NEW DEVELOPMENTS IN RPV HEAD PACKAGING & DISPOSITION

D. M. Wheeler, A. A. Freitag, E. J. Posivak
WMG, Inc
16 Bank St., Peekskill, NY 10566

D. Price, W. C. Sims
Dominion Power
5000 Dominion Blvd, Glen Alen, VA 23060

ABSTRACT

Reactor Pressure Vessel (RPV) Head replacements remain in the forefront for all US commercial nuclear PWR plants. Davis-Besse was the first operating nuclear power plant to undergo an RPV Head replacement in the United States, which required disposition of the retired RPV Head for disposal.

This paper presents new developments for packaging and disposition of old RPV Heads and control rod drive mechanisms (CRDM's), as applicable. It addresses the major regulatory and design requirements associated with the packaging, transportation and disposition of old RPV Heads. The specific topics that are covered include radiological characterization methodology, shielding design, packaging design, on-site storage, transportation, and disposition.

INTRODUCTION / BACKGROUND

There are sixty-nine (69) pressurized water reactor (PWR) type, operating commercial nuclear power plants in the United States today. To date ten (10) of the sixty-nine (69) operating PWR plants have performed their RPV Head replacements. Approximately 50% of the sixty-nine (69) plants will perform RPV Head replacements over the next three years. The remaining 50% of the PWR plants will eventually have to change out their heads as well. Regulatory inspection requirements, economics, new head fabrication schedules, and availability of manpower are several of the key issues which factor into the decision to perform the RPV Head replacements.

Each PWR plant must also decide what to do with their old RPV Head(s) and CRDM's, as applicable. They need to determine whether to store their old RPV Heads on-site (i.e., in a mausoleum) or ship them off site to be dispositioned (i.e., processed and/or disposed of). They must weigh the costs and risks associated with on-site storage versus the costs and risks associated with disposition. Of the ten (10) PWR plants that have performed RPV Head replacements to date, four (4) have elected to store their RPV Heads on site in mausoleums. For the remaining six (6) plants, four (4) have disposed of their Heads at Envirocare of Utah's LLW disposal facility and the other two (2) have chosen to have their Heads processed at the RACE Processing Facility in Memphis, Tennessee. The two (2) RPV Heads that are being processed include one (1) without CRDM's (i.e., the TMI Head) and the one (1) with CRDM's intact (i.e., Surry Unit 2).

New packaging has been designed, fabricated, and tested for the transport and disposition of the Surry Unit 2 RPV Head with CRDM's attached. This packaging was designed and fabricated by WMG, Inc. and is a "first-of-a-kind" (patent pending) design that has been approved for use by the US Department of Transportation (i.e., DOT). WMG has received a DOT manufacturing exemption for the use of this packaging.

At the time of the writing of this paper the Surry Unit 2 old RPV Head, with the CRDM's intact, was packaged and stored on site at plant's facility in Surry, Virginia, awaiting the issuance of transportation permits from the states through which it will travel on its way to the RACE Processing Facility in Memphis, Tennessee. Shipment is anticipated to occur by the end of March 2004.

The process associated with packaging and disposition of old RPV Heads and CRDM's, as applicable, is a fairly involved one. It begins with the plant's decision to replace their old RPV Head. Once this decision is made the process of characterization must begin. Radiological surveys, reactor operating history, and physical data must be collected so that characterization can be performed. Shielding models are developed to establish the size and configuration of the packaging. The owner must decide whether to store the old RPV Head on site or disposition it. This decision has some bearing upon the packaging design and should take into consideration the fact that the old RPV Head will have to be dispositioned at some point in time. Mode of transport and method of disposition must be determined to adequately design the packaging for this end purpose. DOT regulations and the disposition facility regulations must also be considered since they govern how the component will be transported and dispositioned, respectively. Shortsighted decisions to store on site, without consideration of future transport and disposition costs and requirements, could prove to be considerably more costly.

CHARACTERIZATION

Waste characterization is the process which is used to determine both the waste classification for disposal in accordance with 10CFR61 (Reference 1) and the transportation classification in accordance with 49CFR173 (Reference 2). The primary nuclide distribution for the RPV Head (and CRDM's if shipped intact with the Head) is determined based upon one or more smear sample analyses (i.e., "Part 61 analysis"). The activation nuclide distribution is determined via an activation analysis that accounts for the plant's unique operating parameters. Dose-to-curie conversion factors are established via detailed three-dimensional models and calculations then these conversion factors are applied to detailed survey data to establish the amount of curies of each of the radionuclides. To date all RPV Heads have been classified as NRC "Class A" waste.

The 49CFR173 transportation classification is established by comparing the activation and surface activity of the RPV Head (and CRDM's if shipped intact with the Head) to the LSA and SCO limits, and by comparing the nuclide activities to the corresponding A_2 values in 49CFR173. The RPV Heads are then classified as either Type A or > Type A, SCO or LSA material.

