

BARTON® MODEL 202E DIFFERENTIAL PRESSURE RECORDERS

User Manual

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Safety Information

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



WARNING: This symbol identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

CAUTION: Indicates actions or procedures which if not performed correctly may lead to personal injury or incorrect function of the instrument or connected equipment.

IMPORTANT: Indicates actions or procedures which may affect instrument operation or may lead to an instrument response that is not planned.

Section 1—Introduction

General

The Barton Model 202E Differential Pressure Recorder measures and records system operation parameters, including gas and liquid flow rate, liquid level in a vessel, and other system variables that can be measured by differential pressure and static pressure methods.

Main Components

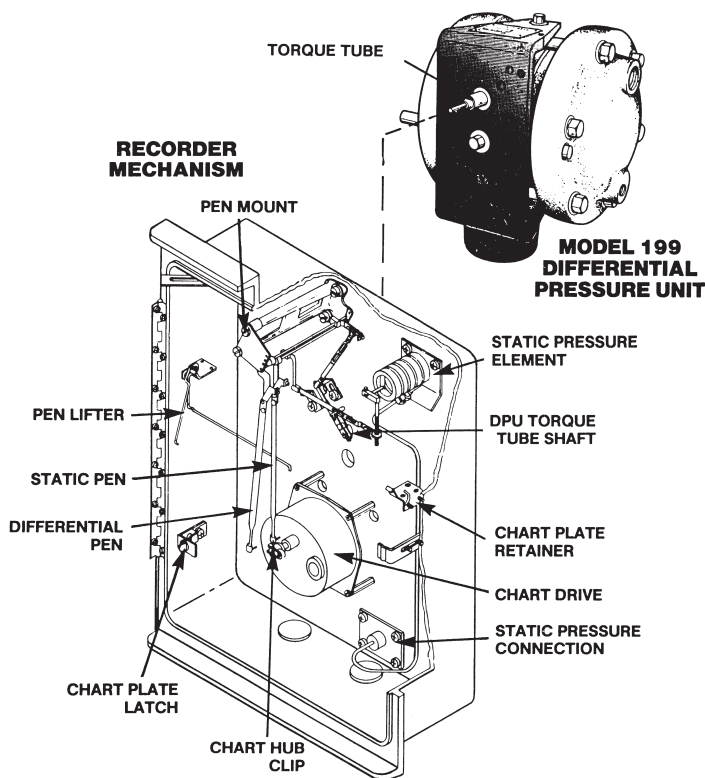


Figure 1.1—202E recorder components

Differential Pressure Unit

The Barton Model 199 Differential Pressure Unit (DPU) shown in Figure 1.1 actuates the recorders. The DPU is a dual bellows assembly enclosed within pressure housings. The bellows are liquid-filled and withstand overranges equal to the working pressure of the housing without calibration change. Movement of the bellows is transmitted through a torque tube from the DPU

to the recording mechanism. The torque tube is hermetically sealed to eliminate friction and leakage; it does not require lubrication.

The DPU is attached to the back of the recorder case. The torque tube is inserted through a hole in the case and connected to the DP drive arm of the recorder mechanism. Movement of the bellows is transmitted by the DPU drive arm to the torque tube as a rotary motion, which in turn rotates the recorder mechanism. The pressure housings of the DPU are connected by pipe or tubing to the high- and low-pressure sides of the primary device located in the process system.

The range of the 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, balance the DP applied to the unit (see bellows unit assemblies in Figure 1.2 and Figure 1.3, [page 5](#)). The number of springs and their ratings vary with individual DP range requirements.

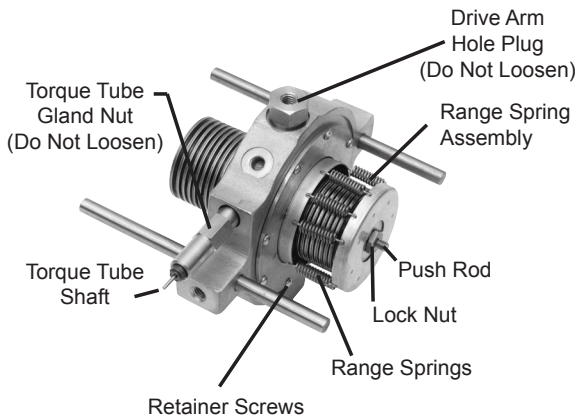


Figure 1.2—Bellows unit assembly (2 1/8-in.)

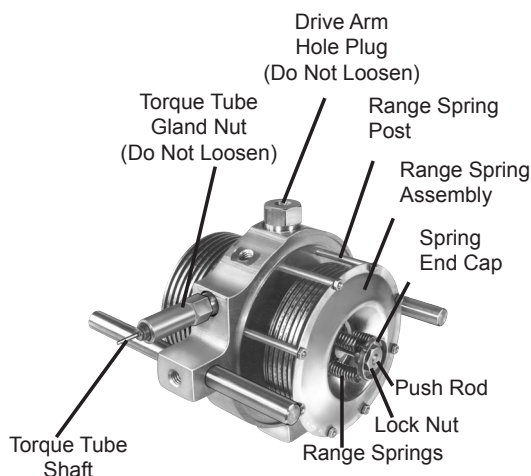


Figure 1.3—Bellows unit assembly (3 3/4-in.)

Adjusting Pulsation Dampener

The built-in pulsation dampener (Figure 1.4) controls the flow of fill-liquid between the high and low pressure bellows, with an externally adjustable needle valve. In applications where pulsation is not a problem, the needle is set to the full open position.

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

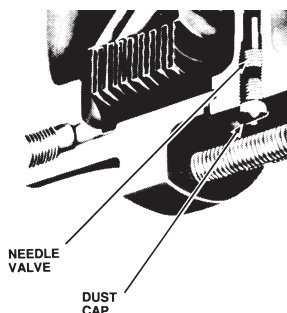


Figure 1.4—Pulsation dampener

Recording Mechanism

The recording mechanism is a linkage and pen system that permanently records data. It converts mechanical inputs from the DPU and static pressure element to transcribe lines on a revolving chart. All operative parts of the recorder mechanism are made of stainless steel for a longer field life. The pen mount is exceptionally rugged. All lines are adjustable. Screw adjustments for zero, range, and linearity assure fast and accurate calibration.

The DP recording mechanism is shown in Figure 1.5.

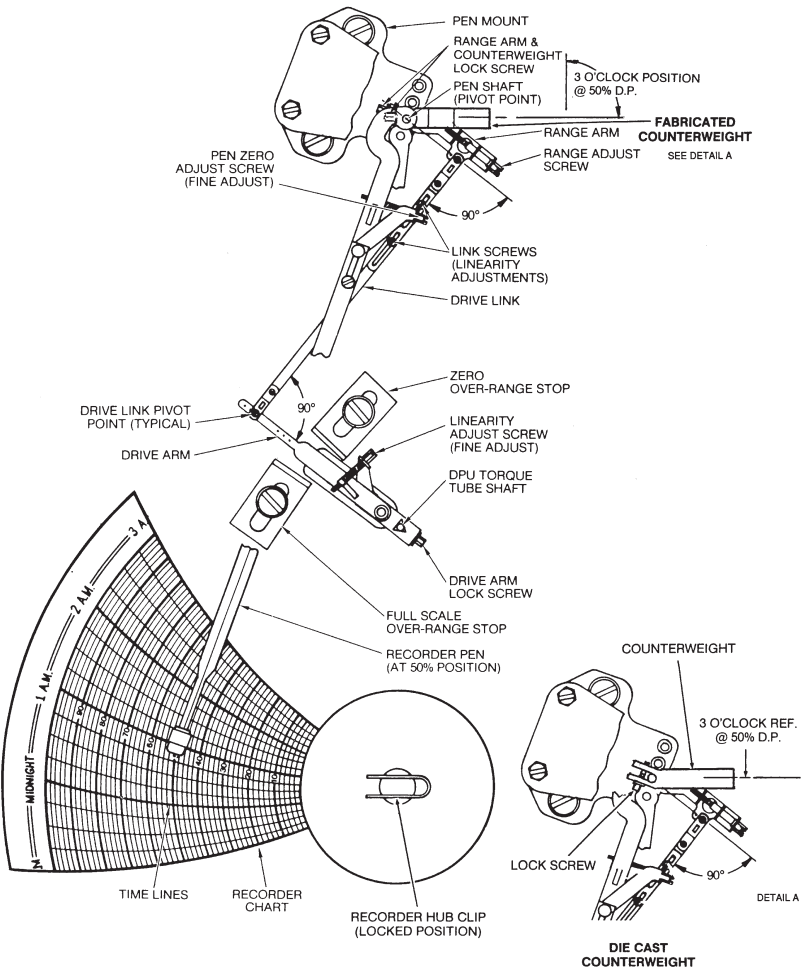


Figure 1.5—DP recording mechanism

Static Pressure Element

This element measures static pressure in a piping system from 0 to 30 inches of Hg (mercury) vacuum or from 0 to 10,000 psi. The sensor element is a bourdon tube consisting of a slightly flattened cross-section of tubing coiled into a helix or flat spiral. The outer end of the tubing is sealed and attached to a drive arm, which is attached to the static pressure connection tubing.

The static pressure recording mechanism is shown in Figure 1.6.

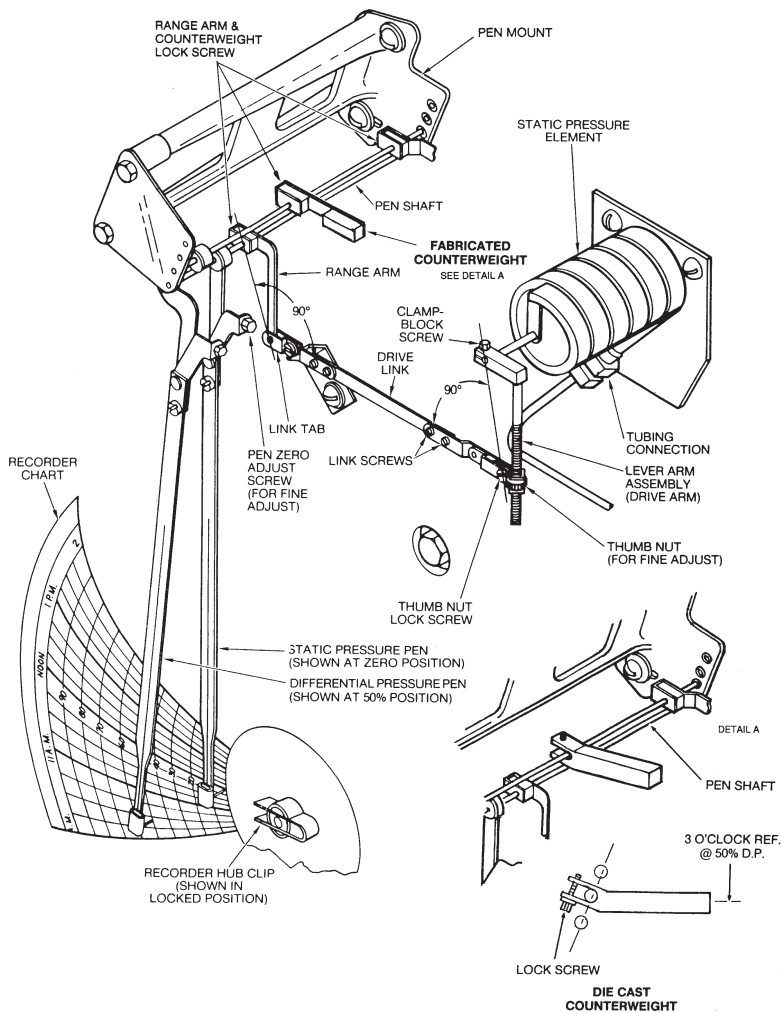


Figure 1.6—SP recording mechanism

The static pressure connection is located on the back of the recorder case. Static pressure introduced through the tubing causes the spiral or helix to unwind. A reduction of pressure within the tubing causes the element to wind more tightly. Sensor elements are available in various alloys for a variety of pressure ranges (see [Table 6.2—Static Pressure Elements on page 47](#)).

