Brookhaven Graphite Research Reactor (BGRR) D&D Project - 11243

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ABSTRACT

S.A.Technology was selected to deliver a safe and effective remote system to begin the decommissioning and final cleanup actions for the Brookhaven Graphite Research Reactor (BGRR) located in Upton, NY on Long Island. The decision made by the DOE, the U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation was to develop a top-down approach to dismantling the BGRR reactor. S.A. Technology accomplished this goal by developing an innovative remote excavator system that employed an independent structural steel rail system to trolley 12.19m over the deck floor. This rail system allowed the excavator to perform decommissioning operations over the top of the reactor. This rail system also supported a 10-ton crane that aided in the removal of waste mined by the excavator. This entire system was housed in one of the largest contamination control enclosures (CCEs) ever built. This CCE allowed controlled access to the excavator, giving it the ability to deploy a number of robust tooling systems that allow it to easily accomplish all of the tasks required to mine out the cavity of the reactor. The successful removal of the BGRR graphite core has proven this remote excavator system to be an effective method of decommissioning retired graphite reactors. The achievements and processes developed from the BGRR decommissioning project will help to provide S.A.Technology with insightful information as this process continues to lead the way with this innovative methodology for decommissioning graphite reactors. The focus of this tooling was to provide an ALARA solution to removing the moderator and biological shield. The intrusive radiation and contamination work is done by remote tooling and controlled by active and passive contamination control systems.

INTRODUCTION

The BGRR was the world's first reactor built purely to perform scientific research on peaceful uses of the atom. It was an air-cooled, graphite-moderated reactor that operated from 1950 to 1968 and served as a valuable research facility. Having reached criticality on August 2, 1950, it was used for a wide range of scientific, medical, and engineering research purposes. In 1968, DOE decided to permanently shut down the reactor, as it no longer provided the high neutron flux preferred by researchers, which was available at the then-new High Flux Beam Reactor. The reactor was de-fuelled in 1972.

At the center of the BGRR is the graphite moderator, a graphite cube (pile) measuring about 7.62 meters on each side and weighing about 700 metric tons. The graphite pile consists of approximately 60,000 rectangular blocks and is completely surrounded by a five-foot thick biological (radiation) shield. The graphite is precision-machined with penetrations to allow nuclear fuel to be inserted and control rods to be positioned throughout the moderator and core to control the reaction. The bioshield, or reactor block, is a rectangular prism, approximately 12.19m W X 15.24m L X 11.28m H, constructed of a 76.2mm-to-152.4mm steel liner on the inside and a 3-inch steel liner on the outside. The approximately 1.52 meter thick concrete filler lies between the liners. The inside liner is attached to the outside liner with angle steel and penetration tubes that support fuel charging and discharging and loading of experiments. The roof is of similar dimensions and construction but supported with steel I-beam-like girders. The roof has removable concrete plugs that provide access to the top of the pile (reactor cavity). This high-density concrete shield was designed to reduce the exposure of the reactor operators and personnel in the building to radiation.

In 2005, the DOE, the U.S. Environmental Protection Agency, and the New York State Department of Environmental Conservation agreed on a final cleanup action for the BGRR. This agreement required the removal of the graphite pile, biological shield, fuel-canal structure, and reasonably accessible contaminated soils, as well as the installation of a water infiltration control and monitoring system.

Several actions to prepare the BGRR for decommissioning were taken after the closing of the reactor in 1968, including spent-fuel disposal, removal of certain support structures, and deactivation of the below-ground ductwork and canal.

