EURAMET project no. 1388 Supplementary comparison in dosimetry — ISO Narrow x-ray beams

Technical protocol EURAMET.RI(I)-S3.2

Pilot laboratory: SSDL of Norwegian radiation Protection Authority (NRPA)

Contact person: Hans Bjerke

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1 Object and participants

The SSDLs of Norway (NRPA), Sweden (SSM) and Finland (STUK) together with the PSDL (LNE-LNHB) of France have agreed to perform supplementary comparisons in the ISO Narrow x-ray beams [1].

This technical protocol produced by the dosimetry laboratories specifies the procedure to be followed for the particular dosimetry comparison.

The purpose of this supplementary comparison is to compare the calibration and measurement capabilities (CMCs) in the participating secondary standard dosimetry laboratories (SSDLs), not to require each participant to adopt precisely the same conditions of measurement [2]. The protocol, therefore, specifies the procedures necessary for the comparison, but not the procedures used in the calibration of the national secondary dosimetry standards being compared.

There are two previous supplementary comparisons in the field of X-ray radiation protection: EUROMET.RI(I)-S3 [3] and EURAMET.RI(I)-S3.1 [4].

Therefore, this protocol covers the procedure for the supplementary comparison EURAMET.RI(I)-S3.2.

1.1 Object of the comparison

The object of the comparison is to support the ionising radiation CMCs of Norway, Sweden and Finland in the dosimetry branch for the quantity air kerma/rate from the source x-ray 10 kV to 50 kV and 50 kV to 420 kV. The radiation qualities will be taken from the ISO Narrow beams 10 kV to 300 kV.

The outcome of the comparisons is to validate the calibration practice of the SSDL participants; i.e. to support the CMC claims of the Norwegian, the Swedish and the Finnish SSDLs.

1.2 Participants

In appendix I, you will find complete addresses of the participants.

Table 1 Participants in the comparison

Institute	Country	Contact	e-mail
NRPA (pilot)	Norway	Hans Bjerke Per Otto Hetland	Hans.Bjerke@nrpa.no Per.Otto.Hetland@nrpa.no
SSM	Sweden	Linda Persson	Linda.Persson@ssm.se
STUK	Finland	Jussi Huikari	Jussi.Huikari@stuk.fi
LNE-LNHB	France	Marc Denoziere	Marc.Denoziere@cea.fr

2 Details of the transfer instruments

The Exradin A6 was selected for the comparisons. Table 2 outline the information of the chamber for the ISO Narrow series.

Table 2 Technical data of the transfer chamber for ISO Narrow series

Chamber type	Exradin A6
Serial number	XQ152602
Geometry	spherical
Wall material	C-552
Wall thickness / g cm^{-2}	0.53
External diameter / mm	120
Cavity height / mm	120
Nominal volume / cm^{3}	800
Reference point (on chamber wall)	Ring on wall and mark on stem toward source
Polarising voltage / V	+300

2.1 Traceability of the standards

Table 3 outline the traceability of the secondary standards at the SSDLs.

Table 3 Traceability of calibrations at the SSDLs

SSDL	CCRI medium
NRPA	VSL
SSM	PTB
STUK	PTB

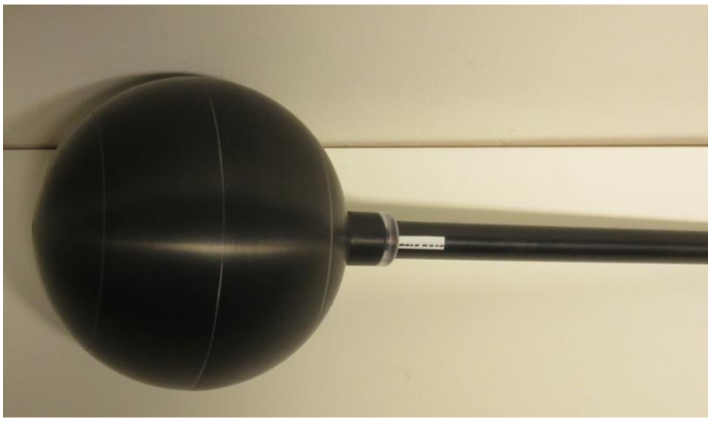

Figure 1 The transfer standard Exradin A6

3 Radiation qualities

The radiation quantities used are selected from the ISO 4037-1 narrow spectrum series [1] and are given in table 4. The recommended source to chamber distance x-ray beams is 2500 mm. The recommended air kerma rate is 3 mGy/h.

