A WM Facility for the Processing of Radioactive Materials Arising from the Decommissioning Activities of the Belgian Nuclear Power Plant of Doel – 16042

Serge Vanderperre, Caroline Goessens, Candice De Jonghe, Denis Maloir and Maxime Wadin

Tractebel Engineering - Ariane Avenue 7, B1200 Brussels - Belgium

ABSTRACT

Doel Nuclear Power Plant is located in the northern part of Belgium in the harbour of Antwerp on the Scheldt River. On this 80-hectare site Electrabel, the Belgian utility, operates four PWRs with a total generation capacity of 2911 MWe. Those nuclear power units were commissioned in 1975 (Doel 1 and 2 – twin units), in 1982 (Doel 3) and in 1985 (Doel 4) [1].

In light of the Belgian governments decision to definitively shutdown the oldest units of the site (Doel 1 and 2 – 433 MWe each) in 2015 at the end of their 40-year design lifetime, Electrabel launched a D&D program in partnership with Tractebel Engineering in July 2012.

During the D&D preparation phase prior to the final shutdown, studies performed by Tractebel Engineering showed the added benefit of a purpose-built Waste Management Facility (WMF) specifically equipped to process contaminated and activated components generated by the in-situ dismantling activities.

The WMF is a key infrastructure contributing to a large extent to the Waste Minimization Policy within the global D&D program. The present paper aims at presenting its strategic, logistic, infrastructural, and design principles.

At the end of 2014, the Belgian government and Electrabel entered into discussions to envisage a 10-year lifetime extension of Doel 1 and 2 units. Therefore, Electrabel decided to put the D&D program on hold.

Nevertheless, the preparatory studies for the future D&D activities on Doel site are set on solid assumptions and pave the way towards a safe, cost-effective and waste minimizing decommissioning process.

INTRODUCTION

In 2012 the Belgian government decided to definitively shut down Doel 1 and 2 twin PWR units (433 MWe each) of the Doel site in 2015 after 40 years of operation.

Consequently, dedicated studies were launched by Electrabel, the Belgian utility, in partnership with Tractebel Engineering for the D&D of the Doel 1 and 2 units. The future decommissioning of the other units of the Doel site (Doel 3 and 4) also had to be taken into account in the framework of a site integrated D&D project.

The construction of a purpose-built WMF was chosen above performing all dismantling works in situ in the units. Especially due to the specific characteristics of the Doel site with 4 operating PWR units and 10 steam generators (SGs) already taken out of service and stored on site which eventually need to be dismantled, a dedicated building was preferred. Following arguments contributed to the final decision to erect a WMF:

- In the units, the accessibility to dismantle the components is more difficult and large tools cannot be used everywhere. The result is lower work efficiency, lower throughputs and higher dose rate exposure of the workers. In the WMF, the workers will benefit from optimum working conditions relying on the most appropriate dismantling tools;
- The work of removing material from the units is not directly coupled to the dismantling work within the WMF. Therefore the Treatment and Conditioning (T&C) work can be organised and optimised separately.

STRATEGY

The various functional units of the WMF will be located in three distinct buildings, taking advantage of buildings already existing on site that will be adapted for decommissioning purposes. The Incoming Buffer Storage (IBS) with containers featuring the materials to be processed and the Outgoing Buffer Storage (OBS) with conditioned waste containers will be accommodated in the existing turbine hall of Doel 1 and 2. The Free Release Measurement Facility (FRF), characterized by a low radiation background area, will find its place in the existing spare parts store.

The remaining functional units, encompassing T&C techniques such as cutting, decontamination, super-compaction, grouting, as well as radiological characterization capabilities will be located in the new infrastructure (9 200 m²) to be built next to the IBS and OBS (4 200 m²).

Throughout the feasibility and basic design phases, special emphasis was put on the use of proven and flexible technologies and on an effective decoupling of the in-situ dismantling activities from the downstream T&C efforts through adequate sizing of the installations and buffer storage areas.

The start of operation of the WMF is planned at the start of the dismantling activities of the Doel 1 and 2 units (i.e. at the end of the post-operational phase). The WMF will in a later phase perform as well the T&C of the radioactive materials arising from the D&D activities of Doel 3, Doel 4 and from the other D&D activities of common nuclear on-site facilities.

The WMF will contribute to the waste minimization policy of the D&D program and has following main objectives:

- To segregate and decontaminate (as far as reasonably achievable) solid radioactive material into material that can be free released for recycling or management as conventional waste. Liquid waste, as well as liquid secondary waste resulting from the T&C operations in the WMF, will be managed by the on-site waste water treatment building currently processing the operational waste at Doel site;
- To reduce the volume of radioactive waste (as far as reasonably achievable);
- To condition the radioactive waste into final packages (i.e. Monoliths) meeting the applicable acceptance criteria for final disposal in the near surface repository (category A waste, i.e. LLW) defined by ONDRAF/NIRAS, the Belgian waste management agency [2].

