THE DESIGN AND CONSTRUCTION OF A FACILITY FOR THE HANDLING AND PACKAGING OF RADWASTE FROM JET OPERATIONS.

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ABSTRACT

The volume of radioactive wastes (radwastes) and the procedures for collection and disposal were influenced by the first tritium experiment on JET in 1991. Most of the primary and secondary arisings of radwaste have resulted from the removal of components from the vacuum vessel, in preparation for the installation of the pumped divertor. Operations in other controlled areas in support of shutdown programs have also produced secondary wastes. The for-seen increase in the volume of potentially radioactive waste led to the need for a facility to effectively and efficiently deal with the waste produced. The initial designs were produced and, against a tight time-scale, the facility was completed to fulfill its role in the pumped divertor shutdown.

INTRODUCTION

The JET Joint Undertaking was set up to construct and operate the Joint European Torus (JET). JET is the largest single project of the co-ordinated nuclear fusion research program of the European Atomic Energy Community (Euratom) aimed at proving the feasibility of thermonuclear fusion as a new energy source. The project was established in 1978 and commenced operation in June 1983. The current operations program is due to run until the end of 1996. Experimental operation of JET has, since June 1983, produced deuterium plasmas. D-D fusion reactions have produced 2.45 MeV neutrons, which together with photo-nuclear (γ-n) reactions, have lead to limited activation of the vacuum vessel materials. Following an initial dominance of Ni 57, resulting dose rates were mainly due to Co 56, Co 57, Co 58 and Ni 57. JET policy is to restrict the dose burden to radiation workers to 5 mSv/annum and for this reason the neutron flux during D-D operations was limited to $< 3\text{x}\,10^{19}$ neutrons, resulting in an in-vessel dose rate of $< 100\ \mu$Sv/h. As a result of these operations, JET maintenance tasks have produced small quantities of potentially radioactive waste for some time. The characteristics of the waste generated changed in 1987 with the introduction of beryllium as a cladding material for the inner wall of the main vacuum chamber (first-wall). Tritium, used in the successful First Tritium Experiment (FTE) in November 1991 (1), resulted in an additional constraint affecting waste management. All wastes so far produced have been initially stored on the JET site. Sampling and analysis have been carried out to characterize the waste, some of which has been disposed of as non-active beryllium contaminated waste to a licensed land-fill site. The remainder is shipped to the UK Repository for low level waste.

CONCEPTUAL DESIGN

In the early spring of 1991 it was established during the planning of a shutdown for the installation of the 'pumped divertor' (2), scheduled to begin in February 1992, that there would be a need to provide a facility where:

- first wall components and drummed equipment could be transferred to and from ISO containers. The installation of the coil assemblies for the pumped divertor necessitated the removal of all components attached to the inner wall of the vacuum vessel. These included wall-protection tiles, components of the plasma additional heating systems, dump plates and limiters.
- operational waste from other areas could be sorted and sampled.
- volume reduction on all radioactive low level secondary 'soft' waste could take place.
- samples of various hard and soft material could be taken to determine its level of activity and hence its disposal route.

Work began in April 1991 on the conceptual design of a Waste Handling Facility (WHF) including the internal plant features necessary to deal with the unique cocktail of wastes likely to be handled throughout the shutdown. A key feature in the design of the new facility was a layout which would enable the materials removed from the JET machine and be handled without affecting the very tight time schedule for the shutdown. All the components were to be removed during a strip-out phase and transferred to the new facility. Materials could then be sampled, inspected and segregated into those suitable for reuse and those to be disposed of as waste. During this time other interested groups at JET were asked to provide details of the type of waste that they may produce. Details of the activity and surface contamination levels on typical components and materials to be handled that have arisen from the current shutdown are shown in (Table I). Using this information the overall concept was established and, except for minor detail changes, the design was agreed (Fig. 1).

PLANNING PERMISSION AND TENDER EXERCISE

To be consistent with the planning permission for the JET site and the time constraints imposed on the project, a prefabricated and modular construction was selected. The units were to be preassembled and tested as far as possible at their place of manufacture then reassembled and commissioned on the JET site. A design review of the facility was held in June 1991 and the design was frozen. Planning permission was granted in late July with the restriction that the facility was used only for waste handling, i.e., sorting and sampling. Invitations to tender, along with the specification for each major contract were released immediately planning permission was granted and all the major contracts were placed on 12/09/91.