Accurate and current radiological and physical data, from the plant in question, is extremely important for accurate characterization of the waste. The radiological data that is necessary includes the complete operational power history of the reactor (including any and all fuel failures), the most recent radiological surveys of the RPV Head, and any applicable smear samples of parts or pieces of the RPV Head, reactor internals, or reactor coolant system piping near the reactor. If possible, the plants should also provide the "N-1" data (i.e., surveys and smears of the RPV Head from the plant outage that occurred one cycle prior to the removal outage).

The physical data that is necessary includes dimensions and weights of the heads (including the CRDM's for those plants that choose to leave them intact with the head). This information is very important for the development of an accurate model for the head in question. The best source for this information is the manufacturer's drawings for the associated RPV Head (and CRDM's if applicable). The manufacturer's drawings are also used to obtain materials of construction, geometric information for the establishment of computer models, and to calculate surface areas and volumes. WMG uses this information to develop a detailed, three-dimensional shielding model of each RPV Head (with CRDM's attached where applicable).

Additional requirements are evaluated to confirm that the RPV Head shipping/disposal package designs meet all of the 49CFR173 transportation criteria which include (but are not limited to): the conveyance limits; the 3-meter unshielded dose rate limit, the exclusive use shipment criteria, the reportable quantities (RQ) limits, and the applicable packaging requirements. The RPV Head packages are designed such that they will meet all 49CFR173 transportation criteria.

The RPV Head packages must also be designed to satisfy the waste acceptance criteria for the disposition facility (i.e., disposal or processing facility) to which they will be shipped. The waste acceptance criteria ensure that the waste conforms to the licensing agreements established between the disposition facility and the particular state in which the facility is located.

Characterization Method

Characterization of the RPV Head (and CRDM's if applicable) is a two-step process, which is required to document that the Department of Transportation (DOT) and disposition facility requirements for transport and disposition, respectively, are met. First, a detailed three-dimensional shielding model of the Head (with CRDM's attached if applicable) is prepared. This model is used as input to QAD-CGGP-A. The nuclide distribution is established from the Part 61 analyzed smears obtained from the inside surfaces of the RPV Head, and from ORIGEN based activation products, as applicable. These nuclide distributions are 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 RPV Head (and CRDM’s if applicable) is calculated using the measured dose rates and the dose-to-curie factors.

The resultant total activity is homogeneously distributed on the interior surface areas to obtain a surface contamination level (i.e., in $\mu Ci/cm^2$). The activity is decayed to the anticipated shipping date to obtain the approximate total activity and the total surface contamination level.

DOT Regulations for Package Design

The general transport (packaging) requirements for RPV Heads are specified in 49CFR173.427, “Transport requirements for low specific activity (LSA) Class 7 (radioactive) materials and surface contaminated objects (SCO)”. The general requirements specified in this section of the CFR include:

(1) The external dose rate must not exceed an external radiation level of 10 mSv/h (1 rem/h) at 3 m from the unshielded material;
(2) The quantity of LSA and SCO material in any single conveyance must not exceed 100 times the A_2 limits;
(3) Packages must meet the contamination control limits specified in 49CFR173.443;
(4) External radiation levels must comply with 49CFR173.441; and
(5) For LSA material and SCO the shipments must be “exclusive use”

An evaluation of the RPV Head (with CRDM’s if applicable) and its packaging must be performed, based upon these regulations, to determine whether it can be shipped in a “strong tight” or Industrial Package (IP). Strong tight containers have less stringent requirements (per 49CFR173.427(b)(3)). The requirements that must be satisfied for the package to qualify as “strong tight” include:

(1) The package must prevent leakage of the radioactive content under normal conditions of transport
(2) The shipment must be exclusive use
(3) The quantity of radioactive material in the RPV Head package must be less than a Type A quantity of material ($<1A_2$)
(4) 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

RPV Heads with CRDM’s attached exceed the criteria for shipment in “strong tight” containers because they are typically greater than a Type A quantity of material. Some of the RPV Heads without the CRDM’s attached have also been classified as greater than Type A quantities of material and did not meet the “strong tight” container criteria.

