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# Operational Experience on Utilities and Remote Handling on ISIS

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**Abstract**. The ISIS Facility at RAL has been producing neutrons for science from the original Target Station (TS1 – 40/50Hz) since 1984. The second, lower power, low-repetition-rate Target Station (TS2 – 10Hz) came on line in 2008. Although the two Target Stations are different in many ways they do both have the same basic layout and the same main components:

- a moveable target, reflector and moderator (TRAM) assembly in which the neutrons are produced,
- a Remote Handling Cell (RHC) located behind the TRAM for maintenance and repair operations,
- a Target Services Area (TSA) located behind the RHC containing cooling plant and cryogenic coldboxes.

In each Target Station neutrons are produced when the proton beam from the ISIS accelerator hits a tungsten target positioned in a helium filled void vessel. Water cooling channels remove the heat generated in the target via the cooling plant located in the TSA. Moderators (ambient water, liquid $CH_4$, liquid $H_2$, solid $CH_4$) slow down the neutrons escaping from the target and these moderators are surrounded by water-cooled beryllium reflectors which scatter neutrons back into the moderators. In operation, all TRAM components become highly radioactive. The complete TRAM assembly (along with cooling plant, cryogenic systems and shielding plugs) is rolled back to withdraw the TRAM from the void vessel into the RHC for maintenance. The RHCs have a pair of master/slave manipulators on each side, an overhead crane which is remotely controlled, and all RHC operations are viewed through shielding windows and video cameras with zoom and focus capability. This presentation will highlight the many routine procedures such as target and moderator changes carried out over the life of ISIS, as well as more complex and unusual work such as complete reflector replacements, void vessel door seal changes, water filtration and numerous unscheduled repairs.

## 1. Layout and features of ISIS Target Stations.

The ISIS buildings and layout of TS1 and 2 can be seen in the aerial view in Figure 1. The ISIS 70Mev injector, synchrotron ring and building R55 (TS1) and R80 (TS2) are shown and give a clear indication of the ISIS layout.

