

KING-GAGE®

D/P LiquiSeal Purge Control and D/P Purge Control

Calibration Instruction Manual

for models

**738 D/P LiquiSeal Purge Control and
788 D/P Purge Control**



D/P LiquiSeal Purge Control Model Number Designation

738-1918-108

Fittings

1 = None
3 = Polyflo; (1) 3/8" tube, (1) 1/4" tube
4 = Swagelok; (1) 3/8" tube, (1) 1/4" tube

Range (Nominal)

0 = 0–5 psid
1 = 0–10 psid
2 = 0–15 psid
3 = 0–30 psid
4 = 0–50 psid

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The information contained in this manual was accurate at the time of release. Specifications are subject to change without notice.

Warranty—All King Engineering products are guaranteed to be free from defects in material and workmanship for one year from the date of purchase. Any product or part found to be defective under normal use within one year of purchase will be repaired or replaced at no charge if returned to the company at Ann Arbor, Michigan within ten days of discovery of the defect. No other warranties, whether expressed, implied, or statutory, including the warranties of fitness for a particular purpose or merchantability, are given by this agreement.

The exclusive remedy for nonconformity of these goods shall be repair and/or replacement of the nonconforming goods or parts.

Seller will not be liable for consequential damages resulting from breach of this agreement. The term "consequential damages" shall include but shall not be limited to damage to all machines, equipment and goods other than the goods sold hereby, interruption of production, loss of profits, delays of any kind, administrative expense, and overhead.

D/P Purge Control Model Number Designation

788-198-158

Fittings

1 = None
3 = Polyflo; (1) 3/8" tube, (1) 1/4" tube
4 = Swagelok; (1) 3/8" tube, (1) 1/4" tube

Range (Nominal)

5 = 0–5 psid
6 = 0–10 psid
7 = 0–15 psid
8 = 0–30 psid
9 = 0–50 psid

Revisions:

- (A) June, 2008 – Original release (TL-190 Calibration Kit)
- (B) June, 2010 – Revised, expanded calibration procedures

Specifications

Pressure Range

Transmitter adjustment turndown is 3:1 for the 0–15, 0–30, 0–50 psid nominal ranges.

Nominal Minimum Range of Adjustment

0–5 psid	0–3 psid	0–83 in. thru 0–138 in. water/ 0–2.1 m thru 0–3.5 m water
0–10 psid	0–3 psid	0–83 in. thru 0–277 in. water/ 0–2.1 m thru 0–7.0 m water
0–15 psid	0–3 psid	0–83 in. thru 0–415 in. water/ 0–2.1 m thru 0–10.5 m water
0–30 psid	0–10 psid	0–277 in. thru 0–830 in. water/ 0–7.0 m thru 0–21.0 m water
0–50 psid	0–15 psid	0–415 in. thru 0–1384 in. water/ 0–10.5 m thru 0–35.1 m water

Output

4–20 milliamperes (mA_{dc})

Accuracy

± 0.15% FS (± 0.10% FS, typical)
includes non-linearity, hysteresis, non-repeatability

Repeatability

± 0.10% of calibrated span (± 0.03%, typical)

Compensated Temperature Range

32°F to 120°F/0°C to 54°C

Thermal Effects

(Over Compensated Temp. Range)
less than .007%/°F (.011%/°C) span shift—sensitivity
less than .007%/°F (.011%/°C) span shift—zero

Environmental Limits

-40°F to 180°F/-40°C to 82°C operating
(-60°F to 185°F/-51°C to 85°C storage)

Voltage Supply Requirements

14–40 Vdc (unregulated) to power signal loop

Power Supply Stability

(Effect on FSO) less than 0.005% of span change in output per volt change at input terminals

Operating Limit (Maximum Pressure)

Pressure above 300% nominal range (overrange) will result in damage to the transmitter (200% may cause a shift in calibration). Burst pressure is 200 psi and will cause catastrophic and physical failure of the pressure element.

Signal Loop and Pressure Input Connections

Pressure (Pneumatic) Input

The D/P transmitter is designed to generate a 4–20 milliamp electrical signal in direct proportion to backpressure created within a downpipe inserted into the tank and purged with compressed air. This forms the high pressure input of the D/P (differential pressure) sensing element.

E – Low Pressure Input generally vents to atmosphere (using supplied vent plug) if no external connection is required. When used on a sealed vessel (especially when pressure or vacuum is internally applied), this connection is used for the low pressure input to the transmitter.