Shielding Evaluation

The RPV Head package shielding is designed in accordance with 49CFR173.441, which provides the external radiation dose rate limitations for packages used for the transport of radioactive materials, as mentioned previously. Per 49CFR173.441, “…,each package of Class 7 (radioactive) materials offered for transportation must be designed and prepared for shipment, so that under conditions normally incident to transportation,…” the following criteria are met:

(1) 2 mSv/h (200 mrem/h) on the external surface of the package (49CFR173.441(b)(1))
(2) 2 mSv/h (200 mrem/h) at any point on the outer surfaces of the transport vehicle, including the top and underside of the vehicle (49CFR173.441(b)(2))
(3) 0.1 mSv/h (10 mrem/h) at any point 2 meters (6.6 feet) from, in the case of an open vehicle, the vertical planes projected from the outer edges of the conveyance (49CFR173.441(b)(3))
(4) 0.2 mSv/h (2 mrem/h) in any normally occupied space (49CFR173.441(b)(4))

PACKAGING

Package Design

All RPV Head packages must be designed in accordance with the requirements of 49CFR173 (Reference 2). The general design requirements that the packages must meet are contained in 49CFR173.410 and .411. The shielding is designed such that the package will meet the dose rate requirements established in 49CFR173.441. The package components can be designed and fabricated in accordance with the requirements of the American Institute for Steel Construction (Reference 3) and ANSI/AWS D1.1 (Reference 4).

Package Descriptions

There are two basic package designs used by WMG. Both of these designs have been approved by the DOT: the standard shipping/disposal package configuration for RPV Heads without CRDM’s intact (Figure 1), has been successfully used for the Davis-Besse, North Anna Unit 2, North Anna Unit 1, and Surry Unit 1 RPV Heads; and the Intact Vessel Head Transportation System (IVHTS – Figure 2), which will be used to package and transport the Surry Unit 2 RPV Head with the CRDM’s attached. These packages are designed to provide containment comparable to that of an Industrial Package Type 2 (IP-2).

The standard shipping/disposal package consists of the RPV 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 (Figure 1). The total package weights for the loaded standard shipping/disposal packages range from approximately 125,000 to 250,000 lbs.

The WMG IVHTS (patent pending) consists of the RPV Head, including the full-length CRDM’s, a bottom shield and contamination cover plate and three cylindrical ring sections (Figure 2). The total package weights for the loaded IVHTS shipping/disposal packages range from approximately 235,000 to 425,000 lbs.

Both the standard package and IVHTS package are designed to accommodate all PWR RPV Head designs. RPV Heads range in size from approximately 13’-4” to 17’-1” in diameter and approximately 8’-6” to 9’-6” tall (to the top of the CRDM nozzles). The RPV Heads range in weight from approximately 79,000 to 163,300 lbs

