Bel V activities[1] in the Belgian context of dismantling research reactor and fuel cycle facilities

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Abstract:
In this paper an overview of the main decommissioning projects in Belgium since the eighties is firstly presented. The licensing approach and the involvement of the Belgian TSO in these decommissioning activities are then described. The evolution of the follow up and safety review of these activities by the Belgian TSO is highlighted.

1 INTRODUCTION

In Belgium, decommissioning programmes started since 1987 with R&D and small pilot projects on dismantling and decontamination techniques so as to develop appropriate dismantling and decontamination techniques, as well as to gain information on their performances and costs.
Since the publication of a new Royal Decree in September 2001, the operators which are intending to decommission a nuclear facility in a near future have to introduce to the competent authorities a request for a decommissioning license. Those which had already partly started decommissioning activities had to introduce a request for a decommissioning license within one year after publication of a this Royal Decree. The application for license has to contain information, such as the ultimate objective of the decommissioning, the destination of the radioactive waste and a preliminary safety report.

2 LICENSING APPROACH IN BELGIUM

The term “decommissioning” refers to the administrative and technical operations taken to allow the removal of some or all of the regulatory controls from a nuclear facility after its shutdown and the return of the site to an acceptable end-state.
The administrative operations refer to the elaboration of a decommissioning plan and appliance for decommissioning license. The technical operations refer to the dismantling, decontamination, waste management…
From a regulatory point of view two federal organizations are involved in decommissioning activities:

- The Federal Agency for Nuclear Control (FANC) for aspects related to radiation protection and safety;
- The Radioactive Waste management Agency (ONDRAF/NIRAS) for the management of radioactive wastes and for the coordination of the decommissioning of nuclear facilities in Belgium.

[1] The TSO activities related to the installations considered in this paper were carried out previously by the Authorized Inspection Organizations Corapro and then by AVN (after a merge of these two companies in 1996). They are since 14th April 2008 carried out by Bel V, a subsidiary of the FANC, that took over the regulatory activities of AVN.

The regulation laid down by the Royal Decree (RD) of July 20, 2001 requires in the case of cessation of a licensed activity from the operator to inform the FANC and ONDRAF/NIRAS of the intention to stop the activity.
The application for decommissioning has to be introduced to FANC and must be submitted to ONDRAF/NIRAS for advice on all matters related to its responsibilities. Moreover the licensee must submit its initial decommissioning plans to ONDRAF/NIRAS which must approve them in the frame of its legal missions. These decommissioning plans are reviewed and approved every five years.

In Belgium a file requesting decommissioning authorisation must include three parts:

- 1st part: A report containing a brief description of the site, installations and dismantling operations;
- 2d part: A report including a detailled description of the installations to be dismantled, the methods, technics of dismantling and the radiation protection measures that will be implemented;
- 3d part: An Environment impact assesment report of the dismantling (EIAR).

Information such as description and planning of the different phases of the dismantling, description of the means implemented in order to ensure radiation protection, risk analysis regarding the external and internal accidents must be included in the application file.

The TSO is also in charge of conducting a safety evaluation based on the Preliminary Safety Report presented by the applicant. The TSO advice as well as propositions of license conditions are integrated in the TSO report, which is submitted to the Scientific Council of the FANC. This Council examines the application file and the TSO/FANC advice. It then formulates a provisional preliminary advice.
The license application is transmitted to the concerned local authorities for a public enquiry and also to other member(s) of the European Community in case the article 37 of the Euratom treaty applies.
Once all the necessary advices (local authorities, European Commission) have been received the Scientific Council issues a motivated preliminary advice. The applicant has the right to comment on the advices issued by the Scientific Council. If the applicant has no remarks the advice is considered as final and a decommissioning license is granted by RD.

After granting the license, compliance with the provisions of the decommissioning license is organized for each of the licensed facilities on three levels:

- The Health Physics department of the licensed facility;
- The TSO that is recognized by the competent authority to supervise the Health Physics department of the facility;
- FANC.

Even when the decommissioning license is granted, every single phase in the decommssioning process must obtain prior approval of the Health Physics department, confirmed by the TSO.

