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THE HRA-SOLARIUM PROJECT: PROCESSING OF HISTORICAL WASTE ON THE BELGOPROCESS SITE (BELGIUM): PROJECT DESCRIPTION AND LESSONS LEARNED AFTER 3 YEARS OPERATIONS

JM Cuchet
BELGATOM
Avenue Ariane 4,
B 1200 Brussels, Belgium

P.Luycx, M.Wathion, M.Willems
BELGOPROCESS
Gravenstraat 73,
B 2480 Dessel, Belgium

A.DE Goeyse, M.Braeckeveldt
NIRAS / ONDRAF
Avenue des Arts 14,
B 1210 Brussels, Belgium

ABSTRACT

At the end of the 80'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 are in operation, the HRA/SOLARIUM project was launched.

The bulk of these wastes, 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. About 4800 packages of various types are concerned and must be treated (standard steel barrels, special containers, shielded overpacks,…); they contain medium-active wastes (solid or liquid), radium bearing or not, β/γ or α/β/γ, and special wastes (Al, spent resins, Na/Nak, …).

The new HRA/SOLARIUM facilities, located on site 2 of Belgoprocess in Mol, have been commissioned in the 2nd semester 2003.

The paper describes the project itself and focuses on the lessons learned from first operation years.

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 m^3 of widely varying high- and medium level waste. The gross volume of primary and secondary packages amounts to 2600 m^3.

The waste is stored in 4800 primary packages, of which; 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.

Figure 1 and 2 illustrate the non conditioned waste storage facilities in 2003.

Fig. 1 (2003) : Overview of the concrete shielded containers

Fig.2 (2003) : Overview of the storage pits

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

Started in 2003, Belgoprocess is proceeding with the treatment and conditioning of some 200 m^3 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 2600 m^3. 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 m^3.

In September 2004, a new processing facility (B280) has been commissioned.
Furthermore several cells of the PAMELA former vitrification facility onsite were adapted for the treatment of high-level and highly α-contaminated waste; low-level β/γ waste are foreseen to be treated in the existing facility for super compaction and conditioning by embedding into cement (CILVA).
All conditioned waste resulting from the treatment operations will be stored in appropriate storage facilities onsite.

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.

700 primary packages contain 120 g (5.10^{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 0.4 Mbq to 40 TBq 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.

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.

PROJECT DESCRIPTION

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
- αβγ waste
- βγ 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 βγ 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 CONDTIONING 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 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 hereif 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 characterization cell.

PAMELA Facility

The PAMELA facility is an existing facility on site 1 that has been modified and adapted for the processing of non-radium waste. Some existing cells in PAMELA have been converted into processing, conditioning and measurement cells.

CILVA Facility

CILVA is an existing facility which is foreseen to be used for processing (supercompaction and cementation) of βγ 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 3 and 4 and described in the following subsections.

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.

