EUROPEAN RADIATION DOSIMETRY GROUP e. V.

EURADOS Report 2022-01

Neuherberg, May 2022

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# Content

# Abstract

The EURADOS intercomparison IC2021area was carried out between May 2021 and April 2022 for 66 participating passive $H^*(10)$ area dosimetry systems from 47 different institutes and monitoring services. Three measurement conditions were provided at locations of the Karlsruhe Institute of Technology: 3-months indoor, 3-months outdoor and 6-months outdoor. The challenge of this intercomparison was measuring additionally irradiated low dose radiation. Six dosemeters of each participating system were irradiated with Cs-137 gamma reference radiation: Three dosemeters with 150 µSv and three dosemeters with 300 µSv. Another six dosemeters of each participating system were not irradiated and were used for background dose subtraction. Typical values of the measured background dose were between 200 µSv and 450 µSv with a few significantly higher values up to 1.6 mSv. Despite the challenge of the low reference dose values, more than 90 % of the resulting response values of the irradiated dosemeters were within the recommended ISO 14146 trumpet curve response limits.

# 1. Introduction

The European Radiation Dosimetry Group EURADOS (www.eurados.org) is a network of 80 European institutions and more than 600 members. Working Group 3 (WG3) carries out research projects and coordinated activities within the field of area dosimetry. The aim of WG3 is to provide information about the measurement of ambient dose and dose rate and radioactivity concentrations for different scenarios, e.g. nuclear disaster with transboundary implications. The tasks of WG3 are divided into three subgroups: SG1 - Spectrometry systems for environmental dosimetry, SG2 - Passive environmental dosimetry and SG3 - Radon in metrology and field measurements.

The topic of SG2 is focused on environmental monitoring of nuclear, industrial, medical and research installations in Europe with passive area dosimetry systems. At present the main aims are harmonization of passive area dosimetry within Europe and intercomparisons of passive dosemeters used in workplace and environmental radiation monitoring. The initial task of SG2 provided an overview of passive dosimetry practices in Europe [1, 2].

Based on the analysis of this survey the first EURADOS intercomparison of passive $H^*(10)$ area dosemeters IC2014env [3] was organized. The goal of the first intercomparison was to measure and compare response of passive dosimetry systems to secondary cosmic radiation, terrestrial radiation and Cs-137 gamma reference radiation. 33 dosimetry systems from 16 countries and 30 institutions participated in the intercomparison. The second intercomparison IC2017prep [4] of passive dosimetry systems was organized under the umbrella of the EURAMET Preparedness project. 34 institutions which are mainly involved in ambient radiation monitoring in Europe took part.

The results obtained witihin these intercomparisons are important for the quality assurance systems of the participants and for the performance comparison and harmonization of passive area dosimetry systems in Europe. The current intercomparison IC2021area differs from previous intercomparisons because of its focus on low dose response. Irradiated dose values were lower than the expected background dose of the measurement periods of three months and six months.

# 2. Organization

## 2.1 Organization Group, Coordinator and Administrator

The organization group (OG) members are J. Aslan, M. A. Duch, T. Haninger, C. Hranitzky, Ž. Knežević and C. Naber. The intercomparison coordinator is C. Hranitzky, the administrator is C. Gärtner. The OG started its work shortly after the EURADOS Annual Meeting AM2021 in February 2021 by regular online meetings. All members declared their confidentiality and provided their offer to EURADOS.

## 2.2 Irradiating Laboratory

The ISO 17025 accredited calibration laboratory of KIT Karlsruhe was chosen by the OG as the irradiating laboratory based on the OG specifications finalized on 2021-03-03 and the corresponding KIT offer to EURADOS.

## 2.3 Online Platform

The communication between the coordinator, administrator and the participants is carried out via the online platform developed at Seibersdorf: https://www.eurados-intercomparison.org/ic2021area. Registration for the interested participants started 2021-05-01.

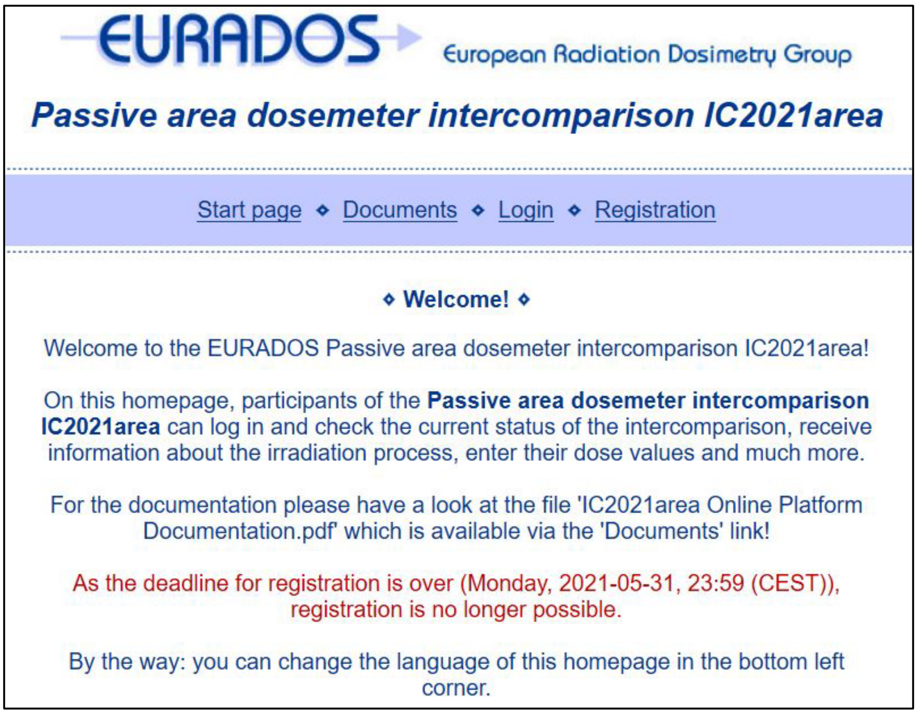



Figure 2.1: Start page with welcome and information, registration ended 2021-05-31.

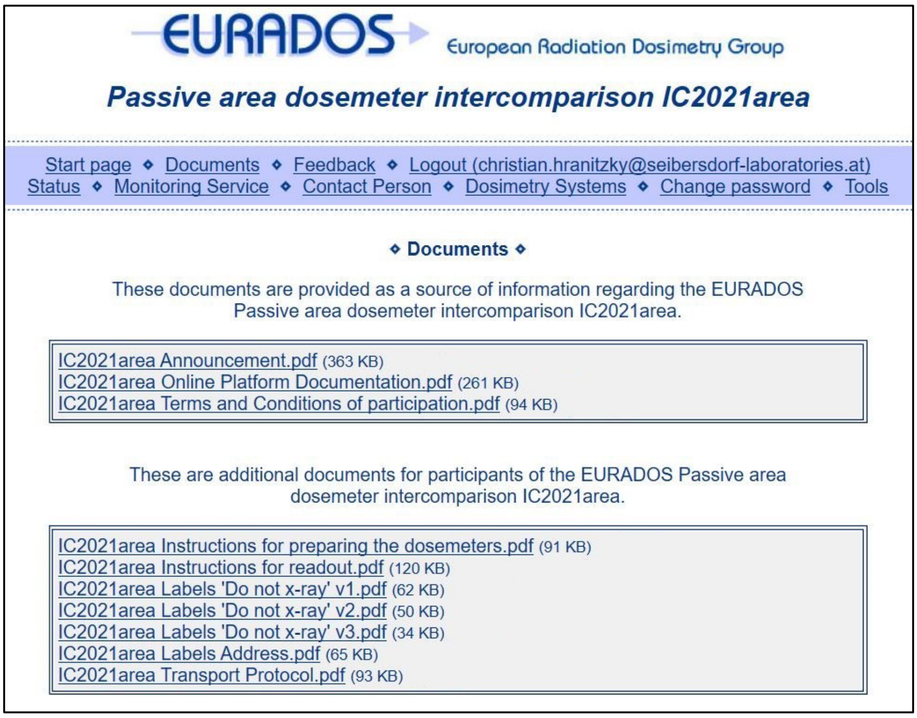



Figure 2.2: Documents page with 3 general documents (Announcement, Online Platform Documentation and Terms and Conditions of participation) accessible before login.

