Working Group of Fluid Flow - WGFF

Consultative Committee of Mass – CCM

Review protocol for Fluid Flow Calibration and Measurement Capabilities (CMCs)
Draft A

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1. Introduction

At the 2012 meeting, the WGFF decided to develop a protocol for the submission and review of fluid flow (FF) CMCs that could be applied by all RMOs during the inter- and intra-regional review process. The following protocol was developed, with JCRB guidelines and the MRA review protocol in mind, to provide harmonized procedures and acceptance criteria for the FF CMC reviews. The goal is an efficient and consistent review process to produce CMCs that concisely reflect the NMIs' capabilities.

2. Revision procedure of inter RMO review

In order to reduce the time spent in the inter-RMO review the following review time line is proposed:

- Announcement of review by RMO maximum of 30 days after submission of CMC set. Coordination between RMO chairs should be done so that a submitted entry is reviewed only by one or two RMOs.
- The inter-regional review (including sending review report to the submitting lab) should be no longer than 60 days after the announcement of the review.
- The corrected CMC file should be sent by email within 30 days after the review report.
- Informal acceptance or denial of corrections should be sent by email within 14 days
- The accepted files should be posted for official approval immediately after the inter-regional review process is concluded.

3. General instructions for filling of the CMC sheet

The general instructions described herein complement the information and rules defined in the JCRB instructions for Appendix C.

3.1 Template

- Use the basic excel template from the BIPM web site (http://www.bipm.org/en/cipm-mra/documents/cmc_excel_files.html).
- Save a working copy of the file as "FF.Country.date.xls"; use the YYYY-MM-DD date format.
- Review the information on the "Field descriptions" and "Formatting instructions" worksheets.
- Edit header & footer of the page configuration of the excel sheet to change "NMI (Country)" to your names; insert the date of this version.
- Change the worksheet label from "template" to the name of your Country.
- Delete the unnecessary worksheets, save the file and send it to your RMO Flow Chairperson.

3.2 Language and symbols

- Only English should be used in the excel sheet and in all evidence documents sent.
- Decimal point (.) should be used, not comma (,).
- For volume use L or m^3.

- To define a range, use the word “to”, not a hyphen (-), e.g. use the format 10 L to 100 L or (10 to 100) L.

3.3 Criteria for creating a CMC Row

- A separate CMC row in the Excel spread sheet shall be made in each case of a distinct type of artefact (volume), a distinct measurand, or a distinct calibration procedure.
- In general, a single CMC row should be used for a particular method and flow measurement apparatus. For example a piston prover with multiple tubes should each be entered as a single CMC row and the same is true for a set of bell provers, or a set of working standard flow meters. A brief description that allows database users to identify the particular flow standard in other supporting documents and in comparison reports, e.g. “500 L bell prover”, should be entered under the “Reference Standard used in calibration”, “standard”, column N.
- Use only one CMC row for both the volume flow and mass flow capabilities of a reference standard and give the uncertainty of the fluid density in the “Comments” column Q. The smaller uncertainty measurand (volume flow or mass flow) should be listed in the “Expanded Uncertainty” column I since NMIs are not allowed to use smaller values in their calibration reports than those listed in their CMCs (see the ILAC Policy for Uncertainty in Calibration).
- Use the classification services described at the KCDB, Mass services.
- The range of important available parameters (e.g. temperature, pressure, fluid kinematic viscosity, gas types, pipe diameters, etc.) should be presented in separate rows in columns G and H.
- Hyperlinks for the comparisons should be supplied in the excel sheet, column P.

