

ARIEL Heavy Duty Balanced Opposed Compressors

TECHNICAL MANUAL
For Models:

JGW, JGR and JGJ



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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, BUILD AND PRACTICES. THIS MANUAL MAY NOT BE APPLICABLE TO EQUIPMENT BUILT PRIOR TO THE DATE ON FRONT COVER AND IS SUBJECT TO CHANGE WITHOUT NOTICE. CONTACT ARIEL WITH ANY QUESTIONS (REFER TO "Ariel Telephone and Fax Numbers" on page 7-9).

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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 JGW, JGR or JGJ 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.

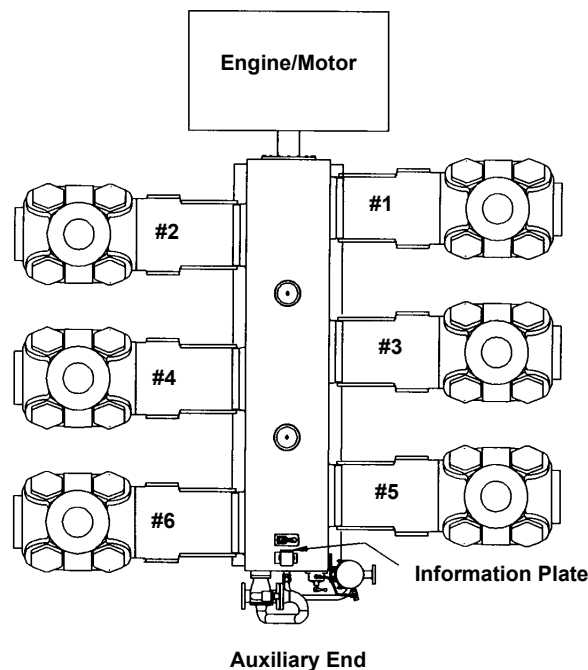


FIGURE 1-1: TYPICAL COMPRESSOR THROW NUMBERING AND INFORMATION PLATE LOCATION

Specifications

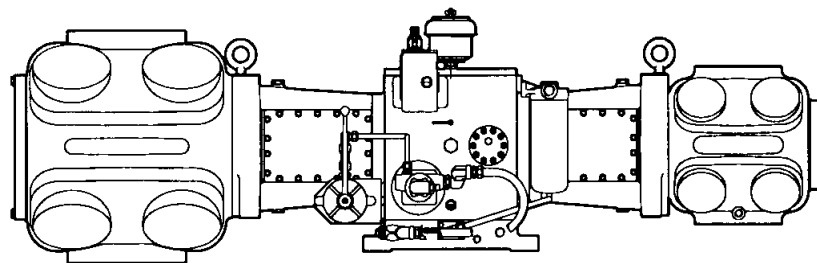


FIGURE 1-2: AUXILIARY END VIEW

TABLE 1-1: JGW/JGR FRAME SPECIFICATIONS

MODEL	JGW/2	JGW/4	JGR/2	JGR/4
Stroke, inches (mm)	4-1/4 (108)	4-1/4 (108)	4-1/4 (108)	4-1/4 (108)
Speed, RPM	600 to 1200	600 to 1200	600 to 1200	600 to 1200
Piston Speed, FPM (m/s)	To 850 (4.32)	To 850 (4.32)	To 850 (4.32)	To 850 (4.32)
Number of Throws	2	4	2	4
Horsepower (kW)	To 325 (242)	To 650 (485)	To 430 (321)	To 860 (641)
Height - Bottom to Crankshaft Centerline, in. (mm)	12 (305)	12 (305)	12 (305)	12 (305)
Connecting Rod Centerline To Centerline, in. (mm)	10.250 (260.35)	10.250 (260.35)	10.250 (260.35)	10.250 (260.35)
Maximum Width, in. (m)	103 (2.62)	103 (2.62)	103 (2.62)	103 (2.62)
Maximum Length, in. (m)	41 (1.04)	77 (1.96)	41 (1.04)	77 (1.96)
Approximate Weight with Cylinders, lb. (kg)	4000 (1814)	7000 (3175)	4200 (1905)	8200 (3720)
Oil Pump Capacity, GPM (L/s)	8 (0.50)	14 (0.88)	8 (0.50)	14 (0.88)
Oil Heat Rejection, BTU/hr. (J/s)	7000 (2065)	12,000 (3540)	8000 (2360)	14,000 (4130)
Sump Capacity, US gallons (L)	6 (23)	15 (57)	6 (23)	15 (57)
Piston Rod Diameter, in. (mm)	1.500 (38.1)	1.500 (38.1)	1.500 (38.1)	1.500 (38.1)
Internal Rod Load - Double Acting:				
Compression + Tension, lbf. (kN)	24,000 (107)	24,000 (107)	32,000 (142)	32,000 (142)
Tension, lbf. (kN)	12,000 (53)	12,000 (53)	16,000 (71)	16,000 (71)
Compression, lbf. (kN)	15,000 (67)	15,000 (67)	20,000 (89)	20,000 (89)
Internal Rod Load - Single Acting:				
Tension, lbf. (kN)	12,000 (53)	12,000 (53)	16,000 (71)	16,000 (71)

TABLE 1-2: JGJ FRAME SPECIFICATIONS

MODEL	JGJ/2	JGJ/4	JGJ/6
Stroke, inches (mm)	3-1/2 (88.9)	3-1/2 (88.9)	3-1/2 (88.9)
Speed, RPM	900 to 1800	900 to 1800	900 to 1800
Piston Speed, FPM (m/s)	To 1050 (5.33)	To 1050 (5.33)	To 1050 (5.33)
Number of Throws	2	4	6
Horsepower (kW)	To 620 (460)	To 1240 (920)	To 1860 (1380)
Height - Bottom to Crankshaft Centerline, in. (mm)	12 (305)	12 (305)	12 (305)
Connecting Rod Centerline To Centerline, in. (mm)	10.250 (260.35)	10.250 (260.35)	10.250 (260.35)
Maximum Width, in. (m)	103 (2.62)	103 (2.62)	103 (2.62)
Maximum Length, in. (m)	41 (1.04)	77 (1.96)	113 (2.87)
Approximate Weight with Cylinders, lb. (kg)	4200 (1905)	8200 (3720)	12,000 (5445)
Oil Pump Capacity, GPM (L/s)	8 (0.50)	14 (0.88)	20 (1.26)
Oil Heat Rejection, BTU/hr. (J/s)	10,000 (2940)	16,000 (4700)	21,000 (6170)
Sump Capacity, US gallons (L)	6 (23)	15 (57)	24 (91)
Piston Rod Diameter, in. (mm)	1.500 (38.10)	1.500 (38.10)	1.500 (38.10)
Internal Rod Load - Double Acting:			
Compression + Tension, lbf. (kN)	42,000 (187)	42,000 (187)	42,000 (187)
Tension, lbf. (kN)	21,000 (93)	21,000 (93)	21,000 (93)
Compression, lbf. (kN)	23,000 (102)	23,000 (102)	23,000 (102)
Internal Rod Load - Single Acting:			
Tension, lbf. (kN)	21,000 (93)	21,000 (93)	21,000 (93)

Product Information and Safety Plates

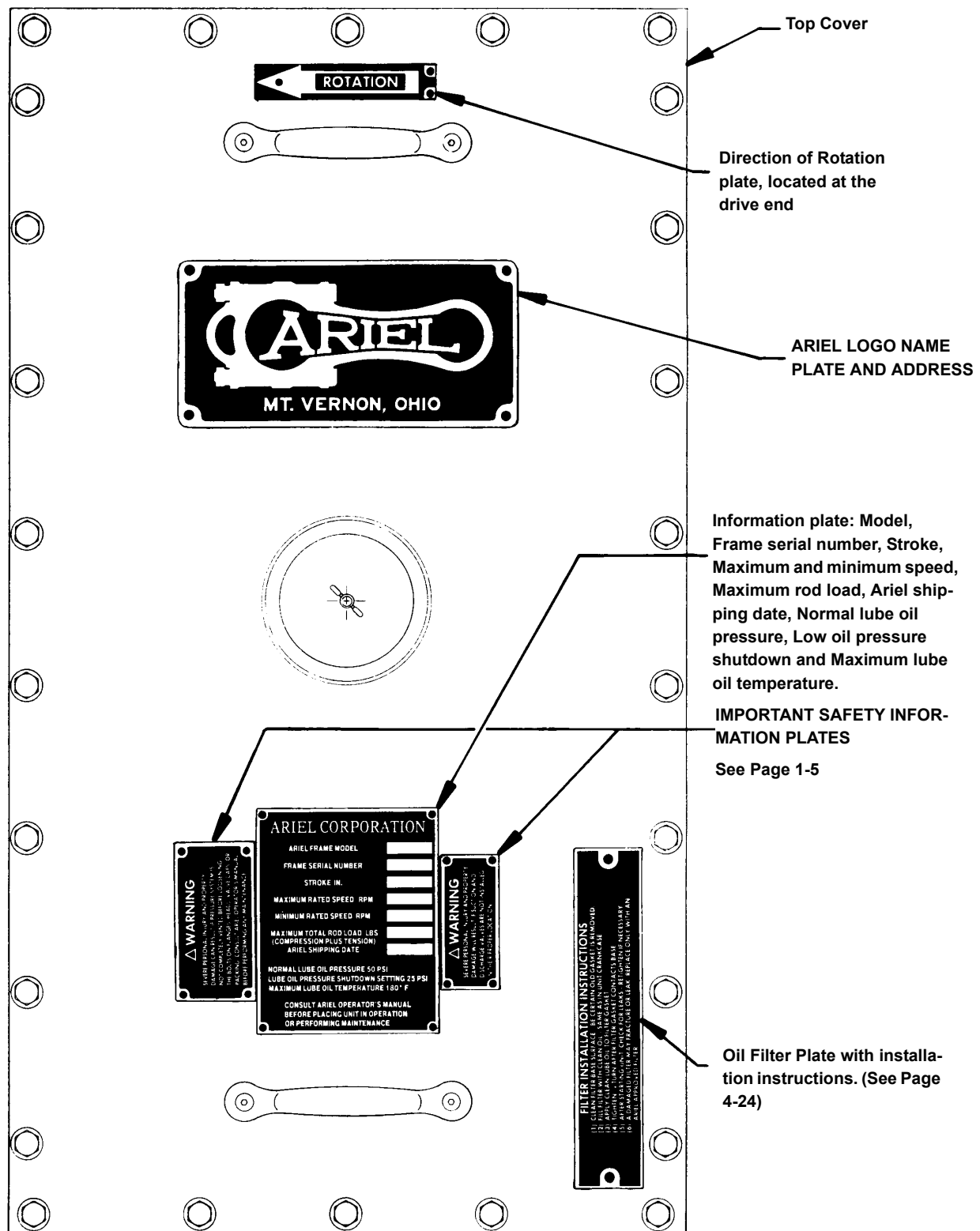


FIGURE 1-3: TOP COVER

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.

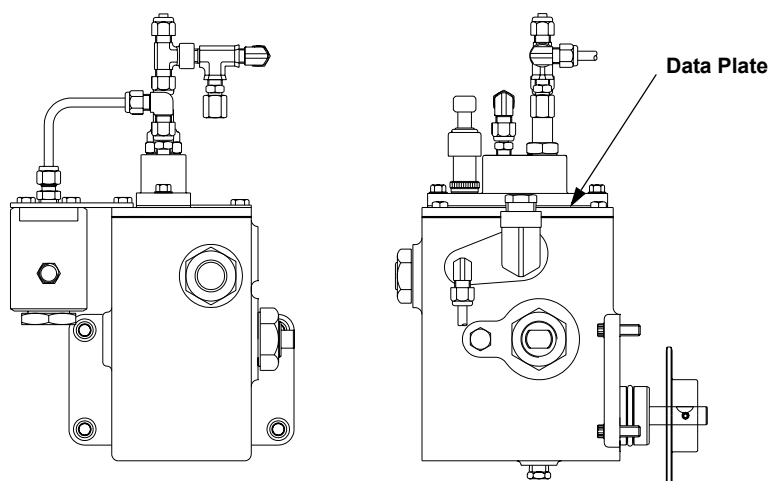


FIGURE 1-4: FORCE FEED LUBRICATOR PUMP - TYPICAL

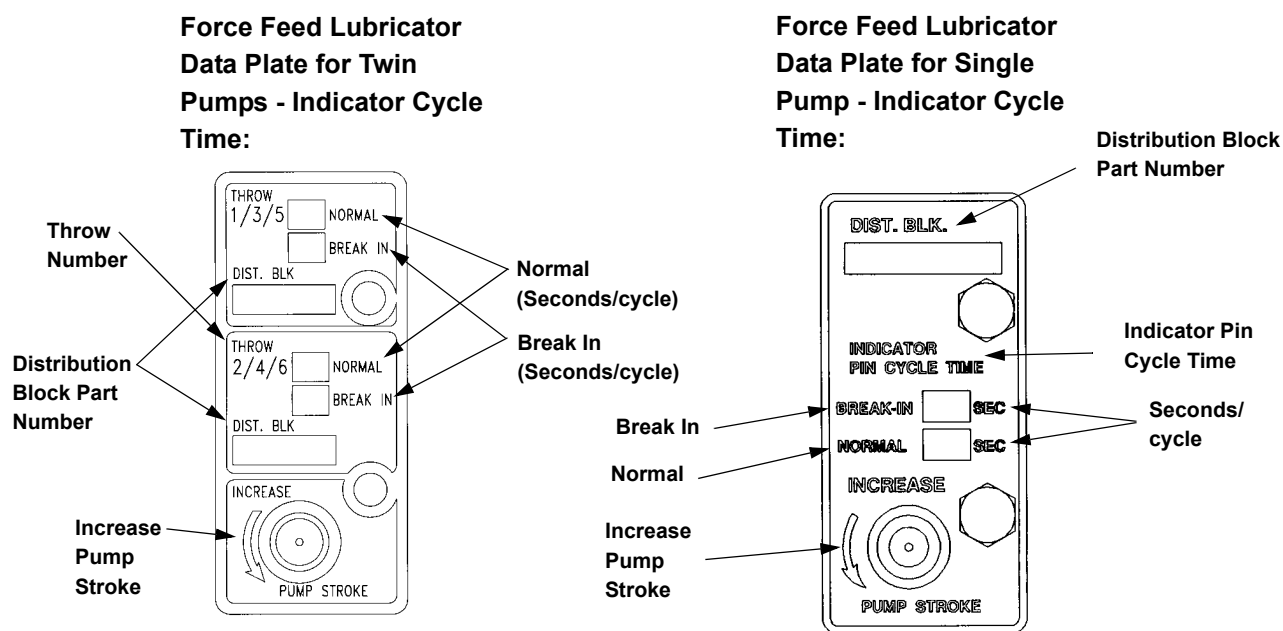


FIGURE 1-5: FORCE FEED LUBRICATOR DATA PLATES

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.

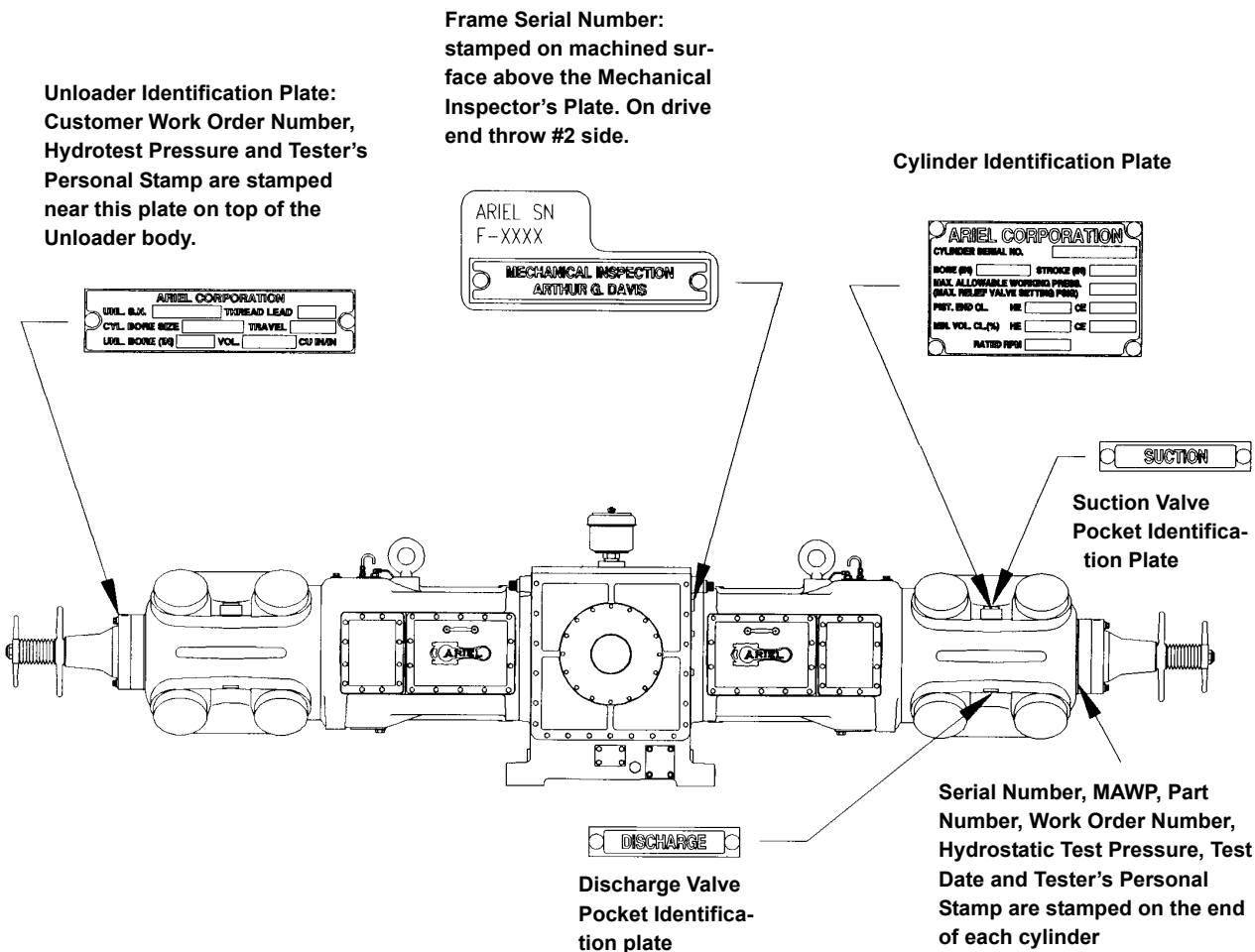


FIGURE 1-6: IDENTIFICATION PLATES - TYPICAL

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:

The diagram shows a rectangular identification plate for a cylinder. It contains the following fields and labels:

- Nominal Bore Diameter Inches:** Points to the **BORE(IN)** field.
- Stroke Inches:** Points to the **STROKE (IN)** field.
- Maximum Allowable Working Pressure (Maximum Relief Valve Setting PSIG - Pounds per Square Inch Gauge):** Points to the **MAX.ALLOWABLE WORKING PRESS. (MAX.RELIEF VALVE SETTING PSIG)** field.
- Piston End Clearance Inches:** Points to the **PIST.END CL.** field.
- Minimum Volumetric Clearance Percentage:** Points to the **MIN.VOL. CL.(%)** field.
- Class:** Points to the **CLASS** field.
- Rated Revolutions per Minute:** Points to the **RATED RPM** field.
- Crank End:** Points to the **CE** field in the **PIST.END CL.** and **MIN.VOL. CL.(%)** rows.
- Head End:** Points to the **HE** field in the **PIST.END CL.** and **MIN.VOL. CL.(%)** rows.
- Cylinder Serial Number:** Points to the **CYLINDER SERIAL NO.** field.

The plate itself contains the text: ARIEL CORPORATION, BORE(IN), CLASS, STROKE (IN), RATED RPM, MAX.ALLOWABLE WORKING PRESS. (MAX.RELIEF VALVE SETTING PSIG), PIST.END CL. HE, CE, MIN.VOL. CL.(%) HE, CE, and CYLINDER SERIAL NO.

