ANL/TD/CP--84268
Conf-950216--108

Argonne-West Facility Requirements for a Radioactive Waste Treatment Demonstration

Carla C. Dwight, Frank S. Felicione, David B. Black, R. Bruce Kelso, and Grant C. McClellan;
Argonne National Laboratory

ABSTRACT

At Argonne National Laboratory - West (ANL-W), near Idaho Falls, Idaho, facilities that were originally constructed to support the development of liquid-metal reactor technology are being used and/or modified to meet the environmental and waste management research needs of DOE. One example is the use of an Argonne-West facility to conduct a radioactive waste treatment demonstration through a cooperative project with Science Applications International Corporation (SAIC) and Lockheed Idaho Technologies Company. The Plasma Hearth Process (PHP) project will utilize commercially-adapted plasma arc technology to demonstrate treatment of actual mixed waste. The demonstration on radioactive waste will be conducted at Argonne's Transient Reactor Test Facility (TREAT). Utilization of an existing facility for a new and different application presents a unique set of issues in meeting applicable federal, state, and local requirements as well as the additional constraints imposed by DOE Orders and ANL-W site requirements. This paper briefly describes the PHP radioactive demonstrations relevant to the interfaces with the TREAT facility. Safety, environmental, design, and operational considerations pertinent to the PHP radioactive demonstration are specifically addressed herein. The personnel, equipment, and facility interfaces associated with a radioactive waste treatment demonstration are an important aspect of the demonstration effort. Areas requiring significant effort in preparation for the PHP Project being conducted at the TREAT facility include confinement design, waste handling features, and sampling and analysis considerations. Information about the facility in which a radioactive demonstration will be conducted, specifically Argonne's TREAT facility in the case of PHP, may be of interest to other organizations involved in developing and demonstrating technologies for mixed waste treatment.

BACKGROUND

Introduction

Argonne National Laboratory (ANL), one of the nation's largest energy research and development organizations, is operated by the University of Chicago for the U.S. Department of Energy (DOE) with sites in Illinois and Idaho. At Argonne National Laboratory - West (ANL-W), near Idaho Falls, Idaho, facilities that were originally constructed to support the development of liquid-metal

reactor technology are being used and/or modified to meet the environmental and waste management research needs of DOE. One example is the use of an Argonne-West facility to conduct a radioactive waste treatment demonstration through a cooperative project with Science Applications International Corporation (SAIC) and Lockheed Idaho Technologies Company. The Plasma Hearth Process (PHP) project will utilize commercially-adapted plasma arc technology to demonstrate treatment of actual mixed waste. The demonstration with radioactive waste will be conducted at Argonne's Transient Reactor Test Facility (TREAT).

Argonne Experience

Argonne's experience began at the dawn of the nuclear age and throughout its history nuclear activities have played the central role. Argonne is a recognized leader in alpha confinement and remote operations technologies--key elements in a realistic PHP development program. At ANL-W, metric ton quantities of plutonium and uranium are a part of daily operations. Some 25,000 plutonium items in 2600 containers and 73,000 uranium items in 2140 containers exist on the site. For the past 10 years, plutonium and actinide fuel has been cast in the Experimental Fuels Laboratory. In gearing up for applying the ANL electrometallurgical process to the DOE spent fuel problems, new facilities and analysis techniques have been developed. As a result, new capabilities have been developed for process control, actinide and fission product waste streams, materials control and accountancy, criticality control, employee and public safety, and regulatory permit processing. From decades of transuranic (TRU) facility/equipment design and operations, a few simple lessons learned are now applied to all ANL-W TRU projects: 1) simplify the process, equipment, and facility to the maximum extent; 2) minimize confinement penetrations; 3) minimize moving parts, and 4) limit the energy potential. These principals are being implemented in the PHP Support Systems in TREAT, described in a subsequent section of this paper.

Plasma Hearth Process Program Description

Plasma-arc technology is an existing, commercially available processing method used primarily in the high-purity metals industry. Adaptation of this technology to treatment of mixed waste, and demonstration of this application on actual mixed waste is the focus of the PHP Project. The PHP is a high temperature vitrification technology which utilizes a plasma arc torch to melt waste material into a fixed hearth. The melted waste solidifies into separable metal and glassy-slag phases. Results of testing to date show promising results with regards to volume reduction of waste, destruction of hazardous organic constituents, stabilization of hazardous inorganic constituents in the vitrified product, and resistance to leaching from the final product. One of the greatest benefits of the PHP is the apparent flexibility to process a wide variety of waste forms without the need for pretreatment steps such as shredding or the need for additives to achieve the final product. Also, the PHP discharges much less offgas than incinerators, which are currently being scrutinized by regulators and the public. The PHP Project is funded by DOE's Office of Technology Development (EM-50), specifically the Mixed Waste Integrated Program. Programmatic aspects and results of non-radioactive PHP testing are widely published. (1,2,3)

The PHP program ultimate goal is to conduct a full-scale demonstration using actual mixed waste. To ensure success in this goal, two PHP systems will be built and tested prior to the full-scale system. A bench-scale PHP system will be constructed at the ANL-W TREAT facility to test the treatment of radioactive material containing waste forms for assessment of radiological considerations. The bench-scale system is approximately one-tenth scale of a full scale system in terms of torch power and processing rate. In parallel, a pilot-scale PHP system will be built and operated on non-rad waste to ensure system operability and reliability at a large scale as well as conformance to all environmental criteria.

