Equivalent dose to the lens of the eye at nuclear facilities and shielding factors for protective eye wear – measurements and calculations

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Background

ICRP Statement on Tissue Reactions , April 21, 2011:

- “Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv in a year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.”

References:

-IAEA BSS No. GSR Part 3 (Interim) (2011)

-ICRP Publication 118 (2012)

-COUNCIL DIRECTIVE 2013/59/EURATOM, 5 December 2013

-IAEA TECDOC SERIES TECDOC No. 1731 Implications for Occupational Radiation Protection of the New Dose Limit for the Lens of the Eye, December 2013

-ISO/CD 15382 ”Radiological protection – procedures for monitoring the dose to the lens of the eye, the skin and the extremities” (under develompent)

Project objective

Swedish Radiation Safety Authority decided in April 2013 that the nuclear sector was to investigate the following aspects regarding dose to the lens of the eye:

- Mapping of radiation fields and energies at the site.
- Identification of critical work situations.
- Identification of proffessions of importance.
- Determine the effectiveness of protective eye wear used today.

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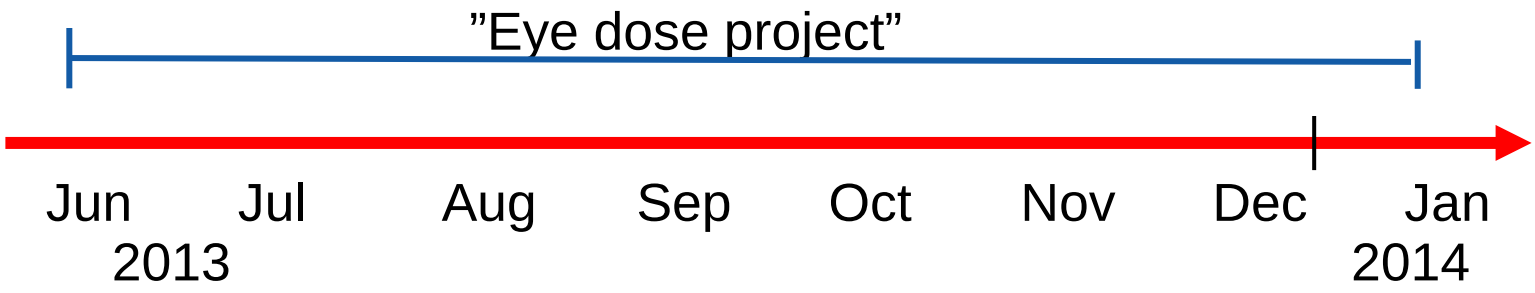
Time frame



Participating sites (all in Sweden):

Forsmark Kraftgrupp AB, Svensk Kärnbränslehantering AB, Studsvik Nuclear AB, OKG Aktiebolag,
Barsebäck Kraft AB, AB SVAFO, Westinghouse Electric Sweden AB och Ringhals AB

Project manager:

Vattenfall AB

Approach

1. Agreement on a general list of radiation sources at the sites
2. Review of work situations for each radiation source
3. Estimation of dose to the lens of the eye for a selection of the identified work situations
   - calculations
4. Selection and test of head band dosimeter
5. Survey - Measurement of $H_p(3)$ for workers at the sites
6. Estimation of shielding factor for protective eye wear
   - irradiations
   - calculations

1. General list of radiation sources

- Fuel
- Crud
- Activated components
- Reactor coolant
- Water from fuel pool
- Ion-exchange resins
- Noble gases
- Aerosols (particles, filter samples)
- Waste monitoring
- Work in a hot cell and glove box
- Chemistry samples
- Other, contaminated components not included in the reactor system for example fuel transport equipment

2. Identified work situations

Types of situations:

- Where trunks may be shielded but not the head;
- Where heads are close to a source of penetrating radiation;
- Exposure to beta radiation.

