Effective: August, 2000 (May, 1999) **EX-1683**

Electronic Sensor

5700 Series Electronic Liquid Level Sensor

KING-GAGE®

Electronic Liquid Level Sensor/Transmitter (4-20 mA Output)

Operation and Calibration Instructions

User's Guide to Range Calculation Procedures, Zero/Span Adjustments for Liquid Level Sensor/ Transmitter

KING ENGINEERING CORPORATION
Since 1937

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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.

Revisions:

(A) January, 1988 – Original Release.
(B) May, 1990 – Revised Mat'l. Specifications
(C) May, 1995 – Revised/Redrawn
(D) March, 1996 – Corrected Service Parts, ECR no. 3473
(E) February, 1997 – Added new enclosure, ECR no. 3499
(F) February, 1998 - LevelPRO 3-Terminal Connector
(G) July, 1998 - Updated Drawings for No Bracket
(H) May, 1999 - Revised Illustration page 5
(I) August, 2000 - Revised Illustration page 5 and page 7

Contents:

KING-GAGE Series 5700 Electronic Liquid Level Sensor

Two-wire sensor/transmitter provides a direct 4-20 mAdc analog electronic output signal. Fixed-range sensor with nominal span/zero adjustments designed specifically for hydrostatic pressure measurement for liquid level gauging.

Sensor package includes 25 feet of cable and corrosion-resistant Signal Junction Enclosure. (This enclosure also houses the external zero/span adjustments and signal loop connection terminals.)

Range Designation

A model number/range designation is listed on the end of the sensor housing. The last two digits of the model number actually refer to the sensor range. As an example, MODEL 5702-1-10 is a 0-10 psig range sensor.

Pressure Ranges -

-05 ..... (0-5 psig pressure range)
-10 ..... (0-10 psig pressure range
-15 ..... (0-15 psig pressure range)
-30 ..... (0-30 psig pressure range)
-50 ..... (0-50 psig pressure range)

Dimensions Chart

Model No.	Dim. A	Dim. B	Dim. C
5701-1-xx	7-5/8 in. 194 mm	-- --	2-1/4 in. 57 mm
5701-2-xx	-- --	9-1/8 in. 232 mm	2-1/4 in. 57 mm
5702-1-xx	7-5/8 in. 194 mm	-- --	6-5/8 in. 168 mm
5702-2-xx	-- --	9-1/8 in. 232 mm	6-5/8 in. 168 mm
5703-1-xx	9-57/64 in. 251 mm	-- --	8-7/8 in. 225 mm
5703-2-xx	-- --	11-1/2 in. 292 mm	8-7/8 in. 225 mm

Model No. Designations

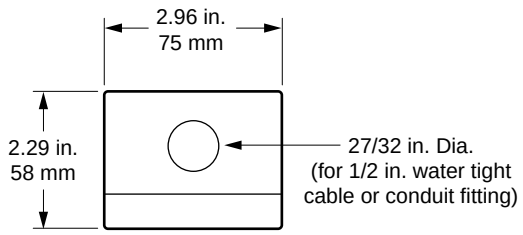
5702-x-xx

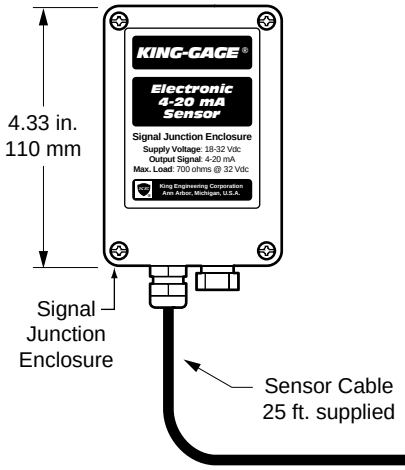
Pressure Range

05 ..... 0-5 psig
10 ..... 0-10 psig
15 ..... 0-15 psig
30 ..... 0-30 psig
50 ..... 0-50 psig

Configuration

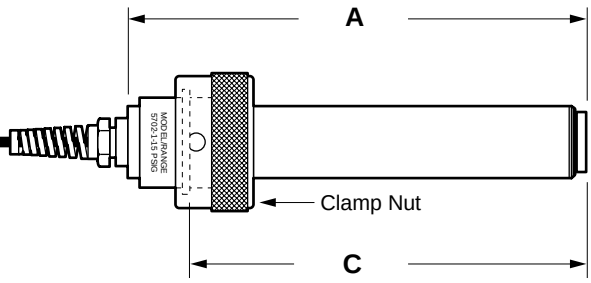
1 ..... Standard
2 ..... Optional
3/4 in. NPS-F

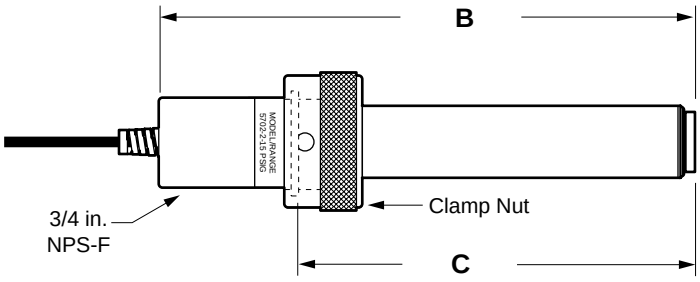




Standard Configuration

Includes watertight cable compression fitting with integral strain relief at end of sensor housing.



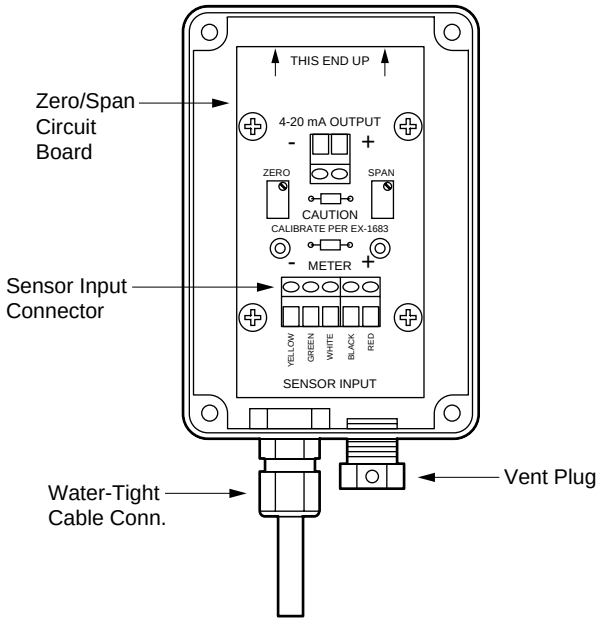


Optional Configuration

Sensor housing has a 3/4 in. NPS-F tapped end designed for rigid or flexible conduit to afford greater protection for cable assembly

Mounting Supplied Junction Enclosure

This corrosion resistant non-metallic enclosure houses the zero/span circuit board and serves as the signal terminal connections for the sensor. The supplied sensor cable must terminate within the enclosure to maintain the atmospheric reference vent integrity. Do not mount enclosure beyond what the supplied cable length will allow — DO NOT SPLICE additional cable onto the sensor.



