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Saskatchewan

**Corrections and
Public Safety****Licensing and Inspections****Boiler & Pressure Vessel Safety**
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Monday, April 07, 2003

Waterflood Service & Sales Ltd.

Box 1490

Estevan, Saskatchewan S4A 2L7

**Our File** 32186[0V]**ATTENTION :** Brent Blackburn, P.Eng.

With reference to your submission respecting the registration of the item below, for legal use in the province, please note we have surveyed, approved and registered this design as noted.

VESSEL SERIAL # 03103502

MANUFACTURER :	Waterflood Service & Sales Ltd.	
ITEM :	DRAWING NUMBER :	CRN :
Oil Coalescing Vessel	600T0S-1-4 Rev 1	R2078.23

An invoice covering survey and registration fees will be forwarded from our Codes and Standards Compliance Office.

We wish to point out that every vessel must be constructed strictly in accordance with the registered design, CSA B-51, and the Saskatchewan Boiler and Pressure Vessel Act and associated regulations.

In addition to stamping every vessel with the registration number given above and as required in CSA Code B51, a Manufacturer's Data Report must be forwarded to this office immediately at the time a vessel is shipped. Such forms may be obtained upon request.

Sincerely,

John Gosselink

Codes and Standards Compliance

#327 Reg. of Design

REMARKS: CRN registered under reciprocal agreement.

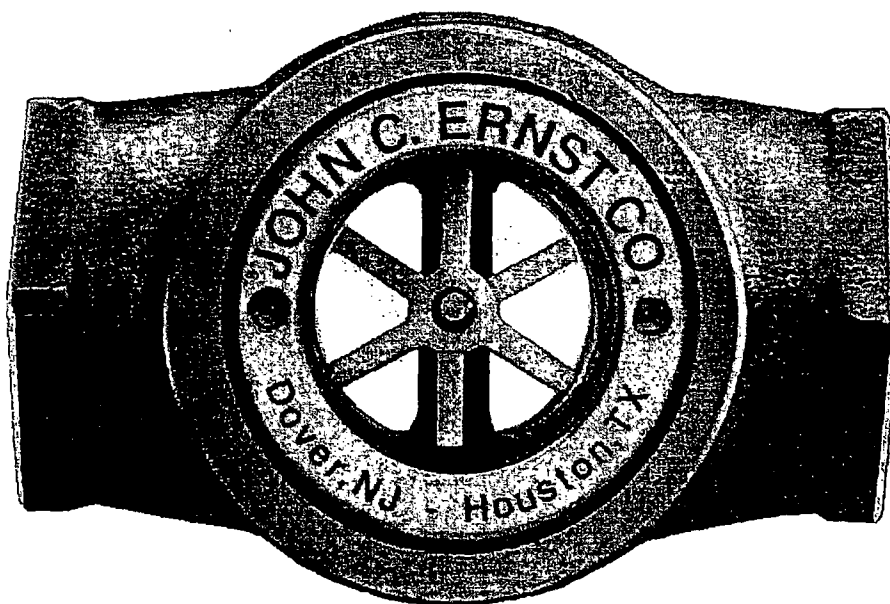
JOHN C. ERNST CO., INC. P.O. BOX 100 Dover, New Jersey 07802		Title: Sight Flow Indicator - Threaded Window IOM		Drawing No. E10024	Rev D
Date: 19-Jul-00	Dr. by: DMF	Size:	Tolerances, unless otherwise specified: Fraction Decimal Angle		
Scale: 3962-993	App. by: JCW	Sheet: 1 of 7			

Sight Flow Indicator

Threaded Window

Includes Model #'s

100	101	102	103
140	141	142	143
160	161	162	163
190	191	192	193



Installation/Operation/Maintenance Instructions

Installation/Operation/Maintenance Instructions For Sight Flow Indicator, Threaded Window

This manual has been prepared as an aid and guide for personnel involved in installation and maintenance. All instructions must be read and understood thoroughly before attempting any installation, operation and maintenance. All instructions must be read and understood thoroughly before attempting any installation, operation, or maintenance.

WARNING: Failure to follow instructions could result in a malfunction or breakage of the indicator, resulting in fluid escaping from the unit and fragmenting glass. Always wear safety glasses when installing, servicing or operating a sight flow indicator. Failure to follow precautions can result in personal injury and property damage.

I. INTRODUCTION:

John C. Ernst Co. Threaded Window Sight Flow Indicators have been designed to enhance the visibility of process media as they pass by the glass window. The glass window assists the operations manager by creating a window to the fluid process volumes, directions, and reactions without interrupting the process flow. The process flow stream can be monitored in many orientations with a variety of indication devices. John C. Ernst Co. models are available in a variety of materials and sizes.

At a glance, the Threaded Window sight Flow Indicators allow for monitoring of:

- Liquid interfaces - change in level or evidence of liquid in the viewing area
- Foam interfaces - change in level or evidence of foam in the viewing area
- Fluid movement - change in direction or volume
- Color - change in tint or hue
- Clarity - change in opacity, brightness or purity

A. System Description

The John C. Ernst Co. Threaded Window Sight Flow Indicator consists of four basic components. Each component may vary slightly, depending on the desired physical and mechanical properties for the indicator. Use the exploded parts view in Section 10 as additional reference material.

Body - the threaded style connector ends provide rigid in-line attachment capability for the Threaded Window Sight Flow Indicator. In addition, the body provides a flat, machined cavity in which the retaining ring compresses the cushion and glass.

Glass - the glass disk is in between the gaskets and cushions to provide a window for observation of the media through the body.

Gaskets - the gaskets are covers to tightly seal the gap between the body and to prevent leaks. Gaskets are standard with all 316 STS, which are Teflon®.

Covers - the covers provide a machined surface in which the glass and cushion are positively seated. The threaded cover provides an effective means of "screw" compressing the glass between the cushions, gasket and body on either side of the sight flow indicator.

II. Available Models:

John C. Ernst Co. offers five standard Threaded Window Sight Flow Indicator models. Standard materials of construction are ductile iron, bronze, carbon steel and 316 STS. Threaded Window Sight Flow Indicators are divided into the following models:

TABLE 1 - Model Numbers

Carbon Steel	Bronze	Stainless Steel	Iron	Description (NPT)
100	140	160	190	Plain
101	141	161	191	Rotator
102	142	162	192	Flapper
103	143	163	193	Drip Tube

Covers are available in brass and 316 stainless steel. Spanner wrenches for retaining cover removal, installation, and torquing are available from John C. Ernst Co.

A. Indicator Pressure and Temperature Specifications

WARNING: Exceeding the design ratings or application's data limits can cause the glass to break, the unit to leak or sudden release of pressure. Do not exceed the design ratings for each particular unit. Failure to keep operations below design ratings may result in serious personal injury and property damage.

Maximum Design Ratings for Units with Tempered Glass

Body Material	Temp. Rating	Gasket Material						
		Teflon®	Asbestos	Grafoil®	Viton®	Kel-F®	Neoprene	Buna N
Iron	-20°F to 150°F	175	175	175	175	175	175	175
	At 250°F							150
	At 300°F						140	
	At 350°F	125	125	125	125	125		
Bronze	-20°F to 150°F	225	225	225	225	225	225	225
	At 250°F							205
	At 300°F						190	
	At 400°F	150	150	150	150	150		
Carbon Steel	-20°F to 100°F	285	285	285	285	285	285	285
	At 250°F							245
	At 300°F						230	
	At 400°F				200	200		
316 STS	At 500°F	170	170	170				
	-20°F to 100°F				275			
	-65°F to 100°F						275	275
	-120°F to 100°F	275						
	-150°F to 100°F		275					
	-300°F to 100°F			275		275		
	At 250°F							230
	At 300°F						215	
	At 400°F				195	195		
	At 500°F	170	170	170				

III. ASSEMBLY:

Upon receipt of a John C. Ernst Co. sight flow indicator, check all components carefully for damage, which may have been, incurred during shipping. **IMPORTANT:** If damage is evident or suspected, do not attempt installation. Notify your carrier immediately and request a damage inspection.

John C. Ernst Co. standard Threaded Window Sight Flow Indicator unit is comprised of (1) body, (2) gaskets, (2) cushions, (2) glass disks, (2) covers, and (1) identification nameplate.

Confirm that the information on the identification nameplate conforms to the size, model, and performance data on the purchase order and the actual operating conditions at the installation sight.

A. Assembling Indicators

Refer to the exploded view in Section 10 for component identification assistance and position.

- Carefully remove the glass disks from the shipping package, examine the glass to ensure that it is free of scratches and other imperfections, and place in a safe area.
- Clean any material from gasket and cushion seating cavity.

- Place body on a clean flat surface and place gasket in one side.

- Place glass on top of the gasket on the body.

- Place cushion on top of the glass and thread the cover clockwise until it is finger tight.

- Turn assembly over and repeat steps 2 through 6.

- Using a spanner wrench, hand torque covers to the values in tables below:

WARNING: Torquing under pressure increases the likelihood of glass breakage and contents spraying out of the indicator, than if sight flow were de-pressurized. A sight flow indicator in service must be freed of all pressure or vacuum, allowed to reach ambient temperature and drained or purged of all fluids before re-torquing. Failure to follow this procedure could result in serious personal injury and property damage.

IV. INSTALLATION:

CAUTION: Only qualified experienced personnel who are familiar with sight flow indicator equipment and thoroughly understand the implications of the tables and all the instructions should assemble the sight flow indicator. Failure to read and comply with the following instructions could result in personal injury or property damage.

Unit Ratings and Torque Values

Gasket Material		Viton, Buna N, Butyl, Neoprene, EPR	
Unit Rating and Torque Value (ft. lbs.)		150 PSIG Torque (ft. lbs.)	150 ANSI Torque (ft. lbs.)
Unit Size	1/4", 3/8"	3 to 4	5 to 6
	1/2", 3/4"	6 to 7	10 to 12
	1"	7 to 8	13 to 15
	1 1/4", 1 1/2"	16 to 18	29 to 33
	2"	23 to 27	44 to 48

Table 3

Unit Ratings and Torque Values

Gasket Material		Teflon®, Asbestos, Kel-F®, Grafoil®, Durabala®, Nobestos, Garlock®, Gylon®	
Unit Rating and Torque Value (ft. lbs.)		150 PSIG Torque (ft. lbs.)	150 ANSI Torque (ft. lbs.)
Unit Size	1/4", 3/8"	7 to 8	8 to 9
	1/2", 3/4"	15 to 17	16 to 18
	1"	20 to 24	22 to 26
	1 1/4", 1 1/2"	35 to 39	44 to 48
	2"	53 to 57	65 to 69

Table 4

A. Inspection

1. Examine the glass to see that it is free of scratches, chips or other imperfections.
2. Ensure that the connections and inside of the sight flow have been cleaned and are free of any foreign material.

B. Location Precautions

DO NOT impose system piping loads on the Threaded Window Sight Flow Indicator. The sight flow indicator is not designed to be a load bearing component. Piping must be supported and aligned with the sight flow indicator end connections to reduce the possibility of load or torsional stresses.

Locate the Threaded Window Sight Flow Indicator:

1. Where it can be easily seen.
2. Away from areas where objects may be dropped, thrown or generally allowed to contact the glass.
3. So that it is protected from dust, grit or other objects that could damage the glass.
4. So it is protected from external thermal shock such as high a temperature application being exposed to a cold air blast or cold water wash.

C. Cover Torque Check

Cover torque is vital to the proper operation of a Threaded Window Sight Flow Indicator. Torque values should be checked after initial installation, and periodically thereafter, to ensure that the unit is in compliance with the torque values described in Section 4.1.

WARNING: Failure to inspect, locate and check the sight flow indicator as described above within the Inspection, Loading Precautions, and Cover Torque Sections could result in serious personal injury and property damage.

V. OPERATION:

Before initializing sight flow operation, check that all installation procedures have been completed. Use only qualified, experienced personnel who are familiar with sight flow indicator equipment and thoroughly understand the implications of the tables and all the instructions. Check that the covers have been torqued to their proper limits as stated in Section 4. Check that all connections are pressure tight and the glass is clean and free of any damage.

CAUTION: Sight flow indicator installations should be brought into service slowly to avoid excessive shock or stress on the glass. Rapid pressurization of a sight flow indicator can cause glass breakage/fragmentation and fluid leakage. Hydrostatically pressure test the Threaded Window Sight Flow Indicator to at least 50 psig and correct any leakage to help avoid personal or property damage.

VI. MAINTENANCE:

Use only qualified, experienced personnel who are familiar with sight flow indicator equipment and thoroughly understand the implications of the tables and all the instructions.

WARNING: Torquing under pressure increases the likelihood of glass breakage and contents spraying out of the indicator, than if sight flow were depressurized. A sight flow indicator in service must be freed of all pressure or vacuum, allowed to reach ambient temperature and drained or purged of all fluids before re-torquing. Failure to follow this procedure could result in serious personal injury and property damage.

Create a maintenance schedule for each specific installation of a Threaded Window Sight Flow Indicator. On all inspections, regularly check the following items:

1. Glass for cleanliness and signs of damage or wear.
2. Sight flow indicator for signs of leakage at gaskets or connections.
3. Sight flow indicator for signs of internal or external corrosion.
4. Cover torque values (see Section 4)

A. Maintenance Procedures

1. **GLASS** should be given regular and careful attention. Keep glass clean using a commercial glass cleaner and a soft cloth. Inspect the surface of the glass for any clouding, etching or scratching or physical damage such as bruises, checks or corrosion. Glass that is damaged is weakened and may break under pressure. Shining a light at approximately a 45° angle will aid in detecting some of these conditions. Typical damaged areas will glisten more brightly than the surrounding glass because the light is reflected.

Detection of any damage, problem areas or surface wear is sufficient evidence to take the sight flow indicator out of service. **DO NOT** proceed with operation of the sight flow indicator until the glass has been replaced by following the assembly instructions in Section 4.

2. GASKET LEAKS must be repaired immediately. **DO NOT** proceed with operation of a sight flow indicator until gaskets have been replaced by following the assembly instructions in Section 4.

3. CONNECTION LEAKS at a threaded connection should be corrected by tightening the NPT connection, or by taking the sight flow indicator out of service and wrapping the connection threads with Teflon® tape on all male pipe threads.

4. CORROSION may occur if the user has selected an improper material for the Threaded Window Sight Flow Indicator application. It is the responsibility of the user to choose a material of construction compatible with the contained fluid and the surrounding environment. If internal or external corrosion are present, an investigation must immediately be performed by the user. It may be necessary to contact an authorized John C. Ernst Co. distributor to better determine the origin of the corrosion.

B. Troubleshooting

Problem

Glass becomes etched or clouded in service.

Cause	Cure
Fluid being handled is not compatible with the glass	Replace the glass.

Problem

Glass continually breaks in service.

Cause	Cure
Warped body as a result of mechanical or thermal stresses.	Reduce the stress and replace sight flow indicator

VII. REMOVAL/DISASSEMBLY/REASSEMBLY:

WARNING: **DO NOT** remove sight flow indicator while it is under pressure. A pressurized sight flow indicator fragments the glass and sprays contents in a more violent manner than if it were de-pressurized. A sight flow indicator in service must be freed of all pressure or vacuum, allowed to reach ambient temperature and drained or purged of all fluids before re-torquing. Failure to follow this procedure could result in serious personal injury and property damage.

A. Disassembly

Threaded Window Sight Flow Indicators should be by placing the sight flow indicator on a clean, level table surface. Ensure that the unit is stable and secure, hold the sight flow indicator firmly, and loosen the covers with a spanner wrench. Remove the cushions, glass and gaskets from the indicator using the appropriate safety precautions. Once a sight flow indicator has been disassembled, all glass must be disposed of because of wear, and, all gaskets must be disposed of since they are permanently deformed by compression during service.

WARNING: DO NOT under any circumstances reuse glass or gasketing items previously in service, since they can cause leaks or high stress points resulting in glass breakage and serious personal injury and property damage.

Glass that is broke or damaged in any way is dangerous and should be disposed of in a safe manner determined by the user.