Table 4 Characteristics of the ISO Narrow spectrum x-ray series

Radiation quality	N-40	N-60	N-120	N-300
Generating potential / kV	40	60	120	300
Al HVL / mm	0.66	-	-	-
Cu HVL / mm	0.084	0.24	1.71	6.12
$\dot{K}$ / mGy h^{-1}	3	3	3	3

4 Measurement procedure and reference conditions

4.1 Measurement procedure

The dosimetry laboratories is expected to ensure that their standard is in perfect working order prior to the comparison and to make all the arrangements for safe transport of the transfer standard.

This comparison uses one stable transfer standard; this will be calibrated at the NRPA prior to the comparison at the SSM, the STUK and the LNE-LNHB and at the NRPA again after the comparison round trip.

4.2 Reference condition.

The calibration coefficients for the transfer chambers should be given in terms of air kerma per charge in units of Gy/C and referred to standard condition of air temperature, pressure and humidity; T = 293.15 K, P = 101,325 kPa and h =50 %.

4.3 Comparison of standards

The LNE-LNHB will measure the air kerma using the transfer standard in the LNE-LNHB reference beams and compare the results with that measured by the LNE-LNHB standards, the comparison reference value (CRV).

5 Course of comparison

5.1 Transport and time schedule

In general, each participating institute is responsible for its own costs regarding the measurements and transportation to the next institute. The transfer standards will be accompanied with an ATA Carnet when leaving Norway. NRPA will insure the standards.

An aluminium box works as cover for the transfer standard, which are packed together with a complete list of the devices: manufacturer, type, serial number, size, weight and technical data needed for their operation. The information also includes weight and size of the whole package.

All participants will calibrate the transfer standard in their own respective x-ray beams. The NRPA will cover the cost of transportation of the chamber to the STUK and from LNE-LNHB back to the NRPA. The SSM and STUK will cover the cost of transportation to the next institute.

The measurements will start in April 2016 and the last measurements performed in September 2016. Table 5 summarise the proposed schedule of the comparison.

Table 5 Proposed schedule of the comparison

Institute	Measuring period, transport date	Date of chamber leaving next participant
NRPA	Week 10 – 15	15th April 2016
STUK	Week 16 – 20	20th May 2016
SSM	Week 21 – 25	24th June 2016
LNE-LNHB	Week 26 – 30	30th July 2016
NRPA	Week 33 – 37	

5.2 Report of results

The calibration coefficients of the transfer standard and the associated uncertainties should be given to the Executive secretary of the CCRI within 4 weeks of the comparison measurements. The NRPA will perform two independent calibrations before and after the round trip. The standard deviation of these four calibration results will make the stability of the transfer standard in the different x-ray beams.

The measurements for each comparison at the dosimetry laboratories takes normally 5 weeks.

The pre- and post-comparison results from the NRPA should be sent to the Executive secretary of the CCRI within 4 weeks of the comparison measurements, José María Los Arcos jm.losarcos@bipm.org.

The Executive secretary of the CCRI will disclose results to the pilot laboratory (NRPA) and LNE-LNHB once the whole sets of data have been received unless there are major discrepancies.

The report of the results shall contain at least the following information:

- Description of the radiation field (type of x-ray source, field size (50% isodose), 1st and 2nd HVL (or homogeneity factor) and air kerma rate at reference distance.
- Description of the set-up (electrometer type and traceability of calibration)
- Calibration coefficients of the two transfer chambers for the four radiation qualities
- Complete uncertainty budget of the calibration coefficients.

Reporting of the results in a template make the evaluation effective. An Excel form will be distributed to the participants. Reports marked ISO Narrow + acronym of the laboratory.

The uncertainties shall be given in accordance with the ISO Guide to the expression of the uncertainties in measurements (GUM) [5]. Uncertainties are evaluated at a level of one standard uncertainty.

A full uncertainty budget should be provided by the SSDLs, preferably in advance of the comparison. A template for an uncertainty budget is enclosed in appendix II.

The uncertainty budget of the LNE-LNHB should be given in in comprehensive form.