Detail - Junction Enlosure

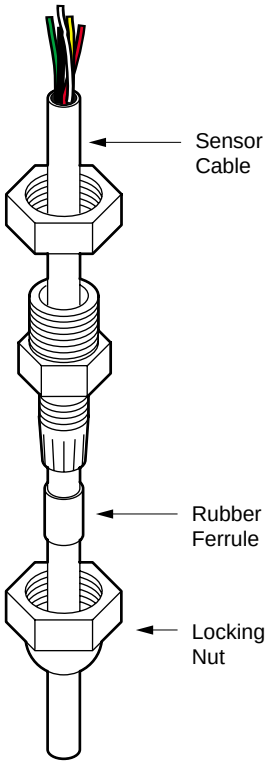
The enclosure is designed to accept two (2) mounting screws (not supplied). Refer to the illustration on page 7.

Enclosure Vent - a vent plug is furnished installed into the bottom of the Junction Enclosure. If mounting location of enclosure exposes vent to frequent washdown, steam or extremely humid atmosphere, additional provisions may be required. A 1/4 in. NPT fitting may be used in lieu of the vent plug to permit installing a vent tube to a more protected (i.e., dry) location.

Electrical Conduit - The pass-through hole at top of enclosure is intended to accept a bulkhead-type 1/2 in. conduit hub or cable fitting. Conduit runs should incorporate condensate traps or downward loops (see page 8).

Sensor Cable

The polyethylene cable contains five (5) individual color coded wires. Three (3) of these wires are connected to the span/zero adjustments on the circuit card. The remaining two (2) wires (black, red) are for +Signal and -Signal (common) output of the transmitter.

