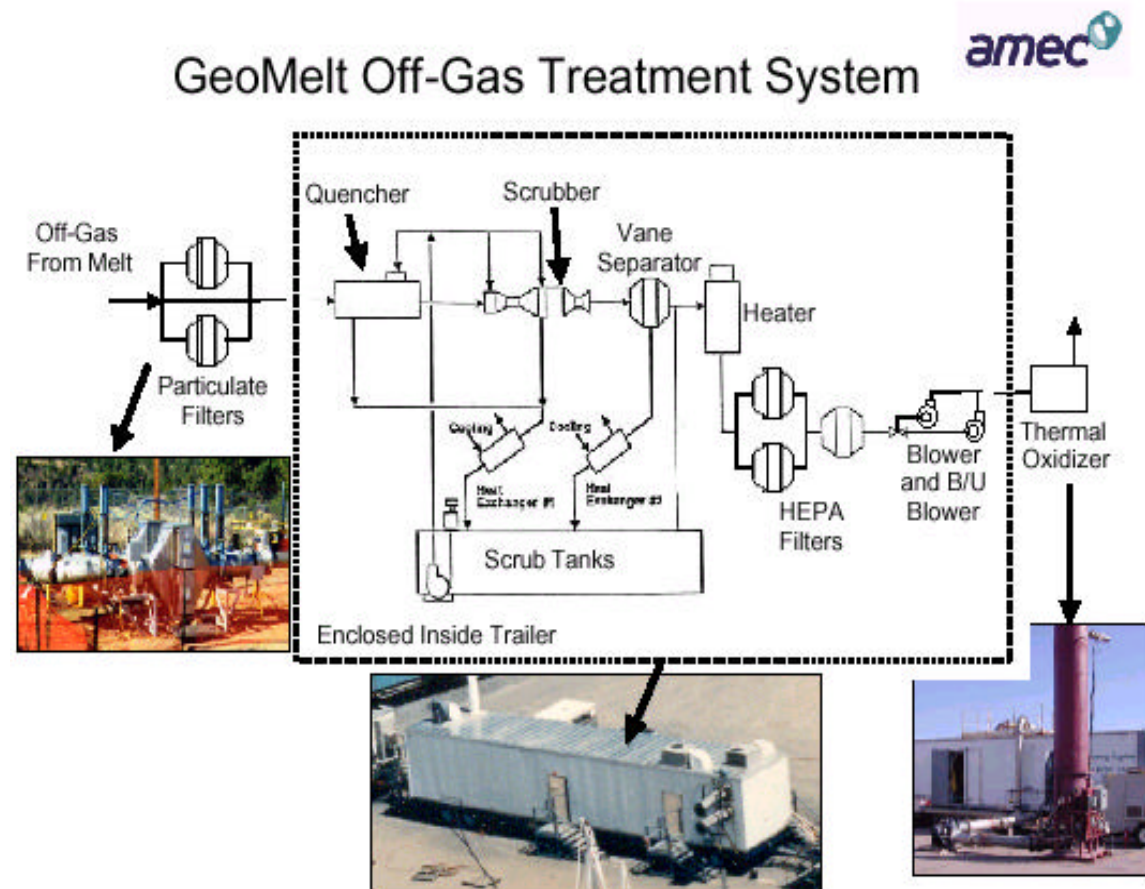


<p><b>Name of Process:</b> AMEC's GeoMelt™ Vitrification process</p>	<p><b>Status:</b> The GeoMelt process has been in commercial use since the early 1990's. Numerous projects have been successfully completed in the US, Australia, and Japan. In the US, sites contaminated with pesticides, herbicides, solvents, PCBs, dioxins, furans, and heavy metals have been remediated with the GeoMelt process.</p>
<p><b>Vendor:</b> AMEC Earth and Environmental Inc. GeoMelt Division Web site: <a href="http://www.geomelt.com">http://www.geomelt.com</a></p>	<p>The US Environmental Protection Agency has issued a National Toxic Substance Control Act (TSCA) Permit to the GeoMelt process for remediation of sites with PCB-contaminated soils at concentrations up to 17,860-ppm (~1.8-wt%).</p>
<p><b>Applicable Pesticides and related POPs wastes:</b> Virtually all chlorinated organic compounds including solvents, pesticides, herbicides, 2,4-D, 2,4,5-T, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, heptachlor, pentachlorophenol, chlordane, dieldrin, dioxins, furans, hexachlorobenzene, polychlorinated biphenyls. In addition, effective for remediating materials contaminated with heavy metals including arsenic, lead, cadmium, and chromium</p>	<p>In Australia, the GeoMelt process has been selected as the preferred technology for remediation of hexachlorobenzene wastes.</p> <p>In Japan, the GeoMelt process has been deployed to remediate an incinerator and associated site materials contaminated with dioxins and furans. It has also been deployed to treat asbestos-contaminated wastes.</p> <p>In the US, the GeoMelt process has successfully remediated soils contaminated with radioactive materials – including plutonium, uranium, cesium, strontium, americium, technetium, and iodine. Sites contaminated with hazardous heavy metals (e.g. – arsenic, chromium, cadmium, and lead) have also been successfully remediated using the GeoMelt process.</p>
<p><b>Technology description:</b> The GeoMelt process works by establishing a melt between pairs of electrodes inserted into the soil-bound waste materials. Initially, electrical current is passed through a relatively high-conductivity starter path staged in the soil/waste matrix. Heat dissipated in the starter path is transferred to the surrounding soils causing them to melt. Once molten, the soil becomes sufficiently conductive