

# Guidelines for Submission and Review of Calibration and Measurement Capabilities

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## Consultative Committee for Mass and Related Quantities

### 1. Introduction and general considerations

This document provides guidance on how National Metrology Institutes (NMIs) or Designated Institutes (DIs) submit Calibration and Measurement Capabilities (CMCs) for mass and related quantities and describes the CMC review procedure followed by the Consultative Committee for Mass (CCM), its Working Groups (WGs), and the Regional Metrology Organizations (RMOs). The Joint Committee of the RMOs and the BIPM (JCRB) is responsible for coordinating the submission and review of CMCs for Appendix C of the Mutual Recognition Arrangement (MRA). JCRB documents available at: <http://www.bipm.org/en/committees/jc/jcrb/documents.html> give general information related to the CMC review process, acceptance criteria, etc. This Guide is based on the CIPM MRA-D-04 document version 5 (March, 2017), taking into account the Recommendations from the WG on the Implementation and Operation of the CIPM MRA (2016). It is intended to help make CMC reviews more efficient by avoiding redundant CMC entries and applying an informed sampling process to CMC reviews (a risk based approach). As explained in Section 2.5, Working Groups may use expertise about their measurands to set criteria whereby more proof is required to support CMCs of small uncertainty claims and less proof is required for large uncertainty claims. This document also advises CMC reviewers on how to use comparison reports and other provided evidence to assess CMC claims.

The measurement capabilities of NMIs are published, after final approval, in Appendix C of the BIPM key comparison database (KCDB), maintained by the BIPM and publicly available on the Web (<https://kcdb.bipm.org/>). In order for CMCs to be approved for publication in Appendix C, they must first be reviewed and approved by the Technical Committees (TCs) of the RMO. Once this approval is obtained, CMCs undergo an inter-regional review, where TCs from other RMOs verify that the JCRB criteria for acceptance of data for Appendix C have been followed, thus providing the technical confidence required for publication. The Working Groups of the Consultative Committee for Mass facilitate this process and may develop their own guidelines that give more specific instructions, for instance preferred SI units for particular measurands and criteria for reviewing CMC claims.

### 2. CMC preparation and review

The CMC review process can be divided into three stages: 1) preparation of the CMCs by the NMI/DI for submission to their RMO, 2) intra-regional review by the RMO, and 3) inter-RMO review.

## 2.1. Preparation of CMCs

Section 2 of the [CIPM MRA-D-04](#) specifies the format to be used in reporting CMCs in an Excel spreadsheet template. The instructions given here are a sample of the information and rules given in those instructions.

### 2.1.1. Template

- Use the [Excel template for CMCs](#) from the BIPM web site.
- Save a working copy of the file as “ZZ.Country.date.xls”; use the YYYY-MM-DD date format. The field “ZZ” is a one or two letter code for the various measurands under the CCM where M=mass, F=force, P=pressure, D=density, H=hardness, FF=fluid flow, V=viscosity, T=torque, G=gravity, and MM=material metrology.
- Review the information on the “Field descriptions” and “Formatting instructions” worksheets of the Excel template.
- Edit header & footer of the page configuration of the excel sheet to change “NMI (Country)” to your names; insert the date of this version. In case of more than one NMI/DI per Country, all the NMI/DI acronyms should be reported in the header.
- In the table, at the right side of the white columns, there are three blue, five yellow (divided by two white columns for Comments and Uncertainty matrix to be published via the database) and three green columns. The blue columns are for describing the CMC traceability. The yellow columns are for the administration of the table and for the names of the uncertainty matrices and of the tags for closely related CMCs. The green columns are to be used during the review processes. The white columns and the blue and yellow columns, but not the green ones, are to be filled in by the submitting NMI. Only the white columns, the yellow columns “NMI Service Identifier”, “NMI”, and “Uncertainty Matrix”, with attached uncertainty matrices, will be reported, in the Appendix C.
- Delete the unnecessary worksheets, save the file, and send it to your RMO TC Chairperson.
- Follow the specifications of Section 2 of the [CIPM MRA-D-04](#) such as: only English should be used in the Excel sheet and in the supporting evidence documents.

### 2.1.2. 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 where it affects uncertainty, is a distinct measurand, or uses a distinct calibration procedure.
- In general, a single CMC row should be used for a particular method and measurement apparatus. For example a piston prover for gas flow measurement that has multiple tubes should be entered as a single CMC row. Similar recommendations may be offered for other measurands in Working Group Guidelines.
- A brief description that allows database users to identify the particular 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 the classification services described at the KCDB, [Mass services](#).

### 2.1.3. Expanded uncertainty

- For a CMC entry, the statement of uncertainty must be based on careful consideration of all uncertainty contributions of Type A and B following the “[Guide to the expression of uncertainty in measurement](#)” (GUM). The expanded uncertainty is usually expressed in terms of a confidence level of 95 %.

