International Cooperation for the Dismantling of Chooz A Reactor Pressure Vessel – 9087

Jean-Jacques Grenouillet
Electricité de France – Centre d'Ingénierie Déconstruction et Environnement
35-37, rue Louis Guérin – BP 21212 – 69611 VILLEURBANNE Cedex – France

Ed Posivak
WMG, Inc.
16 Bank Street, Peekskill, New York 10566

ABSTRACT

Chooz A is the first PWR that is being decommissioned in France. The main issue that is conditioning the success of the project is the Reactor Pressure Vessel (RPV) and Reactor Vessel Internals (RVI) segmentation. Whereas Chooz A is the first and unique RPV and RVI being dismantled in France, there are many similar experiences available in the world. Thus the project team was eager to cooperate with other teams facing or being faced with the same issue.
A cooperation programme was established in two separate ways :

- Benefiting from experience feedback from completed RPV and RVI dismantling projects,
- Looking for synergy with future RPV dismantling projects for activities such as segmentation tools design, qualification and manufacturing for example.

This paper describes the implementation of this programme and how the outcome of the cooperation was used for the implementation of Chooz-A RPV and RVI segmentation project. It shows also the limits of such a cooperation.

INTRODUCTION

Located in the north of France, close to Belgian border, Chooz A is the first PWR that was built in France from 1962 to 1967. Chooz A is a PWR with an electrical capacity of 305 MW. The Nuclear Steam Supply System was designed by WESTINGHOUSE and the equipment built in France and Belgium. The Reactor Cooling System is a four loop circuit including 4 steam generators, 4 primary pumps and one isolation valve.

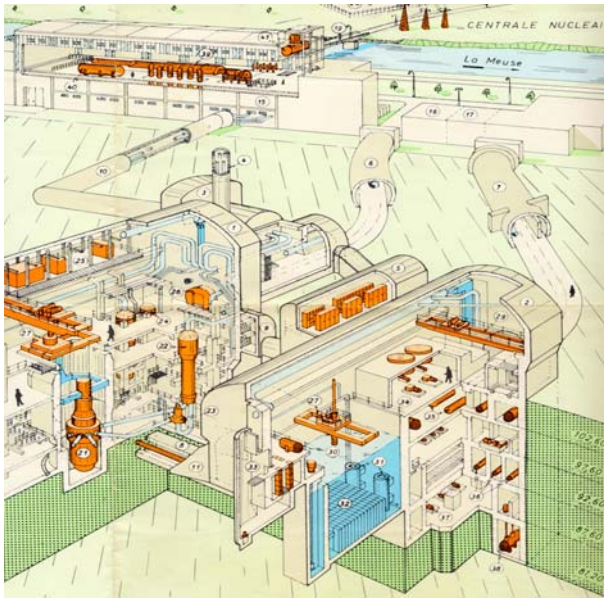

Fig. 1. Drawing of Chooz A Plant – The Reactor and Auxiliary Caves

The particularity of the plant is that it was built in two caves excavated into a hill. At the top of the hill, 200 m above the caves, some nuclear buildings were erected to host the Emergency Core Cooling System and the ventilation stack. A steep gallery , containing nuclear and ventilation pipes, was connecting those buildings to the caves. Because of this design, a specific system was installed to collect the potentially contaminated water drained by the hill.
During the operation period, the plant was owned by a French and Belgium company called SENA. At the end of deactivation, the dismantling liability was transferred to EDF.
When it was shutdown in 1991, a deferred dismantling strategy was selected. Further to an evolution of EDF decommissioning strategy in 2001, the decommissioning of the plant was accelerated by reducing the safe enclosure period to only a few years.
A new Decommissioning License was issued in September 2007. Chooz-A decommissioning is now planned in three stages :

1. Dismantling of the equipment within the caves except the equipment needed to collect, check and release the drained water from the hill
2. Surveillance of the activity of the drained water (presence of tritium)
3. Final dismantling of the plant (mainly the liquid waste treatment plant)