3 D&D PROJECTS IN BELGIUM

In this section a short review is given about the main D&D projects in Belgium, which started for some of them since the eighties. Three D&D projects - one research reactor (BR3 at SCK°CEN) and two fuel cycle facilities (Eurochemic at Belgoprocess and a Plutonium facility at Belgonucléaire) - have been chosen in this paper in order to illustrate past, present and very near future decommissioning activities. Other decommissioning projects like several buildings for the treatment of waste at Belgoprocess site 2, the Thetis research reactor at

University of Ghent (the decommissioning project is still under development) will not be developed here.

3.1 BR 3 research reactor (SCK°CEN)

Fig. 1 View of the BR3 research reactor at SCK°CEN

The BR3 reactor (see Fig. 1) is a PWR-type of reactor, with one primary loop. The power of BR3 is 40 MWth and 10,5 MWe. It was made critical for the first time on August 19th, 1962 and was coupled the same year to the electric grid on October 10th.
In 1975, a first decontamination of the primary loop by chemichal method was performed in collaboration with Westinghouse.
Eleven successive operation campaigns, separated by periods for reloading the reactor with fuel were spread over the years starting from the first coupling to the distribution system. In total, the reactor produced 964,6 GWh. The reactor was definitely shut down on June 30, 1987 at 24:00.
In 1989, BR3 was selected by the European Commission (EC) as one of its four pilot projects in the framework of its five-year Research and Technological Development programme on the decommissioning of nuclear installations [3]. According to plan, the plant will be completely decommissioned by the end of 2011.

The global objective of the decommissioning project was to demonstrate the technical feasibility and the acceptability by the public of the dismantling of a nuclear power plant just after its shut down. The project aimed at demonstrating that the dismantling of a nuclear facility can be completed in a safe and economic way while minimizing the amount of radioactive waste, and in compliance with the protection of the workers and of the environment.
The general strategy of the project was:

- To develop, to test and to optimize the implemented technologies.
- To collect for the different operations the data regarding the cost, the amount of waste and the dosis received by the workers.
- To develop an expertise in the dismantling of nuclear plants to be implemented in future dismantling of nuclear facilities.
- To develop dry and underwater cutting techniques for the highly activated core internals.

An important step of the decommissioning process was a very extensive decontamination of the primary circuit which reduces the doses when cutting the primary pipes, the reactor internals and the pressure vessel.

The objectives of this first decontamination were to reduce the radiation dose rate near the low- and non-activated components and to limit the transfer of surface contaminants during subsequent segmentation. The three successive cycles of the CORD® decontamination process allowed to remove 2 TBq of gamma emitters, which is not less than 90% of the activity of the primary circuit.

Another operation aimed mainly at decontaminating, after segmentation, a large amount of non-activated metallic components at very low residual radioactivity levels, in order to evacuate or recycle them as non-radioactive waste. The cerium process, called MEDOC (for MEtal Decontamination by Oxidation using Cerium) process, which is based on the high oxidation potential of cerium at valence 4+, has been selected to decontaminate the dismantled pieces. It was able to attack both the oxides and the base metal.

In 2002, the spent fuel from the BR3 was transported to Belgoprocess (a subsidiary of ONDRAF/NIRAS) for dry storage in CASTOR BR3 dual purpose casks.

For the preparation of different dismantling operations, and in the context of the optimisation of the radiation protection, a specific computer code called VISIPLAN 3D ALARA planning tool was extensively used by the licensee to plan the interventions and analyse the different strategies, on the basis of the dose uptake.

3.2 EUROCHEMIC (Belgoprocess)

Fig. 2 View of the main process building of the former Eurochemic reprocessing plant

The Eurochemic reprocessing facility at Dessel in Belgium [1], was constructed from 1960 to 1966. A consortium of 13 OECD countries operated this demonstration plant from 1966 to 1974, and reprocessed 180 tons of natural and low-enriched and 30 tons of high-enriched uranium fuels. After shutdown, the plant was decontaminated from 1975 to 1979 to keep it in safe standby conditions at reasonable cost.

