Developments in Contamination Control and Respiratory Protection at JET

A D Haigh, R Middleton, P Edwards, C P Callaghan,
C May, P Macheta.

JET Joint Undertaking, Abingdon, Oxfordshire, OX14 3EA,

1. INTRODUCTION

Since the introduction of beryllium in 1989, and the tritium campaigns in 1991 and 1997, the issue of controlling the spread of contamination and the protection of the workforce has had an increasing impact on operational tasks at JET. When considering engineering controls for the protection of the workforce the following hierarchy generally applies:-

1. containment- to provide a continuous barrier between the contaminant and the workplace
2. confinement- the use of ventilation systems and the directed flow of air to capture and contain the contaminant
3. respiratory protection- the provision of personal protective equipment to protect the individual worker from a noxious environment

2. CONTAINMENT

There are many examples of containment technology developed at JET including glove boxes; ventilated slit boxes and enclosures; tailored flexible membranes (isolators); and tents. In preparation for the Remote Tile Exchange Shutdown (RTE), facilities were designed which would cope with:-

- Enhanced radiation levels from inconel activation (enhanced dose rates)
- particulate contamination, both beryllium and tritium impregnated graphite
- surface and off gassing tritium (elemental and water vapour)

A dual purpose glove box/ventilated enclosure was developed to provide a facility for items with elevated contact dose rates, up to 500 μ Sv h^{-1} measured at 30 cm, and with the facility to provide either containment, in its glove box mode; or with elevated tritium off gassing rates, in its flow cabinet mode. The box was specifically designed to accommodate long diagnostic components with an adaptable flexible containment at one end.

Figure 1. Ventilated Enclosure / Glove Box

The enclosure incorporates a ventilation throughput of up to 1 $m^3 s^{-1}$,removable shielding plates and lead/wool blankets, removable glove ports, a lead glass viewing panel, a services feedthrough and a posting port in the base. The structure was designed to accommodate a distributed load of up to 1 tonne to allow additional lead shielding blocks to be arranged inside the enclosure for specific operations. The top and end panels are removable to allow overhead lifting of large or heavy items into the box.

2.1 Isolators

Figure 2. A selection of isolators.

During the lead up, and throughout, the RTE over 350 specifically designed and tailored isolators and tents were fabricated and used. Isolator operations have been carried out which involve beryllium contamination of the order of milligrams per meter squared on the inside and after the operation there is routinely no detectable beryllium contamination on the external surfaces (limit of detection is 0.03 μg). Since the isolator material is of a welded construction and is impervious to particulate beryllium in its solid form, protection factors can be anticipated greater than 10^6 Isolator operations involving airborne tritium atmospheres within the isolator at levels up to 5 GBq m^{-3} have been carried out. External surface contamination from direct permeation has not been detected for operation of a few hours in duration.

Airborne concentrations within the torus hall have typically been measured in the range 50 to 2000 Bq m^{-3}. Operator doses have typically been below 10 μSv per operation, implying a protection factor of 10^5 for operations up to 5 hours in duration.

2.2 Gaiters

The use of gaiters to provide protection to plant has become commonplace at JET, either as a surface contamination barrier, or incorporating positive pressure ventilation within the gaiter. During the RTE both robot arms and many mascot sections were gaitered with sacrificial PU membranes which were subsequently removed. Contamination levels on ungaitered sections were measured at 5 k Bq cm^{-2} and in corresponding areas below gaiters were of the order of 20 Bq cm^{-2}.

3. CONFINEMENT

Since the introduction of tritium during DTE the default tritium concentration assumed to be present in vacuum interspaces had been

1 GBq m^{-3}.

The increased tritium concentrations within the isolators has lead to precautionary measures outside the isolator including:-

- a secondary containment, or tent,
- local exhaust ventilation attached to the isolator
- environmental exhaust ventilation sweeping the volume in the tent

Figure 3. A tented isolator operation

4. SURFACE CONTAMINATION CONTROL

A facility designed to operate with a potential contamination hazard will generally incorporate the following features; a clearly defined facility boundary; a contamination control barrier; provision of protective clothing; clearly defined transfer procedures for potentially contaminated items.

Within an area good housekeeping procedures must be employed to minimise the spread of contamination including the use of localised sheeting and, if necessary sub-change barriers. An extension of the use of sacrificial sheeting is the use of specifically developed strippable coatings. These coatings provide a continuous membrane to cover the facility surfaces and form a barrier which can become contaminated and then removed. This technique has been successfully employed during the NIB intervention at the start of DTE 1 and the RTE in both Boom Tent and TCTF facilities [1]. Contamination levels exceeding 100,000 Bq cm^{-2} were measured within the areas on the coatings and typically 500 Bq cm^{-2} after the initial removal of the strippable coatings.

