

THE HRA/SOLARIUM PROJECT: PROCESSING OF WIDELY VARYING HIGH- AND MEDIUM-LEVEL WASTE

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ABSTRACT

Starting in 2003, Belgoprocess will proceed with the treatment and conditioning of some 200 m³ of widely varying high- and medium-level waste from earlier research and development work, to meet standard acceptance criteria for later disposal. The gross volume of primary and secondary packages amounts to 2,600 m³. The waste has been kept in decay storage for up to 30 years. The project was started in 1997. Operation of the various processing facilities will take 7-8 years. The overall volume of conditioned waste will be of the order of 800 m³.

All conditioned waste will be stored in appropriate storage facilities onsite. At present (November, 2002), a new processing facility has been constructed, the functional tests of the equipment have been performed and the start-up phase has been started. Several cells of the Pamela vitrification facility onsite will be adapted for the treatment of high-level and highly α -contaminated waste; low-level β/γ waste will be treated in the existing facility for super compaction and conditioning by embedding into cement (CILVA). The bulk of these waste, of which 95% are solids, the remainder consisting of mainly solidified liquids, have been produced between 1967 and 1988. They originate from various research programmes and reactor operation at the Belgian nuclear energy research centre SCK·CEN, isotope production, decontamination and dismantling operations.

The waste is stored in 4800 primary packages, of which 700 contain 120 g ($5 \cdot 10^{12}$ Bq) radium. Half the radium inventory is present in 25 containers. The presence of radium in waste packages, resulting in the emission of radon gas, requires particular measurements. The total activity at the moment of production amounted to 18,811 TBq β/γ and 34.4 TBq α , with individual packages emitting up to 555 TBq β/γ and 2.2 TBq α . According to calculations, the β/γ activity has decreased to some 2,000 TBq, with individual packages up to 112 TBq.

The extreme diversity of the waste is not only expressed in their radiological characteristics, but also in their chemical composition, physical state, the nature and condition of the packages. Radioactivity ranges between 0.01 mCi to 1,000 Ci per package. Some packages contain resins, Na, NaK and Al containing waste, poison rods, residues of fuel elements. Although most of the liquid waste are solidified, a small fraction – both aqueous and organic - still remains liquid. Primary packages may be plastic bags, metal boxes, wire gauze, La Calène boxes; secondary packages may be steel drums and concrete containers. Solid waste may be sources, counters, nuclear fuel residues, filters, synthetic materials, metals, resins, granulates, rock, sludges, cables, glass, etc. Some 1000 primary packages are stored in a dry storage vault comprising 20 concrete cells, while 3800 primary packages are stored in some 2,000 concrete containers, on a concrete floor, surrounded by an earth bank to the height of the waste stacking and covered by a metal construction.

At present, the annual production of similar waste amounts to 2 m³ divided over some 30 containers. Generally, the primary waste packages will be loaded in 80-l drums (an average of 2 packages per drum), and compacted in a 150 ton hydraulic press. The pellets will be collected in 100 l drums (an average of 3 pellets per drum). Low-level β/γ waste is transferred to the CILVA facility for further treatment, while the other 100-l drums are filled up with sand and, in the case of radium-contaminated waste, tight-welded. Subsequently, the 100-l drums are loaded into 400-l drums and embedded into cement. Certain packages, for example solidified radium-contaminated liquids in welded metal containers, are conditioned as such in overpacks. Specific procedures will be established for the various non-standard waste, such as sources, control and poison rods,

resins and filters, fuel residues. Highly active and/or heavily α -contaminated waste are transferred to the existing Pamela facility for treatment and conditioning.

Ideally, gamma spectrometry measurements are carried out on the primary packages, but due to the extreme diversity of these packages, ranging from plastic bags containing cardboard to highly active steel valves, preference was given to measurements on the conditioned waste, or at least on already pre-compacted waste in the case of treatment in the 2,000 ton press of the CILVA facility. Thus tremendous problems of calibration can be largely avoided. All operations are remotely controlled. Transfers between buildings are carried out within appropriately shielded containers and secondary waste will be treated in existing facilities onsite. The new processing facility is being built partly over the dry storage vaults, in the immediate vicinity of the already covered storage area.

