NORM INDUSTRIES
Planned Exposure Situations

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Public Health England
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- Research into radiation effects
- Advisor to UK government
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- Technical services

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Basic Safety Standards: rule of 3

- 3 Basic Principles
  - Justification
  - Optimization
  - Dose Limits
- 3 Exposure Situations
  - Planned (184 paragraphs)
  - Emergency (21 paragraphs)
  - Existing (33 paragraphs)
- 3 Types of exposed person
  - Workers
  - Public
  - Patients
# BSS and NORM
## Exposure Situations, Persons and Principles

<table>
<thead>
<tr>
<th>Exposure Situation</th>
<th>Exposed persons</th>
<th>Basic principles</th>
<th>Dose Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Workers</td>
<td>Public</td>
<td>Just.</td>
</tr>
<tr>
<td>Planned</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Existing</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

- Workers: YES
- Public: YES
- Just.: YES
- Optimisation: YES Dose Constraints
- Dose Limits: Workers and public
- Reference Levels: NO
## NORM: Planned or Existing Exposure Situation?

<table>
<thead>
<tr>
<th>Existing Exposure Situations</th>
<th>Exceptions - subject to the requirements for Planned ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure to residual radioactive material from unregulated or inadequately regulated past activities</td>
<td>No exceptions</td>
</tr>
<tr>
<td>Exposure to radionuclides in everyday commodities, e.g. food, feed, drinking water, fertilizer, soil amendments, construction materials</td>
<td>No exceptions</td>
</tr>
<tr>
<td>Exposure to radionuclides in material other than everyday commodities</td>
<td>Where activity concentration exceeds:</td>
</tr>
<tr>
<td>eg NORM industries</td>
<td>- 1 Bq/g (U, Th series) or</td>
</tr>
<tr>
<td>• Minerals</td>
<td>- 10 Bq/g ($^{40}$K)</td>
</tr>
<tr>
<td>• Metals</td>
<td>and</td>
</tr>
<tr>
<td>• Oil and gas</td>
<td><strong>Public exposure to discharges and waste (irrespective of activity concentration)</strong></td>
</tr>
<tr>
<td>• etc</td>
<td></td>
</tr>
</tbody>
</table>
Exposure to radon is subject to the requirements for existing exposure situations: A reference level is set, above which it is not appropriate to plan to allow exposures to occur — maximum 1000 Bq/m$^3$.

However, Occupational exposure to radon is subject to regulation according to the applicable requirements for planned exposure situations if:

- Exposure to other U, Th series radionuclides is already controlled as a planned ES, or
- After remedial action, the radon concentration remains above the reference level, e.g. underground mining of non-radioactive ores.
PLANNED EXPOSURE SITUATIONS: Exemption and Clearance

EXEMPTION

• Government or Regulatory Body
  • Determine which practices or sources are exempt
  • Determine exemption from which BSS requirements
    • including notification, registration or licensing
    • Requires a graded approach

CLEARANCE

• Regulatory Body
  • Approve which sources/materials/objects may be cleared
  • Ensure they do not become controlled again

Exemption and Clearance criteria in BSS Schedule 1
# Exemption and Clearance
## BSS Schedule 1: summary

<table>
<thead>
<tr>
<th>Source/material</th>
<th>Exemption</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>All artificial sources</td>
<td>&lt;10 µSv/y</td>
<td>&lt; 1 Bq/g (U and Th)</td>
</tr>
<tr>
<td></td>
<td>&lt;1 mSv/y (low probability)</td>
<td>&lt;10 Bq/g (K-40)</td>
</tr>
<tr>
<td>Bulk NORM</td>
<td>&lt; 1 mSv/y</td>
<td>For <strong>construction materials</strong> and <strong>water contamination</strong>:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>derive clearance levels (Bq/g) based on 1 mSv/y</td>
</tr>
<tr>
<td>“Modest quantities” Artificial</td>
<td>Table I-1</td>
<td></td>
</tr>
<tr>
<td>and NORM</td>
<td>Total activity (Bq)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Activity conc (Bq/g)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Typically 10 Bq/g for NORM</td>
<td></td>
</tr>
<tr>
<td>radionuclides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Graded Approach to Regulation

“Requirement 6: application of the requirements for planned ES…shall be commensurate with the characteristics of the practice…and magnitude of exposures..”

Graded Approach - after taking existing industrial hygiene controls into account...

1. EXEMPTION
   • Doses < 1 mSv, no need to regulate

2. NOTIFICATION
   • Dose slightly above 1 mSv, but no additional controls required

3. NOTIFICATION and REGISTRATION
   • Doses above 1 mSv, some simple additional controls needed

4. NOTIFICATION and LICENSING
   • Doses >> 1 mSv and specific additional controls needed to restrict exposure of workers and/or public (e.g. discharges)
NORM: CRITERIA FOR REGULATORY CONTROL?

