Guideline for RMO Key comparison for Air kerma rate in ^{60}Co gamma radiation

This intercomparison will be carried out under the lead of KRISS with the cooperation of ARPANSA. This comparison has been approved by CCRI (I) in May, 2003.

1. Circulate three transfer chambers (two NE2571 from INER and ARPANSA and one PTW 30001 from KRISS), with build-up caps (One of the reasons for circulating three chambers is to be able to assign smaller uncertainty by repeating the same measurement. The other reason is that if one chamber changes during transport or handling, the two that agree can be taken as correct. With only two chambers, if one changes it may be difficult to use either result).

2. The initial stability check of the transfer chambers will be done by KRISS before the circulation of the chambers using ^{90}Sr source. Each NMI is required to return the chambers to KRISS for the stability check when the measurement is done. The chambers will be forwarded to the next NMI by KRISS after the stability check.

3. Perform calibration for air kerma in a ^{60}Co beam, at 1 m with a size of 10 cm × 10 cm in rectangular beam or φ = 10 cm in circular beam (however, the beam size doesn't have to be exact. In that case, specify the beam size).

4. The charge collected by the chamber is measured using NMI's electrometer following a pre-irradiation of at least 1 hour. All the measurements are corrected for current leakage. The measurement of result is expressed in mGy/nC.

5. The experimental details regarding the measurement using the chamber is as follows;
   a) Chamber Positioning : The axis of the chamber is placed in the reference plane at 1 m from the radiation source. The chamber is oriented with the straight line inscribed on the stem facing the radiation source. The chamber center is taken to be aligned with a black line on the build-up cap. No correction is applied for the radial non-uniformity of the beam because an effect for this chamber type is estimated to be less than 2×10^{-4} in relative value.
   b) Collecting Voltage : A collecting voltage of 250 V (negative polarity) is applied to the chamber at least 1 hour before any measurement. Collecting voltage should be applied to outer shell of the chamber and circuit diagram for the measurement is described in the figure.
   c) Ambient Condition : During the calibration the surrounding air temperature is to be stable to better than 0.05 ^{o}C. The ionization current is normalized to the reference conditions 20 ^{o}C and 101.325 kPa. The relative humidity within the range from 40 to 70 % is highly recommended.
   d) Reproducibility of measurement : For the determination of chamber calibration factor, a set of ten measurements for each chamber is recommended.

6. Each participant must include the percentage relative standard uncertainty of their air kerma standard as outlined in the ISO document 'Guide to the Expression of Uncertainty in Measurement', 2nd edition, 1995. As in this document, uncertainties

should be classified as either type A (determined by statistical methods, with associated degrees of freedom) or type B (determined by other than statistical).

All contributing uncertainties should be separately identified and their values tabulated. In particular, uncertainties for the following quantities must be included:

For the participants from the primary standard institutions

a) Primary standard cavity chamber current measurement.
b) Measurement time, electrometer (voltage readout, internal or external capacitance), temperature, pressure and humidity.
c) Conversion of primary standard current measurement to air kerma.
d) Each correction factor applied in the absolute measurement.
e) Transfer chamber ionization current measurement.
f) Same as b) but for the transfer chamber measurement.
g) Position of the transfer chamber relative to that of the primary standard chamber.

Uncertainty component	Type A	Type B
▪ Air kerma rate Ionization current measured by primary standard chamber Sensitive volume of the primary standard chamber Air density under the measurement condition Physical constants used in the primary laboratory - Average energy spent by an electron of charge to produce an ion pair in dry air - fraction of energy loss by bremsstrahlung - Mean mass-energy absorption coefficient ratio between air and graphite - Mean stopping power ratio between graphite and air Correction factors to be applied to the standard - Correction for attenuation and scatter in the wall - Correction for Mean center of electron production - Correction for loss of ionization due to recombination - Correction for scattering from the chamber stem - Correction for humidity - Correction for radial and axial non-uniformity of the beam - Correction for polarity effect Current measurement system Environmental condition under which the measurement is done (temperature and pressure) Position of the primary standard chamber ▪ Ionization current of transfer chamber ▪ Environmental condition for the measurement with transfer chamber (temperature and pressure) ▪ Position of transfer chamber		
Quadratic summation Combined Standard Uncertainty		

For the participants from the secondary standard institutions

h) Secondary standard thimble chamber current measurement. (identify the traceability)
i) Same as b), plus uncertainty of the calibration factor of the secondary standard chamber.
j) Same as b) but for the transfer chamber measurement.
k) Position of the transfer chamber relative to that of the secondary standard chamber.

Uncertainty component	Type A	Type B
▪ Air kerma rate Calibration factor of secondary standard chamber Current measurement system Environmental condition (temperature and pressure) Position of secondary standard chamber ▪ Ionization current of transfer chamber ▪ Environmental condition for the measurement with transfer chamber (temperature and pressure) ▪ Position of transfer chamber		
Quadratic summation Combined Standard Uncertainty		

7. Each participant should specify the measurement conditions at their laboratory, *i.e.* distance from the source to the reference plane, central axis air kerma rate, beam size and shape in the reference plane at 50 % of the central axis air kerma rate.

8. Three chambers will be circulating in a single group of 10 participants.

Stability check :

The stability check of the transfer chambers will be done by KRISS (NMI 0) whenever each NMI finishes the measurement. The chambers will return to KRISS and will be sent to the next NMI after the stability check.