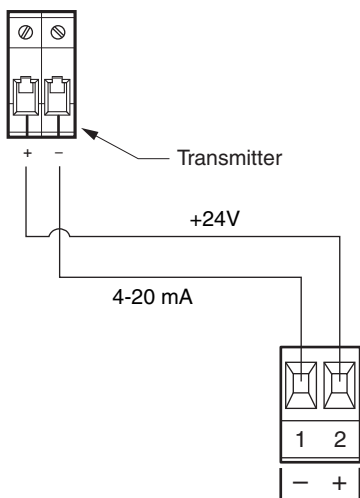
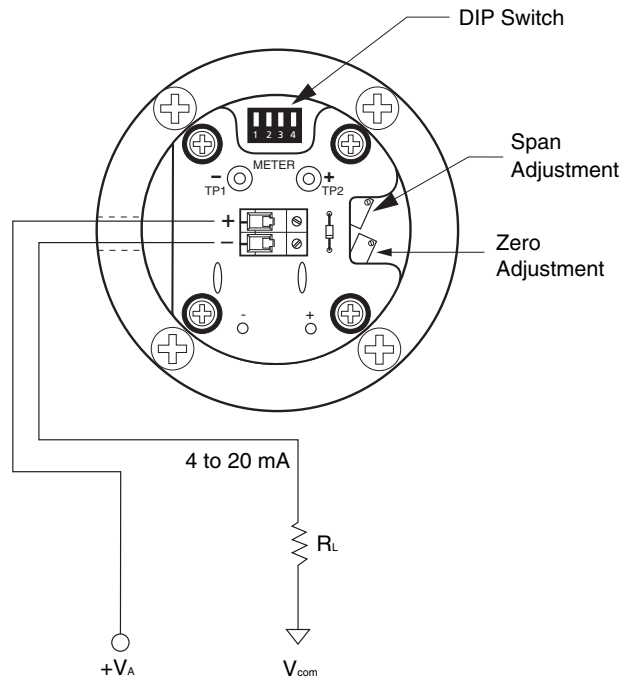
Model 738 D/P LiquiSeal Control



Model 788 D/P Purge Control

Signal Connections (4–20 mA Current Loop)

Screw clamp terminals are provided for positive (+) and negative or common (-) sides of the signal loop. As is typical of two-wire transmitters, all electrical power is supplied through the signal loop wiring. Refer to the following diagram for proper wiring of the 4–20 mA loop circuit:



**2-Terminal Input Connection
KING-GAGE LP2 multiple
tank indicators**

Power Requirement

The D/P transmitter requires a source of DC power for operation. Minimum excitation voltage must be no less than 14 VDC. Any receiver installed on the signal loop (meters, data loggers, controllers, etc.) must be taken into account when determining the required power supply voltage to be used. The internal resistance of each device added together represents the total “load” residing on the signal loop circuit.

$$\frac{\text{Load Capacity}}{\text{(ohms)}} = \frac{\text{(Supply Voltage - 14 Volts)}}{.02}$$

Load Capacity at Supplied Voltage

20 Vdc	24 Vdc	28 Vdc	32 Vdc	36 Vdc	40 Vdc
300 ohms	500 ohms	700 ohms	900 ohms	1100 ohms	1300 ohms

KING-GAGE® tank processors and LevelBAR provide 24 Vdc excitation to power the signal loop circuit. (If the application requirement exceeds 500 ohms, an external power supply of appropriate voltage will be required.)

Signal Cabling

The 4–20 mA signal loop needs to be run using twisted pair (two conductor) cable. “Noise” or EMI (electromagnetic interference) does not generally create a problem since it is common to both wires in the pair and essentially cancels itself out. In most applications, non-shielded twisted pair instrumentation cable (20–22 AWG) will be suitable for the signal loop between the LP2 and sensor/transmitter.

Internal Signal Connections

Screw clamp terminals are provided for positive (+ Signal) and negative (- Signal) or common sides of the signal loop circuit. As is typical of two-wire transmitters, all electrical power is supplied through the signal loop wiring. Refer to the Current Loop diagram for proper wiring of the circuit with polarity to the external power (V) source.

Test Point Terminals (TP1, TP2)—Test meter terminals are provided within the transmitter housing (see diagram) for measuring the output signal without disturbing the signal loop. Do not connect any device or meter whose internal resistance exceeds 20 ohms across these test points. Also refer to **Using Multimeter** in the following section.

