Enhancement of the state primary standard of the unit of total radiance

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The State primary standard of the total radiance unit, which was approved in the end of 2018, is described. The range of the total radiance reproduced by the standard is from 54,36 to 61·10^3 W/(sr·m^2) with the expanded uncertainty not more than 1,5·10^{-3} relative units.

INTRODUCTION

The first work on creating standards in the field of the total radiation in Russia was started at VNIIM in 1964. In 1974, the first radiometric state primary standard of total radiation unit (SPS) was approved. Work directed at expanding the range and improving accuracy continued, which was reflected in the SPS approved in 2001.

Due to the increased measurement tasks to provide measuring instruments with higher metrological characteristics, the improvement of the SPS was required. In addition, there was a need to increase the reliability of unit transfer from SPS to secondary and working standards.

Thus, in 2015, the enhancement of the state primary standard of the unit of total radiance was started, which was successfully completed at the end of 2018.

DESCRIPTION OF THE STANDART

The main parts of the standard created in 2001 were blackbodies sources based on the phase transitions of pure substances [1].

Preserving the ideology of construction the standard, the main efforts in its improvement were aimed at creating a new blackbody source based on the triple point of mercury (BB-Hg).

As a result of work in the framework of enhancement of the SPS, a black body was developed [2]. The new blackbody based on the triple point of mercury reproduces value of total radiance 54.36 W/(sr·m^2) at a phase transition temperature of 234.32 K in accordance with ITS-90.

In addition, modernization of the blackbody sources of reference points of pure elements: tin (BB-O), indium (BB-I), aluminum (BB-A) [3] and copper (BB-C).

A fundamental element of any blackbody sources is the cell filled corresponding pure substance. Construction the cell must enforce mandatory requirements for the external dimensions of the cell, thickness the wall and emissivity parameters of cavity.

With the enhancement of the SPS, the development of new designs of the cell of blackbody sources based on phase transitions of pure metals was done. New cells were made and filled with high-purity metals. The new three-zone furnaces were development for blackbody sources placement and subsequent implementation.

The reproducible values of units total radiation for BB-O, BB-I, BB-A, BB-C compose 1173.4, 4151.0, 13691 and 61282 W/(sr·m^2) respectively.

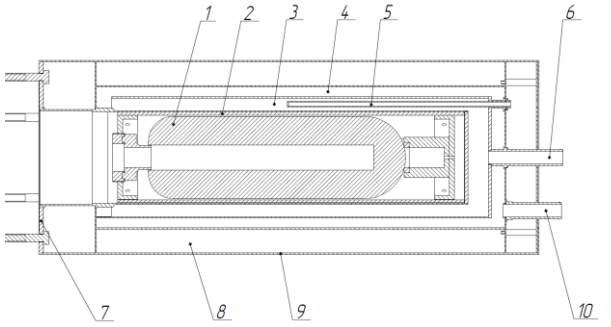
The use of new cells designs has significantly increased the life of the blackbody sources.

Also, a novel blackbody sources based on a triple point of water (BB-TPW) was developed.

BB-TPW include the following main units:

- Cell of the triple point of water fixed point;
- Passive thermostat for placing the cell of triple point of water;
- Cryostat, designed to provide the necessary thermal regime for the realization of a triple point of water;
- Connecting elements.

Passive thermostat and cryostat form a thermostatic device.



1 - the cell of triple point; 2 - container; 3 - the internal cavity of a heat exchanger; 4 - the outer cavity of a heat exchanger; 5 - thermometer channel; 6 - inlet branch pipe; 7 - connecting flange; 8 - thermal insulation; 9 - envelope; 10 - outlet branch pipe;

Figure 1. Design of a passive thermostat

Design of a passive thermostat is based on heat exchanger in the form of the “pipe in the pipe” that working in the opposite connection. The coolant, enters to the inlet branch pipe (6) and flows through the internal cavity of the heat exchanger (3). After passing through the internal cavity of the heat exchanger, the coolant is poured through the specialized technological slots into the outer cavity of the heat exchanger (4) and through an outlet branch pipe (10) it returns to the cryostat.

The temperature of the cavity is controlled by the resistance thermometer located in the channel (5). The attachment to the vacuum chamber of the primary standard is carried out by means of the connecting flange (7).

The results of the measurements are showed, that the metrological characteristics of the thermostatic device satisfy the requirements necessary for the realization and maintenance of the fixed point of water. Reproducible value of total radiance of BB-TPW is 100.39 W/(sr·m^2).

As part of the enhancement of the standard, a new thermostat was developed for the blackbody source of gallium. Its use allowed to reduce the non-uniformity of the temperature field during the implementation of the melting plateau of high-purity gallium.

CONCLUSIONS

The SPS was enhancement, within the framework new blackbodies source were developed. Also blackbodies sources from the previous state primary standard were modernized. Research done have shown that the expanded value of the uncertainty does not exceed 1,5·10^{-3} relative units at k = 2.

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