RoHS 2 Compliant

502A-E
4-20 THERMOCOUPLE TRANSMITTER

10634ML-01

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1.0 GENERAL INFORMATION

The 502A-E two-wire transmitter takes in microvolt signals generated by a type E thermocouple, provides cold (reference) junction compensation, amplification, common-mode isolation, and controls the current drawn from a 9-to-50 V dc source to produce the 4-to-20 milliampere output signal.

Common-mode voltage between the input thermocouple and the output current circuit is tested at 1500 V rms. As much as 750 ohms dropping resistance may be used in the power leads of the 502A-E when the unit is energized from a 24 V dc source because of the small compliance voltage needed by the unit. Accidental overloads of over one minute by 120 V rms on either input or output leads do not damage the 502A-E.

1.1 ACCURACY AND STABILITY

The 502A-E has tailored resistance values installed to provide curvilinear cold-junction compensation matched to the NBS E thermocouple table. Selected bridge resistors in a temperature-sensing bridge also provide cancellation of Span temperature effects. The unit is certified for accuracy from -40 to +85°C (-40°F to +185°F) through verification of high-ambient-temperature compensation points.

1.2 ADAPTABILITY/TURNDOWN

The Span of the 502A-E can be ranged anywhere from 100 to 1050°C by selection of one of four jumper positions, with fine tuning provided by a multiturn, top-accessible potentiometer. Sixteen Zero steps, also provided by 502A-E jumpers, allow placement of the 4-mA output temperature anywhere from -50 to 900°C, with fine tuning provided by another top-accessible, multiturn potentiometer. This 502A-E turndown capability exceeds that of any other known transmitter.

1.3 ELECTRICAL ISOLATION

502A-E input (thermocouple and shield) and output (DC power) barrier strips accept wires up to two mm in diameter (13 gauge), and are mechanically isolated from each other to prevent input/output wiring contact during installation.

1.4 SHOCK RESISTANCE

Lightweight 502A-E circuit boards are formed into a rigid box structure and firmly soldered to the case top. The circuit-board box is doubly coated with RTV silicone for environmental protection. When installed in the rugged, die-cast case, the 502A-E can withstand the shock of a 6-foot drop onto a hard surface (although scarring of the case and/or deformation of the plastic cover can occur).

1.5 WATERPROOF/RFI-RESISTANT CASE

The 502A case is made from Zamac (zinc alloy), coated with polyurethane, and gasketed with fluorosilicone. Fluorosilicone plugs protect the top-access Span and Zero potentiometers. An optional opaque top cover shields the barrier strips from uneven heating or cooling in exposed environments.

1.6 MOUNTING ADAPTABILITY

The small size of the 502A (less than 75 mm or 3 in. outside diameters) permits snap mounting into the American 8TK2 relay track or wall mounting in confined areas. With a bulkhead adapter, the 502A can be snap mounted into the larger American TR2/2TK relay track or wall mounted by rotating the adapter 90 degrees. With the use of the rail clamp adapter, the 502A may be mounted onto the narrow DIN EN-50-022 relay track. Using the spring retainer option, the 502A can be mounted into explosion-proof housings.

2.0 SPECIFICATIONS

2.1 INPUT

Configuration:	Isolated input
Thermocouple type:	E, Chromel/Constantan
Input impedance:	5 Megohms
Thermocouple break-detect current:	50 nA max
Burnout indication:	Selectable up or down overscale
Thermocouple lead resistance:	To 500 Ω for specified performance
Normal mode rejection:	60 dB at 50/60 Hz with 100 mV input
Common mode voltage, input to case or output:	2100 V peak per high pot. test; 354 V peak per IEC spacing
Common mode rejection, input to case or output:	100 dB min from DC to 60 Hz
Overvoltage protection:	120 V ac max / 1 min exposure

2.2 OUTPUT

Linear range:	4 to 20 mA dc
Compliance (supply-voltage):	9 to 50 V dc
Overvoltage protection:	120 V ac
Reverse polarity protection:	400 V peak

Common mode voltage, output to case or input:	2100 V peak per high pot. test; 354 V peak per IEC spacing
Common mode rejection, output to case or input:	100 dB min from DC to 60 Hz

2.3 ACCURACY

Hysteresis and repeatability:	Within ±0.2°C ±0.1% of Span
Conformity, 100°C Span:	±1°C
Six-month stability:	Within ±0.2°C ±0.2% of 4 mA temperature
Power supply effect:	Within ±0.005%/V
Ambient temperature effect for 50°C change:	ZERO Error: +/-0.04°C/°C Typical SPAN Error: +/-0.03°C/°C Typical

2.4 ENVIRONMENTAL

Operating temperature:	-40 to 85°C
Storage temperature:	-55 to 125°C
Humidity:	To 100%
Vibration:	1.52 mm (.06 in) double amplitude, 10-80 Hz cycled
Shock:	55g, half-sine, 9-13 msec duration, 6' drop to hard surface
Watertight pressure limit:	35 kPa (5 psi)
Mounting position:	Any

2.5 MECHANICAL

Case material:	Zamac (zinc alloy), polyurethane-coated, fluorosilicone-gasketed
Weight:	300 g (10 oz)
Diameter:	74 mm (2.9 in)
Height (including barriers):	52 mm (2.1 in)
Connections:	#6 screws with wire clamps

3.0 MECHANICAL ASSEMBLY AND INSTALLATION

3.1 SAFETY CONSIDERATIONS

This instrument is protected according to Class I (Protective Earth) of the IEC (International Electrotechnical Commission) 348 and the VDE 0411 regulations. To ensure safe operation, follow the guidelines below:

EXERCISE CAUTION: The typical installation of a transmitter may expose the installer to high voltage on both the signal and the power leads to earth ground. Be sure that all sources of power are turned off during installation. Also use caution while calibrating this instrument if the signal and power are connected.

VISUAL INSPECTION: Do not attempt to operate the unit if damage is found.

POWER VOLTAGE: Verify that the instrument is connected for the power voltage rating that will be used (9-50 V dc). If not, make the required changes as described in Section 4.

POWER WIRING: This instrument has no power switch; it will be in operation as soon as the power is connected.

The transmitter must be grounded in accordance with the latest local safety regulations.

SIGNAL WIRING: Do not make signal wiring connections or changes while power is on.

RAIN OR MOISTURE: Do not expose the instrument to condensing moisture.

FUMES AND GASES: Do not operate the instrument in the presence of flammable gases or fumes.

