



T.O. 33K5-4-42-1

TECHNICAL MANUAL
CALIBRATION PROCEDURE
FOR
THERMOMETERS

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LIST OF EFFECTIVE PAGES

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NOTE: The portion of the text affected by the changes is indicated by a vertical line in the outer margins of the page. Changes to illustrations are indicated by miniature pointing hands. Changes to wiring diagrams are indicated by shaded areas

Dates of issue for original and changed pages are:

Original..... 0..... 30 April 1997
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THERMOMETER

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 Best obtainable Accuracy is: ±0.44 °C (±0.8 °F) from -36 to +395 °F, ±2.2 °C (±4.0 °F) from +395 to +680 °F	Compared against Standard Thermometer
Temperature (Method #2)	Range: -170 to +750 °F, -112 to +400 °C Best obtainable Accuracy is: ±0.06 °C, ±0.11 °F	Compared against Standard Resistance Thermometer and Digital Multimeter
Temperature (Method #3)	Range: -170 to 750 °F, -112 to +400 °C Best obtainable Accuracy is: ±0.03 °C, ±0.06 °F	

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	

Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.4 STANDARD THERMOMETER	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 1 KΩ Accuracy: ±(0.004% +6 digits) (High Resolution)	Hewlett-Packard 3455A	
2.7 DIGITAL MULTIMETER***	Range: 0 to 1 KΩ Accuracy: ±0.003%	Hewlett-Packard 3458A	
2.8 LABORATORY STAND	24' rod with 6' X 9' base	6640-00-440-1200	
2.9 LABORATORY RING	3' outside diameter	6640-00-440-1315	
2.10 UTILITY CLAMP	9' length	6640-00-417-6000	
2.11 SUPPORT ROD CLAMP	Swivel type	6640-00-428-2460	
2.12 ICE BATH	Range: 0 °C For Accuracies to ±0.05 °C	Local Manufacture per T.O. 33K-1-104	
2.13 TRIPLE POINT OF WATER	Range: 0 °C For Accuracies to ±0.03 °C	Trans-sonics 230 T.O. 33C3-3-1	

* Used in Calibration Method #1 only.

** Used in Calibration Method #2 only.

*** Used in Calibration Method #3 only.

**** Used in Calibration Method #2 and 3.

Use remaining equipment as necessary.

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with entire procedure before beginning calibration process.

WARNING

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.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that Temperature Bath is adjusted for ambient temperature, where applicable. Use care when installing, or removing instruments from 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 388 to 680 °F. If they exceed this accuracy 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.

3.3 If calibration method used has a lesser accuracy than that stated by the TI manufacture, a Limited Certification Label must be attached to the TI listing the accuracy to which the TI was calibrated.

3.4 Temperature Conversion Chart covering -40 to +550 ° Celsius and Fahrenheit may be found in T.O. 33-1-19, section 8, Figure 8-6, or conversions may be made by using the following formula:

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 C ?

3.6 If applicable, check the TI Batteries and Battery Compartment for corrosion caused by battery leakage. Any corrosion must be removed and neutralized prior to beginning calibration. (This step is Ref. T.O. 33-1-27 para 1-6c(1)(c)).

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3.7 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.

3.8 Before using Method #2 or #3 one of the following must be observed:

a. For Accuracies to ± 0.05 °C:

Place the PRT in a Ice Bath before and after each TI calibration. The resistance at 0 °C should be measured and recorded. Divide this value by .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. The difference between the before and after measured resistance at 0 °C must be within ± 0.0001 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.

b. For Accuracies to ± 0.03 °C:

Place the PRT in a Triple Point of Water Cell before and after each TI calibration. The resistance at 0 °C should be measured and recorded. If this differs more than 0.003 Ω from the charted value on Report of Measurement, contact AFPSL. The difference between the before and after measured resistance at 0 °C must be within ± 0.0001 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. ASTM E1 is available from:

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

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

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 appropriate range Standard Thermometer for temperature being tested into Temperature Bath test well.

