EVALUATION OF THE ACCURACY OF A THERMOMETRIC RESISTANCE BRIDGE TO DIFFERENT VALUES OF ATMOSPHERIC PRESSURE

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Abstract: ***T****he accuracy of a commercial thermometric resistance bridge at different atmospheric pressures is assessed, this device has an accuracy of 1x10-6 µΩ / Ω and it is used to measure the electrical resistance of platinum resistance thermometers. The manufacturer's specifications indicate that this equipment works properly up to 2000 meters above the sea level.*

The resistance bridge is part of the National Standards of Temperature which is maintained at INEN's Temperature Laboratory, therefore, it is required to ensure that this equipment is suitable to work under that accuracy in the atmospheric pressure conditions where the Laboratory is located.

Keywords: Thermometry, thermometer bridge

INTRODUCTION

The INEN Temperature Laboratory uses available national standards such as a cell of the triple point of water, two platinum resistance thermometers and a calibrated thermometric resistance bridge: With this standards platinum resistance thermometers are calibrated by means of comparison by applying isothermal media according to the International Temperature Scale of 1990 (EIT 90) [1].

The manufacturer's operating specifications of the thermometric resistance bridge [2] indicate that the equipment must operate at altitudes lower than 2000 meters above sea level.

The INEN Temperature Laboratory is at 2560 meters above sea level and an atmospheric pressure of 743 hPa. Due to this aspect INEN Temperature Laboratory performed several measurements with the thermometric resistance bridge to know its behavior for different values of atmospheric pressure, simulating altitudes lower and higher than 2000 meters.

The difference found between the measurements at atmospheric pressure at sea level and the location of INEN laboratories are going to be evaluated.

The thermometric bridge under study is the Fluke-Hart Scientific, Model: 1590. This information is included in order to complete this work, without implying any recommendation on the equipment.

MEASUREMENT TECHNIQUE

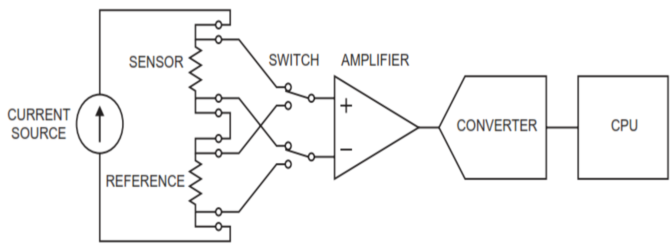
The Thermometric resistance bridge measures the resistance ratio between two resistors by comparing their voltages when equal currents are applied. The simplified schematic in Figure 1 shows the basic components of the measurement circuitry.

These include the current source, sensor, reference resistor, relay switch, amplifier, analog-to-digital converter (ADC), and central processing unit (CPU).

The reference resistor (internal) and sensor are connected in series and the current flows through both simultaneously. The current produces a voltage on each that is proportional to their respective resistances.

The voltages are measured with the amplifier and ADC. Since only one of the voltages can be measured at a time, the relay must be used to switch between them. The reference resistor is internal [3].

FIGURE 1. Simplified Schematic Diagram of the Measurement Circuit



DESCRIPTION OF THE EXPERIMENT

The experiment consisted in performing a calibration by comparison in the range of -40 ° C to 232 ° C by the EIT 90 [3] carried out in thermostatic baths and triple point of water (PTA) at 743 hPa

(2560 m) and 1013 hPa (0 m) of atmospheric pressure, in order to know whether the equipment is suitable to work under the same accuracy at INEN facilities.

We performed a calibration exercise because the laboratory does not have external standard resistors.

The bridge (working with a internal resistors) was placed in a barometric chamber operating in the range of 400 hPa to 1100 hPa.

The stability of barometric pressure chamber is of 0.2 hPa (Figure 2).

Figure 2. Barometric Chamber with a Thermometric resistance bridge

In the first series of experiments a platinum resistance thermometer (PRT) in the triple point of water (TPW) nominal resistance of 25 ohms was connected to the bridge.

The PRT is inside a TPW cell (Figures 3 and 4). Therefore the PRT and TPW cell is outside the chamber.

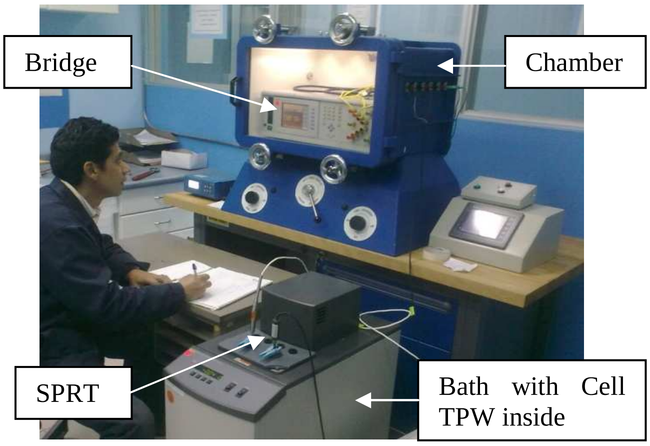


Figure 3. Measurement in the Triple Point of water cell

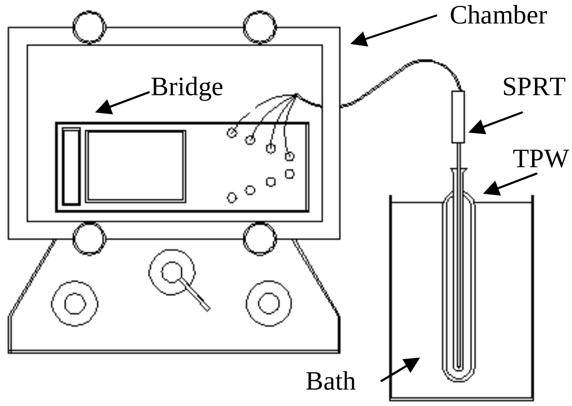


Figure 4. Measurement in the Triple Point of water cell

Two atmospheric pressure points listed in table 1 were taken as reference.

