

Reactor Vessel and Reactor Vessel Internals Segmentation at Zion Nuclear Power Station – 13230

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ABSTRACT

Zion Nuclear Power Station (ZNPS) is a dual-unit Pressurized Water Reactor (PWR) nuclear power plant located on the Lake Michigan shoreline, in the city of Zion, Illinois approximately 64 km (40 miles) north of Chicago, Illinois and 67 km (42 miles) south of Milwaukee, Wisconsin. Each PWR is of the Westinghouse design and had a generation capacity of 1040 MW.

Exelon Corporation operated both reactors with the first unit starting production of power in 1973 and the second unit coming on line in 1974. The operation of both reactors ceased in 1996/1997.

In 2010 the Nuclear Regulatory Commission approved the transfer of Exelon Corporation's license to ZionSolutions, the Long Term Stewardship subsidiary of EnergySolutions responsible for the decommissioning of ZNPS. In October 2010, ZionSolutions awarded Siempelkamp Nuclear Services, Inc. (SNS) the contract to plan, segment, remove, and package both reactor vessels and their respective internals.

This presentation discusses the tools employed by SNS to remove and segment the Reactor Vessel Internals (RVI) and Reactor Vessels (RV) and conveys the recent progress. SNS's mechanical segmentation tooling includes the C-HORCE (Circumferential Hydraulically Operated Cutting Equipment), BMT (Bolt Milling Tool), FaST (Former Attachment Severing Tool) and the VRS (Volume Reduction Station). Thermal segmentation of the reactor vessels will be accomplished using an Oxygen-Propane cutting system.

The tools for internals segmentation were designed by SNS using their experience from other successful reactor and large component decommissioning and demolition (D&D) projects in the US. All of the designs allow for the mechanical segmentation of the internals remotely in the water-filled reactor cavities.

The C-HORCE is designed to saw seven circumferential cuts through the Core Barrel and Thermal Shield walls with individual thicknesses up to 100 mm (4 inches). The BMT is designed to remove the bolts that fasten the Baffle Plates to the Baffle Former Plates. The FaST is designed to remove the Baffle Former Plates from the Core Barrel. The VRS further volume reduces segmented components using multiple configurations of the 38i and horizontal reciprocating saws.

After the successful removal and volume reduction of the Internals, the RV will be segmented using a "First in the US" thermal cutting process through a co-operative effort with Siempelkamp NIS Ingenieurgesellschaft mbH using their experience at the Stade NPP and Karlsruhe in Germany.

SNS mobilized in the fall of 2011 to commence execution of the project in order to complete the RVI segmentation, removal and packaging activities for the first unit (Unit 2) by end of the 2012/beginning

2013 and then mobilize to the second unit, Unit 1. Parallel to the completion of the segmentation of the reactor vessel internals at Unit 1, SNS will segment the Unit 2 pressure vessel and at completion move to Unit1.

INTRODUCTION

Siempelkamp Nuclear Services Inc. (SNS) is contracted to perform the segmentation and packaging of the Zion Nuclear Power Station (ZNPS) Reactor Vessel Internals (RVI) and Reactor Vessels (RV). The ZNPS is a two unit Westinghouse Pressurized Water Reactor (PWR) facility that has been shut down for approximately 15 years.

The ZNPS is located on the Lake Michigan shoreline, in the city of Zion, Illinois approximately 40 miles (64 km) north of Chicago, Illinois and 42 miles (67 km) south of Milwaukee, Wisconsin. Each PWR had a generation capacity of 1040 MW.

Exelon Corporation operated both reactors with the first unit starting production of power in 1973 and the second unit coming on line in 1974, both served Chicago and the northern quarter of Illinois. The operation of both reactors ceased in 1996/1997.

In 2010 the Nuclear Regulatory Commission approved the transfer of Exelon's Corporation's license to ZionSolutions, the Long Term Stewardship subsidiary of EnergySolutions responsible for the decommissioning of ZNPS. In October 2010, ZionsSolutions awarded SNS the contract to plan, segment, remove, and package both reactor vessels and their internals. [1]

During operation, the RV and RVI became irradiated to the point that their removal requires segmentation by remotely-operated cutting equipment.

CUTTING AND SEGMENTATION APPROACH

SNS decided to use a two-step segmentation approach. The first step was to cut, segment and package the RVI by using mechanical segmentation processes. These mechanical processes include milling, drilling, and sawing.

The tools for internals segmentation were designed by SNS using their experience from other successful reactor and large component decommissioning and demolition (D&D) projects in the US. The designs address the mechanical segmentation of the internals remotely in the water-filled reactor cavity.

