Swedish Metrology and Quality AB

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC) of the calibration in the force area

(Concerning the calibration of a tensile testing machine)

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Calculations

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Content

Abstract

This report presents the outcome of an inter-comparison in calibrating a tensile testing machine. The calibration covered the tension and compression up to 2,2 kN in 8 measurement points and an optical extensometer from 0,5 to 50 mm in 10 points. A total overview is presented in the diagram 1, 6 and 11. The comparison focus on the stated indication errors found by the participants with respect to their own reference load cells and their reported uncertainties.

For 4 measurement points in both tension and compression and for 5 points in the extensometer measurement a quantitative evaluation based on the En-value was performed. As no expert laboratory data was available consensus values were used as reference for the comparison. For each measurement point these reference values were determined as the mean from the participants reported error. The belonging uncertainties were based on the respective standard deviation between the results.

These comparison results are presented in all together 13 tables and diagrams. Not all eight participants managed to perform all the stipulated 13 calibration points. Most of the total of 80 En-values were quite low but 17 exceeded the value of $|1|$.

Purpose and implementation of the comparison

This interlaboratory comparison serves as a tool to verify results from the calibrations 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.

Advisory group

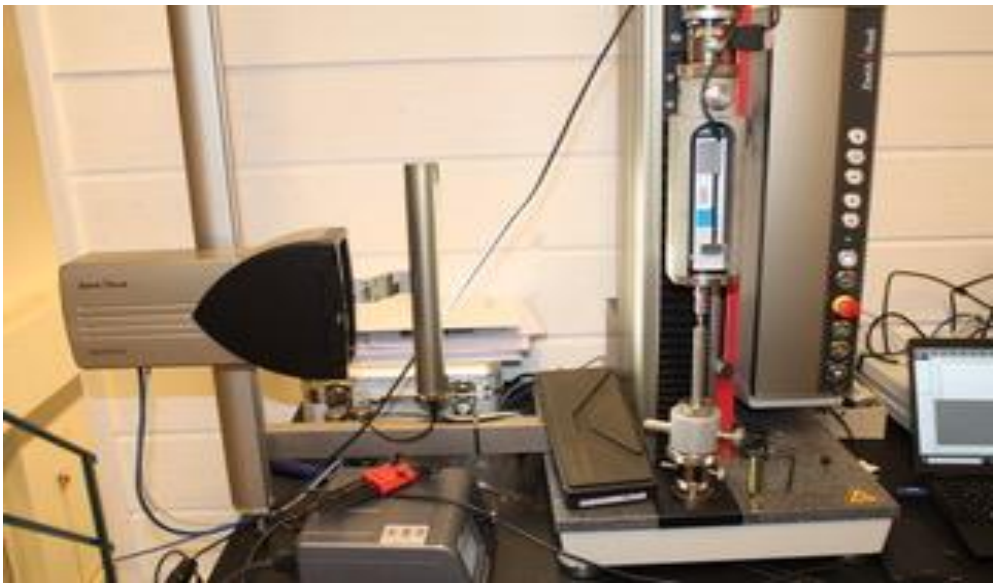
A part of the work as an accredited organiser of proficiency testing schemes (PT/ILC) is to establish professional reference groups related to the actual subject.

The advisory group in this case consists of Aykurt Altintas, Force Technology Denmark, Peter Lau MNE Konsult and Håkan Källgren Swedish Metrology and Quality.

The intercomparison has followed the recommendations of the advisory group. The advisory group has defined the choice of measuring points that are defined to be included in the evaluation of the results.

Information about the testing machine that was calibrated

Machine type Z2,5 manufactured by Zwick GmbH, Germany



Extensometer **Force**

Participants in the intercomparison and time schedule.

Date	Lab	Force	Extensometer
Week 21			
2022-05-23	ZRS, Sweden	X	X
2022-05-24	Sandvik Materials Technology, Sweden	X	X
2022-05-25	KmK Instrument AB, Sweden	X	
Week 22			
2022-05-30			
2022-05-31	Kvalitest Industrial AB, Finland	X	X
2022-06-01			
2022-06-02	RISE Research Institutes of Sweden	X	X
2022-06-03	MTS, Sweden	X	
Week 23			
2022-06-07	Labroc OY, Finland	X	
2022-06-08			
2022-06-09	Testing Calibration Services Ltd, UK	X	

This intercomparison was initiated by the company ZRs testing systems having a site in Billdal close to Gothenburg, Sweden. There the calibration object was installed and available for calibration for all travelling participants during one working day. Several calibrating laboratories sent 2 technicians to do the calibrations.

The leader of SMQ Håkan Källgren was present all the time to handle practical issues. The company ZRs further supplied some support in running the machine in the background if the calibration companies would need so. But they were not allowed to look at or to support the calibrations itself in any way.

Calibration instructions

The basic instructions to participate in the intercomparison is found here: ILC in force, torque, hardness, and related areas – SMQ Conference (smquality.se)

The laboratories could use one day for calibrations. They were advised to use their own calibration procedures with focus on agreed calibration points described below which were important for the inter-comparison outcome.

They should use their own mechanical equipment and the software they normally use.

Agreed calibration points

The participants performed the calibration according to their procedure but only the following points were evaluated as a part of this project.

Force tension, N	Force compression, N	Extensometer length, mm
50	50	0,5
100	100	1
250	250	2
500	500	3
1000	1000	4
1500	1500	5
2000	2000	10
2200	2200	20
		30
		40
		50

Note: The 2 extra calibration points (50N and 0,5mm) are not included in the relevant ISO Standards, but they were requested by the participants.

Planning and instruction details

The organiser was around full time during the calibration and the owner of the machine was available to assist if there were questions about the functionality of the machine.

For protocolling the participants got excel sheets (enclosed in Annex) to fill in and deliver to the organizer before leaving the site.

The participants were asked to send calibration certificates to the organiser within one week after finishing the calibration.

The evaluator uses the principles of the ISO/IEC 17043:2010 in the reporting.

