Steam Dryer Segmentation and Packaging at Grand Gulf Nuclear Station – 13577

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ABSTRACT

Entergy recently performed an Extended Power Uprate (EPU) on their Grand Gulf Nuclear Station, near Port Gibson, Mississippi. To support the EPU, a new Steam Dryer Assembly was installed during the last refueling outage. Due to limited access into the containment, the large Replacement Steam Dryer (RSD) had to be brought into the containment in pieces and then final assembly was completed on the refueling floor before installation into the reactor. Likewise, the highly contaminated Original Steam Dryer (OSD) had to be segmented into manageable sections, loaded into specially designed shielded containers, and rigged out of containment where they will be safely stored until final disposal is accomplished at an acceptable waste repository.

Westinghouse Nuclear Services was contracted by Entergy to segment, package and remove the OSD from containment. This work was performed on critical path during the most recent refueling outage. The segmentation was performed underwater to minimize radiation exposure to the workers. Special hydraulic saws were developed for the cutting operations based on Westinghouse designs previously used in Sweden to segment ABB Reactor Internals. The mechanical cutting method was selected because of its proven reliability and the minimal cutting debris that is generated by the process.

Maintaining stability of the large OSD sections during cutting was accomplished using a custom built support stand that was installed into the Moisture Separator Pool after the Moisture Separator was installed back in the reactor vessel. The OSD was then moved from the Steam Dryer Pool to the Moisture Separator Pool for segmentation. This scenario resolved the logistical challenge of having two steam dryers and a moisture separator in containment simultaneously.

A water filtration/vacuum unit was supplied to maintain water clarity during the cutting and handling operations and to collect the cutting chips.

INTRODUCTION

The Westinghouse team included WMG, Inc. and Barnhart Crane and Rigging Co. WMG supplied the specially designed containers used to move the Steam Dryer sections out of containment and transport them to the on-site mausoleum where they will be stored indefinitely until final disposal. Barnhart performed all the rigging required to move the containers into and out of containment and the transportation to move them to the mausoleum.

In preparation for the Steam Dryer replacement, Entergy performed an engineering evaluation to determine the optimum ingress/egress routes to bring the new Steam Dryer sections into containment, and to remove the old Steam Dryer and move it to interim storage in the on-site mausoleum. This was critical to the success of the project due to the highly congested environment and the large component size. Laser scanning of the proposed route was performed along with walk-downs to obtain physical measurements. All of the data was combined into a 3D CAD model and made available to Westinghouse. Based on this modeling, the Westinghouse team determined the bounding external size and shape of the containers that could be used to move the old Steam Dryer sections out of containment. Working within these dimensional constraints, the Westinghouse team designed a container that met the structural and shielding requirements to safely contain and manipulate the dryer sections through the arduous rigging path. As a check, a model of the proposed container design was added to the environment model and the entire rigging sequence was simulated to identify any potential interferences.

SEGMENTATION METHODOLOGY AND EQUIPMENT

Segmentation Plan

As typical for a internals dismantling project, the storage container design drove the segmentation plan. The primary object of the segmentation plan was to minimize the amount of cutting time required to remove the Steam Dryer from the MS/SD Pool. Another goal was to limit the number of containers to three in order to reduce container handling time and save available workspace in containment.

