

**MODEL 224/224C**  
**DIFFERENTIAL PRESSURE UNIT (DPU)**

(M224C for Industrial Service and  
Barton® brand M224 (non-C) for  
Nuclear Service)

**Installation Manual**

(Replaces/Supersedes ID#10085)

Part No. 10087, Rev.01

July 2007

[This manual is for DPU only - see separate instrument manual.]

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Before installing this instrument, become familiar with the installation instructions in Section 2 and in the separate instrument manual.

DANGER notes indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if warning is ignored.

WARNING notes indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if warning is ignored.

CAUTION notes indicate the presence of a hazard which will or can cause moderate personal injury or property damage if warning is ignored.

DANGER, WARNING, and/or CAUTION notes that appear on the following pages of this manual should be reviewed before proceeding: 3, 7, 8, 19, 20, and 23. (Important! Before installing or operating this instrument, review all safety notices contained in the separate actuated instrument manual.)

### **PRODUCT WARRANTY STATEMENT**

Product warranty for this instrument is as stated on the back cover of this manual.

NOTICE: DPU warranty will be voided if the following limitations are exceeded:

Temperature - Do not subject the DPU to temperatures above 200°F or below -60°F (+40°F minimum for water filled units).

Pressure - Do not subject the DPU to operating pressures in excess of the working pressure rating stamped on the unit or attached dataplate.

Corrosion - Do not subject the DPU to incompatible process media.

Sealed Components - Do not loosen or remove the torque tube gland nut, the drive arm hole plug, or the torque tube housing from the centerplate. To do so will cause loss of bellows fill fluid and render the unit inoperable.

Vibration/Shock - Do not subject the DPU to severe mechanical or hydraulic shock.

### **"C" VERSION DESIGN CHANGE**

The 224C is a redesigned version of the 224 DPU. The "C" version is identical in function, performance, installation, and operation to the previous version - redesign was for improved manufacturing only. This design change does not affect the instrument being actuated. **Barton-brand Model 224 (Non-C) DPU configurations are for Nuclear service only.**

### **RECORD OF CHANGES**

VERSION	DATE	DESCRIPTION (initial issue 95E1 [5/95])
99D8	8/99	Updated specs., Table 4-1, Table 5-1, and Section 6 drawings
01D18d	4/01	Revised to Booklet Format
03G50c	7/03	Rev. Co. Name/Logo; Rev. Sections 1, 2, & 3 for PED compliance
03H50b (ID#10087)	8/03	Rev. Spec. Table 1-1; Combined 224 and 224C (replaces 10080); Add 224 DPU information to Section 6
04C50b (ID#10085)	8/03	Produced separate manual under Barton brand for Nuclear/Government Service (No Tech. Changes from ID#10085)
06C75m (ID#10087)	4/06	Eliminated separate Barton-brand manual (ID#10085); Rev. Safety/ "C" Ver. statements; Rev. Tables 1-1, 3-1, and 6-1; Added Piping/Startup Examples (para. 2-4); Rev. housing bolt caution to warning (page 8); Rev. Figure 6-1; non-technical changes throughout
06D76a	4/06	Removed Government Service designation; No Tech. Changes.
01	7/07	Revised corporate name/logo/contact information to reflect Cameron ownership.

## SECTION 1 - INTRODUCTION

### 1-1. General

The Model 224/224C Differential Pressure Unit (DPU) is a mechanical device that measures differential pressure relative to a gas or liquid flowing through a process system, or to the level of a liquid contained in a process vessel.

For process flow measurements, the DPU is connected across a primary device (e.g., venturi, orifice plate, or flow tube) located in the process system.

For liquid level measurements, the DPU may be connected in a variety of ways to measure the difference in pressure caused by variations in the level of the liquid in the process vessel.

### 1-2. Product Description

The Model 224/224C DPU is a dual bellows assembly enclosed within pressure housings. The dual bellows assembly consists of two opposing internally connected liquid-filled bellows, a center-block, range springs, overrange valves, and a torque tube assembly.

The pressure housings are connected by pipe or tubing to the primary device located in the system piping. Variations in differential pressure within the pressure housings cause the bellows to expand or contract in a linear direction towards the side having the lowest pressure.

The linear movement of the bellows is converted into angular rotation when transmitted to the torque tube shaft by the drive arm and this mechanical motion actuates the mechanism of the process monitoring instrument.

The process monitoring instrument that is connected to the torque tube assembly may be an indicator, a switch, a transmitter, a recorder, or other process control device.

### 1-3. Specifications

The Model 224/224C DPU is available in various pressure ratings to measure to specific ranges between 0-30 inches of water column and 0-1000 psi, with safe working pressure (SWP) ratings from 500 to 10,000 psi (224 Non-C limited to 500 to 3,000 psi SWP). See Table 1-1, page 4.

The 224C Bellows Unit Assembly (BUA) is produced in three bellows sizes: 1-5/8 inch, 5/8 inch, and 3/4 inch diameter.

The 1-5/8 inch diameter BUA accommodates differential pressures to 55 psi. The range springs of this BUA are contained within the bellows and do not come in contact with the measured liquid.

The 3/4 inch BUA accommodates differential pressures up to 400 psi and the 5/8 inch BUA up to 1,000 psi. The range springs of these BUAs are grouped around the outside of the bellows and must be of a material that is compatible with the liquid being measured.



### CAUTION

Ambient temperatures below +40°F should never be allowed for water filled (D-fill) units.

Table 1-1. 224/224C DPU Material/Range Specifications (4/06a)

SWP psi (bar)	BODY	AVAILABLE DIFFERENTIAL PRESSURE RANGES						PRESSURE CONNECTIONS		
		Housing Material	Stainless Steel or Inconel Bellows 1-5/8" (41mm) O.D.	Beryllium Copper Bellows (224C Only)		Inconel Bellows		Top	Bottom	
				1-5/8" (41mm) O.D.	3/4" (19mm) O.D.	3/4" (19mm) O.D.	5/8" (16mm) O.D.			
224C 224 (Non-C)*	Forged Brass (ASTM-B124#2)	500 (34)	0-30" w.c. (0-75 mbar) to 0-60 psi (0-4.1 bar)	0-30" w.c. (0-75 mbar) to 0-60 psi (0-4.1 bar)	0-61 psi (0-4.2 bar) to 0-400 psi (0-27.6 bar)	0-61 psi (0-4.2 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-500 psi (0-34 bar)	1/4" NPT	1/4" NPT	
				0-30" w.c. (0-75 mbar) to 0-60 psi (0-4.1 bar)	0-61 psi (0-4.2 bar) to 0-400 psi (0-27.6 bar)	0-61 psi (0-4.2 bar) to 0-400 psi (0-27.6 bar)	0-400 psi (0-27.6 bar) to 0-500 psi (0-34 bar)	1/4" NPT	1/4" NPT	
	Cold Rolled Steel (C1018) Stainless Steel (316)	500 (34)	0-30" w.c. (0-75 mbar) to 0-60 psi (0-4.1 bar)							
	Copper Nickel (70-30)	1,000 (69)								
	Cold Rolled Steel (C1018) Stainless Steel (316)	1,500 (103)								
	Cold Rolled Steel (C1018) Stainless Steel (316) Monel	3,000 (207)		0-60" w.c. (0-149 mbar) to 0-60 psi (0-4.1 bar)		0-61 psi (0-4.2 bar) to 0-400 psi (0-27.6 bar)				
Cold Rolled Steel (C1018) Stainless Steel (316)	6,000 (414)		0-100" w.c. (0-248 mbar) to 0-60 psi (0-4.1 bar)		0-61 psi (0-4.2 bar) to 0-400 psi (0-27.6 bar)					
Alloy Steel (4140)	10,000 (689)									
Net Volume cu.in. (cu.cm)	L.P. Head	H.P. Head		1.66" (27.2 cc)	2.51" (41.1 cc)	2.51" (41.1 cc)	2.61" (42.8 cc)	1/4" NPT	1/4" NPT	
				1.55" (25.4 cc)	2.42" (39.7 cc)	2.42" (39.7 cc)	2.50" (40.9 cc)	9/16 ANINCO (1/4" ODT)	9/16 ANINCO (1/4" ODT)	
Displacement cu.in. (cu.cm) for full-scale Travel				0.14" (2.3 cc)	0.03" (0.49 cc)	0.03" (0.49 cc)	0.025" (0.41 cc)			

Performance: Torque Tube Rotation = 8° ±10%; Torque Tube Material = Beryllium Copper (BeCu); Temperature Limits = -40°F/C to +180°F (+82°C); Maximum Non-linearity = per Range; Repeatability = 0.2% of full scale differential pressure (see DP Indicators, Switches, & Transmitters bulletin #21920 for additional information).

Notes: Zero center or split ranges available on special order (e.g. 0-60" w.c. (0-149 mbar) range may be ordered 30-0-30" w.c. (75-0-75 mbar) or (15-0-45" w.c. (37-0-112 mbar). Absolute pressure ranges available from 30" w.c. (75 mbar) to 600 psi (41.4 mbar). Other sizes and types of connections (welding stubs, MA, A.N.D., etc.) available upon request. Outline dimension drawings available upon request. Metric conversions ( ) are approximate. M224C with NACE (MR-01-75) compliant materials available upon request. \*Model 224 (Non-C) for specific Nuclear service applications only.

#### 1-4. Theory of Operation

The M224/224C DPU measures the differential pressure (DP) in a process system relative to process functions and produces a mechanical output that actuates process monitoring instruments and process control devices.

