CCRI

Rules for Ionizing Radiation CMCs

Regional Metrology Organization Working Group, December 2023

Introduction

This document sets out the international rules for submitting or modifying CMCs using the Key Comparison Database (KCDB) interface. The rules have been devised to ensure consistency between and within regional metrology organizations.

The rules should be read together with the instructions set out in CIPM-MRA-G-13 "CMCs in the context of the CIPM MRA: Guidelines for their review, acceptance and maintenance" (available on the BIPM website). Information on using the KCDB interface is available on the BIPM website (contact bipm.kcdb@bipm.org for links to the latest information). Reference is also made to the CCRI CMC Service Categories CMC Service Categories (bipm.org).

The field of ionizing radiation can be divided into three technical areas, which correspond to the three Sections of the CCRI: Dosimetry, Radioactivity and Neutron measurements. The data entry options depend on the Section (branch) selected.

All CMC writers must prepare a brief explanatory document, to be uploaded under "Add Supporting Document" as described in section 4.7, which can be used by the reviewer as a guide to simplify the review. This file must be generated even if no complications exist for a particular CMC and can contain a single line indicating "The CMC is fully supported by the results outlined in the attached international comparison or other validation method."

1. Classification of services

1.1. Branch

Choose Dosimetry, Radioactivity or Neutron Measurements

1.2. Institute service identifier

Each laboratory can choose how to specify its internal service identifiers. Examples are a simple consecutive number or an NMI catalogue number. This may be completed by a link.

Dosimetry, Radioactivity and Neutron Measurements:
The NMI service identification must be unique for each CMC entry. This will enable its fast location by the service administration. The following format must be used:

- EUR-RAD for EURAMET
- GLF-RAD for GULFMET

- APM-RAD for APMP
- SIM-RAD for SIM
- COO-RAD for COOMET
- AFR-RAD for AFRIMETS

followed by the acronym for the NMI, then a four-digit number stating with

- 1xxx for dosimetry,
- 2xxx for measurement of radionuclides,
- 3xxx for neutron measurements

e.g., COO-RAD-VNIIM-2001

Note: It is important to ensure that the four-digit number has not been used previously for another CMC.

Numbering should be sequential, without omissions, for each NMI. This will not affect the order of display when the database is interrogated. Note that a single identifier must be used for a multi-nuclide source or for a material containing more than one radionuclide.

1.3. Link to institute service identifier

A specific link to the service, to the institute web page for services, etc. may be indicated (it is the responsibility of the originating institute to update the link as needed).

2. Measurand

2.1. Quantity

The latest version of the Service Categories for Ionizing Radiation CMCs must be followed.
The quantities are the agreed service categories in the 'CMC Service Categories', available on the BIPM website: CMC Service Categories (bipm.org)

Dosimetry:
Note: Absorbed dose and absorbed dose rate are no longer to be submitted as independent entries, nor are air kerma and air kerma rate. Exposure should not be used.

Radioactivity:
The word radioactivity should not be used as a quantity.

Note: Surface emission rate is expected to be as measured in 2π. Efficiency refers to that of ionization chamber, γ-ray spectrometer, or contamination monitor.

Neutron Measurements:
Refer to the service category link above.

2.2. Instrument or Artifact

This section should describe the instrument or artifact (source) which is calibrated:

Dosimetry:

- In the description the term "dosemeter" should be used for, e.g., an area meter and "dosimeter" for a personal monitor

- The term “doserate meter” is not used.
- The NMI should specify the instrument or artifact as closely as possible e.g., ionization chamber, personal dosimeter, survey meter, chemical dosimeter.

Radioactivity:

The item to be measured could be

- A single or multiple nuclide, solid, gas or solution or extended area source, then the use of the source in some cases may be added in brackets (e.g., surface contamination or medical or gamma-ray detectors), or
- A reference material, or
- An instrument e.g., spectrometer, ionization chamber, etc.

Neutron measurement:

The item to be measured could be

- (Sealed) neutron source
- Neutron sensitive device
- Dosemeter (neutron survey meter) or
- Neutron personal dosimeter

2.3. Instrument type or method

Dosimetry:

A brief description of the calibration with reference to the transfer instrument (if applicable) and phantom material. For example:

- Calibration against a transfer standard in a water phantom (for an instrument)
- Irradiation in a calibrated field in air (for a personal dosimeter)

Radioactivity:

The method by which the service is performed should be given (e.g., 4πβ-γ absolute measurement, high pressure well type ionization chamber, HPGe spectrometer, liquid scintillation counter, 2π proportional counter).