D/P Calibration Procedures

Principle of Operation: Understanding the basic operation of the downpipe purge transmitter will aid in the understanding of the procedure used for calibration. The transmitter models referenced in this manual combine two separate functions—constant air flow regulation for purging a downpipe in the tank and a differential pressure transmitter that measures the resulting backpressure due to liquid depth. The constant air flow regulator supplies compressed air at a nominal rate of 1 cfh (cubic foot per hour) through the purge (P) port. Back pressure at this port is also internally directed into the differential pressure transmitter portion of the unit. The calibration procedure uses the constant air flow to create the pressure for which the transmitter is adjusted (either to adjust the “zero” or span full scale output).

NOTE: Due to the internal porting arrangement of the purge transmitter, you cannot simply apply an external pressure to the purge (P) port to check calibration of the unit.

Zero/Span Adjustment

This procedure is intended to recalibrate the existing zero and span output settings. It is generally recommended that the zero output be checked at least every 12 months. Generally speaking, slight adjustment of the zero potentiometer is all that is needed to maintain transmitter accuracy. However, since zero is an offset adjustment, shifting this setting upward or downward will have some corresponding effect on span.

Adjusting Zero Setting

Check zero by measuring the output using the meter terminal posts (TP1 & TP2) on the transmitter board.

- Adjust zero potentiometer as necessary to increase output (clockwise) or decrease output (counterclockwise) until the signal displays as 4.00 or 4.01 mA on the test meter.

Adjusting Span Setting

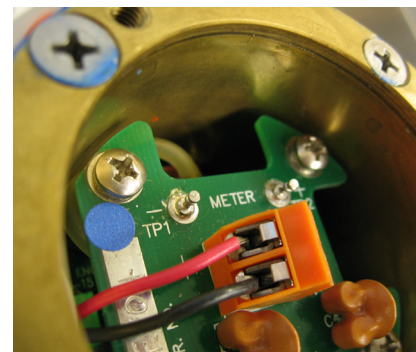
King Engineering offers the TL-190 D/P Calibration Kit which is the recommended method to recalibrate these downpipe purge transmitters. This instruction manual also covers an alternative method when this kit is not employed.

Equipment required for calibration procedure:

- Digital milliamp meter (minimum resolution ± 0.01 mA)
- Digital pressure gauge/manometer (minimum accuracy $\pm 0.5\%$ FS)
- 24 Vdc power supply
- Two (2) pressure regulators with fine adjustment

Preliminary

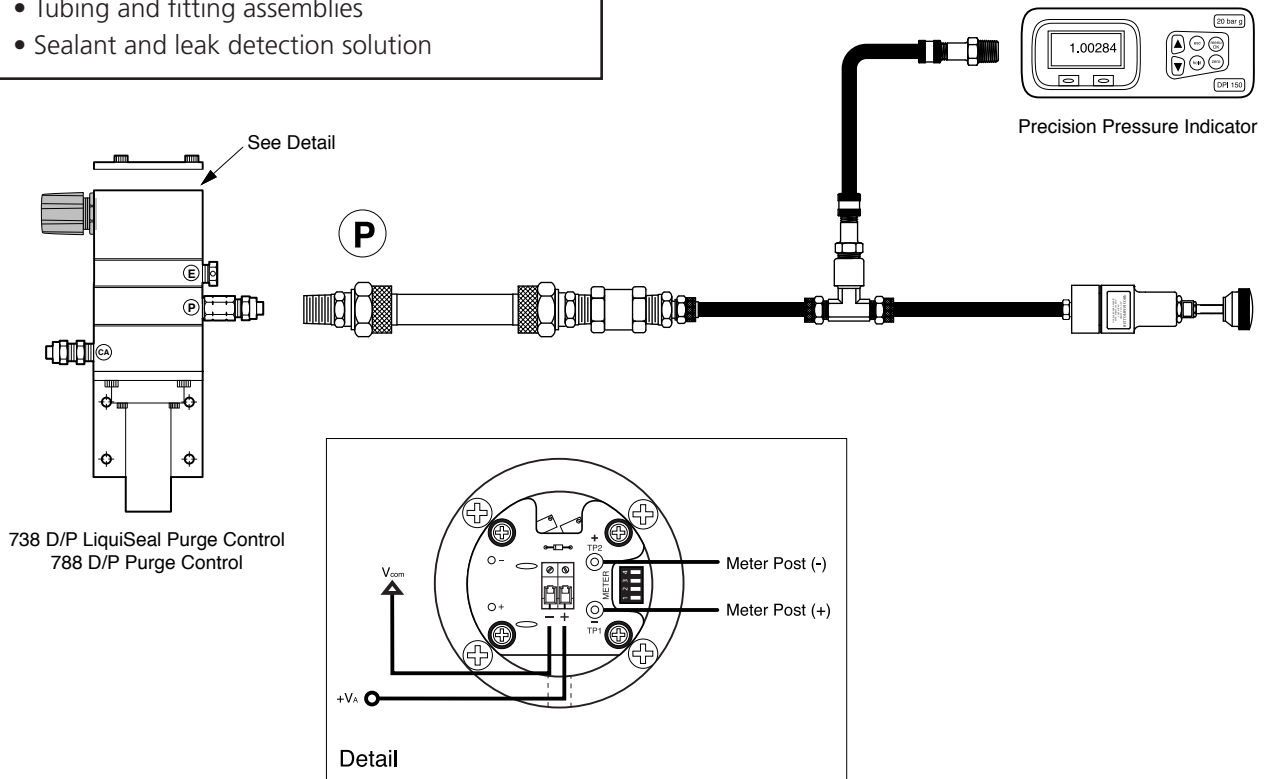
Remove cover plate from top of D/P Purge Control by unthreading three (3) screws. Do not place the milliamp meter in series into the 4–20 mA signal loop but rather use the test meter posts provided inside of the D/P Purge Control housing.



