REACTOR PRESSURE VESSEL HEAD PACKAGING & DISPOSAL

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ABSTRACT

Reactor Pressure Vessel (RPV) Head replacements have come to the forefront due to erosion/corrosion and wastage problems resulting from the susceptibility of the RPV Head alloy steel material to water/boric acid corrosion from reactor coolant leakage through the various RPV Head penetrations. A case in point is the recent Davis-Besse RPV Head project, where detailed inspections in early 2002 revealed significant wastage of head material adjacent to one of the Control Rod Drive Mechanism (CRDM) nozzles. In lieu of making ASME weld repairs to the damaged head, Davis-Besse made the decision to replace the RPV Head. The decision was made on the basis that the required weld repair would be too extensive and almost impractical.

This paper presents the packaging, transport, and disposal considerations for the damaged Davis-Besse RPV Head. It addresses the requirements necessary to meet Davis Besse needs, as well as the regulatory criteria, for shipping and burial of the head. It focuses on the radiological characterization, shipping/disposal package design, site preparation and packaging, and the transportation and emergency response plans that were developed for the Davis-Besse RPV Head project.

INTRODUCTION/BACKGROUND

The Davis-Besse nuclear power plant is a 906 Mwe pressurized water reactor located near Toledo, Ohio. B&W was the NSSS supplier and Bechtel was the original AE for this plant. It is owned and operated by First Energy Nuclear Operating Company (FENOC) and has been in operation since April 22, 1977.

During the thirteenth refueling and maintenance outage in February 2002, in accordance with a 2001 NRC directive, Davis-Besse performed the reactor vessel head nozzle inspection, when cracks were detected in three of the control rod drive mechanism (CRDM) nozzles. In an effort to perform repairs to these nozzles, workers removed dry deposits of boric acid from the vessel head. During the removal of these boric acid deposits a corrosion area of approximately 20 square inches was discovered on the vessel head. The 6.625" thick carbon steel shell had wasted down to the stainless steel cladding on the inside of the vessel head. It was this corrosion wastage issue that resulted in FENOC's decision to replace their reactor pressure vessel head.

FENOC contracted with Bechtel for the replacement of the reactor pressure vessel (RPV) head and with WMG for the packaging, transport and disposal of the damaged RPV Head. Bechtel designed and fabricated top and bottom covers for contamination control. These components were installed on the Head prior to removal from the Containment Building. The Head was also coated with a lockdown coating prior to removal from Containment.

WMG performed the characterization and shielding analysis of the Head and proceeded with design and fabrication of the DOT qualified shipping/disposal package. The package components were installed on the RPV Head, in Davis-Besse's Turbine Building Train Bay, immediately following removal of the Head from Containment.

The Davis-Besse RPV Head package is currently positioned on their Dry Fuel Storage Pad in a temporary enclosure. It will remain there until the plant staff has an opportunity to remove additional head/nozzle material for analysis, as requested by the NRC. Once the material extraction has been completed, WMG

will complete the packaging and load the RPV Head onto a depressed center heavy-duty (DCHD) railcar for shipment to Envirocare of Utah (EOU) for disposal.

CHARACTERIZATION

The Waste Characterization determined both the waste classification for disposal of the Davis-Besse RPV Head in accordance with 10CFR61 (Reference 1) and the transportation classification in accordance with 49CFR173 (Reference 2). The primary nuclide distribution for the RPV Head was based upon smear sample analysis. Dose-to-curie conversion factors were established by detailed three-dimensional calculations. Radiation surveys were utilized to establish average dose rates. The Davis-Besse RPV Head was determined to be NRC Class A waste.

The 49CFR173 transportation classification was established by comparing the surface activity of the RPV Head to the SCO limits, and the nuclide activities to the corresponding A_2 values in 49CFR173. The RPV Head was determined to be DOT SCO-II.

Additional requirements were evaluated to confirm that the package met conveyance limits, 3-meter unshielded dose rate limit, fissile material limits, and reportable quantities (RQ) limits. The RPV Head package met all 49CFR173 transportation criteria.

The Davis-Besse RPV Head, as a whole, satisfies the waste acceptance criteria for disposal at Envirocare of Utah, as well as the requirements for exclusive use shipment in a strong tight container per 49CFR173.427(b)(3).

Characterization Method

Physical dimensions and weights of the Head were obtained from vendor drawings. Surface areas of interest were also calculated from these drawings. The RPV Head has an outside diameter of 200 inches, a height of approximately 96 inches, and weighs about 163,300 lbs. WMG developed a detailed, three dimensional shielding model of the Head using dimensions from the drawings.

