SMQ-ILC weighing instruments 2021:1 2021-12-31

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC) on the calibration of industrial weighing instruments below called truck scale and front wheel loader scale

Indicator Max 60 000 kg; d= 20 kg

Load receptor 6*12 meters

Front wheel loader

Max 10 000 kg d= 100 kg

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Calculations

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Content

Purpose and implementation of the comparison

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

The inter-comparison was supported by the company Volvo Construction Equipment AB in Eskilstuna that provided the site and the weighing instruments during the time of the exercise (one week).

The truck scale is specially designed for the purpose of testing front wheel loaders. That fact gave a good possibility to arrange reference values for front wheel loaders.

Participating laboratories:

- Mettler Toledo AB, Sweden
- Flintab AB, Sweden
- TAMTRON
- JV Norway
- Pilot Laboratory—Swedish Metrology and Quality AB, Sweden

One of the participants performed more than one calibration on the balances using different methods. All participants performed a calibration of the truck scale but only two were able to calibrate a front wheel loader at the time available.

During the exercise all together 8 calibrations (including SMQ reference calibration) were performed in 5 working days.

Reverifications were done as well in 4 cases. The reverifications were partly simulated as the truck scale had no product verification approval. A specific report will be issued on questions related to the reverification part.

Some participants have an accreditation by SWEDAC on ISO/IEC on 17025 and ISO/IEC 17020.

The measuring scheme for the comparison

Planned calibration scheme:

Date	Participant truck scale	Participant front wheel loader
2021-09-20	SMQ, Pilot laboratory	Nothing
2021-09-20	1 participant	Nothing
2021-09-21	No laboratory, SMQ functional tests	No laboratory, SMQ functional tests
2021-09-22	1 participant	SMQ reference test and 1 participant
2021-09-23	1participant	SMQ reference test and 1 participant
2021-09-24	1participant	
2021-09-24	SMQ functional tests	Functional tests

Principles on the calibration in general

Prior to each calibration by a participant the pilot laboratory handed over a document for documentation that should be used during the calibration and returned to the organiser before leaving the test site.

Further it was checked that no significant change at some calibrated values had occurred before the next participant could start its calibration.

Weighing conditions during the measurement period

The weighing instruments used in this inter-comparison were a loan from Volvo Construction Equipment AB in Eskilstuna. This arrangement guaranteed that this exercise could be handled efficiently and enable the participants to work independently and undisturbed from each other.

The conditions during the reference calibration of the weighing instruments by the pilot were good. Neither rain nor wind could affect the reference values.

During most of the laboratory calibrations there was no real influence on the calibration environment except for one day. One participant experienced environmental disturbance by about 5 mm of rain during the calibration of the truck scale and the wind was mostly about 2-3 m/sec and sometimes changing in different directions up to 6 m/sec.

As a rough estimation the amount of water collected on the truck scale platform of 72 m^2 with varying height (0,3 and 0,7 mm) would add at least about 21 to 50 kg to the load of weights if the load receptor was dry when starting the calibration and all water stayed on the platform

Calibration instructions

The laboratories were allowed to use approximately 3 hours for each balance calibration. In the call they were advised to use their own calibration procedures with focus on the points described below that were important for the inter-comparison outcome. They were not allowed to perform any type of adjustment on the weighing systems themselves. This task was reserved for the pilot laboratory.

In this way the laboratories were able to apply their uncertainty calculations.

Using their own procedures also meant it was up to the laboratories which measurement points they would select if the following compulsory points were included.

Even the number of repetitions was free to choose. The laboratories further were encouraged to use the estimated uncertainty values even if those would differ from the CMC values in their accreditation scope.

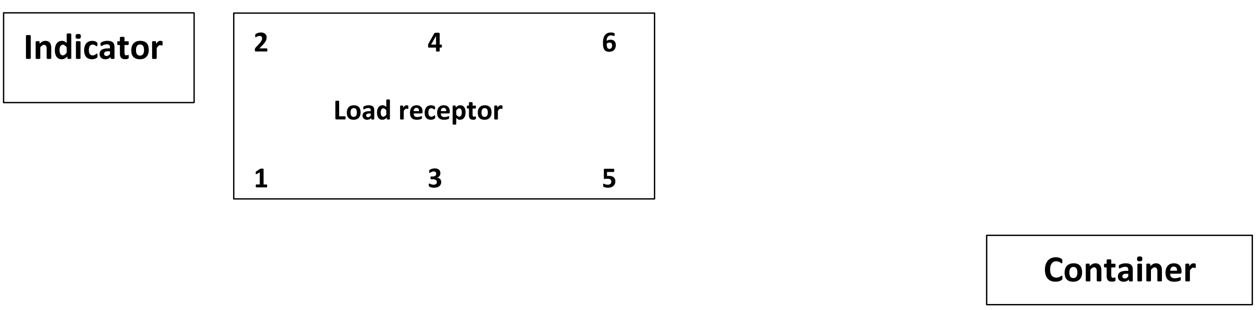
The decreasing load on the truck scale was not included in the concept but was a request from some laboratories and the pilot laboratory then did that as well. The result is reported in a diagram below.

