (NFPA 70) 501-4 (b) EXCEPTION (NONINCENDIVE FIELD CIRCUIT)

 NFPA 70 National Electrical Code ARTICLE 501-4(b) EXCEPTION: "WIRING IN NONINCENDIVE CIRCUITS SHALL BE PERMITTED USING ANY OF THE METHODS SUITABLE FOR WIRING IN ORDINARY LOCATIONS."

IN NORMAL OPERATION

DEVICES CONTROL THROUGH-CURRENT

PARAMETERS	DEVICE	ROSEMOUNT 2051	ROSEMOUNT 2051	ROSEMOUNT 2051
V_{oc}	\leq Minimum of ($V_{max1}, V_{max2}, \dots, V_{maxN}$)	4-20mA/ HART	1-5 VDC/ HART	FIELDBUS (F or W)
I_{max1}	$\geq I_{q1} + I_{signal1}$	V_{max} 30v	30v	30v
I_{max2}	$\geq I_{q1} + I_{signal2}$	Maximum normal operating current	22mA	3.1mA
.	.	C_a	.010uF	.020uF
.	.	L_a	10uH	10uH
.	.	L_a w/T1		.75mH
I_{maxN}	$\geq I_{qN} + I_{signalN}$			
C_a	$\leq C_{I1} + C_{I2} + \dots + C_{IN} + C_{cable}$			
L_a	$\leq L_{I1} + L_{I2} + \dots + L_{IN} + L_{cable}$			

I_{max} for an individual device = $I_q + I_{signal}$
 I_q = Quiescent current through device
 (Maximum quiescent current for the device)
 I_{signal} = Signaling current through device
 (Protocol may limit signaling to one device at a time)

Operating $I_{max} = I_{q1} + I_{q2} + \dots + I_{qN} + I_{signal\ max}$
 $I_{signal\ max} = \text{Max. of } (I_{signal1}, I_{signal2}, \dots, I_{signalN})$

ROSEMOUNT 2051 TRANSMITTERS ARE CURRENT CONTROLLERS ON INDIVIDUAL PARALLEL BRANCHES WITH RESPECT TO THE POWER SUPPLY. IN NONINCENDIVE INSTALLATIONS THE I_{max} FOR EACH TRANSMITTER IS NOT RELATED TO THE MAXIMUM CURRENT OF THE POWER SUPPLY (I_{sc}) IN THE SAME MANNER AS FOR TRANSMITTER INSTALLED PER I.S. REQUIREMENTS, BECAUSE NONINCENDIVE REQUIREMENTS INCLUDE ONLY NORMAL OPERATING CONDITIONS.

REFERENCE: APPENDIX A7.3 (FM3611)

Rosemount Inc.
8200 Market Boulevard
Chanhassen, MN 55317 USA

CAD MAINTAINED (MicroStation)

DR.	Myles Lee Miller	SIZE	FSCM NO	DWG NO.	02051-1009
ISSUED		SCALE	N/A	WT.	

SHEET 12 OF 13

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AA				

NOTES:

1. NO REVISION TO THIS DRAWING WITHOUT PRIOR FM APPROVAL.
2. ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT.
3. DUST-TIGHT CONDUIT SEAL MUST BE USED WHEN INSTALLED IN CLASS II AND CLASS III ENVIRONMENTS.
4. CONTROL EQUIPMENT CONNECTED TO ASSOCIATED APPARATUS MUST NOT USE OR GENERATE MORE THAN 250 Vrms or Vdc.
5. RESISTANCE BETWEEN INTRINSICALLY SAFE GROUND AND EARTH GROUND MUST BE LESS THAN 1.0 OHM.
6. INSTALLATION SHOULD BE IN ACCORDANCE WITH ANSI/ISA-RP12.06.01 "INSTALLATION OF INTRINSICALLY SAFE SYSTEMS FOR HAZARDOUS (CLASSIFIED) LOCATIONS" AND THE NATIONAL ELECTRICAL CODE (ANSI/NFPA 70).
7. THE ASSOCIATED APPARATUS MUST BE FM APPROVED.
8. WARNING - SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
9. THE ENTITY CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS WITH ASSOCIATED APPARATUS WHEN THE FOLLOWING IS TRUE:
 V_{max} or U_1 IS GREATER THAN or EQUAL TO V_{oc}, V_t or U_o
 I_{max} or I_1 IS GRETER THAN or EQUAL TO I_{sc}, I_t or I_o
 P_{max} or P_1 IS GRETER THAN or EQUAL TO P_o
 C_a IS GREATER THAN or EQUAL TO THE SUM OF ALL C_i 's PLUS C_{cable}
 L_a IS GREATER THAN or EQUAL TO THE SUM OF ALL L_i 's PLUS L_{cable}
10. WARNING - TO PREVENT IGNITION OF FLAMMABLE OR COMBUSTIBLE ATMOSPHERES, DISCONNECT POWER BEFORE SERVICING.
11. THE ASSOCIATED APPARATUS MUST BE A RESISTIVELY LIMITED SINGLE OR MULTIPLE CHANNEL FM APPROVED BARRIER HAVEING PARAMETERS LESS THAN THOSE QUOTED, AND FOR WHICH THE OUTPUT AND THE COMBINATIONS OF OUTPUTS IS NON-IGNITION CAPABLE FOR THE CLASS, DIVISION AND GROUP OF USE.

Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA		CAD MAINTAINED (MicroStation)		
DR.	Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02051-1009
ISSUED		SCALE N/A	WT. _____	SHEET 13 OF 13

Form Rev. AC

Canadian Standards Association (CSA)

CONFIDENTIAL AND PROPRIETARY INFORMATION IS CONTAINED HEREIN AND MUST BE HANDLED ACCORDINGLY	REVISIONS				
	REV	DESCRIPTION	CHG. NO.	APP'D	DATE
	AA	NEW RELEASE	RTC1025889	J.G.K.	4/21/08
	AB	UPDATE PER CSA REQUIREMENT	RTC1026355	J.G.K.	6/18/08

APPROVALS FOR
2051C
2051L
2051T


OUTPUT CODE A (4-20 mA HART) I.S. SEE SHEETS 2-3
OUTPUT CODE M (LOW POWER) I.S. SEE SHEETS 3-4
OUTPUT CODE F/W (FIELDBUS) I.S. SEE SHEETS 5-7
OUTPUT CODES A,F,W I.S. ENTITY PARAMETERS SHEET 8-9

TO ASSURE AN INTRINSICALLY SAFE SYSTEM, THE TRANSMITTER AND BARRIER MUST BE WIRED IN ACCORDANCE WITH THE BARRIER MANUFACTURER'S FIELD WIRING INSTRUCTIONS AND THE APPLICABLE CIRCUIT DIAGRAM.

WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS
MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION I.

AVERTISSEMENT - RISQUE D'EXPLOSION - LA SUBSTITUTION DE COMPOSANTS
PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS
DE CLASSE I, DIVISION I.

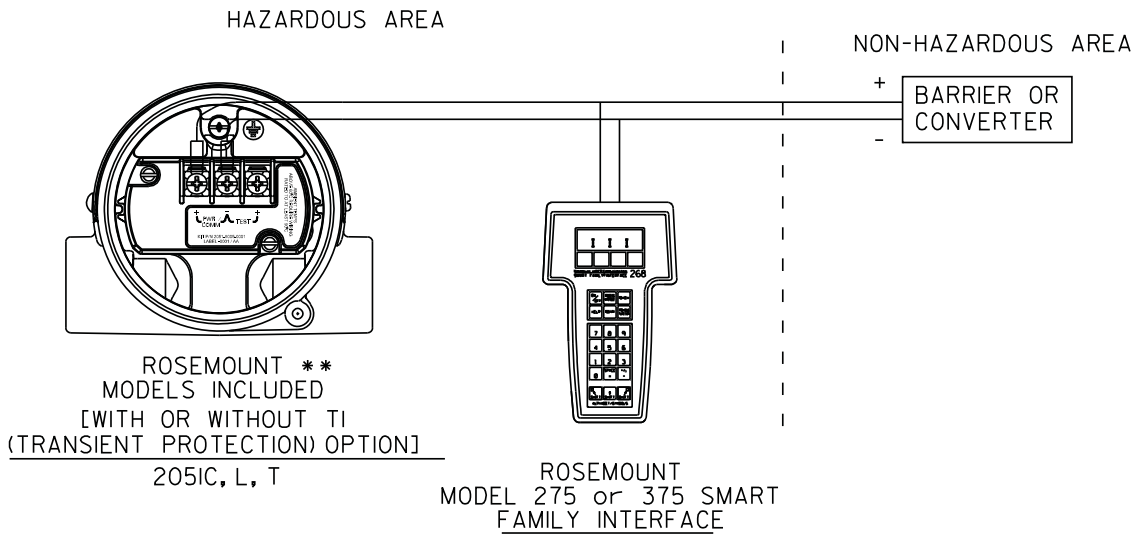
CAD MAINTAINED (MicroStation)

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES [mm]. REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125	CONTRACT NO.		 ROSEMOUNT® 8200 Market Boulevard • Chanhassen, MN 55317 USA					
	DR.	Myles Lee Miller 4/15/08	TITLE INDEX OF I.S. CSA FOR 2051C/L/T					
	CHK'D							
	APP'D.		SIZE	FSCM NO	DWG NO.			
			A		02051-1008			
DO NOT SCALE PRINT	APP'D. GOVT.	SCALE	N/A	WT.		SHEET	1 OF	9

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB				

CSA INTRINSIC SAFETY APPROVALS
 CIRCUIT CONNECTION WITH BARRIER OR CONVERTER

Ex ia
 INTRINSICALLY SAFE/SECURITE INTRINSEQUE
 4-20 mA, ("A" OUTPUT CODE)



** FOR THE LOW POWER OPTION, SEE PAGE 4 FOR THE CIRCUIT CONNECTION WITH BARRIER OR CONVERTER. FOR FIELDBUS OPTIONS("F" or "W" OUTPUT CODE), SEE PAGE 5 FOR PARAMETERS AND CIRCUIT CONNECTION TO BARRIER.

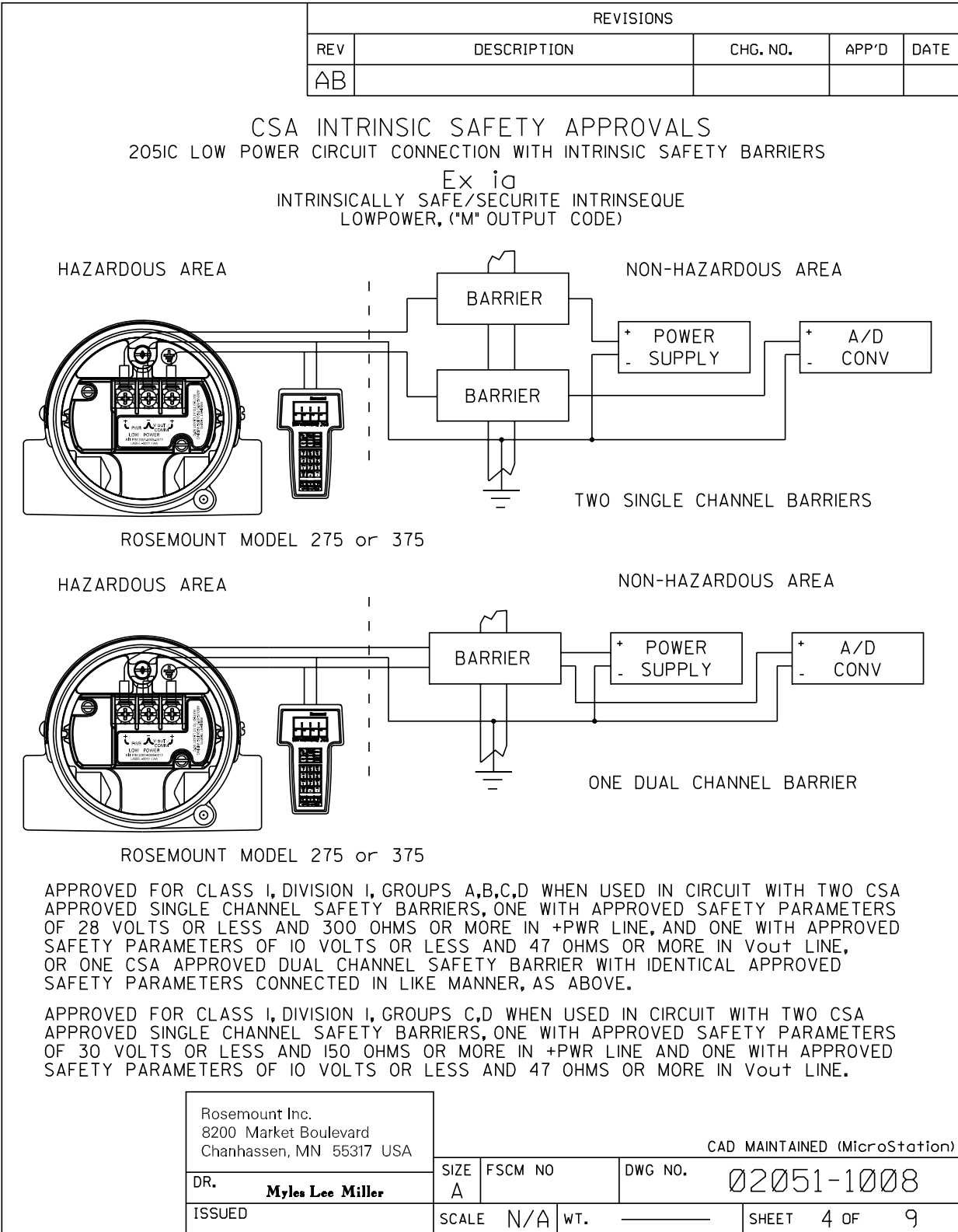
Rosemount Inc. 8200 Market Boulevard Chanhassen, MN 55317 USA		CAD MAINTAINED (MicroStation)		
DR. Myles Lee Miller 4/15/08	SIZE A	FSCM NO.	DWG NO. 02051-1008	
ISSUED	SCALE N/A	WT.	SHEET 2 OF	9

Form Rev. AC

Rosemount 2051

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB				
4-20 mA, ("A" OUTPUT CODE)				
DEVICE	PARAMETERS	APPROVED FOR CLASS I, DIV. I		
CSA APPROVED SAFETY BARRIER	30 V OR LESS * 330 OHMS OR MORE * 28 V OR LESS * 300 OHMS OR MORE 25 V OR LESS 200 OHMS OR MORE * 22 V OR LESS * 180 OHMS OR MORE	GROUPS A, B, C, D		
FOXBORO CONVERTER 2A1-I2V-CGB, 2A1-I3V-CGB, 2AS-I3I-CGB, 3A2-I2D-CGB, 3A2-I3D-CGB, 3AD-I3I-CGB, 3A4-I2D-CGB, 2AS-I2I-CGB, 3F4-I2DA		GROUPS B, C, D		
CSA APPROVED SAFETY BARRIER	30 V OR LESS 150 OHMS OR MORE	GROUPS C, D		
LOW POWER, ("M" OUTPUT CODE)				
DEVICE	PARAMETERS	APPROVED FOR CLASS I, DIV. I		
CSA APPROVED SAFETY BARRIER	Supply $\leq 28V, \geq 300 \Omega$ Return $\leq 10V, \geq 47 \Omega$	GROUPS A, B, C, D		
CSA APPROVED SAFETY BARRIER	Supply $\leq 30V, \geq 150 \Omega$ Return $\leq 10V, \geq 47 \Omega$	GROUPS C, D		
* MAY BE USED WITH ROSEMOUNT MODEL 275 or 375 SMART FAMILY INTERFACE.				
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DR. Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02051-1008	
ISSUED	SCALE N/A	WT. _____	SHEET 3 OF 9	

Form Rev. 02



Form: Rev. AC

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB				

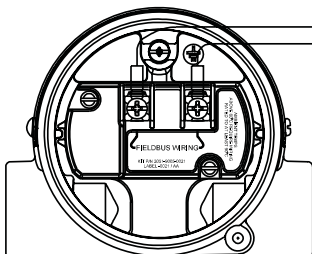
FIELDBUS, ("F" or "W" OUTPUT CODE)

DEVICE	PARAMETERS	APPROVED FOR CLASS I, DIV.I
CSA APPROVED SAFETY BARRIER	30 V OR LESS 300 OHMS OR MORE	GROUPS A, B, C, D
	28 V OR LESS 235 OHMS OR MORE	
	25 V OR LESS 160 OHMS OR MORE	
	22 V OR LESS 100 OHMS OR MORE	
	22 V OR LESS 100 OHMS OR MORE	
	22 V OR LESS 100 OHMS OR MORE	

CSA INTRINSIC SAFETY APPROVALS
CIRCUIT CONNECTION WITH BARRIER OR CONVERTER

Ex ia
INTRINSICALLY SAFE/SECURITE INTRINSEQUE
FIELDBUS, ("F" or "W" OUTPUT CODE)

HAZARDOUS AREA



ROSEMOUNT **
MODELS INCLUDED
[WITH OR WITHOUT TI
(TRANSIENT PROTECTION) OPTION]
2051C, L, T

NON-HAZARDOUS AREA

+ BARRIER OR CONVERTER

- BARRIER OR CONVERTER

WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS
MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION I.

AVERTISSEMENT - RISQUE D'EXPLOSION - LA SUBSTITUTION DE COMPOSANTS
PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS
DE CLASSE I, DIVISION I.

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ISSUED	SCALE N/A	WT.		SHEET 5 OF 9

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REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB				

FISCO CONCEPT APPROVALS

THE FISCO CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIALLY EXAMINED IN SUCH COMBINATION. FOR THIS INTERCONNECTION TO BE VALID THE VOLTAGE (U_i or V_{max}), THE CURRENT (I_i or I_{max}), AND THE POWER (P_i or P_{ma}) THAT INTRINSICALLY SAFE APPARATUS CAN RECEIVE AND REMAIN INTRINSICALLY SAFE, INCLUDING FAULTS, MUST BE EQUAL OR GREATER THAN THE VOLTAGE (U_o , V_{oc} , or V_t), THE CURRENT (I_o , I_{sc} , or I_t), AND THE POWER (P_o or P_{max}) LEVELS WHICH CAN BE DELIVERED BY THE ASSOCIATED APPARATUS, CONSIDERING FAULTS AND APPLICABLE FACTORS. ALSO, THE MAXIMUM UNPROTECTED CAPACITANCE (C_i) AND THE INDUCTANCE (L_i) OF EACH APPARATUS (BESIDES THE TERMINATION) CONNECTED TO THE FIELD BUS MUST BE LESS THAN OR EQUAL TO 5nF AND 10 μ H RESPECTVELY. ONLY ONE ACTIVE DEVICE IN EACH SECTION (USUALLY THE ASSOCIATED APPARATUS) IS ALLOWED TO CONTRIBUTE THE DESIRED ENERGY FOR THE FIELD BUS SYSTEM. THE ASSOCIATED APPARATUS' VOLTAGE U_o (or V_{oc} or V_t) IS LIMITED TO A RANGE OF 14V TO 24 V.D.C. ALL OTHER EQUIPMENT COMBINED IN THE BUS CABLE MUST BE PASSIVE (THEY CANNOT PROVIDE ENERGY TO THE SYSTEM, EXCEPT A LEAKAGE CURRENT OF 50 μ A FOR EACH CONNECTED DEVICE) SEPARATELY POWERED EQUIPMENT REQUIRES A GALVANIC ISOLATION TO AFFIRM THAT THE INTRINSICALLY SAFE FIELD BUS CIRCUIT WILL REMAIN PASSIVE. THE PARAMETER OF THE CABLE USED TO INTERCONNECT THE DEVICES MUST BE IN THE FOLLOWING RANGE:

LOOP RESISTANCE R': 15...150 OHM/km
 INDUCTANCE PER UNIT LENGTH L': 0.4...1mH/KM
 CAPACITANCE PER UNLIT LENGTH C': 80...200nF

C' = C' LINE/LINE +0.5C' LINE/SCREEN, IF BOTH LINES ARE FLOATING, OR
 C' = C' LINE/LINE +C' LINE/SCREEN, IF THE SCREEN IS CONNECTED TO ONE LINE
 TRUNK CABLE LENGTH: ≤ 1000 m
 SPUR CABLE LENGTH: ≤ 30 m
 SPLICE LENGTH: ≤ 1 m

AN APPROVED INFALLIBLE LINE TERMINATION TO EACH END OF THE TRUNK CABLE, WITH THE FOLLOWING PARAMETERS IS APPROPRIATE:

R = 90...100 OHMS C = 2.2 μ F

AN ALLOWED TERMINATION MIGHT ALREADY BE LINKED IN THE ASSOCIATED APPARATUS. DUE TO I.S. REASONS, THE NUMBER OF PASSIVE APPARATUS CONNECTED TO THE BUS SEGMENT IS NOT LIMITED. IF THE RULES ABOVE ARE FOLLOWED, UP TO A TOTAL LENGTH OF 1000 m (THE SUMMATION OF TRUNK AND ALL SPUR CABLES), THE INDUCTANCE AND THE CAPACITANCE OF THE CABLE WILL NOT DAMAGE THE INTRINSIC SAFETY OF THE SYSTEM.

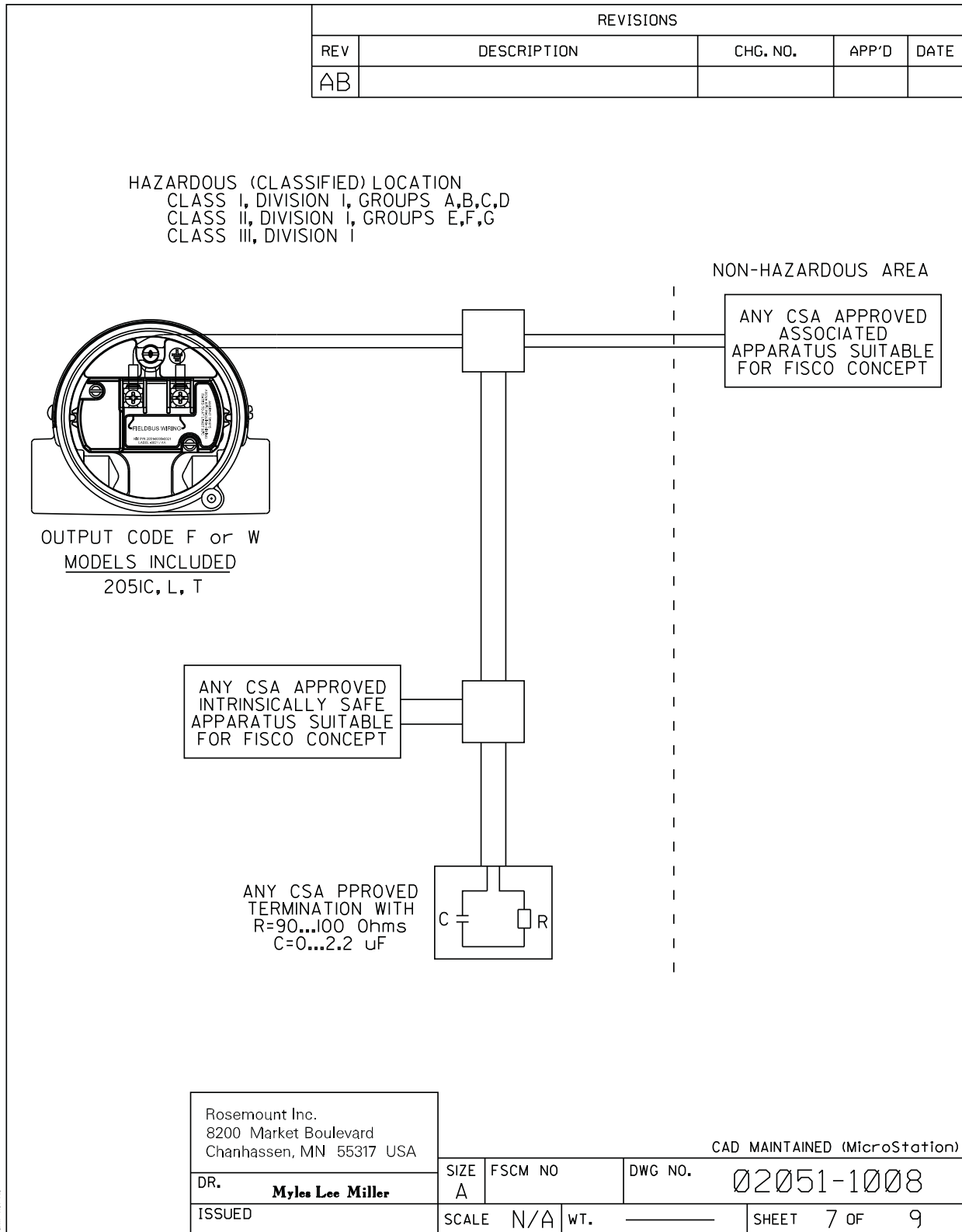
NOTES:
 INTRINSICALLY SAFE CLASS I, DIV. 1, GROUPS A, B, C, D

1. THE MAXIMUM NON-HAZARDOUS AREA VOLTAGE MUST NOT EXCEED 250 V.
2. CAUTION: ONLY USE SUPPLY WIRES SUITABLE FOR 5°C ABOVE SURROUNDING TEMPERATURE.
3. WARNING: REPLACEMENT OF COMPONENTS MAY DAMAGE INTRINSIC SAFETY.

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		A		02051-1008
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Rosemount 2051



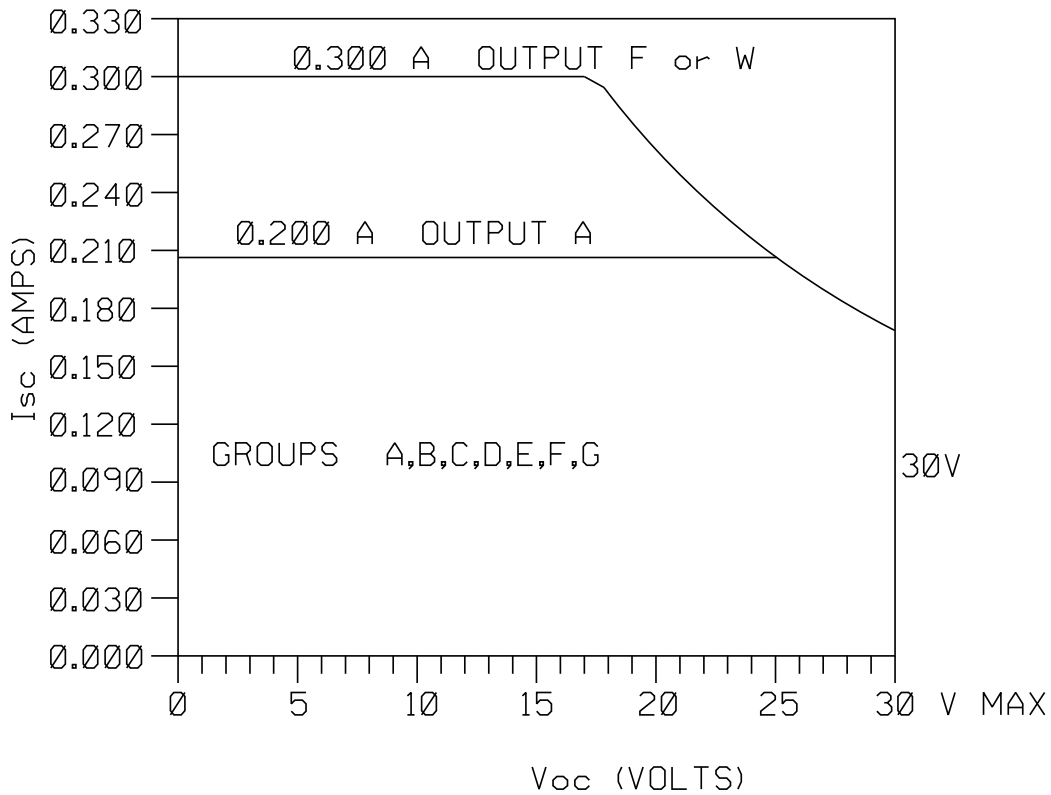
Form: Rev. A/C

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AB				

2051 I.S. ENTITY PARAMETERS.
 (OUTPUT CODE A,F, or W)

BARRIER PARAMETERS (APPLICABLE TO OUTPUT CODE A,F, or W)

$P_{max} = 1.3$ WATT OUTPUT F or W
 $P_{max} = 1.0$ WATT OUTPUT A



Rosemount Inc.
 8200 Market Boulevard
 Chanhassen, MN 55317 USA

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ISSUED		SCALE	N/A	WT.		SHEET	8 OF 9

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REVISIONS				
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AB				

ENTITY CONCEPT APPROVALS

THE ENTITY CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIFICALLY EXAMINED IN COMBINATION AS A SYSTEM. THE APPROVED VALUES OF MAX. OPEN CIRCUIT VOLTAGE (V_{OC}) AND MAX. SHORT CIRCUIT CURRENT (I_{SC}) AND MAX. POWER ($V_{OC} \times I_{SC}/4$), FOR THE ASSOCIATED APPARATUS MUST BE LESS THAN OR EQUAL TO THE MAXIMUM SAFE INPUT VOLTAGE (V_{MAX}), MAXIMUM SAFE INPUT CURRENT (I_{MAX}), AND MAXIMUM SAFE INPUT POWER (P_{MAX}) OF THE INTRINSICALLY SAFE APPARATUS. IN ADDITION, THE APPROVED MAX. ALLOWABLE CONNECTED CAPACITANCE (C_A) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE CAPACITANCE AND THE UNPROTECTED INTERNAL CAPACITANCE (C_I) OF THE INTRINSICALLY SAFE APPARATUS, AND THE APPROVED MAX. ALLOWABLE CONNECTED INDUCTANCE (L_A) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE INDUCTANCE AND THE UNPROTECTED INTERNAL INDUCTANCE (L_I) OF THE INTRINSICALLY SAFE APPARATUS.

FOR OUTPUT CODE A

CLASS I, DIV. 1, GROUPS A, B, C AND D: CLASS I, ZONE 0, GROUP IIC

$V_T = 30V$	V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_T = 200mA$	I_{SC} IS LESS THAN OR EQUAL TO 200mA
$P_{MAX} = 1 \text{ WATT}$	$(\frac{V_{OC} \times I_{SC}}{4})$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = .01\mu f$	C_A IS GREATER THAN $.01\mu f + C \text{ CABLE}$
$L_I = 10\mu H$	L_A IS GREATER THAN $10\mu H + L \text{ CABLE}$

FOR OUTPUT CODE F or W

CLASS I, DIV. 1, GROUPS A, B, C AND D: CLASS I, ZONE 0, GROUP IIC

$V_T = 30V$	V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_T = 300mA$	I_{SC} IS LESS THAN OR EQUAL TO 300mA
$P_{MAX} = 1.3 \text{ WATT}$	$(\frac{V_{OC} \times I_{SC}}{4})$ IS LESS THAN OR EQUAL TO 1.3 WATT
$C_I = 0\mu f$	C_A IS GREATER THAN $0\mu f + C \text{ CABLE}$
$L_I = 0\mu H$	L_A IS GREATER THAN $0\mu H + L \text{ CABLE}$

FOR OUTPUT CODE M

CLASS I, DIV. 1, GROUPS A, B, C AND D: CLASS I, ZONE 0, GROUP IIC

$V_T = 30V$	V_{OC} IS LESS THAN OR EQUAL TO 30V
$I_T = 200mA$	I_{SC} IS LESS THAN OR EQUAL TO 200mA
$P_{MAX} = 1 \text{ WATT}$	$(\frac{V_{OC} \times I_{SC}}{4})$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = .02\mu f$	C_A IS GREATER THAN $.01\mu f + C \text{ CABLE}$
$L_I = 10\mu H$	L_A IS GREATER THAN $10\mu H + L \text{ CABLE}$

*** FOR T1 OPTION:**

$L_I = 0.75mH$	
----------------	--

NOTE: ENTITY PARAMETERS LISTED APPLY ONLY TO ASSOCIATED APPARATUS WITH LINEAR OUTPUT.

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DR.	Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02051-1008
ISSUED	SCALE	N/A	WT.	SHEET 9 OF 9

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Appendix C Glossary

Some of the terms used in this manual relate specifically to the operation of Rosemount transmitters, hand-held HART Communicators, and other Rosemount products. The following list provides brief definitions. See the sections listed for additional information.

Analog Output Trim	Digital trim operation that allows adjustment of the output electronics to conform to the plant standard of current. Two types of analog output trim are available: 4–20 mA output trim and 4–20 mA other scale.
Cloning	Off-line operation that uses a HART-based communicator to copy configuration data from one transmitter to one or more other transmitters that require the same data.
Commissioning	Functions performed with the HART-based communicator and the transmitter that test the transmitter and test the loop, and verify transmitter configuration data.
Configuration	Process of setting parameters that determine how the transmitter operates.
Damping	Output function that increases the response time of the transmitter to smooth the output when there are rapid input variations.
Descriptor	Sixteen-character field for additional identification of the transmitter, its use, or location. The descriptor is stored in the transmitter and can be changed using the HART-based communicator.
Digital Trim	Format function that allows you to adjust the transmitter characterization for purposes of digital calibration to plant standards. Digital trim includes two separate operations: sensor trim and analog output trim.
Failure Mode Alarm	Transmitter function that drives the analog output to a jumper-selectable high or low value in the event of an electronics failure.
Factory Characterization	Factory process during which each sensor module is subjected to pressures and temperatures covering the full operating range. The sensor module memory stores data generated from this process for use by the microprocessor in correcting the transmitter output during operation.
Full Trim	Sensor trim function in which two accurate, end-point pressures are applied and all output is linearized between them. The selected end points should always be equal to or outside the LRV and URV.
HART (Highway Addressable Remote Transducer) Protocol	Communications standard that provides simultaneous analog and digital signal transmission between control rooms and field devices such as transmitters.

Rosemount 2051

Lower Range Limit (LRL)	Lowest value of the measured variable that the transmitter can be configured to measure.
Lower Range Value (LRV)	Lowest value of the measured variable that the analog output of the transmitter is currently configured to measure.
Multidropping	The connection of several transmitters to a single communications transmission line. Communication between the host and the transmitters takes place digitally with the analog output of the transmitters deactivated.
Reranging	Configuration function that changes the transmitter 4 and 20 mA settings.
Send Data	HART-based communicator command that transfers configuration data from the hand-held communicator's memory to the transmitter memory.
Sensor Trim	Digital trim function that allows you to adjust the digital process variable reading to a precise pressure input. Zero trim and sensor trim are the two sensor trim functions.
Smart	Term used to describe instruments that are microprocessor-based and feature advanced communications capabilities.
Span	Algebraic difference between the upper and lower range values.
Tag	Eight-character field for identifying the transmitter. The tag is stored in the transmitter and can be changed using the HART Communicator and the transmitter information function.
Transmitter Address	Unique number (1-15) used to identify a multidropped transmitter. Transmitters that are not multidropped have 0 as an address.
Transmitter Security	Jumper-selectable feature that prevents accidental or deliberate changes to configuration data.
Upper Range Limit (URL)	Highest value of the measured variable that the transmitter can be configured to measure.
Upper Range Value (URV)	Highest value of the measured variable that the analog output of the transmitter is currently configured to measure.
Zero Trim	A zero-based, one-point adjustment used in differential pressure applications to compensate for mounting position effects or zero shifts caused by static pressure.

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Reference Manual

00809-0100-4101, Rev AA
July 2008

Rosemount 2051

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Models 2088, 2090P, and 2090F Pressure Transmitters



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Models 2088, 2090P, and 2090F Pressure Transmitters

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IMPORTANT

Procedures and instructions in this manual may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). **Refer to the safety messages, listed at the beginning of each section, before performing an operation preceded by this symbol.**

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Introduction

USING THIS MANUAL

This manual provides information on commissioning, installing, and operating the Rosemount Models 2088, 2090P, and 2090F Pressure Transmitters. The manual is organized into the following sections:

Section 2: Commission the Transmitter

provides information on commissioning and operating the transmitters, software functions, configuration parameters, and on-line variables.

Section 3: Installation

provides mechanical and electrical installation instructions.

Section 4: Maintenance and Troubleshooting

provides basic troubleshooting instructions, including sensing module checkout, disassembly, and reassembly procedures.

Section 5: Specifications and Reference Data

provides functional specifications, physical specifications, performance specifications, for the Model 2088, 2090P, and 2090F Pressure Transmitters.

Appendix A: LCD Meter

provides operating instructions for the optional LCD meter.

Appendix B: Model 275 HART Communicator

contains a communicator overview, a HART Communicator menu tree for the Model 2088 Smart, and a table of HART Communicator fast key sequences. A table of diagnostic messages associated with this communicator is also included.

Appendix C: Low Power Option

provides installation and calibration information specific to the Low Power Option.

Appendix D: Transient Protection Option

provides installation, wiring, and specification information for the transient protection option

Appendix E: Approval Drawings

provides the drawings necessary to install the transmitter in hazardous location.

Appendix F: European ATEX Directive Information

provides information on European ATEX compliance.

SAFETY MESSAGES

Procedures and instructions in this manual may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the safety messages, listed at the beginning of each section, before performing an operation preceded by this symbol.

Commissioning the Transmitter

OVERVIEW

This section contains information on commissioning the transmitter. Commissioning involves reviewing configuration data, setting the 4 and 20 mA points, configuring the transmitter to recognize accessories such as an LCD meter, and testing the transmitter output.

SAFETY MESSAGES

This section contains procedures that require connecting a communicator to the transmitter, or making connections in an explosive atmosphere. The following safety messages apply to all procedures throughout this section requiring cover removal and communicator or ammeter connection to the transmitter terminal block. Keep the following safety messages in mind whenever you perform an operation requiring cover removal or the connection of a communicator or other device to a measurement loop.

Warnings

WARNING

Explosions could result in death or serious injury:

- Do not remove the transmitter covers in explosive atmospheres when the circuit is alive.
- Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- Both transmitter covers must be fully engaged to meet explosion-proof requirements.

WARNING

High voltage that may be present on leads could cause electrical shock:

- Avoid contact with leads and terminals.

COMMISSION: ON THE BENCH OR IN THE LOOP


Commission the Model 2088 Transmitter before or after installation. It may be useful to commission the transmitter on the bench before installation to ensure proper operation, to familiarize yourself with transmitter functionality, and to avoid exposing the transmitter electronics to the plant environment.

Commissioning consists of :

- Reviewing configuration data
- Setting output units
- Setting the 4 and 20 mA points
- Configuring the transmitter for any non-standard accessories or functions, and testing the transmitter output

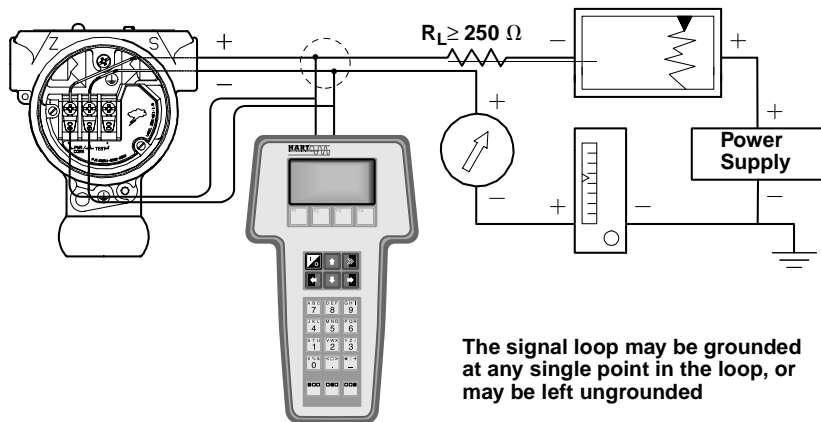
COMMISSIONING THE SMART TRANSMITTER

Set up the Smart Transmitter and the Communicator

 To configure the smart transmitter on the bench, connect the transmitter and the communicator as shown in Figure 2-1. To power the transmitter you will need a power supply capable of providing 10.5 to 36.0 V dc and a meter to measure output current. To enable communication, a resistance of at least 250 ohms must be present between the communicator loop connection and the power supply. You can connect the communicator leads at any termination point in the signal loop, but it is most convenient to connect them to the terminals labeled "COMM" on the terminal block.

After you connect the bench equipment as shown in Figure 2-1, turn on the communicator by pressing the ON/OFF key. The communicator will search for a HART-compatible device and will indicate when the connection is made. If the connection is not made, the communicator will indicate that no device was found.

FIGURE 2-1. Connecting a HART Communicator to a Transmitter Loop.



2088S-2088C02C

REVIEW CONFIGURATION DATA

Review all of the factory-set configuration data to ensure that it reflects the needs of your application before operating the transmitter in an actual installation.

Review

HART Fast Keys	1, 5
----------------	------

Review the transmitter configuration parameters set at the factory to ensure accuracy and compatibility with your particular application. After activating the review function, scroll through the data list to check each variable. Refer to “Basic Setup” in this section of the manual if a change to the transmitter configuration data is necessary.

CHECK OUTPUT

Before performing other transmitter on-line operations, review the digital output parameters to ensure that the transmitter is operating properly and is configured to the appropriate process variables.

Process Variables

HART Fast Keys	1, 1
----------------	------

The process variables for the Model 2088 provide the transmitter output, and are continuously updated. The *Process Variables* menu displays the following process variables:

- Pressure
- Percent Range
- Analog Output

BASIC SETUP

From the *Basic Setup* menu you can configure the transmitter for certain basic variables. In many cases, all of these variables are pre-configured at the factory. Configuration may be required if your transmitter is not configured or if the configuration variables need revision.

Tag

HART Fast Keys	1, 3, 1
----------------	---------

The *Tag* variable is the easiest way to identify and distinguish between transmitters in multi-transmitter environments. Use this variable to label transmitters electronically according to the requirements of your application. The tag you define is automatically displayed when a HART-based communicator establishes contact with the transmitter at power-up. The tag may be up to eight characters long and has no impact on the primary variable readings of the transmitter.

Output Units

HART Fast Keys	1, 3, 2
----------------	---------

The *Unit* command sets the desired primary variable units. Set the transmitter output to one of the following engineering units:

- inH₂O
- inHg
- ftH₂O
- mmH₂O
- psi
- bar
- mbar
- inH₂O @ 4 °C
- g/cm²
- kg/cm²
- Pa
- kPa
- torr
- atm
- mmH₂O @ 4 °C

NOTE

After changing units, press SEND (F2) so the microprocessor will recalculate the associated variables (4–20 mA points, for example). The Model 2088 Smart recalculates all variables that depend on units. After the transmitter recalculates the variables, you may change any of the remaining parameters.

Rerange

HART Fast Keys	1, 3, 3
----------------	---------



The *Range Values* command sets the 4 and 20 mA points (lower and upper range values). Setting the range values to the limits of expected readings maximizes transmitter performance; the transmitter is most accurate when operated within the expected pressure ranges for your application. In practice, you may reset the transmitter range values as often as necessary to reflect changing process conditions.

NOTE

Regardless of the range points, the Model 2088 Smart will measure and report all readings within the digital limits of the sensor. For example, if the 4 and 20 mA points are set to 0 and 10 inH₂O, and the transmitter detects a pressure of 25 inH₂O, it digitally outputs the 25 in H₂O reading and a 250% percent of span reading. However, there may be up to ±5.0% error associated with output outside of the range points.

You may use one of three methods to rerange the transmitter. Each method is unique; examine all three closely before deciding which method to use.

Method 1:Rerange Using the Communicator

Reranging using only the communicator is the easiest and most popular way to rerange the transmitter. This method changes the values of the analog 4 and 20 mA points independently without a pressure input.

To rerange using only the communicator enter the fast-key sequence above, select *1 Keypad input*, and follow the on-line instructions. Or enter the values directly from the HOME screen.

Method 2:Rerange Using the Communicator and a Pressure Source or Process Pressure

Reranging using the communicator and a pressure source or process pressure is a way of reranging the transmitter when specific 4 and 20 mA points are not known. This method changes the values of the analog 4 and 20 mA points. When you set the 4 mA point the span is maintained; when you set the 20 mA point the span changes.

To rerange using the communicator and a pressure source or process pressure enter the fast-key sequence above, select *2 Apply values*, and follow the on-line instructions.

Method 3:Rerange Using the Local Zero and Span Buttons and a Pressure Source or Process Pressure

Reranging using the local zero and span adjustments and a pressure source is a way of reranging the transmitter when specific 4 and 20 mA points are not known and a communicator is not available. When you set the 4 mA point the span is maintained; when you set the 20 mA point the span changes.

Damping

HART Fast Keys	1. 3. 5
----------------	---------

The *Damping* command changes the response time of the transmitter to smooth variations in output readings caused by rapid changes in input. Determine the appropriate damping setting based on the necessary response time, signal stability, and other requirements of the loop dynamics of your system. The default damping value is 0.50 seconds and can be reset in fixed increments of 0.05, 0.10, 0.20, 0.40, 0.80, 1.60, 3.20, 6.40, 12.8, or 25.6 seconds.

DETAILED SETUP

Meter Setup

HART Fast Keys	1, 3, 6
----------------	---------

The *Meter Type* command allows you to configure the transmitter for use with an LCD meter. Transmitters shipped without meters are set to “NONE.” Change the meter settings as often as necessary to reflect changing process or application conditions. To change the meter settings, and thereby configure the transmitter to recognize the LCD meter, perform the following procedure.

1. Select 1 Device setup, 3 Basic setup, 6 Meter type to prepare to change the meter settings.
2. Select the appropriate variable configuration from the “Meter type” screen, and press enter.

NOTE

Selecting “None” from the meter type screen will disable the meter.

3. Select SEND to download the new meter configuration information to the transmitter.

For a more detailed description of the LCD meter features and diagnostic messages, refer to “LCD Meter” on page A-1.

Burst Mode

HART Fast Keys	1, 4, 3, 3, 3
----------------	---------------

Burst Mode sets the transmitter to maintain digital contact with a Digital Control System that has custom software to support burst mode. When the Model 2088 Smart is configured for burst mode, it provides faster digital communication from the transmitter to the control system by eliminating the time required for the control system to request information from the transmitter.

Burst mode is compatible with use of the analog signal. Because HART® protocol features simultaneous digital and analog data transmission, the analog value can drive other equipment in the loop while the control system is receiving the digital information. Burst mode applies only to the transmission of dynamic data (pressure and temperature in engineering units, pressure in percent of range, and/or analog output in mA), and does not affect the way other transmitter data is accessed.

Access to information other than dynamic transmitter data is obtained through the normal poll/response method of HART communication. A HART-based communicator or the control system may request any of the information that is normally available while the transmitter is in burst mode. Between each message sent by the transmitter, a short pause allows the HART-based communicator or a control system to initiate a request. The transmitter will receive the request, process the response message, and then continue “bursting” the data approximately three times per second.

Save, Recall, or Clone Configuration Data

HART Fast Keys	left arrow, 3 (note)
----------------	----------------------

Data that was entered off-line can be stored in the communicator memory and downloaded to other transmitters later. Data also can be copied from a transmitter in order to be sent to other transmitters in a process known as “cloning”. This is especially useful if you work with a large number of transmitters that require the same configuration data.

Enable or Disable Local Span and Zero Buttons

HART Fast Keys	1, 4, 4, 1, 7
----------------	---------------

The *Local Keys* command allows you to enable or disable the local span and zero buttons. Disabling the local keys will prevent unauthorized reranging using the span and zero buttons, but will not prevent reranging using the communicator. To prevent all changes to the configuration data, use the transmitter security jumper (see “Transmitter Security” on page 3-13).

CALIBRATION

Calibrating the transmitter increases the precision of your measurement system. You may use one or more of a number of trim functions when calibrating.

To understand the trim functions, it is necessary to understand that smart transmitters operate differently from analog transmitters. An important difference is that smart transmitters are factory-characterized; they are shipped with a standard sensor curve stored in the transmitter firmware. In operation, the transmitter uses this information to produce a process variable output, in engineering units, dependent on the sensor input. The trim functions allow you to make corrections to the factory-stored characterization curve by digitally altering the transmitter’s interpretation of the sensor input.

The trim functions should not be confused with the rerange functions. Although the rerange command matches a sensor input to a 4–20 mA output—as in conventional calibration—it does not affect the transmitter’s interpretation of the input.

Calibration Overview

Complete calibration of the Model 2088 Smart Pressure Transmitter involves one or more of the following tasks:

Configure the Analog Output Parameters

- Set Process Variable Units (Page 2-3)
- Rerange (Page 2-3)
- Set Output Type (Page 2-3)
- Set Damping (Page 2-4)

Calibrate the Sensor

- Full Trim (Page 2-8)
- Zero Trim (Page 2-7)

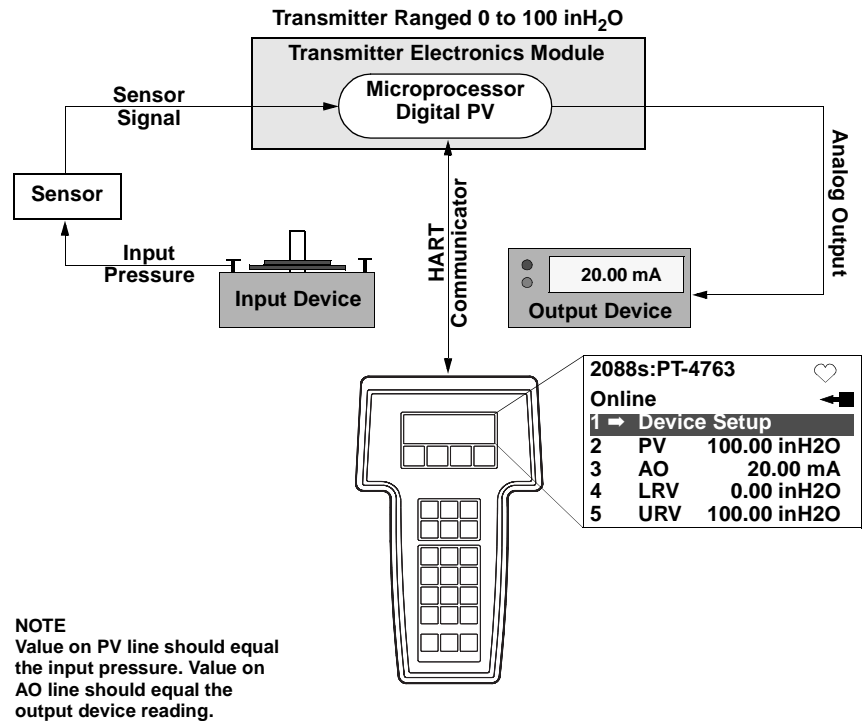
Calibrate the 4–20 mA Output

- Digital to Analog Trim (Page 2-9) or
- Scaled Digital to Analog Trim (Page 2-9)

Figure 2-2 illustrates the Model 2088 Smart Pressure Transmitter data flow. This data flow can be summarized in four major steps:

1. A change in pressure is measured by a change in the sensor output (Sensor Signal).
2. The sensor signal is converted to a digital format that can be understood by the microprocessor (Analog-to-Digital Signal Conversion).
3. Corrections are performed in the microprocessor to obtain a digital representation of the process input (Digital PV).
4. The Digital PV is converted to an analog value (Digital-to-Analog Signal Conversion).

FIGURE 2-2. Transmitter Data Flow with Calibration Options.



Deciding Which Trim Procedure to Use

To decide which trim procedure to use, you must first determine whether the analog-to-digital section or the digital-to-analog section of the transmitter electronics is in need of calibration. To do so, refer to Figure 2-2 and perform the following procedure:

1. Connect a pressure source, a HART communicator, and a digital readout device to the transmitter.
2. Establish communication between the transmitter and the communicator.
3. Apply pressure (100 in H₂O, for example).
4. Compare the applied pressure to the Process Variable (PV) line on the Communicator Online Menu. If the PV reading on the communicator does not match the applied pressure, and you are certain your test equipment is accurate, perform a sensor trim.
5. Compare the Analog Output (AO) line on the communicator online menu to the digital readout device. If the AO reading on the communicator does not match the digital readout device, and you are certain your test equipment is accurate, perform an output trim.

Sensor Trim

You can trim the sensor using either the full trim or the zero trim function. The trim functions vary in complexity, and their use is application-dependent. Both alter the transmitter’s interpretation of the input signal.

Zero Trim

HART Fast Keys	1, 2, 3, 3, 1
----------------	---------------

A *Zero Trim* is a single-point adjustment. It is useful for compensating for mounting position effects, and is most effective when performed with the transmitter installed in its final mounting position. Since this correction maintains the slope of the characterization curve, it should not be used in place of a full trim over the full sensor range.

NOTE

Use full trim on absolute transmitters; do not use zero trim.

To calibrate the sensor using the *Zero Trim* function, perform the following procedure.

1. Vent the transmitter and attach a communicator to the measurement loop.
2. From the communicator main menu select *1 Device setup, 2 Diagnostics and service, 3 Calibration, 3 Sensor trim, 1 Zero trim* to prepare to adjust the zero trim.

NOTE

The transmitter must be within 3% of true zero (zero based) in order to calibrate using the zero trim function.

3. Follow the commands provided by the communicator to complete the adjustment of the zero trim.

Full Trim

HART Fast Keys	1, 2, 3, 3
----------------	------------

A *Full Trim* is a two-point sensor calibration where two end-point pressures are applied, and all output is linearized between them. You should always adjust the low trim value first to establish the correct offset. Adjustment of the high trim value provides a slope correction to the characterization curve based on the low trim value. The factory-established characterization curve is not changed by this procedure. The trim values allow you to optimize performance over your specified measuring range at the calibration temperature.

To calibrate the sensor using the *Full Trim* function, perform the following procedure.

1. Assemble and power the entire calibration system including a transmitter, communicator, power supply, pressure input source, and readout device.

NOTE

Use a pressure input source that is at least three times more accurate than the transmitter, and allow the input pressure to stabilize for 10 seconds before entering any values.

2. From the communicator main menu select *1 Device setup, 2 Diagnostics and service, 3 Calibration, 3 Sensor trim, 2 Lower sensor trim* to prepare to adjust the lower trim point.

NOTE

Select pressure input values so that the low and high values are equal to or outside the 4 and 20 mA points. Do not attempt to obtain reverse output by reversing the high and low points. The transmitter allows approximately a 5% URL deviation from the characterized curve established at the factory.

3. Follow the commands provided by the communicator to complete the adjustment of the lower value.
4. Repeat the procedure for the upper value, replacing *2 Lower sensor trim* with *3 Upper sensor trim* in Step 2.

Output Trim

The *Output Trim* commands allow you to alter the transmitter's conversion of the input signal to a 4–20 mA output (see Figure 2-2 on page 2-7). Adjust the analog output signal at regular intervals to maintain precision. You can trim the transmitter output using either the digital to analog trim or the scaled digital to analog trim function.

Digital to Analog Trim

HART Comm.	1, 2, 3, 2, 1
Model 268	F4, F4, F3, F1, F1

To perform a *Digital-to-Analog Trim*, perform the following procedure.

1. From the HOME screen, select *1 Device setup, 2 Diag/Service, 3 Calibration, 4 D/A trim*. Select “OK” to after you set the control loop to manual.
2. Connect an accurate reference meter to the transmitter at the “Connect reference meter” prompt. To do so, connect the positive lead to the positive terminal and the negative lead to the test terminal in the transmitter terminal compartment, or shunt the transmitter power through the reference meter at some point.
3. Select “OK” after connecting the reference meter.
4. Select “OK” at the “Setting fld dev output to 4 mA” prompt.
The transmitter outputs 4.00 mA.
5. Record the actual value from the reference meter, and enter it at the “Enter meter value” prompt.
The communicator prompts you to verify whether or not the output value equals the value on the reference meter.
6. Select *1 Yes* if the reference meter value equals the transmitter output value, or *2 No* if it does not.
If you select *1 Yes*, proceed to Step 7.
If you select *2 No*, repeat Step 5.
7. Select “OK” at the “Setting fld dev output to 20 mA” prompt, and repeat Steps 5 and 6 until the reference meter value equals the transmitter output value.

Select “OK” after you return the control loop to automatic control.

Scaled Digital to Analog Trim

HART Comm.	1, 2, 3, 2, 2
Model 268	F4, F4, F3, F1, F2

The *Scaled Digital-to-Analog Trim* command matches the 4 and 20 mA points to a user-selectable reference scale other than 4 and 20 mA (1 to 5 volts if measuring across a 250 ohm load, or 0 to 100 percent if measuring from a DCS, for example). To perform a scaled D/A trim, connect an accurate reference meter to the transmitter and trim the output signal to scale as outlined in the Output Trim procedure.

NOTE

Use a precision resistor for optimum accuracy. If you add a resistor to the loop, ensure that the power supply is sufficient to power the transmitter to a 20 mA output with the additional loop resistance.

DIAGNOSTICS AND SERVICE

Test Device

HART Fast Keys	1, 2, 1, 1
----------------	------------

The *Test Device* command initiates a more extensive diagnostic routine than that performed continuously by the transmitter. The transmitter test routine can identify an electronics failure. If the transmitter test detects a problem, the communicator displays messages to indicate the source of the problem.

Loop Test

HART Fast Keys	1, 2, 2
----------------	---------

The *Loop Test* command verifies the output of the transmitter, the integrity of the loop, and the operations of any recorders or similar devices installed in the loop. To initiate a loop test, perform the following procedure:

1. Connect a reference meter to the transmitter. To do so, either connect the meter to the test terminals on the transmitter terminal block, or shunt the power to the transmitter through the meter at some point in the loop.
2. From the HOME screen, Select *1 Device Setup, 2 Diagnostics and Service, 2 Loop Test*, to prepare to perform a loop test.
3. Select “OK” after you set the control loop to manual.
The communicator displays the loop test menu.
4. Select a discreet milliamp level for the transmitter to output. At the “Choose analog output” prompt, select *1 4mA, 2 20mA*, or select *3 other* to manually input a value between 4 and 20 milliamps.
5. Check the current meter installed in the test loop to verify that it reads the value you commanded the transmitter to output. If the readings do not match, the transmitter requires an output trim or the current meter is malfunctioning.

After completing the test procedure, the display returns to the loop test screen and allows you to choose another output value.

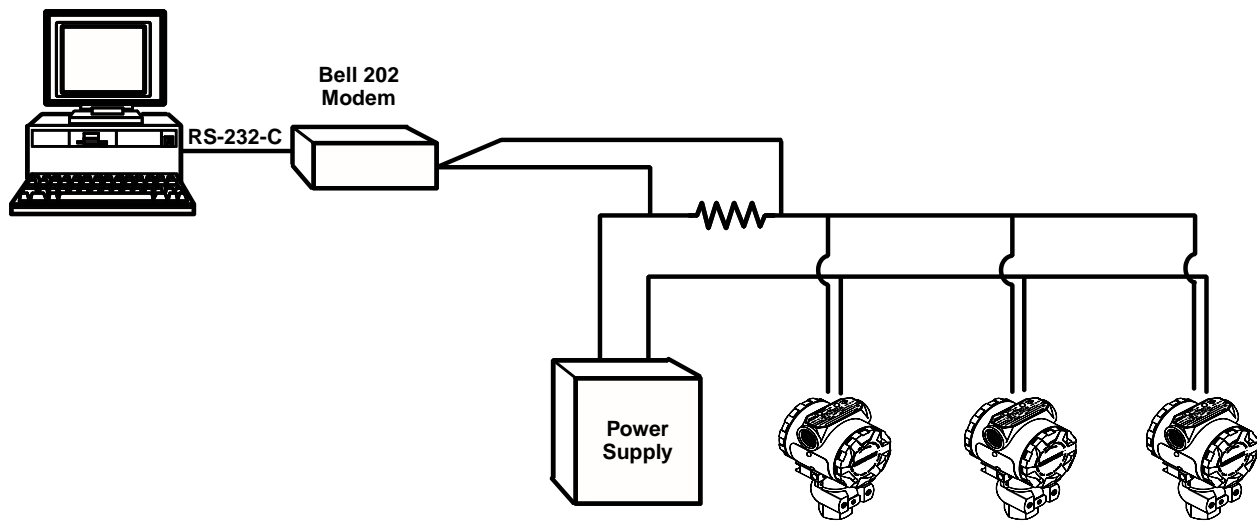
MULTIDROP COMMUNICATION

Multidropping transmitters refers to the connection of several transmitters to a single communications transmission line. Communication between the host and the transmitters takes place digitally with the analog output of the transmitters deactivated. Many of the Rosemount SMART FAMILY transmitters can be multidropped. With the HART communications protocol, up to 15 transmitters can be connected on a single twisted pair of wires or over leased phone lines. Note that Burst Mode Operation is not compatible with multidrop communications.

The application of a multidrop installation requires consideration of the update rate necessary from each transmitter, the combination of transmitter models, and the length of the transmission line. Multidrop installations are not recommended where intrinsic safety is a requirement. Communication with the transmitters can be accomplished with commercially available Bell 202 modems and a host implementing the HART protocol. Each transmitter is identified by a unique address (1-15) and responds to the commands defined in the HART protocol.

Figure 2-3 shows a typical multidrop network. This figure is not intended as an installation diagram. Contact Rosemount product support with specific requirements for multidrop applications.

FIGURE 2-3. Typical Multidrop Network.



3051-0087A

HART-based communicators can test, configure, and format a multidropped transmitter the same way as a transmitter in a standard point-to-point installation.

NOTE

The transmitter is set to address 0 at the factory, allowing it to operate in the standard point-to-point manner with a 4–20 mA output signal. To activate multidrop communication, you must change the transmitter address to a number from 1 to 15. This change deactivates the 4–20 mA analog output, locking it to 4 mA. It also disables the failure mode alarm signal, which is controlled by the upscale/downscale jumper position.

Changing a Transmitter Address

HART Fast Keys	1, 4, 3, 3, 1
----------------	---------------

To change the address of a multidropped transmitter, follow these fast key sequences. To activate multidrop communication, the transmitter address must be changed to a number from 1 to 15.

Communicating with a Multidropped Transmitter

HART Fast Keys	1, 4, 3, 3, 2
----------------	---------------

To communicate with a multidropped transmitter for the purpose of testing, configuring, or formatting.

Polling a Multidropped Loop

HART Fast Keys	Left Arrow, 4, 1, 1
----------------	---------------------

Polling a multidropped loop determines the model, address, and number of transmitters on the given loop.

NOTE

The Model 275 HART Communicator requires you to use the Utility Menu to perform an auto poll. This menu is available from the Main Menu of the HART Communicator. Press the left arrow to move from the Online Menu to the Main Menu. Press 4 from the Main Menu to access the Utility Menu.

Installation

OVERVIEW

This section is designed to guide you through a successful Models 2088, 2090F, or 2090P Transmitter installation. Starting with an installation flowchart, this section contains information on installation considerations and transmitter options. Dimensional drawings are also included in this section.

SAFETY MESSAGES

Instructions and procedures in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

Warnings

⚠ WARNING

Explosions could result in death or serious injury:

- Do not remove the transmitter cover in explosive atmospheres when the circuit is alive.
- Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- Verify that the operating atmosphere of the transmitter is consistent with the appropriate hazardous locations certifications.
- Both transmitter covers must be fully engaged to meet explosion-proof requirements.

⚠ WARNING

Failure to follow these installation guidelines could result in death or serious injury:

- Make sure only qualified personnel perform the installation.

