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Agenda Item 6 **CX/MAS 19/40/6-Add.1**

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON METHODS OF ANALYSIS AND SAMPLING

40th Session

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REVISION OF THE *GUIDELINES ON MEASUREMENT UNCERTAINTY* (CXG 54-2004)

Replies to CL 2019/16-MAS

Comments of Australia, Canada, Ecuador, Egypt, Jamaica, Morocco, New Zealand, Norway, Peru and BIPM

AUSTRALIA

While Australia was surprised after the eWG round of comments that the proposed GL54 required such a comprehensive re-write, we now only suggest this proposed draft guideline in Appendix 1 could be condensed.

With respect to the further points for discussion raised in Paragraph 21,

• Should the examples on acceptance sampling be part of the guideline:

As these examples deal primarily with Acceptance Sampling they may prove to be unbeneficial and better located in GL50, if not addressed by an GL50 App.

• Should the figure 1 (former Figure 5) be part of the guideline?

Yes.

• Therefore it might be reasonable to think of a guideline to explain the several ISO standards, guides and publications.

At this time finalising a revised GL54 document for consideration as a replacement of the existing guidance should be priority, as it has been proposed at Step 3.

• It should be considered whether an adapted version of GL59, chapter 4 could be included in GL54.

As the CCMAS scope in commodities and range in provision concentrations for sampling and analysis is much broader than CCPR, this additional guidance would need to be detailed to cover this scope and so require significant effort to develop.

CANADA

Canada is pleased to provide the following comments in response to CL 2019/16-MAS.

General Comments:

Canada continues to support the reporting of measurement uncertainty along with the analytical result. A number of acceptable ways to calculate MU exist. Depending on the approach taken, the MU could be larger or smaller. Ultimately, it is up to the country to consider MU.

Specific Comments:

Summary and Conclusion:

Para 21 (Further points for discussion):

Bullet 1:

Recommend that the two examples of acceptance sampling not be included in the guideline to avoid any overlap with the sampling plan development guidance.

Bullet 2:

Recommend that Figure 1 **not** be part of the guideline, since it is stated in several places within the guideline that it is up to National Authorities to determine how to use MU and its interval with respect to acceptance sampling or conformity assessment. Having this figure within the document will confuse that position.

Appendix I:

Introduction:

Para 1, line 3: Suggest deletion of: ~~taken into account in conformity assessment~~ and replaced with **considered**.

Para 1, line 7: Suggest replacing ~~testing for regulatory compliance~~ with **analytical testing**.

Para 2, lines 7/8: ~~Moreover, it is required that decision rules applied in conformity assessment must be based on the uncertainty of measurement and sampling~~

Footnote:

Add sections/revise as follows:

The heterogeneity between test portions **is composed of compositional heterogeneity (CH) and distributional heterogeneity (DH). Both of these lead to random errors when selecting a test portion, known as Fundamental Sampling Error – also called Fundamental Variability – and Grouping and Segregation Error. Fundamental variability results from CH and is the variability between test portions that remains even under the best achievable degree of particle size reduction.** The fundamental variability has a dominant effect on total variability when the "target compound" is predominantly located in a specific fraction of the particles (there is a low number of particles with relatively high concentrations of the target compound). **The fundamental variability can be controlled by collecting a sufficient test portion mass. Grouping and segregation error results from DH and is the non-random distribution (spatial or temporal) of the "target compound" within the material from which a test portion is selected. The grouping and segregation error can be controlled through the collection of a sufficient number of random increments to comprise a test portion.**

Para 24:

Suggest replacing ~~taken into consideration when deciding~~ with "**reported to allow for a decision as to. . ."**

Para 26:

Suggest removing: ~~The influence of the measurement uncertainty on the interpretation of results is illustrated in the diagram below. The diagram shows how the measurement uncertainty can be taken into account when interpreting the analytical result against a legal limit~~, consistent with recommendation that Figure 1 be removed.

Figure 1:

All text related to Figure 1 should be removed to the end of Note 3.

Para 31 – 35:

Suggest removing the discussion of measurement uncertainty in sampling plans section and the examples to avoid any overlap/confusion with the guidance on sampling plans being developed.

Appendix II:

Para 5:

With respect to the sample preparation definition, suggest revision to read: Freezing, **comminution (particle-size reduction)**, homogenization, etc.

