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Traceability of Temperature Measurement

Platinum Resistance Thermometers, Thermocouples, Liquid-in-glass Thermometers and Radiation Thermometers

Contents

Changes since last edition

Only minor editorial changes have been made from the previous edition.

1. Introduction

1.1 The requirements for equipment calibration and measurement traceability are given in ISO/IEC 17025. Several guidance publications on the application of these requirements in the case of particular items of equipment and forms of measurement are listed on the UKAS website www.ukas.com.

1.2 This publication provides guidance for laboratories needing to meet the requirements for the traceability of temperature measurement in support of testing and calibration activities, using platinum resistance thermometers (PRTs), thermocouples, liquid-in-glass thermometers and radiation thermometers. By following this guidance, laboratories will be able to demonstrate at assessment that they meet the requirements. Alternative methods may be used, provided they are shown to give an equivalent outcome. Traceability in this case is defined as the ability to relate a measurement result to the appropriate International Temperature Scale of 1990 (ITS-90). Guidance for the selection and use of devices for measuring temperature is given in the relevant sections of British Standards Specification, BS 1041, *Temperature Measurement*.

1.3 In some situations, specific procedures and specialised expertise may be required to ensure traceability of temperature measurement to the level of precision demanded by individual tests and calibrations. It is not intended to indicate all such points in this publication, but they will be taken into account during the assessment by UKAS.

1.4 UKAS is a signatory to the *European Cooperation of Accreditation* Multilateral Agreement (EA MLA) and the *International Laboratory Accreditation Cooperation* Mutual Recognition Agreement (ILAC MRA). These MLA/MRAs recognise the equivalence of the accreditation provided by UKAS and other Accreditation Bodies (ABs) that are signatories to the Agreements. Where reference is made below to UKAS accredited calibration laboratories and UKAS certificates, it is to be understood to also include calibrations carried out by calibration laboratories accredited by other MLA/MRA signatory ABs and corresponding national standards laboratories when accompanied by a valid certificate. Further information about other AB signatories of the MLA/MRAs can be found on the EA and ILAC websites (linked from the UKAS website).

2. General

2.1 All reference temperature measuring devices used by a laboratory to calibrate PRT's thermocouples, liquid-in-glass thermometers and radiation thermometers should be calibrated, and should be traceable to ITS-90.

2.2 Calibration of all reference temperature measuring devices needs to be carried out by a competent laboratory, e.g., a UKAS accredited calibration laboratory, the National Physical Laboratory (NPL) or other recognised laboratories (see also paragraph 1.4).

2.3 A valid certificate should be obtained, i.e., one that is current (within the specified calibration period) and bears the UKAS symbol (or the identity of the national standards laboratory or accreditation symbol authorised by an accreditation body recognised by UKAS) and provides the required level of uncertainty of measurement for those measurements for which the equipment will be used.

2.4 Reference temperature measuring devices should be kept secure in a suitable environment.

2.5 All in-house calibrations and checks should be carried out to a documented procedure, and the results, together with the estimate of the uncertainty of the measurement, should be recorded and retained.

2.6 In general, the intervals between calibrations depend upon the conditions of use. Since different temperature measuring devices may be used under a wide variety of conditions, precise calibration intervals cannot necessarily be specified. In such cases, evidence (e.g. from regular 'between calibration' checks) should be available to demonstrate that calibration intervals have been selected so that calibration takes place before any significant changes in calibration corrections occur.

2.7 It is good practice to use two reference or working standard thermometers together, in all calibrations, with a documented tolerance on their agreement. In this way they are mutually self-checking.

3. Platinum Resistance Thermometers

3.1 Reference Platinum Resistance Thermometers

3.1.1 Reference PRTs should be checked at the ice or water triple-point before use to ensure that the resistance (or indicator reading, in the case of a digital thermometer with PRT sensor) has not significantly changed since the previous calibration of the instrument. It is recommended that the documented procedure should include a maximum permitted change since the last calibration. Calibration should be carried out at intervals depending upon the frequency and temperature of use, but should not exceed 5 years (see BS 1041:Part 3: 1989, *Guide to Selection and Use of Industrial Resistance Thermometers*).

3.2 Working Platinum Resistance Thermometers

3.2.1 A valid certificate of calibration should be held for all working PRTs, or they should be calibrated periodically in-house against suitable reference standards.

3.2.2 The intervals between successive calibrations will depend upon the application and range of temperature measurement of the PRT, but normally should not exceed one year. Checks at the ice or water triple-point should be carried out at regular intervals, dependent on the frequency of use and temperature range, but not normally greater than 6 months. A documented procedure should specify a maximum permitted change from the last calibration.