Administrative information

Address to send the required documents:
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Analysis of the calibration results

The calibration information compared is the indication error for the instruments force and length measurement capability found by the participating laboratories. A total overview for the deviations in force (tension and compression) and length measurement from the corresponding nominal values is given graphically for all listed measurement points. Half of these points are then also compared to suitable inter-comparison reference values to derive a quantitative measure, in form of an En-value. This value expresses the closeness of a participants calibration result to the assigned reference value for the compared quantity in question also taking into consideration the specified measurement uncertainties in each point.

Thus, each individual measurement result is reviewed using the E_n – criteria. For each measurement point it is the distance of respective laboratory result x_i to the corresponding reference value x_{ref} normalised with respect to the uncertainty in determining this difference.

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

x_i: Single measurement result (error of indication); the index i counts the various participants.

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

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

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

The indication error is the difference between the individually recorded instrument readings in force or length and the used references available to the participants for their calibration. A calibration result is generally accepted if its En-value is between -1 and +1.

Assigned inter-comparison reference value

In the actual comparison no assigned reference value existed prior to the comparison measurements for instance performed by a calibration of an expert laboratory. The reference value x_{ref} therefore is derived as a consensus value from the reported results x_i of the participants (i=1 to n=8), i.e. the reported indication errors. Without a separately derived reference value there is also no in advance given uncertainty U_{ref} for each reference point.

Concerning the presented force data, the uncertainty values stated by the participants do not differ much. The results therefor can be regarded as equivalent. The fairest consensus value in this case is the arithmetic mean for each set of reported indication errors giving all results the same weight. In the case of the length measurement that only four participants took part in the uncertainty estimates differed considerably. In such a situation the weighted mean giving results with low uncertainty a larger and those with large uncertainty less weight would be the choice to determine the consensus value. In the length comparison, however, one participant's results were totally deviating whereas the rest lay close together, which again made the arithmetic mean value the preferred consensus value.

Outlier issues

A prerequisite for using the mean or the weighted mean as most suitable consensus value is that all results are comparable in the sense that they belong to the same normal distribution, which means that no result "pulls" the mean strongly to its own side. For this reason, doubted results are checked on being an outlier, i.e., from a statistically point of view does not belong to the rest of the other results. In the force comparison two results were abandoned from taking part in the consensus value as the Grubbs outlier test clearly pointed out them as such. In two other situations the statistical significance for being an outlier was on the borderline, but those results were accepted for the consensus value. In the length comparison due to the outlier problem all results from one participant were discarded from the determination of the consensus value.

Uncertainty of the mean as assigned consensus value

If all individual results forming the mean value are regarded equally good, which can be assumed in this comparison, the uncertainty of the mean as reference is based on the spread between the participants. This spread is calculated using the standard deviation s. The standard deviation of the mean s_m then is given by dividing s by the root of the total number n of results

$$s_m = \frac{s}{\sqrt{n}} = \frac{\sqrt{\frac{\sum_{i=1}^{n}(x_i - x_{ref})^2}{n-1}}}{\sqrt{n}}$$

As this applies to a standard uncertainty level it must be enlarged using an expansion factor for transformation to a 95 % confidence level. The appropriate factor *t* is taken from the Student t-distribution for the correct degree of freedom ν = n-1in the data set.

Uncertainty calculation formula: $U = s_m \cdot t_{n-1}^{2\sigma}$

The number n in building the mean varies between the series because of outliers. The following table specifies the used t-factors

Number n of results building the mean	Degree of freedom ν	Students t-factor
8	7	2,43
7	6	2,52
6	5	2,65
3	2	4,53

These t-factors are taken from table G.2 in the GUM. They transform the standard uncertainty to a 95 % confidence level.

Traceability of reference values

The traceability of the reported values was demonstrated by the participants via documenting their reference equipment in their calibration certificates. The laboratories equipment was calibrated by accredited laboratories or National Metrology Institutes.

Comments on the set up of equipment

The laboratories used different types of mechanical attachment of their references
The number of load cells used to cover the force range varied from 1 to 3.
The laboratories documented the use of different load cells in the certificate differently. Some indicated 2 values where e.g., 2 load cells overlapped each other.

The documentation in the diagram uses the value from the small load cell used in the calibration when the laboratory is indicating 2 values for the same load. The reason for this is that smaller load cells are normally giving better uncertainty expressed in percentage.

Most of the laboratories used a warming up procedure by loading the load cell 3 times to maximum load. Some of the laboratories rotated the mechanical attachment 120 degree for each loading and some of them did not rotate.
The laboratories used very different software a purchased standard software or developed excel sheets. They were in principle divided in documenting of raw data, calculation of difference and uncertainty and establishing of calibration certificate. In some cases, were all these steps integrated in one software.

Drift of the instrument during the time of the exercise

The possible drift of the instrument was checked by letting the same person with the same equipment repeat the force measurement in the middle and at the end of the comparison. The observed “drift” was at average a factor of 1/8 of the stated measurement uncertainty in tension. Concerning compression, the factor was between 1/3 and 1/6 except for the lowest compression level where the “change” between the first and the last measurement was twice the claimed uncertainty. The “drift” between the start and the middle of the experiment on the other hand was of the same size as the measurement uncertainty at the lowest level which indicates that in compression this low level is experimentally hard to calibrate accurately.

