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Calibration and Measurement Traceability for Construction Materials Testing Equipment

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1 Introduction

1.1 The requirements for equipment calibration and measurement traceability are given in ISO / IEC 17025. Several guidance publications providing interpretation of these requirements for particular items of equipment and forms of measurement are listed in *UKAS Publications*, M4.

1.2 This publication provides guidance for laboratories needing to meet the requirements as applied to construction materials testing. By following this guidance, laboratories will be able to demonstrate at assessment that they meet these requirements. Alternative methods may be used provided that they are shown to give an equivalent outcome.

1.3 In general, calibration of equipment needs to be traceable to national standards. When laboratories use external calibration services, they should obtain a valid certificate from a calibration laboratory that demonstrates competence, measurement capability and traceability. A calibration certificate bearing the UKAS calibration accreditation mark [or identity of the national standards laboratory mark of an accreditation body with which UKAS has a recognition agreement] for the relevant calibration / verification will be sufficient evidence.

2 Terminology

2.1 For the purposes of this publication the following terms apply:

2.2 **Calibration**: specific types of measurement performed on measurement standards, material measures and measuring instruments to establish the relationship between the indicated values and known values of a measured quantity. The term covers calibrations carried out using appropriate reference equipment at any location.

2.3 **Check**: specific types of inspection and / or measurement performed on materials and equipment to indicate compliance or otherwise with stated criteria. The term covers checks carried out at any location.

2.4 **Repeatability**: *r* is the value below which the absolute difference between two or more single test results obtained with the same method on replicate test samples, under the same conditions, (same operator, same apparatus, same laboratory and a short interval of time), may be expected to lie with a specified probability; which, in the absence of other indicators, is 95%.

2.5 **Reproducibility**: *R* is the value below which the absolute difference between two or more single test results obtained with the same method on replicate test samples, under different conditions (different operators and / or different apparatus and / or different laboratories and / or different time), may be expected to lie with a specified probability; which, in the absence of other indications, is 95%.

2.6 **Uncertainty of measurement**: a statement of the limits of the range within which the true value of a measurement is expected to lie at a given level of confidence (see UKAS publication M3003, *The Expression of Uncertainty and Confidence in Measurement*).

The definitions of *r* and *R* are consistent with those given in BSI PD 6461 : Part 1 : 1995 : Vocabulary of Metrology.

3 General

3.1 The laboratory's programme for the maintenance and calibration of equipment will typically comprise periodic cleaning, servicing, calibration and safety checks (where applicable). Performance and compliance checks may also be necessary as part of the calibration aspect of the programme.

3.2 Standards often define the accuracy to be achieved and include specifications for equipment considered suitable for use. In order to ensure that the equipment available complies with the requirements of a particular test method, each item must be suitably calibrated and / or checked. These calibrations and / or checks can be achieved in a number of ways depending on the parameters being measured, the specified tolerances and the capability of the laboratory.

3.3 When establishing a calibration programme, aspects of measurement traceability, procedures, intervals and records for both calibration and checks, need to be considered for each item of equipment in relation to the particular test method for which it may be used. These key components are considered in this publication in order to assist construction materials laboratories establish a suitable equipment verification programme.

3.4 Appendix A lists key items of reference equipment and working equipment used to carry out a wide range of tests on construction materials, 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 4.2), and for which items external certificates of various forms are advised (see paragraphs 7.2; and 7.6). 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.

3.5 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.

4 Measurement traceability

4.1 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.

4.2 Calibrations and checks carried out on equipment used for testing construction materials and products may be conveniently classified into four general levels as listed below:

(a) *Level 1*: A calibration carried out by a laboratory accredited by UKAS for the measurements concerned and 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 / equipment. The reference standards / equipment 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 check, which may be carried out in-house, performed by competent staff using appropriately calibrated equipment to a documented procedure.

(d) *Level 4*: A visual check, where the item is inspected to provide assurance that the equipment meets the requirements of the appropriate standard, but no measurements are required.

4.3 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. As a guide, any instrument or reference standard used should have an accuracy 10 times better than that of the device being calibrated. 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. As an example, a device having a ±0.5 % tolerance might be calibrated using a standard having an uncertainty of ±0.05 %. There may, however, be exceptions to this rule where a factor of 2 or 5 may be acceptable.

4.4 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.

4.5 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.

5 Calibration and check intervals

5.1 Before equipment is placed into service, a suitable calibration or check is needed to confirm compliance with the respective standard requirements. Most items of equipment also require periodic recalibration or checking, as the accuracy or value may change with use/time. It is important that the recalibration or check is undertaken before any probable change in accuracy or value has occurred that is of significance to the use of the equipment. To confirm such changes have not occurred in between recalibration, interim checks may also be required.