ECUADOR

(i) General Comments:

Ecuador thanks the work done by the Electronic Working Group and wishes to support the document considering the following comments:

(ii) Specific Comments:

- Ecuador suggests deleting the following in para 9 of General Comments: (…) "atribuirse razonablemente a la cantidad medida ~~mienten~~". *(Mistranslation of the word "lie" into Spanish in the fragment "…attributed to the measured quantity will lie…")*

  Rationale: To have a better understanding of the document.

- In General Comments, para 11, change the translation as follows:

  Por esta razón, ~~el foco~~ **el enfoque** radica en la identificación y evaluación de los componentes principales de la incertidumbre de la medición. For this reason, the ~~focus~~ **approach** lies on the identification and evaluation of the *main* components of measurement uncertainty.

  Rationale: To improve the understanding of the text.

The country considers that the translation in para 12 of Uncertainty Components should be changed as follows:

  Estas fuentes pueden no ser independientes, en cuyo caso las correlaciones respectivas deben tenerse en cuenta en el ~~presupuesto~~ **cálculo de la incertidumbre** (…). These sources may not be independent, in which case the respective correlations should be taken into account in the uncertainty ~~budget~~ **calculation** (…).

  Rationale: To have a better understanding of the document.

The country suggests to include a clearer explanation in para 16 on what the “ring trial” refers to.

In para 20 the country requests reviewing the updating of the quoted standards since for ISO/IEC 17025 the current version is of year 2017.

Ecuador thinks that the two examples for the inspection by variables (packages) and inspection by variables (bulk) should be part of the guidelines.

  Rationale: Keeping the examples would make the document clearer, because otherwise there would be a need to refer to the la corresponding guide.

The country suggests keeping Figure 1 in para 28 as part of the guidelines.

In para 45 the country requests the following change:

  Así, por ejemplo, la incertidumbre de la preparación de la muestra se separa en las incertidumbres de los distintos pasos como el pesaje, ~~la homogeneización~~ **la homogenización**, el secado, la extracción, la dilución, etc., que deben combinarse.

  Therefore, for example, the uncertainty of the sample preparation is separated into the uncertainties of the individual steps of weighing, homogenizing, drying, extracting, diluting etc., which are to be combined. *(Note of the translator: homogenización is a word not accepted by the DRAE, Dictionary of the Royal Academy of Spain while homogeneización is accepted).*

  Rationale: To have a better understanding of the document.

EGYPT

Egypt appreciates and agrees the work done by eWG; and wants to highlight some **general comments** as follows:

1- REFERRING TO ISO NO. 19036/2006 "MICROBIOLOGY OF FOOD AND ANIMAL FEEDING STUFFS - GUIDELINES FOR THE ESTIMATION OF MEASUREMENT UNCERTAINTY FOR QUANTITATIVE DETERMINATIONS" IN THE CLAUSE OF LITERATURES IN PAGE NO. (22).

2- REFERRING TO "SUM OF COMPONENTS" AS THE ABOVE MENTIONED GUIDELINES REFER ONLY TO "SINGLE METHOD".

JAMAICA

General comments:

- Jamaica recommends that the two examples on acceptance sampling be excluded as part of the guideline. Taking into consideration paragraph 6 under background, the section "The use of measurement uncertainty in sampling plans" at the start of paragraph 29 should be removed. It may be better placed in General Guidelines on Sampling (CXG 50 - 2004), when this guideline is to be revised.
- There is no objection to Figure 1 being part of the guideline.
- Jamaica supports the development of guidelines to explain the several ISO standards, guides and publications
- Jamaica supports the inclusion of a section "Guidance Values for Acceptable Uncertainties" as in chapter 4 of GL 59 into GL 54, if it is generalized.

MOROCCO

Specific Comments:

- **Background:**

Point 4: in the French text delete "de l'évaluation" *(the English text is not affected)*

Rationale: This is a repetition

- **Summary of the main changes**

Morocco suggests to delete the last point: "The two remaining examples are shaded in yellow in order to indicate that a decision has to be taken whether they should be included in the draft."

Rationale: to avoid overloading the document.

- **Further points for discussion**

21. The following points could be discussed:

• Should the two examples on acceptance sampling be part of the guideline?

Reply: Morocco does not agree that these two examples on acceptance sampling should be included in the guidelines.

