1. FIRST DISMANTLING OF A FRENCH INDUSTRIAL REACTOR

The EL4 nuclear power plant in Brennilis is located in the north west of France. The permanent shutdown occurred in 1985. Now it constitutes the first dismantling in France of a prototype industrial reactor of 70MWel heavy water moderated and cooled with CO2 gas which operated 17 years starting 1967.

At the end of 2008, the operator and owner of the plant, Electricité de France (EDF), commissioned the French-German consortium ONET TECHNOLOGIES and NUKEM TECHNOLOGIES GmbH with the dismantling of the reactor block (BR). The block essentially contains the reactor pressure vessel including built-in units and biological shields, the peripheral piping as well as all systems for controlling the nuclear-related processes. In addition to the complete dismantling of the above-mentioned elements, the scope of the contractual services also includes their proper handling in accordance with applicable regulations.

2. OPERATION PRINCIPLE OF THE REACTOR

The central element of the plant is the reactor pressure vessel filled with heavy water which is located in the middle of the reactor block. Its cylindrical body which is oriented east/west has a diameter of 9.7m and a length of 5.9m. In 216 pressure tubes made of zircaloy which run through its interior, fuel assemblies transfer nuclear heat to carbon dioxide flowing around them. The control rods are introduced vertically into the reactor. Thanks to extension tubes connected to the feed points to the east and west of the plant, it was possible to equip the reactor with the help of two refuelling machines with new fuel elements during operation.

Each of the 216 fuel element channels is at each side connected to a pipe which directs the heat transfer gas to a header mounted in the upper part of the reactor block. Here, the gas is collected and directed to the heat exchangers. The cooled gas was then directed to a cold header and fed back into the reactor, thus closing the coolant cycle. It should be pointed out that due to this reactor design, the reactor pressure vessel is equipped with a complex pipe system to all sides which makes it difficult to freely access the core area of the reactor block and thus to dismantle the reactor. In this context, the axial and lateral neutron shields should be mentioned, which are situated in close proximity to the reactor as well as the biological shield which protects from ionizing radiation originating from the pressure vessel.
3. TECHNICAL CHALLENGES

The Brenniiiis EL4 block reactor dismantling is a real technical challenge considering that – as with most first generation nuclear power plants – no dismantling requirements were taken into account during construction of the reactors. The access to the core area is made difficult due to a high local dose rate and the extremely high constructive complexity of the prototype, the interior of which is really criss-crossed by complex piping. The elevated local dose rate in the area of the reactor pressure vessel makes manual work in this zone impossible (even after 30 years), so that remote dismantling techniques have to be used. Due to the high number of repetitions especially in connection with the dismantling of the peripheral D2O and CO2 pipes, there are high demands put on the capacity and reliability of the remote devices. Before starting dismantling, these are determined with the help of a test stand which representatively simulates the real conditions of the reactor block in respect to dimensions and material. As relates to the first generation, it is also important to mention in this context the insufficient documentation quality of the actual state in comparison to current standards which has especially to be taken into consideration during the test stand phase. A number of special challenges arise from the above-mentioned circumstances. How these challenges can be met will be illustrated in the following.

4. VIEW DISMANTLING SCENARIOS

4.1 Use of remote technology

For operating the cutting tools, standardized industrial robots are used which are known from areas such as clean room technology or automotive manufacturing. These are “nuclearized” for their work in the controlled-access area and installed on a rail-mount, motorized drive unit which allows for a correspondingly high repeatability of the driving movements.

Fig. 3 – Sectional drawing of the reactor pressure vessel

Fig. 4 – Dismantling scenario using the remote technology: remote controlled equipment

To create an access to the interior of the BR, a 4.7m high working platform will be attached to the reactor block in the northern part of the plant. A standing airtight steel plate caisson on the platform forms a walk-in room between the reactor building ER and BR. After completion, wall openings will be created from inside the caisson in axial direction to the reactor corridors and closed with two massive radiation protection gates. Thus, the requirements are met for removing material under radiation-proof conditions from the BR. The waste containers can be transported via a lift to the conditioning facility right underneath. Maintenance engineers and radiological safety officers have the possibility to enter the caisson from the reactor building through a double door airlock entry system. The caisson is further equipped with the necessary locking system which prevents accidental access of staff.

Fig. 5 – Dismantling scenario using the remote technology: intervention concept
4.2 Dismantling of the coolant piping and the axial shield

At the beginning of the remote dismantling process, the reactor corridors will be filled with coolant piping with a pipe diameter of 114-133mm and a wall thickness of 5-8mm which blocks the access to the reactor pressure vessel which lies behind the corridors. To cut the piping, the robots will use inner pipe cutters which will gradually work their way in the direction of the reactor. The lines of rails which the robots will drive on will be extended in regular time intervals to follow the steadily progressing work area. After completion of the cutting process of all 216 pipes with an average total length of 13m, the reactor and the axial shield will be accessible. The shields which consist of elements built of water tanks will be thermally cut to create additional room for the dismantling of the reactor.

Fig. 6 – Dismantling of CO2-tubing and axial shielding

4.3 Dismantling of the reactor pressure vessel and the lateral shield

The reactor will be dismantled from the inside to the outside. The first step consists in creating a window in the reactor bottom with the help of a circular saw which will set up itself. The temperature of the cutting zone is monitored by a temperature sensor which automatically switches off the circular saw if a certain temperature limit is exceeded. This safety precaution is necessary to prevent the zircaloy pressure tubes in the reactor from catching fire. Due to the pyrophoric properties of the material, the zircaloy particles are not to be heated above a certain temperature, which is depending on their size, in order to prevent them from burning. The pressure tubes segmented in an earlier stage are collected and transported to the conditioning cell. After removal of all elements containing zircaloy, thermal cutting techniques can again be applied to cut the reactor and the shield therein from the inside to the outside. The cutting segments will be transported via the usual way to the conditioning cell where they are processed so that they are ready for the final disposal site.

Fig. 7 – Retrieval of zircaloy piping. Dismantling of reactor pressure vessel and lateral shielding

5. GENERAL CONDITIONS OF THE PROJECT

The aim of the project is the complete dismantling of the large elements within the BR which have been activated and contaminated during operation of the plant. Special attention is put on minimization of the radioactive waste produced. Further conditions to be observed are the compliance with the applicable regulations of the French atomic law, of environmental and radiation protection, of industrial safety and with the terms of acceptance of the radioactive waste management agency ANDRA. On the regulatory level, the application of the dismantling decree that the starting of the dismantling works is depending on is currently in progress. Additionally, there are several specific operative requirements. For example, organizational and technical measures are to reduce the collective dose rate and the risk of incorporation for the operational staff as much as possible.

6. CONCLUSION

The remote dismantling of the Brennìlis reactor block is one of the first dismantling projects of first generation nuclear power plants in France. It will provide valuable experience feedback for subsequent decommissioning projects in France and beyond. The project offers interesting technical challenges which are connected to the method of construction, the complexity of the tubing system, the prototype character of the installation, the age of the plant and the civil work constraints.