Operating Experience of the Tile Carrier Transfer Facility during the JET Remote Tile Exchange

P Edwards, B Patel, N Davies, F Hurd[1], R Middleton, S Mills, J Palmer, L Pedrick, D W Wilson.

JET Joint Undertaking, Abingdon, Oxfordshire, OX14 3EA,
[1]NET Team, Garching, Germany.

During the Remote Tile Exchange shutdown at JET, the purpose built Tile Carrier Transfer Facility (TCTF) [1] has been successfully used for the remote removal and storage of activated, tritiated and beryllium contaminated torus components. The short boom, end effector and tine arrangement was also used during the installation of the new Gas Box Divertor. Tritium levels required the use of techniques and practices which were successful in confining contamination and allowed the declassification of work areas. A holding area and posting facilities enabled ancillary equipment/ tool logistics to be managed efficiently.

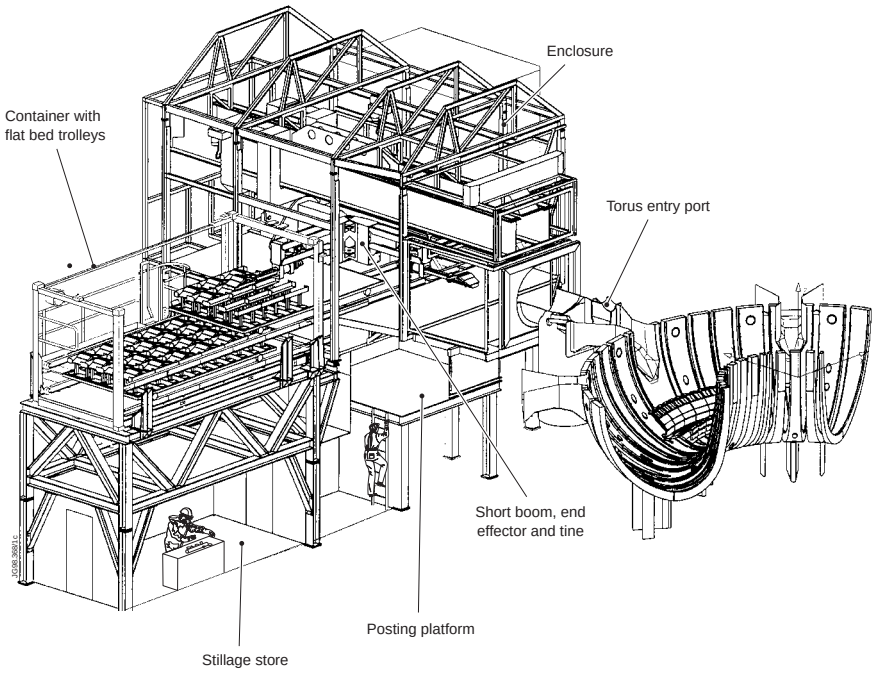

Figure 1. Tile Carrier Transfer Facility (TCTF)

1. INTRODUCTION

After the deuterium/tritium (D-T) operational programme during the latter part of 1997, the 144 MK2A divertor carriers were removed from the JET machine and replaced with 192 Gas Box divertor carriers. In addition to the presence of significant beryllium contamination, the D-T experiments resulted in an activated vessel (typically ~4.3mSv/hr [2]) and with an initial tritium concentration of ~1GBq/m^3 (1200 DAC) at the start of remote handling activities. All invessel activities were performed remotely by the Mascot servo manipulator and articulated boom[3]. The TCTF (figure1) was used for the transfer of various component systems (divertor carriers, diagnostics, Mascot tools) into and out of the Torus in co-ordination with the Mascot and articulated boom (figure 2). The component parts of the TCTF are now described in detail.

