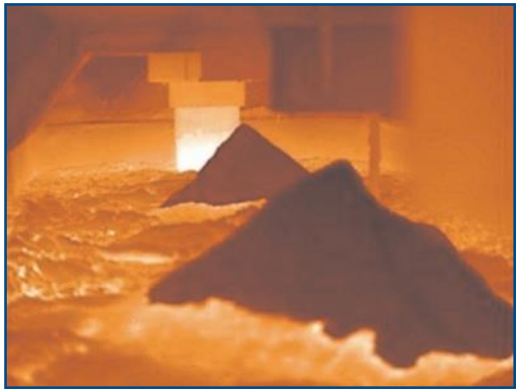
ICV Thermal Treatment for Waste Immobilisation

Trieste

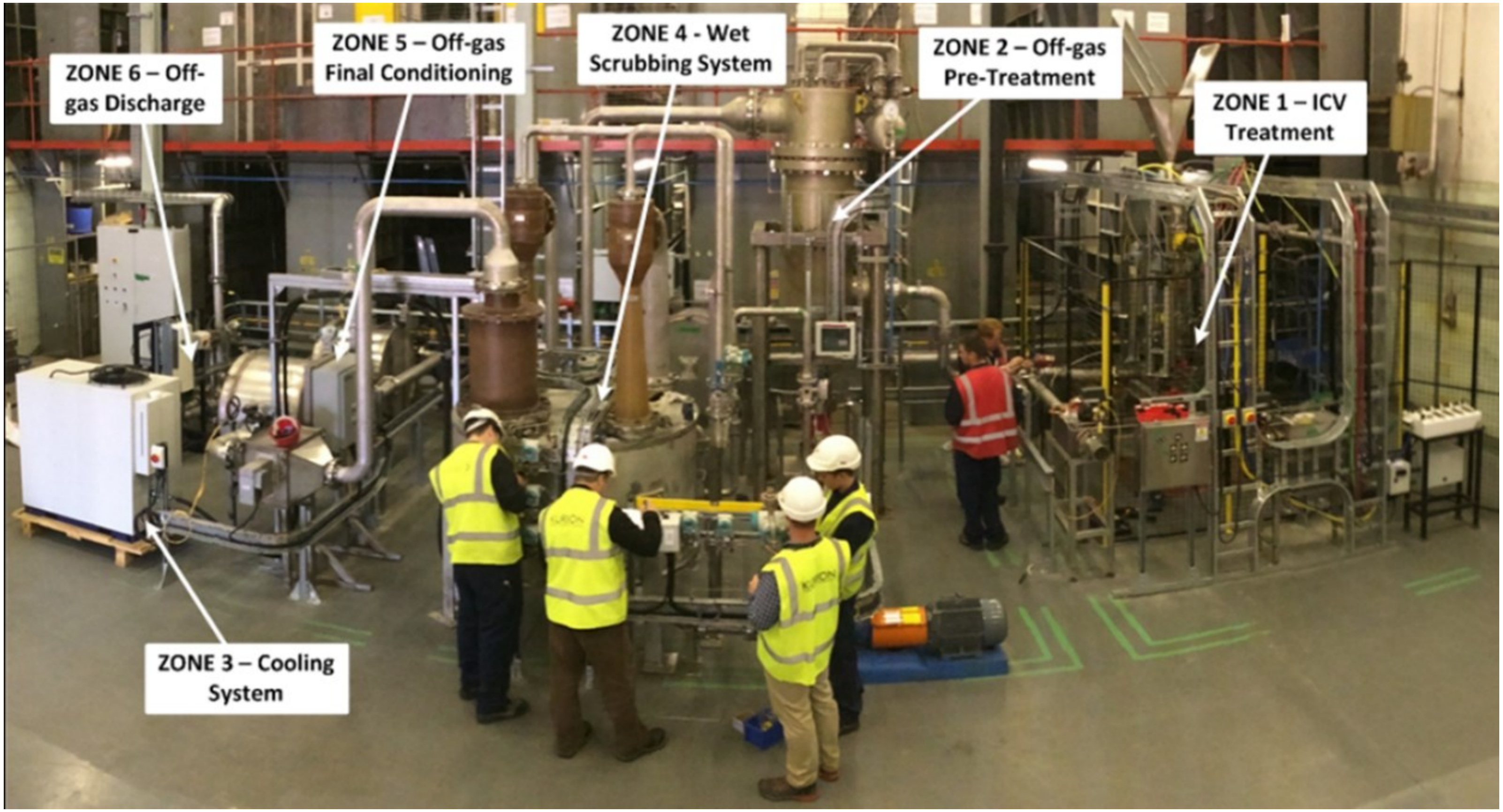
September 2019

Introduction

- Developed at Hanford in the early 1980s
- Electric melting of contaminated soils and wastes
- Heavy metals and radionuclides are retained in the melt and glass
- Organics are destroyed by melt by pyrolysis and combustion
- Off-gases are treated with filtration, wet scrubbers, and thermal oxidizer.
- Vitrified product suitable for disposal
- Installation in NNL Central Lab active area in 2015/16 co-funded by NNL and Veolia
- Trials funded through NDA, SL and EU Theramin programme to demonstrate possibilities of ICV treatment on radwastes



