



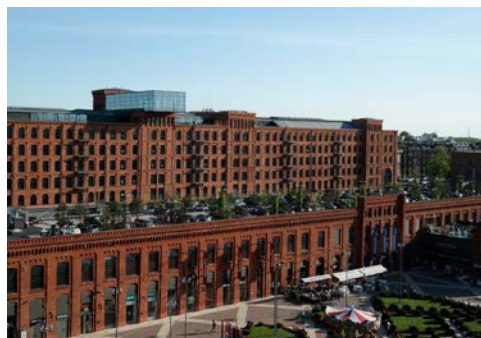
Evolution of international standards for neutron personal dosimeters

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Introduction

Results of the IC2017n inter-comparison presented in the next talk

- Do the dosimetric system fulfil international requirements ?

In the last intercomparison (IC2012n):

- Overview over the available standards concerning personal neutron dosimetry
- Main conclusion : no criteria internationally accepted at that time for passive neutron dosimetry
- Chosen criteria : $0,5 < R < 2$

➔ For IC2017:

- Any changes in the standards ?

- Which criteria for the performance of the neutron dosemeters for this intercomparison?

Available standards and guidelines

Revision of the 21909-1 standard

Revision of the 14146 standard

Comparison between 21909-1
and 14146

Conclusion: which criteria
for inter-comparison?



Available standards and guidelines

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Available neutron standards and guidelines

Realization of neutron reference radiation fields

- [ISO 8529](#), Reference neutron radiations
- [ISO 12789](#), Reference radiation fields, Simulated workplace neutron fields

Documents applicable to personal neutron dosimetry

- [ANSI/HPS N13.52-1999](#), Personnel Neutron Dosimeters  No change since IC2012n
- [DIN 6802](#), Neutron dosimetry
- [ICRU report n°66](#), Determination of Operational Dose Equivalent Quantities for Neutrons

Standards applicable to personal neutron dosimetry

- [ICRP Publication n°75](#), General Principles for the Radiation Protection of Workers
- [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
- [ISO 21909](#), Radiation protection - Passive personal neutron dosimeters - Performance and test requirements; 2005-06 and Corrigenda 1 as of 2007-10

 Concerning passive dosimeters

 New version in 2015 !

Available neutron standards and guidelines

Specific standard for intercomparisons

New version of the 14146 standard

- Radiological protection – Criteria and performance limits for the periodic evaluation of dosimetry services
- New version in 2018
- Now, it includes neutron dosimetry !

➡ 1/ What are the differences induced by the revision, for these two standards ISO 21909 and ISO 14146?

2/ What are the implication for IC2017n?

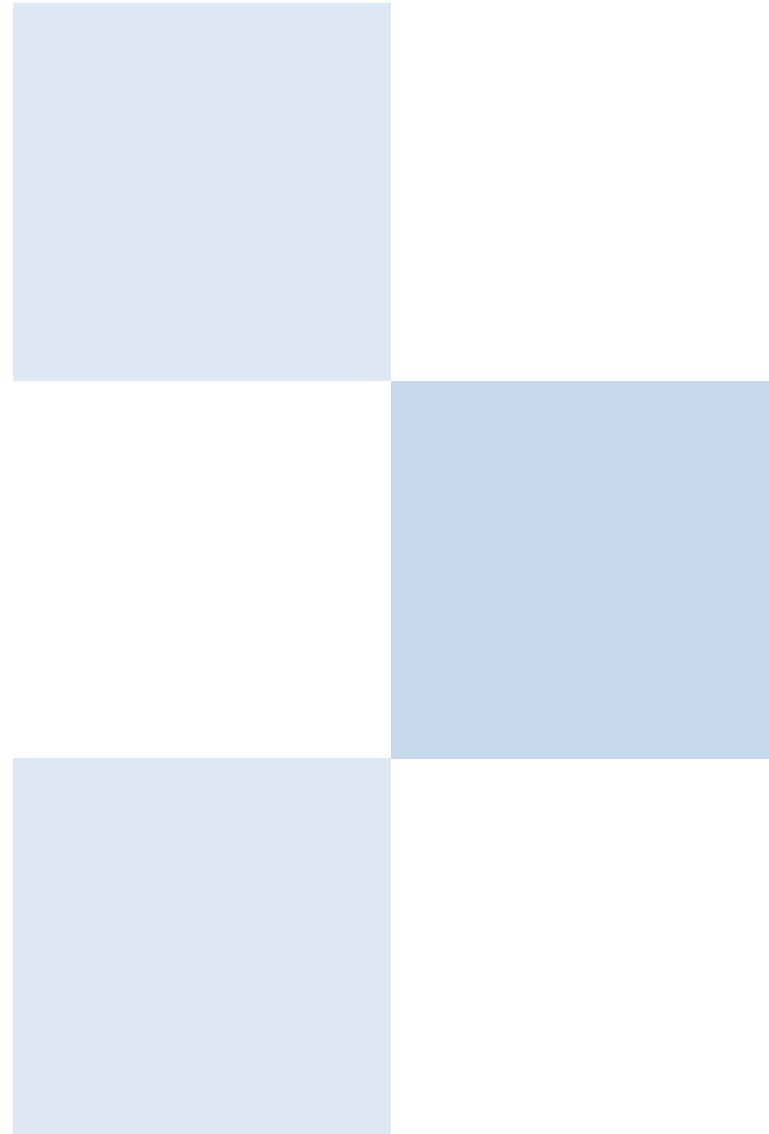
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Publication of the 21909-1 standard

Two weaknesses in the former version of 21909 standard (2005):

- First weakness : criteria depending on the considered technique

- 5 different techniques :


- Nuclear tracks emulsions dosimeters
 - Solid state nuclear track dosimeters
 - Thermoluminescence albedo dosimeters
 - Superheated emulsion dosimeters
 - Ion chamber dosimeters with direct ion storage

- Example of difference : Angular response

- $\pm 30\%$ for thermoluminescence albedo dosimeters
 - $\pm 40\%$ for solid state nuclear track dosimeter

