Removal of the Plutonium Recycle Test Reactor – 13031

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ABSTRACT

The 309 Facility housed the Plutonium Recycle Test Reactor (PRTR), an operating test reactor in the 300 Area at Hanford, Washington. The reactor first went critical in 1960 and was originally used for experiments under the Hanford Site Plutonium Fuels Utilization Program. The facility was decontaminated and decommissioned in 1988-1989, and the facility was deactivated in 1994. The 309 facility was added to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) response actions as established in an Interim Record of Decision (IROD) and Action Memorandum (AM). The IROD directs a remedial action for the 309 facility, associated waste sites, associated underground piping and contaminated soils resulting from past unplanned releases. The AM directs a removal action through physical demolition of the facility, including removal of the reactor. Both CERCLA actions are implemented in accordance with U.S. EPA approved Remedial Action Work Plan, and the Remedial Design Report / Remedial Action Report associated with the Hanford 300-FF-2 Operable Unit. The selected method for remedy was to conventionally demolish above grade structures including the easily distinguished containment vessel dome, remove the PRTR and a minimum of 300mm (12in) of shielding as a single 560 TON unit, and conventionally demolish the below grade structure. Initial sample core drilling in the Bio-Shield for radiological surveys showed evidence that the Bio-Shield was of sound structure. Core drills for the separation process of the PRTR from the 309 structure began at the deck level and revealed substantial thermal degradation of at least the top 1.2m (4LF) of Bio-Shield structure. The degraded structure combined with the original materials used in the Bio-Shield would not allow for a stable structure to be extracted. The water used in the core drilling process proved to erode the sand mixture of the Bio-Shield leaving the steel aggregate to act as ball bearings against the core drill bit. A redesign is being completed to extract the 309 PRTR and entire Bio-Shield structure together as one monolith weighing 1100 TON by cutting structural concrete supports. In addition, the PRTR has hundreds of contaminated process tubes and pipes that have to be severed to allow for a uniformly flush fit with a lower lifting frame. Thirty-two 50mm (2in) core drills must be connected with thirty-two wire saw cuts to allow for lifting columns to be inserted. Then eight primary saw cuts must be completed to severe the PRTR from the 309 Facility. Once the weight of the PRTR is transferred to the lifting frame, then the PRTR may be lifted out of the facility. The critical lift will be executed using four 450 TON strand jacks mounted on a 9m (30LF) tall mobile lifting frame that will allow the PRTR to be transported by eight 600mm (24in) Slide Shoes. The PRTR will then be placed on a twenty-four line, double wide, self powered Goldhofer for transfer to the onsite CERCLA Disposal Cell (ERDF Facility), approximately 33 km (20 miles) away.

HISTORY

The 309 Facility housed the Plutonium Test Recycle Reactor (PRTR), an operating test reactor in the 300 Area at Hanford, Washington. The reactor first went critical in 1960 and was originally used for experiments under the Hanford Site Plutonium Fuels Utilization Program. The facility with its distinguished containment vessel dome is shown below in Photograph 1: The 309 Facility in 1968. The facility was decontaminated and decommissioned in 1988-1989, and the facility was deactivated in 1994.

Photograph 1: The 309 Facility in 1968

TYPE A (MOST SERIOUS) ACCIDENT

On September 19th, 1965 a Type A Accident occurred at the Fuel Element Rupture Test Facility (FERTF) inside of the 309 PRTR Facility. The incident report stated, “The precise sequence of events during the incident and the absolute flow paths of the water which entered the reactor core are not known.”

Due to the unknown nature of the flow paths and associated heat bloom, the location of the effects of the accident on the surrounding biological shield could not be determined.

BIOLOGICAL SHIELD CORE DRILLS

Initial 2011 sample core drilling at -3.4m (-11LF) from deck level in the Bio-Shield for radiological survey showed evidence that the Bio-Shield was of sound structure. In 2012, core drills for the separation process of the PRTR from the 309 structure began at the deck level and revealed substantial thermal degradation of at least the top 1.2m (4LF) of Bio-Shield structure. The degraded structure combined with the original materials used in the Bio-Shield would not allow for a stable structure to be extracted. The water used in the core drilling process proved to erode the sand mixture of the Bio-Shield leaving the steel aggregate to act as ball bearings against the core drill bit. The biological shield concrete sustained extended exposure to heat generated by the reactor producing thermal degradation which is evidenced in Photograph 2: Thermally Degraded Biological Shield. The characteristic color change from grey to orange of the cementitious matrix is easily identified in this Photograph 2.