5. TRANSFER OPERATIONS

Controlling the spread of contamination frequently relies on the discipline involved in ensuring items leaving a contamination controlled area are externally clean. There have been many attempts to develop docking systems to transfer items from one facility to another. At JET a double lidded docking system has been developed to enable ISO freight containers to be docked to the TCTF during the RTE. The principle of double lidded docking is:-

1. dock the container to a specifically designed facility door

2. latch the doors together producing a seal

3. open the latched doors as a single unit and transfer items from facility to container

4. close the doors and de-latch them

5. part the containers leaving the external surfaces clean.

This system has been used successfully during tritiated tile transfers. Contamination levels within the TCTF were measured exceeding 100,000 Bq cm^{-2} during tile retrieval. After removing containers which had been installed on the TCTF for up to 5 weeks the external surface contamination levels were less than 2 Bq cm^{-2}.

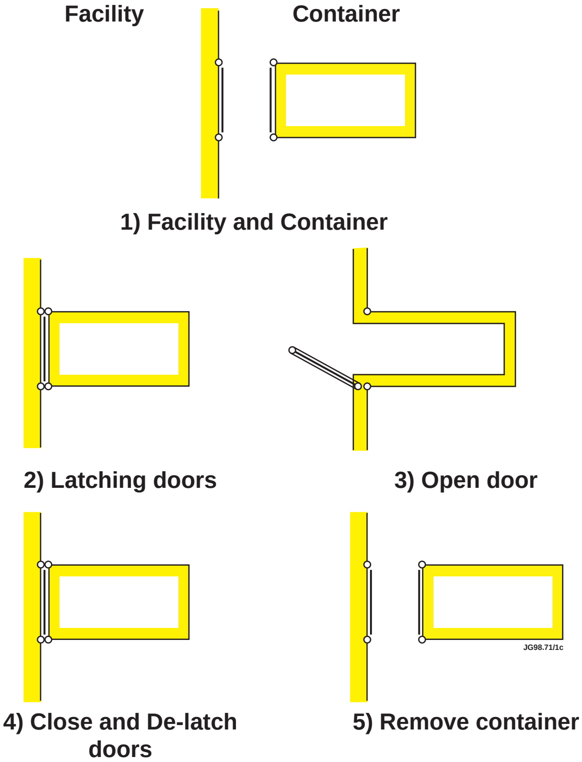

Figure 4. Schematic operation of the double door

The two faces of the double door assembly are shown in figure 5. The facility door mates with the ISO container door effecting a seal around the periphery. The latching mechanisms are spaced equidistant around the door and are operated from within the facility. The doors, once latched , are withdrawn into the facility, in the case of the RTE by suited operators as shown in figure 6.

Figure 5. The double door ready for docking

Figure 6. Operators withdrawing the double door.

6. RESPIRATORY PROTECTION

Since 1989 a wide variety of respiratory protection has been used at JET as described elsewhere [2]. The use of air line fed respiratory protection has become a common feature of shutdowns.

Initial suited operations used PVC suits, but in an attempt to reduce the amount of chlorine associated with in vessel components a change to polyurethane suits has been made.

During a manned entry into the Neutral Injection Box (NIB) in tritium levels up to 100 DAC (80 MBq m^{-3}), it was necessary to erect a temporary scaffold. This was carried out by an operator wearing a suit incorporating a safety harness and fall arrest system. This modified suit enabled the scaffolder to be afforded the same level of protection as other operators carrying out the work in the NIB box.

Figure 7. Suited operator with fall-arrest harness.

7. CONCLUSION

JET has developed many different techniques in the field of contamination control since 1989. Isolator techniques are well established for beryllium and tritium operations where containment factors of the order of 10^6 and 10^5 have been achieved. The issue of tritium permeation has been addressed by the incorporation of environmental and local exhaust ventilation. Double lidded technology has been applied in practice to transfer technology and respiratory protection has continued to be adapted to new applications.

8. REFERENCES

[1] Edwards, P., “Operating Experience of the Tile Carrier Transfer Facility”, This conference.

[2] Russ, R. M., “Beryllium Safety at JET”, Symposium of Fusion Engineering, San Diego, 1991