TABLE I
Activity and Contamination Levels on JET Components

Carbon Tiles	
Tritium Content	< 10MBq/tile
Tritium surface contamination	< 50Bq/cm^2
Be7 content	< 10Bq/g
Be loose on surface	< 0.06μg/cm^2
Be layer on surface	< 540μg/cm^2
Antenna doors and tile fixtures	
Tritium content	< 1-4KBq/g
Tritium surface contamination	< 50Bq/cm^2
Be loose on surface	< 0.06μg/cm^2
Be layer on surface	< 540μg/cm^2
Co^{57}	< 14Bq/g
Co^{58}	< 25Bq/g
Co^{60}	< 3Bq/g
Cr^{51}	< 1Bq/g
Tools	
Tritium surface contamination	< 0.37Bq/cm^2
Be loose on surface	< 0.06μg/cm^2

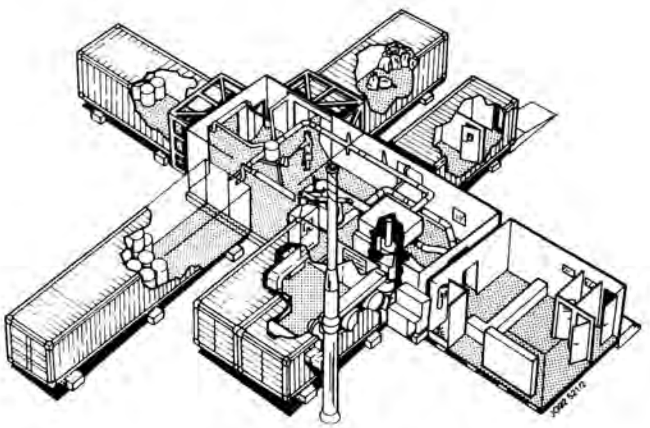


Fig. 1. Waste handling facility.

DESIGN FEATURES

Main Operation Area

The facility had to be equipped to deal with the waste handling operations of sampling and sorting, volume reduction of compactable wastes and the movement and handling of drums and components. The layout and size for the floor area of the main facility were established by a logistics exercise that considered all the activities and material handling that would be required.

The dimensions of the main area 12 x 5 meters, were dictated by the UK road transport restrictions which limits the width of loads to 5 meters. The average height of the operations area is 3 metres.

The specification for the facility called for a fully welded steel structure with a floor loading of 1.5 ton /m^2. Both the roof and walls had a seal welded steel cladding inside and out, with a fully insulated cavity. A blister in the roof provided an aperture to lower the in-drum waste compactor into position and to remove the cylinder, if necessary, during routine servicing.

Inside, the exposed surfaces are smooth faced and easily cleaned. A peelable coating initially used on the floor was not sufficiently durable to be used during operation and was replaced with a zinc rich, high build, painted surface.

In order to make best use of the main operations area and to speed up the off-site manufacture it was decided to create most of the additional modules from specially adapted ISO containers. These ancillary features are as follows;

- Goods Inward Air-lock: for posting in clean drums, components, tools etc. and posting-out cleaned or double- bagged items for transfer to other areas.
- Buffer Store: to hold material in transit, clean drums or to allow collections of 'same type' components to be mustered prior to being dispatched.
- Ventilation Modules: to house the input and extract plant. These had to be kept separate, the input plant being on the clean, atmospheric side of the system and providing a suitable location for the main power and switch gear, air compressor and stack monitoring equipment.
- ISO Container Air-locks: these are a unique feature of the WHF. They are made of steel sheet with an external skeleton exposing a smooth, easily cleaned surface to the main operations area. The air-locks can accommodate the entire end of an ISO container which, once 'docked-on' to the main operations area, with its doors closed, can be opened without risk of a contamination spread outside the controlled area. This is achieved through the use of flexible wiper seals and the high specification ventilation system which keeps the main operations area under depression and provides an air flow rate in excess of 1.0 m/s across the annular opening. Access into the containers is gained by drawbridges which span the gap between the floors of the main operations area and container.

Fig. 2. In-drum waste compactor.

- Change Area: is constructed in a similar manner to most temporary site buildings. It is fitted with an emergency dowsing shower, full change facilities, toilet, change barrier, shelving for Respiratory Protection Equipment (RPE), a supervisor's desk along with various cupboards and cabinets. It is connected to the main operations area by a twin door air-lock arrangement.