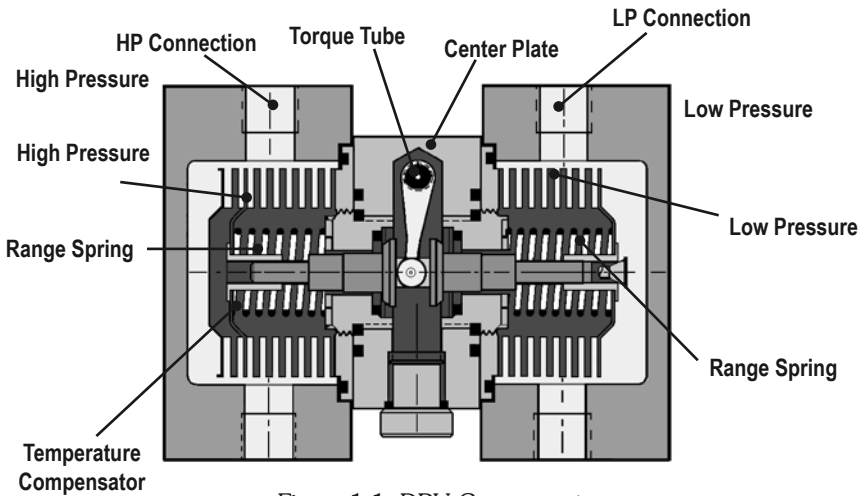


Figure 1-1. DPU Components

The high-pressure (HP) housing is connected by pipe or tubing to the high-pressure side of the primary device. The low-pressure (LP) housing is connected to the low-pressure side of the primary device.

Any pressure changes within the housings causes the bellows to move in the direction of least pressure. As the bellows move laterally, the connecting drive arm follows the motion of the bellows, and twists the torque tube.

The torque tube shaft, which is freely supported within the torque tube at its outer end, but attached to the torque tube and drive arm at the inner end, rotates through the same angle as the drive arm. The rotation of the torque tube shaft provides the mechanical motion required to actuate process instruments, such as recorders, indicators, transmitters, controllers, and switches.

If the bellows are subjected to a pressure greater than the range of the DPU, they move their normal travel range and a small amount of overtravel until the overrange valve seals against the valve seat. As the valve closes, the fill liquid is trapped in the bellows. Since the fill fluid is essentially noncompressible, the bellows are fully supported and will not be damaged regardless of the overpressure (up to the full rated pressure of the instrument) applied to them. Also, since dual overrange valves are used, full protection against overrange is provided in either direction.

An additional convolution in the high-pressure side of the bellows provides for expansion or contraction of the fill fluid relative to ambient temperature changes. This extra convolution acts as an accumulator permitting the fill fluid to change volume without materially affecting the pressure within the bellows or changing the physical relationship of the two bellows.

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## SECTION 2 - INSTALLATION

### 2-1. General

The instrument should be inspected at time of unpacking to detect any damage that may have occurred during shipment. **Note:** *The DPU was checked for accuracy at the factory — do not change any of the settings during examination or accuracy will be affected.*

*For applications requiring special cleaning/precautions, a polyethylene bag is used to protect the instrument from contamination. This bag should be removed only under conditions of extreme cleanliness.*

### 2-2. DPU Mounting

#### A. Flush or Panel

1. Cut an opening in the panel and drill four holes (17/64"), per outline dimension drawings in Section 5.
2. Pass the instrument through the cutout in the panel (from panel front).
3. Attach the indicator to the panel with four screws.

#### C. Pipe

Refer to Section 5. The unit must be mounted approximately level for proper operation.

### 2-3. DPU Piping



#### **WARNING**

HIGH PRESSURE HAZARD. TO PREVENT PERSONAL INJURY OR DAMAGE TO EQUIPMENT, DIRECT ALL PIPING AWAY FROM THE OPERATOR WHILE CONNECTING THE DPU TO THE SYSTEM PIPING.

#### **WARNING**

EXPLOSION HAZARD. NO ORGANIC COMPOUNDS, OIL, GREASE, DIRT, OR SCALE OF ANY KIND CAN BE TOLERATED IN AN OXYGEN INSTALLATION.

#### **WARNING**

FOR INSTALLATIONS WHERE THE PRESSURE COULD EXCEED THE RATED MAXIMUM SAFE WORKING PRESSURE OF THE DPU, THE PIPING SYSTEM MUST INCLUDE PROTECTIVE MEASURES TO PREVENT OVER PRESSURE, IN ACCORDANCE WITH APPLICABLE LOCAL AND NATIONAL PIPING CODES.

#### **WARNING**

THE MODEL 224/224C DPU IS NOT DESIGNED FOR HIGH STATIC OR DYNAMIC LOADS AT IMPULSE LINE CONNECTIONS. THE IMPULSE PIPING SYSTEM MUST BE DESIGNED WITH ADEQUATE SUPPORTS TO MINIMIZE THE LOADS AT THE DPU.



DO NOT REUSE HOUSING BOLTS. SEE HOUSING BOLT WARNING ON PAGE 20.

**CAUTION**

DPU pressure rating has been determined using standard methods without specific considerations for corrosion (internal or external) or fatigue. The system designer should appropriately derate any DPU where these considerations are significant issues. Do not subject DPU to unnecessary shock/overrange pressure during operation.

**CAUTION**

DPU bellows protects torque tube from exposure to process fluid. Cyclic conditions can cause undetected bellows failure resulting in exposure of the torque tube to the process fluid.

**NOTICE**

Do not share filling or vapor return lines with DPU piping lines.

Standard Piping Practices (observe when installing piping):

1. Shorten distance between primary device and DPU as much as possible. Distances exceeding 100 feet are not recommended. For distances up to 50 feet, use 1/4-inch pipe or tubing. For runs 50 to 100 feet, use 1/2-inch pipe or tubing. The recommended limitation does not apply if an air purge or blow-back system is used.
2. Slope all piping at least 1-inch/linear foot to avoid liquid/gas entrapment.
3. Provide two feet of un-insulated piping between the DPU and the primary device for each 100 degrees in excess of +180°F (+162°C), if process media exceeding +200°F (+93.3°C) must be measured.
4. Assure that the temperature of the DPU never exceeds 180°F (+162°C). When steam tracing is necessary, the steam pressure should not exceed five pounds per square inch and insulation should not be used. If pressure must exceed five pounds per square inch, limit the length of tubing around the DPU to two turns and do not insulate.
5. When severe pulsation is present, install a suitable pulsation dampening device upstream of the DPU; otherwise, accuracy will be affected.
6. Mount DPU on a solid support to minimize vibration. Tighten all points, using a suitable compound; leaks in piping can cause measurement errors.
7. Rotate the housing as necessary to place the connection in the proper position. The DPU has connections in the pressure housings to accommodate various pipe sizes (refer to Section 5).
8. Install a valve manifold connecting the DPU and the source of differential pressure to facilitate operation and checking of the DPU.
9. Install all shutoff and bypass valves so they are easily accessible from front of instrument. Locate block valves at the source of differential pressure.
10. For gas service, it is recommended that zero check be performed with both block valves closed. If gas flow is pulsating, a standing wave effect may be in the process line displacing the indicator (appearing to be a zero error).



## 2-4. DPU Piping/Startup Examples

"Typical" piping diagrams and startup procedures are presented on pages 9-17. For specific application/installation/piping information, contact Cameron. Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

- Flow Applications (pages 9-13) (HP = High Pressure)

Ensure DPU HP housing is connected to the primary device upstream tap.

**NOTICE:** To prevent overheating DPU during blow-down, operator should monitor temperature by placing his hands on pipe between DPU and the manifold pipe containing the vent valves.

- Liquid Level Applications (pages 13-16)

The process media may be used as a reference leg seal fluid when it is of a type that will condense in the reference leg under all conditions. If the process or process media characteristics are such that the above conditions cannot be met, a special reference leg seal fluid will be required.

If special seal fluid media characteristics are such that the above conditions cannot be met, a special reference leg seal fluid will be required. The special seal fluid must not be volatile and must not be miscible with the process media. The difference in densities (special seal fluid vs process media) will require compensation in calculating differential pressure range of the DPU.

- Liquid Specific Gravity Applications (page 17)

This method of piping is used for determining specific gravity changes in a process media using differential pressure instruments.

### A. Gas Flow, DPU Above Run

Recommended for use whenever possible, as the DPU is self-draining. However, NOT recommended when hydrates are present.

1. Open bypass valve(s) and close vent valve.
2. Open both shutoff valves and one block valve to pressurize DPU, then close block valve.
3. Close one bypass valve and check system for leaks. If output travels upscale, check for low-pressure piping leaks. If output travels downscale, check for high-pressure piping leaks.
4. Repair piping if necessary and repeat steps 1 through 3 until output remains stationary at zero.
5. Close both shutoff valves and open bypass valve(s).
6. Open both block valves and slowly open both shutoff valves.
7. Close bypass valves and if two bypass valves are used, open vent valve.
8. Close bypass valves, and if two bypass valves are used, open vent valve.

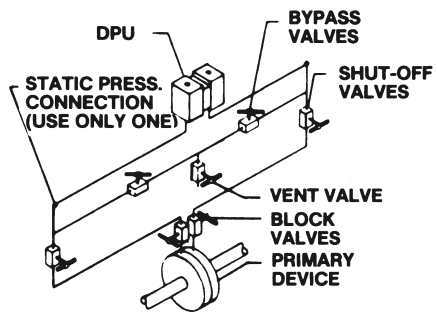


Figure 2-1. Gas Flow, DPU Above Run

## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

### B. Gas Flow, DPU Below Run

Used only when necessary to mount the DPU below run. Drip pots are required when wet gas is present.

1. Open bypass valve(s) and close vent valve.
2. Open both shutoff valves and one block valve to pressurize DPU, then close block valve.
3. Close one bypass valve and check system for leaks. If output travels upscale, check for low-pressure piping leaks. If output travels downscale, check for high-pressure piping leaks.