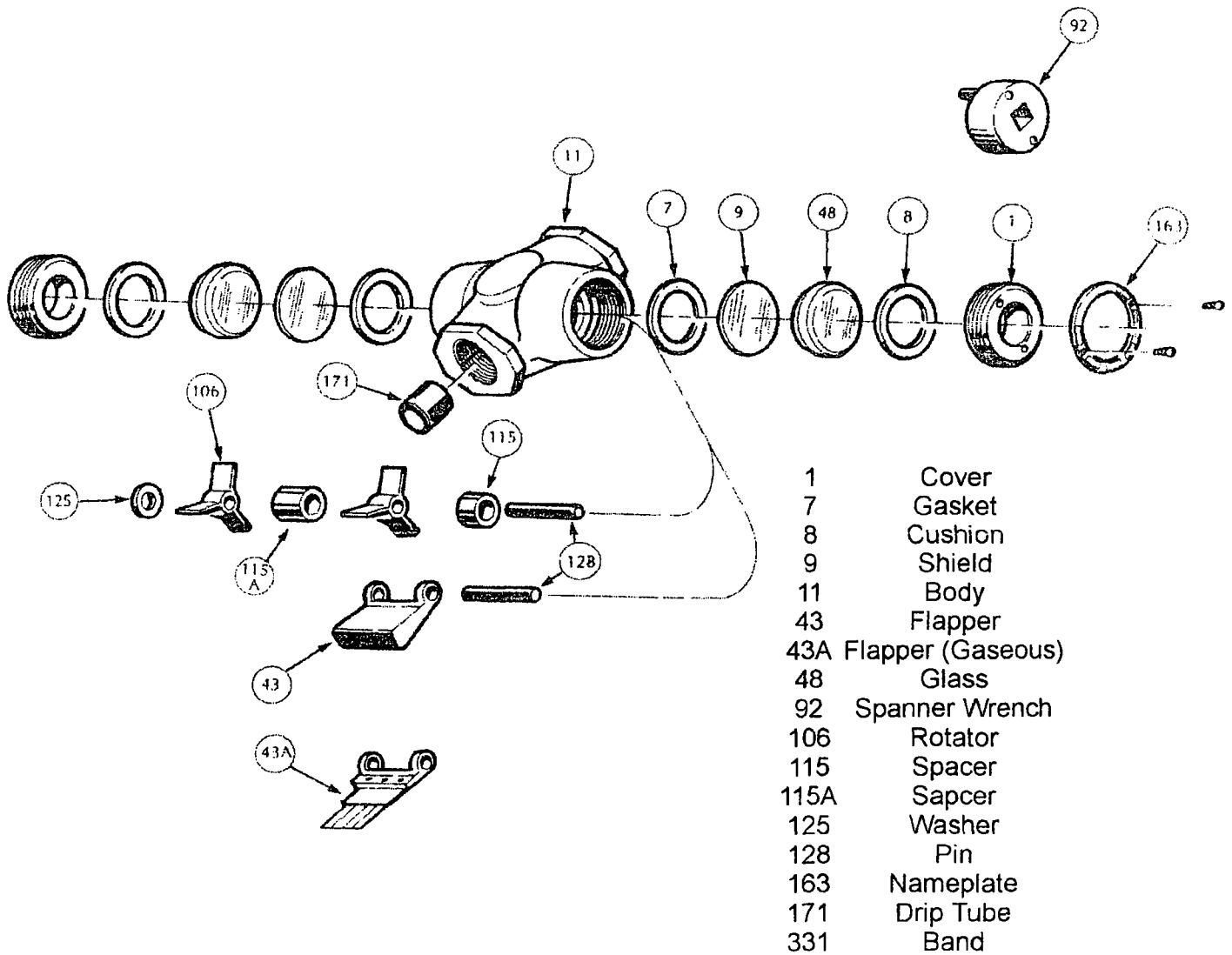
B. Reassembly

To prepare for installation of new glass, clean the gasket seating surfaces on the body and cushion seating surface of cover. This should be done using a soft metal scraper (preferably brass) to remove all burrs, rust and remnants of the previous gasket or cushion. Exercise extreme care to avoid gouging or scarring gasket seating surfaces. Failure to prepare the gasket surfaces will result in leaks and/or glass breakage.

Before installation, inspect the replacement glass for imperfections. During inspection, and during any subsequent handling of the glass, keep the glass from contacting other surfaces. Bumping or sliding of glass against other surfaces can result in glass breaking, scratching or chipping. Install the new glass disks by following the procedure in Section 4.

Recommended Spare Parts

Ref. #	Item	Quantity
7	Gasket	2
48	Glass	2



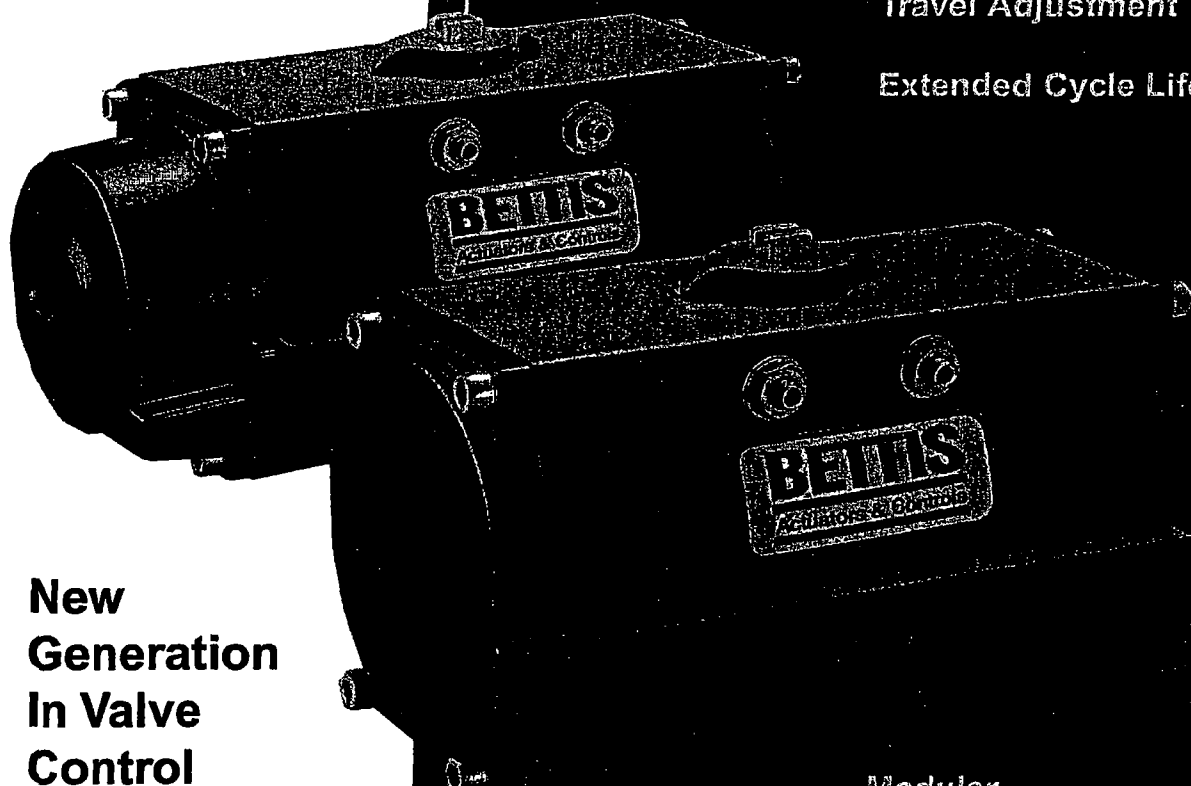


BETTIS

Actuators & Controls

A Daniel Industries Company

RPC-Series Rack and Pinion Pneumatic Actuators



**New
Generation
In Valve
Control**

BettisGuard

NAMUR / ISO

**Bi-directional
Travel Adjustment**

Extended Cycle Life

Modular

Internal Porting

**Blow-out Proof
Pinion Gear**

Replaceable Bearings

Design and Construction

Introduction

Bettis RPC-Series pneumatic rack and pinion actuators represent a new generation of valve control, incorporating the latest technologies and materials available to offer a reliable, economical and long lasting product. Specifically designed for quarter-turn applications, the RPC-Series is ideally suited for the operation of plug, butterfly, ball valves, dampers and other 90° turn devices.

Advantages

RPC-Series actuators offer many significant features and benefits, among these are:

- **BettisGuard** – An advanced, highly corrosion resistant surface conversion process which combines hard anodizing with fluoropolymer codeposition to protect the aluminum housing inside and out with an extremely hard wear resistant layer. This process, applied after finished machining, ensures that all housing surfaces are fully protected from hostile environments.

End caps are polyester powder coated, providing excellent corrosion protection.

All external metal fasteners are 300 series stainless steel.

- **NAMUR Mounting** – RPC-Series meets the latest NAMUR standards allowing direct or close coupling of NAMUR designed accessories. The pinion gear interface features a positive, international standard drive for positioners, switches and other accessories. The solenoid interface allows direct acceptance of any NAMUR designed control valves.
- **Bi-directional Travel Adjustment** – Bettis RPC-Series actuators feature bi-directional pinion travel stops. Side located stops allow a full $\pm 5^\circ$ of valve travel adjustment, giving a guaranteed range of

adjustment between 80° and 100° of actuator travel. These travel stops are designed to absorb the maximum rated torque of the actuator and the maximum impact loads associated with recommended stroke speed.

- **Extended Cycle Life** – Replaceable upper and lower pinion gear, piston head and heel bearings are made from an internally lubricated thermoplastic. This material contributes significantly to extended cycle life, wear resistance and efficiency.
- **Blow-out Proof Pinion Gear** – In addition to the stainless steel retaining ring, the RPC pinion gear features a unique internal safety ring.
- **Serviceability and Confidence** – Bettis rack and pinion actuators are designed to be safe, simple and rugged. Unlike other rack and pinion actuators, servicing the RPC actuator does not require special tools.
- **Modular** – The modular design of the RPC-Series simplifies the conversion from double-acting or spring-return configurations.
- **ISO/DIN Valve Interface** – The imperial and metric RPC output drive features a female, double square (eight point pattern) as standard. Optional output drive configurations are available. The ISO centering interface or female groove is standard on the metric models. The centering ring is available as an option. (See drawing on page 9.)
- **Operating Ranges** – RPC-Series double-acting actuators produce guaranteed minimum torque outputs up to 16,500 lb-in (1,865 Nm). The spring-return units produce spring ending torques up to 5,230 lb-in (591 Nm).*

RPC-Series pneumatic actuators are suitable for continuous opera-

tion at pressures ranging from 40 to 120 PSIG (3 to 8 BAR) while exposed to temperatures of -40°F to $+180^\circ\text{F}$ (-40°C to $+82^\circ\text{C}$). Optional temperature trims extend the range to 350°F (177°C).

Maximum width piston rack gear teeth provide optimum pinion gear tooth engagement; higher cycle life and accurate valve positioning in throttling applications.

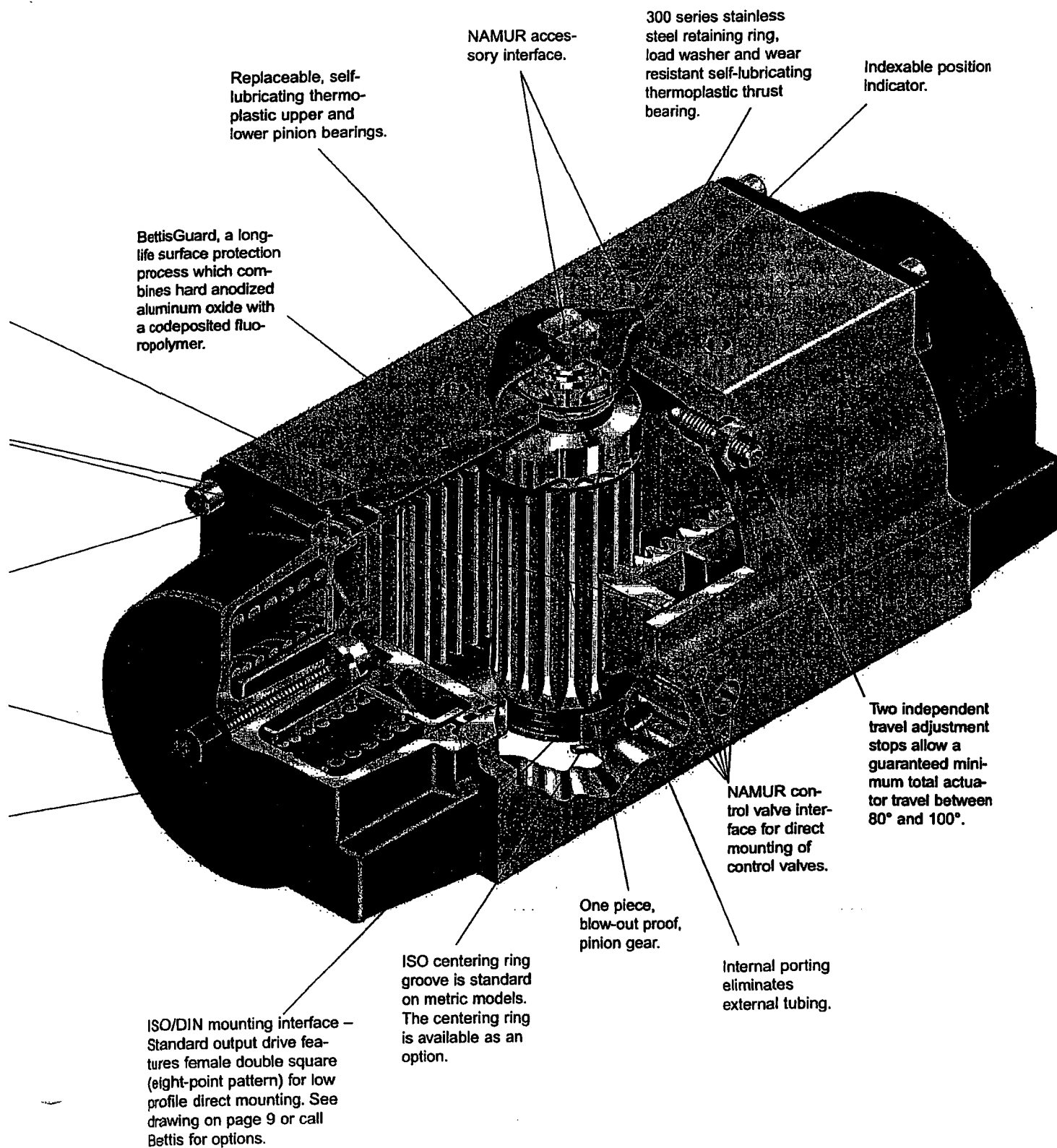
Replaceable low friction piston head and heel bearings.

300 series stainless steel metal fasteners.

Acorn nut and O-ring seal protects spring bolt threads.

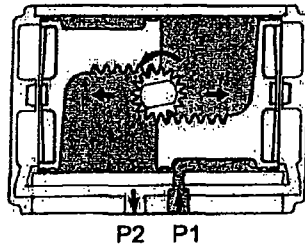
Polyester powder coating provides excellent corrosion protection and chip resistance of end caps.

* Double-acting models use pressure to rotate in both directions. Spring-return models use pressure for one direction of rotation and spring force for the reverse rotation.



Operation

**Double-Acting
(TOP View)**

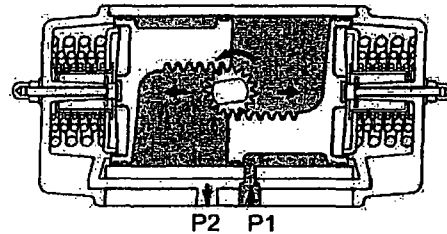


Double-Acting – Standard Configuration

For counterclockwise output rotation, apply pressure to Port 1, driving the pistons apart.

When required, the pistons can be inverted in the housing resulting in a clockwise rotation when pressure is applied to Port 1.

**Spring-Return
(TOP View)**



Spring-Return – Standard Configuration

Actuator to Fail Clockwise

For counterclockwise pressure rotation, apply pressure to Port 1, driving the pistons apart and compressing the springs. During this pressure stroke, the volume on the spring side of the pistons is vented/exhausted at Port 2.

Spring force rotates the actuator clockwise when the pressure is vented/exhausted at Port 1. The BettiSolenoid valve, when used, directs some of the exhaust gas to the spring side of the piston, creating a closed purge system. This helps to prevent corrosive outside contaminants from entering the spring chamber and can greatly extend the service life in hostile environments. See page 11 for schematics.

Actuator to Fail Counterclockwise

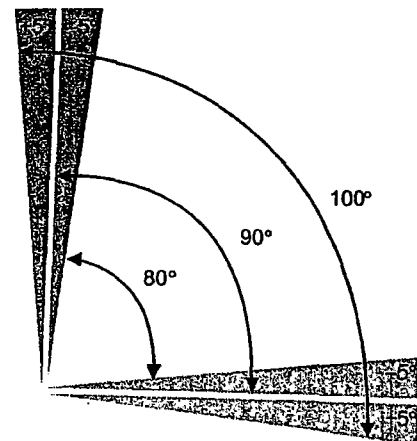
When fail counterclockwise is required, the pistons must be inverted in the housing.

Bi-directional Travel Stop Illustration

Bettis RPC-Series actuators feature bi-directional pinion travel stops. Side located stops allow a true $\pm 5^\circ$ of valve travel adjustment, giving a guaranteed range of adjustment between 80° and 100° of actuator travel. These travel stops are designed to absorb the maximum rated torque of the actuator and the maximum impact loads associated with recommended stroke speed.

Standard Assembly

Adjustment of the counterclockwise and clockwise rotation limits are accomplished by turning the respective left and right stop adjustment screws to reduce or increase output rotation.



Typical Specifications

The following information may be used as a guide to compile specifications for rack and pinion pneumatic actuators. Bettis RPC- Series actuators meet, or exceed these specifications.