Neutron measurement:

A brief description of the calibration with reference to the standard or transfer instrument (if applicable) should be given, for example:

- Calibration in a manganese bath or
- Calibration relative to (or with) a national standard source
- Calibration relative to a calibrated monitor or a primary standard instrument
- Irradiation with a calibrated neutron source
- Irradiation in a reference neutron field

2.4. International standard

Indicate if a specific international standard or other recommendation is followed.

2.5. Medium

Indicate medium (refer to [CMC Service Categories (bipm.org)]() for the options).

2.6. Nuclide

Indicate the nuclide (visible only when the branch "Radioactivity" has been selected).

Two options are available:

- Add the radionuclide in the format Co-60. Multi-nuclide sources need one CMC per radionuclide with the CMCs linked using the group identifier, or
- If more than one nuclide is grouped into a single CMC (not as a multi-nuclide source), include a table consisting of the grouped radionuclides as described in section 2.7.

2.7. Source

Indicate source (refer to [CMC Service Categories (bipm.org)] for the options).

Dosimetry:
The radiation type is specified as indicated in the "classification of services".

Radioactivity:
The radionuclide in question is specified as indicated in the "classification of services". One line being used per radionuclide, even for multi-nuclide sources and for reference materials containing more than one radionuclide.

Note: Multi-radionuclide sources and reference materials will be grouped together in the database according to their institute service identification (section 1.2) as single CMCs (despite multiple lines).

Note: If several radionuclides are to be grouped together as a single CMC line, list them (separated by commas) on the free-fill block. All relevant information such as specifications (if any), lower/upper limits, and expanded uncertainties for each individual radionuclide must appear in a table as described in section 3.6 of this document.

Neutron measurement:
The neutron radiation type is specified, as indicated in the "classification of services".

Note: When specifying the fluence or the absorbed dose/rate, the distance from the (point) source or neutron producing target may be added here (e.g., [at 1 m from the source]).

2.8. Specification on nuclide or source

Dosimetry:

- The radiation quality should be specified in sufficient detail, e.g., give values for beam quality specifiers.
- If used, the standard ISO conversion factor applied to extend the results from an air kerma comparison to support a claim for ambient dose equivalent must be specified.

Radioactivity:
More details on the type of source may be given, such as:

- In the case of ^{3}H, "Tritiated water"
- The chemical form
- Source geometry
- In the case of a reference material, the matrix *must* be given (e.g., "bone ash")
- In the case of a group of radionuclides, the basis for the grouping may be given.

Neutron Measurements:

The neutron quality is specified in more detail, e.g.:

- Neutron spectrum according to standard ISO 8529-1 (e.g., for radionuclide sources such as Cf-252, Am-241-Be-9, etc.).
- Neutron producing reaction, neutron energy or energy range and, in some cases, standard ISO 8529-1 (in the case of accelerator-based neutron sources).

2.9. Unit

The unit is chosen in a fixed drop-down menu; "(dimensionless)" may be chosen for measurands without units, such as ratios or indices, and will create an empty space when displayed. If a unit is not available, the Writer is invited to contact the KCDB Office: (bipm.kcdb@bipm.org).

- SI units must be used and should be that of the quantity to be measured.
- Superscripts should be used. Slashes, prefixes and decimal points should be avoided.

Dosimetry:

- In the fields of radiotherapy and industrial processing, units may be expressed in Gy and Gy s^{-1}
- In the field of radiation protection, units may be expressed in Gy or Sv and mGy h^{-1} or Sv h^{-1}
- Other examples:
  - Kerma length product   mGy cm
  - Kerma area product   mGy cm^2
  - Tube voltage   kV

Radioactivity:

- Activity   Bq
- Surface emission rate s^{-1}
- Emission rate s^{-1}
- Efficiency   calibration factor units e.g., s^{-1} Bq^{-1} or "indicated Bq Bq^{-1}"

Neutron Measurements:

- Fluence rate cm^{-2} s^{-1}
- Emission rate s^{-1}
- Absorbed dose/rate   Gy or Gy s^{-1}

2.10. Lower and upper limits

If the lower and upper limits are identical (such as when a service is offered at a specific level), they should be indicated the same in both "Lower limit" and "Upper limit" fields.