UNLOADER IDENTIFICATION PLATE:

The diagram shows a rectangular identification plate for an unloader. It contains the following fields and labels:

- Unloader Serial Number:** Points to the **UNL. S.N.** field.
- Nominal Cylinder Bore Diameter Inches:** Points to the **CYL. BORE (IN)** field.
- Nominal Unloader Bore Diameter Inches:** Points to the **UNL.BORE (IN)** field.
- Volume:** Points to the **VOL.** field.
- Cubic Inches Per Inch:** Points to the **CU IN/IN** field.
- Thread Lead - Threads Per Inch:** Points to the **THD. LEAD (TPI)** field.
- Travel Inches:** Points to the **TRAV. (IN)** field.

The plate itself contains the text: ARIEL CORPORATION, UNL. S.N., THD. LEAD (TPI), CYL. BORE (IN), TRAV. (IN), UNL.BORE (IN), VOL., CU IN/IN, and a small circular symbol with a crosshair.

FIGURE 1-7: CYLINDER AND UNLOADER IDENTIFICATION PLATES

Clearances

TABLE 1-3: 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)	0.0085 to 0.019	(0.215 to 0.48)
Crankshaft Journal Bearing (Jack)	0.001 to 0.004	(0.025 to 0.10)
Crankshaft Pin to Connecting Rod Bearing (Jack)	0.002 to 0.005	(0.05 to 0.125)
Connecting Rod Thrust (Side)	0.010 to 0.021	(0.25 to 0.53)
Connecting Rod Bushing to Crosshead Pin	0.0015 to 0.0035	(0.038 to 0.089)
Crosshead Bushing to Crosshead Pin - JGJ/JGR	0.0015 to 0.0035	(0.038 to 0.089)
Crosshead (Bronze) to Crosshead Pin	0.0015 to 0.0028	(0.038 to 0.071)
Crosshead (Gray Iron) to Crosshead Pin - JGW	0.0015 to 0.0028	(0.038 to 0.071)
Crosshead (Babbitted Ductile Iron) to Guide - JGJ/JGR (Feeler Gauge ^a)	0.0060 to 0.0095	(0.152 to 0.241)
Crosshead (Babbitted Bronze) to Guide (Feeler Gauge ^a)	0.0080 to 0.0115	(0.203 to 0.292)
Crosshead (Gray Iron) to Guide - JGW (Feeler Gauge ^a)	0.0090 to 0.0125	(0.229 to 0.318)
Total Piston End Clearance - Double Acting ^b	0.110 to 0.170	(2.79 to 4.32)
Piston End Clearance - Crank End - Double Acting ^b	0.040	(1.02)
Piston End Clearance - Head End - Double Acting ^b	0.070 to 0.130	(1.78 to 3.30)
Total Piston End Clearance - Tandem ^b	0.200 to 0.260	(5.08 to 6.60)
Piston End Clearance - Crank End Tandem ^b	0.040	(1.02)
Piston End Clearance - Head End Tandem ^b	0.160 to 0.220	(4.06 to 5.59)

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.

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 JGW, JGR and JGJ compressor piston rings and packing rings when new are as follows:

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

NOMINAL WIDTH	ACTUAL GROOVE WIDTH	TEFLON ONE-PIECE	BRONZE
3/16 (4.76)	0.187 to 0.189 (4.75 to 4.80)	0.0035 to 0.0075 (0.09 to 0.19)	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)	0.008 to 0.012 (0.20 to 0.30)	0.004 to 0.008 (0.10 to 0.20)
3/4 (19.05)	0.750 to 0.752 (19.05 to 19.10)	0.016 to 0.022 (0.41 to 0.56)	0.006 to 0.010 (0.15 to 0.25)

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

ACTUAL GROOVE WIDTH	CLEARANCE
1.000	0.012 to 0.018 (0.30 to 0.46)
2.000	0.024 to 0.030 (0.61 to 0.76)
3.000	0.036 to 0.042 (0.91 to 1.07)
4.000	0.048 to 0.054 (1.22 to 1.37)

TABLE 1-6: PACKING RING SIDE CLEARANCE

RING TYPE OR MATERIAL	SIDE CLEARANCE, INCHES (mm)
Bronze	0.006 to 0.008 (0.15 to 0.20)
Teflon One-Piece	0.010 to 0.012 (0.25 to 0.30)
P (PEEK)	0.010 to 0.015 (0.25 to 0.38)
BTR (TFE/CI)	0.012 to 0.018 (0.30 to 0.46)
AL (TFE)	0
BD (TFE)	0.010 to 0.015 (0.25 to 0.38)
3RWS (CI)	0.006 to 0.012 (0.15 to 0.30)

TABLE 1-7: PISTON TO BORE CLEARANCE AND CONVENTIONAL PISTON RING END GAP, INCHES (mm) - W & R CLASS CYLINDERS

BORE DIAMETER	PISTON TO BORE CLEARANCE	PISTON RING END GAP ^a	
		NEW	MAXIMUM
1.75 (44)	Uses Wearbands, see Table 1-9 on page 1-13 and Table 1-10 on page 1-14		
2 (51)			
3.625 (92)	0.010 to 0.015 (0.25 to 0.38)	0.044 to 0.068 (1.12 to 1.73)	0.204 (5.18)
3.875 (98)	0.010 to 0.015 (0.25 to 0.38)	0.046 to 0.070 (1.17 to 1.78)	0.210 (5.33)
4.125 (105)	0.010 to 0.015 (0.25 to 0.38)	0.049 to 0.073 (1.24 to 1.85)	0.219 (5.56)
4.25 (108)	0.010 to 0.015 (0.25 to 0.38)	0.051 to 0.075 (1.30 to 1.91)	0.225 (5.72)
4.625 (117)	0.012 to 0.017 (0.30 to 0.43)	0.056 to 0.080 (1.42 to 2.03)	0.240 (6.19)
4.75 (121)	0.012 to 0.018 (0.30 to 0.46)	0.057 to 0.081 (1.45 to 2.06)	0.243 (6.17)
5.125 (130)	0.012 to 0.017 (0.30 to 0.43)	0.061 to 0.085 (1.55 to 2.16)	0.255 (6.48)
5.5 (140)	0.013 to 0.018 (0.33 to 0.46)	0.066 to 0.090 (1.68 to 2.29)	0.270 (6.86)
6 (152)	0.013 to 0.018 (0.33 to 0.46)	0.072 to 0.112 (1.83 to 2.84)	0.336 (8.53)
6.375 (162)	0.014 to 0.019 (0.36 to 0.48)	0.077 to 0.117 (1.96 to 2.97)	0.351 (8.92)
7 (178)	0.015 to 0.020 (0.38 to 0.51)	0.084 to 0.124 (2.13 to 3.15)	0.372 (9.45)
7.125 (181)	0.015 to 0.021 (0.38 to 0.53)	0.085 to 0.125 (2.16 to 3.18)	0.375 (9.53)
7.375 (187)	0.015 to 0.020 (0.38 to 0.51)	0.089 to 0.129 (2.26 to 3.28)	0.387 (9.83)
7.5 (191)	0.015 to 0.021 (0.38 to 0.53)	0.089 to 0.129 (2.26 to 3.28)	0.387 (9.83)
8 (203)	0.016 to 0.022 (0.41 to 0.56)	0.096 to 0.136 (2.45 to 3.45)	0.408 (10.36)
8.375 (213)	0.017 to 0.023 (0.43 to 0.58)	0.101 to 0.141 (2.57 to 3.58)	0.423 (10.74)
8.5 (216)	0.017 to 0.023 (0.43 to 0.58)	0.102 to 0.142 (2.59 to 3.61)	0.426 (10.82)
8.875 (225)	0.018 to 0.023 (0.46 to 0.58)	0.107 to 0.147 (2.72 to 3.73)	0.441 (11.20)
9.25 (235)	0.019 to 0.025 (0.48 to 0.64)	0.111 to 0.151 (2.82 to 3.84)	0.453 (11.51)
9.75 (248)	0.020 to 0.026 (0.51 to 0.66)	0.117 to 0.157 (2.97 to 3.99)	0.471 (11.96)
10.375 (264)	0.022 to 0.026 (0.56 to 0.66)	0.124 to 0.164 (3.15 to 4.17)	0.492 (12.50)
11 (279)	0.022 to 0.028 (0.56 to 0.71)	0.131 to 0.179 (3.33 to 4.55)	0.537 (13.64)
11.5 (292)	0.023 to 0.029 (0.58 to 0.74)	0.138 to 0.186 (3.51 to 4.72)	0.558 (14.17)
13 (330)	0.026 to 0.032 (0.66 to 0.81)	0.156 to 0.204 (3.96 to 5.18)	0.612 (15.54)

a. A piston/rider ring is optional for all W and R Class cylinders and is standard for R Class cylinders with diameters of 13.5 to 19.5 inches (343 to 495 mm).

TABLE 1-8: PISTON TO BORE CLEARANCE AND PISTON/ RIDER RING END GAP, INCHES (mm) - W, R & J CLASS CYLINDERS.

BORE DIAMETER	PISTON TO BORE CLEARANCE	PISTON RING END GAP	
		NEW	MAXIMUM
1.75 (44)	Uses Wearbands, see Table 1-9 on page 1-13 and Table 1-10 on page 1-14		
2 (51)			
3.625 (92)	0.090 to 0.096 (2.29 to 2.44)	0.044 to 0.060 (1.12 to 1.52)	0.180 (4.57)
3.875 (98)	0.090 to 0.096 (2.29 to 2.44)	0.045 to 0.061 (1.14 to 1.55)	0.183 (4.65)
4.125 (105)	0.090 to 0.096 (2.29 to 2.44)	0.049 to 0.065 (1.24 to 1.65)	0.195 (4.95)
4.25 (108)	0.090 to 0.096 (2.29 to 2.44)	0.050 to 0.066 (1.27 to 1.68)	0.198 (5.03)
4.625 (117)	0.090 to 0.096 (2.29 to 2.44)	0.056 to 0.072 (1.42 to 1.83)	0.216 (5.49)
4.75 (121)	0.090 to 0.096 (2.29 to 2.44)	0.057 to 0.073 (1.45 to 1.85)	0.219 (5.56)
5.125 (130)	0.090 to 0.096 (2.29 to 2.44)	0.062 to 0.078 (1.57 to 1.98)	0.234 (5.94)
5.5 (140)	0.090 to 0.096 (2.29 to 2.44)	0.068 to 0.084 (1.73 to 2.13)	0.252 (6.40)
6 (152)	0.090 to 0.096 (2.29 to 2.44)	0.074 to 0.090 (1.88 to 2.29)	0.270 (6.86)
6.125 (156)	0.090 to 0.096 (2.29 to 2.44)	0.069 to 0.099 (1.75 to 2.51)	0.297 (7.54)
6.375 (162)	0.090 to 0.096 (2.29 to 2.44)	0.073 to 0.103 (1.85 to 2.62)	0.309 (7.85)
6.5 (165)	0.090 to 0.096 (2.29 to 2.44)	0.074 to 0.104 (1.88 to 2.64)	0.312 (7.92)
7 (178)	0.090 to 0.096 (2.29 to 2.44)	0.091 to 0.121 (2.31 to 3.07)	0.363 (9.22)
7.125 (181)	0.090 to 0.096 (2.29 to 2.44)	0.083 to 0.113 (2.11 to 2.87)	0.339 (8.61)
7.375 (187)	0.090 to 0.096 (2.29 to 2.44)	0.097 to 0.127 (2.46 to 3.23)	0.381 (9.68)
7.5 (191)	0.090 to 0.096 (2.29 to 2.44)	0.088 to 0.118 (2.24 to 3.00)	0.354 (8.99)
8 (203)	0.090 to 0.096 (2.29 to 2.44)	0.106 to 0.136 (2.69 to 3.45)	0.408 (10.36)
8.375 (213)	0.090 to 0.096 (2.29 to 2.44)	0.112 to 0.142 (2.84 to 3.61)	0.426 (10.82)
8.5 (216)	0.090 to 0.096 (2.29 to 2.44)	0.114 to 0.144 (2.90 to 3.66)	0.432 (10.97)
8.875 (225)	0.090 to 0.096 (2.29 to 2.44)	0.120 to 0.150 (3.05 to 3.81)	0.450 (11.43)
9.25 (235)	0.090 to 0.096 (2.29 to 2.44)	0.125 to 0.155 (3.18 to 3.94)	0.465 (11.81)
9.75 (248)	0.090 to 0.096 (2.29 to 2.44)	0.133 to 0.163 (3.38 to 4.14)	0.489 (12.42)
10.375 (264)	0.090 to 0.096 (2.29 to 2.44)	0.142 to 0.172 (3.61 to 4.37)	0.516 (13.11)
10.5 (267)	0.090 to 0.096 (2.29 to 2.44)	0.144 to 0.174 (3.66 to 4.42)	0.522 (13.26)
11 (279)	0.090 to 0.096 (2.29 to 2.44)	0.152 to 0.182 (3.86 to 4.62)	0.546 (13.87)
11.5 (292)	0.090 to 0.096 (2.29 to 2.44)	0.160 to 0.190 (4.06 to 4.83)	0.570 (14.48)
13 (330)	0.090 to 0.096 (2.29 to 2.44)	0.182 to 0.212 (4.62 to 5.38)	0.636 (16.15)
13.5 (343)	0.090 to 0.096 (2.29 to 2.44)	0.190 to 0.220 (4.83 to 5.59)	0.660 (16.76)
15.25 (378)	0.090 to 0.096 (2.29 to 2.44)	0.216 to 0.246 (5.49 to 6.25)	0.738 (18.75)
15.75 (400)	0.090 to 0.096 (2.29 to 2.44)	0.224 to 0.254 (5.69 to 6.45)	0.762 (19.35)
16.75 (425)	0.090 to 0.096 (2.29 to 2.44)	0.239 to 0.269 (6.07 to 6.83)	0.807 (20.50)
17.25 (438)	0.090 to 0.096 (2.29 to 2.44)	0.247 to 0.277 (6.27 to 7.04)	0.831 (21.12)
19 (483)	0.090 to 0.096 (2.29 to 2.44)	0.273 to 0.303 (6.93 to 7.70)	0.909 (23.09)
19.5 (495)	0.090 to 0.096 (2.29 to 2.44)	0.281 to 0.311 (7.14 to 7.90)	0.933 (23.70)

TABLE 1-9: PISTON TO BORE CLEARANCE, PISTON RING END GAP AND WEAR BAND END GAP AND RADIAL PROJECTION, INCHES - RJ AND HJ CLASS CYLINDERS

BORE DIAMETER	PISTON TO BORE CLEARANCE	PISTON RING END GAP ^a		WEAR BANDS - NEW	
		NEW	MAXIMUM	END GAP MINIMUM	RADIAL PROJECTION
1.75	0.030 to 0.037	0.025 to 0.035	0.105	0.058	0.0075 to 0.0145
2	0.030 to 0.037	0.028 to 0.038	0.114	0.065	0.0075 to 0.0145
3.625	0.069 to 0.077	0.044 to 0.068	0.204	0.116	0.023 to 0.031
3.875	0.069 to 0.077	0.047 to 0.071	0.213	0.124	0.023 to 0.031
4.25	0.070 to 0.078	0.051 to 0.075	0.225	0.136	0.023 to 0.031
4.625	0.070 to 0.078	0.056 to 0.080	0.240	0.148	0.023 to 0.031
5.125	0.073 to 0.081	0.061 to 0.085	0.255	0.164	0.023 to 0.031
5.5	0.073 to 0.081	0.065 to 0.089	0.267	0.176	0.023 to 0.031
6	0.079 to 0.087	0.072 to 0.112	0.336	0.192	0.025 to 0.033
6.375	0.079 to 0.087	0.077 to 0.117	0.351	0.204	0.025 to 0.033
7	0.085 to 0.093	0.084 to 0.124	0.372	0.224	0.028 to 0.036
7.375	0.085 to 0.093	0.089 to 0.129	0.387	0.236	0.028 to 0.036
8	0.090 to 0.099	0.096 to 0.136	0.408	0.256	0.030 to 0.038
8.375	0.090 to 0.099	0.101 to 0.141	0.423	0.268	0.030 to 0.038
9.25	0.094 to 0.103	0.111 to 0.151	0.453	0.296	0.032 to 0.040
9.75	0.094 to 0.103	0.117 to 0.157	0.471	0.312	0.032 to 0.040
10.375	0.097 to 0.106	0.124 to 0.164	0.492	0.332	0.032 to 0.042
11	0.100 to 0.109	0.131 to 0.179	0.537	0.352	0.032 to 0.042
11.5	0.100 to 0.109	0.138 to 0.186	0.558	0.368	0.032 to 0.042
13	0.108 to 0.117	0.155 to 0.203	0.609	0.415	0.034 to 0.044
13.5	0.108 to 0.117	0.162 to 0.210	0.630	0.432	0.034 to 0.044
15.25	0.115 to 0.126	0.183 to 0.231	0.693	0.488	0.036 to 0.046
15.75	0.115 to 0.126	0.189 to 0.237	0.711	0.504	0.036 to 0.046
16.75	0.123 to 0.134	0.201 to 0.251	0.753	0.536	0.038 to 0.048
17.25	0.123 to 0.134	0.207 to 0.259	0.777	0.552	0.038 to 0.048
19	0.131 to 0.142	0.228 to 0.292	0.876	0.608	0.037 to 0.049
19.5	0.131 to 0.142	0.234 to 0.298	0.894	0.624	0.037 to 0.049

a. A piston/rider ring is optional for all W and R Class cylinders and is standard for R Class cylinders with bore diameters of 13.5 to 19.5 inches (343 to 495 mm).

TABLE 1-10: PISTON TO BORE CLEARANCE, PISTON RING END GAP AND WEAR BAND END GAP AND RADIAL PROJECTION, (mm) INCHES - RJ AND HJ CLASS CYLINDERS

BORE DIAMETER (mm) INCHES	PISTON TO BORE CLEARANCE	PISTON RING END GAP ^a		WEAR BANDS - NEW	
		NEW	MAXIMUM	END GAP MINIMUM	RADIAL PROJECTION
(44) 1.75	(0.76 to 0.94)	(0.64 to 0.89)	(2.67)	(1.47)	(0.19 to 0.37)
(51) 2	(0.76 to 0.94)	(0.71 to 0.97)	(2.90)	(1.65)	(0.19 to 0.37)
(92) 3.625	(1.75 to 1.96)	(1.12 to 1.73)	(5.18)	(2.95)	(0.58 to 0.79)
(98) 3.875	(1.75 to 1.96)	(1.19 to 1.80)	(5.41)	(3.15)	(0.58 to 0.79)
(108) 4.25	(1.78 to 1.98)	(1.30 to 1.91)	(5.72)	(3.45)	(0.58 to 0.79)
(117) 4.625	(1.78 to 1.98)	(1.42 to 2.03)	(6.10)	(3.76)	(0.58 to 0.79)
(130) 5.125	(1.85 to 2.06)	(1.55 to 2.16)	(6.48)	(4.17)	(0.58 to 0.79)
(140) 5.5	(1.85 to 2.06)	(1.65 to 2.26)	(6.78)	(4.47)	(0.58 to 0.79)
(152) 6	(2.01 to 2.21)	(1.83 to 2.84)	(8.53)	(4.88)	(0.64 to 0.84)
(162) 6.375	(2.01 to 2.21)	(1.96 to 2.97)	(8.92)	(5.18)	(0.64 to 0.84)
(178) 7	(2.16 to 2.36)	(2.13 to 3.15)	(9.45)	(5.69)	(0.71 to 0.91)
(187) 7.375	(2.16 to 2.36)	(2.26 to 3.28)	(9.83)	(5.99)	(0.71 to 0.91)
(203) 8	(2.29 to 2.51)	(2.44 to 3.45)	(10.36)	(6.48)	(0.76 to 0.97)
(213) 8.375	(2.29 to 2.51)	(2.57 to 3.58)	(10.74)	(6.81)	(0.76 to 0.97)
(235) 9.25	(2.39 to 2.62)	(2.82 to 3.84)	(11.51)	(7.52)	(0.81 to 0.97)
(248) 9.75	(2.39 to 2.62)	(2.97 to 3.99)	(11.96)	(7.92)	(0.81 to 0.97)
(264) 10.375	(2.46 to 2.69)	(3.15 to 4.17)	(12.50)	(8.43)	(0.81 to 1.07)
(279) 11	(2.54 to 2.77)	(3.33 to 4.55)	(13.64)	(8.94)	(0.81 to 1.07)
(292) 11.5	(2.54 to 2.77)	(3.51 to 4.72)	(14.17)	(9.35)	(0.81 to 1.07)
(330) 13	(2.74 to 2.97)	(3.94 to 5.16)	(15.47)	(10.54)	(0.86 to 1.12)
(343) 13.5	(2.74 to 2.97)	(4.11 to 5.33)	(16.00)	(10.97)	(0.86 to 1.12)
(387) 15.25	(2.92 to 3.20)	(4.65 to 5.87)	(17.60)	(12.40)	(0.91 to 1.17)
(400) 15.75	(2.92 to 3.20)	(4.80 to 6.02)	(18.06)	(12.80)	(0.91 to 1.17)
(425) 16.75	(3.12 to 3.40)	(5.11 to 6.38)	(19.13)	(13.61)	(0.97 to 1.22)
(438) 17.25	(3.12 to 3.40)	(5.26 to 6.58)	(19.74)	(14.02)	(0.97 to 1.22)
(483) 19	(3.33 to 3.61)	(5.79 to 7.42)	(22.25)	(15.44)	(0.94 to 1.24)
(495) 19.5	(3.33 to 3.61)	(5.94 to 7.57)	(22.71)	(15.85)	(0.94 to 1.24)

a. A piston/rider ring is optional for all W and R Class cylinders and is standard for R Class cylinders with bore diameters of 13.5 to 19.5 inches (343 to 495 mm).