1.0 Bettis RPC-Series Pneumatic Rack and Pinion Actuators

- 1.1 The pneumatic actuator shall be quarter-turn, opposed piston rack and pinion type of a totally enclosed design with no external moving linkages.
- 1.2 The actuator shall be capable of 100° rotation and shall include open and closed position stops with a minimum of 20° total travel adjustment.
- 1.3 The actuator shall be rated for continuous operation using dry or lubricated non-corrosive gas and be suitable for mounting in any position.
- 1.4 Trims shall be available for temperature ranges from -40°F to +350°F (-40°C to +177°C).

2.0 Construction

- 2.1 Actuator body shall be precision-extruded aluminum alloy, hard anodized with fluoropolymer codeposition process inside and out after finished machining.
- 2.2 All metal fasteners shall be 300 series stainless steel.
- 2.3 The output shaft/pinion shall be one piece steel, bottom loaded, blow-out proof secured by a non-exposed, redundant stainless steel retaining ring for safety.
- 2.4 End caps shall be cast aluminum, UV and chip resistant polyester powder coated.
- 2.5 Actuator shall incorporate internal porting to permit use of either NAMUR direct mount or remote controls.
- 2.6 Actuator shall be provided with a mechanical indexable visual position indicator and NAMUR accessory drive.

3.0 Design

- 3.1 Double-acting and spring-return models shall be field convertible without the use of special tools.
- 3.2 All spring module assemblies shall be of self contained and service safe design.
- 3.3 All actuators shall be designed and manufactured in accordance with ISO 9001 quality standards to meet NAMUR and ISO/DIN dimensional standards.
- 3.4 Actuator shall have replaceable, self-lubricating thermoplastic upper and lower pinion, piston head and heel bearings.
- 3.5 Pressure containing seals shall be outboard of all bearings.
- 3.6 Use of self-threading thread forming fasteners and metal-to-metal pressure seals are strictly prohibited.
- 3.7 All spring designs shall be qualified by fatigue and load test.
- 3.8 Actuator shall include side located bi-directional pinion travel stops which provide a guaranteed ±5° of valve travel adjustment between 80° and 100° of actuator travel. Travel stops shall be designed to absorb the maximum rated torque of the actuator and the maximum impact loads associated with recommended maximum stroke speed.
- 3.9 Full tooth engagement, at the pitch line, shall be maintained throughout full range of travel.
- 3.10 Attachment of shaft driven accessories shall not require removal of the visual position indicator.
- 3.11 Actuator shall incorporate a one-piece blow-out proof pinion.
- 3.12 A secondary extended bolt pattern shall be provided to accommodate installation on non ISO/DIN valve designs.
- 3.13 Gear teeth shall be designed to AGMA specifications, minimizing back lash and suitable for throttling applications.

Materials of Construction

- A. **Body:** Precision-extruded aluminum alloy, hard anodized with fluoropolymer codeposition process inside and out after finished machining.
- B. **Pinion Gear:** Alloy steel, corrosion protected.
- C. **Pistons:** Cast aluminum alloy, dichromate dipped.
- D. **End Caps:** Cast aluminum alloy, polyester powder coated.
- E. **Fasteners:** 300 series stainless steel.
- F. **Seals:** Low temperature Nitrile is standard -40°F to +180°F (-40°C to +82°C). Options, Viton 0°F to +350°F (-18°C to +177°C).
- G. **Springs:** Carbon steel, shot peened, and corrosion protected by a pliable self-healing coating.
- H. **Heel Bearings:** Acetal, self lubricating.
- I. **Piston Bearings:** Acetal, self-lubricating.
- J. **Pinion Gear (output shaft) Bearings:** Standard trim; Upper – PEEK composite; Lower – Acetal; Thrust – Acetal. Optional high temperature trim has PEEK composite upper and lower bearings.

Torque Ratings — Imperial

Double-Acting Actuators

RPC-Series

Model	Position	Nominal Operating Pressure (PSIG)				
		20	25	30	35	40
		Pressure Torque Output (Start/Min/End) (Lb-in)				
RPC 250	0	125	188	250	313	375
RPC 450	0	225	338	450	563	675
RPC 1000	0	500	750	1000	1250	1500
RPC 2250	0	1125	1687	2250	2812	3375
RPC 3650	0	1825	2738	3650	4563	5475
RPC 5000	0	2500	3750	5000	6250	7500
RPC 11000	0	5500	8250	11000	13750	16500

0 The torque output for double-acting rack & pinion actuators remains constant from start to end of stroke.

Spring-Return Actuators

RPC-Series

Model	Position	Spring Set #	Nominal Operating Pressure (PSIG)											
			20	25	30	35	40	45	50	55	60	65	70	75
250	2	10	76	47	139	110	202	172	264	235	327	298	258	219
	3	10	—	—	113	70	176	133	238	196	301	258	219	180
	4	10	—	—	88	31	151	94	214	156	276	219	180	141
	5	10	—	—	—	—	127	54	189	117	252	180	141	102
	6	10	—	—	—	—	—	—	164	78	227	141	102	63
450	2	10	137	84	250	198	364	311	477	424	590	538	466	395
	3	10	—	—	205	126	318	240	432	353	545	466	395	324
	4	10	—	—	159	55	273	168	386	282	499	395	324	252
	5	10	—	—	—	—	228	97	341	210	455	324	252	180
	6	10	—	—	—	—	—	—	296	139	409	252	180	102
1000	2	10	301	184	550	434	800	683	1049	932	1298	1182	1026	868
	3	10	—	—	449	278	698	527	948	776	1197	1026	868	711
	4	10	—	—	350	120	600	370	849	619	1098	868	711	554
	5	10	—	—	—	—	501	213	750	462	999	711	554	402
	6	10	—	—	—	—	—	—	651	305	901	554	402	252
2250	2	10	702	403	1274	975	1848	1546	2417	2118	2989	2689	2317	1947
	3	10	—	—	1051	603	1622	1174	2194	1746	2765	2317	1947	1577
	4	10	—	—	829	232	1401	804	1973	1378	2544	1947	1577	1207
	5	10	—	—	—	—	1182	434	1753	1006	2325	1577	1207	935
	6	10	—	—	—	—	—	—	1532	635	2103	1207	935	663
3650	2	10	1152	659	2063	1570	2975	2482	3886	3393	4797	4305	3730	3157
	3	10	—	—	1726	996	2637	1907	3549	2819	4460	3730	3157	2584
	4	10	—	—	1388	423	2300	1335	3211	2246	4123	3157	2584	1911
	5	10	—	—	—	—	1967	744	2878	1655	3789	2584	1911	1338
	6	10	—	—	—	—	—	—	2540	1082	3452	1911	1338	965
5000	2	10	1625	750	2875	2000	4124	3249	5374	4499	6624	5749	4874	3999
	3	10	—	—	2437	1125	3687	2375	4937	3624	6187	4874	3999	3124
	4	10	—	—	2000	250	3249	1500	4499	2749	5749	3999	3124	2249
	5	10	—	—	—	—	2812	625	4062	1874	5312	3124	2249	1374
	6	10	—	—	—	—	—	—	3624	999	4874	2249	1374	899
11000	2	10	3576	1651	6327	4402	9078	7153	11829	9904	14580	12655	10726	8800
	3	10	—	—	5363	2473	8114	5224	10865	7975	13616	10726	8800	6874
	4	10	—	—	4398	547	7149	3298	9900	6049	12651	8800	6874	4949
	5	10	—	—	—	—	6188	1372	8939	4123	11690	6874	4949	3024
	6	10	—	—	—	—	—	—	7975	2197	10726	4949	3024	1549

* Spring Set # x 20 = Nominal Operating Pressure

All Published Torques are Guaranteed Minimum Values.

Torque Ratings — Metric

Double-Acting Actuators RPC-Series

Actuator	Bore (mm)	Operating Pressure (Bar)						
		10	15	20	25	30	35	40
RPC 251	0	15	20	26	28	31	36	41
RPC 451	0	28	37	46	51	55	65	74
RPC 1001	0	61	82	102	113	123	143	164
RPC 2251	0	138	184	230	253	277	323	369
RPC 3651	0	224	299	374	411	449	523	598
RPC 5001	0	307	410	512	563	615	717	819
RPC 11001	0	676	901	1127	1239	1352	1577	1803

† The torque output for double-acting rack & pinion actuators remains constant from start to end of stroke.

Spring-Return Actuators RPC-Series

Actuator	Bore (mm)	Stroke (mm)	Operating Pressure (Bar)															
			10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
251	2	10	7	15	12	20	17	23	19	25	22	30	27	36	32	41	37	46
	3	—	—	12	7	17	12	20	15	22	18	27	23	33	28	37	33	42
	4	—	—	—	—	14	8	17	11	20	13	25	18	30	23	33	26	39
	5	—	—	—	—	—	—	—	—	17	9	22	14	27	19	30	22	35
	6	—	—	—	—	—	—	—	—	—	—	19	9	24	14	27	19	30
451	2	18	12	27	21	38	30	41	35	46	40	55	49	64	58	74	67	83
	3	—	—	22	13	31	22	36	27	40	32	50	41	59	50	67	58	74
	4	—	—	—	—	26	14	31	19	35	24	45	33	54	42	61	50	67
	5	—	—	—	—	—	—	—	—	30	15	40	25	49	34	54	42	59
	6	—	—	—	—	—	—	—	—	—	—	34	17	44	26	54	42	59
1001	2	39	26	59	46	80	67	90	77	100	87	121	107	141	128	164	147	193
	3	—	—	48	29	68	49	79	59	89	69	109	90	130	110	164	147	193
	4	—	—	—	—	57	31	67	41	78	52	98	72	118	93	164	147	193
	5	—	—	—	—	—	—	—	—	66	34	87	54	107	75	164	147	193
	6	—	—	—	—	—	—	—	—	—	—	—	—	96	57	164	147	193
2251	2	91	57	138	104	184	151	208	174	231	197	278	244	325	291	381	347	451
	3	—	—	112	62	159	108	183	132	208	155	253	202	300	249	381	347	451
	4	—	—	—	—	134	67	158	90	181	114	228	160	275	207	381	347	451
	5	—	—	—	—	—	—	—	—	156	72	203	119	250	165	381	347	451
	6	—	—	—	—	—	—	—	—	—	—	178	77	225	124	381	347	451
3651	2	148	93	223	167	298	242	335	279	372	317	447	391	522	466	612	556	728
	3	—	—	185	102	259	177	297	214	334	252	409	326	483	401	612	556	728
	4	—	—	—	—	221	112	259	150	296	187	371	262	445	336	612	556	728
	5	—	—	—	—	—	—	—	—	258	120	333	195	408	270	612	556	728
	6	—	—	—	—	—	—	—	—	—	—	295	130	370	205	612	556	728
5001	2	208	109	311	212	413	314	464	366	516	417	618	519	720	622	823	724	925
	3	—	—	261	119	364	215	415	267	468	318	569	420	671	523	823	724	925
	4	—	—	—	—	314	117	366	168	417	219	519	321	622	424	823	724	925
	5	—	—	—	—	—	—	—	—	367	120	470	223	572	325	823	724	925
	6	—	—	—	—	—	—	—	—	—	—	420	124	523	226	823	724	925
11001	2	459	241	684	466	909	692	1022	805	1135	917	1360	1143	1586	1368	1809	1591	2032
	3	—	—	575	248	800	474	913	587	1026	699	1251	925	1477	1150	1809	1591	2032
	4	—	—	—	—	691	256	804	369	917	482	1142	707	1368	933	1809	1591	2032
	5	—	—	—	—	—	—	—	—	808	264	1034	490	1259	715	1809	1591	2032
	6	—	—	—	—	—	—	—	—	—	—	—	—	1150	497	1809	1591	2032

All Published Torques are Guaranteed Minimum Values.

Performance Data — Imperial and Metric

Double-Acting Actuators

RPC-Series – Imperial

Model	Volume (cu in) Δ	Volume (liters) Δ	Maximum Operating Pressure (PSIG)	Approximate Weight (lb)
RPC 250	8.5	10.4	120	3.7
RPC 450	15.4	19.8	120	4.9
RPC 1000	30.2	43.2	120	9.1
RPC 2250	71.0	96.0	120	16.9
RPC 3650	147.4	163.1	120	33.0
RPC 5000	174.7	184.2	120	43.5
RPC 11000	341.2	389.4	120	87.5

Spring-Return Actuators

RPC-Series – Imperial

Model	Volume (cu in) Δ	Maximum Operating Pressure (PSIG)	Approximate Weight (lb)
RPC 250-SR	10.4	120	4.4
RPC 450-SR	19.8	120	6.6
RPC 1000-SR	43.2	120	12.2
RPC 2250-SR	96.0	120	23.1
RPC 3650-SR	163.1	120	46.0
RPC 5000-SR	184.2	120	65.1
RPC 11000-SR	389.4	120	125.2

Double-Acting Actuators

RPC-Series – Metric

Model	Volume (cc) Δ	Volume (liters) Δ	Maximum Operating Pressure (PSI)	Approximate Weight (kg)
RPC 251	139	170	8.5	1.7
RPC 451	252	324	8.5	2.2
RPC 1001	495	708	8.5	4.1
RPC 2251	1163	1573	8.5	7.7
RPC 3651	2415	2673	8.5	15.0
RPC 5001	2863	3018	8.5	19.7
RPC 11001	5591	6381	8.5	39.7

Spring-Return Actuators

RPC-Series – Metric

Model	Volume (cc) Δ	Maximum Operating Pressure (PSI)	Approximate Weight (kg)
RPC 251-SR	170	8.5	2.0
RPC 451-SR	324	8.5	3.0
RPC 1001-SR	708	8.5	5.5
RPC 2251-SR	1573	8.5	10.5
RPC 3651-SR	2673	8.5	20.9
RPC 5001-SR	3018	8.5	29.5
RPC 11001-SR	6381	8.5	56.8

Notes:

Operating Temperature:

Standard: -40°F to +180°F [-40°C to +82°C]

High Temperature: 0°F to +350°F [-18°C to +177°C]

Operating Pressure Range: 40 to 120 PSIG [3 to 8 BAR]

Operating Media: Dry non-corrosive gas.

▲ Maximum volume including cavity required for calculating consumption per stroke.

* Maximum Operating Pressure (MOP) is the pressure required to produce the maximum rated torque of the actuator. RPC Maximum Operating Pressure is 120 PSIG [8 BAR].

If a relief valve is required, the relief valve set pressure shall be equal to the supply pressure plus 15% or regulator setting plus 15%, whichever is less, however, in no instance shall this setting exceed 140 PSIG (9.3 BAR).

