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MICROWAVE SOLIDIFICATION PROJECT OVERVIEW

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**MICROWAVE SOLIDIFICATION
Project Overview**

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Technology Need:

The generation rate of 1,200 cubic feet per year coupled with an existing backlog of 18,000 cubic feet makes precipitation sludge one of the largest waste problems by volume at Rocky Flats Plant (RFP). Current treatment of this waste stream is accomplished by cementation, which results in large waste volume increases. Due to Land Disposal Restrictions (LDR), this waste form is not acceptable for land disposal. The improved waste form produced by microwave solidification offers significant waste volume reductions as compared to cementation. Microwave solidification was shown to reduce volume by up to 80% over the present immobilization process. Additionally, microwave solidification of precipitation sludge removes water (the source of ground water mobilization and hydrogen generation), while immobilizing radionuclides and heavy metals and eliminating releasable particulates. Thus, a waste form can be produced that is suitable for land disposal.

Several other waste streams at RFP and other DOE facilities in the complex have been identified as potentially amenable to microwave solidification. The RFP streams include fluid bed incinerator ash, nitrate salts, sand, slags, crucibles, and remediation soils. Other DOE applications for microwave technology include the nitrate salts buried at Idaho National Engineering Laboratory, the by-pass sludge from TA-50 at Los Alamos, and use in the Waste Handling and Packaging Plant (WHPP) at Oak Ridge. Additional wastes forms may be identified in the future as microwave application investigations continue.

The RFP Microwave Solidification Project has application potential to the Mixed Waste Treatment Project and the Mixed Waste Integrated Program. The technical areas being addressed by microwave solidification include (1) Waste Destruction and Stabilization, (2) Final Waste Form, and (3) Front-end Waste Handling and Feed Preparation. Due to the maturity of the development project at RFP, microwave solidification could be easily incorporated into the MWTP or MWIP demonstration programs. This would provide an immediate opportunity to investigate a treatment option under consideration for implementation in the future DOE complex. Not only would this benefit MWTP and MWIP, but it would accelerate the

design and construction of COMPLEX 21.

Technology Description:

The aqueous wastes from the plutonium recovery areas at the Rocky Flats Plant are treated in a hydroxide precipitation process to remove heavy metal constituents. The precipitate is collected in a large clariflocculator for several weeks to accumulate enough material to process. The resultant slurry is passed through a rotary drum vacuum filter, precoated with a diatomaceous earth filter media, to remove the solids from the waste stream. A thin layer of filter cake is continuously cut from the drum filter, producing a wet sludge. The wet sludge alone does not meet the Waste Isolation Pilot Plant-Waste Acceptance Criteria (WIPP-WAC) prohibiting the presence of free liquids. In the present immobilization operation, a Portland cement/diatomite mixture is added to the waste container to absorb the free liquids.

The process for microwave solidification treatment involves drying the waste, mixing with a silica source and a matrix modifier, transferring the material to a processing container, subjecting the mixture to microwave energy to melt the material, and allowing the processed waste material to cool and solidify. As the process takes place at elevated temperatures, nitrates, sulfates, and residual organics are driven from the molten material. Thus, off-gas containment and treatment systems are required. The resulting waste form is a glass-like mineral that does not contain free liquid, it has limited releasable particulates, and is highly leach resistant due to its vitreous nature.

At the heart of the proposed production system is a 60 kW, 915 MHz microwave generator which is connected to a 40 inch cubic applicator cavity by a WR975 waveguide. Other features of the facility include 1) feed characterization and preparation systems, 2) a frit preparation and transfer system, 3) a waste pelletizer and dryer to produce a particle which can be handled in the system with minimal dust generation, 4) an integrated hoist and bagless posting system to transfer items into and out of the glovebox facility, and 5) associated off-gas treatment systems to remove dust and regulated emissions.

During operation of the system, the waste material is introduced into the glovebox as is appropriate for the physical form of the waste material. The waste is then comminuted to meet material handling requirements of the down-stream equipment. A silica source/matrix modifier (composed of diatomaceous earth and borax in a two to one ratio) is added to the material to produce a waste loading of approximately 60 to 70%. The mixture is pelletized using an extrusion pelletizer to create a robust particle which will not produce dust during subsequent transfer operations and is dried using a multiple-tray, direct dryer. The dried material is transferred to a surge hopper where it is accumulated prior to the melting process.

