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THE D&D OF THE EXPERIMENTAL BOILING WATER REACTOR (EBWR)

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ABSTRACT

Argonne National Laboratory has completed the D&D of the Experimental Boiling Water Reactor. The Project consisted of decontaminating and/or packaging as radioactive waste the reactor vessel and internals, contaminated piping systems, miscellaneous tanks, pumps, and associated equipment. The D&D work involved dismantling process equipment and associated plumbing, ductwork, drain lines, etc., performing size reduction of reactor vessel internals in the fuel pool, packaging and manifesting all radioactive and mixed waste, and performing a thorough survey of the facility after the removal of activated and contaminated material. Non-radioactive waste was disposed of in the ANL-E landfill or recycled.

The EBWR D&D project was divided into four phases. Phases I and II were performed by ANL-E personnel, while Phases III and IV were performed by a contractor under ANL-E management. The final survey was performed by the contractor, while the verification survey was performed by ANL-E.

The project lasted 118 months. Phase I was initiated in April 1986 and the final report was issued in February 1996. The total exposure to project personnel was 208.7 person-mSv (20.87 person-rem), with no individual exceeding the EBWR D&D Project limit of 15 mSv (1.5 rem).

A total of 360,205 kg (792,452 lbs) of radioactive waste were packaged for off-site disposal at a low level radioactive waste repository, with a total activity of 24,798 Gbq (670.23 Ci). Additionally, 26,829 kg (59,023 lbs) of mixed waste, with a total activity of 3,171 Mbq (85.7 mCi) were packaged for disposal. The total cost of the EBWR D&D project, including labor, management and waste disposal, was \$19,586,000.

The EBWR containment building will be used by ANL-E for interim storage of transuranic waste. Some very small amounts of inaccessible residual contamination was left in place for economic or structural reasons.

In January 1996 the EBWR facility was formally decommissioned and transferred from EM-40 to EM-30. This paper will discuss the details of this ten year effort.

INTRODUCTION

The EBWR D&D project began in 1986 with general facility preparations (Phase I D&D). This work consisted of typical mobilization activities including the establishment of a project management structure and preparation for hands-on dismantling work. The remainder of Phase I was dedicated to asbestos insulation removal throughout the facility. Phase II of the D&D began in 1988 and consisted of all reactor system piping, components, and associated equipment both radioactively and non-radioactively contaminated. This phase of the D&D was completed in 1990.

Phase III of the D&D included the removal of reactor vessel components. A D&D subcontractor was hired to perform decontamination activities for this phase and Phase IV. Preparations for this phase involved the setup of the ventilation system and the containment tent, the refilling of the fuel storage pool, and mockup training. This portion of Phase III was completed in 1993. The remainder of Phase III was divided in Phase IIIA and Phase IIIB. Reactor vessel closure items were removed as part of Phase IIIA. Items within the reactor vessel were removed next, including control rods, core assembly and thermal shields. Phase IIIB included the removal of the reactor vessel, which was sectioned for disposal. Phase III (including both Phase IIIA and IIIB) of the project was completed in June 1995.

Phase IV involved activities associated with the removal of the biological shield. Components of the biological shield, including concrete and lead bricks, were removed and decontaminated for salvage or disposed of accordingly. Remaining radioactivity which could not be removed was sealed in place in such a way that all accessible areas in the EBWR shell were at or below background levels of radioactivity. Phase IV also included the performance of any final

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decontamination activities. This phase was completed in November 1995. Project closeout included the performance of the final surveys and the issuance of project reports and miscellaneous documentation. The D&D contractor performed a final release survey to confirm that residual activity in the EBWR facility was below unrestricted limits. ANL-E Health Physics group performed a verification survey to confirm the contractor's results.

BACKGROUND

The Experimental Boiling Water Reactor (EBWR) was built as a test reactor to demonstrate the feasibility of operating an integrated power plant using a direct cycle boiling water reactor as a heat source. The reactor was designed to produce 20,000 kilowatts (kW) of heat in the form of 600 lbs/in² gage saturated steam that was fed directly to a turbo-generator producing 5,000 kW of electricity. Full power operation at its design output of 20,000 kilowatts thermal (kWt) was achieved in December 1956.

