Individual Monitoring Procedures

Dr Phil Gilvin

Public Health England, UK

EURADOS

Individual Monitoring Procedures

Aim

To answer the question, *"how should individual monitoring be carried out?"*

- **Which workers?**
- **How frequently?**
- **What method?**
- ***Et cetera***

EURADOS

Individual Monitoring Procedures

1. Risk Assessment
2. System of Protection
3. Individual Monitoring Programme
4. Ensuring Reliability
5. Types of Dosemeter
6. Choosing the System
7. Other Matters

1. Risk Assessment

You cannot design a monitoring programme without knowing what the risks are, for all workers and tasks.

Radiation fields

- **types, energies, directions**
- **uniform or non-uniform?**

Nature of work

- **positions of workers relative to sources**
- **stationary or mobile?**
- **environmental conditions (temperature, humidity, fields)**

1. Risk Assessment

Potential for accidents

- **routine doses may be low**
- **but what could go wrong?**
- **how would that change the conditions?**

Which workers?

- **any special considerations, e.g. pregnancy**

Undertaking should consult with RPE

2. System of Protection

Dose Limits from BSS [Council Directive 2013/59/Euratom]

Limiting Quantity	Exposed Workers (over age 18)	Apprentices & Students (age 16-18)	Public
Effective Dose	20 mSv*	6 mSv	1 mSv**
Equivalent dose – eye lens***	20 mSv*	15 mSv	15 mSv
Equivalent dose – extremities & skin	500 mSv	150 mSv	50 mSv

* Provision for authorities to approve annual limit of 50 mSv, subject to 5-year limit of 100 mSv.

** Higher value my be authorised provided the average over 5 y does not exceed 1 mSv.

*** Previous, higher values may remain in force until 2018.

2. System of Protection (2013/59/Euratom)

Category A: "those exposed workers who are liable to receive an effective dose greater than 6 mSv per year or an equivalent dose greater than 15 mSv per year for the lens of the eye or greater than 150 mSv per year for skin and extremities"

Category B: "those exposed workers who are not classified as exposed category A workers"

Exposed Worker: *"a person, either self-employed or working under an employer, who is subject to exposure at work carried out within a practice regulated by this Directive and who is liable to receive doses exceeding one or other of the dose limits for public exposure."*

2. System of Protection

Risk Assessment will also cover:

Not sure what category? => Category A, but keep under review

Is Personal Protective Equipment (PPE) needed? By how much will it reduce doses?

Category A => routine, systematic monitoring

Category B => monitoring optional but keep under review

3 Individual Monitoring Programme

How will the results be used?

- **to demonstrate legal compliance**
  - employer can demonstrate compliance to regulator, to workers etc.
- **to feed back into practices**
  - helps to decide when doses are as low as reasonably practicable
- **to feed back into risk assessment**
  - gives information for reviews of risk assessment
- **to reassure workers**
  - demonstrates safety culture

3 Individual Monitoring Programme

Who should see the results?

- **Undertaking** (Employer) – has paid for results, has primary responsibilities
- **Radiation Protection Expert** (RPE) – so that best advice can be given
- **Workers** – are entitled to see information about themselves – promotes safe working
- **National Dose Registry** – helps to improve safety at national level
- **Regulator** – high doses and investigations, according to national requirements
- **Medical/ Occupational Health** – part of surveillance for cat. A workers

3 Individual Monitoring Programme

Systematic – Continuous

- **Category A workers, legal requirement**
- **Category B workers, reassurance and quality reasons**

Campaign – Periodic or Once-only

- **Confirm that workers are in Category B**
- **Category B where systematic monitoring is difficult or inconvenient**

3 Individual Monitoring Programme

For high-risk situations where dose rates could be high – i.e. where doses can exceed investigation levels or dose limits in a short time:

- consider potential for accident situations
- special monitoring programme
- active direct reading/ alarming dosemeters
- pay special attention to capabilities/ limitations of dosemeters
- special calculations may be needed to arrive at effective dose or organ doses
- also consider environmental effects

Change Interval?

Category A: Short change interval, e.g. 1 month.