5.2 To assist laboratories develop their calibration and check programme, the table in Appendix A contains periods between successive calibrations or checks which have been defined in published standards or are considered to be acceptable. Normally, these intervals are the maxima acceptable for each specified type of equipment provided that the equipment:

(a) is of good quality and known stability;

(b) has achieved satisfactory performance at previous calibrations and checks;

(c) is checked before first use or as defined in 5.1, and at appropriate intervals thereafter to show stability has not been impaired following suspected or indicated mishandling, overloading or malfunctioning;

5.3 When determining recalibration and check intervals, the applicable test methods in published standards, UKAS publications and manufacturer's instructions should be referred to for initial guidance. The guidance set by these publications and the compliance of each item of equipment with the criteria detailed under paragraph 5.2, will determine the interval finally set. Where there is doubt regarding an individual item's ability to meet the above criteria, the calibration / check interval for that piece of equipment may have to be shortened to ensure continued accuracy and performance. In some instances this calibration interval may be extended for an individual piece of equipment eg when a stable calibration history has been established. **Calibration intervals may not, however, be relaxed if they are a mandatory element of the test method**.

5.4 To ensure that calibrations and checks are carried out at the appropriate frequency a forward planner should be prepared. A planner may take one of a number of forms. A wall calendar which identifies the items requiring attention in each month, is just one example of a forward planner. Whatever form the system takes it needs to provide adequate notice of a pending calibration or check to ensure it is carried out by the due date. This is particularly important where items are calibrated externally and considerable time may be required to organise the calibration, to have it carried out and to evaluate the results before the item is returned to service..

6 Calibration and check procedures

6.1 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.

6.2 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.

7 Records

7.1 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 recalibrations.

7.2 When an external calibration is required (para 4.2a, Level 1), it is the responsibility of the laboratory to check each certificate (UKAS or otherwise) in order to ensure that the corresponding item of equipment is suitable for use. In particular, the certificate must be checked to ensure that the equipment has been calibrated over the appropriate range and with the required uncertainty for the test method. Any queries should be raised with the calibrating body or, where necessary, UKAS.

7.3 The use of proforma record sheets for in-house calibrations or checks (para 4.2b level 2 and para 4.2c & d levels 3 & 4) is recommended as this ensures that all necessary information is recorded. When preparing such proformas, care should be taken to ensure space is provided for all components of the calibration or check and all applicable details.

7.4 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 in other areas eg to indicate the placement of temperature measuring devices during a check of the temperature distribution within the working space of an oven.

7.5 Where a simple measurement or visual check of an item is required before each use (eg a visual check of sieves) it is acceptable and often most appropriate to record the check on the relevant test work sheet rather than on a separate form.

7.6 For some items, parameters, such as the material of manufacture, are specified in the test method for which calibrations are not required. In such cases, when an item is purchased, an authoritative certificate or statement of compliance to the design specification will be needed as evidence that the item is designed and manufactured to meet the requirements of the test method.

8 Uncertainty of measurement

8.1 Laboratories testing construction materials are expected to estimate the uncertainty of measurement for all calibrations carried out in-house (Level 2) on measuring equipment (ie equipment which is used to take measurements such as length, temperature and mass). Guidance on where this is required is given in Appendix A and typical worked examples are given in Appendix B. The practicability of this will largely depend on whether the calibration involves measurements by equipment for which uncertainty values are available or readily determinable.

8.2 To determine the uncertainty associated with a calibration the procedure should first be broken down into its component measurements. The significant sources of all uncertainties should then be identified and quantified. In most cases, uncertainties may then be combined by an appropriate method to produce an overall uncertainty value.

8.3 Every time a measurement is taken, random effects from various sources contribute uncertainty to the value of the reading taken. These include variability resulting from imprecise definition of the calibration (eg poor accessibility for taking a length measurement), uncertainty in discrimination (eg interpolation on a scale) and random fluctuations (eg fluctuation in an influencing parameter such as temperature).

8.4 The uncertainties arising from random effects are principally evaluated from repetitive measurements by statistical methods (a Type A evaluation). Information contained in Standards on repeatability and reproducibility may be useful when evaluating these uncertainties.

8.5 Systematic effects also contribute uncertainty, and sources associated with a calibration include those relating to the equipment used to make each specific measurement and any peripheral measurements, such as room temperature. The uncertainty associated with each piece of equipment used to carry out the calibration will in most cases be available from its current calibration certificate. Where this is not applicable, information which may be acceptable to UKAS may be available from the equipment manufacturer. In many cases, it will be practical to eliminate many of the sources of uncertainty, eg by applying corrections from the external calibration report and by carrying out the calibration at the same temperature at that used for calibrating the reference equipment.

8.6 More detailed guidance on the expression of uncertainty and confidence in measurements may be found in the UKAS publication M 3003, *The Expression of Uncertainty and Confidence in Measurement.*

8.7 Appendix B gives worked examples of uncertainty budgets for two commonly used parameters in materials testing laboratories.