⚠ WARNING

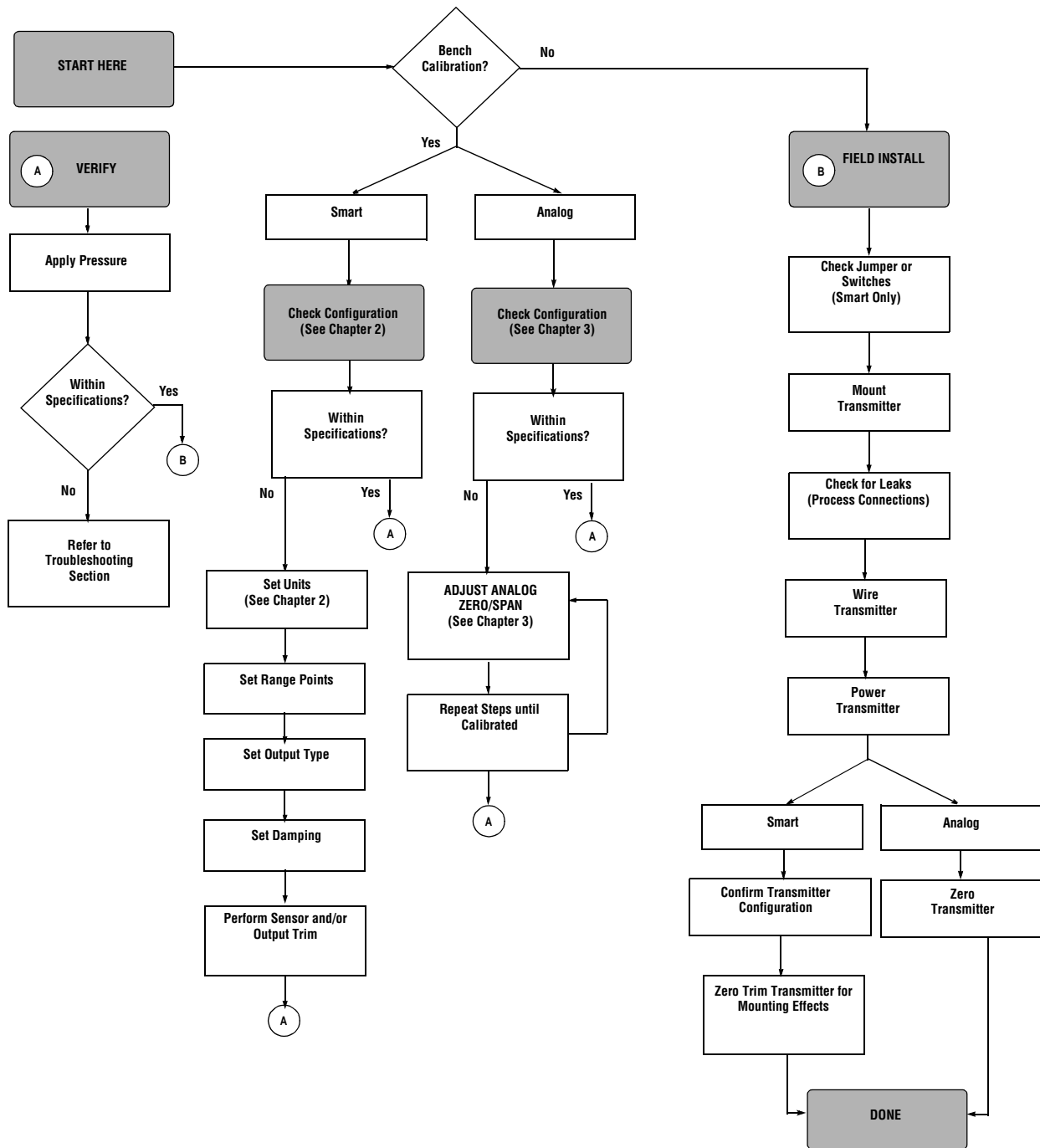
High voltage that may be present on leads could cause electrical shock:

- Avoid contact with leads and terminals.

⚠ WARNING

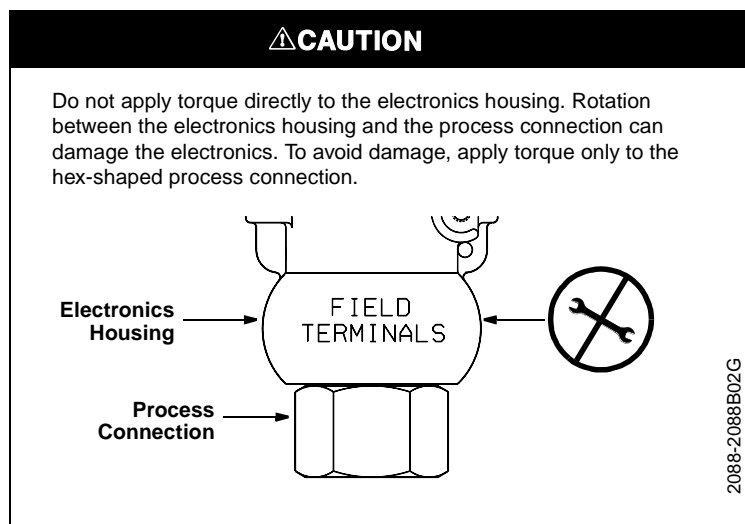
Use appropriately rated sanitary clamps and gaskets during installation. The maximum working pressure of the clamp and gasket must be greater than or equal to the working pressure range of the transmitter. Failure to use proper clamps and gaskets can cause process leaks and can result in death or serious injury.

FIGURE 3-1. Installation Flowchart.



GENERAL CONSIDERATIONS

The accuracy of the pressure measurement depends on proper installation of the transmitter and impulse piping. The piping between the process and transmitter must accurately transmit pressure to the transmitter. Mount the transmitter close to the process and use a minimum of impulse piping to achieve the best accuracy. Keep in mind, however, the need for convenient access, safety of personnel, practical field calibration, and a suitable transmitter environment. In general, install the transmitter to minimize vibration, shock, and temperature fluctuations.



ENVIRONMENTAL CONSIDERATIONS

Temperature

Mount the transmitter in a manner that minimizes variations in ambient temperature.

Moisture and Corrosives

The transmitter is designed to resist attack by moisture and corrosives. The electronics module is fully encapsulated and mounted in a compartment that is sealed from the power-side conduit entries. O-ring seals protect both compartments when the covers are installed.

In humid environments, it is possible for moisture to accumulate in the conduit lines and reach the terminal compartment of the transmitter housing. To prevent moisture from entering the terminal compartment, mount the transmitter at a high point in the conduit run, if possible. Also, remove the terminal compartment cover periodically and inspect the terminals for moisture and corrosion.

Hazardous Locations Installations

Models 2088, 2090P, and 2090F transmitters are designed with explosion-proof electronics enclosures and circuitry that complies with intrinsic safety requirements and non-incendive operation. Individual transmitters are clearly tagged with approvals. Refer to Section 5: Specifications and Reference Data for a complete list of available approvals. To maintain certified ratings for installed transmitters, install with applicable installation codes and approval drawings.

NOTE

Once a device labeled with multiple approval types is installed, it should not be reinstalled using any other approval types. Permanently mark the approval label to distinguish it from unused approval types.

MECHANICAL CONSIDERATIONS

Mounting

Model 2088

The Model 2088 Smart Transmitter weighs approximately 2.44 lb (1,11 kg). The Model 2088 Analog Transmitter weighs approximately 1.9 lb (0,86 kg). In many cases, its compact size and light weight makes it possible to mount the Model 2088 directly to the impulse line without using an additional mounting bracket. When this is not desirable, mount directly to a wall, panel, or two-inch pipe using the optional mounting bracket (see Figure 3-2).

The Model 2088 also offers several process connections. Use your plant-approved thread sealant to ensure a leak-proof connection.

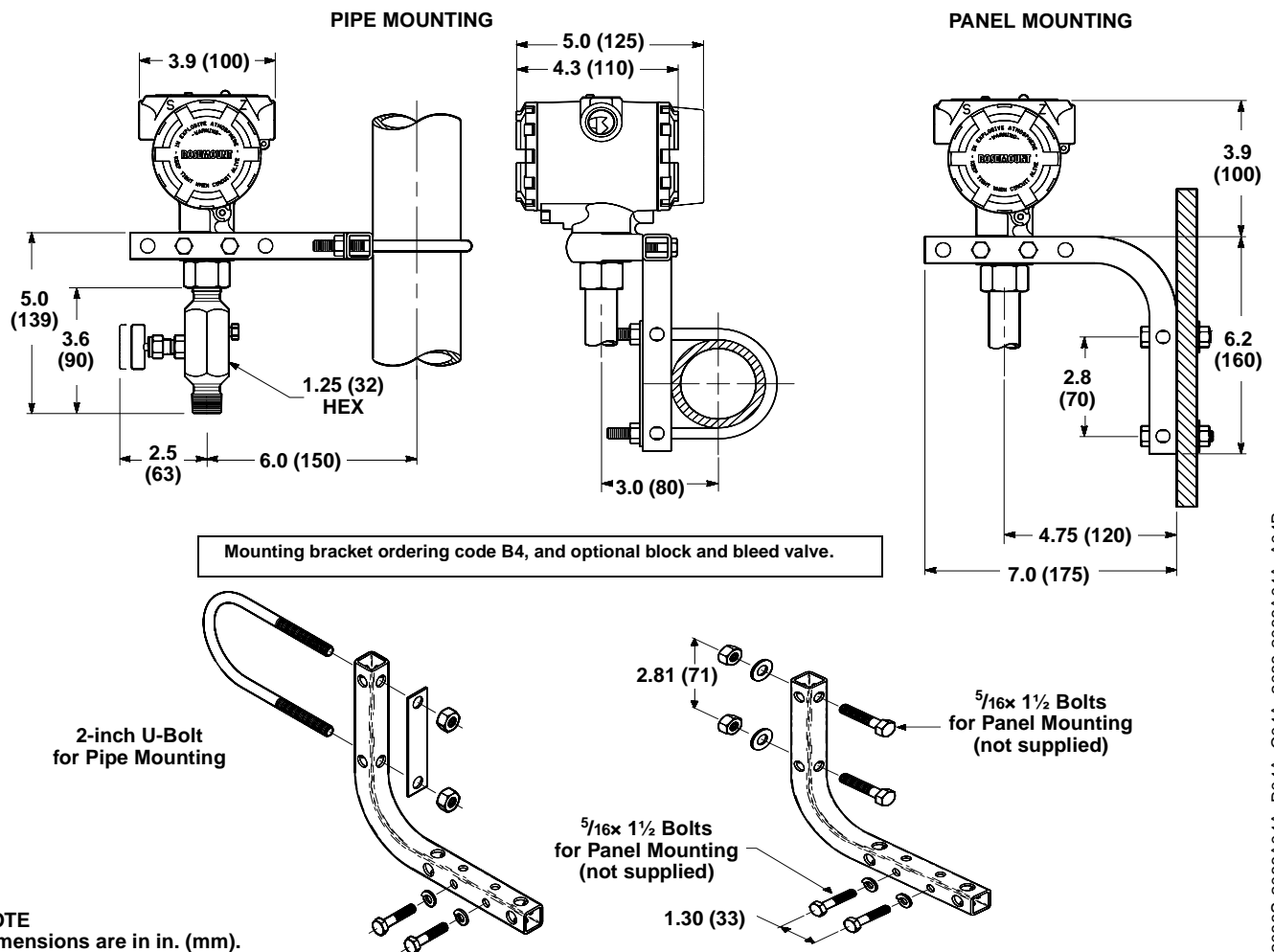
Model 2090P

The Model 2090P is designed to be mounted directly to the process pipe using a weld spud (see Figure 3-7). Mount the transmitter using an existing weld spud, or install a new one using the instructions on page 3-7.

Model 2090F

The Model 2090F is designed to be mounted directly to the process pipe using a standard sanitary fitting (see Figure 3-8). The transmitter is available with either a 1.5- or 2-inch Tri-Clamp® connection.

FIGURE 3-2. Transmitter Mounting Configurations with Optional Bracket.



2088S-2088A04A, B04A, C04A; 2088-2088A04A, A04B

Impulse Piping

Impulse piping configurations depend on specific measurement conditions. Use the following information and Figure 3-3 as a guideline when installing impulse piping.

Liquids: Make the line tap on the side of the pipe to prevent sediment deposits from plugging the impulse line or transmitter. Mount the transmitter level with or below the tap so gases vent into the process line.

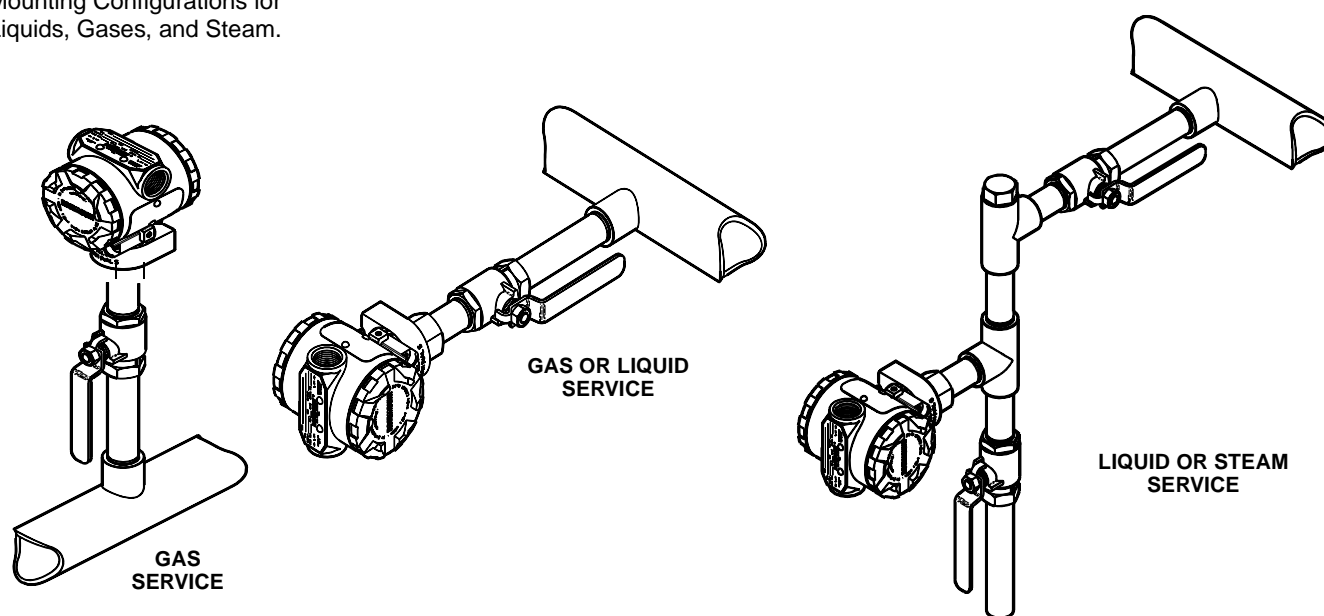
Gases: Make line taps on either the top or the side of the process line. Mount the transmitter level with or above the line tap so liquids drain into the process line.

Steam: Make line taps in the side of the process line. Mount the transmitter below the line tap to ensure that the impulse line remains filled with condensate.

NOTE

Installing a “T”-connection with a shut-off valve in the impulse line between the transmitter and the valve to the process line will allow you to vent the transmitter to atmosphere, thereby enabling calibration without removing the transmitter.

FIGURE 3-3. Transmitter Mounting Configurations for Liquids, Gases, and Steam.



2088-2088A01A, C, B

NOTE

In steam or other high-temperature services, the temperature at the process connection must not exceed the process temperature limit of the transmitter, which is 250 °F (121 °C).

In steam service above 250 °F (121 °C), fill impulse lines with water to prevent steam from contacting the transmitter. Condensate chambers are not necessary since the volumetric displacement of the Model 2088 is negligible.

Access Requirements

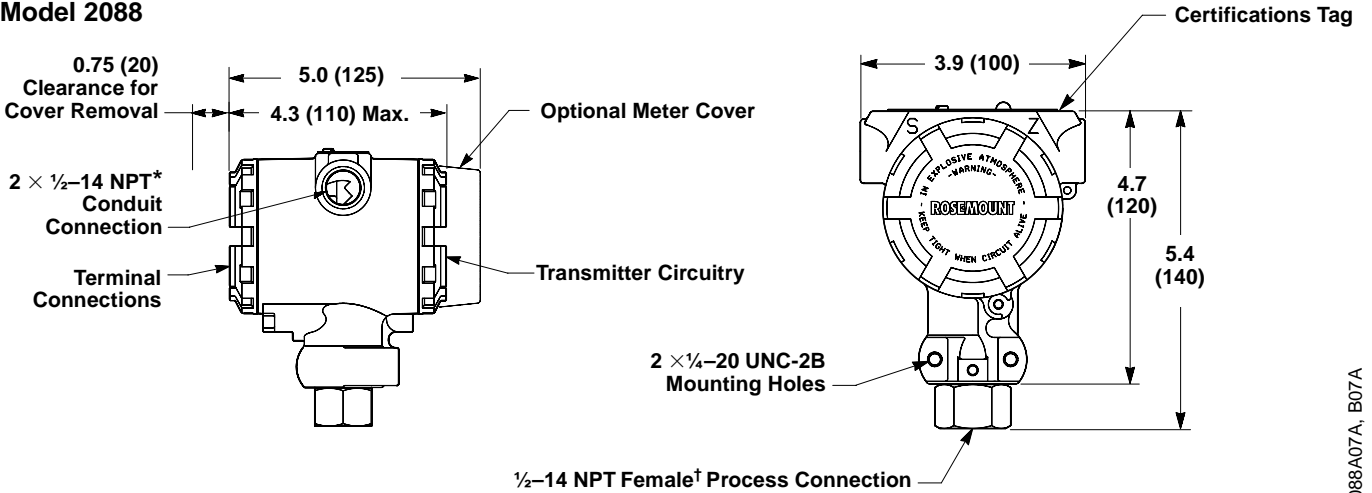
When choosing a mounting location and position, take into account the need for access to the transmitter.

Make wiring terminations through the conduit openings at the top of the electronics housing. The field terminal side of the transmitter is clearly marked on the transmitter neck. Test terminals are incorporated on the terminal block; you do not need access to the electronics compartment to perform calibration procedures.

The transmitter electronics compartment contains the electronics module with failure mode and security jumpers, and the optional LCD meter. Consider the need for access to both compartments when installing the transmitter. Refer to Figure 3-4 for transmitter dimensional drawings.

FIGURE 3-4. Smart Transmitter Dimensional Drawings.

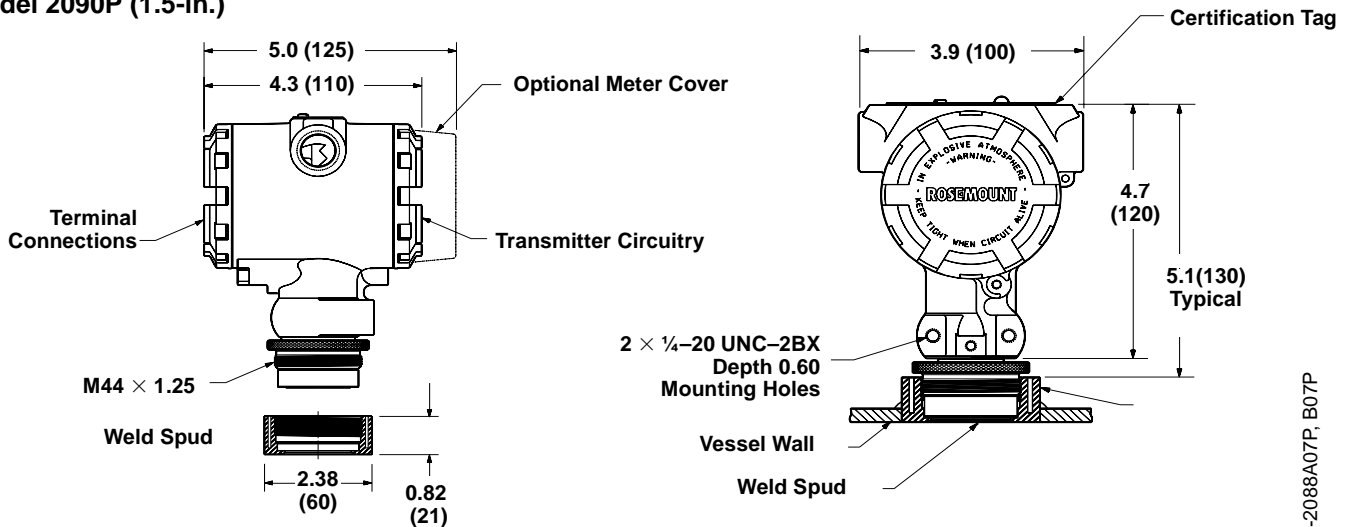
Model 2088



* M20 × 1.5 Female (CM20), PG 13.5, and G 1/2 Female (PF 1/2) also available as options.
 † DIN 16288 G 1/2 Male, RC 1/2 Female (PT 1/2), and M20 × 1.5 Male (CM20) also available.

2088S-2088A07A, B07A

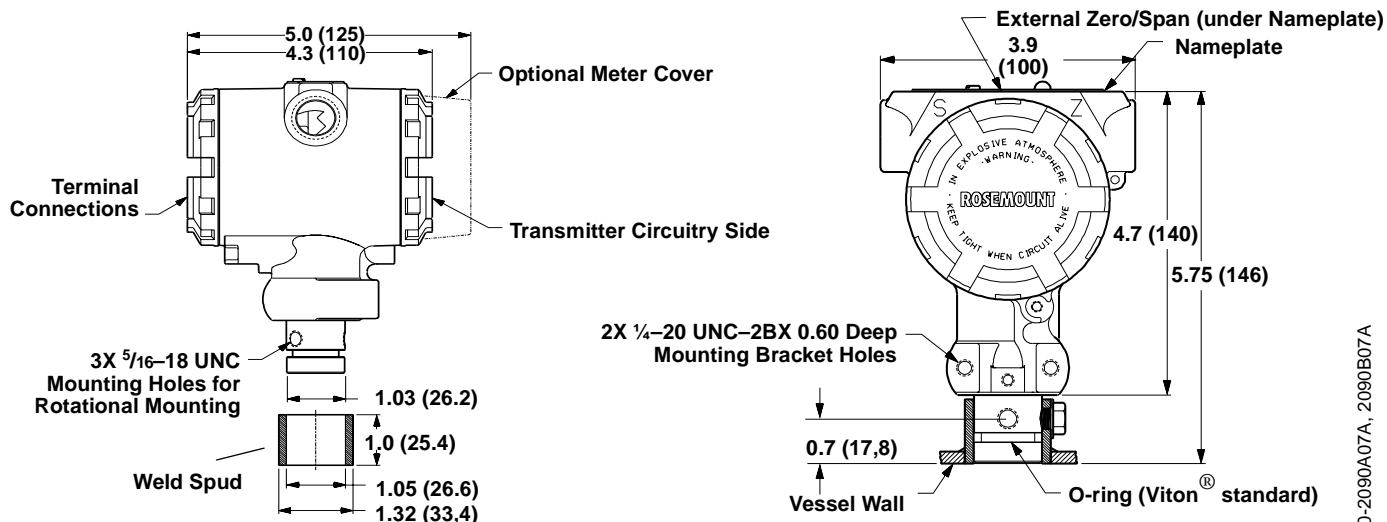
Model 2090P (1.5-in.)



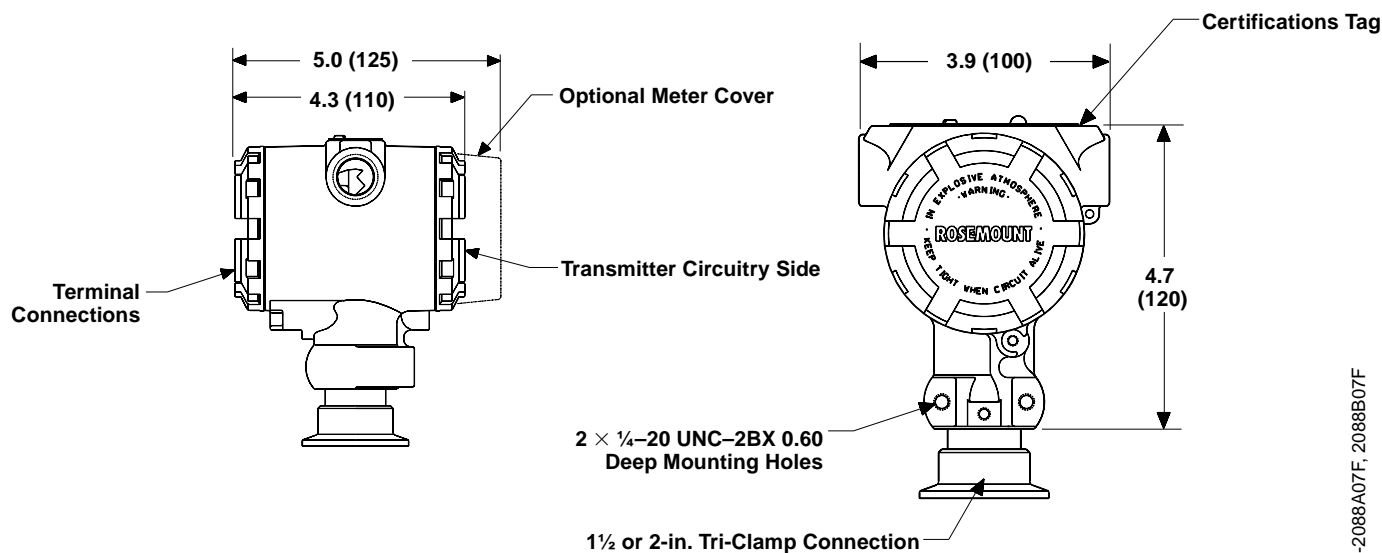
NOTE: Dimensions are in in. (mm).

2090-2088A07P, B07P

Model 2090P Compatible with 1-in. PMC® Process Connection



Model 2090F



* M20 x 1.5 Female (M20) and PG 13.5 also available.
 NOTE: Dimensions are in inches (millimeters).

Model 2090P

Installing the Model 2090P transmitter involves attaching a weld spud to the tapped process vessel, attaching the transmitter to the weld spud, and making electrical connections. If you intend to use an existing weld spud, proceed to the transmitter section of this installation procedure.

NOTE

The Model 2090P Isolating Diaphragm can be mounted flush with the inside diameter of any vessel larger than three inches in diameter.

CAUTION

Installation of the weld spud should be performed by a skilled welder using a TIG welder. Improper installation may result in weld spud distortion.

Weld Spud

1. Using the appropriate size hole saw, cut a hole in the process vessel to accept the weld spud. The diameter for a weld spud with heat isolator groove is 2.37 inch (60 mm); when compatible with 1-in. PMC[®] process connection style spud, diameter is 1.32 in. (33,4 mm). The hole should produce a tight, uniform fit when coupled with the weld spud.
2. Bevel the edge of the vessel hole to accept filler material (see Figure 3-5).
3. Remove the weld spud from the transmitter and remove the Teflon[®] gasket from the weld spud.

⚠ CAUTION

Excessive heat will distort the weld spud. Weld in sections, as shown in Figure 3-5, cooling each section with a wet cloth. Allow adequate cooling between passes.

To reduce the chances of distorting the weld spud (for 1.5-in. connection), use a heat sink—Rosemount Part Number 02088-0196-0001.

4. Position the weld spud in the vessel hole, place heat sink and tack spud in place using the welding sequence shown in Figure 3-5. Cool each section with a wet cloth before proceeding to the next section.
5. Weld the spud in place using 0.030 to 0.045 in. (0,762 to 1,143 mm) stainless steel rod as filler in the bevelled area. Using between 100 and 125 amps., adjust the amperage for 0.080 in. (2,032 mm) penetration.

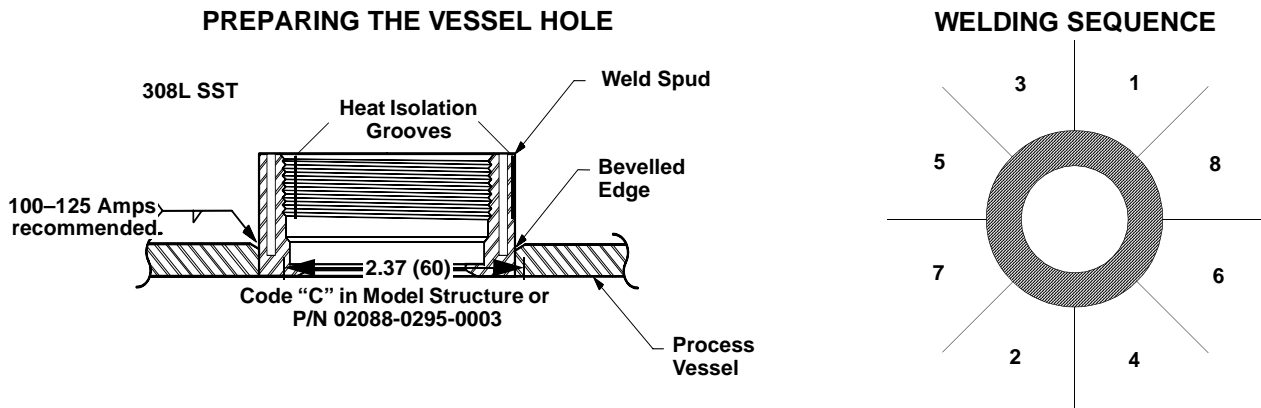
Transmitter

1. After the weld spud has cooled, remove the heat sink and install the Teflon gasket into the weld spud. Ensure that the gasket is properly positioned within the weld spud; improper placement could cause a process leak (see Figure 3-6).
2. Position the transmitter into the spud and begin to engage the threads. Rotate the transmitter prior to seating the threads completely to enable access to the housing compartments, the conduit entry, and the local indicator.
3. Hand tighten the transmitter using the knurled retaining ring, then snug an additional 1/8 turn with adjustable pliers.

IMPORTANT

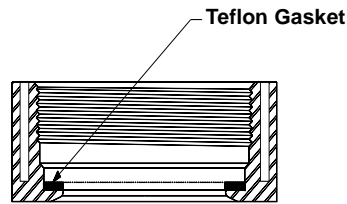
Do not over-tighten the retaining ring. A spanner wrench (P/N 02088-0193-0001) hole is located on the knurled portion of the retaining ring to assist in transmitter removal if it is over-tightened.

FIGURE 3-5. Installing the Weld Spud.



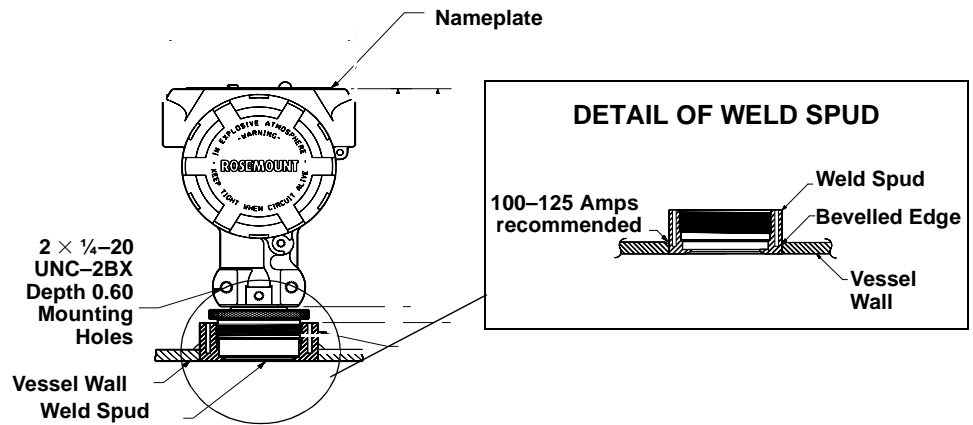
2090-0208E07B

FIGURE 3-6. Teflon Gasket Placement.




2090-2088E07A

FIGURE 3-7. Model 2090P Mounting Configuration Using a Weld Spud.



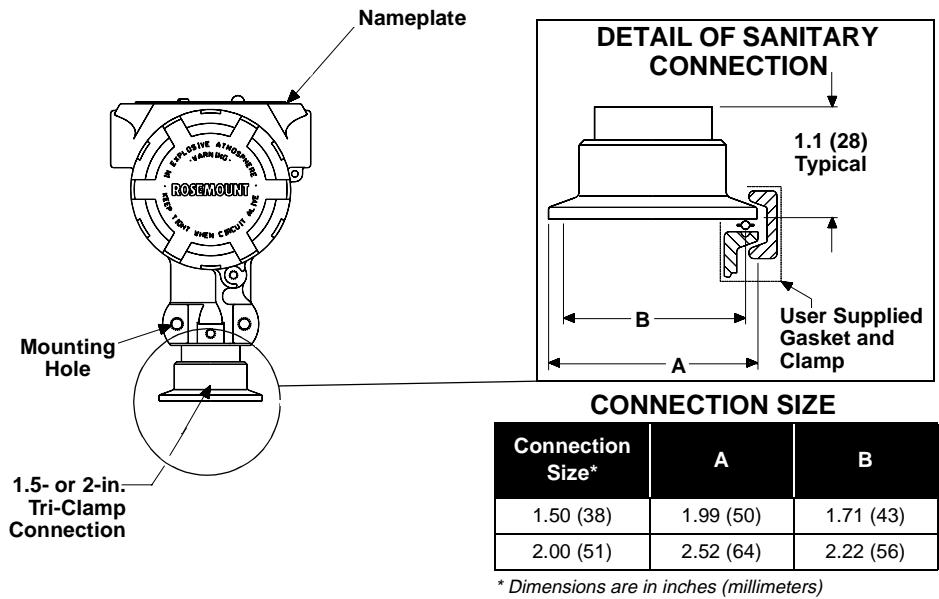
2090-2088E07P, 2088E07B

Model 2090F

 The Model 2090F sanitary pressure transmitter is designed to be installed directly to a sanitary fitting. The transmitter is available with either a 1.5- or 2-inch clamp connection.

When installing the transmitter to the sanitary fitting it is important to use the proper sanitary clamp and gasket (user-supplied). Check the clamp and gasket specifications before installing. Refer to *Standard Sanitary Clamp Models* in Figure 3-8 for a list of standard sanitary clamps, their respective maximum pressure ranges, and the recommended torque to be applied when mounting.

FIGURE 3-8. Model 2090F Mounting Configuration Using a Sanitary Fitting.



STANDARD SANITARY CLAMP MODELS

Clamp Model	psi @ 70 °F (kPa @ 21 °C)	psi @ 250 °F (kPa @ 121 °C)	Recommended Torque
13 MHHM 1.5-inch	450 (3 103)	250 (1 724)	25 in-lb (2.8 N•m)
13 MHHM 2-inch	500 (3 448)	250 (1 724)	
13 MHHS 1.5-inch	600 (4 138)	300 (2 069)	25 in-lb (2.8 N•m)
13 MHHS 2-inch	550 (3 793)	275 (1 896)	
13 MHP 1.5-inch	1500 (10 345)	1200 (8 276)	20 ft-lb (27 N•m)
13 MHP 2-inch	1000 (6 896)	800 (5 517)	

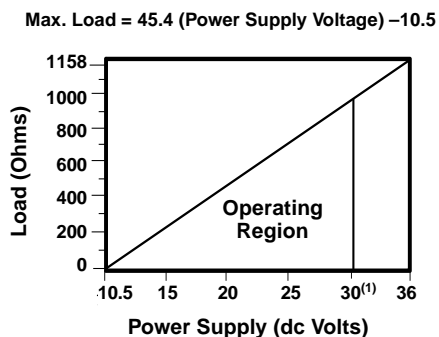
ELECTRICAL CONSIDERATIONS

The wiring terminations on the Models 2088, 2090P, and 2090F are located in the side of the transmitter housing marked “FIELD TERMINALS.” Access to these terminations is required during installation and may be necessary during periodic calibration of the transmitter.

Power Supply

The dc power supply should provide power to the transmitter with less than one percent ripple. The total loop resistance load is the sum of the resistance of the signal wires and the resistance load of the controller, indicator, and other pieces of equipment in the loop. Note that the resistance of intrinsic safety barriers, if used, must be included. Figure 3-9 shows the transmitter power supply load limitations.

FIGURE 3-9. Transmitter Load Limitations.



(1) For CENLEC EX ia Approval, power supply must not exceed 30 volts.

NOTE

Minimum load impedance for Output Code N is 100 kilohms.

2088-0098A

Field Wiring

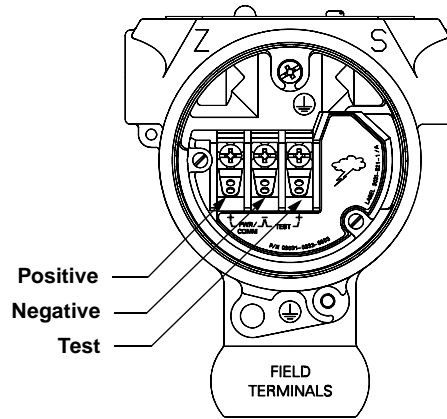
⚠ All power to the transmitter is supplied over the signal wiring. Signal wiring need not be shielded, but use twisted pairs for best results. Do not run unshielded signal wiring in conduit or open trays with power wiring, or near heavy electrical equipment. To power the transmitter, connect the positive power lead to the terminal marked “PWR/COMM+” and the negative power lead to the terminal marked “-” (see Figure 3-10). Tighten the terminal screws to ensure that proper contact is made. Avoid contact with the leads and the terminals. No additional power wiring is required.

⚠ To connect test equipment for monitoring the output of the Model 2088 Smart during maintenance procedures, connect one lead to the terminal labeled “TEST+” and the other lead to the terminal labeled “-” (see Figure 3-10). Avoid contact with the leads and the terminals.

Signal wiring may be grounded at any one point on the measurement loop, or it may be left ungrounded. The negative side of the power supply is a recommended grounding point. The transmitter case may be grounded or left ungrounded.

Conduit connections at the transmitter should be sealed to prevent moisture accumulating in the field terminal side of the transmitter housing. Also, install wiring with a drip loop with the bottom of the drip loop lower than the conduit connection of the transmitter housing.

FIGURE 3-10. Model 2088 Smart Signal Wiring Terminals.



FAILURE MODE AND SECURITY JUMPERS

Failure Mode

As part of normal operation, the Model 2088/2090 Smart Pressure Transmitter continuously monitors its own operation. This automatic diagnostic routine is a timed series of checks repeated continuously. If the diagnostic routine detects a failure in the transmitter, the transmitter drives its output either below or above specific values depending on the position of the failure mode jumper or switch.

The values to which 4–20 mA transmitters drive their output in failure mode depend on whether they are factory-configured to *standard* or *NAMUR-compliant* operation. The values for each are as follows:

Standard Operation

Linear output: $3.9 \leq I \leq 20.8$ mA

Fail low: $I \leq 3.75$ mA

Fail high: $I \geq 21.75$ mA

NAMUR-Compliant Operation (Option Code C4)

Linear output: $3.8 \leq I \leq 20.8$ mA

Fail low: $I \leq 3.6$ mA

Fail high: $21.0 \leq I \leq 23.0$ mA


To determine the failure mode configuration of your transmitter, review the failure mode options using a Model 275 HART Communicator.

NOTE


The failure mode configuration, whether standard or NAMUR-compliant, is configured at the factory and can not be changed in the field.

Jumper Locations

Without a meter installed

 The failure mode alarm jumper is located on the front side of the electronics module just inside the electronics housing cover and is labeled ALARM (See Figure 3-11). Do not remove the transmitter cover in explosive atmospheres when the circuit is alive. Both covers must be fully engaged to meet explosion-proof requirements.

With a meter installed

 The failure mode alarm jumper is located on the LCD faceplate in the electronics module side of the transmitter housing and is labeled ALARM (See Figure 3-11). Do not remove the transmitter cover in explosive atmospheres when the circuit is alive. Both covers must be fully engaged to meet explosion proof requirements.

Transmitter Security

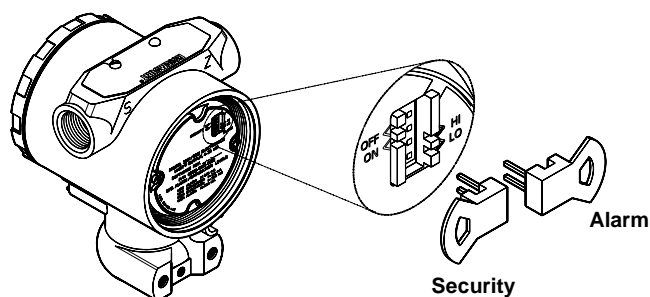
After commissioning the transmitter, you may wish to protect the configuration data from unwarranted changes. The transmitter is equipped with a security jumper that can be positioned to prevent changes to the configuration data (see Figure 3-11). The circuit board is electrostatically sensitive. Observe handling precautions for static-sensitive components to avoid circuit board damage.

When the transmitter security jumper is in the “ON” position, the transmitter will not accept any “writes” to its memory. This means that configuration changes (such as digital trim and reranging) cannot take place when the transmitter security is on. To reposition the jumper, use the following procedure.

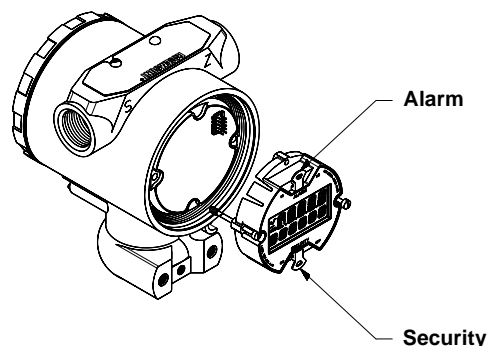
1. If the transmitter is installed, secure the loop, and remove power.
2. Remove the housing cover opposite the field terminal side. Do not remove the instrument cover in explosive atmospheres when the circuit is alive.
3. Reposition the jumper. Avoid contact with the leads and the terminals. Refer to Figure 3-11 for the location of the jumper and the ON and OFF positions.
4. Reattach the transmitter cover. The cover must be fully engaged to comply with explosion-proof requirements.

FIGURE 3-11. Transmitter Alarm and Security Jumper Locations.

Alarm and Security Jumpers Without Meter



Alarm and Security Jumpers With Meter



2088S-2088A05A, 2088A05C

NOTE

If either the alarm or security jumper is dislodged or removed from its position the transmitter reverts to default alarm or security settings of:
Alarm: Output high; Security: Off

ZERO AND SPAN ADJUSTMENTS

The smart Model 2088 is equipped with local zero and span adjustment buttons. The buttons are located on the top of the transmitter beneath the certifications label. Use the zero and span adjustments to set the 4 and 20 mA output points.

Rerange Procedure

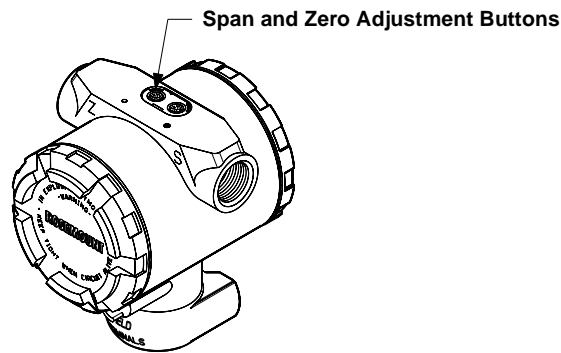
To rerange the transmitter using the span and zero buttons, perform the following procedure.

1. Loosen the screw holding the nameplate on top of the transmitter housing and rotate the nameplate to expose the zero and span buttons (see Figure 3-12).
2. Using a pressure source with an accuracy three to ten times the desired calibrated accuracy, apply a pressure equivalent to the lower range value.
3. To set the 4 mA point, press and hold the zero button for at least two seconds, then verify that the output is 4 mA. If a meter is installed, it will display ZERO PASS.
4. Apply a pressure equivalent to the upper range value.
5. To set the 20 mA point, press and hold the span button for at least two seconds, then verify that the output is 20 mA. If a meter is installed, it will display SPAN PASS.

NOTE

If the transmitter security jumper is in the “ON” position, or if the local zero and span adjustments are disabled through the software, you will not be able to make adjustments to the zero and span using the local buttons. Refer to Figure 3-11 on page 3-13 for the proper placement of the transmitter security jumper.

FIGURE 3-12. Local Zero and Span Adjustments.



2088S-2088A02A

Disabling the Zero and Span Adjustments

After you rerange the transmitter using the span and zero adjustments, you may wish to disable the adjustments to prevent further reranging. To disable the span and zero adjustments, activate the transmitter security jumper (see Transmitter Security on Page 3-13).

NOTE

The transmitter security jumper prevents any changes to the transmitter configuration data. The software lockout sequence only disables the local span and zero adjustment buttons.

Maintenance and Troubleshooting

This section contains the following transmitter maintenance and troubleshooting information:

- Troubleshooting
- Disassembly Procedure
- Reassembly Procedure
- Return of Materials
- Replacement Parts

SAFETY MESSAGES

This section contains procedures that require connecting a communicator to the transmitter, or making connections in an explosive atmosphere. The following safety messages apply to all procedures throughout this section requiring cover removal and communicator or ammeter connection to the transmitter terminal block. Keep the following safety messages in mind whenever you perform an operation requiring cover removal or the connection of a communicator or other device to a measurement loop.

WARNING

The following performance limitations may inhibit efficient or safe operation. Critical applications should have appropriate diagnostic and backup systems in place.

Pressure transmitters contain an internal fill fluid. It is used to transmit the process pressure through the isolating diaphragms to the pressure sensing element. In rare cases, oil leak paths in oil-filled pressure transmitters can be created. Possible causes include: physical damage to the isolator diaphragms, process fluid freezing, isolator corrosion due to an incompatible process fluid, etc.

A transmitter with an oil fill fluid leak can continue to perform normally for a period of time. Sustained oil loss will eventually cause one or more of the operating parameters to exceed published specifications while a small drift in operating point output continues. Symptoms of advanced oil loss and other unrelated problems include:

- Sustained drift rate in true zero and span or operating point output or both.
- Sluggish response to increasing or decreasing pressure or both.
- Limited output rate or very nonlinear output or both.
- Change in output process noise.
- Noticeable drift in operating point output.
- Abrupt increase in drift rate of true zero or span or both.
- Unstable output.
- Output saturated high or low.

⚠ WARNING

Unauthorized procedures or parts can affect product performance and the output signal used to control a process, and can cause death or serious injury. Use only the procedures and new parts specifically referenced in this manual. Direct any questions concerning these procedures or parts to Rosemount Inc.

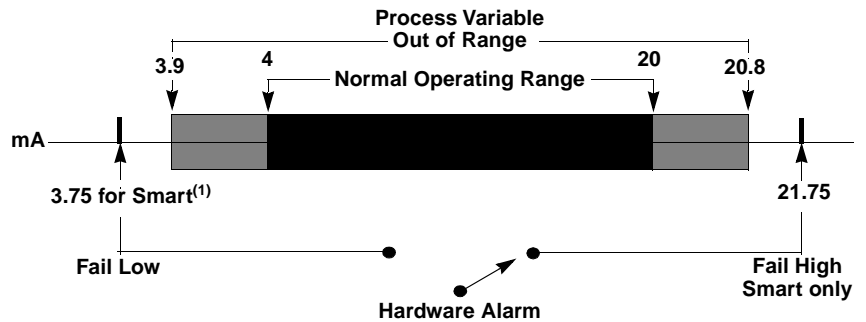
⚠ WARNING

Explosions can result in death or serious injury. Do not remove the instrument cover in explosive environments while power is supplied to transmitter.

⚠ WARNING

Mishandling products exposed to a hazardous substance can cause death or serious injury. If the product being returned was exposed to a hazardous substance as defined by OSHA, a copy of the required Material Safety Data Sheet (MSDS) for each hazardous substance identified must be included with the returned goods.

FIGURE 4-1. Range of Output.



(1) Failure mode for output code M is $\leq 1V$.
 (2) Above Values are for Standard Failure Mode. NAMUR compliant values are different than above.

TROUBLESHOOTING

TABLE 4-1. Smart Transmitter Troubleshooting and Corrective Actions.

Symptom	Potential Source	Corrective Action
High Output	Impulse Piping,	<ul style="list-style-type: none"> • Check for blockage in the impulse line. • Check to ensure that the blocking valve is fully open. • Check for trapped gas in a liquid line, or trapped liquid in a gas line. • Check to ensure that the density of the fluid in the impulse line is unchanged. • Check for sediment in the transmitter process connection. If you find sediment, flush the process connection clean with water or an appropriate solvent. Do not attempt to scrape sediment free; doing so could puncture the thin isolating diaphragm and destroy the transmitter. • Check for frozen process fluid in the process connector.
	Electronics	<ul style="list-style-type: none"> • Check test equipment. • Perform full sensor trim.
	Power Supply	<ul style="list-style-type: none"> • Check the output voltage of the power supply at the transmitter.⁽¹⁾
	Other Components	<ul style="list-style-type: none"> • Replace the transmitter.
Erratic Output	Impulse Piping	<ul style="list-style-type: none"> • Check for leaks or blockage in the impulse line. • Check to ensure that the blocking valve is fully open. • Check for trapped gas in a liquid line, or trapped liquid in a gas line. • Check to ensure that the density of the fluid in the impulse line is unchanged. • Check for sediment in the transmitter process connection. If you find sediment, flush the process connection clean with water or an appropriate solvent. • Check for frozen process fluid in the process connector. • Check for trapped gas in a liquid line, or trapped liquid in a gas line.
	Loop Wiring	<ul style="list-style-type: none"> • Check for adequate voltage to the transmitter.⁽¹⁾ • Check for intermittent shorts, open circuits, and multiple grounds.
	Electronics	<ul style="list-style-type: none"> • Check for EMF interference. • Check damping. • Replace the output board and recalibrate the transmitter.
	Other Components	<ul style="list-style-type: none"> • Replace the transmitter.
Low Output or No Output	Impulse Piping	<ul style="list-style-type: none"> • Check for leaks or blockage in the impulse line. • Check to ensure that the blocking valve is fully open. • Check for trapped gas in a liquid line, or trapped liquid in a gas line. • Check to ensure that the density of the fluid in the impulse line is unchanged. • Check for sediment in the transmitter process connection. If you find sediment, flush the process connection clean with water or an appropriate solvent. Do not attempt to scrape sediment free; doing so could puncture the thin isolating diaphragm and destroy the transmitter. • Check for frozen process fluid in the process connector.
Low Output or No Output	Loop Wiring	<ul style="list-style-type: none"> • Check test equipment. • Check for adequate voltage to the transmitter.⁽¹⁾ • Check the current rating of the power supply against the total current being drawn by all transmitters being powered. • Check for intermittent shorts, open circuits, and multiple grounds. • Check for proper polarity at the signal terminals. • Check the loop impedance.
	Electronics	<ul style="list-style-type: none"> • Replace the electronics board and recalibrate the transmitter.
	Other Components	<ul style="list-style-type: none"> • Replace the transmitter.

(1) A transmitter with Output Code S should have 10.5–36.0 V dc with no load at the terminals; A transmitter with Output Code M should have 6.0–14.0 V dc.

TABLE 4-2. Analog Transmitter Troubleshooting Symptoms and Corrective Actions.

Symptom	Potential Source	Corrective Action
High Output	Impulse Piping	<ul style="list-style-type: none"> • Check for blockage in the impulse line. • Check to ensure that the blocking valve is fully open. • Check for trapped gas in a liquid line, or trapped liquid in a gas line. • Check to ensure that the density of the fluid in the impulse line is unchanged. • Check for sediment in the transmitter process connection. If you find sediment, flush the process connection clean with water or an appropriate solvent. Do not attempt to scrape sediment free; doing so could puncture the thin isolating diaphragm and destroy the transmitter. • Check for frozen process fluid in the process connector.
	Power Supply	<ul style="list-style-type: none"> • Check the output voltage of the power supply at the transmitter.⁽¹⁾
	Output Electronics	<ul style="list-style-type: none"> • Replace the output board and recalibrate the transmitter.
	Other Components	<ul style="list-style-type: none"> • Replace the transmitter.
Symptom	Potential Source	Corrective Action
Erratic Output	Impulse Piping	<ul style="list-style-type: none"> • Check for leaks or blockage in the impulse line. • Check to ensure that the blocking valve is fully open. • Check for trapped gas in a liquid line, or trapped liquid in a gas line. • Check to ensure that the density of the fluid in the impulse line is unchanged. • Check for sediment in the transmitter process connection. If you find sediment, flush the process connection clean with water or an appropriate solvent. • Check for frozen process fluid in the process connector. • Check for trapped gas in a liquid line, or trapped liquid in a gas line.
	Loop Wiring	<ul style="list-style-type: none"> • Check for adequate voltage to the transmitter.⁽¹⁾ • Check for intermittent shorts, open circuits, and multiple grounds.
	Output Electronics	<ul style="list-style-type: none"> • Replace the output board and recalibrate the transmitter.
	Other Components	<ul style="list-style-type: none"> • Replace the transmitter.
Low Output or No Output	Impulse Piping	<ul style="list-style-type: none"> • Check for leaks or blockage in the impulse line. • Check to ensure that the blocking valve is fully open. • Check for trapped gas in a liquid line, or trapped liquid in a gas line. • Check to ensure that the density of the fluid in the impulse line is unchanged. • Check for sediment in the transmitter process connection. If you find sediment, flush the process connection clean with water or an appropriate solvent. Do not attempt to scrape sediment free; doing so could puncture the thin isolating diaphragm and destroy the transmitter. • Check for frozen process fluid in the process connector.
	Loop Wiring	<ul style="list-style-type: none"> • Check for adequate voltage to the transmitter.⁽¹⁾ • Check the current rating of the power supply against the total current being drawn by all transmitters being powered. • Check for intermittent shorts, open circuits, and multiple grounds. • Check for proper polarity at the signal terminals. • Check the loop impedance.
	Output Electronics	<ul style="list-style-type: none"> • Replace the output board and recalibrate the transmitter.
	Other Components	<ul style="list-style-type: none"> • Replace the transmitter.

(1) A transmitter with Output Code A should have 10.5–36.0 V dc with no load at the terminals; A transmitter with Output Code M should have 6.0–14.0 V dc.

DOWNSCALE ALARM

Models 2088, 2090P, and 2090F transmitters can identify certain types of failure conditions. These failures may arise from four possible sources:

1. No updated information is being received by the microprocessor from the sensor.
2. The sensor is damaged.
3. Calibration information for zero and span is not being stored correctly within the memory of the microprocessor.
4. Microprocessor malfunction.

If the transmitter experiences failure conditions, it drives the output below the lower output limit (less than 3.75 mA for Output Code S; less than 1 V for Output code M), and if a local indicator is installed, it displays “FAIL.” If the transmitter encounters the first or second condition it locks the output at the lower limit. If the transmitter encounters the third condition it locks the output at the lower limit after the switch is turned to the “RUN” position.

If you experience downscale alarm, momentarily interrupt power to the transmitter. After re-applying power, attempt to reset the calibration point that caused the failure. If the transmitter does not accept the set value after repeated attempts, the microprocessor board is probably inoperable. Check the operation of the microprocessor board by eliminating other sources of low output (i.e. blocked impulse piping). Remove the output board for spare parts and replace the transmitter.

DISASSEMBLY PROCEDURE



You can easily repair the Models 2088, 2090P, and 2090F Pressure Transmitters in the event of a malfunction in the output stage of the transmitter electronics.

To remove the output circuit board use the following procedure:

CAUTION

Disconnect power to the transmitter before removing the output board. Failure to follow this procedure could result in permanent damage to the transmitter electronics.

1. Remove the cover from the electronics side of the transmitter housing.
2. Loosen the two captive screws that hold the output board in place.
3. Carefully remove the output board from the multi-pin connector and the power leads.

REASSEMBLY PROCEDURE

To replace the output circuit board use the following procedure:

CAUTION


The circuit board is electrostatically sensitive. To prevent damage to the circuit board, observe handling precautions for static-sensitive components.

1. Align the two long power leads on the transmitter electronics board with the power receptacles on the output board. Gently insert the power leads into the receptacles.
2. Align the multi-pin connector on the output board with the receptacles on the transmitter electronics board. Gently insert the multi-pin connector into the receptacles.
3. Push the board firmly into position and tighten the screws.

To view an exploded view, see Figure 5-1 on page 5-7.



**RETURNING ROSEMOUNT
PRODUCTS AND/OR
MATERIALS**

 To expedite the return process outside the United States, contact the nearest Rosemount representative.

Within the United States, call the Rosemount National Response Center using the 1-800-654-RSMT (7768) toll-free number. This center, available 24 hours a day, will assist you with any needed information or materials.

The center will ask for product model and serial numbers, and will provide a Return Material Authorization (RMA) number. The center will also ask for a description of the process material to which the product was last exposed.

The Rosemount National Response Center will detail the additional information and procedures necessary to return goods exposed to hazardous substances.

Specifications and Reference Data

OVERVIEW

This section contains the following transmitter specifications and reference data:

- Model 2088, Model 2090P, and Model 2090F
 - Functional Specifications
 - Performance Specifications
 - Physical Specifications
- Spare Parts
- Ordering Information

FUNCTIONAL SPECIFICATIONS

Service

Model 2088

Liquid, gas, and vapor applications.

Model 2090P

Liquid, gas, vapor, and high-viscosity applications.

Model 2090F

Liquid, gas, vapor, and sanitary applications.

Ranges for Model 2088

Range	Minimum Span (Smart)	URL/Max.span/Sensor Limit
1	1.5 psi (103 mbar)	30 psi (2,06 bar)
2	7.5 psi (517 mbar)	150 psi (10,34 bar)
3	40 psi (2,76 bar)	800 psi (55,15 bar)
4	200 psi (13,8 bar)	4000 psi (275,79 bar)

Ranges for Model 2090F

Range	Minimum Span (Smart)	URL/Max.span/Sensor Limit
1	1.5 psi (103 mbar)	30 psi (2,06 bar)
2	7.5 psi (517 mbar)	150 psi (10,34 bar)
3	40 psi (2,76 bar)	300 psi (20,68 bar)

Ranges for Model 2090P

Range	Minimum Span (Smart)	URL/Max.span/Sensor Limit
1	1.5 psi (103 mbar)	30 psi (2,06 bar)
2	7.5 psi (517 mbar)	150 psi (10,34 bar)
3	40 psi (2,76 bar)	300 psi (20,68 bar)

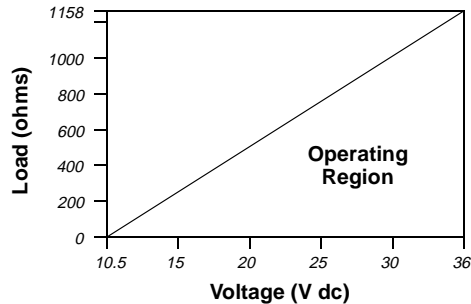
Output

Code S: 4–20 mA dc.

Load Limitations⁽¹⁾

Maximum loop resistance is determined by the power supply voltage, as described by:

$$\text{Max. Loop Resistance} = 45.4 \times (\text{Power Supply Voltage} - 10.5)$$



Note: Communication requires minimum loop resistance: 250 ohm:

Power Supply

External power supply⁽²⁾ required. Transmitter operates on 10.5–36 V dc with no load. Reverse polarity protection is standard.

Zero Elevation and Suppression

Zero can be suppressed between atmosphere for gage transmitters, or 0 psia for absolute transmitters, and upper range limit, provided the calibrated span is equal to or greater than the minimum span, and the upper range value does not exceed the upper range limit. Vacuum calibrations are allowed on the Model 2088G transmitter with compound range option (CR).

Overpressure Limits

Ranges 0 and 1: 120 psig max.
All other ranges: twice the upper range limit.

Temperature Limits

Process

- Model 2088 Silicone fill sensor: –40 to 250 °F (–40 to 121 °C).
 Inert fill sensor: –22 to 250 °F (–30 to 121 °C).
- Model 2090P –4 to 250 °F (–20 to 121 °C).
- Model 2090F –4 to 284 °F (–20 to 140 °C).

Ambient:

- Model 2088 –40 to 185 °F (–40 to 85 °C).
 –4 to 175 °F (–20 to 80 °C) with LCD meter.
- Model 2090P –4 to 185 °F (–20 to 85 °C).
- Model 2090F –4 to 185 °F (–20 to 85 °C).

Storage:

- Model 2088 –50 to 230 °F (–46 to 110 °C).
 –40 to 185 °F (–40 to 85 °C) with LCD meter.
- Model 2090P –50 to 185 °F (–45 to 85 °C).
- Model 2090F –22 to 185 °F (–30 to 85 °C).

(1) Minimum load impedance for Output Code M is 100 kilohms.
(2) For CENELEC Ex ia approval, the power supply must not exceed 30 volts.

Process temperatures above 185 °F (85 °C) require derating the ambient limits:

$$\text{Maximum Ambient Temperature in } ^\circ\text{F} = 185 - \frac{(\text{Process Temp} - 185)}{1.5}$$

$$\text{Maximum Ambient Temperature in } ^\circ\text{C} = 85 - \frac{(\text{Process Temp} - 85)}{1.5}$$

Humidity Limits

0–100% relative humidity.

Volumetric Displacement

Less than 0.00042 cm³.

Turn-on Time

Output Code S

2.0 seconds, no warm-up required.

Failure Mode

Output Code S

If self-diagnostics detect a sensor or microprocessor failure, the analog signal is driven either high or low to alert the user. High or low failure mode is user-selectable with a jumper on the transmitter. The values to which the transmitter drives its output in failure mode depend on whether it is factory-configured to *standard* or *NAMUR-compliant* operation. The values for each are as follows:

Standard Operation

Linear Output: $3.9 \leq I \leq 20.8$

Fail High: $I \geq 21.75 \text{ mA}$

Low: $I \leq 3.75 \text{ mA}$

NAMUR-Compliant Operation (Option Code C4)

Linear Output: $3.8 \leq I \leq 20.5$

Fail High: $I \geq 22.5 \text{ mA}$

Low: $I \leq 3.6 \text{ mA}$

PERFORMANCE SPECIFICATIONS

(Zero-based spans, reference conditions, and 316 SST isolating diaphragm.)

Reference Accuracy

Output Code S

±0.20% of calibrated span. Includes combined effects of linearity, hysteresis, and repeatability.

Ambient Temperature Effect

Expressed as a total effect per 100 °F (56 °C).

Output Code S

± (0.3% URL + 0.3% of span) from –40 to 185 °F (–40 to 85 °C).

Stability

Output Code S

±0.10% of upper range limit for 12 months.

Vibration Effect

Less than ±0.1% of upper range limit when subjected to vibration of: peak to peak constant displacement of 4 mm (5–15 Hz) and constant acceleration of 2 g (15–150 Hz) and 1 g (150–2000 Hz).

Power Supply Effect

Less than 0.01% of calibrated span per volt.

Mounting Position Effect

Zero shift of up to 1.2 inH₂O (3 mbar), which can be calibrated out. No span effect.

RFI Effect

Less than $\pm 0.25\%$ of upper range limit from 20–1000 MHz at 30 V/m with leads in conduit. Less than $\pm 0.25\%$ of upper range limit at 10 V/m with unshielded twisted pair (no conduit).

Transient Protection Limits

IEEE 587 Category B

6 kV Crest ($1.2 \times 50 \mu\text{s}$).

3 kV Crest ($8 \times 20 \mu\text{s}$).

6 kV Crest ($0.5 \mu\text{s}$ by 100 kHz).

IEEE 472

SWC 2.5 kV Crest.

1 MHz waveform.

General Specifications

Tested to IEC 801-3.

Ordinary Location Certification

Factory Mutual (FM) Approval

As standard, the transmitter has been examined and tested to determine that the design meets basic electrical, mechanical, and fire protection requirements by FM, a nationally recognized testing laboratory (NRTL) as accredited by the Federal Occupational Safety and Health Administration (OSHA).

Hazardous Locations Certifications

Factory Mutual (FM) Approvals

- E5** Explosion Proof for Class I, Division 1, Groups B, C, and D.
Dust-Ignition Proof for Class II, Division 1, Groups E, F, and G.
Suitable for Class III, Division 1, indoor and outdoor (NEMA 4X) hazardous locations; factory sealed.
- I5** Intrinsically safe for use in Class I, Division 1, Groups A, B, C, D; Class II, Division 1, Groups E, F, and G; and Class III, Division 1 when connected in accordance with Rosemount drawing 02088-1018. Non-incendive for Class I, Division 2, Groups A, B, C, and D.

Canadian Standards Association (CSA) Approvals

- C6** Explosion Proof for Class I, Division 1, Groups B, C, and D.
Dust-Ignition Proof for Class II, Division 1, Groups E, F, and G.
Suitable for Class III, indoor and outdoor hazardous locations, CSA enclosure Type 4X; factory sealed. Approved for Class I, Division 2, Groups A, B, C, and D.

Intrinsically Safe for Class I, Division 1, Groups A, B, C, and D.
Temp. Code T3C. Intrinsically safe when connected with approved barriers in accordance with Rosemount drawing 02088-1024.

CENELEC Flameproof Approvals

- E8** Centro Elettrotecnico Sperimentale Italiano (CESI) Flameproof Approval (*Analog only*)
Certification Number Ex 91C120.
EEx d IIC T4 ($T_{\text{amb}} = 80 \text{ }^\circ\text{C}$)
EEx d IIC T6 ($T_{\text{amb}} = 40 \text{ }^\circ\text{C}$).
- ED** KEMA/CENELEC 97 ATEX 2378 (*Smart only*)
EEx d IIC T4 ($T_{\text{amb}} = 80 \text{ }^\circ\text{C}$)
EEx d IIC T6 ($T_{\text{amb}} = 40 \text{ }^\circ\text{C}$).

British Approvals Service for Electrical Equipment in Flammable Atmospheres (BASEEFA) Approvals**I1** BASEEFA/CENELEC Intrinsic Safety

Ex 90C2158 for analog transmitters

Ex97D2276X for smart transmitters.

