AWS
Advanced Witness Systems Ltd.
Torque Measurement & Calibration

ENGINEERING SOLUTIONS LIVE

Understanding and Implementing Torque Standards relating to Torque Tools

With a focus on BS EN ISO 6789:2017

5 Things you will learn during this session:

1. Understanding the scope of the ISO 6789:2017 standard and the definition of its two parts.
2. Classes and differences of types of tools.
3. Explanation of the errors and uncertainties.
4. The requirements in calibration.
5. How to read the calibration certificate.

BS EN ISO 6789 History

BS EN ISO 6789:2003

- This earlier version was a conformity standard, derived from the 1992 version and still much preferred by many.
- Used for conformity and calibration prior to 2017.
- It rated the tools as either within ±6% tolerance of reading below 10 N.m or within ±4% tolerance of reading above 10 N.m. Dependant on tool type.
- The 2003 version did not have uncertainty calculations.

BS EN ISO 6789 History Cont'd.

BS EN ISO 6789:2003

- Typical allowed test mounting and force application angle allowance.
- The time of force application over the last 20% of the setting on the torque tool.
- Accuracy of the measurement instrument to be within ± 1% of the indicated value.
- Settings for testing to be at 20%, 60% and 100% of full tool rating if a variable setting tool and 5 or 10 times operations at each setting where all readings were to be within the tolerance limits.
- Temperature to be within 20°C ± 5°C (Variation of ±1°C during calibration).

BS EN ISO 6789:2017

- Divided into 2 parts.
- Part 1 : Requirements and methods for design conformance testing and quality conformance testing: minimum requirements for declaration of conformance (BS EN ISO 6789-1:2017).
- Part 2 : Requirements for calibration and determination of measurement uncertainty (BS EN ISO6789-2:2017).

ISO 6789:2017 Part 1 Conformity

- Much more detailed document.
- Similar to the 2003 version.
- Drive types have been expanded to include hex drives.
- Definition of torque range of tools changed.
- Time of loading for last 20% of setting modified (Type II only).
- Importance of avoiding parasitic forces.
- Flow charts of methods (Annex C).
- Requirements for certificate of conformance.

ISO 6789:2017 Part 2 Calibration

- Entirely new part.
- Relies on part 1 for tool specifications , identification of tool types etc.
- Calibration only with no conformity statements.
- Addresses method of calibration.
- New section addressing and ascertaining Uncertainties of measurement.
- Annex C for requirements of the Torque calibration device or if the calibration laboratory already has a recognised standard this is accepted.
- Contains examples of calibrations to allow users to verify their methods, calculations and results.
- States the data to be present on the calibration certificate.

ISO 6789:2017: Tool Types

There are two categories that manual torque tools are classified into: Type I and Type II.

- Type I Indicating torque Tools: All subclasses (5 Readings).

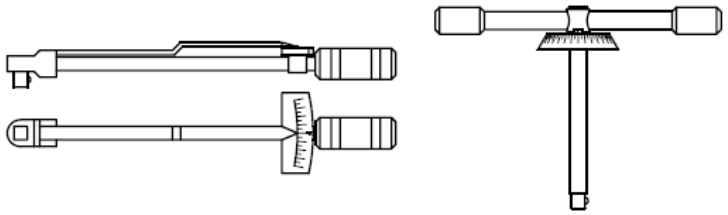


Figure A.1 — Class A: wrench, torsion or flexion bar

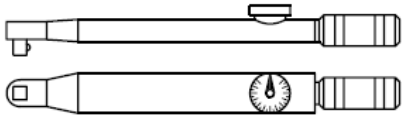


Figure A.2 — Class B: wrench, rigid housing, with scale or dial or display

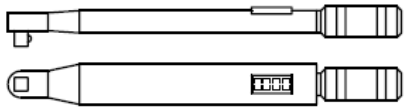


Figure A.3 — Class C: wrench, rigid housing and electronic measurement

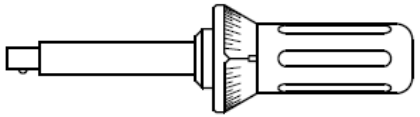


Figure A.4 — Class D: screwdriver, with scale or dial or display

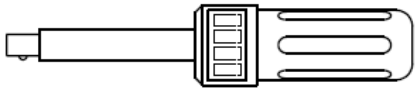


Figure A.5 — Class E: screwdriver, with electronic measurement

ISO 6789:2017: Tool Types Cont'd.

- Type II Setting torque tools:
  - Sub Classes A,D, and G. Adjustable (5 Readings).
  - Sub Classes B,C, E, F. Fixed(10 Readings).

