# ENVIRONMENTAL IMPROVEMENT AND RESTORATION OF THE FORMER EUROCHEMIC SITE: STATUS OF THE DECOMMISSIONING AND WASTE MANAGEMENT OPERATIONS

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## ABSTRACT

This paper presents a status of the environmental improvement and restoration as a result of the decommissioning of the former EUROCHEMIC reprocessing plant and the associated waste management. Following the initial activities of EUROCHEMIC, these programs are now being carried out on the nuclear site of Mol-Dessel by BELGOPROCESS in co-operation with the Belgian national waste management organization NIRAS/ONDRAF.

The action plan comprises all activities carried out since the shut down of the plant in 1974 and the successive decisions taken with respect to the take-over of the facilities by the Belgian State : the setting up of the new company Belgoprocess as nuclear operator of the site, the withdrawal of the project to resume reprocessing, the dismantling of the shut down facilities, the definition and funding of a remedial action plan and the integration of the nuclear site in the Belgian national waste management program.

An overview is given of the cleaning and decontamination of the facilities after the shut down, the subsequent waste management operations, including vitrification of high-level liquid wastes generated by EUROCHEMIC, the dismantling project and the long term program objectives.

## HISTORY OF EUROCHEMIC

EUROCHEMIC was constituted in 1957 as an international joint undertaking of 13 European OECD/NEA member states with the aim of carrying out research and development in the field of reprocessing of spent fuel, the construction and operation of an industrial pilot plant and the training of specialists.

The reprocessing plant was constructed on the nuclear site of Mol-Dessel, in the north-east of Belgium, between 1960 and 1966. During the eight years of active operation until 1974, 181.5 t of natural and slightly enriched uranium fuels and 30.6 t of highly enriched uranium-aluminum alloy fuels were reprocessed. The shut down of the plant, which was already decided by EUROCHEMIC's Board of Directors in 1971, was carried out at the end of 1974. This decision was based upon a number of facts and considerations related to policy changes among participating states, the evolution of the reprocessing market, the creation of an industrial reprocessing consortium between France and the UK and therefore large uncertainties as to future commercial activities of EUROCHEMIC.

Negotiations between EUROCHEMIC and the Belgian State on the take-over of the facilities and the execution of the remaining legal obligations of EUROCHEMIC as a licensed nuclear operator were started in 1975 and led to the conclusion of a Convention in 1978. The ownership of the installations was gradually transferred to Belgium between 1981 and 1983.

EUROCHEMIC ceased its nuclear operating activities at the end of 1984. The new company BELGOPROCESS, constituted as a subsidiary of SYNATOM, the Belgian nuclear fuel management company, became the nuclear operator in 1985. The initial objective was to prepare and execute the refurbishing and recommissioning of the reprocessing plant, as accepted by the Belgian Parliament in 1983. This plan was eventually abandoned in 1986, due to the absence of interest from other countries to share the associated industrial risks. Consequently, BELGOPROCESS became a subsidiary of NIRAS/ONDRAF, the national organization in charge of the management of radioactive wastes and fissile materials. As from then, the EUROCHEMIC site was integrated in the Belgian waste management program, set up by NIRAS/ONDRAF.

The present and future activities of BELGOPROCESS concentrate on:

- centralized processing and storage of radioactive wastes, generated in the Belgian nuclear power program, fuel cycle operations, research and the production and use of isotopes
- site remedial actions with respect to waste management from the former nuclear activities as well as dismantling of obsolete facilities.

The milestones of the history of EUROCHEMIC are summarized in Fig. 1. The implantation of the different facilities at the former EUROCHEMIC site, at present BELGOPROCESS Site 1, is schematically given in Fig. 2.

### Decommissioning Program of EUROCHEMIC

The obligations of EUROCHEMIC associated with the shut down of the reprocessing plant in 1974 and formalized in the Convention with the Belgian State of 1978 were included into two large action programs :

- the cleaning and decontamination of the reprocessing plant and all related facilities;
- the treatment, conditioning and on-site storage of the radioactive wastes generated during the reprocessing campaigns and the subsequent cleaning and decontamination activities.