Calibration Zero Check: Disconnect the tubing/piping routing to the downpipe (or stand pipe) in the tank at the “P” port. Check the zero output as measured at the test meter terminals inside of the transmitter housing. If there is no current measured, check continuity of the signal cabling and/or determine that Vdc power is present on the loop wiring.

TL-190 Kit Contents:

- Precision low flow pressure regulator
- Tubing and fitting assemblies
- Sealant and leak detection solution

**Calibration/Sensor Function (under pressure)**

Compressed air must be supplied to the transmitter supply inlet port (CA) during this procedure.

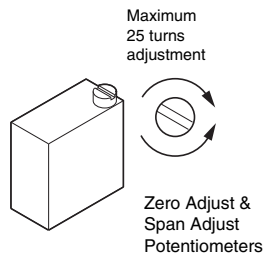
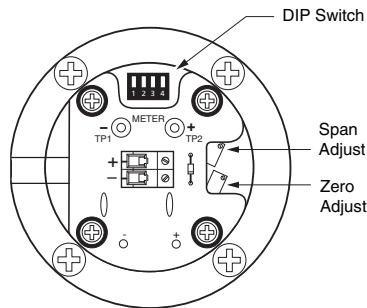
1. Connect the purge side of the TL-190 assembly to port "P". Pressure gauge is to be connected at the gauge side of the assembly. To avoid applying excess pressure to the purge port, ensure that the regulator is set to its minimum pressure (by turning the knob fully counter-clockwise).
2. Confirm the nominal or calibrated range of the D/P Purge Control prior to beginning the purge pressure testing using the TL-190 regulator. (Calibrated range other than nominal will be identified on the transmitter label and may also be confirmed by the serial number—use the calibrated pressure indicated for the purge pressure test.)

3. Connect the inputs of the milliamp meter to the test terminal posts within the transmitter housing.

Using Multimeter: Set multimeter for DC current, using mA or .001 amp scale. The internal resistance of the meter must be 20 ohms or less since higher resistance values will create incorrect readings. Connect the meter leads to the TP1 and TP2 posts on the internal circuit board.

4. Turn on the compressed air supply. Very slowly adjust the TL-190 regulator while watching the pressure reading on the pressure gauge.
5. Slowly set the pressure to match the D/P Purge Control full scale pressure rating. (Use the calibrated range noted for units so indicated.) Allow adequate time for pressure to equalize—pressure reading must remain stable for 20–30 seconds.

6. In the event that you cannot set the pressure high enough, check for leaks. The purge control produces 1 SCFH (standard cu.ft./hr). At this extremely low flow rate even small leaks will not allow the pressure to build up within the TL-190 assembly.
7. If necessary, adjust the span potentiometer until the loop current is 20.00 mA.



