

Chooz A, First Pressurized Water Reactor to be Dismantled in France – 13445

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ABSTRACT

Nine commercial nuclear power plants have been permanently shut down in France to date, of which the Chooz A plant underwent an extensive decommissioning and dismantling program. Chooz Nuclear Power Station is located in the municipality of Chooz, Ardennes region, in the northeast part of France. Chooz B1 and B2 are 1,500 megawatt electric (MWe) pressurized water reactors (PWRs) currently in operation. Chooz A, a 305 MWe PWR implanted in two caves within a hill, began operations in 1967 and closed in 1991, and will now become the first PWR in France to be fully dismantled.

EDF CIDEN (Engineering Center for Dismantling and Environment) has awarded Westinghouse a contract for the dismantling of its Chooz A reactor vessel (RV). The project began in January 2010. Westinghouse is leading the project in a consortium with Nuvia France. The project scope includes overall project management, conditioning of the reactor vessel (RV) head, RV and RV internals segmentation, reactor nozzle cutting for lifting the RV out of the pit and seal it afterwards, dismantling of the RV thermal insulation, ALARA (As Low As Reasonably Achievable) forecast to ensure acceptable doses for the personnel, complementary vacuum cleaner to catch the chips during the segmentation work, needs and facilities, waste characterization and packaging, civil work modifications, licensing documentation. The RV and RV internals will be segmented based on the mechanical cutting technology that Westinghouse applied successfully for more than 13 years. The segmentation activities cover the cutting and packaging plan, tooling design and qualification, personnel training and site implementation. Since Chooz A is located inside two caves, the project will involve waste transportation from the reactor cave through long galleries to the waste buffer area. The project will end after the entire dismantling work is completed, and the waste storage is outside the caves and ready to be shipped either to the ANDRA (French National Radioactive Waste Management Agency) waste disposal facilities – (for low-level waste [LLW] and very low-level waste [VLLW], which are considered short lived) – or to the EDF Interim Storage Facility planned to be built on another site – (for low- and intermediate-level waste [LILW], which is considered long lived).

The project has started with a detailed conceptual study that determines the step-by-step approach for dismantling the reactor and eventually supplying the packed containers ready for final disposal. All technical reports must be verified and approved by EDF and the French Nuclear Safety Authority before receiving the authorization to start the site work. The detailed conceptual study has been completed to date and equipment design and manufacturing is ongoing.

This paper will present the conceptual design of the reactor internals segmentation and packaging process that will be implemented at Chooz A, including the planning, methodology, equipment, waste management, and packaging strategy.

INTRODUCTION

Westinghouse, in a consortium with Nuvia France, was awarded the reactor dismantling project at the Chooz A nuclear power plant in France and started the project in January 2010. The reactor, an early Pressurized Water Reactor (PWR) design, was the first pressurized water reactor built in France. This 4-loop plant is located inside two caves under a hill of 200 meter high. Westinghouse designed the Chooz A plant and later provided nuclear services during its operation. The plant has been shut down in 1991 and its dismantling was initially deferred to allow minor radiation to decay naturally. EDF got the decommissioning decree approved in September 2007. The Chooz A decommissioning program is now entering in its most challenging part with the reactor dismantling.

The scope of this project covers the reactor vessel (RV) head, RV and RV internals segmentation, reactor nozzle cutting for lifting the RV out of the pit and seal it afterwards, dismantling of the RV thermal insulation, ALARA (As Low As Reasonably Achievable) forecast to ensure acceptable doses for the personnel, complementary vacuum cleaner to catch the segmentation chips during the segmentation work, working bridge, heavy handling tools, air filtration, confinement workshops, needs and facilities, waste characterization and packaging, civil work modifications, licensing documentation. The Chooz A reactor vessel to be dismantled is shown on Figure 1.