## 2.4 Newsletter and Questionnaire

The information of the planned intercomparison IC2021area was distributed among the EURADOS members and the radiation protection community via the EURADOS homepage (www.EURADOS.org), the EURADOS Newsletter 2021-03-03, emails and individual communication.

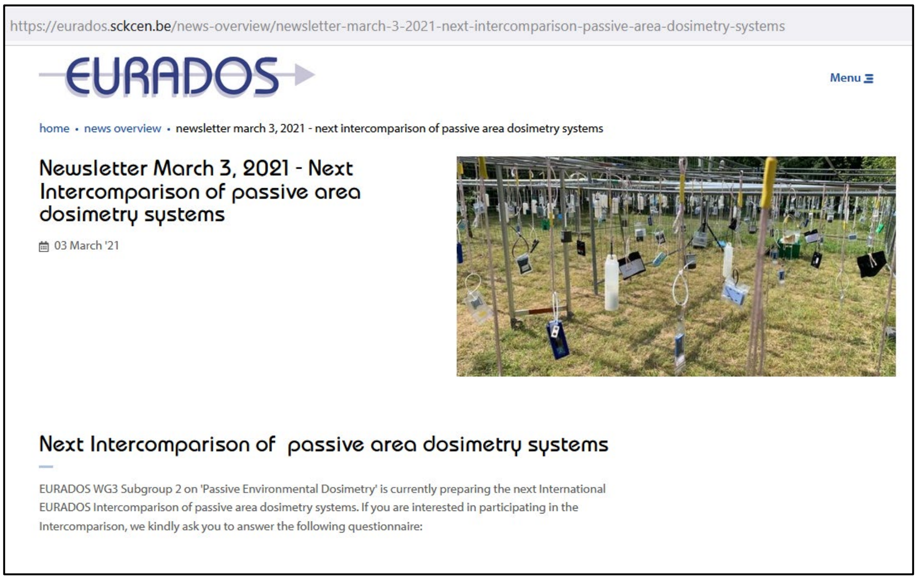
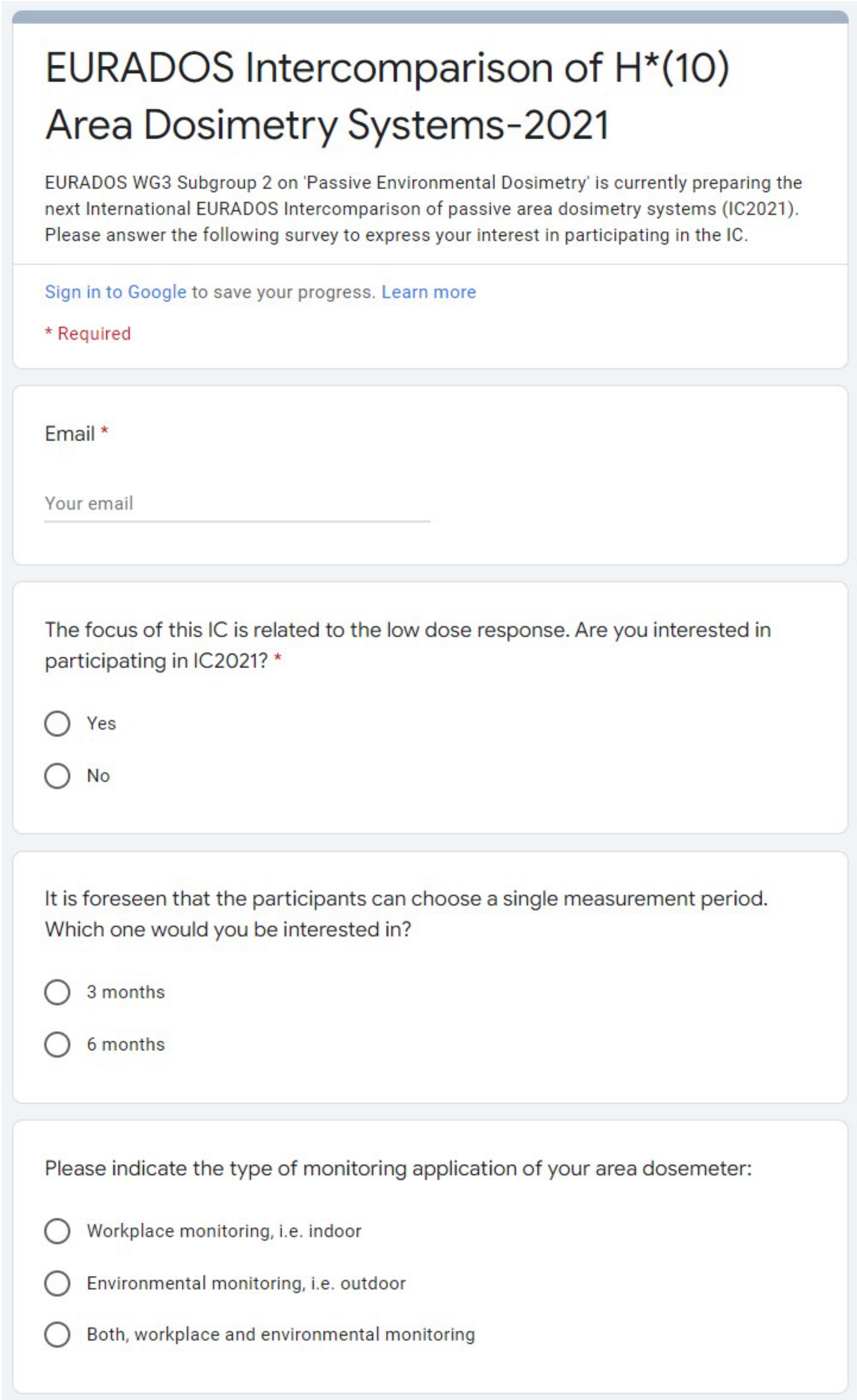



Figure 2.3: Newsletter posted on the EURADOS homepage: https://eurados.sckcen.be/news-overview/newsletter-march-3-2021-next-intercomparison-passive-area-dosimetry-systems.



EURADOS Intercomparison of H*(10) Area Dosimetry Systems-2021

EURADOS WG3 Subgroup 2 on 'Passive Environmental Dosimetry' is currently preparing the next International EURADOS Intercomparison of passive area dosimetry systems (IC2021). Please answer the following survey to express your interest in participating in the IC.

Sign in to Google to save your progress. Learn more

* Required

Email *

Your email

The focus of this IC is related to the low dose response. Are you interested in participating in IC2021? *

- Yes
- No

It is foreseen that the participants can choose a single measurement period. Which one would you be interested in?

- 3 months
- 6 months

Please indicate the type of monitoring application of your area dosemeter:

- Workplace monitoring, i.e. indoor
- Environmental monitoring, i.e. outdoor
- Both, workplace and environmental monitoring

Figure 2.4: Online questionnaire for expression of interest. The link to the Google Form questionnaire is included in the Newsletter 2021-03-03. In total, 50 persons expressed their interest in participating IC2021area.

According to the answers of the persons who expressed their interest in participating in IC2021area, 83 % were interested in a 3-months measurement period and 17 % in a 6-months period. It is also worth mentioning that in most cases the type of monitoring application of the area dosemeters was either workplace and environmental monitoring (62 %), 24 % of answers indicated environmental monitoring, and only 14 % workplace monitoring.

European Radiation Dosimetry Group

EURADOS

## Announcement of the IC2021area

### EURADOS Intercomparison 2021 for passive area dosemeters

EURADOS Working Group 3 SG 2 offers the possibility of participating in the 2021 intercomparison for passive area dosemeters using the EURADOS intercomparison online platform.

**Registration:** https://www.eurados-intercomparison.org/ic2021area

The IC2021area intercomparison is intended for $H^*(10)$ environmental and workplace dosemeters with the possibility of choosing the measurement condition: 3-months inside, 3-months outside or 6-months outside. Extra irradiations with photon radiation will be carried out in the accredited irradiation laboratory with low and very low doses, certainly below 0.5 mSv.

