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

Technology Information	
Area	4 (Select the number from "Areas of Technologies Requested")
Title	**Management of Contaminated Water Inside the Buildings Using GeoMelt Sub-Planar Vitrification Outside the Building**
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 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 5 for additional information.

(1) Technologies to Block Water Inside the Buildings

While the GeoMelt technology is not suitable for forming water stops from inside a building, it can be used to form external water stops between buildings and by blocking underground water from continuously flowing into the buildings. This is accomplished by forming underground glass walls or dams to seal flow paths between buildings, seal cracks in building foundations or by diverting groundwater as described in (2) below and as discussed in the Kurion response to Technology Area 5 - "Management measures to block groundwater from flowing into the site".

(2) Technologies for Soil Improvement

The following discusses how GeoMelt can be used for soil improvements that can be:

- implemented by remote control near or between buildings to stop underground water from flowing into the buildings even in the case of a high radiation environment or with space limitations, and
- used to block water even inside underground obstacles that can disturb implementation of soil improvement, such as underground trenches.

The GeoMelt technology can be used to form external water stops between buildings to block underground water from continuously flowing between and into the buildings. This is accomplished by forming underground glass walls or dams to seal flow paths between buildings, seal cracks in building foundations or by diverting groundwater as described in the Kurion response to Technology Area 5 - block groundwater from flowing into the site.

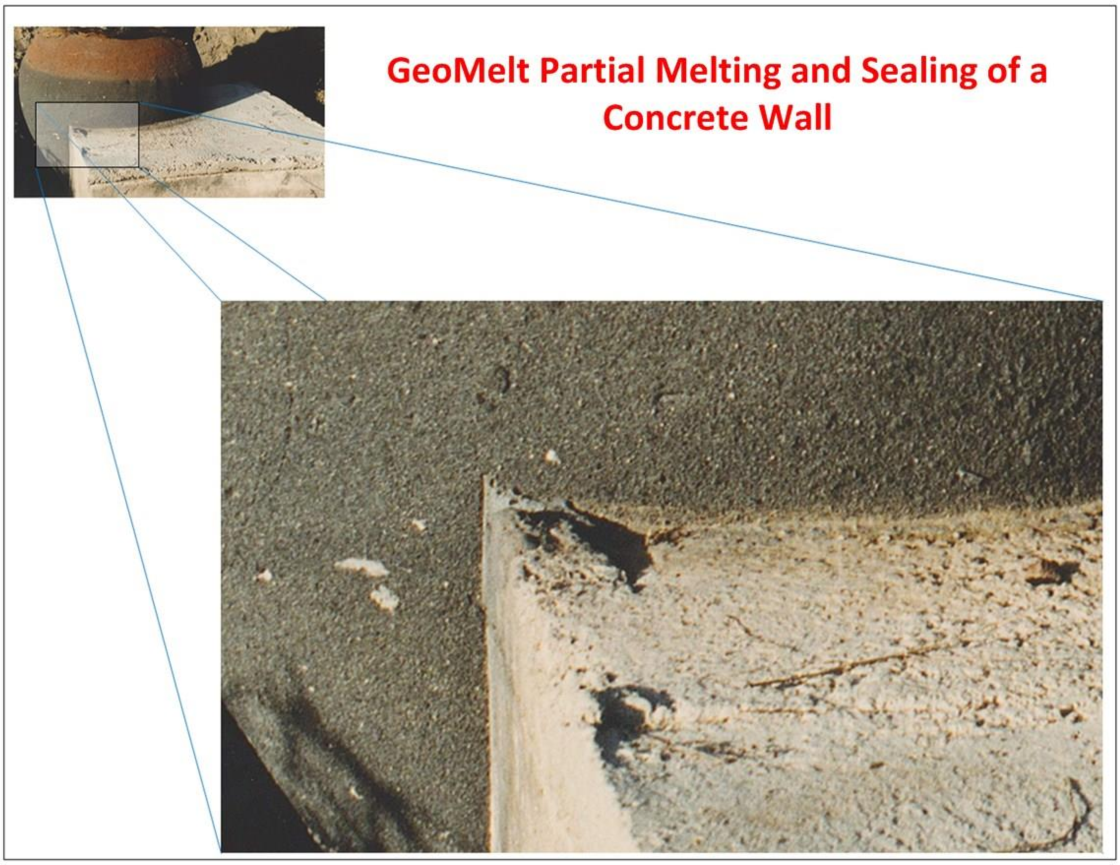
In-ground glass walls can be created to prevent contaminated water infiltration at Fukushima Daiichi by placing electrodes next to the areas to be sealed off. For example, a 3-m long by 1-m wide by 16-m deep glass wall could be produced that would seal each of the edges of the six gaps between the Reactor Buildings and Turbine Buildings (1 and 2) as shown in IRID's Figure 4 – "Underground map of the buildings" (other dimensions also possible for the glass walls).