BACKGROUND

At the end of the 1980's, the Belgian State ordered an inventory of the liabilities of the Belgian nuclear programme, to be fully or partially financed by them. ONDRAF/NIRAS (National Agency for Radioactive Waste and Enriched Fissile Materials) was entrusted with the management of the waste and the development of a programme for the clearance of the identified liabilities. One of these liabilities is the treatment and conditioning of some 200 m³ of widely varying high- and medium level waste. The gross volume of primary and secondary packages amounts to 2600 m³.

As the waste is stored in vaults or in concrete shielding containers and no appropriate treating and conditioning facilities is in operation, the HRA/SOLARIUM project was launched. The HRA/SOLARIUM project, which is planned for a period of 6 years (1998-2003), aims to process and condition the waste belonging to the constituent 221 classified as medium-level waste located on site 2 of Belgoprocess in Mol. After construction of the facilities and delivery of the different authorisations, the facilities will be run for a period of 7 to 8 years in order to conform the waste taken up in the inventory in efficient processing units (building 280 on site 2 and Pamela on site 1 of Belgoprocess).

INTRODUCTION

The waste is currently stored on site 2, in the dry storage HRA (high-level radioactive waste) and in the Solarium zone. The aim is to process and condition the waste into an acceptable end form. The conditioned waste will be stored in the appropriate storage buildings on site 1, before later transfer to the final disposal site. The waste in the storage HRA is stored in concrete square or rectangular wells, generally still packed in its primary package. The waste at Solarium is stored in concrete secondary shielding containers which are piled on top of each other in the storage area covered by a roof.

The stored waste mainly comes from previous research programmes of the SCK-CEN, besides waste originating from Electrabel, IRE and other producers in the nuclear sector. It is varied in nature both by its radiological characteristics, its chemical composition, its type of package and its physical state. Similar waste from the Research Center is still produced. The production of similar waste amounts to 2 m³ divided over some 30 containers.

A very specific element in the treatment aspect of this project, is the radium-bearing waste that requires specific controls, for example on the welding of the packages or on the production of Radon. It is very important to underline here once more that this project aims to clear the present situation, the overall objective being to process and condition the waste mentioned above into an acceptable product that fulfills the acceptance criteria for disposal.

CHARACTERISTICS OF THE WASTE

The waste, which has to be processed and which is stored in the HRA zone and on the Solarium zone, concerns approximately 200 m³ of primary waste, and has the following nature:

- α waste
- $\alpha\beta\gamma$ waste
- $\beta\gamma$ waste

- radium-bearing waste (partly solidified liquids).

Great efforts have been made to improve the data of the inventory and the knowledge of the waste, including mapping. The primary waste at Solarium is stored in about 2,000 concrete containers of different dimensions (from 1,000 kg to 6,000 kg). The total activity for Solarium is estimated at 16,000 TBq $\beta\gamma$ and 33 TBq α , while it is estimated at 1,200 TBq β and 3 TBq α for the HRA zone. There are around 575 containers filled with radium-bearing waste which contains a total quantity of 120 g Ra-225 of these containers contain half of it. Besides the so-called standard waste, there are also certain specific types of waste such as resins, NaK, Na-bearing waste and aluminium-bearing waste.

PROCESSING AND CONDITIONING METHOD

The general principle for the processing of the waste into a final end package, consists of several stages: firstly, the primary package is put in an 80-l drum and compacted into a pellet, secondly, this pellet is transferred to a 100-l drum which is, after having been filled up with sand (and welded for radium-bearing waste), placed in a 400-l drum in which it is then conditioned with a matrix (cement and sand). Some waste packages can, however, not be processed in this manner (e.g. solidified packages of liquids containing radium, welded packages, etc.). In this case, the waste is placed in an appropriate metal overpack. A specific processing procedure is worked out for each type of special waste.

PROCESSING FACILITIES

The following section presents the processing facilities with their main functions that were planned and are in construction.