Fastener Tightening Torque

Listed in the following tables are fastener tightening torque values required for proper assembly of Ariel JGW, JGR and JGJ 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.

For latest available torque values, see ER-63 at www.arielcorp.com.

TABLE 1-11: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE, INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Main Bearing Cap - Cap Screw	5/8 - 11	12 Point - Grade 8	97 (132)
Connecting Rod Cap/Detuner Donut - Cap Screw	5/8 - 18	12 Point - Grade 8	123 (167)
Connecting Rod Cap/Detuner Donut - Cap Screw	3/4 - 16	12 Point - Grade 8	216 (293)
Crosshead Pin Thru Bolt - Lock Nut	7/16 - 20	Hex - Prevailing	39 (53)
Spacer Bar - Cap Screw	3/4 - 16	12 Point - Grade 8	160 (217)
Crosshead Guide to Frame - Cap Screw	5/8 - 11	12 Point - Grade 8	97 (132)
Crosshead Guide to Cylinder - Cap Screw	5/8 - 11	12 Point - Grade 8	97 (132)
Crosshead Guide to Cylinder -Stud Nut	1/2 - 13	Hex	48 (65)
Crosshead Guide to Cylinder -Stud Nut	9/16 - 12	Hex	70 (95)
Crosshead Guide to Cylinder -Stud Nut	5/8 - 11	Hex	97 (132)
Crosshead Guide Support - Cap Screw	3/4 - 10	Hex - Grade 8 or 9	160 (215)
Crosshead Guide Support - Cap Screw	5/8 - 11	Hex - Grade 8 or 9	90 (120)
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	5/8 - 11	12 Point - Grade 8	70 (95)
Piston Nut	1-1/4 - 12	Ariel Design	695 (940)
Crosshead Nut	1-3/8 - 12	Ariel Design	650 (885)

TABLE 1-11: FASTENER TIGHTENING VALUES

FASTENER	NOMINAL SIZE, INCH - TPI	TYPE	TORQUE, LB X FT (N·m)
Valve Cap/Cylinder Head/Unloader/Gas Passage Cap - Cap Screw ^a	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)
Piston Rod Oil Slinger - Lock Nut	1/4 - 28	Hex - Jam	96 lb x in. (11)
Hold Down - Studnut	7/8 - 9	Hex Stud - nut	280 ^b (380)
Rupture Disk - Blow-Out Fitting Cap	1/4 Nom. Tube	Hex - Tube Fitting	36 lb x in. (4.1)
Tandem Cylinder to Cylinder - Cap Screw ^a	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. When studs are specified for cylinder applications, tighten stud-nuts to the same values as cap screws in similar applications. Reference Figure 1-8:
- b. Minimum torque for recommended 7/8" - 9 TPI 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 the ultimate strength of the stud material, as specified by packager.

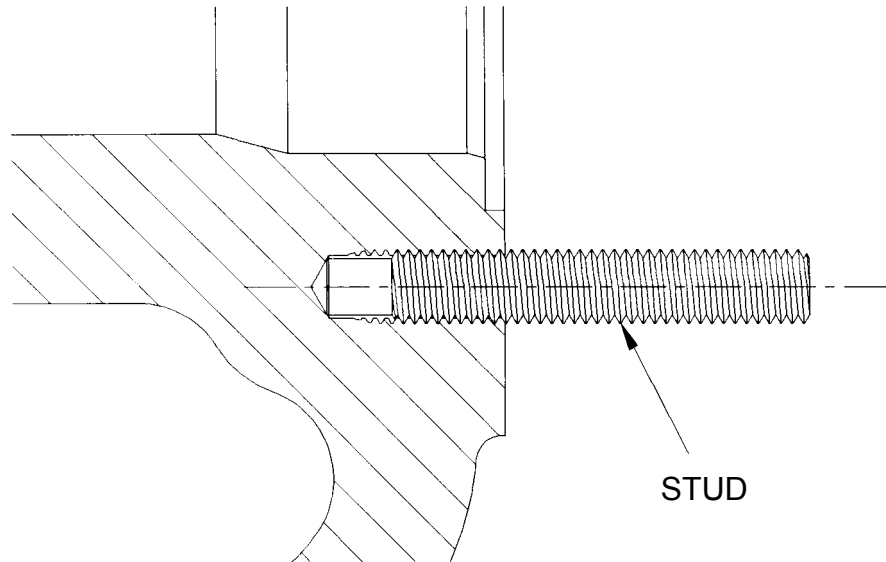


FIGURE 1-8: DOG POINT STUDS

TABLE 1-12: 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.

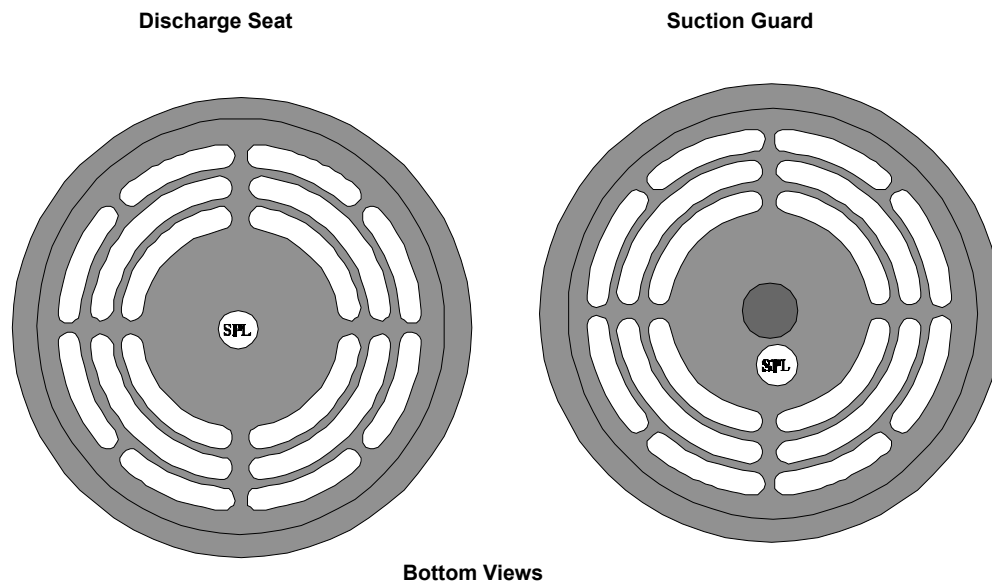


FIGURE 1-9: SPIRALOCK THREADED VALVE ASSEMBLY - MARKED SPL

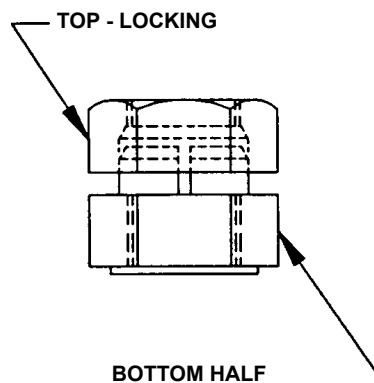


FIGURE 1-10: DRAKE LOCK NUT

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

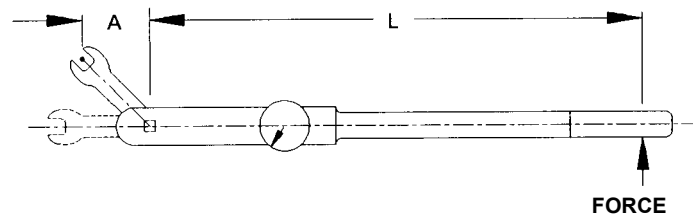
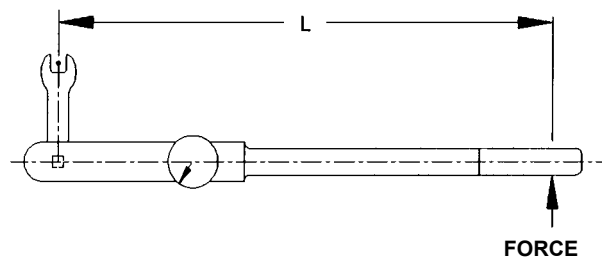
T_a = Torque required at fastener, lb x ft

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.

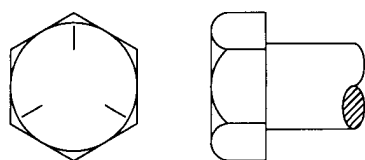
1. The exception is when the adapter is 90° to the torque wrench. The torque will be the same as on the wrench scale (see Figure 1-12:).

**FIGURE 1-11: TORQUE WRENCH WITH ADAPTOR AT ANY ANGLE****FIGURE 1-12: TORQUE WRENCH WITH ADAPTOR AT RIGHT ANGLE**

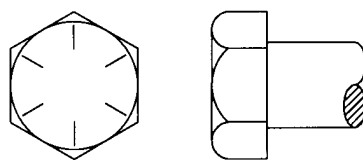
Ariel Bolting

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 1-11 on page 1-15. Figure 1-13: is provided to assist in the identification of bolts used in an Ariel compressor.

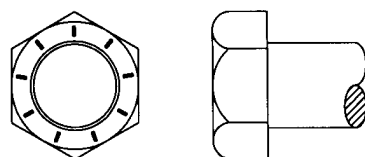
Connecting rod, valve cap and suction/discharge nozzle-Ariel supplied specialized companion flange-bolting is modified to prevent fatigue and cannot be replaced with standard bolts. If attempting to replace other bolting with standard bolts and there is any question, contact your packager or Ariel. Ariel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



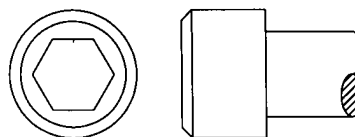
Hex head Grade 5



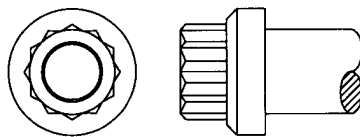
Hex head Grade 8



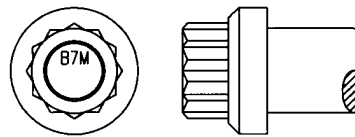
Hex head Grade 9



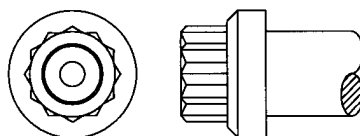
Hex Socket Head Grade 8



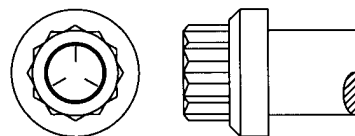
12 Point Grade 8



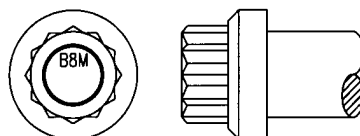
12 Point Grade B7M (NACE)



12 Point Interim Grade 5



12 Point Grade 5



12 Point Stainless
Steel Grade B8M

FIGURE 1-13: BOLT IDENTIFICATION

Optional Main Bearing Temperature Instrumentation - Alarm & Shutdown

Amot 4103 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 shims or careful grouting.
 - Have enough stiffness and mass to resist vibration induced by the 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.
3. Each crosshead guide will deflect an amount relative to the weight of the cylinder mounted on that throw. This amount of deflection, which does not include the weight of the pulsation bottles or piping, is shown in the **Ariel Application Data Book**. Shims equaling the deflection value as listed on the cylinder outline drawing are to be added to the shim pack under the crosshead guide, elevating the crosshead guide to a level position. The crosshead guide supports must be capable of carrying the combined weight of the cylinders, bottles and piping.
4. 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.

5. Compressor cylinders that have water-cooled packing are to be connected to water cooling unless prior approval is obtained from Ariel Field Service.

Setting

The following procedure is to be used for setting the compressor on the skid:

After finding the approximate position of the compressor frame, the mounting bolts are to be tightened in place and then loosened. Shims are then to be adjusted so there is no movement more than a variation of 0.002 inches (0.05 mm) between the bottom of the frame and the skid supports. With the frame again bolted into place and the crosshead guide supports free, the distance from the crosshead guide supports to their respective skid supports is to be measured. To these measurements add the amount of deflection due to the cylinder weight as listed on the appropriate compressor cylinder outline drawing. Raise the cylinder and shim between the guide and guide support before tightening the crosshead guide mounting bolts. Consult Packager's information for mounting bolt tightening torque values. This work must be performed prior to the addition of bottles and piping.

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 3-4. 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 KNOWLEDGABLE ON THE INFORMATION CONTAINED IN THIS SECTION. IT IS ALSO ESSENTIAL TO REFER TO THE PACKAGER'S OPERATING MANUAL.

Start-Up Check List

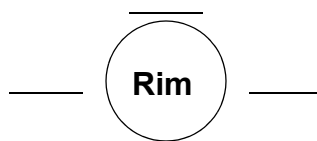
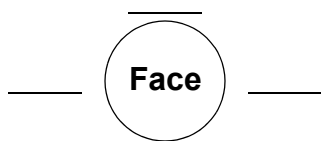
For latest available start Up Check List, see ER-10.4.0 at www.arielcorp.com.

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 oil?	_____	_____
27. Is the force feed lubrication system primed?	_____	_____
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 Technical Manual 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?	_____	_____

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?	_____	_____
14. Have all safety functions been tested to ensure shutdown of unit upon malfunction?	_____	_____

Compressor Model _____ Serial No. F- _____

YES NO

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 1-7).



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.

JGW, JGR and JGJ frames are 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%, 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 1-6). 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. An indicator on

the distributor block shows the rate at which the block is cycling. To adjust, screw down the feed regulator 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 1-6).

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.

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

NOTES:

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 4-10: 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. 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 and Table 1-2 on page 1-3). A start permissive should disable the start-up sequence if oil pressure is below 15 psig (1.0 bar_g). A compressor prelube cycle is strongly recommended for all compressors to extend bearing life.

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 polyalkylene 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.

JGW, JGR and JGJ 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 4-7: on page 4-17.

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 4-8: on page 4-19. 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 3-9. 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 (Water Saturated 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 (Water Saturated 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 (Water Saturated 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 (Water Saturated 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 (Water Saturated 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:

0.4 PINTS/DAY/INCH BORE (0.0074 L/DAY/mm BORE) FOR JGJ FRAMES AND
0.3 PINTS/DAY/INCH BORE (0.0056 L/DAY/mm BORE) FOR JGW AND JGR
FRAMES.

PISTON ROD DIAMETER IS DOUBLED AND TREATED LIKE A CYLINDER FOR
CALCULATING PACKING LUBE RATE. FOR CYLINDERS WITH A TAIL ROD,
THE LUBE RATE FOR EACH OF THE (TWO) PACKINGS IS TO BE CALCU-
LATED SEPARATELY AND BOTH VALUES ADDED TOWARD THE RECOM-
MENDED TOTAL DAILY LUBE RATE.

CYLINDERS HAVE ONE POINT BORE LUBE AS STANDARD, EXCEPT FOR
ALL T CLASS CYLINDERS AND CYLINDERS LARGER THAN 13 INCHES (330
mm) 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 OPERA-
TION, 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):

$$(\text{RPM}_{\text{MAX}} \div \text{RPM}_{\text{RUNNING}}) \times \text{CYCLE TIME SEC}_{\text{LUBE PLATE}} = \text{CYCLE TIME SEC}_{\text{RUNNING}}$$

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 CER-
TIFY SUITABILITY OF THE FORMULATION FOR SITE CONDITIONS SHOULD
PROVIDE APPROPRIATE DOCUMENTATION. CONTACT ARIEL FOR VERIFI-
CATION 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 4-7: on page 4-17.

All cylinders have both top and bottom lubrication injection points available as an order option, except for the T class and cylinders in the larger sizes, 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 overhead tank (see Figure 4-8: on page 4-19). 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.

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 4-6: on page 4-17).

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 Lubricator Adjustment

See instructions “Force Feed Lubricator Adjustment” on page 3-9 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 Table 1-11 on page 1-15 for blow-out fitting cap tightening torque. Do not over tighten cap or blow-out pressure can be reduced.

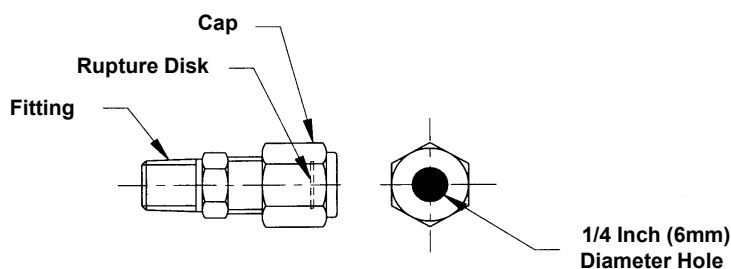


FIGURE 4-1: LINCOLN ST. LOUIS BLOW-OUT FITTING ASSEMBLY

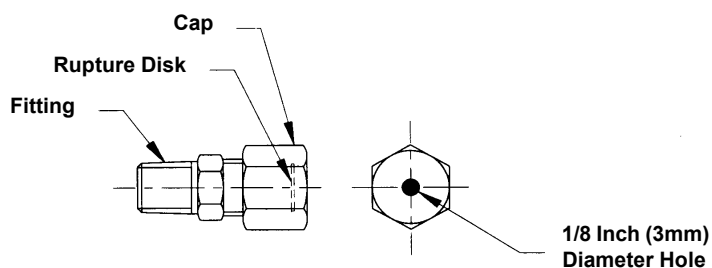


FIGURE 4-2: LUBRIQUIP BLOW-OUT FITTING ASSEMBLY

Divider Valves

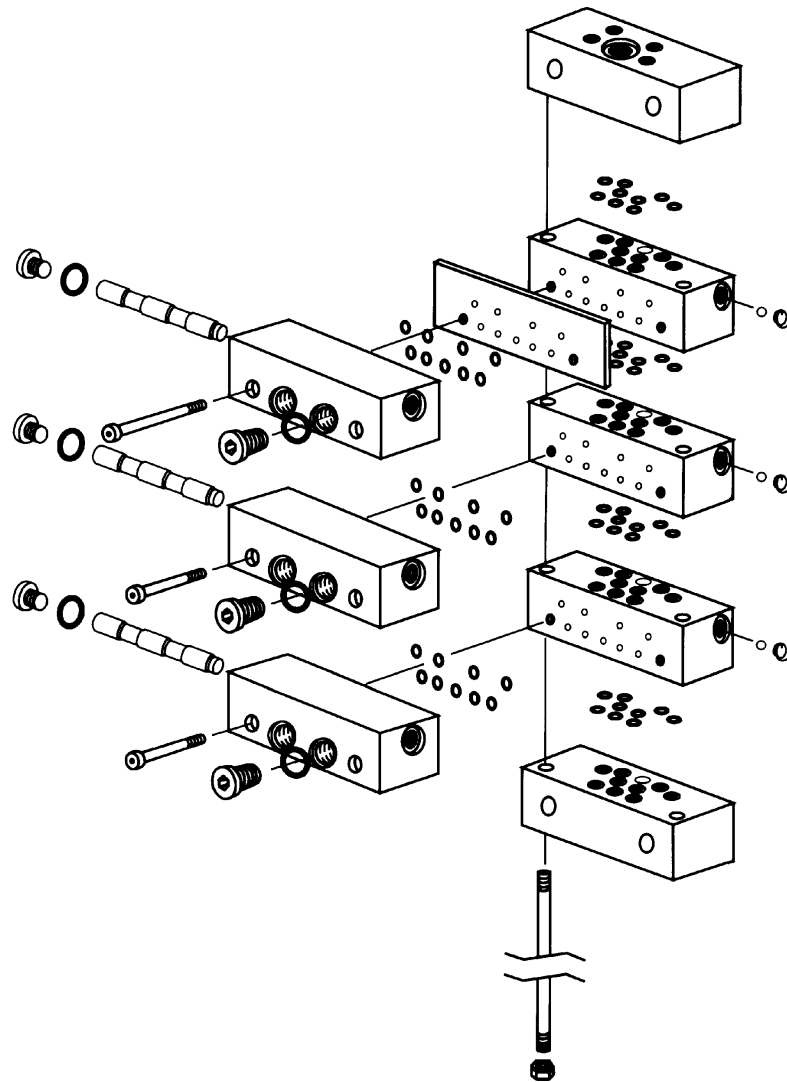


FIGURE 4-3: DIVIDER VALVE; DISTRIBUTION BLOCK - TYPICAL

NOTE: REFER TO PARTS BOOK FOR THE FRAME BEING SERVICED FOR ASSEMBLY DRAWINGS, PARTS LIST AND REPAIR KITS THAT ARE AVAILABLE FOR DIVIDER VALVES.

