

Operational Experience in Hot Cell Transfer Systems at Radio Metallurgy Laboratory

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Abstract

Transfer systems are vital for any hot cell facility to facilitate seamless movement of radioactive materials in and out of the hot cell. The hot cell facility of Radio Metallurgy Laboratory (RML) at IGCAR has five different routes for radioactive material transfer. The salient design features of these transfer systems and the operational experience gained over the two decades are presented in this paper.

Key Words: Hot cells, Fast Breeder Test Reactor, irradiated subassemblies, post irradiation examination, transfer systems.

1. Introduction

Fast Breeder Test Reactor (FBTR) located at Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, India acts as a test bed for the development of fuel and structural materials for the future fast reactor programme in India. The RML hot cell facility is co-located with FBTR. A series of seven concrete hot cells of alpha, beta, gamma type are in operation since 1994 for carrying out post irradiation examination (PIE) of fuel and structural materials irradiated in FBTR [1,2]. The shielded hot cells are designed to handle radioactivity of about 5.5×10^6 GBq of 1 MeV of γ -rays and have concrete walls of 1200 mm thick high density concrete. These hot cells have a high purity nitrogen gas atmosphere maintained at a negative pressure (-25 mm water column nominal) with respect to operating area.

The hot cell facility has established five routes for material transfer: vertical transfer system (VTS), horizontal transfer system (HTS), hot cell rear door opening, roof opening and quick transfer system. The transfer of fuel bearing materials is carried out without breach of containment using the VTS and HTS. The other three routes are used for various purposes including posting of new equipment, tools and jigs into the cells, discharge of unserviceable items and hulls of fuel subassemblies from the cells and also for interventions into the hot cells for maintenance. In the following sections, the details of the routes/transfer systems engineered for various purposes are described.

2. Description of Vertical Transfer System

Vertical transfer system (VTS) is used for transfer of irradiated sub-assemblies from FBTR fuel storage bay (FSB) to hot cell #1 of RML. Fig.1 shows the schematic of vertical transfer system as well as horizontal transfer system. The irradiated subassembly (1661 mm long and have bodies of hexagonal cross section of width-across-flat 50 mm) discharged from the reactor core is stored in special pots under argon atmosphere in the fuel storage bay of FBTR.

There is an underground trench, connecting the regions below the fuel storage bay of FBTR and hot cell #1 of RML. A delivery port is provided on the floor of the FSB for lowering the pot with FSA into the cask stationed below in the trench. A remotely operated motorized trolley with lead shielded cask is provided for movement of pot with FSA received from the fuel storage bay to hot cell #1. Shipping cask contains internal mechanism for up and down movement of pot.

The receiving station on the hot cell floor is established with a flange and door supported on a stainless steel bellow over the vertical port. This flange inside the hot cell is designed for leak-tight engagement with the corresponding flange on the top of the pot while the subassembly is being transferred from the pot into the hot cell.

The trolley is operated remotely to position the pot precisely below the hot cell. By operating the cask internal mechanism and pneumatic cylinders, the pot is lifted-up, rotated and engaged with the cell flange/door. The mated doors are then disengaged and removed using in-cell crane for receiving the sub-assembly into the hot cell. A camera is provided in the trench for viewing and controlling the entire transfer operations remotely from the operating area using control panel.

