Nuclear Decommissioning Authority

GeoMelt Vitrification of ILW (Preliminary stage)

Summary of Assessment Report

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Background

AMEC is an international engineering services company providing planning, investigations, remediation, engineering, design and construction services to government and commercial/industrial clients. The company works at local, national and international levels, covering North America, the United Kingdom, Continental Europe and other countries worldwide. The GeoMelt process represents a group of vitrification technologies that can be configured in various ways to meet a wide range of treatment requirements. The GeoMelt processes are known to transform hazardous chemical and radioactive wastes into a stable vitreous and crystalline material. In GeoMelt applications, a waste and soil mixture is electrically melted to destroy, remove, or permanently immobilise contaminants. Melt temperatures generally are between 1200 and 2000°C, depending on the composition of the waste and soil mixture. Organic materials are destroyed and/or removed during the melting process. It is understood that the product of the GeoMelt process is semi-crystalline glass, which immobilises heavy metals and radionuclides in a durable wasteform. The GeoMelt vitrified product has been shown to be suitable for long-term management and disposal in certain overseas facilities. The GeoMelt technology is the property of AMEC and/or its Licensors.

AMEC has sought views on feasibility of the application of the GeoMelt vitrification process to the packaging of intermediate level waste (ILW) in the UK. This is to enable AMEC to offer to the UK waste packagers the implementation of a new method of treatment for disposal of ILW and other mixed wastes with the confidence that the process is compatible with long-term management as defined by the Geological Disposal Facility (GDF).

It is proposed that soil (including radioactively contaminated material) may be used in the UK as the primary glass former. This would enable two waste streams to be treated and disposed of together. If required, additives such as silica sand can also be included in the melt to change the characteristics of the glass if the feed wastes do not result in a suitable final product.

This document summarises the results of a preliminary assessment carried out by NDA Radioactive Waste Management Directorate (RWMD) to determine the compatibility of the vitrified waste with developing plans for waste management including transport to and emplacement in, a geological disposal facility.

Scope of the Proposals

The submission is not provided in support of a specific UK waste stream. Instead, it is based on generic information collated for application of the GeoMelt technology to the conditioning and solidification of contaminated soil for an overseas project.

In agreement with AMEC, the assessment has concentrated on the disposability issues raised by the GeoMelt vitrified product itself and for simplicity it has been assumed that the product is presented for disposal in a $3m^3$ Box meeting RWMD packaging standards. In line with existing practice, the assessment has considered the compatibility of the $3m^3$ Box containing GeoMelt vitrified product with the expected requirements for safe long-term management, including transport, emplacement and disposal, as currently expressed by the RWMD reference concept for geological disposal of ILW.

The process of assessing a significant quantity of different material, in this case vitrified material, for disposal under the geological concept for ILW, which utilises cementitious materials to provide a *'chemical'* barrier, might be expected to identify incompatibilities between the new material and the generic concept. The outcome of this preliminary assessment is therefore considered as an important input to evolving both the development of vitrified products and of the disposal concept to accommodate them.

This preliminary assessment considers 3,000m^3 of conditioned waste. It is assumed that the GeoMelt vitrified waste would be packaged into 1,112 boxes based on a package payload of 2.7m^3 in a 3m^3 Box.

Packaging Proposals

The GeoMelt process can be applied using In-Container Vitrification (ICV), or In-Situ Vitrification (ISV), or a newer, more advanced in-situ method called Subsurface Planar Vitrification (SPV). If the ICV process is followed it is assumed that the waste will be placed in a steel container (for example 3m^3 Box), which is lined with separate layers of insulating and refractory materials, inside which the waste is vitrified. If the ISV or SPV processes are followed it is assumed that the vitrified product is removed from its external in-situ location and placed into the disposal container.

During the GeoMelt process hazardous wastes are stabilised by inserting electrodes in a soil and waste matrix and establishing an electric current between the electrodes. Two to four graphite electrodes are normally used to supply power from the transformer to the melt in the ICV container. Electrode sizes range from 50 to 300mm in diameter depending on the application. Soil is used as an inexpensive glass-former in ICV applications, or is naturally occurring in ISV treatment of contaminated earthen media.

For start up a small amount of graphite flake mixed with either soil or glass frit is placed in paths between the electrodes on the soil surface. Dissipation of power through the starter material creates temperatures high enough to melt a layer of soil, thereby establishing a molten, conductive path.

When applied for the treatment of radioactive wastes, the process is understood to destroy the organic content of the waste and to decompose and melt many inorganic constituents, resulting in the production of a vitrified wasteform. Some of the radionuclides in the waste would be volatilised in the high temperature process, and an off-gas treatment plant would be required to manage them. Information provided by AMEC suggests that the use of the GeoMelt process would reduce the volume of waste to be disposed; the extent of the volume reduction is dependent on the nature of the waste.

Assessment of Disposability

The acceptability of the waste packages produced by the application of the GeoMelt vitrification process has been assessed against criteria established for the Geological Disposal concept and associated Generic Waste Package Specification. The Assessment of Disposability is based upon a set of radionuclide inventories derived by RWMD for the purposes of this generic assessment.

It has been found that the GeoMelt vitrification process can potentially reduce the volume of the waste requiring disposal to the repository. It can also use contaminated soil as part of the glass-forming matrix for the formation of vitrified ILW wasteform, hence reducing further the volume of the waste ultimately requiring disposal. The high temperatures used in the GeoMelt vitrification process are understood to destroy organic and hazardous materials. Gas generation from the corrosion of reactive metals and radiolysis of vitrified wasteform is expected to be negligible as water content of the wasteform is minimised through the high temperature treatment process.

