Advances in NORM Management in Norway and the Application of the ICRP Publication 103 Recommendations

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www.nrpa.no
NORM industries in Norway

- Oil and gas production
- TiO$_2$ pigment production
- Production of phosphate fertilisers
- Cement production, maintenance of clinker ovens
- Primary iron production,
- Tin/lead/copper smelting,
- Mining of ores (other than uranium)
Oil and gas industry – discharges and waste I

- **Scaling**
  - Ra co-precipitates with BaSO$_4$
  - Pipes cleaned either onshore or offshore
  - Activity concentrations of Ra-226 <1 to ~ 100 Bq/g

- **Contaminated equipment other than pipelines**

Examples of Heavy Scaling within Oil Production Pipelines (Statoil)

Filters with NORM from gas extraction. Radioactive and pyrophoric material
Produced water
• Discharges (162 mill m\(^3\) in 2007)
• Reinjection (27 mill. m\(^3\) in 2007)
• Industry obliged to study possible purification technology offshore (BAT)

OSPAR goal:
• Substantial and progressive reduction in discharges
• Concentrations in the environment near background values for NORM
New legislation from 1 January 2011 where radioactive discharges and waste are regulated under the Pollution Control Act

*Pollution Control Act (administered originally by the Climate and Pollution agency)*

- Regulations on pollution control
- Regulations on the recycling of waste
- Regulations on the application of the Pollution Control Act on radioactive pollution and radioactive waste

*The purpose of the Pollution Control Act is to “protect the environment from future pollution, reduce existing pollution, reduce the amount of waste and promote better waste handling”*
Implications of the new legislation I

- Radioactive discharges and radioactive waste is regulated under the same legislation as contaminant discharges and hazardous waste
- Situations where the content of NORM has been enhanced due to human activities is included
- Pollution is illegal (both discharges and waste dispersal) and practices must have a licence for discharges
- All hazardous and/or radioactive waste must be handled safely and practices must have a licence for waste handling
Implications of the new legislation II

- A set of activity levels is defined for when material is considered radioactive waste, when waste is subject to obligatory final disposal and when radioactive discharges require a licence.

- Examples for Ra-226:
  - Waste with specific activity $< 1$ Bq/g is not regulated as radioactive waste.
  - Waste with specific activity $\geq 10$ Bq/g and total activity $\geq 10,000$ Bq is subject to obligatory final disposal.
  - Discharges requires a licence if the specific activity is $\geq 1$ Bq/g or total activity is $\geq 1000$ Bq.
Radioactive Waste

• Three tier approach

<table>
<thead>
<tr>
<th>Activity concentration</th>
<th>Waste has to be sent to a final repository</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Waste which is only radioactive can be sent for disposal at a facility with a license from NRPA</td>
</tr>
<tr>
<td>1</td>
<td>Waste which is also classified as hazardous can be sent for disposal at a facility with license for hazardous or radioactive waste</td>
</tr>
<tr>
<td>0</td>
<td>Waste is not regulated as radioactive waste</td>
</tr>
</tbody>
</table>

E.g. Ra-226 (Bq/g)
Radioactive and hazardous waste I

- NORM waste is often also classified as hazardous waste
  - Heavy metals, hydrocarbons, chemicals etc.

- Requirements in the new legislation are similar for hazardous waste and radioactive waste:
  - Duty to declare and a duty to deliver radioactive waste to authorised companies at least once a year
  - License requirement for companies who handle radioactive waste and an annual report to NRPA
  - Requirement of justifiable waste management
Radioactive and hazardous waste II

• Radioactive waste has to be declared
  – Common form with hazardous waste,
  – Easier for the industry and better overall information to the authorities

• European waste list for hazardous waste + Norwegian waste category number
  – Specifies what is hazardous AND radioactive waste
  – Specifies what is ONLY radioactive waste
  – Specifies different types of ONLY hazardous waste
Waste Repository Gulen – purpose built for NORM waste from the oil and gas industry, 2008

• Authorized by the Norwegian Radiation Protection Authority and the Climate and Pollution Agency
• Authorized for radioactive waste from the petroleum industry at the Norwegian Continental shelf

• Disposal here mandatory when ≥ 10 Bq/g for Ra-226/228, Po-210

• Private company run the repository
  – Fund for closure and post closure remediation