In-Drum Waste Compactor

Past experience had shown that around 90% of JET secondary waste was trapped air. The cost of disposal of the waste, should it be potentially contaminated with radioactivity, would have been prohibitively high. The decision was made to install an 'in-drum' compactor to 'size-reduce' the volume of the waste (Fig. 2) .

The waste is compacted into standard 200 liter drums with a usual compaction factor of 7:1 and sometimes up to 10:1. In order to minimize the risk of contamination spread to the working area, it is connected directly to the facility's ventilation system which draws air from the compactor during all stages of loading and compacting.

The downward force of 16.0 tons (max) is delivered by a hydraulic cylinder through a flow and pressure control unit. All the functions of the main hydraulic ram and loading hood are interlocked to prevent accident.

Waste Sorting and Sampling Station

It was realized at an early stage that there was likely to be a low potential for radioactive contamination (tritium) for the majority of secondary housekeeping waste, coveralls, wipes, etc. Even so all the waste, unless we could demonstrate otherwise, would have to be regarded as radioactive. It was agreed that a method of sampling the waste in batches would be implemented to facilitate analysis and sentencing. Therefore the need for a waste sorting and sampling station capable of allowing this task to take place in a controlled environment was necessary. After extensive enquiries it became evident that such a workstation would have to be specially designed (Fig. 3).

The main difficulty was to create a work station to meet varying needs. The unit, effectively a slit/glove box, comprises a stainless steel work area mounted on a frame. The frame has two sets of rollers to allow easy load/unload of drums containing the sampled material and a box, with a controlled air flow, at the rear in which it is possible to open drums with a potential tritium content. Also inside this box is a mechanism, pneumatically operated, which, when the door from box to work area is open, can tilt the drum and dispense its contents for sorting or sampling. All the tilting controls are interlocked to prevent unsafe operation.

The waste samples are analyzed for both beryllium and activity content. Gross β/γ activity is determined by γ-spectrometry on a Marinelli beaker sample. Other methods of analysis were studied, including waste bag and drum monitors. Unfortunately, the activity signature of the JET wastes is characterized by the absence of hard g emitters. Available detection systems are normally calibrated to look at Co 60 and Cs 137, neither of which are present in the wastes handled. An additional problem is the determination of tritium at very low levels. Waste packages and drums are sniffed in the facility but the low threshold of detection is around 100 Bq/g. Studies are ongoing at JET to develop a method of sample preparation which, used in conjunction with liquid scintillation counting, would permit tritium levels at < 0.4 Bq/g to be determined.

Ventilation System

The ventilation system was designed as an air-conditioner as well as being able to provide, for any gap or opening, an 'air' barrier of 1m/s which could be drawn across it. This obviated the need for perfect seals around what were likely to be less than perfect surfaces. The system, with its potential inventory of tritium, required the use of a monitored discharge stack.

The input plant consists of a unitary air handler with a capacity of 1.544 m^3/s, a maximum velocity of 2.75 m/s and an external resistance of 350 Pa. Also inside this module is housed all the associated control panels for, heating, frost protection, fan overrun, filter differential pressure and high and low temperature control along with the compressed air system which provides the motive power for the Waste Sorting and Sampling Station as well as driving the main air dampers and air eject static air sampler.

The extract plant comprises of an all welded duct work system to AESS 6008 Part 2 and safe change HEPA-V filters in canisters fitted with ultra low leakage dampers. The centrifugal duty and standby fans give 1.2m^3/s against a head of 1500 N/m^2. During normal operation the main operations area is kept at an internal depression of 10mm (water gauge). The whole plant extracts through a discharge stack that terminates

Fig. 3. Waste sorting and sampling station.

Fig. 4. Ventilation (extract) module.

10m above ground level, the extract rate is monitored by a flow grid.

Other Plant and Equipment

The handling of drums and heavy components inside the facility is carried out using a pedestrian operated, counter-balanced, fork lift truck. The required specification of this truck was dictated largely by the confined areas in which it was likely to be used. The maximum turning radius is 1.0 m and the total mast height at full extension can not exceed 1.9m. This ruled out the use of a standard model and we had to adapt a stock product (Fig. 5).