- Results of key, supplementary and bilateral comparisons are important information providing evidence for validity of CMC claims. Hyperlinks for supporting comparisons should be supplied in the Excel sheet, column P.
- The declared expanded uncertainty should take into consideration the uncertainty of the best existing device likely to be submitted for calibration. See for example, the Working Group for Fluid Flow document [Guidelines for CMC Uncertainty and Calibration Report Uncertainty](#).
- An uncertainty statement may be expressed as a fixed value (in percent or in dimensional units), a range of values (which should scale with the measurement range specified), an equation, or as a matrix. NMI/DIs are encouraged to use uncertainty ranges, equations or matrices wherever possible to reduce the number of CMC entries.
- 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 %.

## 2.2. Modification of CMCs already in Appendix C

Following the JCRB document [Procedure for modifying CMCs already in Appendix C](#), modified CMCs fall into three categories:

- a) CMCs corrected for material or editorial errors or for improving the explanatory text; these CMCs do not require a new review;
- b) CMCs modified to increase the uncertainty or to reduce the scope; these CMCs also do not require a new review, but if the change is due to the results of a comparison the other RMOs need to be notified;
- c) CMCs modified to change the method of measurement or to reduce the uncertainty or to increase the scope; these CMCs require a new review.

For CMCs of categories a) and b), modifications must be made to the Excel files corresponding to the published CMCs. Download these files from the restricted access JCRB CMC site (ask your TC chairperson for the user name and password). After downloading the file of your Country, modify its name as follows: “RMO\_Country\_M\_date\_mod\_ab”, where *RMO* is the acronym of the regional metrology organization, *Country* is the ISO two-letter abbreviation for the Country ([http://www.iso.org/iso/home/standards/country\\_codes.htm](http://www.iso.org/iso/home/standards/country_codes.htm)), and *date* is the date of the re-submission in the form yymmdd. The letter *M* indicates mass and related quantities and *mod\_ab* is to show the type of file. No other documentation is required to support the proposed changes, unless requested by the TC chairperson.

Modified CMCs in category c) will follow the same rules as for new CMCs given above.

The CCM recommends that NMI/DIs review CMCs that are already posted on the KCDB every 10 years to ensure currency and accuracy of the CMC entries. If these CMC reviews lead to increases in the scope or reduced uncertainty, the CMCs should undergo a new intra-regional review (category c above).

## 2.3. Intra-regional review by the RMO

In order for CMCs to be approved for publication in Appendix C, they must first be reviewed and approved by the appropriate Technical Committee for mass and related quantities within the RMO (intra-regional review).

NMIs submit their CMC tables and supporting documents to the relevant RMO TC Chair for intra-regional review. These CMCs must be approved by the NMI's/DI's management and be fully covered by its Quality Management System (QMS). The intra-regional CMC review process is defined by each RMO. See the documents available at <http://www.apmpweb.org/documents/qsdocuments.php> and [http://www.sim-metrologia.org.br/docs/SIM\\_05\\_Procedure\\_for\\_cmc\\_review.pdf](http://www.sim-metrologia.org.br/docs/SIM_05_Procedure_for_cmc_review.pdf) for examples. Here we only describe some generally accepted practices.

Some RMO TCs have formed a Working Group for CMC Review, set a fixed time of year for submission (e.g., the annual TC meeting), and set a fixed period for intra-regional review. The TC Chair collects submitted CMCs and sends them to the members of the TC for review. The TC members are directly involved in the review process and the results of the review are discussed at TC meetings or via email. The CMC review usually involves direct contact between the reviewers and the persons responsible from the submitting NMIs until a consensus is reached. If all concerns cannot be resolved, the TC Chair contacts the reviewers and the submitting NMIs for resolution, the final decision being with the RMO Chairperson. The results of the review together with possible comments of the reviewers and the submitting NMIs are listed in the CMC tables. The intra-regional review must examine all submitted CMCs: sampled review is only applied during the inter-regional review.

#### *2.4. Inter-RMO review*

The inter-regional review procedure is explained in section 5 of the document [CIPM MRA-D-04](#). The CMC review process is carried out through a password-protected CMC review web page which can be entered via the JCRB section of the BIPM site (<http://www.bipm.org/JCRBCMCs/>) by clicking on the link labelled "JCRB CMC website". TC Chairs can obtain a username and a password from the JCRB Executive Secretary. The CMC files to be reviewed can be entered and downloaded from this page. The JCRB requires that CMCs submitted for publication in Appendix C are accompanied by an RMO report indicating that the local TC/WG has approved the range and uncertainty of said CMCs and that each of them is supported by a fully implemented Quality Management System reviewed and approved by the local RMO. Once the files are posted for review, the corresponding technical contacts in each RMO get in touch directly with each other to exchange comments or concerns and to decide which RMO TCs will review the submitted CMCs.

