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May a CMC's uncertainty be lower than the uncertainty declared in the relevant key comparison?

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This note deals with the problem of the consistency between the uncertainties in Appendix B and in Appendix C of the Mutual Recognition Arrangement (MRA) and it is aimed to giving an answer in terms of *yes* or *not* to the following question: *may a CMC's uncertainty be lower than the uncertainty declared in the relevant key comparison?*

Appendix B and Appendix C are the technical basis of the MRA, as they contain the results of the key and supplementary comparisons and the lists of the quantities for which calibration and measurement certificates are recognised by institutes participating in the agreement, respectively. The level of the information included in the two appendices is different, being those in Appendix B the actual results of measurements and those in Appendix C just declarations of each NMI. Consequently, to form a coherent system of information, the MRA demands for uncertainties in Appendix C being consistent with the results given in Appendix B. The uncertainties claimed by each NMI and reported in Appendix C for the different Calibration and Measurement Capabilities (CMCs) are the parameters used to verify the consistency with Appendix B.

For a better understanding of the terms of the problem it is worth to recall the main information included in the two appendices, as they are summarised in the text of the MRA [1]:

> ***Appendix B***
> *For each key comparison the following are included:*
>
> *a) individual values for each institute together with their declared uncertainties;*
> *b) the key comparison reference value with its associated uncertainty;*
> *c) for each institute, the deviation from the key comparison reference value and the uncertainty in that deviation (at the 95 % level of confidence), i.e., its degree of equivalence;*
> *d) the degree of equivalence between the standards of each participating institutes.*
>
> ***Appendix C***
> *Quantities for which calibration and measurement certificate are recognised by institutes participating in part two of the agreement. The quantities, ranges and calibration and measurement capabilities expressed as an*

uncertainty (normally at a 95 % level of confidence) are listed for each participating institute.

The regional metrology organisations (RMOs) and the Joint Committee of the RMOs and the BIPM (JCRB), which are responsible for the review, analysis and inclusion of the CMCs in Appendix C, should decide whether the declared uncertainties for the CMCs are consistent with the information in Appendix B. Because no guidelines about have been given in the text of the MRA, different interpretations could be assumed by the different organisations if a common interpretation is not agreed.

The decision-making process could reveal particularly critical in analysing a CMC at a same accuracy level of a key-comparison exercise because the respective uncertainties may be very close and, in some cases, the uncertainty in the CMC may be lower.

Consider the case of an NMI offering a primary calibration of an instrument or artefact of the same type as that used by the same NMI in the key comparison. The two uncertainty budgets estimated by the NMI in question, i.e., for the CMC and for the key comparison, may be different, being that for the key comparison higher. This is not surprising because additional uncertainty components may originate during the comparison exercise due, for example, to a drift in the transfer standard.

A clear example is offered by the CCT-K5 [2] where ITS-90 realisations by radiation thermometry were compared using tungsten-strip lamps as transfer standards. Because the radiance temperature of tungsten-strip lamps is wavelength dependent, it was decided to refer the calibration results to a common reference wavelength of 650 nm. Because the actual wavelengths of the participating laboratories ranged from about 649 nm to about 665 nm, the reduction to 650 nm implied corrections up to a maximum of about 4.5 °C at the maximum calibration temperature of 1700 °C. Since the uncertainty associated with the correction was 10% of its absolute value, additional uncertainties of several tenths of degree were thus originated. For some laboratories this uncertainty component resulted to be the predominant component that largely increased the overall uncertainty of their comparison results. Unfortunately, only the overall uncertainty appears in Appendix B so any information about the components originating from the comparison itself is missing. This makes impossible to any evaluation body to judge about the actual capability of a given laboratory. However, it must be considered that the different uncertainty components are listed separately in the documentation of the key comparison, being they included in the report that each laboratory has send to the co-ordinator. For the sake of a correct evaluation, the individual reports should be taken as official documents and submitted to the attention of the evaluation body in case of controversial specifications for the uncertainties in Appendix B and in Appendix C.

Following the reasoning above, it is quite evident that we can not simply refer to the total comparison uncertainty in deciding for the inclusion of a CMC in Appendix C, but an analysis of the different components should be done. As a first and obvious step, it should be verified that the uncertainty claimed for the CMC is not lower than the corresponding uncertainty components in the comparison's report (because the uncertainty originating from the comparison is not present in the CMC, this

uncertainty must not be considered). If things are so and the results of the key comparison are consistent with the uncertainty estimate of the laboratory, the uncertainty claimed for the CMC should be supported. A possible objection could be that in case the additional components due to the comparison itself (drifts, reduction to reference values, etc.) are predominant, the other components may be partially, or in same case completely, hidden and consequently they could loose of significance. In such a case there is no means of disclosing a possible underestimate of its uncertainty by the laboratory, but *we must consider as credible the estimate of the laboratory, as the results of the key comparison confirmed its declarations*. On the other hand, a laboratory cannot be penalised for uncertainties that are stemming from sources beyond its control.

In conclusion, the answer to the original question should be: *yes, the uncertainty of a CMC may be lower than that of the relevant key comparison.*

REFERENCES

[1] Mutual Recognition Arrangement (MRA), Appendices to the Arrangement, p.41, Paris, October 1999

[2] CCT-K5: *Protocol to the comparison of local realizations of the ITS-90 between the silver point and 1700 °C using vacuum tungsten-strip lamps as transfer standards.*

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