Compulsory measurement points

	Truck scale, in-creasing load	Truck scale, de-creasing load	Front Wheel loader scale
Capacity, Max resolution	Max 60000 kg d= 20 kg	Max 60000 kg d= 20 kg	Max 10 000 kg d=100 kg
Point 1	500 kg	500 kg	500 kg
Point 2	4000 kg	4000 kg	2 500 kg
Point 3	10 000 kg	10 000 kg	3 500kg
Point 4	20 000 kg	20 000 kg	5 000 kg
Point 5	40 000 kg	40 000 kg	10 000 kg
Point 6	58 000 kg	58 000 kg	

Specific eccentricity checks on truck scale.

The test of eccentricity should be done with a load of 12 000 kg according to the sketch below.



Specific points on front wheel loader at 3 500 kg

There were several specific tests done as follows using a constant load of 3500 kg.

Situation	**Comment**
Low driving speed	3-4 km/h
High driving speed	8-10 km/h
Slow lifting speed	700-1100RPM
Fast driving speed	1 200-1600 RPM
Eccentricity test point 1 to 6	See picture above
Tilting front down	About 5 %
Tilting front up	About 5 %
Tilting left side down	About 5 %
Tilting right side down	About 5 %

Planning and instruction details

The laboratories were asked to hand over original calibration data in pre-defined forms either on paper or in digital form by e-mail before leaving the site. The final calibration certificate and reports should then be sent to the organizer within one week, which most of them also managed to deliver. The evaluator used the principles of the ISO/IEC 17043:2010 in the reporting.

The participants should deliver calibration certificates which at least stated the measured values together with a belonging uncertainty for the points stated above. Several of them delivered data on further calibration points according to their procedures.

It was possible to provide additional information or supplementary documentation eventually needed to understand the results.

Administrative information

Site for calibrations	Dates and place:	Address to send the reports:
Volvo Construction Equipment AB Sweden	October 20-24. Bolindervägen 100, 635 10 Eskilstuna	Swedish Metrology and Quality AB Håkan Källgren Dragspelsgatan 21 Contact phone +46705774931 SE-504 72 Borås, Sweden e-mail: hakan.kallgren@smquality.se

Summary of the timeline planning:

- One week after the calibration/measurement send the calibration certificate to the evaluator of the intercomparing report.
- A draft report will be sent to the participants 4 weeks after receiving the last certificate.
- Comments on the draft report within 1 week
- Final report will be finalized within 2 weeks after receiving comments from all participants

Analysis of the calibration results

The main information compared is the “error of indication” (EoI) at all measurement points. This error is simply the difference between the documented balance indication and the calibrated value of the used weights given by the participants.

The quality of each individual measurement result is reviewed using the E_n – criteria. For each measurement point it is the distance of respective laboratory result to the corresponding reference value normalised with respect to the uncertainty in determine this difference.

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

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

x_{ref}: Provided 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.

Inter-comparison reference value

In every comparison the reference value is a crucial fact. ISO 13528 suggest various situations. In this exercise a pilot laboratory SMQ performed a first calibration at all measurement points before the start. This was then repeated partly to check the stability of the reference value especially with a 500 kg and 4000 kg load where there were some unclear results.

There was no possibility to make a complete reference calibration of the truck scale at the end of the intercomparison week because the time did not allow this exercise on the site. However, the comparison with the registered values by the laboratory on the last day indicated a stable behaviour of the truck scale.

Uncertainty of inter-comparison reference value

The uncertainties of the reference values are calculated as described in the chapter Analysis of uncertainty in the pilot values.

The reference value for the truck scale is based on calibrated weights, their calibration uncertainty, known previous drift and instrument specific parameters.

For the calibration and testing of the front wheel loader it was not possible to perform a pilot measurement in this way. Instead, a reference value was generated with the help of the calibrated truck scale. This was accomplished by weighing the front wheel loader twice on the truck scale for every additional weight in the shovel, i.e., empty and after a new weight was added. In this way the real load for each of the five measuring points during calibration was determined and was different for the different participants. The corresponding uncertainty for the weighing difference was calculated from the uncertainties of the belonging loads on the truck scale with respect to the correlation in the respective uncertainty contributions. The found uncertainty for these weighing differences is lower than the resolution of the weighing system in the front wheel loader, which limits its weighing uncertainty in the various tests.

The reference value was then used to calculate the En values according to ISO/IEC 17043:2010, B.4.1.1

An absolute value of $|E_n| \leq 1$ is often used as a criterion for an acceptable measurement quality.

Traceability for the pilot values at each point

The traceability for the pilot laboratory SMQ is established by calibration using hired weights. The calibration of these were done at RISE (the NMI in Sweden).

The reference weights used during calibration by the pilot laboratory are of class M2, but the calibrated value that were used have un uncertainty of the tolerance of M2 divided by 3.

Analysis of uncertainty in the pilot values for the truck scale

The stated expanded uncertainty for the pilot values following Euramet guide 18 version 4.0 are calculated according to:

$$U_{Pilot} = 2 \cdot \sqrt{u_{ref.w}^2 + u_{stab.w}^2 + u_{rep}^2 + u_{zero}^2 + u_{read}^2 + u_{ecc}^2 + u_{rain}^2 + u_{wind}^2}$$

$u_{ref.w}$ = combined uncertainty of the reference weights, from the calibration certificate

$u_{stab.w}$ = uncertainty due to the stability of reference weights – direct sum from earlier known drift

u_{rep} = the standard deviation calculated from 10 repeated measurement at two different loads

u_{zero} = uncertainty with respect to zero setting the balance in question

u_{read} = uncertainty based on the enhanced balance resolution (display) that was 10 times better than the normal resolution.

u_{ecc} = uncertainty due to balance eccentricity

u_{rain} = uncertainty due to rainy weather conditions (added water load on balance platform)

u_{wind} = uncertainty due to windy weather conditions (change in display by gust of wind)

The last two components had very marginal effect as the weather was suitable during the pilot calibration.

