Upfront Update on Barsebäck 1-2 Reactor Internals Segmentation Project - 17382

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ABSTRACT

Westinghouse is currently executing a contract, awarded in June 2015 from Barsebäck Kraft AB, to segment all the reactor vessel (RV) internal parts in the two units 1 and 2.

The scope of work covers the dismantling and segmentation of the RV internals under water, including the upfront engineering studies and equipment manufacturing and qualification. It also includes the loading of the segmented parts into waste cassettes, handling the cassettes, reactor internals sampling (73 samples), complementary water filtration system to catch the segmentation chips and contribute to maintaining water clarity during the segmentation work. Before leaving the site, the pool environment must be restored to the initial condition and all equipment will be decontaminated and shipped off site.

The site work started in August 2016 with the mobilization on the Unit 2 and the actual cutting of the first component (steam dryer) started in September. Cutting will be performed with different types of Westinghouse designed cutting equipment.

This paper presents the conceptual design of the reactor internals segmentation and packaging process that will be implemented at Barsebäck, including the planning, methodology, equipment, waste management and packaging strategy. A first feedback on the site work will be provided for the segmentation of the Unit 2 reactor internals.

INTRODUCTION

In June 2015, Barsebäck Kraft AB awarded Westinghouse a contract for the segmentation of all the Reactor Vessel Internal (RVI) parts in the two units 1 and 2 at the Barsebäck Nuclear Power Station. Barsebäck is an ABB-designed boiling water reactor (BWR) plant (2x615 MW) located in the south of Sweden, 30 kilometers from Malmö. The first reactor, Barsebäck 1, was closed on Nov. 30, 1999, and the second, Barsebäck 2, ceased operation on May 31, 2005.

Since Barsebäck is the first commercial nuclear power plant to be dismantled in Sweden, interesting lessons learned will be provided for the coming Swedish commercial reactors to be shut down in the short term.

SCOPE OF WORK

The scope of work covers the dismantling and segmentation of the RV internals under water, including the upfront engineering studies and equipment manufacturing and qualification. It also includes the loading of the segmented parts into waste cassettes, handling the cassettes, complementary water filtration system to catch the segmentation chips and contribute to maintaining water clarity during the segmentation work and reactor internals sampling (73 samples).

The Westinghouse site work includes preparation, handling and segmentation of the internals in accordance with procedures and cutting plans, packing of the cut pieces in containers according to a packing plan and a waste disposal plan, handling of the containers and finally restoration of the he pool environment to the initial condition.

DESCRIPTION OF COMPONENTS TO BE CUT

The segmentation started in Barsebäck 2 in August 2016 and the start at Barsebäck 1 is scheduled approximately 18 months later.

The Reactor Vessel Internals to be cut at Barsebäck 1 & 2 are as follows (see Fig. 1):

- Steam dryer (2x1)
- Steam Separator (2x18)
- Core Shroud Cover (2x2)
- Top Grid (2x2)
- Core Shroud (2x1)
- Lower Core Shroud (2x1)
- Test Specimen Channel (2x6)
- Feed Water Spargers (2x4)
- Core Spray Sparger Assembly (2x2)
- Core Spray Riser Pipe (2x16)
- Boron Injection Riser Pipes (2x2)
- Control Rod Guide Tubes (2x109)
- Fuel Channels (18+36)
- Neutron Detector Guide Tubes (2x41)
- Instrumentation Plugs (2x15)