TABLE 1. Measurement points at different operating pressures.

Exercise	Atmospheric Pressure, hPa	Altitude: metters, m
1	743	0.0
2	1013	2560.00

In the second experiment a SPRT was calibrated by comparison in the range of -40 °C to 232 °C under two pressures, the first 1013 hPa and second 743 hPa.

RESULTS

Measurements in the triple point of water cell

In the first experiment the following results were obtained:

Results from 743 hPa:

$R_{TPW(743hPa)}$ = 25,536 25 Ω

Results from 1013 hPa

$R_{TPW\,(1013hPa)}$ = 25,536 247 Ω = 25,536 25 Ω

We performed the uncertainty calculation for each atmospheric pressure to be able to calculate the standard error.

$U_{R_{TPW}\,(743hPa)}$ = 0,000 04 Ω

$U_{R_{TPW}\,(1013hPa)}$ = 0,000 04 Ω

The error between the measurement at 743 hPa and 1013 hPa is as follows:

$$E = R_{TPW\,(743hPa)} - R_{TPW\,(1013hPa)}\,[\Omega] \quad (1)$$

$$E = (25.53625 - 25.53625)[\Omega]$$

$$E = 0[\Omega]$$

The error obtained in the equation 1 corresponds to:

$$E = 0[mK]$$

The standard error calculated according to equation 2, following the definition commonly used in the literature, is:

$$S_E = \frac{\left|R_{TPW\,(743hPa)} - R_{TPW\,(1013hPa)}\right|[\Omega]}{\sqrt{\frac{\left(U^2_{TPW\,(743hPa)} + U^2_{TPW\,(1013hPa)}\right)}{1000^2}}\,[\Omega]} \quad (2)$$

$$S_E = \frac{|25.53625 - 25.53625|[\Omega]}{\sqrt{0.00004^2 + 0.00004^2}\,[\Omega]}$$

$$S_E = 0$$

Based on this value, we can affirm that there is no significant difference between the measurements of the thermometric resistance bridge at TPW in the two pressure values considered in the experiment.

Calibration by comparison of SPRT in the range of -40 ° C to 232 ° C for two pressures

In the second experiment a calibration by comparison according to the EIT90 to 743 hPa and 1013 hPa was performed.
The compatibility of the results was checked within standard error.
The results of the calibration of a SPRT at 743 hPa are given in Table 2.

The results of the calibration of a SPRT to 1013 hPa are given in Table 3.

TABLE 2. Calibration results at 743 hPa..

Standard Instrument, [t90 / °C]	**Instrument under calibration,** [t90cal / ºC]	**Error** $E_{T(743\ hPa)}$, [mK]	**Measurement Uncertainty (k=2),** [mK]
232.040	232.061	0.021	25
200.071	200.051	-0.020	25
156.983	156.965	-0.019	25
80.337	80.363	0.025	25
30.133	30.136	0.003	15
15,011	15.012	0.001	15
0.010	0.010	0.000	4
-20.036	-20.073	-0.037	20
-40.088	-40.075	0.013	25

TABLE 3. Calibration results at 1013 hPa..

Standard Instrument, [t90 / °C]	**Instrument under calibration, [t90cal / ºC]**	**Error** $E_{T(743\ hPa)}$**, [mK]**	**Measurement Uncertainty (k=2), [mK]**
232,030	232,053	0,023	25
200,063	200,042	-0,021	25
156,981	156,959	-0,022	25
80,332	80,351	0,019	25
30,133	30,127	-0,006	15
15,018	15,021	0,003	15
0,010	0,010	0,000	4
-20,034	-20,068	-0,034	20
-40,085	-40,071	0,014	25

Table 4 shows the analysis of the results obtained based on the error attained; for each temperature measurement point in each measurement standard error was calculated.

TABLE 4. . Evaluation of the standardized error

Nominal Value , [t90 / °C]	**Error t(743 hPa) - t(1013 hPa),** [t90cal / ºC]	**Measurement Uncertainty (k=2),** [mK]	**SE**
232	-0,003	25	0,07
200	0,001	25	0,03
157	0,003	25	0,09
80	0,007	25	-0,19
30	0,009	15	0,12
15	-0,002	15	0,11
0	0,000	4	0,00
-20	-0,003	20	-0,10
-40	-0,001	20	0,04

Example:

$$S_E = \frac{\left|E_{232°C(743hPa)} - E_{232°C(1013hPa)}\right|[mK]}{\sqrt{\frac{\left(U^2_{232°C(743hPa)} + U^2_{232°C(1013hPa)}\right)}{1000^2}}[mK]}$$

$$S_E = \frac{\left|0.021 - 0.023\right|[mK]}{\sqrt{\frac{\left(25^2 + 25^2\right)}{1000^2}}[mK]}$$

$$S_E = 0.07$$

CONCLUSIONS

In the first experiment, the error was of zero (0) Ω as a result of the difference between the measurement at 743 hPa and 1013 hPa temperature of TPW, this value is meaningless as to make a correction to be considered as a source of uncertainty because the uncertainty reported [5] as the best measurement capability is 4 mK, still in process to register for the KCDB.

In the second experiment, the results show that they at different pressures show no significant differences.

It was shown that the thermometric bridge works within the specified accuracy of 1x10-6 μΩ / Ω at an atmospheric pressure of 743 hPa (2560 meters above sea level)

REFERENCIAS

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