The major activities that will be implemented during the first stage are the following:

- Dismantling of the electro-mechanical equipment in the Auxiliary Cave and the Reactor Cave
- Decategorisation of the steam generators from Low Level Waste to Very Low Level Waste (VLLW) by chemical decontamination
- Steam Generators storage in one piece in a VLLW repository (operated by ANDRA since 2003)
- RPV and RVI under water dismantling

One of the objectives of the project is the provision of experience feedback for the decommissioning of the 58 units currently operating in France. Therefore there is a strong willingness to achieve through the implemntation of Chooz-A decommisioning projet high performance results in terms of schedule, cost, worker exposure, safety and waste management.

LEARNING FROM OTHERS

An initial dismantling scenario for RPV and RVI dismantling had already be defined by EDF in 2004 in the framework of the application for the decommissioning license. This scenario was described in the Safety Report and had been reviewed by the French Regulatory Body.

When the Decommissioning License was pending and before issuing the request for proposal for RPV and RVI segmentation this dismantling scenario was reviewed by EWN, a German company responsible for the decommissioning of Greifswald and Rheinsberg NPPs. EWN had at that time already segmented one RPV and its internals. They had also tested all types of segmentation processes, i.e. mechanical, thermal and Abrasuve Water Jet.

Segmentation Seminar

In fall 2006 EDF inquired about US experience in decommissioning reactors similar to Chooz A unit. With the support of Polestar Applied Technology (now Polestar Worley Parsons) EDF arranged a seminar with a team of experienced professionals including present and former decommissioning experts from Maine Yankee, SONGS1 and Trojan as well as representatives of WMG, inc., an American company involved in the characterisation of several US RPVs already dismantled.

The segmentation seminar was a valuable exchange of information. During the seminar the team of experts could present the different approaches of reactor vessel and internals segmentation. US experience varied from a no segmentation approach achieved at Trojan, through a minimal segmentation approach at Maine Yankee, to the full segmentation approach at SONGS1. The Polestar team explained the various drivers and provided the background that influenced the decisions culminating in the different approaches.
The seminar indicated too some limitation for the application of US experience to Chooz-A RPV and RVI dismantling. For example, US segmentation experience feedback with the use of Abrasive Water Jet Cutting (AWJC) for RPV and RVI segmentation is very positive. With this process high performance results were achieved in the US in terms of schedule, cost and dose rate. The situation is different in France, and AWJC could not be the best option due to the amount of secondary waste generated, i.e. the garnet. Actually, when in the US there is an efficient way for final disposal of the garnet, in France most of the secondary waste have to be conditioned in C1PG, a concrete container with a capacity limited to1m^3, due to their activity.

The collected experience helped EDF to draft the technical specifications for Chooz A RPV and RVI dismantling.
Other operators' experience with RPV and RVI dismantling demonstrated that each type of segmentation process - i.e. mechanical, thermal or abrasive water jet – had its own strengths and weaknesses. This experience showed also that a lot of attention has to be paid to the type and quantity of secondary waste produced, gas release and water clarity mainly to keep dose rate reasonably low.
Therefore EDF decided to let the selection of the segmentation process open. Only the dismantling scenario was prescribed : a segmentation sequence was defined, wet or dry condition selected for each task and some location were also prohibited for some tasks such as the reactor pit for RPV segmentation. Some requirements were defined regarding water clarity and gas release with higher values during segmentation phases and lower values for the other phases.
Because water filtration is directly linked to the segmentation process, the provision of the filtration system was included in the segmentation contract. A separate contract would be awarded for the provision of the reactor cavity flooding and flushing system and the water treatment process prior to release as well. Waste disposal costs were also given to the bidders, regarding primary and secondary waste, so that they could select the most appropriate segmentation process on the basis of:

- Their experience with the process
- The process efficiency and reliability

- The quantity and type of secondary waste produced
- The adequacy of the filtration system with the segmentation process