In Belgium there is no very low level waste category. Therefore, decontamination will be performed for free release purposes and not in order to try to lower the radioactive waste categorization.

When possible, mechanical cutting tools are preferred above thermal cutting ones. Cutting operations will be performed:

- To reduce the size/weight of handled pieces for further treatment or loading in waste containers;
- To make surfaces accessible for decontamination;
- To remove portions of materials not compatible with the rest of the process or requiring special treatment.

LOGISTICS

The dismantled materials will be removed from the units and, depending on their origin and radiological properties, free released in-situ, sent for free release measurements in the FRF or T&C in the WMF.

An overview of the management of the radioactive materials arising from dismantling activities is shown in Fig. 1.

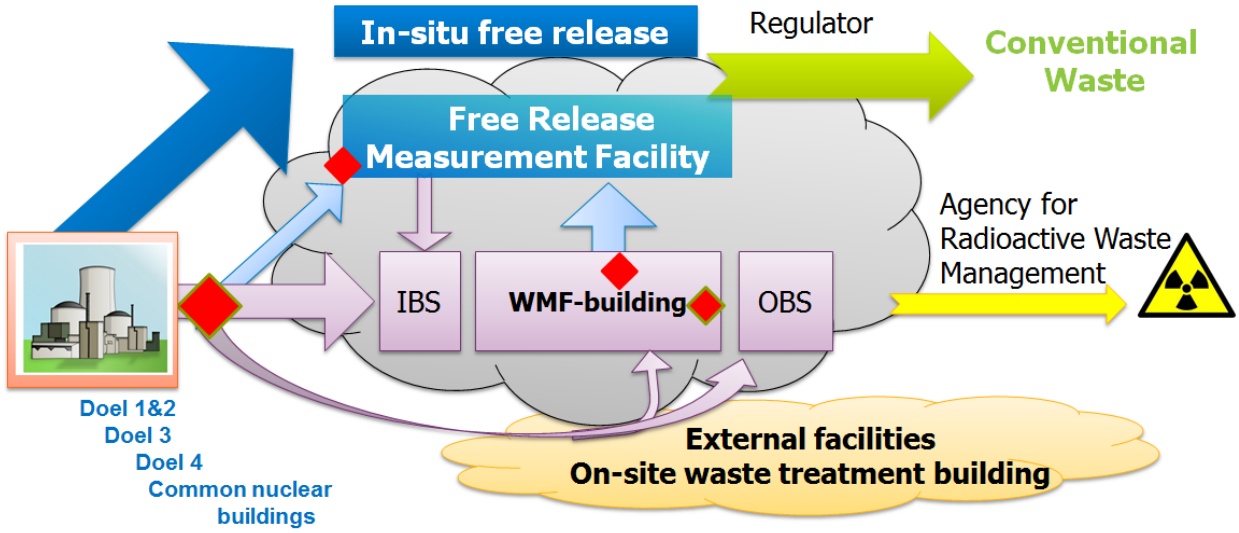

Fig. 1: Management of radioactive materials from dismantling activities.

Dismantled materials outside of the controlled area will be treated as conventional waste while dismantled materials from the controlled area are sorted in situ in the unit and undergo radiological measurements before being sent to the WMF for T&C. ISO IP-2 20 ft. containers will be used for the transfer of the radioactive materials from the units to the IBS. Large components (e.g. SGs, pressurizer,…) will be transferred in one piece and stored in the IBS awaiting treatment.

Non-activated and non-contaminated materials from the controlled area, or parts of, will be removed from the units and will not be sent to the WMF. After a first free release measurement, performed within Doel 1 and 2 units themselves, these materials are transferred to the FRF to be free released.

Also the cleaning or decontamination of only slightly contaminated materials will be performed in situ, therefore limiting the throughput of (lightly contaminated) materials that will go through the WMF. Next, these materials will be sent to the FRF.

The contaminated materials will be removed from the units, after in situ dismantling, and transferred to the WMF for further treatment. Part of this stream of contaminated material can be decontaminated down to free release levels. The first free release measurement will be performed within the WMF. The second independent free release measurement will be made within the FRF. Contaminated material that cannot be sufficiently decontaminated will be conditioned as radioactive waste in the WMF.

The activated materials are packaged in the units in High Integrity Containers (HICs) or Monolith caissons depending on their overall radiological content. Activated material eligible for near surface repository is packaged in Monolith caissons and further conditioned in the WMF. HICs with lead shielding, containing the remaining materials, are considered as category B waste (ILW) and are destined for geological disposal [2]. These can be buffer stored in the OBS. No treatment and conditioning of materials packaged in HICs is foreseen within the WMF.

