

**Reply to the UK comments on the 2nd CD IR "Blackbody Radiators for the Temperature Range from - 50 °C to + 2 500 °C"**  
(NWML, Contact in International, Training & Consultancy Team NWML John Goulding)

No	Comments	Reply
Table 1	Some of what they call 'obligations of procedure' are missing from table 1. Operations 4, 5, 6 and 7 need to be carried out both at 'initial verification' and at 'periodical verification'.	Accepted
Annex 4.1, 4.2	<p>It would be better to calibrate the test blackbody source in terms of radiance temperature versus the temperature indicated by the contact probe within the source. The radiance temperature is not the same as the 'thermometer readings of the standard blackbody radiator' (third column in 4.1, fourth column of 4.2). Therefore, for clarity, we would prefer the headings here to be 'radiance temperature of the test blackbody source', and the headings of the previous columns (column 2 in 4.1 and column 3 in 4.2) re-worded to make it clear that this temperature is that indicated by the contact thermometer within the test source.</p> <p>Also what is meant by 'difference between the thermometer readings in a blackbody radiator to be calibrated' (last column of table in 4.1)? Is this the difference between the standard blackbody temperature and the reading of the contact thermometer within the test source? Likewise for the heading in the last column of the table in 4.2.</p>	Accepted
Annex 4.3	The heading of the third column of the table in 4.3 is not clear - are the 'readings of the calibrated (verified) blackbody radiator' meant to be the 'temperature indicated by the contact probe within the source', or the 'radiance temperature of the source'? Also, as stated above, we feel it would be better to specify the temperature corrections for each spectral band at which the calibration was carried out, and also for each viewing angle separately, not average them all out.	Rejected. Averaging does not impede anything, but gives a chance to overview the estimation of a calibrated radiator in whole. Corrections for each range and angle are given in a column 3.
6.3.2	What would count as a 'defect' for the purposes of 6.3.2, and presumably, if such a defect is found, the blackbody could be rejected rather than simply being 'not subject to calibration'?	Accepted. The explanation is added in the text.
6.5.3	The 'temperature measuring device' is not specified: is it a contact thermometer or non-contact (radiation) thermometer? In other words, is it the stability of temperature of the contact probe within the source or the stability of the radiance temperature that is being measured? In any case, we don't feel that a resolution 'of 1 °C' is sufficiently small to give good enough information. Also we feel it is necessary to measure the stability not only of the temperature of the source using the contact thermometer, but the radiance temperature as well, and also ensure that one is tracking the other sufficiently well.	Accepted
6.6	What stability is being measured here: the stability of the radiance temperature or the contact probe temperature? Again, the stability of both needs to be checked to ensure that they are tracking each other sufficiently well. It is also not clear how this 'temperature instability' is different from the 'drift' measured in the previous section	Accepted

No	Comments	Reply
6.7	<p>a) It is important that the calibration of the test blackbody source is calibrated traceable to national standards and the International Temperature Scale (the ITS-90). Therefore the standard instruments used in the calibration (standard blackbody source and/or standard radiation thermometer) must have traceable calibrations.</p> <p>The calibration must be carried out by an accredited calibration laboratory.</p> <p>This is not stated.</p> <p>The calibration uncertainties of the standard blackbody source and/or standard radiation thermometer also need to have been correctly and rigorously evaluated. I cannot see any mention either of the required emissivity of the standard blackbody source</p> <p>b) The document describes the calibration of a test blackbody source by comparison with a standard blackbody source using a transfer radiation thermometer or comparator. It then specifies that the results are to be given in terms of the standard blackbody temperature, the temperature reading of the contact thermometer within the test source, and the temperature difference between the two. I feel it is preferable to calibrate in terms of the radiance ('apparent') temperature of the test source versus the temperature reading of the thermometer within the test source. Then the temperature difference would be that between the radiance temperature of the test source and the reading of the contact thermometer within the test source.</p> <p>c) For rigorous measurements it would be necessary to set the apertures of the standard and test blackbody sources to be the same size. Alternatively, if the sizes are different, a correction will probably need to be applied to take into account the optical characteristics (technically known as the 'size-of-source effect') of the transfer radiation thermometer or comparator. There is no mention of this.</p>	Accepted
6.7.6, 9, 15, 16	It is unclear what is meant.	Edited.
6.7.8,9 6.7.13	<p>I am not sure why the correction value only needs to be included in the calibration certificate when it exceeds half the value of the expanded uncertainty, nor (in section 6.7.9) why the one temperature correction value should be applied at all blackbody temperatures.</p> <p>The correction value needs to be put in the certificate whatever its magnitude, and the individual temperature corrections obtained at each temperature need to be included, not just one value over all temperatures.</p> <p>Similarly, if the correction values obtained at different spectral ranges do not agree with each other, they should not be averaged (section 6.7.13). Instead the correction values for each of the ranges should be quoted individually. Differences in the temperature corrections at different spectral ranges could be due to the effect of the emissivity of the test source, and this information could be masked by averaging.</p>	<p>Accepted partly. The correction within half expanded uncertainty is doubtful.</p> <p>Accepted</p> <p>Accepted partly.</p> <p>The correction within half expanded uncertainty is doubtful.</p>
6.7.13, 16,6.8	The definition, and usage, of the various uncertainty components are a bit muddled.	Edited.
6.7.17	It would be better to have more information about where measurements need to be made on the surface of the extended radiator	Edited.
6.8	Uncertainty components $u_3$ and $u_4$ seem to be duplicates, and I don't understand the definition of $u_5$ (section 6.8.1)	Edited.
6.9.3	It is not clear what is meant by item 9	Edited.

