RETRIEVAL OF INTERMEDIATE LEVEL WASTE AT TRAWSFYNYDD NUCLEAR POWER STATION

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ABSTRACT

In 1996 RWE NUKEM Limited were awarded two contracts by BNFL Magnox Generation as part of the decommissioning programme for the Trawsfynydd power station. From the normal operations of the two Magnox reactors, intermediate level waste (ILW) had accumulated on site, this was Miscellaneous Activated Components (MAC) and Fuel Element Debris (FED). The objective of these projects is retrieval of the waste from storage vaults, monitoring, packaging and immobilisation in a form suitable for on site storage in the medium term and eventual disposal to a waste repository.

The projects involve the design, supply, commissioning and operation of equipment to retrieve, pack and immobilise the waste, this includes recovery from vaults in both reactor and pond locations and final decommissioning and removal of plant from site after completion of waste recovery.

INTRODUCTION

Trawsfynydd nuclear power station has two Magnox type reactors which were shut down in 1995 at the end of their working life. During normal operations two types of intermediate level waste (ILW) have accumulated on site; namely Miscellaneous Activated Components (MAC) and Fuel Element Debris (FED). MAC is predominantly components, which have been activated by the reactor core and then discharged. FED mainly consists of fuel cladding produced when fuel elements were prepared for dispatch to the reprocessing facility. As part of the decommissioning programme for the site, these waste streams are to be retrieved from storage vaults, monitored, packed and immobilised in a form suitable for on site storage in the medium term and for eventual disposal in the long term waste repository to be commissioned by NIREX at a later date.

In 1996, BNFL Magnox Generation, defined the waste storage strategy and awarded two contracts to RWE NUKEM Limited for the design, supply, commissioning and operation of equipment to retrieve, pack and immobilise the two waste streams. This included waste recovery from vaults in both reactor and pond locations and the final decommissioning and removal of plant from the site after successful completion of the waste recovery programme.

PROJECT REQUIREMENTS

The Waste

Operation of the Trawsfynydd Nuclear power station has resulted in the production of radioactive waste material of both low and intermediate level activity. Low level wastes have been packaged and transferred to the Drigg disposal site in Cumbria, but solid intermediate level waste is stored in below ground concrete vaults on site.

MAC

MAC waste mainly comprises of irradiated core components such as flux flattening, bars which are cylindrical, 75mm in diameter and 760mm long and pantagraph rods, but also includes a wide range of items discharged from the charge face, such as thermocouples, cables, grabs and steel components from stand pipe closure assemblies.

MAC is stored in two vaults located in the basement areas of the bioshields of reactors 1 and 2. The waste was discharged through a chute that starts at the reactor pile cap and travels approximately 35 metres down into the vaults. Some of the smaller items were packed into canisters and some of them have split open as a result of the drop.

The MAC Vaults

The two MAC vaults are approximately 7.5m by 6.5m by 3m deep. They are constructed from concrete and have a wall thickness of 1m and roof thickness of 1.5m. The walls of the vault were protected from the falling waste by mild steel crash plates. These are part of the vault structure and as such will not be retrieved as waste but will be decontaminated, as necessary, during final decommissioning. The vaults are located beneath the large carbon dioxide inlet gas duct chambers of the reactor basements.

FED

FED waste consists of magnox cladding and end fixtures stripped from the fuel elements prior to their dispatch for reprocessing. The waste includes magnox splitter cages, nimonic springs, housing cups and thermocouple attachments. This material has been discharged into two sets of 16 storage vaults located at the north and south ends of the ponds buildings.

The FED Vaults

Each of the FED vaults is approximately 2m by 2m by 4m deep and they are between three quarters and completely full. The waste was discharged into using a vibratory conveyor system housed in the chambers directly above the vaults.

SCOPE OF THE PROJECTS

The projects includes all activities necessary for the safe recovery and packing of the defined ILW waste streams in a form suitable for on site storage and eventual disposal in the NIREX waste repository.

Primary activities required to be completed included;

- Detailed site survey of the vault and adjacent areas including the layout of existing plant and equipment and available services.
- Scheme and detail design of the new equipment and site works supported by calculations, specifications and manufacturing drawings
- Preparation of the safety case (BNFL Magnox obtain necessary approvals)
- Manufacture, assembly and off site works testing of the plant and equipment
- Site civil and structural works, equipment, delivery, installation and commissioning
- Training of operators and operation of the facility.

