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Explanation of Significant Differences for the Record of Decision for Interim Action to Remove Fuel and Flush Salts from the Molten Salt Reactor Experiment Facility at the Oak Ridge National Laboratory, Oak Ridge, Tennessee

This document is approved for public release per review by:

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U.S. DEPARTMENT OF ENERGY

Site Name and Location

U.S. Department of Energy (DOE)
Oak Ridge Reservation (ORR)
Molten Salt Reactor Experiment Facility (MSRE)—Building 7503
MSRE Decontamination and Decommissioning (D&D) Support
Oak Ridge National Laboratory (ORNL)
Oak Ridge, Tennessee
CERCLIS ID TN1890090003

Introduction and Statement of Purpose

The MSRE facility complex is located in Roane County, Tennessee, on the DOE ORR, approximately 1 km (0.6 miles) south of the ORNL main plant in Melton Valley. MSRE operated from 1965 through 1969 to investigate the practicality and feasibility of the molten salt reactor concept. The circulating fluid in the reactor was a molten salt mixture composed of various fluorides. Uranium-235 (^{235}U), in the form of uranium tetrafluoride (UF_4), was the fissile component of the fuel salt that was used to produce a controlled nuclear chain reaction. In August 1968, the ^{235}U fuel was replaced with ^{233}U, and in September 1969, a small quantity of plutonium was added. After the reactor was permanently shut down three months later, the molten fuel salt was allowed to cool and solidify, and surveillance and maintenance were initiated. DOE is removing the reactor fuel salt from MSRE under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

Removal of the salt mixture from MSRE is addressed by a CERCLA document entitled *Record of Decision for Interim Action to Remove Fuel and Flush Salts from the Molten Salt Reactor Experiment Facility at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/02-1671&D2). This Record of Decision (ROD) was signed on July 7, 1998, by DOE, the Tennessee Department of Environment and Conservation (TDEC), and the U.S. Environmental Protection Agency (EPA). The objective of the defueling is to reduce current potential on- and off-site risk from the highly radioactive salt. The selected remedy includes melting the salt mixture, separating the uranium as UF_6 from the salts, loading the UF_6 on sodium fluoride (NaF) traps, converting the UF_6 to a chemically stable oxide, transferring the uranium oxide to the national ^{233}U repository at ORNL Building 3019, and placing the residual salt in interim storage at ORNL in Solid Waste Storage Area (SWSA) 5. Final disposal of the salt was not addressed in the ROD.

Following issuance of the MSRE ROD, DOE initiated planning for processing of the total ^{233}U inventory in storage in Building 3019 at ORNL. The ^{233}U inventory includes UF_6-laden NaF traps from a previously completed MSRE removal action and will also include additional UF_6-laden NaF traps from the current MSRE remedial action. The ^{233}U recovered from MSRE is a small percentage of the total ^{233}U inventory in Building 3019. Based on preliminary planning, it was determined that processing of the MSRE ^{233}U materials as an integral part of the total 3019 ^{233}U inventory would be more cost effective than the originally planned conversion of the materials to a stable oxide as prescribed in the MSRE ROD. Accordingly, DOE, with agreement of the Federal Facility Agreement (FFA) regulators, placed MSRE uranium conversion actions on hold pending completion of the planning for the processing of the total 3019 ^{233}U inventory.

Based on the status of this planning, the ROD requirement to convert the MSRE separated ^{233}U to an oxide is deleted. Storage of the MSRE ^{233}U in Building 3019 completes all MSRE CERCLA obligations for this material. The MSRE ^{233}U would then be managed under the same authority as the remainder of the 3019 material. The processing of the MSRE ^{233}U materials would not be part of the ROD remedy, but would be a part of the processing of the total 3019 ^{233}U inventory. In accordance with 40 *Code of Federal Regulations* (*CFR*) 300.435, DOE and the regulators categorized this change as a "significant" change to the MSRE ROD. In accordance with CERCLA Sect. 117 (c) and 40 *CFR* 300.435(c)(2)(i), such a significant change is documented with an Explanation of Significant Differences (ESD).

