Realization of the Temperature Scale in the SMU, Present Situation and Future Vision

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Abstract. *The temperature scale in the SMU is realised in accordance with the ITS - 90 (International Temperature Scale 1990) in the temperature range from –39 °C up to 960 °C. Improvement of the temperature scale assurance is the permanent task and it is connected with the decreasing of the uncertainties. During the last years arose the needs to extend the scale up to –180 °C. The situation in this field is described in the following contribution.*

Keywords: *Temperature scale, ITS-90, SPRT calibration, Uncertainties, Low Temperatures*

1. Introduction

Realization of the temperature scale is assured in accordance with the document "International Temperature Scale of 1990" (ITS - 90) [1] in the Centre of Thermometry, Photometry and Radiometry of the Slovak Institute of Metrology (SMU). It is connected with the assurance of the traceability of the measuring instruments in temperature. At present time the temperature scale in Slovakia is realized within the range from -39 °C up to 2200 °C according to the needs of our customers and also to the technical possibilities of the SMU. In the range from -39 °C to 961,78 °C temperature scale is realized by means of contact thermometry and in the range form 961,78 °C by means of non-contact thermometry. International acceptation of the realization of the temperature scale in the SMU is assured by participation in international comparisons (preferably key comparisons). This contribution provides the actual information about the situation in the realization of the temperature scale in the range from –39 °C to 962 °C, and also about the future intention with respect to the reduction of standard platinum resistance thermometer calibration uncertainty and extension of the temperature scale realized by the SMU to the low temperatures.

2. International Temperature Scale of 1990

ITS-90 was adopted by International Committee of Weights Measures as the document specifying internationally agreed procedures and practical thermometers that will enable laboratories to realize scale independently and / or independently determine high reproducible value of temperature.

ITS-90 approximate thermodynamic scale by:

- defined temperature points (defining fixed points),
- reproducible interpolating instruments,
- interpolating relations for related interpolating instruments.

Defining fixed point (DFP) is the system witch temperature is given by physical process. The defining fixed points of the ITS-90 range from –38,8344 °C to 961,78 °C consist of triple points, melting point and freezing points of pure substances.
Interpolating instrument for range from 13,8033 K to 961,78 °C is standard platinum resistance thermometer (SPRT).
Interpolating equations characterize temperature dependence of the SPRT resistance.

3. National Standard of Temperature Kept in the SMU

National Standard of temperature in Slovakia covers the temperature range 0,01 °C to 961,78 °C. Temperature scale in the SMU is realized from –39°C, but the range from –39 °C up to 0,01 °C is not covered by the National Standard. The National Standard consists from the following instruments:

- set of defining fixed points,
- interpolating instruments – standard platinum resistance thermometer, high-temperature standard platinum resistance thermometer,
- other devices for realization of defining fixed points – furnaces, baths,
- auxiliary facilities for data reading – resistance bridge, multimeter, resistance standard, hardware and software facilities.

The SMU defining fixed point cells are designed and made in the SMU and some of them are commercial ones. Defining fixed point cells used in the SMU are shown in table 1.

***Table 1.** SMU defining fixed point cells*

DPB	Teplota t_{90}/°C	Source
Triple point of Hg	-38,8344	SMU
Triple point of water	0,01	SMU
Freezing point of In	153,5985	comercial
Melting point of Ga	29,7646	SMU
Freezing point of Sn	231,982	comercial
Freezing point of Zn	419,527	comercial
Freezing point of Al	660,323	comercial
Freezing point of Ag	961,780	comercial

System for the realization of DFPs and for the SPRT calibration is presented in figure 1. Resistance of the SPRT is measured by AC resistance bridge, that measure ratio of the SPRT resistance and resistance of standard resistor. Standard resistor is temperature stabilized for its temperature dependence. Standard resistor is stored in the thermostat (liquid bath) and its temperature is continually measured by the calibrated PRT. Resistance of the SPRT is measured by appropriate multimeter. The value of the resistance of the standard resistor is calculated for its real temperature. Data from resistance bridge and multimeter are collected by the PC using interface IEEE 488 and they are subsequently processed.

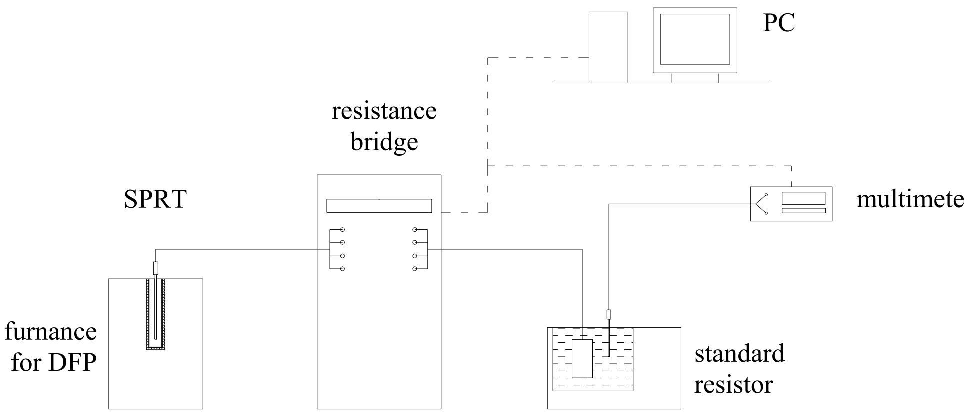

***Figure 1**. System for the realization of defining fixed points and calibration of the SPRTs.*

4. Improvement of the Temperature Scale Assurance

Research in the realization of temperature scale is focused to the improvement of two basic areas:

- reduction of the SPRT calibration uncertainty,

- extension of realized temperature scale to the low temperatures.

