Inspection and Assessment Of The H-Canyon Ventilation System At The Savannah River Site - 15385

Bob J. Gilliam*, Jay Ray*, and Bill Giddings**
* U.S. Department of Energy, Savannah River Site, Aiken, South Carolina, USA
** Savannah River National Laboratory, Aiken, South Carolina, USA

ABSTRACT

Innovative methods and unique equipment were required to perform the inspection of a large inaccessible sand filter tunnel in an aging facility. Among the singular methods utilized was a specialized robot that addressed the difficulties encountered while performing mandatory structural integrity inspections of the Department of Energy (DOE) Savannah River Site (SRS) H-Canyon Sand Filter Tunnel. There were many unanticipated hazards related to degraded conditions.

Novel approaches and support equipment were used, including new measurement techniques, high-strength *Kevlar*™ cable, a boom-mounted camera, and a larger, more robust robot. With each evolution, additional analysis mandated requirements and considerations for future inspections.

Because this was a visual inspection, many photos were taken to document the mission and lessons learned from the earlier incomplete robotic attempts to inspect these areas. Anyone working with aging facilities that have inaccessible structures, systems and components will find the technical process, with resulting solutions, useful.

INTRODUCTION

Structural integrity inspections of the SRS Sand Filter tunnel at the H-Canyon were mandated, by mission requirements.

The H-Canyon is the only remaining chemical processing facility in America capable of reprocessing plutonium, Highly-Enriched Uranium (HEU) and other radioactive materials. The tunnel is a reinforced concrete structure whose Functional Classification is Safety Class (SC) with the Natural Phenomenon Hazard (NPH) Seismic Design Category of 3 (SDC-3). It is part of “Enterprise•SRS,” the site strategy for leveraging existing facilities and workforce competencies into a sustainable future for the DOE and National Security missions. The sand filter has strategic advantages over standard HEPA air filters, in that it is permanent and can withstand hazardous acid vapors and fire events.

DESCRIPTION

The sand filter facility was constructed in the early 1950’s and remains as a fully-functional, high-value critical investment. The footprint of the filters is three hundred meters in length by 150 meters and constructed with heavy reinforced concrete walls and all stainless steel ductwork**.**

Fig. 1. H-Canyon with Sand Filter Facility in the Background

The internal structure is too large and varied for normal remote inspection techniques, and a tether is required for continuous power, positive communications and measurements.

Fig. 2. H-Canyon Sand Filter Facility

Fig. 3. Original Sand Filter/Tunnel Internal Construction

The current ground-level release calculation required a detailed internal structural integrity inspection for the tunnel, including sealed expansion joints and penetrations. The ventilation exhaust is directed through a concrete tunnel under the facility. This tunnel is approximately three meters wide and three to four meters tall and leads to a sand filter and stack. Acidic vapors in the exhaust have degraded the interior surfaces of the concrete tunnels. Some small areas were inspected; however, the condition of other areas was unknown. There was originally only a small access area inside the canyon which was traversed across a ledge with a drop of over four meters to the tunnel floor.

Several small robotic crawlers were used with incomplete success and this necessitated a more sophisticated inspection system. A larger more robust robotic crawler, with extensive local modifications, was built to accomplish the full structural integrity inspections.

Fig. 4. Modified Large Robot

Fig. 5. Automated Tether

Extensive mock-up facilities were constructed to test this system. Each task was based on experience gained in previous deployments. A scaffolding system was built to set the new manway in place at the proper height to duplicate the conditions in the exhaust tunnel ceiling. This mock-up was used to demonstrate the operation of the special rigging hardware, so the crawler could be lowered in a vertical position and then transitioned to a horizontal orientation for setting it on the floor.

