ЗБОРНИК РАДОВА

XXX СИМПОЗИЈУМ ДРУШТВА ЗА ЗАШТИТУ ОД ЗРАЧЕЊА СРБИЈЕ И ЦРНЕ ГОРЕ

2. - 4. октобар 2019. године
Хотел “Дивчибаре”, Дивчибаре, Србија

ДРУШТВО ЗА ЗАШТИТУ ОД ЗРАЧЕЊА
СРБИЈЕ И ЦРНЕ ГОРЕ

ЗБОРНИК РАДОВА

XXX СИМПОЗИЈУМ ДЗЗСЦГ
Дивчибаре
2- 4. октобар 2019. године

Београд
2019. године

RADIATION PROTECTION SOCIETY OF SERBIA AND MONTENEGRO

PROCEEDINGS

XXX SYMPOSIUM RPSSM
Divčibare
2nd- 4th October 2019

Belgrade
2019

ЗБОРНИК РАДОВА

ХХХ СИМПОЗИЈУМ ДЗЗСЦГ
2-4.10.2019.

Издавачи:
Институт за нуклеарне науке „Винча“
Друштво за заштиту од зрачења Србије и Црне Горе

За извршног издавача:
Проф. др Снежана Пајовић, научни саветник
в.д. директора Института за нуклеарне науке Винча

Уредници:
Др Михајло Јовић
Др Гордана Пантелић

ISBN 978-86-7306-154-2

Техничка обрада:
Михајло Јовић, Гордана Пантелић

Електронско издање:
Институт за нуклеарне науке ”Винча”, Мике Петровића Аласа 12-14, 11351 Винча, Београд, Србија

Тираж:
150 примерака

Година издања:
Септембар 2019.

EURAMET DOSETRACE PROJECT AND SUPPLEMENTARY COMPARISON

Miloš ŽIVANOVIĆ[1], Oliver HUPE[2], Amra ŠABETA[3], Nikola KRŽANOVIĆ[1] and Vedrana MAKARIĆ[3]

1) Vinca Institute of Nuclear Sciences (VINS), University of Belgrade, Belgrade, Serbia, milosz@vinca.rs, krzanovic@vinca.rs

2) Physikalisch-Technische Bundesanstalt (PTB), Braunsweig, Germany, oliver.hupe@ptb.de

3) Institute of Metrology of Bosnia and Herzegovina (IMBiH), Sarajevo, Bosnia and Herzegovina, amra.sabeta@met.gov.ba, vedrana.makaric@met.gov.ba

ABSTRACT

Accurate and traceable measurements of operational quantities are required for adequate radiation protection. National Measurement Institutes (NMI) and Designated Institutes (DI) are responsible for disseminating the SI unit sievert and for calibrating user equipment. However, in many emerging European countries, calibration and measurement capabilities for operational quantities are limited or nonexistent. The main objective of DOSEtrace project is to improve these capabilities and for the participants to achieve the expanded measurement uncertainty of less than 5% (k = 2). Within the project, a Supplementary comparison of calibration factors in terms of ambient dose equivalent will be conducted. This comparison will help to validate the capabilities that the partners developed during and before the project and will help emerging institutes gain international recognition. The comparison will cover both radionuclide and x-ray radiation qualities according to ISO 4037-1.

1. Introduction

Appropriate calibration and use of dosimeters is of key importance for radiation protection. Radiation protection dosimeters are calibrated in terms of operational quantities – personal, ambient and directional dose equivalent [1]. The calibrations are performed in dosimetry laboratories, which need to provide traceability to primary standards of Primary Standards Dosimetry Laboratories (PSDL) and therefore to the SI system of units. International measurement system is established in order to provide traceability from end user measurements through Secondary Standards Dosimetry Laboratories (SSDL) to PSDLs. This system is supported by International Committee of Weights and Measures (CIPM) Mutual Recognition Arrangement (MRA), Regional Metrology Organizations (RMO), but also by the SSDL network organized by International Atomic Energy Agency (IAEA) and World Health Organization (WHO). National Metrology Institutes (NMI) and Designated Institutes (DI) are signatories of CIPM MRA, are members of RMOs and are responsible for disseminating SI units within respective countries. Most of the European countries are members of EURAMET RMO [2, 3, 4].

In Europe, there is a significant number of Primary Standards Dosimetry Laboratories, as well as the International Bureau of Weights and Measures (BIPM) laboratory and the IAEA Dosimetry Laboratory. Most of the countries have at least one SSDL [4, 5]. However, capacity for calibrations in terms of operational quantities is not well established in many smaller NMIs and DIs. This is also reflected in BIPM database, where only 14 NMIs and DIs from EURAMET have published Calibration and Measurement Capabilities (CMC) for any of the operational quantities [4]. Furthermore, only three supplementary comparisons for operational quantities have been conducted so far by EURAMET, and none by the other RMOs [6, 7, 8].
17RPT01 DOSEtrace – Research capabilities for radiation protection dosimeters, is a metrological project aiming to improve the capabilities for calibrations in terms of operational quantities within European countries. This is a project from 2017 research potential EMPIR call. The project started in 2018 and involves 12 NMIs and DIs, as well as one university. The project is planned to last 36 months [9].