Appendix A

Table detailing calibration and checking of equipment used to test construction materials

A.1 This table has been prepared as a guide to the effective calibration and checking of items of equipment used to carry out tests on construction materials. Where more than one type of a particular item is listed (eg reference or working thermometers; coarse sieves and fine sieves) guidelines are given for each specified type. 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 or check procedures are not appropriate**.

A.3 For ease of use, the table is divided into five sections indicating the nature of the material for which the item is commonly used. These are headed ‘General’, ‘Aggregate’, ‘Bituminous Materials’, ‘Concrete’ and ‘Soils’. Items of equipment are listed alphabetically within the section to which they relate.

A.4 The table specifically provides guidance on the:

(a) minimum level of traceability (see Section 4 of this publication), considered appropriate for each calibration / check;

(b) maximum period between successive calibrations considered to be appropriate (see Section 5 of this publication);

(c) the certificates or records of various types that shall be held.

(d) uncertainty of measurement requirements (see Section 8 of this publication)

A.5 The specified level of traceability is the minimum considered appropriate. An organisation may choose to achieve a higher level of traceability for a calibration / check, but not a lower one, eg Level 1 rather than Level 2.

A.6 The specified calibration interval is the maximum considered appropriate and may not normally be extended (see Section 5 of this publication).

A.7 Where the calibration / check requirement for a particular item of equipment (ie 3rd column of table) refers to items of equipment used to carry out the calibration / check, many of these auxiliary items are themselves listed as separate entries in the table.

A.8 The relevant parts of the following standard test methods were consulted when preparing this table.

BS 598 : Parts 102; 105; 107

BS 812 : Parts 100; 101; 102; 103.1; 105.1; 105.2; 109; 110; 111; 112; 113; 114; 118; 120; 121; 124

BS 1377 : Parts 1 – 9

BS 1881 : Parts 101; 102; 103; 105; 106; 107; 108; 112; 114; 115; 116; 117; 118; 119; 120; 122; 125; 127

BS 2000 : Parts 49; 58

Note: These Standards were correct at the time this publication was printed, but calibration requirements in them may be subject to amendment.

Notes: 1. This Table details recalibration and check intervals, but each item of equipment requires appropriate calibration and / or checking before it is placed into service.

2. Where a UKAS calibration certificate is indicated by the table, certificates from other sources may be acceptable (see para 1.3)

3. Where an item is calibrated in-house and is defined as a calibration rather than a check, an uncertainty budget should normally be determined for that specific calibration procedure. The extreme right-hand column of the table below indicates where an uncertainty budget should be determined.

4. Calibrations must cover the **full range** for which the equipment is to be used or specified.

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
General						
Bottle shakers & rollers		Check speed of operation of machine when fully loaded	3	Yearly	In-house	No
Chemical reagents		Use AR grade [grades other than AR grade chemical reagent may be used where permitted by the test method] from reputable manufacturer (if possible ISO 9000 approved). Establish date of expiry	4	Consult UKAS guidance publications on chemical reagents	In-house, eg, labelling QC checks or charts	N / A
Distilled or de-ionized water		Check as defined in test method	3	At appropriate intervals, depending on production batch size and storage conditions (max 6 months)	In-house	N / A
Force measuring devices	(a) Compression testing machines for concrete & mortars	Calibrate against BS 1610: Part 1	1	Must not exceed 1 year	UKAS	Yes
		Calibrate machine performance using strain cylinder	1	Must not exceed 1 year	UKAS	N / A

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Force measuring devices — *continued*		Check rate of load pacer and that platens, auxiliary platens and spacing blocks meet the specifications given in the relevant standard	3	Yearly	In-house	No
		Hardness and surface texture of platens and auxillary platens	2	Initial and after maintenance or repair	UKAS test	No
	(b) Loading frames for soils, aggregates and bituminous testing	Calibrate in accordance with the relevant standard, eg, BS 812, BS 598, BS 1377	2	At least yearly	In-house	Yes
		Check the load pacing / strain rate where rates are specified by the test method	3	Yearly	In-house	No
Hydrometer	Density	Shall comply with BS 718	1	Initial only	UKAS	Yes
		Soils. Scale calibrate in accordance with BS 1377 : Part 2	3	Yearly	In-house	No
Length measuring devices	*1. Gauge blocks*					
	(a) Reference	Shall comply with the relevant grade of BS EN ISO 3650. Calibrate	1	5 yearly	UKAS	Yes
	(b) Working	Calibrate against appropriate calibrated reference equipment	2	Yearly	In-house	Yes
	2. Micrometers					
	(a) Reference	Calibrate externally	1	Yearly	UKAS	Yes
	(b) Working	Calibrate against calibrated gauge blocks meeting the appropriate grade requirements of BS EN ISO 3650	2	Yearly	In-house	Yes

