

Risø High Dose Reference Laboratory

HDRL Technical note number E5 (2)

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Dosimetry comparisons of Risø High Dose Reference Laboratory.

Ref: HDRL Quality Manual, sect 5.4.5 and 5.9.1.

Revision history				
Edition	Date	Issued by	Author	Changes
1	2016.08.24	Arne Miller and Mark Bailey	Arne Miller and Mark Bailey	New Technical note, E5
2	2017.07.29	Torben E. Mølholt and Arne Miller	Torben E. Mølholt	Added: Revision history. Added: References Added: Comparison Risø HDRL – NPL 2017 Appendix 10

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Abstract

The dosimetry comparison programme of Risø High Dose Reference Laboratory (Risø HDRL) is described. Measurement traceability is maintained to the primary national standards at National Physical Laboratory, UK (NPL), and annual blind bilateral comparisons are carried out between Risø HDRL and NPL with reference to the Quality Management System of the two laboratories. The results of these and other comparisons are given in this report.

Introduction

Technical University of Denmark is appointed Designated Institute (DI) by the Danish Safety Technology Authority (“Sikkerhedsstyrelsen”) within 3 measurement areas: Length, Thermometry (Infrared) and Ionising Radiation (absorbed dose). Risø HDRL maintains the latter within high-dose measurements for industrial applications. Risø HDRL is accredited by the Danish Accreditation and Metrology Fund (DANAK) in accordance with EN ISO 17025, accreditation number 266. General information about Risø HDRL is found at the www.dtu.dk/nutech-hdrl

The calibration areas of Risø HDRL are given in the Calibration and Measurement Capability (CMC) and the measurement areas are given in the list of test methods, both published by DANAK, see http://english.danak.dk/English/database_eng/

The national standard of Risø HDRL is since 2008 the reference standard radiation field of the cobalt-60 gamma-cell number 3. The dose rate of this radiation field was calibrated initially using transfer standard dosimeters from NPL. Measurement traceability of dose measurements and calibrations made by Risø HDRL is derived from the dose rate of the reference standard radiation field.

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Comparisons NPL – Risø HDRL

The comparison program with NPL is described in Risø HDRL procedure HDRL-P-18. This procedure refers to the individual comparisons through instructions HDRL-I-45 through HDRL-I-50 as given below (The procedure and instructions are available at request).

- 1 Gamma cell 1; verification of dose rate and transient dose.
 - a. Irradiation: Risø HDRL Gamma cell 1
 - b. Time of measurement: 2nd quarter, uneven years
 - c. Instruction HDRL-I-45

- 2 Gamma cell 3; verification of dose rate and transient dose.
 - a. Irradiation: Risø HDRL Gamma cell 3
 - b. Time of measurement: 2nd quarter, every year
 - c. Instruction HDRL-I-46

- 3 Alanine pellet dosimeter; Verification of calibration, gamma.
 - a. Irradiation: NPL gamma cell
 - b. Time of measurement: 2nd quarter, uneven years
 - c. Instruction: HDRL-I-47

- 4 Alanine pellet dosimeter; Verification of calibration, electrons.
 - a. Irradiation: 10 MeV electron accelerator
 - b. Time of measurement: 2nd quarter, even years
 - c. Instruction: HDRL-I-48

- 5 Alanine film dosimeter; Verification of calibration, electrons.
 - a. Irradiation: 10 MeV electron accelerator
 - b. Time of measurement: 2nd quarter, even years
 - c. Instruction: HDRL-I-49

For comparisons 1 and 2 Risø HDRL requests transfer standard dosimeters from NPL. These are irradiated in the Risø HDRL gamma cells and sent to NPL together with certificate stating the given doses and the irradiation temperature. NPL measures the dosimeters and sends certificate to Risø HDRL with the measurement results. NPL does not inform Risø HDRL of the results if certificate with information about the given doses has not been received.

For comparisons 3 and 6 Risø HDRL sends dosimeters to NPL and requests irradiation at the NPL cobalt-60 gamma cell within approximate dose ranges. NPL irradiates and returns the

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irradiated dosimeters to Risø HDRL with information of the used approximate dose ranges and irradiation temperature. Risø HDRL measures the irradiated dosimeters and sends certificate to NPL with the measurement results. After having received the Risø HDRL results, NPL sends certificate with the given doses to Risø HDRL. NPL does not inform Risø HDRL of the given doses if certificate with information about the doses measured by Risø HDRL has not been received.

For comparisons 4 and 5 Risø HDRL requests transfer standard dosimeters from NPL. These are irradiated at a 10 MeV electron accelerator together with Risø HDRL transfer standard dosimeters. Risø HDRL measures its dosimeters and reports measured doses to NPL in an irradiation certificate. The NPL dosimeters are sent back to NPL, who measures and reports the results to Risø HDRL in a certificate. NPL does not inform Risø HDRL of the results if certificate with information about the doses measured by Risø HDRL has not been received.

