



EUROPEAN COMMISSION

DIRECTORATE-GENERAL

CLIMATE ACTION

Directorate C - Climate strategy, governance, and emissions from non-trading sectors

CLIMA.C.2 - Governance & Effort Sharing

EU ETS Monitoring and Reporting – Training on Uncertainty Assessment

M&R Training Event of 28 November 2019

This document comprises training material for competent authorities and verifiers for the checking of uncertainty assessments according to Commission Regulation (EU) No. 601/2012 of 21 June 2012 on the monitoring and reporting of greenhouse gas (GHG) emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (the [MRR](#))¹.

¹ <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1574681890853&uri=CELEX%3A02012R0601-20190101>

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1. LEGAL BACKGROUND

Article 12(1) MRR requires the operator to submit to the Competent Authority (CA) uncertainty assessments as supporting documents concerning approval of the monitoring plan (MP). CA interest extends to the following information:

- Evidence for compliance with the uncertainty thresholds for activity data
- Evidence for compliance with the uncertainty required for calculation factors, if applicable
- Evidence for compliance with the uncertainty requirements for measurement based methodologies, if applicable
- If a fall-back methodology is applied, an uncertainty assessment for the total emissions of the installation

Article 19(1) AVR requires the verifier to confirm the validity of the information used to calculate the uncertainty levels.

2. OBJECTIVE

The M&R training event of 28 November 2019 aimed at:

- Providing technical support to the participants in performing their day-to-day tasks when assessing uncertainty involved in the approval of MPs, based on a more extensive training² provided on 31 May 2016;
- Provide hands-on training with the “uncertainty assessment tool”, published in December 2019.

Experience and feedback from discussions in the EU ETS MRVA Technical Working Group (TWG) and the EU ETS Compliance Forum M&R Task Force had shown that uncertainty assessment is an area where Member States (MS) and CAs usually most welcome training. Information had shown shown major differences in how MS check uncertainty assessments. These differences between MS concern differences in experience, in background of staff members, in the resources of the CAs and in practices by which checks are carried out, e.g. level of detail, spot checks.

An additional objective for the training was to allow for further cascade to other MS audiences based on the case studies and this document.

² The training material of the event on 31 May 2016 can downloaded from:
https://ec.europa.eu/clima/sites/clima/files/ets/monitoring/docs/uncertainty_assessment_training_material_en.pdf

3. SET-UP OF THE TRAINING EVENT

The training was set up in the following two sessions:

- **A theoretical part** covering the principles of uncertainty assessment in EU ETS monitoring and reporting: This part included a short introduction and outline of uncertainty assessment in the EU ETS which followed the narrative of MRR Guidance Documents 4 and 4a. This part constituted a shortened presentation of what had been presented in the first training event on this matter on 31 May 2016.
- **A practical part** with MS representatives sharing their experiences in uncertainty assessments and a discussion of case studies in discussion groups.

Annex I: Introductory presentation



Uncertainty assessment

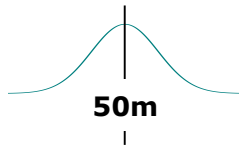
Christian HELLER

**EU ETS Compliance Forum Training Event 2019
Brussels, 27 November 2019**

Information on this presentation

- *The content of this presentation is based on the "M&R training event on Uncertainty Assessment", held in May 2016*
- *The full handbook can be downloaded from DG CLIMA's MRVA website under:*

https://ec.europa.eu/clima/policies/ets/monitoring_en#tab-0-1



Calibration Certificate
Brakes
Braking distance 50m
(100 km/h):

Why not exactly 50m?

- Car (wheels, brakes,..) tested for the certificate do not have exact same properties
- Temperature/material properties differences to testing conditions causes differences in:
 - Friction within the braking system
 - Rolling resistance between wheels and road
 - Air resistance (which also depends on density/viscosity of the air, wind speed)
- Speedometer display or its reading may not be correct
- Etc.

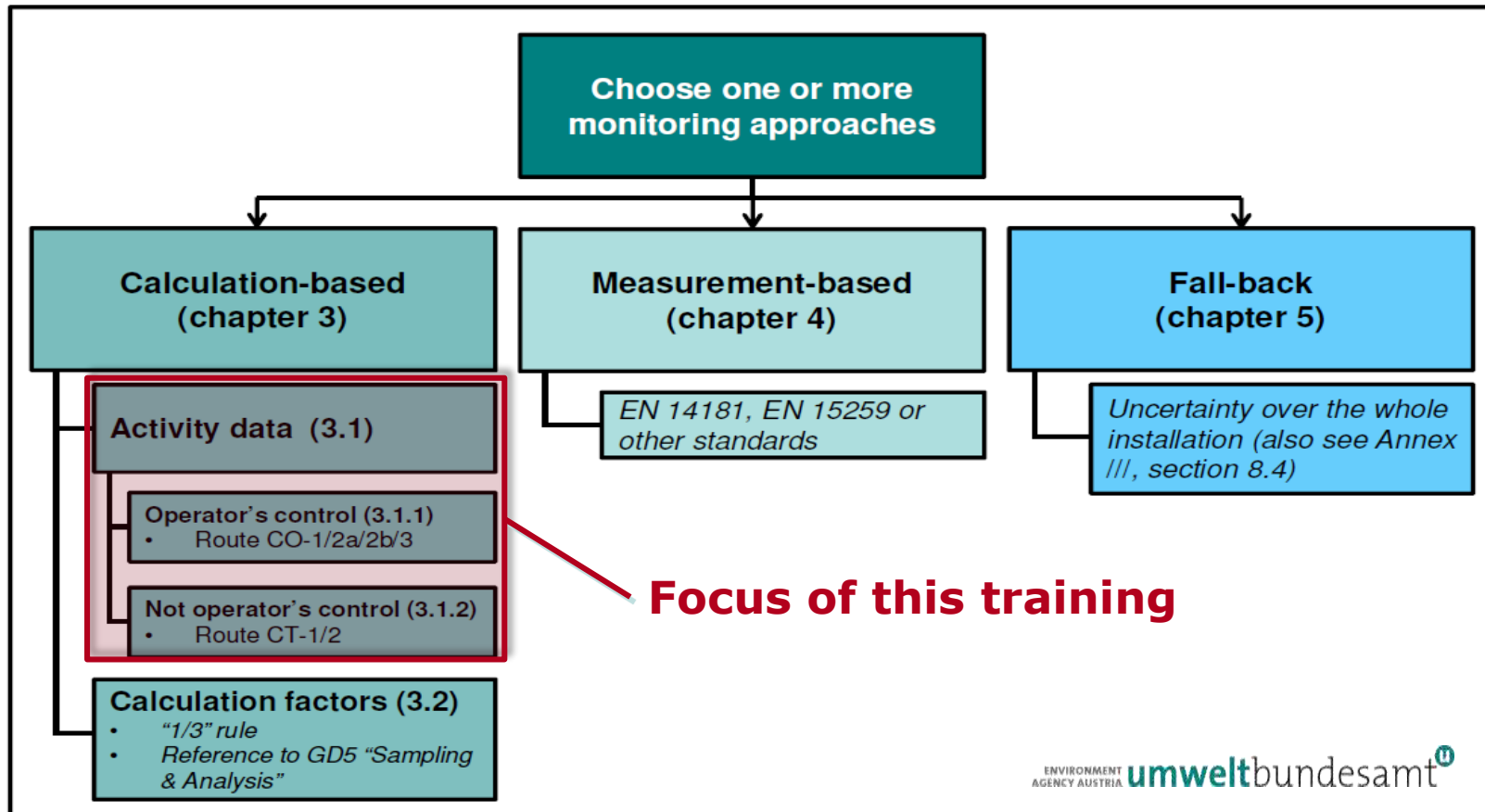
What is the best guess for your chances of stopping before hitting the wall?