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Length measuring devices — *continued*	*3. Callipers*					
	(a) Reference	Calibrate externally	1	Yearly	UKAS	Yes
	(b) Working	Calibrate against calibrated gauge blocks meeting the appropriate grade requirements of BS EN ISO 3650	2	Yearly	In-house	Yes
	4. Steel rules					
	(a) Reference	Calibrate externally	1	5 yearly	UKAS	Yes
	(b) Working	Rules complying with BS 4372; Engineers' rule not confirmed as BS 4372 check against reference using suitable visual aid	2	Initial	In house	Yes
		All rules – visual check for readability and wear	4	Yearly	In-house	No
		All rules – recalibration	2	5 yearly	In-house	Yes
	5. Feeler gauges	Calibrate with appropriate calibrated reference equipment	2	Yearly	In-house	Yes
	6. Straight edge/ Engineers' square					
	(a) Reference	Calibrate externally	1	5 yearly	UKAS	Yes
	(b) Working	Carry out appropriate checks to satisfy the relevant standards	3	Yearly	In-house	No
	7. Dial gauges and displacement transducers	Calibrate against a calibrated micrometer device or in a comparator frame using calibrated gauge blocks or calibrated length bars in an appropriate environment	2	Yearly	In-house	Yes
Muffle furnace		Check temperature profile in working space	3	Initial and after maintenance or repair	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Muffle furnace — *continued*		Recalibrate or check as appropriate for the accuracy required by the test method ie, recalibrate using calibrated reference thermocouple	2	Yearly	In-house	No
		or check temperature profile using substances of known melting point or other suitable indicator	3	Yearly	In-house	No
Nuclear density / moisture meter		Manufacturer's calibration		2 yearly	Manufacturer's or agent's	N / A
		Stability check	3	1-3 monthly	In-house	N / A
		Standardisation check	3	Daily or 8 hourly	In-house	N / A
		For soils testing to BS 1377 : Part 9, carry out the following: (a) *bulk density*: verify by comparison with in situ measurement or preferably the bulk container method (b) *moisture content*: verify by comparison to moisture contents obtained by BS : 1377 : Part 2 method or by the method given in (a) above	3	As specified by method	In-house In-house	N / A
Ovens (conventional)	(a) Required temperature tolerance < ± 2 °C	Check temperature profile in working space with a calibrated reference thermometer or calibrated reference thermocouple. Clause 5.6.1 of prEN 932-5 may be suitable	3	Initial and after maintenance or repair	In-house	No
		Check temperature at the midpoint of the working space with calibrated reference thermometer or calibrated reference thermocouple	3	At least yearly depending on use	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Ovens (conventional) — *continued*	(b) Required temperature tolerance ≥ ± 2 °C	Check temperature profile in working space with a BS 593 thermometer or calibrated thermocouple (with a unique serial number)	3	Initial and after maintenance or repair	In-house	No
		Check temperature at the midpoint of the working space with BS 593 thermometer or calibrated thermocouple	3	At least yearly depending on use	In-house	No
Pressure / vacuum gauges	(a) Reference	Calibrate. Refer to BS EN 837–1	1	Yearly	UKAS	Yes
		Liquid manometers / barometers	1	5 yearly	UKAS	Yes
	(b) Working (Bourdon tube or electrical transducers)	Calibrate against calibrated deadweight tester or a calibrated reference gauge. Refer to BS 1780: clause 7; BS 1377: Part1	2	6 monthly	In-house	Yes
Tachometer or stroboscope	Reference	Calibrate	1	3 yearly	UKAS	Yes
Test sieves	All sizes	Refer to current UKAS guidance publications				
Thermocouples	Refer to current UKAS guidance publications					
	(a) Reference	Calibrate externally Refer to BS 1041: Part 4: for selection of appropriate type	1	1 - 4 yearly depending on requirement of test method, use or type	UKAS	Yes
	(b) Working	Calibrate against reference thermocouple or liquid-in-glass thermometer.	2	Yearly (6-monthly for BS 598: Part 102: BS 812: Part 100: BS 1377: Part 1	In-house	Yes

