L15b Validation of external personal monitoring with TLDs /OSL Systems
How to validate

• Scientific approach
  ➢ Systematic assessment of the influence of representative parameters of the result and uncertainty of a measurement method.
  ➢ The selection of assessed parameters shall be based on published scientific and technical literature.
  ➢ It may be supported by special investigations.
How to validate

• Comparative approach
  ➢ Comparison with other, validated, methods.
  ➢ Use of extended calibration routines with certified standard materials.
  ➢ Participation in intercomparison exercises.
  ➢ Simulation or modelling including expert judgement.
Validation planning

- Validation of external monitoring, using film batches, TLD, or similar devices can be done by:
  - Calibration of the readers and dosimeters by irradiating at a Secondary Standard Dosimetry Laboratory
  - Systematic investigations by using control dosimeters running with the field dosimeters whenever applicable
  - Laboratory intercomparison exercises
  - Performance Testing
Validation planning

- Start with method selection
- Define acceptable performance criteria
- Plan irradiations to cover the performance criteria
- Do the irradiations
- Evaluate the dosimeters
- Assess the performance criteria
- Issue validation statement
Performance criteria

• The performance criteria are recommended by

• ISO/IEC61066

• “Thermo luminescence dosimetry systems for personal and environmental monitoring” and

• IAEA Safety Guide No RS-G-1.3. “Assessment of occupational exposure due to external sources of radiation”
Performance Requirements

- Batch homogeneity
- Reproducibility
- Linearity
- Detection threshold
- Self Irradiation
- Residual signal
- Energy response
- Isotropy

Further test, additionally to performance requirements:
- Pre-irradiation fading
- Post-irradiation fading
- High dose linearity
- Reader stability
Batch homogeneity

- The evaluated value for any one dosimeter in a batch shall not differ from the evaluated value for any other dosimeter in the batch by more than 30% for a dose equal to 10 times the required detection threshold limit.
Batch homogeneity

- **Method:**
  - TLD cards were cleaned with Methanol p.a. and left for drying for at least 2 hours
  - The annealed cards were exposed to Sr-90 (irradiator integrated in 6600 TLD Reader) and read out.
  - The value $E$ was assessed for each dosimeter.
  - $E_{\text{max}}$ and $E_{\text{min}}$ were determined.
Reproducibility

• The coefficient of variation of the evaluated value shall not exceed 7.5% for each dosimeter separately and all \( n \) dosimeters collectively for a dose of 10 mSv.

• **Method:**
  • Five dosimeters were prepared, irradiated to 10 mSv and read out. This procedure was repeated 10 times.
The response shall not vary by more than 10% over the range:

- 7 mg · cm\(^{-2}\): 0.5 mSv – 1 Sv (50 mrem – 100 rem)
- 100 mg · cm\(^{-2}\): 0.1 mSv – 1 Sv (10 mrem – 100 rem)
Linearity

Method

➢ Prepare, irradiate and read out four groups of dosimeters.
➢ The dosimeters were annealed before irradiation
➢ The value E was determined for each group of irradiated dosimeters
➢ The mean of the evaluated value E was calculated for each group.
➢ The standard deviation for all groups of dosimeters was calculated.
Detection threshold

- The detection threshold shall not exceed:
  - $P_e (7 \text{ mg} \cdot \text{cm}^{-2})$ 0.5 mSv
  - $P_e (1000 \text{ mg} \cdot \text{cm}^{-2})$ 0.1 mSv

Method

- 30 dosimeters were prepared and read out.
- The value $E$ was determined for each unirradiated dosimeter.
- The mean of the evaluated value $E$ was calculated.
- The standard deviation for all 30 dosimeters was calculated.
Self Irradiation

- After a storage period of 30 d, the zero point shall not exceed:

  - $P_e (7 \text{ mg} \cdot \text{cm}^{-2})$ : 0.5 mSv
  - $P_e (1000 \text{ mg} \cdot \text{cm}^{-2})$ : 0.1 mSv
Self Irradiation

• **Method**
  ➢ Prepare 30-40 dosimeters and store them for 30 days under standard test conditions in a location where the background dose rate is known.
  ➢ Read out the dosimeters and determine the value $E$.
  ➢ Calculate $E$ and $s_E$.
  ➢ Determine the conventional true value $C_b$ (background irradiation)
Residual signal

- After irradiation with a conventional true value of 100 mSv, the required detection threshold shall not be exceeded and the response shall not change by more than 10% at a dose level of 2 mSv
Residual signal

• **Method**
  - Four dosimeters were prepared, irradiated to 100 mSv and read out.
  - The same dosimeters were irradiated to 2 mSv and read out.
  - The value E was determined for each dosimeter.
  - The mean value E and the standard deviation were calculated.
Energy response

- When irradiated with photons in the range: 15 keV – 3.0 MeV, the evaluated value shall not differ from the conventional true value by more than 30%.
- When irradiated with beta rays in the range ($E_{\text{max}}$) 0.5 MeV to 3.0 MeV, the response shall not vary by more than 30%.
Energy response

• Method
• Several dosimeters irradiated at the IAEA SSDL with the following radiation qualities: N-40, N-80, N-120, N-150, S-Cs, S-Co
Isotropy (Directional dependence)

- When irradiated in two perpendicular planes with photons of 
  $60 \pm 5$ keV, the mean value of the responses at an angle of incidence of $20^\circ$, $40^\circ$ and $60^\circ$ from normal shall not differ from the corresponding response for normal incidence by more than $15\%$. 

![Graph showing angular dependence at 65 keV](image-url)
Isotropy (Directional dependence)

- **Method:**
  - Radiation quality N-15 to N-300, S-Cs, S-Co
  - Dose range of 1-5 mSv and 5-10 mSv and
  - Angles of incidence: -30°, -45°, -60°, -70°, 0°, 30°, 45°, 60°, 70°
The evaluated values of dosimeters read out 24 h apart and 168 h apart shall not differ from each other by more than 5% and 10% respectively.

Test Method:
The reader stability is checked by quality control of the PMT noise, the reference light and the RCF behavior over the time.
Reader stability
Resume

- In this lecture we have discussed on how to:

  - Perform validation of external personal monitoring with TLDs/OSL Systems using published scientific and technical literature based parameters