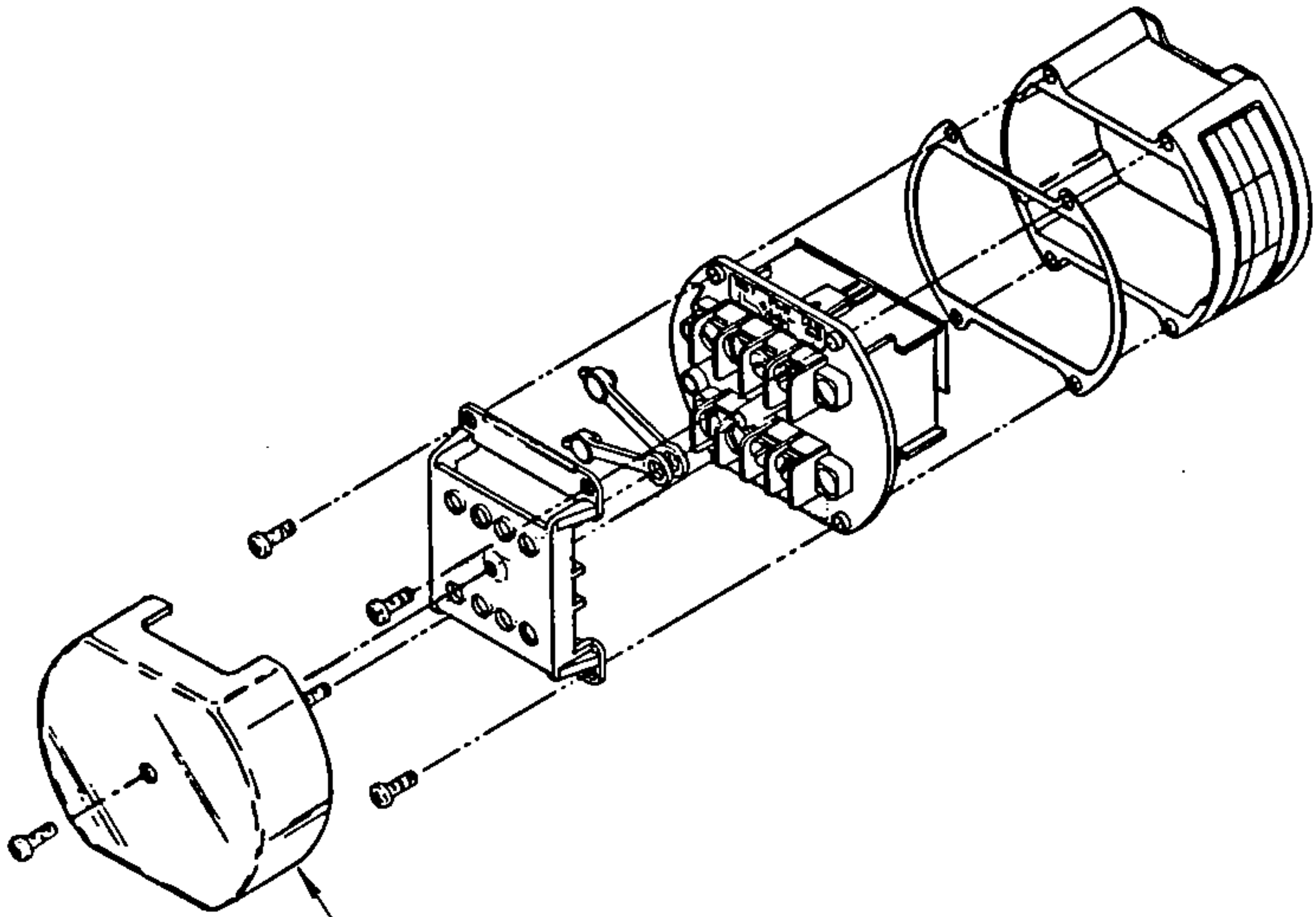
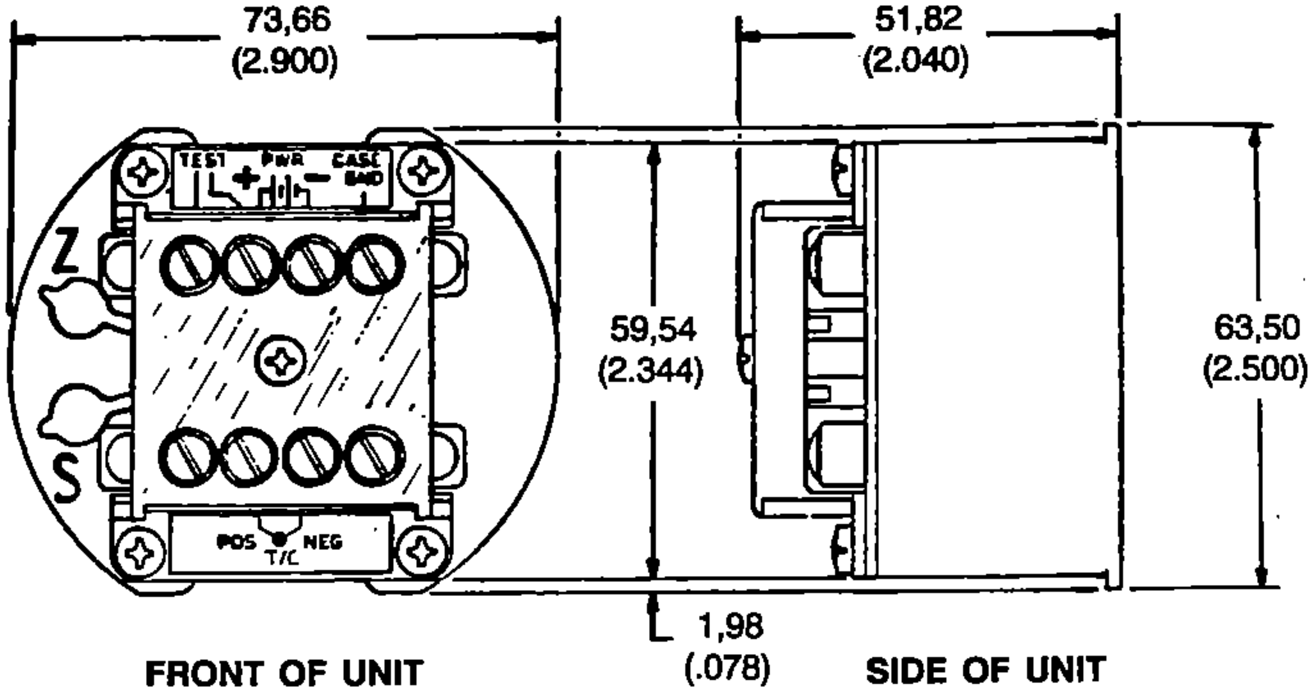
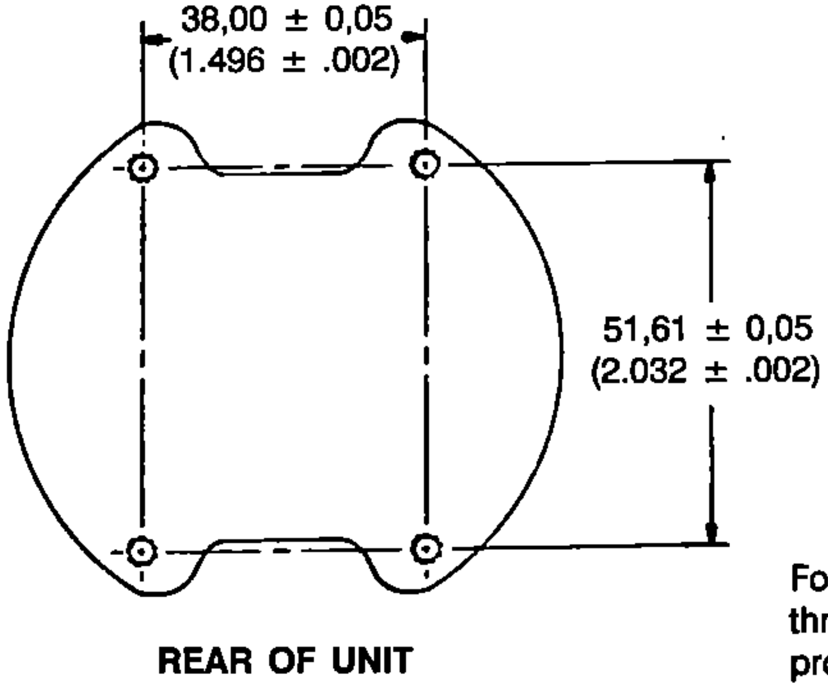


Figure 3-1 Exploded View





Four tapped holes with #6-32 screw threads on the rear of the case provide behind-the-wall access for bulkhead mounting; flanges on the rear of the case snap into the American 8TK2 rail for track mounting.

Figure 3-2 Case Dimensions

3.2 OPTIONAL ADAPTERS FOR MOUNTING

The following optional adapters provide various mounting choices:

a. Adapter plate for either front-screw-entry surface mount or TR2/2TK relay track mount. (See Figure 3-3.)

b. Rail clamp for DIN EN-50-022 relay track mount. (See Figure 3-4.)

c. Spring retainer for explosion-proof housings that have internal diameters of 76.4 to 88.9 mm (3.0 to 3.5 in.). (See Figure 3-5.)

For ordering purposes, the options are identified as follows:

Adapter plate	MAT1
Rail Clamp	MDT1
Spring Retainer for Explosion-proof or Waterproof housing	MXS1
Explosion-proof/ Waterproof housing	EPH (Includes MXS1)

