Uncertainty contributions of the device under calibration or measurement

Introduction

The ongoing CMC review processes within and among Regional Metrology Organizations have brought up the question of uncertainty contribution of the *device under calibration or measurement* (DCM). Behind the metrological question there is a more fundamental aspect, namely whether under the CIPM MRA the mutually recognized and published CMCs should

- tell the customers what uncertainty the NMI calibration and measurement system can provide, e.g. the NMI's capability independent of the customer's device

or

- what uncertainty customers may expect from a calibration or measurement on his device.

Information gathered by members of the *ad hoc* JCRB WG CMC Uncertainties in their RMOs shows diverging views and practice as well as a wish for clarification. And not surprising, even within RMOs, depending on the subject field, there are varying views and practice.

Regional accreditation organizations like the European co-operation for Accreditation (EA) have tackled the question of uncertainty contribution of the device itself some time ago. In paragraph 1.3 of its document EA-4/02[1)] the EA specifies the best measurement capability as the one *with the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation, when performing more or less routine calibrations of nearly ideal measurement standards intended to define, realize, conserve or reproduce a unit of that quantity or one or more of its values, or when performing more or less routine calibrations of nearly ideal measuring instruments designed for the measurement of that quantity.*

The terms "ideal" or "nearly ideal" used in the EA-4/02 and commented in its Appendix A with „even the most 'ideal' available device contributes to the uncertainty of measurement". In other words, ideal means also "real", that is a real instrument with non-zero uncertainty contribution when being calibrated with a reference standard by the accredited laboratory. As the reference standard is usually of higher accuracy than the DCM, the uncertainty contribution of the DCM becomes significant, and, for at least the type A evaluated uncertainty contribution, often dominant. But clearly, the term "ideal" is widely open for interpretation and opinion and goes as far as "with negligible" uncertainty contribution.

This document, prepared by a JCRB *ad hoc* Working Group CMC Uncertainties, is to analyze the situation and to clarify the issue in the context of the CIPM MRA. Furthermore, the document is intended to provide participating NMIs and RMO reviewers recommendations on the inclusion or exclusion of uncertainty contribution of the DCM.

The CIPM MRA and CMC uncertainty

Two paragraphs of the MRA and its Technical Supplement are indirectly relevant to the raised question.

Paragraph 2.2 of the MRA states on CMC certificates:

"*Participating institutes recognize the validity of calibration and measurement certificates issued by other participating institutes for quantities and ranges specified in Appendix C*".

From this formulation it may be concluded that MRA participants directly recognize the validity (and thereby the contents) of certificates and indirectly NMI measurement capabilities being a prerequisite among others.

Paragraph T.7 of the MRA's Technical supplement states among others "*... The calibration and measurement capabilities referred to in this paragraph are those that are ordinarily available to the customers of an institute through its calibration and measurement services; they are sometimes referred to as best measurement capabilities."*

The expression "ordinarily available to customers" in the MRA context means:

- the CMCs are offered to customers without extraordinary preparation or special conditions,. e.g. they are published in the NMIs service list and available at any time in principle;
- the CMCs are available to customers for their devices.

The reference to best "measurement capabilities" implies best, but real conditions including best (ordinarily available) customer devices.

Uncertainty contribution of the DCM

Two kinds of uncertainty components of the DCM eventually contributing to the total CMC uncertainty may be distinguished, those arising before and after its calibration or measurement (among them the so-called transport uncertainty) and those arising during the calibration or measurement itself.

The information gathered with respect to uncertainty components of the DCM before or after its calibration or measurement shows an almost uniform view and practice: It is not a part of the calibration or measurement performed at the NMI and therefore out of the NMI's control. It is up to the customer to consider them. It is normally not included with the determination of the CMC uncertainty.

Recommendation 1
It is recommended to exclude contributions to the CMC uncertainty caused by the customer device before or after its calibration or measurement at the institute.

The information gathered with respect to uncertainty contributions caused by the customer device during calibration or measurement is less uniform. But there is dominant opinion that contributions caused by the the best available DCM during its calibration or measurement should be taken into account. Uncertainty components determined by repeated measurements (type A) inherently include the DCM itself. Moreover, with the uncertainty determination the actual calibration or measurement process on a real customer device gets characterized – not just the NMI's set-up.

Recommendation 2
It is recommended to include contributions to the CMC uncertainty caused by the best ordinarily available customer device during its calibration or measurement at the institute. In general, these values will be published in Appendix C of the CIPM MRA. For individual certificates the actual characteristics of the customer device must be considered.

[1)] Expression of the Uncertainty of Measurement in Calibration, **EA-4**/02, December 1999.