8. For any transmitter that requires adjustment in Step 7, repeat the Calibration Zero Check procedure.

Acceptance Tolerance

COMPRESSED AIR

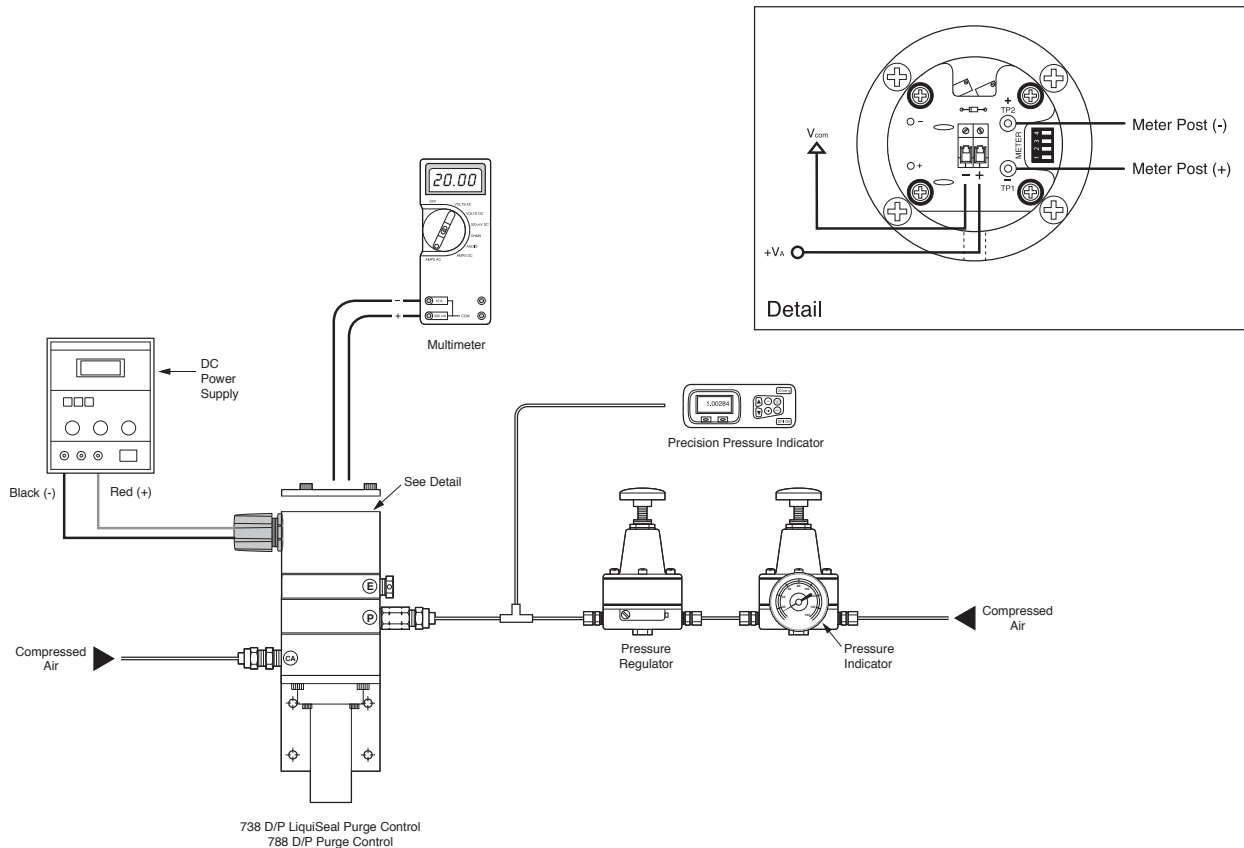
DISCONNECTED Check Zero Output **3.98~4.01 mA**

COMPRESSED AIR

CONNECTED Check Zero Output **4.00~4.02 mA**

COMPRESSED AIR

CONNECTED Check FS Output **19.98~20.01 mA**



Calibration—Alternative Method

This is the recommended alternative procedure and setup for checking calibration of the downpipe purge transmitter. Compressed air must be simultaneously supplied to the transmitter supply inlet port (CA) and the pressure regulator(s) during this procedure.

Equipment required for calibration procedure:

- Digital milliamp meter (minimum resolution ± 0.01 mA)
 - Digital pressure gauge/manometer (minimum accuracy $\pm 0.5\%$ FS)
 - 24 Vdc power supply
 - Two (2) pressure regulators with fine adjustment*
1. Connect the test equipment as shown in the figure. All fittings and joints must be leak-tight to ensure good results. It is also recommended to check all the joints by pouring leak detection fluid (such as Swagelok Snoop® or similar) on the fittings.

* We recommend that two regulators be used since this will permit much finer pressure adjustment (this is because the first regulator minimizes the pressure differential across the second regulator). You may choose to use one regulator but will notice stability is difficult to hit precise pressure settings.

