Status of the decommissioning of the Belgian MOX-facility of Belgonucleaire

C. Kennes, C. Mommaert, M. Van haesendonck – Bel V
H. Libon, A. De Backer - Belgonucleaire

EUROSAFE- Brussels- 5&6 november 2012

Abstract:
This paper presents the decommissioning project of the Belgonucleaire facility at Dessel. It focuses on the strategy and the structure of the project as well as on the legal framework underlying the project.
Beside waste management, release of materials, safety aspects, radiation protection and technological issues are also considered.
The role of Bel V as a subsidiary of FANC, its specific missions, results of inspections, relation with the licensee Belgonucleaire and lessons learned are described.

1 DECOMMISSIONING PROJECT

Belgonucleaire has been operating the Dessel plant to produce MOX fuel since 1973. During the first years the production was limited to fuel for prototype reactors of the LWR type (mainly for the BR3 PWR in Mol) and of the FBR type (SNR-300 in Kalkar). From the mid-80's to 2006 Belgonucleaire produced at industrial scale 650 ton of MOX fuel for 20 NPP's, corresponding to the recycling of about 40 ton of plutonium, separated by reprocessing LWR fuel. Late 2005 the decision was taken to stop the production, because of the shrinking MOX fuel market. Belgonucleaire applied in 2006 for a decommissioning license and this license was granted in 2008.
The decommissioning of the facility started in March 2009 and is planned to end in 2014. The plant consists of two one-floor process buildings (~ 5000 m^2): the production building containing glove boxes for the processing of MOX powders and pellets, and the quality control building restricted to the processing of sealed sources. The significant part of the decommissioning project of the plant is the decommissioning of about 170 medium-sized glove boxes and of 1200 metric ton of structure and equipment.

1.1 Legal framework

Belgonucleaire is a class 1 facility in the sense of the Belgian regulation. As such, in the frame of decommissioning, it has to comply with the regulatory framework described hereafter.

1.1.1 Regulatory framework

The regulatory framework involves the following stakeholders.

1.1.1.1 Licensee.

The licensee must comply with the RD of July 20, 2001 - article 17, stipulating that the decommissioning of nuclear facilities is subject to prior authorization. The licensee must inform as soon as possible ONDRAF/NIRAS and FANC and provide them with information included in a final decommissioning plan and in a safety assessment report (SAR).

1.1.1.2 ONDRAF/NIRAS

ONDRAF/NIRAS is a federal organization, which is legally (RD of March 30, 1981) in charge of the management of radioactive waste and of monitoring the decommissioning of nuclear facilities.
Article 5.1 of this RD states that at least 3 years before the definitive cessation of activity, the licensee must provide ONDRAF/NIRAS with a decommissioning plan, which must be approved by ONDRAF/NIRAS. The structure and content of the final decommisioning plan is defined by ONDRAF/NIRAS. After having analyzed the final decommissioning plan, ONDRAF/NIRAS transmits its comment and advice to the FANC.

1.1.1.3 Federal Agency for Nuclear Control (FANC).

In accordance with the law of April 15, 1994 and the RD of July 20, 2001, the function of Regulatory Body (RB) for radiological protection and nuclear safety, including for the decommissioning and for waste management, is assumed by FANC.
Article 17 of this RD stipulates that the licensee has to apply for a decommisioning license to the FANC. The license application is supported by a Safety Assessment Report (SAR) and by an Environmental Impact Assessment (EIA). The EIA is also sent to the regional authorities for advice regarding non-nuclear aspects. On the other hand, article 37 of the EURATOM Treaty is not applicable for the decommissioning of fuel fabrication plants.
After having analyzed the SAR and received the comment and advice of ONDRAF/NIRAS on the final decommissioning plan, FANC may issue a decommissioning license. For a class 1 facility the decommissioning license is granted by RD and it involves a public inquiry in the municipalities located up to 5 km around the considered nuclear installation.

1.1.1.4 Bel V

Acting as a TSO and as a subsidiary of the FANC, the role of Bel V for decommissioning implies:

- Safety evaluation on basis of the SAR
- Compliance with the conditions of the decommissioning license
- Approval of measurement protocols (specific clearance methodology)
- Approval of every safety significant step
- Periodic control of the facility under decommissioning

After the decommissioning license is granted, every significant evolution in the decommissioning process must obtain the prior approval of the Health Physics department and of the TSO.