Rationale: They may overload the document on the revised guidelines and as measurement uncertainty relating to sampling would be covered by the work on the revision of the General Guidelines on Sampling, GL50 - 2004, it would be preferable not to include them in the guidelines.

• Should the Figure 1 (former Figure 5) be part of the guideline?

Reply: Morocco agrees to include Figure 1 in the guidelines.

Rationale: This would facilitate decision-making on the compliance to a particular specification by taking measurement uncertainty into consideration.

• During the revision of the first draft it became more and more obvious how complex the decision making process is. Furthermore, ISO 17025 attaches great importance to the decision making process. It requires that decision rules applied in conformity assessment must be based on the uncertainty of measurement and sampling. Therefore it might be reasonable to think of a guideline to explain the several ISO standards, guides and publications.

Reply: Morocco supports this proposal.

Rationale: Standard 17025 requires that the rules for decision-making applied in the assessment of the declaration of conformity should be based on the measurement uncertainty of the sample and also of the sampling, therefore it became mandatory to document the rule used for decision-making, taking into account the risk levels, hence the need for a guideline that meets the requirements of the standard.

• It should be considered whether an adapted version of GL 59, chapter 4 could be included in GL 54.

Reply: Morocco is in favour of the inclusion of Chapter 4 in GL 54.

Rationale: The evaluation of measurement uncertainty is applied to any type of activity within the laboratory and in order to avoid any overlap with GL 59, it is reasonable to include it in GL 54.

APPENDIX I DRAFT REVISED GUIDELINES ON MEASUREMENT UNCERTAINTY (CXG 54 – 2004)

Introduction:

Paragraph 1: Morocco proposes to include sampling uncertainty in this guideline.

Rationale: According to standard 17025 sampling uncertainty is a requirement, otherwise it should be treated as a stand-alone activity in the General Guidelines on Sampling (GL 50).

NEW ZEALAND

We have provided comment on the scope and soundness of the latest version of the revision to the Guidelines (the current draft) under 'General Comment'. We have set out our key concern under 'Specific Comment' as well as including a response to Section 21.

Contents

General Comment

New Zealand acknowledges the work of the EWG and Germany's leadership in producing the draft revised Guidelines on Measurement Uncertainty.

New Zealand has made a number of contributions to the EWG, and wishes to thank the German delegation for preparing the latest version of the revision to the Guidelines (the current draft) and for taking many of New Zealand's comments into consideration. Nevertheless despite this involvement New Zealand considers that the **scope of the current draft is too wide, and does not provide clear, concise and correct guidance.** We also have a key technical concern that is as yet unresolved.

In regard to scope, it would be helpful to go back to basics and ask: What does Codex need in terms of measurement uncertainty? We believe Codex guidelines on measurement uncertainty should fulfil the requirements set out in ISO 17025:

- The contributions to measurement uncertainty
- How measurement uncertainty can be evaluated
- How measurement uncertainty can be reported

We also believe the current draft should provide guidance, or reference to guidance, on how users should interpret measurement uncertainty on analytical test reports, in particular how test results are related to the true values those test results represent, and on the role of measurement uncertainty in the use of test results. Limitations on the use of measurement uncertainty should also be noted.

This is a narrower scope than covered in the current draft. We believe that no guidance on the use of measurement uncertainty in sampling inspection is needed, because the revised CXG 50 will explain Measurement Error and how it is used in sampling inspection. Some guidance on the use of MU in conformity assessment will also be provided in the revised GL50.

In regard to the soundness of the current draft, **New Zealand's key technical concern relates to Figure 1.** See specific comments below. We do have some other points for consideration in the on-going work on the guidelines.

We have provided 4 different technical responses to the EWG in addition to several emails and a teleconference. Our German colleagues have been very responsive and certainly considered our input; we note they referred to how complex the decision making process is for this work.

Specific Comment

FIGURE 1 (page 8)

New Zealand feels that the text is considerably improved. However our key technical concern about Figure 1 and associated commentary remain because they can easily be taken as an approved conformity assessment procedure.