2. With the regulators in the fully open position turn on the compressed air supply. Set the first regulator to a few psi above the D/P transmitter range. Very slowly adjust the second regulator while watching the pressure reading on the gauge.
3. Slowly set the pressure to match the purge transmitter full scale pressure rating. (Use the calibrated range noted for units so indicated.) Allow adequate time for pressure to equalize—pressure reading must remain stable for 20–30 seconds.
4. In the event that you can not set the pressure high enough, check for leaks. The purge transmitter produces 1 SCFH (standard cu.ft./hr). At this extremely low flow rate even small leaks will not allow the pressure to adequately build up within the transmitter.
5. If necessary, adjust the span potentiometer until the loop current is 20.00 mA.
6. For any transmitter that requires adjustment to the span setting, repeat the calibration zero check procedure noted under the **Preliminary** section at the beginning of the manual.

D/P Range Adjustment DIP Switch Settings

Nominal range is the factory default span setting of the D/P transmitter based on its model designation. Each model can have the span turned down over a lower pressure range. This is how the transmitter’s pressure range can be changed for a specific application. When the D/P transmitter is used with a KING-GAGE® digital tank level indicator, the “Application Datapack” (SRAM or iButton memory module) is generally programmed with the nominal range setting. The indicator programming will correlate the output signal to tank capacity regardless of whether the maximum tank level generates less than 20.00 mA output from the transmitter.

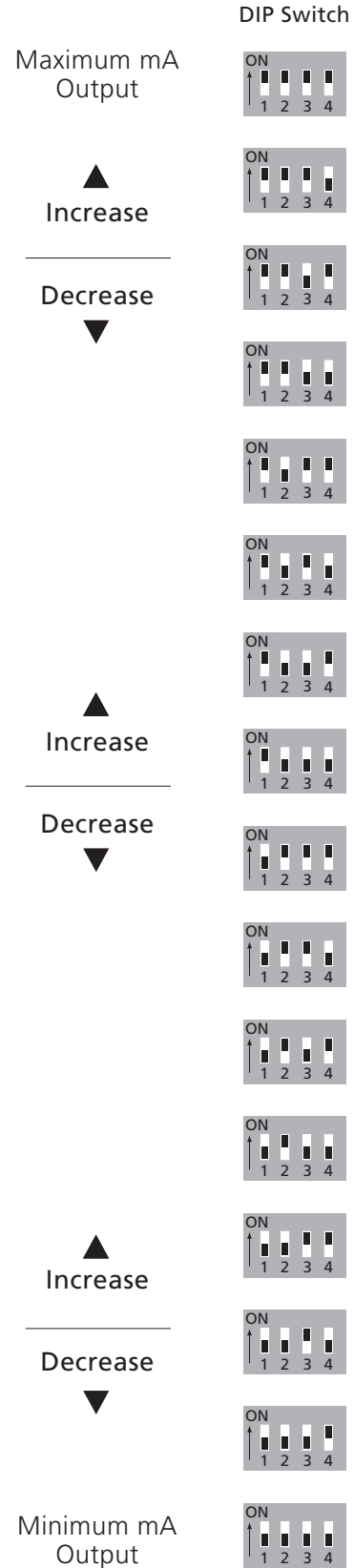
WHEN NOT TO CHANGE SPAN—If a KING-GAGE indicator is part of the system, you should not have to change the range (span) of the transmitter.

Coarse Range Setting

The DIP switches on the transmitter circuit board affect the span (range) of the transmitter. These provide coarse adjustment in addition to the fine span adjustment of the potentiometer. Please refer to the individual DIP switch positions listed for adjusting the existing setting of the transmitter.

The four (4) switches provide 16 increments of coarse adjustment. Prior to changing any switch setting, check the current output of the transmitter at the desired upper pressure value. Also note the existing switch setting.

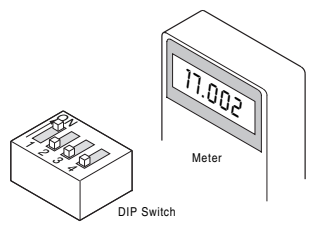
1. Apply the desired maximum pressure to the D/P transmitter (following the procedure using the TL-190 or the alternate method).
2. Record the existing setting positions of the DIP switches.
3. Adjust the potentiometer to maximum output by turning clockwise until it “clicks”.
4. To increase the milliamp output, use a higher switch setting arrangement; to reduce the milliamp output, use a lower switch setting arrangement. (The goal is to achieve a output signal value just slightly above 20 milliamps and then use the potentiometer to trim the setting.)
5. Follow the Zero/Span Calibration procedure to check both the zero and span output.