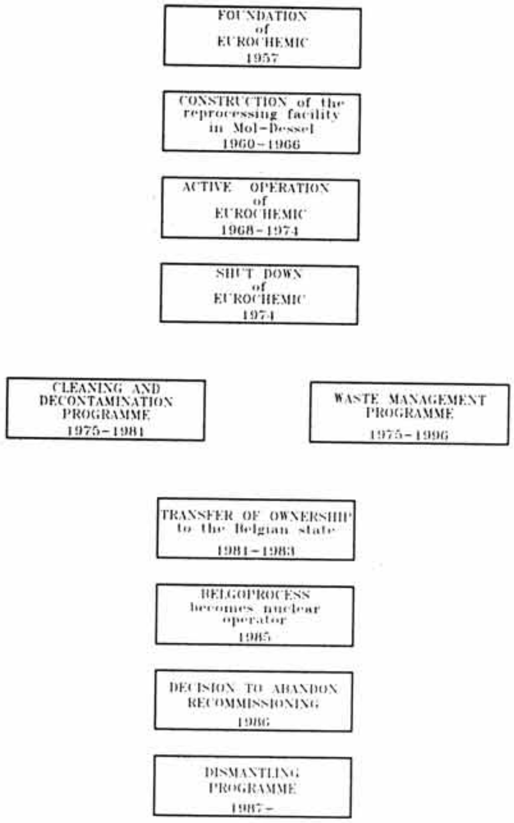


**Fig. 1. Milestones of the history of Eurochemic.**

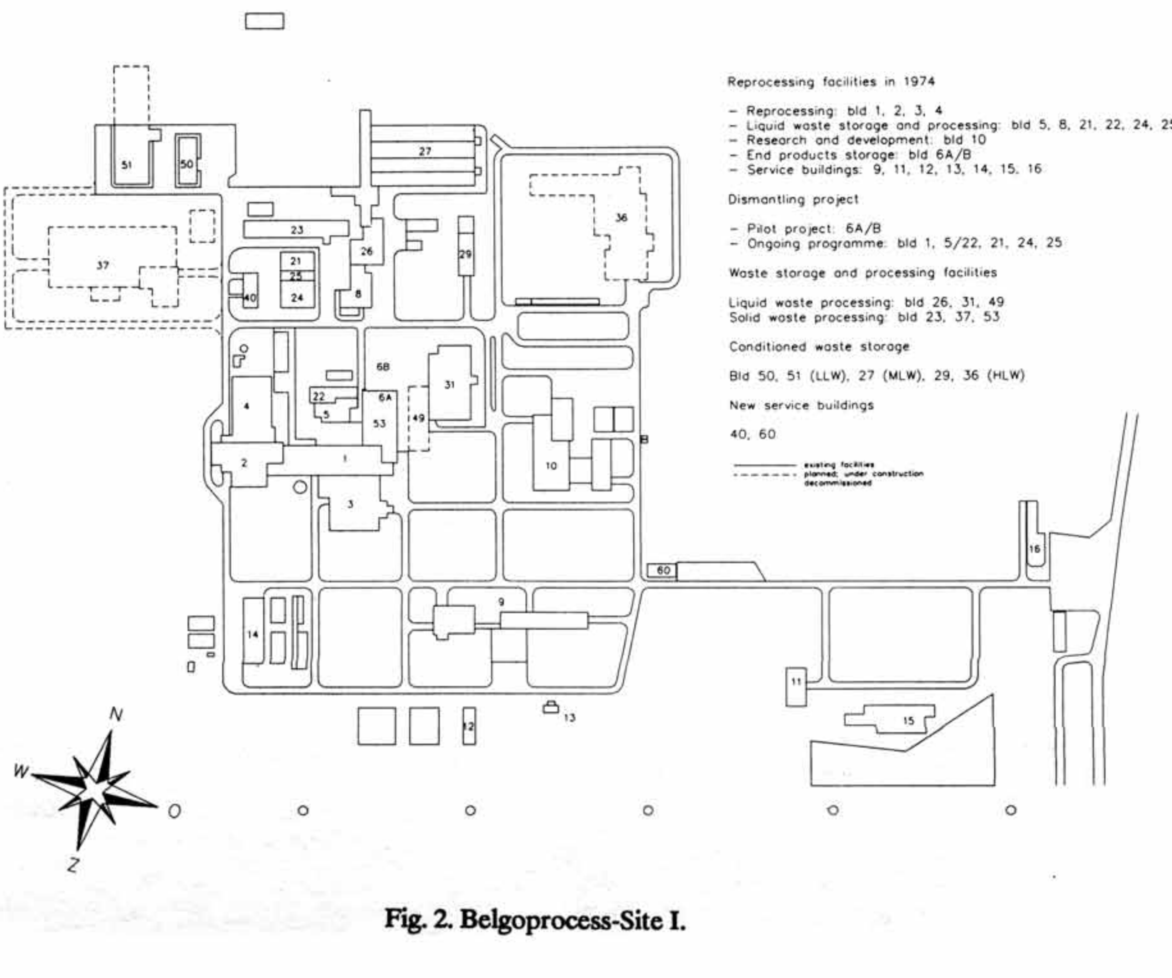


**Fig. 2. Belgoprocess-Site I.**

**Cleaning and Decontamination Program**

The primary objective of these works was initially to achieve a residual level of contamination and radiation that would enable the new owner to carry out plant modifications and refurbishing under reasonable radiological conditions of direct accessibility of the plant components. Pending the decision on restarting the reprocessing activities, the facilities were to be brought in safe stand-by conditions under permanent surveillance and at minimized costs.

To meet this objective, the working program had to take into account the following technical boundary conditions :

- the radioactive wastes generated during cleaning and decontamination were to be processed in facilities already available on site or decided to be built;
- the decontamination techniques should not preclude the further use of the plant components, maintaining their original function and quality.

In a first stage (1975-1981) the facilities involved were the chemical reprocessing plant, the spent fuel reception and storage building, the analytical process laboratories and the ventilation system of the main building complex. (1,2,3) As a result, 80% of the 40 cells of the main chemical process plant were decontaminated to radiation levels of less than 25 $\mu$Sv/h and to residual contamination levels of $\leq 2$ Bq/cm$^2$ and 20 Bq/cm$^2$ for respectively alpha and beta-gamma emitters. The total decontamination program of this facility, terminated early 1981, required about 73,000 manhours of operators and radiation control surveyors. The collective occupational dose has been estimated at 7.5 manSv. (4) Although these dose commitments were well within the legal limits, it should be stressed that the radiation protection principles as applied today would not allow the same dose levels on the basis of ALARA. However, a large benefit has been gained from these decontamination operations, since they resulted in good accessibility of the facilities and direct contact for dismantling operations, as carried out at present.

The facility has been put into safe stand-by conditions and the obtained results allowed to reduce substantially the ventilation regime as well as the routine contamination controls and technical surveys.

In a second stage (1980-1994) and following the processing of the intermediate- and high-level liquid wastes, the storage vessels were cleaned and are progressively being decontaminated to allow their dismantling. (5)

**Radioactive Waste Management Program**

With the exception of low-level liquid and solid wastes, which were transferred on a routine basis to the neighboring processing facilities of the SCK/CEN, all other alpha-bearing, intermediate- and high-level wastes generated during the reprocessing campaigns and those from the subsequent decontamination activities were put into temporary storage. This approach was adopted, pending the availability of appropriate treatment and conditioning processes and facilities, as well as storage capabilities for the conditioned products.