EEx ia IIC T5 ($T_{amb} = 40\text{ }^{\circ}\text{C}$).EEx ia IIC T4 ($T_{amb} = 70\text{ }^{\circ}\text{C}$).**N1** BASEEFA Type N Certification

Ex 90Y4159 for analog transmitters

Ex 97Y4277X for smart transmitters.

Ex N IIC T5 ($T_{amb} = 70\text{ }^{\circ}\text{C}$).**Standards Association of Australia (SAA)****Explosion Proof (Flameproof) Certification****E7** Ex d IIC T6 ($T_{amb} = 40\text{ }^{\circ}\text{C}$) (Available with analog output, Code A, only.)**I7** Ex ia IIC T6. (Available with analog output, Code A, only.)Ex ia IIC T4 ($T_{amb} = 70\text{ }^{\circ}\text{C}$).**Combinations of Approvals****K5** Combination of E5 and I5**K6** Analog: Combination of C6, I1, and E8.

SMART: Combination of C6, I1, and ED.

**PHYSICAL
SPECIFICATIONS****Electrical Connection** $\frac{1}{2}$ -14 NPT, M20 \times 1.5 (CM20), PG 13.5, or G $\frac{1}{2}$ female (PF $\frac{1}{2}$ female) conduit entry.**Process Connection****Model 2088** $\frac{1}{2}$ -14 NPT female, DIN 16288 G $\frac{1}{2}$ male, RC $\frac{1}{2}$ female (PT $\frac{1}{2}$ female), M20 \times 1.5 (CM20) male.**Model 2090P**M44 \times 1.25 male, compatible with a 1-in. PMC[®] process connection.**Model 2090F**1 $\frac{1}{2}$ -inch or 2-inch Tri-Clamp Connection**Process Wetted Parts****Isolating Diaphragm****Model 2088** 316L stainless steel or Hastelloy.**Model 2090P** 316L stainless steel.**Model 2090F** 316L stainless steel.**Process Connector****Model 2088** 316L stainless steel or Hastelloy.**Model 2090P** 316L stainless steel.
TFE process connector gasket.**Model 2090F** 316L stainless steel.**Non-wetted Parts****Electronics Housing**

Low-copper aluminum, NEMA 4X, IP65, IP67, CSA enclosure Type 4X.

Paint

Polyurethane.

Cover O-rings

Buna-N.

Fill Fluid

Model 2088 Silicone or inert fill.

Model 2090P Silicone

Model 2090F Neobee

Weight

Model 2088 Approximately 2.44 lb (1,11 kg).

Model 2090P Approximately 2.96 lb (1,34 kg).

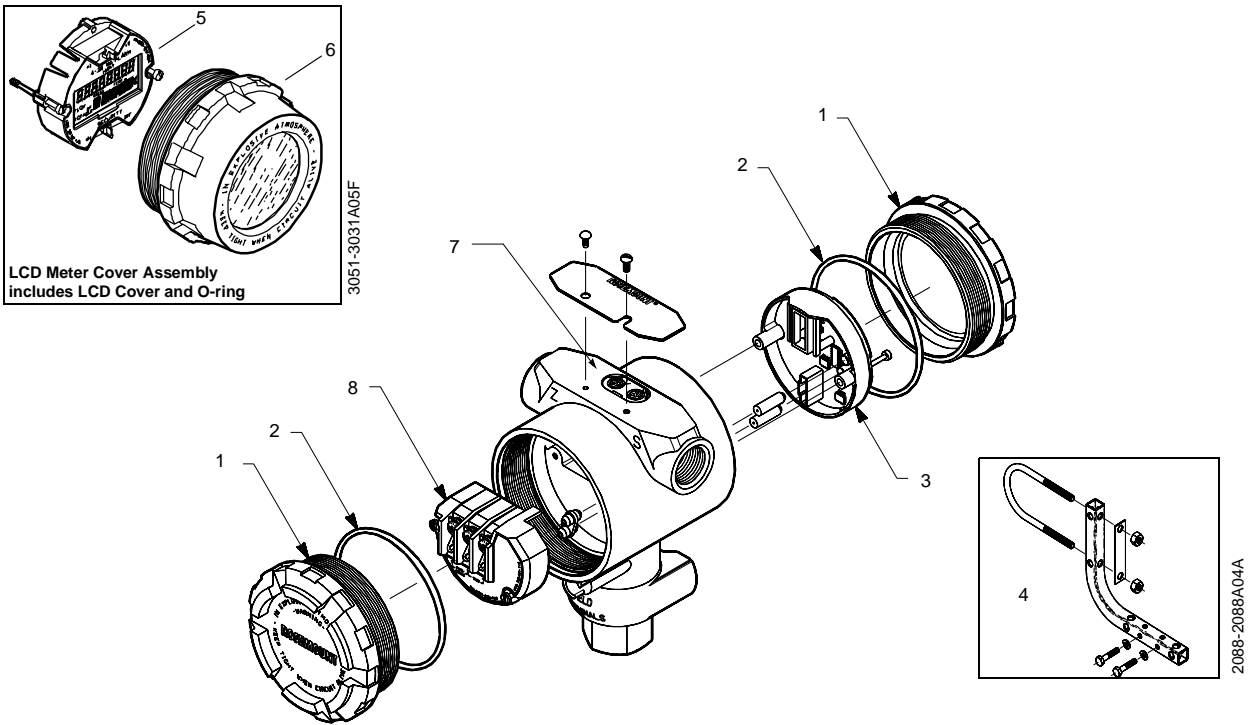
Model 2090F Approximately 2.74 lb (1,24 kg).

Accessory Block and Bleed Valve (S5 Option)

For information on Model 306 Integral Manifold (pre-assembled to transmitter and leak checked), refer to Product Data Sheet 00813-0100-4733.

SPARE PARTS

FIGURE 5-1. Replacement Parts for the Model 2088 Smart Transmitter.

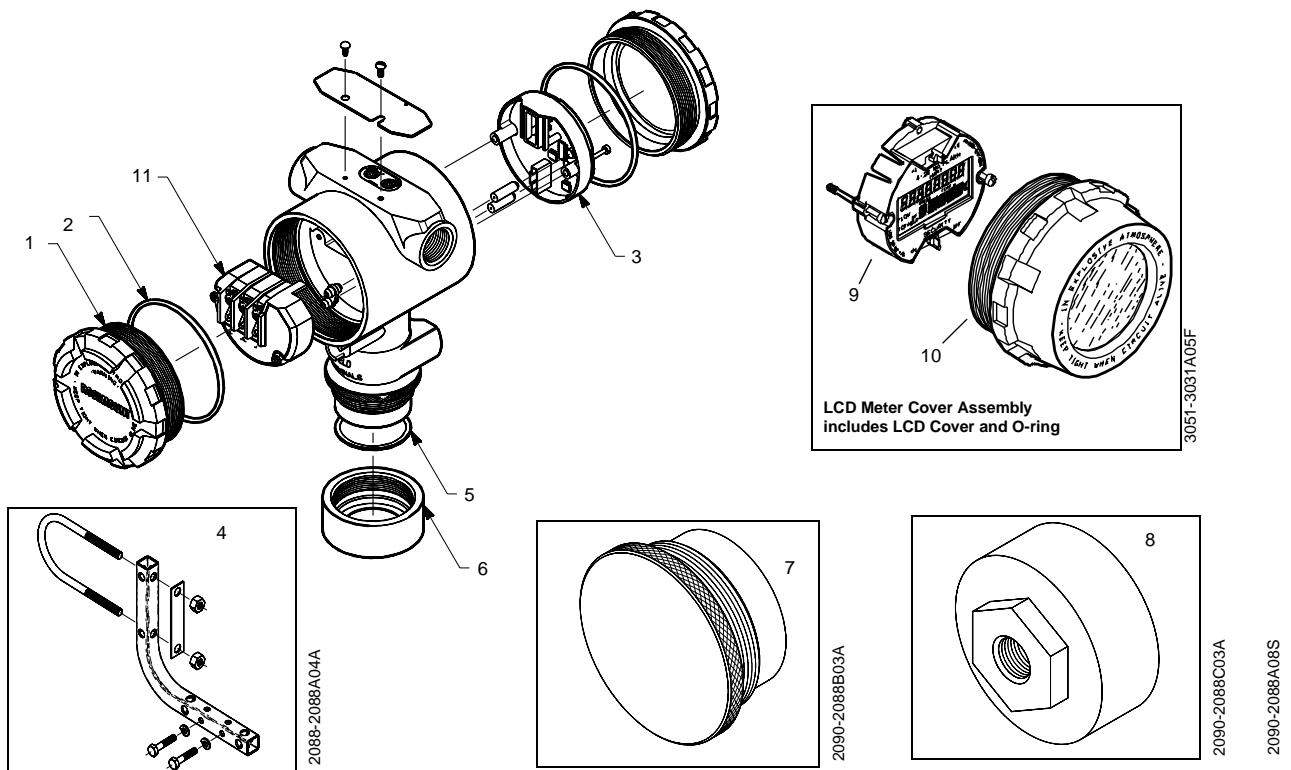


Item No.	Part Description	Part Number	Spares Category ⁽¹⁾
1, 2	Smart Transmitters (Output Code S) Electronics Cover (with O-ring)	03031-0292-0001	—
6	LCD Meter Cover Assembly	03031-0193-0002	B
2	Cover O-rings	03031-0232-0001	B
3	Electronics Board Kits S Output (4–20 mA/Digital HART Protocol)	02088-0306-0002	A
3	S Output (NAMUR Compliant Operation)	02088-0306-0003	A
4	Optional Mounting Bracket (with 2-inch U-Bolt for Pipe Mounting)	02088-0071-0001	—
5, 6	LCD Meter Kit with Cover	03031-0193-0101	—
5	LCD Meter Kit without Cover	03031-0193-0103	A
7	Local Zero and Span Kit	3031-0293-0002	A
8	Standard Terminal Block	3031-0332-0003	B
8	Transient Protection Block	3031-0332-0004	B

(1) One spare part is recommended for every 25 transmitters in category A, and one spare part for every 50 transmitters in category B.

Rosemount Model 2088/2090 Pressure Transmitters

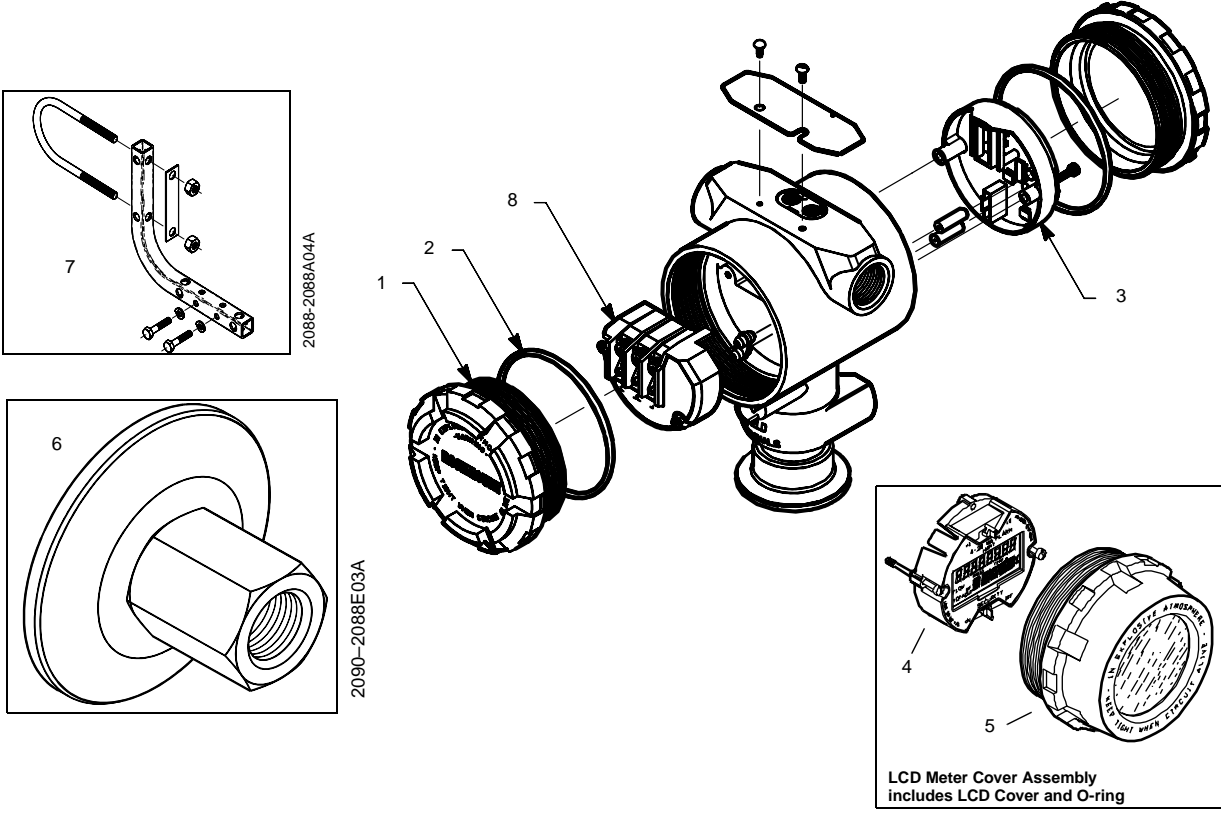
FIGURE 5-2. Replacement Parts for the Model 2090P.



Item No.	Part Description	Part Number	Category ⁽¹⁾
1,2	Smart Transmitters (Output Code S) Electronics Cover (with O-ring)	03031-0292-0001	—
10	LCD Meter Cover Assembly	03031-0193-0002	B
2	Cover O-rings	03031-0232-0001	B
3	Electronics Boards S Output (4–20 mA/Digital HART Protocol)	02088-0306-0002	A
3	S Output (NAMUR Compliant Operation)	02088-0306-0003	A
4	Optional Mounting Bracket (with 2-inch U-Bolt for Pipe Mounting)	02088-0071-0001	—
9, 10	LCD Meter Kit with Cover	03031-0193-0101	—
9	LCD Meter Kit without Cover	03031-0193-0103	A
8	Calibration Adapter	02088-0197-0001	A
5	Teflon Gaskets (package of 12)	02088-0078-0001	A
6	316 SST Weld Spud with Heat Isolator Groove	02088-0295-0003	—
6	316 SST Weld Spud	02088-0195-0001	—
7	316 SST Plug/Heat Sink	02088-0196-0001	A
11	Standard Terminal Block	03031-0332-0003	B
11	Transient Terminal Block	03031-0332-0004	B

(1) One spare part is recommended for every 25 transmitters in category A, and one spare part for every 50 transmitters in category B.

FIGURE 5-3. Replacement Parts for the Model 2090F.



Item No.	Part Description	Part Number	Category ⁽¹⁾
1	Smart Transmitters (Output Code S) Electronics Cover (with O-ring)	03031-0292-0001	—
5	LCD Meter Cover Assembly	03031-0193-0002	B
2	O-rings	03031-0232-0001	B
3	Electronics Boards S Output (4–20 mA/Digital HART Protocol)	02088-0306-0002	A
3	S Output (NAMUR Compliant Operation)	02088-0306-0003	A
7	Optional Mounting Bracket (with 2-inch U-Bolt for Pipe Mounting)	02088-0071-0001	—
4, 5	LCD Meter Kit with Cover	03031-0193-0101	—
4	LCD Meter Kit without Cover	03031-0193-0103	A
6	Calibration Adapter, 1½ inch	02088-0197-0011	A
6	Calibration Adapter, 2 inch	02088-0197-0012	A
8	Standard Terminal Block	03031-0332-0003	B
8	Transient Terminal Block	03031-0332-0004	B

(1) One spare part is recommended for every 25 transmitters in category A, and one spare part for every 50 transmitters in category B.

NOTE: Sanitary clamp and gasket to be supplied by user.

ORDERING INFORMATION

TABLE 5-1. Model 2088 Typical Model Structure.

Model	Product Description (Select One)		
2088A	Absolute Pressure Transmitter		
2088G	Gage Pressure Transmitter		
Code	Range	Rangeability	
0 ⁽¹⁾	0–8 psi (0–6,89 to 0–552 mbar) Low power only	Output Code	Min.Span
1	0–30 psi (0–2 bar)	S	URL/20
2	0–150 psi (0–10,3 bar)	M	URL/10
3	0–800 psi (0–55,15 bar)		
4	0–4000 psi (0–275,8 bar)		
Code	Output		
M	1–5 V dc Low Power		
S	4–20 mA dc/Digital HART Protocol		
MATERIALS OF CONSTRUCTION			
Code	Process Connection	Isolating Diaphragm	Oil Fill
22 ⁽²⁾	316 SST	316 SST	Silicone
33 ⁽²⁾	Hastelloy C-276	Hastelloy C-276	Silicone
2B ⁽²⁾	316 SST	316 SST	Inert ⁽³⁾
3C ⁽²⁾	Hastelloy C-276	Hastelloy C-276	Inert
Code	Process Connection		
A	½–14 NPT Female		
B	DIN 16288 G ½ Male		
C	RC ½ Female (PT ½ Female)		
D	M20 x 1.5 (CM20)		
Code	Conduit Thread		
1	½–14 NPT		
2	M20 x 1.5 (CM20)		
3	PG 13.5		
4	G ½ Female (PF ½ Female)		
Code	Remote Seal Connection		
S1	One Remote Seal (Select from Product Data Sheet 00813-0100-4016)		
Code	Options ⁽⁴⁾		
M5	LCD Meter, scaled 0–100%		
M7	LCD Meter, special configuration		
B4	SST Mounting Bracket with SST Bolts		
S5	Assembly to Model 306 Integral Manifold (see PDS 00813-0100-4733 for ordering information)		
S1	One Diaphragm Seal (Select from Product Data Sheet 00813-0100-4016)		
C6	CSA Explosion-Proof, Intrinsic Safety, and Non-Incendive Approval		
I1	BASEEFA EEx ia IIC T5 (CENELEC) Intrinsic Safety Approval (Entity Concept)		
N1	BASEEFA Type N EX N IIC T5		
E4 ⁽⁴⁾	JIS Explosion-Proof Approval		
E5	FM Explosion-Proof Approval		
E7 ⁽⁴⁾	SAA Flame-Proof Certification		
E8	CESI/CENELEC Explosion-Proof Approval (available with analog output, Code A, only)		
ED	KEMA/CENELEC Explosion-Proof Approval (available with smart output, Code S, only)		
I5	FM Non-Incendive and Intrinsic Safety Approval (Entity Concept)		
I7 ⁽⁴⁾	SAA Intrinsic Safety Certification		
K5	E5 and I5 Combination		
K6	CSA/CENELEC Explosion-Proof and Intrinsic Safety Approval		
N7 ⁽⁴⁾	SAA Non-Incendive Certification		
P2	Cleaning for Special Service		
Q4	Calibration Data Sheet		
Q8	Material Traceability per DIN 3.1B		
T1	Transient Protection Terminal Block		
C4	Analog Output Levels Compliant with NAMUR Recommendation NE43, 27-June-1996 (Available with Output Code S only) <i>NOTE: NAMUR-Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.</i>		
CN	Analog Output Levels Compliant with NAMUR Recommendation NE43, 27-June-1996: Low Alarm Configuration <i>NOTE: NAMUR-Compliant operation is pre-set at the factory and cannot be changed to standard operation in the field.</i>		
C9	Software Configuration (Available with Output Code S only)		
Typical Model Number: 2088G 1 S 22 A 1			

(1) Range 0 is only available with low power output, 8 to 1 rangedown, stainless steel wetted parts and silicone oil fill fluid.

(2) Meets NACE material recommendations.

(3) Inert fill fluid not available with range 0 transmitters.

(4) Hazardous locations approvals not available for Model 2088 Smart Transmitter (Output Code S).

TABLE 5-2. Model 2090P Typical Model Structure.

Model	Product Description (Select One)		
2090PA	Absolute Pressure Transmitter		
2090PG	Gage Pressure Transmitter		
Code	Range	Rangeability	
1	0–30 psi (0–2 bar)	Output Code	Min.Span
2	0–150 psi (0–10,3 bar)	S	URL/20
3 ⁽¹⁾	0–300 psi (0–20,7 bar)		
Code	Output		
S	4–20 mA dc/Digital HART Protocol		
MATERIALS OF CONSTRUCTION			
Code	Process Connection	Isolating Diaphragm	Oil Fill
22	316 SST	316 SST	Silicone
Code	Process Connection		
A	No Weld Spud, includes <i>Teflon</i> Gasket		
B	316 SST Weld Spud, <i>Teflon</i> Gasket		
C	316 SST Weld Spud with Heat Isolator Groove		
Code	Conduit Thread		
1	½–14 NPT		
2	M20 x 1.5 (CM20)		
3	PG 13.5		
Code	Options		
M5	LCD Meter, scaled 0–100%		
M7	LCD Meter, special configuration		
B4	SST Mounting Bracket with SST Bolts		
S5	Assembly to Model 306 Integral Manifold (see PDS 00813-0100-4733 for ordering information)		
C6	CSA Explosion-Proof, Intrinsic Safety, and Non-Incendive Approval		
I1	BASEEFA EEx ia IIC T5 (CENELEC) Intrinsic Safety Approval (Entity Concept)		
N1	BASEEFA Type N EX N IIC T5		
E5	FM Explosion-Proof Approval		
E8	CESI/CENELEC Explosion-Proof Approval (available with analog output, Code A, only)		
ED	KEMA/CENELEC Explosion-Proof Approval (available with smart output, Code S, only)		
I5	FM Non-Incendive and Intrinsic Safety Approval (Entity Concept)		
K5	E5 and I5 Combination		
K6	CSA/CENELEC Explosion-Proof and Intrinsic Safety Approval		
P2	Cleaning for Special Service		
Q4	Calibration Data Sheet		
Q8	Material Traceability per DIN 3.1B		
T1	Transient Protection Terminal Block		
Typical Model Number: 2090PG 2 S 22 B 1			

(1) Range 3 minimum span: 0–40 psi.

Rosemount Model 2088/2090 Pressure Transmitters

TABLE 5-3. Model 2090F Typical Model Structure.

Model	Product Description (Select One)		
2090FA	Sanitary Absolute Pressure Transmitter		
2090FG	Sanitary Gage Pressure Transmitter		
Code	Range	Rangeability	
1	0–30 psi (0–2 bar)	Output Code	Min.Span
2	0–150 psi (0–10,3 bar)	S	URL/20
3 ⁽¹⁾	0–300 psi (0–20,7 bar)		
Code	Output		
S	4–20 mA dc/Digital HART Protocol		
MATERIALS OF CONSTRUCTION			
Code	Process Connection	Isolating Diaphragm	Oil Fill
2D	316 SST	316 SST	Neobee
Code	Process Connection		
E	1½-inch <i>Tri-Clamp</i> Connection		
F	2-inch <i>Tri-Clamp</i> Connection		
Code	Conduit Thread		
1	½–14 NPT		
2	M20 x 1.5 (CM20)		
3	PG 13.5		
Code	Options		
M5	LCD Meter, scaled 0–100%		
M7	LCD Meter, special configuration		
B4	SST Mounting Bracket with SST Bolts		
S5	Assembly to Model 306 Integral Manifold (see PDS 00813-0100-4733 for ordering information)		
C6	CSA Explosion-Proof, Intrinsic Safety, and Non-Incendive Approval		
I1	BASEEFA EEx ia IIC T5 (CENELEC) Intrinsic Safety Approval (Entity Concept)		
N1	BASEEFA Type N EX N IIC T5		
E5	FM Explosion-Proof Approval		
E8	CESI/CENELEC Explosion-Proof Approval (available with analog output, Code A, only)		
ED	KEMA/CENELEC Explosion-Proof Approval (available with smart output, Code S, only)		
I5	FM Non-Incendive and Intrinsic Safety Approval (Entity Concept)		
K5	E5 and I5 Combination		
K6	CSA/CENELEC Explosion-Proof and Intrinsic Safety Approval		
P2	Cleaning for Special Service		
Q4	Calibration Data Sheet		
Q8	Material Traceability per DIN 3.1B		
T1	Transient Protection Terminal Block		
Typical Model Number: 2090FG 2 S 2D E 1			

(1) Range 3 minimum span: 0–40 psi.

NOTE

One product manual is included per shipment.

CALIBRATION

All transmitters are factory calibrated to customer's specified range. If calibration is not specified, transmitters are calibrated at maximum range. Calibration is at ambient temperature.

TAGGING

Transmitter are tagged, at no charge, in accordance with customer requirements. All tags are stainless steel. The standard tag is wired to the transmitter. Tag character height is ⅜-inch (0,318 cm). A permanently attached tag is available upon request.

LCD Meter

LCD METER

The LCD meter provides local indication of the output, and abbreviated diagnostic messages governing transmitter operation. The meter is located on the electronics module side of the transmitter, maintaining direct access to the signal terminals. An extended cover is required to accommodate the meter.

The new meter features a two-line display that accommodates five digits for reporting the process variable on the top line, and six characters for displaying engineering units on the bottom line. The meter uses both lines to display diagnostic messages. You can configure the meter to display the following information:

- Engineering Units
- Percent of Range
- User-Configurable LCD Scale
- Alternating between any two of the above

SAFETY MESSAGES

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Refer to the following safety messages before performing an operation preceded by this symbol.

Warnings (⚠)

WARNING

Explosions can result in death or serious injury.

- Do not remove the transmitter covers in explosive environments when the circuit is alive.
- Transmitter covers must be fully engaged to meet explosionproof requirements.
- Before connecting a communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or nonincendive field wiring practices.

CUSTOM METER CONFIGURATION

The user-configurable scale is a feature that enables the LCD meter to display flow, level, or custom pressure units. The meter can be configured using a Model 275 HART Communicator or AMS.

The user-configurable scale feature can define:

- decimal point position
- upper range values
- lower range values
- engineering units
- transfer function

To configure the meter using AMS, click the **LOCAL DISPLAY** tab on the **CONFIGURATION PROPERTIES** screen. To configure the meter with a HART communicator, perform the following procedure:

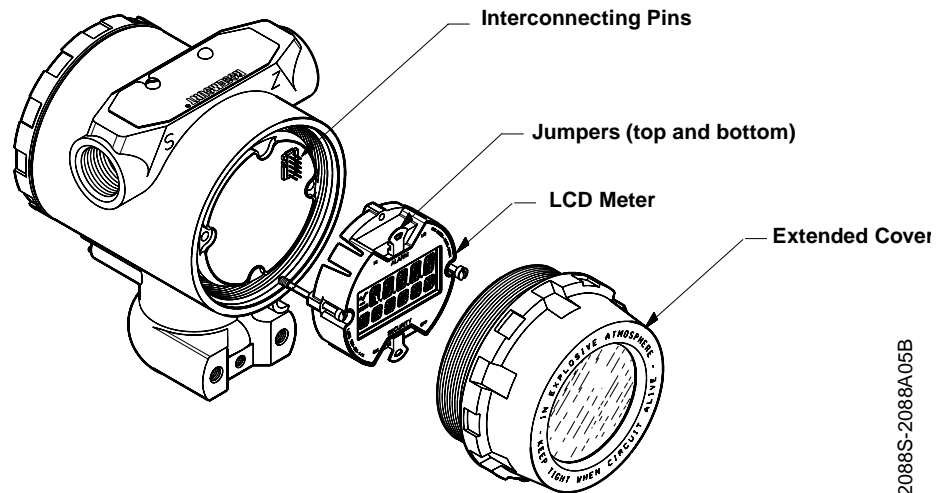


1. Connect the communicator to the transmitter. Before connecting a communicator in an explosive atmosphere, make sure the instruments in the loop are installed according to intrinsically safe or nonincendive field wiring practices.
2. From the **ONLINE** screen, select *1 Device Setup, 3 Basic Setup, 7 Meter Options, 2 Custom Meter Setup*.
3. To specify decimal point position:
 - a. Select *1 Sel dec pt pos*. Choose the decimal point representation that will provide the most accurate output for your application. For example, when outputting between 0 and 75 GPM, choose *XX.XXX*.
 - b. Go to step 8.
4. To specify a custom upper range value:
 - a. Select *2 CM Upper Value*. Type the value that you want the transmitter to read at the 20 mA point.
 - b. Go to step 8.
5. To specify a custom lower range value:
 - a. Select *3 CM Lower Value*. Type the value that you want the transmitter to read at the 4 mA point.
 - b. Go to step 8.
6. To define custom units:
 - a. Select *4 CM Units*. Enter the custom units (five characters maximum) that you want the meter to display.
 - b. Go to step 8.
7. To choose the transmitter transfer function for the meter:
 - a. Select *5 CM xfer fnct*. Enter the transmitter transfer function for the meter. Select *sq root* to display flow units. The custom meter transfer function is independent of the analog output transfer function.
8. Select **F2 SEND** to upload the configuration to the transmitter.



See "Safety Messages" on page A-1 for complete warning information.

FIGURE A-1. Exploded View of the Transmitter with Optional LCD Meter.



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DIAGNOSTIC MESSAGES

In addition to the output, the LCD meter displays abbreviated operation, error, and warning messages for troubleshooting the transmitter. Messages appear according to their priority, with normal operating messages appearing last. To determine the cause of a message, use a Model 275 HART Communicator to further interrogate the transmitter. A description of each LCD diagnostic message follows.

Error

Error messages appear on the LCD meter display to inform you of serious problems effecting the operation of the transmitter. The meter displays an error message until the error condition is corrected, and the analog output is driven to the specified alarm level. No other transmitter information is displayed during an alarm condition.

FAIL

The transmitter CPU board and the sensor module are incompatible.

FAIL MODULE

The sensor module is disconnected or is malfunctioning. Verify that the sensor module ribbon cable is connected to the back of the electronics board. If the ribbon cable is not disconnected, there is a problem within the sensor module. Possible sources of problems include:

- Pressure or temperature updates are not being received in the sensor module.
- A non-volatile memory fault that will effect transmitter operation has been detected in the module by the memory verification routine.

FAIL ELECT

The transmitter electronics module is malfunctioning. Possible causes include:

- Internal fault
- A non-volatile memory fault that will effect transmitter operation has been detected in the module by the memory verification routine

Neither problem is repairable; the electronics board must be replaced.

FAIL CONFIG

A non-volatile memory fault has been detected in the transmitter memory by the memory verification routine. The memory fault is in a location that could effect transmitter operation, and is user-accessible. To correct this problem, use a Model 275 HART Communicator to interrogate and reconfigure the appropriate portion of the transmitter memory.

Warnings

Warnings appear on the LCD meter display to alert you of user-repairable problems with the transmitter, or current transmitter operations. Warnings appear alternately with other transmitter information until the warning condition is corrected or the transmitter completes the operation that triggered the warning message.

PRESS LIMIT

The process variable read by the transmitter is outside of sensor range limits.

CURR FIXED

The transmitter is in multidrop mode. The analog output is not tracking pressure changes.

CURR SATURD

The pressure read by the module is outside of the specified range, and the analog output has been driven to saturation levels (see **Failure Mode and Security Jumpers** on page 3-12).

LOOP TEST

A loop test is in progress. During a loop test or 4–20 mA trim, the analog output is set to a fixed value. The meter display alternates between the current selected in milliamps and “LOOP TEST.”

XMTR INFO

A non-volatile memory fault has been detected in the transmitter memory by the memory verification routine. The memory fault is in a location containing transmitter information. To correct this problem, use a Model 275 HART Communicator to interrogate and reconfigure the appropriate portion of the transmitter memory. This warning does not effect the transmitter operation.

Operation

Normal operation messages appear on the LCD meter to confirm actions or inform you of transmitter status. Operation messages are displayed with other transmitter information, and warrant no action to correct or alter the transmitter settings.

ZERO PASS

The zero value, set with the local zero adjustment button, has been accepted by the transmitter, and the output should change to 4 mA.

ZERO FAIL

The zero value, set with the local zero adjustment button, exceeds the maximum rangedown allowed for a particular range, or the pressure sensed by the transmitter exceeds the sensor limits.

SPAN PASS

The span value, set with the local span adjustment button, has been accepted by the transmitter, and the output should change to 20 mA.

LOCAL DSBLD

This message appears during reranging with the integral zero and span buttons and indicates that the transmitter local zero and span adjustments have been disabled. The adjustments may have been disabled by the transmitter security jumper on the transmitter circuit board or through software commands from the Model 275. Refer to **Failure Mode and Security Jumpers** on page 3-12 for information on the position of the security jumper, and for information on the software lockout.

WRITE PROTCT

The write protect (SECURITY) jumper is set to disable changes to the transmitter configuration data. Refer to **Failure Mode and Security Jumpers** on page 3-12 for more information on the security jumper.

Model 275 HART Communicator

OVERVIEW

This appendix provides basic communicator information on the Model 275 HART Communicator when used with Models 2088, 2090P, or 2090F Smart Pressure Transmitters.

Included in this appendix are a menu tree, a table of fast key sequences, and information on using the HART communicator.

For more complete information on the HART Communicator, refer to the HART Communicator Product Manual 00809-0100-4275.

This brief appendix will familiarize you with the HART Communicator but is not meant to replace the HART Communicator product manual.

SAFETY MESSAGES

Instructions and procedures in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Please refer to the following safety messages before performing an operation preceded by this symbol.

Warnings

⚠WARNING

Explosions could result in death or serious injury:

- Do not make connections to the serial port or NiCad recharger jack in an explosive atmosphere.
- Before connecting a HART-based communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or non-incendive field wiring practices.
- Both transmitter covers must be fully engaged to meet explosion-proof requirements.

⚠WARNING

High voltage that may be present on leads could cause electrical shock:

- Avoid contact with leads and terminals.

FIGURE B-1. HART Communicator Menu Tree for the Model 2088 Smart.

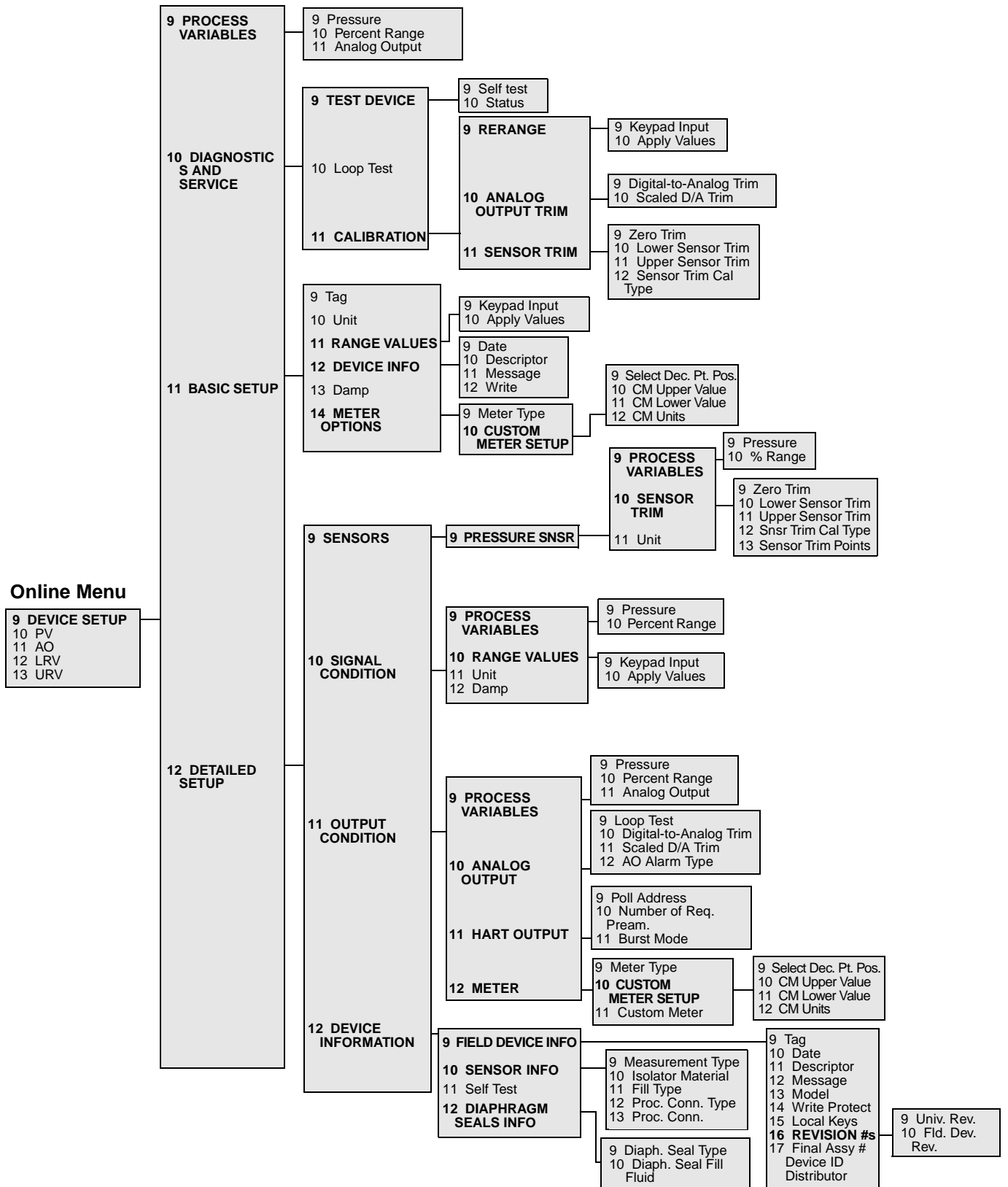


TABLE B-1. HART Fast Key Sequences for the Model 2088S.

Function	HART Communicator Fast Key Sequences
Analog Output	3
Analog Output Alarm	1, 4, 3, 2, 4
Burst Mode Control	1, 4, 3, 3, 3
Burst Operation	1, 4, 3, 3, 4
Calibration	1, 2, 3
Damping	1, 3, 5
Date	1, 3, 4, 1
Descriptor	1, 3, 4, 2
Digital To Analog Trim (4–20 mA Output)	1, 2, 3, 2, 1
Disable Local Span/Zero Adjustment	1, 4, 4, 1, 7
Field Device Info	1, 4, 4, 1
Keypad Input	1, 2, 3, 1, 1
Loop Test	1, 2, 2
Lower Range Value	4, 1
Lower Sensor Trim	1, 2, 3, 3, 2
Message	1, 3, 4, 3
Meter Type	1, 3, 6, 1
Number of Requested Preambles	1, 4, 3, 3, 2
Output Trim	1, 2, 3, 2
Percent Range	1, 1, 2
Poll Address	Left Arrow, 5, 1
Pressure	2
Range Values	1, 3, 3
Rerange	1, 2, 3, 1
Scaled D/A Trim (4–20 mA Output)	1, 2, 3, 2, 2
Self Test (Transmitter)	1, 2, 1, 1
Sensor Info	1, 4, 4, 2
Sensor Trim (Full Trim)	1, 2, 3, 3
Sensor Trim Points	1, 2, 3, 3, 5
Status	1, 2, 1, 2
Tag	1, 3, 1
Transmitter Security (Write Protect)	1, 3, 4, 4
Units (Process Variable)	1, 3, 2
Upper Range Value	5
Upper Sensor Trim	1, 2, 3, 3, 3
Zero Trim	1, 2, 3, 3, 1

CONNECTIONS AND HARDWARE


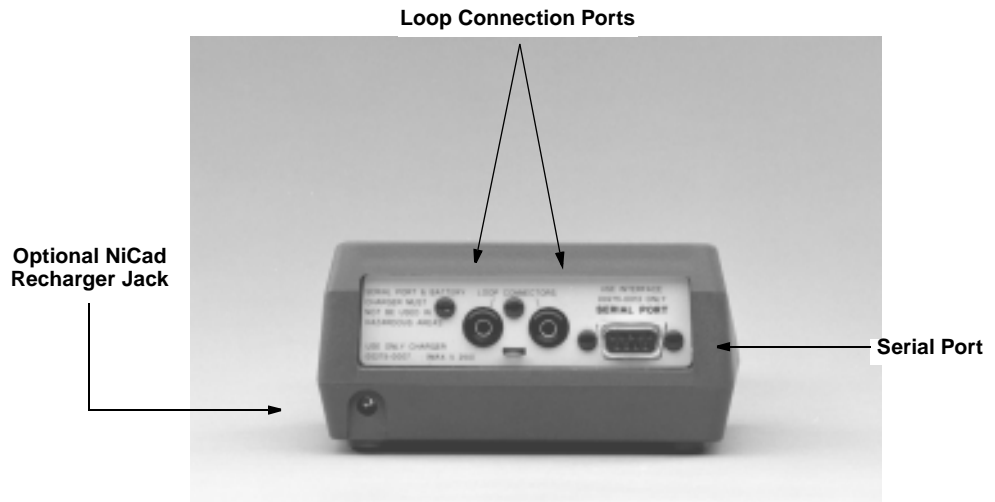
 The HART Communicator Model 275 can interface with a transmitter from the control room, the instrument site, or any wiring termination point in the loop through the rear connection panel as shown in Figure B-2. To communicate, connect the HART Communicator in parallel with the instrument or load resistor. The connections are non-polarized. Avoid contact with leads and terminals. Do not make connections to the serial port or NiCad recharger jack in an explosive atmosphere. Before connecting the HART Communicator in an explosive atmosphere, make sure the instruments in the loop are installed in accordance with intrinsically safe or nonincendive field wiring practices. Both transmitter covers must be fully engaged to meet explosion proof requirements.

FIGURE B-2. Rear Connection Panel with Optional NiCad Recharger Pack.

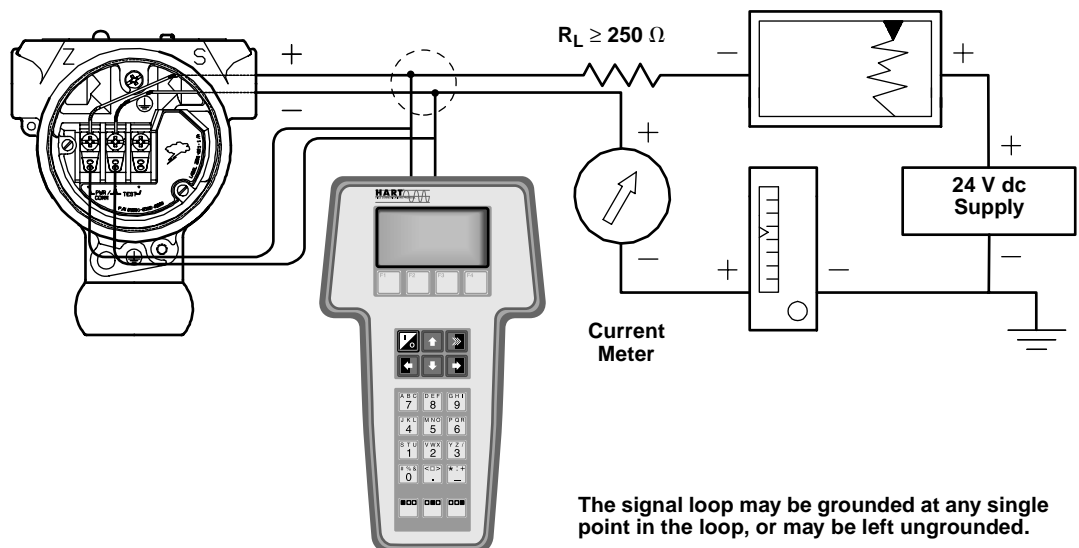


275-008AB

NOTE

The HART Communicator needs a minimum of 250 ohms resistance in the loop to function properly. The HART Communicator does not measure loop current directly.

FIGURE B-3. Bench Hook-up (4–20 mA Transmitters).



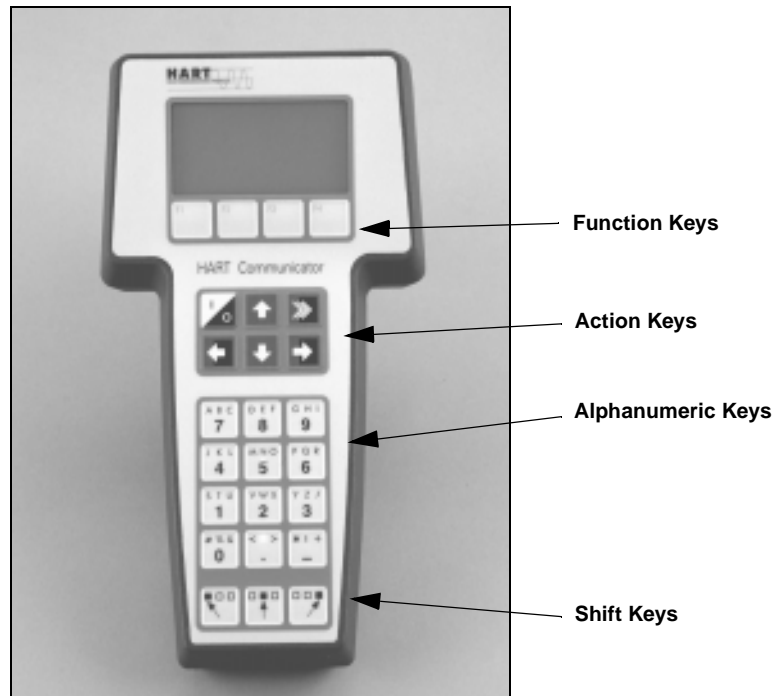
The signal loop may be grounded at any single point in the loop, or may be left ungrounded.

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COMMUNICATOR KEYS

The keys of the HART Communicator include action, function, alphanumeric, and shift keys

FIGURE B-4. The HART Communicator.



275-011AB

Action Keys

As shown in Figure B-4, the action keys are the six blue, white, and black keys located above the alphanumeric keys. The function of each key is described as follows:

ON/OFF Key

Use this key to power the HART Communicator. When the communicator is turned on, it searches for a transmitter on the 4–20 mA loop. If a device is not found, the communicator displays the message, “No Device Found. Press OK.”

If a HART-compatible device is found, the communicator displays the Online Menu with device ID and tag.

Directional Keys

Use these keys to move the cursor up, down, left, or right. The right arrow key also selects menu options, and the left arrow key returns to the previous menu.

HOT Key

Use this key to quickly access important, user-selectable options when connected to a HART-compatible device. Pressing the Hot Key turns the HART Communicator on and displays the Hot Key Menu. See Customizing the Hot Key Menu in the HART Communicator manual for more information.

Function Keys

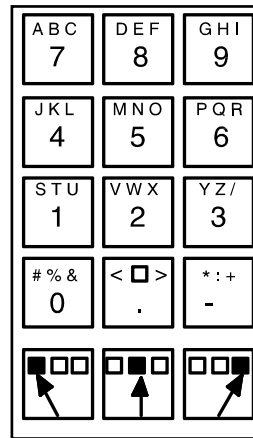


Use the four software-defined function keys, located below the LCD, to perform software functions. On any given menu, the label appearing above a function key indicates the function of that key for the current menu. As you move among menus, different function key labels appear over the four keys. For example, in menus providing access to on-line help, the **HELP** label may appear above the F1 key. In menus providing access to the Online Menu, the **HOME** label may appear above the F3 key. Simply press the key to activate the function. See your HART Communicator manual for details on specific function key definitions.

Alphanumeric and Shift Keys

The alphanumeric keys, see Figure B-5 perform two functions: the fast selection of menu options and data entry.

FIGURE B-5. HART Communicator Alphanumeric and Shift Keys.



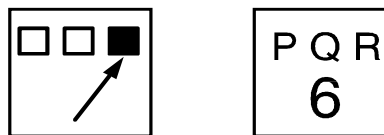
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Data Entry

Some menus require data entry. Use the alphanumeric and shift keys to enter all alphanumeric information into the HART Communicator. If you press an alphanumeric key alone from within an edit menu, the bold character in the center of the key appears. These large characters include the numbers zero through nine, the decimal point (.), and the dash symbol (—).

To enter an alphabetic character, first press the shift key that corresponds to the position of the letter you want on the alphanumeric key. Then press the alphanumeric key. For example, to enter the letter R, first press the right shift key, then the “6” key, see Figure B-6. Do not press these keys simultaneously, but one after the other.

FIGURE B-6. Data Entry Key Sequence.



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Fast Key Sequences

HART Fast Key Sequences provide quick on-line access to transmitter variables and functions. Instead of stepping your way through the menu structure using the action keys, you can press a HART fast key sequence to move from the Online Menu to the desired variable or function. On-screen instructions guide you through the rest of the screens.

Conventions

The fast key sequences for the Model 275 use the following conventions for their identification:

1 through 9—Refer to the keys located directly below the dedicated keypad.

Left Arrow—Refers to the left arrow directional key.

Example

HART fast key sequences are made up of the series of numbers corresponding to the individual options in each step of the menu structure. For example, from the Online Menu you can change the **Date**. Following the menu structure, press 1 to reach **Device Setup**, press 3 for **Basic Setup**, press 4 for **Device Info**, press 5 for **Date**. The corresponding HART fast key sequence is 1,3,4,5.

HART fast keys are operational only from the Online Menu. If you use them consistently, you will need to return to the Online Menu by pressing **HOME** (F3) when it is available. If you do not start at the Online Menu, the HART fast key sequences will not function properly.

Use Table B-1, an alphabetical listing of every on-line function, to find the corresponding HART fast key sequences. These codes are applicable only to Model 2088S transmitters and the HART Communicator.

MENUS AND FUNCTIONS

The HART Communicator is a menu driven system. Each screen provides a menu of options that can be selected as outlined above, or provides direction for input of data, warnings, messages, or other instructions.

Main Menu

When the HART Communicator is turned on, one of two menus will appear. If the HART Communicator is connected to an operating loop, the communicator will find the device and display the Online Menu (see below). If it is not connected to a loop, the communicator will indicate that no device was found. When you press OK (F4), it will display the Main menu.

The *Main Menu* provides the following options:

- *Offline*—saves or retrieves transmitter configuration information.
- *Online*—connects the communicator to a compatible device.

NOTE

Online communication with the transmitter automatically loads the current transmitter data to the HART Communicator. Changes in online data are made active by pressing SEND (F2). The transfer function is used only for off-line data retrieval and sending.

- *Frequency Device*—The Frequency Device option displays the frequency output and corresponding pressure output of current-to-pressure transmitters.
- *Utility*—The Utility option provides access to the contrast control for the HART Communicator LCD screen and to the autopoll setting used in multidrop applications.

Once selecting a main menu option, the HART Communicator provides the information you need to complete the operation. If further details are required, consult the HART Communicator manual.

Online Menu

The *Online Menu* can be selected from the main menu as outlined above, or it may appear automatically if the HART Communicator is connected to an active loop and can detect an operating transmitter.

NOTE

The main menu can be accessed from the Online Menu. Press the left arrow action key to deactivate the on-line communication with the transmitter and to activate the main menu options.

When configuration variables are reset in the on-line mode, the new settings are not activated until the data are sent to the transmitter. Press SEND (F2) when it is activated to update the process variables of the transmitter.

On-line mode is used for direct evaluation of a particular meter, reconfiguration, changing parameters, maintenance, and other functions.

Diagnostic Messages

The following pages contain a list of messages used by the HART Communicator (HC) and their corresponding descriptions.

Variable parameters within the text of a message are indicated with *<variable parameter>*.

Reference to the name of another message is identified by *[another message]*.

Message	Description
Add item for ALL device types or only for this ONE device type.	Asks the user whether the hot key item being added should be added for all device types or only for the type of device that is connected.
Command Not Implemented	The connected device does not support this function.
Communication Error	Either a device sends back a response indicating that the message it received was unintelligible, or the HC cannot understand the response from the device.
Configuration memory not compatible with connected device	The configuration stored in memory is incompatible with the device to which a transfer has been requested.
Device Busy	The connected device is busy performing another task.
Device Disconnected	Device fails to respond to a command.
Device write protected	Device is in write-protect mode. Data can not be written.
Device write protected. Do you still want to shut off?	Device is in write-protect mode. Press YES to turn the HC off and lose the unsent data.
Display value of variable on hotkey menu?	Asks whether the value of the variable should be displayed adjacent to its label on the hotkey menu if the item being added to the hotkey menu is a variable.
Download data from configuration memory to device	Prompts user to press SEND softkey to initiate a memory to device transfer.
Exceed field width	Indicates that the field width for the current arithmetic variable exceeds the device- specified description edit format.
Exceed precision	Indicates that the precision for the current arithmetic variable exceeds the device- specified description edit format.
Ignore next 50 occurrences of status?	Asked after displaying device status. Softkey answer determines whether next 50 occurrences of device status will be ignored or displayed.
Illegal character	An invalid character for the variable type was entered.
Illegal date	The day portion of the date is invalid.
Illegal month	The month portion of the date is invalid.
Illegal year	The year portion of the date is invalid.
Incomplete exponent	The exponent of a scientific notation floating point variable is incomplete.
Incomplete field	The value entered is not complete for the variable type.
Looking for a device	Polling for multidropped devices at addresses 1–15.
Mark as read only variable on hotkey menu?	Asks whether the user should be allowed to edit the variable from the hotkey menu if the item being added to the hotkey menu is a variable.
No device configuration in configuration memory	There is no configuration saved in memory available to reconfigure off-line or transfer to a device.
No Device Found	Poll of address zero fails to find a device, or poll of all addresses fails to find a device if auto-poll is enabled.
No hotkey menu available for this device.	There is no menu named "hotkey" defined in the device description for this device.
No offline devices available.	There are no device descriptions available to be used to configure a device offline.
No simulation devices available.	There are no device descriptions available to simulate a device.
No UPLOAD_VARIABLES in ddl for this device	There is no menu named "upload_variables" defined in the device description for this device. This menu is required for offline configuration.
No Valid Items	The selected menu or edit display contains no valid items.
OFF KEY DISABLED	Appears when the user attempts to turn the HC off before sending modified data or before completing a method.
Online device disconnected with unsent data. RETRY or OK to lose data.	There is unsent data for a previously connected device. Press RETRY to send data, or press OK to disconnect and lose unsent data.

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Message	Description
Out of memory for hotkey configuration. Delete unnecessary items.	There is no more memory available to store additional hotkey items. Unnecessary items should be deleted to make space available.
Overwrite existing configuration memory	Requests permission to overwrite existing configuration either by a device-to-memory transfer or by an offline configuration. User answers using the softkeys.
Press OK...	Press the OK softkey. This message usually appears after an error message from the application or as a result of HART communications.
Restore device value?	The edited value that was sent to a device was not properly implemented. Restoring the device value returns the variable to its original value.
Save data from device to configuration memory	Prompts user to press SAVE softkey to initiate a device-to-memory transfer.
Saving data to configuration memory.	Data is being transferred from a device to configuration memory.
Sending data to device.	Data is being transferred from configuration memory to a device.
There are write only variables which have not been edited. Please edit them.	There are write-only variables which have not been set by the user. These variables should be set or invalid values may be sent to the device.
There is unsent data. Send it before shutting off?	Press YES to send unsent data and turn the HC off. Press NO to turn the HC off and lose the unsent data.
Too few data bytes received	Command returns fewer data bytes than expected as determined by the device description.
Transmitter Fault	Device returns a command response indicating a fault with the connected device; the transmitter is in alarm.
Units for <variable label> has changed. Unit must be sent before editing, or invalid data will be sent.	The engineering units for this variable have been edited. Send engineering units to the device before editing this variable.
Unsent data to online device. SEND or LOSE data	There is unsent data for a previously connected device which must be sent or thrown away before connecting to another device.
Use up/down arrows to change contrast. Press DONE when done.	Gives direction to change the contrast of the HC display.
Value out of range	The user-entered value is either not within the range for the given type and size of variable or not within the min/max specified by the device.
<message> occurred reading/writing <variable label>	Either a read/write command indicates too few data bytes received, transmitter fault, invalid response code, invalid response command, invalid reply data field, or failed pre- or post-read method; or a response code of any class other than SUCCESS is returned reading a particular variable.
<variable label> has an unknown value. Unit must be sent before editing, or invalid data will be sent.	A variable related to this variable has been edited. Send related variable to the device before editing this variable.

Model 2088 Low Power Option

OVERVIEW

The information in this appendix is specific to the Model 2088 Low Power Pressure Transmitter. This transmitter outputs a 1–5 V dc signal proportional to input pressure. The Low Power Option is designated with Output Code M.

SAFETY MESSAGES

Instructions and procedures in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol (⚠). Power and signal connections are made by removing the housing cover on the field terminal side of the transmitter housing.

⚠ WARNING

Explosions could result in death or serious injury:

- Do not remove the transmitter cover in explosive atmospheres when the circuit is alive.
- Verify that the operating atmosphere of the transmitter is consistent with the appropriate hazardous locations certifications.
- Both transmitter covers must be fully engaged to meet explosionproof requirements.

⚠ WARNING

Failure to follow these installation guidelines could result in death or serious injury:

- Make sure only qualified personnel perform the installation.

COMMISSIONING THE TRANSMITTER

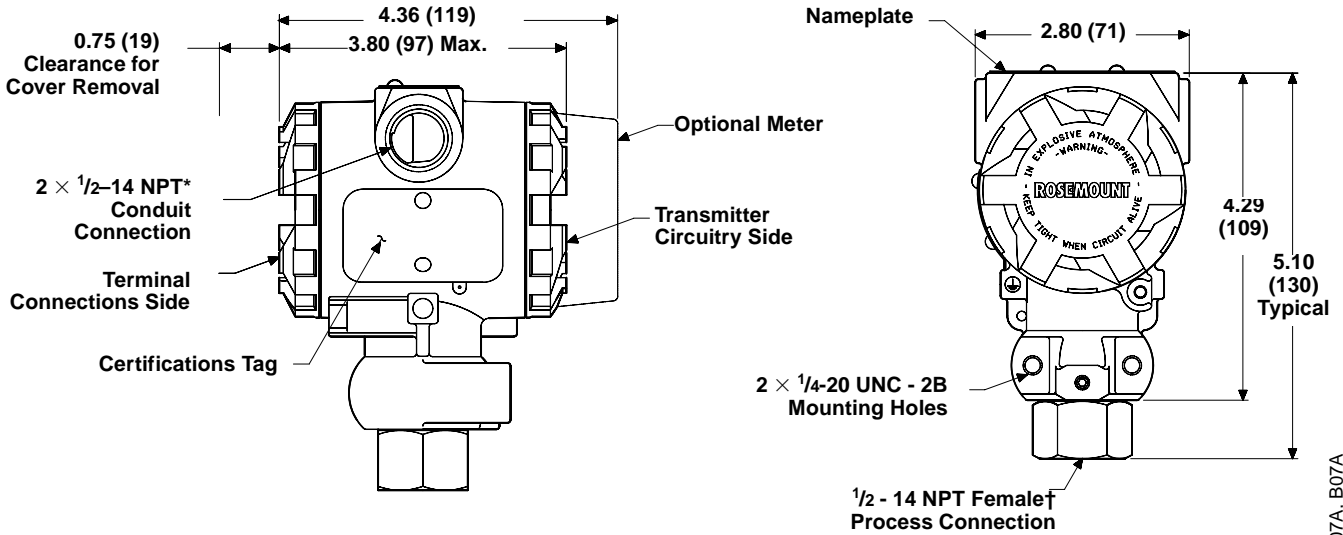
The Model 2088 Analog Pressure Transmitter can be continuously adjusted to spans between maximum span and $\frac{1}{10}$ of maximum span⁽¹⁾. Transmitter linearity information is programmed into the microprocessor at the factory; linearity adjustment is not necessary in the field.

INSTALLATION

To install the low power analog transmitter, follow the procedures in Section 3 Installation. The housing of the analog transmitter is slightly different from that of the smart transmitter. Dimensional drawings of the analog transmitter are provided in Figure C-1.

(1) For Model 2088 Range 0, minimum span is 1 psi.

Figure C-1. Low Power Analog Transmitter Dimensional Drawings.



* M20 × 1.5 Female (CM20), PG 13.5, and G 1/2 Female (PF 1/2), also available as options.
 †DIN 16288 G 1/2 Male, RC 1/2 Female (PT 1/2+) and M20 × 1.5 Male [CM20], also available as options.
 Dimensions are in in. (mm).

2088-2088A07A, B07A

WIRING

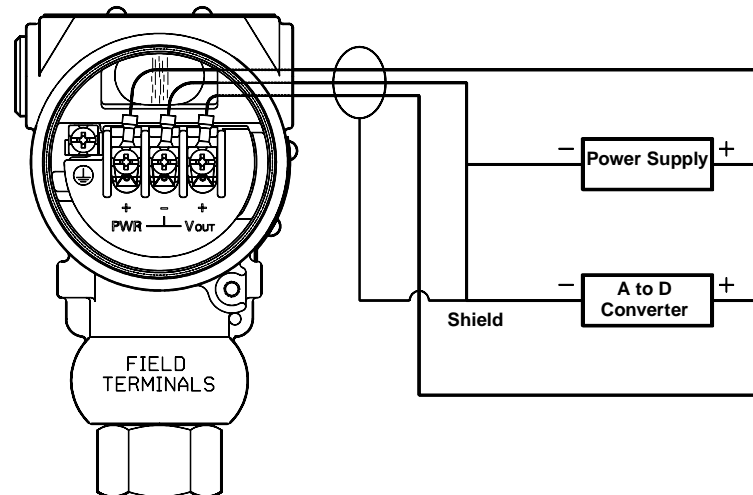
Power and signal connections are made by removing the housing cover on the field terminal side of the transmitter housing.

⚠ CAUTION

Do not connect the positive lead from the power supply to the “+” V out termination on the terminal side of the electronic housing. This may result in an erroneous output and may damage the output board, the power supply, or both.

Connect the positive lead from the power supply to the (+) PWR terminal and the negative lead to the (–) terminal. Connect the positive lead of the readout device or A/D converter to the “Vout” terminal and the negative lead to the “–” terminal. Shielded pair wiring is recommended and all common leads should be connected to the same ground, see Figure C-2.

Figure C-2. Field Wiring for Model 2088—Low Power Option Code M.



2088-B02F

CALIBRATION

The procedure for calibrating the Model 2088 is different from that of other pressure transmitters and takes some time to become accustomed to. However, this method of calibration is considerably faster than other calibration methods. In addition, there is no interaction between the zero and span adjustments.

An important feature of this design is that the potentiometer is an active part of the circuit only during calibration. The potentiometer is removed from the active circuit when the switch is placed in the “RUN” position. The design that allows deactivation of the potentiometer eliminates the temperature drift and stability shifts often associated with common potentiometers.

Selector Switch

The selector switch is labeled “Z” (Zero), “RUN,” and “S” (Span). The switch is set to the “RUN” position at the factory and should remain there under normal operation. The microprocessor will not accept a new value from the switch until you adjust the potentiometer. Therefore, in case you accidentally change the switch position, you can return it to the “RUN” position without affecting calibration if you do not turn the potentiometer.

⚠ CAUTION

The selector switch must be returned to the “RUN” position after setting the proper calibration. Failure to return the switch to the “RUN” position will result in erroneous transmitter output during an overpressure condition.

Potentiometer Adjustment

The potentiometer is marked “DN” (Down), “FINE,” and “UP.” The coarse adjustment regions are at each end, and a fine adjustment region is in the center. The output of the transmitter increases or decreases automatically when the potentiometer is placed in the coarse adjustment regions. The longer the potentiometer is held in the coarse adjustment region, the faster the rate of change in output.

CAUTION

The potentiometer is a $\frac{3}{4}$ -turn device and has a mechanical stop to prevent full rotation. Do not exert large twisting forces against the mechanical stop or damage will result.

NOTE

When the transmitter output is saturated, the potentiometer may appear to have no effect on the transmitter calibration because the microprocessor is adjusting the calibration, but the current-limiting circuitry is maintaining the output at the saturation levels. Place the potentiometer in the coarse-adjust region and wait several seconds for the output to change.

Setting the Zero

CAUTION

Do not contact meter leads from either test terminal on the output board to case ground. Contact can result in the maximum current from the power supply flowing through the test meter and may blow the test meter fuse, or damage the test meter or transmitter.



Setting the zero point of the transmitter involves applying pressure and adjusting the potentiometer accordingly. To set the zero point of the transmitter, use the following procedure.

1. If the transmitter does not have a readout device, attach a voltmeter. Terminals for monitoring or calibrating are located in two separate locations. The first is in the terminal compartment. Connect the positive lead to the “-” terminal. When calibrating directly from the output board, connect the positive lead of the voltmeter to the terminal labeled “+ TEST” and the negative lead to the “- TEST” terminal, see Figure C-3.
2. Ensure that the selector switch is in the “RUN” position. Apply the pressure to which the zero point will be calibrated.
3. Set the selector switch to “Z.”
4. Using the potentiometer, adjust the transmitter output until the readout device reads the desired value.
5. Return the selector switch to the “RUN” position.



Setting the Span

⚠ CAUTION

Do not contact meter leads from either test terminal on the output board to case ground. Contact can result in the maximum current from the power supply flowing through the test meter and may blow the test meter fuse, or damage the test meter or transmitter.