Characterization of the RPV Head was a two-step process. First, a detailed three-dimensional shielding model of the Head was prepared from the Head drawings. This model was used as input to QAD-CGGP-A. The nuclide distribution used the Part 61 analyzed smears obtained from the inside surfaces of the Head. The nuclide distribution was used in conjunction with the shielding model results to determine dose-to-curie factors for the survey measurement locations. Finally, the total activity of the interior surfaces of the Head was calculated using the measured dose rates and the dose-to-curie factors. Specifically for Davis Besse, the activity from activation of the Head was not considered because the neutron flux at the Head region is too low to result in any discernable change in the total activity levels.

The resultant total contamination activity was homogeneously distributed on the interior surface area to obtain a surface contamination level of approximately 10.1 $\mu Ci/cm^2$. The activity was decayed to June 10, 2002, at which time the total activity was approximately 3.8 curies and the (total) surface contamination level was 9.2 $\mu Ci/cm^2$.

For transportation and disposal, the RPV Head package must meet Department of Transportation criteria as well as Envirocare waste acceptance criteria. The results of the characterization identified that the RPV Head package does satisfy the DOT shipping criteria and the Envirocare WAC. The following determinations were made to support exclusive use shipment of the Head in a strong tight container (per 49CFR173.427(b)(3)):

(1) The Head represents less than a Type A quantity of material ($<1A_2$)
(2) The underside of the Head will be made inaccessible, and the contamination levels on the inaccessible surfaces are less than 8.0E+05Bq/cm^2 beta gamma (and LTA), and less than 8.0E+04Bq/cm^2 alpha

PACKAGING

Package Description

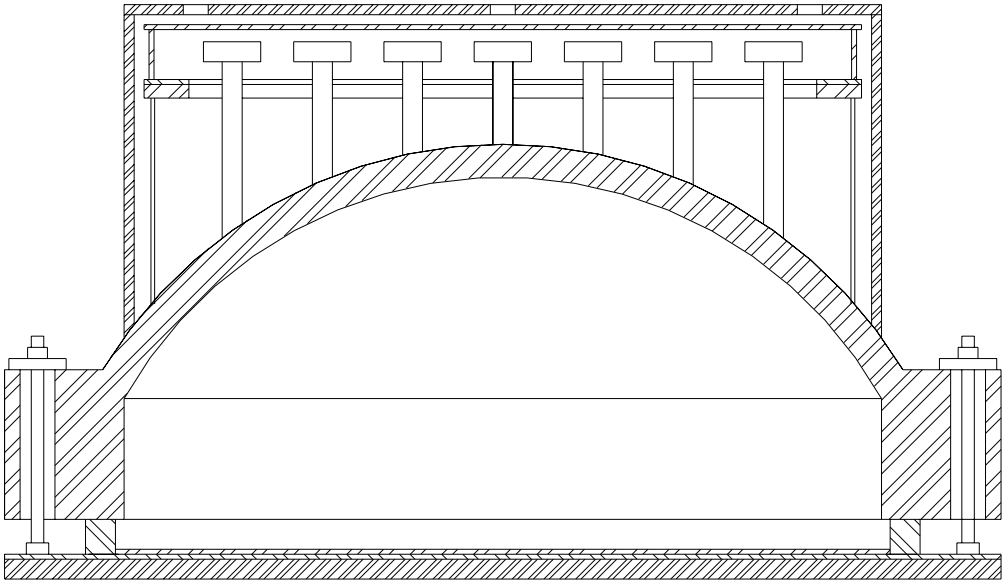

Figure 1. RPV Head Shipping/Disposal Package Configuration

The Davis-Besse RPV Head shipping/disposal package consists of the Head, including the control rod drive mechanism (CRDM) nozzles, a bottom cover plate for contamination control, a bottom shield plate, an inner dome "top hat" for contamination control, and an outer dome "top hat" for shielding (see Figure 1). The Head is 16'- 8" in diameter and approximately 9' tall (to the top of the CRDM nozzles). The wall thickness of the dome of the Head is approximately 6". The weight of the Head alone is 163,300 lbs. The total weight of the package is approximately 265,000 lbs and has a volume of 1620 ft^3.

Package Design

The Davis-Besse RPV Head package was designed in accordance with 49CFR173 (Reference 2). General design requirements were obtained from 49CFR173.410 and .411. The shielding was designed such that the package would meet the dose rate criteria established in 49CFR173.441 (i.e., less than 10 mRem/hr at 2 meters and less than 200 mRem/hr on contact). The design and fabrication of the package components are in accordance with the requirements of the American Institute for Steel Construction (Reference 3) and ANSI/AWS D1.1 (Reference 4).