**The participation fee is 1000 Euro for one dosimetry system and 800 Euro for any additional system. EURADOS sponsors will pay 900 Euro for one system and 800 Euro for any additional system.**

**Intercomparison coordinator & administrator:**

Christian Hranitzky & Christian Gärtner (Seibersdorf Labor GmbH, Austria)

**Contact:** ic2021area@eurados-intercomparison.org

**Organization group:**

Julia Aslan & Christian Naber (KIT Karlsruhe), Maria A. Duch (UPC Barcelona), Thomas Haninger (Mirion AWST, Munich), Christian Hranitzky (SL Seibersdorf), Željka Knežević (IRB Zagreb).

**Intercomparison procedure:**

Participants complete the application form which can be accessed after registration on the online platform. On acceptance of the application, the participants will receive an invoice from EURADOS and instructions. Before the given deadline, 12 dosemeters per system must be sent and arrive at the irradiation laboratory:

Karlsruher Institut für Technologie (KIT)
c/o Christian Naber
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Germany

After the 3-months and 6-months measurement periods, the irradiation laboratory will return the dosemeters to the participants for readout. Within one month the participants submit their 12 dosemeter results in terms of ambient dose equivalent. After confirmation of the results, EURADOS will finally provide the response results in a "Certificate of Participation".

**Time Schedule**

| | |
|---|---|
| 01 May 2021 | Start of Registration |
| 31 May 2021 | Deadline for sending application forms |
| 15 July 2021 | Deadline for dosemeter arrival at KIT |

Figure 2.5: Announcement information with registration and participation details, contact addresses and the planned time schedule.

| Terms and conditions of participation |
| --- |

1. The participant shall send 12 clearly labelled passive area dosemeters of a dosimetry system (specifying the type of the system and one of the three possible measurement conditions in this Application Form). The dosemeters must arrive before 15 July 2021 at the irradiation laboratory KIT Karlsruhe.
2. The participation fee is 1000 EUR for one dosimetry system and 800 EUR for any additional system. EURADOS sponsors will pay 900 EUR for one dosimetry system and 800 EUR for any additional system. Fees must be transferred in advance to the EURADOS bank account free of bank transfer costs (transfer costs should be borne by the customer) after receiving the invoice from EURADOS including instructions for payment, latest until 15 July 2021. Refunding will only be possible in the unlikely event that the intercomparison is cancelled by EURADOS.
3. Participants can send an electronic dosemeter (ED) together with the passive area dosemeters – for transport dose control, but not for transport dose correction. EDs will be switched off during the measurement period. EDs must have fresh batteries and disabled alarms. Appropriate transport insurance by the participant is strongly recommended.
4. Each participant is responsible for the transport costs to the irradiation laboratory, for a transport insurance to/from the irradiation laboratory and for customs formalities. EURADOS, the intercomparison organization group, the coordinating laboratory and the irradiation laboratory will not accept additional costs for transport insurance, transport damages or loss, customs or import/export duties when receiving/sending the dosemeters from/to participants. Participants from non-EU countries are responsible for making the necessary arrangements (e.g. preparation of documents such as pro forma invoices).
5. EURADOS, the intercomparison organization group, the coordinating laboratory and the irradiation laboratory accept no liability for any direct or consequential loss or damage arising from this intercomparison.
6. Dosemeters will be positioned according to the participant's chosen measurement condition (3-months inside, 3-months outside or 6-months outside), extra irradiations will be performed with photon radiation in terms of ambient dose equivalent H*(10) in the low and very low dose region, certainly below 0.5 mSv. Participants have to be aware, that significant transport dose contributions may produce outliers in resulting response values. Non-irradiated dosemeters will be used by the intercomparison organization for background/transport dose subtraction.
7. The participant must report the 12 dosemeter results in terms of H*(10) without background or transport dose correction within 1 month after dispatch from the irradiating laboratory. Change of results after distribution of the irradiation data is only possible in case of errors made by the irradiation laboratory or the intercomparison organization (to be judged by the intercomparison organization).
8. Intercomparison results will be treated by EURADOS as confidential data and participant identity will not be disclosed. Data used in technical and scientific studies, publications or presentations will be presented anonymously. Photos of the dosimetry systems will be used for publications.

Figure 2.6: Terms and condition also included in the application forms which were signed by the participants.

# 3. Dosimetry systems

## 3.1 Participants

66 passive $H^*(10)$ area dosimetry systems from 47 institutes and monitoring services from 20 countries took part in the intercomparison. 3 of the participants come from outside Europe (Argentina, Canada, and Japan) although higher transport dose contributions can be expected.

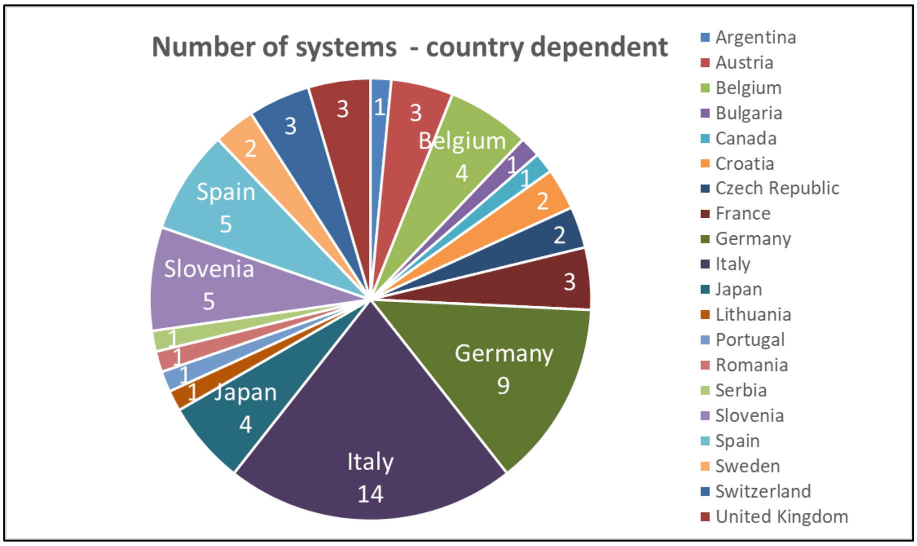



Figure 3.1: Number of participating dosimetry systems from various countries. The name of the country is shown for countries with more than 3 participating dosimetry systems. Italy has the highest number (14) of participating systems.

## 3.2 System specifications

The 66 participating dosimetry systems can be grouped according to their type of detector and the number of detectors within a dosemeter. The participant also selected the appropriate range of the lower limit of detection (alternatively the lower measurement limit).

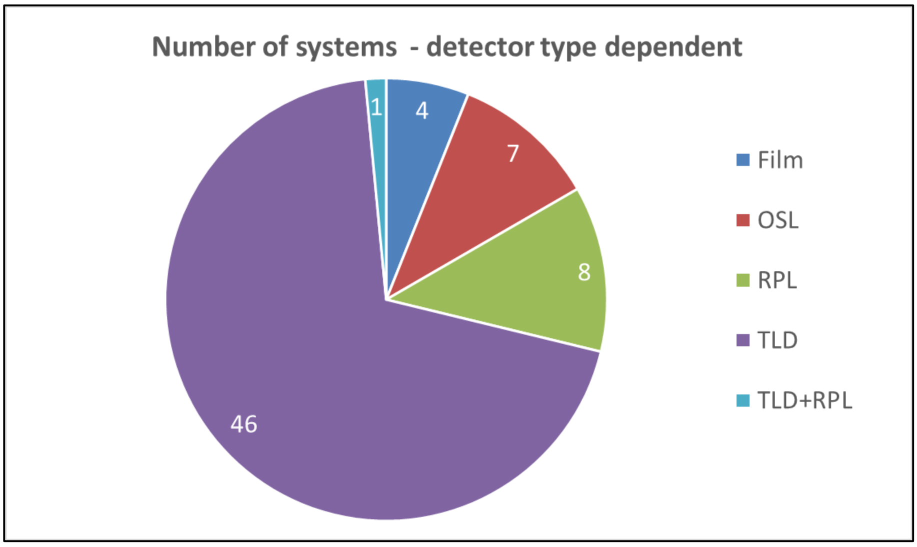



Figure 3.2: Number of participating dosimetry systems with different radiation detector materials. About 70 % are TLD based systems.

