HARWELL ALPHA BETA/GAMMA WASTE FACILITY

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ABSTRACT

The Harwell Alpha Beta/Gamma Waste Facility will be a new facility for the packing and storage of radioactive solid waste in stainless steel drums. The facility will contain a suite of concrete shielded, stainless steel lined cells in which the waste will be input, assayed and repacked in 400 liter drums, before being stored in a large vault store adjacent to the cells.

The purpose of this paper is to describe the cell design, i.e. its organization, operation, assay instrumentation and safety features.

INTRODUCTION

The UKAEA strategy for the management of alpha contaminated beta gamma Intermediate Level Waste is to recover current stocks from their present location and process them to give immobilized products that are acceptable to NIREX for disposal. To implement this strategy it is proposed to build a Vault Store with a Head End Facility. Together these have the capability for the assay of wastes, for overpacking existing stocks and future arisings of ILW in 400 liter stainless steel drums, storing these wastes until they are removed for immobilization and then temporarily storing the 400 liter drums of immobilized waste until they are transferred off site for ultimate disposal.

The Harwell Alpha Beta/Gamma Waste Facility is currently under construction with a completion date of 1995. It will provide processing and storage capacity for all Harwell's existing and new arisings of intermediate level (alpha) beta/gamma waste.

To allow for changes of strategy the facility has been designed with flexibility as a key consideration. The Head End cell suite allows for remote dismantling and conversion to a sorting facility and provision has been allowed for the addition of cementation and/or receipt/dispatch facilities. The facility has been designed and is being constructed to comply with the requirements of the Nuclear Installations Inspectorate (NII) site license.

DESCRIPTION OF THE FACILITY

Introduction

The site plan showing the location and layout of the facility including the personnel building is shown in Fig. 1. The existing Alpha, Beta/Gamma stores will be linked to the new facility by the Interim Store.

The Head End Cell Suite

The cell suite will be situated at one end of the waste handling complex as shown in Figs. 1 and 2. The outer wall of the suite will be concrete, 1400 mm thick. The inner surface of the walls will be lined with stainless steel. Penetrations fitted with viewing windows, lighting units, input facilities and master slave manipulators will enable remote handling operations to be carried out. A Closed Circuit TV (CCTV) system will be installed where conventional viewing is not possible.

The cells will be side by side in a straight line to allow ease of progression through input, assay, packing, lidding and storage. At the front will be the cell working face which will back onto the personnel change areas. At the rear and south west end of the cells will be the transfer area where flasks will be handled and all the input facilities to the cells will be situated. The north west end of the suite will be attached to the vault store so that inputs can be made to the store without breach of shielding.

The Head End suite of cells is designed to receive and process between 4 and 12 waste cans per 8 hour shift, producing between 1 and 2 storage drums per 8 hour shift for transfer to the Vault Store.

The various components of the facility are described in detail below:

The Input Cell

The input cell receives all the waste cans from the various input facilities. Two types of input port are used; one floor mounted and the other wall mounted. The main waste input is via the electrically operated, floor mounted, double lidded port, designed to take the standard transfer drum used in the retrieval of the existing stored waste. The transfer drums will be delivered and raised to connect with the ports by means of an under-cell transfer system which is semi-automatic and has built-in safety interlocks.

There is in addition a master slave manipulator operated, wall mounted input port designed to take double lidded transfer drums from existing waste generating facilities on site. This port will also be used for introducing materials, tools etc required for cell operation.

The Assay Cell

The assay cell will be bounded on the working face and transfer area sides by the 1400 mm thick concrete cell suite walls and will be separated from the cells on either side by partition walls. These walls will have doors for the in-cell transfer systems. The cell has two major items of assay equipment, a neutron interrogator and a gamma spectrometer.

The gamma spectrometer will confirm the main isotope activities and fingerprint each can. The neutron assay is by both active and passive interrogation - the well type detector is used in Californium shuffler mode and as a passive neutron (coincidence) counter. This allows assay for both Pu and U isotopes.

