



To participants

Final Report on ILC on exhaust gas and opacitet 2024:1



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Abstract

This interlaboratory comparison (ILC) was performed to verify calibration results from different accredited laboratories and support demonstration of technical competence according to **ISO/IEC 17025:2017** (SS-EN ISO/IEC 17025:2018, section 7.7.2). The comparison, organized by SMQ, followed reporting principles in **ISO/IEC 17043:2023** and evaluated calibrations of a combined **gas analyzer and opacity meter** used for vehicle exhaust testing.

Calibration of the gas analyzer was based on certified reference gases containing **CO, CO₂, and propane (HC)**, where participant results were reported as correction values between certified concentrations and instrument readings.

Opacity calibration was simulated using calibrated filters, with measurements recorded both in **% opacity** and **k-value (m⁻¹)**.

Because participants used different gas concentrations and filter values, assigned reference values were established using a **consensus mean** rather than a reference laboratory. Performance was assessed using **En-values**, combining participant and reference uncertainties. Results showed strong agreement: **None of the 21 gas calibration points exceeded |En| = 1, and 0 opacity points exceeded |En| = 1**, indicating satisfactory interlaboratory consistency. The comparison also identified variation in certificate presentation and decision-rule reporting, suggesting a need for clearer harmonization and regulatory guidance.

Purpose of this comparison

This comparison calibration serves as an aid to verify the results of calibrations from different laboratories. It is a recognized method for demonstrating the technical capability of calibration laboratories as a basis for the accreditation required by ISO/IEC 17025:2017 (SS-EN ISO/IEC 17025:2018), as specified in section 7.7.2.

Advisory Group

The implementation of this ILC is based on experiences from previous comparisons and implemented by Håkan Källgren.

Information about this intercomparison/ILC

Information about this calibration comparison was provided in 3 ways:

On the website <https://smquality.se/interlaboratory-comparisons-ilc>

Email to accredited laboratories in this field in Europe

Detailed information with a description of this ILC was published on smquality.se

Lab Participation

The planning was organized to conduct the exercises over a period of 5 hours per participant. Based on this, a work schedule was established so that the participants would not disturb or influence each other.

The participants have an accreditation in this area from Swedac. The participants were asked to provide preliminary results for the comparison to the organizer immediately upon completion (in excel sheets) of the calibration. This avoided the possibility for the laboratories to compare the results with each other.

Laboratory
Techmec
Sun Maskin Maskin & Service
Lidköpings Carpart 2 participants
JB Maskin 2 participants
DEKRA Quality Management AB

Calibration instruction

As a calibration object, a combination instrument was selected: a gas meter with an addition as an opacity meter. The calibration task in the first case consists of simulating the measurement of vehicle exhaust gases by connecting a gas cylinder containing 3 gas components (CO, CO₂, and HC propane) and comparing the values read from the displays with the certified concentrations in the gas cylinder. The calibration result is given as the difference between the certified concentration values and the read values, i.e., the difference constitutes a correction to the latter. The correction applies to the gases CO, CO₂, and HC propane that are covered by the calibration.

The opacity meter is designed to measure the density of diesel exhaust and is sometimes also called a smoke meter. During calibration, the smoke density is simulated using calibrated opacity filters. These consist of gray glasses whose opacity is independent of the wavelength of the absorbed light. The opacity is read both in the unit % and as a k-value in the unit m⁻¹ and compared to the calibrated filter values. The difference is documented as a correction to the measured value.

In this case, the equipment in question is new on the market, so the organizer provided an opacity filter that all participants used.

Reference values for correction in the comparison

In connection with a calibration comparison, several fixed, pre-agreed measurement points are normally determined. Typically, 5 or more points distributed across the measurement range of the instrument are chosen. At these measurement points, the 5 (or more) relevant reference values are then determined, against which all participant results are to be measured. These reference values are obtained either through a better measurement procedure from a party with lower measurement uncertainty or, more commonly, through a consensus value based on the participants' reported measurements. An unavoidable prerequisite, however, is that all results refer to the same measurement points for a fair assessment, as an error of the instrument often varies across the measurement range, which is precisely the reason why calibration is needed.

