Waste Treatment Facility

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Abstract

After completion of the *Storage and Treatment Building for High-level Radioactive Waste* (Dutch acronym: HABOG) at the COVRA site in Borsele, The Netherlands, in the year 2003, the stock of high-active nuclear waste at ECN / NRG will have to be made ready for transport to, and storage in this new building. To this purpose a Waste Treatment Facility will have to be built in the Hot Cell Laboratories at NRG.

To minimise the amount of waste and to guarantee the stability to the future the waste will have to be conditioned in a number of steps. After opening of the present waste drums a manual selection of high-active and intermediate-active waste will have to be performed remotely. To this purpose the Waste Treatment Facility will be equipped with a gamma camera, a cutting device, and other additional tools. The intermediate-level waste will be transported as usual.

In the past PVC containing materials were also disposed of in the same high-level environment. Due to the high gamma field of in particular ^{60}Co this PVC has disintegrated into a tar-like product and chlorine gas. In due course and in reaction with water this provides an aggressive chemical environment unsuited for long term intermediate storage. Therefore a dedicated facility will be developed and integrated into the new Waste Treatment Facility to separate this PVC contamination from the high-active waste.

To avoid any contamination at the HABOG-facility, the exterior of the waste storage canisters must fulfil severe decontamination criteria. This inhibits the loading of the waste canister into the active part of the Waste Treatment Facility. In stead only the interior will come in contact with the active environment by means of an opening and an appropriate seal. Before the waste canister is loaded into the transport container it will be checked for external contamination and the dose rate, the nuclide inventory, and the weight will have to be measured.

Keywords: hot cell, high-active solid waste, waste treatment, separation of waste, PVC, poly phenyl chloride

1. Introduction

The Waste Storage Facility (WSF) of NRG has been in use for approximately 35 years as an interim storage for radioactive waste and irradiated and non-irradiated fissile materials. Until 1984 radioactive materials coming from various research locations were collected, processed and stored on the Petten-site. After 1984 this task was taken over by COVRA and only radioactive materials from the Petten-site were stored at the WSF.

The Dutch terminology concerning the levels of types of waste is different from international standards. At NRG three levels of radioactive solid waste can be distinguished: low ($H < 2$ mSv·h^{-1}, or LAVA), intermediate (2 mSv·h^{-1} $< H <$ 20 mSv·h^{-1}, or MAVA) and high ($H >$ 20 mSv·h^{-1}, or HAVA). Whereas the low and intermediate-level waste can be transported to a final storage facility at COVRA LOG, there are currently no facilities available for the final storage of high-level active solid waste.

According to the Nuclear Energy Act license all historical waste from the Petten-site is to be stored at the COVRA site before the year 2009. The historical low-level and the intermediate-level waste has already been transported in recent years. In 1992 the construction of the Storage and Treatment Building for High-level Radioactive Waste (Dutch acronym: HABOG) has started. The purpose of this building is the long term above ground interim storage of high-active nuclear waste, both fissile and non-fissile, for a time period of approximately 100 years. After this interim storage a final depository is assumed to be available. The expected hot commissioning of the HABOG facility is mid-2003 after which all the waste produced until 1998 will have to be transported in a four and a half year time frame.

As mentioned, the high-level radioactive waste stored at the WSF at NRG is to be transported to the HABOG-facility at COVRA. However, before actual transport can commence the waste has to be pre-treated. The current high-level waste drums contain a large amount of intermediate-level waste. To minimise the storage costs these types of waste have to be separated from each other.

In this paper the preliminary design of the waste disposal hot cell is laid out which will be able to address all of the above described items. This will be discussed together with the building and the operational logistics.

2. Time schedule and boundary conditions

As already mentioned the expected "hot commissioning" of the HABOG-facility will be mid-2003. In order to be able to comply with the imposed schedule of delivery to COVRA-HABOG a very tight time schedule to design the waste treatment unit with the desired functionality will have to be followed. The overall phasing of the project is given in Table 1.

Table 1 Phasing of the waste optimisation project.

phase	description	time period	
0	establishing inventory and status of stored waste	June 1999	July 2001
1	design of waste treatment facility	April 2001	July 2002
2	realisation waste treatment facility	August 2002	June 2003
3	active period I	July 2003	June 2006
4	modification to accept PVC containing materials	July 2006	December 2006
5	active period II	January 2007	December 2008

Actually in order to perform a correct time management for designing, building and operating the Waste Treatment Facility detailed information about the waste is indispensable. This information is established in a separate project that is indicated in Table 1 as "phase 0". The results of this phase are described in more detail in section 3 "Characterisation of the waste".