[IAEA tecdoc]

Examples of identified work situations:

- Reactor coolant system;
  - Decontamination of pump
- Water from fuel pool;
  - Sample collection

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3. Estimation of dose to the lens of the eye - calculations

- For photon radiation, MicroShield was used

- For beta radiation, MCNP was used

Results - $H_p(3)$ survey should at least be conducted for the following situation:

- Work with open systems where crud is present, at NPP.
- Work situations at the nuclear fuel factory.

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4. Selection and test of head band dosimeter

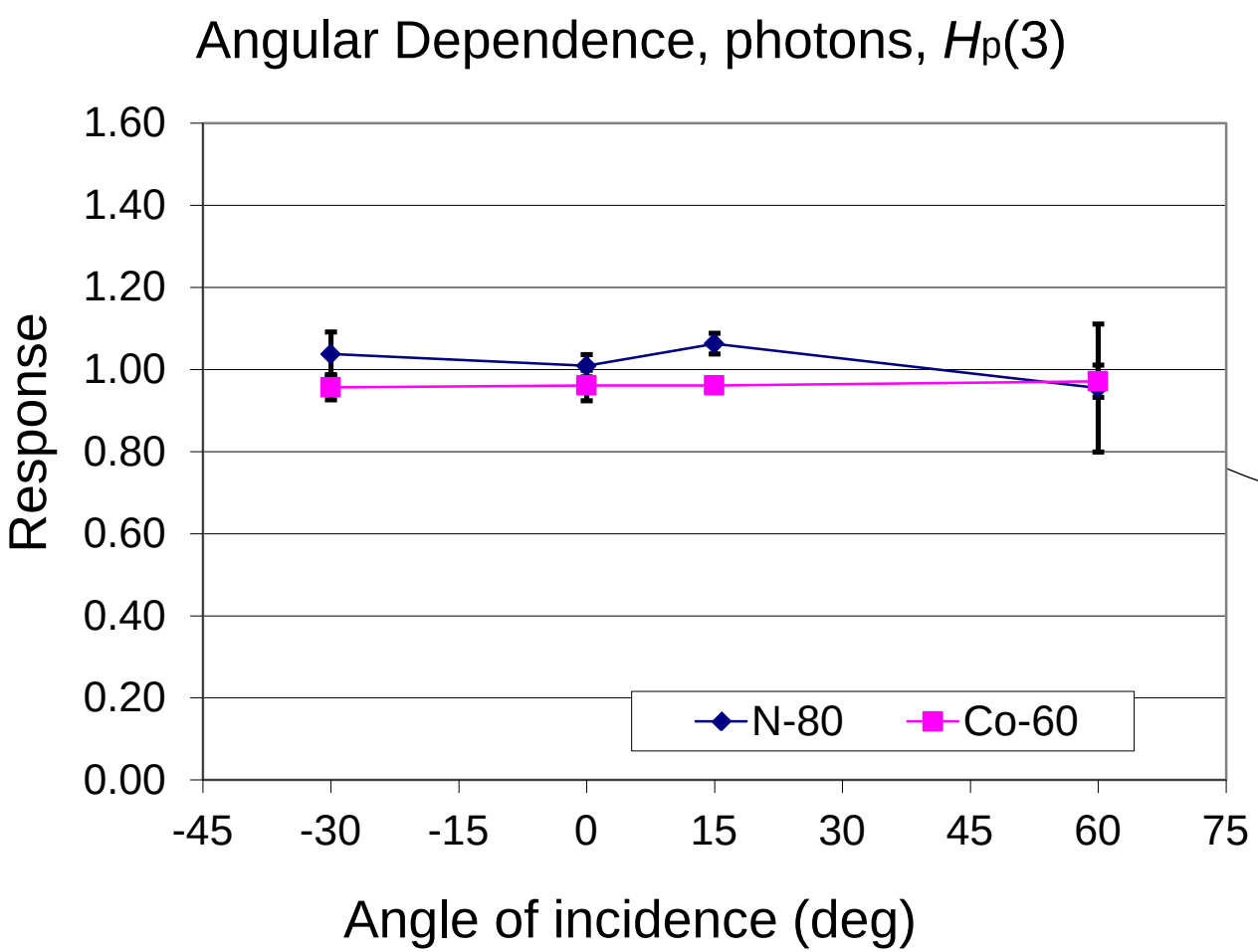
Head band dosimeter including EXTRAD™ and PTFE filter [ref]