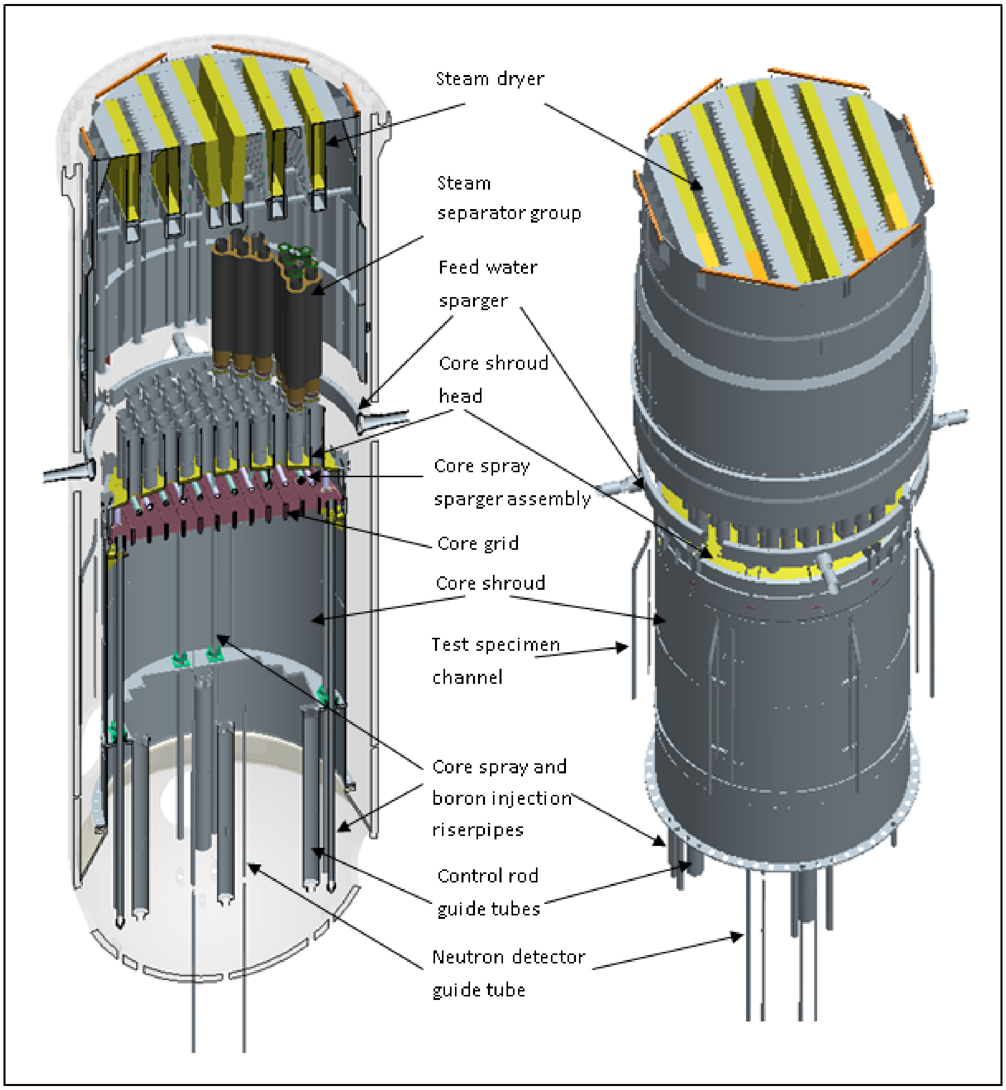

Fig. 1. Barsebäck 1-2 Reactor Vessel Internals

GENERAL ARRANGEMENT

The reactor is located close to the Storage Pool for Internals (SPI), see Fig.2.

The segmentation work will be performed in the SPI, where the water depth is approximately 10 m. This depth is enough to provide sufficient shielding when cutting the largest internals (e.g. steam dryer). The pool area will also be used for loading the waste cassettes and for interim storage of the cut pieces.

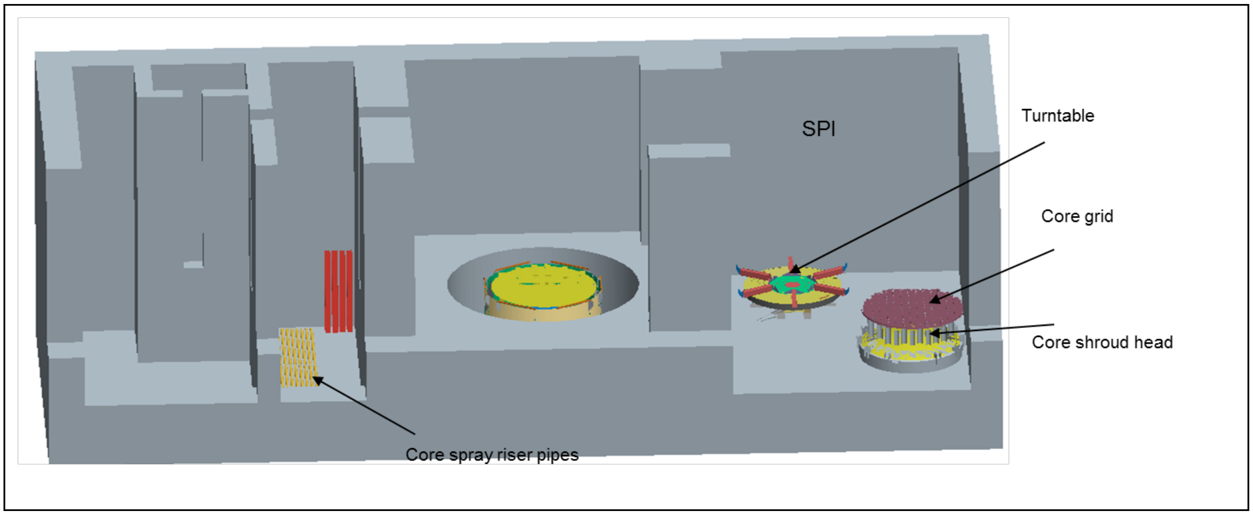

Fig. 2. Barsebäck pool layout

Enclosed areas for tool maintenance, service and decontamination will be setup on the reactor hall floor. This area will be equipped with special service stands that will be used to facilitate service and overhauling.

