SMQ-ILC force 2022:3 2025-05-08

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC force 2022:3) on 100 N-Part 2

Part 1 covered 1000 N load cell using a distributed amplifier

Part 2 cover 100 N load cell using a distributed amplifier

Part 3 will cover 100 N and 1000 N load cell without distributed amplifier. Will not be published as there was only one participant.

The bags carrying the equipment for calibration.

Author

Håkan Källgren

Swedish Metrology and Quality AB

Content

Abstract

This report is about an inter-comparison/ILC of two load cells with 5 participating laboratories.

The load cells were calibrated with a possibility to calibrate the load cells either separate or with a circulated amplifier. This part 2 of the report covers the results on the 100 N load cell together with the circulated amplifier.

Calibration should be done in tension and compression.

The calibration was documented by the error and its uncertainty at all calibrations points. This data were reported in two ways, as an excel-protocol and by sending a calibration certificate. The excel-protocols form the evaluation basis after checking the conformity with the certificate.

RISE (Swedish National Metrological Institute) and HBM calibrated the sensor before and after the circulation. Their average serves as assigned inter-comparison reference values and are used together with the stated reference uncertainty to calculate En-values at each measuring point for each participant.

The report covers 8 forces on compression and tension on the 100 N load cell.

Of a total number of 64 results by calibration laboratories using the supplied amplifier 3 was getting an En-value above 1.

Purpose and implementation of the comparison

This interlaboratory comparison serves as a tool to verify results reported 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.

Advisory group

The intercomparison has followed the recommendations of the advisory group. The advisory group has defined the set-up of instruments that should be included in the ILC force 2022:3 intercomparison as well as the choice of calibration points that are defined to be included in the evaluation of the results.

The advisory group consists of Aykurt Altintas Denmark, and Håkan Källgren Swedish Metrology and Quality.

Information about the intercomparison

The information about the intercomparison was given in 3 different media:

- Linkedin
- The data base https://www.eptis.org
- On the web https://smquality.se/interlaboratory-comparisons-ilc

The information on the web was done in 2 steps. General information as ILC force 2022:3 published on smquality.se and enclosed to this report in annex 1.

Detailed information as a description of the intercomparison/ILC published on smquality.se and enclosed to this report the reporting forms as annex 2 and appendix 1.

Object

Load cells 100 N and 1000 N as well as an amplifier

Participating laboratories and measuring scheme for the comparison

Laboratory
RISE, reference laboratory Sweden and HBM
CA Mätsystem AB, Sweden
Element Metech, Sweden
Teknologiskt Institut, Denmark
TAP air Portugal
LABORATRONIC Poland
RISE, reference laboratory Sweden

The circulation ended in week 20 in 2024.

All participants are accredited by Swedac, PCA, COFRAQ, IPAC and DANAK.

The reference laboratory RISE, Sweden has the status as a National Metrology Institute, NMI.

Principles concerning the calibration in general.

The reference laboratories calibrated both sensors at the beginning and after finishing the circulation.

During the whole exercise the preliminary reported results were used for checking possible drift behaviour of the sensors. The purpose was to maintain equal conditions for all participants over the total measurement period. In doubt the sensors were planned to be called back for a new reference calibration, which however was not necessary.

Compulsory calibration points

The participants were asked to calibrate at the following points both at increasing and decreasing force:

Range: 0-100 N
Calibration points: 10, 20, 30, 40, 50, 60, 80 and 100 N

Calibration instructions

The laboratories were allowed maximum 10 days for each calibration. In the call they were advised to use their own calibration procedures with focus on the predefined pressure points. They weren't allowed to perform any type of adjustment on the object.
Using own procedures also meant it was up to the laboratories which measurement points over the compulsory ones.
The prepared excel sheets documented the results and those results are used in this report.

Planning and administrative details

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

Summary of the timeline planning in the call:

- The preliminary results (excel-protocol) should be sent to the organiser when the parcel was sent to next participant.
- One week after the calibration/measurement the calibration certificate should be sent to the evaluator of the intercomparison.
- A draft report should be dispatched to the participants 2 weeks after receiving the last calibration certificate. **The organiser was not able to deliver according to this rule**.
- Comments or feed-back on the draft report to the organiser are expected within 1 week.
- Final report should be finalized within 2 weeks after receiving all comments or feed-back from the participants.

Analysis of the calibration results

The evaluator used the principles of the ISO/IEC 17043:2022 in the reporting.

As an easy-to-understand measure to judge each result of the participant its distance to the assigned reference value is used, normalized with respect to the uncertainty in this difference. This measure the En-value is calculated for every calibration point according to equation 1).

$$E_n = \frac{x_i - x_{ref}}{\sqrt{U_{i,}^2 + U_{ref}^2}} \qquad \text{(eq. 1)}$$

x_i Single measurement result of indication the various participants.

x_{ref} Assigned inter-comparison reference value for calibration point.

U_i The estimated expanded uncertainty (k=2) stated by each laboratory for respective calibration point.