After the successful segmentation, removal and volume reduction of the RVI, the second step is to segment the RV using a thermal cutting process new to the United States through a co-operative effort with Siempelkamp NIS Ingenieurgesellschaft mbH using their gained experience at the Stade NPP and Karlsruhe reactors in Germany. This thermal cutting will take place in a dry vessel and cavity.

TEMPORAL SEQUENCE OF THE PROJECT

Time is essential. These words are important in each D&D project. So SNS had to find a compromise between labor costs, shifts, and interactions with other decommissioning activities to find an optimal sequence for both RVIs and RVs.

SNS decided to segment the RVIs of both units in a sequential order (starting with Unit 2, followed by Unit 1). During the segmentation process of Unit 1, the mobilization for the RV segmentation at Unit 2 will start. The work is planned to begin using some of the labor in Unit 2 as their RVI responsibilities are completed, helping to minimize labor costs.

The SNS approach is to segment the RVI and the vessels of both reactors in approximately 3 years. This is a challenge. The success depends on the performance of the Siempelkamp team, the successful operation of our tools and also of the close cooperation with ZionSolutions. [2]

Lessons learned in the Unit 2 segmentation efforts will be applied to optimize the implementation of our segmentation processes in Unit 1 (the second unit).

MECHANICAL TOOLS, DISMANTLING EQUIPMENT AND TECHNOLOGIES

The conceptual approach developed for the Zion RV and RVI segmentation took advantage of experience and lessons learned obtained on several reactor decommissioning projects, including Rancho Seco, Fermi and PARR. The specific segmentation tools for Zion include the Volume Reduction Station (VRS), the Bolt Milling Tool (BMT), the Circumferential Hydraulically Operated Cutting Equipment (C-HORCE) and the Former Attachment Severing Tool (FaST). [3]

VRS: Once the upper and lower internals are removed from the RV, further segmentation and volume reduction is necessary in order to package the materials in acceptable low level waste disposal containers and GTCC canisters. The VRS employs a circular milling saw and a reciprocating milling saw to segment the upper internals, upper and lower Core Plates, Core Barrel sections and Thermal Shield sections. The VRS includes a cutting platform capable of supporting reactor components up to approximately 54,000 kg (120,000 lbs.). The platform can rotate 360° and can move the components forward and aft 36 inches in either direction in order to position the component for segmentation at a fixed saw position.

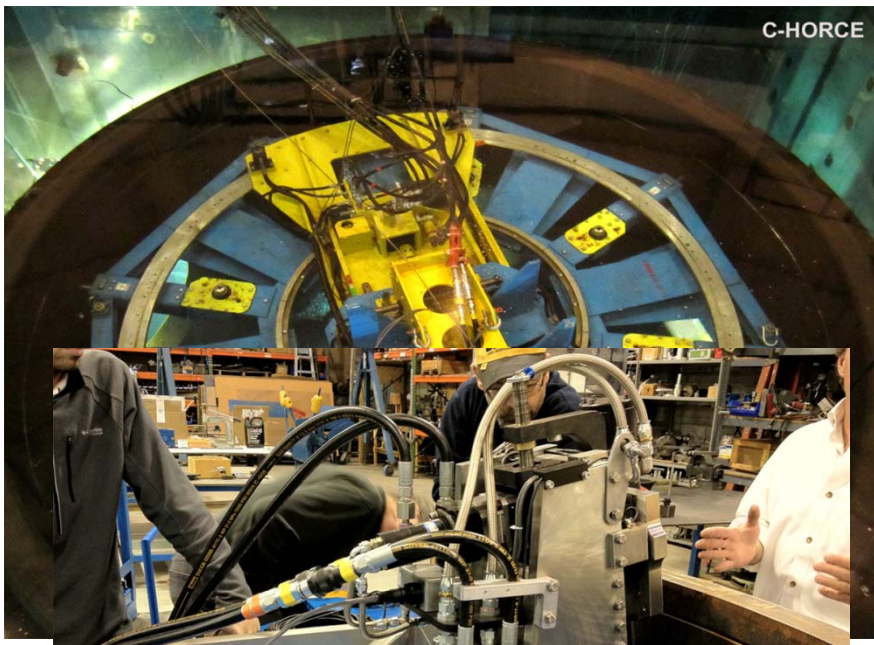


Figure 1: C-HORCE in operation

C-HORCE: The C-HORCE is



Figure 2: FaST during mock-up

designed to make seven circumferential cuts through the lower internals (flange area, Core Barrel wall, and Thermal Shield) with thicknesses up to 100 mm (4 inches) (figure).

