[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	5 (Select the number from "Areas of Technologies Requested")
Title	**Management Measures to Block Groundwater from Flowing into the Site Using an Underground GeoMelt® Barrier**
Submitted by	**Kurion, Inc.**

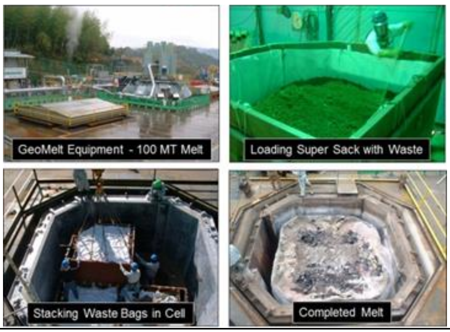
1. Overview of Technologies (features, specification, functions, owners, etc.)

Kurion, Inc. is the owner of the GeoMelt® process, a worldwide patent-protected vitrification technology that has been commercially active since 1992, and which has undergone continual refinement during the years since it was first developed by the U.S. DOE Pacific Northwest National Laboratory (PNNL). Kurion has several GeoMelt systems in the U.S. and Japan that can be immediately deployed for off-site or on-site demonstrations or work.

In-Situ

In-Container

In-Cell



The GeoMelt process involves sending an AC electric current between graphite electrodes that are positioned in-situ (in-place in-ground), in-container and in-cell to process the contaminated soil, debris, and other wastes either individually or in combination (see image to right). The electrical current creates joule (resistive) heating between the electrodes, and this heat is also transmitted into the nearby material until it eventually melts. As more power is applied, the molten material progressively develops into a larger melted volume between and near the edge of the electrodes. Once all of the pre-determined volume of material has been melted (treated), power is terminated, and the resulting glass product is allowed to cool into a solid block.

The technology safely destroys (organics, asbestos, etc.) and immobilizes contaminants (radionuclides), creating a durable glass and crystalline product.

The durability of the GeoMelt glass has been proven many times, using internationally accepted durability tests (PCT, TCLP, SPFT, VHT, Leachability, Compression, etc.). It can withstand extreme environmental conditions, including groundwater corrosion/erosion, while lasting thousands of years without measurable degradation. The durability of glass subjected to long periods of wet conditions was demonstrated when 1,800-year old glass objects were recovered from a shipwreck in the Adriatic Sea. These objects were subjected to the extreme conditions of warm salty water for millennium, conditions that are expected to be more challenging than the groundwater or marine environment at Fukushima. For more information on the study by the PNNL, refer to http://energy.gov/em/articles/ancient-glass-nuclear-age-denis-strachan-and-joseph-ryan).

In December 2012 the U.S. Department of Energy (US DOE) issued a 6000 page Final Environmental Impact Statement for the Hanford Site that summarized ten years of study on a number of matters, including alternative waste stabilization methods. The conclusion was that the GeoMelt technology (also known as Bulk Vitrification) was deemed as having the lowest life-cycle cost over concrete, fluidized bed steam reforming (pyrolysis) and competing vitrification technologies (refer to Table S–31, Tank Closure Alternatives – Total Cost Projections, Including Waste Disposal). Refer to: http://energy.gov/nepa/downloads/eis-0391-final-environmental-impact-statement.

Please also see Kurion's response to IRID Task Area 4 for additional information.

(1) Construction Technologies for Impervious Walls

The following discusses how GeoMelt can be used to construct impervious walls that:

- divert groundwater flow away from the area 10 meters above sea level (hereinafter referred to as the o.p. 10m area) where unit buildings are located, by installing, for example, walls at the hillside,
- do not interfere with already planned impervious walls, but can mate up to or work with them, and
- lower the amount of groundwater on the hillside, using, for example, walls on the o.p. 35m area.

An impervious underground wall made of Kurion's proprietary GeoMelt® glass product can be constructed to prevent groundwater from flowing into the buildings at Fukushima Daiichi. This wall, as shown in Figure 1, would surround the Reactor and Turbine Buildings, extending downward from the surface to the low-permeable layer (up to 30 meter depth) beneath the facilities. In this case, a 1300 to 1500 meter long perimeter around the buildings would be needed.

Figure 1 – GeoMelt Treatment Zone around Fukushima Daiichi Facilities 1 and 2

Landside groundwater inflow would be prevented, and seaside outflow of contaminated water would be prevented with this wall building method.