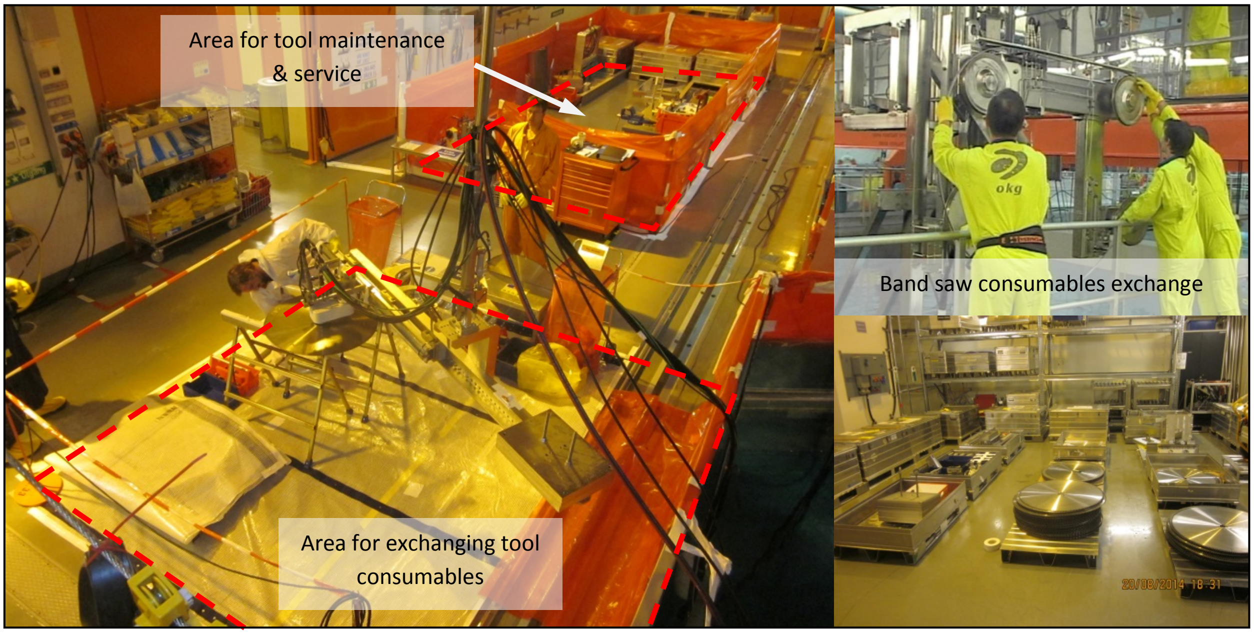

Fig. 3. Utility service areas

DESCRIPTION OF WASTE CONTAINERS

The waste containers are very essential in a segmentation project as they set the boundaries for the size of the pieces that can be cut. The waste containers that will be used in this project vary from 5,4m^3 to 7,5m^3 packable inner volume, depending on the activity level of the waste to be packaged.

Packaging is done with handling tools normally used during the segmentation work (see Fig.4).

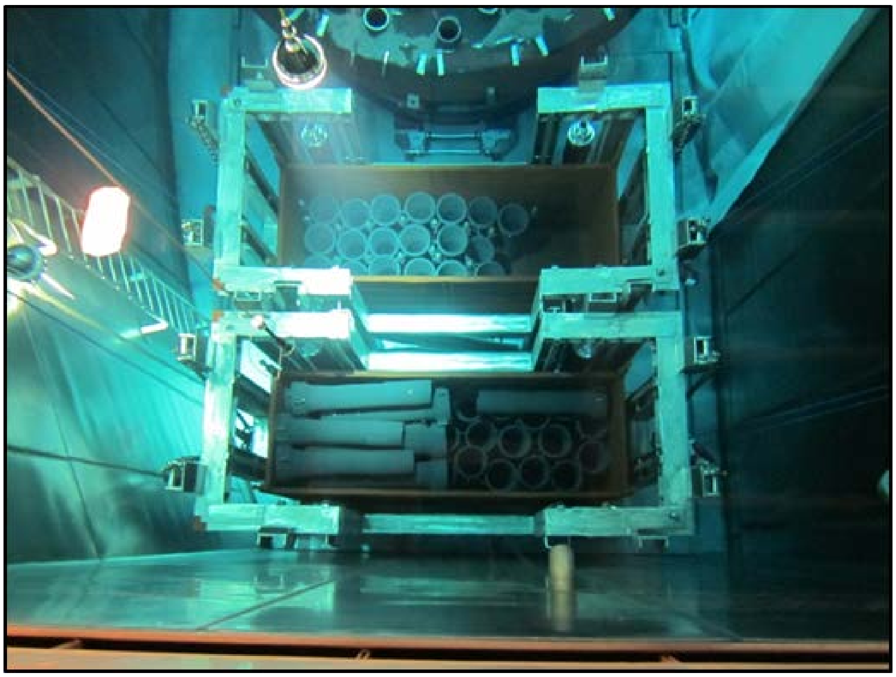

Fig. 4. Inserts for waste containers

DESIGN ACTIVITIES

As all segmentation projects, this project has to be thoroughly planned together with the customer. The radiation level of the internals and complexity of the site work has to be foreseen in all aspects and all procedures and design of advanced tools has to be tested and qualified before the work on site starts.