Dimensions — Imperial and Metric

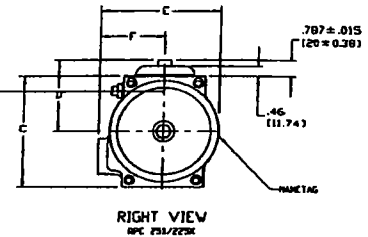
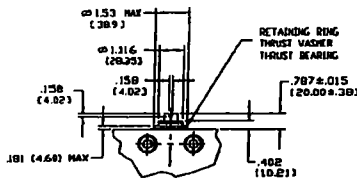
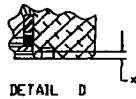


TABLE 1										UNITED STATES		
SIZE		W		H		D		L		S		
250	in.	6.33	8.15	3.165	4.075	3.03	2.30	3.19	1.87	1.260	M5 x 0.8-6H	.516
450	in.	8.33	8.54	3.165	4.270	3.78	2.68	3.90	2.12	1.280	M6 x 1-6H	.516
1000	in.	7.59	10.85	3.795	5.425	4.72	3.15	4.80	2.69	1.820	M8 x 1.25-6H	.654
2250	in.	10.63	14.55	5.315	7.275	5.51	3.54	5.51	3.0	2.124	M10 x 1.5-6H	.747
3650	in.	11.91	18.94	5.95	9.47	6.89	4.25	7.33	4.14	3.27	M12 x 1.75-6H	1.02
5000	in.	14.20	19.12	7.10	9.58	7.72	4.58	8.20	4.39	3.124	M12 x 1.75-6H	1.122
11000	in.	19.11	25.30	9.56	12.65	9.61	5.47	9.50	5.06	3.750	M16 x 2-6H	1.419

			CITY			COUNTY			STATE			FEDERAL			
			PERCENT	DOLLARS	DOLLARS	PERCENT	DOLLARS	DOLLARS	PERCENT	DOLLARS	DOLLARS	PERCENT	DOLLARS	DOLLARS	
250	In.	% NPT	1.05	.562	.433	1.08	.250-20 UNC	.31	1.392	3.250	1.172	.250-20UNC	.31	.155	4.38
450	In.	% NPT	1.08	.721	.551	1.08	.250-20 UNC	.31	1.392	3.250	1.172	.250-20UNC	.31	.152	4.33
1000	In.	% NPT	1.28	1.014	.748	1.09	.312-18 UNC	.47	1.950	4.312	1.750	.312-18 UNC	.39	.145	5.42
2250	In.	% NPT	1.51	1.156	.866	1.69	.375-16 UNC	.59	2.840	4.312	1.750	.312-18 UNC	.39	.163	7.95
3650	In.	% NPT	3.75	1.318	1.063	1.38	.500-13 UNC	.75	2.84	3.48	3.48	.375-16 UNC	.59	.222	8.31
5000	In.	% NPT	4.18	1.318	1.063	1.38	.500-13 UNC	.75	3.480	10.00	3.480	.500-13 UNC	.75	.172	9.67
11000	In.	% NPT	5.22	1.788	1.418	1.77	.625-11 UNC	.94	3.896	10.00	3.896	.625-11 UNC	.94	.272	12.77

		E			E			E			MTHD	
251	mm	160.8	207.0	80.4	103.5	77.0	58.5	81.1	47.5	32.51	M5 x 0.8-6H	13.111
451	mm	160.8	216.9	80.4	108.5	96.0	88.1	98.9	53.9	32.51	M6 x 1-6H	13.111
1001	mm	192.8	275.6	96.4	137.8	120.0	80.1	121.8	68.3	46.23	M8 x 1.25-6H	16.611
2251	mm	270.0	369.6	135.0	184.8	140.0	89.9	140.0	76.2	53.95	M10 x 1.5-6H	18.977
3651	mm	363.0	481.0	151.0	241.0	175.0	108.0	186.0	105.0	83.00	M12 x 1.75-6H	26.000
5001	mm	360.7	485.6	180.4	242.8	196.0	116.4	208.3	111.5	79.36	M12 x 1.75-6H	28.491
11001	mm	485.4	642.6	242.8	321.3	244.0	139.0	242.0	128.52	95.26	M16 x 2-6H	36.051

Model	T/HO	F	V	H	QTHD ISO/DIN	S	S	P	V	V	V		
mm	% BSPP	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm		
251	M6 x 1-6H	26.7	14.27	11	27.4	M6 x 1-6H	7.9	35.36	82.55	29.77	M6 x 1-6H	7.9	3.94
451	M6 x 1-6H	27.4	18.31	14	27.4	M6 x 1-6H	7.9	35.36	82.55	29.77	M6 x 1-6H	7.9	3.86
1001	M8 X 1.25-6H	32.1	25.76	19	27.8	M8 X 1.25-6H	11.9	49.53	109.52	44.45	M8 X 1.25-6H	10	3.68
2251	M10 X 1.5-6H	38.4	29.36	22	43.0	M10 X 1.5-6H	15	72.14	109.52	44.45	M8 X 1.25-6H	10	3.87
3651	M12 X 1.75-6H	95.25	33.48	27	35.05	M12 X 1.75-6H	19.05	72.14	88.39	88.39	M10 X 1.5-6H	15	5.64
5001	M12 X 1.75-6H	106.2	33.48	27	35.05	M12 X 1.75-6H	19.05	88.39	254.00	88.39	M12 X 1.75-6H	19.05	4.37
11001	M16 X 2-6H	132.6	45.42	36	44.96	M16 X 2-6H	23.88	98.96	254.00	98.96	M16 X 2-6H	23.88	6.91



RPC Solenoid

RPC Solenoids are custom designed for use with the RPC-Series pneumatic actuator product line. They are standard as NAMUR, the direct mount feature which eliminates interconnecting tubing and fittings.

General Description

Balanced spool construction allows 5/2 NAMUR valve to be converted to 3/2. Bi-directional tapered T-seal of carboxylated nitrile provides up to 5 times the abrasion resistance and service life of Buna-N seals.

Operation

The normally closed solenoid valve operates when the coil is electrically energized and returns when the coil is de-energized.

Note, if your application requires reduced or slow spring stroke travel times, consult the factory.

Media

Dry or lubricated non-corrosive gas.

Pressure

Minimum operating differential: 35 psi (2 BAR).
Maximum operating differential: 150 psi (10 BAR).

Flow Factor

Cv=2

Orientation

Valve may be mounted in any attitude/position.

Coil Enclosure

NEMA 4X – Watertight, dust tight, and corrosion resistant – indoor and outdoor. Intended for use indoors or outdoors to protect against splashing water, seepage of water, falling or hose directed water and severe external condensation. All coils are UL and CSA listed.

NEMA 4X, 7, 9 – combination watertight and explosion proof – indoor and outdoor. Offers the same protection as NEMA 4X listed above plus hazardous location ratings NEMA 7, Class I, Division I & II Group C & D, NEMA 9, Class II, Division I & II Group E, F & G. UL & CSA Listed.

Coil Construction-NEMA 4X-7-9

1/2 NPT., potted, 2-18" leads.

Optional DIN connector

Temperature: -20°F to +150°F (-29°C to +66°C)

Coil Rating

NEMA 4X-7-9: Continuous duty molded Class H insulation.

Coil Voltage

- DC-12, 24, 48, 120
- AC-24/60, 110/50-120/60, 220/50-240/60
- ±10% of Nominal

Power Consumption

Standard construction NEMA 7	6 Watts
Standard construction NEMA 4	4.8 Watts
Intrinsically safe construction	2.1 Watts
Low Power NEMA 7	1.8 Watts

Materials

Valve Body – Aluminum Anodized.

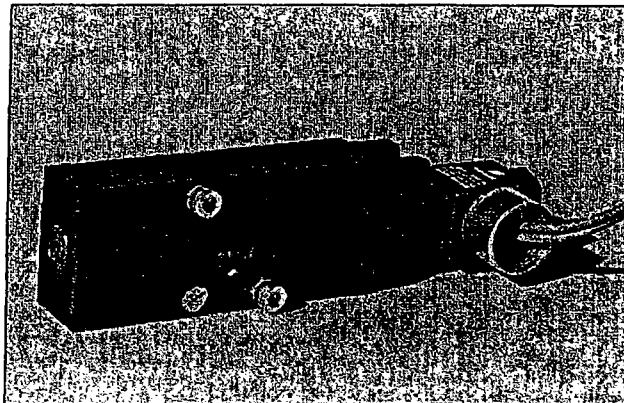
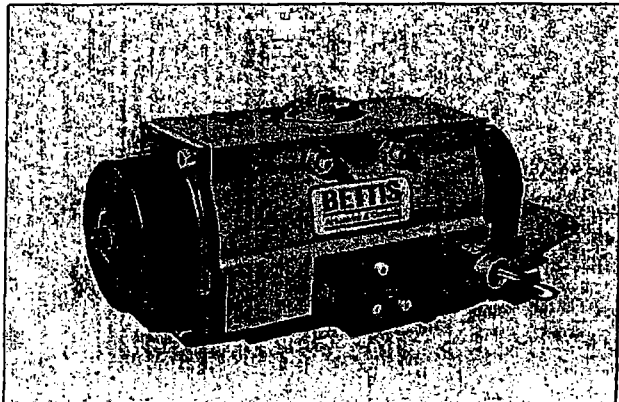
Seals/O-rings – Carboxylated Nitrile.

Fasteners – Stainless Steel.

Optional Features

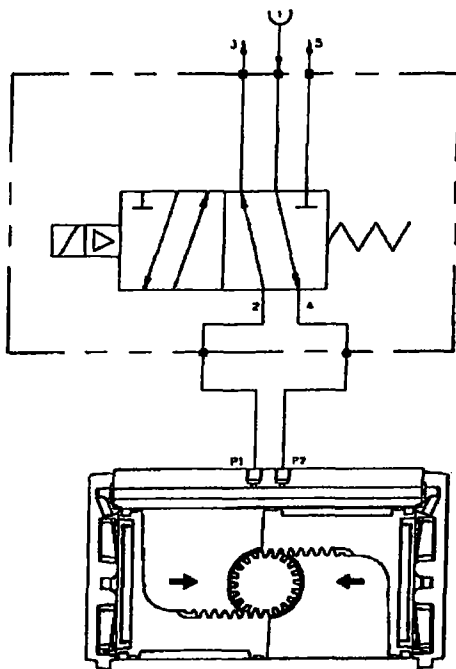
Dual coil – 2 position.

Close-loop spool.

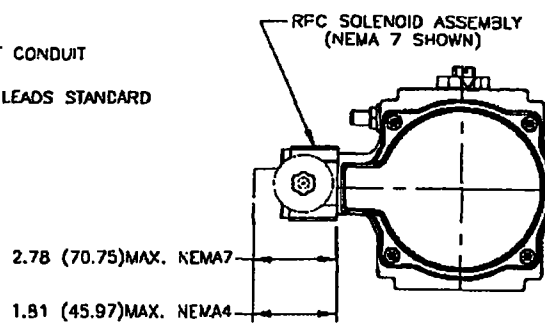
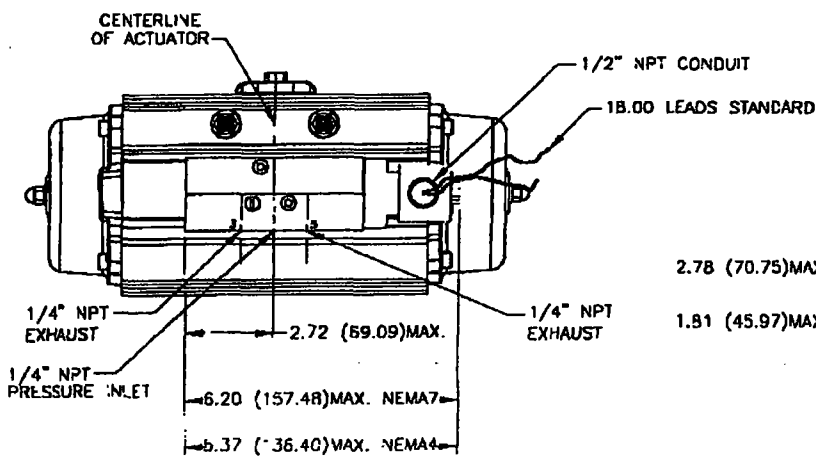
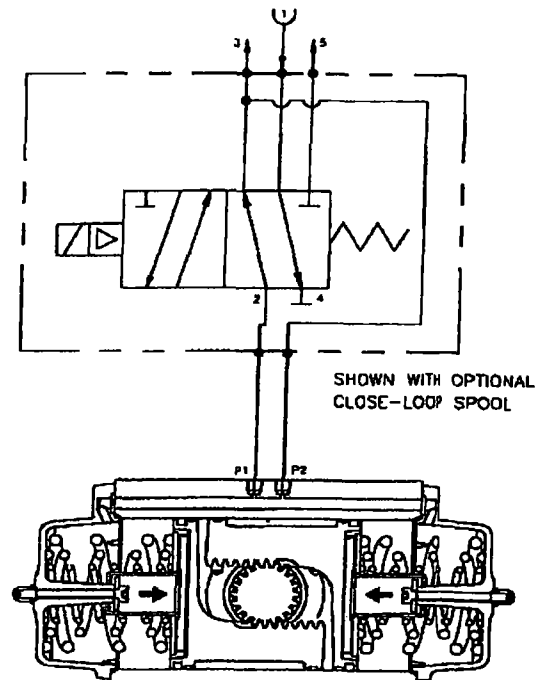


Solenoid Dimensions

5/2 (4-way)



3/2 (3-way)



Solenoid valve dimensions are applicable to double-acting and spring-return models.

BETTIS

Actuators & Controls

A Daniel Industries Company

Accessories/Options

Gear Operators

Gear Operators are offered for all models in declutchable (double-acting) or non-declutchable (spring-return) configurations. RPC gear overrides come with all components necessary for new or retrofit installation.

Partial Test Stroke Devices (PTSD)

Partial Test Stroke Devices (PTSD) allow for a simple, mechanical means of testing for the proper operation of your automation system without upsetting flow processes. Bettis has PTSD for testing in either clockwise or counter-clockwise direction with variable degrees of rotation.

End of Stroke Locking Devices

End of Stroke Locking Devices provide positive locking of both actuator and valve, helping to ensure system and downstream safety.

BettiSwitch

Bettis offers the BettiSwitch for dependable position indication and other system uses.

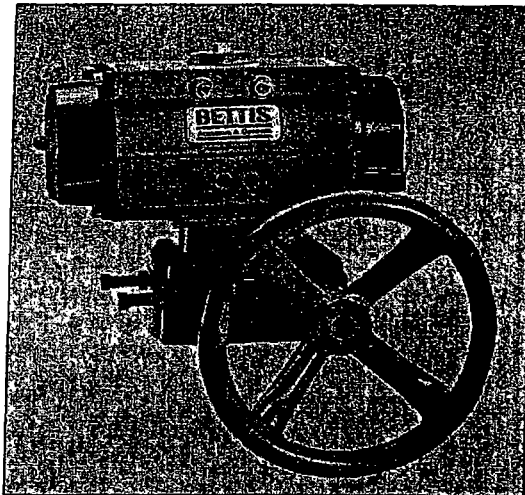
Limitswitches, Positioners and Accessories

Bettis can meet your requirements for practically any accessory, control device or control system you may need (ie., air fail systems, positioners, switches, and potentiometers).

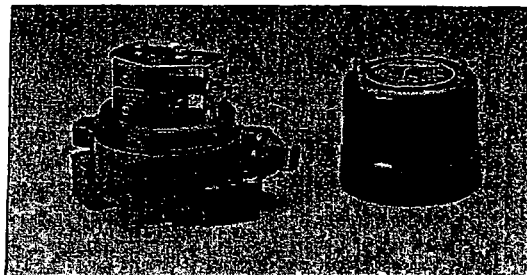
Quality Assurance

Bettis Actuators are designed and built to meet or exceed the highest international quality standards and procedures. Lloyd's Register Quality Assurance, ISO 9001 and many other international, corporate, and Bettis' own internal quality standards assure you of receiving what you paid for - confidence in quality.

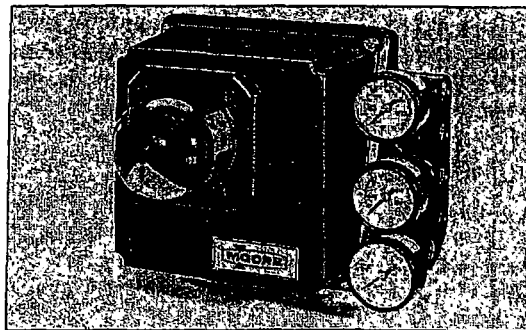
Gear Operator



BettiSwitch



Positioners



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Fax: 281/463-5103
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Fax: 0148-988-5200

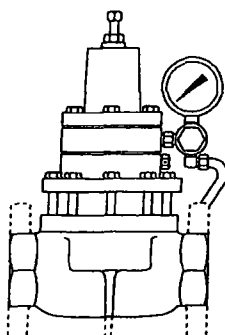
Bettis Canada Ltd.
4112-91 A Street
Edmonton, Alberta T6E 5V2
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Tel: 48 12 26 10
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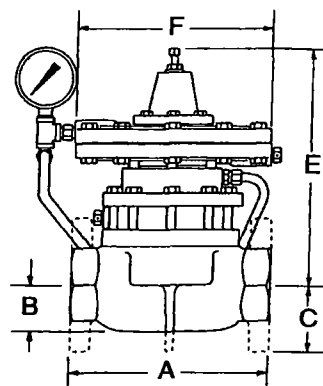
BACK PRESSURE
PRESSURE REDUCING
PRESSURE REDUCING-BALANCED
LIQUID BACK PRESSURE
PRESSURE DIFFERENTIAL
UPSTREAM DIFFERENTIAL PRESSURE
BACK PRESSURE VACUUM
PRESSURE REDUCING VACUUM

LOW PRESSURE BACK PRESSURE
OUNCES BACK PRESSURE TO VACUUM
OUNCES PRESSURE REDUCING
OUNCES PRESSURE REDUCING VACUUM
VACUUM BACK PRESSURE TO VACUUM

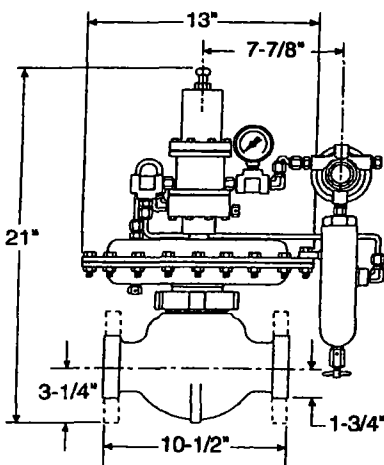
CAST IRON OR DUCTILE



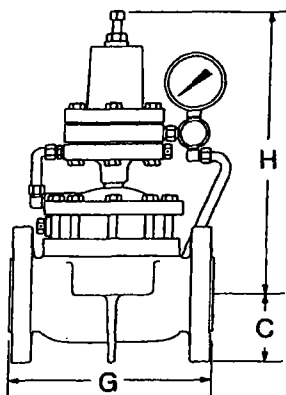
CAST IRON OR DUCTILE BODY



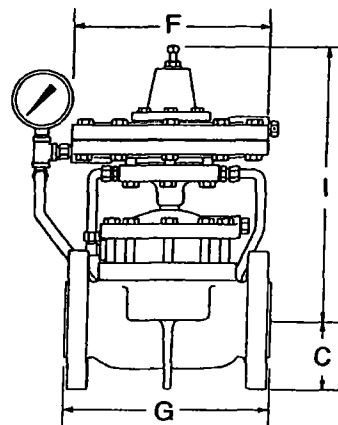
250 S/FGT-BP-S



STEEL



STEEL BODY



LINE SIZE	BODY STYLE	A	B	C	D*	E	F	G	H*	I
1"	SCRD	4 ³ / ₈	1 ¹ / ₈		7 ¹ / ₂	11 ⁵ / ₈	8 ³ / ₈			
2"	SCRD	8 ¹ / ₂	2 ¹ / ₈		11 ¹ / ₂	10 ¹ / ₂	8 ³ / ₈			
	FLGD	9		3	11 ¹ / ₂	10 ¹ / ₂	8 ³ / ₈	9 ¹ / ₈	14 ¹ / ₂	14
	GRVD	8 ³ / ₄	2 ¹ / ₈		11 ¹ / ₂	10 ¹ / ₂	8 ³ / ₈			
3"	SCRD	12	3 ¹ / ₁₆		13	12	8 ³ / ₈			
	FLGD	12 ³ / ₁₆		3 ³ / ₄	13	12	8 ³ / ₈	12 ⁵ / ₁₆	16 ¹ / ₂	15 ¹ / ₂
4"	SCRD	15	4		14 ¹ / ₂	13 ³ / ₁₆	8 ³ / ₈			
	FLGD	15 ¹ / ₈		4 ¹ / ₂	14 ¹ / ₂	13 ³ / ₁₆	8 ³ / ₈	15	18 ¹ / ₂	16 ¹¹ / ₁₆
6"	FLGD	22 ¹ / ₈		5 ¹ / ₂	17	14 ⁷ / ₈	8 ³ / ₈	22	20 ¹ / ₂	18 ³ / ₈

FLANGE DIMENSIONS ARE ASA 150 LB. STANDARD. *Add 7/8" to PRB and USDP Regulators for this dimension.