## Reply to the Japan comments on the 2nd CD IR "Blackbody Radiators for the Temperature Range from - 50 °C to + 2 500 °C"

National Metrology Institute of Japan (NMIJ)/ National Institute of Advanced Industrial Science and Technology (AIST) Contact Secretariat of OIML Activities in Japan Hiroe SAKAI (Mrs.)

No	Comments	Reply
1	<p>The present scope includes all "blackbody" radiators in its scope. However, as for the blackbody furnaces in the scope of this Recommendation, their structure and applications etc. shall be limited from the technical viewpoints.</p> <p>When the present scope is to be applied, the evaluation items and testing methods etc. described in chapter 3 and thereafter are required to have contents applicable to all various blackbody furnace equipment. However, in the present Draft, the descriptions are not so generalized for that purpose.</p> <p>For example, in the present Draft, it is deemed that appropriate evaluation of fixed-point blackbody furnace equipment, etc. may be difficult. Application of this Recommendation shall be limited to cavity type blackbody radiators with variable temperature.</p> <p>The above comment on this item has been submitted against CD1 and we think that it was accepted. Notwithstanding, we recognize that the Draft Recommendation is not yet properly modified. We would like to request strongly secretariat to take appropriate steps in their activities.</p> <p>Japanese Committee recognizes that this Recommendation should specify only performance guidepost and testing methods for blackbody radiators (blackbody furnace equipment) used for calibration and test of radiation thermometers and that it is unnecessary to specify the criteria for the determination. We would like to request that the contents and purposes of this Recommendation shall be explicitly described in the scope.</p> <p>If appropriate modification is not made in the scope, it would be difficult to agree with the Draft Recommendation to the next version thereafter.</p>	<p style="text-align: center;">Reply</p> <p>Objections:</p> <p>This Recommendation does not pretend to cover all possible radiators including those that are developed specially for unique applications, but for the bulk of commercialized BBRs intended for calibration and verification of radiation thermometers.</p> <p>No participant has stated the necessity to restrict this Recommendation to a cavity type blackbody radiators with variable temperature. Such restriction is only expedient in case of calibration of high precision ad-hoc BBRs, where a through knowledge of all characteristics of the measuring system is required, including the properties of the radiation thermometer used and of the intervening medium.</p> <p>The Recommendation can well cover all possible radiators, both cavity- and extended-type, with fixed and regulated temperature. In principle, the approaches to the testing of characteristics are similar. This document does not need to go into technical details of the designs.</p> <p>As far as the terminology is concerned, the term "furnace" should rather be avoided, as it is funny to call "furnace" a radiator with a temperature of minus 50 C.</p>
2.1	<p>In the definition of BB radiator, effective emissivity is specified to be 0.95 or more. This figure can be understood that its application including flat type blackbody furnace, etc. is assumed. As in the case of above comment 1, applicable objects of this Recommendation shall be limited to cavity type blackbody furnace equipment. Therefore, it will be appropriate to specify emissivity to be 0.98 or more.</p>	<p>Objections:</p> <p>Among the commercialized products there are many blackbody radiators with the effective radiativity of 0.95. The same value is specified in the developed ISO/DIS 10878 (Non-Destructive Testing - Infrared Thermography - Vocabulary). Specification of the effective radiativity value is actually not important, but it must not restrict the applications of the document.</p>
4	<p>As the performance indexes for blackbody furnace equipment, it is essential to evaluate the following 3 points in addition to the items in chapter 4 of this draft; <math>\epsilon</math> - effective emissivity, <math>\Delta T</math> - temperature distribution and <math>\lambda</math> - wavelength dependence property. With the performance indexes proposed now, it will be impossible to evaluate and compare objectively the practical performance of equipment at users' level of blackbody fur-</p>	<p>Accepted</p> <p>(see Comments 1, 2 to subitem 3.1.6). Temperature distribution is determined in subitem. 6.7.17</p>

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	nace equipment.	
5	The temperature and humidity environmental conditions are required to be altered because there is no rationality as an international standard.	Accepted
6.5.3	It is not appropriate to specify 0.1 °C as indicated temperature resolution for the test of warm up time of blackbody furnace (Among the commercialized products, many blackbody furnaces with high temperature range have indicated resolution of 1 °C). We would like to request to change to "...having resolution appropriate for performance and construction of blackbody furnace equipment to be tested."	Accepted
6.6.3 and 6.7.11	As the determination requirements, 2σ and 4σ are specified, but its technical justification is unclear. We do not agree with it. (This standard should specify only performance indexes and testing method, and we do not agree to specify criteria of the determination.)	Accepted
6.7	We do not agree to specify temperature range (such as from – 50 °C to + 300 °C) for blackbody furnace equipment in the specification of determination of the correction, etc. The technical basis is unclear and there is no rationality. We request not to specify the temperature range.	The wording is corrected. However, it is necessary to specify at least approximately what means a part of the temperature range.
6.8	We do not agree with the formula (5). The technical basis to specify the factor for combined uncertainty to be 1/3 without variation is unclear. It will be sufficient to specify as "...combined uncertainty shall be performed based on GUM".	Accepted