Dosimetry, Radioactivity and Neutron Measurements:

A point (.) is used as the decimal separator. The symbol "E" represents exponential of 10 (e.g., 10300 may be expressed as 1.03E04; 0.0067 may be expressed as 6.7E-03). Only significant digits should be specified.

2.11. Parameters

As many as five sets of parameters may be indicated if needed by opening the parameter window. Laboratory conditions impacting the measurement, such as temperature or humidity, can be indicated.

3. Expanded uncertainty

Dosimetry, Radioactivity and Neutron Measurements:

The uncertainty quoted should be the lowest that can be achieved under normal conditions, and made available to customers, with the types of instruments or artifacts used in the calibration.
Note: The expanded uncertainty relating to a CMC for an NMI should normally not be smaller than the expanded uncertainty given in the supporting evidence unless the circumstances in the RMO warrant this.

3.1. Units

Dosimetry, Radioactivity and Neutron Measurements:

The uncertainties should be stated as relative uncertainties in % despite the longer list on the pull-down menu.

3.2. Lower and upper limit

The measurement uncertainty is normally declared as a single value valid throughout the measurement range. A range of uncertainties may be given only if the uncertainty varies linearly within the range given. e.g., for an activity ranging from 100 Bq to 1000 Bq, the uncertainty range 10 % to 1 % is valid if the uncertainty at 500 Bq is 6 % and is inversely proportional to the activity range. Alternatively, the uncertainty may be given as an explicit function of the measurand or a parameter, or the measurement uncertainties may be declared in a table whose entries depend on the measurand and one or more other parameters. For broad scope CMCs in neutrons, a range may be given which is variable and defined by a lower and an upper limit. Refer to CIPM MRA-G-13 for details.

Dosimetry:

- **The lower limit corresponds to the lowest uncertainty which can be realized in a field of a single source or within a given energy range or within a given absorbed dose/dose rate range.**
- The upper limit can be declared higher than the lower limit in the case of a given energy range or a given absorbed dose/dose rate range.
- If only one absorbed dose/rate value and energy value is specified, the lower and the upper limit shall be identical.

Radioactivity:

- For a CMC of a single radionuclide (whether alone or as part of a mixed source; refer to section 2.7), the measurement uncertainty is declared as a single value, which is valid throughout the measurement range:
    - For grouped radionuclides as described in Section 2.7, the measurement uncertainties are declared in a table (under the "Edit Table" function in this section, see 3.6 below) including each radionuclide in the group as a single value, which is valid throughout the measurement range. The smallest uncertainty in the table defines the lower limit and the highest uncertainty in the upper limit of the one CMC.

Neutron Measurements:

- The lower limit corresponds to the lowest uncertainty for a kind of neutron source or within a given energy range (e.g., of mono-energetic neutrons) which can be realized under normal conditions. If only one source or energy is specified, the lower and the upper limit can be identical.
- The upper limit can be larger than the lower limit in the following cases:
  - The service is valid for a range of e.g., energies, emission rates, etc. In this case, the upper limit corresponds to the lowest uncertainty possible assuming the service is performed under to most difficult condition in the specified range (e.g., for a source with an emission rate at the lower limit specified in the "range" parameter).
  - The same can be applied to a range of monoenergetic energies.

3.3. Coverage factor

Dosimetry, Radioactivity and Neutron Measurements:

The coverage factor <u>must be stated</u>. In the absence of knowledge of the distribution function, a value of k = 2 (default value) should be applied. If the distribution is known to be other than Gaussian, the default value can be modified.

3.4. Level of confidence

Dosimetry, Radioactivity and Neutron Measurements:
This field should not be left blank. A normal distribution function is generally assumed with a confidence level of about 95 % (~95 %), which is the default value.

3.5. Absolute or Relative uncertainty

The uncertainties should be stated as relative uncertainties for all ionizing radiation CMCs.

3.6. Edit Table option

In the case of multiple radiation fields or a grouping of radionuclides, the Edit Table option should be used (by creating directly a table or importing an Excel sheet). The lower and upper limit of the CMC value should indicate the entire uncertainty range. In the case of a grouping of radionuclides, use the comment field to indicate additional information in the table such as measurement range.