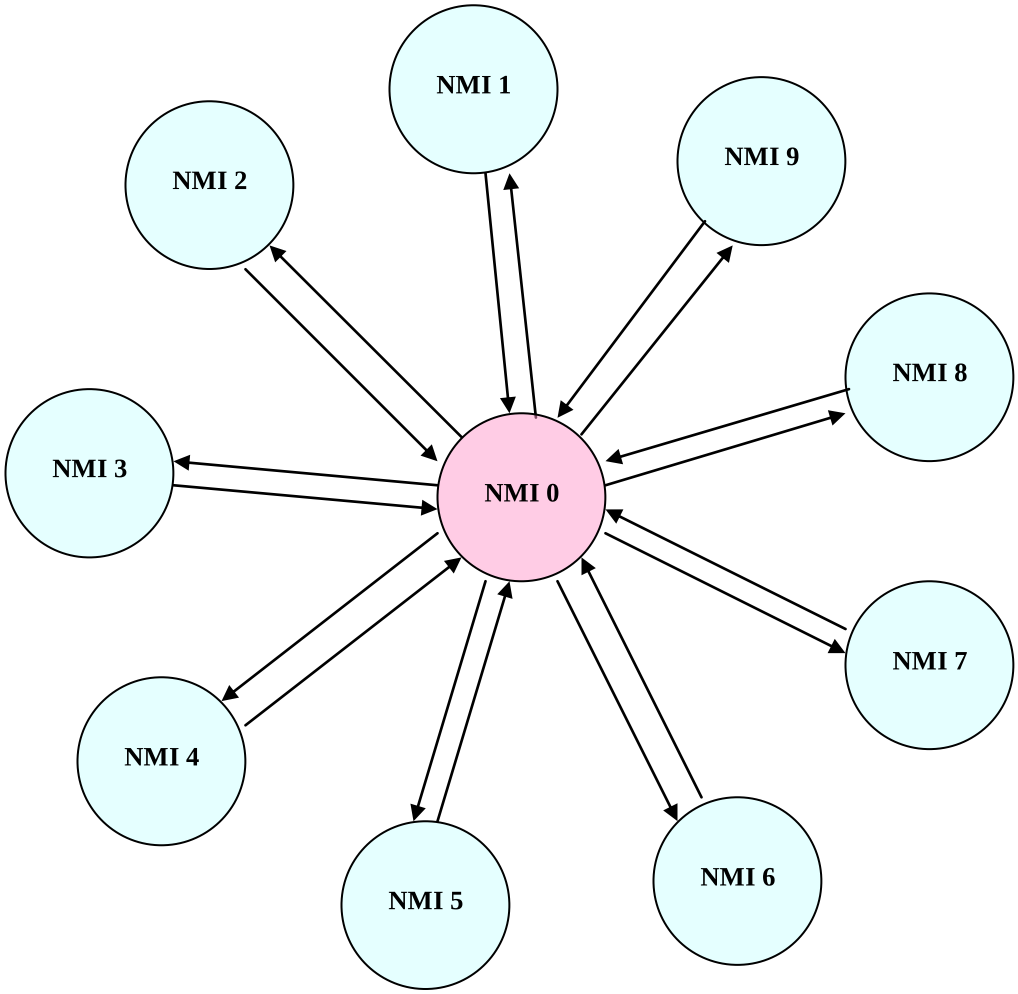
Measurement :

Three chambers will be circulated through the participating NMI's and will be calibrated by ARPANSA, AIST and BARC before, in the middle and after the circulation. The sequence is as follows;

Three chambers calibrated by AIST (NMI 1)
Three chambers will be circulated to the participating NMI 0, 2, 3.
Three chambers calibrated by ARPANSA (NMI 4)
Three chambers will be circulated to the participating NMI 5, 6.
Three chamber calibrated by BARC (NMI 7)
Three chambers will be circulated to the participating NMI 8, 9.

9. The types of the transfer chamber for the RMO Key Comparison will be NE2571 (#3072, #3259) and PTW 30001-2229.

10. The diagram describing the way the comparison will be conducted is shown below;



For each transfer chamber,

$$NMI_{ave} = (NMI_1 + NMI_4 + NMI_7)/3$$

$$\text{Ratio } 1 = \frac{NMI_1}{NMI_{ave}}, \quad \text{Ratio } 2 = \frac{NMI_2}{NMI_{ave}}, \ldots\ldots\ldots \text{ Ratio } 10 = \frac{NMI_0}{NMI_{ave}}$$

$$\text{APMP reference value} = \frac{\text{Ratio}_1 + \text{Ratio}_2 + \text{Ratio}_3 \cdots + \text{Ratio}_{10}}{10}$$

11. Each NMI is required to notify the result and the condition of the chambers when the measurement is done. If something happens to the transfer chambers during the measurement, the corresponding NMI should return the chambers to KRISS

immediately. If this is prevented by unforeseen circumstances, the pilot laboratory must be informed without delay, as it may be necessary to reschedule the timetable.

12. Each NMI should be responsible for the safe transportation of the chambers as well as delivery fee back to KRISS and KRISS is also responsible for the delivery to the next NMI. It is strongly recommended that the allocated measurement time be 3 weeks.

13. KRISS, ARPANSA, BARC and NMIJ will collect the results and KRISS will be responsible for the summary and report of the final result to APMP.

14. Three BIPM linked NMI's (ARPANSA, AIST and BARC) are required to provide KRISS with the result of Key comparison with BIPM so that KRISS will use them to obtain APMP reference values for the transfer chambers.

Figure : Circuit diagram of applying collecting voltage to the ionization chamber