In the design of the Waste Treatment Facility several boundary conditions have been considered.

- The interference of the intended activities with the ongoing activities should be minimal. This demand led to the conclusion that the activities could not be performed in the existing hot cells.

The waste treatment unit should be situated inside the existing Hot Cell Laboratories. Other locations than the HCL were considered, however, none of these could satisfy the requirements for handling high-level waste. Apart from that, the building of a new nuclear facility outside of the Hot Cell Laboratories would be very difficult from a licensing point of view.

The waste canister should fulfil COVRA specifications, regarding maximum dose, surface contamination (0.4 $Bq{\cdot}cm^{-2}$ for alpha emitters and 4.0 $Bq{\cdot}cm^{-2}$ for beta and gamma emitters), weight, dimensions and above all an integrity guaranty for at least 100 years.

The transported waste canister should meet to the rules and regulations for the handling of waste at COVRA – HABOG. The maximum height a waste canister is lifted inside the HABOG facility is approximately 9 metres. The canister to contain the waste should withstand a fall from this height.

3. Characterisation of the waste

In 1999 a campaign was started to inspect the status of the waste drums and to determine the nuclide inventory of the intermediate and high-level active waste. To this purpose a special device (VINISH or **V**isual **I**nspection and **N**uclide **I**dentification **S**ystem for **H**igh-level radioactive waste) was developed which enabled us to visually inspect the outside of the waste drums for corrosion and administrative code numbers and to measure gamma ray energies at high specific activity up to 10 TBq (^{60}Co). In the last two years all of the waste drums have been measured and the results have been incorporated into a computerised management system called PLUG2000. This computer system contains all the necessary information on the waste drums varying from storage location, the physical description of the content to the nuclide specific gamma activity.

In total 1576 waste drums have been listed, the main nuclides being ^{60}Co and ^{137}Cs. In agreement with COVRA no further characterisation of the nuclide content is required provided that it does not exceed 5% of the total content. The total activity is $5.5{\cdot}10^{14}$ Bq ^{60}Co and $1.9{\cdot}10^{12}$ Bq ^{137}Cs, the mean weight of the waste drums (+ content) is approximately 27 kg. The physical content of the waste drums consist mainly of remnants remaining after the dismantling of irradiation experiments performed in the High Flux Reactor, tools, equipment, cleaning rags and in some cases poly phenyl chloride (PVC), vermiculite and sodium metal. The latter three materials are considered potentially problematic and have to be pre-treated first before further disposal.

Vermiculite is a clay-like substance used as an absorbent for liquids. Unfortunately the absorbed liquid is not retained permanently. If the liquid is liberated this may have unwanted side effects on the stability of the waste. Fortunately drying of vermiculite waste is straightforward, though time consuming. Sodium metal also imposes unwanted effects on the chemical stability of waste. Likewise for vermiculite methods are available for stabilisation though, again, time consuming.

A similar approach will not be possible with PVC-containing high-level waste. PVC-containing waste is considered a problem as it inhibits a straightforward long-term disposal of the current waste stock. In the past, PVC-containing items were stored in waste drums together with gamma active materials, or stored in the WSF in the direct neighbourhood of gamma active waste. If PVC is exposed to a gamma radiation field for a sufficiently long period of time, the PVC starts to degrade, thereby releasing chlorine gas. This chlorine gas in turn will react with water vapour to form hydrochloric acid, which is very aggressive towards unprotected steel. As a result some of our waste drums are subjected to visible corrosion.

It is obvious that PVC-containing waste cannot be considered for direct storage in the HABOG-facility. In a separate project closely related to the development of the Waste Treatment Facility a study is started to identify potentially suitable methods to neutralise the corrosive behaviour of PVC. This may vary from the development of a method to separate PVC from the rest of the waste to the development of a waste canister that is inert to the chemical behaviour of chlorine. Since the development of such a suitable method is time consuming the phasing of the waste optimisation project is divided into two active periods (Table 1). The first period, starting directly after the hot commissioning of the HABOG-facility, will be dedicated to non-PVC containing waste, the second active period starting in January 2007, will be committed to the treatment of PVC-containing waste entirely. In between these two periods the waste treatment unit will be transformed to be able to fulfil this new task. By separating these periods time has become available to perform the necessary research on how to treat the PVC-containing waste.