Uncertainty of the reference weights

Euramet guide 18 version 4.0 formula 7.1.2-2

Taken from the certificate and divided by the stated k-factor. In this case 2.

Stability of the reference weights

Euramet guide 18 version 4.0 formula 7.1.2-11

The mean drift of the reference weights estimated from different calibrations over time

Euramet guide 18 version 4.0 formula 7.1.1-6

Standard deviation based on ten repeated measurements at two loads

Uncertainty based on the accuracy of zero setting

The zero setting is within the range of ¼ of the reading resolution. The resolution divided by 4 and rectangular distribution is used. Euramet guide 18 version 4.0 formula 7.1.1-2c

Uncertainty based on resolution of the display

Resolution on the balance in each calibration point. Rectangular distribution is used.

Euramet guide 18 version 4.0 formula 7.1.1-3a

Uncertainty based on eccentricity

A proportional figure from possible eccentricity influence divided by square root of 6 EURAMET/cg-18-7.1.1.4

Analysis of uncertainty in the pilot values for the front wheel loaders

The reference value for each load in the front wheel loader is determined by the difference of two weighing results R_A and R_B of the front wheel loader on the truck scale, i.e., before loading (B) and after loading (A).

$$U_{fwl.ref} = \sqrt{U^2_{trsc.A} + U^2_{trsc.B} - 2\sum_{i=1}^{5}\sum_{j=1}^{6} u_i.u_j.r(x_i, x_j) + u_{err}(x_i)}$$

This means the uncertainty in this difference is the combined uncertainty from each of the two weighing uncertainties on the truck scale.

$U_{fwl.ref}$	=	Measurement uncertainty of the reference value = weighing difference
$U_{trsc.B}$	=	Uncertainty of the weight of the empty front wheel loader on truck scale
$U_{trsc.B}$	=	Uncertainty of the weight of the loaded front wheel loader on truck scale
u_i	=	Uncertainty component i from truck scale calibration with empty front wheel loader
u_j	=	Uncertainty component j from truck scale calibration with loaded front wheel loader
$r(x_i,x_j)$	=	estimated correlation coefficients between contributions – only i=j are relevant
$u_{err}(x_i)$	=	difference in uncorrected indication error from truck scale calibration

Several of the ingoing uncertainty components u_i with respect to the truck scale are almost the same (reference weights, their drift, eccentricity of balance), i.e. some are highly correlated (correlation coefficient ≈0,9), which lowers the uncertainty of the difference compared to the direct combination. The size of the correlation effect for a difference of 0,5 t is U = 22,4 → 10,2 kg and for a maximum difference of 10 t, U= 26 → 12,2 kg. But to this uncertainty also the uncorrected error (0,12 to 5,02 kg) of the truck scale found in the calibration needs to be added which leads to uncertainties in the reference values used in the calibration of the front wheel loader from 10,3 to 17,2 kg.

Measuring results on calibration of the weighing instruments

The following tables and diagrams present the error of indication along with the stated measurement uncertainty for each calibration point.

Part 1a Calibrations of truck scale 60 ton increasing load

The calibration was originally announced to be done for the following points 0,5; 4; 10; 20; 40 and 60. The process was started by the pilot, but due to an accident with some 500 kg weights only 58 t could be reached. In the following all participants used this load as well but also calibrated at the maximum of 60 t. Some of the participants, following their standard method, also reported measuring points in between, however, these were not used for the comparison.

For three of the participants downloading from 60 t backwards was a part of their calibration method.

The results of the uploading in the various points are shown in the following tables and diagrams.

Table 1: Reported data from calibration point; 500 kg

including pilot reference R and 5 participant results, and calculated En-values.

Measurement point 0,5 ton			
Partici-pant	Error of indi-cation [kg]	Uncer-tainty [kg]	En-Value
R	-0,018	1,62	
P1	-2	9,3	-0,210
P2	0	40	0,0004
P3	2	1,16	1,013
P4	0	60	0,0003
P5	0	41	0,0004

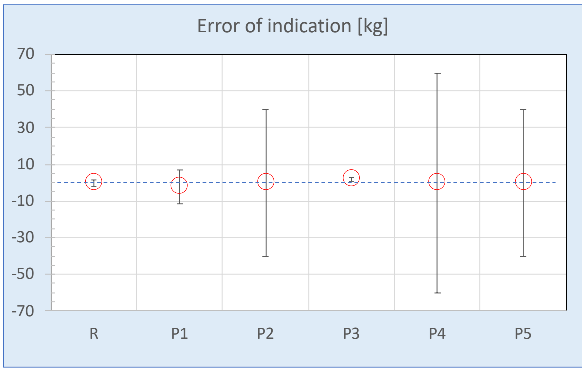


Diagram 1: Reported error of truck scale with uncertainties - dotted line corresponds to reference value.

