Further Underpinning of Grout Enclosure Techniques

2nd June 2009

UKAEA

What is Grout Enclosure?

- Inner container of waste is placed within a larger disposal container.
- The waste within the inner container is non-encapsulated.
- The inner container is entombed in grout within the disposal container to form the overall waste package.
- Potential packaging strategy for ILW considered problematic due to unacceptable interaction with grout.

Aim of the Programme

- To provide further underpinning of the grout enclosure packaging concept with a focus on the properties of particular Magnox wastes for which this disposal strategy has been identified.

Approach

- Identify relevant Magnox wastestreams
  - TBuRD review
- Identify generic waste packaging requirements
  - Focus on UK requirements
- Identify existing grout enclosure techniques
  - Wastestream, packaging strategy, technical issues
- Grout enclosure approach for Magnox wastes
  - Potential modes of implementation should grout enclosure be identified as preferred packaging strategy
- Applied assessment
  - Thermal properties
  - Wasteform assessment
  - Gas pressurisation

Magnox Wastestreams

- Desiccant and Ceramic Pellets – tritiated wasteform,
- ILW Oil – very low incorporation rate with cement grout,
- Submersible Caesium Removal Unit (SCRU) Pre Filters and HEPA Filters – avoidance of actively breaking filters apart,
- CXPP Cave Line Waste – tritiated wasteform,
- Spent Fuel Furnaces – contain depleted uranium.

Generic Requirements

- Focussed on NDA RWMD packaging and disposal requirements.
- Identified potential issues which may need to be addressed in a packaging proposal to NDA RWMD which considered grout enclosure.
- Not a waste specific assessment.

Packaging Requirements

- Requirements for packages containing non-encapsulated waste,
- Thermal properties,
- Response to fire accident,
- Response to an impact accident,
- Waste degradation,
- Gas generation.

Disposal Requirements

- Free liquids,
- Loose particulate material,
- Hazardous materials,
- Waste degradation,
- Gas generation & release,
- Rapid generation of gas & heat,
- Radionuclide release during transport & operations,
- Shifting loads,
- Container integrity,
- Voidage.

Existing Grout Enclosure Techniques

- Magnox low activity IONSIV IE-911 cartridge waste.
- Hunterston A MAETP post-filters.
- Trawsfynydd desiccant waste.
- Harwell RHILW – radium evaporation vessels.
- Harwell RHILW – fines.
- JET decommissioning wastes.
- Windscale Pile Reactors core graphite and aluminium charge pans.

Magnox Wastes for Grout Enclosure

- Desiccant & Ceramic Pellets:
  - Has been shown to be a feasible approach should desiccant be disposed as ILW.
- ILW Oil:
  - Solidification and grout enclosure
  - Potentially analogous to desiccant for grout enclosure approach once solidified.
- SCRU pre-filters:
  - Issue: May need to demonstrate sufficient grout fluidity to enclose filter body.
  - Solution: Multi-barrier approach & superplasticised grout.

Magnox Wastes

- HEPA filters:
  - Issue: Corrosion of aluminium in alkaline environment releasing hydrogen.
  - Solution: Alternative encapsulants/ compaction.
- Chapelcross Cave Line Waste:
  - Issue: Voidage may be an issue.
  - Solution: Use of inert void filler or alternative encapsulant may provide solution.
- Spent fuel furnaces:
  - Issue: Presence of significant internal voidage may be an issue.
  - Solution: Infill bulk voidage.

Applied Assessment

- Thermal properties of inner container.
- Wasteform assessment.
- Gas Pressurisation.

Thermal properties of Inner Container

- Range of inner containers available.
- Thermal properties of container may provide benefit; insulating the enclosed waste from the exotherm of grout curing.
- Cast iron, mild steel, stainless steel and epoxy all have thermal conductivities higher than cement.
- Epoxy has higher thermal conductivity than mild or stainless steel.
- Not necessarily advantageous as material will insulate temperature increases and decreases.
- Key point is that the thermal conductivity of the inner container is higher than that of the grout which will offset temperature profile in time.
- In the case of the use of alternative encapsulants such as polymers the use of an inner container material with a lower thermal conductivity may be preferable.

Wasteform Assessment

- Calorimetry, flow, viscosity, density, set time, bleed water, compressive strength and gas permeability.
- Formulations:
  - 3:1 PFA/OPC (w/s 0.42),
  - 9:1 BFS/OPC (w/s 0.39),
  - 3:1 PFA/OPC (w/s 0.37) with 0.3% ADVA Cast 551 superplasticiser,
  - 3:1 PFA/OPC (w/s 0.50),
  - Alchemie epoxy resin,
  - APS epoxy resin.

Wasteform Assessment

Parameter	3:1 PFA/OPC	3:1 PFA/OPC	3:1 PFA/OPC + 0.3% ADVA Cast 551	9:1 BFS/OPC
Water/solids ratio (w/s)	0.42	0.50	0.37	0.39
Time to peak heat release (Hrs)	27.78	26.60	18.80	9.23
Peak heat release (watts/kg)	0.305	0.254	1.035	0.330
Total heat released after 140 hrs (kJ/kg)	54.7	50.6	71.9	65.6
Initial Flow (mm)	430	680	1030+	610
Initial Viscosity (@106/s shear rate) (Pa)	1.00	0.40	0.77	0.44
Initial set time (Hrs)	<19.5	<16.5	>13	12.5
Final set time (Hrs)	<24	<31	<20.5	<18
Bleed Volume (%)	8.0	7.9	2.5	5.8
Liquid Density (g/mL)	1.72	1.75	1.73	1.76