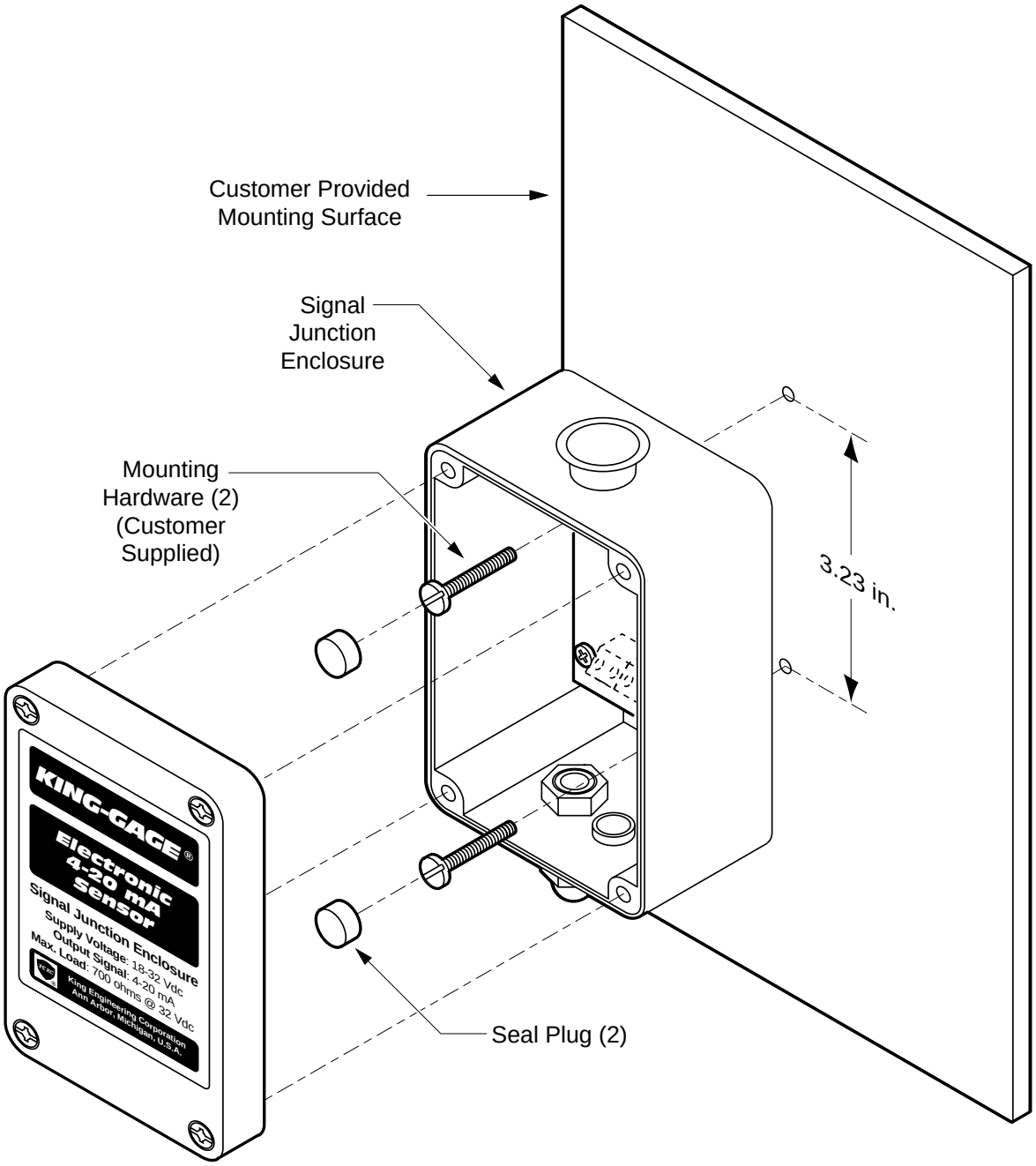


Detail - Sensor Cable

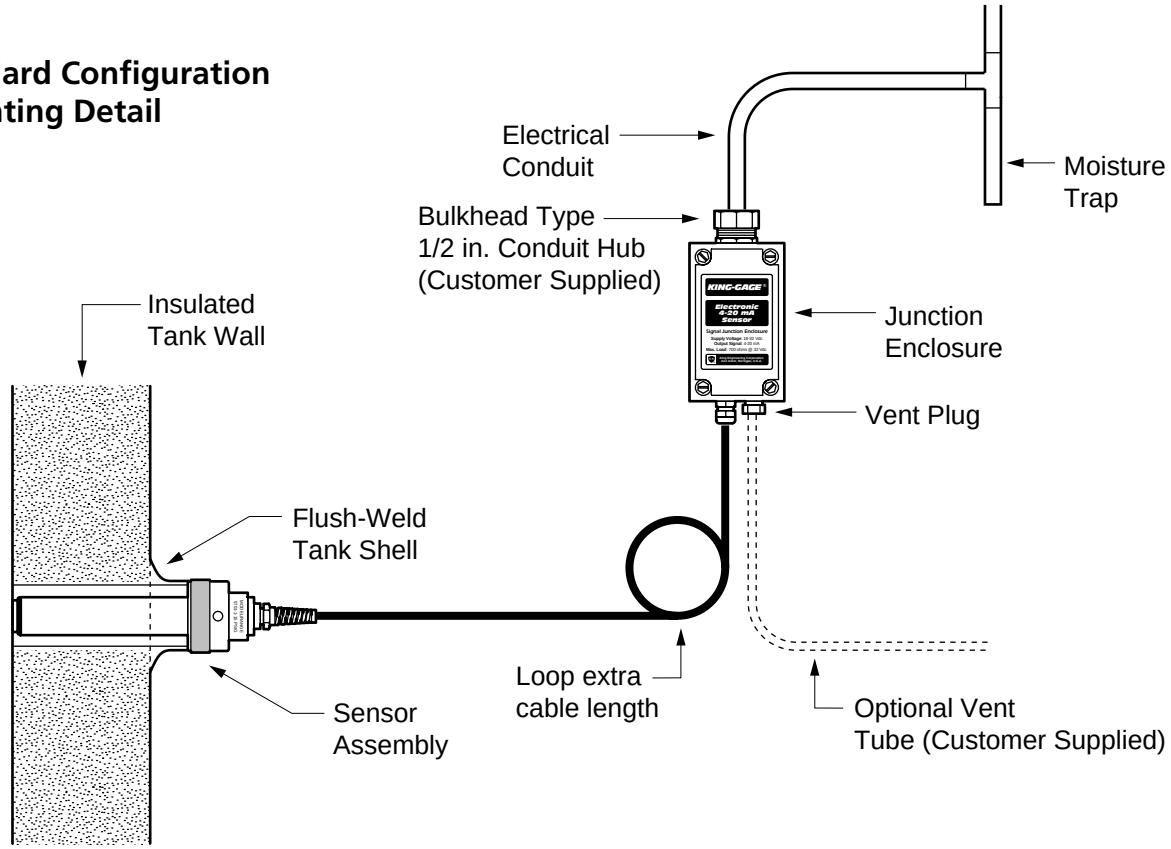
This integral cable maintains the necessary atmospheric reference vent for the sensor. It must be terminated within the supplied vented enclosure. We recommend that any excess cable be lightly coiled which will further protect against the migration of moisture into the internal sensor circuitry.

A water-tight plastic connector seals the sensor cable at the bottom of the junction enclosure. Make certain that the rubber ferrule is used when inserting the sensor cable. The polyethylene cable should protrude slightly into the interior of the enclosure when properly installed.