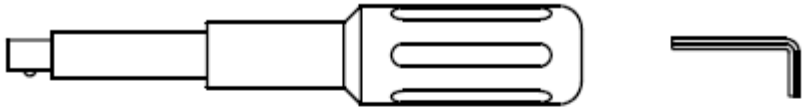


Figure B.6 — Class F: screwdriver, adjustable, non-graduated

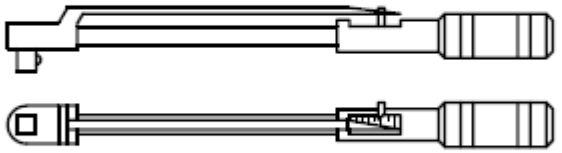


Figure B.7 — Class G: wrench flexion bar, adjustable, graduated

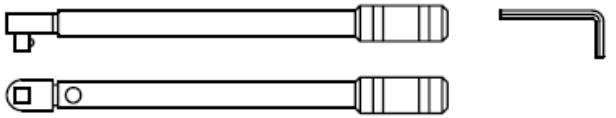


Figure B.3 — Class C: wrench, adjustable, non-graduated

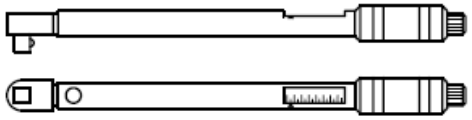


Figure B.1 — Class A: wrench, adjustable, graduated or with display

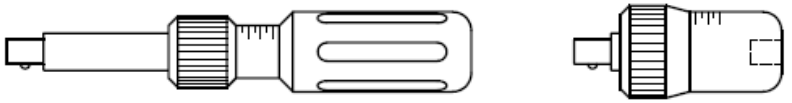


Figure B.4 — Class D: screwdriver, adjustable, graduated or with display

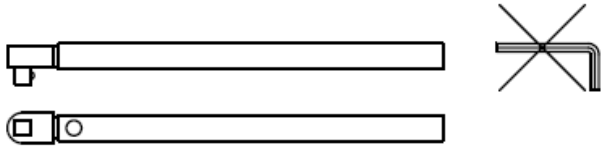


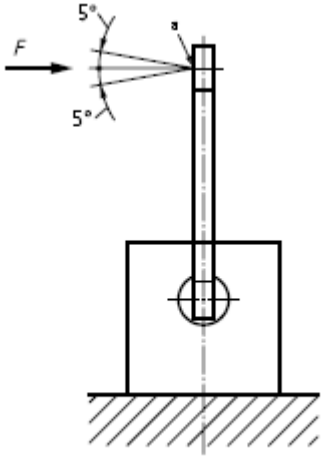
Figure B.2 — Class B: wrench fixed adjustment

Figure B.5 — Class E: screwdriver, fixed adjustment

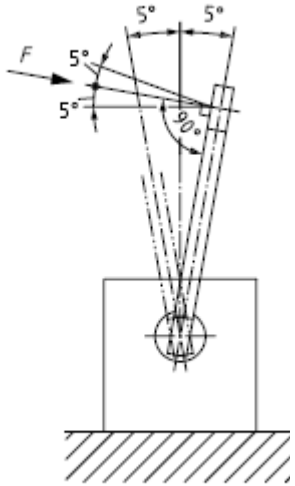
ISO 6789:2017 Part 2 Calibration: Method

Set Up

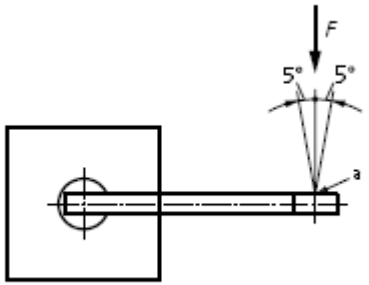
- Mounting of Tools. Allowed configurations.
- Limits of force application control angles.



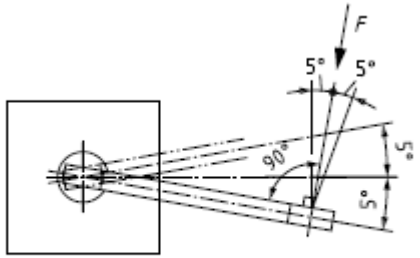
a) Wrench in a vertical position



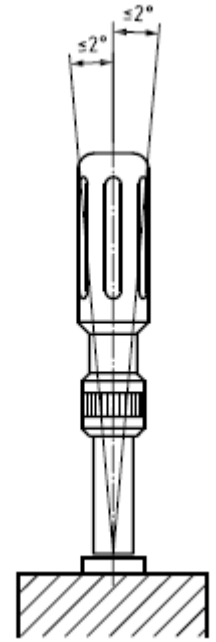
b) Wrench in 5° offset



a) Wrench in a horizontal position



b) Wrench in 5° offset



Screwdriver and T-handle torque wrench in horizontal or vertical position

ISO 6789:2017 Part 2 Calibration: Method Cont'd.

Set Up

- Minimising parasitic forces on the Tool handle during force application.
- Control of torque rate for last 20% of setting (Type II only).
- Allowed range of settings for calibration. Scale markings.
- Sources of Variation.
- Use of Drive adapters-uncertainties.
- Ratchet heads-rotation.

ISO 6789:2017 Part 2 Calibration: Method Cont'd.