Comment: The circle size is chosen to reveal the small uncertainty stacks of participants that is based on a scale resolution of 2kg in contrast to others that only had a resolution of 20 kg available.

Table 2: Reported data from calibration point; 4000 kg

Measurement point 4 ton			
Partici-pant	Error of indi-cation [kg]	Uncer-tainty [kg]	En-Value
R	1,63	2,0	
P1	8	9,3	0,67
P2	20	40	0,46
P3	0	1,2	-0,71
P4	0	60	-0,03
P5	20	41	0,45

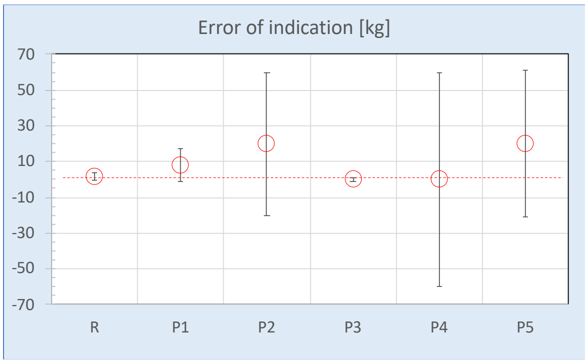


Diagram 2: Reported indication error of truck scale with uncertainties.

Comment: The uncertainty stacks all overlap the reference line (± reference uncertainty) defining the inter-comparison reference value leading to acceptable En-values, i.e. -1 ≤ En ≤ +1.

Table 3: Reported data from calibration point; 10 000 kg

Measurement point 10 ton			
Partici-pant	Error of indi-cation [kg]	Uncer-tainty [kg]	En-Value
R	-2,72	3,23	
P1	28	9,3	3,12
P2	0	40	0,07
P3	0	1,35	0,78
P4	20	60	0,38
P5	0	40	0,07

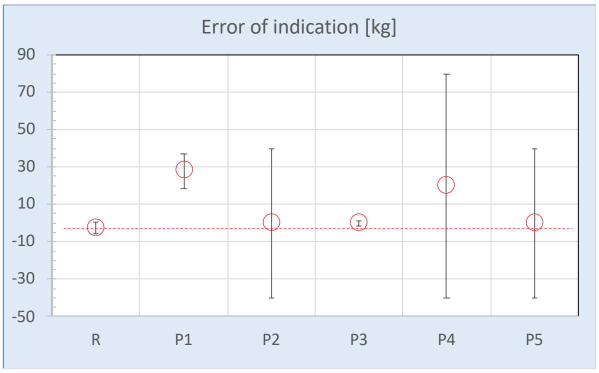


Diagram 3: Reported error of truck scale with uncertainties at 10 t load

Comment: At this load the resolution of 20 kg reveals deviations from the reference line most significant for participant P1 leading to a high En-value.

Table 4: Reported data from calibration point; 20 000 kg

Measurement point 20 ton			
Partici-pant	Error of indi-cation [kg]	Uncer-tainty [kg]	En-Value
R	4,85	5,85	
P1	48	9,3	3,93
P2	20	40	0,37
P3	14	1,82	1,49
P4	20	60	0,25
P5	20	41	0,37

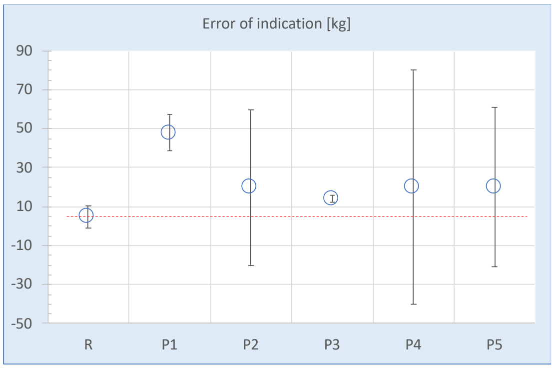


Diagram 4: Increasing error indication of truck scale from loaded weights.

Comment: For two results the uncertainty stacks do not overlap the reference line uncertainty (± uncertainty of the reference value) anymore leading to considerable En-values.

Table 5: Reported data from calibration point; 40 000 kg

Measurement point 40 ton			
Partici-pant	Error of indi-cation [kg]	Uncer-tainty [kg]	En-Value
R	-1,64	11,19	
P1	66	9,3	4,65
P2	20	40	0,52
P3	8	3,03	0,83
P4	0	60	0,03
P5	20	52	0,41

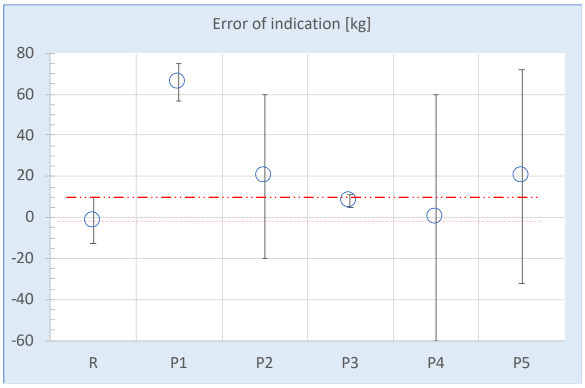


Diagram 5: Constant uncertainty stacks for four results, increasing ones for R and P3.

Comment: Almost the same picture. Only one result leads to high En-value. The uncertainty stacks of P3 and R do overlap each other leading to an En-value < 1.

