THE STORAGE OF MISCELLANEOUS BETA GAMMA WASTE AT SELLAFIELD

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ABSTRACT

The paper explains BNFL's strategy for waste management at its Sellafield site and concentrates on the design, construction and operating experience of the miscellaneous beta gamma waste store. The processes by which solid radioactive scrap items from nuclear fuel handling and reprocessing activities at the Sellafield site are received, sorted, packaged and stored are described.

The various design options which were considered, and the regulatory requirements which had to be met are described. A relatively simple process has been adopted being primarily one of mechanical movement of waste. Casks are used for transporting waste outside shielded facilities whilst remote handling equipment in shielded cells are utilized for subsequent sorting and packaging operations. The waste is ultimately placed in lidded cement lined steel boxes in a shielded storage vault.

INTRODUCTION

Reprocessing operations have been carried out at the British Nuclear Fuels plc (BNFL) Sellafield site for more than thirty five years. This reprocessing of irradiated fuel produces a range of radioactive wastes. BNFL have adopted a policy for radioactive waste management whereby effluent discharges to the environment are minimized, solid low level waste is disposed of as it arises, and all other wastes are stored, conditioned and treated for eventual disposal. To achieve this latter objective, safe and cost effective treatment and storage methods have been developed and various stores designed, built and operated at Sellafield.

WASTE CATEGORIES

In the United Kingdom, radioactive wastes are classified as follows:-

1. High Level Wastes (HLW)
2. Intermediate Level Wastes (ILW)
3. Low Level Wastes (LLW)

HLW or heat generating wastes are defined as those in which the temperature may rise significantly as a result of their radioactivity.

ILW are wastes containing radioactivity above the levels set for low level waste, but which do not experience a significant temperature rise as a result of their radioactivity.

LLW are wastes containing radioactive materials not exceeding 4 GBq/te (0.1 curies/ton) alpha or 12 GBq/te (0.3 curies/ton) beta gamma.

ILW STREAMS

Although a large number of ILW streams are generated during reprocessing operations, they can for convenience be grouped according to their origins and/or properties as follows:-

i. solid fuel element cladding wastes from Magnox and oxide fuel;

ii. slurries, sludges and flocs such as ion exchange materials, pond water and liquid effluent treatment flocs and sludges arising from corrosion of Magnox fuel cladding;

iii. plutonium contaminated material with alpha emitting isotopes, which usually only have low beta gamma contamination;

iv. miscellaneous beta gamma wastes which are solid and are contaminated primarily with beta-gamma isotopes and only very limited alpha emitting contamination.

Plants for encapsulation of ILW streams from groups (i), (ii) and (iii) are currently operational or are being designed and constructed. In line with UK Government policy conditioned ILW will eventually be disposed of in a deep underground repository.

MISCELLANEOUS BETA GAMMA WASTE

A wide range of solid radioactive scrap items arise from nuclear fuel handling and reprocessing activities, which are contaminated primarily with beta-gamma emitting isotopes and contain only very limited alpha emitting contamination. These waste items are typically scrapped tools and equipment such as pumps or valves from process plants, used HEPA (high efficiency particulate air) filters, organic material and non-combustible Magnox reactor materials. The four Calder Hall Magnox reactors are part of the Sellafield site.

In view of the variety of items which make up this type of waste it is not surprising that there is a wide range of activity levels. These vary from 7.5 mSv/hr to 10 Sv/hr (1 Sv is equivalent to 100 Rem).

It is estimated that approximately 150 m^3 (5,300 cubic feet) of these wastes arise each year at Sellafield.

DESIGN PHILOSOPHY FOR WASTE STORAGE

In the mid 1980's it was decided that an interim storage facility for these miscellaneous beta gamma wastes would be required as existing facilities on the Sellafield site were becoming full. It was also decided that since the waste was solid and stable it should be stored in an unencapsulated form until an underground repository was available for ultimate disposal.