In 1975, EUROCHEMIC launched an ambitious waste management program in order to develop, install and operate such processes and facilities for the management of

- about 2,200 m$^3$ of intermediate-level liquid waste, arisen from the chemical decladding of spent fuel and the evaporation of liquid process wastes;
- 80 m$^3$ of intermediate-level solid wastes, comprising mainly vessel ventilation filters, ion exchange resins and filter precoat materials from pond water treatment;
- about 60 m$^3$ and 775 m$^3$ of high-level liquid wastes from the dissolution of low- respectively high-enriched spent fuel;
- some 27 m$^3$ of high level solid wastes with fuel decladding residues, dissolution residues and end pieces of fuel elements;
- about 5 m$^3$ of solid alpha-bearing wastes with a high Pu inventory mainly from the Pu tail-end of the reprocessing plant.

**Bituminization of ILLW**

The intermediate-level liquid wastes were stored in two shielded above-ground tank farms, housing 10 vessels with an individual capacity ranging from 260 to 500 m$^3$. The radioactive concentration varied between 0.02 and 0.4 Ci/l (0.7 and 15 GBq/l) in beta-gamma emitters and between 0.2 and 4 mCi/l (7 and 150 MBq/l) in alpha emitters.

Development work carried out at EUROCHEMIC constituted the basis for a bituminization project, comprising a chemical pre-treatment of the waste solutions and the homogeneous incorporation of the resulting slurries into bitumen, using a continuous screw extruder. (6)

Active operation of the EUROBITUM facility was gradually started in the second half of 1978 and the plant was operated on a fully continuous basis as from 1980. Between 1980 and 1985, all the storage vessels were emptied and subsequently submitted to an intensive rinsing and decontamination program. During the total bituminization campaign, about 12,000 stainless steel drums of 200 l with bitumen-waste end products were produced, having a dry solid/bitumen weight ratio up to 40/60 and showing contact dose rates up to 1.5 Sv/h.

In parallel to the construction of the bituminization plant, an engineered bunker storage facility was designed and built at the EUROCHEMIC site. The EUROSTORAGE facility comprises a reception station, a transfer corridor and 4 bunkers with a capacity of 5,000 drums each. It is remotely operated by means of an automatic overhead crane. (7)

At present, some 12,800 drums of 200 l have been brought into safe storage conditions.

**Vitrification of HLLW**

The high level liquid wastes, resulting from the reprocessing of low-enriched (LEWC) respectively high-enriched (HEWC) spent fuel, were transferred to above ground shielded stainless steel vessels, equipped with cooling loops.

In 1979, EUROCHEMIC concluded an agreement with the German company DWK (Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen) for the vitrification of the initial volume of 60 m$^3$ of LEWC according to the PAMELA process. As a result of an extensive R&D program, the construction of the PAMELA facility started in September 1981. This facility was financed by the Government of the Federal Republic of Germany as a demonstration plant for vitrification in the frame of the German reprocessing project, which was abandoned in 1989.

Active operation of the plant started in October 1985. The vitrification of the remaining 47.2 m$^3$ LEWC (due to evaporation during storage) was completed in June 1986 and resulted in the production of 567 glass canisters of 60 l.

The decision was taken in 1986 to vitrify also the HEWC in the *PAMELA* facility. A specific glass composition was developed to allow for aluminum oxide, which is the main chemical component of the HEWC. This large vitrification campaign started in October 1986 and was successfully achieved in September 1991, about one year earlier than *planned*.(8)

The operation of the PAMELA facility required the availability of an engineered storage facility for the resulting glass canisters. This facility was built between 1983 and 1985 in the immediate vicinity of the PAMELA plant. The adopted storage principle is a series of vertical storage baskets, in which the glass canisters are loaded by a shielded charging machine. These baskets are housed in a shielded storage cell equipped with forced ventilation for heat removal.(9) The construction of an extension of this facility for the larger canisters (150 l) with HEWC glass was terminated in 1988.

Since 1991, 2,201 canisters are stored for an anticipated period of 50 years, in accordance with the ongoing geological disposal R&D project. The vitrification operations have largely contributed to the site restoration program, since more than 12 MCi (45 PBq) were transformed from a liquid into a stable solid form.