These assumed conditions are not met with the current instruments with only one measurement point.

Since the various participants use completely different gas concentrations it is a delicate task to determine fair reference correction values. Entrusting the task to a reference laboratory is not an option.

Planning Details

The documentation protocol carried out in Excel was completed and submitted to the organizer immediately after the calibration (in digital form or on paper). The signed calibration certificates were then to be delivered to the organizer within some weeks after the calibration was performed.

The organizer applies the principles in ISO/IEC 17043:2023 in reporting this comparison. Participants were asked to use their own methodology for the calibrations. The calibration certificates were to be complete and include measured values and uncertainties for the calibration values. Opportunities were also provided for the laboratories to provide additional information.

Administrative information

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Traceability of reference values

During the calibrations, the consensus principle was applied and the calculations, and traceability is based on calibration laboratories providing accredited calibration certificates or calibration certificates from recognized National Metrology Institutes (NMI) for the reference equipment used. All participating laboratories could demonstrate that they have accredited reference equipment.

Discussions about the calibration results

As it is not possible to establish a reference measurement on this intercomparison, the reference value for the comparison needs to be based on a consensus value among the participants. This is chosen at all results reported values of the participants. Overall, the participants' results are quite consistent, with a few exceptions, the simplest and most reasonable approach is to choose the arithmetic means, i.e., to assign the same significance to all results.

There was no need to perform a chi-square test.

Principle of the Calibration Comparison

In this ILC, the participants recorded correction values are not compared directly, but rather their difference from a reference correction for the same gas concentration or opacity value. Together with the participants reported measurement uncertainty and the uncertainty of the reference values, the participants' En-values are calculated according to the equation below. An absolute value of En that is less than 1 is used as a criterion for an acceptable calibration ring quality according to ISO/IEC 17043:2010, B.4.1.1

Analysis of the calibration results

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

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

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

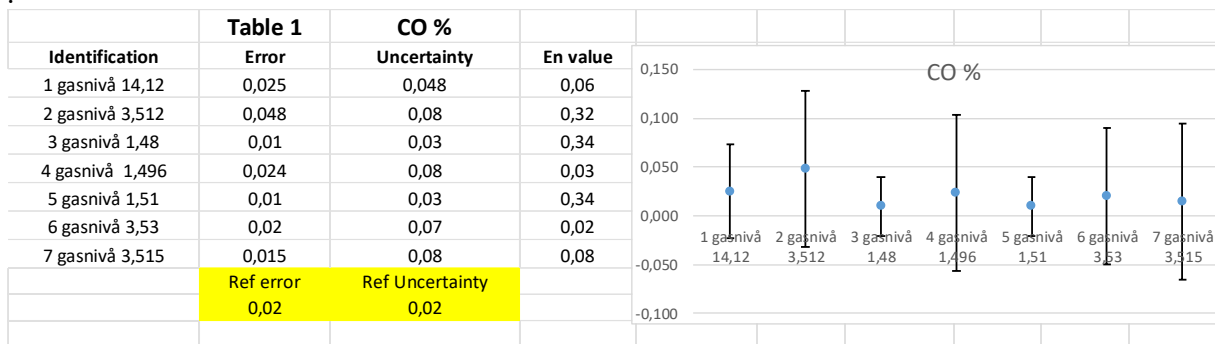
$x_{i,j}$: Single measurement result (deviation from nominal mass value); index i and j count the various participants respectively.