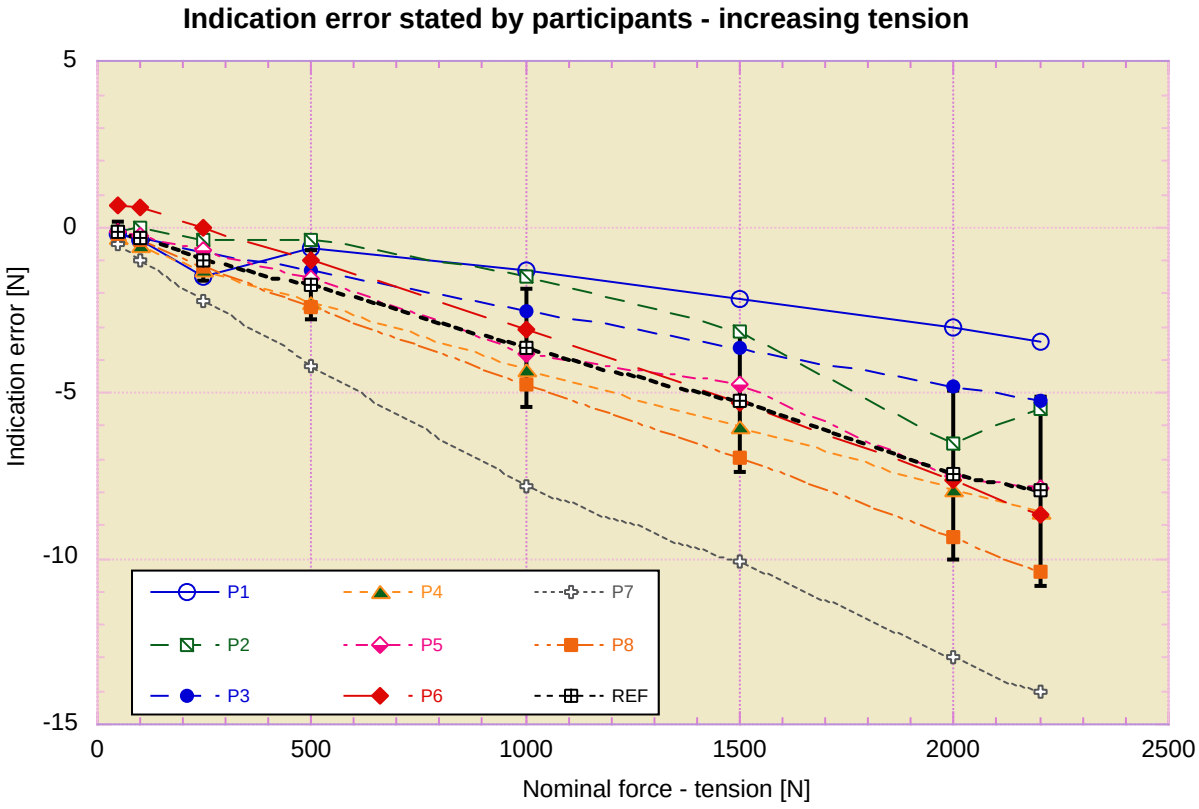
Does this possible drift influence the outcome of the comparison? The answer is no. If there is a drift this also applies to the reference value as it is represented by mean. If one would correct all data for an assumed linear drift with time, which is hard to accept under the above conditions, it would lead to a lower/higher mean value than the original one. Further the spread and the uncertainty in this mean would be lower and thus would its uncertainty. Both would influence the participant’s En-values. If there is no really stated linear drift, as in this case, the mean over the original data works as a fair consensus value.

Force calibration tensile and compression related to ISO 7500-1:2018

Tension

An overview of all participant results is given in diagram 1. It shows the reported indication errors in Newtons at all eight levels at increasing tension and the calculated mean value with the corresponding uncertainty bars. To give a numerical qualification of the participants results for half of the force levels an En-value was calculated directly showing the distance to the assigned inter-comparison reference value.

Diagram 1 errors in tension



Reported indication error as a function of increasing tension with the mean as reference

All results (8 participants and the reference values at one glance. The symbol REF stands for the (assigned) mean value over all results with belonging uncertainty staples based on the spread between results.

The following 4 tables and 4 diagrams represent the found display error of the build-in force measurement equipment. The left column specifies the anonymous identity of the eight participants in the inter-comparison. They are listed in random number, not in time order.

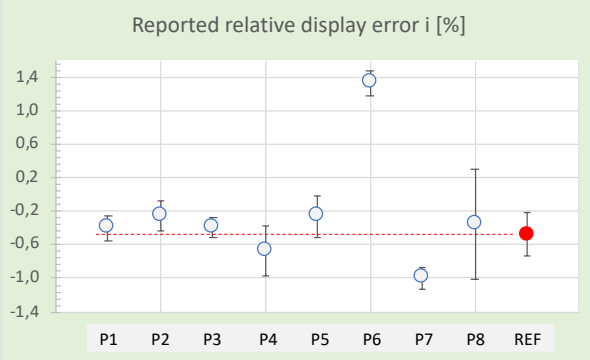
The second column indicates the value [N] which was read off the participants own load cell (reference) and the third column shows the value which was displayed [N] on the screen of the drag force machine (calibration object). The indication error is simply the difference object - minus reference value. However, most of the participants are used to present the relative error i.e. the difference in percent to the applied force as shown in column 4. The estimated uncertainty is predominantly specified

in relative units as well. The last column finally contains the calculated En-values. The diagrams display the reported error (column 4) for each participant along with its stated uncertainty bars from column 5. The last "participant" REF refers to the last line in the corresponding table and represents the reference value and its belonging uncertainty. The En-calculation for each force level is always related to this reference value indicated by the red symbol and a doted red line. The closer to this line the lower the participants En-value and vice versa.

Table 1. Reported error at 50 N – tension force. Diagram 2.

Results column 4 with uncertainty in comparison with the reference value.

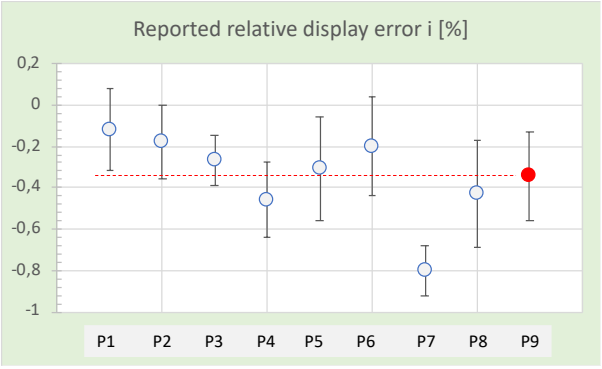
Partici-pant	Reference pressure [N]	Displayed value [N]	Reported error [%]	Specified uncertainty [%]	En-value
P1	*50,20*	*50,00*	*-0,40*	*0,15*	***0,28***
P2	48,72	48,60	-0,26	0,18	**0,71**
P3	50,20	50,00	-0,40	0,12	**0,29**
P4	50,33	50,00	-0,67	0,30	**-0,47**
P5	50,13	50,00	-0,26	0,25	**0,62**
P6	49,36	50,01	1,33	0,15	**6,12**
P7	50,50	50,00	-1,00	0,12	**-1,83**
P8	50,00	49,83	-0,35	0,66	**0,19**
REF			-0,48	0,26	



Comments: Participant P1 (italic style) did not provide a result for the three lowest force levels in his certificate. The data taken from the excel-protocol, however, are in total agreement. The result of P6 was the only one with positive sign. Clearly classified as an outlier (Grubb's outlier test) it was excluded in the building of the mean value forming the comparison reference value. Including it would drag the mean in positive direction lowering its own and increasing all others En-value. Moreover, it would increase the uncertainty of the mean to be quite a bit larger than the uncertainty stated by most of the participants, thus lowering all En-values correspondingly.