 **Revision of 2015: performance tests defined independently of the techniques -> more universal text.**

- 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


 **Revision of 2015: aims at reaching an adequacy between performance tests and situations of use at the workplaces.**

Publication of the 21909-1 standard

Tests stability in the range of realistic use conditions

- Fading, ageing, influence of climatic conditions, of radon, radiations others than neutrons (photons, radon), ...
- Two types of tests :
 - effect of the dose response (level of dose generally between 1 to 3 mSv)
 - effect for un-exposed dosimeters

HOWEVER for the tests of intrinsic characteristics:

- Need an adequacy between performance tests and situations of use at the workplaces
 - Dose level
 - Neutron spectra  **Main issue of the revision !**

Publication of the 21909-1 standard

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 three levels of dose:

- at one dose within the range [0,8 mSv - 2 mSv]
- close to the minimal recording value : H_{\min} and $H_{\min} + 0,1$ mSv

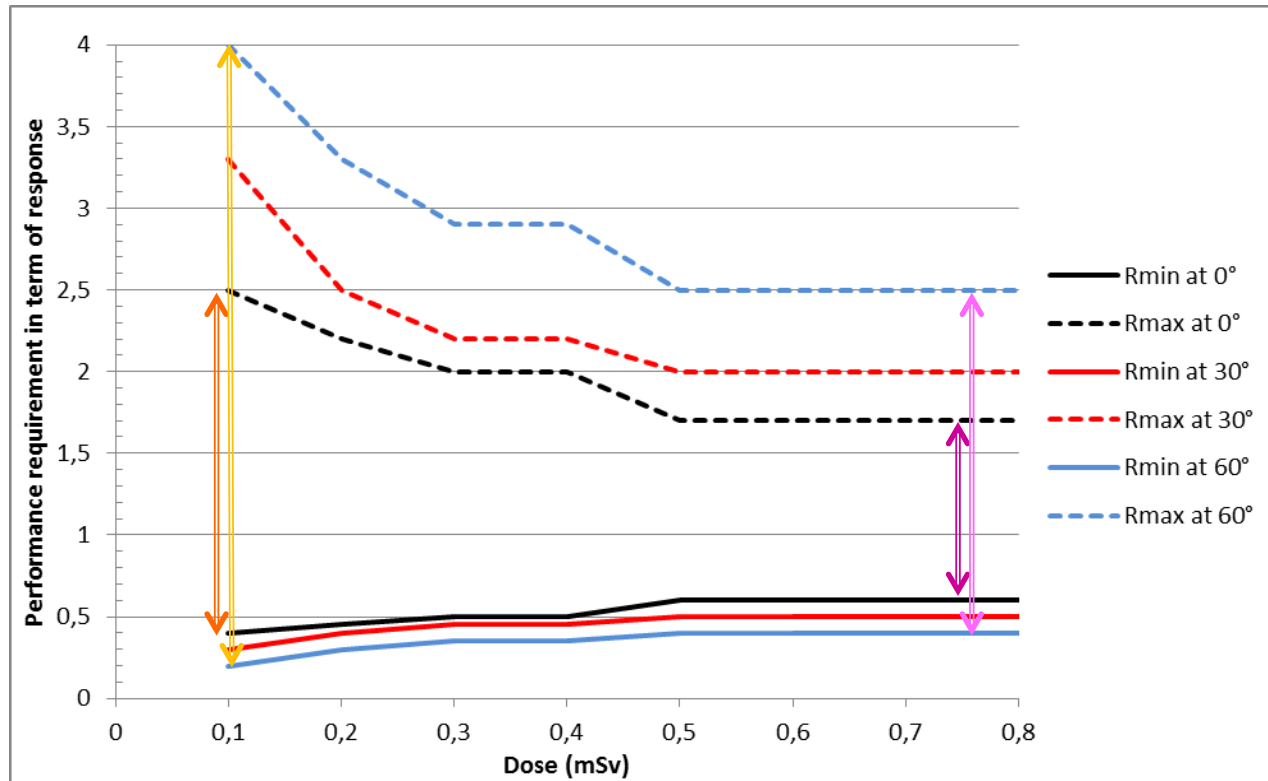
- With H_{\min} = minimal recording value
 - Depends on national regulation
 - Can be 0.5 mSv or 0.1 mSv
 - Hard to compare systems which requirements in term of minimal recording value is so different.

➔ Different criteria depending on dose level

But criteria defined independently of the chosen H_{\min}

Publication of the 21909-1 standard

But criteria defined independently of the chosen H_{min}



For low doses (100 μ Sv) :

- at 0° : -60% +150%
- at 60° : -80% +300%

For high doses :

- at 0° : -40% +70 %
- at 60° : -60% + 150%

Publication of the 21909-1 standard

Criteria defined independently of the chosen H_{\min}

As a remind, for IC2012n

- Chosen « guideline » was :

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

- Not stated as reference but a sensible order of magnitude to consider that the neutron dosimetry is reliable enough.

In ISO 21909-1:2015

- Same criteria $0.5 \leq \frac{H_{mes} \pm l_{mes}}{H_{ref}} \leq 2$ for :

- Level of dose 0,3 mSv or 0,4 mSv at 0°
- Level of dose $\geq 0,5$ mSv at 30°

 Consistency of the criteria

Publication of the 21909-1 standard

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 dosimeters 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.

Some performance tests with mono-energetic neutrons fields at low energies

- Question raises for the dosimetric system which will not fulfill the requirements in term of energy and angular responses
- Case for systems whose response highly depends on the neutron energy as albedo dosimeters

Need a calibration at workplaces (requirement in the 21909-1)

Goal of the second part of the 21909 standard

Publication of the 21909-1 standard

ISO 21909 - part 2

- “Passive neutron dosimetry systems – Part 2: Methodology and criteria for personal dosimetry systems requiring qualification at workplaces
- Work in progress. For a publication in 2020.
- In parallel, the ISO 21909-1 will be revised
 - In order to have the two documents consistent together
 - To take into account the potential difficulties raised by the IMSs after trying to be characterized according to the first part.