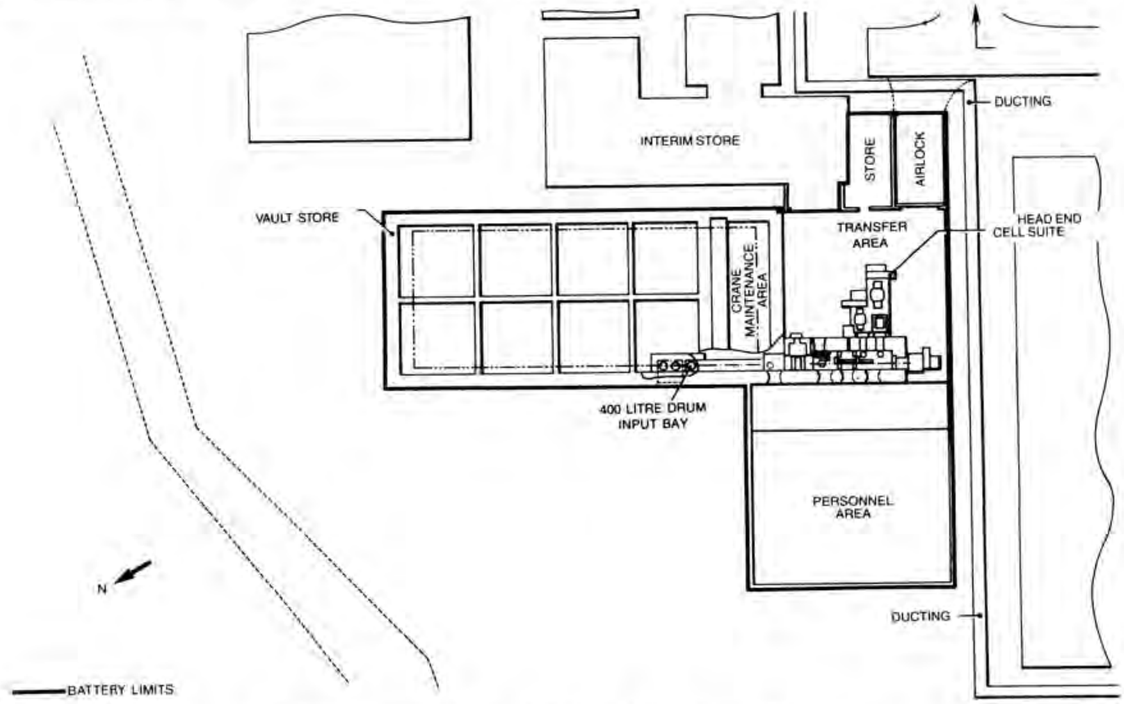

Fig. 1. Layout of Head End and Vault Store plants.