GeoMelt ICV Layout



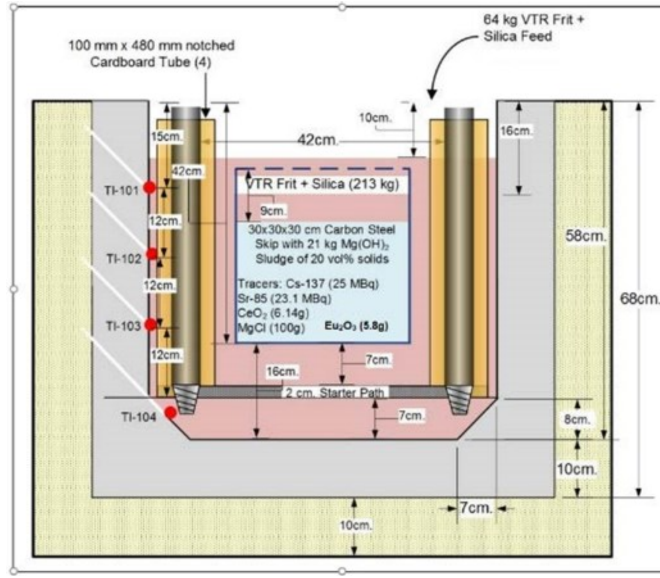
GeoMelt ICV Installed in NNL Central Laboratory

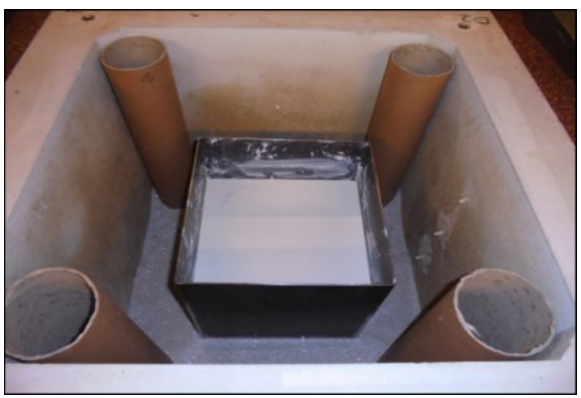
Melt Demonstrations

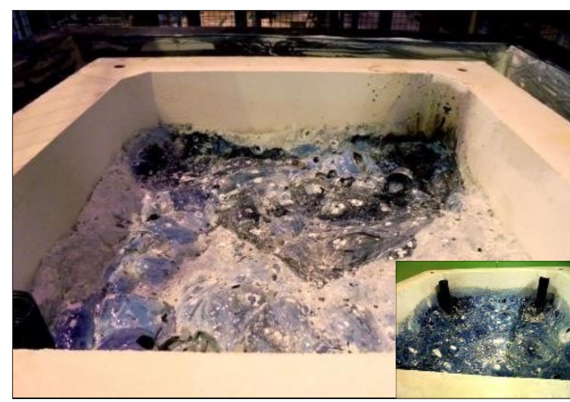
- Assess thermal treatment as an option for a range of generic waste streams
- Demonstration only, no inference for utilisation in UK
- Separate programmes of work for NDA (DRP), SL and EU Theramin
- Use of active components to assess partitioning throughout the process
    - Cs-137
    - Sr-85
    - Natural uranium
- Following examples of waste treatment

