

Barton MODEL 199
DIFFERENTIAL PRESSURE UNIT (DPU)
Standard and NACE Service



User Manual
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(This manual is for the DPU only.) Refer to the appropriate (separate) instrument manual for information on the instrument being actuated.



Before installing this instrument, become familiar with the installation instructions in Section 3 and in the separate DPU 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: **10, 13, 14, 19, 22, and 28.** **(Important! Before installing or operating this instrument, review all safety warnings/notices contained in the separate Instrument manual that is appropriate for the instrument being actuated.)**

PRODUCT WARRANTY STATEMENT

The product warranty applicable to this Barton instrument is as stated on the back (last page) of this manual. **NOTICE:** The warranty of this instrument and the associated DPU will be voided if the following limitations are exceeded:

Temperature - Do not subject the DPU to temperatures above 200°F or below -60°F (35°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 - Do not subject the DPU to severe mechanical shock.

Shock - Do not subject the DPU to hydraulic shock.

Pulsation - Do not subject the DPU to severe pulsation.

SECTION 1 - INTRODUCTION

1-1. General

The Barton[®] Model 199 Differential Pressure Unit (DPU) (see Figure 1 -1) is a mechanical device which accurately 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 (a venturi, an orifice plate or a 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.

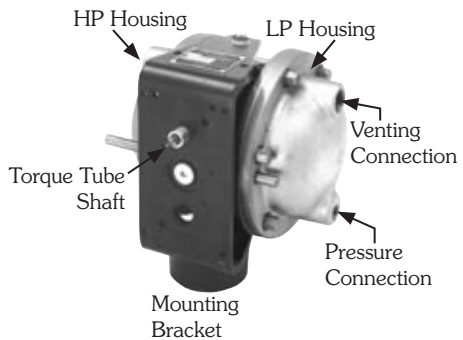
1-2. Product Description

The Model 199 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 plate, 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

Torque Tube Rotation (full scale DP).....	8° ±10%
Torque Tube Material.....	Beryllium Copper (BeCu)
Temperature Limits	-40°F/°C to +180°F (+82°C)
Maximum Non-linearity:	
0-10" w.c. to 0-400" w.c.	
(0-25 mbar to 0-993 mbar)	±0.5% of full scale with appropriate linkage
0-401" w.c. to 0-100 psi	
(0-996 mbar to 0-6.9 bar)	±0.75% of full scale with appropriate linkage
Repeatability	0.20% of full scale DP
Housing Materials/Ranges	Refer to Table 1-1

Table 1-1. Model 199 DPU Material/Range Specifications

SWP psi (bar)	Body Housing Material	Available DP Ranges			
		Stainless Steel Bellows		Inconel Bellows	
		2-1/8" (55mm) O.D.	3-3/4" (95mm) O.D.	2-1/8" (55mm) O.D.	3-3/4" (95mm) O.D.
1,000 (69)	Cast Aluminum 356T6 Forged Stainless Steel 316				
NACE 2,000 (138)	Forged Steel AISI C1018 (For NACE Service)				
2,500 (172)	Forged Steel AISI C1018	0-15 psi to 0-100 psi (0-1 bar to 0-6.9 bar)	0-10" w.c. to 0-400" w.c. (0-25 mbar to 0-993 mbar)	0-15 psi to 0-100 psi (0-1 bar to 0-6.9 bar)	0-10" w.c. to 0-400" w.c. (0-25 mbar to 0-993 mbar)
3,000 (207)	Forged Stainless Steel 316				
4,500 (310)	Forged Alloy Steel 4142				
6,000 (414)	Forged Alloy Steel 4142 Forged Stainless Steel 17-4 PH				
Net	Low Pressure (LP) Head	35" (575 cc)	30" (490 cc)	35" (575 cc)	30" (490 cc)
Volume in cu. in. (cc)	High Pressure (HP) Head	31" (510 cc)	26" (425 cc)	31" (510 cc)	26" (425 cc)
Displacement travel	Displacement in cu. in.(cc) for full-scale travel	0.5" (8.2 cc)	1.5" (25 cc)	0.5" (8.2 cc)	1.5" (25 cc)

NOTES: Zero center or split ranges available on special order (e.g., 0-50" w.c. (0-124 mbar) range may be ordered 25-0-25" w.c. (62-0-62 mbar) or 10-0-40" w.c. (25-0-99 mbar). Intermediate DP ranges available from 0-20" w.c. to 0-100 psi (0-50 mbar to 0-6.9 bar). Other sizes and types of connections (welding stubs, MS, A.N.D., etc.) available upon request. Standard pressure connections are 1/2" (top) and 1/4" (bottom) NPT. Range springs are not interchangeable between the different size bellows, the inconel bellows, or the 10" w.c. (25 mbar) range. 3,000, 4,500, and 6,000 SWP versions can be specified to meet NACE MR-01-75 (Rev. 80). Metric conversions are approximate. Outline dimension drawings available upon request.

SECTION 2 - THEORY OF OPERATION

2-1. Basic Components (See Figure 2-1)

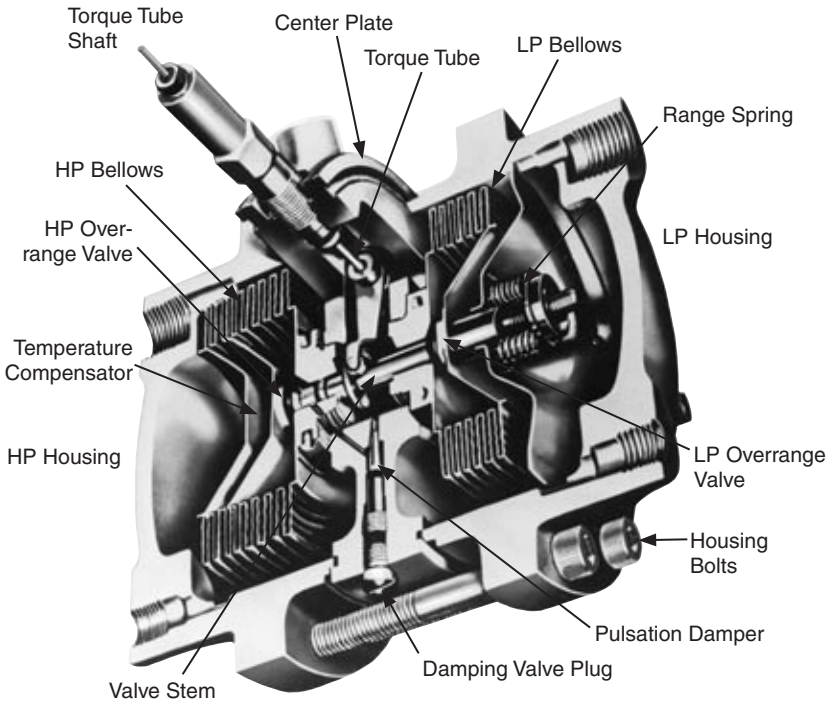


Figure 2-1. 199 BUA Cutaway

A. Pressure Housings

The two pressure housings of the Model 199 DPU are available in the various safe working pressure ratings defined in Table 1-1 and in the Outline Dimensional Drawings (seen in Section 6 DRAWINGS).