Requirements for waste storage included the use of 'NIREX' $3m^3$ stainless steel boxes together with separate concrete overpack boxes which provide the necessary shielding. The $3m^3$ boxes and overpacks are stored in the reactor sub-basements and special handling equipment is needed accordingly.

The MAC and FED waste streams are in four locations within existing buildings which provide very limited access for the deployment of the recovery and packaging equipment. Appropriate access routes have to be cut through existing structures to enable the waste to be recovered to a facility which provides containment and can safely catalogue and pack the waste into $3m^3$ stainless steel boxes. The waste is immobilised in grout and the $3m^3$ Box then placed inside a reinforced concrete shielding overpack. The completed package is transferred to one of four temporary ILW stores constructed in the reactor sub-basements.

TECHNICAL SOLUTION

Outline

Because of the access difficulties a conventional solution would involve recovery of the waste and local loading into a specialist transport container which would then transport the waste to across site for input to a separate multi-waste processing facility. This approach was considered unattractive for the following reasons.

- Cost — a large multi waste facility would be expensive to build and decommission.
- Programme — the design/construction programme would be comparatively long compared to the operating life.
- Production rate — the required production rate would be difficult to achieve due to double handling and the number of potential waste movements across site.
- Secondary waste — potential for large quantities of secondary waste during final decommissioning.
- Public relations — difficult to obtain approval to construct a major new facility on a decommissioning site.

An alternative and innovative approach was adopted, whereby the plant size was minimised and the recovery and packaging plants were located in the existing spaces above and adjacent to the vaults. This had advantages in the control of contamination and secondary waste and also reduces the subsequent decommissioning required by making use of areas already scheduled for decommissioning. This strategy has resulted in two facilities (one each for MAC and FED) designed to be operated at the point of waste recovery. At the completion of recovery operations at the first location the plant design enables them to be dismantled and transferred to the second locations.

Waste Retrieval

The treatment of MAC and FED waste after recovery is similar but the method of waste retrieval is different, reflecting the different problems involved. The most significant differences in the retrieval solutions are;

- MAC recovery is achieved with a hydraulic Artisan manipulator arm deployed through a series of new access points in the vault roof.
- FED recovery utilises two retrieval units, which deploy grabs through tubes originally connected to the waste discharge conveyors.

MAC Retrieval

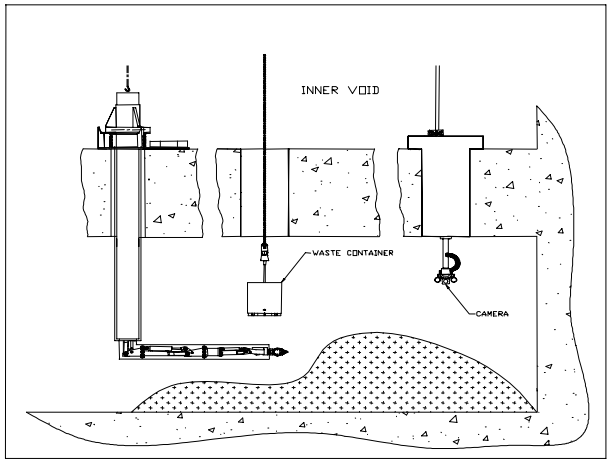
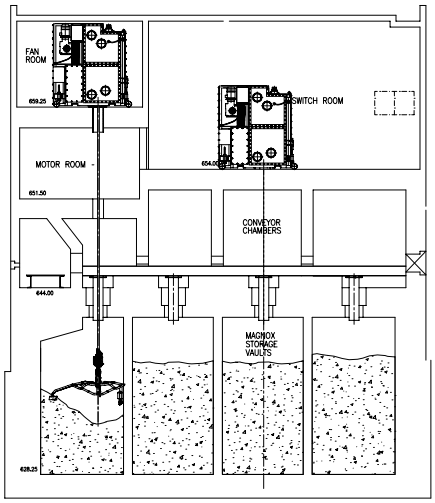


Fig. 1. Artisan deployed in the Vault

MAC waste is picked up using a hydraulic manipulator, operating through a access holes in the roof of the vault. The waste is loaded into a basket suspended in the vault from a travelling hoist. The manipulator is a proprietary unit developed for use in a radioactive environment and it is used to deploy a range of grabs and tools. It can operate from any one of six newly cut holes in the vault ceiling to give full coverage of the vaults. The manipulator is operated from a remote control room by means of two 3-axis joysticks, linked to a PC controller, and two CCTV monitors. Radiation tolerant cameras and associated light units, mounted from plug units in the roof of the vaults, provide pan tilt and zoom functions.

