IN SITU PLASMA VITRIFICATION OF BURIED WASTES

Louis J. Circeo[1] and Robert C. Martin, Jr.[2]

Abstract: The subterranean application of plasma arc technology would result in the in situ plasma vitrification and remediation of virtually any buried waste or contaminated soil into a rock-like mass that is durable, strong, and highly resistant to leaching. Conceptually, a plasma arc torch, creating temperatures exceeding 7,000 °C, would be lowered into a borehole to any depth and operated to destroy hazardous compounds and to vitrify the soil and its contaminants. By producing a wasteform with long-term chemical durability and stability, in situ plasma vitrification (ISPV) is considered to be a permanent treatment technology, as opposed to interim technologies which may require repeated applications. A buried waste deposit requiring treatment by in situ plasma remediation would be treated by inserting the plasma torch near the bottom of a borehole and vitrifying the material around the torch, producing a column of vitrified material as the torch is slowly withdrawn. Plasma arc torches operated at multi-megawatt power levels would be expected to produce vitrified columns greater than 10 feet in diameter. A matrix of overlapping columns would form a contiguous vitrified mass of treated and remediated soil. Similarly, plasma vitrification can be used for selective underground treatment; e.g., to vitrify subterranean contaminated zones and to treat “hot spots” in landfills and in aquifers which feed groundwater contamination plumes. This process of ISPV technology is expected to be rapid, efficient, cost-effective, and simple. An industrial-scale ISPV field test using a 1 megawatt plasma torch was successfully completed at the Savannah River Site in late 1996. As a result of this experiment ISPV was demonstrated to be a practical process which can be implemented on a production scale.

A plasma torch is a device that converts electrical energy into thermal energy (Camacho, 1988). Plasmas occur naturally in the form of lightning. The plasma arc creates a "flame" that has temperatures ranging from 4,000°C to 7,000°C. Thus, plasma torches operate at much higher temperatures, higher enthalpies, and at efficiencies much greater than those of fossil fuel burners. In addition, plasma torches require only about 5% of the gas necessary for fossil fuel burners. Therefore, the volume of effluent gas is greatly reduced, which allows the offgas to be collected and treated. Several plasma torch furnace processes for the destruction of hazardous and toxic wastes have been developed and successfully tested. The very high temperatures and energy densities, in conjunction with an ionized and reactive medium, have fully demonstrated the potential of plasma technology to remediate many waste and mixed-waste materials in an environmentally safe and cost-effective manner. Materials vitrified with plasma arc torches readily pass all standard leaching tests. Among the promising waste disposal technologies are

[1] Director, Plasma Research, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, GA 30332-0837, USA, Ph 404-894-2070, Fx 404-894-2184, lou.circeo@gtri.gatech.edu (corresponding author)
[2] Branch Head, Environmental Technology Branch, Georgia Tech Research Institute, Georgia Institute of Technology, Atlanta, GA, 30332-0837, USA, Ph 404-894-8446, Fx 404-894-2184, bob.martin@gtri.gatech.edu

processes to remediate asbestos, polychlorobiphenyls (PCB's), hospital medical wastes, municipal solid wastes, hazardous or toxic wastes, and low-level radioactive wastes. Some of these processes have been commercialized, while others are still in the development stage.

The ISPV concept should be directly applicable to the remediation of contaminated sites by operating one or more multi-megawatt-power-level plasma torches in cased boreholes. The process would start at targeted depths of remediation to produce in situ melting and subsequent solidification (see Figure 1). As the melt grows, the torch is raised within the borehole to form a cylindrical melt. Large sites may be treated by forming contiguous melts through the use of properly spaced boreholes placed in a grid configuration. All gases would be drawn out through the top of the boreholes and collected in a hood for eventual treatment as appropriate. Contaminated sites would include soil and rock materials containing subsurface contaminants such as hazardous/toxic wastes, heavy metals and organics, buried objects, concentrated waste sediments and sludge, sanitary landfills, radioactive wastes, and underground storage tanks (Circeo et al, 1994).