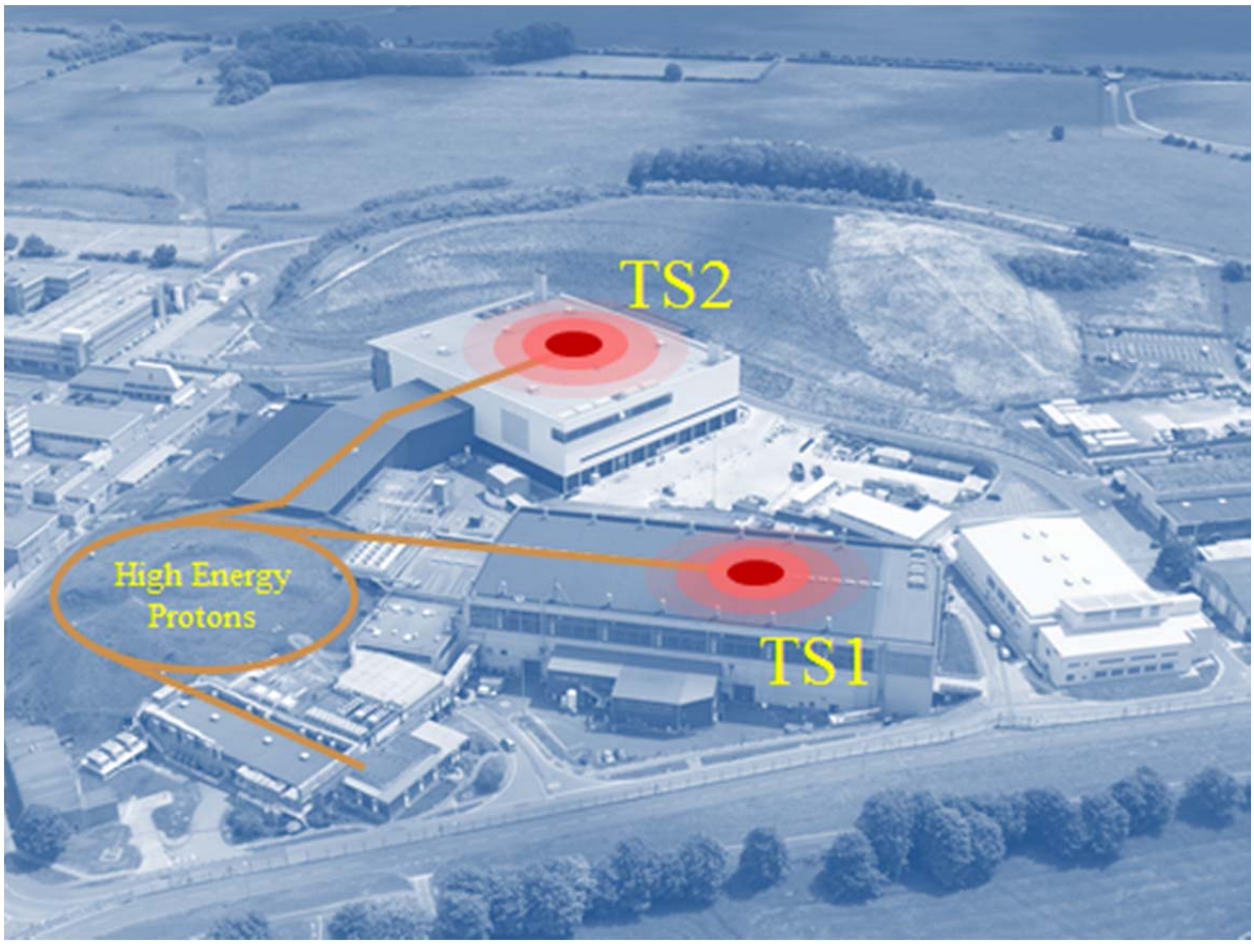


Figure 1 – ISIS Facility with TS1 & 2 Experimental Halls

The basic layout of the ISIS Target Stations is shown in Figure 2 – TS1 and 2 layouts are both the same. In each case there is a proton beam extracted from the ISIS accelerator and the beam is focused onto a Tungsten target which sits in a helium filled void vessel inside the target blockhouse and shutter array.

Neutrons produced by spallation from the target material are reflected and moderated and then pass through windows in the void vessel (nine on each side) to instruments on the ISIS beamlines.

Behind the target is a moveable shielded train with a Remote Handling Cell (RHC). There is then a secondary shield plug and then a Target Services Area (TSA) containing target cooling plant and cryogenic coldboxes for moderators, plus other equipment necessary for target operation. This arrangement allows the Target, Reflector and Moderator (TRAM) assembly to be moved back from the operating position into the maintenance position for replacement of various components using the manipulator arms in the RHC.

This basic layout and method of operation is exactly the same for TS1 and TS2.

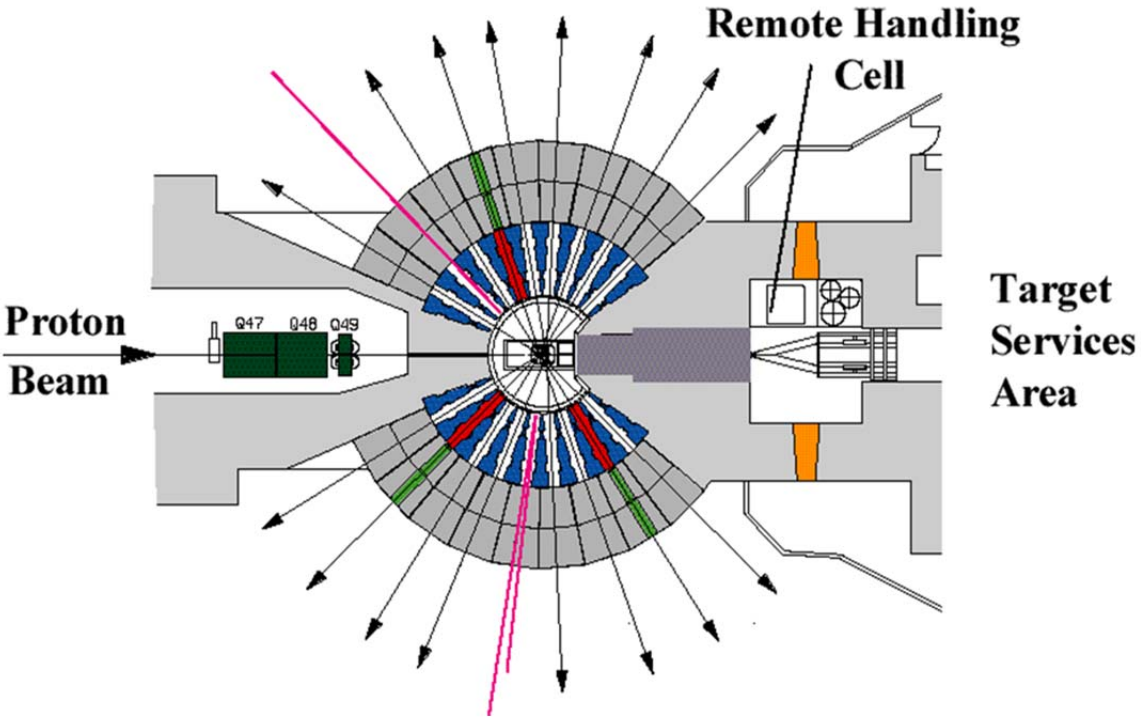


Figure 2 – Layout of ISIS Target Stations

ISIS TS1 has been in operation since 1985 and is currently operating with a target made up of 12 tungsten plates clad with a thin layer of tantalum. The ISIS Accelerator produces a 50Hz beam – 40Hz goes to TS1 and every fifth pulse from the accelerator is directed to TS2 (10Hz operation). Figure 3 shows ISIS TS1 target withdrawn into the RHC for maintenance.

