Effective: June, 2002 (October, 1998) **EX-1673-2**

KING-GAGE®

4-20 mA Pressure Transmitter

D/P Transmitter

4-20 mA Pressure Transmitter

Operation/Calibration Manual

User Guide to Range Calculation, Calibration Procedures, Zero/Span Adjustments for Differential Pressure Transmitters

KING ENGINEERING CORPORATION
Since 1937

Box 1228, Ann Arbor, Michigan 48106-1228 U.S.A.
3201 South State Street, Ann Arbor, Michigan 48108-1625 U.S.A.
Phone: (734) 662-5691 ▪ FAX: (734) 662-6652 ▪ www.king-gage.com

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

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Revisions

- Original Release - April, 1987
- Revised Test Equip. Spec. - December, 1987
- Revised Zero/Span Adjust - August, 1990
- Corrected Zero/Span positions (p. 11) - August, 1991
- Revised text (update model numbers) - September, 1994
- 3-terminal signal connector (pg15) - February,1998
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SPECIFICATIONS

■ **Ranges (Nominal)**
0- 5 psid/ 0-138 in. water
0-10 psid/ 0-275 in. water
0-15 psid/ 0-415 in. water
0-30 psid/ 0-830 in. water
0-50 psid/ 0-1384 in. water

■ **Output**
4-20 milliamperes (mAdc)

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

■ **Repeatability**
± 0.10% of calibrated span (± 0.03%, typical)

■ **Operating Limit (Maximum Pressure)**
300% nominal pressure overrange

■ **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**
10-42 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

■ **Span Adjustment Range**
Approximately ± 40% of nominal ranges as indicated:

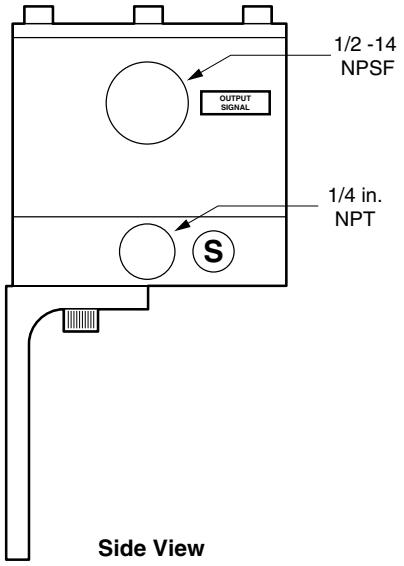
5 psid 0-3.00~6.50 psid (0-83 thru 180 in. water)
10 psid 0-6.50~12.00 psid (0-180 thru 332 in. water)
15 psid 0-12.00~19.50 psid (0-332 thru 581 in. water)
30 psid 0-19.5~36.00 psid (0-581 thru 997 in. water)
50 psid 0-36.00~70.00 psid (0-997 thru 1937 in. water)

Signal Loop and Pressure Input Connections

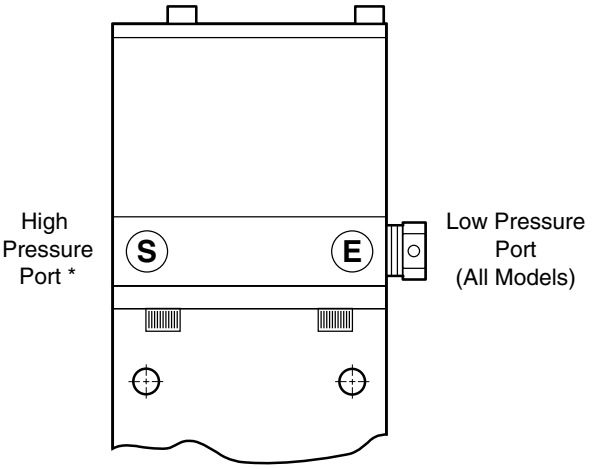
■ **Pressure (Pneumatic) Input**
The D/P Transmitter is designed to generate a 4-20 milliamp electrical signal in direct proportion to pressure inputs. It is intended for clean, dry air or gas pressure media. Tube fittings, if supplied, are for 1/4 inch (O.D.) tubing.

"S" - <u>High pressure input</u>
(738 D/P LiquiSeal and 788 D/P Purge Control are internally ported and do not have this external connection.)

"E" - <u>Low pressure input</u>
(Vents to atmosphere if no external connection is required - use supplied vent plug.)



