Belgoprocess

Abrasive blasting, a technique for the industrial decontamination of metal components to unconditional release levels

1. Introduction

Belgoprocess started the industrial decommissioning of the main process building of the former Eurochemic reprocessing plant in 1990, 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 main conclusions of this pilot decommissioning project denoted that emphasis had to 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. About 106 individual cell structures have to be dismantled, involving the removal and decontamination of equipment from each cell, the decontamination of the cell walls, ceilings and floors, the dismantling of the ventilation system. These activities are followed by a complete monitoring to allow for unconditional release of the remaining structures. As such, about 1,500 Mg of metal structures, and 12,500 m^3 of concrete with 55,000 m^2 of concrete surfaces have to be removed and/or to be decontaminated.

Most of the work involves hands-on operations under protective clothing tailored to each specific task. Tool automation and automatic positioning systems are successfully applied.

The specific Belgoprocess approach should be highlighted in which decommissioning activities are carried out on an industrial scale with special emphasis on cost minimisation, a commitment to results within an overall planning, and the use of technology on an industrial representative scale. This approach includes specific actions to reduce standby costs. It takes great care to limit radioactive waste management costs, keeping the generation of radioactive waste to a minimum, minimising the spread of radioactivity as much as possible, and optimising the possibilities for recycling and reuse of valuable components from existing and potential waste streams. Extensive use of adequate decontamination techniques is made in order to allow dismantled components and materials to be unconditionally released, as is indicated in Table 1 which can be seen in the "Strategy", taking into account the limited availability of funding.

2. Decontamination of contaminated metal components

During the years 1990-1991, various evaluations and laboratory tests were carried out to identify decontamination techniques that enable the removal of surface contamination from metal components such that unconditional release levels are met, and that the material can be reused without radiological restrictions. In many cases, this requires the removal of a thin layer of structural material, which means that much more aggressive methods have to be used than during normal maintenance operations. Based on the evaluations, it was concluded that appropriate decontamination techniques should be selected based on specific criteria:

- **Safety**: the application should not result in increased radiation hazards due to external contamination of workers or through inhalation of radioactive dust or aerosols formed during the decontamination activities;
- **Efficiency**: the surface contamination should be removed to a level that enables the recycling or the reuse of the material;

- **Waste minimisation**: the production of large quantities of secondary waste should be avoided, that require excessive work power and costs for treatment and disposal, and that result in additional exposure;
- **Cost-effectiveness**: the decontamination costs should not exceed the costs for waste treatment and disposal of the material; and
- **Feasibility of industrialisation**: the quantities of contaminated materials that are produced during decommissioning activities and that may be available for decontamination, in general do not favour methods or techniques that are labour intensive, difficult to handle or difficult to automate.

As a result, a comparative, semi-industrial demonstration programme was elaborated for the decontamination of metallic components using the dry and wet abrasive blasting techniques. It was shown that it is economically interesting to decontaminate such components to unconditional release levels, when all costs for conditioning and disposal of the resulting wastes are considered. Using adequate dry blasting, 32 Mg of contaminated profiles and plates were decontaminated to clearance levels, while avoiding the intrusion of contamination into the material. In a wet abrasive blasting system, another 3 Mg of metal components were decontaminated and measured to be below clearance levels. The results of these tests are indicated in Table 1. They show that the wet abrasive blasting technique presents higher costs, less efficiency, much higher secondary waste production and much greater difficulties at measurements to clearance levels.

	Dry System	Wet System
Material Treated	32 Mg	3 Mg
Efficiency	Very high	Lower
Grid Consumption	55 g/kg metal	109 g/kg metal
Secondary Waste Production • Intervention Clothing • Grit Waste • Water Consumption	 5.3 % 5.5 % --	 8.2 % 10.9 % 6.9 l/kg metal
Decontamination Rate • Plates • Profiles	 57.4 kg/h 2.8 m^2/h 127.7 kg/h 1.8 m^2/h	 48.0 kg/h 2.3 m^2/h 106.8 kg/h 1.3 m^2/h
Grit Cost	0.5 €/kg	2.35 €/kg
Decontamination Cost for the Demonstration Programme	20.08 €/kg	35.70 €/kg

Table 1. Results of the comparative demonstration programme on dry and wet abrasive blasting decontamination techniques

Following the demonstration programme, the installation of an automated industrial abrasive blasting infrastructure was evaluated. Estimates indicated that the decommissioning programme for the Eurochemic reprocessing plant would produce in a short time more than 309 Mg of slightly contaminated metal. This would include flat sheets of metal, profiles, casings of tanks and neutron shields that could be decontaminated to unconditional release levels. In addition, more than 1,500 Mg of other metal structures would be available for decontamination by abrasive blasting.