Chart Drive

Spiral wound chart drives (electrical or mechanical) can be selected to fit a wide variety of chart speeds or time intervals to reduce maintenance time. All chart drives are interchangeable and fitted with a flow recorder hub clip, which locks the chart in place. Explosion proof electrical drives are also available. See [Table 6.3—Chart Drives on page 48](#) for a complete list of chart drives.

Section 2—Installation/Calibration Check

General

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

Standard Practice Considerations

The following practices should be observed upon installation:

1. The distances between the primary device and the DPU should be minimized. 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 when an air purge or blow-back system is used.
2. Slope all piping at least 1-inch/linear foot to avoid liquid or gas entrapment.
3. Provide 2 ft 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 (82.2°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 DPU. Severe pulsation will affect the accuracy of flow measurement. Avoid severe pulsating flows, such as reciprocating pumps or compressors.
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.
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 (See [Section 5—Installation/Dimensional Drawings on page 37](#)).
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 and bypass valves so they are accessible from the front of the instrument. Locate block valves at the source of differential pressure.

Application Considerations

Flow—Make sure the DPU high pressure housing is connected to the upstream tap of the primary device.

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

Liquid Level—The process media can 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 process or process media characteristics prevent meeting the above requirements, 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 DP range of the DPU.



WARNING: Explosion Hazard. No organic compounds, oil, grease, dirt, or scale of any kind can be tolerated in an oxygen installation.

Calibration Check

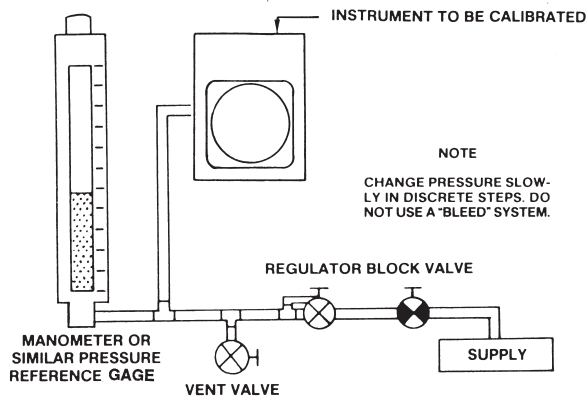
IMPORTANT: There should be enough pen pressure to produce a continuous line. The pen should spring free of chart when chart is pushed inward about 1/8-inch. If necessary, adjust pen pressure by bending pen arm in the required direction.

Differential Pressure Pen

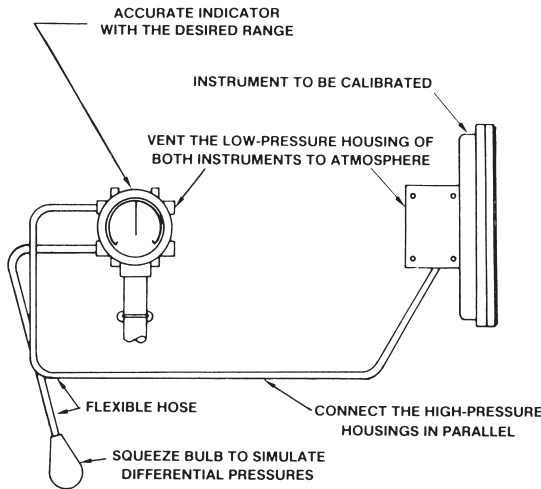
To adjust the instrument to factory-set calibration levels:

1. Verify the instrument is positioned approximately level and is securely mounted.
2. Connect the high-pressure housing into the calibration setup.
3. Vent the DPU low-pressure side to atmosphere by removing one vent plug from the low-pressure housing.
4. Remove the dust cap of the pulsation dampener valve, using a regular screwdriver. Open the dampener valve by turning it fully counterclockwise until it stops turning (using a 1/8-inch Allen wrench).
5. Place a recording chart onto the chart plate. Lock the chart into position with the hub clip.
6. Set the pen precisely at zero, using the pen zero adjustment screw.

- 7. Apply 100% pressure. Verify that the pen moves across scale to the 100% pressure indication.
- 8. Apply 50% pressure. Verify that the pen indicates 50% pressure on the chart.
- 9. If the pen does not accurately indicate the pressure being applied, further adjustments are necessary; perform the calibration procedure outlined in [Differential Pressure Pen Calibration on page 15](#).



TYPICAL CALIBRATION SETUP



PORTABLE CALIBRATION SETUP

Figure 2.1—Calibration configurations

Static Pressure Pen

If the instrument includes a static pressure element, use the following to check the static calibration:

1. Connect the static pressure element into the calibration setup:

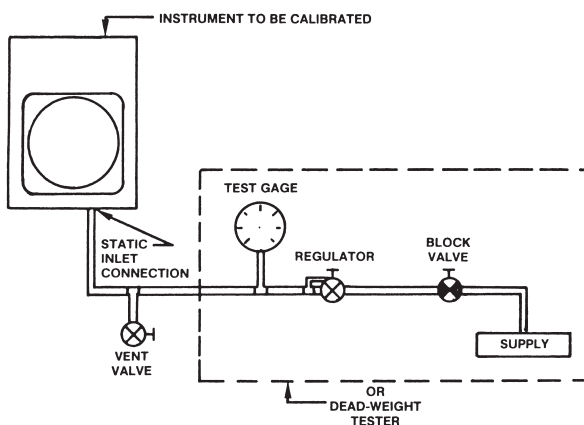


Figure 2.2—Static pressure element calibration setup

2. Release pressure. Set the pen to zero, using the zero adjustment screw.
3. Apply 100% pressure. Verify that the SP pen moves across scale to the 100% pressure indication.
4. Apply 50% pressure. Verify that the SP pen indicates 50% pressure on the chart.
5. If the pen does not accurately indicate the pressure being applied, further adjustments are necessary; perform the calibration procedure outlined in [Static Pressure Pen Calibration on page 19](#).

Recorder Mounting

IMPORTANT: Before installation, perform a calibration check ([page 10](#)). Do not place unit near vents or bleed holes that discharge corrosive vapors or gases. Do not apply wrench/bar pressure to recorder case. All fittings must be leaktight. All tubing must be secure to minimize vibration. Mount the instrument as level as possible.

Flush Mounting

1. Cut opening in panel to the dimensions shown in Section 5.
2. Drill out pilot holes located on top and bottom of case. Use a No. 1 (0.288) drill. Limit drill penetration and remove chips.
3. Attach mounting brackets to case bottom with supplied self-tapping screws.
4. Slide case (from front of panel) into the panel cutout.
5. Attach remaining mounting bracket and install panel mounting screws.

Pipe Mounting

1. Place a suitable length of 2-inch pipe into a well-secured floor or wall flange; or attach the 2-inch pipe to existing pipe with a saddle that is fitted with a 2-inch NPT outlet.
2. Thread the DPU onto the pipe, orient the instrument (with wrench or bar applied to the DPU bracket only), and tighten retaining screws.

Piping

Connect the pressure element to system pressure using tubing or pipe. The pressure connection on the outside of the recorder case is 1/4-inch NPT, female.

Electrical Connections

Two knockouts are on the bottom of the case. One knockout is on the back of the case to accommodate conduit clamping connections, through which wiring is fed to the terminal strip. The terminal strip is below the chart drive motor. The standard electrical power supply requirement is 110 VAC, 60 Hz (50 Hz wiring available upon request).

Chart Installation

Perform the following steps to install the chart:

1. Open the recorder door and release the chart lock (on chart drive hub).
2. Raise the pen lifter arm and slide the chart between the pen(s) and the chart plate. Insert the chart in the chart guides in the chart plate, and locate the hole in the chart onto the chart hub. Place the pressure chart onto the chart hub. Then, lower the pen lifter arm and position the chart to place the pen(s) on the desired chart time line.
3. Secure the chart in place with the chart hub lock.

Startup

IMPORTANT: Be careful not to subject the DPU to unnecessary shock or overrange pressure during operations.

1. Always start with the block valves closed.

IMPORTANT: Do not perform a zero check with only one block valve closed. If seal pots are used, some of the sealing fluid will be lost or displaced. In gas service, a standard wave effect may occur that will displace the zero reading.

2. Perform a zero check on the instrument, per the following:

For Gas Service:

- a. Verify the instrument is mounted approximately level and is properly connected to the pressure source.
- b. Tighten process connections to each DPU housing.
- c. Check manifold and piping for leaks:
 - i. Close shutoff valves, open the equalizer or bypass valve(s), and then slowly open one shutoff valve to pressurize the instrument.
 - ii. When system is pressurized, close both valves opened in Step 1.
 - iii. Any leakage will be indicated by pen movement, up or down the scale. If leakage is indicated, check all manifold and piping joints. Tighten as necessary.
 - iv. Repeat Steps i through iii until no pen movement occurs.
- d. The pen should indicate zero. If it does not indicate zero, check for gas or liquid entrapment in the lines or in the DPU (depending upon orientation of piping and service). If no entrapment is found, set the pen to zero using the pen zero adjustment screw.
- e. Close equalizer valve and observe the pen:
 - i. If zero, no further check is needed.
 - ii. If upscale, a leak may exist on the low-pressure side. Check and tighten connections.
 - iii. If downscale, a leak may exist on the high-pressure side. Check and tighten connections.
 - iv. If still slightly off, make a fine adjustment using the pen zero adjustment screw.

For Liquid Service:

- a. Fill the service lines with process fluid. Vent and bleed each side of the DPU before tightening the vent plugs.
 - b. Perform steps 2.a. through 2.e. in the Gas Service procedure above.
 - c. Open the shutoff valve. Leave the equalizer valve closed. The flow recorder is now operational.
3. Adjust the dampener valve as required.

Operation

To place the instrument into operation:

1. Turn on the drive.
2. Verify that the pen has ink and is in contact with chart.
3. Turn on pressure to the recorder.

Section 3—Maintenance and Calibration

Maintenance

Generally, Barton recorders require no maintenance other than replacement of the chart, replenishment of the ink, winding of the spring-wound chart drives, and occasional calibration. In addition, the operator should periodically check the door seal for wear and the pressure fittings for tightness. See Table 3.1 for a list of tools required for routine maintenance.

Table 3.1—Required Tools

Tool	Purpose
1/2-inch open-end wrench	Pushrod—bellows cup connection
Modified box/open-end 7/16-inch wrench	Kickoff spring lock nut
Torque wrench (100 ft-lb)	Pressure housing bolts
Screwdriver	Bracket screws

Differential Pressure Pen Calibration

To calibrate the DP pen, perform the following steps. Refer to [Figure 3.1—DP recording mechanism on page 17](#) as necessary.

