

TECHNICAL MANUAL
CALIBRATION PROCEDURE
FOR
THERMOMETERS



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THERMOMETERS

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Temperature (Method #1)	Range: -38 to 680 °F, -38 to 360 °C Accuracy: ±0.45 °F (±0.25 °C) from -38 to 395 °F; ±2.0 °F (±1.1 °C) from 395 to 680 °F	Compared against a Standard Thermometer
Temperature (Method #2)	Range: -189 to 500 °C; -308 to 932 °F Accuracy: ±0.03 °C; ±0.054 °F	Compared against a Standard Resistance Thermometer and a Digital Multimeter

2 EQUIPMENT REQUIREMENTS:

Noun	Minimum Use Specifications	Calibration Equipment	Sub- Item
2.1 TEMPERATURE BATH	Range: -30 to 150 °C Accuracy: N/A	Hart 5303	
2.2 TEMPERATURE BATH	Range: -100 to 300 °C Accuracy: N/A	Hart 5309	
2.3 TEMPERATURE BATH	Range: -170 to 750 °F Accuracy: N/A	Rosemount Engineering 913A	
2.4 STANDARD THERMOMETER SET	Range: -36 to 680 °F Accuracy: ±0.2 °F from -36 to 395 °F; ±1.0 °F from 395 to 680 °F	Princo 76, 77	
2.5 STANDARD RESISTANCE THERMOMETER	Range: -110 to 400 °C Accuracy: ±0.01 °C	Leeds & Northrup 8163	
2.6 DIGITAL MULTIMETER	Range: 0 to 100 Ω Accuracy: ±(12 ppm rdg + 5 ppm rng)	Hewlett-Packard 3458A	

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.7 LABORATORY STAND	Range: 24 in rod with 6 in × 9 in base Accuracy: N/A	As available	
2.8 LABORATORY RING	Range: 3 in outside diameter Accuracy: N/A	As available	
2.9 UTILITY CLAMP	Range: 9 in length Accuracy: N/A	As available	
2.10 SUPPORT ROD CLAMP	Range: Swivel type Accuracy: N/A	As available	
2.11 ICE BATH	Range: 0.0 °C Accuracy: ±0.002 °C; ±0.0036 °F	Local Manufacture	
2.12 TRIPLE POINT OF WATER (Optional, may be used in place of 2.11)	Range: 0.01 °C Accuracy: ±0.0005 °C; ±0.0009 °F	Jarret A-11	
2.13 FLUID LEVEL ADAPTER (Optional)	Range: N/A Accuracy: N/A	Hart 2019	

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with entire procedure before beginning Calibration Process.



Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.



Unless otherwise designated, and prior to beginning the Calibration Process, ensure that the Temperature Bath is adjusted for ambient temperature, where applicable. Use care when installing or removing instruments from the Temperature Bath when higher temperatures exist.

3.2 Princo Standard Thermometers Model numbers 76 and 77 are to be calibrated to an accuracy of ± 0.2 °F from -36 to 395 °F, and ± 1 °F from 395 to 680 °F. If this accuracy cannot be obtained, a correction chart must be prepared.

NOTE

After initial certification, Standard Thermometers such as Princo Thermometers Model numbers 76 and 77 require only a two-point calibration, Ice Point and one other selected higher temperature. If the Ice Point is near the top of the thermometer range, a lower temperature will be required.

3.3 If the calibration method used has a lesser accuracy than that stated by the TI manufacturer, a Limited Certification Label must be used. Annotate the Limited Certification Label with the TIs calibrated accuracy.

3.4 Temperature Conversion Chart covering -40 to 550 °C and °F may be found in T.O. 33-1-19, section 8, Figure 8-6. Conversions may also be made by using the following formulas:

Fahrenheit to Celsius

$$C = \frac{(F - 32)}{1.8}$$

Celsius to Fahrenheit

$$F = 1.8 (C) + 32$$

3.5 Psychrometers will be calibrated at room temperature by comparison to the Standard Thermometer with the sock removed from the Psychrometer. The Standard Thermometer and Psychrometer Thermometers must agree within ± 1 °F or ± 0.5 °C depending on model of Psychrometer. Attach a Limited Certification Label with the following annotations: Calibrated for use as a Psychrometer only, calibrated at room temperature only ± 1 °F or ± 0.5 °C.