Each pressure housing has two tapped connection ports: one port is located in the top of the housing, the other port is located in the bottom of the housing.

The pressure housings may be rotated 180 degrees to facilitate connection at the top of the housing for draining when used in gas service, or at the bottom to provide venting when used in liquid service.

The housings enclose the bellows on each side of the center plate.

B. Bellows

The bellows of the Model 199 DPU are available in the various materials and sizes (refer to Table 1-1) to accommodate the various safe working pressure ratings.

The DPU has two bellows. One end of each bellows is sealed. The open end of each bellows is attached and sealed to a side of the center plate (one bellows on each side).

The bellows and center plate are filled with fill liquid via the drive arm hole plug. An opening through the center plate provides a passageway for the transfer of fill liquid between the two bellows. This opening also allows the bellows to be connected internally by a valve stem.

C. Range Springs

The range of the dual-bellows type DPU is determined by the force required to move the bellows through their normal range of travel.

The range springs, which are available in various ranges (refer to Table 1-1), act with the bellows and torque tube to balance the differential pressure applied to the unit. The number of springs used and their spring rate depends on the individual differential pressure range requirement.

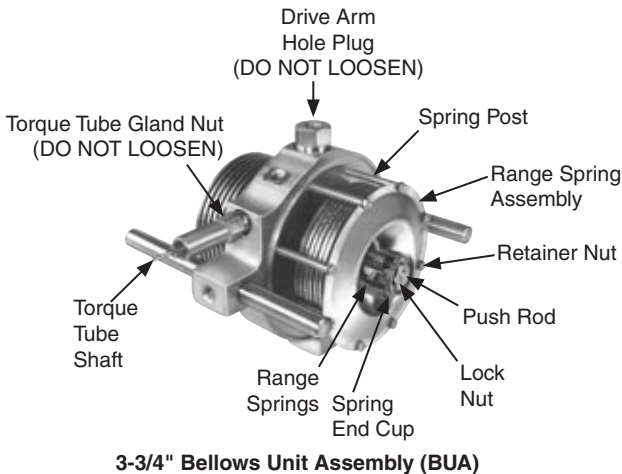
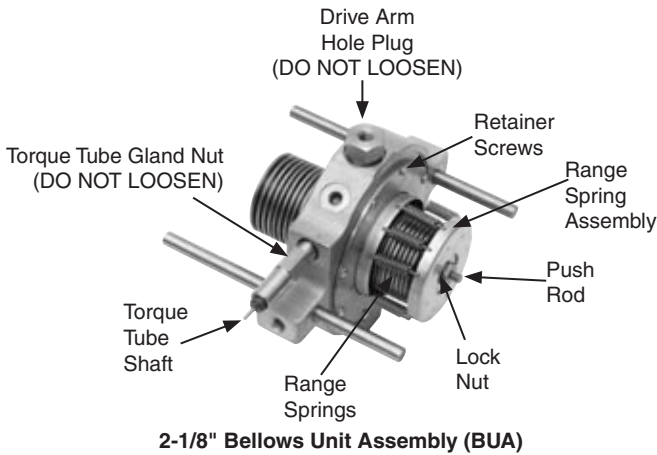


Figure 2-2. Bellows Unit Assemblies (BUAs)

D. Torque Tube Assembly

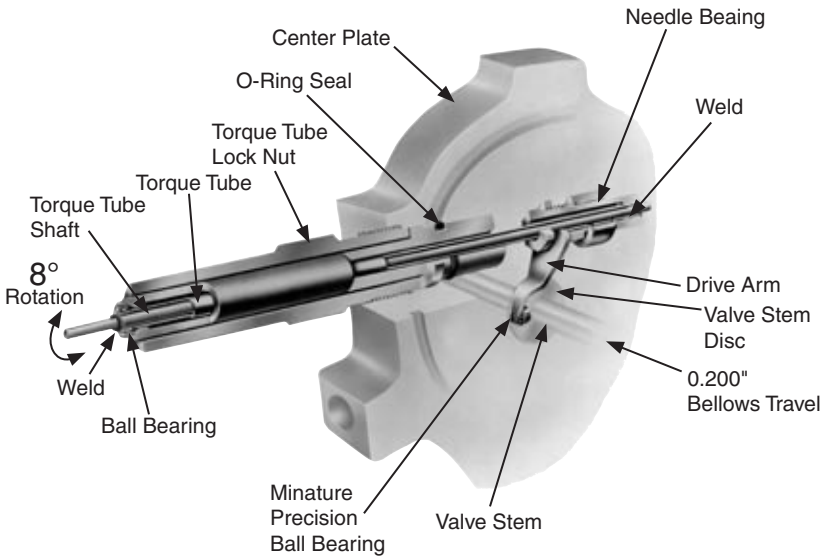


Figure 2-3. Torque Tube Assembly

As illustrated in Figure 2-3, the torque tube assembly consists of a torque tube, a torque tube shaft, and the supporting members. The outboard end of the torque tube shaft is attached to the center plate. The torque tube shaft, located in the center of the torque tube, is welded to the inboard end of the tube.

Movement of the bellows is transmitted by the drive arm to the torque tube as a rotary motion. Since the torque tube is attached to the center plate, the tube must twist when subjected to torque. The torque tube shaft, which is freely supported within the torque tube at its outer end, but connected to the torque tube and drive arm at its inner end, rotates through the same angle as the differential pressure unit.

NOTE: An extended torque tube is used on electronic transmitters and explosion-proof instruments.

E. Pulsation Dampener

The pulsation dampener (see Figure 2-1) controls the flow of fill-liquid between the high and low-pressure bellows with an externally adjustable pulsation dampener needle valve. Restriction of liquid flow reduces the effects of pulsation. In applications where pulsation is not a problem, the needle valve is set to the fullopen position.

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SECTION 3 - INSTALLATION/OPERATION

3-1. Unpacking

The 199 DPU should be inspected at time of unpacking to detect any damage that may have occurred during shipment.

NOTICE: *The instrument was checked for accuracy at the factory — do not change any of the settings during examination or accuracy will be affected.*

NOTICE: *For application in critical media, requiring special cleaning processes and precautions, a polyethylene bag is used to protect the instrument from contamination. This protective bag should be removed only under conditions of controlled extreme cleanliness.*

NOTICE: *Do not locate the instrument near vents or bleed holes that discharge corrosive vapors or gases.*

3-2. Mounting

A. Flush or Panel Mounting

Attach the case of the instrument (recorder, indicator etc.) to the panel. Refer to the Installation and Operation Manual for the specific instrument for the mounting details.

B. Pipe Mounting

Refer to the Outline Dimension Drawing in Section 6 for the pipe mounting diagram. The DPU must be mounted approximately level to operate properly.