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 is the basis for tooling design and provides invaluable support in determining the optimum strategy for component cutting and disposal in waste containers, taking account of the radiological and packaging constraints. Equipment and personnel were thereafter qualified in a specially designed test facility before the equipment was sent to site. The chosen strategy for the cutting work, which was also favored by the customer, was mechanical cutting. One other decision was to do the segmentation work in the Storage Pool for Internals. The existing working bridge and refueling machine are used for the segmentation work as working platforms.

QUALIFICATION

The qualification has been performed in the Westinghouse test facility in Västerås where 1:1 scale mockups of chosen parts of the internals had been manufactured. The mockup testing is an important step in order to verify the function of the equipment and minimize risk on site. When the qualification was approved by the customer, all equipment was transported to the Barsebäck site.

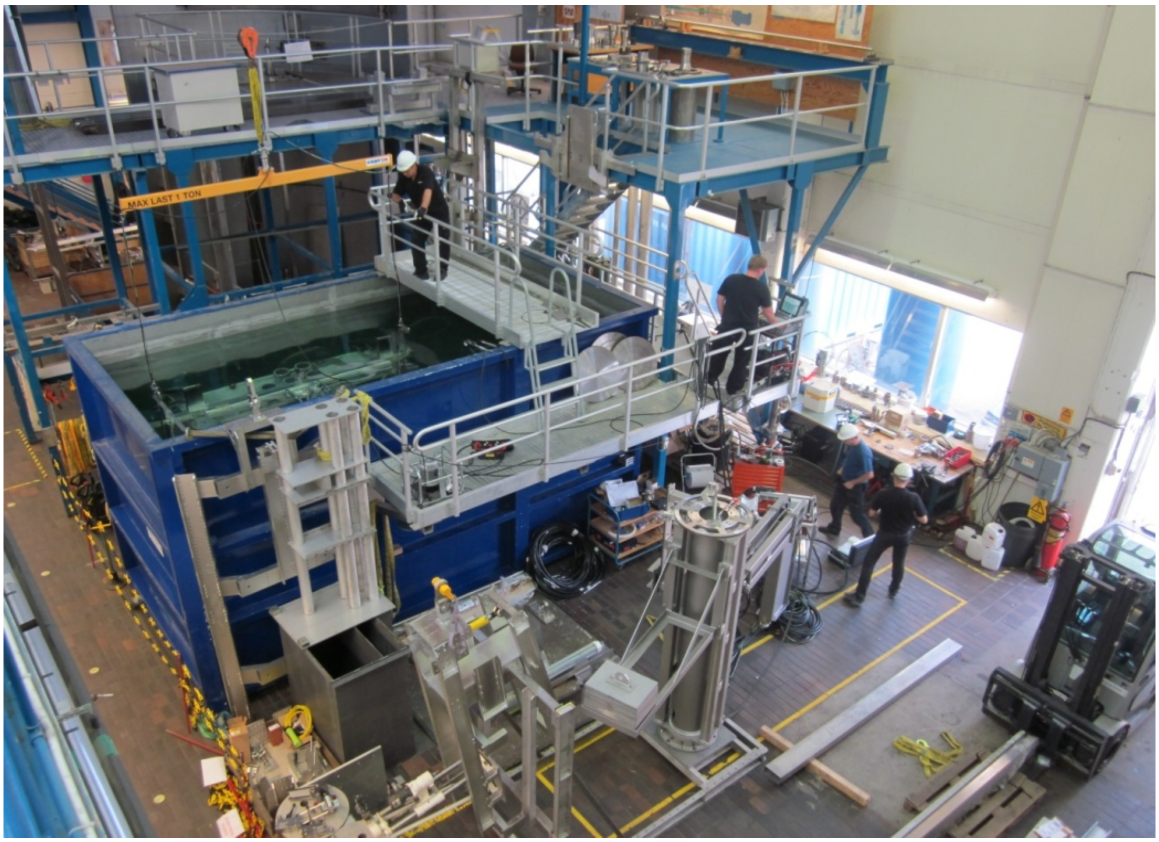

Fig. 5. Qualification in Västerås

PREPARATORY ACTIVITIES

A number of activities had to be performed before the actual cutting activities could start:

- The storage pool for internals was drained and cleaned and protection plates were placed on the pool floor.
- Control rod guide tubes were dismounted from the reactor and placed in racks in the SPI and the fuel pool.
- A FME barrier was installed to keep the chips from entering the reactor pool

- Some brackets were removed from the fuel pool to make room for racks for control rod guide tubes

CUTTING OF REACTOR VESSEL INTERNALS

The next step in the project was to extract and position the Reactor Vessel Internals one by one into the Storage Pool for Internals onto a turn table. The purpose of the turntable is to facilitate the cutting activities in the crowded pool. Once placed on the turntable, the internals are cut with a number of different cutting tools such as disc saw, band saws and shearing tools. The cut pieces can then be packaged in dedicated baskets.