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Thermometers	Refer to current UKAS guidance publications					
	(a) Reference: liquid-in-glass	Calibrate for precision and range of measurement required	1	5 yearly	UKAS	Yes
		and Check at ice point (or exceptionally, some other reference point).	3	Yearly	In-house	No
	(b) Reference: platinum resistance	Calibrate for precision and range of measurement required	1	1 – 5 yearly depending on requirement of test method, use or type	UKAS	Yes
		and Check at ice point.	3	Before use	In-house	No
	(c) Working: platinum resistance	Calibrate against reference PRT or reference thermometer	2	Yearly	In-house	Yes
	(d) Working: liquid-in-glass temperature tolerance < ± 0.5 °C	Calibrate against a calibrated reference thermometer.	2	Initially, then 5 yearly	In-house	Yes
		and Check at ice point or another reference point.	3	6 monthly for first year of use and yearly thereafter	In-house	No
	(e) Working: liquid-in-glass temperature tolerance ≥ ± 0.5 °C	Use a BS 593 thermometer (with unique serial number) or calibrate against a suitable reference thermometer	2	5 yearly; recalibrate or replacement	In-house	Yes
		and Check at ice point or other reference point.	3	6 monthly for first year of use and yearly thereafter	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Thermometers — *continued*	(f) Working: IP & ASTM liquid-in-glass	Complete calibration	1	Initial	UKAS	Yes
		Partial recalibration	1	5 yearly	UKAS	Yes
		Reference point check. Refer to BS 2000: Part 0 (IP thermometers); ASTM Designation E77 (ASTM thermometers)	3	Yearly		No
Time measuring devices	(a) Required tolerance ≤ ± 0.5 sec	Calibrate appropriately according to required accuracy	1	Yearly	UKAS	Yes
	(b) Required tolerance > ± 0.5 sec	Check against BT speaking clock	3	Yearly	In-house	No
Volumetric glassware	Where calibration is specified or Grade A required by test method)	Calibrate by calculating the volume or amount of distilled water contained or delivered at a measured temperature (referring to the temperature correction tables in BS 1797) or by reference to appropriate test method	2	Initial, then consult *UKAS* guidance publications on volumetric glassware	In-house	N / A
Volume-change indicators	(a) Transducers and readout units	Calibrate by weighing the amount of distilled water delivered at a measured temperature (referring to the correction tables in BS 1797)	2	Yearly	In-house	Yes
	(b) Burette type indicators	Calibrate by weighing the amount of distilled water delivered at a measured temperature (referring to the correction tables in BS 1797)	2	2 yearly	In-house	Yes

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Water baths, tanks etc, constant temperature	(a) Required temperature tolerance < ± 2 °C	Check bath or tank temperature with an appropriate calibrated thermometer or calibrated continuous recording device	3	During use	In-house	No
		Check temperature profile with a calibrated thermometer; refer to the relevant BS or standard method for individual requirements	3	Initial and after maintenance or repair	In-house	No
	(b) Required temperature tolerance ≥ ± 2 °C	Check bath or tank temperature with a BS 593 thermometer or calibrated max / min thermometer	3	During use	In-house, eg,test worksheet	No
		Check temperature profile; refer to the relevant BS or standard method for individual requirements	3	Initial and after maintenance or repair	In-house	No
Weighing machines	Refer to current UKAS guidance publications					
	(a) Laboratory balances, platform scales, etc	Complete calibration.	2	Yearly (6 monthly for BS 1377)	In-house	Yes
		Zero and 1 / multi-point check.	3	Daily or before use	In-house	No
	(b) Spring balances	Check with working masses at suitable points.	3	Before each use	In-house	No
Weights	Refer to current UKAS guidance publications					
	(a) Reference: Class E1 & E2	Calibrate.	1	2 yearly	UKAS	Yes
	(b) Reference: Class F1, F2 & M1.	Calibrate.	1	Yearly	UKAS	Yes