- provides more regular information
- provides early warning if cumulative doses are too high
- provides early warning of unusual doses
- provides back-up for any additional APDs used

Category B: Longer change interval, e.g. 3 months

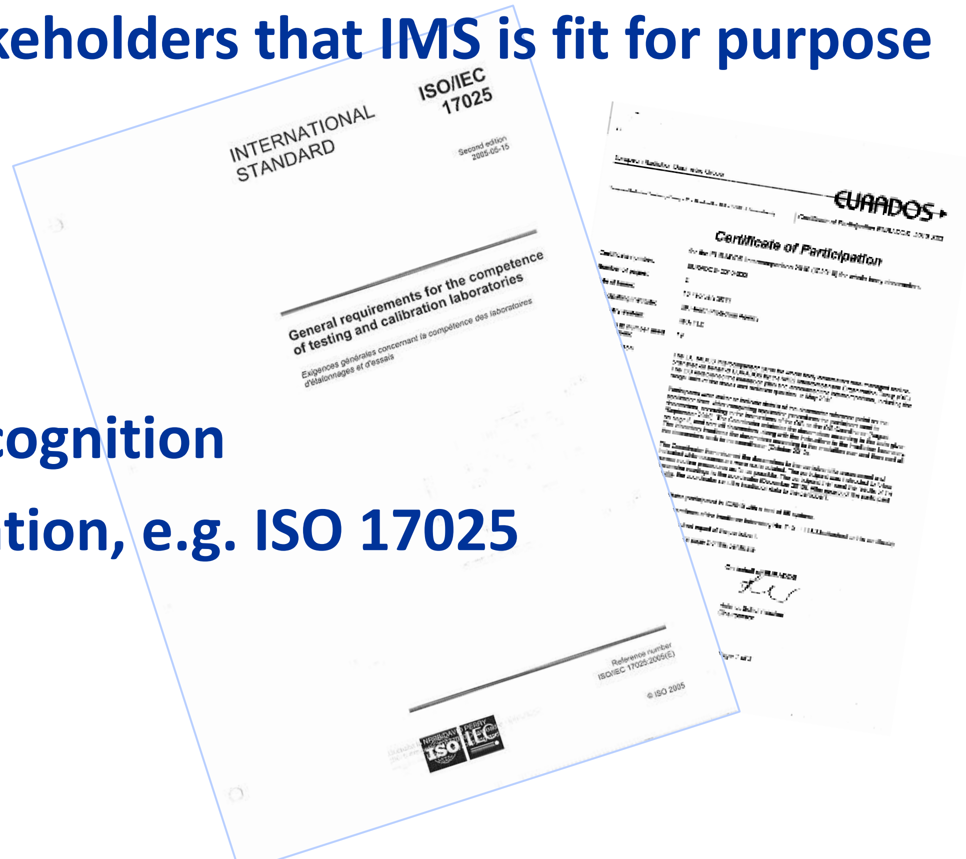
- negligible risk of unusually-high dose
- lower cost

Note – is the dosemeter suitable for longer wear periods?

4 Ensuring Reliability

Quality & reliability

- **Demonstrate to <u>all</u> stakeholders that IMS is fit for purpose**
  - Undertaking
  - Workers
  - Regulator
  - Etc.
- **National approval / recognition**
- **Formal quality certification, e.g. ISO 17025**
- **Accuracy & precision**
  - Intercomparisons
  - Internal QC



EURADOS

5. Types of Dosemeter

Active personal dosemeters (APDs)

- **Advantages: Real-time functions**
  - Alarms
  - Display
  - Frequent updates to dose database (daily or more often)
  - High sensitivity
- **Disadvantages**
  - High unit costs
  - Maintenance costs
  - Environmental limitations (e.g. **pulsed fields**) – check!

- **Essential where high / variable dose rates are possible**
- **Can fulfil "legal" role too**

5. Types of Dosemeter

Passive Dosemeters

- Need to be collected & returned to IMS → up to 2 weeks until report
- No real-time capability
- Relatively cheap
- Suitable for mass monitoring
- Most are environmentally robust

Discriminating:

- Different filters or elements required
- Can give information about field
- Some types discriminate between static/ mobile exposures

5. Types of Dosemeter

Passive Dosemeter Technologies

Luminescence : electrons elevated into trapping centres and released by stimulation. Measure: light output