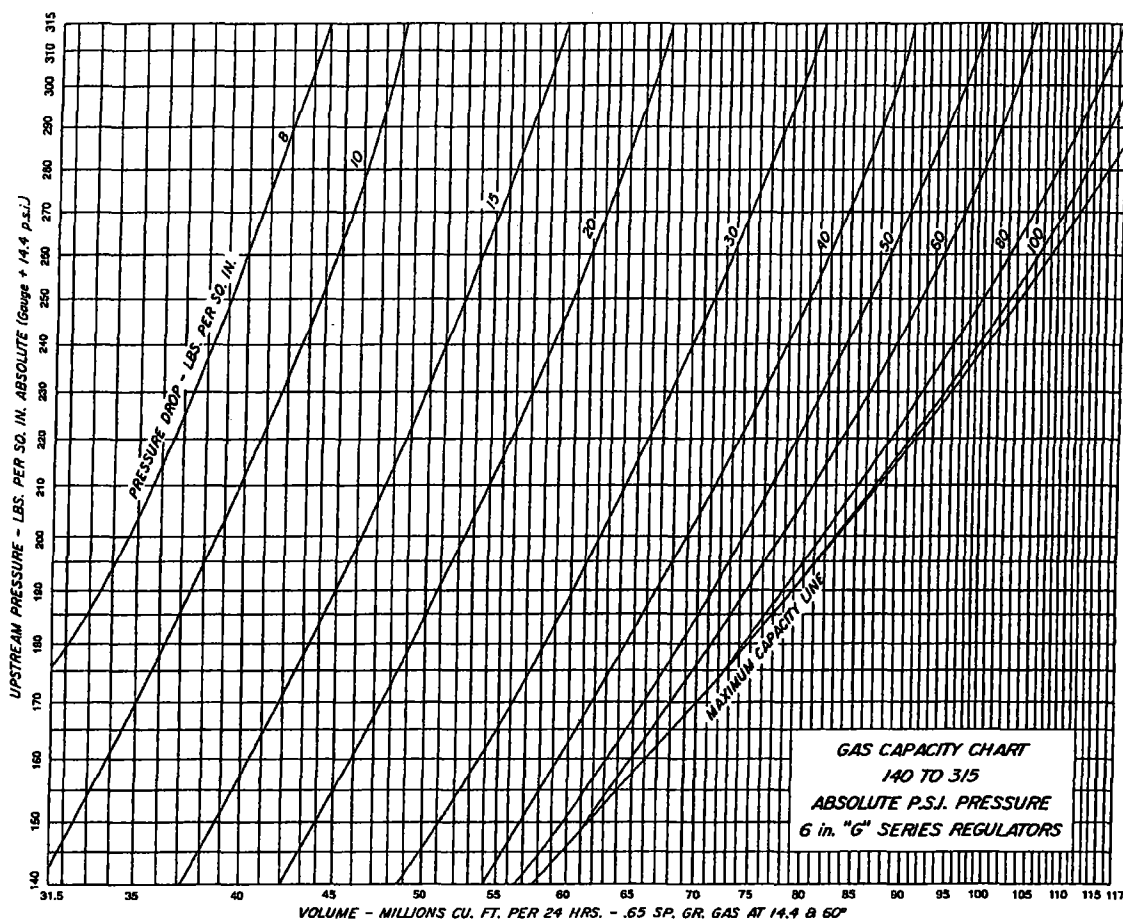
300 lbs. Maximum W.P. Valves

CAPACITY-Bbls. Water/Day, Steady Flow

PRESSURE DROP ACROSS VALVE PSIG	VALVE SIZE - INCHES			
	1	2	3	4
1	745	1,760	3,350	7,800
2	1,060	2,500	4,900	11,000
3	1,300	3,050	6,100	13,500
4	1,500	3,500	7,000	15,600
5	1,700	3,900	7,800	17,500
10	2,300	5,600	11,000	24,700
15	2,900	6,800	13,500	30,200
20	3,300	7,900	15,600	34,900
30	4,100	9,600	19,200	42,700
40	4,700	11,100	22,100	49,300
50	5,300	12,400	24,800	55,200
60	5,800	13,600	27,100	60,500
70	6,200	14,700	29,300	65,400
80	6,700	15,700	31,300	69,800
100	7,500	17,600	33,500	78,200
125	8,400	19,700	39,200	87,500
150	9,300	21,500	40,750	93,000
200	10,750	25,000	47,000	108,000
250	12,100	28,000	52,000	120,000
300	13,300	30,900	57,250	130,000

For gravity correction, multiply the above figures by $\sqrt{\frac{1}{G}}$
Where "G" is the specific gravity of the flowing liquid.

220, 275 and 300 lbs. Maximum W.P. Valves



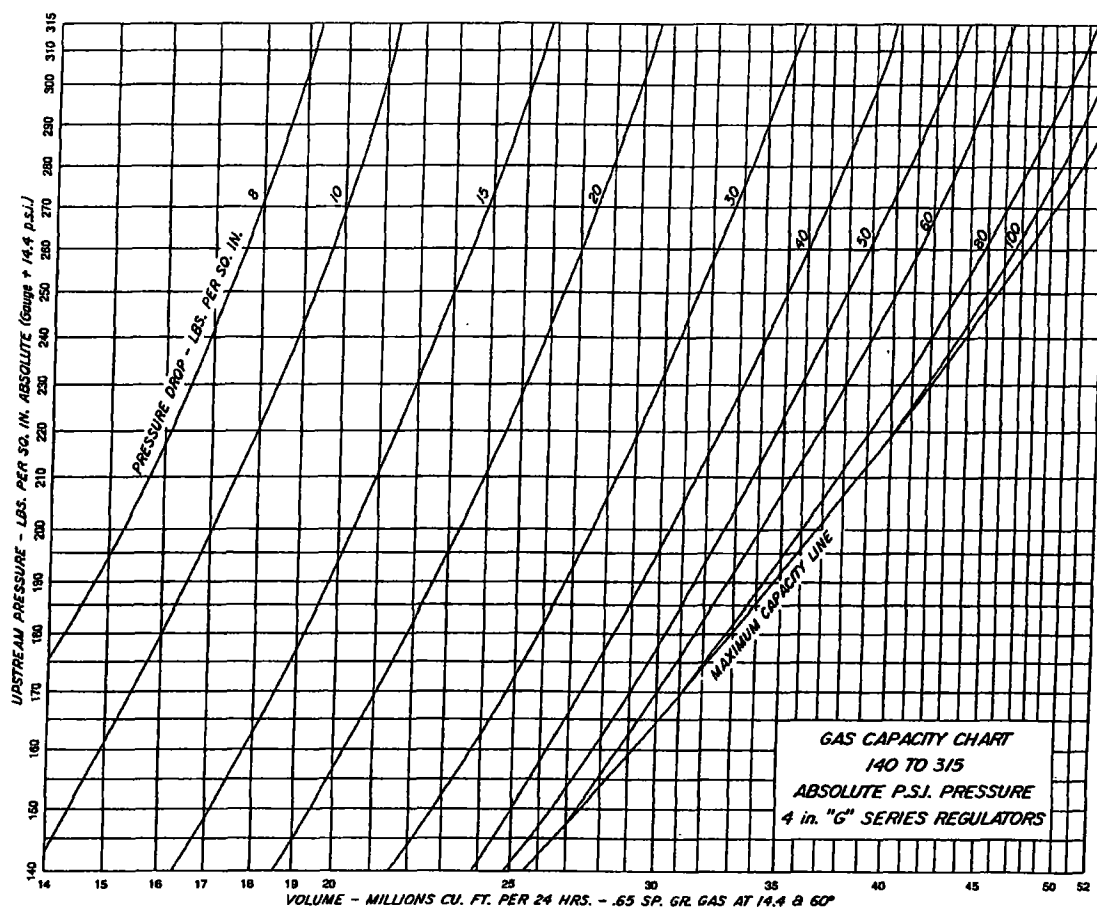
Gas capacities are based on pressure taken immediately upstream and downstream from the regulator in a wide open position.

Critical flow exists across a valve or orifice when the downstream absolute pressure is approximately half of the upstream absolute pressure. Any decrease in downstream pressure will not increase the flow through the valve. Critical flow conditions on the charts are represented by the MAXIMUM CAPACITY LINE.

HOW TO USE CHARTS: Locate UPSTREAM PRESSURE at left of chart. Follow horizontally across to PRESSURE DROP (upstream minus downstream pressure). Read VOLUME directly below. If the horizontal projection of the upstream pressure does not intersect the given pressure drop, flow is critical. In this case project UPSTREAM PRESSURE horizontally to the MAXIMUM CAPACITY LINE and read VOLUME directly below.

*For gravity correction multiply above capacities by $\sqrt{\frac{.65}{G}}$ where G equals specific gravity of gas.

220, 275 and 300 lbs. Maximum W.P. Valves



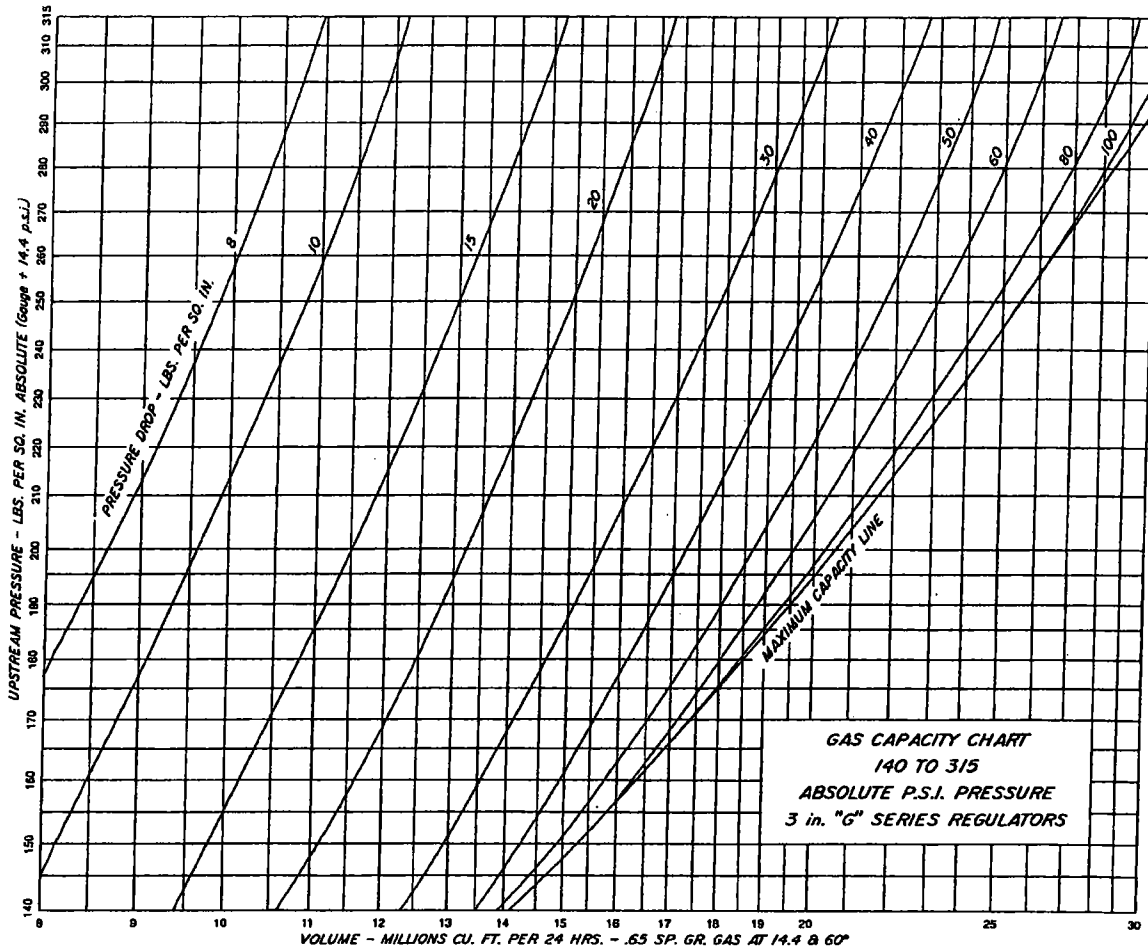
Gas capacities are based on pressure taken immediately upstream and downstream from the regulator in a wide open position.

Critical flow exists across a valve or orifice when the downstream absolute pressure is approximately half of the upstream absolute pressure. Any decrease in downstream pressure will not increase the flow through the valve. Critical flow conditions on the charts are represented by the MAXIMUM CAPACITY LINE.

HOW TO USE CHARTS: Locate UPSTREAM PRESSURE as left of chart. Follow horizontally across to PRESSURE DROP (upstream minus downstream pressure). Read VOLUME directly below. If the horizontal projection of the upstream pressure does not intersect the given pressure drop, flow is critical. In this case project UPSTREAM PRESSURE horizontally to the MAXIMUM CAPACITY LINE and read VOLUME directly below.

*For gravity correction multiply above capacities by $\sqrt{\frac{65}{G}}$ where G equals specific gravity of gas.

220, 275 and 300 lbs. Maximum W.P. Valves



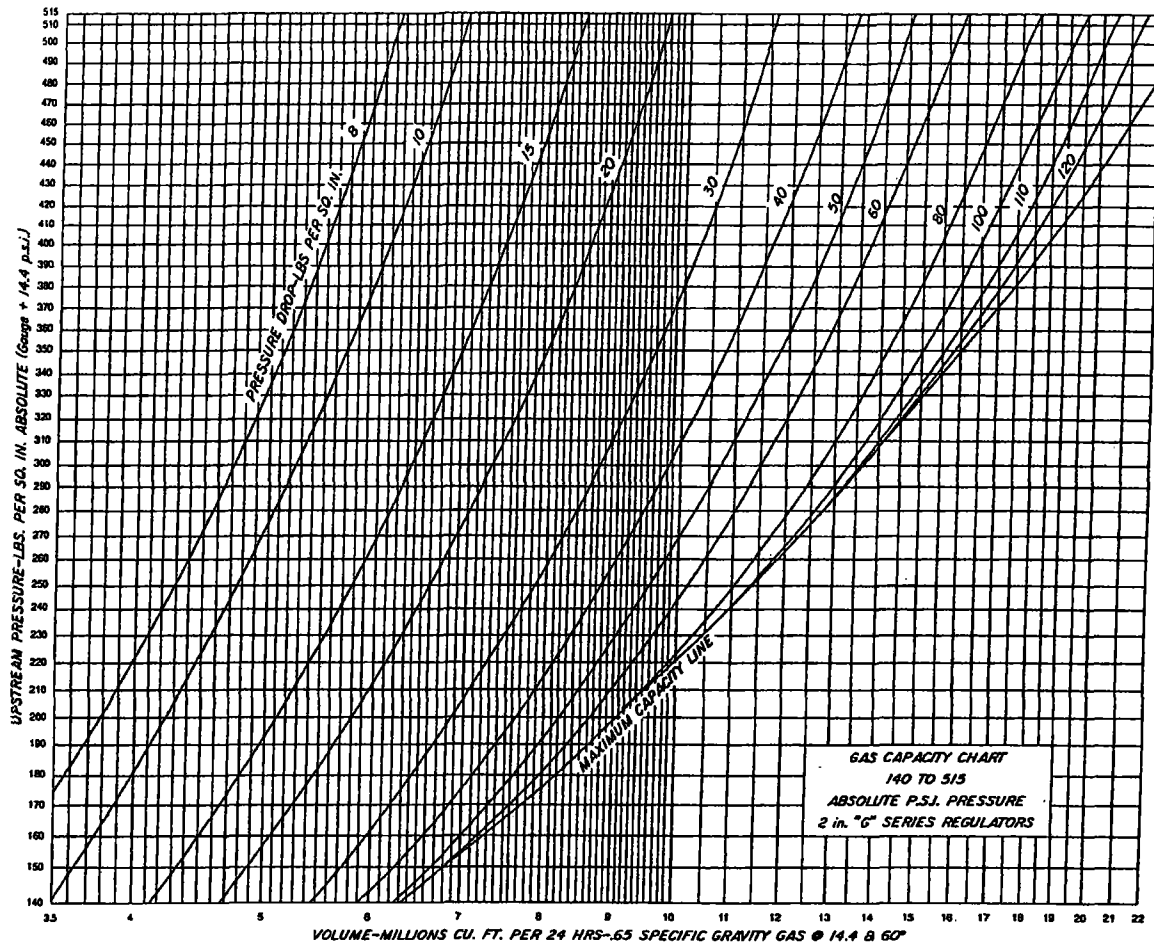
Gas capacities are based on pressure taken immediately upstream and downstream from the regulator in a wide open position.

