Extrapolation of the functions of the International Temperature Scale of 1990

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The aim of this study is to explore the possibility of extrapolating functions of the International Temperature Scale of 1990 in the case of standard platinum resistance thermometers. The study was carried out in order to meet specific Ifremer requirements. The proposed extrapolation is limited to the range of -10°C to 0°C and 30°C to 60°C. The purpose is to cut down on experiments and thus, calibration time, cost and handling risks.

CONTEXT

Main oceanographic metrological requirements

Small uncertainties (a few Celsius millidegrees)

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Short temperature range (-10°C to 60°C)

Metrological reference equipment

Figure 1: Rosemount 162CE (STRP) (Standard Platinum Resistance Thermometer)

Figure 2: Leeds & Northrup

SPRT ITS90 calibration

- Triple Point of Mercury (TPM) (-38.8344°C)
- Melting Point of Gallium (MPG) (29.7646°C)
- Triple Point of Water (TPW) (0.01°C)
- Freezing Point of Indium (FPI) (156.5985°C)

→ ITS90 negative temperature equations

→ ITS90 positive temperature equations

Reference and deviation functions[a]

Calibration issues

- Shock hazards due to transport and handling
- Cost
- Equipment unavailability
- Exposure to extreme temperatures

Ifremer proposal:

Extrapolate the equations of the International Temperature Scale of 1990 dedicated to positive temperatures as well as the calibration results at Melting Point of Gallium and Triple Point of Water to cover the range of -10°C to 60°C.

METHODOLOGY

The study was performed in three stages: the extrapolation impact is shown for negative temperatures, then positive temperatures and an inter comparison was finally carried out to validate the results.

Negative temperatures

Extrapolation: -10°C to 0.01°C

The ITS90 functions for positive temperatures are used instead of the ITS90 functions for negative temperatures.
The coefficient « a » of the deviation function is calculated with the Melting Point of Gallium *(Equation 1)*.

Extrapolation results:

Results come from a study of 13 calibrations of Rosemount SPRT and 5 calibrations of Leeds & Northrup SPRT. All calibrations were performed by the Laboratoire National de métrologie et d'Essais (LNE – France) at TPM, TPW, MPG and FPI *(Figure 3)*.

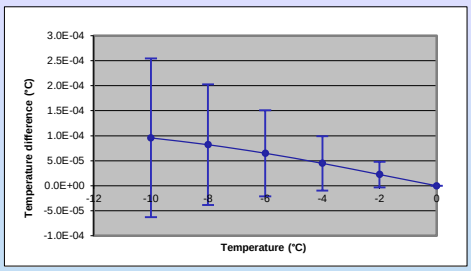

Figure 3: Extrapolation impact on negative temperature range:Temperature difference s due to both coefficient and ITS90 equation differences (negative temperature equations-positive temperature equations) (means and ranges)

The « conventional » and « proposed » practices agree within 5.10^{-4} °C.

Positive temperatures

Extrapolation: 30°C to 60°C

The Melting point of Gallium replaces the Freezing Point of Indium to evaluate the « a » coefficient of the deviation function:

$$W(T_{90}) - W_r(T_{90}) = a\left[W(T_{90}) - 1\right] \quad \begin{cases} W(T_{90}) = \dfrac{R(T_{90})}{R(0{,}01°C)} \\ R(T_{90}) : SPRT\ resistance \end{cases}$$

Equation 1: Deviation function for positive temepratures

Extrapolation results:

Results are issued of a study on 13 calibrations of Rosemount SPRT and 5 calibrations of Leeds & Northrup SPRT. All calibrations have been performed by the Laboratoire National de métrologie et d'Essais (LNE – France) at TPM, TPW, MPG and FPI *(Figure 4)*.

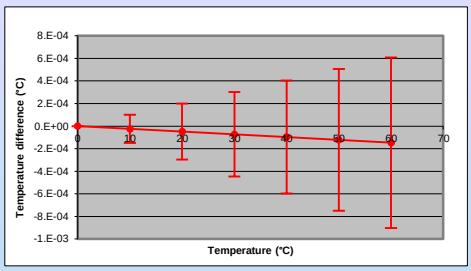

Figure 4: Extrapolation impact on positive temperature range:Temperature differences due to coefficient difference a(In) -a(Ga) (means and ranges)

The « conventional » and « proposed » practices agree within 1.10^{-3} °C.

Validation: Inter comparison in a temperature regulated bath

Four « extrapolated » SPRT were compared with one « conventional » SPRT: the difference reaches 3.10^{-3}°C (1.10^{-3}°C due to extrapolation, 1.10^{-3}°C due to TPW bias, 1.10^{-3}°C due to bath stability).

CONCLUSION

The proposed extrapolation is possible. It cuts down on experiments and thus, calibration time, cost and handling risks. However, each laboratory interested in the extrapolation has to evaluate its own impact and it is highly recommended to monitor carefully its fixed point cells (inter laboratory comparisons, redundant equipment, etc…).

[a] Collection des monographies du Bureau National de Métrologie, monographie n°17, Compléments d'information à L'Echelle Internationale de Température de 1990, Paris : BNM, 1989, ch. 3, pp. 128-132.