Side View

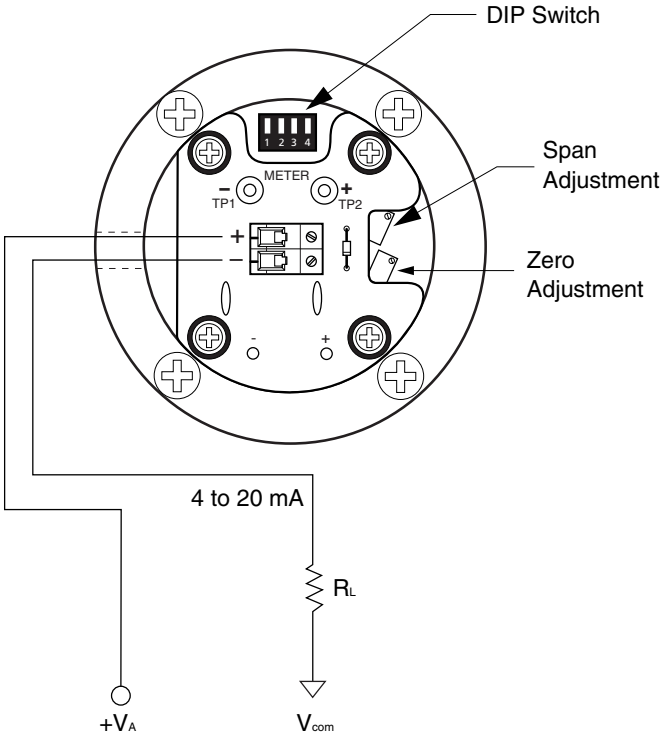


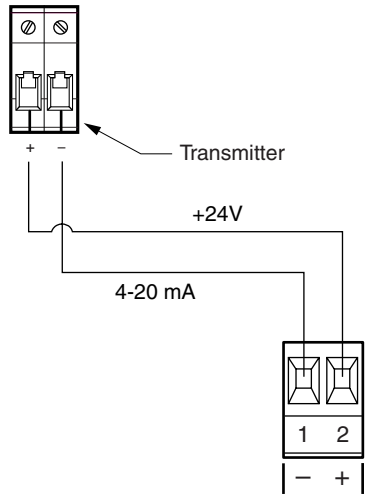
Front View

* 5600 D/P Transmitter, 868 D/P sensor control models only

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 LevelPRO multiple tank indicators

Power Requirement

The LevelTRAN transmitter requires a source of DC power for operation. Minimum excitation voltage must be no less than 18 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.

$$\text{Load Capacity (ohms)} = \frac{\text{(Supply Voltage - 10 Volts)}}{.02}$$

Load Capacity at Supplied Voltage

20 Vdc	24 Vdc	28 Vdc	32 Vdc	36 Vdc	40 Vdc
500 ohms	700 ohms	900 ohms	1100 ohms	1300 ohms	1500 ohms

KING-GAGE® tank processors and LevelBAR provide 24 Vdc excitation to power the signal loop circuit. (If the application requirement exceeds 700-ohms, an external power supply of appropriate voltage will be required.)

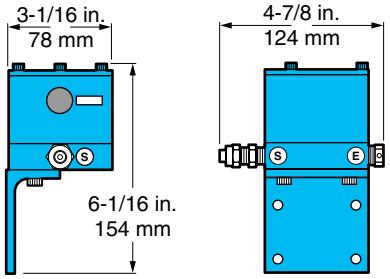
Signal Cabling
The 4-20 mA signal loop needs to be run using twisted pair (two conductor) cable. "Noise" or EMI (electromagnetic interference) does not generally create a problem since it is common to both wires in the pair and essentially cancels itself out. In most applications, non-shielded twisted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

D/P Transmitter Models

These transmitters are designed for use in hydrostatic tank level gauging systems. These include hybrid versions combined with airflow controls for pneumatic sensors or downpipe (bubbler) to enable direct 4-20 mA signal transmission from the tank.

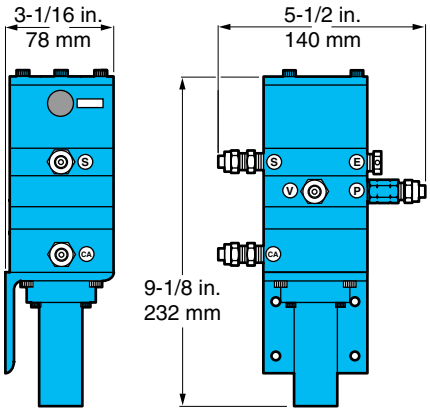
5600 D/P Transmitter - Differential pressure transmitter accepts high and low pressure pneumatic input. 1/4 in. NPT pressure connections and 1/2 in. NPSF outlet to accept conduit or other suitable connectors.