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 4-4:

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 non-replaceable sealed internal lithium battery, with an expected battery life of 6 to 10 years depending on cycle time. Optional models are available with a factory replaceable battery. Battery failure results in a fail safe DNFT no-flow output signal for shutdown. Battery failure requires replacement of the DNFT. Expired DNFT's may be returned for partial credit.

While earlier versions of the DNFT required position adjustment on the magnet housing assembly, DNFT's supplied after August 1997 no longer require such adjustment. To replace the DNFT, remove conduit and mark wiring connections. Remove wiring and the old

DNFT. Retain for partial credit return. Disassemble the magnetic housing from the switch body by loosening the (2) 1/4"-20 set screws on a new DNFT. Be sure magnet pin and spring are intact and working in the magnetic housing assembly. You should feel spring force when pushing on the magnet pin by hand. Screw the magnetic housing assembly into the end of the divider valve housing. Be sure set screws are loosened and slide the switch body all the way onto the nut of the magnetic assembly. Tighten set screws and re-attach wiring and conduit.

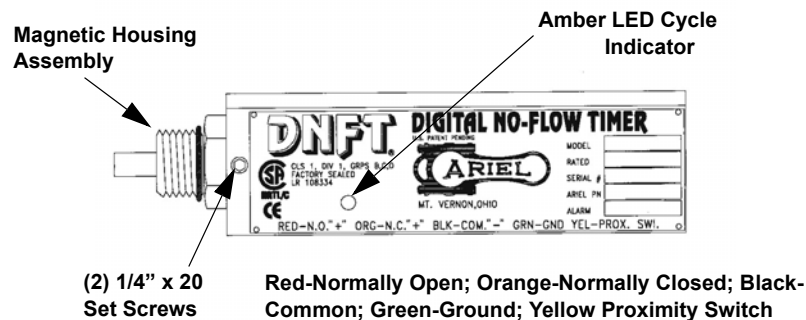


FIGURE 4-4: DIGITAL NO-FLOW TIMER SWITCH - (DNFT)

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 4-5: 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 4-5: 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 4-5: 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 4-5: 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.

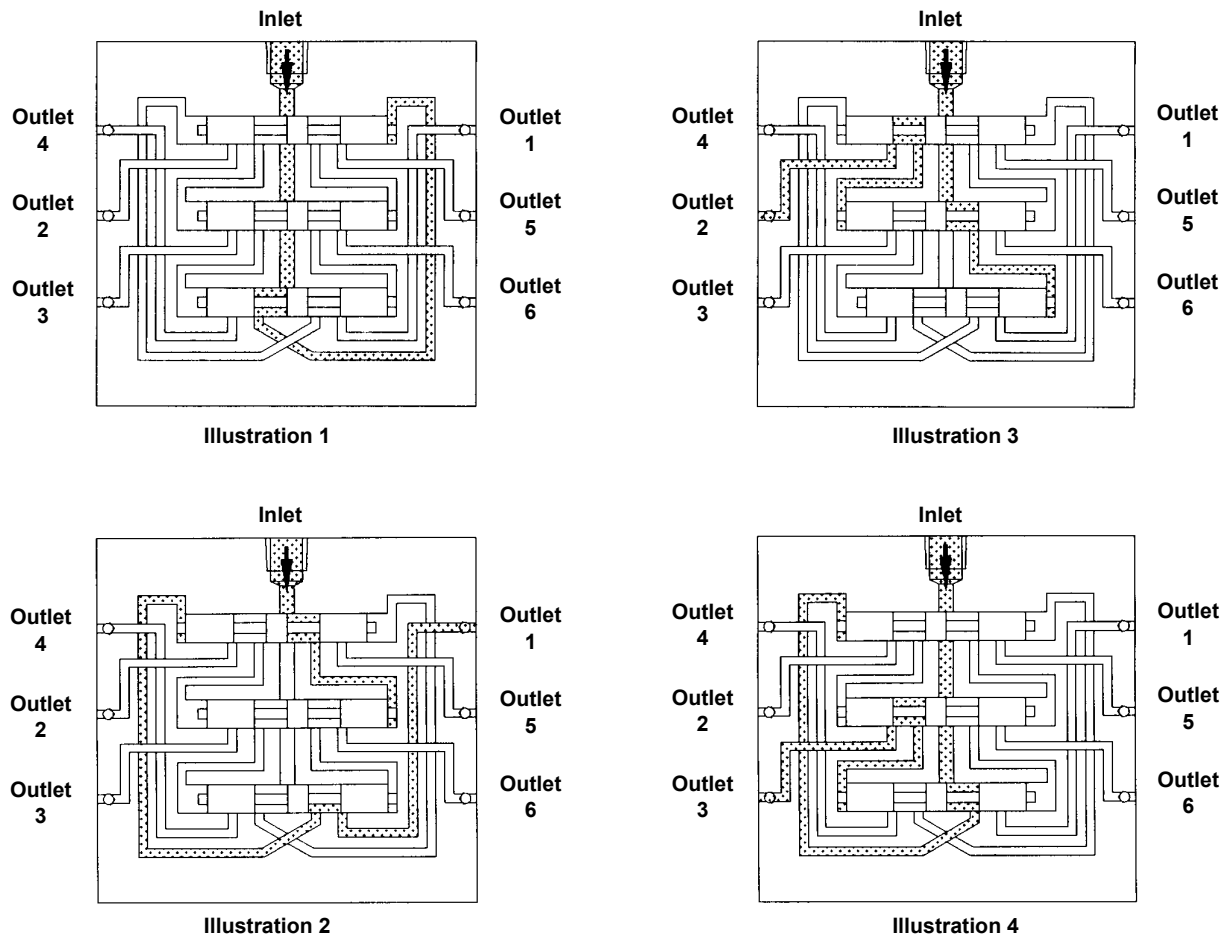


FIGURE 4-5: DIVIDER VALVE OPERATION SCHEMATIC

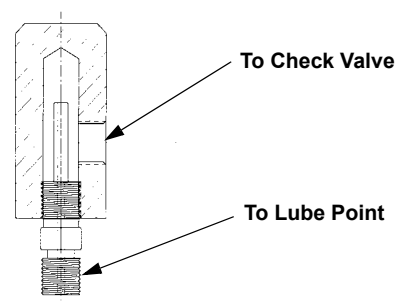


FIGURE 4-6: OIL HEAD TRAP FITTING

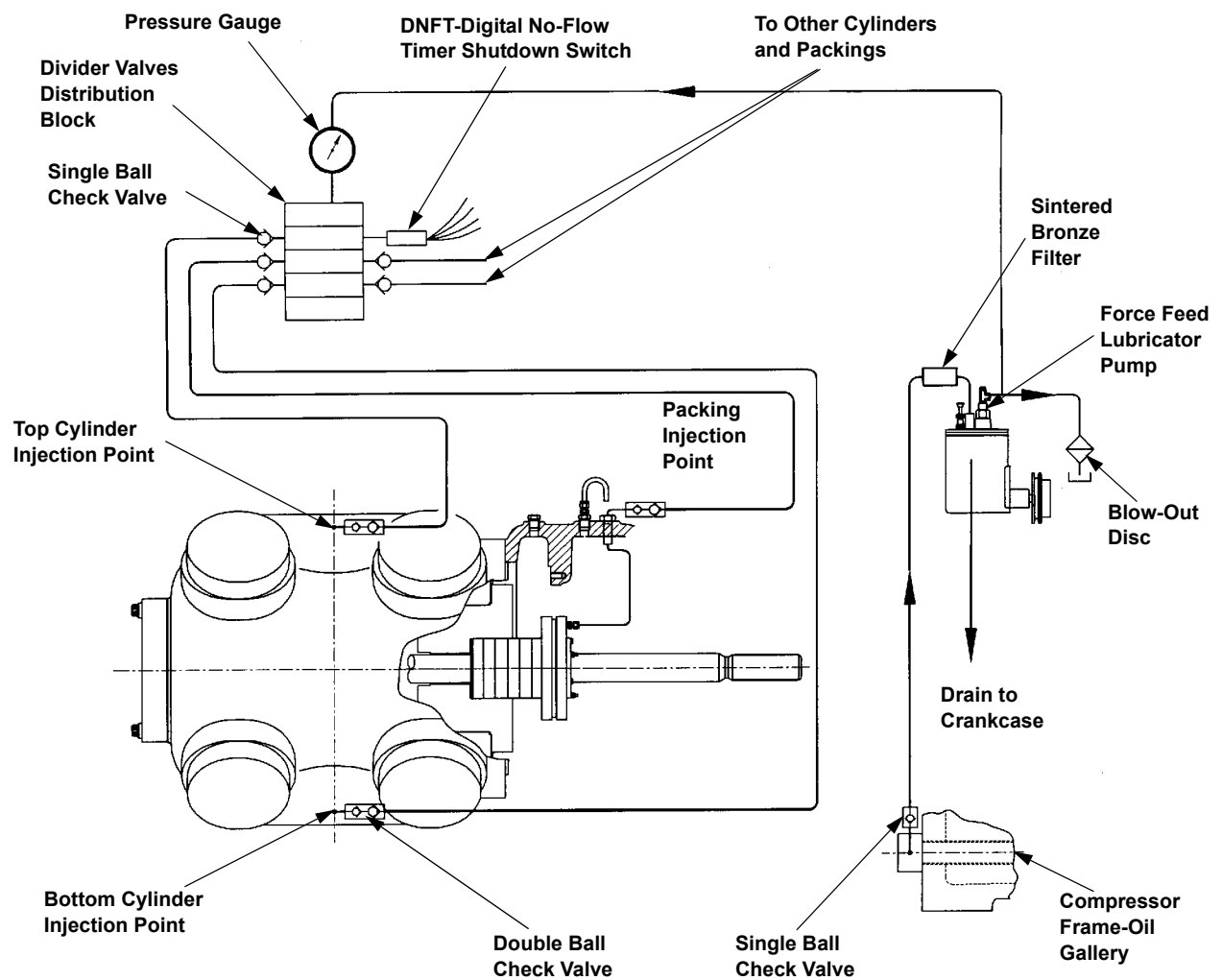


FIGURE 4-7: FORCE FEED LUBRICATION SYSTEM SCHEMATIC - TYPICAL

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.
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 5-1.
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 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.

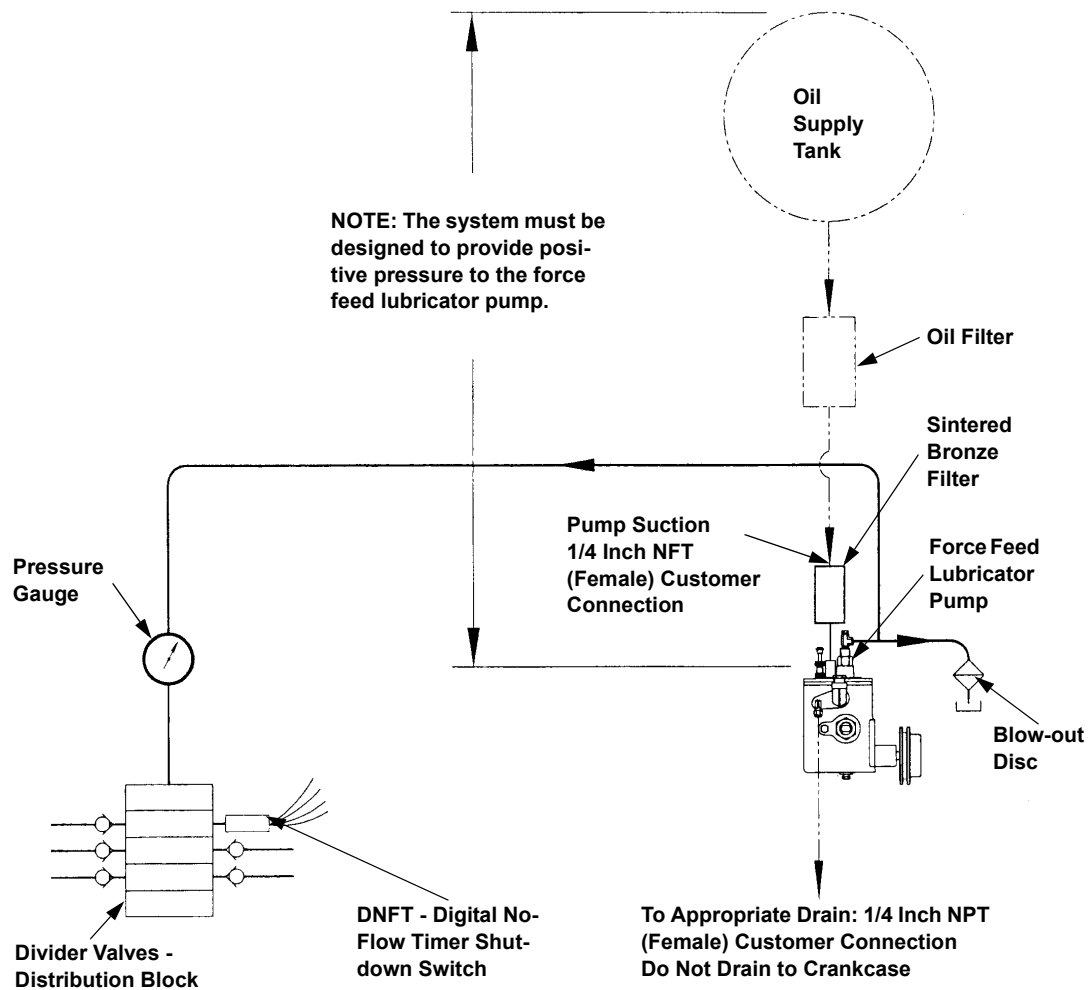


FIGURE 4-8: FORCE FEED LUBRICATION SYSTEM - INDEPENDENT OIL SUPPLY

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 4-9:.

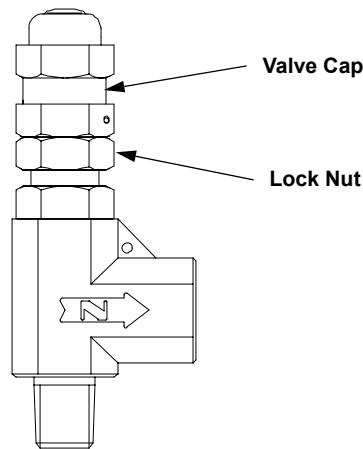


FIGURE 4-9: FORCE FEED BALANCE VALVE

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 4-10: Lube Oil System Schematic - Typical).

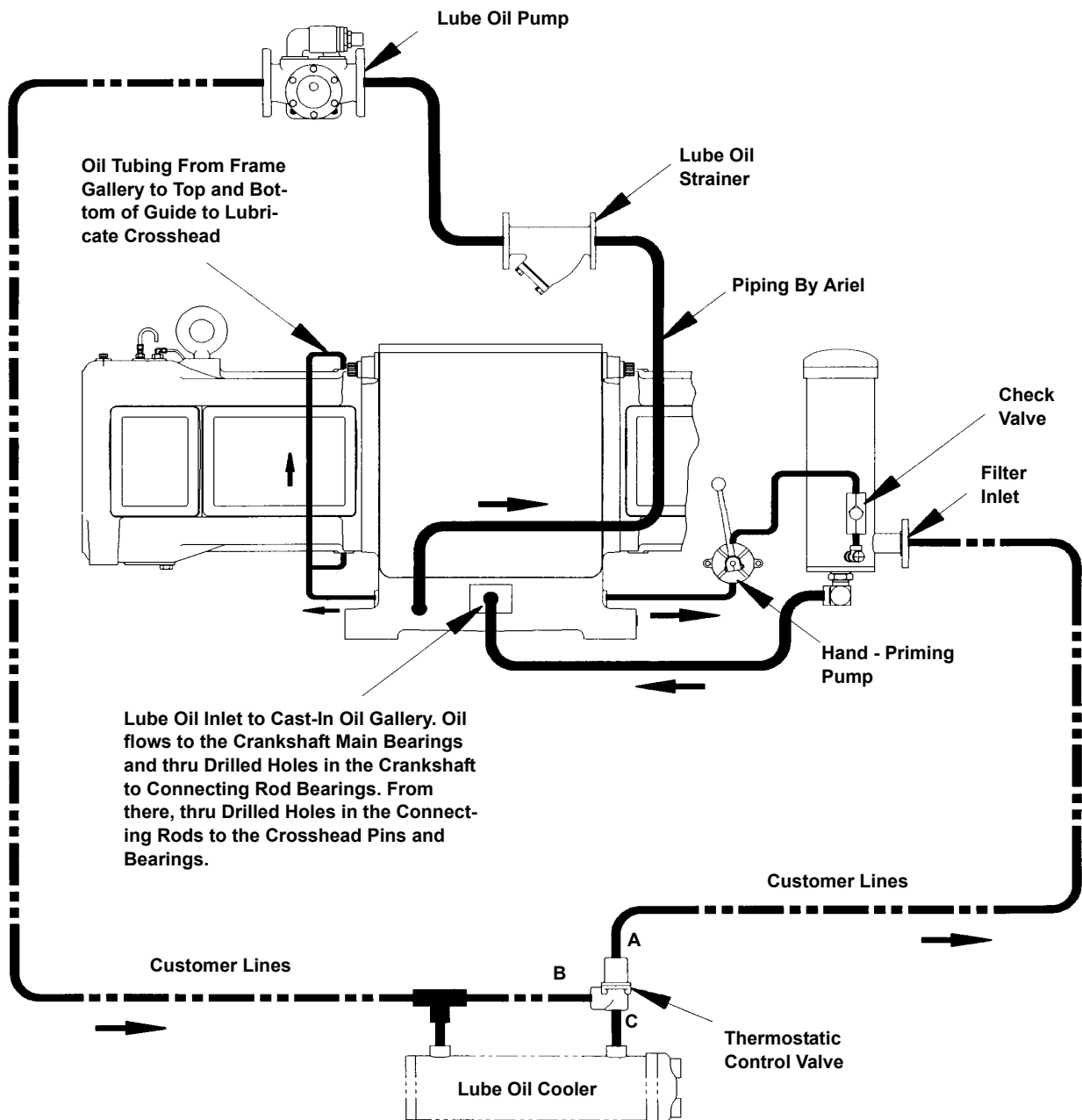


FIGURE 4-10: LUBE OIL SYSTEM SCHEMATIC - TYPICAL

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

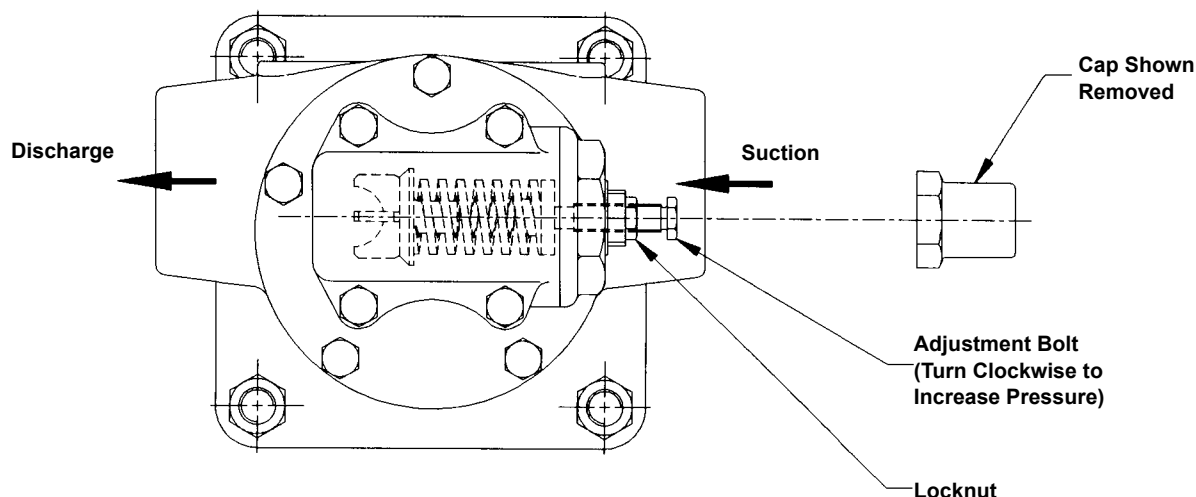


FIGURE 4-11: LUBE OIL PUMP

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 4-11:).