Table 2. Reported error at 500 N tension force. Diagram 3.

Partici-pant	Reference pressure [N]	Displayed value [N]	Reported error [%]	Specified uncertainty [%]	En-value
P1	500,62	500,00	-0,12	0,20	**0,80**
P2	496,95	496,58	-0,18	0,18	**0,62**
P3	501,33	500,00	-0,27	0,12	**0,34**
P4	502,28	499,99	-0,46	0,18	**-0,39**
P5	501,55	500,00	-0,31	0,25	**0,13**
P6	500,73	499,73	-0,20	0,24	**0,47**
P7	504,20	500,00	-0,80	0,12	**-1,84**
P8	500,00	497,60	-0,43	0,26	**-0,23**
REF			-0,35	0,21	



Comment: The P7 result is at the edge being an outlier but was not discarded from building the reference value.

Table 3. Reported error at 1500 N – tension force. Diagram 4.

All result accepted for the mean.

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[N]	[N]	[%]	[%]	
P1	1502,15	1500,00	-0,14	0,10	**1,26**
P2	1497,95	1494,81	-0,21	0,18	**0,65**
P3	1503,63	1500,00	-0,24	0,12	**0,64**
P4	1505,77	1499,76	-0,40	0,18	**-0,17**
P5	1504,74	1500,00	-0,32	0,23	**0,16**
P6	1504,80	1499,51	-0,35	0,10	**0,06**
P7	1510,10	1500,00	-0,70	0,17	**-1,53**
P8	1500,00	1493,05	-0,46	0,20	**-0,40**
REF			-0,36	0,14	

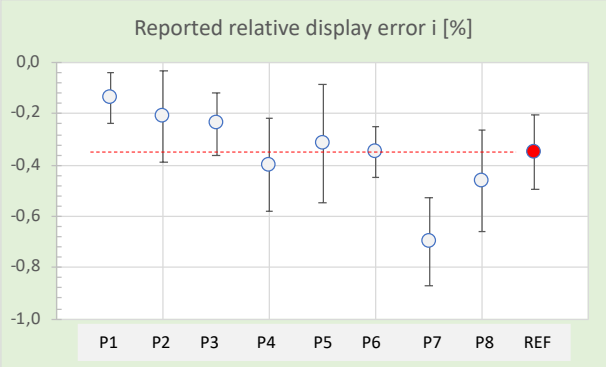
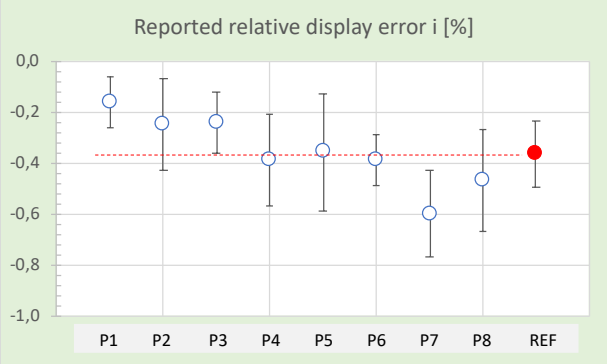


Table 4. Reported error at 2200 N – tension force. Diagram 5.

Error at maximum tension level.

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[N]	[N]	[%]	[%]	
P1	2203,43	2200,00	-0,16	0,10	**1,30**
P2	2200,27	2194,78	-0,25	0,18	**0,56**
P3	2205,27	2200,00	-0,24	0,12	**0,76**
P4	2208,37	2199,77	-0,39	0,18	**-0,07**
P5	2207,87	2200,00	-0,36	0,23	**0,06**
P6	2208,19	2199,51	-0,39	0,10	**-0,10**
P7	2214,00	2200,00	-0,60	0,17	**-1,06**
P8	2200,00	2189,60	-0,47	0,20	**-0,40**
REF			-0,37	0,13	