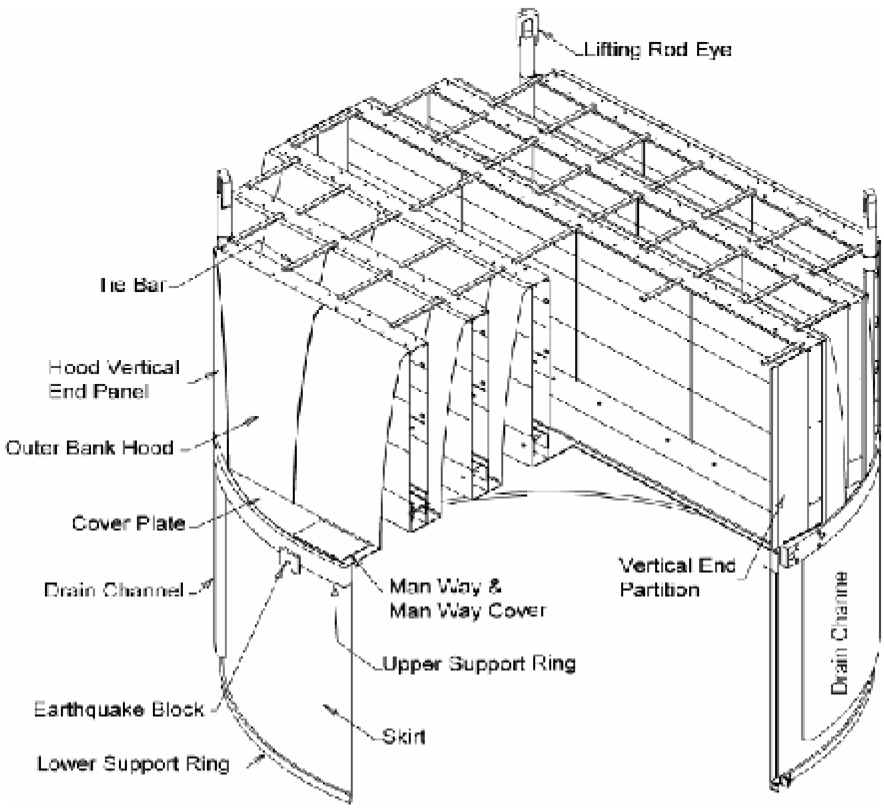

Figure 1 - BWR 6 Steam Dryer (Courtesy EPRI BWRVIP-139)

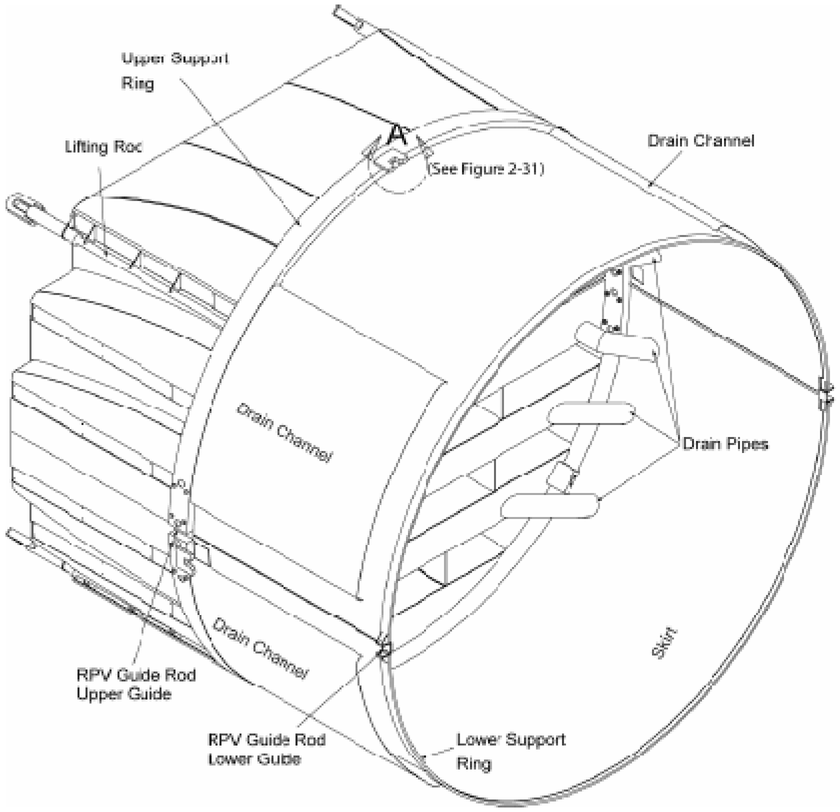

Figure 2 - BWR-6 Steam Dryer Bottom View (Courtesy EPRI BWRVIP-139)

Referring to Figures 1 and 2, the cutting sequence was as follows:

1. Vertical cuts to sever Drain Channels
2. Horizontal cuts to remove Drain Channels
3. Internal bore cuts to sever Drain Pipes
4. Cut and remove center row Tie Bars
5. Sever Cover Plate
6. Vertical cuts to sever Vane Bank End Partitions
7. Hold Down Removal
8. Vertical cuts to segment Skirt Assembly
9. Horizontal cut to sever Skirt sections
10. Cut and remove Lifting Eyes

More than seventy cuts were required using several different cutting machines. The resulting sections included the Vane Bank Assembly severed into two equal pieces, the Skirt Assembly cut into multiple curved plates, and the removed Lifting Eyes. Each Vane Bank section was packed into its own container. The Skirt Assembly sections were packed into the third container. The lifting eyes were packed in with the skirt sections.