BMT: The BMT is designed to remove the bolts that fasten the Baffle Plates to the Baffle Former Plates.

FaST: The FaST is designed to remove the Baffle Former Plates from the Core Barrel.

SEGMENTATION SEQUENCE FOR THE RVI

The RVI at Zion is composed of two assemblies which are designed to be removed from the RV. The Upper Internals weigh approximately 50,000 kg (110,000 lbs.); the Lower Internals weigh approximately 120,000 kg (260,000 lbs.).

The following procedure reflects the sequence performed on Unit 2.

The process starts with the lifting of the Upper and Lower Internals with their existing lifting devices. The Upper Internals (UI) were placed on a fixture designed to present it in a horizontal position and the Lower Internals (LI) were positioned on the LI stand.

The UI was laid on its side and placed on the VRS for segmentation. The Guide Tubes and the Support Columns of the UI were cut and removed using a 38i Saw (38-inch diameter circular milling blade) on the VRS and loaded into disposal liners.

Parallel to these activities, the C-HORCE was used to cut two rings from the Core Barrel (the flange area and the Core Barrel at the top of the Thermal Shield). After this the BMT was used to mill the fasteners that secure the Baffle Plates to the Baffle Former Plates. After milling 1,232 bolts with the BMT, the Baffle Plates were removed and lifted out of the LI for placement in the GTCC liners.

The next step inside the LI was the deployment of the FaST to mill the fasteners that held the Baffle Former Plates to the Core Barrel. This milling process continued until the Baffle Former Plates were removed below the next cut location for the C-HORCE circumferential saw. The process of alternating FaST cuts and C-HORCE cut were continued until all of the LI was segmented. The resulting Core Barrel and Thermal Shield rings were staged and later volume reduced into segments necessary for packaging into disposal liners after the UI segmentation was completed.

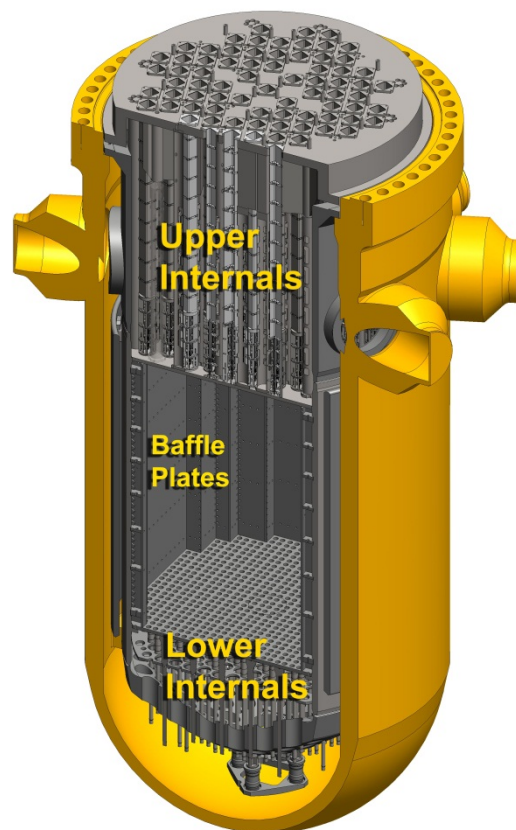


Figure 3: Zion reactor Vessel with Internals

The top section of the UI consists of the Deep Beam Weldment, the Upper Core Plate and the remaining sections of the Guide Tubes and Support Columns. After removal of the Guide Tubes and Support Columns, the Deep Beam Weldment was cut into ten segments, each weighing less than 4,500 kg (10,000 lbs.).