to support the flow of electrical current, thereby dissipating enough joule heat to sustain and propagate the melting process. Electrical energy is continuously supplied to the melt until such time that it has grown to encompass the entire treatment volume. Individual melts of up to approximately 1,000-tons can be formed. These range in size from 9 to 11 meters in diameter and up to 5 meters thick. With the GeoMelt™ Subsurface-Planar Vitrification method, the melting process can be initiated at virtually any depth below grade, and can be propagated from this initial start-up depth to the desired treatment depth.</p> <p>Off gases generated by the process are collected inside a stainless-steel hood covering the treatment area and are drawn-off for processing by an off-gas treatment system (OGTS). The OGTS consists of a combination of filtration, dry &amp; wet scrubbing, and thermal treatment stages. The small quantity of secondary wastes generated by the OGTS (e.g. – filters, scrubber liquids, and personal protective equipment) can be loaded into subsequent GeoMelt applications for processing.</p> <p>When electrical power is shut off, the molten mass cools and ultimately solidifies into a vitreous and crystalline, rock-like monolith. The process destroys organic contaminants such as dioxins, pesticides, and PCBs directly. Heavy metals, radionuclide, and other non-volatile constituents are retained in the melt and immobilised in the vitrified monolith. The vitrified product has exceptional physical, chemical, and weathering properties compared to alternative solidification/stabilisation technologies. It is typically ten times stronger than concrete and is extremely leach resistant.</p> <p>The GeoMelt process generates a vitrified product that is far superior (orders of magnitude better) in terms of durability, strength, and leach resistance compared to other stabilisation or encapsulation technologies. The monolith can be safely left in place. Alternatively, it can be readily recovered for transport to a disposal site. In certain applications, the vitrified product can be recycled for subsequent use (e.g. – roadbed materials, breakwater riprap, and roofing tiles)</p>	

Process diagram:



Note to process diagram: The oxidiser is shown at the end of the system in this instance. In most cases the oxidiser is put immediately after the high temperature filters and then a quench.