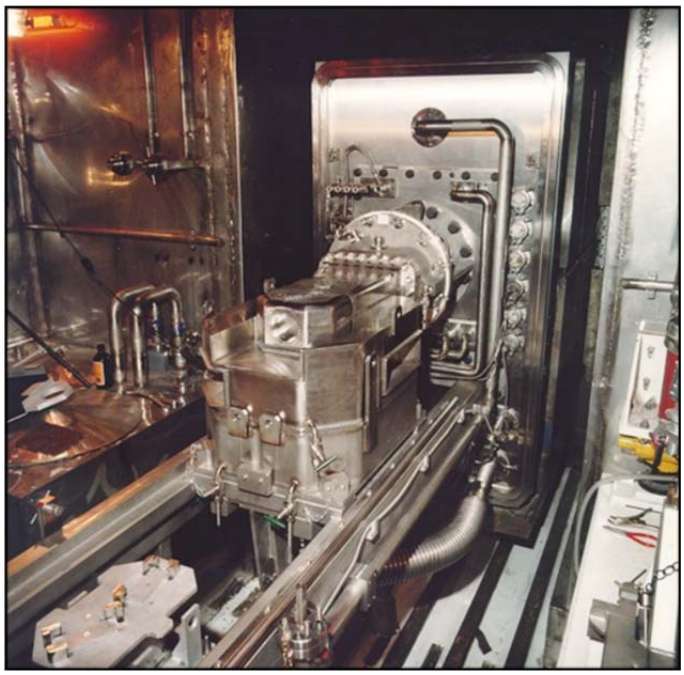

Figure 3 – TS1 TRAM Assembly in RHC

The TS1 target is cooled with $D_2O$. A bulk flow of 500 litres per minute is spilt between three cooling channels with more flow directed to the front target plates than to those at the rear. TS1 has four moderators, two containing $H_2O$ at ambient temperature, one containing liquid $CH_4$ at 100K and one containing liquid H2 at 20K. The TS1 reflector is made up of stainless steel boxes containing beryllium rods and these rods are also cooled with $D_2O$.

ISIS TS2 has been operating since 2008. The TS2 target is a solid cylinder of tungsten, clad with a thin layer of tantalum and this target is cooled with $H_2O$. A flow of 90 liters per minute is split between two flow channels, both of which flow along the outside of the target body and across the front face where the beam hits the target. TS2 has two moderators, one containing liquid $H_2$ at 20K and one containing solid $CH_4$ at 45K. Both of these moderators are fitted with ambient water pre-moderators which sit inside the solid beryllium reflector. This reflector is edge cooled using $H_2O$ via aluminium cooling pads clamped to the sides of each reflector half. Figure 4 shows the layout of the TS2 TRAM in the RHC with the reflector opened and rolled forward for maintenance.

Figure 4 – ISIS TS2 TRAM in maintenance position

## 2. A Typical Remote Handling Operation on ISIS – Removal of TS1 Target

TS1 tungsten target life is typically five years of ISIS operation. After this time the target is removed from service and stored in the ISIS Active Handling Facility (R40) prior to final disposal to Sellafield in Cumbria.

To place the target into storage it is necessary to prepare the RHC and other equipment for target removal, seal and package the target in-cell, place the packaged target into a storage flask and finally transport the flask and target to ISIS Building R40 for storage prior to final disposal. Figure 5 shows the TS1 service tunnel layout for removal of active components from the RHC.