**Other Waste Processing Activities**

The intermediate-level solid wastes have been processed between 1983 and 1990 in a remotely operated shielded caisson, comprising segregation, cutting, compaction and cementation.(10)

Combustible alpha-bearing solid wastes, mainly generated in the Pu tail-end of the reprocessing plant, were processed by acid digestion in the ALONA laboratory facility, operated between 1983 and 1986. This facility resulted from a co-operation agreement between EUROCHEMIC and the German Research Center KfK, Karlsruhe and included also recovery of Pu from the residues (11).

The only remaining wastes, arisen from the reprocessing operations, are some 27 $m^3$ of high-level solid wastes. They comprise fuel decladding and dissolution residues as well as activated end pieces of fuel elements. The treatment and conditioning of these wastes will be carried out by remote cutting and cementation in handling cells of the PAMELA facility in 1995-1996.

**Dismantling Project**

The eventual decision to abandon the recommissioning plan of the reprocessing facility, taken at the end of 1986, also included the start of a dismantling project for those on-site facilities, that could not be integrated into the present and future activities of BELGOPROCESS.

**Preliminary Studies**

Within the strategy of site transformation for the national centralized waste processing and storage activities, the following buildings and facilities were identified for dismantling :

- the storage buildings for plutonium and uranium products and for spent extraction solvents;
- the main chemical process facility;
- the associated analytical process laboratories;
- the storage tank farms for intermediate- and high-level liquid wastes;
- the buffer storage building for solid wastes;
- the research and development laboratories.

The application of an ad hoc de minimis principle, the destination of the demolition materials, the currently applied waste specifications and the anticipated availability of the required financial means were taken into account to consider a complete demolition of these buildings, including a local decontamination of soil if required. This stage 3 objective was adopted to progressively reduce the controlled areas to the boundaries of the remaining buildings.

Detailed inventories of plant components and contaminated concrete surface areas, as well as estimates of quantities of radioactive wastes to be expected from the dismantling operations were established. This set of quantitative data was combined with an anticipated operating scenario, and led to the following study results in 1987 :

- the dismantling program would require 835 man-years between 1987 and 2002, 48% of which is needed for the dismantling works of the main process building;
- the costs were estimated to be 5,725 million BEF (value 1987) including 30% for contingencies; the waste conditioning, storage and disposal costs would amount to 1,290 million BEF.

**Pilot Dismantling Program**

In order to verify the validity of the operating, safety and cost parameters in the preliminary studies, a pilot dismantling program was carried out between 1988 and 1990. The smaller buildings that had been used for the storage of U and Pu products and spent solvents were emptied and decontaminated. They were demolished and the debris were removed from the site. The latter was considered to be an essential project objective, in order to demonstrate the feasibility of the general decommissioning strategy.

All process equipment was removed from the buildings and considered as radioactive, unless complete monitoring of the surface area would show contamination levels not above natural background in the absence of other than natural radionuclides.

The floors, walls and ceilings of the buildings were decontaminated to background levels. Complete monitoring for de-restriction has been carried out twice by Belgoprocess, and then by an independent approved radiation protection control organization.

After confirmation of these monitoring results by analyses of concrete core samples, both buildings were withdrawn from the controlled area. Their demolition and the off-site disposal as industrial waste was executed in 1990.

The pilot dismantling project provided a number of valuable results in terms of adopted techniques, waste production, manpower requirements and cost factors, allowing the further execution of the large-size dismantling project, in particular with respect to the main process building.

**Large-scale Dismantling Program**

**The main process building**

The main process building is a large parallelepipedic construction of about 80 m long, 27 m wide and 30 m high, with a rectangular cross section. The basic inventories of the building are :

- building volume : 56,000 $m^3$
- concrete volume : 12,500 $m^3$
- concrete surface : 55,000 $m^2$
- metal structures : 1,000 ton.

The core of the building consists of a large block of 40 cells. Access areas and service corridors are located on 7 floor levels.

Taking into account that the preservation of the two main piping systems, the radioactive liquid waste system and the ventilation exhaust ducts, is a major technical boundary condition, an appropriate dismantling sequence was set up. This sequence, starting with the tail-end cells, going on with the extraction section and ending with the head-end cells, allows to prevent any re-contamination after dismantling and decontamination of the different structures.