Model 5600 D/P Transmitter



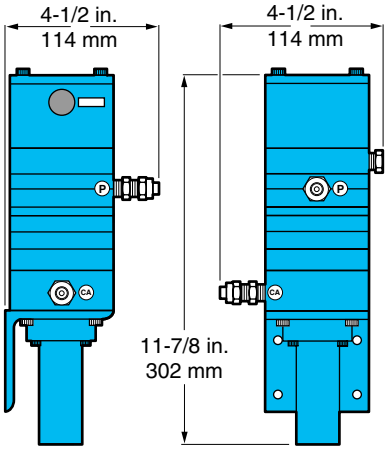
868 D/P Sensor Control - Fully integrated D/P transmitter with constant flow regulator, backpressure regulator and vent generator for use with King-Gage AcraSensor II metal diaphragm sensors. 1/4 in. NPT pressure connections and 1/2 in. NPSF outlet to accept conduit or other suitable connectors.

Model 868 D/P Sensor Control



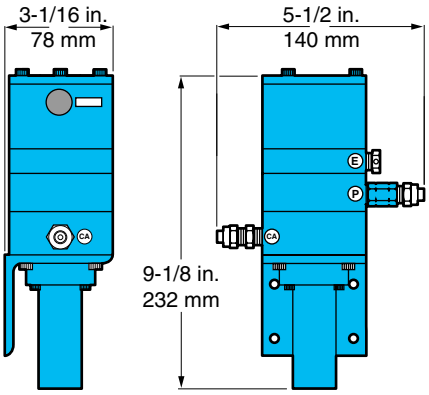
738 D/P LiquiSeal Control - Fully integrated D/P transmitter with constant flow air purge regulator for downpipe (bubbler) sensing of tank level. 1/4 in. NPT pressure connections and 1/2 in. NPSF outlet to accept conduit or other suitable connectors.

Model 738 D/P LiquiSeal Control



788 D/P Purge Control - Fully integrated D/P transmitter with constant flow air purge regulator for downpipe (bubbler) sensing of tank level. 1/4 in. NPT pressure connections and 1/2 in. NPSF outlet to accept conduit or other suitable connectors.

Model 788 D/P Purge Control



Calibrating Range (Span) for D/P Transmitter

D/P Transmitters may be used for either gage pressure or differential pressure applications. The following section outlines range calculations for determining the precise span adjustment for gauging typical storage or processing tanks. If required, the span and zero can be adjusted for specific tank conditions as necessary to achieve the full 4.00 to 20.00 mA signal output.

IMPORTANT - READ BEFORE CHANGING SPAN
For most applications employing a KING-GAGE® Tank Processor or Digital Indicator, transmitter output is generally calculated at less than 20.00 mA when tank is full. These microprocessor-based devices use an "Application Datapack" non-volatile memory (e.g., PROM, SRAM or iButton) programmed with application parameters that will account for transmitters whose nominal range is greater than maximum tank pressure. When the transmitter output is used only for remote level indication, there is no need to adjust span settings from the nominal range.

> If a KING-GAGE tank processor (or digital indicator) is used, changing transmitter span will necessitate reprogramming the Datapack with these updates.

Span and Resolution: While adjusting span does increase resolution, this does not directly result in greater accuracy. For most liquid level or tank gauging applications, the transmitter can be effectively used with the preset nominal span.

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:

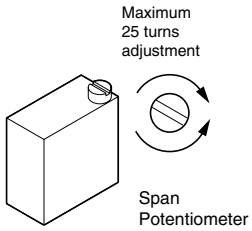
$$\frac{\text{(16 x Calculated PSID)}}{\text{3.0}} + 4 = \text{mA Output}$$

■ 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.