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 600 RPM FOR THE JGW AND JGR AND 900 RPM FOR JGJ. 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.

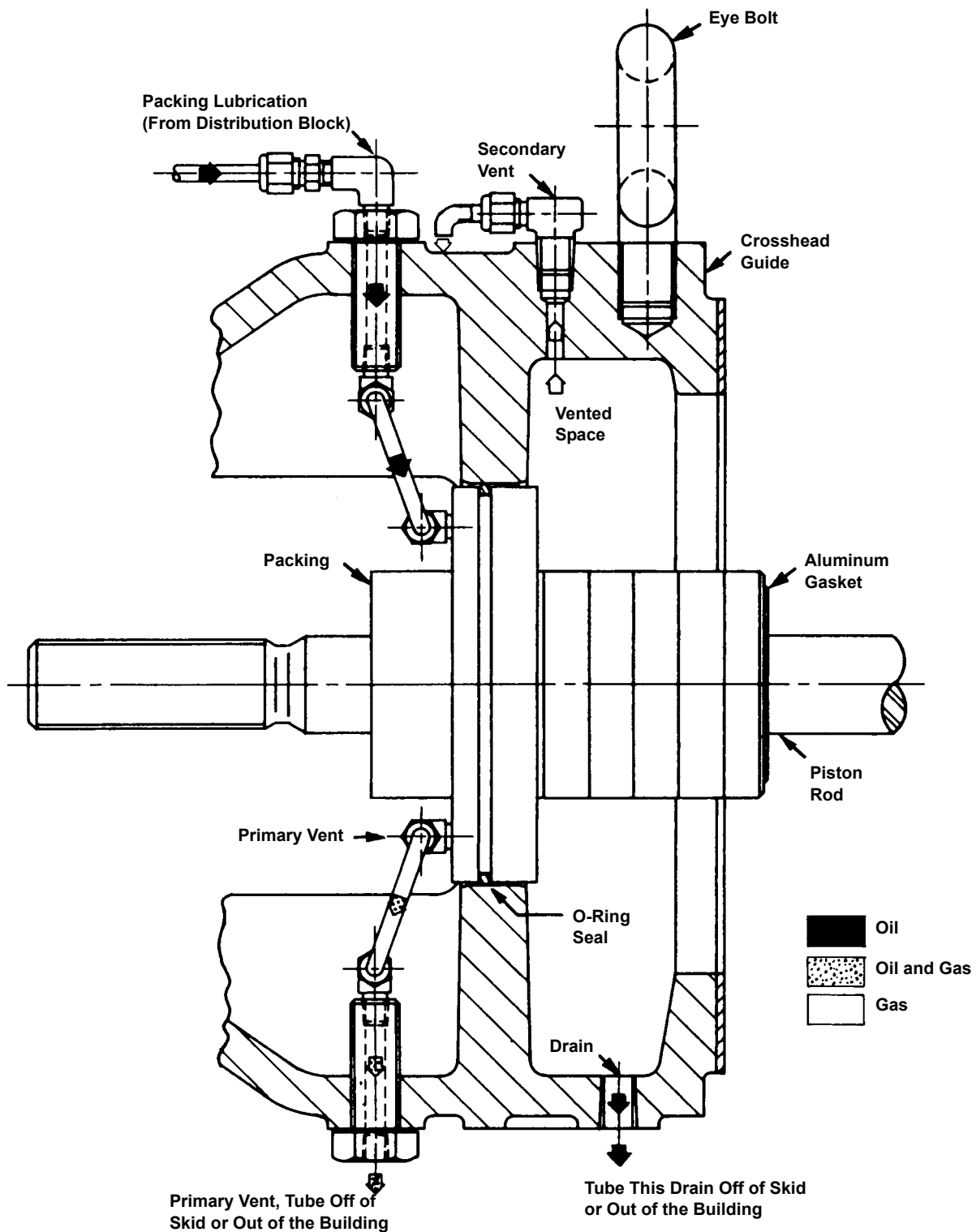


FIGURE 4-12: PACKING, TUBING AND DISTANCE PIECE VENTING

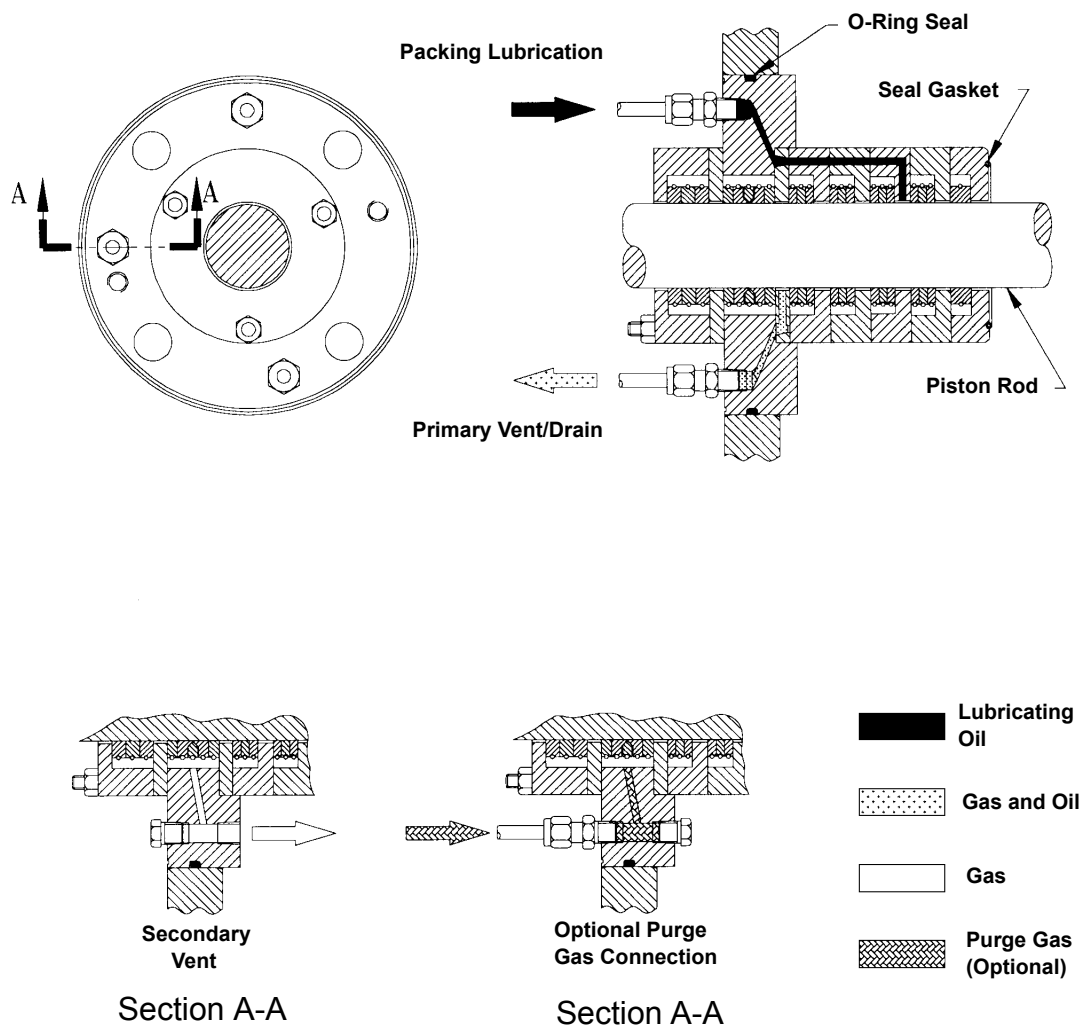


FIGURE 4-13: PACKING LUBRICATION AND VENTING

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 excepting the conn 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 and Fax Numbers" on page 7-9.

 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.

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.

NOTE: CRANK PIN BEARINGS AND MAIN BEARINGS ARE NO LONGER FUNCTIONALLY INTERCHANGEABLE. CRANK PIN (CONNECTING ROD) BEARINGS HAVE A NARROWER GROOVE. DO NOT PUT A CRANK PIN BEARING IN A MAIN BEARING LOCATION.

Connecting Rod Bushing

Check crosshead pin to bushing clearance (see Table 1-3 on page 1-9 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 1-11 on page 1-15.
4. Tighten the connecting rod bolts in 25% increments to full torque to the values listed in Table 1-11 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 1-3 on page 1-9. 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**

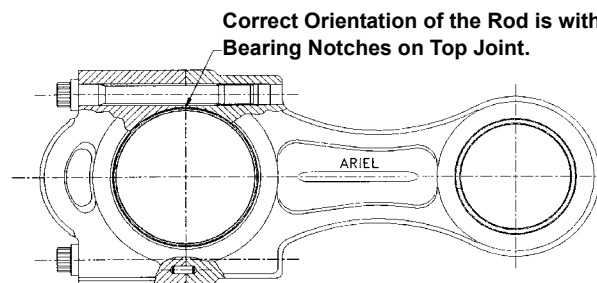


FIGURE 5-1: CONNECTING ROD - TYPICAL

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 1-11 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

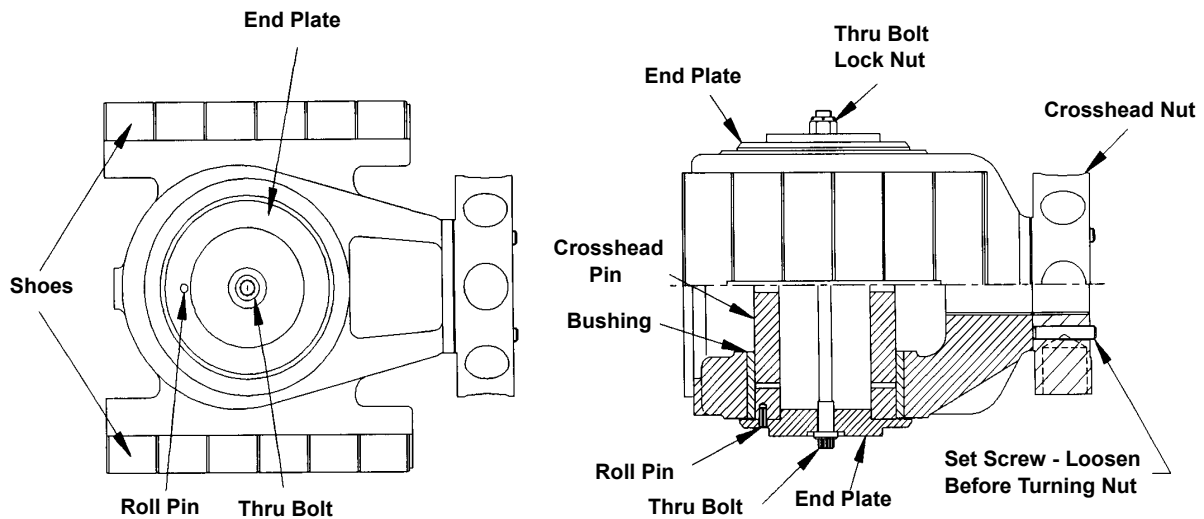


FIGURE 5-2: CROSSHEAD - TYPICAL



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 1-4 FOR LOCATION.)

 CAUTION

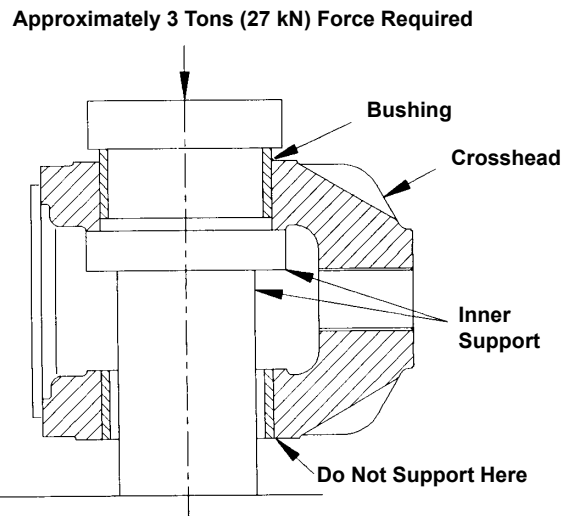
CROSSHEADS ARE HEAVY. CARE MUST BE TAKEN WHEN HANDLING TO AVOID PERSONAL INJURY. THE WEIGHT OF EACH CROSSHEAD IS LISTED IN THE BALANCE SHEET THAT COMES IN THE MANUAL WITH EACH COMPRESSOR.

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.
3. Use the Piston Nut Spanner (Torquing Adaptor) shown in Figure 7-1: 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 1-3 on page 1-9.) 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. Gray iron crossheads (JGW) and 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 CROSS-HEAD 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 lock-nut. Tighten the locknut to the torque value listed in Table 1-11.
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 Torquing Adaptor. 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 1-3 on page 1-9 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.
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.

Crankshaft - Removal

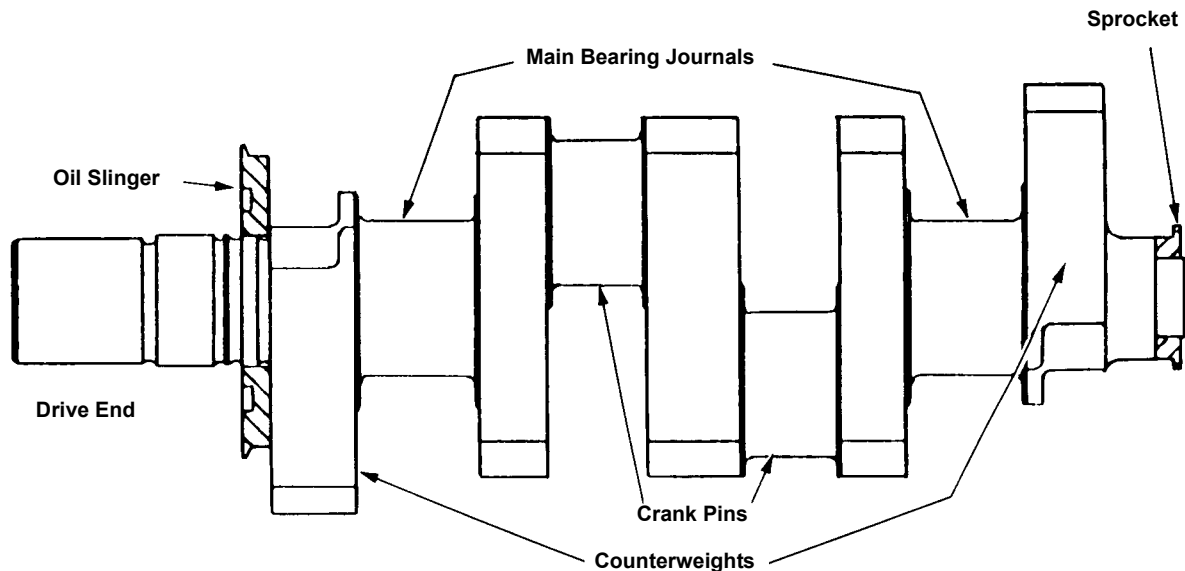
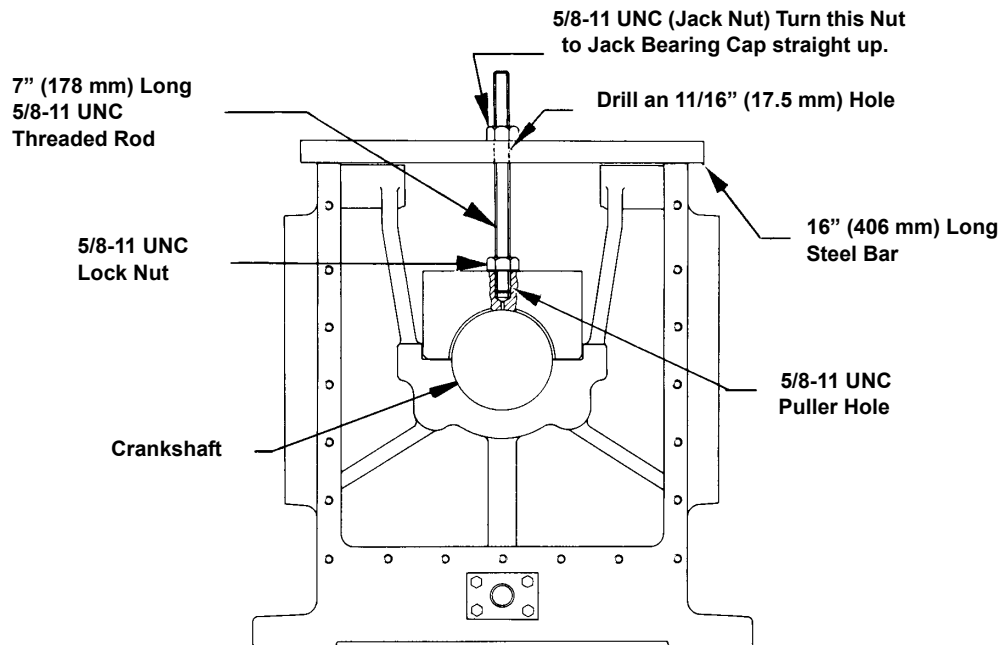


FIGURE 5-4: CRANKSHAFT WITH SLINGER AND SPROCKET - TYPICAL

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 (see Table 5-1). 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. (As with each operation, 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.

TABLE 5-1: APPROXIMATE WEIGHTS OF BARE CRANKSHAFTS

NUMBER OF THROWS	POUNDS (kg)
2	210 (95)
4	450 (200)
6	950 (430)

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 "Crankshaft - Removal" 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.

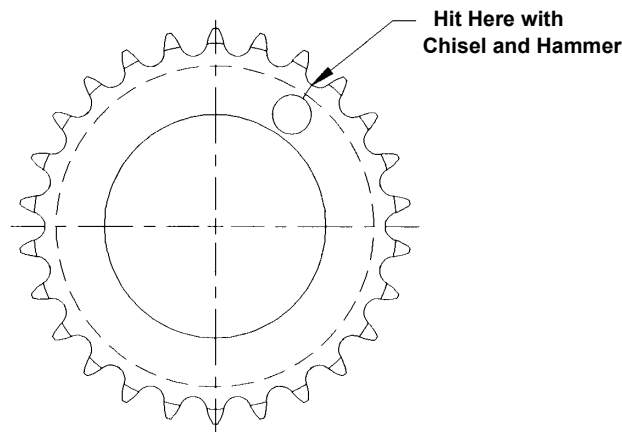


FIGURE 5-6: CRANKSHAFT - CHAIN SPROCKET

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.