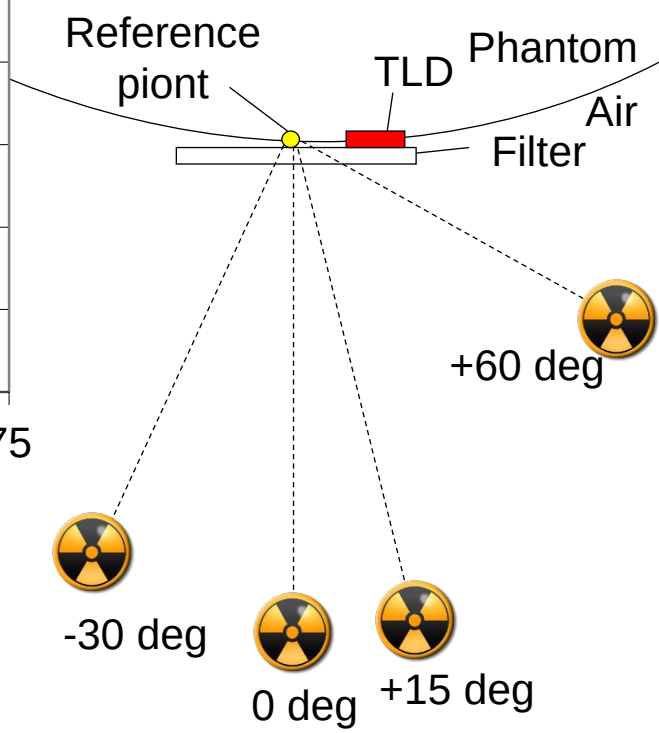
- EXTRAD™ is using TLD (LiF:Mg, Cu, P)
- PTFE filter
  - Thickness: 1.5 mm
  - Equivalent to 3.3 mm tissue

avaliable at:
https://www.phe-protectionservices.org.uk/pds

[ref] P.J. Gilvin et al. ”Type testing of headband dosemeter for measuring eye lens dose in terms of $H_p(3)$” Radiation Protection Dosimetry (2013) pp. 1-7