3.6 Liquid-in-glass Thermometers used in fuel accountability (manufactured to ASTM specifications) require only a two-point calibration, Ice Point and one other selected higher temperature. If the Ice Point is near the top of the thermometer range, a lower temperature will be required.

NOTE

If calibrating a liquid-in-glass Thermometer, refer to T.O. 33K-1-100-1, Section 3.1, para c. Specific TMDE and Equipment; Thermometers, page 3-9.

3.7 Before using Method #2:

NOTE

Ensure Digital Multimeter is set up to read high accuracy resistance as in step 4.2.3.3.

Place the Standard Resistance Thermometer in an Ice Bath or Triple Point of Water Cell before and after each TI calibration. The resistance at 0 °C (0.01 °C TPW) should be measured and recorded. If using an Ice Bath, divide this value by 0.99996015 to obtain the Triple Point of Water resistance. If this differs more than 0.003 Ω from the charted value on Report of Measurement, contact AFPSL. Use the latest R0.01 measurement to calculate resistance ratios. The difference between the before and after measured resistance at 0.01 °C must be within ±0.001 Ω or the resolution of the indication device, whichever is greater. If not, repeat the reference and calibration until this condition is met. If several TIs are to be calibrated at one time, it is permissible to take one set of reference measurements (before and after) and at least one more measurement per day of use.

NOTE

Thermometers may be calibrated to test points called out in ASTM E1 in lieu of test points listed in this procedure. If ASTM test points are used, the Calibration Label must be annotated as follows: Calibrated to ASTM E1.

ASTM E1 is available from:

SCIENTIFIC APPARATUS MAKERS ASSN:
Connecticut AV, NW
Washington, DC 20036

3.8 Use only that portion of the procedure applicable to TI being calibrated.

3.9 Auxiliary Thermometers used in para 4.2 are part of the Standard Thermometer Set.

4 CALIBRATION PROCESS:

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met, before proceeding.

4.1 TEMPERATURE CALIBRATION: (Method #1)

4.1.1 Insert TI, or TI probe, and Standard Thermometer (appropriate range for temperature being calibrated) into the Temperature Bath test well.

4.1.2 Adjust the Temperature Bath control to the temperature being calibrated and allow to stabilize.

4.1.3 The TI and Standard Thermometer must agree within the specified accuracy.

4.1.4 Calibrate TI at lowest value of range and at approximately 20, 40, 60, 80 and 100% of range within the capability of the Standard Thermometer and Temperature Bath being used.

4.1.5 Adjust the Temperature Bath to ambient temperature. Remove TI and Standard Thermometer from the test well and secure equipment.

4.1.6 Annotate and attach the Calibration Certification Label with the TIs calibrated accuracy.

4.2 TEMPERATURE CALIBRATION: (Method #2, with Digital Multimeter)

NOTE

After initial certification, Standard Thermometers such as Princo Thermometers Model numbers 76 and 77 require only a two-point calibration, ice point and one other selected higher temperature. If the Ice Point is near the top of the thermometer range, a lower temperature will be required.

4.2.1 Assemble the ring stand apparatus on top of the Temperature Bath as shown in Figure 1, using extreme caution with the Standard Resistance Thermometer. Ensure that the Thermometers and probes are submersed as deeply as possible into the Temperature Bath.

NOTE

A Fluid Level Adapter may be used with Hart Temperature Baths. The Fluid Level Adapter eliminates the necessity of stem corrections for immersion type thermometers (0.2° increment or less) by placing the thermometer meniscus above the edge of the Temperature Bath test well for clear viewing. If the Fluid Level Adapter is used, disregard any instructions pertaining to the application of stem corrections.

