EURADOS IC2012n
Participant Meeting

Overview on standards and guidelines available for personal neutron dosimetry

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ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development · IAEA International Atomic Energy Agency · IRSN Institut de Radioprotection et de Sûreté Nucléaire · NPL National Physical Laboratory · Paul Scherrer Institut PSI · PTB · Public Health England · SCK•CEN Studiecentrum voor Kernenergie Centre d'Étude de l'Énergie Nucléaire

Introduction

- Results of the IC2012n inter-comparison presented in the next talk
- Do the dosimetric system fulfil international requirements?

- No document regulating internationally the terms and conditions or requirements for personal neutron dosimetry

- Overview over the available standards concerning personal neutron dosimetry-

➡ **Which criteria for the performance of the neutron dosemeters for this intercomparison?**

Available standards and guidelines for personal neutron dosimetry

Revision of the ISO 21909 standard

Criterium for the performance of individual monitoring measurements for neutrons

Conclusion: which criteria for inter-comparison?

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Available neutron standards and guidelines

Which organizations ?

- Different organizations for standardization:
  - International ones :
    - ISO : International Organization for Standardisation
    - IEC : International Electro technical Commission
  - National ones :
    - DIN : Deutsches Institut für Normung
    - ANSI : American National Standard Institute
    - …

→ **In principle, no or few overlap of the standards**
Each country decide to use the standard it want

- Others organizations giving recommendations:
  - ICRU : International Commission on Radiation Units and Measurements
  - ICRP : International Commission on Radiolgical Protection
  - ...

Available neutron standards and guidelines

Standards applicable to personal dosimetry in general

- ANSI/HPS N13.11-2009, American National Standard for Dosimetry, Personnel Dosimetry Performance – Criteria for Testing

- IEC 62387 Ed.1, 2012 (all passive dosemeters) IEC 62387, Radiation protection instrumentation - Passive integrating dosimetry systems for environmental and personal monitoring of photon and beta radiation; 2012-12 (including *H*p(3))

Standards with neutron conversion factors

- ISO 8529-3:1998, Part 3: Calibration of area and personal dosemeters and determination of response as a function of energy and angle of incidence

- DIN6802, Part 2: Conversion coefficients for the calculation of ambient and personal dose equivalent from the neutron fluence, and correction factors for radiation protection devices

Available neutron standards and guidelines

Realization of reference radiation fields

- ISO 8529, Reference neutron radiations
  - ISO 8529-1:2001, Part 1: Characteristics and methods of production
  - ISO 8529-2:2000, Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field
  - ISO 8529-3:1998, Part 3: Calibration of area and personal dosemeters and determination of response as a function of energy and angle of incidence

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- Neutron fields defined in this standard :
  - Neutrons sources :
    - Bare ^{252}Cf, D_2O moderated ^{252}Cf, ^{241}Am-B(n,α), ^{241}Am-Be(n,α) ➡ "Easily" available neutron fields
  - Mono-energetic neutron fields : ➡ Less available fields but very useful for the characterization
    - 2 keV; 24 keV; 144 keV; 250 keV; 565 keV; 1.2 MeV ; 2.5 MeV; 2.8 MeV ; 5 MeV, 14.8 MeV, 19 MeV
  - Thermal spectra ➡ Thermal dose usually low but useful field for dosemeter particularly sensitive to thermal neutron field

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➡ **The several situations of exposure in term of neutron spectra encountered on workplaces not taken into account**

Available neutron standards and guidelines

Realization of reference radiation fields

- ISO 12789:2008, Reference radiation fields, Simulated workplace neutron fields
  - ISO 12789:2008, Part 1: Characteristics and methods of production
  - ISO 12789-2:2008, Part 2: Calibration fundamentals related to the basic quantities

→ **Standard very useful to characterize the dosemeter in neutrons fields similar to the one encountered at workplace situations**

→ **But rarely available neutron facilities in the world**

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→ **Situations of exposure in term of neutron spectra encountered on workplaces not really taken into account while determining the performances of the neutron dosemeters**

