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Method for calibration and classification of torque measuring devices

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 August 2017. It was prepared by Panel ISE/101/1/2, *Torque measuring and testing*, under the authority of Subcommittee ISE/101/1, *Uniaxial testing*, and Technical Committee ISE/101, *Test methods for metals*. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession

This British Standard supersedes BS 7882:2008, which is withdrawn.

Information about this document

This revision introduces the relative measurement uncertainty interval, the range in which the expected error is likely to lie, calculated as the sum of the absolute relative deviation and the expanded uncertainty.

Some of the values in [Table B.4](#) and [Table B.7](#) are given to 8 decimal places, to allow users to check the data manually against these and the other tables in [Annex B](#), and to eliminate rounding errors. It is not necessary to report at this level.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies requirements for the calibration and classification of torque measuring devices, including those used for the calibration of torque tools.

It describes the method of calibration, calculation of calibration results and the classification of the torque measuring device in a static mode. The information to be given on the certificate of calibration is also listed.

[Annex A](#) provides diagrams of the application of torque, and examples for the calibration of torque measuring devices. [Annex B](#) indicates how to determine uncertainty of the calibration results of the torque measuring device.

2 Terms, definitions, abbreviations and symbols

For the purposes of this British Standard, the following terms, definitions, abbreviations and symbols apply.

NOTE Where applicable, this British Standard has been prepared using JCGM 200.

2.1 calibration torque T

torque with traceability derived from national standards of mass, length and time, and of specified expanded uncertainty of measurement (U_T), which can be applied to the torque measuring device

2.2 deflection d

algebraic difference between the indicator reading prior to the application of a torque and the indicator reading for each applied torque in a given measurement series

NOTE The deflection can be derived from either digital data output or visual data output.

2.3 data acquisition system

electronic module that has the ability to acquire signals from a torque measuring device and transmit data based on those signals for analysis

NOTE Where analogue signals are acquired by the torque measuring device, and these are converted into a digital data stream using an analogue to digital converter, the stream of data can be digitally filtered, re-sampled and stored, or logged ready for analysis.

2.4 loading direction

direction of applied torque, either clockwise or anti-clockwise about the axis of rotation, when viewed from the end of the torque measuring device to which the calibration torque is applied

2.5 lower limit of calibration $T_{\min}$

lower value of torque at which a torque measuring device of a given class can be calibrated

2.6 reference standard

equipment used to generate or to measure the reference torque applied to the torque measuring device that is being calibrated

NOTE Torques can be generated by a power source monitored by the reference standard.

2.7 relative error of indication <incremental torques> E_i

for a given applied torque, the difference between the mean incremental deflection and the applied torque

NOTE 1 For the purposes of this standard, relative error of indication is expressed as a percentage of applied torque.

NOTE 2 Relative error of indication is only used where the deflection is in units of torque.

2.8 relative error of indication <incremental and decremental torques> E_{id}

for a given applied torque, the difference between the deflection with the maximum deviation from the applied torque and the applied torque

NOTE 1 For the purposes of this standard, relative error of indication is expressed as a percentage of applied torque.

NOTE 2 Relative error of indication is only used where the deflection is in units of torque.

2.9 relative error of interpolation <incremental torques> E_{it}

for a given applied torque, the difference between the value of the mean incremental deflection and the corresponding calculated value of deflection, obtained from a mathematically fitted curve

NOTE For the purposes of this standard, relative error of interpolation is expressed as a percentage of the computed deflection for the given increasing torque.

2.10 relative error of interpolation <incremental and decremental torques> E_{itd}

for a given applied torque, the difference between the deflection with the maximum deviation from the corresponding calculated deflection obtained from a curve fitted to the incremental deflections and this corresponding calculated deflection

NOTE For the purposes of this standard, relative error of interpolation is expressed as a percentage of the computed deflection for the given increasing torque.

2.11 relative repeatability R_1

closeness of the agreement between the results of two successive measurements from the same applied torque, carried out under the same conditions of measurement

2.12 relative reproducibility R_2

closeness of agreement between the results of successive measurements from the same applied torque, carried out under changed conditions of measurement

2.13 relative residual deflection R_0

maximum residual deflection obtained from all the series of torques

NOTE For the purposes of this standard, relative residual deflection is expressed as a percentage of the mean deflection for the maximum torque applied.