1.1.2 Decommissioning plan

The decommissioning plan contains information on strategy, time planning, technical and financial feasability of the decommissioning project. For new plants (i.e. which are licensed after implementation of the RD of July 20, 2001) the licensee has to set up an initial decommissioning plan: this was not the case for Belgonucleaire. Belgonucleaire issued its decommissioning plan at the end of 2003, and this plan received approval by ONDRAF/NIRAS in 2004.

1.1.3 Authorization and associated conditions

The authorisation for the decommissioning of Belgonucleaire has been issued by FANC in 2008.
The authorisation is supplemented with conditions stating that during decommissioning:

- The licensee remains solely responsible for safety
- The situation of the facility, the inventory of the radioactive waste produced and of released material must be continously updated
- Modifications, which could impact the safety, must be approved by Bel V and sometimes FANC
- Subcontractors must have necessary training and experience
- Use of best available techniques for glove box cutting and decommissioning
- New cutting or decommissioning techniques must be approved by Bel V on basis of a safety assessment
- Any new free release of radioactive material must be approved by Bel V
- The licensee must send an annual progress report to the FANC
- At the end of the decommissioning, the licensee must send to the FANC a final report, including the final radiological status of the site.

1.2 Decommissioning strategy

Belgonucleaire has chosen the option of immediate decommissioning, which means prompt decontamination, decommissioning and removal of material and equipment.

1.2.1 Driving factors for strategy selection

The driving factors for chosing the immediate decommissioning strategy, selected by Belgonucleaire are:

- Preservation of plant knowledge
- Immediate decrease of the contamination risk with regard to the safety of neighbouring population and environment
- No interim maintenance and surveillance cost
- Avoid risk of gradual deterioration of structures and equipment designed to confine the contamination.
- Due to the type of production, the potential to take advantage of the natural decay of radionuclides over time is marginal or even detrimental, because of build-up of Am-241 from decay of Pu-241.

1.3 Project management of the licensee

Project management depends on safety issues, planning, technological choices and special skills required.

1.3.1 Project management and planning

1.3.1.1 Safety issues

The following main safety issues have been identified in the SAR:

- Occupational exposure and contamination
- Atmospheric release
- Fire hazards
- Criticality

1.3.1.2 Permanent shut-down

The production of MOX came to a standstill on August 15, 2006.
The first objective was to decrease the risk of criticality, spreading of contamination, fire, explosion etc.. .
Immediately after ending the production technical risk-reducing steps were taken:

- Conditioning unprocessed fissile material and shipping it back to the clients;
- Purging and disabling circuits and tanks containing flammable and explosive gases;
- Ventilation of the glove-boxes with air instead of helium and nitrogen;
- Consignation of electrical cabinets;
- ...

Once the risks were reduced, the shutdown of the nuclear installation was notified to the Authorities, and the post-operational phase could start.

1.3.1.3 Post-operational phase (2007 – 2008)

This phase was used to select and qualify decontamination, decommissioning and measurement techniques by means of cold tests and mockups (glove boxes and tents) and calibrated sources (waste measurement techniques) and to perform a radiological survey. This survey confirmed the results of the former surveys, that were performed during the operational period, showing that outside of the glove boxes there is no significant contamination of the plant.

1.3.1.4 Decommissioning phase (2009 – 2013)

The decommissioning is being performed in 2 main phases which are related to the production building and the quality control building. The glove boxes are dismantled room after room according to the following steps:

- Removal of the fissile materials;
- Isolation and decontamination;
- Decommissioning using cold cutting techniques and filling of 200-liter drums.

Other workplaces are gradually cleared up and decontaminated in order to to be used to sort out and measure contaminated material.

1.3.1.5 Release of buildings and site (2014)

Belgonucleaire aims to decommission the plant to reach unconditionnal release of the buildings and sites.
One of the licensing conditions stipulates that at the end of the decommissioning activities a final report has to be established with feedback experience, description of activities and a final radiological survey of the plant and the site.. Belgonucleaire will be discharged of its obligations as an operator, providing the radioactivity of the plant and site is below the regulatory levels. In case the release criteria are not met, the licensee shall establish a report assessing the long term impact of the site and will propose further protection measures or restrictions towards the future use of the site.

