Review Protocol for Relative Humidity CMC's

1. Scope: To provide a method of reviewing relative humidity CMC's for acceptance in Appendix C of the KCDB.

The CMC review protocol described in this document is primarily designed for use during the RMO review of the CMC's by the RMO CMC review committee. After the RMO review, the CCT inter-RMO CMC review committee shall review only those CMC entries that are labelled "under review" from the RMO CMC review process. After the CMC review process is completed, the CMC's are submitted for general acceptance to the JCRB.

The CMC review process is not to bluntly increase uncertainties. In such case the uncertainties become subject to political, rather than scientific arguments. The discussion must have a scientific basis: If during the CMC review any lab is asked to increase uncertainty claims it must be on the basis that a claim is clearly proven inconsistent.

At this point, the NMI has the option of either submitting a new CMC entry to the RMO CMC review committee for another review or submitting the "under review" CMC entry to the inter-RMO review committee through their RMO for resolution.

The review process according to this protocol is presented graphically in appendix A.

2. General Acceptance Criterion for Service Categories 3.2 and 3.3

If the CMC uncertainty claim is larger than the corresponding value in Table 1 and an appropriate uncertainty budget[1] is provided, then the uncertainty is deemed acceptable.

In all other cases, Specific Acceptance Criteria presented in the following sections are applied.

3. Specific Acceptance Criteria for Service Category 3.3[2]

As CCT key comparisons for relative humidity calibrations are not carried out, the NMI should submit other evidence for the CMC review if General Acceptance Criterion is not fulfilled. The evidence can be:

- results of an interlaboratory comparison (case 1)
or
- results of internal evaluation measurements (case 2)

1 If the CMC claim covers a temperature range below 0 °C, the NMI should submit information about applied calculation methods and definitions of humidity quantities.

2 Relative humidity sensors

If comparison results are submitted as the evidence (case 1), the criteria specified in section 3.1. are applied.

In case 2, criteria of section 3.2 are applied. These criteria can only be applied if the NMI uses a saturator-based humidity generator or a chilled mirror hygrometer as the humidity standard in the relative humidity calibrations.

3.1 Interlaboratory-comparison-based criteria

If the General Acceptance Criterion (in Section 2) is not met and the NMI has participated in an interlaboratory comparison, then the uncertainty is deemed acceptable if the following criteria are met (symbols are explained in Table 2)

$$\left|V_{\mathrm{NMI,IC}} - V_{\mathrm{ICRV}}\right| < \sqrt{U^2_{\mathrm{NMI\,CMC}}(k=2) + U^2_{\mathrm{RV}}(k=2)} \quad (1)$$

and

$$u_{\mathrm{NMI\,CMC}} \geq u_{\mathrm{NMI,IC}} \quad (2)$$

and

$$u_{\mathrm{NMI\,CMC}} > \frac{u_{\mathrm{RV}}}{3} \quad (3)$$

and

$$t_{\mathrm{IC,min}} \leq t_{\mathrm{NMI\,CMC}} \leq t_{\mathrm{IC,max}} \quad (4)$$

3.2 Intralaboratory-evaluation-based criteria

If the General Acceptance Criterion (in Section 2) is not met and the NMI uses a saturator-based humidity generator or a chilled mirror hygrometer as the humidity standard in the relative humidity calibrations, the CMC's under Service Category 3.3 claimed by an NMI is accepted if the following criteria (2 criteria for dew-point temperature measurements, 2 criteria for temperature measurements and 1 criterion for the uncertainty budget) are fulfilled:

1) Dew-point temperature (t_d):

a. In the whole claimed operating range (relative humidity and temperature) t_d is within NMI's accepted CMCs in Service Category 3.1

or

in the whole claimed operating range (relative humidity and temperature) acceptable evidence[3] on the traceability to primary dew-point temperature standards maintained by an NMI with accepted CMCs in Service Category 3.1 is provided.

b. Evidence is provided showing that the uncertainty due to water vapour pressure gradients in the measurement chamber is not larger than the uncertainty component included in the uncertainty budget (u_{ewG}). The evidence should cover the whole claimed operating range (relative humidity and temperature)[4].The evidence is primarily following:

i. The difference between the maximum and minimum dew-point temperature in the measurement chamber (t_{dMax} and t_{dMin}, respectively) fulfils the requirement

$$u_{ewG} \geq \frac{e_w(t_{dMax}) - e_w(t_{dMin})}{2\sqrt{3}} \qquad (5)$$

2) Temperature (t_g):

a. In the whole claimed operating range acceptable evidence[5] on the traceability of t_g to ITS-90.

Evidence is provided showing that the uncertainty due to gas temperature gradients in the measurement chamber is not larger than the uncertainty component included in the uncertainty budget (u_{tG}). The evidence should cover the whole claimed operating range.

Further instructions related to the evidence:

i. The evidence is obtained by temperature measurements in the chamber using at least two small thermometers.

ii. The locations of thermometers during the exercise should cover the whole measurement volume in the chamber.