The travelling hoist also operates through a hole in the roof of the vault from the inner void. The hoist is mounted on an overhead monorail, forming the waste transfer system, so that when the basket is full, it can be raised through the access hole and transferred to the packing cell via the waste transfer tunnel. Three gamma monitors in the transfer tunnel measure the exterior dose rate of the container as it passes through.

FED Retrieval



FED is picked up by a petal grab(s) deployed from a retrieval unit(s) situated in the rooms above the vaults. A new waste transfer trolley system has been installed in the chambers below where the vibratory conveyor systems were housed. The old conveyors had to be cleared of waste and removed before the new trolley systems could be installed.

The grab is withdrawn to a point where it releases the waste into the trolley. The trolley is then driven to the waste conveyor that, in turn, transports the waste to the packing cell, via an assay station.

The Retrieval Units

The mobile retrieval units comprise a high integrity glove box which houses an electric winch, pneumatic hose reeling system and grab storage station. Each unit is equipped with 3 different retrieval grabs allowing waste to be recovered from any position in the vault. The retrieval units can be moved over any of the 16 positions in the conveyor chamber floor which give access to the vaults. They locate on 10-inch diameter stand pipes, which cover each of the holes in the floor and are fitted with blanking shield plugs to maintain containment.

The Transfer trolleys

The trolleys run on rails in ducts installed in the old waste conveyor spaces. Each trolley serves four of the vault access shafts and there are four trolleys at each of the two pond locations. Stand pipes, ten inches in diameter, line the access holes and form a containment between the vaults and the trolley ducts and also between the trolley ducts and the retrieval units. A ventilation system maintains the ducts at a depression to produce an inward airflow to minimise the potential for spreading contamination.

MAC and FED Waste Processing

The MAC and FED waste streams undergo similar processing consisting of the following activities:

- Monitoring the retrieved FED waste so that fuel fragments can be identified and separated.
- Monitoring dose rates and waste sorting so that efficient packing and self shielding in the boxes can be achieved
- Packing waste into $3m^3$ boxes for safe storage
- Fitting a lid and grouting the waste to immobilise it in the boxes
- Applying a capping grout to completely fill each box, after the initial fill has cured.
- Swabbing the boxes to ensure they are free from external contamination
- Placing the boxes into overpacks and fitting an outer lid
- Moving the overpacks to interim storage areas in suitable existing buildings on site.

The Processing Cells

The MAC and FED processing cells are similar in design and incorporate the following features (see Figs 3 and 4).

Shielding

The cell shielding panels are constructed from laminated mild steel plates, which interlock, to eliminate shine paths at the joints. Access to the cells is via gamma gates in the Shield walls. Each cell is equipped with lead glass windows and a pair of manipulators to enable operation of incell equipment.

Waste packing and grouting cell

The packing cell is part of the primary containment and incorporates a 'double lidded' port which enables the lid of the $3m^3$ box to be removed whilst preventing the spread of contamination to the outside of the $3m^3$ box or other areas of the processing and grouting cells. Monitoring equipment is provided to enable the activity of the waste being packaged to be controlled. The grout cells are provided with equipment to bolt the $3m^3$ box lid and encapsulate the waste in grout whilst maintaining full containment. The grouting cells are designed to remain free from contamination. A robotic swabbing system checks the exterior surfaces of the box to confirm they not contaminated.

