Advancements in the H-Canyon Exhaust Ventilation System Inspections at the Savannah River Site – 16030

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ABSTRACT

A facility safety envelope requires management of activities to ensure no unacceptable radiological or chemical hazards to the public, site worker and environment occur. While appropriate design and construction methods ensure an initial physical plant configuration, what actions must an operating Facility take to ensure the physical plant continues to meet a safety configuration throughout Facility life? While a physical walk down of the plant is a tried and true method to confirm conditions, what other methods must be used when a walk down is not possible? What inspection methods are used when balancing budget pressures against obtaining inspection data?

The periodic inspections of the H-Canyon Exhaust Tunnel are performed remotely. The 2015 remote Tunnel inspection has been the most successful inspection to date. This presentation highlights the continued lessons learned with the most recent 2015 remote Tunnel inspection. These lessons learned are applicable to Facilities considering or performing remote inspections.

The Recovery Crawler Project was tasked with determining if the 2014 Inspection Crawler could be retrieved, perform the retrieval if feasible and complete the inspection of the remaining sections of the exhaust tunnel that were not previously performed. The objectives for the project were met, the Inspection Crawler was deemed unusable and left in place and the Recovery Crawler performed the complete 143 meters (470 feet) of tunnel inspection and an additional 55 meters (180 feet) of exhaust tunnel inspection not previously completed.

The remote inspection of a 60+ year operating Canyon Exhaust tunnel is a complex endeavor requiring close coordination of multiple organizations, adherence to Conduct of Operations, Radiological Safety, Worker Safety, etc. principles as well as alignment with Facility Safety Basis requirements. This paper discusses the challenges, actions required getting ready for the 2015 recovery and continued inspection and the hazards encountered performing the actual recovery/inspection.

INTRODUCTION

The H-Canyon facility (see Figure 1), located at the Savannah River Site (SRS) in Aiken South Carolina is a DOE owned chemical processing facility that is designed to reprocess Plutonium, High Enriched Uranium and other radioactive materials. This facility includes a ventilation system that directs contaminated air away from the facility and filters the air in a Sand Filter System through an Exhaust Tunnel. The facility is a Safety Class (SC) structure with a Seismic Design Category 3 (SDC-3) designation.

The H-Area Canyon Exhaust Tunnel is a reinforced concrete structure, whose purpose is to contain and direct the exhaust air flow from the Canyon process areas to the Sand Filter System (See Figure 2). The Sand Filter System removes the radionuclide particles from the air stream prior to release to the environment. The tunnel is part of original construction and has been in operation since the 1950's Canyon Operations. The concrete tunnel walls were painted with acid resistant paint to protect against the chemicals that would be in the exhaust air stream from the Canyon processes.

Fig 1. H-Canyon Facility

Fig. 2. H-Canyon Sand Filter Facility

DESCRIPTION

Inspections of the tunnel prior to 2000 were performed with the use of a camera attached to a pole and inserted in several locations along the tunnel route. Over time, these inspections revealed the removal of paint from tunnel surfaces due to chemicals in the air stream and air flow erosion.

In 1999, the Savannah River Site - Canyon Operations Department, during the periodic inspection of a Sand Filter in F-area, identified a structural issue caused by acid degradation of the concrete structure. Because of the inspection and corrective actions for the Sand Filter, a formalized Structural Integrity Program was developed and implemented for the F-Area and H-Area Canyon facilities.

The Structural Integrity Program is one of the Safety Basis requirements for both the F and H-Areas. The Program performs periodic inspections of structures like the H-Area exhaust tunnel to ensure it is capable of performing to the requirements of the Facility's Safety Basis. The periodicity of the inspections is dictated by the inspection results. If structure degradation is identified, an analysis is performed to confirm the structure will still perform to its safety requirements. Repair recommendations are identified and implemented if warranted.

In 2001, the Structural Integrity Program identified the need to perform a baseline inspection of the entire tunnel. Due to the harsh tunnel environment (i.e. radiation and contamination, chemical and air flow), the use of remotely powered vehicles (referred to as crawlers) with mounted video cameras versus a manned tunnel entry was selected as the safest inspection method. H-area was selected as the first facility to focus attention on completing the tunnel inspection.