4. Selection and test of head band dosimeter





Response= $H_p(3)$ measured / $H_p(3)$ true

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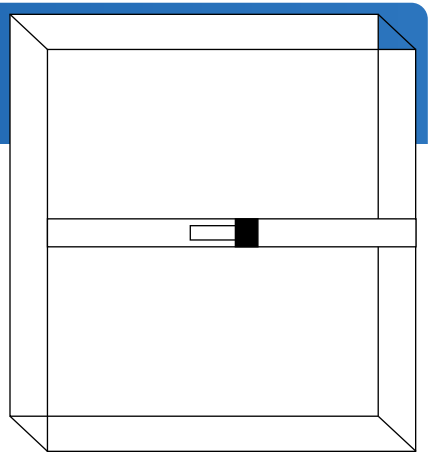
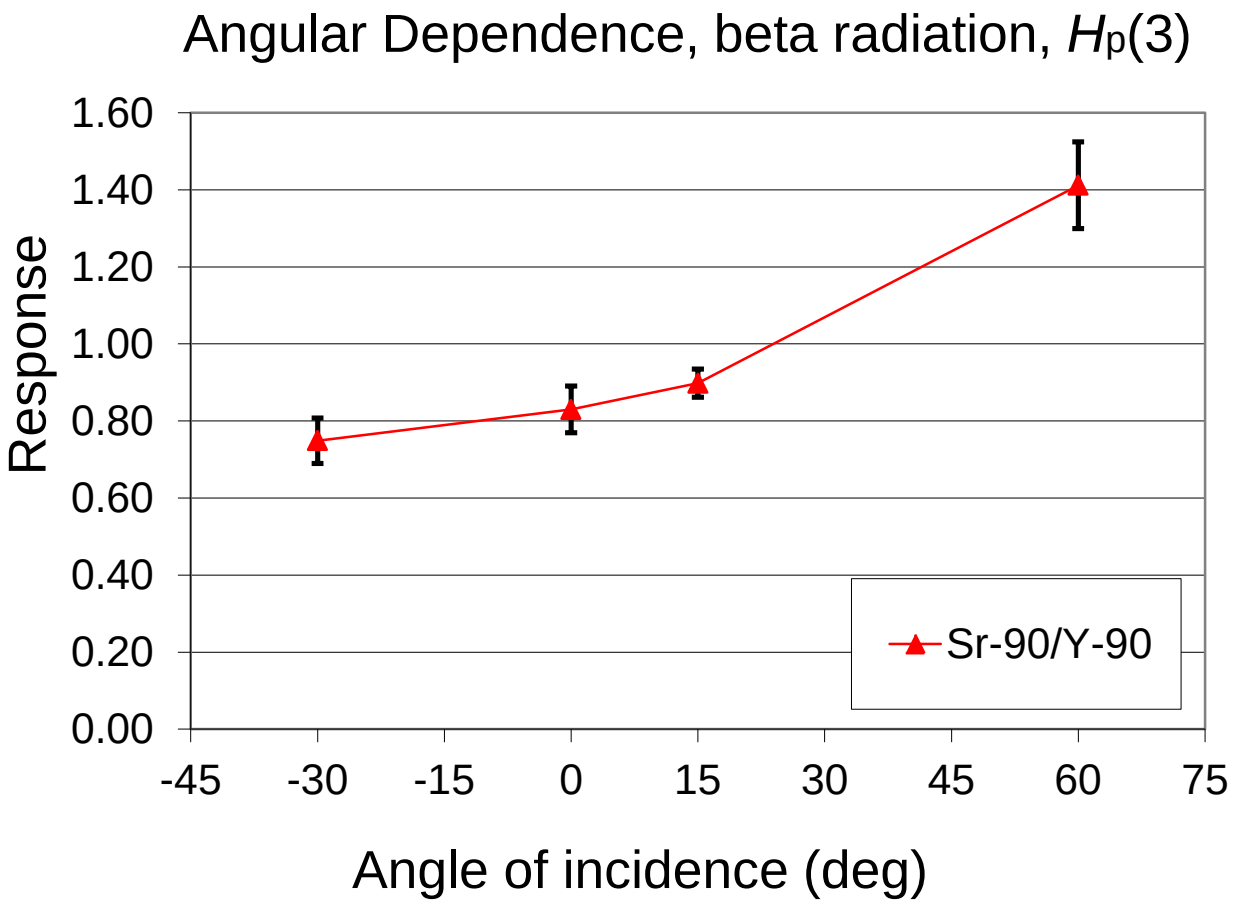
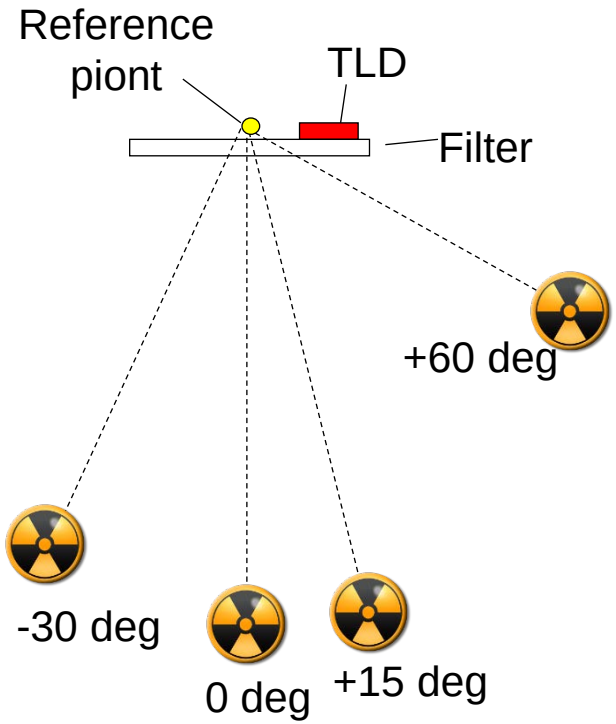
4. Selection and test of head band dosimeter