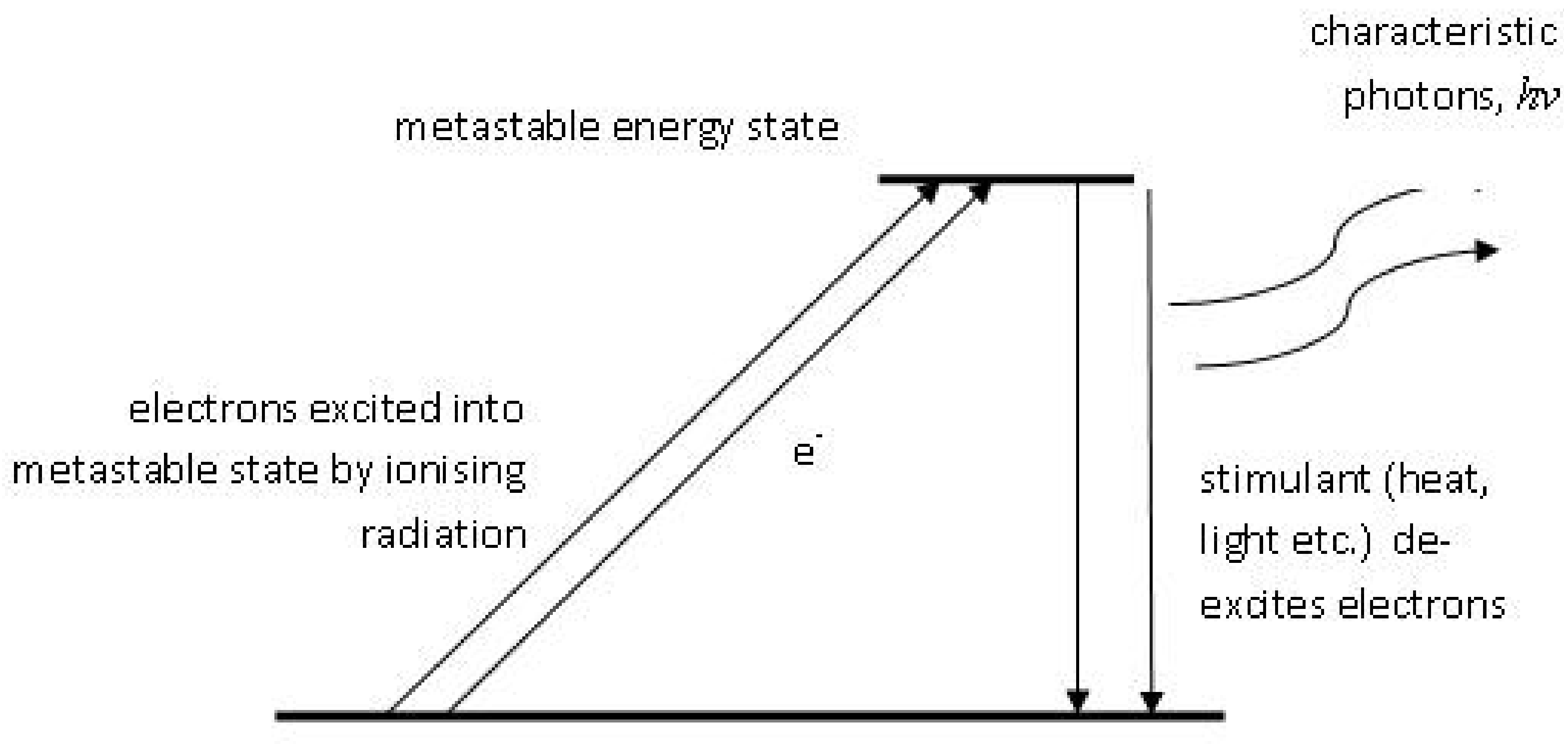
- **stimulated by *heat* (thermo-) (TLD)**
- **stimulated by *light* (photo- or optical) (RPL, PLD, OSL)**

Photographic film: deposited energy changes chemical properties. Measure: optical density after development.

Direct Ion Storage: solid state analogue of ion chamber. Measure: electric charge.

5. Types of Dosemeter

Luminescence methods



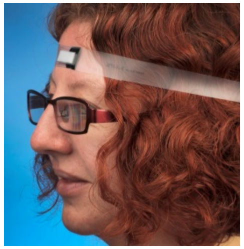
5. Types of Dosemeter

Dosemeters for part-body exposures

"Extremity" dosemeters – hands, feet, arms, legs

"Eye" dosemeters – lens of the eye

- **Miniaturised**
- **Usually TLD**
- **Often have lower sensitivity**
- **Positioning is very important**



"EYE-D" images courtesy of LADIS (Agnieszka Szumska)