≈69%

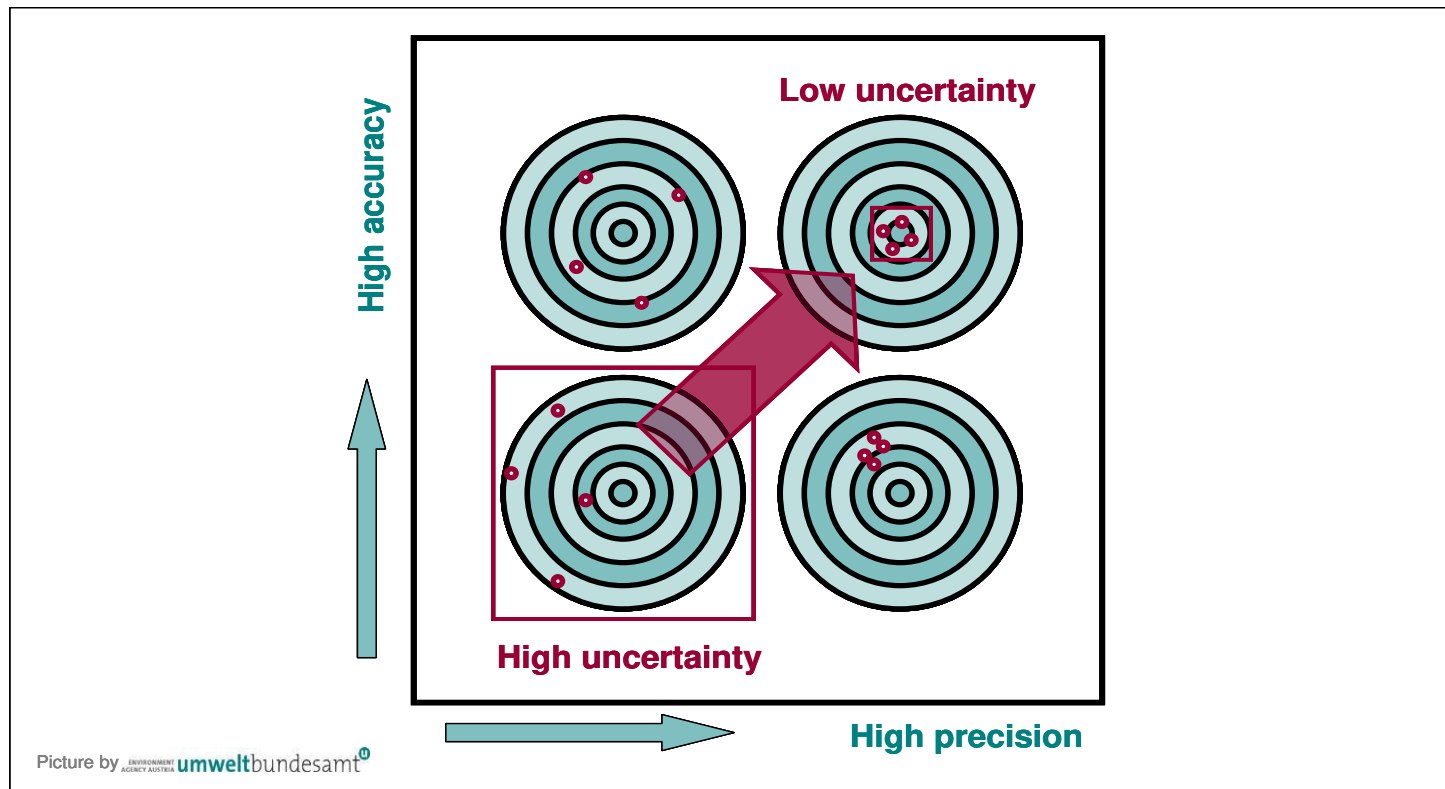
Uncertainty Assessment – Legal Requirements in MRVA

- **Article 12(1) MRR** requires the operator to submit to CA an uncertainty assessment as supporting document to the MP that should contain the following information:
 - Evidence for compliance with uncertainty thresholds for activity data
 - Evidence for compliance with uncertainty required for calculation factors, if applicable
 - Evidence for compliance with uncertainty requirements for measurement based methodologies, if applicable
 - If a fall-back methodology is applied, an uncertainty assessment for the total emissions

Structure of Guidance Document 4



What is Uncertainty?



Uncertainty – Definition in MRR

Article 3(6) MRR

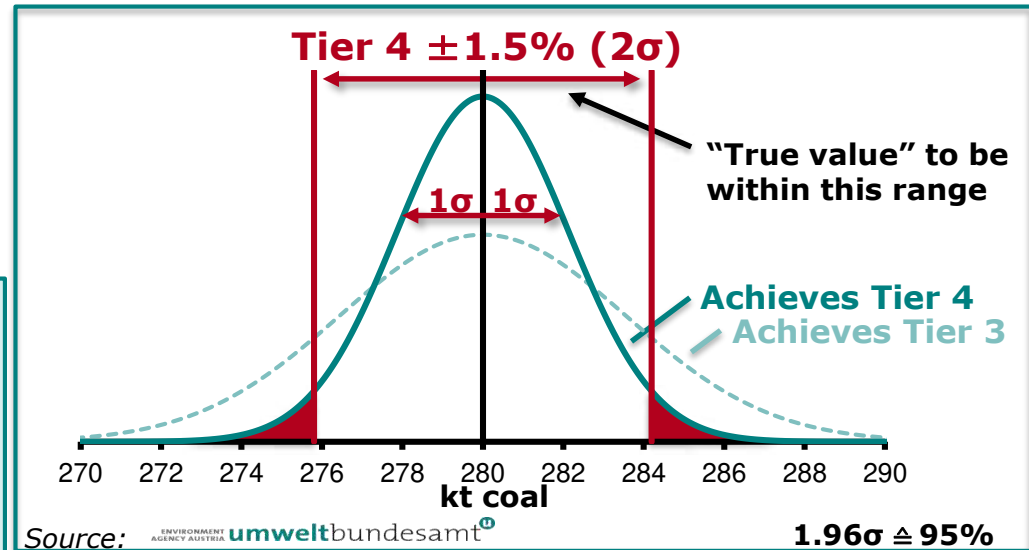
- *Uncertainty threshold of $x\%$ can be understood as the requirement that there is a **95% chance that the “true value” lies within $x\%$ of the measured value***

Uncertainty – What it means

Example: A category C installation consumes **280 kt coal**

- **Tier 4** is required for the determination of the fuel quantity
(**Uncertainty: $\pm 1.5\%$**)