1. Make sure chart plate is on same plane and flush with hub flange. The chart must be flat with the hub locked. Also, make sure the pens and pen arms are correctly connected and that they do not interfere with one another.
2. With a chart locked into place, move the pen from zero to full span and back to ensure that the pen travels along the time line. If adjustments are needed: loosen the two pen mount screws, adjust the pen mount position until the pen follows the time line, then tighten the pen mount screws.
3. Disconnect the differential pressure drive link from the range arm. Move both differential and static pressure pens to full span. Adjust the static pen so that pens are approximately 7 to 15 minutes apart by adjusting the static pen arm mounting location on the pen arm shaft assembly. Move both pens to the 50% indicating position. Ensure that the pens don't interfere with one another. Adjust static pens as necessary; do not alter the differential pressure pen once it has been adjusted to the time line.
4. Assure that there is enough pen pressure against the chart to produce a continuous line. If necessary, adjust the pen pressure by bending the arm in the required direction.
5. Unlock the flow recorder hub clip. Remove the chart and chart plate.

IMPORTANT: Prepare a calibration chart by cutting a chart into the wedge shape and gluing it to a piece of similarly shaped cardboard of stiffer. This allows calibration of the pens and permits access to the flow recorder mechanism when linkage adjustments are necessary.

6. Mount a calibration chart onto the flow recorder hub. Lock the chart in place. Move overrange stops out of play.
-

IMPORTANT: Verify that all linkage is free. Adjust range arm and drive arm at precisely the same distance back of the case. Adjust the lever arm and pen zero adjust screws to their midpoints all 90° midscale linkage angles must be measured.

7. Apply 50% differential pressure to the high-pressure side. Arrange the differential pressure linkage as shown on [page 17](#). Set a 90° angle between the drive arm and link. By varying the length of the link, set a 90° angle between the range arm and link. Slip the range arm on the pen shaft so the pen is at approximately 50% on the chart.
8. Remove pressure. The pen should indicate zero. If the pen deviates less than 10% from zero in either direction, perform fine adjustment by using the pen zero adjust screw (refer to [page 17](#)) and proceed to step 8.b. If the pen deviates more than 10% from zero, make adjustments as follows:
 - a. Rotate pen arm and shaft by gripping the range arm and forcing (or slipping) the pen until it indicates zero. The pen arm and shaft should rotate at the range arm pivot point without loosening the range arm lock screw.
 - b. Apply 100% pressure. Make the necessary adjustment by turning the range arm adjust screw counterclockwise if the pen is slightly under-ranged and clockwise if the pen is slightly overranged. Repeat zero and 100% adjustments until calibration at these points is achieved.
 - c. Apply 50% pressure. The pen should be on the 50% chart line.
 - d. If the pen is low, lengthen the linkage to make a correction forty times as great in the low direction. Adjust the pen to 50% as in step 8.a. (refer to [page 17](#)).
 - e. If the pen is high, shorten the linkage to make a correction forty times as great in the high direction. Adjust the pen to 50% as in Step 8.a. Assure all linkage screws are retightened.
9. Repeat step 8 until calibration of all three points (0, 50, and 100% indication) is achieved. To assure accuracy a nine-point calibration check (1, 24, 50, 74, and 100% ascending and descending) must be run.

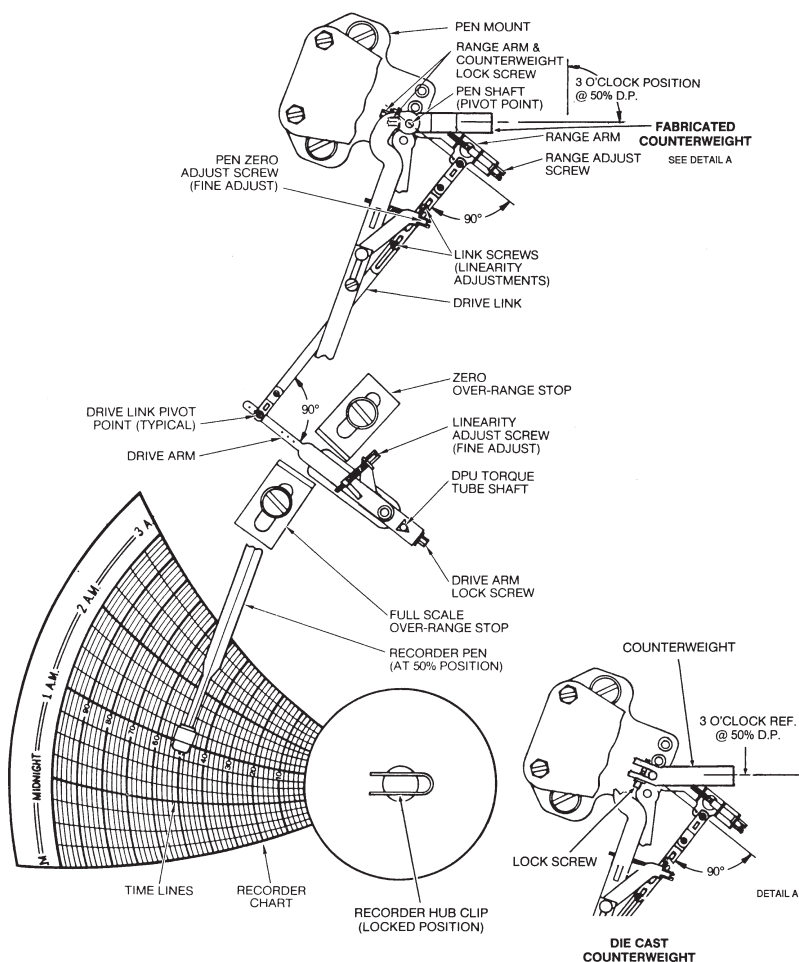


Figure 3.1—DP recording mechanism

Adding Counterweight to #2 Pen (DP)

Fabricated Counterweight for 3-Pen or 4-Pen Flow Recorders:

1. Disconnect the drive link from the range arm.
2. Remove the #2 pen from the pen mount (note approximate position from range arm).
3. Remove the range arm from the shaft, and slip the counterweight to about mid point. Position approximately as shown on [page 17](#) and secure in place. Replace the range arm to approximate position (note step 2) and secure in place.
4. Reassemble in pen mount and prepare for calibration.

Fabricated Counterweight for 2-Pen Flow Recorders:

1. Disconnect the drive link from the range arm.
2. Remove the #2 pen from the pen mount.
3. Slip the counterweight over the shaft in front of the pen (shaft length is approximately 9/16") and position approximately as shown on [page 17](#) and secure in place.
4. Reassemble in pen mount and prepare for calibration.

Die Cast Counterweight

These counterweights slip over the pen shaft without disassembly. This is applicable to a 2-pen or 3-pen assembly:

1. Remove lock screw from counterweight.
 2. Slip over #2 shaft at any convenient location. Replace lock screw carefully, orienting the counterweight in the position shown on [page 17](#).
-

IMPORTANT: The counterweight is die cast zinc, subject to bending if too much torque is applied to the lock screw.

Calibration

1. After removal of the range arm for adding a counterweight, complete recalibration is required.
2. After the addition of the counterweight in front of the DP (#2) pen, set the counterweight at the 3 o'clock position and apply 50% differential (as described in step 7 of [Differential Pressure Pen Calibration on page 15](#)). The addition of the counterweight causes a zero offset, but has little effect on span.
3. Reset zero, check span and adjust as necessary.

Static Pressure Pen Calibration

To calibrate the static pressure pen and associated linkage, perform the following steps. Refer to [Figure 3.2—SP pen mechanism on page 20](#) as necessary.

1. Adjust the static range arm and drive arm at precisely the same distance from the back of the case.
2. Place static drive link in the fourth hole from the pen shaft of the range arm.
3. Adjust static pressure linkage to form 90° angles between the drive link (see above illustration) and pivot points of the associated linkage, as follows:
 - a. Apply 50% static pressure, center thumb nut on the drive arm, and arrange static linkage .
 - b. Set a 90° angle between drive arm & link. Tighten clamp block screw.
 - c. Vary the length of link to get a 90° angle between range arm and link.
 - d. Slip the range arm on pen shaft to 50% on chart.

IMPORTANT: Verify that all linkage is free. Adjust range arm and drive arm at precisely the same distance from the back of the case. Adjust the lever arm and pen zero adjust screws to their midpoints and measure all 90° midscale linkage angles.

4. Release pressure and reset the pen to zero indication, using pen zero adjust screw for fine adjustment (10% or less). For major adjustments (more than 10%), loosen range arm lock screw and slip the pen to zero on chart and retighten lock screw.

IMPORTANT: It may be necessary to raise or lower the pivot point of the drive link on the range arm, as in step 3. If counterclockwise movement of thumb nut (step 5) does not increase the span sufficiently, move the pivot pin up to the next pivot hole; if clockwise movement of the thumb nut does not decrease the span sufficiently, move the pivot pin down to the next pivot hole.

5. Apply 100% pressure and observe the pen. Make the necessary adjustments by turning the drive arm thumb nut counterclockwise if the pen is slightly underranged and clockwise if the pen is slightly overranged.
6. Repeat zero and 100% adjustment until calibration at these two points is achieved.
7. Apply 50% pressure and observe pen indication.
 - a. If pen indicates high or low, adjust drive link to make a correction approximately 40 times the error — in the direction of the error.
 - b. Reset the pen to the 50% line by slipping the pen shaft at the range arm pivot point.

- c. Repeat this step (7), as necessary.
8. Release pressure and reset the pen to zero indication, using pen zero adjust screw for precise adjustment.
9. Repeat steps 4 through 8 until calibration of zero, linearity, and span (0%, 50%, and 100% indication) is achieved.
10. Assure range arm lock screws, thumb nut lock screw, and link screws are tight.
11. Reconnect the DP linkage and range arm.
12. Unlock the recorder hub clip and remove the temporary calibration chart.
13. Replace the chart plate by sliding it into the chart plate retainer brackets and engaging each side into the chart plate latches.

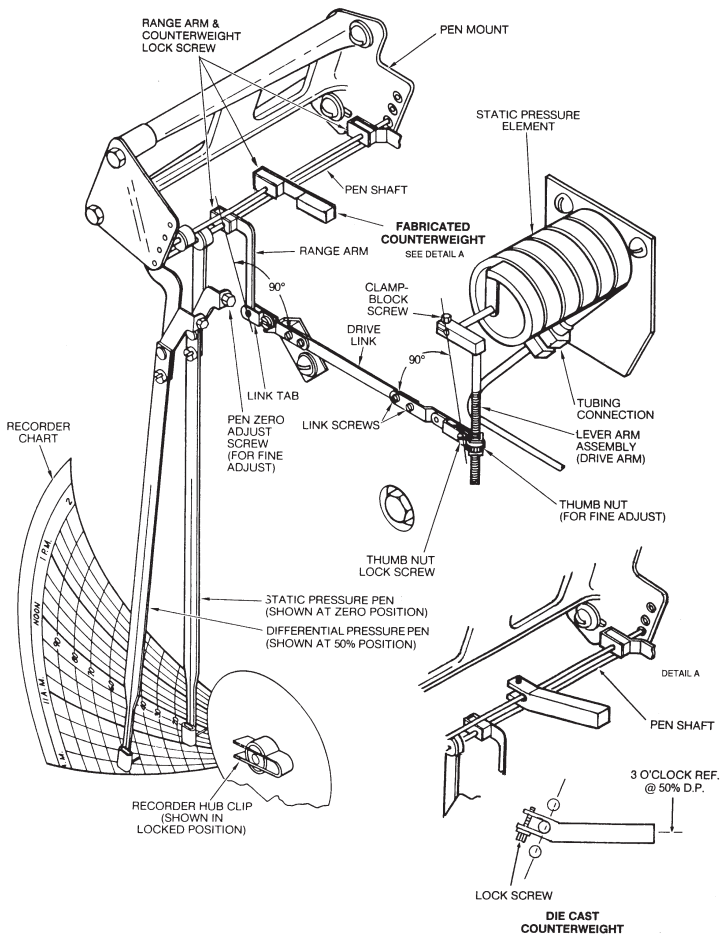


Figure 3.2—SP pen mechanism

Static Pressure Element Replacement

If the static pressure element needs replacement, proceed as follows:

1. Close all valves and turn off the power switch to the recorder.
2. Separate the drive link arm by opening the link table and disengaging the pivot pin from the clamp.
3. Loosen the clamp block screw on the lever arm assembly and separate the drive arm from the static pressure element shaft.
4. Disconnect the tubing from the static pressure element at the tubing connection (refer to [page 20](#)).
5. Remove the mounting screws from the static pressure element and discard the damaged element.
6. Install the new element, using the old mounting screws.
7. Connect tubing to the element at the tubing connection.
8. Assemble the lever arm assembly onto the static pressure element shaft; do not tighten the clamp block screw yet.
9. Connect the drive link to the drive arm by engaging the pivot pin and locking the link tab into place.
10. Align the static pressure linkage (range arm, drive link, and drive arm) so that it lies in the same plane without binding or bending.
11. Tighten clamp block screw.
12. Calibrate in accordance with the procedure outlined in SP Pen Calibration on [page 20](#).