Coarse Range Setting—Alternate Version

Previous versions of the D/P transmitter employ similar DIP switches, but only offer 5 increments of coarse adjustment. With these versions, the span potentiometer offers greater range of adjustment.

Coarse Setting Procedure: The number of switches in the ON position will increase the milliamp value as each switch controls an identical fixed resistor. To increase milliamp output, place additional switches into the ON position. To decrease milliamp output, move switches to the off position.



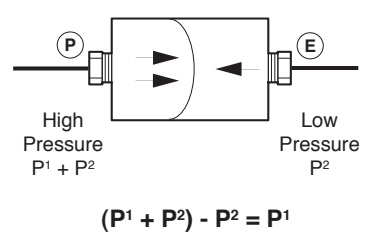
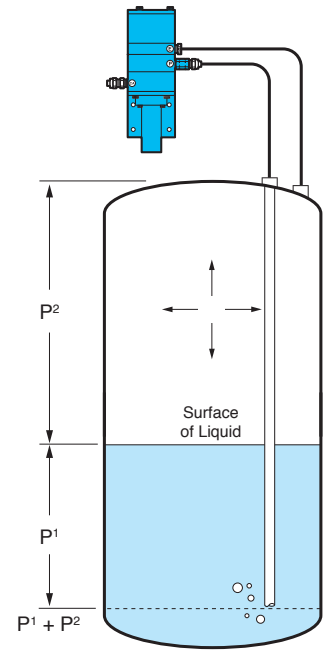
DIP Switch -Coarse Adjustment

Low Pressure Input

Compensating for Void Pressure/Vacuum in Closed Vessels

In a closed tank (including those without an adequate breather vent), or a tank that is pressurized, it is necessary to measure differential pressure. This is achieved by subtracting the internal pressure condition of the tank above the surface of the liquid (void pressure) from the total pressure sensed at the bottom of the tank. When the low pressure (void pressure) is applied to one side of the transmitter sensing element and the high pressure (due to liquid depth) to the other side, the internal tank pressure above the liquid is equalized across the sensing element. This equalization is why we designate the low pressure connection as “E”.

Example: In the illustration below, the low pressure (void pressure) is designated P^2 and is measured above the surface of the liquid. The high pressure (created by liquid depth) is designated P^1 . The D/P Purge Control will feel the total pressure at the bottom of the downpipe of both $P^1 + P^2$. A connection at the top of the tank allows the low pressure (P^2) to be separately introduced via the E port at the transmitter.



Calculating the Transmitter Span Requirement

Nominal range is the factory default span setting of the D/P transmitter based on its model designation. Each model can have the span turned down over a lower pressure range. There are two simple equations that can be used to determine the actual range (span) required for the transmitter. One of these gives the range in PSID and the other in INCHES OF WATER.

$$\frac{(B - A) \times C}{27.6807} = \text{Range (psid)}$$

Where ...

- A = Reserve (inches of depth from low point of tank to sensor)
- B = Full Tank (inches of depth from low point of tank to full)
- C = Specific Gravity of Tank Contents

Converting LBS/GAL to Specific Gravity

If the density of the liquid is expressed as pounds per gallon (e.g., 7.1 lbs/gal), the specific gravity can be determined by dividing the value by 8.33 (weight of water per gallon).

Pressure Range Calculation—Example 1

A typical tank gauging application is illustrated in Figure 1. The “reserve” represents the distance from the lowest point on the bottom of the tank to the installed sensor. “Full” is the level of contents at which the tank is filled to capacity (or may be some point below the tank top, as desired). The liquid contents in the tank is water @ 1.00 specific gravity.

- C = 1.00 (Specific Gravity)
- B = 382" (Full Tank)
- A = 30" (Reserve)

$$\frac{(382 - 30) \times 1.00}{27.6807} = 12.72 \text{ psid}$$

$$(382 - 30) \times 1.00 = 352" \text{ water}$$

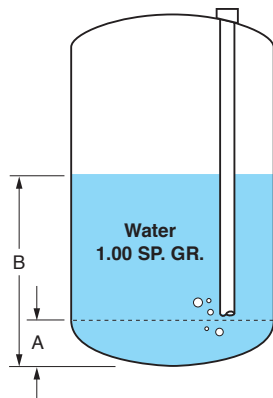


Figure 1

Pressure Range Calculation—Example 2

Figure 2 illustrates another tank gauging application where the “reserve” again represents the distance from the lowest point on the bottom of the tank to the installed sensor. “Full” is the level of contents at which the tank is filled to desired level (which is less than the actual full capacity of the tank). The tank contains B20 Biodiesel with a specific gravity of 0.852.