5.3 Evaluation of the results

The evaluation of the results will follow the international recommendations [6, 7, 8]. The pilot laboratory will evaluate the comparison on the base of the results given by the participants. In general, the mean value obtained from measurements will be regarded as the result for the transfer chamber at one radiation quality. The degrees of equivalence relative to the comparison reference value will be computed, even if this is not mandatory.

Preparation of the report will follow the three-stage process: Draft A, Draft B and Final Report. The EURAMET technical committee will approve the report and forward it to the CCRI Executive secretary and the Chair of the CCRI(I) key comparison working group.

5.4 Publication of results.

Report is published in the Key Comparison Database, KCDB [2]. Reports are also available in the Metrologia Technical Supplement, which is published electronically by IOP Publishing on the internet and is freely available by visiting the BIPM web site.

6 References

1. International Organisation for Standardisation. X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 1: Radiation characteristics and production methods. ISO 4037-1:1996.
2. The BIPM key comparison database (KCDB) is defined in the text of the CIPM MRA as "the database maintained by the BIPM (Bureau International des Poids et Mesures) which contains Appendices A, B, C and D of the Mutual Recognition Arrangement". http://kcdb.bipm.org/
3. Supplementary comparison EUROMET.RI(I)-S3. Metrologia, 2008, 45, Technical Supplement 06013. http://kcdb.bipm.org/AppendixB/KCDB_ApB_info.asp?cmp_idy=565&cmp_cod=EUROMET.RI%28I%29-S3&page=2&search=1&cmp_cod_search=&met_idy=4&bra_idy=17&epo_idy=0&cmt_idy=2&ett_idy_org=2&lab_idy=&cou_cod=0
4. Supplementary comparison EURAMET.RI(I)-S3.1. Metrologia, 2012, 49, Technical Supplement 06011. http://kcdb.bipm.org/AppendixB/KCDB_ApB_info.asp?cmp_idy=1140&cmp_cod=EURAMET.RI%28I%29-S3.1&page=1&search=1&cmp_cod_search=&met_idy=4&bra_idy=17&epo_idy=0&cmt_idy=2&ett_idy_org=2&lab_idy=&cou_cod=0
5. Evaluation of measurement data — Guide to the Expression of Uncertainty in Measurement, JCGM 100:2008. http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf
6. Allisy P.J., Burns D.R., Andreo P., International framework of traceability for radiation dosimetry quantities, Metrologia, 2009, 46(2), S1-S8
7. Burns D.T. and Allisy-Roberts P.J. The evaluation of degrees of equivalence in regional dosimetry comparisons. http://www.bipm.org/cc/CCRI(I)/Allowed/18/CCRI(I)07-04.pdf

8. Measurement comparisons in the CIPM MRA, CIPM-MRA-D-05 version 1.5 2014. http://www.bipm.org/utils/common/documents/CIPM-MRA/CIPM-MRA-D-05.pdf

7 Appendix I: Complete addresses of the participants (used for shipment)

NRPA / Norway

Postal address:
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8 Appendix II: Template for the SSDLs uncertainty budget

Air kerma rate	**Type A**	**Type B**
	Uncertainty (%)	
1 Reference standard, set-up and radiation field		
Calibration coefficient reported by PSDL		
Long term stability of reference standard		
Spectral difference of SSDL and PSDL	-	
Difference in radial non-uniformity of the beam and field size		
Combined uncertainty of reference standard and setup		
2 Use of reference standard		
Chamber positioning (distance, orientation)		
Current/charge measurement including leakage		
Air temperature correction		
Air pressure correction		
Combined uncertainty in measuring with reference standard	**0.00**	**0.00**
Combined uncertainty in air-kerma determination, K_{std} (1+2)	**0.00**	**0.00**
3 Use of transfer chamber		
Chamber positioning (distance, orientation)		
Current/charge measurement including leakage		
Air temperature correction		
Air pressure correction		
Combined uncertainty in measuring with tranfer chamber	**0.00**	**0.00**
Relative combined standard uncertainty (1+2+3)	**0.00**	**0.00**
Total uncertainty for the air-kerma calibration coefficient, 1σ	**0.00**	

Correlation in type B uncertainties associated with the primary standards		
Humidity	-	
Physical contants	-	
Combined correlation in the comparison	-	**0.00**
Total uncertainty for the comparison, 1σ	**0.00**	