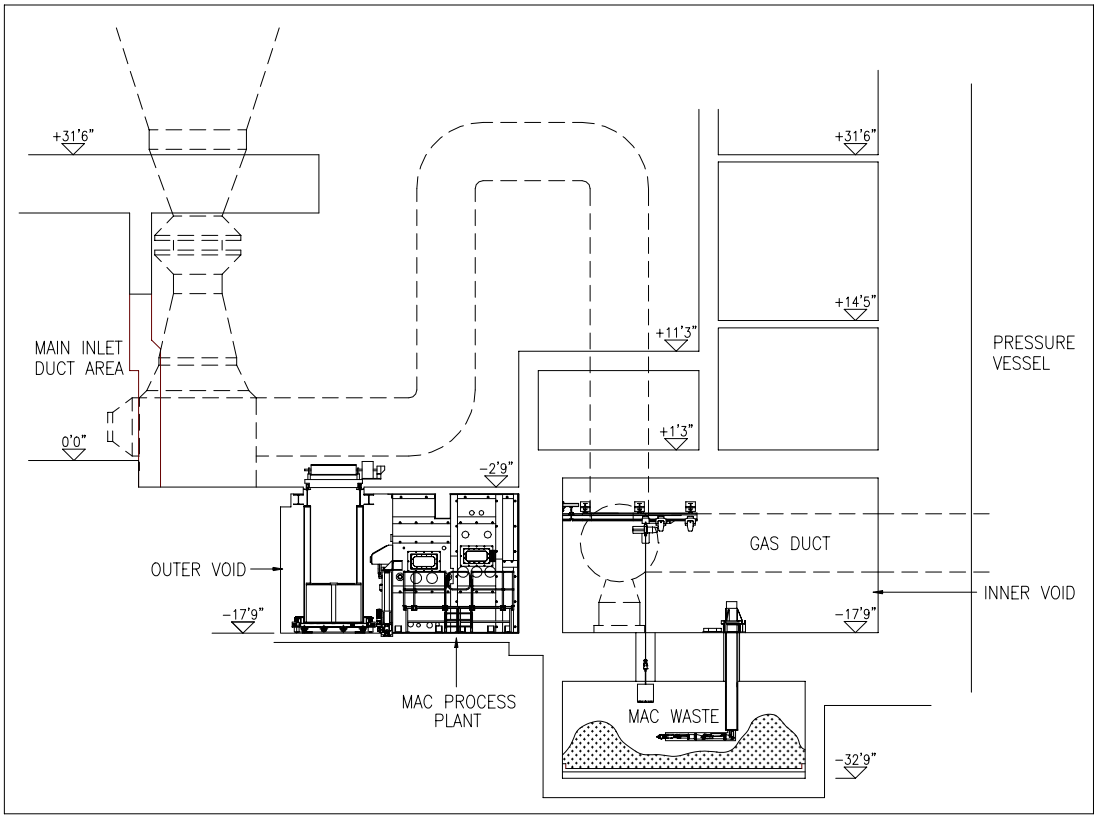


Fig. 3. MAC Plant: Elevation

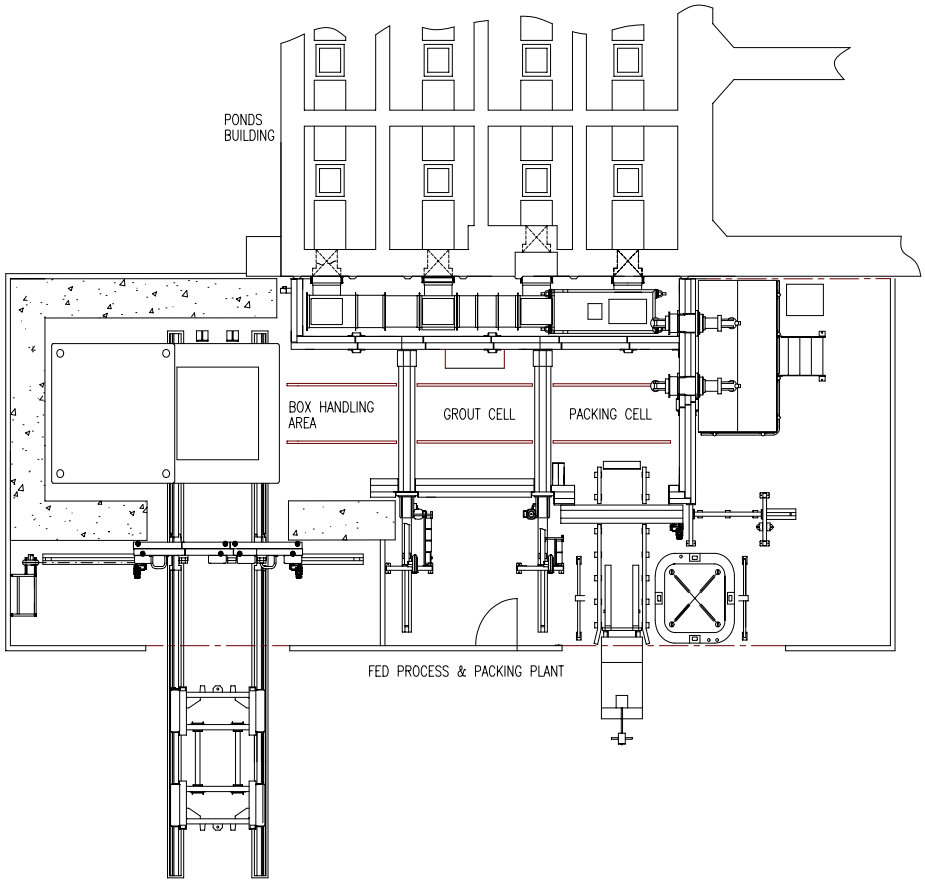


Fig. 4. FED Plant: Plan view

Box Transfer System

Trolley systems transport the $3m^3$ box between cells and to the overpack handling area. The trolleys incorporate jacking and rotation devices to facilitate bolting and swabbing. An integral weigh station is used to ascertain the weight of packed waste.