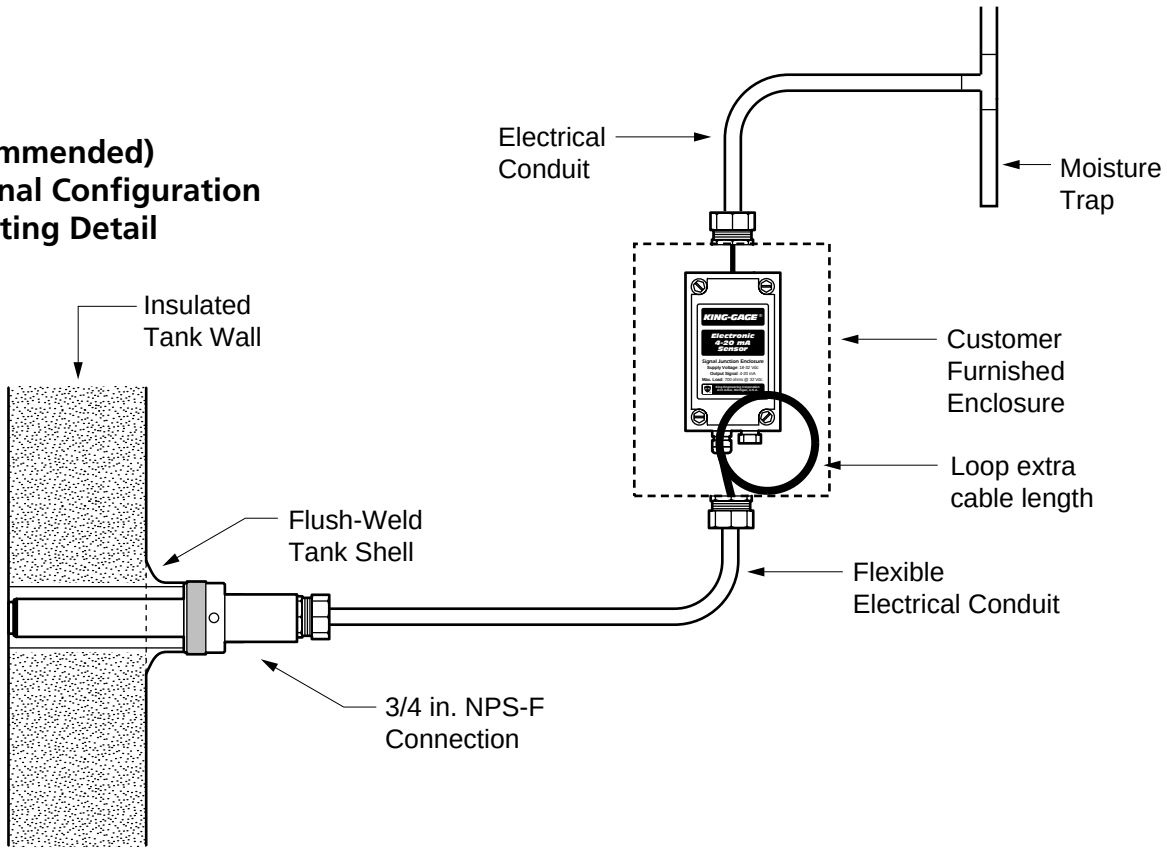
Detail - Mounting Junction Enclosure



Standard Configuration Mounting Detail



(Recommended) Optional Configuration Mounting Detail



Specifications

Output Signal
4-20 mAdc (2-wire current loop)

Pressure Ranges
0-5, 0-10, 0-15, 0-30, 0-50 PSIG (gage pressure only)
Sensor is designed as fixed range unit. Nominal span adjustment is limited to less than 2% FS

Wetted Materials
Diaphragm:
316 stainless steel

O-Ring (Standard):
silicone rubber, food grade (FDA)

O-Ring (Optional)
Teflon* TFE

Sensor Housing
Internal components are isolated within 304 stainless housing by standard buna-N seals. Optional seals available on special order.

Accuracy
± 0.20% FS (at constant temperature)
Calibrated at 70°F (includes linearity, hysteresis, repeatability errors)

Repeatability Error (Worst Case)
less than ± 0.02% FS

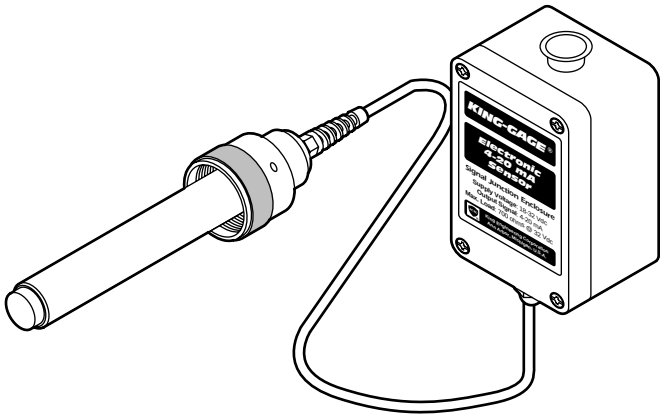
Linearity Error (Worst Case)
less than ± 0.13% FS

Operating Temperature Range
0°F to 175°F (-17°C to 79°C)

Storage Limits
-65°F to 250°F (-54°C to 121°C)

Electrical Data
Input Voltage: 18-32 Vdc (regulated)

Minimum Excitation - Vdc = 18 + (0.02 x R_L)
Resistance value must account for both receiver and line resistance factors.



Maximum Load (Resistance)
700 ohms @ 32 Vdc

Stability (Effect on Output)
less than 0.003 mA change in output signal per volt change in power supply

Thermal Compensation/Effects
30°F to 130°F (0°C to 54°C)

Zero Shift (Worst Case):
less than ± 0.02% FS/°F

Span Shift (Worst Case):
less than ± 0.02% FS/°F

Notes:

1. Operating temperature limit applies to internal electronics only. Process fluid temperatures may be considerably higher or lower. Actual operating temperature limits are dependent upon various environmental factors.

2. Circuit is a true 2-wire, 4-20 mA dc current (16 mA span); delivers rated current into any external load that is between 0-700 ohms. (Factory calibrated using 100 ohm load @ 24 Vdc.) Reverse excitation will not damage circuit.

* "TEFLON" is a registered trademark of the Du Pont Company, Inc.

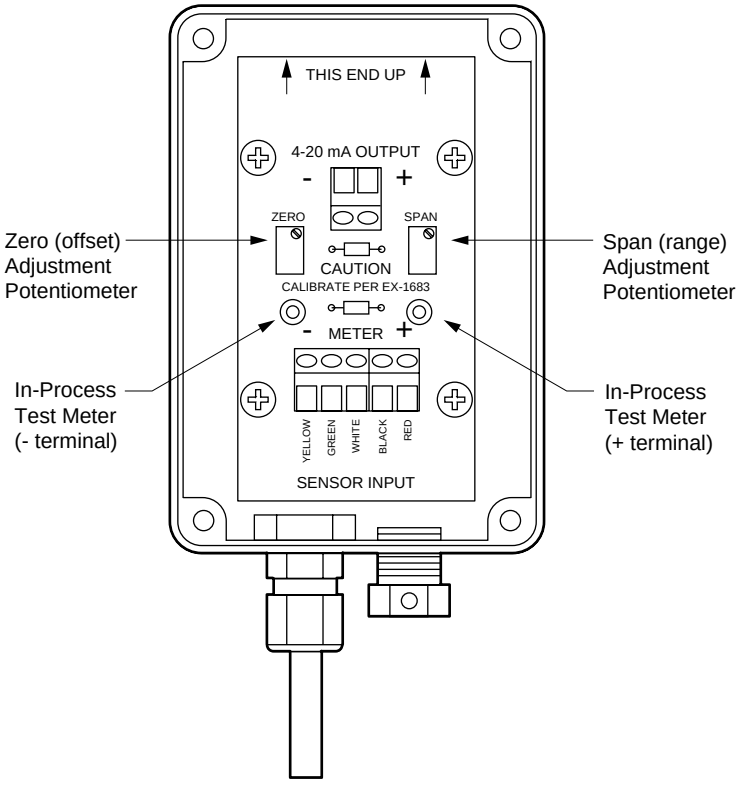
Sensor Zero/Span Adjustments

The SERIES 5700™ Electronic Sensor provides external zero and span adjustments conveniently housed within the Signal Junction Enclosure. Test meter connections are also located within the enclosure making for simplified in-process monitoring by maintenance or operating personnel.

Nominal Span Adjustment (Fixed Range Sensor)
Since the sensor is designed as a fixed-range device, only a nominal span adjustment is obtainable (less than 2% F.S.). Due to the inherent stability of the internal circuitry, very little span adjustment will be needed over time.