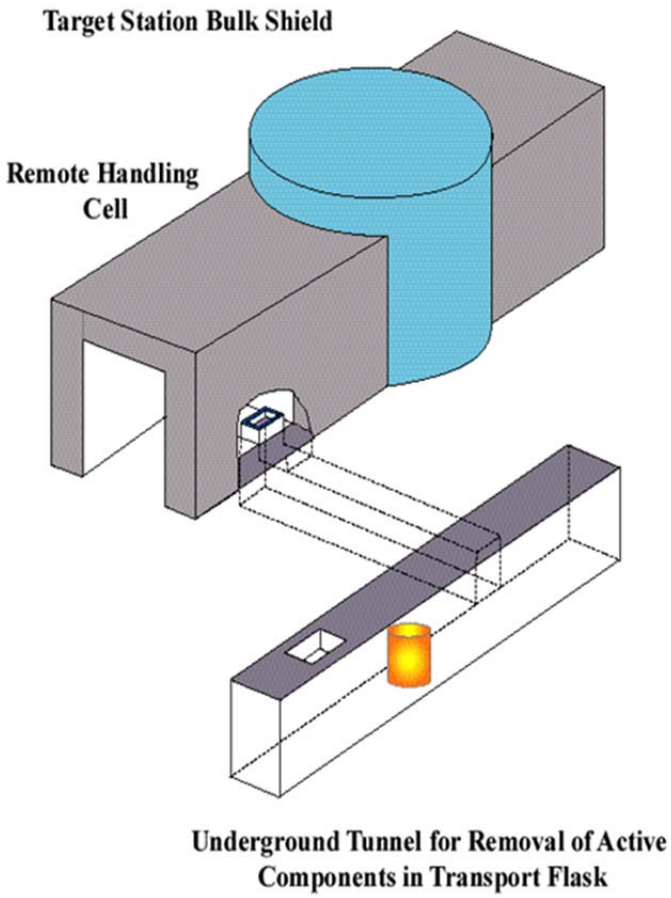


Figure 5 – TS1 Service Tunnel Layout

2.1 Preparation of Storage Flask.

A flask is prepared in R40 and is preloaded with a disposal can and flange assembly ready to be fitted to the target. The whole flask assembly is lowered onto a powered trolley in the underground service tunnel running parallel with TS1 RHC.

After positioning, the outer closure flange of the flask is removed and the flask is then transported into the cross tunnel to position it underneath the service hatch in the floor of the RHC. All operations are controlled from the TS1 Manipulator Rooms either side of the RHC.

The floor hatch is opened and the main shield plug is lifted into the RHC using the installed crane (see Figure 6 overleaf). After the shield plug has been positioned in the RHC the crane is removed and connected to an electrically driven grab mechanism that will connect with the target disposal flange. This will allow the active target package to be remotely handled for storage at ISIS and later for final disposal at Sellafield.

Figure 7 overleaf shows the grab mechanism attached to the target disposal flange and the flange/disposal can assembly being lifted into the RHC. After the assembly has been lifted in the RHC floor hatch is closed and the TRAM is withdrawn into the RHC for target removal.

Figure 6 – Storage flask shield plug being lifted into RHC

Figure 7 – Target disposal can being lifted into RHC

2.2 Removal of Target

Figure 8 below shows the TS1 target in the RHC being prepared for removal. The top section of reflector (complete with water moderators) has been rolled forward to expose the target. In the foreground of the picture is the handling frame which is used to remove and handle the target.