Calibration - Zero/Span Adjustments

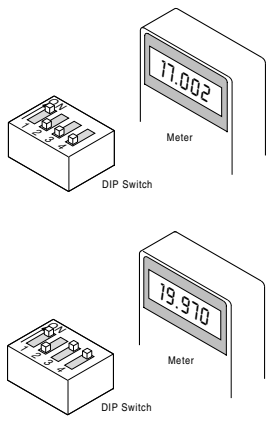
This procedure requires the test set-up to apply pressure as outlined on page 8. The first portion of the instructions applies to transmitter range (span) being adjusted to other than the nominal setting. The second set of instructions covers final trim adjustments for span and zero (assumes that transmitter span requires only a small degree of adjustment). If zero/span requires a slight trim adjustment, skip steps 1-4.

■ Span (Range) Adjustment - Coarse Setting
1. To set the transmitter for either the lower or upper span limits (see page 3), the DIP switches are used.
2. Begin by turning the SPAN potentiometer either clockwise or counter-clockwise until it begins to make a slight "click". Now reverse direction and make 12-1/2 turns. (The potentiometer used has a maximum 25 turns so that the above procedure will center the adjustment to allow either increasing or decreasing setting for final trim later.) *TURN IN EITHER DIRECTION*



UNTIL IT SLIGHTLY "CLICKS"
3. Now apply pressure to the transmitter high pressure connection. The applied pressure should be equivalent to the desired span (range). For example, if the application is for a pressure range of 0" to 131.5" water column (differential or gage pressure) then the supplied pressure should be equal to 131.5" water or 4.75 PSIG.
4. Next, slide any one of the DIP switches into the "ON" position. Continue to turn on or off switches until the value closest to 20 mA is observed on the meter.

DIP Switch
(Coarse Span Adjust)

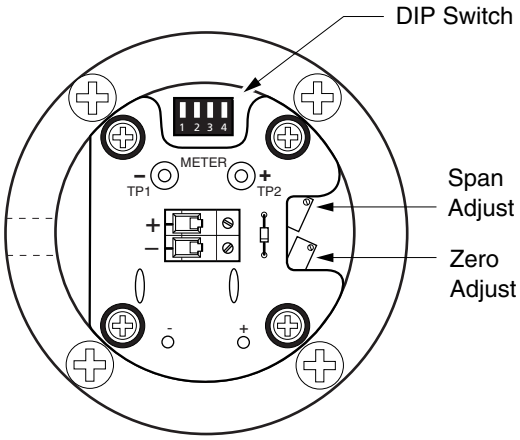


DIP Switch -Coarse Adjustment

■ Zero/Span Final Trim Adjustment

5. Check zero setting of transmitter at 0" W.C. (or 0 PSIG). Adjust ZERO potentiometer until output is 4.00 or 4.01 mA.
6. Apply pressure corresponding to desired span and observe transmitter output on the milliammeter. Adjust SPAN potentiometer to increase or decrease as required.
7. Re-check zero setting at 0" W.C. (or 0 PSIG). If zero output is not 4.00 mA, increase or decrease zero setting as required. If zero is adjusted, also re-check span.

NOTE - Since "zero" is an offset adjustment, shifting the setting upward or downward will have a corresponding effect on span. The degree of zero shift will be matched by a similar span shift.



■ In-Process Zero/Span Adjustments

It is possible to make trim adjustments to the zero and span settings while transmitter is connected to the process signal loop. The meter terminal posts permit in-process monitoring without disturbing the loop wiring.

Adjusting span in-process is not as precise a method for setting span, since liquid level or process pressure may not be accurately known. Zero adjustment, however,can be accomplished while the transmitter is in the process installation. Measure the transmitter output using a milliammeter and adjust zero potentiometer as required (see note below).

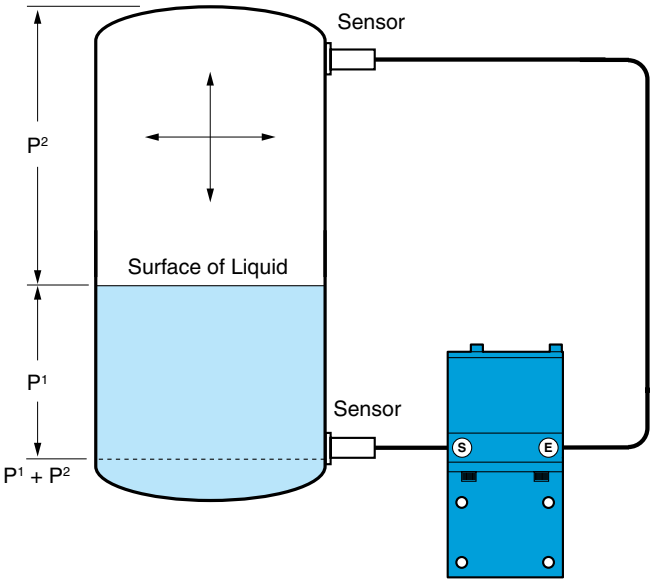
NOTE - Generally, it is advised that the zero setting be adjusted with the compressed air supply turned off or disconnected from the transmitter. This is due to a slight "air-on" pressure output from a pneumatic diaphragm sensor. The effect should not be considered a "bias" since it disappears once liquid level touches the diaphragm face. Do not adjust the zero setting of the transmitter to compensate for "air-on" since it would result in shifting the span and cause a continuous output error above empty reading.

