Impacts of Standards on Mining and Processing of Minerals Containing NORM

Session 3: Optimization of Protection and Safety Activities involving Occupational Exposure to NORM

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Aims of Presentation

• Provide practical perspective
• Broad observations on radiation protection
• What the standards say and what this means in practice
• Share some real world examples
• Provide some thoughts and practical suggestions
Minerals Mining and Processing

All pictures from internet
Existing Operations Characteristics

- Well defined operating parameters
- High capital investment – requires servicing
- Operating cost control
- Productivity improvements
- Retrofitting difficult to justify
- Additional requirements result in additional cost
New Project Characteristics

• Project development (5-25 years)

• Up to 5 years for project approval

• Approval processes can be open ended

• Costs $500m - $10b

• Financing difficult - assurance on investment returns

• A very fine balance to get new projects up and running
The “Twilight Zone”
The “Twilight Zone”

Where you don’t know you have radioactivity

or

When you don’t want to have radioactivity
The “Twilight Zone”

Where you don’t know you have radioactivity

or

When you don’t want to have radioactivity

0.5Bq/g to 5Bq/g

Uranium 40 to 400ppm, Thorium 120 to 1,200ppm

Industries Containing NORM
Sectors Impacted

• Almost any metal deposit that contains elevated U or Th

• Base metals through to exotics

• Any processing facility that treats metal ores
  – Concentrators (sulphides, oxides)
  – Smelters / refineries

• Processes that involve bulk storage or movement of materials

• Processes that handle products and wastes from these processes
3. INDUSTRIAL ACTIVITIES MOST LIKELY TO REQUIRE REGULATORY CONSIDERATION

3.1. Industry sectors
3.1.1. Extraction of rare earth elements
3.1.2. Production and use of thorium and its compounds
3.1.3. Production of niobium and ferro-niobium
3.1.4. Mining of ores other than uranium ore
3.1.5. Production of oil and gas
3.1.6. Manufacture of titanium dioxide pigments
3.1.7. The phosphate industry
3.1.8. The zircon and zirconia industries
3.1.9. Production of tin, copper, aluminium, zinc, lead, and iron and steel
3.1.10. Combustion of coal
3.1.11. Water treatment

3.2. Materials

3.4. Exposure due to natural sources is, in general, considered an existing exposure situation and is subject to the requirements in Section 5. However, the relevant requirements in Section 3 for planned exposure situations apply to:

(a) Exposure due to material in any practice specified in para. 3.1 where the activity concentration in the material of any radionuclide in the uranium decay chain or the thorium decay chain is greater than 1 Bq/g or the activity concentration of $^{40}$K is greater than 10 Bq/g;
1Bq/g

- The concentration of U and Th radionuclides at which a material is defined as “radioactive”
- Below this;
  - “Risks so low as to not warrant regulatory control....”
  - Automatic exemption for moderate quantities of materials
- Above this;
  - Material is labelled as “radioactive”
  - Regulated (graded approach)
  - Dose criterion of 1mSv/y
In Theory - If Material is > 1Bq/g?

Apply a “graded approach” to regulation

1. Exemption (decision not to regulate)
   - Dose < 1mSv/y

2. Notification (similar to exemption but regulator stays informed)
   - Dose < 1mSv/y

3. Notification and registration

4. Notification and licencing
In Practice - If Material is >1Bq/g?

- Exemption mechanisms appear in national regulations - but are seldom applied

- Reasons;
  - Difficulty in conducting dose/risk assessments
  - Difficulty in assessing the dose/risk assessments
  - Reluctance to grant exemption
    - precautionary approach,
    - regulatory conservatism or
    - public concern
  - Once defined as radioactive, the label is difficult to remove
  - 1Bq/g is a clear unambiguous trigger

- No uniformity across national boundaries
In Practice

1Bq/g is........

The cut off that defines a material as being radioactive

and

A defacto “limit”
Examples

Where principles and practice diverge
Example 1

The Radiation “Haves” and “Have Nots”
Context

Radiation is a complicated area

International frameworks on protection

Systems of dose limitation

Sophisticated biological, physical and impact assessment models

Principles underpinned by the science

Ongoing research, peer review and knowledge

Usually good at putting the principles into practice
However.... Some Observations

• Uranium mining

• Mineral sands

• Rare earths

• Other mining/processing (base metals, precious metals, coal etc)
However…. Some Observations

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Number of Operations
However.... Some Observations

• Uranium mining

• Mineral sands

• Rare earths

• Other mining/processing (base metals, precious metals, coal etc)

Number of Operations

Radiation Protection Expertise
Capabilities

Familiar companies and regulators

- Radiation protection culture is mature
- Broad organisational common understanding
- Technical competency
- Internal capacity/capability
- Developed over many years
- Understand regulations
- Understand perspective
## Capabilities

<table>
<thead>
<tr>
<th>Familiar companies and regulators</th>
<th>Unfamiliar companies and regulators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation protection culture is mature</td>
<td>General OHS culture</td>
</tr>
<tr>
<td>Broad organisational common understanding</td>
<td>Limited internal competence</td>
</tr>
<tr>
<td>Technical competency</td>
<td>Limited regulatory competence</td>
</tr>
<tr>
<td>Internal capacity/capability</td>
<td>Approach is very conservative</td>
</tr>
<tr>
<td>Developed over many years</td>
<td>Advice from various sources (sometimes competing)</td>
</tr>
<tr>
<td>Understand regulations</td>
<td>“Fear” of radioactivity</td>
</tr>
<tr>
<td>Understand perspective</td>
<td>“Fear” of regulation</td>
</tr>
</tbody>
</table>
Difficult Questions

• Are workers, the public and the environment safe?