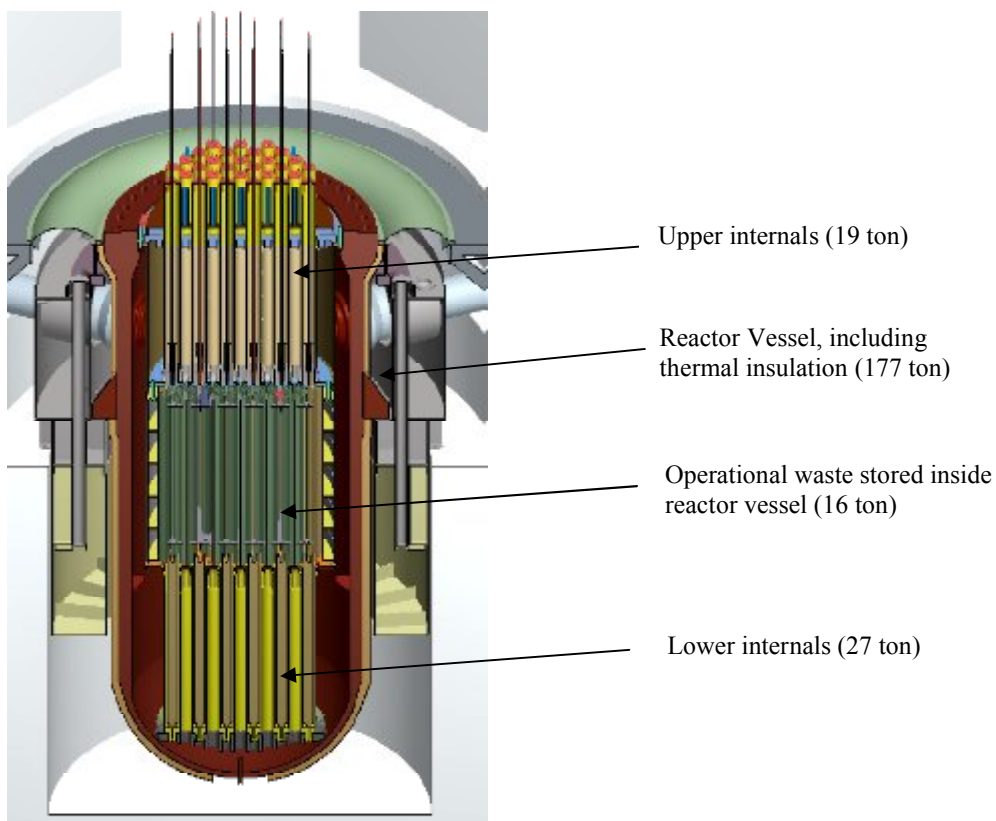


Fig. 1: Chooz A Reactor Vessel

SELECTED SEGMENTATION TECHNIQUE

Westinghouse's experience started in 1986 with the segmentation of the Three Mile Island 2 Lower Core Support Assembly and Baffle Plates to support the defueling operations and remove the molten mass of fuel debris that had flowed to the bottom of the reactor and re-solidified. Since then, Westinghouse has been involved on all types of reactors worldwide: i.e Pressurized Water Reactors (PWR's), Boiling Water Reactors (BWR's), Gas Cooled Reactors (GCR's), sodium reactors. Westinghouse has developed several concepts to dismantle reactor internals based on safe and reliable techniques, including plasma arc cutting (PAC), abrasive waterjet cutting (AWJC), metal disintegration machining (MDM), or mechanical cutting.

In recent years, Westinghouse has streamlined its segmentation strategy by selecting mechanical cutting methods over the other methods for cost and minimization of risk reasons.

Mechanical cutting has a number of advantages that make it suitable for most applications:

- The technique produces almost no secondary waste.
- The visibility during cutting is very good because the cutting produces only a negligible amount of micro particles.
- Chips from the cutting process falls down to the bottom of the cutting pool and are easy to collect.
- No gases are produced that can cause airborne contamination.
- The technique is safe and reliable.
- All reactor internal sizes, materials and thicknesses can be cut.

