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DECOMMISSIONING OF BUILDINGS 105X AND 122X AT BELGOPROCESS

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ABSTRACT

The Eurochemic reprocessing plant was built between 1960 and 1966 and operated from 1966 until the end of 1974. During these eight years of active operation, Eurochemic reprocessed 181.5 t of natural and slightly enriched uranium fuels (less than 4.5% initial ^{235}U enrichment) from various experimental and power reactors, and 30.6 t high enriched uranium fuels from testing reactors, generating approximately 50 m³ of high-level liquid waste from power reactor fuels (LEWC, low enriched waste concentrate) and 850 m³ from research reactor fuels (HEWC, high enriched waste concentrate). As a result of reprocessing and cleaning operations (1975-1981), generated intermediate and high level wastes were put into temporary storage, pending the availability of appropriate treatment, conditioning and storage facilities.

Immediately after LEWC and HEWC vitrification, the corresponding storage vessels were rinsed and decontaminated. The rinsing and decontamination program started in April 1986 and was interrupted between September 1987 and July 1989 in view of possibly reusing the vessels for storage of similar HLLW solutions. Because the storage building itself was not aircraft crash resistant, it was decided not to use the storage vessels anymore and to proceed the decontamination with more aggressive chemicals. Due to this time gap however, and especially because vitrification came to an end in September 1991, a considerable volume of decontamination liquids was produced after this time and stored, pending the availability of the bituminization installation.

In 2005 and 2006 a research program was performed. For both buildings and vessels images and samples were collected and dose rate measurements were executed.

The paper presents an overview of the different studies that were indispensable in order to be able to select the most appropriate decommissioning strategy.

INTRODUCTION

The experimental reprocessing plant Eurochemic, operated by an international consortium from 1966 until the end of 1974, was designed to cope with both HEU test reactor fuel as well as LEU power reactor fuel. During the active operation period, about 182 tons of LEU fuel and 31 tons of HEU fuels were reprocessed, resulting in about 50 m^3 of high level liquid waste from power reactor fuel (LEWC), and about 800 m^3 from research reactor fuels (HEWC).

Two different high level waste tank farms need to be installed, as the chemical and radiological characteristics of both types of waste streams were very different. The specific activity of the LEWC waste stream was about 10 times as high as that of the HEWC waste stream. As a consequence, the LEWC was stored in two heavily cooled double walled horizontal tanks of the first generation located in building 105X, each having a net storage capacity of about 40 m^3. These vessels (253-1a and 253-1b) are about 11 m long by 2.6 m in diameter, and both were set up in narrow concrete cells having wall thicknesses of 1.4 m (figure 1).

The HEWC liquid waste was stored in two moderately cooled vertical 212 m^3 tanks of the second generation, 258-1 and 258-2, which were located in a large thick walled cell inside building 122X (figure 1). After a relatively short cooling period, the HEWC waste could be transferred to a large 500 m^3 vessel without active cooling located in one of the MLW tank farms at the Eurochemic site.
Building 122X also contains the HLW distribution systems including a small 1.1 m^3 spill tank 258-6 which is located in a corner of the tank cell. The tank cell contains a drip tray and stainless steel lining to be able to contain the contents of one 212 m^3 tank in case of a tank rupture. The drip tray collects leaking fluids in a gutter, which is equipped with a steam jet in the lowest point.

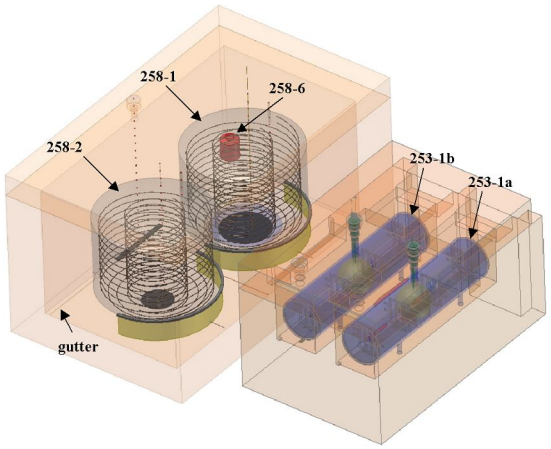

Figure 1. Tank cells inside buildings 105X (right) and 122X (left).