This ESD is part of the Administrative Record file, and it and other information supporting the selected remedy can be found at the DOE Information Center, 475 Oak Ridge Turnpike, Oak Ridge, Tennessee 37830, from 8:00 a.m. to 5:00 p.m., Monday through Friday.

Site History, Contamination, and Selected Remedy

The MSRE reactor loop consists of a reactor vessel, primary heat exchanger, pump, and associated piping. During standby operation, the fluoride salt mixture containing uranium fuel was maintained in its molten state in two fuel drain tanks. Molten salt is a clear, pumpable fluid. During reactor operation, the molten salt was transferred from the fuel drain tanks into the reactor loop where it circulated. As it passed through the reactor vessel, the fuel salt entered a critical configuration where it was further heated by the nuclear reaction. The fuel salt exited the reactor vessel to the primary heat exchanger to transfer its excess heat to a fluoride coolant salt flowing in a separate circuit. When the reactor was shut down, fuel salt was removed from the reactor loop by allowing it to drain by gravity back into the two fuel drain tanks. To remove residual fuel salt from the reactor loop, molten flush salt was circulated through the reactor loop and returned to the flush salt drain tank. The flush salt was similar in composition to the fuel salt but without the uranium. When operations ceased in December 1969, the fuel and flush salts were allowed to cool and solidify in the drain tanks. The two fuel drain tanks and the flush salt tank are located in a below-grade, concrete-shielded, drain tank cell adjacent to the reactor cell. The salt in each tank is in a criticality safe configuration.

After shutdown, fluorine (F_2) generation was expected based on knowledge about the chemical stability of fluoride salt and the effects of radiolysis (a decomposition of compounds by the action of radiation) on the salt. An annealing process to heat the fuel salt to below melting temperatures to force the fluorine in the salt matrix to recombine before it could migrate from the salt was included in the surveillance and maintenance procedures following shutdown. During the annealing process, unknown to operators, uranium hexafluoride (UF_6) gas was formed and liberated from the salt into the drain tank head spaces and associated off-gas system.

In 1994, investigation of the MSRE site indicated that anomalous levels of reactive gases (uranium hexafluoride and fluorine) were present throughout the off-gas piping connected to the fuel and flush salt drain tanks. It was further determined that the reactive gas pressure was above atmospheric. In addition, uranium had migrated through the off-gas system to an auxiliary charcoal bed that resulted in a criticality concern because of the quantity of uranium detected.

Two CERCLA removal actions taken since 1994 have mitigated several of the uranium migration concerns originally identified. The drain tank head space and associated piping, including off-gas piping, were depressurized, and reactive gases were removed. Numerous blockages in the off-gas piping were chemically treated to gain access to pressurized components such that there are no known pockets of

pressurized reactive gases. Uranium recovered during the reactive gas removal processing was captured in NaF traps and transported to ORNL Building 3019 for interim storage. Additionally, uranium that had migrated to the MSRE auxiliary charcoal bed was removed as a part of the uranium deposit removal action and placed into a canister for interim storage.

A third CERCLA decision was the interim action under the MSRE ROD to remove the fuel and flush salts to further mitigate the potential for releases and subsequent migration of contamination from the drain tanks. Following are the major components of the selected remedy:

- Melt and chemically treat the salt in the drain tank cell [i.e., as the salt melts in a drain tank, the molten salt will be treated with hydrogen fluoride (HF) to adjust the salt chemistry and prevent plating out or precipitation of metals].

- Remove the uranium from the salts [i.e., when fluorine is added to the molten salt, uranium hexafluoride gas is liberated from the salt, cold trapped, and then transferred to vertical columns packed with sodium fluoride (NaF), referred to as "NaF traps"].

- Convert the uranium hexafluoride to uranium oxide, a chemically stable form of uranium.

- Package the uranium oxide in suitable containers and prepare the containers for storage with similar packages in a ^{233}U repository in ORNL Building 3019.

- Transfer the residual salt in the drain tanks to storage containers (the salt will be chemically stabilized/packaged to capture fluorine gas that may be generated).

