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Purpose of treatment

• Operations intended to benefit safety and/or economy by changing the characteristics of the waste

• Three basic objectives:
  – Volume reduction
  – Removal of radio-nuclides
  – Change of composition
Treatment of gases

- Gases from nuclear facilities contain aerosols (dust particles) and/or gaseous radioactive isotopes
- Common techniques for cleaning gases:
  - Filtration whether or not containing absorbing agents (e.g. active charcoal for capturing I-131, I-129)
  - Scrubbing units for washing the gases

- Comprehensive info: IAEA – TECDOC - 1744
Treatment of gases

Hepa filter bank and extraction fan

-Common technique: Filtration of air from controlled nuclear areas before releasing to the atmosphere

-Radioactivity is transferred to filters or liquids and has to be treated as radioactive waste:
  -Used HEPA filters treated as solid waste
  -Scrubber liquids as liquid waste
Treatment of liquid waste

Most applicable technologies give supernatant or purified water which can be directly released

• Chemical treatment: addition of different chemicals
• Evaporation gives a purified distillate and concentrate containing the radioactivity.
• Ion exchange
• Membrane methods often in combination with chemical treatment and ion exchange

Evaporation and ion exchange also used for ILW
Liquid Waste: Chemical Treatment LL Waste

Collection tanks Liq Waste

in line injection

settling tank

sludge

collection thanks

discharge

final conditioning

sludge tank

in line injection

pH 7

pH 5
Treatment of organic liquid waste

Typical organic liquid waste streams:
- spent oil from NPP’s
- scintillation liquids, solvents from institutional waste producers

- Thermal treatment: incineration is common used; final product is ash
  - More used for LLW

- Wet oxidation using strong oxidising agents

- Absorbents to make a solid phase
  - Last two can be used for LLW and ILW
Treatment of liquid waste

- Radioactivity is transferred to the sludge, the concentrate or the spent ion exchange resins and has to be further treated or conditioned as radioactive waste.
- Treatment of sludge, concentrates and ion exchange resins by:
  - Mixing with grout
  - Drying and supercompaction or
  - Thermal technologies if dealing with LLW
Treatment of solid waste ILW

- Treatment of intermediate and even high level waste (ILW and HLW) in shielded infrastructures
- Most common techniques: cutting, sorting and supercompaction
- Final destination is mostly geological disposal
Treatment of solid waste: LLW

- Most used technologies for treatment of low level solid waste (LLW):
  - Compaction (Low force compaction and Supercompaction)
  - Incineration
Treatment of solid waste: LLW

Supercompaction (typical 2000 ton; 8 drums per hour):
- HEPA filters, insulation material, concrete debries, metal pieces, granulates such as dried sludge
- Mixtures of organic (burnable) and inorganic (non burnable) waste
- Waste has to be packed in drums (e.g. 200l drums)
Treatment of solid waste: LLW

Incineration (typical 50 to 100kg/h; biggest units 500kg/h)
- Waste has to be sorted out or collected as packages with burnable waste (wood, paper, rags, clothing, gloves, synthetic material, etc)
- Most incinerators can also treat liquids (organic and aqueous liquids, spent oil) and spent resins
## Treatment of solid waste: LLW

<table>
<thead>
<tr>
<th></th>
<th>Supercompaction</th>
<th>Incineration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment Cost</strong></td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td><strong>operation</strong></td>
<td>Easy to operate</td>
<td>More difficult</td>
</tr>
<tr>
<td><strong>Volume Reduction Factor</strong></td>
<td>1.25 to 2.5</td>
<td>35 to 80</td>
</tr>
<tr>
<td><strong>Quality final product for disposal</strong></td>
<td>Poor to moderate</td>
<td>Good (mineralised product)</td>
</tr>
</tbody>
</table>

**Volume Reduction Factor:**

- **Volume of incoming waste**
- **Volume of conditioned waste**
New technologies: plasma treatment

• With plasma, the organic material is vaporised in volatile hydrocarbons, carbon monoxide, etc. while non-combustible and other inorganic constituents are melted and transformed into glassy slag.
• Typical temperature: 5000°C
• Suitable for complex waste mixtures: complete 200l drums containing plastics, wood, metal, insulation material, sludges, etc, can be treated as is.
• Suitable for reconditionning of historical waste which do not comply with actual Waste Acceptance Criteria.
Plasma technology

Industrial facility which operates successfully by ZWILAG in Switzerland from mid 2004

- Nowadays: 2 campaigns of 10 weeks per year
- About 500 drums or 100 ton per campaign
- End 2013: Total 8000 drums or 1300 ton
- Run on a commercial base
Plasma technology

Plasma facility under construction for Kozloduy NPP in Bulgaria
## Plasma technology

<table>
<thead>
<tr>
<th>Program</th>
<th>Plasma facility</th>
<th>Supercompaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 ton or 700m³ per year</td>
<td>20 years</td>
<td>20 years</td>
</tr>
<tr>
<td><strong>Facility cost</strong></td>
<td>20,000,000 €</td>
<td>2,500,000 €</td>
</tr>
<tr>
<td><strong>Operational costs for 250 tons or 700m³</strong></td>
<td>3,000,000 €/year</td>
<td>770,000 €/year</td>
</tr>
<tr>
<td><strong>Final package inclusive cementation</strong></td>
<td>2,500 €/m³</td>
<td>2,500 €/m³</td>
</tr>
<tr>
<td><strong>Disposal cost</strong></td>
<td>15,000 €/m³</td>
<td>15,000 €/m³</td>
</tr>
<tr>
<td><strong>Annual cost inclus 5% amortisation for 250 ton or 700m³</strong></td>
<td>4,000,000 €/y</td>
<td>895,000 €/y</td>
</tr>
<tr>
<td><strong>VRF</strong></td>
<td>20</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Final volume for incoming volume of 700m³</strong></td>
<td>35 m³</td>
<td>350 m³</td>
</tr>
<tr>
<td><strong>Cost final package inclusive final cementation</strong></td>
<td>87,500 €</td>
<td>875,000 €</td>
</tr>
<tr>
<td><strong>Cost disposal</strong></td>
<td>525,000 €</td>
<td>5,250,000 €</td>
</tr>
<tr>
<td><strong>Annual cost plus cost final package</strong></td>
<td>4,087,500 €</td>
<td>1,770,000 €</td>
</tr>
<tr>
<td><strong>Total: Annual cost plus cost final package plus disposal</strong></td>
<td>4,612,500 €</td>
<td>7,020,000 €</td>
</tr>
</tbody>
</table>

**Plasma:** high investment costs, good final product with high VRF, low disposal cost

**Supercompaction:** low investment, poor to moderate final product with low VRF, high disposal cost
Plasma technology
Plasma technology
Conclusions

• Well proven technologies are existing for treating gas, liquid and solid wastes
• Promising alternative technologies are present for treating problematic wastes
• Not only volume reduction of radioactive waste but also the more strict Waste Acceptance Criteria for disposal are important in selecting a solid waste technology
• Supercompaction of organic/inorganic waste mixtures is an easy process and apparently cheap but the more expensive thermal treatment should be considered
Thank you for your attention