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PHE Headband Dosemeter for measuring Occupational Radiation Dose to the Lens of the Eye in Terms of $H_p(3)$

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June 2019 for Canadian Nuclear Safety Commission

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Development of dosimetry

Until headband developed in 2012, eye dose monitoring was carried out by using whole body dosemeters, worn on collar.

- **Whole body dosemeters measuring $H_p(10)$ and $H_p(0.07)$ are good for photons in uniform fields**
- **PHE whole body dosemeter is approved measure $H_p(3)$ in these circumstances**
- **Not satisfactory for betas as $H_p(10)$ underestimates eye lens dose and $H_p(0.07)$ overestimates**

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Development of dosimetry

Advances in computational modelling by PTB, Germany

e.g. Behrens R, and Dietze G. Dose conversion coefficients for photon exposure of the human eye lens.

Phys. Med. Biol. 56 (2011) 415-437

and the European ORAMED project, ***e.g. Radiation Measurements 46 (2011)***

Resulted in:

- **recommended conversion coefficients**
- **validation of $H_p(3)$ as suitable quantity**
- **recommended simple head phantom**

Conversion coefficients and head phantom now adopted in ISO 4037-3: 2019

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UK context

Nuclear Industry:

- good knowledge of eye doses; only a few cases where workers need extra routine monitoring

Medical Sector:

- Originally not all hospitals routinely checked eye doses
- Most potential for overexposures in IC/IR teams
- PPE can be very effective (glasses and lead shields)
- Institute of Physics & Engineering in Medicine carried out work on reduction factors for glasses
- need to check uniformity of x-ray fields

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Dosemeter design

PHE eye dosemeter:

a. measures $H_p(3)$ in all fields and mixtures of fields (so covers full range of radiation energies & angles, photon and beta)

b. simple and inexpensive

c. to be worn close to eyes, to sample radiation field properly

d. sufficiently sensitive

e. cold-sterilisable

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Dosemeter design

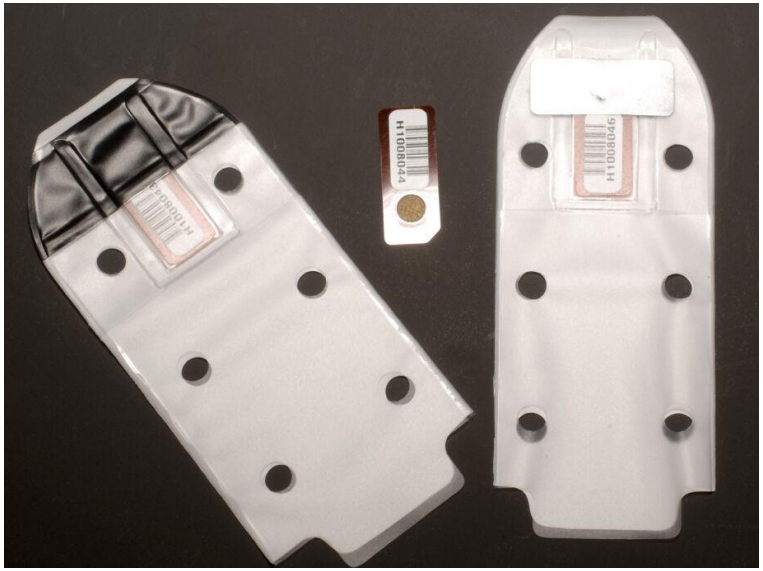
PHE extremity finger stall dosemeter

- uses thin TLD element to measure $H_p(0.07)$ to fingers
- high sensitivity LiF (Mg,Cu,P) gives good energy dependence of response plus low detection limit

Solution:

- use this same TLD element
- keeps costs down
- add a tissue-equivalent filter to achieve

  3 mm tissue depth



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Dosemeter design

- **PVC strip with Velcro fastening**
- **1.5 mm of PTFE (~ 3.3 mm tissue)**
- **PVC strip is single-use**