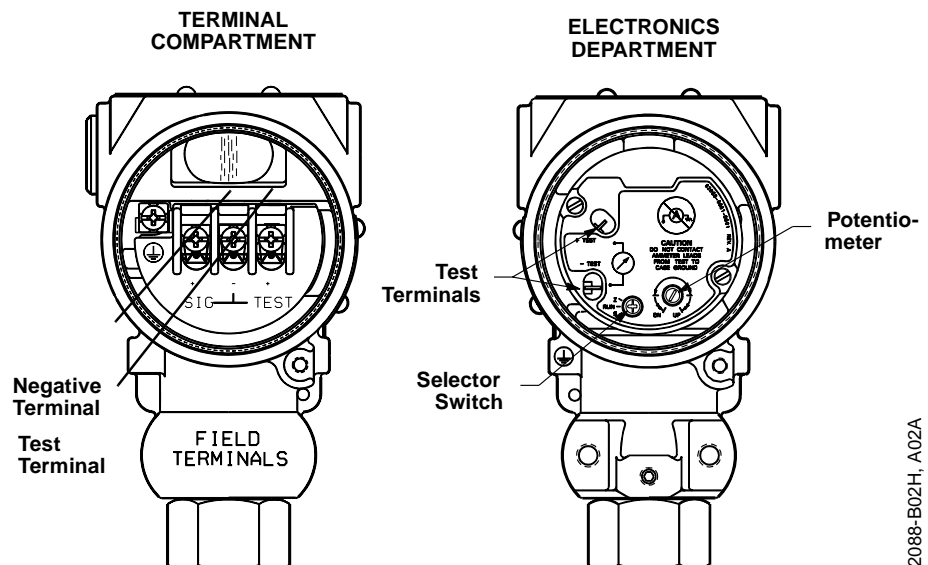
⚠ Setting the span of the transmitter involves applying pressure and adjusting the potentiometer accordingly. To set the span of the transmitter, use the following procedure:

1. If the transmitter does not have a readout device, attach a voltmeter. Terminals for monitoring or calibrating are located in two separate locations. The first is in the terminal compartment. Connect the positive lead of the voltmeter to the “V out” terminal and the negative lead to the “-” terminal. When calibrating directly from the output board, connect the positive lead of the voltmeter to the terminal labeled “+ TEST” and the negative lead to the “- TEST” terminal, see Figure C-3.
2. Ensure that the selector switch is in the “RUN” position. Expose the transmitter to full scale pressure.
3. Set the selector switch to “S.”
4. Using the potentiometer, adjust the transmitter output until the readout device reads the desired value.
5. Return the switch to “RUN.”

NOTE

The microprocessor limits the amount of rangedown allowed for span. If the rangedown conditions are violated, transmitter calibration is unaffected as long as the switch is placed in the “S” position and the potentiometer is adjusted.

Figure C-3. Transmitter Terminal and Electronics Compartments.



2088-B02H, A02A

TRANSIENT PROTECTION OPTION

The transient protection option helps to protect the transmitter electronics from potentially damaging transient voltages.

The transient protection board is installed at the factory or may be installed in the field directly over the transmitter terminal block using the existing terminal screws. To install the transient protection board in the field, perform the appropriate procedure.

NOTE

In order to maintain hazardous locations approvals, transient protection boards must be installed at a Rosemount Service Center. All approvals are void if customer installs transient protection boards.

INSTALLATION PROCEDURES

Transient Protection Board Installation

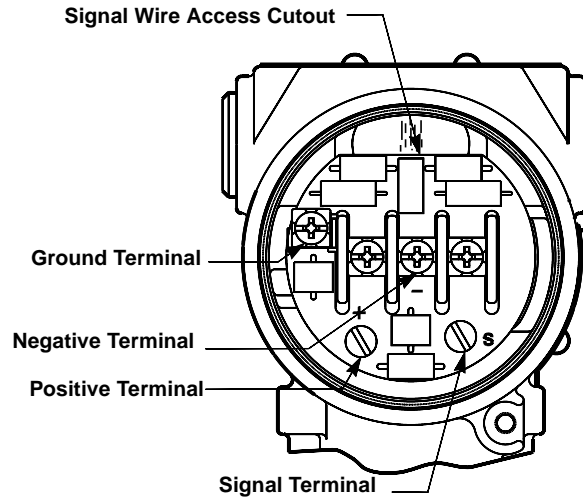
1. Remove the four screws on the transmitter terminal block. Save the screws and the cable clamps.
2. Disconnect the power signal wires from the terminals.
3. Insert the transient protection board directly over the terminal block, taking care to feed the power signal wires through the access cutout at the top of the board, see Figure C-4.
4. Replace and tighten the terminal screws. Take care to adequately tighten the ground (EGND) screw using the #8 lock washer provided.
5. Reconnect the signal wires, see Figure C-4.

Transient Protection Board Wiring

The Model 2088 terminal screws remain visible with a transient protection board installed. **Do not use the existing Model 2088 terminal screws to power the transmitter; doing so will render the transient protection board useless.**

To power the low power transmitter with the transient protection board installed, connect the positive power lead to the terminal marked “+” on the transient protection board, and the negative power lead to the center terminal screw on the transmitter terminal block. Connect the positive lead from the readout device or A/D converter to the terminal marked “S” on the transient protection board, and the negative lead to the center terminal screw on the transmitter terminal block, see Figure C-4.

Figure C-4. 1–5 V dc Transient Protection Wiring.



2088-1000B04B

SPECIFICATIONS

The specifications listed below are unique to the Option code M, Low Power Analog Transmitter. All other specifications are identical to those listed in Section 5 Specifications and Reference Data.

Functional Specifications

TABLE C-1. Ranges for Model 2088.

Range	Minimum Span	URL/Max. Span/Sensor Limit
0	1 psi (69 mbar)	8 psi (552 mbar)
1	3 psi (207 mbar)	30 psi (2,08 bar)
2	15 psi (1 bar)	150 psi (10,34 bar)
3	80 psi (5,5 bar)	800 psi (55,15 bar)
4	400 psi (27,6 bar)	4000 psi (275,79 bar)

Output

1–5 V dc, low power. (Outputs are directly proportional to the input pressure.)

Turn-on Time

0.3 seconds maximum at reference operating conditions.

Failure Mode

If self diagnostics detect a sensor or microprocessor failure, the analog signal is driven low to alert the user ($I \leq 1 \text{ V}$).

Performance Specifications

Ambient Temperature Effect

Temperature	Ranges 1–4	Range 0
–40 to 0 °F (–40 to –18 °C)	$\pm(0.7\% \text{ URL} + 0.8\% \text{ Span})$	$\pm(1.3\% \text{ URL} + 0.5\% \text{ Span})$
0 to 140 °F (–18 to 60 °C)	$\pm(0.5\% \text{ URL} + 0.5\% \text{ Span})$	$\pm(1.0\% \text{ URL} + 0.5\% \text{ Span})$
140 to 185 °F (60 to 85 °C)	$\pm(0.7\% \text{ URL} + 0.8\% \text{ Span})$	$\pm(1.3\% \text{ URL} + 0.5\% \text{ Span})$

Total effect includes zero and span effects.

Approval Drawings

OVERVIEW

This section contains transmitter hazardous location installation drawings. Follow the installation guidelines presented by these drawings in order to maintain certified ratings for installed transmitters.

This section contains the following drawings:

Rosemount Drawing 02088-1018, Rev. AB, 7 sheets:

Index of Intrinsic Safety Factory Mutual for Models 2088 and 2090.

Rosemount Drawing 02088-1024, Rev. AA, 3 sheets:

CSA Intrinsic Safety Approvals for Models 2088 and 2090.

CONFIDENTIAL AND PROPRIETARY INFORMATION IS CONTAINED HEREIN AND MUST BE HANDLED ACCORDINGLY	REVISIONS				
	REV	DESCRIPTION	CHG. NO.	APP'D	DATE
	G	FOR T1, I _{max} 145 was 160 mA; DEL I _{max} for T1, GROUPS C,D	676389	P.C.S.	9/26/96
	AA	ADD SMART OUTPUT OPTION CODE "S"	RTC1002247	K.J.A.	9/25/97
	AB	CORRECT ENTITY PARAMETERS FOR SMART OUTPUT "S"	RTC1007653	J.D.J.	10/25/99

ENTITY APPROVALS

THE ROSEMOUNT 2088 / 2090 TRANSMITTER IS F.M. APPROVED AS INTRINSICALLY SAFE WHEN USED IN CIRCUIT WITH F.M. APPROVED BARRIERS WHICH MEET THE ENTITY PARAMETERS LISTED IN THE CLASS I, II, AND III, DIVISION 1 GROUPS INDICATED, ADDITIONALLY, THE ROSEMOUNT 751 FIELD SIGNAL INDICATOR IS F.M. APPROVED AS INTRINSICALLY SAFE WHEN CONNECTED IN CIRCUIT WITH ROSEMOUNT MODEL 2088 / 2090 AND F.M. APPROVED BARRIERS WHICH MEET THE ENTITY PARAMETERS LISTED FOR CLASS I, II, AND III, DIVISION 1, GROUPS INDICATED.

TO ASSURE AN INTRINSICALLY SAFE SYSTEM, THE TRANSMITTER AND BARRIER MUST BE WIRED IN ACCORDANCE WITH THE BARRIER MANUFACTURER'S FIELD WIRING INSTRUCTIONS AND THE APPLICABLE CIRCUIT DIAGRAM INDICATED ON SHEET 3.

CAD Maintained, (MICROSTATION).

UNLESS OTHERWISE SPECIFIED DIMENSIONS IN INCHES [mm]. REMOVE ALL BURRS AND SHARP EDGES. MACHINE SURFACE FINISH 125 -TOLERANCE- .X ± .1 [2,5] .XX ± .02 [0,5] .XXX ± .010 [0,25] FRACTIONS ANGLES ± 1/32 ± 2° DO NOT SCALE PRINT	CONTRACT NO.	ROSEMOUNT MEASUREMENT		Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA
	DR. Myles Lee Miller 10/3/90	FISHER-ROSEMOUNT		
	CHK'D	TITLE		
	APP'D KAREN CARLSON 10/10/90	INDEX OF I.S. F.M. FOR 2088 / 2090		
	SIZE	FSCM NO	DWG NO.	
	A		02088-1018	
APP'D. GOVT.	SCALE	N/A	WT.	SHEET 1 OF 7

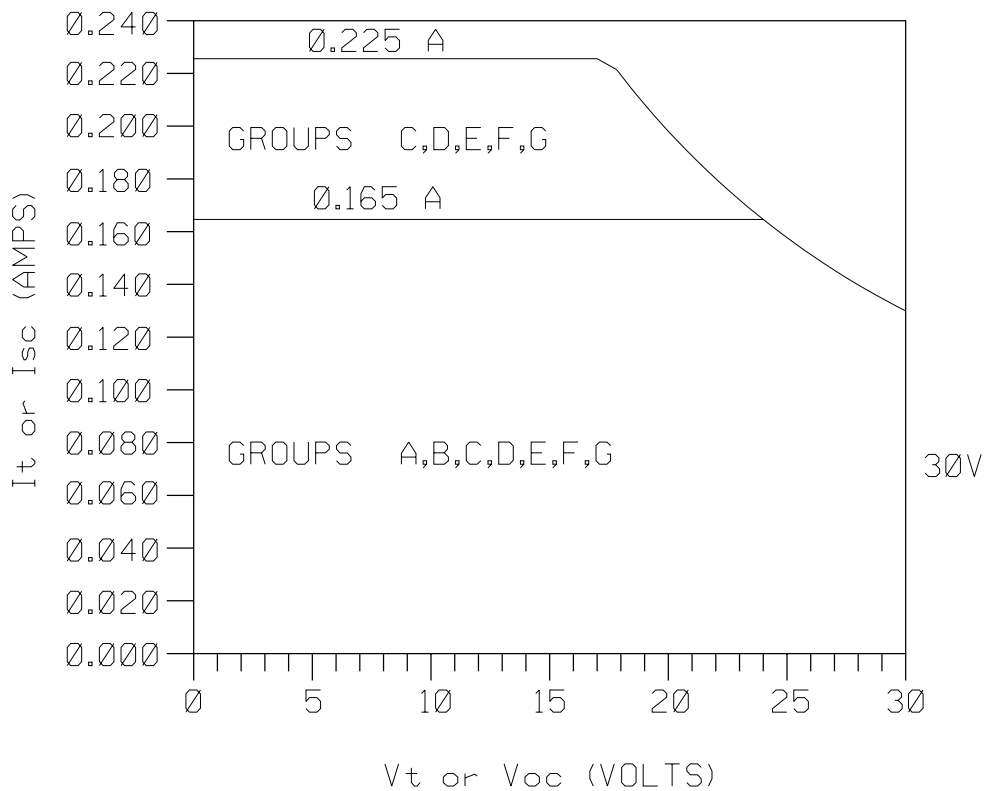
2088-1018AB1

FIGURE D-1. Index of Intrinsic Safety Factory Mutual for Models 2088 and 2090 Installation Drawing 02088-1018, Rev. AB.

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB		RTC1007653		

2088 / 2090 BARRIER PARAMETERS

$P_{max} = 1WATT$



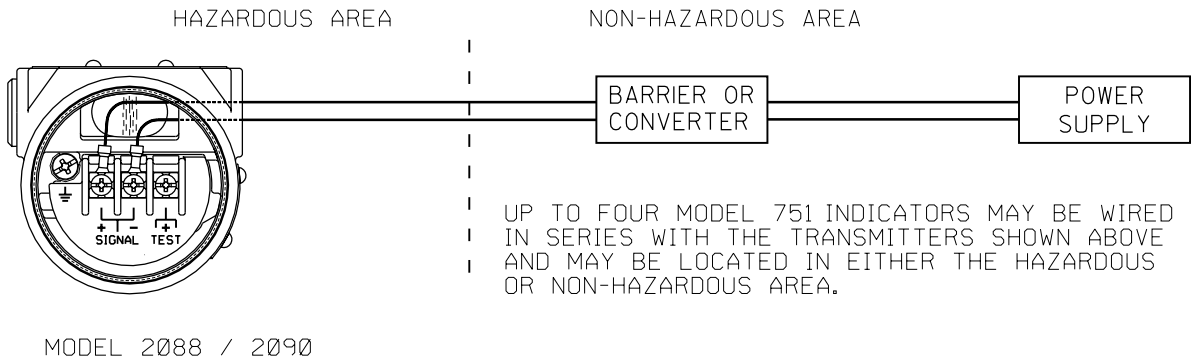
Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA		CAD Maintained, (MICROSTATION).		
DR. Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02088-1018	
ISSUED	SCALE N/A	WT.	SHEET 2 OF 7	

2088-1018AB2

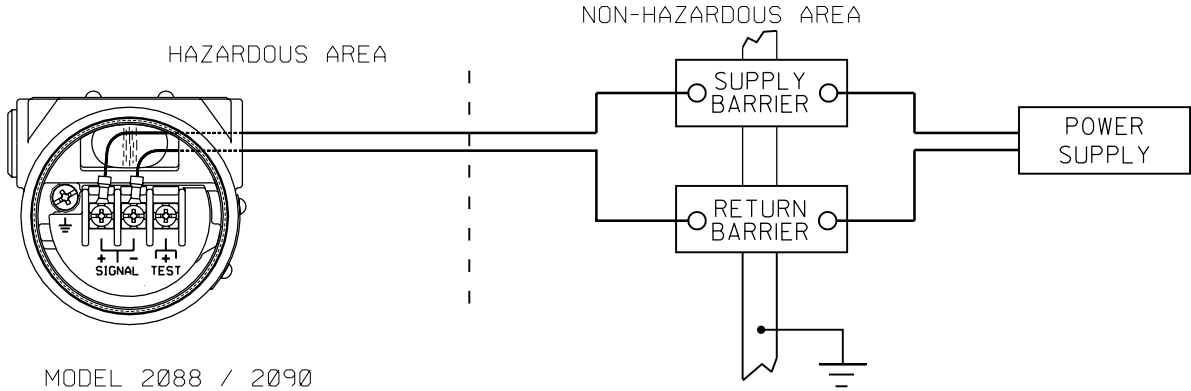
REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB		RTC1007653		

2088 & 2090 TRANSMITTER ("A" OUTPUT: 4-20mA)

CIRCUIT DIAGRAM 1
SINGLE OR DUAL CHANNEL BARRIER OR CONVERTER



CIRCUIT DIAGRAM 2 FOR
SUPPLY AND RETURN BARRIERS
APPROVED IN THIS CONFIGURATION



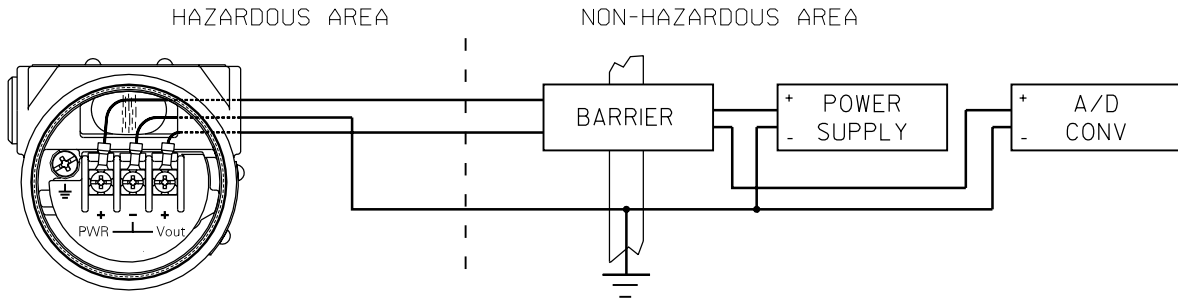
Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA		CAD Maintained, (MICROSTATION).		
DR. Myles Lee Miller	SIZE A	FSCM NO	DWG NO.	02088-1018
ISSUED	SCALE	N/A	WT.	SHEET 3 OF 7

2088-1018AB4

REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB		RTC1007653		

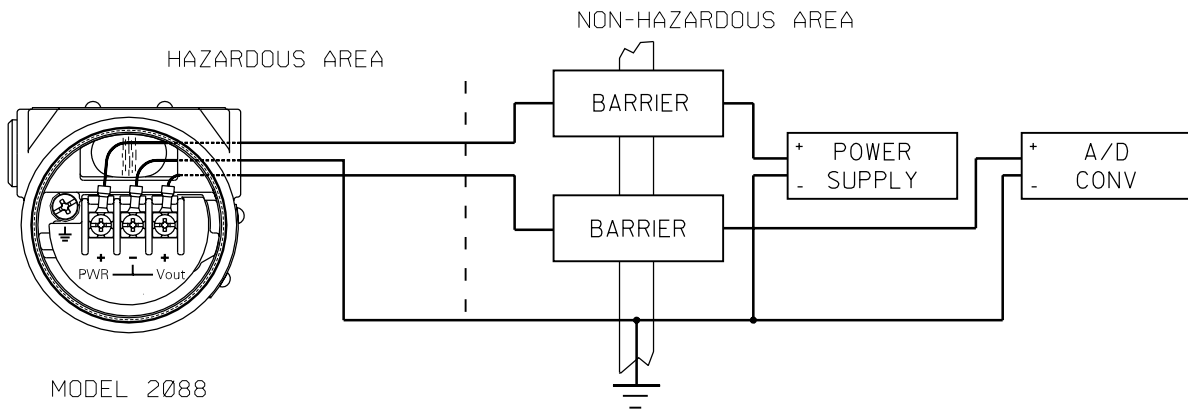
2088 LOW POWER TRANSMITTERS ("M" OUTPUT: 1-5V)

CIRCUIT DIAGRAM 3
ONE DUAL CHANNEL BARRIER



MODEL 2088

CIRCUIT DIAGRAM 2 FOR
SUPPLY AND RETURN BARRIERS
APPROVED IN THIS CONFIGURATION



MODEL 2088

Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA		CAD Maintained, (MICROSTATION).		
DR.	Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02088-1018
ISSUED		SCALE N/A	WT.	SHEET 4 OF 7

2088-1018AB5



REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB		RTC1007653		

ENTITY CONCEPT APPROVALS

THE ENTITY CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIFICALLY EXAMINED IN COMBINATION AS A SYSTEM. THE APPROVED VALUES OF MAXIMUM OPEN CIRCUIT VOLTAGE (V_{oc} or V_t) AND MAXIMUM SHORT CIRCUIT CURRENT (I_{sc} or I_t) AND MAXIMUM OUTPUT POWER ($V_{oc} \times I_{sc}/4$), OR ($V_t \times I_t/4$), FOR THE ASSOCIATED APPARATUS MUST BE LESS THAN OR EQUAL TO THE MAXIMUM SAFE INPUT VOLTAGE (V_{max}), MAXIMUM SAFE INPUT CURRENT (I_{max}), AND MAXIMUM SAFE INPUT POWER (P_{max}) OF THE INTRINSICALLY SAFE APPARATUS. IN ADDITION, THE APPROVED MAXIMUM ALLOWABLE CONNECTED CAPACITANCE (C_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE CAPACITANCE AND THE UNPROTECTED INTERNAL CAPACITANCE (C_i) OF THE INTRINSICALLY SAFE APPARATUS, AND THE APPROVED MAXIMUM ALLOWABLE CONNECTED INDUCTANCE (L_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE INDUCTANCE AND THE UNPROTECTED INTERNAL INDUCTANCE (L_i) OF THE INTRINSICALLY SAFE APPARATUS.

NOTE: ENTITY PARAMETERS LISTED APPLY ONLY TO ASSOCIATED APPARATUS WITH LINEAR OUTPUT.

MODEL 2088 / 2090

CLASS I, DIV. 1, GROUPS A AND B

$V_{MAX} = 30V$	V_t or V_{oc} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 165mA$	I_t or I_{sc} IS LESS THAN OR EQUAL TO 165mA
$P_{MAX} = 1 WATT$	$(V_{oc} \times I_{sc}/4)$ or $(V_t \times I_t/4)$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = 0.012 \mu F$	C_A IS GREATER THAN $0.012 \mu F$.
$L_I = 20 \mu H$	L_A IS GREATER THAN $20 \mu H$.

FOR T1 OPTION:

$I_{MAX} = 145mA$	I_t or I_{sc} IS LESS THAN OR EQUAL TO 145mA
$L_I = 1.448 mH$	L_A IS GREATER THAN 1.448 mH.

CLASS I, DIV. 1, GROUPS C AND D

$V_{MAX} = 30V$	V_t or V_{oc} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 225mA$	I_t or I_{sc} IS LESS THAN OR EQUAL TO 225mA
$P_{MAX} = 1 WATT$	$(V_{oc} \times I_{sc}/4)$ or $(V_t \times I_t/4)$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = 0.012 \mu F$	C_A IS GREATER THAN $0.012 \mu F$.
$L_I = 20 \mu H$	L_A IS GREATER THAN $20 \mu H$.

FOR T1 OPTION:

$L_I = 1.448 mH$	L_A IS GREATER THAN 1.448 mH.
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Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA		CAD Maintained, (MICROSTATION).		
DR.	Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02088-1018
ISSUED		SCALE N/A	WT.	SHEET 5 OF 7

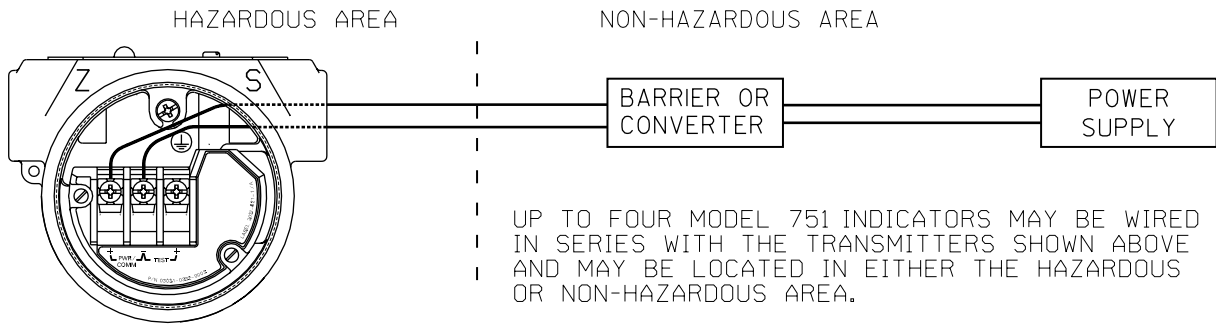


2088-1018AB6

REVISIONS				
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AB		RTC1007653		

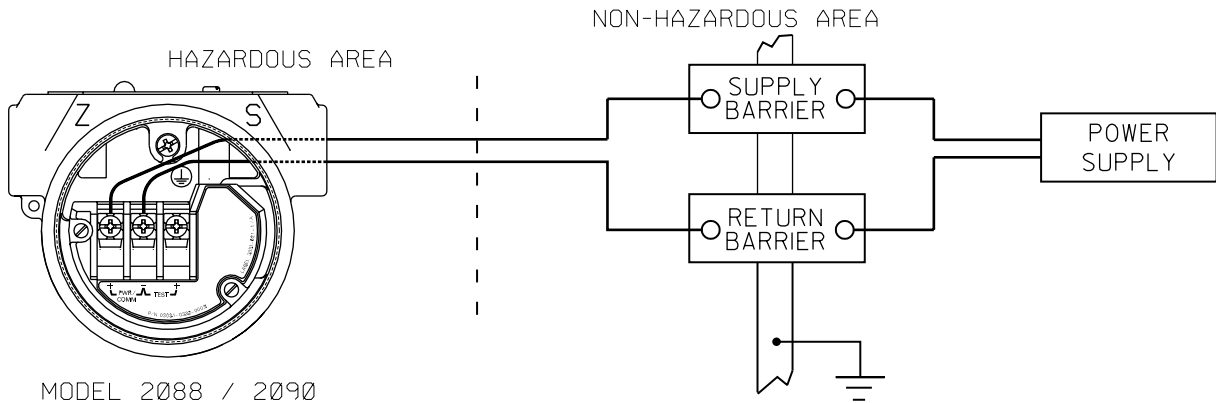
2088 & 2090 TRANSMITTER ("S" OUTPUT: 4-20mA)

CIRCUIT DIAGRAM 1
SINGLE OR DUAL CHANNEL BARRIER OR CONVERTER



MODEL 2088 / 2090

CIRCUIT DIAGRAM 2 FOR
SUPPLY AND RETURN BARRIERS
APPROVED IN THIS CONFIGURATION



MODEL 2088 / 2090

Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA		CAD Maintained, (MICROSTATION).		
DR.	Myles Lee Miller	SIZE A	FSCM NO	DWG NO. 02088-1018
ISSUED		SCALE N/A	WT. _____	SHEET 6 OF 7

2088-1018A/B6



REVISIONS				
REV	DESCRIPTION	CHG. NO.	APP'D	DATE
AB		RTC1007653		

ENTITY CONCEPT APPROVALS

THE ENTITY CONCEPT ALLOWS INTERCONNECTION OF INTRINSICALLY SAFE APPARATUS TO ASSOCIATED APPARATUS NOT SPECIFICALLY EXAMINED IN COMBINATION AS A SYSTEM. THE APPROVED VALUES OF MAXIMUM OPEN CIRCUIT VOLTAGE (V_{oc} or V_t) AND MAXIMUM SHORT CIRCUIT CURRENT (I_{sc} or I_t) AND MAXIMUM OUTPUT POWER ($V_{oc} \times I_{sc}/4$), OR ($V_t \times I_t/4$), FOR THE ASSOCIATED APPARATUS MUST BE LESS THAN OR EQUAL TO THE MAXIMUM SAFE INPUT VOLTAGE (V_{max}), MAXIMUM SAFE INPUT CURRENT (I_{max}), AND MAXIMUM SAFE INPUT POWER (P_{max}) OF THE INTRINSICALLY SAFE APPARATUS. IN ADDITION, THE APPROVED MAXIMUM ALLOWABLE CONNECTED CAPACITANCE (C_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE CAPACITANCE AND THE UNPROTECTED INTERNAL CAPACITANCE (C_i) OF THE INTRINSICALLY SAFE APPARATUS, AND THE APPROVED MAXIMUM ALLOWABLE CONNECTED INDUCTANCE (L_a) OF THE ASSOCIATED APPARATUS MUST BE GREATER THAN THE SUM OF THE INTERCONNECTING CABLE INDUCTANCE AND THE UNPROTECTED INTERNAL INDUCTANCE (L_i) OF THE INTRINSICALLY SAFE APPARATUS.

NOTE: ENTITY PARAMETERS LISTED APPLY ONLY TO ASSOCIATED APPARATUS WITH LINEAR OUTPUT.

MODEL 2088 / 2090 ("S" OUTPUT)

CLASS I, DIV. 1, GROUPS A AND B

$V_{MAX} = 30V$	V_t or V_{oc} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 165mA$	I_t or I_{sc} IS LESS THAN OR EQUAL TO 165mA
$P_{MAX} = 1 \text{ WATT}$	$(V_{oc} \times I_{sc}/4)$ or $(V_t \times I_t/4)$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = 0.01 \mu F$	C_A IS GREATER THAN $0.01 \mu F$.
$L_I = 10 \mu H$	L_A IS GREATER THAN $10 \mu H$.

FOR T1 OPTION:

$I_{MAX} = 160mA$	I_t or I_{sc} IS LESS THAN OR EQUAL TO 145mA
$L_I = 1.06 \text{ mH}$	L_A IS GREATER THAN 1.06 mH.

CLASS I, DIV. 1, GROUPS C AND D

$V_{MAX} = 30V$	V_t or V_{oc} IS LESS THAN OR EQUAL TO 30V
$I_{MAX} = 225mA$	I_t or I_{sc} IS LESS THAN OR EQUAL TO 225mA
$P_{MAX} = 1 \text{ WATT}$	$(V_{oc} \times I_{sc}/4)$ or $(V_t \times I_t/4)$ IS LESS THAN OR EQUAL TO 1 WATT
$C_I = 0.01 \mu F$	C_A IS GREATER THAN $0.01 \mu F$.
$L_I = 10 \mu H$	L_A IS GREATER THAN $10 \mu H$.

FOR T1 OPTION:

$L_I = 1.06 \text{ mH}$	L_A IS GREATER THAN 1.06 mH.
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Rosemount Inc. 12001 Technology Drive Eden Prairie, MN 55344 USA		CAD Maintained, (MICROSTATION).		
DR. Myles Lee Miller	SIZE A	FSCM NO.	DWG NO. 02088-1018	
ISSUED	SCALE N/A	WT.	SHEET 7 OF 7	

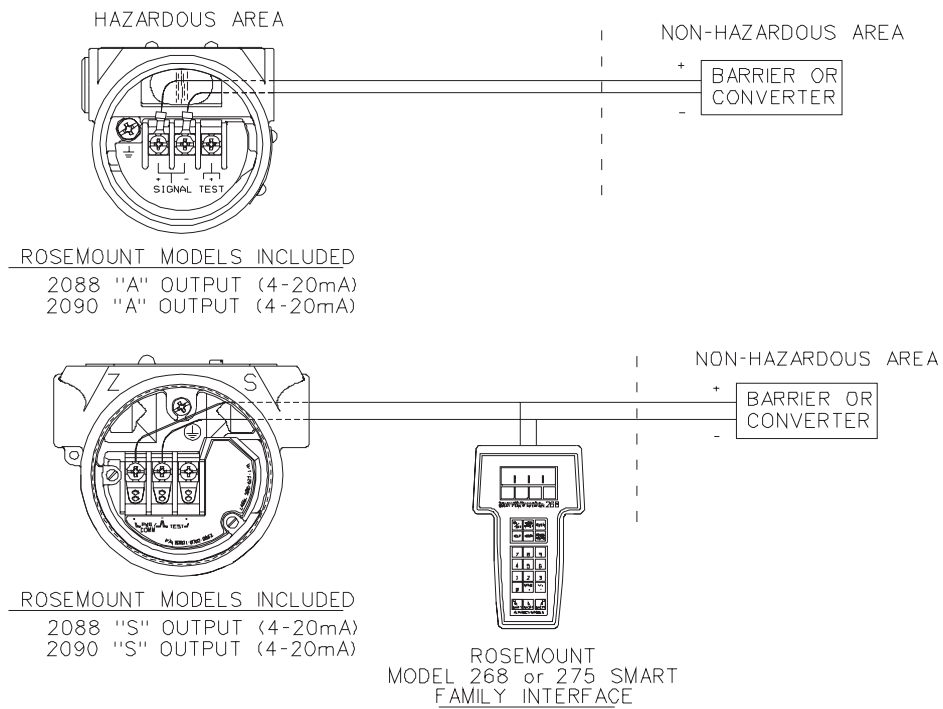


2088-1018AB7

AA	ADD SMART OUTPUT OPTION "S"	RTC1002227	M.L.M.	10/9/97
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CSA INTRINSIC SAFETY APPROVALS
CIRCUIT CONNECTION WITH BARRIER OR CONVERTER

Ex ia
INTRINSICALLY SAFE/SECURITE INTRINSEQUE



SANDI MANSON 12/12/90

KAREN CARLSON 12/20/90

INDEX OF I.S. CSA FOR
2088 / 2090

02088-1024

N/A ————— 1 3

2088-1024_01A

FIGURE D-2. CSA Intrinsic Safety Approvals for Models 2088 and 2090, Rev. AA.

AA | _____ | RTC1002227 | _____

WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS
MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

AVERTISSEMENT - RISQUE D'EXPLOSION - LA SUBSTITUTION DE COMPOSANTS
PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS
DE CLASSE I, DIVISION 2.

DEVICE	PARAMETERS	APPROVED FOR CLASS I, DIV.1
CSA APPROVED SAFETY BARRIER	30 V OR LESS	GROUPS A, B, C, D
	330 OHMS OR MORE	
	28 V OR LESS	
	300 OHMS OR MORE	
	25 V OR LESS	
FOXBORO CONVERTER 2A1-12V-CGB, 2A1-13V-CGB, 2AS-131-CGB, 3A2-12D-CGB, 3A2-13D-CGB, 3AD-131-CGB, 3A4-12D-CGB, 2AS-121-CGB, 3F4-12DA	200 OHMS OR MORE	GROUPS B, C, D
	22 V OR LESS	
	180 OHMS OR MORE	
CSA APPROVED SAFETY BARRIER	30 V OR LESS 150 OHMS OR MORE	GROUPS C, D

SANDI MANSON

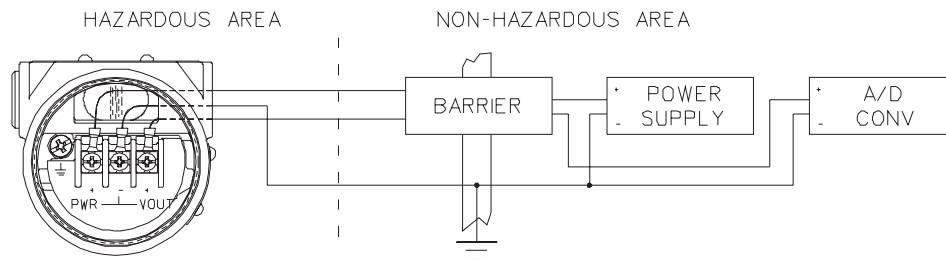
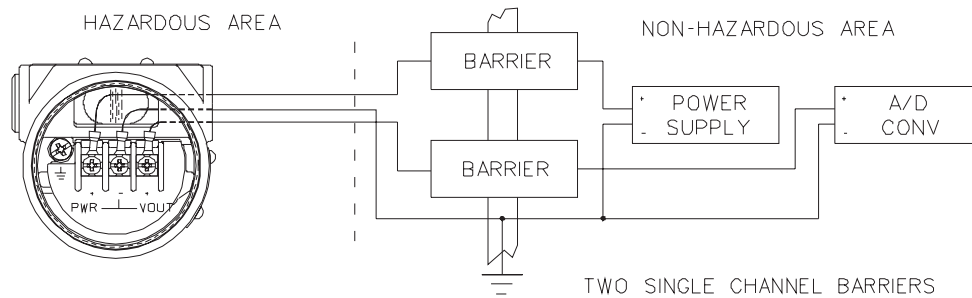
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CSA INTRINSIC SAFETY APPROVALS
 2088 LOW POWER CIRCUIT CONNECTION WITH INTRINSIC SAFETY BARRIERS
 Ex ia
 INTRINSICALLY SAFE/SECURITE INTRINSEQUE



2088 LOW POWER
 2088 "M" OUTPUT (1-5 V)

APPROVED FOR CLASS 1, DIVISION 1, GROUPS A,B,C,D WHEN USED IN CIRCUIT WITH TWO CSA APPROVED SINGLE CHANNEL SAFETY BARRIERS, ONE WITH APPROVED SAFETY PARAMETERS OF 28 VOLTS OR LESS AND 300 OHMS OR MORE IN +PWR LINE, AND ONE WITH APPROVED SAFETY PARAMETERS OF 10 VOLTS OR LESS AND 47 OHMS OR MORE IN Vout LINE, OR ONE CSA APPROVED DUAL CHANNEL SAFETY BARRIER WITH IDENTICAL APPROVED SAFETY PARAMETERS CONNECTED IN LIKE MANNER, AS ABOVE.

APPROVED FOR CLASS 1, DIVISION 1, GROUPS C,D WHEN USED IN CIRCUIT WITH TWO CSA APPROVED SINGLE CHANNEL SAFETY BARRIERS, ONE WITH APPROVED SAFETY PARAMETERS OF 30 VOLTS OR LESS AND 150 OHMS OR MORE IN +PWR LINE AND ONE WITH APPROVED SAFETY PARAMETERS OF 10 VOLTS OR LESS AND 47 OHMS OR MORE IN Vout LINE.

Myles Lee Miller

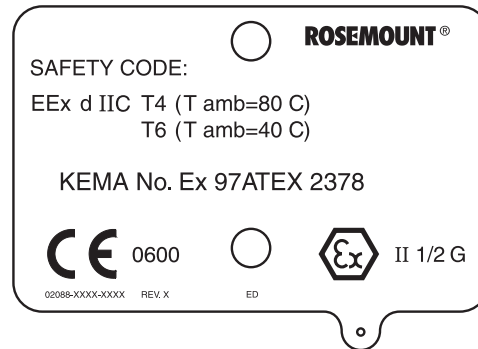
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European ATEX Directive Information

Rosemount Model 2088, 2090P, and 2090F Smart Pressure Transmitters that have the following label attached, have been certified to comply with Directive 94/9/EC of the European Parliament and the Council as published in the Official Journal of the European Communities No. L 100/1 on 19 April 1994.



275_01A

The following information is provided as part of the labeling of the transmitter

- Name and address of the manufacturer (may be any of the following):
 - Rosemount USA
 - Rosemount England
 - Rosemount Germany
 - Rosemount Singapore



- Complete model number
- The serial number of the device
- Year of construction
- Marking for explosion protection:
 - EEx d IIC T6 (Ta = 40 °C)
 - EEx d IIC T4 (Ta = 80 °C)



- KEMA ATEX certificate number: 97ATEX 2378

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Installation & Maintenance Instructions

**3-WAY SOLENOID VALVES — NORMALLY OPEN,
NORMALLY CLOSED AND UNIVERSAL OPERATION
1/4 NPT — BRASS AND STAINLESS STEEL CONSTRUCTION**

BULLETIN

8320

Form No.V5688R3

DESCRIPTION

Bulletin 8320 valves are small 3-way solenoid valves with all three connections located in the body. Valve bodies are made of brass or stainless steel.

Standard valves have a Type 1, General Purpose Solenoid Enclosure. Valves may also be provided with an explosion-proof solenoid enclosure designed to meet Enclosure Type 3-Raintight, Type 7 (C & D)-Explosion-Proof Class I, Groups C & D and Type 9 (E, F, & G)-Dust Ignition-Proof Class II, Groups E, F, & G, and have a temperature range code of TC3. Installation and maintenance instructions for the explosion-proof solenoid enclosure are on Form No.V5380.

OPERATION

Normally Open (Pressure at 3)

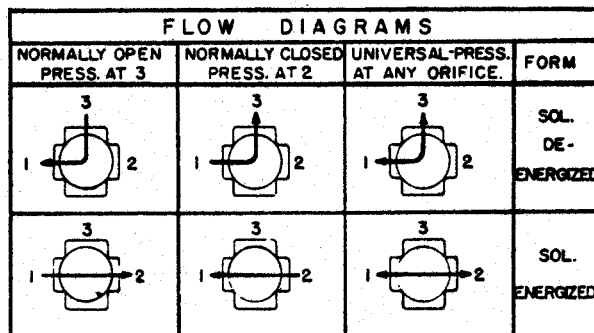
Applies pressure when solenoid is de-energized; exhausts pressure when solenoid is energized. When solenoid is de-energized, flow is from Port "3" to Port "1." Port "2" is closed. When solenoid is energized, flow is from Port "1" to "2." Port "3" is closed.

Normally Closed (Pressure at 2)

Applies pressure when solenoid is energized; exhausts pressure when solenoid is de-energized. When solenoid is de-energized, flow is from Port "1" to Port "3." Port "2" is closed. When solenoid is energized, flow is from Port "2" to Port "1." Port "3" is closed.

Universal (Pressure at 1, 2, or 3)

For normally closed or normally open operation, selection or diversion of pressure can be applied to Ports "1", "2", or "3."



Manual Operator (Optional)

Manual operator allows manual operation when desired or during an electrical power outage. Two types of manual operators are available - push type (Suffix MO) and screw type (Suffix MS). To operate valve manually with push type operator, push stem at base of valve body as far upward as possible. Valve will now be in the same position as when the solenoid is energized. Removing pressure from stem will release manual operator to original position. To operate valve with a screw type manual operator, rotate manual operator stem at base of valve body clockwise until it hits a stop. Valve will now be in the same position as when the solenoid is energized. Rotate manual operator stem fully counterclockwise before operating valve electrically.

INSTALLATION

Check nameplate for correct catalog number, pressure, voltage, frequency, and service.

Temperature Limitations

For maximum valve ambient and fluid temperatures, refer to chart below. Check catalog number prefix and watt rating on nameplate to determine the maximum temperatures. See example below chart.

Construction AC or DC	Catalog Number Prefix	Watts	Maximum Ambient Temp. °F	Maximum Fluid Temp. °F
AC	None, DA, or S	10.5	77	200
	DF, FT, or SF	10.5	122	200
	HT	10.5	140	200
	None, DP, or SP	16.7*	77	200
DC	None, FT, or HT	11.2*	77	150

* Catalog Nos. 8320A 170, 8320A 180, and 8320A 190 are limited to 140 °F fluid temperature.

EXAMPLES: For Catalog No. HT8320A201, AC construction with a watt rating of 10.5, the maximum ambient temperature is 140°F with a maximum fluid temperature of 200°F. For Catalog No. 8320A204, AC construction with a watt rating of 10.5, the maximum ambient temperature is 77°F with a maximum fluid temperature of 200°F.

Positioning

This valve is designed to perform properly when mounted in any position. However, for optimum life and performance, the solenoid should be mounted vertically and upright to reduce the possibility of foreign matter accumulating in the solenoid base sub-assembly area.

Mounting

For mounting dimensions of body boss (brass) or mounting brackets (optional on brass construction), refer to Figures 1, 2, and 3.

Piping

Connect piping to valve according to markings on valve body. Refer to flow diagrams provided. Apply pipe compound sparingly to male pipe threads only. If applied to valve threads, the compound may enter the valve and cause operational difficulty. Avoid pipe strain by properly supporting and aligning piping. When tightening the pipe, do not use valve or solenoid as a lever. Locate wrenches applied to valve body or piping as close as possible to connection point.

IMPORTANT: To protect the solenoid valve, install a strainer or filter, suitable for the service involved in the inlet side as close to the valve as possible. Clean periodically depending on service conditions. See ASCO Bulletins 8600, 8601, and 8602 for strainers.

Wiring

Wiring must comply with local codes and the National Electrical Code. Solenoid housings are provided with a 7/8" diameter hole to accommodate 1/2" conduit. On some constructions, a green grounding wire is provided. Use rigid metallic conduit to ground all enclosures not provided with a green grounding wire. To facilitate wiring, the enclosure may be rotated 360° by removing the retaining cap or clip. **WARNING:** When metal retaining clip disengages, it will spring upward. Rotate enclosure to desired position. Then replace retaining cap or clip before operating.

NOTE: Alternating current (AC) and direct current (DC) solenoids are built differently. To convert from one to the other, it is necessary to change the complete solenoid, including the solenoid base sub-assembly and core assembly.

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Page 1 of 4

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Solenoid Temperature

Standard catalog valves are supplied with coils designed for continuous duty service. When the solenoid is energized for a long period, the solenoid enclosure becomes hot and can be touched by hand only for an instant. This is a safe operating temperature. Any excessive heating will be indicated by the smoke and odor of burning coil insulation.

MAINTENANCE

NOTE: It is not necessary to remove the valve from the pipeline for repairs.
WARNING: Turn off electrical power supply and depressurize valve before making repairs.

Cleaning

All solenoid valves should be cleaned periodically. The time between cleanings will vary depending on the medium and service conditions. In general, if the voltage to the coil is correct, sluggish valve operation, excessive noise, or leakage will indicate that cleaning is required. Clean valve strainer or filter when cleaning the valve.

Preventive Maintenance

1. Keep the medium flowing through the valve as free from dirt and foreign material as possible.
2. While in service, the valve should be operated at least once a month to insure proper opening and closing.
3. Depending on the medium and service conditions, periodic inspection of internal valve parts for damage or excessive wear is recommended. Thoroughly clean all parts. Replace worn or damaged parts. However, for best results, replace all parts as supplied with an ASCO Rebuild Kit.

Causes Of Improper Operation

1. **Faulty Control Circuits:** Check the electrical system by energizing the solenoid. A metallic "click" signifies that the solenoid is operating. Absence of the "click" indicates loss of power supply. Check for loose or blown fuses, open circuited or grounded coil, broken lead wires or splice connections.
2. **Burned-Out Coil:** Check for open-circuited coil. Replace coil as necessary. Check supply voltage; it must be the same as specified on nameplate.
3. **Low Voltage:** Check voltage across the coil lead. Voltage must be at least 85% of nameplate rating.
6. **Incorrect Pressure:** Check valve pressure. Pressure to valve must be within range specified on nameplate.
5. **Excessive Leakage:** Disassemble valve (see Maintenance) and clean all parts. Replace worn or damaged parts. However, for best results, replace all parts as supplied with an ASCO Rebuild Kit.

Coil Replacement (Refer to Figures 4 and 5)

WARNING: Turn off electrical power supply.

1. Disconnect coil lead wires.
2. Remove retaining cap or clip, nameplate and housing. **WARNING:** When metal retaining clip disengages, it will spring upward.
3. Remove spring washer, insulating washer, coil, insulating washer, ground wire terminal (if present) from solenoid base sub-assembly. Insulating washers are omitted when a molded coil is used.
4. Reassemble in reverse order of disassembly. Use exploded view provided for identification and placement of parts.

CAUTION: The solenoid must be fully reassembled because the housing and internal parts complete the magnetic circuit. Be sure to replace insulating washer at each end of the non-molded coil.

Valve Disassembly (Refer to Figures 4 and 5)

WARNING: Depressurize valve and turn off electrical power supply.

1. Disassemble valve in an orderly fashion. Use exploded views for identification and placement of parts.
2. If necessary, disconnect coil lead wires, grounding wire (if present), and rigid conduit from solenoid housing.
3. Remove retaining cap or clip and slip the entire solenoid enclosure off the solenoid base sub-assembly. **WARNING:** When metal retaining clip disengages, it will spring upward.
4. Unscrew solenoid base sub-assembly from valve body.
5. Remove core assembly, core spring, core guide (AC construction only), and solenoid base gasket.
6. Unscrew end cap (or manual operator assembly) and remove end cap gasket, disc holder spring, and disc holder sub-assembly.
7. All parts are now accessible to clean or replace. Replace worn or damaged parts. However, for best results, replace all parts as supplied with an ASCO Rebuild kit.

Valve Reassembly

1. Reassemble in reverse order of disassembly. Use exploded views for identification and placement of parts.
2. Lubricate all gaskets with DOW CORNING® 111 Compound lubricant or an equivalent high-grade silicone grease. For stainless steel valve constructions, apply a small amount of LOCTITE® PST® pipe sealant (ASCO No. 208-832-11) to male threads of end cap (or manual operator assembly). Pipe sealant supplied in ASCO Rebuild Kits.

3. Replace disc holder sub-assembly, disc holder spring, end cap gasket, and end cap (or manual operator assembly). For brass construction, torque end cap to 175 ± 25 inch-pounds ($19,8 \pm 2,8$ newton-meters). For stainless steel, torque end cap to 90 ± 10 inch-pounds ($10,2 \pm 1,1$ newton-meters).
4. Replace solenoid base gasket, core assembly, core spring, core guide (on AC construction only), and solenoid base sub-assembly. Torque solenoid base sub-assembly to 175 ± 25 inch-pounds ($19,8 \pm 2,8$ newton-meters).
5. Replace solenoid enclosure and retaining cap or clip.
6. Restore line pressure and electrical power supply to valve.
7. After maintenance is completed, operate the valve a few times to be sure of proper operation. A metallic "click" signifies the solenoid is operating.

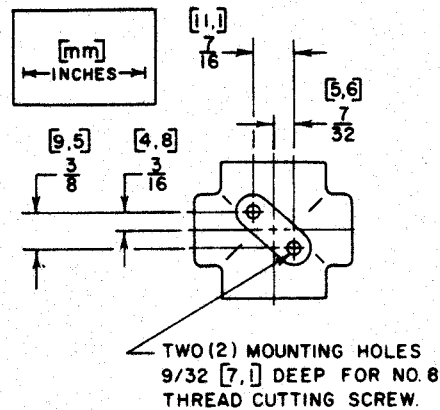


Figure 1. Brass Valve Body Mounting

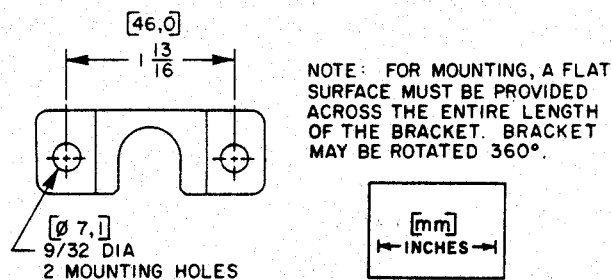


Figure 2. Mounting Bracket for Stainless Steel

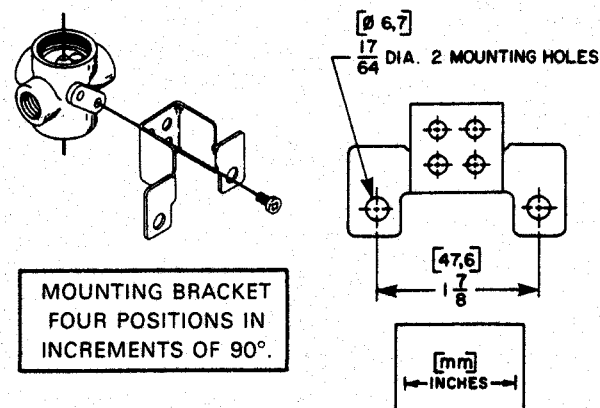


Figure 3. Optional Mounting Bracket for Brass

**ORDERING INFORMATION
FOR ASCO REBUILD KITS AND COILS**

Parts marked with an asterisk (*) in the exploded view are supplied in Rebuild Kits.

- When Ordering Rebuild Kits for ASCO valves, order the Rebuild Kit number stamped on the valve nameplate.+
- When Ordering Coils for ASCO valves, order the number stamped on your coil.+

+ If the number of the Rebuild Kit or the Coil is not visible, order them and specify your valve's Catalog Number, Serial Number, Voltage, and Frequency.

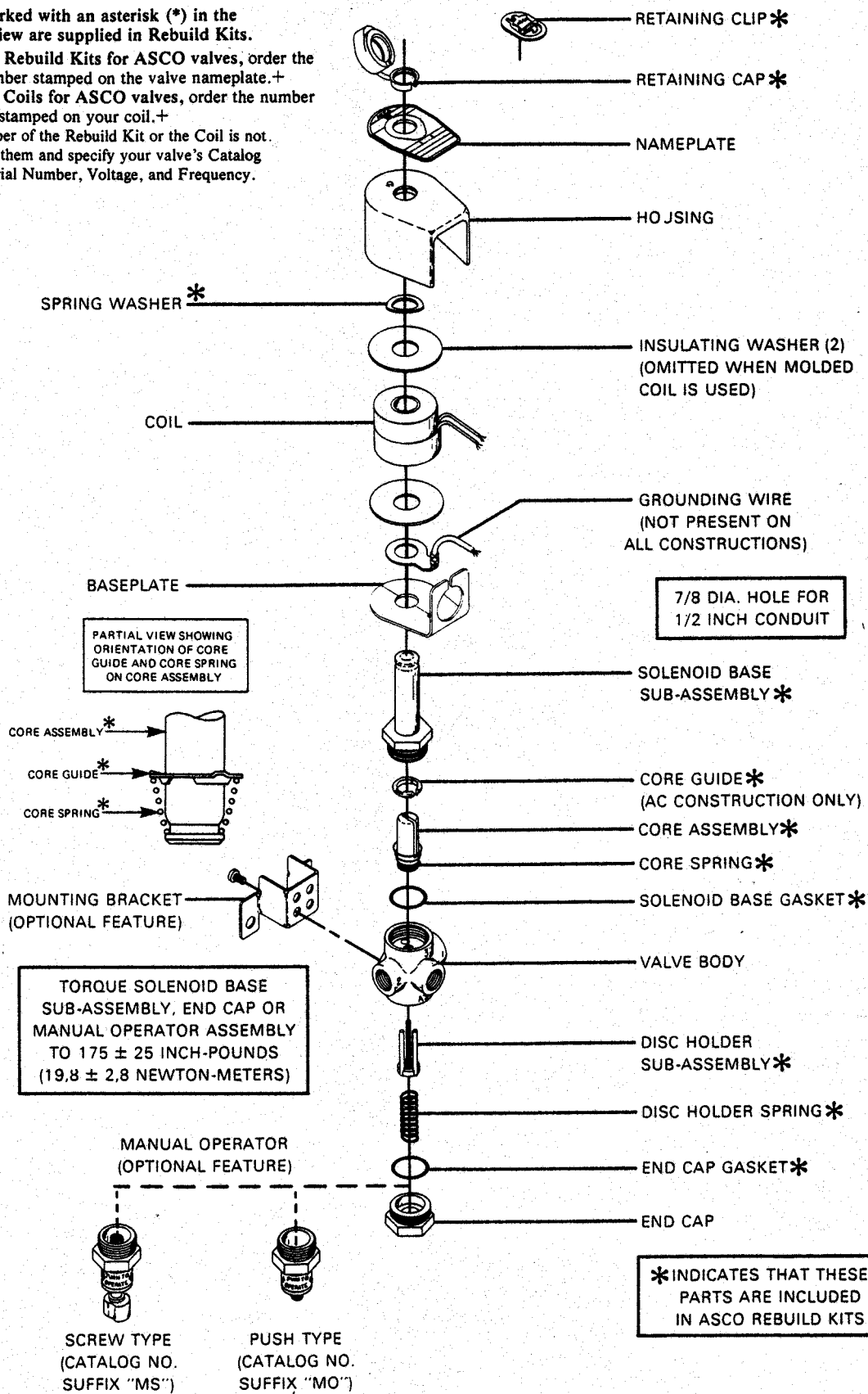


Figure 4. Bulletin 8320, Brass Construction
With General Purpose Solenoid Enclosure Shown
For Explosion-Proof Solenoid Enclosure, See Form No.V5380.

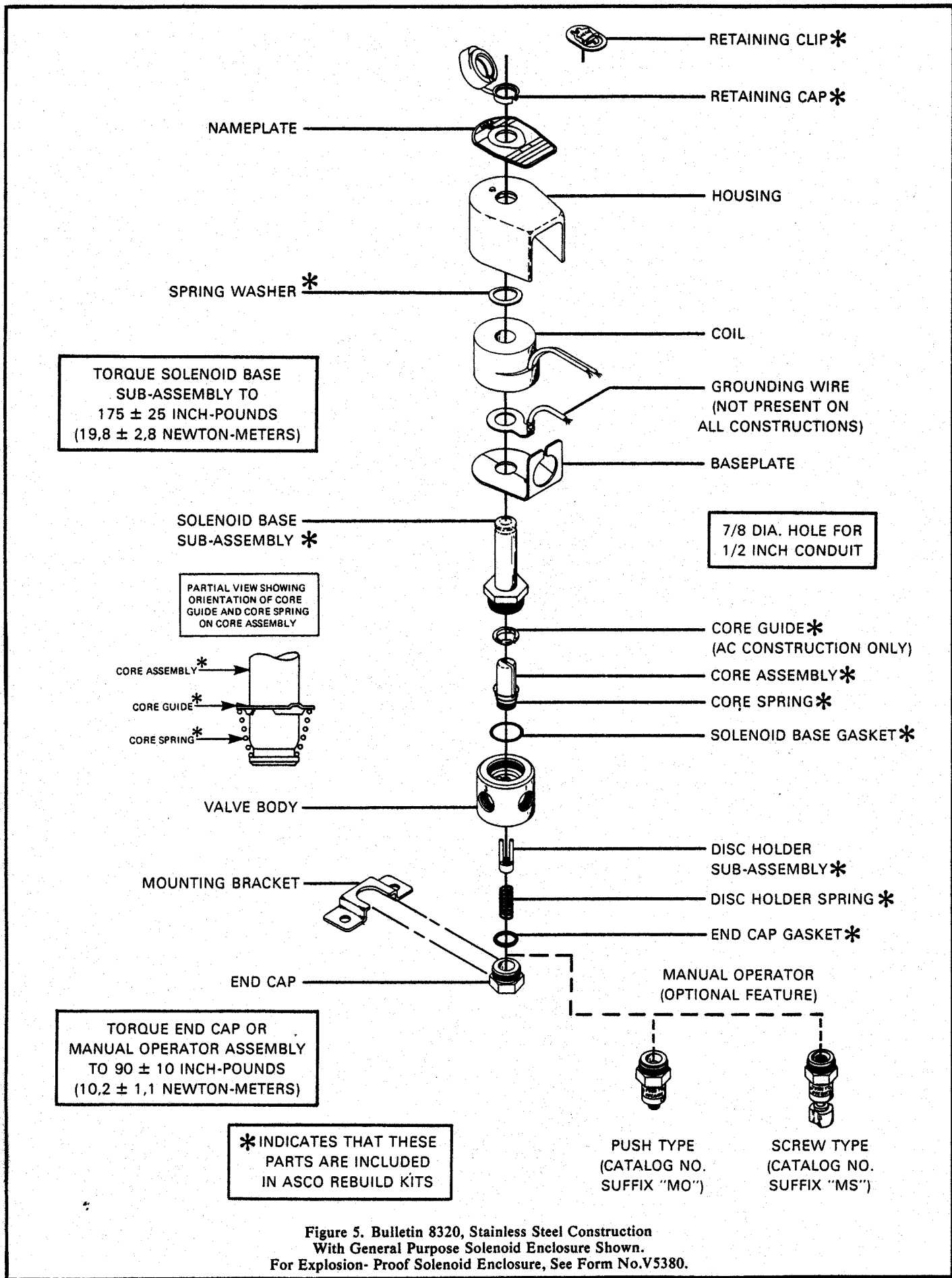


Figure 5. Bulletin 8320, Stainless Steel Construction
 With General Purpose Solenoid Enclosure Shown.
 For Explosion- Proof Solenoid Enclosure, See Form No.V5380.

Type i2P-100 Electro-Pneumatic Transducers

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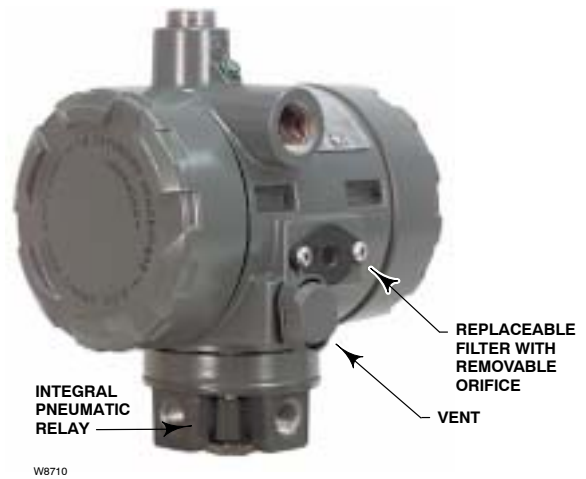


Figure 1. Type i2P-100 Electro-Pneumatic Transducer

information for the Type i2P-100 transducer (see figure 1). Refer to separate manuals for instructions covering equipment used with the transducer.

No person may install, operate or maintain a Type i2P-100 electro-pneumatic transducer without first ● being fully trained and qualified in valve, actuator and accessory installation, operation and maintenance, and ● carefully reading and understanding the contents of this manual. If you have any questions about these instructions, contact your Emerson Process Management™ sales office.

Introduction

Scope of Manual

This instruction manual provides installation, operation, maintenance, and parts ordering

Description

The transducer, shown in figure 3, receives a 4 to 20 milliamper dc input signal and transmits a proportional user field-configurable pneumatic output pressure to a final control element. The pneumatic



i2P-100 Transducer

Table 1. Specifications

Input Signal⁽¹⁾

Available as standard with 4–20 mA.
User configurable by dip switch for split ranging, see table below.

Output Signal^(1,6)

Available as standard 0.2 to 1.0 bar (3 to 15 psig) or 0.4 to 2.0 bar (6 to 30 psig). User configurable by dip switch selection and zero and span potentiometer adjustment, see table below.

INPUT SIGNAL	OUTPUT PRESSURE	
	BAR	PSIG
4 to 20 mA dc	0.2 to 1.0	3 to 15
	0.4 to 2.0	6 to 30
4 to 12 mA dc	0.2 to 1.0	3 to 15
12 to 20 mA dc	0.2 to 1.0	3 to 15

Equivalent Circuit

The Type i2P–100 equivalent circuit is a series circuit consisting of a constant voltage drop (battery) of approximately 4 V dc and a total resistance of 40 ohms. Input is shunted by two 6.8 V zener diodes (see figure 9).

Supply Pressure^(1,5)

Recommended: 0.3 bar (5 psi) higher than upper range limit of output signal
Maximum: 3.4 bar (50 psig)

Medium: Air or Natural Gas⁽⁴⁾

Average Steady State Flow Rate^(1,2)

OUTPUT RANGE							
0.2 to 1.0 bar (3–15 psig)				0.4 to 2.0 bar (6–30 psig)			
SUPPLY PRESSURE							
1.5 bar (20 psig)				2.4 bar (35 psig)			
OUTPUT		FLOW RATE		OUTPUT		FLOW RATE	
Bar	Psig	Normal m ³ /h	Scfh	Bar	Psig	Normal m ³ /h	Scfh
0.2	3	0.08	3.0	0.4	6	0.09	3.6
0.6	9	0.12	4.5	1.2	18	0.19	7.0
1.0	15	0.17	6.3	2.1	30	0.27	10.2

Maximum Output Air Capacity⁽²⁾

8.0 m³/hr (5.0 scfm) at 1.4 bar (20 psig) supply pressure

Performance⁽³⁾

Reference Accuracy: ±1.0% of full scale output span; includes combined effects of hysteresis, linearity, and deadband

Independent Linearity⁽¹⁾: ±0.75% of full scale output span

Hysteresis⁽¹⁾: 0.4% of full scale output span

Frequency Response⁽¹⁾: Gain is attenuated 3 dB at 6 Hz with transducer output signal piped to a typical instrument input

Temperature Effect: ±0.14% per degrees Celsius (±0.75% per degrees Fahrenheit) of span

Supply Pressure Effect: 0.2% of full scale output span per bar supply pressure change (0.2% of full scale output span per psi supply pressure change)

Vibration Effect: Less than 1% of full scale output span when tested to ISA S75.13

Electromagnetic Interference (EMI)⁽¹⁾: Tested per IEC 61326-1 (Edition 1.1). Conforms to the European EMC Directive. Meets emission levels for Class A equipment (industrial locations) and Class B equipment (domestic locations). Meets immunity requirements for industrial locations (Table A.1 in the IEC specification document). Immunity performance shown in table 2.

