



Lens of Eye Radiation Dose Limit: Possible Changes and Effects on Nuclear Power Plant Dosimetry and Protection Programs

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Discussion Outline

- Introduction and EPRI Project Goal
- ICRP reasoning for reduced lens dose limit recommendation
- European experience with reduced lens dose limit
- NRC position/statements on lens of eye dose limit changes
- Industry Survey
- Preliminary list of issues for utilities to consider

Introduction

Introduction:

- ICRP has recommended an equivalent dose limit for the lens of the eye be 20 mSv (2 rem) per year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv (5 rem).
- The current 10 CFR 20 limit for the lens of the eye is 150 mSv (15 rem) per year.
- The NRC is evaluating changes to 10 CFR 20, and it is considering the reduced dose limit for the lens.
- Late in 2012, received Emergent Issues Funding to initiate an EPRI project to investigate industry impacts.

Project Goals

Project Goal:

- Develop a list of issues that utilities will need to consider if lower lens dose limits are adopted, including lens of the eye monitoring and protection.
- Identify R&D gaps and technological needs

Project Team:

- EPRI Project Manager: Phung Tran
- Principal Investigators:
 - Dennis Quinn, MS, CHP
 - Larry Dauer, PhD, CHP

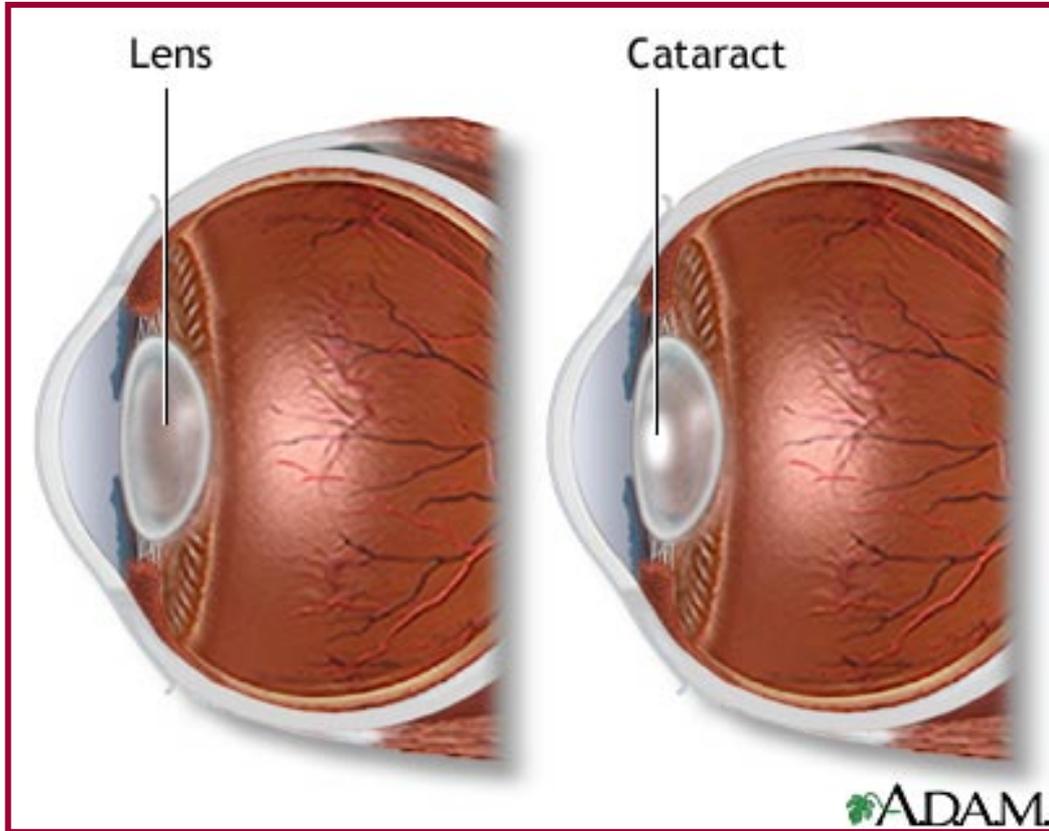
ICRP Reasoning for Reduced Lens Dose Limit

