IAEA
International Atomic Energy Agency
*Atoms for Peace and Development*

# 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:

**DOSE OF RECORD:**

$$E = H_P(10) + \sum_j I_{j,inh} e(g)_{j,inh} + \sum_j I_{j,ing} e(g)_{j,ing}$$

$H_P(10)$ 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)**

# INDIVIDUAL MONITORING PROGRAMMES

- **OCCUPATIONAL INTERNAL DOSIMETRY**

✓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($Bqd^{-1}$, $BqL^{-1}$)

-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

# INDIVIDUAL MONITORING PROGRAMMES

- **OCCUPATIONAL INTERNAL DOSIMETRY**

✓Characterization of internal exposure at WORKPLACE

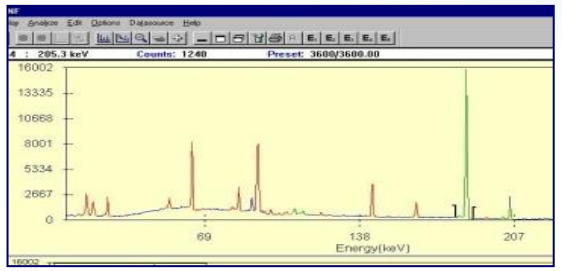
- Radionuclides: Type of radiation α/β/γ, Energy, Ie, $T_{1/2}$, biokinetics (retention/excretion reference bioassay functions m(t) from ICRP/OIR Reports)
- Chemical compound of the radionuclide: Absorption Type in case of inhalation, depending e.g. on the solubility of inhaled material:
  - Type F (Fast) – 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

# INDIVIDUAL MONITORING PROGRAMMES

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

✓ **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**

# 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]**

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

**Able to detect 1 mSv/y**

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

**Uncertainty less than factor of 3**

**DL** = Detection limit of measurement technique (Bq, $Bqd^{-1}$, $BqL^{-1}$)
**$\Delta$T (days)** = Monitoring Interval
**m(t)** = Retention/excretion function at t days after intake (OIR Reports)
**e(50)**= Dose Coefficient $SvBq^{-1}$

- 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

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

ΔT monitoring interval (days)

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

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

e(50) $SvBq^{-1}$: dose coefficient (committed effective dose perunit intake)

# INDIVIDUAL MONITORING PROGRAMMES

- **TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -**
  - ✓ **Routine Monitoring - Dose assessment**
    - **If measurement value M(Bq, $Bqd^{-1}$,$BqL^{-1}$) < Detection limit (DL) or < Critical value (Mc):**

      To document that measurement has been performed and DL
    - **If measurement value M(Bq, $Bqd^{-1}$,$BqL^{-1}$) > Mc:**

      Initial Dose Assessment using **standard assumptions:**
      - Acute Inhalation at midpoint of the monitoring interval
      - Using reference parameters of biokinetic models
        - ❖ AMAD = 5μm
        - ❖ 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
    - after a suspected or confirmed significant intake
  - Measurements
    - Same methods as in routine monitoring
    - Monitoring interval of measurements is adapted to the intake scenario
    - Additional measurements (e.g. screening measurements, nasal swab) may be required
    - Minimum type of data required for dose assessment: IDEAS Guidelines
  - Dose Assessment

# INDIVIDUAL MONITORING PROGRAMMES

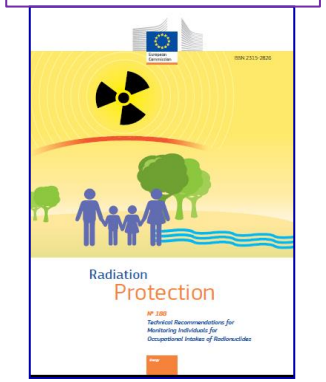
- **TYPES OF INDIVIDUAL MONITORING PROGRAMMES – INTERNAL EXPOSURES -**

