Swedish Metrology and Quality AB

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Final Report on an interlaboratory comparison (ILC) of the calibration in the force area part 1 force tension and compression (rev 2)

There a more separate parts:
Part 2 position of beam
Part 3 speed of beam
Part 4 Extensometer

Material testing machine

Author

Håkan Källgren
Swedish Metrology and Quality AB

Content

Abstract

This interlaboratory comparison (ILC) was conducted to verify and compare force calibration results produced by calibration laboratories, and to demonstrate their technical competence in accordance with ISO/IEC 17025:2017, clause 7.7.2. The comparison focused on the calibration of a universal testing machine with a measuring range of 10 kN in both tension and compression. The calibrated system consisted of a Tinius Olsen force transducer integrated in a 5ST Series universal testing machine, operated using Horizon software.

The intercomparison was announced via professional and web-based channels and involved accredited laboratories as well as laboratories applying for accreditation or extension of scope from several European countries. Participants followed their own accredited calibration procedures and used their normal equipment, without making any adjustments to the test object. Calibration results were evaluated at agreed force points from 1 kN to 10 kN in tension and compression.

Reference values were established using a deadweight force standard machine at the Swedish national reference laboratory. The evaluation of results followed the principles of ISO/IEC 17043:2023, using the normalized error (En-value) to assess the agreement between participant results and the assigned reference values, taking stated measurement uncertainties into account.

The results show that most participants demonstrated satisfactory performance in force calibration in tension, with En-values within the acceptance criterion $|En| < 1$. A higher number of deviations exceeding this criterion were observed in compression measurements.

The comparison provides a robust basis for performance evaluation, supports accreditation activities, and highlights areas for further improvement in force calibration practice.

Purpose and implementation of the comparison

This interlaboratory comparison serves as a tool to verify results from the measurement carried out by calibration laboratories. It is an effective method to demonstrate technical capacity of the participant and serves as a technical base for accreditation as required by ISO/IEC 17025:2017 (SS-EN ISO/IEC 17025:2018) as specified in point 7.7.2.

Information about the testing machine that was calibrated

Tinius Olsen, model DBBSTOL-10kN-08-1035, serial no. AP46115.
Universal testing machine, model 5ST Series, serial no. ST-AFR-02589GB.
PC with Horizon Software, version 10.3.0.7. –
Cable belonging to the object and system.
Measuring range 10 kN compression and tension

Information about the intercomparison

The information about the intercomparison was given in 2 different media:

- LinkedIn
- On the web https://smquality.se/interlaboratory-comparisons-ilc

The information on the web was done in 2 steps. General information as ILC force 2024:2 published on smquality.se.

Detailed information as a description of the intercomparison/ILC is published on smquality.se

Participants in the intercomparison

Laboratory	Country
Primary laboratory RISE, National Reference laboratory of Sweden	Sweden
Contemporary Amperex Technology Thuringia AG	Germany
Elastocon AB	Sweden
MTS System Norden AB	Sweden
Kvalitest Industrial OY	Finland
Eurofins Expert Services OY	Finland
RISE Research Institutes of Sweden AB	Sweden
Analytical Instruments S.A.	Greece
PROCERTUS	Belgium
Sartorom Impex SRL	Romania
Primary laboratory RISE, National Reference laboratory of Sweden	Sweden

Most of the laboratories are accredited by their accreditation organizations and some of them apply for accreditation or apply for an updated accreditation scope.

Calibration instructions

The laboratories could use a specified time for calibrations. They were advised to use their own calibration procedures with focus on the points described below which were important for the inter-comparison outcome.
They should use their own mechanical equipment that they normally use. Most of them are using the same software to document the results and calculations to produce the calibration certificate. They were not allowed to look at each other when they did the calibrations.
They were not allowed to perform any type of adjustment on the objects.

Agreed calibration points

The participants calibrated according to their software as they were using the same software but only the following points were evaluated as a part of this project.

Force calibration tensile and compression

Evaluated calibration points force tensile and compression

- 1 kN
- 2 kN
- 4 kN
- 6 kN
- 8 kN
- 10 kN

Planning and instruction details

The participants were asked to deliver the excel sheets including results before they left the site and send the calibration certificates to the organiser within one week.