Task	Decontamination by Dry Abrasive Blasting	Decontamination by Wet Abrasive Blasting	Supercompaction and Disposal
Capital Costs	71.07	991.57	--
Installation Costs	254.12	264.20	--
Reducing and Packaging	795.89	795.89	1 591.77
Decontamination	263.49	549.56	--
Measurements	160.24	160.24	--
Waste Treatment	344.20	259.47	3 367.63
Intermediate Disposal	15.27	11.11	147.15
Final Disposal	87.26	63.46	840.85
Total Costs	**1 991.54**	**3 095.50**	**5 947.40**

Table 2. Costs for the decontamination of 309 Mg of metal in a dry or a wet abrasive blasting system compared to the costs for waste treatment *(in 1,000 € 1992)*

Based on the results of the demonstration programme, the costs for the decontamination by abrasive blasting of the 309 Mg of metal components were compared to the costs for normal waste treatment and disposal of the same material. Three alternative treatment methods were considered. Cutting and decontamination of the 309 Mg of metal material to unconditional release levels in an industrial wet or dry abrasive blasting system and treatment and disposal of the resulting secondary wastes was compared to cutting, supercompaction, cementation and surface disposal of the material as low level waste. An overview of the costs related to the three alternatives is given in "1,000 € 1992" in Table 2.

Figure 1 gives a view of the total costs for the installation, waste treatment, and intermediate and final disposal for the considered alternatives, as a function of the available quantity of material.

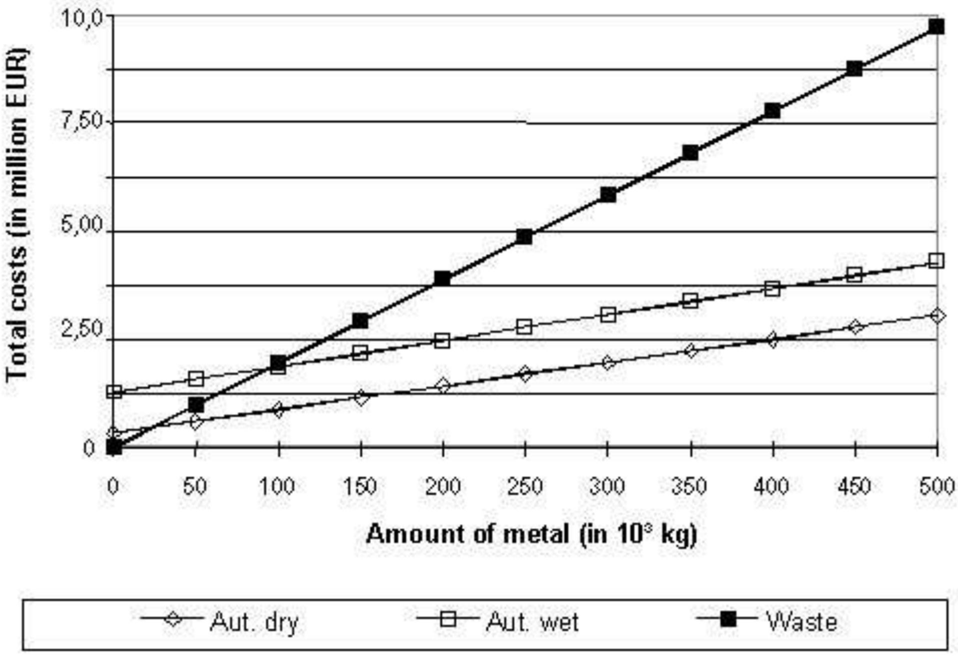

Figure 1. Total costs for waste treatment, intermediate and final disposal compared to the costs for decontamination by abrasive blasting as a function of the amount of material

Considering the decontamination factor, the efficiency, the consumption of abrasives, the cost of the used abrasives, the secondary waste production (abrasives and protective clothing), the financial analysis relating to the operation of the installation, the resulting unit cost for decontamination (30 % of the cost for radioactive waste treatment, conditioning and disposal) and the availability of automated systems on the market, it was decided to install an industrial dry abrasive blasting unit in the Belgoprocess central decontamination infrastructure.

