



ROBOTIC reactor vessel head inspection innovations at Beaver Valley-2

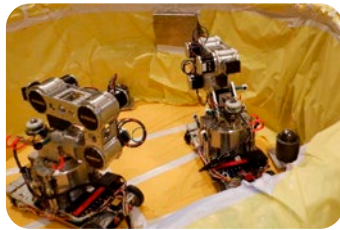
By Jim Graf

Two critical factors for the success of nuclear industry outages are safety and efficiency. This includes personal and nuclear safety for the team members working on the outage, equipment safety through proper inspections and maintenance, and ultimately public safety when a reactor system is returned to service, free of defects and ready for reliable power production.

The goal is to accomplish everything, keeping safety as a priority, in a short period of time and as economically as possible. So how do you maintain safety during an outage while striving for shorter durations and lower cost? Through human innovation and improved technology.

That's exactly what happened during the refueling outage in the fall of 2021 at Unit 2 of Energy Harbor's Beaver Valley Power Station. Through the ingenuity of a team from Beaver Valley and their partners at Westinghouse, major improvements were made in reactor vessel head inspections using the new Gemini Robotic Inspection System. These improvements were a success for the station and earned the team a 2022 Nuclear Energy Institute Top Innovative Practice (TIP) award.

"The Gemini system was a win-win," according to Beaver Valley outage manager Andrew Crotty. "Working with our Westinghouse partners, we were able to enhance safety by lowering dose and reducing trip hazards, as well as improve outage efficiency. We put a great deal of effort into innovation, and it was great to see that effort pay off."



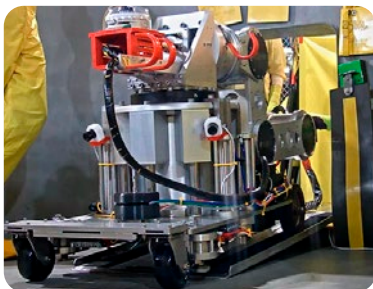
Gemini Robotic Inspection System

During every refueling outage at Beaver Valley, reactor vessel head inspections are performed to verify that the structural integrity of the reactor head is maintained and the reactor's condition is acceptable for continued service. Because of the high radiation dose rates associated with work below the reactor head, the majority of inspections are performed remotely with the help of robotic systems. For this outage, the Beaver Valley team implemented the Westinghouse Robotic Gemini Inspection System for under-head inspections.

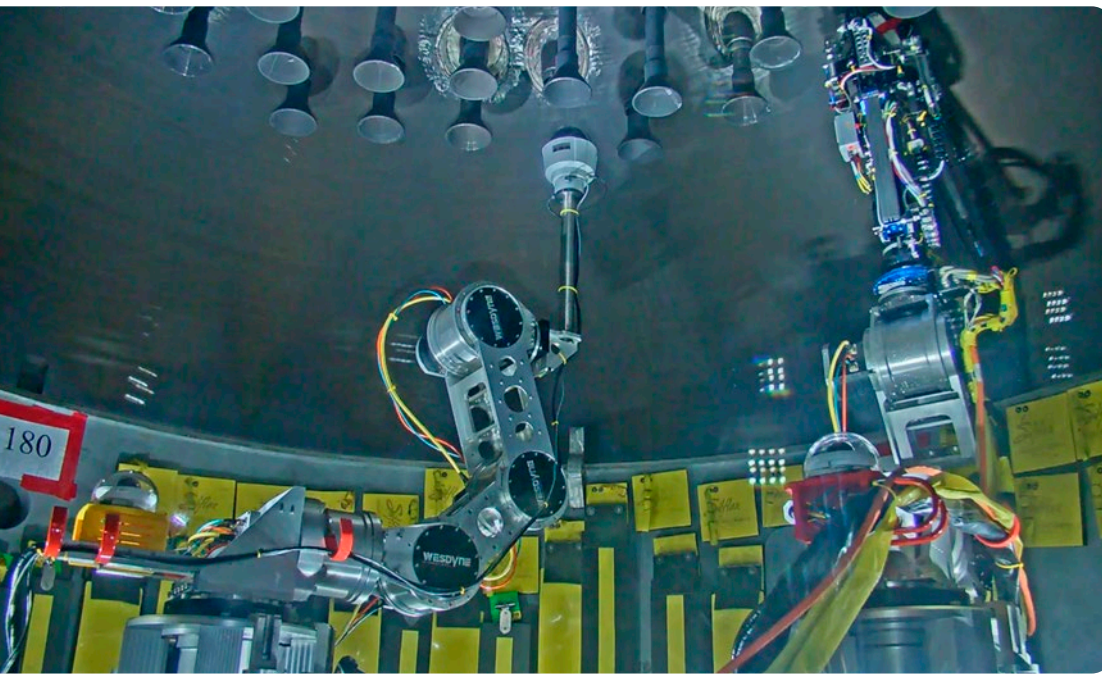
The Gemini system uses two independent articulating robotic arms to perform visual, ultrasonic, and eddy current inspections on two head penetrations in parallel. It is designed to be installed and removed through the personnel access opening in the head stand, alleviating the need to remove the head for installation or demobilization of equipment. Previously, stationary single-end-effector systems were the standard equipment used for head inspections at Beaver Valley.

