Commissioning of a GeoMelt Vitrification Plant at the Central Laboratory on the Sellafield Site – 17561

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ABSTRACT

The National Nuclear Laboratory (NNL) and Kurion Veolia (Kurion) have installed a GeoMelt® In-Container Vitrification (ICV)® radioactive waste treatment system in the Central Laboratory Active Rig Hall at Sellafield. This installation was completed in 2016. GeoMelt incorporates a range of patented and proprietary vitrification processing technologies that are configured in a variety of ways depending on the project and the waste. GeoMelt transforms hazardous chemical and radioactive wastes into an inert vitreous monolith. Hazardous organics are destroyed by pyrolysis and heavy metals and radionuclides are immobilized within the glass matrix where they are not preferentially leached into the environment. GeoMelt IVC produces a durable wasteform for a large variety of input wastes. The batch nature of the process which involves single-use refractory offers a wide range of process benefits over traditional vitrification technologies including:

- a wide range of waste chemistries allowing high waste loadings;
- compatibility with heterogeneous wastes including wastes with high metal content;
- a technological simple solution without stirrers, bubblers, etc.;
- No refractory corrosion concerns or melter drain failure scenarios;
- Flexibility in glass chemistry and melter/disposal container configuration allows the wasteform to be specifically tailored to the storage or disposal site requirements.

As part of the 2016 system commissioning at NNL's Central Laboratory, three demonstration melts were performed, one funded by Sellafield Ltd. and two by the Nuclear Decommissioning Authority (NDA). The first melt processed inactive soil with an inactive caesium tracer. The second melt processed inactive soil with a Cs-137 tracer. The third melt processed active waste soil from a variety of NDA nuclear licensed sites. The work conducted during commissioning was multi-purpose; it successfully demonstrated the benefits that the GeoMelt technology could bring to the UK NDA estate while performing equipment testing/troubleshooting and operator

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training. A significant benefit of the GeoMelt ICV technology is volume reduction for wastes which would otherwise experience a volume increase if encapsulated. Another benefit is the ability to treat difficult radioactive waste streams not amenable to encapsulation (e.g., reactive and/or organic wastes) with a very low energy consumption.

The purpose of the first commissioning melt, Plant Performance Demonstration (PPD)-1, was to operate the GeoMelt system under typical conditions and to perform a post-melt mass balance of the caesium as a surrogate for Cs-137 in order to access retention of caesium in the final glass product. The melt processed a mixture of inactive soil obtained near the Sellafield site (as analogue for contaminated Sellafield soil), additives, and glass frit. An inactive caesium tracer was added to this melt as Cs_2CO_3. The purpose of the second commissioning melt, PPD-2, was to operate the GeoMelt system under typical conditions and to perform a post-melt activity balance using a Cs-137 tracer in order to assess retention of Cs-137 in the final glass product. Materials processed were inactive soil, glass frit, additives, and a radioactive caesium tracer (CsCl). The purpose of the third melt, Experiment-1 (EX-1) was to treat active waste and inactive waste simulant, as a demonstration of simultaneous processing of multiple waste streams. EX-1 consisted of processing active soil, Magnox sludge simulant, inactive soil, additives, and frit. The active soil used for this melt was obtained from the Hunterston A, Bradwell, Capenhurst, and Sellafield nuclear licensed sites. Since most soils are high in silica, the concept for this experiment was to use the active soils to provide glass formers while co-processing Magnox sludge simulant which does not contain glass formers. Beyond demonstration of capability areas of focus of this series of demonstrations included processing efficiency (kWh/kg treated) and caesium retention (%). This paper summarizes operations and results of the three melts.

INTRODUCTION & TECHNOLOGY DESCRIPTION

Since the early 1990s Kurion’s GeoMelt technology has treated hazardous and radioactive waste, producing more than 26,000 tons of stable vitrified product for government and commercial clients in the United States, Japan, Australia, and the United Kingdom.

GeoMelt incorporates a range of patented and proprietary vitrification processing technologies that are configured in a variety of ways depending on the project and the waste. GeoMelt transforms hazardous chemical and radioactive wastes into an inert vitreous monolith. Hazardous organics are destroyed by pyrolysis and heavy metals and radionuclides are immobilized within the glass matrix where they are not preferentially leached into the environment.