## Dismantling Techniques

As a result of the pilot dismantling project and further supporting development work, BELGOPROCESS has gained considerable experience in the techniques that are required to execute safe, cost effective and industrial dismantling operations.(12, 13) These techniques relate to :

- techniques for metal cutting, such as plasma arc, hydraulic shears and nibblers.
- techniques for concrete removal, in particular diamond cable cutting for thick concrete walls (up to 1.3 m), and automatic scabblers with rates up to 20 $m^2$/h for the removal of 3 to 5 mm thick concrete layers.
- air filtration techniques which can remove metallic particulates generated during plasma cutting, and dust from scabbling operations, hereby preventing the cell ventilation systems from blocking.
- intervention techniques, comprising protective clothing and additional safety requirements for the operators, movable working platforms for cells with heights up to 18 m, and isolation of the individual cells by intervention locks.

## Cost Estimation and Present Status

The preliminary study, carried out in 1987, showed a cost estimate for the main chemical process building of 3,610 million BEF (1987) and an expected duration of 10.9 years with a total manpower of 403 manyears.

Due to important changes in waste management policy, resulting in increased processing and disposal costs, an updating of the dismantling program has been carried out in 1992. The results indicate an overall cost increase of 20%, which reflects the need for further decontamination efforts and free release of dismantling materials.

Dismantling of the main chemical process building started in 1991 with a limited operating crew, that has been enlarged in 1992 to 35 units. A further expansion to 50 has been proposed, but is depending upon decisions with respect to additional funding.

## Funding of the Decommissioning Program

It is obvious that the costs associated with the execution of the above described remedial action program for the EUROCHEMIC site since the shut down in 1974, are substantial. They have been subject to several funding agreements involving the member countries of EUROCHEMIC, the Belgian State, the Belgian utilities, SYNATOM and NIRAS/ONDRAF.

The costs of the activities carried out by EUROCHEMIC between 1975 until the end of 1984 were totally borne by the EUROCHEMIC Consortium, with the exception of the postponed costs for storage and disposal of the resulting conditioned wastes.

In 1986 EUROCHEMIC concluded a lump sum agreement with the Belgian State, the new owner of the site, to provide for the remaining activities of EUROCHEMIC beyond 1985, defined as its legal obligations. Including a negotiated contribution for future dismantling operations, EUROCHEMIC has fulfilled its duties in 1990, when the last annual instalment of a total of 4,340 million BEF (1986) was paid.

Since 1989, the additional funding for the dismantling operations, the resulting waste processing activities, as well as the storage and disposal of all wastes is provided for through an agreement between the Belgian State, SYNATOM and the Belgian utilities. The Belgian State contributes 4,405 million BEF (1989) for planned operations until the year 2000, whereas it is committed to bear the remaining costs of all further site remedial actions. NIRAS/ONDRAF was entrusted by the Belgian government with the management of radioactive waste, decommissioning and site restoration. The execution of these activities is subcontracted to BELGOPROCESS by the national waste management organization.

# CONCLUSIONS

The decommissioning and associated waste management operations carried out at the former EUROCHEMIC reprocessing site since the shut down in 1974, have made a substantial progress. Although the final decision to abandon recommissioning was taken only 12 years after shut down, this period of time has been used to successfully achieve the decontamination of the facilities and execute a major part of the waste management program.

In particular, the vitrification of all HLLW on site has largely contributed to an overall improvement of the safety, since it relates to more than 90% of the total radioactivity inventory.

The dismantling project, launched in 1987, is now being executed on an industrial scale and will lead to additional site remediation during the next 10 years.

All these activities are supported by an active communication program of BELGOPROCESS and NIRAS/ONDRAF aimed at the general public and the local and national authorities. It is experienced to be essential in the process of public acceptance of the present and future activities on site.

Finally, BELGOPROCESS has achieved the level of industrial experience in both waste processing and dismantling operations to further accomplish the site remedial objectives.

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