Swedish Metrology and Quality AB

Accred. no. 10436
Proficiency testing
ISO/IEC 17043

To participants

Report on an interlaboratory comparison (ILC weights 2023:2) on weights 5-20 kg.

The bag carrying the weight set for calibration.

Author

Håkan Källgren
Swedish Metrology and Quality AB

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Abstract

This report presents the outcome of an inter-comparison on weights with 11 participating laboratories.

Prior to the circulation of the weights among the participating laboratories the weights were calibrated by RISE (Swedish National Metrological Institute).

RISE performed all calibrations after the circulation as well. Their average from both calibrations serves as assigned inter-comparison reference values. Together with the combined reference uncertainty they are used to calculate En-values on each weight for the participants.

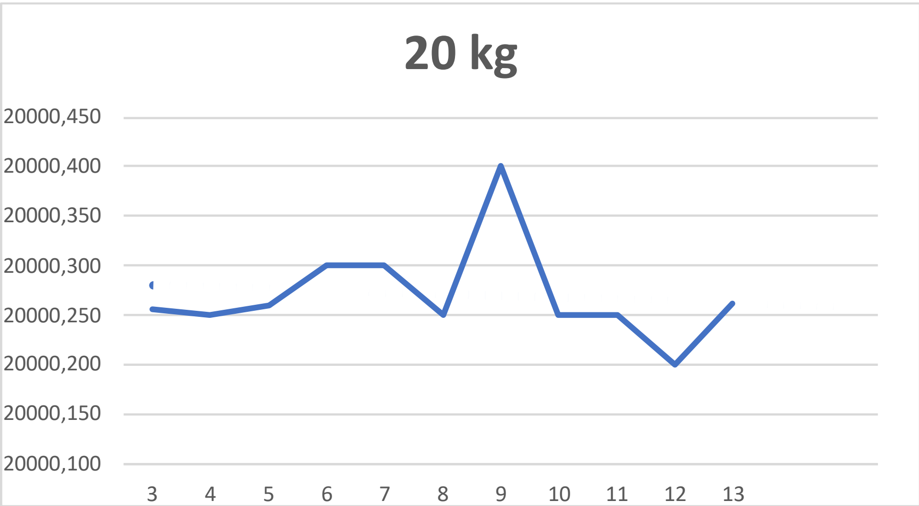
This report covers all together 31 calibrations of weights made by 11 laboratories in 6 countries. Their calibration certificates were mostly in their local language but sometimes in English.

The summarized results from 30 calibrations have 2 results got En values above 1.

The result of this intercomparison in general is good compared to intercomparisons in other fields. This is probably related to long historic cooperation in the mass field in Europe and development of mass comparators that are used for calibrations.

The stability of the weights was followed during the circulation. All 3 weights had in principle the same stability.

Example of stability follow up.



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 weights that should be included in the ILC weights 2023:2.

The advisory group consisted of Peter Lau MNE Konsult 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 weights 2022:1 published on smquality.se and enclosed to this report in annex 1.

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

Participating laboratories and measuring scheme for the comparison

RISE NMI laboratory Research Institutes of Sweden
Kiwa AS
IKM laboratorium AS
Zwiebel
Lahti Precision oy
Oy G.W. Berg & CO Ab
Danish Technological Institute
Metroqualibeiras Lda
Flintab AB
RISE Research Institutes of Sweden accredited laboratory, 2 participants
Multicheck AB
RISE NMI laboratory Research Institutes of Sweden

The circulation started in week 42 in 2023 and ended in week 19 2024.

Several of the participants are accredited by NA, Cofrac, FINAS, DANAK, SWEDAC and IPAC.

The reference laboratory RISE, Sweden has the status as National Metrology Institute, NMI and did the reference calibrations.

Principles concerning the calibration in general.

The reference laboratory calibrated all weights 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 weights. The purpose was to maintain equal conditions for all participants over the total measurement period. In doubt the weights were planned to be called back for a new reference calibration, which however was not necessary.

Conditions and transport during the measurement period

A special case was used for transport.

The case was partly broken during the transport but that did not affect the stability of the weights.

Weights for calibration

The planned uncertainty levels decided by the NMI are given in the table below.

Weight	Uncertainty level, U
kg	mg
5	2,5
10	5
20	10

Table 1: uncertainty levels from the reference laboratories.

The weights are fulfilling the requirements on susceptibility and magnetization in OIML R 111

The essential values in calibration certificates should be the conventional mass values including uncertainty and **not the class determination**.

Calibration instructions

The laboratories were allowed maximum 10 days for their calibration. In the call they were advised to use their own calibration and reporting procedures.
The result should be presented as the conventional mass value as defined by OIML Document D 28
The laboratories should not express a classification according to the rules in OIML Recommendation 111.