Following intermittent operation at power levels up to 61,700 kWt, the EBWR was modified to increase its power output capability to 100,000 kWt. The modifications included the addition of a reboiler plant to utilize 80,000 kW of thermal energy in addition to the 20,000 kWt used by the turbo-generator. In November 1962, the reactor was successfully operated at 100,000 kilowatts thermal (kWt). Experimental work on EBWR was completed in July 1967, and the plant was shutdown permanently and placed in a dry lay-up condition. The nuclear fuel was removed from the reactor and shipped to the DOE-Savannah River Plant. Several of the outbuildings and cooling towers were either demolished or converted for reuse before 1980. Surveillance and maintenance of the facility continued throughout the dry lay-up period. The facility was maintained in a safe storage mode until the actual D&D Project was initiated in the first quarter of FY 1986.

PHASE I - PREPARATORY ACTIVITIES

Phase I included preparatory activities associated with the EBWR D&D project. This included a review of all existing documentation, reports, and radiological surveys. This review was limited by the lack of important informational sources including "as built" drawings and accurate records from the EBWR period of operation. Figure 1 details the activities performed during Phase I.

PHASE II - REACTOR SYSTEM PIPING AND ASSOCIATED EQUIPMENT

Figure 2 shows the tasks which were carried out in Phase II. The turbine-generator was disassembled and

removed, followed by a general clean-up of the plant. The condenser and circulation water systems, and all steam piping, were removed and size reduced for packaging using conventional power tools (sawz-alls, portable band saws, air saws) and oxy-acetylene torches.

Decontamination of larger equipment items, including the condenser unit, was very effective. These decontamination efforts using conventional sand blasting equipment released about 90% of these components to a metal recycler. The Fuel Pool was also cleaned out, drained, and repainted. A general cleanup of the EBWR Building (Shell) was conducted. After the completion of Phase II, safety railings were erected as deemed necessary by the project staff to maintain a safe work area.

PHASE III - REACTOR DISASSEMBLY

Mobilization

Preparation for Phase IIIA and IIIB included the design and construction of a Water Filtration and Transfer System for the fuel pool and a 113.2 m³/min (4,000 cfm) HEPA filtration system near the reactor vessel to filter out airborne radioactivity during cutting operations and to provide fresh air turnover during operations. ANL-E Central Shop constructed mockups of the reactor vessel and internals, and mobilization activities included mock-up training. Additional electrical outlets and wiring were added, the gantry crane was installed, work tables were built and a video system was installed.

Three different shields were also constructed at this time. A basket shield was designed to transfer the basket containing the irradiated hardware segments to a 208 liter (55 gallon) drum. A drum shield was constructed identical to the basket shield except for the rigging. The control rod shield was manufactured for the transfer of the control rods. Figure 3 shows the tasks which were carried out during Phases III (Mobilization), IIIA (Reactor Vessel Internals Removal), and IIIB (Reactor Vessel Removal).

Phase IIIA - Reactor Vessel Internals

Phase IIIA consisted of removing all reactor internals, transfer to the pool, and size reducing these internals. Phase IIIA D&D activities started in March 1994. The control rods and the reactor core assembly were removed from the reactor and placed in the fuel pool for size reduction and packaging. The core assembly had contact dose rates of up to 200 R/hr.

In April 1994, the underwater size reduction of the reactor core assembly began using a 45 amp underwater plasma arc torch. All remaining reactor internals (such as the steam ducts, shock shields,

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thermal shields and experimental appendages) were removed from the vessel using the plasma arc system and were transferred to the fuel pool for further size reduction as needed. All reactor vessel nozzle penetrations were cut flush to the reactor vessel using a split-frame pipe cutter. An access man way was cut into the reactor vessel to provide personnel and equipment access.

