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Traceability for Equipment Used in Acoustical Testing

CONTENTS

	SECTION	PAGE
1	Introduction	3
2	General requirements	3
3	Measurement traceability	4
4	Calibration and check intervals	5
5	Calibration and check procedures	5
6	Records	6
7	Uncertainty of measurement	6
	Appendix A	8
	Guidelines for calibration of equipment used in acoustical testing facilities	

CHANGES SINCE LAST EDITION

A marginal line indicates changes from previous edition.

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1 INTRODUCTION

- 1.1 Laboratories that have been assessed by UKAS as meeting the requirements of ISO/IEC 17025 *General requirements for the Competence of Testing and Calibration Laboratories* may be granted UKAS Accreditation. Several guidance publications on the application of these requirements, providing extra information, detail and limitations are listed in UKAS *Publications* (M4).
- 1.2 In general, calibration of equipment needs to be traceable to national standards. When using external calibration sources, a valid certificate should be obtained from a calibration laboratory that demonstrates competence, measurement capability and traceability. A calibration certificate bearing the UKAS accreditation mark (or identity of the national standards laboratory or mark of an accreditation body with which UKAS has a recognition agreement) for the relevant calibration/verification will be sufficient evidence.
- 1.3 This publication provides guidance for laboratories needing to meet the requirements as applied to acoustical testing. By following this guidance, laboratories will be able to demonstrate at assessment that they meet these requirements. Alternative methods may be used provided they are shown to give an equivalent outcome.

2 GENERAL REQUIREMENTS

- 2.1 The laboratory's programme for the maintenance and calibration of equipment will typically comprise periodic cleaning, checking, servicing, calibration and, where applicable, safety checks.
- 2.2 Some testing specifications define the accuracy to be achieved or specify calibration requirements. To ensure that the equipment available complies with the requirements of a particular test method, each item needs to be suitably calibrated. These calibrations may be achieved in a number of ways depending on the parameters being measured, the specific tolerance and the capability of the laboratory.
- 2.3 When establishing a calibration programme, traceability, procedures, intervals, and records of both calibration and checking need to be considered for each item of equipment in relation to the particular test method for which it may be used.
- 2.4 Appendix A lists key items of reference equipment and working equipment used to carry out a wide range of acoustical tests, and details a programme of calibrations and checks which would normally be considered suitable. The table also indicates the level of traceability generally considered appropriate (see paragraph 3.2), and for which items external certificates of various forms are advised. Appendix A is **not** an exhaustive list of all items of equipment requiring periodic recalibration or checking but may be of assistance as a guide when establishing or reviewing a calibration system.

- 2.5 It must be borne in mind that the calibration and checking guidance given in this publication **does not** supersede the requirements of a nationally published test method.

3 MEASUREMENT TRACEABILITY

- 3.1 The means of establishing traceability of measurement to national standards will vary between different items of equipment depending on a number of factors such as the complexity of the measurement, the accuracy of the measurement, and the capability of the laboratory.
- 3.2 Calibrations carried out on equipment used for acoustical testing may be classified into three general levels as listed below:
- (a) *Level 1*: A calibration carried out by a laboratory accredited by UKAS for the measurements concerned for which a UKAS calibration certificate is issued. Certificates from other calibration bodies may be acceptable provided that full traceability to national standards is demonstrated.
- (b) *Level 2*: A calibration which may be carried out in-house, performed to a documented method by competent staff using appropriate reference standards and equipment. The reference equipment used will need to be calibrated by a laboratory that can demonstrate competence, measurement capability and traceability, eg, a UKAS accredited calibration laboratory.
- (c) *Level 3*: A certificate of conformance issued by the manufacturer of the equipment or an appropriate service organisation.
- 3.3 When determining the programme of calibrations and/or checks appropriate for an item of equipment the capability of the laboratory and requirements of the calibration must be kept in mind. The actual accuracy required will be determined by calculating uncertainty budgets for particular calibration regimes using defined calibration apparatus. Guidance on where this should be performed is given in Appendix A.
- 3.4 Many items of equipment are assemblies of component pieces of apparatus and calibrations or checks may be required on the item as a whole, the individual components or a combination of both. A number of levels of calibration or check may therefore be required on the one item.
- 3.5 Following assessment of a laboratory's equipment calibration and check system, a higher level of traceability may be necessary than that undertaken by the laboratory to achieve the accuracy required in the accredited tests. This situation may arise where the capabilities required to perform the calibration in-house, eg, environment, equipment, staff are not available to the laboratory.