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 certificates.
- Comments or feed-back on the draft report to the organiser were 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 17043:2010 in the reporting.

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

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

$x_{i,j}$: Single measurement result (deviation from nominal mass value); index *i* and *j* count the various participants and weights respectively.

$x_{ref,j}$: Assigned inter-comparison reference value for weight *j*.

$U_{i,j}$: The estimated expanded uncertainty (k=2) stated by each laboratory *i* for respective weight *j*.

$U_{ref,j}$: The estimated expanded uncertainty (k=2) of the assigned reference value for the same weight *j*.

$En_{i,j}$: The calculated En-value for each participant i and each weight *j*.

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 weight *j*.
j: Counting the different weights.
$R_{1,j}$ & $R_{2,j}$: The assigned comparison reference values provided by the reference laboratory at start and end. In the result tables and the diagrams only the symbol REF is used for identifying the assigned reference result.

The measurement uncertainty for weights was calculated as the uncertainty of their mean (equation 3).

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).

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

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.

Given the same uncertainty for a pressure level at start and at the end the uncertainty of the reference value is identical with that stated by the laboratory in one of the calibrations. Otherwise, the reference uncertainty lies close to the middle of both.

The data supplied by the reference laboratory indicated a small drift that was considered. 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.

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

The change in the mass of a weight between first and final calibration half of this difference is added to the combined uncertainty to catch this possible drift. However, the differences found are far below the stated calibration uncertainties and do not contribute much to the uncertainty of the reference values.

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 deviation x_i from the nominal mass value by a participant does not deviate more from the assigned reference comparison value x_{ref} than what can be expected from the calculated uncertainty in this difference.

$$E_n < 1: \quad \left|x_i - x_{ref}\right| < \sqrt{U_i^2 + U_{ref}^2} \qquad \text{(eq. 4)}$$

However, to make this measure a reliable one for an inter-comparison the reference U_{ref} must be small enough not to contribute significantly to the right side of equation 4. Due to the quadratic combination ideally U_{ref} should be in the range of 1/3 of U_i. This is not always easy to achieve in relation to all laboratories, which means that relatively high En-values although between -1 and +1 must not be regarded totally reliable if U_{ref} and U_i are of the same size or if $U_{ref} > U_i$.

Measuring results on calibration in the ILC

The following tables present the found mass deviations from the weights nominal value along with the stated measurement uncertainty for each weight.

Besides these “deviations” and “uncertainty” also the reported “determined mass values” are listed in the following tables. This presentation is chosen to allow the participants to compare the tabled data in this report with their own documentation.

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

It was the ambition of the organizer to incorporate directly the excel-protocols from participants into the evaluation calculations for reporting the outcome of the comparison measurements after first having checked all data against those in the calibration certificates delivered in a separate calibration certificate. This worked quite well.

The following tables are built with increasing participant identity numbers and list at the bottom the belonging reference value based on the average of two calibrations denoted as REF. The identity numbers are not following the logistic scheme. The participants are informed in separate emails about their number.

Calibration certificates RISE

Before calibration 105102-1159138-K01 and 105102-1217064-K02
After calibration 105102-1263080-K01

Result of the weights.

Table 1 Calibration results 5 kg weight

Observe that the results for the laboratories are not in chronological order.

Participant	Deviation from nominal values, g	Stated uncertainty, g	En value
P1	0,000	0,150	-0,34
P2	0,056	0,025	0,21
P3	0,048	0,083	-0,03
P4	0,053	0,025	0,10
P5	0,048	0,025	-0,10
P6	0,060	0,0042	1,76
P7	0,050	0,030	-0,02
P8	0,049	0,008	-0,18
P9	0,040	0,023	-0,46
P10	0,050	0,250	0,00
REF	0,0506	0,0033	

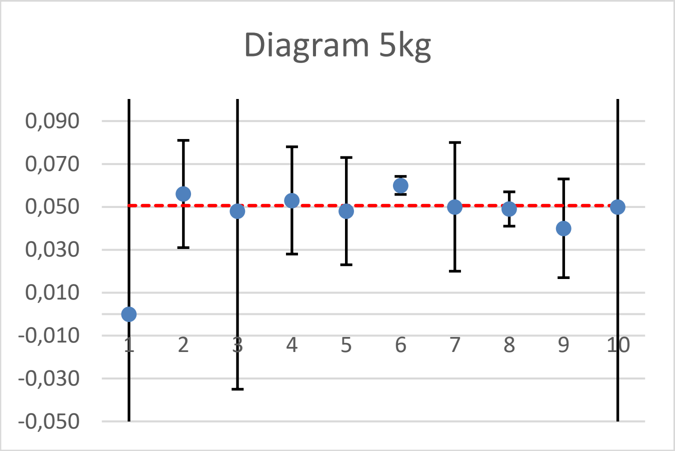


Table 2 Calibration results 10 kg weight

Participant	Deviation from nominal values, g	Stated uncertainty, g	En value
P1	0,200	0,292	0,34
P2	0,098	0,025	-0,08
P3	0,097	0,160	-0,02
P4	0,094	0,040	-0,15
P5	0,080	0,050	-0,40
P6	0,121	0,0045	2,71
P7	0,090	0,060	-0,17
P8	0,098	0,016	-0,12
P9	0,110	0,044	0,22
P10	0,100	0,240	0,00
REF	0,100	0,0063	