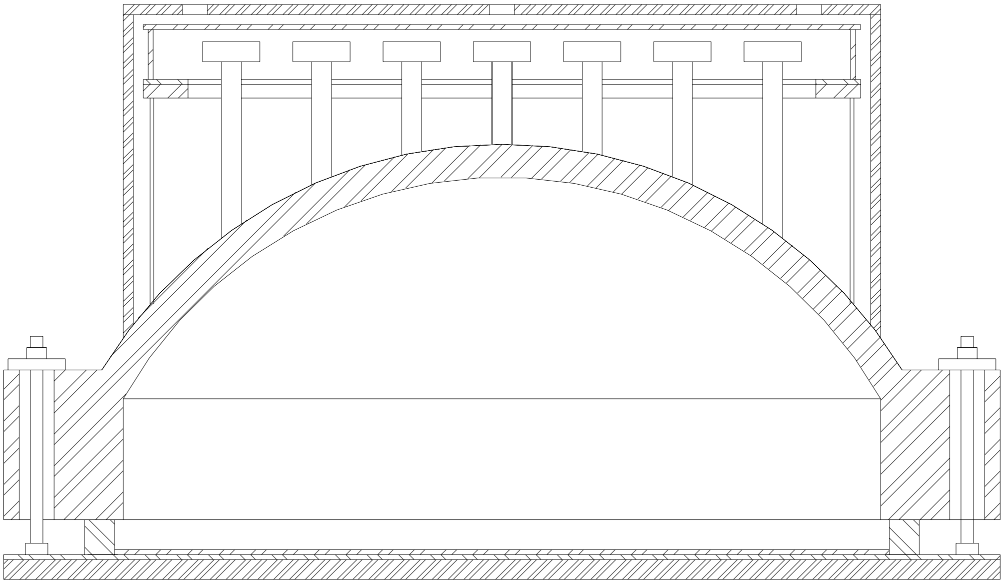

Fig. 1 Standard RPV head shipping/disposal package configuration

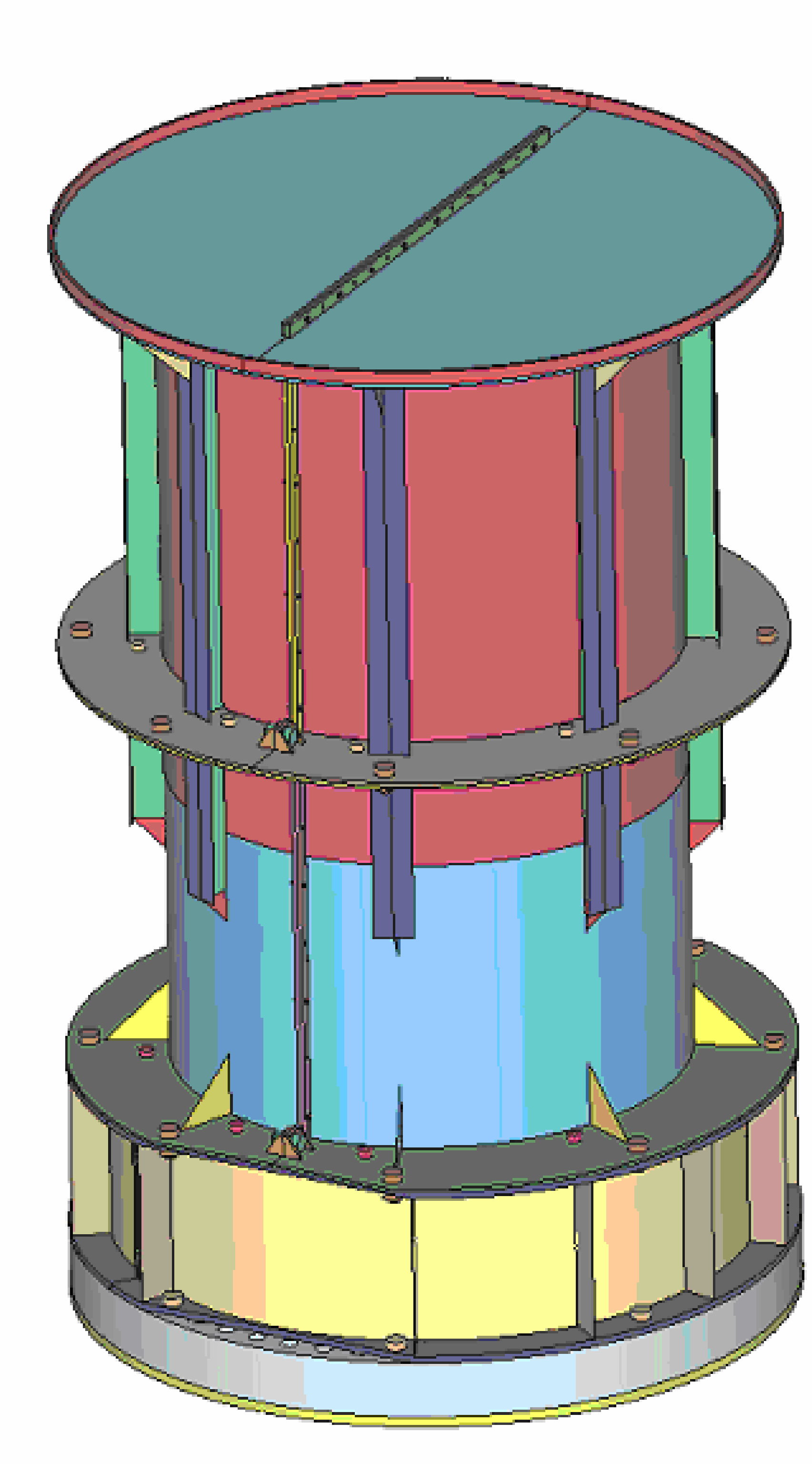

Fig. 2 Intact vessel head transportation system configuration

General Package Design Requirements

The specific package design attributes which are addressed by 49CFR173.410 include handling, lifting attachments, exterior protrusions, water collection pockets, feature safety impacts, normal transport vibrations, chemical compatibility, and valves. The following is a list of each of the attribute requirements:

(1) The package must be designed so that it can be easily handled and properly secured on a conveyance during transport (173.410(a)).
(2) The package must be designed so that each lifting attachment has a minimum safety factor of three against yielding when used to lift the package in the intended manner. It must be designed so that failure of any lifting attachment under excessive load will not impair the ability of the package to meet other requirements (173.410(b)).
(3) The package must be designed such that the external surface, as far as practicable, will be free from protruding features and will be easily decontaminated (173.410(c)).
(4) The outer layer of the package must be designed to avoid, as far as practicable, pockets or crevices where water might collect (173.410(d)).
(5) Any added features must not reduce the safety of the package (173.410(e)).
(6) The package must be designed so that it is capable of withstanding the effects any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (173.410(f)).
(7) The package must be designed such that the materials of construction, including any components or structures, are both physically and chemically compatible with each other and the package contents (173.410(g)).
(8) The package must be designed so that all valves through which the package contents could escape will be protected against unauthorized operation (173.410(h)).

All of these attributes have been incorporated into the WMG packaging design.

