Non-Destructive Radiological and Material Characterization on Decommissioning Sites

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BACKGROUND

- Spin-off of the RWTH Aachen University
- Founded in May 2011
- Interdisciplinary Team with 10 employees
  (Nuclear engineers, physicist, chemist, mathematician, technical designer....)

Business Divisions

- Basic & Advanced Training
- Consulting
- R&D for industry

EDUCATION & TRAINING

Intensive Training & Conferences

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CONFERENCES
5TH ICOND

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CONSULTING

Decommissioning of Nuclear Facilities & Radioactive Waste Management

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OVERVIEW - CONSULTING

Nuclear Simulation
Radiological Characterization of Nuclear Facilities and Waste Packages using Gamma & Neutron Transport Codes

Radiological Characterization
Gamma Spectroscopy coupled with further Analytics

Material Characterization
Prompt and Delayed Gamma Neutron Activation Analysis for the Assay of Chemo Toxic Elements in Radioactive Waste Packages
NUCLEAR SIMULATION

Modelling of Neutron and Gamma Transport
SIMULATION & RESULTS

Total activity [Bq/g]

C-14 activity [Bq/g]
Central questions to be answered for an optimal planning:

- Where is the maximum activation/dose rate?
- How will the dose rate change when components, or walls get removed?
- Estimation of radiation exposure for future activities?

Simulations can answer these questions

- Simulating the activities & dose rates of the core and outer core structures
- Results are representative globally and not just for the part
- See how the activated inventory will change over time
RADIOLOGICAL CHARACTERIZATION

Gamma Spectroscopy coupled with further Analytics
## Characterization of Radioactive Waste by Non-destructive Analytical Methods

<table>
<thead>
<tr>
<th>Radiological</th>
<th>Material</th>
<th>Structural</th>
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<tbody>
<tr>
<td>Gamma-Scanning</td>
<td>Delayed-Gamma-Neutron-Activation-Analysis (DGNAA)</td>
<td>Gamma-Radiography</td>
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<tr>
<td>Neutron-Measurement</td>
<td>Prompt-Gamma-Neutron-Activation-Analysis (PGNAA)</td>
<td>Neutron-Radiography</td>
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</table>
APPROACH

Radiological characterization of waste with an inhomogeneous activity distribution

Conservative sampling

Laboratory analysis of samples (α-, β-, γ-spectrometry)

nuclide vector

Conditioning & packaging

Gamma spectrometric in situ measurements of the waste packages

Covering radiological characterization

TASK

AIM
ACTIVITY DETERMINATION OF HISTORIC WASTE
After weighing and dose rate measurements, the cans were loaded in 200-l-drum.

Inside one 200-liter-drum are 13 to 16 cans positioned.

Just a few cans contain the entire activity inventory.

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Four integral gamma scans of the active volume offset by 90 degrees
Real Time: 3.600 - 36.000 s

Image Source: Canberra ISOCS
DOSE RATE MAPPING AT THE CYLINDRICAL SURFACE

- Coupling of 4 integral gamma scans with dose rate mapping and nuclear simulation to make a best guess of the activity distribution
- Dose-rate mapping over whole cask surface
- Modelling in high level of detail is possible in the measured object including the inner structure
BULK ANALYSIS FOR MATERIAL CHARACTERIZATION

Prompt and Delayed Gamma Neutron Activation Analysis for the Assay of Chemo Toxic Elements in Radioactive Waste Packages (200-L-Drums)
THE MEDINA FACILITY
BULK ANALYSIS FOR 200-L-DRUMS
PHYSICAL PRINCIPLE OF P&DGNAA

Prompt-Gamma-Neutron-Activation-Analysis

$10^{-16} - 10^{-12}$ s

1. \( ^{27}\text{Al}(n,\gamma)^{28}\text{Al} \); \( E_\gamma = 1778.9 \text{ keV} \); \( T_{1/2} = 2.246 \text{ minutes} \)

2. \( ^{1}\text{H}(n,\gamma)^{2}\text{H} \); \( E_\gamma = 2223.3 \text{ keV} \)

Delayed-Gamma-Neutron-Activation-Analysis

$10^{-6} - 10^{2}$ s

Radioactive Nucleus

1. Electron (after beta decay)

Stable Nucleus

2. Delayed-Gamma-Neutron-Activation-Analysis

Prompt-Gamma-Neutron-Activation-Analysis

Compound Nucleus

Stable Nucleus

Electron

Neutron

Target Nucleus

Compound Nucleus

Stable Nucleus

Electron
AINT-SPECTROSCOPY SOFTWARE FOR PGNAA

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DEVELOPMENT OF A 200-L-DRUM ASSAY SYSTEM

Measurement chamber

Support frame

Gamma spectrometer
Components:

- Blocks made of graphite
- Two neutron generator
- Eight eyebolts DIN 580
- Drum turn table
- Turn table disk made of CFK
- Ball caster for chamber top
GAMMA SPECTROMETER

Detector
THANK YOU FOR YOUR ATTENTION

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