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CALCINE DISPOSITION PROJECT

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Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSSF	Calcined Solids Storage Facility
DOE	U.S. Department of Energy
HIP	hot isostatic pressing
HLW	high-level waste
ICP	Idaho Cleanup Project
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
NDAA	National Defense Authorization Act
NEPA	National Environmental Policy Act
NWCF	New Waste Calcining Facility
RCRA	Resource Conservation and Recovery Act
ROD	record of decision
SNF	spent nuclear fuel
WCF	Waste Calcining Facility

Front and back covers:
Calcine Retrieval Project engineers testing retrieval equipment.

G2627-28, Revision 1

CALCINE DISPOSITION PROJECT

Howard Forsythe, Fluor Idaho Project Manager, for the Calcine Disposition Project, observing the human machine interface.

What Is the Calcine Disposition Project?

The Calcine Disposition Project is part of the Idaho Cleanup Project (ICP) Core contract. It is responsible for managing calcined high-level waste (HLW) stored at the Idaho Nuclear Technology and Engineering Center (INTEC). Major federal regulations and requirements govern storage, treatment, and disposal of calcined HLW. These include the 1995 Idaho Settlement Agreement, the Idaho National Laboratory (INL) Site Treatment Plan, the 2002 National Environmental Protection Act (NEPA) Final Environmental Impact Statement, the 2005 NEPA Record of Decision (ROD), and the 2010 NEPA ROD Amendment. The Calcine Disposition Project supports the U.S. Department of Energy's (DOE's) legal obligations to remove calcined HLW from Idaho and the long-term strategic goal to protect human health and the environment.

INTEC in 1993.

Where Did Calcined HLW Come From?

The INL Site is an intermediate storage facility for many types of nuclear waste associated with the U.S. Navy Fleet and spent nuclear fuel (SNF) from a variety of U.S. sites. INTEC historically reprocessed SNF to recover uranium. Reprocessing operations at INTEC involved multiple cycles of solvent extraction to recover U-235 and other defense-related materials from SNF (see Figure 1). These reprocessing activities, as well as other ancillary facility activities and operations, generated millions of gallons of liquid radioactive waste, most of which was stored in the INTEC Tank Farm Facility in large underground storage tanks (300,000 gallons each).

In 1963, a fluidized bed calcination process was put in operation to convert the liquid waste to a granular solid.

The calcination process sprayed liquid waste into a heated (752 to 1,112°F), fluidized bed where the waste thermally decomposed and was converted to solid metallic oxides and fluorides, water vapor, and nitrogen oxides. The calcination process produced a safer product for storage while reducing the volume of stored liquid waste by an average factor of 7.

The resulting granular solid (called calcine) was pneumatically transported through transport lines to the Calcined Solids Storage Facility (CSSF) for storage.

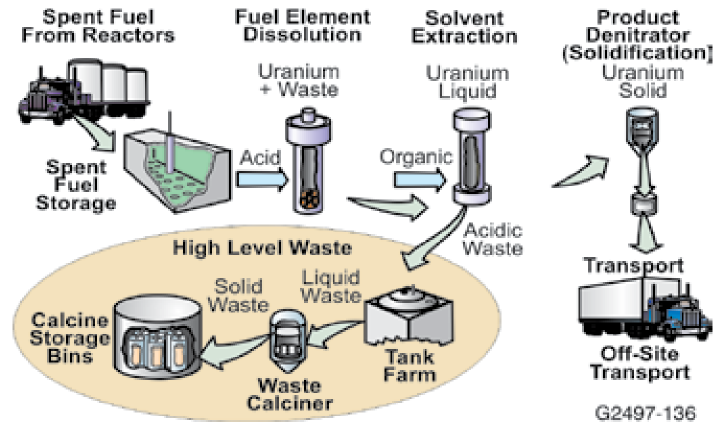

Figure 1. Former reprocessing of SNF at INTEC.