In order to reduce the time spent in the inter-RMO review the following review timeline from [CIPM MRA-D-04](#) should be followed:

- RMO TC chairs coordinate their reviews so that a submitted entry is reviewed only by one or two RMOs. However, it continues to be the fundamental right of an RMO to review any of the submitted CMCs if it so chooses. A decision will be made between the RMO TC Chairs as to which RMOs will review the CMCs a **maximum of 21 days** after the submission of a set of CMCs to the CMC review web page. As a result of the decision the TC Chairs of the RMOs that will not review the set should indicate that decision at the JCRB web-portal by stating "No" in the "Update CMC"- dialog of the CMC-set web-page; the RMOs that will review the CMC set should indicate that by stating "Yes" in the "Update CMC"- dialog of the CMC-set web-page and providing the date for review, taking into account the present recommendations (see next point). If an RMO TC Chair does not provide a date by which they will send comments within this 3 week window, they relinquish the right to perform the review (i.e. it is assumed that they approve the CMCs).
- The inter-regional review (including sending review report to the submitting NMI/DI) should be completed **no longer than 60 days** after the announcement of the review.
- The corrected CMC file should be posted on the JCRB web-portal by the submitting RMO **within 30 days** after the review report.

- Informal acceptance or rejection of corrections should be made by reviewing RMOs through the JCRB web-portal **within 21 days**.
- The accepted files will be posted by BIPM staff to the BIPM web page after the inter-regional review process is concluded.

## 2.5. Acceptance criteria for inter-RMO reviews

[CIPM MRA-D-04](#) gives the following guidance 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.”*

Not all submitted CMC entries need to be scrutinized equally during the inter-regional review process. CMC entries should be broadly surveyed and assessed utilizing the reviewers’ experience in the metrology field. CMC rows with wide ranges or low uncertainty should be selected for more detailed examination of the supporting evidence provided by the submitting NMI/DI. CCM Working Groups are encouraged to produce measurand-specific criteria for this process. For example, the Consultative Committee for Temperature and the CCM Working Group for Fluid Flow use a three-level hierarchy during the review of CMCs, to improve the efficiency of the review process, that is documented in the [Review Protocol for Fluid Flow Calibration and Measurement Capabilities \(CMCs\)](#). Experience and published uncertainty analyses give a good idea of what uncertainty levels can be readily achieved for a given type of reference standard and what uncertainty levels require special effort, redundancy of measurement data, and attention to detail. Additional factors that may be considered in the review criteria are: the history of previous CMC reviews, records of on-site technical reviews, and the magnitude of changes in scope or uncertainty of re-submitted CMCs. Incorporating this uncertainty experience into the CMC review process saves effort while maintaining CMC validity. Therefore, the degree of detail of CMC review will generally depend on the expanded uncertainty submitted by the NMI/DI.

If the laboratory has participated in a key or supplementary comparison with consistent results and the declared uncertainty is equal or higher than 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.

If no comparisons are available for a specific entry and the laboratory has an established quality system, working procedures, or publications, the CMC may 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.

## 2.6. Role of the CCM and its Working Groups in the CMC process

The process of CMC preparation and review is primarily performed by the NMI/DI and RMO Technical Committees. The role of the CCM and its Working Groups is to facilitate the process by informing or training the NMI/DIs and RMOs about the requirements of [CIPM MRA-D-04](#) and developing more specific technical guidelines for its measurands in order to achieve better uniformity and to make CMCs easier to understand. Because RMO TC Chairs are members of the CCM WGs, the inter-RMO review is sometimes conducted in conjunction with WG meetings. All of the Terms of Reference of the CCM WGs include a statement about “coordinating the CMC review process.” More specifically, the WGs:

- ensure that the general instructions, formatting, and inter-regional review process are followed,
- develop service categories that cover necessary measurands,
- ensure the definitions of CMC uncertainty are clear and consistently applied,
- may provide CMC review criteria in order to make the CMC review process more efficient and consistent,
- serve as a forum for discussion and resolution of questions raised during inter-RMO review of CMCs, and
- may periodically review CMCs for correctness.

The CCM and its WGs can also provide measurand-specific guidance to assist the RMO TCs in the formatting and assessment of CMCs. For examples see [Statement 2 of the WG for Pressure and Vacuum on the content of CMC entries](#), and the [Review Protocol for Fluid Flow Calibration and Measurement Capabilities \(CMCs\)](#).