At the end of the reprocessing activities, starting from the end of 1974, rinsing operations of the Eurochemic plant were started to put the installation in operational standby. During this rinsing period an incident took place where tank 253-1b received an uncontrolled overflow from one of the fission product evaporators in the main process building. The concentrated alkaline rinsing solution containing organic complexants provoked a precipitation reaction inside the concentrated nitric acid LEWC solution in the tank, increasing the volume in the vessel from 32.1 m^3 to 39.2 m^3.

From 1985 on, the high level liquid waste was gradually sent to the PAMELA plant for vitrification.

RESULTS FROM CHEMICAL DECONTAMINATION

The rinsing and decontamination of the vessels was started as soon as the vessels had been emptied. First the heel volume was diluted and sent to the vitrification plant. Afterwards, the tanks were rinsed in small batches using weak acid and alkaline solutions. It was clear that a lot of active material was still present in a layer of solids in the tank 253-1b, that received the uncontrolled overflow from the fission product evaporator. Therefore it was necessary to use more aggressive acid and alkaline solutions to remove the remaining activity. In total, about 2^E13 Bq alpha and 3^E16 Bq beta activity could be recovered from this tank, resulting in 362 m^3 of liquid waste. The other horizontal tank 253-1a was easier to decontaminate as it contained much less solids. About 241 m^3 of liquid waste was produced during the decontamination of this vessel, containing 4^E12 Bq alpha and 7^E15 Bq beta activity.

The vertical tanks in building 122X were rinsed in a first step using some of the rinsing solutions resulting from the decontamination of the two horizontal tanks in building 105X. Afterwards, separate rinsing steps were performed and in this way about 490 m^3 of rinsing solutions were produced containing 1.1^E15 Bq beta and 2.7^E12 Bq alpha activity. Dose rates measured at the top of the tank cells of buildings 105X and 122X went from several Gy/h to levels in the order of mGy/h.

3D RADIOLOGICAL VISUALISATION & RADIOLOGICAL FEASIBILITY STUDY

The concept study for the decommissioning of the two buildings was started early 2005. The first phase consisted of a remote inspection of the tanks and tank cells, dose rate mappings and sampling of the deposits inside the tanks and cells. The results of this inspection program were used to produce radiological models of the active deposits inside the tanks and the tank cells. Subsequently, these models did allow to investigate and evaluate the possible decommissioning strategies.

The results obtained during this first phase prove that the rinsing and decontamination step was very successful. However, still some relatively large amounts of active deposits could be identified inside the tanks. The bottom of tank 253-1b is covered with an estimated amount of about 1000 kg of fine-grained active salt deposits, extended over the total tank length. Moreover, it was found that the lowest part of the tank cell drip tray of building 122X was heavily contaminated and still contained active liquids, and also the small spill tank 258-6 contained a considerable amount of active material. The radiation fields were completely dominated by the presence of Cs-137. An overview of the individual radiation sources in both buildings can be found in table 1.

	105X				122X						
	253-1a		253-1b		258-1		258-2		258-6	cell drip tray	
[TBq]	solids	surfaces	solids	surfaces	solids	surfaces	solids	surfaces	solids & liquid	liquid	surfaces
Cs-137	0.67	0.11	10	0.11	0.3	0.01	0.85	0.1	9	2.8	0.4
total alpha	0.3	/	0.23	/	/	/	0.09	/	0.1	0.02	0.002
total beta	550	/	22	/	/	/	10	/	31	4	0.44

Table 1. Radiation sources inside the tank cells of building 105X and 122X.