3.3 SURFACE AND TR2/2TK RELAY TRACK MOUNTING

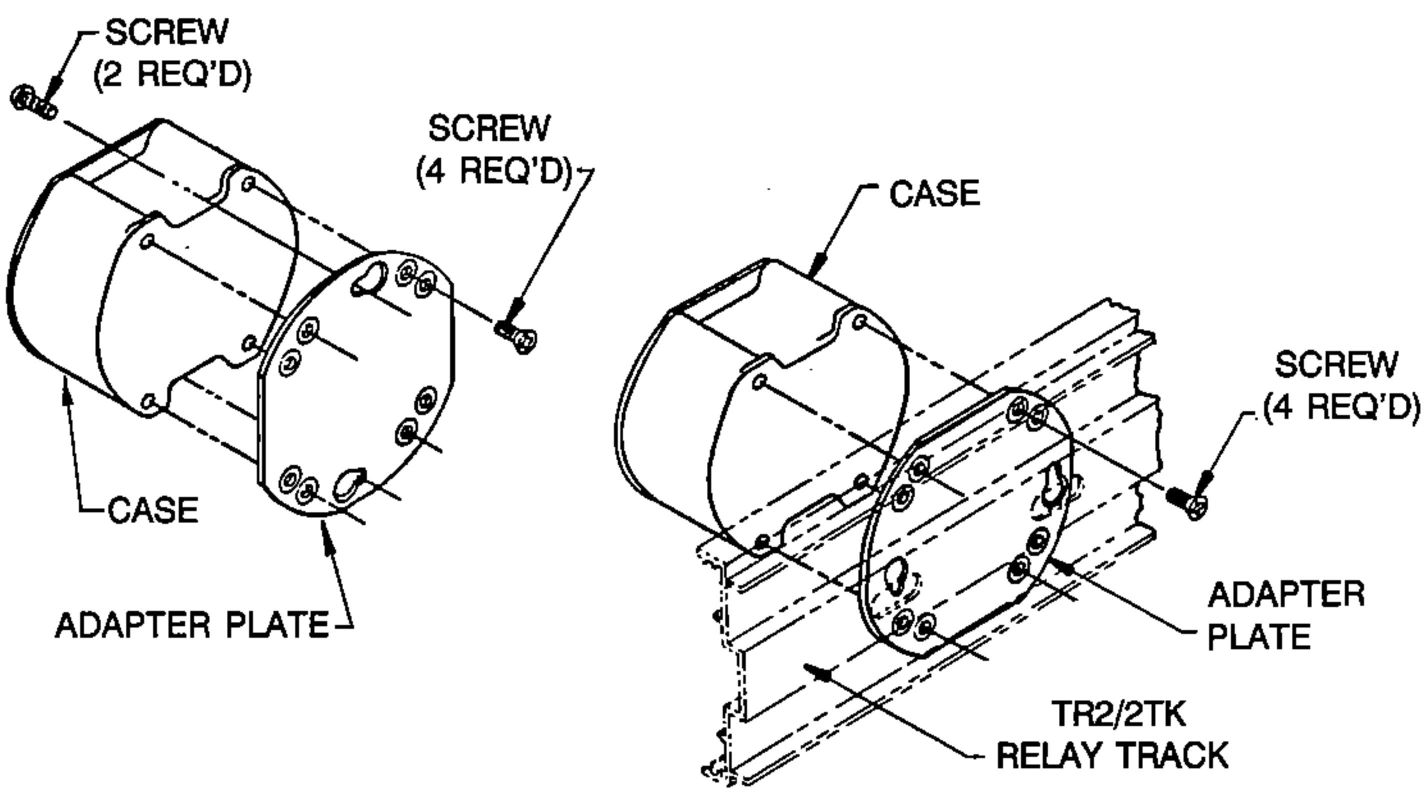
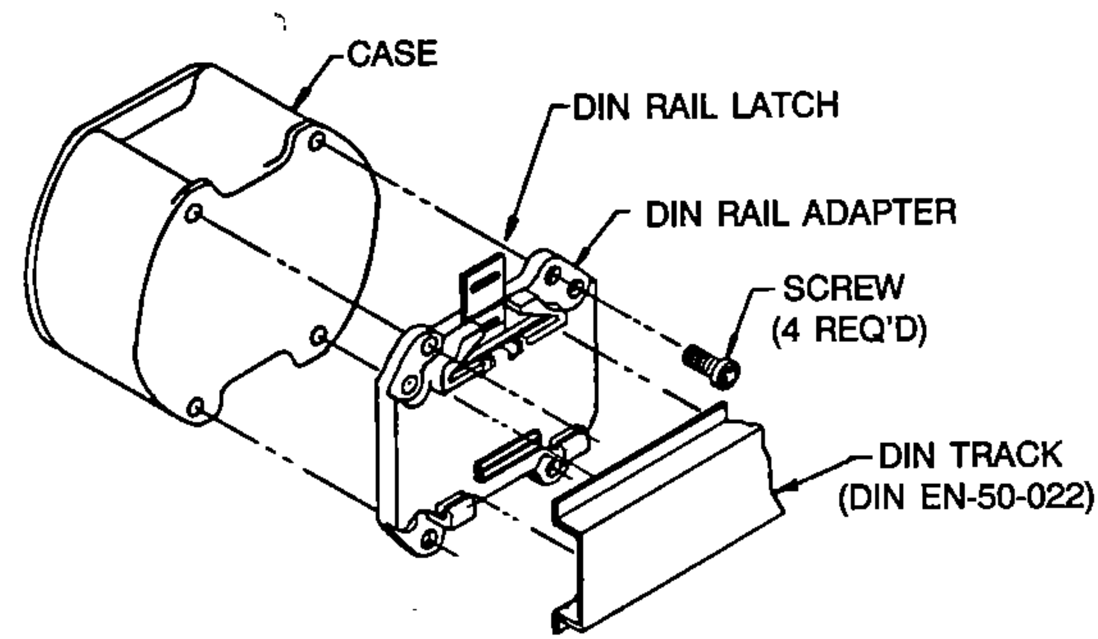


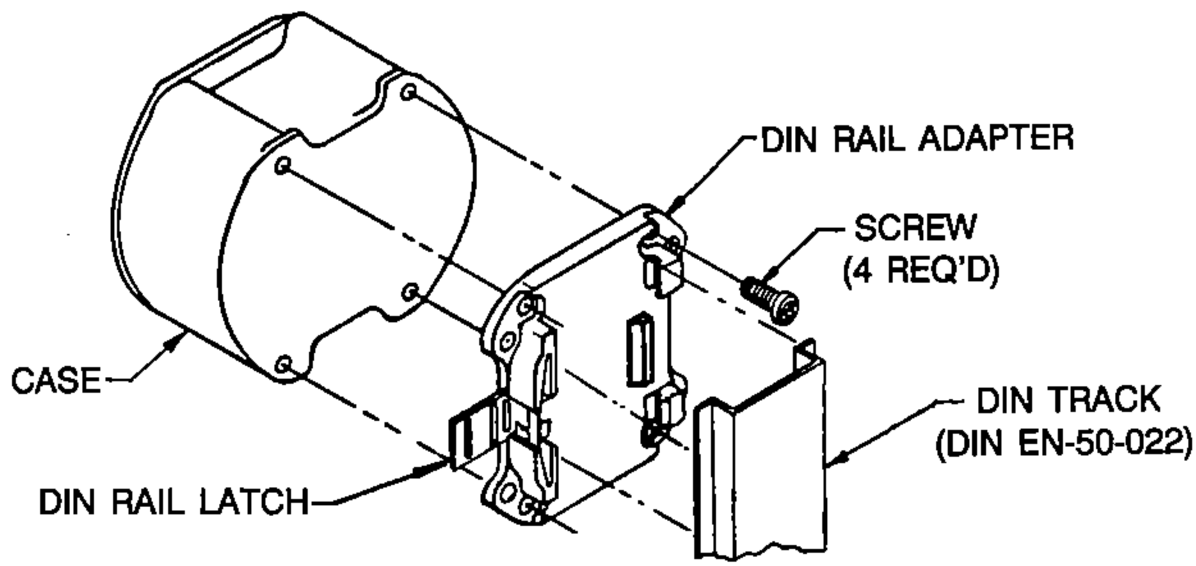
Figure 3-3 Bulkhead and Track Mounting

1. Position plate for desired application.
2. Use #6 hardware to mount plate to back of 502A case.

3.4 DIN EN-50-022 RELAY TRACK MOUNTING



DIN TRACK MOUNTING: SHOWN FOR HORIZONTAL TRACK

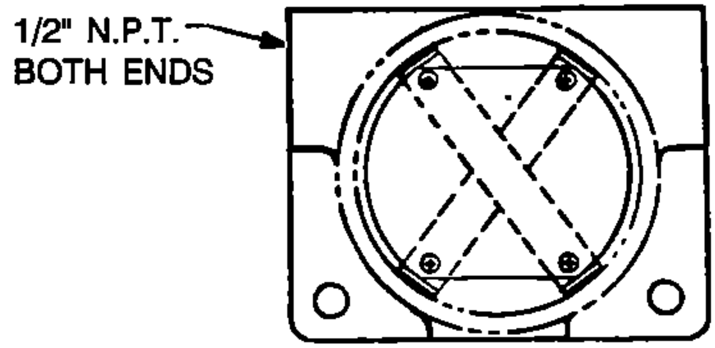


DIN TRACK MOUNTING: SHOWN FOR VERTICAL TRACK

Figure 3-4 DIN Track Mounting

1. Position adapter for desired track direction.
2. Use #6 screws to mount adapter to back of 502A case.
3. Snap 502A case assembly onto DIN rail.

3.5 EXTERNAL EXPLOSION-PROOF HOUSING MOUNTING



TOP VIEW OF EXPLOSION-PROOF HOUSING.
UNIT AND HOUSING SHOWN FOR REFERENCE ONLY.