4 CALIBRATION AND CHECK INTERVALS

- 4.1 Before equipment is placed into service, a suitable calibration or check is needed to confirm compliance with the respective standard requirements. Most items of acoustical equipment also require periodic re-calibration or checking as the accuracy or conformance to specification may change with time, eg, linearity and filter characteristics. It is important that the re-calibration or check is undertaken before any probable change in accuracy or conformance with specification has occurred that is of significance to the use of the equipment. To confirm that changes have not occurred in between re-calibration, interim checks are recommended.
- 4.2 When determining re-calibration and check intervals, the applicable test methods in published standards and manufacturer's instructions should be referred to for initial guidance. The requirements set by these publications, together with any calibration criteria set by the test specification, will determine the interval finally set. Consideration should also be given to the expected use of the equipment, eg, sound levels meters used on site and regularly left in a vehicle may suffer temperature extremes. Where there is doubt regarding an individual item's ability to meet the above criteria, the calibration and/or check interval may have to be reduced to ensure continued accuracy and performance. It is important that calibration intervals are periodically reviewed. In some instances, the calibration interval may be extended for an individual piece of equipment, eg when a stable calibration history has been established. Calibration intervals should not be extended without justification. **Calibration intervals may not, however, be relaxed if they are a mandatory element of the test method.**
- 4.3 To ensure that calibrations and checks are carried out at the appropriate frequency, a forward planning system is usually essential. The planning system needs to provide adequate notice of a pending calibration or check to ensure that it is carried out by the due date. This is particularly important where items are to be calibrated externally and time may be required to organise the calibration and have it carried out.

5 CALIBRATION AND CHECK PROCEDURES

- 5.1 Laboratories should normally have, and follow, documented procedures for all calibrations and checks. [Exceptions may be allowed for measuring equipment when it is technically unnecessary to require a detailed procedure]. Documented procedures may be published Standards, instrument manufacturer's instructions or in-house procedures. It may be necessary to supplement published procedures with in-house instructions.
- 5.2 The appropriate selection and correct execution of these procedures by trained and authorised personnel is fundamental to achieving confidence in the results of the calibrations or checks.

6 RECORDS

- 6.1 For ease of use, laboratories may wish to hold a number of associated records rather than one large document or file. A records systems might for instance consist of an equipment register, calibration/check forward planner and calibration/check and maintenance files, which may be in hard copy or other suitable laboratory information management system. It is essential that these records are available to the staff performing the checks or re-calibrations.
- 6.2 External calibration certificates (UKAS or otherwise) should be checked to ensure that the equipment is suitable for use and has been calibrated over the appropriate range with the required uncertainty for the test method.
- 6.3 The use of proforma record sheets for in-house calibrations or checks is recommended as this ensures that all necessary information is recorded. When preparing such proformas, care should be taken to ensure that space is provided for all components of the calibration or check and all applicable details.
- 6.4 The use of diagrams and tables indicating acceptable values and actual values may be useful, particularly where dimensional checks are made. Diagrams may also be helpful, showing, for example, the location of sound sources and microphone positions.
- 6.5 Where a simple measurement or visual check of an item is required before each use, it is often most appropriate to record the check on the relevant test work sheet rather than on a separate form.
- 6.6 For some tests, eg, sound insulation measurements of commercially available components, it may be necessary to obtain an authoritative certificate or statement of compliance to design specification to show as evidence that the item has been tested by the most appropriate test method.

7 UNCERTAINTY OF MEASUREMENT

- 7.1 Laboratories undertaking acoustical testing are expected to estimate the uncertainty of measurement for each method of testing. Where a test specification identifies pass/fail criteria, uncertainties will normally be needed to apply these criteria.
- 7.2 When any laboratory employs internal calibration methods the laboratory needs to produce an estimate of uncertainty for each calibration method.