GRAPHITE MODERATOR & BIOSHIELD REMOVAL EQUIPMENT & METHODOLOGY

Excavator Gantry Equipment

A gantry-mounted remote manipulator or excavator-like machine was designed, fabricated, tested, and installed by S. A. Technology and fitted with special tools on an independent rail system above the bioshield. This graphite mining machine was designed and tooled to mine out the graphite moderator, deploy a shear for rod-cutting and removal, deploy a thermal cutting robot capable of remotely cutting the inside bioshield liner and support steel, and use a hydraulic demolition hammer attachment to remove the concrete filler and shear the steel that tied the bioshield liners together. The graphite mining manipulator was supported by a structural steel system 12.19 meters off the reactor main floor. The manipulator rode on a set of rails spanning the reactor bioshield. A gantry arrangement with a 15.24 meters long bridge and trolley allowed the manipulator to travel in X-Y (E-W, N-S) directions above the reactor cavity. The excavator could then rotate and reach down into the reactor cavity to perform the mining operations. The equipment was remotely operated from a control room via camera coverage of the entire operation.

Fig. 1. The excavator with the shear attachment is shown here above the access plugs inside the contamination control enclosure (containment).

Support Crane

A dedicated 10-ton crane was designed and installed by SAT and rode on a second set of rails outside those of the excavator gantry. This crane was used to remove the concrete roof plugs on the reactor, perform maintenance of the equipment, and deploy a soil sack inside a lift fixture into the reactor cavity. The lift fixture was designed to support the soil sacks and allow them to be loaded with material and then lowered into an IP-1 container staged on the north side of the reactor at floor/grade level. The lift fixture support rods slid out, releasing the sack into the container, and then was pulled back up and out of the container.

Fig 2. Reactor top straddled by remote gantry-mounted excavator & support crane on an independent rail

Structural Steel Support System

The structural steel system that supported the operating equipment 40 feet off the deck was designed to support a dead load of 70 tons along with the dynamic loading that the equipment created while mining graphite or lifting loads with the crane. The system was designed by Burns & Roe Engineering as a subcontractor to SAT. This system also supported the dynamic loads created when the bioshield concrete was hammered out. This system had to be neatly fit into the over 60-year-old reactor high bay building that housed the reactor. Additional challenges in designing this system involved maintaining all of the large support girders, 15.24 meter long equipment bridge, and major equipment of individual weights below 10 tons so that the existing reactor building's 10-ton crane (not the new support crane) could lift the members. Added structural challenges involved finding and analyzing footings to support the structural steel system. With below-ground ductwork and limited grade beams, the project was forced to do things such as modify an existing elevator shaft into one of the columns and hang a support truss off of one of the reactor building's crane girders. Another significant challenge was to design and install a support system that was completely independent of the bioshield structure. During graphite removal, the bioshield was credited as a containment system (SSC) for the moderator. Eventually, the equipment was used to remotely demolish the bioshield from the inside out, undermining the bioshield as a support structure that could be credited in any way.

Fig. 3. Structural steel system – North face column with converted elevator shaft tied together with truss number 2

Contamination Control Enclosure

The entire excavating system, support crane, waste load-out system, reactor roof, and the entire north side of the reactor was housed in the largest contamination control enclosure (CCE) ever built by Lancs Industries. The support frame for this tent had to be designed to support the massive walls of this containment under negative air pressure.

Airlocks on the each end of the north side waste load-out area enabled waste crates, tooling, and personnel to enter the area and leave while negative pressure was maintained in the containment structure, and it had to support the radiological controls necessary when handling contaminated material.

Ventilation System

The containment system was brought under negative pressure and the atmosphere turned over in the space for contamination control purposes by four 6000 CFM air movers. The HEPA filter banks for this ventilation system were located in the reactor high bay building. The fans for the system were located in a fan house (converted cargo container) outside the high bay. The flow path drew air into the containment through dampers, down through the reactor cavity opening, out of the bioshield through a plenum attached to existing fuel-charging penetrations on the south side of the reactor block, through the HEPA filter banks, and out of the building through the fans and exhausts through a stack that ran up the outside of the high bay building. The exhaust was monitored by instrumentation and probes inserted into the stack. Redundancy in the fan units allowed for filter change-outs and fan maintenance while the containment was maintained under negative pressure.