Phase IIIB - Reactor Vessel

Phase IIIB consisted of removing and size reducing the reactor vessel. Phase IIIB activities ran concurrent with Phase IIIA activities. In May 1994, the cutting and removal of the reactor vessel was performed. The vessel was segmented using a split-frame inside diameter cutting machine. The vessel bowl cut was performed first and the bowl piece removed. The vessel barrel was cut four times, producing five ring segments. Each ring was lowered to the bottom of the vessel cavity until all cuts were completed. The top vessel section was then removed and staged in a holding area on the 4th level of the containment building. Each additional ring was removed with the last ring being placed in the cutting tent for additional size reduction.

PHASE IV - BIOLOGICAL SHIELD

Removal of the activated portion of the bio-shield concrete began in August 1994. This work was accomplished using an electro-hydraulic remote controlled impact machine. Approximately 22,727 kg (50,000 lbs) of activated concrete were removed. Figure 4 shows the tasks which were carried out during Phase IV.

Approximately three thousand lead bricks were removed from the bioshield. Approximately 61,136 kg (134,500 lbs) of this lead (90% of the total) was surveyed and free-released for recycle. This lead was smelted and formed into shield blocks for the Advanced Photon Source Accelerator at the Argonne National Laboratory - East. A total of 15,909 kg (35,000 lbs) of concrete and 3,591 kg (7,900 lbs) of steel from the bioshield were free-released for recycle or scrap.

FINAL SURVEY OBJECTIVES

The purpose of the final status survey was to demonstrate that the radiological conditions in the accessible areas of the EBWR facility satisfy the ANL-E unrestricted release criteria. Areas of contamination above releasable levels were rendered inaccessible through the use of rubber plugs and bolted metal caps. Survey units included the accessible areas of these plugs and caps.

Project Objectives

The specific objectives of the release survey included ensuring:

- Average surface contamination levels for each survey unit were within the authorized values.
- Small areas of residual activity (hot-spots) did not exceed three times the guideline value. The average activity within the 1 m² area containing the hot spot was within the guideline.
- Reasonable efforts were made to clean up removable activity, and removable activity did not exceed the guideline value.
- Exposure rates in occupiable locations were less than 5 µR/hr (micro roentgen per hour) above background. Exposure levels were measured at 1 meter from floor/lower wall surfaces and are averaged over floor areas, not to exceed 10 m². The maximum exposure rate at 1 meter did not exceed 10 µR/hr above background.
- The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters did not exceed 2 µGy (0.2 mrad) per hr at 1 cm.
- Reasonable efforts were made to identify and remove all activated structural material.
- Reasonable efforts were made to identify and remove contaminated paint or coatings on EBWR shell surfaces.

Unrestricted Release Criteria

The release criteria applicable to the EBWR shell are based on DOE Order 5400.5 and ANL-E Health Physics Procedure HPP-610. On the basis of the combination of radiological contaminants present within the EBWR shell, the surface contamination guideline values for beta-gamma contamination were:

83 Bq (5,000 dpm)/100 cm², fixed and removable, average over 1 m²;
250 Bq (15,000 dpm)/100 cm², maximum fixed and removable; and
17 Bq (1,000 dpm)/100 cm², removable contamination including tritium.

Surface contamination guidelines for transuranic alpha contamination were:

1.67 Bq (100 dpm)/100 cm², fixed and removable, average over 1 m²;
5 Bq (300 dpm)/100 cm², maximum fixed and removable; and

0.3 Bq (20 dpm)/100 cm², removable contamination.

Exposure rates in occupiable locations were reduced to less than 5 µR/hr above background. Exposure levels were measured at 1 meter from floor/lower wall surfaces and averaged over floor areas (not exceeding 10 m²). Exposure rates at 1 meter did not exceed 10 µR/hr above background at any location (i.e., upper walls and ceiling).

WASTE VOLUMES

The EBWR D&D project generated low level radioactive waste, mixed waste, and clean waste. These wastes consisted of both liquid and solid wastes. All liquid waste was transferred directly to Waste Management Operations in approved containers or pipelines according to the procedures and requirements outlined in the Waste Management Operations Handbook. Additionally, all waste was packaged and shipped/disposed of in accordance with the procedures and requirements outlined in the Waste Management Procedures Manual.