3-3. Piping — Standard Practices

A. All Applications (flow and liquid level)

1. Shorten the distance between the primary device and the DPU as much as possible. Distances exceeding 100 feet are not recommended. For distances up to 50 feet, use 1/4-inch or 3/8-inch pipe or tubing. For runs of 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 one inch per linear foot to avoid liquid or gas entrapment.
3. Provide two feet of uninsulated piping between the DPU and the primary device for each 100°F (+37.8°C) in excess of +200°F (+93.3°C).
4. Assure that the temperature of the DPU never exceeds 180°F (+82°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. Install a suitable pulsation dampening device upstream of the DPU. Where severe pulsation is present, the accuracy of the flow measurement will be affected.
6. Mount the DPU on a solid support to minimize vibration. Tighten all points, using a suitable compound; leaks in piping can cause measurement errors.

3-3. Piping — Standard Practices (Cont.)

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 6- Drawings).
8. Install a valve manifold connecting the DPU and the source of differential pressure to facilitate operation and checking of the DPU.
9. Locate all shutoff valves and bypass valves to be readily accessible from the front of the instrument. Locate block valves at the source of differential pressure.

B. Flow Applications

Assure that the DPU high-pressure housing is connected to the upstream tap of the primary device.

NOTE: To prevent overheating the DPU during blowdown, the operator should monitor the temperature by placing his hands on the pipe between the DPU and the manifold pipe containing the vent valves.

C. Liquid Level Applications

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. The 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. Also, the difference in the densities of the special seal fluid and the process media will require compensation in calculating the differential pressure range of the DPU.



EXPLOSION HAZARD. ORGANIC COMPOUNDS, OIL, GREASE, DIRT, OR SCALE OF ANY KIND CANNOT BE TOLERATED IN AN OXYGEN INSTALLATION.

3-4. General Startup Practice Considerations

Observe the following practices when starting up an instrument.

1. Always start with the block valves closed.
2. Perform a zero check on the instrument as follows.

NOTICE: For gas service, it is recommended that zero check be performed with both block valves closed. If the gas flow is pulsating, there may be a standing wave effect in the process line which can displace the indicator and appear as a zero error.

- a. Open the bypass valve(s), then open one shutoff valve. This procedure equalizes the pressure between both sides of the instrument. The instrument should indicate zero.
- b. If the instrument does not indicate zero, check for gas or liquid entrapment in the lines or in the DPU (depending on the orientation of the piping layout and service).

3-4. General Startup Practice Considerations (Cont.)

2. Perform a zero check on the instrument as follows (Cont.)
 - c. If necessary, adjust the pen or pointer by turning the zero adjust on the instrument.
3. Check the manifold and piping for leaks as follows.
 - a. Open the bypass valve(s), then open one shutoff valve to pressurize the instrument.
 - b. Close the shutoff valve and the bypass valve.
 - c. Any leakage will be indicated by pen or pointer movement, up or down scale.

NOTE: Be careful not to subject the DPU to unnecessary shock or over-range pressure during operations.

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SECTION 4 - MAINTENANCE, ADJUSTMENT, & CALIBRATION

4-1. Tools Required for Maintenance and Calibration

A calibration tool kit (P/N 0202-1005B) containing the necessary tools is available from the factory. The following tools are required for maintenance and calibration of the DPU:

Table 4-1. Tools

Description	Purpose
Screwdriver	Bracket screws
7/16" Hex wrench	Housing bolts
5/8" Hex wrench	Housing bolts
3/4" Hex wrench	Housing bolt/stud nut (6,000 PSI units)
1/8" Allen wrench	Dampener Adjustment
1/2" Open end wrench	Pushrod - bellows cup connection
1/2" 12-point socket	Housing bolt (6,000 PSI units)
Modified Box/Open-ended Wrench (7/16")	Kickoff spring lock nut
100 ft.-lb. Torque wrench	Housing bolts

4-2. DPU Inspection and Cleaning

WARNING 

**(High-pressure Gas Installations
with pressures greater than 200 psig)**

HIGH-PRESSURE GAS HAZARD ON DISASSEMBLY OF THE 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.**

NOTICE

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

WARNING 
(Housing Bolts)

DO NOT REUSE HOUSING BOLTS. IF BOLTS ARE DISTURBED, REPLACE WITH NEW BOLTS, PER TABLE 4-2 (STANDARD) or TABLES 4-3/4-4 (NACE).

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.

4-2. DPU Inspection and Cleaning (Cont.)

A. Pressure Check Procedure



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

NOTICE: This procedure should be performed before removing the DPU housing bolts, 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 for repair.

Tag the unit and specify "Gas in Bellows".

B. Inspection and Cleaning 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. 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 seals.



DO NOT REUSE HOUSING BOLTS. IF BOLTS ARE DISTURBED, REPLACE WITH NEW BOLTS, PER TABLE 4-2 (STANDARD) or TABLES 4-3/4-4 (NACE).

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.

6. Install NEW pressure housing bolts and set them to the torque values listed in Table 4-2 (Standard) or Tables 4-3 and 4-4 (NACE).

Table 4-2. Standard Bolt Torque Ratings

Housing		Bolts				Lube (Note 1)	Torque Lb/Ft (Note 2)	Rotation (Note 3)
SWP	Mat'l	Mat'l	Size	Qty	Part No.			
1000	Steel	Steel	3/8-16 x 4.5	6	0199-1345C	Yes	45	180°
	Cres	Steel	3/8-16 x 4.5	12	0199-1345C	Yes	40	270°
	Alum	Steel	3/8-16 x 4.5	6	0199-1345C	Yes	40	180°
2500	Steel	Steel	1/2-13 x 5.5	6	0199-0085C	Yes	95	180°
3000	Cres	Steel	1/2-13 x 5.5	12	0199-0085C	Yes	80	180°
4500	Steel	Steel	1/2-13 x 5.5	12	0199-0085C	Yes	95	180°
6000		Steel (Stud)	1/2-20 x 7	12	0199-1001C	Yes	105	180° (Note 4)
		Steel (Nut)	1/2-20	24	0199-1002C			
6000		Steel (Bolt)	1/2-20 x 6	12	0199-1346C	Yes	105	180° (Note 4)
		Steel (Nut)	1/2-20	12	0199-1002C			

NOTES:

- (1) Lubricants: Molykote G paste, Teflon-base pipe dope, graphite-base grease, or similar lubricants. Lube first 2 threads only. Do not lube bearing surface.
- (2) Torque on bolts is accomplished in 3 or 4 steps. Tighten UNIFORMLY.
- (3) Rotation of bolt head is measured after bolt is "snug," with approximately 5 lb/ft torque. DO NOT EXCEED THIS ROTATION. To tighten bolts without torque wrench, use rotation values.
- (4) Rotation reference for bolt with nut is the sum total of bolt head plus nut, or total of 2 nuts.