The method for cutting the Steam Dryers (SD) is based on disc cutting technique. The disc cutting technique has been used in earlier projects (e.g. Olkiluoto 1-2, Forsmark 1-2, Oskarshamn 3) and has been further tested for the Barsebäck project, with very satisfactory results. About 18 different disc saw setups are used to segment the complex geometry of the SD.

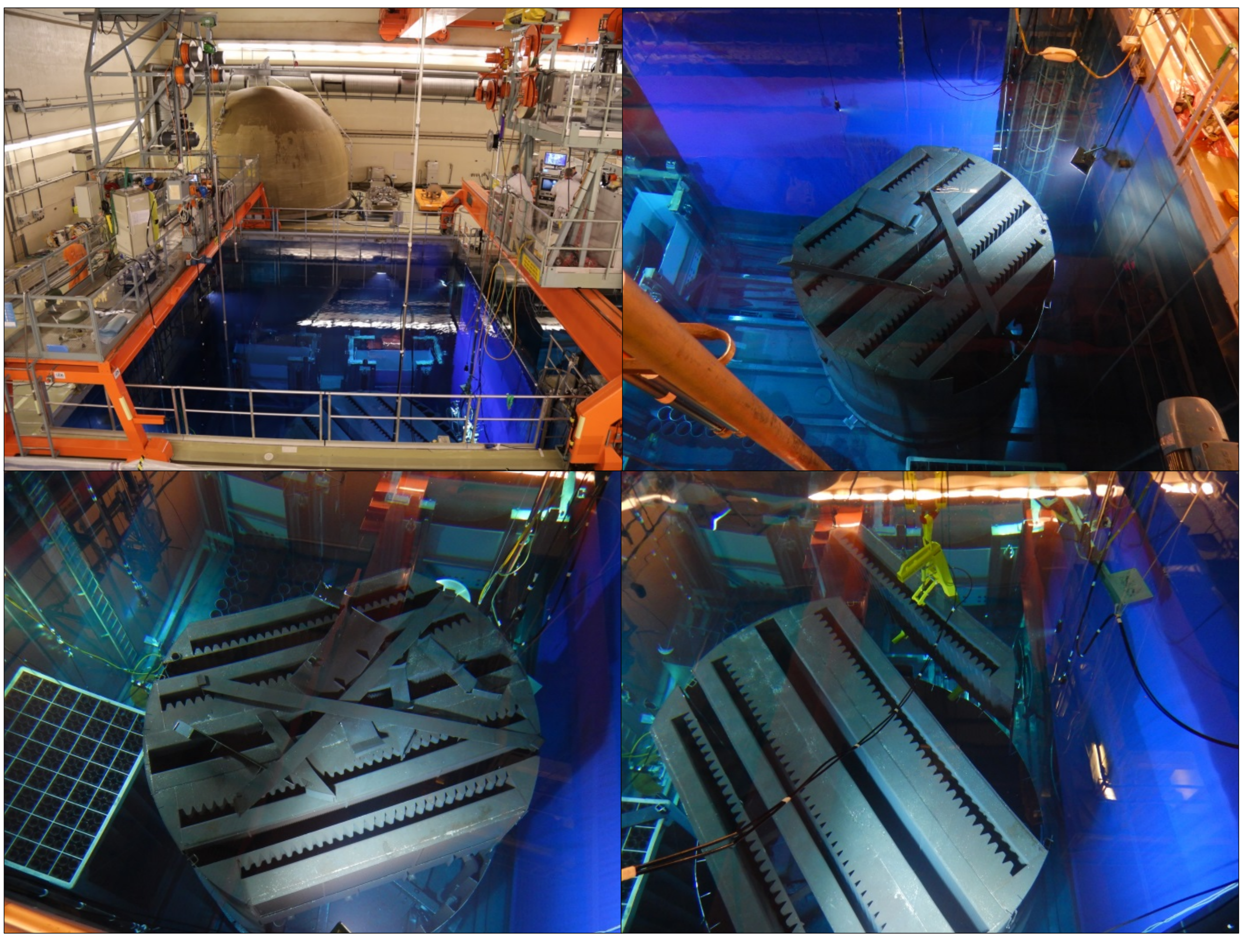

Fig. 6. On-site Steam Dryer segmentation

In parallel with the Steam Dryer segmentation, the Control rod guide tubes (CRGT) are also segmented. The CRGT are first divided with a disc saw cutting station into 5 pieces. Two of the pieces are tubes that are further divided with a punching machine in order to increase the packaging ratio.