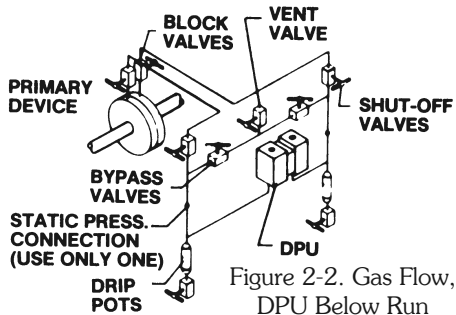


Figure 2-2. Gas Flow, DPU Below Run

4. Repair piping if necessary and repeat steps 1 through 3 until output remains stationary at zero.
5. Close both shutoff valves and open bypass valve(s).
6. Open both block valves and slowly open both shutoff valves.
7. Close bypass valves, and if two bypass valves are used, open vent valve.
8. If drip pots are used, open drip valves and blow out accumulated liquid.

### C. Gas Flow, Hydrates Present

The following is used if hydrates or heavy solids are present, piping and shutoff not less than 1/2-inch in diameter. Bypass the manifold above to isolate the meter from connecting piping. Drip pots prevent plugging.

1. Open bypass valve(s) and close vent valve.
2. Open both shutoff valves and one block valve to pressurize the DPU, then close block valve.
3. Close one bypass valve and check system for leaks. If output travels upscale, check for low-pressure piping leaks. If output travels downscale, check for high-pressure piping leaks.

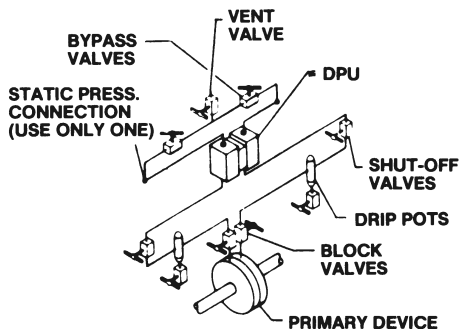


Figure 2-3. Gas Flow, Hydrates Present

4. Repair piping if necessary and repeat steps 1 through 3 until output remains stationary at zero.
5. Close bypass valves. If two bypass valves are used, open vent valve.

## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

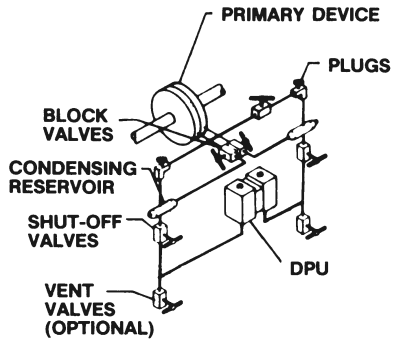
6. Drain drip pots of hydrates at regular intervals.

### D. Steam Flow, DPU Below Run

For this application, condensing reservoirs and piping to orifice taps must be level. Assure that the reservoir and steam lines are at the same level.

Two-inch pipe crosses may be used as seal pots.

1. Close vent valves if used, open bypass and shutoff valves.
2. Remove condensing reservoir side and fill plugs.
3. Pour water into both reservoirs until piping and DPU housings are filled. Piping and housing chambers shall be free of bubbles. The pointer will rest at zero (or output will be 4 mA or 10 mA as applicable) when the instrument and piping are completely filled.



4. Install side and fill plugs in reservoirs.
5. Close shutoff valves and open block valves.
6. Slowly open both shutoff valves simultaneously and check for leaks.
7. Close bypass valve.

NOTICE: Ensure that plugs are used and never valves on the DPU.

### E. Liquid Flow, DPU Above Run

The following steps should be used if sediments may be present. Inspect piping periodically. Not recommended for hot or gassy liquids.

1. Close both shutoff valves and open both block valves.
2. Open bypass valve. Crack vent valves or loosen plugs from top ports of DPU body housings.
3. Crack and close shutoff valves alternately until liquid is free of bubbles and spills out of both upper DPU body ports.
4. Close vent valves or tighten plugs. Close block valves and open shutoff valves.
5. The pointer will rest at zero (or output will be 4 mA or 10 mA as applicable). If not and no leaks are detected, the housing and/or piping are not completely filled with liquid. Repeat steps 1 through 4 until output remains stationary at the lowest value.

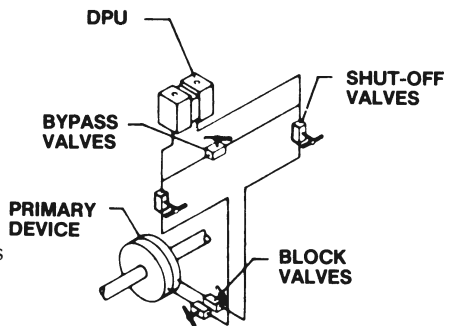


Figure 2-5. Steam Flow, DPU Above Run

## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

6. Slowly open both block valves and close bypass valve.

### F. Liquid Flow, DPU Below Run

The following steps are recommended for hot or gassy liquids. Periodic inspections of piping are recommended.

1. Close both shutoff valves and open both block valves.
2. Open bypass valve. Crack SHUT-OFF VALVES and vent valves or loosen plugs from top ports of DPU pressure housings.
3. Crack and close shutoff valves alternately until the liquid is free of bubbles and spills out of both upper DPU body ports.

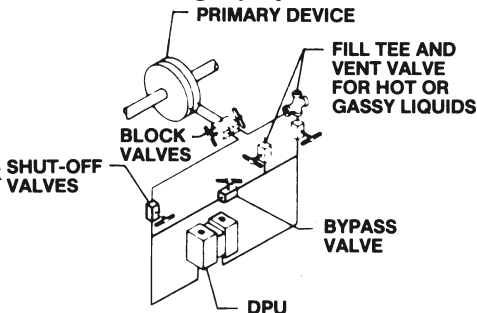


Figure 2-6. Liq.Flow,  
DPU Below Run

4. Close vent valves or tighten plugs. Close block valves and open shutoff valves.
5. The pointer will rest at zero (or output will be 4 mA or 10 mA as applicable). If not and no leaks are detected, the housing and/or piping are not completely filled with liquid. Repeat steps 1 through 4 until output remains stationary at the lowest value.
6. Slowly open both block valves and close bypass valve.
7. For service with hot or gassy liquids, fill both sides of the manifold through the fill tee, with the liquid to be measured cooled to +200°F (+93.3°C) or less, expel gas bubbles from DPU and piping.
8. Open vent valve in the bypass valve. Tighten the fill plug when bubble free liquid flows.

### G. Corrosive Liquid Flow

1. Close shutoff valves and open block valves.
2. Open bypass valve and close DPU drain plugs.
3. Remove fill and side plugs from seal pots.
4. Fill seal pots, piping and DPU housing with immiscible seal fluid by pouring into upper fill ports. DPU housing tubing, and scale pots must be filled to seal pot side ports with bubble-free liquid. The pointer will indicate zero (or 4 mA or 10 mA as applicable) when high and low pressure chambers are filled with liquid.

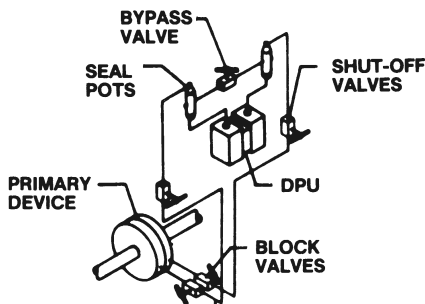


Figure 2-7. Corrosive  
Liquid Flow

5. Install side plugs.

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## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

### G. Corrosive Liquid Flow (Continued)

6. Slowly open each shutoff valve alternately, until bubble-free line liquid spills from both upper fill plugs.
7. Replace fill plugs.
8. Open and close block valves. Check for piping leaks (repair as needed).
9. Close shutoff valves and open block valves.
10. Slowly open both shutoff valves and close bypass valve.

### H. Cool Non-Condensing Liquid, DPU Level with Tank Bottom

High-pressure side of DPU is connected to bottom outlet of tank. The low-pressure side is connected to top or gas outlet of tank.

**NOTICE:** Do not share filling or vapor return lines with DPU piping.

The following steps are suitable for piping layout for water, oil, or other media that will not condense in low-pressure piping.

1. Close both shutoff valves, open lower block valve and crack vent valve.
2. Slowly open lower shutoff valve. When bubble-free liquid spills from vent, close vent valve.
3. Open upper block valve and slowly open shutoff valve.
4. Crack drain valve to remove any condensation and close drain valve.

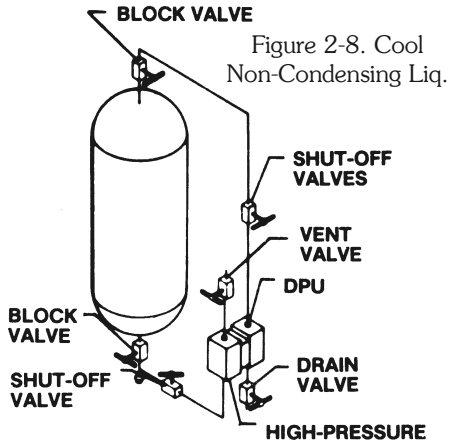


Figure 2-8. Cool Non-Condensing Liq.

### I. Cool Non-Condensing Liquid, DPU Below Tank

High-pressure side of DPU is connected to the bottom outlet of tank. The low-pressure side is connected to top or gas outlet of tank. The following steps are suitable for piping layout for water, oil, or other media that will not condense in low-pressure piping.

1. Close both shutoff valves, open lower block valve and crack vent valve.
2. Slowly open lower shutoff valve. When bubble-free liquid spills from vent, close vent valve.

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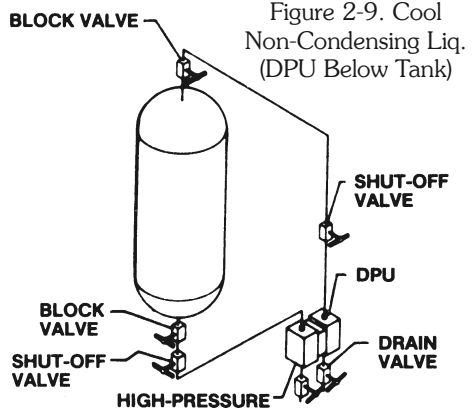


Figure 2-9. Cool Non-Condensing Liq. (DPU Below Tank)

## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

### I. Cool Non-Condensing Liquid, DPU Below Tank (Continued)

3. Open upper block valve and slowly open shutoff valve.
  4. Crack drain valve to remove any condensation and close drain valve.
- NOTICE: Do not share filling or vapor return lines with DPU piping.