The evaluator uses the principles of the ISO/IEC 17043:2023 in the reporting.

Administrative information

Address to send the required documents:
Swedish Metrology and Quality AB Håkan Källgren Dragspelsgatan 21 SE-504 72 Borås, Sweden e-mail: hakan.kallgren@smquality.se Phone: +46 705 774 931

Reference Calibrations

Reference calibrations were done in the deadweight machine Schenck force standard machine 100 kN, inv. no. 400825.

Analysis of the calibration results

The evaluator used the principles in the ISO/IEC 17043:2023.

As an easy-to-understand measure to judge each participant result its distance to the assigned reference value is used, normalized with respect to the uncertainty in this difference. This measure En-value is calculated for every force according to thec following equation.

$$En_{,} = \left| \frac{x_{i,} - x_{ref,}}{\sqrt{U_{i,}^2 + U_{ref,}^2}} \right|$$

x_i: Single measurement result (deviation from nominal value); index *i* and *j* count the various participants and weights respectively.

x_{ref}: Assigned inter-comparison reference value.

U_i: The estimated expanded uncertainty (k=2) stated by each laboratory.

U_{ref}: The estimated expanded uncertainty (k=2) of the assigned reference value.

En_i: The calculated En-value for each participant.

Inter-comparison reference value

Set up of the calibrated equipment

Tinius Olsen, model DBBSTOL-10kN-08-1035,
serial no. AP46115.
- Universal testing machine, model 5ST Series,
serial no. ST-AFR-02589GB.
- PC with Horizon Software, version 10.3.0.7.
- Cable belonging to the object and system.

Measurement method and procedures

Calibration in tension and compression up to 10000 N according to ISO 376:2011.
Creep measurement was performed after preloading at maximum force

The principle of the intercomparison

An absolute value of E_n of less than 1 is often used as a criterion for an acceptable measurement quality, according to ISO/IEC 17043:2023, annex B.4. formula B6. It means a reported deviation x_i from the nominal mass value by a participant does not deviate more from the assigned reference comparison value x_{ref} than what can be expected from the calculated uncertainty in this difference.

$$E_n < 1: \quad |x_i - x_{ref}| < \sqrt{U_i^2 + U_{ref}^2}$$

However, to make this measure a reliable one for an inter-comparison the reference U_{ref} must be small enough not to contribute significantly to the right side of equation 4. Due to the quadratic combination ideally U_{ref} should be in the range of 1/3 of U_i. That was possible in this case

Calibration certificates (reference laboratory)

105102-1328865-K01

Traceability of reference values

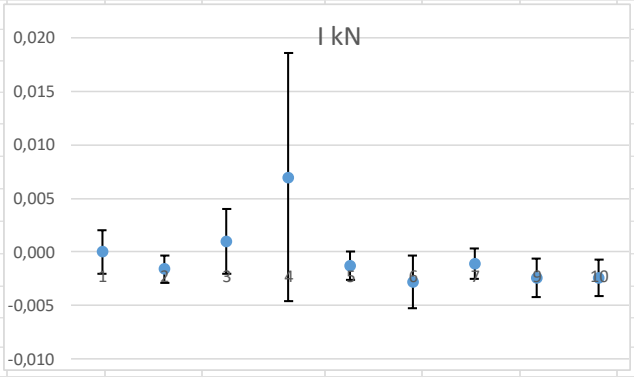
The reference laboratory principle was used as a base for calculating the results as described.

Measuring results on calibration in comparison for the different calibrations

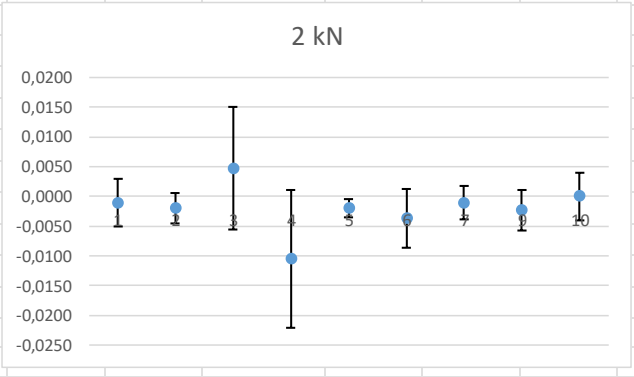
The following tables and diagrams present the deviation of indication along with the stated measurement uncertainty for each calibration point and the resulting En-value based on the reference calibration.