Operating Ambient Temperature Limits⁽⁵⁾

–40 to 85°C (–40 to +180°F)

Electrical Classification

Hazardous Area:



Explosion proof, Dust-Ignition proof, Intrinsic Safety



Explosion proof, Non-incendive, Dust-Ignition proof, Intrinsic Safety

ATEX

Intrinsic Safety, Type n and Flameproof

IECEX

Intrinsic Safety, Type n and Flameproof

Refer to Special Instructions for Safe-Use and Installation in Hazardous Locations, tables 3 and 4, and figures 15, 16, 17, and 18 for specific approval information.

Approved for use with natural gas⁽⁴⁾

(continued)

Table 1. Specifications (continued)

<p>Electrical Housing: NEMA 4X, CSA enclosure 4X & IP66 when remote vented, otherwise NEMA 3, CSA enclosure 3 & IP64</p> <p>Connections Supply and Output Pressure: 1/4-inch NPT female connection Vent: 1/4-inch NPT female Electrical: Standard 1/2-inch NPT Wire Size: 18 to 22 AWG</p> <p>Adjustments⁽⁶⁾ Zero and Span: Trim potentiometers (20 turn) for zero and span adjustments are located under the housing cap (see figure 10). Switch: Allows input signal split range and user-configurable 0.2 to 2 bar (3 to 30 psig) output.</p>	<p>Mounting Position ■ Actuator ■ pipestand or ■ surface</p> <p>Approximate Weight (Transducer Only) 2.5 kg (5.5 lbs)</p> <p>Actuator Stroking Time See figure 2</p> <p>Declaration of SEP Fisher Controls International LLC declares this product to be in compliance with Article 3 paragraph 3 of the Pressure Equipment Directive (PED) 97 / 23 / EC. It was designed and manufactured in accordance with Sound Engineering Practice (SEP) and cannot bear the CE marking related to PED compliance. However, the product <i>may</i> bear the CE marking to indicate compliance with <i>other</i> applicable EC Directives.</p>
--	---

1. These terms are defined in ISA Standard S51.1.
2. Normal m³/hr—Normal cubic meters per hour (0°C and 1.01325 bar, absolute). Scfh—Standard cubic feet per hour (60°F and 14.7 psia).
3. Performance values are obtained using a transducer with a 4 to 20 mA dc input signal and a 0.2 to 1.0 bar (3 to 15 psig) output signal at an ambient temperature of 24°C (75°F).
4. This product is approved for use with Natural Gas. Natural gas to contain no more than 20 ppm of hydrogen sulphide.
5. The pressure and temperature limits in this document and any applicable standard or code limitation should not be exceeded.
6. For other ranges, zero and span adjustments are needed.

Table 2. Immunity Performance

Port	Phenomenon	Basic Standard	Performance Criteria ⁽¹⁾
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	A
	Radiated EM field	IEC 61000-4-3	A
	Rated power frequency magnetic field	IEC 61000-4-8	A
I/O signal/control	Burst (fast transients)	IEC 61000-4-4	A
	Surge	IEC 61000-4-5	A
	Conducted RF	IEC 61000-4-6	A

Specification limit = ±1% of span
1. A=No degradation during testing. B = Temporary degradation during testing, but is self-recovering.

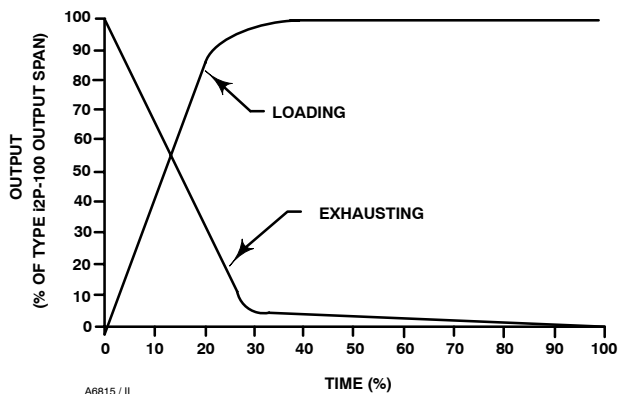


Figure 2. Output-Time Relationships for Type i2P-100 Transducer

output ranges are typically 0.2 to 1.0 bar (3 to 15 psig) and 0.4 to 2.0 bar (6 to 30 psig). A typical application is in electronic control loops where the final control element is a control valve assembly that is pneumatically operated. The input signal and output pressure range of the transducer is indicated on the nameplate, attached to the housing.

CAUTION

Dropping or rough handling of the transducer can cause damage to the converter module resulting in a shifted output or a minimum output.

i2P-100 Transducer

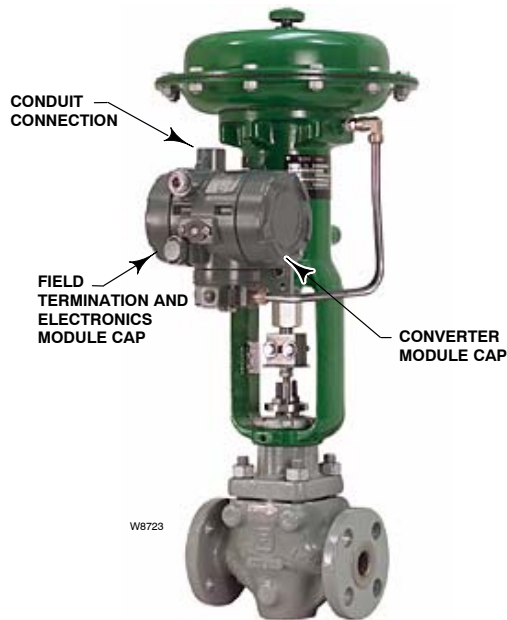


Figure 3. Type i2P-100 Electro-Pneumatic Transducer Mounted on a Size 30 667 Sliding-Stem Actuator

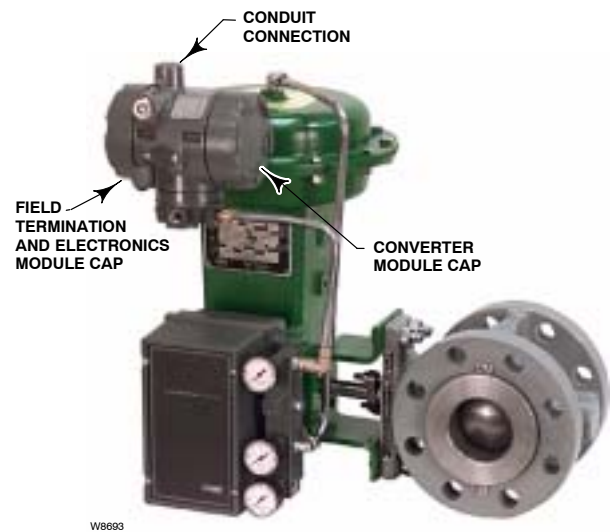


Figure 4. Type i2P-100 Electro-Pneumatic Transducer Mounted on a Size 33 1052 Rotary Actuator, 3610J Positioner and V300B Rotary Valve.

Specifications

Specifications for the Type i2P-100 transducer are listed in table 1.



WARNING

This product is intended for a specific current range, temperature range and other application specifications. Applying different current, temperature and other service conditions could result in malfunction of the product, property damage or personal injury.

Educational Services

For information on available courses for the Type i2P-100 electro-pneumatic transducer, as well as a variety of other products, contact:

Emerson Process Management
 Educational Services, Registration
 P.O. Box 190; 301 S. 1st Ave.
 Marshalltown, IA 50158-2823
 Phone: 800-338-8158 or
 Phone: 641-754-3771
 FAX: 641-754-3431
 e-mail: education@emersonprocess.com

Note

Neither Emerson®, Emerson Process Management, Fisher®, nor any of their affiliated entities assumes responsibility for the selection, use and maintenance of any product. Responsibility for the selection, use and maintenance of any product remains with the purchaser and end-user.

Installation

The i2P-100 transducer has been designed and approved for use with either air or natural gas as the supply medium. If using natural gas as the pneumatic supply medium, natural gas will be used in the pneumatic output connections of the transducer to any connected equipment. In normal operation the unit will vent the supply medium into the surrounding atmosphere unless it is remotely vented. When using natural gas as the supply medium, in a non-hazardous location in a confined area, remote venting of the unit is required. Failure to do so could result in personal injury, property damage, and area re-classification. For hazardous locations remote venting of the unit may be required,

depending upon the area classification, and as specified by the requirements of local, regional, and federal codes, rules and regulations. Failure to do so when necessary could result in personal injury, property damage, and area re-classification.

Additional information for installation and safe-use in hazardous locations can be found in Special Instructions for Safe-Use and Installation in Hazardous Locations.

 **WARNING**

To avoid personal injury or property damage from the sudden release of pressure, air, or natural gas:

- Always wear protective clothing, gloves, and eyewear when performing any installation operations.
- If installing into an existing application, also refer to the **WARNING** at the beginning of the Maintenance section of this instruction manual.
- Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

 **WARNING**

This unit vents the supply medium into the surrounding atmosphere. When installing this unit in a non-hazardous (non-classified) location in a confined area, with natural gas as the supply medium, you must remotely vent this unit to a safe location. Failure to do so could result in personal injury or property damage from fire or explosion, and area re-classification.

When installing this unit in a hazardous (classified) location remote venting of the unit may be required, depending upon the area classification, and as specified by the requirements of local, regional, and federal codes, rules and regulations.

Failure to do so when necessary could result in personal injury or property damage from fire or explosion, and area re-classification.

Vent line piping should comply with local and regional codes and should be as short as possible with adequate inside diameter and few bends to reduce case pressure buildup.

When received from the factory, the set screws (key 8), which provide a locking feature for the housing caps (key 2), are backed off approximately 1 turn. When using the i2P-100 transducer in explosive atmospheres these set screws must be fully engaged.

 **WARNING**

When using this unit in explosive atmospheres, the set screws (key 8) must be fully engaged to lock/secure the housing caps. Failure to fully engage these set screws could result in unauthorized opening of the unit, which may result in personal injury or property damage caused by fire or explosion.

Special Instructions for Safe-Use and Installation in Hazardous Locations

Certain nameplates may carry more than one approval, and each approval may have unique installation requirements and/or conditions of safe-use. Special instructions are listed by agency/approval below.

After reading and understanding these special conditions of use, proceed with standard installation procedures.

 **WARNING**

Failure to follow these conditions of safe-use could result in personal injury or property damage from fire or explosion, and area re-classification.

Table 3. Hazardous Area Classifications for North America (CSA and FM Approvals)

CERTIFICATION BODY	CERTIFICATION OBTAINED	ENTITY RATING	TEMPERATURE CODE	ENCLOSURE RATING
CSA	(Intrinsic Safety) Zone •Ex ia IIC T3/T4/T5 per drawing GE07471 Class/Division •Class I, II, III Division 1 GP A, B, C, D, E, F, G per drawing GE07471	$V_{max} = 30 \text{ Vdc}$ $I_{max} = 150 \text{ mA}$ $P_i = 1.0 \text{ W}$ $C_i = 5 \text{ nF}$ $L_i = 0 \text{ mH}$	T3 ($T_{amb} \leq 85^\circ\text{C}$) T4 ($T_{amb} \leq 81^\circ\text{C}$) T5 ($T_{amb} \leq 46^\circ\text{C}$)	4X*
	(Explosion Proof) Zone •Ex d IIC T5/T6 Class/Division •Class I, Division 1 GP, A, B, C, D	---	T5 ($T_{amb} \leq 85^\circ\text{C}$) T6 ($T_{amb} \leq 75^\circ\text{C}$)	4X*
	(Type n) Zone •Ex nC IIC T5/T6	---	T5 ($T_{amb} \leq 85^\circ\text{C}$) T6 ($T_{amb} \leq 75^\circ\text{C}$)	4X*
	Class I, Division 2, GP A, B, C, D Class II, Division 1, GP E, F, G Class III, Division 2 GP F, G Class III	---	T5 ($T_{amb} \leq 85^\circ\text{C}$) T6 ($T_{amb} \leq 75^\circ\text{C}$)	4X*
FM	(Intrinsic Safety) Zone •Class I Zone 0 AEx ia IIC T3/T4/T5 per drawing GE07470 Class/Division •Class I, II, III Division 1 GP A, B, C, D, E, F, G per drawing GE07470	$V_{max} = 30 \text{ Vdc}$ $I_{max} = 150 \text{ mA}$ $P_i = 1.0 \text{ W}$ $C_i = 0 \text{ nF}$ $L_i = 0 \text{ mH}$	T3 ($T_{amb} \leq 85^\circ\text{C}$) T4 ($T_{amb} \leq 81^\circ\text{C}$) T5 ($T_{amb} \leq 46^\circ\text{C}$)	4X*
	(Explosion Proof) Zone •Class I Zone 1 AEx d IIC T5/T6 Class/Division •Class I, Division 1, GP A, B, C, D	---	T5 ($T_{amb} \leq 85^\circ\text{C}$) T6 ($T_{amb} \leq 75^\circ\text{C}$)	4X*
	(Type n) Zone •Class I Zone 2 AEx nC IIC T5/T6	---	T5 ($T_{amb} \leq 85^\circ\text{C}$) T6 ($T_{amb} \leq 75^\circ\text{C}$)	4X*
	Class I, Division 2, GP A, B, C, D Class II, Division 1, GP E, F, G Class II, Division 2, GP F, G Class III	---	T5 ($T_{amb} \leq 85^\circ\text{C}$) T6 ($T_{amb} \leq 75^\circ\text{C}$)	4X*

* When remotely vented.

CSA

Special Conditions of Use

None stated.

Refer to table 3 for additional information, figure 15 for the CSA loop schematic and figure 16 for the CSA and FM approvals nameplate.

FM

Special Conditions of Use

1. When product is used with natural gas as the pneumatic medium, the maximum working pressure of the natural gas supply is limited to 50 psi.
2. When product is used with natural gas as the pneumatic medium the product shall be provided

with the proper remote venting, as described on page 10 of this instruction manual.

Refer to table 3 for additional information, figure 17 for the FM loop schematic, and figure 16 for the CSA and FM approvals nameplate.

ATEX All Approvals

All ATEX approved units come with a combined nameplate which carries multiple approvals (intrinsic safety and dust, flameproof and dust, and Type n and dust), as shown in figure 18. During installation, only one type of protection method is allowed. The unit shall be marked as to which protection method it was installed as and shall not be changed or utilized in any other manner than was originally marked by the end-user.

Table 4. Hazardous Area Classifications for ATEX and IECEx Approvals

CERTIFICATE	CERTIFICATION OBTAINED	ENTITY RATING	TEMPERATURE CODE	ENCLOSURE RATING
ATEX	⊕ II 1 GD Gas •EEx ia IIC T3/T4/T5 —Intrinsic Safety Dust •T95°C (T _{amb} ≤ 85°C)	U _i = 30 Vdc I _i = 150 mA P _i = 1.0 W C _i = 0 nF L _i = 0 mH	T3 (T _{amb} ≤ 85°C) T4 (T _{amb} ≤ 81°C) T5 (T _{amb} ≤ 46°C)	IP66*
	⊕ II 2 GD Gas •EEx d IIC T5/T6 —Flameproof Dust •T95°C (T _{amb} ≤ 85°C)	---	T5 (T _{amb} ≤ 85°C) T6 (T _{amb} ≤ 75°C)	IP66*
	⊕ II 3 GD Gas •EEx nC II T5/T6 —Type n Dust •T95°C (T _{amb} ≤ 85°C)	---	T5 (T _{amb} ≤ 85°C) T6 (T _{amb} ≤ 75°C)	IP66*
IECEx	Gas •Ex ia IIC T3/T4/T5 —Intrinsic Safety	U _i = 30 Vdc I _i = 150 mA P _i = 1.0 W C _i = 0 nF L _i = 0 mH	T3 (T _{amb} ≤ 85°C) T4 (T _{amb} ≤ 81°C) T5 (T _{amb} ≤ 46°C)	IP66*
	Gas •Ex d IIC T5/T6 —Flameproof	---	T5 (T _{amb} ≤ 85°C) T6 (T _{amb} ≤ 75°C)	IP66*
	Gas •Ex nC IIC T5/T6 —Type n	---	T5 (T _{amb} ≤ 85°C) T6 (T _{amb} ≤ 75°C)	IP66*

* When remotely vented.



WARNING

For ATEX approvals only, end-user must select and mark only one protection method upon installation. Once marked it shall not be changed. Failure to follow these instructions will jeopardize the explosion safety of the transducer, and may result in personal injury or property damage.

ATEX Intrinsic Safety

Special Conditions for Safe-Use

1. Before putting in service, the user shall permanently cross out the areas on the nameplate with the types of protection that are not applicable (EEx ia IIC T3... T5, KEMA 05ATEX1109 X or EEx nA II T5/T6, KEMA 05ATEX1119) or mark the selected type of protection. Once determined the type of protection may not be changed.

2. Because the enclosure of the Type i2P-100 transducer is made of aluminum, if it is mounted in

an area where the use of category 1 G apparatus is required, it must be installed such, that, even in the event of rare incidents, ignition sources due to impact and friction sparks are excluded.

3. Ambient temperature range:

- 40°C – + 46°C for temperature class T5
- 40°C – + 81°C for temperature class T4
- 40°C – + 85°C for temperature class T3

Electrical data:

Unit must be installed with appropriate I.S barrier with maximum entity ratings as follows:

- U_i = 30 V
- I_i = 150 mA (resistively limited)
- P_i = 1 W
- C_i = 0 nF
- L_i = 0 mH

Refer to table 4 for additional information and figure 18 for the ATEX and IECEx approvals nameplate.

i2P-100 Transducer

ATEX Flameproof

Special Conditions for Safe-Use

1. Before putting in service, the user shall permanently cross out the areas on the nameplate with the types of protection that are not applicable (EEx ia IIC T3... T5, KEMA 05ATEX1109 X or EEx nA II T5/T6, KEMA 05ATEX1119) or mark the selected type of protection. Once determined the type of protection may not be changed.

2. Electrical connections are typically made using either cable or conduit.

- If using a cable connection, the cable entry and closing devices shall be certified in type of protection flameproof enclosure “d”, suitable for the conditions of use and correctly installed. For ambient temperatures over 70°C, suitable heat resistant cables and cable glands shall be used.

- If using a rigid conduit connection, a certified sealing device in type of protection flameproof enclosure “d”, such as a conduit seal with setting compound shall be provided immediately to the entrance of the valve housing. For ambient temperature over 70°C, suitable heat resistant wiring and setting compound for the conduit seal shall be used.

Refer to table 4 for additional information and figure 18 for the ATEX and IECEx approvals nameplate.

ATEX Type n

Special Conditions for Safe-Use

1. Before putting in service, the user shall permanently cross out the areas on the nameplate with the types of protection that are not applicable (EEx ia IIC T3... T5, KEMA 05ATEX1109 X or EEx nA II T5/T6, KEMA 05ATEX1119) or mark the selected type of protection. Once determined the type of protection may not be changed.

Refer to table 4 for additional information and figure 18 for the ATEX and IECEx approvals nameplate.

IECEx Intrinsic Safety, Type n, Flameproof

Conditions of Certification

The Intrinsically Safe version has the following Entity Parameters:

$$\begin{aligned} U_i &= 30 \text{ V} \\ I_i &= 150 \text{ mA} \\ P_i &= 1.0 \text{ W} \\ C_i &= 0 \text{ uF} \\ L_i &= 0 \text{ uH} \end{aligned}$$

Refer to table 4 for additional information and figure 18 for the ATEX and IECEx approvals nameplate.

Mounting

When a transducer is ordered as part of a control valve assembly, the factory mounts the transducer on the actuator and connects the necessary tubing, then adjusts the transducer as specified on the order. See figures 3 and 4 for typical mounting configurations.

Transducers also can be ordered separately for mounting on a control valve assembly already in service, or for mounting on a 2-inch diameter pipestand, or a flat surface. The transducer may be ordered either with or without mounting parts.

Mounting parts include a mounting plate and bolts and, if ordered for pipestand mounting, a pipe clamp. Tubing is not included if the transducer is not factory mounted. Use 3/8-inch diameter tubing for all input and output connections. The length of tubing between the transducer output and the final control element should be as short as possible. Transducer overall dimensions are shown in figure 5. If weatherproofing is required, mount the transducer so that the vent can drain. Do not allow moisture or condensate to collect in the vent.

CAUTION

Do not mount the vent in a downward position, as the vent will not drain properly, and may become blocked with ice or debris, resulting in process instability.

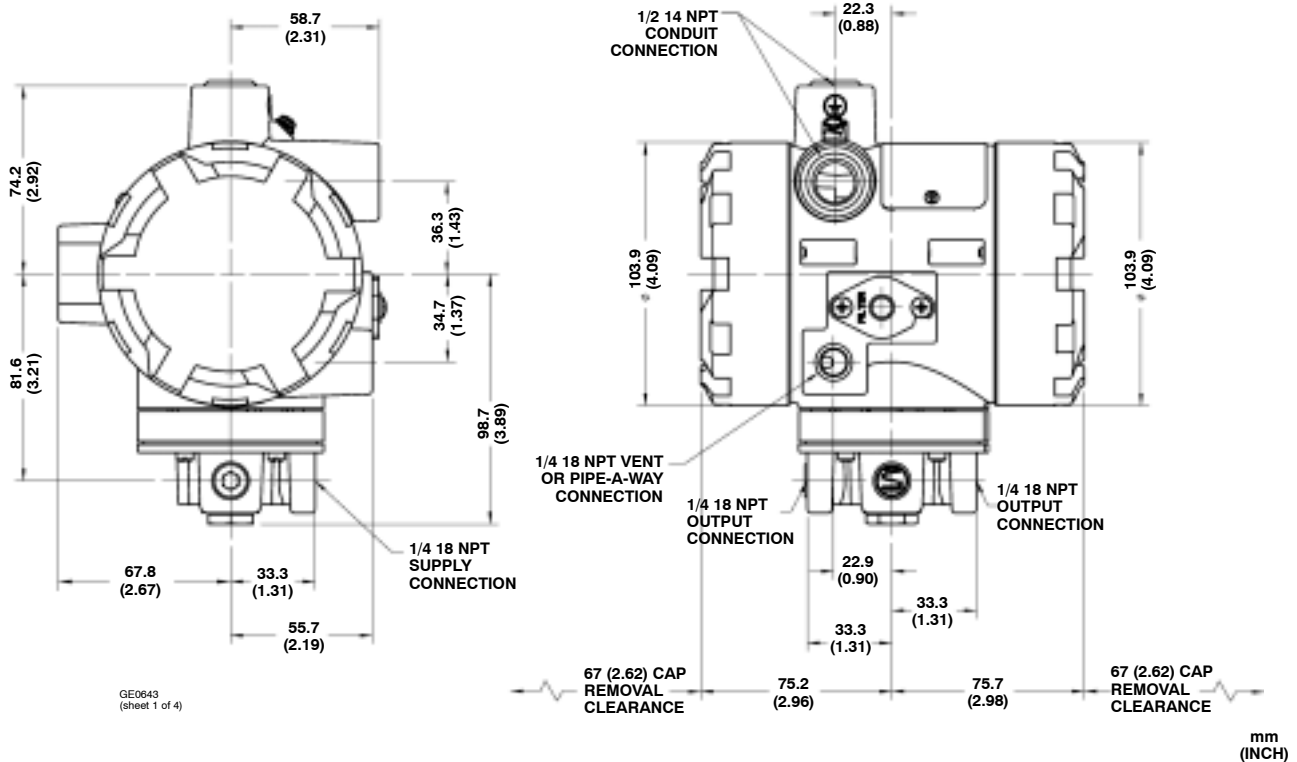


Figure 5. Dimensions and Connections

Pneumatic Connections

As shown in figure 5, all pressure connections on the transducer are 1/4-inch NPT female connections. Use 3/8-inch tubing for all pressure connections. Refer to the vent subsection below for remote vent connections.

office and Industry Instrument air quality standards for use with corrosive air or if you are unsure about the proper amount or method of air filtration or filter maintenance.

Supply Pressure Requirements

WARNING

Severe personal injury or property damage could result from an unstable process if the instrument supply medium is not clean, dry, oil-free and noncorrosive. While use and regular maintenance of a filter that removes particles larger than 40 microns in diameter will suffice in most applications, check with a Fisher Field

Supply pressure must be clean, dry air or noncorrosive gas. Use a Fisher Type 67CFR Filter Regulator, or equivalent, to filter and regulate supply air. The filter regulator can be mounted on a bracket with the transducer as shown in figure 6 or mounted on the actuator mounting boss. An output pressure gauge may be installed on the regulator to indicate the supply pressure to the transducer. Also, as an aid for calibration, a second gauge may be installed on the transducer to indicate transducer output pressure.

Connect the nearest suitable supply source to the 1/4-inch NPT IN connection on the filter regulator (if furnished) or to the 1/4-inch NPT SUPPLY connection on the transducer case (if the filter regulator is not attached).

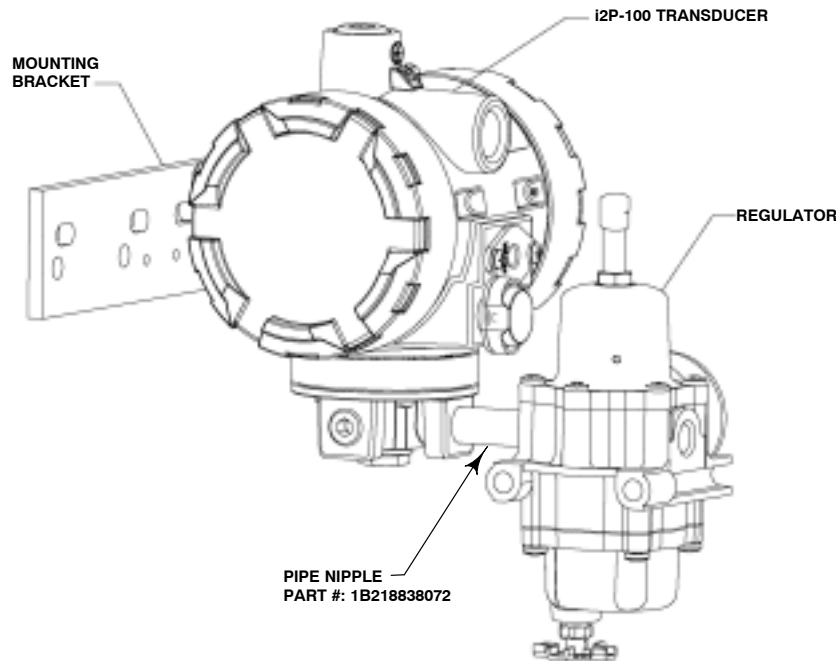


Figure 6. Typical Type i2P-100 Mounting With Type 67CFR Filter Regulator

Diagnostic Connections

To support diagnostic testing of valve/actuator/positioner packages, special connectors and hardware are available. Typical connector installations are shown in figure 7. The hardware used includes a 1/4-inch NPT pipe nipple and pipe tee with a 1/8-inch NPT pipe bushing for the connector. The connector consists of a 1/8-inch NPT body and body protector.

Note

If the Type i2P-100 transducer is used in a valve assembly with a positioner, no hook-up for diagnostic testing is required for the Type i2P-100. The hook-up for diagnostic testing should be installed at the positioner.

Install the connectors and hardware between the Type i2P-100 transducer and the actuator.

1. Before assembling the pipe nipple, pipe tee, pipe bushings, actuator piping, and connector body, apply sealant to all threads.

2. Turn the pipe tee to position the connector body and body protector for easy access when doing diagnostic testing.

Vent

When using natural gas as the supply medium ensure that the following warnings are read and understood. Contact your Emerson Process Management sales office if you have any questions regarding the information contained in this section.



This unit vents the supply medium into the surrounding atmosphere. When installing this unit in a non-hazardous (non-classified) location in a confined area, with natural gas as the supply medium, you must remotely vent this unit to a safe location. Failure to do so

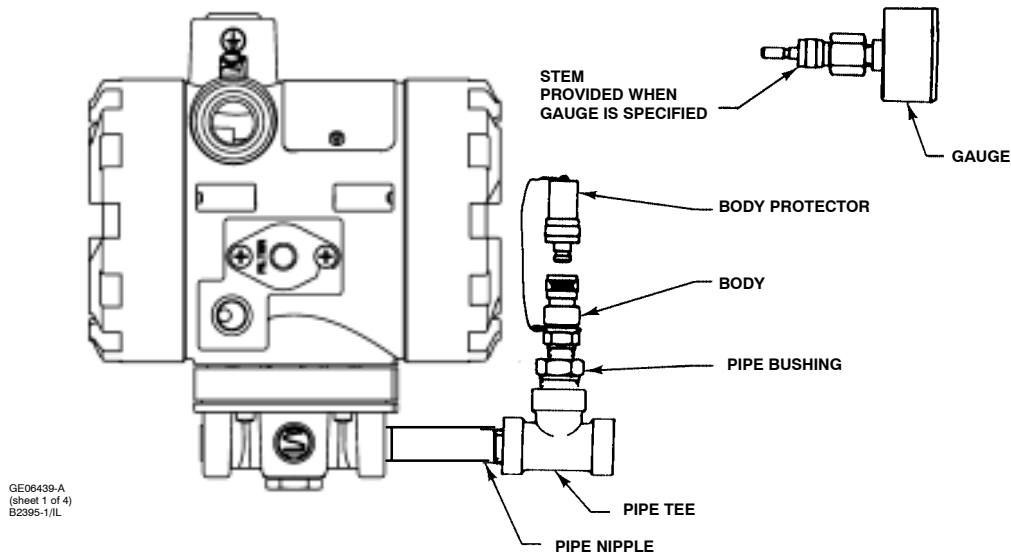


Figure 7. Diagnostics Hookup for Type i2P-100 Transducer

could result in personal injury or property damage from fire or explosion, and area re-classification.

When installing this unit in a hazardous (classified) location remote venting of the unit may be required, depending upon the area classification, and as specified by the requirements of local, regional, and federal codes, rules and regulations. Failure to do so when necessary could result in personal injury or property damage from fire or explosion, and area re-classification.

Vent line piping should comply with local and regional codes and should be as short as possible with adequate inside diameter and few bends to reduce case pressure buildup.

If a remote vent is required, the vent line must be as short as possible with a minimum number of bends and elbows. To connect a remote vent, remove the plastic vent (key 71, figure 13). The vent connection is 1/4-inch NPT female. Use 3/8-inch tubing to provide a remote vent.

Electrical Connections

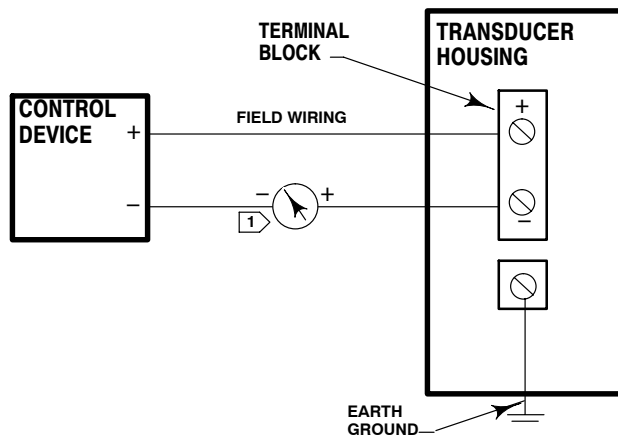
WARNING

For explosion-proof applications, or when using natural gas as the supply medium, disconnect power before removing the housing cap. Personal injury or property damage from fire or explosion may result if power is not disconnected before removing the cap.

For intrinsically safe installations, refer to the nameplate or to instructions provided by the barrier manufacturer, for proper wiring and installation.

Note

For North American explosion-proof applications in the Class/Division system, the i2P-100 has been designed such that a conduit seal is not required. For all other applications install the product as per local, regional, or national code, rules, and regulations.



NOTE:
1 FOR TROUBLESHOOTING OR MONITORING OPERATION, AN INDICATING DEVICE CAN BE A VOLTMETER ACROSS A 250 OHM RESISTOR OR A CURRENT METER.
A3875/IL

Figure 8. Typical Field Wiring Diagram

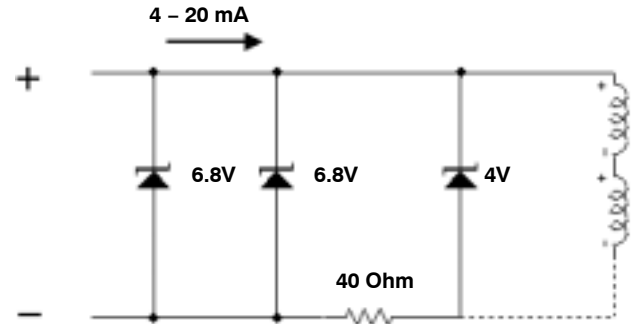


Figure 9. Equivalent Circuit

Calibration

WARNING

Select wiring and/or cable glands that are rated for the environment of use (hazardous location, ingress protection, and temperature). Failure to use properly rated wiring and/or cable glands can result in personal injury or property damage from fire or explosion.

Use the 1/2-inch NPT conduit connection, shown in figure 5, for installation of field wiring.

Refer to figures 8, 9, and 10 when connecting field wiring from the control device to the transducer. Connect the positive wire from the control device to the transducer “+” terminal and, the negative wire from the control device to the transducer “-” terminal. Do not overtighten the terminal screws. Maximum torque is 0.45 N•m (4 lbf•in.). Connect the transducer grounding terminal to earth ground.

Grounding terminals are provided both inside and outside the transducer housing.

Operating Information

During normal operation, the output of the Type i2P-100 transducer is connected to the final control element.

WARNING

On explosion-proof instruments, or when using natural gas as the supply medium, remove electrical power before removing either of the the housing caps in a hazardous area. Personal injury or property damage may result from fire or explosion if power is applied to the transducer with the cap removed in a hazardous area.

For intrinsically safe areas, current monitoring during operation must be with a meter approved for use in hazardous areas.

Equipment Required

Choose a current or voltage source that is capable, without switching ranges, of driving the transducer through its entire input range. Switching ranges on a current or voltage source will produce spikes or mid-scale reverses in the input signal presented to the transducer, causing errors. The current source should be capable of delivering 30 mA with 30 V dc maximum compliance voltage.

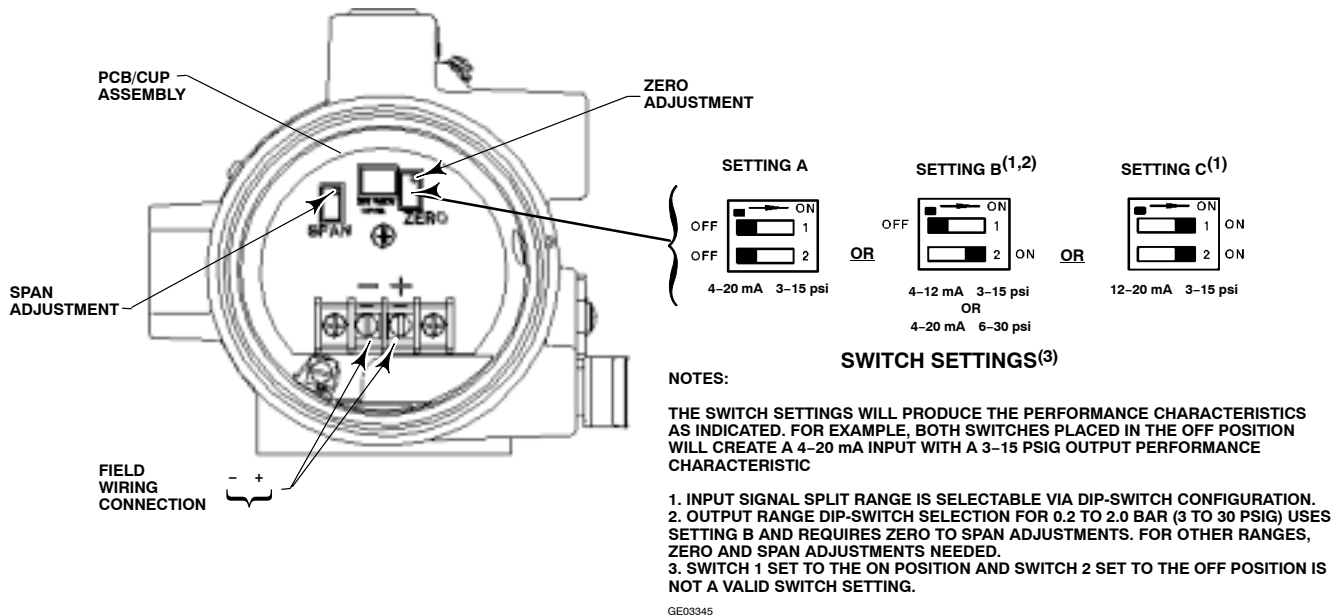


Figure 10. Zero and Span Adjustments and Switch Settings

Calibration Procedure

WARNING

To avoid personal injury or property damage due to an uncontrolled process provide some temporary means of process control before beginning the calibration procedure.

Refer to figure 10 for adjustment locations.

Note

The following steps are for a 4-20 mA, 0.2 to 1.0 bar (3 to 15 psig) configured unit. The same procedure is used for other configurations.

1. Remove electronics module cover (cover adjacent to conduit entry, see figure 3 and 4).

CAUTION

Do not attempt to remove either of the housing caps if the locking set screws (key 8) are engaged. Removing

housing caps without disengaging the set screws can cause damage to the housing caps.

2. Input and output ranges are selectable by dip switch selection. Refer to figure 10 for dip switch settings. Adjust dip switch settings and zero and span as necessary to achieve the desired input/output range.

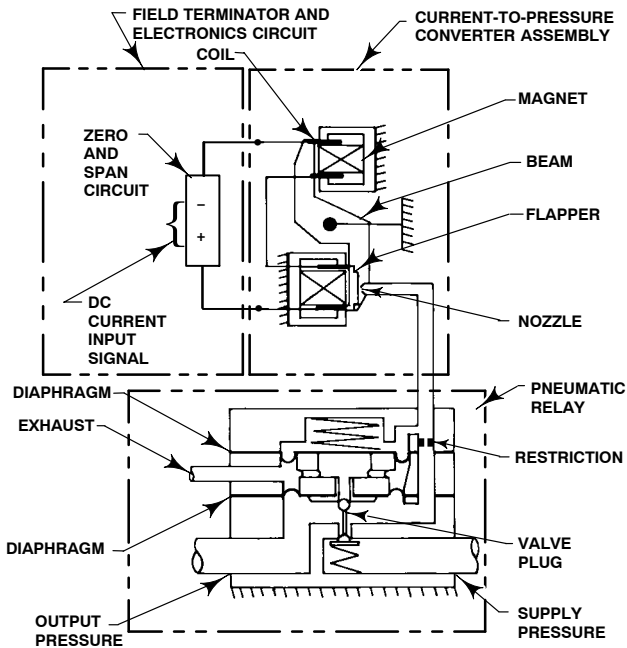
3. If a current source other than the control device is used as the input source, disconnect the control device and connect the current source positive terminal to the transducer “+” terminal and the current source negative terminal to the transducer “-” terminal.

If an external meter is used, connect the current source positive terminal to the transducer “+” terminal. Connect the meter positive terminal to the transducer “-” terminal and the meter negative terminal to the current source negative terminal as shown in figure 8.

4. Check the supply pressure to ensure it is at the recommended pressure. Refer to table 1, the Specifications table, for supply pressure recommendations.

5. Adjust the input current to the low milliamperes dc.

i2P-100 Transducer



A3877-2/IL

Figure 11. Type i2P-100 Transducer Schematic

6. The output pressure should be 0.2 bar (3 psig). If not, adjust the ZERO potentiometer until the output pressure is 0.2 bar (3 psig).
7. Adjust the input current to the high milliamperes dc.
8. The output pressure should be 1.0 bar (15 psig). If not, adjust the SPAN potentiometer until the output pressure is 0.8 bar (15 psig).
9. Repeat steps 5 through 8 until the output pressure is within the referenced accuracy requirements without further adjustment.
10. If a current source other than the control device was used, disconnect the current source and reconnect the control device.

Principle of Operation

The converter module receives a standard dc current input signal from a control device to operate coils in a force balanced beam system which in turn, controls bleed air through an integral nozzle/flapper arrangement. The nozzle pressure provides the input signal to operate the relay as shown in figure 11. Relay output pressure is applied, through tubing, directly to the final control element or valve/actuator assembly.

Maintenance

Due to normal wear or damage from external sources such as debris in the supply medium, periodic maintenance or repair of the transducer may be necessary. Maintenance of the transducer consists of troubleshooting, removal for inspection, and replacement of component parts, as well as removal and inspection of the external removable filter/restriction and cleaning or replacing as necessary (see figure 1).

WARNING

To avoid personal injury or property damage from the sudden release of pressure, air or natural gas:

- Always wear protective clothing, gloves, and eyewear when performing any maintenance operations.
- Disconnect any operating lines providing air pressure, electric power, or a control signal to the actuator. Be sure the actuator cannot suddenly open or close the valve.
- Use bypass valves or completely shut off the process to isolate the valve from process pressure. Relieve process pressure on both sides of the valve.
- Use lock-out procedures to be sure that the above measures stay in effect while you work on the equipment.
- Check with your process or safety engineer for any additional measures that must be taken to protect against process media.

WARNING

When using natural gas as the supply medium, or for explosion proof applications, the following warnings also apply:

- Remove electrical power before removing either housing cap. Personal injury or property damage from fire or explosion may result if power is not disconnected before removing either cap.
- Remove electrical power before disconnecting any of the pneumatic

connections or removing the external removeable filter/restriction.

When disconnecting any of the pneumatic connections or the external removeable filter/restriction, natural gas will seep from the unit and any connected equipment into the surrounding atmosphere. Personal injury or property damage may result from fire or explosion if preventative measures are not taken, such as adequate ventilation and the removal of any nearby ignition sources.

CAUTION

Do not attempt to remove either of the housing caps if the locking set screws (key 8) are engaged. Removing housing caps without disengaging the set screws can cause damage to the housing caps.

CAUTION

When replacing components, use only components specified by the factory. Always use proper component replacement techniques, as presented in this manual. Improper techniques or component selection may invalidate the approvals and the product specifications, as indicated in table 1. It may also impair operations and the intended function of the device

The converter module and the electronics module are non-repairable. If troubleshooting or alignment attempts indicate a faulty converter or electronics module, replace the module or return the transducer to your Emerson Process Management sales office for repair.

Troubleshooting

WARNING

Refer to the WARNING at the beginning of this section.

Electrical

The following procedures require taking the control valve/actuator assembly out of service. Provide some temporary means of process control before taking the control valve out of service.

1. Ensure terminal lug connections from the control device to the transducer are of the correct polarity (refer to the electrical connection procedures in the Installation section of this manual).
2. At the transducer, ensure that the milliampere dc signal is applied, and ensure that it is within the 4 to 20 milliampere range.
3. Check switches and ensure that they are properly set. Refer to figure 10.
4. If the problem has not been resolved, see Electronics Module Replacement in this manual.

Pneumatic

Provide a 4 to 30 milliampere dc current source, supply pressure, and a gauge to monitor the output pressure when checking transducer operation. Refer to figure 13 for key number locations.

1. Ensure that supply pressure to the transducer meets your requirements [0.3 bar (5 psi) higher than upper range limit of output signal, with a maximum of 3.4 bar (50 psi)].
2. Ensure that the filter (key 11) and restrictor (key 10) are open and clean. Remove the two screws (key 14), the filter cap (key 13) and the O-ring (key 12) to access the filter and restrictor.
3. If a filter/regulator is used, ensure that it is working correctly. If not, ensure the dripwell is not plugged because of excessive moisture accumulation. If necessary, drain off any moisture, and clean or replace the filter element.
4. Force the converter module to maximum output pressure with a 30 milliampere dc signal. Output pressure should build up to the approximate value of the supply pressure [maximum of 3.4 bar (50 psi)].
5. When the input current is removed, the transducer output pressure should drop to less than 0.14 bar (2 psig). If it does not, check to ensure the vent and exhaust air passageway is free from foreign material.
6. To inspect the relay assembly, refer to the Relay Maintenance procedures in this manual.
7. If the problem has not been resolved, see Converter Module Replacement in this manual.

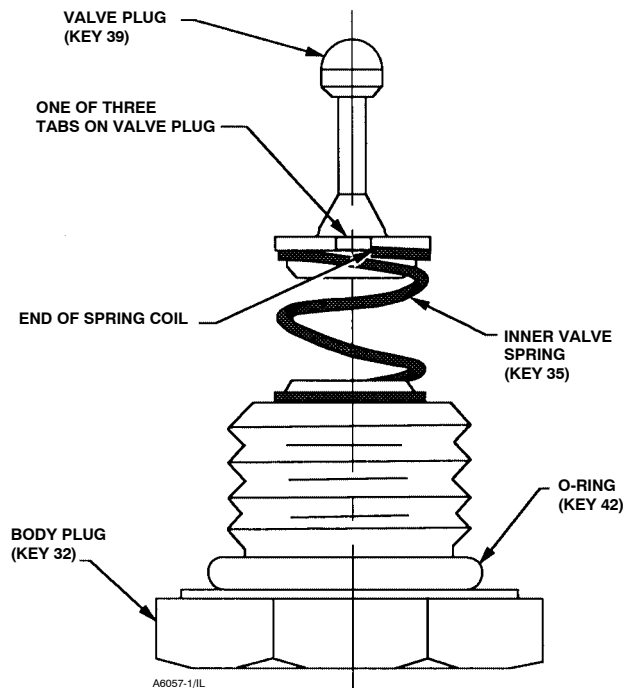


Figure 12. Valve Plug, Inner Valve Spring and Body Plug Assembly

2. Insert the converter module into position in the housing (key 1). Replace the two screws (key 52) and tighten them.
3. Replace the housing cap (key 2), making sure to re-tighten the set screw (key 8).
4. Electrically calibrate the unit using the procedure in the Calibration section of this manual.

Electronics Module Replacement

WARNING

Refer to the **WARNING** at the beginning of this section.

Removal

Refer to figure 13 for key number locations.

1. Remove the housing cap (key 2) (the cap closest to the conduit). Note that the set screw (key 8) associated with this housing cap needs to be loosened to remove the cap.
2. Note the location of the wires, then remove the electrical wiring from the terminal block.
3. Remove the three screws (key 26) and remove the electronics module from the housing.

Replacement

1. Insert the electronics module into position in the housing (key 1). Replace the three screws (key 26) and tighten them.
2. Replace the electrical wiring removed in step 1 of the removal procedures. Do not overtighten the terminal screws. Maximum torque is 0.45 N•m (4 lbf•in).
3. Electrically calibrate the unit using the procedure in the Calibration section of this manual.
4. Replace the housing cap (key 2), making sure to re-tighten the set screw (key 8).

Converter Module Replacement

WARNING

Refer to the **WARNING** at the beginning of this section.

Removal

Refer to figure 13 for key number locations.

1. Remove the housing cap (key 2) (the cap farthest away from the conduit). Note that the set screw associated with this housing cap (key 8) needs to be loosened to remove the cap.
2. Unscrew the two captive screws (key 52) and remove the converter module from the housing.
3. Inspect the O-ring (key 55) and replace if necessary.

Replacement

1. Lubricate the O-ring (key 55) with a silicone sealant before replacing the converter module in the housing.

Relay Maintenance

WARNING

Refer to the **WARNING** at the beginning of this section.

Refer to figures 12 and 14 for key number locations.

Removal

1. Remove the four mounting screws (key 36, shown in figure 14) and remove the relay from the transducer. Be careful not to lose the bias spring (key 34) and input diaphragm (key 38).
2. Remove the body plug (key 32) that holds the inner valve spring (key 35) and valve plug (key 39) in place from the relay body assembly.
3. Remove the exhaust port assembly (key 33) from the relay assembly.
4. Inspect the springs, exhaust seat, valve plug, and other parts for wear or damage; replace as necessary. Note: the valve plug supply seat is an insert in the relay body (key 41). If this insert is bad, replace the relay body.
5. Make sure all parts of the relay are clean and that all passages are clear of foreign matter.

Assembly

1. Assemble the inner valve spring (key 35) onto the body plug (key 32) and fit the valve plug (key 39) onto the inner valve spring as shown in figure 12. To assure best alignment between the valve plug, inner valve spring, and body plug; fit the valve plug onto the inner valve spring so that one of the three tabs at the base of the valve plug sets at the end of the last coil of the inner valve spring.
2. Lubricate the O-ring (key 42) with a silicone sealant (key 37). Insert the assembled valve plug, inner valve spring, and body plug into the relay body (key 41). Compress the spring and thread the body plug (key 5) into place. Then, tighten the body plug.
3. Insert two of the mounting screws (key 36) into two opposite holes of the relay body (key 41). Hold the screws in place while assembling the following parts on the relay body. The screws serve as studs to align the parts as they are being assembled.
4. When replacing the exhaust port assembly (key 33), make sure all passages and screw holes are aligned and that the hole in the center of the exhaust port assembly fits over the valve plug (key 39). Place the exhaust port assembly on the relay body (key 41). Hold assembled parts in place.
5. Make sure the tabs on the body block (key 40) align with the tabs on the relay body (key 41) and that the side with 5 holes faces the relay body. Place the body block on the assembled parts. Hold assembled parts in place.
6. When replacing the input diaphragm (key 38), make sure all passages and screw holes are

aligned. Place the input diaphragm on the body block (key 40). Hold assembled parts in place.

7. Install the bias spring (key 34) into the transducer housing assembly (key 1). Make sure the tabs on the body block and relay body align with the tab on the transducer housing assembly. Place the assembled parts onto the transducer housing assembly. Thread the two mounting screws (key 36) into the transducer housing assembly. Install the remaining two mounting screws. Tighten all mounting screws to 2 N•m (20 lbf•in).
8. Perform the procedure in the Calibration section of this manual.

Parts Ordering

A serial number is assigned to each transducer and stamped on the nameplate. Always refer to this serial number when corresponding with your Emerson Process Management sales office regarding spare parts or technical information. When ordering replacement part, also specify the complete 11-character part number from the Parts list.

Note

Use only genuine Fisher replacement parts. Components that are not supplied by Emerson Process Management should not, under any circumstances, be used in any Fisher instrument. Use of components not supplied by Emerson Process Management will void your warranty, might adversely affect the performance of the instrument, and might jeopardize worker and workplace safety.

Note

Neither Emerson, Emerson Process Management, nor Fisher, nor any of their affiliated entities assumes responsibility for the selection, use and maintenance of any product. Responsibility for the selection, use and maintenance of any product remains with the purchaser and end-user.

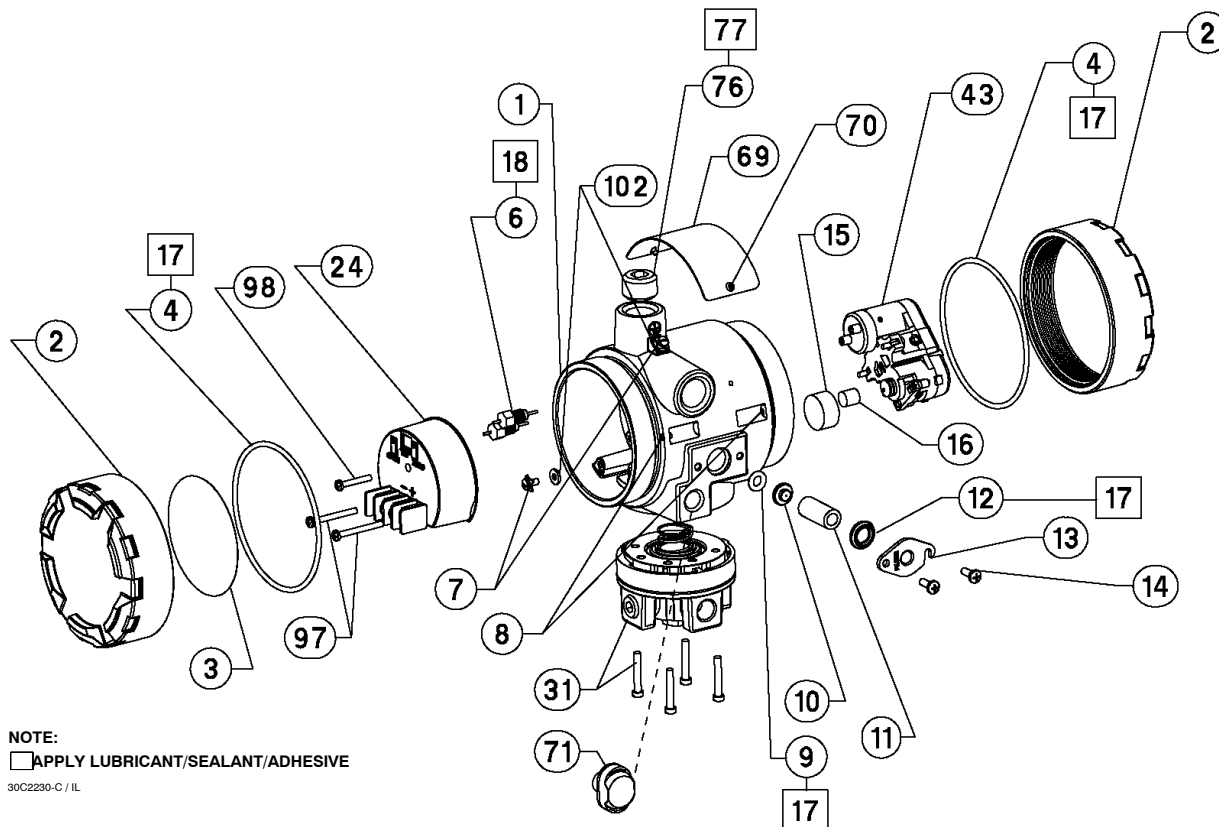


Figure 13. Type i2P-100 Transducer Assembly

Parts Kits

Description	Part Number
Repair Kit for Type i2P-100 electro-pneumatic transducer Contains O-rings (keys 4, 9, 12, and 55) and Filter (key 11)	R2P100X0012

Key	Description	Part Number
8	Set Screw (2 req'd)	1B4556X0012
9*	O-Ring ⁽¹⁾	
10	Restrictor, Primary	10C2233X012
11*	Filter ⁽¹⁾	
12*	O-Ring ⁽¹⁾	
13	Filter Cap	GB0122X0012
14	Machine Screw (2 req'd)	19B0821X012
15	Flame Arrestor	GE06959X012
16	Flame Arrestor	GE02963X012
17	Lubricant, silicone sealant (not furnished with transducer)	
18	Thread locking adhesive, high strength (not furnished with transducer)	
55	O-Ring ⁽¹⁾	
69	Nameplate, aluminum	---
70	Screw (2 req'd)	1P426928982
71	Vent Assembly	GE06162X012
76	Pipe Plug	1H5137X0012
102	Washer	1C332928982

Parts List (see figure 13)

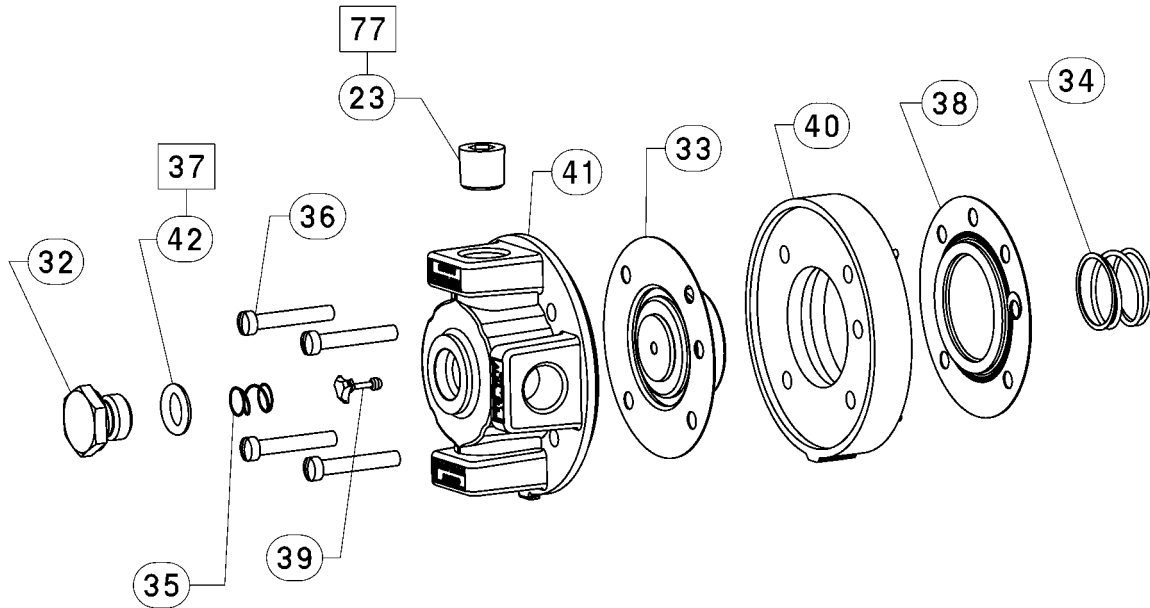
Housing

Key	Description	Part Number
1	Housing, Aluminum	
2	Cover (2 req'd)	48B6515X022
3	Configuration Label	GE03345X012
4*	O-Ring ⁽¹⁾ (2 req'd)	
6	Feed Thru (2 req'd)	
7	Wire Retainer (2 req'd)	16A2821X012

PWB/Cup Assembly

24*	PWB/Cup Assembly	GE10168X012
97	Machine Screw (2 req'd)	GE11776X012
98	Machine Screw	GE11777X012

*Recommended spare parts
1. Available in the Repair Kit



NOTE:
□ APPLY LUBRICANT/SEALANT/ADHESIVE

30C2258-B/IL

Figure 14. Type i2P-100 Relay Assembly

Key	Description	Part Number	Key	Description	Part Number
Relay Assembly (see figure 14)					
41	Relay / Body Assembly	GE03512X012			
42	O-Ring	1E5477X0062			
36	Machine Screw, fill hd (4 req'd)	1H1581X0012			
32	Body Plug	11B2363X012			
33	Exhaust Port Assembly	11B2364X012			
34	Spring	11B2369X012			
35	Spring	11B6843X012			
37	Lubricant, silicone sealant (not furnished with relay)				
38	Upper Diaphragm	21B2362X012			
39	Valve Plug	21B2370X012			
40	Body Block	31B2356X012			
77	Anti-Seize Sealant (not furnished with relay)				

I/P Converter Assembly

43*	I/P Converter Assembly	30C2218X012
-----	------------------------	-------------

Gauge/Pipe Plug

23	Pipe plug, use when gauge is not specified (not shown)	
	Alloy steel pl	1C333528992
	Stainless steel	1C3335X0032
23	Gauge, (not shown)	
	0-30 psig/0-0.2 MPa/0-2 bar	11B8579X022
	0-60 psig/0-0.4 MPa/0-4 bar	11B8579X032

Diagnostic Connections

FlowScanner™ diagnostic system hook-up

Includes pipe tee, pipe nipple, pipe bushings, connector body, and body protector. See figure 7 for part identification. Also, part number provides correct quantities of each item.

Note

If the Type i2P-100 Transducer is used in a valve assembly with a positioner, no hook-up for diagnostic testing is required for the Type i2P-100. The hook-up for diagnostic testing should be installed at the positioner.