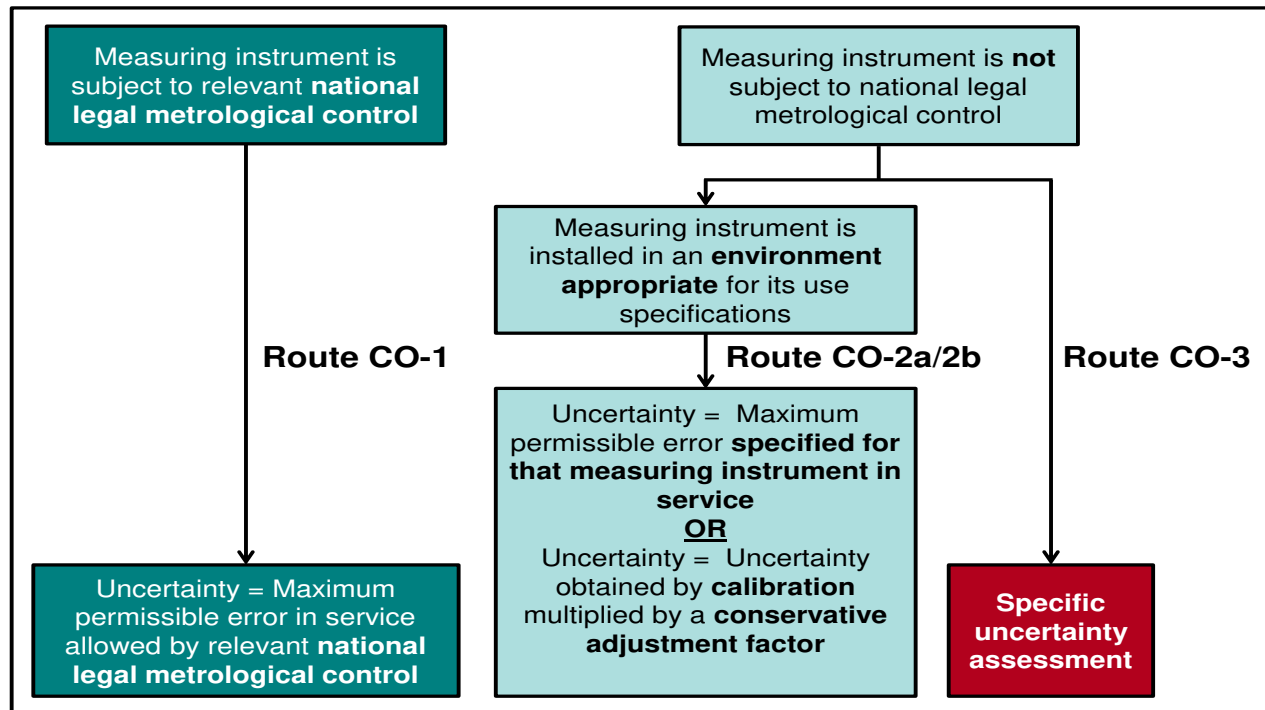
➤ This means that the measurement system needs to provide results that allow the "true value" to be within **280 ± 4.2 kt ($\pm 1.5\%$) at the 95% (2σ) confidence level.**



I THOUGHT I WAS
INTERESTED IN UNCERTAINTY
BUT NOW I'M NOT SO SURE

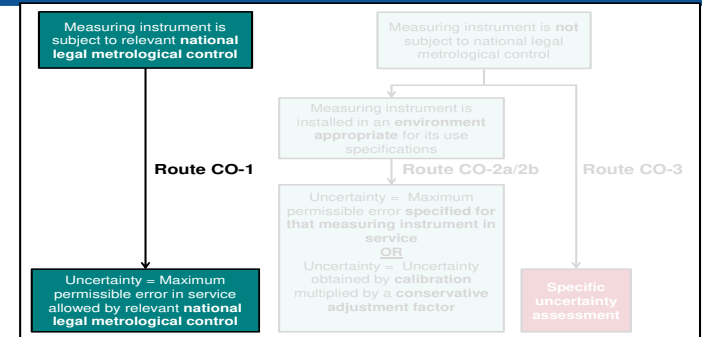


Operator's own control (Art. 28 MRR)



Source: EC Guidance Document 4

Route CO-1

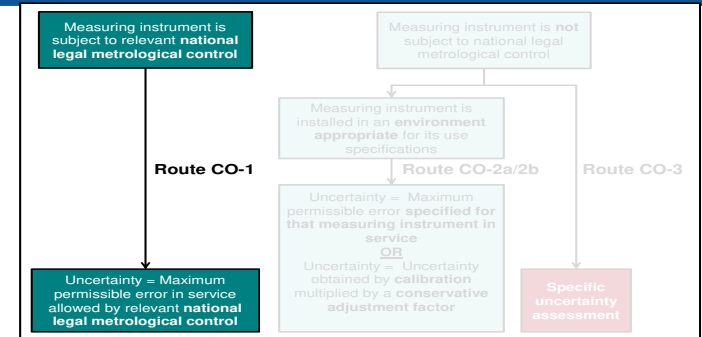


Measuring instrument (MI) is subject to relevant national legal metrological control (NLMC)

- *NLMC usually applicable where market transactions (trades) require the reference to accepted standards (traceability)*

➤ ***Overall uncertainty = Maximum permissible error in service (MPES from relevant NLMC)***

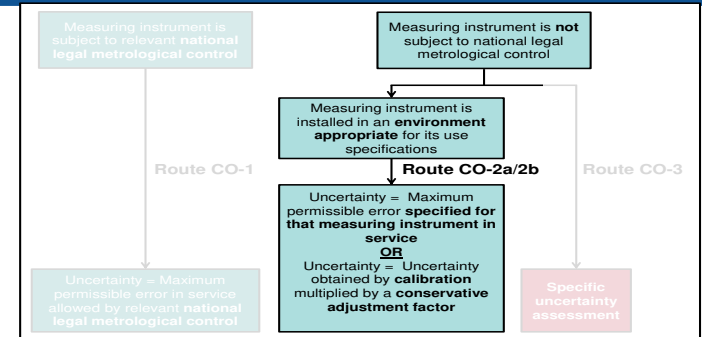
Route CO-1



How to demonstrate evidence?

- *The most appropriate evidence for being under NLMC is a **certificate of the latest (metrological) verification/(re-)calibration** of the instrument*
- *Alternatively, evidence (e.g. a picture) can be provided of the **legal metrology label affixed to the MI***

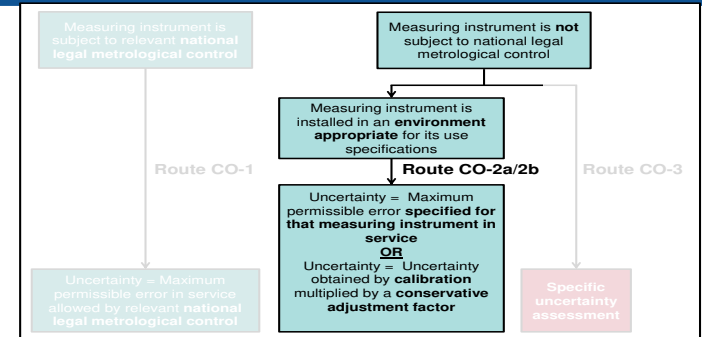
Route CO-2a and CO-2b



- *Two further simplifications applicable if MI is installed in an environment appropriate for its use specifications*
- **What is such an environment?**
 - **Step 1:** Operating conditions regarding relevant influencing parameters (e.g. flow rate range, medium, T, p,..) and maximum permissible deviations for those are available
 - **Step 2:** Operating conditions under step 1 are met (e.g. making a checklist of each relevant influencing parameter)
 - **Step 3 and 4:** Perform (further) quality assured calibration procedures

➤ **Only if all 4 steps are met → MI regarded as installed in an environment appropriate for its use specifications**

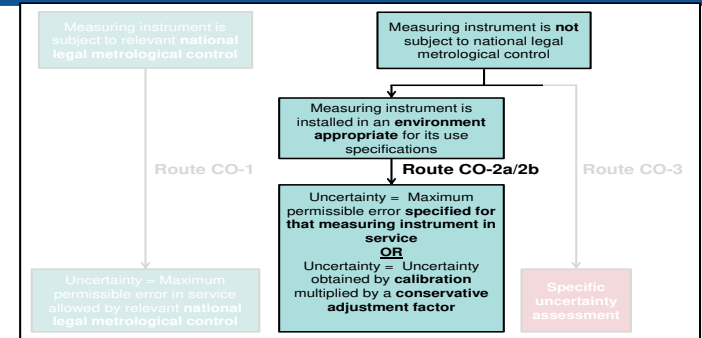
Route CO-2a



- Only if all of the 4 steps are met, it may be assumed that:
 - manufacturer's specifications,
 - specifications from legal metrological control, and
 - guidance documents such as the Commission's guidance (Annex II of Guidance Document 4 provides conservative values for uncertainty ranges of common measuring instruments and additional operating conditions)
- **are suitable sources for the maximum permissible error in service**

➤ **Overall uncertainty = Maximum permissible error in service (MPES from suitable source)**

