

# Instruction Manual T-800 Series Current Transmitter

Model T-800L  
Model T-800LT  
Model T-800TT

M323 Rev H

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# INSTRUCTION MANUAL

## T-800 SERIES CURRENT TRANSMITTER

### 1. INTRODUCTION

This manual provides the principles of operation and the methods for setup and calibration of the JOWA USA T-800 Series 4-20mA Current Transmitters. If you need further information or application assistance, contact the JOWA USA factory, or the nearest sales office.

### 2. MODELS

The T-800 Series transmitters are available in three different models as summarized in the Table 2.1 below. The specific transmitter or transmitters required is based on the number of resistance temperature detectors (RTD) in the sensor.

Model	Description	Number of RTD's in Sensor			
		0	1	2	3
T-800L	Transmitter, Level	1		1	
T-800LT	Transmitter, Level-Temp		1		1
T-800TT	Transmitter, Temp-Temp			1	1

Table 2.1 Transmitter Models

Note that sensors with two or three RTD's require two transmitters. Transmitters have either one channel (T-800L) or two channels (T-800LT and T-800TT). Sensors with 2 RTD's will require adapter cables 1871100, 0461102 and 0461132.

There is one printed -circuit board for each channel in the transmitter. The channel function for the various applications is defined in Table 2.2 below.

Transmitter	Channel 1 (Lower Board)	Channel 2 (Upper Board)	Number of RTD's in sensor
T-800L Level	Level	-----	0
	Level	Lower Temp.	1
T-800LT Level / Temp.	Level	-----	2
	Level	Upper Temp.	3
T-800TT Temp. / Temp.	Lower Temp.	Upper Temp.	2
	Middle Temp.	Lower Temp.	3

Table 2.2 Transmitter Channel Assignments

### 3. TRANSMITTER OPERATION

The T-800 Series 4-20mA current transmitters are designed to operate in conjunction with the JOWA resistance-tape sensor. The resistance-tape level sensor is a two-wire device whose electrical resistance is proportional to liquid level being gauged. The resistance is zero ohms near the top of the sensor and maximum at the bottom of the sensor. The maximum resistance is approximately equal to the sensor length multiplied by 304.8 ohms per foot [1000 ohms per meter]. The resistance-tape sensor may also have one or more resistance temperature detectors (RTD's).

The loop powered transmitter uses a three terminal 5VDC voltage regulator in series with a current sensing resistor. The regulator provides power to its internal circuitry and the current sensing resistor is used to monitor and control the loop current. A constant current is provided to the sensor to develop a voltage proportional to resistance. The excitation current is scaled with the three ZERO DIP switches to provide a wide ZERO adjustment range. The developed voltage is amplified with a scaleable amplifier using the three SPAN DIP switches. The circuitry automatically reverses the sense of the voltage so that increasing resistance decreases the output current. ZERO and SPAN potentiometers provide fine adjustment of those settings.

### 4. INSTALLATION

#### 4.1 Wiring

Figures 4.1 through 4.4 show typical wiring configurations connecting the transmitter to the sensor and to the customer equipment. Select the wiring configuration that most closely meets your needs. Note that Figures 4.1 through 4.3 show configurations for sensors and transmitters located in non hazardous (classified) locations.

Figure 4.4 shows a configuration for a sensor and transmitter located in a hazardous (classified) locations. Drawing A1864900 attached as Appendix D defines all allowable configurations and specific requirements for intrinsically safe installation. For 'custom' installations, observe the specifications of the transmitter described in Section 7. In particular

- a. Ensure that the steady state power supply excitation voltage does not exceed 28 VDC (24VDC nominal recommended).
- b. Note the polarity of the loop current (the transmitter is protected but will not operate if the leads are reversed).
- c. Ensure that the power supply excitation voltage minus the sum of all the loop voltage drops (at 20mA) is greater than 7.5 VDC.