Force calibration tension

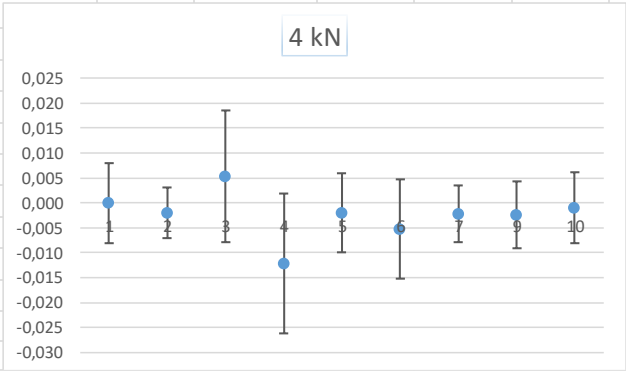
Tension	Table 1	1 kN	
Identification	Error kN	Uncertainty kN	En value
1	-0,0013	0,0020	0,22
2	-0,0016	0,0013	0,55
3	0,0010	0,0030	0,61
4	0,0070	0,0116	0,67
5	-0,0013	0,0013	0,33
6	-0,0028	0,0025	0,77
7	-0,0011	0,0014	0,17
9	-0,0024	0,0018	0,84
10	-0,0024	0,0017	0,89
	Ref error	Ref Uncertainty	
	-0,00085	0,00035	



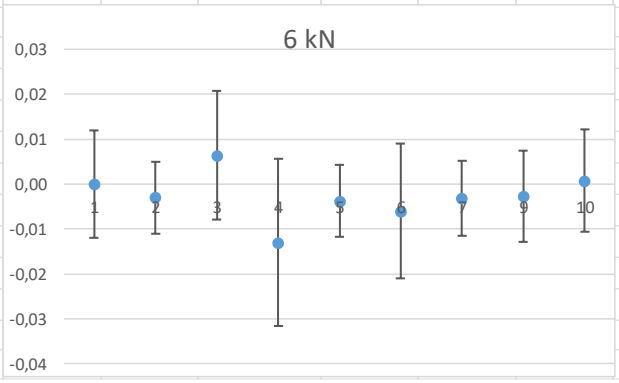
Tension	Table 2	2 kN	
Identification	Error kN	Uncertainty kN	En value
1	-0,0011	0,0040	0,27
2	-0,0020	0,0025	0,74
3	0,0047	0,0103	0,45
4	-0,0105	0,0116	0,90
5	-0,0020	0,0015	1,09
6	-0,0037	0,0050	0,72
7	-0,0011	0,0028	0,37
9	-0,0023	0,0034	0,65
10	-0,0022	0,0040	0,53
	Ref error	Ref Uncertainty	
	0,0000	0,0011	



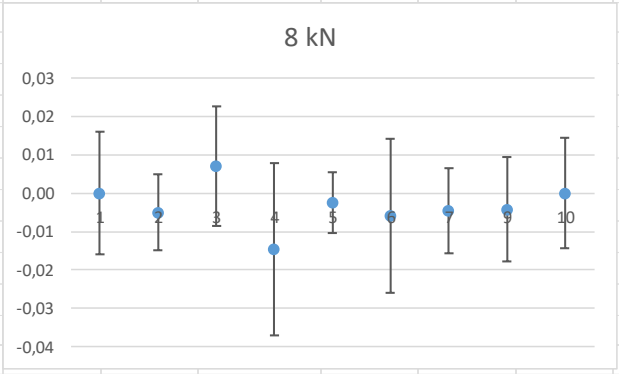
Tension	Table 3	4 kN	
Identification	Error kN	Uncertainty kN	En value
1	-0,0017	0,0080	0,22
2	-0,0020	0,0050	0,40
3	0,0053	0,0133	0,40
4	-0,0122	0,0140	0,87
5	-0,0020	0,0080	0,25
6	-0,0052	0,0100	0,52
7	-0,0022	0,0056	0,39
9	-0,0024	0,0068	0,35
10	-0,0010	0,0072	0,14
	Ref error	Ref Uncertainty	
	0,0000	0,0013	