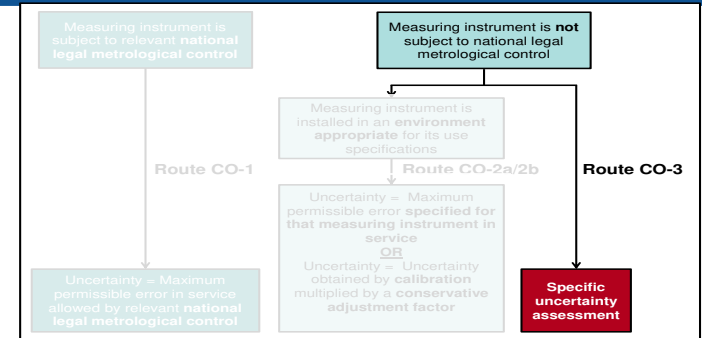
Route CO-2b



- Only if all of the 4 steps are met, it may be assumed that:
 - the **expanded uncertainty from calibration**, multiplied by
 - a **conservative adjustment factor** (e.g. 2) to take into account any further errors in service
- *can be used as the overall uncertainty*

➤ **Overall uncertainty =**
Uncertainty from calibration ×
conservative adjustment factor (to convert to "in service")

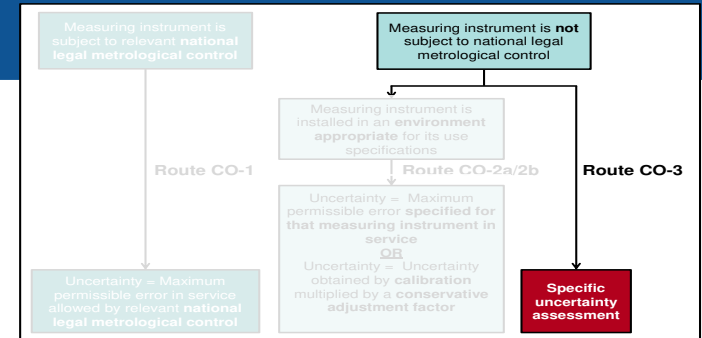
Route CO-3



- ***MI not installed in an environment appropriate for its use specifications, or this cannot be demonstrated → carry out specific uncertainty assessment (e.g. using GUM – Guidance to Expression of Uncertainty in Measurement)***

➤ ***No simplification route applies:
Carry out specific uncertainty assessment***

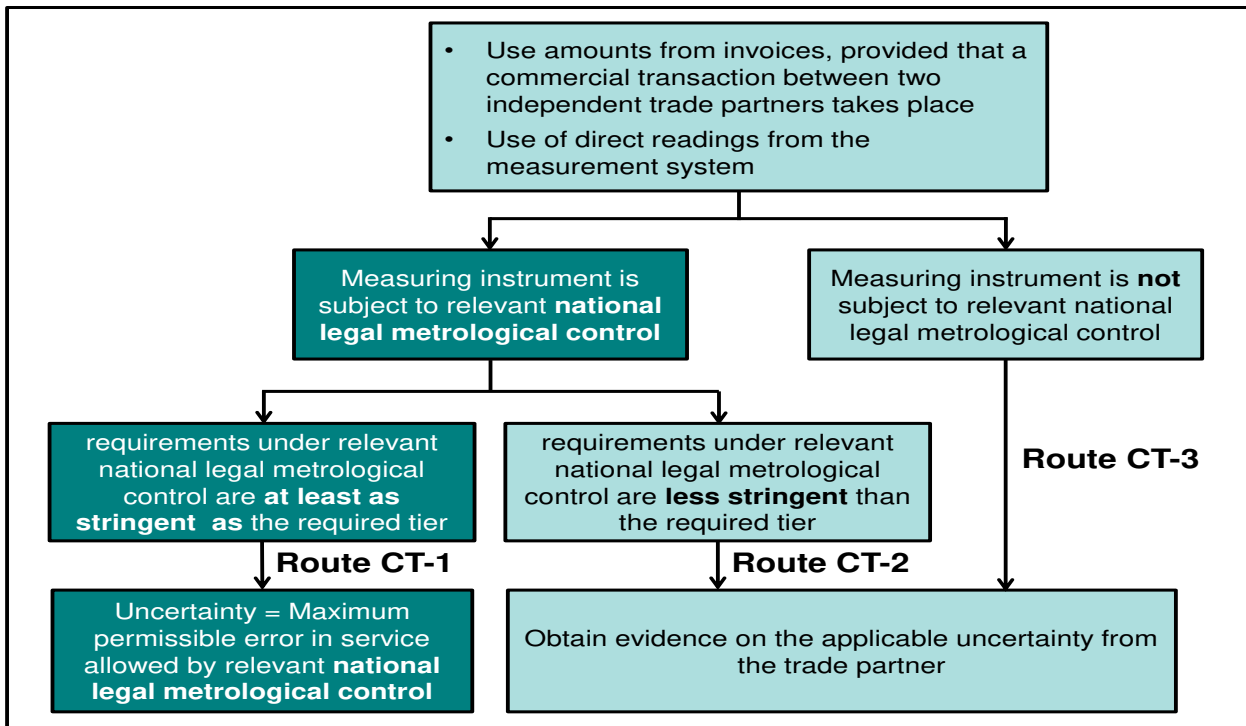
Route CO-3



How to demonstrate evidence to CA

- In principle the **uncertainty assessment shall comprise**
 - the specified uncertainty of the applied measuring instrument
 - the uncertainty associated with the calibration
 - any additional uncertainties connected to how the MI is used in practice (“in service”), e.g. drift, not appropriately installed, etc.
- **Starting point might be uncertainties obtained from Routes 1 or 2, where applicable, taking into consideration further possible influences**

MI under trading partner's control (Art. 29)



Source: EC Guidance Document 4

Routes CT

Conditions:

- *Operator must confirm that those instruments allow the operator to comply with*
 - at least as high a tier,
 - give more reliable results and
 - are less prone to control risks than own instruments

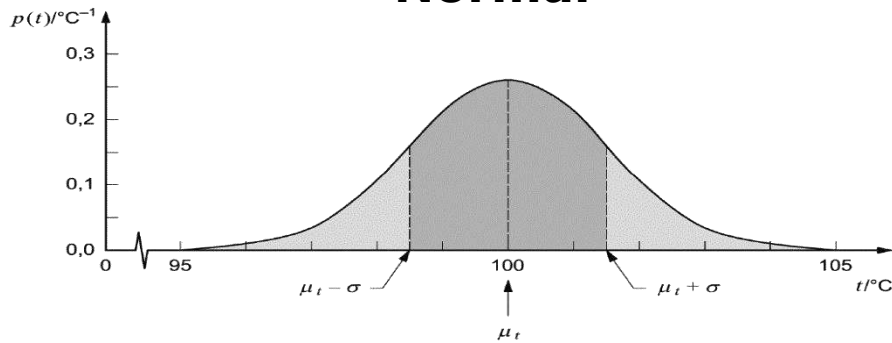
Derogations

- *What if none of the Routes provides evidence that the required tier can be met?*

- Carry out **corrective action**, e.g. install a measurement system that meets the required tier, **OR**
- Provide evidence that meeting the required tier is **technically infeasible** or would incur **unreasonable costs**

Type of distributions

Normal

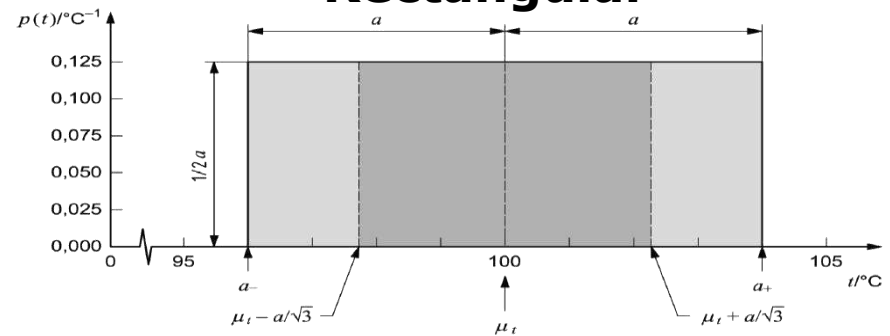


Standard uncertainty
 u (standard deviation)

Typical occurrences

- Calibration reports
- Manufacturer's specifications
- Combined uncertainties

Rectangular



Standard uncertainty
 $u = \frac{a}{\sqrt{3}}$

Typical occurrences

- Maximum permissible errors
- Tolerances
- Reference book values

Propagation of uncertainties

Why and when is this needed?