Chart Drive Replacement

To replace the chart drive, proceed as follows:

1. Release the pressure to the recorder.
2. Turn off the chart drive.
3. Raise the pen lifter and remove the chart and chart plate.
4. Remove the chart drive mounting screws and remove the chart drive.
5. Position the new chart drive at the back of recorder case and attach with mounting screws.
6. Replace the chart plate, adjust the chart drive hub to be level with the chart plate and then install the chart. Lower the pen to the recording position.
7. Check the time line on the first pen from the chart, zero, and span elements.

Linkage Adjustments

Range Arm and Drive Arm Lock Screws

IMPORTANT: Tightening lock screws fingertight is often not tight enough, but tightening them more than a full turn often breaks them.

1. Tighten the lock screw until snug.
2. Hold the drive arm at the clamp block by hand or with a 1/4-inch open wrench (Figure 3.3). If a wrench is used, place it between the torque tube shaft and the lock screw, taking care not to damage the torque tube shaft or bearing. (In the case of the range arm lock screw, place the wrench between the shaft and lock screw.)
3. Tighten the lock screw 1/3 to 1/2 turn beyond snug.
4. Test for tightness by moving free end of drive arm approximately 1/2-inch in either direction. Drive arm should spring back without yielding.

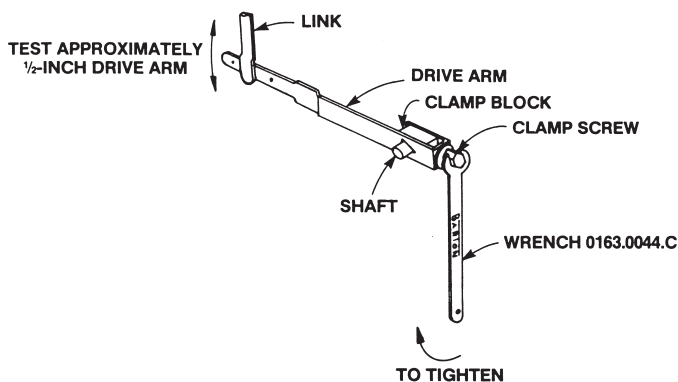


Figure 3.3—Linkage adjustments

Overrange Stops Adjustment

IMPORTANT: Prepare a calibration chart by cutting a chart into the wedge shape shown [page 17](#) and gluing it to a piece of similarly shaped cardboard of stiffer. This allows calibration of the pens and permits access to the flow recorder mechanism when linkage adjustments are necessary.

Overrange stops may be adjusted to prevent the pen from excessive overtravel (check for interference at zero and full span), per the following:

1. Unlock the flow recorder hub clip. Remove the chart.
2. Remove the chart plate by disengaging the chart plate latches on both sides and sliding the chart plate retainer brackets.
3. Mount a calibration chart onto the flow recorder hub and lock in place.

4. Loosen the screws on zero and full scale overrange stops.
5. Vent the DPU low-pressure housing. Apply sufficient pressure to the high-pressure housing to move the pen approximately 3/8-inch above 100% indication.
6. Position the zero overrange stop so that it contacts the drive arm.
7. Tighten the zero scale overrange stop screw.
8. Apply sufficient pressure to the DPU low-pressure housing to move the pen approximately 3/8-inch below zero indication.
9. Position the full scale overrange stop so it is in contact with drive arm.
10. Tighten the full scale overrange stop screw.
11. Unlock the flow recorder hub clip. Remove temporary calibration chart.
12. Replace the chart plate by sliding it into the chart plate retainer brackets and engaging each side into the chart plate latches.
13. Install a regular recorder chart and lock it into place with chart hub clip.
14. Check the pens to make sure that they touch the chart; if necessary, straighten pens by sliding them between two fingers and curling in and out.

DPU Replacement

Before installing a replacement DPU, check the new DPU for proper torque tube rotation as follows (Figure 3.4).

1. Mount the DPU on a suitable pipe stand and connect to a standard pressure source.
2. Adapt a graduated degree scale to torque tube housing.
3. Adapt a pointer to exposed end of the torque shaft.
4. Apply 100 percent differential pressure to the high-pressure housing of the DPU. The pointer attached to the torque tube shaft should indicate 8 degrees of travel.

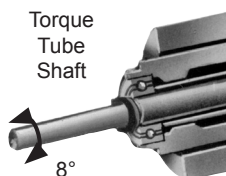


Figure 3.4—Torque tube rotation

DPU Cleaning and Inspection



WARNING: Take necessary precautions when disassembling a DPU that has been used in a high-pressure gas installations (with pressures greater than 200 psi). Before removing the DPU housing bolts, perform the pressure check procedure on [page 24](#).

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

Pressure Check Procedure



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, 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. If the housing moves freely, no pressure is present and servicing or repair may continue.



WARNING: 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 Barton service center for repair. Tag the unit and specify "Gas in Bellows."

Cleaning/Inspection Procedure

Instruments used 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.

CAUTION: 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 O-rings.
6. Set the pressure housing bolts to the appropriate torque values (see Tables 3.2 and 3.3 and Figure 3.5).

Table 3.2—Pressure Housing Bolt Torque Values (Non-NACE)

Housing		Bolt			Lube (Note 1)	Torque ft-lb (Note 2)	Rotation Degrees (Note 3)
SWP	Mat'l	Mat'l	Size	Qty			
1000	SST	Steel	3/8-16 x 4.2	12	Yes	40	180
	Alum.			6		40	270
2500	Steel	Steel	1/2-13 x 5.5	6	Yes	95	180
3000				8			
3000	SST	Steel	1/2-13 x 5.5	12	Yes	80	180
4500	Steel	Steel	1/2-13 x 5.5	12	Yes	95	180
6000	Steel SST	Steel	1/2-20 x 6	12	Yes	105	180
		Steel Nut	1/2-20	12	Yes	105	180 (Note 4)
		Steel Stud	1/2-20 x 6.6	12	Yes	105	180
		Steel Nut	1/2-20	24	Yes	105	180 (Note 4)

NOTES:

1. Lubricants: Molykote G paste, Teflon-base pipe dope, graphite-base grease, or similar lubricants. Lube first two threads only.
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 ft-lb 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 two nuts.

Table 3.3—Pressure Housing Bolt Torque Values (NACE)

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
Torque (ft-lb)	55-60	55-60	55-60

NOTES:

- 1. Lubricants: Molykote G paste, Teflon-base pipe dope, graphite-base grease, or similar lubricants. Lube first two 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.

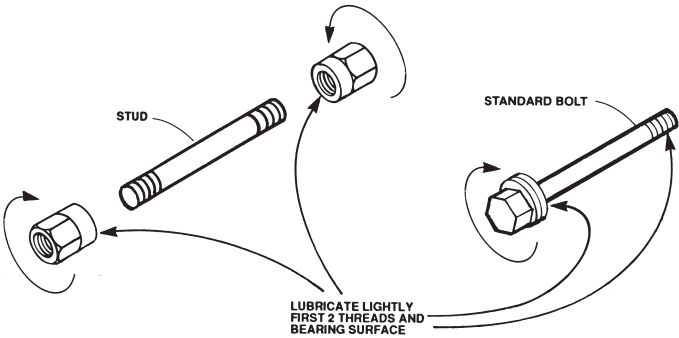


Figure 3.5—Rotation of head bolt and nuts when tightening

Change of DPU Range

Changing the range of the Model 199 DPU requires replacing the bellows unit assembly with a unit of the desired range (see [Bellows Unit Assembly \(BUA\) Replacement on page 30](#)).



WARNING: Take necessary precautions when disassembling a DPU that has been used in a high-pressure gas installations (with pressures greater than 200 psi). Before removing the DPU housing bolts, perform the pressure check procedure on [page 24](#). See [Cleaning and Inspection on page 24](#).

IMPORTANT: 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, perform one of the procedures below. These procedures assume that the DPU is either connected to an indicating instrument or fitted with a scale and pointer to measure torque tube shaft movement.

2-1/8-in. Diameter 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.
-

IMPORTANT: 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.
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 bolts (new gaskets are recommended). Use the torque values listed in [Table 3.2](#) and [Table 3.3](#).
8. Calibrate in accordance with the technical manual for the actuated instrument.

3-3/4-in. Diameter Bellows Without Kickoff Spring (above 50-inches 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.

IMPORTANT: 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 [Table 3.2](#) and [Table 3.3](#).
7. Calibrate in accordance with the technical manual for the actuated instrument.

3-3/4-Inch Diameter Bellows With Kickoff (“anti-stick”) Spring

IMPORTANT: 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.

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.

IMPORTANT: 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.

IMPORTANT: 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.

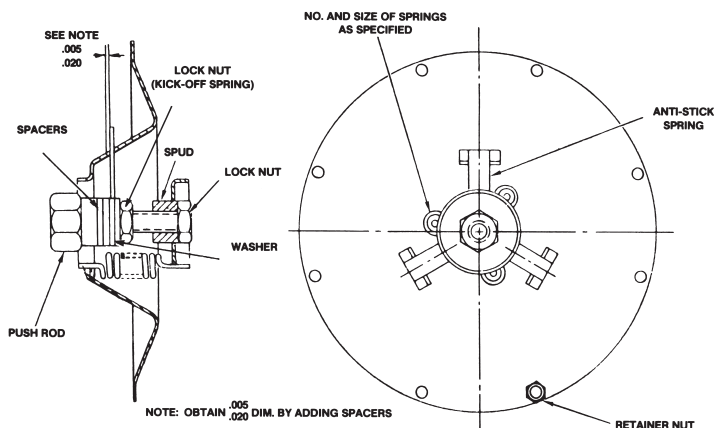


Figure 3.6—Range spring assembly

5. Position the range spring assembly over the retainer posts and replace the retainer nuts.
6. Insert the tubing between the range springs and tighten the 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.

IMPORTANT: The lock nut requires a special wrench for tightening. See illustration below for information on how to modify a 7/16-inch, 12 point box wrench.