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.

NOTE: CRANK PIN BEARINGS AND MAIN BEARINGS ARE NO LONGER FUNCTIONALLY INTERCHANGABLE. CRANK PIN (CONNECTING ROD) BEARINGS HAVE A NARROWER GROOVE. DO NOT PUT A CRANK PIN BEARING IN A MAIN BEARING LOCATION.

Crankshaft - Installation

1. Move the connecting rods to their full outer position. While the crankshaft is being lowered very slowly into the crankcase (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 1-11 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 1-3 on page 1-9. 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.
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.

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, thrust plates), 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 auxiliary 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).

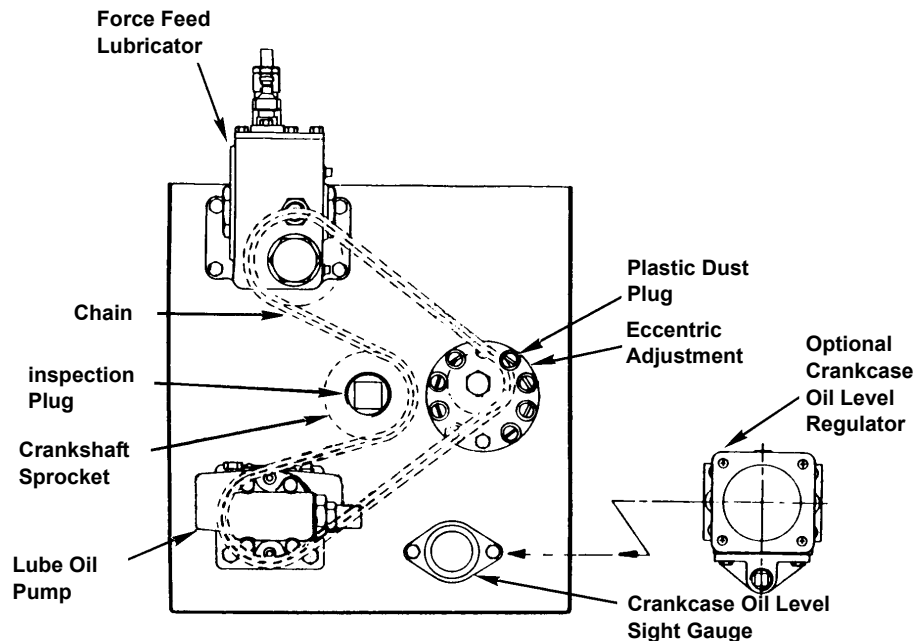


FIGURE 5-7: CHAIN DRIVE SYSTEM - TYPICAL

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 to the recommended torque shown in Table 1-11 on page 1-15, 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 5-2. 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 5-2: CHAIN DEFLECTION LIMITS

COMPRESSOR MODEL	DEFLECTION LIMITS FORCE FEED LUBRICATOR TO IDLER, INCHES (mm)
JGW, JGR & JGJ - 2 Throw	0.065 to 0.109 (1.65 to 2.77)
JGW, JGR & JGJ - 4 Throw	0.068 to 0.114 (1.73 to 2.90)
JGJ - 6 Throw	0.053 to 0.088 (1.35 to 2.24)

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 5.084 inches (129.1 mm) for 1/2 pitch, the chain should be replaced. Any sprocket showing any undercutting should be replaced.

Eccentric Vernier - Chain Idler Sprocket Replacement (Self-Align Sprocket)

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. 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.
4. Reassemble all parts using a new capscrew, Stat-O-Seal washer, sprocket, and locknut. Tighten the idler locknut to the recommended torque shown in Table 1-11 on page 1-15.
5. Install the assembly on the end cover.
6. 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.

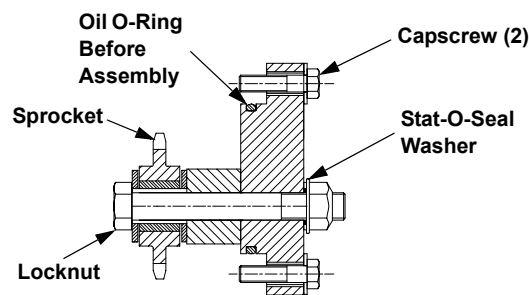


FIGURE 5-8: ECCENTRIC VERNIER - CHAIN IDLER SPROCKET (SELF-ALIGNING SPROCKET) - TYPICAL

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-throw units or a square 3/16 x 1 inches (4.8 x 25 mm) long for 4 and 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.

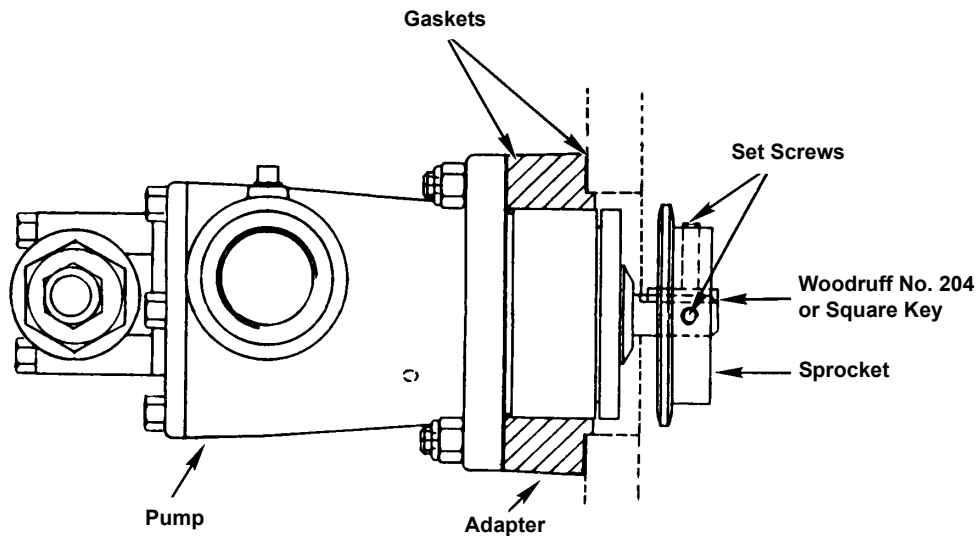


FIGURE 5-9: LUBE OIL PUMP AND SPROCKET - TYPICAL

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.

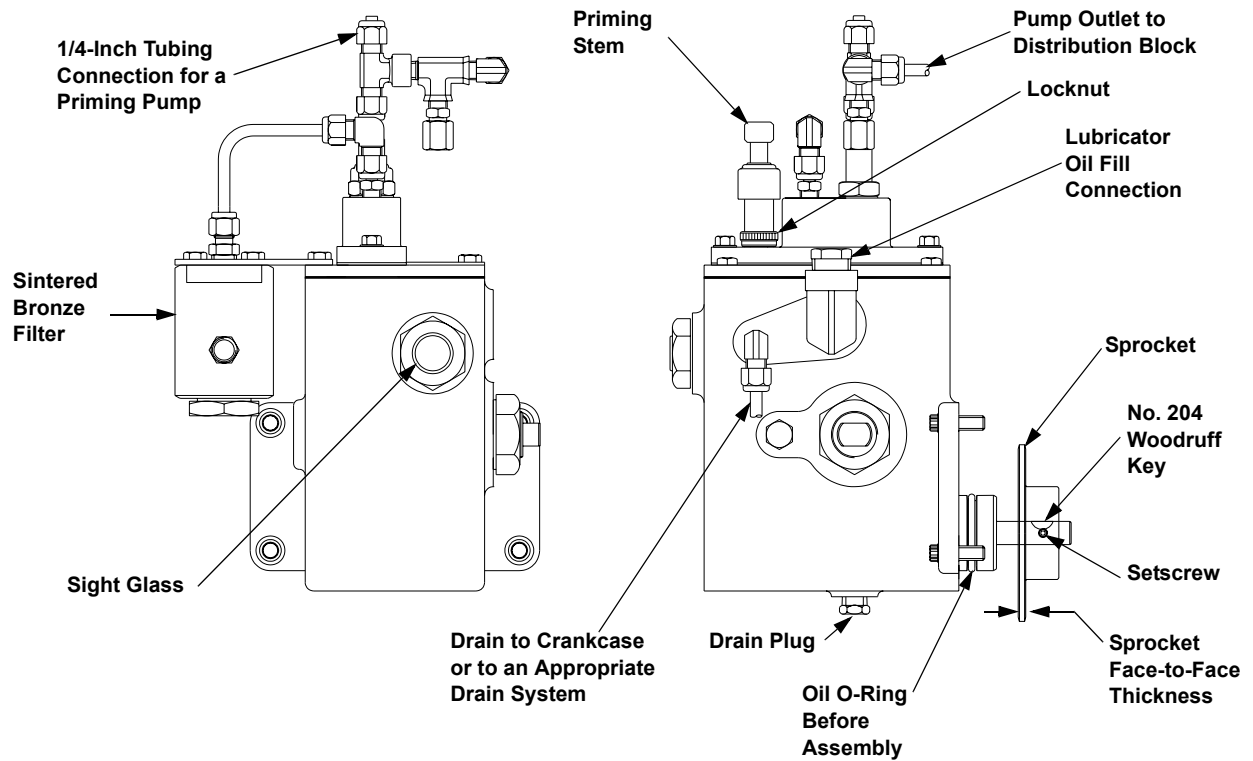


FIGURE 5-10: FORCE FEED LUBRICATOR AND SPROCKET - TYPICAL

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). 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 Ratchet Extension Support to screw the piston and rod assembly out of the crosshead. Refer to Figure 5-11: on page 5-19. 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 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.

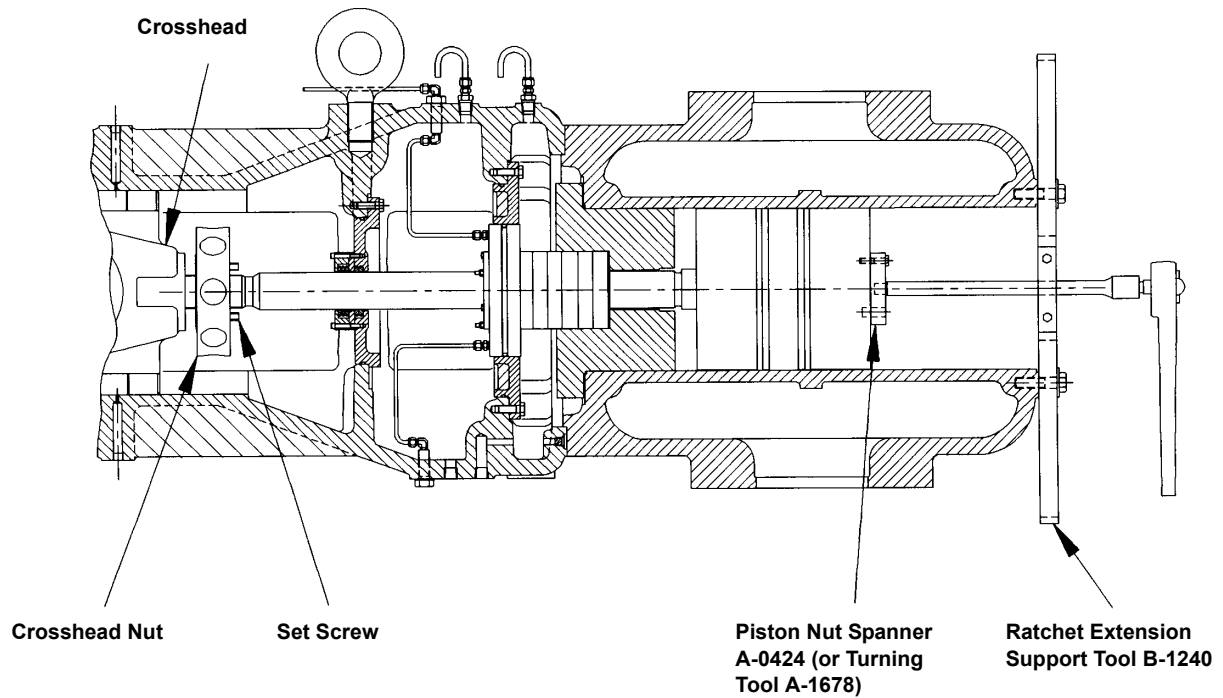
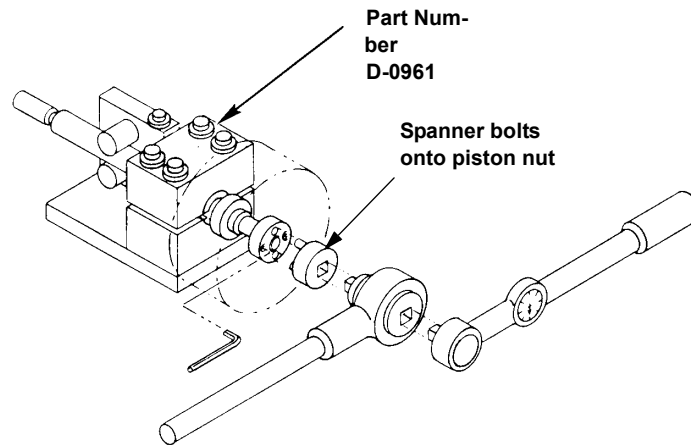


FIGURE 5-11: PISTON AND ROD REMOVAL AND INSTALLATION

Piston and Rod - Disassembly and Reassembly

Disassembly

The Piston and Rod Clamping Fixture shown in Figure 5-12: on page 5-20 will be useful for the piston and rod disassembly and reassembly operations. This fixture may be purchased from Ariel.

**FIGURE 5-12: PISTON AND ROD CLAMPING FIXTURE**

1. Clamp the piston and rod assembly in the special Clamping Fixture (D-0961), using the bushing for a 1-1/2" rod size (see Figure 5-12:). 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 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 5-24 and "Determining Wear Band Wear:" on page 5-24). Replace piston rings and wear bands as required.
5. Assemble the piston, rod, collar and nut by hand.
6. Secure the piston rod in Torque Fixture D-0961. Tighten the piston nut to the recommended torque in Table 1-11 on page 1-15. It may be necessary to use a torque multiplier to achieve the required torque.
7. Install the set screws and prick-punch the piston nut to lock them in place.
8. The set screws should be so tight that the Allen Wrench is slightly deformed (twisted) after tightening.

NOTE: ONE END OF SINGLE PIECE PISTONS ARE MACHINED 0.002" (0.050 mm) UNDERSIZE ACROSS A 3/4 INCH (20 mm) WIDE BAND FOR MANUFACTURING PURPOSES. THIS IS THE HEAD END OF THE PISTON.

Piston and Rod - Installation

1. Install the piston/rod assembly with piston rings and wear band 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.
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 1-3 on page 1-9. Insert a feeler gage, equal to the required crank end clearance, thru the discharge valve pocket. Use the tools illustrated in Figure 5-11: on Page 5-19 to screw the piston rod into the crosshead until piston is snug against the feeler gage. 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 1-11 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 1-3 on page 1-9. 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 1-11 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 1-11 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 “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 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 5-3 to record readings. Bar over crankshaft by hand and record readings at mid-stroke and with piston at the head end.

TABLE 5-3: 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 5-4.

TABLE 5-4: MAXIMUM ACCEPTABLE PISTON ROD RUN OUT READINGS

DIRECTION	JGW & JGR		JGJ	
	INCHES	(mm)	INCHES	(mm)
Vertical	0.0015	(0.038)	0.0010	(0.025)
Horizontal	0.0010	(0.025)	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) for JGJ Models and (-)0.004 inches (0.10 mm) for JGW & JGR Models. 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

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

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 5-5 and record calculations and readings.

TABLE 5-5: 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 JGJ	Line 2 - 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)	- 0.003" (-0.08 mm)
4 JGW & JGR	Line 2 - 0.004" (-0.10 mm)	- 0.004" (-0.10 mm)	- 0.004" (-0.10 mm)	- 0.004" (-0.10 mm)	- 0.004" (-0.10 mm)	- 0.004" (-0.10 mm)	- 0.004" (-0.10 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 JGW, JGR and JGJ cylinders use one-piece angle cut filled Teflon piston rings, excepting tandem cylinders which use stepped seal-joint piston rings and very small cylinders which use two-piece rings. Seal-joint rings are available for double acting cylinders. Refer to Figure 5-13:.

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 5-13: 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 1-7 on page 1-11, Table 1-8 on page 1-12 or Table 1-9 on page 1-13 for new end gap dimensions.)

Removal:

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

Wear Bands

All RJ/HJ 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, 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 one-piece 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 5-21.

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 crankend 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 unstacked. 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. Ariel supplies four parts books with each unit. 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 "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 5-21.
12. After the crosshead nut has been tightened, tighten the rod packing bolts evenly to the recommended torque in Table 1-11 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" on Page 4-18 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 0.030 to 0.036 inches (0.76 to 0.91 mm) for PEEK material and 0.015 to 0.021 inches (0.38 to 0.53 mm) for bronze and cast iron materials. 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 5-14:.