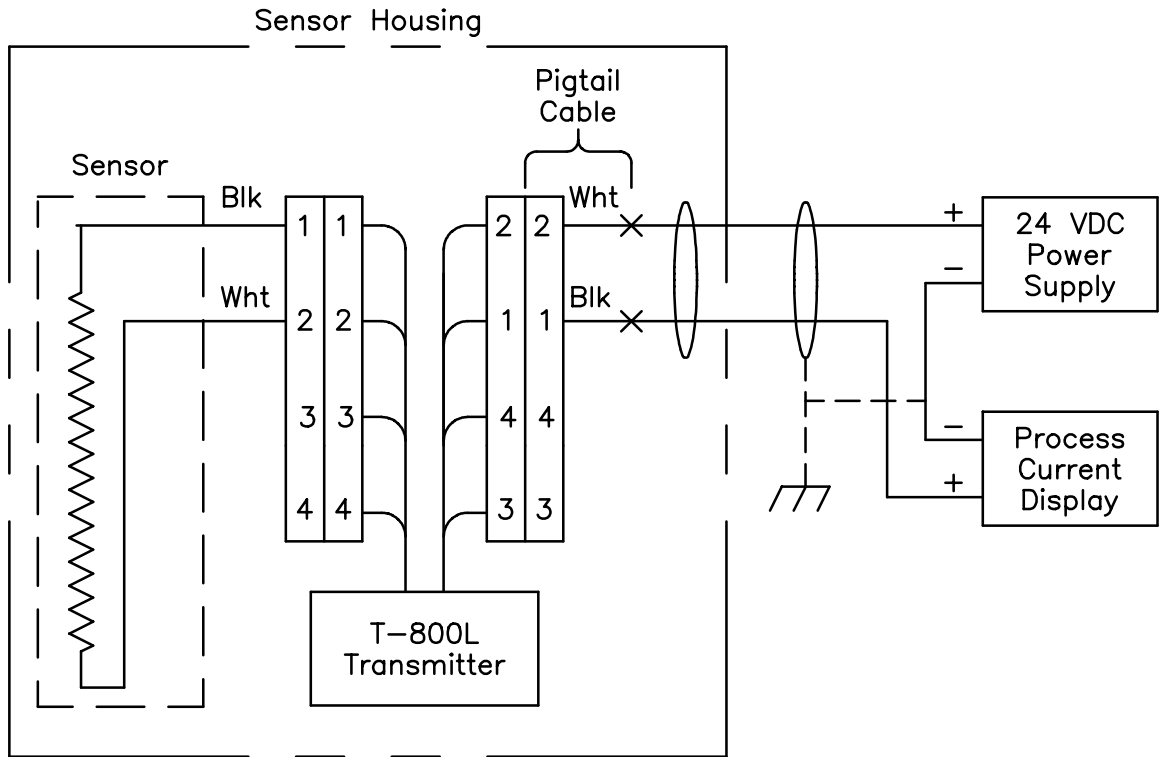


Figure 4.1 Level Wiring to Process Current Display

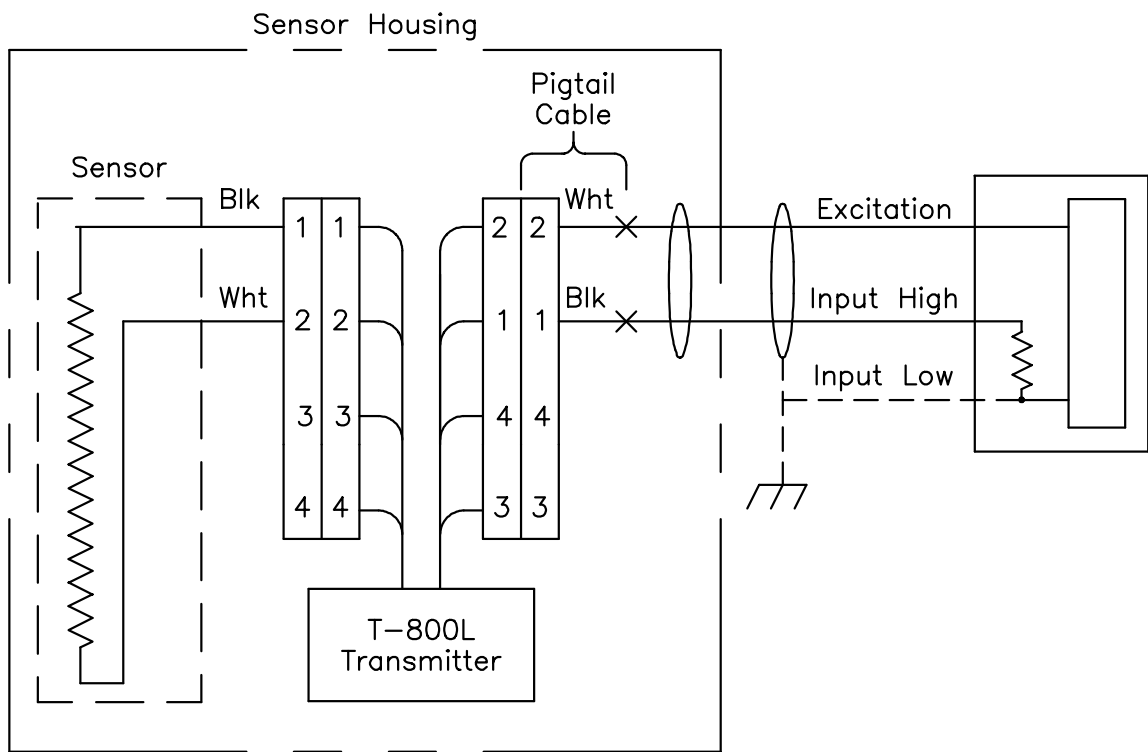


Figure 4.2 Level Wiring to PLC

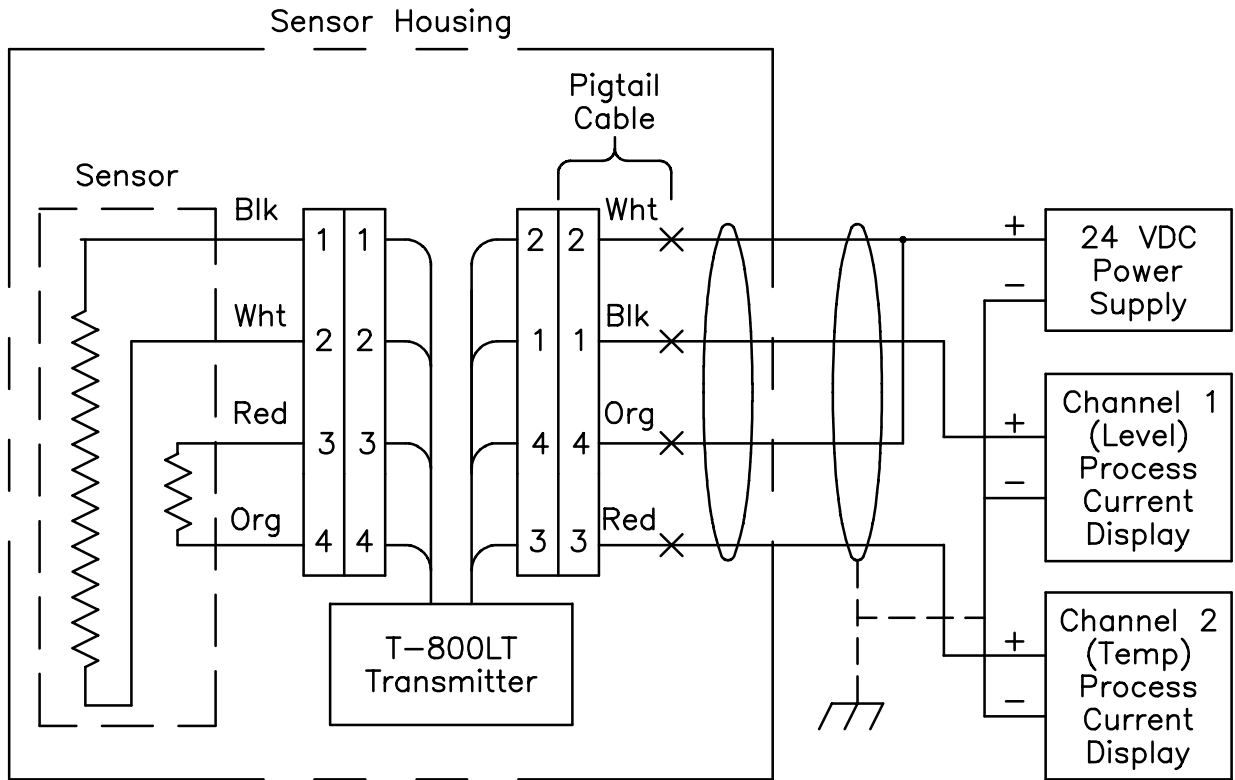


Figure 4.3 Level Temp Wiring to Process Current Displays

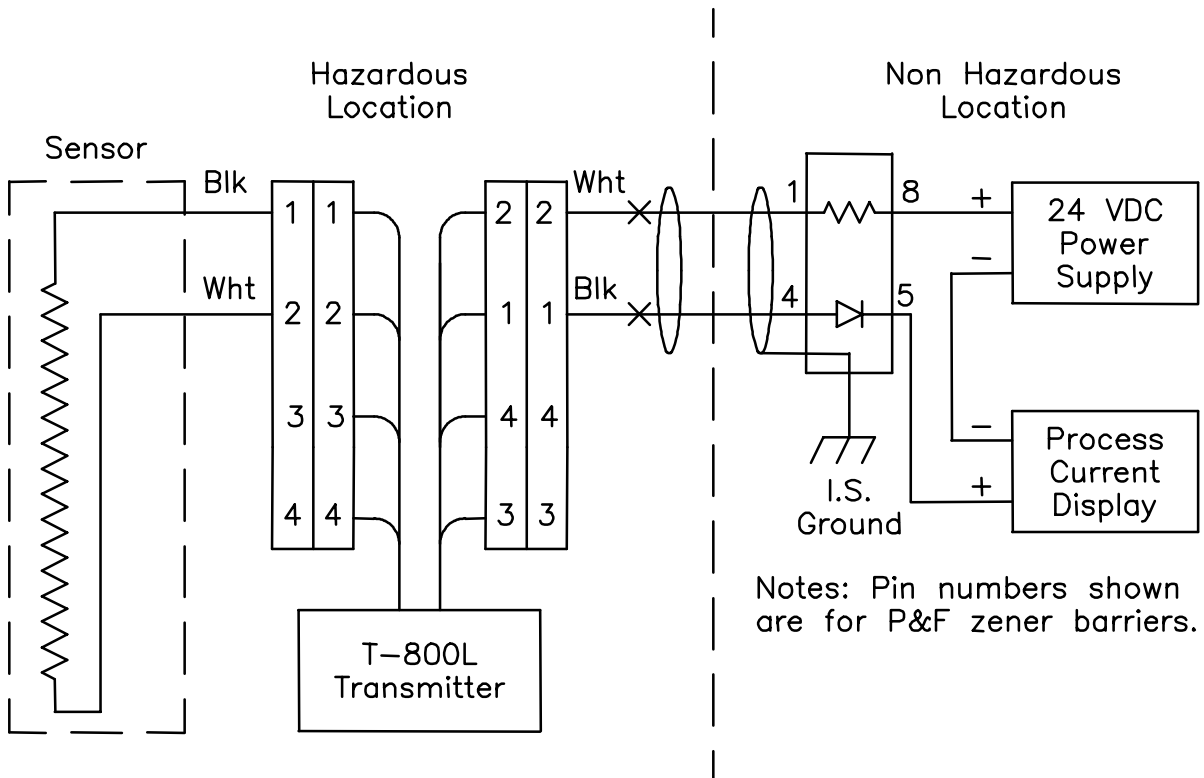


Figure 4.4 Level Wiring to Process Current Display (Hazardous Location)



## 4.2 Shielding

All cables between the sensor housing and the user instrumentation or intrinsic safety barriers should have an overall shield. The shield is best left open at the sensor end and tied either to chassis (earth) ground or signal ground in the instrumentation. The best connection may have to be determined experimentally. In intrinsically safe installations, the shields should be tied to either the IS ground rail (or, if available, to the IS GND connection on the IS barrier).

## 4.3 Internal Component Location

Figure 4.5 shows the internal layout of the T-800L transmitter and the location of the critical component including the 6-position DIP Switch and the ZERO and SPAN potentiometers.