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Weights — *continued*	(c) Working: Class E1 & E2	Calibrate.	2	2 yearly	In-house	Yes
	(d) Working: Class F1, F2 & M1	Calibrate.	2	Yearly	In-house	Yes
	(e) Working: Other (eg traders)	Calibrate to an accuracy appropriate for their use.	2	Yearly	In-house	Yes
Aggregates						
Abrasion machine		Check:				
		dimensions of moulds, trays and plates;	3	2 yearly	In-house	No
		speed of rotation of machine;	3	2 yearly	In-house	No
		mass of weights;	3	Before each run	In-house	No
		rate of flow from feed mechanism	3	At start of run	In-house	No
		Visually check surface of lap for scoring. Refer to BS 812: Part 113: clause 5.1	4	Before test runs		
Abrasive	Silica sand for AAV determination	Check the grading of a sample from each batch Refer to BS 812: Part 113: clause 6.1	3	Before commissioning each batch	In-house	No
Accelerated polishing machine	Polished stone value	Check apparatus as specified in test method				
		Check :				
		rate of flow of flowmeter;	3	At least 6 monthly	In-house	No
		rotational speed of road wheel;	3	Yearly	In-house	No
		planes of rotation of all tyred and road wheels;	3	Yearly	In-house	No
		force of rubber wheels on road wheel;	3	Yearly	In-house	No
		rate of flow of feed mechanism;	3	At start of run and during run	In-house	No
		parallelism of rubber wheels to axis of road wheel;	3	Yearly	In-house	No
		rubber tyred and road wheel dimensions	3	At least yearly, depending on use	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Accelerated polishing machine — *continued*		Ensure rubber tyred wheels of required hardness are purchased and stored correctly		Initial	Manufacturer's or agent's	No
		Refer to BS 812: Part 114.				
Corn emery	Natural corn emery for PSV determination	Check the grading of a sample from each batch	3	Before commissioning each batch	In-house	No
Friction tester	Polished stone value, slip resistance value, etc	Calibrate tester Refer to BS 812: Part 114: clause 5.2.2	1	Yearly	UKAS	No
		Check (Refer to BS 812: Part 114):				
		dimensions of rubber slider;	3	Initial	In-house	No
		mass of rubber slider;	3	Initial	In-house	No
		specimen contact angle of rubber slider;	3	Before each use	In-house	No
		verticality of column;	3	Before each use	In-house	No
		location of specimen holder to rubber slider and to axis of suspension of pendulum	4	Before each use	In-house	No
		condition of rubber slider	4	Before each use	In-house	No
		Ensure slider of required resilience and hardness is purchased and stored correctly		Initial	Manufacturer's or agent's	No
ACV / 10% fines apparatus	Mould, plunger base plate, rod	Check essential dimensions	3	2 yearly	In-house	No
		Hardness where specified	2	Initial	UKAS test	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Impact testing device	Aggregate impact value apparatus	Check (refer to BS 812: Part 112: clause 5.1.1):				
		dimensions of cylindrical steel cup and metal hammer;	3	2 yearly	In-house	No
		mass of circular metal base and metal hammer;	3	2 yearly	In-house	No
		height of drop and free fall of hammer.	3	Before each test	In-house	No
		thickness of reaction block / floor	3	Initial and if moved	In-house	No
Thickness gauges	Flakiness index / elongation	Check with calibrated caliper or micrometer	3	Yearly	In-house	No
Bituminous materials						
Centrifuges		Maintain centrifuge in accordance with BS EN 61010-2-020 and calibrate at speed of rotation used. Where the design gives appropriate access this may be done in-house with a calibrated tachometer or other method of similar accuracy. (Ensure safety requirements are met when calibrating in-house)	2	6 monthly	In-house	No
Compaction hammer	Automatic or manual	Check hammer mass, freefall distance, foot diameter, face of foot, blows and counter function with the requirements of BS 598 : Part 107	3	Yearly	In-house	No
		All other parameters on delivery		Initial		N / A
		In addition to the above, an annual visual inspection should be carried out on the hardwood block and the torqued rods				

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Hardness number apparatus	Mastic asphalt measuring dial	Calibrate penetration dial gauge	2	Yearly	In-house	No
		Calibrate force applied	2	Yearly	In-house	No
		Check dimensions of indenter pin	2	Yearly	In-house	No
		Check general condition and wear on indentor pin	4	Regularly, depending on use		No
Penetrometer	Needle	Calibrate needle against requirements of BS 2000: Part 49: Section 5.3	1	100 uses or 5 years, whichever occurs first	UKAS	Yes
		Check condition of needle	4	Before each use		
	Apparatus	Check apparatus meets requirements of BS 2000: Part 49				
		Check mass of spindle assembly	3	Yearly, or each time mass is changed	In-house	No
		Calibrate dial gauge	2	Yearly	In-house	Yes
		Calibrate timing device	1	Yearly	UKAS	Yes
Rolling straight edge		Calibrate	1	30 km, or yearly depending on use	UKAS	Yes
		Check deflection using spacer strips	3	Before and after each use	In-house	No
Softening point	Apparatus	Check frame assembly, guides, balls and rings against requirements of BS 2000 : Part 58	3	Yearly	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Solvents (eg dichloromethane)	Purchased	Ensure product complying with appropriate standard (eg BS 1994, Specification for dichloromethane) is purchased			Manufacturer's	No
	Recovered in-house	Check re-distilled solvent for parameters specified by standard (eg residue on evaporation - BS 598: Part 102)	3	Regularly, depending on use	In-house	No
Texture meter (laser)		Check operation of equipment		Yearly	Manufacturer's	No
		Calibrate tyre pressure against calibrated pressure gauge;	2	Before each use	In-house	No
		Check texture meter against dedicated texture mat	3	Before each use	In-house	No
		Refer to manufacturer's guidelines				