### J. DPU Below Tank with Reference Leg

Cool Liquids:

Use of reference leg cancels out the "dead leg" (piping from the tank bottom to center line of meter body). Seal fluid in reference leg must not volatilize. Process media can be used as a reference leg seal fluid if it is such that it will condense in reference leg under all conditions. Otherwise, special, immiscible seal fluid must be used. Difference in densities between process media and seal fluid must be considered when computing differential pressure range of DPU.

1. Partially fill reference leg by opening bottom block valve, both shutoff valves, and bypass valve.
2. Crack drain plugs on the DPU housing and vent the valve. Close when clear, bubble-free liquid flows.
3. Close bypass and shutoff valve on reference leg.
4. Remove plug from the top port in 2-inch pipe cross connection, and fill the reference leg manually.
5. Open top shutoff valve and crack vent valve until bubbles are expelled. Leave the reference leg full.
6. Replace plug in pipe cross and close vent valve.
7. Slowly open upper block valve.

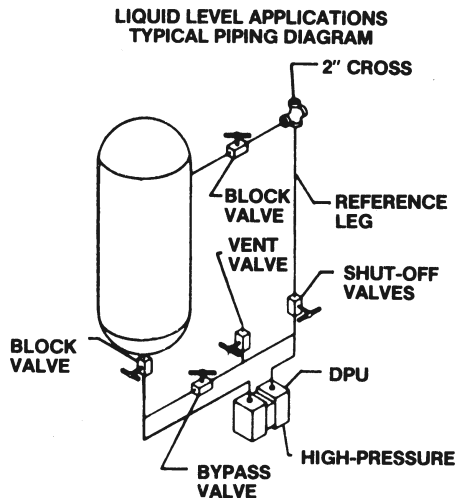


Figure 2-10. DPU Below Tank w/Ref. Leg

Hot Liquids (Volatile):

1. Open both shutoff valves, bypass valve and vent valve.
2. Remove plug from the top port in 2-inch pipe cross. Fill both high and low DPU housings with liquid until it runs out of vent valve. Use liquid to be measured, cooled below +200°F (+93.3°C) or other suitable seal liquid. Expel bubbles in DPU housing.

(continued on next page...)

## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

### J. DPU Below Tank with Reference Leg (Continued)

Hot Liquids (Volatile): (Continued)

3. Close bypass and shutoff valve on reference leg.
4. Remove plug from top port in 2-inch pipe cross connection, and fill reference leg manually.
5. Open top shutoff valve and crack vent valve until bubbles are expelled. Leave reference leg full.
6. Replace plug in pipe cross and close vent valve.
7. Slowly open upper block valve.

NOTICE: Do not share filling or vapor return lines with DPU piping.

If bypass valve is opened at any time, the reference leg must be filled again. If no bypass is installed, disregard steps 1, 2, and 3. Open the lower block valve in step 6 and shut off valve in step 7.

### K. Liquid CO<sub>2</sub>

The instrument may be located above or below the vessel. The recommended vapor generator is a 12-inch length of 1 to 1-1/2-inch diameter pipe. Avoid traps or pockets between the vapor generator and the tank. Install the inverted "U" shaped gas trap inside the vessel.

1. Close shutoff valves.
2. Open drain valve and DPU housing drain plugs to remove all liquid from the system, and close drains.
3. Open bottom block valve slowly to allow liquid to enter gas generator. Assure that vent valve is closed.
4. Open top block valve and shutoff valves.

NOTICE: Do not insulate the piping below the lower block valve. Do not share filling and vapor return lines with the DPU piping lines.

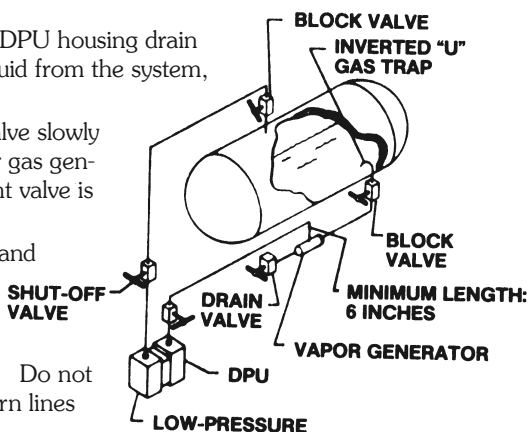


Figure 2-11. Liq. CO<sub>2</sub>

### L. Cryogenic Liquids

Instrument may be located above or below the vessel. The recommended vapor generator is a spiral of 3/8-inch tubing. Install the inverted "U" shaped gas trap inside vessel. Meters for oxygen service are specially cleaned and packaged in polyethylene bags, and must be kept extremely clean.

1. Close shutoff valves.
2. Open drain valve and DPU housing drain plugs to remove all liquid from system, and close drains.

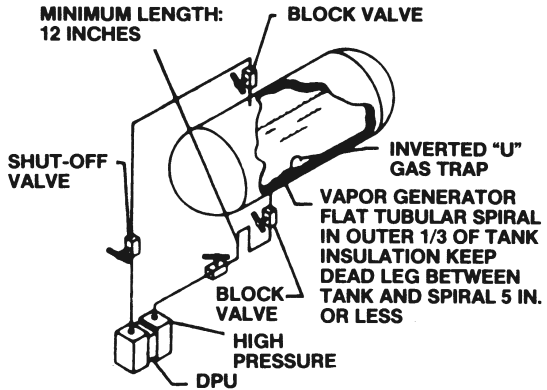
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## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

### L. Cryogenic Liquids (Continued)

3. Open bottom block valve slowly to allow liquid to enter gas generator. Assure that vent valves are closed.
4. Open top block valve and open shutoff valves.



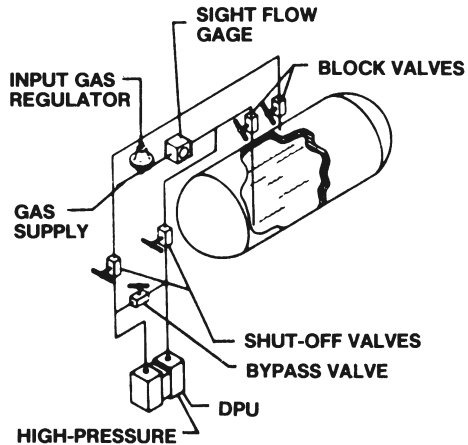
NOTICE: Do not share filling or vapor return lines with DPU piping.

Figure 2-12. Cryo Liq.

### M. Bubbler System

Recommended when piping connections must be made at the top of the tank or whenever solids or sludge are present.

1. Set bubbler input gas regulator pressure slightly higher than process vessel pressure.
2. Open block valves and shutoff valves, and close bypass valve.
3. Check sight-flow into bubbler tube.
4. Adjust bubbler system to minimum flow by adjusting input gas regulator.



NOTICE: Do not share filling or vapor return lines with DPU piping.



## 2-4. DPU Piping/Startup Examples (Continued)

Review all WARNINGS, CAUTIONS, AND NOTICES (pages 7 and 8) before installation or startup.

### N. Liquid Specific Gravity

This method is for determining specific gravity changes in a process media using a differential pressure instrument.

1. Set bubbler input gas regulator pressure slightly higher than process vessel pressure.
2. Open block valves and shutoff valves, and close bypass valve.
3. Check sight-flow into bubbler tube.
4. Adjust bubbler system to minimum flow by adjusting digit flow gages throttling valves.

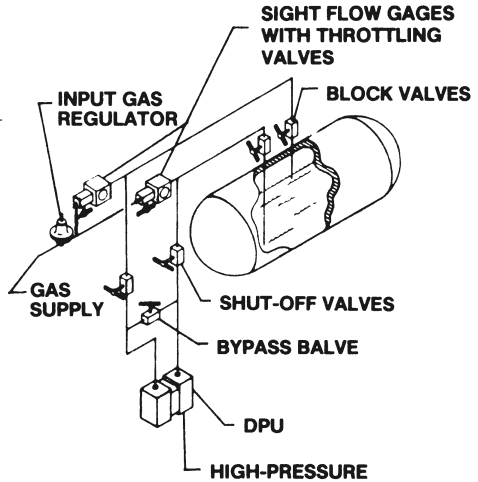


Figure 2-14. Liq. Specific Gravity

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## SECTION 3 - MAINTENANCE

### 3-1. Required Tools

#### Tool

Screwdriver

50 lb. Torque wrench

#### Purpose

Bracket Screws

Pressure housing bolts

### 3-2. Test/Calibration Equipment

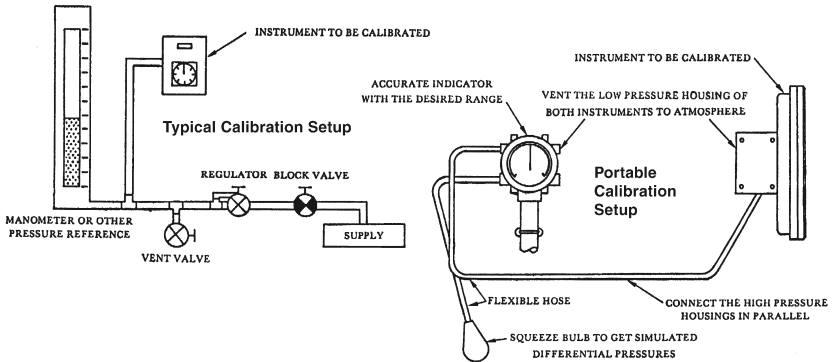


Figure 3-1. Test/Calibration Setup

### 3-3. Preventative Maintenance

- DPU Piping — Periodically inspect the integrity of the DPU piping. Tighten all pipe joints as necessary.
- DPU Inspection and Cleaning — See DPU Cleaning and Inspection Procedure that follows.