Response= $H_p(3)$ measured / $H_p(3)$ true

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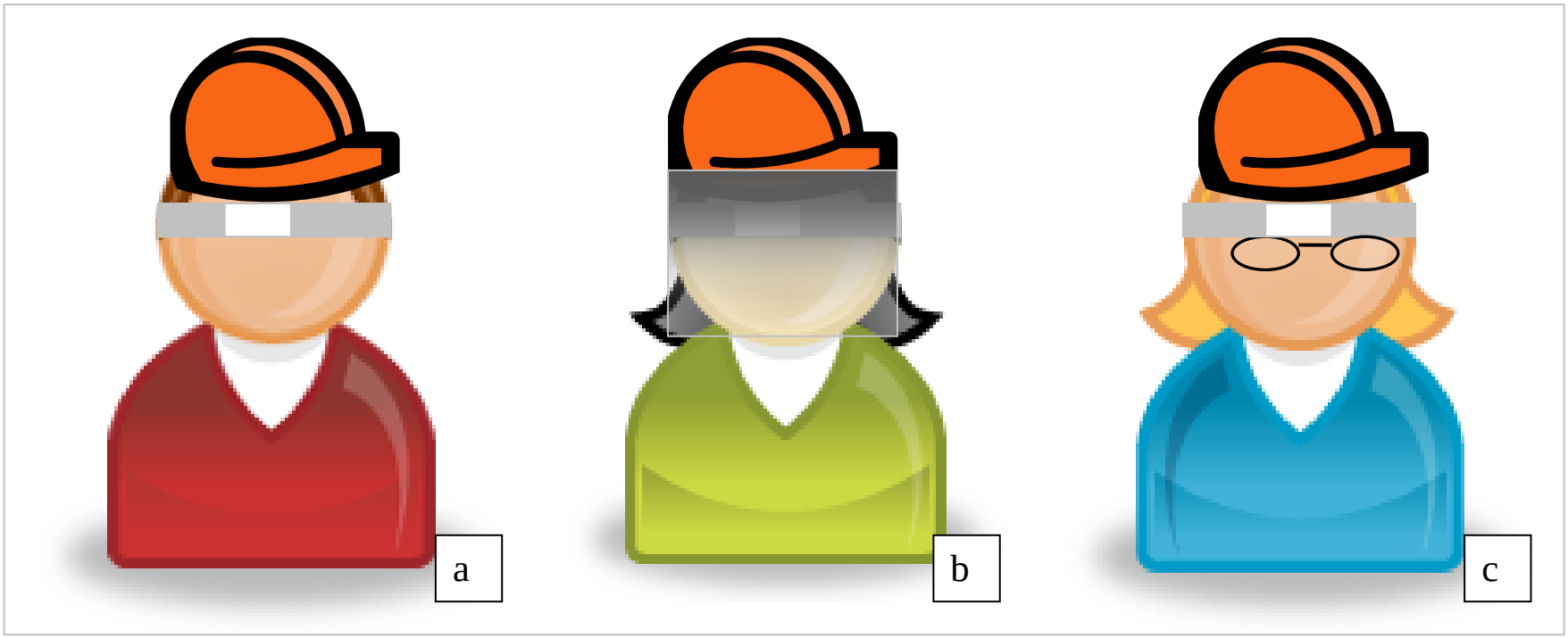
5. Measurement of $H_p(3)$ at workers

Guidelines for how to wear the dosimeter:

a) Centered over the eyes, below the helmet

b) Behind protective eye wear

c) Above regular glasses, if such were used



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5. Measurement of $H_p(3)$ at workers

October 2013

- 126 workers were monitored
- For 26 workers $H_p(3) \geq 0.5$ mSv
- Highest $H_p(3)$ dose was 2.9 mSv (decontamination worker)
  - $H_p(10)$ from whole body dosimeter was 2.3 mSv

