RADIOACTIVE WASTE MANAGEMENT ACTIVITIES AND RELATED RESEARCH IN BELGIUM

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ABSTRACT

Although Belgium is a small European country, it has set up an important electronuclear program in which the radioactive waste problems have continuously received special attention and care. Since 1981, the National Agency for Radioactive Waste and Fissile Materials (ONDRAF-NIRAS) is the public organization entrusted by law with the outlining and application of the radioactive waste management policy in the country. Its strategy aims at developing a central location for the treatment and conditioning of the largest possible fraction of low- and intermediate-level waste, as well as for the temporary storage of all types of conditioned waste. Several facilities are already in operation, some of them for many years. They are continuously adapted to new technologies and some of them will be completely replaced in the coming years. With regard to the final disposal of the conditioned waste, no specific legal regulations have been issued so far, but an important R & D program in this field has been carried out in the past several years in close collaboration with the National Nuclear Research Centre (CEN/SCK at Mol) and other national organizations and private engineering offices.

INTRODUCTION

The radioactive waste to be managed in Belgium arises mainly from:

Seven nuclear power stations, all of the PWR type, totalling a 5,540 MWe capacity and producing some 65% of the electricity generated in the country. These stations are located on two sites: Doel along the river Schelde and Tihange along the river Meuse;

Two nuclear fuel fabrication plants, one currently producing standard LWR assemblies and the other mixed oxide assemblies for either LWR or FBR;

The reprocessing of the Belgian spent fuel is presently performed in the framework of commercial contracts with COGEMA in France, which provide that the resulting conditioned waste will be transferred back to Belgium from 19913 onwards;

The production of radioisotopes and their use in industry, medicine and research;

The former Eurochemic reprocessing pilot plant being managed under Belgian responsibility.

Another important future source of radioactive waste will be the dismantling of the various existing nuclear facilities.

A basic scenario used for the evaluation of the total volume of waste to be managed in Belgium considers that the present nuclear activities will proceed for 30 years, the end of the decommissioning phase being the year 2050. In this case, the total amount of conditioned waste will have risen to about 150,000 m^3 of low-level waste, 25,000 m^3 of intermediate-level and alpha waste and 5,000 m^3 of high-level waste.

Conditions prevailing in Belgium such as a territory of limited surface area, a very high population density or a close-to-surface groundwater table in may locations and, as outlined later on, a limited choice in potential host formations for disposal have from the early beginning of the nuclear era in the country, around 1955, always focused the attention towards the waste problems.

THE NATIONAL AGENCY FOR RADIOACTIVE WASTE MANAGEMENT

In the middle of the seventies, at the time the first nuclear power station was put into operation, the Minister of Economic Affairs launched the idea of creating a National Organization, with a non-defined public participation, in charge of the management of the radioactive waste sector in the country. Representatives of the waste producers and of the concerned Authorities worked out a structure proposal for the future Agency. This concertation led to the law of 8 August 1980 creating the National Agency for Radioactive Waste and Fissile Materials known as ONDRAF (in short in French), NIRAS (in short in Dutch) and NERAS (in short in German), the three national languages. A subsequent Royal Decree of 3 March 1981 defined the field of responsibilities and competences of the Organization which is entrusted with the definition and application of a waste management policy in Belgium.

The government status expresses the will of the legislator to preserve the activities and responsibilities governing the current and long-term management of radioactive waste from any profit seeking. The industrial responsibilities of the Agency range from transport to final disposal, including conditioning and interim surface storage of non-conditioned or conditioned waste for those producers who do not have adequate installations on their own site. The law also specifies that these industrial activities should be carried out by the Agency's own means, by subcontracting to third parties or by ONDRAF's subsidiary companies in which the Agency is the majority partner.