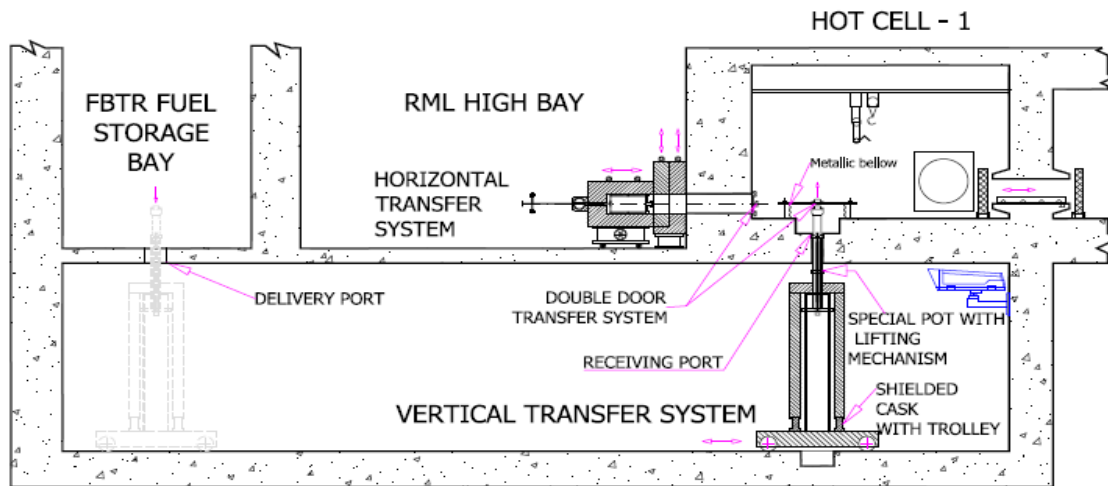


Fig.1 Schematic of vertical transfer system and horizontal transfer system

2.1 Engineered safety features and contingency provisions

Since the double door flange is installed over a bellow in the hot cell floor, it has sufficient margins to accommodate few mm of axial misalignments while the pot gets lifted up from the cask and engages with it over a distance of 2 m. Pneumatically operated cylinders provided for operating the double door are modular and can be replaced if required. All other mechanisms are designed with provision for maintenance from the underground trench, even under contingency when a subassembly is present inside the cask. Provision exists to operate the trolley manually and to take the pot back to the FBTR fuel storage bay in the event of a failed transfer. Electrical interlocks are provided in the system to prevent accidental transfer of subassembly when the prescribed safe conditions are not satisfied.

2.2 Operational experience of vertical transfer system

The drives and motors of the trolley as well as the mechanisms inside the cask for gripping, lifting and rotating the pot require maintenance which is mostly done periodically on

preventive basis and also during dry runs prior to actual operations. This system has been successfully used for more than fifty transfer operations without any incidents. The success is attributed to various factors including the original design philosophy, built-in contingency provisions, adherence to well rehearsed and approved procedures and protocols, dry runs and preventive maintenance. Fig.2 shows receipt of subassembly into the hot cell, through a double-door flange fixed over a bellow installed on the cell floor.

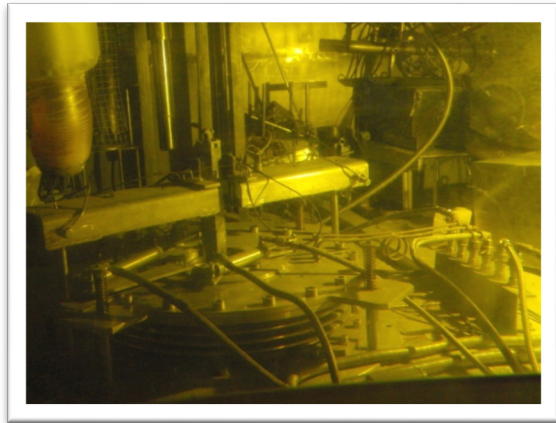


Fig.2 Receipt of subassembly into hot cell

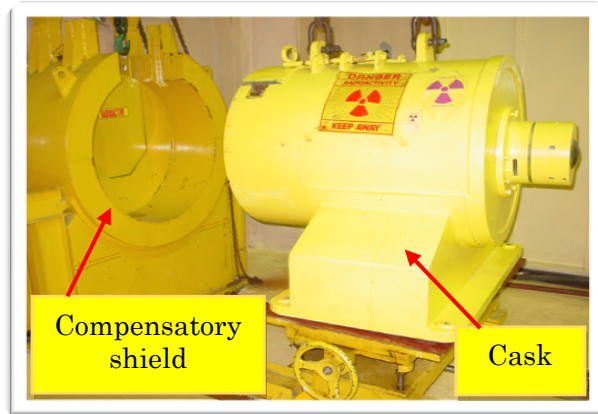


Fig.3 Horizontal transfer system

3. Horizontal Transfer System

Horizontal transfer system shown in Fig.3 is used for transfer of irradiated fuels/structural materials from the hot cells to other laboratories and vice versa in horizontal fashion. A tunnel connecting the hot cell with high bay is utilized for the transfer. The high bay side of the tunnel is provided with a movable lead shielded door and a fixed compensatory shield. The cell side of the tunnel has a double door transfer flange fitted with a pneumatically operated cell door. A container with flange and door housed in a basket and loaded in a shielded cask is used for transferring irradiated materials. The shielded cask placed on a manually operated trolley is positioned in line with the tunnel adjacent to compensatory shield. Using a push rod connected to the basket, the container is engaged with the cell side flange/door and the mated doors of container and cell-flange are opened remotely using pneumatic cylinders. Lip seals provided in the system ensure leak-tightness during transfer operation.

