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Revision of ISO 15382: Procedures for monitoring the dose to the lens of the eye, the skin and the extremities

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ISO standards

- Technical committee 85: *Nuclear energy, nuclear technologies, and radiological protection*

- Sub Committee 2: *Radiological protection*:
  - Lead by Alain Rannou (IRSN)
  - 82 standards
  - 26 participating countries

- Working Group19: *Individual monitoring of external radiation*
  - Lead by François Queinnec (IRSN)

History/status

- The old version of the ISO standard 15382 (2002)
  - *"Procedure for radiation protection monitoring in nuclear installations for external exposure to weakly penetrating radiation, especially to beta radiation"*
  - Mainly treats issues on beta radiation for nuclear power plant workers

- In 2011: revision started
- ISO 15382: circulated twice as DIS (draft international standard)
  - Voting was positive
  - Comments from member states received and answered

Final version published in December 2015

General objectives

- The main objective of the revision of the 15382 standard:
  - to take into account the new situation due to the evolution of the ICRP recommendation for eye lens doses
  - to capitalize on the results of the recent works like ORAMED
  - Focus also on medical exposures

⇒ New title : "*Procedures for monitoring the dose to the lens of the eye, the skin and the extremities*"

- It covers practices which involve a risk of exposure to photons in the range of 8 keV to 10 MeV and electrons and positrons in the range of 60 keV to 10 MeV.
- Does not cover exposure to alphas and neutrons

General objectives

- The questions on which the new standard gives guidance are:
  - How to determine the need to use dosemeters ?
  - How to ensure that individual monitoring is appropriate to the nature of the exposure ?
  - How to design a monitoring program which ensure compliance with legal individual dose limits ?
  - How to choose the type of dosemeters ?
  - How to choose positioning of the dosemeters ?
  - How to use correction factors ?

ISO 15382: content

Quantities: how to measure the extremity doses?

- Skin and extremity monitoring:
  - measurement of $H_p(0,07)$, the equivalent dose to the skin

- The ICRP recommended dose limits :
  - an equivalent dose limit to the extremities (hands and feet) or the skin of 500 mSv in a year.

The equivalent dose limits for the skin apply to the average dose over 1 cm^2 of the most highly irradiated area of the skin.

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Monitoring levels and periods

- The following monitoring levels are recommended:
  - 3/10th of the limit, as recommended in European BSS
- for the extremities or the skin, this means monitoring should be undertaken if there is a reasonable probability to receive a dose greater than 150 mSv per year;
- For dose levels expected to be lower than the recommended monitoring levels, a survey, demonstrating that the levels are not exceeded, should be sufficient.
- For doses above the monitoring level, a monitoring period of one month is recommended

When monitoring?

- in situations with nonhomogeneous exposure conditions for which the whole-body monitoring does not provide an adequate estimate of the dose to the skin or the extremities

- Exposures can be significant when weakly penetrating radiation such as low energy photons or beta radiation is present.

- Workplaces where extremities are particularly close to the radiation emitter or radiation beam
    - E.g. nuclear medicine, and dismantling applications.

Characterisation of radiation fields

- Characterization of the radiation fields is important to determine the need for and the type of monitoring required.
  - Photon fields (X and gamma radiation) of any energy can contribute to the skin and extremity exposure.
  - Electrons (beta radiation) with energy above 60 keV penetrate 0,07 mm of tissue
- In medical fields, the type of radiation and radionuclides are very well known.
- In nuclear installations, low energy betas are to be expected in the vicinity of unsealed radioactive materials. In nuclear installations handling used fuel as well as in nuclear reactors experiencing fuel leakage high energy betas (above 700 keV) should be expected.

- Information about the energy of beta radiation is obtained from the radionuclide composition, spectrometry or the attenuation of the radiation.

Assessment of dose levels prior to monitoring

- Prior to routine monitoring, it is important to assess the dose levels in a workplace field situation in order to decide which method and period of routine monitoring is necessary.
- The doses obtained should be extrapolated to annual doses and compared with the monitoring levels
- The assessment should be repeated when the working conditions or workload change significantly, or if the effect of such changes cannot be estimated with confidence.

1. Indications of workplace monitoring

- In work situations with radiation fields that are predictable over a long period: possible to estimate the worker doses using workplace measurements at relevant locations.

- For determining the directional dose-equivalent rate H'(0,07)/t, suitable dose-equivalent rate meters (i.e., with thin walls and small detector thickness) shall be used. If protective clothing is worn, H'(0,07) shall be measured behind the respective layer of clothing.

- The measurement position shall be representative of the exposure conditions of the person surveyed.

- If tools are used, measurements shall be performed at the distance appropriate for the use of such tools.

