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B. E. Campbell
S. S. Koegler

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Pacific Northwest Laboratory
Richland, Washington 99352

IN SITU VITRIFICATION OF A MIXED RADIOACTIVE AND HAZARDOUS WASTE SITE

by Brett E. Campbell and Sydney S. Koegler

Pacific Northwest Laboratory
Richland, Washington

A large-scale test of the in situ vitrification (ISV) process was performed on a mixed radioactive and hazardous-chemical contaminated waste site on the Hanford Site in southeastern Washington State. A mixed-waste site was selected for this large-scale test to demonstrate the applicability of ISV to mixed wastes common to many U.S. Department of Energy (DOE) sites. In situ vitrification is a thermal process that converts contaminated soil into a durable, leach-resistant product. The ISV operating sequence is shown in Figure 1. Electrodes are inserted into the ground to the desired treatment depth and a layer of electrically conductive material (a "starter path") is placed between the electrodes. Electrical power is applied to the electrodes causing the conductive material to melt, thus melting the surrounding soil. Electrical energy is transferred to the molten soil through Joule (resistance)

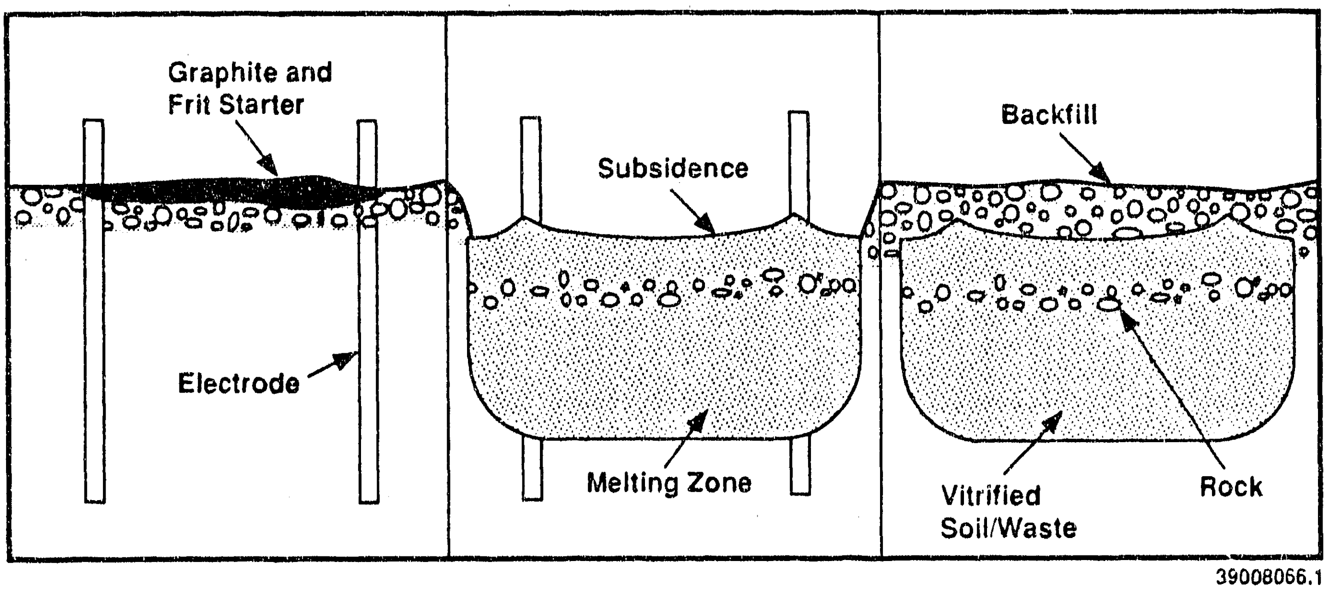

Figure 1. In Situ Vitrification Operating Sequence

heating, and the soil continues to melt to the desired depth, at which time the power to the electrodes is discontinued. A hood placed over the area to be vitrified allows the off gases from the process to be treated before their release to the atmosphere. After completion of the melt, the molten soil cools and solidifies, and soil is backfilled over the subsided area.