### 3-4. Calibration

For calibration procedures, refer to separate actuated instrument manual.

### 3-5. DPU Cleaning and Inspection

#### WARNING



#### **(High Pressure Gas Installations with pressures greater than 200 psig)**

HIGH PRESSURE GAS HAZARD ON DISASSEMBLY OF DPU. TO PREVENT POSSIBLE SEVERE PERSONAL INJURY, DEATH, OR SUBSTANTIAL PROPERTY DAMAGE DUE TO THE RELEASE OF INTERNAL PRESSURE, PERFORM THE PRESSURE CHECK PROCEDURE THAT FOLLOWS (Step A) BEFORE REMOVING THE DPU HOUSING BOLTS.

#### WARNING

THE DPU MAY BE UNDER PRESSURE. ENSURE THAT THE PIPING SYSTEM IS COMPLETELY DEPRESSURIZED BEFORE REMOVING THE METER FOR MAINTENANCE OR INSPECTION.

(Continued on next page...)

### 3-5. DPU Cleaning and Inspection (Continued)

(See **WARNINGS on page 19** before proceeding.)

**WARNING**  
**(Housing Bolts)** 

DO NOT REUSE HOUSING BOLTS. IF BOLTS ARE DISTURBED, REPLACE WITH NEW BOLTS, PER TABLE 3-1.

REUSE OF HOUSING BOLTS, ESPECIALLY IN CRITICAL APPLICATIONS LIKE HYDROGEN SULFIDE AND SALT WATER EXPOSURES, CAN RESULT IN SEVERE INJURY, DEATH OR SUBSTANTIAL PROPERTY DAMAGE DUE TO BOLT FAILURE.

**NOTICE**

If accumulation of solids or semi-solids is extensive, remove the housings carefully to prevent damage to the bellows.

A. Pressure Check

**WARNING** 

FAILURE TO PERFORM THIS PROCEDURE CAN RESULT IN SEVERE INJURY, DEATH OR SUBSTANTIAL PROPERTY DAMAGE DUE TO THE RELEASE OF INTERNAL PRESSURE.

This procedure should be performed prior to removing the DPU housing bolts, especially if the DPU has been installed in gas applications with working pressures greater than 200 psig.

1. Back off all housing bolts 4 turns.
2. Check for internal pressure by attempting to move the housing in and out along the bolts.
  - a. If the housing moves freely — no pressure is present — servicing or repair may continue.
  - b. If the housing does not move freely — the bellows may be pressurized and is **POTENTIALLY HAZARDOUS** if further disassembled. Tighten the bolts and return the unit to the factory or authorized service center for repair.

Tag the unit and specify “Gas in Bellows”.

B. Cleaning/Inspection Procedure

Instruments used in services where solids or semi-solids may accumulate inside the pressure housings require periodic inspection and cleaning, as follows.

1. Remove the DPU from service and remove the pressure housings.
2. Carefully remove the pressure housings from the bellows unit assembly.

**NOTICE**

If the accumulation of material inside the housing is extensive, rapid removal of the housing may damage the bellows convolutions.

### 3-5. DPU Cleaning and Inspection (Continued)

(See **WARNINGS on pages 19 and 20** before proceeding.)

#### B. Cleaning/Inspection Procedure (Continued)

3. Remove the accumulation from between the bellows convolutions and from the inside of the housings. Use a solvent if possible. Do not use a sharp instrument to clean between convolutions.
4. Assure that there are no broken range springs.
5. Replace the housings and O-rings.
6. Review Housing Bolt WARNING (page 20) before proceeding. See Table 3-1 (below and page 22) for pressure housing bolt size, material, part number, and torque values.

Table 3-1. Bolt Torque Ratings

HOUSING		BOLT			LUBE (Note 1)	TORQUE LB-FT (Note 2)	ROTATION (Degrees) (Note 3)
SWP	MATL.	MATL.	SIZE	PART NO.			
400	ALUM (Note 6)	STEEL	1/4-28 x 2	0220-0035J	NO	8-10	135
400	ALUM (Note 6)	18-8	1/4-28 x 2	0220-1016J	NO	8-10	135
500	BRASS	STEEL	1/4-28 x 2	0220-0035J	NO	8-10	135
500	BRASS	18-8 (Note 5)	1/4-28 x 2	0220-1010J	YES	10-12	450
500	BRASS	K-MONEL	1/4-28 x 2	0220-1018J	YES	8-10	180
500	STEEL	STEEL	1/4-28 x 2.5	0220-0029J	NO	12-14	180
500	SST	17-4 PH	1/4-28 x 2.5	0220-1017J	YES	12-14	180
500	SST	A286 (Salt Spray & NACE)	1/4-28 x 2.5	0220-1112J	YES	16-18	—
500	SST	STEEL (NACE)	1/4-28 X 1/2	S408-0067Z	NO	12	—
500	Cu-Ni	K-MONEL	1/4-28 x 2.5	0220-0045J	YES	9-11	180
1,000	Cu-Ni	K-MONEL	1/4-28 x 2.5	0220-0045J	YES	9-11	180
1,500	STEEL	STEEL	1/4-28 x 2.5	0220-0029J	NO	12-14	180
1,500	STEEL	K-MONEL	1/4-28 x 2.5	0220-0045J	YES	12-14	180
1,500	SST	STEEL	1/4-28 x 2.5	0220-0029J	NO	12-14	180
1,500	SST	17-4 PH	1/4-28 x 2.5	0220-1017J	YES	12-14	180
1,500	SST	A286 (Salt Spray & NACE)	1/4-28 x 2.5	0220-1112J	YES	16-18	—

(table continued on next page . . .)

**Notes: (1)** Lubricant: Lightly apply Molykote G-n paste (0002-0010U) on the first two threads only, unless otherwise specified - do not lube bearing surface. Special applications such as Nuclear, Cryogenic, and oxygen services may require special lubricants. Check BOM for specifics such as thread, head, and gasket surfaces. **(2)** Torque on bolts is accomplished in 3 or 4 steps. Tighten uniformly. **(3) Cameron recommends using a torque wrench whenever installing housing bolts.** Rotation of bolt head is measured after bolt is "snug" (approx. 1/16 turn past head contact) with approximately 2 LB-FT torque. Do not exceed this rotation. To tighten bolts without torque wrench, use rotation values. **(4)** Lube threads per Note 1 and under the head of the MP35N bolts. **(5)** Denotes for commercial applications only. **(6)** For reference only - 400 psi ALUM housing is obsolete.

### 3-5. DPU Cleaning and Inspection (Continued)

(See **WARNINGS on pages 19 and 20** before proceeding.)

#### B. Cleaning/Inspection Procedure (Continued)

##### 6. (Continued)

Review Housing Bolt WARNING (page 20) before proceeding.

Table 3-1. Bolt Torque Ratings (Continued)

HOUSING		BOLT			LUBE (Note 1)	TORQUE LB-FT (Note 2)	ROTATION (Degrees) (Note 3)
SWP	MATL.	MATL.	SIZE	PART NO.			
3,000	STEEL	STEEL	3/8-24 x 2.5	0220-0022J	NO	30	90
3,000	SST	17-4 PH	3/8-24 x 1.5	0220-1028J	YES	40	90
3,000	SST	17-4 PH	3/8-24 x 3.0	0220-1015J	YES	35	90
3,000	SST	A286 (Salt Spray & NACE)	3/8-24 x 2.5	0220-1111J	YES	34-36	—
3,000	SST	STEEL (NACE)	3/8-24 x 2-1/2	S408-0065Z	NO	35	—
3,000	SST	17-4 PH	3/8-24 x 2.5	0220-1014J	YES	35	90
3,000	MONEL	17-4 PH	3/8-24 x 2.5	0220-1014J	YES	45	180
3,000	MONEL	A286 (Salt Spray & NACE)	3/8-24 x 2.5	0220-1111J	YES	19-21	—
6,000	STEEL	STEEL	3/8-24 x 2.5	0220-0022J	NO	35	135
6,000	SST	17-4 PH	3/8-24 x 2.5	0220-1014J	YES	40	135
6,000	SST	MP35N (Salt Spray)	3/8-24 x 2.5	0220-1109J	(Note 4)	50-52	—
10,000	STEEL	STEEL	3/8-24 x 2.5	0220-0022J	YES	40	180
10,000	SST	17-4 PH	3/8-24 x 2.5	0220-1014J	YES	45	180
10,000	K-MONEL	17-4 PH	3/8-24 x 2.5	0220-1014J	YES	45	180
10,000	K-MONEL	STEEL	1/2-13 x 3.5	S408-0113C	NO	40	180

**Notes:** (1) Lubricant: Lightly apply Molykote G-n paste (0002-0010U) on the first two threads only, unless otherwise specified - do not lube bearing surface. Special applications such as Nuclear, Cryogenic, and oxygen services may require special lubricants. Check BOM for specifics such as thread, head, and gasket surfaces. (2) Torque on bolts is accomplished in 3 or 4 steps. Tighten uniformly. (3) **Cameron recommends using a torque wrench whenever installing housing bolts.** Rotation of bolt head is measured after bolt is "snug" (approx. 1/16 turn past head contact) with approximately 2 LB-FT torque. Do not exceed this rotation. To tighten bolts without torque wrench, use rotation values. (4) Lube threads per Note 1 and under the head of the MP35N bolts. (5) Denotes for commercial applications only. (6) For reference only - 400 psi ALUM housing is obsolete.

### 3-6. Servicing

#### Range Change

To change the range of the DPU, the bellows unit assembly (BUA) must be replaced with a unit of the desired range.

BUA Replacement



REVIEW ALL WARNINGS, CAUTIONS, AND NOTICES UNDER DPU CLEANING AND INSPECTION (PAGES 19 AND 20) BEFORE PERFORMING THIS PROCEDURE.