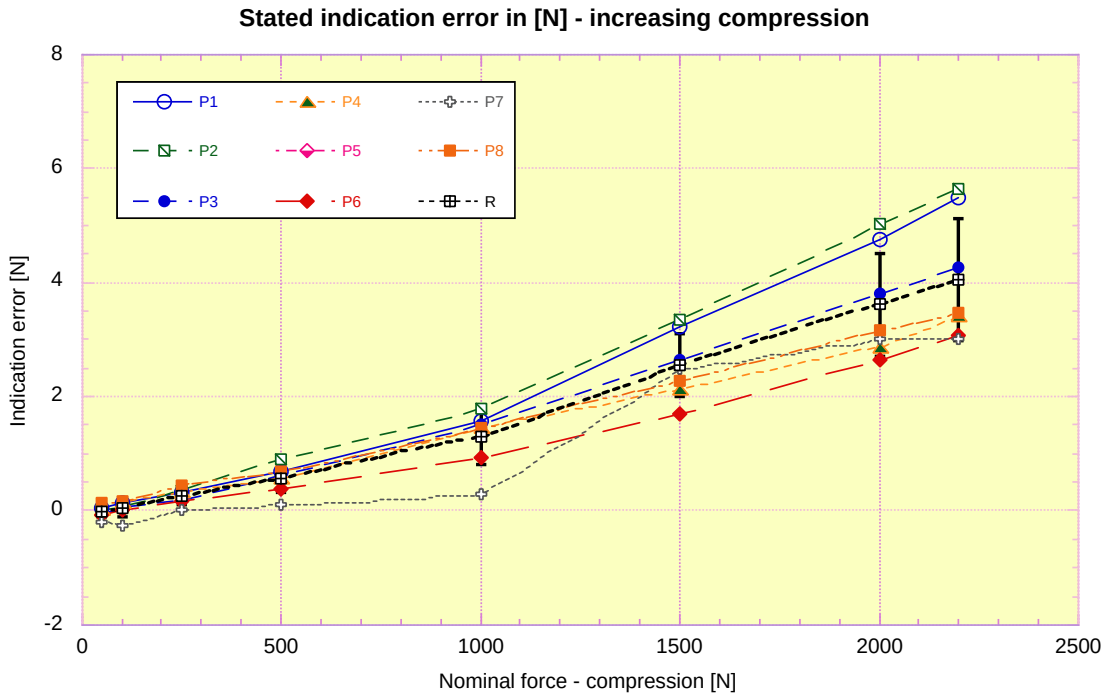


Compression

A complete overview for the found compression error is displayed in diagram 6 showing a much better conformity than in the tension mode.

As many loadcells can work in both tension and compression mode these are sometimes distinguished by giving compression values a -sign. Three of seven participants followed this convention. However, if for compression values different signs are used an error with a positive sign found in positive object and reference readings turns to an error with negative sign if those readings are protocolled with a negative sign. For a customer both a negative or positive error should not be a problem given they know the convention used. As the majority protocolled compression forces with positive sign this convention is followed in this comparison by changing the -signs in error declaration to a +sign for the minority that followed the other convention.

Diagram 6 Errors in compression



Indication error from 7 participants in compression mode – all readings are based on positive force values in reporting.

All compression results (7 participants – none from P5). The symbol R represents the mean value over all results. The belonging uncertainty staples are again based on the spread between results.

At 4 positions (0,5; 500; 1500 and 2200 N) again at a numerical analysis is presented in the following tables 5 to 8.

Table 5. Reported error at 50 N – compression force

Large variation between results at low compression level

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[N]	[N]	[%]	[%]	
P1	49,96	50,00	0,08	0,10	**-0,01**
P2	50,14	50,16	0,04	0,18	**-0,15**
P3	50,04	50,00	-0,08	0,29	**-0,47**
P4	50,00	50,00	0,01	0,34	**-0,19**
P5					
P6	-50,76	-50,85	-0,150	0,10	**-1,11**
P7	-49,79	-50,00	0,400	0,12	**1,45**
P8	-50,00	-49,86	0,270	0,25	**0,61**
REF			**0,082**	**0,18**	

Diagram 7.

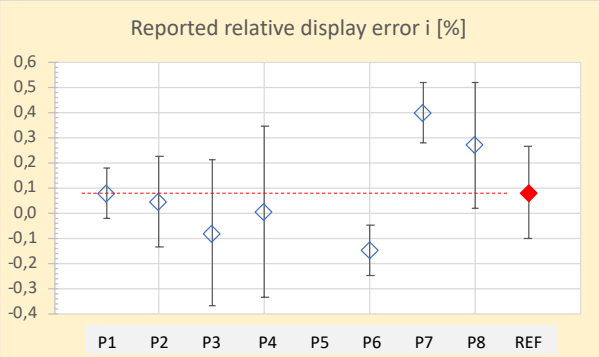


Table 6. Reported error at 500 N – compression force Diagram 8.

Very good agreement in reported error

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[N]	[N]	[%]	[%]	
P1	499,30	500,00	0,14	0,10	**0,24**
P2	495,24	496,14	0,18	0,18	**0,37**
P3	499,38	500,00	0,12	0,15	**0,05**
P4	499,42	500,00	0,12	0,18	**0,02**
P5					
P6	-501,77	-501,40	0,10	0,24	**-0,05**
P7	-500,10	-500,00	0,00	0,12	**-0,86**
P8	-500,00	-499,31	0,13	0,20	**0,08**
REF			**0,11**	**0,05**	

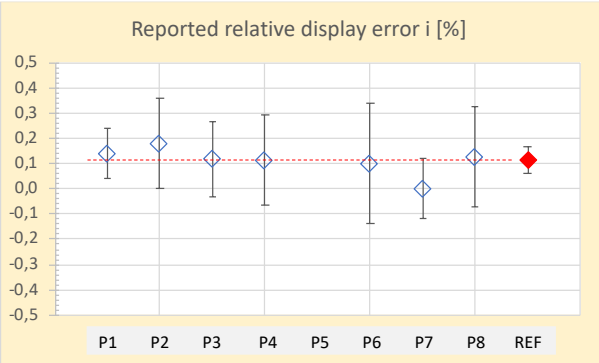


Table 7. Reported error at 1500 N – compression force. Diagram 9.

One deviating result excluded

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[N]	[N]	[%]	[%]	
P1	1496,77	1500,00	0,22	0,10	**0,44**
P2	1494,24	1497,60	0,22	0,18	**0,28**
P3	1497,37	1500,00	0,18	0,13	**0,06**
P4	1497,73	1499,87	0,14	0,18	**-0,15**
P5					
P6	-1500,70	-1499,01	0,11	0,10	**-0,55**
P7	-1502,50	-1500,00	-0,20	0,18	**-1,99**
P8	-1500,00	-1497,72	0,15	0,20	**-0,10**
REF			**0,17**	**0,05**	

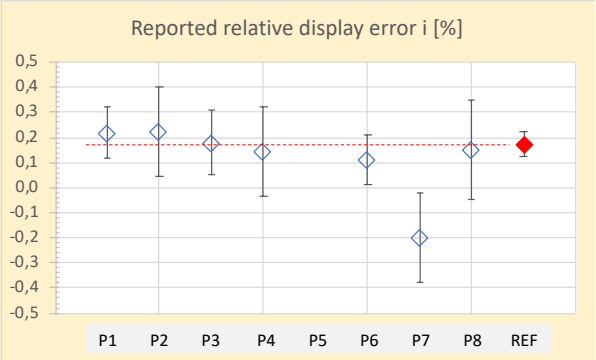


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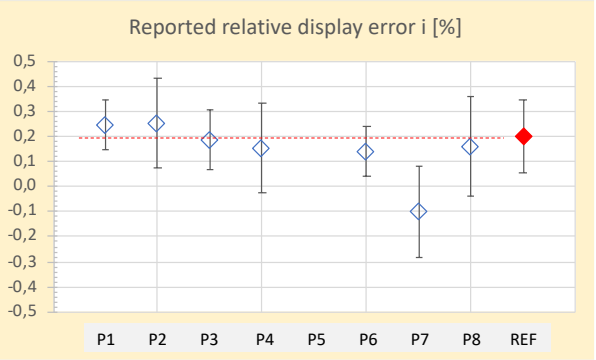
Table 8. Reported error at 2200 N – compression force. Diagram 10.