Building 280X

Building 280X is a new building on site 2 (presently in start-up phase) consisting of the covering of the HRA and the proper processing facility which is connected to it. The covering of the HRA has been foreseen to empty the HRA wells and to introduce the HRA waste in the processing facility. The necessary handling equipment and ventilation systems are installed for this purpose. The following functions are foreseen for the processing facility:

- Feeder locks for introducing the waste.
- Dispatching cell for the transfer of primary waste into 80-l drums. These drums are either sent to the processing cell in this building (amongst others, radium waste) or placed into a transport drum through a double-lid system for dispatching to site 1.
- Processing cell: the 80-l drums are compacted and the pellets are piled up in a 100-l drum which is connected with it through a double-lid system. This 100-l drum is here filled up with sand.
- Transport area: the 100-l drum from the processing cell is completely welded in here if it contains radium-bearing waste and further conditioned (cement matrix) in a 400-l drum before being sent to the storage zone for drying.
- Other functions such as placing containers in an overpack, capping of 400-l drums, transfer of 80-l drums into 400-l shielded transport drums from the dispatching cell, and dispatching of the conditioned and non-conditioned waste to site 1, have also been planned in here.
- Technical rooms (electricity, ventilation, utilities, ...).
- Personnel access.
- Measuring and characterisation cell.

Pamela Facility

The Pamela facility is an existing facility on site 1 that will be modified and adapted for the processing of non-radium waste. Some existing cells in Pamela are being converted into processing, conditioning and measurement cells.

CILVA Facility

CILVA is an existing facility will be used for processing (supercompaction and cementation) of $\beta\gamma$ waste (≤ 2 mSv/h) from the HRA/SOL project which fulfils the licence requirements applicable to this building.

SYSTEMS DESCRIPTION – SITE 2

Processing and operations on site 2 are shown in figure 1 and 2 and described in the following subsections.

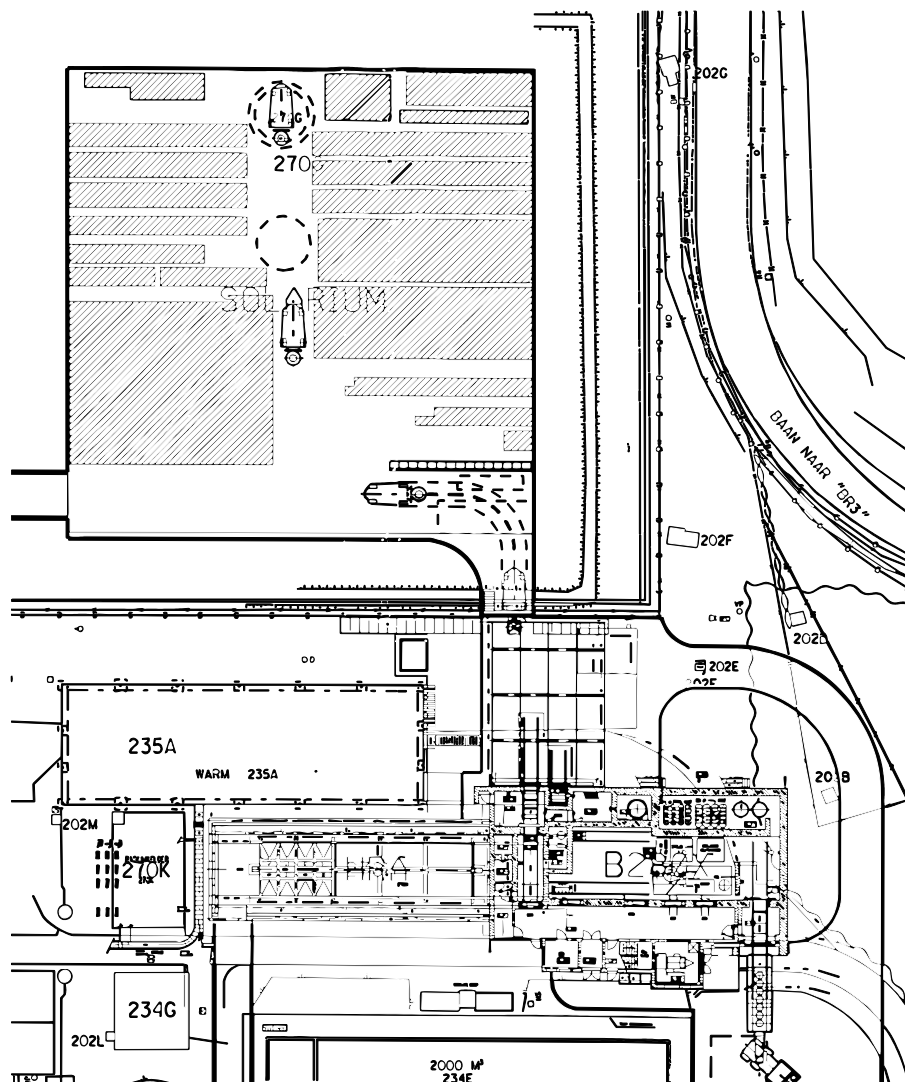


Fig. 1 Transport operations on site 2

Transport of the Waste to the Processing Building

From Solarium (270H)

