EXPERIENCE AND DEVELOPMENTS FROM DECOMMISSIONING OF THE FORMER EUROCHEMIC REPROCESSING PLANT IN BELGIUM

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ABSTRACT

The paper presents a status overview of the decommissioning of the main process building of the former EUROCHEMIC reprocessing plant on the nuclear site of Dessel in Belgium.

The aims of the decommissioning project are to limit radiation risks to the population according to the universal criteria of the ALARA principle, to bring the building into the non-nuclear category, i.e. to decommission up to a level where no controls on contamination and radiation are required any longer and the ventilation may be shut down, and to decontaminate the building completely in view of a conventional demolition.

Decommissioning of the building was started after completion of a pilot project. Two small storage buildings for final 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. They were demolished and the remaining concrete debris was disposed of as industrial waste and green field conditions restored.

The paper gives an overview of the industrial decommissioning of the main process building carried out since 1990. It deals with the adopted dismantling strategy and methodology, techniques developed and used in the decommissioning operations, automation in decontamination, health and safety during the decommissioning operations, release of decontaminated materials, quality assurance programme, total costs of the dismantling project and present status of the decommissioning activities.

INTRODUCTION

The EUROCHEMIC reprocessing facility at Dessel in Belgium, 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 a reasonable cost. In 1984, Belgoprocess took over the activities on site. When it was decided in 1986 not to resume reprocessing in Belgium, the main Belgoprocess activities changed to processing and storage of radioactive waste and to decontamination and decommissioning of obsolete nuclear facilities.

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. They were demolished and the remaining concrete debris was disposed of as industrial waste and green field conditions restored. The main conclusions of this pilot decommissioning project denoted that, in 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 (figure 1). 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/cm² (beta) and 200 Bq/cm² (alpha). Some hot spots give a gamma dose rate of several mSv/h. About 1,500 Mg of metal structures, and 12,500 m³ of concrete with 55,000 m² of concrete surfaces have to be removed and/or to be decontaminated.

Fig. 1. Main process building of the former Eurochemic reprocessing plant

Decommissioning Constraints, Decommissioning Strategy

The decommissioning of nuclear facilities involves radiation and contamination risks. All operations are submitted to strict radioprotection regulations, and the ALARA-principle (As Low as Reasonably Achievable) has become a common rule for radiological dose limitation of decommissioning workers. Also reduction of the workload for the operators has become an important feature when considering decommissioning activities.

As such, it is obvious that remote operation should be more and more systematically considered and applied. Hands-on operations tend to be limited to non-repetitive tasks in low radiation or low contamination areas. However, the word "remote" does not always imply the use of telemanipulators or robotic systems. Specialised machines have been built for specific purposes and operate with remote control.

In addition, the extrapolation of dismantling work on an individual unit to the complete decommissioning of a reprocessing plant required a well-defined dismantling strategy. Such a strategy is influenced by both technical and economic factors. Among the technical factors the layout of the building and the installations inside is a very important one. A major economic factor is the aim to reduce standby costs.

One of the objectives during decommissioning work remains to gather and evaluate various kinds of data related to dismantling activities, useful for planning and execution of future decommissioning activities.

On the whole, considering a decommissioning strategy, the specific BELGOPROCESS approach should be highlighted, in which:

- the decommissioning activities are carried out on an industrial scale with special emphasis on:
  - cost minimisation, including specific actions to reduce standby costs, and taking great care to limit radioactive waste management costs, making extensive use of adequate decontamination techniques in order to allow the dismantled components and materials to be unconditionally released, always taking into account the limited availability of funding;
  - a commitment to results within an overall planning;
  - the use of technology on an industrial representative scale;
- the decommissioning activities make use of state of the art technology, providing own support to nuclearise commercially available technology, in a good collaboration on decontamination and decommissioning with the nuclear and non-nuclear industry, e.g. in the area of scabbling and shaving techniques, protective clothing, decontamination;
- the decommissioning activities have to deal with the specific radiological characteristics of the facilities. The decommissioning of a nuclear power plant mainly being characterised by radiation risks due to the presence of in depth activation products, the alpha contamination of equipment and building surfaces in a reprocessing plant requires the decommissioning work to be done using adequate protective clothing. Specific breathing and cooling air systems also

have to be provided to allow the operators to carry out the decommissioning tasks in acceptable working conditions.