Reduction of the SPRT calibration uncertainty

The sealed cells of DFPs In, Sn, Zn, Al, and Ag are used for the realization of the temperature scale in the SMU. The cell consist of the graphite crucible filled by metal of high purity (6 N). The crucible is put into the quartz envelope filled with inert gas with known pressure. Possible diffusion processes through the quartz envelope leads to uncontrollable change of pressure of gas into cell. The value of temperature strongly depends on the pressure.

Regulation and continual measurement of gas pressure in the cell provides the solution of this problem. This is possible by using the open cells by enabling direct connection to system allowing supply of the gas, regulation and measurement of its pressure. System for the realization of the open cells of defining fixed points is on the figure 2.

The values of the extended uncertainties (for k = 2) [2] [3] [4] for the realizations of the DFPs in the SMU are in the following table 2. These values are now under the process of discussion for their acceptation in the CMC tables [3].

Table 2. *Uncertainties of the DFPs realization in the SMU*

DPB	U / mK (k = 2)
Triple point of Hg	0,7
Triple point of water	0,22
Melting point of Ga	0,22
Freezing point of In	1
Freezing point of Sn	1
Freezing point of Zn	1,4
Freezing point of Al	2
Freezing point of Ag	3,6

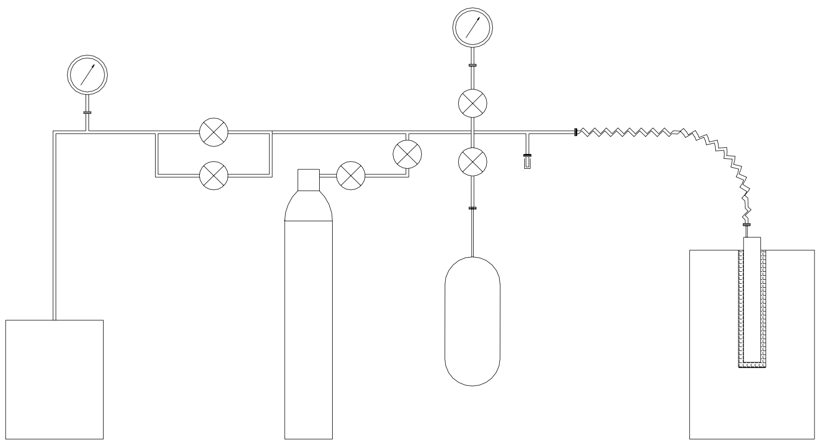

Figure 2. *System for realization of defining fixed points in open cells*

Extension of the realized temperature scale to low temperatures

Extension of the present realized temperature scale to low temperatures needs to integrate mercury triple point to the temperature scale and development of Ar triple point system. The triple point cell was developed and made in the SMU some years ago.

Concerning to needs of industry the Ar triple point system is being designed in the SMU for calibration long-stem SPRTs, shown in figure 3. The cell is placed into the measuring chamber and thermally isolated from surrounding. Heat exchanges by conductance and convection are minimalized by pumping out deep vacuum in measuring chamber and by creating thermal bridge between thermometer storage system and walls of measuring chamber. Cooling of the Ar sample is realized by flowing of liquid nitrogen through flow cooler placed on the bottom of the cell what causes that Ar

start to freeze at the bottom part of the cell. Heating of the sample is realized by resistance heater placed directly on the cell.
Particular problem is filling and sealing of the cell. Because the temperature of triple point of Ar is very sensitive to presence of impurities in the sample it requires building up the system for treatment of Ar high-purity [5].

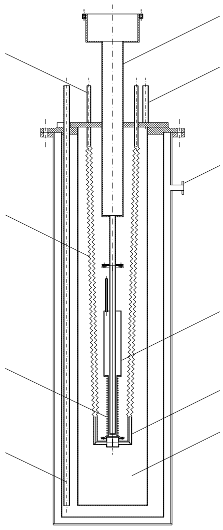

Figure 3. *Triple point Ar system*

5. Conclusion

Extension of the range of the realized temperature scale and increasing of the precise of the realization is permanently studied problem by the thermometry staff in the SMU. This contribution presents very concisely the present situation in Slovakia. The level of the realized temperature scale is very high as it can be seen on the values of the uncertainties. The perspective of the extension corresponds to the orientation in the world.

References

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