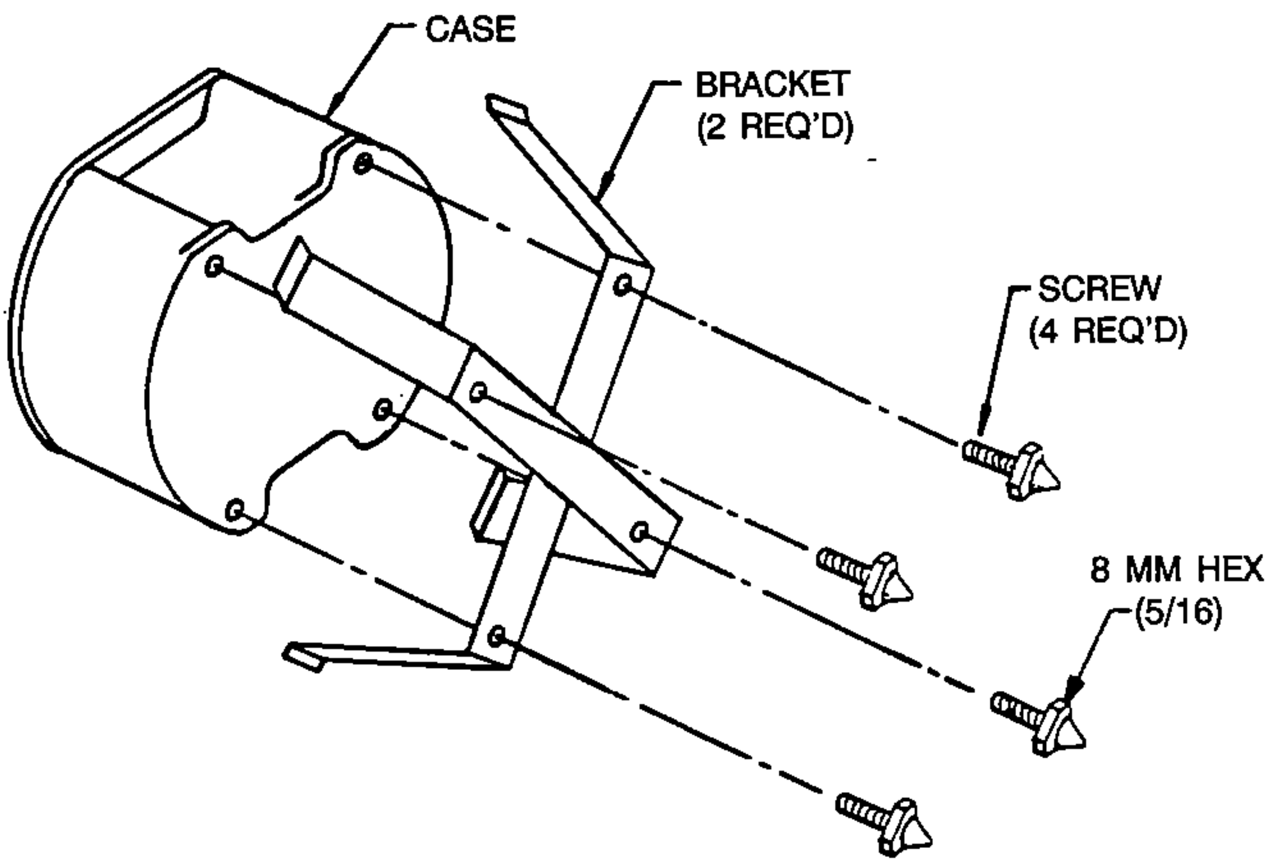


Figure 3-5 Spring Retainer for Explosion-Proof Housing

1. Position spring retainer across back of 502A case.
2. Use wire protector feet (four provided with above option) to hold spring retainers in place.
3. Press 502A case assembly into explosion-proof housing.

4.0 POWER AND SIGNAL INPUT CONNECTIONS

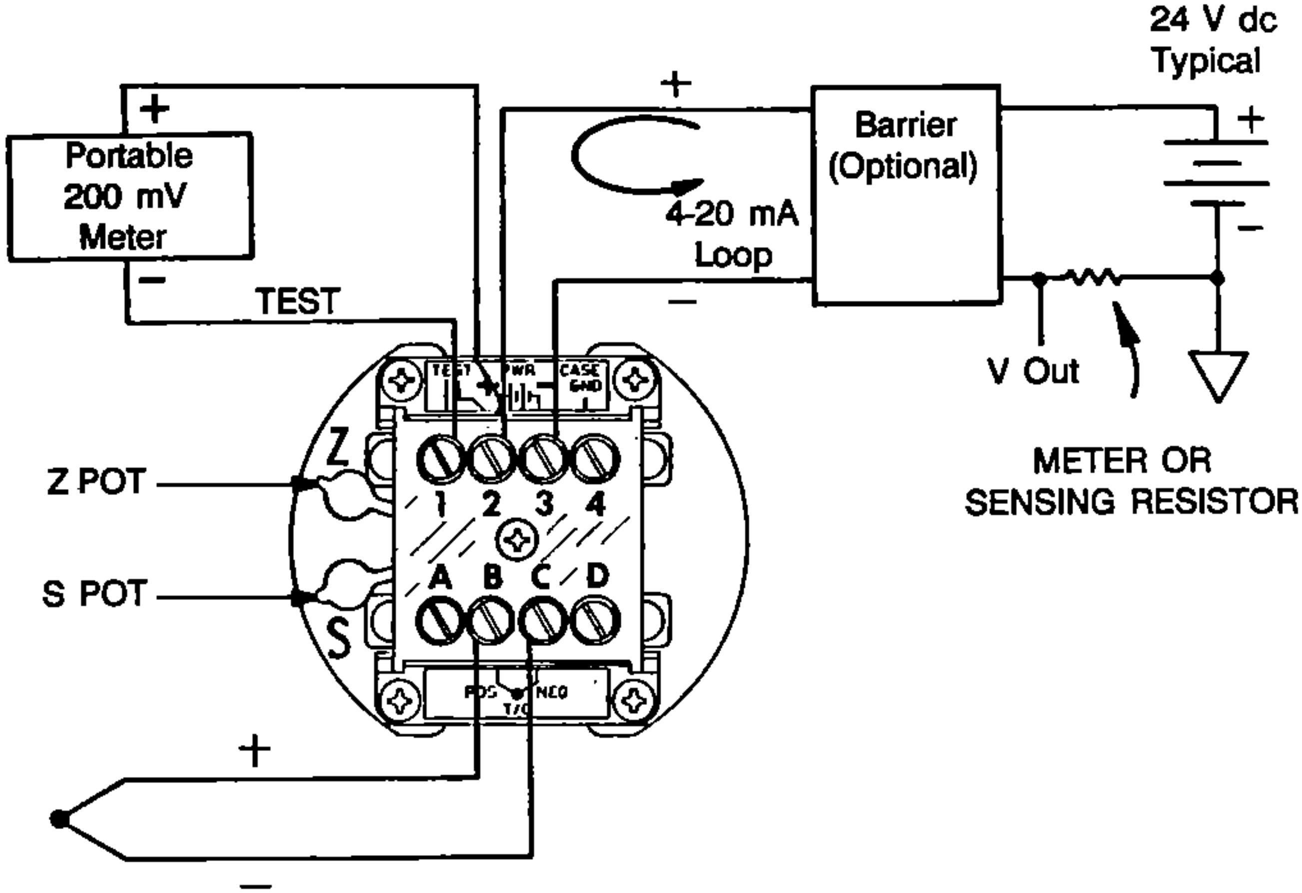


Figure 4-1 Power Input Connections

TEST, PWR +, and PWR - screws accept 2 mm (13 gauge) or lighter wire. CASE GND is grounded to the case. Input range is 9-50 V dc.

SCREW-TERMINAL PIN ASSIGNMENT

1 TEST
2 + POWER/OUTPUT
3 - POWER/OUTPUT
4 CASE GND

A N/C
B + TC
C -TC
D N/C

5.0 CONFIGURATION

The 502A-E is normally delivered configured for 4 - 20 mA = 0 - 500°C.

5.1 TOOLS AND EQUIPMENT

#1 Phillips screwdriver

VACO 17764 or equivalent flathead screwdriver

4 1/2 digit digital voltage meter or 4 1/2 digit 25 mA current meter

10 ohm or 100 ohm 1% resistor

Fixed or variable DC power supply or battery (range of 12-30 V dc)

Precision thermometer

Calibrated microvolt source (in the range of -3000 to 80000 μV)

KAYE 140 or equivalent 0°C ice-point cell (Optional)