Available neutron standards and guidelines

Documents applicable to personal neutron dosimetry

- ANSI/HPS N13.52-1999, Personnel Neutron Dosimeters (Neutron Energies Less Than 20 MeV)

- DIN 6802, Neutron dosimetry
  - DIN6802, Part 1: Special terms and definitions
  - DIN6802, Part 3: Methods for neutron measurement in radiation protection
  - DIN6802, Part 4: Measurement technique for individual dosimetry using albedo dosimeters

→ Concerning albedo dosimetry only

- ICRU report n°66
  - Determination of Operational Dose Equivalent Quantities for Neutrons, International Commission on Radiation Units and Measurements, Bethesda, MD ISSN 1473-6691, 2001

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→ **Documents describing concepts, neutron fields characterization, experimental measurements, ... But, there is no criterium for the performance of individual monitoring measurements for neutrons.**

Available neutron standards and guidelines

Standards applicable to personal neutron dosimetry

- Standards giving criterium for the performance of individual monitoring measurements for neutrons:

- ICRP Publication n°75
  - ICRP 75, 1997, General Principles for the Radiation Protection of Workers

  ➡ **Recommendations**

- IEC 61526
  - IEC 62526 Ed.3, Radiation protection instrumentation – Measurement of personal dose equivalents *H*p(10) and *H*p(0,07) for X, gamma, neutron and beta radiations – Direct reading personal dose equivalent meters and monitors; 2010-07

  ➡ **Concerning active dosemeters**

- ISO 21909
  - ISO 21909, Radiation protection - Passive personal neutron dosemeters - Performance and test requirements; 2005-06 and Corrigenda 1 as of 2007-10

  ➡ **Concerning passive dosemeters**

  ➡ **Under revision**

Available standards and guidelines for personal neutron dosimetry

Revision of the ISO 21909 standard

Criterium for the performance of individual monitoring measurements for neutrons

Conclusion: which criteria for inter-comparison?

Revision of the 21909 standard

- Two weaknesses in the actual version of 21909 standard:
  - First weakness : criteria function of the consideredtechnique
    - 5 different techniques :
      - Nuclear tracks emulsions dosemeters
      - Solid state nuclear track dosemeters
      - Thermoluminescence albedo dosemeters
      - Superheated emulsion dosemeters
      - Ion chamber dosemeters with direct ion storage
    - Example of difference : Angle dependence of response
      - ± 30% for thermoluminescence albedo dosemeters
      - ± 40% for solid state nuclear track dosemeter

    → **Consequently, the new standard will aim at defining performance tests leading to similar results whatever the considered techniques are.**
  - Second weakness : test requirements not enough constraining to insure that the dosimetry will be reliable in most of the usual work situations i.e. dose level and neutron spectra representative of the workplaces

    → **Consequently, the new standard will aim at reaching an adequacy between performance tests and situations of use at the workplaces. This standard should take into account the several situations of exposure in term of dose level and neutron spectra.**

Revision of the 21909 standard

- Main issue of the revision : adequacy between performance tests and situations of use at the workplaces

- Dose level
  - Many annual exposures of workers = sum of several low doses close to the minimal recording value

➡ **Performance tests aiming at characterising the intrinsic properties of the dosimetry system would be required at two levels of dose:**

- 1 mSv

- close to the minimal recording value.

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  - Minimal recording value : function of the national regulation
    - Can be 0.5 mSv or 0.1 mSv.
    - Hard to compare systems which requirements in term of minimal recording value is so different.

➡ **The criterion of the different tests will be function of the value of the chosen H_{min}**

Revision of the 21909 standard

- Main issue of the revision : adequacy between performance tests and situations of use at the workplaces

- Neutron spectra
  - Mean energies of the dose equivalent distributions of the most common reference radiations for calibration are often higher than the ones encountered in workplaces
  - The performance of the dosemeters for energies situated between a few tens and a few hundreds of keV must notably be determined to insure a good response in most of the workplaces.