The policy pursued so far by the Agency is to have its industrial tasks performed by subcontractors as far as transportation is concerned and by a subsidiary company for the other activities (namely BELGOPROCESS, which is 100% controlled by ONDRAF). Moreover, it is the Agency's duty to advise the authorities on any standards, specifications and prescriptions to be applied, to ensure application after official endorsement and to establish the R&D programs in the field of radioactive waste manage-

ment.

The law specifies that the Agency operates at cost price and that all expenses are to be financed by the waste producers. The expenses are distributed among the latter on the basis of objective criteria defined as far as possible by common consent or, failing this, by government decisions at the request of the Agency. The long-term tasks which are essentially related to the final disposal will be financed by a Special Fund to be managed by ONDRAF.

Besides the above-described activities, ONDRAF has been entrusted by government with the management of the decommissioning of the former EUROCHEMIC reprocessing pilot plant as well as the process waste that has remained on the spot. ONDRAF's subsidiary company BELGOPROCESS is in charge of the execution of the program which is financed partly by the countries which have been involved in the EUROCHEMIC project and partly by the Belgian State.

The Agency is also in charge of the fissile materials in the country. Since there are no reprocessing activities in Belgium, movements of fissile materials are not frequent, and the Agency's tasks are limited to keep record of these movements and of the storage of fissile materials, mainly at the fuel fabrication plants.

THE AGENCY'S WASTE MANAGEMENT STRATEGY

The strategy adopted by ONDRAF aims at developing a central location for the treatment and conditioning of the largest possible fraction of low- and intermediate-level waste, as far as it can be safely and economically transported. The fraction that does not fulfill the stipulations is conditioned on the spot by the producer according to processes approved by ONDRAF. This is presently the case only for some categories of waste generated by the power plants on one hand, and by spent fuel reprocessing operations abroad on the other hand.

The centralization concept is also applied to the surface storage of all conditioned waste destined for final disposal in the country.

The Mol-Dessel site where the National Nuclear Research Centre (CEN/SCK) and the former EUROCHEMIC pilot plant are located, has been selected for the establishment of the central facility for conditioning and interim surface storage. Indeed, ONDRAF's subsidiary company BELGOPROCESS runs already the waste facilities on this site. These facilities are currently modernized and adapted to the requirements of the next 20 to 25 years, according to ONDRAF's strategy plan.

The concept of centralization is supported in Belgium by several specific considerations. The nuclear activities are quite extensive for a small country like Belgium, whereas the size of the program is rather limited. Consequently, the optimization of the economic conditions for waste management argues in favor of a concentration of the means. This concentration is also favored by the fact that the Mol-Dessel site is less than 100 km removed from the two major nuclear sites, the power plants of Doel and Tihange, and that excellent rail and road connections exist between the Mol-Dessel area and the other sites. Furthermore, the conditioning strategy applied by ONDRAF aims at applying conditioning processes that offer a maximum volume reduction of the waste produced and a high leaching resistance of the final product, in order to make the maximum use of the existing possibilities for final disposal in the country.

Conditioning high-level and alpha-bearing waste and a not yet defined portion of medium-level waste are planned to be disposed of in deep geological formations. An R&D program has been running since 1975 to evaluate the use of the Boom clay layers under the Mol-Dessel site for this disposal.

Up to 1982, the conditioned low-level waste was dumped in the sea, according to the NEA AND IAEA requirements. Since 1983, this type of waste has been stored in surface-engineered facilities awaiting the results of an investigation program currently going on in order to define an acceptable land disposal system.

THE AGENCY'S MAIN ACTIVITIES

Transport:

ONDRAF's volume reduction policy allows for a reduction in the volume of conditioned low-level waste packages to 60% of the volume achieved at the time sea dumping was practiced. As a consequence, packages with dose rates up to 300 $mSv.h^{-1}$ have to be transported from the power plants to the central storage facility. This is carried out by means of specially-designed shielded truck-trailers provided with remote handling equipment. Evaporator concentrates are also shipped from the power plants to the Mol-Dessel facility using a special 6 m^3 slurry container on a truck-trailer.

