Applying Artificial Intelligence and Machine Learning to Reduce Primary Component NDE Inspection Times

Summary

EPRI has developed AI-based assistance for defect recognition in ultrasonic testing (UT) inspection data, such as reactor pressure vessel (RPV) upper head penetrations. Time and resources can be saved to evaluate data faster.

The approach not only supports the industry-required independent secondary review, potentially reducing the number of qualified examiners needed, but also enables the utility to perform more efficient oversight.

The early identification of potential issues will support cost, schedule, and radiation dose savings if no repairs are necessary, or better allow the utility to adequately plan for a repair. One member is currently working with their regulator to qualify this technique for official credit, and EPRI is developing other inspection improvements by incorporating AI.

APPLICABILITY

All nuclear plants

VALUE

Application can result in savings by ***reducing time and resources needed for required inspections and the likelihood of human error***. Earlier identification of potential issues can support ***cost, schedule, and radiation dose savings*** if no repairs are necessary, or better allow a utility to plan for a repair. In one case, review time was decreased from a 4-day evolution to approximately 4 hours.

EPRI PROGRAM

Nondestructive Evaluation Program

Example – Member Application

EPRI's validated method to inspect reactor pressure vessel head penetrations improves inspection results with significant time savings. In one field trial, the review time was decreased from a four-day evolution to approximately four hours.

Background

During plant outages, analysts spend significant time reviewing large volumes of inspection data—primarily benign—while searching for potential material flaws caused by service-induced degradation in critical, primary plant components. This important but exhaustive process, compounded by the need for multiple independent reviews, often extends outage windows and limits oversight.

To tackle these issues, EPRI collaborated with utilities to adopt an AI-assisted analysis approach, developed with support from EPRI's Nondestructive Evaluation Program.

This innovative technology identifies areas requiring expert review, dramatically reducing analysis time and improving inspection reliability.

EPRI completed the first portions of this R&D during two successful field trials at member sites in 2022 and 2023. This new technique for RPV upper head penetrations is available for use today, and additional applications in other areas have field trials in 2024 and 2025.

EPRI's Role

These are the first known applications of AI and machine learning (ML) for UT examinations at nuclear power plants. EPRI led the development and validation of an AI-based model for automated defect recognition in Time of Flight Tip Diffraction (TOFD) Ultrasonic Inspection data from head penetration inspections. This included extensive coordination and communication with plant staff, vendors (i.e., software, inspection), and a regulator to demonstrate, assess, and refine the effectiveness of the model and related

techniques for the industry. EPRI is working on a qualification protocol, and future plans include R&D on additional methods for inspecting dissimilar welds, the core shroud, in-vessel piping components, and real-time visual inspections.

Value

This innovative technology has been proven to significantly cut data review time. For instance, one utility reduced analysis from several days to under three hours, providing opportunities to reduce outage costs and schedules.

Analysts can concentrate on critical areas without the fatigue and distractions associated with reviewing vast datasets, which supports earlier and more accurate identification of flaws, and enables smoother independent reviews. This approach may also facilitate consistent data comparisons between sequential inspections.

Additionally, AI-assisted analysis has the potential to increase reliability by reducing the likelihood of human performance errors and missed flaws.

Resources

- 3002029360, *AI-Assisted Analysis of Reactor Vessel Upper Head Penetration Ultrasonic Inspections*
- 3002025510, *AI Tool Developed by EPRI Significantly Cuts Analysis Time in U.S. Nuclear Plant Field Trial: Data Analysis Takes Four Hours Compared to Four Days Without Artificial Intelligence*
- 2024 Technology Transfer Award: *Utilities Revolutionize Nuclear Inspections With AI-Assisted Analysis for Faster, Smarter, and More Reliable Outcomes*
- 3002023718, *AI-Assisted Analysis of Ultrasonic Inspections*
- Using AI to Streamline Data Analysis (video)
- 3002026528, *PRE-SW: Assisted Analysis of Remote Visual Examination (AARVE) v0.1 Beta*
- 3002021074, *Quick Insight Brief: Leveraging AI for Nondestructive Evaluation*
- Support from EPRI subject matter experts

To support more effective technology transfer, EPRI is tracking implementation of key R&D activities.

Please access this link to provide input on your company's use of this particular research: https://www.surveymonkey.com/r/QKSDPDB

Access additional Value Guides and examples of EPRI R&D application at: https://interactive.epri.com/nuclear-value/p/1

IMPLEMENTATION GUIDANCE

EPRI can engage with utilities to use this technology with their existing inspection processes, including help with coordination, training, and communication.

After training, no qualification is needed to use the technique in an oversight (backup) capacity to improve inspections.

A utility can review previous outage data to help prioritize inspection orders, assess needed resources, and prepare for pre-job briefings.

Vendors can now develop procedures with AI-assisted analysis for qualification (i.e., ASME).

Additionally, in 2025, a European utility is seeking qualification for inspections.

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