Starting Calibration

- Exercise to full range or the fixed setting of the tool 3 times.

Variable setting or Indication Tools.

- Operation of Tool for the required number of readings at that setting, recording the readings and in the controlled manner of force application. (Repeatability)
- Disturbance of the tool, repeating the previous settings and record the readings (Reproduceability) Type I (All) and II Classes A,D and G only at the lowest setting, 4 sequences of 5 or 10 readings

ISO 6789:2017 Part 2 Calibration: Method Cont'd.

Fixed setting tools

- Exercise to full range or the fixed setting of the tool 3 times.

- Operation of Tool for the required number of readings(10), recording the readings and in the controlled manner of force application. (Repeatability)

ISO 6789: Part 2 Calibration: Uncertainties

- New but now common practise with measurement standards.
- For a tool calibration this is for many a new contentious and expensive to perform part of the standard.
- It requires prior knowledge of a number of aspects of that model of tool or to produce a table of uncertainties by multiple operations.
- If not known then 10 readings at lowest scale graduation of the tools range must be made for all the uncertainty requirements listed.
- This can be a live data base allowing a build up of knowledge to reduce further future testing.

ISO 6789:2017 Part 2 Calibration: Uncertainties Cont'd.

- Knowledge must be built up from testing 10 tools of the same model.
- It can be done by testing a tool 10 times.
- If the wrench has been calibrated to the standard before then its previous uncertainty values for Bod, Bint and Bl can be used.
- Full informative examples are shown in the Annex A for type I tools and B Type II setting torque tools of the standard.
- Formulae and the type of distribution equations applicable are also shown.

ISO 6789:2017 Part 2 Calibration: Uncertainties Cont'd.

7 New Uncertainties. These being:

$w_r -$ *Uncertainty due to the variation in the scale, dial or display resolution*
$w_{rep} -$ *Uncertainty due to reproducibility of torque tools*
$w_{od} -$ *Uncertainty due to geometric effects of the output drive of the torque tool*
$w_{int} -$ *Uncertainty due to geometric effects of the interface between the output drive of the torque tool and the calibration system*
$w_l -$ *Uncertainty due to the variation of the force loading point*
$w_{re} -$ *Uncertainty due to the repeatability*
$w_{md} -$ *Relative standard measurement uncertainty of the measurement device at the target torque*

ISO 6789:2017 Part 2 Calibration: Uncertainties Cont'd.

Type & Class	Recorded Measurements for Calibration		Uncertainties							Total Number of Testing Operations
			w_{rep}	w_{od}*		w_{int}*		w_l*		
	Ex	Re	Re	Ex	Re	Ex	Re	Ex	Re	
All Type I. Type II Classes A, D & G	3	15	20	5	40	5	40	5	20	**153**
Type II Classes B, C, E & F	3	10	0	5	40	5	40	5	20	**128**

*Note: It is to be hoped that manufacturers can type test 10 of each of their models to provide the variationfigures (b_{od}, b_{int}, b_l) as default values, which can be used to generate the uncertainty figures (w_{od}, w_{int}, w_l respectively) to reduce the number of tests performed by the calibration laboratories. If all of these are supplied by the manufacturer, the total number of testing operations is reduced by 115.