• State guarantee from the Ministry of Petroleum and Energy
  – Fund in case the company is no longer able to run the repository
Waste Repository Gulen

- Waste arrives in HDPE drums in containers
- Excess water removed and void space filled with gravel or oil absorbent material
- Moved to the repository tunnel and grouted into concrete blocks
- Capacity 6000 tons, 570 tons disposed here so far
- Estimated 50 tons/year
Waste Repository NOAH - receives NORM waste and Hazardous waste

• Authorized by the Climate and Pollution Agency and the Norwegian Radiation Protection Authority

• Main repository for hazardous waste in Norway

• Receives and treats NORM waste (1-10 Bq/g), hazardous waste and contaminated soil.

• All waste material is stabilized before being deposited below sea level in a former limestone quarry.

• Private company run the repository
  – Fund for closure and post closure remediation
Application of the ICRP Publication 103 Recommendations to NORM industries in Norway
Planned vs existing exposure situation for petroleum industry?

• (31) "The system has to deal with a number of sources of exposure, some already being in place, and others introduced deliberately as a matter of choice by society or as a result of emergencies."
• (39) "In protecting individuals from the harmful effects of ionising radiation, it is the control (in the sense of restriction) of radiation doses that is important, no matter what the source."
• (44) "The term 'source' is used to indicate the cause of an exposure, and not necessarily a physical source of radiation. [...] A source is an entity for which radiological protection can be optimised as an integral whole."
• (48) "The term 'practice' [...] denote an activity that causes an increase in exposure to radiation [...]"
• (49) "It is implicit in the concept of practice that the radiation sources that it introduces or maintains can be controlled directly by action on the source."
• (176) "Planned exposure situations are situations involving the deliberate introduction and operation of sources."
Oil and gas industry is a planned exposure situation

• Deliberate extraction for the benefit of the society
• No exposure of humans or the environment would have occurred without human activities
• Source modified and controllable
• Optimisation in the industrial process is possible, both for discharges and waste
Planned exposure situations implies

- Dose constraints applies, ALARA applies
- (239) ”The first band, 1 mSv or less, applies to exposure situations where individuals receive exposures – usually planned – that may be of no direct benefit to them but the exposure situation may be of benefit to the society.”
- (260) ”For the control of public exposure from waste disposal, the Commission has previously recommended that a value for the dose constraint for members of the public of no more than about 0.3 mSv in a year would be appropriate.” See also Table 8.
- (261) ”Some flexibility may be required for particular situations involving long-lived natural radionuclides […]”
Other relevant paragraphs

• (26) “[…] an appropriate level of protection for people and the environment against the detrimental effects of radiation without unduly limiting the desirable human actions that may be associated with such exposures.”
• (27) “[…] balancing the risks and benefits.”
• (30) “[…] ‘environmental protection’ […] aim is now that of preventing or reducing the frequency of deleterious radiation effects to a level where they would have a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities and ecosystems.”
• (36) “[…] the LNT model remains a prudent basis for radiological protection at low doses and low dose rates.”
• (51) “[…] a graded burden of obligation […]”
Oil and gas – optimisation should be easy

Largest oil producers, million barrels/day (2007)

<table>
<thead>
<tr>
<th>Country</th>
<th>Million Barrels/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>10,4</td>
</tr>
<tr>
<td>Russland</td>
<td>10,0</td>
</tr>
<tr>
<td>USA</td>
<td>6,9</td>
</tr>
<tr>
<td>Iran</td>
<td>4,4</td>
</tr>
<tr>
<td>China (Kina)</td>
<td>3,7</td>
</tr>
<tr>
<td>Mexico</td>
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</tr>
<tr>
<td>Canada</td>
<td>3,3</td>
</tr>
<tr>
<td>Arab states</td>
<td>2,9</td>
</tr>
<tr>
<td>Kuwait</td>
<td>2,6</td>
</tr>
<tr>
<td>Venezuela</td>
<td>2,6</td>
</tr>
<tr>
<td>Norge</td>
<td>2,6</td>
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</tbody>
</table>

In Norway:

% of export (top)
% of GDP (middle)
% of employment (bottom)

Current oil price ~ 111 USD/barrel