 In 2020, the two parts of the 21909 will be published

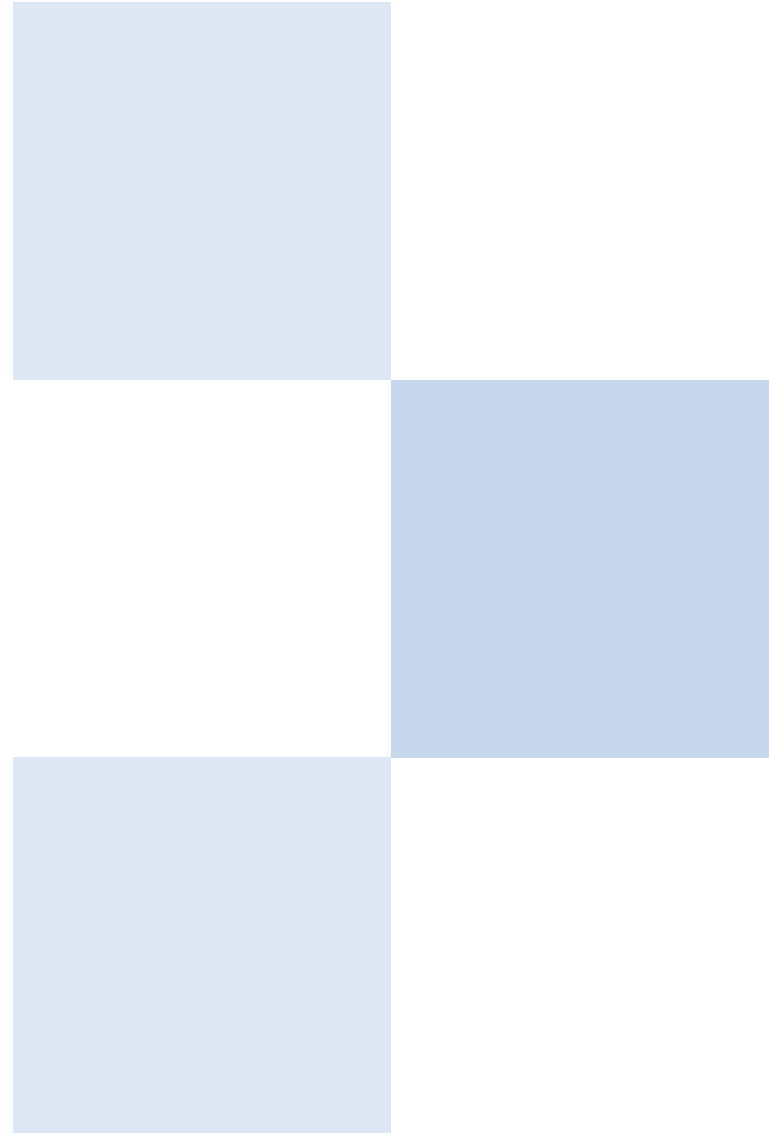
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New version of the 14146 standard

A specific standard for intercomparisons

ISO14146 “Radiological protection – Criteria and performance limits for the periodic evaluation of dosimetry services”

- Published in 2018

This document applies :

- to **personal and area dosimeters** for the assessment of **external radiation**
 - photons, betas
 - **neutron radiations** -> with a (fluence weighted) mean energy between 25,3 meV and 200 MeV.
- It covers all types of personal and area dosimeters needing laboratory processing
 - TLD, OSL, RPL, SNTD ...
- For continuous measurements or measurements repeated regularly at fixed time intervals
- gives test conditions and performance limits and operational procedures

New version of the 14146 standard

A specific standard for intercomparisons

Performance limits

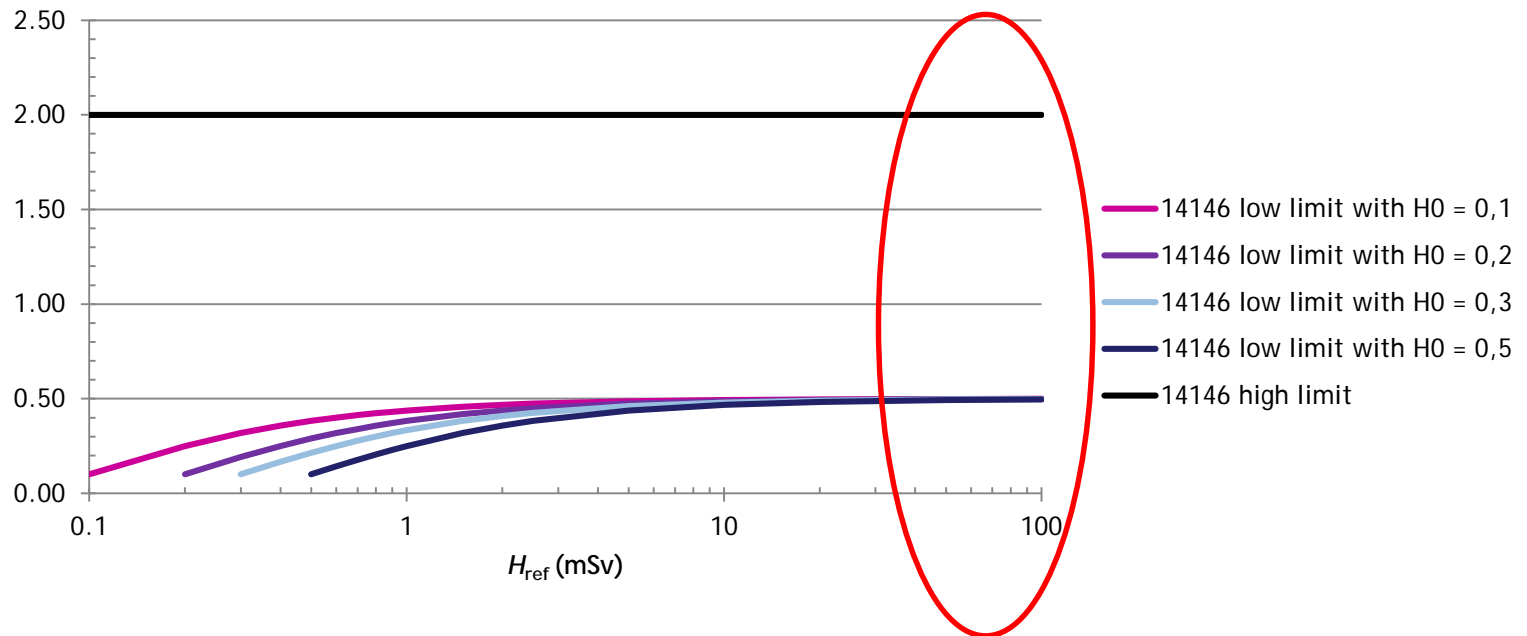
- Trumpet curves according to this equation (for neutrons):