In this intercomparison 70 % of the dosimetry systems are based on thermoluminescent detectors, 13.5 % being RPL or TLD+RPL based systems, followed by OSL systems (6 %) and Film (6 %). These figures are slightly different from the results obtained in the 2012 and 2016 EURADOS questionnaires on Passive Area Dosimetry for Workplace and Environmental Radiation Monitoring, summarised in EURADOS Report 2021-02 [2]. At that time 83 % of the dosimetry systems were based on thermoluminescent detectors, but only 7 % of systems were based in RPL. Other radiation detection materials were also used, but to a lesser extent: OSL (3 %), direct ion storage (3 %) and CR-39 and fission track detectors (4 %). Therefore, in this intercomparison a greater fraction of OSL and RPL based systems has been observed.

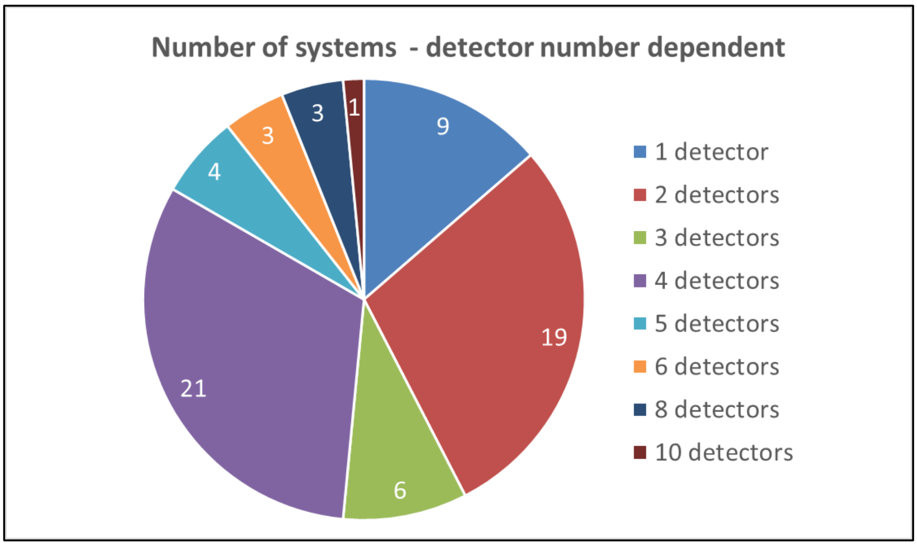



Figure 3.3: Number of participating dosimetry systems with different number of radiation detectors. Almost half of the systems use either 2 or 4 detectors.

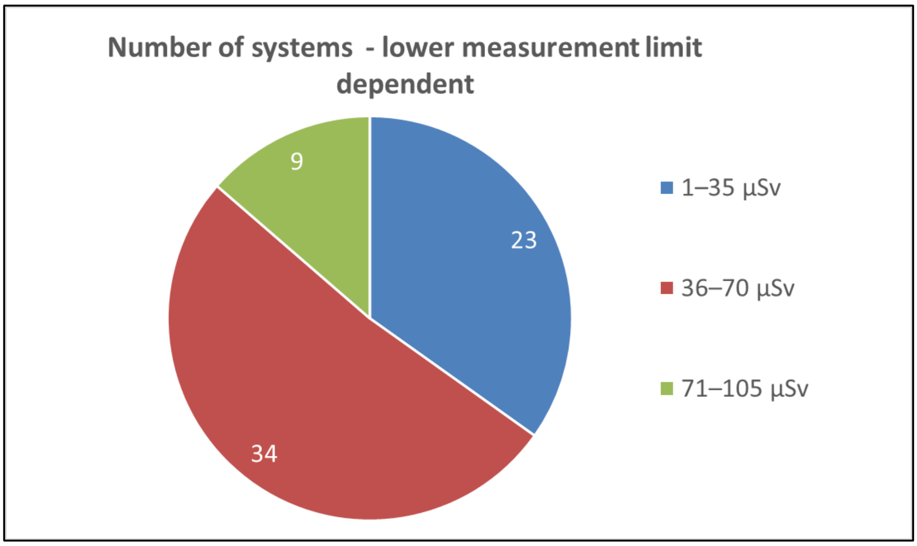



Figure 3.4: Number of participating dosimetry systems with different lower measurement limits and lower limits of detection. All systems are stated to be capable of measuring dose values higher than 105 µSv. The intervals were chosen for a direct comparison to the survey of European passive area dosimetry systems published in EURADOS report 2021-02 [2]. At that time half of the participants reported lower limits of detection in the range 1 - 35 µSv.

### 3.3 Measurement periods and conditions

The participants were asked to choose between the 3-months and the 6-months measurement period. Additionally, for the 3-months period the participant could choose between indoor and outdoor measurement conditions. For the 6-months period, only outdoor measurement conditions were provided. It can be assumed (but no information is available) that outdoor conditions were used by environmental dosimeters and indoor conditions by workplace dosemeters.

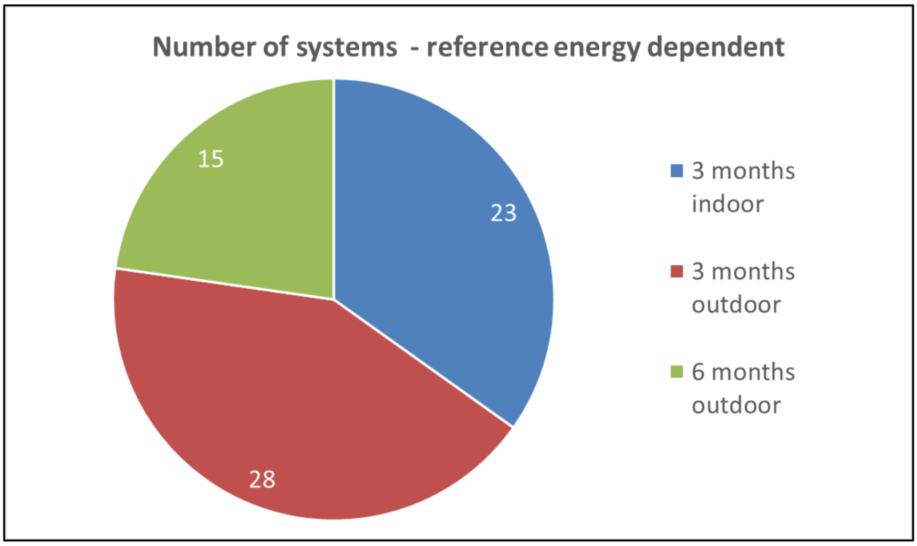



Figure 3.5: Number of dosimetry systems with different measurement periods and measurement conditions. Most dosimetry systems are used with 3-months issuing periods.

### 3.4 Extra irradiation

The OG decided to perform extra irradiations with Cs-137 gamma radiation. This radiation quality is used by most participants as reference radiation quality for their calibration.

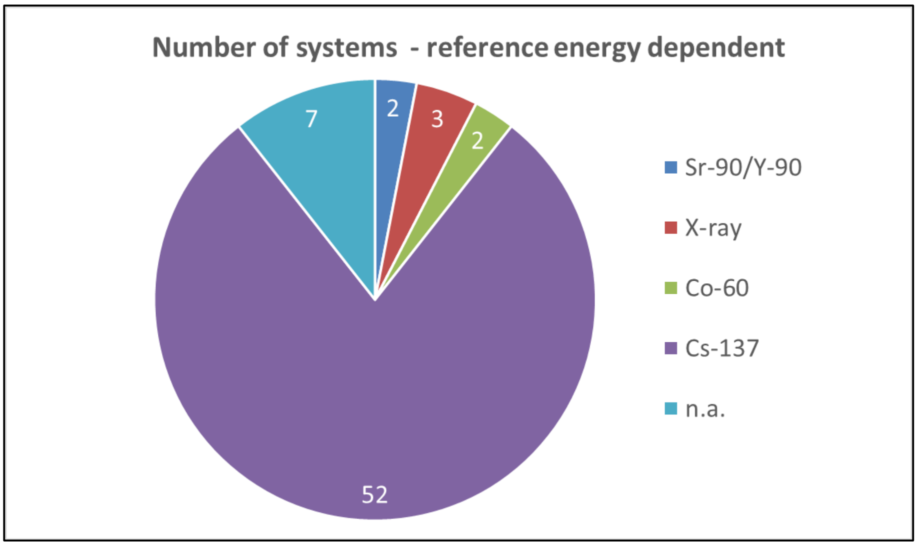



Figure 3.6: Number of participating dosimetry systems with different specified reference radiation energies. About 80 % of the participants use Cs-137. Some participants did not specify their reference radiation quality (shown as n.a.).