Figure 2 and 3 show the radiation fields (ambient dose equivalent rate H*(10)) at the inner wall surfaces of both tank cells inside building 105X. Figures 4 and 5 represent the radiation fields inside cell 009 in building 122X, as seen from two opposite directions.

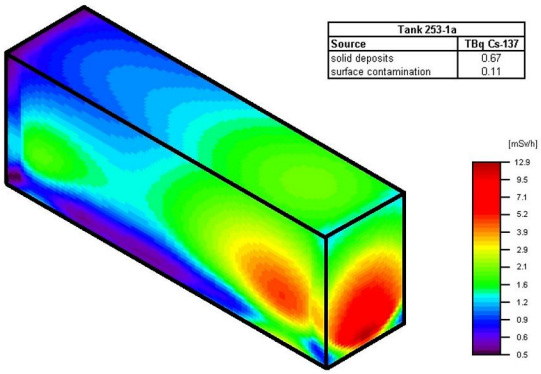

Figure 2. Radiation fields at the walls of the tank cell containing tank 253-1a.

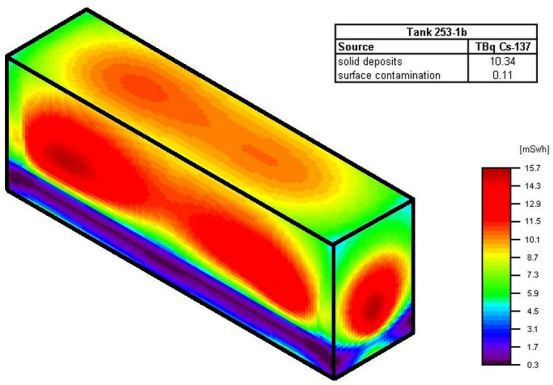

Figure 3. Radiation fields at the walls of the tank cell containing tank 253-1b.

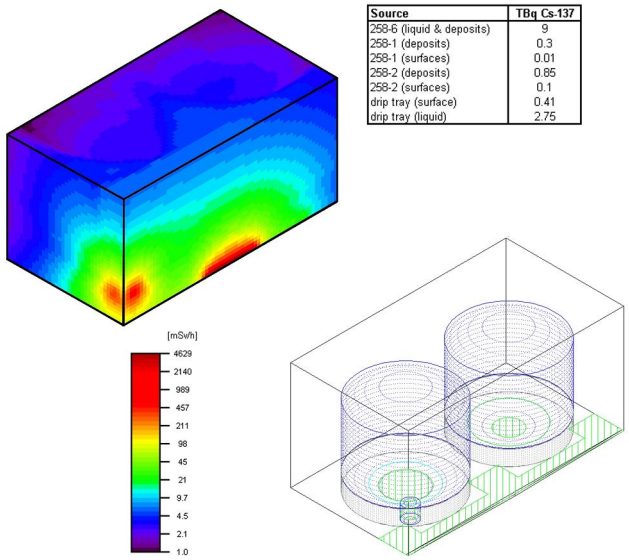

Figure 4. Radiation fields at the walls of the tank cell 009 of building 122X (rear view).

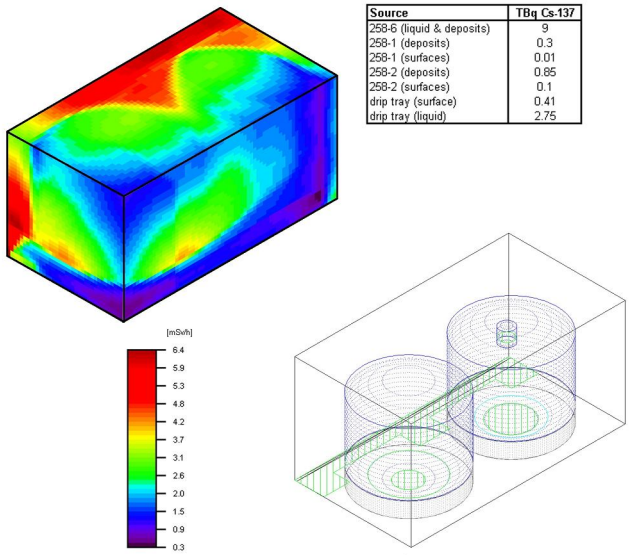

Figure 5. Radiation fields at the walls of the tank cell 009 of building 122X (front view).