Zero Adjustment
Some adjustment of the sensor "zero" setting may be periodically required. It is generally recommended that the zero output be checked at least every 12 months.

Important! Never attempt to adjust the span setting when sensor is in-process (i.e., installed at tank). Due to the fact that the sensor is manufactured to a ± 0.2% FS accuracy tolerance, only calibration procedures performed under controlled conditions should be used. Zero adjustments, however, may be accomplished while sensor is installed while tank is known to be empty.



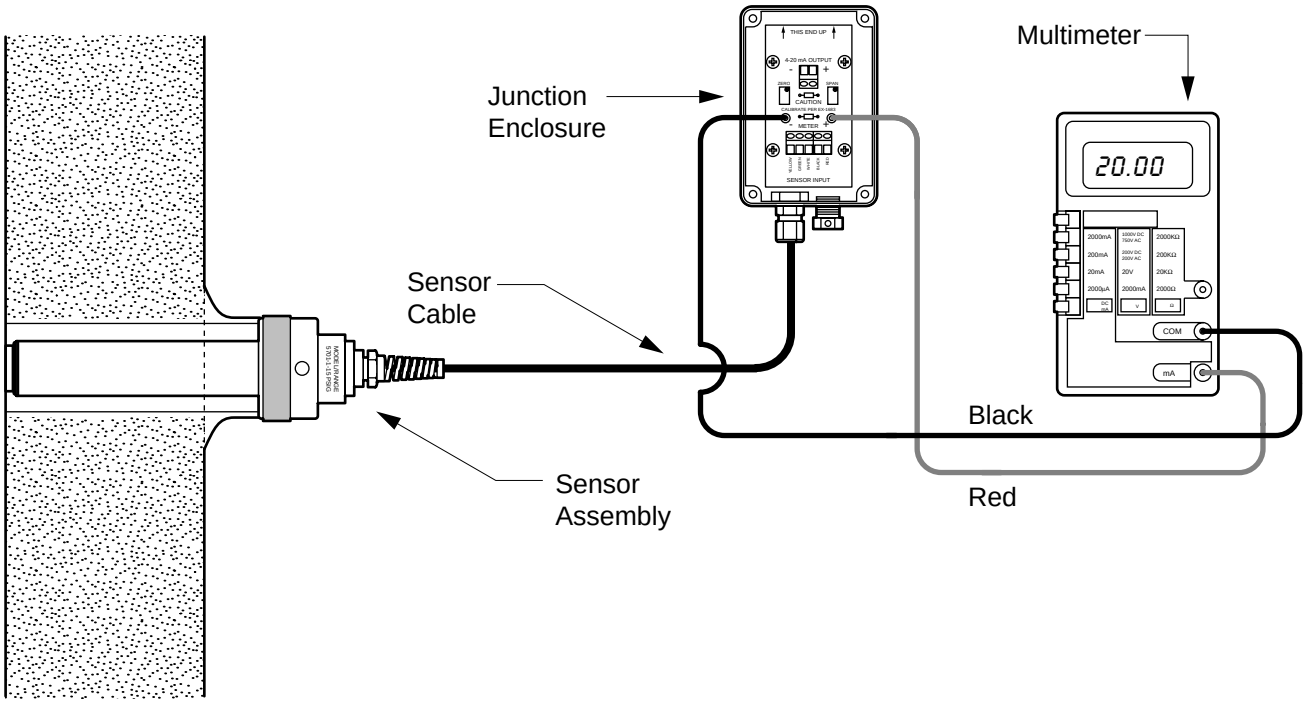
Span/Zero Adjustment Location - Signal Junction Enclosure

In-Process Monitoring

The milliamp output signal (4-20 mAdc) can be checked while the sensor is installed at the tank. Test meter terminals are provided within the Signal Junction Enclosure (see previous page) that permit accurate reading without disturbing the signal loop wiring.

Important! Set meter for DC current, mA or .001 Amp scale. Internal resistance through the meter must be 20 ohms or less. Higher resistance values will erroneously show lower milliamp reading on meter.

Note: Always re-install cover when done.



Calculating Milliamp Output

The King-Gage Electronic Sensor is factory-calibrated to nominal range only. Since there is no appreciable degree of span adjustment, the milliamp output of the sensor at full tank level will generally be less than 20.00 mA.

Actual output can be calculated based on total tank depth and specific gravity of the liquid product:

$$\frac{(\mathbf{B} - \mathbf{A}) \times \mathbf{C}}{27.6807} = \text{Tank Pressure}$$

where ...

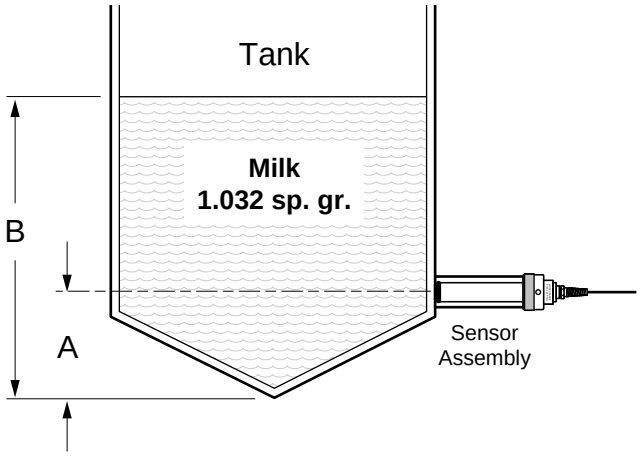
A = Reserve (inches of depth from low point of tank to sensor)

B = Full Tank (inches of depth from low point of tank to full)

C = Specific Gravity of Tank Contents

Now, using the calculated tank pressure from above, the actual milliamp value at full can be determined:

$$\frac{(16 \times \text{Tank Pressure})}{\text{NOMINAL psig RANGE}} + 4 = \text{mA Output}$$



Example - mA Output Calculation for Tank Gauging Application

The following example shows how the milliamp output of the sensor at full tank can be calculated. 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. The liquid contents of the tank is milk @ 1.032 sp.gr. The sensor installed is a nominal 15 psig range model.