Photograph 2: Thermally Degraded Biological Shield

INTRODUCTION

The selected method for remedy was to conventionally demolish above grade structures including the easily distinguished containment vessel dome, remove the PRTR and a minimum of 300mm (12in) of shielding as a single 508 tonnes (560 TON) unit, and conventionally demolish the below grade structure.

However, upon initial core drilling of the Biological Shield, and the resulting issues of degraded structure, the overall design was revised. It should be noted that since this paper's abstract was written, the design has progressed. The paper reflects the most current configuration.

The redesign has been completed to extract the 309 PRTR and the entire Biological Shield structure together as one monolith weighing 998 tonnes (1100 TON) by cutting structural concrete supports in both the vertical and horizontal directions.

PROJECT COMPONENTS

Lower Lifting Frame

The lower lifting frame consisted of a spider hub with six beams on three axis's, two primary axis, and one secondary axis as shown in Figure 1. Lower Lifting Frame. The beams were all W36x395. The installation of these heavy beams and spider hub required an interim structure to receive them, move them, and assemble them in place. The lower lifting once assembled weighed 21.1 tonnes (23.3TON) alone.

The lower lifting frame was connected to the strand jack lifting system through the floating anchors. Each anchor was pinned to the outside radius of the lower lifting frame with 150mm (6in) diameter by 250mm (10in) long pins each weighing 36kg (80lbs).

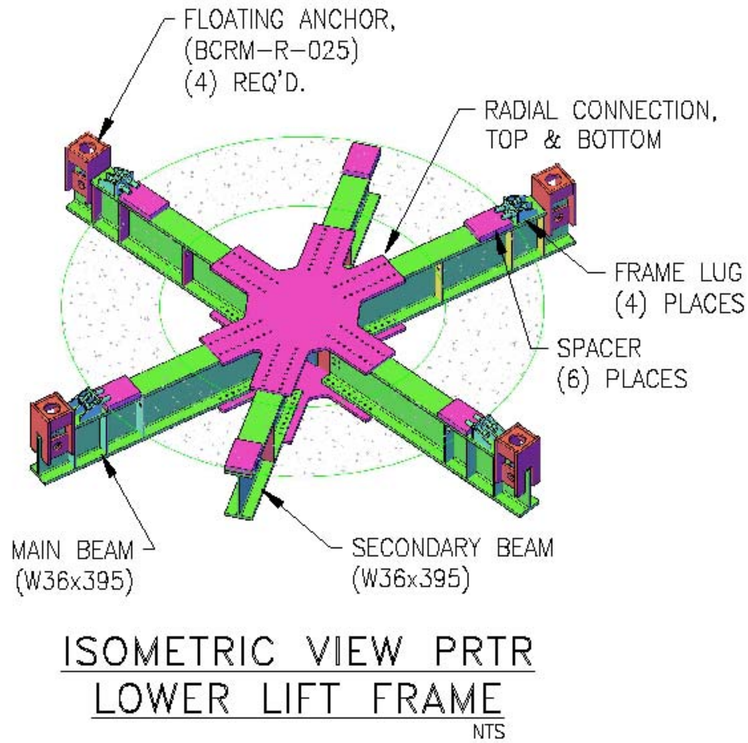

Figure 1. Lower Lifting Frame

Strand Jack Lift System
The critical lift will be executed using four 408 tonnes (450 TON) strand jacks mounted on a 9m (30LF) tall mobile lifting frame that will allow the PRTR to be transported by eight 600mm (24in) Slide Shoes as shown in Figure 2. Lifting and Transport Configuration.

Goldhofer
The transport vehicle selected was a double wide 24-line PST/THP Goldhofer as shown in Figure 2. Lifting and Transport Configuration. The vehicle was 40m (130'-5") long by 12m (40'-0") wide including the transport frame. The vehicle was self powered using the attached power packs, and a contingency prime mover followed the vehicle. The whole transportation package including the Goldhofer was 11m (36'-5") tall. Power lines on Hanford Site had to be raised in order to accommodate the transport of the package to the Environmental Restoration and Disposal Facility (ERDF). The gross vehicle weight was 1,395,070 kg (3,075,600lbs) or 1,395 tonnes (1,538 TON).