Not all radioactive waste will be processed in the WMF, melting of metallic materials and incineration of combustible waste will be outsourced to external facilities located in Belgium or abroad.

INFRASTRUCTURE AND DESIGN

The physical inventory of the largest nuclear power unit on the Doel site (e.g. Doel 4) has been used as a basis for the estimation of the T&C and storage capacity needed in the different functional units. Three different buildings can be distinguished: the IBS and OBS, the WMF new infrastructure building and the FRF.

An overview of the WMF functional units can be found in Fig. 2.

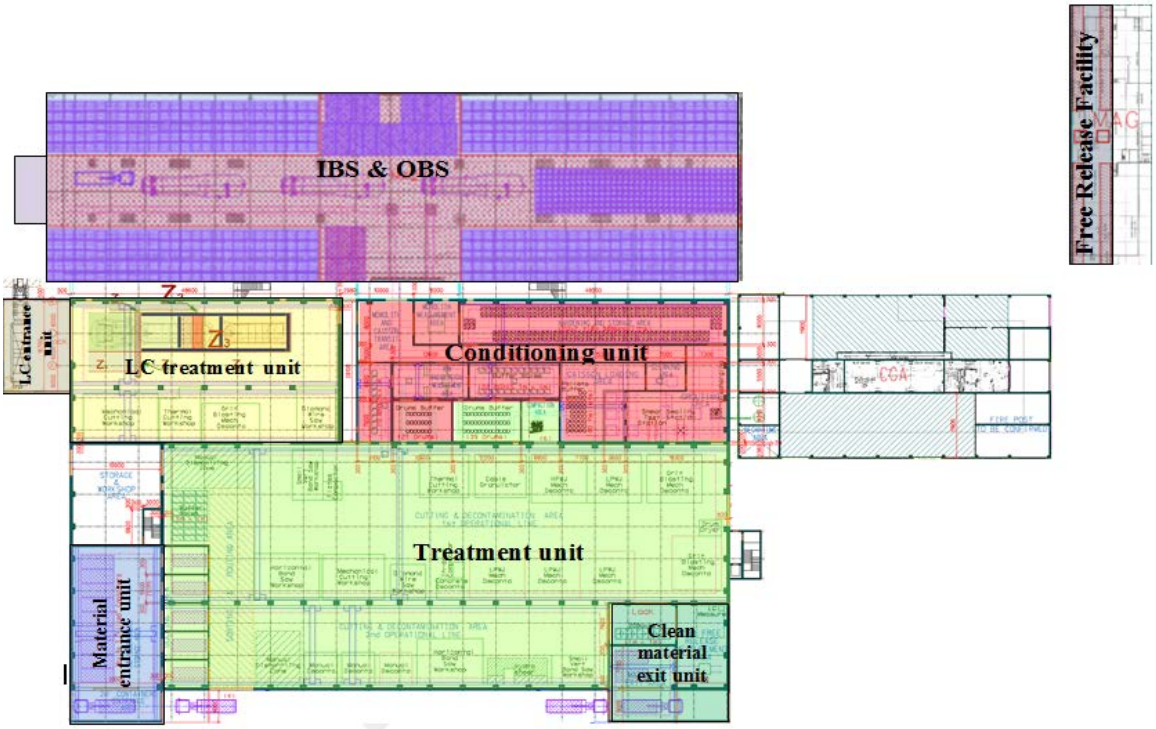

Fig. 2: WMF functional units.

IBS and OBS

The incoming and outgoing buffer storage, with a total useful surface area of about 4 200 m², will be located in the turbine hall of the Doel 1 and 2 twin units.

The IBS will collect and temporary buffer-store dismantled materials, coming from the units, awaiting treatment in the WMF. The contaminated radioactive material will be stored in ISO IP-2 20 ft. containers. If necessary, large components such as SGs can be stored before treatment. The IBS will also temporary store the empty Monolith caissons used in the WMF for the conditioning of the radioactive waste for near surface disposal.

The OBS serves as a temporary buffer store for conditioned Monoliths ready for acceptance and transfer to the Belgian waste management agency. Also HICs with category B (ILW) waste can be temporary stored.

The IBS and OBS enable to decouple as much as possible the in situ dismantling activities from the T&C activities of the dismantled materials in the WMF.

WMF new infrastructure building

Next to the turbine hall of Doel 1 and 2 twin units, a new infrastructure building for the T&C of the radioactive waste coming from the units will be constructed (9 200 m²). The building houses:

a) A material entrance unit:

The radioactive waste coming from the units or the IBS is transferred in ISO IP-2 20 ft. containers to the material entrance unit of the WMF which operates as an airlock. When the contents of a container need to be treated, it will be transferred to a docking area which connects the material entrance unit with the treatment unit. In this way cross contamination with the outside environment can be avoided.

b) A treatment unit:

The cutting and decontamination of the radioactive material is performed in the treatment unit. A special emphasis was put on the use of proven and flexible technologies.