# 4. Irradiating laboratory

## 4.1 Measurement sites

KIT provided 2 measurement sites (indoor and outdoor). On the outdoor field with an area of 74 $m^2$, the dosimeters were hung at the same height (reference point at 1 m above the ground) and at equal distance from each other.

Figure 4.1: Outdoor measurement site with 516 dosemeters.

Figure 4.2: Dosemeters positioned on the outdoor measurement site at about 1 m height. Several dosemeter systems had no hanging possibility and were put into plastic bags which were not watertight.

Figure 4.3: 276 dosemeters positioned indoor in an office at about 2 m height.

## 4.2 Measurement periods

The measurement period is the time between positioning of the dosemeters at the measurement site and retrieving the dosemeters. The 3-months measurement periods were between 90 and 95 days (mid of July 2021 to mid of October 2021). The 6-months periods were about 187 days (mid of July 2021 to mid of January 2022). For both measurement periods, usual weather conditions were observed without any abnormalities.

## 4.3 Extra irradiations

Since the focus of this intercomparison was to determine dose values within a low dose range, the coordinator and the irradiating laboratory finally agreed on two reference dose values identical for all participating dosimetry systems (150 µSv and 300 µSv). The irradiations were performed according to ISO 4037.

The OG also agreed on extra irradiations at normal radiation incidence with 3 dosemeters of a dosimetry system irradiated simultaneously, as far as the dosemeter size allowed it. The radiation field diameter was 461 mm with an isodose of 98 %.

The extra irradiations were performed roughly in the middle of the measurement period. The 3-months systems were irradiated on 2021-08-31 and 2021-09-01, the 6-months systems on 2021-10-20. A photo of each irradiation was made for control purposes. In case of a problem during the irradiation, the OG agreed to use up to 2 spare dosemeters. Finally, KIT provided a calibration certificate for each dosimetry system. The expanded measurement uncertainty of the reference dose values was 4.3 % (expansion factor $k = 2$).

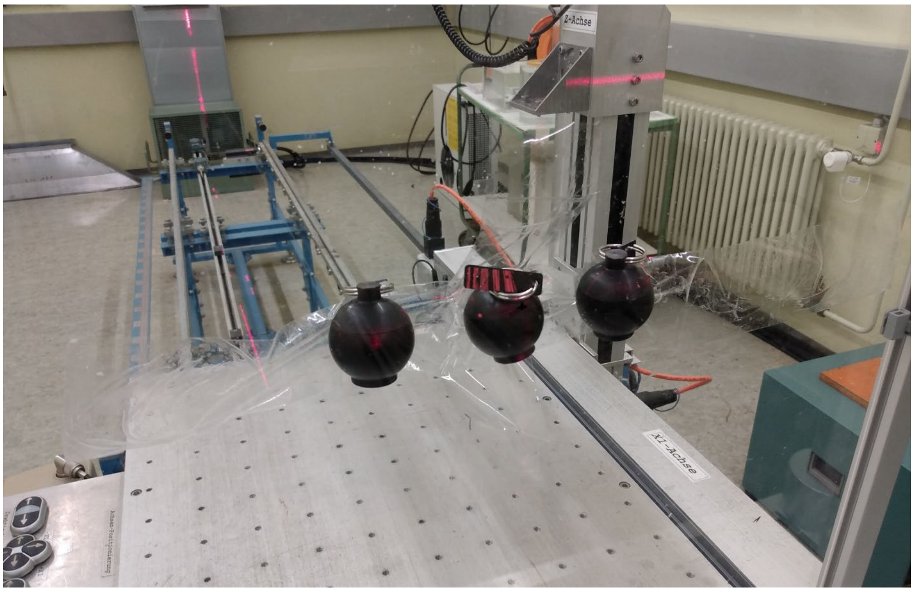


Figure 4.4: Irradiation of 3 dosemeters at about 5 m distance from the $^{137}Cs$ source almost free in air (with permission of KIT).

KIT
Karlsruher Institut für Technologie

**Kalibrierschein / Calibration Certificate**

DAkkS
Deutsche Akkreditierungsstelle
D-K-11068-01-00

Erstellt durch das Kalibrierlaboratorium
*Issued by the calibration laboratory*

**Karlsruher Institut für Technologie (KIT)**
Sicherheit und Umwelt
- Kalibrierlabor -
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen

Kalibrierzeichen
*Calibration mark*

| 000269 |
|---|
| D-K-11068-01-00 |
| 2021-08 |

| | |
|---|---|
| Gegenstand *Object* | passive detector |
| Hersteller *Manufacturer* | IC2021area system id S002/2021 |
| Typ *Type* | area dose meter |
| Fabrikat/Serien-Nr. *Serial number* | see additional remarks |
| Auftraggeber *Customer* | EURADOS e.V. Postfach 1129 85758 Neuherberg, Germany |
| Kalibrierschein-Nr. *Calibration certificate No.* | KA-K-P-2021-08-31-01 |
| Anzahl der Seiten des Kalibrierscheines *Number of pages of the certificate* | 4 |

Dieser Kalibrierschein dokumentiert die Rückführung auf nationale Normale zur Darstellung der Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Die DAkkS ist Unterzeichner der multilateralen Übereinkommen der European co-operation for Accreditation (EA) und der International Laboratory Accreditation Cooperation (ILAC) zur gegenseitigen Anerkennung der Kalibrierscheine.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.
*This calibration certificate documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI).*
*The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.*
*The user is obliged to have the object recalibrated at appropriate intervals.*

Figure 4.5: Screenshot of part of the first page of a KIT calibration certificate (with permission of KIT).

# 5. Results

## 5.1 Reported dose values and response results

The participants reported their measurement results via the online platform and finally by the signed dose value form. According to the date of reporting a reporting number was assigned to each dosimetry system. Reporting number 1 to 51 are used for 3-months systems and number 52 to 66 for 6-months systems. The reporting number of each participant is given in the certificate of participation together with the system number as provided by the online platform upon registration. The participants reported dose values for 12 dosemeters without subtracting a background dose contribution.

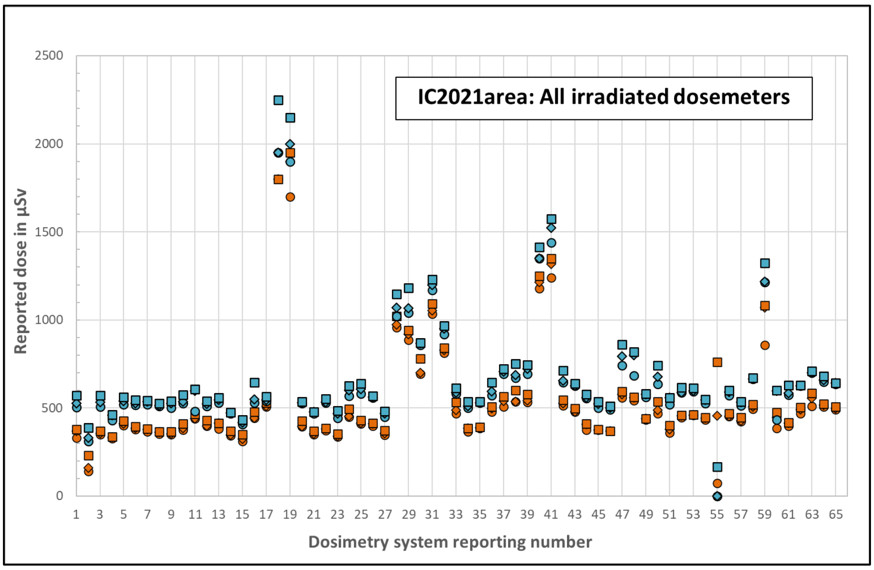



Figure 5.1: Reported dose values of the irradiated dosemeters with reference dose $H_{ref}$ equal to 150 µSv (orange symbols) and $H_{ref}$ equal to 300 µSv (cyan symbols).