Overview of Decommissioning Activities and Equipment Used

Dismantling of metal components is mainly carried out by plasma-arc cutting. Pipes with diameters up to two inches can also be cut using radio-controlled hydraulic shears, equipped with hydraulic clamps. To easily deploy the hydraulic shears at higher levels, a pneumatic manipulator is being applied, carrying the shears, while the operator only has to position the tool in order to cut the pipes. The cutting of cast iron shielding blocks is done with hydraulically controlled saw blades.

Cutting and decontamination of concrete structures is carried out either hands-on, or by electrically powered, hydraulically controlled systems. A mini electro-hydraulic hammering unit (weight only 350 kg) is used in those cell areas where contamination has penetrated deeply into the concrete surface, increasing the decontamination possibilities, reducing significantly the workload for the operators. Cell entrances are created or enlarged with diamond cable cutting machines.

In the early days, concrete walls with limited in depth contamination, were decontaminated using commercially available pneumatic hand scabblers. In addition, 3-headed, 5-headed and 7-headed hand-operated floor scabblers were used. These pneumatic powered machines had adapted dust extraction systems around the scabbler heads. To improve the working conditions for the operators, and to increase capacity, scabblers were progressively automised.

Operation efficiency was improved when shaving machines were introduced, using a diamond tipped rotary head, designed to give a smooth surface finish and making monitoring easier. A floor shaver and a remote controlled diamond wall shaver were developed for decontamination of larger concrete surfaces, showing a threefold increase in efficiency and 30 % less secondary waste production. Due to the absence of machine vibration, the physical load to the operators was also reduced.

Two low weight handheld shaving tools were developed as an alternative for handheld scabblers. A handshaver uses a cupped disk with diamond segments bonded onto the face of the disk. It has a controllable dust extraction guard and produces very low hand-arm vibrations. Decontamination rates from 4 to 6 m^2/h machine time are obtained, compared to 1.5 m^2/h for a hand held DK1 scabbler. Operator’s impressions are very positive, especially related to work load and hand-arm vibration levels.

When decontamination has penetrated deeper into the concrete surface and layers up to

1 cm or more have to be removed from walls, floors or ceilings the use of shavers may require the work to be done in several steps. In order to improve efficiency in these cases, an adapted milling cutter was used. This tool can also fit on a conventional forklift truck. Such tool enables the single-pass removal of a rather thick layer of material from concrete or brick walls. Using this technique results in a rather smooth surface of concrete or brick material, which may be less smooth than in the case of a shaved wall, but still very interesting for making measurements.

Into the main process building a lot of pipe penetrations between the cells has to be removed after the decontamination of the walls and ceilings and before the first release measurement .

These internally contaminated pipe penetrations are closed and welded before removal. For the removal of the pipe penetrations a concrete splitter together with pneumatic hammering is successfully applied. To prevent recontamination of the decontaminated cells, the pipe penetration are covered and sealed with wooden boxes. The concrete debris will be sent to the crushing and sampling installation on site BP2 for the final release measurements.

To remove process equipment in a safe and ergonomic way from cells with heights up to 18 meters, movable platforms are used. On the movable platform a video survey system is installed, enabling the two operators in a cell to be monitored by an operator outside the work area. A communication system provides radio contact with the operators on the working platform. In other cells, lifting platforms with articulated axes are used.

Automation in Decontamination

In a comparative, semi-industrial demonstration programme to decontaminate metallic components using dry and wet abrasive blasting techniques, it was shown that it is economically interesting to decontaminate such components to clearance levels, when all costs for conditioning and disposal of resulting wastes are considered. Using adequate dry blasting, 32 tons of contaminated profiles and plates have been decontaminated to clearance levels, avoiding intrusion of contamination into the material to be decontaminated. In a wet abrasive blasting system another 3 tons of metal components have been decontaminated and measured to be below clearance levels after a second measurement campaign.