5.2 CALIBRATION USING AMBIENT TEMPERATURE

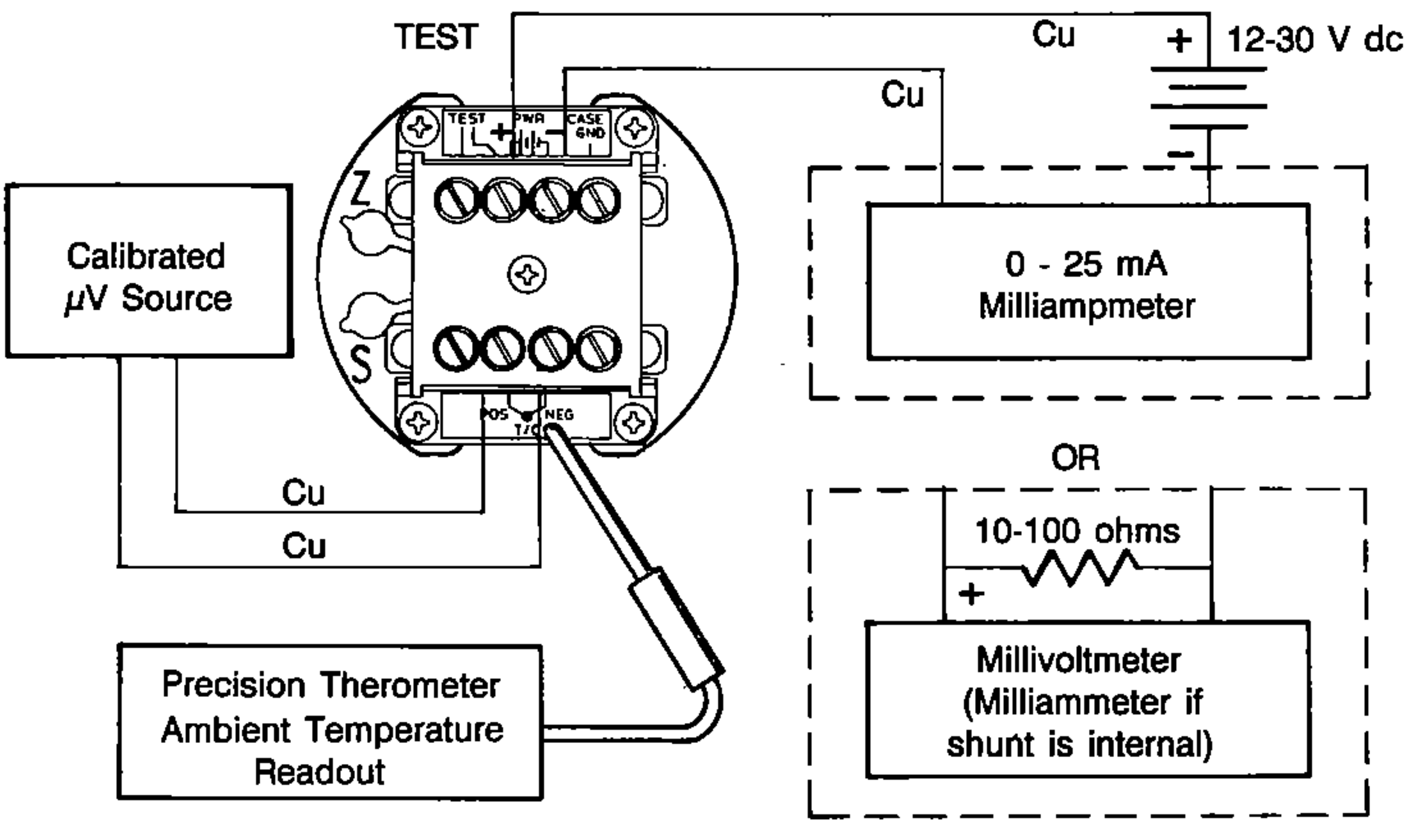


Figure 5-1 Calibration Setup Using Ambient Temperature

Refer to Figure 5-3 (Calibration Flowchart) and familiarize yourself with the general procedure to be followed.

1. Remove the outer four screws from the case top and lift out the electronics assembly (attached to the case lid).
2. Pull out the two sealing plugs which cover the Span and Zero potentiometers (**S pot** and **Z pot**). Adjust the S pot about ten turns clockwise (CW) from the fully counter-clockwise (CCW) position.

NOTE:	S pot and Z pot are both multi-turn pots; 15 complete turns in a CCW direction will ensure that the pot is fully CCW. For maximum stability, the S pot should never be fully CW.

3. Using Table 5-2, select the range which comes closest to your desired 4 and 20 mA temperatures. Note which Zero and Span jumpers are specified in the table for the range selected.
4. Turn the unit so that the jumper pin-forest is in view, and install the push-on jumpers on the positions indicated (see Figure 5-4). Place unused jumpers in storage positions.
5. Refer to Figure 5-1 and connect the transmitter to the power supply, microvolt source, milliammeter (or current shunt and millivoltmeter). Place the temperature probe as close as possible to the 502A-E input terminals. **Better calibration stability is obtained if the electronic assembly is configured while in the case.**
6. Using Table 5-1, determine the microvolt level that the ambient (Room) temperature represents. Subtract this from the microvolt level corresponding to the desired 4.00 mA temperature, found in Table 5-1. This value is **LO-IN**.
7. Set the microvolt calibration source to LO-IN microvolts and adjust the Z pot until the milliammeter reads 4.00 mA.
8. Using the previously determined microvolt level of the ambient (Room) temperature, subtract this from the microvolt level corresponding to the desired 20.00 mA temperature (Table 5-1). This value is **HI-IN**.
9. Set the microvolt calibration source to HI-IN microvolts and read the output current on the milliammeter. This current level is designated **Initial Top Current** (ITC), normally not equal to 20.00 mA.

10. Calculate the **Corrected Top Current** (CTC) with the following equation (generally this will not equal 20.00 mA).

$$CTC = 16 \cdot ITC / (ITC - 4\ mA)$$

11. Adjust the S pot to obtain the Corrected Top Current on the milliammeter.
12. Now readjust the Z pot so that the milliammeter reads 20.00 mA.
13. Set the microvolt source to LO-IN microvolts. If the output current is not 4.00 mA, repeat steps 7 through 12.
14. When calibration is complete, remove the transmitter from the setup and replace the sealing plugs. Reinstall the unit in the case and ensure that the four screws are tightened enough to compress but not flatten the gasket.

EXAMPLE:

Temperature Range = -58 to 662°F or -50 to 350°C *
* Conversion Formula for Fahrenheit to Celsius: (°F - 32) x 5/9 = °C

Zero Jumper required	C	(Table 5-2)
Span Jumper required	NONE	(Table 5-2)

4.00 mA Output = -50°C or -2787 μV (Table 5-1)
20.00 mA Output = 350°C or 24961 μV (Table 5-1)

Ambient Temperature = 25°C or 1495 μV (Table 5-1)
LO-IN = -2787 - 1495 = -4282 μV
HI-IN = 24961 - 1495 = 23466 μV

For specific values not given in Table 5-1, interpolation may be used.

Calibration steps:

1. Adjust the S pot about ten turns CW from a fully CCW position.
2. Set microvolt source to -4282 μV.
3. Adjust the Z pot so that the milliammeter reads 4.00 mA.
4. Set microvolt source to 23466 μV.
5. Read the Initial Top Current.
6. Calculate the Corrected Top Current.
7. Adjust the S pot to obtain the Corrected Top Current.
8. Adjust the Z pot to obtain a 20.00 mA current reading.
9. Set microvolt source to -4282 μV.
10. If the output is not 4.00 mA, repeat steps 2 through 9.