Critical flow exists across a valve or orifice when the downstream absolute pressure is approximately half of the upstream absolute pressure. Any decrease in downstream pressure will not increase the flow through the valve. Critical flow conditions on the charts are represented by the MAXIMUM CAPACITY LINE.

HOW TO USE CHARTS: Locate UPSTREAM PRESSURE at left of chart. Follow horizontally across to PRESSURE DROP (upstream minus downstream pressure). Read VOLUME directly below. If the horizontal projection of the upstream pressure does not intersect the given pressure drop, flow is critical. In this case project UPSTREAM PRESSURE horizontally to the MAXIMUM CAPACITY LINE and read VOLUME directly below.

*For gravity correction multiply above capacities by $\sqrt{\frac{.65}{G}}$ where G equals specific gravity of gas.

220, 275, 300 and 500 lbs. Maximum W.P. Valves



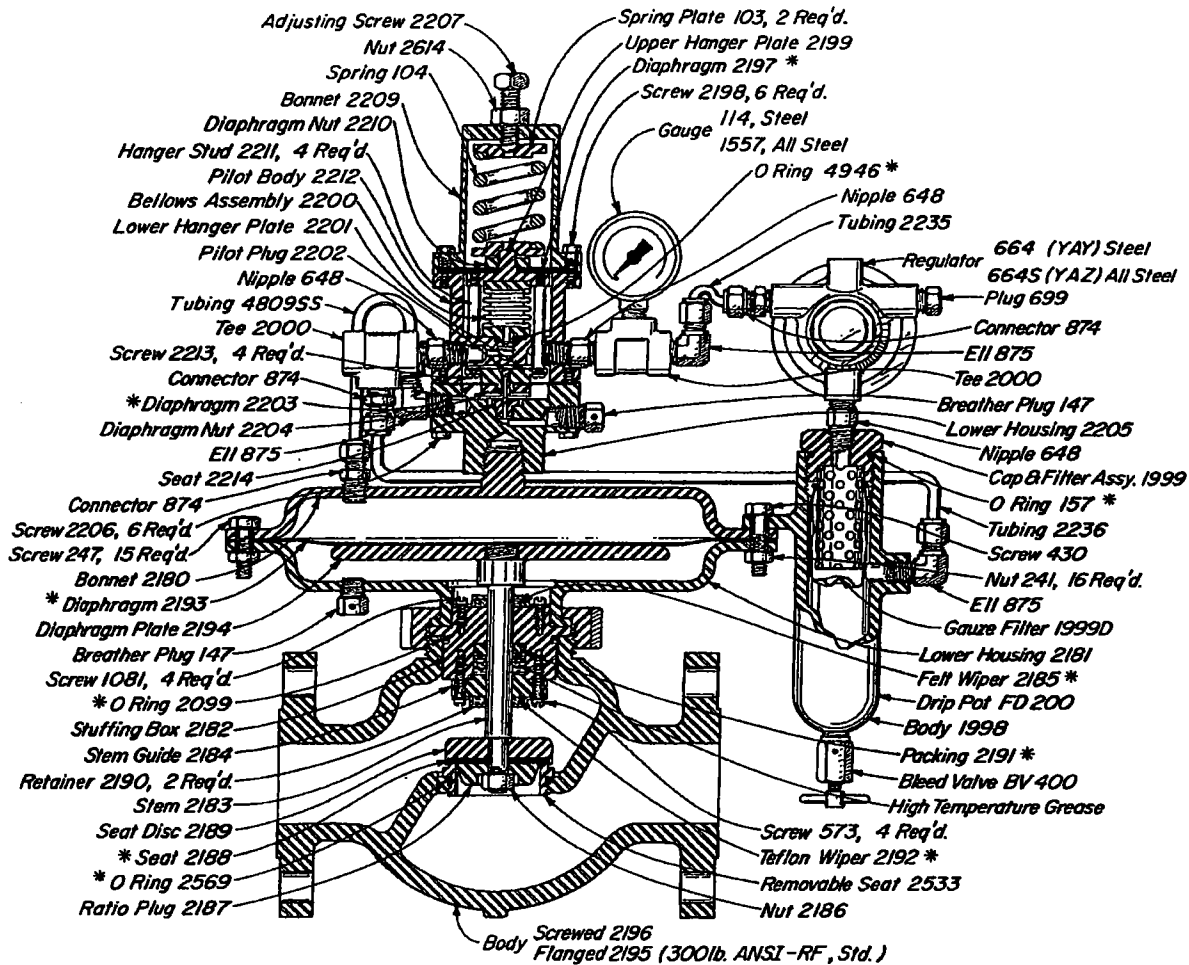
Gas capacities are based on pressure taken immediately upstream and downstream from the regulator in a wide open position.

Critical flow exists across a valve or orifice when the downstream absolute pressure is approximately half of the upstream absolute pressure. Any decrease in downstream pressure will not increase the flow through the valve. Critical flow conditions on the charts are represented by the MAXIMUM CAPACITY LINE.

HOW TO USE CHARTS: Locate UPSTREAM PRESSURE at left of chart. Follow horizontally across to PRESSURE DROP (upstream minus downstream pressure). Read VOLUME directly below. If the horizontal projection of the upstream pressure does not intersect the given pressure drop, flow is critical. In this case project UPSTREAM PRESSURE horizontally to the MAXIMUM CAPACITY LINE and read VOLUME directly below.

*For gravity correction multiply above capacities by $\sqrt{\frac{.65}{G}}$ where G equals specific gravity of gas.

250 S/FGT BP-S/STL
STEEL/ALL STEEL
500 lbs. W.P.



VALVES AVAILABLE: STEEL & ALL STEEL

CAT. NO.	SIZE	TYPE	REG. NO	DES. PRESS.	OPER. PRESS.
ABB	2"	SCRD.	250 SGT BP-S	500	500
ABA	2"	FLGD.	250 FGT BP-S	500	500
ABB1	2"	SCRD.	250 SGT BP-STL	500	500
ABA1	2"	FLGD.	250 FGT BP-STL	500	500

Dimensions, refer to Table of Contents.

*These parts are recommended spare parts and are stocked as repair kits. To order repair kit, specify size of regulator. Example: "2" 250G Repair Kit."

APPLICATION:






Vent lines on oil and gas separators, flow treaters, compressor stations, gas gathering systems.

PRESSURE RANGE:

50 psig to 500 psig

CAPACITY:

Refer to Table of Contents.

-  Pilot Bellows Assembly
-  Motor Valve Stem Assembly
-  Upstream Pressure
-  Pilot Supply Pressure
-  Motor Valve Diaphragm Pressure

OPERATION:

The Pilot Assembly and Motor Valve Stem Assembly (Crosshatched) are the only moving units in the regulator. The PILOT PLUG consists of two stainless balls rigidly connected together. The upper seat for the PILOT PLUG is the Motor Valve Diaphragm Pressure Inlet (Violet to Yellow). The lower seat for the PILOT PLUG is the pressure vent (Yellow to Atmosphere).

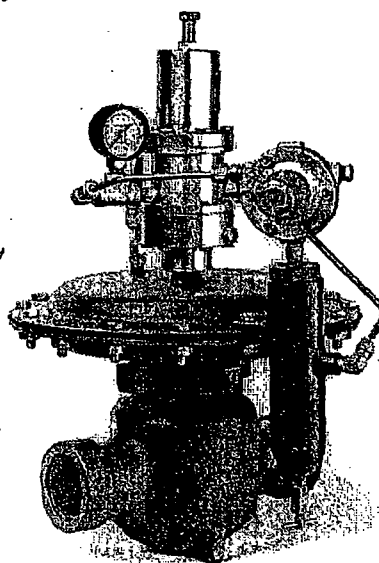
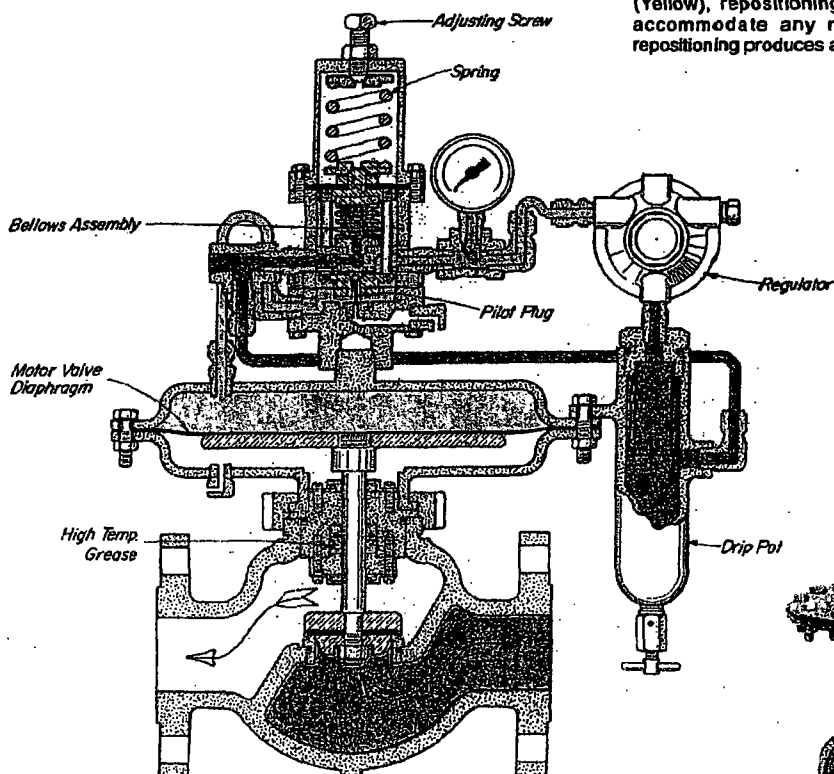
The PILOT SPRING in the bonnet loads the upper side of the Pilot Assembly and is opposed on the underside by Upstream Pressure (Red) in the BELLOWS ASSEMBLY.

Assume the PILOT SPRING is compressed with the ADJUSTING SCREW for a set pressure greater than the Upstream Pressure (Red) in the BELLOWS ASSEMBLY. The Pilot Assembly is forced downward by the PILOT SPRING. The lower seat for the PILOT PLUG (Yellow to Atmosphere) is closed and the upper seat for the PILOT PLUG (Violet to Yellow) is open. This allows Pilot Supply Pressure (Violet) to load the MOTOR VALVE DIAPHRAGM to close the motor valve. The area of the MOTOR VALVE DIAPHRAGM is sixteen times the area of the motor valve seat, assuring a positive shut-off.

As the Upstream Pressure (Red) increases to the set pressure, the BELLOWS ASSEMBLY expands upward against the Pilot Assembly, moving the PILOT SPRING to first close the upper seat (Violet to Yellow) and then open the pressure vent (Yellow to Atmosphere). As the Motor Valve Diaphragm Pressure (Yellow) is decreased, the Upstream Pressure (Red) acting under the motor valve seat, opens the valve.

With relief of Upstream Pressure (Red) through the motor valve, the Pilot Assembly assumes a position in which both seats of the PILOT PLUG are closed.

The non-bleed, three-way valve action of the PILOT PLUG against its seat adjusts the Motor Valve Diaphragm Pressure (Yellow), repositioning the Motor Valve Stem Assembly to accommodate any rate of flow. The rapid but stable repositioning produces a true throttling action.



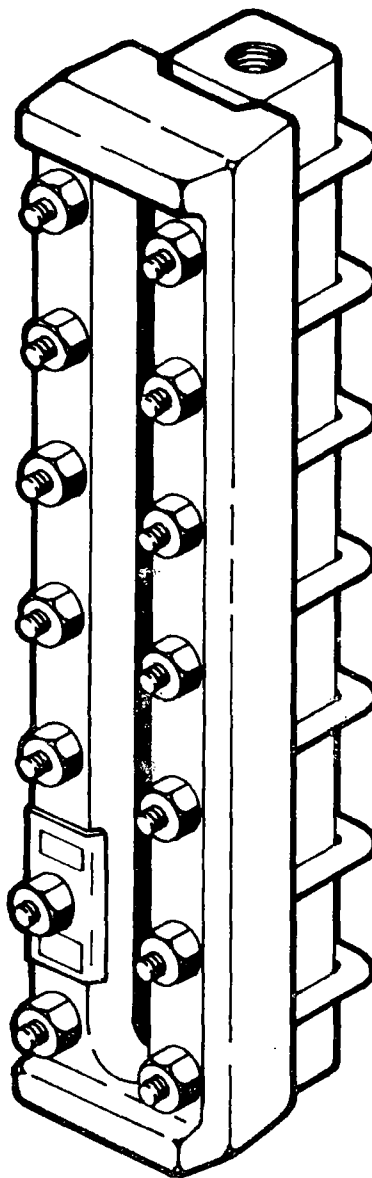
250 SGT BP-S

PENBERTHY®

Section	2000
Instal. Instr.	2950M
Issued	9/96
Replaces	6/95

Flat Glass Gages

Series M



Installation/Operation/Maintenance Instructions

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PRODUCT WARRANTY

Penberthy Inc., warrants its products as designed and manufactured by Penberthy to be free of defects in material and workmanship for a period of one year after the date of installation or eighteen months after the date of manufacture, whichever is earliest. Penberthy will, at its option, replace or repair any products which fail during the warranty period due to defective material or workmanship.

Prior to submitting any claim for warranty service, the owner must submit proof of purchase to Penberthy and obtain written authorization to return the product. Thereafter, the product shall be returned to Penberthy in Prophetstown, Illinois, with freight prepaid.

This warranty shall not apply if the product has been disassembled, tampered with, repaired or altered outside of the Penberthy factory, or if it has been subjected to misuse, neglect or accident.

Penberthy's responsibility hereunder is limited to repairing or replacing the product at its expense. Penberthy shall not be liable for loss, damage, or expenses directly or indirectly related to the installation or use of its products, or from any other cause or for consequential damages. It is expressly understood that Penberthy is not responsible for damage or injury caused to other products, building, property or persons, by reason of the installation or use of its products.

THIS IS PENBERTHY'S SOLE WARRANTY AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED WHICH ARE HEREBY EXCLUDED, INCLUDING IN PARTICULAR ALL WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This document and the warranty contained herein may not be modified and no other warranty, expressed or implied, shall be made by or on behalf of Penberthy unless modified or made in writing and signed by the President or a Vice President of Penberthy.

1.0 About the Manual

This manual has been prepared as an aid and guide for personnel involved in installation or maintenance. All instructions must be read and understood thoroughly before attempting any installation, operation, or maintenance. Failure to follow *any* instruction could possibly result in a malfunction of the gage or glass breakage with resulting sudden release of pressure, property damage or physical injury to personnel.

SAFETY INSTRUCTIONS

Penberthy does not have any control over the manner in which its liquid level gage is handled, installed or used. Penberthy cannot and will not guarantee that a liquid level gage is suitable or compatible for the user's specific application.



WARNING



Contained fluids may be pressurized and can unexpectedly exit vessel connections due to apparatus or material failure. Safety glasses should be worn when installing a liquid level gage. Failure to do so could result in serious physical injury to personnel.

2.0 Introduction

Penberthy liquid level gages are used to allow direct visualization of liquid level in vessels. By peering through the glass, it is possible to monitor color, clarity, and level of a gas/liquid interface. Gages are available in varying lengths and configurations (end connect, side connect, multiple sections, NPT or flange connections, etc.). Visual indication can be enhanced by using reflex glass or illuminators (accessory).

