Ultrasonic Examination of BWR Core Shroud Vertical Welds Without Impacting Outage Critical Path

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ABSTRACT

In response to Exelon Generation Company request to provide core shroud ultrasonic examination services at the Oyster Creek Nuclear Generating Station during a recent refueling outage (1R22), IHI Southwest Technologies (ISwT) used equipment and tooling that was capable of performing the examinations without the use of a work platform or refuel bridge. The IHI developed AIRIS-CS examination system is a unique system consisting of a remotely operated scanning tool that is designed for core shroud ultrasonic examinations. ISwT’s previous operation of this system, included deploying the scanning tool from a work platform or refuel bridge and using a hand-held camera, also deployed from a platform or bridge, to visually monitor the scanner while positioned on the outer shroud wall.

Since the Oyster Creek Station did not have a work platform during 1R22 and it was not desirable to deploy the tooling from the refuel bridge because of increased critical path time, ISwT used alternative methods for deploying the scanner and the camera which deleted the requirement for platform or bridge support during critical path. These alternative methods include deploying the AIRIS-CS tool from the edge of the cavity using a flotation device used many times in the past by ISwT to install a similar AIRIS tool (AIRIS-21) used for the reactor vessel examinations. Also, a camera mounted to a second AIRIS tool allowed visual observation of the first tool during the examinations without support from a bridge or platform. The purpose of this paper is to provide an overview of the development and use of this equipment to reduce critical path time during a core shroud examination at Oyster Creek Nuclear Generating Station.

AIRIS EXAMINATION EQUIPMENT

AIRIS-CS Tool Description and Method of Operation

The AIRIS CS™ scanner is small (approx. 15 in. wide, 18 in. tall, and 2 in. thick) and weighs only 20 lbs (reference Figure 1). The small, thin design makes the device ideal for use in tight, narrow conditions such as the annulus between a BWR core shroud and vessel wall. Once the AIRIS CS™ is lowered to the approximate location on the shroud, it uses two small thrust propellers to move in contact with the shroud wall. Once on the wall, a flexible skirt makes contact and the thrusters create a partial vacuum between the device and the wall, allowing the drive wheels to maintain contact with the surface.
Two independent drive wheels (travel motion) and one caster wheel allow free maneuvering around the shroud surface. Independent encoder wheels provide coordinated tracking of device position regardless of motion direction. A linear drive (scanner motion) provides search unit module movement perpendicular to the traveling motion of the device. Both the traveling motion and the scanner motion can be used for UT scanning or incrementing.

Positional location of the AIRIS CS™ is accomplished using a combination of measurements integrated and displayed by the control system. An origin reference point is established for each examination zone by locating a specific elevation and azimuth. Elevation can be determined by the use of two high-accuracy water depth sensors, one on the device and one located at a fixed location such as the vessel flange, or it can be determined visually by driving the device to a fixed component inside the vessel whose elevation is known.

Azimuth reference location is typically accomplished visually by driving the device to a fixed component whose azimuth is known or a physical reference can be obtained from other components such as sparger piping.

Once the device is on the shroud wall in the referenced position, the encoded drive wheels provide travel distance and a gravity sensor keeps track of device orientation. The control unit integrates this information and provides constant positional information relative to the device location. A graphic display unit also shows the orientation of the device and direction of movement.

The device is controlled through a single umbilical cable bundle, which contains all inputs and outputs to the control system as well as the AUT transducer cables. This device control cable also contains a steel braided cable so that the cable can also function as a device retrieval mechanism in the unlikely event of a power failure or thrust propeller failure. Device operation is monitored visually during the inspections using an independent remote video camera.

**AIRIS-21 Tool with Camera Modification**

The AIRIS-21 looks very similar to the AIRIS-CS (reference Figure 2). It is larger than the AIRIS-CS tool and was designed for reactor vessel weld examination. It operates in the same manner as CS tool and was modified to hold an underwater camera to observe the CS tool during the core shroud examinations.
The modifications that were required to allow the AIRIS-21 to be converted to a camera deployment tool included the following:

- **Remove Ultrasonic Transducer Module** – removal of the UT module (item that holds the ultrasonic transducers) and mounting hardware.
- **Camera Mounting Hardware** – camera mounting hardware was designed and fabricated that allowed attachment of two types of underwater cameras (color CCD-type and radiation hardened black & white) and lights to the AIRIS-21 tool.
- **Buoyancy Compensation** – buoyancy was added to the AIRIS-21 tool to offset the additional weight of the camera system.