- ICRP Publication 118, *ICRP Statement on Tissue Reactions and Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context*
 - Statement on **Tissue Reactions** issued April 21, 2011:
 - Threshold for Lens of Eye effects (cataracts and opacities) now considered to be nominally 0.5 gray (50 rad).
 - Occupational exposure for lens of eye recommended to be 20 mSv/yr, averaged over 5 years; no single year > 50 mSv.
 - Other information concerning circulatory disease (0.5 gray threshold for dose to heart or brain).

ICRP Concerned with 'Detriment' (per ICRP-103)

- Primary ICRP aim is to contribute an appropriate level of protection against the detrimental effects of radiation exposure without unduly limiting desirable human actions associated with such exposure
- Detriment – total harm to health as a result of exposure to a radiation source.
- **Tissue reactions**
 - Detriment arising from non-cancer effects of radiation on health
 - Previously called 'deterministic effects'
 - Now called 'tissue reactions' because some effects are not determined solely at the time of irradiation but can be modified after radiation exposure.

Cataracts



Risk Factors:

- Corticosteroids
- Diabetes Mellitus
- Sunlight (UVB)
- Trauma
- Infections
- Nutritional deprivation
- Age (~ 50% >65 yrs)
- Heredity
- Smoking
- Radiation

Lens showing Post Subcapsular Cataract

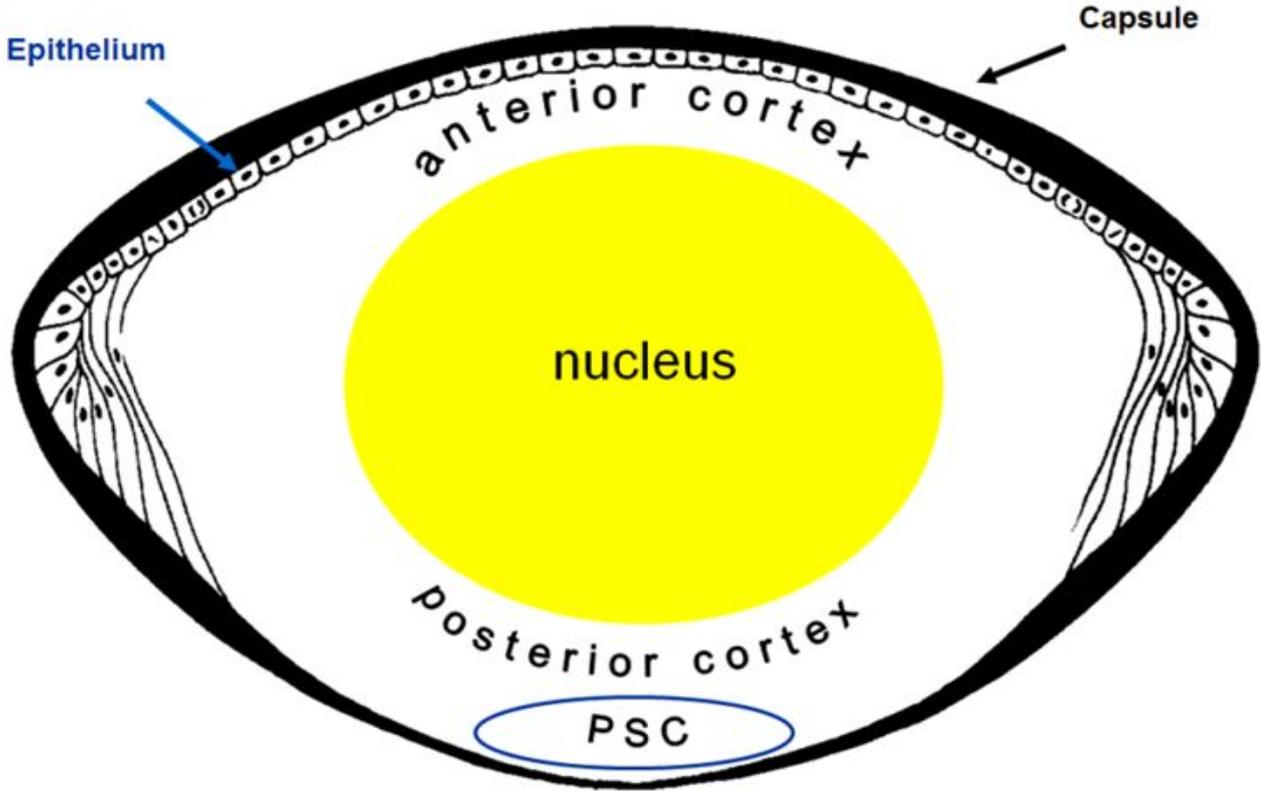


Image courtesy of IAEA

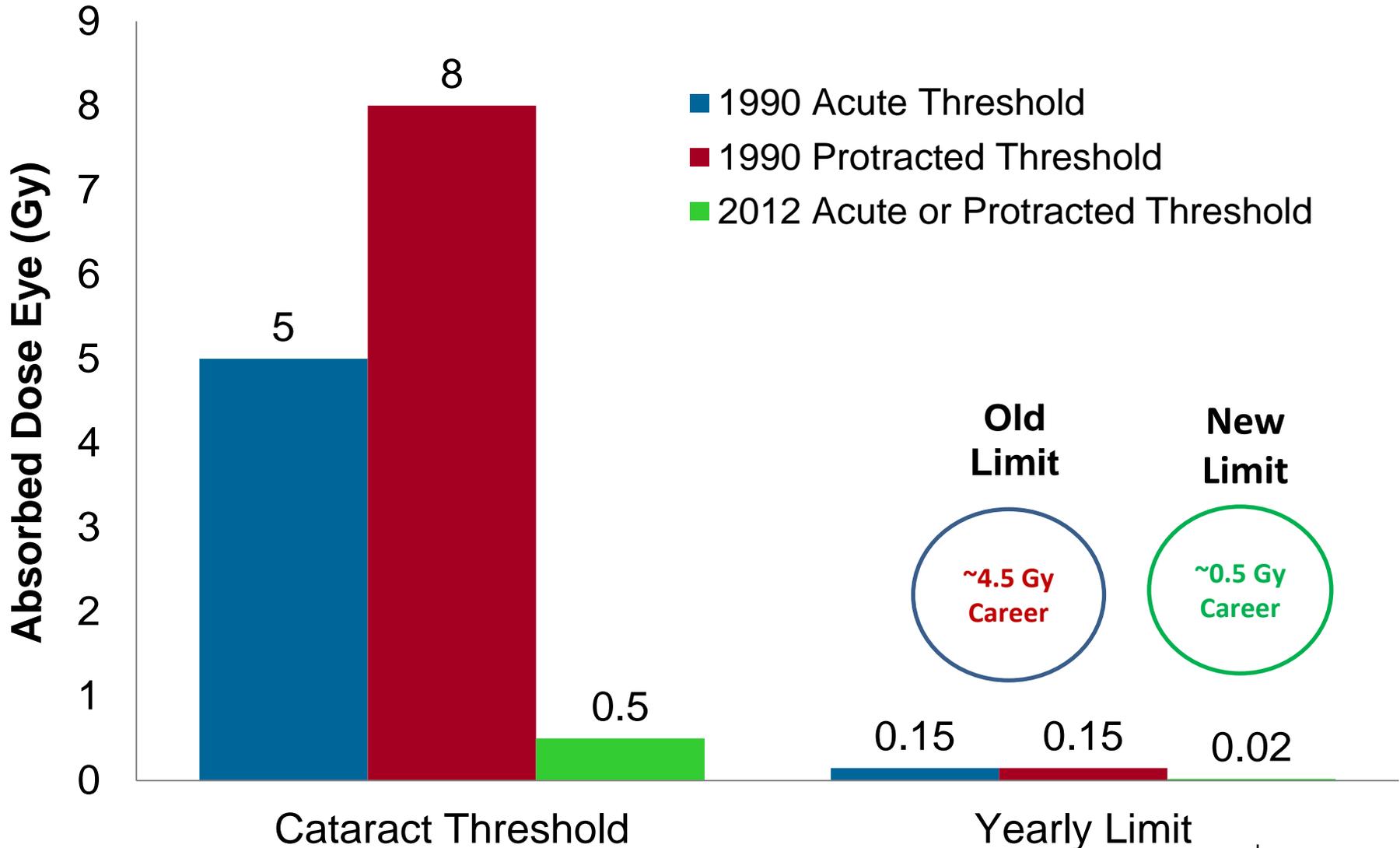
ICRP-118 – Recent Cataract Formation Studies