[3] NMI should provide information on 1) the source of traceability (i.e name of the NMI), 2) chilled mirror hygrometer(s) or generator used as the standard, 3) calibration interval for the standard, 4) range(s) covered by the calibration of the standard (NOTE: in a case of a generator both temperature and dew-point temperature ranges should be specified)

[4] The evidence should cover at least RH maxima and minima at both ends of the temperature range. If uncertainty is significantly smaller in a middle temperature range, the evidence should also cover this.

[5] NMI should provide information on 1) the source of traceability (i.e. name of laboratory calibrating the thermometer(s)), 2) type of the thermometer(s), 3) calibration interval for the thermometer(s).

iii. Information about the volume of the measurement chamber, size and type of the thermometer probes should be reported.

iv. Possible differences in self-heating and heat conduction along the thermometer probes during the exercise should be analysed (at least a comment on this is required).

v. Effect of loading to temperature gradients should commented (in a case of a small measurement chamber, the measurement result should be given showing the effect, i.e. measurement gradients without any RH probe and with maximum number of probes).

3) Uncertainty budget

The uncertainty budget should cover at least the following components:

- determination of the water vapour pressure in the chamber:
  a. dew-point temperature of the gas supplied to the chamber
  b. water vapour pressure gradients
  c. adsorption/desorption (in low temperatures)
  d. temporal variation
- determination of the gas temperature in the chamber:
  a. thermometer(s):
     i. calibration
     ii. self-heating
     iii. long-term instability
     iv. hysteresis (if not included in the calibration)
     v. resolution
     vi. heat conductance along the probes
  b. temperature gradients
  c. temporal variation
  d. effect of thermal radiation
- uncertainty of water vapour formulae and applied calculation method
- device under calibration:
  a. temporal variation
  b. hysteresis
  c. resolution

If the CMC claim covers a temperature range below 0 °C, the NMI should submit information about applied calculation methods and definitions of humidity quantities.

4. Specific Acceptance Criteria for Service Category 3.2[6]

If the General Acceptance Criterion (in Section 2) is not met, then the CMC under Service Category 3.2 claimed by an NMI is accepted if

- the specific acceptance criteria specified in section 3 are fulfilled

and:

- the uncertainty budget includes a component for humidification effect of the psychrometer under calibration
- NMI has submitted measurement data showing the appropriateness of the estimation of the humidification effect.

Table 1. Review criteria uncertainty values

t / °C *RH* / %rh [1)]	-60	-50	-40	-30	-20	-10	5	15	30	45	60	75	90
98	6.0	5.0	4.0	3.5	3.0	2.8	2.2	2.1	2.1	2.0	2.0	2.0	2.0
90	5.0	4.5	3.5	3.0	2.5	2.5	2.0	1.9	1.9	1.8	1.7	1.7	1.7
70	4.0	3.5	3.0	2.5	2.0	2.0	2.0	1.9	1.9	1.8	1.7	1.7	1.7
50	3.0	2.5	2.0	2.0	1.8	1.7	1.6	1.5	1.5	1.5	1.4	1.4	1.4
30	2.0	2.0	1.5	1.5	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
10	--	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
2	--	--	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4

[1)] In the temperature range below 0 °C, the relative humidity is given with respect to ice

[6] Psychrometers

Table 2: Nomenclature

IC	Interlaboratory comparison
RV	Comparison reference value
$V_{NMI,IC}$	NMI Comparison result
$u_{NMI,\ RC}$	Standard uncertainty of $V_{NMI,IC}$
V_{ICRV}	Reference value of the interlaboratory comparison
U_{RV}	Expanded uncertainty $U_{RV} = k \cdot u_{RV}$ where u_{RV} is the standard uncertainty of V_{ICRV} (coverage factor given in the parentheses)
$U_{NMI\ CMC}$	Expanded uncertainty $U_{NMI\ CMC} = k \cdot u_{NMI\ CMC}$ where $u_{NMI\ CMC}$ is the NMI CMC standard uncertainty claim (coverage factor given in the parentheses)
t_{IC}	Temperature at which the $V_{NMI,IC}$ was measured
$t_{IC,\ max}$	Maximum temperature at which the $V_{NMI,IC}$ values were measured
$t_{IC,\ min}$	Minimum temperature at which the $V_{NMI,IC}$ values were measured
$t_{NMI\ CMC}$	Temperature of the NMI CMC claim
u_{ewG}	Claimed uncertainty due to water vapour pressure gradients in the measurement chamber
e_w	Water vapour pressure
t_d	Dew-point temperature of the gas
t_{dIn}	Dew-point temperature of the gas entering the measurement chamber
t_{dOut}	Dew-point temperature of the exiting the measurement chamber
t_{dMax}	Maximum dew-point temperature in the measurement chamber
t_{dMin}	Minimum dew-point temperature in the measurement chamber
t_g	Gas temperature in the measurements chamber
u_{tG}	Claimed uncertainty due to gas temperature gradients in the measurement chamber

APPENDIX A: DIAGRAM SHOWING THE RH CMC REVIEW PROCESS