After the GeoMelt Treatment Hood is installed (electrode manipulation and off-gas controls), operation of the system would be implemented by remote control at a safe distance from the Treatment Hood, allowing the project to be completed even in the expected high radiation environment near the buildings. The hood size and shape, as well as electrodes size could be tailored to different geometries, depths and challenges. Electrodes would be energized and as they melt the soil could be pushed down into the soil to the target depth via remotely operated mechanical actuators.

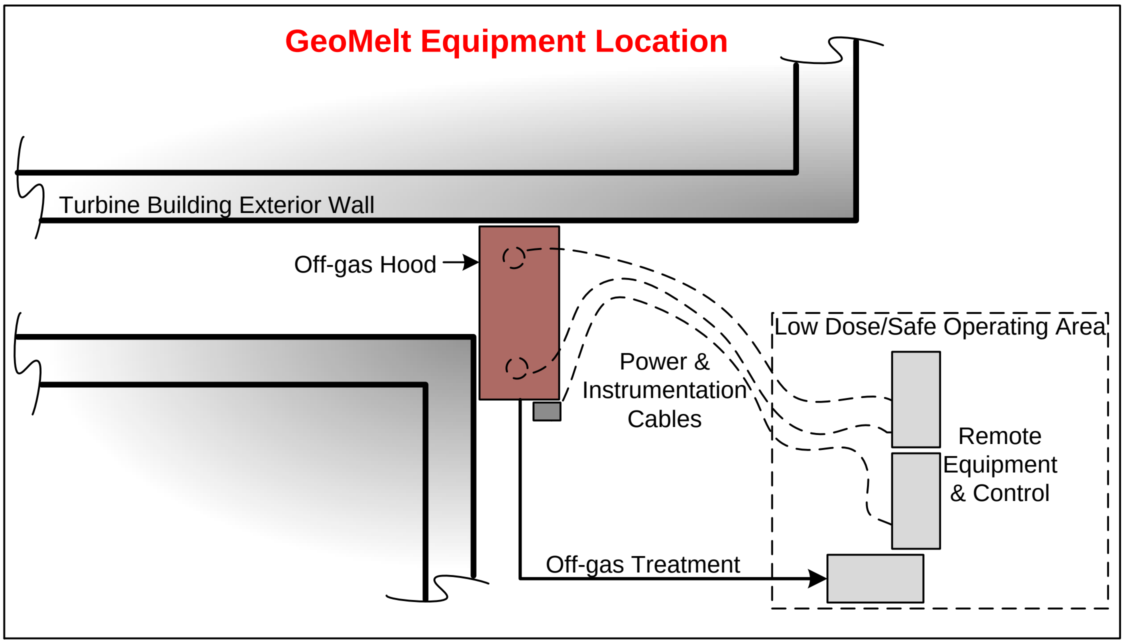
Because the soil will densify as it is transformed into glass, volume reduction will occur as the melt progresses downward (approximately 40 percent). To compensate, backfill soil (clean or contaminated) will be added onto the melt surface during treatment. This process will produce a glass barrier extending from the surface down to the impermeable layer beneath the Reactor Building.

Contaminated or clean soils may be scrapped from the surface and added to slumped areas during in-situ processing or processed separately in-container or in-cell (see images on first page). Melts in this manner are available up to several dozen tons in size (e.g. 50 ton melts in large roll-off in-container melts) or larger for in-cell.