We are pleased to see that the first Note [Section 28, top of page 9] now says that "The measurement uncertainty interval used in Figure 1 and its comparison to the maximum level is not intended for use in acceptance sampling or for conformity assessment". However Figure 1 is still liable to be misunderstood and misused because of the way other text is worded. For instance:

- Section 7 of the introduction reports that the committee agreed that the revised CXG 54 should contain information on the use of measurement uncertainty and this is repeated in Section 13 "illustrate the use of measurement uncertainty…", so there is an expectation that the guidelines will contain a procedure for its use
- Figure 1 is presented in conjunction with internationally-accepted methods for conformity assessment in paragraphs 28 and 29, implying that the Figure 1 also represents a valid procedure
- Figure 1 and associated commentary describing how results are to be "interpreted" have been borrowed from CXG 59, and the third Note (section 28, page 9) refers to CXG 59 for further discussion on the interpretation. However important limitations and explanations in CXG 59 have been omitted or varied. It is not adequate or appropriate to use Figure 1 as a general illustration of the influence of measurement uncertainty on interpretation of results, as intended by paragraph 26.
- The term "interpreted" could be taken to mean the decision whether the one or more samples tested, and as a consequence the lot from which those samples are taken, should be accepted or rejected; particularly when read in conjunction with the third note, which refers to "a compliant test result" and "acceptance of trade consignments".
- The title of the section and paragraphs 23-25 refer to conformity assessment, describe the purpose of conformity assessment and provide guidance on how the requirement of ISO 17025 in regard to conformity assessment (stated in paragraph 2) should be applied.

In summary, the assessment procedure suggested by Figure 1 does not represent conventional statistical practice and cannot be used as a valid conformity assessment procedure or in the wider context of sampling inspection.

Conformity assessment differs from sampling inspection but this very important difference appears to be the source of confusion in the way test results are used in practice. Use of conformity assessment for sampling inspection is, in general, unfair and therefore contradicts the Codex Procedural Manual '*Codex Methods of Sampling are designed to ensure that fair and valid sampling procedures are used when food is being tested for compliance with a particular Codex commodity standard*'. The revised CXG 50 will eventually provide guidance on both.

Recommendations

We would like to see:

Either:

- Figure 1 and associated commentary removed and replaced by a diagram that correctly illustrates how test results are related to the corresponding true values through the measurement uncertainty, for example by Figure 8 of the JCGM 106 (reference [5]) (see response below to section 21); and
- Inclusion of text to the effect:
  a. that measurement uncertainty information supplied in test reports should be used in conjunction with a recognised conformity assessment procedure; and
  b. conformity assessment is not suitable for use in acceptance sampling.

Or:

- If Figure 1 is retained, the first Note [Section 28, top of page 9] should be strengthened to read: "The measurement uncertainty interval used in Figure 1 and its comparison to the maximum level **does not represent conventional statistical practice and cannot be used as a valid conformity assessment procedure;** and
- The interpretations at the bottom of Figure 1 removed; ~~and~~

Regardless of the decision on Figure 1, we recommend that the details of conformity assessment procedures in Sections 27 and 28 are combined into a single section located immediately after the cautionary note, with a sub-heading “Procedures for Conformity Assessment”.

In addition, we believe that given this is not a valid procedure for either conformity assessment or for acceptance sampling much of the discussion e.g. the last two paragraphs of section 28 (i.e. the second and third Notes), and sections 30-33 is unnecessary and should be removed.

COMMENTS ON SECTION 21 OF THE INTRODUCTION **(PAGE 3)**

In response to the bullet points in Section 21 New Zealand believes that:

Bullet 1

The two examples relating to acceptance sampling should not be included in the revised CXG 54. They are not useful given that measurement uncertainty is not used in this way in acceptance sampling.

Bullet 2

Figure 1 should be replaced by Figure 8 of the JCGM 106 (reference [5]). This diagram provides a much better illustration of the effect of measurement uncertainty as it shows different scenarios for the true and measured values.

Bullet 3

There are already ISO and other standards and published papers containing valid procedures for conformity assessment. Three of these are mentioned in the current document. If the scope of this revised CXG is based on the contributions to, the evaluation and reporting of measurement uncertainty along with some guidance on how users interpret measurement uncertainty on analytical test reports, in particular how test results are related to the true values those test results represent, and on the role of measurement uncertainty in the use of test results, then a separate un-related guideline explaining ISO standards would not be needed.

Bullet 4

As set out in Section 9, Background, CCMAS has agreed ‘to avoid any kind of overlapping with the CXG 59 – 2006’. New Zealand supports this decision, and therefore does not support the proposed inclusion of an adapted section from GL 59.