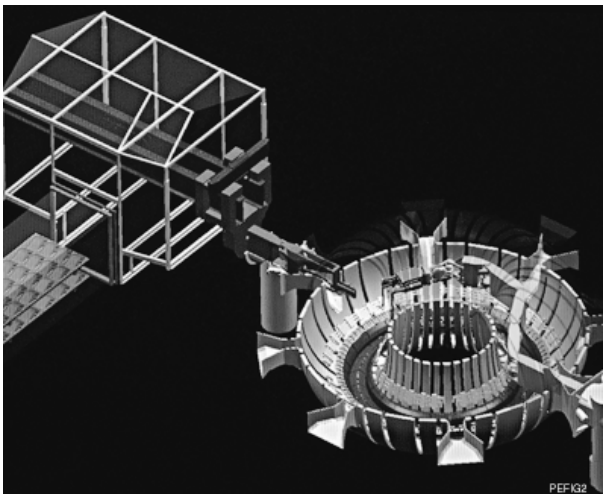

Figure 2. View of the short boom inserted through the torus entry port and interfacing with the articulated boom.

Figure 3. end effector remotely storing carriers into an ISO container

2. SHORT BOOM, END EFFECTOR AND TINE.

A 10m carriageway supports the short boom, end effector and tine configurations. This assembly has 7 degrees of freedom which enables it to traverse in and out of the torus entry port and articulate through 90° to access docked ISO containers outside the torus. The end effector enables various components to be manipulated at the interface with the articulated boom and when remotely storing tritiated carriers within the facility (Figure 3). Components are secured to the tine by means of actuated latches with position sensors. Two interchangeable tines were used during different phases of the campaign. The computer control system includes multi-axis control with path planning, joystick or position command and teach/repeat functionality. Three cameras, one being a pan and tilt, and a tine mounted microphone give additional operator feedback. The short boom, end effector and tines worked reliably, both in the pre-programmed transfer of Mascot tools and carriers to and from the torus and also in performing unplanned manoeuvres.

3. ENCLOSURE

The enclosure framework is supported from the short boom carriageway and is hermetically sealed against the torus entry port. Personnel access is gained through a controller/dresser unit (CDU) via an airlock. Personal protection equipment consisted of air line fed full pressurised suits which allowed the Mascot tooling to be manually loaded onto and off of the tine. A double lidded door system allows different ISO containers to dock with the enclosure. The containers and their contents can then be isolated and separated giving a ‘clean break’ hence maintaining their containment boundaries [4]. Two 500 Kg capacity hoists were used for handling the double lidded door system, Mascot tooling, torus components and the posting of items to and from the stillage stores. Two posting ports were incorporated into the floor of the enclosure to accommo-

date the transfer of tooling, hard/soft waste and contingency equipment. Three strategically placed cameras enabled the monitoring of the hybrid manual and remote handling activities from a central control room.

4. ISO CONTAINERS

A total of four ISO containers were used during the RTE campaign. Three of these were used to store the highly tritiated MK2A carriers on support stands attached to flatbed trolleys. Connected by tooth belts and driven by DC motors with positional feedback the trolleys are driven in and out of the enclosure to suit the position of the end effector and short boom assembly. A ceiling mounted dome camera (pan and tilt) provided additional views for the remote storage of the carriers. Rails in the ISO containers connect with those in the enclosure by 0.5m make-up rails which are then removed during the docking procedure. Radiation shielding on the container sides and support stillage limited dose rates from a fully populated ISO container to 30-80μSv/hr in contact. The fourth container, the man-access container (MAC) was used to supply the new GB carriers into the TCTF. A partition divided the MAC into dirty and clean areas. The GB carriers were first inspected and then loaded into the partition posting box. These were then removed from the dirty side and manually loaded onto the tine (figure 4). Compliance with operating and posting procedures allowed the clean side of the MAC to be immediately declassified at the end of RTE.