As in both cases the majority of the activity could be found in layers of solid insoluble deposits at the tank bottoms, it is possible to shield the majority of the radiation by putting water inside the tanks to a level of about 1.2 m. In this way, the radiation fields are dominated by the relatively limited surface contamination levels of the upper tank surfaces, conservatively estimated ~ 1^E5 Bq Cs-137 / cm^2 in case of tanks 253-1a, 253-1b and 258-2, and ~ 1^E4 Bq Cs-137 / cm^2 in case of tank 258-1. Consequently, it can be proved that by removing ~ 95% of the surface contamination of the upper tank parts, the ambient radiation levels in the tanks will be in the order of 100 to 200 µSv/h. Furthermore, when also 90% of the solid deposits at the tank bottoms are removed, the radiation levels in the tanks drop to levels less than 100 µSv/h.

Figure 6 shows the radiation fields inside tank 253-1b and its cell (cross section at 50 cm height above the central tank axis), when 90% of the solid deposits are removed and 5% of the surface contamination remains and the tank is partially filled with water. Figure 7 and 8 give a view on the radiation fields inside cell 009 when also 90% of the deposits inside tanks 258-1 and 258-2 are removed, and the surface contamination inside the tanks is reduced with a factor 2 and 20 respectively. The bottoms of the tanks are filled with water. The activity in the small spill tank and the drip tray is reduced with a factor 100, and a small part of the drip tray is covered with water.

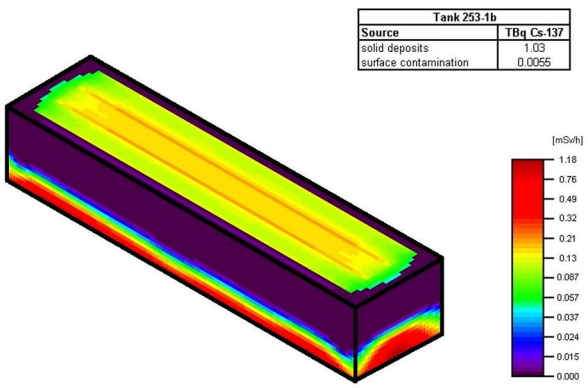

Figure 6. Cross section of the tank cell containing tank 253-1b, 50 cm above the central tank axis. Tank partially filled with water (1.2 m height). 90 % of solid deposits removed from tank bottom, 95% reduction of surface contamination level.

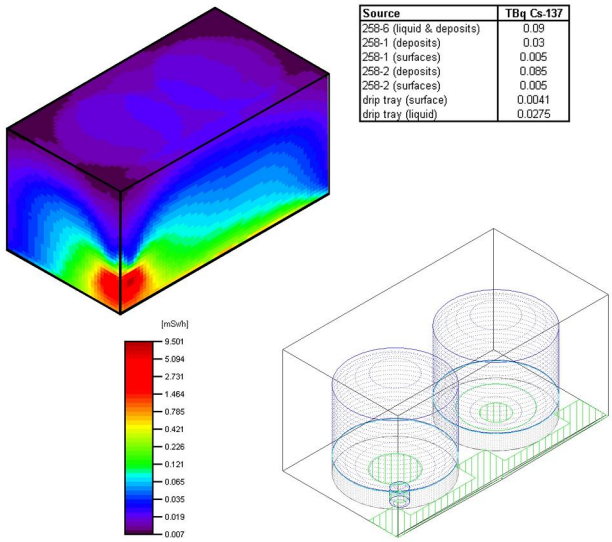

Figure 7. Radiation fields inside tank cell 009. Vertical tank bottoms filled with water (1.1 m height). 90 % of solid deposits removed from tank bottoms, respectively 50% and 95% reduction of surface contamination levels inside tanks 258-1 and 258-2. 99% removed of the original activity in spill tank 258-6 and the cell drip tray.