Alternate landside treatment locations, including A) locating the land-side perimeter wall on the sloped area between the 10m OP and the 35m OP, and B) on the 35m OP, are shown in Figures 2 and 3. Option A has the advantage of avoiding high contamination areas and areas with existing equipment. Option B has the advantages of requiring less depth to reach the Low-Permeable layer, thus needing less time to complete each individual melt zone. It would also be performed in areas with less radioactive contamination and dose and where less equipment is located.

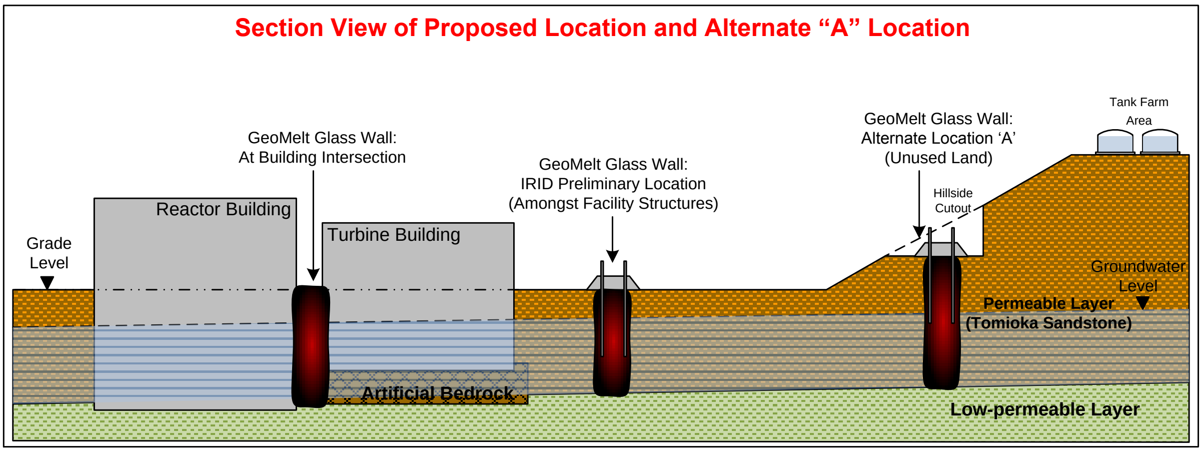


Figure 2 - Preliminary and Alternate "A" Location for GeoMelt Wall (glass wall to right) as well as the plant perimeter glass wall and intra-building glass water stop (see also Kurion IRID Task Area 4 response)

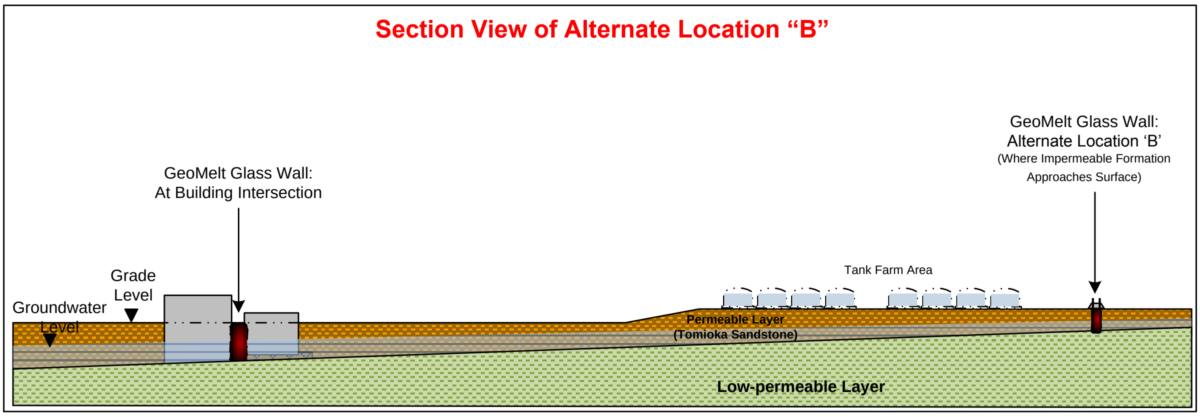


Figure 3 – Alternate "B" Location for GeoMelt Wall (see Kurion response to IRID Task Area 4 for more information)

Individual treatment zones, each measuring 12-m long by 1-m wide by 12-m deep (or deeper), would be produced for any of the optional locations, until the entire perimeter is sealed in an impermeable glass wall. Two zones can be treated concurrently with a single system, joined with previously melted zones, as shown in Figure 4.

