ONorm S 5223: Estimation of Dose Due to Work Activities Involving Materials Containing Naturally Occurring Radionuclides

A. Brandl, A. Hefner and the Members of Working Groups 11 and 17
of ON-Committee 088 at the Austrian Standards Institute

From Data to Dose

- **Scope of the standard**
  - Responsibilities
  - Work activities
- **Methodology and measurements**
  - Input data necessary
  - Relevant radionuclides
  - Design and measurement
- **Estimation of dose**
  - Effective dose and committed effective dose
  - Inhalation of aerosols
  - Radon
  - External exposure

Scope and Responsibilities I

- **Austrian legal framework**
  - Work activities involving naturally occurring radioactive materials explicitly included
  - Legal entity (person, company, etc.) required to perform dose assessment
  - For exposures due to ^{222}Rn, U, Th, or their decay products (with the exception of ^{222}Rn)

- **Relevant industries (as examples)**
  - ^{222}Rn: mining/caves including tourist attractions, tunnel construction, radon wellness and spas, water treatment facilities
  - U/Th: welding industry with thorium-rich electrodes, production and work involving Th gas glow devices, production of Th-enhanced metals, rare earths products

Scope and Responsibilities II

- **Definition of dose for assessment**
  - Effective dose
  - External and internal exposure
  - Sum of all exposure pathways

- **Scope and Purpose of the standard**
  - Methodology to estimate effective dose
  - To be used by employers and individuals performing work activities involving materials including naturally occurring radionuclides

General Methodology I

- **Three possible exposure pathways to be considered**
  - Effective dose due to external exposure
  - Committed effective dose due to incorporation (inhalation) of naturally occurring radioactive materials excluding radon
  - Effective dose due to inhalation of radon and progeny

- **External exposure**
  - Representative measurements of ambient dose rate at every work place
  - Average annual occupancy at work places for individuals
  - Sum of various work place contributions

General Methodology II

- **Committed effective dose to do incorporation**

  - Determination of activity concentration in process materials
  - Determination of dust and aerosol concentrations in ambient air at the work places
  - Average annual occupancy at work places, annual intake by inhalation, dose calculation
  - Conservative parameters to be used: consideration only of process material which, if sole contributor, would result in highest dose given the intake estimates
  - To verify conservative approach: at least one air filter measurement for radiological characterization to be performed, comparison with activity concentration in process materials
  - Chemical analysis possible, if sufficient stable isotopes present

Assessment Design and Measurements I

- **Measurement plan, information requirements**
  - Operational working procedures and processes
  - Materials balance (type and amounts of process materials)
  - Work places and tools and machines
  - Possible exposure pathways and work routines for individuals
  - Analysis of processes determines measurement methodology and intervals
- **Determination of activity concentration in process materials**
  - Representative sampling, possible parameter shifts to be evaluated
  - Gamma spectrometry, alpha spectrometry, liquid scintillation counters, mass spectrometry

Assessment Design and Measurements II

- **Air sampling**
  - Representative for individual workers
  - Stationary or personal air samplers
  - Measurement of dust and aerosol mass

- **Effective Dose due to external Exposure**
  - H_p (10) or H* (10)
  - H_p (10): personal dosimeter, direct estimate of effective dose
  - H* (10): ambient dose rate, to be multiplied by time of occupancy

Dose Assessment I

- Total effective dose
  - Sum of the three exposure pathways

$$E = E_{ext} + E_{inc} + E_{Rn}$$

- External exposure

$$E_{ext} = \sum_j \dot{H}_j^*(10) \cdot T_j$$

- Inhalation of aerosols
  - Determination of intake
  - Committed effective dose

$$E_{inc} = \sum_j \mathrm{I}_j \cdot e_j(50)$$

Dose Assessment II

- Intake I_j $$I_j = \frac{C_j \cdot m}{V} \cdot B \cdot T_j$$

- C_j … activity concentration in process materials with highest dose relevance
  m … mass of aerosol deposited on air sampler filter
  V … air volume through filter
  B … average intake of air volume (~ 1.2 m³/h)

- Parameters to be considered
  - Sampling during operational periods
  - Usual operations including technical and personal protective measures
  - Seasonal variations in processes and aerosol concentrations
  - Filter capacity of aerosol samplers

Dose Assessment III

- Radon

  - For F ~ 0,4 $$E_{Rn} = 3{,}11 \cdot \sum_i C_{Rn,i} \cdot T_i$$

  - For F ~ 0,2 $$E_{Rn} = 1{,}56 \cdot \sum_i C_{Rn,i} \cdot T_i$$

  - For F ~ 0,7 $$E_{Rn} = 6{,}62 \cdot \sum_i C_{Rn,i} \cdot T_i$$

  - If potential alpha energy concentration is measured $$E_{Rn} = 1{,}4 \cdot \sum_i PAEC_i \cdot T_i$$

Conclusions

- National standard ONorm S 5223
  - Provides tools for dose assessment as required by national legislation
  - Basis for accreditation or certification by Competent Authority

- Three exposure pathways
  - Ambient gamma radiation
  - Inhalation of aerosols
  - Radon and progeny

- Responsibility of operator
  - Examples of relevant industries, no comprehensive list
  - Further regulation by national laws (drafts completed)