- Load the salt waste packages into shielded casks and place the casks in interim storage at an ORNL operating storage facility in SWSA 5.

After completion of the remedy, the drain tanks and associated equipment will be managed in place as part of the facility maintenance program until D&D of the MSRE reactor building occurs.

The selected remedy specifies storage rather than disposal for both the MSRE uranium and the residual salt. Storage rather than disposal was specified because at the time of ROD approval, potential storage locations were available, but final disposal locations and waste acceptance criteria for those locations were highly uncertain or speculative. Because final disposal was not specified, the remedy was considered an interim action. Selecting interim storage allowed DOE to defer decisions regarding further treatment and disposal of the uranium and residual salt to a later date when an acceptable, final disposal pathway would become available. Although the remedy was not a final action for the fuel, implementation of the remedy did allow DOE to address the identified risks associated with the uranium migration at MSRE.

Basis for the Document

This section summarizes information that prompts and supports the need for a ROD change.

The decision being documented by this ESD is to eliminate the conversion of the separated uranium to a stable oxide from the scope of the remedy, and to document that the separated uranium will be stored in Building 3019 for processing. This processing would be a part of the processing of the total 3019 ^{233}U inventory.

A portion of the United States inventory of ^{233}U in the fissile materials disposition program is stored at ORNL Building 3019, primarily in the form of oxides such as U_3O_8. At the time the ROD was signed, the ^{233}U inventories were administratively considered an asset to the government, although no specific uses for the ^{233}U inventories were being planned or implemented. Because the inventories were considered an asset, and because no other viable disposition pathway had been identified for the MSRE uranium, the ROD appropriately specified that the separated uranium would be converted to a stable oxide and then managed as part of the existing ^{233}U repository inventory at ORNL Building 3019. Once placed in storage, it was expected that the MSRE uranium would cease to be a unique material (i.e., it would be fully integrated into the total 3019 ^{233}U inventory, and the MSRE project would cease to own or be responsible for the material).

Since the issuance of the MSRE ROD, DOE has formally declared the nation's ^{233}U inventories surplus with no programmatic use for the ^{233}U stored at ORNL Building 3019 except for the possible extraction of medical isotopes. Although the inventories have been declared surplus, some of the older ^{233}U inventories have had sufficient in-growth of the radioactive daughter ^{229}Th to make extraction of the ^{229}Th potentially attractive. The long-lived daughter ^{229}Th is a potential source of medical research isotopes (e.g., ^{213}Bi is a useful, short-lived decay product of ^{229}Th).

Following issuance of the MSRE ROD, DOE initiated planning for processing of the DOE ^{233}U inventory in storage in Building 3019 at ORNL. The ^{233}U inventory contains UF_6-laden NaF traps from a previously completed MSRE removal action and will also include additional UF_6-laden NaF traps from the current MSRE remedial action. The ^{233}U recovered from MSRE is a small percentage of the total ^{233}U inventory in Building 3019. Based on preliminary planning, it was determined that processing of the MSRE ^{233}U materials as an integral part of the total 3019 ^{233}U inventory would be more cost effective than the originally planned conversion of the materials to a stable oxide as prescribed in the MSRE ROD. Accordingly, DOE, with agreement of the FFA regulators, placed uranium conversion actions on hold pending completion of the planning for the processing of the total ^{233}U inventory.

DOE is currently finalizing plans for the processing of the total 3019 ^{233}U inventory. Alternatives include downblending the total 3019 inventory with depleted uranium, conversion of the downblended uranium to a stable oxide, and storage/disposal options. For these reasons, the post-ROD change to the selected remedy documented by this ESD is to eliminate the oxide conversion of the separated uranium phase. It is planned that separated uranium as UF_6 in NaF traps recovered from MSRE under the ROD remedial action will be processed as a part of the total 3019 ^{233}U inventory. Storage of the MSRE ^{233}U in Building 3019 completes all MSRE CERCLA obligations for this material. The MSRE ^{233}U would then be managed under the same authority as the remainder of the 3019 material.