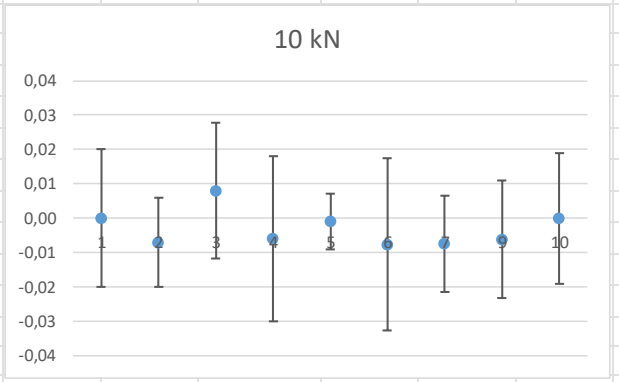
Tension	Table 4	6 kN	
Identification	Error kN	Uncertainty kN	En value
1	-0,0019	0,0120	0,12
2	-0,0030	0,0080	0,32
3	0,0063	0,0143	0,47
4	-0,0131	0,0186	0,68
5	-0,0038	0,0080	0,42
6	-0,0060	0,0150	0,37
7	-0,0032	0,0084	0,33
9	-0,0027	0,0102	0,22
10	0,0007	0,0114	0,10
	Ref error	Ref Uncertainty	
	-0,0004	0,0012	



Tension	Table 5	8 kN	
Identification	Error kN	Uncertainty kN	En value
1	-0,0034	0,0160	0,22
2	-0,0050	0,0100	0,49
3	0,0070	0,0156	0,43
4	-0,0146	0,0224	0,65
5	-0,0025	0,0080	0,31
6	-0,0059	0,0200	0,30
7	-0,0046	0,0112	0,41
9	-0,0042	0,0136	0,31
10	-0,0037	0,0144	0,26
	Ref error	Ref Uncertainty	
	0,0001	0,0031	

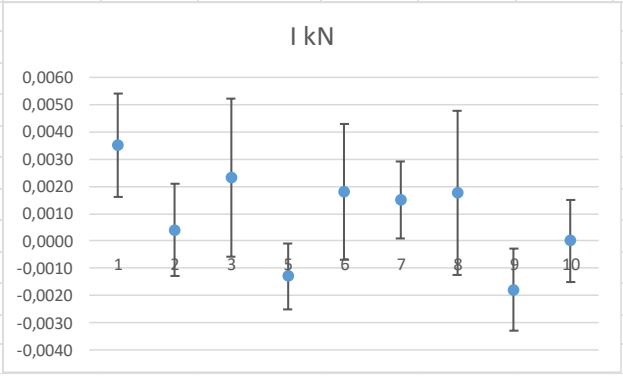


Tension	Table 6	10 kN	
Identification	Error kN	Uncertainty kN	En value
1	-0,0061	0,0200	0,20
2	-0,0070	0,013	0,35
3	0,0080	0,0198	0,48
4	-0,0060	0,0240	0,16
5	-0,0010	0,0080	0,09
6	-0,0077	0,0250	0,22
7	-0,0074	0,0140	0,35
9	-0,0062	0,0170	0,23
10	-0,0044	0,0190	0,12
	Ref error	Ref Uncertainty	
	-0,001968	0,00660	