$$0,5 \cdot \left(1 - \frac{2 \cdot H_0 / 1,5}{H_0 / 1,5 + H_{\text{ref}}} \right) \leq R \leq 2$$

- Independent of the energy and the angle of incidence

New version of the 14146 standard

A specific standard for intercomparisons

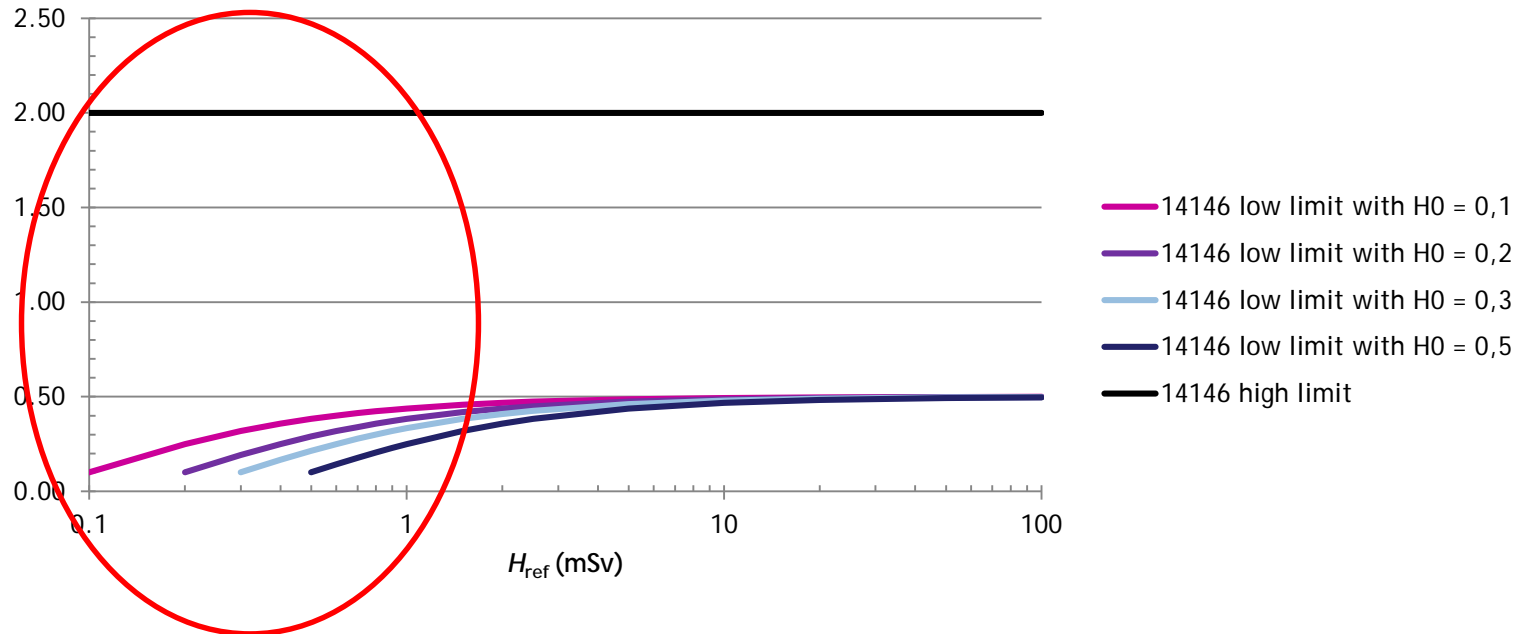


➔ Similar criteria between IC2012n and 14146 for very high level of dose

$$0.5 \leq \frac{H_{\text{mes}} \pm 1_{\text{mes}}}{H_{\text{ref}}} \leq 2$$

New version of the 14146 standard

A specific standard for intercomparisons



- Depends of a choice of H_0 : “lower dose limit”
 - > “dose below which irradiations should not be performed” according to the definition
- Importance of the choice of H_0

Conclusion: which criteria for inter-comparison?

Point to have in mind !

In the ISO 14146, added to the performance limits, there exist also an **approval criterion**:

- “The criteria stated in 7.1 are valid for a coverage interval with a coverage probability of 95 %. A maximum of one-tenth of the dosimeters irradiated may exceed the limits.” [section 7.2 of ISO 14146-2018]

➡ For IC2017n : 28 measurements

⇒ Approval criterion fulfilled for a maximum of 2 measurements exceeding the limits.