Description of Significant Differences

This ESD deletes the ROD requirement to convert the MSRE separated ^{233}U to an oxide. Storage of the MSRE ^{233}U in Building 3019 completes all MSRE CERCLA obligations for this material. The MSRE ^{233}U would then be managed under the same authority as the remainder of the 3019 material. This post-ROD change impacts the scope and cost of the MSRE remedy.

Scope. A side-by-side comparison of the original and proposed remedy components is given in Fig. 1 to clearly display the significant differences with regard to scope. A shaded box indicates a component of the proposed remedy that is different from the original remedy.

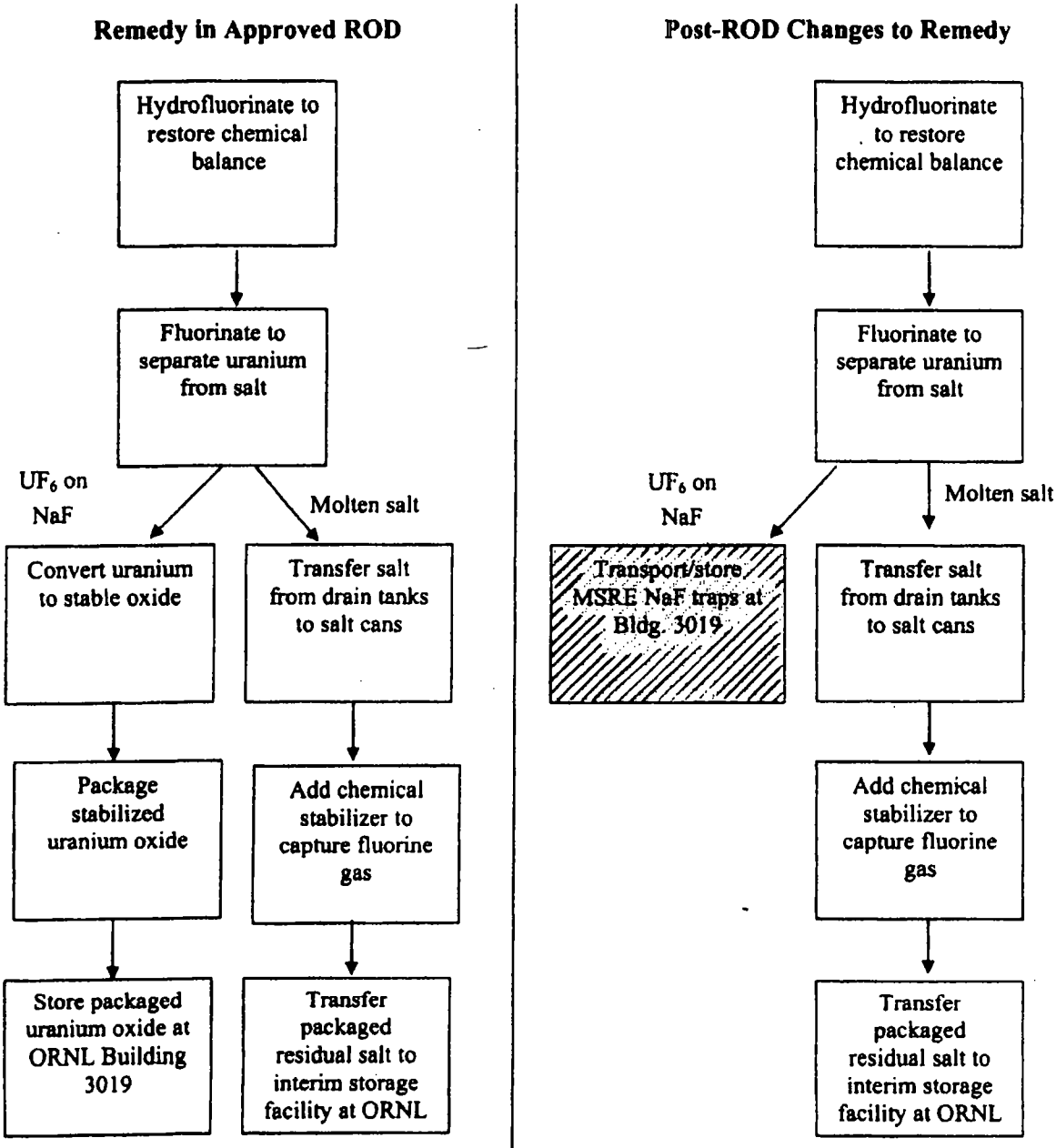

Fig. 1. Graphic comparison of approved ROD and ESD remedies.