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  - Question raises for the dosimetric system which will not fulfill the requirements in term of energy response (especially systems whose response highly depends on the neutron energy as albedo dosemeters)

➡ **Need a calibration at workplaces**

➡ **Redaction of the second part of the 21909 standard**

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➡ **Redaction of the second part of the 21909 standard**

➡ **Even in the new version of ISO 21909 standard, there will not be a criterium for the "overall" performance**

Available standards and guidelines for personal neutron dosimetry

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Criterium for the performance of individual monitoring measurements for neutrons

Differences in function of the considered standard

- ICRP 75, paragraph 251 :
  - “The commission has noted that . . . in the workplace, where the energy spectrum and orientation of the radiation field are generally not well known, . . . the overall uncertainty at the 95% confidence level in the estimation of the effective dose around the relevant dose limit may well be a factor of 1.5 in either direction for photons and may be substantially greater for neutrons of uncertain energy and for electrons.
  - Greater uncertainties are also inevitable at low levels of effective dose for all qualities of radiation.”

Criterium for the performance of individual monitoring measurements for neutrons

Differences in function of the considered standard

- Energy dependence of response
- IEC 61526

$$0.65 \leq \frac{H_{mes}}{H_{ref}} \leq 4.0 \quad \text{for} \quad E_{min} \leq E_n \leq 100\,\text{keV}$$

$$0.65 \leq \frac{H_{mes}}{H_{ref}} \leq 2.22 \quad \text{for} \quad 100\,\text{keV} \leq E_n \leq 10\,\text{MeV}$$

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- For $100\,\text{keV} \leq E_n \leq 1\,\text{MeV}$
  - at least 3 mono-energetic fields
- For $1\,\text{MeV} \leq E_n \leq 10\,\text{MeV}$
  - at least 3 mono-energetic fields

    or 2 mono-energetic fields and one broad source (^{241}Am-Be or ^{252}Cf)

+ Combined energy and angle response (0° ≤ α ≤ ±60°)

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- Actual ISO 21909
  - Thermoluminescence albedo dosemeters:
    - Not applicable
  - Solid state nuclear track dosemeters: ± 50%

$$0.5 \le \frac{H_{mes} \pm l_{mes}}{H_{ref}} \le 1.5$$

    - for a personal dose equivalent of at least 1 mSv
    - for only 4 chosen energies

+ Combined energy and angle response (0° ≤ α ≤ ±60°)

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Criterium for the performance of individual monitoring measurements for neutrons

Conclusion: which criteria for inter-comparison?

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Difficulties induced by the inter-comparison exercice

- First difficulty:
  - Several documents which give recommendations or requirements for personal neutron dosimetry
  - Fulfilment depend on the techniques and the considered standards
- Second difficulty:
  - Inter-comparison : not a characterization, not all the test requirements are done
  - Test are not done in the same conditions than required in the standard
    - » Number of dosemeters are different for instance
  - For one test in the inter-comparison, which criteria of which test requirement should be chosen?

Conclusion: which criteria for inter-comparison?

Difficulties induced by the inter-comparison exercice

- Third difficulty:
  - No reference document detailing how to manage a inter-comparison exercice for neutron dosemeters

  - ISO 14146 standard: Radiation protection, Criteria and performance limits for the periodic evaluation of processors of personal dosemeters for X and gamma radiation
    - Standard existing for photons should be revised
      - » Number of dosemeters too high for one test: 20 !
    - However, this standard refers to the ICRP 75

Conclusion: which criteria for inter-comparison?

And for the IC2012n?