Since 1999, Westinghouse has segmented all types of BWR reactor internals in Sweden and Finland, using mechanical cutting methods. The projects have been performed at Forsmark 1, 2 and 3, Oskarshamn 1, 2 and 3 and Olkiluoto 1 and 2 for replaced reactor internals. Westinghouse is currently cutting reactor internals at the Zorita PWR plant in Spain (also called José Cabrera). Based on the technical constraints provided in the EDF specification, it has been decided to also select the mechanical cutting process for Chooz A. Transfer of experience feedback and synergies with other projects has been also identified in an assessment of international projects as a key issue for decreasing cost of dismantling activities and associated risk [1]

SEGMENTATION PROCESS

Detailed planning is essential for 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 the waste disposal requirements imposed by the customer, what type and size of containers are available for the different disposal options and working backwards to select the best cutting tools and finally the cut geometry required. These plans are made utilizing advanced 3-D CAD software to model the process. Another area where the modeling has proven invaluable is in determining the logistics of component placement and movement in various stages of segmentation. The main objective of the segmentation and packaging plan is to determine the strategy for separating the highly activated components from the less activated material, so that they can be disposed of in the most cost effective manner. For Chooz A, the short lived low-level waste [LLW] and very low-level waste [VLLW] will be shipped to the ANDRA (French National Radioactive Waste Management Agency) waste disposal facilities. The long lived low- and intermediate-level waste [LILW] will be shipped to the EDF Interim Storage Facility planned to be built on another site. Dismantling of the lid and conditioning are in the scope of the consortium but not detailed in this paper.

All segmentation tools are remotely controlled since the mechanical segmentation projects that Westinghouse has executed so far have been performed under water due to the high radiation levels. ALARA and personal safety is the number one priority during the site work. The complexity of the work requires well designed and reliable tools. Before going to site, testing and qualification are therefore

performed on full scale mock-ups in a specially designed pool for segmentation purposes (see figures 2 and 3).



Fig. 2: Westinghouse test facility

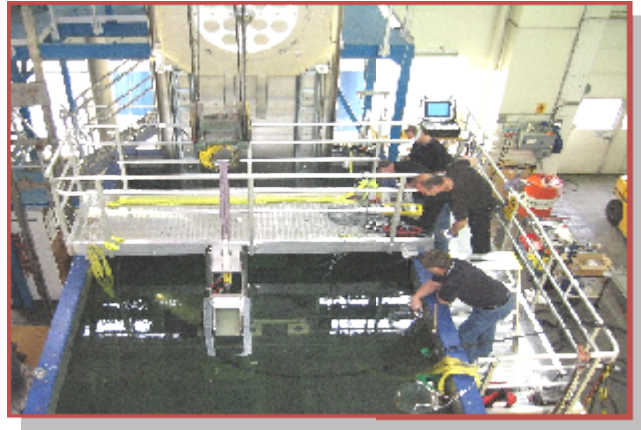


Fig. 3: FAT (Zorita, June 2011)

CHOOZ A TOOLING

The tools that have been selected for the Chooz A reactor dismantling are based on the wide Westinghouse experience in previous segmentation jobs. The main cutting tools are depicted on Figure 4. These are:

- **Band saw:**
Band sawing uses a continuous flat blade that rides around a set of coplanar pulleys, one of which is driven by a motor. The driven pulley drives the blade through contact friction between the pulley and the blade. The other pulley(s) are idler pulleys that provide tension in the blade. A flat section of blade is usually supported by hardened slotted guides. This area contacts the workpiece and is where the cutting takes place. The blade is made from special tool steel and has multiple teeth on one edge that repeat in a pattern over the entire length. The size, shape and tooth pattern are available in a variety of combinations for different workpiece materials and applications. The pulleys, blade and drive motor are all mounted to a rigid frame that provides a feed mechanism to move the cutting assembly into the workpiece as material is removed by the sawing action. Common feed mechanisms include hinge pivot, single column or double column devices with gravity, hydraulic, or screw feed drives.
- **Disc saw:**
Disc sawing uses a disk of steel with saw teeth located about its periphery, which is clamped in arbor passing through the blade center. The arbor and blade is revolved by a spindle motor. This assembly is mounted to a rigid frame. As the blade rotates, it is also fed into the workpiece by a mechanism that provides motion at a continuous feed rate.
- **Shear tools:**
Shearing is a useful cutting method for components in limited shapes and sizes. A mechanical shear cuts metal by creating a plastic strain in the material by squeezing it between two or more close fitting hardened steel blades with sharp edges. The blades are typically attached to opposing jaws that can be clamped together with extremely high force. A hydraulic cylinder or screw mechanism is used to provide the shearing force. Shears can be either frame mounted or portable and they are moved/handled by long poles or cables.

