ASSESSMENT OF OCCUPATIONAL EXPOSURE DUE TO INTERNAL RADIATION SOURCES

UNIT 7
INDIVIDUAL MONITORING PROGRAMMES
- INTERNAL EXPOSURES -
INDIVIDUAL MONITORING PROGRAMMES

LECTURE CONTENT

• OCCUPATIONAL INTERNAL DOSIMETRY.

• MONITORING INDIVIDUALS EXPOSED TO INTAKES OF RADIONUCLIDES AT THE WORKPLACE

• TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -
INDIVIDUAL MONITORING PROGRAMMES

- OCCUPATIONAL INTERNAL DOSIMETRY

✓ Objective: Assessment of Effective Dose $E$ (Sv) in a radiation protection frame to demonstrate compliance with dose limits, taking into account internal and external exposures:

$$E = H_{P}(10) + \sum_{j} I_{j, inh}e(g)_{j, inh} + \sum_{j} I_{j, ing}e(g)_{j, ing}$$

**DOSE OF RECORD:**

- $H_{P}(10)$ Sv External Exposures - Personal Dose Equivalent
- $E(50)$ Sv Internal Exposures – Committed Effective Dose
  - $I_{inh}$: Intake (Bq) by inhalation $I_{inh}$
  - $e(g)_{inh}$: dose coefficient SvBq$^{-1}$ – inhalation
  - $I_{ing}$: Intake (Bq) by ingestion
  - $e(g)_{ing}$: dose coefficient SvBq$^{-1}$ - ingestion

- $e(g)_{inh}, e(g)_{ing}$: Dose coefficients from ICRP OIR (Occupational Intakes of Radionuclides) Reports. Parts 1-5 (consistent with ICRP103 recommendations)
The doses due to intakes of radionuclides can not be measured directly but must be assessed from:

- In-vivo measurements of the retained activity $M(Bq)$ in total body or organs
- In-vitro measurements of the activity concentration in excreta samples $M(Bqd^{-1}, BqL^{-1})$
- Workplace monitoring - Activity concentration in the air $M(Bqm^{-3})$, in the working environment

Or by a combination of these methods

The interpretation of the monitoring data for the assessment of the Committed Effective Dose $E(50)$ Sv:

- requires the application of biokinetic and dosimetric models (ICRP Publications)
- the evaluator needs to know or to make assumptions about:
  - Type of intake (acute, chronic),
  - Pathway of intake (inhalation, ingestion, injection, absorption through intact skin or a wound)
  - Time of intake (elapsed time from the exposure and the measurement)
  - Physical (e.g. particle size) and chemical properties of internal contaminants (absorption type)
INDIVIDUAL MONITORING PROGRAMMES

• OCCUPATIONAL INTERNAL DOSIMETRY

✓ General Approach:
1. Characterization of internal exposure at the workplace
   - Information to be provided (e.g. by the Radiation Protection Officer)
2. Design of Individual Monitoring Programmes – internal exposures
   - Selection of the Monitoring Techniques + monitoring period
   - Selection of the workers to be included in the monitoring programmes

3. Individual Monitoring of workers:
   - Direct and Indirect techniques.
   - Identification and quantification of incorporated radionuclides.
   - Monitoring Data M(Bq), M(Bq d^{-1}, Bq L^{-1})

-4. Assessment of intake and committed effective dose E(50)
   - Interpretation of Monitoring Data
   - Step by step procedure: calculation of Intake I (Bq) and dose E(50) Sv
   - ICRP Dataviewer and available commercial software
OCCUPATIONAL INTERNAL DOSIMETRY

Characterization of internal exposure at WORKPLACE

- Radionuclides: Type of radiation α/β/γ, Energy, Ie, T_{1/2}, biokinetics (retention/excretion reference bioassay functions m(t) from ICRP/OIR Reports)

- Chemical compound of the radionuclide: Absorption Type in case of inhalation, depending e.g. on the solubility of inhaled material:
  - Type F (Fast) – Short time of the radionuclides in the lungs, fast absorption to the blood
  - Type M (Moderate) – Medium time in lungs
  - Type S (Slow) – Long time in lungs, slow absorption to the blood
  - Intermediate Type F/M and M/S materials (from ICRP/OIR Reports, e.g. Uranium in ICRP Publication 137)

- Particulate or vapour

- Particle size of the inhaled aerosol: AMAD, AMATD

  AMAD: Activity Median Aerodynamic Diameter of inhaled aerosol
  Default values: 5 μm (occupational exposures), 1 μm (public exposures)
INDIVIDUAL MONITORING PROGRAMMES

• OCCUPATIONAL INTERNAL DOSIMETRY

✓ Design of Individual monitoring programmes:
  - Selection of technique and monitoring period
    - In vivo and in vitro bioassay will allow:
      - Identification of radionuclides
      - Quantification in terms of activity $M$ (Bq) or activity concentration $M(Bq.d^{-1}, BqL^{-1})$
  - Identification of workers at risk of internal exposures at the workplace

ISO20553: The objective of the monitoring of workers exposed to a risk of internal contamination is to guarantee the detection of the Committed Effective Dose of 1 mSv/year due to internal exposures
INDIVIDUAL MONITORING PROGRAMMES

• MONITORING PROGRAMMES OF INDIVIDUALS EXPOSED TO INTAKES OF RADIONUCLIDES

✓ Important part of a radiation protection programme
✓ Implemented to verify that the worker is protected adequately against the risks from radionuclide intakes and that the protection complies with legal requirements. [ISO 20553]

✓ Factors which determine the need for a monitoring programme [ISO 20553]
  ▪ The magnitude of the likely exposure
  ▪ The need to recognize and evaluate events resulting in intakes of radionuclides
  ▪ The need to assess the effectiveness of protective equipment.
INDIVIDUAL MONITORING PROGRAMMES

• TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -

✓ Routine Monitoring - exposure situations with a possibility of accidental or chronic intakes.