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

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

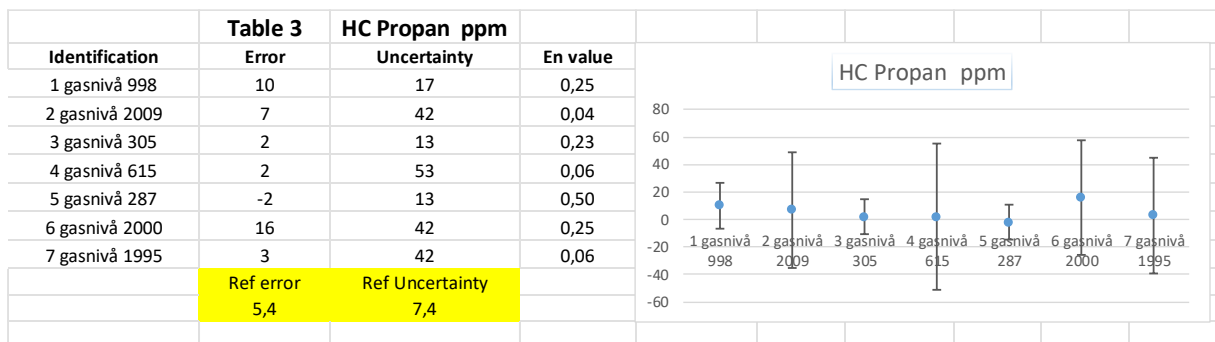
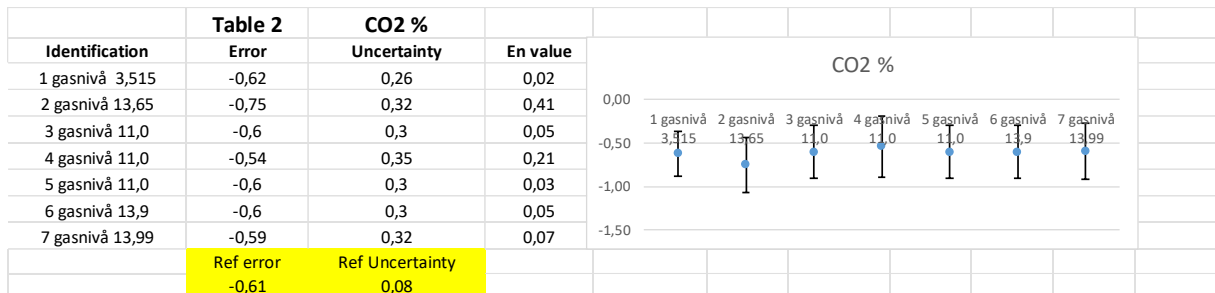
$U_{ref,j}$: The estimated expanded uncertainty ($k=2$) of the assigned reference value j .

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



Comment:

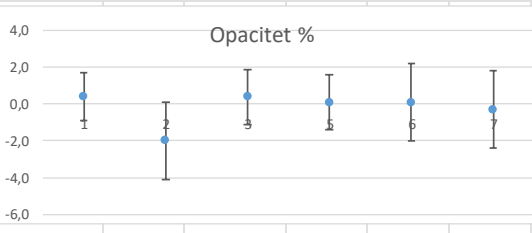
Despite significant differences in reference gas concentrations, the consistency between the participants' calibration results is surprisingly good.



Comment

In this case all laboratories are getting good En values independent of gas content.

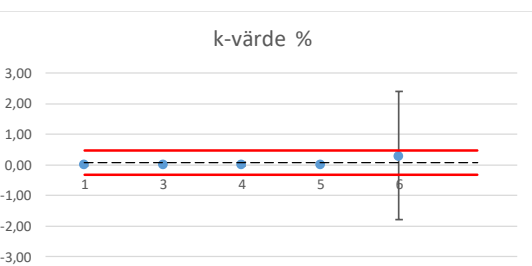
Table 4		Opacitet %	
Identification	Error	Uncertainty	En value
1	0,4	1,3	0,36
2	-2,0	2,1	0,75
3	0,4	1,5	0,33
5	0,1	1,5	0,17
6	0,1	2,1	0,13
7	-0,3	2,1	0,04
Ref error		Ref Uncertainty	
-0,22		1,11	



Comment

All laboratories are getting good En values that is natural as they are all using the same filter that was provided by the organizer. The equipment was a new model, and all laboratories did not have filter that could be used in the calibrated equipment.