**Performance:**

**Treatment efficiency:**

To date, over 25,000-tons of contaminated soil and debris have been successfully remediated using the GeoMelt process. Examples of typical chemically-contaminated sites remediated with the GeoMelt process include:

- 4,350-tons of soil and debris contaminated with pesticides (e.g. – chlordane, DDT, dieldrin, and small concentrations of dioxins & furans) and heavy metals (e.g. – arsenic, cadmium, chromium, lead, and heavy metals (e.g. – arsenic, cadmium, chromium, lead, and mercury) in Grand Ledge, Michigan USA [1], [2], [3]
- 7,000-tons of PCB-contaminated soil and debris at a transformer repair site in Spokane, Washington USA [4]
- 5,440-tons of soil and debris contaminated with dioxins, pentachlorophenol, DDT, 2,4-D, hexachlorobenzene, and a range of other pesticides and herbicides at a chemical waste site near Salt Lake City, Utah USA [5], [6]

Two examples of sites contaminated with radioactive materials that were successfully remediated using the GeoMelt process include:

- 5,400-tons of soil, steel, barytes bricks, and other debris contaminated with plutonium and uranium at the Maralinga Taranaki Pits in southern Australia [7]
- 500-tons of soil and cobble contaminated with plutonium, uranium, americium, heavy metals, and phosphates [8]

In addition to these in-situ applications, a series of GeoMelt In-Container Vitrification (ICV) demonstrations were performed in Australia on soils contaminated with 33-wt% hexachlorobenzene (HCB) wastes. The successful results obtained from these tests have led to the design and construction of a facility to process the 16,000 208-L drums of HCB wastes present at a chemical processing plant there. This facility is scheduled for operation in 2004.

The GeoMelt process achieves a very high destruction/retention efficiency (DRE) in the melt, which is the first step of the overall treatment process. The high temperature of the melt promotes pyrolysis and dechlorination reactions in the hot soil surrounding the melt. Consequently, organic destruction efficiencies ranging from 90 to 99.99% have been demonstrated by the melt itself in the GeoMelt process. Heavy metals, radionuclides, and other non-volatile constituents present in the soil/waste matrix are retained in the vitrified product where they are immobilised and effectively isolated from the surrounding ecosystems for perpetuity.

Off-gases generated during GeoMelt processing are collected within the stainless steel off-gas hood placed over the treatment zone. These are piped to the OGTS for subsequent processing. The wet and dry treatment systems making-up the OGTS contribute to further destruction and/or removal of the trace quantities of contaminants present in the off-gas flow. When combined with the destruction efficiency of the melt itself, overall DREs in the range of 99.99 to 99.9999% have been demonstrated by the GeoMelt process for a wide range of hazardous organic and inorganic contaminants. Consequently, the concentration of hazardous chemical constituents present in the off gas at the stack exit is typically at or near detection limits, and is two or more orders of magnitude below acceptable emission limits.

For example, at the Parsons Chemical Site in Grand Ledge, Michigan USA [1], initial soil concentrations of 4,4'-DDT (@ 340,000-ppb) and dieldrin (@ 4,600-ppb) were reduced to non-detect levels in the vitrified product. This is to be expected as neither of these compounds can survive the extreme thermal conditions imposed by the GeoMelt vitrification process. Analysis of the concentration of these constituents in the stack emissions generated during processing indicated non-detect levels. Prior to GeoMelt processing, samples of the site soils were subjected to Toxicity Leach Test Procedure (TCLP) testing to assess its propensity for leaching heavy metals. The vitrified product generated by the GeoMelt process was also subjected to TCLP testing for this purpose. The concentration of arsenic, barium, chromium, and lead present in the leachate from these tests was 8 to 1300 times lower for the vitrified product than for the site soil. In all cases, the concentration of these heavy metal constituents present in the leachate generated by applying the TCLP procedure to the vitrified product was well below the established regulatory limits.