Concrete

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Air content apparatus	(a) Type A	Calibrate apparatus. Refer to BS 1881: Part 106: clause 5.3	3	Yearly, & when site of operation varies in elevation by > 200 m from that of previous calibration	In-house	No
	(b) Type B	Calibrate. Refer to BS 1881: Part 106: clause 6.3	3	Yearly	In-house	No
Compacting factor apparatus		Check machine complies with requirements of BS 1881: Part 103	3	2 yearly	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Concrete reinforcement cover	Electromagnetic apparatus	(a) Calibrate against requirements of BS 1881 : Part 204	2	Initial	Manufacturer's	No
		(b) Check against test block (s)	3	Before each use	In-house	No
Cube moulds		*Initial*				
		Either: certificate of conformance		Initial	Manufacturer's	No
		or: check dimensions and surface condition on all moulds	3	Initial	In-house	No
		plus hardness on 10% of each batch	2	Initial	UKAS test	No
		Subsequent				
		Check dimensions and surface conditions	3	Yearly	In-house	No
		Visually check general condition. Refer to BS 1881: Part 108	4	Yearly	In-house	No
Curing tanks	(a) Required temperature tolerance < ± 2 °C	Check tank temperature with a calibrated max-min thermometer or calibrated continuous temperature recording device	3	During use	In-house	No
		Check temperature profile of tank with a a calibrated thermometer	3	Initial and after maintenance, adjustment or repair	In-house	No
	(b) Required temperature tolerance ≥ ± 2 °C	Check tank temperature with BS 593 thermometer, calibrated continuous temperature recording device or calibrated max / min thermometer	3	During use	In-house, eg test worksheet	No
		Check temperature profile of tank	3	Initial and after maintenance or repair	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Flow table		Check apparatus complies with requirements of BS 1881: Part 105: clause 3.1	3	Yearly	In-house	No
Half cell equipment	(a) Millivolt meter	Check millivoltmeter output against reference calomel electrode of known millivolt output	3	Monthly	In-house	No
	(b) Copper & silver cells	Check millivolt meter	1	Yearly	UKAS	Yes
Slump cone		Check dimensions	3	Yearly	In-house	No
		Visually check general condition	4	At regular intervals, depending on use		
Slump rod / tamping bar		Check dimensions and mass for tamping bars	3	Yearly	In-house	No
Soils						
Compaction mould		Check dimensions	3	Yearly, or before each use, as detailed in test procedure	In-house	No
Compaction rammer		Check mass and dimensions	3	Yearly, depending on use	In-house	No
Depth gauge		Calibrate, eg using calibrated gauge blocks	2	Yearly	In-house	Yes
Hanger weights	Consolidation & direct shear tests	Check weight using appropriate calibrated balance	3	2 yearly	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Hydraulic consolidation cell & accessories		Cell calibration	3	Yearly, depending on use	In-house	No
		Diaphragm calibration	2	Yearly	In-house	No
		Check diaphram pressure, back pressure and pore pressure systems -				
		'Complete' check	3	3 monthly	In-house	No
		'Routine' check	3	Before each use		
		Refer to BS 1377: Part 6: clauses 3.2.5 & 3.2.6				
Liquid limit device	Casagrande apparatus	Check dimensions of cup and grooving tool	3	Yearly	In-house	No
		Check general condition of grooving tool and cup	4	Before each use		No
		Ensure rubber base of hardness and resilience specified by standard is purchased		Initial	Manufacturer’s	
		Check hardness / resilience of rubber base	2	2 yearly or replace	In-house	No
	Cone penetrometer	(a) calibrate dial gauge	2	Yearly	In-house	Yes
		(b) Check cone dimensions, cone assembly mass, timer and cone tip gauge using appropriate reference equipment	3	Yearly	In-house	No
		Cone tip sharpness (refer to BS 2000 : Pt 49; BS 1377 : Pt 2)	4	Daily or before each use	In-house	No
Moisture meter	Calcium carbide pressure moisture meter	Check according to manufacturer's instructions	3	Yearly	In-house	No

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Moisture condition apparatus		Check that components of the apparatus meet the requirements of BS 1377: Part 4, clause 5.2.1, including	3	Yearly	In-house	No
		mass of base	3	Initial	In-house	No
		Check operation of apparatus as detailed in BS 1377: Part 4: clause 5.3	4	Before and after a series of tests	In-house	No
		Acceleration (by approved technique) if required by client	3	Yearly	In-house	No
Oedometer (consolidation apparatus)		Calibrate apparatus - deformation characteristics Refer to BS 1377: Part 5: clause 3.2.4.2	2	Initial	In-house	No
		Calibrate/check component items (eg consolidation ring, consolidation cell, dial gauge, weights, loading device). Refer to BS 1377 : Parts 1 & 5	2, 3	Refer to individual listings	In-house	Yes/No
Ohmmeter	Impedence	Calibrate against a calibrated reference instrument	2	Yearly	In-house	Yes
Penetration resistance apparatus	Field tests	Calibrate and check components of apparatus to ensure compliance with BS 1377: Part 9	2,3,4	As appropriate	In-house	Yes/No
pH meter		Check with at least two standard buffer solutions of appropriate pH	3	Before each use	In-house	No
Pore water pressure measuring device		Calibrate pressure transducer or gauge using a calibrated reference pressure gauge	2	6 monthly	In-house	Yes

