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OIML/TC11/SC3

Title: Blackbody Radiators For
Calibration Of Radiation
Thermometers. Calibration and
Verification Procedure

Secretariat: Russian Federation

Circulated to P- and O members
and liaison internal bodies and
external organizations for:

○ discussion at:

○ comments by:

● vote (P-members only) and
comments by: 17 Aug 2012

TITLE OF THE CD (English): 4CD Recommendation “Blackbody Radiators For
Calibration Of Radiation Thermometers. Calibration and Verification Procedure”

TITLE OF THE CD (French): 4CD de la Recommandation “Radiateurs corps noir
pour la calibration des thermomètres à radiation. Procédures de calibration et de
vérification ».

Explanatory Note for the 4th Draft OIML Recommendation
"Blackbody Radiators for Calibration of Radiation Thermometers.
Calibration and Verification Procedure "

This draft is prepared with regard to comments received for the previous 3rd draft.

It also takes into account the recommendations set forth in the documents adopted by the Consultative Committee for Thermometry (CCT of CIPM) for the field of thermometry.

Importance of traceability to the national standards and the International Temperature Scale 90 (ITS-90) is emphasized.

The contents of the Draft are formalized as much as possible with a view to eliminating specificities and value levels of estimates of the metrological characteristics used in different countries. The recommendation specifies the direction of the work and methods for testing the blackbody radiators used for calibration and testing of radiation thermometers, but it does not fix any numerical criteria to determine the quality of radiators.

In unclear, ambiguous and complicated cases explanations and clarifying footnotes were added and a number of wordings were improved. The misprints in formulas (4) and (5) in item 6.8.1 were corrected.

The convener of the project is especially grateful to the Japanese commentator for his thorough examination of the draft and his valuable remarks and suggestions that have been in most cases taken into account.

Summary of comments to the 3rd CD
 "Blackbody Radiators for Calibration of Radiation Thermometers. Calibration and Verification Procedure "
 (TC11/CD3)

Item	Comments	Reply
Comments of Japan (13 July 2011)		
1 Scope and entire recommendation	<p>Recommend replacing all "<i>pyrometers</i>" with "<i>radiation thermometers</i>" in this draft recommendation since it is a more generally-accepted expression of the instrument.</p> <p>The term "<i>and radiometers</i>" in Scope may not be necessary since it means a measuring instrument for optical radiation.</p>	<p>Partially accepted. A footnote was added on page 3 explaining that the terms "pyrometer" and "radiation pyrometer" are widely used in literature, especially in the names of the manufactured instruments.</p> <p>By the instruments called "radiometers" are understood those instruments that are used to measure the parameter of optical radiation, against which the radiation characteristic of "blackbody" is estimated.</p>
2. Terms, Definitions, Units and References	<p>Request adding definitions for "<i>emissivity</i>" and "<i>effective emissivity</i>" as below.</p> <p><i>Emissivity: the ratio of the radiance of a substance to the radiance of a blackbody at the same temperature as that of the substance.</i></p> <p><i>Effective emissivity: an apparent emissivity of a blackbody cavity or a surface of a planar blackbody radiator. That should be taking into account of an intrinsic emissivity of surface, a geometrical factor, a temperature distribution, and an ambient thermal radiation.</i></p>	Accepted.
2.1.1 Blackbody radiator (BBR)	Request deleting " <i>($\epsilon \geq 0.95$)</i> " since such a numerical limitation is not appropriate in a definition of the term. Also, this value might be a too strict requirement for a BBR with an extended flat surface.	Accepted partially. The definition of BBR was improved.
2.1.3 Temperature keeping instability	Recommend deleting the sentence " <i>i.e. standard deviation of the BBR temperature values measured every 10 – 15 seconds during 15 – 20 minutes with reference to their average value during the same period</i> " since it explains a practical measurement method that is also described in Clause 6.6.	Accepted.

Item	Comments	Reply
2.1.4 Temperature drift	Delete the sentence “ <i>which is equal to the maximum difference of average temperature values determined every five minutes (measurements being taken every 10 – 15 seconds) during fifteen minutes</i> ” since it explains a practical measurement method that is also described in Clause 6.6.	Accepted.
2.1.7 and 2.1.8	In the name of the terms, change “ contact sensors ” to “ contact thermometers ” since they actually refer to thermometers.	Accepted
3.1.1	Recommend changing the expression as “ <i>The BBRs have a radiating area that is composed of a cavity or a plain surface</i> ”. In addition, we recommend adding illustrations of two kinds of BBRs using a cavity and a plain surface.	Accepted
3.1.6	Recommend changing “ correction factor ” to “ correction factor or value ” since temperature is frequently corrected using an offset value rather than a factor (ratio). In addition, the two notes should not be necessary for this recommendation since the content is too detailed and technical. If the notes are really necessary, we recommend moving them to an annex or an explanatory note at the end the document.	Accepted. Rejected. The developer sticks to the opinion that the notes are pertinent and the details ensure the clarity of the document concept with respect to these characteristics.
4.2	Change “ emitting area ” to “ radiating area ” in compliance with the expression in 3.1.6.	Accepted
5.2	Recommend deleting this clause since it refers laboratory accreditation and it seems out of the scope of the present technical recommendation on BBR.	Accepted