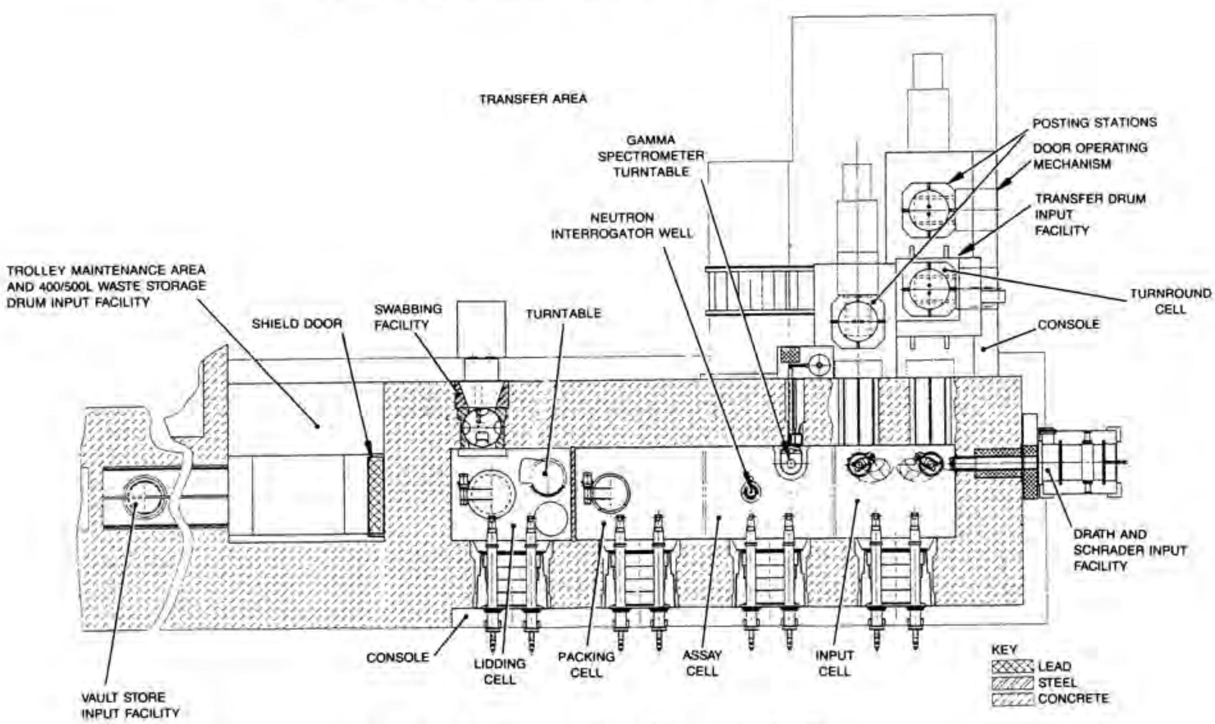

Fig. 2. Schematic plan of Head End cell.

The Packing Cell

The third cell in the suite will be the packing cell in which the cans will be stored temporarily after assay so that a suitable combination of cans may be grouped for efficient overpacking in the 400 liter storage drum. The drum will be connected to a double lidded port in the base of the cell.

When the double lidded port is opened the drum will be filled with waste cans using the 250 kg in-cell hoist and electrically actuated grab. The port will then be closed and the drum taken to the lidding cell by means of the under-cell transfer system.

The packing cell, together with the assay and input cells, forms a complete stainless steel clad containment.

The Lidding Cell

The lidding cell will be separately contained from the other cells, and from the under-cell transfer area. It will be used to place a secondary lid on the waste drums prior to storage. It will consist of a stainless steel clad cell with viewing window, lights and master slave manipulator. An in-cell hoist will be used to lift the drum through a simple (non-double lidded) port in the floor of the cell after the storage lid is placed and bolted on remotely. The lidding cell will also contain a swabbing facility and monitoring equipment.

The Vault Store

The Vault Store will be a rectangular structure with thick reinforced concrete walls, floor and roof. It will have the capacity to store approximately 3500 400 liter drums stacked up to 6 layers high. Current plans are to store 2470 drums 5 layers high. The store is divided into 8 bays by internal walls 0.5 m thick by 6 m high, bonded into the main walls of the building. One storage bay will always remain empty to allow drums to be moved when the store is "full", should this ever be necessary. Access for storage drums is via a tunnel leading to the Head End plant; crane access is via the shielding door. Transport of the drums within the Vault Store will be by the store crane which will be operated remotely from the control room with the aid of closed circuit television.

The store is rectangular with internal dimensions 27 m long by 14 m wide by 11 m deep (Fig. 1). Floor level is approximately 3 meters below ground. Foundations are 1.4 m thick; total excavation depth is 4.3 m. External walls are of reinforced concrete 1.4 meters thick below and above ground. The roof is manufactured from pre-cast bridge beams as permanent shuttering with reinforced concrete infill 1 m thick. The normal temperature limits are -10 to +40°C. The fire resistance is estimated to be 4 hours.

SAFETY CONSIDERATIONS

A detailed analysis of the safety aspects of the plant has been carried out covering all operations from the entry of the flask containing the waste into the facility, to the storage of the waste drums and the provisions for recovery of waste from storage. The safety of future expansions of the plant (these could include waste immobilization and the final unloading of the vault store) will be considered when the decision is made as to the acceptable immobilized waste form.

Hazard Assessment

Normal Operation: Normal radiation levels in the plant have been established according to the ALARP principle. Assessments show that the shielding design, facility containment and method of operation will allow the plant to be operated well within the basic criteria that stipulates the maximum permissible annual dose to the operators (5 mSv average, 15 mSv individual maximum) and members of the public (50 μSv).

Fault Conditions: Faults leading to the release of activity were identified systematically using established Hazard and Operability (HAZOP) techniques. The facility has been designed to expedite the recovery from fault situations.