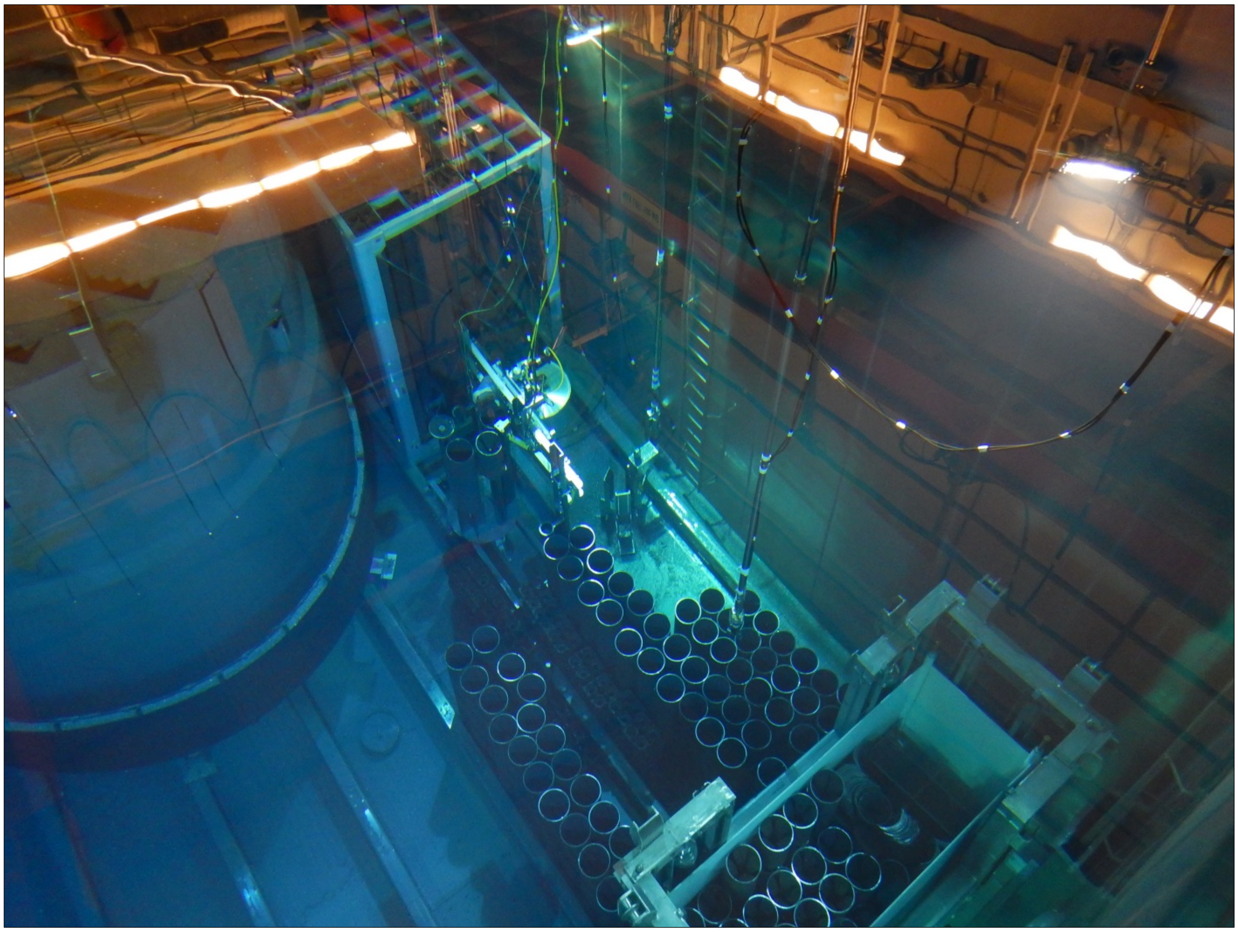

Fig. 7. On-site Control Rod Guide Tubes cutting station

The next step will be to dismantle the Core Shroud Cover including the Steam Separator groups. A turn table will be used with a stand to facilitate the cutting. The nozzle pipes will be removed before placing the Core Shroud Cover on the turn table stand. The segmentation of the Core Shroud Head & Core Spray Sparger System will be done with band saw, disc saw and shearing tools.

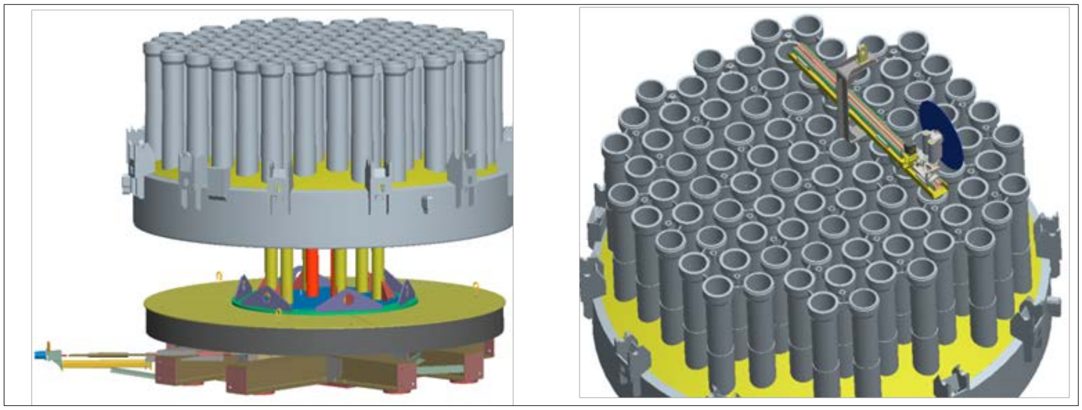

Fig. 8. Core Shroud Cover segmentation

The turn table will then be adapted with a support structure to install the Core Grid. A disc saw and a shearing tool will be used for the cutting operation (see Fig. 9).

