Revision of the ISO 15382 : Answers to the challenges of monitoring the dose to the lens of the eye

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Context

- New scientific data about risks from lens of the eye exposure to ionising radiations

- In April 21, 2011, ICRP has reviewed its recommendation about the equivalent dose limit for the lens of the eye from 150 msv/year to **20 mSv/year** *[ICRP, 2012. ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs - Threshold Doses for Tissue Reactions in a Radiation Protection Context. ICRP 118. Ann. ICRP 41(1/2).]*

- Revision of the international and European BSS

- Transposition of the new limits of dose into national law

=> Very challenging in term of radiation protection but also in term of specific dosimetry which becomes necessary and need to be done with more accuracy for more situations than in the past.

When is there specific risk for the lens of the eye ?

Situations that could lead to an important exposure to the lens compared to the rest of the body :

- the worker wears a IPE at the level of the body,
- the **geometry** of the workplace leads **to expose more the head than other parts of the body**,
- The worker is directly esposed to **weakly penetrating radiation** (β emitter of max energy > 700 keV or photons of low energy).

MEDICAL sector

- Interventional radiology
- Nuclear medecine, research

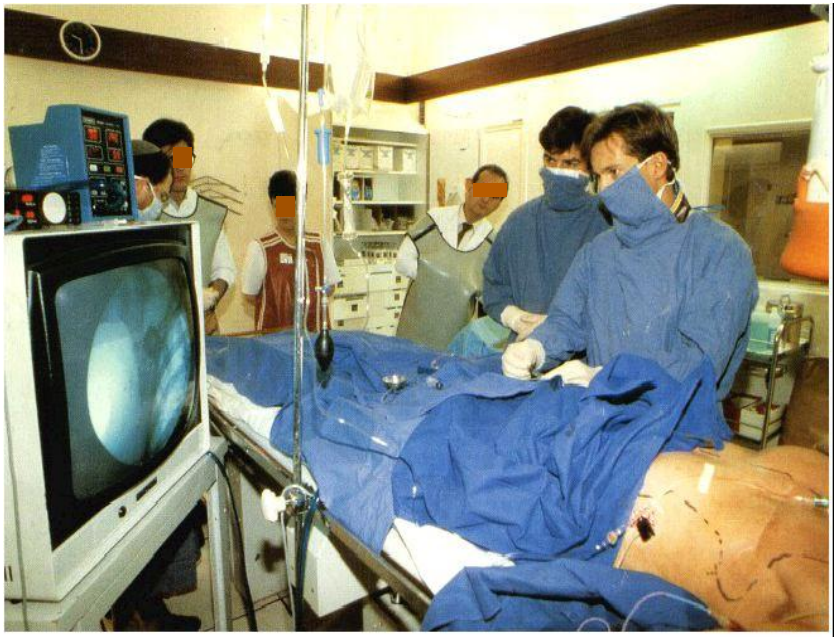
INDUSTRIAL sector

- Operations using gloves boxes, dismantling, control, maintenance of contaminated equipments …

Ref : IAEA TECDOC 1731 (2013) : "Implications for Occupational Radiation Protection of the New Dose Limit for the Lens of the Eye"

When is there specific risk for the lens of the eye ?

Interventional Radiology



crédit photo http://www.utc.fr

Dose to the lens of the eye in interventional radiology:

- Between a few µSv and a few hundred of µSv by procedure (without lead glass)
- With extrapolation: **> 20 mSv/year possible** in a lot of cases

When is there specific risk for the lens of the eye ?

Curitherapy, nuclear medecine, research

CURIETHERAPY

- abandonment of Iridium 92 fil
- permanent implants of Iodure 125 : **dose to the lens of the eye 10-20 µSv/implantation**

MEDECINE NUCLEAIRE ET RECHERCHE MEDICALE

- radionuclides : photons of a few 10 keV (^{125}I) to a few 100 keV (^{11}C, ^{18}F, ^{131}I), bêta (^{90}Y – Emax 2,28 MeV)
- dosimetrical studies : **dose to the lens of the eye can be > 20 mSv/year**
- contamination accident (projection)

When is there specific risk for the lens of the eye ?

Industrial activity

- In **glove boxes** (particularly when face is in front of the glove holes whithout biological protection),
- **Demantling** (inventory activities, reconditioning, triage and cutting),
- **control** (visual quality control of fuel pells, of fuel assembly, etc.)
- **maintenance of contaminated equipements** in normal work

+ accidental situations : liquides or aerosol spill of

Several studies (AREVA, EDF) show an exposure of the lens of the eye for some tasks.

Need **to practice workplace studies**

References documents for Monitoring dose to the lens of the eye

Type tests characterization of individual dosemeters :

- IEC 62387, Radiation protection instrumentation — Passive integrating dosimetry systems for personal and environmental monitoring of photon and beta radiation, (2012).

