Reactor Vessel Head Penetration Repair Contingency Planning

Background

Examinations of the reactor vessel head penetration tubes and J-groove welds occasionally detect flaws that must be dealt with before returning to operation. More recent Alloy 600 cracking has been identified in "cold," less-susceptible heads, requiring welded repairs. Westinghouse offers the embedded flaw weld repair technique, a U.S. Nuclear Regulatory Commission (NRC)-approved, permanent repair that isolates the flaw from the environment, eliminating further crack propagation due to primary water stress corrosion cracking.

Completing an emergent repair is neither cost-effective nor efficient. Consequently, the industry has seen an increased demand for contingency planning options. With contingency plans in place, including trained machinists and welders on standby and tooling/equipment available, the critical path is less impacted, allowing for a faster return to service.

Description

To allow for an expedited repair to the reactor vessel head, Westinghouse has developed the following contingency planning options.

Field Engineering and Repair Planning

Three-dimensional Engineering Modeling –

To allow for the existing tooling application or to validate the tooling modifications necessary for the plant-specific design, the first priority is to create an engineered three-dimensional (3D) model of the reactor vessel head, including all penetrations, storage stand and bio-wall. Repair procedures will be prepared using these results, taking into account the unique head design and clearances required for specialized tooling.

Project Management Planning –

Westinghouse project management and headquarters pre-outage support may include draft scheduling, look-ahead planning, pre-outage support, identification of long-lead activities and materials, and support of plant planning (e.g., as low as reasonably achievable [ALARA]), as well as essential procedure development.

Equipment Reservation –

Primary mitigation tooling can be reserved between receipt of the purchase order and completion of inspection. This equipment set will be capable of performing thermal sleeve removal and reinstallation, and embedded flaw repairs on the tube outside diameter (OD), inside diameter (ID) or J-groove weld. Also available will be retaining collar or thermocouple column funnel removal tooling, as well as electrical discharge machining equipment.

Full-contingency Planning with Crew Training –

Full-contingency planning provides the greatest benefits, greatly reducing the impact on critical path. Choosing a full contingency includes the previously stated items, as well as contingency crew training (e.g., machinists, welders, e-techs). This trained crew will be on standby and ready to mobilize should a repair be required.

Quality Assurance (QA) –

Westinghouse and its subsidiaries, such as PCI Energy Services (PCI), which provide technical skill sets for welding and machining functions, have a robust Quality Assurance (QA) program. Having fully integrated QA programs and processes, Westinghouse can effectively support its customers.

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Fracture Mechanics and Engineering Analyses

In order to avoid additional outage delays due to engineering efforts, fracture mechanics and engineering analyses can be performed prior to the outage. These are not included in the above field engineering and repair planning efforts, and may be offered separately.

Flaw Evaluation Handbook –

Using a prepared flaw evaluation handbook may allow a flaw to be left in place without repair, should it meet the acceptance criteria. The reactor vessel head penetrations (RVHP) Flaw Evaluation Handbook includes two pieces: a finite element residual stress analysis and flaw evaluation charts. The stress analysis is input to the flaw evaluation charts, which addresses common types of flaws located on the ID and OD of the upper head penetration nozzles. The handbook provides technical support for continued operation without repair. The IWB-3660 evaluation procedure and acceptance criteria in the American Society of Mechanical Engineers Section XI code is used in the development of the flaw evaluation charts. Since any indications in the J-weld are not acceptable in accordance with the IWB-3660 acceptance criteria, indications in the J-weld will not be addressed in the flaw evaluation charts.

Flaw Repair Handbook –

Using a flaw repair handbook prepared prior to the outage may enable advanced preparation of the plant's draft NRC relief request referencing the approved embedded flaw technique, per WCAP-15987-NP, Revision 2-NP-A, Technical Basis for the Embedded Flaw Process for Repair of Reactor Vessel Head Penetrations. Westinghouse will perform a series of evaluations to identify the largest flaw size that can be repaired using the embedded flaw repair technique, covering the most common flaw configurations. Technical bases will be developed to demonstrate the acceptability of embedded flaw repair for ID and OD surface flaws in the penetration tube as well as for the J-weld.

Thermal Sleeve Wear and Replacement Engineering –

Prior to the outage, Westinghouse can develop wear criteria to allow prescribed additional time of operation prior to repair. If a repair is required, a weld repair analysis will be completed, providing justification for adding a partial penetration weld at an elevation determined by the repair crew. Included is a dynamic analysis of the thermal sleeve and driveline to determine loads on the thermal sleeve at the elevation of the repair weld, and a structural evaluation of the partial penetration weld. Westinghouse can supply replacement funnels with configuration concurrence from engineering.

Hardware Procurement

Replacement Thermal Sleeves and Guide Funnels –

If thermal sleeves or guide funnels must be removed to facilitate head penetration repairs or if excessive wear is found, Westinghouse can supply replacement thermal sleeves and guide funnels. The replacement hardware will be installed to replace the removed sections of the original equipment. The thermal sleeve wear and replacement engineering efforts previously described will be offered.

Post-repair Inspection

Should repairs be required, Westinghouse will use a portion of the WesDyne reactor vessel head inspection (RVHI) crew that is already onsite to perform the post-repair ultrasonic testing exam.

Benefits

Teaming with Westinghouse prior to performing the reactor vessel head inspection reduces overall risk and effect on the plant's critical path, should a repair be required. RVHP inspections and repairs require many specialized tools, qualified resources, significant training and preparation time to execute, and upfront engineering and licensing efforts.

Westinghouse has fully qualified and proven welding processes and supporting documentation and procedures to support the RVHP efforts. The company provides integrated project experience by coordinating its engineering, field and installation, and inspection organizations.

In addition, unlike other repair methods, the Westinghouse embedded flaw repair is permanent, and the NRC staff has approved the embedded flaw mitigation process in WCAP-15987-NP, Revision 2-NP-A. A plant's reference of the generic relief request has already been approved for multiple in-service plants.

Experience

Many utilities have wisely invested in RVHP repair contingency planning efforts to reduce the risk of extended outages. 3D engineering modeling and other upfront efforts bring the most benefit. In addition, over 30 RVHP Flaw Evaluation Handbooks and 13 RVHP Flaw Repair Handbooks have been developed since 1993 to help customers prepare for potential indications found during inspections and their associated repairs.

Westinghouse has completed over 40 RVHP repairs since 1997, with 80 percent of those repairs being on the OD or J-weld. Additionally, nearly 120 thermal sleeves have been removed and/or replaced. Services have been successfully provided on a planned and emergent basis.

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