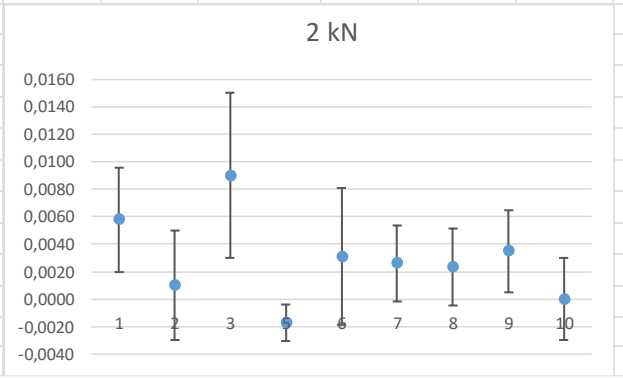


Force calibration compression

Compression	Table 7	1 kN	
Identification	Error kN	Uncertainty kN	En value
1	0,0035	0,0019	1,07
2	0,0004	0,0017	0,49
3	0,0023	0,0029	0,34
5	-0,0013	0,0012	1,85
6	0,0018	0,0025	0,19
7	0,0015	0,0014	0,12
8	0,0018	0,0030	0,14
9	-0,0018	0,0015	1,86
10	-0,0011	0,0015	1,44
	Ref error	Ref Uncertainty	
	0,0013	0,0008	



Compression	Table 8	2 kN	
Identification	Error kN	Uncertainty kN	En value
1	0,0058	0,0038	0,72
2	0,0010	0,0040	0,41
3	0,0090	0,0060	0,99
5	-0,0017	0,0013	2,09
6	0,0031	0,0050	0,06
7	0,0026	0,0028	0,06
8	0,0024	0,0028	0,14
9	0,0035	0,0030	0,20
10	-0,0031	0,0030	1,71
	Ref error	Ref Uncertainty	
	0,0028	0,0017	



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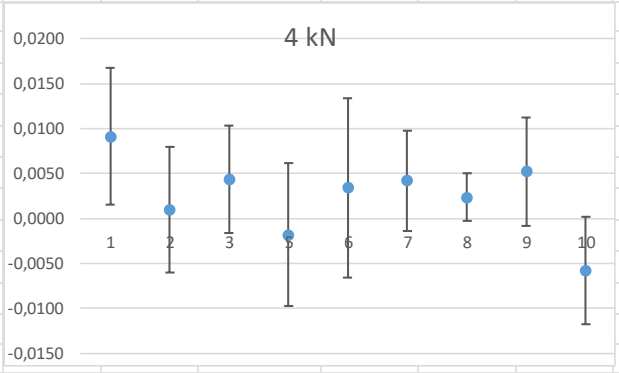
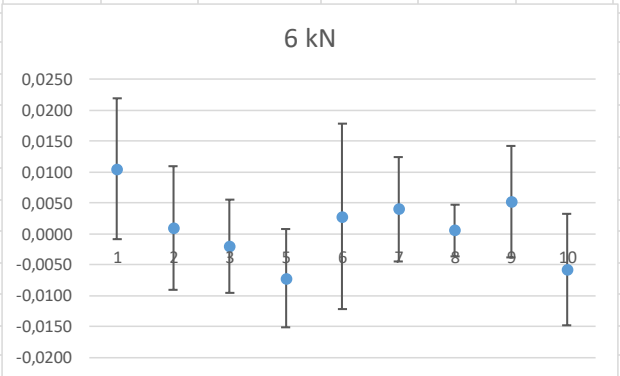
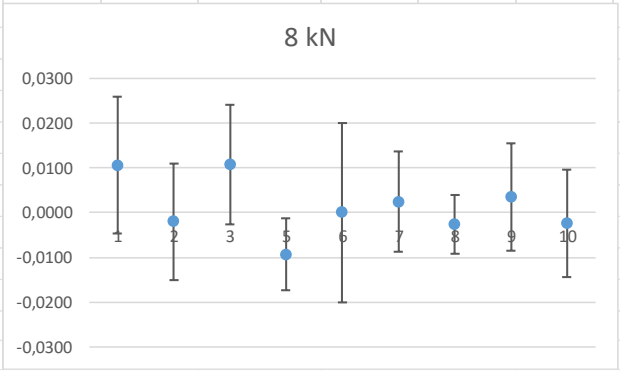
Compression	Table 9	4 kN	
Identification	Error kN	Uncertainty kN	En value
1	0,0091	0,0076	0,71
2	0,0010	0,0070	0,35
3	0,0043	0,0060	0,13
5	-0,0018	0,0080	0,65
6	0,0034	0,0100	0,01
7	0,0042	0,0056	0,11
8	0,00237	0,00268	0,36
9	0,0052	0,0060	0,26
10	-0,0058	0,0060	1,48
	Ref error	Ref Uncertainty	
	0,0035	0,0019	