The only significant hazard from internally initiated events was identified as a criticality incident. However using pessimistic assumptions about critical mass configurations the assessed frequency of a criticality incident was shown to be well within the target frequency criteria.

Externally initiated events have also been assessed. An aircraft crash is by far the most significant event but the risk and frequency criteria are still met. The requirement to seismically qualify the facility in terms of shielding but not containment in the event of a design base earthquake was also identified.

Plant Life and Decommissioning

The nominal life of the facility is 25 years (50 years for the storage vault itself) and as outlined above, it will initially be used to store raw waste and then possibly conditioned waste pending its disposal in a waste repository. Due to the nature of the operations the store itself will remain relatively uncontaminated as each drum placed in the store will be clean. All Head End cells, where there is potential for internal contamination, are lined with stainless steel to allow easy cleaning. Items difficult to decontaminate can be fed into the waste stream. Decommissioning of the facility is not expected to lead to unacceptable hazards.

Management Operations

The facility will operate under a written 'Authority to Operate'. All activities in the facility will be carried out in accordance with written procedures and will be subject to an integrated quality assurance program. Waste movements will be centrally planned and a record will be kept of the content of each waste package and its location in the facility. Health Physics monitoring will be carried out according to written procedures to ensure safe operation of the facility. The operations carried out at the facility will be reviewed and reported on annually to support the justification for its continued operation.

THE OPERATIONAL SEQUENCE

Twelve can sizes, varying in volume between 8 and 50 liters and from various site locations will be processed in the repackaging plant. Previously generated waste cans will be retrieved from their current storage locations and placed in a standard transfer drum before being transported to the plant in a shielded flask. They will enter the input cell by the double lidded input ports beneath the floor of the cell.

When the plant is operational the waste cans from other facilities on the Harwell site will be transported to the plant in a shielded flask. Some of the waste will be contained in cans that are compatible with the horizontal double lidded posting interface in the cell wall. Waste cans not compatible with this system will be routed via a 'Turnround Cell' where they will be put into a standard transfer drum so that they may enter the input cell via the port in the floor.

The proposed sequence of operations is shown in Fig. 3. The waste can(s) will be lifted into the input cell using the in-cell hoist. Each can will have a unique identifying number attached before being placed on the inter-cell transfer system. The can identification, can contents (radiological), and drum identification will be recorded and logged for future reference and storage control. The can will then be transferred to the assay cell for measurement by the gamma spectrometer and neutron interrogator. The can will be then moved on a similar transfer system to the packing cell where it will be overpacked into a 400 liter double lidded drum. Cans may be stored in the packing cell until a suitable drum payload permutation is achieved before they are packed into the drum.

The 400 liter drum will be connected to a double lidded port in the base of the packing cell and when it is full, the drum will be moved on to the lidding cell. There the drum will have a storage lid fitted and be lifted into the cell by means of the

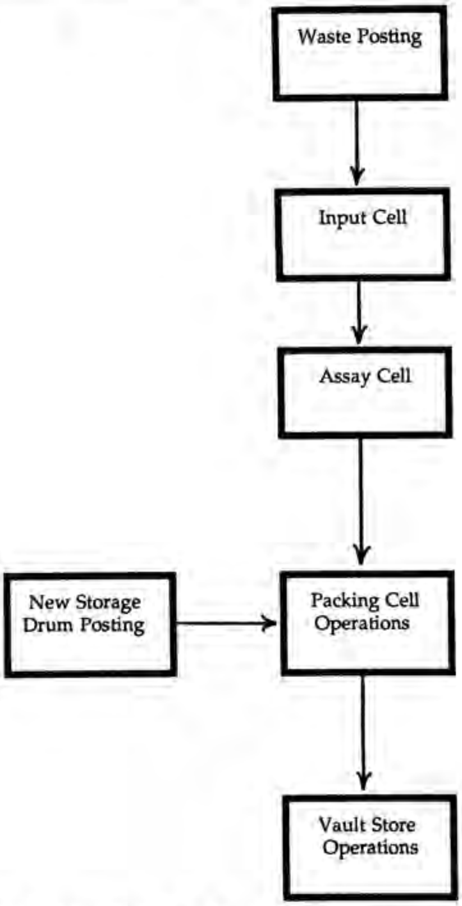

Fig. 3. Head end and vault store process outline.

cell hoist. Swab tests will be carried out to check for contamination. If the swabs are clean, the drum will be lowered back into the trolley and moved via a tunnel to the Vault Store.