3.1 Engineered Safety features and contingency plans

Unlike the VTS, HTS is manually operated and has better corrective control with respect to positioning of cask, aligning and mating with the cell door flange. Like in VTS, the pneumatically operated cylinders for operating the double door are modular and can be replaced if required. Provisions exist for remotely dismantling and replacing the entire flange assembly located inside the hot cell in case of any contingencies.

3.2 Horizontal transfer system – case study

The horizontal system has been used for more than hundred successful transfer operations. The success is attributed to the built-in design principles, safety and contingency provisions, preventive maintenance and dry runs. During one of the horizontal transfer operations, the basket housing the container could not engage properly with the double-door flange of the cell due to loosening of a screw connecting the basket with the container. This resulted in damage to the cell side door. The basket assembly was repaired. A special operation was undertaken to replace the combined door system remotely from the hot cell side with the

container/basket in position inside the tunnel. After fixing the new double door, the container was disengaged from the cell door and withdrawn. After few successful dry runs, the system was cleared for normal transfer operations

4. Hot cell rear door opening

An opening of 900 mm diameter is provided on the rear side wall of each hot cell for man entry into the hot cells for maintenance. Hot cell #4 rear sealing door was re-engineered incorporating a 200 mm diameter port as an interim measure for transferring β , γ wastes. The arrangement consists of a 3 ton cask on a trolley, mobile compensatory shield, 1.8 m long containers etc. Fig.4 shows photograph of the rear sealing door with transfer port and Fig.5 shows schematic arrangement of transfer system. Wastes for disposal are loaded into a steel container inside the cells and the container is positioned over a turn-table for pushing into a cask through the 200 mm port.

Based on the experience of waste transfer through the rear door, and considering the need for establishing equipments inside the hot cells which needs occasional hands-on-maintenance, the rear door in few cells were further modified and equipped with viewing window, glove ports, transfer port etc. (Fig.6). This augmentation facilitated installation of equipment like optical microscope inside the hot cell with provision for hands on contact for activities like changing the microscope lenses. Several administrative controls are applicable during such campaigns.

