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9007

Portable Low Temperature Calibrator Calibration Procedure Manual

Rev. 582202

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1 Identification and Description

The user may want to calibrate the Portable Low Temperature Calibrator (PLTC) to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants so that the temperature of the PLTC as measured with a standard thermometer agrees more closely with the set-point. The thermometer used must be able to measure the well temperature with higher accuracy than the desired accuracy of the PLTC. By using a good thermometer and by carefully following this procedure, the calibrator can be calibrated to an accuracy of better than 0.1°C over a range of –40°C to 140°C.

Table 1 *Calibration Description*

Test Instrument Characteristics	Performance Specifications	Test Method
Temperature Accuracy	±0.15°C –40°C to 140°C	Comparison against a reference Platinum Resistance Thermometer (PRT)
Temperature Stability	±0.02°C	Comparison against a reference Platinum Resistance Thermometer (PRT)

2 Equipment Requirements

Table 2 lists the calibration equipment required in the calibration process.

Table 2 *Equipment Requirements*

Description	Minimum Use Specifications	Model	Manufacturer
Thermometer Readout	Temperature Range: –40° to 140°C Temperature Accuracy: ±0.025°C Temperature Resolution: 0.01°C	1560/2560	Hart Scientific
SPRT	Calibration uncertainty of 0.03 or better. Able to achieve a maximum of 140°C (284°F) or better	2562-12 or Rosemount 162CE	Hart Scientific
PRT	Calibration uncertainty of 0.03 or better. Able to achieve a maximum of 140°C (284°F) or better	5614	Burns Engineering

3 Preliminary Operations

- Pre-calibration procedure for new blocks: Cycle unit up and down between –40°C and 140°C ten times to ensure unit is operating properly.
- Turn the PLTC on.
- Insert appropriate probe/well insulation on top of the block.
- Insert the probe in the test well to the correct depth.
- Record the ambient humidity and the ambient temperature.

4 Calibration Process

Sometimes the user may want to calibrate the PLTC to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R01, ALPHA1, DELTA1, BETA1, R02, ALPHA2, DELTA2, and BETA2 so that the temperature of the PLTC as measured with a standard thermometer agrees more closely with the set-point. The thermometer used must be able to measure the well temperature with higher accuracy than the desired accuracy of the PLTC. By using a good thermometer and following this procedure the PLTC can be calibrated to an accuracy of better than 0.1°C from –40°C to 140°C.

4.1 Calibration Points

In calibrating the PLTC, R0x, ALPHAx, DELTAx, and BETAx (where x stands for 1 or 2 depending on the sensor depth) are adjusted to minimize the set-point error at each of four different PLTC temperatures. Any four reasonably separated temperatures may be used for the calibration. For best accuracy, –40°C, 0°C, 75°C and 140°C are suggested.

4.2 Calibration Procedure

The following procdure is used for the 6" sensor depth and the 3" sensor depth. R01, ALPHA1, DELTA1, and BETA1 correspond to the 6" sensor depth. R02, ALPHA2, DELTA2, and BETA2 correspond to the 3" sensor depth. Ensure that the PLTC and sensor are set to the proper calibration depth (see Section 6.3.1 of the 9007 Portable Low Temperature Calibrator User Manual).

1. Use four set-points (–40°C, 0°C, 75°C, and 140°C) to calculate R0x, ALPHAx, DELTAx, and BETAx (where x stands for 1 or 2 depending on the sensor depth).

2. Set the PLTC to the lowest set-point. When the PLTC reaches that set-point and the display is stable, wait 15 minutes or so and then take a reading from the thermometer. Sample the set-point resistance by holding down the “SET” key and “DOWN” key simultaneously. Write these values down as T_{1x} and R_{1x}, respectively.

3. Repeat step 2 for the other three set-points recording them as T_{2x}, R_{2x}, T_{3x}, R_{3x}, T_{4x}, and R_{4x} respectively.

4. Using the recorded data, calculate new values for R0x , ALPHAx, DELTAx, and BETAx parameters using the equations given below:

4.2.1 Compute DELTA

$$A_x = T_{4x} - T_{3x}$$

$$B_x = T_{3x} - T_{2x}$$

$$C_x = \left[\frac{T_{4x}}{100}\right]\left[1-\frac{T_{4x}}{100}\right]-\left[\frac{T_{3x}}{100}\right]\left[1-\frac{T_{3x}}{100}\right]$$

$$D_x = \left[\frac{T_{3x}}{100}\right]\left[1-\frac{T_{3x}}{100}\right]-\left[\frac{T_{2x}}{100}\right]\left[1-\frac{T_{2x}}{100}\right]$$

$$E_x = R_{4x} - R_{3x}$$

$$F_x = R_{3x} - R_{2x}$$

$$delta_x = \frac{AF - BE}{DE - CF}$$

where

T_{1x} and R_{1x} are the measured temperature and resistance at –40.0 °C

T_{2x} and R_{2x} are the measured temperature and resistance at 0 °C

T_{3x} and R_{3x} are the measured temperature and resistance at 75.0 °C

T_{4x} and R_{4x} are the measured temperature and resistance at 140.0 °C

4.2.2 Compute R0x & ALPHAx

$$a_{1x} = T_{2x} + delta_x\left[\frac{t_{2x}}{100}\right]\left[1-\frac{t_{2x}}{100}\right]$$

$$a_{3x} = T_{4x} + delta_x\left[\frac{T_{4x}}{100}\right]\left[1-\frac{T_{4x}}{100}\right]$$

$$rzerox = \frac{R_{4x}a_{1x} - R_{2x}a_{3x}}{a_{1x} - a_{3x}}$$

$$alphax = \frac{R_{2x} - R_{4x}}{R_{4x}a_{1x} - R_{2x}a_{3x}}$$

deltax is the new value of DELTAx computed above.

4.2.3 Compute BETAx

$$x = \left[\frac{T_1}{100}\right]-1$$

$$y = \left[\frac{T_1}{100}\right]$$

$$betax = \frac{1}{(alphax)(x)(y^3)} + \frac{t}{x(y^3)} - \frac{deltax}{y^2} - \frac{\frac{R_{1x}}{rzerox}}{(alphax)(x)(y^3)}$$

where t and r are the measured temperature and resistance at –40°C and alpha, rzero, and delta are the new values of R_0, ALPHA, and DELTA calculated above.

Program the new values for R0x (rzerox), ALPHAx (alphax), DELTAx (delta), and BETAx (betax) into the PLTC with the following steps.

a. Press “SET” and “EXIT” keys at the same time and then press “SET” until R0x is displayed.

b. Press “SET” then use the “UP” or “DOWN” keys until the correct numerical setting is displayed. Press “SET” to accept the new value.

c. Repeat step b for ALPHAx, DELTAx, and BETAx.

4.2.4 Accuracy & Repeatability

1. Check the accuracy of the PLTC at various points over the calibrated range.

2. If PLTC does not pass specification at all set-points, repeat the Calibration Process.

5 Calibration Performance Tables

Refer to the Report of Calibration.