Table 6: Reported data from calibration point; 58 000 kg

Measurement point 58 ton			
Partici-pant	Error of indi-cation [kg]	Uncer-tainty [kg]	En-Value
R	-6,36	15,9	
P1	46	9,3	2,84
P2	20	40	0,61
P3	-4	4,23	0,14
P4	0	60	0,10
P5	20	66	0,39

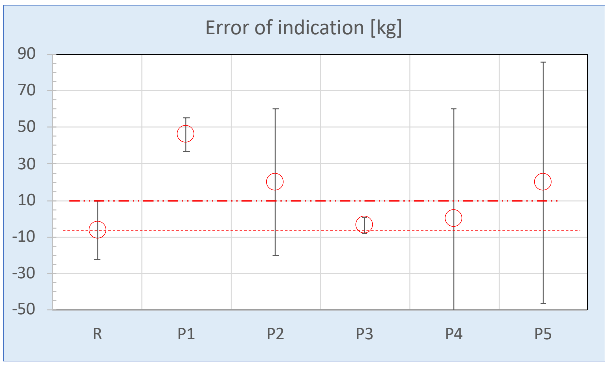


Diagram 6: Like before only the P1-result leads to a high En-value. The uncertainty stacks of all other participants are within the reference uncertainty band or overlapping it (red line - roughly being a border for accepted En-values).

Comment: The results R, P1 and P3 are based on an enhanced scale resolution of 2 kg, whereas the other participants only could use the ordinary resolution of 20 kg. This has a huge impact on the determination of the scale error and limits the measurement uncertainty.

Observations on the linearity test: The different laboratories placed the loads on the platform in different order where some laboratories started at the end of the platform and some laboratories from the centre. This could in principle give different values depending on the amount of eccentricity.

With one exception all participants gave repeatability values in the calibration certificates. The repeatability tests were done at different loads between 30 ton and 51 ton. All laboratories performed 3 repetitions.

Three laboratories stated just one uncertainty value. Two documented varying uncertainty values for all loads except for the eccentricity testing. For the evaluation in this report this single uncertainty value was used for all loads when nothing else were documented.

Two laboratories gave indicated values and uncertainty values rounded to the scale division 20 kg.

One laboratory included a calibration curve for the different loads in the calibration certificate.

Two laboratories are referring the uncertainty to the Euramet guide cg-18. The other laboratories are referring to EA publication EA-4/02.

Truck scale 60 ton decreasing load

For the four teams that reported the scale error with both increasing and decreasing load only the increasing situation is evaluated above. The full cycle is displayed in diagram 7 below.

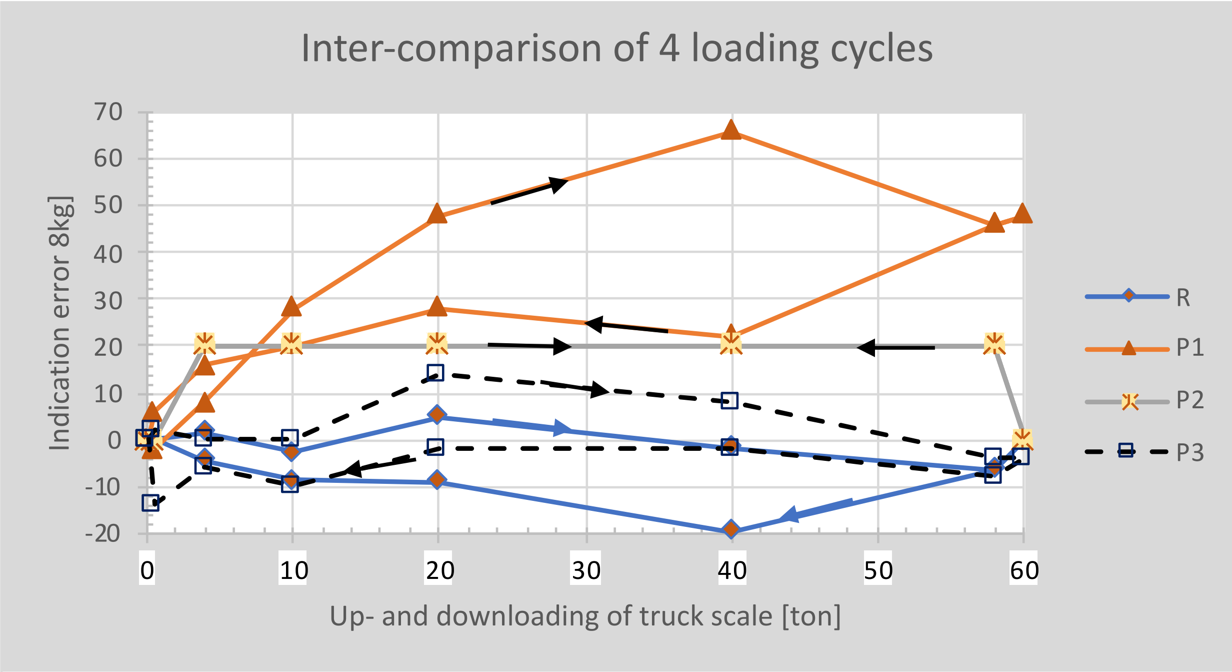


Diagram 7: Picture of the hysteresis of the truck scale. Arrows to the right uploading, arrows to the left downloading.