- *The measurand, the particular "output" quantity (Y) subject to measurement, is often not directly measured
→ e.g. not just one MI involved in determination of AD*
- *Instead, "input" quantities (X_i) are measured on which the "output" quantity depends*

How is this done? $Y = f(X_1, X_2, \dots, X_n)$

- *Express mathematical function:*

$$R = f(V, I) = \frac{V}{I}$$

- **Example:** Electrical resistance of a resistor not directly measured but calculated from measuring voltage and current

Propagation laws: uncorrelated

$$U_Y = \sqrt{\left(\frac{\partial Y}{\partial X_1} \cdot U_{X_1}\right)^2 + \left(\frac{\partial Y}{\partial X_2} \cdot U_{X_2}\right)^2 + \dots + \left(\frac{\partial Y}{\partial X_n} \cdot U_{X_n}\right)^2}$$

- Propagation of uncertainty of a sum*

Example: total fuel oil consumption of two boilers, each equipped with one flow meter (F1, F2)

F1: 10,000 t (standard uncertainty: 1%)

F2: 7,500 t (standard uncertainty : 3%)

$$u_{total} = \frac{\sqrt{(U_1)^2 + (U_2)^2}}{|x_1 + x_2|} = \frac{\sqrt{(100)^2 + (225)^2}}{17,500} = 1.4\%$$

$$\Rightarrow u_{95\%} (k = 2) = 2.8\%$$

- Propagation of uncertainty of a product*

Example: determination of mass from volume and density

Volume: standard uncertainty 1.5%

Density: standard uncertainty 3%

$$\frac{U_m}{m} = u_m = \sqrt{u_v^2 + u_\rho^2} = \sqrt{1.5\%^2 + 3\%^2} = 3.35\%$$

$$\Rightarrow u_{95\%} (k = 2) = 6.7\%$$

Propagation laws: correlated

$$U_Y = \left(\left| \frac{\partial Y}{\partial X_1} \right| \cdot U_{x_1} \right) + \left(\left| \frac{\partial Y}{\partial X_2} \right| \cdot U_{x_2} \right) + \dots + \left(\left| \frac{\partial Y}{\partial X_n} \right| \cdot U_{x_n} \right)$$

- *Propagation of uncertainty of a sum*

Example: purchased limestone weighed on the same truck scale (weighing bridge)

Weighing bridge: standard uncertainty: 0,5%
100 deliveries about 10t each

$$u_{total} = \frac{U_1 + U_2 + \dots + U_n}{|x_1 + x_2 + \dots + x_n|} = \frac{100 \cdot 0.05}{1,000} = 0.5\%$$
$$\Rightarrow u_{95\%} (k = 2) = 1\%$$

- *Propagation of uncertainty of a product*

$$u_{total} = u_1 + u_2$$

Example: loss on ignition of clay → material before and after ignition weighed on the same scale

Tool for unreasonable costs

- *Similar functioning as tool for "unreasonable costs"*
- *Contains guidance based on GD4/GD4a*
- *Contains further guidance on how to proceed if a parameter is unknown (e.g. type of distribution) → conservative values applied*

a. Amount of fuel or material imported to/consumed within the installation

	Quantity (Import, Consumption,..)	Quantity per measurement [e.g. t or Nm ³]	Annual number of measurements	Annual quantity [e.g. t or Nm ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
i.	Import from supplier XY	25	400	10 000	1,23%	normal	standard	not in service	2,0	uncorrelated
ii.										
iii.										
iv.										
v.										

Example: Clay in ceramics plant

- ***Specific information***
 - Clay is gathered from the clay pit directly by the operator
 - Operator transports the clay from the pit to the installation on trucks
 - Trucks weighed on a weighing bridge owned by the operator
 - No commercial transaction → not subject to NLMC
 - Measurement instrument is used in an environment appropriate for its use specifications ("Route CO-2a")
- *See more details in Guidance Document 4a*

Example – Step-by-step approach

- **Step 1:** Mathematical relationship $Q = P - E + (S_{\text{begin}} - S_{\text{end}})$

- **Step 2:** Determine standard uncertainty “in service” for each input quantity

- Route 2a: MPES from manufacturer’s specification for **P** (e.g. $\pm 1\%$)
→ MPES usually rectangular distribution → convert to standard uncertainty

$$u_{Pi} = \left(\frac{MPES}{\sqrt{3}} \right)$$

- Route 3: (Simplified) uncertainty assessment for **S_{begin, end}** (e.g. standard $u \pm 5\%$)

- **Step 3:** Check for any correlation between input quantities (e.g. all **P_i** correlated because they are measured on the same instrument)

- **Step 4:** Combine uncertainties $u_Q = \frac{\sqrt{2 \cdot (U_S)^2 + (U_P)^2}}{Q}$

- **Step 5:** Calculate expanded uncertainty $u_{(95\%, k=2)} = 2 * u_Q$

Example: Clay in ceramics plant

Suppose:

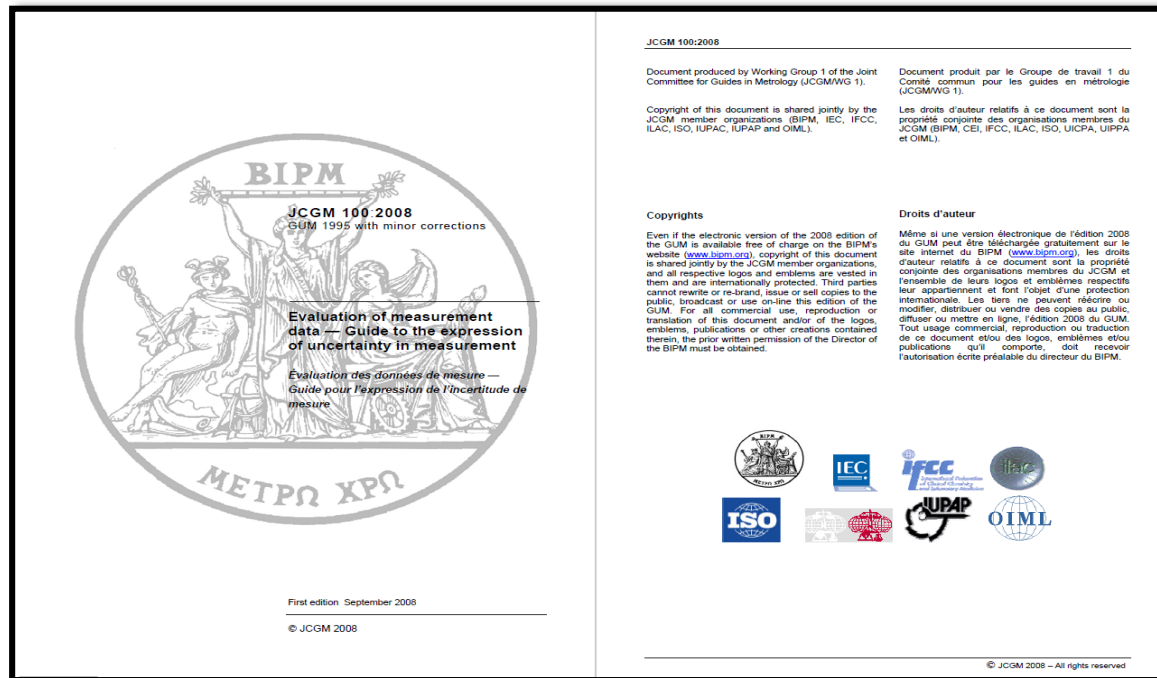
- Annual total amount of clay consumed (P) = 125,000t
- Stock level capacity = 10,000t

$$u_Q = \frac{\sqrt{2 \cdot (10,000 \cdot 5\%)^2 + \left(125,000 \cdot \frac{1\%}{\sqrt{3}}\right)^2}}{125,000} = 0.8\%$$

- Expanded uncertainty $u_{(95\%, k=2)} = 2 * 0.8\% = \mathbf{1.6\%}$

*Demonstration of this example in the
“**uncertainty assessment tool**”*

The "GUM"



Evaluation of measurement data — Guide to the expression of uncertainty in measurement (JCGM 100:2008)

Questions?