The contract would be awarded on the basis of the total cost for RPV and RVI dismantling including the price of the contract and the waste disposal cost. Therefore the optimisation of the segmentation plan on the basis of the waste containers quantity was a key issue for the contract award. This is particularly the case for the part of the internals that are very close to the limits of two different categories of waste, i.e. A waste thate are disposed at the Low Level Waste repository operated by ANDRA and B waste, the equivalent in France of GTCC waste un the US, that have to be stored in an interim storage facility – called ICEDA – that will be erected by EDF waiting for the availability of an deep geological disposal in France (See Figure 2).

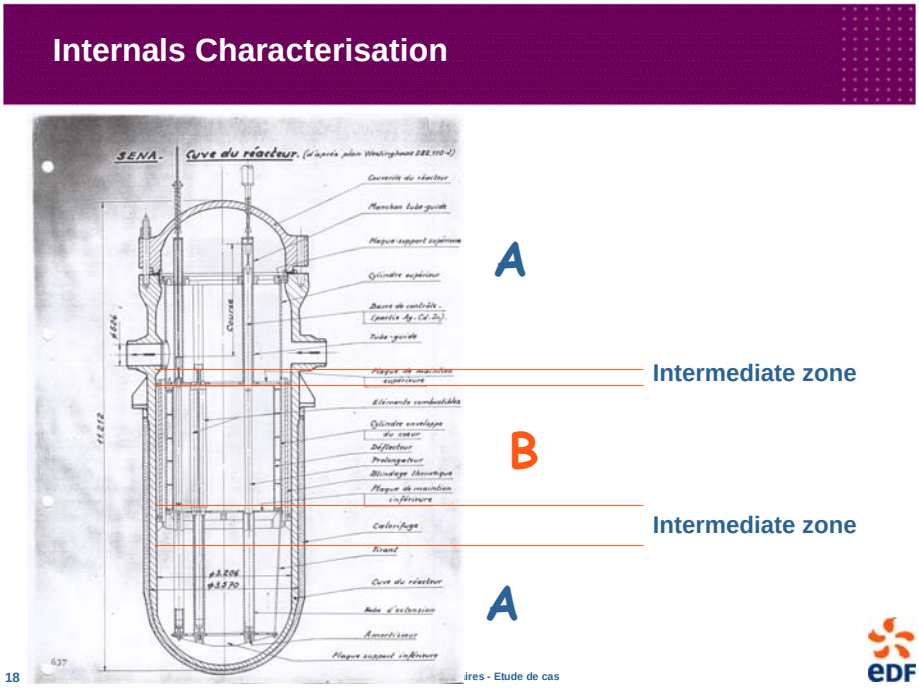

Fig. 2. Categories of waste to be produced depending on the internals activation

The zone identified as “intermediate zone” in Figure 2 contains some equipment such as the Lower Core Plate, the Upper Core Plate, Cruciform Support Tubes and Cruciform Control Rod Guide Tubes. This type of waste can be disposed at the LLW repository after a decay period of about 20 years at ICEDA. The zone identified as “B waste” includes equipment such as the Core Barrel and the Core Baffles.

Last but not least, the one piece removal of the RPV including a RVI segmentation limited to the most activated part, was also included as an alternate scenario in the request for proposal. Simultaneously some feasibility studies were engaged regarding the final disposal of the RPV including the non-activated part of the internals and its transportation as well.

Characterisation

Because the RPV and RVI characterisation is a key input data for the segmentation process selection it was thus necessary to secure the validity of the characterisation. Chooz A RPV and RVI characterisation had been established on the basis of an activation model that had been calibrated through some activity measurements made on few samples taken from the vessels and the internals. But EDF was not familiar with the US method of normalising the model results to empirical data.