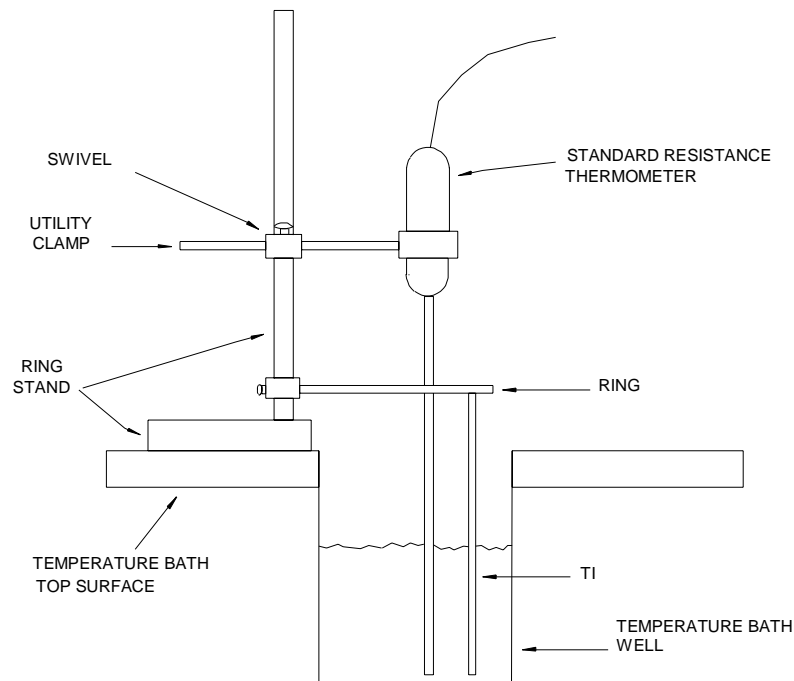


Figure 1.

4.2.2 Apply power to the Digital Multimeter and allow 4 hour warm-up.

4.2.3 Use the following procedure to set up the Digital Multimeter for 100 Ω , four wire, high accuracy resistance measurement.

NOTE

Press blue key for Shift.

4.2.3.1 On Digital Multimeter, press the following keys in sequence.

MENU: AUTO CAL

MENU SCROLL DOWN (4 times)

NUMERICAL/USER: , 3 4 5 8 ENTER (wait approx 11 minutes)

4.2.3.2 Connect equipment as shown in Figure 2.

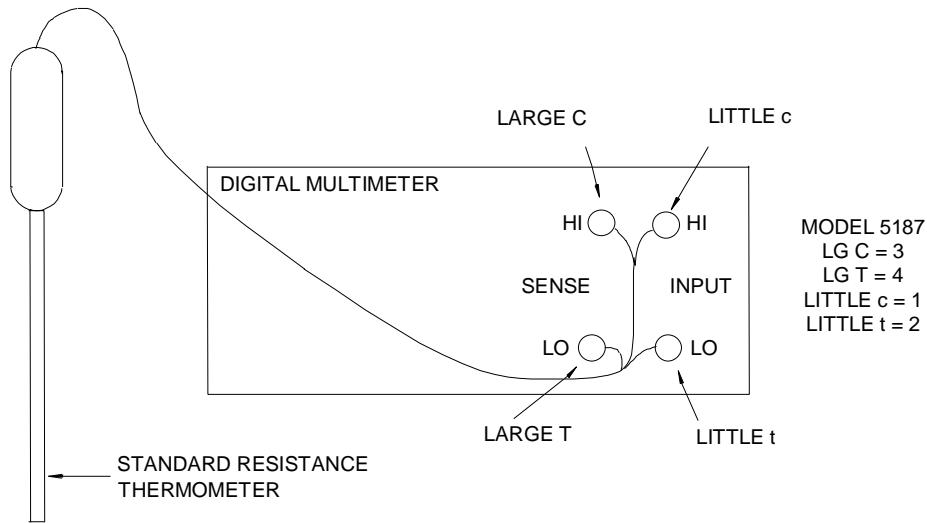


Figure 2.

4.2.3.3 On Digital Multimeter, press SHIFT (blue key) and RESET.

SHIFT OHMF
SHIFT N 8 ENTER
OFFSET COMP Ω \uparrow ENTER
NPLC 100 ENTER

4.2.4 Use the following procedure to set up the Digital Multimeter to display resistance ratio.

4.2.4.1 On Digital Multimeter, press SHIFT MENU 0 ENTER.

4.2.4.2 On Digital Multimeter, press as follows:

SHIFT
S
MENU SCROLL DOWN KEY (3 times) (display will indicate SMATH)
7, 0 ENTER

4.2.4.3 On Digital Multimeter, press as follows:

SHIFT
S
MENU SCROLL DOWN (3 times) (display will indicate SMATH)

1 1, Triple Point of Water / 1000 ENTER (Use actual TPW value recorded in step 3.7)
(example: . 0 2 5 5 2)

4.2.4.4 On Digital Multimeter, press as follows:

SHIFT

L

MENU SCROLL DOWN (4 times) (display will indicate MATH)

1 3 ENTER

4.2.4.5 On Digital Multimeter, press as follows:

SHIFT

E

MENU SCROLL DOWN (3 times) (display will indicate FUNC)

5, 1 3 0 ENTER

4.2.4.6 Digital Multimeter is now set up to indicate in ratio.

4.2.5 Using AFPSL Report of Measurement, find the temperature of TI lowest value of range and at approximately 20, 40, 60, 80 and 100% of TI range. Obtain the equivalent ratio value from the table.

