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Initiating the D&D Project for the EBR-II

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Rick Demmer

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Rick Demmer
Idaho National Laboratory, Idaho Falls, ID, 208-533-7321

INTRODUCTION

A novel decommissioning project is underway to close the Experimental Breeder Reactor-II (EBR-II) "fast" reactor at the Idaho National Laboratory (INL), Materials and Fuels Complex (MFC) facility near Idaho Falls, ID. The facility was placed in cold shutdown in 1994 and work began on the removal of the metallic sodium coolant. The bulk of the sodium was drained and treated beginning in 2001. The residual sodium heel was chemically passivated to render it less reactive in 2005 using a novel carbon dioxide treatment. Approximately 700 kg of metallic sodium and 3500 kg of sodium bicarbonate remain in the facility. A RCRA Waste Treatment Permit, issued in 2002 by the State of Idaho Department of Environmental Quality, requires annual progress toward closure of the facility, and that all regulated materials be removed or deactivated, and the waste products removed by 2022. The baseline sodium removal technology would result in about 100,000 gallons of low-level waste solution requiring treatment along with separate handling of the large components (intermediate heat exchanger, rotating plug, etc) outside of the primary tank.

BACKGROUND

Several activities have progressed in the last few years towards closure of the EBR-II facility. A workshop was held in February 2008 with a panel of seven sodium cooled reactor cleanup and decommissioning technical experts from the U.S. and the U.K. The workshop reviewed past sodium removal efforts and current EBR-II closure plans, identified and evaluated alternative cleanup methods and recommended a best path forward. Subsequent to the workshop a major decommissioning project (under the American Recovery and Reinvestment Act of 2009) was initiated with the Idaho Cleanup Project (ICP) contractor to actually proceed with closure.

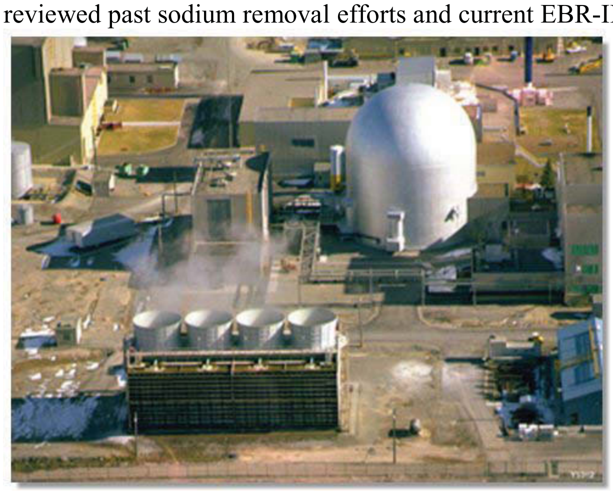

Fig. 1. Experiemental Breeder Reactor-II.

DESCRIPTION OF THE ACTUAL WORK

The Experimental Breeder Reactor-II (EBR-II) Wash-Water Workshop [1] was convened to determine the best method by which the EBR-II primary tank system could be flushed clean to meet environmental closure requirements.

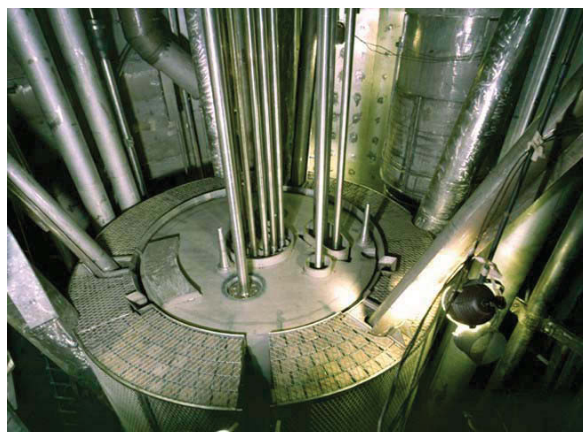

Fig. 2. EBR-II Core and Internals.

The system currently contains a small amount of reactive sodium and does not meet the requirements for "clean closure" under the Resource Conservation and Recovery Act (RCRA). Experts from two countries (U.S. and Great Britain) were brought together in a facilitated workshop to determine if filling the EBR-II primary vessel with water, and draining it (perhaps several times) would be the most effective method of accomplishing the objective. Results from the workshop include a number of recommendations and a path forward to accomplish this work.

