

## **Importance of Upfront Preparatory Works for Vessel Internals Segmentation Projects - 16096**

Joseph Boucau, Per Segerud, José Valdivieso, Jean-Luc Guyot  
Westinghouse Electric Company

### **ABSTRACT**

For more than thirty years, Westinghouse has been involved in reactor internals segmentation activities in the U.S. and Europe. Westinghouse completed in 2015 the segmentation of the reactor vessel and reactor vessel internals at the José Cabrera nuclear power plant in Spain and a similar project is on-going at Chooz A in France. Four more major reactor internals segmentation projects have been recently awarded in Sweden (Barsebäck 1-2) and in Germany. (Philippsburg 1 and Neckarwestheim 1).

For all reactor dismantling projects, it is essential that all activities are thoroughly planned and discussed upfront together with the customer.

Detailed planning is crucial for achieving a successful project. One key activity in the preparation phase is the "Segmentation and Packaging Plan" that documents the sequential steps required to segment, separate, and package each individual component, based on an activation analysis and component characterization study.

Detailed procedures and specialized rigging equipment have to be developed to provide safeguards for preventing certain identified risks.

The preparatory work can include some plant civil structure modifications for making the segmentation work easier and safer.

Some original plant equipment is sometimes not suitable enough and need to be replaced.

Before going to the site, testing and qualification are performed on full scale mock-ups in a specially designed pool for segmentation purposes. The mockup testing is an important step in order to verify the function of the equipment and minimize risk on site.

This paper is describing the typical activities needed for preparing the reactor internals segmentation activities using under water mechanical cutting techniques. It will provide experiences and lessons learned that Westinghouse has collected from its recent projects and that will be applied for the new awarded projects.

### **UPFRONT PLANNING**

Detailed planning is essential to a successful project, and typically a "Segmentation and Packaging Plan" is prepared to document the effort. The usual method is to start at the end of the process, by evaluating handling of the containers, the waste disposal requirements, what type and size of containers are available for the different disposal options and working backwards to select a cutting method and finally the cut geometry required. 3-D models help complete those tasks as well as for determining the logistics of component placement and movement in the reactor

cavity, which is typically very congested when all the internals are out of the reactor vessel in various stages of segmentation.

The main objective of the segmentation and packaging plan is to determine the strategy for separating the components so that they can be disposed of in the most cost effective manner. Such strategy can be driven by many factors such as waste container selection, disposal costs, transportation requirements, etc., but must be considered early in the planning phase.

Once the preliminary packaging plan is developed, the primary cutting methodology can be determined (e.g. Plasma Arc Cutting, Abrasive Water Jet Cutting, mechanical cutting). All cutting processes typically generate varying degrees of secondary waste. This waste must also be properly controlled, collected and packaged for disposal. The methodology and equipment for this effort is specific to the cutting process.

For the José Cabrera reactor internals segmentation, the first year of the project was dedicated to engineering studies, design work and manufacturing of equipment needed to perform the work. Detailed 3-D modeling has been the basis for tooling design and provided invaluable support in determining the optimum strategy for component cutting and disposal in waste containers, taking account of the radiological and packaging constraints. Fig.1 shows an example of a 3-D model that helped determine how to cut the guide tubes at the José Cabrera plant.

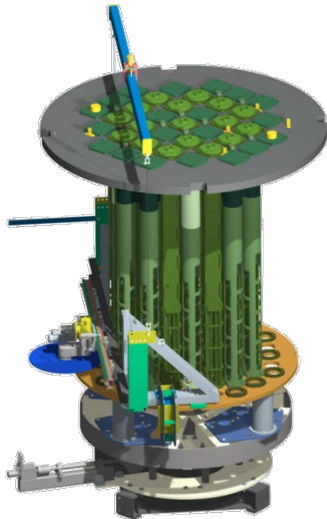


Fig.1. Guide Tube segmentation

## **RISK MITIGATION**

Another key element of the segmentation and packaging plan is the material handling plan. Many of the pieces that will be cut and packaged need to be rigged and manipulated to get them into their respective disposal container. Since many of these pieces could potentially produce a lethal dose of radiation if they were inadvertently raised out of the water, safeguards must be in place to prevent any possibility of this occurring. Another risk is if one of the cut pieces were dropped, damage to the reactor cavity liner or other critical equipment could result. Detailed

procedures and specialized rigging equipment have been developed to provide these safeguards.

To mitigate the possible risks due to uncontrolled drop of heavy pieces and resulting damages to the Stainless Steel liner of the pool floor, Westinghouse steel protection plates are always installed to cover all exposed floor areas. The plates have a typical thickness of 6 mm. For the José Cabrera reactor vessel internals and reactor vessel segmentation projects, protection plates have been installed at the bottom of the spent fuel pool and in addition, two contingency pumps have been foreseen to address the residual leakage risk. Fig.2 shows the installation of protection plates at the bottom of the pool.

Moreover, a dedicated circular steel plate is recommended to be placed inside the reactor vessel, resting on the upper flange. The objective of this plate is twofold: 1) it is serving as a protection of the Reactor Vessel inside volume against drop of pieces or equipment, and 2) it will effectively isolate the Reactor Coolant System from the Refueling Cavity/Spent Fuel Pool water, preventing any recontamination.