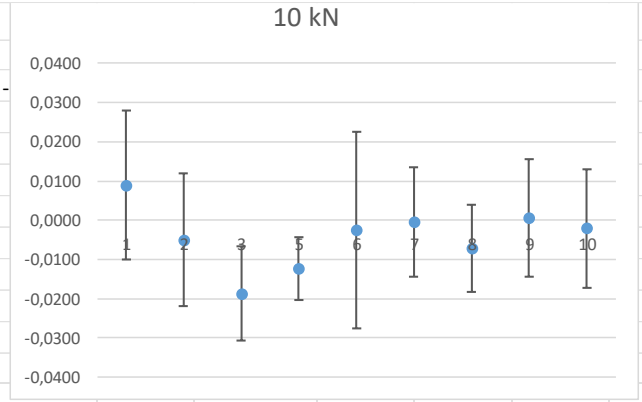
Compression	Table 10	6 kN	
Identification	Error kN	Uncertainty kN	En value
1	0,0105	0,0114	0,76
2	0,0010	0,0100	0,06
3	-0,0020	0,0075	0,46
5	-0,0072	0,0080	1,05
6	0,0028	0,0150	0,08
7	0,0040	0,0084	0,27
8	0,00059	0,0042	0,21
9	0,0052	0,0090	0,38
10	-0,0058	0,0090	0,79
	Ref error	Ref Uncertainty	
	0,0016	0,0027	



Compression	Table 11	8 kN	
Identification	Error kN	Uncertainty kN	En value
1	0,0106	0,0152	0,76
2	-0,0020	0,0130	0,04
3	0,0107	0,0134	0,86
5	-0,0093	0,0080	0,87
6	0,0000	0,0200	0,07
7	0,0024	0,0112	0,32
8	-0,00265	0,00656	0,16
9	0,0036	0,0120	0,40
10	-0,0024	0,0120	0,08
	Ref error	Ref Uncertainty	
	-0,001	0,004	



Compression	Table 12	10 kN	
Identification	Error kN	Uncertainty kN	En value
1	0,0089	0,0190	0,75
2	-0,0050	0,0170	0,05
3	-0,0187	0,0120	0,98
5	-0,0124	0,0080	0,68
6	-0,0025	0,0250	0,13
7	-0,0004	0,0140	0,37
8	-0,0072	0,0110	0,11
9	0,0006	0,0150	0,41
10	-0,0021	0,0150	0,24
	Ref error	Ref Uncertainty	
	-0,0059	0,0052	



Comments on the calibration certificates

The calibration certificates looked very different and was focused on results in % instead of absolute values that was the purpose of this intercomparison.

That means that the evaluation in many cases depend on results from the excel sheets.

A number of results have changed depending on mistakes in the distributed exelsheets and misunderstanding of the documented results.

Changes since rev 1 of the report

Redactional changes were done.
Interpretation of results from 2 laboratories was not correct and has now been updated.

Explanations from participants on their reference equipment

The laboratories explain that they use one or more load cells (maximum 4)

Final conclusions

In this inter comparison most of the participants could demonstrate a capacity to calibrate and give relevant values in relationship to their uncertainties force calibration on tension, documented by the size of En-values

There was 1 of En value above 1 in tension

There was 8 results giving En-values higher than 1 in compression.

Evaluation of the results

The participants shall evaluate their results according to ISO/IEC 17025:2017 7.7.3

It is then recommended to evaluate according to descriptions above including:

- the size of En-values
- En- values in relation to the stated CMC values by the laboratory

Acknowledgement

Elastocon AB that allowed us to use the machine on their site during the process

Primary laboratory RISE, National Reference laboratory of Sweden

References:

- ISO/IEC 17043:2023 Conformity assessment – General requirements for proficiency testing
- ISO/IEC 17025:2017 General requirements for the competence of testing and calibration laboratories
- ISO 13528 Statistical methods for use in proficiency testing by interlaboratory comparison
- Evaluation of measurement data – Guide to the expression of uncertainty in measurement, GUM (JCGM 100:2008)
- EA-4/02 M:2013 Evaluation of Uncertainty of Measurement in Calibration
- International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)
- ISO 7500-1:2018 calibration of force machines
- ISO 9513:2012 calibration of extensometers