Fig. 1. GeoMelt at the NNL Central Lab Facility

GeoMelt ICV is batch waste treatment process that is performed in a single-use refractory-lined steel container. ICV containers range from small (i.e., 206-liter drums) [2] to fairly large (i.e., purpose-built containers that hold over 44,000 kg of glass) [3]. The process has been successfully used to treat a wide range of contaminated wastes and debris including mixed low-level radioactive wastes, polychlorinated biphenyls, pesticides, dioxins, and a range of heavy metals. The waste is blended with glass-formers and melted using Joule heat generated by electrical current supplied by graphite electrodes imbedded in the batch. The glass-formers can be contaminated soil, industrial minerals, glass frit, or a combination of any of the three. Melting is initiated by passing current through a moderately conductive starter path composed of a mixture of graphite flake and frit. The starter path frit melts and transfers the current to the surrounding waste which is conductive once it begins to melt. The melt is then able to propagate. As waste is processed into dense glass, volume is made available inside the container for additional waste and glass formers to be added to the melt. Thermal convection mixes the waste as it is melted, eliminating the need for complicated mechanical stirrers or bubblers. Electrical power is shut off when the container is full and vitrification of all the waste materials is complete. When power is shut off, the molten glass cools into a homogenous glass monolith with excellent chemical durability. The ICV container either is reused or disposed of after each melt.

The process is conducted under vacuum induced by a process blower that exhausts off-gasses from the melt through an off-gas treatment system which consists of a combination of high-efficiency particulate air (HEPA) filtration and wet scrubbing. Additional components may be added to the off-gas treatment system for waste-specific off-gas abatement (e.g., selective catalytic reduction (SCR) for oxides of nitrogen (NO_x), sintered metal filtration (SMF) for additional particulate removal, etc.).

Vitrification is a thermal treatment process that offers several key benefits for radioactive waste treatment, including immobilisation of radionuclides in glass which is a very leach-resistant wasteform; passivation of reactive metals (e.g., magnesium, zirconium, sodium, uranium, plutonium, etc.) by oxidation; and destruction of organic wastes which results in significant volume reduction and eliminates compatibility issues associated with alkaline cement matrices [1]. The GeoMelt ICV process has several unique advantages over other vitrification methods owing to the batch nature of the process which involves single-use refractory without the requirement for glass pouring:

- Wide range of waste chemistries allow for high waste loadings
- Compatible with heterogeneous wastes including wastes with high metal content
- Technologically simple without stirrers, bubblers, etc.
- Flexibility in that the final glass product can be tailored to the storage or disposal site requirements, including by using an approved waste package as the treatment container.

GeoMelt has recently been deployed in the UK at NNL’s Central Laboratory Active Rig Hall on the Sellafield Site. As part of the 2016 system commissioning, three demonstration melts were performed, one funded by Sellafield Ltd. and two by the Nuclear Decommissioning Authority (NDA). The first melt processed inactive soil with an inactive caesium tracer. The second melt processed inactive soil with a Cs-137 tracer. The third melt processed active waste soil from a variety of NDA nuclear licensed sites. The work conducted during commissioning was multi-purpose; it successfully demonstrated the benefits that the GeoMelt technology could bring to the UK NDA estate while performing equipment testing/troubleshooting and operator training. This work is described here.

SYSTEM DESCRIPTION

The GeoMelt system commissioned at the Sellafield Central Laboratory is shown on Figure 2. The system is divided into 6 zones: 1) ICV Treatment; 2) Off-gas Pre-Treatment; 3) Cooling System; 4) Wet Scrubbing; 5) Off-gas Final Conditioning; and 6) Off-gas Discharge. Figure 2 shows the system with demarcations of zones which are described in the following sections.

Zone 1: ICV Treatment

Zone 1 includes a 150 kW Scott-Tee transformer that provides power to the ICV melter. The Scott-Tee transformer converts 3-phase line power to two independent phases that provide the electrical power to the melt. GeoMelt ICV is based on joule heating, which occurs when an electrical current passes though molten material. As the molten mass grows in volume, electrical resistance decreases, consequentially requiring an increase in current to maintain or increase the power level for continued waste processing. The changing voltage/current needs are provided by use of multiple voltage taps on the transformer.

The melter consists of a steel container lined with refractory materials that contain the melt. The refractory lining consists of a pre-cast 200-L crucible surrounded by refractory silica sand. The ICV material feed system incorporates a dual-isolation valve airlock to add materials to the melter during processing. An off-gas hood attached to the melt container routes emissions and surplus heat to the downstream off-gas treatment equipment. Off-gas flow is induced by a blower that maintains a vacuum throughout the system. Process temperature and pressure are monitored at key points to provide hood vacuum control and aid operators in controlling power input to the melter. As melt conditions change, a pre-set vacuum on the ICV container is maintained by a fast acting feedback loop to the speed controller on the main off-gas blower. Real-time viewing of the hood interior is providing by an infrared (IR) camera that records continuous video to a dedicated workstation.