The results of these tests showed that the wet abrasive technique presents much higher costs, less efficiency, much higher secondary waste production and much greater difficulties at measurements to clearance levels.

Based on the results of the demonstration programme, on the calculated unit cost for decontamination (only 33 % of the cost for radioactive waste treatment, conditioning, storage and disposal), and the availability of automated dry abrasive blasting installations on the market, it was decided to install an industrial automatic dry abrasive blasting unit (see figure 2) in the BELGOPROCESS central decontamination infrastructure.

The equipment was ordered in 1995, and was installed during the first trimester of 1996. Operational activities started on the 9th May 1996, and at the end of September 2004, about 904 Mg of contaminated metal has been treated. 219 Mg of this material has been released, having been measured twice by the in-house health physics department. About 615 Mg of metal, presenting surfaces that cannot be measured due to their shape, have been packed in drums and were melted for release in a controlled melting facility.

Fig. 2. Operational view of the abrasive blasting installation

The working efficiency of the installation proved to be better than expected. A critical evaluation of the operating period showed that the overall industrial performance of the activities could be increased significantly. The limiting factor proved to be the time required for making adequate release measurements with acceptable accuracy.

To verify the suitability of the abrasive blasting system more specifically, impact of abrasives into the material surface, which could at the same time introduce contamination into the surface layer, has been checked by means of two independent control actions on samples taken from the material. Contamination levels were monitored by non-destructive gamma measurements on samples before and after decontamination. In addition, electrochemical control monitoring was carried out on some samples after decontamination. By electrolysis, surface material of the sample was removed and dissolved in the electrolyte. A radiological characterisation of this electrolyte proved that there was no intrusion of contamination into the material surface.

In December, 1999 in a specific experiment, some 14.4 Mg of heavy concrete blocks were decontaminated in the same abrasive blasting installation. 12.2 Mg of this material could be released after two specific measurements carried out by the in-house health physics department. Only 2.2 Mg of dust material was recovered as secondary waste. This promising result was the start of a new and interesting decontamination technique.

Since the end of September 2004, some 237 Mg of concrete and heavy concrete blocks were decontaminated in the abrasive blasting installation. 210 Mg (89 %) of this material was unconditionally released, having been monitored twice by the in-house health physics department or after treatment into the crushing and sampling installation. The unit cost for abrasive decontamination proved to be about 45 % of the global cost for radioactive waste treatment, conditioning and disposal of the same material.

Ensuring Health and Safety During the Decommissioning Operations

During the decommissioning operations, major importance is given to ensuring health and safety of the operators and to avoiding spread of contamination. Based on experience, this is mainly a matter of optimisation of radiological protection and a well developed organisation and close follow-up of the decommissioning activities.

Optimisation of radiological protection is achieved by limiting the exposure time to radioactive radiation and by protecting operators against potential contamination. Operator exposure time may be drastically reduced when adapted dismantling techniques are used, combined to a well-developed and strictly followed working scheme. As a result, each operator only stays a limited number of hours in the area to be dismantled, while health physics control ensures a close follow-up of all activities. Moreover, each operator involved in the decommissioning activities is continuously subject to medical controls. The decommissioning areas are kept under a slightly negative pressure in order to avoid external spread of contamination.

When decommissioning nuclear installations, the operators use various combinations of protective clothing and equipment, especially in areas with alpha contamination. To provide breathing and cooling air to the operators in their protective clothing, a specific personal protection system was developed, comprising an in-line breathing air filter, a distribution block to control breathing and cooling air, a low profile automatic, first breath activated, positive pressure demand valve, a special facemask with two standard connections, and a safety device, allowing breathing through an absolute filter when the normal air supply has dropped. A bypass on the positive pressure demand valve enables additional air supply to refresh the operator’s face and to remove excessive moisture. Special attention was paid to minimise weight and dimensions of the components and to improve carrying comfort. Filtered breathing air is provided from specific units including emergency supply and alarm systems.