- 7.3 To determine the uncertainty associated with a test or calibration, the procedure should first be broken down into its component measurements. The significant sources of uncertainty should then be identified and quantified. In most cases, uncertainties may then be combined by an appropriate method to produce an overall uncertainty value.
- 7.4 Sources of uncertainties associated with a test or calibration, include those relating to the equipment used to make each specific measurement, and any peripheral measurement such as room temperature, pressure or humidity. The uncertainty associated with each piece of equipment used to carry out the test or calibration will in many cases be available from its current calibration certificate. Where this is not applicable, information may be available from the manufacturer.
- 7.5 Each time a measurement is taken, random effects from various sources contribute to the value of the reading. These include variability due to fluctuations in the measured parameter, variations in background noise and uncertainty of discrimination.
- 7.6 Uncertainties due to random effects are principally estimated from repetitive measurements. Information contained in standards on repeatability and reproducibility may be helpful when quantifying these uncertainties.
- 7.7 More detailed guidance on the expression of uncertainty and confidence in measurements may be found in the UKAS publication M3003, *The Expression of Uncertainty and Confidence in Measurement*.

Appendix A

Guidelines for calibration of equipment used in acoustical testing facilities

- A.1 This Table has been prepared as a guide to the effective calibration and checking of items of equipment used in acoustical testing and, as such, it is the expected standard to which laboratories should work. Note that further guidance on calibration for specific items may be available: consult *UKAS Publications* (M4) for current UKAS publications.
- A.2 The Table does not list all items of equipment that may be used, and the absence of an item in the table does not necessarily indicate that calibration is inappropriate.
- A.3 For many pieces of equipment there are no defined calibration protocols, eg amplifiers, level recorders and tape recorders. Where such equipment is used, the laboratory should review the role of each piece of equipment and demonstrate an adequate control/measurement capability for the use to which the instrument is put.
- A.4 For convenience the Table is divided into four sections:
Acoustics
Audiometry
Electrical
General
In each section, items are listed alphabetically.
- A.5 The Table provides guidance on:
(a) the minimum level of traceability considered appropriate. See Section 3 of this publication;
(b) the maximum interval considered appropriate. See Section 4 of this publication.
- A.6 The specified level of traceability is the minimum considered appropriate. An organisation may choose to achieve a higher level of traceability for calibration, eg Level 2 rather than Level 3. A lower level than specified is not normally acceptable.
- A.7 The specified calibration interval is the maximum considered appropriate to equipment in regular use, unless an extended interval is justified. Where a piece of equipment is not in regular use, it should be calibrated within the specified period before use.
- A.8 Good working practice may also include checks/setting up before use, eg, using a calibrator on a sound level meter before use.
- A.9 Where a national or international standard is referenced, unless otherwise stated, the most recent version of the standard applies.

Item	Type	Calibration details	Maximum interval between calibration	Minimum level of certificate	Uncertainty budget required?
Acoustics					
Dosemeters (personal)		Check linearity, integration time etc (refer to IEC 61252)	1 year	Level 3	No
Filters	Analogue	Check filter skirts and centre frequency ripple against IEC 61260	2 years	Level 3	No
Filters	Digital	Check filter skirts and centre frequency against IEC 61260 and operation of A/D converter	2 years	Level 3	No
Floor tapping machines		Check conformance with specification	2 years	Level 2	No
Frequency counters	Where used for in-house calibration	Calibrate	1 year	Level 2	Yes
Level recorders		Check functionality	2 years	Level 3	No
Microphones	Reference	Calibrate	2 years (depending on use)	Level 1	Yes
Microphones	Working	Calibrate	2 years (depending on use)	Level 2	Yes
Noise analysers	For building acoustics work	Calibrate as for sound level meters including supplementary checks on microphone channels, filter skirts and reverberation time	2 years	Level 2	No

Item	Type	Calibration details	Maximum interval between calibration	Minimum level of certificate	Uncertainty budget required?
Acoustics (continued)					
Pistonphones/ calibrators multi-frequency calibrators	(a) Required accuracy of equal to or better than 0.25 dB (eg 0.2 dB)	Calibrate, including frequency and distortion check	1 year (depending on use)	Level 1	Yes
Pistonphones/ calibrators multi-frequency calibrators	(b) Required accuracy not better than 0.25 dB (eg 0.3 dB)	Calibrate, including frequency and distortion check	1 year (depending on use)	Level 2	Yes
Reference sound sources	Fan type	(i) Calibrate	2 years	Level 2	Yes
	Loudspeaker type	(ii) Check fan speed Calibrate	3 months 1 year	Level 3 Level 2	No Yes
Signal generators	Pure tone	Check frequency and distortion	1 year	Level 3	No
	White/pink noise	Check spectral characteristics	1 year	Level 3	No
Sound intensity meters		Calibrate (refer to ISO 9614)	1 year	Level 2	Yes
Sound level meters (where BS 7580 relevant)	Where results quoted on final report or used to verify base conditions	Verify to BS 7580: Part 1			
		(i) For EC noise directives	2 years	Level 1	No
		(ii) Reference Devices	2 years	Level 1	No
		(iii) Working meters	2 years	Level 2	No

