IRSN
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Risk of radiation exposure of the lens of the eye for members of the public
Bibliography study

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Objectives of this literature review

New dose limit recommended by ICRP for the lens of the eye for occupational exposure : \ to 20 mSv per year [1]
No explicit recommendation regarding the dose limit for the public

➡ **Are there potential situations where public exposure can lead to equivalent doses to the lens of the eye exceeding 1mSv per year?**

Methodology

Three steps :
1/ Exhaustive list of consumer goods containing radioactive substances [2] [3]
2/ Focus on goods that may lead to significant eye lens exposure
3/ IRSN calculations of dose to the lens of the eye using when necessary MCNPX code [5]

- Scenarii chosen in order to reflect daily life situations
- Calculations made with the spare quantitative information from the literature review

Situations for workers and patients are not considered in the scope of this study

Weapon sights

Tritium used to illuminate the aiming triangle in the night

Not widely spread, concerns only specialists
Radionuclides: tritium (up to 10 GBq)

Photographic films

Old photographic prints, developed using uranium nitrate

Exotic situation
Radionuclides: uranium

TV receivers and PC monitors

Television receivers or PC monitors with cathode-ray tubes

Essentially television manufactured before 1970
X-rays (up to 5.3 $\mu Sv.h^{-1}$ averaged over 10 cm^2 at any readily accessible point 5 cm from the surface)

➡ No risk of significant radiation exposure to the eye lens

Timepieces

Radioluminous paint added to timepieces

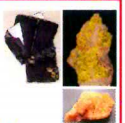
Not widely spread, concerns only amateur repairing timepieces

Radionuclides: radium-226 (170 kBq maximum), tritium or promethium-147

- 0.25 mSv per year
- Not significant

➡ Limited or even insignificant radiation exposure to the eye lens

Naturally radioactive minerals



Concerns only amateur collecting radioactive minerals

Radionuclides: uranium, thorium, ^{40}K, radium-226

- ~ 0.85 mSv per year
- 0.01 µSv per year
- For photon radiations only : ~2.3 mSv per year (if 1 ppm of ^{226}Ra) Complete calculation in progress

➡ Significant exposure for some minerals, but very rare situations

Dental products

Dental ceramics with added uranium

Before the 1980's, natural or depleted uranium was added in dental porcelains for aesthetic purpose (fluorescent properties)

Only few people may be concerned

Radionuclides: uranium (≤ 10 $kBq.g^{-1}$) , ^{40}K

Dose to the eye lens induced by γ radiations only ≤ 0.1 mSv

New dental ceramics

Nowadays, only natural presence of potassium-40, rubidium-87, and uranium and thorium (as impurities)

Radionuclides: uranium, thorium, ^{40}K, ^{47}Ru

- Amounts of several orders of magnitude below former dental ceramics
- Activities similar to the former dental ceramics
- Beta emitter at low energy

➡ No risk of significant radiation exposure to the eye lens

Gemstones

Two scenarii of exposure: gemstones in a piercing (0.02 carat, 3 cm from the eye) or in earrings (2x10 carat, 7 cm from the eye)

Naturally radioactive gemstones

Uranium, thorium and potassium-40 may be naturally present in some gemstones as zircon (widely used) or eukanite, thorianite,...

- Zircon: ≤ 7 µSv per year ➡ Dose to the eye lens is not significant
- Other gemstones: up to 31 mSv per year (143 kBq of natural thorium in thorianite) ➡ Exotic situations

Irradiated gemstones

Some gemstones are irradiated to modify their colour
Most commonly irradiated gemstones : topaz
also: tourmaline, zircon, beryl, quartz, diamonds...

Many activated elements due to the irradiation
^{46}Sc, ^{54}Mn, ^{134}Cs, ... and thorium (as impurities)

- US release limits for each radionuclides ➡ Dose is not significant
- Concentrations at higher activity ➡ Very rare situations

Lenses

Thorium occurs naturally in rare earths and zirconium oxides used to process the glass, or thorium is intentionally added to improve optical properties. It can also be used in surface coating.

Lenses in eyeglasses

500 kBq of natural thorium
Eyeglasses worn 16 hours per day, all the year

Dose rate: 0.3 $mSv.h^{-1}$
1 mSv/year is reached for activity ~ 0.3 kBq

➡ Significant dose rate but the activity of thorium considered could not be confirmed

Lenses in cameras

500 kBq of natural thorium
Viewfinder of a camera, used 1 h per week, all the year

Dose rate: 2.8 $\mu Sv.h^{-1}$
1 mSv/year is reached for activity ~7 kBq

➡ Very rare situations

Conclusion

No current situation was identified where member of the public might receive significant radiation dose to the lens of the eye.

The very few existing situations where the dose to the lens of the eye could reach 1 mSv/year are exotic ones:
- One significant exposure comes from ophthalmic lenses with 500 kBq of thorium. But this activity mentioned in the literature could not be confirmed and no information about the use of those items nor their quantity on the marketplace were available.
- The second situation comes from radioactive minerals that could be owned by mineral collectors, and especially radiobarites. The highest concentration of radium-226 found in the bibliography could not be confirmed, and the only other values of concentrations found in the literature review are several orders of magnitude lower. In that case, there is no significant exposure to the lens of the eye any more.

REFERENCES
[1] International Commission on Radiological Protection, Statement on Tissue Reactions, approved by the Commission on April 21, 2011
[2] J. Shaw, J. Dunderdale and R. A. Paynter, RADIATION PROTECTION 146, A Review of Consumer Products Containing Radioactive Substances in the European Union, NRPB Occupational Services Department, 2007
[3] National Council on Radiation Protection, Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources, NCRP Report No. 95, 1987
[4] M.-A. Chevallier, A. Rannou, I. Clairand, C. Villagrasa, Risk of radiation exposure of the lens of the eye for members of the public, bibliography study, IRSN report, PRP-HOM/SDE n°2012-00061
[5] J.S. Hendricks et al, MCNPX 2.6.0 Extensions, LA-UR-08-2216, April 2005