Activity concentration determination of NORM radionuclides in large quantity containers.

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Overview

1. Introduction
   NuTeC

2. Aims
   Megaports Project
   NuTeC-NORM Project

3. Results
   Megaports projects (results related to NORM)
   NuTeC-NORM project methodology

4. Conclusion & future perspectives
Overview

1. Introduction
   NuTeC

2. Aims
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NuTeC

○ XIOS University College (Diepenbeek, Belgium)
  ▪ Industrial Sciences:
    "Nuclear and environmental Engineering"
    (Industrial Engineer)
      - Environmental Technology-Radiochemistry
      - Medical Nuclear Technology

Nuclear Technological Center
• Environmental and Energy related research
• Development and application of nuclear measurement aperture
NuTeC – Support for the non-nuclear sector

- NuTeC provides (educational) support for working with radioactive materials in the non-nuclear sector.
  - Steelworks (Steel plants, Scrap yards)
  - Waste treatment industry (e.g. Waste incinerator)
  - NORM industry
  - Medical Sector
  - ...

NuTeC

Nucleair Technologisch Centrum

Vlaanderen In Actie

met steun van het Agentschap Ondernemen

Europese Unie

EFRO

Xios Hogeschool Limburg
NuTeC – Audits for nuclear measurement applications and work protocols

- Audits in working with Detection portals (Steelworks, scrap yards,...)

- Belgian dosimetry Audits in RadioTherapy (BELdART)
  (Belgian Hospital Physics Association)
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2. Aims
   Megaports Project
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3. Results
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• Support for Belgian customs for nuclear control of containers (tracking illicit trafficking of radioactive materials)

• A radiological study of the container transport in the harbor of Antwerp [period: Juni 2006 – Mei 2007]

Pascal Fias
Niki Bergans
Sonja Schreurs
Nuclear control of containers

- Equipment used:
  - Detection portals
    - Passive control
    - Gamma- and neutron detection
  - Portable detection devices: tracking a source
Radiological study

- Equipment used:
  - Detection Portals
  - Portable detectors for dose- and nuclide determination
  - Scanner
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1. Introduction
   NuTeC

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   Megaports Project
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3. Results
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“NuTeC – NORM” project

○ New project:
  ▪ “Knowledge diffusion” regarding Natural Occurring Radioactive Materials by supporting the Flemish Non-Nuclear industry. Preparing companies for future (European) directives.

○ The roots of the project:
  ▪ 1st Workshop of the European ALARA Network for NORM
  ▪ Megaports project (a lot of NORM is detected!)

○ Duration of the project: 15/12/08 – 14/12/10
Why focus on NORM?

1. Manipulation of NORM material (natural resources) in non-nuclear sector

2. Accumulation of concentration of radionuclides during production processes

3. Radiation exposure due to processing/storage of NORM material
Aims of the project:

1. Making an Inventory of NORM in the ports of Antwerp

⇒ Construction of a NORM-database
Aims of the project:

2. Developing a tool to estimate the activity concentration of NORM in large quantity containers
Aims of the project:

3. Case Studies at several NORM Companies
   - Supplying information and training for companies in working with NORM
   - Making an inventory of the presence and activity of NORM and propose appropriate action.
“NuTeC – NORM” project

- Sponsored by:
  - Flemish Community (Hermesfonds, 45%),
  - European Funds for Regional Development (EFRO-support, 40%)
  - XIOS University College Limburg (15%).

- Collaboration: Federal Agency for Nuclear Control
  Administratie der Douane en Accijnzen
  3 NORM companies
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2. Aims
   Megaports Project
   NuTeC-NORM Project

3. Results
   Megaports projects (results related to NORM)
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### Radiological study – Results

**[period: June 2006 – May 2007]**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of the investigated containers</td>
<td>9145</td>
</tr>
<tr>
<td>Total number of alarms</td>
<td>624 (6.8%)</td>
</tr>
<tr>
<td>Number of containers investigated with the detection portal of NuTeC</td>
<td>2380</td>
</tr>
<tr>
<td>Number of alarms (alarm at detection portal)</td>
<td>181 (7.6%)</td>
</tr>
<tr>
<td>Investigated with portable detectors</td>
<td>37 (1.6%)</td>
</tr>
<tr>
<td>Number of opened containers</td>
<td>3 (0.1%)</td>
</tr>
</tbody>
</table>
Radiological study - Results

- Alarms at the detection portal: **99.9%** of the alarms generated by transport of NORM
## Radiological study – Results

<table>
<thead>
<tr>
<th>Contents of containers</th>
<th>Dose (µSv/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiles of regular pottery</td>
<td>0,09</td>
</tr>
<tr>
<td>Stones</td>
<td>0,06</td>
</tr>
<tr>
<td>Tiles</td>
<td>0,15</td>
</tr>
<tr>
<td>Ceramics</td>
<td>0,15</td>
</tr>
<tr>
<td>pottery (limestone bottles )+ iron bars</td>
<td>0,05</td>
</tr>
<tr>
<td>mica + sports clothing</td>
<td>0,035</td>
</tr>
<tr>
<td>Stones for pavement (granite)</td>
<td>0,12</td>
</tr>
<tr>
<td>Stones (arduin)</td>
<td>0,05</td>
</tr>
<tr>
<td>Forks, knives and spoons of stoneware</td>
<td>0,12</td>
</tr>
<tr>
<td>dinner set</td>
<td>0,14</td>
</tr>
<tr>
<td>Potassium chlorate</td>
<td>0,32</td>
</tr>
<tr>
<td>Salts of citric acid, esters of citric acid</td>
<td>0,35</td>
</tr>
<tr>
<td>Christmas articles</td>
<td>0,06</td>
</tr>
<tr>
<td>manufactured articles</td>
<td>0,12</td>
</tr>
<tr>
<td>zirconium sands</td>
<td>0,6</td>
</tr>
</tbody>
</table>