- C = 0.852 (Specific Gravity)
- B = 300" (Upper Level)
- A = 28" (Reserve)

$$\frac{(300 - 28) \times 0.852}{27.6807} = 8.37 \text{ psid}$$

$$(300 - 28) \times 0.852 = 232" \text{ water}$$

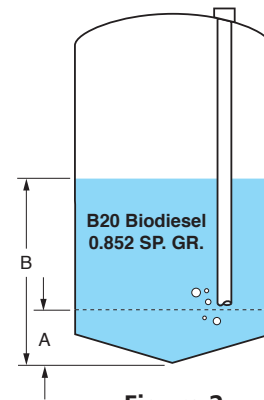


Figure 2

NOTE: Should the calculated range exceed the upper span limits of the transmitter, the next higher range is required. If the calculated range falls below the lower span limits, a lower range transmitter is required (to obtain 20 mA dc).

When Output will be Less Than 20 mA ...

Maximum Pressure Below 3.00 PSID

When the nominal 5 PSID transmitter is used on an application whose maximum pressure is less than 3.00 PSID, the full calculated range output will be less than 20 mA. To determine the actual milliamp output of the transmitter when the maximum applied pressure is below the lower span limit, use the following formula:

$$\frac{(16 \times \text{Calculated PSID})}{3.0} + 4 = \text{mA Output}$$

Other Ranges

The above formula may also be used for other nominal range transmitters if maximum applied pressure will be less than the adjustment range allows. Merely divide by the lower span limit PSID value (see page 3) in place of the “3.0” shown in the formula.

Troubleshooting

No signal

- Check that Vdc power is connected to the signal loop circuit (V+ at transmitter + signal terminal).
- Polarity reversed—check by reversing the + and - leads at the input terminals.

Output greater than 20.0 mA

- Check zero output of transmitter—adjust zero to 4.00 mA if necessary.
- Check span setting—adjust to 20.00 mA at nominal range or calculated full pressure.

Maximum output less than 20.00 mA

- Check that applied pressure is within span limits for transmitter range. (Refer to Specifications for span adjustment range based on nominal range.)
- Check span setting—adjust to 20.00 mA at nominal range or calculated full pressure.
- Higher resistive load on signal loop may exceed voltage/load capacity (see page 4).



D/P Housing and Housing Cover

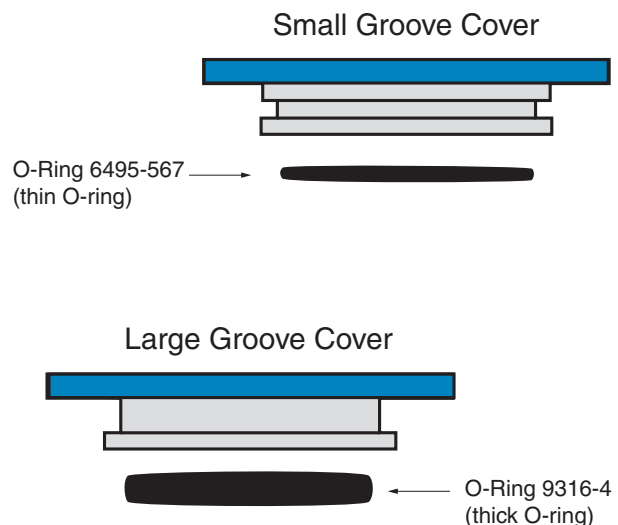
Housing Cover (O-Ring Replacement)

An O-ring seal is provided for the cover (top plate) of the D/P housing to ensure no penetration of moisture or other contaminant to the electronics inside. If the O-ring is cut or becomes brittle, it should be replaced. There are two variations on the O-ring supplied with KING-GAGE D/P Transmitters—they are not interchangeable.

The O-ring application is based on the size of the machined groove on the underside of the cover (top plate). These can be identified by the number of “steps” seen on the top plate. Refer to the illustrations for details.

SMALL GROOVE (Multiple Step Profile)—uses O-ring Part No. 6495-567

LARGE GROOVE (Single Step Profile)—uses O-ring Part No. 9316-4





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8019 Ohio River Blvd. Newell, WV 26050 U.S.A.

Phone: 304-387-1200 ■ Fax: 304-387-4417

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