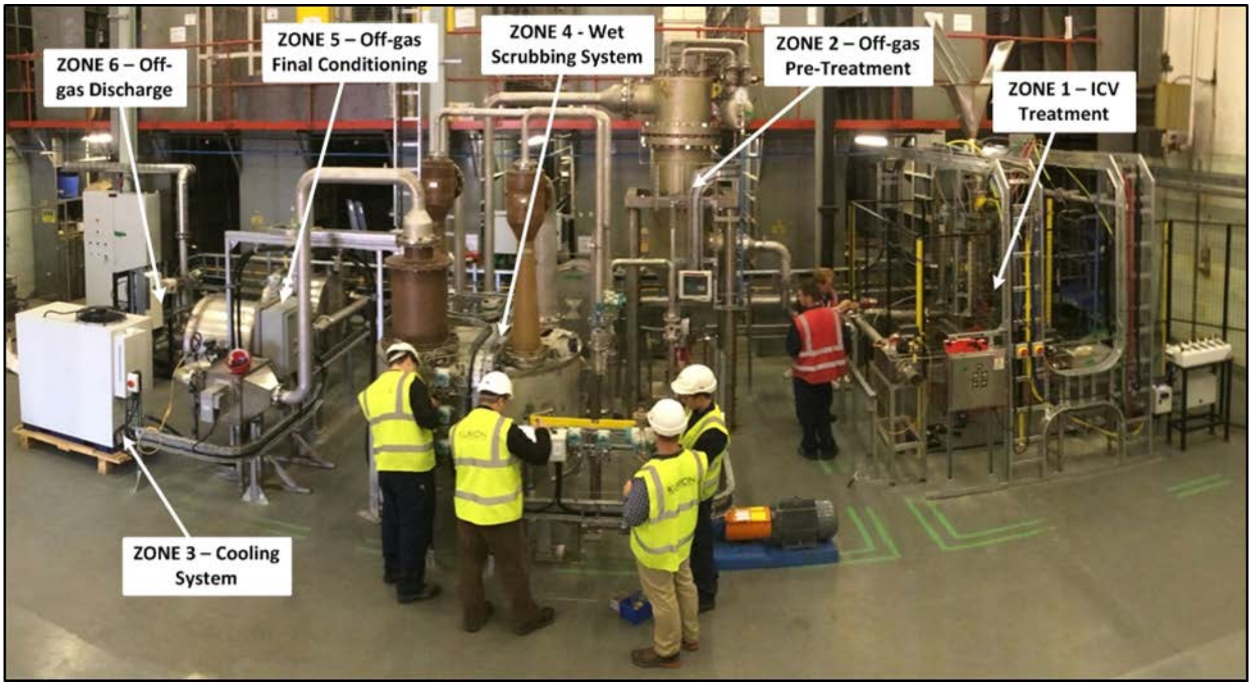


Fig. 2. GeoMelt ICV System (at Workington before installation at Sellafield) Showing Zones

Zone 2: Off-gas Pre-Treatment

Off-gas from the ICV melter is routed directly to a back-pulsable sintered metal filter (SMF) that captures 99.5% of 1 micron or larger particulate. The filter is designed to withstand elevated off-gas temperatures and provides long term use before replacement of the stainless steel filter media is required. An integrated back-pulsing system removes particulates from the filters preventing them from loading up during operations. The particulate is discharged to a particulate bagging system and captured in a sealed plastic bag. The particulate can then be recycled into the melter or disposed separately. A bypass line to high temperature HEPA filter is also available for use instead of the SMF.

Zone 3: Cooling System

A secondary liquid cooling system is used to cool scrub waster from the wet scrubbing system which is Zone 4. Water from the scrubbing system passes through the primary side of a plate heat exchanger and transfers heat across the plates to the secondary side and into a cooling liquid that is chilled by a dedicated chiller unit. The cooled scrubber liquid enables excess moisture in the off-gas to more effectively condense and remain in the scrub water rather than exiting the off-gas stack as a vapour.

Zone 4: Wet Scrubbing

The off-gas from the SMF enters a wet scrubbing system consisting of two venturi scrubbers connected in series, followed by a mist eliminator. Water spray nozzles inside the venturi scrubber quench and cool the incoming off-gas flow. The spray pattern promotes good mixing, condensation, and heat transfer between the spray and off-gas flow streams. The venturi scrubbers cool the off-gas, remove particulate, and condense and neutralize acid gasses that may have passed through the first stage filtration. Scrub water is recirculated from a holding tank (1800 L) to the scrubbers and the tank pH is adjusted by automatic addition of sodium hydroxide solution. The off-gas exits the second venturi scrubber into a mist eliminator that removes entrained water droplets before the off-gas leaves the scrubbing system to the final conditioning stage.

Zone 5: Off-gas Final Conditioning

After wet scrubbing, the off-gas passes through an inline electrical heater that raises the gas temperature (nominally by 10 °C) to ensure any entrained water is kept in a vapour phase for the final off-gas treatment. After heating, the off-gas enters a HEPA filter to remove remaining particulate, and then enters the primary off-gas blower for discharge to the off-gas stack. A backup HEPA filter and backup off-gas blower are available if needed. The backup blower starts automatically by an independent safety circuit in the event of a loss of vacuum or flow in the system. Final destruction and removal efficiency (DRE) for pollutants is typically 99.9999% or better through the ICV equipment and off-gas system.

