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THERMAL TREATMENT FOR RADIOACTIVE WASTE MINIMISATION

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The waste hierarchy

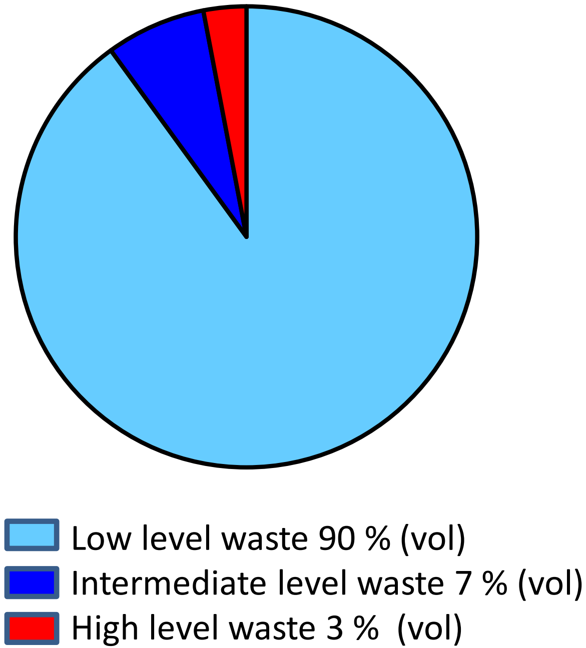
- Environmental impacts of waste has to be minimised
- Priority on waste prevention and the lowest priority on disposal
- Disposal only when no other alternatives are available
- **The amount of waste to be disposed should be minimised**

- Should also be applied for radioactive waste, though with due regard to safety standards and regulations

Source: European Commission.

Low and intermediate level waste (LILW)

- Low and intermediate level waste (LILW)
  - One of the least radioactive waste
  - Volumes involved by far the greatest (together with the very low level waste)
- Many cases rich in organic matter contaminated by some radioactive components
- May also contain poisonous or hazardous components
- Disposal of LILW causes significant cost



Thermal treatment of LILW

- Thermal vitrification is applied for high level waste (HLW) in industrial scale
  - The capacity of western European vitrification plants is about 1000 t/a
- Thermal treatment offers also an alternative way to process LILW before disposal
- Thermal processing will
  - reduce volume
  - enhance safety
  - reduce toxicity
- In many cases enable best possible immobilisation of radioactive components

Waste glass sample from the SHIVA trial

- Thermal processing is not free of charge and risk but it might save money and improve safety in longer term

The Horizon 2020 funded THERAMIN project

- Thermal treatment for radioactive waste minimisation and hazard reduction
- The main objectives of the project are to
  - promote thermal treatment of LILW by piloting/demonstrating several thermal treatment technologies
  - improve the overall understanding and knowhow on thermal treatment
  - make thermal treatment technologies more well-known technologies

Large number of thermal treatment alternatives

- **Incineration** (with burner and refractory walls): Rotary kiln incineration, pyrolysis, gasification, calcination, underwater plasma incineration, hydrothermal oxidation
- ***Conditioning by immobilisation in glass****:* Joule-Heated In-Can Vitrification, Joule-Heated Ceramic Melter (JHCM), Cold crucible induction melter (CCIM), Advanced CCIM (A-CCIM), Indirect induction (metallic wall - hot metal pot), Coupled cold wall direct metal induction melting and plasma burner, Coupled cold wall direct glass induction melting and plasma burner and Refractory wall plasma burning and melting
- ***Conditioning by immobilisation in ceramic, glass or glass-ceramic***: Hot Isostatic Pressing (HIP)