Shielding Evaluation

49CFR173.441 provides the external radiation level limitations for packages used for the transport of radioactive materials. Per 49CFR173.441, "each package of Class 7 (radioactive) materials offered for transportation must be designed and prepared for shipment, such that under conditions normally incident to transportation, the following criteria are met:

- 200 millirem/hr on the external surface of the package (49CFR173.441(b)(1))
- 200 millirem/hr at any point on the outer surfaces of the transport vehicle, including the top and underside of the vehicle; (49CFR173.441(b)(2))
- 10 millirem/hr at any point two meters from, in the case of an open vehicle, the vertical planes projected from the outer edges of the conveyance (49CFR173.441(b)(3))
- The requirements for 49CFR173.441(b)(4) are met by the Transportation Plan, therefore, the requirements for this section do not apply to the shielding evaluations

Surveys taken on May 16, 2002 were used as input to the shielding models for the package design. The calculated dose rates were well below the requirements of 49CFR173.441(b), and provided good assurance that the package shielding would be adequate. The actual dose rates were measured on August 29, 2002 following the initial packaging of the Head. The survey results are summarized in Table 1 below.

Table 1: Summary of Actual Dose Rates for RPV Head

(From surveys taken 5/16/02 and 8/29/02)

	Contact Dose Rate Before Packaging (mrem/hr)	Contact Dose Rate After Packaging[1] (mrem/hr)	2 meter Dose Rate After Packaging[2] (mrem/hr)
Side of RPV Head	240	27	**later** (4)
Bottom of RPV Head	778 (3)	**later** (4)	**later** (4)
Top of RPV Head	101	**later** (4)	**later** (4)

NOTES:

1. Maximum allowable dose rate is 200 mrem/hr (§173.441(b)(1)).
2. Maximum allowable dose rate is 10 mrem/hr (§173.441(b)(3)).
3. Maximum dose rate at the plane of the bottom flange of the Head taken 5/16/02
4. Dose rate will be measure just prior to shipment

Figure 2. RPV Head Package

Blocking and Bracing

Blocking and bracing is necessary to hold the RPV Head rigidly to the DCHD rail car. The blocking and bracing is designed to accommodate the RPV Head in a vertical orientation. A conceptual sketch of the RPV Head loaded onto the DCHD rail car is shown below in Figure 3 (tie-downs are not shown).

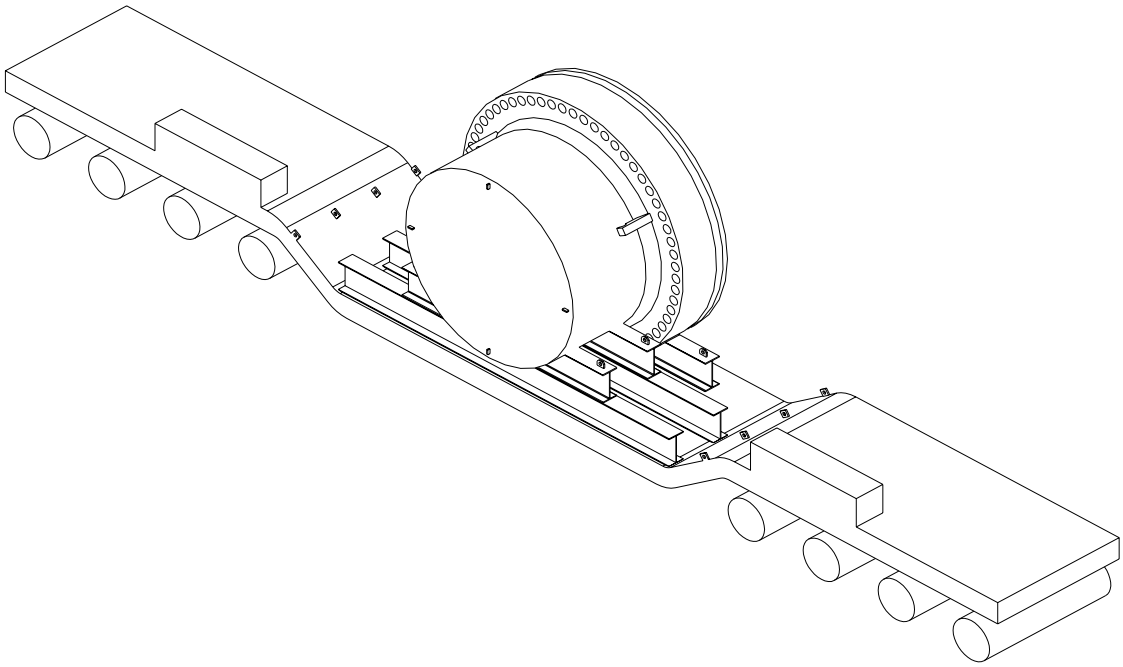

Figure 3. DCHD Railcar with RPV Head

The blocking and bracing, which is being provided by MHF Logistical Solutions (the transportation subcontractor to WMG, Inc), was designed in accordance with the requirements of the Association of American Railroads (AAR) (Reference 6) to resist vertical, longitudinal, and lateral load. These requirements are as follows:

- Vertical restraint required = 2G
- Longitudinal restraint required = 3G
- Lateral restraint required = 2G

The loaded railcar is balanced with ballast that is added to oppose the load. The center of gravities for the RPV Head package, railcar and ballast are all calculated and then combined to determine the center of gravity of the entire conveyance.