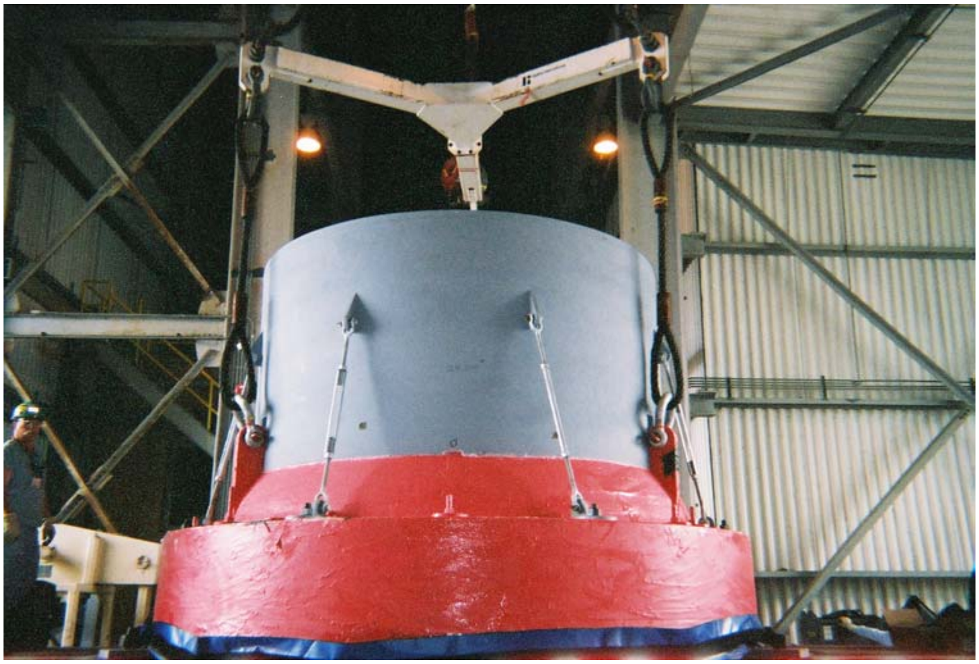

Fig. 3 WMG Standard RPV Head Package

Fig. 4 WMG Intact Vessel Head Transport System

ON-SITE STORAGE EVALUATION

Inherent to the RPV Head replacement project is the decision on what to do with the old RPV Head(s). Each plant must determine whether to store the old RPV Head(s) on site in a mausoleum, or send them off site to be dispositioned.

The determination to store the old RPV Head on site needs to include all related costs, some of which are difficult to quantify accurately. Minor changes in risk assumptions and discount factors could have a significant impact on the storage cost. Some of the major costs that the owner needs to address when considering whether to store on site include:

(1) Mausoleum construction
(2) Mausoleum operating costs
(3) Mausoleum dismantlement
(4) Packaging
(5) Disposal
(6) Transportation
(7) Regulation

If the power station is fortunate enough to have an existing mausoleum it may be able to modify the existing facility, in lieu of having to start anew, to accommodate the RPV Head(s). Incremental construction cost can still be very expensive. Some demolition of the existing facility may be necessary and could result in the generation of waste, some of which may be radioactive. The cost associated with new construction will include site permitting, excavation, design, and construction. The mausoleum must be designed to accommodate the movement of the heavy rigging and handling equipment so that the component can be off-loaded and on-loaded within the facility. This could significantly impact the size of the facility. One plant failed to take this into consideration and had to leave the component on a heavy hauler within the facility.

Mausoleum operating costs, which include those associated with radiological monitoring, facility maintenance, and component maintenance, must be considered. These costs are dependant upon the packaging design and can be reduced if the packaging is designed for its’ eventual (and inevitable) future transport and dispositioning. The shielding and containment capabilities of the component packaging can augment the mausoleum design to minimize exposure to the worker (and the public if its location is accessible to the public) and contain any radioactive contamination that could leak out of, or off of, the component. Inadequate packaging can result in greater than acceptable dose rates, which in turn can result in extra stringent administrative controls. Contamination control problems can result in significant clean up efforts. Radiological monitoring, which includes monitoring of dose rates and leakage of contamination from the component, must be performed on a routine schedule to verify continued package integrity. The storage facility must be maintained to ensure that the radiological monitoring equipment, fire detection system, lighting, ventilation, and sump level monitor (and heating and cooling system if applicable) remain functional. In the event that the package integrity fails these systems need to be operational to minimize the effects of the failure. Preventative maintenance schedules must be followed to ensure that this equipment remains operational.

Mausoleum dismantlement must also be factored into the decision on whether to store on site. The mausoleum will have to be dismantled during the decommissioning of the plant (i.e., after the old RPV Head has been removed from the mausoleum for transport and dispositioning). Radiological surveys (i.e., baseline, intermediate, and final site surveys), demolition, and disposition costs are a function of the component packaging design integrity. They can range from one quarter of the initial construction cost to the full construction cost.