Using a shielded forklift with a clamping system, the containers are brought to the gateway of the new processing building where the container is placed on a transport pallet. The shielded forklift remains at Solarium to prevent the dispersion of contamination. A second forklift moves the transport pallet with the container to the feeder lock of the new building where the container is placed on a lorry. If it contains non-radium waste, the container is first checked for Ra and Rn in a specially equipped measurement cell.

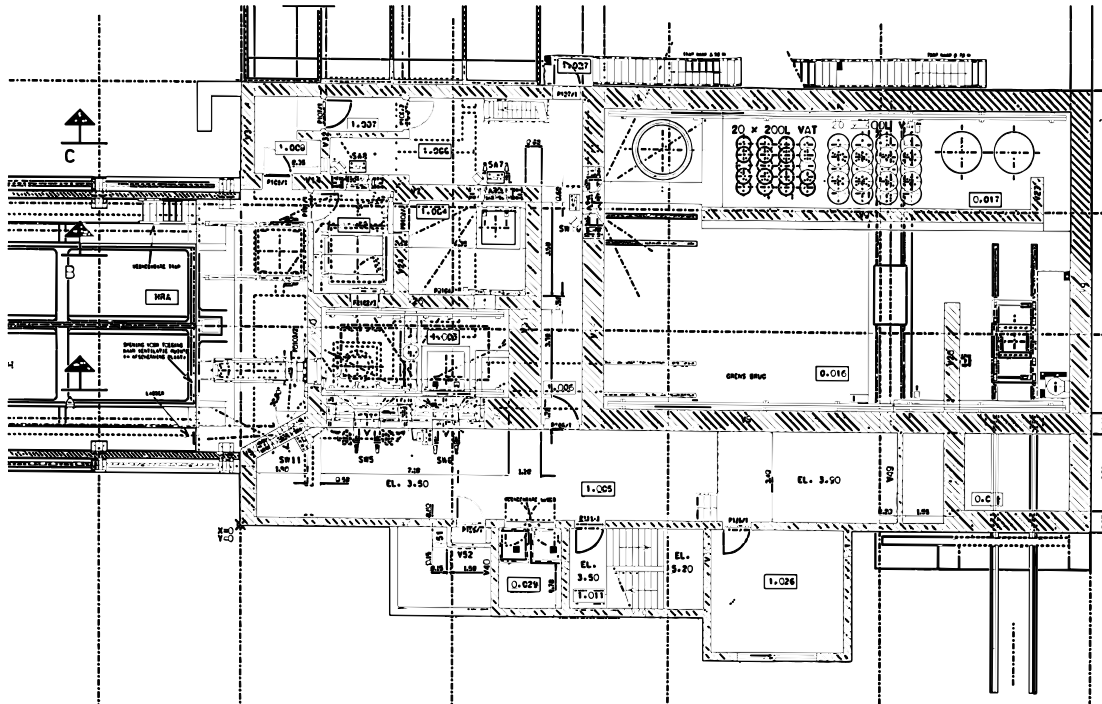


Fig. 2 Processing in 280X

From the HRA covering (270H)

All sorts of packages are stored in the HRA wells (containers, drums, separate primary packages, leaden containers, wire guides, tubes,,etc.). These packages are introduced into the processing building using the foreseen handling systems. For separate primary packages, damaged packages and wire guides, overpack systems are used to transport this waste safely to the processing building.