Item	Comments	Reply
6.1.1, Table 1, No. 4 and 6	<p>It is very difficult to understand true meaning the following expressions for magnitudes of uncertainty.</p> <p><i>“with resolution in ≥ 3 times as much than U_{pBB}”</i></p> <p><i>“in ≥ 3 times as less than U_{pBB}”</i></p> <p><i>“in ≥ 3 times as much than U_{pBB}”</i></p> <p><i>“with resolution in ≥ 3 times as much than U_{pBB}”</i></p> <p>We recommend changing these expressions simpler without using a sign of inequality or the word “times” (e.g., “<i>with a resolution less than 1/3 of U_{pBB}</i>”).</p>	Accepted
6.1.2	<p>Recommend changing the clause as shown below:</p> <p><i>“All Measuring instruments specified in Table 1 shall should be calibrated traceable to national standards and provided with the corresponding legal documents about their verification or calibration.”</i></p> <p>It is because a requirement for traceability for <u>all</u> instruments might be too strict for some institutes, and the term “<u>legal</u>” is not appropriate as calibration is not legally required in many countries.</p>	Accepted
6.1.6	<p>Recommend deleting this clause since it refers to the qualification of experts, and it might be out of the scope of this technical recommendation.</p>	Accepted
6.4.1	<p>The terms “<i>by means of a linear measuring instrument</i>” are not necessary. It is self-explanatory.</p>	Accepted
6.4.3	<p>Recommend deleting the whole clause. The resolution of doubts is out of the responsibility of calibration/verification institutes. Also, the cited references [2, 3] contain too technical contents which might not be appropriate in a practical calibration / verification.</p>	Accepted

Item	Comments	Reply
6.6.4	Recommend deleting this clause. We consider that an operation getting out of the greatest value is not an appropriate statistical procedure in obtaining a standard deviation.	Accepted
6.7.2, 6.7.12 and 6.7.14	As a general comment to these clauses, we recommend proposing two alternative calibration methods for all of the three temperature ranges. The methods actually mean (1) comparison with a standard BBR using a radiation thermometer as a comparator and (2) calibration in reference to a standard radiation thermometer. In addition, we hope that the numerical ranges of temperature and wavelength in these clauses will be expressed only as an informative example.	Rejected. The developer is of opinion that the detailed information is necessary to clarify the specificities proper to each range. Accepted. Footnotes were added to these items.
6.7.4	The practical meaning of “ <u>equal signals method</u> ” is not clear. Also, the next sentences might not be necessary since they are about practical procedures which are too detailed. “ <i>The operation is carried out using a measuring rule, a crosshair stop inserted into the radiating aperture, and a comparator viewfinder. The comparator is turned on and its output signal (display indication, voltage, current, code) is measured.</i> ”	Accepted. Explaining footnote was added. Accepted.
6.7.15	The practical meaning of “ <u>concrete type</u> ” is not clear. Please explain.	The word “concrete” was substituted for “special” and the wording of the sentence was changed.
6.7.16	The whole content becomes unclear since the meaning of “ <u>view angle</u> ” is ambiguous. Does view angle mean a field angle of view, or an angle between the line of observation and the normal line to the radiating area?	Was added a footnote explaining that the “view angle” is the angle between the line of observation and the normal line to the radiating area.
6.7.17	Recommend changing “ <u>non-uniformity</u> ” to “ <u>non-uniformity in radiance temperature</u> ” to express the practical meaning clearly. In addition, the following sentence might not be necessary since it seems not related to the main content of this clause. “ <i>These measurements are made according to items 6.7.2 – 6.7.13. In this case the dependence of correction on the view angle is not determined. Usually it needs at temperatures lower than 300 °C</i> ”	Accepted. Accepted.

Item	Comments	Reply
6.8.1	Correct two misprints by changing the expression from “ by multiplying by the coverage factor ” to “ by dividing by the coverage factor .”	The meaning was clarified: the word “reduced” was substituted for “adjusted” and “standard” for “expanded”.
6.8.1 Eq. (4)	Change Eq. (4) to “ $u_A(T) = u(T_i) / \sqrt{n}$ ” since average temperature divided by the square root of “n” does not equivalent to uncertainty.	Accepted. Corrected .
6.8.1 Eq. (5)	Change Eq. (5) to “ $u_B(T) = \sqrt{[u_{st}^2 + (u_{ci}^2 + c_{si}^2 + u_{va}^2 + u_{rs}^2) / 3]}$.” Because U_{st} expresses an expanded standard uncertainty with a normal distribution of uncertainty, it cannot be treated with the same method for the other uncertainties (u_{ci} , c_{si} ...) which have a rectangular distribution.	Accepted. Corrected.
Comments of Poland (28.06.2011)		
6.8.1 (p.12)	The item should be changed and written as follows: "The uncertainty of the standard measuring instruments u_{st} in this case shall be equal to u_{sp}	Accepted. Corrected.