Figure 2 depicts the large-scale process equipment required for ISV of radioactive and hazardous waste sites. Controlled electrical power is distributed to the electrodes, and special equipment contains and treats the gaseous effluents. Four major subsystems comprise the process equipment to perform those functions: 1) electrical power supply, 2) off-gas hood, 3) off-gas treatment and cooling system, and 4) process control. Except for the off-gas hood, all components are contained in three transportable trailers.

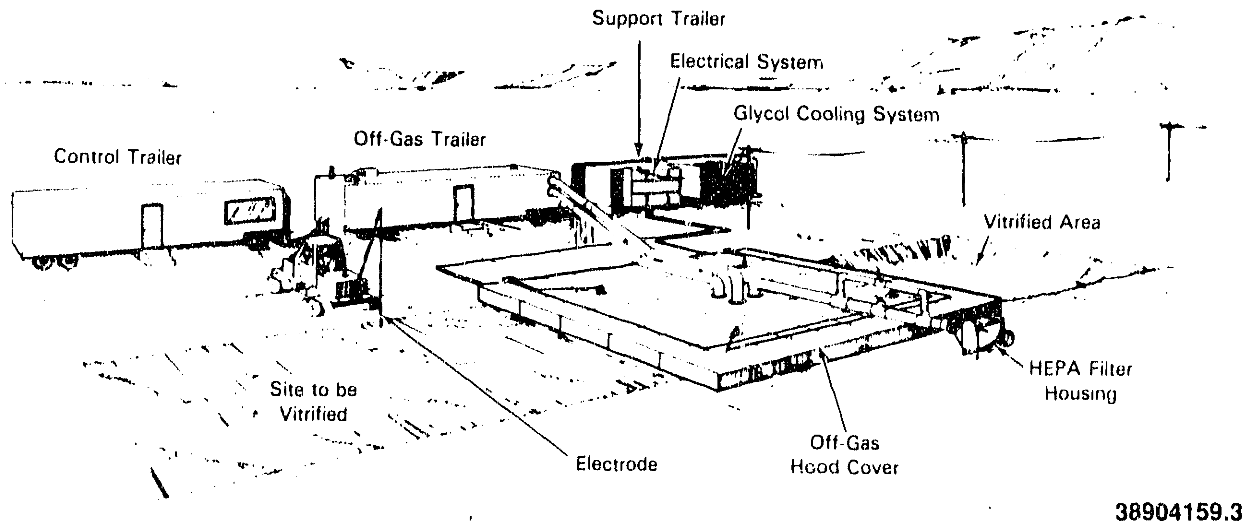

Figure 2. Large-Scale Equipment Required for In Situ Vitrification

The effluents exhausted from the hood are cooled and treated in the off-gas treatment system. The off-gas hood and off-gas lines are dismantled and placed on a flatbed trailer for transport between the sites to be treated. The entire process is monitored and controlled from the process control trailer.

The product resulting from ISV is a glass and crystalline mass resembling natural obsidian. For typical earthen materials within the United States, the density of the ISV product varies from 2.3 to 2.5 g/cm^3 (144-156 lb/ft^3). Although the ISV product is only 3 to 11 % heavier than concrete (at 140 lb/ft^3), it possesses about 5 to 10 times the strength of unreinforced concrete in both tension and compression. The ISV product is extremely inert, with a chemical leach resistance approaching that of Pyrex[a] glass. Some crystallization will be present in the product, resulting in even greater physical properties.

The 116-B-6A Crib site was chosen for this ISV demonstration because it contains both radioactive and hazardous contaminants and has a potential for impacting groundwater. The waste site is located in the 100-BC area on the Hanford Site, as shown in Figure 3. Between 1951 and 1968, the crib received about 5000 L of liquid waste from the 111-Building, which was used as a decontamination facility. The site was retired in 1968. The surface geology of this area consists of fine, light brown, slightly silt sand underlain by a sand-gravel mixture to 200 ft. Depth to groundwater is 80 ft. The estimated inventory of radioactive material includes 900 mCi of ^{90}Sr and 150 mCi of ^{137}Cs. Small amounts of ^{60}Co and ^{239}Pu are also present. The site also contains nonradioactive chrome, lead, and other hazardous constituents.