In 2003 and in 2009, remote inspection crawlers were deployed in the H-area Canyon exhaust tunnels. The 2003 crawler successfully inspected the tunnel under the main Canyon Structure. In 2011, a third remote inspection crawler successfully re-inspected the tunnel underneath the main Canyon Structure and traveled approximately 140 feet from the Canyon Structure toward the Sand Filter System. This 2011 inspection identified intervals of degraded concrete walls exposing of embedded reinforcement. An analysis was performed and provided confidences that Operations could safety continue until 2013, when another inspection and analysis would be performed. In 2013, a variety of pole camera inspections were performed. The results allowed continued Operations thru December 2014.

In early 2014, a remote crawler was built in coordination with robotic equipment experts from the Savannah River National Laboratory (SRNL). Crawler unit operations demonstrations were completed in a mockup environment, similar to that expected in the H-Canyon Exhaust Tunnel. In June 2014, the H-Area Operations and Engineering, with assistance from the SRNL robotics personnel, successfully deployed the remote crawler and inspected over 300 feet of tunnel structure from the 294-H Sand Filter towards the 221-H Canyon building before it toppled onto the tunnel floor. This inspection coupled with the previous 2011 inspection results; provided Structural Mechanics with a nearly total inspection of the areas of concern for the tunnel. The results of the inspections were evaluated and a comprehensive report detailing the inspection and the structural analysis to confirm Tunnel safety basis requirements was completed in December 2014. (See Figures 3 -6 for the evolution of the crawler systems in H-Canyon)

Because of the investment and success of the Inspection Crawler, a Recovery effort was started to develop and deploy a recovery crawler system. This was completed in June 2105.

The Evolution of the Crawler Units from the inception of the program in early 2001 to the Inspection Crawler development thru 2014 and the End States of the Units

Crawler Evolution | **2015 Recovery Crawler Photos**

Fig. 3. – 2003 Crawler

Fig. 3a. – 2003 & 2009 Crawlers as Left

Fig. 4. – 2009 Crawler

Fig. 5. – 2011 Crawler

Fig. 5a. – 2011 Crawler under Duct

Fig. 6. – 2014 Inspection Crawler

Fig. 6a. – 2014 Crawler under Duct

2015 RECOVERY DEPLOYMENT

As a precursor to the start of the recovery effort, the facility needed to install a permanent structure to serve as the containment for the project. Project activities included the deployment of the recovery crawler (Figure 7), the operations of the both the Recovery Crawler and old Inspection Crawler, complete the inspection of the tunnel and retrieve the crawlers as appropriate.

