

BIG ROCK POINT RESTORATION PROJECT BWR MAJOR COMPONENT REMOVAL, PACKAGING AND SHIPPING – PLANNING AND EXPERIENCE

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ABSTRACT

The Big Rock Point boiling water reactor (BWR) at Charlevoix, MI was permanently shut down on August 29th 1997. In 1999 BNFL Inc.'s Reactor Decommissioning Group (RDG) was awarded a contract by Consumers Energy (CECo) for the Big Rock Point (BRP) Major Component Removal (MCR) project. BNFL Inc. RDG has teamed with MOTA, Sargent & Lundy and MDM Services to plan and execute MCR in support of the facility restoration project.

The facility restoration project will be completed by 2005. Key to the success of the project has been the integration of best available demonstrated technology into a robust and responsive project management approach, which places emphasis on safety and quality assurance in achieving project milestones linked to time and cost.

To support decommissioning of the BRP MCR activities, a reactor vessel (RV) shipping container is required. Discussed in this paper is the design and fabrication of a 10 CFR Part 71 Type B container necessary to ship the BRP RV. The container to be used for transportation of the RV to the burial site was designed as an Exclusive Use Type B package for shipment and burial at the Barnwell, South Carolina (SC) disposal facility.

INTRODUCTION

Planning for and executing the removal and ultimate disposal of major components from a retired nuclear power plant (NPP) is an aspect of the decommissioning process that requires a significant commitment of funding, project management capabilities, and engineering expertise. This project scope includes components, such as the poison tank, emergency condenser, and steam drum in addition to the RV. The most challenging component of NPP decommissioning projects, however, is the removal and ultimate disposition of the Reactor Vessel (RV). This activity uses multidisciplinary skills such as:

- Nuclear Engineering
- Mechanical Engineering
- Structural analysis and design
- Radiological and industrial safety
- Quality assurance and nuclear licensing
- Management of public and stakeholder issues

The RV at Consumer Energy's Big Rock Point Nuclear Power Plant is part of the Major Component Removal scope of work being conducted by the BNFL Inc. decommissioning team. The successful removal and disposition of the RV has and will continue to require close coordination between CECo and BNFL Inc. BNFL Inc. has the overall responsibility for the preparation, removal, packaging, and transport of the RV.

The BRP BWR was originally procured and designed for early research into the irradiation of experimental high power density, long life-time fuel in addition to electrical power generation. The plant was initially synchronized onto the local grid in August 1962 and first declared commercially available in January 1965. The plant ceased operation for economic reasons in August 1997, after 35 years of power generation. The RV is a 30'-0" long vertically mounted cylindrical unit with an outside diameter of 9'-8" and 11'-6" inches at the vessel flange. It is principally fabricated from steel, weighs 240,000lbs without water and internals but including the head, and is located in the containment sphere, within a massive concrete shielding/support structure.

Characterization data was developed for the RV, including its insulation and minimal selected internal components (see GTCC below) will remain in the RV for shipment and disposal. The mirror insulation provides a considerable contribution to the residual dose rate of the RV transport package, but has been left in place because of ALARA considerations regarding dismantlement and removal. Using both this RV characterization and material sample data recently obtained and industry precedence, regulatory criteria and guidelines have been examined that control the packaging and transportation of such components as the BRP RV. From this analysis it has been determined that the RV will be packaged and transported as a 10CFR 71 Type B Transportation Package. The packaging and disposal scheme considers the package activity requirements of the disposal facility in Barnwell, SC. which are in addition to those of the USDOT and NRC.

The packaging, removal and disposal of the RV can be broken into six distinct work evolutions. These are:

- Design of the Reactor Vessel Transportation System (RVTS)
- Fabrication of the RVTS
- Removal of Internals
- RV Preparation for Lifting
- RV Removal and Low Density Grout Injection
- Packaging and Transportation to Disposal Site

DESIGN AND FABRICATION OF THE REACTOR VESSEL TRANSPORTATION SYSTEM (RVTS)

Preliminary design of the RVTS package involved developing a container configuration that would satisfy regulatory requirements while considering physical constraints such as transportation route width, height, and weight restrictions; fabricator handling restrictions; and BRP Containment Sphere space limitations.

The regulatory requirement governing the 3 meter unshielded dose rate of the material to be shipped played the major role in pursuing a 10 CFR Part 71 Type B package design. While the radioactive material included in the RV package can be demonstrated to meet the A2 limits under the definition of Low Specific Activity (LSA), the calculated dose rate at 3 meters exceeded the 1 Rem/hr 10 CFR Part 71 limit. Consideration of the criteria governing shipment of 'Greater Than Class C' (GTCC) materials as well as the Barnwell disposal criteria for A2 fraction averaging led to a decision to remove some internals from the RV prior to shipping. Among these are any GTCC components specifically the upper grid bars and neutron windows.

