NORM Transportation in the Port of Antwerp

From Megaports to a special-purpose measurement methodology

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Outline

- Megaports project – Port of Antwerp
  - Procedures
  - Conclusions
- NuTeC-NORM project
  - Project objectives
  - NORM Inspection Database
  - Measurement methodology
  - Case studies at companies
- Discussion & Outlook
Megaports Project

- US Government initiative
- Nuclear detection equipment in ports
- Track nuclear smuggling
- NuTeC
  - Support for Belgian Customs
  - Radiological study of container transport
NORM in the Port of Antwerp: Procedure – Primary Inspection

- 3-phase inspection
- Primary inspection
  - Entrance gate
  - 4 plastic scintillation detectors ($\gamma$) and neutron detector
  - Documents check
  - Alert: 3 (legally) accepted possibilities
    - Licensed transport
    - Error in measurement (e.g. sudden high BG)
    - **NORM beneath acceptable limit!**
  - Otherwise $\rightarrow$ secondary inspection
NORM in the Port of Antwerp: Procedure – Primary Inspection

![Image of a truck at a port entrance]

[Logos and affiliations]

NuTeC
Nucleair Technologisch Centrum
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 ($\gamma$) and neutron detector
    - Advanced Spectroscopy Portal (NaI or HPGe)
    - X-ray scanner (examine content)
    - Physical inspection
NORM in the Port of Antwerp: Procedure – Ternary inspection

- Federal Agency for Nuclear Control (FANC) becomes owner of the situation

- FANC determines further steps in agreement with radiation experts
Conclusions Megaports project

- NORM cause of many alarms
- A lot of secondary inspections are NORM-related
- BSS draft: legislation based on activity concentration
  - U-238 & Th-232 $\rightarrow$ 1 Bq·g$^{-1}$
  - K-40 $\rightarrow$ 10 Bq·g$^{-1}$
- Need for measurement methodology
  - Determine whether activity concentration is below the limits
  - Avoid sample analysis if possible
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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
NuTeC-NORM project objectives:

1. Making an inventory of NORM in the Port of Antwerp: primary + secondary inspections
NuTeC-NORM project objectives:

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

3. Case Studies at several NORM Companies
   - Supplying information and training for companies that work with NORM
   - Making an inventory of the presence and activity of NORM and propose appropriate action.
NORM inspection database

- Capturing primary and secondary inspections
- 75289 primary alerts in database
- $1 \text{ sigma } = \sqrt{BG}$
METHODOLOGY

- Objectives
- Sample
- Detector Position
- Detection Time
- Analysis
METHODOLOGY – Objectives

○ Output = activity concentration of radionuclide lies beneath, around or above the limits given by European Directives for NORM nuclides

○ Methodology = estimation of the activity concentration within certainty limits of NORM nuclides in sample, for a certain geometry
METHODOLOGY – Sample

- Sample = big bag, shipping container
- Geometry (bb)
  - Height
  - Nett Mass
  - Perimeter
  - Bag thickness
METHODOLOGY – Detector Position big bag

- Detectors: temp. stabilized NaI and LaBr coupled with handheld spectrometer

- Position: On top of big bag, in centre
METHODOLOGY – Detector Position container

- Detectors: temp. stabilized NaI and LaBr coupled with handheld spectrometer
- Position: in centre of container sidewall
METHODOLOGY – Detection Time

- **Big Bags:**
  - Each sample is measured ten times
  - Detection Time: 900 s

- **Shipping containers**
  - Container is measured once
  - Detection Time: 600 s
METHODOLOGY – Analysis

- Energy calibration
- Efficiency calibration
- Peak locate
- Peak area
- NID plus Interference Correction

- NOTE: assumed sequilar equilibrium for $^{238}\text{U}$ and for $^{232}\text{Th}$
3. Industrial Case Studies

- Transport Company in the Port of Antwerp
- Dry bulk material
- Processes
  - (Re)bagging
  - Reconditioning
  - Sieving
  - Blending
Zirconium (493 alerts)

![Graph showing ZrO₂ and ZrSiO₄](image)

- ZrO₂
- ZrSiO₄

# alerts

<table>
<thead>
<tr>
<th>Gamma Sigma Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
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<td>50</td>
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<td>60</td>
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<td>70</td>
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<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

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The graph shows the alert distribution for Zirconium with peaks at certain Gamma Sigma values. ZrO₂ and ZrSiO₄ are highlighted.
Zirconium Analysis Results

- Following results are based on:
  - sample of zirconium coarse grade
  - Number of measurements: 10
  - Land of origin: Australia
  - Weight: $2 \cdot 10^3$ kg
  - Packaging: big bag
  - Detector used: NaI
## Zirconium Analysis Results

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Activity Concentration (Bq·g⁻¹)</th>
<th>Rel.Error (%)</th>
<th>Stand Deviation (Bq·g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>²³⁸U</td>
<td>1.51E+00</td>
<td>-22</td>
<td>4.3E-01</td>
</tr>
<tr>
<td>²³²Th</td>
<td>5.11E-01</td>
<td>4</td>
<td>1.8E-02</td>
</tr>
<tr>
<td>²²⁶Ra</td>
<td>2.09E+00</td>
<td>4</td>
<td>8.6E-02</td>
</tr>
</tbody>
</table>
$\text{K}_2\text{SO}_4$ (383 alerts)
K₂SO₄ Analysis Results

Following results are based on:
- sample of K₂SO₄
- Number of measurements: 10
- Weight: 1.2 \cdot 10^3 \text{ kg}
- Packaging: big bag
- Detector used: NaI
**K₂SO₄ Analysis Results**

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Average Activity Concentration (Bq·g⁻¹)</th>
<th>Rel.Error (%)</th>
<th>Stand Deviation (Bq·g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K⁴⁰</td>
<td>8.68E+00</td>
<td>-18</td>
<td>8.0E-02</td>
</tr>
</tbody>
</table>
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Conclusions

- Measurement methodology
  - determination of radionuclides
  - industrial settings
- Good results
  - Th-232, Ra-226
- More research required
  - U-238, K-40
Outlook

- Analysis of LaBr spectra
  - Higher resolution
  - Less peak interference
- More samples to determine uncertainty and range of zone
- Other substances & geometries

To be continued ...
Q&A

To be continued ... NORM & Natural Radiation Management 2010, London IRPA 2010, Helsinki