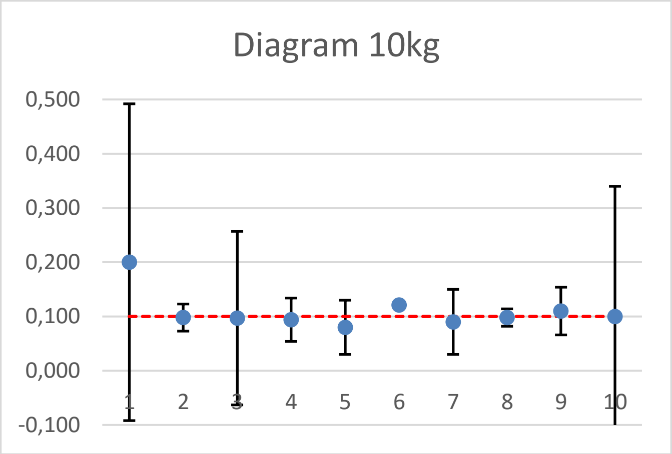
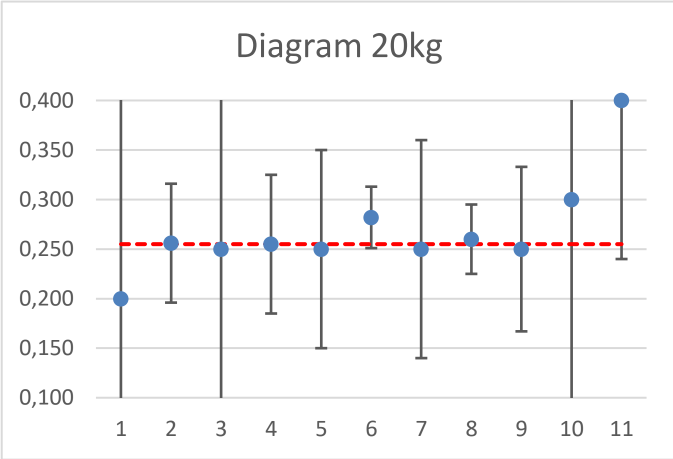


Table 3 Calibration results for 20 kg weight

Partic-ipant	Deviation from nominal values, g	Stated uncertainty, g	En value
P1	0,200	0,579	-0,09
P2	0,256	0,060	0,02
P3	0,250	0,330	-0,02
P4	0,255	0,070	0,00
P5	0,250	0,100	-0,05
P6	0,282	0,031	0,77
P7	0,250	0,110	-0,04
P8	0,260	0,035	0,13
P9	0,250	0,083	-0,06
P10	0,300	1,300	0,03
P11	0,400	0,160	0,90
REF	0,255	0,016	



Comments on the calibration certificates

-- not a part of the intercomparison

Most of the laboratories report measurement error, but others the mass value.

Most of the laboratories indicate that the result is conventional mass.

Most of the laboratories specified their uncertainty with 2 digits in the certificate, but some laboratories gave 1 or 3 significant digits and that is not following the rules about presentation of uncertainty values.

One laboratory mentions the material in the weights.

One laboratory mentions the shape of the weights (rectangular).

Most of the laboratories have an accreditation by their national accreditation body.

Additions and changes to the DRAFT report

Diagrams are added.

Final conclusions

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

Many uncertainty claims are comparable between participants. That is probably based on the OIML Recommendation r111 on weights.

The summarized results from 33 number of calibrations have 2 results got En values above 1.

Acknowledgement

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

Annex 1 ILC weights 2023:2

Published on https://smquality.se/

Annex 2 Description of the intercomparison/ILC

Published on https://smquality.se/

Appendix 1 Reporting form

Intercomparison ILC Weights 2023:2

CODE för lock: **504**

Reporting form for preliminary calibration results

Comparison ID

Laboratory:	
Name:	
e-mail:	-
Date of reporting:	

Calibration intercomparison on weights

Date of calibration

Weight identification	Nominal weight	Actual measured weight mass	Stated error	Measurement uncertainty
	[g]	[g]	[mg]	[mg]
X6501	5000			
X2833	10000			
X2773	20000			

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:2022 Evaluation of Uncertainty of Measurement in Calibration
- International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)