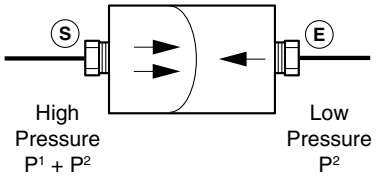
Low Pressure Input

Internal Tank Pressure or Vacuum

In a closed, pressurized or evacuated tank, 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 from the total pressure sensed at the bottom of the tank. When the low pressure is applied to one side of the transmitter sensing element and the high pressure to the other side, the internal tank pressure above the liquid (low pressure) is balanced across the sensing element. This is also referred to as being "equalized" (which is why we designate the low pressure connection as "E").

CAUTION: While the internal pressure above the liquid is not a factor in determining range (span), there may be instances where the sum of the liquid and internal pressure exceeds the 150 PSI burst pressure rating of the transmitter. Also, do not subtract pressure when a vacuum condition is present within the tank (since loss of vacuum would be seen as an increase at the high pressure connection of the transmitter).





$(P^1 + P^2) - P^2 = P^1$

Calibration Test Setup (Typical)

This D/P transmitter has a specified accuracy of ± 0.15%. To ensure your calibration maintains this degree of accuracy, the equipment used to check zero and span settings must conform to the recommendation listed below. Use of equipment with less than specified accuracy figures will not provide acceptable results. King assumes no responsibility for transmitter accuracy if test equipment does not meet recommended minimum standards.

Recommended Equipment:

MILLIAMMETER; 3-1/2 digit minimum, 0.05% accuracy (20 OHMS max. internal resistance)