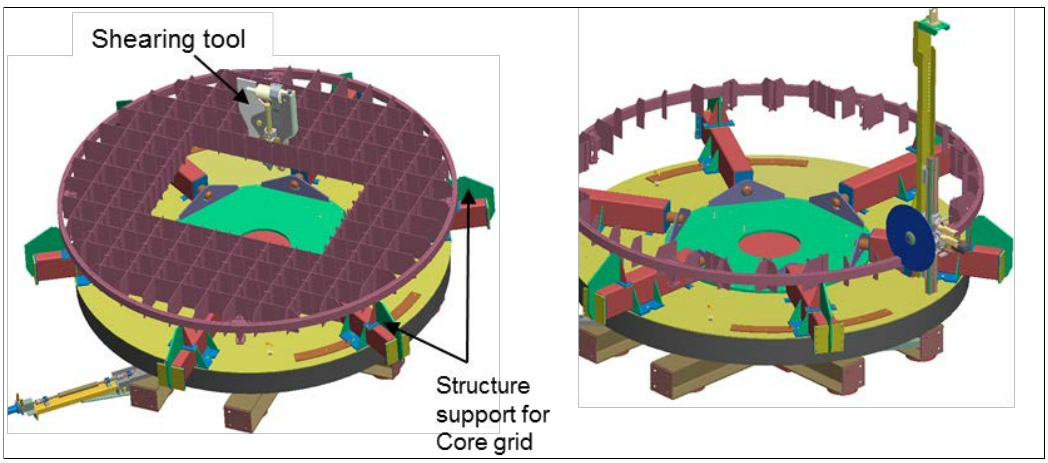

Fig. 9. Core Grid segmentation

The last major component is the core shroud that will be placed on the turn table and segmented with a number of different disc saws.

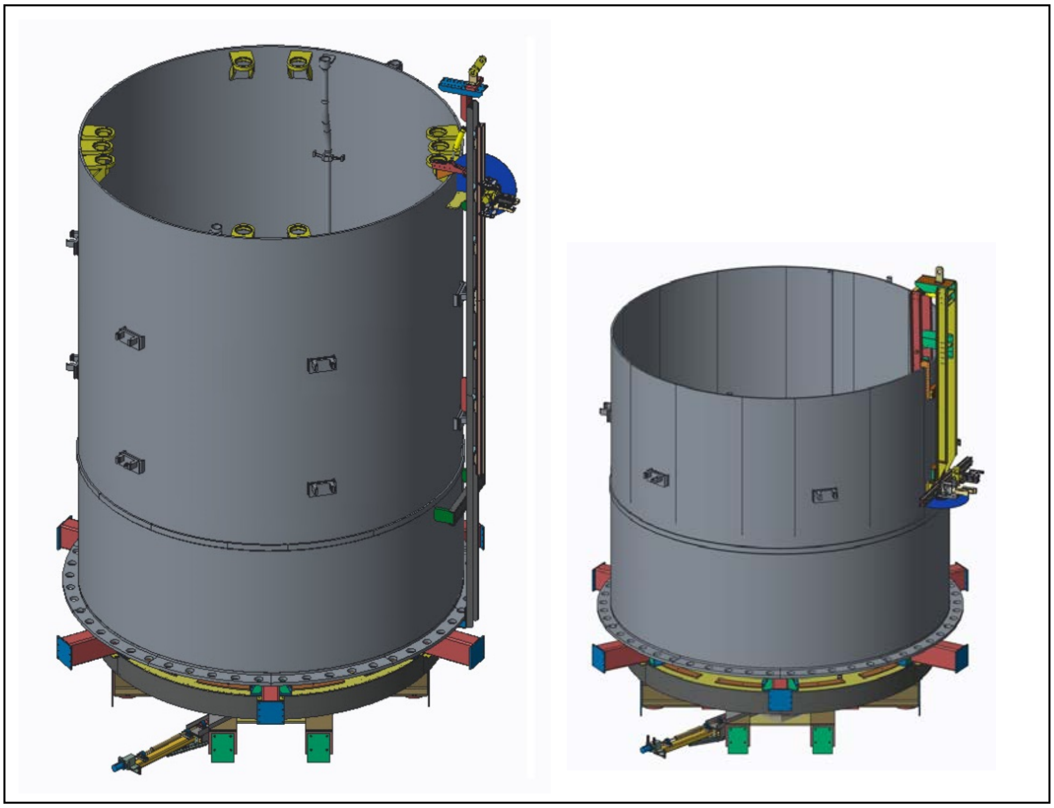

Fig. 10. Core Shroud segmentation

The scope also includes a number of minor components such as feed water spargers, fuel channels, test specimen channels and neutron detector guide tubes. These components will be cut with different disc saw or band saw tools.