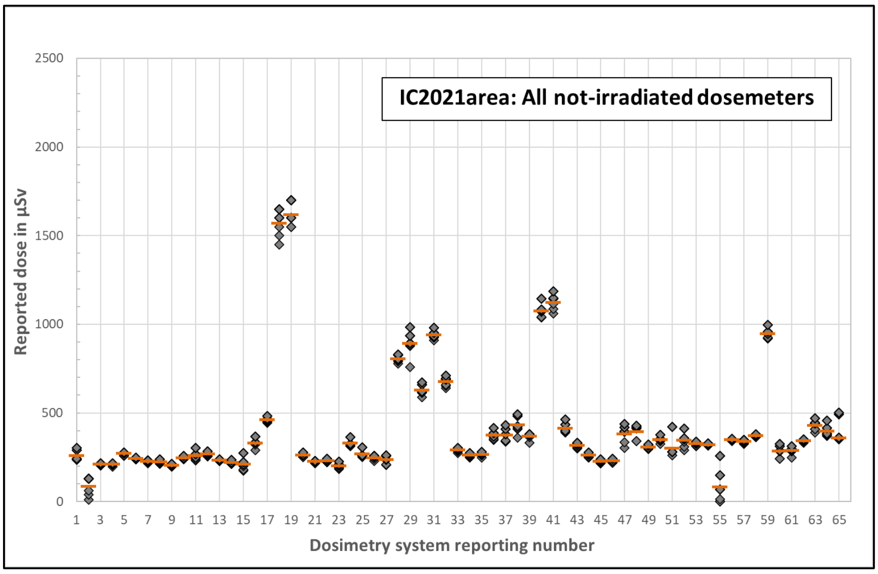



Figure 5.2: Reported dose values of the not-irradiated dosemeters (cyan symbols). The average values of the not-irradiated dosemeters (orange bars) are used as background dose value for each system. Typical background values are about 200-300 µSv (3-months) and 300-500 µSv (6-months) but significantly higher values due to transport dose contributions can be seen.

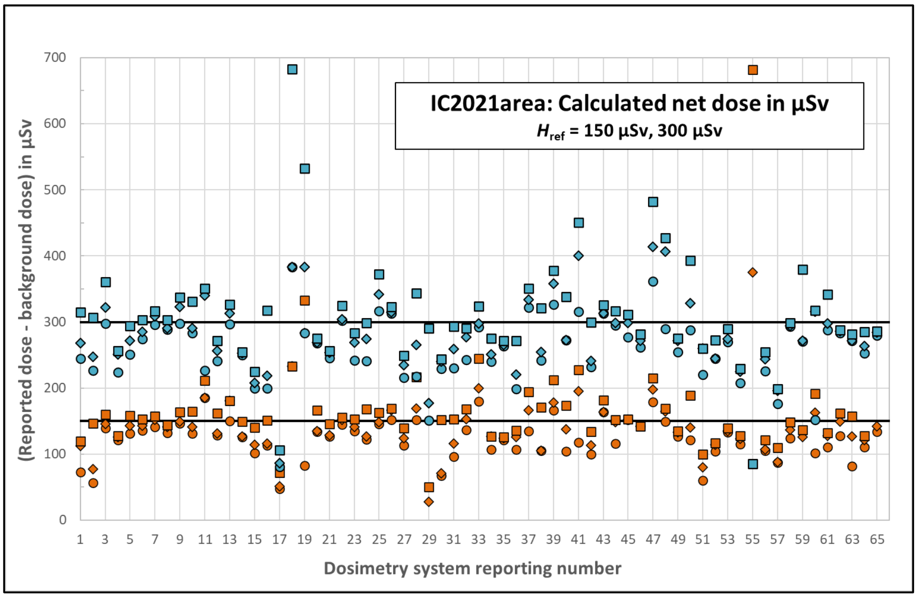



Figure 5.3: Calculated net dose values of the 6 irradiated dosemeters of a system after subtraction of the average background dose. The two reference dose values $H_{ref}$ equal to 150 µSv and $H_{ref}$ equal to 300 µSv are included (black horizontal lines).

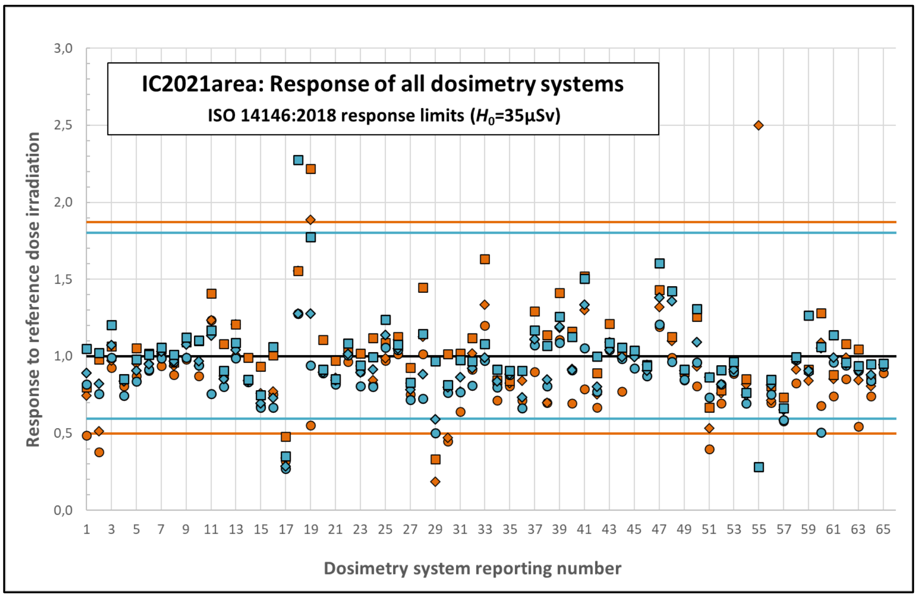



Figure 5.4: Dosemeter response values calculated as the ratio of net dose value and the reference dose value for the 6 irradiated dosemeters of a system. 3 dosemeter response values refer to $H_{ref}$ equal to 150 µSv (orange symbols) and the other 3 dosemeter response values refer to $H_{ref}$ equal to 300 µSv (cyan symbols). ISO 14146 lower and upper response limits are indicated as horizontal lines of similar colour.

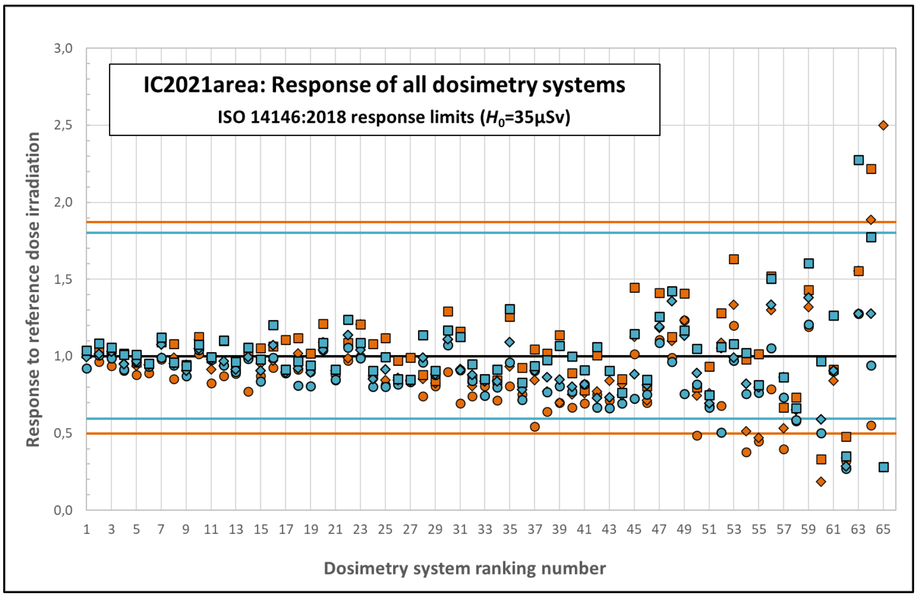



Figure 5.5: Sorted dosemeter response values. Compared to the previous figure, the dosimetry systems are sorted according to their ranking number based on the sum of the squared deviations from the ideal response value equal to 1. 93 % of the response results are within the response limits.