Dryer Support Stand

A specially designed Dryer Support Stand was provided to elevate the Steam Dryer Assembly above the pool floor to give saw access for the Skirt Assembly cuts. The stand also stabilized the heavy dryer sections, preventing them from falling and damaging the cutting equipment or pool liner as they were cut free. The stand was a two-piece design to facilitate ingress/egress in and out of containment. Protective steel floor plates were integral to the stand design and located at all vertical cut positions near the pool floor.

Figure 3 - Steam Dryer Support Stand

Spreader Beam

A spreader beam was required to lift the cut Upper Bank Assembly halves out of the MS/SD Pool and load them in to the Storage Containers. This device provided a safe 4-point lifting arrangement. The original lifting eyes had to be removed from the dryer so that the Vane Bank Assemblies would fit in the storage containers. Remotely actuated clevis devices were designed to provide temporary attachment points for the rigging. Lifting holes were punched through the dryer sections using a specially designed hydraulic hole punch. A high strength pin on the clevis device was then passed through the hole and locked in place. Polyester slings attached to the spreader beam were connected to the clevises to complete the rigging assembly. After loading each dryer section into a storage container, the sacrificial slings were disengaged and packaged with the dryer sections. This technique was an ALARA effort to minimize exposure to the workers.

Temporary Gantry Crane

To provide dedicated crane support to the segmentation activities, a portable Gantry-style crane was erected over the MS/SD Pool. The 2-ton crane used the existing refueling machine rails that straddled the pool. The crane features included a motorized hoist, trolley and rail drive, an anti-tipping device and 18 feet of under hook height. The segmentation technicians worked from the existing Auxiliary Bridge that runs on an inboard parallel set of rails, using the gantry crane to support various tools and material handling devices. This arrangement greatly decreased the dependence on the Polar Crane which was needed for other refueling operations during the outage. The modular design allowed for ease of set-up and dismantling with minimum impact to schedule.

CUTTING EQUIPMENT

Disk Saw

The primary cutting tool was the versatile Westinghouse Disk Saw. The Disk Saw was originally developed in Sweden for segmenting ABB- BWR components across the Nordic fleet. The design has evolved to adapt to a multitude of PWR dismantling applications and now GE-BWRs. Its modular design allows this tool can be configured in a variety of different ways to suit the application. Typically the saw drive unit is attached to a feed table that clamps to the work piece. The hydraulic drive spindle rotates a large diameter blade that has been developed specifically for use on irradiated stainless steels. The variable speed spindle and feed axes are remotely controlled.

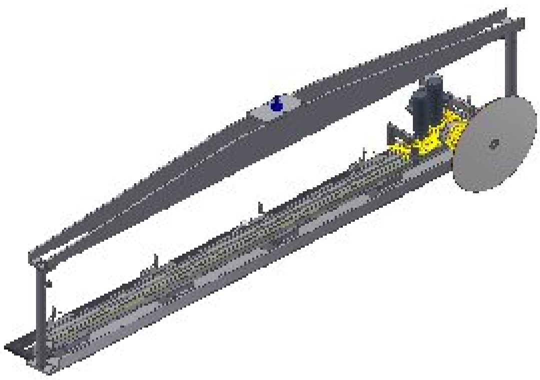

Figure 4 - Westinghouse Disk Saw (Tie-Bar Configuration)

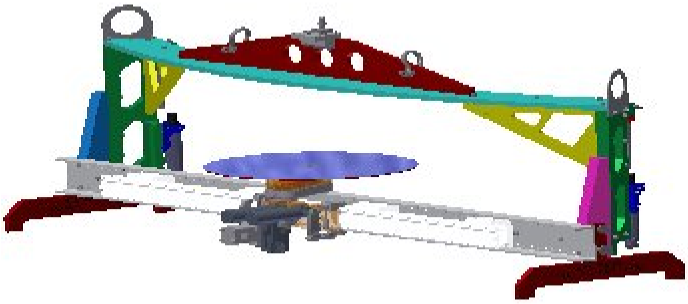

Figure 5 - Westinghouse Disk Saw (Skirt Configuration)