To initiate microwave melting, a 30 gallon stainless steel drum is connected to the applicator cavity by placing it in an insulation cage and compressing it against a rotary choke mechanism using a lifting turntable. An initial ten kilogram charge of waste material is added to the drum while the turntable oscillates continuously to assure an even distribution of the waste in the drum. Microwave energy is transmitted to the 30 gallon drum thereby raising the temperature of the material to approximately 1000 degrees centigrade causing it to melt. After the initial charge becomes molten, waste material is continuously transferred from the surge hopper to the 30 gallon drum through a vibrating feeder which penetrates the wall of the applicator cavity.

Effluent gases generated during the melting process are removed by ventilating the cavity using a down-stream blower system. Suspended particulates are removed from the effluent gas by passing the stream through a high efficiency cyclone and a sintered metal filter. Oxides of nitrogen and sulfur are treated using a catalytic reduction apparatus. The temperature of the effluent gas is reduced by means of a spray quencher and demister system. Finally, the clean effluent is passed through a roughing filter before entering the building filter plenum system where it is polished through several stages of HEPA filtration.

The process continues until 160 kilograms of processed waste material have accumulated in the 30 gallon drum. At this time, the process is momentarily interrupted while the drum is removed from the melting cavity and transferred to a cool-down/inspection station and an empty drum is loaded into the melting system. While still molten, the contents of the processed drum are sampled for analytical characterization and certification. The drum is allowed to cool and is then transferred to the bagless posting system for removal from the glovebox.

Advantages associated with the microwave treatment process include:

- 1) The ability to achieve waste loading of up to 70% and product densities of near 3.0 g/cc. This results in waste reductions of up to 80% when compared to the current cementation process for newly generated by-pass sludge.
- 2) The process equipment is inexpensive and is easy to maintain.
- 3) The microwave energy provides selective heating of the waste form thereby avoiding thermal cycling of the process equipment which can lead to stress failures.
- 4) The material is processed "in-drum" which eliminates viscosity concerns and the need to transfer the waste to a final container.

Significance:

The alternatives to microwave solidification are the continued use of cementation or development of a polymer solidification system. Although cementation is the only immediately available technology,

it is not the optimum treatment technology and results in significant volume increases over microwave solidification.

The microwave solidification process eliminates water and other hydrogenous materials thus preventing leaching and hydrogen formation at the disposal facility. Microwave solidification was shown to reduce weight and volume by up to 80% over the present immobilization system thereby significantly reducing disposal costs and relieving storage limitations. The process equipment is also more easily maintained than cementation equipment and produces a waste form ideal for disposal at Waste Isolation Pilot Plant (WIPP). Glass and synthetic minerals, such as the product of the microwave solidification process, offer a leach resistant, stable matrix especially suited for hazardous wastes. The high temperatures involved ensure destruction of soluble materials, such as nitrates. Additional benefits include in-container treatment and a high degree of public acceptance.

A recent economic analysis determined that implementation of a microwave solidification facility to treat precipitation sludge could yield a cost savings of \$11.68 per pound of sludge processed as compared to the present treatment process. This same analysis indicated that alternative cementation and polymer solidification processes could provide savings of \$8.07/lb and \$10.45/lb, respectively. These estimates include costs of waste processing materials and shipping/storage of the final waste form. Equipment and installation costs were not included, neither were operational costs such as labor and utilities.

The use of bagless posting was recommended by a Bagless Posting Feasibility Study performed at Rocky Flats in 1988. That study indicated that bagless posting should decrease waste plastic bag generation by at least 5%. The bagless posting system is desired for material handling issues associated with the microwave.