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

E_n The calculated En value at actual point.

Inter-comparison reference value and its uncertainty

The reference values $x_{ref,j}$ are calculated as the average from the first and last calibration provided by the reference laboratory.

$$x_{ref,j} = \frac{R_{1,j} + R_{2,j}}{2} \qquad \text{(eq. 2)}$$

For each instrument

$x_{ref,j}$: The calculated inter-comparison reference value for the level *j*.
j: Counting points.
$R_{1,j}$ & $R_{2,j}$: The assigned comparison reference values provided by the reference laboratories at start and end.

At some calibration points the reported uncertainties differed slightly between the calibration at the beginning and the end. Thus, the measurement uncertainty for each calibration level was calculated as the uncertainty of the mean (equation 3).

$$U_j = \frac{\sqrt{U_{1,j}^2 + U_{2,j}^2}}{\sqrt{2}} \qquad \text{(eq. 3)}$$

For each instrument

U_j: The combined uncertainty from two calibrations (at different pressure levels *j*).
Index 1: Refers to the calibration prior the circulation.
Index 2: Refers to the calibration at the end of circulation.

The data supplied by the reference laboratory indicated a small drift which, however, on the limit of the always was within the stated uncertainty. The uncertainty of the inter-comparison reference value was then composed by adding half of the detected drift over the time for the total exercise, see equation 4.

$$U_{ref,j} = U_j + \frac{1}{2} abs\left(R_{2,j} - R_{1,j}\right) \qquad \text{(eq. 4)}$$

For details se appendix 2

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 17043:2010, B.4.1.1. It means a reported indication error x_i from 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.

$$E_n < 1: \quad \left|x_i - x_{ref}\right| < \sqrt{U_i^2 + U_{ref}^2} \qquad \text{(eq. 5)}$$

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 5. Due to the quadratic combination ideally U_{ref} should be in the range of 1/3 of U_i.

Measuring results on calibration in the ILC

The following tables and graphs present the error of indication along with the stated measurement uncertainty for each calibration point. This presentation is chosen to allow the participants to compare the tabled data in this report with their own documentation.

The following tables are built with increasing participant identity numbers (but not in chronicle order) and list at the bottom the belonging reference value based on the average of two calibrations by the reference laboratory.

The laboratories will get their identity code by separate mails.

Together with the estimated uncertainty U_{ref}, the values are used for calculating each participants E_n-value displayed in the last column.

The load cells were new and not used before. The amplifier was from Force in Denmark.

100 N load cell with supplied amplifier.

Table 1 tension 10 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-0,19999	0,0001	0,25
3	-0,20054	0,00006	4,56
6	-0,199988	0,000074	0,31
	Ref	**U**	
	-0,200025	0,000096	

Table 2 tension 20 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-0,40001	0,0002	0,41
3	-0,40046	0,00012	2,14
6	-0,399999	0,000092	0,72
	Ref	**U**	
	-0,400105	0,000115	

Table 3 tension 30 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-0,60003	0,0003	0,40
3	-0,60045	0,00018	1,22
6	-0,60003	0,00014	0,66
	Ref	**U**	
	-0,600165	0,000150	

Table 4 tension 40 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-0,80005	0,0004	0,45
3	-0,80036	0,00024	0,39
6	-0,80007	0,00018	0,70
	Ref	**U**	
	-0,800245	0,000172	

Table 5 tension 50 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-1,00005	0,0005	0,50
3	-1,00044	0,0030	0,04
6	-1,00011	0,00023	0,69
	Ref	**U**	
	-1,000320	0,000201	

Table 6 tension 60 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-1,20006	0,0006	0,48
3	-1,20031	0,00036	0,14
6	-1,20015	0,00028	0,60
	Ref	**U**	
	-1,200370	0,000232	

Table 7 tension 80 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-1,60004	0,0008	0,50
3	-1,60035	0,00048	0,21
6	-1,60021	0,00037	0,54
	Ref	**U**	
	-1,600470	0,000313	

Table 8 tension 100 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	-1,99994	0,0010	0,55
3	-2,00028	0,0006	0,34
6	-2,00019	0,00046	0,56
	Ref	**U**	
	-2,000525	0,000389	

Table 9 compression 10 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	0,19998	0,0001	0,66
3	0,20004	0,00005	0,26
6	0,200024	0,000050	0,43
	Ref	**U**	
	0,200065	0,000080	

Table 10 compression 20 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	0,40000	0,0002	0,65
3	0,40013	0,00010	0,11
6	0,400068	0,000088	0,58
	Ref	**U**	
	0,400145	0,000100	

Table 11 compression 30 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	0,60003	0,0003	0,53
3	0,60021	0,00015	0,03
6	0,60013	0,00013	0,41
	Ref	**U**	
	0,600205	0,000131	

Table 12 compression 40 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	0,80007	0,0004	0,50
3	0,80030	0,00020	0,04
6	0,80020	0,00018	0,36
	Ref	**U**	
	0,800290	0,000176	