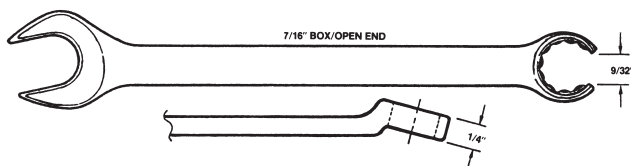


Figure 3.7—Modified wrench for tightening lock nut

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.
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 [Table 3.2](#) and [Table 3.3](#).

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 technical manual of the actuated instrument.

Bellows Unit Assembly (BUA) Replacement



WARNING: Take necessary precautions when disassembling a DPU that has been used in a high-pressure gas installations (with pressures greater than 200 psi). Before removing the DPU housing bolts, perform the pressure check procedure on [page 24](#). See [Cleaning and Inspection on page 24](#).

IMPORTANT: Support the DPU during disassembly. Do not loosen the drive arm hold plug located in the top of the BUA center plate, when removing the mounting bracket. If the plug is loosened, the bellows fill fluid will be lost.

The reference designations (#) relate to 199 DPU Parts Drawing on [page 49](#).

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. Remove three mounting bracket screws and remove bracket (18).
5. Remove the pressure housings bolts and pressure housings (26).
6. Place the pressure housings (26) on the replacement bellows unit assembly (1) and insert and start (only) the pressure housing bolts.
7. Attach the case mounting bracket (18) to the replacement assembly, using three mounting bracket screws.
8. Support the DPU and tighten and torque the pressure housing bolts to the specifications listed in [Table 3.2](#) and [Table 3.3](#).
9. Attach the case assembly using four case retaining screws.
10. Attach linkage to DPU torque tube shaft.
 - a. Tighten clamp screw until “snug.”
 - b. Tighten further, 1/3 to 1/2 turn of screw.
 - c. Test by moving end of drive arm, approx. 1/2”.
4. Replace/adjust components removed or moved to gain access to DPU case mounting screws.
5. Calibrate the instrument before returning it to service.

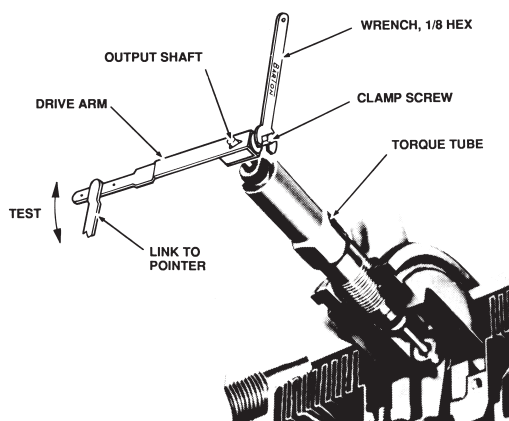


Figure 3.8—Linkage attachment to DPU

Section 4—Troubleshooting

Table 4.1 and Table 4.2, [page 34](#), provide a description of problems, common causes, and recommended corrections. For further assistance, contact your local Cameron field representative.

Table 4.1—Troubleshooting Guide

Problem	Source	Probable Cause	Corrective Action
Low or No Indication	Mechanism	Loose links or movements	Tighten or replace
		Out of calibration	Recalibrate
		Corrosion or dirt in mechanism	Clean or replace
		Pen arm loose	Tighten
	Pen arm	Pen arm bent	Straighten or replace pen arm
High Indication	Mechanism	Loose links or movements	Tighten or replace
		Out of calibration	Recalibrate
Erratic Indication	Mounting	Excessive vibration	Secure the means of mounting
	Mechanism	Linkage dragging or dirty	Adjust or clean
		Excessive pen pressure on chart	Adjust
No Chart Rotation	Fuse	Fuse blown	Check and replace fuse
	Chart Drive	Electric drive not turned on	Turn on chart drive
		Clock motor not wound	Wind chart drive
		Defective drive	Replace drive
Wrong Chart Speed	Chart Hub Lock	Lock not latched	Latch hub lock
	Chart Drive	Wrong chart drive	Replace with proper chart drive

Table 4.2—199 DPU Troubleshooting Guide

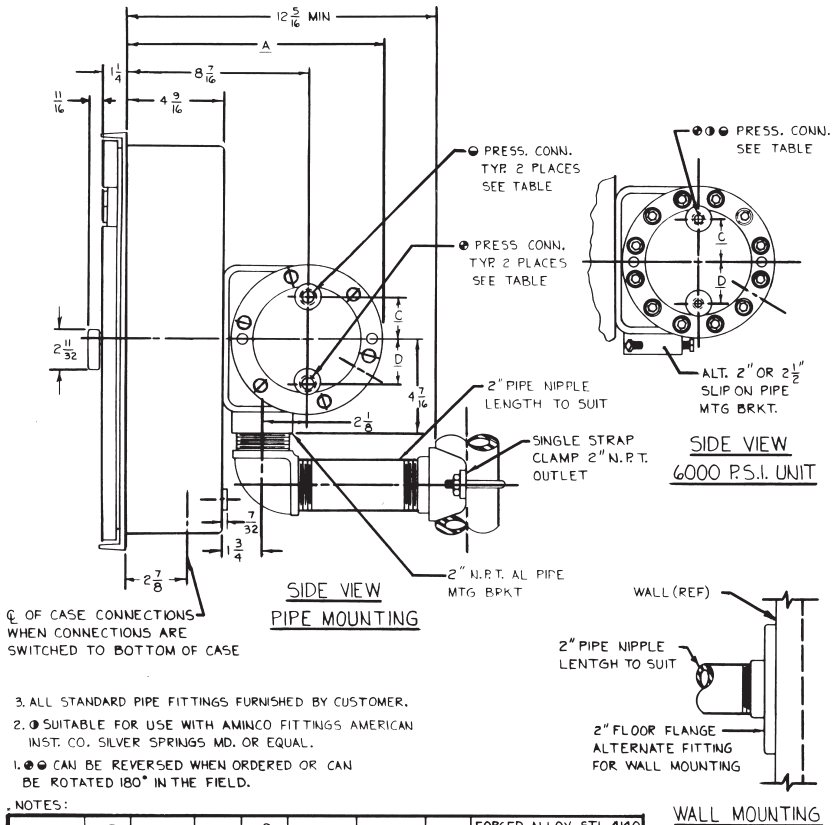
Problem	Source	Probable Cause	Corrective Action
Low or No Indication	Primary Element or DPU	Orifice installed backwards or oversized	Replace orifice
		Flow blocked upstream from run	Clean out run or open valve
		Loss of liquid in reference leg (liquid level)	Refill reference leg
		Density changes in process media or reference leg	Refill reference leg with liquid that has the same density 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 valves 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 leak
	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

Table 4.2—199 DPU Troubleshooting Guide

Problem	Source	Probable Cause	Corrective Action
Erratic Indication	Primary Element	Flow pulsating	Install dampening device upstream or 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 gasy 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 procedures)

Section 5—Installation/Dimensional Drawings

Model 202E (Part No. 9A-0202-101.3)

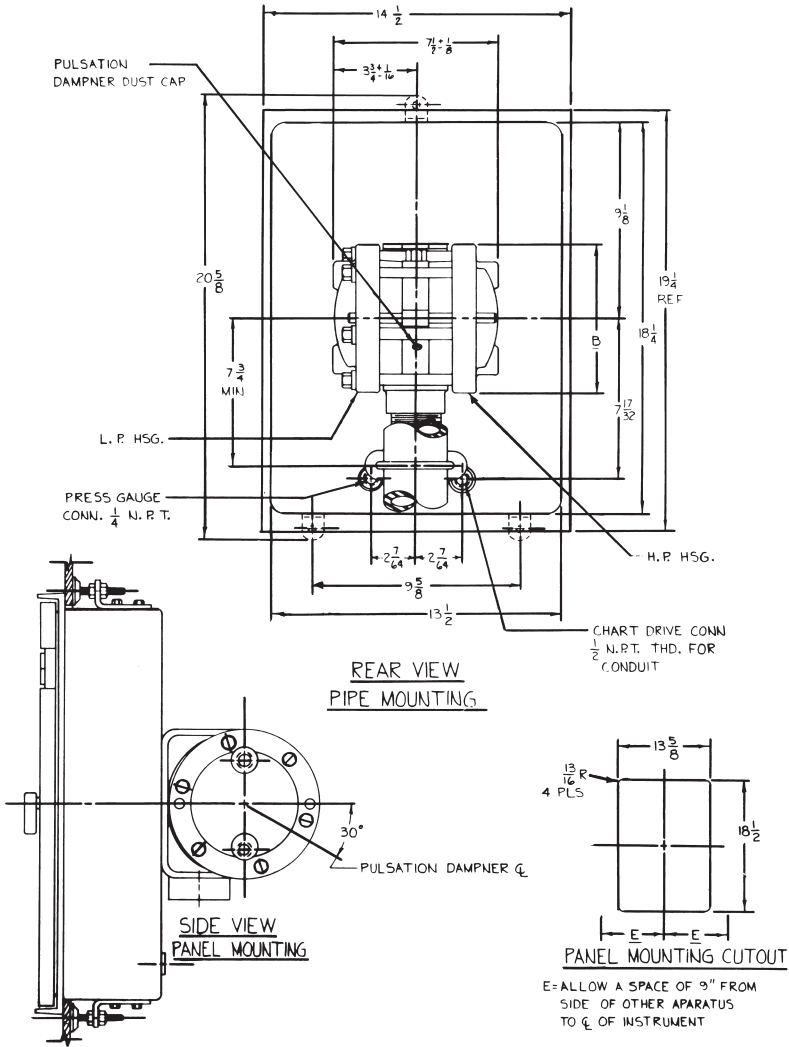


- 3. ALL STANDARD PIPE FITTINGS FURNISHED BY CUSTOMER.
- 2. 0 SUITABLE FOR USE WITH AMINCO FITTINGS AMERICAN INST. CO. SILVER SPRINGS MD. OR EQUAL.
- 1. 0 0 CAN BE REVERSED WHEN ORDERED OR CAN BE ROTATED 180° IN THE FIELD.