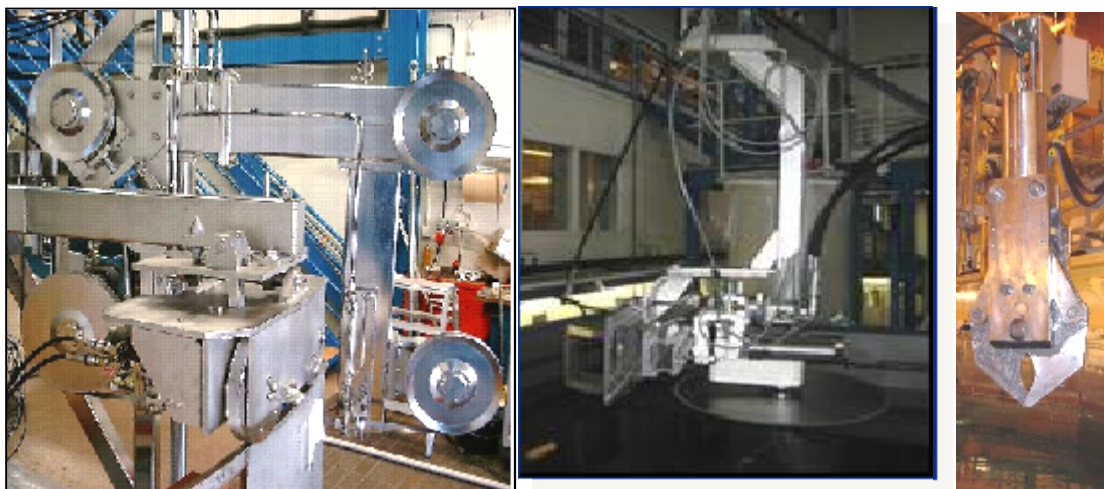


Fig. 4: Band saw, disc saw and shear tool

Other tooling (e.g. handling and lifting tools, drilling tool, turntable, compactor) supplement the above tool kit.

CHOOZ A SEGMENTATION

The cutting sequence will be as follows:

1. Upper Internals
2. Operational Waste
3. Lower Internals
4. RPV with insulation

Extensive 3-D modeling has been performed to determine the optimum segmentation technique and set up.

Upper Internals

The height of the upper internals is about 3.6 m (excluding the drive rods) and the diameter is about 3 m. The internals are made of stainless steel (AISI 304) and have a total weight of about 19 ton.

The large parts (instrumentation plate, guide tube support casting and the upper core plate) will be cut out and stored in the reactor pool for later segmentation. The CRDM drive rods and some instrumentation plate pieces will be cut first with a shearing tool. The extension tubes, support columns and guide tubes will thereafter be cut with a disc cutting tool. The last items to be cut are the upper core plate, guide tube support casting and instrumentation plate which will be cut with a band saw.

Segmentation of operational waste

The waste stored in the reactor vessel after plant shutdown includes dummy fuel, MOX bottom pieces, Control Rod followers, adapters, control rods. The weight of this waste is about 16 ton.

The waste elements will be transported from their current position into the reactor cavity where they will be segmented. The Control Rod followers are made of zircaloy material and the handling and cleaning must be carefully planned. Shearing is selected cutting technique for avoiding production of tiny particles. The Control Rods (silver indium cadmium pellets in a cross section stainless steel) are also planned to be cut with a shearing tool. The dummy fuel assemblies will be cut with a band saw.

Segmentation of lower internals

The height of the lower internals is about 9 m and the diameter is about 3 m. The internals are made of stainless steel (AISI 304) and have a total weight of about 27 ton.

The large parts, lower core plate and lower support casting, will be cut out and stored on the pool floor for a later segmentation.

The lower internals will first be lifted into a position where the upper barrel can be cut. The segmentation will be done with a band saw attached to a center column that will be placed inside the lower internals.

The principle used is to cut a number of vertical cuts and then turn the band saw blade 90 degrees and make a horizontal cut so that the pieces come loose. The same technique will be used for the core barrel and the baffle plate.

The remaining part of the lower internals will then be positioned in a stand where the shroud tubes will be cut with a disc cutting tool. The last items to be cut are the lower support casting, the core radial support and the lower core plate, which will be cut with a band saw on a stand.