Zone 6: Off-gas Discharge

The off-gas stack is connected to the Central Laboratory C3 Ventilation system where additional HEPA filtration occurs. Emissions are then exhausted to the atmosphere.

Instrumentation

The entire treatment and off-gas system is instrumented to provide continual monitoring of key process parameters, including temperature, pressure, and flow. This information is fed to a supervisory control and data acquisition (SCADA) system that monitors, records data, and controls key system components. A secondary and independent Safety Integrity Level 2 (SIL2) rated system monitors temperature, pressure, and flow at key points, and will shut off power to the GeoMelt equipment and/or start the backup blower if one of these parameters falls outside predetermined safety limits.

METHOD

Demonstration Overview

Three melts were conducted in this piece of work, each with different goals. These are summarized below:

1) **Plant Performance Demonstration 1 (PPD-1):** The purpose of the first commissioning melt (PPD-1) was to operate the GeoMelt system under typical conditions and to perform a post-melt mass balance of the caesium as a surrogate for Cs-137 in order to access retention of caesium in the final glass product. Aspects of melt preparation and performing the melt activities were carried out as if the material being treated was active for purposes of familiarization of Kurion operators to Sellafield rules controlling working with active wastes. Materials processed were non-active soil, glass frit, additives, and a non-active caesium tracer.
2) **Plant Performance Demonstration 2 (PPD-2):** The purpose of the second commissioning melt (PPD-2) was to operate the GeoMelt system under typical conditions and to perform a post-melt activity balance using a Cs-137 tracer in order to assess retention of Cs-137 in the final glass product. Materials processed were non-active soil, glass frit, additives, and a radioactive caesium tracer (CsCl).
3) **Central Lab Experiment 1 (EX-1):** The purpose of Experiment 1 (EX-1) was to treat active waste and inactive waste simulant, as a demonstration of simultaneous processing of multiple waste streams using the GeoMelt ICV process. EX-1 consisted of processing active soil, Magnox sludge simulant, inactive soil, additives, and frit. The active soil used for this melt was obtained previously from Hunterston A, Bradwell, Capenhurst, and Sellafield, for a previous Remediation Technology Demonstrators programme funded by the NDA [4], and was left over without a disposition path. Since most soils are high in silica, the concept for this experiment was to use the active soil to provide glass formers while co-processing Magnox sludge simulant which does not contain glass formers. The end vitrified product would be a magnesium-rich homogenous glass.

Melt Preparation

Preparation consisted of installing 3 Type K thermocouples (TI-101 through TI-103) and one Type R thermocouple (TI-104) into the inner cast refractory lining. Type K thermocouples are rated to 1250°C and Type R thermocouples are rated to 1450ºC. The thermocouples are installed in alumina sheathes that protect them from melting and allow some improvement on their temperature ratings. Loading of the refractory comprised an initial batch of soil, additives, and frit to be melted. The tracer/waste material was also loaded for each of the demonstrations as follows:

PPD-1: A caesium tracer was placed in the initial batch in the center of the soil layer as 6.13 g of caesium carbonate (5 g Cs); see Figure 3.