2. Indications of whole body monitoring

- When individual monitoring is performed, a dosemeter worn on the trunk is used for the estimation of effective dose. The results from the whole body dosemeter can give an indication of the level of exposure to the extremities or the skin, provided the exposure conditions and the radiation field characteristics (especially the spatial distribution) are taken into account.

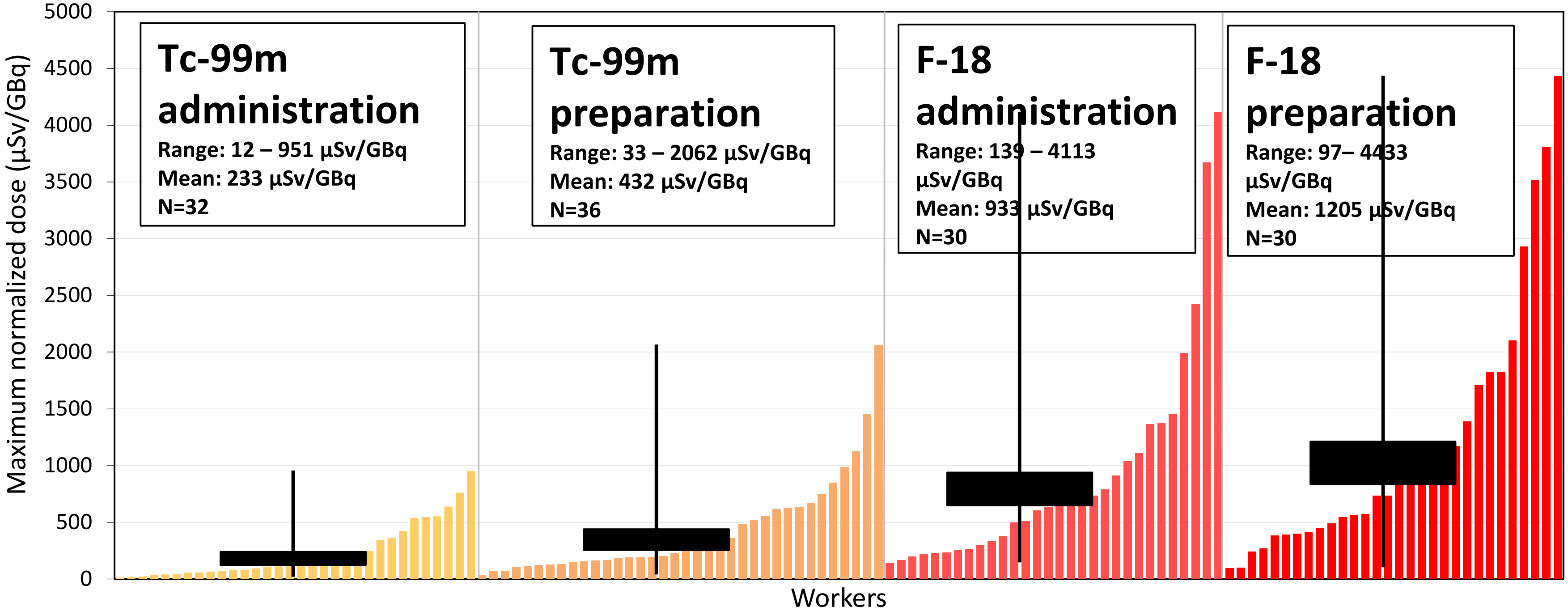
- When the whole body dosemeter is worn under the protective clothing, its reading strongly underestimates the dose to the unprotected extremities and can therefore not be used to provide an indication of the level of these doses.

3. Indications of literature

- In the literature, some typical dose values are given for various workplace situations.

- When using literature it should be ensured that the data are truly representative of the current workplace conditions regarding the radiation source, the geometry and types of protective measures

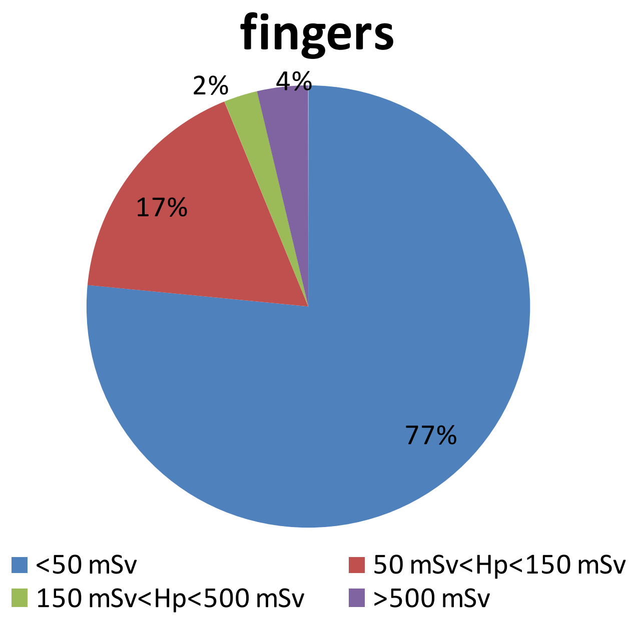
ORAMED: Overview on finger doses in diagnostic NM



- Very large range of maximum finger doses among the same procedure.