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

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

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

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

4.1.6 Annotate the Calibration Certification Label with the accuracy TI was calibrated to.

4.2 TEMPERATURE CALIBRATION: (Method #2)

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

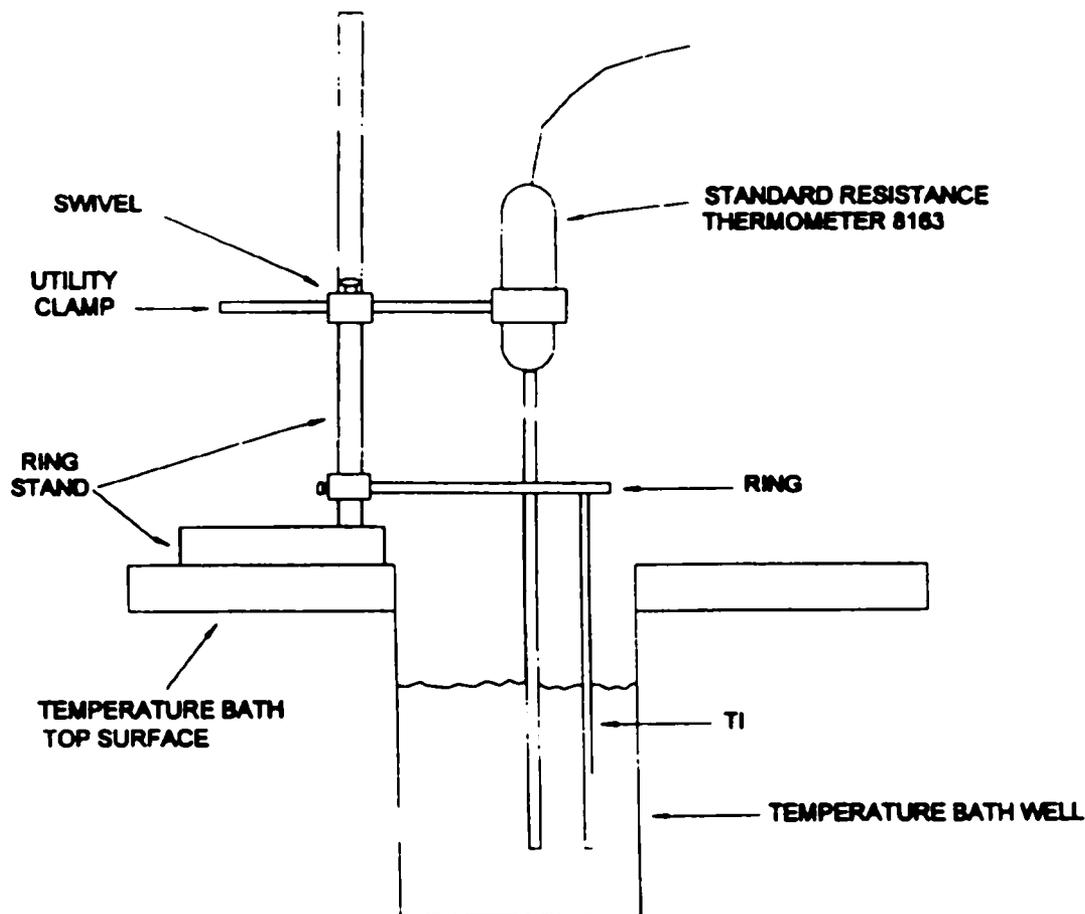


Figure 1.