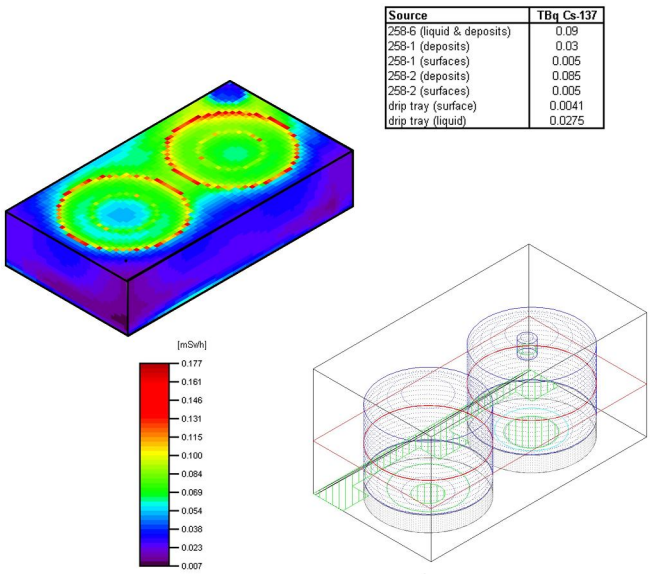

Figure 8. Cross section of cell 009 at 3.5 m height. Vertical tank bottoms filled with water (1.1 m height). 90 % of solid deposits removed from tank bottoms, respectively 50% and 95% reduction of surface contamination levels inside tanks 258-1 and 258-2. 99% removed of the original activity in spill tank 258-6 and the cell drip tray.

FUNDAMENTAL PRINCIPLES AND PRACTICAL IMPLEMENTATION OF THE BELGOPROCESS STRATEGY

To cope with problems of increased waste processing and disposal costs, and to meet the proposed planning for decommissioning activities, Belgoprocess puts a lot of emphasis on waste minimisation. In practice, some fundamental principles are considered for the management of materials resulting from the decommissioning of nuclear installations, equipment and/or components, which are mainly based on the guidelines of the IAEA-Safety Fundamentals with respect to radioactive waste management. The practical implementation of the fundamental principles has been developed based on the following considerations:

- Minimise the spread of radionuclides as much as possible;
- Keep the generation of radioactive waste to a minimum;
- Optimise the possibilities for recycling and reuse of valuable components;
- Minimise the amount of radioactive waste once it has been created by applying adequate processing technology.

The objective is achieved through the application of advanced decontamination techniques.

DECOMMISSIONING CONCEPT

In 1992 it was decided to end the chemical rinsing operations based on a cost-benefit evaluation and the chemical route was considered to be exhausted. Prior experience with the decontamination of MLW-tanks proved that high pressure water jetting is extremely effective for the removal of radioactive contaminants from metallic surfaces while minimising waste volumes. As a consequence, this technique was considered to be the most appropriate for further decontamination of the tanks.

The decommissioning concept consists of a hands-off decontamination of the tanks, including the remote controlled removal of the majority of the deposits on the tank bottoms, followed by a hands-on decommissioning phase where the vessels will be decontaminated even further and scrapped following a top-down approach. Throughout decontamination and dismantling, water will be used as the first barrier against radiation and contamination.

The concept study showed that for the horizontal tanks the introduction of decontamination tools through a new access hole at the head-end of the tank was the most viable option. For the decontamination of the vertical tanks, additional access holes will be created through the upper part of the tanks.

The small spill tank 258-6 and the cell drip tray will be rinsed and decontaminated by means of the existing wash-out circuitry. In a first rinsing step already 90 % of the Cs-137 activity in vessel 258-6 and the drip tray gutter could be removed.