Using the newly developed equipment, physical condition tests and measurement of workload on the operators were executed under normal working conditions of plasma cutting and hydraulic hammering or scabbling. Compared to similar tests carried out when older systems were used, and although the physical condition of the operators showed to have decreased by 7 %, the results of the measurements proved to be 20 % more favourable as compared to the proposed heat stress limits. Increases in heart rate and rectal temperature proved to be less explicit as with the former systems, and operators’ recuperation during lunchtime proved to be 100 %. As such, the positive influence of the new combined breathing and cooling system was explicitly shown.

As in the metallurgical industry, in construction, and in forestry, exposure to hand-arm vibrations also occurs in the decommissioning of nuclear installations. Health effects induced by hand-arm vibrations are for instance ‘white fingers’, but also physical deformations of bones and joints, and other disorders. In different countries, alternative standards or target values have been proposed to limit vibration load on operators. A proposal for a general regulation, however, is not yet available. The current situation related to exposure of hand-arm vibrations during the decommissioning of nuclear installations at Belgoprocess has been submitted to a global representative evaluation method. The results of the analyses carried out do not give reasons to some concern. To further improve working conditions, and to keep the vibration load on the operators below the proposed health limit, additional technical and organisational objectives have been proposed. Precautions for personal protection and medical supervision have been provided, as well as for calculating and follow-up of the daily exposure of the operators to vibrations.

Release of Decontaminated Materials

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. Materials monitored and found to be under the detection limits of the used portable contamination monitors, can be disposed of without any restrictions. With the equipment used, demonstrating an alpha contamination on metal surfaces that have been decontaminated, requires a minimum measurement time of about 6 to 10 seconds per 50 cm^2. 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.

For the small buildings in the pilot project, all concrete surfaces were monitored twice in view of unconditional release, and core samples were taken at the previously most contaminated places. For the remaining structures or larger buildings, this will result in a large number of samples to be taken and to be analysed. In addition, it will be very difficult or impossible to prove that these samples are representative for the remaining structures of the buildings. Though this methodology is not rejected as such, an alternative has been developed, considering at least one complete measurement of all concrete surfaces and the removal of detected residual radioactivity. This monitoring sequence is followed by a controlled demolition of the concrete structures and crushing of the resulting concrete parts to smaller particles. During the crushing operations, metal parts are separated from concrete and representative concrete samples are taken, the frequency of sampling meeting the prevailing standards. In a further step, the concrete samples are milled, homogenised and a smaller fraction is sent to the laboratory for analyses. After approval of the licensing documents, operations of the facility (figure 3) were started in June, 2001. At the end of September 2004, 1,934 Mg of concrete were monitored. All this material will be unconditionally released and removed from site after analyses and agreement by the in-house health physics department and the authorities. The material is further used in conventional road construction.

Fig. 3. General view of the concrete crushing and sampling facility

Finally, contaminated materials that are not subject to the waste minimisation techniques as discussed before, have to be considered as radioactive waste. The final objective in waste minimisation during decontamination and decommissioning is to ensure that those volumes of remaining radioactive materials that cannot be released are reduced in volume as far as practicable. The methods for processing, conditioning, packaging, handling, storing, transporting and disposing of radioactive waste arising from decommissioning are in general similar to those used in other parts of the nuclear industry.

Quality Assurance Programme

All the decommissioning and decontamination tasks are carried out based on a certified Quality Assurance Programme. The decommissioning and decontamination procedures and instructions have all been integrated in a standard Quality Assurance Plan. In the beginning of 1996, the entire Quality Assurance system was audited by SGS European Quality Certification Institute as compared to the ISO 9001-requirements. As a result, on the 21 March 1996, BELGOPROCESS obtained the ISO 9001 certificate applicable to the decommissioning of nuclear facilities and the decontamination of contaminated materials. End 2003, the Quality Assurance system was recertificated by the SGS European Quality Certification Institute for ISO 9001:2000.