Drain Pipe Severance Tool

The Drain Pipe Severance Tool was specifically designed to for this application. The twelve Drain Pipes had to be cut in two locations each to separate the Upper Bank Assemblies from the Skirt Assemblies and to allow for efficient packing of the skirt sections. Each pipe was positioned at a unique angle and had varying lengths so the tool needed to be easily configurable for each instance. A self-centering, mechanical clamping boring bar design was selected with a radially advancing cutting bit mounted to a rotating head. The tool was pre-configured for each cut and then lowered into the pool with a pole attached to the Gantry Crane hoist. A technician would guide the tool into position by manipulating the pole from the Auxiliary Work Bridge. Once positioned, the tool was locked into place manually and then operated from a remote control console.

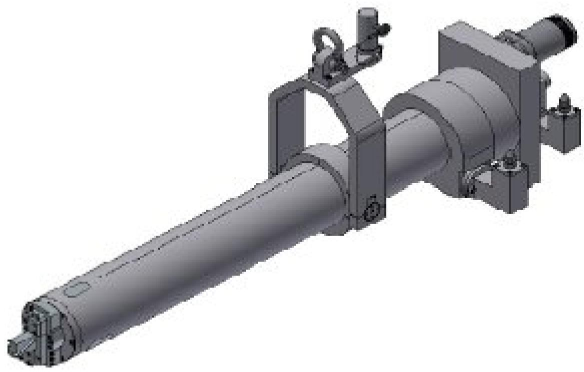

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Figure 6 - Drain Pipe Severance Tool

Metal Nibbler

To gain access to the Drain Pipes that connect the Skirt Assembly to the Upper Bank Assemblies, the Drain Channels must be removed. These channels are formed from 1/8 inch thick stainless steel sheet. To quickly cut these, a commercially available metal nibbler tool was adapted to be operated underwater with remote control and delivered with a long handled pole from the Auxiliary Work Bridge. These vertical cuts were easily accomplished by attaching the delivery pole to the Gantry Crane Hoist and raising the nibbling tool at a moderate feedrate.

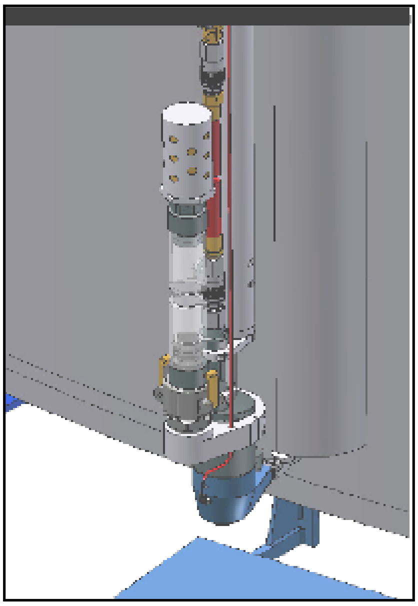

Figure 7 - Modified Metal Nibbler on Drain Channel

DEBRIS CONTROL

Water Filtration/Debris Vacuum System

A modified Tri-Nuclear Water Filtration/Vacuum System was used to supplement the plant water filtration to maintain water clarity during the cutting operations. A custom designed “knock-out can” device was installed in the suction line to collect the cutting chips. The chips were allowed to fall by gravity to the pool floor during cutting and then were vacuumed up using custom vacuum wands after each major cutting operation. A final pool clean up was also performed after all segmentation was completed and all support equipment was removed from the pool. Using this arrangement prevented activated chips from embedding in the filter cartridges resulting in higher dose levels on the cartridges. The knock out device was designed so that the loaded chip can could be easily removed under water and sealed with a closure lid. The loaded chip cans were packaged in the storage containers with the segmented dryer components.

