PRIMARY STATE STANDARD OF THE UNIT OF TEMPERATURE, 
THE KELVIN, IN THE RANGE OF 273.15-2800 K

I. I. Kirenkov, A. Kh. Fayans, 
and G. A. Krakhmal'nikova

This reference standard has been produced at the All-Union Scientific-Research Institute of Metrology (VNIIM).

Many measures adopted during recent years made it possible to apply in the practice of thermometry a test scheme which includes as reference and standard equipment the reference photoelectric comparator, reference and standard high-temperature resistance thermometers, the reference freezing point of tin, a group of reference semi-automatic liquid thermostatic devices (water, oil, tin), reference platinum-platinum thermocouples, special thermostats for checking surface thermometers, and several other devices [1-17].

The reproduction of the temperature unit, the kelvin, is based on the application of several reference IPT-68 scale points, with each of which a group of instruments and devices is associated. The primary state standard of the unit of temperature, the kelvin, developed on this basis for the range of 273.15-2800 K (from 0 to 2500°С) consists of the following aggregate of measuring instruments used for reproducing, storing, and transferring the above unit:

- equipment for reproducing as reference points
  - the triple point of water at 273.16 K (0.01°C),
  - the boiling point of water at 373.15 K (100°C),
  - the freezing point of tin at 505.1181 K (231.9681°C),
  - the freezing point of zinc at 692.73 K (419.58°C),
  - the freezing point of silver at 1235.08 K (961.93°C),
  - the freezing point of gold at 1337.58 K (1064.43°C);
- platinum resistance thermometers for determining the triple point of water, the boiling point of water, and the freezing points of tin and zinc;
- platinum resistance thermometers for determining the freezing points of silver and gold;
- standard temperature lamps for the freezing point of gold;
- photoelectric equipment for doubling luminance in the temperature range of 1337.58 to 2800 K (from 1064.43 to 2500°C);
- electrical measuring equipment.

The reference triple point of water is reproduced by means of a hermetically sealed glass container with a test-tube well fused into it. The volume of the container is partly filled with highly purified natural water. The space above the water surface is filled only with steam. The test-tube well is covered before its application with a layer of ice (condensed onto it). Thus, the space inside the container is filled only with water in its three phases. The working space inside the container well is maintained at the equilibrium temperature of the three phases of water with an error smaller than 0.0002 K. For practical work in the course of reference measurements there are three triple-point-of-water installations in constant use at the VNIIM.

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A hermetically sealed system has been developed at the VNIIM for reproducing the reference boiling point of water. This equipment consists of a boiler, manostat, and manometer. The temperature gradient in the working base of the boiler does not exceed 0.01 K m⁻¹. Therefore, the reproducibility of temperature readings remains within 0.0005 K for variation of 50 mm in the immersion depth and 10% in the boiler power.

The manostat serves to maintain the vapor pressure constant and independent of the atmospheric pressure.

Steam pressure is measured with a precision mercury barometer which has an interference-method reading device and is located in premises with an automatically controlled temperature. The error in measuring pressure with the barometer amounts to 0.5 Pa, which corresponds to the temperature error of less than 0.0002 K.

The stability of temperature equilibrium between water and its vapor is ensured within the range of 0.0003 K.

Freezing points of tin are provided in thermostatic installations of the type "Tin 2" and "Tin 1." The installation "Tin 2" has automatic units which provide a programmed regulation of temperature. They ensure a stable equilibrium temperature between solid and liquid tin within the range of 0.0002 K and a reproducibility during approximately 6 months within 0.0005 K.

Reference silver and gold freezing points are obtained in shaft furnaces. The working space of the furnace consists of ceramic tubes with nickel-chrome tape heaters.

The silver and gold melting furnaces provide a constant freezing temperature within the range of 0.005 K; moreover, the reproducibility of these metals' freezing points with the use of high-temperature resistance thermometers remain within the range of 0.01 K.

Reference platinum resistance thermometers are intended for reproducing and transmitting the value of the kelvin in the range of 273.15-903.89 K.

The basic part of these thermometers comprises a sensing element which consists of a 0.1-mm platinum wire spiral wound on a helical quartz former. Their mean temperature resistance coefficient in the range of 0 to 100°C amounts to 0.003927 K⁻¹. The sensing element with its lead-out wires is enclosed in a hermetically sealed quartz test tube which is 500 mm long and is filled with dry air. The thermometers' nominal resistance is \( R_0 = 25 \Omega \).

The resistance thermometers are calibrated at the constant primary IPTS-68 points, namely at the triple point of water, boiling point of water at normal atmospheric pressure or at the freezing point of tin and at the freezing point of zinc.

Reference high-temperature resistance thermometers (HTRT) are intended for reproducing and transmitting the value of the kelvin in the range of 903.89-1331.58 K. Their basic part consists of a highly pure platinum wire 0.4 mm in diameter located in a spiral groove of a quartz former. The mean temperature resistance coefficient of the wire amounts to 0.003927 K⁻¹. The nominal thermometer's resistance is \( R_0 = 0.6 \Omega \).

The HTR thermometers are calibrated at the primary reference IPTS-68 points, namely at the freezing points of zinc and gold.

The root-mean-square error of measurements made with the HTR thermometers does not exceed 0.005 K at the freezing point of zinc and 0.01 K at the freezing point of gold.

Spectropyrometric installation SP-4K is intended for basic metrological work in the field of high temperatures (exceeding 1064.43°C). Its operation is based on the zero modulation method for balancing luminances. The SP-4K installation uses a double monochromator. This has eliminated the effect of light scattering and made it possible to obtain a radical solution to the problem of precise measurements of effective wavelengths. In designing components of the external optical system measures were also adopted to reduce substantially light scattering. The design of photocells provides the possibility of controlling the photomultiplier adjustment.

The double monochromator is suitable for working in the wavelength range of 470-1000 nm, with linear dispersion amounting to from 36 to 270 nm/mm. The standard temperature lamps are calibrated by means of the hydrogen, mercury, helium, and krypton spectra with a slot width of 0.1-0.2 mm. The sensitivity threshold amounts to 0.02-0.05 K for the entire spectral range at the temperature of 1064°C, and deviations among lamps are within the range of 0.1-0.4 K.