At the TSCA Demonstration Test Site in Spokane, Washington USA [2], the concentration of polychlorinated biphenyls (PCBs) in the contaminated soil at the Site ranged from 170-ppm to over 17,860-ppm, with the average concentration being 14,377-ppm. The PCB concentration found in the vitrified product was below detection limits. Moreover, soil samples obtained from areas surrounding the vitrified block indicated no detectable concentration of PCBs, dispelling the notion that these contaminants can migrate away from the advancing melt front into the surrounding, non-contaminated soils. Samples obtained from the off-gas stack exit during processing were analysed to determine the presence of PCBs and TCDD equivalents. In all cases, the concentrations were essentially non-detect, with concentrations not statistically different from background, ambient airborne concentrations. The off-gases were also analysed to determine the concentration of polynuclear aromatic hydrocarbons (PAHs – e.g., naphthalene, fluorene, phenanthrene, fluoranthene, and pyrene) and other VOCs. The measured concentrations were in the low ppb range for these constituents. Consequently, the concentrations were typically three orders of magnitude below their respective accepted NIOSH exposure limits. Finally, the off-gas effluent was analysed for particulates, chloride, CO, and NO<sub>x</sub> emissions. PM<sub>10</sub> particulate emissions were in the range of 0.23 to 7 -mg/dscm; HCl emissions were in the range of 0.6 to 14-ppm. These emission levels are at least one order of magnitude lower than US federal guideline values. NO<sub>x</sub> emissions were in the range of 30 to 40-ppm; CO concentrations were below detection limits. Again, these values are well below established guideline levels. These combined results indicated that the overall PCB DRE for the process ranged from greater than 99.99962% to greater than 99.99998%. Discounting the off-gas treatment system's contribution to the overall DRE, these results indicate the PCB DRE for the melt itself was in the range of 97.11 to 99.77%.

The inset table on page 4 indicates the effectiveness of the GeoMelt process for remediating the assortment of hazardous chemical wastes present in the soils at the Wasatch Chemical Site near Salt Lake City, Utah USA. Analysis of the off-gas effluents at the stack exit indicated that the concentration of the pesticides and herbicides listed in this table were all below the part per trillion detection (ppt) limits. Similarly, dioxin analysis of the off-gas effluents indicated that the concentration of these constituents was also below the ppt detection limits. This included analysis for TCDD, PeCDD, HxCDD, HpCDD, and OCDD. The concentration of furans were similarly low. HpCDF and OCDF, if present, were at concentrations below the ppt detection limits. The concentration of TCDF, PeCDF, and HxCDF were 0.49-ppt, 0.21-ppt, and 0.07-ppt, respectively. Analysis of the off-gas effluent for the presence of VOCs indicated that the concentration of these compounds was below the detection limit of 5.8-ppb. The PM<sub>10</sub> particulate concentration in the off-gas effluent was measured at 0.54-mg/dscm. Finally, the concentration of HCl in the off-gas effluent was measured at less than 0.0054-mg/dscm.