Central Treatment and Conditioning Facilities

Low-level waste is currently treated in three main installations; one for flocculation of liquid effluents followed by embedding of the slurries into bitumen, one for incineration at 900 1/2C of combustible solid waste and one for compaction of the other solid waste followed by incorporation into concrete or bitumen. For the conditioning of medium- and high-level liquid waste, the EUROCHEMIC reprocessing pilot plant was also equipped with a medium-activity vitrification plant (Pamela facility - a German patent). These facilities are still in operation for the conditioning of the former EUROCHEMIC waste but can also be used for national waste when needed.

The strategy developed by ONDRAF requires a progressive renewal of the treatment installations for low-level solid wastes which were operated since about 20 years ago by the National Nuclear Research Centre (CEN/SCK).

For non-combustible waste, a new supercompaction installation is scheduled for operation around 1992; it will be located in a building yet to be constructed which will also house subfacilities for reception, storing, pretreatment, concreting, packaging and quality control.

Around 1995, the existing incinerator for combustible waste will possibly be replaced by a high-temperature

slagging incineration system (+/- 1,600 1/2 C). The slag obtained could be packaged with or without embedding into cement. The process has been developed by the National Nuclear Research Centre (CEN/SCK), but still requires an industrial qualification of its technological aspects.

The use of these two new facilities for contaminated alpha-waste is being considered in the ongoing studies.

Interim Surface Storage

With the interruption of sea dumping in 1983, it became necessary to organize the interim storage of conditioned low-level waste during the time required for developing and implementing an alternative disposal system.

As the EUROCHEMIC waste is already stored at the Mol-Dessel site, and according to the general waste management policy aiming at centralizing the activities, it has been decided to use the same site for the interim storage of all conditioned waste packages awaiting disposal.

The following facilities are already in operation or under development:

For low-level waste packages up to 5 $mSv.h^{-1}$, a prefabricated concrete building offering a storage capacity of more than 2,000 m^3 has been erected in order to face the immediate needs resulting from the abrupt interruption of sea dumping in 1983. At the same time, the construction of a more sophisticated storage facility has been initiated. This building, which is served by remotely-operated bridge cranes, has a capacity of 6,300 m^3 of conditioned waste packages. This facility, which was operational since the beginning of 1988, has a modular design that allows for extension of its capacity up to 14,000 m^3;

For intermediate-level waste packages up to 2 $Sv.h^{-1}$, a shielded building called EUROSTORAGE was erected at the end of the seventies to store the 2,750 m^3 of conditioned intermediate-level waste resulting from the reprocessing of spent fuel in the former EUROCHEMIC pilot plant. The storage capacity, which is presently made of four adjacent identical storage bunkers, can easily be extended. The available remaining capacity (more than 1,000 m^3) is now used for the storage of conditioned intermediate-level waste arising from the nuclear power plants;

For high-level reprocessing waste packages, a ventilated storage building to house 250 m^3 of the EUROCHEMIC vitrified waste, is already in operation and a new facility for the glass, the conditioned cladding materials and the bituminized medium-level waste arising from Belgian fuel reprocessed abroad, is currently under development and will be operational in early 1993. The modular design of the plant allows extension as a function of the actual needs.

FINAL WASTE DISPOSAL

No specific legal regulations have been issued so far concerning the final disposal of the radioactive waste and the disposal, as waste, of the spent fuel has not been considered up to now. However, one of the main tasks entrusted by law to ONDRAF is the development and the operation of the final repositories.

Sea dumping of conditioned low-level waste has been interrupted since 1982 and will not be considered again as long as the present international attitude does not change drastically towards this practice. Land disposal of conditioned low-level waste is presently subject to an intensive study program as well as the disposal in deep clay lay which is in development for the high-level and alpha-bearing waste.