Table 4-3. NACE Bolt Torque Ratings

Item	SWP		
	2000 PSI (13.8 MPa)	3000 PSI (20.7 MPa)	4500 PSI (31.0 MPa)
Fastener	12 Pt. Head Bolt	12 Pt. Head Bolt with Hex Nut	12 Pt. Head Bolt with Hex Nut
Bolt Size	1/2-13 x 5.5"	1/2-20 x 6"	1/2-20 x 6"
Bolt Material	B7M/L7M Steel	B7M/L7M Steel	B7M/L7M Steel
Nut Size	N/A	1/2-20	1/2-20
Nut Material	N/A	4140 Steel	4140 Steel
Quantity	6	12	12
Bolt Part Number	0220-1075J	S408-0064Z	S408-0064Z
Nut Part Number	N/A	S408-0021Z	S408-0021Z
HSG. Gasket	0001-1140R	S528-0001Z	S528-0001Z
HSG. O-Ring	0001-1099R	N/A	N/A
Torque (ft/lbs)	55-60	55-60	55-60

SPECIAL NOTES:

- (1) Lubricants: Molykote G paste, Teflon-base pipe dope, graphite-base grease, or similar lubricants. Lube first 2 threads only. Do not lube bearing surface.
- (2) Torque on bolts is accomplished in 3 or 4 steps. Tighten UNIFORMLY.
- (3) If originally supplied with unit, re-install the "Do Not Reuse Bolts" and "NACE" product tags.

Table 4-4. Special 6,000 PSI NACE Bolt Torque Ratings
(6,000 PSI NACE Units/Bolts available from Canada Only)

Item	SWP
	6000 PSI (41.4 MPa)
Fastener	Stud with Hex Nuts
Bolt Size	9/16-18 x 6.6"
Bolt Material	17-4 PH SST
Quantity	12 (24 Nuts)
Bolt Part Number	0199-9001J
Nut Part Number	0199-9002J
HSG. O-Ring	0199-9003R
Torque (ft/lbs)	150

SPECIAL NOTES:

- (1) Lubricants: Molykote G paste, Teflon-base pipe dope, graphite-base grease, or similar lubricants. Lube first 2 threads only. Do not lube bearing surface.
- (2) Torque on bolts is accomplished in 3 or 4 steps. Tighten UNIFORMLY.
- (3) For DP units marked as 1850 PSI (12.7 MPa) and 1500 PSI (10.3 MPa) originally supplied with 12- point head bolts, Cameron has re-rated these lower pressure DPUs to 2000 PSI (13.7 MPa). Apply the parts and use the torque values for the 2000 PSI model (Table 4-3).
- (4) For DP units marked as 1500 PSI (10.3 MPa) originally supplied with 6-point head bolts, use a standard B7 alloy steel bolt that is suitable only for applications where the application environment is not deemed to be sour. With the exception of 0199-0085C bolts, apply the parts and use the torque values for the 2000 PSI model (Table 4-3).
- (5) If originally supplied with unit, re-install the "Do Not Reuse Bolts" and "NACE" product tags.

4-3. Calibration Setup

The test equipment required to calibrate the Model 199 DPU, when attached to a recorder, indicator, or switch is shown in Figure 4-1.

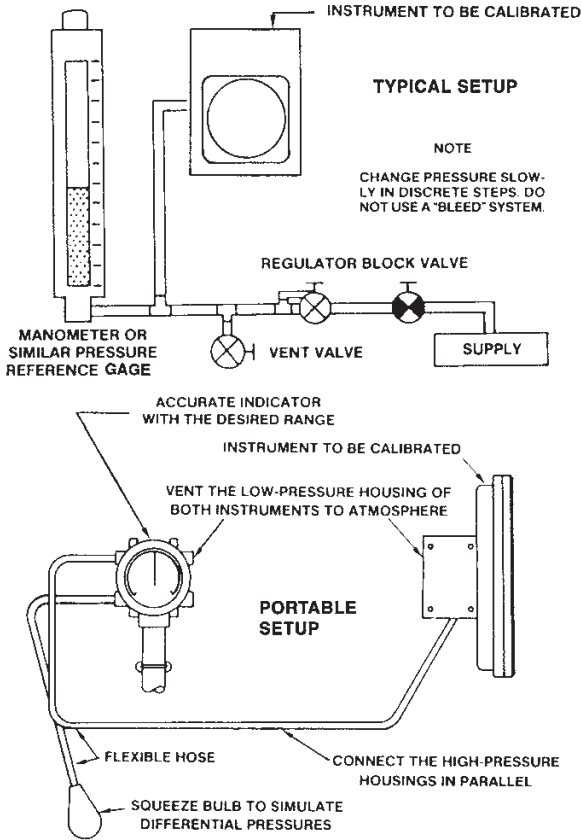


Figure 4-1. Calibration Setup

All Barton instruments using 199 DPU as actuator are calibrated at the factory. All DPUs sold as replacement units or as actuators for other applications are checked for accuracy prior to shipment.

Normally, the DPU is calibrated after installation on a specific instrument. Refer to the separate instrument manual for specific calibration procedures.

4-4. Torque Tube Rotation Check (Replacement Units)

Prior to installation as a replacement units, a DPU should be checked for proper torque tube rotation, per the following procedure:

1. Mount DPU on a pipe stand and connect to a standard pressure source.
2. Adapt a scale graduated in degrees to the torque tube housing.
3. Adapt a pointer to the exposed end of the torque tube shaft.
4. Apply 100% DP to the high pressure (HP) housing fo the DPU. The pointer should indicate 8 degrees of travel.

4-5. Range Change

Changing the range of the Model 199 DPU requires replacing the bellows unit assembly with a unit of the desired range (see para. 4-7 Bellows Unit Assembly (BUA) Replacement).



**(High-pressure Gas Installations
with pressures greater than 200 psig)**

HIGH-PRESSURE GAS HAZARD ON DISASSEMBLY OF THE DPU. TO PREVENT POSSIBLE SEVERE PERSONAL INJURY, DEATH, OR SUBSTANTIAL PROPERTY DAMAGE DUE TO THE RELEASE OF INTERNAL PRESSURE, **PERFORM THE PRESSURE CHECK PROCEDURE IN PARA. 4-2, Step A BEFORE REMOVING THE DPU HOUSING BOLTS.**

NOTICE

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



DO NOT REUSE HOUSING BOLTS. IF BOLTS ARE DISTURBED, REPLACE WITH NEW BOLTS, PER TABLE 4-2 (STANDARD) or TABLES 4-3/4-4 (NACE).

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: The calibration range of the DPU was carefully set at the factory. The following procedure maintains the original factory bellows travel setting while the range spring change is performed. This procedure must be strictly followed while changing the range spring assembly or altering the adjustment.

To replace the range spring assembly with either a new assembly of the same range or one with a different range value, proceed as follows (this procedure assumes that the DPU is either connected to an indicating instrument or fitted with a scale and pointer to measure torque tube shaft movement):

A. 2-1/8-inch Dia. Bellows

1. Remove the DPU from service.
2. Remove the pressure housing bolts and the low-pressure housing.
3. With the pointer at zero, remove the spring retainer screw, retainer springs, and the range spring assembly.

NOTE: The pointer will shift from zero. This is a normal action and the pointer should not be readjusted at this point.