The packaging design is important whether the component is stored on site in a mausoleum or shipped off site and dispositioned. Packaging is required for both shielding and containment of contamination. Sufficient shielding of the source term and containment of contamination must be incorporated for ALARA purposes, even if the component is stored on site. This is necessary to reduce radiological exposure to the worker during the handling and movement of the component to the mausoleum. It is also necessary for the future, and inevitable, handling and movement in preparation for transport and dispositioning. A shortsighted decision to package the component in a non-DOT approved configuration could result in a significant amount of (unnecessary) exposure to the workers as well as a significant additional expense to the owner. The additional costs are those related to re-handling and re-packaging the component prior to it being dispositioned. If a non-DOT approved packaging system is used a special installation area (or facility) will be needed for its removal and for installation of the DOT approved packaging. There will also be a need for special, heavy duty handling equipment for removal of the initial packaging and installation of the new packaging. Thus a significant cost savings can be realized by utilization of DOT approved packaging from the beginning. The cost of the DOT approved packaging will be incurred regardless of when the component is dispositioned, however inflation, and increased disposition costs associated with inflation, must also be accounted for. Historically, disposal costs have risen at a rate greater than inflation – the long-term disposal contracts escalate at about 5% per year as compared to the inflation rate of about 3.9%. It is reasonable to assume that as burial access decreases, the cost for burial of LLW will increase.

The costs associated with transportation are impacted by security upgrades and the degradation of transport systems (i.e., rail spurs, waterways, and roadways). Security measures are ever changing since the terrorist acts of September 11, 2001, in an effort to maintain the highest level of protection. The NRC and DOT have invoked changes that have resulted in increased security requirements for transporting radioactive waste. Security requirements for monitoring and maintaining barge slips at nuclear power plants have become more stringent. Nuclear power plant site access is considerably more difficult than it was before September 11, 2001. The owner must consider these present security changes, and the increased risk associated with future (unknown) changes into his decision to postpone the dispositioning. The owner must also consider the future availability and condition of each transportation mode in his decision to delay dispositioning. The degradation of the condition of the plants transport loading facilities (i.e., truck, barge, or rail), and the future conditions of highways, waterways, and rail lines, all add to the potential for increased costs associated with delaying the dispositioning. It is difficult to quantify the relationship of the degradation of these facilities and byways with time, however one must at least consider that there is real risk associated with this. A four and one-half year drought delayed the barge shipment of numerous large radioactive components to the Barnwell disposal facility. Many waterways that were once navigable are no longer maintained by the Army Corps of Engineers. More and more rail lines are suffering from lack of maintenance, thereby reducing the availability of viable routes for transport of large components.

Each owner must also consider the potential cost risk associated with on-site storage from a regulatory standpoint. Some utilities feel that the Nuclear Regulatory Commission (NRC) may take an active position against on-site storage of such waste. The specifics regarding the timing of, or rationale for, this position are lacking, however national security and/or recent business events could influence the NRC in their position on this subject. A large multi-station utility recently requested quotes for disposing of wastes previously stored in a mausoleum. The utility's corporate policy changed in response to the Enron accounting scandal, and they now book waste as a liability upon generation/packaging. Changes in storage requirements by federal, state, or local authorities could necessitate prompt disposition of the waste, even after a decision to store on site has been made.

There is substantially more financial risk associated with on-site storage than with immediate dispositioning of the old RPV Head (and CRDM's if applicable). The storage decision must consider all factors associated with on-site storage, including the fact that disposition of the component is imminent. Component readiness must also be considered to cover the possibility that the NRC, or other governing authority order the prompt removal of the component from site. If the decision is made to store the component(s) on site the owners should make the conscious decision to store them in DOT approved packaging.

TRANSPORTATION

Transportation Mode Selection

There are three viable modes of transportation available for transport of the old RPV Heads to a disposition facility (i.e., a processor or disposal site). These modes include truck, barge, and rail. Air transport is an option, however the expense associated with this mode of transport for radioactive waste is cost prohibitive, therefore this option is not considered to be viable.

Once the decision has been made to ship the old RPV Head to a disposition facility, the plant must then decide which mode(s) of transport to use. The size and weight of the packaged component must be factored into the decision. Ground loading and weight distribution must be considered for all movements of the packaged component and for all modes of transport. A site evaluation must be performed to determine which of the three modes of transport are viable for the particular site. This evaluation begins with site walk downs to assess the site roadways, from the point at which the component will exit the Containment Building to the interim storage/loading area (if applicable), to the conveyance loading facility (i.e., truck loading area, barge slip, or rail siding). The site roads are evaluated to determine if repairs are necessary and to determine if underground or above ground utilities need to be relocated or protected. The access road(s) to the conveyance loading facilities must also be evaluated. The condition of the roadway into, and out of, the plant must be evaluated for the truck transport option. The condition of the loading facilities for each of the modes must be assessed as well. The costs associated with any repairs or modifications that are required must be factored into the decision. The costs of repairs and/or modifications are added to the associated costs for each of the modes of transportation to tally the total cost for each mode.