The exchange of information at the segmentation seminar indicated the same drivers would influence segmentation choices for EDF. Although the constraints would be different, for example ANDRA – the French waste management agency – concentration limits instead of NRC Part 61 concentration limits, the segmentation optimisation process would similar between the US and France.
After the success of the segmentation seminar, Polestar developed a proposal to provide WMG's characterisation and segmentation planning services to EDF. The objective of this activity was to check that the characterisation results based on the activation model developed for Chooz-A RPV and RVI were consistent with the actual values measured on US RPVs.
EDF provided the necessary input information to WMG. There were no real language problems for a variety of reasons:

- The Chooz A reactor drawings were primarily Westinghouse drawings in English
- WMG characterised the Yankee Rowe reactor vessel and internals – a sister plant to Chooz-A – and could easily interpret other similar drawings in French
- EDF photo archives of Chooz-A construction and maintenance activities clearly showed the as-built conditions from earlier design drawings

Document control was critical to the success of characterisation efforts because the stored conditions of Chooz-A – Safestore with a reactor cavity flooding system fully decommissioned – did not facilitate gathering of current radiological data.
Trace impurity concentrations are important to characterisation both in France and the US because of low permissible concentration for certain regulated isotopes. The regulated isotopes are different between the different countries, but seemingly unimportant trace impurities can have a significant impact on waste acceptance. For example NUREG 3474 which cites average, maximum and minimum values for trace impurities in a variety of reactor vessel indicates the presence of Cl-36. Cl-36 concentrations are not of regulatory interest in the US but are important for ANDRA disposal acceptance.
WMG demonstrated how operational an maintenance data such as neutron flux measurements and dose rate measurements can be used to adjust modelled results to match measured data. The particularly good historic survey of the bare reactor vessel wall in air was used for final results adjustment.

Using the methodology and characterisation provided by WMG, EDF would refine and compare the results of their detailed 3D neutron transport and activation analysis of the Chooz-A reactor vessel and internals system.

Segmentation planning

As discussed in the segmentation seminar, detailed characterisation results are the necessary starting point for internals segmentation planning. By knowing the location-dependent isotope concentrations, decisions regarding where to segment components for loading into transport and disposal containers and waste acceptance can proceed. Segmentation planning, including cut-line development, is a constrained optimisation process. Cost and risk define the compromise required between competing factors. For example, additional segmentation can lead to enhanced packaging efficiency, but additional segmentation is more costly and can lead to additional secondary waste. Weight and expected dose of the packaged waste constrain the planned packaging too.
EDF further engaged Polestar/WMG to develop a preliminary segmentation plan based on the characterisation results. WMG had performed similar work for most US decommissioning plants but required EDF assistance in defining the constraints prevailing in France regarding waste conditioning. Many of the constraints could be communicated via documents such as transport waste container options, transport cask alternatives and different disposal waste acceptance criteria. French packages waste acceptance concentrations are influenced by the type of packaging used, which involves an additional level of calculation but also provides additional opportunities for innovative packaging.

WMG was able to estimate the quantity of containers of secondary waste based on past US segmentation experience. With a base segmentation plan available, EDF would be able to compare and evaluate the vendor's segmentation bids.

COOPERATION WITH OBRIGHEIM

Kraftwerk Obrigheim, KWO, is a Nuclear Power Plant owned and operated by EnBW, a German utility. The unit was built on the Neckar river from 1965 till 1968 as one of the first commercial nuclear power plant in Germany. The plant, with an electrical capacity of 357 MW, was designed by SIEMENS. The plant was connected to the grid in April 1969 and shutdown on May 11th 2005 after 37 years of operation and a generation of 90.9 TWh.
The decommissioning strategy selected for Obrigheim is immediate dismantling. Currently Obrigheim is in the so-called post-operating phase. During this phase all preparatory measures for the dismantling of the plant are performed. Spent Fuel has been transported to the external wet storage pool on site for decay.

Because EDF is a major shareholder of EnBW, the objective of this cooperation with Obrigheim was very ambitious. Initially both companies were exploring the possibility to develop a single contract for the segmentation of Chooz-A and Obrigheim RPVs and RVIs.