4. References

Each CMC should have a corresponding supporting comparison or publication. The publication must be available to reviewers. This section must not be left blank (refer to Chap. 3.3 Technical evidence of CIPM MRA-G-13 for acceptable references). If available, the documents should be joined to the CMC as attached documents (see 4.5). In the case of grouped radionuclides under a single CMC, supporting evidence must be given or referenced for each radionuclide.

4.1. Reference standard used in calibration:

Dosimetry, Radioactivity and Neutron Measurements:
The relevant national reference standard(s) of the calibrating laboratory should be stated. Examples are: free air chamber, graphite calorimeter, 4πβ-γ absolute measurement, hydrogen gas proportional counter, or secondary standard ionization chamber, Mn-bath, calibrated neutron source.

If a different method is used in the calibration, then this should also be stated. *All* standards used to provide the calibration traceable to the SI should be indicated.

4.2. Source of traceability

Dosimetry, Radioactivity and Neutron Measurements:

If the NMI national standard is a primary standard, this should state the acronym for the NMI itself; if the NMI does not hold the appropriate primary standard, the laboratory from which its traceability was obtained should be indicated. The CMC should show each source of traceability for the different standards used in the particular calibration.

4.3. Group identifier

Optional; may be used to indicate a unique label (a number or a short string) for those CMCs that are associated with one another such as a multi-radionuclide source.

4.4. KCDB support for CMC claim

This section allows for the CMC to be linked to the comparisons published in the KCDB.

4.5. Other support (evidence supporting the measurement / calibration service)

Indicate the titles or references (other than those published in the KCDB) that support the CMC claim and upload them under the “Add supporting document” button (section 4.7).

Note: These will *not* be available to viewers of the database after publication. It is part of the review and verification process for the RMOs and the JCRB.

Dosimetry, Radioactivity and Neutron Measurements:

If no directly related comparison is available, a similar type of comparison or other validation can be used to support the CMC; the reference should be preceded by the words “similar to” or some other indication as to the indirect nature of the comparison.

- If an NMI holds primary standards, supporting comparisons are expected to include key comparisons. As far as practical, there should be a supporting comparison for a CMC.
- If an NMI receives its traceability from another laboratory, supporting comparisons referring to this other laboratory should not be listed here. A regional comparison or other validation supporting the NMI's own calibration capability should be cited.
- Any comparison or other validation supporting the measurement capability of the NMI with secondary standards should be given.
- Traceability of a secondary method to a primary method (for which there is a supporting comparison) is to be fully supported within the NMI’s RMO-approved quality management system and made available to reviewers on request.
- If an NMI has more than one validation supporting its capability, only one of these should be quoted and the expanded uncertainty of the calibration should reflect that used in the validation chosen.

For key and supplementary comparisons, such as BIPM, CCRI or RMO comparisons, only the reference is required. For other forms of validation as per CIPM MRA-G-13 Section 3.3, reference of the publication (or internal report) must be given. If the validation is based on a multilateral comparison, the participating laboratories and the year should be indicated between brackets (for RMO); for CCRI- and BIPM comparisons, see BIPM website.

Dosimetry:

- A comparison of air kerma may be used to support a CMC of ambient dose equivalent using the appropriate ISO conversion factor. The ISO conversion factor that is used must be indicated.
- In general, a comparison for low-dose-rate source-based brachytherapy (e.g., I-125) may be used to support claims for other low-dose-rate brachytherapy radionuclides (e.g., Pd-103) independent of seed type.

Radioactivity:

The "Measurement Methods Matrix (MMM") (available on the BIPM website) on primary measurement methods should be used to optimize comparison support for CMCs, noting that:

- A comparison result from a radionuclide measured using a specific primary method *generally* cannot support claims for that radionuclide measured by other primary methods.
- Claims are allowed for radionuclides in the same column of the MMM **only**, and according to degree of difficulty (red allowing claims for red, yellow, green; yellow allowing claims for yellow and green; green allowing claims only for green)
- Claims should be made for only those radionuclides actually measured by the submitting laboratory.