PACKING OF WASTE

As it has been mentioned earlier in this paper, the cut internals will be packed in different waste containers depending on the irradiation of the material. The cut internals will be packaged in inserts in the Storage Pool for Internals. The inserts will then be transferred into dedicated waste containers on the refueling floor using a shielded transport container (the so called “wet hood system”). An optimization of the cutting time versus the number of containers have been done by Westinghouse to get a cutting and packing plan that is as cost efficient as possible. Another important input for the optimized cutting and packaging plan is the characterization report, provided by the customer. This characterization is verified during the project by taking a number of samples from the internals that are analyzed and the results are compared with the characterization report.

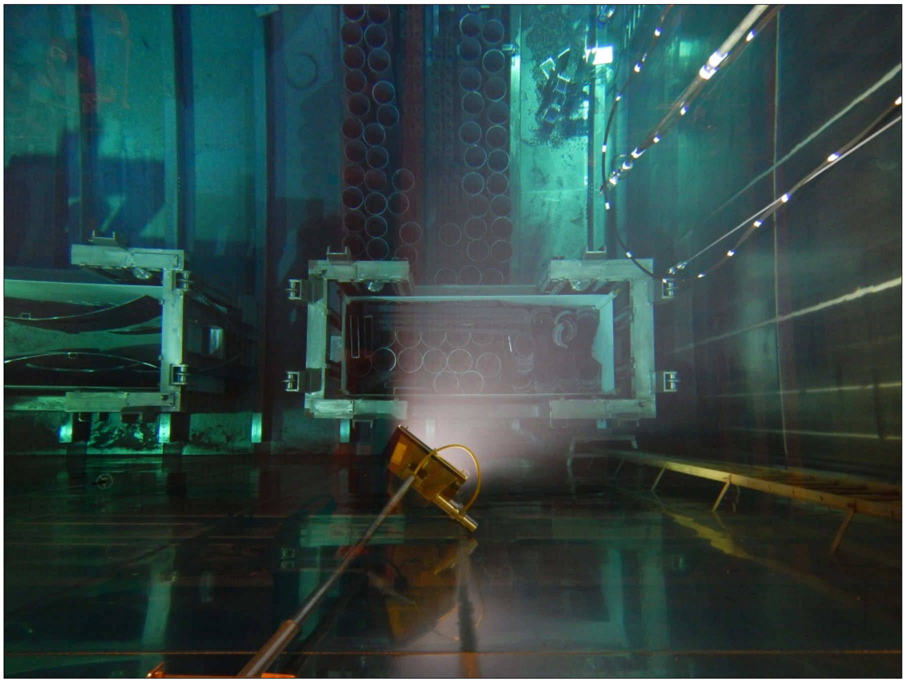

Fig. 11. Packing of cut internals

CLEANING OF POOL AND EQUIPMENT

A continuous activity in the segmentation project is to clean all tools that have been used. Cleaning is performed by rinsing the equipment with high pressure water, if needed the equipment will also be wiped with decontamination fluid. Chips that have been produced during the cutting operations will be picked up by the means of a scoop tool and finally with an underwater suction device. Westinghouse scope will end when the pool and all equipment will be clean and all waste will be loaded in the dedicated cassettes. The equipment that is not project specific will be packed in containers and transported to Westinghouse hot storage facility where it will be stored until it can be used again in another segmentation project.

Fig. 12. Cleaning on-going

CONCLUSION

Westinghouse’s experience in mechanical cutting shows that it is an excellent technique for segmentation of internals. All segmentation projects in the Nordic region have been performed with the highest customer satisfaction. The Westinghouse set of cutting tools is small, easy and fast to handle. Equipment performance has been optimized throughout the segmentation projects over the last 15 years. The tooling has been proved to be reliable and to have a safe functionality. The safety aspect of the cutting technique can best be illustrated by the fact that no incident involving personal injury has ever occurred in a segmentation project performed so far.

The early stage of the Barsebäck segmentation work confirms the excellent tooling performance.

The Barsebäck lessons learned, together with past experiences that Westinghouse has accumulated (ref.1), provides confidence for the next segmentation contracts that Westinghouse has to start soon at Chooz A, Philippsburg 1 and Neckarwestheim 1.

REFERENCE

1. PER SEGERUD, MOISÉS SANCHEZ, JOSEPH BOUCAU, « Feedback From José Cabrera Plant Decommissioning Project », Phoenix WM 2014 – paper 14272