The adaptation to KWO of EDF conceptual design for the dismantling of the RPV and the RVI was assessed.
Although it was obvious that the wet segmentation of the RVI was also the best option for KWO, the segmentation and manipulation scenario defined for Chooz A internals was not fitted to KWO because of the different configurations of Chooz A and KWO pools. Because KWO reactor cavity is in fact much smaller than Chooz A's one and because the spent fuel at KWO plant pool is close to the reactor cavity, the best place for RVI segmentation at KWO is in the spent fuel pool.

Regarding the RVP segmentation at KWO, due also to space limitation in the reactor cavity, the segmentation in the reactor pool seemed not so easy. A segmentation in the spent fuel pool seemed feasible but it was necessary to lift the RPV and handle it in the spent fuel pool. But the manipulation had to be made in air because the hatch between the two pools was too small. Of course KWO was a little bit reluctant to do that because of radiation protection considerations. So several options were open for RPV segmentation and it was difficult to choose the right one.
Because the segmentation of the internals was the most critical issue from a technical point with a lot of potential impacts on the critical path of the project, and because the fixed cost of KWO operation were quite high, it was decided to award the contract for the RVI segmentation as soon as possible without waiting for the finalisation of the feasibility study for RPV segmentation.
So KWO intended to award two separate contracts : one for the internals and another one for the reactor pressure vessel.

Another key driver in the segmentation process selection is the type of waste containers and waste conditioning specifications available for disposal of the primary and secondary waste. An optimum has to be found between the numbers of cuts to be made, and thus the works duration and quantity of secondary waste to be produced, and the quantity of containers produced. For example, if it is possible to dispose large piece of equipment, less cuts will be necessary and it will be possible to choose a segmentation process that produces more secondary waste such as the Abrasive Water Jet Cutting. The same thing applies if a conditioning specification that optimises the quantity of waste containers necessary for the garnet produced by AWJC is available.
There is only one type of container available in Germany for the disposal of the segmented internals and RPV : the MOSAIK type. The size of the segmented parts is rather small because the MOSAIK container has a maximum inner capacity of 500 litres. Due to the permitted dose rates some containers need an additional lead shielding inside. In France, larger containers are available mainly for the disposal of the less activated part of the RPV and RVI. So it appeared that the different constraints prevailing in france

and in Germany regarding waste management could lead to the selection of different segmentation processes for Chooz-A and for KWO.

Due to all those considerations, it seemed difficult to choose the same segmentation process and scenario at KWO and for Chooz A. It was decided to go separately for the bids and contracts award but to continue to exchange information about the technical solutions proposed by the vendors.
Obrigheim is now considering to award one single contract too the one piece removal of the RPV not for final disposal but for interim storage and further dismantling.

Conclusion

The experience feedback collected from completed RPV dismantling projects was adapted as much as possible to the technical constraints prevailing in France. Applying lessons learned to the Chooz A decommissioning project has helped to streamline the development of technical specifications for the segmentation tender process.
This example shows that dismantling projects can benefit from international cooperation programmes through :

- Learning from others experience
- Confront different points of view
- Bringing new ideas

It demonstartes also some limitation to international cooperation. For example, it was not possible to fully apply the best practices identified in the US segmentation projects because some requirements regarding waste management were different in France.
Although the participants involved in the synergy programme were very enthusiastic, the outcome of the cooperation in this field was limited. Once again, apart from internal decisions regarding procurement strategy and schedule priority, waste conditioning requirements limitated the initial ambition of the cooperation.

Last but not least, this cooperation example shows also the benefits that can be brought to the projects by international acceptance of some dismantling options such a the one piece removal, transportation and disposal of the RPV. For example, the transportation of Chooz A RPV to the repository through foreign countries could be eased if this scenario is considered by international bodies as a safer option than full segmentation.