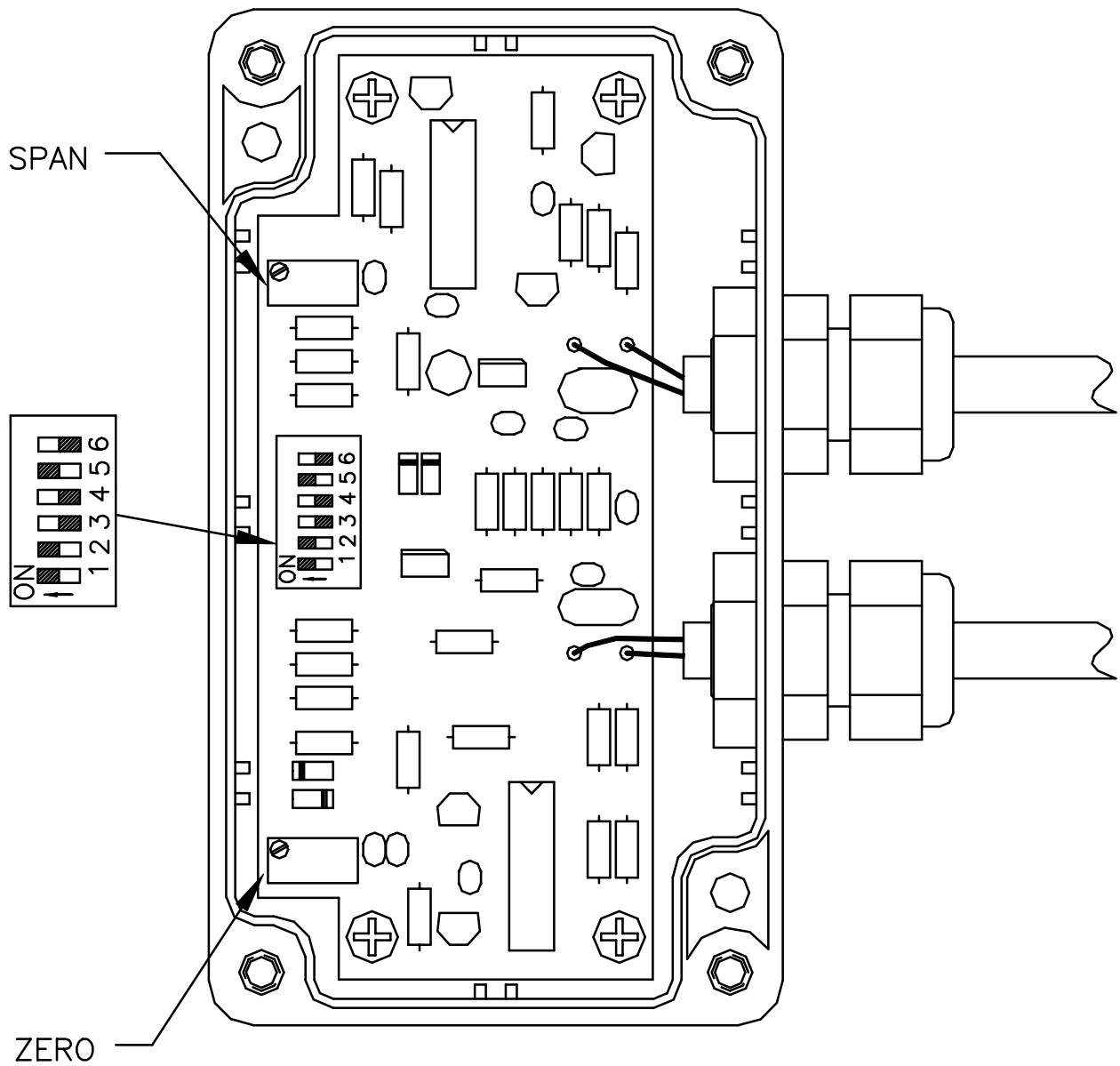


Figure 4.5 T-800L Component Layout

Figure 4.6 shows the internal layout of the T-800LT and T-800TT transmitters and the location of the critical component including the 6-position DIP S-switch and the ZERO and SPAN potentiometers. Note that Channel 1 is always the bottom board and Channel 2 is always the top board.

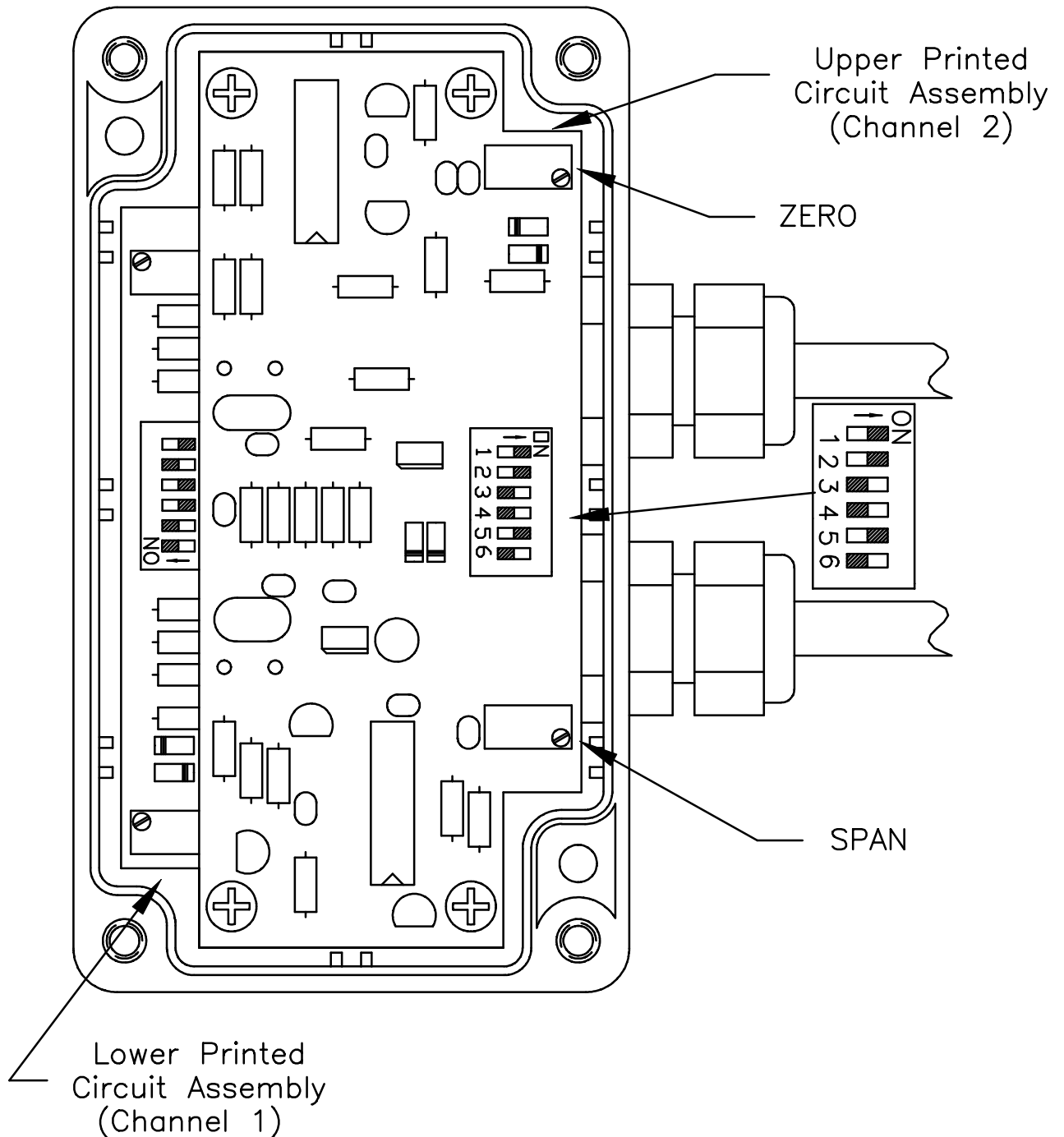


Figure 4.6 T-800LT / T-800TT Component Layout

#### 4.4 Initial Bench Calibration

It is recommended that DIP switch setting and initial calibration be performed “on the bench” if possible. If not proceed directly to Initial Installation (paragraph 4.5).

- a. If performing initial calibration on the bench, connect the transmitter to a power supply and milliammeter per Figure 4.7. Note that connections shown in dashed line are for second channel.

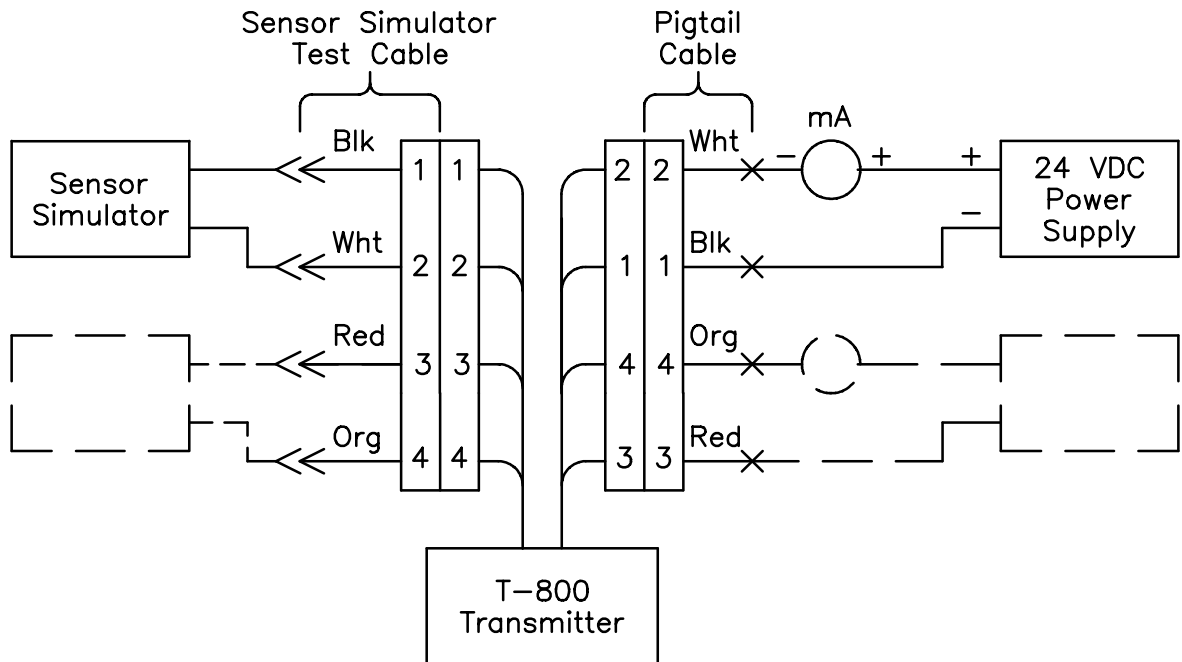


Figure 4.7 Bench Connection for Calibration

**NOTE:** The mating cable connecting from the transmitter to the power supply and milliammeter is supplied. It may be removed and temporarily used to calibrate the transmitter. The part numbers for the 2-wire and 4-wire mating cables are 0461106 and 0461102 respectively.