November 2013

- 144 workers were monitored
- For 22 workers $H_p(3) \geq 0.5$ mSv
- Highest $H_p(3)$ dose was 1.2 mSv (two radiation protection workers)
  - $H_p(10)$ from whole body dosimeter was 0.8 mSv and 1.1 mSv

- 0.5 mSv x 12 months = 6 mSv (monitoring level according to ISO/CD 15382)

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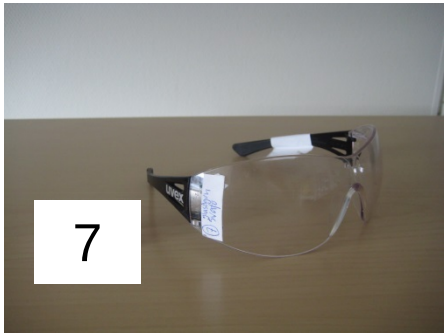
6. Shielding factors for protective eye wear



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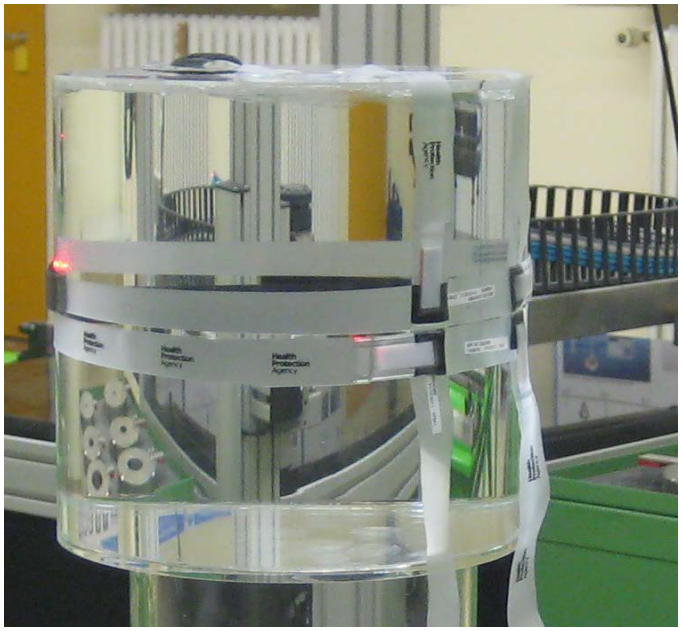
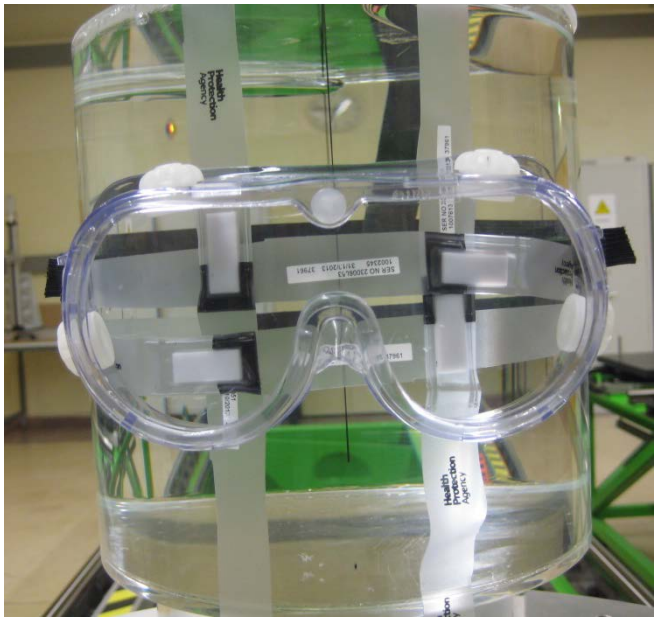
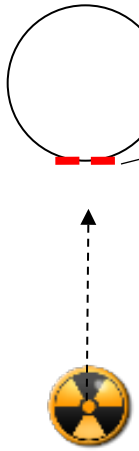


