INTERNATIONAL STANDARD

ISO 6789-2

First edition
2017-02

Assembly tools for screws and nuts — Hand torque tools —

Part 2: Requirements for calibration and determination of measurement uncertainty

Outils de manoeuvre pour vis et écrous — Outils dynamométriques à commande manuelle —

Partie 2: Exigences d'étalonnage et détermination de l'incertitude de mesure

Reference number
ISO 6789-2:2017(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 29, *Small tools*, Subcommittee SC 10, *Assembly tools for screws and nuts, pliers and nippers*.

This first edition of ISO 6789-2, together with ISO 6789-1, cancels and replaces ISO 6789:2003 which has been technically revised with changes as follows.

a) ISO 6789:2003 has been divided into two parts. ISO 6789:2003 has become ISO 6789-1 which specifies the requirements for design and manufacture including the content of a declaration of conformance. This document specifies the requirements for traceable certificates of calibration. It includes a method for calculation of uncertainties and provides a method for calibration of the torque measurement device used for calibrating hand torque tools.

b) This document includes detailed methods for calculation of the uncertainty budget which shall be performed for each individual tool.

c) This document includes example calculations that are provided for different types of torque tool.

d) Annex C provides requirements for calibrating the torque measurement device where the calibration laboratory does not utilize a national standard giving such requirements.

A list of all parts in the ISO 6789 series can be found on the ISO website.

Introduction

The revision of ISO 6789:2003 has been designed to achieve the following improvements.

ISO 6789 has been split to provide two levels of documentation. It recognizes the different needs of different users of the standard.

ISO 6789-1 continues to provide designers and manufacturers with relevant minimum requirements for the development, production and documentation of hand torque tools.

This document provides detailed methods for calculation of uncertainties and requirements for calibrations. This will allow users of calibration services to more easily compare the calibrations from different laboratories. Additionally, minimum requirements for the calibration of torque measurement devices are described in Annex C.

The purpose of this document is to define the requirements for a calibration in which the sources of uncertainty are evaluated and used to define the range of values within which the readings probably fall. Additional uncertainties may exist in the use of the torque tool. The evaluation of uncertainties for each individual tool is time-consuming and where there are sufficient data to estimate the Type B uncertainty components by statistical means, it is acceptable to use these values for a given model of torque tool, providing that the uncertainty components are subject to periodic review.

Assembly tools for screws and nuts — Hand torque tools —

Part 2:
Requirements for calibration and determination of measurement uncertainty

1 Scope

This document specifies the method for the calibration of hand torque tools and describes the method of calculation of measurement uncertainties for the calibration.

This document specifies the minimum requirements for the calibration of the torque measurement device where the relative measurement uncertainty interval, W'_{md}, is not already provided by a traceable calibration certificate.

ISO 6789 is applicable for the step by step (static) and continuous (quasi-static) calibration of torque measurement devices, the torque of which is defined by measuring of the elastic form change of a deformable body or a measured variable which is in proportion to the torque.

This document applies to hand torque tools which are classified as indicating torque tools (Type I) and setting torque tools (Type II).

NOTE Hand torque tools covered by this document are the ones identified in ISO 1703:2005 by reference numbers 6 1 00 11 0, 6 1 00 11 1 and 6 1 00 12 0, 6 1 00 12 1 and 6 1 00 14 0, 6 1 00 15 0. ISO 1703 is currently under revision. In the next edition, torque tools will be moved to an own clause, and with this change the reference numbers will also change and additional reference numbers will be added.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6789-1:2017, *Assembly tools for screws and nut — Hand torque tools — Part 1: Requirements and methods for design conformance testing and quality conformance testing: minimum requirements for declaration of conformance*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in ISO 6789-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
Type A evaluation (of uncertainty)
method of evaluation of uncertainty by the statistical analysis of series of observations

Note 1 to entry: These data are taken directly from the measurements obtained during calibration of each torque tool and cannot be prepared in advance.

[SOURCE: ISO/IEC Guide 98-3:2008, 2.3.2, modified — Note 1 to entry has been added.]