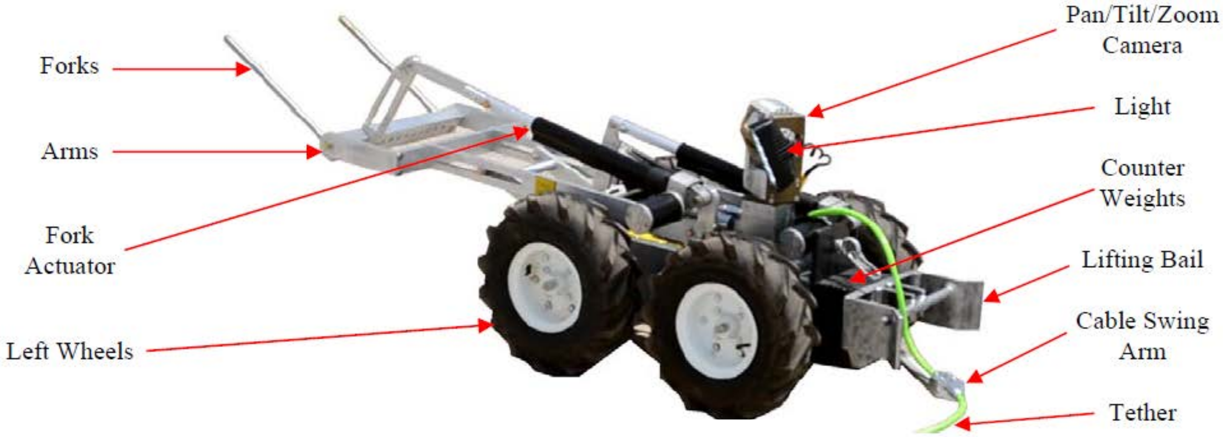

Fig. 7. – 2015 Recovery Crawler

The containment hut (Figure 8) is a fabricated building that provides an entrance, a transition area (vestibule) for support activities and a work zone (Manway room) for direct interface with crawler components (Figure 9) and the exhaust air stream. The work zone was set up as an airborne activity area because of the direct access to the exhaust tunnel air stream. The workers were protected from the exhaust air stream as the air was directed from the inside of the building into the manway and into the exhaust stream. The Permanent hut is mounted on the suction side of the exhaust tunnel.

Fig. 8. – Permanent Hut for Crawler Work

The permanent hut was set up to have temporary utilities, since access to the hut was only expected to occur every one to two years, depending on the outcome of the structural integrity evaluations and requirements for periodic inspections. Power supplied to the facility is currently via a portable generator; however, the facility is reviewing options for permanent power to be applied to the area.
The infrastructure requirements to support the recovery effort included the following:

- Control trailer - for crawler operations
- Monitoring trailer - for visitors and guests and act as a cool down location for workers
- Two portable generators – one for the permanent hut, the other for the control/monitoring trailers
- Portable breathing air - for respiratory suit use
- Water buffalo – to supply decontamination water for the spray wand (described later)