3.4 Expanded uncertainty

- The declared expanded uncertainty should take into consideration the best existing device according to the WGFF “Guidelines for CMC uncertainty and Calibration Report Uncertainty”.
- Although tables of uncertainty values are allowed for presentation of the expanded uncertainty, a single value or an equation are preferred.
- If a range of uncertainties is listed for a range of the measurand, the order of entries is important and the uncertainty is assumed to vary linearly between the range endpoints. For example, if a CMC states “1 L/min to 50 L/min” and the uncertainty statement is “0.1 % to 0.05 %” the uncertainty at 1 L/min is 0.1 %, the uncertainty at 50 L/min is 0.05 %, and the uncertainty at 25.5 L/min is 0.075 %.
- It is preferred that the uncertainty be stated in percent rather than the units of the measurand, for air speed, it is reasonable to use m/s.
- If a laboratory has used correlation methods to separate reference standard repeatability from Best Existing Device repeatability, the “Comments” column Q should include the statement “Contributions to the uncertainty from the device are not included”.

4. Revision table

The inter-regional review comments should be presented according to the following table:

Table 1 – Review comments

Service Identifier (CMC entry)	Comments	Response

Each CMC entry should have a separated comment line.
The file should have the date and identification of the RMO Chairperson.

5. Acceptance criteria (to be used in intra and inter RMO review)

5.1 General criteria

The CIPM guidance document CIPM MRA-D-04 (page 13) says the following concerning criteria for acceptance of CMCs:
"Furthermore, the JCRB requires that the range and uncertainty of the CMCs submitted be consistent with information from some or all of the following sources:
1. Results of key and supplementary comparisons
2. Documented results of past CC, RMO or other comparisons (including bilateral)
3. Knowledge of technical activities by other NMIs, including publications
4. On-site peer-assessment reports
5. Active participation in RMO projects
6. Other available knowledge and experience
While the results of key and supplementary comparisons are the ideal supporting evidence, all other five sources listed above may be considered to underpin CMCs not directly related to the available comparison results and those for which comparison results are not yet available."

The WGFF uses a three-level hierarchy during the review of CMCs to improve the efficiency of the review process. Experience and uncertainty publications give us a good idea of what uncertainty levels can be readily achieved for a given type of reference standard and what uncertainty levels require extraordinary effort, redundancy, and attention to detail. Incorporating this uncertainty experience into the WGFF CMC review process saves effort while maintaining CMC validity. Therefore, the degree of detail of CMC review will depend on the expanded uncertainty submitted by the laboratory (see tables below).

If the laboratory has participated in a key or supplementary comparison with consistent results and the declared uncertainty is equal or higher that the uncertainty stated in the comparison report, then the CMC is usually accepted. However, considering that Pilot labs normally use uncertainty weighting to calculate the Key Comparison Reference Value, comparisons will not always reveal incorrectly low uncertainty claims. For this reason, labs with exceptionally low uncertainties warrant detailed review of their uncertainty analyses (see Tables below).

If no comparisons are available for a specific entry and the laboratory has an established quality system, working procedures, or publications, the CMC can be approved based on other supplied information. For example, if a lab has reference standards linked together and validated by internal comparisons, this should be considered during the CMC review, and a CMC can be approved based on supplied information.

Table 2 – Volume CMC review criteria

Instrument/method	Detailed uncertainty analysis review and consistent comparison results required	Consistent comparison results required	Internal documents, publications, or other proof required
Glassware/gravimetry	< 0.01 %	0.01 % up to 0.05 %	> 0.05 %
Picnometer and Overflow tipe volume devices	< 0.005 %	0.005 % up to 0.01 %	> 0.01 %
Piston operating apparatus/gravimetry	< 0.1 %	0.1 % up to 0.5 %	> 0.5 %
Proving tanks/gravimetric	< 0.01 %	0.01 % up to 0.05 %	> 0.05 %
Proving tanks/volumetric	< 0.02 %	0.02 % up to 0.07 %	> 0.07 %

Table 3 – Liquid flow CMC review criteria

Instrument/method	Detailed uncertainty analysis review and consistent comparison results required	Consistent comparison results required	Internal documents, publications, or other proof required
Piston or displacement prover	< 0.03 %	0.03 % up to 0.1 %	> 0.1 %
Gravimetric standard	< 0.03 %	0.03 % up to 0.1 %	> 0.1 %
Secondary standard flow devices (i.e. turbine,coriolis, ultrasonic).	< 0.1 %	0.1 % up to 0.25 %	> 0.25 %