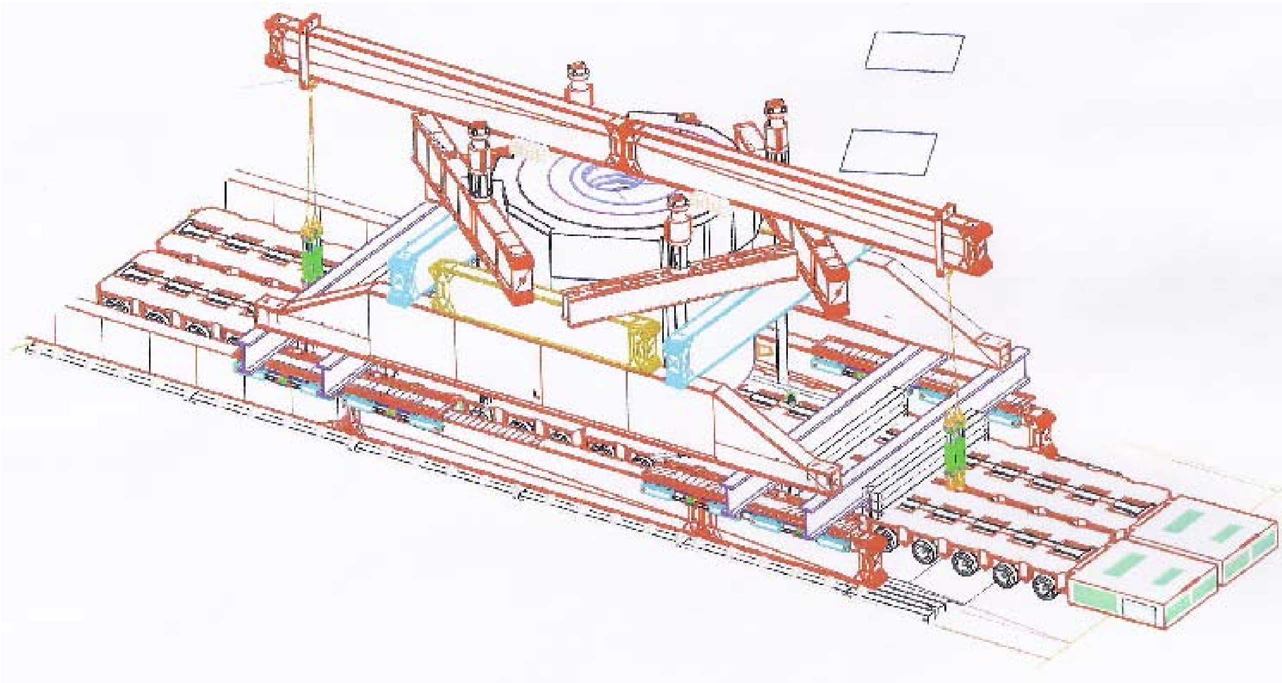

Figure 2. Lifting and Transport Configuration.

Load Test

Prior to the actual lift a Load Test of the system was performed. The load test verified configuration and components, and was completed to 110% of the estimated actual load.

PRTR REMOVAL

Design, fabrication and construction activities progressed through three phases. Phase I – Core Drilling, Wire Cutting and Installation of Structural Shoring, Phase II – 309 PRTR Removal, and Phase III – Transportation and Off Load.

Phase I as the title suggests consisted of core drilling activities to allow for the insertion of saw cut wire. During the core drilling activities, pipe removal and structural shoring were ongoing. Once structural shoring was completed wire cutting could begin.

Core Drilling

In order to facilitate saw cutting operations, fifty vertical and tapered 50mm (2in) core drills have been executed to allow for the vertical saw cut diamond wire to be installed. These vertical core drills were necessary on three of the four levels of the building. Nineteen horizontal 50mm (2in) core drills have been executed in walls and columns to allow for the horizontal saw cut diamond wire to be installed. All core drilling activities were executed using a vacuum ring attachment to minimize the amount of water and slurry loss inside the structure to mitigate the spread of contamination throughout the building. Slurry was allowed to settle and water was recycled to make this process more efficient. Currently the core drilling activities have been completed, and the project will be progressing to saw cut activities after completion of the pipe removal and structural shoring activities.