## References

	Document name / web address	Comment
1	<a href="http://www.bipm.org/en/committees/jc/jcrb/documents.html">http://www.bipm.org/en/committees/jc/jcrb/documents.html</a>	Web page holding JCRB documents with guidance on CMCs and Quality Systems.
2	Recommendations from the WG on the Implementation and Operation of the CIPM MRA (2016). <a href="https://www.bipm.org/utis/common/documents/CIPM-MRA-review/Recommendations-from-the-WG.pdf">https://www.bipm.org/utis/common/documents/CIPM-MRA-review/Recommendations-from-the-WG.pdf</a>	Recommends a more efficient and uniform CMC review process.
3	Calibration and Measurement Capabilities in the context of the CIPM MRA, CIPM MRA-D-04, version 5 (March, 2017). <a href="https://www.bipm.org/utis/common/documents/CIPM-MRA/CIPM-MRA-D-04.pdf">https://www.bipm.org/utis/common/documents/CIPM-MRA/CIPM-MRA-D-04.pdf</a>	Gives specifications for CMC entries, describes inter- and intra-RMO review processes.
4	<a href="http://www.bipm.org/en/cipm-mra/documents/cmc_excel_files.html">http://www.bipm.org/en/cipm-mra/documents/cmc_excel_files.html</a>	Web page for CMC Excel spreadsheet template.

5	<a href="https://kcdb.bipm.org/appendixC/M/M_services.pdf">https://kcdb.bipm.org/appendixC/M/M_services.pdf</a>	Classification of services in mass and related quantities.
6	Guide to the expression of uncertainty in measurement. <a href="https://www.bipm.org/en/publications/guides/gum.html">https://www.bipm.org/en/publications/guides/gum.html</a>	
7	Working Group for Fluid Flow Guidelines for CMC Uncertainty and Calibration Report Uncertainty, October, 2013. <a href="https://www.bipm.org/utis/en/pdf/ccm-wgff-guidelines.pdf">https://www.bipm.org/utis/en/pdf/ccm-wgff-guidelines.pdf</a>	Flow specific guidelines on CMC uncertainty calculations.
8	Procedure for modifying CMCs already in Appendix C. <a href="https://www1.bipm.org/utis/common/documents/jcrb/modifying_cmcs-20030813.pdf">https://www1.bipm.org/utis/common/documents/jcrb/modifying_cmcs-20030813.pdf</a>	
9	<a href="http://www.iso.org/iso/home/standards/country_codes.htm">http://www.iso.org/iso/home/standards/country_codes.htm</a>	ISO two-letter abbreviations for Countries to be used in CMC submissions.
10	<a href="http://www.apmpweb.org/documents/qsdocuments.php">http://www.apmpweb.org/documents/qsdocuments.php</a>	Web page with Asia Pacific Metrology Program documents related to CMC review process.
11	SIM Procedure for Review of Calibration and Measurement Capabilities Submitted for Appendix C of the CIPM MRA. <a href="http://www.sim-metrologia.org.br/docs/SIM_05_Procedure_for_cmc_review.pdf">http://www.sim-metrologia.org.br/docs/SIM_05_Procedure_for_cmc_review.pdf</a>	Sistema InterAmericano de Metrologia document related to CMC review process.
12	<a href="http://www.bipm.org/JCRBCMCs/">http://www.bipm.org/JCRBCMCs/</a>	Web page for submission and inter-RMO review of CMCs by TC Chairs.
13	Review Protocol for Fluid Flow Calibration and Measurement Capabilities (CMCs). <a href="https://www.bipm.org/utis/en/pdf/ccm-wgff-protocol.pdf">https://www.bipm.org/utis/en/pdf/ccm-wgff-protocol.pdf</a>	Specific CMC submission and review guidelines for flow.
14	Statement 2 of the WG for Pressure and Vacuum on the content of CMC entries. <a href="https://www.bipm.org/utis/en/pdf/CCM-WGPV-Statement_2_CMCs.pdf">https://www.bipm.org/utis/en/pdf/CCM-WGPV-Statement_2_CMCs.pdf</a>	Specific CMC submission and review guidelines for pressure and vacuum.

## List of Acronyms

BIPM	Bureau International des Poids et Mesures
CCM	Consultative Committee for Mass and Related Quantities
CIPM	Comité International des Poids et Mesures
CIPM MRA	Mutual Recognition Arrangement
CMC	Calibration and Measurement Capability
DI	Designated Institute
GUM	Guide to the expression of Uncertainty in Measurement
JCRB	Joint Committee of the RMOs and the BIPM

KCDB                    Key Comparison Data Base  
NMI                    National Metrology Institute  
QMS                    Quality Management System  
RMO                    Regional Metrology Organization  
TC/WG                Technical Committee / Working Group  
SI                      International System of Units

**Document history**

<b>Version</b>	<b>Date</b>	<b>Remarks</b>
1.3	22.05. 2018	First approved document