3.1.2
Type B evaluation (of uncertainty)
method of evaluation of uncertainty by means other than the statistical analysis of series of observations

[SOURCE: ISO/IEC Guide 98-3:2008, 2.3.3]

3.1.3
calibration system
combination of a measurement device and the loading system for application of torque that acts as the measurement standard for the hand torque tool

Note 1 to entry: A calibration system can also be used as a torque measurement system as defined in ISO 6789-1.

3.1.4
measurement device
working measurement standard provided either mechanically or by an electronic torque transducer and display

Note 1 to entry: A measurement device can also be referred to as a torque measurement device as defined in ISO 6789-1.

3.1.5
reference measurement standard
measurement standard designated for the calibration of other measurement standards for quantities of a given kind in a given organization or at a given location

[SOURCE: ISO Guide 99:2007, 5.6]

3.1.6
measurement error
measured quantity value minus a reference quantity value

[SOURCE: ISO/IEC Guide 99:2007, 2.16, modified — Notes 1 and 2 to entry have been omitted.]

3.2 Symbols, designations and units

The designations used in this document are indicated in Table 1.

Table 1 — Symbols, designations and units

Symbol	Designation	Unit
a_s	Calculated relative measurement error of the torque tool for the calibration torque	%
$\bar{a}_s$	Mean value of the relative measurement error at each calibration torque	%
b_e	Stated measurement error of the measurement device	N·m
$b_{ref,e}$	Measurement error of the reference at the calibration torque	N·m
b_{ep}	Stated relative measurement error of the measurement device	%
NOTE While N·m is the unit commonly used, the output signal can be detected in various units, e.g. voltage.		

Table 1 *(continued)*

Symbol	Designation	Unit
$b_{\text{ref,ep}}$	Relative measurement error of the reference at the calibration torque	%
b_{int}	Variation due to geometric effects of the interface between the output drive of the torque tool and the calibration system	N·m
b_{l}	Variation due to the variation of the force loading point	N·m
b_{od}	Variation due to geometric effects of the output drive of the torque tool	N·m
b_{re}	Variation due to the repeatability of the torque tool	N·m
$b_{\text{md,re}}$	Variation due to the repeatability of the measurement device in the same mounting position	N·m
b_{rep}	Variation due to the reproducibility of the torque tool (Type I and Type II Classes A, D and G only)	N·m
$b_{\text{md,rep}}$	Variation due to the reproducibility of the measurement device in different mounting positions	N·m
b_{z}	Measurement hysteresis error of the zero signal after loading	N·m
I	Indicated value of measurement device without zero-value compensation	N·m
I_0	Indicated value of the zero signal 30 s after preload and prior to load in mounting position	N·m
I_{z}	Indicated value of the zero signal 30 s after unloading	N·m
k	Coverage factor k = 2 applied to the relative measurement uncertainty to achieve a confidence level of approximately 95 %	—
r	Resolution of the display (Type I and Type II Classes A, D and G only)	N·m
r_{md}	Resolution of the measurement device display	N·m
T_{A}	Minimum limit of measuring range of the measurement device	N·m
T_{E}	Maximum limit of measuring range of the measurement device	N·m
T_{min}	Minimum limit value of the measurement range of the torque tool declared by the manufacturer	N·m
w	Relative standard measurement uncertainty of the torque tool at the calibration torque	%
w_{int}	Component of w due to geometric effects of the interface between the output drive of the torque tool and the calibration system	%
w_{l}	Component of w due to the length variation of the force loading point	%
w_{md}	Relative standard measurement uncertainty of the measurement device at the calibration torque	%
$w_{\text{md,c}}$	Combined relative standard measurement uncertainty of the measurement device	%
$w_{\text{md,t}}$	Relative standard measurement uncertainty of the measurement device transducer	%
$w_{\text{md,d}}$	Relative standard measurement uncertainty of the measurement device display	%
w_{od}	Component of w due to geometric effects of the output drive of the torque tool	%
w_{r}	Relative standard measurement uncertainty due to resolution of the display of the torque tool (Type I and Type II Classes A, D and G only)	%
$w_{\text{md,r}}$	Relative standard measurement uncertainty due to resolution of the measurement device display	%
w_{re}	Component of w due to repeatability of the torque tool	%
$w_{\text{md,re}}$	Component of w_{md} due to repeatability of the measurement device	%
w_{rep}	Component of w due to reproducibility of the torque tool (Type I and Type II Classes A, D and G only)	%
$w_{\text{md,rep}}$	Component of w_{md} due to reproducibility of the measurement device	%
$w_{\text{md,z}}$	Component of w_{md} due to the measurement hysteresis error of the zero signal of the measurement device	%
NOTE While N·m is the unit commonly used, the output signal can be detected in various units, e.g. voltage.		