Dispatching Cell

All of the waste, with exception of the waste that is placed in overpacks, enters the dispatching cell. The primary packages are transferred in this cell into 80-l drums. The wire guides from the HRA, are dismantled here. A measurement of the dose rate is carried out in this cell to decide where the waste will be processed (on the spot ≤ 50 mSv/h, in Pamela > 50 mSv/h or in Cilva ≤ 2 mSv/h). This cell is fully equipped with a stainless steel interior lining to simplify the decontamination of the cell and equipment such as the power manipulator, the remote handling manipulators, the double-lid system and the airtight trap doors.

Processing Cell (≤ 50 mSv/h, $\text{Co60}_{\text{max}} = 0,34$ Ci, $\text{Cs137}_{\text{max}} = 1,36$ Ci, $\text{Ra}_{\text{max}} = 0,5$ Ci)

In the processing cell the 80-l drums containing the primary packages are compacted into pellets using a bell-shaped press of approximately 150 tons. The pellets are placed in a 100-l drum connected to the cell by a double-lid system. The empty space between the pellets and the drum is filled with sand, except for the low active non-radium waste which has also been compacted in this cell but is sent to CILVA on site 1. This cell is also entirely equipped with a stainless steel interior lining for decontamination, of the remote handling manipulators, the power manipulator, the conveyor belt for the transport of waste from the dispatching cell, the double-lid system for the 100-l drum, the sand-filling facility and the airtight trapdoors.

Transport Area

The conditioning takes places in the “transport area”. The 100-l drum is supplied with a weldable lid in order to guarantee the radium tightness of the radium-bearing waste. The 100-l drum is then embedded in concrete in a 400-l standard drum. After drying of the concrete, the lid is capped on the 400-l drum. The drums and containers which have already been conditioned and do not need to be further processed, are immediately placed in an overpack. After that, they are cemented and supplied with a lid (welded for the radium-bearing waste).

The final end packages are temporarily stored to allow the setting of the concrete and the organisation of a grouped transport to site 1.

A cell is foreseen in the transport area where measurements can be carried out on the packages with the appliances used for pre-characterization (measurement of Ra and Rn). This measurement equipment can also be used for test measurements of the welded 100-l drums (control of the tightness of the welding on the radium-bearing waste). The transport area is thus equipped with a remote controlled welder (to weld automatically a lid on a 100-l drum and to weld overpack containers), a cementation facility, a drum capping machine and the necessary handling equipment such as a 10-tonne overhead bridge, conveyor belts, lorries, etc.

SYSTEM DESCRIPTION – SITE 1

Processing and operations on site 1 is through the Pamela Facility that is shown in Figure 3 as described below.