Table 13 compression 50 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	1,00010	0,0005	0,48
3	1,00039	0,00025	0,07
6	1,00027	0,00022	0,30
	Ref	**U**	
	1,000365	0,000233	

Table 14 compression 60 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	1,20013	0,0006	0,53
3	1,20047	0,00030	0,01
6	1,20034	0,00026	0,38
	Ref	**U**	
	1,200475	0,000243	

Table 15 compression 80 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	1,60016	0,0008	0,55
3	1,60063	0,00040	0,02
6	1,60047	0,00035	0,34
	Ref	**U**	
	1,600640	0,000349	

Table 16 compression 100 N

Identification	Reading mv/V	Uncertainty mv/V	En value
2	2,00012	0,0010	0,58
3	2,00072	0,00050	0,05
6	2,00053	0,00044	0,37
	Ref	**U**	
	2,000755	0,000430	

Comments on the calibration certificates

-- not a part of the intercomparison

Some laboratories give classification explaining in relation to ISO 376:2011 and the decision rule including an explanatory diagram.

Some laboratories refer to the specification from the manufacturer even if this was not asked in the intercomparison and decided if the equipment would pass or fail the specification.

Some laboratories are clearly explaining when the reference equipment is calibrated and when the next calibration shall be done

Most of the laboratories refer to EA-4/02 as a base for uncertainty evaluations.

Several laboratories explain clearly the used excitation voltage to be 5 V.

Some laboratories give value on the object in mV/V and uncertainty in N

Some laboratories explain clearly that the result is the mean value of 3 measurements and documents the results in rotation angles 0, 120 and 240.

Used reference weights are explained in some cases

Uncertainty is expressed in fixed values and/or percentage.

Some laboratories document the MRA agreement in their calibration certificates.

All laboratories document temperature during the calibration.

Zero drift and interpolation effects are explained in some cases.

Most of the laboratories gave both reading and uncertainty at zero while others did not indicate anything at the zero point.

All laboratories document the accreditation by their national accreditation body.

Additions and changes to the DRAFT report

Implementation of the values that was wrong from one laboratory was updated.

Some redactional adjustments were made.

Final conclusions

In this inter comparison several of the participants could demonstrate a capacity to calibrate and give relevant values in relationship to their uncertainties.

The summarized result on tension is that only 3 of 16 results have an En value above 1 on tension

The summarized results compression is 0 of 16 results have an En value above 1 on compression.

Acknowledgement

We gratefully thank the member of the advisory board and expert in pressure calibrations Mr Aykurt Altintas Denmark.

We also acknowledge the primary calibrations by RISE Sweden that supported the ILC with reference calibrations.

We acknowledge support for the calculations and checking of the details made by Wilmer Manfredsson and Arvid Manfredsson.

Annex 1 ILC force 2022:3

Published on https://smquality.se/

Annex 2 *D*escription of the intercomparison/ILC

Published on https://smquality.se/

Appendix 1 Reporting forms

ILC- Force 2022:3

Calibration of load-cell 1

Between 0 and 100 N in both directions separately

Code to open the box: **504**

Comparison ID

Documentation protocol for participant

Laboratory:	
Person:	
e-mail:	-
Date:	

No adjustments allowed - no zeroing during the whole calibration procedure

Preferred excitation voltage 5V AC 225 Hz

Only increasing load i calibration

Load cell 1 **TENSION** **use this table with own measurement equipment**

Obligatory calibration points	Applied reference force	Average signal* Xr from signal amplifier **	Stated*** measurement uncertainty of mV-signal
[N]	[N]	[mV/V]	[mV/V]
0			
10			
20			
30			
40			
50			
60			
80			
100			

* Please state for each force level the average from three mounting angles

** Report the difference between the recorded mV-signal and the actual zero-value at start of each series.

*** Only for tension application

Load cell 1

COM-PRESS-ION

when using own measurement equipment

Obligatory calibration points	Applied reference force	Average signal* Xr from signal amplifier **	Stated*** measurement uncertainty of mV-signal
[N]	[N]	[mV/V]	[mV/V]
0			
-10			
-20			
-30			
-40			
-50			
-60			
-80			
-100			

***Only applied to compression

Load cell 1

TENS-ION

use this table with supplied amplifier

Obligatory calibration points	Applied reference force	Average signal* Xr from signal amplifier **	Stated*** measurement uncertainty of mV-signal
[N]	[N]	[mV/V]	[mV/V]
0			
10			
20			
30			
40			
50			
60			
80			
100			

Load cell 1

COM-PRESS-ION

use this table with supplied amplifier

Obligatory calibration points	Applied reference force	Average signal* Xr from signal amplifier **	Stated*** measurement uncertainty of mV-signal
[N]	[N]	[mV/V]	[mV/V]
0			
-10			
-20			
-30			
-40			
-50			
-60			
-80			
-100			

References:

- ISO/IEC 17043:2022 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:2022 Evaluation of Uncertainty of Measurement in Calibration
- International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)
- ISO 376:2011