The drum will then be lifted from the trolley by a grab suspended from a remotely operated overhead crane. The drum will be deposited in a predetermined storage position. All the information on the contents of the drum will be recorded in a database.

CONTROL AND INSTRUMENTATION PHILOSOPHY FOR SAFETY

The function of the control and protection systems employed is to process and pack the waste cans safely with the minimal risk of radiation exposure to either the operators or to the public. Exposure could occur either directly from unshielded waste cans or following the occurrence of a criticality incident within the cell suite, transfer area or Vault Store.

Overview of Cell Line Controls and Monitors

The computer systems employed can be partitioned into three interconnected areas namely, the process control system which is responsible for overall control of operations, the assay system which conducts the gamma and neutron analyses of the waste cans and the database system which registers, for permanent record, information concerning the can and 400 liter vault drum contents. The plant control room will incorporate, in addition to the waste management computer system, the following items of equipment:

- Hardwired cell line mimic
- Ventilation mimic and controls
- Fire panel
- Scram initiator
- Health Physics mimic or indicators
- Intercom and Public Address system
- Vault store crane controls
- Cell line, under-cell tunnels and transfer area CCTVs systems
- Limited remote ventilation indication from the plant complex.

Process Control

Process control will be performed by a network of programmable logic controllers (PLC) and a central control room PC. Each cell will have an associated PLC and a cell workstation (simple one line monitor with keypad). The workstation will reside alongside the other hardwired controls in a command console below the cell face window.

The control room computer will incorporate a minimum of one large color monitor with dynamic mimic displays covering all plant operations. Control over specific operations will be authorized from the control room only, whilst for others, control of operations will be either locally on the plant or alternatively from within the control room.

In instances where risk reduction is practicable, fault tolerance from erroneous PLC commands is to be provided by autonomous hardwired protection circuits. The inputs to the protection system will be segregated from the process control system.

Assay System

The assay system will consist of a gamma spectrometer and neutron interrogator based on the same PC computer, with an IBM Token Ring network providing communication between it and the other computers in the facility.

Existing data concerning the waste cans will be loaded by the control room operator into the assay system prior to the command from the cell face to execute the analysis. The results of the analysis will be displayed on the control room monitor and transferred (together with the existing data) via the network to the plant database PC after acceptance by the control room operator.

Plant Database

The Plant Database will record on two separate relational databases. The Waste Can Database will hold information on the identification, contents and origin of each of the processed cans. The Vault Store Drum Database will contain similar information for each 400 liter drum and include the identity of waste cans in the drum and its location in the Vault Store. The two databases will reside on a single PC.

Outline Criticality Control Philosophy

The philosophy of the criticality control within the facility is to limit the mass of fissile material to safe levels at predetermined positions/areas within the facility. For example, within the vault store, control is achieved by limiting the mass of fissile material within each storage drum to an acceptably safe level such that the large array of drums in the store will be safe.

To facilitate the maintenance of criticality safety, the current intention is to:

- identify the cans and record their progress through the Head End cell suite.
- quantify the fissile arisings at the facility by measuring the fissile content of waste cans after entry into the Head End suite
- record the fissile inventory and location of storage drums being sent to the Vault Store.

To ensure criticality safety the fissile content of each can is assessed from the historical can inventory and its comparison with the measured fissile content. Appropriate interlocks will be provided to limit the fissile arisings in each area of the facility. It should be noted that no specific control requirements are currently envisaged over the quantities of moderator present within the facility. The fissile inventory within the facility will be confined to waste cans and storage drums. In the event of fissile bearing debris arising in the facility, routine operations will be curtailed until recovery has been effected.

ASSAY INSTRUMENTATION AND MEASUREMENTS

Two assay instruments will perform measurements on the waste cans before they are combined and repackaged in 400 liter drums:

A Gamma Spectrometer to measure and identify gamma-emitters that constitute more than 5% of the total emission from the waste cans. This information is primarily used as a confirmation check on the identity of the can against plant records, but also provides isotopic measurement in advance of eventual disposal.