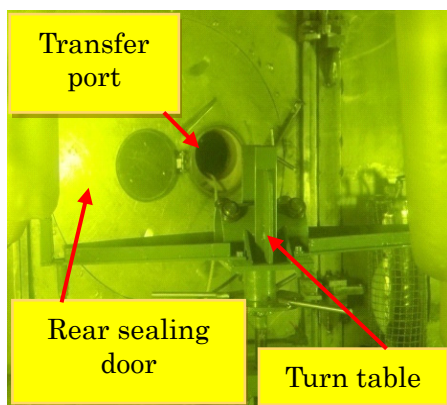


Fig.4 Rear sealing door with transfer port system

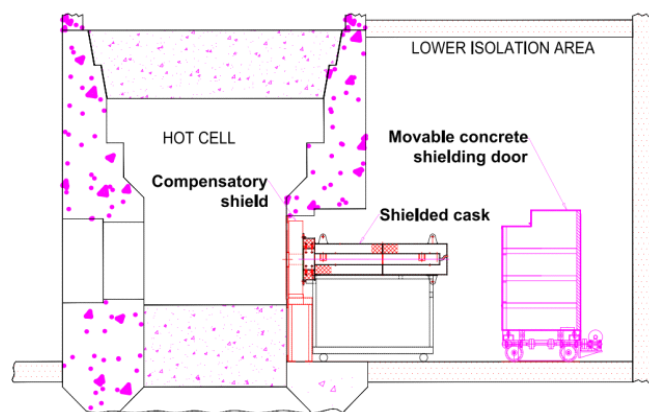


Fig.5 Schematic arrangement of transfer system

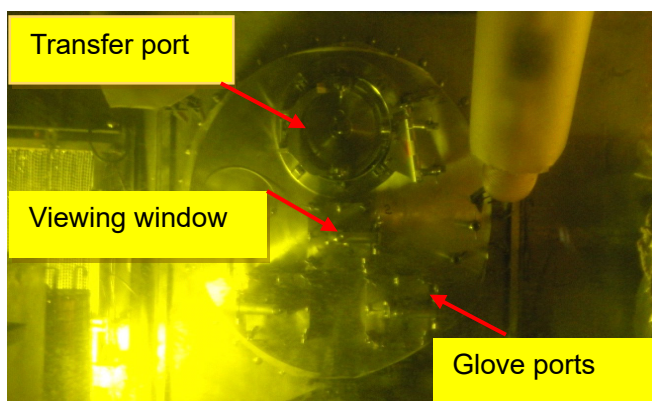


Fig.6 Modified rear door fitted with glove ports, viewing window and transfer port

5. Roof opening and hatch provision

Roof opening (Fig. 7) and hatch are provided in each hot cell to facilitate the installation of new equipment, decommissioning of unserviceable equipment and service of equipment. The size of the opening is 3 m X 1 m. The roof opening has been used innovatively for minimally intrusive entry into the cell for repair and decommissioning of hot cell equipment. Special man entry systems (MES) have been developed which facilitate man entry inside hot cell, for carrying out maintenance/repair/dismantling of in-cell equipment without making contact with the highly contaminated internal surfaces. Man entry system - I & II are shown in Fig.8 and Fig.9. These systems also facilitated transfer of β , γ wastes accumulated in the hot cells over the years.



Fig.7 Roof plug opening



Fig.8 Man Entry System - I



Fig.9 Man Entry System-II

6. Quick Transfer System

Quick transfer system is designed to facilitate introduction into the hot cells, of small components like tools, spares, gadgets or consumables which may be required during the course of operation inside the hot cells. The transfer operations are effected without breaching the hot cell atmosphere and without affecting the shielding and sealing requirements.

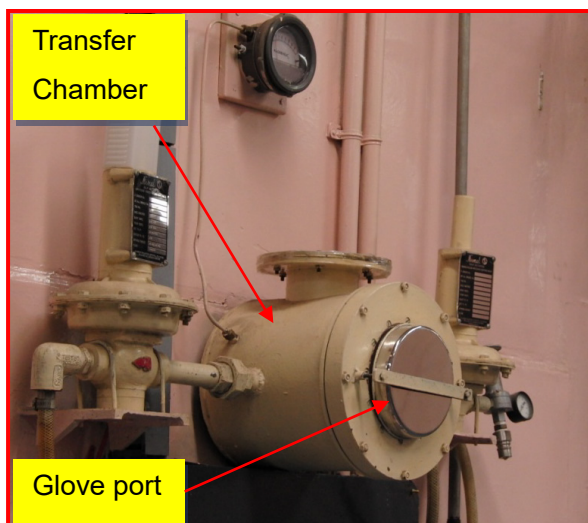


Fig.10 Quick Transfer System

Quick Transfer System (Fig.10) comprises of an S-shaped transfer duct embedded in the cell wall, sealing door and collection tray on the hot side, sealing-plug and transfer chamber on the cold side and transfer container.

Materials to be transferred into hot cell are inserted in to the transfer container which is then posted into the transfer chamber on the cold side. The operator then opens the plug by using the gloves, and the container is quickly pushed inside till it slides down to the other end. The cold side plug is closed immediately. The hot side door of the system is opened using master slave manipulator remotely. The container is collected in the collection tray. The system has been used for rapid and quick transfer of small tools and spares. The chamber is kept under inert atmosphere and the pressure is controlled during the operation through downstream and upstream pressure controllers, with provision for nitrogen supply into the chamber and for venting it into the hot cell.

7. Summary

The transfer systems have performed safely and are still meeting the requirements of the hot cell facility successfully after nearly 23 years of operation. This success is attributed to the robustness of design philosophy, built-in safety-interlocks and contingency provisions, periodic reviews, maintenance-cum-dry-runs, well established procedures and protocols and introduction of additional provisions, based on experience.

Acknowledgements

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