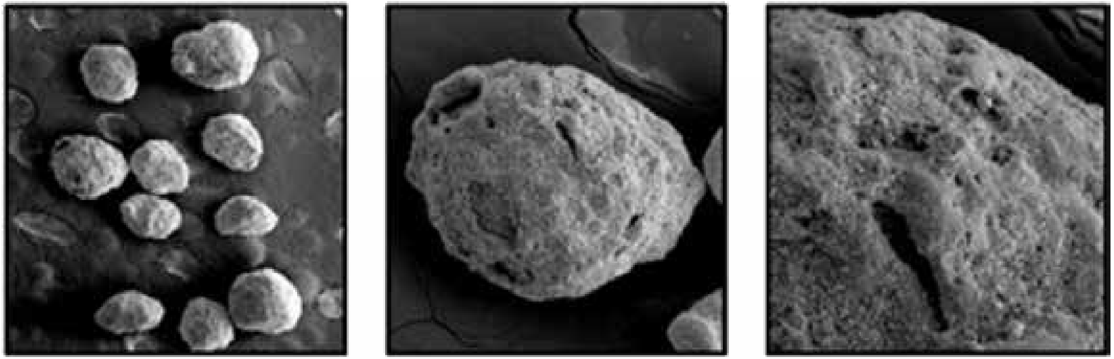

Figure 2. Photos of calcine samples from left to right at 40x, 150x, and 500x.

What Is Calcined HLW?

Calcine is a dry, solid, granular material, similar to coarse sand. It is highly radioactive and is managed as HLW, as defined by the Nuclear Waste Policy Act and *Radioactive Waste Management Manual*. Primary chemical components of calcine are zirconium, aluminum, fluoride, and calcium. While its radionuclide inventory includes plutonium, calcine is primarily made up of short-lived cesium and strontium.

Calcine also is classified as hazardous waste, as defined by 40 CFR 261 under the Resource Conservation and Recovery Act (RCRA), and must be stored and disposed of in accordance with RCRA regulations. Figure 2 shows magnified photos of calcine samples.

How Much Calcined HLW Is There?

Approximately 7.5 million gallons of liquid waste was thermally treated between 1963 and 2000 in two different INTEC waste calcining facilities—the Waste Calcine Facility (WCF), closed under RCRA in 1999, and the New Waste Calcining Facility (NWCF), closure pending. The calcination process generated approximately 4,400 m^3 (or 12.4 million pounds) of calcine. Calcine is stored in discrete bin sets CSSFs 1 through 6. CSSF 7 was built to store future calcine but was never placed in service.

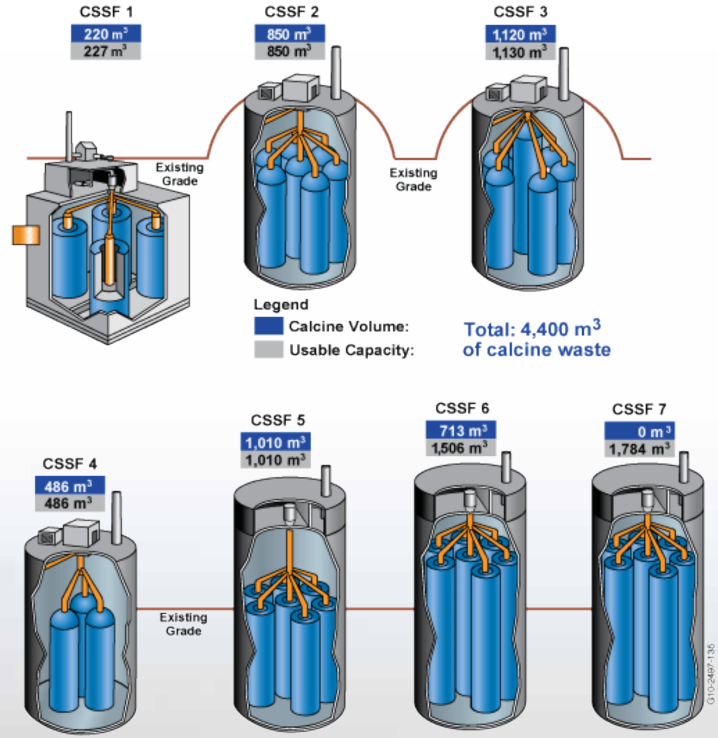

Figure 3. CSSF bin set configuration and stored HLW calcine volumes.

How Is the Calcined HLW Stored?

The individual bin sets are of varying designs, containing from 3 to 12 stainless-steel bins per CSSF for a total of 43 bins within CSSFs 1 through 6 (see Figure 3). The bins range from 20 to 68 ft in height, and each bin set is housed in its own concrete vault. Calcine is currently stored and managed under a RCRA Part B permit issued in November 2006 for a 10-year term and recently revised in June 2017 for another 10-year term. An exemption from the RCRA secondary containment requirements was granted in the RCRA permit based on the calcine waste form. Under the RCRA permit, inspections are completed daily, monthly, and annually, and the bin vaults are video inspected every five years. No degradation to date has been observed. Figure 4 shows where the CSSFs are located at INTEC.