C = 1.032 (specific gravity)

B = 400 in. (full level)

A = 28 in. (reserve)

$$\frac{(400 - 28) \times 1.032}{27.6807} = 13.87 \text{ psig}$$

$$\frac{(16 \times 13.87)}{15 \text{ PSIG}} + 4 = 18.79 \text{ mA}$$

Span Calibration Test Equipment Set-Up

Since the King-Gage Electronic Sensor has an accuracy of ± 0.20%, the equipment used to re-calibrate the zero and span settings must conform to the recommendations given below. (Use of test equipment with less than the accuracy specified will not yield acceptable results and King cannot assume responsibility for sensor accuracy under such conditions.)

Caution - Some regulators have a "live" pressure output even when completely shut. Even slight pressure output (2 in. water) will have noticeable affect when adjusting zero setting of sensor. Vent sensor to atmosphere and check output to ensure proper zero setting of sensor.

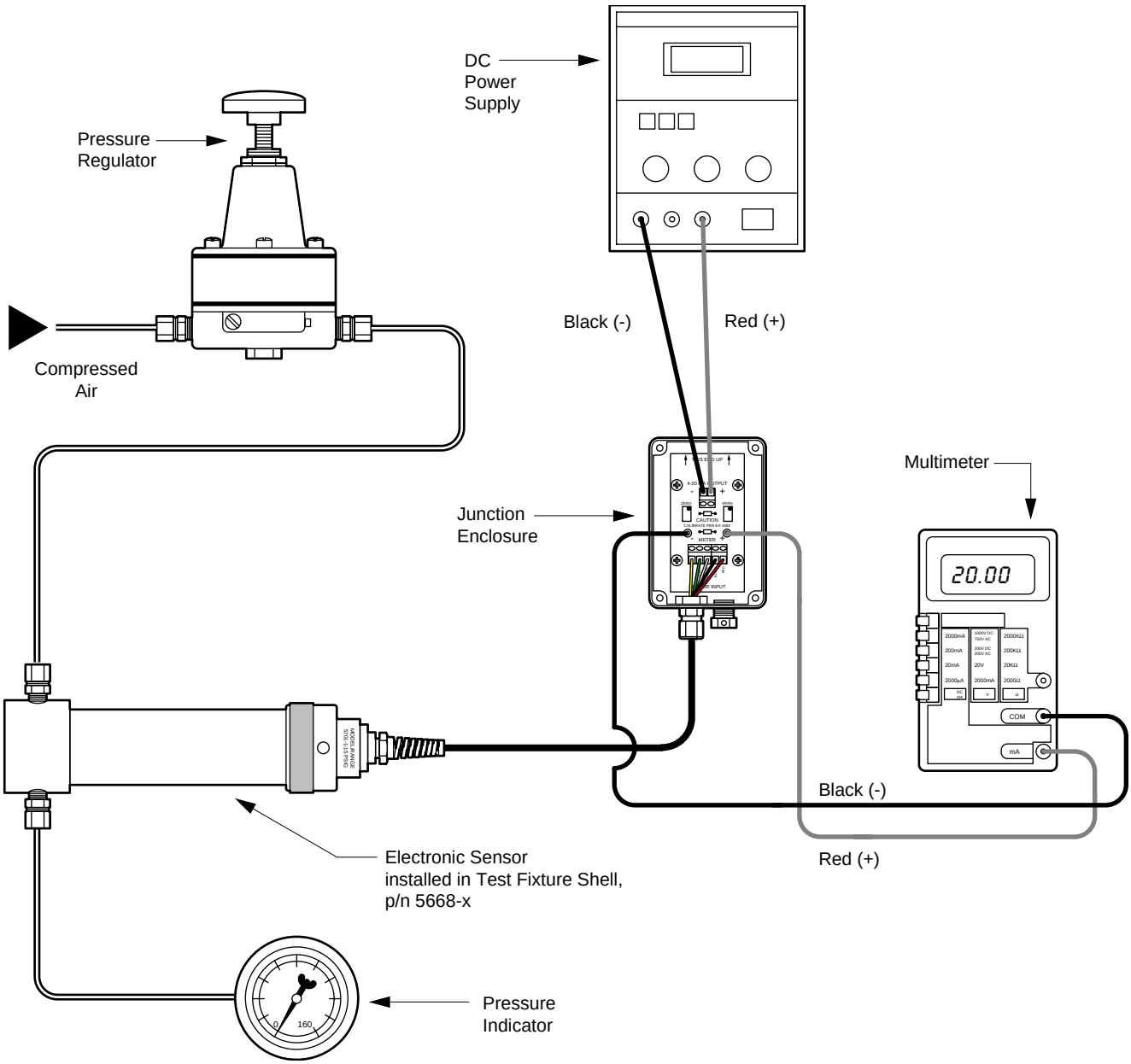
Equipment Required:

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

Power Supply; 18 - 32 Volts DC (regulated)

Pressure Indicator; PSI or IN. OF WATER, 0.05% accuracy corresponding to sensor range:

0-5 PSIG nominal ..... ± .0025 psi or .0693 in. of water
0-10 PSIG nominal .... ± .005 psi or .1385 in. of water
0-15 PSIG nominal .... ± .0075 psi or .2078 in. of water
0-30 PSIG nominal .... ± .015 psi or .4156 in. of water
0-50 PSIG nominal .... ± .025 psi or .6927 in. of water



Span Calibration Procedure

The King-Gage Electronic Sensor must be calibrated to nominal range only. It is generally recommended that the sensor be removed from the process application when checking the span calibration.

Sensor and Signal Junction Enclosure

The Signal Junction Enclosure contains the external zero/ span adjustments and connection terminals for the sensor cable. The Signal Junction Enclosure also carries the same serial number as the sensor. This matched set must be used when calibrating zero and/or
span output

Zero/Span Adjustment Procedure

1. The first step should be to check both the zero and span output of the sensor before making any adjustments. Span (or full pressure) output must be checked using carefully regulated compressed air pressure corresponding directly to the nominal PSIG rating of the sensor. Make certain that regulator output is actually 0 PSIG when checking the zero setting of the sensor.