#### NOTICE

Do not loosen drive-arm hold plug (located on the top of the BUA center plate) when removing the mounting bracket. If the plug is loosened, the fill fluid in the bellows will be lost and the unit will be rendered inoperable.

1. Disconnect the DPU piping, remove the instrument from service, and remove the mounting bracket from the DPU.
2. Loosen the actuated instrument drive arm and separate it from the torque tube shaft. Do not disconnect the actuated instrument linkage.

#### NOTICE

See the actuated instrument's manual for particular components that must be removed to gain access to the DPU mounting fasteners.

3. Perform Pressure Check Procedure (A) under DPU Cleaning and Inspection on page 20. **If internal pressure was found, do not continue this procedure.**
4. Remove pressure housing bolts and pressure housings.

#### NOTICE

It is recommended that new O-Rings be used whenever pressure housings are replaced.

5. Install the pressure housings onto the new BUA and attach with appropriate housing bolts (see Table 3-1 for torque requirements).
6. Re-attach DPU (See para. 3-7, page 24 for procedure) to the actuated instrument.

#### NOTICE

*(Drive Arm/Torque Tube Tightness Test)*

For nuclear seismic/high impact qualified units, a tightness test must be performed whenever a DPU is attached to an instrument. See para. 3-8., page 24 for specific instructions.

7. Install the assembled instrument into service (in reverse order of removal) and calibrate, per separate actuated instrument manual.

### 3-7. Attaching Drive Arm to Torque Tube

#### NOTICE

See separate actuated instrument manual for instrument specific details.

#### Drive Arm Assembly Procedure

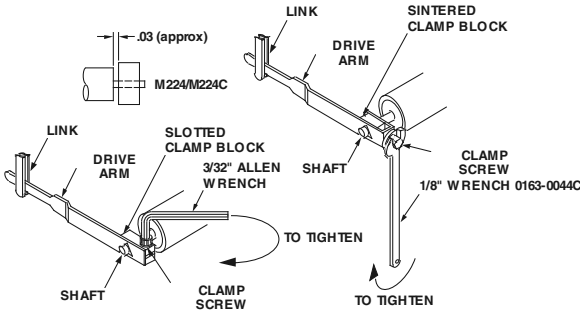


Figure 3-2. Attaching Drive Arm to Torque Tube

1. Slip drive arm over torque tube shaft; clear end of torque-tube housing by approximately 0.030-inches before securing to prevent interference.
2. To tighten drive arm assembly onto torque-tube shaft:
  - a. Support block/shaft and tighten clamp screw until snug to shaft.
  - b. Still supporting block/shaft, tighten clamp screw an additional:
    - Sintered: 1/3 to 1/2 (This screw can normally turn one full revolution before breaking.)
    - Slotted: 1/4 to 1/3 turn (The slot in the slotted clamp block should still be open.)

### 3-8. Drive Arm Tightness Test Procedure

#### (Required for Nuclear Seismic/High Impact Shock Qualified Units)

This procedure tests drive arm to torque-tube attachment tightness by applying torque developed by DPU onto a fixed drive arm. *Care should be taken to apply pressure slowly as the torque is being applied to the connection through the torque-tube drive shaft and not the torque-tube itself.*

With pointer at normal 0% torque-tube rotation position (max. minimum scale position or 0% on a normal 0 to 100% scale unit), adjust drive arm stop bracket (or use alternate means) to prevent pointer from moving (stop bracket interferes with drive arm movement). Note: On reverse acting and split range units, the DPU must be pressurized to move pointer to max. minimum scale position and on suppressed units it will be necessary to apply pressure to establish a reference point to check for “zero” shift.

Pressurize DPU as required to full calibrated scale differential pressure (100% of the full scale range). This achieves 8-degree of torque-tube drive shaft equivalent torque onto the connection.

Observe shift in unit “zero” following DPU depressurization (as required) and drive arm stop bracket readjusting (to allow free movement of the drive arm and pointer). A downscale (counter-clockwise) shift in “zero” of greater than 1/2% is indicative of drive arm slippage necessitating further clamp block tightening.



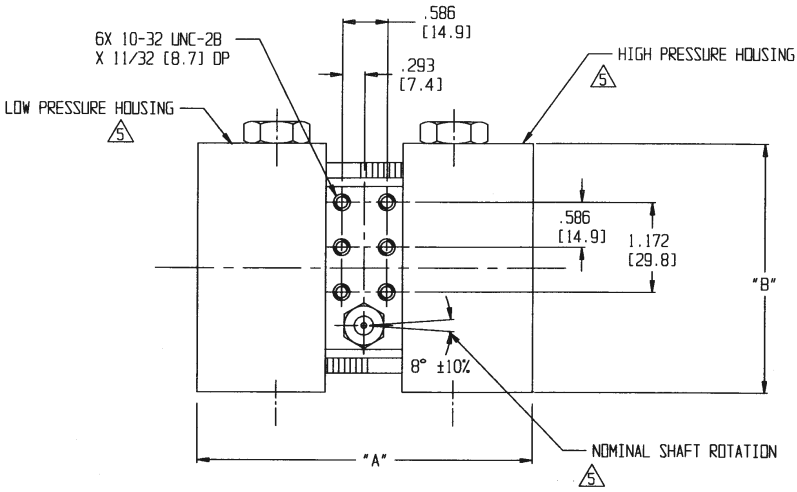
## SECTION 4 - TROUBLESHOOTING

Table 4-1. Troubleshooting

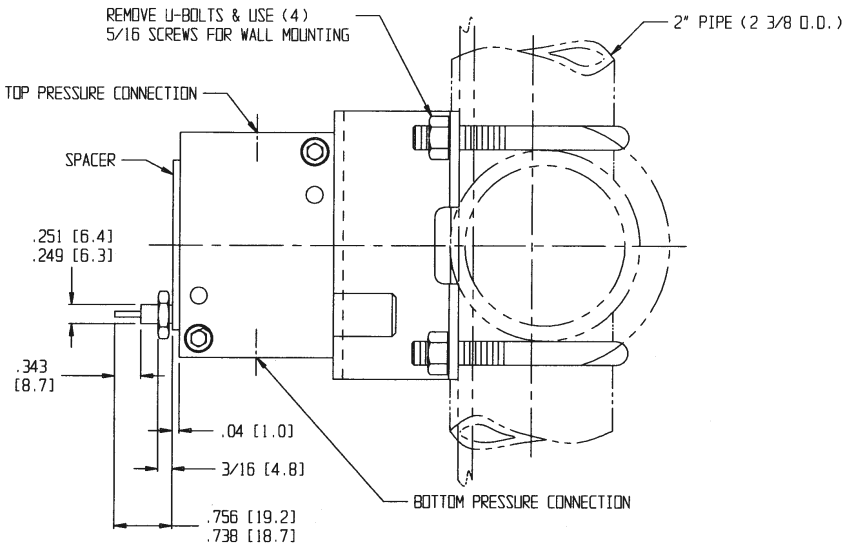
Problem	Possible Sources	Probable Cause	Corrective Action
Low or No Indication	Primary Element or DPU	Orifice Installed Backwards or Oversized	Replace Orifice
		Flow Blocked Upstream from Run	Clean Out Run or Open Valve
		Loss of Liquid in Reference Leg (Liquid Level)	Refill Reference Leg
		Density Changes in Process Media or Reference Leg	Refill Reference Leg with Same Density Liquid as Process Media
	Piping from Primary Element to DPU	Pressure tap holes plugged and/or Piping Plugged	Clean Out Piping
		Bypass Valve Open or Leaking	Close Bypass Valve(s) or Repair Leaks
		Liquids or Gases Trapped in Piping	Vent Piping
		Block or Shut-off Valves Closed	Open Block or Shut-off Valves
		Piping Leaks on High Pressure Side	Repair Leaks
	Bellows Unit	Housings Filled Up with Solids Restricting Bellows Movement	Clean Out Housing
		Gas Trapped in Housing in Liquid Service or Liquid Trapped in Housing in Gas Service	Vent Housing
		High Pressure Housing Gasket Leaks	Replace Gasket
		DPU Tampered With	Return BUA for Repair
High Indication	Primary Source	Orifice Partially Restricted or too Small	Clean Out or Replace
	Piping from Primary Element to DPU	Leak in Low Pressure Side Piping	Repair
	Bellows Unit	Gas Trapped in Low Pressure Housing in Liquid Service or Liquid Trapped in Housing in Gas Service	Vent Housing
		Low Pressure Housing Gasket Leaks	Replace Gasket
		Range Spring Broken or DPU Tampered With	Return BUA for Repair
Erratic Indication	Primary Element	Flow Pulsating	Install Dampening Device Upstream of DPU Run
	Piping from Primary Element to DPU	Liquid Trapped in Gas Piping or Gas Bubble in Liquid Piping	Remove
		Vapor Generator Incorrectly Installed	Repipe
		Reference Leg Gassy or Liquid Vaporizing	See Piping Instructions
	Bellows Unit	Obstructed Bellows Travel	Clean Bellows
		Gas Trapped in DPU High Pressure or Low Pressure Housing	Remove (See Startup Procedure)

Note: See actuated instrument manual for additional troubleshooting information.