4.2.2 Connect the Standard Resistance Thermometer to the Digital Multimeter as shown in Figure 2.

4.2.3 Apply power to the Digital Multimeter (3455A) and allow 1 hour warm-up.

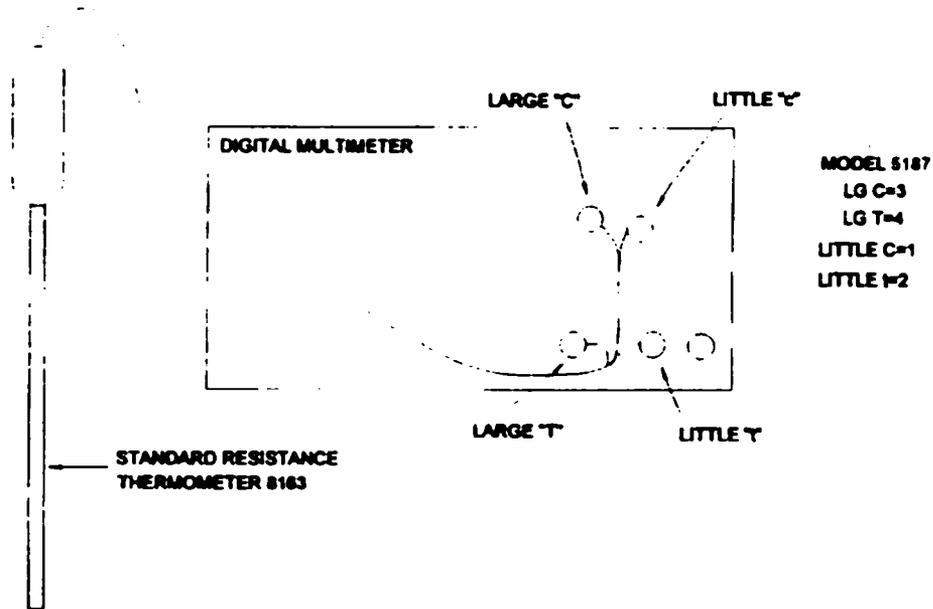


Figure 2.

4.2.4 Set the Digital Multimeter controls as follows:

RANGE	AUTO
FUNCTION	4 WIRE K
AUTO CAL	ON
HIGH RESOLUTION	ON
TRIGGER	INTERNAL
MATH	OFF

4.2.5 Press the blue button marked "Z" under ENTER on the Digital Multimeter and key in the value of 0.000000 then press the button labeled "Z" under STORE.

4.2.6 Multiply the resistance at the Triple Point of Water by 0.001. This value is to be taken from the AFPSL Report of Measurement.

4.2.7 Press the blue button labeled "Y" under ENTER on the Digital Multimeter and key the value obtained in step 4.2.6, then press the button labeled "Y" under STORE on the Digital Multimeter.

4.2.8 Under MATH on the Digital Multimeter, press the button labeled Scale. The Digital Multimeter is now displaying the temperature as a ratio derived from the Triple Point of Water.

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

- 4.2.10 Adjust the Temperature Bath control to the temperature selected in step 4.2.9.
- 4.2.11 Using the FINE control on the Temperature Bath, make adjustment until Digital Multimeter reads the ratio selected in step 4.2.9. When the ratio is being displayed, the Temperature Bath will be at the desired temperature.
- 4.2.12 TI must indicate the selected temperature to within the specified accuracy for TI.
- 4.2.13 Adjust the Temperature Bath for ambient temperature, remove power from all equipment, disconnect and secure.
- 4.2.14 Annotate the Calibration Certification Label with the Accuracy TI was calibrated to.

NOTE

Immersion type thermometers 0.2 ° increment or less calibrated not fully immersed must apply a stem correction 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)

CAUTION

Stem correction request must be coordinated between owning activity and PMEL to confirm that thermometer is used in total submersion. Stem correction used for thermometers not total submerged in use, will be in error.

4.3 TEMPERATURE CALIBRATION: (Method #3)

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.

- 4.3.1 Assemble the ring stand apparatus on top of Temperature Bath as shown in Figure 1, using extreme caution with the Standard Resistance Thermometer. Ensure that the thermometers and probes are submersed as deep as possible into the Bath.
- 4.3.2 Apply power to the Digital Multimeter (3458A) and allow 2 hour warm-up.

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4.3.3 Use the following procedure to set up the H-P/3458A Multimeter for 1 K Ω , four wire hook up, to display the Standard 8163 PRT in Ratio.

NOTE

Depress BLUE key for Shift.