The railcar will be inspected prior to placement in the secure area of the Davis Besse Site at Oak Harbor, OH. It will be inspected for overall quality of the railcar, cleanliness of critical deck areas, and its compliance with American Association of Railroads (AAR) safety and interchange rules. The ballast will be installed on the railcar while the railcar is on site and prior to placing the reactor Head on the railcar in

the position shown above. After the RPV Head has been secured to the railcar, the position of the ballast will be adjusted to level the rail car, and then welded in place to secure it for transit.

The blocking and bracing will also be installed on the railcar prior to loading the RPV Head. Measurements of the RPV Head will be taken to establish the alignment and positioning of the Head on the railcar. The blocking will be positioned on the railcar then welded in place to form a cradle arrangement. The railcar will be moved into position such that the RPV Head can be upended and loaded onto the blocking. Once the Head is loaded onto the blocking, shims will be driven into place and welded, to shore the Head longitudinally. Lateral supports will be welded to the deck of the railcar to support the outside edge of the flange and resist side movement of the Head. Tie-downs will be provided to secure the RPV Head to the railcar and resist uplift.

The blocking and bracing arrangement was designed and fabricated by MHF in accordance with the AAR standards to insure the safe transit of the Davis-Besse RPV Head. It will be installed in compliance with applicable Davis Besse safe operating practices and ALARA goals.

SITE PREPARATION

Because the Davis-Besse RPV Head was too large to be removed from the Containment Building through the Equipment Hatch, Bechtel was contracted to provide a temporary access opening through the Containment Building wall for both the damaged Head and the replacement Head. This work was performed in parallel with the design and fabrication of the Head packaging. A platform (i.e., "runway") was also erected outside the Containment Building to facilitate the movement of both Heads through the opening..

A ground load evaluation was performed to verify that the ground along the load paths of both Heads was capable of supporting these heavy loads. The damaged Head transport path was to the Turbine Building. All buried utilities along the load path to the Turbine Building were evaluated to determine if additional support was needed over the areas where they existed. Some of the buried utility trenches had to be covered with heavy steel plate to protect them. There were no major modifications necessary to allow the transport to occur.

The 8-mile rail spur into the Davis-Besse site required repair prior to its use for transport of the damaged Head. This repair was performed in parallel with the design and fabrication of the Head packaging. Prior to the shipment of the Head to EOU, a rail inspection will be performed to verify that the rail spur is satisfactory for transport of the package.

At the time of this writing, the damaged Head is packaged and stored in an temporary enclosure on the Dry Fuel Storage Pad. At a future date (yet to be determined), it will be moved into Auxiliary Building Train Bay to allow the extraction of additional material for analysis, as requested by the NRC. Upon completion of the material extraction, the RPV Head will be re-packaged, loaded onto the DCHD railcar, and shipped to EOU.

TRANSPORT

Transportation and Emergency Response Plan

A Transportation and Emergency Response Plan was developed to establish the minimum requirements for overall management, coordination and control for the safe shipment of the Davis-Besse RPV Head from the Davis-Besse site in Oak Harbor, Ohio to the Envirocare of Utah (EOU) disposal facility in Clive, Utah. This plan contains the prerequisites and restrictions for transport, a procedural checklist and signoff, a description of the routes to be taken, and response actions for emergencies that could occur during transit from Davis-Besse to EOU. The plan contains the responsibilities for all parties involved with the transportation of the RPV Head. The parties involved include the owner (FENOC), the waste disposal

contractor (WMG, Inc), the transportation contractor (MHF Logistical Solutions), and the disposal facility contractor (EOU). This plan will be maintained by FENOC and used as necessary to support the transport of the RPV Head package to EOU.

DISPOSAL

The Davis-Besse damaged RPV Head will be disposed at Envirocare of Utah (EOU). A waste profile based on WMG's characterization results was prepared by Davis-Besse and submitted to EOU for this package. A package configuration sketch was included with the waste profile to show the locations of all package components as well as the grout ports. The package will be disposed of in EOU's "bulk cell" as Class A waste.

References

1. 10CFR61, Licensing Requirements for Land Disposal of Radioactive Waste
2. 49CFR173, Subpart I, Class 7 (Radioactive) Materials, Revised October 1, 1998
3. American Institute for Steel Construction, Manual of Steel Construction Allowable Stress Design, Ninth Edition
4. ANSI/AWS D1.1, Structural Welding Code – Steel, 1998
5. ANSI N14.2, American National Standard "Tiedown for Truck Transport of Radioactive Waste"
6. Association of American Railroads
7. 10CFR71, Packaging and Transportation of Radioactive Material