- IEC 61526, Radiation protection instrumentation — Measurement of personal dose equivalents Hp(10) and Hp(0,07) for X, gamma, neutron and beta radiations — Direct reading personal dose equivalent meters (2010)

References documents for Monitoring dose to the lens of the eye

- IEC 60846-1, Radiation protection instrumentation — Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation — Part 1: Portable workplace and environmental meters and monitors, (2009)

- IAEA TECDOC 1731 (2013) : “Implications for Occupational Radiation Protection of the New Dose Limit for the Lens of the Eye”

⇒parts of the revision of the ISO 15382 standard were adopted from this document.

The ISO/15382 standard

General objectives and content

- **The present version of the ISO standard 15382:2002** "Nuclear energy — Radioprotection — ***Procedure for radiation protection monitoring in nuclear installations for external exposure to weakly penetrating radiation, especially to beta radiation***" was issued in April 2002.

- It treats of the question of lens of the eye monitoring. But with the dose limits recommended at that time by ICRP, it is considered in the standard that: "**For beta radiation with maximum energies $E_{\beta,max}$ < 3,5 MeV (ICRU 43) and for photons with energies E_{ph} < 10 keV**, the ratio of dose equivalent on the skin surface to that at 3 mm depth is greater than 3,3, i.e. greater than the ratio of the annual limits recommended by ICRP for skin and the lens of the eyes. In these cases, **the dose on the skin determines the limit**. A partial-body dose determination for the lens of the eyes is therefore **not required for the radiation specified above if the skin dose near the eyes** does not exceed the dose limit".

The ISO/15382 standard

Project leader of the revision:
Filip Vanhavere (SCK-CEN)

Agenda: **new version should be available before the end of 2015**

General objectives and content

- The **main objective of the revision of the 15382** standard, which considers all type of exposure except those due to alpha and neutron is :
  - to **take into account the new situation** largely due to the evolution of the ICRP recommendation
  - to **capitalize on the results of the recent works** like ORAMED
  - to **take into account the last standard references** to be followed for type test characterization of the dosemeters

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

- It will cover 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.

The ISO/15382 standard

General objectives and content

The questions on which the new standard will give 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, when it is needed, determine correction factors ?

The ISO/15382 standard

General objectives and content

1	Scope
2	Normative references
3	Terms and definitions
4	**Individual monitoring**
4.1	Quantities
4.2	Dose limits and monitoring levels
4.3	Monitoring period
4.4	Extremity, skin and lens of the eye monitoring
4.5	Uncertainties
4.6	Characteristics of radiation fields
5	**Assessment of dose levels prior to routine monitoring**
5.1	Introduction
5.2	Indications from workplace measurements
5.3	Indications from whole body dosimetry
5.4	Indications from literature data
5.5	Indications from simulations
5.6	Indications from confirmatory measurements
6	**Personal dosimetry**
6.1	Extremity and skin dosimetry
6.2	Monitoring of the lens of the eye

7	**Interpretation and management of the results**
7.1	Analyses of results
7.2	Optimization
7.3	Registration and documentation
8	Special cases
8.1	Contamination
8.2	Estimation of dose from exposure to radioactivity in the air
8.3	Need to correct estimated doses due to contamination of dosemeters
Annex A (normative)	Technical specifications of dosemeters
Annex B (informative)	**Practice to monitor the dose to the lens of the eye**
Annex C (informative)	Special considerations in nuclear power plants
C.1	Effect of protective clothing
C.2	Skin dose calculation
Annex D (informative)	Special considerations in the medical sector
D.1	References for occupational exposures in interventional procedures
D.2	References for skin and extremity exposures in nuclear medicine departments
Bibliography	

The ISO/15382 standard

Dosimetry of the lens of the eyes / Location of the dosemeter :

- The dosemeter for the lens of the eye **shall be worn as close as possible to the eye**, if possible in contact with the skin, and facing towards the radiation source. In case of usage in interventional radiology, the side closest to the X-ray tube shall be chosen.

Dosimètre EYE-D™ (Radcard)
Développé dans le cadre du
projet ORAMED

The ISO/15382 standard

Dosimetry of the lens of the eyes / Location of the dosemeter :

- **When using protective lead glasses or face masks, the dosemeter shall be worn preferably behind them**. This is often not very practical, and a dosemeter on the outside or next to the lead glasses can be chosen. In this case, some correction factors should be applied.

- It can also be **an option to cover the front of the dosemeter with a filter that mimics the attenuation by the lead glasses**. It shall be realised that some types of lead glasses do not offer adequate protection for oblique angles. In those cases, covering the dosemeter with a filter **can lead to underestimation**, and this method is not recommended."