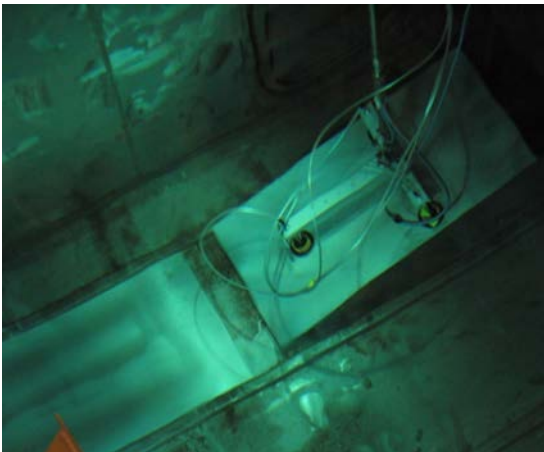


Fig.2. Installation of protection plates

## **PREPARATORY ACTIVITIES**

The preparatory work can include some plant civil structure modifications for making the segmentation work easier and safer.

At José Cabrera, a number of activities had to be performed before the actual cutting activities could start: e.g. cutting of the wall between the reactor cavity and the spent fuel pool, securing the pool integrity, characterizing the internals, retrieval of spent fuel racks, installing a new working bridge and cleaning of the pool floor and water.

Cutting of the wall between the reactor cavity and the spent fuel pool was necessary to provide access to a deeper pool and led to better water shielding for the operators.

That constituted a substantial design change and detailed structural analyses had to be performed to demonstrate that this demolition was safe. Moreover, this civil modification proved to be useful for the next reactor vessel segmentation project,

facilitating the transfer of the vessel in one piece to the spent fuel pool area. Fig.3 shows the new connection created between the spent fuel pool and the reactor cavity.



Fig.3. Demolition of the spent fuel pool separation wall

The sealing of the pool walls was a challenging task as the initial leakage was substantial and coming from all over the pool area. The floor of the reactor pool was therefore reinforced with a 15 cm thick concrete layer whereas leakages in the wall were sealed by injecting sealant into all identified cavities and the whole surface was then painted with an impermeable paint. The leakages in the spent fuel pool steel liner had to be sealed under water because highly irradiated operational waste was stored in that pool which prevented draining of it. This operation was performed using divers as indicated on Fig.4.



Fig. 1. Diver performing leak tightening

In Chooz A, the entrance to the reactor cave has been enlarged to allow access to some heavy equipment, like the future reactor vessel stand that will be sealing the reactor pit after removal of the vessel (see Fig.5.). Other significant civil work modifications occurred for allowing the installation of a hot cell for the future drying and characterization of the cut internals and final container loading. To achieve that, a previous steam generator pit has been sealed with a concrete slab to create the necessary space for installing the hot cell. Another steam generator pit has been also sealed for installing the future dry cutting workshop. Other significant works had to be performed for bringing new electrical cabinets and installing new ventilation ducts.



Fig.5. Enlargement of reactor cave entrance

At José Cabrera, a new working bridge has been installed in the spent fuel pool (see Fig.3.). The existing spent fuel pool bridge led to some concerns about the adequacy of its load capacity (2 tons) and the fact that it should have been removed to raise water level higher during the Lower Internals transfer, have compelled Westinghouse to decide its replacement by a new bridge, with higher capacity, and placed as at a height compatible with the maximum water level. This new arrangement had the additional benefit of placing the access to the bridge at the floor level, simplifying the access of personal and equipment to it. The same replacement will occur at Chooz A.

## REMOVAL OF THE SPENT FUEL RACKS AND CUTTING OF OPERATIONAL WASTE

At José Cabrera, before installing the new working bridge, the spent fuel racks had to be removed from the spent fuel pool. However, some operational waste was still stored in rack cells and needed to be segmented and packaged first. A number of operational waste such as RCCA's, primary sources, secondary sources were cut with shearing tools and positioned into special designed canisters that was later put into the Multi-Purpose Canisters along with the other high activated waste. Fig.6 shows an example of the type of operational waste retrieved from the spent fuel racks.



Fig. 6. Flow diffuser in spent fuel rack

## QUALIFICATION

A qualification is usually performed in the Westinghouse test facility located in Västerås where 1:1 scale mockups of chosen parts of the internals are manufactured (see Fig.7). The mockup testing is an important step in order to verify the function of the equipment and minimize risk during segmentation work on site. When the qualification is approved by the customer, all equipment is then transported to site with a high confidence of a successful implementation.



Fig. 7. Qualification in Västerås

## CONCLUSION

Many lessons have been learned during the preparation of segmentation projects. The most important ones were as follows:

- Reactor dismantling is not just cutting internals and a vessel.
- A detailed study of the optimum dismantling scenario must be done taking account of the available plant systems and infrastructure.
- Especially for old plants, significant plant modifications need to be considered for meeting the project goals, including civil work modifications, new water filtration system, new power supply, new HVAC system, ...
- Specific waste management constraints may also require installation of dedicated equipment.

These lessons learned will help us perform successfully the future dismantling of reactor vessel internals.