The EBR-II facility at the Materials and Fuels Complex (MFC) of the Idaho National Laboratory (INL) was designed and built to test the fuel cycle operations for the second generation of fast neutron breeder reactors. The EBR-II achieved criticality in 1965 and operated continuously for 30 years. A breeder reactor produces more nuclear fuel than it consumes by converting "fertile" uranium (U-238) into fissile plutonium (Pu-239). The Pu-239 may then be used to fuel the nuclear reaction. A "fast neutron" type of breeder reactor does not use a moderator, such as water, to slow the fission causing neutrons, but instead allows a "fast" neutron that is more efficient for converting U-238 to Pu-239. Most fast breeder reactors use a liquid metal, predominantly metallic sodium or a sodium/potassium eutectic alloy (commonly referred to as NaK), to cool the reactor.

Liquid metal cooled reactors containing sodium or NaK present a difficult cleanup task. Sodium metal and NaK are very reactive and must be isolated from water and air. They may spontaneously burst into flame if in contact with any moisture. For this reason great care is taken when using sodium metal to ensure it remains within a dry, inert atmosphere (typically argon or nitrogen), especially when used as a coolant in nuclear reactors. The treatment of spent sodium is also hazardous, resulting in critical injuries [2]. Only a small amount of reactive sodium remains in the EBR-II reactor system. About 130,000 gallons of the sodium was drained from the primary and secondary coolant systems in the early 2000s. This material was reacted at the Sodium Processing Facility (SPF) at the INL to make sodium hydroxide which was disposed of at the Radioactive Waste Management Complex (RWMC) at the INL. Moist carbon dioxide was then introduced into the primary tank and secondary system to convert the remaining sodium into sodium bicarbonate. It is estimated that currently only about 100 gallons of sodium remain in the primary tank [3].

The next phase of the closure process would be to remove the large reactor components and wash everything to neutralize the remaining sodium. This will likely be a difficult process because of the soldering affect of sodium metal and the buildup of sodium bicarbonate in the tank would probably prevent some of the components from being withdrawn from the vessel. Also, washing all tank surfaces and components will likely generate massive amounts (a minimum of 100,000 gallons) of contaminated water that must be treated and managed. An optimized baseline approach (OBA), developed in this workshop, provides a path to react the sodium material without generating the massive amount of liquid waste.

RESULTS/LESSONS LEARNED

The Workshop followed a structured, facilitated process using Value Engineering (VE) techniques to gather information, identify functions, develop alternatives, and select the top alternatives for further analysis. VE uses facilitation, function analysis, and a formal job plan to improve product or process quality, reduce cost, maintain quality, and build teamwork. The formal job plan is Preparation/Planning, Information Gathering, Creativity, Evaluation, and Development/Path Forward.

After the presentation of EBR-II background and current status, the team developed the functions and criteria that the alternatives would need to meet and what the evaluation of the criteria would use. The three primary functions were identified as neutralize hazards, maximize byproduct removal, and minimize waste. Alternatives for sodium cleanup were brainstormed based on cleaning the primary tank system only; treating the components in place if possible; and meeting RCRA clean closure requirements. Each identified alternative was discussed to determine how it might be used, and how well it addressed the three main functions. The team combined and refined the list to produce full alternatives that would meet the RCRA clean closure criteria. Finally, the team discussed the advantages and disadvantages of each alternative relative to the process and the results.

One of the final activities of the meeting was a discussion with the sodium metal specialists about their perspectives on EBR-II primary system cleanup. One primary recommendation was that the closure be "projectized" and not performed in a piecemeal manner. While there were differences in cleanup recommendations, all agreed that developing a good and consistent relationship with the regulators would be critical to the success of the project. They also stressed that knowing the desired end state for the EBR-II reactor would be helpful in determining the best alternative for residual sodium cleanup. The team accomplished the objectives of this phase of the project through their subject matter knowledge and dedication to resolving the issues associated with sodium waste. The specialists were open and forthcoming with ideas and provided excellent advice on choosing a path forward.

REFERENCES

1. BRAASE, L., "EBR-II Wash Water Evaluation Expert Panel Review", Letter LAB-01-08, March 7, 2008.

2. ROUTLEY, G. J., "Sodium Explosion Critically Burns Firefighters in Newton, Massachusetts, October 1993.

3. SHERMAN, S.R., et al, "Experimental Breeder Reactor II RCRA Treatment Cost Estimate," INL/EXT-06-01158 R1, February 2006.