The equipment was ordered in 1995, and was installed during the first trimester of 1996. Functional and cold tests were carried out successfully in the beginning of May 1996 and operational activities started on May 9, 1996. A picture of the abrasive blasting installation is given in Figure 2. A schematic diagram of the facility is indicated in Table 3.

Figure 2. Operational view of the abrasive blasting installation

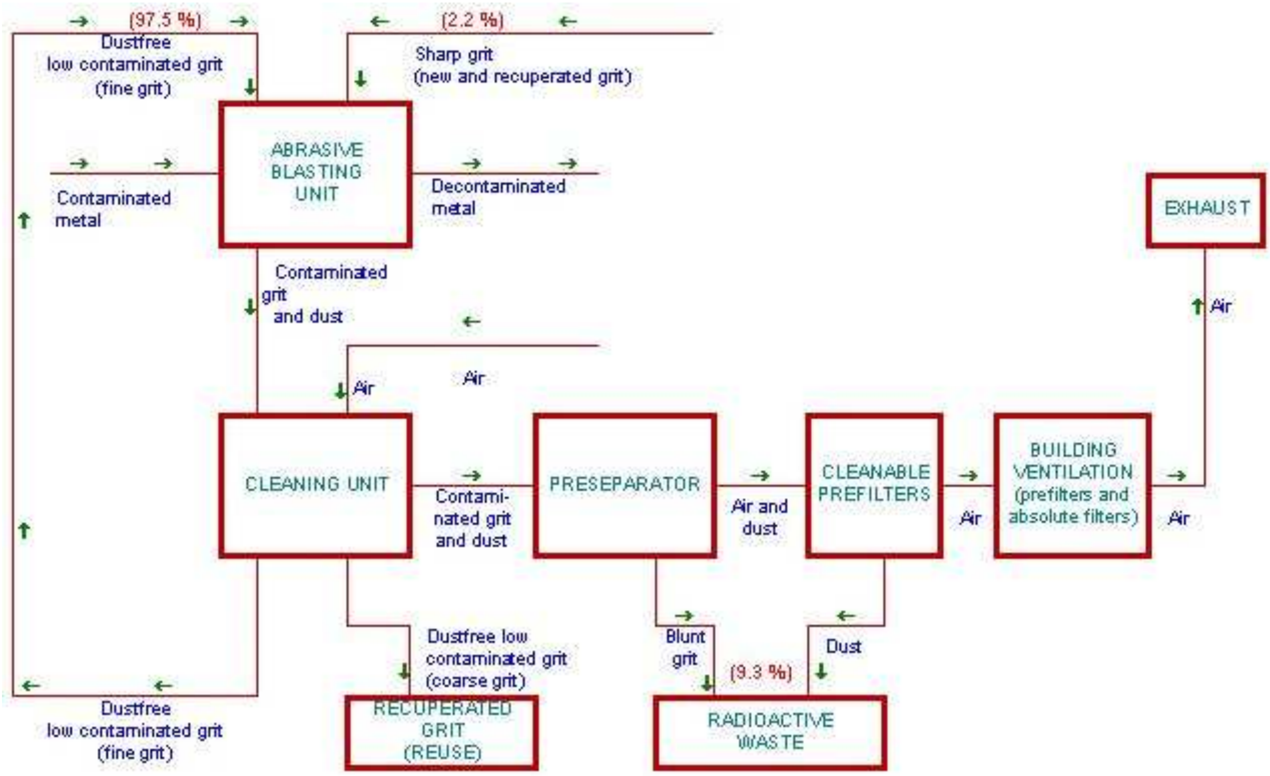

Table 3. Schematic diagram of the dry abrasive blasting installation for the decontamination of metal components

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

The unconditional release of decontaminated material is based on current procedures. This means that all equipment, material and areas with contamination levels above background are considered to be radioactive. Materials monitored and found to be under the background levels of the used portable contamination monitors can be disposed of without any restrictions. With the existing equipment, demonstrating that there is no alpha contamination on metal surfaces that have been decontaminated, requires a minimum monitoring time of about 6 to 10 seconds per 50 cm2. Surface areas have to be monitored twice at 100 %, and surfaces or areas that can not be monitored are considered to be radioactive.

As it could be considered that the impact of the abrasives could at the same time introduce contamination into the surface layer, the suitability of the abrasive blasting system was verified. Therefore, the impact of the abrasives into the material surface was checked by means of two independent control actions on samples taken from the material. First of all, contamination levels were monitored by non-destructive gamma measurements on samples taken before and after decontamination. In addition, a control monitoring was carried out on samples taken after decontamination by removing some surface material from the sample through chemical dissolution. A radiological characterisation of this solution proved that there was no intrusion of contamination into the material surface.