2.14 relative reversibility R_3

difference between the deflection obtained from the last given torque series applied in an increasing mode and the deflection obtained from the same given torque applied in a decreasing mode

NOTE For the purposes of this standard, relative reversibility is expressed as a percentage of the deflection of the last series for the given torque, applied in an increasing mode.

2.15 residual deflection d_0

algebraic difference between the indicator readings before and after the application of a single series of torques

2.16 resolution r

smallest discernible measurement interval on the torque measuring device indicator

2.17 torque

product of tangential force and length applied about a known centre of rotation

2.18 torque measuring device

system comprising an electrical, mechanical, hydraulic or optical torque transducer, with associated instrumentation, including the automated logging of data when part of the device

2.19 relative deviation rd

percentage value calculated from the average deviation from the mean of the deflections, at each setting

2.20 relative measurement uncertainty interval U'_{interval}

range in which the expected error is likely to lie, calculated as the sum of the absolute relative deviation and the expanded uncertainty

3 Preparation for calibration**3.1 Reference standard****3.1.1 Uncertainty of calibration torques**

The maximum permissible uncertainty of the calibration torques applied for the determination of different classifications of the torque measuring device shall not exceed the values given in [Table 1](#). Where a reference standard is used to determine a calibration torque, it shall conform to [Table 1](#).

Table 1 — *Uncertainty of calibration torques*

Class of torque measuring device to be calibrated	Maximum permissible uncertainty of calibration torque applied ^{A)}
	%
0.05	±0.01
0.1	±0.02
0.2	±0.04
0.5	±0.10
1.0	±0.20
2.0	±0.40
5.0	±1.00

^{A)} Using a coverage factor of $k = 2$ to give a confidence level of approximately 95%.

3.1.2 Traceability of measurements

All definitive measurements, such as mass, length, time and temperature, shall be traceable to national standards, as evidenced by a certificate of calibration.

3.2 Condition and identification of a torque measuring device

- 3.2.1** Calibration shall not be commenced unless the torque measuring device is considered to be in good working order. The maximum working torque shall first have been established.

NOTE Good working order includes the drive components being of a sufficiently good fit to exert a minimum bias on the system.

- 3.2.2** All parts of the torque measuring device shall be uniquely identified, including the following, where applicable:

- a) signal cables;
- b) switch boxes;
- c) interfaces;
- d) data acquisition systems;
- e) computers;
- f) software (where information is available); and
- g) mechanical drive adapters.

- 3.2.3** Where an electrical indicator used with a torque measuring device is replaced with another, the following requirements shall be met to ensure that the calibration is not invalidated.

- a) The original and replacement indicators shall have calibration certificates, traceable to national standards, which give the results of calibration in terms of electrical units (volt, ampere). The replacement indicator shall be calibrated over a range equal to or greater than the range for which it is used with the torque transducer, and the resolution of the replacement indicator shall be at least equal to the resolution of the original indicator when it is used with the torque transducer.

NOTE If the indicator is set to display in units of torque, the same conversion factors should be used in the replacement indicator.

- b) The units and excitation source of the replacement indicator shall be respectively of the same quantity (e.g. 5 V, 10 V) and type (e.g. AC or DC carrier frequency).
- c) The uncertainty of each indicator (both the original and the replacement indicators) shall not significantly influence the uncertainty of the whole torque measuring device. It is recommended that the uncertainty of the replacement indicator be no greater than $\frac{1}{3}$ of the uncertainty of the entire system.
- d) If it is necessary to replace cables, the replacement cables shall be of the same specification as the originals.

3.3 Resolution of the indicator

COMMENTARY ON 3.3

An indicator can be a direct reading display or the output of a data acquisition system.

3.3.1 Analogue scale

When the output of the torque measuring device is measured by an indicator with an analogue scale, i.e. a dial gauge or Bourdon tube instrument, the resolution, r , shall be determined from the ratios between the width of the pointer and the centre-to-centre distance between two adjacent scale graduation marks (scale interval) multiplied by the value of torque which one scale interval represents.

NOTE 1 The ratios should be $\frac{1}{2}$, $\frac{1}{5}$ or $\frac{1}{10}$.

A spacing of at least 1.25 mm shall be used for the estimation of a tenth of the division on the scale.