To maintain shipping width and height such that a combination highway and rail route would be feasible for the RVTS package, the package diameter is limited to approximately 13'. Determining that the RV upper head can be shipped separately and disposed of without a Type B package has resulted in a shorter, lighter package that provides benefits in the areas of shipping, handling, transportation, and fabrication. The package configuration selected is a right cylinder with flat end plates. Final package dimensions are approximately 13 feet in diameter and 25 feet in length.

The package top plate also serves as the lifting plate for removing the RV from the reactor cavity and transferring it to the upended RVTS container. Once placed into the container, the bottom of the RV will be cradled in a support ring that will provide vertical and lateral support. The top plate will then be welded onto the container fully enclosing the RV within the container.

Shielding design resulted in a container with varying wall thickness. In the vicinity of the active fuel region of the RV, approximately 96 inches axially, the necessary wall thickness, 7 inches, is significantly greater than the 3 inch thickness required in other side wall areas. To adequately address design issues such as increased susceptibility to brittle fracture with increasing plate thickness and fabrication concerns with rolling 7 inch thick plate, the design adopted an outer shell of 3 inch uniform thickness with a 4 inch layer of additional shielding welded to the inside of the container.

Final design of the RVTS to meet the Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) as defined in 10 CFR 71 has been performed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code Section III Subsection NB. NUREG 1609 and Reg. Guide 7.9 provide general guidance on aspects of design that should be considered. While NCT and HAC present a variety of challenges in the design phase, for the BRP RV package the specific HAC for the '30 foot' drop to an essentially unyielding surface required the greatest effort to meet. In order to satisfy this HAC of 10 CFR 71 for package performance, the RVTS design team employed sophisticated finite element analysis techniques to perform a series nonlinear, elastic-plastic analyses, determining potential areas of package containment breach, and then assessed the radiological consequences. By demonstrating that the radiological consequences from such postulated containment breaches are within the 10 CFR 71 acceptance criteria for HAC, a major challenge to design of the RVTS has been met.

Fabrication of the RVTS

As a Type B shipping package designed per ASME BPV Code Section III Subsection NB, stringent fabrication practices are required. For elements that form a part of the package containment boundary or are welded integrally to the boundary, materials are specified to ASME Section III SA criteria. To ensure low temperature performance, notch toughness requirements at a lowest service temperature of –20 degrees F are specified. To guard against laminations in the thick plates used for the package, ultrasonic testing of base metal is required. Welding joints qualified to ASME requirements are specified, including a specialized field weld using narrow gap groove weld technology. This specialized weld will result in lower total heat input into the materials and a shorter welding time while still providing a container closure weld that achieves full penetration.

Prior to fabrication, vendor welding procedures and welder qualifications will be reviewed to verify that code requirements are met. Vendor surveillance during fabrication will ensure a consistently high quality container is built.

Design and Fabrication of the RVTS Tie Down System and Handling Devices

Transportation of the RVTS to the disposal site in Barnwell, SC will involve a combination of highway and rail transport. This requires designing a support structure that is adequate for inertial loads from both AAR and ANSI standards for tie down systems, has provisions for lifting or jacking as required to move the package from one transport vehicle to another, and maintains shipping clearance profiles. The transport tie down system employs readily available structural plate material, wire rope, and turnbuckles. Since the tie down system is not an integral part of the package containment boundary, it will be fabricated to AISC / AWS / ANSI standards using pre-qualified welding procedures and joint configurations on ASTM specified materials.

To accommodate the shifting of the package from the highway transport to the rail car, the RVTS tie down structure has been designed with identified jacking points. By jacking the package to allow placement of hydraulically driven slide beams, the transfer from highway transport to railcar can be accomplished without the need for a crane at the rail siding location.

To facilitate handling of the RVTS package prior to shipment from site, a lifting lug will be bolted to the top plate and two trunnions will be bolted to the side of the package. These devices are intended for handling prior to shipment only and will be removed before the highway transporter exits the site with the RVTS package. The trunnions, machined from solid billets, allow the container to pivot about cradles at the tops of A-frame supports. These facilitate upending the empty container from its horizontal delivery position using the existing crane. The A-frames/trunnions and the lifting lug, fabricated from plate material, are used to down-end the package once the RV is in place and the top welded.

