meatest

EN, rev. 03

Calibration procedure for 91 Cold Junction Compensator

application note AN108 for 9000 / 9010 / 9010+ / M160

1. Performance verification procedure

This procedure verifies the entire temperature measurement chain including the Adapter 91 and either 9000-series Multifunction Calibrator or M160 Precision DC Calibrator. Measurement accuracy of Adapter 91 is 0.3 °C by default or 0.1 °C if previously adjusted as described in chapter 2.

1.1. Required equipment

Following instruments are required for Adapter 91 verification procedure:

- 91 Cold Junction Compensator (Adapter 91)
- 9000-series Multifunction Calibrator or M160 Precision DC Calibrator
- Temperature calibration bath with ethanol or methanol as bath medium. Required calibration uncertainty is 0.05 °C or better; use additional PRT standard if needed.
- (optional) Adapter 91 Calibration Set – Extender

Figure 1 Adapter 91 Calibration Set - Extender

1.2. Verification procedure

1. Place the calibrator in reference conditions and let it warm up.
2. Connect Adapter 91 to LEMO connector on the calibrator and submerge the adapter into the temperature calibration bath. Use the Extender cable if needed.
3. Verify RTD temperature measurement accuracy of the system in test points defined in table 1 below. Recommended minimum stabilization time is 10 minutes.

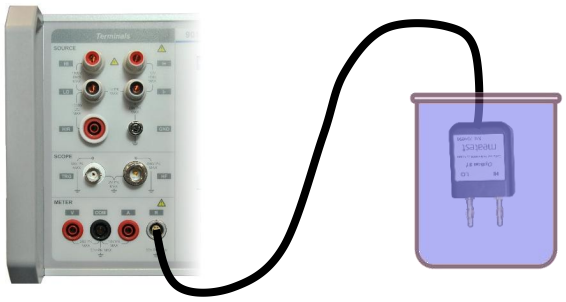


Figure 2 Temperature calibration bath - Calibrator

Function	Nominal	Min value [1]	Max value [1]	Unit	Standard unit	Required uncertainty
RTD temperature measurement	15	14.7 (14.9)	15.3 (15.1)	°C	Temperature calibration bath	0.05 °C or better
	20	19.7 (19.9)	20.3 (20.1)			
	25	24.7 (24.9)	25.3 (25.1)			
	30	29.7 (29.9)	30.3 (30.1)			
	35	34.7 (34.9)	35.3 (35.1)			

1. Value in parenthesis apply to paired calibrator-Adapter 91 systems. See Chapter 2 for more info.

Table 1 List of Adapter 91 test points

2. Adapter 91 pairing

Each 9000-series Multifunction Calibrator and M160 Precision DC Calibrator can be paired with one 91 Cold Junction Compensator, improving RTD temperature measurement uncertainty from default 0.3 °C to 0.1 °C.

This is achieved by adjusting the RTD approximation curve used by the calibrator to convert measured resistance of Adapter 91 to temperature. The RTD approximation curve is defined by 3 coefficients – R_0 (resistance at 0 °C) and exponential coefficients A and B. This chapter explains how to measure these coefficients and save them into the calibrator, enabling 0.1°C temperature measurement accuracy.

2.1. Required equipment

Following instruments are required for Adapter 91 calibration:

- 91 Cold Junction Compensator (Adapter 91)
- 9000-series Multifunction Calibrator or M160 Precision DC Calibrator
- 9000-60 option (9010-series MER option accessory)
- Adapter 91 Calibration Set – DMM Adapter and (optional) Extender
- Standard ohmmeter or 6½ digit DMM with resistance measurement accuracy 100 ppm or better
- Temperature calibration bath with ethanol or methanol as bath medium. Required calibration uncertainty is 0.05 °C or better; use additional PRT standard if needed.

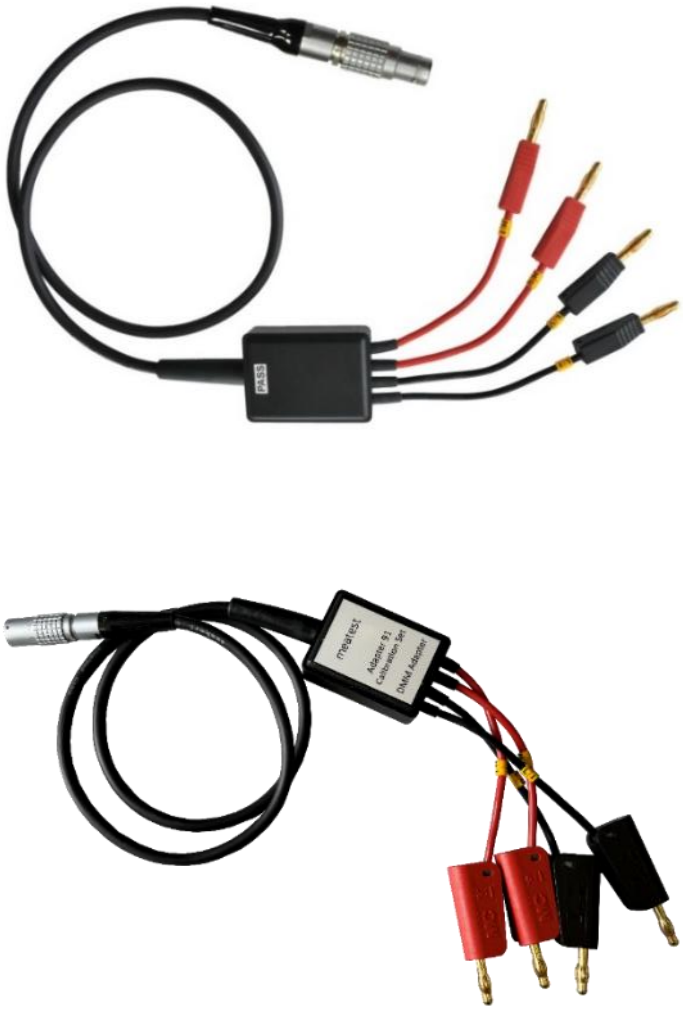


Figure 3 Option 9000-60 with male LEMO connector

2.2. Calibration procedure

1. Connect one end of DMM Adapter to Ohmmeter and the other end to Adapter 91. Then submerge the adapter into the temperature calibration bath. Use the Extender cable if needed.
2. Set the temperature bath 15 °C, let the temperature stabilize for at least 10 minutes and take a note of the associated resistance value on the ohmmeter.
3. Repeat step 2 with two more temperature points: 25 °C and 35 °C