4. Install the new range spring assembly onto the push rod, and replace the spring retainer screw.

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A. 2-1/8-inch Dia. Bellows (Cont.)

5. If the pointer is set above zero, rotate the spring adjustment clockwise until the pointer is set at zero. If the pointer is below zero rotate the spring adjustment counterclockwise until the pointer is set at zero.
6. Replace and tighten the lock nut. If the pointer shifts from zero, loosen the lock nut and reset the pointer as in step 5. Tighten the lock nut.
7. Replace the low-pressure housing and install NEW bolts (new gaskets are recommended). Use the torque values listed in Tables 4-2 through 4-4. **Refer to Housing Bolt WARNING, para. 4-5, page 19.**
8. Calibrate in accordance with the manual for the actuated instrument.

B. 3-3/4-inch Dia. Bellows Without Kickoff Spring (>50" w.c.)

1. Remove the instrument from service.
2. Remove the pressure housing bolts and the low-pressure housing.
3. With the pointer set at zero, remove the lock nut retainer nuts, and the range spring assembly. To remove the range spring assembly, rotate the assembly counterclockwise while pulling outward on the assembly.
NOTE: The pointer will shift from zero. This is a normal action and the pointer should not be readjusted at this point.
4. Thread the new assembly onto the push rod, and align the holes in the range spring assembly with the spring posts. Replace and tighten the retainer nuts.
5. Using a spanner wrench, rotate the spring adjustment until the pointer is set at exact zero. Replace and tighten the lock nut. The pointer must remain at the zero setting. If the pointer shifts from zero, loosen the lock nut and repeat this step.
6. Replace the low-pressure housing and bolts (new gaskets are recommended). Use the torque values listed in Tables 4-2 through 4-4. **Refer to Housing Bolt WARNING, para. 4-5, page 19.**
7. Calibrate in accordance with the manual for the actuated instrument.

C. 3-3/4-inch Dia. Bellows w/Kickoff* Spring (see Figure 4-2)

NOTE: The kickoff spring is supplied with the 0-40" w.c. and lower range DPUs as standard equipment. It is optional with 0-50" w.c. DPUs.

*Also referred to as the "anti-stick" spring.

1. Remove the instrument from service. Set the pointer (or pen) at zero, using the instrument zero adjustment.
2. Remove the pressure housing bolts and remove the low-pressure housing.
3. With the pointer set at zero, remove the lock nut, four spring retainer nuts, washer and lock nut, and range spring assembly.
NOTE: The pointer will shift from zero. This is a normal action and the pointer should not be readjusted at this time.
4. Install the range spring assembly, using a 1/2-inch open-ended wrench to connect the push rod to the low-pressure bellows cup.
NOTE: The range spring assembly consists of the range springs, kickoff spring assembly, and the push rod. The assembly is furnished as a complete and assembled unit.

- C. 3-3/4-inch Dia. Bellows w/Kickoff* Spring (Cont.)** (see Figure 4-2)
5. Position range spring assembly over retainer posts and replace retainer nuts.
 6. Insert the tubing between the range springs and tighten inboard lock nut.
 7. Zero the pointer by adjusting the spud on the push rod. Be sure that the kickoff spring is not engaged during this operation.
 8. Position the kickoff spring to prevent interference with the coil springs and tighten the kickoff spring lock nut. If clearance is needed for the wrench during this operation, note the position of the spud (measure with a scale or count threads to the end of the push rod) and move the spud for the required clearance. After the lock nut is tightened, return the spud to the original position.

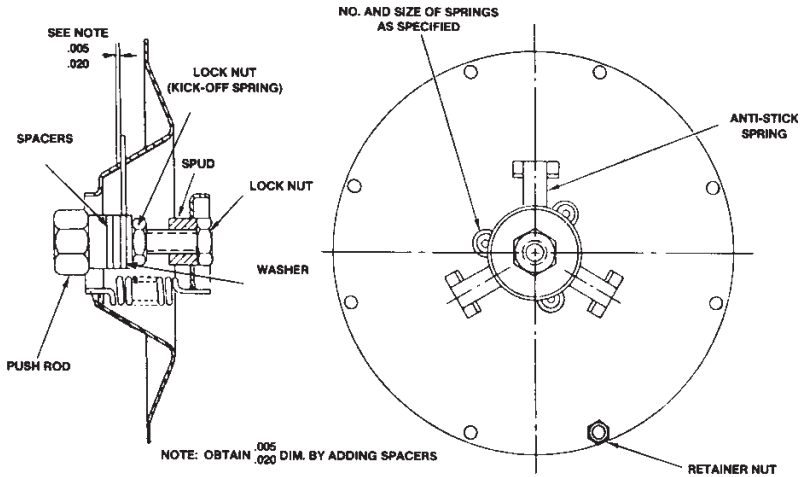


Figure 4-2. Kickoff Spring Assembly

NOTE: The lock nut requires a modified 7/16", 12-point box wrench for tightening (Figure 4-3).

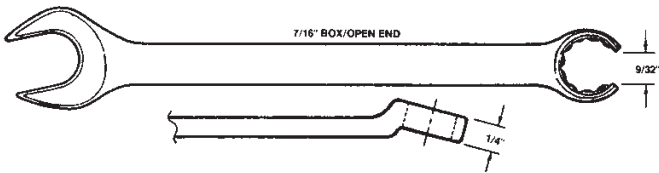


Figure 4-3. Wrench Modification

9. Check the back-clearance between the kickoff spring and the slot. Use a wire feeler gage or comparable measuring device. The clearance will vary between each individual slot but must be at least 0.005-inch for any one slot to prevent interference with instrument zero. Add or remove washers as required to obtain the proper clearance. Tighten the lock nut securely.
10. Install the jam nut and lock the spud to the push rod. Hold with pliers. If the spud was moved in step 9, return the spud to the proper position before tightening the jam nut.

C. 3-3/4-inch Dia. Bellows w/Kickoff* Spring (Cont.)

11. Apply 100 percent negative pressure to the high-pressure side of the DPU and repeat the clearance check and adjustment of step 9.
12. Apply 100 percent positive pressure to the high-pressure side of the DPU and repeat the clearance check and adjustment of step 9.
13. Release all pressure from the instrument and replace the low-pressure housing. Use new gaskets.
14. Replace the housing bolts. Use the torque values listed in Tables 4-2 through 4-4. **Refer to Housing Bolt WARNING, para. 4-2, page 13.**

4-6. Setting Bellows Travel

The travel of the DPU bellows must be adjusted if one of the following occurs.

1. The range spring assembly is removed without following the procedure.
2. Broken range springs are replaced.
3. The indicator pointer has excessive overtravel.
4. The indicator pointer has excessive undertravel.

To set the bellows travel requires that the DPU be attached to the actuated instrument and connected to a test pressure source. The procedure for this adjustment is presented in the manual of the actuated instrument.