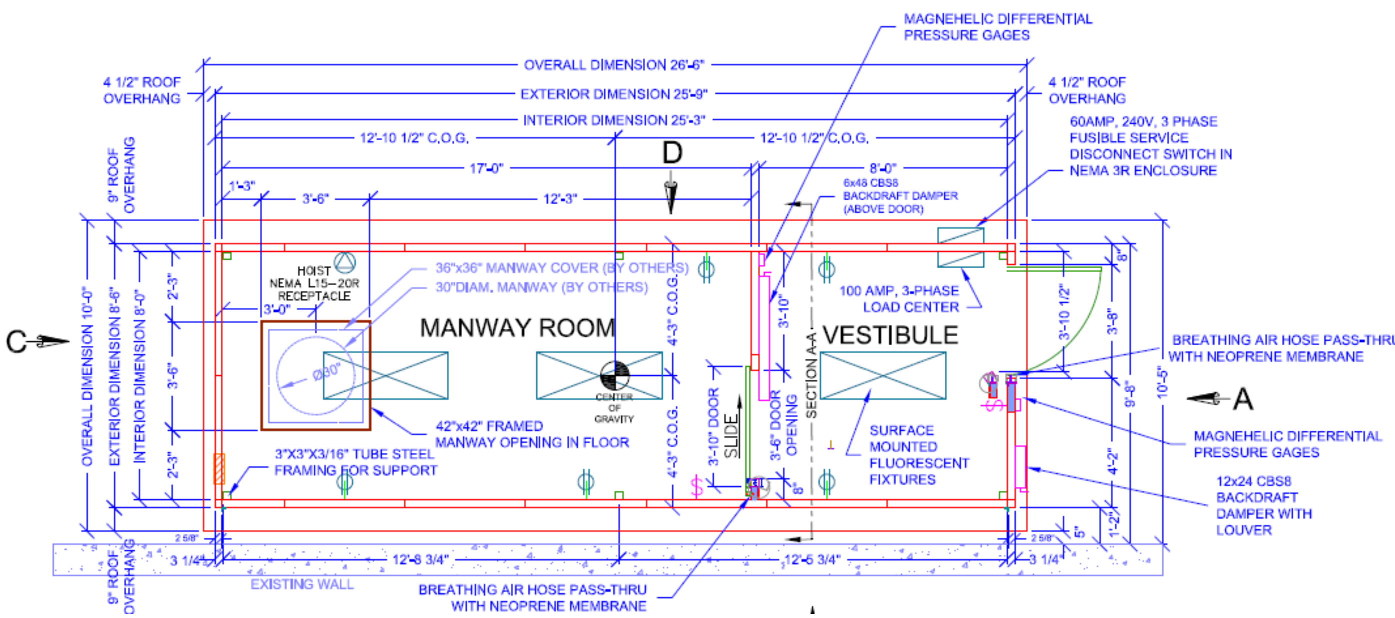

Fig. 9. – Permanent Hut w/Dimensions

Figure 10 shows the major components used in support effort with exception to the portable breathing air supply to the area.

Fig. 10. – Support Equipment for Crawler Inspection

Since the recovery effort involved the operation of not one, but two crawler systems, the need existed to have two separate control stations with independent operators for each of the units. A crawler drive system has two major operating stations; one for the main unit to control the wheels, lifts and camera drives and the other to control the cable spooling and retrieval. This could have been made to work in conjunction with each other off a universal drive system, however, that was cost prohibited by the available project funding for the effort. Figure 11 a&b shows the two main drive stations and the video control station for the various camera views available to the engineers monitoring and directing the effort. The monitoring station feeds were shared to the separate monitoring trailer for guests and visitors and recorded on a Samsung Digital DVR system for a detailed review by structural engineers.

Fig. 11 a&b Control and Monitoring Equipment for Crawler Work

The crawler controls included independent wheel controls (forward and back), which allowed for skid turning. The controls also included video unit drives to position the cameras and zoom for the lens and lift functions to control the forklifts on the recovery crawler and the scissor lift on the 2014 Inspection unit.

The Manway room is a 5.2 meter by 2.4 meter (17'x 8') work space (Figure 12) that housed the overhead hoist system, the bulkhead control (Figure 13), the Manway, the fall protection, crawler cable reels, video display and lifting devices.

Fig. 12. Manway Room inside Permanent Hut

Fig. 13. Crawler Bulkhead inside Permanent Hut

One of the improvement made to the crawler system from the past experiences involved the addition of an incline-o-meter system, to monitor tilt and pitch of the crawler and a dual Electronic Pocket Dosimeter (EPD) display, of Beta and Gamma radiation measurements, to allow for monitoring/characterization of the tunnel as the crawler traversed the area (Figure 14).

Fig. 14. Recovery Crawler Indications

To assist with the decontamination of equipment, when the crawler(s), cabling and rigging equipment were to be removed, a spray wand device (Figure 15) was developed. This collapsible spray wand was custom designed by the Savannah River National Laboratory Robotic Engineers to be able to remotely clean the components while inside the exhaust tunnel proper and provide lighting and video feeds to the operators performing the decontamination effort. Water was supplied from a 1000 gallon Water Buffalo with a system designed 175 psig supply pump and recirculation process. The process was established to allow for constant water pressure to be applied when needed and recirculation capability when spray was not applied.

Fig. 15. Custom Spray Wand

The recovery activities involved five Robotic and Video Engineers from the Savannah River National Laboratory, two Structural Engineers, one Ventilation Engineer, four Riggers, three Operators, four Radiological Protection Technicians and three Project Support team members. A full walkthrough of work sequences at the job site, by workers involved in the recovery effort, was completed on June 8th, 2015; the day before the start of recovery actions. In this walkthrough, personnel and equipment placement was demonstrated to ensure personnel understood the complex maneuvering required in the tight radiological work area. Focus was placed on job responsibilities, personnel positioning, lifting techniques, breathing air hose control, communications cable control and hazards inside the work space.

On June 9th, 2015 the facility entered into a reduced exhaust fan configuration and Limiting Condition of Operations. Tunnel vacuum conditions and permanent hut building ventilation conditions were monitored. When these conditions were determined to be satisfactory, recovery operations commenced. The Recovery Crawler (RC) was inserted into the exhaust tunnel via the Manway inside the permanent hut (Figure 16). This insertion required coordination between the SRNL drivers inside the control trailer and the riggers performing the insertions. SRNL positioned the forks down for insertions, up following movement through the Manway and to the tunnel floor and then back down for the travel through the tunnel. This was to ensure the forks were not damaged with the vertical insertion process.