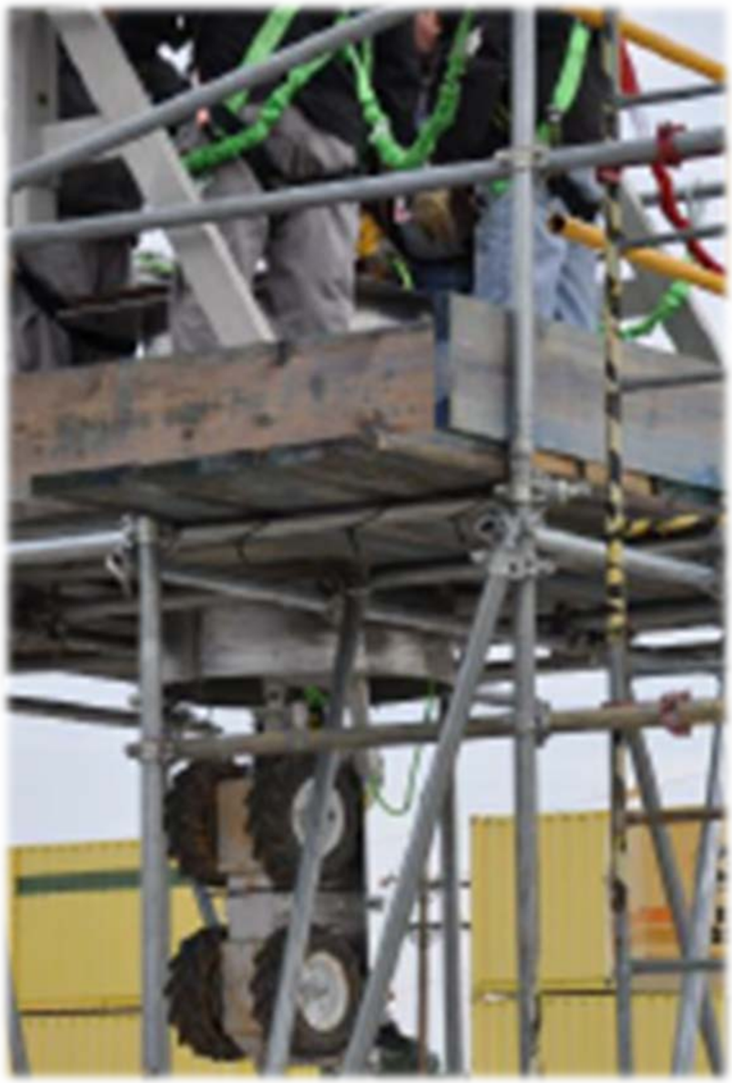

Fig. 6. Mock-up, Equipment Testing and Large-Scale Training

Various landmarks, pipe hangers and exposed rebar as well as tether length indicators were used as reference points to establish the position inside the tunnel. A 232-centimeter diameter manway was drilled into the ceiling of the exhaust tunnel near the sand filter, where the tunnel is above ground. One of the primary objectives was to look at the south wall behind the 93-centimeter duct; therefore, the new crawler included a feature to raise the camera and extend it over the duct. Once in this position, the pan-tilt-zoom camera could be aimed anywhere on the wall of interest.

Fig. 7. Camera on boom mock-up

A setup using three air-blower units was arranged to show that the crawler could operate with a fully-raised camera, with the air flow expected in the tunnel during the inspection (~48.28 kph). The blower arrangement was also used to demonstrate that the crawler yoke could be attached and released with the expected air flow. All tests demonstrated the functions could be performed as planned.

Fig. 8. Fully-extended Wind Tunnel Testing

The traction/turning test was performed in debris about 21 centimeters thick, and the crawler was driven through the material, both wet and dry, a number of times. In addition, several cables and a pipe were placed in the debris; and the crawler proved its ability to drive over the obstacles. The tires slipped on a PVC pipe at first; however, after some maneuvering, the crawler was able to drive over the pipe.

Fig. 9 and 10. Traction and Turning Tests

The tether is made of *Kevlar*™ reinforced with a tough polyethylene jacket, and features a pull and cable reel retrieval mechanism. The crawler was driven on the storage lot, across gravel, dirt and grass surfaces. It was able to pull the tether off the reel for 150 meters, until the reel was empty. The crawler was then driven back to the starting point, while the powered reel was used to retrieve the cable. No problems were encountered during this test.

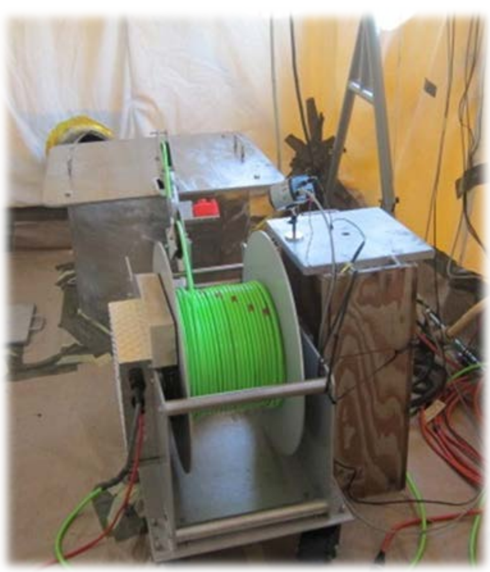

Fig. 11. Automated Tether Control Mechanism

The video recording test was performed while operating the crawler in the canyon tunnel mock-up. The purpose of this test was simply to ensure that all equipment worked properly, and the Digital Video Recorder (DVR) was able to record the camera views successfully. This test provided assurance that all necessary equipment and cables were identified and taken to H-Area for the field deployment.

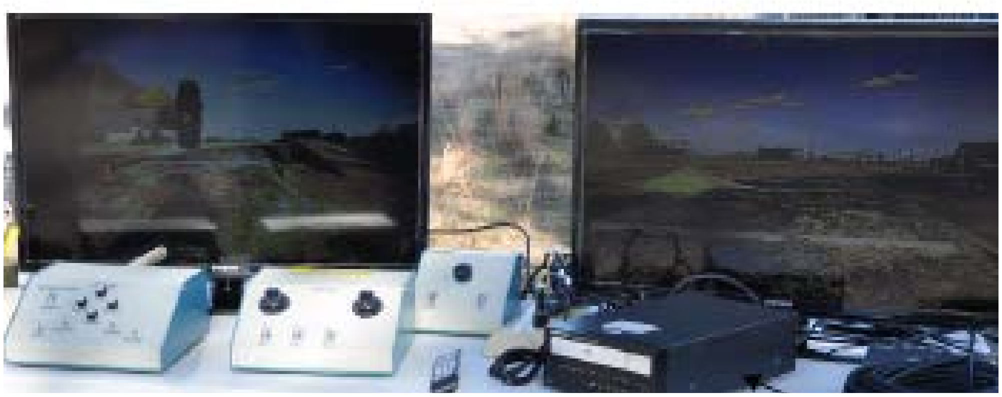

Fig. 12. Video Control Recording Panel

DEPLOYMENT

A new manway was installed in the top of the Air Exhaust Tunnel near the sand filter to provide an alternate means of accessing the tunnel. This new access point allowed for a larger opening and was positioned to offer a much straighter path for an inspection crawler.