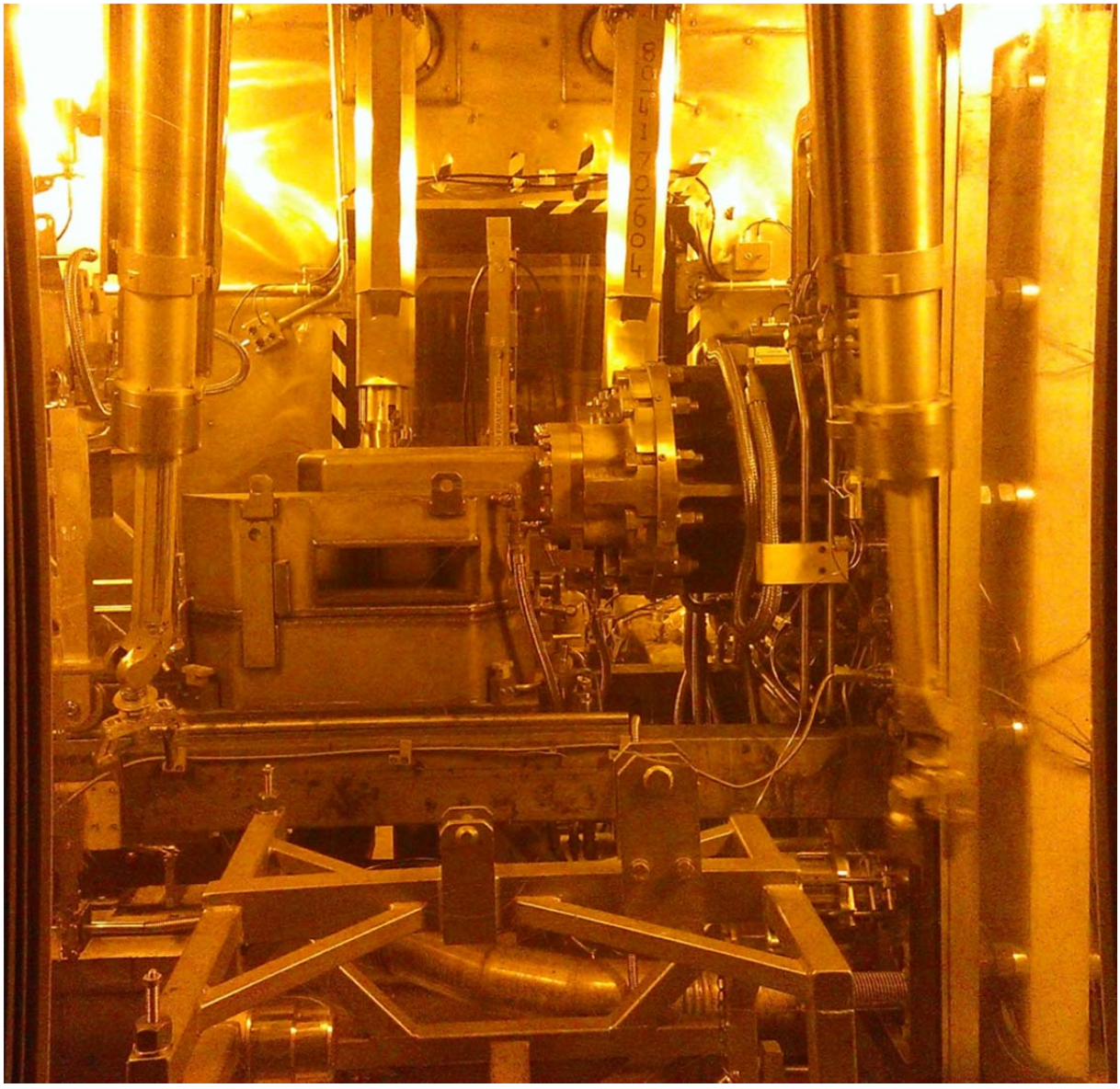

Figure 8 – ISIS TS1 Target in RHC viewed through Zinc Bromide shield window

The handling frame is lifted into position and connected to the body of the target. At this stage all $D_2O$ in the target cooling circuits is drained and blown down into a holding tank in the service tunnel under the target station. The large flange at the rear of the target serves as a mechanical fixing to support and position the target but also seals the water connections for the cooling water for the target plates and casing circuits.

Figure 9 overleaf shows the target being lifted clear of the back door after all the bolts in this sealing flange have been released and the target umbilical connector (carrying thermocouple connections) has been disconnected.