4-7. Bellows Unit Assembly (BUA) Replacement (See Figure 2-1)

WARNING

**(High-pressure Gas Installations
with pressures greater than 200 psig)**



HIGH-PRESSURE GAS HAZARD ON DISASSEMBLY OF THE DPU. TO PREVENT POSSIBLE SEVERE PERSONAL INJURY, DEATH, OR SUBSTANTIAL PROPERTY DAMAGE DUE TO THE RELEASE OF INTERNAL PRESSURE, **PERFORM THE PRESSURE CHECK PROCEDURE IN PARA. 4-2, Step A BEFORE REMOVING THE DPU HOUSING BOLTS.**

NOTICE

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

WARNING

(Housing Bolts)



DO NOT REUSE HOUSING BOLTS. IF BOLTS ARE DISTURBED, REPLACE WITH NEW BOLTS, PER TABLE 4-2 (STANDARD) or TABLES 4-3/4-4 (NACE).

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.

4-7. Bellows Unit Assembly (BUA) Replacement (Cont.) (See Figure 2-1)

COMPONENT REMOVAL NOTICE: See (separate) actuated instrument Manual for particular components that must be removed to gain access to DPU case mounting screws. Support DPU during disassembly. **Do not loosen drive arm hold plug** (located in the top of the BUA center plate) when removing mounting bracket. **If plug is loosened, bellows fill fluid will be lost.**

NOTE: The reference designations listed relate to Parts Drawing in Section 5.

1. Disconnect the DPU piping and remove the instrument from service.
2. Loosen the actuated instrument drive arm and slide off of the torque tube shaft. Do not disconnect the instrument linkage.
3. Remove the four case-retaining screws and remove the case assembly.
4. (Indicators only) Remove the three pipe mounting adapter bracket screws (10, 11) and remove the adapter bracket (13).
5. Remove the three mounting bracket screws and remove the case mounting bracket (18).
6. Remove the pressure housings bolts and pressure housings (26).
7. Place the pressure housings (26) on the replacement bellows unit assembly (1) and insert and start (only) the pressure housing bolts.
8. Attach the case mounting bracket (18) to the replacement assembly, using three mounting bracket screws.
9. (Indicators only) Attach the pipe mounting adapter bracket (13) using three screws.
10. Support the DPU and tighten and torque the pressure housing bolts to the specifications listed in Tables 4-2 through 4-4. **Refer to Housing Bolt WARNING, para. 4-7, page 22.**
11. Attach the case assembly using four case retaining screws.
12. Attach drive arm and linkage.
13. Tighten drive arm to torque tube, per para. 4-8.
14. Replace any instrument components that were removed (refer to the COMPONENT REMOVAL NOTICE above).
15. Calibrate the instrument before returning it to service.

4-8. Attaching Drive Arm to Torque Tube

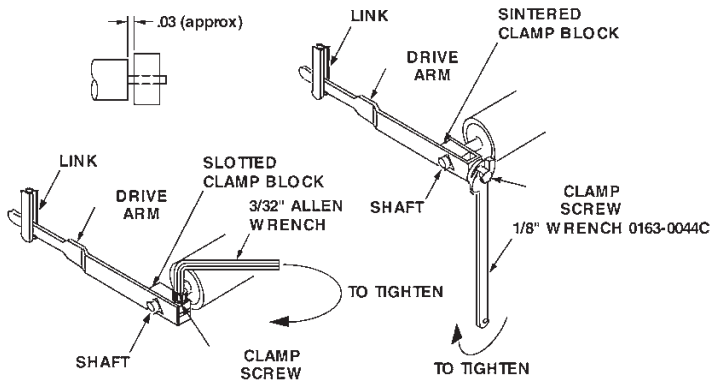


Figure 4-4. Drive Arm to Torque Tube Connection

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 the drive arm assembly onto the torque tube shaft:
 - a. Supporting block and shaft, tighten clamp screw until snug to shaft.
 - b. Still supporting block/shaft, tighten clamp screw an additional:
 - Sintered: 1/3 to 1/2 turn (screw can normally turn one full revolution before breaking.)
 - Slotted: 1/4 to 1/3 turn (slot in the slotted clamp block should still be open.)

NOTICE: For Nuclear, Seismic, and High Shock Qualified Units, perform Drive Arm Tightness Test, per para. 4-9.

4-9. Drive Arm Tightness Test

(Nuclear, Seismic, and High Shock Qualified Units Only)

This procedure tests the drive arm to torque tube attachment for tightness, by applying torque developed by the DPU onto a fixed drive arm. Care should be taken to apply pressure slowly, as 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/split range units, it will be necessary to pressurize DPU 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-degrees of torque tube drive shaft equivalent torque onto the connection.

Observe shift in the unit "zero" following DPU depressurization (as required) and drive arm stop bracket readjusting (to allow free movement of 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.

4-10. Adjusting Pulsation Dampener (See Figure 2-1)

1. Remove dust cover and insert 1/8 hex key into needle valve.
2. Turn valve clockwise to closed position, approx. 3 turns.
3. Back out valve 1/2 turn or as required to reduce pulsations/shock pressures.

4-11. Troubleshooting

See Table 4-5 and refer to actuated instrument Manual for more information.

Table 4-5. Troubleshooting Chart

Trouble*	Possible Source	Probable Cause	Corrective Action
Low or No Indication	Primary Element or Differential Pressure Source	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	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 shutoff valves closed	Open block or shutoff valves
		Piping leaks, HP side	Repair leaks
		High flapper setting	Align drive arm re-calibrate
	Bellows Unit	Housing(s) filled up with solids, restricting bellows movement	Clean out housing(s)
		Gas trapped (liquid service) or liquid trapped (gas service) in housing(s)	Vent housing(s)
		HP Housing gasket leaks	Replace gasket
		DPU tampered with	Return BUA for repair
	Mechanism	Loose links/movements	Tighten or replace
		Out of calibration	Calibrate
		Corrosion or dirt in mechanism	Clean or replace
		Pointer loose	Tighten pointer

Table 4-5. Troubleshooting Chart (Continued)

High Indication	Primary	Orifice partially restricted or too small	Clean out or replace
	Piping from Primary Element to DPU	Leak in LP side piping	Repair leaks
	Bellows Unit	Gas trapped (liquid service) in LP housing or liquid trapped (gas service) in HP housing	Vent housing
		LP housing gasket leaks	Replace gasket
		Range spring broken or DPU tampered with	Return BUA for repair
	Mechanism	Loose links or movements	Repair or replace
		Out of calibration	Calibrate
Erratic Indication	Primary	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 (see Startup Procedure-Section 3)
		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 HP or LP housing	Remove (see Startup Procedure-Section 3)
	Mechanism	Linkage dragging or dirty	Adjust or clean
		Pointer dragging on scale plate	Adjust

SECTION 5 - PARTS DRAWING/LIST

5-1. General

The parts list and parts identification drawing(s) for the DPU are presented in the separate DPU Manual.