Thermal treatment technologies selected for demonstrations

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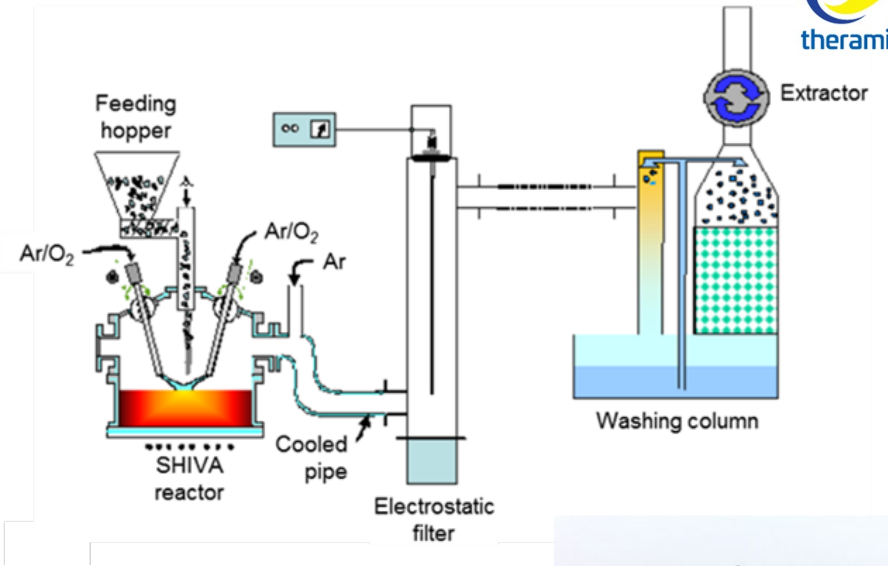
- Six different thermal treatment techniques selected for demonstration test trials
- Eight waste stream/treatment process combination
- Part of the demonstrations with radioactive waste, rest using simulated waste materials
- Demonstration test trials completed
- Characterisation of the products
- Evaluation of impact of thermal treatment on the disposability

Demonstrator	Waste stream	Product
Shiva (CEA/Orano)	Organic ion exchange resin	Vitrified
In Can (CEA/Orano)	Ashes	Vitrified
Geomelt 1 (NNL)	Cementitous wastes	Vitrified
GeoMelt 2 (NNL)	Heterogeneous sludges	Vitrified
Thermal gasification (VTT)	Organic ion exchange resin	Solid residue
VICHR (Vuje/Javys)	Chrompik	Vitrified
HIP USFD	Uranium containing feeds	Vitrified/Ceramics
HIP (NNL)	Sludge/clinoptilolite	Vitrified/Ceramics

SHIVA (CEA/Orano)

- Suitable for the treatment of organic and mineral waste with high alpha contamination and potentially high chloride or sulfur content
- A single reactor, waste incineration by plasma burner and ashes vitrification
- Waste can be in solid or liquid form (must not contain metals)
- The end product is glass
- THERAMIN demonstration test trial:
  - 25 kg mixture of inorganic and organic ion exchange media
  - 38.5 wt-% of waste and 61.5 wt-% of glass frit

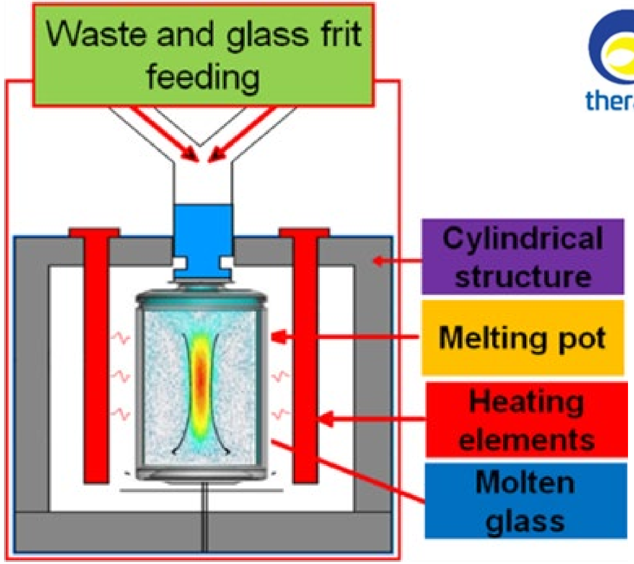



Waste glass sample from the SHIVA trial

Refractory furnace crucible melter

In Can (CEA/Orano)