From a dedicated sorting and routing area the materials coming from the docking area or the large components (LC) treatment unit will be transferred to the different cutting and decontamination areas.

Next equipment types will be foreseen in the WMF treatment unit for the T&C of the radioactive waste:

- Cutting equipment:
  - Horizontal band saws;
  - Vertical band saws;
  - Portal band saws;
  - Hydraulic shears;
  - Thermal cutting equipment;
  - Diamond wire saws;
  - Portable cutting equipment (band saws, hydraulic shears, diamond disk saws, etc.);
  - Cable pelletizing and separation system;

- Decontamination equipment:
  - Low Pressure Water Jetting (LPWJ) equipment;
  - High Pressure Water Jetting (HPWJ) equipment;
  - Grit blasting equipment;
  - Concrete decontamination equipment;
  - Manual decontamination workshop;
- In-drum compactor;
- Supercompactor.

c) A LC treatment unit:

Large components such as SGs will be transferred in one piece to the dedicated entrance airlock of the LC treatment unit for cutting and decontamination. The large components will be cut into smaller dimensions and transferred:

- To the treatment unit for further cutting and decontamination;
- The conditioning unit as radioactive waste;
- To an external treatment facility, i.e. for melting.

d) A conditioning unit:

The radioactive waste is transferred to the conditioning unit for loading into Monolith caissons where they will be grouted by an immobilization mortar. After waste immobilization, the Monoliths will be transferred to a hardening and storage area.

The conditioning unit consists of:

- The radioactive waste radiological characterization area before Monolith loading;
- The Monolith caisson loading area with dedicated handling tools;
- The grouting area for the immobilization of the radioactive waste;
- The hardening and storage area;
- The Monolith measurement area to determine the dose rates for transport and check for external contamination;
- The cleaning area for caisson decontamination if necessary.

e) A clean material exit unit

The clean material exit features the necessary equipment for the first free release measurement and the transfer of the free releasable material to the FRF. A gross gamma counting of the material packages (1 m^3 boxes or 220-l drums) will be performed to determine if they can be sent to the FRF. If the packages are successfully measured, samples are taken and put in 220-l drums for analysis in the FRF.

FRF

The FRF will be situated in the existing spare parts store (useful surface of about 1 500 m²). Materials which successfully passed the first free release measurement in the units of the WMF will be transferred to the FRF for the second independent free release measurement in a low radiation background area.

The second free release measurement will enable to verify the mass specific clearance levels of all possible radionuclides that could be present in the drums containing the samples collected from the first free release measurements. If the criteria for free release are met, the material can be released from nuclear regulations. If not, the material is returned to the WMF for further treatment.

Sufficient buffer storage before and after the second free release measurement will be foreseen.

SAFETY

During the feasibility and basic design phases, Electrabel, as a future owner and operator of the WMF facility, has been in close contact with the Belgian Safety Authorities and has provided them with a Design Options and Provision File in order to secure the pre-licensing of the project [3].

CONCLUSION

In partnership with Electrabel, the Belgian utility, Tractebel Engineering completed the feasibility and basic design studies related to the erection of installations dedicated to the management of waste arising from the future decommissioning activities on the site of Doel Nuclear Power Plant.

These installations feature an incoming and an outgoing buffer storage for the Waste Management Facility, the Waste Management Facility itself and a Free Release Measurement Facility.

At the end of 2014, the Belgian government and Electrabel entered into discussions to envisage a 10-year lifetime extension of Doel 1 and 2 twin units. Therefore, Electrabel decided to put the D&D program on hold, among which the detailed design of the Waste Management Facility.

Nevertheless, the preparatory studies for the future D&D activities on Doel Nuclear Power Plant site are set on solid assumptions and pave the way towards a safe, cost-effective and waste minimizing decommissioning process.

REFERENCES

[1] Electrabel s.a./n.v., Key figures of the Doel nuclear power plant, http://www.electrabel.com/en/corporate/nuclear-power-plant-belgium/doel-tihange/news.

[2] ONDRAF/NIRAS, Classification of radioactive waste, http://www.ondraf.be/content/classification.

[3] AFCN/FANC, “Note conceptuelle de l’AFCN: Arrêt définitif et démantèlement d’établissements nucléaires” (Conceptual note of the Federal Agency for Nuclear Control: Definitive shutdown and decommissioning of nuclear facilities), 2012, http://www.fanc.fgov.be/nl/news/stopzetting-en-ontmanteling-van-nucleaire-inrichtingen-het-fanc-publiceert-conceptnota/527.aspx.