Example 1 Demonstration of Sludge in a Skip

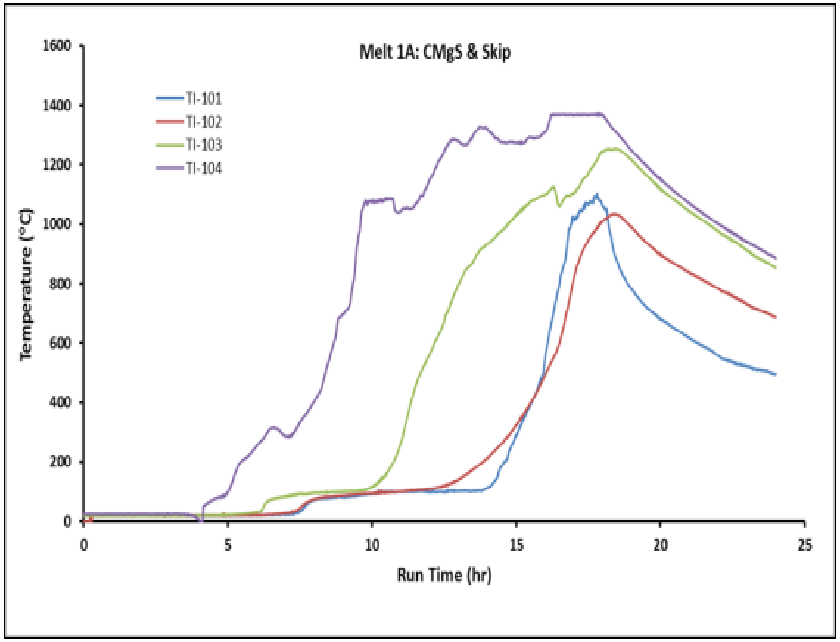
- Strategy to immobilise sludge in skip reduces handling
- Aim to remove water and then react sludge with frit
- Materials batch loaded
- Feed While Melt system used to add further material
- 2 melts carried out
  - Inactive surrogate melt
  - Melt doped with Cs-137 and Sr-85

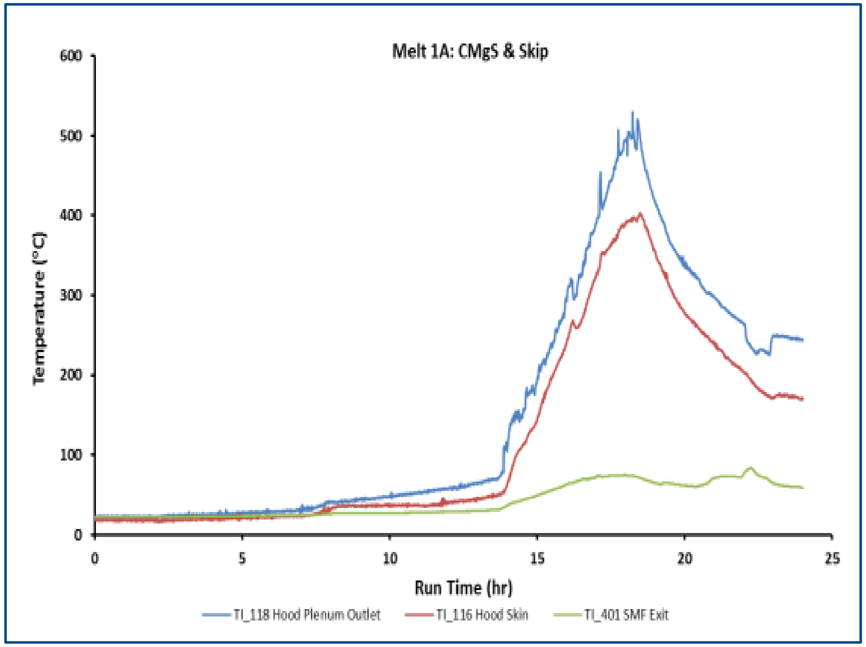






Sludge in a Skip II Operational Data





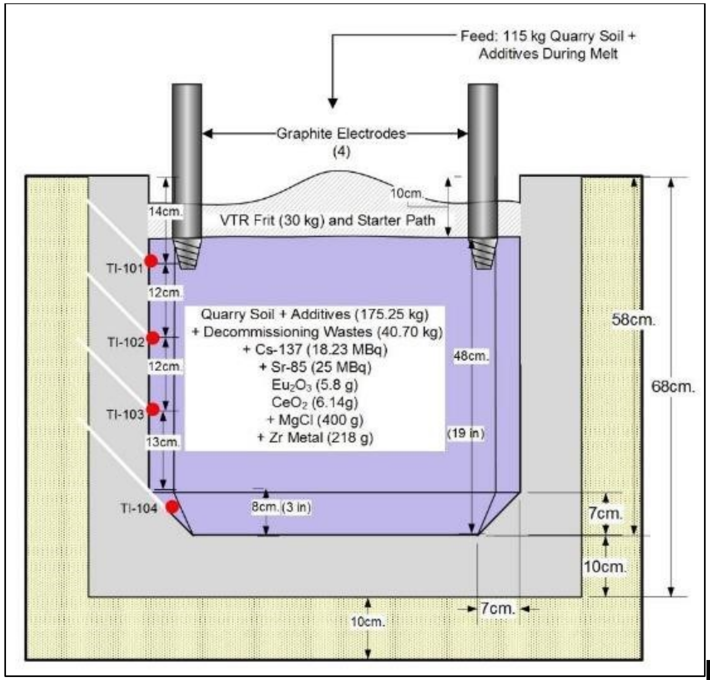
Sludge in Skip Analysis

- Major glass forming elements analysed by XRF to assess homogeneity of melt
- Gamma scan used to assess partitioning through the process on the active melts
- Mg well distributed in block showing immobilisation of sludge feeds
- A significant proportion of the skip still in metallic form. Not necessarily a problem for disposal
- Even distribution of Cs in vitrified product
- Analysis of off gas suggests little activity reaches SMF and may be deposited in plenum.
- Materials captured in SMF can be recycled
- Optimisation of glass chemistry and melt operation expected to significantly reduce Cs carryover from melt.