Where to find more information?

Regulation No. 601/2012 (MRR)

<https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1573811654278&uri=CELEX%3A02012R0601-20190101>

Guidance Documents on European Commission's website

https://ec.europa.eu/clima/policies/ets/monitoring_en#tab-0-1

in particular Guidance Documents 4, 4a and the M&R Uncertainty Training Handbook

Annex II: Case Studies and Model Answers (Suggested Approaches)

- **Example 1:** Fuel oil delivered on trucks
- **Example 2:** Petcoke
- **Example 3:** Natural gas meter with electronic volume converter

Note that these three examples and model answers are taken from the previous training event held on 31 May 2016. They are only amended with model solutions as to how the situation should be reflected in the “uncertainty assessment tool”.

Example 3 corresponds to example 8 of that event.

- **Example 4:** Natural gas exported to non-ETS installations

Disclaimer: *Each example (except Example 10 which is informative as it stands) is accompanied by a ‘model’ answer (approach) that aims to facilitate understanding for participants and to illustrate at least one possible solution for each case. Each answer recognises the simplifications provided by the M&R Regulation in order to carry out an uncertainty assessment with proportionate effort. As a consequence, it is not claimed that these ‘model’ answers show the only correct solution(s). Other approaches might be technically and scientifically correct as well and fully in line with the requirements in the M&R Regulation for carrying out an uncertainty assessment.*

Uncertainty assessment, example 1:

Fuel oil delivered on trucks from many different suppliers

The overall annual consumption of gasoil is calculated from the aggregated deliveries with tank trucks (see Art. 27 (1) b) MRR):

$$Q = P - E + (S_{\text{begin}} - S_{\text{end}})$$

where:

PPurchased quantity of fuel oil over the whole year

EExported quantity of fuel oil the whole year

S_{begin}.....Stock level reading of fuel oil at the beginning of the year

S_{end}.....Stock level reading of fuel oil at the end of the year

- The trucks are equipped with flow meters on the truck subject to national legal metrological control
 - Maximum Permissible Error: 0.5%.
 - Each truck delivery: 25,000 litres of fuel oil.
 - Number of truck deliveries per year: 50
- Fuel oil is stored in tanks on-site:
 - Storage capacity of 30,000 litres
 - Uncertainty of level reading (k=1): 2.5%

QUESTION A) How should the overall expanded uncertainty of the amount of fuel oil be calculated?

QUESTION B) Is there any information missing for calculating annual activity data of the fuel oil consumption and associated uncertainties?

QUESTION C) What further supporting evidence would you request from the operator?

PLEASE USE THE TOOL FOR “UNCERTAINTY ASSESSMENT”, TO THE EXTENT POSSIBLE.

Uncertainty assessment, example 1: Model answers

Fuel oil delivered on trucks from many different suppliers

ad A)

In total, there are 50 truck deliveries per year, each with a typical load of 25,000 litres of fuel oil. Each delivery is measured by the flow meter on each truck. Deliveries each have an uncertainty (MPES) of 1.0% and can be treated as uncorrelated input quantities to determine P, the annual quantity of purchased fuel oil.

How should the calculations be done if the type of uncertainty distribution is known?

As a first step, the MPES, which usually of a rectangular distribution, has to be converted to normal distribution by dividing by the square root of 3:

$$u_{Pi} = \frac{MPES}{\sqrt{3}} = \frac{1.0\%}{\sqrt{3}}$$

The uncertainty related to the stock level reading is the same for both readings (beginning and end of the year). As the difference between S_{begin} and S_{end} may not be predictable, $S_{begin}-S_{end}$ can be assumed as zero. However, the uncertainty related to both readings must not be omitted.

Subsequently, in accordance with the example 7 in section 8.3 of guidance document 4, the following equation can be used to determine the uncertainty:¹

$$u_Q = \frac{\sqrt{2 \cdot (U_S)^2 + n \cdot (U_{Pi})^2}}{P}$$

where:

u_Q total (relative) uncertainty associated of Q (i.e. total annual quantity of fuel oil consumed)

U_S, P_i (absolute) uncertainty of the stock level reading or quantity provided by one truck

$$u_{Q(k=1)} = \frac{\sqrt{2 \cdot (30,000 \cdot 2.5\%)^2 + 50 \cdot (25,000 \cdot \frac{1.0\%}{\sqrt{3}})^2}}{50 \cdot 25,000} = 0.12\%$$

$$\text{expanded uncertainty (95\%): } u_{Q(k=2)} = 2 \cdot 0.12\% = 0.24\%$$

¹ Note that this equation is only valid if all individual measurements are uncorrelated. However, in reality there might be a considerable correlation, in particular if only a small number of different trucks are used.

How to enter this information in the “uncertainty assessment tool”?

a. Amount of fuel or material imported to/consumed within the installation

Quantity (Import, Consumption,...)	Quantity per measurement [e.g. t or Nm ³]	Annual number of measurements	Annual quantity [e.g. t or Nm ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
i. Fuel oil on trucks	25 000	50	1 250 000	1,00%	rectangular		in service		uncorrelated

c. Storage capacity for the fuel or material in the installation

Quantity stored	Storage capacity [e.g. t or m ³]	Storage capacity [e.g. t or m ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
Storage tank	30 000	30 000	2,50%	normal	standard	in service		uncorrelated

e. Average annual quantity consumed [e.g. t or Nm³]

1 250 000

Storage capacity (share of annual quantity):

2,4%

f. Total uncertainty (k=1, 1σ, 68%)

0,12%

g. Total uncertainty (k=2, 2σ, 95%)

0,24%

What should be done if the type of uncertainty distribution is not known?

In this case the overall expanded uncertainty may be calculated as follows:

$$u_{Q(k=2)} = \frac{\sqrt{2 \cdot (30,000 \cdot 5.0\%)^2 + 50 \cdot (25,000 \cdot 1.0\%)^2}}{50 \cdot 25,000} = 0.22\%$$

ad B)

So far, we have only calculated uncertainty related to the annual amount of fuel oil consumed, expressed as litres. However, for the multiplication with NCV and EF for the determination of annual emissions, the annual quantity needs to be expressed as tonnes.

Therefore, the operator has to describe in the monitoring plan how the density of the fuel oil is determined and how associated uncertainties are being assessed. For instance, if the density of a mixed sample from samples drawn from each fuel oil delivery is determined with an uncertainty (k=1) of 2%, the annual uncertainty of the quantity in tonnes would be as follows²:

$$u_{Q(\text{tonnes})} = \sqrt{u_{Q(\text{Volume})}^2 + u_{\text{density}}^2} = \sqrt{0.12\%^2 + 2\%^2} = 2\% \rightarrow u_{Q(k=2)} = 4\%$$

As can be seen, despite the very good uncertainty achieved for the volume-based quantity, the mass-based uncertainty is considerably higher in comparison. This is almost exclusively caused by the uncertainty related to the determination of the density. Therefore, if the operator has to achieve a higher tier, the uncertainty associated with the determination of the density would have to be improved, e.g. by measuring the density of each truck delivery.

ad C)

In principle, the operator should obtain copies of (metrological) verification certificates for the flow meters from each supplier. It may be reasonable for an operator to suggest the seeking of certificates only from a smaller number of suppliers which would still leave enough margin to prove that the overall uncertainty is well below the next tier threshold. How many certificates are sought with a year and how it is ensured that track is kept appropriately, may best be addressed by an appropriate procedure which would be part of the monitoring plan and subject to the CA's approval, provided that the sampling of the selection is done in a representative way, e.g. randomly.