NORWAY

Norway would like to thank Germany for their continued effort to improve the area of measurement uncertainty in Codex and for undertaking the extensive work of a complete revision of the first draft of a new CXG 54.

(i) General Comments

Comments to para 21, page 3: Further points for discussion:

- Should the two examples on acceptance sampling be part of the guideline?

Response: The two examples on acceptance sampling gives important examples on the implications of non-negligible measurement uncertainty on both sample size and the analytical method’s measurement uncertainty and should be included but simplified if possible.

- Should the Figure 1 (former Figure 5) be part of the guideline?

Response: We support that Figure 1 should be part of this general guideline on measurement uncertainty since it illustrates the different situations when comparing a measurement to a specification, and because this figure is also included in the more specific CXG 59 related to pesticides.

- During the revision of the first draft it became more and more obvious how complex the decision making process is. Furthermore, ISO 17025 attaches great importance to the decision making process. It requires that decision rules applied in conformity assessment must be based on the uncertainty of measurement and sampling. Therefore it might be reasonable to think of a guideline to explain the several ISO standards, guides and publications.

Response: Since both CXG 50 and CXG 54 are under revision it would be beneficial to make a document to connect these two interlinked but yet separate guidelines.

- It should be considered whether an adapted version of GL 59, chapter 4 could be included in GL 54.

Response: We support the inclusion of an adapted version of CXG 59, chapter 4 in CXG 54. Chapter 7 of the explanatory notes of the current CXG 54 should also be included since the Horwitz equation and HorRat has important functions in Codex and in the Codex Procedural Manual. The general model for the precision of a method described by the Horwitz equation is specifically applied in the assessment of acceptability of the

precision characteristics of a standard method of analysis, and is also used by CCMAS and other Codex committees both in the assessment of future codex methods and for the elaboration of codex method criteria.

- Repeatability is used many times throughout the document. The term “repeatability” should be replaced with the more general term “precision” to not exclude intermediate precision or reproducibility.

Rationale: Repeatability (VIM definition: *measurement precision under a set of repeatability conditions of measurement*) is a specific kind of precision (VIM definition: *closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions*). We therefore think that the specific term “repeatability” should be replaced with the more general term “precision” throughout the document in order not to exclude intermediate precision (VIM definition: *measurement precision under a set of intermediate precision conditions of measurement*) and reproducibility (VIM definition: *measurement precision under reproducibility conditions of measurement*).

- Regarding literature references: References need to be updated in the document since reference 2, 6, 7, 8, 10, 11, 16, 17 and 19 are missing from the text, reference 1 is listed first time in para 20, reference 9 is listed first time in para 30 and reference 18 is listed first time in para 34. NMKL Procedure No. 5, 2nd edition (2003): “Estimation and Expression of Measurement Uncertainty in Chemical Analysis” should also be added to the updated list of references (see specific comment below).

(ii) Specific Comments

Suggest to underline the fundamental importance of measurement uncertainty in ensuring that analytical measurements are metrologically traceable by inserting the following sentence to para 1 on page 4.

> All measurement results have an associated uncertainty; the non-estimation of measurement uncertainty does not mean that there is no uncertainty. **The estimation of measurement uncertainty is requisite for making an analytical measurement result metrologically traceable.** Accordingly, measurement uncertainty is of utmost importance in testing for regulatory compliance and subsequent decision-making. It should be noted that, in this guideline, sampling uncertainty is not included.

Rationale: The VIM-definition of metrological traceability is: “*property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty*”. Hence, the measurement uncertainty of the analytical measurement result, together with the unbroken relation of the analytical measurement result to a reference, comprises metrological traceability of the analytical measurement result. Recognizing the dual mandate of the Codex Alimentarius, metrological traceability is as fundamental to analytical measurements, just as traceability in general is principal for the facilitation of international trade and an indispensable aspect of transparency.