Various interim storage options were considered such as the use of redundant cells or modifications to existing buildings, in addition to the provision of a new store. A total of six storage concepts were evaluated:-

- WET
    1. bulk storage in a deep underwater store
    2. bulk storage shallow underwater store
    3. containerized waste in an underwater store
- DRY
    4. waste packed in unshielded containers in heavily shielded cells
    5. waste packed in heavily shielded containers stored in a lightly shielded store
    6. bulk storage in dry shielded cells.

The overriding consideration was that the store would have to be designed to meet regulatory guidelines for waste management operations. The relevant regulatory authority, the Nuclear Installations Inspectorate (NII), are an independent Government agency responsible for licensing of all nuclear sites in the United Kingdom, and without whose consent no plants can operate at Sellafield.

In the context of a beta gamma waste store, the most important requirements are:-

i. stored waste should be 'inspectable' or monitorable and fully retrievable

ii. stores should be intrinsically passive, ie. capable of operating with minimal services and management surveillance

iii. stores should be designed to minimize the release of radioactivity during accident conditions.

Following a detailed evaluation it was concluded that a new purpose built facility should be constructed, and that option (5) above should be chosen. The wet storage options were rejected since inspection or monitoring of wastes would be problematical. Option (6) would result in inspection and retrievability problems. Both options (4) and (5) complied with the NII waste storage principles, and if subsequently considered necessary, grout could be injected into the container boxes. Option (5) had the advantage that waste could be easily transported around or between sites.

The store has been designed to provide a capacity of 3000 m^3 (100,000 cubic feet) which is equivalent to about 20 years Sellafield site arisings. It has a design life of 50 years and meets all the relevant safety and regulatory requirements.

The process adopted is simple being primarily one of mechanical movement of waste. Casks are used to transport waste outside shielded facilities whilst remote handling equipment in shielded cells would be utilized for subsequent operations, with the waste being finally stored in a shielded vault.

STORE DESCRIPTION

Physically the store comprises two main buildings; a receipt building to handle and sort the incoming waste and a storage vault. The receipt building is 72m x 32m x 17m high and incorporates the Services Section containing mechanical, electrical, instrumentation and ventilation services together with changing rooms and management control facility. Cask handling, shielded cells and equipment for receipt, storage and transfer of waste to the store are also included. The storage vault is 83m x 42m x 7m high and can accommodate more than 1800 storage boxes.

TRANSPORT AND RECEIPT

Approximately 80% of the waste originates on the Sellafield site with the remaining 20% coming from other nuclear facilities in the United Kingdom.

Waste arrives at the store, either by road or rail, in shielded casks. The transporter enters the receipt bay, where the casks are raised by a 20 ton crane and traversed to a shielded buffer store capable of holding up to six casks in individual compartments. Casks are monitored for radiation and contamination in this buffer store. When a cask is required for processing it is lifted out of its compartment by the 20 ton crane and transferred to the preparation area.

The storage boxes are 1.85m (6 ft 1 inch) square and 1.37m (4 ft 6 inch) high. They are concrete lined, and are made of carbon steel with a capacity of 3.5m^3 (123 cubic feet). New boxes received from the manufacturers undergo quality checks prior to loading in the box receipt area. When required a new box is remotely moved to the packaging area.

PREPARATION AND SORTING

When a cask has been moved on a cask trolley to the preparation area, the lid is unbolted. The cask preparation area is then evacuated and the cask trolley remotely transferred into the cask cell. The lid is then removed, and the contents of the cask are monitored for radiation levels. The cask liner which contains the waste is removed using a 5 ton in-cell crane and placed into a liner tipping facility. This clamps the liner before tipping the waste onto a sorting tray.

The waste on the tray is then sorted using either remotely operated master-slave manipulators, a power manipulator or a tendril grab attached to the 5 ton crane. The waste is then sorted into three streams:

a. combustible

b. non combustible

c. filters

This sorting approach (ie. sorting by type of waste material) was adopted rather than alternatives of sorting by means of origin or activity level for the following reasons. Firstly it would allow selective immobilization of the waste if required sometime in the future, secondly selective volume reduction to items such as filters could be carried out if required, and thirdly inspection checks could be carried out for degradation of items such as organics.