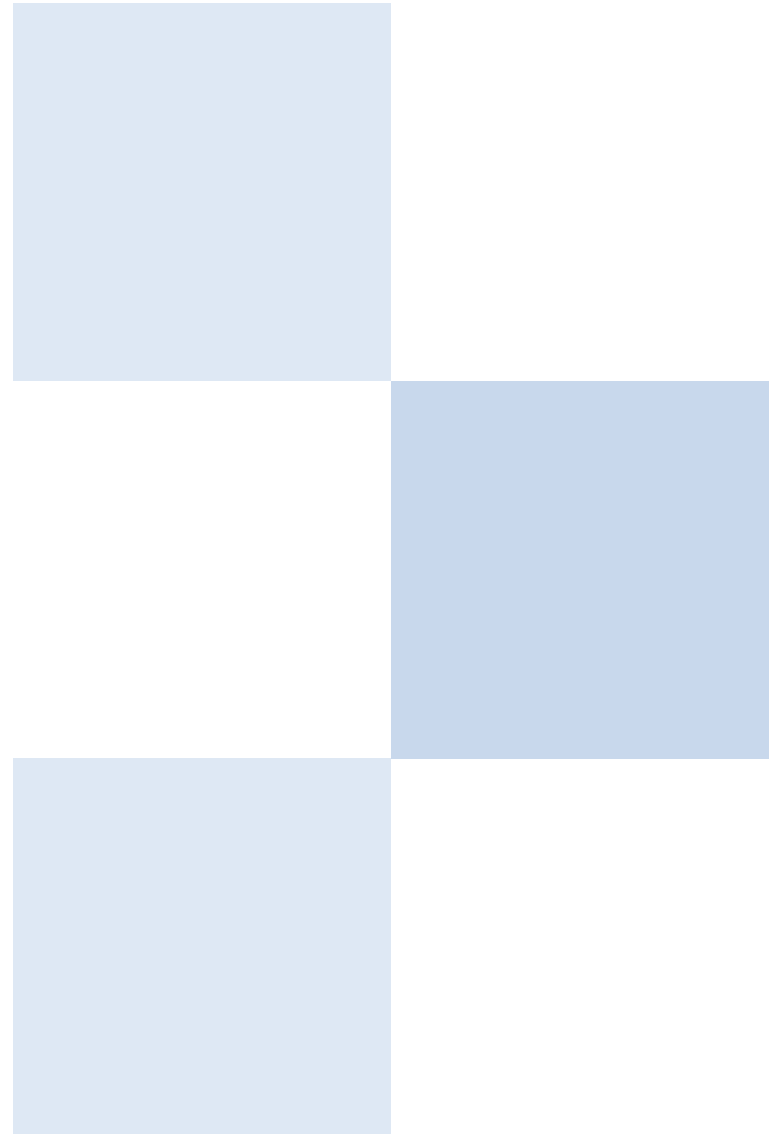
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**Comparison between 21909-1
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Available neutron standards and guidelines

Point to have in mind !

Differences between 21909 and 14146

- Different goal - different philosophy of the tests to perform

21909

Goal : **characterization of the dosimetric system**

Overview of the behaviour of the dosimeter

-> many configurations tested

Mean behaviour tested : several dosimeters for one configuration

Tests on the **mean value** from the dosimeters

Performance limits: relatively strict and « narrow »

Not aimed at be used for an inter-comparison of the dosimeters

Available neutron standards and guidelines

Point to have in mind !

Differences between 21909 and 14146

- Different goal - different philosophy of the tests to perform

14146

Goal : **intercomparaison between different dosimetric systems**

Here : not all configuration, not many doseimeters. **A sampling !**

Not mean behaviour as the 21909

Performance limits: a bit larger than 21909' limits but approval criteria of 10 % maximum of outliers

Available neutron standards and guidelines

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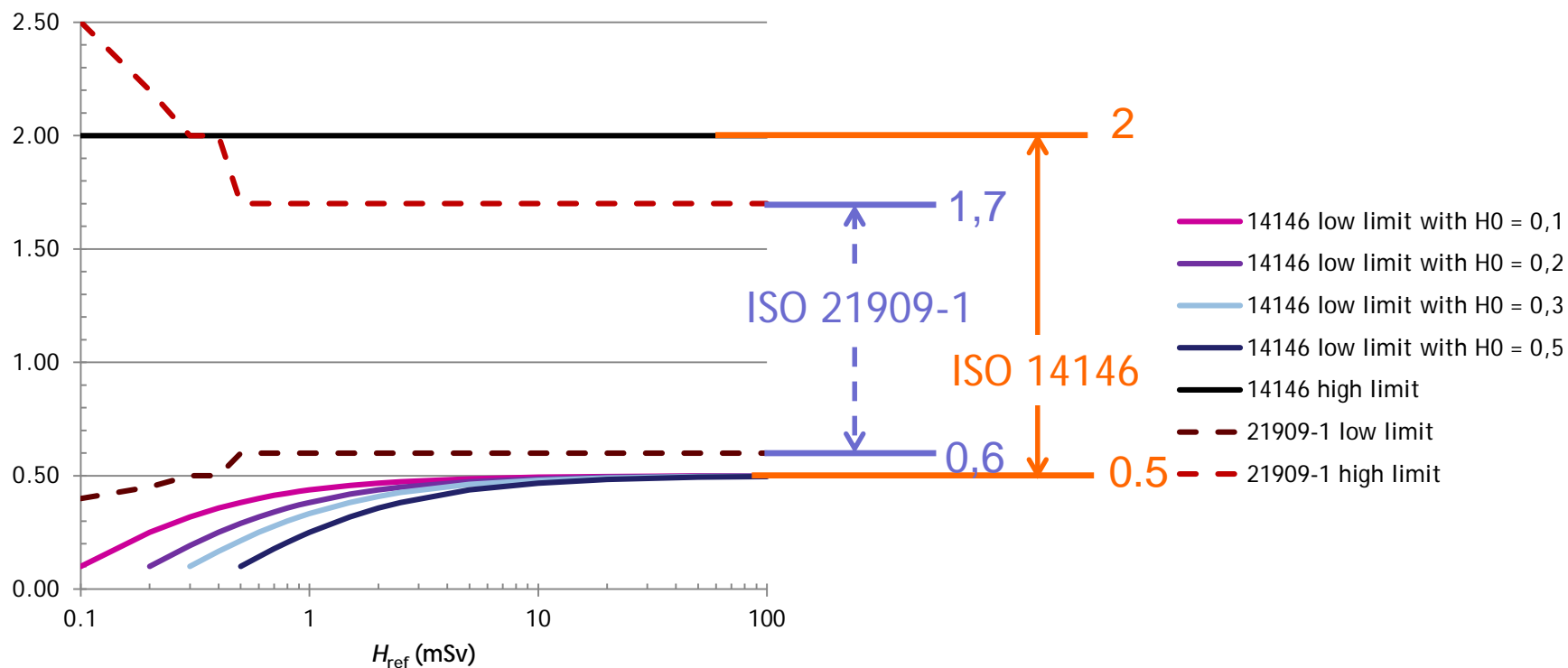
As the goals of each document are different,

➡ The way the doseimeters are tested are different !