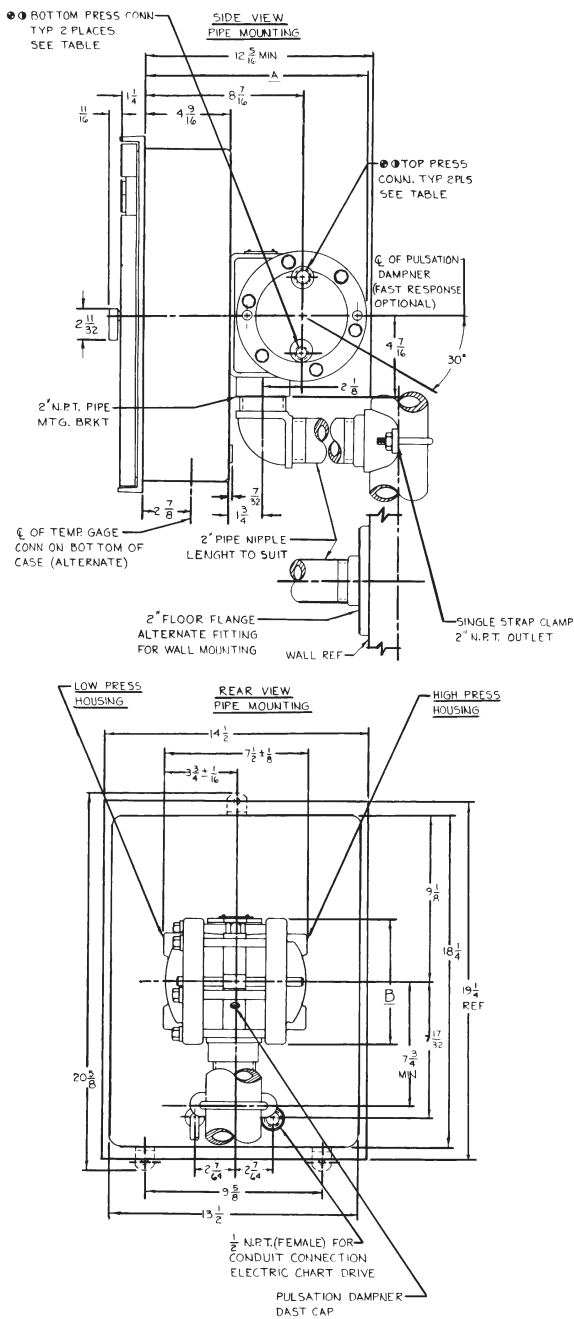
NOTES:

6000 P.S.I.	11 15/16	7 1/8 DIA	2	2 3/64	0 1/2 N.P.T.	0 1/4 N.P.T.	12	FORGED ALLOY STL 4140 FORGED STNL. STL. 329
4500 P.S.I.	11 15/16	7 1/8 DIA	2	2 3/64	0 3/16-18UNF	0 3/16-18UNF	12	FORGED ALLOY STL 4140 FORGED STNL. STL. 329
3000 P.S.I.	11 15/16	7 1/8 DIA	2	2 3/64	0 1/2 N.P.T.	0 1/4 N.P.T.	12	FORGED ALLOY STL. 4140
2500 P.S.I.	11 15/16	7 1/8 DIA	2	2 3/64	0 1/2 N.P.T.	0 1/4 N.P.T.	12	FORGED ST. STL. 316 MONEL K500
1000 P.S.I.	11 11/16	6 5/8 DIA	2	2 3/64	0 1/2 N.P.T.	0 1/4 N.P.T.	6	FORGED STL. A.I.S.I. FORGED STNL. STL 316 FORGED STL. A.I.S.I. C1018 CAST ALUMINUM 356T6
PRESSURE RATING	DIM. A	DIM. B	DIM. C	DIM. D	TOP PRESS CONNECTION	BOTTOM PRESS CONNECTION	NO. OF BOLTS	HOUSING MATERIAL

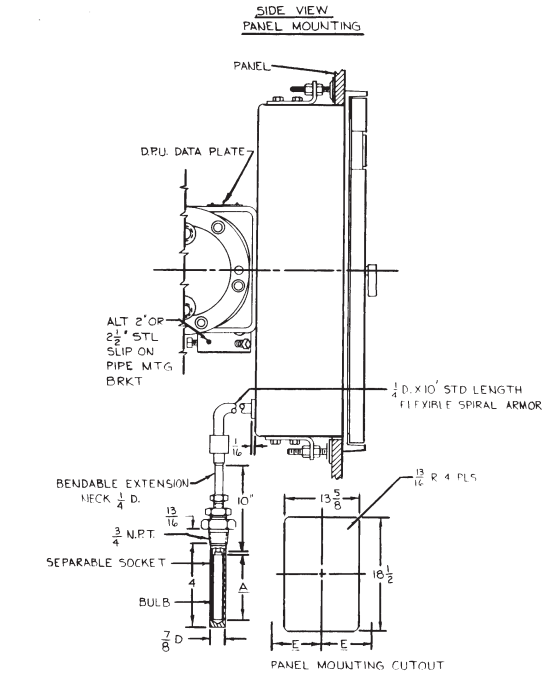
Model 202E (cont'd)



Model 202E w/Temperature Element (Part No. 9A-0202-1011.3)



Model 202E w/Temperature Element (cont'd)



0-300°F	2 1/8
0-200°F	2 1/4
0-150°F	3 3/32
0-120°F	3 1/2
0-100°F	3 5/16
RANGE	DIM. A MAX.
TEMP. ELEM. DATA	

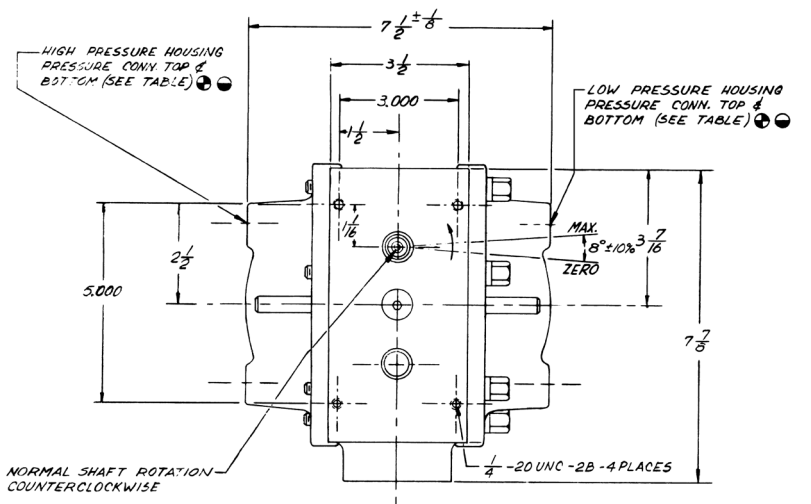
1250 PSI	1100 PSI	1000 PSI
AT 207	AT 600°F	AT 800°F
100°F		
SEPARABLE SOCKET		
PRESSURE RATING		

ALLOW A SPACE OF 9" FROM SIDE OF OTHER APPARATUS TO 1/4" OF INSTRUMENT

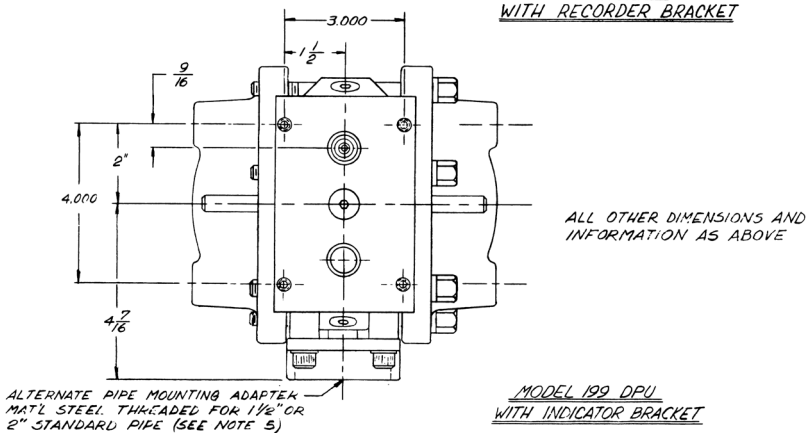
6000 P.S.I.	11 15/16	1 7/8 DIA	2	2 3/64	1/2 N.P.T.	1/2 N.P.T.	12	FORGED ALLOY STL 4142
								FORGED STL. STL 329
4500 P.S.I.	11 15/16	1 7/8 DIA	2	2 3/64	1/2 N.P.T.	1/2 N.P.T.	12	FORGED ALLOY STL 4142
								FORGED STL. STL 329
3000 P.S.I.	11 15/16	1 7/8 DIA	2	2 3/64	1/2 N.P.T.	1/2 N.P.T.	12	FORGED STL. STL 316
								MONEL K-500
2500 P.S.I.	11 15/16	1 7/8 DIA	2	2 3/64	1/2 N.P.T.	1/2 N.P.T.	6	FORGED STL. A.I.S.I. 304
								FORGED STL. STL 316
1000 P.S.I.	11 15/16	1 7/8 DIA	2	2 3/64	1/2 N.P.T.	1/2 N.P.T.	6	FORGED STL. A.I.S.I. 304
								CAST ALUMINUM 356T6
D.P.U. PRESS. RATING	DIM A	DIM B	DIM C	DIM D	TOP PRESS CONNECTION	BOTTOM PRESS CONNECTION	NO. OF PORTS	HOUSING MATERIAL

4. ALL DIMENSIONS IN INCHES.
 3. ALL STANDARD PIPE FITTINGS FURNISHED BY CUSTOMER.
 2. SUITABLE FOR USE WITH AMINCO FITTINGS (AMERICAN INST. CO. SILVER SPRING, MD.) OR EQUIV.
 1. CAN BE REVERSED WHEN ORDERED OR CAN BE ROTATED 180° IN THE FIELD.
- NOTES:

Model 199 DPU (Part No. 9A-0199.0903.3)

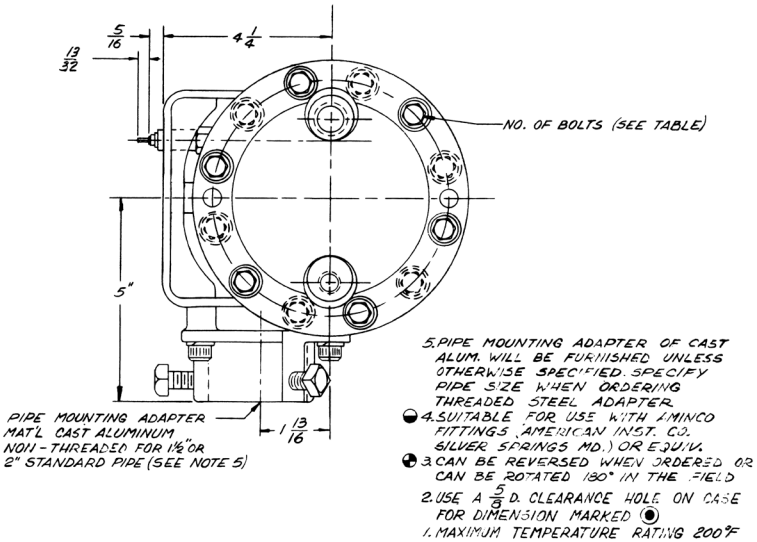
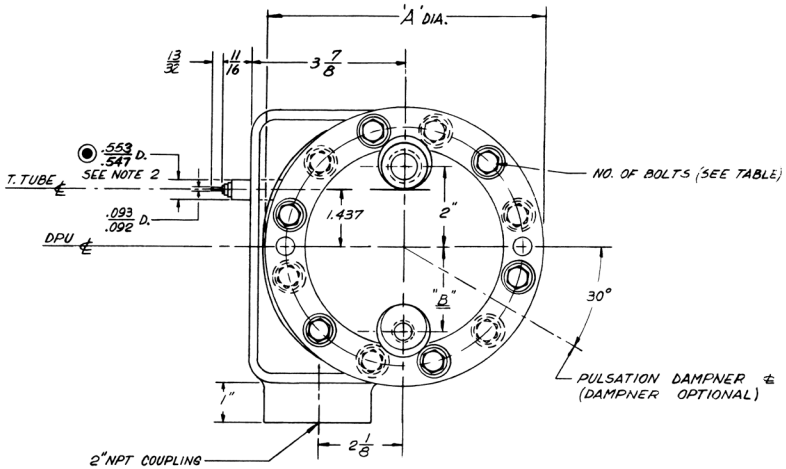


MODEL 199 DPU
WITH RECORDER BRACKET



1000 PSI	FORGED SST 316	12	6 -5/8	2 -9/64	⌀ 1/2 NPT	⌀ 1/4 NPT
	CAST ALUM 356 T6	6				
2500 PSI	FORGED ST AISI C1018	6	7 -1/8			
3000 PSI	CAST MONEL K500	12				
	FORGED SST 316					
	FORGED ST AISI C1018	8				
4500 PSI	FORGED ALLOY ST 4142	12	7 -1/8	2	⌀ 9/16-18UNF	⌀ 9/16-18UNF
6000 PSI	FORGED ALLOY ST 4142					
	FORGED SST 17-4PH					
6000 PSI	FORGED ALLOY ST 4142	12				
	FORGED SST 17-4PH					
PRESSURE RATING	HOUSING MATERIAL	NO. OF BOLTS	DIM "A"	DIM "B"	TOP	BOTTOM
					PRESSURE CONNECTION	