1. Activity concentration
   • exposure situation (both require control)
   • exemption of modest quantities
   • clearance of bulk NORM

2. Annual doses
   • exemption of bulk NORM
   • clearance of construction materials and water contamination

3. List of NORM industries (“the positive list”)  

4. Also (BSS):
   • Public exposures from NORM waste discharges = Planned ES
   • NORM in food, water, fertiliser, construction materials and existing residues = Existing ES requiring control
The “positive” list
IAEA Safety Series Report 49

Apply regulation based on **INDUSTRY TYPE**

(1) Extraction of rare earth elements
(2) Production and use of thorium and its compounds
(3) Production of niobium and ferro-niobium
(4) Mining of ores other than uranium ore
(5) Production of oil and gas
(6) Manufacture of titanium dioxide pigments
(7) The phosphate industry
(8) The zircon and zirconia industries
(9) Production of tin, copper, aluminium, iron, steel, zinc and lead
(10) Combustion of coal
(11) Water treatment
Industry-specific safety reports

- Radiation Protection and NORM Residue Management in 
  - **Titanium Dioxide** and Related Industries, SRS No. 76, 2012
  - Production of **Rare Earths** from Thorium containing Minerals, SRS No. 68, 2011.
  - **Zircon and Zirconia** Industries, SRS No. 51, 2007
  - **Oil and Gas** Industry, SRS No. 34, 2003

- Radiation Protection against Radon in **Workplaces other than Mines**, SRS No. 33, 2003
- Monitoring and Surveillance of Residues from the **Mining and Milling of Uranium and Thorium**, SRS No. 27, 2002
Need to consider:

- Inputs - feed materials
- Outputs - products and intermediates for re-use
- Outputs - wastes
- Enhancement due to physical, chemical and thermal processes
  - Filtrates, sludges, scales and other surface deposits
  - Gas exhaust, treatment and collection systems

For example:

- Oil extraction: scales up to 15,000 Bq/g Ra-226/228
- Gas extraction: thin surface deposits up to 3,000 Bq/g Pb-210
- Zirconia (chemical production): up to 5,000 Bq/g Ra-226 in ion exchange plant
- Furnaces: up to 600 Bq/g Pb-210 in deposits and gas cleaning systems
- Titanium dioxide: up to 400 Bq/g in filters
NORM: exposure situations and (regulatory) controls

Controlling exposures from NORM

Past practices
Existing ES

Building materials
Existing ES

Other NORM < 1 Bq/g
Existing ES

Planned ES
Exposures in a practice using > 1 Bq/g U/Th
Public exposures to discharges and waste

>1 mSv/y
Regulation
Graded Approach

< 1 mSv
EXEMPTION

< 1 Bq/g
CLEARANCE
BSS Requirements for Planned Exposure Situations (NORM)
BSS requirements for Planned ES
Government or Regulatory Body

- Establish responsibilities
  - Registrants, licensees, suppliers, etc.
- Set and enforce dose limits
- Enforce optimization
- Establish or approve dose constraints (or approve the process), taking account of:
  - Source characteristics
  - Good practice for similar sources
  - Total public dose from all authorised practices
  - Views of interested parties
- Review safety assessment prior to authorization
- Establish or approve discharge limits
NORM: Planned Exposure Situations Optimization: Dose Constraints

- Dose constraints are NOT LIMITS
  - Doses above DC: may initiate action to reduce doses
  - Doses below DC: apply optimization
- Source-related (workers) or site-related (public)
- Prospective – set before exposures take place
- For workers
  - Set by Regulatory Body or licensees (1 - 20 mSv/y)
  - RB to establish/approve DCs or the process for DCs
- For public
  - Set by Government/Regulatory Body (0 - 1 mSv/y)
Assessing NORM worker doses

- To determine whether exempt (planned ES)
- To compare against dose limits
- To help set dose constraints
- To identify patterns of exposure, and aid optimisation

Avoid pessimistic models, Use workplace measurements and data where possible
Assessing external doses

• Dose rates can initially be estimated from Bq/g
• Better dose estimates from dose rate monitoring and survey of work patterns
• Best dose estimates are from personal monitoring
  • Passive (TLD)
  • Electronic (best method)
• Measured doses are always lower than estimated doses
Exposures from dust inhalation

In some workplaces dust inhalation is NOT an issue, eg:

• Solid, wet, non-dispersible materials
• NORM contained within plant or containers
• Existing dust control measures are effective

In other workplaces, e.g. processing of fine sands and minerals

• High levels of airborne dust (>> 5 mg/m³) which is 100% NORM
• High worker occupancy
• Limited/poor use of RPE
Assessment of inhalation doses

In practice
• Use existing dust surveys, if available
• Use “total dust” – closest to ICRP
• Can use gravimetric analysis
  • If close to 100% NORM
• Or use XRF or radiometric
• Particle size measurements
  • If very different to 5 µm
• Decide on Lung Class
  • Often insoluble (Type S)
• Take realistic account of RPE
Other internal exposures from NORM

INGESTION: doses normally very low
- At low Bq/g, large quantities need to be ingested
- Good industrial hygiene prevents ingestion
  - Gloves, washing and changing
  - No eating, drinking, etc.