What can be observed is that the indication error is positive when increasing the load, i.e., the balance indicates a to high value, whereas it is negative when decreasing the load. Obvious is the high error indication for participant P1. The plane reason for this is the different whether situation during this day with increasing rain during the calibration as well as wind.

Part 1b Eccentricity Test

Most of the laboratories started with the eccentricity test before the linearity test. This was done at 12 000 kg according to the sketch below.

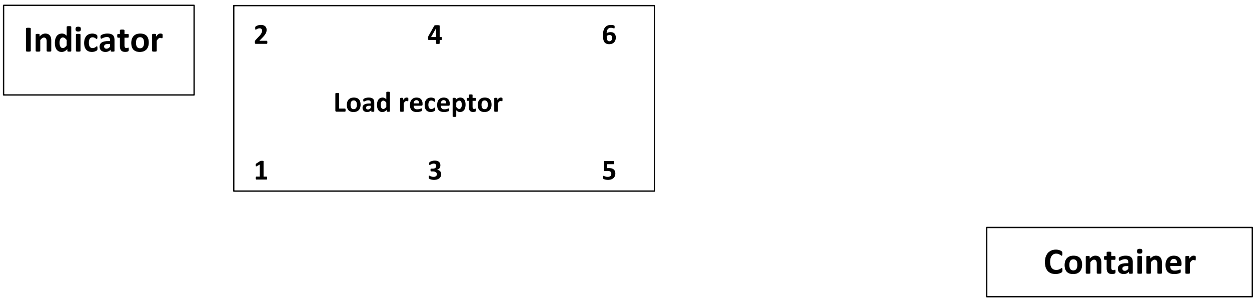


Table 7: The eccentricity calibration points no 1 to 6, including pilot, reference, and En-values

Partici-pant	Corner 1	Corner 2	Coner 3	Corner 4	Corner 5	Coner 6	Uncertain-ty [kg]	En-value for maximum eccentricity
R	9	-5	-4	22	-8	5	3,71	
P1	12	28	4	18	-8	2	9,3	**0,60**
P2	0	20	0	20	0	20	40	**-0,05**
P3	10	18	-4	16	-2	8	1,43	**-1,01**
P4	0	0	0	0	-20	0	60	**-0,70**
P5	0	20	0	20	0	20	40	**-0,05**

Comments: The table shows the measured differences to the nominal loaded weight (12 t) placed at 6 different points according to the above sketch for all 5 participants and the reference value by the pilot which is the average from two loadings at each point.

The maximum eccentricity values for each participant are framed. Obviously, not all identified the maximum deviation to the same corner point. The En-values to the right in the table are only calculated for the maximum eccentricity values as a measure how the truck scale is judged in this respect by the participants. The difference making up the En-value is between each framed value for participant P1 to P5 and R, the pilot determination. Due to the limited resolution (20 kg) 3 participants found even values, whereas R, P1 and P3 with a higher resolution (2 kg) came up with more detailed results. After putting together all data, it became clear that the corner 2 result of the pilot R was influenced by some not identified disturbances (may be a small stone under the rubber parts even if that was cleaned before the calibrations).

Observations on the eccentricity tests: The laboratories placed the weights on the predefined positions but distributed the weights on different surface areas. The laboratories did not indicate any uncertainty related to the values in the calibration certificates on eccentricity tests except in one case.
The definition of test points was not distinct in some calibration certificates and had to be cleared out afterwards due to misunderstanding of the original sketch, that was not clear.

Front wheel loader scale 10 ton

The original plan was to calibrate a 10 t and a 30 t front wheel loader. However, it appeared that only one part was interested to perform a calibration on the bigger front wheel loader. The organiser therefore decided to not include that test. For the smaller one only two participants could take part.

This calibration inter-comparison was performed by two participants and contained 5 separate tasks that were executed on the same object. The first part was a calibration using weights in the shovel. In the middle of this process part 2 to 5 were performed always with the same weights of 3,5 ton. There after the calibration continued with the last two weight load combinations up to 10 tons. Before a weight was added the front wheel loader was weighed on the truck scale and again after the loading. In this way the organizer could derive a reference value (reading with a certain weight in the shovel minus the first reading with empty shovel) for the different parts in the total exercise. In practice this means different reference values for the two participants. The reported uncertainty by the participants is the same in these 5 parts. The reference uncertainty is calculated from the difference measurement on the truck scale.

Part 1: Calibration of the front wheel loader

Table 8 Reported data from calibration point 500 kg including pilot reference, and En-values

Measuring point 1: 0,5 t			
Participants	Registered weight [kg]	Measurement uncertainty [kg]	En- value
Reference 1	494	10,3	
P1	400	100	**-0,94**
Reference 2	492	10,3	
P2	400	59	**-1,54**

Comments: The instrument resolution available for the participants was 100 kg. With such a difference to the real load the calculation of En-values necessarily will produce large values.