4.3.3.1 On front panel of Multimeter depress the following in sequence.

MENU: AUTO CAL

MENU SCROLL DOWN (4 times)

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

4.3.3.2 Connect Standard PRT to Multimeter Input terminals as follows:

C to HI SENSE

c to HI INPUT

T to LO SENSE

t to LO INPUT

4.3.3.3 On Multimeter depress SHIFT (blue key) and RESET.

4.3.3.4 On Multimeter depress SHIFT MENU 0 ENTER.

4.3.3.5 On Multimeter depress as follows:

SHIFT

S

MENU SCROLL DOWN KEY (3 times) (display will read "SMATH")

7, 0 ENTER

4.3.3.6 On Multimeter depress as follows:

SHIFT

S

MENU SCROLL DOWN (3 times) (display will read "SMATH")

1 1, Triple Point of Water / 1000 ENTER
(example: . 0 2 5 5 2)

4.3.3.7 On Multimeter depress as follows:

SHIFT

L

MENU SCROLL DOWN (4 times) (display will read "MATH")

1 3 ENTER

4.3.3.8 On Multimeter depress as follows:

SHIFT

E

MENU SCROLL DOWN (3 times) (display will read "FUNC")

5, 1 3 0 ENTER

4.3.3.9 Multimeter is now set up to read in ratio.

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

4.3.5 Adjust the Temperature Bath control to the temperature selected in step 4.3.4.

4.3.6 Using the FINE control on the Temperature Bath, make adjustment until Digital Multimeter reads the ratio selected in step 4.3.4. When the ratio is being displayed, the Temperature Bath will be at the desired temperature.

4.3.7 TI must indicate the selected temperature to within the specified accuracy for TI.

4.3.8 Adjust the Temperature Bath for ambient temperature, remove power from all equipment, disconnect and secure.

4.3.9 Annotate the Calibration Certification Label with the accuracy TI was calibrated to.

NOTE

Immersion type thermometers 0.2° increment or less calibrated not fully immersed must apply a stem correction 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

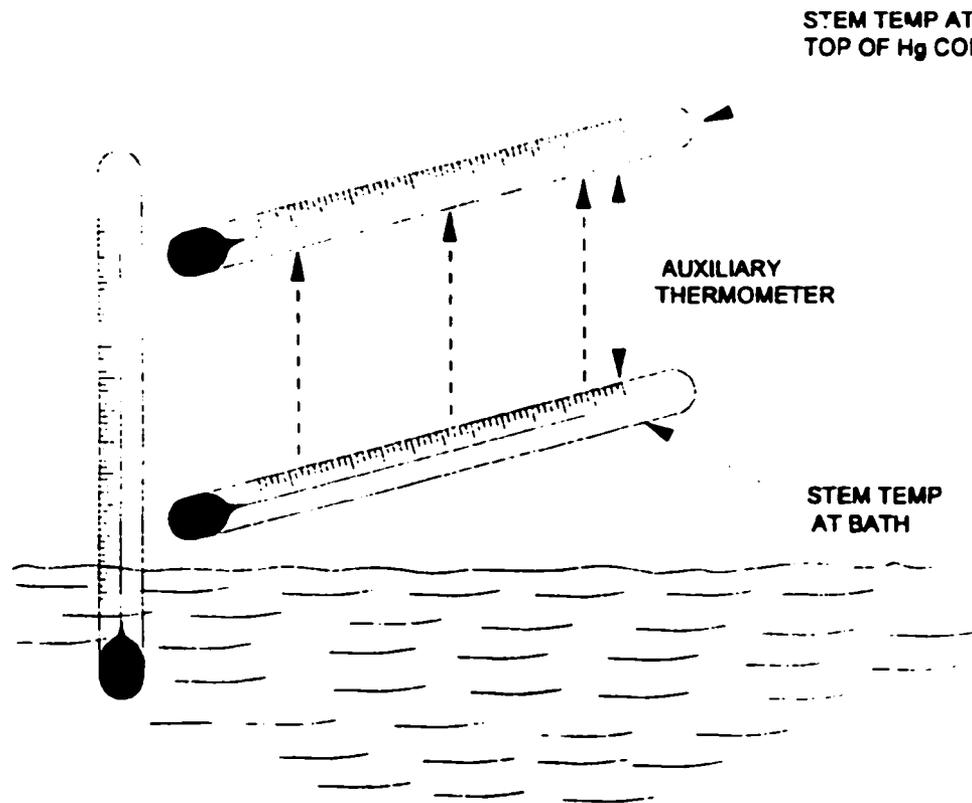


Figure 3.

CAUTION

Stem correction request must be coordinated between owning activity and PMEL to confirm that thermometer is used in total submersion. Stem correction used for thermometers not total submerged in use, will be in error.

CALIBRATION PERFORMANCE TABLE

Not Required