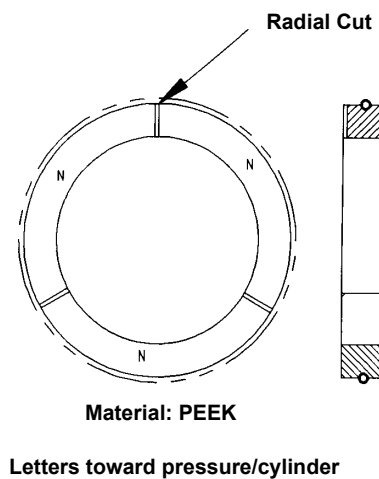


FIGURE 5-14: TYPE "P" PRESSURE BREAKER

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 with an installed total end gap of 0.078 to 0.109 inches (1.98 to 2.77 mm) for Teflon material and 0.156 to 0.187 inches (3.96 to 4.75 mm) for bronze, Polyimide and PEEK materials. The second ring is a tangentially step cut ring and is also made of Teflon. 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 5-15:

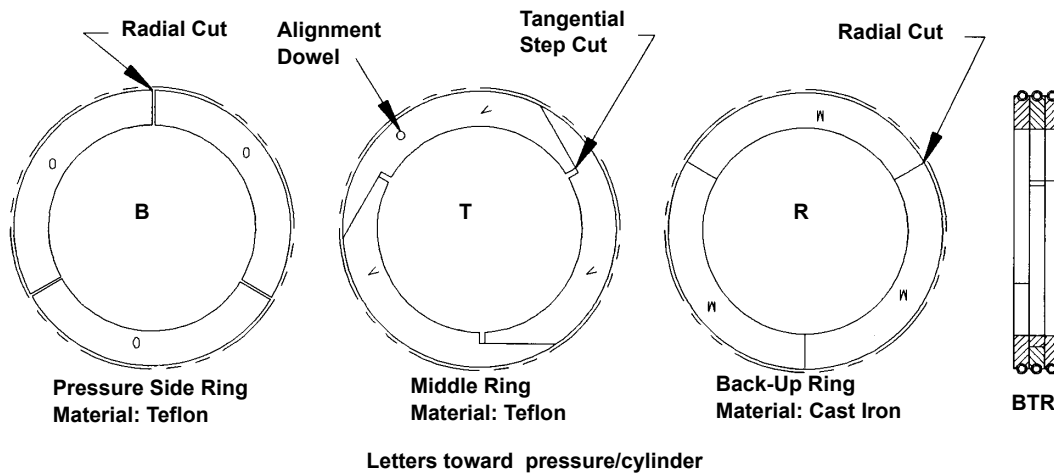


FIGURE 5-15: TYPE "BTR" SINGLE ACTING SEAL SET

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 0.078 to 0.109 inches (1.98 to 2.77 mm) for Teflon material and 0.156 to 0.187 inches (3.96 to 4.75 mm) for bronze, Polyimide and PEEK materials. 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:

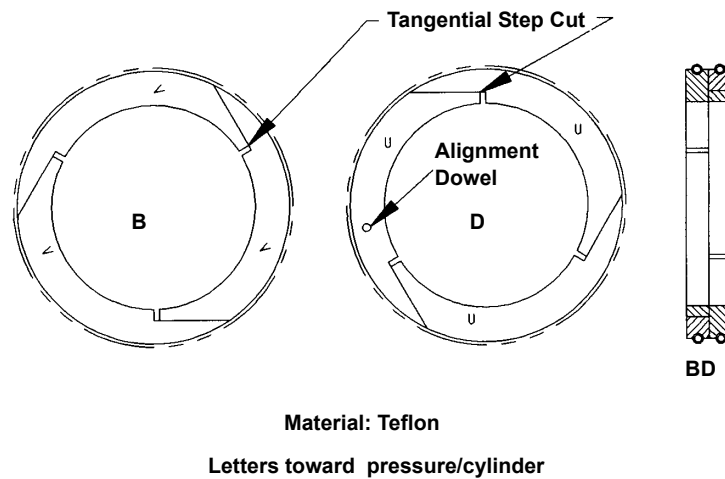


FIGURE 5-16: TYPE "BD" DOUBLE ACTING

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:

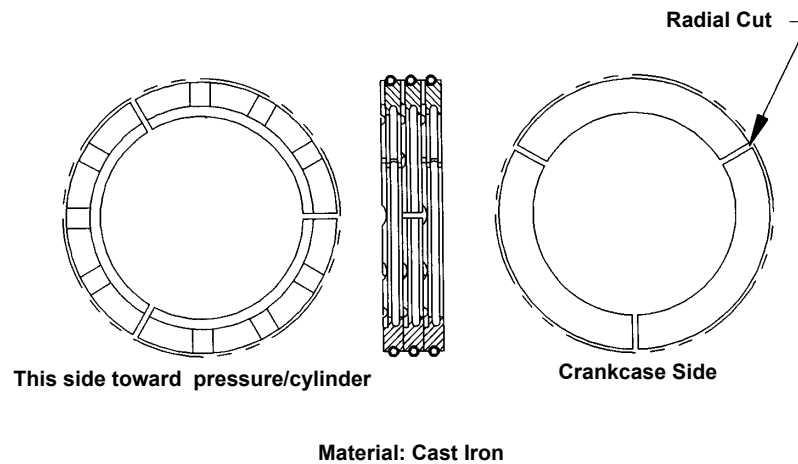
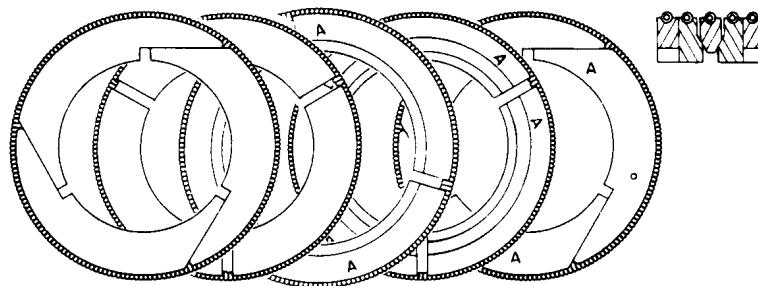


FIGURE 5-17: TYPE "3RWS" WIPER SET

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 installed total end gap is 0.078 to 0.109 inches (1.98 to 2.77 mm). 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. This ring set is designed for gas purge applications. See Figure 5-18:.



Material: Teflon

FIGURE 5-18: TYPE “AL” DOUBLE ACTING

Typical Arrangement of Piston Rod Packing Rings

Ariel supplies JGW, JGR and JGJ packings in two pressure ranges. The general arrangement of the oil supply, seal ring and vent locations is shown below:

Pressure Side	Pressure Breaker Ring	Oil Supply	3-Single Seal Ring Sets	Primary Vent	Double Seal Ring Set	Wiper Set	Crankcase Side
	1-Single Seal Ring Set						

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 4-27 FOR PACKING TUBING AND DISTANCE PIECE VENTING AND page 4-28 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 1-4 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 5-19: on Page 5-34.
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 2R-FS-HE and 2RJ-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 1-11 on page 1-15. See "Bolt Tightening for Valve Caps" on page 5-34. 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.

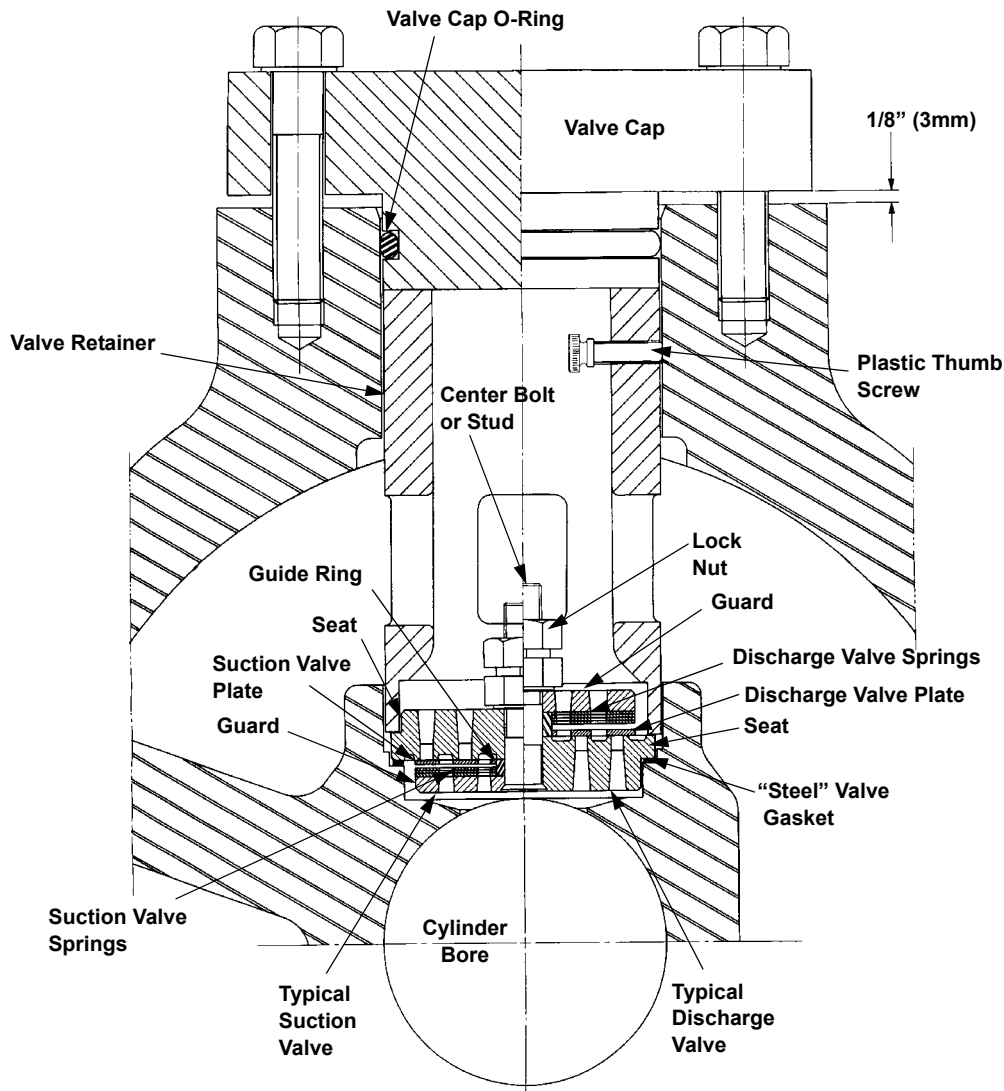


FIGURE 5-19: TYPICAL VALVE ASSEMBLIES

Bolt Tightening for Valve Caps

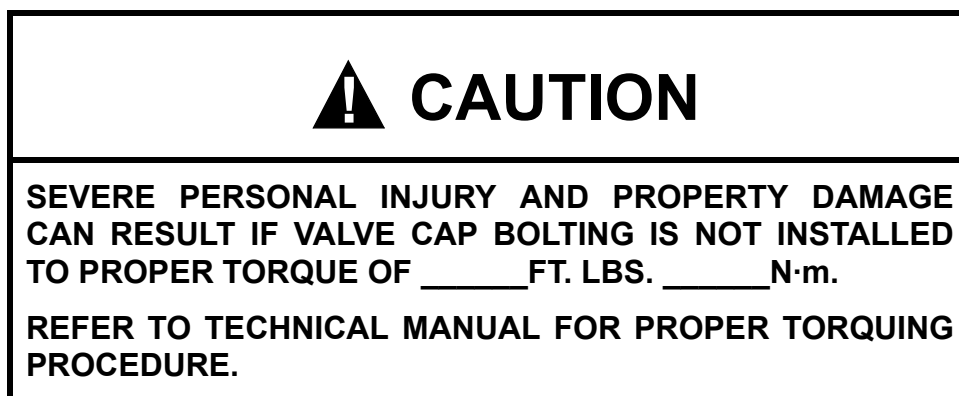
Proper fastener tightening technique is essential for sealing of valve caps with soft metallic wire gaskets used in some high pressure cylinders. It is important to draw up bolting to full torque in even and gradual steps. Do not allow the valve cap to be tightened with bias on one bolt or to become 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 gaskets) and valve retainer, in the valve pocket. See "Valves - Reassembly" on page 5-33. 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 5-20: 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:



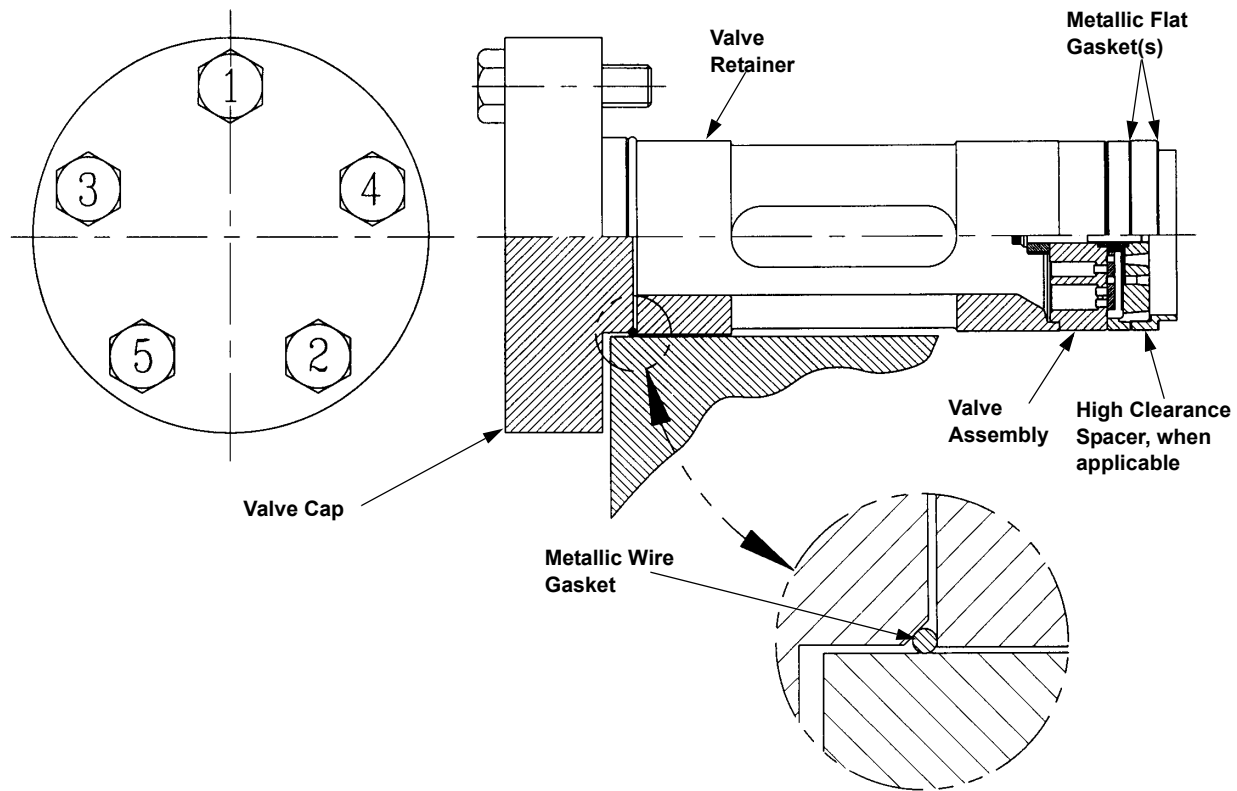


FIGURE 5-20: HIGH PRESSURE VALVE CAP ASSEMBLY

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 1-11 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 1-3 on page 1-9 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.

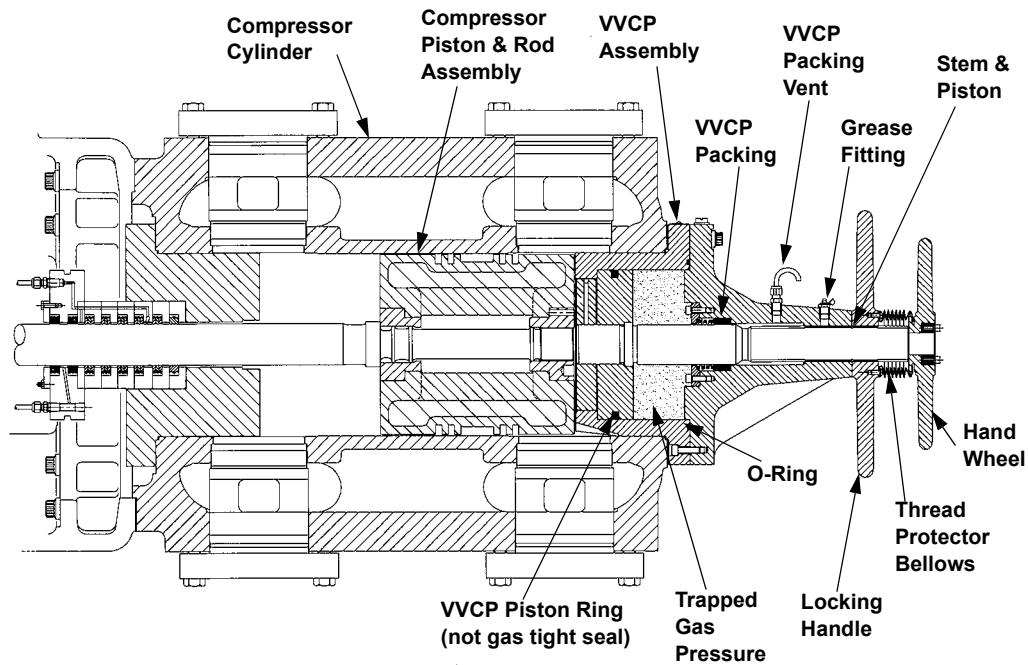


FIGURE 5-21: CYLINDER WITH VVCP - TYPICAL

Water-Cooled Compressor Rod Packing

When any disassembly of (optional) water-cooled rod packing cases is required from the as supplied - as received condition from the manufacturer, 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 Figure 1-11 on page 1-15. Using fingers, make sure that all rings move freely, radially, in their grooves. Side loaded WAT and 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) compressed air pressure to the "Coolant In" connection>
- 3 Submerge the pressurized case in a tank of oil (use water for non-lube cylinders).
- 4 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.

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. 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 5-39, using water instead of oil for testing. 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.

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 and Fax Numbers" on page 7-9) for preservation instructions to ER-34.

NOTES

SECTION 6 - TECHNICAL ASSISTANCE

Recommended Maintenance Intervals

For latest available Recommended Maintenance Intervals, see ER-8.2 at www.arielcorp.com.

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

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 Figure 4-9: on page 4-20).

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 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. Check fluid level in damper (if applicable).
8. 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.
9. For cylinders rated greater than 3500 psi (24 000 kPa), inspect piston ring end gap. Replace rings that are outside the maximum limits listed in Table 1-7, Table 1-8, Table 1-9 and Table 1-10.

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 1-3 on page 1-9, replace the affected bearings.
2. Check crosshead guide clearance with feelers, and if outside the limits listed in Table 1-3 on page 1-9, 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 1-12 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 (0.001m/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 rings that are outside the maximum limit listed in Table 1-7, Table 1-8, Table 1-9 and Table 1-10.
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 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 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.
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.

Problem	Possible Causes
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.
Piston Rod Oil Wiper Leaks	- Worn wiper rings. - Wipers incorrectly assembled. - Worn/scored rod. - Improper fit of rings to rod/side clearance.

NOTES

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 1" Diameter (A-0324)
- Open End Wrench for Hex Crosshead Nuts 3" (C-0195)
- 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)
- 5/8" x 3/4" UNF Valve Tool for Installing or Removing Valves (A-0626)
- Valve Tool for Installing or Removing 'CT' Valves (A-2289)
- Piston Nut Spanner for 3/4" Square Drive Ratchet (A-0424)
- Piston Turning Tool for 9/16" socket (A-1678) provided with small tandem cylinders only
- 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: 1/8", 5/32", 3/16", 1/4", 3/8" & 1/2"

Ariel Optional Tools

- Piston and Rod Clamping Fixture (D-0961) (see Figure 5-12: on page 5-20)
- Force Feed Lubricator Bearing Housing Spanner Wrench (A-8158)
- Force Feed Lubrication Hand Purge Pump (G-7162)
- Piston Rod Entering Sleeve (A-8560)

Minimum Hand Tools Required

The following hand tools are normally all that is required to work on Ariel JGW, JGR and JGJ 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.

- 1/2" Square Drive Ratchet Wrench
- 2" and 6" Extensions for above Ratchet
- 1/2" Square Drive Breaker Bar
- 1/2" Drive Speed Wrench
- 1/2" Female x 3/4" Male Adaptors
- 1/2" 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)
- 3/4" Square Drive Torque Wrench (to 1590 LB-FT)
- 5/16", 3/8", 7/16", 1/2", 9/16", 3/4", 5/8" and 15/16" 12 Point Sockets for a 1/2" Square Drive Ratchet Wrench
- 1/2" 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
- 7/8" x 15/16" Open End Wrench
- 2 - Medium Size Screw Drivers
- Bobbitt or Plastic-Faced Slugging Hammer
- Set of 3/8" 12 Point Drive Sockets
- 3/8" Square Drive Ratchet Wrench

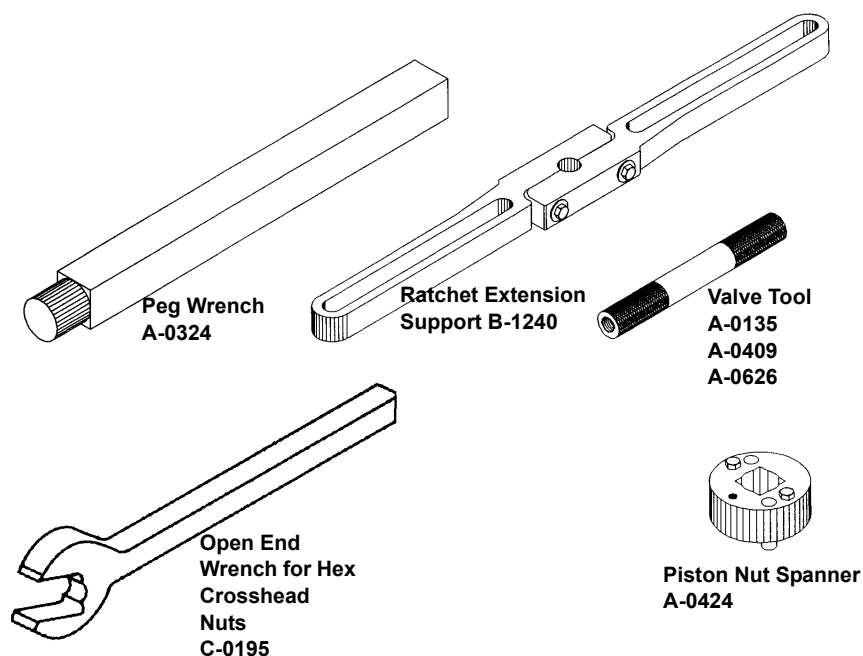


FIGURE 7-1: ARIEL TOOLS

Terms, Abbreviations¹ and Conversion to SI Metric²

Area

in^2 or square inch $\times 0.00064516 = \text{meter}^2$, or m^2

in^2 or square inch $\times 6.4516 = \text{centimeter}^2$, or cm^2

Flow - Gas

MMSCFD or million standard cubic feet per day (at 14.696 psia & 60°F) $\times 0.310 = \text{normal meter}^3/\text{second}$ (at 1.01325 bar & 0°C), or m_n^3/s

SCFM or standard cubic feet per minute (at 14.696 psia & 60°F) $\times 1.607 = \text{normal meter}^3/\text{hour}$ (at 1.01325 bar & 0°C), or m_n^3/h

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.