• Is my material dangerous?

• Why is my material defined as radioactive?

• What does “radioactive” mean?

• Does a lowering of the standard meaning that my material is more dangerous?

• What do you mean by ingrowth, decay, half life, non human biota, dose modelling, mobilisation?
Practical Suggestions – Develop Capacity

- No proprietary information when it comes to OHS
- Radiation mentoring
- Experienced professionals assisting and coaching
- Models exist in other areas
- Build competence and confidence
Example 2

Perception is Everything
The “Radiation” Word

- Word causes immediate concern
- Unclear whether material is dangerous or not
- Materials are “seen” differently (by producer and customer)
- Added requirements on producer and customers
- Everyone is cautious and conservative and nervous
- No difference between NORM, radioactive and nuclear
- Potential project killers
'Uranium dust' from Yorke Peninsula Hillside mine could contaminate crops, campaigners say

By Malcolm Sutton
Updated yesterday at 12:08pm

Key points
- Rex Minerals to store 57ppm uranium
- Safe guidelines to be reduced to 80ppm
Denial of Shipment

- Customs requirements – based on 1Bq/g
- Initial gamma check – trigger is 400nSv/h

- If triggered, material is impounded and sample sent for analysis
  - Material < 1Bq/g – OK
  - Material > 1Bq/g – Not OK

- If not OK
  - Shipment reloaded and returned

“We know that it is dangerous above 400nSv/h”
Progress on the calculation of **dose coefficients** was reviewed, in particular for exposure to **radon-222** and progeny. There is a remarkable consistency between radon dose coefficients obtained by dosimetric calculations and conversion coefficients based on epidemiological comparisons. **In an upcoming publication, the Commission intends to recommend a single coefficient for use in most circumstances, with a value of 12 mSv/WLM (3.4 mSv per mJ h m⁻³).** Additional data will be provided for circumstances significantly divergent from typical conditions where sufficient and reliable information is available to support an adjustment.
Nuclear, Radioactive and NORM

- The words can be used interchangeably
- The words are being forced to mean the same thing
- Reinforced in some legislation AND the way we treat it
- Completely separate NORM activities from nuclear activities in legislation
Suggestions - Perception

• When we increase control we make radiation look more dangerous

• Develop clear and simple messages that we all agree on

• Cost effective screening monitoring;
  – Provides confidence that levels are being checked
  – Avoids unjustified expensive monitoring

• Avoid mixed messages
  – “doses are low but you still need to calculate them”

• Language must be precise
Example 3

Risk Inequality
Occupational Exposure During Smelting of Copper

All pictures from internet
Occupational Exposure During Smelter Tapping

- Copper concentrate feed containing above 1 Bq/g of Po$^{210}$, Pb$^{210}$
- Smelting volatilises radionuclides – released during tapping
- Authority contracted to assess inhalation doses;
  - Workplace and personal measurements over a week
  - Mass and activity concentrations
  - Radionuclide content determined
- Results
  - Average dust/fumes concentrations of 20mg/m$^3$
  - Annual inhalation dose calculated to be approximately 5mSv/y
- Advice was to limit radionuclides in feed
Occupational Exposure During Smelter Tapping

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• Results
  – Average dust/fumes concentrations of 20mg/m$^3$
  – Worked out that gives about 5mSv/y

• Advice was to limit radionuclides in feed

The TLV for Copper fume level is 0.5mg/m$^3$
Suggestions

• “One of a number of workplace hazards”

• Incorporate into safety management plan (for NORM)

• No real need for a standalone RMP (that may consume a lot of attention)

• Drives general safety improvements

• Simple assessment and monitoring tools

• Hand in hand with developing capacity
Example 4

Does This Cost?
What Does Radioactivity Look Like?

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Activity (Bq/g)</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{238}U$</td>
<td>1</td>
<td>80ppm</td>
</tr>
<tr>
<td>$^{234}U$</td>
<td>1</td>
<td>4.1ppb</td>
</tr>
<tr>
<td>$^{230}Th$</td>
<td>1</td>
<td>1.5ppb</td>
</tr>
<tr>
<td>$^{226}Ra$</td>
<td>1</td>
<td>30ppt</td>
</tr>
<tr>
<td>$^{210}Po$</td>
<td>1</td>
<td>7ppq</td>
</tr>
<tr>
<td>$^{210}Pb$</td>
<td>1</td>
<td>0.4ppt</td>
</tr>
</tbody>
</table>

These are really low levels!

Technologically quite difficult to remove.
Direct Cost Impacts

- $100’s million to reduce product from 2Bq/g to 1Bq/g
- $10’s million for tailings lining and underdrainage systems
- Penalties / increased treatment charges
- Approval delays
- Operational constraints (monitoring, external scrutiny, regulations)
- Material considered to be inferior (loses value)
- Specialist waste disposal
Unfortunately No Suggestions

• Ultimately, it all just costs more

• Companies forging ahead and spending the money

• Considered to be the price of compliance

• The price of demonstrating safety (from company and regulators perspective)
Conclusions

• Radiation is complex, confusing and contradictory

• One of a number of hazards (and not the most important)

• NORM requires a much broader understanding of radiation and its impacts

• Understand how policy is implemented in practice - graded approaches collapse to pure compliance

• Communication, education and simplicity

• Stop sending the wrong message for low risks

• It is OK to say something is safe and exempt it, but need the tools to do so