Control Room, Hydraulics, & Fixative Spray System

The operation of the excavator, crane, and ventilation system was primarily accomplished from a control room located on the east side of the reactor. An actual Gradall excavator control chair was outfitted with additional controls for added tool features. The remote video system provided multiple views of the reactor cavity and displayed them on monitors in front of the operator. Another panel and radio frequency belly pack were used to operate the crane with added camera coverage and video display. Two of the ventilation fans were operated from a remote panel with a pressure indication in the control room to allow for negative pressure adjustments and flow adjustments within the CCE atmosphere. A fixative spray system provided contamination control fixative up through the excavator gantry arm through nozzles on the primary tools to spray down the pile and keep dust down. This system, along with the primary and backup hydraulic skids, were located on the east side of the reactor building.

DESCRIPTION OF ACTUAL WORK - OPERATIONS

The graphite moderator was completely removed by 5/15/2010. This excavator/mining equipment was successfully used to remove the graphite blocks from the pile and load them into the supersacks. The pile was safely removed in just a few months. The supersacks are supported and positioned in the reactor cavity by the lift fixture attached to the crane. After loading, the lift fixtures deploy the sack down into the permanent waste crate staged on the north side of the main floor. The sack is released into the crate and the lift fixture is pulled back out of the crate. The lift fixture is prepared with a new sack while the crate is lidded. The crate is surveyed and removed from the waste load-out area by a fork truck through the air locks. When tie rods and alignment rods need to be size-reduced the shear attachment is installed on the excavator arm and positioned down into the cavity to shear the rods and load them into the lift fixture. They are then placed inside the IP-1 crates, like the graphite, for shipment to the DOE’s Nevada Test Site for disposal. The pile is sprayed down with fixative as layers of graphite are removed to keep dust and contamination under control. The equipment and system, along with an S.A.Technology thermal cutting robot are currently being used to demolish the biological shield from the inside out.

Fig. 4. Bucket/thumb tool extended down into the cavity by excavator arm - mining

Results/Lessons Learned

The remote equipment involved saved a tremendous amount of man-rem exposure to contamination and was a huge ALARA savings tool. Production rates were as designed. The equipment worked as designed with very little down-time. The bucket and thumb assembly removed the graphite layers and readily deployed the graphite into the soil sacks located/stationed in the lift fixture. The lift fixture was easily deployed by the support crane into the reactor cavity. The crane and lift fixture further provided deployment and simple operation in releasing the soil sacks into waste crates on the main floor, their final resting place. As of the writing of this paper, about 95% of the graphite moderator had been removed. The success of these systems, equipment, and customers opinion is featured in the "*Weapons Complex Monitor*" vol 21 no. 26 dated June 7, 2010

The ventilation system was successful at keeping contamination contained within the reactor cavity, with very little airborne dust. The remote tools were plumbed to deploy a latex paint and CC wet from the fixative spray system. This system was successful and worked as designed to keep dust down and contaminations under control. As well the CCE worked containing the entire operation within an envelope and allowing the negative pressure created by the ventilation system and air turnovers to keep the atmosphere inside the CCE clean and habitable. The airlock into the CCE functioned as designed in allowing material and equipment movement into and out of the CCE while maintaining negative pressure within the space. As of the writing of this paper, no HEPA filters had required replacement. Only the pre-filters within the filter housings required replacement.

A used Gradall piece of equipment was used as part of the excavator assembly. Project cost prohibited the use of a new Gradall. If project funding had allowed it, a new Gradall should have been used. The camera and video system that support remote operations had a small time delay in the system. An upgraded system with no time delay should have been used for smoother remote operations.

REFERENCES

1. Brookhaven Graphite Research Reactor, Documented Safety Analysis, Brookhaven National Laboratory, Upton, NY. April 17, 2007
2. Brookhaven Graphite Research Reactor, Technical Manual, Brookhaven National Laboratory, Upton, NY. October 1962