Table 1 *(continued)*

Symbol	Designation	Unit
W	Relative expanded measurement uncertainty of the torque tool at the calibration torque	%
W'	Relative measurement uncertainty interval of the torque tool at the calibration torque	%
W_{md}	Relative expanded measurement uncertainty of the measurement device at the calibration torque	%
W'_{md}	Relative measurement uncertainty interval of the measurement device at the calibration torque	%
W_{ref}	Relative expanded measurement uncertainty of the reference measurement standard	%
W'_{ref}	Relative measurement uncertainty interval of the reference measurement standard	%
X	Indicated value of measurement device with zero-value compensation	N·m
X_a	Target indicated, set or nominal value depending on the type and class of the torque tool	N·m
X_{min}	Minimum value of X observed during different mounting positions	N·m
X_{max}	Maximum value of X observed during different mounting positions	N·m
X_r	Reference value determined by the measurement device	N·m
$\overline{X}_r$	Mean reference value determined by the measurement device	N·m
X_{ref}	Reference value determined by the reference device	N·m
NOTE While N·m is the unit commonly used, the output signal can be detected in various units, e.g. voltage.		

4 Requirements for calibration

4.1 Calibration during use

If the user utilizes procedures for the control of test devices, torque tools shall be included in these procedures. The interval between calibrations shall be chosen on the basis of the factors of operation such as required maximum permissible measurement error, frequency of use, typical load during operation as well as ambient conditions during operation and storage conditions. The interval shall be adapted according to the procedures specified for the control of test devices and by evaluating the results gained during successive calibrations.

If the user does not utilize a control procedure, a period of 12 months, or 5 000 cycles, whichever occurs first, may be taken as default values for the interval between calibrations. The interval starts with the first use of the torque tool.

Shorter interval between calibrations may be used if required by the user, their customer or by legislation.

The torque tool shall be calibrated when it has been subjected to an overload greater than the values given in ISO 6789-1:2017, 5.1.6, after repair, or after any improper handling which might influence the torque tool performance and the fulfilment of the quality conformance requirements.

4.2 Calibration method

The method for the calibration of the torque tools shall be in accordance with the measurement method of ISO 6789-1:2017, Clause 6. Additionally, the requirement for the torque measurement device defined in ISO 6789-1:2017, 6.1 is replaced by 4.3.

4.3 Calibration system

The calibration system shall be chosen to be suitable for the measurement of the specified range of the torque tool.

At each target value, the relative uncertainty interval, W'_{md}, of the measurement device shall not exceed 1/4 of the expected maximum relative uncertainty interval of the torque tool, W'.

The measurement device shall have a valid calibration certificate issued by a laboratory meeting the requirements of ISO/IEC 17025. Alternatively, the measurement device shall be calibrated by a laboratory maintaining the national measurement standard.

If the user does not utilize a control procedure, a period of 24 months shall be the maximum interval between calibrations.

The measurement device shall be re-calibrated if it was exposed to an overload larger than 20 % of T_E, after a repair has been carried out or after an improper use which can influence the measurement uncertainty.

5 Measurement error

5.1 Calculation of the relative measurement error

The calibration values shall be measured and recorded according to the requirements in ISO 6789-1:2017, 6.5.

The evaluation of the relative measurement error is calculated using Formula (1):

$$a_s = \frac{(X_a - X_r) \times 100}{X_r} \tag{1}$$

The mean value of the relative measurement error at each calibration torque is calculated using Formula (2):

$$\overline{a_s} = \frac{1}{n} \sum_{j=1}^{n} a_{s,j} \tag{2}$$

where

$j = 1, 2, \ldots, n$ is the number of individual measurements at each calibration torque.