Sample	Activity (Bq/g)	
	Cs-137	Sr-85
1B SP 1.1	64.2	56.9
1B SP 1.2	54.4	48.7
1B SP 1.3	67.0	59.4
1B SP 2.1	68.5	60.8
1B SP 2.2	64.0	56.5
1B SP 3.1	64.3	59.4
1B SP 3.2	63.9	56.7
1B SP 3.3	68.3	61.7
Average	64.3	57.5
SD	4.5	4.1
Expected activity	91.5	84.4
Retention rate (%)	70	68

Example 2 Demonstration of Decommissioning Wastes

- Use of ICV to treat miscellaneous wastes arising from future decommissioning
- Filter, metals, organics, concrete, scaffolding poles
- Soils added as glass forming component



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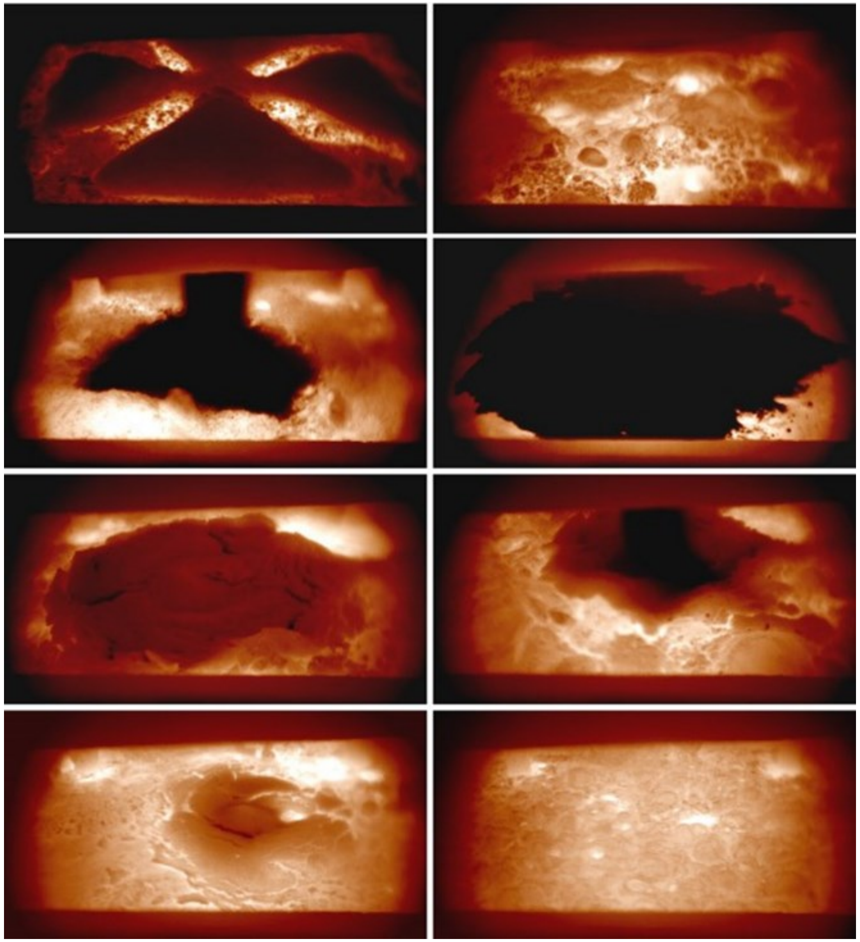
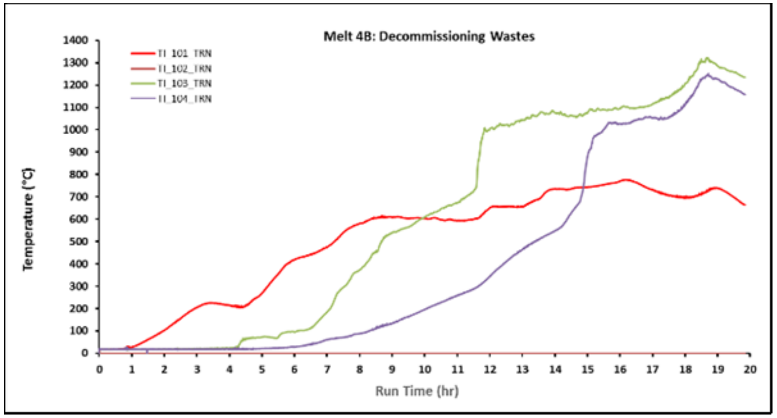
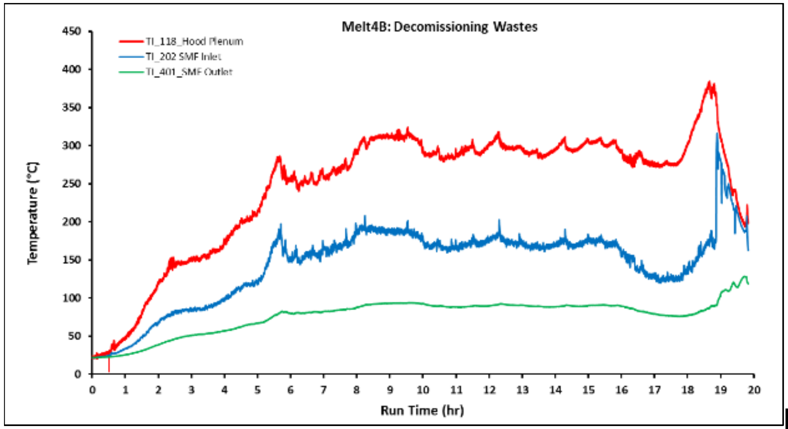
Upper photos – waste materials loaded into box
Bottom left – box prepared