5.3 CALIBRATION USING ICE-POINT CELL

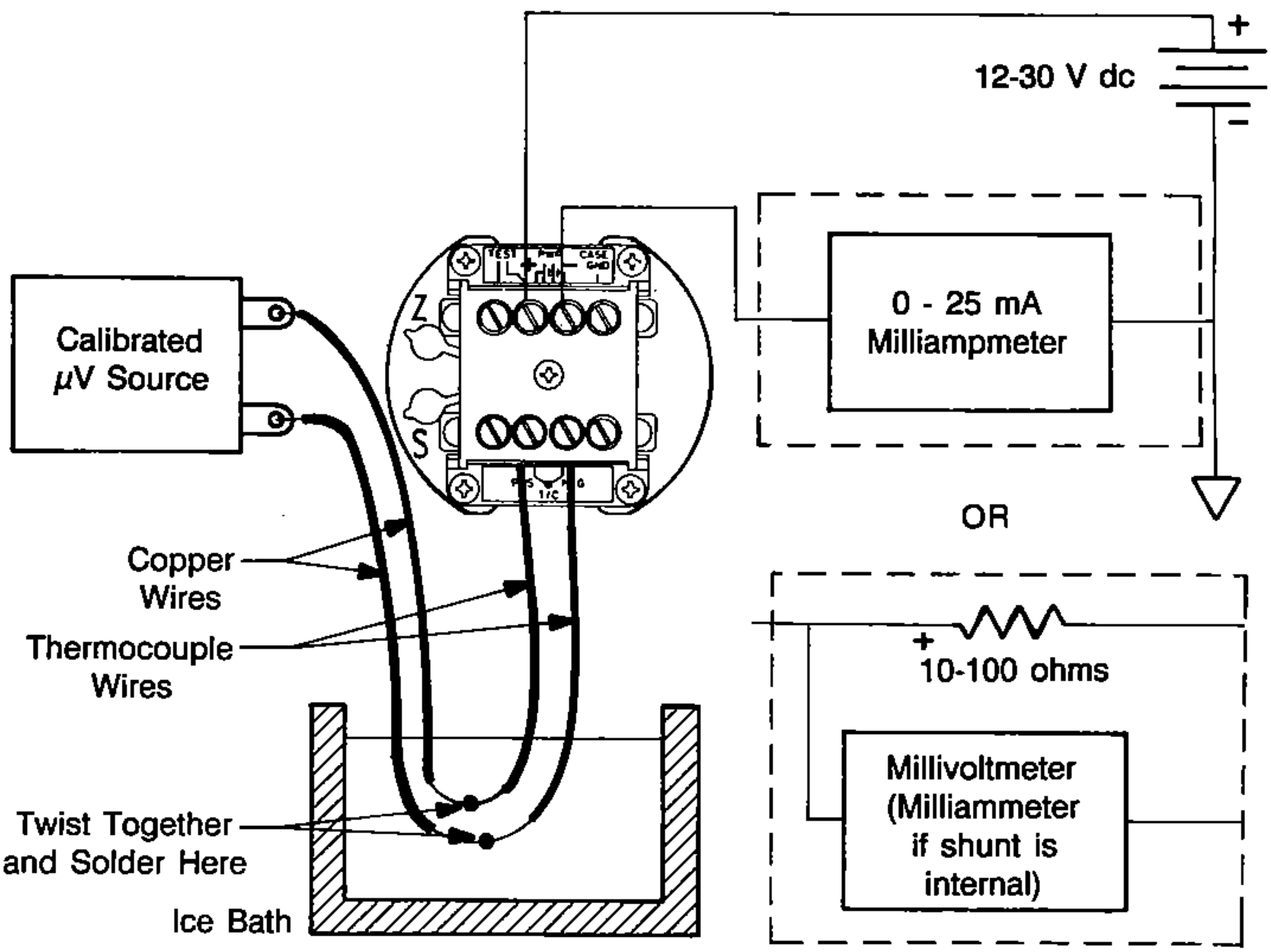


Figure 5-2 Calibration Setup Using Ice-Point Cell

Refer to Figure 5-3 (Calibration Flowchart) and familiarize yourself with the general procedure to be followed.

1. Remove the outer four screws from the case top and lift out the electronics assembly (attached to the case lid).
2. Pull out the two sealing plugs which cover the Span and Zero potentiometers (**S pot** and **Z pot**). Adjust the S pot about ten turns clockwise (CW) from the fully counter-clockwise (CCW) position.

NOTE:	S pot and Z pot are both multi-turn pots; 15 complete turns in a CCW direction will ensure that the pot is fully CCW. For maximum stability, the S pot should never be fully CW.

3. Using Table 5-2, select the range which comes closest to your desired 4.00 and 20.00 mA temperatures. Note which Zero and Span jumpers are called out in the table for the range selected.
4. Turn the unit so that the jumper pin-forest is in view and install the push-on jumpers on the positions indicated (see Figure 5-4). Place the unused jumpers in storage positions.
5. Refer to Figure 5-2 and connect the transmitter to the power supply, microvolt source, milliammeter (or current shunt and millivoltmeter). Ensure that the copper wires from the millivolt source and the thermocouple wires from the 502A-E are soldered together and immersed in the ice bath. **Better calibration stability is obtained if the electronic assembly is configured while in the case.**
6. Using Table 5-1, determine the microvolt level corresponding to the desired 4 mA temperature. This value is **LO-IN**.
7. Set the microvolt calibration source to LO-IN microvolts and adjust the Z pot until the milliammeter reads 4.00 mA.
8. Determine the microvolt level corresponding to the desired 20.00 mA temperature. This value is **HI-IN**.
9. Set the microvolt calibration source to HI-IN microvolts and read the output current on the milliammeter. This current level is designated **Initial Top Current** (ITC), normally not equal to 20.00 mA.
10. Calculate the **Corrected Top Current** (CTC) with the following equation (generally this will not equal 20.00 mA).

$$CTC = 16 \cdot ITC / (ITC - 4\ mA)$$

11. Adjust the S pot to obtain the Corrected Top Current on the milliammeter.
12. Now readjust the Z pot so that the milliammeter reads 20.00 mA.
13. Set the microvolt source to LO-IN microvolts. If the output current is not 4.00 mA, repeat steps 7 through 12.
14. When calibration is complete, remove the transmitter from the setup and replace the sealing plugs. Reinstall the unit in the case and ensure that the four screws are tightened enough to compress but not flatten the gasket.

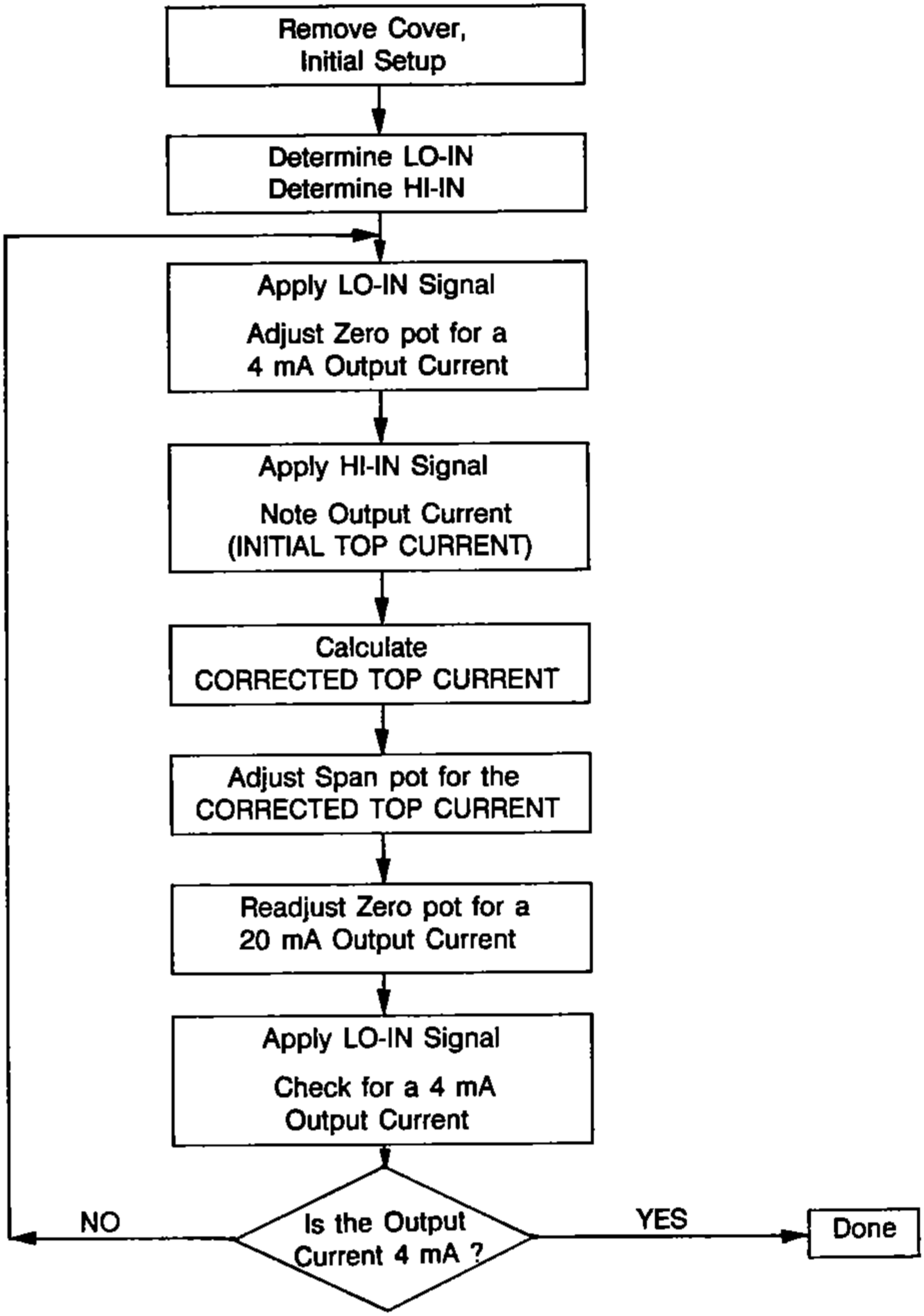


Figure 5-3 Calibration Flowchart

Type E Thermocouple Output Voltage, E, and Slope Sensitivity or Seebeck Coefficient, S, per NBS Monograph 125 (based on IPTS-68) or IEC publication.