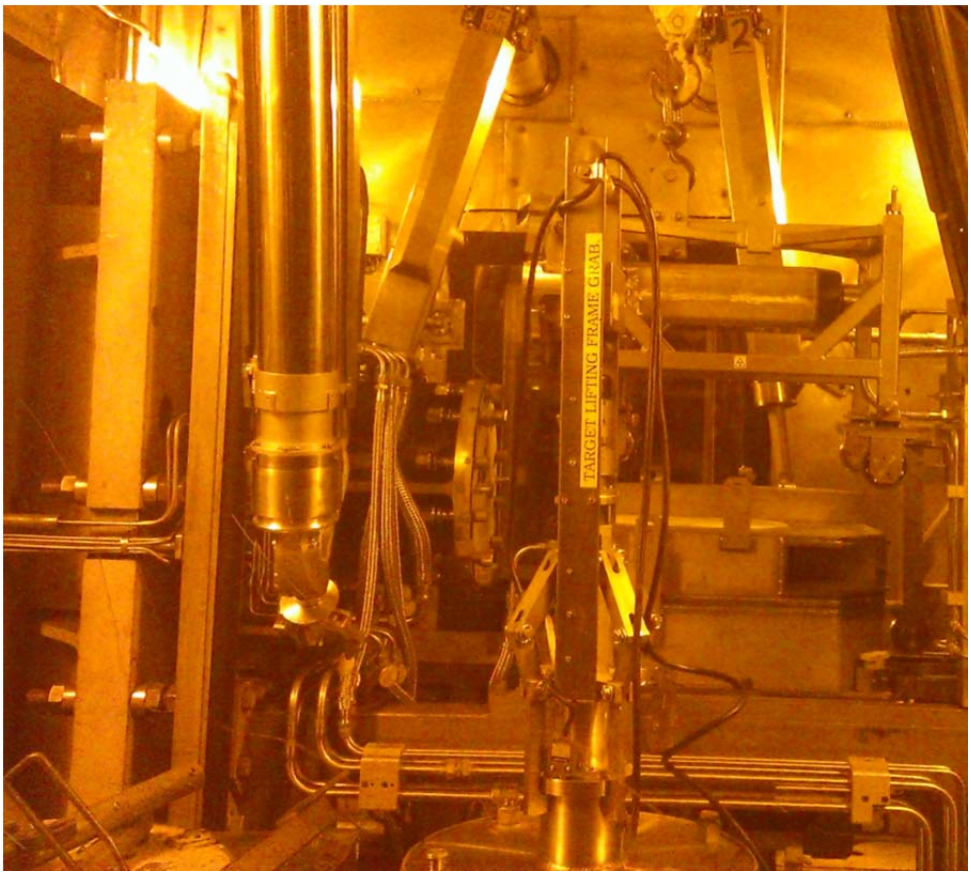


Figure 9 – Target being lifted clear of lower reflector

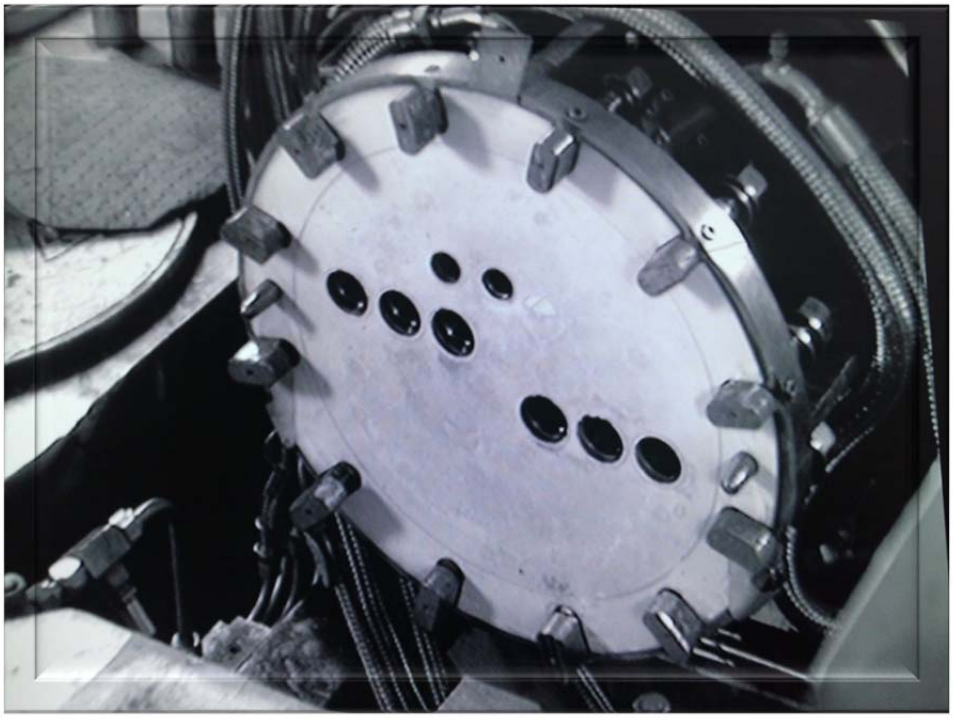

Figure 10 – Mounting flange view after target has been lifted away

2.3 Packaging Target in Preparation for Removal from RHC.
After removal the target is lifted to the north side of the RHC and placed into a rollover frame. This mechanism rotates the target into the vertical plane so that the disposal flange can be fitted. Figure 11 below shows the disposal flange being lowered onto the target (with seal in place) and figure 12 shows the nuts being tightened to clamp the flange onto the target. The flange serves a dual purpose; it seals the target in case of any Tritium release during storage and also provides a means of handling the target which is compatible with the Sellafield handling system.