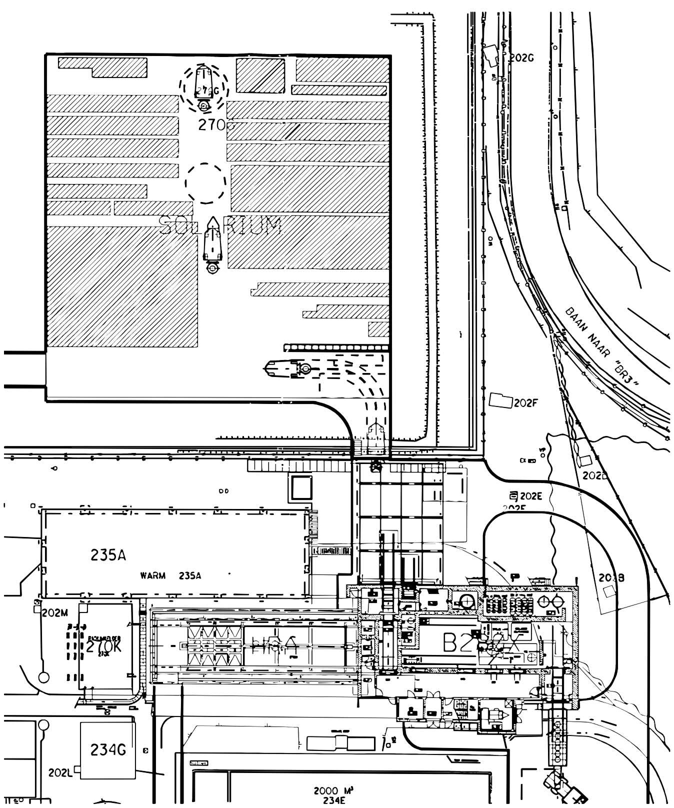

Fig. 3 Transport operations on site 2

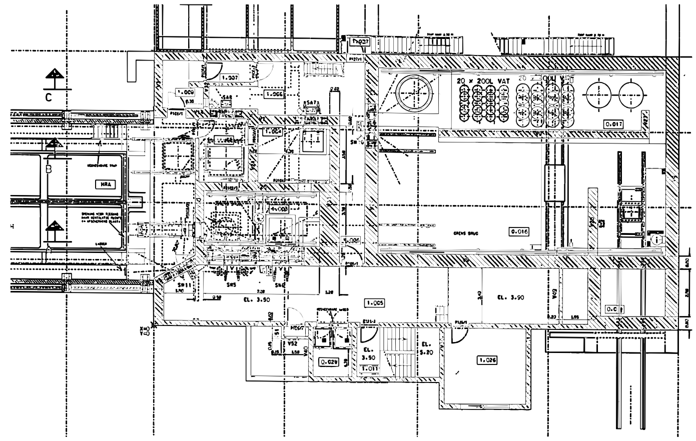

Fig. 4 Processing in 280X

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, $Co60_{max}$ = 13 GBq, $Cs137_{max}$ = 5,0 GBq Ra_{max} 1,9 GBq)

In the processing cell the 80-l drums containing the primary packages are compacted into pellets using a bell-shaped press of approximately 150,000 daN. 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 place 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

SYSTEMS DESCRIPTION – SITE 1 (PAMELA – CILVA)

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 the primary containers (80-l drums) is then introduced in the processing cell 0.035 through a double-lid system.
The processing cell results from the adaptation of the former decontamination cell of the PAMELA facility; the adaptations mainly concerned 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 adapted processing cell 0.035 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 (spent resins, Na-NaK, …) inside PAMELA, other cells could also be used (detail study still running).

Processing in CILVA :
The processing of $\beta\gamma$ waste (< 2 mSv/h, α_{max} < 0,4 GBq/220 l) 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

The radiological characterization of the waste is accomplished at site 2. 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 gammas 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.

EXPERIENCE OF 3 YEARS OPERATIONS / LESSONS LEARNED

Overview :

The installation 280X started operating in september 2004. Because of the diversity in packages and content found in the HRA zone, production has focused on solarium containers, leaving operations in the HRA zone to a later date.
Due to a delayed start-up of the modified 'PAMELA' installation, the operational planning of 280X had to be revised forcing a selection of the waste based on a measured dose rate.

To that effect the sequence of containers / packages to be processed can be outlined as follows :

- β / γ containers with low dose rate (CILVA / 280X)
- α / β / γ containers with low dose rate (CILVA / 280X)
- α / β / γ containers with high dose rate (280X / 131X)
- Containers with fissile material or specials
- Containers with Radium contents

Since the processing of waste containing not solidified liquids has not been approved, this waste will now be transferred to the PAMELA building for processing.
Similarly the production of overpacks for special containers or radium bearing waste has not yet been started.

Organisation :

The installation is run under the responsibility of a supervisor, supported for project, planning and administrative actions. A team leader, supported by 3 operators, is in charge of the day to day operations in 280X. The team operates in standard working hours and carries out all actions concerning the retrieval, transfer and conditioning of the waste. This operational team is supported by RP agents for the measurement of containers and the final characterisation.
Each year, there is a planned shutdown of 2 to 3 weeks for maintenance purposes.

Production summary :

The table below and corresponding graph show the production since start up (figures of May 2007).
For the years 2005-2007 a target of 250 emptied containers had been set.

	2004	2005	2006	2007	Total
Containers processed	46	292	308	139	785
# colli /waste packages					1587
80-l drums compacted	67	382	367	151	967
100-l drums filled	12	88	94	48	242
200-l drums for further conditioning in CILVA	12	55	17	4	88
400-l drums destined for final disposal (*)	-	28	82	44	154

Table 1 : production summary

(*) These figures are not for official use: they represent the yearly production and may vary from reported values (80-l drums compacted in 2006 can be part of a 400-l drum cemented in 2007 but still represent production of 2006, a 400-l drum can be produced in 2006 but cemented in 2007).