2.1 System Description

Penberthy gages are comprised of six basic components. Each component may vary slightly, depending on the desired physical and mechanical properties for the gage. Use the exploded parts view in Section 11 as additional reference material.

Chamber - provides a pressure retaining metallic channel for the liquid to enter and be viewed. Slot(s) are machined into the chamber to provide direct visualization of the process fluid.

Gaskets - seal the gap and prevent leakage between the chamber and the glass. Gaskets are available in a variety of materials for compatibility with the media in the gage.

Glass - glass allows for visual observation of the process fluid in the chamber

Cushion - acts as a protective buffer between the glass and the cover. For proper sealing cushions must be as hard as or harder than the gasket material.

Cover - protects the glass assembly from external hits and provides a flat, rigid surface that is used to evenly compress the gage assembly.

Bolting - compresses the components between the covers (transparent gages) or cover and chamber (reflex gages).

Shield (optional) - used to prevent the process media from contacting the glass.

3.0 Available Models

Penberthy medium (Series M) pressure liquid level gage are designed for applications other than steam/water: 1) requiring pressure ratings lower than that of Penberthy Series H liquid level gages, 2) where pressure ratings are greater than those possible using low pressure (Series L) liquid level gages, or 3) for Series L pressure ranges where iron covers are not allowed.

3.1 Design Ratings at Maximum and Minimum Operating Temperatures

Gasket Material	Glass Size	Model RM Reflex	
		Wetted Parts Material Steel or Stainless Steel w/B7 Bolting	
Grafoil® (standard) or Non-Asbestos	1 - 9	-20°F (-29°C) to 100°F (37°C)	600°F (315°C)
		3000 PSIG (20685 KPa)	2220 PSIG (15305 KPa)
		2910 PSIG (20065 KPa)	2150 PSIG (14825 KPa)
		2820 PSIG (19445 KPa)	2080 PSIG (14340 KPa)
		2725 PSIG (18790 KPa)	2040 PSIG (14065 KPa)
		2630 PSIG (18135 KPa)	1950 PSIG (13445 KPa)
		2535 PSIG (17480 KPa)	1875 PSIG (12930 KPa)
		2440 PSIG (16825 KPa)	1805 PSIG (12445 KPa)
		2345 PSIG (16170 KPa)	1740 PSIG (12000 KPa)
		2250 PSIG (15515 KPa)	1660 PSIG (11445 KPa)
PTFE/ Top-Chem 2000®	1 - 9	3000 PSIG (6205 KPa) at -20°F (-29°C) to 500°F (260°C) reference Application Report for gage pressure limitation at specific temperatures	
25% glass filled PTFE	1 - 9	900 PSIG (6205 KPa) at -20°F (-29°C) to 100°F (37°C) 450 PSIG (3105 KPa) at 500°F (260°C)	
NBR/Buna N®	1 - 9	300 PSIG (2070 KPa) at -20°F (-29°C) to 100°F (37°C) 225 PSIG (1550 KPa) at 250°F (121°C)	
FKM/Viton®	1 - 9	300 PSIG (2070 KPa) at -20°F (-29°C) to 100°F (37°C) 180 PSIG (1240 KPa) at 400°F (204°C)	
PTFE/Teflon®	1 - 9	300 PSIG (2070 KPa) at -20°F (-29°C) to 100°F (37°C) 150 PSIG (2275 KPa) at 500°F (260°C)	

TABLE 1

NOTE:

Lower temperatures are possible with metallic material variation. (e.g., 316 Stainless construction, Grafoil® gaskets/cushions useable to -325°F [198°C])

Gasket Material	Glass Size	Model TM Transparent	
		Wetted Parts Material Steel or Stainless Steel w/B7 Bolting	
Grafoil® (standard) or Non-Asbestos		-20°F (-29°C) to 100°F (37°C)	600°F (315°C)
	1	2500 PSIG (17235 KPa)	1850 PSIG (12755 KPa)
	2	2315 PSIG (15960 KPa)	1720 PSIG (11860 KPa)
	3	2130 PSIG (14685 KPa)	1575 PSIG (10860 KPa)
	4	1940 PSIG (13375 KPa)	1435 PSIG (9895 KPa)
	5	1750 PSIG (12065 KPa)	1295 PSIG (8930 KPa)
	6	1565 PSIG (10790 KPa)	1160 PSIG (8000 KPa)
	7	1375 PSIG (9480 KPa)	1015 PSIG (7000 KPa)
	8	1190 PSIG (8205 KPa)	880 PSIG (6070 KPa)
	9	1000 PSIG (6895 KPa)	740 PSIG (5100 KPa)
PTFE/ Top-Chem 2000®	1 - 9	2500 PSIG (6205 KPa) at -20°F (-29°C) to 500°F (260°C) reference Application Report for gage pressure limitation at specific temperatures	
25% glass filled PTFE	1 - 9	900 PSIG (6205 KPa) at -20°F (-29°C) to 100°F (37°C) 450 PSIG (3105 KPa) at 500°F (260°C)	
NBR/Buna N®	1 - 9	300 PSIG (2070 KPa) at -20°F (-29°C) to 100°F (37°C) 225 PSIG (1550 KPa) at 250°F (121°C)	
FKM/Viton®	1 - 9	300 PSIG (2070 KPa) at -20°F (-29°C) to 100°F (37°C) 180 PSIG (1240 KPa) at 400°F (204°C)	
PTFE/Teflon®	1 - 9	300 PSIG (2070 KPa) at -20°F (-29°C) to 100°F (37°C) 150 PSIG (2275 KPa) at 500°F (260°C)	
PCTFE/(Kel-F®) Shields 0.063" (1.6 mm) thick	1 - 9	300 PSIG (2067 KPa) at -20°F (-29°C) to 100°F (37°C) 180 PSIG (1240 KPa) at 400°F (148°C)	

TABLE 2

NOTE:

Lower temperatures are possible with metallic material variation. (e.g., 316 Stainless construction, Grafoil® gaskets/cushions useable to -325°F [198°C])

The pressure and temperature ratings may deviate from the above tables if the gasketing materials of construction and/or bolting are other than those specified. Higher and/or lower temperature ratings are available with different materials of construction.

To determine the maximum allowable working pressure for a specific temperature within the design limits stated in the tables, the user should refer to Penberthy dimension sheets, or when provided, the specifically stated design limits on a Penberthy product proposal.

NOTE: under no circumstances should shields be used in reflex style gages. Installation of shields in reflex style gages will keep the liquid from coming in contact with the refractive prisms, thereby prohibiting visualization of the liquid level in the gage.



DANGER



NEVER exceed these design ratings or application data. Exceeding design ratings or application data may result in mechanical failure of gage components resulting in death, serious personal injury and property damage.

4.0 Inspection

Upon receipt of a liquid level gage, check all components carefully for damage incurred in shipping. If damage is evident or suspected, do not attempt installation. Notify carrier immediately and request damage inspection.

Penberthy's standard 1 section TM gage consists of: (1) chamber, (2) gaskets, (2) borosilicate flat glass, (2) rubber bands, (2) cushions, (2) covers, (1) washer, (1) nameplate, and (6 - 14) bolting sets, depending on the size.

4.1 Glass Inspection

The self stick caution tape was applied at the factory to protect the glass during shipping, handling, and installation. Do not remove the tape from the glass until all installation procedures have been completed, except during receiving inspection to momentarily inspect glass for shipping damage. Glass that is not protected will be vulnerable to dust, grit, tools and any other objects which may scratch, chip, or break the glass.



WARNING



DO NOT use glass that is chipped or even slightly scratched. Glass surface defects weaken the glass which may result in glass breakage and fluid loss under pressure resulting in serious personal and property damage.

4.2 User Rating Inspection

The user should confirm that:

- 1) the Series M liquid level gage model and assembly number stamped on the nameplate conforms to the description on the user's purchase order,
- 2) the operating conditions described in the purchase order agree with the actual operating conditions at the installation site,
- 3) the actual operating conditions at the installation site are within the application data shown on the Penberthy Technical Data Bulletin or product proposal referred to above, and
- 4) the materials of construction of the liquid level gage are compatible with both the contained media and surrounding atmosphere in the specific application.

SAFETY INSTRUCTIONS

If the size, model, or performance data of the liquid level gage as received does not conform with any of the criteria above, do not proceed with installation. Contact an authorized Penberthy distributor for assistance. The incorrect gage can result in unacceptable performance and potential damage to the gage.

5.0 Installation

Installation should only be undertaken by qualified personnel who are familiar with equipment of this type. They should have read and understood all of the instructions in this manual. The user should refer to Penberthy dimension sheets or Penberthy product proposal to obtain dimensional information for the specific size and model liquid level gage.

Penberthy recommends that all liquid level gage installations be provided with gage valve sets equipped with ball check shut-off. Gage valve sets are designed to isolate the gages from the pressure vessel when it becomes necessary to drain or service the gages. The ball check shut-off is designed to retard leakage of the contained fluid in the event of gage glass breakage. Ball checks are available for both positive and negative vessel pressures.

The number of different types of gage and valve installations is too great to adequately detail in an installation manual. It is, therefore, the user's responsibility to assure that the knowledgeable installation personnel plan and carry out the installation in a safe manner. The following procedures are some of the installation guidelines that should be employed.

5.1 Piping Strain

The gage should be mounted and connected so that it does not support any piping weight. Piping not properly supported, independent of the gage, may subject the gage to stresses that can cause leaks or glass breakage. Support brackets are available as an accessory.

5.2 Differential Thermal Expansion

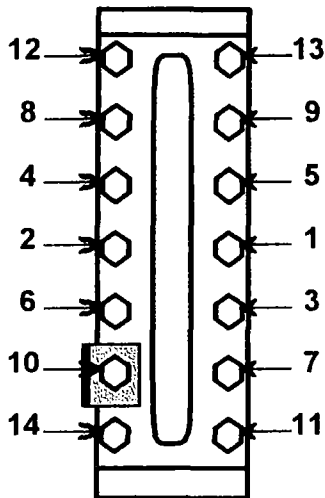
High mechanical loads may be imposed on a gage by expanding and contracting pipes due to hot or cold service. Such mechanical loads on the gage must be minimized by the use of expansion loops in the system. Failure to allow for expansion or contraction can result in leaks or glass breakage.

5.3 Mirror Viewing

For added safety, a system of indirect viewing by means of mirrors should be installed to protect personnel from the hazards of possible gage failure.

5.4 Nut Retorquing (not applicable for gages with Belleville washers) - see Section 5.5

Nut retorque is vital to the operation of a liquid level gage because gaskets take permanent set under initial bolt loading at assembly. Tightening of nuts before installation to values specified in Table 3 is necessary to insure pressure retaining capabilities of liquid level gage to specific design ratings. The user must refer to the liquid level gage model and assembly number and to the purchase order or tag to determine materials of construction.



**Nut Tightening Sequence
Figure 1**

BOLT TORQUE VALUES

GAGE MODELS and GASKET MATERIAL	ft-lb
RM, TM w/Grafoil® (standard)	25 to 30
RM, TM w/Non-asbestos (optional)	30 to 35
Top-Chem 2000®	25 to 30
25% glass filled PTFE	20
All Models w/Teflon®, Viton® or elastomeric (optional)	10
TM with PCTFE/(Kel-F®) Shields (optional) 0.063"	10

Table 3

Using a torque wrench, tighten nuts in five **ft-lb** increments following the "Z" pattern sequence in Figure 1, until the torque values shown in Table 3 above for the specific liquid level gage are reached. For multiple section gages, torque the center section(s) and progressively work toward the ends of the gage.

If bolting, gasketing or glass on any section of a multi-section gage is disturbed, all sections must be checked for integrity and retorqued if necessary.



WARNING

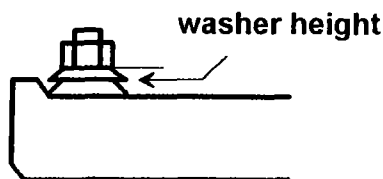


Failure to comply with the proper torquing sequence or force/height value can lead to leakage, gasket blow-out or glass breakage resulting in gage failure, serious injury and/or property damage.

NOTE: Depending on gage size there may be less bolting than shown in Figure 1. Start at the center and follow "Z" pattern outward to the limit of bolting on a specific gage.

5.5 Belleville Washers

Belleville washers are used to reduce or eliminate the need to retorque nuts. This is especially important for gages subject to pressure and/or thermal cycling and also in offshore applications where use of wrenches often cracks or chips the protective coat. The conical washers allow for material expansion and contraction while maintaining axial bolt loading and, therefore, compression on the gasket.



Belleville Washer Height
Figure 2

**CONICAL SPRING HEIGHT
FOR BELLEVILLE WASHERS**

GAGE MODELS	No. of Washers per nut	Spring Height (top of cover to bottom of nut) inch (mm)
RM	4	0.264 (6.7)
TM	2	0.136 (3.5)

Table 4

The effective range of a Belleville washer is measured in height (or compression distance) of the washer **NOT TORQUE**. Refer to Figure 2 and Table 4 for proper compression height. Do not tighten nuts until the washers are flat. Belleville washers cannot absorb expansion when flat.

If bolting, gasketing or glass on any section of a multi-section gage is disturbed, all sections must be checked for integrity and stack height, if necessary.

6.0 Operation

Before initializing liquid level gage operation, check that all installation procedures have been completed. Use only qualified, experienced personnel who are familiar with liquid level gage equipment and thoroughly understand the implications of the tables and all the instructions. Check to determine that all connections are pressure tight. Assure that nuts have been retorqued to their proper values as specified in Table 5. Remove self stick caution tape from the glass and inspect to be sure that glass is clean and free of any damage such as cracks, scratches, pits, and chips.

6.1 Hydrostatic Test



DANGER



Liquid level gage installations should be brought into service slowly to avoid excessive shock or stress on the glass. Rapid pressurization or sudden changes in temperature may cause glass breakage. To avoid excessive thermal shock or mechanical stress on glass, the connecting valves should be opened slightly, and the gage temperature and pressure allowed to slowly equalize. If the valves are equipped with ball checks, the valves must be opened all the way after the pressure and temperature have equalized to permit operation of the automatic ball checks in the event of failure. Failure to follow the recommended operating procedures can result in death, severe personal injury and/or property damage.

Take all precautions necessary to handle the possibility of leakage during the test. Hydrostatically pressure test all installations to at least 100 PSIG but less than design pressure and correct any leakage before proceeding.

7.0 Maintenance



WARNING



Use only qualified, experienced personnel who are familiar with liquid level gage equipment and thoroughly understand the implications of the tables and all the instructions. DO NOT proceed with any maintenance unless the liquid level gage has been relieved of all pressure or vacuum, has been allowed to reach ambient temperature and has been drained or purged of all fluids. Failure to do so can cause serious personal injury and property damage.

The rate at which components degrade is dependent upon a variety of conditions. Pressure, temperature and process media all influence the rate at which gage components deteriorate. Higher temperatures can accelerate the deterioration of gaskets, cushions, glass, and metals. Acids and similar chemicals can break down the integrity of almost any material. Concentration of chemicals can accelerate the corrosion rate. Penberthy cannot create a blanket maintenance schedule for every application.

The end user is the most familiar with the process media and conditions and must be responsible for creating a maintenance schedule. The user must create maintenance schedules, safety manuals, and inspection details for each liquid level gage. Realistic maintenance schedules can only be determined with full knowledge of the services and application situations involved. These will be based upon the user's own operating experience with their specific application.

If bolting, gasketing or glass on any section of a multi-section gage is disturbed, all sections must be checked for integrity and retorqued or repaired as necessary.

On all installations the following items should be regularly evaluated by the user for purposes of maintenance:

- 1) glass, for cleanliness and signs of damage or wear,
- 2) shields, if used, for signs of clouding, wear or deterioration,
- 3) gage, for signs of leakage around gaskets or at connections and
- 4) gage, for signs of internal or external corrosion.

7.1 Maintenance Procedures

GLASS should be given regular and careful attention. Keep glass clean using a commercial glass cleaner and a soft cloth. Inspect the surface of the glass for any clouding, etching or scratching or physical damage such as bruises, checks or corrosion. Glass that is damaged is weakened and may break under pressure. Shining a light at approximately a 45° angle will aid in detecting some of these conditions. Typical damaged areas will glisten more brightly than the surrounding glass because the light is reflected.

Detection of any damage, problem areas or surface wear is sufficient evidence to take the liquid level gage out of service. DO NOT proceed with operation of the liquid level gage until the glass has been replaced with a glass replacement kit following the assembly instructions in Section 8.

SHIELDS showing any signs of clouding, wear, or deterioration are an indication that the gage glass has been exposed, or could soon be exposed to the contained fluid. Immediately take liquid level gage out of service. **DO NOT** proceed with operation of the liquid level gage until shields and glass have been replaced by following the disassembly-reassembly instructions in Section 8.

GASKET LEAKS must be repaired immediately. **DO NOT** proceed with operation of a liquid level gage until gaskets have been replaced by following Section 8 assembly instructions.