The ISO/15382 standard

Dosimetry of the lens of the eyes / Location of the dosemeter :

http://www.hpa.org.uk

- In practical situations, eye lens dosemeters are often placed in various positions: above the eyes, at the forehead, at the side of the head, between the eyes
- Some studies suggest **estimating the dose to the lens of the eye from a well-placed dosemeter at collar level or from the reading of the whole body dosemeter**.
- Although this **might be acceptable in homogenous fields with higher energy radiation**, this is in general not recommended in other fields.
- **For example, for interventional radiology** different correction factors have been published to convert collar doses (above the lead apron) to doses to the lens of the eye for interventional procedures. Such **correction factors are very dependent on the type of procedure, personal habits, the exact place of the above apron dosemeters and the protection measures taken**, so they cannot be applied to all routine cases.

http://www.lps-berlin.de/personendosismessstelle/teilkoerperdosimetrie/augendosimeter.html

The ISO/15382 standard

Dosimetry of the lens of the eyes / Types of dosemeters:

- Doses to the lens of the eye shall be estimated by measuring the operational quantity $H_p(3)$.
- Dosemeters designed to measure $H_p(3)$ were very rare in the past, but recently specifically designed $H_p(3)$ dosemeters became available on the market.
- If the radiation field is well known in advance, $H_p(3)$ monitoring can be performed by the use of dosemeters type tested and calibrated in terms of other quantities, i.e., $H_p(0,07)$ and $H_p(10)$ as, in many cases, they can provide an adequate estimate of the dose to the lens of the eye (depending on the radiation field).

Exemples of avalable dosemeters

AV-Controlatom Belgium

IRSN France

EYE-D™ (Radcard)

DOZIMED S.R.L. Roumania

The ISO/15382 standard

Dosimetry of the lens of the eyes / Types of dosemeters:

- The dosemeters used for monitoring the lens of the eye are **generally based on passive techniques** : mainly thermoluminescent (TL) materials, although, detectors based on other methods, such as film badges, optically-stimulated luminescence (OSL) and radiophoto luminescence (RPL) can also be used.

- **Electronic devices, e.g. made of small silicon probe(s)** can also be used

=> interesting for training and optimization purposes but suitability in pulsed radiation fields shall be confirmed (Performance requirements for the measurement in pulsed radiation fields, adopted from IAEA TECDOC 1731 (2013) will be provided in Annex of the standard).

The ISO/15382 standard

Dosimetry of the lens of the eyes / Technical specifications:

- The technical specifications for dosimetry systems for the lens of the eye measuring the quantity $H_p(3)$ are **defined in IEC 62387 for passive dosemeters.**

- Reference dosimetric quantity to estimate the equivalent dose to the lens of the eye is **$H_p(3)$ but not yet avalaible in an ICRU reference** => **ICRU** should publish early reference conversion **coefficients** for calibration of individual dosemeters in $H_p(3)$ for electrons, photons and neutrons.

- IEC 62387 **gives conversion coefficients** for calibration of individual dosemeters in $H_p(3)$ for electrons, photons to use as long as not available in ICRU reference.

- **For active dosemeters, currently no International Standard is available for the quantity $H_p(3)$** but IEC 61526 can be applied accordingly by adopting the radiological requirement from IEC 62387.

The ISO/15382 standard

Dosimetry of the lens of the eyes / Application of correction factors:

- **If the dosemeter for the lens of the eye is not worn optimally** (not close to the lens of the eye or behind shielding like e.g., lead glasses), then **appropriate correction factors shall be applied**. These factors shall normally be **determined by means of measurements**, possibly accompanied by numerical simulations.

- **For interventional clinicians**, a correction factor for eye dose should only be applied if the clinician is conscientious in wearing protective eyewear. **Correction factors to be used when the dosemeter is not worn under the protective shielding** determined through local assessment **should be conservative** and are likely to be in the range of 0,2 to 0,3. **If no facility or expertise is available** to assess protection, then **a correction factor of 0,5 may be applied**, provided the lenses contain the equivalent of 0,5 mm of lead and the frames include protection.

The ISO/15382 standard

Analyze of the results / Optimization

- 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. The measurement results should initiate follow up actions when needed. The annual results should be compared to the legal dose limits.
- The application of the ALARA principle is important, also for doses to the skin, the extremities and the lens of the eye. The radiation protection measures shall be optimized to limit these doses.

Avaibility of dosemeters : things are moving

EURADOS intercomparison exercise of eye lens dosemeters for medical applications

Main objective: check the performance of eye lens dosemeters used **in routine in the medical field.**

20 participants – 15 countries
(Austria, Belgium, Czech Republic, France, Greece, Italy, Lithuania, Poland, Roumania, Serbia, Slovakia, Spain, Switzerland, UK, Ukraine)

4 irradiation labs:
SCK-CEN (Belgium), UPC (Spain), CEA (France) and IRSN (France)

- **Irradiations** performed – July and August 2015
- **Reporting of the results by participants** – November 2015
- **Analysis** of the results – in progress
- **Individual results** sent to participants – January 2015
- **Final report** – April 2015 (IM2015 comm.)