Pipe Removal
The PRTR has hundreds of contaminated process tubes and pipes that have been severed and removed to allow for a uniformly flush fit with a lower lifting frame. All tubes and pipes were verified to be free of standing liquids, by tapping and draining at the low point of the system. Pipes were fogged with a fixative to mitigate contamination spread then capped. Pipes were then cut within a general set of tolerances followed by flush cuts for pipes inside of contact patches with the lower lifting frame.

Structural Shoring
The containment vessel that housed the PRTR underwent massive structural modification in order to extract the PRTR. The PRTR acted as part of the containment vessel itself. Therefore structural shoring in each of the three cells of the containment vessel is required in order to maintain structural integrity. Shoring will be installed in six locations prior to wire saw cutting, and through each of the three floors of the containment vessel.

Saw Cutting
Saw cuts will be completed in a combination of completely vertical orientation and in a vertically tapered orientation to create a slightly conical shape to the encased reactor which will ensure that the encased reactor does not catch upon the surrounding structure during lifting. Both vertical and horizontal saw cuts are closely followed with installation of shims to mitigate any potential movement of the encased reactor prior to lift. Saw cut operations will also have a water and slurry capture system installed to collect and recycle as much water as possible to mitigate the spread of contamination throughout the building.

Phase II – 309 PRTR Removal involved insertion of the lower lifting frame as described earlier underneath the PRTR, and the critical lift of the PRTR itself.

Lower Lifting Frame
The size and weights of the components of the lower lifting frame required an interim structure be assembled at the -9.75m (-32.0’) level of the containment vessel. This was nick named the “dance floor” as the structure is based upon pipe stands connected to W14x120s in the cells with custom wall brackets that will be installed over the moderator tank directly underneath the PRTR. The moderator tank directly underneath the PRTR will not support the weight of the lower lifting frame thereby requiring the “dance floor” to bridge this area. Finally the “dance floor” will be plated to facilitate the use of omni-directional rollers.

The lower lift frame beams will be threaded through the restrictive openings in the supports of the PRTR and into the beam pockets that will be wire saw cut into the walls. The spider hub will be positioned and connected, and the floating anchors attached. Once the floating anchors are attached the contact patches will be shimmed for proper fit and the system will be brought snug.

Lift System Assembly
The lift system requires a rail system to allow for the lift system to crawl onto the containment vessel and the rail system requires regrading and compaction of the adjacent soils to allow for a smooth transition from on top of the containment vessel back onto the adjacent grade where the Goldhofer will be positioned.

The lift system from the bottom up consists of a truck slide system directly bearing on the rails, (4) W40x431 transport beams, (2) 2.4m (8LF) undercut girders, (4) 1.5m (5LF) girders, with (4) 408 tonnes (450 TON) strand jacks sitting on opposing diagonally positioned (2) 1.5m (5LF) girders & (2) strand jack girders. See Figure 2. Lifting and Transport Configuration.

Functional Test
The lift system will be functionally tested prior to the critical lift in order to verify operational parameters. This functional test will be completed under no load conditions (other than the dead weight of the lift system itself).

Critical Lift of the PRTR
Once the PRTR saw cutting and removal of superfluous materials are completed, the Goldhofer staged, and the lift system erected and functionally tested, the PRTR will be lifted under a critical lift plan from its position inside the containment vessel onto the awaiting Goldhofer.

The penetrations into the PRTR from existing pipe, conduit, and ducts will be sealed using a graded approach from foaming small penetrations to fully sealed cover plates installed on the larger openings. All penetrations then will have a layer of polyurea applied to the outside of the PRTR to mitigate any water ingress in the future.

Phase III – Transportation and Off Load will involve packaging of the PRTR, securement of the package to the Goldhofer, transport to ERDF, and Off Load of the package onto the appropriate storage location.

PRTR Transportation Package
The PRTR will be packaged into two independent IP-1 packages and the package will be made to conform to CE-SPA criteria. Grout ports internal to the package will be installed so as to allow for internal void fill to occur at the destination to reduce travel weights.

Securement of the Package to the Goldhofer
The securement of the package to Goldhofer will be accomplished through the installation of restraint beams attached to the Goldhofer and connected at diagonal

and longitudinal directions to the lower lifting frame through 75mm (3in) diameter Dywidag thread bar on four locations diagonally and in two locations longitudinally.