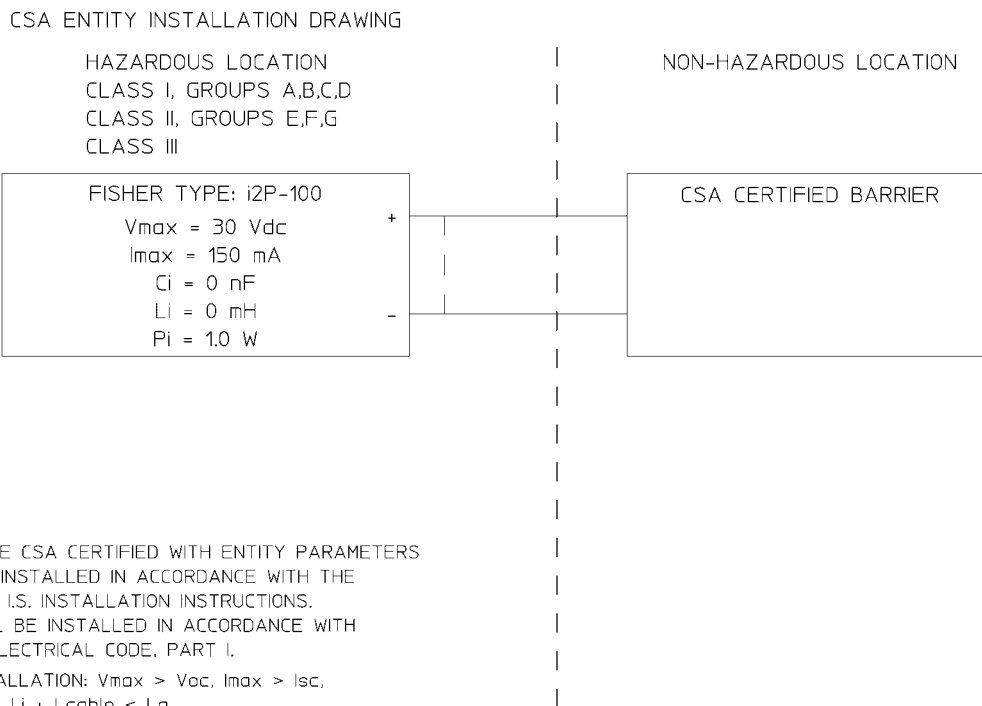
Side Output

For units with gauges	
SST fittings	12B8040X052
Brass fittings	12B8040X062
For units without gauges	
SST fittings	12B8040X072
Brass fittings	12B8040X082

*Recommended spare parts

Key	Description	Part Number	Key	Description	Part Number
Mounting Parts					
Yoke Mounting					
Type 470 size 23 through 64					
80	Mounting Bracket, steel	3P426825022			
81	Washer, steel pl (4 req'd)	1B865928982			
82	Cap Screw, steel pl (4 req'd)	1A381624052			
480 Series actuator boss					
80	Mounting Bracket, steel	3P426825022			
81	Washer, steel pl (4 req'd)	1B865928982			
82	Cap Screw, steel pl (4 req'd)	1A381624052			
83	Screw, steel pl (2 req'd)	1C5958X0022			
85	Mounting Bracket, Steel	3L276725092			
86	Hex Nut, steel pl (2 req'd)	1A352724122			
Type 585C size 25 and 50					
80	Mounting Bracket, steel	3P426825022			
81	Washer, steel pl (4 req'd)	1B865928982			
82	Cap Screw, steel pl (4 req'd)	1A381624052			
83	Screw, steel pl (2 req'd)	1A352624052			
Type 585C (470) size 60, 68, 100, and 130 ; Type 657 and 667 size 30, 34, 40, 45, 50, 60, 70, 80 & 87; Type 1051 and 1052 size 40, 60 and 70; Type 1061 all sizes					
80	Mounting Bracket, steel	3P426825022			
81	Washer, steel pl (4 req'd)	1B865928982			
82	Cap Screw, steel pl (4 req'd)	1A381624052			
83	Screw, steel pl (2 req'd)	1C870224052			
84	Spacer	1K766824092			
Casing Mounting					
Type 657 and 667 size 30, 34, 40, 45, 50 and 60					
80	Mounting Bracket, steel		1F401225072		
81	Washer, steel pl (2 req'd)		1B865928982		
82	Cap Screw, steel pl (2 req'd)		1A381624052		
83	Screw (req'd)		1A582824052		
Type 657 and 667 size 70					
80	Mounting Bracket, steel		1F401225072		
81	Washer, steel pl (2 req'd)		1B865928982		
82	Cap Screw, steel pl (2 req'd)		1A381624052		
83	Screw (2 req'd)		1A368324052		
Type 1051 and 1052 size 20, 33, 40, 60 and 70					
80	Mounting Bracket, steel		1F401225072		
81	Washer, steel pl (2 req'd)		1B865928982		
82	Cap Screw, steel pl (2 req'd)		1A381624052		
83	Screw (req'd)		1A582824052		
Type 1250 and 1250R all sizes					
80	Mounting Bracket, steel		30B1265X022		
81	Washer, steel pl (2 req'd)		1B865928982		
82	Cap Screw, steel pl (2 req'd)		1A381624052		
87	Washer		10B6610X012		
91	U-Bolt (2 req'd)		19A7930X012		
92	Hex Nut (req'd)		19A4838X012		
Pipestand Mounting					
80	Mounting Bracket, steel		3P426825022		
81	Washer, steel pl (4 req'd)		1B865928982		
82	Cap Screw, steel pl (2 req'd)		1A381624052		
88	Pipe Clamp, steel pl		1P427028982		
Surface Mounting					
80	Mounting Bracket, Steel		GE07077X012		
82	Cap Screw		1B6098X0012		

Loop Schematics/Nameplates



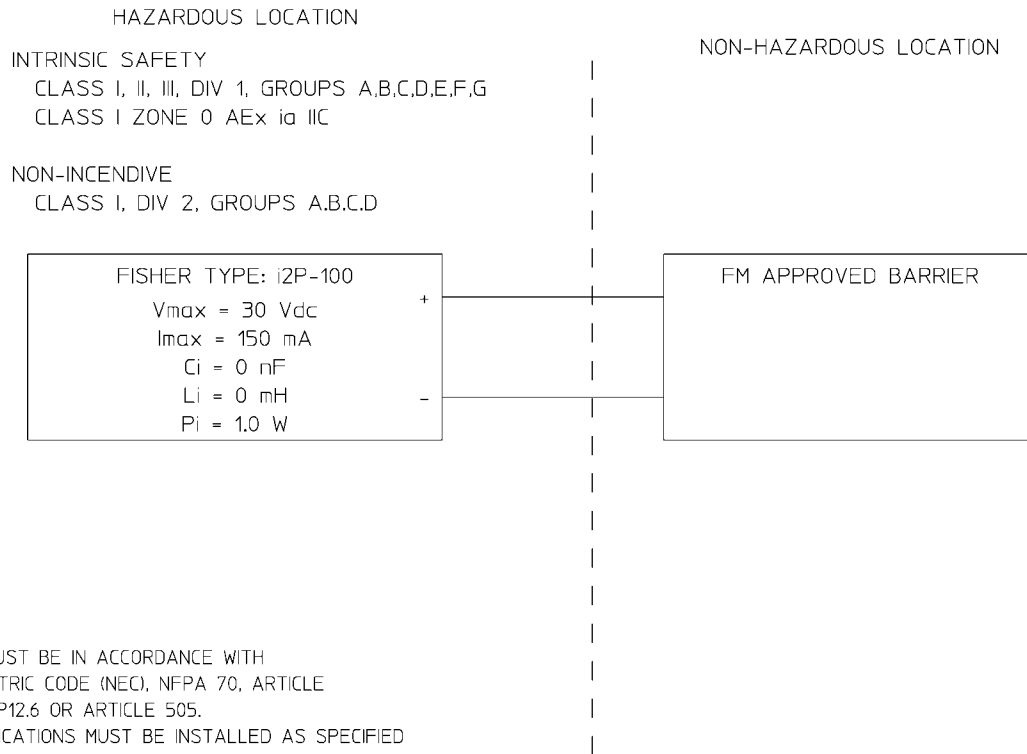
GE07471

Figure 15. CSA Loop Schematic

TYPE i2P-100	20 mADC == MAX, 30 VDC == MAX, 50 PSI MAX AMB. TEMP: -40 TO 85°C	APPROVED FOR NATURAL GAS AS SUPPLY MEDIUM. CSA ENCLOSURE 3, NEMA 3	FISHER CONTROLS INTL LLC MARSHALLTOWN, IOWA, USA MFG LOCATION:
SERIAL NO. <input style="width: 100%;" type="text"/>	FACTORY CALIBRATED AS: INPUT: 4-20 mADC OUTPUT: 3-15 PSI <input type="checkbox"/> 6-30 PSI <input type="checkbox"/>	FIELD CALIBRATED AS: INPUT: _____ mA OUTPUT: _____ PSI	
 	SEAL NOT REQUIRED. CL I DIV 1 GP ABCD T5; CL I DIV 2 GP ABCD T5 CL II DIV 1 GP EFG T5; CL II DIV 2 GP FG T5 Ex ia INTRINSICALLY SAFE CL I,II,III DIV 1 GP ABCDEFG T3(Tamb≤85°C)/T4(Tamb≤81°C)/T5(Tamb≤46°C) WHEN INSTALLED PER DRAWING GE07471 Ex ia IIC T3(Tamb≤85°C)/T4(Tamb≤81°C)/T5(Tamb≤46°C) Ui,Vmax=30V Ii,Imax=150mA Pi=1.0W Ci=0nF Li=0uH Ex d IIC T5(Tamb≤85°C)/T6(Tamb≤75°C) Ex nC IIC T5(Tamb≤85°C)/T6(Tamb≤75°C)	APPROVED	SEAL NOT REQUIRED IS: CL I,II,III DIV 1,2 GP ABCDEFG T3(Tamb≤85°C)/T4(Tamb≤81°C)/ T5(Tamb≤46°C) WHEN INSTALLED PER DWG GE07470 XP: CL I DIV 1 GP ABCD T5(Tamb≤85°C)/T6(Tamb≤75°C) NI: CL I DIV 2 GP ABCD T5(Tamb≤85°C)/T6(Tamb≤75°C) DIP: CL II DIV 1 GP EFG T5(Tamb≤85°C)/T6(Tamb≤75°C) S: CL II DIV 2 GP FG T5(Tamb≤85°C)/T6(Tamb≤75°C) CLASS I ZONE 0 AEx ia IIC T3(Tamb≤85°C)/T4(Tamb≤81°C)/ T5(Tamb≤46°C) Ui,Vmax=30V Ii,Imax=150mA Pi=1.0W Ci=0nF Li=0mH CLASS I ZONE 1 AEx d IIC T5(Tamb≤85°C)/T6(Tamb≤75°C) CLASS I ZONE 2 AEx nC IIC T5(Tamb≤85°C)/T6(Tamb≤75°C)
	WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY. OPEN CIRCUIT BEFORE REMOVING COVER. WHEN OPERATING OVER 70°C USE SUITABLE CABLING/WIRING.		 GE13955

Figure 16. CSA and FM Approvals Nameplate

i2P-100 Transducer



NOTES:

1. THE INSTALLATION MUST BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE (NEC), NFPA 70, ARTICLE 504 AND ANSI/ISA RP12.6 OR ARTICLE 505.
2. CLASS 1, DIV 2 APPLICATIONS MUST BE INSTALLED AS SPECIFIED IN NEC ARTICLE 501-4(B). EQUIPMENT AND FIELD WIRING IS NON-INCENDIVE WHEN CONNECTED TO APPROVED BARRIERS WITH ENTITY PARAMETERS.
3. LOOPS MUST BE CONNECTED ACCORDING TO THE BARRIER MANUFACTURER'S INSTRUCTIONS.
4. MAXIMUM SAFE AREA VOLTAGE SHOULD NOT EXCEED 250 V_{rms} .
5. RESISTANCE BETWEEN BARRIER GROUND AND EARTH GROUND MUST BE LESS THAN ONE OHM.
6. NORMAL OPERATING CONDITIONS 30 Vdc 20 mADC.
7. FOR ENTITY INSTALLATION (U.S. AND N.I.):
 - $V_{max} > V_{oc}$, or V_t $C_i + C_{cable} < C_a$
 - $I_{max} > I_{sc}$, or I_t $L_i + L_{cable} < L_a$
 - $P_i > P_o$, or P_t

GE07470

Figure 17. FM Loop Schematic

ATEX INTRINSIC SAFETY APPROVAL INFORMATION

ATEX FLAMEPROOF APPROVAL INFORMATION

ATEX TYPE n APPROVAL INFORMATION

TYPE i2P-100 | US PATENTS - 4836011 - 4595029 | 20 mADC == MAX, 30 VDC == MAX, 50 PSI MAX
 OTHER PATENTS PENDING | AMB TEMP: -40 TO 85°C, IP64 | APPROVED FOR NATURAL GAS AS SUPPLY MEDIUM | FISHER CONTROLS INTL LLC
 MARSHALLTOWN, IOWA, USA
 MFG LOCATION:

SERIAL NO [] FACTORY CALIBRATED AS:
 SERIE NO [] INPUT: 4-20 mADC == OUTPUT: 3-15 PSI [] 6-30 PSI []
 SERIEV NO [] FIELD CALIBRATED AS: INPUT [] mADC == OUTPUT []

<p><input type="checkbox"/> KEMA 05 ATEX 1109X II 1 G D EEx ia IIC T3(Tamb≤85°C) T4(Tamb≤81°C) T5(Tamb≤46°C) Ui = 30V li = 150mA Pi = 1.0W Ci = 0F Li = 0H USE ONLY WITH A LINEAR BARRIER MAXIMUM ENCLOSURE SURFACE TEMPERATURE T95°C(Tamb≤85°C)</p>	<p><input type="checkbox"/> KEMA 05 ATEX 2099X II 2 G D EEx d IIC T5(Tamb≤85°C) T6(Tamb≤75°C)</p>	<p><input type="checkbox"/> KEMA 05 ATEX 1119 11 3 GD EEx nC II T5(Tamb≤85°C) T6(Tamb≤75°C)</p>
MAXIMUM ENCLOSURE SURFACE TEMPERATURE T95°C(Tamb≤85°C)	MAXIMUM ENCLOSURE SURFACE TEMPERATURE T95°C(Tamb≤85°C)	MAXIMUM ENCLOSURE SURFACE TEMPERATURE T95°C(Tamb≤85°C)

IECEX CSA 05.0010X
 Ex ia IIC T3(Tamb≤85°C) T4(Tamb≤81°C) T5(Tamb≤46°C)
 Ui=30V li=150mA Pi=1.0W Ci=0F Li=0H
 Ex d IIC T5(Tamb≤85°C) T6(Tamb≤75°)
 Ex nC IIC T5(Tamb≤85°C) T6(Tamb≤75°C)

CAUTION/WARNINGS:
 • ELECTROSTATIC CHARGE HAZARD - DO NOT RUB OR CLEAN WITH SOLVENTS. TO DO SO COULD RESULT IN AN EXPLOSION.
 • WHEN OPERATING OVER 70°C, USE SUITABLE CABLING/WIRING.
 • FOR ATEX APPROVALS ONLY - USER MUST SELECT AND MARK ONLY ONE PROTECTION METHOD UPON INSTALLATION. ONCE MARKED IT SHALL NOT BE CHANGED. NOT FOLLOWING THESE INSTRUCTIONS WILL JEOPARDIZE THE EXPLOSION SAFETY.

GE06337

IECEX APPROVAL INFORMATION

Figure 18. ATEX and IECEx Approvals Nameplate

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Emerson Process Management

Fisher

Marshalltown, Iowa 50158 USA

Cernay 68700 France

Sao Paulo 05424 Brazil

Singapore 128461

www.Fisher.com





Lube Level Maintainer

Models LM2000/LM2000S

Installation Instructions

In order to consistently bring you the highest quality, full featured products, we reserve the right to change our specifications and designs at any time. The latest version of this manual can be found at www.fwmurphy.com.

Warranty - A two year warranty on materials and workmanship is given with this FW Murphy product. A copy of the warranty may be viewed or printed by going to www.fwmurphy.com/support/warranty.htm. In the event of a fault or technical query, please contact your Murphy representative for technical support.



Please read the following information before installing.

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT:

- A visual inspection of this product for damage during shipping is recommended before installation.
- It is your responsibility to ensure that qualified mechanical and electrical technicians install this product.
- Disconnect all electrical power to the machine.
- Make sure machine cannot operate during installation.
- Follow all safety warnings of the machine manufacturer.
- Read and follow all installation instructions.
- Please contact FW MURPHY immediately if you have any questions.

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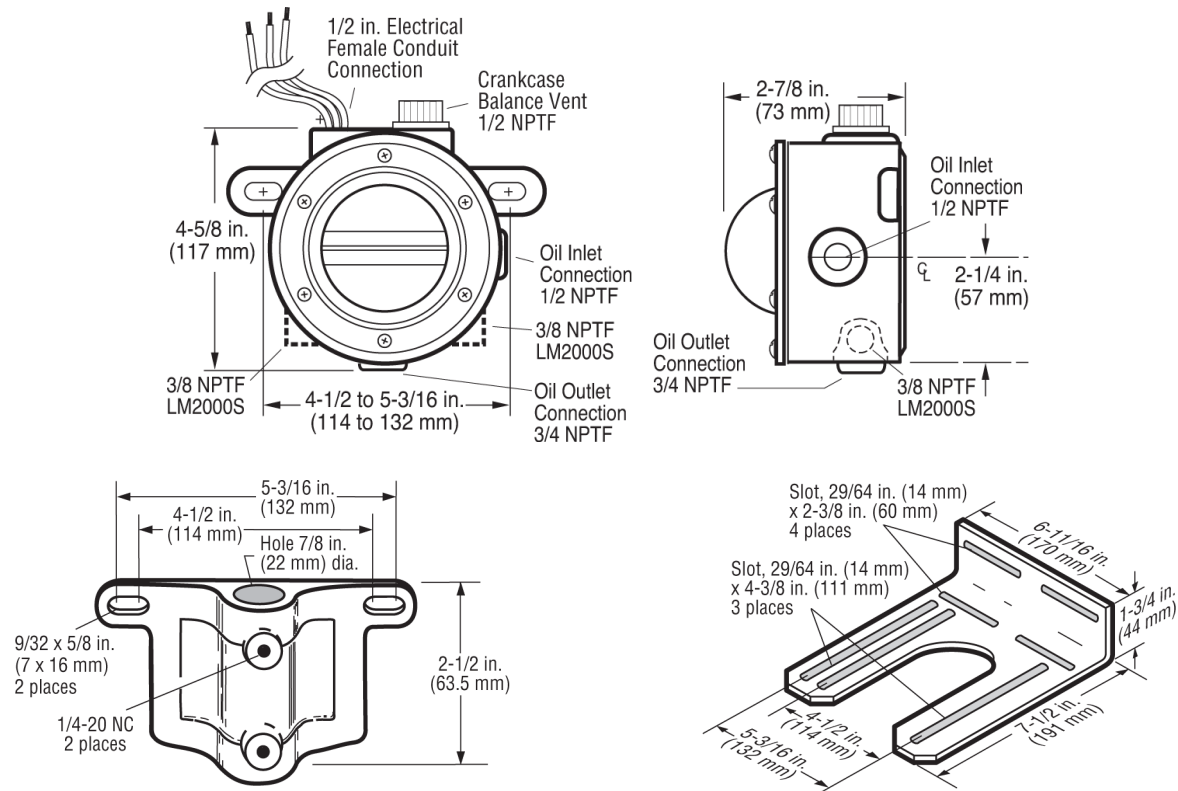
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General Information

Description

The Murphy LM2000 model maintains the crankcase oil level of an engine, pump or compressor. Adjusted to the correct running-oil-level, the LM2000 will replenish oil as it is used. An integral, low-level switch will alarm and/or shutdown the equipment if supply oil is lost and the equipment continues to use oil.

Dimensions



Operating Range of the Snap-Switch

Figure 1 shows the LM2000 dial and the operating range of the switch. If level is within the designated zones the switch will activate.

The switch activates approximately 1/4 in. (6 mm) from the bottom of the low zone. The dial in Figure 1 shows that if level continues to drop into the low-low zone, a shutdown will occur.

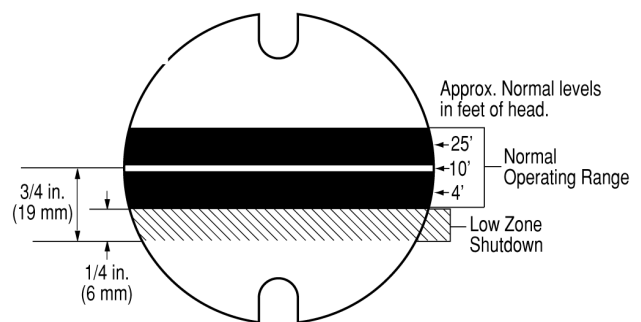


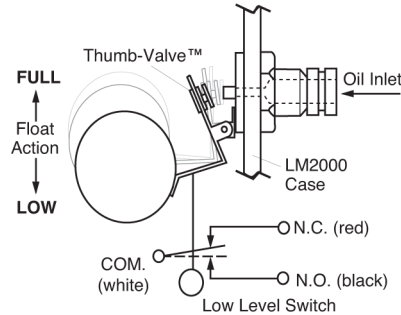
Figure 1

NOTE: Color zones on dial face show approximate normal operating zones. Actual conditions may vary depending upon operating characteristics of the engine. Placement of the LM2000 according to the above instructions will compensate for these conditions.

General Information—continued

Thumb-Valve™ Operation

As the equipment uses oil, the float falls, providing immediate level compensation. At FULL position, the float holds the valve closed. If the clean oil supply is depleted and oil level continues to fall, the low level switch will operate an alarm or equipment shutdown.



Service Parts (Specify part number)

Description	Part Number
Vent Fittings Kit	15000954
Hose Kit	15000355
1/2NPT x 1/2 in. Hose Barbed Fitting	89080801
3/4NPT x 1/2 in. Hose Barbed Fitting	89081001
3/8NPTF x 1/2 in. Hose Barbed Fitting	89080601
Pipe Bracket Kit	15000238
Universal Flange Kit	15010224

Optional Hose Kit: 15000355

Quantity	Description
1	1/2 in. (13 mm) I.D. x 3 ft. (914 mm) long hose (89020202)
1	1 in. (25 mm) I.D. x 3 ft. (914 mm) long hose (89020203)
2	1/2 in. (13 mm) worm gear clamp (00003502)
2	1 in. (25 mm) worm gear clamp (00003503)
2	1/2 NPT x 1/2 in. (13 mm) barbed fitting (89080801)
2	3/4 NPT x 1 in. (25 mm) barbed fitting (89081001)

Optional Vent Fittings Kit: 15000954

The 15000943 kit is sold separately. It includes the following items:

Quantity	Description
1	Tubing vent (15050202).
1	1/4 x 1/4 NPT Connector (85030447).

Typical Installation

Mounting the LM2000

NOTE: Mount the LM2000 as close as possible to the crankcase.



CAUTION: Excessive vibration can cause overflow. Be sure mounting brackets are supported.

The following instructions are based on the usage of the pipe and universal mounting brackets shown on page 1.

Pipe Bracket Mounting (15000238)

1. Mount a nominal 1/2 inch (13 mm) diameter pipe to the base of the engine.
2. Install the pipe bracket to the LM2000 using two 1/4-20 UNC x 1 inch bolts, nuts and lock washers supplied. See Figure 2A.
3. Slip the LM2000 onto the pipe and install the two adjustment bolts. Each bolt consists of a 1/4-20 UNC x 1 in. bolt, nuts and lock washers. See Figure 2B. **DO NOT** tighten the adjustment screws too tightly because you will have to adjust the LM2000 later in the installation process.

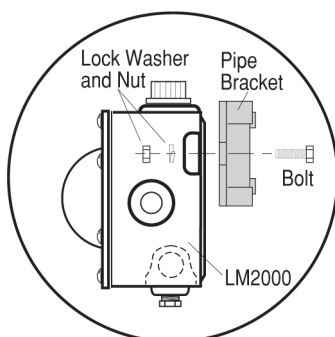


Figure 2A

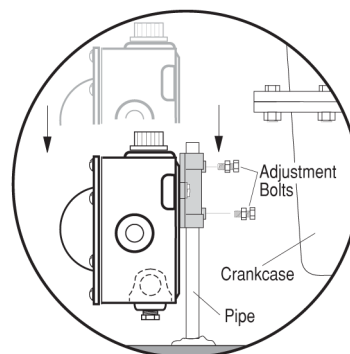


Figure 2B

Mounting with Universal Bracket (15000370)

The universal bracket has two mounting methods: base mounting or pan mounting.

Base Mounting

1. Install the universal bracket to the base as shown in Figure 3A using two flat washers and two 5/16 inch dia. bolts or others as necessary.
2. Mount the LM2000 to the universal bracket using two 1/4-20 UNC x 1-1/4 inch (32 mm) bolts, nuts and lock washers supplied (Figure 3B). **DO NOT** tighten the adjustment screws too tightly. You will have to adjust the LM2000 later in the installation process.

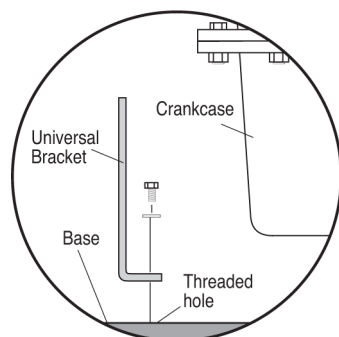


Figure 3A

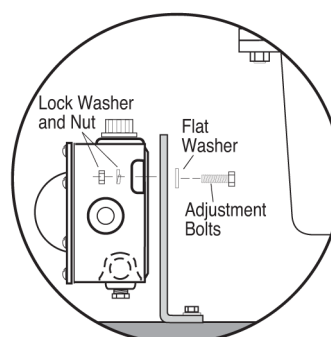


Figure 3B

Typical Installation—continued

Mounting with Universal Bracket (15000370)—continued

Crankcase (Oil Pan) Mounting

1. Install the universal bracket to the crankcase using the existing crankcase bolts (Figure 4A). Crankcase bolt diameter must be no larger than 7/16 inch (11 mm).

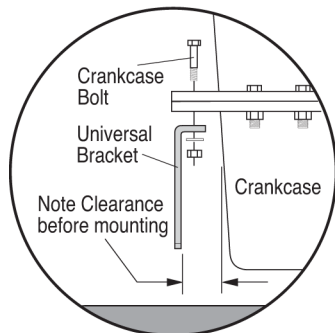


Figure 4A

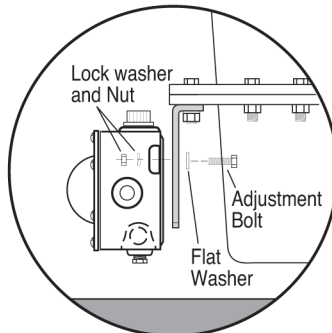


Figure 4B

NOTE: Check clearance between crankcase and mounting bracket before installing the mounting bracket. If space between the crankcase and mounting bracket does not allow installation and access to the adjustment bolts advance to Step 3.

2. Mount the LM2000 to the universal bracket using two 1/4-20 UNC x 1- 1/4 inch bolts, nuts and lock washers supplied. DO NOT tighten the adjustment bolts too tight. You will have to adjust the LM2000 later in the installation process.
3. If space between the crankcase and mounting bracket is narrow, install the universal mounting bracket to the LM2000 before installing to the crankcase oil pan.

Connecting Fittings and Hoses

The following instructions are based on the Murphy optional hose kit described on page 1. If you did not order the optional hose kit, use the list designation as a guide to the required materials.

1. Install the LM2000 fittings in their proper locations.

NOTE: Apply a sealant such as Teflon®, to all threaded connections.

2. Attach the 1 inch (25 mm) diameter, flexible monitoring hose to the crankcase and the monitoring port on the LM2000. See Figure 5.



CAUTION: The hose must slope slightly downward from the LM2000 and MUST NOT have any droops or low spots.

NOTE: If the drain plug on the crankcase is used for the connection, we recommend installation of a tee to allow draining of the crankcase for service.

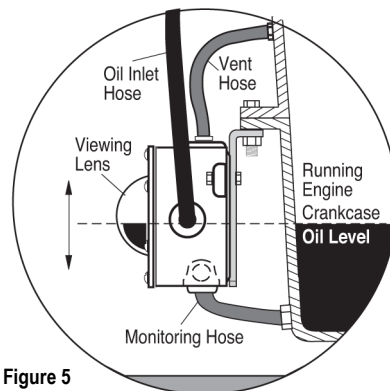


Figure 5

3. Install the 1/2 inch (13 mm) I.D. x 3 ft. (914 mm) hose to the vent connection on the LM2000 and to the vent connection on the crankcase. See Figure 5. **The vent connection on the crankcase must be well above the regulated oil level.** All hoses must be clear of obstructions, valleys, or dips that could create liquid traps, or gas/air pockets. The vent and crankcase connections should be as straight as possible.

Typical Installation—continued

Connecting Fittings and Hoses—continued

BEFORE CONTINUING, VERIFY THAT ALL HOSE CLAMPS ARE TIGHT.

4. Fill the crankcase to the proper oil level. With the engine running and warm, loosen the mounting bracket adjustment bolts and adjust the LM2000 so that the oil level in the sight gauge is aligned with the white “index line” on the dial (Figure 5). Tighten the adjustment bolts securely.

Connecting the LM2000 to an Oil Supply Tank

1. Remove the plug from the oil inlet connection. Be sure the removable screen, inside the connection, is clear of debris. Install the oil inlet connection.
2. Connect a 1/2 inch I.D. (13 mm) or larger hose to the oil inlet fitting on the LM2000 and to the shutoff valve on the oil supply tank. See Figure 5. Recommended minimum height above the LM2000 is 2 ft. (0.6m); maximum 25 ft. (7.7m). The hose must maintain a downward slope and not have low spots or droops. Maximum head pressure rating is 9.50 psi or 25 ft oil (head pressure).
3. Before filling the supply tank with oil, be sure the tank is clean and dry and the shutoff valve is closed. Also, be sure all hoses and clamps are tight. Fill the tank with CLEAN oil.



WARNING: Overfill condition can be caused by excessive inlet pressure and/or improper “vent to crankcase” installation.

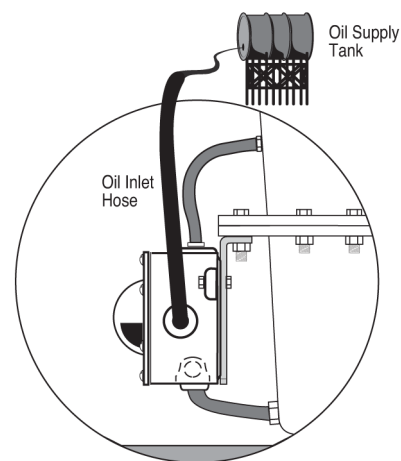


Figure 6

4. After oil supply tank is full, open the shutoff valve.

Next, make the proper electrical connections for the application. (See Snap-switch ratings and schematic on page 1.)

Switch Test

To test the shutdown or alarm functions perform the following:

■ **NOTE:** Installations with closed vent systems can only be tested with the engine off.

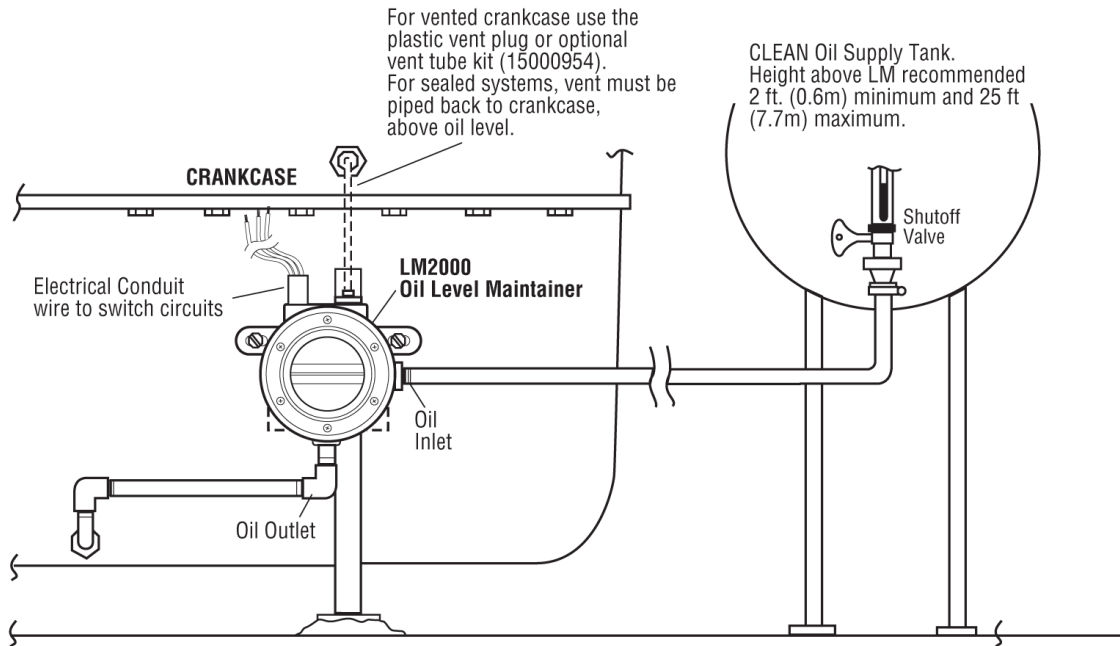
1. Unscrew the vent fittings.
2. Using a long narrow shank screw driver, gently insert until contact is felt with float arm. Gently push the float arm down.
3. Verify proper switch operation

Typical Installation—continued

LM2000 Typical Installation Shown with FSV Series Valves



WARNING: Perform this installation using appropriate protection. Trapped air and hot oil may cause burns.



Specifications

Crankcase Balance Vent Connection: 1/2 NPTF (top).

Inlet Connection: 1/2 NPTF with removable screen (side).

Outlet Connection: LM2000 3/4 NPTF (bottom).
LM2000S 2 x 3/8 NPTF (side)
1 x 3/4 NPTF (bottom)

Thumb-Valve™ Material: Viton.

Snap-switch: SPDT rating 10 A, 125 VAC; 0.5 A, 125 VDC; 10 A, 30 VDC.

Wire leads: 18 AWG x 14 in. ± 2 in. (355 mm) length.

Conduit Connection: 1/2 inch conduit (female, top).

Case: Die cast aluminum

Lens: Clear “Frog Eye” non-staining, high impact, high temperature nylon; UV and heat stabilized.

Dial: High visibility white background with green and white “index” lines for normal level indication.

Maximum Inlet Pressure: 9.50 psi/25 ft. oil (head pressure).

Maximum Case Pressure: 15 psi (103 kPa).

Maximum Differential: 2 in. (51 mm) between running and stopped.

Maximum Ambient Temperature: 250°F (121°C).

Float: Brass

Flow Rates: SAE 40 motor oil @ 32°F (0°C) with 2 ft. head pressure: 0.5 GPH (1.9 LPH).

■ **NOTE:** Friction losses due to piping not considered.

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USA-ISO 9001:2000 FM 28221
UK-ISO 9001:2000 FM 29422
Registered Facilities

ISO 9001
REGISTERED

Printed in U. S. A.

07/09



MLS Series Liquid Level Switches

Installation and Operations Manual

In order to consistently bring you the highest quality full featured products, we reserve the right to change our specifications and designs at any time. The latest version of this manual can be found at www.fwmurphy.com.

Warranty - A limited warranty on materials and workmanship is given with this FW Murphy product. A copy of the warranty may be viewed or printed by going to <http://www.fwmurphy.com/warranty>



CAUTION: MLS Series parts are not interchangeable with other Murphy liquid level products. Damage caused by using incorrect parts is not covered by our Limited Warranty.



Please read the following information before installing. A visual inspection for damage during shipping is recommended before mounting.

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT:

Disconnect all electrical power to the machine.

Make sure the machine cannot operate during installation.

Follow all safety warnings of the machine manufacturer.

Read and follow all installation instructions.

OBSERVE all pressure and electrical ratings and requirements for the devices and the operating environment.

BE SURE all pressure **HAS BEEN REMOVED** from the vessel before opening any pressure connections.

Please contact FW MURPHY immediately if you have any questions.

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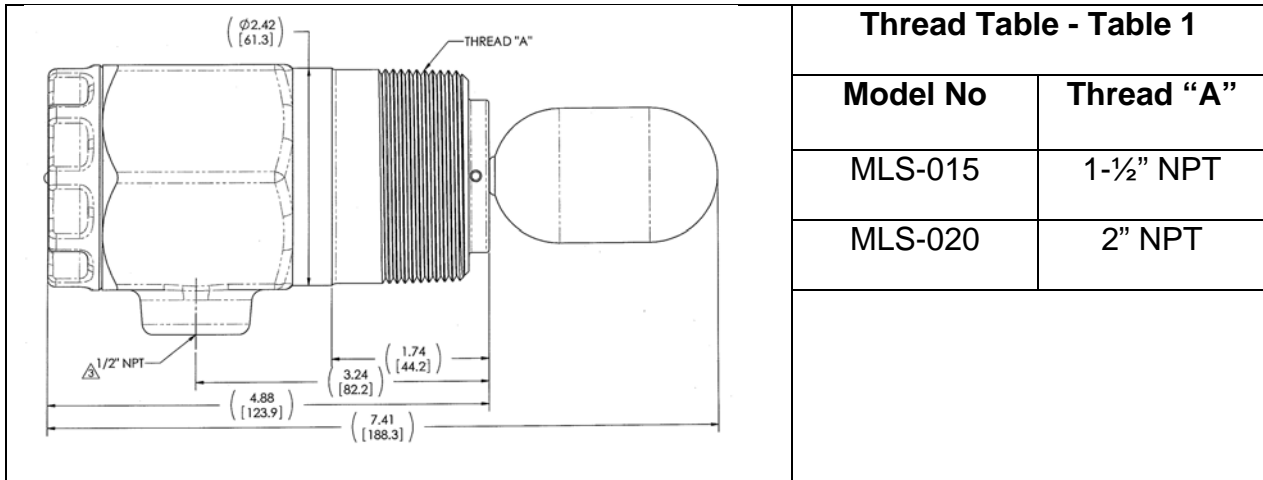
Product Information

Features

- Clean Magnet Design virtually eliminates iron filing accumulation onto the magnet
- Seal-Free Construction
- Designed for harsh gas compressor scrubber applications
- CF8 (304) cast stainless steel body and 304 stainless steel float
- MLS Series rated for 2000 psi (13.8 MPa) [138 bar] working pressure
- Electric model only available
- Improved design provides better dependability with reduced number of moving parts
- All models screw directly into the scrubber or can be mounted via external float chamber
- CSA C/US Class 1, Div. 1, Grp. B, C & D locations
- Canadian Registration Number: 0F01476.2

MLS-020, MLS-015

MLS Series Liquid Level Switches with 2" NPT and 1-1/2" NPT mounting are float activated to operate an electrical SPDT reed switch for alarm or shutdown of an engine or electric motor. The MLS Series connects directly into the scrubber wall and can be used with a Murphy weld collar (P/N 15050375) or Murphy external float chamber (P/N 15700799).



NOTE: Refer to Table 2 for clearances.

Pressure Vessel Installation: MLS-020 and MLS-015

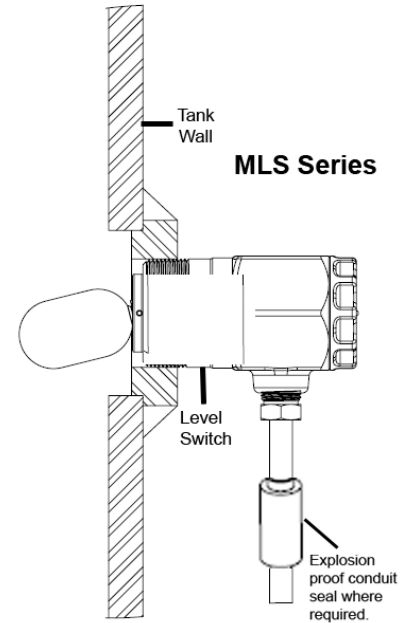
Direct Installation into the Wall of the Pressure Vessel

CAUTION: Determine that the float travel is not obstructed by the coupling in the vessel wall, internal baffles, etc.
 Refer to tables 1 and 2 for application data. **INSTALLATION BY QUALIFIED PERSONNEL ONLY.**

1. Make certain the float is tightly screwed onto the counter-balance.
2. Before installing the level switch, use of a pipe thread sealant is recommended. Screw the unit directly into the threaded connection in the wall of the pressure vessel.
3. Verify that the electrical connection is positioned at the bottom.

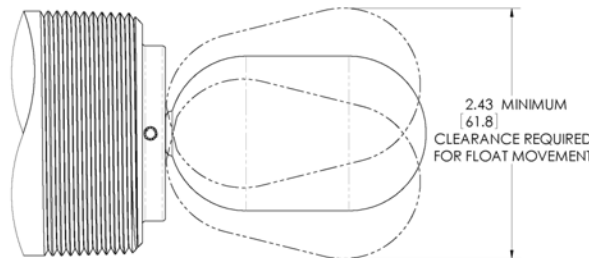
NOTE: The word TOP is cast into the top of the body. M

4. Make the electrical wiring connections according to appropriate wiring diagrams for the alarm or shutdown system to be used. The electrical connection is 1/2"-14 NPT.
5. Ensure all electrical connections are insulated and the cover is fully installed before reconnecting electrical power.
6. Verify all pressure connections are tight before pressurizing the system.



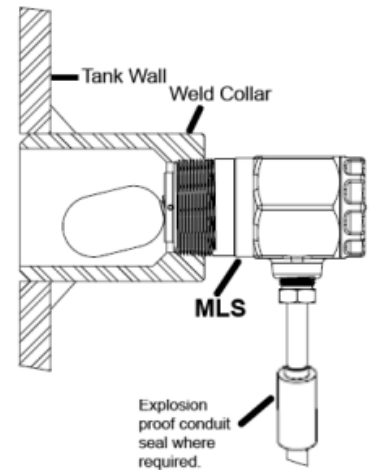
Float Clearance Reference Tables

Nom. Size (inches)	O.D. (inches)	Schedule Number	Wall Thickness (inches)	Inside Diameter (inches)
2.5	2.875	40STD	0.203	2.469
3	3.5	40STD	0.216	3.068
3	3.5	80XS	0.3	2.9
4	4.5	40STD	0.237	4.026
4	4.5	80XS	0.337	3.826



Installation with a Weld Collar

1. The weld collar, P/N 15050375, must be welded into the wall of the pressure vessel according to code standards and good welding practices.
2. Follow above instructions for installation directly into the wall of the pressure vessel.



Installation Using Murphy External Float Chamber

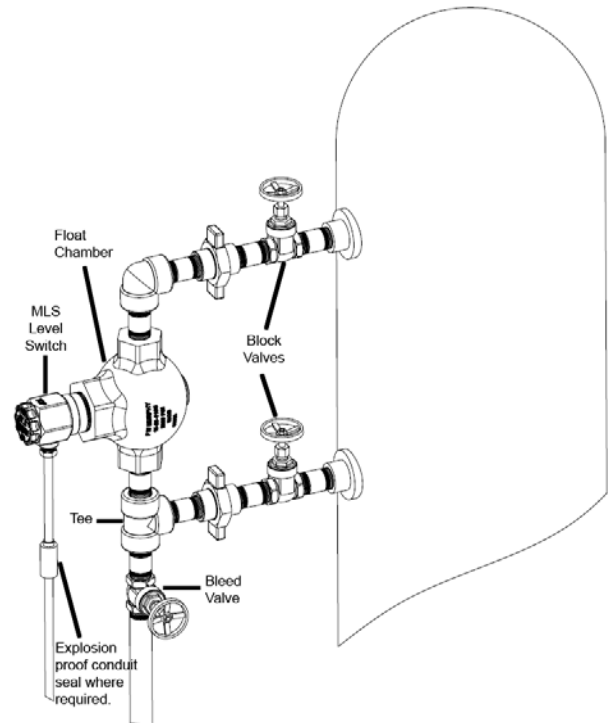
1. Install the Murphy float chamber 15051098 or 15700799 on the outside wall of the pressure vessel using 1" NPT piping. Position the 2" NPT threaded connection at the height where you want the level switch to operate. The 2" NPT threaded connection must be positioned away from the tank wall.

NOTE: If using Float Chamber 15051098, best practices recommend a surface mount installation.

2. A tee and bleed valve are typically installed at the bottom of the lower 1 inch pipe riser to allow draining of the float chamber for servicing or replacement.

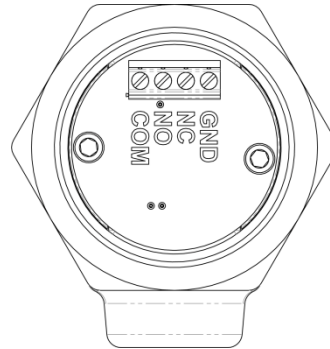
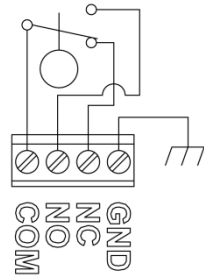
NOTE: A typical installation with blocking and bleed valves is shown at right.

3. Install the MLS-020 in the 2" NPT connection of the float chamber. BE SURE float travel is not restricted and that the float is tight onto the counter-balance.
4. To complete the installation and wiring, follow the instructions for mounting directly into wall of the vessel and for wiring.



Electrical Wiring

STD WIRING DIAGRAM



Switch Rating: 30VDC/VAC @ 75 mA

Replacement Parts

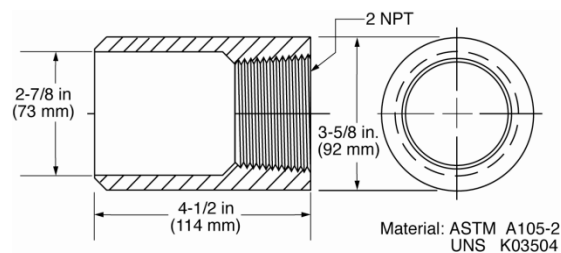
Order by part number designation.

15000531: MLS Float

Stainless Steel Float, MLS Series (not interchangeable with any other Murphy Level Switch Float)

Accessories

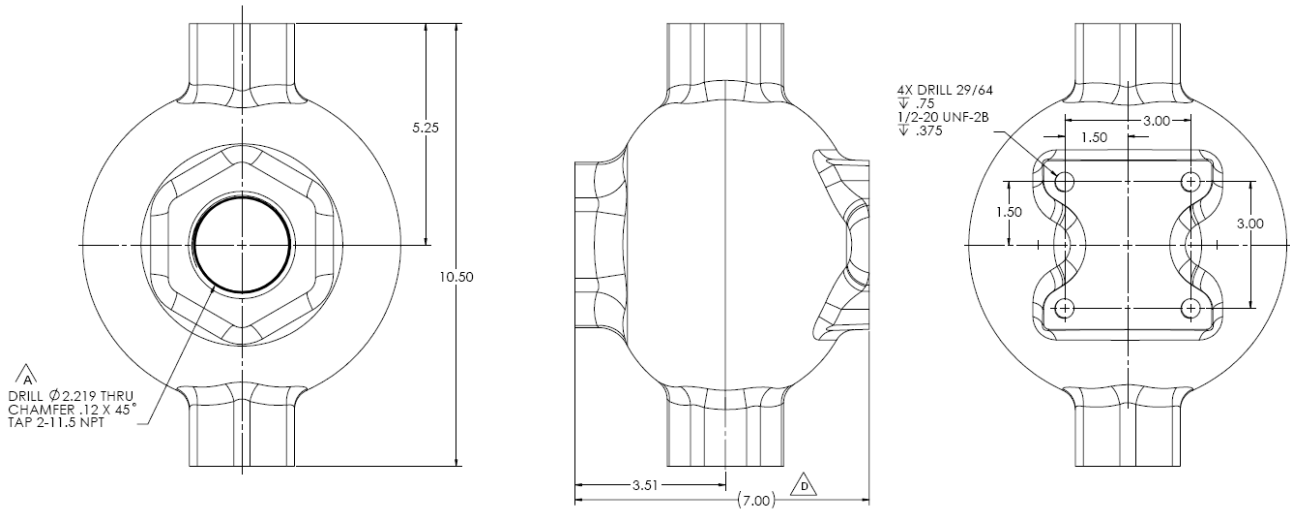
15050375: Weld Collar



Operating Pressure: 2000 psi (13.8 MPa) [138 bar].

Operating Temperature: 400°F (204°C).

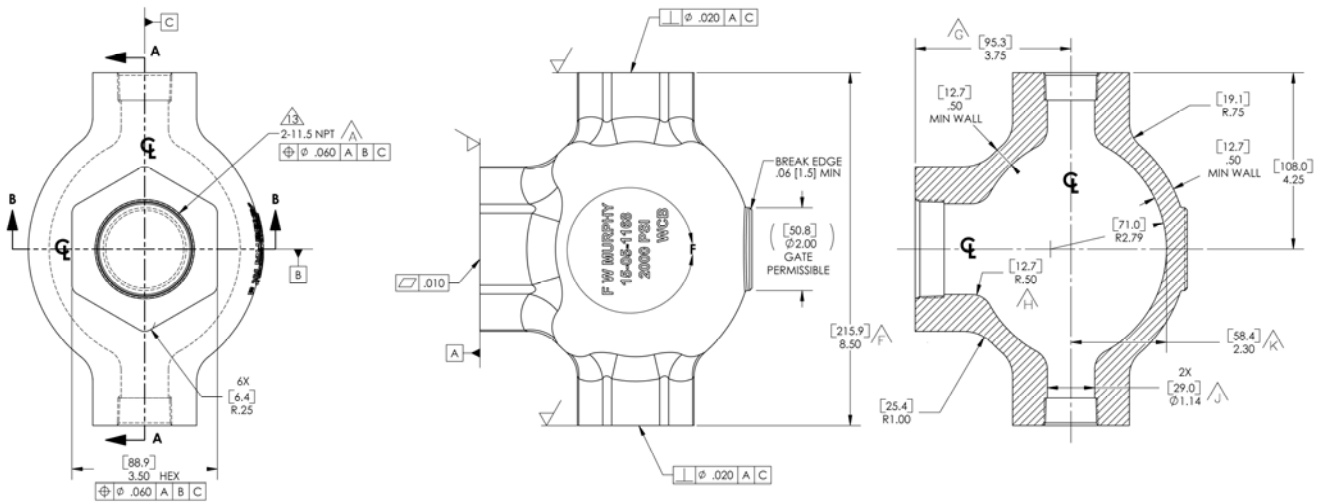
15051098: External Float Chamber



Operating pressure: 2000 psi (13.8 MPa) [138 bar]

Operating temperature: 400°F (204°C).

15700799: Series 100 External Float Chamber



Operating pressure: 2000 psi (13.8 MPa) [138 bar]

Operating temperature: 400°F (204°C).

Specifications

MLS Series

Process connection: 2" NPT (MLS-020)
1-1/2" NPT (MLS-015)

Fluid Density (SG): 0.50

Pressure Rating: 2000 psig (13.8 MPa)[138 bar]

Materials:

Body: ASTM A351 CF8 (304 SS)

Cover: ASTM A351 CF8 (304 SS)

Other Wetted Parts: 304 or 316 SS

Meets NACE MR0175 for direct exposure to H₂S

Process Temperature: -20 to 300°F (-29 to 149°C)

Electrical: 30VAC/VDC 75mA Form C SPDT

Approximate Shipping Weights and Dimensions

All models: 5.5lbs (2.49 kg);

Dimensions: 14 x 5 x 3.5 in. (356 x 127 x 89 mm)

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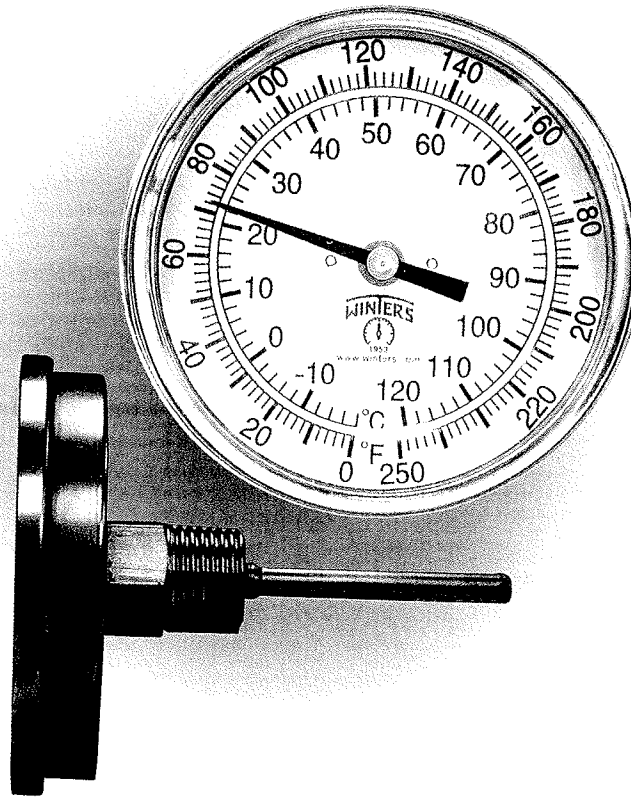
USA-ISO 9001:2008 FM 28221
UK-ISO 9001:2008 FM 29422
CHINA-ISO 9001:2008 FM 523851
Registered Facilities



Printed in U. S. A.

02/11/2011

330 Series Bi-Metal Thermometer



Thermometers

Description & Features:

- A general purpose, tamper-proof, 304 Stainless Steel thermometer
- Hermetically sealed case
- Bi-metallic sensing element for reliable readings
- Back connected
- Stem length from 2.5" and up
- Grade 1A Accuracy (1%)
- Anti-parallax dial that reduces operator reading errors
- Lexan® lens

Applications:

- Heating, Ventilation, Air Conditioning, food processing, wastewater, Industrial processes, Compressors.

Lexan® is a registered trademark of General Electric



330 Series Bi-Metal Thermometer

How to order: Specify Product Code and Range

Product Codes

T33025	3" (75 mm) dial with 2.5" (63 mm) stem
T33040	3" (75 mm) dial with 4" (100 mm) stem
T33060	3" (75 mm) dial with 6" (150 mm) stem
T33090	3" (75 mm) dial with 9" (225 mm) stem

Available Temperature Ranges

Code	Ranges (F/C)
B2	(-40°F to 120°F / -40°C to 50°C)
B4	(-40°F to 160°F / -40°C to 70°C)
B6	(0°F to 200°F / -20°C to 90°C)
B8	(0°F to 250°F / -20°C to 120°C)
B9	(50°F to 300°F / 10°C to 150°C)
B10	(50°F to 400°F / 10°C to 200°C)
B11	(50°F to 500°F / 10°C to 260°C)
B12	(150°F to 750°F / 100°C to 400°C)
B13	(200°F to 1000°F / 100°C to 540°C)

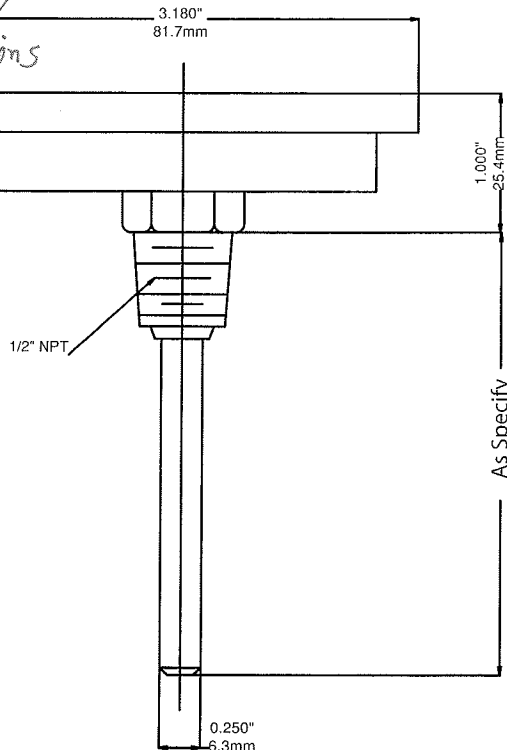
Specifications

Dial:	3" (75mm) dial, aluminum with black markings, dished shaped
Case/Ring:	AISI 304 stainless steel
Lens:	Lexan [®] , hermetically sealed
Pointer:	Brass, painted black
Movement:	Bi-metallic coil
Stem:	AISI 304 stainless steel
Connection:	1/2" NPT, center back
Welding:	TIG
Maximum Operating Pressure:	125 psi (861 kpa)*
Ambient Temperature:	Maximum +248F (+120C)
Operating Temperature:	Recommended maximum 75% of full scale value
Accuracy:	± 1% full scale
Enclosure Rating:	IP65

*For pressures above 125 psi (861 kPa) it is recommended that a Winters thermowell be used in conjunction with the Bi-Metal Thermometer. Please see pg.198

Example: T33040 B4

T33025B8 example only
we stock many combinations



Shock/Vibration Control Switches Installation Instructions

Models: VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94



Please read the following instructions before installing. A visual inspection of this product for damage during shipping is recommended before mounting. It is your responsibility to have a qualified person install the unit, and make sure installation conforms with NEC and local codes.

GENERAL INFORMATION

WARNING

BEFORE BEGINNING INSTALLATION OF THIS MURPHY PRODUCT

- ✓ Disconnect all electrical power to the machine.
- ✓ Make sure the machine cannot operate during installation.
- ✓ Follow all safety warnings of the machine manufacturer.
- ✓ Read and follow all installation instructions.



Model VS2EX

Description

The Murphy shock and vibration switches are available in a variety of models for applications on machinery or equipment where excessive vibration or shock can damage the equipment or otherwise poses a threat to safe operation. A set of contacts is held in a latched position through a mechanical latch and magnet mechanism. As the level of vibration or shock increases an inertia mass exerts force against the latch arm and forces it away from the magnetic latch causing the latch arm to operate the contacts. Sensitivity is obtained by adjusting the amount of the air gap between the magnet and the latch arm plate.

Applications include all types of rotating or reciprocating machinery such as cooling fans, engines, pumps, compressors, pump jacks, etc.

Models

VS2: Base mount; non hazardous locations.

VS2C: C-clamp mount; non hazardous locations.

VS2EX: Explosion-proof; Class I, Div. 1, Groups C and D.

VS2EXR: Explosion-proof with remote reset.

VS2EXRB: Explosion-proof; Class I, Div. 1, Group B; with remote reset.

VS94: Base mount; non hazardous locations, NEMA 4X/IP66.

Remote Reset Feature (VS2EXR, VS2EXRB and VS94 only)

Includes built-in electric solenoid which allows reset of tripped unit from a remote location. Standard on VS2EXR and VS2EXRB. Optional on VS94 (options listed below).

-R15: Remote reset for 115 VAC

-R24: Remote reset for 24 VDC

Time Delay Option (VS94 only)

Overrides trip operation on start-up. For VS94 series models, the delay time is field-adjustable from 5 seconds up to 100 seconds with a 20-turn potentiometer (5 seconds per turn approximately). Options listed below:

-T15: Time delay for 115 VAC

-T24: Time delay for 24 VDC

Space Heater Options (VS94 only)

This optional space heater board prevents moisture from condensing inside the VS94 Series case. Options listed below:

-H15: Space heater for 115 VAC

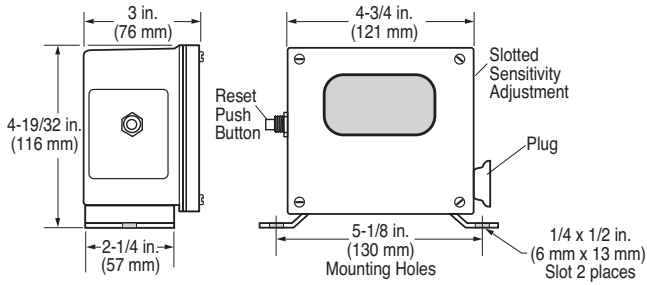
-H24: Space heater for 24 VDC

Warranty

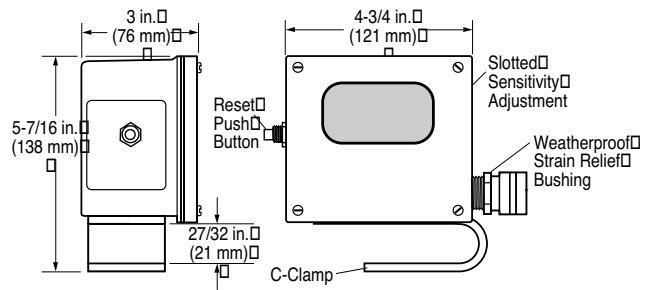
A limited warranty on materials and workmanship is given with this FW Murphy product. A copy of the warranty may be viewed or printed by going to www.fwmurphy.com/support/warranty.htm

DIMENSIONS

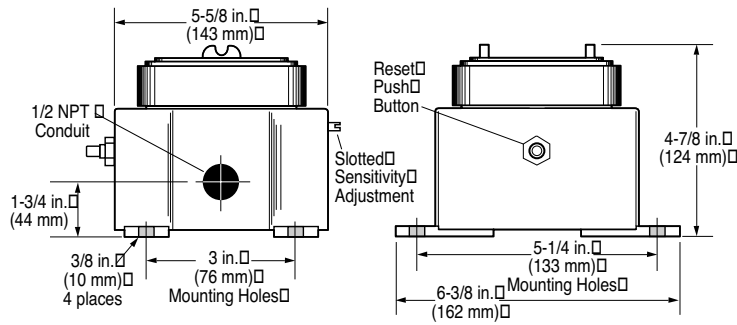
VS2



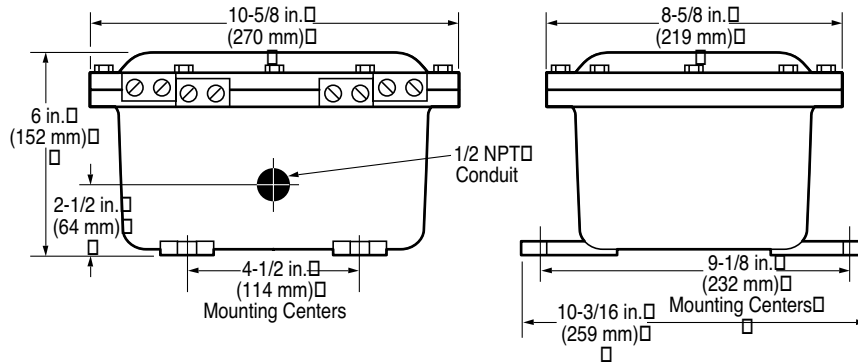
VS2C



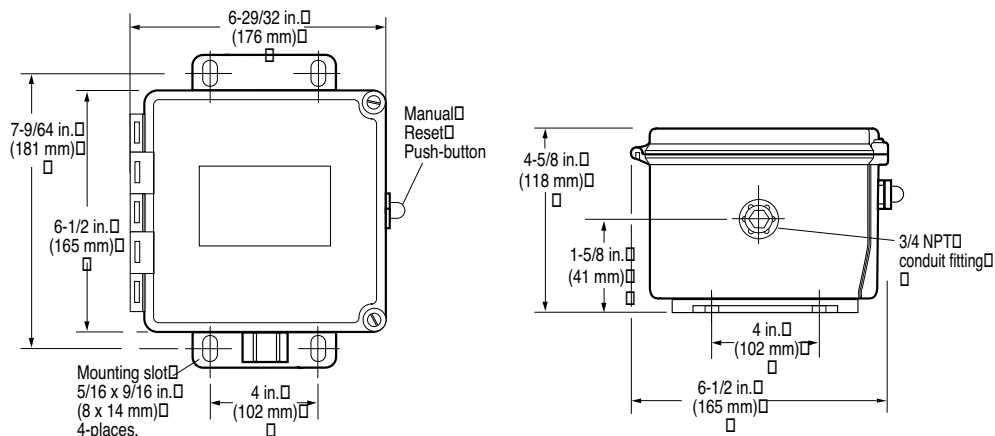
VS2EX and VS2EXR



VS2EXRB



VS94



SPECIFICATIONS

VS2 and VS2C

- **Case:** Weatherproof (equal to NEMA 3R) suitable for non-hazardous areas.
VS2: *Base mount*
VS2C: *C-clamp mount. Includes 45 feet (13.7 meters), 2-conductor 16 AWG, 30 strands/0.25 mm strand dia. (1.5 mm²) cable, and five cable hold down clamps.*
- **Contacts:** SPDT double make leaf contacts, 5A @ 480 VAC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.

VS2EX

- **Case:** Explosion-proof and weatherproof aluminum alloy housing; meets NEMA 7/IP50 specifications; Class I, Division 1, Groups C & D; UL and CSA listed.*
VS2EX: *base mount.*
- **Snap-switches:** 2-SPDT snap-switches; 5A @ 480 VAC;* 2A resistive, 1A inductive, up to 30 VDC.
 - **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.
- **Normal Operating Temperature:** -40 to 140°F (-40 to 60°C).

VS2EXR

- **Case:** Same as VS2EX.
- **Snap-switch:** 1-SPDT snap-switch and reset coil; 5A @ 480 VAC;* 2A resistive, 1A inductive, up to 30 VDC.
- **Remote Reset (optional):**

<i>Option</i>	<i>Operating Current</i>
-R15:	350 mA @ 115 VAC
-R24:	350 mA @ 24 VDC
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.
- **Normal Operating Temperature:** -40 to 140°F (-40 to 60°C).

VS2EXRB

- **Case:** Explosion-proof aluminum alloy housing; rated Class I, Division 1, Group B hazardous areas.
- **Snap-switch:** 1-SPDT snap-switch with reset coil (option available for

additional SPDT switch); 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC.

Remote Reset:

Option Operating Current

- R15: 350 mA @ 115 VAC
- R24: 350 mA @ 24 VDC

- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.

VS94

- **Case:** Polyester fiberglass reinforced; NEMA type 4 and 4X; IP66; CSA types 4 and 12.
- **Conduit Fitting:** 3/4 NPT conduit fitting connection.
- **Normal Operating Ambient Temperature:** 0 to 140°F (-18 to 60°C).
- **Snap-switches:** 2-SPDT snap acting switches; 5A @ 480 VAC; 2A resistive, 1A inductive, up to 30 VDC.
- **Range adjustment:** 0 - 7 G's; 0 - 100 Hz /0.100 in. displacement.
- **Heater (optional):**

<i>Option</i>	<i>Operating Current</i>
H15	.023 A @ 115 VAC
H24	.12 A @ 24 VDC
- **Remote Reset (optional):**

<i>Option</i>	<i>Operating Current</i>
R15	.17 A @ 115 VAC
R24	.36 A @ 24 VDC
- **Time Delay (optional):**

<i>Option</i>	<i>Operating Current</i>	<i>Standby Current</i>
T15	.360 A @ 115 VAC	.01 A @ 115 VAC
T24	1.15 A @ 24 VDC	.01 A @ 24 VDC
- **Time Delay/Remote Reset:** Adjustable 20-turn potentiometer from 5 seconds to 100 seconds (5 seconds per turn approximately).

*CSA and UL listed with 480 VAC rating.

INSTALLATION



WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

The VS2 and VS94 series shock switches are sensitive to shock and vibration in all three planes of motion - up/down, front/back and side/side. Front/back is the most sensitive (The reset pushbutton is located on the "front" of the unit). For maximum sensitivity mount the unit so that the front faces into the direction of rotation of the machine. (See Dimensions on page 2 for sensitivity adjustment location).

The VS2 and VS94 Series must be firmly attached/mounted to the machine so that all mounting surfaces are in rigid contact with the mounting surface of the machine. For best results, mount the instrument in-line with the direction of rotating shafts and/or near bearings. In other words, the reset push button should be mounted pointing into the direction of shaft rotation (see page 5). It may be necessary to provide a mounting plate or bracket to attach the VS2 and VS94 Series to the machine. The mounting bracket should be thick enough to prevent induced acceleration/vibration upon the VS2 or VS94 Series. Typically 1/2 in. (13mm) thick plate is sufficient. See illustrations on page 5 for typical mounting locations.



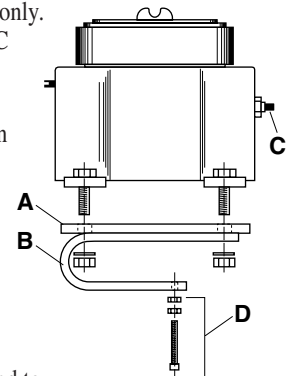
CAUTION: A dust boot is provided on the reset pushbutton for all series to prevent moisture or dust intrusion. The sensitivity adjustment for model VS2EX is not sealed; therefore, mounting

orientation should be on a horizontal plane or with the sensitivity adjustment pointing down. Sensitivity adjustment for model VS2 is covered by a plug. The plug must be in place and tight to prevent moisture or dust intrusion.

C-Clamp Installation (VS2C model only)

A C-Clamp is supplied with the VS2C model only. The C-Clamp is shipped installed on the VS2C but must be installed on the VS2EX and VS2EXR switches.

1. The C-Clamp (B) will already be installed on a 1/4 in. (6 mm) thick steel mounting plate (A). Bolt the VS2 switch to the mounting plate as illustrated — with four 5/16 in. bolts, nuts, and washers.
2. The mounting location should provide convenient access to the TATTLETALE® push button (C).
3. The hardened set screw and nuts (D) are used to tighten the switch to an I-Beam or cross member such as a Sampson post of an oilwell pumpjack.



Continued on next page.

All Models



WARNING: STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING INSTALLATION.

1. Firmly secure the unit to the equipment using the base foot mount or C-Clamp if applicable. See *C-Clamp Installation* page 3.
For oilwell pumpjacks attach the VS2 and VS94 Series to the Sampson post or walking beam. See *Typical Mounting Locations* page 5.
2. Make the necessary electrical connections to the vibration switch. See *Internal Switches*, page 6 for electrical terminal locations and page 7 for typical wiring diagrams. **DO NOT EXCEED VOLTAGE OR CURRENT RATINGS OF THE CONTACTS.** Follow appropriate electrical codes/methods when making electrical connections. Be sure that the run of electrical cable is secured to the machine and is well insulated from electrical shorting. Use of conduit is recommended.

