Installation and Operation of GeoMelt® In Container Vitrification in NNL Central Lab Active Rig Hall at Sellafield – 15328

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ABSTRACT

Cleanup and subsequent immobilization of wastes on the UK's NDA estate brings major challenges. With the exception of HLW where vitrification is utilized for immobilization, cement is typically used in the management and immobilization of non-heat generating wastes.

However some legacy feeds such as those containing reactive metals can be incompatible with cementation technologies, and the application of engineered cement encapsulating product to raw wastes increases wasteform volume. Cementation has also been developed to be compatible with the repository concept, which provides it with a level of protection from the environment. Potential delays in repository implementation and as yet to be determined repository waste form acceptance criteria for some wastes may require the duration of above ground storage of immobilized wastes to be extended with potential effect on the integrity of the wasteform.

Vitrification is a treatment option which destroys organics and hazardous inorganics such as asbestos, reduces wasteform volume, and produces a robust leach resistant wasteform. Kurion's GeoMelt®[1] In-container Vitrification (ICV)™[2] is a vitrification process wherein the treatment vessel can serve as an interim-storage, transport, and final long-term storage vessel - thus negating the need to pour glass into a separate container, effectively leading to a much simpler system than traditional waste melters.

The inherent volume reduction from vitrification results in a dense product with self-shielding properties, and the GeoMelt treatment process has been demonstrated to homogenize elemental metals and radionuclide contaminants of concern, eliminating hot spots and mitigating criticality concerns. All of which opens up alternatives strategies for storage and disposal.

GeoMelt has been proven in the commercial and US DOE waste treatment environment with over 26,000 tonnes of hazardous waste treated to date (half of this radioactive). Kurion and the UK's National Nuclear Laboratory (NNL) plan to demonstrate its application to Sellafield radioactive wastes. A small (engineering) scale demonstrator is being installed in the active rig hall at NNL's Central Laboratory at Sellafield UK with a twofold mission; 1) demonstration of the vitrification of ILW/LLW, and 2) processing of smaller volume orphan wastes that currently have no treatment path.

The NNL facility will allow the handling of uranium containing materials which form a substantial component of ILW currently stored on the Sellafield site. Accurate DFs across the melter and off gas system are often difficult to obtain using inactive materials at the low concentrations present in radioactive wastes. Installation in the NNL facility will allow trace quantities of active species such as Cs-137 and Tc-99 to be processed as part of a simulant ILW stream and monitoring will allow accurate decontamination factors (DFs) to be established to support future vitrification facility design.

In addition to underpinning melter operation and obtaining DFs across the system, the facility will allow the processing of radioactive waste arisings of low activity which may either be typical of larger waste volumes or may present as orphans without a disposition route. In either case the melter facility will be

[1] GeoMelt® is a registered trademark of Geosafe Corp.
[2] In-Container Vitrification (ICV)™ is a trademark of Kurion, Inc.

able to vitrify these wastes into a form that will be suitable for interim storage and disposal. Among the feeds envisaged for processing will be asbestos from power stations, contaminated soils, feeds containing uranium metals, ponds solids, sludge, and miscellaneous active laboratory wastes.

The NNL Central Lab capability will be used to analyze the active product to support disposal requirements whether through letters of compliance for the Geological Disposal Facility (GDF) or waste acceptance criteria for the Low Level Waste Repository (LLWR).

INTRODUCTION

Thermal treatment of nuclear waste is undergoing renewed consideration in the UK and elsewhere, in part due to the recognition of drawbacks inherent in other baseline waste treatment approaches, such as grout encapsulation. Vitrification has been recognized internationally as the established treatment method for high level nuclear waste for many years, but only until recently has it been considered as a viable option for lower level radioactive waste treatment in the UK. The Nuclear Decommissioning Authority (NDA) is currently evaluating thermal treatment for Low Level Waste (LLW) and Intermediate Level Waste (ILW), as demonstrated by their funding of several technology evaluations over the last 5 years. A symposium specifically focusing on thermal treatment of nuclear waste was held in the UK for the first time in 2013, and recognized UK academia are allocating resources for the study and promotion of thermal treatment for disposition of LLW and ILW.

The baseline approach for disposal of LLW and ILW in the UK is cementation, however this treatment approach is problematic for certain wastes. Typically it increases the overall waste volume rather than reduces it, and is not compatible with reactive metal bearing wastes (e.g., Pu, U, Mg, Al, etc.) because of the hydrogen gas produced by radiolysis in the cement. Cemented wastes are designed for disposal in a cement backfilled repository and have a limited shelf life for storage; as such any delays in repository implementation can result in degradation of cemented product in above ground storage.

