QUALITY AND CERTIFICATION

USING RESISTANCE THERMOMETERS AND THERMOELECTRIC SENSORS

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Details are given of the range of temperature sensors produced by the Etalon Scientific Company. Descriptions are given of the design and other instrumental features, the temperature measurement ranges, and the measurement methods.

This company produces a wide range of primary temperature sensors of two forms for industry: resistance thermometers (RT) and thermoelectric sensors (thermocouples). The copper RT are intended for measuring temperatures between –50 and +180°C, while platinum ones cover the range from –200 to +600°C. Two types of characteristic have been standardized for the platinum RT: \( \alpha_{100} = 1.3910 \) and \( \alpha_{100} = 1.3850 \), in which \( \alpha_{100} \) is the ratio of the RT resistance at 100°C to that at 0°C. The company produces platinum RT with \( \alpha_{100} = 1.3910 \) and \( \alpha_{100} = 1.3850 \), which serve to replace imported RT. Copper RT are produced with \( \alpha_{100} = 1.4280 \), but the deviation from \( \alpha_{100} = 1.4260 \) is small, and the replacement does not cause difficulty; for example, at 180°C the deviation is 0.7°C.

Tight specifications are applied to the RT used in heat metering. Such RT are supplied as the KTSPR 9514 set (Fig. 1), in which the resistances of the two RT in the set at 0°C differ by not more than 0.01%. At present the company supplies KTSPR sets corresponding to international standards, with checks at three points. As the RT have standardized limits for the permissible deviation in the resistance from the nominal static characteristics (NSC), if it is necessary to replace the sensors, there is no need for adjustment or the introduction of corrections in the secondary measuring or regulating instrument.

The most important condition for the correct temperature measurement with RT is electrical insulation of the measuring resistance itself and also the connecting leads. The insulation resistance should not be less than 10 MΩ, since otherwise the shunting leads to considerable error. For that reason, the RT leads are mounted at the outlet in a protective sleeve made of epoxide resin. The leads joining the RT to the secondary instrument must not be laid out together with line cables in order to avoid interference that would distort the measurements.

The RT design influences the heat transfer from the medium to the resistor, and to reduce the measurement error it is necessary to take this into account in choosing the mode of mounting. If the mounting is on a pipeline, it is necessary to provide thermal insulation of the pipe around the insertion zone. Particularly, this is necessary when the medium is air or gas at low pressure (one atmosphere or several atmospheres).

The measurement error is the smaller the greater the ratio of the immersion length to the RT diameter. The RT should be installed at a point where the flow speed of the medium is largest. The necessary immersion length is dependent to a considerable extent on the heat-transfer rate, which itself is

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Fig_1.png}
\caption{Ways of installing the KTSPR-9514 set on a pipe.}
\end{figure}

\footnote{Etalon Scientific Company, Omsk, Russia.}
dependent on the characteristics of the medium. In liquids and high-pressure steam, there is very good heat transfer, and the immersion depth should be about 1.5 times larger than the active length of the temperature sensor, while for gases at normal pressure the factor is 2, i.e., it constitutes at least 6 – 8 times the diameter of the protective jacket. For example, for the TSP 9201 with an active length of the sensor of 60 mm, this constitutes 90 mm in the first case and 120 mm in the second. If the measurements are made not in a pipe but in still air or gas, it is best for the immersion to be at a depth of about 30d (where d is the diameter), or in a liquid at rest, about 10d.

To provide for installing and removing the RT in a pipeline without releasing the pressure in it, one uses a sleeve that protects the RT from high pressures in the line. As the temperature range for industrial RT is from +200 to +600°C, the protective sleeve is usually made of 12Kh18N10T stainless steel. To protect the RT from corrosive media (alkaline or acid) up to +200°C, one uses a coating of polymer materials inert in such media.

Measurements in circumstances of rapidly varying temperature are influenced by the RT thermal response time. That time is the time necessary on insertion in a medium with constant temperature to be such that the temperature difference between the medium and any point in the RT should be 0.37 of that difference at the time when the regular thermal mode sets in.

RT measurements involve correction for the resistance of the internal leads joining the sensing element (SE) to the RT outputs as well as the resistance of the line joining the RT to the measuring instrument. The resistance of the connecting leads is eliminated from the measurement circuit only if one uses a four-lead system, where the measurement current is brought through one set of leads, while the potential difference across the SE is measured by an instrument with a high input impedance joined by means of the other two leads, which are connected directly to the SE outputs. For primary-standard RT and working RT of classes A and AA, one uses only the four-lead connection mode. This not only provides the highest accuracy but also simplifies the measurement procedure because it does not require correction for the resistance of the connecting leads. This becomes particularly important if the connecting lines are long. An advantage of the four-wire system is that in the working zone (in the zone where the RT is immersed in the medium whose temperature is measured) one has firstly a temperature distribution that is not known, while secondly it very often varies in time, so one cannot perform an exact calculation on the correction to eliminate the effects of the connecting leads and the changes that may occur during the measurements.

In ordinary industrial temperature measurements one usually employs class B RT, whose internal conductors may be brought out to the RT terminals in a two-wire, three-wire, or four-wire system. The RT standards lay down that for a two-wire circuit for a connection of the internal conductors of the RT with the SE, their resistance should not exceed 0.1% of the nominal resistances at 0°C; these values are entered into the working document for the RT. One chooses the type of connecting line between the RT and the secondary instrument (two, three, or four wires) on the basis of the distance between the RT and the secondary instrument, and as one knows the resistance of the internal wires in the RT and the resistance of the connecting line, one can calculate the correction. Checking (calibrating) the RT may be performed with two types of test equipments produced by the company: with the UPST-2M apparatus or with the ARM PTS automated equipment.

The thermocouples made by the company have the following temperature ranges: chromel-copel from –40 to +600°C, chromel-alumel from –40 to +1050°C, platinum-rhodium-platinum ones from 0 to +1300°C, and platinum-rhodium ones from +300 to +1600°C; the characteristics of these thermocouples are standardized, and the Russian standards correspond to international ones. The permissible deviations of the thermo-EMF from the standardized characteristics are also themselves standardized. For example, for chromel-alumel thermocouples KhA(K) of tolerance class 2, the limits are ±2.5°C in the range from –40 to +333°C and ±0.0075°C in the range from 333 to 1300°C. This makes the thermocouples interchangeable, including with imported ones.

The thermocouples have the following basic features:

- they generate the thermo-EMF, which is dependent on the temperature difference between the working (hot) junction and the free (cold) ends. The standard normalizes their characteristics and the tolerance limits for the deviations for temperatures at the free ends of 0°C;