Initial Waste Soil, GeoMelt Product & Surrounding Soil (post-GeoMelt) Contaminant Levels [2]				
Contaminant	Pre-GeoMelt (ppb)	Post-GeoMelt (ppb)	Surrounding Soil (ppb)	Regulatory Limit (ppb)
TCDD dioxin	11	< 0.12 <sup>(1)</sup>	< 0.0045	20
2,4-D	34,793	< 20	ND	NA <sup>(3)</sup>
2,4,5-T	1,137	< 14	ND	NA
4,4'-DDD	52	ND <sup>(2)</sup>	ND	28,000
4,4'-DDE	3,600	ND	<2.4	19,000
4,4'-DDT	1,090	ND	ND	19,000
Total chlordanes	535,000	<80	<83.4	7,000
Heptachlor	137.5	ND	ND	2,000
Hexachlorobenzene	17,000	ND	ND	7,000
Pentachlorophenol	272,918	<10.3	<1.2	<10
Trichloroethene	36,875	ND	ND	103,000
<p>Notes: (1) &lt; values indicate that contaminants were not detected at the reported detection limit  (2) Non-detect  (3) Not available</p>				
<p>Tests in Australia involving applying the GeoMelt In-Container Vitrification process to treatment of soil contaminated with 33-wt% hexachlorobenzene (HCB) yielded an overall DRE of 99.9999%. When the influence of the off-gas treatment system is removed from this value, a DRE of 99.75% is obtained for the melt itself. The off-gas effluent at the stack was sampled and analysed during this test. The results indicated concentrations of 89-ppb for HCB, 1.2-ppm for bis(2-ethylhexyl) phthalate, and non-detect (less than 72-ppb) levels for the dichlorobenzene isomers, 1,2,4-trichlorobenzene, hexachloroethane, naphthalene, and hexachlorobutadiene. Total VOC and HCl concentrations in the off-gas effluent were less than 1.5-ppm and 0.7-ppm, respectively. Particulates were measured at 3.3-mg/dscm in the off-gas effluent. The concentration of CO in the off-gas effluent was in the range of 2 to 4-ppm, while NO<sub>x</sub> concentrations ranged from 27 to 74-ppm.</p>				
<p><b>Throughput:</b>  The existing US and Australian GeoMelt large-scale vitrification systems have a demonstrated process rate of approximately 90-tons per day when applied to in-situ applications. Depending upon the composition and configuration of the waste matrix, a typical 800-ton large scale in situ melt requires approximately 10 to 14 days of operation. The US GeoMelt In-Container Vitrification unit can process wastes at a nominal rate of 45-tons per day. The Japanese GeoMelt staged-batch facility has a demonstrated process rate of approximately 30-tons per day. When completed, the Australian GeoMelt In-Container Vitrification facility will process at a nominal rate of 25-tons per day.</p>				
<p><b>Wastes/Residuals:</b>  Typical waste streams generated by the GeoMelt process include scrub solution, particulate and carbon filter media, and personal protective equipment (e.g. – gloves, coveralls, and respirator cartridges). The quantities generated in each application are very case-specific. Solid secondary waste materials are typically staged in subsequent melts. Scrub solution can be condensed by evaporating-off excess water during the final stages of operation. Consequently, typical waste volumes for this component are on the order of 5,000-10,000 litres. These volumes are per PROJECT, not per melt.</p>				
<p><b>Reliability:</b>  To date, all commercial GeoMelt applications have successfully and completely processed the entire target volume of hazardous chemical wastes to which it has been applied.</p>				
<p><b>Limitations:</b>  As the commercial experience described above indicates, the GeoMelt process is very robust. It can be applied to a broad spectrum of contaminants in a wide range of configurations. There are conditions in which some pre-treatment activities are appropriate, however. For example, in situations wherein there exists excessive moisture levels in the waste form (i.e. – super-saturated), the GeoMelt process is most effectively employed if this moisture is first reduced to at most fully-saturated levels by some other means (e.g. – pumping, drying, and/or sorbing the excess moisture onto additional soil). When the potential exists for significant groundwater recharge during processing, precautionary measures should be invoked prior to GeoMelt processing to either prevent or redirect the groundwater flow. This can be done by conventional methods in common use in the industry. For example, a system of wells placed can be installed at strategic locations around the region targeted for GeoMelt processing to alter the site's hydrological conditions. Alternatively, diversion barriers can be inserted up-gradient from the region targeted for GeoMelt processing so that the groundwater flow is suitably redirected.</p>				

The GeoMelt process should also not be applied to direct processing of waste streams containing sealed containers of volatile materials. In these situations, the sealed containers should be punctured or otherwise compromised to preclude a build-up of pressure within the container during processing. This concern also applies to waste zone configurations wherein the potential exists to trap the transport of volatilised materials between an impermeable barrier (e.g. – a shale layer) and the advancing melt. Again, pre-treatment activities should be invoked prior to GeoMelt processing to insure adequate pathways exist for the controlled release of these volatilised materials to the off-gas hood and treatment system.

In both instances, the required pre-treatment technologies are readily available in the industry and represent only marginal additions to the overall treatment cost.

**Transportability:**

The US and Australian GeoMelt vitrification and off-gas treatment systems are transportable over the roadways via common carrier. The Japanese GeoMelt and Australian GeoMelt HCB-Processing plants are fixed-base facilities, however. They are located near Ube City, Japan and Adelaide, Australia, respectively.

**Detailed information:**

The references listed at the end of this document provide extensive operational and analytical data for each of the commercial applications to which the GeoMelt process has been applied.