➡ The performance limits are adapted to this goal !

Performances limits

Comparison between 21909-1 and 14146

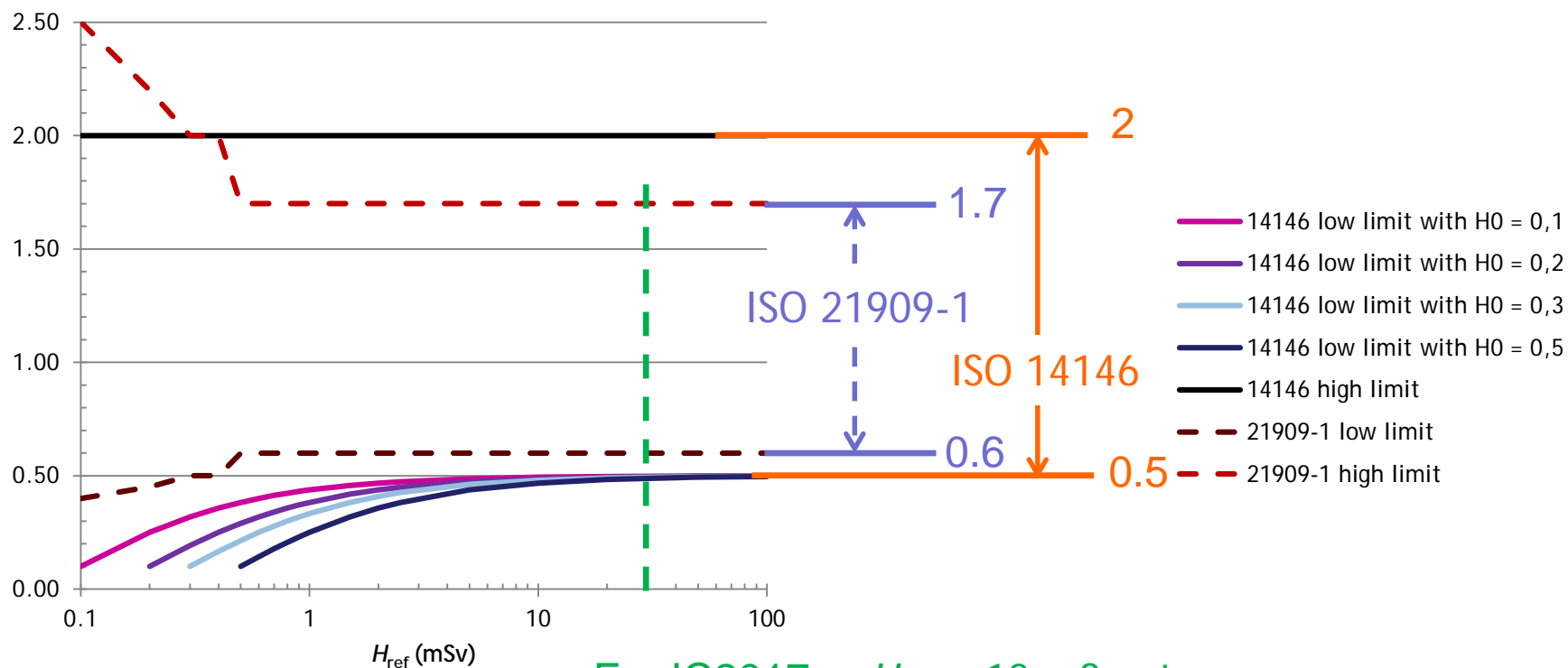


For high levels of dose:

➔ ISO 14146 less restrictive than ISO 21909-1

Performances limits

Comparison between 21909-1 and 14146



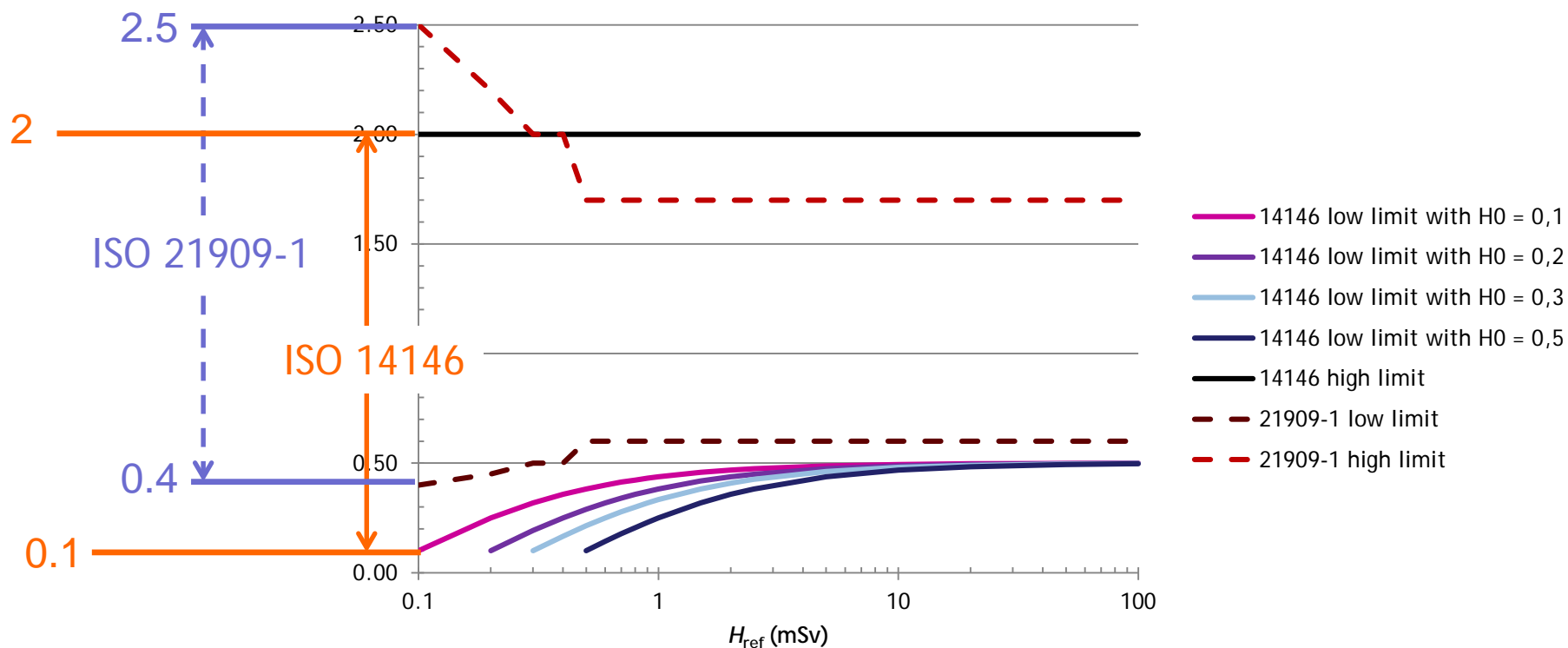
For high levels of dose:

➡ ISO 14146 less restrictive than ISO 21909-1

➡ Similar criteria between IC2012n and 14146: $0.49 \leq R \leq 2$

Performances limits

Comparison between 21909-1 and 14146

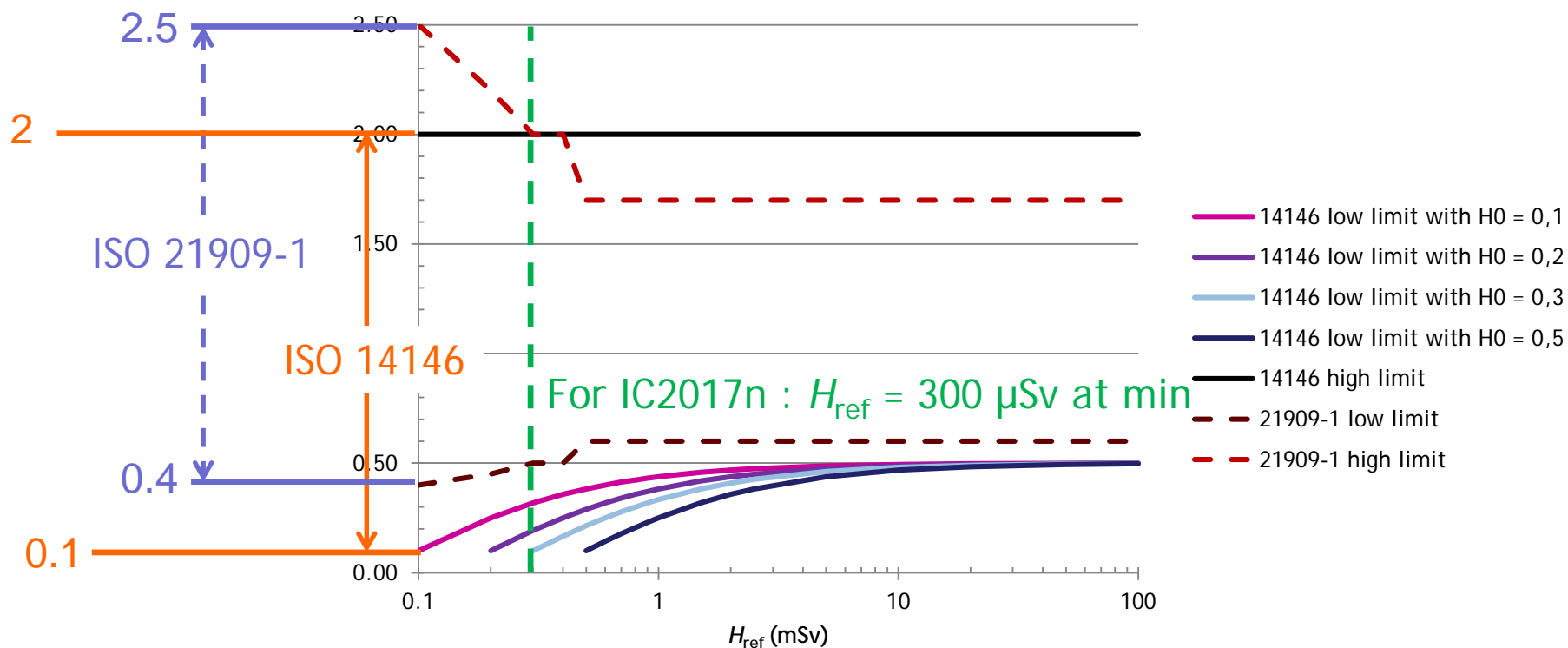


For low level of dose (100 μ Sv):

- ➡ Similar range of limits accepted: more or less 200%
- ➡ But ISO 21909 placed in order to have an over-estimation of the dose, instead of under-estimation ; to be more in accordance with the radioprotection principle
- ➡ Importance of the choice of H_0 for 14146