Model 199 DPU (cont'd)



NOTES:

Section 6—Assembly Drawings and Parts Lists

202E Recorder

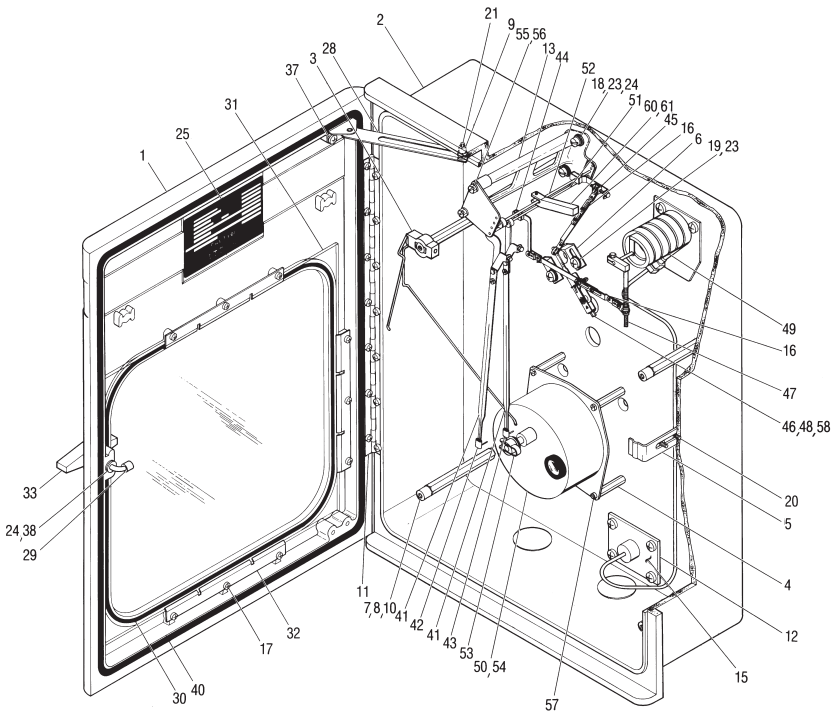


Table 6.1—202E Parts List

Item	Description	Part No.	Per Unit
1	Door Assembly, Flow Recorder	9A-0238.1023.B	1
2	Case, Flow Recorder	9A-0238.1186.C	1
3	Assembly, Pen Lifter	9A-0238.1159.B	1
4	Riser, Chart Drive	9A-0238.0007.C	3
5	Door Latch	9A-0238.0071.C	1
6	Overrange Stop	9A-0238.0082.C	2
7	Riser, Chart Plate	9A-0238.1210.C	4
8	Screw, Fil. Hd. (Chart Plate)	9A-0114.1036.J	4
9	Bushing, Door Stop	9A-0238.1018.C	1
10	Screw, Cap 1/4-20 x 5/8 (Riser)	9A-S797.0048.Z	4
11	Hinge, Door	9A-0238.1034.C	1

Table 6.1—202E Parts List

Item	Description	Part No.	Per Unit
12	Gasket, Cover Plate Connection	9A-0238.0019.C	1
13	Pen Mount Assembly, Dual	9A-0238.0014.B	1
14	Pen Mount Assembly, Single (not shown)	9A-0238.0013.B	1
15	Static Pressure Connection Assembly	9A-0238.0046.B	1
16	Link Assembly	9A-0238.0015.B	2
17	Screw, Rd. Hd., Self-Tapping 6-32 x 1/4	9A-0938.0001.J	26
18	Screw, Fil. Hd., 10-32 x 1/2	9A-0114.0031.J	2
19	Screw, Rd. Hd., 10-32 x 5/16	9A-0111.0085.J	10
20	Screw, Self-Tapping, 10-24 x 1/4	9A-0946.0002.J	10
21	Screw, 10-24 x 5/8 SST	9A-0918.1009.J	1
22	Screw, Rd. Hd., (Plug) 10-32 x 1/4 (not shown)	9A-0111.0086.J	1
23	Washer, No. 10 Flat	9A-0003.0047.K	4
24	Washer, No. 10, Shakeproof	9A-0003.0033.K	3
25	Plate, Data Flow Recorder	9A-0238.1026.G	1
26	Screw, Self-Tap, 1/4-20 (not shown) Hex Hd., C'Sunk Washer	9A-0938.0004.J	4
27	Chart Plate (not shown)	9A-0238.0903.C	1
28	Door Stop Assembly	9A-0238.1019.B	1
29	Door Latch Hook Assembly	9A-0238.0029.B	1
30	Gasket, Cover Glass	9A-0238.0015.C	A/R
31	Glass, Cover	9A-0238.0016.C	1
32	Clip, Cover Glass	9A-0238.0017.C	4
33	Assembly, Handle-Door Latch	9A-0238.1038.B	1
34	Bushing, Door Handle (not shown)	9A-0238.0094.C	1
35	Not Used	—	—
36	Not Used	—	—
37	Screw, Self-Tapping	9A-0946.0002.J	2
38	Flat Washer	9A-0003.1064.K	2
39	Pin (not shown)	9A-0003.0022.T	1
40	Gasket, Door	9A-0096.1003.T	A/R
41	Arm, Pen, Standard	9A-BDP-A-1-1	A/R
	Arm, Pen, Long Slotted	9A-BDP-A-2-1	A/R

Table 6.1—202E Parts List

Item	Description	Part No.	Per Unit
42*	Disposable Pen, 1st from Chart, 6 per pkg		A/R
	Blue, Scanner, High Temp.	9A-BDP-S-1-BL-S-6	
	Blue Scanner, Low Temp.	9A-BDP-S-1-BL-L-6	
	Black, Scanner, High Temp.	9A-BDP-S-1-BK-S-6	
	Black Scanner, Low Temp	9A-BDP-S-1-BK-L-6	
	Blue, Integrator, High Temp.	9A-BDP-I-1-BL-S-6	
	Blue Integrator, Low Temp.	9A-BDP-I-1-BL-L-6	
	Black, Integrator, High Temp.	9A-BDP-I-1-BK-S-6	
	Black Integrator, Low Temp.	9A-BDP-I-1-BK-L-6	
	Blue, Universal, High Temp. ****	9A-BDP-U-1-BL-S-6	
	Blue Universal, Low Temp. ****	9A-BDP-U-1-BL-L-6	
	Black, Universal, High Temp. ****	9A-BDP-U-1-BK-S-6	
	Black Universal, Low Temp. ****	9A-BDP-U-1-BK-L-6	
	High Temp = +20° to +120° F (-7° to 48°C); Low Temp = -40° to +90° F (-40° to 32° C)		
43*	Disposable Pen, 2nd from Chart, 6 per pkg		A/R
	Red, Scanner, High Temp.	9A-BDP-S-2-RD-S-6	
	Red Scanner, Low Temp.	9A-BDP-S-2-RD-L-6	
	Red, Integrator, High Temp.	9A-BDP-I-2-RD-S-6	
	Red Integrator, Low Temp	9A-BDP-I-2-RD-L-6	
	Red, Universal, High Temp. ***	9A-BDP-U-2-RD-S-6	
	Red Universal, Low Temp ***	9A-BDP-U-2-RD-L-6	
	High Temp = +20° to +120° F (-7° to 48°C); Low Temp = -40° to +90° F (-40° to +32°C)		
	Disposable Pen, 3rd from Chart, 6 per pkg (Not shown)		A/R
	Green, Scanner, High Temp.	9A-BDP-S-3-GN-S-6	
	Green Scanner, Low Temp.	9A-BDP-S-3-GN-L-6	
	Green, Integrator, High Temp.	9A-BDP-I-3-GN-S-6	
	Green Integrator, Low Temp.	9A-BDP-I-3-GN-L-6	
	Green, Universal, High Temp. ****	9A-BDP-U-3-GN-S-6	
	Green Universal, Low Temp ****	9A-BDP-U-3-GN-L-6	
	High Temp = +20° to +120° F (-7° to 48°C); Low Temp = -40° to +90° F (-40° to 32°C)		

Table 6.1—202E Parts List

Item	Description	Part No.	Per Unit
	Disposable Pen, 3rd from Chart, 6 per pkg (Not shown)		A/R
	Purple, Universal, High Temp. ****	9A-BDP-U-4-PL-S-6	
	Purple Universal, Low Temp. ****	9A-BDP-U-4-PL-L-6	
	High Temp = +20° to +120° F (-7° to 48°C); Low Temp = -40° to +90° F (-40° to +32°C)		
44	Static Shaft Arm Assembly	9A-0202.0034.B	1
45	Range Arm Assembly	9A-0238.0012.B	1
46	Block, Clamp	9A-0250.0003.C	1
47	Lever Arm Assembly	9A-0238.0031.B	1
48	Drive Arm Assembly	9A-0238.0004.B	1
49	Element, Static Pressure	See Table 6.2	
50	Drive Chart	See Table 6.3	
51	Shaft, Pen Arm (1st from Chart)	9A-0238.0006.B	1
52	Shaft, Pen Arm (2nd from Chart)	9A-0238.0007.B	1
53	Hub, Chart	9A-0238.0033.B	1
55	Screw, Sl. Hex Hd., 8-32 x 1/4 (Pen Mount, Top Plate)	9A-0116.0014.J	2
56	Washer, Lock #8 (Pen Mount, Top Plate)	9A-0003.0036.K	2
57	Screw, Sl. Fil. Hd., 6-40 x 1/4 (Chart Drive)	9A-0114.0017.J	3
58	Screw, Set, 2-56 x 5/32 (Drive Arm)	9A-0200.0040.C	3
59	Differential Pressure Unit (not shown)	Specify	1
60	Counterweight	9A-0238.1165.C	1
61	Screw, Counterweight Clamp	9A-0238.1201.C	1