All results accepted for the mean

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[N]	[N]	[%]	[%]	
P1	2194,50	2200,00	0,25	0,10	**0,27**
P2	2192,20	2197,84	0,26	0,18	**0,23**
P3	2195,73	2200,00	0,19	0,12	**-0,07**
P4	2196,62	2200,03	0,16	0,18	**-0,20**
P5					
P6	-2202,56	-2199,50	0,14	0,10	**-0,36**
P7	-2203,00	-2200,00	-0,10	0,18	**-1,31**
P8	-2200,00	-2196,54	0,16	0,20	**-0,17**
REF			**0,20**	**0,14**	

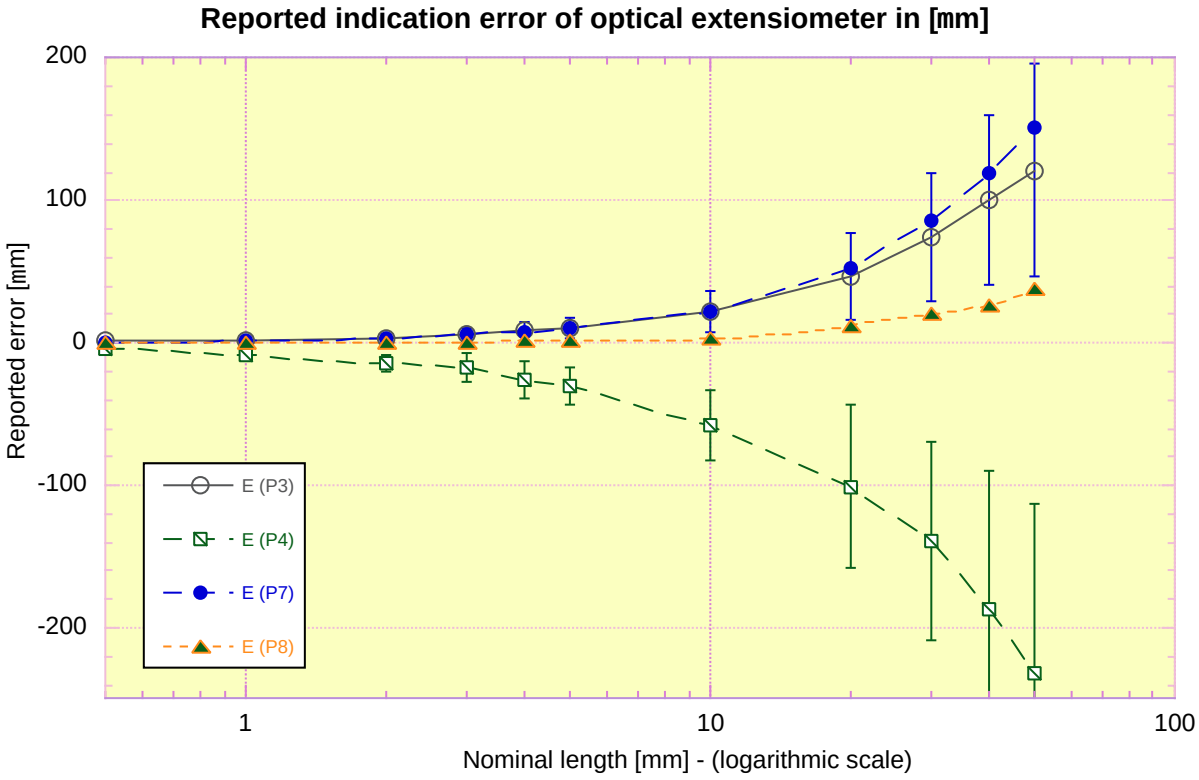


Comments: One participant P5 could not deliver a compression result. The values in the tables are all rounded to two decimals. As comparison-reference value again the mean value is chosen. However, as the minimum result P7 in table 7 is a clear outlier it was discarded from building the mean value. The minimum in table 8 is a borderline case but contributes to the reference value. These two different decisions determine the size of the uncertainty in the mean as can be seen comparing diagram 9 and 10.

Extensometer calibration Related to EN ISO 9513:2012

Four out of eight participants did not take part in the calibration of the optical extensometer. Probably they were not familiar with its function. The calibration comparison was performed at 11 measurement points. Diagram 11 presents all results at one glance. In their calibration certificate all participants specified 2 separate measurement series. The tables 9 to 13 present the average of these two, which also was given in their excel-protocol.

Diagram 11 Errors related to the extensometer



Error of the optical extensometer found by four participants with increasing length. For better discrimination at low distances a logarithmic scale was used.

For a numerical evaluation comparable to the force comparison 5 points (0,5; 2; 5; 20 and 50 mm) were selected. As can be seen one participant P4 reports the indication error with an opposite sign over the whole measurement range.

For the assigned reference comparison value again, the arithmetic mean was chosen. As four participants presented very differing uncertainties a weighted mean was taken into consideration for determining the reference value. With few participants this, however, would favour a result with very low uncertainty in an unjust way, although it would in the actual situation not change the outcome significantly.

But as one of the error curves showed a negative sign only the three with a positive sign were used for determining the mean REF. In all five measurement points P4 is considered a clear outlier and the mean is only based on the three other (positive error) results.

The tables 9 to 13 and diagrams 12 to 16 show the comparison results at those points of the length scale. The last line in the table corresponds to the red symbol in the diagram and the dashed line.

Table 9. Reported error at 0,5 mm.

Reference based on 3 results.