Item	Type	Calibration details	Maximum interval between calibration	Minimum level of certificate	Uncertainty budget required?
Acoustics (continued)					
Sound level meters Manufactured to IEC 61672: Part 1	Where results quoted on final report or used to verify base conditions	Verify to IEC 61672:Part 3 when available. See web site for interim arrangements.			
		(i) For EC noise directives	2 year	Level 1	No
		(ii) Reference Devices	2 years	Level 1	No
		(iii) Working meters	2 years	Level 2	No
Sound level meters (other)		Check conformance with specification	1 year	Level 3	No
Tape recorders	Digital	Check linearity, frequency response and A/D converter	1 year	Level 3	No
Tape recorders	Analogue	Check linearity and frequency response	1 year	Level 3	No
Audiometry					
Artificial ears/ reference couplers using reference earphone	Audiometric	(i) System calibration	2 years	Level 1	Yes
		(ii) Check system calibration	3 months	Level 2	No
Audiometers	Pure tone	Calibrate frequency, linearity, distortion and level (refer to IEC 60645-1)	1 year	Level 2	Yes

Item	Type	Calibration details	Maximum interval between calibration	Minimum level of certificate	Uncertainty budget required?
<i>Audiometry (continued)</i>					
Mechanical couplers	Audiometric	(i) System calibration	1 year	Level 1	Yes
		(ii) Check calibration using reference bone vibrator	3 months	Level 2	No
<i>Electrical</i>					
Attenuators	Independent	Calibrate	2 years	Level 2	Yes
Voltmeters	AC/DC	Calibrate	1 year	Level 2	Yes
<i>General</i>					
Anemometers		Calibrate	2 years	Level 3	No
Barometers	(a) Mercury type	Calibrate	5 years	Level 2	No
	(b) Aneroid	Calibrate	2 years	Level 2	No
	(c) Electronic	Calibrate	1 year	Level 2	No
Hygrometers	(a) Reference	Calibrate	1 year	Level 1	No
	(b) Working	Calibrate	1 year	Level 2	No

Item	Type	Calibration details	Maximum interval between calibration	Minimum level of certificate	Uncertainty budget required?
<i>General (continued)</i>					
Length measuring devices	(a) Steel rules (required BS: 4372 stamped and calibrated or replaced at the specified interval or of good quality, from a reputable manufacturer and checked at specified intervals against a UKAS certified rule using a suitable visual aid, eg, magnifying glass)		5 years	Level 1	Yes
			5 years	Level 2	Yes
	(b) Reference steel tapes or electronic distance meters	Calibrate	5 years	Level 1	Yes
	(c) Working steel or linen tapes, electronic distance meters	Check	1 year	Level 2	Yes
	(d) Vernier calliper	Calibrate	1 year	Level 2	Yes
Tachometers	(a) Reference	Calibrate	3 years	Level 1	Yes
	(b) Working	Calibrate	1 year	Level 2	Yes

Item	Type	Calibration details	Maximum interval between calibration	Minimum level of certificate	Uncertainty budget required?
General (continued)					
Thermometers	Reference	(i) Calibrate for precision and range of measurement required	5 years	Level 1	Yes
		(ii) Check at ice point or, exceptionally, other reference point	1 year	Level 2	No
Thermometers	Working (required accuracy of not better than 0.5 °C)	(i) Use BS 593 thermometer ie marked in accordance with provisions of BS 593 or Calibrate	5 years		Yes
		(ii) Check at ice point or, exceptionally, other reference point	1 year 6 monthly for first year of use and yearly thereafter	Level 2 Level 2	Yes Yes
Time measuring devices	Required accuracy not better than 0.5 sec eg 1 sec	Calibrate against BT speaking clock Rugby time signal Teletext/Ceefax	1 year	Level 2	No
Weighing machines	Laboratory balances, platform scales	Calibrate	1 Year	Level 2	Yes
Weights	(a) Reference	Calibrate	2 years	Level 1	Yes
	(b) Working	Calibrate	1 to 2 years (depending on class)	Level 2	Yes