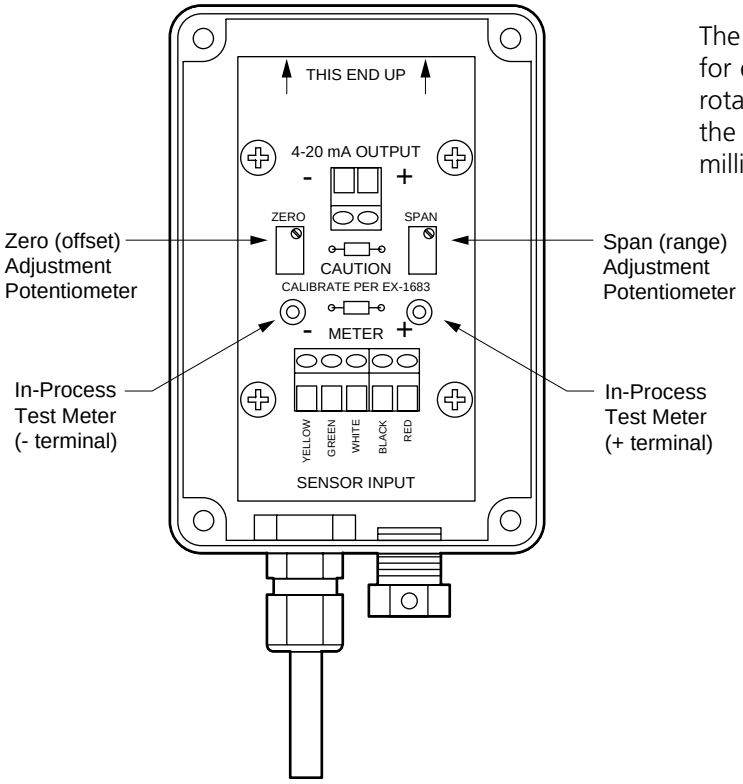
2. Check "zero" setting of sensor at 0 PSIG (or with sensor exposed to ambient air pressure). Adjust ZERO potentiometer until output reads 4.00 mA on the meter.

3. Apply full range pressure (nominal PSIG rating of sensor) to sensor and check milliamp output. If necessary, adjust SPAN potentiometer until output reads 20.00 mA on the meter.

4. Recheck "zero" setting at 0 PSIG. If the output is not 4.00 mA, increase or decrease ZERO as required.

5. If "zero" setting was adjusted in Step #4, also re-check full pressure (span) output.

   (Whenever you make an adjustment to the ZERO potentiometer, it is necessary to check that SPAN or full pressure output is still 20.00 mA. The same holds true for adjustments made to the SPAN potentiometer, after which the ZERO output should be checked to ensure it is still 4.00 mA.)

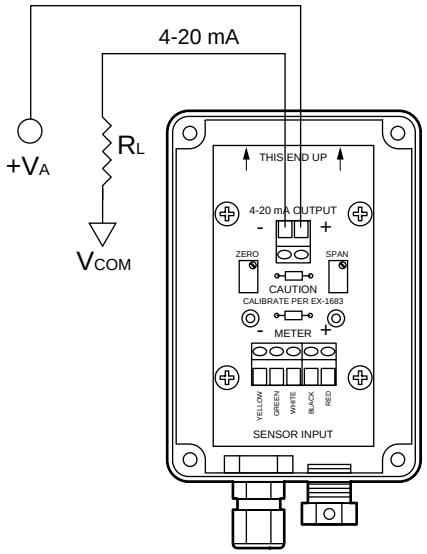


The 'ZERO' and 'SPAN' potentiometers are low sensitivity for ease of adjustment. Use a small screw screwdriver to rotate potentiometer adjustment clockwise to **Increase** the milliamp output or counterclockwise to **Decrease** milliamp output from sensor.

Voltage/Load Capacity

The King-Gage Electronic Sensor 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.

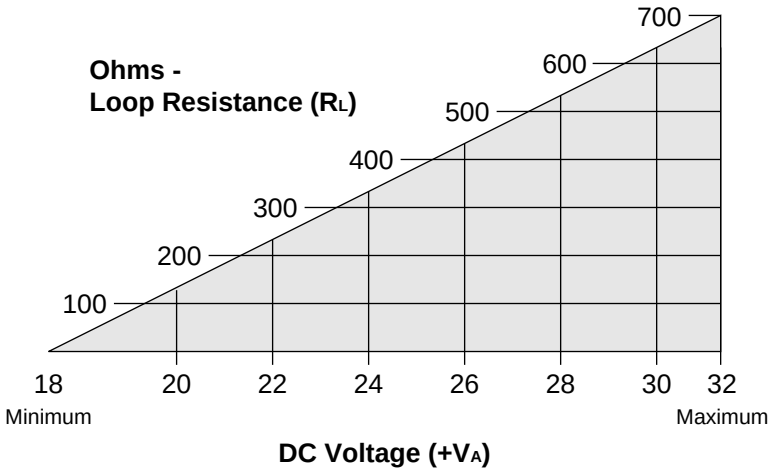
$$\text{Load Capacity (OHMS)} = \frac{\text{(Supply Voltage - 18 Volts)}}{.02}$$



Load Capacity Chart

Refer to voltage/load capacity chart shown when total resistance factor is known.

Note: When using AC-powered King-Gage digital indicator or digital tank processor is used, dc power output to sensor is nominal 24 Vdc. Internal indicator resistance is nominal 120-ohms. Additional loop components and cabling may not exceed 180-ohms (because of the 300-ohm maximum capacity @ 24 Vdc).



Load Capacity Chart

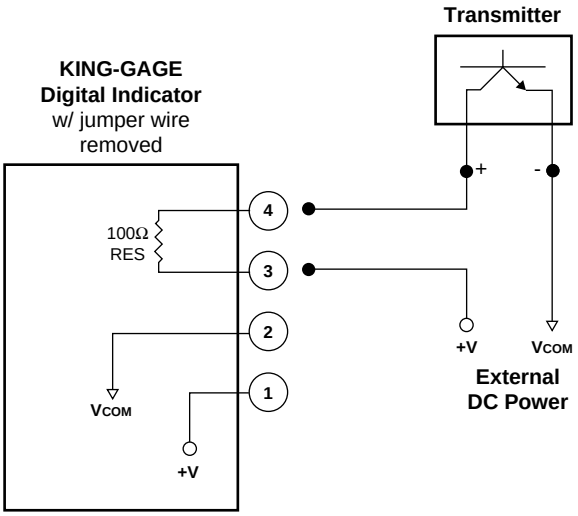
KING-GAGE Digital Indicator or Tank Processors (Gauging System with 4-20 mA Liquid Level Indicators)