- For liquid or solid waste feeds
- Only tolerate small amounts of organics (with the current gas treatment)
- Can operate remotely for high-activity waste
- The product can be glass, glass ceramic or simply a high-density waste product
- THERAMIN demonstration test trial:
  - 25 kg of ashes
  - 50 % of ashes and 50 % of glass frit



One Canister
~ 108 kg of glass

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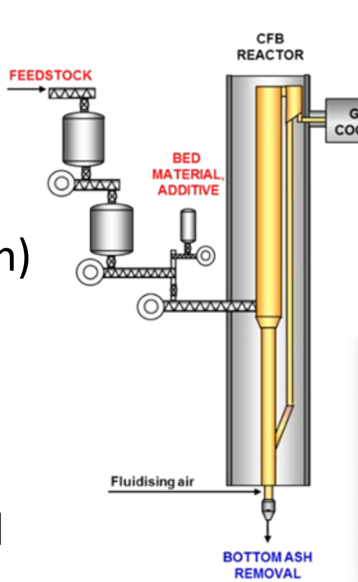
Thermal gasification (VTT)

- Designed for processing of high organic matter containing ion exchange resins and organic operational waste (liquid organic waste not yet tested)
- Product: solid residue (filter dust and bottom ash)
- VTT has developed geopolymerisation for immobilisation of the product ash
- THERAMIN demonstration test trial: 325 kg organic ion exchange resin was treated and solid residue was geopolymerised => 40…70 kg geopolymerised final product



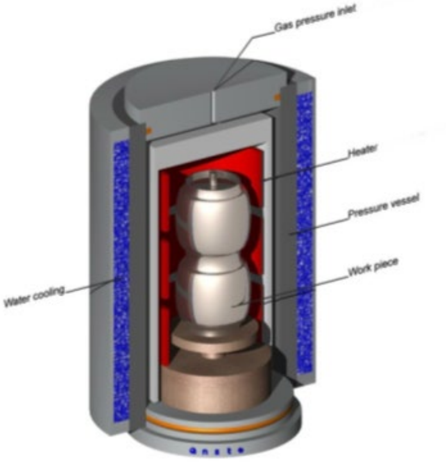
GeoMelt (NNL)

- The GeoMelt melter consists of a steel container lined with refractory materials containing the melt
- Direct electric heating (Joule heating)
- Product of the process is semi-crystalline glass, which immobilises heavy metals and radionuclides
- THERAMIN demonstration test trials:
  - Thermal treatment of 279 kg of representative cementitious waste stream with a pre-treatment waste loading of 49%
  - 238 kg of a sludge stream consisting of clinoptilolite, sand and Magnox sludge with a pre-treatment waste loading of 72%

Hot Isostatic Pressing

HIP (NNL and USFD)

- The HIP is used to consolidate a pre-prepared waste feed sealed in a HIP can resulting in a monolithic waste form
- The can is placed inside the furnace and the vessel closed before applying pressure and temperature furnace
- THERAMIN test trials:
  - USFD: magnesium hydroxide sludges with triuranium octoxide (U_3O_8)
  - NNL: sludge feeds



Schematic of HIP (courtesy of ANSTO)

HIP installed at NNL Workington

Disposability of thermally treated waste products

- Samples from demonstrations are characterised in order to evaluate the disposability of the treated waste (currently ongoing)
- The first step of the evaluation was the identification of the relevant criteria (Waste Acceptance Criteria, WAC)
- Available data on current waste acceptance criteria were collected from partner countries
- Some generic disposability criteria were developed based on examination of these data
- These generic disposability criteria can be used to evaluate any products from any form of thermal treatment for disposal at any type of facility

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The EC project THERAMIN will host a conference to share the results of the project and other recent developments in the field of thermal treatment of radioactive waste

theramin 2020 conference thermal treatment of radioactive waste

MECHANICS INSTITUTE, MANCHESTER

TUESDAY 4TH TO WEDNESDAY 5TH FEBRUARY 2020

Plus optional visit to University of Sheffield on Thursday 6th February 2020

More information available: http://www.theramin-h2020.eu/