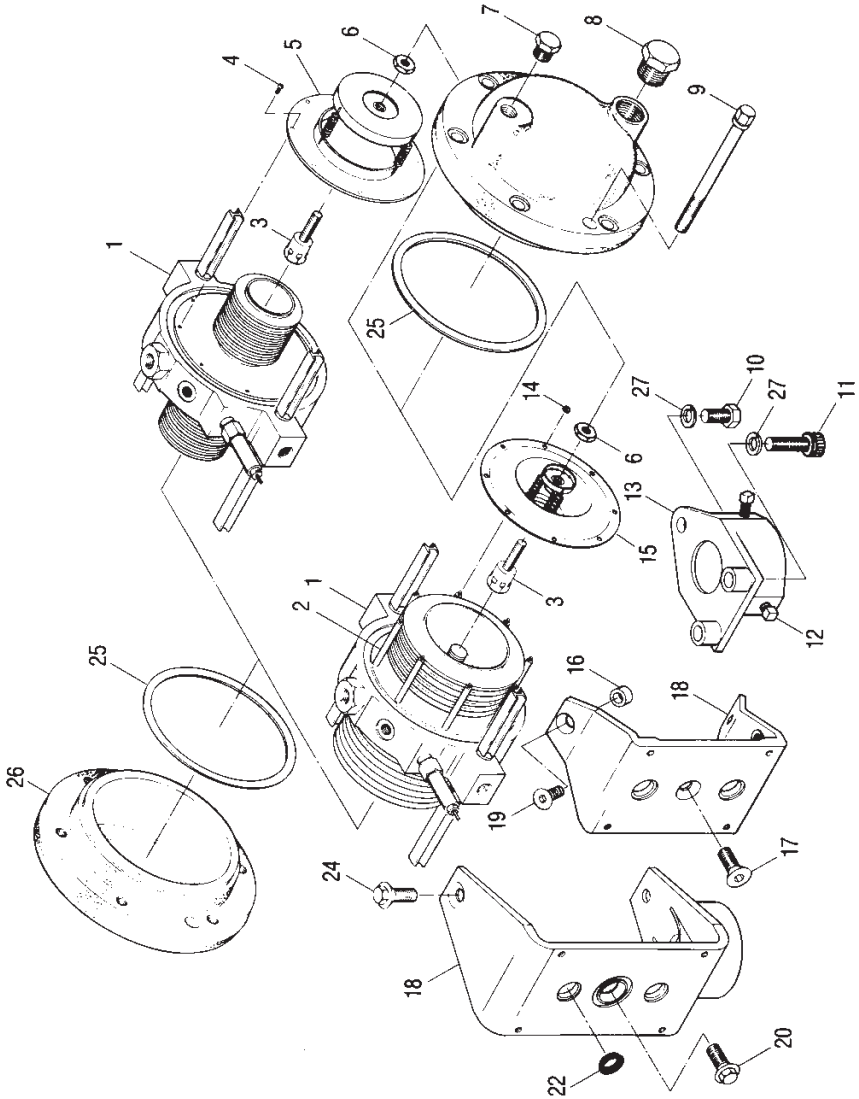


Figure 5-1. 199 DPU Parts Drawing

WARNING
(NACE SERVICE) 

HAZARDOUS GAS AND PRESSURE HAZARD IN NACE QUALIFIED SERVICE. **USE ONLY NACE QUALIFIED REPLACEMENT PARTS** FOR HOUSINGS, BOLTS, AND BUA. **FOR NACE BOLT PART NUMBERS, REFER TO TABLES 4-3 & 4-4.**

ANY DEVIATION FROM USE OF QUALIFIED NACE PARTS IN NACE SERVICE WILL VOID THE INSTRUMENT/DPU NACE RATING(s).

Table 5-1. 199 Parts List

ITEM	DESCRIPTION	PART NO.	PER UNIT
1	BELLOWS UNIT ASSEMBLY (BUA)	(SPECIFY)	1
*2	POST, CALIBRATION SPRING RETAINER (FOR 3-3/4" BELLOWS)	0199-0019C	4
3	ROD, SPRING PUSH	0199-0049C	1
*4	SCREW, RETAINER, 6-32 x 5/16"	0111-0049J	8
*5	SPRING ASSEMBLY, CALIBRATION TENSION (FOR 2-1/8" BELLOWS)	(SPECIFY)	1
6	NUT, LOCK - SPRING ADJUST	0199-0144C	1
7	PLUG, PIPE, 1/4" NPT, STEEL	0199-0191C	2
8	PLUG, PIPE, 1/2" NPT, STEEL	0199-0192C	2
9	BOLT, HOUSING (STANDARD UNITS):** STAINLESS STEEL, 1000 PSI UNITS STEEL, 2500/3000/4500 PSI UNITS STUD, ALLOY STEEL, 1/2-20 X 7 FOR 6000 PSI UNITS (NOT SHOWN) BOLT FOR 6000 PSI UNITS (NOT SHOWN)	0199-1345C 0199-0085C 0199-1001C 0199-1346C	A/R
*10	SCREW, PIPE MOUNT ADAPTER, 3/8-16 X 3/4"	0210-0012J	1
11	SCREW, SCH CAP, STEEL, 3/8-16 X 1-1/2" LG.	0220-1102J	2
*12	SCREW, 3/8-16 X 5/8", STEEL (FOR ITEM 13)	0310-0013J	3
13	ADAPTER, PIPE MOUNTING	0199-0988C	1
*14	NUT, SPRING RETAINER, HEX, 6-32, SM PATTERN, SST (FOR 3-3/4" BELLOWS)	0500-0028J	8
*15	ASSEMBLY, RANGE SPRING (FOR 3-3/4" BELLOWS)	(SPECIFY)	1
16	SPACER, INDICATOR BRACKET	0199-0006C	2
17	SCREW, INDICATOR BRACKET (SOC. FLAT, 3/8-16 X 7/8", ST)	0240-0003J	1
18	BRACKET	(SPECIFY)	1
19	SCREW, INDICATOR BRACKET, HEX, WASHER HD., 3/8 X 1-1/8	0002-1009T	2
20	SCREW, RECORDER BRACKET, HEX, WASHER HD., 3/8-16 X 1/2	0002-0034T	1

Table 5-1. 199 Parts List (Continued)

ITEM	DESCRIPTION	PART NO.	PER UNIT
*21	O-RING, 2-127, NITRILE N3 **	0001-1178R	1
*22	GASKET, TORQUE TUBE	0199-0209C	1
23	NOT USED		
24	SCREW, RECORDER BRACKET, HEX, WASHER HD., 3/8-16 X 5/8	0002-0033T	2
*25	GASKET, PRESSURE HOUSING: ** 1000 PSI ALUMINUM UNITS 2500/3000/4500 PSI STEEL UNITS 1000/3000/6000 PSI SST & MONEL UNITS	0199-0027C 0199-0027C 0199-0184C	2
26	HOUSING, PRESSURE	(SPECIFY)	2
27	WASHER, LOCK, 3/8" (USED WITH ITEMS 10 AND 11)	0275-0049C	1
28	NOT USED		
29	NUT, 1/2-20, 6000/3000 PSI MONEL UNITS (USED WITH ITEM 9)	0199-1002C	A/R
*30	PLUG, DAMPENER VALVE (NOT SHOWN) BD HD., 1/4-28 X 1/4, SST	0199-0036C	1
31	NOT USED		
*32	WRENCH, RANGE SPRING ADJUSTMENT	0199-0142C	1
33	KEYS, SET OF HEX (NOT SHOWN)	0016-0013T	1
<p>NOTES: * INDICATES RECOMMENDED SPARE PART; A/R INDICATES AS REQUIRED; WHEN ORDERING PARTS, SPECIFY INSTRUMENT SERIAL NUMBER. ** FOR NACE SPECIFIC PART NUMBERS, REFER TO TABLES 4-3 AND 4-4.</p>			