The crib is constructed of wooden timbers with rocky backfill, as shown in Figure 4. The crib is 12 ft on each side, 8 ft high, and is covered by 6 ft of fill dirt. The crib dimensions and location were determined from

(a) Pyrex is a registered trademark of Dow-Corning Glass Works.

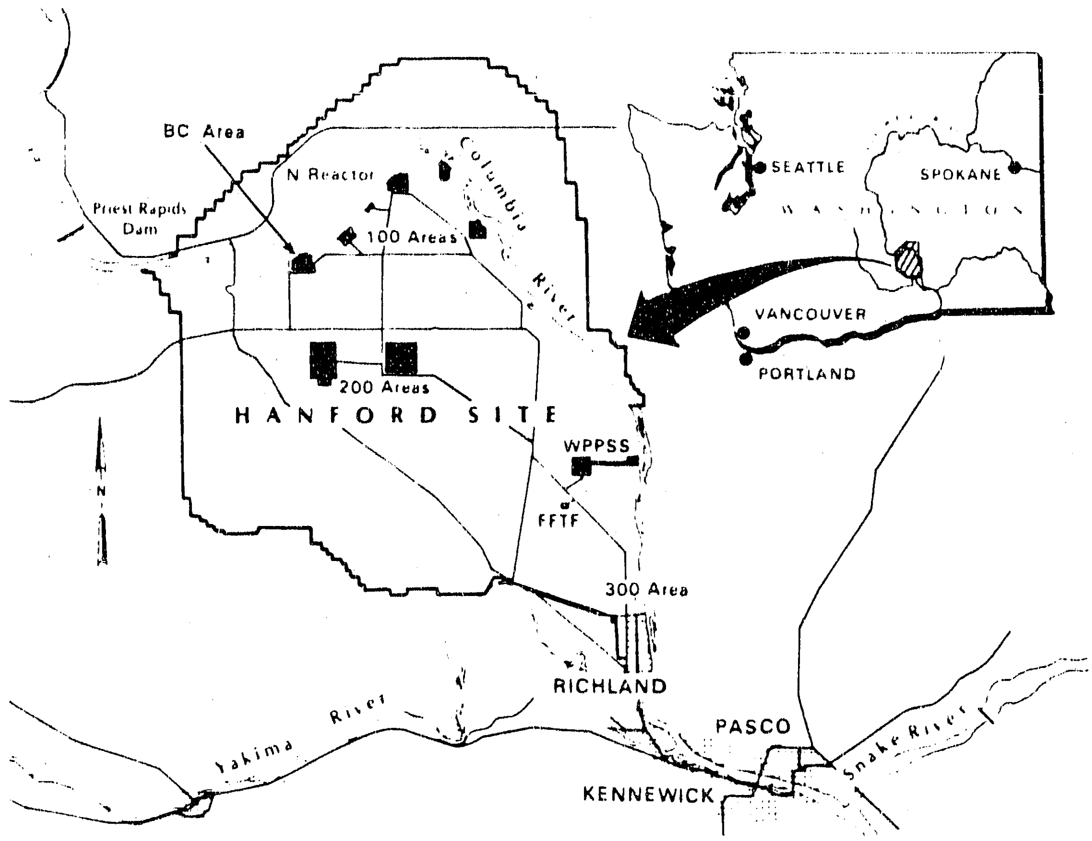

Figure 3. Test Site for Large-Scale ISV Demonstration

historical data and confirmed in 1988 by ground-penetrating radar. In 1976 a borehole was placed into the site about 2 ft south of the crib marker and soil samples were retrieved for radionuclide analysis. (No nonradioactive chemical analyses were performed on the soil samples at that time.) The radioactivity was confined to the soil immediately below the bottom of the crib structure, from 15 to 22 ft deep. In 1989, two additional boreholes were placed into the crib and a third borehole was placed 10 ft north of the crib to obtain additional characterization samples. The soil analyses from these boreholes confirmed the radionuclide contamination and revealed the presence of lead,