- 0.3 % of alarms above action threshold
  (Dose measured at the wall of the container)
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   NuTeC

2. Aims
   Megaports Project
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NORM in the Port of Antwerp: Procedure – Primary Inspection

- 3-phase inspection
- Primary inspection
  - Entrance gate
  - 4 plastic scintillator detectors (\(\gamma,n\))
  - Documents check
  - Alert: 3 (legally) accepted possibilities
    - Licensed transport
    - Error in measurement (e.g. sudden high BG)
    - \textbf{NORM beneath \textit{acceptable} limit!}
  - Otherwise \(\rightarrow\) secondary inspection
NORM in the Port of Antwerp: Procedure – Primary Inspection
NORM in the Port of Antwerp: Procedure – Secondary inspection

- Secondary inspection
  - Lorry is sent to Central Alert Station (CAS)
  - Extra measurements
    - 4 larger plastic scintillator detectors ($\gamma$,n)
    - Advanced Spectroscopy Portal (NaI or HPGe)
    - X-ray scanner (examine content)
    - Physical inspection
NORM in the Port of Antwerp: Procedure – Secondary inspection

- Linear Accelerator
- Measurement portal
- Scanner (X-ray)
NORM in the Port of Antwerp: Procedure – Secondary inspection

- Physical Inspection
  - Gamma count
  - Dose rate
  - Multi-Channel Analyzer: activity & spectrum
  - Portable HPGe detector: nuclide identification & spectrum
  - Spectrum analysis (radiation expert)
  - Clearance or ternary inspection
NORM in the Port of Antwerp: Procedure – Ternary inspection

- Federal Agency for Nuclear Control (FANC) becomes owner of the situation
NORM in the Port of Antwerp: NORM measurements

- NORM cause of many alarms
- A lot of secondary inspections are NORM-related (database)
- BSS draft: legislation based on activity concentration
- Need for measurement methodology
  - Determine whether activity concentration is below the limits
  - Avoid sample analysis if possible
NORM in the Port of Antwerp: NORM measurement methodology

- Measurement methodology
  - Multi-Channel Analyser (NaI) placed in contact with container
  - Automated measurement steered by tablet PC
  - Activity concentration calculated
  - User feed-back (Bq/g)
NORM in the Port of Antwerp: NORM measurement methodology
NORM in the Port of Antwerp: NORM measurement methodology
NORM in the Port of Antwerp: NORM measurement methodology (INPUT)

<table>
<thead>
<tr>
<th>ISO Code:</th>
<th>22G1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lengte Container:</td>
<td>6,068 m</td>
</tr>
<tr>
<td>Breedte Container:</td>
<td>2,438 m</td>
</tr>
<tr>
<td>Hoogte Container:</td>
<td>2,591 m</td>
</tr>
<tr>
<td>Type Container:</td>
<td>Passieve ventilatie aan bovenzijde van cargo</td>
</tr>
<tr>
<td>Netto Gewicht (kg):</td>
<td>24000</td>
</tr>
<tr>
<td>Inhoud:</td>
<td>Kaliumchloride</td>
</tr>
<tr>
<td>Percentage Vulling (%):</td>
<td>70</td>
</tr>
</tbody>
</table>
NORM in the Port of Antwerp: NORM measurement methodology (OUTPUT)

<table>
<thead>
<tr>
<th>Gevonden Radionuclide</th>
<th>Zekerheid (%)</th>
<th>Activiteitsconcentratie (Bq/g)</th>
<th>Concentratiefout (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-40</td>
<td>99.1</td>
<td>0.0383016</td>
<td>1.209578</td>
</tr>
<tr>
<td>U-238+d</td>
<td>100</td>
<td>0.02413108</td>
<td>1.189252</td>
</tr>
</tbody>
</table>
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Conclusion & Future perspectives

- 99,9% of the alarms generated at the detection portals in the Harbor of Antwerp are caused by transport of NORM

- Increase statistics of the NORM database
  - Provide more detailed information regarding the NORM that passes the harbor of Antwerp
Conclusion & Future perspectives

- Fine-tune measurement methodology
  - Calibration (sample analysis)
  - Support different geometries
    - Customized for corporate environment
  - Increase usability tool

- NORM studies in companies
  - Distinct NORM industries
  - Create awareness about NORM
Conclusion & Future perspectives

- Focus on radioactivity in building materials
  - Create awareness of NORM among the workers?
  - Measurement and analysis of activity concentration?
  - Appropriate measures?

Idea’s for new projects???
Collaboration?

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Collaboration?

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