RV PREPARATION

The work to facilitate RV removal and packaging includes:

- Removal of the RV internals top grid bars and loading them into GTCC containers.
- Removal of the neutron windows and placement into GTCC containers
- Evaluation of the existing structure for floor load and crane reactions associated with Major Component Removal
- Providing an Opening in the Containment Sphere
- Upgrading the Containment Crane
- Removing a Section of the Concrete Pedestal to Facilitate RV Removal
- Removing the Concrete Block Surrounding the RV
- Preparing the Nozzles
- Removing the Stabilizer Arms and Support Brackets
- Receiving and Placing the RV Shipping Package and Up-ender

Evaluation of Existing Structure for MCR Floor Loads

While the existing structure could be considered robust for supporting the loads to which it was subjected during normal operation, providing an adequate travel path for a package whose total weight approaches 300 tons requires revisiting the design of a structure that was built 40 years ago. At that time, the materials used were typical of the state of the industry. The original design loads on the 2500 psi to 3000 psi concrete and 40 ksi reinforcing steel did not consider movement of components as heavy as our decommissioning project requires. From high, localized jacking loads to moving loads affecting larger areas, the BRP MCR project loads the structure in ways such that existing slabs require clearly defined load paths with the addition of local shoring to ensure a safe load movement.

Providing an Opening in the Containment Sphere

To enable the RVTS to be delivered and removed from the containment, an opening of sufficient size has been engineered and cut in the Containment Sphere at the existing equipment hatch location. The opening allows access to an existing loading dock and then to the site access roads. Designed to withstand seismic and tornado loads, it was necessary to provide substantial steel reinforcing around the opening.

Because of the overall length and weight of the RVTS package, the existing loading dock crane is not adequate to handle moving the package from the slide beam system on the dock to the bed of the highway transport. This will be accomplished using a hydraulic gantry system which will lift the package, allow it to be rotated 90° to align with the highway transport, and then lowered onto the tie down support skid.

Upgrading of the Containment Electric Overhead Traveling (EOT) Crane

In order to lift the RV from the reactor cavity, a crane of approximately 125 ton capacity is required. The existing EOT crane is rated at a capacity of 75 tons. The required upgrade being provided by CEC Co will incorporate a temporary column/bridge/single-failure-proof trolley configuration that can be removed and reused after work inside the BRP Containment is complete.

After upgrading, the crane will be used to lift the RV from the cavity, move it west to the shipping package location, and lower it into the upended shipping package.

Removing a Section of the Concrete Pedestal to Facilitate RV Removal

When the RV at BRP was initially installed, it was transported into the Containment on a sled and upended before the reactor cavity was completed. Now, to remove the RV from the reactor cavity, the vessel must be lifted to clear the top of the cavity at elevation 632'-6". The upgraded EOT crane configuration does not remove the existing EOT gantry legs or bridge. Therefore, no additional headroom has been provided to permit lifting the RV clear of the 632'-6" deck.

To allow sufficient clearance to remove the RV, a trench is to be cut in the reactor cavity structure. The Trench will be cut and sectioned using diamond wire cutting technology and the sections will be placed into containers for removal. An added benefit to this slot is that it facilitates handling other large components for removal such as the steam drum.

Removal of the Concrete Block Surrounding the RV

Where the pipework accesses the RV cavity on the southern side of the RV, concrete blocks surround the pipes. From inspection 40% of these blocks are 'dry stacked' while the remainder are bonded into position. These will be removed and stacked for disposal by the waste contractor.

Nozzle Preparation

There are Sixty-one pipe penetrations into the RV of differing diameters. Each one of these penetrations will be cut and capped for RV shipping. Where viable, a hydraulically powered split ring cutter will be used to cut and prepare the nozzle. Where the split ring cutter cannot access the pipe, alternative means of cutting will be employed such as wire saws or thermal cutting.

In order to maintain clearance for placing the RV into the RVTS package, all nozzles through the sides of the RV will be cut such that they fall within an 11'-8" diameter envelope. The control rod drive (CRD) tube stubs at the vessel bottom will be trimmed to within 2" of the bottom of the RV shells lowest most point to ensure a proper fit into the shipping container

Removal of the Stabilizer Arms and Support Brackets

Twelve brackets that are attached to the exterior vessel shell support the vessel. Twenty-four 2½-inch diameter hanger rods attached to these brackets transmit the vessel weight to supports anchored in the supporting concrete. Six of the hanger rods that are attached to large steelwork inserts are classed as main restraints. The remaining Eighteen hanger rods are secondary suspension rods. They and their support brackets will be removed while the reactor is supported on the main steelwork embedment hanger supports and not from the crane. Once the RVTS lifting plate is installed and the crane attached to take the weight of the RV, the remaining supports will be removed. It is anticipated that nut splitters will be used to rupture the nuts that fasten the RV to the brackets, although additional equipment will be available as required.