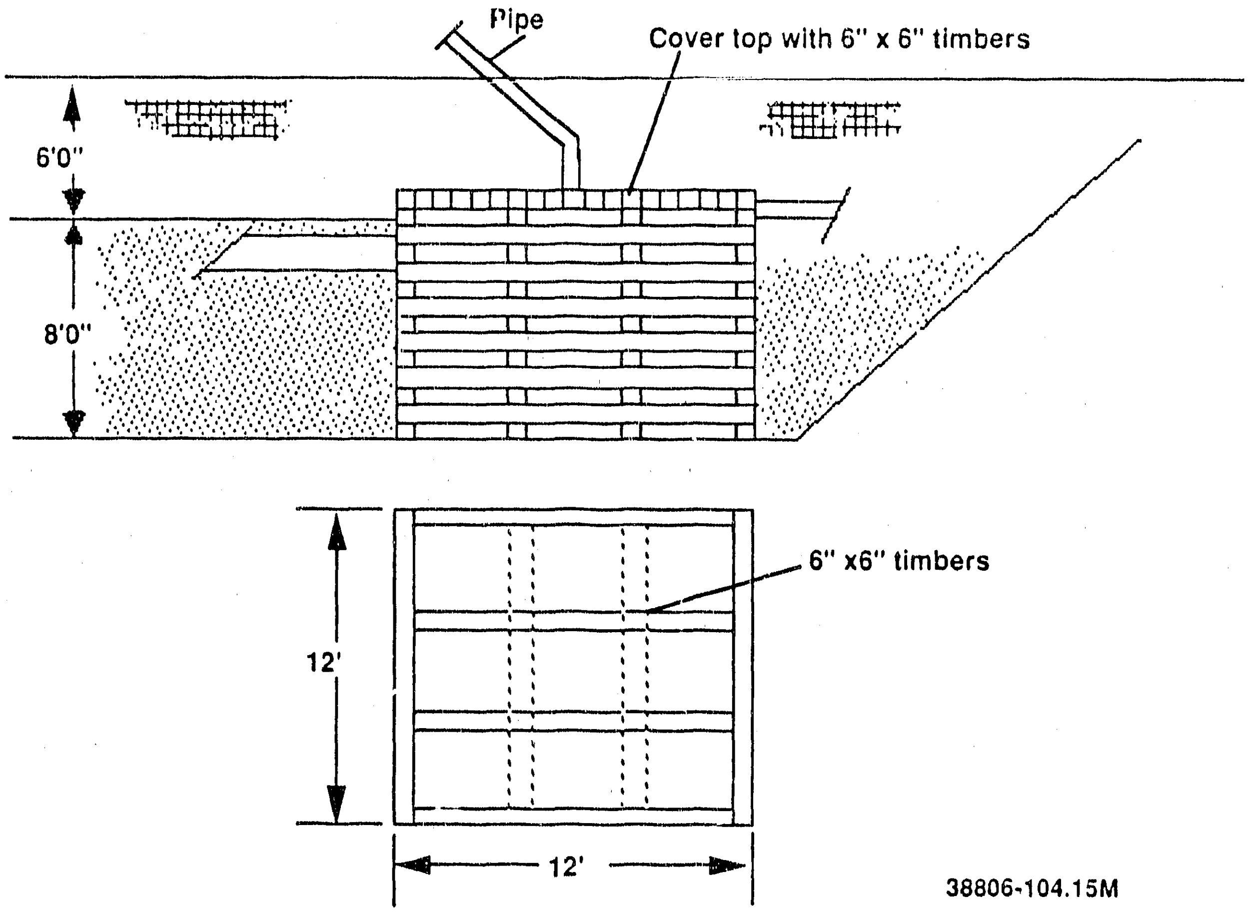

Figure 4. 116-B-6A Crib Construction

chrome, and small amounts of polyaromatic compounds concentrated near the top and bottom of the crib. No contamination was found in the borehole outside of the crib.