Fig. 16. Vertical Insertion of the RC through the Manway

Once on the tunnel floor, the RC control functions were checked to ensure equipment was operating as required and initial radiological conditions were recorded. Video feeds were adjusted and the Manway was covered with a slotted lid (for the drive cable) to reduce ventilation draw from the hut and improve tunnel vacuum. The facility wanted to ensure the delta pressure in the tunnel remained greater than 0.75

inches of water to meet facility ventilation requirements.
Additionally, the Inspection Crawler cable was reconnected and powered up. Both IC cameras displays were operational. The higher resolution camera was viewable, but the navigation camera was blurred. When power was applied to the wheels they rotated as required. These initial checks provided assurance to the team to attempt to upright the IC.

Once equipment conditions were verified, then the recovery actions could commence. In order to reach the fallen Inspection Crawler (IC), the Recovery Crawler (RC) had to traverse numerous obstacles. The first obstacle was a 0.3 m – 0.6 m (1'-2') deep water/sand hazard at a low point in the tunnel (Figure 17 a&b). The crawler had to climb a 2.5 – 5.1 mm (1-2") lip and around a concrete support pole obstruction.

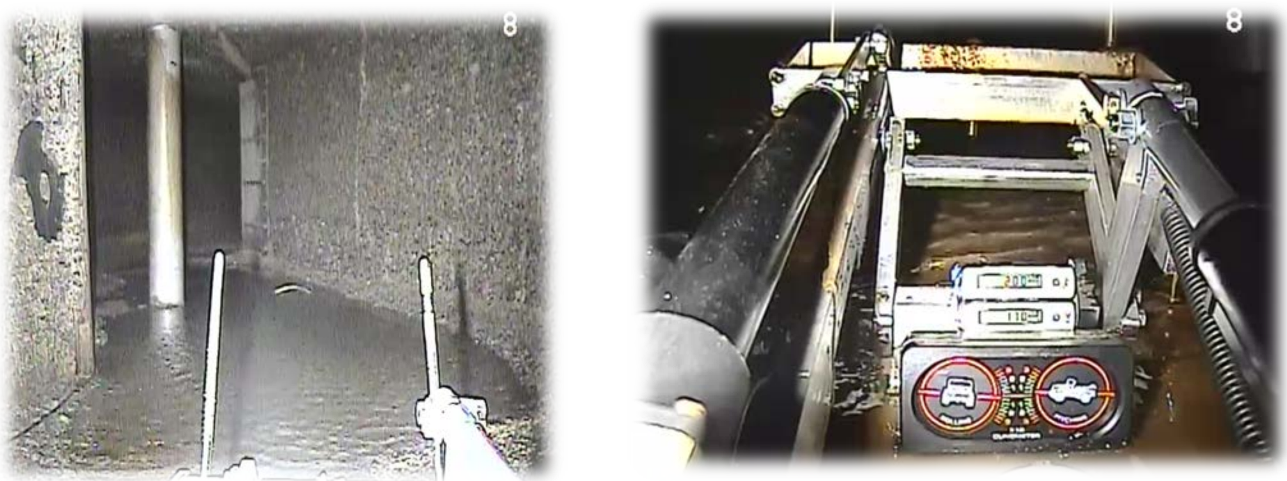

Fig. 17 a&b. Water Hazard inside Exhaust

After the water hazard was cleared, the crawler ascended the tunnel slope that had a rise of 1.8 m (6') over a 27.4 m (90') run to reach the top of the main tunnel leading to the 221-H Canyon (Figure 18)