Clean waste was free released and recycled or disposed of in a sanitary facility. A total of approximately 102,725 kg (226,000 lbs) of steel and 15,909 (35,000 lbs) of concrete were scrapped or recycled as clean material. Mixed waste was transferred to Waste Management Operations and stored on-site. Liquid radioactive waste was treated on-site. Low level radioactive waste was packaged at the EBWR facility and shipped to the low level waste disposal site at INEL (Phases I and II) or Hanford, WA (Phases III and IV).

Radiological Waste

The EBWR D&D project generated approximately 420.4 m³ (14,841 ft³) of low-level radioactive waste requiring off-site disposal. The waste included materials and equipment which could not be decontaminated, including the reactor vessel and its internals, process and drain systems piping, ion exchangers, pumps, tanks, filters, and contaminated building materials comprised primarily of concrete. Neither high level nor TRU waste were generated during this project. The approximate amounts of radioactive material generated during this project are as follows:

<u>Type</u>	<u>Volume m³ (ft³)</u>	<u>Weight kg (lbs.)</u>
Metal	200.0 (7,061)	167,712 (368,966)
Concrete	63.8 (2,252)	85,705 (188,550)
Compactibles & Miscellaneous	156.6 (5,528)	106,789 (234,936)
TOTAL	420.4 (14,841)	360,206 (792,452)

Special Waste

Approximately 72.9 m³ (2,574 ft³) of asbestos was removed from the facility. Approximately 71.9 m³ (2,538 ft³) of non-radiologically contaminated asbestos was disposed of on-site at the ANL-E landfill. Approximately 1 m³ (36 ft³) of asbestos weighing 292 kg (642 lbs) containing low level radioactivity was shipped to the INEL disposal site as low level radioactive waste. Activated lead was disposed of as mixed waste with a total volume of 11.7 m³ (413 ft³). A total of 17,491 kg (38,480 lbs) of material containing 1,736 Mbq (46.93 mCi) of activity was sent to Hanford, WA as mixed waste.

The paint on the EBWR retention tanks was found to contain lead and PCB's. Additionally, PCB's were found in some electrical equipment. The paint was removed and disposed of as hazardous waste.

EBWR D&D PROJECT EXPOSURE SUMMARY

Total radiation exposure to all project personnel was 208.7 person-mSv (20.87 person-REM). The original estimated Project dose equivalent was 400 person-mSv (40 person-REM).

EBWR D&D PROJECT COST

The estimated total cost of the project was \$19,586,000.

PROJECT CLOSEOUT

Project closeout activities included closing out all outstanding Radiation Work Permits (RWP's) and submitting final results to the appropriate divisions. All final worker dose records were archived by Health Physics. The contractor demobilized and removed all temporary housing, equipment, etc. off site. All waste was removed from the facility and disposed of appropriately. Figure 5 shows the tasks associated with project closeout.

The EBWR D&D project report was developed, summarizing the D&D activities and the results. The EBWR facility was transferred from EM-40 to EM-30 on January 19, 1996 for use as a transuranic waste storage facility.

- Establish Facility Services
- Assemble Tools and Equipment
- Assemble Work Force
- Erect Truck Enclosure
- Remove Nonradioactive Components
- Remove Asbestos Piping Insulation

FIG. 1. PHASE I - GENERAL FACILITY PREPARATION

- Remove Primary and Auxiliary Systems
- Remove Turbine/Generator System
- Remove Condenser and Circulating Water System
- Clean-Up From Phase II D&D

FIG. 2. PHASE II - EBWR SYSTEM D&D

- Remove Vessel Closure Items
- Remove Vessel Internals
- Remove Reactor Vessel

FIG. 3. PHASE III - REACTOR VESSEL D&D

- Remove Cavity Liner and Shielding Items
- Decontaminate Vessel Cavity and Fuel Pool
- Miscellaneous Decontamination and Clean-Up

FIG. 4. PHASE VI - BIOLOGICAL SHIELD D&D

- Final Radiological Characterization
- Certify Facility Use Status
- Prepare Final Report
- Place Project Records In Storage

FIG. 5. PROJECT CLOSEOUT

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