A Neutron Interrogator to measure the uranium and plutonium content of the waste cans, primarily the fissile isotope content, to assist in criticality control and accountancy.

The requirements that chiefly influenced the design of these instruments are as follows:

- Throughput. The average time for completing both sets of measurements on a can (including can handling operations) should not exceed 1 hour.
- Can size and content. The instruments must be capable of handling the wide variety of can types that have been used and which will be used in future waste arisings (12 different types with widely differing dimensions have been specified). Because of the diversity of sources of this waste, there is a large range of possible can contents, both in terms of radionuclide inventory and the waste matrix (the can mass may vary in the range 0.5 - 140 kg and the surface dose rate from 0-1000 Sv/h).
- Plant compatibility. The complete assay measurement system must be capable of 'turnkey' operation and should interface with other computer and PLC systems controlling operations within the waste facility. Also, the mechanical design must be compatible with the biological shielding philosophy of the waste facility; in particular the number of in-cell components requiring regular servicing or replacement should be minimized.

The Gamma Spectrometer

The gamma spectrometer consists of a single high purity germanium (HPGe) detector located outside the assay cell which views the waste can through an adjustable collimator penetrating the rear wall of the assay cell.

The collimator has two functions: it restricts the detector's field of view to a small region of the can and it controls the amount of radiation incident on the detector from the viewed region. Because of the very large range of possible can activities, the collimator aperture is adjustable. The collimator mechanism is computer controlled and so can be set appropriately, based on the recorded can activity, to achieve a suitable count rate in the detector.

The Neutron Interrogator

Neutron interrogation involves placing a waste can inside a 'neutron well counter', exposing the waste cans to neutrons from a sealed ^{252}Cf source, removing the source to a shielded 'home' position and counting the delayed fission neutrons from the can. In order to reduce the effects of the inhomogeneity of the contents, the can is rotated to each of eight equi-spaced positions around its axis during an assay and the vertical position of the interrogating source can be varied. Interrogation with different energy neutrons (thermal or epicadmium) is used to identify and correct for the effects of any sample self-shielding. The fissile isotope content is expressed in terms of the equivalent amount of ^{235}U (or ^{239}Pu).

The system also measures the passive neutrons that are emitted by spontaneous fission of the even isotopes of plutonium; ^{238}Pu, ^{240}Pu, ^{242}Pu). Between 2 and 3 neutrons are emitted per fission so coincidence counting can be used to distinguish these neutrons from background neutrons emitted singly (eg α, n neutrons). Comparison of the results of the fissile and spontaneous fission measurements will generally enable the masses of uranium and plutonium to be separately estimated.

The neutron interrogator is designed to fit closely around a well in the stainless steel floor of the assay cell. The can to be measured is placed in the well and remains within the containment of the cell while the detectors, moderator and electronics remain outside to avoid contamination. The interrogator is designed so that all the functional components can be accessed for maintenance by withdrawing the instrument from below the cell.

Calibration of the Neutron Interrogator System

The neutron interrogator measurements are affected by the precise form of the waste e.g. the container size, the composition and uniformity of the waste matrix, the distribution of the fissile material in the can and the degree of self-shielding of the neutron signal within the fissile material itself. The method of calibration adopted involves carrying out measurements on well characterized simulated waste cans which are used to benchmark Monte Carlo calculations of the neutron interrogator response. The Monte Carlo simulations are then used to derive the calibration factors over the full range of sample types. Each can type will be characterized by subsidiary on-line measurements to ensure accurate assay.

Realization

The mechanical design of both assay instruments were reached by an iterative process, especially in the case of the neutron interrogator, whereby the instrument design was closely coupled to that of the assay cell. The design of both the assay cell and the instruments evolved together - the instrumentation is not an 'add-on extra' to the waste facility.

Software controlling the operation of both instruments runs in a single IBM-PC compatible computer, which forms the main operator interface during assay measurements. The gamma-ray counting electronics is in the standard NIM format while the main neutron counting and electro-mechanical control subsystem is implemented in VME format. Both the NIM and VME units are interfaced to the controlling PC via dedicated data connections.

STATUS AND SCHEDULE

The Building and Civil work is planned to be completed in early 1993 when comprehensive commissioning will begin. Active operation is planned for mid 1995 with the issue of the Authority to Operate.