Three phases of testing will be conducted in the bench-scale PHP experiments. First, simulated waste, which will include radionuclide surrogate materials like cerium, will be tested to check out the PHP systems operationally and to verify the ability of the bench-scale system to model performance of the pilot-scale system. Then, simulated waste matrices will be spiked with radionuclides, specifically plutonium, cesium, and uranium. Radionuclide concentrations in various locations throughout the PHP primary system will be measured. Finally, tests will be performed on actual waste. The actual waste streams will include inorganic sludge, organic sludge, combustibles, and a heterogeneous mixture of waste matrices. The actual waste tests are expected to demonstrate the PHP technology's relative insensitivity to variations in waste feed compositions. Also, the system will be operated to vary stoichiometry for the purpose of evaluating final waste form performance. The effects of including waste-form-enhancing additives to the feed material will also be investigated in the actual waste tests.

All of the test material to be treated in the PHP system will be packaged in small (3.8 liter) metal containers. Approximately 8 containers will be processed per test. Approximately 39 tests will be processed (312 containers) in the PHP experiments, expected to be conducted over a 6- to 9-month time period. For the spiked waste tests, each container may include up to 500mg plutonium, 20g depleted uranium, and 3700 Bq of cesium-137. The radionuclides for the actual waste tests will consist of plutonium in quantities much less than the spiked tests.

TREAT History

The TREAT facility at Argonne-West was originally constructed in 1958 as an experimental, air-cooled, thermal reactor used for fuel and material testing under transient conditions. Reactor operations started in 1959, and continued for 35 years; over 2800 reactor transients have been conducted. The facility was upgraded to modern standards in 1989. The TREAT facilities existing infrastructure is being utilized to conduct the non-reactor PHP experiment. The features which make TREAT suitable for the PHP experiments include the large high bay area (35m x 21m x 23m high), double HEPA-filtered building exhaust, existing electrical and water supplies, overhead crane coverage, and truck access. TREAT support systems specific to the PHP Project are described in the following section.

PHP SUPPORT SYSTEMS IN TREAT

New support systems are being provided to the TREAT facility that will enable the PHP process equipment to be operated safely and effectively to perform the experimenters' testing and evaluation mission. Existing TREAT systems will be supplemented by additional systems for non-reactor nuclear experiments. These new systems will provide: a secondary radiological confinement to the PHP process equipment which is independent of the TREAT building; inert gases; exhaust and ventilation; communications, monitoring, alarming; process residue sampling and handling capabilities; and extended utilities and fire protection. The addition of these support systems considerably broadens the usefulness of the TREAT facility and will result in a versatile installation capable of fulfilling the facility needs to support developmental testing and evaluation of other waste processing technologies. The new support systems will be designed and installed in accordance with DOE, Environmental Protection Agency (EPA), and ANL requirements as outlined in the following sections.

General Design Requirements

Experiments in TREAT are currently constrained by the following principal requirements established by TREAT: a) Plutonium is limited to a maximum of 150 g and 1705 g biological equivalent of Pu-239 per experiment; b) Double containment is required for all test specimens containing plutonium; and c) the primary containment shall be designed to retain its integrity during all planned testing conditions, and at least one level of containment must be ensured during the maximum credible accident conditions.

Compliance to DOE Orders requires a determination of the natural-phenomena-hazard classification. DOE Order 5480.28 uses a graded approach: structures, systems, and components are assigned to one of five performance categories (PCs) in accordance with performance criteria given in DOE-STD-1021-93. Due to the low radioactive inventory involved, the PHP experiment will be classified as PC-1. Design and evaluation criteria for structures, systems, and components for earthquake, wind, and flood are based on DOE-STD-1020-94.

Specific standards to which the PHP support systems are being designed include: U. S. DOE Order, DOE-6430.1A, "General Design Criteria"; National Fire Protection Association Codes and Standards; American National Standards Institute (ANSI) N13.1, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities"; ANSI-N317, "Performance Criteria for Instrumentation Used for In-Plant Plutonium Monitoring"; ANSI-N323, "Radiation Protection Instrumentation Test and Calibration;" U. S. DOE Order 5400.5, "Radiation Protection of the Public and the Environment"; U. S. DOE Order, 5480.5, "Safety of Nuclear Facilities"; U. S. DOE Order, 5480.11, "Radiation Protection for Occupational Workers"; International Conference of Building Officials, "Uniform Building Code"; and ANL-W "Environment Safety and Health Manual."

The PHP bench-scale experiments also require consideration of environmental requirements. A permit-to-construct will be obtained from the State of Idaho in accordance with the Clean Air Act. The EPA granted a permit for the bench-scale experiments under the National Emission Standards for Hazardous Air Pollutants. A categorical exclusion in accordance with the National

Environmental Policy Act, paragraph B3.10 of Appendix B to Subpart D of 10 CFR 1021, was approved by DOE. The experiments will be conducted under a Resource Conservation and Recovery Act treatability study in accordance 40 CFR 261.4.