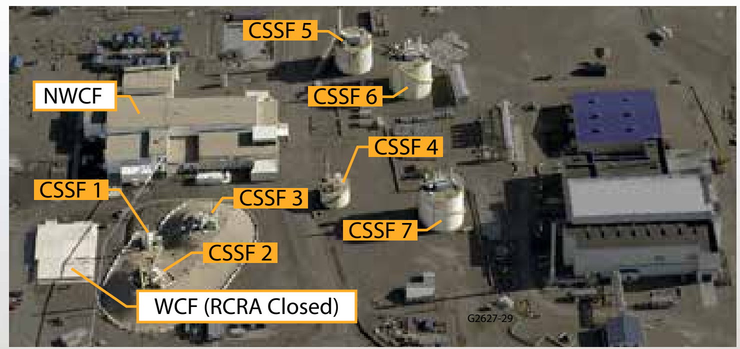

Figure 4. Location of the CSSFs and calcining facilities at INTEC.

CSSFs 4, 6, and 7.

What Are the Associated Risks?

There is minimal environmental and safety risk associated with calcine storage due to the rigorous structural design of the bin sets. However, any release to the vault or environment could complicate future calcine retrieval. Risk of a release to the environment is mitigated by the purposeful design of the bin sets, which have two levels of containment, continuous monitoring systems, and routine surveillance and maintenance of the bin sets and equipment.

What Needs to Happen to Remove Calcined HLW from Idaho?

In October 1995, the State of Idaho, U.S. Navy, and DOE reached a settlement agreement, which requires DOE to treat calcined waste, putting it into a form suitable for transport to a permanent repository or interim storage outside of Idaho by December 31, 2035. DOE selected hot isostatic pressing (HIP) as the treatment option in the 2010 NEPA ROD Amendment. HIP generates a glass-ceramic waste form that is essentially water insoluble. Continued delays in opening a HLW deep geological repository or in developing an interim storage facility outside of Idaho may affect DOE's ability to meet this deadline.

What Is the Calcine Disposition Status?

In 2015, DOE initiated an independent analysis of alternatives for the treatment and disposal of calcined waste. DOE determined that HIP may not be the most effective path forward and disposal of calcine is uncertain at this time, because there is no designated long-term storage site (i.e. deep geological repository such as Yucca Mountain). DOE concluded that regardless of disposal uncertainties, all treatment and disposal options require retrieval of calcine from the bin sets. Thus, per recommendations in the analysis of alternatives, DOE divided the Calcine Disposition Project into two subprojects: calcine retrieval and calcine processing, with a near-term project priority on calcine retrieval activities. The Calcine Retrieval Project was initiated in 2016, and scope was added to the ICP Core contract to develop and test a full-scale retrieval system to demonstrate DOE's ability to safely retrieve calcine from CSSF 1 and transfer it to CSSF 6. The Calcine Retrieval Project is currently testing retrieval and transfer designs using a vacuum retrieval system for bulk and residual cleanout (see Figure 5). Testing objectives are to eliminate risks, optimize final design configurations, and determine the efficacy of calcine removal for environmental closure.

Figure 5. Calcine Retrieval Project engineers performing retrieval system testing.

CALCINE RETRIEVAL PROJECT

Retrieval Project Mission?

The Calcine Retrieval Project mission is to (1) conduct a full-scale retrieval and transfer demonstration, (2) retrieve calcine from CSSF 1 and transfer to CSSF 6, and (3) place CSSF 1 in a configuration that is protective of human health and the environment under multiple regulatory authorities. Because the project is in the technology development phase, the strategy is to devlop a detailed scope of work on an annual basis (as requested by DOE).

This strategy allows DOE to consider, plan, and adjust accordingly during the design process, as well as respond to legislative or regulatory decisions that impact treatment and disposal of calcined waste.

Full-scale mockup at the former Fuel Processing Restoration Facility (CPP 691).

Full-Scale Retrieval and Transfer Demonstration

Testing began in 2015 and is expected to continue until final designs are complete. There are three primary elements of the full-scale retrieval and transfer system that are being developed and tested prior to actual retrieval and transfer of calcined waste:

- A full-scale mockup that will be used to prove retrieval and transfer system design capabilities, verify operating parameters, and establish a basis for calcine retrieval efficacy.
- Bulk retrieval and residual cleanout systems that will be used to remove calcine from the bin sets.
- A video monitoring system that will be used to monitor, evaluate, and document design testing.