Wasteform Assessment

Parameter	Alchemie Low Temperature	APS Low Temperature
Time to peak heat release (Hrs)	0.6	0.6
Peak heat release (watts/kg)	2.349	2.821
Total heat released after 140 hrs (kJ/kg)	171.0	195.4
Viscosity (Pa)	2.67	0.24
Gel Time 70° C (Hrs)	45.9	15.3
Final set time (hrs)	~145	~240

Wasteform Assessment

- If a low curing exotherm is required, e.g. for tritiated wastestreams, polymers should be avoided.
- Polymers may provide a solution for:
  - HEPA filters providing a barrier between Al and alkaline porewater.
  - SCRU pre-filters providing good infiltration due to their low viscosity.
  - Spent fuel furnaces, in conjunction with a void filler, to minimise internal voidage.
- Lowest total heat release was observed for 3:1 PFA/OPC (0.50 w/s). This formulation also had better flow properties compared to 0.42 w/s for PFA/OPC and BFS/OPC.
- 3:1 PFA/OPC (0.50 w/s) also had a long curing time and high bleed water.
- Super-plasticised grout formulation had the lowest level of bleed water, but high initial viscosity.
- The total heat release from superplasticised grouts was marginally higher than for non-superplasticised grouts. However, it remained within acceptable limits.

Gas Pressurisation

- Gas generation within a wasteform may include:
  - Radiolysis
  - Organic degradation
  - Corrosion of waste/metals
- MAGGAS used to model gas generation and corrosion profiles of wastes, encapsulants and packages with time.

Gas Generation

- Scenarios modelled:
  - Trawsfynydd desiccant enclosed with cementitious grout,
  - Trawsfynydd ILW oil absorbed on Nochar polymer enclosed with cementitious grout,
  - Oldbury SCRU pre-filters enclosed in cementitious grout,
  - Hunterston A HEPA filters enclosed in cementitious grout,
  - Hunterston A HEPA filters enclosed in polymer,
  - Chapelcross Cave Line waste enclosed in cementitious grout,
  - Chapelcross spent fuel furnaces enclosed in cementitious grout,
  - Chapelcross spent fuel furnaces enclosed in polymer.

Gas Pressurisation

- Modelling aimed to assess:
  - Bulk gas generation,
  - Radioactive gas generation,
  - Gas release methods.
- Bulk gas – assessment of total gas produced. Predominantly hydrogen and carbon based gases.
- Radioactive gases – ^{14}C and ^{3}H containing gases.

UKAEA

Gas Generation

- Modelling assumed $3m^3$ box except for Oldbury SCRU pre-filters (500 L drum).
- $3m^3$ box total gas generation should not exceed 86 litres per day.
- 500 L drum the total gas generation should not exceed 63 litres per day.
- Majority of scenarios fall within acceptable limits for bulk gas generation.

Gas Generation

- MAGGAS modelling indicated that gas generation leading to pressurisation of the package and potential failure may be an issue should the measures in place within containers to guard against this fail e.g. machined vents or holes.
- Radiolysis was found to be the most common form of gas generation, but low volumes were observed and it reduced with time due to radioactive decay. In some cases there was insufficient inventory information to take account of certain daughter radionuclides.
- Gas release from corrosion was observed for Hunterston A HEPA filters and Chapelcross spent fuel furnaces due to Al and dU. Special care required to maintain vent or use of polymer encapsulant which reduced gas generation in both cases.
- Organic degradation was observed for ILW oil and Chapelcross Cave Line waste. The generation rate reduces with increasing temperature but was found to have a consistent release rate over extended periods. Issue identified was the increased difficulty of maintaining vents over extended periods of time.

Conclusions

- Proposed Grout Enclosure approach:
  - Desiccant and ceramic pellets – package material in 200 L drum non-encapsulated. These drums may then be grout enclosed in $3m^3$ boxes when appropriate. The inner container should incorporate filtered vents to prevent over pressurisation.
  - ILW Oil – Absorb oil on to appropriate absorbent and package in 200 L drums non-encapsulated. These drums may then be grout enclosed in $3m^3$ boxes when appropriate. The inner container should incorporate filtered vents to prevent over pressurisation.

Conclusions

- SCRU Pre-filters – use pre-filter housing as the inner container and enclose in 500 L drum. Encapsulant may require further formulation to ensure suitable flow is maintained whilst minimising bleed to ensure infiltration of filter media. The waste package should include a filtered vent to prevent over pressurisation.
- HEPA Filters – may be compacted or directly enclosed with a suitable polymer within an inner container. This can then be enclosed in a standard NDA RWMD waste package. The inner container and waste package should incorporate filtered vents to prevent over pressurisation.

Conclusions

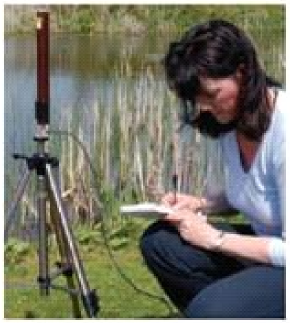
- Cave Line Waste – may be housed within a suitable inner container and suitably immobilised. Recommend use of a void filler in conjunction with an encapsulant to minimise internal voidage and minimise temperature excursions during curing.
- Spent Fuel Furnaces – may be housed in a inner container and suitably immobilised. Recommend use of an inert void filler in conjunction with an encapsulant to minimise internal voidage and minimise temperature excursions during curing. The internal container may be grout enclosed within a standard NDA RWMD container.

Acknowledgements

- Magnox North 2008/09 Generic Waste and Decommissioning R&D Programme





UKAEA