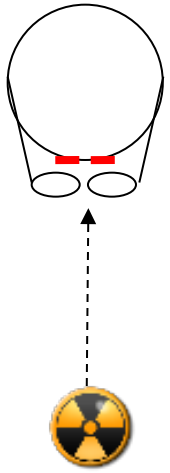


a



$H_{m,source}$

b



$H_{m,shield,source}$

Irradiations without (a) and with (b) safety goggles

6. Shielding factors for protective eye wear

Shielding factor was defined as the part of the dose that is reduced by the protective eye wear

$$F_{shield,source} = \frac{H_{m,source} - H_{m,shield,source}}{H_{m,source}}$$

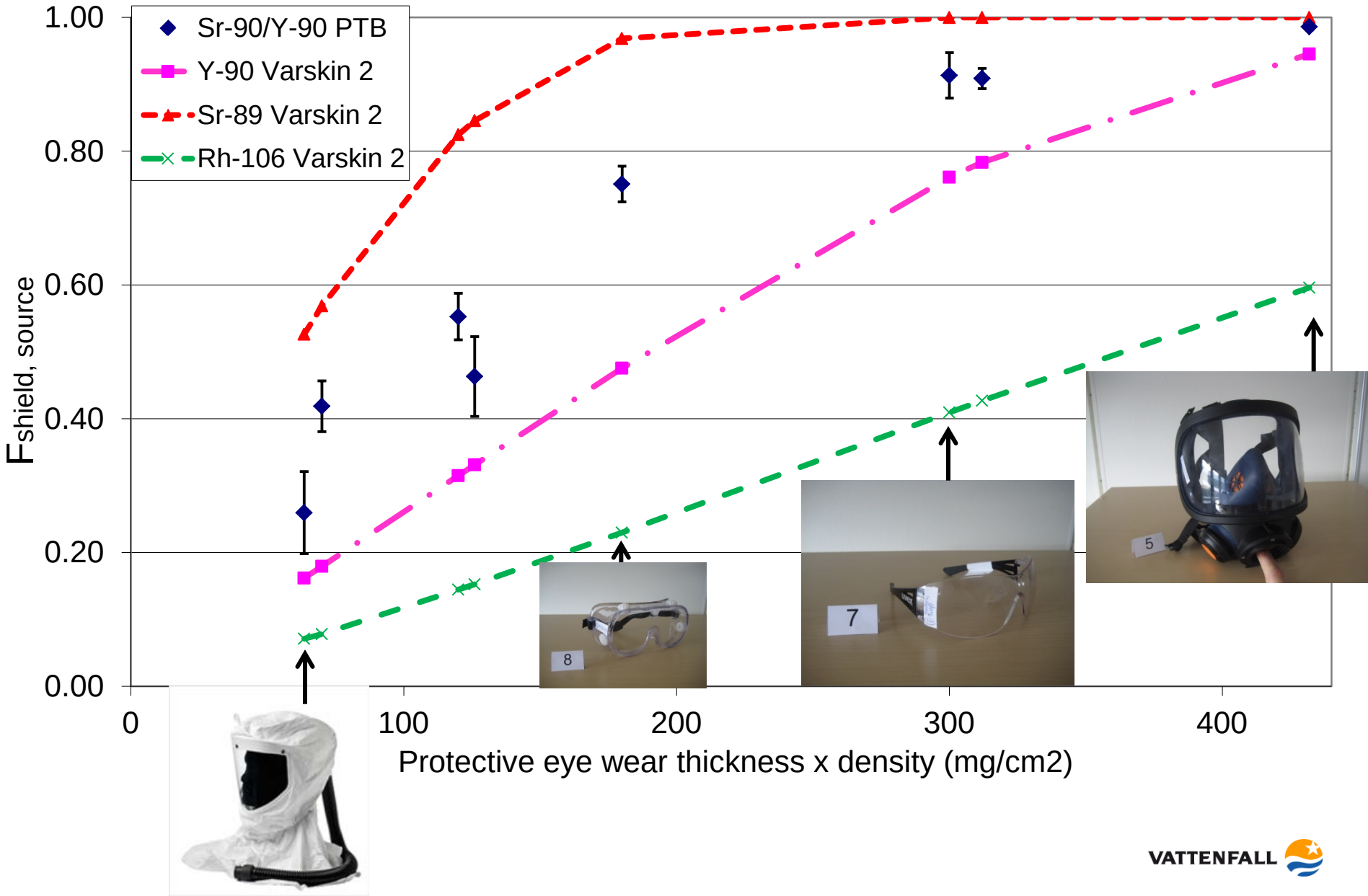
Photon radiation (65 keV, 662 keV and 1250 keV)