All these efforts, coordinated by ONDRAF, are performed in close cooperation with various national and international organizations (CEN/SCK, National geological service, the Ministry office, EEC, NEA, and AIEA) as well as with the producers who have to finance the programs.

The investigations related to conditioned low-level waste disposal include four different possibilities:

Surface burial in engineered structures,

Shallow land burial at selected sites with favorable geological conditions,

Use of coal mines to be closed down, and

Disposal in deep clay layers near the HLW repository.

A low- or medium-level waste disposal system near the surface has to guarantee that the waste buried does no longer present any danger or hazard for human beings and their environment after a limited period of time. A 300-year period corresponding to 10 half-lives of the main isotopes Cs 137 and Sr 90 is considered acceptable. More or less sophisticated engineered structures, depending on the natural migration barrier that can be asserted by the site characteristics, are able to afford the required environmental protection.

As far as surface and shallow burial are concerned, two sets of rather qualitative site selection criteria were set up a few years ago in close collaboration with the Belgian Geological Service. The first set includes factors allowing for a discard of part of the national territory for disposal, while the second set refers to natural favorable characteristics of surface and shallow formations. This led to a subdivision of the country into three zones: An exclusion zone, a favorable zone and a neutral zone.

In the exclusion zone, no surface or shallow depth disposal is possible. In the favorable zone, a relatively simple engineered structure could guarantee the safety because it is compensated by the natural barrier properties of the site. In the neutral zone, only sophisticated,engineered structures could be envisaged to ensure safety.

A detailed study, still on the basis of the existing available information, is presently going on in order to select in the favorable zone 4 to 5 potential sites with a surface area of at least 50 hectares. If this option is retained, field investigation work will be started on these sites in agreement with the local authorities concerned.

Available information on coal mines planned to be closed down in the coming years indicated that some of these mines offer potential opportunities for safe disposal

of conditioned and non-alpha-bearing, low-level waste. However, for economical and socio-political reasons, the prospects for future routine operations are rather limited.

Disposal in a subfacility to be built for high-level and alpha-bearing waste in a geological host medium is the fourth option ONDRAF is studying. The only question to be examined is to know whether this option is acceptable from an economical point of view. Therefore, the consequences for the complete low- and medium-level waste management cycle have to be evaluated. A thorough study of this subject is being performed, with particular attention to the financial impact and the technological feasibility of the disposal system.

According to its plans, ONDRAF will present the results of its comparison work, related to the various options, to the National Authorities before 1990. These Authorities, taking into account the socio-political outlooks, will be invited to endorse the conclusions of ONDRAF with regard to the future development of a low- and medium-level disposal system. ONDRAF expects an industrial facility could be put into operation in the period 1995-2005, depending on the option chosen and the ability of the authorities to decide in due time.

The investigations related to disposal of high-level and alpha-bearing waste are focussed on deep clay formation. The inventory of potential geological host formations for a repository, established in 1974 in cooperation with the Belgian Geological Service, indicated that only clay and shale layers present in Belgium held suitable characteristics for waste disposal. One of these Tertiary Age clay layers, known as the Boom clay, located in the northeast part of the country, where the CEN/SCK and some fuel cycle facilities are located, was chosen for preliminary site investigations.

During the first five-year R&D program (1975-1979), the main objectives were:

To collect information on the clay's various characteristics and possible interactions with the waste packages,

To perform some field studies to explore and define the lithostratigraphy of the underground, and

To assess the technical feasibility and the long-term safety of a burial system in clay.

The favorable results obtained allowed us to progress during a second five-year program (1980-1984) with:

A detailed study of the local and regional hydrogeology. this study required the creation of an extended hydraulic measurement network;

Further laboratory studies on clay-waste interactions; and

The construction of an underground laboratory in the Boom clay formation.

All these works should produce realistic input data for more precise safety evaluations.