The assessments of Transport Safety show that it would be possible for packages containing the GeoMelt vitrified product to comply with all relevant criteria if transported in 285 mm thick walled Type B transport containers such as the Standard Waste Transport Container (SWTC). The current assessments indicate that the bounding assessment inventory could include significant fissile material content, but that this is within the limits proposed for safe transport within the SWTC.

The assessments of Operational Safety show that it should be possible for $3m^3$ Boxes containing the GeoMelt vitrified product to be handled and stored safely within a geological repository. The current assessments indicate that assessed doses do not represent significant fractions of the limits applied by RWMD. Furthermore, consideration of the conservatisms in the assessments and expected future revisions to methodologies and assumed parameters would be expected to reduce the assessed doses considerably.

The assessments of Post-closure Performance show that the potential destruction of the organic content of the waste through high temperature processing is beneficial to the post-closure safety case. The efficiency and effectiveness of destruction remains a residual issue where further information is required. The principal barrier to the release of radionuclides from a vitrified wasteform is the low leach rate of the radionuclides from the vitrified matrix. Therefore, it would be necessary to establish the potential for degradation of the wasteform due to interaction with alkaline porewater, and the effect on leach rate.

In the context of the existing repository design and specification, the calculations carried out as part of the investigation of pH buffering performance in the geological repository nearfield indicate that the product of the reaction of the GeoMelt vitrified wasteform with local backfill would not provide an adequate pH buffer. The potential reaction of silicon in the GeoMelt vitrified wasteform with the cementitious backfill could reduce its buffering capacity. In general, the analysis has shown that the volume of vitrified product disposed to a vault backfilled with cementitious material, under the present models and underlying assumptions, would have to be limited to a relatively small amount to provide confidence that long-term pH buffering requirements can be met. Additionally, incompatibility with the cementitious chemical barrier could arise because it is possible that a high pH environment could lead to a faster dissolution rate of the GeoMelt wasteform than at lower pH environment.

In the event that the GeoMelt vitrified wasteform would ultimately prove to be incompatible with the cementitious chemical barrier as used in the current disposal concept, alternative disposal options avoiding the high pH environment could be developed.

RWMD notes that the assessment has been restricted to consideration of 'generic waste' defined in this Assessment Report In the event that AMEC, or any waste packager adopting this waste treatment process, wishes to apply the GeoMelt vitrification process to actual wastes or materials then, additional detailed disposability issues might be expected to be raised.

Requirements for further development work

The preliminary assessment of the application of GeoMelt vitrification process to the packaging of ILW has identified a number of recommendations for further work that will be required to facilitate any future formal endorsement of such packages.

The recommendations arising from the assessment are divided into those relating to information or development work to be undertaken by AMEC and/or waste packager, which should be provided in formal submissions (20 recommendations) and those relating to the development of assessment methods and models for use by RWMD (3 recommendations). Of the 20 recommendations identified for action by AMEC and/or waste packager, 9 recommendations are identified as generic needing attention at the next stage of the LoC submission, whereas the remaining 11 recommendations are related to GeoMelt-specific issues requiring further information and development work on the vitrification process itself.

The following will need to be provided as part of any future packaging proposal for the GeoMelt vitrification process:

- Provision of a substantiated waste package inventory, with particular emphasis on the disposition of volatile species and radionuclides of significance following high temperature processing;
- Identification of the nature of any additives that may be required for the purposes of operational control or glass-network formation;
- Development of wasteform performance criteria and demonstration that the proposed process is robust to potential variations in the waste characteristics;
- Demonstration of control process variables to avoid irregularities in the waste matrix caused by foam formation or accumulation of (scrap) metal parts;
- Demonstration of radionuclide retention and wasteform performance under conditions representative of the repository near-field;
- Confirmation of details of the waste container design and refractory liner.

The above points have been raised as a series of recommendations within the Assessment Report.

Conclusions

A preliminary assessment of the potential application of the GeoMelt vitrification process for the packaging of ILW has been performed. In addition to considering the specific performance of packages containing the GeoMelt vitrified product, the assessment was also intended to identify any incompatibilities with the existing ILW disposal concept.

An Assessment Report has been produced setting out the preliminary assessment of disposability judged against the Geological Disposal concept. This identifies the extent of compatibility with the disposal concept and areas where further information or developments are required. A number of recommendations have been made, which will require to be addressed as part of any development of the proposals by AMEC and/or waste packagers.

It has been found that the GeoMelt vitrification process can potentially reduce the volume of the waste to be disposed to a repository. It can also use contaminated soil as part of the glass-forming matrix for the formation of vitrified ILW wasteform, hence reducing further the volume of the waste ultimately requiring disposal. The high temperatures used in the GeoMelt vitrification process are understood to destroy organic and hazardous materials. Gas generation from vitrified products is expected to be negligible as water content of the wasteform is minimised by the high temperature treatment process.

The assessments of Transport and Operational Safety have shown that the packages containing the GeoMelt vitrified product, if packaged in a suitable container such as $3m^3$ Box and with the extent of inventories examined in the assessment, are likely to comply with all relevant criteria.

In the context of the Post-closure Performance Assessment, the calculations carried out as part of the investigation of pH buffering in the geological repository nearfield, indicate that the product of the reaction of the GeoMelt wasteform with local backfill could compromise pH buffering. Further work to investigate this issue is recommended.

In the event that the GeoMelt wasteform will ultimately prove to be incompatible with the cementitious chemical barrier as used in the current ILW disposal concept, alternative disposal options avoiding the high pH environment could be explored.