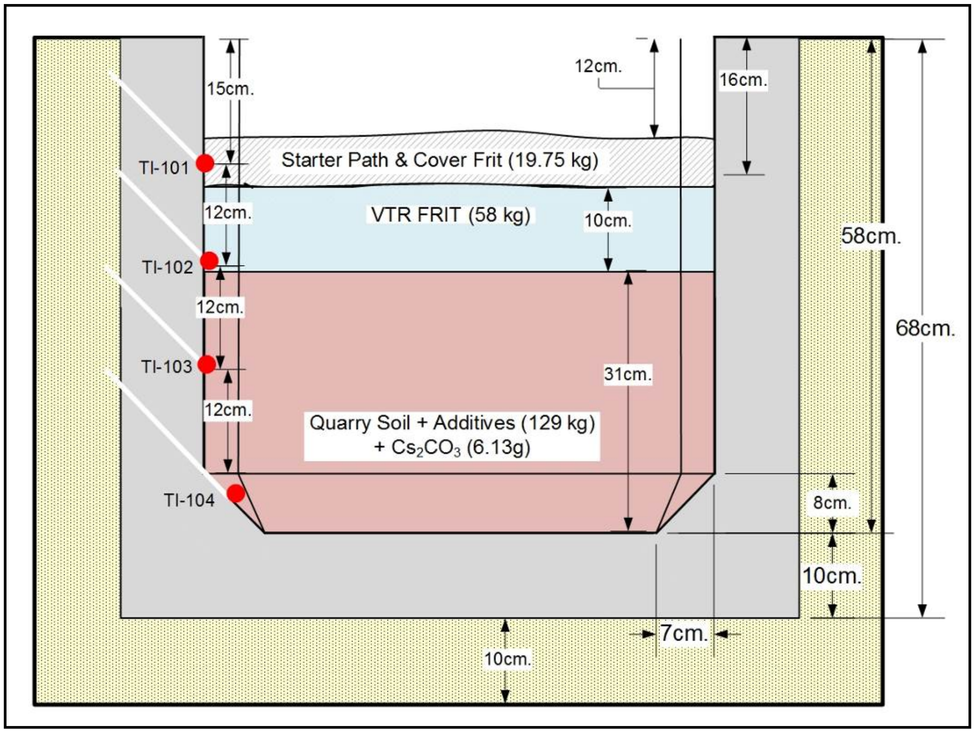
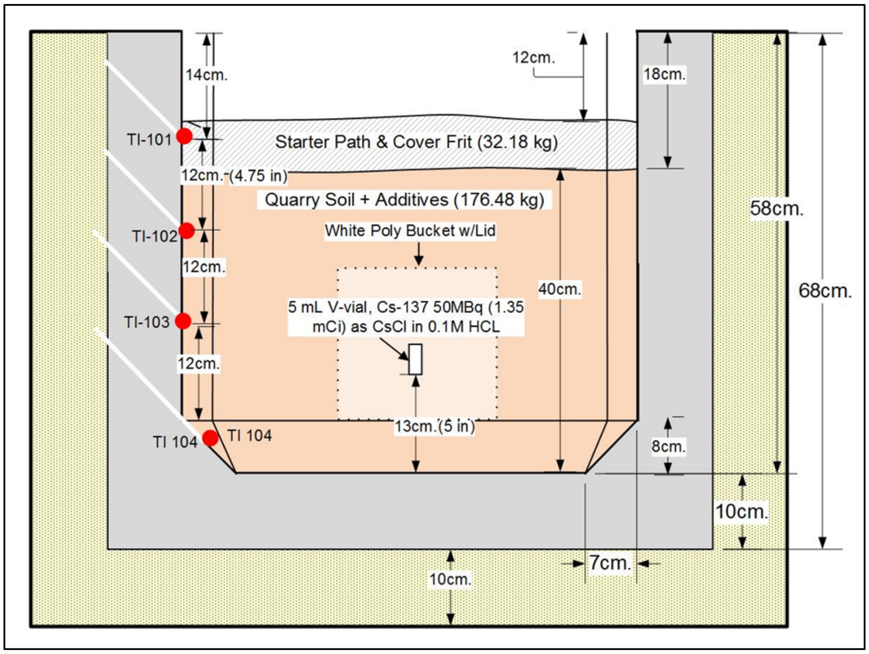


Fig. 3. PPD-1 Refractory Loading

PPD-2: A caesium tracer was placed in the initial batch in the center of the soil layer as a 50 MBq CsCl solution in a glass vial, which was packed in a polyethylene pot filled with blended soil; see Figure 4.



EX-1:

Fig. 4. PPD-2 Refractory Loading

Active soil and sludge simulant was loaded as shown in Figure 5. The active soil consisted of soil in 4 double-bagged plastic bags, and in 27 polyethylene pots. The total mass of the soil and packaging was 72 kg. The activity of the soils used in this experiment is shown in Table I. 34 kg of magnesium hydroxide [$Mg(OH)_2$], used as a substitute for corroded Magnox sludge simulant (CMgS), was also added.

TABLE I. Central Lab Experiment 1 (EX-1) Soil Activity

Soil Origin	**Gross Alpha (Bq/g)**	**Gross Beta (Bq/g)**	**Strontium-90 (Bq/g)**	**Uranium-238 (Bq/g)**
Hunterston A	0.295 ± 0.074	4.81 ± 0.34	0.175 ± 0.021	0.93 ± 0.14
Bradwell	2.3 ± 1.2	220 ± 16	6.2 ± 1.1	1.6 ± 0.24
Capenhurst	0.387 ± 0.087	1.125 ± 0.092	0.022 ±1 0.0067	0.691 ± 0.10
Sellafield	2.23 ± 0.26	3.08 ± 0.23	0.343 ± 0.038	9.0 ± 1.4