Schedule constraints must also be factored into the transport mode decision. Any constraints associated with the modes of transport could impact the decision. Schedule constraints typically include windows of opportunity when trucking routes are available, waterways are navigable, or rail lines are available. Truck companies and truck availability must be considered for each load because there are a limited number of companies that are certified to haul hazardous waste and have trucks large enough to haul these "super loads". Truck route availability is the other schedule constraint that needs to be considered. It is generally a function of "time of day" transport requirements for each state, road conditions, bridge capacities, and bridge clearances. It can take several months per state to obtain the transport permits for loads of this size and type.

Barge transport is dependant upon waterway depth, width, and availability. Water releases may have to be scheduled to accomplish the transport via barge through various waterways. Water releases are governed by hydroelectric needs, flood control, needed downstream flows, recreational use, drinking water needs, and wildlife habitat requirements, all of which must be considered by the agency that controls navigation on the waterway in question. This can be a constraint at both the origination and destination waterways. For example, if the component is shipped to Barnwell via the Savannah River, the water conditions for transport have to meet specific criteria for depth and flow rate before the conditions are considered to be navigable - the threshold guidelines below which transport is not generally performed on the Savannah River are a flow of 8500 CFS and a stage elevation of 7.5 feet at the station near Clyo, Georgia at river mile 60.9. The Savannah River was in a drought condition for approximately four and one-half (4-1/2) years, which resulted in shipping delays for some major components that were to be shipped to the Barnwell disposal facility.

Barge transport is also dependant upon the availability of equipment such and crews. Coordination of the use of the barge(s), tug boat(s) and crews with the availability of the particular waterway(s) needed for transport can be very challenging. Long-range weather forecasting is far from an exact science. This variable causes a level of uncertainty that can be exasperating at best, unless the owner of the waste has the ability to store it on site until conditions for transport exist. Interim storage capability needs to be factored into the decision for this reason.

Rail transport is also dependant upon the availability of equipment. For rail shipments of this size however, the railcar availability is normally not the problem. Availability of a clear rail transport path from the shipping point of origination to transport destination is the biggest problem with rail shipment. Rail lines are most restrictive east of the Mississippi River, where the bridges are generally older and more restrictive from both a load capacity and clearance standpoint. Another significant problem with using rail as the mode of transport is rail line availability. There are a limited number of rail lines, which can be utilized for these large component shipments, particularly from the west coast power plants. As a result of this there are stringent schedule constraints that are invoked by the railroad companies, which limit the feasibility of rail as a mode of transport. The rail companies have to constrain these shipments because of the impact upon their "bread and butter" shipments. The San Onofre nuclear power plant is a prime example of this. They negotiated with the rail companies to allow them to transport their reactor vessel from the plant location in California to Houston, Texas, where it would be loaded from the railcar onto a barge for transport to Barnwell, South Carolina via the Gulf of Mexico and the Intercoastal Waterways. The railroad companies initially agreed to allow this transport to occur, but only during a specific window of time in the winter when it would have the least impact upon their "bread and butter" shipments. Prior to San Onofre completing their negotiations, the railroad companies retracted their initial agreement to allow San Onofre to ship their reactor. As a result San Onofre is now planning to barge ship their reactor to the Barnwell disposal facility from the West Coast via international waters.

Transportation and Emergency Response Plan

A Transportation and Emergency Response Plan must be developed to establish the minimum requirements for overall management, coordination and control for the safe shipment of the radioactive component from the owner's facility to the dispositioning facility. 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. The transportation and emergency response plan contains the responsibilities for all parties involved with the transportation of the component. The parties that are typically involved include the owner, the waste disposal contractor, the transportation contractor, and the dispositioning facility. This plan is maintained by the owner and used as necessary to support the transport of the component to the dispositioning facility.

DISPOSITION

Disposition means processing and/or direct disposal (i.e., burial) of the old RPV Head and CRDM's, as applicable. Of the ten (10) PWR plants that have performed RPV Head replacements to date, six (6) plants have elected disposition over on-site storage. Four (4) of these six (6) have been disposed of at Envirocare of Utah's LLW disposal facility and the remaining two (2) are being processed at the RACE Processing Facility in Memphis, Tennessee.

Once the owner has decided to go with disposition over on-site storage he must then decide whether to process or directly dispose of the component. Direct disposal may appear to be the easiest method for disposition of the old RPV Head (and CRDM's, if applicable), however numerous factors must be considered before making this decision. This decision is a "risk based" economic decision. The factors that the owner must take into consideration prior to making this decision include the configuration of the component (i.e., are CRDM's attached?), the mode and cost of transport, the type and cost of packaging (i.e., is it re-useable?), the presumed risk associated with processing versus direct disposal of the component, and finally the cost of processing versus direct disposal of the component. The lowest cost option may not be the best option based upon the real or perceived risk associated with it. The owner must weigh all of these factors prior to making his decision.