5. Types of Dosemeter

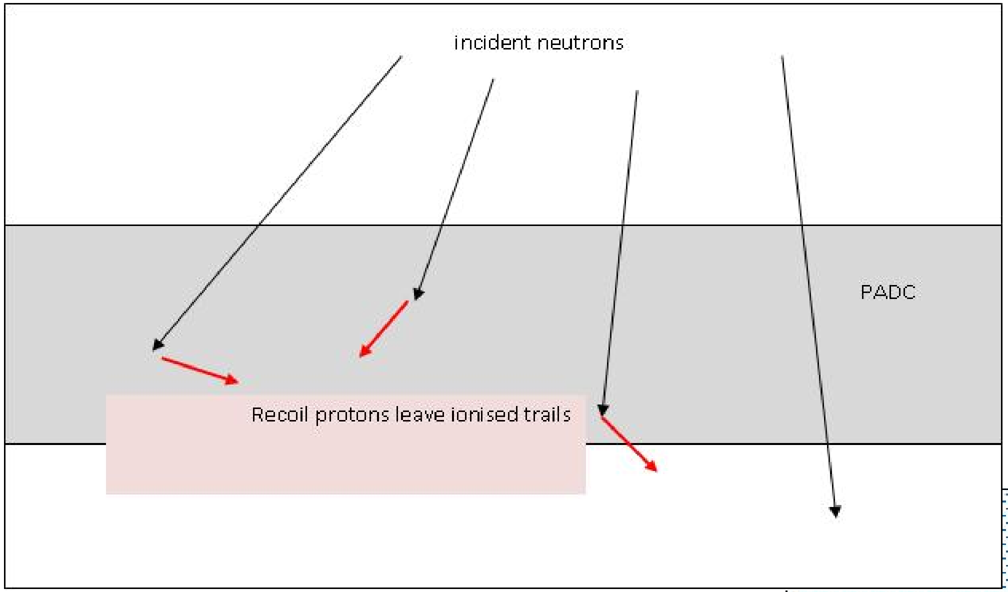
Neutron Dosemeters

Track Etch: Chemical (or electro-chemical) amplification of the physical damage trails caused by secondary protons

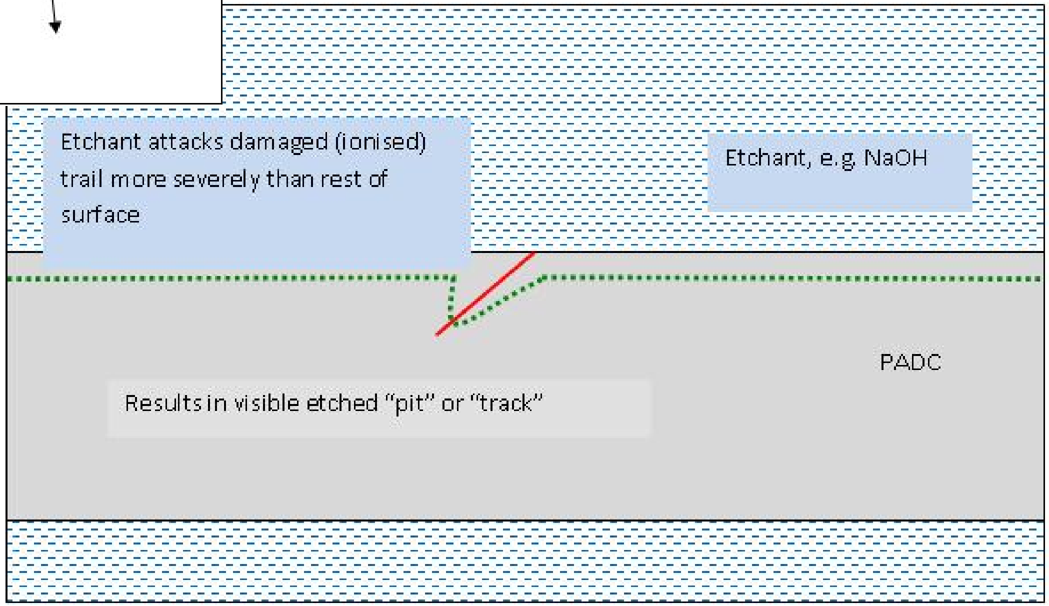
Albedo: Detection of secondary radiations (e.g. gamma) arising from capture of thermal neutrons scattered back from wearer's body