Item	Type	Calibration or check	Level	Interval	Type of certificate	Uncertainty budget required?
Ring shear apparatus		For component items such as dial gauges and load application, refer to BS 1377 : Parts 1 and 6	2, 3	Refer to individual listings	In-house	Yes / No
Sand	In situ density replacement sand	Check a sample from the batch for grading and purity requirements. Refer to BS 1377 : Part 9	3	Before commissioning a batch	In-house	No
Shearbox apparatus		Calibrate force measuring and displacement devices. Refer to B S 1377 : Parts 1 and 7		Refer to individual listings	In-house	Yes
Shrinkage limit apparatus	Definitive	Calibrate component micrometer with appropriate calibrated reference equipment	2	Yearly	In-house	Yes
	Linear	Engineers' steel rule – see Length measuring devices	2	Yearly	In-house	No
Springs	Torque etc	Calibration	1	Yearly	UKAS	Yes
Triaxial cell & accesories		Calibrate component items. Refer to BS 1377 : Parts 1, 7 and 8		Refer to individual listings	In-house	No
Vane apparatus		Calibrate torsion springs	1	Yearly	UKAS	Yes
		Calibrate area ratio of the vane	2	Yearly	In-house	No
Voltmeter		Calibrate against a calibrated reference	2	Yearly	In-house	Yes

Appendix B

Examples of uncertainty budgets

Example 1 Accuracy of micrometer traverse up to 150 mm using grade 1 gauge blocks

The table below gives all possible input values derived from the calibration of a working micrometer used to measure lengths up to 150 mm.The micrometer was checked at ten equally spaced distances in the range of 150 mm using a gauge block or combinations of gauge blocks to determine the point of maximum inaccuracy, this point was then determined ten times to give the repeatability (0.5 µm). All other values are obtained from the environmental conditions during the performance of the calibration and the reference equipment used.

Source of uncertainty	Value, µm	Probability distribution	Divisor	Standard uncertainty, µm
Uncorrected errors in length of gauge block	0.30	Rectangular	√3	0.173
Uncertainty of gauge block	0.1	Normal	2	0.05
Repeatability	0.5	Normal	1	0.5
Temperature effect	N / A	Rectangular	√3	
Resolution of micrometer	1.0	Rectangular	√3	0.577
Sum of squares	—	—		0.615
Combined standard uncertainty	—	Normal	—	0.784
Expanded uncertainty	—	Normal (k = 2)	—	1.569

Uncertainty would be reported as ± 2 µm.

Notes

1 The repeatability values given were derived from an internal calibration procedure being performed under truly repeatable conditions 10 times.

2 The combined standard uncertainty multiplied by coverage factor of k = 2 provides a confidence level of approximately 95%.

3 References and further reading are given in UKAS publication M3003.

4 The above uncertainty budget is intended to consider all relevant input values, but it is possible to eradicate some input values, depending on how a calibration is performed.

Example 2 Accuracy of liquid-in-glass total immersion thermometer used full range

The table below gives all possible input values derived from the calibration of a working total immersion thermometer using a platinum resistance reference thermometer.The repeatability value of 0.05 is derived from performing the calibration at ten equally spaced points over the working range of the thermometer then determining the repeatability at the point of maximum inaccuracy. It can also be noticed that the instruments drift has been taken into account, similarly the possible discrepancy due to where the instruments are placed in the heating medium (bath).

Source of uncertainty	Value, °C	Probability distribution	Divisor	Standard uncertainty, °C
Uncorrected error on calibration of reference thermometer	0.05	Normal	2	0.025
Uncorrected error on reference thermometer	0.02	Rectangular	√3	0.0115
Drift of reference thermometer	0.05	Rectangular	√3	0.0289
Resolution of reading of reference thermometer	0.05	Rectangular	√3	0.0289
Resolution of reading of test theremometer	0.1	Rectangular	√3	0.0577
Temperature source (bath) non-uniformity	0.01	Rectangular	√3	0.0058
Repeatability of measurements	0.05	Normal	1	0.050
Sum of squares	—	—	—	0.00831
Combined standard uncertainty	—	Normal	—	0.0914
Expanded uncertainty	—	Normal (k = 2)	—	0.18

Uncertainty would be reported as ± 0.2 °C.

Notes

1 The repeatability values given were derived from an internal calibration procedure being performed under truly repeatable conditions 10 times.

2 The combined standard uncertainty multiplied by coverage factor of k = 2 provides a confidence level of approximately 95%.

3 References and further reading are given in UKAS publication M3003.

4 The above uncertainty budget is intended to consider all relevant input values, but it is possible to eradicate some input values, depending on how a calibration is performed.