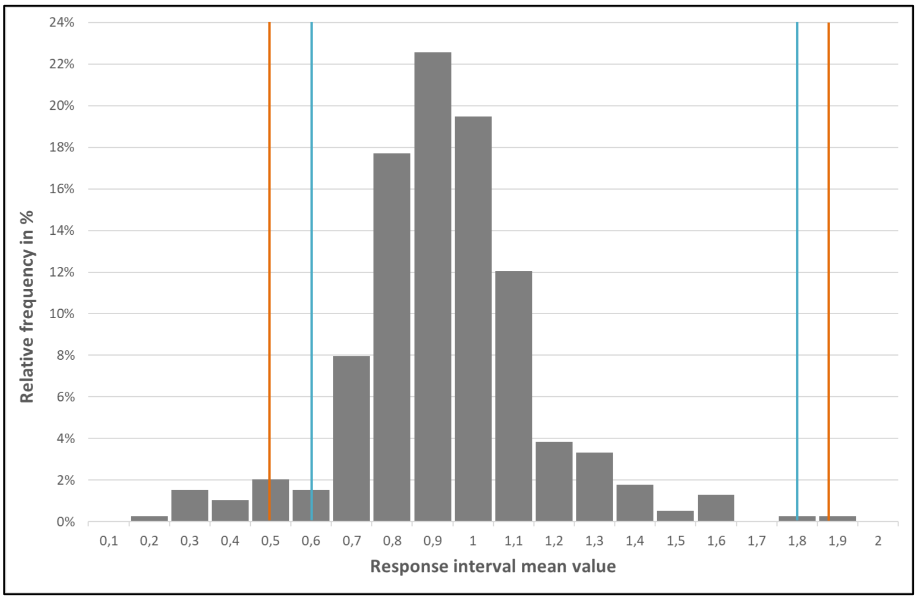



Figure 5.6: Relative frequency of all response values greater than 0.05 and smaller than 2.05. The highest frequency (about 23 %) is in the response interval 0.85 to 0.95. The mean value of all response values is equal to 0.94. ISO 14146 lower and upper response limits are indicated as vertical lines.

## 5.2 Background dose variations

The values of the not-irradiated dosemeters and the average background dose values were presented in the previous chapter. The quality of the background is crucial for the determination of the net dose due to the low reference dose values chosen in this intercomparison. Therefore, the OG decided to use the average over 6 dosemeters.

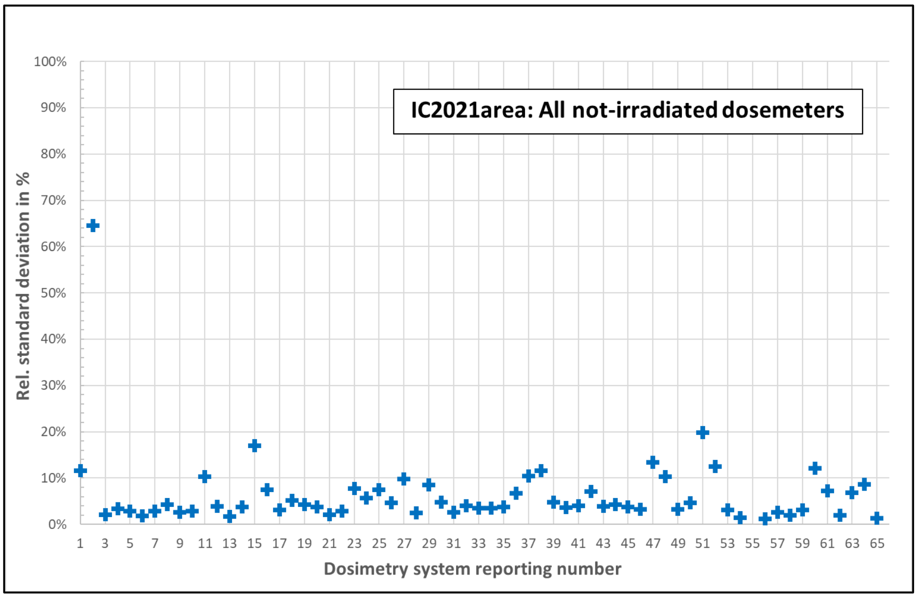



Figure 5.7: Coefficient of variation of the background dose values, i.e. the relative standard deviation of the 6 not-irradiated dosemeters of a system. Most variations are within 5 % or slightly higher, but a few systems show significantly higher background dose variations.

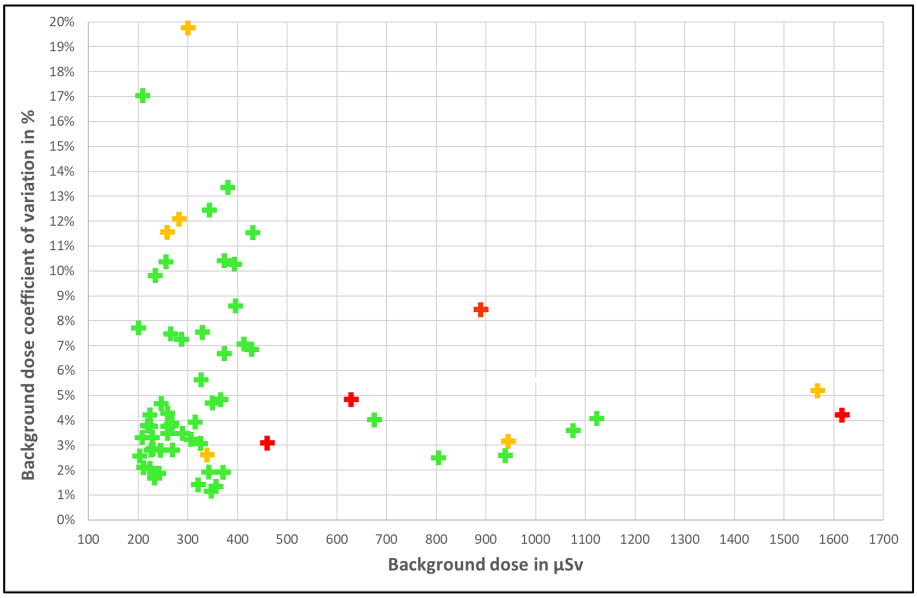



Figure 5.8: Relative standard deviation of the background dose (coefficient of variation) in dependence of the background dose. Two systems with background dose values lower than 100 µSv and one system with background dose coefficient of variation greater than 20 % are not shown here. Systems passing the response limit criteria (green crosses), systems with a single fail (orange crosses) and systems with multiple fails (red crosses) are shown. Systems with high background dose values (high transport dose contributions) are from Italy, United Kingdom and Japan.

# 6. Response Limits

## 6.1 Applied ISO 14146 criteria

The OG decided to apply response limits in the certificates. The assessment of conformity is especially interesting for accredited laboratories. ISO standard 14146 [5] provides an appropriate trumpet curve criterion in section 7.1.1.

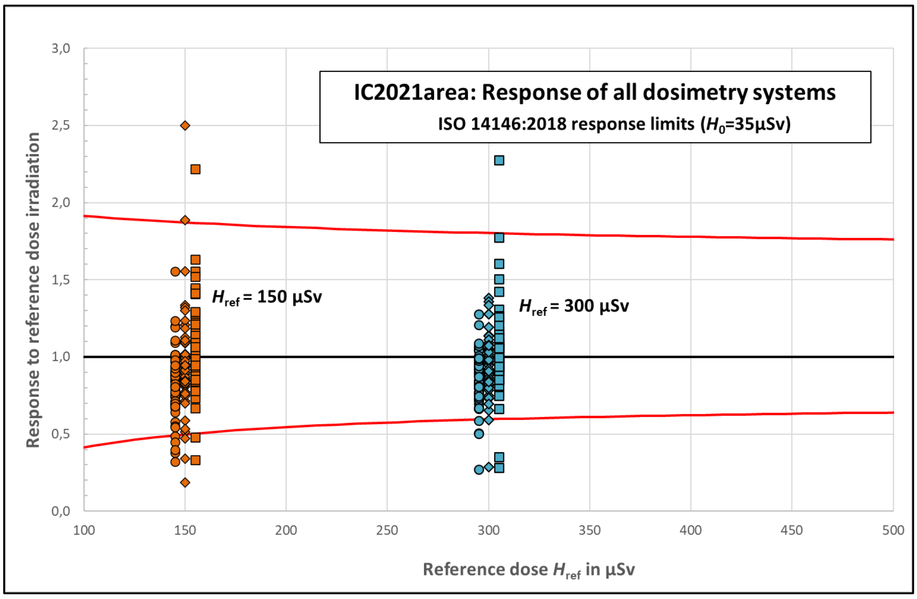



Figure 6.1: All dosemeter response values plotted at their reference dose values $H_{ref}$ equal to 150 µSv (orange symbols) and $H_{ref}$ equal to 300 µSv (cyan symbols). For a better visibility the response values are plotted in a range +/- 5 µSv around the reference dose values. ISO 14146 lower and upper response limits so-called trumpet curves (red lines) are applied with trumpet curve parameter $H_0$ equal to 35 µSv.