The original and proposed remedy components differ only after the point in the process where the uranium has been separated from the salt by fluorination and then collected on NaF traps.

Applicable or Relevant and Appropriate Requirements (ARARs). The ARARs as listed in the ROD are unchanged.

Cost. The estimated cost of the remedy stated in the ROD was $39.3M (unescalated), and included less than $1M for conversion from UF_6 to U_3O_8 per the associated Feasibility Study (DOE/OR/02-1559&D2).

Schedule. Table 1 shows a schedule comparison for the MSRE fuel and flush salts removal. The dates shown represent completion of operation and do not necessarily include demobilization or other post-construction activities. The first schedule is for the original ROD remedy, and the second schedule is for the proposed remedy.

Table 1. Schedule comparison for MSRE fuel and flush salts removal

Component	Estimated dates for completion of operation[1]	
	Original ROD remedy (July 1998)	Proposed remedy (2006)
Uranium separation from salt and recovery	Feb 2003	May 2007
Uranium conversion and placement in the ^{233}U repository at ORNL (via original ROD remedy)	Feb 2003	NA
Residual salt stabilization, packaging, and placement in interim storage at ORNL	Feb 2003	August 2007
Submittal of Remedial Action Report (D1 version)	May 2003	Dec 2007

[1]Schedules for completion of the MSRE defueling, as set forth in this subsection, are estimates provided for informational purposes only and are not considered to be enforceable elements of the remedy. The enforceable milestones and nonenforceable FY +3 milestones for performance of remedial actions for MSRE are set forth in Appendix E and Appendix J of the FFA, respectively. Any additional milestones, timetables, or deadlines for sites included in this ROD will be identified and established independent of this ROD, in accordance with the existing FFA protocols.

FY = fiscal year
FFA = Federal Facility Agreement
NA = not applicable
ORNL = Oak Ridge National Laboratory
ROD = Record of Decision

EPA and TDEC Comments

Regulator comments and responses are contained in the Administrative Record. Through signature of this document, regulators endorse the modification of the MSRE ROD remedy as presented in this final ESD.

Statutory Determinations

As required under CERCLA Sect. 121, the modified remedy protects human health and the environment, complies with federal and state requirements that are ARAR to the remedial action, is cost-effective, and uses permanent solutions and alternative treatment technologies to the maximum extent practicable. No ARAR waivers are required for this remedy. This ESD does not affect the prior ROD determination that the remedy satisfies the statutory preference for treatment. As required by CERCLA, a review will be conducted no less often than every 5 years after initiation of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Public Participation Compliance

Prior to issuance of this ESD, DOE developed a fact sheet explaining the scope of the proposed change to the MSRE ROD and the potential impacts to the original decision. In early 2006, the Oak Ridge Site Specific Advisory Board (SSAB) reviewed the fact sheet for clarity and completeness. The finalized fact sheet was then made available to the public at the DOE Information Center in 2006, and public notice of its availability was made.

The public participation requirements set forth in 40 *CFR* 300.435(c)(2)(i) will be met. After approval of the ESD by the regulators, DOE will publish a public notice of availability and a brief description of the ESD in major local newspapers of general circulation. Also, the ESD will be made available to the public through placement in the Administrative Record file and the DOE Information Center.

APPROVALS

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Oak Ridge, Tennessee

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December 2006

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Oak Ridge Office
U.S. Department of Energy

4/26/07
Date

John A. Owsley, Director
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5/3/07
Date

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5/23/07
Date

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