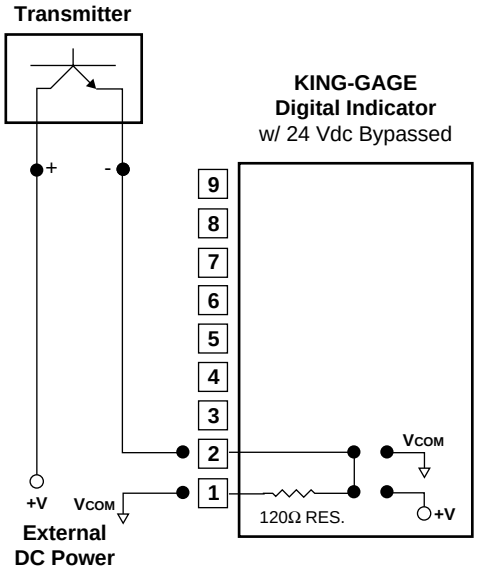
King-Gage Digital liquid level indicators accept the 4-20 mA output signal from the Electronic Sensor and provide 24 Vdc excitation to power the signal loop circuit. (If the application requirement exceeds 300-ohms, an external power supply of appropriate voltage will be required.)

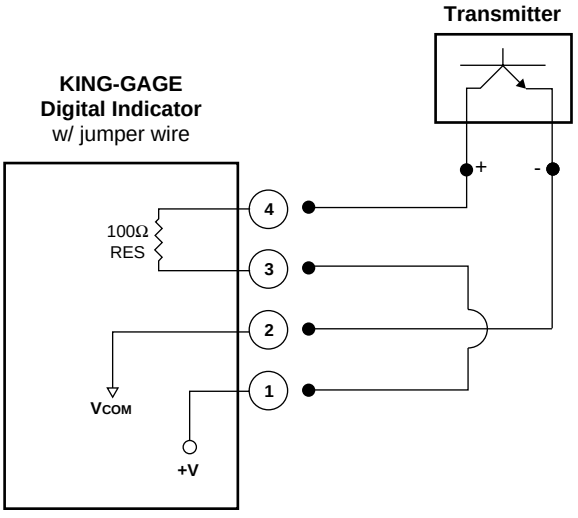
Note: Series 5350, TANK PLUS and LevelPRO Digital Indicators have an impedance rating (resistance load) of 120-ohms.

Signal Loop Electrical Cable Recommendation

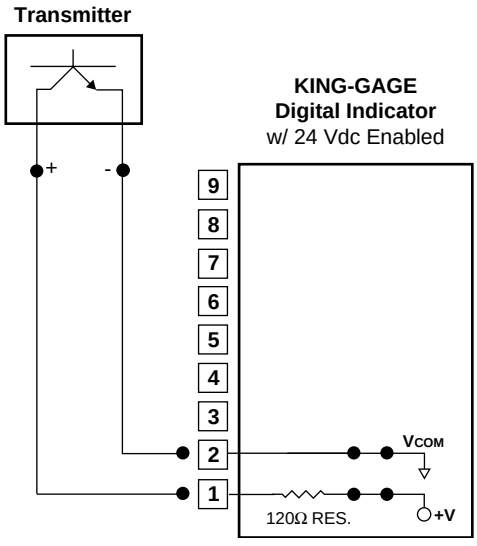
Two-Conductor; Twisted Pair, Shielded Cable, 20 AWG (BELDEN 9320 or Equivalent) - Low impedance permits long cable runs and minimizes overall line resistance. Suitable for all applications.







KING-GAGE Indicators having 4-terminal signal connection



KING-GAGE Indicators having 9-terminal plug/socket connectors

Troubleshooting

Apparent Symptoms & Possible Causes

No Output

No power to sensor. Signal connections at junction enclosure may be reversed. Also, check for disconnected wiring in the signal loop. Make certain that power supply is turned on and + Vdc is connected to + signal terminals of sensor junction enclosure.

Low Output Signal

Possible zero shift. Check output of sensor with tank completely empty and adjust zero setting if necessary. Also, make certain that power supply is adequate for total resistance of signal loop - see next section.

Low Output (Full Tank)

If full tank pressure is less than the nominal rating (psig) of sensor, output will be less than 20.00 mA.

If power supply voltage is insufficient for total loop resistance, milliamp output will not increase. Check loop wiring and components for total resistance value and refer to load/voltage capacity on page 12.

No Change in Output

Possible physical damage to sensor - including internal contamination of sensor electronics. Check for evidence of moisture infiltration such as, breaks in sensor cable or presence of liquid inside of the junction enclosure.

If sensor output does not vary when exposed to different pressures, replacement or factory service by authorized K.E.C. personnel may be required.

High Ouput

Check "zero" setting of sensor with empty tank or no pressure applied to diaphragm. Re-adjust if necessary.

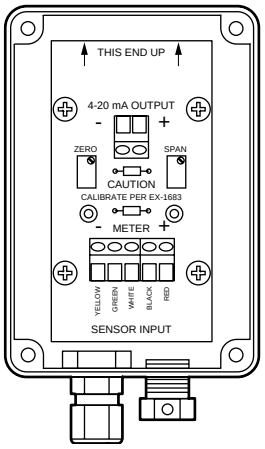
Make certain that tank is fully vented. Even slight internal tank pressure can result in slightly higher sensor output.

Exposure to vacuum within tank may have caused zero setting of sensor to shift upward. Remove sensor from tank and check output at 0 psig (or sensor diaphragm exposed to atmosphere). If output drops, try readjusting zero setting. (NOTE: If sensor zero adjustment has no effect on output, damage to unit may have occurred - consult factory service personnel.)

Service/Replacement Parts

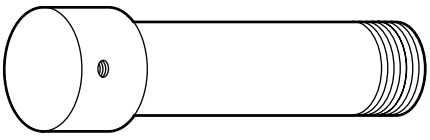
5630-1 ..... Junction Enclosure w/ Circuit Card
5630-10 ..... Replacement Junction Enclosure & Cover only
7967-17-22 ..... Zero/Span Circuit Card

Junction Enclosure w/ Circuit Card



Test Fixture Shells

5668-1 ..... Short mount fixture (5701)
5668-2 ..... Standard mount fixture (5702)
5668-3 ..... Long mount fixture (5703)



Test Fixture Shell

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