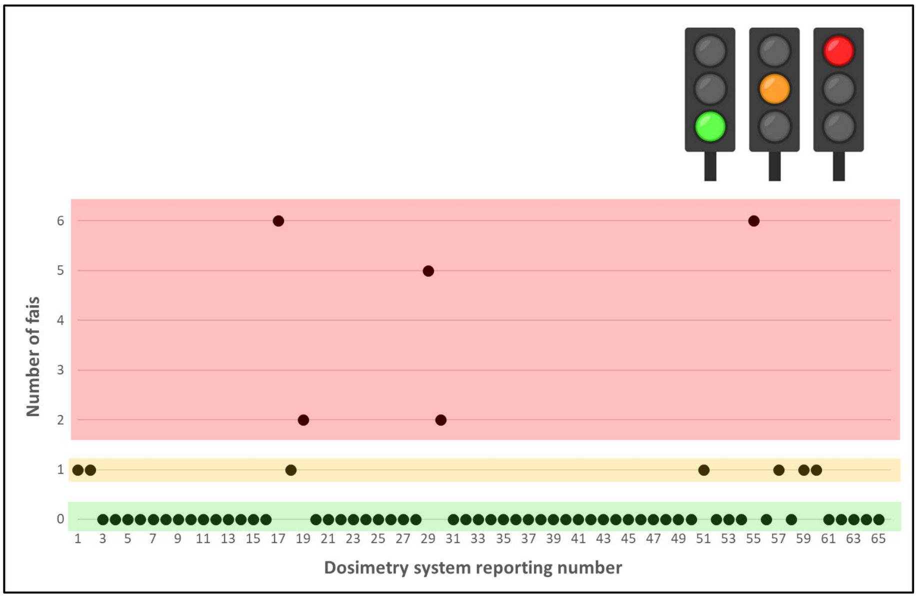



Figure 6.2: According to the applied ISO 14146 response criteria, 93 % of the response values were within these limits. In total, 53 dosimetry systems passed the criteria with all irradiated dosemeters (green area, 0 fails), 7 dosimetry systems had a single fail (orange area) and 5 dosimetry systems had more than one fail (red area).

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**5. Evaluation of intercomparison results**

The final results of the participant are presented in the last column of the previous table as 6 individual dosemeter response values $R(H_{\text{ref}})$ for the irradiated reference dose values $H_{\text{ref}}$.

The organization group recommends $H_{\text{ref}}$ dependent performance criteria for this low-dose intercomparison according ISO 14146:2018 using an appropriate trumpet-curve parameter.

| | |
|---|---|
| **Response limits for** $H_{\text{ref}} = 150\ \mu Sv$ | $0{,}50\ \leq R\ \leq 1{,}87$ |
| **Response limits for** $H_{\text{ref}} = 300\ \mu Sv$ | $0{,}60\ \leq R\ \leq 1{,}80$ |

The number of dosimeters of the participant failing these limits is 0.

Comment 1: Due to the limited number of irradiated dosemeters, a fail of 1 dosemeter may be statistically acceptable.

Comment 2: The organizers have no information about the intended use of the dosimetry systems, therefore a minimum requirement for both types of area dosemeters, environmental and workplace dosemeters, is proposed with the lowest admissible response of $0{,}50$ resulting in the trumpet-curve parameter $H_0 = 35\ \mu Sv$ in conformance with ISO 14146:2018 chapter 7.1.1 criterion formula 2.

Figure 6.3: Screenshot of page 4 of the IC2021area certificate of participation. In comment 2 the choice of the response criterion and the parameter $H_0$ is shortly explained.

## 6.2 Discussion about ISO 14146 criteria

This intercomparison differs from other, previous ones, because the irradiated dose $H_{\text{ref}}$ is lower than the background dose (including transport dose). The purpose of this intercomparison was to show that dosimetry systems exposed for several months to natural radiation are capable of measuring low artificial extra dose values $H_{\text{ref}}$ within acceptable limits. The recommendation of ISO 14146, that $H_{\text{ref}}$ should be larger than three times the expected background dose (see NOTE 1 in clause 6.3 of ISO 14146) was therefore not followed. Hence the OG decided to use slightly enhanced limits with trumpet-curve parameter $H_0$ = 35 µSv (see equation 2 in subclause 7.1.1). According to the standard, an appropriate choice of $H_0$ is allowed (see clause 6.3 of ISO 14146). With the applied parameter $H_0$ = 35 µSv a lower response limit of 0.50 for the lowest used reference dose $H_{\text{ref}}$ = 150 µSv should be fulfilled by all area dosemeters.

It must be noted, that in subclause 7.1.2 of ISO 14146 additional limits for the response of environmental dosimeters for Cs-137 and environmental radiation ($0.80 \leq R \leq 1.33$) are defined. The OG decided not to use these strong limits, which do not include a trumpet-curve broadening at low dose. The evaluation of this intercomparison has raised a number of questions regarding the application of the ISO 14146 for environmental dosemeters, especially of subclause 7.1.2. A list of comments has been submitted to the ISO committee to trigger a revision of the standard and to achieve clarity.

# 7. Summary and conclusions

## 7.1 Dose reporting and dose correction

Participants with a 3-months measurement period (reporting number 1 to 51) were asked to provide dose results between 2021-10-25 and 2021-11-30, participants with a 6-months measurement period (reporting number 52 to 66) between 2022-01-25 and 2022-02-28. One participant (reporting number 66) was not able to provide the dose results within an extended deadline (2022-03-11 date of the draft certificates, 2022-04-05 date of the final certificates).

One participant was allowed to correct reported dose results before publication of the draft reports. The OG allowed another participant to correct reported dosemeter IDs after publication of the draft reports. Finally, two participants were allowed to correct reported dose results because of wrongly reported dose units (mSv instead of µSv).

Most of the reported dose values were between 350 µSv and 750 µSv, the highest value was 2150 µSv. Eight participants reported dose values with decimal places. These dose values were rounded to integers in the certificates of participation. According to the technical standard IEC 62387 [6] it is recommended to report dose results with 2 or 3 significant digits.

## 7.2 Response to extra irradiation

The average response value of all irradiated dosemeters (65 dosimetry systems) is 0.94. Excluding dosimetry systems with one or more fails of the applied ISO 14146 response limits yields an average response value of 0.96 (53 dosimetry systems). The average response value for the 3-months indoor systems is 0.98 (20 dosimetry systems out of 23 without fails), for the 3-months outdoor systems also 0.98 (23 dosimetry systems out of 28 without fails) and for the 6-months outdoor systems 0.87 (10 dosimetry systems out of 14 without fails).

The irradiations of the accredited irradiating laboratory of KIT were carried out without any problems (1 irradiation was repeated) providing reliable reference dose values. The calculation of the dosemeter response by subtracting an average background dose value determined by the mean of 6 not-irradiated dosemeters worked well for most dosimetry systems. It must be noted that some dosimetry systems showed background values significantly higher than the reference dose values of the extra irradiations. The highest background dose was 1617 µSv. Nevertheless, the recommended ISO 14146 response criteria were met by 93 % of all irradiated dosemeters.

## 7.3 ISO 14146 response limits

53 dosimetry systems passed the recommended ISO 14146 response criterion with the 6 irradiated dosemeters. 5 dosimetry systems had 1 fail, i.e. 1 response value outside the recommended limits. 2 dosimetry systems had 2 fails and 3 dosimetry systems 5 or 6 fails. A problem in the calibration (or fading) seems obvious only for a few participants. Another problem may be attributed to the moisture during the outside measurement period. Some participants did not provide dosemeters with appropriate attachment for a hanging position. These dosemeters were put in plastic bags. This issue can be improved for a future intercomparison. All in all, it can be concluded that this intercomparison with 66 participating passive area dosimetry systems was quite a success despite the challenge of the low dose irradiations.

# 8 References

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