Inservice Inspection (ISI) and Inservice Testing (IST) of Nuclear Power Plant Components

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ASME Nuclear Codes and Standards
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Inservice Inspection (ISI) and Inservice Testing (IST)

Why test and inspect?

To detect

- Functional degradation
  - By testing active mechanical equipment

- Structural degradation
  - By examination of active and passive mechanical equipment
Inservice Inspection (ISI) and Inservice Testing (IST)

Why test and inspect?
To prevent

- Structural failure
- Fluid leakage
- Radiation leakage
- Loss of operability
Inservice Inspection (ISI) and Inservice Testing (IST)

Why test and inspect?
- Aging management
  - Monitor degradation
  - Maintain design margins
Active Functions

- Wear
- Corrosion
- Erosion
- Vibration
- Leakage
- Radiation damage
- Thermal aging
- Unusual or unanticipated loads
Passive Functions

- Corrosion
  - General oxidation
  - Pitting
  - Crevices
  - Microbiological
  - Flow-accelerated
  - Erosion/cavitation
Passive Functions

- Stress-corrosion cracking or hydrogen embrittlement
  - Intergranular
  - Transgranular
  - External Chloride
  - Primary Water
Passive Functions

- Fatigue
  - Mechanical
  - Thermal
  - Corrosion

- Irradiation embrittlement

- Unanticipated events
  - Water hammer
  - Pressurized thermal shock
  - Large seismic event
Detection of Degradation

How do we detect degradation?

- Establish baseline (PSI or reference condition)
  - As early as possible
  - Using inservice methods
  - Update after changes

- Monitor changes
  - Performance testing
  - Nondestructive examination
  - Destructive testing
Performance Testing

- **Pumps**
  - Vibration
  - Flow rate
  - Differential pressure
  - Bearing temperature

- **Valves**
  - Stroke time
  - Seat leakage for RCS or containment isolation
  - Relieving Pressure

- **Snubbers**
  - Range of motion
  - Lockup
Destructive Testing

- Tensile testing
- Impact testing
- Fracture toughness testing
Nondestructive Testing and Examination

- Chemical analysis
- Volumetric examination
  - Radiographic, ultrasonic, eddy current, acoustic emission
- Surface examination
  - Liquid penetrant, magnetic particle, ultrasonic, eddy current
- Visual examination
- Leak testing
NRC Regulations

- 10CFR50.55a(b) mandates use of ASME Section XI & OM Code
  - 50.55a(a)(3) provides alternatives, when authorized by NRR
    - Acceptable level of quality and safety
    - Hardship or difficulty without compensating increase in quality or safety
    - Includes ASME Code Cases not pre-approved by NRC
  - 50.55a(b)(5) and Reg. Guide 1.147 identify pre-approved Cases
NRC Regulations

- 50.55a(g)(6)(i) provides relief from impractical requirements, when granted by Commission
- 50.55a(g)(4)(ii) requires update of ISI Program to use later Edition and Addenda of ASME Section XI every 120 months (10 years)
- 50.55a(g)(4)(iv) permits use of later Editions and Addenda of Section XI, incorporated by reference in 10CFR50.55a(b), subject to Commission approval
  • RIS 2004-12 and 2004-16 explain NRC position on use of later Editions and Addenda incorporated by reference
Inservice Inspection (ISI) and Inservice Testing (IST)

- **Inservice Inspection**
  - ASME Section XI, Inservice Inspection of Nuclear Power Plant Components

- **Inservice Testing**
  - ASME Code for Operation and Maintenance (OM Code)
Inservice Inspection (ISI)

- **Scope of ASME Section XI**
  - Preservice and inservice examination
    - Mostly nondestructive (NDE)
    - Identify degradation
  - Evaluation Standards
  - Repair/Replacement Activities
    - Including modifications

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Inservice Inspection (ISI)

- Why is ISI required?
- Identify degradation
  - Flaw growth
Purpose of ISI

- **Periodic examination to detect degradation**
  
  "The intent of the Code is to provide for, on a case by case basis, a review of the indications that show potential signs of distress and relate the condition to the service requirements to which the component is subjected. For the case where the review shows that no changes have occurred, disposition would require nothing further. For the case where the evaluation shows potential signs of distress, but the condition meets (is within) the original acceptance standards, disposition may require nothing more than the examination of an additional number of components or like areas." (1968 Section XI)
Periodic Examination to Detect Degradation

Quality, or Level of Compliance with Construction Code
Technical Requirements

Initial Compliance with Construction Code

Section XI Acceptance Criteria

- Start of Operation
- 1st Periodic Inspection (Accept)
- 2nd Periodic Inspection (Reject and Correct)

Time

Service-induced Degradation

Restore to Compliance with Construction Code

Continued Degradation

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Organization of Section XI

- Division 1 - Light-water-cooled Nuclear Power Plants
- Division 2 - Gas-cooled Nuclear Power Plants (discontinued 1993)
  - HTGR
    - Helium-cooled
    - Carbon-encapsulated fuel in a graphite matrix
    - Graphite-moderated, prismatic core and reflector elements
  - Currently being rewritten for PBMR and other next-generation gas reactors
- Division 3 - Liquid-metal-cooled Nuclear Power Plants (discontinued 2004)
Organization of Section XI

- Subsection IWA - General Requirements
- Subsection IWB - Class 1 Components
- Subsection IWC - Class 2 Components
- Subsection IWD - Class 3 Components
- Subsection IWE - Class MC Metal Containment Vessels and Containment Penetrations Not Backed by Concrete, and Liners of Class CC Containment Vessels
- Subsection IWF - Class 1, 2, 3, and MC Component Supports
- Subsection IWG - Core Support Structures and Reactor Vessel Internal Structures
- Subsection IWL - Concrete Containment Vessels
- Mandatory & Nonmandatory Appendices
Subsection IWA

- IWA-1000 Scope and Responsibility
  - Jurisdiction
  - Classification
  - Owner’s Responsibility

- IWA-2000 Examination and Inspection
  - Authorized Inspection
  - Examination methods and extent
  - Personnel qualification
  - ISI Program (Plans and Schedules)
  - Code Cases

- IWA-3000 Standards for Evaluation of Examination Results
Subsection IWA

- IWA-4000 Repair/Replacement Activities (including modifications)
  - Scope and applicability
  - Alternatives and exemptions
  - Procurement of replacement items
  - Design (modification)
  - Programs and Plans
  - Failure analysis and corrective action
  - Welding, brazing, and defect removal
  - Examination and pressure testing
Subsection IWA

- **IWA-5000 Pressure Testing**
  - Applies to both periodic testing and testing following repair/replacement activities

- **IWA-6000 Records and Reports**
  - Documentation of examinations, tests, evaluations, and repair/replacement activities
  - Reporting to regulator
Design for ISI & IST

- How are in-service inspection and testing considered in system design and construction?
- Who is responsible?
Design for ISI & IST

- System Designer responsibilities
  - Identify degradation mechanisms
  - Select resistant materials
  - Understand examination and testing methods capable of detecting degradation
  - Provide access for examination and testing (NDE, chemical, mechanical, functional)

- Owner verifies adequacy of design for ISI & IST
Access Requirements

- Physical space around component, volume, or surface
- Physical or visual access of personnel
- Environmental hazards
- Equipment limitations
- Instrumentation
Questions?