Protective eyewear do not shield to any measurable extent

Beta radiation

Protective eyewear are, depending on nuclide, a very good shield

6. Shielding factors for protective eye wear – betarad.



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Summary/conclusions

- Identification/mapping of radiation sources has been done.
- Identification of work situations has been done.

- The headband dosimeter fulfills the Swedish requirements for personal dosimeters.
- Monitoring of dose to the lens of the eye has been done. The doses are relatively low.
  - All sites must value if the monitoring period is representative
  - If the dose is < 6 mSv/year, no regular monitoring is needed

- Protective eye wear can be a very good shield for beta radiation.

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Thank you!
Questions?

Please also visit the Forsmark NPP's poster regarding this project.

5. Measurement of $H_p(3)$ at workers

October 2013

- 126 workers were monitored

- For 26 workers $H_p(3) \geq 0.5$ mSv
    - Radiation protection workers, mechanics, welders, decontamination workers, insulators, melting workers, laboratory engineers, cleaners, operator powder formulation
    - For 8 workers the $H_p(3) < H_p(10)$ at the trunk (TLD or OSL)
    - For 13 workers the $H_p(3) > H_p(10)$ at the trunk. 0.8 mSv was the greatest disc
    - For 5 worker the $H_p(3) = H_p(10)$ at the trunk

- Highest $H_p(3)$ dose was 2.9 mSv
    - Decontamination worker, OKG
    - $H_p(10)$ from whole body dosimeter was 2.3 mSv

5. Measurement of $H_p(3)$ at workers

November 2013

- 144 workers were monitored

- For 22 workers $H_p(3) \geq 0.5$ mSv
    - Radiation protection workers, decontamination workers, melting workers, waste management workers, operators and mechanics.
    - For 5 workers the $H_p(3) < H_p(10)$ at the trunk (TLD or OSL)
    - For 14 workers the $H_p(3) > H_p(10)$ at the trunk. 0.4 mSv was the greatest disc
    - For 2 worker the $H_p(3) = H_p(10)$ at the trunk
    - For one worker the $H_p(10)$ at the trunk was not known

- Highest $H_p(3)$ dose was 1.2 mSv (two radiation protection workers)
    - $H_p(10)$ from whole body dosimeter was 0.8 mSv and 1.1 mSv

6. Shielding factors for protective eye wear

#	Name	Company	Model	Article-number	Thickness (mm)	Density (g/cm^3)	Th. x den. (mg/cm^2)	Material
1	Procap	Scott Safety	Procap	64401	1,05	1,20	126	Polycarbonate
2	Mururoa	Sperian	Mururoa V4F1	CC8481X1T	0,5	1,40	70	PVC, Polyvinyl chloride
3	Visor	Honeywell Safety products	Bionic Faceshield-Clear	1011623	1,0	1,20	120	Polycarbonate
4	Open-air hood	Sundström	SR 561	H06-5012	0,5	1,27	64	PETG, Polyethylene terephthalate
5	Full face mask	Sundström	SR 200	H01-1212	3,6	1,20	432	Polycarbonate
6	Full face mask	Scott Safety	Promask black	012980	2,6	1,20	312	Polycarbonate
7	Safety goggles	UVEX	x-trend HC/AF clear black	9177280	2,5	1,20	300	Polycarbonate
8	Safety goggles	Worksafe Puma	Korgglasögon	330180	1,5	1,20	180	Polycarbonate

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