Safety first

The largest benefit to utilizing the Gemini system is personal safety. The system's compact footprint removes obstructions from the floor of the head stand that were caused by the track system of the previous inspection equipment, improving industrial safety during the reactor head repair by reducing trip hazards and containment floor clutter. Dose and contamination risk are reduced by implementing remote inspections of the head vent penetration in place of the manually delivered tool used previously. Similarly, decontamination is simplified because of the overall decrease in inspection equipment located within the reactor head stand and because the Gemini robots can be relocated during repairs. While the Beaver Valley-2 head inspection was not an emergent situation, if an emergent inspection became



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Gemini robots performing nondestructive examinations on two reactor vessel head penetrations in parallel. (Photo: Westinghouse)

necessary during an outage, the Gemini system can be installed and removed while the head is still in the stand, eliminating the need for an additional head lift.

Outage efficiency

The use of the Gemini system to inspect two penetrations in parallel improves the outage baseline schedule by about 36 hours, which is achieved by using a detailed pre-outage inspection plan to maximize the impact of the dual inspection. The simplified design of the system and ease of mobility allow for additional reductions in setup, decontamination, and equipment demobilization time, leading to an overall savings of over \$1 million in planned outage costs (with the potential for greater time and costs savings in the event of an emergent issue). An added bonus of earlier setup is earlier detection of any issues discovered through inspection, allowing emergent repairs to be absorbed into the outage schedule sooner, reducing the impact to the overall critical path of the outage.

Using new technology

The nuclear industry does not implement new technology without a thorough investigation of its impact to equipment health. Beaver Valley site procedures were applied to

this first-of-its-kind project implementation to ensure precise and timely communication between utility and vendor team members. The pre-outage planning meetings and scheduling efforts dictated by those established procedures were key to the success of the project.

The Gemini system showcases how cutting-edge robotic platforms can perform work in environments with high radiation dose rates, furthering the ideals of continuous improvement, nuclear safety, and ALARA (as low as reasonably achievable) in the nuclear industry. Adoption of the technology for reactor vessel head inspections at Beaver Valley required procedure and scheduling paradigm changes. Thanks to the innovative team from Beaver Valley and Westinghouse, this was accomplished with an education and communication strategy that ensured all stakeholders understood the benefits of the new technology.

The gains in safety and efficiency at Beaver Valley can be used as a benchmark for implementation of the Westinghouse Gemini system across the industry. ☒

Jim Graf is a communications staff member at Energy Harbor's Beaver Valley plant.