4. Design

4.1.1. Functional design

In order to design the Waste Treatment Facility first the functionality of the unit will have to be established firmly. A rough lay out of the functionality is show in Figure 1. On the left hand side of the figure the results of the waste characterisation have been given schematically. On the right hand side, the functionality of the waste treatment unit is indicated, the identified waste streams, and possible alternatives for, for instance, transport to COVRA.

The functional demands for the Waste Treatment Facility are:

- As already mentioned the majority of the waste consists of remnants originating from irradiation experiments performed in the High Flux Reactor at the Petten site. After dismantling several parts remain, depending on their position in the HFR and the materials used, activated to a higher or lesser extent. Primarily based upon experience, hot cell operators roughly differentiate between the several types of radioactive waste. However, due to the fact that no specific tools are available the separation of intermediate-level and high-level waste can be further optimised and consequently the stream of high-level radioactive waste can be minimised. Tools considered here are an in-cell gamma camera combined with video vision and in-cell dose rate measurement devices.
- Often the shape and size of dismantling parts is not ideal for close packing in waste canisters. To optimise this indispensable tools are pneumatic devices for cutting, flattening off and sawing.
- Further separation of steel, aluminium and non-metals. As mentioned, the degree of activation depends very much upon the type of materials used. Due to contamination or functional additions steel components become more activated for a longer period of time than aluminium components. Since the waste treatment unit will be built for historic waste the initially activated aluminium will have decayed substantially to be separated from the high-level waste. Recognition of aluminium will be "on site". Therefore well trained hot cell operators will be necessary (this of course is applicable to all the handling to be performed in the Waste Treatment Facility).
- Furthermore, the unit will have to have enough space to spread out the content of a waste drum and to separate the waste into specially designated areas with a minimum of effort.
- In time the Waste Treatment Facility will have to be made suitable for the treatment of PVC-containing waste. A complication is that no concept for PVC-treatment is available yet.
- The Waste Treatment Facility must be able to accept the current waste drums stored in the WSF and to be able to handle the waste canister for COVRA without the risk of permanent external contamination. Furthermore, the waste route must be reversible at all times. The latter

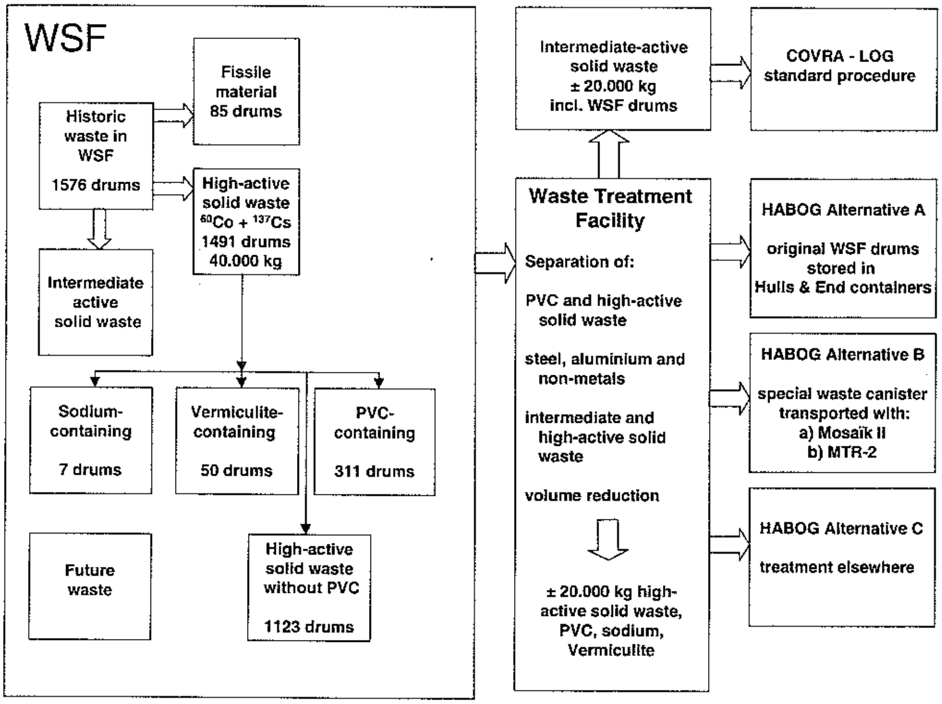

Figure 1 A flow chart showing the optimisation of the historical waste currently stored at the NRG Waste Storage Facility.

demand is to avoid that a waste canister cannot be emptied anymore and blocks the use of the Waste Treatment Facility or the transport container.