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

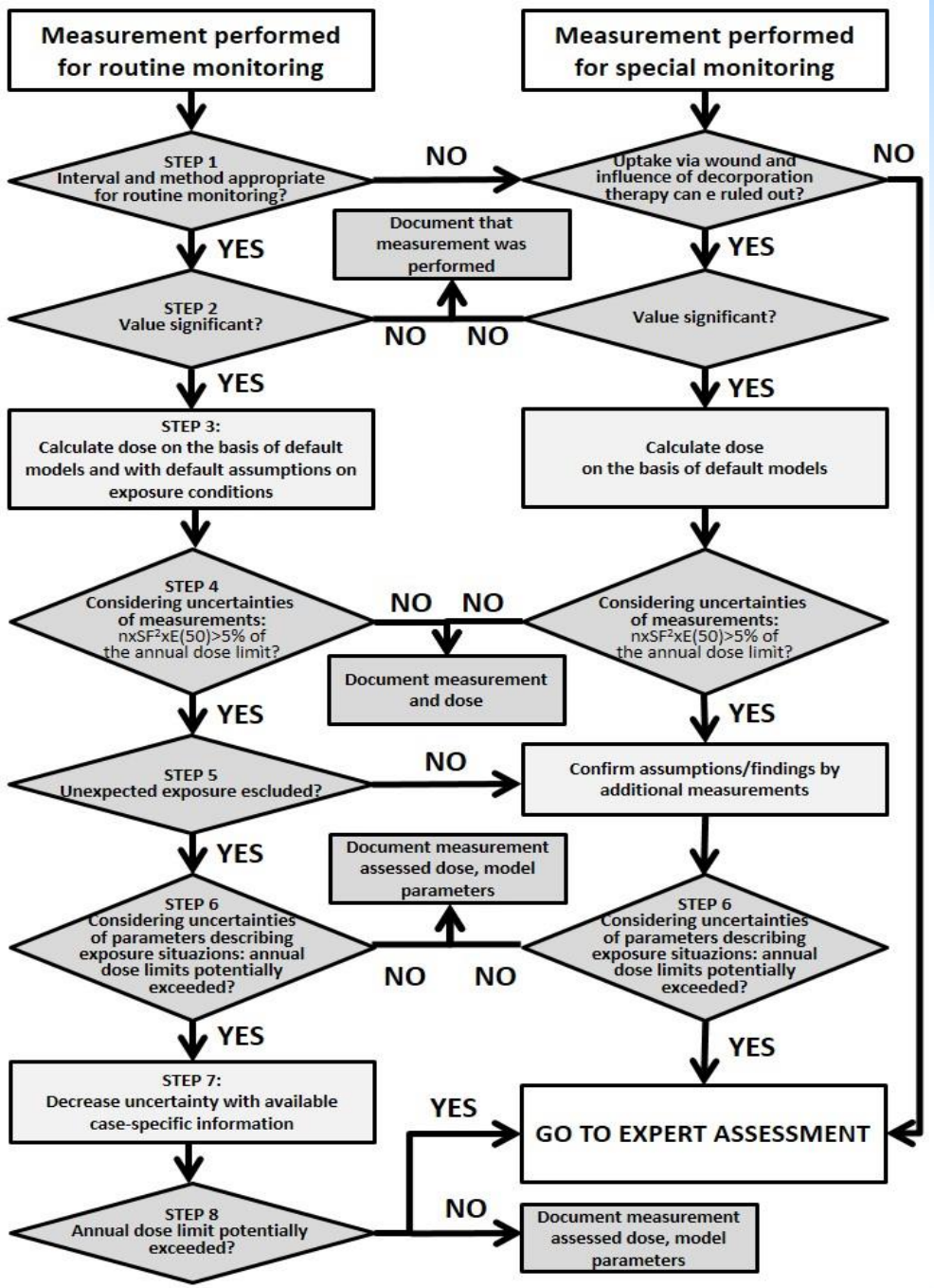
  - **ISO 16637 Radiological protection — Monitoring and internal dosimetry for staff members exposed to medical radionuclides as unsealed sources**

    - 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)

## EC RP 188




**ROUTINE MONITORING**




**SPECIAL MONITORING**

## EC RP 188

**EC Report 188** - Technical Recommendations for Monitoring Individuals for Occupational Intakes of Radionuclides **(ec.europa.eu/energy/sites/ener/files/rp_188.pdf )**

# REFERENCES - UNIT 7 - INDIVIDUAL MONITORING PROGRAMMES


EUROPEAN COMMISSION - RADIATION PROTECTION REPORT SERIES No.188 - Technical Recommendations for Monitoring Individuals for Occupational Intakes of Radionuclides (ec.europa.eu/energy/sites/ener/files/rp_188.pdf ). EC RP 188 (2018).

EUROPEAN RADIATION DOSIMETRY GROUP [EURADOS] - IDEAS Guidelines (Version 2) for the Estimation of Committed Doses from Incorporation Monitoring Data. EURADOS Report 2013-01 ISBN 978-3-943701-03-6 (2013).

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. RADIATION PROTECTION – *Monitoring of Workers Occupationally Exposed to a Risk of Internal Contamination with Radioactive Material*. ISO 20553:2006. (ISO:Geneva) (2006)

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