Transport of the Goldhofer to ERDF

The haul route has been preplanned. The haul route had all below grade and overhead utilities identified. The reactions and heights of the fully loaded Goldhofer were then analyzed against each utility to identify any mitigate actions that were needed. Power lines were raised accordingly, and plate steel was positioned accordingly to protect all utilities that were in conflict. The slopes into ERDF were customized to allow for the Goldhofer to be kept inside of operating parameters, specifically concerning the crest and sag curves for the ramp into ERDF.

Off Load of the Package at ERDF

The off load of the PRTR at ERDF will be accomplished in two stages. The first stage consists of placing a 815mm (32in) grout pad for the PRTR to rest upon. The second stage involves positioning the Goldhofer over the grout pad, removing the transport restraints, self-loading the PRTR package onto mats and pipe stands, driving the Goldhofer out from underneath the PRTR package, reconnecting the strand jacks to the hydraulic pump and lowering the PRTR package to the grout pad.

Finally both the systems at ERDF and at the 309 containment vessel will be demobilized and a weather cover installed over the containment vessel to protect from the elements.

CONCLUSION

At the time of this paper’s submission, the removal 309 PRTR is not yet complete.

Due to quality control issues with the original 1958 construction of the biological shield and apparent, subsequent, thermal degradation during operations in the 1960s a major redesign was required after the initial design had been approved and began core drilling. The major redesign required a substantial amount of time, approximately 8 months. During which very little construction could be completed.

Construction of the extraction system is ongoing. The new system will lift almost twice the original load. The waste package will be shipped in a completely different configuration, hanging from the strand jacks, braced diagonally in place.

The lessons learned from this project are many. The quality control of 1950s construction, the thermal degradation of concrete shielding due to the nuclear reactors operations and accidents, the use of strand jacks for lifting, the use of a double wide 24 axle Goldhofer for shipment, the securement method using diagonal bracing bars and the final off load at ERDF requiring a specialized pad to receive the spider frame which generates a large point load. The most unique of the lessons learned have been expanded upon for this paper.

LESSONS LEARNED

Quality Control of Bio-Shield Installation

The reactor assembly drawing states that the biological shield is made of "heavy aggregate concrete". Construction drawings stated that all concrete shall have a 20.7 MPa (3,000 psi) compressive strength. It was confirmed that in fact the biological shield concrete does not meet the compressive strength requirement.

A note in the "composite section" of the drawing states the concrete must be a minimum weight of 3,363 kg/m^3 (210 pcf). A point of note is that the heavy aggregate concrete of the PUREX Facility specifically calls out testing to ensure that the heavy aggregate concrete must be 20.7 MPa (3,000 psi) compressive strength. 309 construction specifications, provided a detailed specification for the control tests that indicate that strength was not the most paramount activity. That is, the Atomic Energy Commission (AEC) wanted to make sure the concrete provided shielding as its primary function, allowing the strength of the facility to be carried in the structural concrete which surrounded the biological shield.

Since the specifications were not followed precisely or revised to represent actual field placement, basic assumptions of the reliability of the bioshield's compressive strength in the design of the extraction method were inaccurate. Had the placement of the bioshield's "heavy aggregate concrete" been noted to not follow specifications, issues may have been identified prior to core drill implementation.

Core Drilling in the Thermally Degraded Bio-Shield

While drilling the holes in the biological shield necessary to cut out the 309 reactor from its foundation, the progress of drilling was essentially stopped as the concrete self-destructed under the drill bits, (instead of being cored out). Drilling at a lower portion of 309 performed by WCH as part of its due diligence evaluation of radiological control issues, provided useable, solid cores. It should be noted that these radiological control samples were only visually inspected by civil engineers for soundness and actual compression tests were not performed. The 50mm (2 in) diameter core was drilled at an average of 250mm (10 in) per 8 hour work day over the course of 8 days at a depth of almost 5m (-16.0 LF) below the deck. Therefore the bioshield appeared to be of sound heavy aggregate concrete.

Since the top of the reactor is where the Type A accident occurred, the thermal degradation was only found to be in the top portion of the bioshield. A known depth of degradation is not known since coring was cancelled. A more thorough core sampling regiment would have uncovered significant change conditions from the originally assumed sound conditions.