The goals of the test are to 1) demonstrate at least 99% retention of fission products and hazardous metals in the ISV glass during the test, 2) demonstrate the ability of the ISV off-gas treatment system to process a waste site containing significant quantities of combustible material (i.e., crib timbers), and 3) demonstrate the ability of ISV to vitrify the site to a depth of 20 ft or greater. The test was completed in April 1990.

Vitrification of the crib concluded after 244 h of actual processing time as the vitrified block diameter approached the edges of the off-gas hood. The resulting vitrified block measured approximately 4.2 m (14 ft) deep and 12 m (40 ft) in diameter. Figure 5 depicts the melt geometry resulting from vitrifying the crib. It is projected that the block weighs over 900 tonnes and incorporated 75% of the crib and its contents.

The wooden timbers used to construct the crib were processed safely by ISV. Wood when contacted by the ISV process pyrolizes (thermally induced decomposition of compounds into their elements) into gaseous forms. These gases are then collected in a containment system where they combust or are treated in an off-gas treatment system.

Retention of fission products and hazardous metals in the ISV glass will be determined from analyzing scrub solution samples and core samples taken of

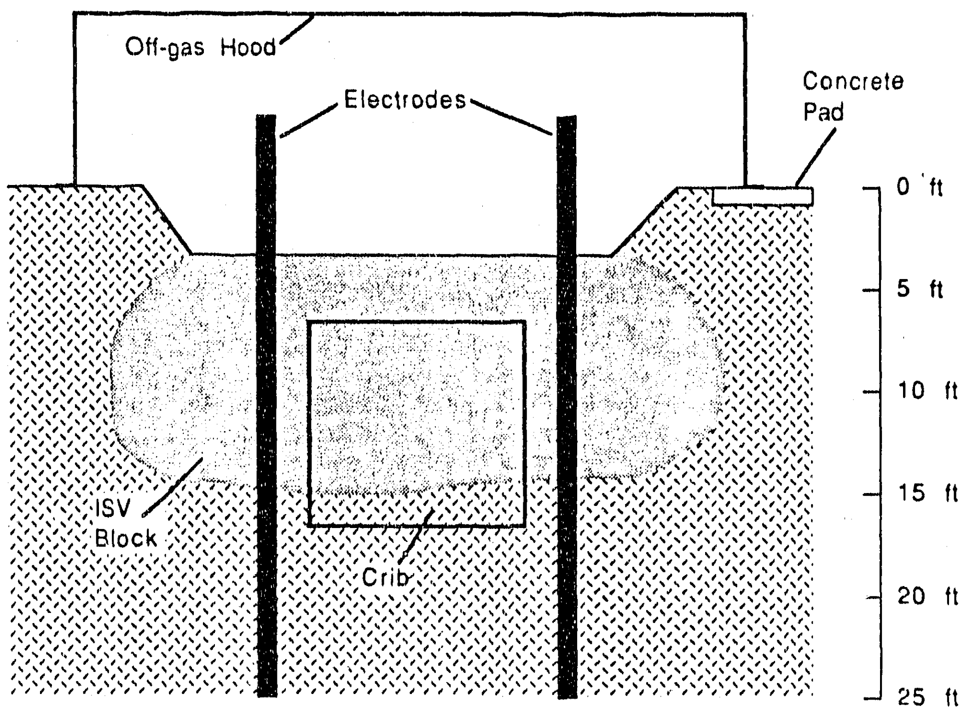

Figure 5. 116-B-6A Crib After Vitrification

the glass once its cooled. Typically it takes approximately 1 year for a block to cool to temperatures that will allow core sampling. Samples of surrounding soil will be analyzed to determine if any material present in the crib migrated outside of the vitrified zone.

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