Since 1985, extensive in situ experiments are performed with regard to geomechanics, corrosion, migration, heat transfer, etc. The very encouraging results obtained, particularly with regard to the mineability of clay at depth and its excellent retention capacity for most of the long-lived radionuclides, brought ONDRAF to prepare a first safety and feasibility report (SAFIR), to be submitted in the very near future to the competent national Authorities. The aim of this report is to obtain the principal agreement of the Authorities on the clay disposal option as currently developed, in order to prepare progressively and after large-scale feasibility demonstrations, the construction of an industrial repository by the year 2020.

Although no final concept for a repository in the Boom clay has been set up for the time being, various studies and evaluations have been and are still being performed.

The particular geotechnical properties of the Boom clay allow only the construction in the deep underground of lined circular tunnels with a useful diameter of 3 to 4 m. Consequently, the underground facility will be a network of interconnected galleries. The high-level waste canisters (vitrified waste) could be laid down either in small boreholes drilled in the lower part of the main galleries or directly in the central axes of the galleries. The other waste packages could be placed in separate galleries in the first arrangement, and around the high-level waste packages in the second one.

Up to now, no detailed technological studies have been devoted to the waste-package handling problems. However, it is considered that reception, handling and lowering of the various packages could be performed with already existing or slightly adapted devices.

An inventory of the existing and expected waste packages has been established, their volumes varying between 120 l for some vitrified high-level waste canisters and 1,600 l drums for some particular conditioned alpha-waste.

For the backfilling of the main galleries, the re-use of the excavated clay mixed or not with other natural or synthetic materials is being investigated.

Laboratory investigations and near-surface dummy tests led to consider a maximum allowable temperature of 100 1/2 C at the canister/clay interface. The maximum allowable thermal load was estimated at about 15 kw per hectare. However, all these data have to be confirmed with full-scale experiments scheduled in the underground laboratory.

The external pressure on the waste package can reach a value corresponding to the lithostatic pressure at disposal level which could be of the order of 50 bar.

Surface interim storage of the canisters and the possible use of an overpacking are foreseen to meet the specific requirements of the geological layer used.

Requirements for long-term monitoring are not investigated, since retrievability is not considered except for a very short period of time during the operation of the repository.

Decommissioning of Nuclear Facilities

Public concern about the decommissioning of nuclear facilities is growing. The power plant operators have recently agreed to provide funds on an annual basis for the future

decommissioning of their plants.

A first full-scale decommissioning operation has already started. The EUROCHEMIC reprocessing pilot facility located on the nuclear site of Mol/Dessel has been shut down since the end of 1974. The decontamination and cleaning of the plant was started nearly immediately in order to put the plant in stand-by condition, awaiting a decision about its future; refurbishing or decommissioning.

The decision to decommission the plant was made by the Belgian Authorities in 1986. ONDRAF and its subsidiary company, BELGOPROCESS, have been entrusted with this operation. The cleaning and decontamination of the installations have been so successful that al the process cells are easily accessible today.

ONDRAF submitted in mid-1987, a comprehensive decommissioning plan for the site, as well as the required budgets to execute the plan. The plan concerned all buildings and equipment which are no longer needed for the future use of the site, the objective being to reduce stand-by and ventilation costs. A first phase of the plan was approved by the government on September 17, 1987. This first phase (1987-1988) consisted mainly in the realization of a pilot decommissioning project, which should be representative of the expected overall decommissioning problems on the site. The buildings chosen were two UNH storage buildings. The pilot decommissioning was successful and allowed comparison of different systems for concrete cutting and boreholes. The cost figures for the global decommissioning plan, over the period 1989-2018, as submitted in 1987 could be confirmed at around 11.2 billion BF (300 million US dollars). As soon as financial means will have been secured, the actual decommissioning will be started.

CONCLUSIONS

In spite of limited resources, Belgium has implemented an important nuclear program, in which the management of the radioactive waste has, since the origins, continuously received attention and care. The aim of this paper was to contribute to an understanding of what has been achieved and is still in progress in this field in Belgium.