**NOTE:** The JOWA USA Model SS904D Sensor Simulator is a precision thumbwheel selectable resistance box with an overall accuracy of  $\pm 0.02\%$  of reading or  $\pm 0.5$  ohms (whichever is greater) over the entire range from 0 to 30000 ohms. Any resistor decade box with similar specifications may be used for calibration.

The Sensor Simulator comes with a cable that connects from the transmitter’s input and to two pairs of banana jacks (to connect to the sensor simulator). If connecting directly via probes, Figure 4.8 shows the pin and socket arrangement of both the transmitter input (from sensor) and the transmitter output current (4-20mA) connectors. Table 4.1 shows the function of each pin.

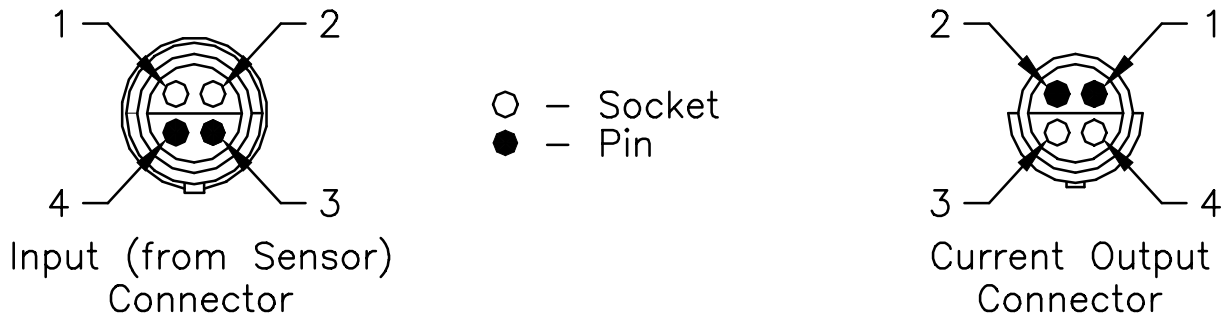


Figure 4.8 Connector Pin Arrangement

Input (from sensor) Connector (female)			Output Current (4-20mA) Connector (male)		
Pin-Socket	Transmitter Wire Color	Function	Pin-Socket	Transmitter Wire Color	Function
Socket 1	Black	+ Channel 1	Pin 1	Black	- Channel 1
Socket 2	White	- Channel 1	Pin 2	White	+ Channel 1
Pin 3	Red	+ Channel 2	Socket 3	Red	- Channel 2
Pin 4	Green	- Channel 2	Socket 4	Green	+ Channel 2

Table 4.1 Transmitter Connector Pin/Socket Assignment

Note that transmitter wire colors shown are internal to transmitter cables.

- b. Perform “bench” setup and adjustments of Channel 1 per paragraphs 5.1 through 5.3 (T-800L).
- c. If the transmitter does not have a second channel, go directly to Initial Installation paragraph 4.5.
- d. Perform “bench” setup and adjustments of Channel 1 per paragraphs 6.1 through 6.3 (T-800TT).
- e. Reconnect sensor simulator, power supply and milliammeter per Figure 4.7 (Channel 2).
- f. Perform “bench” setup and adjustments of Channel 2 per paragraphs 6.1 through 6.3 (T-800LT or T-800TT).

#### 4.5 Initial Installation

- a. At tank top, remove and set aside sensor housing cover bolts
- b. If replacing existing transmitter separate the transmitter connectors to sensor and to the field wiring.
- c. Remove cover from new transmitter. Connect transmitter connectors to sensor and field wiring.

- d. 4.6 Initial Tank Calibration
  - a. If initial setup and calibration was performed on the bench, go directly to Final Calibration (paragraph 4.7).
  - b. Perform initial level calibration of channel 1 per paragraphs 5.1 through 5.3 (T-800L or T-800LT)
  - c. If there is only one channel in this transmitter proceed directly to paragraph 4.7.
  - d. Perform initial temperature calibration of channel 1 per paragraphs 6.1 through 6.3 (T-800TT)
  - e. Perform initial temperature calibration of channel 2 per paragraph 6.1 through 6.3 (T-800LT or T-800TT)

#### 4.7 Final Calibration

- a. For each level channel, perform final calibration steps required per paragraph 5.4.
- b. For each temperature channel, perform final calibration steps required per paragraph 6.4.

#### 4.8 Final Installation

- a. Install transmitter cover using screws removed in step 4.5 c. above.
- b. Install housing cover using bolts removed in step 4.5 a. above.

### **CAUTION**

Ensure that the filter tubing is not pinched or kinked and that wiring does not extend under cover.

## **5. LEVEL SETUP AND CALIBRATION**

### 5.1 Tank Geometry

Figure 5.1 shows the two tank dimensions required to properly calibrate the transmitter for simple installations where 4mA is at tank bottom and 20 mA is at tank top. Figure 5.2 shows the more general definition of dimensions. The Distance to Tank Bottom (DTB) is the distance from the stillpipe sensor housing mounting flange to the bottom of the tank. The level at the 4mA point ( $L_{4MA}$ ) is the distance from tank bottom to the desired level to be set to 4mA. The bottom of the tank is normally calibrated to represent zero level (4 mA) and in this case  $L_{4MA} = 0.00$ . The Height of the Tank (HT) is the distance from the bottom of the tank to the top of the tank. The level at the 20 mA point ( $L_{20MA}$ ) is the distance from tank bottom to the desired level to be set to 20mA.

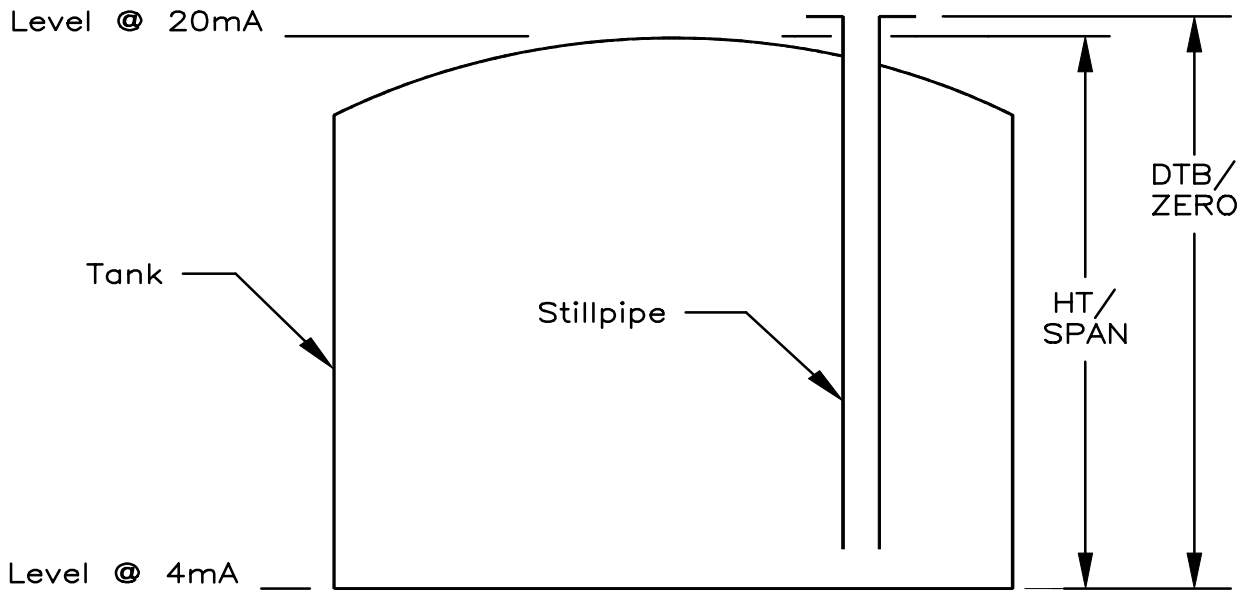


Figure 5.1 Tank Dimensions (Simple)

The top of the tank is normally calibrated to represent the maximum level (20 mA) and in this case  $L_{20A} = HT$ . The SPAN distance is the difference between the level at the 20 mA point and the level at 4 mA point.