PLANNING & COSTS

Item	Planning
Concept study	2005-2007
Expert review	2008
Detailed engineering; Final decommissioning plan; Licensing	2009-2013
Commissioning of new building (annex)	2014-2017
Decommissioning and demolition activities	2017-2027

Table 2. Planning.

In 2007, the overall costs were estimated at 62M€. These costs cover (30% uncertainty added) :

- Engineering and investment costs for the new annex building;
- Decommissioning costs;
- Costs for primary, secondary, solid and liquid waste processing;
- Costs for interim storage and final waste disposal.

Buildings 105X and 122X will be decommissioned and demolished until ‘brown field conditions’ are reached.

LESSONS LEARNT

Important lessons learnt so far are :

Precipitation must be prevented

In 1975, an uncontrolled overflow from one of the fission product evaporators in the main process building provoked a precipitation in a horizontal tank of building 105X, resulting in relatively large amounts of fine-grained active salt deposits all over the tank bottom. The incident proved to be a factor of major importance during the decision making process. Excessive precipitation due to the mixing of different solutions must be prevented by all means.

Vertical storage tanks with curved bottoms are preferable

In view of limiting precipitation as much as possible, vertical storage tanks with curved bottoms and minimum heel volume are preferable. Horizontal tanks have a larger base surface area compared to vertical tanks of the same capacity. Furthermore, liquids are easier mixed in vertical tanks with less precipitation as a result. Vertical cylindrical tanks with access holes located in the centre are much easier to decontaminate.

Design of facilities should take into account requirements for dismantling

Costs for decontamination and dismantling of nuclear facilities can be greatly reduced when requirements for decommissioning are taken into account at the design stage. The presence of numerous cooling pipes and obstacles in the horizontal cylindrical tanks do not facilitate the introduction of decontamination equipment. During the design of internal cooling coils and tank access holes, the introduction of decontamination equipment should be taken into account. Moreover, service areas should be provided to facilitate decontamination and decommissioning activities. The availability of internal wash-out circuits allows the decontamination of auxiliary equipment.

CONCLUSIONS

Due to the large heavily contaminated surface areas, the presence of large amounts of solid insoluble precipitations, and tank and building designs lacking provisions for future decontamination and decommissioning, the decommissioning of high level waste tank farms is not an easy and straightforward task.

Although the chemical rinsing of the HLW tanks of the former Eurochemic plant, performed in the period 1986-1992, proved to be very successful, the dose rates are still much too high to allow hands-on decommissioning without prior remote decontamination steps and without making excessive use of biological shielding.

Belgoprocess has made a straightforward choice to avoid the spread of the radioactive source. An uncontrolled spread of dry radioactive salt deposits would jeopardize the selected strategy and create a situation where risks and costs are no longer manageable. However, risks can be managed by:

- applying a worst case approach and the 'always return to safe conditions' principle;
- selecting the appropriate decommissioning strategy, always taking into account backup solutions.

REFERENCES

1. Luycx P., Demonie M., Kokkelenberg F. and Trauwaert E., "Lessons Learnt from the Decontamination of Two Storage Vessels for High-Level Liquid Waste", Belgoprocess, Dessel, Belgium, August 1994.
2. IAEA-Safety Fundamentals. The Principles of Radioactive Waste Management. Safety Series No.111-F, IAEA, Vienna, 1995.
3. Teunckens L., Millen D., Lewandowski P., Walthéry R. and Baumann S., "The Belgoprocess Strategy in Decommissioning and Decontamination", Belgoprocess, Dessel, Belgium, 2001.
4. Ooms B., Lievens B., Van Campfort E. en Van Laer W., nota UBT/2007-03594, "Ontmanteling van de HEWC/LEWC-tanks in de gebouwen 105X en 122X op site 1 van Belgoprocess", editie B van 19 november 2007.