Partici-pant	Reference length [mm]	Displayed value [mm]	Reported error [µm]	Specified uncertainty [µm]	En-value
P1					
P2					
P3	0,50770	0,50880	1,10	0,8	**0,34**
P4	0,50360	0,50000	-3,6	2,5	**-1,51**
P5					
P6					
P7	0,5000	0,5006	0,5	0,4	**-0,06**
P8	0,50000	0,49979	0,2	1,6	**-0,21**
REF			0,6	1,17	

Diagram 12.

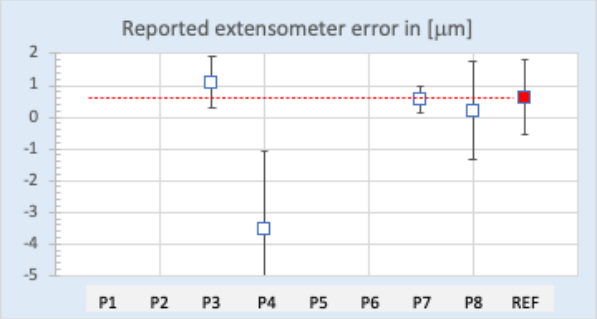


Table 10. Reported error at 2 mm

Two uncertainties too small to discriminate.

Partici-pant	Reference pressure [mm]	Displayed value [mm]	Reported error [µm]	Specified uncertainty [µm]	En-value
P1					
P2					
P3	2,0253	2,0281	2,9	3,0	**0,07**
P4	2,01	2,00	-13,9	5,4	**-2,52**
P5					
P6					
P7	2,00	2,00	3,7	0,4	**0,33**
P8	2,00	2,00	1,0	6,2	**-0,21**
REF			2,5	3,7	

Diagram 13.

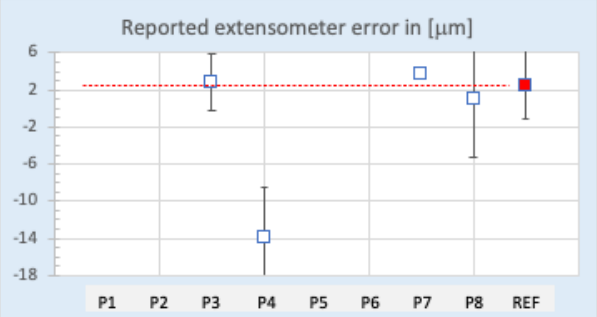


Table 11. Reported error at 5 mm

Partici-pant	Reference pressure [mm]	Displayed value [mm]	Reported error [µm]	Specified uncertainty [µm]	En-value
P1					
P2					
P3	5,0063	5,0165	10,2	7,5	**0,18**
P4	5,0300	5,0000	-30,0	13,0	**-1,94**
P5					
P6					
P7	5,0000	5,0106	10,6	0,5	**0,24**
P8	5,0000	5,0011	1,1	15,5	**-0,30**
REF			7,3	14,1	

Diagram 14.

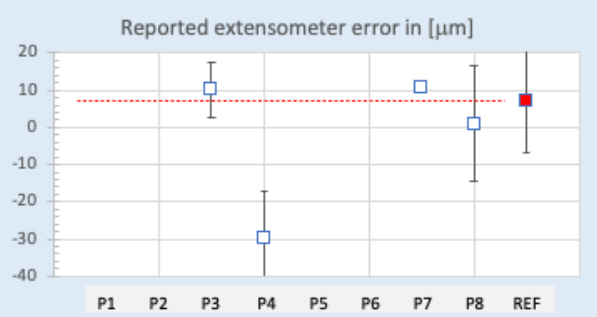


Table 12. Reported error at 20 mm

Partici-pant	Reference pressure [mm]	Displayed value [mm]	Reported error [µm]	Specified uncertainty [µm]	En-value
P1					
P2					
P3	19,9632	20,0101	47	30	**0,15**
P4	20,1006	20,0000	-101	57	**-1,70**
P5					
P6					
P7	20,0000	20,0520	52	1	**0,26**
P8	20,0000	20,0118	12	62	**-0,30**
REF			37	57	

Diagram 15.

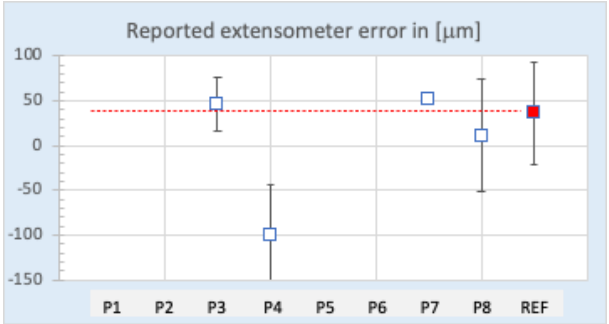
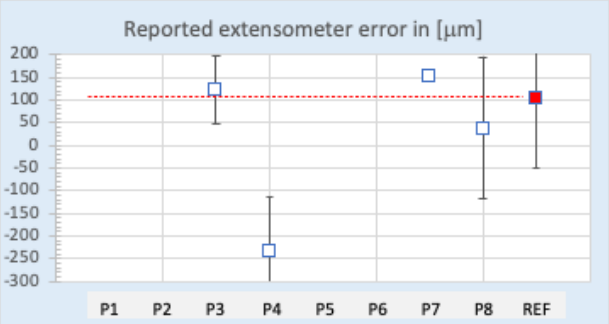


Table 13. Reported error at 50 mm

Partici-pant	Reference pressure	Displayed value	Reported error	Specified uncertainty	En-value
	[mm]	[mm]	[µm]	[µm]	
P1					
P2					
P3	49,9383	50,0596	121	75	**0,10**
P4	50,23	50,00	-232	120	**-1,72**
P5					
P6					
P7	50,00	50,15	152	2	**0,31**
P8	50,00	50,04	38	155	**-0,30**
REF			104	154	

Diagram 16.



Comments:
Diagrams 9 to 13 reveal almost the same relations concerning the relative positioning despite the increasing indication error at larger distances. The stated uncertainties are partly too small to be exposed in the diagram. The large difference in the uncertainty is also remarkable, which probably means that some of them are not justified. The En-values of participant P4 are large because of the systematic negative sign of the error.