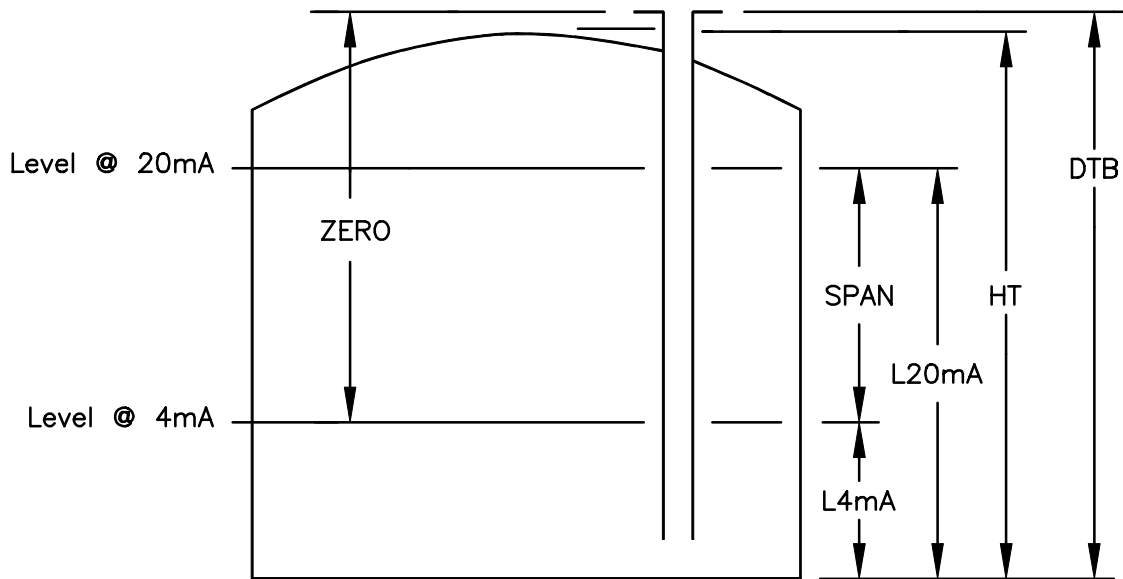


Figure 5.2 Tank Dimensions (General)

It will be necessary to determine the DTB (or ZERO) and the HT (or SPAN) for proper calibration in the following steps. If the transmitter is connected to a display instrumentation,  $D_{4MA}$  is the value to be displayed at  $L_{4MA}$  and  $D_{20MA}$  is the value to be displayed at  $L_{20MA}$ .

## 5.2 DIP Switch Settings

- a. Determine the span and zero distance as described in paragraph 5.1 above.
- b. Multiply the exact span distance by the sensor resistance gradient (RG) in ohms per foot. This value is nominally 304.8 ohms per foot but the exact value is printed on the sensor tag and on the sensor log.

$$R_{SPAN} \text{ (ohms)} = \text{SPAN distance (in feet)} \times \text{RG (in ohms per foot)}$$

- c. Determine the approximate 4 mA resistance by multiplying the ZERO distance (distance from the top of the still pipe to your 4 mA point (in feet) by the Resistance Gradient (RG) in ohms per foot, to define the 4 mA resistance in ohms.

$$R_{ZERO} \text{ (ohms)} = \text{ZERO distance (in feet)} \times \text{RG (in ohms per foot)}$$

See paragraph 5.4.2, if desired, for deriving exact ZERO resistance.

- d. The DIP Switch settings may be determined by either using the Resistance Table in Appendix A or the Distance Table in Appendix B. Location of the DIP Switch is shown in Figure 4.5. The Resistance Table is more accurate and is correct independent of any tank geometry. If the Distance Table is to be used, proceed to step h).
- e. Using Appendix A and the value of  $R_{ZERO}$ , set the ZERO DIP Switches (1 - 3) on the Level Board (Channel 1).
- f. Using Appendix A and the value of  $R_{SPAN}$ , set the SPAN DIP Switches (4 - 6) on the Level Board.
- g. Go to step j)
- h. Using Appendix B and the value of ZERO, set the ZERO DIP Switches on the Level Board (Channel 1).
- i. Using Appendix B and the value of SPAN, set the SPAN DIP Switches on the Level Board.
- j. Determine the 20 mA resistance ( $R_{20MA}$ ) by subtracting the span resistance ( $R_{SPAN}$ ) from the 4 mA resistance ( $R_{ZERO}$ ).

$$R_{20MA} = R_{ZERO} - R_{SPAN}$$

## 5.3 Initial Calibration

The following steps precisely calibrate the span of the sensor / transmitter and approximately calibrate the zero.

- a. Connect the Sensor Simulator (precision decade box) to the transmitter level channel.
- b. Set the Sensor Simulator resistance to  $R_{ZERO}$
- c. Adjust the ZERO potentiometer to obtain 4.00 mA (if using current meter) or to obtain the displayed value ( $D_{4MA}$ ) at  $L_{4MA}$  (if using instrumentation display)

**NOTE:** Clockwise rotation of the SPAN and ZERO potentiometers will increase the current for either adjustment. If the transmitter output is less than 3 mA, turning the ZERO potentiometer clockwise may initially reduce the current output. Continue to turn clockwise so that you get into the linear portion of the transmitter output.

**NOTE:** On rare occasions, if adjustment of the potentiometer does not allow the desired current or value to be reached, it may be necessary to go to the next DIP Switch position. This will also happen if the DIP switch setting has been set incorrectly to start with. If the ZERO DIP Switch setting is changed, it may be immediately necessary to change the SPAN DIP Switch setting. Table 5.1 below indicates which DIP switch setting to try “next” in Appendix A or Appendix B. After changing DIP switch setting, the corresponding potentiometer will have to be moved some distance in the opposite direction.

Rotation	ZERO - Can't reach 4mA	SPAN - Can't Reach 20 mA
Clockwise	Next further up	Next further left
Counter clockwise	Next further down	Next further right

Table 5.1 Level DIP Switch Readjustment

- d. Set the Sensor Simulator resistance to  $R_{20MA}$ .
- e. Adjust the SPAN potentiometer to obtain 20.00 mA (if using current meter) or to obtain the displayed value ( $D_{20MA}$ ) at  $L_{20MA}$  (if using instrumentation display).
- f. Repeat steps b) through e) until no further change in current or display occurs.

#### 5.4 Final Calibration

There are two methods for performing final calibration. The first (and preferred) uses an accurate tank measurement at one point to index the sensor and transmitter (paragraph 5.4.1). The second uses an accurate calculation of the ZERO resistance and uses that number to perform final indexing (paragraph 5.4.2). The latter is used when it is impractical to make a precise measurement or when the tank is empty.

**NOTE:** Do not adjust the SPAN potentiometer in any of the following steps.

##### 5.4.1 In-tank Indexing

These steps use the sensor in the tank with the liquid being gauged to make a final ZERO adjustment.

- a. If not yet installed in the sensor housing, place the transmitter in sensor housing and connect in final configuration per paragraph 4.5.
- b. If calibration is being made to instrumentation display, skip this step. If not already in place, connect DC current meter in series with current loop.
- c. Carefully make a precise level measurement using a handline or some other precision device.



**NOTE:** For the most accurate calibration, make this adjustment when the tank is approximately one-half full. As a minimum, the level must be at least 1 foot above the bottom of the sensor to ensure that the liquid is activating sensor contacts.

- d. Determine the correct process current (I) expected or the correct display value (D) expected (on user instrumentation) based on the level measurement made (L). For simple installations where SPAN = HT and  $L_{4MA} = 0$  (or  $D_{4MA} = 0$ ):

$$I = 16.00 \times L / HT + 4.00$$

$$D = D_{20MA} \times L / HT$$

For other installations:

$$I = (L - L_{4MA}) \times 16 / SPAN + 4.00$$

$$D = (L - L_{4MA}) \times (D_{20MA} - D_{4MA}) / SPAN + D_{4MA}$$

- e. Adjust the ZERO potentiometer to obtain the current or displayed value determined above. Do not adjust SPAN potentiometer.

#### 5.4.2 Simulated / Bench Indexing

These following steps use a calculated sensor resistance at the 4mA point to make a final ZERO adjustment.

- a. Calculate the resistance at the 4mA point using the following equation.

$$R_{4MA} = RZB + RLW + RG \times (ZERO + N - DTH + AD / SG)$$

where:

**RZB** Resistance of the zener barrier (if any). Note that this only applies if the zener barrier is placed between the sensor and the transmitter. This only happens when the transmitter is mounted in the non-hazardous location. A zener barrier in the current loop is not part of the resistance calculation.

**RLW** Lead wire resistance. This is the resistance of the lead wire between the sensor and the transmitter. If the transmitter is inside the sensor housing,  $RLW = 0$ .

**RG** Sensor resistance gradient. If all dimensions are in feet, the resistance gradient is nominally 304.8 ohms per foot. The exact value is located on the sensor tag or on the sensor log.

**ZERO** Distance from the sensor housing mounting flange down to the 4mA point (typically tank bottom). In the case of the Aquatape housing, ZERO is measured from the top of the threaded stillpipe to the 4mA point. This value was determined in paragraph 5.1.