NOTE: If the electrical cable crosses a pivot point such as at the pivot of the walking beam, be sure to allow enough slack in the cable so that no stress is placed on the cable when the beam moves.

If conduit is not used for the entire length of wiring, conduit should be used from the electrical supply box to a height above ground level that prevents damage to the exposed cable from the elements, rodents, etc. or as otherwise required by applicable electrical codes. If conduit is not attached directly to the VS2 and VS94 Series switch, use a strain relief bushing and a weatherproof cap on the exposed end of the conduit. A “drip loop” should be provided in the cable to prevent moisture from draining down the cable into the conduit should the weathercap fail.

Sensitivity Adjustment



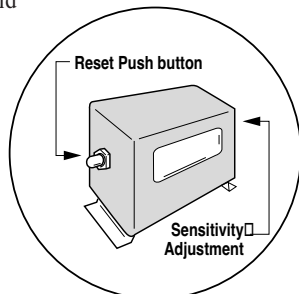
WARNING: REMOVE ALL POWER BEFORE OPENING THE ENCLOSURE. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON PERFORM ADJUSTMENTS, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES. DO NOT ADJUST SENSITIVITY WHILE THE MACHINE IS RUNNING. STAND CLEAR OF THE MACHINE AT ALL TIMES WHEN IT IS OPERATING.

All models of the VS2 and VS94 Series cover a wide range of sensitivity. Each model is adjusted to the specific piece of machinery on which it is installed. After the switch has been installed in a satisfactory location (see page 5) the sensitivity adjustment will be increased or decreased so that the switch does not trip during start-up or under normal operating conditions. This is typically done as follows:

1. REPLACE ALL COVERS, LIDS, AND ELECTRICAL ENCLOSURES.

2. Press the reset push button to engage the magnetic latch. To be sure the magnetic latch has engaged, observe latch through the window on the VS2 and VS2C (see DETAIL “A”). On the VS2EX, VS94 series the reset button will remain depressed meaning the magnetic latch has engaged.

DETAIL “A”



3. Start the machine.
4. If the instrument trips on start-up,

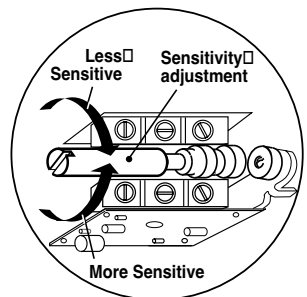
allow the machine to stop. Turn the sensitivity adjustment 1/4 turn clockwise, (adjustment for VS94 and VS2EXRB models is located within the box, see DETAIL “B”).



WARNING: MAKE THE AREA NON-HAZARDOUS BEFORE OPENING THE EXPLOSION-PROOF (-EX) ENCLOSURES.

Depress the reset button and restart the machine. Repeat this process until the unit does not trip on start-up.

DETAIL “B”



5. If the instrument does NOT trip on start-up, stop the machine. Turn the sensitivity adjustment 1/4 turn counter-clockwise. Repeat the start-up/stop process until the instrument trips on start-up. Turn the sensitivity adjustment 1/4 turn clockwise (less sensitive). Restart the machine to verify that the instrument will not trip on start-up.

6. Verify that the unit will trip when abnormal shock/vibration exists.

VS94 Time Delay Adjustment

1. Apply power to the time delay circuit. (see page 7 for time delay circuit). The time delay function will be initiated.
2. Time the length of the delay with a watch. Let time delay expire. After it expires, the override circuit will de-energize the solenoid, allowing the latch arm to trip. A clicking noise is heard.



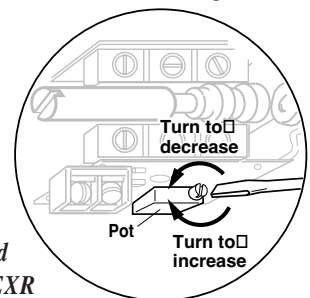
WARNING: REMOVE ALL POWER BEFORE OPENING ACCESS DOOR. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON ADJUST THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND LOCAL CODES.

3. **TURN THE POWER OFF TO RESET THE TIME DELAY CIRCUIT.**

NOTE: Allow 30 seconds bleed-time between turning the power “OFF” and “ON”

4. Locate the time adjustment pot (DETAIL “C”). The time is factory-set at the lowest setting (5 seconds approximately). To increase time, rotate the 20-turn pot clockwise as needed (5 seconds per turn approximately).

DETAIL “C”



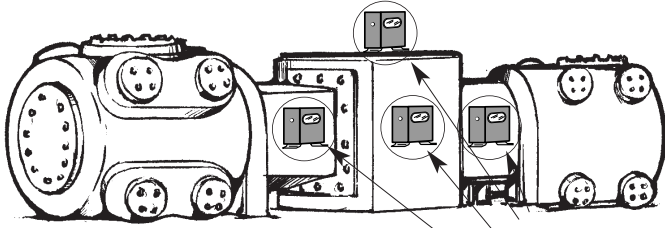
5. Repeat the above steps as necessary to obtain desired time delay.

NOTE: An external time delay can be used with the remote reset feature of the VS2EXR series to provide a remote reset and override of the trip operation on start-up. Time delay must automatically disconnect after equipment start-up.

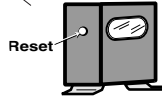
TYPICAL MOUNTING LOCATIONS

NOTE: These are typical mounting locations for best operation. Other mountings are possible. See *Installation* section on page 3.

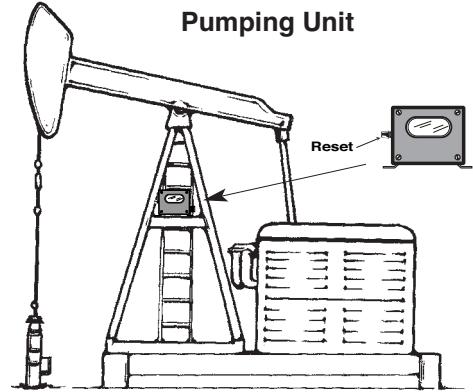
2-Throw Balance-Opposed Compressor



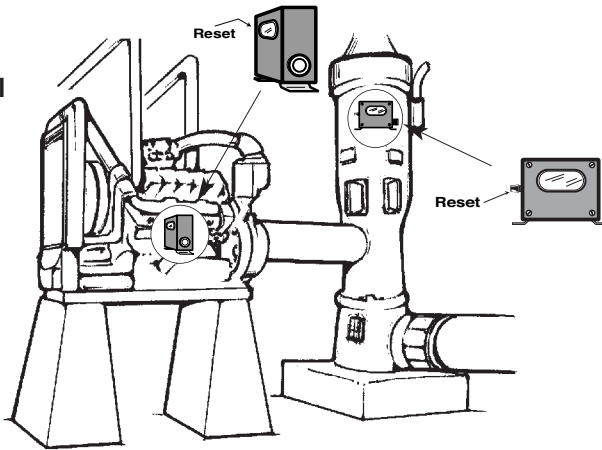
NOTE: If installing on cylinders, 2 vibration/shock switches are recommended- 1 for each cylinder.



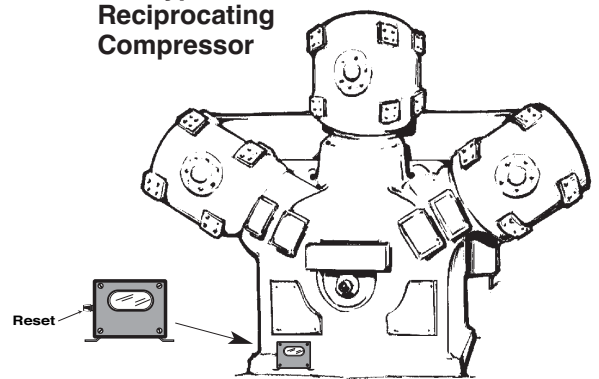
Pumping Unit



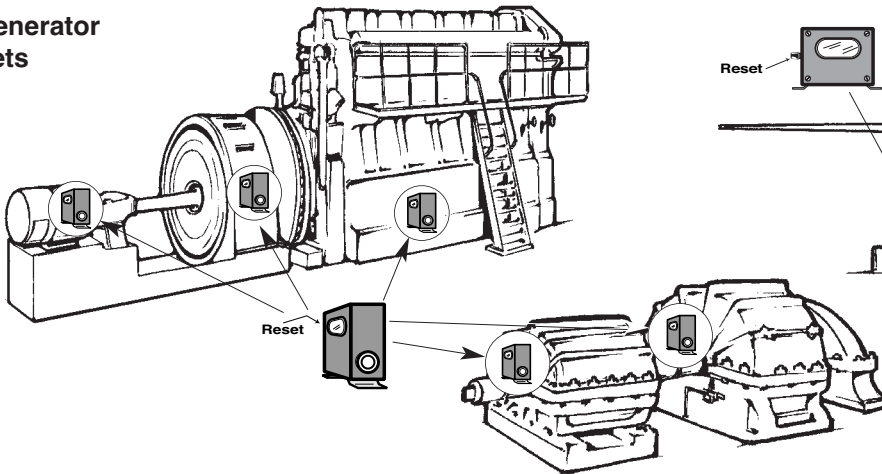
Engine and Vertical Shaft Pump



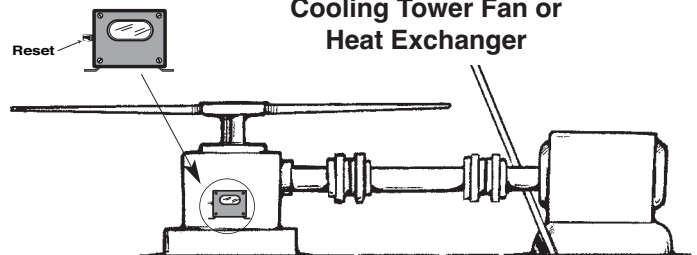
"Y" Type Reciprocating Compressor



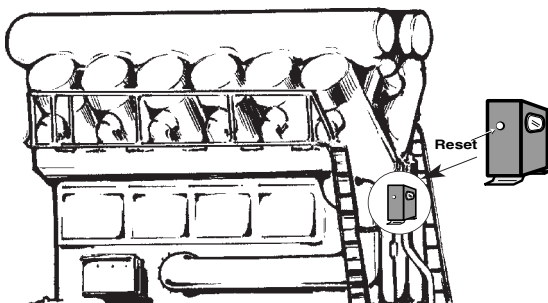
Generator Sets



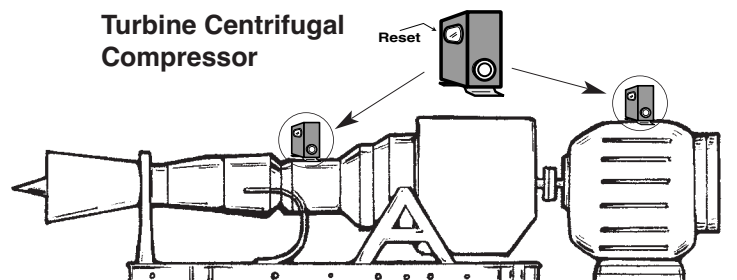
Cooling Tower Fan or Heat Exchanger



Engine Compressor

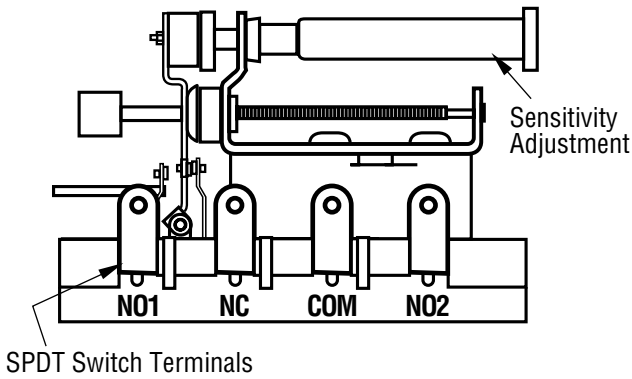


Turbine Centrifugal Compressor

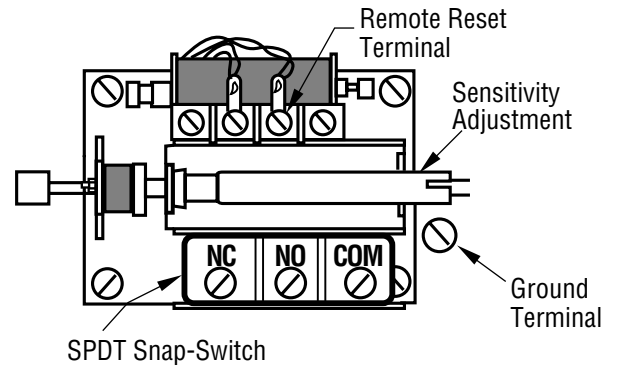


INTERNAL SWITCHES

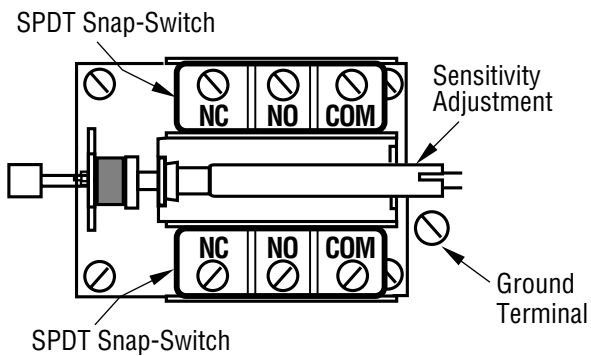
VS2 and VS2C



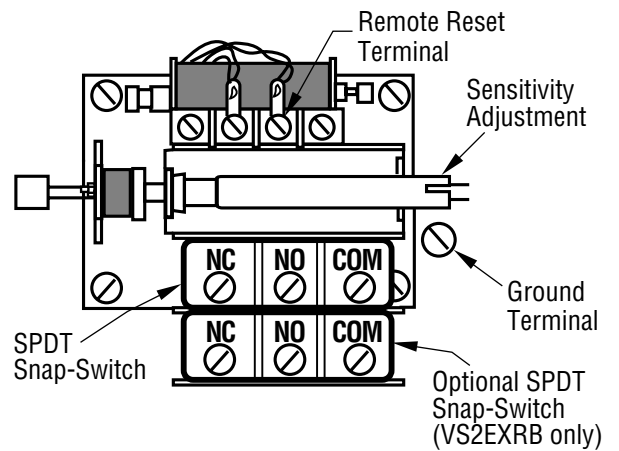
VS2EXR



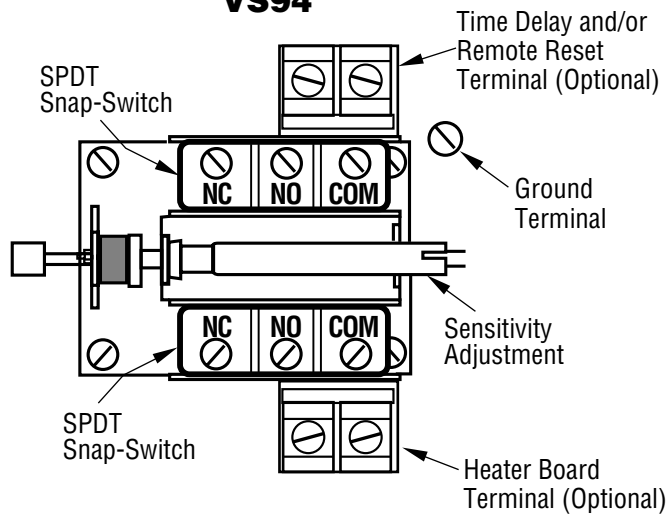
VS2EX



VS2EXB and VS2EXRB



VS94

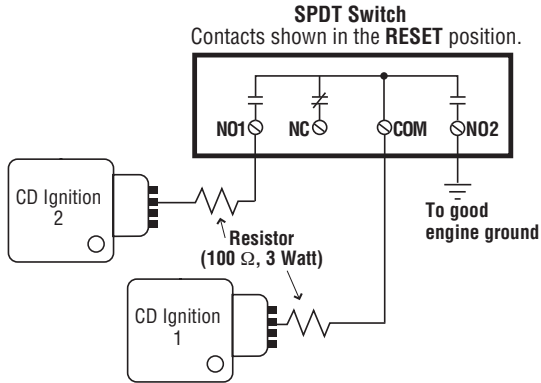


ELECTRICAL

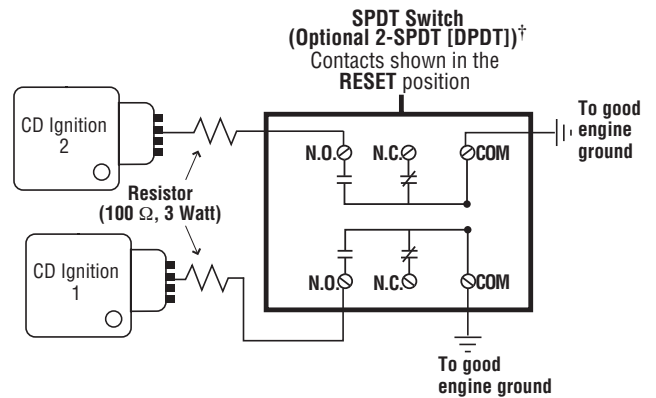


WARNING: REMOVE POWER BEFORE OPENING THE UNIT (ACCESS DOOR). STOP THE MACHINE AND DISCONNECT ALL ELECTRICAL POWER BEFORE BEGINNING THE WIRING OPERATION. IT IS YOUR RESPONSIBILITY TO HAVE A QUALIFIED PERSON INSTALL AND WIRE THE UNIT, AND MAKE SURE IT CONFORMS WITH NEC AND APPLICABLE CODES.

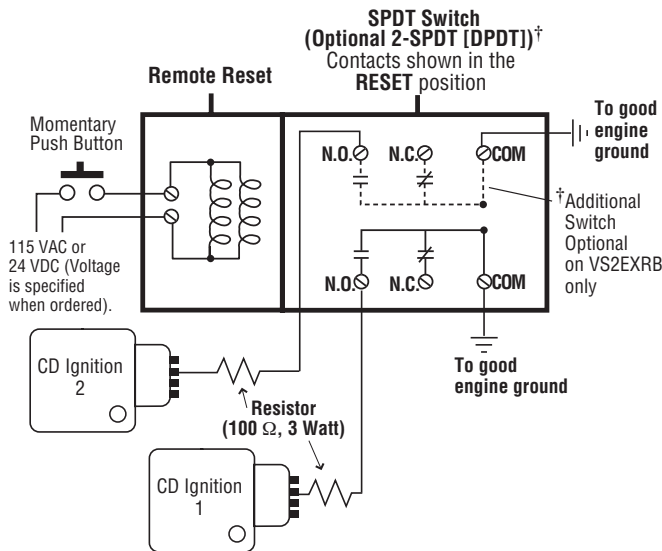
VS2 and VS2C Typical Wiring Diagram for Single or Dual CD Ignition



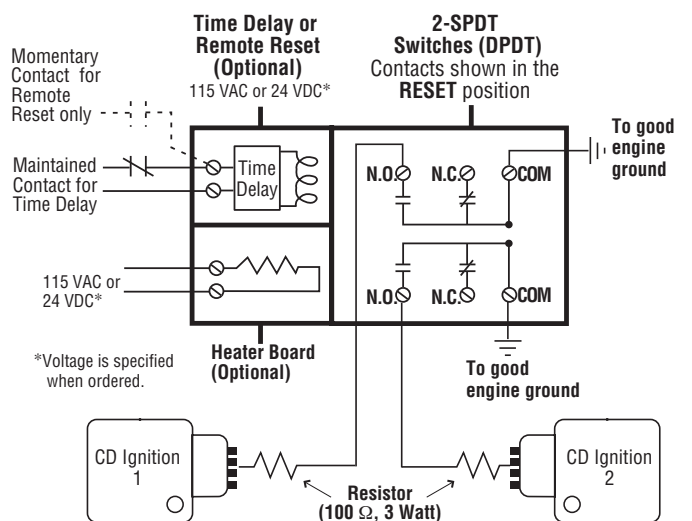
VS2EX Typical Wiring Diagram for Single or Dual CD Ignitions



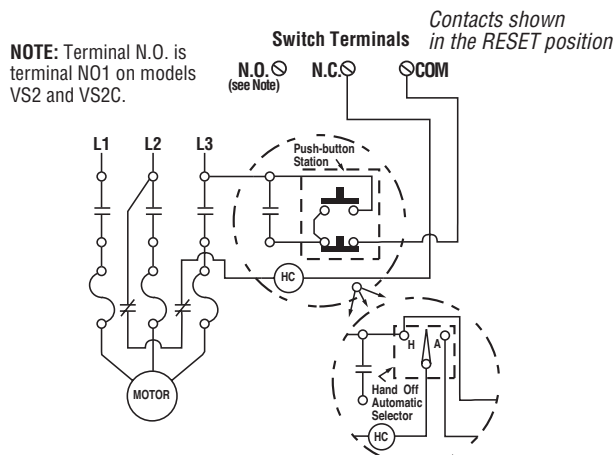
VS2EXR and VS2EXRB Typical Wiring Diagram for Single or Dual CD Ignitions



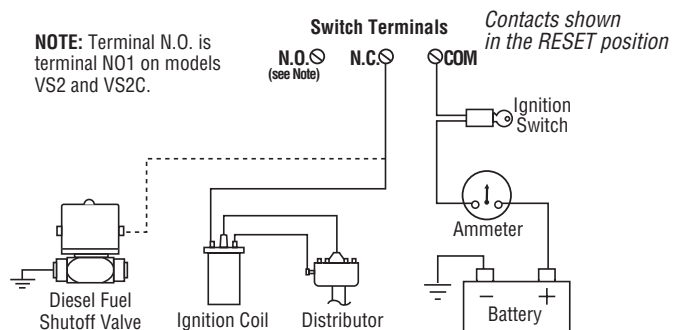
VS94 Typical Wiring Diagram for Single or Dual CD Ignitions



VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94 Typical Wiring Diagram for Electric Motors



VS2, VS2C, VS2EX, VS2EXR, VS2EXRB and VS94 Typical Wiring Diagram for Distributor Ignition or Diesel



SERVICE PARTS

PART NO. DESCRIPTION

VS2

20000030 Movement assembly
 20000031 Glass and gasket assembly
 20000032 Reset push button assembly

VS2C

20000030 Movement assembly
 20000031 Glass and gasket assembly
 20000032 Reset push button assembly
 20050021 Mounting clamp
 20000185 VS2C 5-clamp hardware package assembly.
 20050465 2-Conductor electrical cable, 45 feet (13.7 meters)

VS2EX

20010091 Movement assembly
 20050087 Cover
 00000309 Cover gasket
 20010090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
20000288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
 20000289 C-clamp conversion mounting kit

VS2EXR

20000262 Movement assembly
 20050087 Cover
 00000309 Cover gasket
 20010090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
20000288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
 20000049 Reset solenoid assembly (115 VAC)
 20000234 Reset solenoid assembly (24 VDC)
 20000289 C-clamp conversion mounting kit

PART NO. DESCRIPTION

VS2EXRB

20010090 Snap-switch and insulator kit (1 switch per kit)
prior to September 1, 1995.*
20000288 Snap-switch and insulator kit (1 switch per kit) for models manufactured on September 1, 1995 or later.*
 20000057 *Inside* snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D **prior to September 1, 1995.***
 20000058 *Outside* snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D **prior to September 1, 1995.***
20000287 Outside snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D manufactured on September 1, 1995 or later.*
20000290 Inside snap-switch and insulator kit (1 switch per kit) for model VS2EXRB-D manufactured on September 1, 1995 or later.*
 20050077 Adjustment shaft
 20000262 Movement assembly
 20000049 Reset solenoid assembly (115 VAC)
 20000234 Reset solenoid assembly (24 VDC)

VS94 Series

25050506 Dust boot
 00000232 Conduit fitting
 20010090 Snap-switch and insulator kit (1 switch per assembly)
prior to September 1, 1995.**
20000288 Snap-switch and insulator kit (1 switch per assembly) for models manufactured on September 1, 1995 or later.***

* If no date code is found, refer to the old switch. Models with date 0895 and before use old switch. Dated 0995 after, use straight snap-switch arm, no rollers.

** Models dated Q1 thru Q8 (formed snap-switch arm and rollers).

***Models date coded Q9 thru Q12 and R1 thru R12 (straight snap-switch arm, no rollers).

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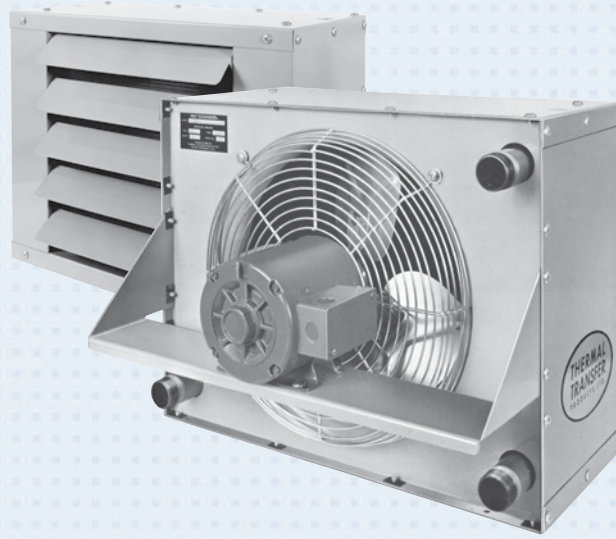
In order to consistently bring you the highest quality, full featured products, we reserve the right to change our specifications and designs at any time.

FLUID COOLING | Industrial AO Series

AIR COOLED AO/AOR

FEATURES

- Young Interchange – OCH
- Adjustable Louvers
- Medium Flow Rates
- Moderate Heat Removal
- One or Two Pass
- Fluid Power Systems
- Gear Drives
- Injection Molding Machines
- Machine Tools
- Torque Converters
- Hydraulic Presses



OPTIONS

- SAE & Metric Connections
- Relief Bypass
- Foot Brackets
- Corrosive Resistant
- Marine Coating

Ratings

- Operating Pressure** - 300 psi
- Test Pressure** - 300 psi
- Operating Temperature** - 400° F

Materials

- Tubes** Copper
- Fins** Aluminum
- Turbulators** Steel
- Fan Blade** Aluminum with steel hub
- Fan Guard** Zinc plated steel
- Cabinet** Steel with baked enamel finish
- Manifolds** Steel
- Connections** Steel

Weights

MODEL	Net Weight (LBS)
AO-5	47
AO-10	62
AO-15	72
AO-20	86
AO-25	120
AO-30	135
AO-35	160
AO-40	185

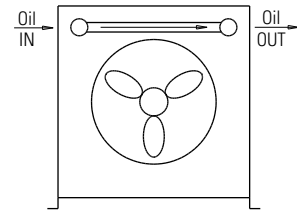
One Pass (Medium to High Oil Flows)

Model Number	Flow Range GPM (USA)
AOR - 5-1	2 - 80
AOR - 10-1	3 - 80
AOR - 15-1	4 - 80
AOR - 20-1	5 - 80
AOR - 25-1	6 - 100
AOR - 30-1	7 - 100
AOR - 35-1	8 - 112
AOR - 40-1	9 - 118

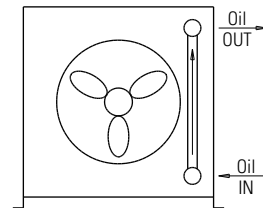
Two Pass (Low to Medium Oil Flows)

Model Number	Flow Range GPM (USA)
AOR - 5-2	2 - 25
AOR - 10-2	2 - 30
AOR - 15-2	2 - 30
AOR - 20-2	2 - 40
AOR - 25-2	2 - 40
AOR - 30-2	2 - 40
AOR - 35-2	3 - 40
AOR - 40-2	4 - 40

One Pass



Two Pass



How to Order

Model Series AO	Model Size Selected	Number of Passes* Blank - No Bypass 1 - One Pass 2 - Two Pass	Connection Type Blank - NPT S - SAE M - Metric	Relief Bypass Setting* 30-30 psi 60 - 60 psi	Foot Mounted Brackets Blank - No Brackets FB - Foot Brackets	Specify Motor Required Single Phase Single Phase Expl. Proof Three Phase Three Phase 575 Volt Three Phase Expl. Proof

*ADD FOR AOR MODELS ONLY: Relief Bypass Setting & Number of Passes

TTPSales@thermasys.com 262.554.8330 www.thermaltransfer.com

Specifications

Electric motor & Fan data*

Model	CFM	Sound dB(A)** at 7 ft.	Horse Power	Volts	Phase	Full Load Amps	Hz	Nema Frame	RPM	Type	Circuit	Thermal Overload	Bearing B-Bal S-Sleeve
AO-5	401/487 494	68 70	1/12 1/4	110/115 208-230/460	1 3	1.2/1.2 1.4-1.3/.65	50/60 60	48	1400/1700 1725	TEAO TEFC	A D	No	B
AO-10	576/700 710	68 70	1/12 1/4	110/115 208-230/460	1 3	1.2/1.2 1.4-1.3/.65	50/60 60	48	1400/1700 1725	TEAO TEFC	A D	No	B
AO-15	824/1000 1015	69 71	1/12 1/4	110/115 208-230/460	1 3	1.2/1.2 1.4-1.3/.65	50/60 60	48	1400/1700 1725	TEAO TEFC	A D	No	B
AO-20	1555	70 72	1/6 1/4	115/208-230 208-230/460	1 3	4/2.1-2 1.4-1.3/.65	60 60	48	1725	TEFC TEFC	C D	No	B
AO-25	2240	72 73	1/6	115/208-230 208-230/460	1 3	4.6/2.2 1.3-1.2/.6	60	48	1140	TEFC	C D	No	B
AO-30	3100	75 76	1/6	115/208-230 208-230/460	1 3	5.2/2.7-2.6 1.3-1.2/.6	60	48	1140	TEFC	C D	No	B
AO-35	4370	76 77	1/2	115/208-230 208-230/460	1 3	8/4.2-4 2.5-2.4/1.2	60	56	1140	TEFC	C D	No	B
AO-40	5450	78 79	1/2	115/208-230 208-230/460	1 3	8/4.2-4 2.5-2.4/1.2	60	56	1140	TEFC	C D	No	B

*Published electrical ratings are approximate, and may vary because of motor brand. Actual ratings are on motor nameplate.

**Catalog dB(A) sound levels are at seven (7) feet. dB(A) sound levels increase by six (6) dB(A) for halving this distance and decrease by six (6) dB(A) for doubling this distance.

Explosion Proof Motors (Class I GP.D & Class II GP.F, G)*

Model	CFM	Sound dB(A)** at 7 ft.	Horse Power	Volts	Phase	Full Load Amps	Hz	Nema Frame	RPM	Type	Circuit	Thermal Overload	Bearing B-Bal S-Sleeve
AO-5	494	68 70	1/4	115/230 208-230/460	1 3	5.8/2.9 1.4-1.3/.65	60	48	1725	FC	C D	Yes	B
AO-10	710	68 70	1/4	115/230 208-230/460	1 3	5.8/2.9 1.4-1.3/.65	60	48	1725	FC	C D	Yes	B
AO-15	1015	69 71	1/4	115/230 208-230/460	1 3	5.8/2.9 1.4-1.3/.65	60	48	1725	FC	C D	Yes	B
AO-20	1555	70 72	1/4	115/230 208-230/460	1 3	5.8/2.9 1.4-1.3/.65	60	48	1725	FC	C D	Yes	B
AO-25	2240	72 73	1/3	115/230 208-230/460	1 3	6.8/3.4 1.8-1.6/.8	60	56	1140	FC	C D	Yes	B
AO-30	3100	75 76	1/3	115/230 208-230/460	1 3	6.8/3.4 1.8-1.6/.8	60	56	1140	FC	C D	Yes	B
AO-35	4370	76 77	1/2	115/230 208-230/460	1 3	8/4 2.5-2.4/1.2	60	56	1140	FC	C D	Yes	B
AO-40	5450	78 79	1/2	115/230 208-230/460	1 3	8/4 2.5-2.4/1.2	60	56	1140	FC	C D	Yes	B

*Published electrical ratings are approximate, and may vary because of motor brand. Actual ratings are on motor nameplate.

575 Volt

Model	CFM	Sound dB(A)** at 7 ft.	Horse Power	Volts	Phase	Full Load Amps	Hz	Nema Frame	RPM	Type	Circuit	Thermal Overload	Bearing B-Bal S-Sleeve
AO-5	494	70	1/4	575	3	.52	60	48	1725	TEFC	D	No	B
AO-10	710	70	1/4	575	3	.52	60	48	1725	TEFC	D	No	B
AO-15	1015	71	1/4	575	3	.52	60	48	1725	TEFC	D	No	B
AO-20	1555	72	1/4	575	3	.52	60	48	1725	TEFC	D	No	B
AO-25	2240	73	1/2	575	3	.88	60	56	1140	TEFC	D	No	B
AO-30	3100	76	1/2	575	3	.88	60	56	1140	TEFC	D	No	B
AO-35	4370	77	1/2	575	3	.88	60	56	1140	TEFC	D	No	B
AO-40	5450	79	1/2	575	3	.88	60	56	1140	TEFC	D	No	B

*D Squirrel Cage

**Catalog dB(A) sound levels at seven (7) feet. dB(A) sound levels increase by six (6) dB(A) for halving this distance, and decrease by six (6) dB(A) for doubling this distance.

Lubrication Notes

Caution: Do not over oil or over grease. **Ball bearings** – No grease needed at start up. Grease as follows:

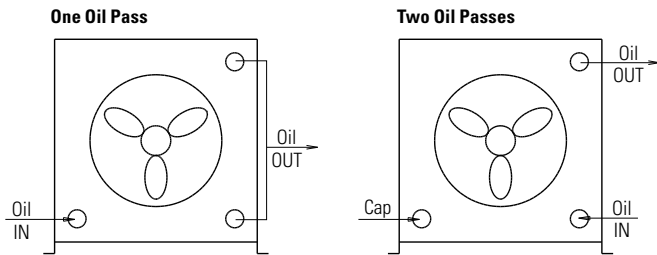
5,000 Hours/Year	5 Year Grease Interval
Continuous Normal Applications	2 Years
Seasonal Service Motor is idle for 6 months or more	1 Year
Continuous High ambients, dirty or moist locations, high vibration	6 Months

Dimensions

Model	A	B	C	D	E	F	G	H	J	K	L	M NPT	M SAE	N	P	T
AO-5	7.40	14.81	5.90	11.81	20.00	9.19	8.31	6.47	12.94	3.78	7.56	1"	#16 SAE	5.84	11.69	—
AO-10	9.50	19.00	6.56	13.12	19.25	10.50	12.50	8.56	17.12	4.44	8.88	1"		1-5/16-12UN-2B	7.94	15.88
AO-15	10.19	20.38	7.87	15.75	19.25	13.12	13.88	9.25	18.50	5.75	11.50	1"	Thread	8.62	17.25	—
AO-20	11.91	23.81	9.19	18.38	19.25	15.75	17.91	10.90	21.81	7.00	14.00	1-1/4"	#20 SAE	10.28	20.56	—
AO-25	13.34	26.68	11.81	23.62	19.25	21.00	20.19	12.40	24.81	9.62	19.25	1-1/4"		1-5/8-12UN-2B	11.78	23.56
AO-30	15.81	31.62	13.78	27.56	19.50	24.94	25.12	14.87	29.75	11.59	23.19	1-1/4"	Thread	14.25	28.50	11.00
AO-35	16.90	33.81	15.09	30.19	21.50	27.56	27.31	15.97	31.94	12.90	25.81	1-1/4"		15.34	30.69	11.00
AO-40	20.81	41.62	18.37	36.75	20.50	34.12	35.12	19.87	39.75	16.19	32.38	1-1/4"		19.25	38.50	13.25

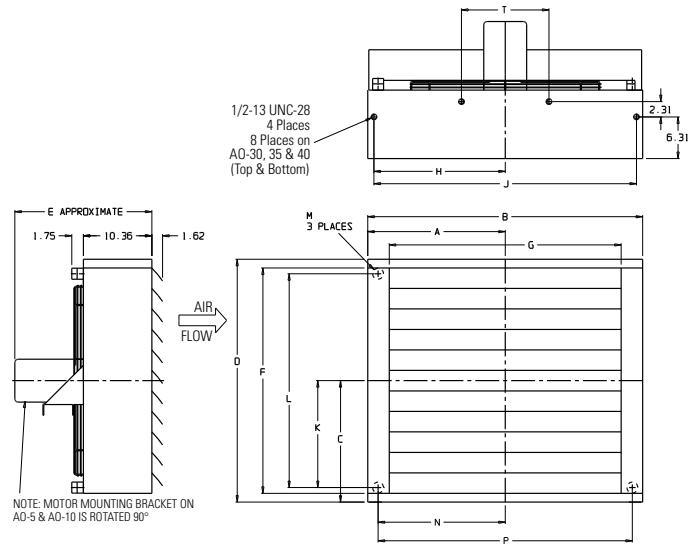
NOTE: All dimensions in inches.

Installation Piping Diagram



*See dimension chart for NPT or optional internal SAE connection size.

Fan Rotation Clockwise/Facing Motor Shaft

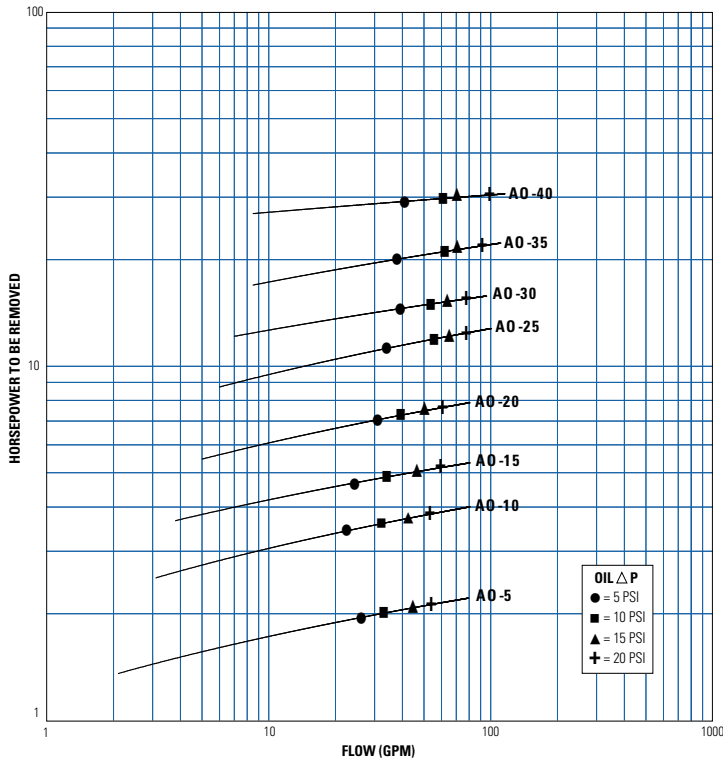


C_v Viscosity Correction

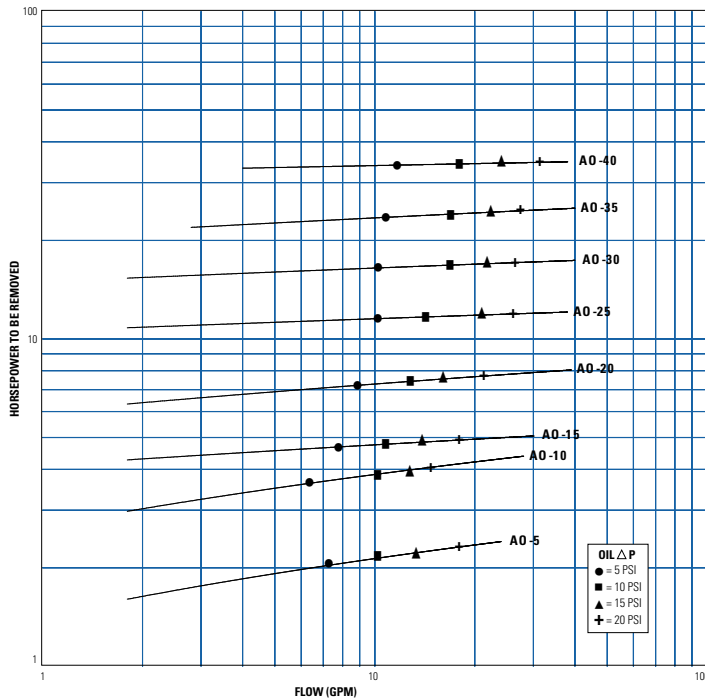
Average Oil Temp °F	OIL					
	SAE 5 110 SSU at 100°F 40 SSU at 210°F	SAE 10 150 SSU at 100°F 43 SSU at 210°F	SAE 20 275 SSU at 100°F 50 SSU at 210°F	SAE 30 500 SSU at 100°F 65 SSU at 210°F	SAE 40 750 SSU at 100°F 75 SSU at 210°F	50-50 Ethylene Glycol & Water
100	1.14	1.22	1.35	1.58	1.77	1.11
150	1.01	1.05	1.11	1.21	1.31	1.02
200	.99	1.00	1.01	1.08	1.10	.96
250	.95	.98	.99	1.00	1.00	.95

Performance Curves

One Pass Oil



Two Pass Oil



Selection Procedure

Performance Curves are based on 50SSU oil leaving the cooler 40°F higher than the ambient air temperature used for cooling. This is also referred to as a 40°F approach temperature.

STEP 1 Determine the Heat Load. This will vary with different systems, but typically coolers are sized to remove 25 to 50% of the input nameplate horsepower.

(Example: 100 HP Power Unit x .33 = 33 HP Heat load.)

$$\text{If BTU/Hr. is known: } \text{HP} = \frac{\text{BTU/Hr}}{2545}$$

STEP 2 Determine Approach Temperature. Desired oil leaving cooler °F – Ambient air temp. °F = Actual Approach

STEP 3 Determine Curve Horsepower Heat Load. Enter the information from above:

$$\text{Horsepower heat load} \times \frac{40 \times \text{Cv}}{\text{Actual Approach}} = \text{Curve Horsepower}$$

STEP 4 Enter curves at oil flow through cooler and curve horsepower. Any curve above the intersecting point will work.

STEP 5 Determine Oil Pressure Drop from Curves:

● = 5 PSI; ■ = 10 PSI; ▲ = 14 PSI; + = 20 PSI. Multiply pressure drop from curve by correction factor found in oil ΔP correction curve.

Desired Reservoir Temperature

Return Line Cooling: Desired temperature is the oil temperature leaving the cooler. This will be the same temperature that will be found in the reservoir.

Off-Line Recirculation Cooling Loop: Desired temperature is the oil temperature entering the cooler. In this case, the oil temperature change must be determined so that the actual oil leaving temperature can be found.

Calculate the oil temperature change (oil ΔT) with this formula:

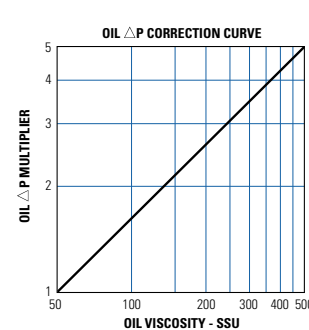
$$\text{Oil } \Delta T = (\text{BTU's/Hr.}) / (\text{GPM Oil Flow} \times 210)$$

To calculate the oil leaving temperature from the cooler, use this formula:

$$\text{Oil Leaving Temp.} = \text{Oil Entering Temp} - \text{Oil } \Delta T$$

This formula may also be used in any application where the only temperature available is the entering oil temperature.

Oil Pressure Drop: Most systems can tolerate a pressure drop through the heat exchanger of 20 to 30 PSI. Excessive pressure drop should be avoided. Care should be taken to limit pressure drop to 5 PSI or less for case drain applications where high back pressure may damage the pump shaft seals.



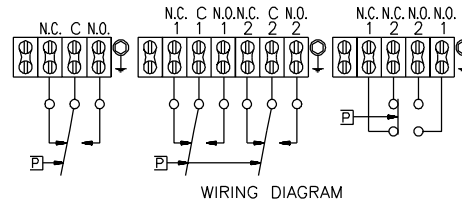
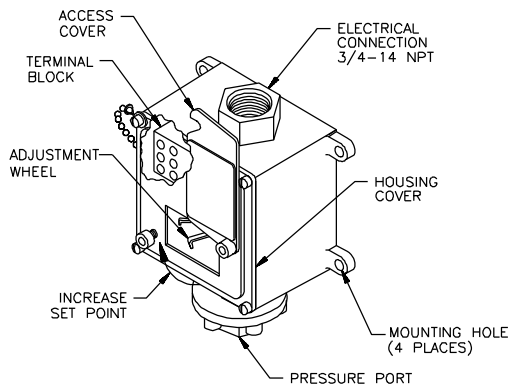
Oil Temperature

Typical operating temperature ranges are:

Hydraulic Motor Oil	110° - 130°F
Hydrostatic Drive Oil	130° - 180°F
Bearing Lube Oil	120° - 160°F
Lube Oil Circuits	110° - 130°F

CUSTOM CONTROL SENSORS, INC.

604 INSTALLATION INSTRUCTION



General:

- a. Observe all Warnings and Cautions contained on the attached Warning Sticker, the Warning Declaration and the CCS Catalog.
- b. Follow all applicable Governmental or other Codes or Regulations such as, but not restricted to NEC, ASME, CSA and OSHA.

Mounting:

- a. Units may be mounted in any position. On a flat surface using (4) mounting holes provided and 1/4" screws at least 1/2" long.

Warning: Release all pressure prior to installation or removal of this device. Do not exceed nameplate listed proof pressures.

- a. Units are supplied with female NPT ports suitable for connection to NPT pipe nipples or NPT taper threaded pipe. CCS recommends use of either a union or bendable tubing. This will eliminate excessive strain on the housing.
- b. Pipe joint sealing compound is preferred over Teflon tape. However, either method of sealing is acceptable with proper care to avoid introducing sealing material into pressure switch or plumbing.

Electrical Connections:

WARNING: Do not make electrical connections while electrical power is ON.

- a. Remove housing cover to allow access to the terminal block per illustration.

- b. The electrical connection is provided with a 3/4" NPT female conduit connection. Flexible conduit is recommended. Connect conduit to housing.

- c. Make electrical connections in accordance with the NEC and all other appropriate codes and regulations, see wiring diagrams.

Note: Circuitry coding is provided on instruction label inside housing.

- d. When making wire connections disconnect electrical power. Check for multiple circuits.

- e. Grounding: Proper grounding must be accomplished by use of green terminal screw provided.

Adjustment: (Not applicable if units are factory set) Pressure settings are externally adjustable.

- a. If the electrical circuit cannot be used for testing disconnect electrical power and use a suitable circuit tester or light box.

- b. Loosen access cover. Adjust wheel as illustrated.

- Clockwise to increase settings.
- Counterclockwise to decrease settings.

- c. Re-tighten access cover.

- d. Reconnect electrical circuit.

- e. Return power to unit.

WARNING DECLARATION

If this switch is used to protect equipment or personnel from unsafe pressure or to guard against the hazardous release of contained substances it must be installed and operated in accordance with applicable codes, regulations and standards. This switch must be used in conjunction with system design(s) or procedure(s) necessary to mitigate any hazard resulting from its failure. Conform to installation instructions accompanying this switch. Individuals who ignore this warning may suffer serious or fatal injury and do so at their own risk. Custom Control Sensors is not liable for any misuse, abuse, suitability or adequacy of user's application of the switch. Service by qualified personnel only.

Medium Pressure Flat Glass Gages



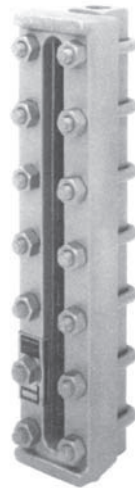
for most common process conditions...

Strength and versatility make Penberthy's medium pressure gages ideal for most common process conditions. Offshore specification 2600.1 is preferred with medium pressure gages in offshore and other corrosive environments.

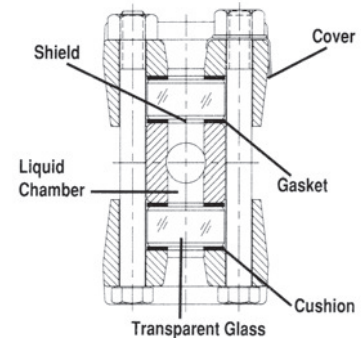
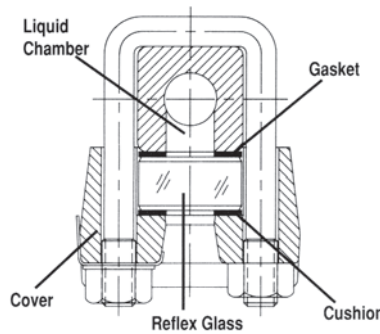
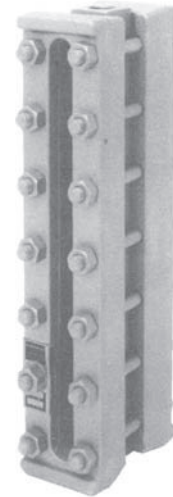
All materials in medium pressure gages conform to ASTM specifications. RM gages can achieve pressures to 3000 psig [20680 kPa] @ 100°F [38°C] and TM gages can achieve pressures to 2500 psig [17240 kPa] @ 100°F [38°C] when manufactured with size 1 glass – see ratings table below.

Although not designed for thermal cycling, Penberthy allows use of medium pressure gages for steam/water applications due to historical precedence - see Application Report 2781 in Penberthy Catalog.

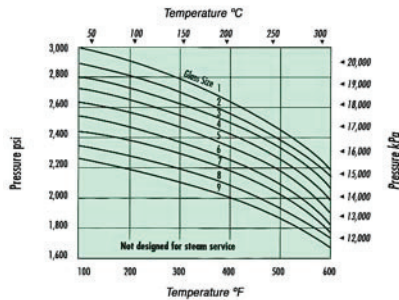
Model RM – Reflex Medium Pressure



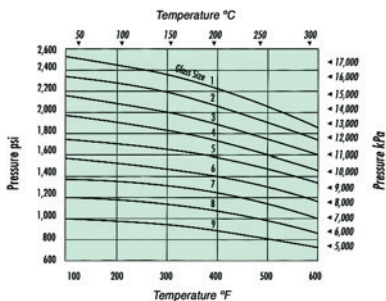
Model TM – Transparent Medium Pressure



Model RM Pressure/Temperature



Model TM Pressure/Temperature



Standard/Optional Features

CONNECTION TYPE	STANDARD	OPTIONAL
End Connections		
<i>Threaded</i>		
1/2" NPTF	X	
3/4" NPTF		X
<i>Socketweld</i>		
1/2" female		X
3/4" female		X
<i>Flanged</i>		X
Side or Back (typically reflex only) Connections		
<i>Threaded</i>		
1/2" NPTF		X
3/4" NPTF		X
<i>Socketweld</i>		
1/2" female		X
3/4" female		X
<i>Flanged</i>		X
Chambers		
<i>Recessed Gasket</i>		X

*Gages with recessed gaskets are designed with the letter R at the end of the Model Number (i.e. RMR)

NOTE: Pressure/Temperature ratings shown for standard gasket, otherwise see chart on page 13.

For environmental Nace MR0175 &/or MR0103 gages, pressure de-rating is required

Low Pressure Flat Glass Gages



for less demanding process conditions...

Penberthy's low pressure gages are designed to maximize the mechanical and economical advantages of ductile iron covers.

All materials in low pressure gages conform to ASTM specifications. RL gages can achieve pressures to 2400 psig [16550 kPa] @ 100°F [38°C] and TL gages can achieve pressures to 2000 psig [13790 kPa] @ 100°F [38°C] when manufactured with size 1 glass – see ratings table below.

Penberthy does not recommend low pressure gages for steam/water applications.

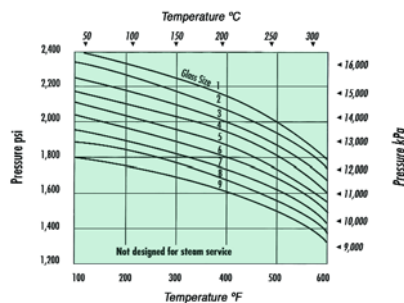
Model RL – Reflex Low Pressure



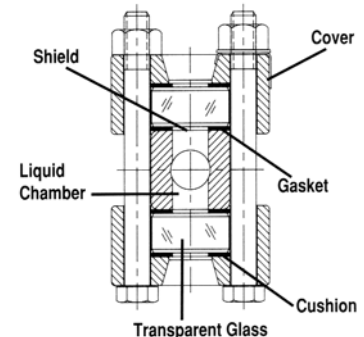
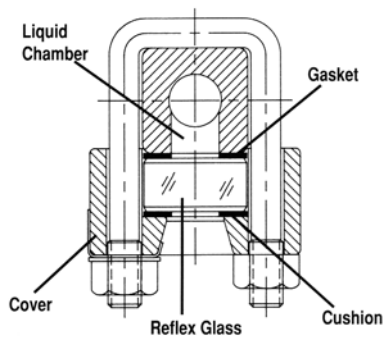
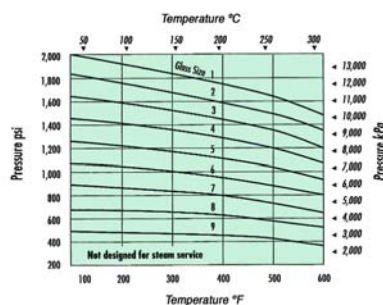
Model TL – Transparent Low Pressure



Model RL Pressure/Temperature



Model TL Pressure/Temperature



Standard/Optional Features

CONNECTION TYPE	STANDARD	OPTIONAL
End Connections		
<i>Threaded</i>		
1/2" NPTF	X	
3/4" NPTF		X
<i>Socketweld</i>		
1/2" female		X
3/4" female		X
<i>Flanged</i>		X
Side or Back (typically reflex only) Connections		
<i>Threaded</i>		
1/2" NPTF		X
3/4" NPTF		X
<i>Socketweld</i>		
1/2" female		X
3/4" female		X
<i>Flanged</i>		X

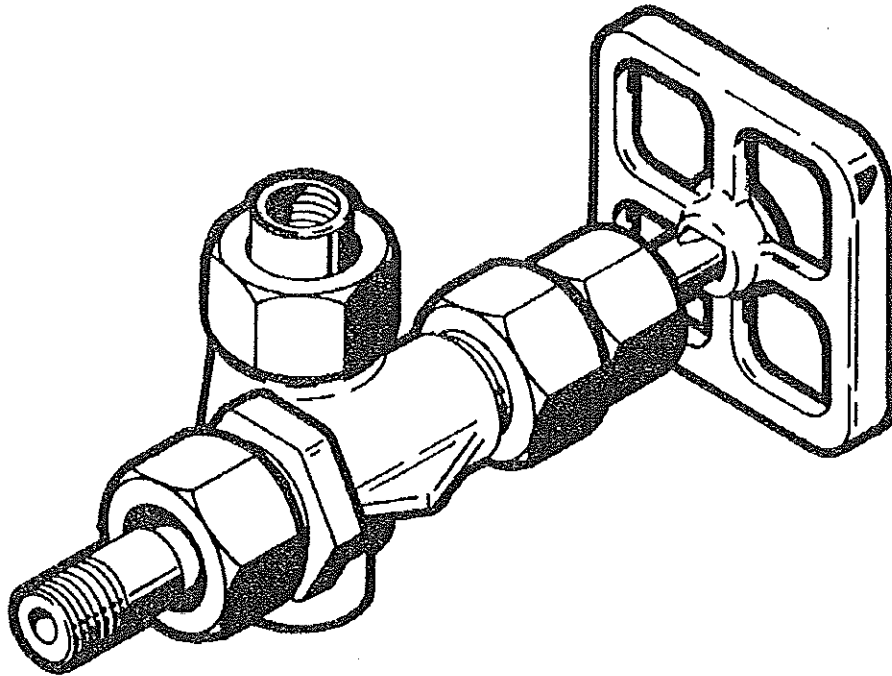
NOTE: Pressure/Temperature ratings shown for standard gasket, otherwise see chart on page 13.

PENBERTHY®

Section 2000
Instal. Instr. 2960
Issued 8/96
Replaces 2/94

Gage Valves

Series 100, 200, 300 and 400



Installation/Operation/Maintenance Instructions

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PRODUCT WARRANTY

Penberthy Inc., warrants its products as designed and manufactured by Penberthy to be free of defects in material and workmanship for a period of one year after the date of installation or eighteen months after the date of manufacture, whichever is earliest. Penberthy will, at its option, replace or repair any products which fail during the warranty period due to defective material or workmanship.

Prior to submitting any claim for warranty service, the owner must submit proof of purchase to Penberthy and obtain written authorization to return the product. Thereafter, the product shall be returned to Penberthy in Prophetstown, Illinois, with freight prepaid.

This warranty shall not apply if the product has been disassembled, tampered with, repaired or altered outside of the Penberthy factory, or if it has been subjected to misuse, neglect or accident.

Penberthy's responsibility hereunder is limited to repairing or replacing the product at its expense. Penberthy shall not be liable for loss, damage, or expenses directly or indirectly related to the installation or use of its products, or from any other cause or for consequential damages. It is expressly understood that Penberthy is not responsible for damage or injury caused to other products, building, property or persons, by reason of the installation or use of its product.

THIS IS PENBERTHY'S SOLE WARRANTY AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED WHICH ARE HEREBY EXCLUDED, INCLUDING IN PARTICULAR ALL WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This document and the warranty contained herein may not be modified and no other warranty, expressed or implied, shall be made by on behalf of Penberthy unless modified or made in writing and signed by the President or a Vice President of Penberthy.

1.0 About the Manual

This manual has been prepared as an aid and guide for personnel involved in installation or maintenance. All instructions must be read and understood thoroughly before attempting any installation, operation, or maintenance. Failure to follow *any* instruction could possibly result in a malfunction of the valve with resulting sudden release of pressure, property damage or physical injury to personnel.

SAFETY INSTRUCTION

Penberthy does not have any control over the manner in which its gage valves are handled, installed, or used. Penberthy cannot and will not guarantee that a gage valve is suitable or compatible for the user's specific application.



CAUTION



Vessel fluids may be pressurized and can unexpectedly exit vessel connections due to apparatus or material failure. Safety glasses should be worn when installing a gage valve. Failure to do so could result in serious physical injury to personnel or property damage.

2.0 Introduction

Penberthy armored gage valves are used to isolate gage glass, magnetic gages or other apparatus from the holding or pressure vessel when it becomes necessary to drain and service the gage. Penberthy Series 100, 200, 300, and 400 gage valve are supplied in pairs (upper and lower) and are available with socketweld, flanged and NPT connections.

These valves are equipped, as a standard feature, with a floating shank union vessel connection, which permits up to 3/8" [9.5mm] variation in center to center distance and with ball check shut-offs to prevent leakage of contained fluid in case of accidental gage glass breakage.

Series 100, 200, 300, and 400 valves for process use should include ball check shut-off feature. Valves without the ball check shut-off feature will not automatically stop leakage of contained fluid in the event of accidental gage glass breakage.

2.1 System Description

Penberthy armored valves are comprised of six basic components. Each component may vary slightly, depending on the desired physical and mechanical properties for the valve. Use the exploded parts view in Section 11.0 as additional reference material.

Body – a pressure retaining structure through which liquid passes to enter a gage glass or other apparatus. Provides a rigid, union, or spherical union connection to the vessel and seating surfaces for most valve components. Series 100 and 200 are straight pattern bodies; Series 300 and 400 are offset pattern bodies.

Ball Checks – sphere installed loosely within the body of the valve that seats to prevent significant leakage when a differential pressure surge occurs (e.g., mechanical failure). Ball checks for ASME steam service incorporate a vertically rising lower and leaky horizontal upper or omit ball checks completely. "Reverse acting" ball checks are available for vacuum service.

Trim – wetted parts that mechanically control the liquid path from the vessel to the gage glass or other apparatus. The ball and stem act to seal and release the liquid. In the event of mechanical failure, the ball will seat to prevent large quantities of the contained fluid from exiting the vessel. Liquid is allowed to exit the vessel into the gage glass or other apparatus when the stem is screwed away from its seated position. The liquid is sealed when the stem is screwed into its seated position.

The stem packing retainer provides a compression surface between the process liquid and the stem packing. A stem packing gland is used to compress the packing against the retainer and around the stem to prevent leakage.

Stem Packing – under compression the stem packing is forced to mold around the stem and prevent leakage of media during operation.

Gage Connection – provides connection between the valve and the gage glass or other apparatus. A union, spherical union or rigid connection may be used. A union connection can move in a plane parallel to the vessel connection.

Handwheel/Lever – rotated to engage threads and provide screw action of stem.

3.0 Available Models

Armored valves standard feature are listed in chart below.

Features	Model No.							
	120	130	220	230	320	330	420	430
Straight Pattern	X	X	X	X				
Offset Pattern					X	X	X	X
Integral Bonnet	X	X			X	X		
Union Bonnet			X	X			X	X
Union Gage Connection	X		X		X		X	
Rigid Gage Connection		X		X		X		X
Screwed in Seat			X	X			X	X

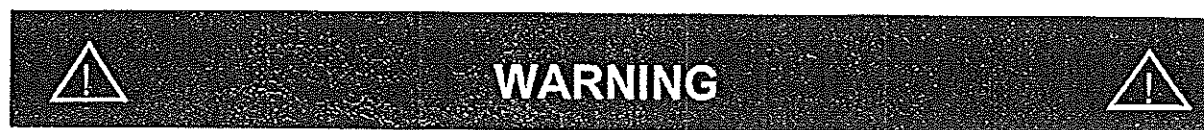
3.1 Design Ratings at Maximum and Minimum Operating Temperatures

To determine the maximum allowable working pressure for a specific temperature within the design limits stated below, the user must refer to Penberthy Dimension Sheets, or when provided, the specifically stated design limits on a Penberthy product proposal.

DESIGN RATINGS FOR THREADED OR WELDED CONNECTIONS

Valve Series	Material of Construction	Maximum Allowable Working Pressure	
		Teflon® packing	Grafoil® packing
100 200	Carbon Steel	4000 psig [27579 kPa] @ -20°F to +100°F [-29°C to +38°C]	4000 psig [27579 kPa] @ -20°F to +100°F [-29°C to +38°C]
		3525 psig [24304 kPa] @ 500°F [260°C]	2620 psig [18064 kPa] @ 750°F [399°C]
300 400	316 STS Construction	4000 psig [27579 kPa] @ -300°F to +100°F [-184°C to +38°C]	4000 psig [27579 kPa] @ -300°F to +100°F [-184°C to +38°C]
		3525 psig [24304 kPa] @ 500°F [260°C]	2755 psig [18995 kPa] @ 750°F [399°C]
For other materials or connections consult factory			

TABLE 1



NEVER exceed these design ratings or application data. Exceeding design ratings or application data may result in mechanical failure of valve components resulting in serious personal injury and/or property damage.

3.2 Steam Application

Penberthy series 100, 200, 300 and 400 valves are designed for process conditions. In low pressure steam/water applications (≤ 350 psig [2413 kPa] @ 431°F [221°C]), Penberthy allows the use of 300 and 400 series valves because the potential mechanical stress imposed on the valve assembly by the thermodynamic steam environment is relatively small. Request Penberthy Application Reports for more detailed information.

4.0 Inspection

Upon receipt of a gage valve set, check all components carefully for damage incurred in shipping. If damage is evident or suspected, do not attempt installation. Notify carrier immediately and request damage inspection. Refer to exploded view drawing in Section 11.0 to inventory parts.

4.1 User Rating Inspection

The user should confirm that:

- 1) The gage valve set model number and pressure/temperature rating stamped on nameplate (163) conforms to the description on the user's purchase order
- 2) The operating conditions described in the purchase order agree with the actual operating conditions at the installation site
- 3) The actual operating conditions at the installation site are within the applications data shown on the Penberthy Technical Data Bulletin or product proposal referred to previously.

- 4) The materials of construction of the gage valve set are compatible with both the contained fluid and the surrounding atmosphere in the specific application.

SAFETY INSTRUCTIONS

If the size, model or performance data of the gage valve set as received does not conform with any of the criteria above, do not proceed with installation. Contact an authorized Penberthy distributor for assistance. The incorrect valve can result in unacceptable performance and potential damage to the gage.

5.0 Installation

Installation should only be undertaken by qualified personnel who are familiar with this equipment. They should have read and understood all of the instructions in this manual. The user should refer to Penberthy dimension sheets or Penberthy product proposal to obtain dimensional information for specific size and model gage valve.

Penberthy recommendations on gage valve installations are not necessarily related to the installation of flat glass liquid level gages. The number of different types of gage and valve installations is too great to adequately explain in an installation manual. Therefore, it is the user's responsibility to assure that knowledgeable installation personnel plan and carry out the installation in a safe manner. The following procedures are some of the guidelines that should be employed.