SECTION 6 - OUTLINE DIMENSION DRAWINGS

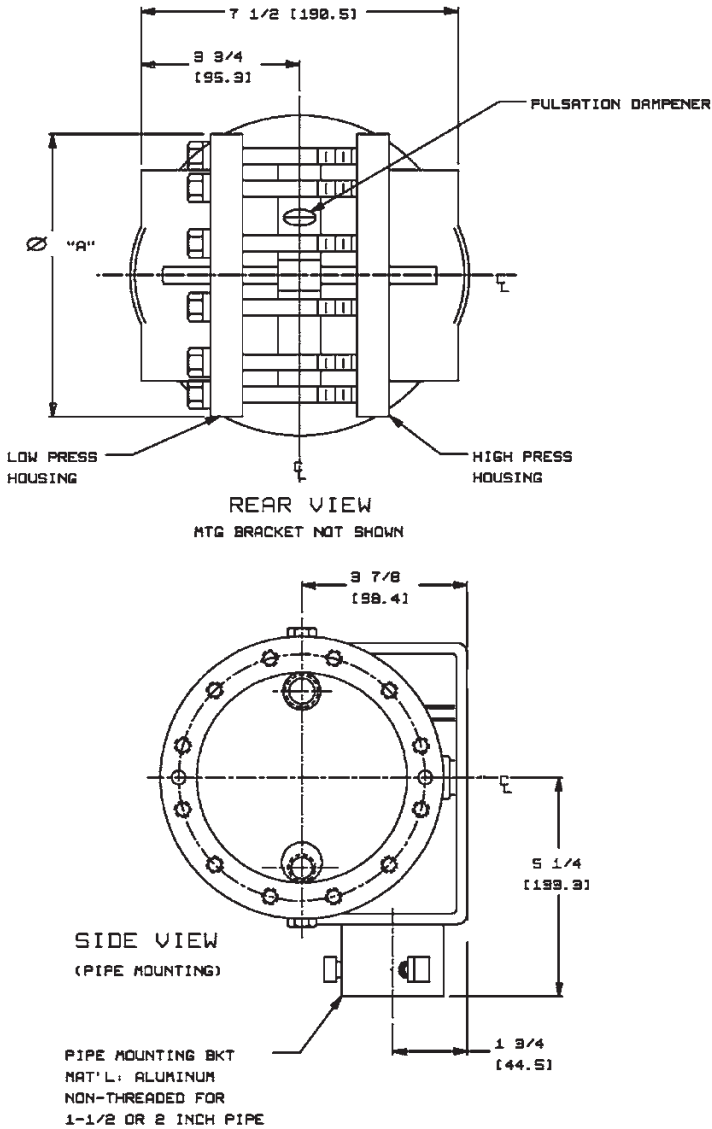


Figure 6-1. 199 DPU Dimension Drawing (Part 1 of 2)

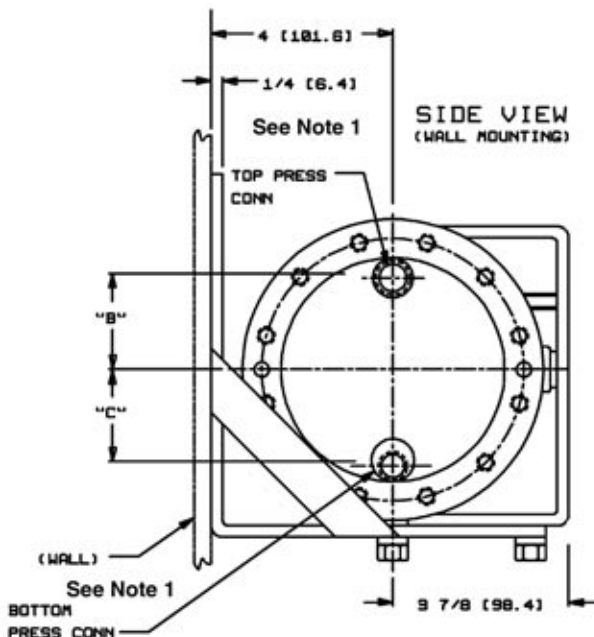


Figure 6-1. 199 DPU Dimension Drawing (Part 2 of 2)

PRESSURE RATING PSI (MPa)	HOUSING MATERIAL	PRESSURE CONNECTION		DIM. A INCHES (mm)	DIM. B INCHES (mm)	DIM. C INCHES (mm)	# BOLTS
		TOP	BOTTOM				
1,000 (6.9)	CAST ALUM. 356T6	1/2 NPT (Note 1)	1/4 NPT (Note 1)	6-5/8 (168.3)	2 (50.8)	2-9/64 (54.4)	6
NACE 2,000 (13.8)	FORGED ST. AISI C1018 (For NACE Service)	1/2 NPT (Note 1)	1/4 NPT (Note 1)	Ø 7 (177.8)	2 (50.8)	2-9/64 (54.4)	6
2,500 (17.2)	FORGED ST. AISI C1018	1/2 NPT (Note 1)	1/4 NPT (Note 1)	Ø 7 (177.8)	2 (50.8)	2-9/64 (54.4)	6
3,000 (20.7)	FORGED STNL. ST. 316	1/2 NPT (Note 1)	1/4 NPT (Note 1)	Ø 7 (177.8)	2 (50.8)	2-9/64 (54.4)	12
4,500 (31.0)	FORGED ALLOY ST. 4142	1/2 NPT (Note 1)	1/4 NPT (Note 1)	Ø 7 (177.8)	2 (50.8)	2-9/64 (54.4)	12
6,000 (41.4)	FORGED ALLOY ST. 4142 FORGED STNL. ST. 17-4 PH	9/16-18 UNF (Note 2)	9/16-18 UNF (Note 2)	Ø 7 (177.8)	2 (50.8)	2 (50.8)	12
	FORGED ALLOY ST. 4142 FORGED STNL. ST. 17-4 PH	1/2 NPT (Note 1)	1/4 NPT (Note 1)	Ø 7 (177.8)	2 (50.8)	2-9/64 (54.4)	12

Note 1: Can be reversed when ordered or can be rotated 180° in the field.
Note 2: Suitable for use with Aminko fittings (American Inst. Co., Silver Springs, MD.) or equiv..
Note 3: All Standard pipe fittings furnished by customer.
(Metric conversions are approximate.)

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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