ORAMED: Radiological risks: Hands

Frequency distribution of how many times the annual dose for workers exceed a certain dose level



> 500 mSv: exceeding the annual limit

> 150 mSv: exceeding 3/10th of the limit

> 50 mSv: exceeding 1/10th of the limit

< 50 mSv: low doses

4. Indications from simulations

- Numerical simulations can be very powerful and can provide important information on the parameters affecting and influencing the doses

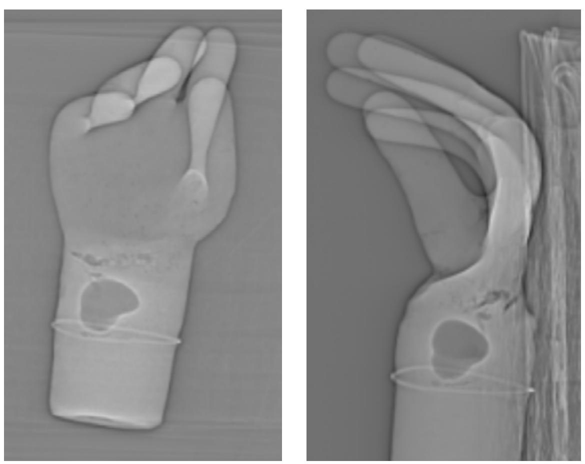
- Simulations are often complex and time consuming

From real to numerical world

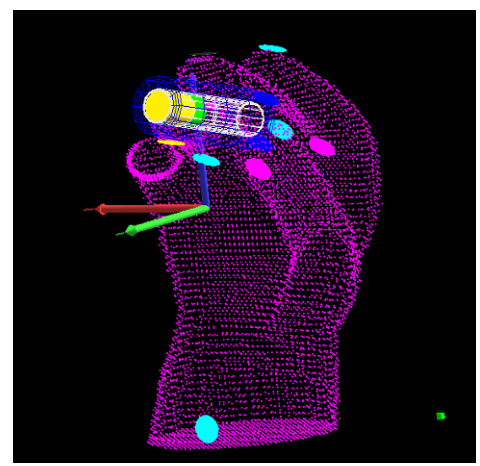
1. Defining the case

2. Creating a moulding

3. Scanning the moulding



4. Generating a voxel phantom



5. Adding the source and dosemeters

5. Indications from confirmatory measurements

- Measurements to assess the level of doses to the workers in the specific workplace field.

- Confirmatory measurements can be used as guidance in determining whether the monitoring level might be reached.

- Shall fulfil the following requirements:
  - the confirmatory measurements shall mimic routine measurements:
  - the working procedures shall not be changed because of the confirmatory measurements
  - the confirmatory measurements shall be performed for a minimum of 3 consecutive periods. The intention is to have a representative sample of the annual doses.

Locations for monitoring

- The skin of the extremities is the limiting organ rather than the extremity itself. An estimate of the equivalent dose to the skin, Hskin, is normally a conservative estimate of the equivalent dose to the extremities. Therefore, an extremity dosemeter becomes a skin dosemeter and shall be placed as close as possible to the most exposed part of the skin surface.

- In non-uniform fields, it is often difficult to place one single extremity dosemeter at the most highly exposed part of the skin since this part is not known a priori.

- In addition, it is not always the hands or fingers that are the most exposed area, also legs or feet can be the most exposed area.

Locations for monitoring

- For direct or close handling of radioactive sources, finger-stall dosemeters on the fingertip, or ring dosemeters should be used on the finger which is frequently the most exposed.

- The dosemeter should be oriented towards the radiation source.

- For nuclear industry fields, interventional radiology, or other similar radiation fields, either a ring dosemeter or a wrist dosemeter worn at the most exposed hand shall be used. It can be necessary to monitor the doses at different locations using several dosemeters simultaneously

- The dosemeter shall be worn under protective clothing, especially inside gloves, if such clothing is worn.

- The dosemeter can also be worn outside the protective clothing, but under an appropriate thickness of material that approximates the type and thickness of the protective clothing.

