**Protocol for a CCRI(II) Supplementary Trilateral**

**Comparison of 222Rn**

**1 - Introduction**

Radon-222 is a radioactive noble gas decaying through alpha transition to short half-life solid progenies and is one of the main sources of natural radioactivity. It is monitored with commercial detectors and devices to evaluate radon activity concentration in rooms, water or soil. National standards of 222Rn are available in several countries and comparison of these standards is necessary to ensure the international traceability of this radionuclide and to support the CMC’s of the National Metrology Institutes.

**2 - Previous comparisons**

International comparisons were organized by NPL in 1992 and 19941. At this time, 222Rn activity references were based on 226Ra source emanation or on gamma-ray spectrometry. Other CCRI(II) comparisons are available through the SIR2,3.

In the case of SIR measurements, the variability of the glass ampoules thickness could be an additional cause of uncertainty. A comparison of standards using a more reliable metallic container have been organized in 20154. In this comparison, different measurement methods were used. The method using Ionization Chamber with glass ampoule performed at the institute of Radiation Physics (IRA) in Switzerland gave an outlier result of several percent’s. The reason of this discrepancy was ascribe to the non-control quality of the glass ampoule, which could have fluctuation in the thickness5.

Therefore, IRA expressed the need to perform a measurement comparison using Alpha Counting in Defined Solid Angle that has already shown good performances in the past4.

In addition, the National Institute of Metrology in China (NIM) has set up a new measurement system to standardize 222Rn and is requesting to have also a comparison.

Therefore, this trilateral comparison will be organized as a round-robin exercises between LNE-LNHB (pilot), IRA and NIM, using the method of Alpha Counting in Defined Solid Angle. The sample will be circulated between the 3 laboratories and finally sent back to LNE-LNHB.

**3 - Specificity of 222Rn comparison**

Due to the short half-life of this radionuclide (3,8232(8) d), the logistics is important and all precautions must be taken in advance to be sure that measurement systems are operational at the reception date. The shipment will be organized as an exempted parcel transportation which imposes two constraints: the activity must be lower than 100 MBq and the dose rate at the contact of the parcel must be lower than 5 μSv/h.

**4 - Comparison protocol**

**4.1 - Participants:** IRA (Switzerland), NIM (China) and the pilot laboratory LNE-LNHB (France). Each participant will measure the radon activity in his own setup.

**4.2 - Source composition:** 222Rn will be delivered in a metallic container with approximately 300 kBq at time of shipment by LNHB.

**4.3 - Container:** metallic (stainless steel) container of 105 cm3 supplied by LNE-LNHB. The 222Rn source is to be transferred by each participant into their own measurement device. The internal pressure of the container will be about 10-2 Pa of nitrogen, the typical partial pressure of 222Rn being negligible.

A picture of the container is given in *Appendix 1*.

**4.4 - Measurand:** total activity of 222Rn in the container at the reference date, uncertainty *k* = 1.

**4.5 - Reference date:** 01st September 2018, 12:00 UTC but could be modified according to the shipping schedule.

**4.6 - Recommended nuclear data:** Decay Data Evaluation Project, <http://www.nucleide.org/DDEP_WG/Nuclides/Rn-222_tables.pdf>

**4.7 – Distribution/Circulation:**

LNE-LNHB will prepare and measure around 300 kBq of 222Rn in a metallic container.

The container will be shipped to IRA between weeks 35 and 37 where it will be transferred to the measurement chain and measured.

After refill of the container, it will be shipped to NIM where it will be measured. Again, after the transfer to the NIM system, 222Rn will be measured and transferred back to the container which will be sent back to LNHB for a final measurement.

Transport of the 222Rn containers will be arranged by each laboratory using their normal shipment arrangements for exempted parcels. A list of requested information will be sent to participants before the beginning of the exercise in order to avoid any delay due to logistic problems.

Immediately after receipt, the participating institute shall acknowledge the reception, check for any damage to the sample and report this to the LNE-LNHB.

The time between the first and last measurement should not exceed 2 weeks.