Regulatory Requirements:

Rocky Flats Plant is out of compliance with the Resource Conservation and Recovery Act (RCRA) regulations because many of its wastes are prohibited from land disposal and they have been stored at RFP in violation of the law's storage prohibition. The Federal Facility Compliance Agreement I (FFCA I) which is an agreement between DOE, and the Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH), allowed RFP to continue operations with the condition that means would be developed to treat its LDR wastes by pursuing suitable treatment technologies. RFP identified those technologies in its Treatment Plans I and II and laid out a summary level development schedule for each. Microwave Solidification was one of the technologies identified. When FFCA I expired after one year, DOE negotiated a new agreement, FFCA II, with the EPA and made a verbal commitment to pursue the schedules in Treatment Plans I and II until a more thorough systems analysis (the Comprehensive Treatment and

Management Plan--CTMP) identified a better or different approach and that approach was approved by the EPA. Thus, in order to meet EPA's and CDH's expectations under FFCA II, DOE should pursue the approach developed under Treatment Plans I and II. A failure to do so will delay DOE's coming into compliance with RCRA/LDR and may be interpreted as a lack of commitment to the intent of the FFCAs.

Accomplishments to Date:

At present, microwave melting for waste solidification is not a commercially available technology. Although a similar technology, which could potentially be used for solidification of bypass sludge, is available at Japan's Tokai Works, appropriate operating parameters would have to be defined as the existing system is used for processing incinerator ash. Also, ORNL has developed a pilot-scale salt drier utilizing microwave technology. However, the ORNL technology does not immobilize LDR components.

The Microwave Solidification Project was initiated at Rocky Flats in 1986 at the request of the Waste Operations organization. Since that time, laboratory-scale tests have been performed on actual and surrogate wastes and pilot-scale tests have been performed on surrogate materials. The basic design of the Rocky Flats microwave technology has been demonstrated with bench-scale tests on actual waste. Test results indicate that volume reductions of up to 80% are achievable by the continuous feeding of dried sludge into a waste container while applying microwave energy.

Currently, a full-scale, cold demonstration system is available and has been operational since March 1991. To date, sixteen tests have been performed on the full-scale system. The demonstration system, which is a successful scale-up of 30X from the bench-scale system, is sized and designed for specific application to RFP wastes, and certain components of the design have been patented by RFP engineers. Preliminary NO_x off-gas treatment systems have been identified and documented. RFP has also assisted ORNL in the development of a microwave process to treat nitrate salts for the WHPP facility at Y-12. A preliminary economic evaluation was completed for RFP's system. NEPA documentation has been completed for the demonstration phase of the RFP project.

Significant reports published to date under this project include:

Application of Microwave Energy for Solidification of TRU Waste, R. D. Peterson and A. J. Johnson, prepared for Waste Management 88, Tucson, Arizona

Pilot/Demonstration Scale Microwave Solidification of Mixed Waste, R. D. Peterson, prepared for ASME Mixed Waste Symposium, Baltimore, Maryland, 1991

Microwave Vitrification of Rocky Flats TRU Sludge, R. D. Peterson, SPECTRUM 1990, Williamsburg, Virginia, presented by

A. J. Johnson

Future Plans:

The focus of the project has been on the development of operational data and design criteria necessary to implement a system to treat hydroxide precipitation sludge from liquid waste treatment operations at RFP. Continued development will focus on integration of ancillary equipment required for the production microwave system, including bagless posting to move waste drums efficiently in and out of gloveboxes. Key personnel at Rocky Flats have been involved in development and implementation of automated systems for use in glovebox applications over the past 10 years. The experience gained by these individuals and their access to information required to implement a system is invaluable to the success of this project.

Development program success will be measured by Reliability and Maintainability data obtained during testing and by economic evaluation based on the physical parameters of the final waste form. Waste form requirements will be determined by DOT shipping regulations and waste acceptance criteria specified by the disposal facility. These requirements include no free-liquids, no releasable particulates, and TCLP durability. The success of the bagless posting system depends on demonstration of its use with a waste drum system. The selected waste drum system must become a DOT certified package. In particular, the criteria for success are; reliable operation, reduction of waste generation, decrease in contamination potential, and an increase in safeguarding of nuclear material.

Overall program success will be measured by successful implementation and operation by Waste Operations. Criteria for the acceptance of the system have been developed by Waste Operations. An Implementation Task Team has been formed which includes representatives from the Waste Operations (WO) group at RFP. This team will provide a mechanism for incorporating WO requirements into the development effort and it allows the opportunity to keep the user apprised of the project status. Since Microwave Solidification has been identified as a target technology in the FFCA-II, the regulatory agencies will be kept current on development activities through annual status reports which are required by the FFCA.