**Note: No Wrep for Type II B,C,E & F.

ISO 6789: Part 2 Calibration: Examples

Calibration Machines-Manual operation

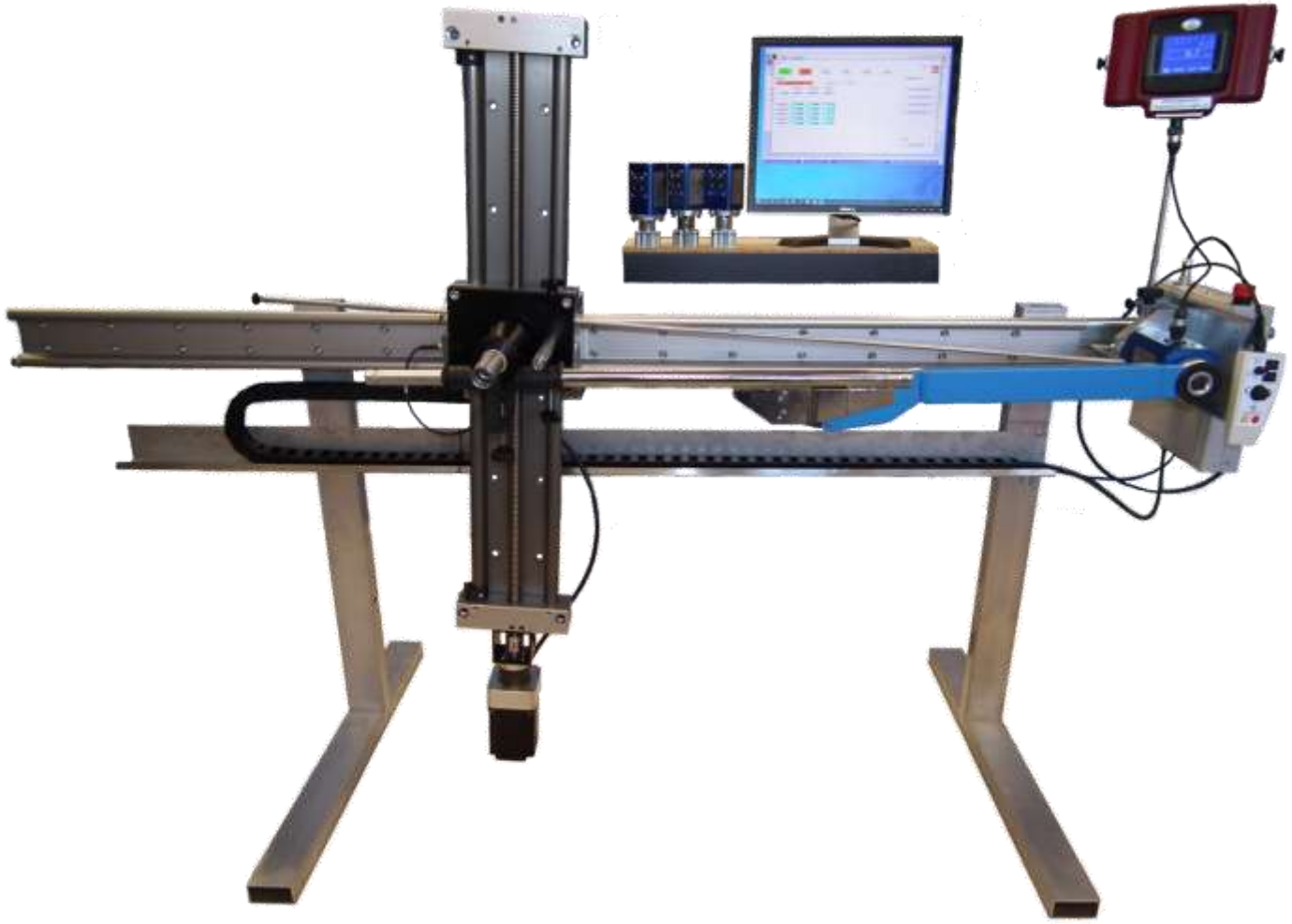
- Require some skill on the operators behalf to over come the parasitic requirements, time control and manual effort when large torques are required.
- There is likely to be more uncertainty and operator fatigue.

ISO 6789: Part 2 Calibration: Examples

Calibration Machines-Powered operation

- Remove much of the skill of the operators.
- Compensate by design to minimise parasitic forces.
- Time control 80-100% is automatic .
- No manual effort in torque/force application.