4.2.6 Adjust the Temperature Bath control to the temperature selected in step 4.2.5.

4.2.7 Using the FINE control on the Temperature Bath, make adjustments until the Digital Multimeter indicates the equivalent ratio selected in step 4.2.5. When the equivalent ratio is displayed, the Temperature Bath will be at the desired temperature.

4.2.8 The TI must indicate the selected temperature to within the specified accuracy.

4.2.9 Adjust the Temperature Bath to ambient temperature. Remove power from all equipment. Disconnect and secure all equipment.

4.2.10 Annotate and attach the Calibration Certification Label with the TIs calibrated accuracy.

NOTE

Immersion type Thermometers (0.2° increment or less) calibrated while not fully immersed must apply a stem correction (refer to Figure 3) according to the following formula:

$$+ CORR = Kn(T - t)$$

WHERE:

K= 0.00016 for Celsius Thermometers

K= 0.00009 for Fahrenheit Thermometers

n = The number of Thermometer Scale degrees the Mercury is out of the Bath

T = Thermometer Bulb Temp (Thermometer reading)

t = Thermometer Stem Temp = (Stem Temp at Bath + Stem Temp at top of Hg column)/2

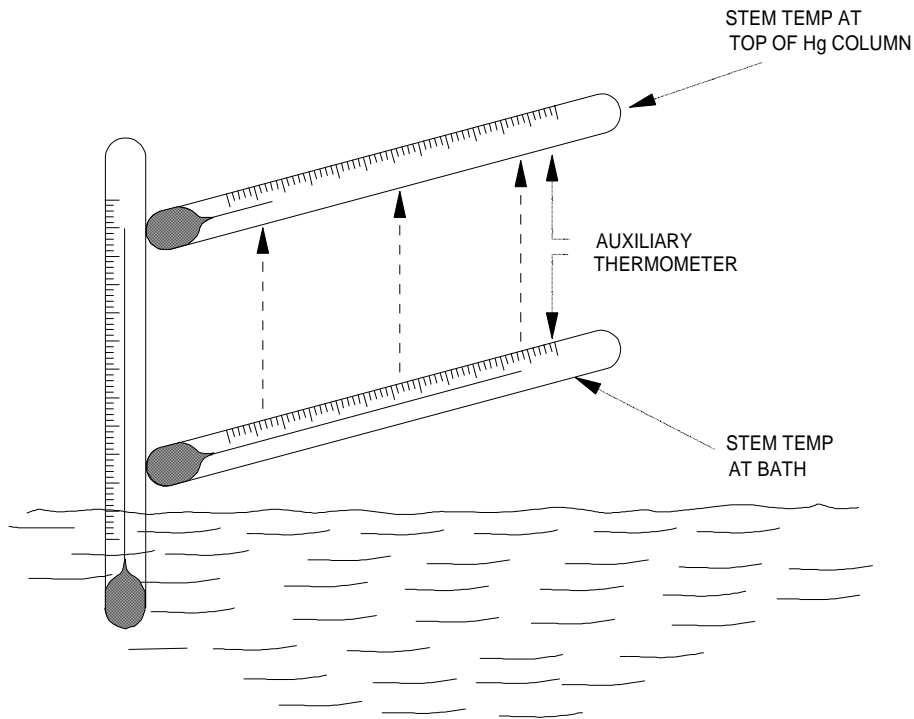


Figure 3.

CAUTION

A stem correction request must be coordinated between the owning activity and PMEL to confirm that the Thermometer is used in total submersion. A stem correction not applied to a Thermometer which is not totally immersed when in use, will be in error.

NOTE

Place the Auxiliary Thermometers (part of the Standard Thermometer Set) in contact with the Thermometer that requires a stem correction.

CALIBRATION PERFORMANCE TABLE

Not Required