Also shown in Figure 1 are alternatives for transport of waste to the HABOG-facility. The three alternatives considered are:

A. Originally it was intended to use the same type of waste drums, albeit slightly modified, as currently in use for waste storage in our WSF. As the dimensions of these WSF-drums are 28 cm in diameter and 70 cm in height, the transport configuration (in an MTR-2 transport container) and the storage configuration at HABOG in Hulls & End containers were considered to be economically not favourable.

B. In this alternative a maximised volume of the waste drums was taken as a starting point. Maximisation was with reference to possible transport containers that could be handled at HABOG without alteration of their existing concept and the maximum lifting capabilities at NRG-HCL. Two possible transport containers were identified: the MTR-2 and the Mosaïk II Behälter, both from GNS (Germany). Using the waste optimisation scheme shown in Figure 1 the mean activity content per canister was estimated to be approximately 10^{13} Bq ^{60}Co. Based on this only the radiation shielding of a MTR-2 transport container was considered to be sufficient to satisfy the nuclear transport regulations.

C. This alternative was considered in case the "in house" treatment of the high-level waste was not possible and for the placement of the project in a wider perspective. Due to additional transport costs involved this option is not feasible.

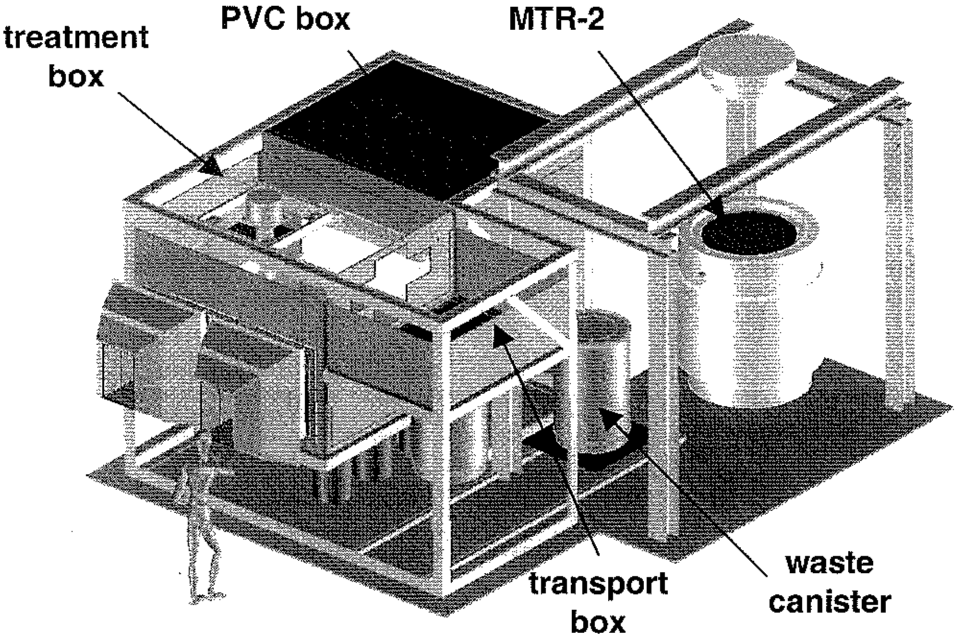

Figure 2 An impression of the Waste Treatment Facility. Indicated are the different compartments in the facility. Not shown is the maintenance box, which will be next to the transport box.

Careful consideration of all the alternatives and the boundary conditions mentioned earlier led to the conclusion that the most promising option was to build a new hot cell dedicated to the treatment of waste within the existing Hot Cell Laboratories of NRG; the decontamination area. This area is accessible by crane and would not interfere too much with the existing logistics.