ISO 6789: Part 2 Calibration: Examples

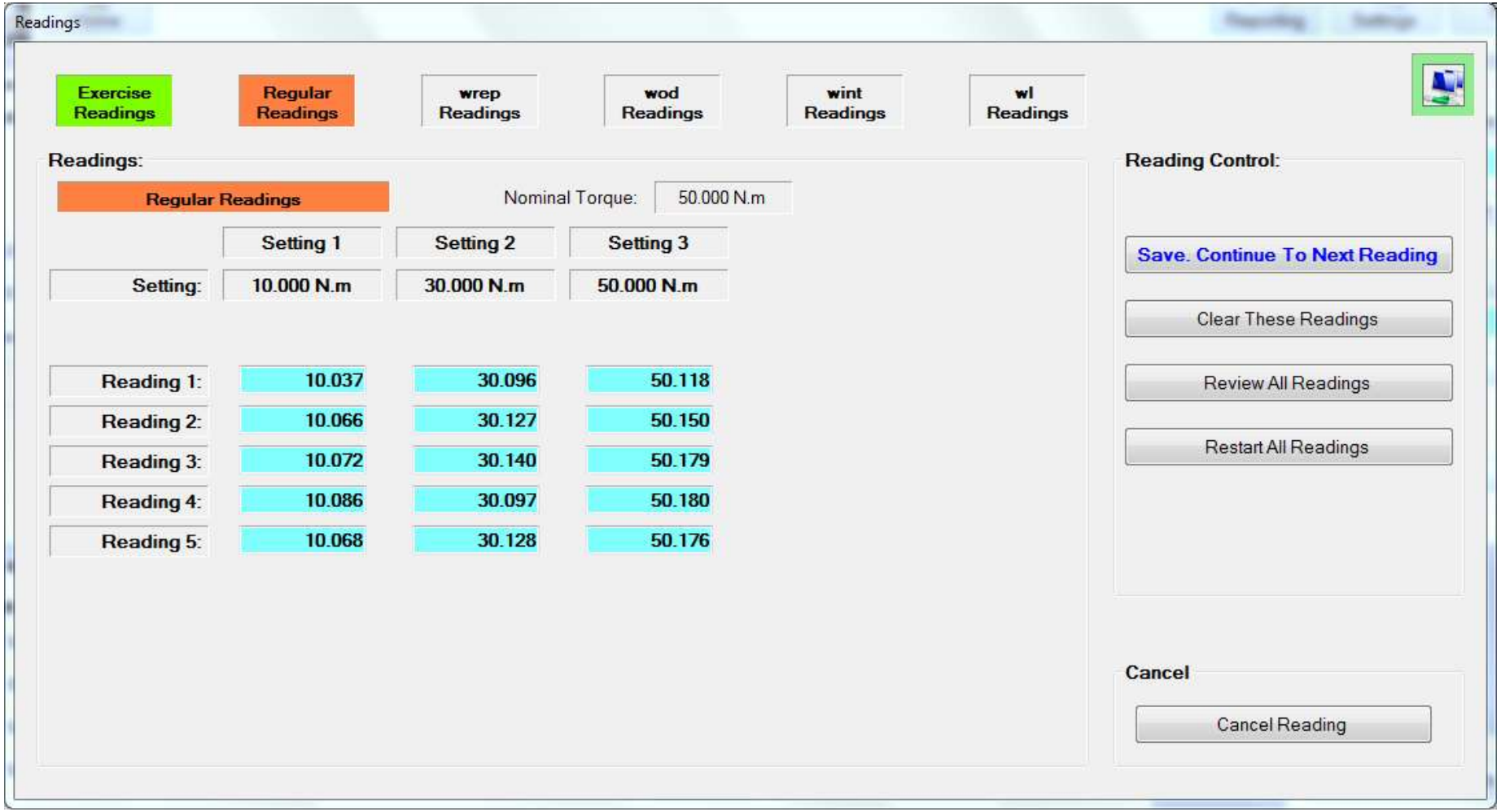


ISO 6789: Part 2 Calibration: Examples

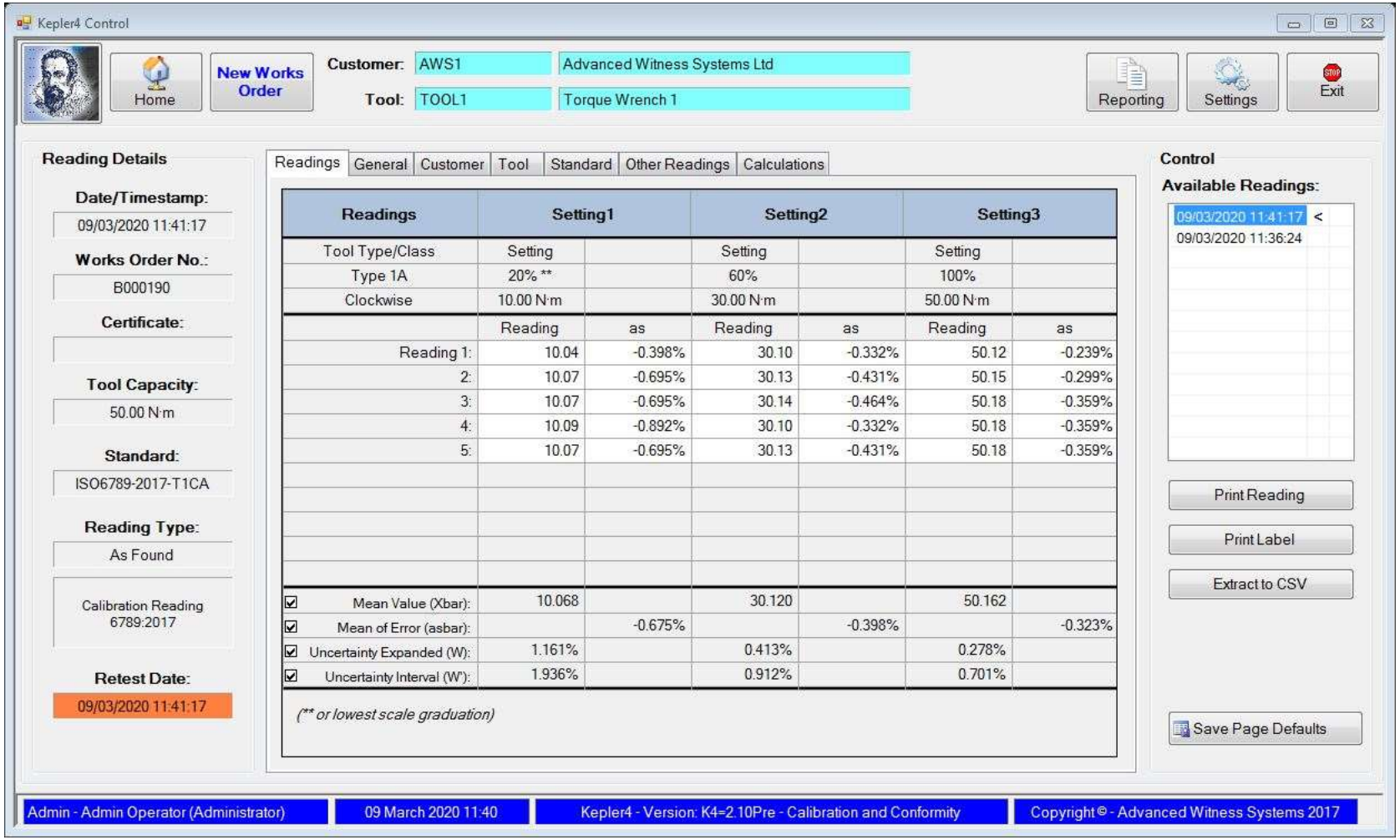
ISO 6789: Part 2 Calibration: Examples- spread sheets and software