Figure 2 – AIRIS-CS (left) and AIRIS-21 (right)
Cable Management Float Tool for AIRIS Deployment

IswT has the ability to deploy the AIRIS tools from the edge of the cavity using a tethered cable float (reference Figure 4). The AIRIS umbilical cable is feed through the center of the float and the float is moved over the reactor vessel using rope tethers (reference Figure 4). When in position over the vessel, the AIRIS tool is lowered into the vessel by feeding additional cable through the float.
PRE-JOB DEMONSTRATION

Prior to the Oyster Creek refueling outage, a demonstration was conducted at the IswT AIRIS maintenance facility in San Antonio, Texas to confirm the capability to deploy the AIRIS-CS tool without work platform or bridge support and test the camera system mounted to an AIRIS-21 tool. An RPV / Core Shroud mockup was fabricated and submerged in one of IswT’s test tanks for this activity. Reference Figure 6 for an illustration of AIRIS tools positioned on mockup.

A successful demonstration was conducted for members of the Exelon Oyster Creek Outage team which included the following activities:

- Installation of AIRIS-21 with attached camera utilizing the cable management float and successful attachment to vessel wall (AIRIS-21 tool was lowered and submerged from edge of test tank to verify that tool was capable of attaching to the vessel wall).
- Installation of AIRIS-CS with cable management float and successful attachment to core shroud wall (AIRIS-CS tool was lowered and submerged in test tank to verify that tool was capable of attaching to the vessel wall).
- Maneuver AIRIS-CS on mockup wall and verify that CS tool can be observed with camera mounted on AIRIS-21 tool. Reference Figure 6 for illustration.
- Setup and run simulated exam (verified that CS tool could be properly positioned for exam and capable of performing examination).
- Remove AIRIS tools from mockup and test tank (verified that tooling could be removed from mockup without any difficulties).
FIELD APPLICATION

The automated ultrasonic (AUT) examination of 10 core shroud vertical welds was conducted by IswT during the 1R22 refueling outage at the Oyster Creek Nuclear Generating Station using qualified phased array AUT examination techniques and the IHI developed AIRIS examination system. In order to save critical path time, IswT deployed the AIRIS equipment in a unique way for a portion of the examinations. The unique deployment method was used during the portion of the outage schedule when fuel was being moved and there was no work platform or refuel bridge available to support the insertion or removal of examination equipment into the reactor.

The AIRIS examination equipment was deployed from the edge of the cavity using a cable management floatation ring that allowed the AIRIS scanner to be positioned over the reactor and lowered into the RPV / Core Shroud annulus region. A second AIRIS tool, with an underwater camera mounted to it was also lowered in a similar manner and used to provide visual feedback to assist with the positioning of the examination tool on the core shroud surface.

Exelon personnel determined that this first of a kind approach and innovative delivery technique resulted in both critical path time and radiation dose savings while providing the necessary AUT data to accurately evaluate the structural integrity of the core shroud. The time / cost savings was estimated to be 15 critical path hours or $515,000 and the estimated dose savings from deploying the tooling from the edge of the cavity rather than over the reactor from the refuel bridge was 600 mr.

The successful execution of this examination has lead Exelon to nominate this project for a 2009 Nuclear Energy Institute (NEI) Top Industry Practice (TIP) award.
CONCLUSIONS

Examination of the vertical core shroud welds at Oyster Creek Nuclear Station were completed during the 1R22 refueling outage using proven examination equipment and techniques combined with a unique, first of a kind, delivery method which resulted in critical path time savings and radiation dose savings. This technology is unique but highly transferable for use at other nuclear sites, which makes it valuable to the nuclear industry.

REFERENCES

1) BWRVIP-03, Revision 11, “BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines”, UT Demonstration # 56.