The industrial decommissioning of the main process building of the former Eurochemic reprocessing plant was started in 1990, after completion of a pilot project. Two small storage buildings for end products from reprocessing were dismantled to verify the assumptions made in a previous paper study on decommissioning, to demonstrate and develop dismantling techniques and to train personnel. Both buildings were emptied and decontaminated to background levels. The main conclusions of this pilot decommissioning study denoted that in the future emphasis should be put on the automation of concrete decontamination, and the decontamination of metal components.

The main process building is a large rectangular construction of about 80 m long, 27 m wide and 30 m high (see Fig. 2). The core of the building consists of a large cell block of 40 main cells, containing the chemical process equipment. Access areas and service corridors are located on 7 floor levels. About 106 individual cell structures have to be dismantled. Some cells have contamination levels up to 125 Bq/cm^2 (beta) and 200 Bq/ cm^2 (alpha). Some hot spots give a gamma dose rate of several mSv/h.
Decommissioning involves the removal and decontamination of equipment from each cell, the decontamination of cell walls, ceilings and floors, and the dismantling of the ventilation system. These activities are followed by a complete monitoring for unconditional release of the remaining structures. Most of the work involved hands-on operations under protective clothing tailored to each specific task. Tool automation and automatic positioning systems were applied extensively.
The specificities of the Belgoprocess approach for the decommissioning of Eurochemic are as follows:

- the decommisioning activities are carried out on an industrial scale with special emphasis on waste minimisation, extensive decontamination to unconditional release levels and cost minimisation;
- available technology is used in good cooperation with the nuclear or non-nuclear industry;
- the alpha contamination on equipment and building surfaces in a reprocessing plant requires the use of adequate protective clothing (specific breathing and cooling systems are needed).

The main challenges encountered by Belgoprocess during the last years of decommissioning the Eurochemic building were the following [1]:

- high dose rates due to remaining liquids from former reprocessing activities;
- more material/equipment to be removed than considered in the inventory;
- pipe penetrations between cells to be removed in order to obtain low radiation background levels;
- contamination had penetrated deeper than expected into the concrete of cell structures.

The decommissioning project, launched in 1990, is now being executed on an industrial scale. In view of the final demolition of the main process building, Belgoprocess has divided the entire building into 3 parts. Each part will be isolated and separated from the other ones in order to facilitate and to simplify the demolition works. The demolition of the Eastern part of the main process building started on 23th June 2008.

3.3 Plutonium facility (Belgonucléaire)

The Belgonucleaire (BN) MOX production plant located in Dessel, was commissioned in the early 70's. In de mid-80's, the industrial stage was reached with the development of the MIMAS process for LWR fuels. During the last two decades, 35 metric tons of plutonium were processed into about 650 tons of LWR fuel.
The Dessel MOX plant is erected on a single floor and is arranged in an intricate network of interconnected glove-boxes with volumes ranging from 0.5 m^3 up to 15 m^3 and arranged on two levels [2].
The decision to stop the production was taken in the second half of 2005 and the conditioning and evacuation of the remaining production scrap was organized up to the point where the glove boxes are empty of reusable fissile materials. After cleaning, the radioactive material remaining in the glove-boxes as contaminant is limited to uranium and plutonium with following typical isotopic composition (aged 5 years):
Pu-238 (3.2%), Pu-239 (50.2%), Pu-240 (26.9%), Pu-241 (7.6%), Pu-242 (8.6%), Am-241 (3.5%).
BN decided to perform decommissioning as soon as possible because the activity results from long-lived radio-isotopes and there is no activation. In addition, some Am-241 build-ups with time have to be considered.

The Belgian Royal Decree (RD) of 20th July, 2001 provides the legal framework for protection of the population, workers and environment against the ionizing radiation hazards.
As required by the above mentionned RD, BN introduced a license application for decommissioning to the FANC in 2006 and was granted its decommissioning license in March 2008. Because decommissioning is a specialized activity and not part of BN's past core business, it was early decided to subcontract the decommissioning work. The process of selecting subcontractors for the decommissioning and dismantling activities in compliance with specifications, should be finalized in September 2008. Dismantling of the plant is foreseen to start early 2009.
The IAEA and EURATOM organizations continue to be in charge of the safeguards of the fissile material remaining after cleaning.
For project management and obtaining the decommissioning authorizations, the full plant inventory for contaminated objects, including a radiological survey, was prepared based on samplings and measurements performed by an independent organization. The inventory, which includes 170 glove-boxes and their internal equipment and the infrastructures, accounts for about 1000 ton of free release material and about 400 ton of radio-active waste.
Accurate estimation of primary and secondary waste helps the waste flow management. The waste will be transferred regularly to the final conditioning plant during the dismantling period in containers and packaging similar to the ones already used for the previous operations.