1.3.2 Technological key choices

1.3.2.1 Decontamination methods

The selection of decontamination methods by Belgonucleaire was based on the following principles:

- Personal exposure (ALARA)
- Cost effectiveness

- Waste minimization

Decontamination of objects (PVC, stainless steel, etc..) can be based on either wet (ultrasound) or dry (mechanical) techniques.
Decontamination of glove boxes (or at least reduction of contamination in order to reduce exposure and the risk of spread of contamination) is done manually or with the help of a vacuum cleaner.
Decontamination of Kyowa panels is done by washing and/or mechanical polishing.
Decontamination of rooms and buildings will be necessary for final unconditional release of buildings. Shaving and scrabbling methods will probably be used.

1.3.2.2 Radiation protection

Compliance with regulatory limits and with ALARA principles is enforced by setting a yearly individual dose constraint of 12 mSv and an objective on collective dose defined for the overall decommissioning of the glove boxes, being 1500-2000 man.mSv.

1.3.2.3 Decommissioning techniques

The aim is to use existing and proven technologies and adapt them to the environment and to their specific application. Great care is taken of the dose forecast (ALARA approach), the amount of secondary waste and the operator's safety.
Volume reduction techniques are used, since all waste has to fit in drums according to Belgian Waste Acceptance Criteria.

1.3.2.4 Waste management

Waste management comprises the steps necessary for:

- Releasing the material after radiological control, including characterisation, segregation, decontamination and clearance levels expressed in Bq/kg (see Annex IB from RD of July 20, 2001).
- Preparing the material for transfer to ONDRAF/NIRAS, including packaging and characterisation of the waste in accordance with the acceptance criteria.

To reduce the total waste volume, recycling by melting of stainless steel in recycling facilities abroad is performed, whereby the remaining secondary waste is returned to Belgonucleaire.
It is foreseen that a major fraction of the total waste volume can be released.
More precisely, most of the materials outside the glove boxes, that were not a priori destined for radioactive waste, will be released without restriction on the basis of the applicable legal regulations in Belgium, along with the buildings and the plant site.

1.3.2.5 Industrial safety

Main concern in industrial safety are fire hazards, handling of heavy loads, use of cutting devices, …
It is worthwhile noticing that in this regard Belgonucleaire applies the regulations on temporary and mobile construction sites set in the RD of January 25, 2001 and modified in January 19, 2005. It is stipulated that for decommissioning projects involving more than one contractor, a safety-coordinator is appointed for the development/study/design phase ("coordinator-design") and a coordinator is appointed for the execution phase ("coordinator-execution"): this facilitates the coordination of the information and prevention practices between Belgonucleaire and its contractors.

1.3.2.6 Organisation

As Belgonucleaire has to keep full responsibility for the decommissioning operations, the latter operations are executed by an integrated organization comprising Belgonucleaire and

its main contractors Studsvik, Belgoprocess - SCK●CEN and Tecnubel. Belgonucleaire assumes the leadership of this integrated team, and defines the safety rules to be applied for all decommissioning operations.

2 STATUS OF THE PROJECT

2.1 Status of the decommissioning activities

2.1.1 Time schedule

A total of 170 glove boxes and 1200 ton of infrastructures have to be decommissioned. Decommissioning works started in March 2009, after selection of the main contractors. The remainder of 2009 was dedicated to training and qualification of personnel.

The decommissioning of glove boxes (GB) proceeds in three steps, namely the emptying of the GB, the separation of the GB from the fabrication line, and the cutting of the GB in a tent. Priority was given in 2010 and 2011 on emptying of the GB, one of the main motivations being to reduce the radiation source term ("hot spots"). Since early 2012, the priority has shifted towards the separation and the cutting up of the GB. The end of the decommissioning of the GB is foreseen in 2013.

The decommissioning of the infrastructures will be the main activity of 2013 and 2014, even if some long lead infrastructure activities start already in 2012.

The activities related to the final cleaning of buildings and site are scheduled in 2014, and they will allow free release of the site, pending a final radiological characterisation report.