CUTS AND WOUNDS
- doses also normally low
- Can potentially be significant at high Bq/g
Typical dose assessment results for bulk NORM processing plants

<table>
<thead>
<tr>
<th>Exposure Pathway</th>
<th>Estimated Annual dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>External (gamma)</td>
<td>&lt;0.2 – 5</td>
</tr>
<tr>
<td>Inhalation of dust</td>
<td>&lt;0.2 – 5</td>
</tr>
<tr>
<td>Ingestion</td>
<td>negligible</td>
</tr>
<tr>
<td>Radon</td>
<td>?</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>&lt;0.2 – 10?</td>
</tr>
</tbody>
</table>

Doses must be measured or **realistically estimated**
- Many results well below 1 mSv
- But significant numbers close to 1 mSv
- Results above 6 mSv are rare (if estimated properly)
  - especially in well-managed installations
Application of BSS requirements for Planned ES - Optimization

- Dose constraints
  - Workers: likely to be at lower end of 1 – 20 mSv/y?
  - Public: 0.3 mSv/y for discharges/waste
    - Can be a significant problem with old industries
- Optimization in Practice: requires an integrated and pragmatic approach
  - External radiation:
    - location of bulk stores, working patterns
    - Shielding rarely required
  - Internal radiation
    - Control of dust by good engineering and maintenance
    - Good working procedures, cleaning regimes
    - PPE, training, washing and changing, etc.
Application of BSS for Planned ES - specific requirements (1)

- Safety assessment (dose estimates)
  - Take account of existing controls
  - Determine additional (radiological) controls for NORM
- Good engineering practice
  - Control of airborne dust
  - Difficult for old industries with bulk NORM
  - Requires regular inspection and maintenance
- Requirements for radioactive sources
  - Source inventory is normally based on processing records
  - “Marking and labelling” often difficult - or even impractical
  - Need a sensible approach to “loss” and “spills”
Application of BSS for Planned ES - specific requirements (2)

• Classification of areas:
  • Controlled Areas: where specific additional controls are needed (eg RPE, entry/exit controls)
  • Supervised Areas: always required where NORM is treated as a (non-exempt) Planned ES?

• Local rules

• Monitoring occupational exposures/health surveillance
  • Required only in certain NORM industries, where significant doses are predicted by the safety assessment
  • Specific studies or trials may be more useful

• Information, Instruction and Training
  • Very important to develop a suitable NORM safety culture
Discharges
Registrants/licensees

- When applying for an authorization for discharges:
  - Determine activity and characteristics of waste
  - Specify discharge points and methods
  - Determine all significant public exposure pathways
  - Assess dose to representative person
    - To compare with dose constraint
  - Consider integrated environmental impacts
- Submit the information to Regulatory Body
  - RB reviews (inspects) and issues authorization
  - RB sets discharge limits and other conditions
Public dose assessment methods

IAEA Safety Report Series No.19

- Screening levels for discharges
- Atmospheric dispersion
- Aquatic dispersion (surface and coastal)
- Terrestrial and aquatic food chains
- Dosimetric and habit data
- Estimation of collective dose
- Iterative approach
  - Screening
  - Generic modelling
  - Site-specific modelling

MODELLING SOFTWARE

- CROM (Spain, IAEA SRS 19)
- PC-CREAM (UK, EC RP72)
Regulatory control of discharges

IAEA Publications

• “Regulatory Control of Radioactive Discharges to the Environment.” IAEA Safety Standards Series WS-G-2.3
• “Setting Authorized Limits for Radioactive Discharges: Practical Issues to Consider” IAEA-TECDOC-1638

• Currently being revised
Management of NORM residues: use, recycling and disposal

- BSS requires minimisation of waste
- Some NORM residues are produced in very large quantities
  - often with low NORM content (but other hazards)
  - increasingly recognised as a resource
- Need to re-use with care
  - May produce the largest collective dose in the NORM life-cycle – especially building materials
- Final disposal option is required for some NORM residues
  - $< 1 \text{ Bq/g}$ (or higher?): normal disposal (clearance)
  - Higher activity concentrations: hazardous waste sites
  - High activity concentrations: specialised disposal facilities
- Dilution \textbf{may} be an option
NORM Planned Exposure Situations
BSS: Implementation Issues

- Exposure situations
  - Planned or Existing? Does it matter?
- Establishing a system for NORM exemption and clearance
  - Defining “Moderate” and “Bulk” quantities
  - Application to liquids and gases?
  - Exemption conditions
- Applying a graded approach to regulation of NORM
  - And be practicable for NORM industries
- Optimisation
  - Setting dose constraints
  - Optimising below dose constraints
Other NORM issues

Use of activity concentration reference levels

• 1 Bq/g is **NOT** a limit
• Does not apply to everything - too restrictive in many cases

Future needs

• Better NORM residue management
• More disposal options for NORM waste
• More training of NORM workers
Thank you for your attention

*Merci pour votre attention*

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