5.2 Exemplary calculations of the relative measurement error

5.2.1 Example 1

Calculation of the relative measurement error of indicating and setting torque tools (except Type II, Class B, C, E and F):

— indicated value of dial, mechanical scale or display (Type I, Classes A, B, C, D and E), or

— set value of mechanical scale or display (Type II, Classes A, D and G):

X_a = 100 N·m

— Reference values (determined by the calibration device):

X_{r1} = 104,0 N·m

X_{r2} = 96,5 N·m

X_{r3} = 102,6 N·m

$X_{r4} = 99{,}0$ N·m

$X_{r5} = 101{,}0$ N·m

— Calculated relative measurement errors of the torque tools in %:

$$a_{s1} = \frac{(100{,}0 - 104{,}0) \times 100}{104{,}0} = -3{,}85$$

$$a_{s2} = \frac{(100{,}0 - 96{,}5) \times 100}{96{,}5} = +3{,}63$$

$$a_{s3} = \frac{(100{,}0 - 102{,}6) \times 100}{102{,}6} = -2{,}53$$

$$a_{s4} = \frac{(100{,}0 - 99{,}0) \times 100}{99{,}0} = +1{,}01$$

$$a_{s5} = \frac{(100{,}0 - 101{,}0) \times 100}{101{,}0} = -0{,}99$$

5.2.2 Example 2

Calculation of the measurement error of setting torque tools, adjustable, non-graduated (Type II, Class B, C, E and Class F):

— nominal value set (Type II, Class B and E), or

— lowest specified torque value or pre-set value (Type II, Class C and F):

$X_a = 100$ N·m

— Reference values (determined by the calibration device):

$X_{r1} = 104{,}0$ N·m

$X_{r2} = 103{,}0$ N·m

$X_{r3} = 102{,}8$ N·m

$X_{r4} = 102{,}0$ N·m

$X_{r5} = 101{,}0$ N·m

$X_{r6} = 101{,}2$ N·m

$X_{r7} = 101{,}7$ N·m

$X_{r8} = 101{,}9$ N·m

$X_{r9} = 102{,}2$ N·m

X_{r10} = 102,5 N·m

— Calculated relative measurement errors of the torque tools in %:

$$a_{s1} = \frac{(100{,}0 - 104{,}0) \times 100}{104{,}0} = -3{,}85$$

$$a_{s2} = \frac{(100{,}0 - 103{,}0) \times 100}{103{,}0} = -2{,}91$$

$$a_{s3} = \frac{(100{,}0 - 102{,}8) \times 100}{102{,}8} = -2{,}72$$

$$a_{s4} = \frac{(100{,}0 - 102{,}0) \times 100}{102{,}0} = -1{,}96$$

$$a_{s5} = \frac{(100{,}0 - 101{,}0) \times 100}{101{,}0} = -0{,}99$$

$$a_{s6} = \frac{(100{,}0 - 101{,}2) \times 100}{101{,}2} = -1{,}19$$

$$a_{s7} = \frac{(100{,}0 - 101{,}7) \times 100}{101{,}7} = -1{,}67$$

$$a_{s8} = \frac{(100{,}0 - 101{,}9) \times 100}{101{,}9} = -1{,}86$$

$$a_{s9} = \frac{(100{,}0 - 102{,}2) \times 100}{102{,}2} = -2{,}15$$

$$a_{s10} = \frac{(100{,}0 - 102{,}5) \times 100}{102{,}5} = -2{,}44$$

6 Sources of uncertainty

6.1 General

The elements of uncertainty associated with the calibration of a torque tool shall be derived from at least one of the two following methodologies.

— The uncertainties shall be established using the procedures as set out in 6.2. Where a laboratory or manufacturer has sufficient data as defined in 6.2, this value may be determined statistically for a sufficient number of specimen (at least 10) of a model of tool, and its determination does not need to be repeated each time for future calibrations of this model. The validity of this value shall be reviewed systematically.

— The uncertainties shall be taken from manufacturers or other third-party data. Care shall be taken to ensure that any such data can be sufficiently validated and reproduced in the laboratory.

EXAMPLE Examples of calculations are provided for Type I wrenches in Annex A and Type II wrenches in Annex B.