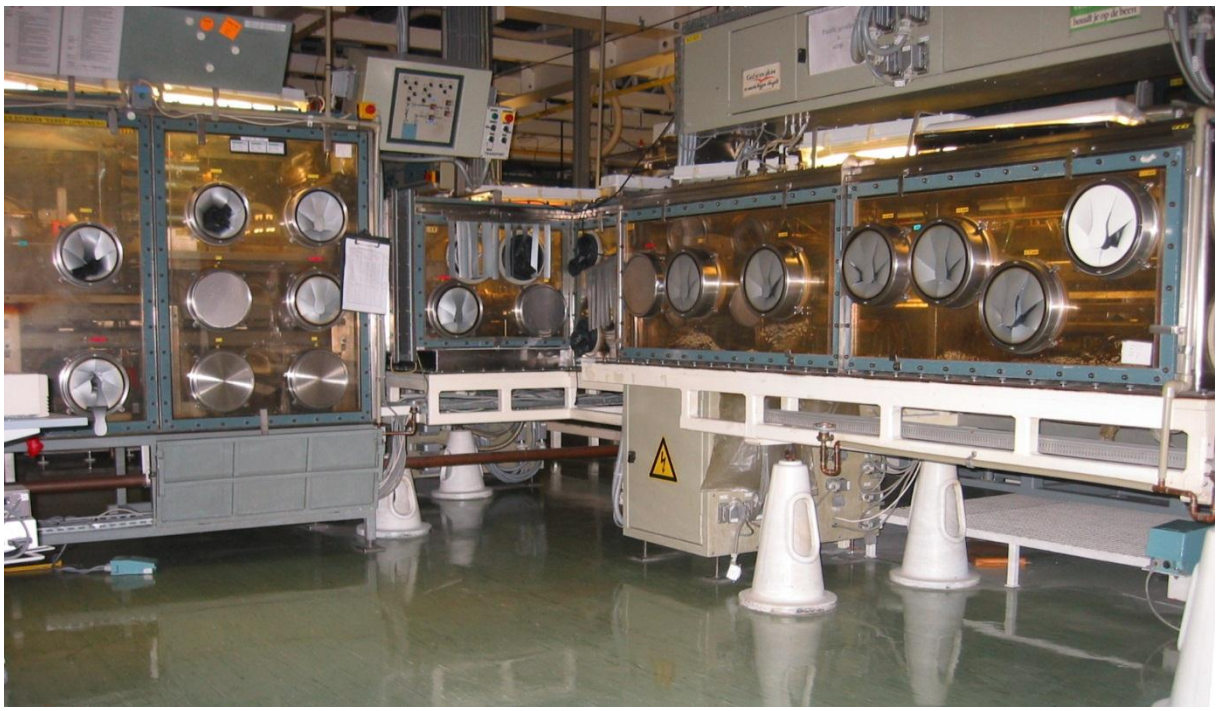

Fig. 1 : Glove boxes of the production line to be dismantled.

2.1.2 Safety related issues

2.1.2.1 Occupational exposure and contamination.

Both neutron and gamma (total body and extremities) dose is monitored for the workers, using both passive and electronic dosemeters. The use of personal protective equipment is defined at the beginning of each task, in agreement with the estimated risk. Lead apron and lead charged gloves will be used where necessary, as well as a respiratory masks.

From the start of the decommissioning works until today, no individual dose limit (set at 12 mSv/year by BN) has been exceeded and no internal contamination has been recorded.

One notices a decreasing trend in collective dose over the decommissioning period, due to reduction of the source term in the installation.

2.1.2.2 Atmospheric release

A system of dynamic confinement is in place, with a cascade of underpressures and filters to reduce the risk of spread of contamination to a minimum. In practice, in the production building a glove box (p = 250 Pa) is surrounded by a decommissioning tent (peditent) (p = 200 Pa), put in a 'greenhouse' in slight depression with respect to the work place (p = 50 Pa). The work place is in small depression with respect to the halls of the building (p = 30 Pa).
There is a double monitoring system for atmospheric contamination of the work place : paper filters are read out on a daily base and an on-line CAM-head[1] system monitors continuously the α-contamination of the air.
No accidental release has taken place since 1973. The maximum weekly release in 2011 was 600 Bq, being about 700 times lower than the limit of 3,7 MBq/week. The total release of 10 kBq in 2011 can be compared to the annual limit of 190 MBq, but it corresponds in fact approximately to the radon concentration in the atmosphere.