**Conclusion:**

The GeoMelt™ vitrification process has been successfully applied to remediate numerous hazardous waste sites and materials in the US, Australia, and Japan. The process has been in commercial application since the early 1990s. It can be applied to a wide range of organic and inorganic contaminants, including virtually all pesticides, herbicides, PCBs, solvents, and heavy metals. The GeoMelt process has also been applied to remediation of radioactively contaminated wastes.

The process is very robust. It can treat a broad spectrum of waste materials, simultaneously, without the need for separation and/or segregation prior to processing. In some situations, limited pre-treatment of the waste zone and surrounding area may be required to reduce excess moisture in the waste stream below super-saturated levels. This may also be required in some applications to insure that direct processing volatile materials trapped inside sealed containers or between impermeable barriers and the advancing melt is precluded.

Site	Reference(s)	Location	Major Contaminants
Parsons Chemical Works Site	[1],[2],[3]	Grand Ledge, Michigan USA	Agricultural chemicals including pesticides, herbicides, solvents, heavy metals
Spokane TSCA Demonstration Site	[4]	Spokane, Washington USA	PCBs
Wasatch Chemical Site	[5], [6]	Salt Lake City, Utah USA	Agricultural chemicals including pesticides, herbicides, fertilisers, acids, caustics, and solvents
Maralinga Taranaki Pits	[7]	Australian Outback in South Australia	Radioactive elements (principally Pu & U), barytes bricks, steel, and concrete
Los Alamos National Laboratory MDA V Site	[8]	Los Alamos, New Mexico USA	Radioactive elements (principally Pu & Am), phosphates, and heavy metals

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*\*Note: This NATO/CCMS fellowship report does not certify any particular technology, but tries to summarise the state of the art of the concerned technology on the basis of data deliver by the company or other sources been made available to the author and refers the reader to original documents for further evaluation. Without the efforts of the Technology supplier it would not have been possible to set up this fact sheet.  
 \*\* Note: The text for this report is verified by the Technology supplier on 9. October 2002*

**Patents:**

The GeoMelt™ technology is covered by a number of patents. These patents assign AMEC exclusive, worldwide rights to application of the technology. They are:

"In-Situ Vitrification of Soil" – US Patent #4,376,598

"Improved Method of Melting Solid Materials" – US Patent #6,120,430; European Patent #98926394.2-2309

"Apparatus and Method for Vitrification of Contaminated Soil or Waste" – Patent Applied For

**References:**

- [1] US EPA. 1995. "Geosafe Corporation In Situ Vitrification Innovative Technology Evaluation Report " EPA/540/R-94/540.
- [2] Mostardi-Platt Assoc. 1993. "Particulate and Gaseous Emission Study Performed for Geosafe Corporation at the Parsons/ETM Superfund Site" Project No. 33109. Mostardi-Platt Associates, Inc. 945 Oaklawn Avenue, Elmhurst, Illinois USA 60126.
- [3] Mostardi-Platt Assoc. 1993. "Particulate and Gaseous Emission Study Performed for Geosafe Corporation at the Parsons/ETM Superfund Site" Project Nos. 32606 & 32717. Mostardi-Platt Associates, Inc. 945 Oaklawn Avenue, Elmhurst, Illinois USA 60126.
- [4] Geosafe. 1995. "TSCA Demonstration Test Performance Report", Geosafe GSC 2501, Geosafe Corporation, 2952 George Washington Way, Richland, Washington USA 99352.
- [5] Air Chem. 1995. "Report on Air Emissions Testing – Phase I" Air Chem Laboratories, 463 West 3600 South, Salt Lake City, Utah USA 84115.
- [6] Air Chem. 1995. "Report on Air Emissions Testing – Phase II" Air Chem Laboratories, 463 West 3600 South, Salt Lake City, Utah USA 84115.
- [7] Geosafe. 2002. "ISV Treatment Process Report – In Situ Vitrification of the Maralinga Taranaki Pits" GSA 40102. Geosafe Australia Party Ltd., Adelaide, South Australia.
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