In the case of grouped radionuclides, include a table of all radionuclides that includes their supporting documentation (comparison, published paper, etc.). In the case of a modified CMC (e.g., the list of included radionuclides is revised in any way), indicate which radionuclide(s) is to be reviewed (using red font for corrections/additions, highlighting in light pink with a comment for deletions). <u>This is separate from the table under 3.6</u>.

Neutron Measurements:

- A comparison result for the quantity 'emission rate' using a primary method (e.g., Mn bath measurements with a Cf-252 source) can also support claims for other types of neutron sources (e.g., Am-241-Be-9).
- Comparison results for the quantity 'fluence rate' for monoenergetic neutrons using either a primary method or a secondary method (e.g., proton recoil counter or Long Counter) can be used to support claims for other monoenergetic neutron energies. The energies must be within the operational range of the device and there should normally be supporting results from comparisons both higher and lower in energy.

4.6. Comments to be published via the KCDB

Any comments here will appear in the KCDB for the customer to see. Adding information here is optional but can be important for clarification, e.g.,

- Production of a point source by the institute
- Reference material production
- Derivation of the dose measurement (e.g., dose derived by integral of dose-rate)
- Derivation of dose equivalent/rate

This is a free-fill block and text will wrap around as it reaches the end of the line. Bullets may be used to list specific comments in the block.

For radioactivity, in the case of claiming a group of radionuclides under a single CMC, a complete list of those radionuclides must be indicated.

4.7. Add Supporting Document

Upload any documents (other than accessible KCDB comparisons) to which you refer as well as the necessary supporting evidence of the RMO approval of the Quality Management System. This gives direct access to the documents for the reviewing experts but will not appear with the published CMC. The CCRI considers "Supporting Documents" to include all documents or explanations needed for the review of the CMC.

For radioactivity, if radionuclides are grouped under a single CMC, a table including nuclides, ranges, uncertainties and the support for each claim should be added. This will be a compilation of tables from sections 3.6 and 4.5 of this document.

A document summarizing details of the CMC, to include the specifics of what (if any) modifications have been made, the basis and justification for grouping radionuclides (if done), and other factors not otherwise captured in the CMC must be uploaded. <u>The file needs to be generated even if there are no complications for a particular CMC and can contain a single line indicating, "This CMC is fully supported by the results outlined in the attached international comparison or other validation method."</u> In particular, when submitting a modified CMC or adding a new isotope to an existing group of radionuclides under a single CMC, the document must indicate what has changed to prevent a review of the entire CMC. The addition or modification of an isotope to a group of radionuclides under a single CMC should have only the new addition or modification reviewed and not the entire, already published and unchanged, CMC. The traceability chain for other than a primary measurement can also be described.

Uploading an explanatory document is especially important if the support of the CMC is not a straightforward interpretation of a comparison or analysis document used as evidence, or if the limits of the uncertainty listed require clarification. In moving from the RMO review to the JCRB review, this document should be amended to capture discussions (if any) and/or corrections that may have been captured during the RMO review. The comments attached to a CMC sometimes indicate an issue that had been resolved offline but is not reflected in the CMC undergoing JCRB review. This naturally leads a JCRB reviewer to wonder about the solution, which can be outlined in the explanatory document. Such a document should capture the narrative of the CMC, a history of its declaration and/or provide a roadmap for the reviewer in performing their duty.

<u>Note</u>: Tick the box at the bottom of the page to confirm authorization to submit the CMC and to confirm that there exists a validated Quality Management System. The CMC cannot be submitted without having confirmed this information.

5. Comments to reviewers

Add comments to assist reviewers to efficiently review your CMC e.g., indicate whether it is an administration change, or uncertainty change.

Version number	Date	Revision comments
-	29 April 2010	Based on agreed Table of 29 April 2010 (as currently posted)
-	13 March 2018	Revisions from RMO WG Meeting 13 March 2018
1.0	16 September 2020	Revisions to align with the KCDB 2.0 1 September 2020
2.0 DRAFT	28 September 2021	Revisions taking into account EURAMET adopted proposal
2.1 DRAFT	10 August 2023	Track changes from 2.0 accepted, additional modifications not tracked but comments remain
3.0 FINAL	22 December 2023	Final clean up for publication. Updates to sections 2.7, 3.5, 4.5 and 4.7 regarding grouped radionuclides. Comments removed, tracking not used.