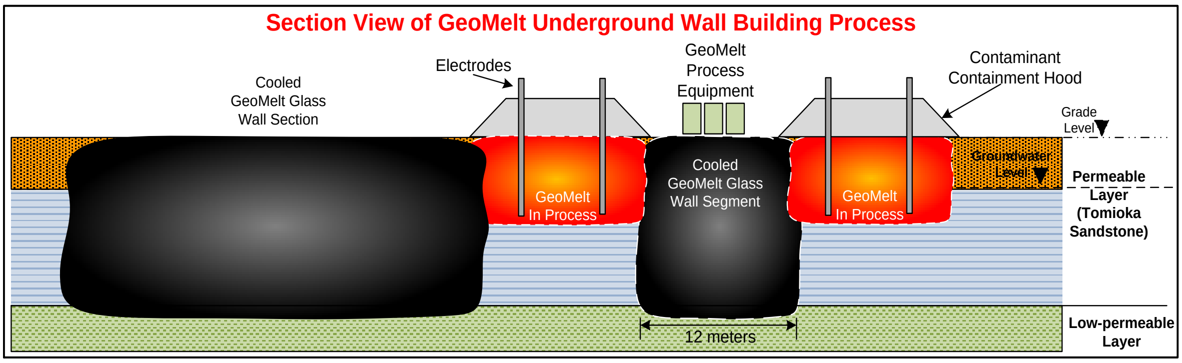


Figure 4 – Section view of Proposed GeoMelt Underground Wall Building Process

An example aerial photo of this process of melting distinct zones, side by side, is shown in Figure 5. In this case, the melt on the left was excavated to verify the glass was melted properly, the second melt from the left was just completed, and the melter hood on the far right is being staged for treatment of the next zone. This particular photo differs from the proposed method in that it uses a 4 electrode hood, instead of the two electrode hood planned for Fukushima Daiichi site.

Figure 5 - Aerial view of adjacent treatment zones to create a single GeoMelt wall

Because the soil will densify as it is transformed into glass, and thereby volume reduce as the melt progresses downward (approximately 40 percent), backfill soil (clean or contaminated) will be added onto the melt surface during treatment. This will compensate for the initial volume reduction and provide a solid glass barrier that fully extends from the ground surface down to the low-permeable zone.

At the ends of each treatment zone, next to the electrodes, the molten glass will partially melt into the glass zone that has already been created, thereby producing a watertight bond between each section of glass so that the finished wall will be one continuous barrier, with no gaps between treatment zones.

This ability to melt adjacent treatment zones and produce a seamless interface when completed has been demonstrated on numerous occasions in the United States and Australia. One example project treated persistent organic pollutants in Michigan, USA, which treated six distinct melt locations, 8.5 meters wide, joined together as proposed here, into one long 50 meter melt. (Ref. EPA Innovative Technology Evaluation Report 540/R-94/520). This same process of joining adjacent melts to treat a larger area was also successfully performed in Washington State and Utah State, USA.

It is estimated that 108 individual zones would be needed to complete the approximately 1300 meter long wall. At an estimated treatment time of 14 days per four concurrent zones averaging 12 meters deep, the wall will be completed within one year. This time frame can be shortened to any desired duration by adding additional GeoMelt Treatment Systems operating simultaneously. A GeoMelt system designed for this type of application is currently available for use, and can be mobilized and operational within weeks.

A distinct advantage of the GeoMelt product is that it requires no maintenance once it is complete and can be mated up with other groundwater walls (e.g. concrete, frozen). It is a passive and permanent product, requiring no active power or monitoring systems to maintain its integrity. This is especially attractive in an environment like Fukushima Daiichi, where a protective barrier will need to be in place for many decades. In the event of a power loss caused by tsunami, typhoon or other event, there is no risk of failure of the passive GeoMelt Barrier as opposed to the active ice wall approach. In addition, this “no maintenance” solution means no personnel will be needed and put at risk for unnecessary radiation exposure, unlike other proposed treatment methods.

Finally, a distinct advantage of the GeoMelt Barrier is that any radioactive materials contained in the soil will be trapped in the glass product, with no risk of escape, for thousands of years.