**N** Sensor housing nipple height. The following chart shows the nipple height for the standard JOWA USA sensor housings:

JOWA USA Sensor Housing	Nipple height	
	Inches	Feet
AGS/SH666	0.00	0.00
PGS/SH887	1.75	0.15
CGS/SH887	1.75	0.15
SH/SS887	1.75	0.15
SH/SS887M	1.75	0.15
SH/SS8D9	1.75	0.15
SH/SS12D12	1.75	0.15

Table 5.2 Sensor Housing Nipple Height

- DTH Distance to top helix. This is the distance from the sensor mounting flange (sensor zero) to the first helix wire. This information is located on the sensor tag or the sensor log.
- AD Actuation Depth. This represent the constant head of water pressure required to close a contact. This information is located on the sensor tag or the sensor log.
- SG Specific Gravity. The specific gravity applies to the liquid being gauged. Nominal values of SG can be used as it only provides a second order correction to the derived resistance (a 5% change in specific gravity represents approximately a 0.02 foot change in level).

- b. Set the Sensor Simulator to the value determine in step a).
- c. Adjust the ZERO potentiometer to obtain a current of 4.00 mA or to obtain the display reading of  $D_{4MA}$ . Do not adjust the SPAN potentiometer.

## 6. Temperature Setup and Calibration

### 6.1 RTD Parameters

A sensor may have no resistance temperature detectors (RTD's) or it may have one to three RTD's depending on the model of the sensor. If the transmitter is a model T-800LT or T-800TT, there are one or two channels of temperature conversion.

### 6.2 DIP Switch Settings

- a. Determine whether the sensor has nickel-iron RTD(s) or 1000 ohm platinum RTD(s). Sensors having platinum RTD's will have "TP" in the model number. Sensors having nickel-iron RTD's will have T (without a "P") or TN in the model number.
- b. Determine the temperature ( $T_{4MA}$ ) that will be represented by 4mA. It is intended that that 4 mA be either 0°F or 0°C although the 4 mA point may be set within the range specified in Appendix C.
- c. For the RTD type determined in a. above, determine the resistance ( $R_{4MA}$ ) at  $T_{4MA}$  using Table 6.1.
- d. Determine the temperature ( $T_{20MA}$ ) that will be represented by 20 mA.

- e. For the RTD type determined in a) above, determine the resistance ( $R_{20MA}$ ) at  $T_{20MA}$  using Table 6.1.
- f. Calculate the temperature span  $T_{SPAN}$  using the following  

$$T_{SPAN} = T_{20MA} - T_{4MA}$$
- g. Calculate the temperature span resistance using the following  

$$R_{SPAN} = R_{20MA} - R_{4MA}$$
- h. If the RTD is nickel-iron, set the Temperature Board ZERO DIP switch S1-3 to the "On" position. If the RTD is 1000 ohm platinum, set the Temperature Board ZERO DIP switch S1-3 to the "Off" position.
- i. The span DIP Switch settings may be determined by either using the Resistance part or the Temperature part of Appendix C. The resistance table is more accurate and is correct independent of actual  $T_{4MA}$  used. The temperature table is accurate as long as the value of  $T_{4MA}$  is either 0°F or 0°C. If the Temperature table is to be used, proceed to step 13).
- j. Using Appendix C, ensure that the value of  $R_{4MA}$  is within the adjustable range.
- k. Using Appendix C and the value of  $R_{SPAN}$ , set the SPAN DIP Switches on the Temperature Board.
- l. Go to paragraph 6.3.
- m. Using Appendix C and the value of  $T_{SPAN}$ , set the SPAN DIP Switches on the Temperature Board.

### 6.3 Initial Calibration

The following steps calibrate the span of the temperature sensor / transmitter and approximately calibrate the zero.

- a. Connect the Sensor Simulator (precision decade box) to the transmitter temperature channel.
- b. Set the Sensor Simulator resistance to  $R_{4MA}$
- c. Adjust the ZERO potentiometer to obtain 4.00 mA (if using current meter) or to obtain the displayed value ( $D_{4MA}$ ) at  $T_{4MA}$  (if using instrumentation display)

**NOTE:** Clockwise rotation of the SPAN potentiometer and counterclockwise rotation of the ZERO potentiometer will increase the current for either adjustment. If the transmitter output is less than 3 mA, turning the ZERO potentiometer counterclockwise may initially reduce the current output. Continue to turn counterclockwise so that you get into the linear portion of the transmitter output.

°F	°C	Ni-Fe	Pt1000
-40	-40.00	498.6	842.8
-31	-35.00	511.2	862.5
-30	-34.44	512.6	864.7
-22	-30.00	523.9	882.2
-20	-28.89	526.7	886.6
-13	-25.00	536.8	901.9
-10	-23.33	541.1	908.5
-4	-20.00	549.9	921.6
0	-17.78	555.8	930.3
5	-15.00	563.1	941.2
10	-12.22	570.6	952.1
14	-10.00	576.6	960.9
20	-6.67	585.6	973.9
23	-5.00	590.2	980.4
30	-1.11	600.9	995.7
32	0.00	604.0	1000.0
40	4.44	616.4	1017.4
41	5.00	618.0	1019.5
50	10.00	632.1	1039.0
59	15.00	646.5	1058.5
60	15.56	648.1	1060.7
68	20.00	661.0	1077.9
70	21.11	664.2	1082.2
77	25.00	675.7	1097.3
80	26.67	680.6	1103.8
86	30.00	690.5	1116.7
90	32.22	697.2	1125.3
95	35.00	705.6	1136.1
100	37.78	714.0	1146.8
104	40.00	720.8	1155.4

°F	°C	Ni-Fe	Pt1000
110	43.33	731.0	1168.3
113	45.00	736.2	1174.7
120	48.89	748.3	1189.7
122	50.00	751.8	1194.0
130	54.44	765.8	1211.1
131	55.00	767.5	1213.2
140	60.00	783.5	1232.4
149	65.00	799.6	1251.6
150	65.56	801.4	1253.7
158	70.00	815.9	1270.7
160	71.11	819.5	1275.0
167	75.00	832.3	1289.8
170	76.67	837.8	1296.2
176	80.00	849.0	1308.9
180	82.22	856.4	1317.4
185	85.00	865.8	1328.0
190	87.78	875.2	1338.6
194	90.00	882.8	1347.0
200	93.33	894.2	1359.7
203	95.00	900.0	1366.0
210	98.89	913.5	1380.8
212	100.00	917.3	1385.0
220	104.44	932.9	1401.8
221	105.00	934.9	1403.9
230	110.00	952.6	1422.9
239	115.00	970.5	1441.7
240	115.56	972.5	1443.8
248	120.00	988.5	1460.6
250	121.11	992.6	1464.8
257	125.00	1006.8	1479.4

Table 6.1 RTD Resistance vs. Temperature

**NOTE:** On rare occasions, if adjustment of the potentiometer does not allow the desired current or value to be reached, it may be necessary to go to the next DIP Switch position. This will also happen if the DIP switch setting has been set incorrectly to start with. Table 6.2 below indicates which DIP switch setting to try “next” in Appendix C. After changing DIP switch setting, the corresponding potentiometer will have to be moved some distance in the opposite direction.

Rotation	ZERO - Can't reach 4mA	SPAN - Can't Reach 20 mA
Clockwise	Outside range	Next further left
Counter clockwise	Outside range	Next further right

Table 6.2 Temperature DIP Switch Readjustment

- d. Set the Sensor Simulator resistance to  $R_{20MA}$
- e. Adjust the SPAN potentiometer to obtain 20.00 mA (if using current meter) or to obtain the displayed value ( $D_{20MA}$ ) at  $T_{20MA}$  (if using instrumentation display).
- f. Repeat steps b) through e) until no further change in current or display occurs.
- g. Repeat all steps in paragraphs 6.1 through 6.3 for any other temperature transmitter channels (if any).

#### 6.4 Final Calibration

There are two methods for performing final calibration. The first (and preferred) uses an accurate tank measurement at one point to index the sensor and transmitter (paragraph 6.4.1). The second requires determining the point where highest accuracy is required and using that point to for final calibration. The latter is used when it is impractical to make a precise temperature measurement or when the tank is empty.

**NOTE:** Do not adjust the SPAN potentiometer in any of the following steps.

##### 6.4.1 In-tank Indexing

These steps use the sensor in the tank with the liquid being gauged to make a final ZERO adjustment.

- a. If not yet installed in the sensor housing, place the transmitter in sensor housing and connect in final configuration per paragraph 4.5.
- b. If calibration is being made to instrumentation display, skip this step. If not already in place, connect DC current meter in series with temperature channel current loop.
- c. Carefully make a precise temperature measurement

**NOTE:** For the most accurate calibration, this measurement should be made at approximately the same height as the RTD location and near the stillpipe. For single RTD sensors, this distance is approximately 2 feet above sensor bottom. Actual position of all RTD's is located on the sensor log.

- d. If adjusting to obtain correct process current, determine current (I) expected based on the temperature measurement T. For measurements where the temperature at 4mA is either 0°F or 0°C, the current I is calculated as follows:

$$I = 16.00 \times T / T_{20MA} + 4.00$$

Otherwise:

$$I = 16.00 \times (T - T_{4MA}) / (T_{20MA} - T_{4MA}) + 4.00$$

- e. Adjust the ZERO potentiometer to obtain the current determined above or displayed value. Do not adjust SPAN potentiometer.

#### 6.4.2 Simulated / Bench Indexing

These following steps use a calculated sensor resistance at the 4mA point to make a final ZERO adjustment.