Fig. 18. Ramp up from Sand Filter inside Exhaust Tunnel

Once traversing the sloped exhaust tunnel section leading to the 221-H building, the hazards encountered changed to debris and expansion joint cover plate construction obstacles (Figure 19 a&b). The expansion joints are constructed with a small lip 76 mm – 152mm (2”- 3”) high. The expansion joints had cover-plates attached to the walls, however, several of the plates had fallen to the ground below. The cover-plates became an obstacle as concrete debris had piled up around the plates acting as a barrier to movement. In some cases, the crawler would have to travel around these and in other cases; the crawler could push the plates out of the way. In addition, if the crawler wheels drove over the plates, the wheel would lose traction and not allow for forward movement. (Note: If time had allowed, the recovery crawler would have been used to move the debris out of the way all together, however, because of the need to minimize the recovery task and the Limiting Condition of Operation durations, debris removal was not performed)

Fig. 19 a&b. Expansion Joint Debris inside Exhaust Tunnel

After passing the expansion joint area, the RC could be moved to the IC area for the inspection and recovery actions. In 2014, when the IC fell, the project team had a general understanding of how the unit was laying in the tunnel. The RC footage (Figure 20a) showed that the location was nearly accurate to the prediction. The only difference was that the scissor lift on the IC was not as extended as believed and it was not as much under the 914 mm (36”) duct as expected. After several iterations, including dragging of the IC back several feet and pushing the back of the unit, the RC was able to lift and push the IC to the wheel position (Figure 20 b), where the IC driver was able to assist using the operable wheel drives on the IC. Once on its wheels, the RC was used to perform a more thorough inspection of the IC unit.

Fig. 20 a. Fallen IC inside Exhaust Tunnel

Fig. 20 b. Restored IC inside Exhaust Tunnel

The IC was investigated for operability and it was found that the scissor lift was corroded and stuck and would not lower. This precluded a removal action, since the manway opening was too small for the extended scissors and the special lift tool would not fit over the scissor mechanism as extended. In addition, both camera units were significantly degraded and the main camera drive arm was stuck in the outer most position. It was determined that the crawler could not be reused and it was left in the tunnel (Figure 20 c)

Fig. 20 c. Final Location of IC inside Exhaust Tunnel

The Recovery Crawler was then used to complete the inspection of the tunnel area, and traveled past the location of where the Inspection Crawler had fallen. The inspection covered the entire 143 meters (470 feet) of tunnel and returned to the Manway location, where it then traveled in the opposite direction for an additional 55 meters (180 feet) to inspect the tunnel along the north wall of the sandfilter building. This addition area was not previously inspection by video means and it provided some valuable information to the Structural Engineers for evaluation. The crawler was then returned to the Manway location, where the Rigging personnel successfully attached to the lifting points in the 56.4 kph (35 mph) wind in the tunnel on the first attempt. The crawler was lifted to the position just under the Manway lower lip where the spray wand was used to decontaminate the unit (Figure 21)

Fig. 21. Decontamination of the RC inside Exhaust Tunnel

The crawler was removed from the exhaust tunnel on June 11th, 2015 after a successful decontamination (Figure 22) of the unit and it was wrapped in plastic and placed inside a specially designed containment bag for future use.