The cask liner which is reusable is replaced into the cask, which after re-lidding is then transferred to the decontamination area. The cask is swabbed and monitored, and any required decontamination carried out. The cask is then moved to the buffer store to await return to the consignor plant.

PACKAGING

The waste of a particular sort is transported on a tray to the Fissile Material Detector (FMD). This facility, within the transfer cell, is a neutron generating device which measures the fissile content of the waste. These measurements are required to demonstrate that significant quantities of fissile material are not present which could pose a criticality hazard. The FMD has been included in the store to prove compliance with the relevant operating rules, because even though the wastes contain very limited alpha emitting isotopes the exact composition from some of the consigning plants is not known.

Providing the fissile content is acceptable, the waste on the tray is then transferred to a tipping tray device, which clamps the tray and tips the waste into a packaging box positioned underneath. In the unlikely event of the fissile content being unacceptable, the waste is returned in its cask to the plant of origin.

Several waste consignments are usually needed to fill the waste box. The lid is then lowered onto the box, which is remotely traversed to a box gallery area. The empty box and lid weigh 2.8 tonnes and the full waste load is 8 tonnes. A 16 ton crane is used to move the filled box to a monitoring area.

At the box monitoring area, the box is remotely swabbed for loose contamination and external radiation is monitored. The box lid is securely fastened to the box body by remote means.

STORAGE VAULT

The filled box is loaded onto a stool, located on the transfer trolley. Boxes are triple stacked on the trolley, and then the doors to the vault are opened and the trolley remotely powered into the vault.

At a pre-determined point in the vault the transfer trolley is halted and the stack of boxes lowered on to the floor. The transfer trolley is moved away, and a vault trolley which runs at right angles to the transfer trolley, picks up the stool with its stack of boxes and transports them along the vault aisle to the storage position. This vault trolley is a ground level rail operated bogie system. There are a total of 18 aisles, in each of which there is sufficient room to accommodate 34 stacks of boxes.

The building has been designed to withstand seismic events. Extensive shake table tests have shown that a stack of three vertical boxes will not topple or move appreciably out of position during the Design Base earthquake.

During storage life it is expected that small quantities of hydrogen may be generated as a result of radiolysis of any organic material within a box. Therefore the storage vault is provided with adequate ventilation to remove hydrogen.

The store is monitored for humidity and dehumidifiers will operate at preset levels in order to maintain low humidity levels and thus minimize corrosion of the carbon steel boxes.

Closed circuit television monitors are inserted into the storage vault through penetrations in the concrete shielding in order to provide viewing facilities.

The stored boxes will remain in their respective positions in the vault until required for selective monitoring. A given box may be retrieved for inspection at any time, and if necessary the box can be opened to remove the contents for more detailed inspection or retreatment.

CONSTRUCTION AND OPERATING EXPERIENCE

The project was sanctioned in 1986. Site clearance and preparation in the latter part of the year allowed main construction to commence in March 1987. Construction was completed at the end of 1989, and following commissioning trials, active operation started in May 1990. This date was some two months ahead of the original estimate. The total project cost of £53M (approximately $100M) was within budget.

Operating experience to date has been encouraging. No significant contamination has been observed, and radiological data has shown very low dose levels in operating areas, with only minimal aerial and liquid effluent discharges. Of particular significance is the acceptance in the plant of waste, such as reactor thermocouples with high cobalt content, having radiation levels as high as 10 Sv/hr with no adverse effect on dose uptake by operating personnel. This radiation level is ten times the original design figure. There have been no problems to date with sorting or packaging, and a variety of waste forms have been handled successfully.

CONCLUSION

The detailed design effort with consideration of viable options for interim storage of solid beta gamma waste items has resulted in the construction within time and budget of a receipt, sorting and storage plant whose initial operating experience has been of a very high standard.