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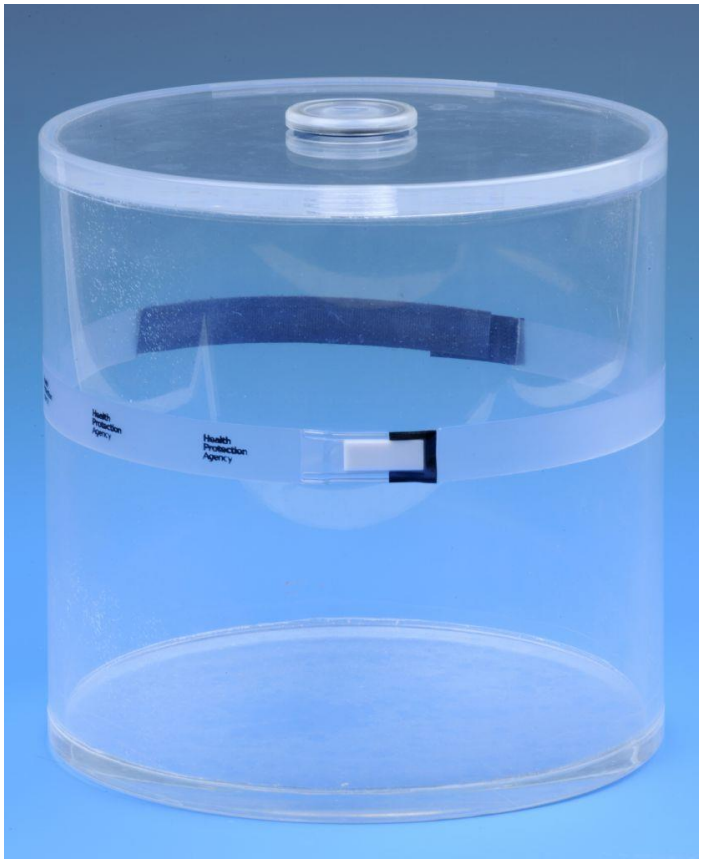
Dosemeter design

- **Type tested to ISO 12794 (in 2012) with additional criteria recommended by ORAMED**
- **Used ORAMED phantom**
- **Used ORAMED & PTB conversion Coefficients**
- **Would now test to IEC62387**



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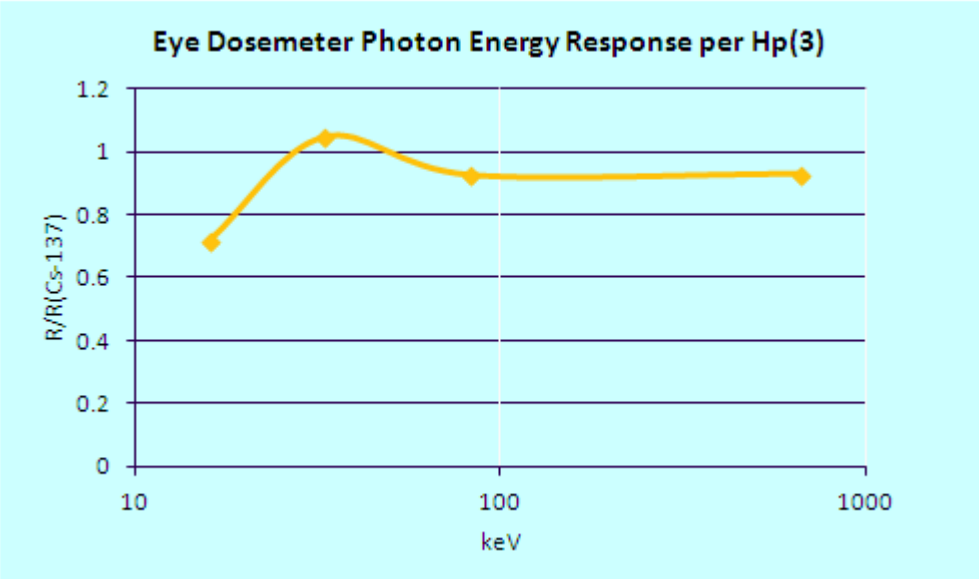
Dosemeter design

Results

- Good photon and beta energy
- Beta energy threshold

~ 1 MeV E_{max}

- Dose range 0.05 mSv to 10 Sv



Uncertainty (1 sigma) ± 10% in known radiation field or ± 17% where field is unknown

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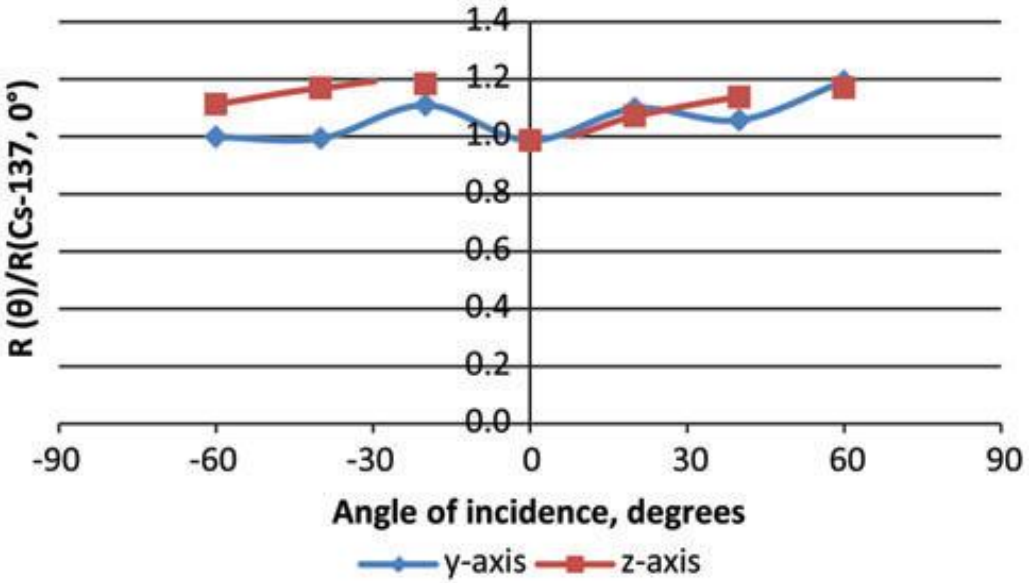
Dosemeter design