Funding of the Decommissioning Programme

The costs associated with the execution of the remedial action programme 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 (involved in the management of Belgian nuclear fuel), and NIRAS/ONDRAF (the National Institute for the Management of Radioactive Wastes and Fissile Material). In a preliminary study, as carried out in 1987, the time needed for the dismantling activities into the main process building was figured for 10.9 years with a total manpower of 403 man-year.

In 1992, a revised cost estimate has also been performed were relevant changes in this evaluation can be summarised as follows:

- the specific costs for treatment and conditioning of the primary and secondary solid wastes have significantly increased, due to general waste management adaptations (safety, quality assurance, traceability, administrative follow-up and reporting) and to important investments in new processing facilities,
- the storage and disposal costs of the final waste products have also significantly increased, mainly because suspect alpha-waste is now classified as waste for geological disposal instead of near surface disposal,
- the dismantling velocities (kg metal and concrete per man-day) have been realistically increased, taking into account the present availability of technology,
- the further declassification of waste materials by improved decontamination techniques has been taken into consideration,
- an enlargement of the total operation crew in order to shorten the time schedule has been assumed.

In 2004 the total costs for the decommissioning of the Eurochemic Reprocessing Plant was revised as indicated in Table I.

Table I. Decommissioning Costs of the EUROCHEMIC Reprocessing Plant

	Initial estimation		**1990 - 2003**	**> 2003**	**Total**	
	M€1987	**M€2003**	**M€2003**	**M€2003**	**M€2003**	**Ratio**
Dismantling costs	54.8	76.4	85.5	60.0	145.5	1.9
Waste management	68.7	95.7	28.8	5.0	33.8	0.35
Total	123.5	172.1	114.3	65.0	179.3	1.04

Current Status of the Decommissioning Activities

Dismantling of the main chemical process building started in 1990 with a limited operating crew, which was enlarged in 1992 to 24 operators. Today, 41 operators are involved in all the decommissioning activities on Belgoprocess, while 8 operators take care of the decontamination work. All activities are assisted, supervised and managed by 13 supervising and management people.

Decommissioning work has been carried out in 100 of the 106 individual cell structures to be dismantled. At the end of October 2004, 43 cells have been decontaminated to background levels. After being completely dismantled, in 11 other cells concrete decontamination was started. In another 46 cell structures, component and material removal has been started.

In view of the increased waste processing and disposal costs, much effort has gone into decontamination and free release (clearance) of decommissioning materials, as is clearly indicated in Table II.

Table II. Contaminated Material Production from the Beginning of 1990, until the end of October 2004 at the Decommissioning of the EUROCHEMIC Reprocessing Plant

	Inventory (Mg)	Produced (Mg) 1990 - Oct. '04	Unconditionally released %
Metal	1,225	1,316	67.5
Concrete	1,725	1,719	50.3
Heavy concrete	472	476	92.5
Other material	187	143	40.6
TOTAL	**3,609**	**3,654**	**61.6**

CONCLUSION - FUTURE DECOMMISSIONING PROGRAMME

The decommissioning operations carried out at the main building of the former EUROCHEMIC reprocessing plant have made substantial progress. 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 will divide the entire building into 2 or 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 will start in 2007.

Additional installations will be put in a standby status on the EUROCHEMIC site during the next years, and will become available for decommissioning. It considers buildings 105, 122, 121, 124, and others, presenting the specific challenge to dismantle the large storage vessels for the high level liquid wastes from the EUROCHEMIC reprocessing activities, and still containing a important amount of radioactive material.

Also on the site of the former waste treatment department of the Belgian nuclear research centre, an important number of installations will be put in a standby status, available for decommissioning. It considers a number of storage facilities, the incinerator for beta-gamma wastes and some water treatment installations. Depending on available funding, these decommissioning tasks will also have to be included in the global decommissioning planning for the future.

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