T °C	E µV	S µV/°C	T °C	E µV	S µV/°C	T °C	E µV	S µV/°C
-50	-2786.8	52.574	350	24961.4	79.155	750	57082.8	79.133
-40	-2254.4	53.892	360	25754.0	79.360	760	57873.4	79.000
-30	-1709.1	55.162	370	26548.5	79.551	770	58662.7	78.863
-20	-1151.3	56.389	380	27344.9	79.728	780	59450.7	78.723
-10	-581.5	57.578	390	28143.0	79.892	790	60237.2	78.580
0	0	58.696	400	28942.7	80.043	800	61022.3	78.432
10	591.3	59.573	410	29743.9	80.181	810	61805.8	78.281
20	1191.5	60.473	420	30546.3	80.307	820	62587.9	78.125
30	1800.8	61.385	430	31349.9	80.420	830	63368.3	77.964
40	2419.2	62.299	440	32154.7	80.522	840	64147.1	77.799
50	3046.8	63.210	450	32960.3	80.611	850	64924.3	77.629
60	3683.4	64.110	460	33766.9	80.689	860	65699.7	77.454
70	4328.9	64.993	470	34574.1	80.755	870	66473.3	77.273
80	4983.2	65.857	480	35381.9	80.810	880	67245.2	77.088
90	5646.0	66.697	490	36190.3	80.854	890	68015.1	76.898
100	6317.1	67.511	500	36999.0	80.887	900	68783.1	76.704
110	6996.1	68.298	510	37808.0	80.909	910	69549.1	76.506
120	7682.9	69.054	520	38617.1	80.920	920	70313.2	76.306
130	8377.1	69.781	530	39426.3	80.922	930	71075.3	76.106
140	9078.4	70.477	540	40235.5	80.913	940	71835.3	75.907
150	9786.5	71.142	550	41044.6	80.895	950	72593.4	75.712
160	10501.2	71.776	560	41853.4	80.868	960	73349.6	75.524
170	11222.0	72.381	570	42661.9	80.832	970	74103.9	75.346
180	11948.7	72.956	580	43470.0	80.788	980	74856.6	75.184
190	12681.0	73.502	590	44277.6	80.736	990	75607.7	75.043
200	13418.6	74.021	600	45084.7	80.676	1000	76357.5	74.929
210	14161.3	74.513	610	45891.1	80.609			
220	14908.8	74.979	620	46696.8	80.535			
230	15660.8	75.421	630	47501.8	80.455			
240	16417.2	75.839	640	48305.9	80.369			
250	17177.5	76.234	650	49109.2	80.277			
260	17941.8	76.609	660	49911.5	80.181			
270	18709.6	76.962	670	50712.8	80.080			
280	19480.9	77.296	680	51513.0	79.974			
290	20255.5	77.612	690	52313.2	79.865			
300	21033.1	77.910	700	53110.3	79.751			
310	21813.6	78.190	710	53907.2	79.634			
320	22596.9	78.455	720	54703.0	79.514			
330	23382.7	78.703	730	55497.5	79.390			
340	24170.9	78.937	740	56290.8	79.263			

Table 5-1 Type E Thermocouple Reference Table

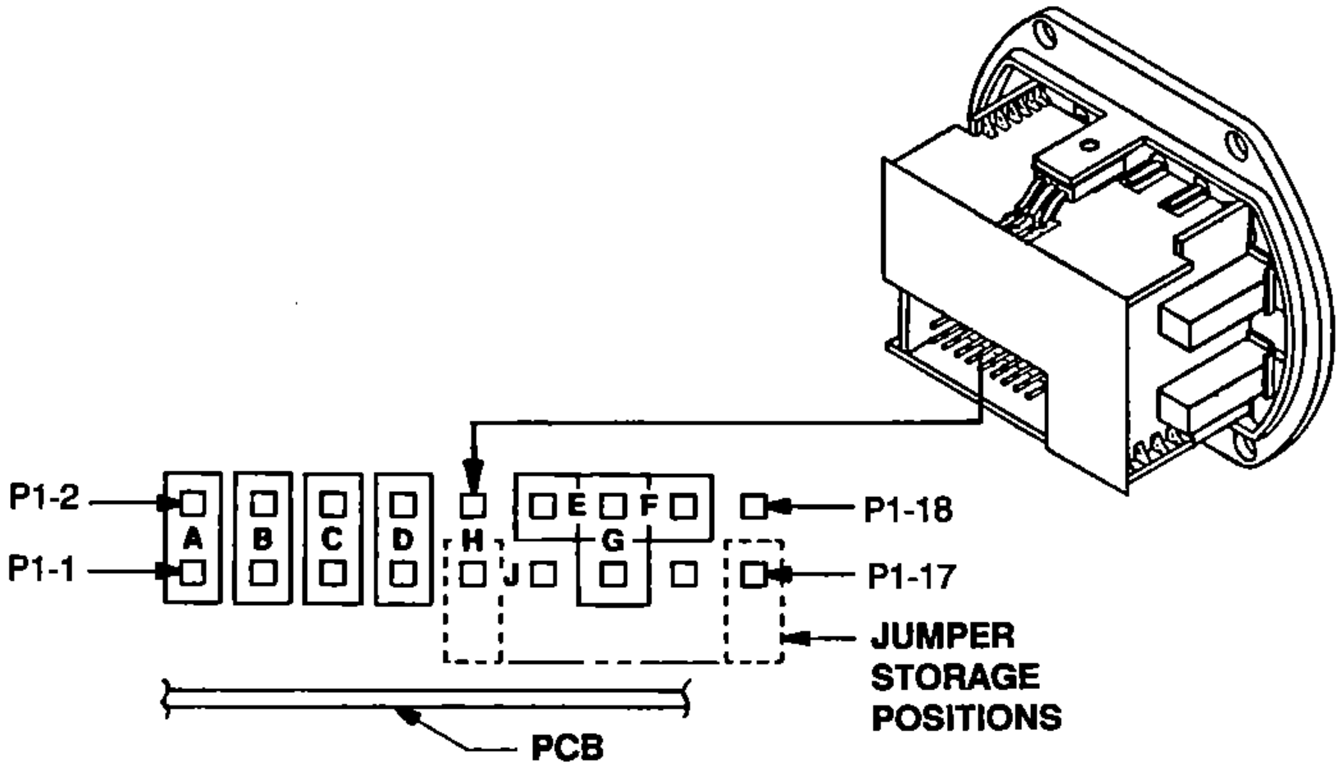


Figure 5-4 Jumper Diagram

5.4 PIN ASSIGNMENTS (Jumper Pin-forest P1)

Jumper Function	P1 Pins Used
'A' Zero	1 and 2
'B' Zero	3 and 4
'C' Zero	5 and 6
'D' Zero	7 and 8
'E' Span	12 and 14
'F' Span	14 and 16
'G' Span	13 and 14

NOTE: P1 connector pins 9, 10, 11, 15, 17 and 18 are used solely for computerized testing by the factory.

5.5 CALIBRATION FORMULA (Alternate to Using 4 mA to 20 mA Tables)

5.5.1 Calculation of ZEXTRA

When the SPAN pot is turned Clockwise it increases the output, decreasing the SPAN required for full-scale output and adding ZEXTRA, which is used to set the Zero (4 mA Temperature) jumpers.

$$ZEXTRA = (MAXSPAN - SPAN) / 4$$

5.5.2 Zero Jumper Selection (Equation alternate to Table 5-2)

From none to four jumpers may be placed on the connector to suppress the ZERO (temperature corresponding to 4 mA output). The equation is:

$$(ZERO+ZEXTRA) = 90\ (8A+4B+2C+D) + 70 \times ZPOT\ ,\ ^{\circ}C$$

Where we put in a '1' for each jumper used (A,B,C,D) and the value of ZPOT ranges from +1.0 to 0 to -1.0 as we turn it Clockwise.

Store unused jumpers between the bottom connector pins and the printed-circuit board.

→ INCREASING SPAN

↓ INCREASING ZERO SUPPRESSION

	Span Jumper G 100 to 300°C Span		Span Jumper F 300 to 500°C Span		Span Jumper E 300 to 800°C Span		Span Jumper None 800 to 1050°C Span	
Zero Jumpers	4 mA	20 mA	4 mA	20 mA	4 mA	20 mA	4 mA	20 mA
NONE	-50	50	-50	140				
D (ONLY)	-50	120	-50	190	-50	280		
C (ONLY)	20	170	-10	240	-40	310	-50	450
C AND D	70	230	50	290	30	350	-10	500
B (ONLY)	130	280	110	340	80	400	50	540
B AND D	180	330	170	390	140	440	110	590
B AND C	230	390	230	450	200	490	170	640
B, C AND D	290	440	290	510	260	540	220	700
A (ONLY)	340	500	350	560	310	590	280	760
A AND D	400	550	410	630	370	650	340	820
A AND C	460	610	470	690	440	710	400	880
A, C AND D	520	680	540	750	500	770	460	950
A AND B	590	740	610	830	570	830	530	1000
A, B AND D	670	820	690	910	640	900	590	1000
A, B AND C	740	910	770	960	710	970	670	1000
A,B,C AND D	830	1000	850	1000	790	1000		

Table 5-2 Celsius Temperature Ranges Obtained with Jumpers

NOTE: The 502A has a slight variation in the input offset of the opamp. If the selected range cannot be obtained with the designated jumpers in Table 5-2, move to the previous or next jumper and range selection.

Reference Sections 5.5.1 and 5.5.2.