In addition to that, the operator should provide you with further information of how he determined the uncertainty of the stock readings. However, with storage facilities capable of containing only less than 5 % of the annual quantity of fuel oil (30,000/1,250,000), Art. 28(2) of the MRR would also allow to exclude stock level readings from the uncertainty assessment in the first place.

² assuming measurements of volume and density are not correlated to any significant extent.

Example 2:

Uncertainty Associated with Measurement of Petcoke Activity Data

Petcoke usage in an installation is determined by aggregation of metering of quantities separately delivered taking into account relevant stock changes (see Art. 27 (1) b) MRR), using the following formula:

$$Q = P - E + (S_{\text{begin}} - S_{\text{end}})$$

where:

- PPurchased quantity over the whole year
- EExported quantity of petcoke over the whole year
- S_{begin}.....Stock of petcoke at the beginning of the year
- S_{end}.....Stock of petcoke at the end of the year

The weighbridge (scale interval 25 kg) used for the purchased amount of petcoke delivered on trucks is subject to Legal Metrological Control.

- Maximum Permissible Error: +/- 1.5 scale intervals.
- Truck deliveries per year: 95
- Typical load on each truck: 30t (=total purchased amount of 2,850t)
- No export of petcoke.

Stock measurements are carried out at year end to determine closing stock / opening stock. There is a maximum surveyors uncertainty of 1-1.5%. A value of 1.5% is chosen as a worst case scenario.

For the weighbridge (25kg scale interval; typical load of 30t), an adjustment factor of x 2 is applied for converting the MPE (+/- 1.5 scale intervals) to MPE "in service".

$$MPES = \frac{1.5 \cdot 25kg \cdot 2}{30,000kg} = 0.25\%$$

The operator follows the example provided in MRR Guidance Document 4, section 8.3, and provides you with the following calculation of the overall uncertainty:

$$u_{\text{petcoke},(k=2)} = \frac{\sqrt{2 \cdot (1,300 \cdot 1.5\%)^2 + 95 \cdot (30 \cdot 0.25\%)^2}}{2,850} = 0.97\%$$

QUESTION A) Do you agree with the way the operator calculated the overall uncertainty?

QUESTION B) What further supporting evidence would your request from the operator?

PLEASE USE THE TOOL FOR "UNCERTAINTY ASSESSMENT", TO THE EXTENT POSSIBLE.

Uncertainty assessment, example 2: Model answers

Uncertainty Associated with Measurement of Petcoke Activity Data

ad A)

The general outline of the uncertainty assessment seems to be reasonable. However, the operator failed to provide you with one very important information: what coverage factor is used for the uncertainty assessment.

Without further information, the term “uncertainty” is commonly understood as the “standard” uncertainty, i.e. the uncertainty related to the coverage factor of 1 implying a confidence level of only 68%.

For instance, if the uncertainty related to the stock surveyors of 1.5% only corresponds to the 68% confidence level (k=1), the whole calculation of the overall uncertainty would only correspond to the coverage of k=1 and would need to be multiplied by 2 to obtain the uncertainty at the 95% level.

Moreover, the operator assumed that individual measurements are uncorrelated. However, in reality this may not be the case as the same weighbridge is used for all measurements. In the absence of further information on correlation it would be the more conservative approach to assume correlation between measurements.

How should the calculations be done if the type of uncertainty distribution is known?

Furthermore, a minor incorrectness (minor only in this specific case due to the figures provided) concerns the use of the MPES for the weighing bridge. If this was the sole MI used for determination annual quantities the use of MPES without further adjustment would be allowed by the MRR. However, this is not the case because also stock changes are factored in as well. Where an MPES is combined with other uncertainties it would, as a first step, have to be appreciated that an MPES most commonly exhibits a rectangular distribution and needs to be converted into a standard uncertainty (k=1) prior to combination. This is achieved by dividing the MPES by the square root of 3.

$$MPES = \frac{0.25\%}{\sqrt{3}}$$

When taking this into account and suppose the uncertainty related to the stock levels is indeed only the standard uncertainty, the correct calculation should look as follows:

$$u_{petcoke,(k=1)} = \frac{\sqrt{2 \cdot (1,300 \cdot 1.5\%)^2 + (2,850 \cdot \frac{0.25\%}{\sqrt{3}})^2}}{2,850} = \frac{\sqrt{760.5 + 16.9}}{2,850} = 0.98\%$$

$$u_{petcoke,(k=2)} = 2 \cdot 0.98\% = 1.96\%$$

a. Amount of fuel or material imported to/consumed within the installation

Quantity (Import, Consumption,...)	Quantity per measurement [e.g. t or Nm ³]	Annual number of measurements	Annual quantity [e.g. t or Nm ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
i. Weighbridge measurements	30	95	2 850	0.25%	rectangular		in service		correlated

c. Storage capacity for the fuel or material in the installation

Quantity stored	Storage capacity [e.g. t or m ³]	Storage capacity [e.g. t or m ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
Survey	1 300	1 300	1.50%	normal	standard	in service		uncorrelated

e. Average annual quantity consumed [e.g. t or Nm³]

2 850

Storage capacity (share of annual quantity):

45,6%

f. Total uncertainty (k=1, 1σ, 68%)

0,98%

g. Total uncertainty (k=2, 2σ, 95%)

1,96%

Two things can be seen:

- Firstly, if the uncertainty related to the stock levels only denotes the standard uncertainty, the highest tier would no longer be achieved because the overall uncertainty at the 95% confidence level is above 1.5%.
- Secondly, as stated above, the treatment of the MPES only plays a minor role due to the high stock levels (1,300t) compared to the quantities purchased (2,850).

What should be done if the type of uncertainty distribution is not known?

In this case the overall expanded uncertainty may be calculated as follows:

$$u_{petcoke,(k=2)} = \frac{\sqrt{2 \cdot (1,300 \cdot 3.0\%)^2 + (2,850 \cdot 0.25\%)^2}}{2,850} = \frac{\sqrt{1,521 + 50.7}}{2,850} = 1.95\%$$

ad B)

Further supplementary evidence to be requested from the operator for uncertainty of the weighbridge may include e.g. certificate of the latest (metrological) verification or a picture of the affixed legal metrology label.

However, for the reasons given above, this is not the main source of the overall uncertainty. Instead, the surveyors are. Therefore, the operator should provide sound and robust evidence for the uncertainty provided on meters used including their uncertainties and how they were obtained (calibration, manufacturer's specification, "Steps 1 to 4" under Routes CO-2a/2b,..)

Uncertainty assessment, example 3:

Gas meter with electronic volume converter

An operator measures the activity data of natural gas using a gas flow meter which the manufacturer declared to be in conformity with OIML R 137, accuracy class 1. Since the flow meter only measures actual volume, it is equipped with an electronic volume converter (EVC) to convert actual volume measured to reference conditions.

- MPES of the gas meter for the usual flow range: $\pm 2\%$
- Uncertainty of the EVC (manufacturer's specifications): 0.5%

The operator suggests to calculate the overall uncertainty by considering these two parameters via the propagation rule for independent uncertainties of a product:

$$u_{overall} = \sqrt{u_1^2 + u_2^2}$$

QUESTION A) What is the overall uncertainty associated with the natural gas activity data?

QUESTION B) What kind of evidence would you request and is any information missing?

PLEASE USE THE TOOL FOR "UNCERTAINTY ASSESSMENT", TO THE EXTENT POSSIBLE.