**SECTION 5 - DIMENSIONS**



**FRONT VIEW**



**SIDE VIEW**  
WALL OR YOKE MOUNTING

Figure 5-1. 224/224C Dimensional Drawing (Part 1 of 2)  
(based on 224C-12303, Rev. 00)

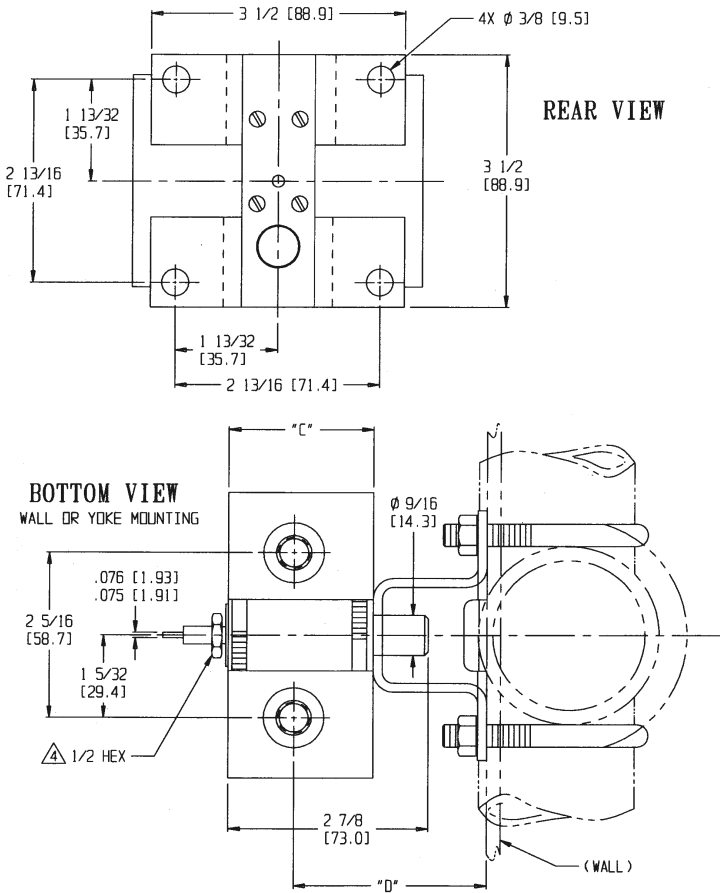


Figure 5-1. 224/224C Dimensional Drawing (Continued) (Part 2 of 2)  
 (based on 224C-12303, Rev. 00)

PRESSURE RATING	MATERIAL	DIM A ±.03	DIM B ±.01	DIM C ±.01	DIM D	PRESS CONNECTION	
						TOP	BOTTOM
500 TO 1500 PSI	ALL	4 [101.6]	2-15/16 [74.6]	2 [50.8]	2-5/8 [66.7]	1/2 NPT	1/4 NPT
						9/16-18 UNF	9/16-18 UNF
						1/4 NPT	1/4 NPT
3000 TO 10,000 PSI	ALL	4-3/8 [111.1]	3-1/4 [82.6]	2-1/4 [57.2]	2-3/4 [69.9]	1/2 NPT	1/2 NPT
						7/16 MS	7/16 MS
						1/8 NPT	1/8 NPT

- ▲ SHAFT ROTATION (SPECIFY):  
 A. STANDARD: COUNTERCLOCKWISE.  
 B. OPTIONAL: CLOCKWISE UNIT WITH COUNTERCLOCKWISE ROTATION SHOWN. FOR CW ROTATION HIGH & LOW PRESSURE HOUSINGS ARE CHANGED.
- ▲ PROVIDE A 19/32 [15.1] DIA CLEARANCE HOLE FOR 1/2 HEX.
- 3. ALL STANDARD PIPE FITTINGS FURNISHED BY CUSTOMER.
- ▲ SUITABLE FOR USE WITH AMINCO FITTINGS, AMERICAN INST. CO., SILVER SPRINGS, MO, OR EQUAL.
- ▲ CAN BE REVERSED WHEN ORDERED OR CAN BE ROTATED 180° IN THE FIELD.

NOTES:

**SECTION 6 - PARTS DRAWING/LIST**

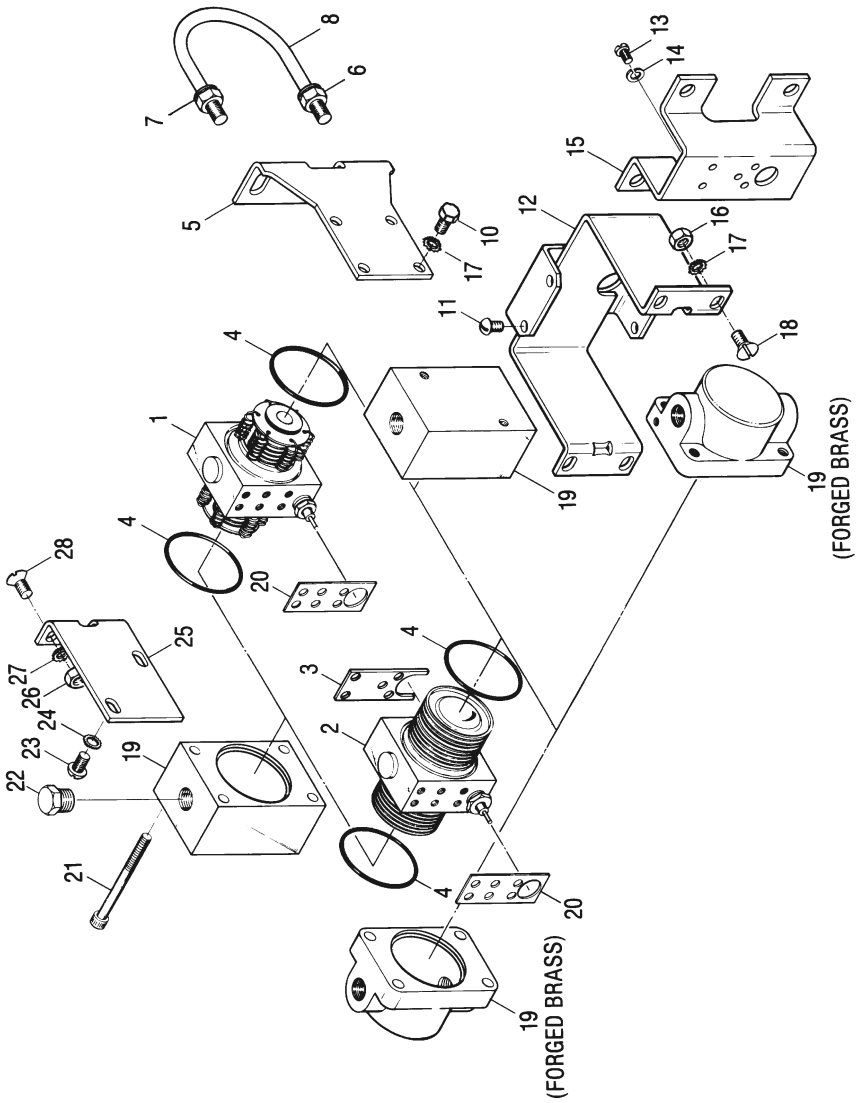


Figure 6-1. 224/224C DPU Parts Drawing

**224/224C DPU Parts List (See Notes and NOTICE, page 33)**

Table 6-1. 224/224C DPU Parts List

Item	Description	Part Number	Qty.
1	Bellows Unit Assembly, 3/4" or 5/8"	Specify	-
2	Bellows Unit Assembly, 1-5/8"	Specify	-
3	Spacer, Bracket	0224-0302C	1
4	O-Ring, Housing Gasket		2
	Buna-N	0001-0028R	
	Viton	0001-0039R	
	Viton (NACE)	0001-1164R	
	Viton (10,000 psi units only)	0001-0062R	
	EPT	0001-1054R	
5	Bracket, Mounting (Not for use with Brass Housings)	0273-0001C	2
6	Nut, Hex, Steel, 5/16-18 CP	0500-0033J	4
7	Washer, Split Lock, 5/16" Steel	0003-0006K	4
8	2" Pipe Mounting Kit (w/U-bolts, Nuts, & Washer)	0440-0001J	2
9	Not Used		
10	Screw, Hex Hd., 1/4-28 x 1/2"	0116-1011J	8
11	Screw, Rd. Hd., Steel CP, 10-32 x 3/8"	0111-0057J	4
12	Bracket, Flush (500 psi Forged Brass only)	0224-0235B	1
13	Screw, Fil. Hd., SST, 10-32 x 1/2"	0114-0031J	4
14	Washer, Split Lock, #10, SST	0003-0032K	4
15	Bracket, Universal Mounting (Wall or Yoke Mtg.)	0273-0003C	1
16	Nut, Hex, Steel CP, 1/4-28	0500-0011J	4
17	Washer, Lock, Ext. Tooth, SST, 1/4"	0003-0068K	12
18	Screw, Fl. Hd., Steel CP, 1/4-28 x 1/2"	0112-0018J	4
19	Housing, Pressure (See Note 5)		2
	224C DPU		
	Brass, Forged, 500 psi, 1/4 NPT Ports	224C-1016C	
	Brass, Forged 500 psi, 1/8 NPT Ports	224C-1018C	
	Steel, 500/1500 psi, 1/4 NPT Ports	224C-1113C	
	Steel, 500/1500 psi, 1/4 X 1/2 NPT Ports	224C-1123C	
	Steel, 500/1500 psi, 1/2 NPT Ports	224C-1130C	
	Steel, 3000/6000 psi, 1/2 X 1/4 NPT Ports	224C-1108C	
	Steel, 3000/6000 psi, 1/4 NPT Ports	224C-1120C	
	Steel, 3000/6000 psi, 1/2 NPT Ports	224C-1128C	

**224/224C DPU Parts List (See Notes and NOTICE, page 33) (Cont.)**

Table 6-1. 224/224C DPU Parts List (Continued)