There is the question of cracking of the GeoMelt in-ground barrier, such as from an earthquake, potentially allowing additional water to pass through as a result. Although it is unlikely that an earthquake would cause sufficient crack separation to allow large amounts of water to permeate, given all of the surrounding hydraulic pressures to keep the block intact, a simple corrective action could be taken in such an event. Nearby leak detection that will be installed at key locations behind the wall would easily pinpoint the location of the leak. GeoMelt equipment could then be sited above or adjacent to the barrier where the leak was indicated, and the selected area can be treated again, melting into the existing glass wall and effectively sealing the leak and preventing further leakage.

Above ground obstacles that prevent placement of standard ICV hoods will need to be addressed for a specially designed hood solution.

Underground obstacles such as electrical cabling, concrete or steel piping, etc. will pose no difficulty for the process since those materials will readily melt and become part of the molten block. Molten material that might travel laterally into nearby piping or trenches will cool and solidify after a short distance, creating a self-sealing plug in those locations. Underground facilities that should not be melted, if any, such as cables, can be suitably protected via local concrete walls or injection of materials that don’t melt.

2. Technology readiness level:

GeoMelt® is a very mature treatment technology, having been successfully deployed internationally, including in Japan, Australia, the UK, and the United States. The two main GeoMelt methods, in-ground SPV (Sub Planar Vitrification)™ and ICV (In-Container Vitrification)™, have been used to treat radioactively contaminated soils and debris, hazardous POPs, asbestos, sludge, debris, and many other hazardous waste materials. Ever since the technology was developed in 1980 by the Pacific Northwest Nuclear Laboratory, almost 26 000 metric tons of wastes have been transformed into a safe and durable glass product.

Japanese standards: Kurion is an equity owner in, and licensor to ISV Japan Ltd. (ISVJ) of its GeoMelt technology. ISJV has been continuously treating PCBs, dioxin, asbestos, and other hazardous materials and contaminated soils in Japan since 1993. The ISVJ facility operates under a license from the Ministry of Environment and is located at the Mie Chuo Kaihatsu commercial waste treatment facility in the Mie Prefecture owned by Daiei Kanko Corporation. See http://www.kurion.com/applications/stabilization/hazardous-and-toxic-waste-treatment-across-japan.

United States standards: GeoMelt has been considered mature since it was commercially launched and the U.S. Environmental Protection Agency (EPA) authorized an operating permit for treatment of contaminated soil and hazardous waste. Since then, GeoMelt has treated thousands of tons of soil and hazardous waste at sites across the United States. For example, the technology was deployed at the US DOE's Los Alamos National Laboratory to vitrify 500 tonnes of radioactive waste.

The United States uses a Technology Readiness Assessment (TRA) process wherein Technology Readiness Levels (TRL) are applied to define technology maturity, on a scale of 1 to 9. A score of 7 and above indicates mature full-scale demonstrations and deployments. Because GeoMelt deploys in a range of configurations, depending on the site and waste to be treated, it has consistently achieved a TRL ranging from 7 to 9, when evaluated against each site's project specific requirements. See http://www.lbl.gov/dir/assets/docs/TRL%20guide.pdf.

Australian standards: GeoMelt is considered mature because GeoMelt was chosen over several competing technologies to vitrify thousands of tons of plutonium contaminated soil at the Maralinga Nuclear Test Site. Here the technology was operated successfully for several years in the austere conditions of the southern Australian Outback desert. For more, please refer to http://www.kurion.com/applications/stabilization/contaminated-soil-at-nuclear-weapons-site.

European standards: Waste owners are partnering in the United Kingdom and a confidential European country with Kurion to establish radioactive waste treatment facilities at several government sites where their most problematic wastes are stored, and for which there are few, if any, other treatment options. Kurion expects to announce the new deployments by the first quarter 2014.

- **Recommendations for Next Step**

Kurion has several GeoMelt systems in the U.S. and Japan that can be immediately deployed for off-site or on-site demonstrations or work. Using existing equipment Kurion recommends the following be taken as the next step:

1) Perform a baseline treatability test using the unique soil conditions and depths to be treated at Fukushima Daiichi to generate necessary data to support design and schedule considerations.

2) A study would need to be performed on melting in the presence of constant groundwater flow to determine power drain impacts or suitable design precautions.

- **Others (referential information on patent if any)**

Kurion holds exclusive worldwide patent rights to the GeoMelt® Technology, both SPV™ and ICV™, in Japan, the United States, Europe, the UK and elsewhere. These patents are kept current, and additional information, such as specific patent numbers, etc. can be provided upon request.