- The calibration recordings and calibrations can be accomplished using a comprehensive in house produced spread sheet program.
- It can be checked by using the data examples and results in the standard.
- Conversely there are proven software programs to carry out these operations .
- These may also have other attributes to assist in calibration management such as databases to store historical information, tracking , certification and certificate templates.

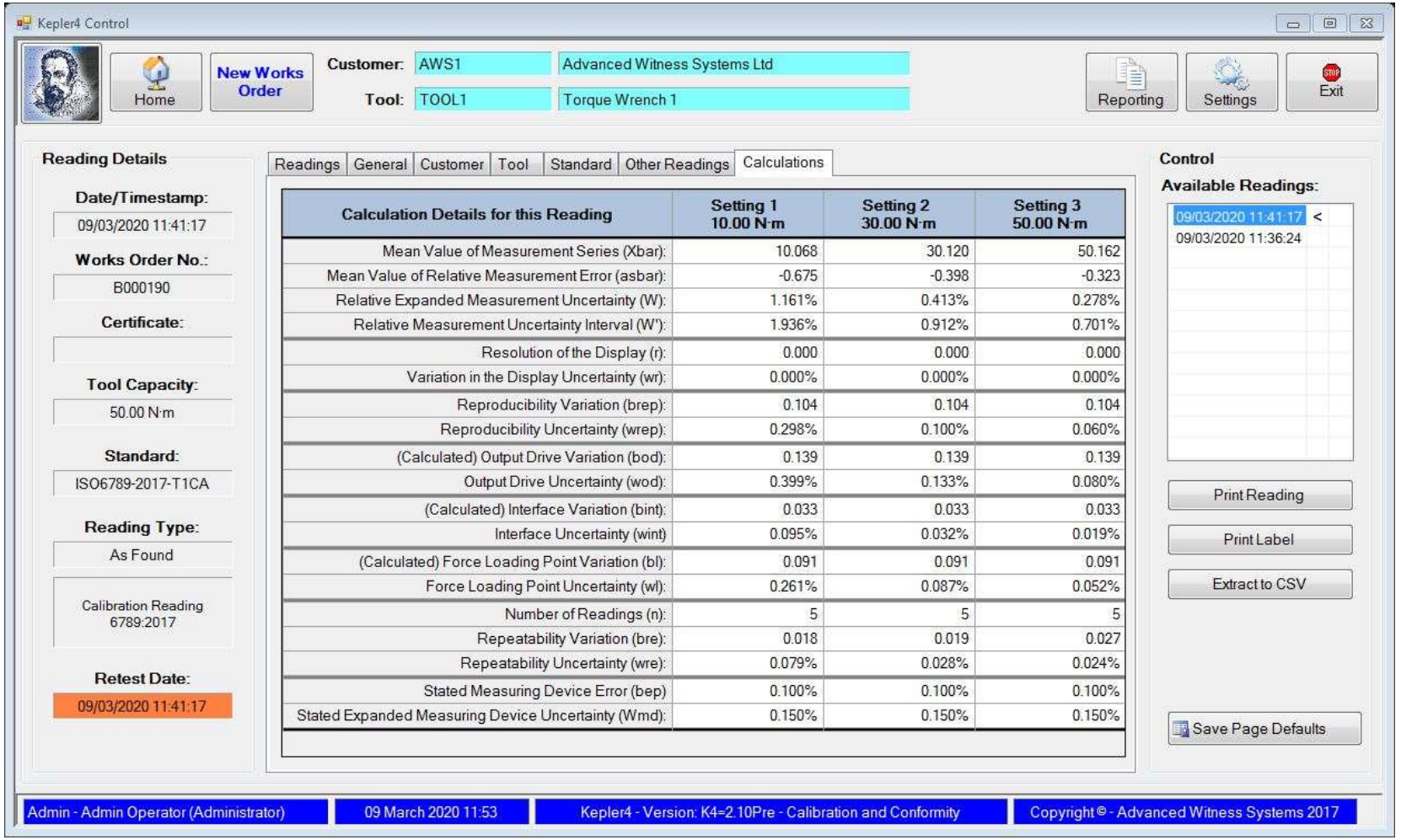
ISO 6789: Part 2 Calibration: Examples- spread sheets and software