Full-Scale Mockup

A full-scale mockup has been constructed to simulate pneumatic retrieval and transfer of calcined waste. Calcium carbonate ($CaCO_3$), which has been determined to be the closest material to calcined waste in bulk density and particle size and distribution, will be used as a surrogate for the testing. The full-scale mockup simulates transfer of calcine from CSSF 1 to CSSF 6 to demonstrate the capability to safely retrieve and transfer calcine. The full-scale mockup includes a replica of a CSSF 1 nested bin (see Figure 6), transport piping, and all other appurtenances needed for operation of the mockup.

The full-scale mockup bin was transported to and installed at the former Fuel Processing Restoration Facility (CPP-691) at INTEC.

Figure 6. CSSF 1 nested bin replica and storage vessel.

Placement of the CSSF 1 nested bin replica in a below grade cell at the former Fuel Processing Restoration Facility (CPP-691).

Bulk Retrieval

The bulk retrieval system will use a pipe-in-pipe vacuum air system to retrieve calcine from the bottom of a bin. A bottom-up retrieval system removes the need to add pipe sections during operation or have a hose management system. Additionally, the pipe-in-pipe design reduces the area for the vacuum portion of the vertical line, which increases the velocity and aids in transport of solids. Historical retrieval tests demonstrated or estimated that less than 1% of the total calcine waste remains after bulk retrieval using a vacuum system. Initial testing of the pipe-in-pipe bulk retrieval system indicates it will perform equally as well.

Residual Cleanout

It is expected the bulk retrieval system will remove most of the calcine; however, some calcine is expected to remain piled on the stiffening rings, floor, and other areas of the bins. To address this issue, DOE intends to remove remaining calcine using a residual cleanout system. Two custom-designed residual cleanout systems, the robotic vacuum crawler and articulated arm, are being developed (see Figure 7). Generally, these systems will be able to remotely maneuver and reach through most of the tank interior to remove residual calcine. The systems will be able to deploy different tools, such as an air nozzle, vacuum tool, and visual equipment.

In addition to the remote residual cleanout systems, a more simplistic approach to remove residual calcine is being evaluated. An air lance to push residual calcine off internal surfaces is being designed and tested. The purpose of the air lance is to create a circular wind to help agitate material off the surface and direct it toward the bulk retrieval system.
Plans are to down select or identify a combination of systems after designs are tested and evaluated for their efficacy.

Video Monitoring System

The visual monitoring system has been used extensively during design testing and will be used during actual operations to monitor, evaluate, and document retrieval activities. Data collected will allow engineers to easily identify problem areas and system improvements during design testing, reduce the need for individuals to access high-radiation fields during operations, and increase calcine retrieval effectiveness.

Figure 7. Calcine Retrieval Project engineer testing the vacuum crawler.

The video monitoring system is network based and will use a combination of pan-tilt zoom and fixed-position cameras. Ethernet cables connect system components and provide camera power, camera control, and image data transfer per camera location. The system is easily expanded, and any laptop computer running a common operating system can connect to the local area network and serve as a camera-control and viewing station. Figure 8 shows still images collected from inside the CSSF 1 bin replica during initial retrieval testing. Different camera systems and configurations are being tested in high-radiation fields to determine tolerance levels, suitability, and optimal configurations.

Environmental Compliance

The CSSF closure strategy requires an integrated approach to ensure environmental compliance throughout the project. Closure under the Calcine Retrieval Project will focus on CSSF 1, however, the closure approach will be applicable to future closures of all CSSF bin sets. Applicable statutes and orders include NEPA, RCRA, CERCLA, National Defense Authorization Act (NDAA) Section 3116, and DOE O 435.1. The full-scale retrieval and transfer demonstration is critical for showing that retrieval meets the "maximum extent practical" criterion in NDAA Section 3116 and DOE O 435.1, as well as establishing criteria for ending calcine removal activities and evaluating cost and benefits associated with performing additional removal. The demonstration will also ensure standards under other requirements, such as RCRA performance-based criteria and CERCLA remedial action objectives, are met. Information collected during testing will support a determination that the final end state is protective of human health and the environment.

Figure 8. Video monitoring system images from conceptual design testing.

For More Information

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Calcine Retrieval Project team members.

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