2. DOSEtrace project

Main goal of DOSEtrace project is improving calibration and measurement capabilities for operational quantities within European countries. First step towards achieving this goal was surveying the current status and training needs of project participants and other European NMIs, DIs and other relevant institutions. The results of the survey are being used to organize several training courses in order to facilitate dissemination of knowledge, to improve technical competence and to help emerging institutes to establish or improve capabilities. Several events took part in the first half of the project, including "Metrology and Calibration in Radiation Protection" course in Instituto Superior Tecnico (IST), Lisbon and Hands on Training in Physikalisch-Technische Bundesanstalt (PTB), Braunschweig [9].
The goal for the newly developed and improved capabilities is to keep the combined uncertainty below 5% (k = 2). The new capabilities are validated by organizing an intercomparison, which started in February 2019. Even though only one operational radiation protection quantity was chosen for the comparison, it can be used to validate all operational quantities, because the same equipment is used, the same radiation qualities, the same procedure to determine the corresponding conversion coefficients and the same general calibration procedure. Finally, successful development and validation of the new capabilities will be followed by submission of CMCs to the Key Comparison Data Base (KCDB) of BIPM. All partners will be required to develop long term strategies, to maintain and improve capabilities [9].
Meeting the main goal of the project will help ionizing radiation metrology community within European countries but will also improve the confidence in measurements by technical services and other end users and reduce the overall measurement uncertainty in the whole measurement chain. This will benefit the whole community, from occupationally exposed workers to general public.
The project will also help European countries to implement the requirements set by EU Council Directive 2013/59/EURATOM, which is laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation [10].
Another project goal is to develop and test a secondary standard for eye lens dosimetry, because currently there are none available. This would enable conducting comparisons

in terms of $H_p(3)$, and also calibration of eye lens dosimeters by direct comparison with secondary standard.

3. DOSEtrace supplementary comparison

Having in mind the lack of supplementary comparisons for operational quantities in Europe and the whole world, it was decided during the planning phase of DOSEtrace project that it was necessary to organize such comparison. The goal of the comparison was to validate the capabilities of the project partners that are developed or improved during the project, but also to train partners to organize comparisons on international level. The quantity for the comparison was chosen having in mind several criteria:

- need for the calibrations in respective countries
- existing and planned capabilities of project partners
- availability of the suitable transfer instrument (i.e. secondary standard for operational quantity)
- existing supplementary comparisons

According to the mentioned criteria, it was decided to choose ambient dose equivalent, $H^*(10)$. Only one comparison of this type was previously conducted, and it covered two radiation qualities – N-60 and S-Cs [6]. The last one at different dose rates to cover the challenges of the calibration of large radiation protection devices.
DOSEtrace supplementary comparison started in February 2019 and is planned to finish by the end of 2020. During this time, 13 laboratories will take part in the comparison. Comparison is organized by following EURAMET guide [11].
A Seibersdorf HS01 chamber was selected as the transfer chamber. The chamber is of spherical shape and has a nominal volume of 1 litre [12]. It is shown in Figure 1. Participants will use their own electrometers with the transfer chamber. Stability of the transfer chamber will be checked by performing periodic calibrations in all 5 radiation qualities.

Figure 1. HS01 S/N 112, Secondary standard chamber for $H^*(10)$ (Photo credit Bildstelle PTB).

In total, 5 γ-ray and X-ray radiation qualities, 3 mandatory and 2 additional ones, were selected for the purposes of the comparison:

- N-40 (mandatory)
- N-100 (mandatory)

- N-200 (additional)
- S-Cs (mandatory)
- S-Co (additional)

All radiation qualities are defined in ISO 4037-1 standard [13].
The partners will report their results in the provided templates, including measurement uncertainty budgets. Template for measurement uncertainty is provided in table 1. Measurement uncertainty will be expressed according to relevant international guides and standards [14].

Table 1. Model uncertainty budget.

Reference *H*10* measurements				
Source of uncertainty	Type A uncertainty $u_{i,\mathrm{A}}$	Type B uncertainty $u_{i,B}$	$u_{i,\mathrm{A}}^2 + u_{i,\mathrm{B}}^2$	Comment
Calibration coefficient of the national/reference standard				
Collected charge/ionization current				
Air density correction				
Source to chamber distance				
Conversion coefficient				
Other sources of uncertainty				
Combined uncertainty, *H(10)**				
Transfer chamber measurements				
Source of uncertainty	$u_{i,\mathrm{A}}$	$u_{i,\mathrm{B}}$	$u_{i,\mathrm{A}}^2 + u_{i,\mathrm{B}}^2$	Comment
Collected charge/ionization current (*Q/I*)				
Air density correction				
Source to chamber distance				
Other sources of uncertainty				
Combined uncertainty, *Q/I*				
Combined uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,\mathrm{A}}^2 + u_{i,\mathrm{B}}^2\right)} =$			

4. Conclusion

Research within DOSEtrace project will focus on improving calibration and measurement capabilities of European NMIs and DIs, specifically for operational quantities used in radiation protection. Main goals are development and validation of the capabilities, submitting CMCs to KCDB and developing individual strategies. An $H_p(3)$ secondary standard will also be built within the project.