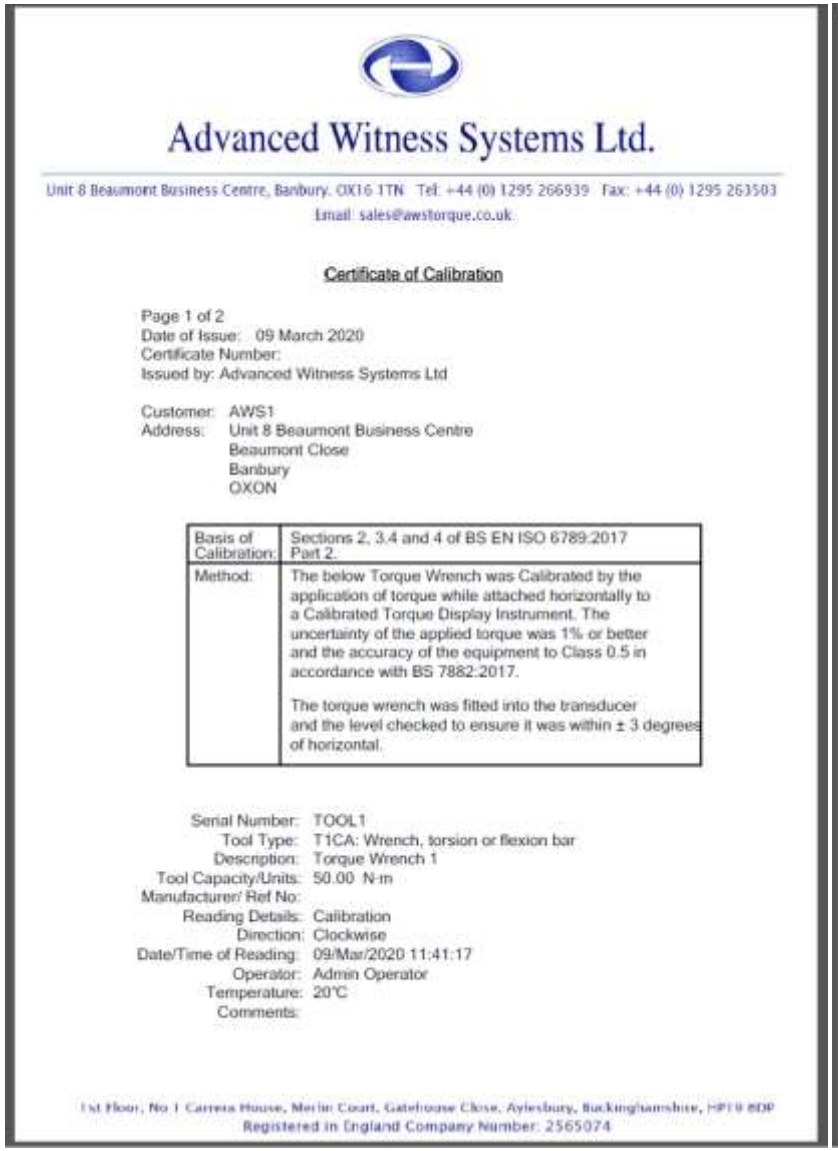
ISO 6789:2017 Part 2 Calibration: Uncertainties Cont'd.



ISO 6789:2017 Part 2 Calibration: Uncertainties Cont'd.



Reading the Calibration Certificate



Advanced Witness Systems Ltd.

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Email: sales@awstorque.co.uk

Certificate of Calibration

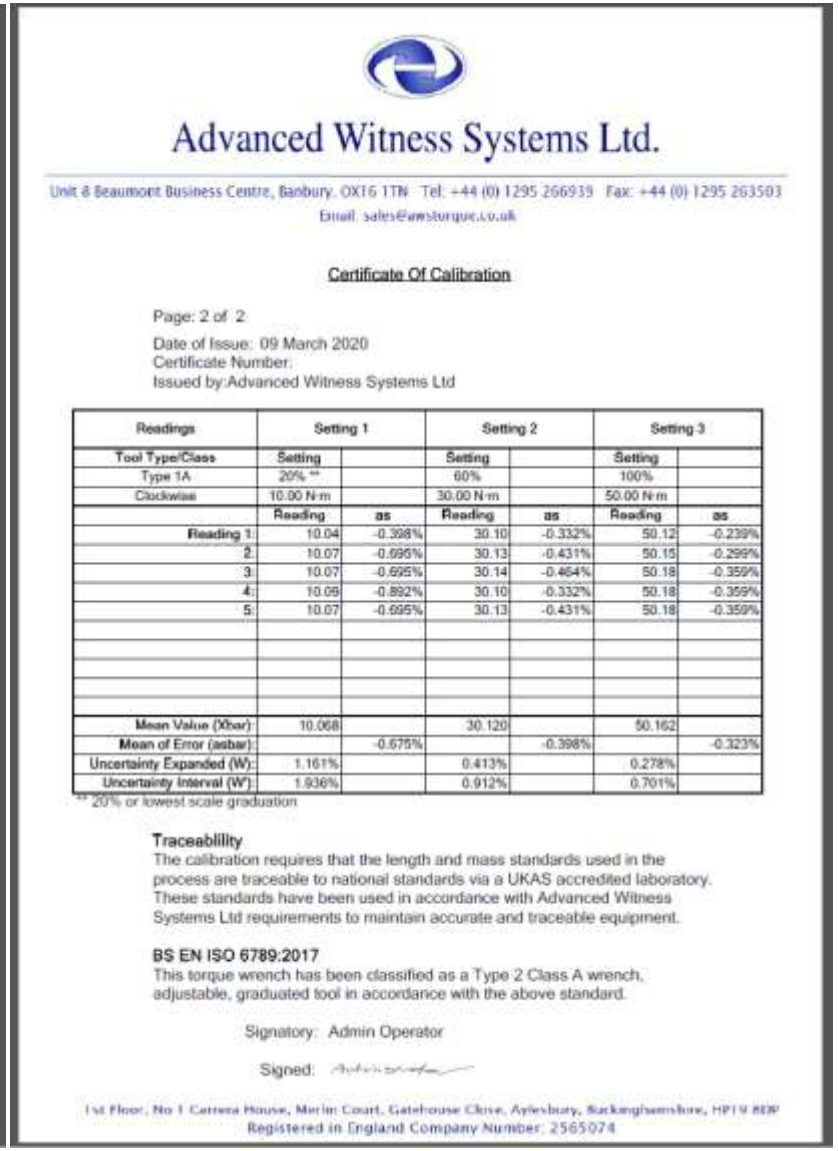
Page 1 of 2
Date of Issue: 09 March 2020
Certificate Number:
Issued by: Advanced Witness Systems Ltd