Fig. 13. Transition to Horizontal Rigging

Fig. 14. Deployment Enclosure

Fig. 15. Crawler Entering Hoist for Deployment

Water was pumped from a low point in the tunnel near the deployment location and the crawler was lowered into the tunnel. Cameras for viewing the cable reel feed were installed in the temporary hut prior to performing the inspection. There were about 20 centimeters of water remaining in the low point, through which the crawler traveled easily.

Fig. 16. Tunnel Conditions, After Pumping

Ultimately, the remote vehicle was able to view and record images of approximately 100 meters of the exhaust tunnel--which is more than double the previously available footage. The inspection vehicle was also within about 15 meters of the 2011 crawler. The majority of the tunnel was inspected in this 2014 and the 2011 deployments. The Digital Video Discs (DVD's) of the entire video were analyzed, with the conclusion that adequate images were obtained to complete the required structural evaluation.

Fig. 17. Concrete Corrosion Coupon Inspection

Fig. 18. Duct and Expansion Joint

Fig. 19. Other Expansion Joints and Falling Debris on Duct-Work

Several unexpected hazards from construction debris, including a bar with spikes, wires, plywood and metal panels were traversed during the inspection.

Fig. 20. Spikes in Floor

Fig. 21. Tunnel Debris

Following an inspection of the south wall, which required extending the scissor lift and slide to view above and behind the 91.44 centimeter-diameter ventilation duct; debris lodged in the camera extension device. While trying to recover from the disabled extension, the crawler unexpectedly tipped on its side, abruptly ending the inspection.

Fig. 22. Toppled Crawler

Planning for the recovery and re-use of this vehicle is ongoing for future missions.

CONCLUSIONS

2014 Inspection	Accomplishments	2015 Goals
Primary Engineering Mission		
General: Design and test robotic tunnel inspection crawler	Completed	Design and test a new, multifunctional rescue/recovery remote vehicle
Over-arching: Structural integrity via visual inspection of entire tunnel wall, from manway to main building	Incomplete, but acceptable for analysis	Complete remaining 16.2 meters of tunnel/cross-tunnel inspection
Specific Goals		
Inspection of wall behind 93-centimeter duct	Completed	N/A
Inspect tunnel joints to ascertain condition of seals	Completed	N/A
Inspect tunnel pipe hangars	Completed	N/A
Locate and determine obstructions/debris	Completed through the 34 meters inspected	Remove debris from drain sump with new robotic vehicle

Table 1. Mission Accomplishments

The ongoing need to implement a visual inspection of inaccessible areas in the H-Canyon air tunnel has led to the development of several tethered, remote control vehicles over the last ten years. The latest wheeled crawler was able to perform an inspection and preserve views with a DVD recording. The crawler was able to obtain video footage of the inside of the concrete tunnel, including the South wall behind the 91.44-centimeter duct. Approximately 100 meters of the tunnel south wall, north wall and ceiling were successfully completed.

The video has been used to estimate the extent of degradation and to build a computer model. The report from structural engineers was completed in December 2014.

Mock-up testing and training were essential to prepare for remote operations prior to deploying equipment into radioactive and other high-hazard contaminated areas. Remote inspection systems were developed for the mission with all the necessary features for success. A realistic mock-up improved the function of the remote device, improved the proficiency of the operators, reduced risk, identified problems prior to deployment and allowed easy modifications.

The video footage from this deployment provided the necessary views to determine the extent of degradation for the structural evaluation. The structural evaluation was based on the surveillances which were loaded into several different models using the soil backfill from actual test data. The structural evaluations concluded that the tunnel sections meet all non-seismic and seismic load combination requirements.

BIBLIOGRAPHY

Department of Energy, Archival Photos

BILL GIDDINGS "H-Canyon Air Exhaust Tunnel Inspection Crawler Report," *Savannah River National Laboratory*, SRNL –L4500-2014-00059 (September 12, 2014)

JAGDISH J. BHATT, and GUY R. BALDWIN, "Assessment of H-Canyon Exhaust Tunnel Based on Current Photographic Information," *Savannah River Nuclear Solutions*, T-ESR-H-00016 (October 15, 2013)

RICK MINICHAN and BOB FOGLE, "H-Canyon Air Exhaust Tunnel Remote Inspection Crawler Report," *Savannah River National Laboratory*, SRNL-L1300-2011-00088 (September 20, 2011)