Table 4.3. Recent epidemiological studies of cataract formation where formal estimates of threshold doses were made.

Study	Cataract type	Threshold dose	Confidence intervals	Reference
Atomic bomb survivors (acute exposure)	Cortical cataract	0.6 Sv	90%: <0–1.2 Sv	Nakashima et al. (2006)
	Posterior subcapsular opacity	0.7 Sv	90%: <0–2.8 Sv	
Atomic bomb survivors (acute exposure)	Postoperative cataract	0.1 Gy	95%: <0–0.8 Gy	Neriishi et al. (2007)
Chernobyl clean-up workers (fractionated protracted exposure)	Stage 1–5 cataract	0.50 Gy	95%: 0.17–0.65 Gy	Worgul et al. (2007)
	Stage 1 cataract	0.34 Gy	95%: 0.19–0.68 Gy	
	Stage 1 non-nuclear cataract	0.50 Gy	95%: 0.17–0.69 Gy	
	Stage 1 superficial cortical cataract	0.34 Gy	95%: 0.18–0.51 Gy	
	Stage 1 posterior subcapsular cataract	0.35 Gy	95%: 0.19–0.66 Gy	

Posterior Subcapsular Opacities (PSC) are at the back of the lens & are generally radiation related.

Change in ICRP Understanding of Lens Dose Tissue Reactions



Cataracts - Previous Studies vs. Recent Studies

Previous Studies:

- Short follow-up periods
- Did not take into account increasing latent periods with decreasing doses
- Relatively few subjects with doses < several Gray

New Studies:

- Longer follow-up
- Larger numbers of cases
- Lower doses

IAEA- Basic Safety Standards to implement ICRP Reduced Lens of Eye Limit

- IAEA – International Basic Safety Standards – recently approved, and includes the ICRP recommendations for lens of eye dose limits.
- This is expected to be made into legislation, following the ICRP recommendation for 20 mSv (2 rem) per yr average lens dose.

European Experience: Estimate of Lens Dose from Measuring at Different Depths

Radiation	Quantity	Good to Estimate H_{Lens}?
Photons	H_p (0.07)	Appropriate
	H_p (3)	Appropriate
	H_p (10)	Underestimates < 40 keV
Electrons	H_p (0.07)	Extreme overestimate
	H_p (3)	Appropriate
	H_p (10)	Underestimate

Simplification of a table from Dr. R. Behrens, PTB, IAEA October 2012

European Experience – New Dosimeters



Eye-D™ by
Radcard

NRC Position/Statements on Lens of Eye Dose

NRC-2009-0279 (August 2011) is a request for public comment on possible lens dose limit changes.

- Per 10 CFR 20.1003, lens dose equivalent (LDE) is defined at a tissue depth of 0.3 cm, and the current limit is 150 mSv (15 rem) per year.
- NUREG-0713 “Occupational Radiation Exposure at Commercial Nuclear Power Reactors...” is published annually based on NRC Form 5 data. The NRC assumes that there are infrequent direct measurements of LDE. That is, DDE and LDE are believed to be taken from the same measurement.

NRC – 2009-0279 (continued)

The NRC must consider the effects of this potential regulation change on all radiation users, not only nuclear power plants. Hospitals, uranium manufacturing, and other industries will have different hazards and exposure situations.