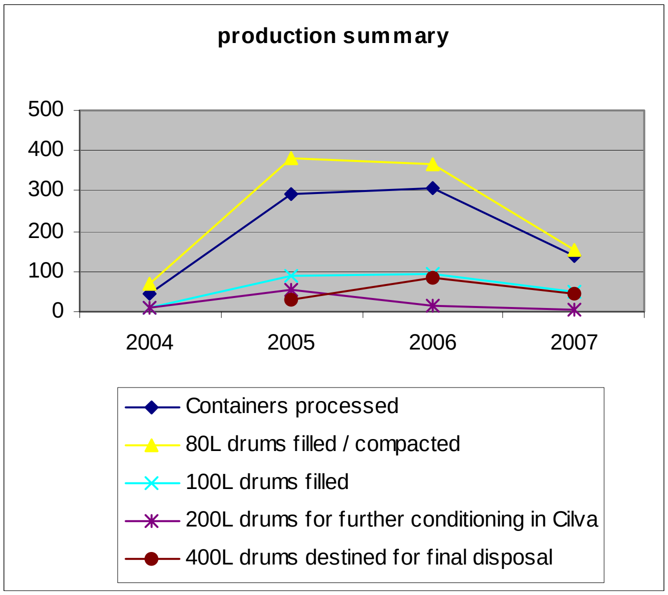

Figure 5 : Production summary

The installation 280X has currently processed roughly one third of the total waste recipients, and with the necessary reservations for the waste to be processed at a later stage (namely HRA, Ra waste and specials), we feel confident that the production falls within the allotted time frame.
As for the number of drums / overpacks destined for final disposal, we continue working with the projected numbers as listed in the Tractebel document 'HRA-SOL/4NT-242 Finale Eindverpakkingen'. This document listed approximately 1400 drums of 400L (shielded or non shielded version) and 105 overpacks (of various type and dimensions). Current experience shows the number of 400L drums produced to fall significantly lower than the projected number, but a more in-depth analysis will be made after a re-evaluation of the treatment and characterisation scenarios.

Data management :

Production in 280X is controlled by a specifically written process control system called PBS.
This system is linked with GeNA, the database for all nuclear waste at Belgoprocess, for data transfer and generation of various production documents.

Although GeNA holds the information concerning the waste package and the 400-l drum for final disposal, all data regarding the intermediate drums and the production process itself are stored in PBS; that system records the various steps in the production process from the concrete container to the drum destined for final disposal.

Modifications after start-up:

The concept and the operating procedures have remained mainly such as originally foreseen.
After the start-up, some modifications have been made to increase efficiency and the amount of waste processed.

Measurements

- Since the delayed start-up of PAMELA did not initially allow for the processing of HLW, a procedure for dose rate measurement on containers has been put in place. The containers with a high dose rate are put back in the storage area.
- Inside the installation but prior to the docking of the container, a dose rate measurement on the opened container is performed.
- The originally foreseen Rn measurement took up too much time and gave no added information compared to the ISOCS gammaspectroscopy measurement. The Ra / non Ra distinction is now being made solely on the peak area of the ^{214}Bi line.

Modifications to installation

- After frequently encountering water, loose debris or broken / deteriorated canisters inside the containers an adapted vacuum system has been installed in the dispatchcell. This system works well, but is too susceptible to water so a cyclone will be added.
- In order to retrieve loose debris of reasonable size and mass, extra tools for the heavy duty manipulator have been

added. The heavy duty manipulator has also been equipped with an integrated camera.

- The containers often have bits and pieces missing of its concrete shell, so the normal sealing ring has been replaced by an extra wide version.
- The original system for the transport and loading of sand in the sand distribution system has been changed to improve worker conditions.

Modifications to procedures

- The empty 80-l drums for use in the dispatchcell were originally entered by means of a docking container. This was a frequent and time consuming operation so it was opted to install a separate docking system for empty 80-l drums using an existing docking system.
- The 400-l drums to be cemented (6-7 drums) are placed in proximity of the cementation area (no longer in the storage area) to diminish the transport time and improve the cementation process.
- Transports of the drums for final disposal are no longer restricted to the use of a singular transport means.
- Specific measures and controls are put in place to facilitate the production documentation files and facilitate their pick-up for final disposal.