Decommissioning Wastes



IR camera showing progression of melt





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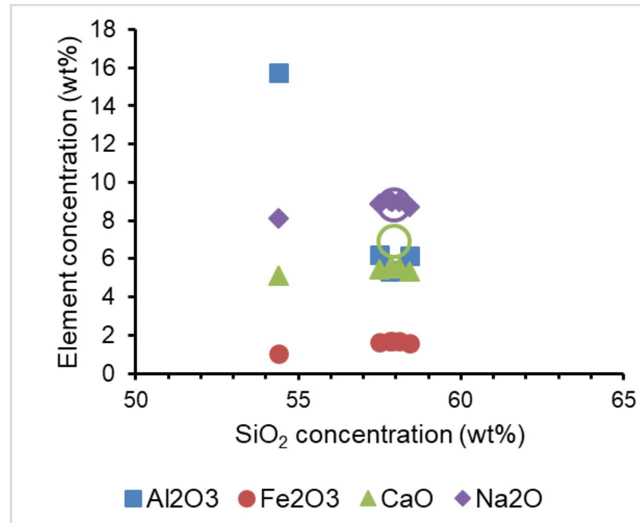
Decommissioning Wastes

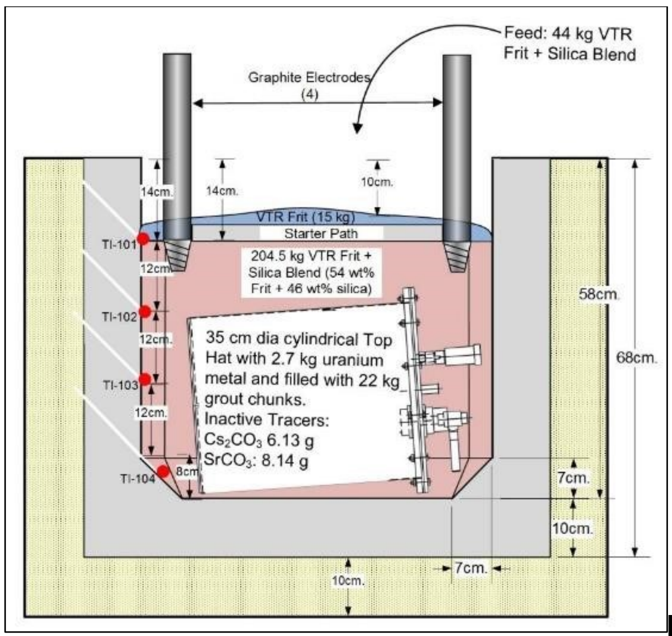
Product surface active melt (inset inactive melt)



Variation diagram of elemental concentration in product

Example 3 Uranium Containing Feeds

- Aim to demonstrate thermal treatment of surrogates from degraded fuel.
- Metallic uranium in a top hat
- Key is to assimilate uranium in the melt