Fig.3 Typical glove boxes intallation at the Belgonucleaire MOX plant *[2].*

BN has selected as decommissioning technique for glove-boxes the in-situ size reduction in shielded disposable tents for several reasons, among which [2]:

- Reduced contamination risks
- Radiation protection adjustable to the situation.
- Safety of the workers by using dry and cold cutting processes.
- Containment protection similar to glove boxes during MOX-production
- Parallel processing possible
- Secondary waste is acceptable.

BN will benefit from the use of proven techniques and is therefore confident in a safe and timely completion of its decommissioning project.

4 BEL V ACTIVITIES

During more than 20 years of history of decommissioning activities in Belgium, the approaches, the techniques, the scope of safety evaluations and the licensing procedure have drastically evolved. The TSO approaches and activities related to these decommissioning projects did not escape from a necessary evolution along the years.

The present section will describe the type of TSO activities (and their evolution) for the three different decommissioning projects. It is aiming at summarizing specific and common aspects amongst these projects and providing trends for the future.

4.1 Introduction

A good knowledge of the nuclear installation to be dismantled is an important asset when judging of the adequacy of decommissioning options and dismantling techniques. TSO experts involved in the inspection activities of these installations were (and are still) deeply involved in the safety evaluation of the decommissioning activities of the installation they are inspecting. Along the years the TSO activities in Belgium regarding decommissioning projects evolved from a situation where decommissioning was treated and analysed by the operators and the TSO through progressive modifications of the nuclear installations to a situation where decommissioning activities are formally the subject of a new license. This leads to a more systematic analysis of the multiple aspects of decommissioning projects with particular focus on the following topics:

- the evaluation (with update along the dismantling phases) of a global safety case for decommissioning (including facility description, project management, surveillance and maintenance programs, waste management, safety analysis of normal operation and accidental conditions, …);
- the management of modifications with respect to the description of the global safety case for decommissioning;
- the definition of decommissioning phases important for safety (and hold-points);
- periodical reporting;
- return of experience;
- clearance aspects.

The TSO activities - and their evolution - in the framework of the decommissioning of BR3, Eurochemic and the future decommissioning of a Plutonium facility are briefly presented below.

4.2 BR3

As the safety requirements continue to apply during decommissioning as much as the corresponding safety functions must be ensured, the organisation of the inspection conducted by the TSO during decommissioning was not modified. Concerns for the inspection of the installation remained the same: Availability of systems and components needed to ensure the remaining safety functions, radiation protection, waste management…
Periodicity or subjects of the inspection may vary, according to the progress of the decommissioning, in order to ensure that necessary maintenance, care and surveillance are carried out and reach their aim. Specific inspections also concerned the implementation of dismantling techniques and of decontamination methods.

For each decommissioning phase the documentation shall include a status report of the installation at the beginning, a description of the activities to be performed together with their safety management, radiological potential consequences and a description of the waste management.
Concerning the waste clearance, the related procedures are written by the Health Physics department and have to be approved by the Belgian TSO. The acceptable levels of activity are given in the RD of July 2001. A yearly inventory of the cleared products has to be sent to FANC.

SCK•CEN and the TSO defined the methods that had to be used to analyse and monitor the radioactivity from the start of the decommissioning until the final release, namely:

- Monitoring the entire wall and floor surfaces;

- Radiological analyses of the wash-water of walls and floors;
- Measurement of selective core samples.

When the results of these measurements and analyses were below the above-mentioned limits, the Health Physics department established the certification of unrestricted reuse and submitted it for approval to the TSO.

The TSO also reviewed the safety analysis of the CASTOR BR3 casks regarding the mechanical, thermal and criticality aspects.