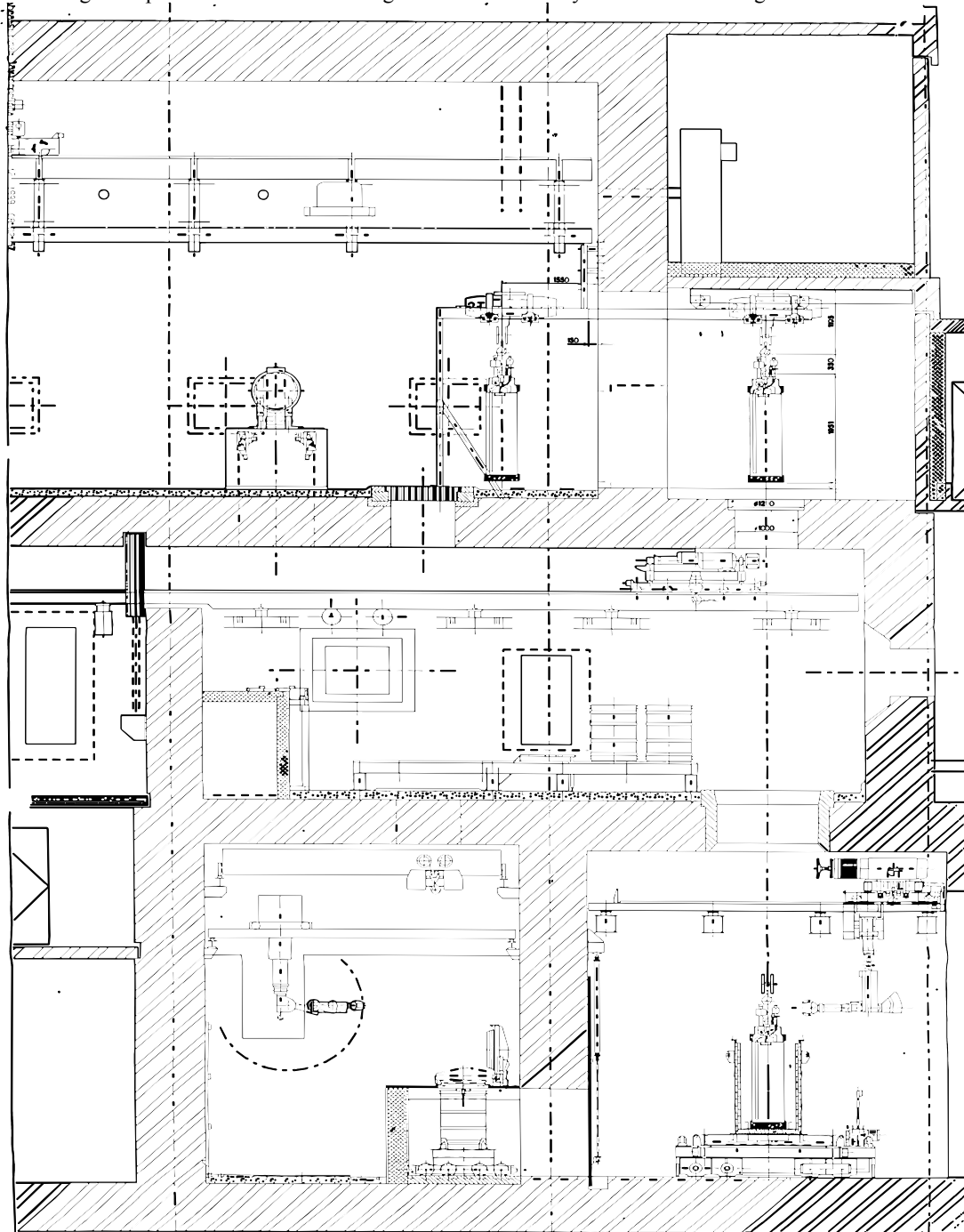


Fig. 3 Processing in Pamela

The “standard” waste (> 50 mSv/h) to be processed in Pamela is transferred in the dispatching cell into an 80-l drum which is then placed into a 400-l transport container and transported to Pamela on site 1. These transport containers are transferred through the intermediate rooms 0.032 and 0.035 and through a double-lid system in the processing cell 0.035.

The process includes the necessary adaptations to this former decontamination cell of the Pamela facility. The adaptations mainly concern the α leak tightness of this cell, the addition of double-lid systems for in- and out-

going waste, the installation of a new lock, adjustments to the ventilation, the supply of a press, transport systems, etc. The processing in this cell is similar to the processing in the new building on site 2, namely, compacting 80-l drums, placing pellets in a 100-l drum, filling up of the empty spaces with sand, placing of the 100-l drum in a 400-l drum and the cementation of the 400-l drum. For the import of the empty drums, the removal of the conditioned drums, the temporary storage, the personnel entrances, etc., the existing facilities will be used.

For the processing of special waste inside Pamela, other cells could also be used (cells 018, 037 still being studied).

Processing in CILVA ($< 2 \text{ mSv/h}$, $\alpha_{\text{max}} < 10 \text{ mCi/220 l}$) of the $\beta\gamma$ waste is accomplished in accordance to the qualified procedures respecting the applicable exploitation conditions; this means by super compaction and cementation.