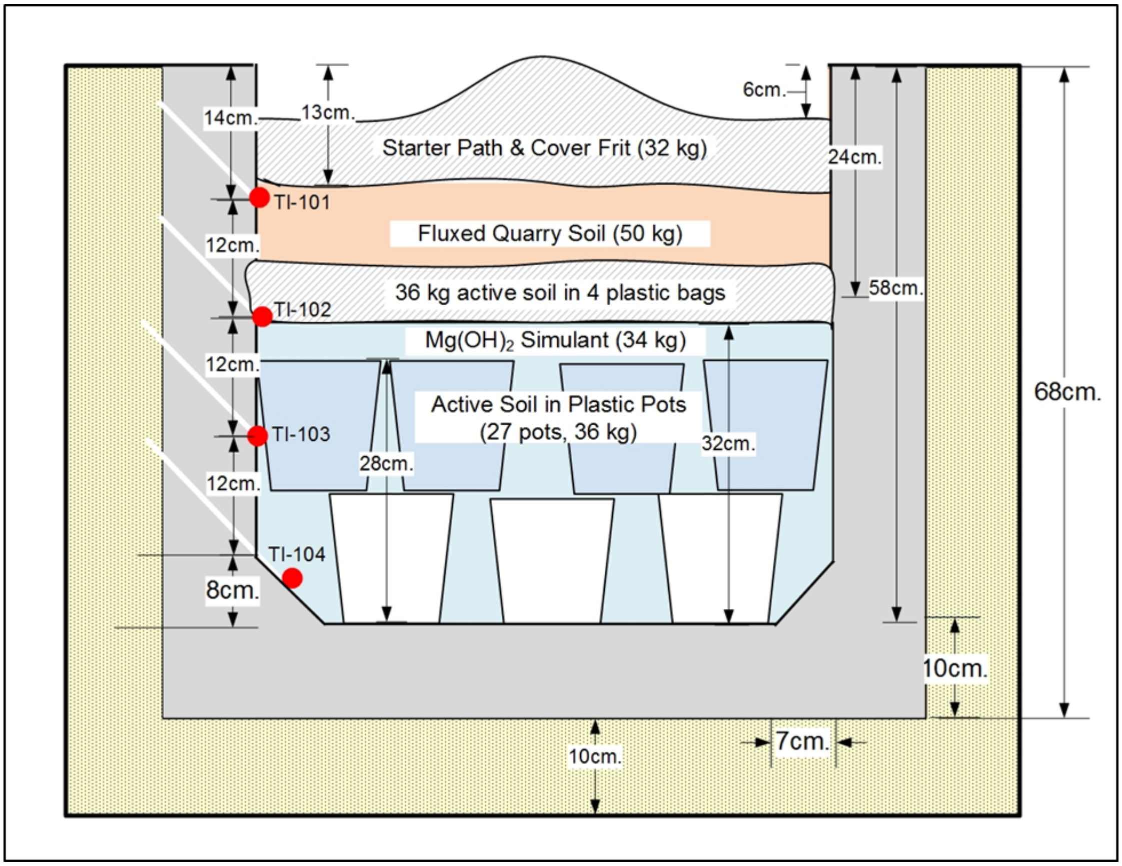


Fig. 5. EX-1 Refractory Loading

In order to begin each melt, a starter path composed of a mixture of graphite flake and porcelain frit was installed above the material to be treated. The starter path is moderately conductive and transmits the electrical current between the electrodes while heating the surrounding frit to a point where it becomes molten. Once molten, it is capable of transmitting the electrical current, allowing the melt to propagate. After installation of the starter path and cover frit, the ICV container was connected to the off-gas hood, and 4 graphite electrodes were installed vertically through electrode seals on the hood to make contact with the starter path. The starter path was covered with additional frit after it was connected to the electrodes.

Melt Execution

Figure 6 shows the GeoMelt ICV system during melt operations. The arrow in this figure points to the ICV container. The power supply transformer is on the right side of this image. Melt duration for this series of melts ranged between 25 – 28 hours; maximum power delivered to the melts was 50 kW with a ramp up and ramp down at the beginning and the end of the melts. The melts were monitored from a control station located adjacent to the ICV system in the Active Rig Hall.

Fig. 6. GeoMelt ICV System at NNL Central Laboratory Active Rig Hall.

Sampling & Analysis

After the each melt had cooled, the glass and the refractory crucible was removed from the ICV container. The glass surface was photographed, and for PPD-1 the entire crucible was cut in half in order to verify complete melting of the test material.

Inspection of the glass cross section verified complete melting. It is anticipated that the glass from PPD-1 and PPD-2 will be sampled for caesium analysis so that a complete mass and activity balance may be performed. In order to assess the distribution of caesium in the off-gas treatment system and to perform preliminary activity and mass balances, the following process samples were collected:

- Scrub Liquor sample of scrubwater tank liquor.
- SMF Particulate
- Hood Wipe

RESULTS & DISCUSSION

Melt Summary

The melts were conducted without difficulty, with only minor equipment issues which were resolved either during commissioning or between melts. Experiment EX-1 successfully demonstrated the concept of simultaneous processing of waste soil (providing glass-formers necessary for the vitrification process) from several NDA nuclear licensed sites with a non-glass former (Magnox sludge simulant). Success of all three melts was characterized by vitrification of the contents delivered to the ICV container. The core melt performance characteristics are summarised in Table II. An example of the glass formed can be seen in Figure 7 and Figure 8 shows the refractory (R)-glass (G) interface; the arrow on this figure points to a corner behind one of the electrodes showing a clean glass-refractory contact.