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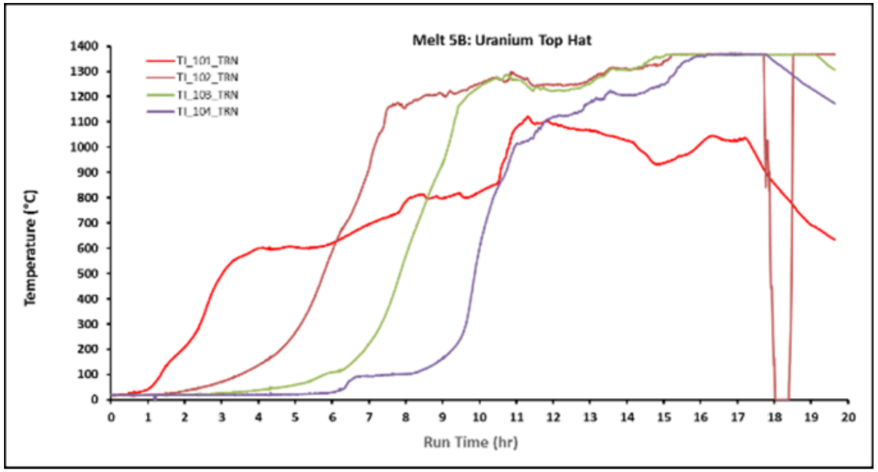
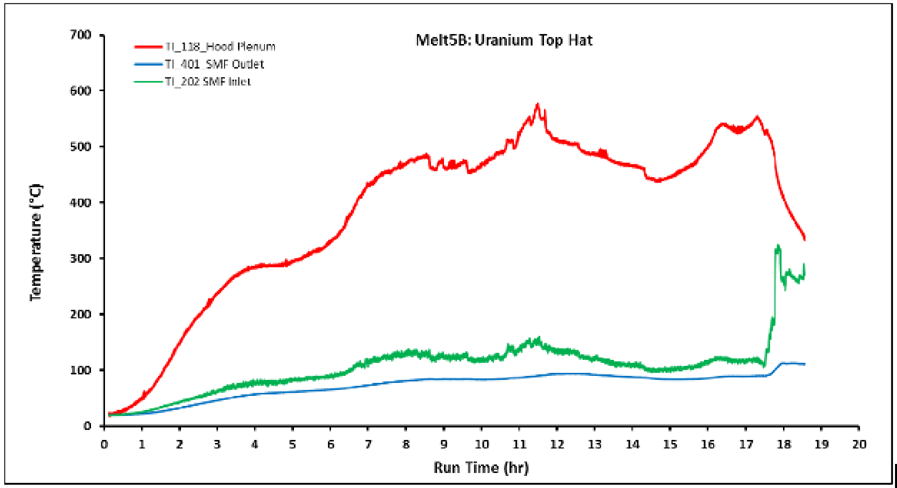
Uranium Containing Feeds





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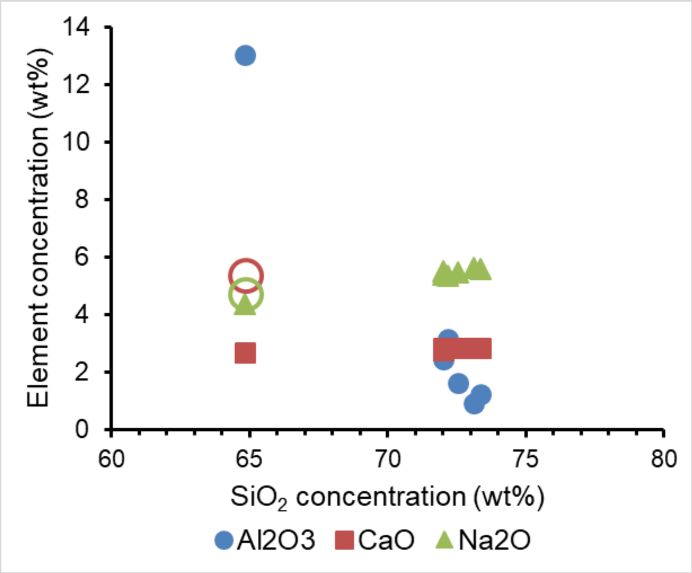
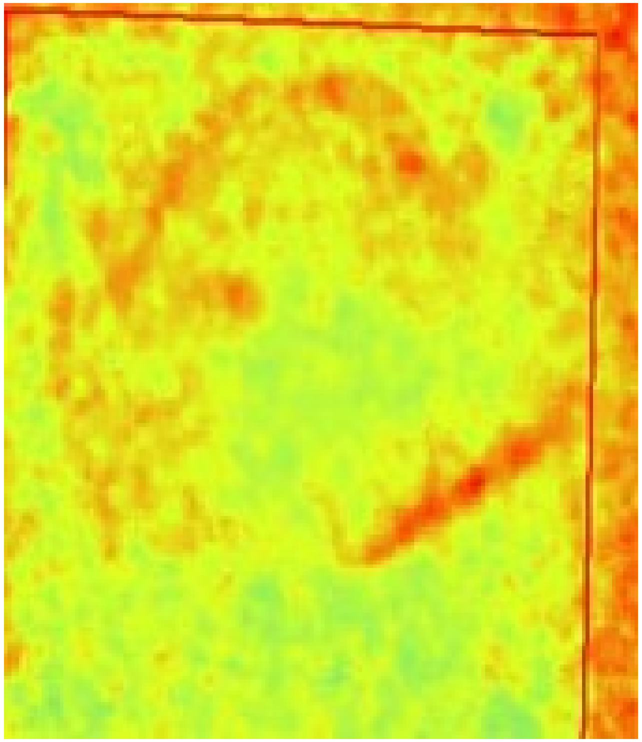
Surface of product (inset previous inactive melt)