6.0 DRAWINGS

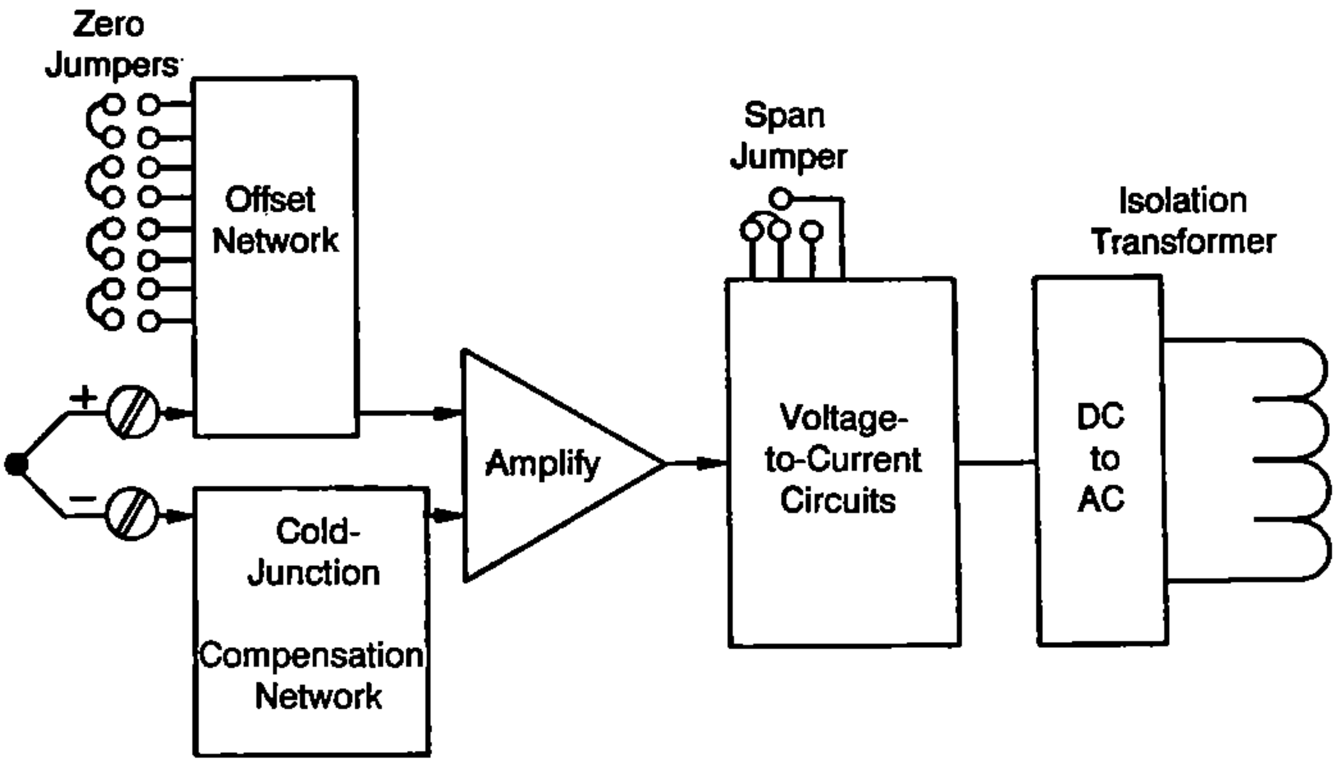


Figure 6-1 502A-E Preamp Block Diagram

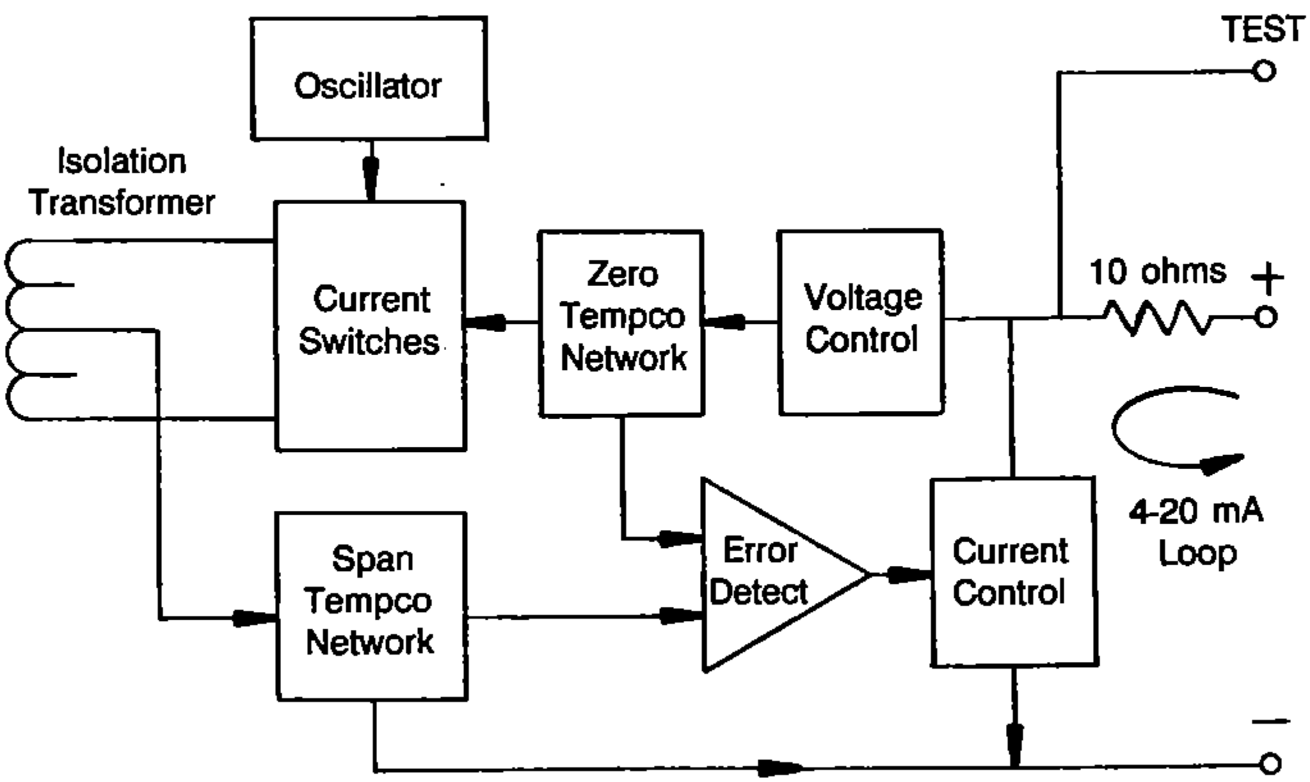


Figure 6-2 502A-E Postamp Block Diagram

APPENDIX A

TRANSMITTER ACCURACY SPECIFICATIONS

The complex current-transmitter circuitry necessary to amplify, isolate, protect, and offset weak input signals while consuming only small amounts of power can distort the signal in many ways. Additional accuracy limitations occur in thermocouple transmitters, which require precise cold-junction compensation and large Zero-suppression ranges in order to obtain good sensitivity and linearity for high temperatures.

Many transmitter data sheets omit key accuracy factors and/or express performance in percentage values without mentioning the full-scale value. Design limitations can be disguised by such "specsmanship"; the 502A-E specifications, however, are detailed in order to present the complete performance accuracy.

For a given thermocouple type, input errors are logically expressed in degrees (rather than microvolts), and output errors are readily expressed in microamperes, since output is current. Transmitter users are rarely interested in microamperes. Therefore, these output current errors are translated back to input degrees as a percentage (or ppm) of the selected Span.

Another fundamental division of errors is that of independence or dependence on Zero and Reading. Resistor aging and tempco mismatch in the Zero and Voltage Reference circuits will produce errors which increase with Zero suppression but which are independent of the amount of Reading (value above the Zero). Resistor aging and tempco mismatch in the amplifier gain (feedback) circuits will usually affect both Zero and Reading accuracy; amplifier gain tempco variations are important to just the Reading stability. A complete error specification needs a term proportional to Zero (suppression) and a term proportional to Reading.

For thermocouple transmitters, the Cold-Junction Compensation (CJC) is never perfect, even when factory-tailored over wide ambient excursions with curvilinear adjustments, as in the 502A-E. This error component is readily stated as a percentage of the ambient temperature excursion from the nominal temperature at which the Zero was set (assuming, as in the 502A-E, that the Zero potentiometer has ample resolution on all Zero and Span ranges). For transmitters with restricted turndown ratios (low Zero Suppression capability), the tempco errors may be lumped into a single error term.

In addition to these three components of tempco (ambient temperature effects), there are other possible errors, often referred to as "hysteresis," "repeatability," "drift," or "time" errors. No statistically-significant errors of these types have yet been observed for the 502A-E, which utilizes a solid-state, band-gap input voltage reference, matched-pair input PNP transistors, integrated-circuit current source and imbalance control, and matched-tempco bridge resistors. The 502A-E also provides a variable-tempco output adjustment (factory-set) which eliminates many of the errors lumped in this category for other units. Its specification includes a 0.2°C tolerance for the calibration accuracies.

NOTES