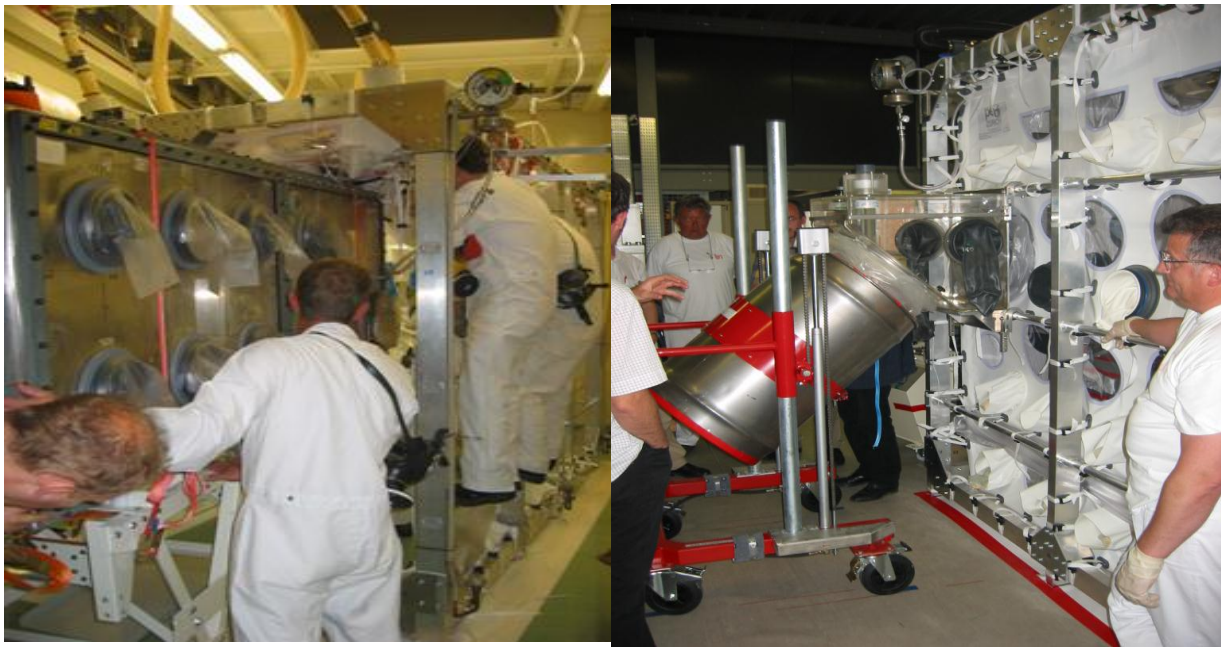

Fig. 2 : Left : glove box being inserted in frame for peditent. Right : peditent mounted around glove box, waste drum hooked up, ready for filling.

[1] **CANBERRA** Alpha Sentry Continuous Air Monitor (**CAM**) sampling **head.**

2.1.2.3 Fire hazards

The fire hazard has decreased during decommissioning in comparison to the production period, since ovens, welding equipment, etc... have been consigned and decommissioned and the amount of inflammable material has been reduced.
New fire hazards have been taken in account with the introduction of new installations and methods for decommissioning. A risk analysis has been performed and one of the outcomes is the selection of cold, no spark cutting techniques for volume reduction of glove boxes.
Fire detection and extinguishing systems remain operational during decommissioning.

Fig. 3 : Cold cutting techniques of glove box components through peditent : nibbler (left), bandsaw (right).

2.1.2.4 Criticality

The maximum amount of Pu that remained in all glove boxes of one workplace has been limited to a small fraction op the previous operation limit. The criticality risk is controlled by limiting the mass of Pu and moderator per glove box and per waste drum. An ALARA analysis has shown that it is safer to increase the mass of plutonium per waste drum. This allows to decrease the collective dose with respect to the situation where the plutonium remains in the GB.

To introduce an additional safety layer on the criticality criteria defined above, only dry techniques will be used during decommissioning of glove boxes.
The criticality detection system remains operational during decommissioning.

2.1.2.5 Incidents

Only one significant incident took place up till now, in 2010. A double layered PVC-bag confining a can containing MOX-powder was damaged during a manipulation, with spread of contamination as consequence. The damage resulted from overpressure generated by radiolysis attributed to organic material in contact with plutonium. The two experienced operators involved in manipulation were decontaminated in the plant, one with the help of the

occupational physician; one operator showed a positive nose-blow, but excreta measurements resulted in an effective dose below the registration level of 0,2 mSv.

The event was classified as INES 1 on the INES scale.
Additional protection measures have been introduced to prevent the recurrence of this event.