TABLE II. Melt Characteristics

	PPD-1	PPD-2	EX-1
Melt Run Time (hrs)	25	25.75	26.5
Total Energy Consumption (kWh)	676	787	757
Material Processed (kg)	400	430	336
Energy Consumption per kg (kWh/kg)	1.69	1.83	2.06
Max. Melt Temperature (°C)	1064	1367	1367

Fig. 7. PPD-1 Glass

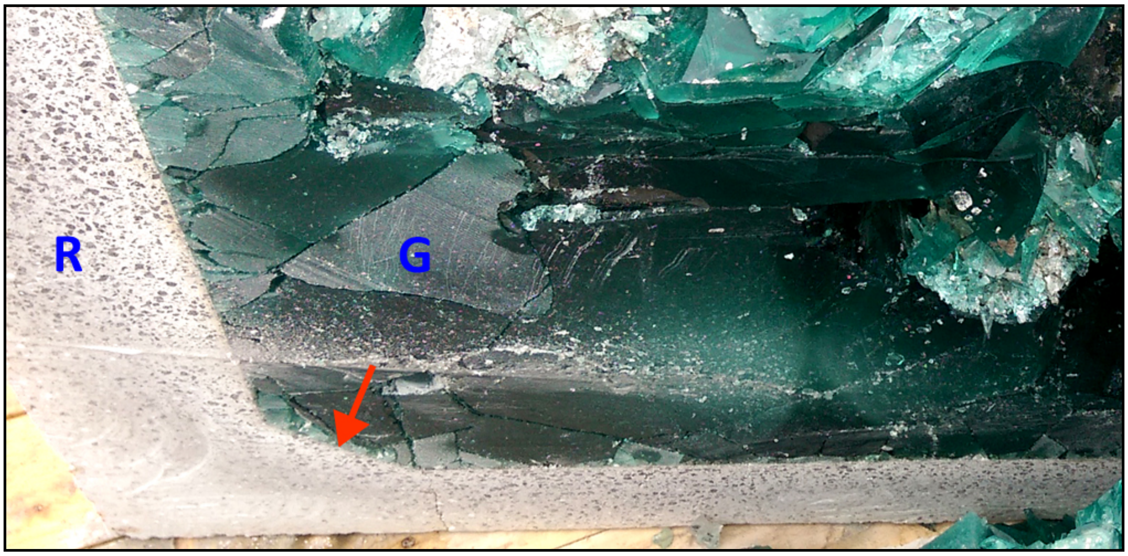


Fig. 8. Cross Section of PPD-1 Glass

Preliminary Caesium Mass and Activity Balance

The following sections provide mass and activity balance calculations for PPD-1 and PPD-2, respectively. These calculations are based on limited process samples with some degree of extrapolation. A potential uncertainty is the possibility of uneven distribution of caesium on the inner surfaces of the off-gas hood and process piping, since only 1 large wipe sample was collected for each melt and this sample result was extrapolated to represent the entire inner surface area from the hood to the first scrubber. It is planned to supplement the calculations presented here after glass samples from PPD-1 and PPD-2 have been sampled and analysed. Caesium retention calculated for PPD-1 and PPD-2 are similar, suggesting consistent caesium retention between the melts, and high degree of analytical precision. Results for EX-1 were unavailable at the time of writing this paper.

PPD-1 Caesium Mass Balance

Samples were collected from the scrub liquor tank, the SMF, and the interior of the melter off-gas containment hood to test for Cs. The PPD-1 scrub liquor sample was split into duplicates which were analysed by Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS). The total mass of Cs captured in the scrub tank was derived by multiplying the concentration of each duplicate by the volume of scrub liquor in the tank.

The entire discharge of the SMF was submitted for analysis as a single sample weighing 286.2 g. From this, three subsamples were collected and split into duplicates. The subsamples were dissolved and analysed by ICP-MS. The total mass of caesium captured by the SMF and discharged as particulate was calculated by multiplying the concentration of each subsample and duplicate by the mass of particulate discharged.

A single hood wipe consisting of a Kimtech Kimwipe® cloth that was soaked in de-ionized water and used to clean the interior surface of the back hatch of the melter off-gas containment hood was submitted for analysis. The sample was dissolved and spit into duplicates. A similar procedure was used for a clean Kimwipe for a total of two duplicates and two blanks, all of which were analysed for caesium by ICP-MS. The mass of caesium for each sample wipe and blank was calculated by multiplying the concentration by the volume of each sample solution. The mass of caesium for each sample represents total caesium deposited on the inside surface of the hatch (261.61 cm2).

A preliminary mass balance for cesium based on the post-melt process samples was calculated by comparing the mass distributed in the scrub liquor, the SMF particulate and on all interior surfaces of the system from the off-gas hood to the first scrubber (this was arrived at by extrapolation of the hood wipe results to the entire surface area obtained from a Solidworks® model of the system). Any residual caesium that may remain in the off-gas once it reaches the scrubber is removed by the scrubber and deposited in the scrub tank where it is accounted for in the scrub liquor sample. In the mass balance, summarized in Table III, the highest result from each analysis was used, rather than an average, and blanks were not subtracted, giving a worst-case result for each sample result. Analytical uncertainty was ignored since it generally was less than the variability between subsample splits and duplicates. The mass of caesium staged in PPD-1 was calculated by dividing the molecular weight of Cs_2 (265.8109 g/mol) by the molecular weight of Cs_2CO_3 (325.82 g/mol), then multiplying this result (0.81582) by the mass of Cs_2CO_3 staged in the ICV container (6.13 g). The retention of caesium in the final vitrified wasteform was calculated by subtracting the total mass derived from the process samples from the initial mass staged in the melt, then dividing this quotient by the initial mass. The result was 99.96 % retention. Glass sampling and analysis is planned to be carried out in order to complete the caesium mass balance.