- Good angle dependence of response
- Mean response value (photons) from 0, 20, 40 & 60 angles lie within +15 % relative to normal incidence

Photon angle dependence of response, per $H_p(3)$



X-rays: ISO W-80

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Dosemeter performance

Since 2013 Headband Eye dosemeter has performed well in:

- **EURADOS Intercomparison for eye dosemeters 2014, 2016 (entered 2019)**
- **Closed NHS ADS group eye dosemeters intercomparisons 2015, 2016, 2017, 2018 and 2019)**

This confirms the continuing good performance of the dosemeter and compares it to other similar dosemeters.

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PHE service

- **supplies headband dosemeter to measure $H_p(3)$ with sufficient accuracy in all photon and beta fields (and mixtures thereof).**
- **is worn outside of lead glasses, so measures directly if using lead shields**
- **if wearing lead glasses can be an over-estimate.**
- **can be used as a valuable tool for risk assessments.**
- **recommended for classified workers**

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PHE service

- **In 2018, we issued over 11,000 eye bands**

  (mainly to UK hospitals)
- **But also in Europe to Denmark, Ireland, Netherlands and Sweden**
- **Extremity/Eye dosimetry demand increasing – expanding to meet opportunities**
- **Expecting to issue over 15,000 in 2019**

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Doses from PHE dosemeters

Doses from UK Hospitals

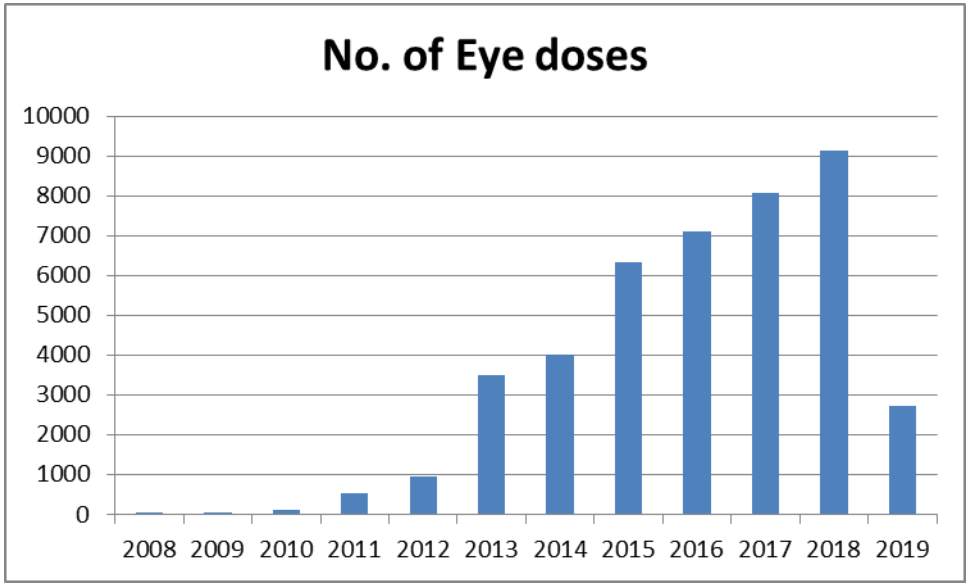
No. of eye doses recorded in database increased

- **49 in 2008**
- **9143 in 2018**

More expected in 2019

Q1 = 2735

Predicted 11,000 to 15,000



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Future investigations/plans

Industry:

- Assess risks of veterinary practices carrying out large-animal radiography
- Investigate lateral exposures
- Medical sector to review 2018 doses to assess workers requiring classification

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Future investigations/plans

For PHE:

- Explore altering the PTFE filter - different length to improve angular response for betas (started) and possible dome shaping
- Explore possibility of altering HSE approval to include correction factor for PPE:
    - **Carry out exposures on head phantom using lead glasses to assess reduction in dose (starting in June)**
    - **Make changes to software to allow correction factor per group or worker**
    - **Apply for re-approval of headband with HSE to include correction factor (discussion started with HSE)**

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Any Questions?