4. Thermocouples

4.1 Reference Thermocouples

4.1.1 Calibration intervals will depend upon several factors, including the type of thermocouple and the period of use at high temperatures. Specific intervals cannot be given, but the closer the temperature of use of the reference thermocouple is to the maximum recommended in Tables 3 and 4 of BS 1041 Part 4:1992 *Guide to the Selection and Use of Thermocouples*, and the more frequently the thermocouple is used, the shorter the calibration interval should be. In any case, the calibration interval should not exceed 4 years. In addition, it is recommended that regular 'between calibration' checks should be carried out (at least annually) by comparison with another calibrated thermometer, with specified tolerances (appropriate to the calibration uncertainties of the two instruments) on the agreement.

4.2 Working Thermocouples

4.2.1 A valid certificate of calibration should be held for the complete thermocouple. Where thermocouple wire is to be used, it is advised that a certificate of calibration be obtained for samples of the wire taken from each end and the centre of the reel. Alternatively, working thermocouples can be calibrated in-house against suitable reference standards. Calibration intervals will depend upon the application and the range of temperature measurement of the thermocouple, and should not exceed one year, unless the thermocouple is in continuous, undisturbed use under steady temperature conditions, e.g. when creep-testing metals. Intermittent operation, or use in aggressive environments, will normally necessitate shorter calibration intervals.

4.2.2 The selection of appropriate materials for working thermocouples, and the control of their conditions of use, should be made with due consideration of the guidance given in BS 1041:Part 4.

4.2.3 Oxidation, contamination, deformation and ageing of thermocouples have a deleterious effect on their performance. In general, for a given type of thermocouple, these effects will be more severe the smaller the diameter of wire used. They can usually be minimised by using a metal-sheathed mineral-insulated type of thermocouple. In general, replacement rather than re-calibration of base-metal thermocouples is recommended.

4.3 Calibration of Thermocouples

4.3.1 Details on the calibration of thermocouples (including uncertainty calculations) can be found in EURAMET/cg-08 available as a free download from the EURAMET website (http://www.euramet.org/index.php?id=calibration-guides).

5. Liquid-in-Glass Thermometers

5.1 Reference Liquid-in-Glass Thermometers

5.1.1 Reference thermometers should be selected having regard to the precision and range of measurement required of the working thermometer(s) to be calibrated. Details on these aspects may be found in, for example, BS 593:1989, Specification for Laboratory Thermometers, BS 1900:1976, *Specification for Secondary Reference Thermometers*, and BS 5074:1974, *Specification for Short and Long Solid-Stem Thermometers for Precision Use*.

5.1.2 Calibration should be carried out at least once every 5 years.

5.1.3 The ice point or, exceptionally, some other appropriate single reference point should be checked at least once per year, so that any changes at the reference temperature can be applied throughout the thermometer scale. A procedure for checking at the ice point is given in BS 1041:Section 2.1:1985, *Guide to Selection and Use of Liquid in-glass Thermometers*, Appendix C.

5.2 Working Liquid-in-Glass Thermometers

5.2.1 Where the accuracy of temperature measurement has a significant effect on the test result (or on its uncertainty or validity), a valid calibration certificate should be held for the working thermometer. Alternatively, it should be calibrated in-house against a reference thermometer (or thermometers) held by the laboratory. Guidance on calibration can be found in BS 1041:Section 2.1:1985:Clause 6.

5.2.2 Working thermometers should be monitored by annual checks at the reference point (see paragraph 5.1.3). Calibration should be carried out after 5 years, or sooner if the checks at the reference point indicate that a change, significant in terms of the uncertainty of the original calibration, or in excess of a documented permitted change since the previous calibration, has taken place.

5.2.3 New thermometers may be subject to changes due to stabilisation of the bulb volume. These are likely to be greatest during the first year of use, and reference point checks should be carried out at intervals not exceeding 6 months during this period.

5.2.4 In the case of a test (not calibration) procedure where temperature measurement is specified but does not have a significant bearing on the test result, an uncalibrated, suitable thermometer may be selected from those British Standard specifications which detail the 'maximum error' in use. This is a manufacturing tolerance in relation to the temperature range of use and the designated immersion condition. The following specifications are relevant: BS 593:1989, BS 791:1990, BS 1365:1990, BS 1704:1985 and BS 1900:1976.

6. Radiation Thermometers

6.1 Reference Radiation Thermometers (Pyrometers) and Reference Radiation Sources (Pyrometric Sources, including Blackbody Sources and Standard Lamps)

6.1.1 Calibration should be carried out at intervals depending upon the period of use at temperature, but in any case at least every 2 years (see BS 1041:Part 5:1989, *Guide to the Selection and Use of Radiation Pyrometers*).

6.2 Working Radiation Thermometers

6.2.1 A valid certificate of calibration should be held for all working radiation thermometers. Alternatively, they should be calibrated in-house against reference radiation sources, or by comparison with a reference radiation thermometer, operating at the same effective wavelength and measuring a similar effective wavelength and measuring a similar effective area of the radiation source. The interval between calibrations will depend on the period and temperature range of use but should not normally exceed 3 months.