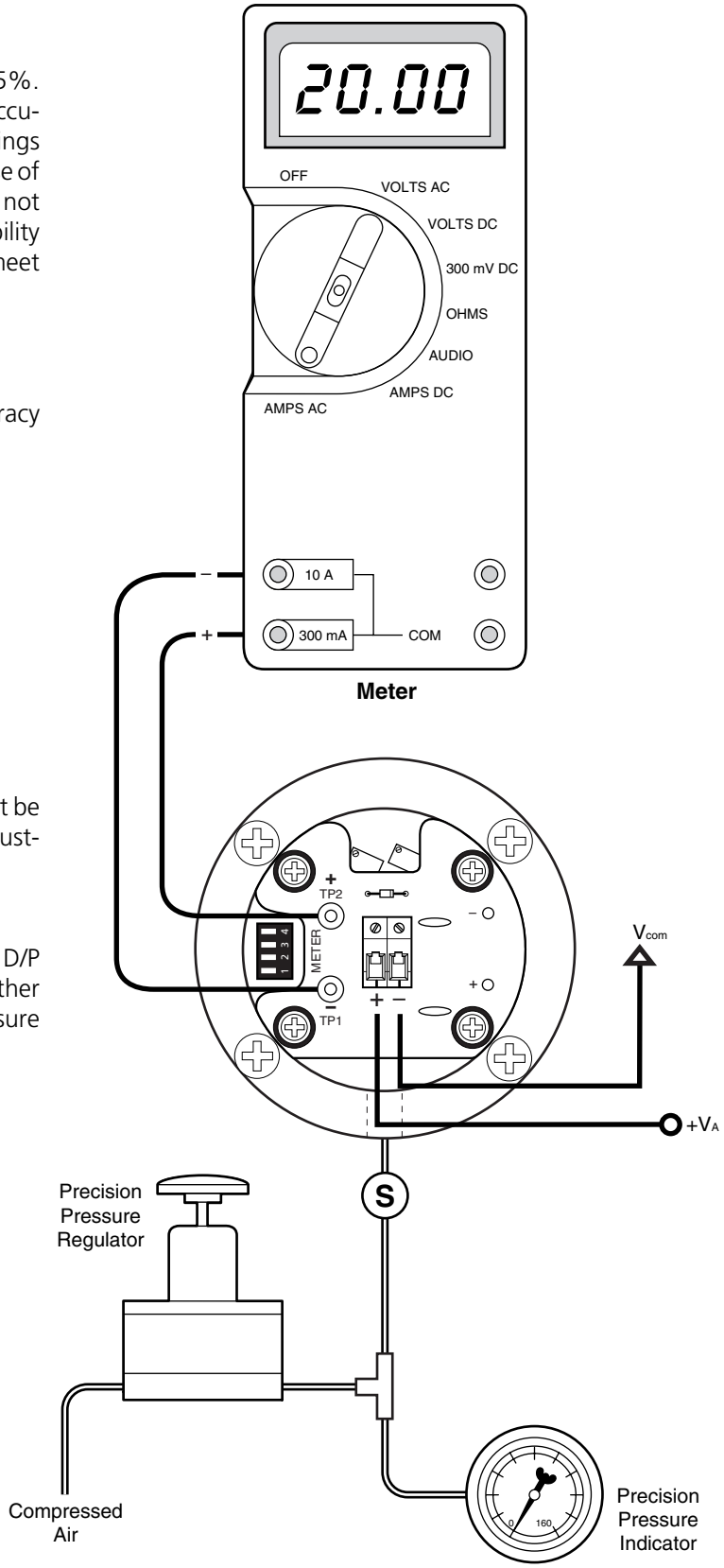
DC POWER SUPPLY

PRESSURE INDICATOR; PSI or IN. OF WATER
0.05% accuracy corresponding to transmitter range

5 PSID nominal	± .0025 psi or .0693" of water
10 PSID nominal	± .005 psi or .1385" of water
15 PSID nominal	± .0075 psi or .2078" of water
30 PSID nominal	± .015 psi or .4156" of water
50 PSID nominal	± .025 psi or .6927" of water

NOTE - The low pressure port ("E") of transmitter must be vented to atmosphere during the calibration and adjustment procedures.

Typical test setup shown applies only to model 5600 D/P Transmitter and model 868 D/P Sensor control. (Other transmitter models do not incorporate an external pressure input connection).



Calculation

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., 8.6 lbs/gal), the specific gravity can be determined by dividing the value by 8.33 (weight of water per gallon).

Examples - Pressure Range Calculations
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 of 1.032.

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) x 1.00 = 352" water

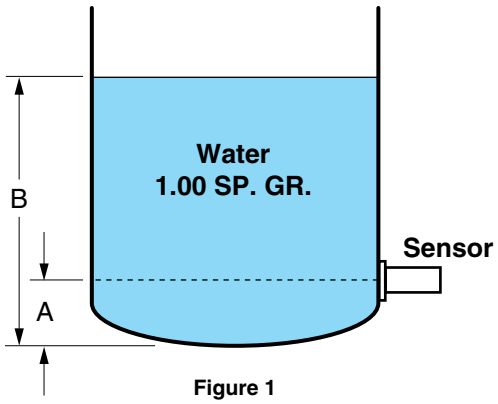


Figure 1

A second tank gauging application is illustrated in Figure 2. 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 desired level (which is less than the actual full capacity of the tank). The liquid contents in the tank has a specific gravity of 1.032.

C = 1.032 (Specific Gravity)
B = 300" (Upper Level)
A = 28" (Reserve)

$$\frac{(300 - 28) \times 1.032}{27.6807} = 10.14 \text{ psid}$$

(300 - 28) x 1.032 = 281" water

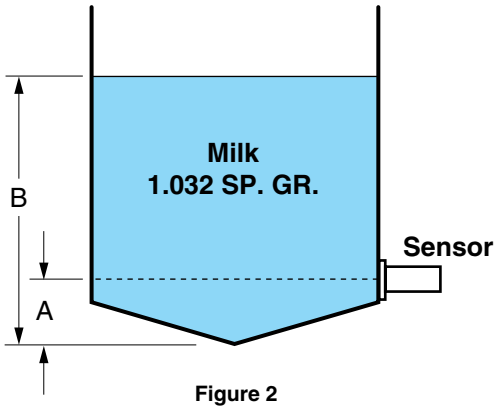


Figure 2

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 mAdc

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. (Transmitter has ±40% span adjustment.)
- 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).

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