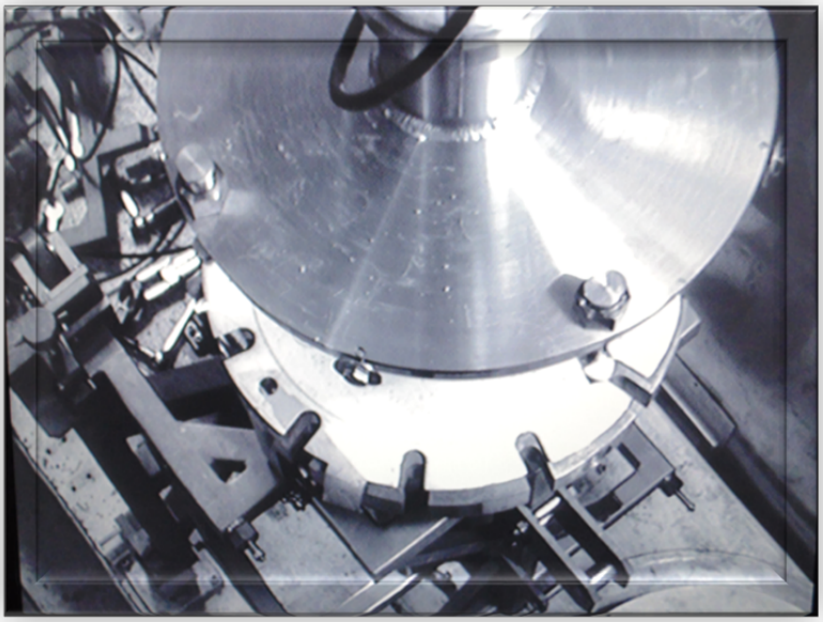

Figure 11 – Target disposal flange being lowered into place

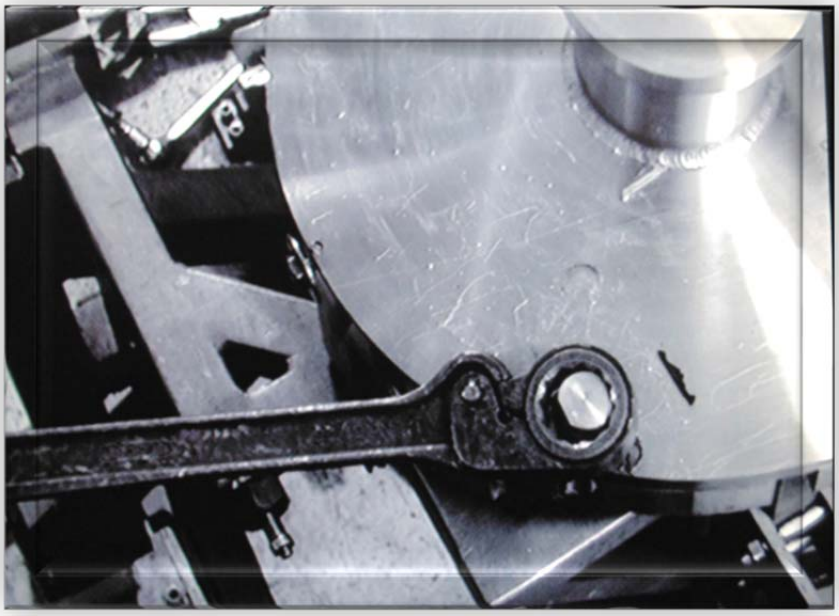

Figure 12 – Disposal flange being bolted to target

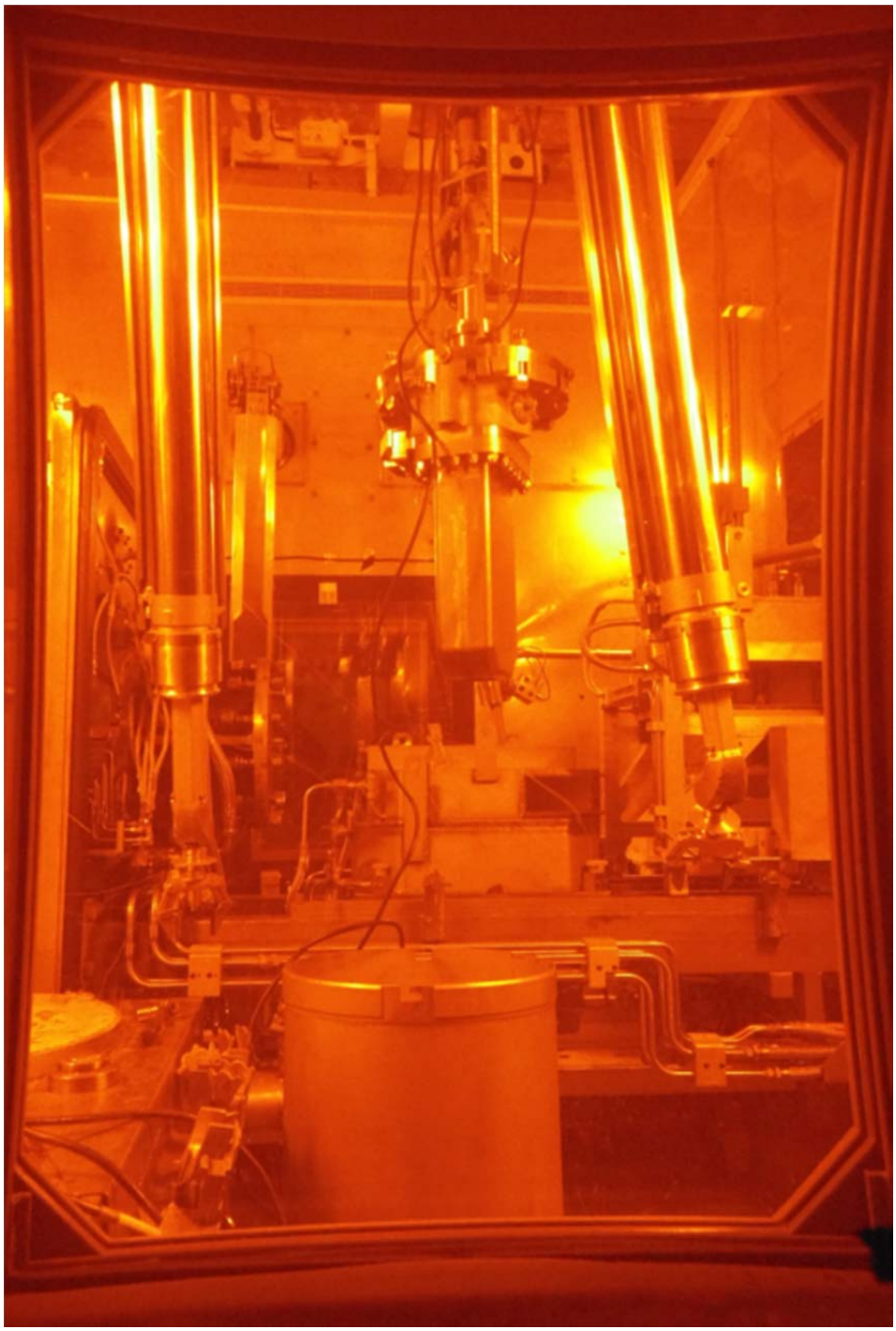

Figure 13 – Target being lifted across RHC to disposal can

In Figure 13 the target can be seen hanging vertically from the electric grab mechanism on the RHC crane. The target is being lifted across to the south side of the RHC toward the disposal can which can be seen in the foreground of this picture.