- *Values taken in previous inter-comparisons:*
  - *EURADOS 1999*

$$\frac{1}{1.5}\cdot\left(1-\frac{2\cdot H_0}{H_0+H_{ref}}\right) \leq \frac{H_{mes}}{H_{ref}} \leq 1.5\cdot\left(1+\frac{H_0}{2\cdot H_0+H_{ref}}\right) \quad \text{with} \quad H_0 = 0.085\,\text{mSv}$$

  - *IAEA 2007*

$$\frac{1}{1.5}\cdot\left(1-\frac{2\cdot H_0}{H_0+H_{ref}}\right) \leq \frac{H_{mes}}{H_{ref}} \leq 2 \quad \text{with} \quad H_0 = 0.1\,\text{mSv}$$

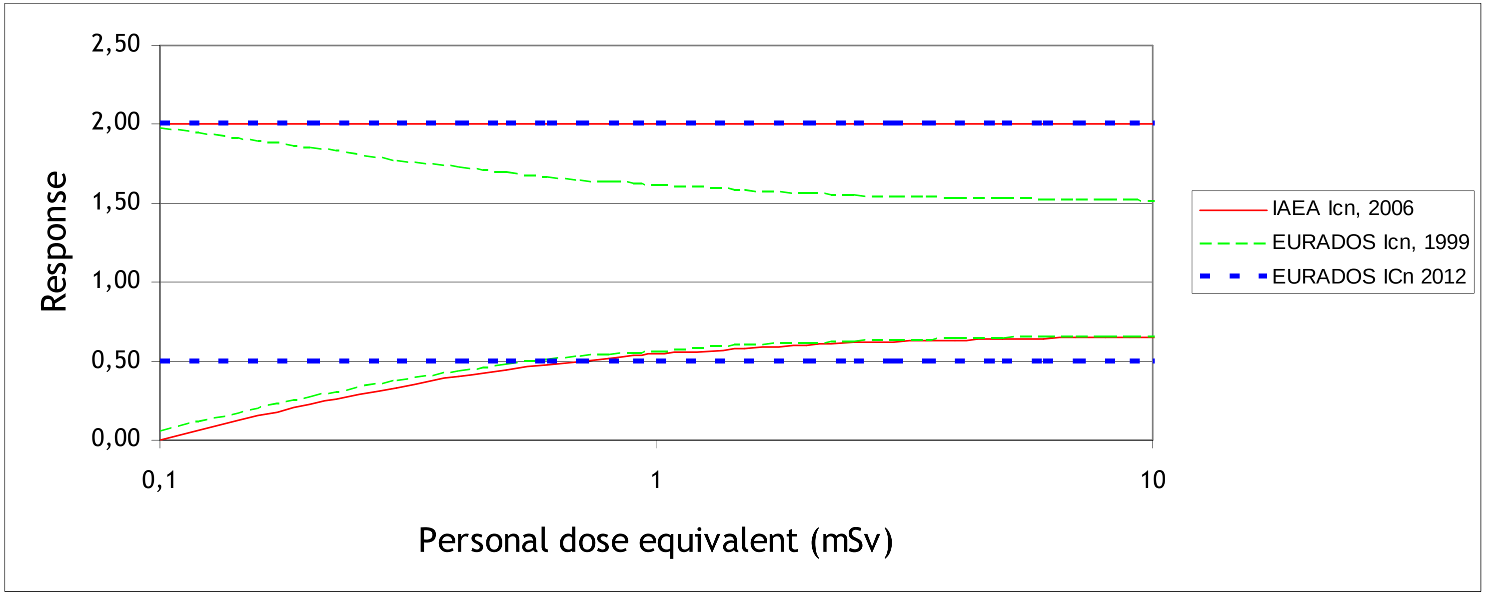
Conclusion: which criteria for inter-comparison?

And for the IC2012n?

- *A suggest guideline for the IC2012n:*
  - *factor 2 chosen:*

$$0.5 \leq \frac{H_{mes} \pm l_{mes}}{H_{ref}} \leq 2$$

  - *Only a guideline ! Not stated as* recommendations or other standards" or document of relevance as reference but a sensible order of magnitude to consider that the neutron dosimetry is enough reliable.



Thank you for your attention !

Any questions ?