Item	Description	Part Number	Qty.
19	Housing, Pressure (See Note 5) (Continued)		2
	224C DPU (Continued)		
	Steel, 10,000 psi, 1/4 NPT Ports	224C-1049C	
	Steel, 10,000 psi, 9/16 AMINCO Ports	224C-1189C	
	Cu-Ni, 1000 psi, 1/4 NPT Ports	224C-1021C	
	Cu-Ni, 1000 psi, 1/2 NPT Ports	224C-1022C	
	Cu-Ni, 1000 psi, 1/8 NPT Ports	224C-1292C	
	SST, 500/1500 psi, 1/2 NPT Ports	224C-1032C	
	SST, 500/1500 psi, 1/4 NPT Ports	224C-1033C	
	SST, 500/1500 psi, 3/8 NPT Ports	224C-1036C	
	SST, 500/1500 psi, 1/8 NPT Ports	224C-1238C	
	SST, 500/1500 psi, 1/4 NPT Ports (NACE)	0224-1621C	
	SST, 500/1500 psi, 1/4 X 1/2 NPT Ports (NACE)	0224-1626C	
	SST, 500/1500 psi, 1/2 NPT Ports (NACE)	0224-1697C	
	SST, 3000/6000 psi, 1/4 NPT Ports	224C-1040C	
	SST, 3000/6000 psi, 1/2 NPT Ports	224C-1041C	
	SST, 3000/6000 psi, 1/4 X 1/2 NPT Ports	224C-1042C	
	SST, 3000/6000 psi, 9/16 AMINCO Ports	224C-1187C	
	SST, 3000/6000 psi, Seal Welded, 3/4	0224-1641C	
	SST, 3000/6000 psi, 1/4 X 1/2 NPT Ports (NACE)	0224-1637C	
	Monel, 3000 psi, 1/4 X 1/2 NPT Ports	224C-1028C	
	Monel, 3000 psi, 1/2 NPT Ports	224C-1029C	
	Monel, 3000 psi, 1/4 NPT Ports	224C-1121C	
	Monel, 3000 psi, 1/4 X 1/2 NPT Ports (NACE)	0224-1685C	
	K-Monel, 10,000 psi, 9/16 AMINCO Ports	224C-1215C	
	224 (Non-C Version) DPU (See Note 3)		
	Brass, Forged, 500 psi, Absolute (No Ports)	0224-1602C	
	Brass, Forged, 500 psi, 1/4 NPT Ports	0224-1532C	
	Brass, Forged, 500 psi, 1/8 NPT Ports	0224-1606C	
	Steel, 500/1500 psi, 1/4 NPT Ports	0224-1576C	

**224/224C DPU Parts List (See Notes and NOTICE, page 33) (Cont.)**

Table 6-1. 224/224C DPU Parts List (Continued)

Item	Description	Part Number	Qty.
19	Housing, Pressure (See Note 5) (Continued)		2
	224 (Non-C Version) DPU (See Note 3) (Continued)		
	Steel, 500/1500 psi, 1/2 NPT Ports	0224-1577C	
	Steel, 500/1500 psi, Absolute (No Ports)	0224-1664C	
	Steel, 500/1500 psi, 3/8 NPT Ports	0224-1667C	
	Steel, 500/1500 psi, 1/4 X 1/2 NPT Ports	0224-1613C	
	Steel, 3000/6000 psi, Absolute (No Ports)	0224-1715C	
	Steel, 3000/6000 psi, 1/4 NPT Ports	0224-1555C	
	Steel, 3000/6000 psi, 1/2 NPT Ports	0224-1578C	
	Steel, 3000/6000 psi, 1/4 X 1/2 NPT Ports	0224-1607C	
	Steel, 10,000 psi, 1/4 NPT Ports	0224-1662C	
	Steel, 10,000 psi, 9/16 AMINCO Ports	0224-1663C	
	SST, 500/1500 psi, 1/4 NPT Ports	0224-1543C	
	SST, 500/1500 psi, 1/2 NPT Ports	0224-1579C	
	SST, 500/1500 psi, 1/4 X 1/2 NPT Ports	0224-1610C	
	SST, 500/1500 psi, Absolute (No Ports)	0224-1618C	
	SST, 500/1500 psi, 1/4 NPT Ports, Nipple Mod.	0224-1619C	
	SST, 500/1500 psi, 1/8 NPT Ports	0224-1675C	
	SST, 500/1500 psi, Seal Welded, 1/2 NPT Ports	0224-1679C	
	SST, 500/1500 psi, 3/8 NPT Ports	0224-1721C	
	SST, 500/1500 psi, 1/2 NPT Ports (NACE)	0224-1697C	
	SST, 500/1500 psi, 1/4 NPT Ports (NACE)	0224-1621C	
	SST, 500/1500 psi, Seal Welded, 1/4 NPT Ports	0224-1622C	
	SST, 500/1500 psi, 1/4 X 1/2 NPT Ports (NACE)	0224-1626C	
	SST, 3000/6000 psi, 1/4 NPT Ports	0224-1556C	
	SST, 3000/6000 psi, 1/2 NPT Ports	0224-1580C	
	SST, 3000/6000 psi, 1/4 X 1/2 NPT Ports	0224-1608C	
	SST, 3000/6000 psi, Seal Welded, 3/4	0224-1641C	
	SST, 3000/6000 psi, 9/16 AMINCO Ports	0224-1645C	
	SST, 3000/6000 psi, 1/4 X 1/2 Ports, Nipple Mod.	0224-1647C	

**224/224C DPU Parts List (See Notes and NOTICE, page 33) (Cont.)**

Table 6-1. 224/224C DPU Parts List (Continued)

Item	Description	Part Number	Qty.
19	Housing, Pressure (See Note 5) (Continued)		2
	224 (Non-C Version) DPU (See Note 3) (Continued)		
	SST, 3000/6000 psi, 1/4 X 1/2 NPT Ports (NACE)	0224-1637C	
	Cu-Ni, 1000 psi, 1/4 NPT Ports	0224-1581C	
	Cu-Ni, 1000 psi, 1/4 X 1/2 NPT Ports	0224-1616C	
	Cu-Ni, 1000 psi, Absolute (No Ports)	0224-1651C	
	Cu-Ni, 1000 psi, 1/2 NPT Ports	0224-1655C	
	Monel, 3000 psi, 1/4 X 1/2 NPT Ports (NACE)	0224-1685C	
	Monel, 3000 psi, 1/4 X 1/2 NPT Ports	0224-1687C	
	Monel, 3000 psi, 1/2 NPT Ports	0224-1696C	
20	Spacer, DPU Mounting	0224-1547C	1
21	Bolt, Housing (Refer to Housing Bolt WARNING on page 20.)	Refer to Table 3-1, pg. 21/22 for Part No.	4
22	Plug, Pipe/Port		2
	Pipe Plug, 1/4" NPT Brass	0224-0100C	
	Pipe Plug, 1/8" NPT, Brass	0224-0058C	
	Pipe Plug, 1/8" NPT, SST	0224-1676C	
	Pipe Plug, 1/4" NPT, Steel CP	0199-0191C	
	Pipe Plug, 1/4" NPT, Monel	0199-0235C	
	Pipe Plug, 1/4" NPT, SST	0199-0214C	
	Pipe Plug, 1/2" NPT, Steel CP	0199-0192C	
	Pipe Plug, 1/2" NPT, SST	0199-0215C	
	Pipe Plug, 1/2" NPT, Monel	0199-0234C	
Pipe Plug, 3/8" NPT, SST	0605-0010L		
23	Screw, 1/4-28 x 5/8", Steel, CP	0111-0033J	4
24	Washer, Lock, Ext. Tooth, SST, 1/4"	0003-0068K	4
25	Bracket, Mounting (Not for use with Brass Housings)	0224-0055C	2
26	Nut, Hex, 1/4-28, Steel, CP	0500-0011J	4



**224/224C DPU Parts List (See Notes and NOTICE, below) (Cont.)**

Table 6-1. 224/224C DPU Parts List (Continued)

Item	Description	Part Number	Qty.
27	Washer, Ext. Tooth, 1/4" SST	0003-0068K	4
28	Screw, Fl. Hd., 1/4-28 x 1/2", Steel, CP	0112-0018J	4
Notes: (1) Typically two Pipe Plugs required, size depends upon ports to be plugged. (2) Stainless steel housing screws are recommended when the instrument is installed in a corrosive environment. (3) Non-C Versions for specific nuclear service applications only. (4) When ordering, please specify model number of instrument. Minimum parts order is \$100.00. For actuated instrument parts, refer to separate instrument manual. (5) Housing pressure ratings are for housings only - not DPU or instrument.			

**NOTICE**

*(Use Identical Replacement Parts)*

Always replace parts with identical parts (same material, rating(s), certs, size, etc.), unless otherwise directed by Cameron.

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## **Product Warranty**

### A. Warranty

Cameron International Corporation ("Cameron") warrants that at the time of shipment, the products manufactured by Cameron and sold hereunder will be free from defects in material and workmanship, and will conform to the specifications furnished by or approved by Cameron.

### B. Warranty Adjustment

- (1) If any defect within this warranty appears, Buyer shall notify Cameron immediately.
- (2) Cameron agrees to repair or furnish a replacement for, but not install, any product which within one (1) year from the date of shipment by Cameron shall, upon test and examination by Cameron, prove defective within the above warranty.
- (3) No product will be accepted for return or replacement without the written authorization of Cameron. Upon such authorization, and in accordance with instructions by Cameron, the product will be returned shipping charges prepaid by Buyer. Replacements made under this warranty will be shipped prepaid.

### C. Exclusions from Warranty

- (1) THE FOREGOING WARRANTY IS IN LIEU OF AND EXCLUDES ALL OTHER EXPRESSED OR IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE.
- (2) Components manufactured by any supplier other than Cameron shall bear only the warranty made by the manufacturer of that product, and Cameron assumes no responsibility for the performance or reliability of the unit as a whole.
- (3) "In no event shall Cameron be liable for indirect, incidental, or consequential damages nor shall the liability of Cameron arising in connection with any products sold hereunder (whether such liability arises from a claim based on contract, warranty, tort, or otherwise) exceed the actual amount paid by Buyer to Cameron for the products delivered hereunder."
- (4) The warranty does not extend to any product manufactured by Cameron which has been subjected to misuse, neglect, accident, improper installation or to use in violation of instructions furnished by Cameron.
- (5) The warranty does not extend to or apply to any unit which has been repaired or altered at any place other than at Cameron's factory or service locations by persons not expressly approved by Cameron.

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