Segmentation of reactor pressure vessel

The reactor vessel with its rock wool insulation material is initially standing in the reactor pit with the eight nozzles penetrating the concrete wall around the reactor pit. The reactor pressure vessel weighs around 177 ton and is made of carbon steel clad with stainless steel. Prior to the reactor vessel lifting with the reactor building crane, the nozzles will be cut with an orbital cutting tool inserted inside.

The reactor vessel insulation needs to be removed before vessel cutting can start. To do this, the vessel will be lifted remotely out of the pit and a leak tight plate will be placed. The thermal insulation is likely to be vitrified due to irradiation exposure and a disc saw will be used. The next step is the segmentation of the RPV which will be done from top to bottom with a band saw attached to a center column inside the vessel. The same principle with vertical and horizontal cuts as for the lower internals cutting will be used.

The segmentation process requires intensive 3-D modeling of the various pieces to be segmented and tooling. Figure 5 illustrates the way the upper core plate will be segmented.

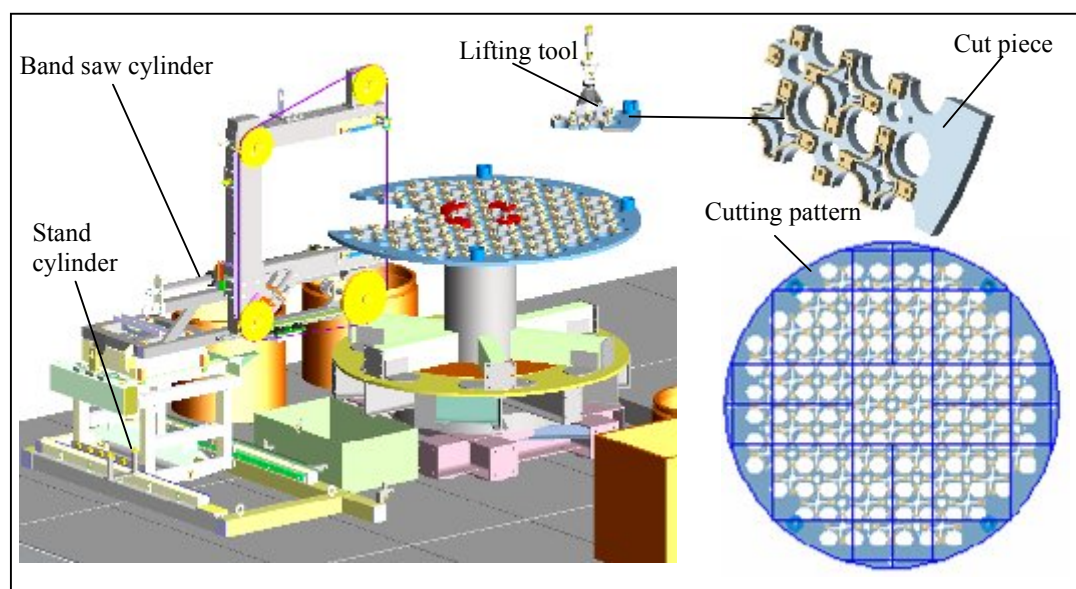


Fig. 5: Band sawing of the upper core plate.

CONCLUSIONS

EDF's strategy is to aim for immediate decommissioning of reactors which have ceased generating rather than deferring the clean-up work. An ambitious program is now under way to totally dismantle the nine oldest French nuclear reactors which started generating power in the 1960s and 1970s. Chooz A will be the first commercial PWR that will be decommissioned in France and therefore, feedback from experience will be valuable for the future.

Westinghouse has accumulated a combined experience with design capabilities and project execution skills necessary to successfully perform dismantling of reactor vessel internals. Westinghouse's selected platform is mechanical cutting which has been used for several segmentation projects in Europe and USA. The same tooling will be used for the Chooz A reactor vessel dismantling project. The detailed engineering design is now completed and the qualification program is on-going. The site work will start beginning of 2014.

REFERENCE

1. JJ GRENOUILLET, « International Cooperation for the Dismantling of Chooz A Reactor Pressure Vessel », Phoenix WM 2009 – session 18, paper 9087