Uncertainties

- In the evaluation of the uncertainty, all knowledge of the dosemeter and evaluating system should be used, possibly in combination with information from the client/customer

- The amount of effort put into the uncertainty should be realistic in view of its purpose in radiation protection.

- The expanded uncertainty (95 % coverage probability) for values of assessed annual dose values at or near the dose limit should not exceed 0,67 to 1,5 (factor 1,5) after all corrections have been made. This applies also to the equivalent dose to a small area of skin,

Application of correction factors

- Common extremity monitoring positions, such as the base of the fingers or the wrist, often underestimate the maximum dose.
  - To estimate the maximum skin dose from a routine dosemeter, a correction factor shall be established and employed.
- This value could be determined independently for each worker by individual measurements for a short trial period.
- If for practical reasons, these measurements are not possible, existing correction factors can be employed considering the routine monitoring position.
  - For nuclear medicine, ICRP Publication 106 recommends placing the routine dosemeter on the base of the middle finger with the detector positioned on the palm side. In this case, a correction factor of 3 (6 if the dosemeter faces the back) can be applied to get the value at the tip of the finger.
  - ORAMED recommend a mean factor of 6 between the location of the maximum dose and the measured value at the base of the index finger of the nondominant hand.

Types of dosemeters

- The dosemeters used for extremity monitoring are generally based on passive techniques and made of thermoluminescent (TL) materials
  - other methods, such as film badges, optically-stimulated luminescence (OSL) and radiophoto luminescence (RPL) can also be used.
- Many whole body dosemeters are also capable of measuring skin doses through Hp(0,07). In principle these dosemeters can also be used to measure the skin dose on different parts of the body.
- Electronic devices, e.g. made of small silicon probe(s) wire-connected with a command and reading box are available. These systems offer the advantage of a direct reading of the dose, useful for training and optimization purposes.

- The technical specifications for extremity dosimetry systems measuring the quantity Hp(0,07) shall be as defined in **IEC 62387** for passive dosemeters and **IEC 61526** for active dosemeters.

Interpretation and management of the results

- Analyses of results:
  - The dose results from monitoring of the skin, the extremities, and the lens of the eye shall be treated in a similar way as the dose results from the whole body monitoring.
    - The results shall be evaluated after each monitoring period.
    - In the framework of optimization, dose constraints and reference levels shall be established per monitoring period.
- Optimization
  - The application of the ALARA principle is important.

Contamination: general

- The monitoring requirements given in the previous part are not applicable in the case of contamination, or where the air is contaminated.

- Additionally, corrections of the measured dose might need to be made if a dosemeter is contaminated.

- The best way to limit cross-contamination is to frequently measure contamination during and after a manipulation by means of a contamination monitor.

- In cases of skin contamination with radioactive substances, immediate and rapid decontamination measures are of higher priority than an exact evaluation of skin activity and dose.

Estimation of the dose to the skin from contamination

- A skin contamination in the working environment is unlikely to be recorded by a personal dosemeter but can be detected by the routine use of contamination monitors.
- To evaluate the contribution of the contamination an on-site investigation shall be performed to localize and identify the contamination and then quantify its activity.
- The dose rates per unit of activity over 1 cm2 can be calculated by several methods: a calculation with the deterministic code like VARSKIN and a Monte Carlo simulation code of radiation transport

Estimation of dose to the skin from contamination on protective clothing

- The contamination on protective clothing (e.g. gloves) irradiates the skin and contributes to the skin dose. Its contribution to the skin dose should be quantified.
- After quantification, if its value is higher than the dosemeter reading, it shall be registered as the skin dose value
- When the contamination is homogenous across the protective clothing or located directly at the dosemeter position, the dosemeter reading already takes into account the contribution.

Estimation of dose from exposure to radioactivity in the air

- Radionuclides in the air in the working environment lead to exposure of the personnel. This leads to exposure of the skin
- The directional dose-equivalent rate, H'(0,07) caused by radioactive contamination in room air is to be calculated, if necessary, from the radionuclide composition and "concentration" or should be determined by a measurement

- Dosemeters measuring Hp(0,07) provide in most cases the requested dose value.

Need to correct estimated doses due to contamination of dosemeters

- If an individual dosemeter is contaminated, the dosemeter reading is larger than the true dose to the respective individual.
- If the time the dosemeter has been contaminated, the activity and position of the contamination is known, this excessive reading of the dosemeter can be determined.

Conclusion

- ISO 15382: updated to include medical exposures, both for skin and extremity dosimetry, and for eye lens dosimetry:
  - Quantities to be used
  - How to decide on monitoring period, levels,…
  - How to decide on correction factors
  - How to design monitoring program