**4.8 - Schedule of the comparison:**

**Reporting deadline:** 15th October 2018

Draft A sent to participants: 30th October 2018

Draft A acceptance deadline: 15th November 2018

Draft B sent to participants: 30th November 2018

Draft B acceptance deadline: 15th December 2018

The LNE-LNHB will be responsible for maintaining up-to-date key comparison status reports and will transmit them to the CCRI(II) Executive Secretary.

The costs associated with the shipment of the 222Rn containers will be borne by each laboratory which will send them.

**4.9 - Expression of the results:** LNE-LNHB will send a copy of its own results to the CCRI Executive Secretary prior to the receipt of any results from participants. The participants will be explicitly notified that they can submit their results to the LNE-LNHB. Please do not submit any results until you have received the notification. All results, method of standardization, associated uncertainties and other additional details which may be requested shall be sent to the LNE-LNHB using the reporting forms that will be provided. Participants shall supply a list and an evaluation of the principal components of the uncertainty budget based on the Guide to the Expression of Uncertainty in Measurement. In addition to the principal components of the uncertainty, common to all of the participants, individual institutes must add any other components they consider appropriate.

**5 - Preparation of the report on the comparison**

**5.1 - Treatment of the participants’results** : The results obtained by IRA and NIM will be compared to the two measurements made at LNHB.

**5.2 - Reports edition:** LNE-LNHB is responsible for the preparation of the report of the comparison. The report passes through a number of stages before publication which are here referred as Draft A and Draft B.

After reception of the explicit request to send the reporting forms to LNE-LNHB (see 4.9), the results will be kept confidential by the pilot laboratory until the Draft A is circulated to all the participants.

A result from a participant is not considered complete without an associated uncertainty and is not included in the draft report unless it is accompanied by an uncertainty supported by a complete uncertainty budget. Uncertainties are drawn up following the guidance given in this Technical Protocol and in the reporting forms.

If, on examination of the complete set of results, LNE-LNHB finds results that appear to be anomalous, the corresponding institutes are invited to check their result for numerical errors but without being informed of the magnitude or the sign of the apparent anomaly. If no numerical error is found, the complete set of results is used to prepare the Draft A.

The Draft A report is prepared as soon as possible after all the results have been received from the participants. It includes the results, uncertainties, standardization methods and experimental details transmitted by the participants, identified by name.

Draft A of the report is sent to all the participants for comments, with a reasonable deadline for replies. The date at which this draft is sent to the participants is taken to be the end date for the comparison and is subsequently referred to as such.

If any controversial or contradictory comments are received by the LNE-LNHB, they will be circulated to all participants and discussion continues until a consensus is reached.

Draft A is still considered as confidential to the participants. Copies are not given to non-participants, and graphs or other parts of the draft are not used in oral presentations at an external conference without the specific agreement of all the participants. The results may be the subject of an internal report if they are shown in relative terms and the names of participants hidden. At this stage, a participant may publish experimental techniques of special interest or new developments of a measurement method made in the frame of the comparison, as long as no information or comments are made about the comparison results.

Note that once all participants have been informed of the results, individual results and uncertainties may be changed or removed, or the complete comparison abandoned, only with the agreement of all participants and on the basis of a clear failure of the travelling standard or some other phenomenon that renders the comparison or part of it invalid. On receipt of final comments from the participants, the LNE-LNHB will incorporate them into a revised Draft A which, once circulated and agreed by all the participants, will become Draft B. The LNE-LNHB will then complete the Draft B to include the preliminary key comparison reference value and degrees of equivalence.

The Draft B is circulated through the participants and is no longer confidential and may be the subject of a publication, with the exception of the section containing the proposals for the degrees of equivalence.

The Draft B shall be sent to the CCRI Executive Secretary for preliminary editorial revision and circulation first through the KCWG(II) for technical review, and second through the CCRI(II) for approval. Once it is approved it will become the Final Report of the trilateral comparison and will be uploaded into the KCDB.

The BIPM will assist as needed at any of the stages described above and would possibly link the results in the Final Report to the BIPM.RI(II)-K2.Rn-222, if relevant.

**Appendix 1 - Container description**