2.2 Role of the Regulatory Body/TSO during decommissioning

Compliance of the decommissioning to the Royal Decree of 20th of July 2001 and to the decommissioning license is controlled by the regulatory body. The decommissioning license is based on the initial Safety Analysis File, consisting of the Safety Analysis Report and a list of Operation Permits.
One can distinguish permits describing the different safety systems, such as fire protection, electrical supply systems, air monitoring, vent monitoring, ventilation, criticality detection, etc.... and permits describing the operational conditions, such as operation of rooms and halls in the production building or quality control building H, use of a decommissioning tent, storage of waste on site, inventory of radioactive waste and cleared material, organisation of BN, qualification and competence of personnel, etc…
These Operation Permits are evolutive documents, subject to modifications according to changes during the decommissioning activities.
The decommissiong license stipulates which type of decommissioning activities and modifications are subject to approval by the regulatory body.
Modifications with respect to the organisation of the licensee have to be justified and approved both by Bel V and FANC. For each new cutting or decommissioning technique, a safety and risk analysis has to be performed, that requires approval by the Health Physics Department and Bel V. The number of air renewals and the underpressure in the rooms and in the glove box cutting installations are subject to approval by Bel V.
The operator has to adapt his existing emergency organisation in function of the decommissioning activities and the risk changes. These modifications have to be approved by Bel V and are transmitted for information to the FANC.
The measurement procedures and techniques to verify compliance with the official clearance levels defined in [1], have to be submitted to Bel V for approval and subsequently to FANC for information. Each clearance is subject to approval by the Health Physics Department and, when it is the first of a batch, Bel V has to confirm the approval.

Bel V has a regular on-site inspection programme, with a periodicity of 3 weeks on average.
These visits have a fixed agenda, starting with a discussion on occurred incidents, contaminations, recorded non-conformities since the last visit, as well as clearance topics, implementation of planned modifications, new projects and overall status of the decommissioning and the operation permits. The second part of the visit is a walk-through of the installation, with special attention for the discussed technical topics as well as the housekeeping, the radiation protection and the safety culture in the installation.

Beside this periodic follow-up inspections, Bel V also performs thematic and specific inspections, focussed on particular topics or systems.
Since the start of decommissiong, the following topical inspections have taken place:

- Fire Protection (November 2009)
- Emergency Plan (October 2010)
- Subcontracting (December 2010)
- Radiation Protection (March 2011)
- Ventilation Systems (November 2011)
- Document Management (December 2011)
- Specific Modification Files (April 2012)

Each Bel V inspection is documented in a report. An action list is defined when necessary and registered in an internal Bel V data base for follow-up.

On a yearly base, a joint FANC-Bel V “Management Inspection“ is carried out, among others based on the yearly Safety Evaluation of the licensee by Bel V.
For other specific FANC inspections (e.g discussion of the annual decommissioning report), Bel V is invited to participate.
These combined inspections are documented in FANC reports.

There are still important tasks to be completed before the end of the decommissioning and the release of buildings and site from radiological control.
The Decommissioning Decree requires that at the end of the decommissioning activities, the licensee composes a final decommissioning file and submits it to Bel V for approval. This final decommissioning file should contain an overview of the effectively applied decommissioning strategy and techniques and an evaluation of the completion of the final goal, as specified in the original decommissioning license and an overview of the generated waste.
In case of release of buildings and site, a final radiological characterisation has to be carried out where it is demonstrated that the final terms, as specified in the license application, have been met. The applied methodology and the results of the final characterisation of the cleared buildings and site, have to be approved by Bel V and the FANC.

3 CONCLUSIONS

Started in March 2009, the decommissioning activities of Belgonucleaire are proceeding without any major incident or difficulty. This is mainly the result of a detailed preparation and qualification of the used techniques and a of a very substantial training effort for the personel involved, but above all on a drive for continuous improvement based on lessons learned.
Through a regular presence on-site and open discussions with the operator and the management of Belgonucleaire, Bel V can play its role as part of the regulatory body and together with FANC, monitor the safety of the decommissioning of the Belgian MOX-facility.

4 LIST OF ABBREVIATIONS

- MOX: Mixed Oxide
- LWR: Light Water Reactor
- FBR: Fast Breeder Reactor
- PWR: Pressurized Water Reactor
- RB: Regulatory Body
- SAR: Safety Assessment Report
- EIA: Environmental Impact Assessment
- RD: Royal Decree
- ONDRAF / NIRAS: French and Dutch acronyms for, National Agency for Radioactive Waste and Enriched Fissile Materials
- FANC: Federal Agency for Nuclear Control
- ALARA: As Low As Reasonably Achievable

5 REFERENCES

[1] 20/07/2001 Royal Decree: Arrêté royal du 21 juillet 2001 portant règlement général de la protection de la population, des travailleurs et de l’environnement contre le danger des radiations ionisantes (Moniteur belge du 30/08/2001).