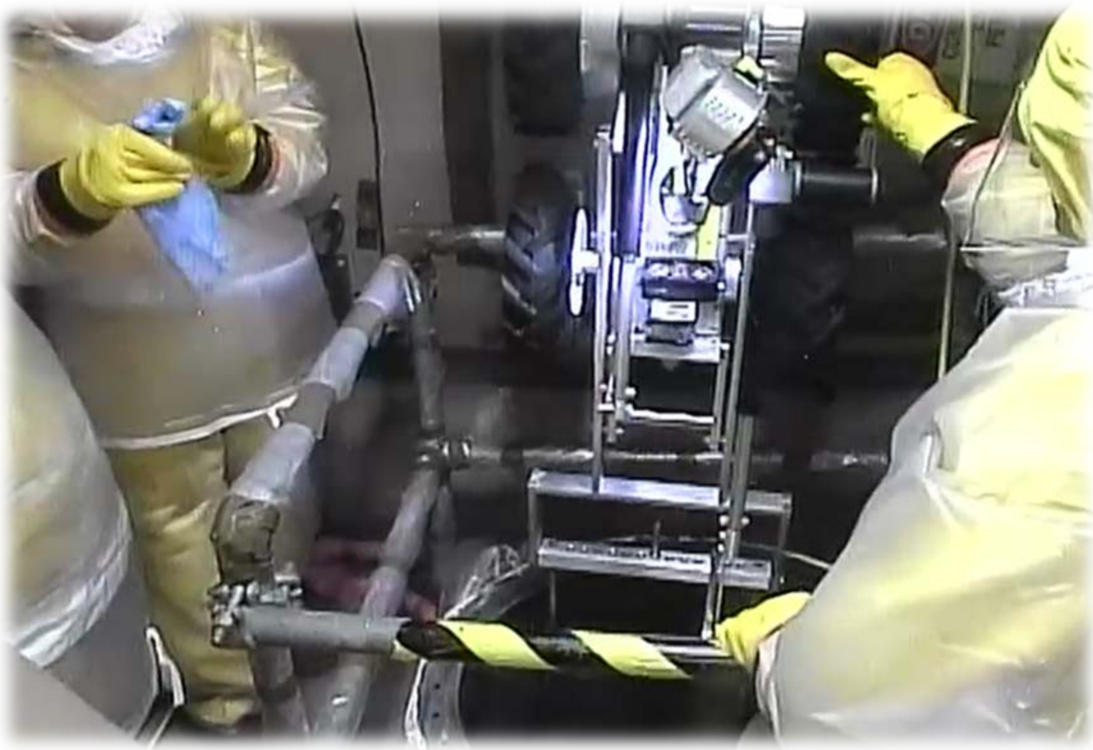

Fig. 22. Cleaned RC in Containment Hut

CONCLUSIONS

Table 1. Project Goals and Accomplishments

Project Requirements	Results	Notes
Design and test robotic tunnel Recovery Crawler	Completed	Verified through Mockup testing at vendor location and numerous mockup demonstrations at SRS
Complete Installation of Permanent Hut for Containment	Completed	Some future modifications are being considered
Traverse the Obstacles inside the tunnel with RC	Completed	Crawler was very back-heavy making some movements difficult, however, the unit successful travelled over every obstacle encountered
Upright and inspect the IC for possible reuse	Completed	After several attempts, was able to bring the IC to its wheels and drive the unit with the existing controls.
Disposition the IC following inspection	Completed	Found the IC to be too degraded for future use and left the IC under the ventilation duct and out of the way for future inspections to be completed as necessary
Complete the travel through the entire tunnel	Completed	Was able to travel from the manway location to the canyon building and back to the insertion location. Also traveled the opposite direction to view a previously uninspected area of the tunnel
Complete Inspection of the tunnel	In-Progress	Was not able to view behind the 36" duct to view the wall conditions, however, will review video data to determine if this can be evaluated using the data obtained
Recover the crawler following activities	Completed	Returned the crawler to the insertion location for the first time since crawler inspections began and successfully performed a decontamination of the unit for reuse

The 221-H facility will need to continue periodic visual inspections of the exhaust tunnel based on the structural evaluation completed in December 2014 and June 2015 inspections. It has been proven the tethered crawler system can effectively traverse the variety of obstacles in the exhaust tunnel and provide valuable visual data for use in continued use justifications. The Recover Crawler provided valuable information for structural engineers to review, however, that vehicle was mainly designed as a recovery vehicle first and then an observation vehicle. The Recover Crawler was able to obtain video footage of the inside of the concrete tunnel, not including the South wall behind the 91.4 cm (36") duct. The video obtained from the recovery will be used to improve the computer model estimate on the extent of degradation of exhaust tunnel.

Mock-up testing and training were essential to prepare for recovery operations prior to deploying equipment into radioactive and other high-hazard contaminated areas.

Because of the long lead time for the development of the Recovery Crawler, the facility will begin activities to plan for the next generation of inspection crawlers incorporating improvements based on the successes and challenges from the 2015 recovery activities and in obtaining high quality videos to enhance tunnel computer models.

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