In contrast, vitrification provides several advantages, including: 1) It typically decreases the waste volume to be stored and disposed which proportionally reduces waste storage costs (which typically far exceed near-term processing costs), 2) the glass product contains no water and is therefore unaffected by radiolysis or freezing/thawing concerns, 3) the leach resistance is superior to other waste forms, including cement, 4) it is a completely oxidized and final waste form requiring no inspection or monitoring of the waste package during storage, 5) the natural convective currents induced during processing homogenize the radionuclides precluding criticality concerns, and 6) the densified product provides for an inherent shielding characteristic.

TECHNOLOGY BACKGROUND

Although relatively unknown in the UK until recently, GeoMelt® vitrification has been used for treatment of low level (LAW) and mixed waste in the USA for over two decades and in Japan and Australia for more than a decade. Over 26,000 tonnes of hazardous waste have been treated with the process, with half (13,000 tonne) of this being radioactive materials.

GeoMelt In-Container Vitrification (ICV)™ provides additional benefits over traditional vitrification technologies in that the melt vessel also serves as the transport and disposal vessel, eliminating the usual (but complex) step of transferring the molten glass into a separate transport and storage vessel. A photo of a 10 tonne ICV melter is shown in Figure 1 and a photo of the melting process within the ICV vessel is shown in Figure 2.

Fig. 1 Ten tonne ICV Melter during waste treatment operations.

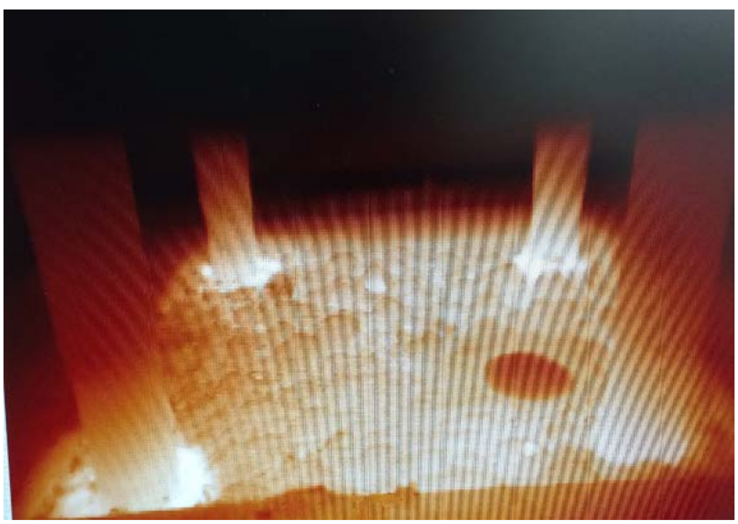

Fig. 2 Interior of ICV Melter during waste treatment.

GeoMelt is ideally suited to treat mixed waste streams concurrently, especially attractive where multiple treatment and disposal paths would otherwise normally need to be pursued. In particular waste that is bulky as in demolition debris, earthen material as in contaminated soils and sludges, and material that would otherwise need to be size reduced, sorted, and pretreated often times requires no size reduction or special preparation for vitrification.

PATH FORWARD

Recognizing the opportunity for application at the Sellafield nuclear site, the UK's National Nuclear Laboratory and Kurion, Inc. have partnered together to showcase the technology in NNL's newest licensed radioactive facility at Sellafield. A small-scale GeoMelt ICV system, which has been performing cold trials in the US and UK since 2009, is being installed at the NNL's Central Laboratory (B170 Building) Rig Hall, shown in Figure 3, in early 2015. This world class facility is uniquely equipped to accommodate the system, and it has the requisite nuclear safety controls needed for treatment of active wastes.