✓ Special Monitoring - to better quantify significant exposures or following actual / suspected accidental intakes.

✓ Confirmatory Monitoring –
  to check assumptions when establishing a radiation protection programme.
  to check the effectiveness of protective measures or
  to confirm the level of exposure in a working environment.

✓ Task-Related Monitoring - specific operations of limited duration.

✓ Triage Monitoring – e.g. for short-lived radionuclides
**IDENTIFICATION OF WORKERS AT RISK OF INTERNAL EXPOSURES**

- **To identify** groups of workers that may have a risk of intakes of radionuclides from **normal operations**, 
  - Comparison with Reference Levels [ISO 20553] - **Recording Level** = 1 mSv/year
    - **If Likely annual dose** ≥ **Recording Level**:  
      - ROUTINE MONITORING
    - **If Likely annual dose** < **Recording Level**:  
      - CONFIRMATORY MONITORING

- **To identify workers involved** in **dedicated (singular) tasks with elevated risks of intakes of radionuclides**
  - TASK RELATED MONITORING

- **In case of incident/accident, suspected significant intake or unexpected exposure**:
  - SPECIAL MONITORING
• TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -

✓ Routine Monitoring - exposure situations with a possibility of accidental or chronic intakes

General Requirements [ISO 20553]

\[ e(50) \cdot \frac{DL}{m(\Delta t)} \cdot \frac{365}{\Delta T} \leq 1 \frac{mSv}{y} \]  

**Able to detect 1 mSv/y**

\[ \frac{m(\Delta T/2)}{m(\Delta T)} \leq 3 \]  

**Uncertainty less than factor of 3**

- A routine monitoring programme must be able to reliably detect all annual exposures that can exceed the recommended maximum recording level of 1 mSv/y;
- The uncertainties in the assessed doses resulting from an unknown time interval between intake and measurement are limited so that the maximum underestimate of the dose resulting from a single intake does not exceed a factor of three;
- At least two measurements must be performed in a year
INDIVIDUAL MONITORING PROGRAMMES

- TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -

- Routine Monitoring - exposure situations with a possibility of accidental or chronic intakes

  General Requirements [ISO 20553]
  Critical Value Mc [ISO 27048]

  - Assuming a single acute intake at the midpoint of the monitoring interval

\[
M_C = \frac{D_v \cdot m(\frac{\Delta T}{2})}{e(50)} \cdot \frac{\Delta T}{365}
\]

\(\Delta T\) monitoring interval (days)

\(D_v\): Doses lower than \(D_v\) (0.1 mSv) are discounted in the monitoring programme

\(m(\Delta T/2)\): value of the bioassay function at the time \(\Delta T/2\) after a unit intake

\(e(50)\) SvBq\(^{-1}\): dose coefficient (committed effective dose per unit intake)
INDIVIDUAL MONITORING PROGRAMMES

- **TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES**

  ✓ **Routine Monitoring** - Dose assessment

  ▪ If measurement value \( M(Bq, Bqd^{-1}, BqL^{-1}) < \text{Detection limit (DL)} \) or \(< \text{Critical value (Mc)} \):
    - To document that measurement has been performed and DL

  ▪ If measurement value \( M(Bq, Bqd^{-1}, BqL^{-1}) > \text{Mc} \):
    - **Initial Dose Assessment** using **standard assumptions**:
      - Acute Inhalation at midpoint of the monitoring interval
      - Using reference parameters of biokinetic models
        - \( \text{AMAD} = 5\mu m \)
        - Reference Absorption Type of Compounds at workplace
      - To document measurement, assessed dose and assumptions
        - Check if further assessment is required → **special monitoring**
INDIVIDUAL MONITORING PROGRAMMES

• TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -

✓ Special Monitoring

  ▪ To provide information for more accurate dose assessment
    o after a suspected or confirmed significant intake
  ▪ Measurements
    o Same methods as in routine monitoring
    o Monitoring interval of measurements is adapted to the intake scenario
    o Additional measurements (e.g. screening measurements, nasal swab) may be required
    o Minimum type of data required for dose assessment: IDEAS Guidelines
  ▪ Dose Assessment
INDIVIDUAL MONITORING PROGRAMMES

- TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -

 ✓ Triage Monitoring (e.g. exposures to short lived radionuclides)

  - ISO 16637 Radiological protection — Monitoring and internal dosimetry for staff members exposed to medical radionuclides as unsealed sources

     - Short lived Radionuclides of half-Lives < 8 days (\(^{131}\)I). Measurements using equipment available at workplace (e.g. contamination monitors) performed by workers
     - Define triage threshold values, using a 1 mSv/y decision threshold - given in the reading of the instruments (e.g. cps)
     - If measurement < triage threshold - to document measurement
     - If measurement > triage threshold - Initiate individual monitoring (→ special monitoring)
REFERENCES - UNIT 7 - INDIVIDUAL MONITORING PROGRAMMES