Table 9 Reported data from calibration point 2,5 t

Measuring point 2: 2,5 t			
Participants	Registered weight [kg]	Measurement uncertainty [kg]	En- value
Reference 1	2492	11,3	
P1	2400	100	**-0,91**
Reference 2	2498	10,3	
P2	2500	59	**0,03**

Table 10 Reported data from calibration point 3,5 t

Measuring point 3: 3,5 t			
Participants	Registered weight [kg]	Measurement uncertainty [kg]	En- value
Reference 1	3498	11,9	
P1	3500	100	**0,02**
Reference 2	3488	11,9	
P2	3400	59	**-1,46**

Table 11 Reported data from calibration point 5 t

Measuring point 4: 5 t			
Participants	Registered weight [kg]	Measurement uncertainty [kg]	En- value
Reference 1	4998	12,9	
P1	5000	100	**0,02**
Reference 2	5004	12,9	
P2	5000	59	**-0,07**

Table 12 Reported data from calibration point 10 t

Measuring point 5: 10 t			
Participants	Registered weight [kg]	Measurement uncertainty [kg]	En- value
Reference 1	10010	17,2	
P1	10100	100	**0,89**
Reference 2	10018	17,2	
P2	9900	59	**-1,92**

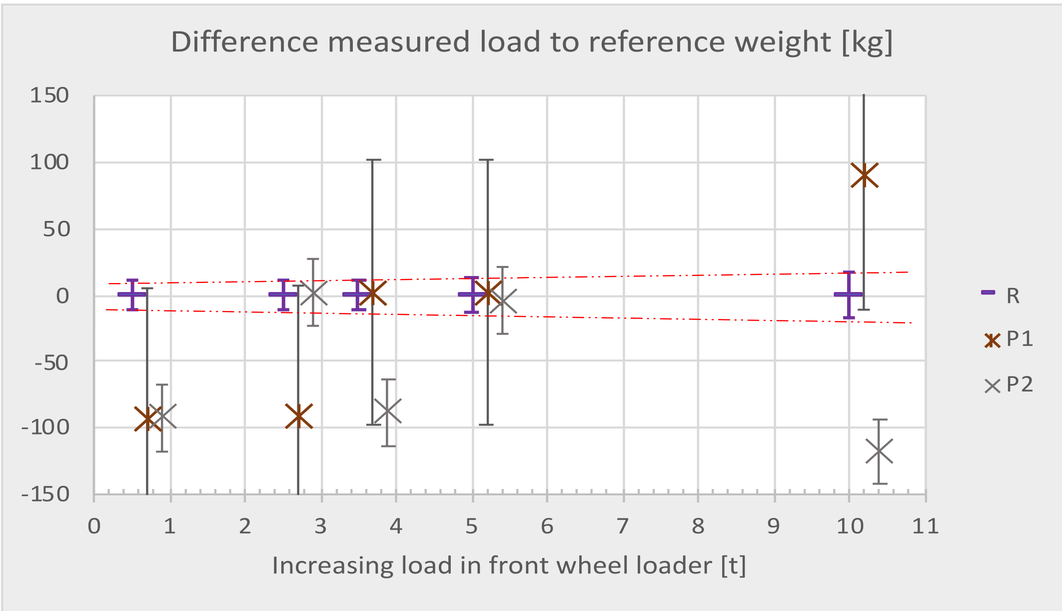


Diagram 8. The two results at 5 different loading levels 0,5 to 10 t with their stated uncertainty. Displayed is the difference to the corresponding reference value; it is a different one for the two results. Thus, the reference value in the diagram is zero. Three of the P2 uncertainty stacks do not overlap the reference uncertainty margins. For clearness the P1 and P2 results are somewhat shifted to higher x-axis values to make them observable.

Observations: There are several confusing results in the calibration values e.g., there is a big difference in the result of 10-ton load. The design of calibration certificates has no big difference.
The resolution d on the scale was 100 kg which does not make it ideal for an intercomparison. On the other hand, however, that is the situation one finds.
It is surprising that the similarity in the handling of different tests is quite good as there probably has not been any intercomparison in Europe that could support the knowledge.

Part 2: Calibration of the front wheel loader with four different inclination positions

The tilting test was performed with a load of 3,5 t in four different directions – all with an inclination of roughly 5 %. The organiser indicated the point on the gravel road where the tilting should be about that size.

Table 13 Reported data from calibration point 3 500 kg tilting front down

Part 2 - Tilting of front loader 5 % in 4 directions				
Participants	R	P1	R	P2
Reference load [kg]	3498		3488	
Front down [kg]		3600		3500
Front up [kg]		3600		3500
Left side down [kg]		3600		3500
Right side down [kg]		3600		3500
Uncertainty [kg]	11,9	100	11,9	59
En-value (all 4 situations)		**1,01**		**0,20**

Comments: Each reported value is the average of five readings, which all gave the same result within the limited resolution of 100 kg. The tilting plane does not seem to have any influence on the weighing function. Thus, the calculated En-value is identical for all four tilting situations.
However, a difference of 100 kg (resolution) can be seen between the two participants performing the test at the same advised site. However, Participant 1 reported a measured inclination of 5 %, whereas participant 2 reported an angle of 5 ° (which would correspond to 8,7 %).

Part 3: Calibration of the front wheel loader at two different driving speeds

Low and high speed suggested to a range of 3 to 4 km/h for low and 8 to 10 km/h for high speed.