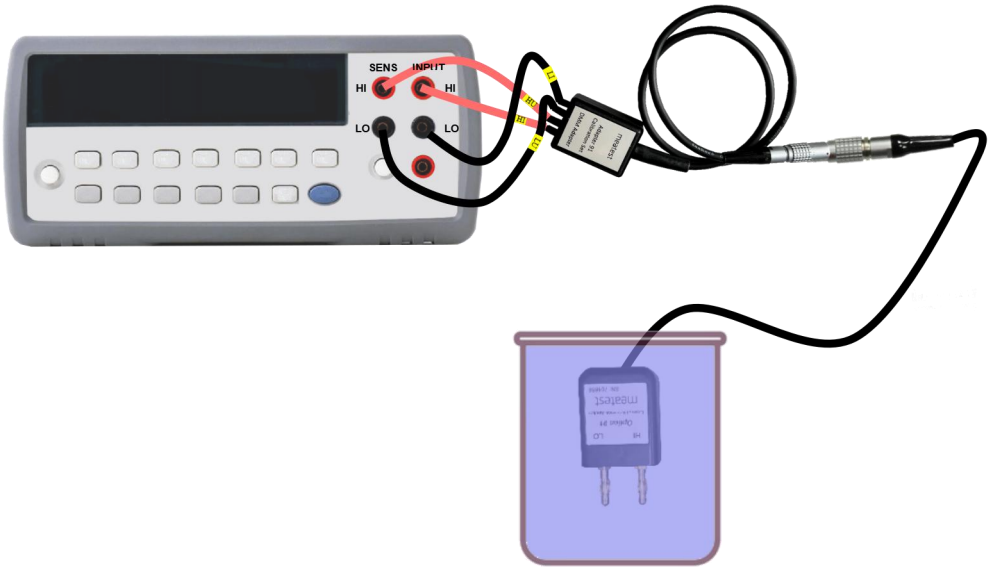
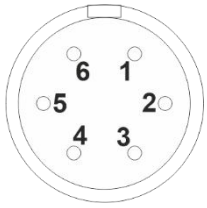


Figure 4 Temperature calibration bath - Ohmmeter

4. Enter measured resistances into attached Excel Spreadsheet to calculate RTD constants R_0, A, B of the Adapter 91. Alternatively, RTD constants can be calculated manually using formulas in Annex B.
5. Enter calculated RTD constants R_0, A, B of the Adapter 91 into the calibrator as follows:
    a. Go to MENU > Device > Meter > RTD (MENU > Device > TC > External RJ in M160).
    b. Set Type to “Platinum” and Standard to “PT user”.
    c. Enter constants R_0, A, B in menu items R0, RTD coefficient A and RTD coefficient B. RTD coefficient C is not used here so leave the value as is.
6. (optional) Adjust the calibrator’s resistance measurement function (RJ temperature measurement in M160) as described in calibrator’s user manual. To get more accurate temperature readings with the Opt 91, it’s recommended to adjust the calibrator’s measurement range at 100 Ohms instead of 1 kOhm. Keep in mind that this might push the upper end of the range (typically 2 kOhm) outside specified limits.

Annex A: Female LEMO connector pinout

Front view of female RTD connector (calibrator side)



PIN 1	HU (sense High)
PIN 2	HI (current High)
PIN 3	LI (current Low)
PIN 4	not used
PIN 5	shield
PIN 6	LU (sense Low)

Male connector used in Adapter 91, Adapter 9000-60, Extender:
LEMO FGG.1B.306.CLAD62Z + LEMO GMA.1B.054.DN

Annex B: RTD constant calculation formulas

Resistance at temperature t is calculated as:

$$R_t = R_0\left(1 + At + Bt^2\right)$$

Where:

R_t, R_0	are sensor resistances at temperatures t and 0°C in Ω
A	is constant in $°C^{-1}$
B	is constant in $°C^{-2}$

RTD sensor constants R_0, A and B are calculated as follows:

$$R_0 = \frac{R_x - \frac{R_y - R_z\frac{y^2}{z^2}}{y - \frac{y^2}{z}} * x - R_z * \frac{x^2}{z^2} + \frac{x^2}{z} * \frac{R_y - R_z * \frac{y^2}{z^2}}{y - \frac{y^2}{z}}}{1 + \frac{\frac{y^2}{z^2} - 1}{y - \frac{y^2}{z}} * x - \frac{x^2}{z^2} - \frac{x^2}{z} * \frac{\frac{y^2}{z^2} - 1}{y - \frac{y^2}{z}}}$$

$$A = \frac{R_y - R_0 + \frac{y^2}{z^2}(R_0 - R_z)}{R_0\left(y - \frac{y^2}{z}\right)}$$

$$B = \frac{R_z - R_0 + R_0 Az}{R_0 z^2}$$

Where:

R_x, R_y, R_z	are sensor resistances at temperatures x, y and z in Ω
x, y, z	are temperatures in °