Uncertainty assessment, example 3: Model answers

Gas meter with electronic volume converter

How should the calculations be done if the type of uncertainty distribution is known?

In order to combine uncertainties the MPES for the gas flow meter is divided by the square root of 3 to account for the rectangular distribution of the MPES. The resulting standard uncertainty (k=1) of the gas flow meter is combined with the standard uncertainty of the EVC using the formula suggested by the operator:

$$u_{natural\ gas,(k=1)} = \sqrt{\left(\frac{2\%}{\sqrt{3}}\right)^2 + 0.25\%^2} = 1.18\%$$

Finally, in order to obtain the overall uncertainty at the 95% confidence level, a coverage factor of two is applied to the combined uncertainty above:

$$\text{expanded uncertainty: } u_{natural\ gas,(k=2)} = 2 \cdot 1.18\% = 2.36\%$$

a. Amount of fuel or material imported to/consumed within the installation

Input quantity - name of parameter	Uncertainty related to the input quantity	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"
i. Flow meter	2,00%	rectangular		in service	
ii. Electronic volume converter	0,50%	normal	expanded	in service	
b. Are inputs under a) correlated or uncorrelated?		uncorrelated			
c. Total uncertainty (k=1)		1,18%			
d. Total uncertainty (k=2)		2,36%			

What should be done if the type of uncertainty distribution is not known?

In this case the overall expanded uncertainty may be calculated as follows:

$$u_{natural\ gas,(k=2)} = \sqrt{2\%^2 + 0.5\%^2} = 2.06\%$$

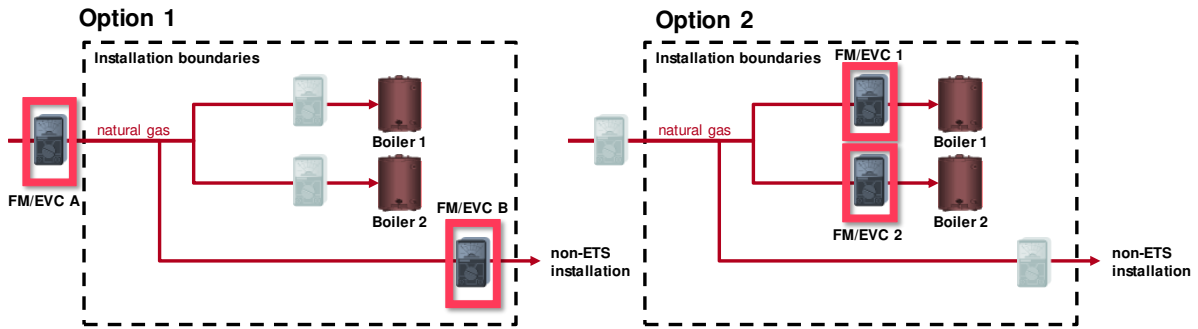
a. Amount of fuel or material imported to/consumed within the installation

Input quantity - name of parameter	Uncertainty related to the input quantity	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"
i. Flow meter	2,00%	unknown	expanded	in service	
ii. Electronic volume converter	0,50%	normal	expanded	in service	
b. Are inputs under a) correlated or uncorrelated?		uncorrelated			
c. Total uncertainty (k=1)		1,03%			
d. Total uncertainty (k=2)		2,06%			

Uncertainty assessment, example 4:

Natural gas exported to non-ETS installations

A category B installation is firing natural gas in two boilers. Part of the natural gas imported from the grid is exported to connected installations which are all non-ETS.



The annual consumption of natural gas can be determined by either of the following two options:

- **Option 1:** The difference between:
 - Flow meter (FM) A from the grid
 - Flow meter (FM) B to the non-ETS installation
- **Option 2:** The sum of:
 - Flow meter (FM) 1 to boiler 1
 - Flow meter (FM) 1 to boiler 2

Measuring instrument	MPES	Distribution	Annual amount [1 000 Nm ³]
Flow meter A (incl. EVC)	1,0%	Rectangular	230 000
Flow meter B (incl. EVC)	2,5%		50 000
Flow meter 1	1,5%	Unknown (manufacturer specifications say 95% and "in service")	120 000
EVC 1	0,5%		60 000
Flow meter 2	2,0%		
EVC 2	0,5%		

QUESTION A) Which option should the operator apply and why?

QUESTION B) What further evidence would you request?

PLEASE USE THE TOOL FOR "UNCERTAINTY ASSESSMENT", TO THE EXTENT POSSIBLE.

Uncertainty assessment, example 4: Model answers

Natural gas exported to non-ETS installations

@Question A:

Option 1

For this option the operator the results of the uncertainty assessment tool would be an expanded uncertainty of 1.68%.

a. Amount of fuel or material imported to/consumed within the installation

Quantity (Import, Consumption,..)	Quantity per measurement [e.g. t or Nm ³]	Annual number of measurements	Annual quantity [e.g. t or Nm ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
i. Main meter + EVC A	230 000	1	230 000	1,00%	rectangular		in service		

b. Amount of fuel or material exported from the installation

Quantity (Export)	Quantity per delivery [e.g. t or Nm ³]	Annual number of deliveries	Annual quantity [e.g. t or Nm ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
i. Sub-meter + EVC B	50 000	1	50 000	2,50%	rectangular		in service		

e. Average annual quantity consumed [e.g. t or Nm³]

180 000

Storage capacity (share of annual quantity):

0,0%

f. Total uncertainty (k=1, 1σ, 68%)

0,84%

g. Total uncertainty (k=2, 2σ, 95%)

1,68%

Option 2

This option is slightly more complex to reflect in the tool. As a first step, the operator would need to determine the uncertainties of the two flow meters adjacent to the boilers by taking into account the uncertainty of the EVCs by using the tools in sheet "Uncertainty_Product" (Note: this calculation is similar to the steps carried out for example 3).

a. Amount of fuel or material imported to/consumed within the installation

Input quantity - name of parameter	Uncertainty related to the input quantity	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"
i. Flow meter 1	1,50%	unknown	expanded	in service	
ii. EVC 1	0,50%	unknown	expanded	in service	

b. Are inputs under a) correlated or uncorrelated?

uncorrelated

c. Total uncertainty (k=1)

0,79%

d. Total uncertainty (k=2)

1,58%

a. Amount of fuel or material imported to/consumed within the installation

Input quantity - name of parameter	Uncertainty related to the input quantity	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"
i. Flow meter 2	2,00%	unknown	expanded	in service	
ii. EVC 2	0,50%	unknown	expanded	in service	

b. Are inputs under a) correlated or uncorrelated?

uncorrelated

c. Total uncertainty (k=1)

1,03%

d. Total uncertainty (k=2)

2,06%

Subsequently, the resulting uncertainties of 1.58% and 2.06%, respectively, have to be used in sheet "Uncertainty_Sum". The overall uncertainty of this option is then determined to be 1.26%

a. Amount of fuel or material imported to/consumed within the installation

Quantity (Import, Consumption,...)	Quantity per measurement [e.g. t or Nm ³]	Annual number of measurements	Annual quantity [e.g. t or Nm ³]	Uncertainty related to each measurement	Type of distribution	Standard or expanded uncertainty?	Value "in service"?	Conversion factor to "in service"	Correlated or uncorrelated?
i. Flow meter + EVC 1	120 000	1	120 000	1,58%	unknown	expanded	in service		
ii. Flow meter + EVC 2	60 000	1	60 000	2,06%	unknown	expanded	in service		
e. Average annual quantity consumed [e.g. t or Nm ³]					180 000		Storage capacity (share of annual quantity):		0,0%
f. Total uncertainty (k=1, 1σ, 68%)					0,63%				
g. Total uncertainty (k=2, 2σ, 95%)					1,26%				

As a consequence, option 2 allows to achieve a higher tier and should therefore be applied as the primary monitoring methodology. Option 1 should however be used for corroborative purposes to plausibility check results annually.