5.1 Piping Strain

The gage valve should be mounted and connected so that it can support the gage without binding. Torsional stresses can make it difficult or impossible to seal tailpipes. Although union connections will allow marginal errors in piping alignment, misalignment can still create unusual strain on connectors. Gages not properly supported by brackets may subject the gage valve to stresses that can cause leaks or mechanical failure.

5.2 Differential Thermal Expansion

High mechanical loading may be imposed on a gage valve by expanding and contracting gages due to hot or cold service. Such mechanical loads on the valve must be minimized by controlling process conditions in the system.

5.3 Mounting

- 1) Prior to installation, turn the handwheel of each valve clockwise until the stem closes against the seat
- 2) Remove union vessel connections from valves, where applicable, and apply heavy grease (where allowable) to tailpipe seat. (the grease minimizes galling of the seat surfaces when tightening the coupling nuts.)

- 3) Wrench tighten tailpipes of upper and lower valves to the vessel using Teflon® tape, or equivalent, on all male tapered pipe thread connections as shown in Figure 1. If the valve is flanged or weld mount, use proper industry standard procedures.

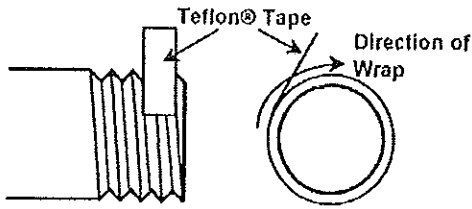


FIGURE 1

- 4) If installing with a flat glass gage, follow all installation instructions for the specific liquid level gage as there are many points to consider on gage installation; among them, piping strain, differential thermal expansion, weight and bolt torque.
- 5) Install gage tailpipes to union gage connections, where applicable, making sure that coupling nuts are in place.

6.0 Operation

Before initializing gage valve operation, check that all installation procedures have been completed. Use only qualified, experienced personnel who are familiar with valve equipment and thoroughly understand the implications of the tables and all the instructions. Check to determine that all connections are pressure tight.



DANGER



Valve installations should be brought into service slowly. Valves should be opened slightly, and the valve assembly temperature and pressure allowed to slowly equalize. If the valves are equipped with ball checks, the valves must be opened all the way after the pressure and temperature have equalized to permit operation of the automatic ball check in the event of failure. Failure to follow the recommended operating procedures can result in severe personal injury and property damage.

6.1 Hydrostatic Test

Take all precautions necessary to handle the possibility of leakage during the test. Hydrostatic pressure test all installations to 100 psig [689 kPa] and correct any leakage before proceeding.

7.0 Maintenance



WARNING



Use only qualified, experienced personnel who are familiar with valve equipment and thoroughly understand the implications of the tables and all the instructions. DO NOT proceed with any maintenance unless the valve assembly has been relieved of all pressure or vacuum, has been allowed to reach ambient temperature, and has been drained or purged of all fluids. Failure to do so can cause serious personal injury and property damage.

The user must create maintenance schedules, safety manuals, and inspection details for each gage valve. These will be based upon the users own operating experience with their specific application. Realistic maintenance schedules can only be determined with full knowledge of the services and application situations involved.

During system shutdown, the valves should be left open to permit the gage to lose pressure and cool with the rest of the system. Failure to leave the valve open during system shutdown may trap high pressure fluid in the gage.

7.1 Preventive Maintenance

On all installations the following items should be regularly evaluated by the user for purposes of maintenance:

- 1) Leakage around stem area
- 2) Internal stem leak
- 3) Leakage around union connections
- 4) Internal or external corrosion

The user must determine upon evaluation of his or her own operating experience an appropriate maintenance schedule necessary for his or her own specific application. Realistic maintenance schedules can only be determined with full knowledge of the services and application situation involved.

7.2 Ball Check Shut-Off

SAFETY INSTRUCTION

Ball checks, when installed, may fail to seat due to corrosion of the ball or seat, foreign material in ball chamber or viscous material in the ball chamber. A routine operational test of the ball check can prevent significant seepage of liquid in the event of glass breakage.

An operational check can be performed on the valve ball checks by closing both the upper and lower valve stems completely. Drain contents from and relieve pressure on liquid gage to an appropriate safe container/area. NOTE: some loss of process fluid to the drain line is expected with this test procedure.



WARNING



Use only qualified, experienced personnel who are familiar with valve equipment and thoroughly understand the implications of the tables and all the instructions. DO NOT proceed with any maintenance unless the valve assembly has been relieved of all pressure or vacuum, has been allowed to reach ambient temperature, and has been drained or purged of all fluids. Failure to do so can cause serious personal injury and property damage.

10.0 Telephone Assistance

If you are having difficulty with your armored gage valve, notify your local Penberthy distributor. You may also contact the factory direct at (815) 537-2311 and ask for an applications engineer. So that we may assist you more effectively, please have as much of the following information as possible when you call:

- Model #
- Name of the company from whom you purchased your valve
- Invoice # and date
- Process fluid
- Operating pressures
- Operating temperature
- A brief description of the problem
- Troubleshooting procedures that failed

If attempts to solve your problem fail, you may be requested to return your valve to the factory for intensive testing. You must obtain a Return Authorization (RA) number from Penberthy prior to returning anything. Failure to do so will result in the unit being returned to you, without being tested, freight collect. To obtain a R.A. number, the following information (in addition to that above) is needed:

- Reason for return
- Person to contact at your company
- "Ship To" address
- MSDS sheet if in harmful service

We recommend that you return the entire valve set for testing. There is a minimum charge of \$50.00 for evaluation of non-warranty units. You will be contacted before any repairs are initiated should the cost exceed the minimum charge. If you return a unit that is covered by the warranty, but is not defective, the minimum charge will apply.

Grafoil® is a registered trademark of Union Carbide Corporation
Teflon® is a registered trademark of E.I. duPont de Nemours and Company

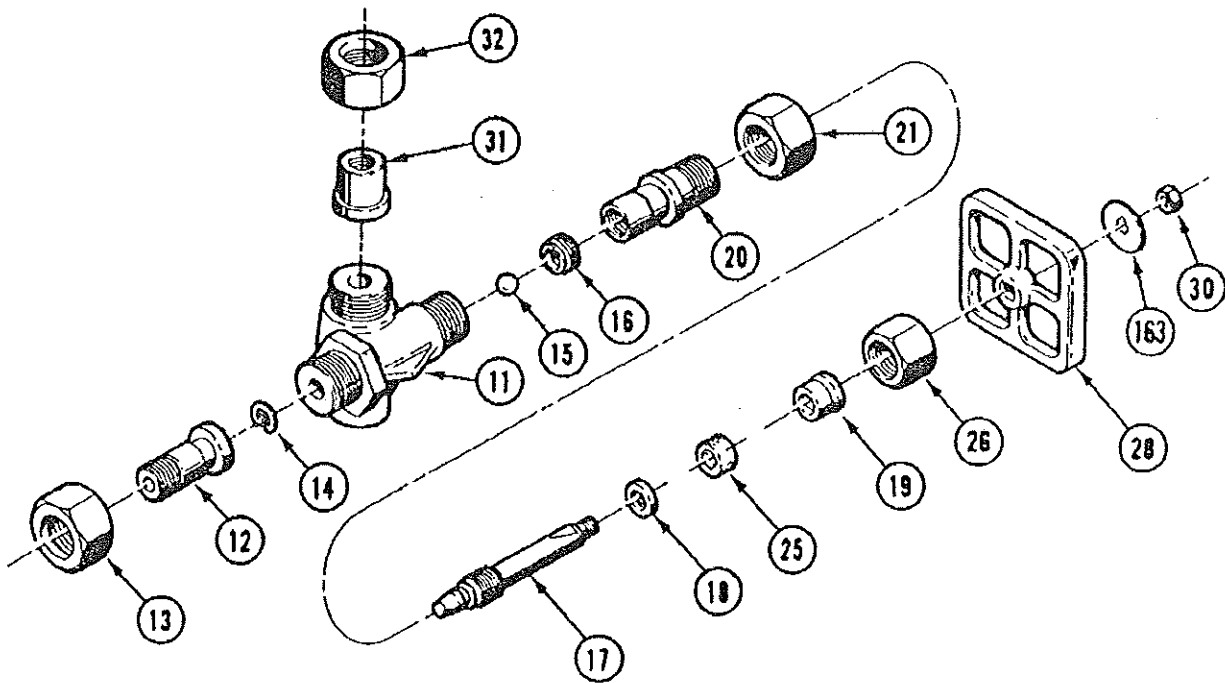
11.0 Exploded Parts Drawing

- 11 Body
- 12 Tailpipe, Vessel
- 13 Nut, Vessel Coupling
- 15 Ball
- 16 Seat
- 17 Stem
- 18 Retainer, Stem Packing
- 19 Gland, Stem Packing
- 20 Bonnet
- 21 Nut, Bonnet
- 25 Packing, Stem
- 26 Nut, Stem Packing
- 30 Nut, Handwheel
- 31 Tailpipe, Gage
- 32 Nut, Gage Coupling
- 163 Nameplate
- 261 Lever

SPARE PARTS

Ref. No.	Item	Min. Qty.
18	Retainer, Stem Packing	1
19	Gland, Stem Packing	1
25	Packing, Stem	1
30	Nut, Handwheel	1

RECOMMENDED MAXIMUM QUANTITIES SHOULD PROVIDE SPARE PARTS FOR 10% OF THE VALVES IN SERVICE



Note: Seat (16), Bonnet (20) and Nut (21) to be used on Series 200 and 400 valves only.

PENBERTHY

DECLARATION of CONFORMITY

In conformance with ISO/IEC Guide 22 - 96
VLV.DC r C


Manufacturer's Name: Penberthy, Incorporated
Manufacturer's Address: 320 Locust Street
Prophetstown, IL 61277-1147 U.S.A

Product:
Type of Equipment: Pressure Vessel - Armored and Tubular Gauge Glass Valves
Equipment Class: Industrial Instrumentation - Hazardous Area
Model Designations: 100, 200, 300, 400, 500, 600, 700 series N2, K2, K3, N6, N7, A5

The product described above is in conformity with:

92/59/EEC	General product safety	1992
87/404/EEC	Simple pressure vessels	1987
89/392/EEC	Machinery	1989
EN 10213-1:4	Technical delivery conditions for steel castings	1996
ISO 7 - 1	Pipe threads where pressure-tight joints are made	1994
BS 10	Flanges and bolting for pipes, valves and fittings	1962
BS 21	Pipe threads for tubes and fittings where pressure tight	1985
BS759	Valves, gauges and other safety fittings for application	1984
BS 970 Part 1	Wrought steels for mechanical and allied engineering	1996
BS 970 Part 3	Wrought steel for mechanical and allied engineering	1991
BS 970 Part 4	Wrought steels in the form of blooms, billets, bars	1970
BS 1502	Steels for fired and unfired pressure vessel	1982
BS 1506	Carbon, low alloy and stainless steel bars and billets	1990
BS 1560	Circular flanges for pipes, valves and fittings	1989
BS 1640 Part 1	Steel butt-welding pipe fittings	1962
BS 1640 Part 2	Steel butt-welding pipe fittings	1962
BS 1965	Butt-welding pipe fittings	1963
BS 3076	Nickel and nickel alloys: bar	1989
BS 3463	Observation and gauge glasses for pressure vessels	1975
BS Part 1	Steel pipes and tubes for pressure purposes	1987
BS 3605	Austenitic stainless steel pipes and tubes	1991
BS 3643	ISO metric screw threads	1981
BS 3799	Steel pipe fittings, screwed and socket-welding	1974
BS 4504	Circular flanges for pipes, valves and fittings	1989
ASME B&PV Code, Section VIII	Rules for construction of pressure vessels	1995
ANSI/ASME B1.1	Unified screw inch threads un and unr thread form	1982
ANSI/ASME B1.20.1	Pipe threads, general purpose (inch)	1983
ANSI/ASME B16.5	Pipe flanges and flanged fittings	1988
ANSI/ASME B18.2.1	Square and hex bolts and screw inch series	1981
ANSI/ASME B18.2.2	Square and hex nuts	1972
ANSI/ASME B18.3	Socket cap shoulder and set screws inch series	1982
ANSI/ASME B31.3	Process piping	1996

Date: 30 December 1996
Prophetstown, IL U.S.A.

Signature: 
Name: David J. Williams, C.Q.E.
Position: Quality Assurance Manager

Technical Construction File is available at stated address. Signatory is contact person.

SWING CHECK VALVES

Tom Wheatley Check Valves have been designed, manufactured and tested for a wide variety of applications. This has resulted in the development of three major product lines; ie: Swing Checks, Piston Checks, and Wafer Checks, with many variations required to fulfill customer requirements. The following pages are intended to show the different sizes, ANSI classes, and general overall dimensions of the swing check valve line. With this basic information in hand, it is possible to create the check valve that meets your particular application by using the "technical information" in the catalog and/or calling the factory.

The Tom Wheatley swing check valve is designed to fulfill your need for a quality product to control back-flow in your system. Uses can range from environmental protection at river crossings to equipment protection at steam turbines. In every case, Tom Wheatley swing check valve provides the dependable back-flow protection you need and/or specify.

Standard materials of construction are carbon steel body, cover and clapper with an elastomer seal. It is available in ANSI and API ratings.

OPTIONS FOR MODIFYING A STANDARD CHECK VALVE TO YOUR SPECIAL APPLICATION

CORROSIVE SERVICE:

- High alloy materials (bodies and/or trim)
- Special seals (Elastomer, TFE, Metal, etc.)
- NACE specification MR-01-75 materials

CRITICAL SERVICE:

- Special casting quality
- Special material traceability
- Non destructive testing (X-ray, magnetic particle, liquid penetrant)
- Extended Duration hydrostatic testing
- Special chemical and physical testing

HIGH TEMPERATURE SERVICE:

- Special alloy materials (bodies and/or trims)
- Metal to metal seal
- Metal ring type joint cover gasket

LOW TEMPERATURE SERVICE:

- Grade LCC material (bodies and covers)
- Special physical testing

SPECIALTY:

- Body drain taps
- Vertical Flow Applications
- Accessory mounting
- Lever lock open/close assembly
- Hydraulic slam retarder
- Externally actuated, spring loaded, clappers



TOM WHEATLEY VALVE COMPANY

3131 WEST LITTLE YORK, P.O. BOX 920835
HOUSTON, TEXAS 77292-0835
713-688-6666 TELEX: 79-1055 FAX: 713-688-5914

SWING CHECK VALVE

INSTALLATION, OPERATION & MAINTENANCE

INSTALLATION/OPERATION

Remove shipping protectors from end connections. Check interior of the valve through each end for foreign objects and/or shipping braces.

All Tom Wheatley Valve Company standard Swing Check Valves are designed for horizontal service. Swing Check Valves must be specifically ordered for vertical flow when intended for that service.

HORIZONTAL SERVICE: Valves should be installed with inlet and outlet at the same level and the bonnet/cover facing upward for proper clapper action. The valve must be installed with the arrow on the body pointing in the direction of intended flow.

VERTICAL FLOW UP: Check Valve is installed with the clapper seat end down and the arrow pointing up.

VERTICAL FLOW DOWN: Counterbalance and weight arm must be provided to insure proper operation. Do not obstruct the movement of the counterbalance arm.

Clean the end connections and mating pipe thoroughly prior to assembly. Proper support of the valve and/or pipe should be provided to eliminate strain on end connections.

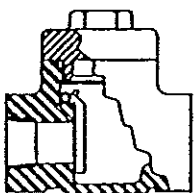
Pressures in excess of the working pressure should not be applied to the closed clapper. All valves have been hydrostatically tested to 1-1/2 times the rated working pressure. Operating temperatures should not exceed 300°F (149°C) continuous or 350°F (177°C) intermittently. Specify when ordering if operating temperatures exceed the above.

MAINTENANCE

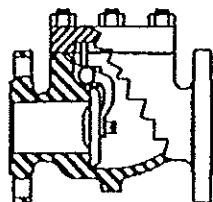
Tom Wheatley Swing Check Valves require minimum maintenance due to simplicity of design and rugged construction. Recommended spare parts kit consists of clapper, clapper seal, clapper shaft and bushings, and cover seal. If the valve has a four digit figure number (15XX), a seat ring and seat ring seal are also required.

INSPECTION/REPAIRS

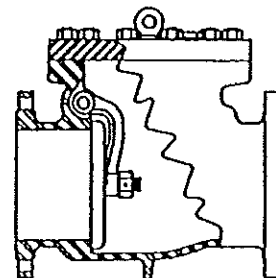
- A. Remove the cover
- B. (4" and smaller) lift clapper assembly out of hanger pocket.
(6" and larger) Remove shaft retaining plug, shaft and clapper assembly.
- C. Inspect seals and sealing surfaces for foreign material, nicks and/or gouges.
- D. Check hanger pocket and body seat face for wear or damage.
- E. Replace any parts showing signs of damage, excess wear or deterioration.
- F. Reassemble in reverse order.



SCREWED TOP
(3" & SMALLER)



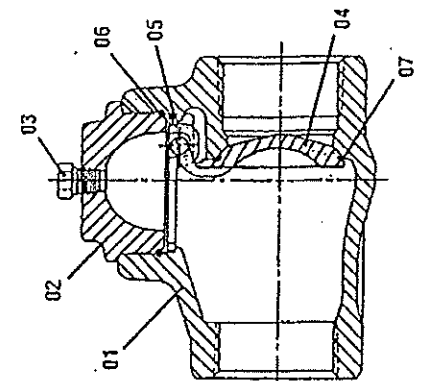
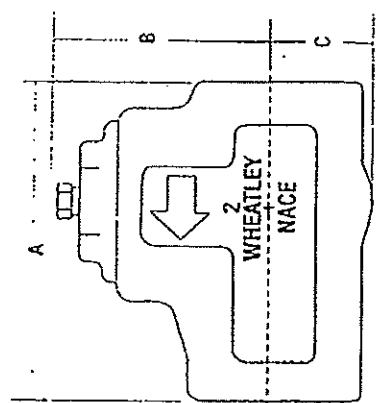
BOLTED TOP
(4" & SMALLER)



BOLTED TOP

820 SERIES OPERATIONAL & DIMENSIONAL CHARACTERISTICS

MATERIAL	ORDER NUMBER	VALVE SIZE	END CONNECTION	WORKING PRESSURE	WEIGHT (LBS)	A (INCHES)	B (INCHES)	C (INCHES)
GRAY IRON	820-023030-031	2"	NPT	300	12	7-1/4	4-1/4	1-13/16
	820-023030-031	2-1/2"	NPT	300	21	8	5-3/4	2-1/2
	820-023030-031	3"	NPT	300	23	8	5-3/4	2-1/2
	820-023030-031	4"	NPT	300	35	10	6-5/8	
DUCTILE IRON	820-013100-231	1"	NPT	1000	4	4-1/4	2-3/4	1-1/8
	820-013150-231	1"	NPT	1500	4	4-1/4	2-3/4	1-1/8
	820-013200-231	1"	NPT	2000	4	4-1/4	2-3/4	1-1/8
	820-023100-231	2"	NPT	1000	10	6	4-1/2	1-13/16
	820-023150-231	2"	NPT	1500	10	6	4-1/4	1-13/16
	820-023200-231	2"	NPT	2000	10	6	4-1/4	1-13/16
	820-023100-280	2"	NPT	1000	13	7-1/4	4-1/4	1-13/16
	820-023150-280	2"	NPT	1500	13	7-1/4	4-1/4	1-13/16
	820-023200-280	2"	NPT	2000	13	7-1/4	4-1/4	1-13/16
	820-033100-231	3"	NPT	1000	23	8	5-3/4	2-1/2
	820-033150-231	3"	NPT	1500	23	8	5-3/4	2-1/2
	820-033200-231	3"	NPT	2000	23	8	5-3/4	2-1/2
CARBON STEEL	820-043100-231	4"	NPT	1000	35	10	6-5/8	3
	820-XX3072-131	1/2" & 3/4"	NPT	290	4	3-1/2	2-3/4	1-1/8
	820-XX3072-131	(see note)	NPT	750	4	3-1/2	2-3/4	1-1/8
	820-XX3144-131	(see note)	NPT	1500	4	3-1/2	2-3/4	1-1/8
	820-XX3216-131	(see note)	NPT	2250	4	3-1/2	2-3/4	1-1/8
	820-XX3380-131	(see note)	NPT	3750	4	3-1/2	2-3/4	1-1/8
	820-013072-131	1"	NPT	290	4	4-1/4	2-3/4	1-1/8
	820-013144-131	1"	NPT	750	4	4-1/4	2-3/4	1-1/8
	820-013216-131	1"	NPT	1500	4	4-1/4	2-3/4	1-1/8
	820-013380-131	1"	NPT	2250	4	4-1/4	2-3/4	1-1/8
	820-153072-131	1-1/2"	NPT	3750	10	6	4-1/4	1-13/16
	ALUMINUM BRONZE	820-023072-131	2"	NPT	290	13	7-1/4	4-1/4
820-023072-131		2"	NPT	750	13	7-1/4	4-1/4	1-13/16
820-023144-131		2"	NPT	1500	13	7-1/4	4-1/4	1-13/16
820-023166-131		2"	NPT	2250	13	7-1/4	4-1/4	1-13/16
820-021380-131		2"	NPT	3750	13	7-1/4	4-1/4	1-13/16
820-033072-131		3"	NPT	290	28	8-3/4	5-3/4	2-1/2
820-033072-131		3"	NPT	750	28	8-3/4	5-3/4	2-1/2
820-033144-131		3"	NPT	1500	28	8-3/4	5-3/4	2-1/2
820-033166-131		3"	NPT	2250	28	8-3/4	5-3/4	2-1/2
820-043072-131		4"	NPT	290	38	10	6-5/8	3
820-043072-131		4"	NPT	750	38	10	6-5/8	3
820-043144-131		4"	NPT	1500	38	10	6-5/8	3
ALUMINUM BRONZE	820-013216-631	1"	NPT	2750	4	4-1/4	2-3/4	1-1/8
	820-013360-631	1"	NPT	3750	4	4-1/4	2-3/4	1-1/8
	820-023144-631	2"	NPT	290-1500	13	7-1/4	4-1/4	1-13/16
	820-023216-631	2"	NPT	2250	13	7-1/4	4-1/4	1-13/16



820 SERIES MATERIAL SPECIFICATIONS

ITEM NUMBER	NAME OF PART	MATERIAL SERIES				
		GRAY IRON	DUCTILE IRON	CARBON STEEL	ALUMINUM BRONZE	STAINLESS STEEL
01	Body	ASTM B126 Grade B	ASTM A395	ASTM A216 Grade WCC or LCC	ASTM B148 Alloy 955	ASTM A351 Grade CF8M
02	Cover	ASTM A395	ASTM A395	ASTM A216 Grade WCC or LCC	ASTM B148 Alloy 955	ASTM A351 Grade CF8M
03	Plug	ASTM A105	ASTM A105	ASTM A105	ASTM A276 Type 304	ASTM A276 Type 304
04	Clapper / Arm / Pin	ASTM A351 Investment cast 316 Stainless Steel				
05	Hanger	ASTM A351 Investment cast 316 Stainless Steel				
06	Cover Seal	90 Durometer Peroxide Cured Buna N (Viton-Optional)				
07	Clapper Seal	90 Durometer Peroxide Cured Buna N (Viton-Optional)				

Product Overview

The CM2 (6000 psig - 414 barg) barstock construction needle valve is designed for multiple applications wherever throttling or bubble-tight shutoff is required. The CM2 is available in a wide variety of inlet & outlet configurations and materials. Specific CM2 models meet the requirements of NACE MR0175-2002. The CM2 is available in both hard and soft seat configurations, and is available with Teflon® or Grafoil® packing or an O-ring seal. To simplify installation requirements the CM2 series can be factory configured with various manufacturers tube fittings.

Features:

- Available with either ball or needle stem ends, providing bubble-tight shutoff and ensuring long valve life. The non-rotating ball tip eliminates seat galling.
- All valves are available with a panel mount system option - consult factory.
- All valves are hydrostatically tested to rated pressure prior to factory shipment.

- Full material traceability is standard on each CM2. All valves are shipped standard with full material documentation for wetted components.
- Either the Teflon® or Grafoil® packing is easily adjustable in field.
- All packing is below the threads which ensures the valve's actuation threads are not contaminated by the process. This feature ensures smooth valve operation and long service life.
- All CM2's feature safety back seating ensuring the prevention of both accidental stem blowout and removal under pressure.
- Standard dust covers ensure long service life by preventing the elements (rain, snow, dirt, etc.) access to the bonnet assembly.

CM2 Ordering Code:

CM2 1 M44T D G SC

Materials:

- 1: SS - 316/316L (meets NACE MR0175-2002)
- 2: CS/SS - A105 CS Body w/ SS Trim (meets NACE MR0175-2002)
- 3: CS - A108 CS

(Other construction materials available - consult factory)

Inlet / Outlet Connections:

Standard threaded connections:

- M22T: 1/4" MNPT x 1/4" FNPT
- F22T: 1/4" FNPT x 1/4" FNPT
- M44T: 1/2" MNPT x 1/2" FNPT
- F44T: 1/2" FNPT x 1/2" FNPT
- M64T: 3/4" MNPT x 1/2" FNPT

Optional socketweld or buttweld connections available - consult factory.

Bonnet Assembly:

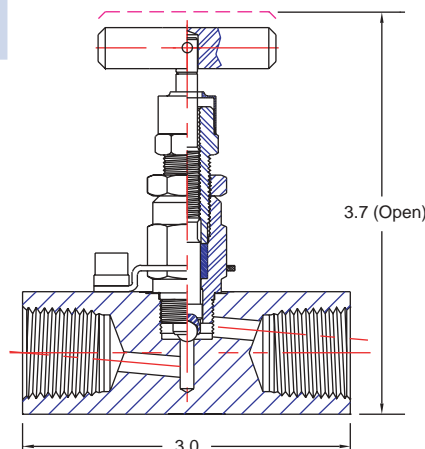
- B: O-ring, Needle tipped stem end
- D: Adjustable packing, Rotating ball tipped stem end
- DN: Adjustable packing, Needle tipped stem end

Packing:

- A: Aflas O-ring
- V: Viton® O-ring
- T: Teflon®, Adjustable packing
- G: Grafoil®, Adjustable packing

Special Construction Options:

- SC-L: Bonnet lock upgrade (in accordance with ANSI B31.1)
- SG: Sour Gas (Valve to meet NACE MR0175-2002)
- SC-O: Gaseous Oxygen Cleaned
- SC: For other special requirements - consult factory





Unit 587

Quality Assurance



C587

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS (A) 610282
(Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by Cado Industries Inc. 7491, 110 Avenue, S.E. Calgary, T2C 3B8, Alberta, CANADA.
2. Manufactured for Compass Compression Services Ltd. 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
3. Location of installation Stock 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
4. Type Vertical 1065 V5076.21 2011-040-301 Rev 0 --- 2011
5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 2010

6. Shell: SA51670N 0.625" 0.125" 22.75" 7'-6" S/S
7. Seams: TYPE 1 Full 1.0 1150°F 1.0 TYPE 1 Full 1.0 1
8. Heads: (a) Material SA51670N (b) Material SA51670N

Table with 11 columns: Location (Top, Bottom, Ends), Minimum Thickness, Corrosion Allowance, Crown Radius, Knuckle Radius, Elliptical Ratio, Conical Apex Angle, Hemispherical Radius, Flat Diameter, Side to Pressure (Convex or Concave). Rows for (a) TOP and (b) BOTTOM.

9. MAWP 645 PSIG at max. temp. 350 °F
Min. design metal temp. -20 °F at 645 PSIG. Hydro., pneu., or comb. test pressure 839 PSIG

Table for Nozzles, inspection, and safety valve openings. Columns include Purpose, Diameter or Size, Type, Material, Nozzle Thickness, Reinforcement, Attachment Details, and Location.

11. Supports: Skirt Yes Lugs --- Legs --- Other --- Attached Head and Welded

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:
Vessel Type : Stage #1 Suction Scrubber, Construction Drawing 2011-040-301 Rev 0, Volume 24 Cu. Ft.
Impact test exempt per UG20(f) 1-5

CERTIFICATE OF SHOP/FIELD COMPLIANCE
We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number 39,285 expires February 10, 2013.
Date 15 Aug 2011 Co. name Cado Industries Inc. Signed [Signature]
CERTIFICATE OF SHOP/FIELD INSPECTION
Vessel constructed by Cado Industries Inc. at Calgary, Alberta, Canada
The undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of Alberta and employed by ABSA
have inspected the component described in this Manufacturer's Data Report on AUG 15 2011 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1.
Date AUG 15 2011 Signed [Signature] Commissions AB 249 NB 12900 A

FORM U-4 MANUFACTURER'S DATA REPORT SUPPLEMENTARY SHEET

As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

Manufactured and certified by Cado Industries Inc. 7491, 110 Avenue, S.E. Calgary, T2C 3B8, Alberta, CANADA.
(Name and address of Manufacturer)

2. Manufacture for Compass Compression Services Ltd. 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
(Name and address of Purchaser)

3. Location of Installation Stock 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
(Name and address)

4. Type: Vertical Stage # 1 Suction Scrubber 1065
(horizontal, vertical, or sphere) (Tank, separator, heat exch., etc.) (Manufacturers serial Number)

15076.21 2011-040-301 Rev 0 --- 2011
(CRN) (Drawing Number) (National Board Number) (Year built)

Data Report

Item Number	Purpose <small>(Inle. Outlet, Drain etc.)</small>	No.	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location <small>(Insp. Open.)</small>
					Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
N1	Inlet	1	2"NPS	CL300 RFWN	SA106B SA234WPB	SA105N	0.344"	0.125"	---	UW16.1(c)	Buttweld	Shell
N2A	Outlet	1	2"NPS	CL300 RFWN	SA106B	SA105N	0.344"	0.125"	---	UW16.1(c)	Buttweld	Shell
N2B	Outlet	1	2"NPS	CL300 RFWN	SA106B SA234WPB	SA105N	0.344"	0.125"	---	UW16.1(c)	Buttweld	Shell
N3	Drain	1	2"NPS	CL300 RFWN	SA106B SA234WPB	SA105N	0.344"	0.125"	---	UW16.1(c)	Buttweld	Head
C1	Insp with Plug	1	2"	T'OL	SA105N		CL6000	0.125"	---	UW16.1(a)	---	Shell
C2	LC	1	2"	H. Cplg	SA105N		CL6000	0.125"	---	UW16.1(c)	---	Shell
C3	LSHH	1	2"	H. Cplg	SA105N		CL6000	0.125"	---	UW16.1(c)	---	Shell
C4	Vent/ Insp w /plug	1	2"	T'OL	SA105N		CL6000	0.125"	---	UW16.1(a)	---	Head
C5A/B	LG	2	3/4"	T'OL	SA105N		CL6000	0.125"	---	UW16.1(a)	---	Shell
C6	TI	1	3/4"	T'OL	SA105N		CL6000	0.125"	---	UW16.1(a)	---	Shell
C7	Liquid Inlet	1	1"	T'OL	SA105N		CL6000	0.125"	---	UW16.1(a)	---	Shell

Certificate of Authorization: Type "U" No. 39,285 Expires February 10, 2013

Date 15 Aug 2011 Name Cado Industries Inc. Signed
(Manufacturer) (Representative)

Date AUG 15 2011 Name Commissions AB 249 NB 12900 A
(Authorized Inspector) (National Board (incl. endorsements), State, Province and Number)

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FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS ① 610284
 (Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)
 As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by Cado Industries Inc. 7491, 110 Avenue, S.E. Calgary, T2C 3B8, Alberta, CANADA.
(Name and address of manufacturer)

2. Manufactured for Compass Compression Services Ltd. 5796, 40th Street, S.E. Calgary, AB, Canada T2C 2A1
(Name and address of purchaser)

3. Location of installation Stock, 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
(Name and address)

4. Type Vertical 1067 V5078.21 2011-040-302 Rev 0 --- 2011
(Horizontal or vertical, tank) (Manufacturer's serial Number) (CRN) (Drawing Number) (National Board number) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 2010
Year

to --- --- ---
(Addenda (date)) (Code Case numbers) (Special service per UG-120(d))

6. Shell: SA106B 0.500" 0.125" 7.625" 4'- 10.5" S/S
(Material spec. number, grade) (Nominal thickness) (Corr. allow.) (Inner diameter) (Length (overall))

7. Seams: Seamless Pipe None 1.0 1150°F 1.0 Type 1 Full 1.0 1
[Long (welded, dbl., snlg., lap, butt)] [R.T. (spot or full)] (Eff., %) (H.T. temp.) (Time, hr) [Girth (welded, dbl., snlg., lap, butt)] [R.T. (spot or full)] (Eff., %) No. of courses

8. Heads: (a) Material SA234WPB (b) Material SA234WPB
(Spec. no., grade) (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	TOP	0.4375"	0.125"	---	---	2 : 1	---	---	---	CONCAVE
(b)	BOTTOM	0.4375"	0.125"	---	---	2 : 1	---	---	---	CONCAVE

If removable, bolts used (describe other fastenings) ---

9. MAWP 645 PSIG --- at max. temp. 350 ° F
(Internal) (External) (Material spec. number, grade, size, number) (Internal) (External)

Min. design metal temp. -20 ° F at 645 PSIG Hydro., pneu., or comb. test pressure 839 PSIG
(Internal) (External)

Proof test -----.

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain etc)	No	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
N1-Inlet/N2-Outlet	2	2"NPS	CL300 RFWN	SA106B	SA105N	0.344"	0.125"	---	UW16.1(c)	Buttweld	Shell
C1-IC / C2-LSHH	2	2"	Half Cplg	SA105N	---	CL6000	0.125"	---	UW16.1(c)	---	Shell
C3 - Siphon Drain	1	1"	Cplg.	SA105N	---	CL6000	0.125"	---	UW16.1(c)	---	Shell
C4A/B - LG, INSP C5-Vent-Insp	3	3/4"	T'OL	SA105N	---	CL6000	0.125"	---	UW16.1(a)	---	C4a/b Shell C5 - Head

11. Supports: Skirt Yes Lugs --- Legs --- Other --- Attached Head and Welded
(Yes or no) (Number) (Number) (Describe) (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: ---

(Name of part, item number, Manufacturer's name and identifying stamp)

Vessel Type : Stage # 2 Suction Scrubber, Construction Drawing 2011-040-302 Rev 0, Volume 1.75 Cu. Ft.
Impact test exempt per UG20(f) 1-5

CERTIFICATE OF SHOP/FIELD COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number 39,285 expires February 10, 2013.

Date 15 Aug 2011 Co. name Cado Industries Inc. Signed [Signature]
(Manufacturer) (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Cado Industries Inc. at Calgary, Alberta, Canada

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of Alberta and employed by ABSA

have inspected the component described in this Manufacturer's Data Report on AUG 15 2011 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date AUG 15 2011 Signed [Signature] Commissions AB 249 NB 12900 A
(Authorized Inspector) (National Board (incl. endorsements), State, Province and Number)

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FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS ① 610286
 (Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)

As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by Cado Industries Inc. 7491, 110 Avenue, S.E. Calgary, T2C 3B8, Alberta, CANADA.
(Name and address of manufacturer)

2. Manufactured for Compass Compression Services Ltd. 5796, 40th Street S.E. Calgary, AB, Canada T2C 2A1
(Name and address of purchaser)

3. Location of installation Stock 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
(Name and address)

4. Type Vertical 1069 V5079.21 2011-040-303 Rev 0 --- 2011
(Horizontal or vertical, tank) (Manufacturer's serial Number) (CRN) (Drawing Number) (National Board number) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 2010
Year

6. Shell: SA106B 0.875" 0.125" 6.875" 58.5" S/S
(Material spec. number, grade) (Nominal thickness) (Corr. allow.) (Inner diameter) (Length (overall))

7. Seams: Seamless Pipe None 1.0 1150°F 1.0 Type 1 Full 1.0 1
(Long (welded, dbl., sngl., lap, butt)) (R.T. (spot or full)) (Eff., %) (H.T. temp.) (Time. hr) (Girth (welded, dbl., sngl., lap, butt)) (R.T. (spot or full)) (Eff., %) No. of courses

8. Heads: (a) Material SA234WPB (b) Material SA234WPB
(Spec. no., grade) (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	TOP	0.760"	0.125"	---	---	2 : 1	---	---	---	CONCAVE
(b)	BOTTOM	0.760"	0.125"	---	---	2 : 1	---	---	---	CONCAVE

If removable, bolts used (describe other fastenings) ---

9. MAWP 1287 PSIG --- at max. temp. 350 °F ---
(Internal) (External) (Internal) (External)

Min. design metal temp. -20 °F at 1287 PSIG Hydro., pneu., or comb. test pressure 1673 PSIG

Proof test -----

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain etc)	No	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
C1-Inlet/C2-Outlet	2	1"	T'OL	SA105N	---	CL6000	0.125"	---	UW16.1(a)	---	Shell
C3-LC / C4-LSHH	2	2"	Half Cplg	SA105N	---	CL6000	0.125"	---	UW16.1(c)	---	Shell
C5 - Siphon Drain	1	1"	Cplg.	SA105N	---	CL6000	0.125"	---	UW16.1(c)	---	Shell
C6A/B - LG, INSP C7/ C9 -Vent Insp/TI	4	3/4"	T'OL	SA105N	---	CL6000	0.125"	---	UW16.1(a)	---	C6A-B, C9 SH C7 - Head
C8 - Lig. Inlet	1	1"	T'OL	SA105N	---	CL6000	0.125"	---	UW16.1(a)	---	Shell

11. Supports: Skirt Yes Lugs --- Legs --- Other --- Attached Head and Welded
(Yes or no) (Number) (Number) (Describe) (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: ---

(Name of part, item number, Manufacturer's name and identifying stamp)

Vessel Type : Stage # 3 Suction Scrubber, Construction Drawing 2011-040-303 Rev 0, Volume 1.4 Cu. Ft.
 Impact test exempt per UG20(f) 1-5

CERTIFICATE OF SHOP/FIELD COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number 39.285 expires February 10, 2013.

Date 15 Aug 2011 Co. name Cado Industries Inc. Signed [Signature]
(Manufacturer) (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Cado Industries Inc. at Calgary, Alberta, Canada

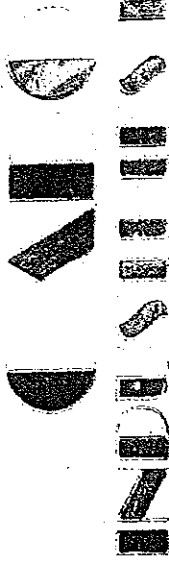
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of Alberta and employed by ABSA

inspected the component described in this Manufacturer's Data Report on AUG 15 2011 and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date AUG 15 2011 Signed [Signature] Commissions AB 249 NB 12900 A
(Authorized Inspector) (National Board (incl. endorsements), State, Province and Number)

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Certified by:



INDEPENDENCE INC.

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FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS ⓐ 610288
 (Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)
 As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by Cado Industries Inc. 7491, 110 Avenue, S.E. Calgary, T2C 3B8, Alberta, CANADA.
(Name and address of manufacturer)

2. Manufactured for Compass Compression Services Ltd. 5796, 40th Street, S.E. Calgary, AB, Canada T2C 2A1
(Name and address of purchaser)

3. Location of installation Stock, 5796, 40th Street S.E. Calgary, AB, Canada, T2C 2A1
(Name and address)

4. Type Vertical 1071 V5116.21 2011-040-304 Rev 2 --- 2011
(Horizontal or vertical, tank) (Manufacturer's serial Number) (CRN) (Drawing Number) (National Board number) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1 2010
Year

6. Shell: SA106B 0.875" 0.125" 6.875" 48" S/S
(Material spec. number, grade) (Nominal thickness) (Corr. allow.) (Inner diameter) (Length (overall))

7. Seams: Seamless Pipe None 1.0 1150°F 1.0 Type 1 Full 1.0 1
[Long (welded, dbl., sngl., lap, butt)] [R.T. (spot or full)] [Eff., %] [H.T. temp.] [Time, hr] [Girth, (welded, dbl., sngl., lap, butt)] [R.T. (spot or full)] [Eff., %] No. of courses

8. Heads: (a) Material SA234WPB (b) Material SA234WPB
(Spec. no., grade) (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Fiat Diameter	Side to Pressure (Convex or Concave)
(a)	TOP	0.760"	0.125"	---	---	2 : 1	---	---	---	CONCAVE
(b)	BOTTOM	0.760"	0.125"	---	---	2 : 1	---	---	---	CONCAVE

If removable, bolts used (describe other fastenings) ---

9. MAWP 2650 PSIG --- at max. temp. 350 ° F
(Internal) (External)

Min. design metal temp. -20 ° F at 2650 PSIG Hydro., pneu., or comb. test pressure 3445 PSIG
(Internal) (External)

Proof test ---

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain etc)	No	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
N1-Inlet/N3-Outlet-In	2	1"	T'OL	SA105N	--	CL6000	0.125"	---	UW16.1(a)	---	Shell
N2 - Outlet	1	2"NPS	CL1500 RFWN	SA106B	SA105N	0.436"	0.125"	---	UW16.1(c)	--	Shell
C1 - Liq. Outlet	1	1"	Cplg.	SA105N	---	CL6000	0.125"	---	UW16.1(c)	---	Shell
C2A/B - LG, C4-TG	3	3/4"	T'OL	SA105N	---	CL6000	0.125"	---	UW16.1(a)	---	C2a/b Shell C4 - Shell
C3- Insp, C5 -Drain	2	1"	T'OL	SA105N	---	CL6000	---	---	UW16.1(a)	---	C3 - Shell C5- Head

11. Supports: Skirt Yes Lugs --- Legs --- Other --- Attached --- Head and Welded ---
(Yes or no) (Number) (Number) (Describe) (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: ---
(Name of part, item number, Manufacturer's name and identifying stamp)

Vessel Type : Discharge Scrubber, Construction Drawing 2011-040-304 Rev 2, Volume 1.2 Cu. Ft.

1-2" BLRF CL1500 RFWN SA105N, 8- Stud 7/8" X 5 3/4" lg SA193B7M, with 2 Hex Nut SA194 2HM, Impact test exempt per UG20(f) 1-5

CERTIFICATE OF SHOP/FIELD COMPLIANCE	
We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization Number <u>39,285</u> expires <u>February 10, 2013</u> .	
Date <u>15 Aug 2011</u>	Co. name <u>Cado Industries Inc.</u> Signed <u>[Signature]</u> <small>(Manufacturer) (Representative)</small>
CERTIFICATE OF SHOP/FIELD INSPECTION	
Vessel constructed by <u>Cado Industries Inc.</u> at <u>Calgary, Alberta, Canada</u>	
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of <u>Alberta</u> and employed by <u>ABSA</u>	
inspected the component described in this Manufacturer's Data Report on <u>AUG 15 2011</u> and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.	
Date <u>AUG 15 2011</u> Signed <u>[Signature]</u> Commissions <u>AB 249 NB 12900 A</u> <small>(Authorized Inspector) (National Board (incl. endorsements), State, Province and Number)</small>	

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PRESSURE PIPING CONSTRUCTION AND TEST DATA REPORT

In accordance with the provisions of the PESR Section 31(1)

AB-83 2011-01

Shop Construction ; Field Construction ;
 Final Data Report ; Partial Data Report (from one ABSA- authorized Contractor to another
 ABSA- authorized Contractor).

Complete both sides of this Form

1. Constructed By: T & K Iron Works Inc Owner's Job No: C586
(Name of ABSA authorized primary contractor or subcontractor)
5476 - 54 Ave SE Calgary, Alberta T2C 3A5
(Address)

Certificate of Authorization Permit No. AQP-1267 Expiry Date: October 17, 2012

2. Constructed For: Compass Compression Services Ltd
(Name of primary contractor if different from above)
1537 - 9 Ave SE, Calgary, Alberta T2G 5N4
(Address)

Certificate of Authorization Permit No. AQP-1267 Expiry Date: _____
(Required when the primary contractor undertakes some/all of the quality functions, e.g., NDE, PWHT, Tie-in, fabrication, hydro test, final assembly etc.)

3. Owner: same
(Name and address)
Stock

(Location of Installation)
 Certificate of Authorization Permit No. AQP-1267 Expiry Date: _____
(Required when the owner undertakes some/all of the quality functions, e.g., NDE, PWHT, Tie-in, fabrication, hydro test, final assembly etc.)

4. Piping Design Alberta Registration No.: PP-
(Required if aggregate piping volume is over 0.5m³)

5. Design Responsibility: Owner ; Contractor

6. WP No.: WP-1731.2 ; Company: T & K Iron Works Inc Owner's WP No. (If used): WP-
(Alberta Registration No.) (Alberta Registration No.)
 WPS No(s). used: TK-4r1, TK-5r1, ; Owner's WPS No(s). (If used): _____

7. Code: ASME B31.1 Non Boiler External Piping ; ASME B31.1 Boiler External Piping ;
 B31.5 ; B31.9 ; CSA Z662 Steam Pipelines ;
 ASME B31.3 - Service Category: Normal , D , M , High Pressure ; Severe Cyclic Condition

Drawing No. Rev. No. Line No.	Fluid (Air/Steam Etc.)	Des. Press. PSI	Des. Temp. °F (Max. & Min.)	Pressure Test PSI	Test Medium	Pipe Mat'l Spec. & Grade	C.A. In.	Pipe NPS & Schedule	Flange Material & Rating	PWHT/ Preheat Temp. °F	NDB
C586-110	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-111	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-112	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-113	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-114	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-115	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-116	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-117	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	4" S40	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-120	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	4" S40	SA105N 300	Yes/1150	RT 100%, VISUAL
C586-121	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes/1150	RT 100%, VISUAL

Drawing No. Rev. No. Line No.	Fluid (Air/Slm. Etc.)	Des. Press. PSI	Des. Temp. °F (Max. & Min.)	Pressure Test PSI	Test Medium	Pipe Mat'l Spec. & Grade	C.A. In.	Pipe NPS & Schedule	Flange Material & Rating	PWHY/ Preheat Temp. °F	NDE
C586-122	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-123	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-124	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-125	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-126	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-127	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-128	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-129	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-130	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-135	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-136	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	3" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-140	GAS	1287	350/-20	1930	WATER	SA106GrB	1/8"	3" S80	SA105N 600	Yes 1150	RT 100%, VISUAL
C586-141	GAS	1287	350/-20	1930	WATER	SA106GrB	1/8"	2" S160	SA105N 600	Yes 1150	RT 100%, VISUAL
C586-153	GAS	2650	350/-20	3975	WATER	SA106GrB	1/8"	2" XXH	SA105N 1500	Yes 1150	RT 100%, VISUAL
C586-202	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-203	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-310	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-312	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-313	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-314	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL
C586-315	GAS	645	350/-20	986	WATER	SA106GrB	1/8"	2" S80	SA105N 300	Yes 1150	RT 100%, VISUAL

Partial Data Reports certified by sub-contractors are listed below and attached to this Data Report

No.	Line No.	Spool No.	Dwg. No. (with Rev. No.)	Sub-contractor (Name)	AQP No. (if from Alberta)	Expiry (if from Alberta)

Remarks: For partial data report provide information about the code work that was not completed by the subcontractor (e.g., hydrostatic test, PWHT etc.). For final data report provide information about the code work that was not completed by subcontractors and subsequently completed by the primary contractor (e.g., hydrostatic test of entire assembly, PWHT etc.)

Endorse certificate 'A' or 'B'

A. CERTIFICATE OF COMPLIANCE
Signed by the subcontractor when supplying this certificate as a
Partial Data Report

We certify that the statements in this Data Report are correct and that materials, construction and workmanship of the piping fabrication conform to the registered quality system and the applicable Piping code(s).

Date: _____

_____ Contractor

Print Authorized Representative's Name Signature

This certificate is not valid unless it forms part of a Final Data Report signed by Primary Contractor

B. CERTIFICATE OF COMPLIANCE
Signed by the primary contractor when supplying this certificate as a
Final Data Report

We certify that the statements in this Data Report are correct and that piping job no. C586/P11-218 described in this Data Report was constructed in accordance with the Province of Alberta Safety Codes Act and Regulations, and applicable ASME Piping Code(s).

Date: Sept 28/11 T&K IRON WORKS INC.

_____ Contractor

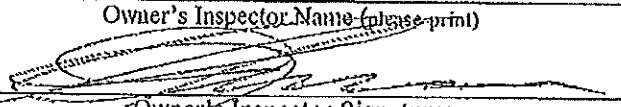
W. Horbanowicz
Print Authorized Representative's Name Signature

CERTIFICATE OF INSPECTION

I, the undersigned, employed by COMPASS COMPRESSION SERVICES LTD. have verified that all required examination and testing has been completed, and inspected the piping described in this construction data report to the extent necessary to be satisfied that it conforms to all applicable examination requirements of the Code and of the engineering design, and state that, to the best of my knowledge and belief, the contractor has constructed this piping in accordance with the Alberta Safety Codes Act and Regulations. By signing this certificate neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the piping described in this construction data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date: Sept 28, 2011 Date: _____

A. F. Moon
Owner's Inspector Name (please print)


Owner's Inspector Signature:

ABSA Safety Codes Officer (please print)
(BOILER EXTERNAL PIPING ONLY)

ABSA Safety Codes Officer's Signature

Current version of this Form may be obtained from www.absa.ca



PRESSURE PIPING CONSTRUCTION AND TEST DATA REPORT

In accordance with the provisions of the PESR Section 31(1)

AB-83 2011-01

Shop Construction ; Field Construction
 Final Data Report ; Partial Data Report (from one ABSA- authorized Contractor to another ABSA- authorized Contractor).

Complete both sides of this Form

1. Constructed By: Compass Compression Services Ltd. Owner's Job No: C586
(Name of ABSA authorized primary contractor or subcontractor)
5796 - 40 Street S.E., Calgary, Alberta T2C 2A1
(Address)

Certificate of Authorization Permit No. AQP-21495 Expiry Date: Dec. 01, 2012

2. Constructed For: N/A
(Name of primary contractor if different from above)

(Address)

Certificate of Authorization Permit No. AQP-21495 Expiry Date: _____
(Required when the primary contractor undertakes some/all of the quality functions, e.g., NDE, PWHT, Tie-in, fabrication, hydro test, final assembly etc.)

3. Owner: Can Gas Solutions Ltd. 401, 100 - 4 Ave.SW, Calgary, AB T2P 3N2
(Name and address)

LSD: stock
(Location of installation)

Certificate of Authorization Permit No. AQP-21495 Expiry Date: _____
(Required when the owner undertakes some/all of the quality functions, e.g., NDE, PWHT, Tie-in, fabrication, hydro test, final assembly etc.)

4. Piping Design Alberta Registration No.: PP-
(Required if aggregate piping volume is over 0.5m³)

5. Design Responsibility: Owner ; Contractor

6. WP No.: WP-3065.2 ; Company: Compass Compression Services Owner's WP No. (If used): WP-
(Alberta Registration No.) (Alberta Registration No.)
 WPS No(s). used: N/A ; Owner's WPS No(s). (If used): _____

7. Code: ASME B31.1 Non Boiler External Piping ; ASME B31.1 Boiler External Piping ;
 B31.5 ; B31.9 ; CSA Z662 Steam Pipelines ;
 ASME B31.3 - Service Category: Normal , D , M , High Pressure ; Severe Cyclic Condition

Drawing No. Rev. No. Line No.	Fluid (Air/Stm. Etc.)	Des. Press. psig	Des. Temp. ° F (Max. & Min.)	Pressure Test psig	Test Medium	Pipe Mat'l Spec. & Grade	C.A. In.	Pipe NPS & Schedule	Flange Material & Rating	PWHT/ Preheat Temp. ° F	NDE
C586-101A Rev. 4/ 142	Sweet Gas	1287	350/-20	1930	Water	SA269- TP316L	0	1" .083"	SA479/SA182 F316L/3100psi	N/A	100%VT
C586-101A Rev. 4/ 143	Sweet Gas	1287	350/-20	1930	Water	SA269- TP316L	0	1" .083"	SA479/SA182 F316L/3100psi	N/A	100%VT
C586-101A Rev. 4/ 150	Sweet Gas	2650	350/-20	3975	Water	SA269- TP316L	0	1" .083"	SA479/SA182 F316L/3100psi	N/A	100%VT
C586-101A Rev. 4/ 151	Sweet Gas	2650	350/-20	3975	Water	SA269- TP316L	0	1" .083"	SA479/SA182 F316L/3100psi	N/A	100%VT
C586-101A Rev. 4/ 152	Sweet Gas	2650	350/-20	3975	Water	SA269- TP316L	0	1" .083"	SA479/SA182 F316L/3100psi	N/A	100%VT
C586-101A Rev. 4/ 170	Sweet Gas	2650	350/-20	3975	Water	SA269- TP316L	0	½" .083"	SA479/SA182 F316L/3100psi	N/A	100%VT
C586-101A Rev. 4/ 171	Sweet Gas	645	350/-20	968	Water	SA269- TP316L	0	¾" .083"	SA479/SA182 F316L/4200psi	N/A	100%VT
C586-101A Rev. 4/ 180	Sweet Gas	215	350/-20	323	Water	SA269- TP316L	0	¾" .083"	SA479/SA182 F316L/4200psi	N/A	100%VT

C586-101A Rev. 4/138	Sour Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	N/A	N/A	100%VT
C586-101A Rev. 4/201	Sour Gas	645	350/-20	968	Water	SA106-B	1/8	1" sch160	SA105N Cl. 300	N/A	100%VT
C586-101A Rev. 4/311	Sour Gas	645	350/-20	968	Water	SA106-B	1/8	1" XXS	SA105N Cl. 300	N/A	100%VT
C586-101A Rev. 4/320	Sweet Gas/ Liquids	645	350/-20	710	Air	SA106-B	1/8	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/321	Sweet Gas/ Liquids	645	350/-20	710	Air	SA106-B	1/8	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/330	Sweet Gas/ Liquids	1287	350/-20	1930	Water	SA106-B	1/16	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/331	Sweet Gas/ Liquids	1287	350/-20	1930	Water	SA106-B	1/16	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/332	Sweet Gas/ Liquids	645	350/-20	710	Air	SA106-B	1/8	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/340	Sweet Gas/ Liquids	2650	350/-20	3975	Water	SA106-B	1/16	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/341	Sweet Gas/ Liquids	1287	350/-20	1930	Water	SA106-B	1/16	1" sch80	N/A	N/A	100%VT
C586-101A Rev. 4/400	Sweet Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	SA105N Cl. 300	N/A	100%VT
C586-101A Rev. 4/401	Sweet Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	N/A	N/A	100%VT
C586-101A Rev. 4/402	Sweet Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	N/A	N/A	100%VT
C586-101A Rev. 4/403	Sweet Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	N/A	N/A	100%VT
C586-101A Rev. 4/404	Sweet Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	N/A	N/A	100%VT
C586-101A Rev. 4/405	Sweet Gas	645	350/-20	968	Water	SA106-B	1/8	1 1/2" sch160	SA105N Cl. 300	N/A	100%VT

Partial Data Reports certified by sub-contractors are listed below and attached to this Data Report

No.	Line No.	Spool No.	Dwg. No. (with Rev. No.)	Sub-contractor (Name)	AQP No. (if from Alberta)	Expiry (if from Alberta)

Remarks: For partial data report provide information about the code work that was not completed by the subcontractor (e.g., hydrostatic test, PWHT etc.). For final data report provide information about the code work that was not completed by subcontractors and subsequently completed by the primary contractor (e.g., hydrostatic test of entire assembly, PWHT etc.)

Endorse certificate 'A' or 'B'

A. CERTIFICATE OF COMPLIANCE

Signed by the subcontractor when supplying this certificate as a
Partial Data Report

We certify that the statements in this Data Report are correct and that materials, construction and workmanship of the piping fabrication conform to the registered quality system and the applicable Piping code(s).

Date: _____
Contractor _____

Print Authorized Representative's Name _____ Signature _____

This certificate is not valid unless it forms part of a Final Data Report signed by Primary Contractor

B. CERTIFICATE OF COMPLIANCE

Signed by the primary contractor when supplying this certificate as a
Final Data Report

We certify that the statements in this Data Report are correct and that piping job no. C586 described in this Data Report was constructed in accordance with the Province of Alberta Safety Codes Act and Regulations, and applicable ASME Piping Code(s).

Date: Oct. 03/11 _____
CCSL
Contractor _____

Larry McKinley _____
Print Authorized Representative's Name _____ Signature _____

CERTIFICATE OF INSPECTION

I, the undersigned, employed by _____ have verified that all required examination and testing has been completed, and inspected the piping described in this construction data report to the extent necessary to be satisfied that it conforms to all applicable examination requirements of the Code and of the engineering design, and state that, to the best of my knowledge and belief, the contractor has constructed this piping in accordance with the Alberta Safety Codes Act and Regulations. By signing this certificate neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the piping described in this construction data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date: _____ Date: _____

Owner's Inspector Name (please print) _____ ABSA Safety Codes Officer (please print)
(BOILER EXTERNAL PIPING ONLY)

Owner's Inspector Signature: _____ ABSA Safety Codes Officer's Signature _____

Current version of this Form may be obtained from www.absa.ca

COMPASS COMPRESSION SERVICES LTD.

LINE LIST

CUSTOMER: CanGas Solutions
UNIT NUMBER: C-587
PROJECT NAME: Truck Loading Unit
LSD:
REVISION: 0
DATE: 9/19/2011
BY: Alex Moon

CS piping
 304 SS tubing



Line#/Rev#	Fluid Service	Des. Press. PSIG	Des. Temp F	MDMT F	Test Press PSIG	Test Medium	Pipe / Tube Mtl Spec and Grade	CA in.	Pipe NPS and Schedule	Flange / Fitting Material	Flange Rating	PWHT 1Hr @ 1150F +/- 25F	Pickle and Oil	Power clean to SSPC-SP3	RT %	MPT / dye penetrant %	Other
C586- 110	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 111	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 112	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 113	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 114	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 115	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 116	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 117	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	4" S/40	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 120	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	4" S/40	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 121	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 122	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 123	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 124	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 125	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 126	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 127	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 128	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 129	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 130	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 132	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	1.5" S/80	SA-105N	300#	NO	NO	Yes	NA	N/A	100% Visual
C586- 133	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	1.5" S/80	SA-105N	300#	NO	NO	Yes	NA	N/A	100% Visual
C586- 135	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 136	Sour Natural Gas	645	350	-20	986	Water	SA-106-B	1/8	3" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 140	Sour Natural Gas	1287	350	-20	1930	Water	SA-106-B	1/8	3" S/80	SA-105N	600#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 141	Sour Natural Gas	1287	350	-20	1930	Water	SA-106-B	1/8	2" S/160	SA-105N	600#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 153	Sour Natural Gas	2650	350	-20	3975	Water	SA-106-B	1/8	2" S/XXH	SA-105N	1500#	Yes	Yes	Yes	100	N/A	100% Visual

Line#/Rev#	Fluid Service	Des. Press. PSIG	Des. Temp F	MDMT F	Test Press PSIG	Test Medium	Pipe / Tube Mtl Spec and Grade	CA in.	Pipe NPS and Schedule	Flange / Fitting Material	Flange Rating	PWHT 1Hr @ 1150F +/- 25F	Pickle and Oil	Power clean to SSPC-SP3	RT %	MPI / dye penetrant %	Other
C586- 201	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	1" S/160	SA-105N	300#	NO	NO	Yes	NA	N/A	100% Visual
C586- 202	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 203	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 310	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 312	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 313	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 314	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual
C586- 315	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8	2" S/80	SA-105N	300#	Yes	Yes	Yes	100	N/A	100% Visual

Line#/Rev#	Fluid Service	Des. Press. PSIG	Des. Temp F	MDMT F	Test Press PSIG	Test Medium	Pipe / Tube Mtl Spec and Grade	CA in.	Pipe NPS and Schedule	Flange / Fitting Material	Flange Rating	PWHT 1Hr @ 1150F +/- 25F	Pickle and Oil	Power clean to SSPC-SP3	RT %	MPI / dye penetrant %	Other
TUBING LINES																	
C586-142-N600	Sweet Natural Gas	1287	350	-20	1930	Water	SA-269-TP316L	0	1"OD, .083"wt	SA-479/SA182-F316L	3100psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-143-N600	Sweet Natural Gas	1287	350	-20	1930	Water	SA-269-TP316L	0	1"OD, .083"wt	SA-479/SA182-F316L	3100psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-150-N1500	Sweet Natural Gas	2650	350	-20	3975	Water	SA-269-TP316L	0	1"OD, .083"wt	SA-479/SA182-F316L	3100psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-151-N1500	Sweet Natural Gas	2650	350	-20	3975	Water	SA-269-TP316L	0	1"OD, .083"wt	SA-479/SA182-F316L	3100psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-152-N1500	Sweet Natural Gas	2650	350	-20	3975	Water	SA-269-TP316L	0	1"OD, .083"wt	SA-479/SA182-F316L	3100psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-170-N1500	Sweet Natural Gas	2650	350	-20	3975	Water	SA-269-TP316L	0	3/4"OD, .083"wt	SA-479/SA182-F316L	3100psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-171-N300	Sour Natural Gas	645	350	-20	968	Water	SA-269-TP316L	0	3/4"OD, .083wt	SA-479/SA182-F316L	4200psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
C586-180-N150	Sweet Natural Gas	215	350	-20	323	Water	SA-269-TP316L	0	3/4"OD, .083wt	SA-479/SA182-F316L	4200psig-WP	N/A	N/A	N/A	NA	N/A	100% Visual
THREADED PIPE																	
C586-201-N300, vent to flare from V-01	Sour Gas	645	350	-20	968	Water	SA-106-B	1/8"	1" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-311-N300, scrubber drain V-01	Sour Natural Gas	645	350	-20	968	Water	SA-106-B	1/8"	1" S/xxx	SA-105N	300#	N/A	N/A	N/A	100	N/A	100% Visual
C586-320-N300, scrubber drain V-02	Sour Gas/Liquid	645	350	-20	968	Water	SA-106-B	1/8"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-321-N300, scrubber drain V-02	Sour Gas/Liquid	645	350	-20	968	Water	SA-106-B	1/8"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-330-N600, scrubber drain V-03	Sweet Gas/Liquid	1287	350	-20	1930	Water	SA-106-B	1/16"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-331-N600, scrubber drain V-03	Sweet Gas/Liquid	1287	350	-20	1930	Water	SA-106-B	1/16"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-332-N300, scrubber drain manifold	Sour Gas/Liquid	645	350	-20	968	Water	SA-106-B	1/8"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-340-N1500, scrubber drain V-04	Sweet Gas/Liquid	2650	350	-20	3975	Water	SA-106-B	1/16"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-341-N600, V-04 scrubber drain to V-03	Sweet Gas/Liquid	1287	350	-20	1930	Water	SA-106-B	1/16"	1" S/80	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-400-N300, second stage suction to dryer	Sweet Gas	645	350	-20	968	Water	SA-106-B	1/8"	1-1/2" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-401-N300, second stage suction to dryer	Sweet Gas	645	350	-20	968	Water	SA-106-B	1/8"	1-1/2" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-402-N300, second stage suction to dryer	Sweet Gas	645	350	-20	968	Water	SA-106-B	1/8"	1-1/2" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-403-N300, second stage suction from dryer	Sweet Gas	645	350	-20	968	Water	SA-106-B	1/8"	1-1/2" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-404-N300, second stage suction from dryer	Sweet Gas	645	350	-20	968	Water	SA-106-B	1/8"	1-1/2" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
C586-405-N300, second stage suction from dryer	Sweet Gas	645	350	-20	968	Water	SA-106-B	1/8"	1-1/2" S/160	SA-105N	NA	N/A	N/A	N/A	N/A	N/A	100% Visual
PSV Reference #																	
PSV Reference #	Make	Model			Orifice Size	Set Pressure	Capacity		Protects Line#								
PSV-100	Mercer	81-43251V07N11			G	65 psig	.375 MMSCFD		110-N300, 112-N300, 171-N300								
PSV-110	Mercer	91-17D51T09EN1			D	285 psig	.375 MMSCFD		111-N300, 120-N300, 121-N300, 122-N300, 123-N300, 124-N300								
PSV-120	Mercer	91-17C51T09N1			C	800 psig	.375 MMSCFD		130-N600, 131-N600, 132-N600, 134-N600								
PSV-130	Mercer	91-17C61P14N1			C	2650 psig	.375 MMSCFD		140-N1500, 142-N1500, 144-N1500, 170-N1500								
By Others	Wellmark-Cemco	W2601-CV-1-111-250			0.295" dia	200 psig	251 SCFM Air		125-N300, 126-N300, 127-N300, 128-N300								