Each of the disposition methods is described in detail below.

Processing

Processing can be defined as "Decontaminating a component to the maximum extent practicable, while minimizing the amount of waste (i.e., both primary and secondary) so that the maximum amount of material from the component can be re-used". This definition is also the objective in the processing of old RPV Heads and CRDM's (as applicable). The extent to which processing is completed is a function of the material make-up of the component, it's geometry, it's age, the condition of the surfaces to be decontaminated, the operating history of the reactor plant from which it came, and the selection of the method(s) used for processing. Depending upon the condition of the component, it may only need minor work to remove the fixed contamination to a level that allows it to be scrapped or smelted. Radiological surveys (i.e., "smear samples") of the RPV Head and CRDM's (as applicable), and the radiological characterization data, are reviewed by the processor to help determine how best to handle the component and which method(s) to employ for decontamination.

Processing of old RPV Heads and CRDM's (as applicable) is performed in a series of steps and usually entails the use of more than one method. It can be an iterative "hit-or-miss" process depending upon the tenacity, depth, and extent of the contamination. Processing begins with receipt of the component and the rigging and handling which is necessary to place the component into a location and an orientation that is manageable. At this point the processor may decide to cut the component into smaller, more manageable pieces prior to decontaminating the component. Once this has been accomplished the task of decontamination of the component begins. The methods that can be utilized for decontamination include, but are not limited to, sand blasting, grit blasting, high pressure water blasting, and chemical etching. The processor will select one of these methods, based upon the component attributes discussed above (i.e., operating history, material make-up, geometry, etc.) and the radiological data provided for the component. The processor establishes a goal for the decontamination process, which is called a decontamination factor (DF). If the initial decontamination effort does not achieve the DF goal that was established, additional processing methods will be employed. Any of the other decontamination methods mentioned above may be utilized to achieve the DF goal. If the additional decontamination efforts do not reduce the level of decontamination sufficiently, and if the processor has not already cut the component into smaller pieces, he may do so at this point in the process, to achieve better access to the pieces and hopefully to obtain greater success with the decontamination. If decontamination efforts are still unsuccessful the processor has the option to package the pieces in standard radiological waste shipping containers and transport it to a Low Level Waste (LLW) disposal facility for burial.

Disposal

Disposal is simply burial of the component in a qualified Low Level Waste facility. As mentioned earlier, four (4) of the ten (10) PWR plants that have performed RPV Head replacements to date have elected to dispose of their RPV Heads at the Envirocare of Utah’s LLW disposal facility. These plants include Davis-Besse, North Anna Unit 1, North Anna Unit 2, and Surry Unit 1. For the sake of this discussion burial of the LLW will be at Envirocare’s disposal facility and processing will occur at the RACE processing facility.

The process of disposal involves development of a waste profile, which is based on the characterization results. This waste profile is submitted to Envirocare of Utah (EOU) for approval of the package. A package configuration sketch is included with the waste profile to show the locations of all package components as well as the grout ports. Once the component is packaged and delivered to EOU’s disposal facility, it disposed of in their “bulk cell” as Class A waste.

Disposal is often considered to be the best option, primarily because it is perceived to entail the least amount of risk. This perception however, is not necessarily true. There is no guarantee that the particular disposal site, for which the component will be buried, will remain open for use. Operational problems, administrative problems, license violations, or any other number of problems could force the facility to close. The chance of this occurring at one of the licensed LLW disposal facilities is fairly low, but not inconceivable. Another likely scenario is that the Envirocare LLW facility will eventually run out of burial space for large components. The point is that even disposal cannot be considered to be risk free.

Cost is the major consideration in the decision on whether to dispose of the component. When performing the economic evaluation packaging, mode of transport, disposal site location, and burial cost all must be factored into this decision. Packaging size and weight can dictate the mode of transport and the feasibility of being able to transport the component to Envirocare’s disposal facility. The location of the owners’ site in relation to Envirocare’s disposal facility can also have a direct bearing upon the mode of transport. If size of the package becomes a limiting factor in getting the component to Envirocare the owner has two options: he can send the component to a processing facility such as the RACE Processing Facility in Memphis, Tennessee, which is accessible via barge, truck, or rail; or he can remove the CRDM’s from the old Head and ship the Head in a WMG type standard package configuration to Envirocare, via truck. Removal of the CRDM’s from non-CE design Heads (i.e., from Heads with welded CRDM’s) can take as much as 150 mSv (15 Rem) of exposure. The costs associated with this extra exposure and lost critical path time needs to be added to the other costs associated with disposal when comparing disposal to processing. Therefore factors associated with disposal and processing must be given adequate consideration so that the best decision can be made.

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 10CFR71, Packaging and Transportation of Radioactive Material