Overpack Handling Area

The overpack handling area is a shielded area where the finished waste package is placed in a concrete overpack. An overhead gantry crane has been designed to handle both overpack lids and $3m^3$ boxes. The overpack lid is first removed and placed on an adjacent stand. The grouted waste package is then lifted and placed inside the overpack and the lid replaced ready for transport out of the facility

FED Assay System

The FED process cells incorporate a fuel monitor, which assays the waste on the tray. By monitoring the data produced the operator is able to maximise the packing density and control the surface dose rates of the box.

The Grout Plant

The grout plant produces a high shear, high fluidity grout in a commercially available colloidal mixer. The grout plant output is $2m^3$ per hour. The plant has systems for:

- cement powder delivery
- chilled water delivery
- grout mixing
- mobile grout storage with agitation
- grout discharge
- wash down

The grout is transported to the packing plants in mobile grout hoppers which discharge the grout through cell delivery pipes into the $3m^3$ box.

The Ventilation System

The active ventilation system comprises a mix of existing plant and ductwork and some additional plant and ductwork for the new facilities.

The ventilation system provides the following design features:

- Air flows from areas of lower risk to areas of higher risk of contamination.
- Primary containment facilities are held at a depression relative to other areas.
- Air velocities across openings are controlled to prevent back diffusion.
- HEPA filters prevent back flow from primary containment facilities.
- All extracted air is drawn through HEPA filters and is sampled for airborne active particles before discharge to atmosphere.
- The extract plant is failsafe and has appropriate monitoring and control systems.
- The ventilation system is monitored and ventilated for hydrogen where appropriate.

Hydrogen

The installed instruments will monitor the flow rate and will check for the presence of hydrogen. The design flow rate will keep hydrogen levels within specified limits during grouting and curing.

Fire Precautions

The main potential fire hazard is on the FED project. There is a potential to ignite the Magnox through the disturbance of hydrided fuel.

Two sophisticated fire detection systems have been provided. The first samples the waste storage vaults and triggers an automatic Argon based fire suppression system. The second system monitors the sort cells, conveyors and retrieval tunnels and generates an alarm to alert the operators to the problem. In cell fires are extinguished by the manual discharge of Graphex powder.

Waste Storage

The Trawsfynydd ILW waste will be packed and immobilised in $3m^3$ boxes, which in turn are placed in, overpacks manufactured to designs approved by Nirex.

The following systems have been provided by BNFL Magnox generation and interface with the retrieval and processing plants.

$3m^3$ Boxes

The boxes are fabricated from stainless steel for corrosion resistance. Lifting features are provided in the top of the box walls for accepting standard twist locks. A separate lid bolts to the box. The maximum allowable weight of a filled box is 12 tonnes.

Overpacks

The waste packages will be placed inside concrete overpacks to facilitate safe handling and storage. They are thick walled reinforced concrete boxes that provide shielding sufficient to reduce exterior surface dose rates to levels in accordance with the transport of radioactive materials regulations. The weight of the overpack and lid is approximately 30.5 tonnes.

Straddle Carrier

The overpacks will be moved across the site from the overpack handling areas adjacent to the process cells to the interim storage area by a straddle carrier. This has been modified from cab to pendant operation and has a capacity of 45 tonnes.

Air Transporter

Within the Overpack handling areas and the storage areas, the overpacks will be moved on an air transporter which is a steel frame fitted with air pads. It has very good manoeuvrability and is very compact.

Interim Storage

The current strategy assumes that the waste will be stored securely on site until NIREX provide a suitable repository. To this end, four of the circulator hall sub-basements cleared of all plant, will act as interim storage.

REVIEW

At the time of writing the MAC facility is successfully recovering and encapsulating waste from its first reactor location and the FED facility is nearing completion of its commissioning phase.

By developing an innovative approach to the project it is believed the following has been achieved.

- Access and waste handling problems solved
- Construction work on site reduced
- Costs of final removal and disposal minimised
- Environmental impact negligible
- Significant reduction in investment required

- Solutions can be adapted for other stations