Table 5		k-värde %	
Identification	Error	Uncertainty	En value
1	0,01	0,04	0,30
3	0,02	0,06	0,25
4	0,02	0,07	0,24
5	0,01	0,06	0,29
6	0,3	2,1	0,11
Ref error		Ref Uncertainty	
0,07		0,20	



Summary assessment of the exhaust comparison

As convincingly shown by tables 1 to 3 and the accompanying diagrams, none of the 21 calibration points En value over 1.

Summary assessment of the flue gas comparison

As convincingly shown by tables 4 to 5 and the accompanying diagrams, none of the 11 calibration points gave En values over 1.

Final Summary

For most of the gases levels the comparison shows good agreement. The same also applies to opacity.

Some of the minor inconsistencies are related to that there are no clear requirements from the authorities on which level the calibrations/measurement shall be done as well as approved levels and decision rules.

Acknowledgment

Carpart as they arrange the site.

Solidutveckling Mattson AB, Traversgatan 10 53140 Lidköping, Sweden gave the possibility to use the facilities during the calibrations

Annex 1 form for preliminary calibration results.

ILC brake force 2025:2

Documentation protocol for participant

Laboratory: _____
 Person: _____
 e-mail: _____
 Date: _____

**OBS fyll bara i gröna och gula fält
 No adjustments shall be done**

Brake force left side force Analog

Obligatory calibration points	Obligatory calibration points	Applied reference force	Measured gauge force	Calculated indication error	Stated measurement uncertainty
kN	daN	kN	kN	kN	N
1	100				
2	200				
3	300				
4	400				
6	600				
7	700				

Brake force right side force Analog

Obligatory calibration points	Obligatory calibration points	Applied reference force	Measured gauge force	Calculated indication error	Stated measurement uncertainty
kN	daN	kN	kN	kN	N
1	100				
2	200				
3	300				
4	400				
6	600				
7	700				

Brake force left side force Digital

Obligatory calibration points	Obligatory calibration points	Applied reference force	Measured gauge force	Calculated indication error	Stated measurement uncertainty
kN	daN	kN	kN	kN	N
1	100				
2	200				
3	300				
4	400				
6	600				
7	700				

Brake force right side force Digital

Obligatory calibration points	Obligatory calibration points	Applied reference force	Measured gauge force	Calculated indication error	Stated measurement uncertainty
kN	daN	kN	kN	kN	N
1	100				
2	200				
3	300				
4	400				
6	600				
7	700				

Ljusinställning Utrustning MLD8516

Nedvinkling	Inställd lutning	Uppmätt lutning	Beräknad felvisning	Osäkerhet	Kommentar
%	%	%	%	%	
0					
1					
2					
3					

OBS om ni gör varianten med bara 0-punkten fyll i rad 1 och skriv kommentar om hur ni gör det

Ljusinställning Utrustning OCH 12400/y/v

Nedvinkling	Inställd lutning	Uppmätt lutning	Beräknad felvisning	Osäkerhet	Kommentar
%	%	%	%	%	
0					
1					
2					
3					

OBS om ni gör varianten med bara 0-punkten fyll i rad 1 och skriv kommentar om hur ni gör det

Avgas

Referens gas	Document vol % or ppm	Reference	Mesured	Calculated error	Uncertainty	Comments
CO						
CO2						
HC propan						

Opacitet

Reference filter	Used reference filter	Measured value	Calculated error	Uncertainty	Comments
	%	%	%	%	
1					Referensfilter finns på platsen
2					Egna filter
3					Egna filter
4					Egna filter

Mätplatsmätning

Position	Level mm	Uncertainty mm	Comments
1			
2			
3			
4			

Ljus inställningsplats

Position 1 Position 2 Positionerna på golvet märks med ett kryss i mitten
 Position 3 Position 4 Och en cirkel med diameter på cirka 10 cm

References

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