Implementation of the Spectral Irradiance Standard based on a high-temperature black body

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The high-temperature black body is widely used as a primary standard source for implementation of spectral irradiance units and can be used for spectral calibration of measuring instruments. Correct determination of a relation between spectral irradiance values of the primary standard and corresponding readings of a measuring instrument, and further obtaining a measurement result from this relation requires a suitably advanced system for making comparative measurements. The presented concept of a measurement system based on modern motion control components helped to achieve a high level of precision and accuracy while achieving better performance of the comparison procedure.

PRIMARY STANDARD

High-temperature black body radiators are widely used in national metrological institutes for implementation and maintenance of radiometric units [1]. The black body BB-PyroG-3000/32 adopted in the GL Optic laboratory was developed and manufactured by All-Russian Research Institute for

Table 1. Properties of BB-PyroG-3000/32 high-temperature black body radiator.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum temperature</td>
<td>3200 K</td>
</tr>
<tr>
<td>Aperture diameter</td>
<td>25 mm</td>
</tr>
<tr>
<td>Cavity diameter</td>
<td>32 mm</td>
</tr>
<tr>
<td>Emissivity in UV-VIS-IR</td>
<td>≥ 0.999</td>
</tr>
<tr>
<td>Temperature resolution</td>
<td>0.01 K</td>
</tr>
<tr>
<td>Temperature stability</td>
<td>± 0.02 K</td>
</tr>
<tr>
<td>Support for HTFP</td>
<td>yes</td>
</tr>
</tbody>
</table>

The Planck’s law describes the spectral distribution of the power of optical radiation emitted by a black body in thermal equilibrium based on a set temperature. Correct determination of the temperature is thus crucial for the whole measurement process. To measure the actual temperature, a Chino IR-RST65H pyrometer was used. It is a monochromatic pyrometer using a silicon
photodiode as a detector. The measurement is made at a wavelength of 650 nm. The diameter of the measurement field is 0.6 mm at the distance of 400 mm. It helps to test the homogeneity of the black body emitting area.

To ensure the most accurate temperature measurement, the pyrometer can be calibrated against the rhenium-carbon high temperature fix point (HTFP), when the HTFP cell is installed in the blackbody.

The spectral irradiance measurement procedure consists of alternating measurements of the black body and a tested source for successive wavelengths within the assumed measurement range (Fig. 1).

Changes in the position of the double monochromator have a significant impact on the total measurement time and may introduce additional misalignment errors.

To ensure fast switching between the two measurement positions, the optical comparator uses servomotors with built in 23-bit absolute encoders dedicated to CNC machining tools. The solution used helped to achieve positioning with standard deviation of 5 μm and with switching time between both positions of about 1.5 s.

The validation procedure revealed a known problem [3] of absorption bands caused by molecular carbon or carbon compounds presented in Figure 3. The additional array spectroradiometer used in combination with a double monochromator helps to identify and correct the deviations from the Planckian spectrum. The results obtained from this instrument are used as input data to the correction algorithm.

**CONCLUSIONS**

The developed Spectral Irradiance Standard facility allows calibration with high efficiency (Figure 4). At the current stage the comparator is a subject of validation and comparative studies with national metrological institutes. The final results of these tests and the obtained calibration procedure times will be presented in the article following this abstract.

**REFERENCES**