Uranium Containing Feeds

- Iron content not full oxidised
- Muon tomography indicates top hat not consumed hindering uranium mixing in the melt (only ca 30% in melt)
- Other elements well mixed
- Longer melt times at maximum temperature should enhance dissolution and mixing

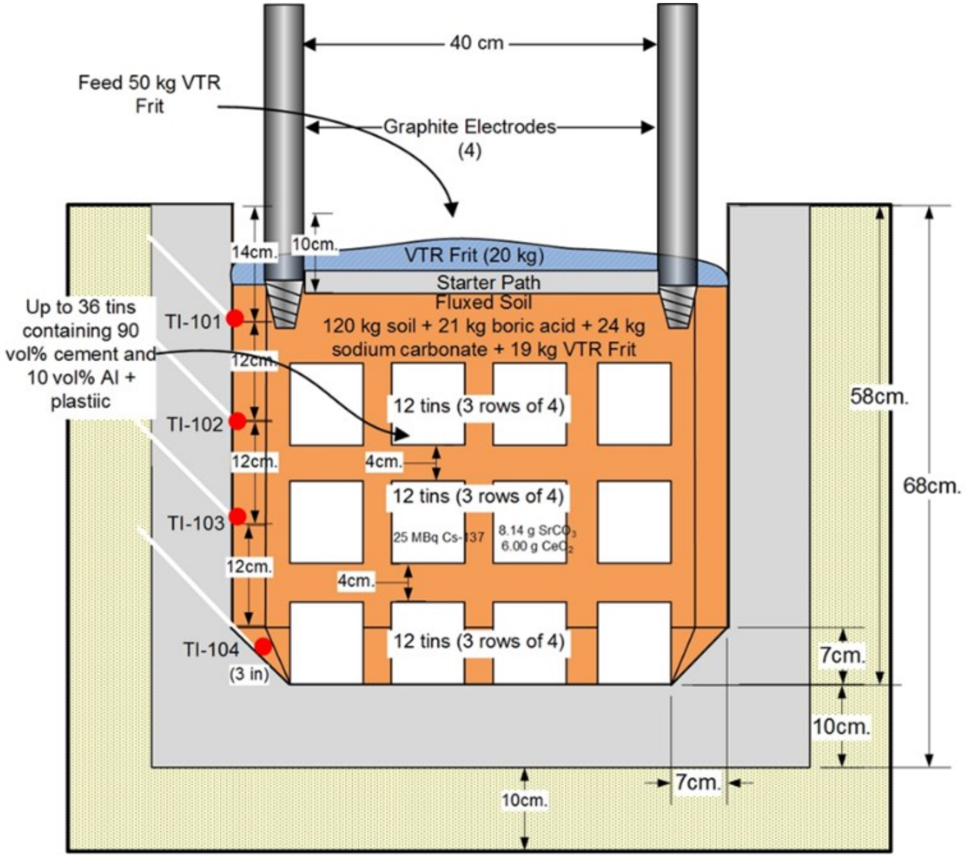




Muon scan of product

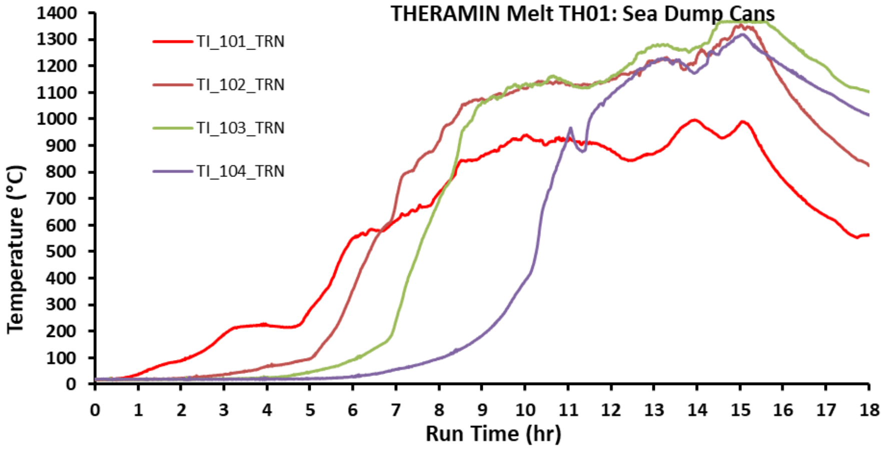
Example 4 Sea Dump Drums

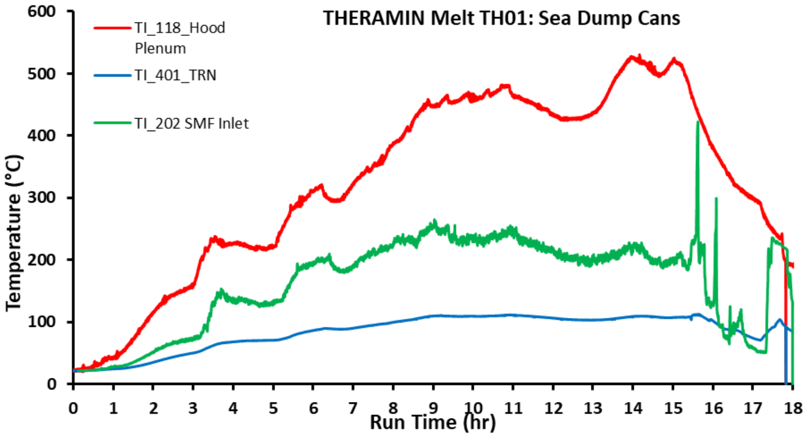
- Aim to demonstrate treatment of conditioned waste such as sea dump drums
- Top down melt
- Co-processing of sea dump drums and contaminated soil
- 36 tins containing grout, aluminium and PVC
- Active tracer: 25 MBq Cs-137
- Non-active tracers: Sr and Ce

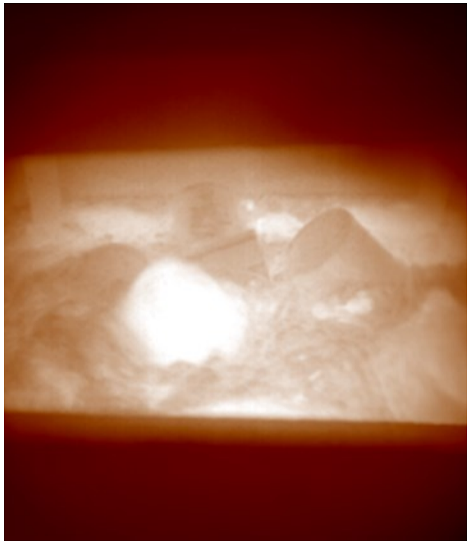


Sea Dump Drums Box Preparation

Sea Dump Drums

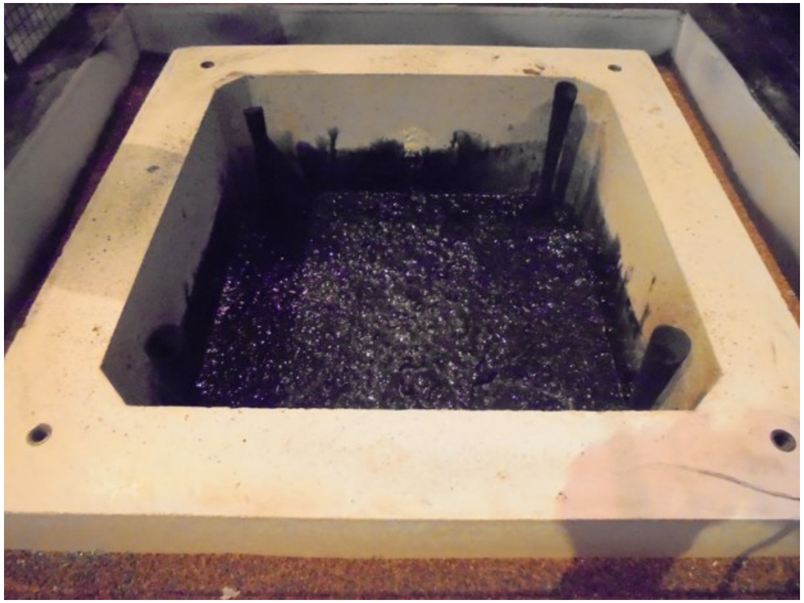






Surface of melt showing surrogate drums

Sea Dump Drums



Product surface

Glass Sample Point	Cs-137 Activity (Bq/g)
SP1.1	anomaly
SP2.1	82.8
SP2.2	80.5
SP2.3	82.4
SP3.1	76.5
Mean	80.5

- Gamma spectroscopy at various sample points illustrated good mixing of the radionuclides through the product
- Cs retention in the product was measured at 76%, a figure that could be improved with melt optimisation

Summary

- A series of demonstration melts have been carried out on a range of nuclear wastes across the NDA estate
- The trials have shown the possibility of using an in container vitrification approach to treatment of solid heterogeneous wastes
- The fidelity of the results are consistent with one-off trials and it is considered optimisation of melter operation and waste chemistry should process parameters such as radionuclide retention, mass balance etc

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