Performances limits

Comparison between 21909-1 and 14146



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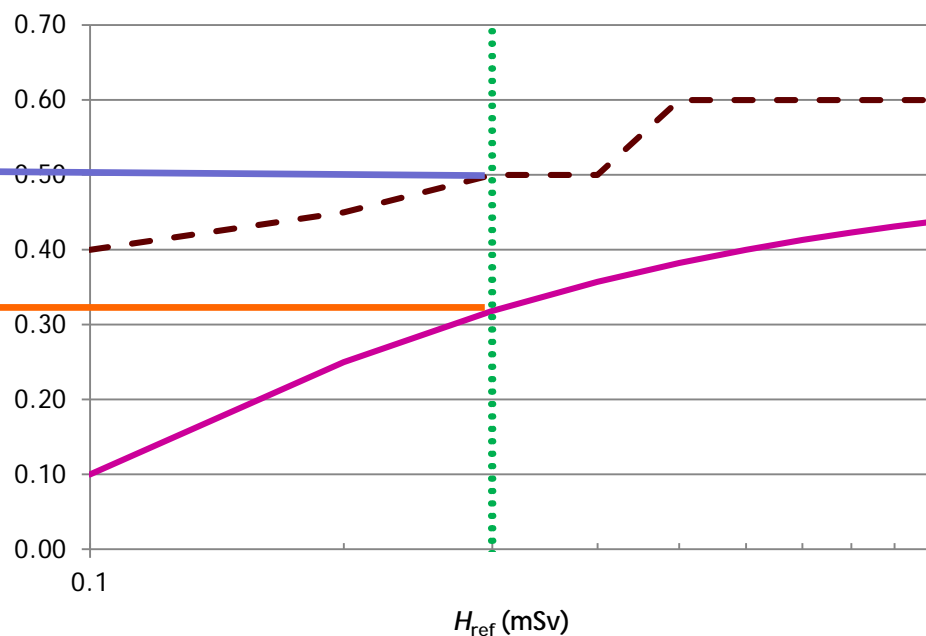
Performances limits

Comparison between 21909-1 and 14146

Low limit

For 21909-1
 $R \geq 0,5$

For ISO 14146
If $H_0 = 100 \mu\text{Sv}$,
 $R \geq 0,32$



— 14146 low limit with $H_0 = 0,1$
- - - 21909-1 low limit
⋯ $H_{ref} = 300 \mu\text{Sv}$

For IC2017n : $H_{ref} = 300 \mu\text{Sv}$ at min

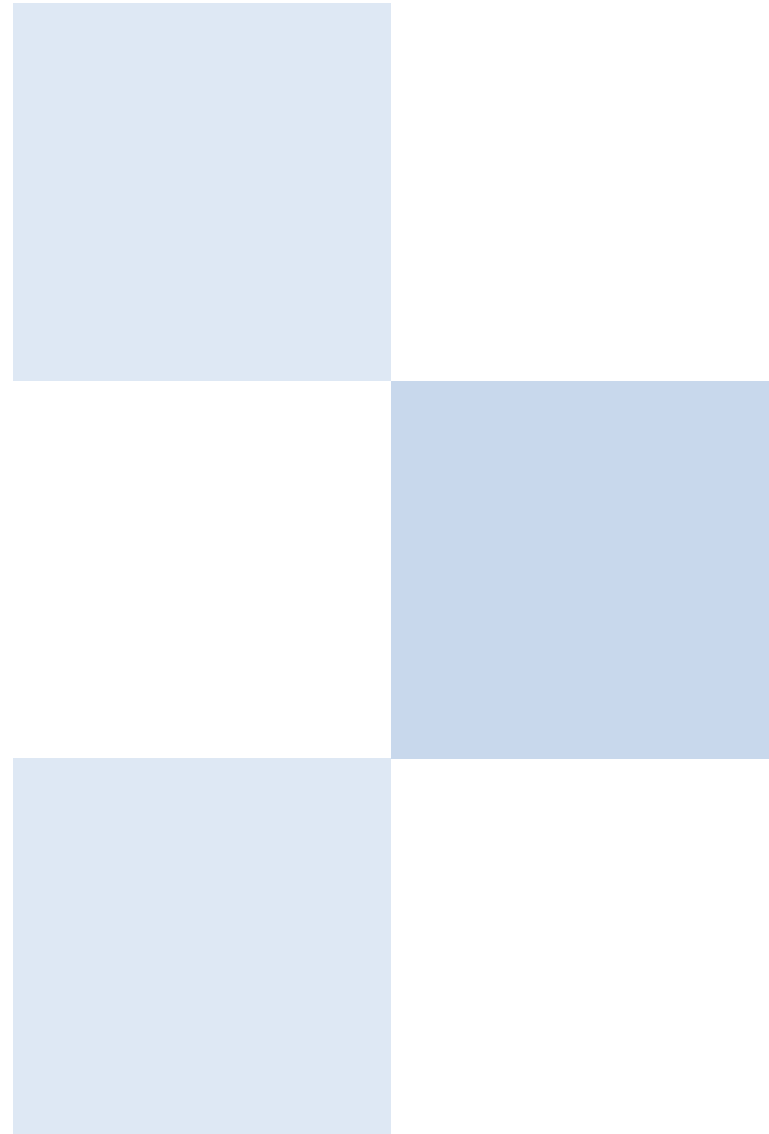
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**Conclusion: which criteria
for inter-comparison?**



Conclusion: which criteria for inter-comparison?

For IC2017n

- Contrary to IC2012n, nowadays, there exist reliable documents for defining performance criteria
- Document of reference: *ISO 14146 standard*
 - *performance limits with $H_0 = 100 \mu\text{Sv}$*

Irradiation dose	Low limit	High limit
0,3 mSv	0,32	2
1 mSv	0,44	
1,2 mSv	0,45	
1,5 mSv	0,46	
12 mSv	0,49	

- *with the approval criterion !*

- *Less restrictive than ISO 21909-1 requirements*
 - *But here, intercomparison exercise and not a characterization of the dosimeters.*



Thank you!

Please let us know your suggestions or claims
by e-mail to coordinator@ic2017n.org