NRC is considering 3 options for lens dose limits:

1. No change; continue with 150 mSv (15 rem) /yr
2. Adopt ICRP recommendation; 20 mSv (2 rem) /yr average, and no single year > 50 mSv (5 rem).
3. Adopt a single, reduced limit. e.g., 50 mSv (5 rem) per year.

Commission's Decisions

SECY-12-0064 (April 2012) – NRC Staff Recommendations related to ICRP Recommendations.

HPS: Further study needed before reducing lens limit.

Commission's response to NRC Staff Recommendations (December 2012).

- TEDE limit:
 - No reduction to 20 mSv/yr (2 rem/yr) averaged over 5 years. Maintain 50 mSv/yr (5 rem/yr) limit.
- Lens of eye: Continue discussions with stakeholders on lens of eye dose limits.
 - No change as yet; still could potentially reduce limit to a lower value, such as 50 mSv/yr (5 rem/yr).

Step 1: Nuclear Industry Survey

Purpose: to obtain information relative to protection programs, monitoring programs, and plant radiological conditions to better evaluate the potential effects of a reduced lens dose limit.

Survey has been sent out to RPMs and responses are due back by the end of January. Responses will be made available to the industry.

Individual plant names will not be associated with the responses in any publication.

Nuclear Industry Survey

1. What are your administrative limits (monthly, quarterly, or annual, if applicable) for:
 - TEDE, Lens of Eye, Extremities, Skin
2. What Dosimeter of Legal Record (DLR) System do you use onsite? Note the type (e.g., TLD, OSL) and vendor or utility processing.
3. Does the dosimetry processor provide a separate response for Lens of Eye?
4. What was the highest lens of eye dose recorded at your station in 2010 and the highest in 2011? In these cases, how did the lens dose compare to the Deep Dose Equivalent?

Nuclear Industry Survey

5. Describe the algorithm to calculate Lens of Eye dose (if applicable). If not applicable, please state reason (e.g., don't calculate separately, no access to algorithm, etc.)
6. Do you use shielding for the lens of eye?... and if yes, then please attach procedure or description as to when this would be used.
7. Do you have a procedure or method for determining lens of eye dose in advance of work in an area? If yes, then please provide the procedure or method.

Nuclear Industry Survey

8. Do you have conditions in your plant that could expose workers to high energy (> 0.75 MeV) beta radiation? If yes, then describe (e.g., Sr/Y-90 near fuel pool; Rb-88 during power entries, etc.)
9. 10. Do you calculate EDEX, and if yes, what method is used? (e.g., ANSI N13.41, EPRI two-dosimeter) If yes, then describe how often this is performed.

Lens Dose Issues/Questions that Utilities will need to answer (Preliminary)

- Determine if field surveys are adequate to accurately measure lens of eye dose.
 - What instruments are use, and what is the density thickness of the “closed window”.
 - Is a closed window of 300 mg/cm² needed on instruments?
- Determine if the decision making process for face/eye protection is adequate for a reduced lens dose scenario.
 - What is the current criteria for face shields or goggles (e.g., 100 mrad/hr and 2 times gamma reading)

Preliminary Lens Dose Issues (continued)

- Does your dosimetry system adequately evaluate lens dose at 0.3 cm depth?
 - Can you describe/defend the algorithm for calculating lens dose?
 - Is an improved eye dose phantom needed?
- Determine if your plant has locations of high energy beta, and if so, in what conditions would they be present. (e.g., containment power entries, BWR steam-affected areas, spent fuel pool, plants with fuel problems/Sr-90, etc.)

Summary

- ICRP has recommended a reduced dose limit for the lens of eye: 20 mSv (2 rem) /yr average
- NRC is considering reducing lens dose limit to 50 mSv (5 rem) /yr.
- EPRI is evaluating current industry practices to see what issues will emerge with a lower lens dose limit.
- Utility input has been requested. Survey questions were sent out during the week of December 17 - results expected by the end of January.