Table 4 – Gas flow CMC review criteria

Instrument/method	Detailed uncertainty analysis review and consistent comparison results required	Consistent comparison results required	Internal documents, publications, or other proof required
Piston prover	< 0.1 %	0.1 % up to 0.25 %	> 0.25 %
Bell prover	< 0.1 %	0.1 % up to 0.25 %	>0.25 %
PVTt or gravimetric standard	< 0.1 %	0.1 % up to 0.25 %	> 0.25 %
Secondary standard flow devices (i.e. turbine,coriolis, ultrasonic).	< 0.15 %	0.15 % up to 0.3 %	> 0.3 %

Table 5 – Flow speed CMC review criteria

Instrument/method	Detailed uncertainty analysis review and consistent comparison results required	Consistent comparison results required	Internal documents, publications, or other proof required
LDV	≤ 0.1 %	0.1 % up to 0.3 %	> 0.3 %

Anemometer	≤ [0.3+0.2/u(m/s)] %	[0.3+0.2/u(m/s)] % up to [1+1/u(m/s)] %	> [1+1/u(m/s)] %
Anemometer or current meter	≤ [0.1+0.8/u(m/s)] %	[0.1+0.8/u(m/s)] % up to [0.5+2.5/u(m/s)] %	> [0.5+2.5/u(m/s)] %

5.2 Specific criteria

Volume

- For the gravimetric method there are three different types of instruments that need separate comparison evidence: glassware, proving tanks (test measures), and piston operating apparatus.
- The volumetric method should have a separate entry from the gravimetric method.
- The capacity of the instrument used in the comparisons is not a restriction to the presented range of the CMCs if the calibration method used and reference conditions are the same.
- A different CMC line should be present for on-site volume calibrations.

Gas flow

- In general, a single CMC row should be used for a particular method or flow measurement apparatus. For example, a piston prover with multiple tubes, a set of bell provers, or a set of working standard flow meters should be entered as a single CMC row.

Liquid flow

- The criteria in Table 3 is not applied for flow standards at extreme conditions, such as very small flow rate, cryogenic flow, high temperature flow, volatile liquid flow, high viscos flow and so on. For these standard, which are difficult to realize, detailed uncertainty analysis review is necessary regardless of its uncertainty value.

Flow speed

- Because of the wide dynamic range, formulas expressing the uncertainty as a function of the flow speed are commonly used, e.g. [0.6 + 1/u(m/s)] % where u is the flow speed.

Unique standard

- If the metrological standard under review is unique and there is no possibility to conduct an inter-comparison, the calibration principle, the facility, the calibration procedure and the uncertainty analysis must be described in a separate document in detail. Prior to the CMC submission, it is highly recommended to make the above descriptions public by publishing a research paper or making a presentation at an academic meeting, such as a WGFF workshop , FLOMEKO, ISFFM, etc.. An on-site review by a technical expert can be an alternative.

6. References

1. WGFF Guidelines for CMC Uncertainty and Calibration Report Uncertainty, 2012
2. Calibration and Measurement Capabilities in the context of the CIPM MRA - CIPM MRA-D-04 Jan. 2011
3. Traceability in the CIPM MRA - CIPM/2009-24 Oct. 2009
4. JCRB guidelines for the monitoring and reporting of the operation of quality systems by RMOs - CIPM MRA-G-02 Jan. 2011
5. Guidelines for the review of CMCs and the monitoring and reporting of the operation of quality systems by international intergovernmental organizations who are signatories of the CIPM MRA - CIPM MRA-G-03 Nov. 2008
6. Recommendations for on-site visits by peers and selection criteria for on-site visit peer reviewers - CIPM/2007-25 Apr. 2008
7. Uncertainty contributions of the device under calibration or measurement - JCRB-8/9 Feb. 2002
8. Subcontracting of measurements under the CIPM MRA - CIPM/2005-09
9. ILAC Policy for uncertainty in calibration, ILAC-P14:12/2010.