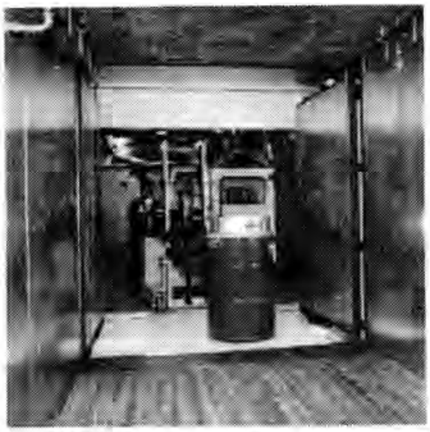


Fig. 5. Fork lift truck.

Drying Bench

At the end of the strip-out phase the internal wall of the vacuum vessel was cleaned using a grit-blasting technique. As a result of this, some of the secondary wastes received at the WHF were damp, having been used to mop-up after the in-vessel wash. As these wastes could not be accepted by the repository, they needed to be dried beforehand.

Consequently a drying bench has been erected with sides made from optically clear PVC into which glove ports are fitted. Warm air is drawn into the enclosure by a direct connection on to the main ventilation plant.

CONSTRUCTION

The main body of the contract was let in early September 1991 to a specialist firm experienced in the construction of nuclear engineering facilities. Their scope included the manufacture of the main building, change area and detailed design of the ventilation system along with the on-site construction of facility. Progress was closely monitored and supervised by JET Waste Management Group.

In parallel to the main contract JET's own site service groups began work on the services and the ground works. The services required for the facility included power, mains water, mains drainage, dedicated active water drain tank, communications and local and remote emergency alarms which are fed back to the main JET control room.

The main contractor's site team mobilized at the beginning of January 1992. The modular design of the facility permitted manufacture of the main components proceeding in parallel enabling the tight program to be met.

COMMISSIONING

On the 6 February and before the construction phase had finished, the on-site commissioning began on those parts of the plant which did not require power. Power to all units was made available on the 10 February and all systems were checked and operated. The major problem encountered during this stage was achieving the specified leak tightness of the main operations area (half an air change per hour). All joints were checked and tested for air ingress but no apparent leaks were identified. After much searching a leak path was found between the welded cladding panels. This was rectified and the specification fulfilled.

The benefit of pre-delivery inspection and works acceptance testing paid dividends, in most cases as this phase of the project was kept down to just 8 working days.

The official hand-over of the WHF took place on Monday 17 February 1992, 2 weeks before the start of the 'pumped divertor' shut-down (Fig. 6).

Fig. 6. Completed waste handling facility.

OPERATION

Since the start of the shutdown the WHF has performed well. To date ISO containers have been docked on and off the facility on more than 60 occasions with in excess of 450 separate drum or component transfers taking place. (3)

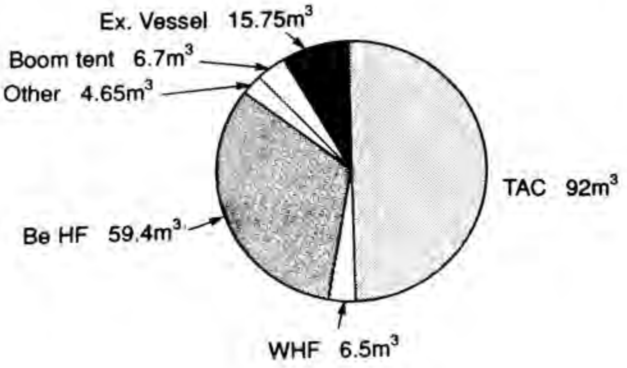
Initial work dealing with operational wastes concentrated on secondary wastes which consist mainly of disposable clothing and housekeeping waste. By the end of January 1993 121 drums of compacted waste had been prepared and shipped for disposal via AEA, Harwell, to the UK Repository at Drigg. Some progress has also been made in the disposal of wastes accumulated from earlier shutdowns.

Most recently work has begun on preparation of primary component waste materials. Some of this is packed into 200 liter drums to IP2 specification but others will be disposed of in 'half height' ISO containers. The total volume of secondary waste material, by area, handled in the facility up to the end of January 1993 is shown in Table II.

CONCLUSIONS

1. The modular design and close supervision and monitoring of progress during off-site manufacture and testing and on- site construction led to the facility being available on schedule.
2. Contamination control has been excellent during the first year of operation and the facility may be

TABLE II
Volume of Waste Handled (By Area) TOTAL = 185 m^3



TOTAL = 185m3

reassessed to permit handling of components with higher contamination levels.

3. The speed in which ISO containers could be emptied and sent back to the vacuum vessel was better than forecast and contributed to the uninterrupted follow of materials during the strip-out phase.

REFERENCES

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