Corrections/changes after participant comments to the draft report

An important part in organizing a comparison is the response from all participants to the presented draft report. Their findings and comments help to reveal misunderstandings or mistakes that can occur in the evaluation and documentation.

The first finding concerns table 10 (diagram 13) where the uncertainty of participant P8 falsely was presented as 0,2 mm. The correct value found in the preliminary excel protocol and the final calibration certificate was 6,2 mm. Table 10 and diagram 13 have been exchanged.

Secondly an evaluation error was found in table 13. It was not detected by the participants and does not influence diagram 16. The En-values were calculated using wrong reference values not the ones stated in table 13. As result of correcting this mistake three of four En-values decrease considerably. Table 13 is updated.

In his response to the draft report participant P4 discovered a handling error concerning the correction of his own reference length scale. The data in the updated calibration certificate show that without this mistake all participants were in much better conformity than displayed in diagram 11 were P4 had negative indication errors. This finding, however, cannot be taken into consideration after publishing the draft report. Had it been reported before publishing both the comparison reference values and their uncertainties and thus all En-values would be shifted somewhat. Anyhow, with the reference values preserved as stated in tables 9 to 13 the En-values of participant P4 would change according to the table below and even become lower if the new data were incorporated in the comparison reference values, which they are not as declared earlier.

Distance [µm]	En-values stated	En-values with updated data
0,5	-1,51	0,48
2	-2,52	0,88
5	-1,94	0,95
20	-1,70	1,03
50	-1,72	1,11

Certificates

-- not a part of the intercomparison

The calibration certificates were designed in many ways. Is it possible for a user of the equipment to correct for the readings? Maybe the classification of the machine is good enough for the user?

Some laboratories documented 3 calibration tests and the mean value in the force calibrations

The error and uncertainty are normally given in % as the ISO 7500-1:2018 describes but some laboratories give the absolute value as well

That is done in the same way for the uncertainty as % and absolute values as well.

Several laboratories classify the machine according to ISO 7500-1:2018 but different decisions are given from class 0,5 to class 2 by different laboratories.

Some laboratories indicated the force from the calibrated machine by a minus or plus sign and others not. This will probably confuse the user of the machine when the purpose is not mentioned. For a customer both a negative and positive error should not be a problem if they know the convention used.

One laboratory is indicating the decision rules in a sketch and relate the decisions to the ISO standard and the ASTM standard in the classification.

Extensometer is documented in one case the mean of 3 measurements and others give 2 results without a calculated mean (as described in ISO 9513:2012).

Final conclusions

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

As a result of this intercomparison the following can be pointed out:

In tension 6 out of 32 results resulted in $|En| > 1$

In compression 4 out of 28 results gave $|En| > 1$

Concerning the extensometer comparison 6 out of 20 results reached $|En| > 1$

The participants shall evaluate their results according to the requirement in EN ISO 17025:2017 point 7.7.3

Acknowledgement

ZRs Sweden made this intercomparison possible as one of their machines could be used as the machine in the intercomparison.

We gratefully thank the member of the advisory board and expert in pressure calibrations Aykurt Altintas, Force Denmark as well as the main evaluator of the results Peter Lau

Annex

ILC force 2022:1 Calibration of force and extension on a static material testing machine

Type BZ2.5/TN1S VideoXtens

Reporting form for preliminary calibration results

Laboratory:	
Name:	
e-mail:	
Reporting date:	

Comparison ID **PX**

Date of calibration

Evaluation part

This right part is hidden and for evaluation and comments
The data only concern the stated indication error and its uncertainty
The green part represents data from the calibration certificate
The yello part is chosen after comparing original and certificate data
Liked to evaluation taples

Force calibration - increasing tension

Compulsory calibration points	Reference gauge value	Indicated measurement value	Absolute display deviation	Relative display deviation	Stated measurement uncertainty		To comparison evaluatiom: Determind error for comparison	To comparison evaluatiom: Determined uncertainty	From certificate: Stated error	From certificate: Expanded uncertainty
[N]	[N]	[N]	[N]	[%]	[N]	[%]	[N] or [%]	[N] or [%]	%	%
50										
100										
250										
500										
1000										
1500										
2000										
2200										

Please do not perform any adjustments and state average values

Please state no of repetitions

Comments or additional information:

Force calibration - increasing compression

Compulsory calibration points	Reference gauge value	Indicated measurement value	Absolute display deviation	Relative display deviation	Stated measurement uncertainty		To comparison evaluatiom: Determind error for comparison	To comparison evaluatiom: Determined uncertainty	From certificate: Stated error	From certificate: Expanded uncertainty
[N]	[N]	[N]	[N]	[%]	[N]	[%]	[N] or [%]	[N] or [%]	%	%
50										
100										
250										
500										
1000										
1500										
2000										
2200										

Please state average values

Comments or additional information:

Length calibration - extensiometer

Compulsory calibration points	Reference gauge value	Indicated measurement value	Absolute display deviation	Relative display deviation	Stated measurement uncertainty		To comparison evaluatiom: Determind error for comparison	To comparison evaluatiom: Determined uncertainty	From certificate: Stated error	From certificate: Expanded uncertainty
[mm]	[mm]	[mm]	[µm]	[%]	[µm]	[%]	[µm]	[%]	[µm]	[µm]
0,5					1,55					
1										
2										
3										
4										
5										
10										
20										
30										
40										
50										

Please state no of repetitions

For evaluation all participants excel protocol files are copied into one common evaluation file. Each participant result makes up a folder with the original data to the left in the above scheme. The right part is hidden and used for the evaluation. The yellow fields are linked to the various evaluation tables

for respective measurement point. Before performing the linkage, all results found in the certificate are filled into the green cells and compared to the white cells in the left part. If a difference occurs between both the green certificate data are copied into the yellow decision table. However, if the data coincide but the excel protocol provides a higher resolution the white cells are copied to the yellow decision table.

The hidden right part works for documentation and also helps to detect calculation or printing errors, both from participants or in evaluation. Through the linking to the evaluation tables any change only needs to be performed in the yellow area and there is much space for comments.

References:

- ISO/IEC 17043:2010 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