4.3 EUROCHEMIC

The decommissioning activities of Eurochemic (started in 1990) were originally treated as a sequence of modifications according to the available procedure for the modification of installations. There were no real "safety case" for dismantling covering all the general aspects of dismantling. The nature of the modifications and technical subjects discussed between Belgoprocess and the TSO at that time were:

- Placing the plant in standby conditions (reduced ventilation regime after a profound rinsing of the plant installation);
- Dismantling of the main plant valve gallery (distribution of chemicals, water, compressed air and steam);
- Alternation of dismantling of units and adaptation of the ventilation of the building;
- Isolation of the Eurochemic building from other adjacent buildings and the necessary adaptation of the ventilation system in the concerned buildings;

Since 2001 a new regulatory document (RD 2001, art. 17) required from the operator to introduce a formal request for the dismantling authorization of nuclear facility. As for Eurochemic the decommissioning activities had already started, the file concerning the request for formal authorization of dismantling of the Eurochemic building was introduced end of August 2002. The different TSO activities in the framework of the request for authorization of dismantling are summarized below.

Decommissioning safety case

In support of the request for authorization, a safety case for the decommissioning of the Eurochemic building and adjacent buildings was introduced by the licensee. The safety case for decommissioning is divided in two main parts:

- 1st part: description of the site and the installations, the dismantling strategy, the project management and the QA programme;
- 2nd part: dismantling activities, safety assessment and environmental impact assessment.

This document was in a first stage analysed by the TSO and discussed with the operator. At a later stage the TSO drew up a report which was presented in 2004 to the Scientific Council of the FANC. The application of the license conditions (derived from the discussions TSO – operator and TSO – Scientific Council and from preliminary and final motivated recommendations of the Scientific Council in 2005 and 2006) were then followed up by the TSO. The main aspects of this follow up are given in the next paragraphs.

Phases important for safety

In the decommissioning licence a list of decommissioning phases important for safety (e.g. the start of evacuation activities of the equipments, the beginning of demolition works) is required from the operator. The start of the "not-nuclear" and controlled demolition of the Eurochemic building is one of these decommissioning phases important for safety. One of the aims of the list of decommissioning phases important for safety is to define hold-points in the dismantling process. These holdpoints are opportunities for the TSO to discuss and review the necessary safety studies considered at each next step of the dismantling. For

each of this step a so-called “project-file” is drawn up by the operator. This project file gathers all the necessary authorizations (about nuclear but also conventional safety), the detailed description of the operations during the considered phase, the safety studies related to nuclear and conventional risks, the clearance methodology and finally the clearance files.

Clearance issue
For the clearance of radioactive waste in Belgium, the acceptable levels of activity are given in the RD of July 2001. The related clearance procedures written by the Health Physics department were discussed and approved by the TSO. For the decommissioning of the Eurochemic building release of decontaminated material is based on current procedures, which means that all equipment, material and areas with contamination levels above background are considered radioactive. Surface area has to be monitored 100%, and surfaces/areas that cannot be monitored are considered radioactive.
A specific approach was developed for taking representative samples and monitoring concrete material in view of the final demolition and unconditional release of the remaining structures of the various buildings after dismantling and decontamination.

4.4 Plutonium facility
The Belgian TSO played a role in the review of the license application procedure of BN for the dismantling of the MOX plant. The license application was sent to the FANC in April 2006 and followed the rules laid out by the Royal Decree of 20th of July 2001. A safety report was established by Belgonucleaire as part of the license application documents (2nd part, see above §2.). The RD also requires that the FANC submits the application file for advice to its Scientific Council (see §2). The TSO produced a concluding report of the application file and presented it to the Scientific Council of the FANC. Taking the advice of the Scientific Council into account, FANC and its TSO wrote down the particular license provisions to be included in the Royal Decree granting the decommissioning. This Royal Decree has been published on the 26th of February 2008.
It stipulates in its provisions that decomissioning can’t start until the specified Safety File has been completed. This Safety File includes the earlier mentioned (initial) Safety Report and a list of Exploitation Permits, describing the buildings, the organization and all systems with their operating conditions during dismantling.