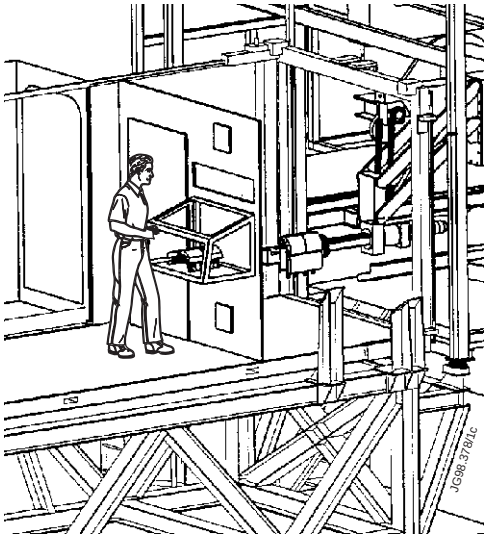

Figure 4. Man-access container showing partition and posting box.

Figure 5. Application of the sacrificial strippable coating by spray gun.

5. POSTING FACILITIES AND STILLAGE STORES

To accommodate and manage the large number of Mascot tools required for in-vessel use and the processing of hard/soft waste, a controlled holding area was established underneath the TCTF. In all 361 postings were carried out during RTE which incorporated a strict logging inventory.

This was crucial in managing the facility and maintaining stringent house keeping. A double bagging posting arrangement maintained the TCTF and stillage store containment. Strict compliance with operating and posting procedures, monitored by contamination checks, allowed the area to be immediately declassified at the end of RTE.

6. OPERATIONAL EXPERIENCES

The preparations to combat the spread of contamination and to control out gassing discharges within the facility were successful. The TCTF ventilation system continually flushed the enclosure at a rate of 10-20 air changes per hour. Clean air was drawn in through the CDU, docked ISO container and from the stillage stores with the enclosure's extract adjacent to the torus entry port. A remotely actuated door was also fitted to the torus entry port to obstruct the ingress of tritium into the TCTF. Significant tritium levels associated with dust and flakes lightly adhering to the MK2A carriers resulted in off-gassing values as high as 0.6GBq/hr [2] *per divertor carrier* and particulate on the enclosure surfaces. Smears as high as 2MBq/cm^2 were measured in known 'hot spots' but generally surface contamination during the removal of the MK2A was in the order of 100-1000Bq/cm^2. By the regular replacement of sacrificial PVC ground sheeting, repeated vacuum cleaning and wiping down with damp clothes the surface contamination on the base layer was significantly reduced and in some cases under the clearance threshold. With a requirement to attempt to declassify the TCTF after RTE all exposed surfaces with exception of the floor were coated with a sacrificial strippable coating prior to the campaign. This water based PVA solution can either be applied by air gun or paint brush and enables inaccessible and awkward areas protection from contamination [5] . Having completed the dirtiest part of the campaign with the removal of the MK2A carriers a 'tie down' coating (trapping the loose contamination) was applied with a differing colour pigment to ensure all surfaces were coated (Figure 5). This reduced the exposed surface contamination to less than 30Bq/cm^2. Having disconnected the TCTF from the torus the sacrificial sandwich layer was removed, the enclosure was then re-sprayed hence providing an environment with negligible contamination. This has allowed a reduction in the required personal protection equipment and will significantly help in the preparations for further remote handling campaigns at JET.

REFERENCES

1. Jones, L.P.D.F., "Design and Development of a New Remote Handling Transporter Facility for JET", SOFT, Lisbon, 1996.
2. Patel, B. et al, "Operational Health Physics Experience during the JET Remote Tile Exchange", JET Health Physics report, July 1998
3. Rolfe, A., "A Report on the First Remote Handling Operations at JET", SOFT, Marseilles, 1998

4. Haigh, A.D., “Developments in Contamination Control and Respiratory Protection at JET”, SOFT Marseilles, 1998.
5. Jordan, P., “A Modular Solution to Temporary Containment Problems”, AEA Technology, AEAT-0501, June 1996.