System Descriptions

An 11m x 14m x 7m high secondary confinement structure will be provided for backup confinement of radiological and hazardous materials during normal and abnormal operations of the PHP without reliance on the TREAT building. This structure will be located within a high-bay section of TREAT having a floor area of 735 m^2, a ceiling height of 23m, and a 55,000kg bridge crane. The secondary confinement will have removable roof panels that allow equipment handling, and is designed for ease of modification, if required.

A process off-gas and ventilation system that contains the process off-gas and secondary confinement ventilation air and discharges it from the TREAT facility stack is being provided. This system includes redundant exhaust fans and HEPA filtering of the off-gas and ventilation air to reduce or limit radioactive contamination levels in the effluent gases to acceptable limits.

The ventilation system maintains a negative pressure within the secondary confinement structure relative to the TREAT building to prevent radioactive contamination spread to other parts of the building. The system is configured such that air flow sweeps from the cleanest regions anticipated to areas within the secondary confinement having successively higher potential for contamination.

A fire protection system will provide detection and suppression of fire (by water sprinkler) within the secondary confinement and shall provide for alarms to personnel and the ANL-W fire department.

An extensive communications, monitoring, and alarm system will incorporate telephone and area-wide audio communications, monitor and record PHP secondary-confinement and process operational conditions (normal and abnormal), and provide both operator and facility alarms at preset conditions and process-parameter thresholds. This system includes extensive video equipment for monitoring and recording the process operation.

Provisions will be made for materials handling that services solid-material-entry and -discharge points. This includes logistics and equipment, as required, for the transport of waste containers to the experiment and the packaging and disposition of process wastes. A major feature is a 6m x 1.5m x 2.7m high glovebox with built-in equipment for lifting, translating, sample drilling, and weighing the PHP hearths. The glovebox will confine alpha contamination. Hearths approximately 1.22m in diameter and weighing up to 816kg will be handled within this structure. The enclosure will also be used for the extraction of representative samples from the hearth, HEPA filters, and acid-gas scrubber liquor.

Extensive radiation monitoring instrumentation will be provided to measure radiation fields and the levels of radioactive materials that are airborne or deposited on surfaces to quantify the level and type of radiation and/or airborne radioactive contamination, provide data to support operations to assess the radiological-safety conditions, and to warn personnel of abnormally high radiation fields. Radioactive emissions from the TREAT stack will be monitored by an emissions-monitoring system to quantify the level and type of radioactive effluent.

Several utility systems are being provided that enhance the usefulness of the facility. An electrical-power system connects to the existing TREAT electrical system to supply the normal- and redundant-diesel/generator power systems and distribution necessary to support the test equipment. Feeders having capacities of 600A and 400A at 480V are being provided, along with an 18kVA uninterruptible power supply.

Cooling-water systems for equipment cooling including both normal service water (12 liter/s at 290K) and a chemistry-conditioned supply of 0.3 liter/s are being provided.

An inert-gases-supply system will furnish nitrogen, helium, and argon to the PHP on process demand for torch gases, for purging the camera and view ports, and for purging the waste-feed system. Nitrogen flow may be up to 25 liter/s from a liquid nitrogen tank and vaporizer. Helium and argon flow rates up to 0.025 and 0.13 liter/s, respectively can be furnished. These flow rates could be easily increased, if needed.

A breathing-air system is being provided that furnishes breathing air to support up to 4 workers for use during suited entries into potentially contaminated areas and equipment.

All of these PHP support systems will be adequately instrumented, where practical, to monitor parameters having significant impact on the systems' operation or capabilities to provide their respective functions. Significant data will be recorded for subsequent system-performance analysis. Alarms are being provided to warn operations personnel whenever significant parameters are outside of established limits.

CONCLUSION

The personnel, equipment, and facility interfaces associated with a radioactive waste treatment demonstration are an important aspect of the demonstration effort. Areas requiring significant effort in preparation for the PHP Project being conducted at the TREAT facility include confinement design, waste handling features, and sampling and analysis considerations. Information about the facility in which a radioactive demonstration will be conducted, specifically Argonne's TREAT facility in the case of PHP, may be of interest to other organizations involved in developing and demonstrating technologies for mixed waste treatment.

REFERENCES

1. R. Geimer; C. C. Dwight, and G. C. McClellan; "The Plasma Hearth Process Demonstration Project for Mixed Waste Treatment," *SPECTRUM 94 Proceedings*; Atlanta, Georgia, August 1994.

2. G. R. Hassel, R. Geimer, J. A. Batdorf, and G. L. Leatherman, "Evaluation of the Plasma Hearth Process for Mixed Waste Treatment Applications," *Proceedings of the 1994 Incineration Conference,* May 1994.

3. R. Geimer, J. A. Batdorf, and W. P. Wolfe, "Test Results from the Demonstration of the Plasma Hearth Process," *Proceedings of the 1993 Incineration Conference,* May 1993.