5. Acknowledgement

The research presented in this paper was realized within 17RPT01 DOSEtrace project. This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

6. References

[1] Quantities and Units in Radiation Protection Dosimetry, ICRU Report 51, ICRU, 1993.

[2] Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes, CIPM, Paris, 1999 (partially revised in 2003).

[3] [SSDL network charter, 2nd edition, IAEA, Vienna, 2018.

[4] The BIPM key comparison database, https://kcdb.bipm.org/, accessed on 2.5.2019.

[5] The IAEA/WHO Network of Secondary Standards Dosimetry Laboratories, https://ssdl.iaea.org/, accessed on 2.5.2019.

[6] O. Hupe, N.A.C. Díaz. EURAMET supplementary comparison of ambient dose equivalent H*(10) in ^{137}Cs and ISO Narrow Beam Series N-60 x-ray beams at low dose rates. *Metrologia* 55, Technical Supplement, 2018, 1-132.

[7] U. Ankerhold, W. Tiefenböck, J. Witzani, P. Ambrosi. EUROMET.RI(I)-S1: personal dose equivalent comparison between the BEV and the PTB. *Metrologia* 39, Technical Supplement, 2002, 1-13.

[8] U. Ankerhold, O. Hupe. EURAMET supplementary comparison of the personal dose equivalent quantity for photon radiation: EURAMET.RI(I)-S5. *Metrologia* 49, Technical Supplement, 2012, 1-169.

[9] DOSEtrace - Research capabilities for radiation protection dosimeters, https://www.euramet.org/research-innovation/search-research-projects/details/?eurametCtcp_project_show%5Bproject%5D=1554 and http://dosetrace-empir.eu, accessed accessed on 12.5.2019.

[10] Council Directive 2013/59/Euratom, laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation. European Council, *Official Journal of European Union* L13, 2014, 1-73.

[11] EURAMET Guide No. 4, EURAMET Guide on Comparisons, Version 1.0 (05/2016), EURAMET, Braunschweig, 2016.

[12] K. E. Duftschmid, J. Hizo, Ch. Strachotinsky. A secondary standard ionisation chamber for the direct measurement of ambient dose equivalent *H**(10). *Radiat. Prot. Dosim.* 40(1), 1992, 35–38.

[13] ISO 4037-1:2019, X and gamma reference radiation fields 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, Geneva, 2019.

[14] JCGM 100:2008, Evaluation of measurement data - Guide to the expression of uncertainty in measurement (GUM 1995), JCGM, 2008.

EURAMET DOSETRACE PROJEKAT I DODATNA INTERKOMPARACIJA

Miloš ŽIVANOVIĆ[1], Oliver HUPE[2], Amra ŠABETA[3], Nikola KRŽANOVIĆ[1] i Vedrana MAKARIĆ[3]

1) Institut za nuklearne nauke Vinča (VINS), Univerzitet u Beogradu, Beograd, Srbija, milosz@vinca.rs, krzanovic@vinca.rs

2) Fizičko-tehnička državna ustanova (PTB), Braunšvajg, Nemačka, oliver.hupe@ptb.de

3) Institut za mjeriteljstvo Bosne i Hercegovine (IMBiH), Sarajevo, Bosna i Hercegovina, amra.sabeta@met.gov.ba, vedrana.makaric@met.gov.ba

SADRŽAJ

Tačna i sledljiva merenja operativnih veličina su neophodna za adekvatnu zaštitu od zračenja. Nacionalni metrološki instituti i Imenovani instituti su zaduženi za diseminaciju SI jedinice Sivert i za etaloniranje korisničke opreme. Ipak, u velikom broju Evropskih zemalja, mogućnosti etaloniranja za operativne veličine su nedovoljno razvijene ili nepostojeće. Glavni cilj DOSEtrace projekta je unapređenje ovih mogućnosti, kao i smanjenje proširene merne nesigurnosti učesnika projekta ispod 5 % (k = 2). U okviru projekta će biti sprovedena Dodatna interkomparacija kalibracionih faktora za ambijentalni dozni ekvivalent. Ova interkomparacija će pomoći učesnicima projekta da validiraju merne mogućnosti razvijene pre i tokom projekta, a takođe će pomoći novim institutima da steknu međunarodno priznanje. U okviru intercomparacije, biće pokriveni kvaliteti zračenja radionuklida, kao i x-zračenja.