Table 14 Reported measurement values [kg] from calibration point 3 500 kg and two driving speeds

Part 3 - Different driving speed (low 3-4 km/h / high 8 - 10 km/h)					
Participant	low speed	high speed	Uncertain-ty [kg]	En-value low speed	En-value high speed
R	3498		11,9		
P1	3500	3680	100	**0,02**	**1,81**
Driving speed [km/h]	4	8			
R	3488		11,9		
P2	3400	3400	59	**-1,63**	**-1,63**
Driving speed [km/h]	3	6			

Comments: The driving speed test gave a considerable difference for participant 1 between the two speeds. Participant 2 reported the same, but clearly lower values. The difference corresponds to the resolution of the weighing system. Participant 2 did not reach the suggested speed interval for high speed. All results are the average of five repetitions.

Part 4: Calibration of the front wheel loader at two different lifting speeds.

Those were declared as low and high. No direct speed limits were suggested, but the motor rotation speed (rpm) for the two situations should be reported.

Table 15 Reported measurement data [kg] from slow and high lifting speed

Part 4 - Two lifting speeds (low / high)					
Participant	low	high	Uncertain-ty [kg]	En-value low speed	En-value high speed
R	3498		11,9		
P1	3600	3600	100	**1,01**	**1,01**
Motor [rpm]	700	1100			
R	3488		11,9		
P2	3400	3440	59	**-1,63**	**-0,96**
Motor [rpm]	1100	1600			

Comments: Again, a clear difference between the two participants can be seen in the results. The difference 200 kg is twice the instrument resolution, although surrounding parameters are the same except the driver and the understanding of low and high speed respectively. The low speed 1100 rpm for participant 2 is the same as the high speed for participant 2. A difference due to speed itself only can be seen for the high lifting speed corresponding to 1600 rpm giving a slightly higher value. Again, all data are the average of 5 repetitions.

Part 5 Calibration of the front wheel loader eccentricity

The same load 3,5 t in form of weights are placed on two different sides of the shovel

Table 16 Reported data from eccentricity test with 3500 kg

Part 5 - Excentricity (relative driving direction)					
Participant	left	right	Uncertainty [kg]	En-value low speed	En-value high speed
R	3498		11,9		
P1	3520	3500	100	**0,22**	**0,02**
R	3488		11,9		
P2	3400	3440	59	**-1,63**	**-0,96**

Comments: The tabled values for the participants are again the average from five measurements in each of the two situations (weights left or right). Also, here a difference between the two participants can be seen in the results. Both participants find an eccentricity of 20 and 40 kg respectively, however on different sides. Participant 1 again reports a higher reading than participant 2, which is seen throughout the calibration. An obvious reason for this cannot be recognised

Observations on front wheel loaders:

The 2 laboratories approved to waive the confidentiality. Description of traceability in the calibration certificate is not very clear in one case. The 2 laboratories did the different calibrations in a similar way.

General observations

(Not a part of the inter-comparison)

In this inter comparison the 4 participating laboratories including one Norwegian laboratory could demonstrate their capacity to calibrate the truck scale in the same manner. For one participant P1 the working conditions during one day of calibrations were very different with of a lot of rain and wind. Without corrections and/or increased uncertainty margins taking care of this fact the measured balance error became much larger compared to the pilot data resulting in high En-values.

Drift of the truck scale from day one to the last day was checked in few points and was not significant.

It is surprising that 2 laboratories operating on these types of weighing instruments in Sweden did not participate in this intercomparison. Intercomparisons of this type are not available very often. The last one was done 13 years ago.

A total of 53 calibration points were documented with results and En values. 18 of these points indicated En values higher than 1. Weather conditions are surely a reason for the truck scale, probably too optimistic uncertainty claims another. That is surprisingly high and the reason for this should be evaluated by all participants and the organiser.

There is obviously a need of more intercomparisons in this field in Sweden and other countries in Europe to give some trust to the market.

All laboratories indicated the load and the measured reading in the calibration certificates. No one used the terms error (except in one case the error of indication was documented as well) or correction in the calibration certificate.

The laboratories performed reverifications on the truck scale as well using the same indications as in calibrations. More details about the verification will be reported separately from this report

Acknowledgement

We gratefully thank Volvo Construction Equipment AB in Eskilstuna especially Stefan Edsvid who supported the ILC with weighing instruments and facilities.

Annex 1 project description

Process Weighing instruments and weigl

Annex 2 templates for measuring points

Protokoll Eskilstuna bilvåg.pdf

Protokoll Eskilstuna INFO.pdf

Protokoll Eskilstuna Skopvåg S.pdf

Protokoll Eskilstuna INFO.pdf

Annex 3 Final planning ILC weighing instruments

Laboratoty	**Date**	**Time**	**Truck scale 60 ton**	**Front wheel loader 10 ton**	**Comments**
Organiser SMQ	Sept 20	9-13	X	X*	Calibrating to establish reference values on the truck scale including repeatability test for calibration of front wheel loaders
Mettler-Toledo AB	Sept 20	13-17	X		Eventually 2 personnel
	Sept 21	9-12		X*	Preparations by SMQ
FLINTAB	Sept 22	9-17	X	X	
TAMTRON	Sept 23	9-17	X	X	
Justervesenet Norge	Sept 24	9-17	X		

*In connection with calibration of front wheel loaders on Wednesday and Thursday of reasons for stability check of reference values.

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 JCGM 100:2008/GUM:2010
- EA-4/02 M:2013 Evaluation of Uncertainty of Measurement in Calibration
- ILAC-P9:06/2014 ILAC policy for Participation in Proficiency Testing activities