TABLE III. PPD-1 Preliminary Cs Mass Balance and Retention

Sample Location	Mass of Cs (µg)	Mass of Cs (g)
Scrub Liquor	87.202	0.000087202
SMF	1848.85	0.00184885
Interior Surfaces from Hood to Scrubber	20.1	0.0000201
	Total	0.001956152
Staged Cs	5,000,850	5.00085
Mass left in glass		4.998893848
% Cs Retention in glass		99.96

PPD-2 Caesium Activity Balance

The scrub liquor sample collected after PPD-2 did not contain detectable total alpha, beta, or gamma activity. A hood wipe sample was collected using the same procedure as in PPD-1 where a Kimwipe was soaked in de-ionized water and used to clean the interior surface of the back hatch of the off-gas containment hood. The sample and a clean Kimwipe (as a blank) were dissolved separately and analysed by gamma spectroscopy.

The entire discharge of the SMF was submitted for analysis as a single sample weighing 69.7 g. From this, three subsamples were collected and split into duplicates. The subsamples were dissolved and counted by gamma spectroscopy. A blank consisting of non-active SMF particulate from PPD-1 was also dissolved and counted as a blank, which did not contain detectable Cs-137. The activity of caesium for each subsample was calculated by dividing the activity of each subsample by the sample mass, then multiplying this result by the total mass of particulate.

A preliminary activity balance for Cs-137 based on post-melt process samples was calculated by comparing the activity distributed in the SMF particulate discharge and on all interior surfaces of the system from the off-gas hood, the piping to the SMF, the SMF interior, and the piping to the first scrubber. In the activity balance, summarized in TABLE IV, the highest result from each analysis was used, rather than an average, giving a worst-case result for each sample result. Analytical uncertainty was ignored for the SMF results since uncertainty was very close to the variability between subsamples. The uncertainty for the wipe sample (32 Bq) was added to its result since there was only one sample (and therefore no variability with which to compare uncertainty). The activity of caesium staged in PPD-2 was known to be 50 Mbq. The retention of Cs-137 remaining in the glass was calculated by subtracting the activity from the process samples from the initial mass staged in the melt, then dividing this quotient by the initial Cs-137 staged in the melt. The result was 99.48 % retention.

TABLE IV. PPD-2 Preliminary Cs-137 Activity Balance and Retention

Sample Location	Cs-137 Activity (Bq)
SMF	16,004.51
Interior Surfaces from Hood to Scrubber	243,503.88
Total	259,508.39
Staged Cs-137	50,000,000
Mass left in glass	49,740,492
% Cs-137 Retention in glass	99.48

CONCLUSIONS

Commissioning melts PPD-1 and PPD-2 successfully processed a combination of soil, frit, and caesium tracers using the GeoMelt ICV system installed at the Sellafield Central Laboratory Active Rig Hall. The melts were conducted without difficulty, with only minor equipment issues which were resolved either during commissioning or between melts. Experiment EX-1 successfully demonstrated the concept of simultaneous processing of waste soil (providing glass-formers necessary for the vitrification process) from several NDA nuclear licensed sites with a non-glass former (Magnox sludge simulant). Success of all three melts was characterized by vitrification of the contents delivered to the ICV container.

Caesium retention, as determined by preliminary non-radioactive and radioactive mass balances calculated for PPD-1 and PPD-2, was consistent between the two melts, and greater than 99%. It is anticipated that additional cesium retention studies will be performed, including: 1) sampling and analysis of the glass product from PPD-1 and PPD-2 in order to close the mass/activity balances to allow retention to be calculated by caesium levels in the glass rather than levels captured in the off-gas treatment components; and 2) performing one or more additional melts with caesium distributed uniformly in the feed rather than only loaded as a point-source.

The GeoMelt ICV process may be applicable to treating a wide range of LLW and ILW orphan wastes from the NDA estate. The GeoMelt process can use a pre-formulated frit or minerals blend to provide glass formers, or contaminated soil can be used. GeoMelt is tolerant of a wide range of waste chemistries allowing for a wide range of waste soils to be used. The process results in immobilization of radionuclides in the glass wasteform and the resultant wasteform is not reactive or corrosive, and can be significantly reduced in volume. Also, the final glass product can be tailored to the storage or disposal site requirements, including by using an approved waste package as the treatment container.

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