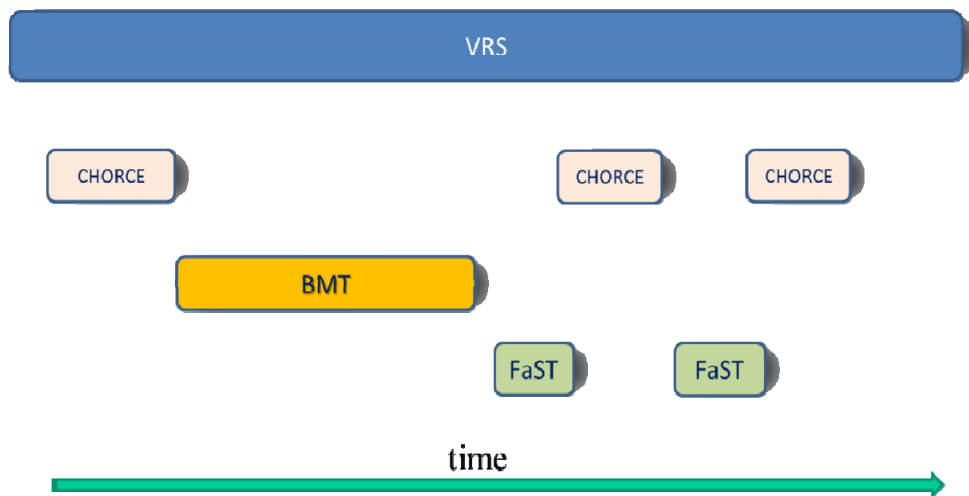


Figure 4: relative schedule for RVI

The Thermal Shield has been provided with guide blocks on the interior of the cylinder. These guide blocks align and rest upon similar blocks provided on the upper end of the lower Core Barrel. These blocks were bolted in place which prevents the removal of the inner Core Barrel without removal of the outer Thermal Shield. Accordingly, the small rings of both the Thermal Shield and Core Barrel were removed concurrently.

The lower Core Plate remained attached to a section of the Core Barrel and was segmented and packaged in the GTCC liners.

WASTE MANAGEMENT

One of the primary goals is to minimize the cost of disposing of the waste. To accomplish this, required the optimization of the packaging of the primary waste (waste resulting from segmentation of the RV Internals and the vessel itself) and to minimize the secondary waste which comes from the:

- cutting materials (saws, end mills, wire, etc.)
- filters
- ion exchange media and activated carbon
- cutting and support equipment
- DAW (dry active waste).

In general, all three waste classes (A, B/C and GTCC) accumulated from the segmentation process.

The priorities for Waste Management are (figure):

- 1) load all GTCC waste within the available numbers of canisters,
- 2) minimize Class B/C Waste,
- 3) with the remainder being Class A waste

For the primary waste we expect the following volumes from both units:

Table 1: Waste Volumes expected from RV and RVI segmentation at Zion

Waste Type	Approximate Volume, m ³ (ft ³)	
	Baseline	Optimized
GTCC, stored at ZNPS	22 (800)	22 (800)
Class B&C Waste, shipped to Andrews, TX	150 (5,300)	92 (3,300)
Class A Waste, shipped to Clive, UT	310 (11,000)	350 (12,500)

In addition, the total amount of secondary waste is expected to be approximately 600 m³ (21,000 ft³).

LESSON LEARNED

During the last 12 months numerous opportunities have arisen that have added to SNS's experience. We would like to mention two challenging issues where we see a high potential for improvements for the segmentation operations in Unit 1:

- a) BMT: When we started using the BMT to mill 1232 bolts, the BMT did not achieve the performance we expected due to a combination of operational and design issues. After a few design changes and modifications (retrofitting) the performance and reliability increased, allowing completion of the effort. Nevertheless, SNS decided to build a second BMT, re-using only the vertical rails, with some design changes to increase productivity in Unit 1. These design changes were collaboratively discussed with the Siempelkamp group in Germany to use our international experience. We would like to say thanks to our colleagues from Siempelkamp Nukleartechnik GmbH in Heidelberg / Germany at this juncture.
- b) Water clarity: As mentioned earlier the segmentation process was performed remotely in the water-filled reactor cavity. During the use of the BMT we struggled with the water clarity. For several weeks the clarity did not allow working in the water-filled cavity. The issues encountered during this period included loss of glycol from the Hydraulic Power Unit, algae bloom, hydrogen peroxide addition, dramatic pH changes and high levels of suspended solids, and color shifts (darkening) of the water through dissolved solids. Ultimately, controlling of the pH, high volume filtration, and mixed bed ion exchange /activated carbon water processing at lower flow rates returned clarity to the water. A loss in schedule was caused by being unprepared to apply these remedies quickly.

CONCLUSIONS

Following completion of the RVI at Unit 2 in Zion, SNS has demonstrated successful mechanical cutting techniques of highly radioactive components on a large scale. SNS is using their next generation of segmentations tools the VRS, C-HORCE, BMT and FaST successfully.

The next challenge will be the thermal cutting of the RV. This project will start in a few months. We hope we can tell you about the successful cooperation of Siempelkamp NIS Ingenieurgesellschaft mbH (Germany) and Siempelkamp Nuclear Service Inc. (USA) for the thermal cutting at the next Waste Management Conference.

REFERENCES

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ACKNOWLEDGEMENTS

The authors would like to thank Dave Brown (ZionSolutions LLC) for the consistently good and pleasant cooperation.