Propose to add the references to definitions missing reference under para 8 on page 5 as specified below:

> laboratory sample
>
> sample as prepared (from the lot) for sending to the laboratory and intended for inspection or testing **[SOURCE: ISO 6498:2012]**
>
> test sample
>
> subsample or sample prepared from the laboratory sample and from which test portions will be taken **[SOURCE: ISO 6498:2012]**
>
> lot
>
> definite amount of some product, material or service, collected together **[SOURCE: ISO 2859-1:2014]**
>
> sample
>
> set of one or more items taken from a lot and intended to provide information on the lot **[SOURCE: ISO 2859-1:2014]**
>
> item
>
> that which can be individually described and considered **[SOURCE: ISO 2859-1:2014]**
>
> sample size
>
> number of items in the sample **[SOURCE: ISO 2859-1:2014]**
>
> sampling increment
>
> amount of bulk material taken in one action by a sampling device **[SOURCE: ISO 10725:2000]**

Rationale: The origin of the definitions should be made clear to the user.

Suggest the following clarification to sentence four in para 9 on page 5.

> Measurement uncertainty is expressed as an interval within which values which can reasonably attributed to the measured quantity will lie **with a stated coverage probability**.

Rationale: The expression of measurement uncertainty should always be accompanied by its stated coverage probability to allow for its correct interpretation.

Propose the following modification of the sentence under para 10, page 6:

> The individual components of measurement uncertainty ~~must~~ **such as precision and bias, should** be identified and quantified~~, especially repeatability and bias~~.

Rationale: The use of individual components is ambiguous in the original sentence and may be interpreted in several ways. The revised sentence clarifies that what is meant by individual components is the random errors (precision) and the systematic errors (bias). Replaced repeatability with precision in order to make the sentence more general, covering different levels of precision instead of only repeatability (see also general comment about repeatability).

Propose the following change to page 6, para 13:

> There are many procedures available for estimating the uncertainty of a measurement result, notably those described in ISO [13]**,NMKL [xx]** and EURACHEM [12].

Where NMKL [xx] should be listed with the appropriate reference number in the updated list of references as:

> **[xx] NMKL Procedure No. 5, 2nd edition (2003): ''Estimation and Expression of Measurement Uncertainty in Chemical Analysis**

Rationale: NMKL Procedure No. 5 is referenced in the current CXG 54 and should be retained in the new guideline, since both EURACHEM and GUM are carried over from the old CXG 54 to the new CXG 54.

Propose to delete para 15, on page 6, except the first sentence which should be moved to the current para 16 (see next proposal below)

Rationale: Both top-down and bottom-up approaches have pros and cons and we therefore propose to delete para 15, since it leaves a very biased impression with respect to the trustworthiness of using different approaches. Alternatively, the characteristics connected to using a bottom up approach should also be clearly stated in a new paragraph.

Propose to move the first sentence of para 15 to para 16 after deletion of para 15.

> 16. **These procedures are not equivalent and may produce different estimates of the measurement uncertainty.** In addition to the fact that these procedures may vary with regard to the influencing effects included there is also often considerable **differences how and which random errors are included in the** ~~variation due to random variability of the~~ standard deviation figures (in-house reproducibility, reproducibility, repeatability). Therefore, both the chosen approach for estimating measurement uncertainty (in-house validation, ring trial, bottom up etc.) and the estimated level of confidence of the measurement uncertainty should be provided.

Rationale: Include the sentence from the deleted para 15 to retain the clarification that the estimate of the measurement uncertainty depends on the information used to calculate the measurement uncertainty. Delete "variation due to random variability of the" and specify that there are differences to how and which random errors are included in the standard deviations.

PERU

General Comments

Peru acknowledges the work done by Germany in the review of CXG 54-2004 Guidelines on measurement uncertainty.

Guidelines provide assistance for calculating uncertainty in sampling, a subject that has been highlighted in the new edition of ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories.

Specific Comments

Peru has no specific comments on CL 2019/16-MAS Request for comments in step 3 on the review of Guidelines on measurement uncertainty (CXG 54-2004).

BIPM

The document CX/MAS 19/40/6 looks slightly different from the last version that I have seen in the corresponding electronic WG.

However, as an observer to the CCMAS I would like to direct your attention to two major specific issues.

1) The formula given on page 18 under point 41 is incorrect. The sensitivity coefficients should be squared. The correct formula is given below.

$$u_c(y) = \sqrt{\sum_{i=1}^{N} [c_i u(x_i)]^2} \equiv \sqrt{\sum_{i=1}^{N} u_i^2(y)}$$

where $c_i \equiv \frac{\partial f}{\partial x_i}$ and $u_i(y) \equiv |c_i| u(x_i)$

2) The references listed on page 21 and 22 are not numbered and have not been assigned in the text as the other references in the rest of the document.