Bubble: Evaporation of superheated liquid droplets, caused by secondary protons

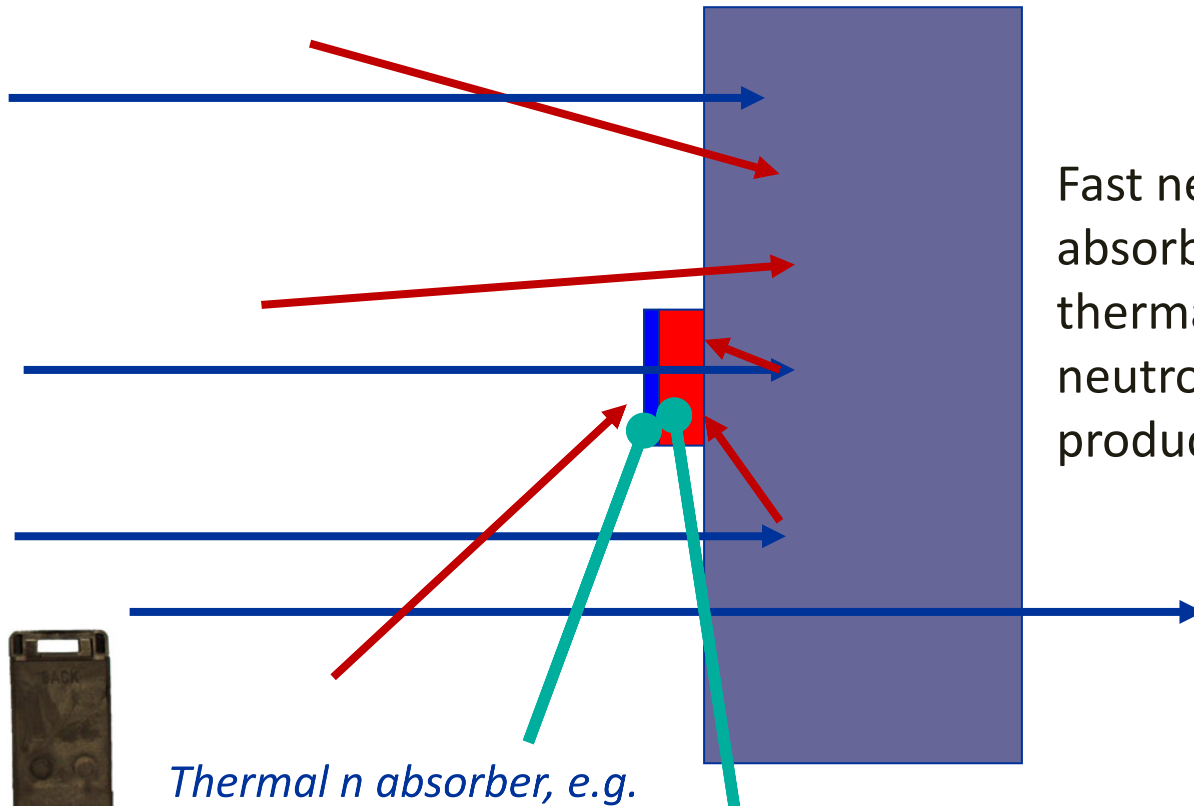
5. Types of Dosemeter



Track Etch Dosemeter



5. Types of Dosemeter – Neutron Albedo



6. Choosing the Dosimetry System

Questions to consider:

- **Legal requirements (national or regional)**
- **Requirements for accuracy (see RP160 Chapter 6)**
- **Requirements for recording & reporting (Chapter 9)**
- **Instant readout needed?**
- **Discriminating or not?**
- **Is the DS suitable for your:**
  - radiation fields?
  - environmental conditions/
  - workers?
  - information needs (e.g. dose quantities used)?
  - intended change interval?