NOTE 2 A vernier scale of dimensions appropriate to the analogue scale can be used to allow direct fractional reading of the instrument scale division.

3.3.2 Digital scale

The resolution, r , shall be considered to be one increment of the last active number of the numerical indicator.

When using an optical recognition system, i.e. video, the video frame rate shall be at least 10 times the display update being recorded.

3.3.3 Variation of readings

If the readings fluctuate by more than the value previously calculated for the resolution, r (with no torque applied to the instrument), the resolution shall be deemed to be equal to half the range of fluctuation.

3.3.4 Units

The resolution, r , shall be converted to units of torque.

3.4 Lower limit of calibration, $T_{\min}$

To ensure that the classification is consistent with the resolution of the torque indicator, a lower limit of calibration shall be determined. The calibration shall not be performed below this lower limit, given by the equation:

$$T_{\min} = a \cdot r$$

where:

r is the resolution determined in accordance with [3.3](#);

a has the following values:

- 4 000 for a class 0.05 torque measuring device;
- 2 000 for a class 0.1 torque measuring device;
- 1 000 for a class 0.2 torque measuring device;
- 400 for a class 0.5 torque measuring device;
- 200 for a class 1.0 torque measuring device;
- 100 for a class 2.0 torque measuring device;
- 40 for a class 5.0 torque measuring device.

3.5 Number of calibration orientations (see [Annex A](#))

For classes 0.05 and 0.1, the torque measuring device shall be calibrated in either three different mounting positions, each rotated 120° about the measurement axis, or in four different mounting positions, each rotated 90° about the measurement axis. For all other classes, the torque measuring device shall be calibrated at a minimum of two different mounting positions at least 90° apart.

Where the design of the torque measuring device does not allow it to be rotated, a physical disconnection and reconnection of the reference standard followed by a third calibration series shall be deemed acceptable. For such devices, classification shall be limited to class 0.2 and above.

4 Preliminary procedure

4.1 Alignment

- 4.1.1** Place the torque measuring device in an appropriate mounting and position it so that it can, where possible, be rotated about its principal measuring axis between series.

NOTE Any bending applied to the torque measuring device during the calibration should be kept to a minimum. Where it is felt that the bending applied could have a significant effect on the torque measuring device's deflection, this should be considered as part of the uncertainty budget.

- 4.1.2** Ensure that there is a minimal misalignment between the reference standard and the torque measuring device.

4.2 Temperature considerations

- 4.2.1** The torque measuring device and its associated measurement system (i.e. indicator and electrical cables) shall be allowed to stabilize within the laboratory environment for at least 4 h before calibration. Where the torque measuring device is electrical, connect the torque measuring device, indicator, switchboxes, interfaces, etc., using the associated electrical cables. Switch on and allow to warm-up for the period stated in the manufacturer's information. In the absence of any recommendation, energize the system for at least 15 min.
- 4.2.2** Position a thermometer close to the reference standard and the torque measuring device to be calibrated. Allow the torque measuring device and all relevant parts of the calibration equipment to attain a stable temperature. Record the temperature at the beginning and end of each measurement series.
- 4.2.3** Calibrate the torque measuring device at a temperature in the range of 18 °C to 28 °C. Do not allow the temperature of the device to vary by more than 1 °C throughout a measurement series.

4.3 Instrumentation set-up

Carry out checks and settings of the instrumentation in accordance with the manufacturer's information, where available. Select the unit of measurement, e.g. N·m, divisions, V, mV or μ V.

4.4 Preloading procedure

Before any calibration or recalibration, preload the torque measuring device and associated connecting components in the appropriate loading direction (i.e. clockwise or anti-clockwise direction) a minimum of three times in succession to the maximum required calibration torque. Maintain each preload for a minimum of 30 s. The interval between successive application and removal of preloads shall be as uniform as possible.

Where the torque measuring device is to be calibrated in both clockwise and anti-clockwise loading directions, preload the torque measuring device for a minimum of three times before calibration in each loading direction.

5 Calibration procedure

5.1 Selection of calibration torques

- 5.1.1** Select a series of at least five approximately equally spaced, increasing values of torque from 20% to 100% of maximum applied torque.
- 5.1.2** If a calibration is conducted at a torque below 20% of the range's upper limit, make supplementary torque measurements. Select four or more different calibration torques for each complete decade