Customer: AWS1
Address: Unit 8 Beaumont Business Centre
Beaumont Close
Banbury
OXON

Basis of Calibration:	Sections 2, 3.4 and 4 of BS EN ISO 6789:2017 Part 2.
Method:	The below Torque Wrench was Calibrated by the application of torque while attached horizontally to a Calibrated Torque Display Instrument. The uncertainty of the applied torque was 1% or better and the accuracy of the equipment to Class 0.5 in accordance with BS 7882:2017. The torque wrench was fitted into the transducer and the level checked to ensure it was within ± 3 degrees of horizontal.

Serial Number: TOOL1
Tool Type: T1CA: Wrench, torsion or flexion bar
Description: Torque Wrench 1
Tool Capacity/Units: 50.00 N·m
Manufacturer/ Ref No:
Reading Details: Calibration
Direction: Clockwise
Date/Time of Reading: 09/Mar/2020 11:41:17
Operator: Admin Operator
Temperature: 20°C
Comments:

1st Floor, No 1 Carrera House, Merlin Court, Gatehouse Close, Aylesbury, Buckinghamshire, HP19 8DP
Registered in England Company Number: 2565074



Advanced Witness Systems Ltd.

Unit 8 Beaumont Business Centre, Banbury. OX16 1TN Tel: +44 (0) 1295 266939 Fax: +44 (0) 1295 263503
Email: sales@awstorque.co.uk

Certificate Of Calibration

Page: 2 of 2
Date of Issue: 09 March 2020
Certificate Number:
Issued by:Advanced Witness Systems Ltd

Readings	Setting 1		Setting 2		Setting 3	
Tool Type/Class	Setting		Setting		Setting	
Type 1A	20% **		60%		100%	
Clockwise	10.00 N·m		30.00 N·m		50.00 N·m	
	Reading	as	Reading	as	Reading	as
Reading 1:	10.04	-0.398%	30.10	-0.332%	50.12	-0.239%
2:	10.07	-0.695%	30.13	-0.431%	50.15	-0.299%
3:	10.07	-0.695%	30.14	-0.464%	50.18	-0.359%
4:	10.09	-0.892%	30.10	-0.332%	50.18	-0.359%
5:	10.07	-0.695%	30.13	-0.431%	50.18	-0.359%
Mean Value (Xbar):	10.068		30.120		50.162	
Mean of Error (asbar):		-0.675%		-0.398%		-0.323%
Uncertainty Expanded (W):	1.161%		0.413%		0.278%	
Uncertainty Interval (W'):	1.936%		0.912%		0.701%	

** 20% or lowest scale graduation

Traceability
The calibration requires that the length and mass standards used in the process are traceable to national standards via a UKAS accredited laboratory. These standards have been used in accordance with Advanced Witness Systems Ltd requirements to maintain accurate and traceable equipment.

BS EN ISO 6789:2017
This torque wrench has been classified as a Type 2 Class A wrench, adjustable, graduated tool in accordance with the above standard.

Signatory: Admin Operator

Signed:

1st Floor, No 1 Carrera House, Merlin Court, Gatehouse Close, Aylesbury, Buckinghamshire, HP19 8DP
Registered in England Company Number: 2565074

- References: BS EN ISO 6789:2017, BS 7882, ISO/IEC 17025 copyright.
- Thank you all for attending and listening.
- Are there any questions?