RADIOLOGICAL CHARACTERIZATION OF THE WASTE

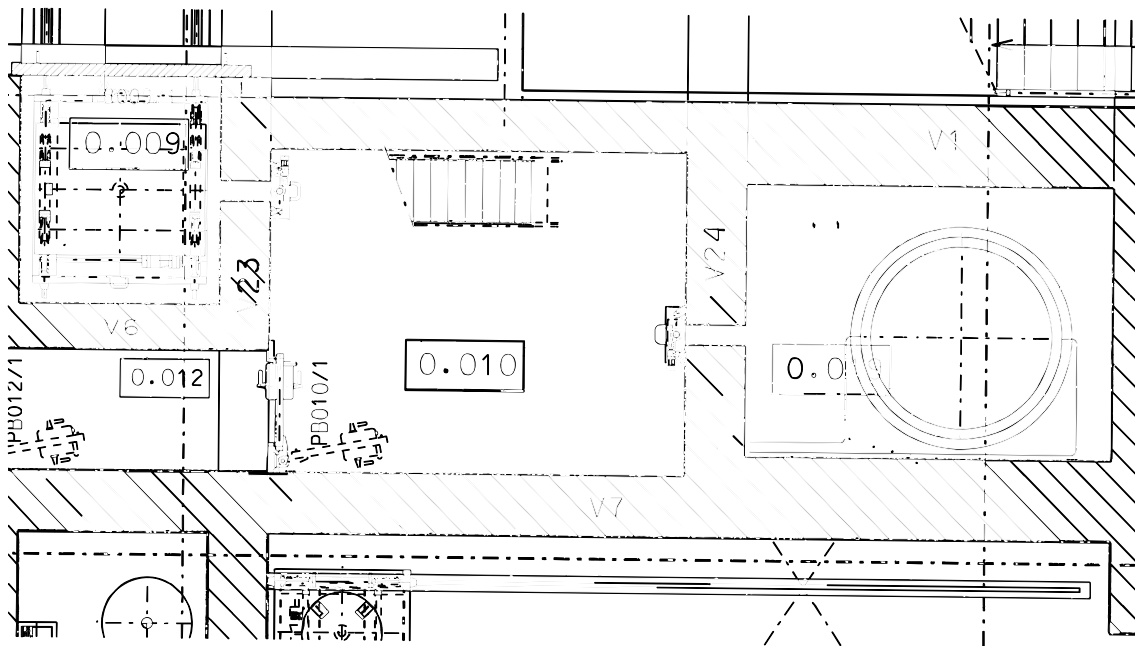


Fig. 4 Radiological characterisation of the waste on site 2

The radiological characterization of the waste is accomplished at site 2 as shown in Figure 4. This characterization step is a very important element in the treatment of the waste. It applies to both the non-conditioned and the conditioned waste. The main purpose of the characterization is as follows:

- avoid that Ra-bearing non-conditioned waste is treated on site 1 (Pamela - CILVA)
- to calculate the total activity of each drum which has to go to the different storage buildings).

The following installations are foreseen to facilitate radiological characterization of the waste:

- Building 280X:
 - pre-characterisation unit based on the Bismuth measure for classification of the incoming waste into radium and non-radium waste
 - final characterisation unit based on gamma spectrometry measurements with high resolution

- with the same installation the welded drums can be checked for tightness
- Pamela
 - final characterisation unit based on a gamma spectrometry measurement with high resolution

PLANNING

The general planning concerning the activities on site 2 are:

- placing of the main orders during the first semester of 2000
- finishing of the civil works by the end of 2001
- assembly of the equipment on the site in 2002
- end of the start-up phase foreseen mid 2003.

The adaptations to the Pamela facility are going on at the writing of this paper (February 2003).

ACTUAL STATUS

At present the covering of the HRA has been executed and the new process facility on site 2 has been constructed; the handling and process equipment have been installed and tested; the start-up is on going.

LESSONS LEARNED

The following positive lessons learned have been experienced in the initial design and construction phase of this project:

- It is justified to invest, during the feasibility analysis phase, in a waste inventory, with detailed identification of the primary containers and mapping :
 - Identification of the containers
 - What is in the primary package, container ?
 - Mapping
 - Where is the primary package, container ?
 - In witch position in the package or container ?
 - Estimation of the risk of error and of the precision of the methodology
- On basis of the inventory, it is justified to perform, as well, a detailed ALARA study in order to facilitate the works on existing storage site or facilities.
- HAZOP studies have been performed in order to minimize the risks of failure during operation, with the main objective to avoid or to reduce to a strict minimum the human intervention in an active area; appropriate retrieval measurements have been developed.
- Building a mock-up, for some critical handling cases, or validation by test campaigns of retained process solutions has been helpful during the design phase.
- The design of the new facility and of the adaptation of existing ones must be based on proven equipment and devices, in order to avoid later surprises during operation (use of prototypes to be avoid !).
- During operation of T/C of such historical waste, the role of the operators must remain essential even in remote control of the process.