4.2. Preliminary design

Due to the imposed restrictions by all of the above the design would have to thrive with available space. In the concept shown in Figure 2 and further described below all these conditions have been met, resulting in a compact and well-ordered Waste Treatment Facility. As a result of the limited space the walls will be made of 30 cm lead, which is equivalent to the 1,20 m of concrete used in the high-active cells at NRG-HCL.

As is anticipated the re-opening of old waste drums, some of which are more than 30 years old, may produce a lot of radioactive dust. To restrict the spreading of radioactive materials through the entire facility different boxes dedicated to specific tasks have been foreseen. Besides this, the pressure in the treatment box will be lower than the surrounding boxes. As a result, a constant airflow will be towards the box with the highest contamination level. Within each box a second polished steel box will be installed to prevent activity from leaking out of the Waste Treatment Facility and to ensure an easy-to-clean surface.

As already mentioned, in the Waste Treatment Facility a number of separate compartments or boxes can be identified:

- *Treatment box.* In this box all of the functionality for the separation of intermediate-level and high-level waste will be incorporated, such as the pneumatic tools, gamma camera and interim waste. The loading and unloading of the existing WSF-drums into the Waste Treatment Facility will be through a shutter system in the roof of this box. This system is already in use at other Hot Cells in the HCL. In the treatment box all the waste is sorted out, either visually (trough the windows) or digitally (video, gamma camera). After this step the intermediate-level waste is unloaded through the roof and the high-level waste is transported into the next box. During this process the content of the waste drums is compared with the content listed in the PLUG2000 computer programme and corrections are made for the mutations.
- *PVC box.* This box remains empty until a procedure has been found to dispose of the tar-like substance. In the lay out of the Waste Treatment Facility provisions have been made for the future use of this box.
- *Transport box.* After the high-level solid waste has been separated in the treatment box, the waste will be shifted to the transport box. In this box a waste canister is docked through a syntacs-type system. The use of this system is entirely aiming for the prevention of external contamination of the waste canister. Although underneath this box equipment will be installed to perform contamination tests and incidentally decontamination procedures, external contamination will have to be prevented. As a back-up system, the roof of the transport box will be equipped with a loading / unloading facility for WSF-drums.
- *Maintenance box.* Next to the transport box and not shown in figure 2 is the maintenance box. The purpose of this box is to perform maintenance on the power manipulator. Unlike the other boxes, the walls are of a transparent material suited with gloves. The radiation shielding to gamma radiation will be much less. Also, a facility will be available to enter this box with a pressure suit.

To lift heavy material and to transport waste from one box to another a power manipulator will be installed. Another task of this power manipulator is to empty the waste canister in case unforeseen reasons make this necessary. As a general remark, the entire process from NRG-WSF to the HABOG-facility will have to be reversible.

After a waste canister has been filled with high-level waste the syntacs port of the transport box is closed and the weight of the canister will be determined. Due to the separation process in the treatment box the nuclide inventory will have to be re-determined before the canister is sealed permanently. To do this a new nuclide detection system will be built capable of measuring dose rates up to 100 $Sv \cdot h^{-1}$. Details of this measuring device are not available yet. After the dose rate has been measured and has been compared with the attenuation by shielding of the MTR-2 transport container either the canister is re-opened or sealed. The re-opening of the canister can probably be prevented by a careful selection of the WSF-drums taken out of the WSF. It is still open to discussion whether or not the canister will be evacuated and filled with an inert gas. After the canister is placed inside the MTR-2 container and the first containment shield is in place, the MTR-2 is rolled out of the Waste Treatment Unit.

Provided that approximately 1123 waste drums (non-PVC containing waste) will have to be processed in 3 years, it can be calculated, assuming an availability of he Waste Treatment Unit of 70%, that the throughput will have to be 1.5 drums per day. Based on experience gained in the past this is only possible if two persons are available on a day-to-day basis. This work scheme will result in a filled waste canister every 30 working days.

5. Next Step

In this paper a description is given of the considerations taken into account for the preliminary design of the Waste Treatment Facility. As is already indicated in Table 1, this facility has to become operational by mid-2003. Before this facility can be commissioned, a final design will have to be drawn up, a risk evaluation on the entire process will have to be performed and last but not least it will have to be built. Until now we are on schedule, this is only possible thanks to the infinite dedication of the teams of NRG IS and ECN TSC involved.