The target engages in slots the disposal can, is turned and locked in place by means of four locking bolts on the side of the disposal flange (see figure 14).

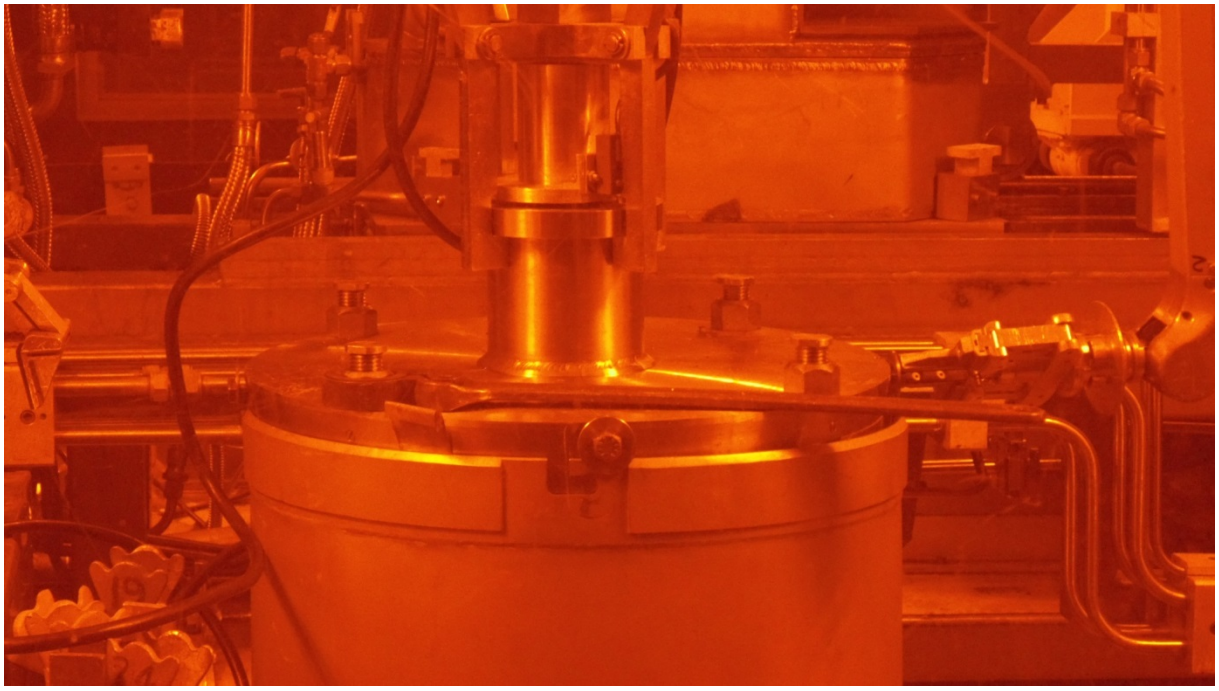

Figure 14 – Disposal flange engaging in slots in Disposal Can

2.4 Removal of Target from RHC.
After the target has been locked into the disposal can the floor hatch is opened and the complete assembly is lowered into the storage flask waiting in the cross tunnel under the RHC – see figure 15 below.

Figure 15 (left) shows target in Disposal Can being lowered into storage flask & Figure 16 (right) shows loaded flask being checked for external radiation dose

Once the target is landed in the flask the electric grab mechanism is opened and lifted back into the RHC, leaving the target in the flask. The electric grab is removed from the crane inside the RHC and the crane is connected to the flask shield plug. This shield plug is then lowered out of the hatch and placed on top of the target inside the flask. The crane is withdrawn, the hatch closed and then the flask is checked for external radiation dose and contamination.

2.5 Transportation of target to ISIS Storage Facility

After external dose rates and contamination levels have been assessed the flask can be removed from the cross tunnel ready for transportation to R40.

The closure flange is fitted to the flask and then the flask is lifted out of the service tunnel using the R55 main hall crane. The total weight of the loaded flask is approximately 9.1 Tonnes

Figure 17(Left) – Loaded flask being lifted clear of services tunnel & Figure 18 (Right) – Flask being transported to R40 for short term storage


Figure 19 – ISIS Target Transport Flask prepared for transportation to Sellafield

Figure 19 shows the target finally packaged in the ISIS Target Transport Flask. This flask is a fully licensed and registered Type B package for use on road and rail transport. This flask is used to transport spent targets from ISIS to final disposal at the Intermediate Level Beta/Gamma Waste Store (ILBGWS) at Sellafield.

**3. Acknowledgements**
The work presented here is the result of a large amount of preparation and organisation by many members of ISIS staff. I would like to thank my colleagues listed here for all of their hard work and dedication to making ISIS the success that it is; Andy Robinson, John Sexton, David Jenkins, Jon Chapman Chris Russell, David Baker, Gordon Burns, Gary Allen, Robin Burridge and Rajesh Gupta.