Receipt and Placement of RV Shipping Package and Up-ender

The shipping package that will consist of the container with an integral transport cradle and turning trunnions will be delivered to the containment sphere by the road transporter. The RVTS container will be reverse slid into the sphere on the hydraulic slide rail system previously mentioned. The container will be positioned with its head directly under the EOT crane. A pair of A-frames will then be attached to the container trunnions. By means of the EOT crane and the A-frames taking the container weight, the bottom portion of the container will be maneuvered into a vertical position, ready to receive the RV.

RV REMOVAL, GROUTING, PACKAGING AND TRANSPORT

After vessel preparation, including draining the RV water inventory and nozzle cutting and capping, the RV will be lifted from the reactor cavity structure, moved across the 632'-6" slab, and lowered into the upended RVTS container. To remove the RV, the lifting plate will be attached to the vessel flange via the head studs. The EOT crane will then be attached to the lifting plate and RV lifted out of the cavity, traversed west and lowered into the container. Using an automated welding machine the plate is then full penetration welded to the container becoming part of the package containment boundary. The lifting lug attached to the top plate will then be removed and Low Density Cellular Concrete (LDCC) will be placed into the interior of the RV through the bolt openings. The LDCC density for filling the RV internal void is 30 pcf (minimum) to 36 pcf (maximum). This will serve to fix loose contamination on the RV's interior surface and the included internals and will establish the RV and internals as an integral component.

Once the RV has been grouted internally the top plate lifting lug will be reinstalled. The container will then be lowered into the horizontal plane by means of the EOT crane and A-frames and will be held in this position by the A-frames ready for placing 50 pcf to 60 pcf LDCC into the void between container and vessel through 4 injection ports. After curing of the RV interior LDCC, the top lifting lug will be removed and the holes in the top plate plugged and welded. After curing of the external void LDCC, the 4 injection ports will be plugged and seal welded, providing a welded containment boundary for the

package. Once the sealing of the package is complete, the unit will be moved using the slide beam system through the Containment access opening to the external loading dock. From the dock, it will be transferred to the highway transport. The package will then be taken by road to a rail site where it will be transferred to rail for transport to Barnwell SC. where the package will be transferred to Chem Nuclear for burial.

LESSONS LEARNED

The BNFL Inc. Major Component Removal Project at Big Rock Point, having completed an initial year of planning, is now in its first full year of decommissioning operations with the RV removal activity scheduled for 2002. The experience of planning this project within Big Rock Point's Site Restoration Project has reemphasized the value of strong project management skills and values, such as building a strong team, emphasizing communication, and encouraging innovation. BNFL Inc. has identified a number of key issues through its lessons learned program, which will be incorporated into subsequent projects to further increase efficiency and reduce cost. These lessons learned can be summarized under the headings of:

- The effort required for initial planning is often underestimated
- Develop characterization data early in the project and capture confirmatory measurements wherever possible prior to implementation
- Establish transportation contacts and an interactive dialogue during planning
- Involve the fabricator early in the design phase
- Set up peer review to assess and facilitate design
- Do not allow precedent to promote tunnel vision
- Manage the client interface to avoid delays in approval, especially when the client is both performing its own and reviewing the contractors work
- For Part 71 licensing, establish who will be the certificate holder early on in the project planning phase and ensure the full significance of being the holder is understood
- Stringent QA procedure developed for operations when spent fuel was present in the fuel pool require considerable effort to modify for D&D activities
- Pre-planning reduces the potential for operational delays and saves time and money by avoiding unforeseen events
- Mock ups, fault analysis and "what if" scenario analysis enhance safety and improve efficiency

- Establish early, interactive and informed dialogue with the NRC to ensure that expertise and regulatory guidance is developed into the design and planning phases
- By working together diligently and effectively the client, contractor and regulator can bring about improvements in safety and cost efficiency of challenging decommissioning projects

CONCLUSION

The Big Rock Point Major Component Removal Project, currently being performed by BNFL Inc and its team members, Sargent & Lundy, MOTA and MDM Services, is on schedule for completion of the reactor vessel removal in 2002. This challenging multidisciplinary project has benefited from an intensive pre-planning phase and an interactive dialogue with both the client and regulator. These factors cannot be over emphasized in planning for success in future decommissioning projects.