- a. Using table 6.1, determine the resistance of the RTD at a temperature (T) where the system should be most accurate.

$$R = RT + RLW + DT \times 0.17$$

where:

R Total "RTD" resistance connected to the transmitter.

RT RTD resistance as determined from Table 6.1

RLW Lead wire resistance. This is the resistance of the lead wire between the sensor and the transmitter. If the transmitter is inside the sensor housing, RLW = 0.

DT Distance of the RTD location from the top of the sensor. This dimension is located on the sensor log.

0.17 Approximate RTD lead wire resistance per foot (per pair)

- b. If calibration is being performed to process current, determine expected process current using step 6.1.4 step d).
- c. Set the Sensor Simulator to the value determine in step a).
- d. Adjust the ZERO potentiometer to obtain a current determined in step b) above or to obtain the display reading of T used in step a) above. Do not adjust the SPAN potentiometer.

## 7. SPECIFICATIONS

Tables 7.1 through 7.6 lists the specifications for the T-800 series transmitters.

Parameter	Specification	Note
Minimum operating voltage (full specifications):	7.5 VDC	
Maximum continuous operating voltage (full specifications):	28.0 VDC	
Maximum continuous voltage:	34 VDC	
Reverse polarity protection:	50 VDC	
Transient protection type:	Metal Oxide Varister	
Transient energy level	0.5 joules	
Maximum continuous current (non fault):	30 mA	

Table 7.1 General Electrical Specifications

Parameter	Specification	Note
Level Type:	Innage	
Zero Adjustment (minimum):	800 $\Omega$	
DTB (minimum)	2.7 ft [0.8 m]	(1)
Zero Adjustment (maximum):	31000 $\Omega$	
DTB (minimum):	102 ft [31 m]	(1)
Zero Coarse Adjustment:	3 position DIP switch (8 steps)	
Zero Coarse Resolution:	3250 $\Omega$	
	10.6 ft [3.2 m]	(1)
Zero Fine Adjustment:	20 turn potentiometer	
Zero Fine Adjustment Range:	5000 $\Omega$	
	16.4 ft [5.0 m]	(1)
Span Coarse Adjustment:	3 position DIP switch	
	(8 steps)	
Span Fine Adjustment:	20 turn potentiometer	
Linearity:	$\pm 0.001\%$ of full scale or $\pm 0.05\%$	(2)
Temperature stability:	$\pm 0.001$ mA/ $^{\circ}$ C or $\pm .005\%$ / $^{\circ}$ C	
Power supply rejection:	$\pm 0.002$ mA / VDC	
Damping (-6 dB):	5 Hz	

Table 7.2 Level Electrical Specifications

Parameter	Specification	Note
RTD Types:	604 $\Omega$ Ni-Fe or 1000 $\Omega$ Pt	
RTD Selection:	DIP Switch	
Zero Adjustment (Ni-Fe position):	503 $\Omega$ to 676 $\Omega$ -35 $^{\circ}$ F [-37 $^{\circ}$ C] to 77 $^{\circ}$ F [25 $^{\circ}$ C]	
Zero Adjustment (1000 $\Omega$ Pt position):	878 $\Omega$ to 1050 $\Omega$ -24 $^{\circ}$ F [-31 $^{\circ}$ C] to 55 $^{\circ}$ F [13 $^{\circ}$ C]	
Zero Fine Adjustment:	20 turn potentiometer	
Span Coarse Adjustment:	2 position DIP switch (4 steps)	
Span Coarse Resolution	69 $\Omega$	
Span Coarse Adjustment Range (Ni-Fe position):	137 $\Omega$ to 414 $\Omega$ 87 $^{\circ}$ F [46 $^{\circ}$ C] to 238 $^{\circ}$ F [127 $^{\circ}$ C]	
Span Coarse Adjustment Range (1000 $\Omega$ Pt position):	194 $\Omega$ to 588 $\Omega$ 90 $^{\circ}$ F [50 $^{\circ}$ C] to 276 $^{\circ}$ F [154 $^{\circ}$ C]	
Span Fine Adjustment:	20 turn potentiometer	

Table 7.3 Temperature Electrical Specifications

Parameter	Specification	Note
Operating Temperature Range:	-40 $^{\circ}$ F to 158 $^{\circ}$ F [-40 $^{\circ}$ C to 70 $^{\circ}$ C]	
Storage Temperature Range:	-67 $^{\circ}$ F to 212 $^{\circ}$ F [-55 $^{\circ}$ C to 100 $^{\circ}$ C]	

Table 7.4 Environmental Specifications

Parameter	Specification	Note
Size (L x W x H):	4.5" x 2.5" x 1.6" [114mm x 63mm x 41mm]	
Connector type:	ITT Sure Seal	
Input Connector (from sensor):	4PF	
Output Connector (to field wiring):	4PM	

Table 7.5 Physical Specifications

Parameter	Specification	Note
Factory Mutual per 3610	Class I, Division 1, Groups C & D	3
Entity Parameters	Vmax	32 VDC
	I <sub>max</sub>	110 mA
	C <sub>i</sub>	0.2 mfd
	L <sub>i</sub>	0.0 mH

Table 7.6 Intrinsic Safety Specifications

- Notes:** (1) Applies to LA series sensors  
 (2) 25 °C  
 (3) See Appendix D for hazardous area installation requirements

## 8. INSPECTION AND MAINTENANCE

The maintenance schedule in Table 8.1 is recommended:

Period	Task
Annually	Perform Final Calibration per paragraphs 5.4 and 6.4
	Inspect sensor housing for evidence of flooding
	Inspect transmitter housing for evidence of moisture
	Inspect field wires for evidence of abrasion or corrosion

Table 8.1 Recommended Maintenance Schedule

## 9. TROUBLESHOOTING

If the transmitter is being connected for the first time, refer to Table 9.1 for list of symptoms and probable causes. If the transmitter has been operating properly, refer to Table 9.2.



Symptom	Probable Cause	Remedy
No output	Lead wires are reversed	a. Correct wiring
	Power supply not turned on or connected	a. Check voltage
Level channel current is very low (<4mA)	Sensor to transmitter connector is open	a. Plug in connectors. b. Check pins of connectors to ensure no pins have been pushed in.
Temperature channel current is high (>20mA)	Sensor to transmitter connector is open	a. Plug in connectors. b. Check pins of connectors to ensure no pins have been pushed in.
Level output appears 'high' when connected to sensor.	Sensor Filter not connected and equalized	a. Connect sensor filter.

Table 9.1 Troubleshooting the Initial Installation

Symptom	Probable Cause	Remedy
Very large current (>100mA) (over range display)	Failed components due to lightning or nearby lightning	Replace Transmitter
	Short or low resistance in field wires	a. Disconnect transmitter connector from field wiring connector. If short still exists, problem is in field wiring; if not, problem is in transmitter or sensor or their wiring. b. Check connections in sensor housing, redo if bad c. Check cable - replace if bad d. Check connections at instrumentation - redo if bad
Large Current (20 - 30 mA) (Over range display)	Liquid level above 20mA point	a. Lower liquid level b. Recalibrate for wider range
	Temperature above 20mA point.	a. Lower temperature b. Recalibrate for wider range

Table 9.2 Transmitter Troubleshooting (Continued on Next Page)

Symptom	Probable Cause	Remedy
	Pins pushed in	a. Verify that pins on both sensor and transmitter connectors are making proper connections.
	Temperature detector open	a. Open connector between sensor and transmitter. Short RTD pins at transmitter input connector. If no response, replace transmitter; otherwise problem is with sensor.
	Short in sensor / transmitter cables.	a. Open connector between sensor and transmitter. If high current goes low, problem is with sensor (check sensor) b. Replace transmitter
Low current (<4mA) (Under range display)	Liquid level is below 4mA point	a. Raise liquid level b. Recalibrate for wider range
	Pins pushed in	a. Verify that pins on both sensor and transmitter connectors are making proper connection.
	Level transmitter leads are open	a. Open connector between sensor and transmitter. Place short between level input pins and verify that current get large. If current does not increase, problem is with transmitter; otherwise problem is with sensor.
Current or display jumps slightly around or near expected value	Waves or ripples on liquid surface	Filter data in display.
	Sensor problem	Put Sensor Simulator or fixed resistor on transmitter input. If current or display is now steady, problem is with sensor or noise pickup with sensor.