FME Barrier

To prevent any suspended cutting debris from migrating over the weir wall that separated the MS Pool from the main Refueling Cavity, a FME (Foreign Materials Exclusion) Barrier was installed across the top of the weir wall prior to start of cutting operations. The lightweight barrier sealed against the pool sides walls with a compliant elastomeric material and extended several inches above the water surface.

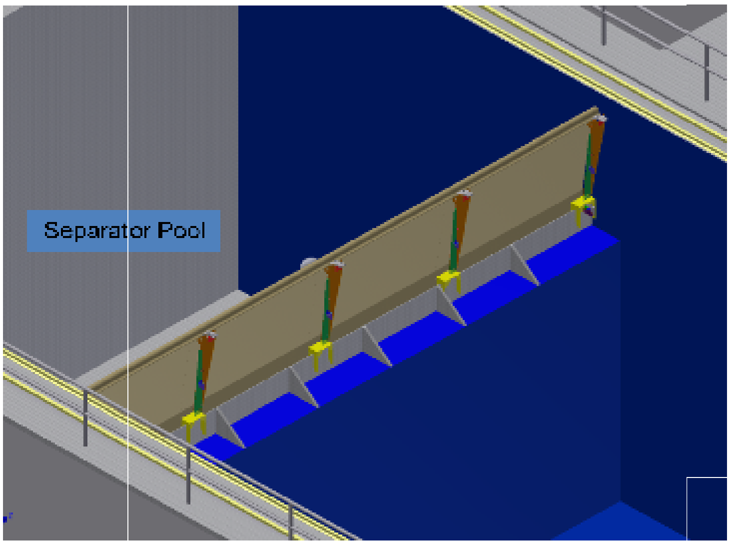

Figure 8 - FME Barrier Installed on Weir Wall

WASTE CONTAINERS

The segmented Steam Dryer sections were packed into three identical custom designed waste containers. The container design was constrained by the maximum outer dimensions determined by the restricted load path. They also had to be structurally optimized to maximize the allowable payload while not exceeding allowable containment floor loads, and provide adequate radiological shielding to the workers guiding the loaded containers through the Containment building. The loaded containers were safely transferred from the refueling floor to the mausoleum without incident.

Figure 9A – Dryer Skirt Sections packed into custom Container

Figure 9B - Loaded Container rigged out of Containment Building

SCHEDULE

The project planning and equipment development phase spanned approximately 14 months. During this time the segmentation and packaging plan was developed, and the custom waste containers were designed and fabricated. In parallel, the cutting, support and handling equipment was designed and manufactured. Extensive equipment testing and qualification was performed using a realistic mock-up at the Westinghouse testing facility in Lake Bluff, IL. After the equipment and procedures were qualified, each technician assigned to the project was trained and qualified. The testing and training was witnessed by various Entergy personnel so they would get a better understanding of the cutting operations prior to the outage.

The segmentation and packaging work was planned to take place on critical path during the Spring 2012 refueling outage. The project schedule allotted 11.5 days for this scope. The actual work was completed in 12 days due to some delays caused by minor equipment issues and other work taking place in parallel that interfered with the segmentation activities. The planned duration for the transfer of the loaded waste containers to the mausoleum and the removal of all Westinghouse equipment from the containment building was originally six days. Due to polar crane re-prioritization by Entergy to expedite other outage work, some of this scope was shifted off critical path. The actual duration for this scope was 15 days. All work was completed with no safety issues and in accordance with the ALARA plan.

CONCLUSIONS

Based on the feedback Westinghouse received from Entergy, the project was deemed a success. Many "Lessons Learned" and "Best Practices" were discovered throughout the project that were documented and will be incorporated in future projects to continuously improve performance and mitigate risk. Detailed planning, extensive testing and personnel training were essential to the successful execution of this project. Timely communication between the Westinghouse team and Entergy was also critical to success. During busy refueling outages, initial plans need to be adjusted to accommodate unforeseen changing conditions. Close coordination between the Westinghouse project manager and the Entergy outage management team allowed for some re-prioritization of activities with minimum impact to the Steam Dryer segmentation and removal scope. And finally, this project was a good example of how modern engineering tools such as laser scanning and 3D CAD simulation can be used to plan a complex component handling challenge in a highly congested environment. Other utilities planning similar work should take advantage of this very useful technology as well.