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

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

1. Horsepower based on 550 ft-lb/sec

2. G suffix (PSIG) indicates gauge pressure, A indicates absolute

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. $(^{\circ}\text{F} - 32)/1.8 = \text{degrees Celsius, or } ^{\circ}\text{C}$

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) = mm^2/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
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
CO ₂	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 SUBMULTIPLE 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	μ

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 News-letters)

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, and copies may be obtained from the Packager or from Ariel.

Ariel Telephone and Fax Numbers

Switchboard	740-397-0311	Weekdays 8 am - 5 pm Eastern Time, except holidays
General Fax	740-397-3856	
Field Service	740-393-5052	Emergency from 5 pm - 8 am, weekends and holidays
Spare Parts ¹	740-397-3602	For all calls to Spare Parts Group, day or night
Spare Parts Fax	740-393-5054	

The after hours system works as follows:

1. Dial number.
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. The call will be immediately forwarded to a responsible individual, who will return the call as soon as possible.

1. User's must order all parts thru Authorized Distributors.

NOTES

**ARIEL CORPORATION**
Recommended Spares Start-Up

Wed Sep 15 17:42:16 EDT 2010

F28585**Project:**

QTY	Part Number	Description	Your Price	Net Amount
JGJ FRAME CLASS				
1	C-0159	GSKT,RET,27-1/2 X15-1/8X1/32	\$0.0000	\$0.00
2	B-0419	GSKT,RET,12-1/4 X 8-1/8X1/32	\$0.0000	\$0.00
1	A-0661	LO FILTER ELEMENT,SPIN-ON	\$0.0000	\$0.00
4	A-0124	BLOW-OUT DISC,3250 PSIG,PURPLE	\$0.0000	\$0.00
1	A-3689	CHECK VALVE,1/8M X 1/8F,PPT,SS	\$0.0000	\$0.00
			Sub Total	\$0.00
			Start-Up Grand Total	\$0.00



ARIEL CORPORATION Recommended Spares Consumables

Wed Sep 15 17:42:16 EDT 2010

F28585

Project:

QTY	Part Number	Description	Your Price	Net Amount
JGJ FRAME CLASS				
1	C-0159	GSKT,RET,27-1/2 X15-1/8X1/32	\$0.0000	\$0.00
4	B-0419	GSKT,RET,12-1/4 X 8-1/8X1/32	\$0.0000	\$0.00
2	A-3780	CHK.VLV,DOU.BALL SOFT SEAT SS	\$0.0000	\$0.00
1	A-8723-K	FILTER KIT, LUBRICATOR 150 MIC	\$0.0000	\$0.00
1	A-9477	FF LUBR PUMP 1/4 PREMIER	\$0.0000	\$0.00
2	A-0661	LO FILTER ELEMENT,SPIN-ON	\$0.0000	\$0.00
4	A-0124	BLOW-OUT DISC,3250 PSIG,PURPLE	\$0.0000	\$0.00
1	A-0080	BLOW-OUT ASSY,SPECIFY DISC.	\$0.0000	\$0.00
3	A-3689	CHECK VALVE,1/8M X 1/8F,PPT,SS	\$0.0000	\$0.00
Sub Total				\$0.00
Consumables Grand Total				\$0.00



ARIEL CORPORATION Recommended Spares Insurance

Wed Sep 15 17:42:16 EDT 2010

F28585

Project:

QTY	Part Number	Description	Your Price	Net Amount
JGJ FRAME CLASS				
2	FP0500FE	DOWEL PIN, 1/4 X 3/4 +.0002	\$0.0000	\$0.00
1	A-0421	CHAIN,35-1 X 122	\$0.0000	\$0.00
13	FW0500GA	FLAT WASHER, 1/2 SAE	\$0.0000	\$0.00
2	B-0300	BUSHING,BZ,ROD,JGR:W:J:ACF	\$0.0000	\$0.00
4	B-2112	SLEEVE BRG,H/S,ROD,R:W:J:ACF	\$0.0000	\$0.00
1	A-0412	GSKT,RND,7-3/4X1/32	\$0.0000	\$0.00
2	B-0298	GSKT,RET,16-25/32X15-1/16X32	\$0.0000	\$0.00
1	C-0159	GSKT,RET,27-1/2 X15-1/8X1/32	\$0.0000	\$0.00
4	FP0512EF	THD.TAPER PIN,#4 X 1"LG	\$0.0000	\$0.00
4	FP0512FH	THD.TAPER PIN,#5 X 1-1/2LG	\$0.0000	\$0.00
1	A-0245-A	DUST SEAL,TFE,JGW:R:J	\$0.0000	\$0.00
2	B-0304	THRUST PLATE,BZ,JGR:W:J	\$0.0000	\$0.00
4	B-0245	SLEEVE BRG,H/S,MAIN,R:W:J:ACF	\$0.0000	\$0.00
2	A-12036	SEAL,DUST/OIL,1.625 SHAFT DIA	\$0.0000	\$0.00
6	B-0301	BUSHING,BZ,XHD,R:J:ACF	\$0.0000	\$0.00
1	A-0419	12 PT,7/16-20 X 7 LG	\$0.0000	\$0.00
2	FN0467FA	SELF-LOCK NUT,FLEXLOC,7/16-20	\$0.0000	\$0.00
1	B-0332	CROSSHEAD PIN,JGR:W:J	\$0.0000	\$0.00
2	A-3763	CHK VLV,1/8MX1/8F,SS,PPT/14PSI	\$0.0000	\$0.00
1	A-0077	SIGHT GLASS,1" NPT	\$0.0000	\$0.00
1	A-5641	SIGHT GLASS,3/4" NPT	\$0.0000	\$0.00
1	A-9477	FF LUBR PUMP 1/4 PREMIER	\$0.0000	\$0.00
1	A-0115	GSKT,SQR,4 X 4 X 1/32	\$0.0000	\$0.00
2	A-0261	GAUGE,100PSI,1/4NPT,BOTT MOUNT	\$0.0000	\$0.00
1	A-8727	GAUGE, 3000 PSI, BACK MOUNT	\$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
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ARIEL CORPORATION
Recommended Spares Start-Up

Wed Jul 7 14:43:49 EDT 2010

C116875, C116876
U78900, U78901
Project:

QTY	Part Number	Description	Your Price	Net Amount
CYL ASSY, 7-3/8R:RJ,STD 845				
2	A-0614	STL GASKET, 7.813 X 7.500 X 60	\$0.0000	\$0.00
2	A-0145	THUMB SCREW,NYLON,1/4-20 X 3/4	\$0.0000	\$0.00
2	A-0617	STL GASKET, 3.930 X 3.734 X 30	\$0.0000	\$0.00
2	A-0026	O-RING,VT, 3.895 O.D. X .210	\$0.0000	\$0.00
1	B-5401-N	DIS VLV, 88CRE, PKX	Call Ariel	Call Ariel
1	B-5404-N	SUC VLV, 88CRE,PKX	Call Ariel	Call Ariel
Sub Total				\$0.00
VVCP, 7-3/8R:RJ:ET				
1	A-0614	STL GASKET, 7.813 X 7.500 X 60	\$0.0000	\$0.00
1	A-0032	O-RING,VT, 7.145 O.D. X .210	\$0.0000	\$0.00
Sub Total				\$0.00
CYL ASSY, 6 R:RJ,STD 1270				
2	A-0604	STL GASKET, 6.813 X 6.500 X 60	\$0.0000	\$0.00
2	A-0145	THUMB SCREW,NYLON,1/4-20 X 3/4	\$0.0000	\$0.00
2	A-0603	STL GASKET, 3.220 X 3.024 X 30	\$0.0000	\$0.00
2	A-0038	O-RING,VT, 3.270 O.D. X .210	\$0.0000	\$0.00
1	B-5079-P	DIS VLV, 70CRE,PKX	\$0.0000	\$0.00
1	B-5080-N	SUC VLV, 70CRE,PKX	\$0.0000	\$0.00
Sub Total				\$0.00
VVCP, 6 R:RJ:ET-HP				
1	A-0604	STL GASKET, 6.813 X 6.500 X 60	\$0.0000	\$0.00
1	A-0724	O-RING,VT, 6.645 O.D. X .210	\$0.0000	\$0.00
Sub Total				\$0.00
Start-Up Grand Total				\$0.00


ARIEL CORPORATION
Recommended Spares Consumables

Wed Jul 7 14:43:49 EDT 2010

C116875, C116876
U78900, U78901
Project:

QTY	Part Number	Description	Your Price	Net Amount
CYL ASSY, 7-3/8R:RJ,STD 845				
2	A-0614	STL GASKET, 7.813 X 7.500 X 60	\$0.0000	\$0.00
2	A-3780	CHK.VLV,DOU.BALL SOFT SEAT SS	\$0.0000	\$0.00
3	A-0616	PISTON RING, 7-3/8R:H:RJ:RJ-CE	\$0.0000	\$0.00
1	B-1683-K	RBLD KIT,PIST ROD PKG,1.500	\$0.0000	\$0.00
1	A-3000	WEAR BAND, 7-3/8RJ:RJ-CE,.75W	\$0.0000	\$0.00
1	A-15469-A	DIS VLV SEAT ASSY, 88CRE	\$0.0000	\$0.00
4	KB-5401-N	KIT,VLV, 88CRE, PKX	Call Ariel	Call Ariel
8	A-1368	LOCKNUT, DRAKE 1/2-20	\$0.0000	\$0.00
16	A-15475	GUIDE RING,88CRE,.173 THK	\$0.0000	\$0.00
1	A-15474	SUC VLV SEAT, 88CRE	\$0.0000	\$0.00
4	KB-5404-N	KIT,VLV, 88CRE,PKX	Call Ariel	Call Ariel
1	A-9478	FF LUBR PUMP 3/8 PREMIER	\$0.0000	\$0.00
			Sub Total	\$0.00
VVCP, 7-3/8R:RJ:ET				
1	A-0614	STL GASKET, 7.813 X 7.500 X 60	\$0.0000	\$0.00
1	A-0032	O-RING,VT, 7.145 O.D. X .210	\$0.0000	\$0.00
			Sub Total	\$0.00
CYL ASSY, 6 R:RJ,STD 1270				
2	A-0604	STL GASKET, 6.813 X 6.500 X 60	\$0.0000	\$0.00
2	A-3780	CHK.VLV,DOU.BALL SOFT SEAT SS	\$0.0000	\$0.00
4	A-0584	PISTON RING, 6R:H:RJ	\$0.0000	\$0.00
1	B-1683-K	RBLD KIT,PIST ROD PKG,1.500	\$0.0000	\$0.00
1	A-2996	WEAR BAND, 6 RJ:RJ-CE,75W	\$0.0000	\$0.00
8	A-1735	GUIDE RING,70RX,.205 THK	\$0.0000	\$0.00
1	A-13980-A	DIS VLV SEAT ASSY, 70CRE	\$0.0000	\$0.00
4	KB-5079-P	KIT,VLV, 70CRE,PKX	\$0.0000	\$0.00
8	A-1367	LOCKNUT, DRAKE 3/8-24	\$0.0000	\$0.00
8	A-15442	GUIDE RING,70RX,.213 THK	\$0.0000	\$0.00
1	A-13977	SUC VLV SEAT, 70CRE	\$0.0000	\$0.00
4	KB-5080-N	KIT,VLV, 70CRE,PKX	\$0.0000	\$0.00
			Sub Total	\$0.00
VVCP, 6 R:RJ:ET-HP				
1	A-0604	STL GASKET, 6.813 X 6.500 X 60	\$0.0000	\$0.00
1	A-0724	O-RING,VT, 6.645 O.D. X .210	\$0.0000	\$0.00

Sub Total	\$0.00
Consumables Grand Total	\$0.00


ARIEL CORPORATION
Recommended Spares Insurance

Wed Jul 7 14:43:49 EDT 2010

C116875, C116876
U78900, U78901
Project:

QTY	Part Number	Description	Your Price	Net Amount
CYL ASSY, 7-3/8R:RJ,STD 845				
2	B-3515	GSKT,RND,16, X 1/64, 16 HOLES	\$0.0000	\$0.00
2	FW0550ID	STAT-O-SEAL,VT,75DUR. 3/4 DIA	\$0.0000	\$0.00
1	B-1261	PISTON COLLAR, J:RJ:HJ:RJ-CE	\$0.0000	\$0.00
1	B-1260	PISTON NUT, JGJ:RJ:HJ:RJ-HE	\$0.0000	\$0.00
1	C-1177	P ROD, 3.50STK/25.512LG	\$0.0000	\$0.00
8	A-0145	THUMB SCREW,NYLON,1/4-20 X 3/4	\$0.0000	\$0.00
8	A-0617	STL GASKET, 3.930 X 3.734 X 30	\$0.0000	\$0.00
8	A-0026	O-RING,VT, 3.895 O.D. X .210	\$0.0000	\$0.00
1	A-16762	FF LUB PUMP GSKT,1/16 X DC100	\$0.0000	\$0.00
1	A-11295	FF.S/D,PRO-FLO,TRAB,SB	\$0.0000	\$0.00
1	A-9478	FF LUBR PUMP 3/8 PREMIER	\$0.0000	\$0.00
4	B-5401-N	DIS VLV, 88CRE, PKX	Call Ariel	Call Ariel
4	B-5404-N	SUC VLV, 88CRE,PKX	Call Ariel	Call Ariel
			Sub Total	\$0.00
VCVP, 7-3/8R:RJ:ET				
1	A-0641	BELLOWS, UNL.THREAD PROTECTOR	\$0.0000	\$0.00
1	A-0032	O-RING,VT, 7.145 O.D. X .210	\$0.0000	\$0.00
1	A-0639	V PACKING, UNL	\$0.0000	\$0.00
1	A-0752	UNL.PISTON RING, 5-1/2 O.D.	\$0.0000	\$0.00
			Sub Total	\$0.00
CYL ASSY, 6 R:RJ,STD 1270				
2	B-3515	GSKT,RND,16, X 1/64, 16 HOLES	\$0.0000	\$0.00
2	FW0550ID	STAT-O-SEAL,VT,75DUR. 3/4 DIA	\$0.0000	\$0.00
1	B-1261	PISTON COLLAR, J:RJ:HJ:RJ-CE	\$0.0000	\$0.00
1	B-1260	PISTON NUT, JGJ:RJ:HJ:RJ-HE	\$0.0000	\$0.00
1	C-1177	P ROD, 3.50STK/25.512LG	\$0.0000	\$0.00
8	A-0145	THUMB SCREW,NYLON,1/4-20 X 3/4	\$0.0000	\$0.00
8	A-0603	STL GASKET, 3.220 X 3.024 X 30	\$0.0000	\$0.00
8	A-0038	O-RING,VT, 3.270 O.D. X .210	\$0.0000	\$0.00
4	B-5079-P	DIS VLV, 70CRE,PKX	\$0.0000	\$0.00
4	B-5080-N	SUC VLV, 70CRE,PKX	\$0.0000	\$0.00
			Sub Total	\$0.00
VCVP, 6 R:RJ:ET-HP				
1	A-0641	BELLOWS, UNL.THREAD PROTECTOR	\$0.0000	\$0.00

1	A-0724	O-RING,VT, 6.645 O.D. X .210	\$0.0000	\$0.00
1	A-0639	V PACKING, UNL	\$0.0000	\$0.00
1	A-0751	UNL.PISTON RING, 5 O.D.	\$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
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Company: Enerflex Ltd.
 Order #: 54075 (AP020189)
 Case 13: Initial Condition

Ariel Compressor Balancing Record

Customer: Husky Oil Operations Ltd
 Inquiry:
 Project: 31833 & 31834



Balance By: **DENNIS PETHTEL**

Completed: 6/29/2010

Frame: **JGJ/2**

Existing
 Frame S/N: **F28585**

Operating RPM: **1800.0**
 Stroke, in: **3.50**

Parts Group	Throw #1		Throw #2									
	7.375RJ		6.000RJ									
	SN:	C116875	SN:	C116876								
	P/N	LB	P/N	LB								
Connecting Rod with Bushing, bolts and bearing shells	D-1152	40.15	D-1152	39.42								
		Existing		Existing								
Piston(s) with rings, rod, collar & nut or stub shaft	C-1199	56.98	C-1196	49.54								
	C-1177		C-1177									
Crosshead with bushings	D-0239	32.86	D-0240	45.39								
		Existing		Existing								
Crosshead nut with setscrews	B-0315	6.44	B-0314	2.44								
Total Recip Weight Max: 220.90	136.43		136.79									
Imbalance Max: 1.00	0.36											



Company: Enerflex Ltd.
Order #: 54075 (AP020189)
Case 12: Min

Ariel Lubrication Sheet

Customer: Husky Oil Operations Ltd
Inquiry:
Project: 31833 & 31834



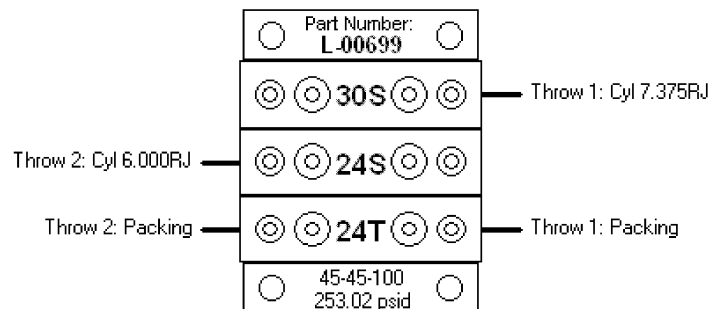
Frame: JGJ/2 Stroke, in: 3.50 Rod Dia, in: 1.500 Frame S/N: F28585
Gas Stream: Air or gas mixtures with >4% oxygen content

Throw	Cylinder Model	MAWP psig	Service	Stage #	Suct Press psig	Disch Press psig	Serial No.
1	7.375RJ	845.0	1	1	125.53	245.06	C116875
2	6.000RJ	1270.0	1	2	239.47	517.63	C116876

Applied Speed, RPM **1800**
Cycle Time at Applied Speed, sec **15.0** (see chart, lower right)
Break-In Cycle Time, sec **N/A** (For period of 200 hours)
Recommended lubricant (synthetic) for application and pressures Synthetic - Diester/Polyolester (minimum ISO 100)

Rupture Disc **Purple** 3250.00 psig, 0.250 in hole dia.
Lubricator Pump Diameter **3/8"** (0.3750 in)
Qty of Pumps feeding this block **1**
Recommended base feed rate **0.40** Pints/day/in of bore diameter

Throw 1, 2



Lube Point Description	Base Rate Multiplier	Recommended Pints/day	Delivered Pints/day	Del/ Rec
Throw 1: Cylinder 7.375RJ	4.00	11.80	11.97	101%
Throw 2: Cylinder 6.000RJ	4.00	9.60	9.58	100%
Throw 2: Packing	4.00	4.80	4.79	100%
Throw 1: Packing	4.00	4.80	4.79	100%

RPM	Cycle Time, sec		Pints/day	
	Normal	Break-In	Normal	Break-In
1800	15.0	15.0	31.1	31.1
1700	15.9	15.9	29.4	29.4
1600	16.9	16.9	27.6	27.6
1500	18.0	18.0	25.9	25.9
1400	19.3	19.3	24.2	24.2
1300	20.8	20.8	22.5	22.5
1200	22.5	22.5	20.7	20.7
1100	24.5	24.5	19.0	19.0
1000	27.0	27.0	17.3	17.3
900	30.0	30.0	15.6	15.6

****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.