Table 6.2—Static Pressure Elements

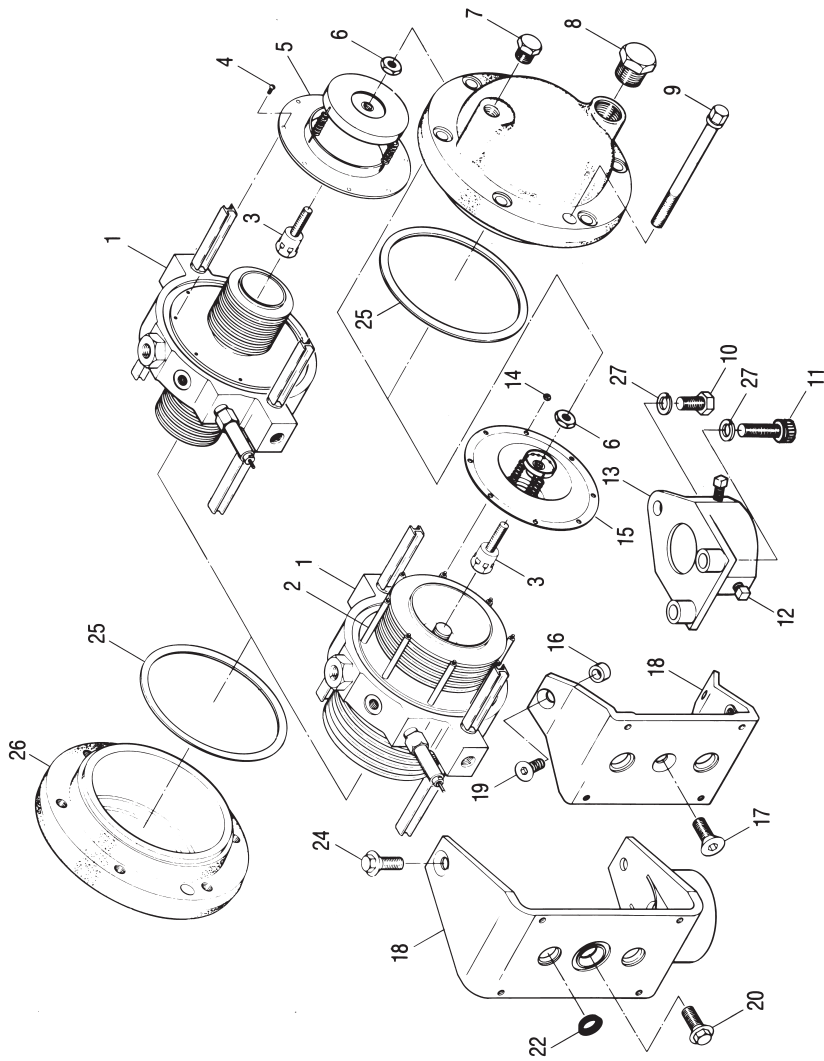
Part No.	Alt. Part No.	Standard Range (psi) ^a
Helical Elements (316 SST; 1/8" Union Connection; Ranges in PSIG)		
9A-B17SL-25		0-25
9A-B17SL-35		0-35
9A-B17SL-50	9A0044-0040T	0-50
9A-B17SL-75		0-75
9A-B17SL-100	9A-0044-0035T	0-100
9A-B17SL-150	9A-0044-0099T	0-150
9A-B17SL-200		0-200
9A-B17SL-250	9A-0044-0036T	0-250
9A-B17SL-300	9A-0044-0044T	0-300
9A-B17SL-350		0-350
9A-B17SL-400		0-400
9A-B17SL-500	9A-0044-0041T	0-500
9A-B17SL-600		0-600
9A-B17SL-750	9A-0044-0100T	0-750
9A-B17SL-1000	9A-0044-0042T	0-1000
9A-B17SL-1500	9A-0044-0046T	0-1500
9A-B17SL-2000		0-2000
9A-B17SL-2500	9A-0044-0048T	0-2500
9A-B17SL-3000		0-3000
9A-B17SL-3500	9A-0044-0050T	0-3500
9A-B17SL-4000		0-4000
9A-B17SL-5000	9A-0044-0054T	0-5000
9A-B17SL-6000		0-6000
Part No.	Standard Range (psi) ^a	
Capsular		
9A-BCR3-15SL	SST: Range (PSI): 3-15	
Monel		
9A-B17MK-XXXX "XXXX" = Range in PSIG	Available in ranges from 0-250 PSIG thru 0-6000 PSIG (W/18" Welded Connection Line) ¼" FNPT Conn.	

^a Unit can be adjusted to include vacuum measurement.

Table 6.3—Chart Drives

Part No.	Description	Model No.
Mechanical (Spring Wound)		
9A-0042-0015T	24 Hour/9 Day	725R060
9A-0042-0016T	7 Day	725R061
9A-0042-0017T	24 Hour/7 Day	725R084
9A-0042-0030	8 Day	725R067
9A-0042-0031T	24 Hour/8 Day	725R068
9A-0042-1004T	31 Day	725R070
9A-0042-1003T	2 Hour/8 Hour	725R077
9A-0042-0024T	4 Hour	725R081
9A-0042-1007T	1 Hour/15 Minute	725R086
9A-0042-0020T	96 Minute/24 Hour	725R175
9A-0042-1009T	1 Hour/3 Hour	725R138
Battery Driven (1.5 VDC - C Cell Alkaline)		
9A-0043-1002T	11 Selectable Speeds	820R001
9A-0043-1003T	11 Selectable Speeds (Foxboro)	820R007
9A-0043-1004T	11 Selectable Speeds (CSA Approved)	820R011
9A-0043-1005T	12 Selectable Speeds (Including 4 Hour)	820R029
9A-0043-2001T	Fast Slow Speeds	830R001
Chart Drive Accessories		
9A-0238-0033B	One Piece Hub	725G190
	Hub (Used w/ 625G070)	725G198
	Cap & Chain (Used w/ 725G198)	625R070
	Universal Mounting Plate	620G164
	Wind Key	725G364
	Wind Key, Long Shank	725G357
	Push/Pull Hub (Foxboro)	725R004

199 DPU Assembly





WARNING: In NACE-qualified service, use only NACE-qualified replacement parts for housings, bolts, and BUA. For NACE bolt part numbers, refer to Table 6.5. Any deviation from use of qualified NACE parts in NACE service will void the instrument/DPU NACE rating(s).

Table 6.4—199 DPU Assembly 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)	9A-0199-0019C	4
3	Rod, Spring Push	9A-0199-0049C	1
4*	Screw, Retainer, 6-32 x 5/16"	9A-0111-0049J	8
5*	Spring Assembly, Calibration Tension (for 2-1/8" Bellows)	(Specify)	1
6	Nut, Lock, Spring Adjust	9A-0199-0144C	1
7	Plug, Pipe, 1/4" NPT, Steel	9A-0199-0191C	2
8	Plug, Pipe, 1/2" NPT, Steel	9A-0199-0192C	2
9	Bolt, Housing (Standard Units):**		A/R
	Stainless Steel, 1000 PSI Units	9A-0199-1345C	
	Steel, 2500/3000/4500 PSI Units	9A-0199-0085C	
	Stud, Alloy Steel, 1/2-20 x 7 for 6000 PSI Units (Not Shown)	9A-0199-1001C	
	Bolt for 6000 PSI Units (Not Shown)	9A-0199-1346C	
10*	Screw, Pipe Mount Adapter, 3/8-16 x 3/4"	9A-0210-0012J	1
11	Screw, Sch Cap, Steel, 3/8-16 x 1-1/2" Lg.	9A-0220-1102J	2
12*	Screw, 3/8-16 x 5/8", Steel (for Item 13)	9A-0310-0013J	3
13	Adapter, Pipe Mounting	9A-0199-0988C	1
14*	Nut, Spring Retainer, Hex, 6-32, SM Pattern, SST (for 3-3/4" Bellows)	9A-0500-0028J	8
15*	Assembly, Range Spring (for 3-3/4" Bellows)	(Specify)	1
16	Spacer, Indicator Bracket	9A-0199-0006C	2
17	Screw, Indicator Bracket (Soc. Flat, 3/8-16 x 7/8", ST)	9A-0240-0003J	1
18	Bracket	(Specify)	1
19	Screw, Indicator Bracket, Hex, Washer Hd., 3/8 x 1-1/8"	9A-0002-1009T	2
20	Screw, Recorder Bracket, Hex, Washer hd., 3/8-16 x 1/2"	9A-0002-0034T	1
21*	O-Ring, 2-127, Nitrile N3**	9A-0001-1178R	1

Table 6.4—199 DPU Assembly Parts List

Item	Description	Part No.	Per Unit
22*	Gasket, Torque Tube	9A-0199-0209C	1
23	Not Used		
24	Screw, Recorder Bracket, Hex, Washer Hd., 3/8-16 x 5/8"	9A-0002-0033T	2
25*	Gasket, Pressure Housing:**		2
	1000 PSI Aluminum Units	9A-0199-0027C	
	2500/3000/4500 PSI Steel Units	9A-0199-0027C	
	1000/3000/6000 PSI SST & Monel Units	9A-0199-0184C	
26	Housing, Pressure	(Specify)	2
27	Washer, Lock, 3/8" (Used with Items 10 & 11)	9A-0275-0049C	1
29	Nut, 1/2-20, 6000/3000 PSI Monel Units (Used with Item 9)**	9A-0199-1002C	A/R
30*	Plug, Dampener Valve (Not Shown) Bd Hd., 1/4-28 x 1/4", SST	9A-0199-0036C	1
32*	Wrench, Range Spring Adjustment	9A-0199-0142C	1
33	Keys, Set of Hex (Not Shown)	9A-0016-0013T	1

* Recommended spare part.

** For NACE parts, refer to Table 6.5.

A/R - As required.

When ordering parts, specify instrument serial number.

Table 6.5—NACE Replacement Parts

Item	Description	Part No.	Per Unit
1	Bolt, Housing, Standard Units, B7M/L7M Steel, 2000 PSI, NACE	9A-0220-1075J	A/R
2	Bolt, Housing, Standard Units, B7M/L7M Steel, 3000/4500 PSI, NACE	9A-S408-0064Z	A/R
3	Nut, 1/2-20, 4140 Steel, 3000/4500 PSI, NACE	9A-S408-0021Z	A/R
4	Gasket, Housing, 2000 PSI, NACE	9A-S0001-1140R	A/R
5	Gasket, Housing, 3000/4500 PSI, NACE	9A-S528-0001Z	A/R
6	O-Ring, Housing, 2-127, Nitrile N3, NACE	9A-0001-1099R	A/R

Instrument Specifications

Case Die-cast aluminum, black epoxy resin paint, water-proof and weather resistant; hinged door; neoprene gasket seal

DP Accuracy:

0-20" w.c. to 0-349" w.c. ±0.5% of full scale

0-350" w.c. to 0-75 psi ±0.75% of full scale

SP Accuracy ±1.0% of full scale

Table 6.6—199 DPU Specifications

SWP - psi (bar)	Housing Material	Available Differential Pressure Ranges		
		Stainless Steel Bellows	Inconel Bellows	
1,000 (69)	Cast Aluminum 356T6 Forged Stainless Steel 316	2 1/8" (55 mm) OD	3 3/4" (95 mm) OD	3 3/4" (95 mm) OD
2,500 (172)	Forged Steel A.I.S.I. C1018	0-15 psi (0-1 bar) to 0-100 psi (0-6.9 bar)	0-10" wc (0-25 mbar) to 0-400" wc (0-993 mbar)	0-20" wc (0-50 mbar) to 0-400" wc (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 Volume (cu. in.)	L.P. Head	35" (575 cc)	30" (490 cc)	30" (490 cc)
Displacement (cu. in.) for Full-Scale Travel	H.P. Head	31" (510 cc)	26" (425 cc)	26" (425 cc)
		0.5" (8.2 cc)	1.5" (25 cc)	1.5" (25 cc)
Performance 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)		
0-20" to 0-4000" wc (0-50 mbar to 0-993 mbar)		±0.5% of full scale with appropriate linkage		
0-15 to 0-100 psi (0-1 bar to 0-6.9 bar)		±0.75% of full scale with appropriate linkage		
Sensitivity		0.05% of full scale DP		
Repeatability		0.10% of full scale DP		

NOTES: Zero center or split ranges available on special order [e.g., a 0-50" wc (0-124 mbar) range may be ordered 25-0-25" wc (62-0-62 mbar) or 10-0-40" wc (25-0-99 mbar)]. Intermediate differential pressure ranges available from 0-20" wc 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" 10" wc (25 mbar) range. Can be specified to meet NACE MR-01-75 (Revised '80). Metric conversions are approximate. Outline dimension drawings available upon request.

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.

Product Brand

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