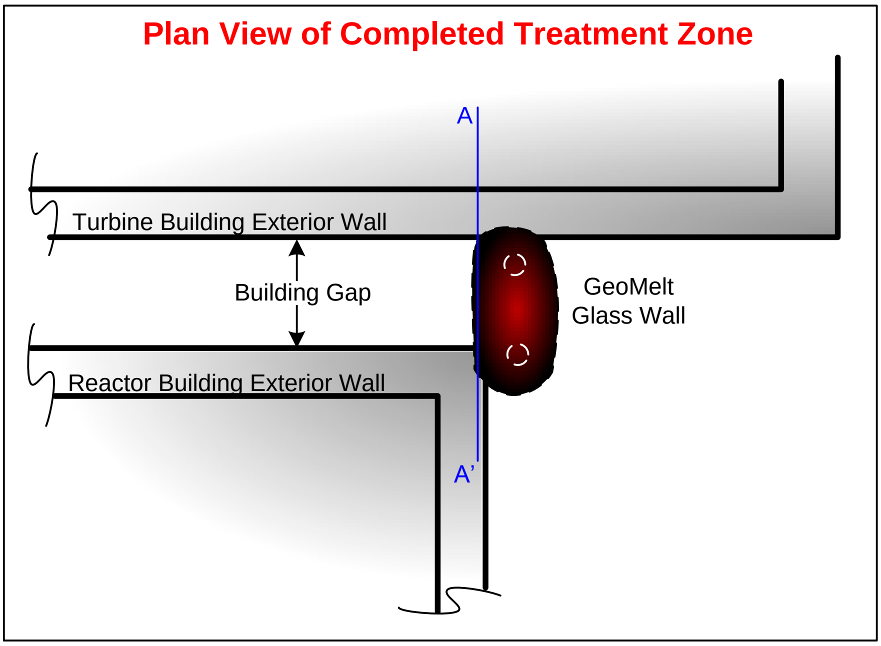
Sealing building foundations can be performed in a similar manner by planning for the melt zone to contact the building concrete walls. When this happens the glass will partially melt into the concrete, creating a watertight bond between the concrete and the glass. This capability to melt into a concrete barrier was established for the Japan Research Institute in the early 1990's (Ref. GeoSafe Corp. contract #01-034953-29). Although concrete can be completely vitrified if desired, controlled and partial melting of a concrete wall can also be achieved. This is done by specifying the initial position of the electrodes and the total power rate applied during treatment, so that a specified melt shape, including the desired penetration into the concrete wall, is achieved. A photo showing the results of this controlled melting into a concrete wall are shown below.

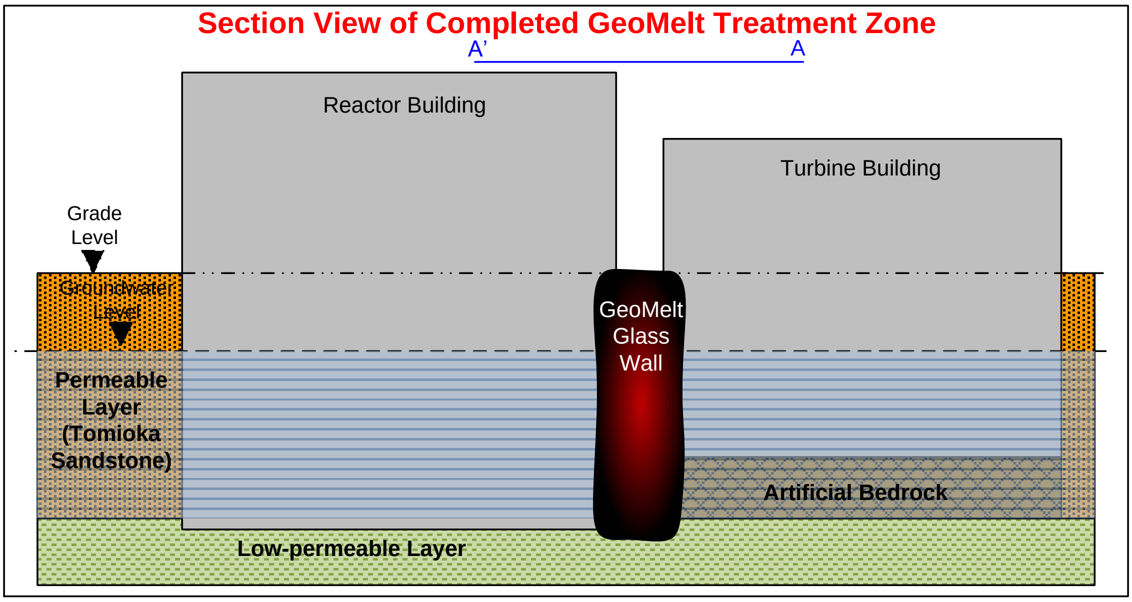


A processing time of approximately 120 hours, or 5 days, is expected to complete each one of the six proposed treatment zones. Offgas produced during treatment would be cleaned using GeoMelt's offgas treatment system, removing any particulates or contaminants before releasing clean offgas into the atmosphere. A graphic of the GeoMelt and ICV offgas process, showing a system installed near one of the junctures between Reactor and Turbine Buildings #2, is provided below:



Top and side cutaway views of the glass wall after treatment are shown here:





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.

- **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 in-situ vitrification (ICV™, also known as Sub Planar Vitrification™ or SPV™), 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.