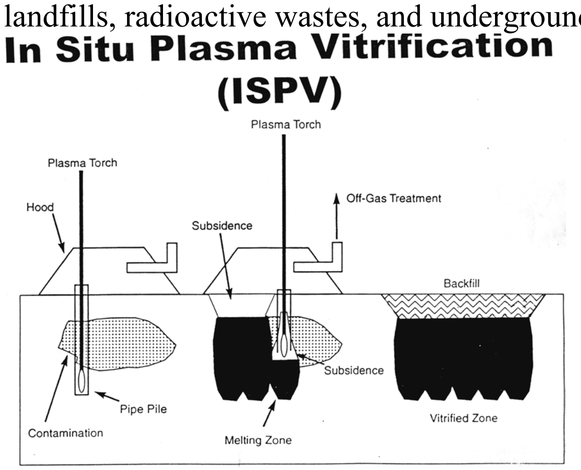

Figure 1. Schematic Illustration of in situ plasma vitrification (ISPV) of contaminated materials.

The ISPV process requires a bottom-to-top in situ plasma vitrification procedure. As has been demonstrated in laboratory-scale studies, this bottom-up melting concept has several advantages over existing technologies (Circeo et al, 1996). In particular, this approach guarantees reaching the target depth, since the process starts there. Also, the borehole itself provides a route for collection and treatment for offgases. The water-cooled torch body would cool the offgases traveling to the surface, thus condensing many metals and other volatiles within the borehole for eventual immobilization in the rock-like vitrified residue. This release path also eliminates the potential for forming subterranean bubbles or elevated pressures within the melt that might cause unanticipated eruptions of melt to the surface. In addition to the complete vitrification of an entire contaminated deposit, the ISPV concept could be used to employ alternative remediation techniques. For example, plasma vitrification can be used for selective underground remediation; e.g., to selectively target and vitrify subterranean contaminated zones such as "hot spots" which feed contamination plumes, and to treat soils contaminated from leaks around buried pipes and adjacent to underground storage tanks (see Figure 2).

The cost-effectiveness of ISPV technology will be highly dependent on several variables relating to the site conditions, types of buried waste, and the plasma torch system. ISPV treatment time and costs are expected to be significantly less than any comparable ex-situ thermal technology. One study estimated the cost of ISPV remediation of hazardous

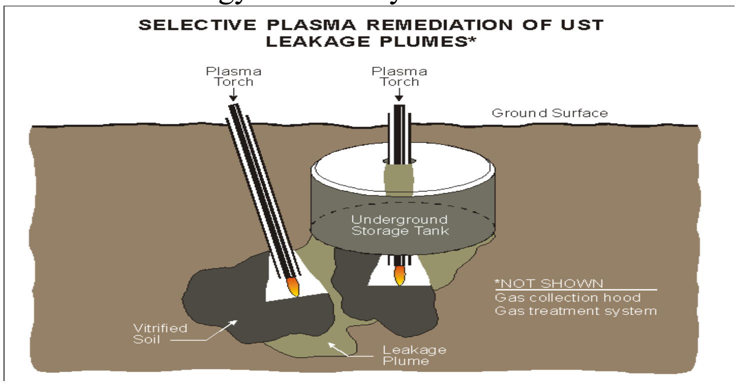

Figure 2. ISPV selective "hot spot" remediation.

buried wastes (with no radioactive material present) to be approximately $130 per ton (Circeo et al, 1994).

A full-scale plasma vitrification demonstration in clean SRS soils using a 1 megawatt mobile plasma torch was conducted at SRS in the fall of 1996 (Blundy et al, 1997). The 6-inch diameter plasma torch was operated in three 8-inch diameter boreholes which were 7 feet deep. The duration of each experiment was between 40 minutes and 105 minutes at power levels ranging from 650 kW to 950 kW. Three highly vitrified soil columns were created between three and four feet in diameter (see Figure 3). This test demonstrated the ISPV process at an industrial level and confirmed its commercialization potential.


Figure 3. Vitrified soil column and cross section produced in the WSRC/GIT 1 MW scale test.

References

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