6. Choosing the Dosimetry System

Notice that we are selecting the

Dosimetry System

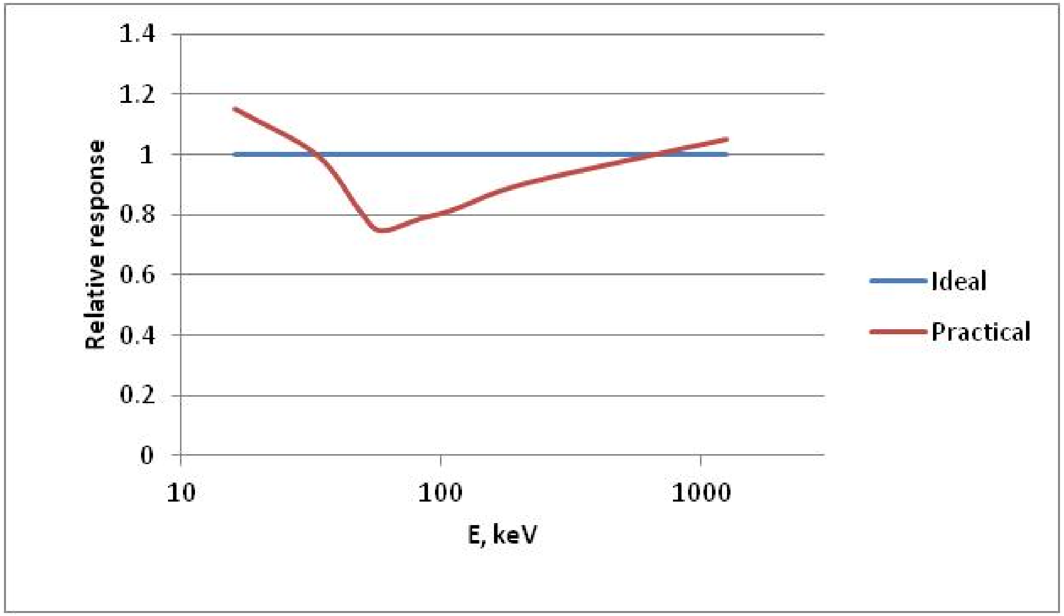
Suitability depends not only on the *type of dosemeter*, but also on *what the IMS does with it*.

See: the rest of RP160 !

6. Choosing the Dosimetry System

Ideal dosemeter has an INVARIANT relative response

But real dosemeters are seldom ideal



TYPE TEST tells you how the response varies with:

- radiation type
- radiation energy
- angle of incidence
- magnitude of dose
- environment
- time
- etc.

International Standards, e.g. IEC 62387, 61526

DS need not comply with all these requirements
So long as it meets **yours**

6. Choosing the Dosimetry System

Response in Accidents

- Does the dosemeter have adequate dose range?
- Does it continue to work in accident situations?
- Can IMS respond quickly?
- Care with APDs – dose rate, pulsed fields?

6. Choosing the Dosimetry System

Approved/ Recognised Dosimetry Service

- **provides assurance to undertaking that the IMS reaches a minimum standard**
- **recognised by competent authority**
- **competent authority decides on recognition criteria**
- **criteria will include**
  - evidence of effective quality system
  - results of proficiency testing
  - reports containing sufficient information
  - measures to ensure reliability

BUT undertakings should still *check that service is right for them* (take advice from IMS and RPE if necessary)

7. Algorithms

Algorithms: link results from several detectors in the same dosemeter

Reasons:

- non-tissue-equivalence of dosemeters
- stringent performance requirements
- albedo neutron dosemeters

Types

- simple
- branching

7. Algorithms

Non-tissue-equivalent dosemeters:

- **response varies widely with radiation energy.**
- **several detectors or areas, with different filtration.**
- **gives energy information (required for right calibration).**
- **energy information can have additional uses.**

Stringent requirements

- **US “NAVLAP” and “DOELAP” requirements: ±30% at a range of discrete energies.**
- **difficult to achieve without algorithms.**

7. Algorithms

Simple algorithms:

- **mathematical formula, e.g. for 4-element dosemeter**

$$H_p(d) = \alpha A + \beta B + \gamma C + \delta D$$

Branching:

- **applies different conditions based on ratios of results, e.g.**

“If A/B > x, then α = 0.3. Otherwise α = 1.1.”

- **requires sensitivity analysis, to avoid mathematical discontinuities => possible problems in workplace fields.**

8. Other Matters

Don't forget to consider uncertainties (next topic). Are they acceptable in your context? Should be reported to undertaking.

Advice & information: dosemeters are no good if the wearer does not use them properly! Provide information to undertakings and workers:

- **correct positioning**
- **avoiding misuse**
- **limitations**

8. Other Matters

Workplace monitoring/ occupancy

- **only where no dosemeter is suitable – why?**
- **requires very detailed knowledge of radiation fields** (energy and angle distributions at different worker locations) - **essential for albedo dosimetry**
- **requires good knowledge of work patterns**

Dose to fetus

- **Where single dosemeter is worn, for uniform fields, this can be considered to adequately assess the dose to the fetus.**

8. Other Matters

Personal Protective Equipment

- IMS may need to provide advice on wearing of dosemeters with PPE
- for dose recording, may need to take PPE into account, e.g. when double dosimetry is used (recommended) with lead aprons
- extremity dosemeters (fingers) will often be worn under gloves
- eye dosimetry: need to characterise protection provided by lead glasses, ceiling shields – remember to consider scatter

Any questions?