Table 9.2 Transmitter Troubleshooting (Continued)

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Appendix A  
Level/Transmitter Zero / Span Switch Settings (Resistance Chart)

RZERO		RSPAN		DIP Switch Setting					
min kΩ	max kΩ	min kΩ	max kΩ	-1	-2	-3	-4	-5	-6
27.2	31.3	30.4	33.9	0	0	0	0	0	0
		27.0	30.4	0	0	0	1	0	0
		23.5	27.0	0	0	0	0	1	0
		20.0	23.5	0	0	0	1	1	0
		16.5	20.0	0	0	0	0	0	1
		13.0	16.5	0	0	0	1	0	1
		9.5	13.0	0	0	0	0	1	1
		6.0	9.5	0	0	0	1	1	1
23.2	27.2	26.6	29.6	1	0	0	0	0	0
		23.6	26.6	1	0	0	1	0	0
		20.5	23.6	1	0	0	0	1	0
		17.5	20.5	1	0	0	1	1	0
		14.4	17.4	1	0	0	0	0	1
		11.4	14.4	1	0	0	1	0	1
		8.3	11.4	1	0	0	0	1	1
		5.3	8.3	1	0	0	1	1	1
19.1	23.2	22.7	25.3	0	1	0	0	0	0
		20.1	22.7	0	1	0	1	0	0
		17.5	20.1	0	1	0	0	1	0
		14.9	17.5	0	1	0	1	1	0
		12.3	14.9	0	1	0	0	0	1
		9.7	12.3	0	1	0	1	0	1
		7.1	9.7	0	1	0	0	1	1
		4.5	7.1	0	1	0	1	1	1
15.3	19.1	18.9	21.1	1	1	0	0	0	0
		16.7	18.9	1	1	0	1	0	0
		14.6	16.7	1	1	0	0	1	0
		12.4	14.6	1	1	0	1	1	0
		10.2	12.4	1	1	0	0	0	1
		8.1	10.2	1	1	0	1	0	1
		5.9	8.1	1	1	0	0	1	1
		3.7	5.9	1	1	0	1	1	1

Note:    0 = Off = Open  
             1 = On = Closed

RZERO		RSPAN		DIP Switch Setting					
min kΩ	max kΩ	min kΩ	max kΩ	-1	-2	-3	-4	-5	-6
11.4	15.3	15.4	17.1	0	0	1	0	0	0
		13.6	15.4	0	0	1	1	0	0
		11.9	13.6	0	0	1	0	1	0
		10.1	11.9	0	0	1	1	1	0
		8.3	10.1	0	0	1	0	0	1
		6.6	8.3	0	0	1	1	0	1
		4.8	6.6	0	0	1	0	1	1
		3.0	4.8	0	0	1	1	1	1
7.4	11.4	11.5	12.9	1	0	1	0	0	0
		10.2	11.5	1	0	1	1	0	0
		8.9	10.2	1	0	1	0	1	0
		7.6	8.9	1	0	1	1	1	0
		6.2	7.6	1	0	1	0	0	1
		4.9	6.2	1	0	1	1	0	1
		3.6	4.9	1	0	1	0	1	1
		2.3	3.6	1	0	1	1	1	1
3.3	7.4	7.7	8.6	0	1	1	0	0	0
		6.8	7.7	0	1	1	1	0	0
		5.9	6.8	0	1	1	0	1	0
		5.0	5.9	0	1	1	1	1	0
		4.2	5.0	0	1	1	0	0	1
		3.3	4.2	0	1	1	1	0	1
		2.4	3.3	0	1	1	0	1	1
		1.5	2.4	0	1	1	1	1	1
0.8	3.3	3.8	4.3	1	1	1	0	0	0
		3.4	3.8	1	1	1	1	0	0
		3.0	3.4	1	1	1	0	1	0
		2.5	3.0	1	1	1	1	1	0
		2.1	2.5	1	1	1	0	0	1
		1.6	2.1	1	1	1	1	0	1
		1.2	1.6	1	1	1	0	1	1
		0.8	1.2	1	1	1	1	1	1

Note: 0 = Off = Open  
1 = On = Closed

Appendix B  
Level Transmitter Zero/Span Switch Settings (Length Chart)

DTB / D4MA		SPAN		DIP Switch Setting					
min (feet)	max (feet)	min (feet)	max (feet)	-1	-2	-3	-4	-5	-6
89.5	102.8	99.9	111.3	0	0	0	0	0	0
		88.4	99.9	0	0	0	1	0	0
		77.0	88.4	0	0	0	0	1	0
		65.6	77.0	0	0	0	1	1	0
		54.1	65.5	0	0	0	0	0	1
		42.6	54.1	0	0	0	1	0	1
		31.2	42.6	0	0	0	0	1	1
		19.8	31.2	0	0	0	1	1	1
76.2	89.5	87.3	97.3	1	0	0	0	0	0
		77.3	87.3	1	0	0	1	0	0
		67.3	77.3	1	0	0	0	1	0
		57.3	67.3	1	0	0	1	1	0
		47.2	57.2	1	0	0	0	0	1
		37.2	47.2	1	0	0	1	0	1
		27.3	37.2	1	0	0	0	1	1
		17.3	27.3	1	0	0	1	1	1
63.0	76.2	74.6	83.2	0	1	0	0	0	0
		66.1	74.6	0	1	0	1	0	0
		57.5	66.1	0	1	0	0	1	0
		49.0	57.5	0	1	0	1	1	0
		40.4	48.9	0	1	0	0	0	1
		31.9	40.4	0	1	0	1	0	1
		23.3	31.9	0	1	0	0	1	1
		14.8	23.3	0	1	0	1	1	1
50.3	63.0	62.0	69.1	1	1	0	0	0	0
		54.9	62.0	1	1	0	1	0	0
		47.8	54.9	1	1	0	0	1	0
		40.7	47.8	1	1	0	1	1	0
		33.6	40.7	1	1	0	0	0	1
		26.5	33.6	1	1	0	1	0	1
		19.4	26.5	1	1	0	0	1	1
		12.3	19.4	1	1	0	1	1	1

Note:    0 = Off = Open  
             1 = On = Closed

DTB / D4MA		SPAN		DIP Switch Setting					
min (feet)	max (feet)	min (feet)	max (feet)	-1	-2	-3	-4	-5	-6
37.6	50.3	50.5	56.2	0	0	1	0	0	0
		44.7	50.5	0	0	1	1	0	0
		38.9	44.7	0	0	1	0	1	0
		33.1	38.9	0	0	1	1	1	0
		27.3	33.1	0	0	1	0	0	1
		21.5	27.3	0	0	1	1	0	1
		15.8	21.5	0	0	1	0	1	1
		10.0	15.8	0	0	1	1	1	1
24.4	37.6	37.9	42.2	1	0	1	0	0	0
		33.5	37.9	1	0	1	1	0	0
		29.2	33.5	1	0	1	0	1	0
		24.9	29.2	1	0	1	1	1	0
		20.5	24.8	1	0	1	0	0	1
		16.2	20.5	1	0	1	1	0	1
		11.8	16.2	1	0	1	0	1	1
		7.5	11.8	1	0	1	1	1	1
11.1	24.4	25.2	28.1	0	1	1	0	0	0
		22.3	25.2	0	1	1	1	0	0
		19.4	22.3	0	1	1	0	1	0
		16.6	19.4	0	1	1	1	1	0
		13.6	16.5	0	1	1	0	0	1
		10.8	13.6	0	1	1	1	0	1
		7.9	10.8	0	1	1	0	1	1
		5.0	7.9	0	1	1	1	1	1
2.8	11.1	12.6	14.0	1	1	1	0	0	0
		11.2	12.6	1	1	1	1	0	0
		9.7	11.2	1	1	1	0	1	0
		8.3	9.7	1	1	1	1	1	0
		6.8	8.3	1	1	1	0	0	1
		5.4	6.8	1	1	1	1	0	1
		3.9	5.4	1	1	1	0	1	1
		2.5	3.9	1	1	1	1	1	1

Note: 0 = Off = Open  
1 = On = Closed

## Appendix C

Temperature Transmitter Zero / Span Settings (Resistance Chart)

RTD Type	R <sub>ZERO</sub>		R <sub>SPAN</sub>		DIP Switch Setting		
	min ohms	max ohms	min ohms	max ohms	-3	-4	-5
1000 Ω Platinum	878	1050	490	588	0	0	0
			391	490	0	1	0
			293	391	0	0	1
			194	293	0	1	1
604 Ω Nickel-Iron	503	676	345	414	1	0	0
			275	345	1	1	0
			206	275	1	0	1
			137	206	1	1	1

Temperature Transmitter Zero / Span Settings (Temperature °C Chart)

RTD Type	T <sub>ZERO</sub>		T <sub>20MA</sub>		DIP Switch Setting		
	min (°C)	max (°C)	min (°C)	max (°C)	-3	-4	-5
1000 Ω Platinum	-31	13	128	154	0	0	0
			102	128	0	1	0
			76	102	0	0	1
			50	76	0	1	1
604 Ω Nickel-Iron	-37	25	109	127	1	0	0
			89	109	1	1	0
			68	89	1	0	1
			46	68	1	1	1

Temperature Transmitter Zero / Span Settings (Temperature °F Chart)

RTD Type	T <sub>ZERO</sub>		T <sub>20MA</sub>		DIP Switch Setting		
	min (°F)	max (°F)	min (°F)	max (°F)	-3	-4	-5
1000 Ω Platinum	-24	55	229	276	0	0	0
			182	229	0	1	0
			136	182	0	0	1
			90	136	0	1	1
604 Ω Nickel-Iron	-35	77	203	238	1	0	0
			166	203	1	1	0
			128	166	1	0	1
			87	128	1	1	1

Note:    0 = Off = Open  
           1 = On = Closed