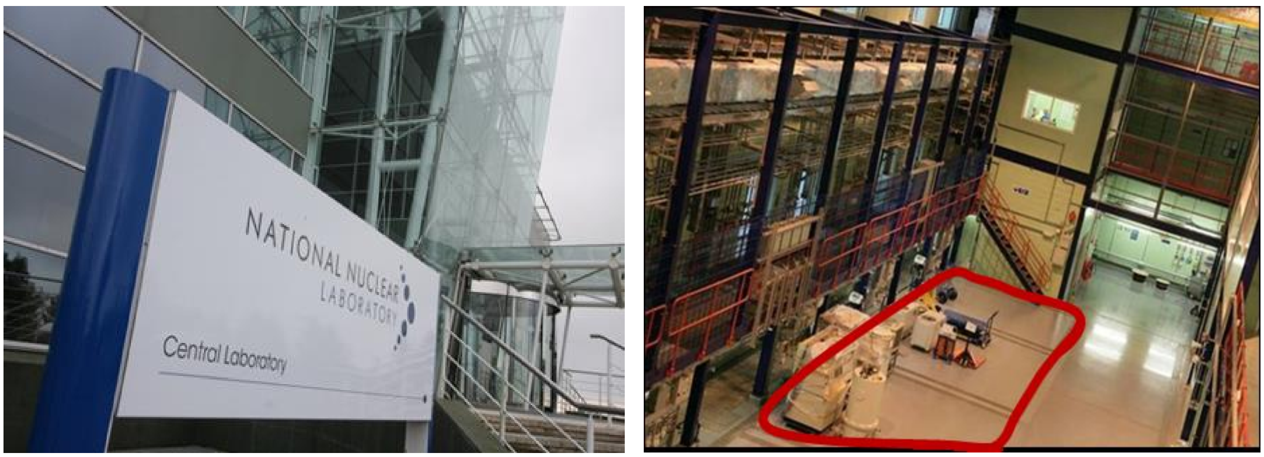

Fig. 3 NNL Central Lab Rig Hall GeoMelt System future location.

The GeoMelt system planned for install at the Central Lab is partially shown as it was arranged for acceptance testing in Figure 4. It is considered engineering scale for this mission given its dual charter to demonstrate treatment for a range of waste feeds and to provide an option for vitrification of small scale inventories of wastes across the NDA estate; typically those regarded as orphans currently without a treatment route. Anticipated wastes to be treated include, but are not limited to, contaminated asbestos, fuel cladding, silo waste, Magnox sludge, contaminated soil, and various orphan waste streams.

Processing typically results in treatment of 99 percent of the average waste feeds through pyrolysis and immobilization. The remaining off-gas effluent is treated and captured in an off-gas treatment system. For this project with NNL at Sellafield, particulate filtration and wet scrubbing will be employed. The first line of particulate filtration is via a sintered metal fibre filter that enables 99% of the particulate to be captured and recycled back to the melter, thereby minimizing secondary arisings. Scrub solution filters, PPE, HEPA filters, and other secondary wastes are also recycled to subsequent melts, as is, further improving process efficiency.

Fig. 4 GeoMelt system planned for install at NNL Central Lab, during construction acceptance testing.

The current off gas system is designed to accommodate a larger melter than the current 100 litre ICV shown in Figure 5, and larger ICV vessels are being evaluated for future use. One such design includes the Sellafield Ltd. generic 3 m^3 container, shown in Figure 6. This container has been previously evaluated for use as a candidate GeoMelt ICV vessel and would allow a significant advantage to the NDA by utilizing an approved waste transport vessel and precluding the need for transfers into and out of the ICV treatment vessel. Waste could be loaded into the standard 3 m^3 vessel at the point of origin, transported to the GeoMelt treatment system, vitrified while remaining in situ, and then transported directly to interim or long-term storage after processing.

GeoMelt, an inherently mobile process, may also be deployed at waste source sites precluding the need to transport unprocessed hazardous waste over the road amongst the public. As can be imagined, this singular vessel has tremendous benefits to waste owners and the NDA. The concept is currently being evaluated and could be incorporated into the NNL system in 2015.

Fig. 5 GeoMelt 100 litre ICV treatment vessel, setup for UK waste trials in the UK.

Fig. 6 Generic 3m3 container considered as future GeoMelt ICV container.

Some higher activity wastes at Sellafield will likely require remote handling during waste treatment operations. Although the GeoMelt treatment process is unaffected by activity level, the associated high gamma dose prevents near contact work by operations personnel. To accommodate the higher activity wastes, specially designed hot cells at the Central Lab are being evaluated as a future setting for a

GeoMelt system. These hot cells have the ability to transfer wastes into and out of the hot cells using remote systems, ensuring worker dose protection and contamination control. Two of these hot cells are shown in Figure 7.

Fig. 7 NNL Central Lab high activity hot cells.

CONCLUSION

The installation of Kurion's GeoMelt technology in the active rig hall of NNL's Central Laboratory on the Sellafield Site presents an opportunity to demonstrate the feasibility of vitrification of low and intermediate level wastes to a form suitable for storage and ultimate disposal, and also to demonstrate the effective management of off gas and other effluents. By using this installation to treat small volumes of lower level wastes, it will raise technology readiness and underpin the potential design and build of plants to treat high volume intermediate level wastes in the UK and worldwide.