CONNECTION LEAKS at a flanged or threaded connection should be corrected by tightening the bolting at the connection or by taking the liquid level gage out of service and wrapping the connection threads with Teflon® tape on all male pipe threads.

CORROSION may occur if the user has selected an improper material for the liquid level gage application. It is the responsibility of the user to choose a material of construction compatible with both the contained fluid and the surrounding environment. If internal or external corrosion is present, an investigation must immediately be performed by the user. It may be necessary to contact an authorized Penberthy distributor to better determine the origin of the corrosion.

7.2 Troubleshooting

Problem:	glass becomes prematurely etched or clouded in service
Cause:	fluid being handled is not compatible with the glass or shields
Solution:	replace the glass and install shields which will not be affected by contained fluid
Problem:	glass continually breaks in service despite careful attention to maintenance procedures
Cause:	thermal shock, hydraulic shock, mechanical loads, exceeding design ratings or a combination of these
Solution:	check entire system to determine possible sources of loads. Check application to determine actual operating conditions and contact an authorized Penberthy distributor on how to proceed.

8.0 Removal - Disassembly - Reassembly



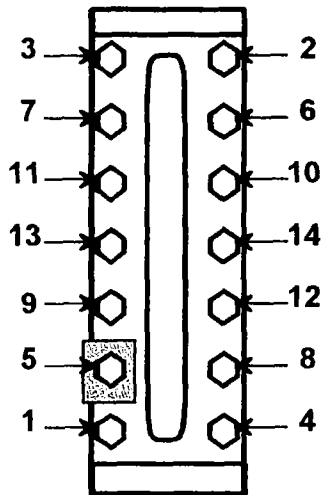
WARNING



Use only qualified, experienced personnel who are familiar with liquid level gage equipment and thoroughly understand the implications of the tables and all the instructions. **DO NOT** proceed with any maintenance unless the liquid level gage has been relieved of all pressure or vacuum, has been allowed to reach ambient temperature, and has been drained or purged of all fluids. Failure to do so can cause serious personal injury and property damage.

8.1 Disassembly

Secure workbench longer than the liquid level gage, and sufficiently wide to lay out parts as they are removed.



Nut Loosening Sequence
Figure 3

- 1) Lay gage on bench so nut side of fastener is up.
- 2) Hold gage firmly, and loosen nuts starting at both ends of each section and then proceeding from both ends to the center of each section as shown in Figure 3.
- 3) Nut Loosening Sequence
 - remove nuts, washer, and nameplate
 - tap covers with rubber hammer as needed to loosen and remove
 - for belleville washer assemblies: to remove covers, studs may need to be removed by laying the assembly on its side and knocking the studs/U-bolts through the cover with a hammer and punch
 - remove cushions, glass, shields (if any), and gaskets
 - tap liquid chamber or remaining covers as necessary with rubber hammer to break loose, and remove remaining components
 - remove, destroy, and dispose of all glass, cushions, gaskets, and shields. Under no circumstances should these components be re-used or installed on a gage

NOTE: If size of gage is smaller than shown, follow spiraling sequence from the ends until all bolting is loosened.



WARNING



Once used cushions, gaskets, and shields are permanently deformed by compression and if re-used, may cause leaks and high stress points resulting in glass breakage. Glass may contain hidden damage and internal stresses caused by previous usage. If re-used, the glass may break under pressure causing personal and property damage.

8.2 Inspection of Glass Seating Surfaces

Clean the glass seating surfaces on the liquid chamber and cover with a soft metal scraper (preferably brass) to remove all burrs, rust, and remnants of the previous gaskets and cushions. Exercise extreme care to avoid gouging or scarring gasket and cushion seating surfaces.

Use a known flat piece of metal the same approximate length as the glass or a new piece of glass and a thickness gage to check flatness of each glass seating surface on liquid chamber and under cover. Surface must be flat within 0.002 inch. If any one surface is found to be beyond a tolerance of 0.002 inch, the entire gage must be disposed of and replaced. Gasket seating surface must have a final surface finish of 450 to 500 AARH.



WARNING



Flatness of glass seating surfaces outside 0.002 inch tolerance specified is an indication of the gage having been overstressed through repeated exposure to mechanical, thermal, or hydraulic shock during its previous service. Operation of a liquid level gage which has been overstressed will result in abnormal stresses on the glass which may cause glass to break. If surface finish is not in the 450 - 500 AARH range, gasket may extrude under pressure with resulting sudden release of pressure, leakage of contained fluid, serious personal injury, or property damage.

Glass seating surfaces should NOT be machined to achieve seating tolerance. The chamber and cover are designed for a critical thickness to achieve the pressure/temperature ratings. Machining glass seating surfaces may result in non-compliance to the necessary critical thickness due to material removal.

8.3 Reassembly

If all glass seating surfaces are found to be within the 0.002 inch (0.051mm) tolerance described in the previous section, proceed to obtain new glass, gaskets, cushions and shields (if used) and proceed to reassemble as follows (refer to exploded parts view in Section 11 if needed):

- 1) clean threads on bolt and nuts to remove all paint, rust, and scale. Apply a light coat of oil to the threads.
- 2) for transparent gages, insert bolts through half the cover and lay out covers along bench, side by side, with the liquid chambers. Use chambers to space covers and line them up with vision slots.
- 3) for reflex style and belleville reflex style gages, lay out covers along bench, side by side, with liquid chambers. Use chambers to space covers and line them up with vision slots.
- 4) for transparent belleville style gages, thread nuts on stud, place two belleville washers under nut with pointed end toward the nut (see Figure 2), insert stud through each cover and lay out covers along bench, side by side, with liquid chambers. Use chambers to space covers and line them up with vision slots.
- 5) install one cushion inside each cover.



WARNING



Separate installation instructions are supplied with replacement glass. All instructions supplied with the glass must be followed as there are precautions to be taken when handling gage glass. Among the precautions is avoidance of bumping or sliding glass against any surface and inspection of individual pieces. Failure to follow any of the replacement gage glass installation instructions could result in glass breakage with resulting sudden release of pressure, personal or property damage.

- 6) install rubber band around each piece of glass, then place glass centered inside each cover.

- 7) install shields, if used, and gasket on glass being careful to keep components centered.
- 8) place liquid chamber on the gaskets (shields - if used) making sure all components are aligned with vision slot.
- 9) for reflex gage, install U-bolts in place by tapping as needed with rubber hammer, being careful not to lose alignment with vision slot.
- 10) for reflex gage, quickly turn over assembly onto back side of U-bolts. Assemble nameplate, washer, and nuts to U-bolts. Tighten nuts with fingers. Using a torque wrench, tighten nuts in five **ft-lb** increments, following the sequence in Figure 1 until the torque values shown in Table 3 are reached.

NOTE: Depending on gage size there may be less bolting than shown in Figure 1. Start at the center and follow "Z" pattern outward to the limit of bolting on a specific gage.

- 11) for transparent gage, install gaskets in place, and shields if used.
- 12) install one cushion on each piece of glass
- 13) install rubber band around each piece of glass, then place glass centered inside each cover
- 14) install covers in place being careful to maintain components alignment inside.
- 15) install nameplate, washer, and nuts to studs. Tighten nuts with fingers. Using a torque wrench, tighten nuts in five **ft-lb** increments, following the sequence in Figure 1 until the torque values shown in Table 3 are reached.
- 15A) for transparent belleville style gages: install nameplate and two belleville washers under each nut with pointed end toward the nut (see Figure 2). Finger tighten nuts.

NOTE: the following procedure is to be done on only one side of the gage.

- 15B) for reflex belleville style gages: install nameplate and four belleville washers under each nut with pointed end toward the nut (see Figure 2). Finger tighten nuts.
- 16A) Using a torque wrench, tighten nuts in five **ft-lb** increments, following the sequence in Figure 1. Once 20 **ft-lb** is reached, begin measuring stack height. Tighten nuts in five **ft-lb** increments until stack spring height is within 0.008" (0.2 mm) of proper height. Individually tighten each nut until stack height is achieved. (see Table 5) To estimate washer height, add the thickness of the nut to the compressed height requirement and use this value to compare to the measurement from the top of the nut to the face of the cover.

Refer to Section 5 for installation and Section 6 for operation of liquid level gage when returning to service.

9.0 Disposal at End of Useful Life

Penberthy gages are used in a variety of fluid applications. By following the appropriate governmental and industry regulations, the user must determine the extent of preparation and treatment the gage must incur before its disposal. A Material Safety Data Sheet (MSDS) may be required before disposal services accept certain components.

Metals, glass, and polymers should be recycled whenever possible. Refer to order and Penberthy's Material Specification sheets for materials of construction.

10.0 Telephone Assistance

If you are having difficulty with your liquid level gage, notify your local Penberthy distributor. You may also contact the factory direct at (815) 537-2311 and ask for an applications engineer. So that

we may assist you more effectively, please have as much of the following information as possible when you call:

- Model #
- Name of the company from whom you purchased your liquid level gage
- Invoice # and date
- Process fluid
- Operating pressures
- Operating temperatures
- A brief description of the problem
- Troubleshooting procedures that failed

If attempts to solve your problem fail, you may be requested to return your liquid level gage to the factory for intensive testing. You must obtain a Return Authorization (R.A.) number from Penberthy prior to returning anything. Failure to do so will result in the unit being returned to you, without being tested, freight collect. To obtain a R.A. number, the following information (in addition to that above) is needed:

- Reason for return
- Person to contact at your company
- "Ship To" address

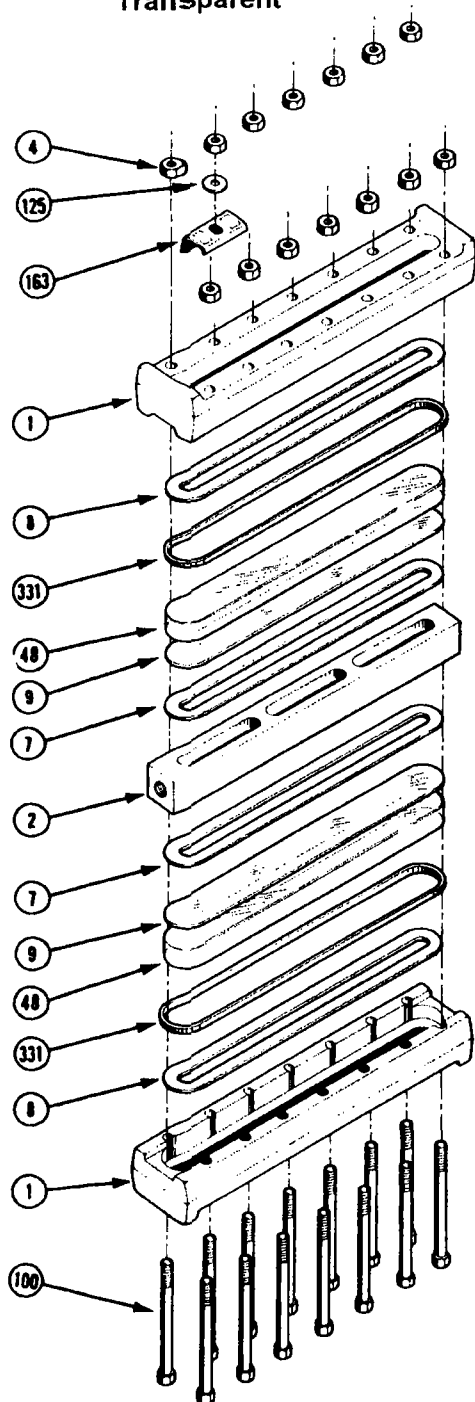
We recommend that you return the entire unit for testing. There is a minimum charge of \$75.00 for evaluation of non-warranty units. You will be contacted before any repairs are initiated should the cost exceed the minimum charge. If you return a unit that is covered by the warranty, but is not defective, the minimum charge will apply.

Grafoil® is a registered trademark of Union Carbide Corporation
Neoprene®, Viton®, and Teflon® are registered trademarks of E.I. du Pont de Nemours and Company
Top Chem 2000® is a registered trademark of Klinger
Ket-F® is a registered trademark of 3M

11.0 Exploded Parts Drawing

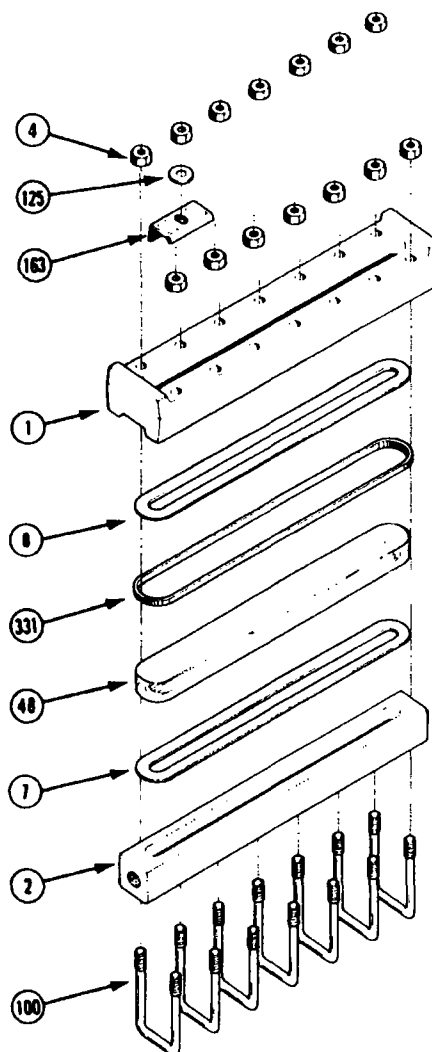
Recommended Spare Parts		
REF #	ITEM	QTY
100	Bolt/U-bolt	2/1 per sect.
4	Nut	2 per sect.
48	Glass	1
7	Gasket	2
8	Cushion	2
9	Shield (if used)	2

Transparent



- 1 - Cover
- 2 - Chamber
- 4 - Nut
- 48 - Glass
- 7 - Gasket
- 8 - Cushion
- 9 - Shield
- 100 - Bolt/U-bolt
- 125 - Washer
- 163 - Nameplate
- 331 - Band

Reflex



NOTE: size 9 shown - actual gage may be shorter and require fewer bolting components

≈ DECLARATION of CONFORMITY ≈

In conformance with ISO/IEC Guide 22 - 96
LLG.DC r C

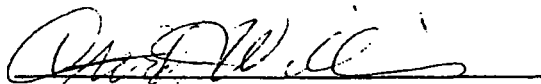
Manufacturer's Name: Penberthy, Incorporated
Manufacturer's Address: 320 Locust Street
Prophetstown, IL 61277-1147 U.S.A.
Product:
Type of Equipment: Pressure Vessel - Liquid Level Gauge Glass
Equipment Class: Industrial Instrumentation - Hazardous Area
Model Designations: RL, TL, RM, TM, RH, TH, RMW, TMW, RLC, TLC

The product described above is in conformity with:

92/59/EEC	General product safety	1992
87/404/EEC	Simple pressure vessel	1987
89/392/EEC	Machinery	1989
EN 10213-1:4	Technical delivery conditions for steel castings	1996
ISO 7-1	Pipe threads where pressure-tight joints are made	1996
BS 10	Flanges and bolting for pipes, valves and fittings	1962
BS 21	Pipe threads for tubes and fittings where pressure-tight	1985
BS 759	Valves, gauges and other safety fittings for application	1984
BS 970 Part 1	Wrought steels for mechanical and allied engineering	1996
BS 970 Part 3	Wrought steel for mechanical and allied engineering	1991
BS 1501 Part 3	Steels for pressure purposes	1990
BS 1502	Steels for fired and unfired pressure vessels	1982
BS 1506	Carbon, low alloy and stainless steel bars and billets	1990
BS 1560	Circular flanges for pipes, valves and fittings	1989
BS 1640 Part 1	Steel butt-welding pipe fittings	1962
BS 1640 Part 2	Steel butt-welding pipe fittings	1962
BS 1965	Butt-welding pipe fittings	1963
BS 3076	Nickel and nickel alloys: bar	1989
BS 3463	Observation and gauge glasses for pressure vessels	1975
BS 3602 Part 1	Steel pipes and tubes for pressure purposes	1987
BS 3605	Austenitic stainless steel pipes and tubes	1991
BS 3643	ISO metric screw threads	1981
BS 3799	Steel pipe fittings, screwed and socket-welding	1974
BS 4504	Circular flanges for pipes, valves and fittings	1989
ASME B&PV Code, Section VIII	Rules for construction of pressure vessels	1995
ANSI/ASME B1.1	Unified screw inch threads and UNR thread form	1982
ANSI/ASME B1.20.1	Pipe threads, general purpose (inch)	1983
ANSI/ASME B16.5	Pipe flanges and flanged fittings	1988
ANSI/ASME B18.2.1	Square and hex nuts and screw inch series	1981
ANSI/ASME B18.2.2	Square and hex nuts	1972
ANSI/ASME B31.3	Process piping	1996

Date: 30 December 1996
Prophetstown, IL U.S.A.

Signature:



Name:

David J. Williams, C.Q.E.

Position:

Quality Assurance Manager

Technical Construction File is available at stated address. Signatory is contact person.