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3. Improving the performance of the global decontamination process

To improve the efficiency and the economic productivity of the global decontamination process, the technical and financial feasibility of alternative options were investigated in order to minimise the time for monitoring without reducing the required quality relating to the unconditional release practices. It was proposed to limit the practical unconditional release measurements on the decontaminated metal to specific dose rate measurements, random sampling and sample analyses, and send the material to a controlled melting facility in order to use the melting process as a monitoring tool for unconditional release. The proposed alternative results in a lower global cost for decontamination and unconditional release of material as:

- Cutting metal components into pieces with geometries and surfaces that can be measured is no longer required;
- Special tooling for handling material that has to be measured is no longer required;

- Unit costs for melting decrease, as larger quantities of material can be melted and monitored for unconditional release, that show no or almost no contamination;
- The capacity of the abrasive blasting installation can be increased by a factor of 2.5, as waiting times and/or storage times have no longer to be considered, and the material can immediately be removed for melting, reducing the unit cost for decontamination as well.

Moreover, operators and radiation protection officers, normally involved in time consuming handling and measurement activities, can be integrated in the decommissioning team itself, contributing to an increased progress of the actual decommissioning work.

From the technical point of view, unconditional release of metal components via melting offers:

- Adequate opportunities for representative, homogeneous sampling, and adapted laboratory analyses;
- Opportunities for the unconditional release of metal components that can be decontaminated, but that cannot be measured due to their shape;
- Increased confidence that the responsibilities with respect to the unconditional release of materials at currently applied release limits can be taken;
- Reduced operator dose uptake as smaller storage facilities, and limited storage times are required.

In addition, the lower quantities of material to be handled and to be reduced in size, will result in:

- Lower risks on heat stress to the operators, working in ventilated suits when cutting;
- Lower physical load on operators having to handle the material less than currently done.

Finally, a combination of the proposed alternatives results in a best technical and economic compromise, improving the performance of the global decontamination process as envisaged, without reducing the required quality related to the current unconditional release practices.

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4. Results after 5 years of experience in abrasive blasting of metal material

At the end of May 2001, after 6 years of operation, 523 Mg of contaminated metal has been treated. 182 Mg (35 %) of this material was unconditionally released, having been monitored twice by the in-house health physics department. About 303 Mg (58 %) of the metal, presenting surfaces that could not be measured due to their shape, were melted for unconditional release in a controlled melting facility. About 12 Mg of metal grit was required to obtain the result as indicated. The total amount of secondary waste produced was 50 Mg, including 12 Mg of grit material and 38 Mg (7 %) of metal components that could not be decontaminated, and material that was removed from the metal surfaces as a result of the decontamination process. During the operations an additional 7 Mg of protective clothing was produced as secondary waste, bringing the total amount of secondary waste production at 3,6 %. The unit cost for abrasive decontamination proved to be about 30 % of the global cost for radioactive waste treatment, conditioning and disposal of the same material, as expected.

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5. Decontamination of concrete blocks in the abrasive blasting installation

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, some 130 Mg of concrete and heavy concrete blocks were decontaminated in the abrasive blasting installation. 115 Mg (88 %) of this material was unconditionally released, having been monitored twice by the in-house health physics department. The total amount of secondary waste produced was 16 Mg, including grit material and material removed from the concrete surfaces as a result of the decontamination process. During the operations an additional 360 kg of protective clothing was produced as secondary waste, bringing the total amount of secondary waste production at about 13 %. 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.

The suitability of the abrasive blasting system was also verified for concrete decontamination. In order to check the impact of the abrasives into the material surface, a small layer of the decontaminated concrete surface was removed by shaving. A gamma-spectrometric characterisation of the produced dust proved that there was no intrusion of contamination into the material surface.

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6. Conclusions

The management of wastes and materials from decommissioning represents a specific type of operations for the nuclear industry. The amount of materials and the very low level of activity present on a large part of the material flow, if any, requests for new ways of evacuation and reuse.

The management of this important flow of materials requires specific tools and instruments in order to ensure that the complete system is well under control and that the return of the materials to the "non-controlled world" is done safely, environmentally friendly and in an economic way.

In all its decommissioning projects, Belgoprocess considers that minimisation of the production of radioactive wastes and optimisation of the recycling of materials is a first order ecological priority. The examples presented here indicate that such a strategy can be developed in a cost effective way as well, taking into consideration the specific boundary conditions.