Analysis of results

For all comparisons the Risø HDRL data and the NPL data are compared and degree of equivalence is determined by calculation of the E_n -value:

$$|E_n| = (X_{lab} - X_{ref}) / \sqrt{(U_{lab})^2 + (U_{ref})^2}$$

where X_{lab} = The result of the Risø HDRL

X_{ref} = The value of the reference (NPL)

U_{lab} = The measurement uncertainty of Risø HDRL

U_{ref} = The measurement uncertainty of the reference (NPL)

The uncertainties are calculated based on the uncertainty budget of NPL and Risø HDRL, respectively, and taken at $k = 2$. Correlated components of uncertainty, such as the uncertainty of the NPL standard are not included in the calculation. The results are accepted if E_n is less than 1. Corrective actions in accordance with the quality management system of Risø HDRL are initiated if the E_n exceeds 1.

Procedure HDRL-P-18 was issued 2013.02.21 (and is currently at edition 3, dated 2015.07.31). Prior to issue of this procedure comparisons NPL – Risø HDRL were carried out according to the same system as described in HDRL-P-18, namely blind with the same flow of information as described above and with the aim to ensure that the different calibration services of Risø HDRL were covered.

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Other comparisons

Risø HDRL takes part in other comparison programmes within high-dose dosimetry that might be offered, such as key or supplementary comparisons conducted by the CIPM/CCRI. These comparisons are executed in accordance with the protocols of the individual comparisons. The most recent of these was in 2009 (see [Supplementary comparison CCRI\(I\)-S2 of standards for absorbed dose to water in ⁶⁰Co gamma radiation at radiation processing dose levels](#)).

Results

A summary of the results for comparisons with NPL and of other comparisons are given in this technical note. Details of the comparisons are given in the appendices. The technical note and its appendices will be updated as new comparisons are carried out, and results become available.

1. Comparison Risø HDRL – NPL 2009 (appendix 1)

Irradiation: 10 MeV electron accelerator

Dosimeters: NPL and Risø HDRL transfer standard dosimeters (alanine/EPR)

Results: Agreement within +/- 2%

2. Comparison Risø HDRL – NPL 2010 (appendix 2)

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Irradiation: 10 MeV electron accelerator

Dosimeters: NPL and Risø HDRL transfer standard dosimeters (alanine/EPR)

Results: Agreement within +/- 2%

3. Comparison Risø HDRL – NPL 2012 (appendix 3)

Irradiation: NPL cobalt-60 gamma cell

Dosimeters: Risø transfer standard dosimeters (alanine/EPR)

Results: Agreement $E_n < 1$

4. Comparison Risø HDRL – NPL 2013 (appendix 4)
 - Irradiation: Risø HDRL cobalt-60 gamma cell
 - Dosimeters: NPL transfer standard dosimeters (alanine/EPR)
 - Results: Agreement $E_n < 1$

5. CCRI(I)-S2 High-Dose comparison 2009 (appendix 5)
 - Irradiation: Risø HDRL cobalt-60 gamma cell
 - Dosimeters: NPL and NIST transfer standard dosimeters (alanine/EPR)
 - Results: Agreement $E_n < 1$

6. Comparison Risø HDRL – NPL 2014 (appendix 6)
 - Irradiation: 10 MeV electron accelerator
 - Dosimeters: NPL and Risø HDRL transfer standard dosimeters (alanine/EPR)
 - Results: Agreement $E_n < 1$

7. Comparison Risø HDRL – NPL 2015 (appendix 7)
 - Irradiation: 10 MeV electron accelerator
 - Dosimeters: NPL and Risø HDRL transfer standard dosimeters (alanine/EPR)
 - Results: Agreement $E_n < 1$

8. Comparison Risø HDRL – NPL 2015 (appendix 8)
 - Irradiation: Risø HDRL cobalt-60 gamma cell
 - Dosimeters: NPL transfer standard dosimeters (alanine/EPR)
 - Results: Agreement $E_n < 1$ for dose rates.

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9. Comparison Risø HDRL – NPL 2016 (appendix 9)

Irradiation: 10 MeV electron accelerator

Dosimeters: NPL and Risø HDRL transfer standard dosimeters (alanine/EPR)

Results: Agreement $E_n < 1$.

10. Comparison Risø HDRL – NPL 2017 (appendix 10)

Irradiation: Risø HDRL cobalt-60 gamma cell 1 and 3.

Dosimeters: NPL transfer standard dosimeters (alanine/EPR).

Results: Agreement $E_n < 1$.

Appendices:

1. Comparison Risø HDRL – NPL 2009 Irradiation at accelerator (Risø HDRL)
2. Comparison Risø HDRL – NPL 2010 Irradiation at accelerator (Risø HDRL)
3. Comparison Risø HDRL – NPL 2012 Irradiation at gamma (NPL)
4. Comparison Risø HDRL – NPL 2013 Irradiation at gamma (Risø HDRL)
5. CCRI(I)-S2 High-Dose comparison 2009 (Irradiation gamma – Risø HDRL)
6. Comparison Risø HDRL – NPL 2014 Irradiation at accelerator (Risø HDRL)
7. Comparison Risø HDRL – NPL 2015 Irradiation at accelerator (Risø HDRL)
8. Comparison Risø HDRL – NPL 2015 Irradiation at gamma (Risø HDRL)
9. Comparison Risø HDRL – NPL 2016 Irradiation at accelerator (Risø HDRL)
10. Comparison Risø HDRL – NPL 2017 Irradiation at gamma (Risø HDRL)

References

EN ISO/IEC 17025 General requirements for competence of testing and calibration laboratories.