Since BN has planned to subcontract the dismantling operations, an important part of the preparation is to write extended technical specifications to call for contractors. This has been done in a detailed list of Work Instructions, which form the underlying base for the Exploitation Permits and indirectly describe the selection criteria for the subcontractor(s). The TSO and FANC approved this methodology. After designation of the subcontractor(s), special attention will be given during dismantling to verification of compliance with technical specifications and quality assurance by both the TSO and FANC by means of a systematic and thematic inspection programme. The dismantling operations are estimated to cover a period of 5 years, starting early 2009.

5 BEL V ACTIVITIES IN THE INTERNATIONAL CONTEXT
To strengthen its capacities, the Belgian TSO is taking part in international projects, working groups and R&D projects.

5.1International working group WENRA - WGWD
The Western European Nuclear Regulator’s Association (WENRA) is an international body made up of the Heads and senior staff members of Nuclear Regulatory Authorities of European countries with nuclear power plants. The main objectives of WENRA is to develop

a common approach to nuclear safety, to provide an independent capability to examine nuclear safety in applicant countries and to be a network of chief nuclear safety regulators in Europe exchanging experience and discussing significant safety issues.
Since 2002 the Belgian TSO participates to the WENRA Working Group on Waste and Decommissioning. This working group recently published on March 2007 a document entitled "Decommissioning safety reference levels report", version 1.0.
This document contains the results of the work of WGWD in the area of the decommissioning of nuclear installations. The objective of this report is to provide safety reference levels (SRL) for these activities, which were based on the Reactor Harmonization Working Group report and IAEA documents (requirements, guidances, etc). Although the IAEA safety standards establish an essential basis for safety of all nuclear installations covering also their decommissioning, the WENRA safety reference levels incorporate more specific requirements for this activity.
Begin 2008, a comparison (benchmark) has been carried out between these SRL's and the Belgian legal requirements in the field of decommissioning. In a next step the Belgian TSO will be involved in evaluating how these SRL's have been implemented in practice for a selection of decommissioning projects in Belgium.

5.2EC projects

Since more than one decade the Belgian TSO[2] is intensively involved in activities of transfer of Western European methodology and practices in the field of nuclear safety to Eastern European countries. In these countries, the Belgian TSO assistance to the Regulatory Authorities and their TSOs is supported by the European Commission (EC) in the framework of TACIS and PHARE projects.
In this context, a few years ago, the safety issues concerning the decommissioning of NPP's, research reactors and fuel cycle facilities were an increasingly part of the Belgian TSO activities.
Support to Lithuanian safety authorities (VATESI and RPC) for the review of PSAR and EIAR of storage and disposal facilities in the framework of the decommissioning of Ignalina NPP is a current project where the Belgian TSO is involved with other Western European TSOs.
Another support activity is currently in progress with the Regulatory Authorities of the Russian Federation in the field of decommissioning a RADON facility in Murmansk. The Belgian TSO is reviewing a PSAR concerning the retrieval and transfer of radioactive waste to better interim storage conditions.

5.3R&D

The main efforts of the Belgian TSO in the field of R&D related to decommissioning are being undertaken in the framework of the IAEA project DeSa, standing for "International Project on Evaluation and Demonstration of Safety for Decommissioning of Nuclear Facilities". The Belgian TSO is involved since 2005 in this project and participated more particularly to the working group about research reactors.
It is foreseen that Bel V will also participate end 2008 to the follow-up project FaSa, standing for "International Project on Use of Safety Assessment Results in the Planning and Implementation of Decommissioning".

6 CONCLUSIONS

Since the beginning of the decommissioning activities in Belgium in the eighties, the Belgian TSO has evaluated - in the framework of its inspection activities on site - the safety aspects related to these activities.

[2] Previously AVN. Now Bel V since 14th April 2008.

Along the years the TSO activities evolved from a situation where decommissioning was treated and analysed by the operators and the TSO through progressive modifications of the nuclear installations to a situation where decommissioning activities are formally the subject of a new license. This leads at the present time to a more systematic approach of the multiple aspects of the decommissioning projects.

To strengthen its capacities, the Belgian TSO is taking part in international projects, working groups and R&D projects.

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