

# NRC INSPECTION MANUAL

EMCB

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## TEMPORARY INSTRUCTION 2515/160

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### PRESSURIZER PENETRATION NOZZLES AND STEAM SPACE PIPING CONNECTIONS IN U.S. PRESSURIZED WATER REACTORS (NRC BULLETIN 2004-01)

CORNERSTONE:       BARRIER INTEGRITY  
                          INITIATING EVENTS

APPLICABILITY:       This Temporary Instruction (TI) applies to all holders of  
operating licenses for pressurized-water reactors (PWRs).

#### 2515/160-01       OBJECTIVE(S)

01.01 The objective of this TI is to support the review of licensees' activities for inspecting pressurizer penetrations and steam space piping connections made from Alloy 82/182/600 materials and to determine whether the inspections of these components are implemented in accordance with pertinent licensee responses to NRC Bulletin 2004-01 (NRC Accession Number ML041480034), which was issued on May 28, 2004. This TI validates that the licensee for a given plant addressed by NRC Bulletin 2004-01 is meeting its inspection commitments using procedures, equipment, and personnel that have been demonstrated to be effective in detecting leakage from Alloy 82/182/600 pressurizer penetrations and steam space piping connections.

01.02 As an ancillary benefit, this TI promotes information gathering regarding the condition of Alloy 82/182/600 pressurizer penetration nozzles, pressurizer steam space piping connections, and pressurizer heads and shells to help the Nuclear Regulatory Commission (NRC) staff identify and shape possible future regulatory positions, generic communications, and rulemaking.

#### 2515/160-02       BACKGROUND

Recent discoveries of leaks and primary water stress corrosion cracking (PWSCC) in the reactor coolant pressure boundary components of PWR-designed nuclear power plants have made clear the need for more effective inspections of ASME Code Class 1 components that are fabricated from nickel-alloy materials. The NRC has issued the following generic communication to address the safety implications of PWSCC events that have occurred in the vessel head penetration nozzles adjoined to the upper and lower RV heads of PWR facilities:

- Bulletin 2001-01, Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles, August 8, 2001
- Bulletin 2002-01, Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity, March 18, 2002
- Bulletin 2002-02, Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Programs, August 9, 2002
- NRC Executive Order EA-03-009, Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors, February 3, 2003
- NRC Executive Order EA-03-009, Issuance of First Revised Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors, February 20, 2004
- RIS 03-13, NRC Regulatory Issue Summary 2003-13: NRC Review of Responses to Bulletin 2002-01, "Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity," July 29, 2003
- Bulletin 2003-02, Leakage from Reactor Pressure Vessel Lower Head Penetrations and Reactor Coolant Pressure Boundary Integrity, August 21, 2003

On May 28, 2004, the NRC issued Bulletin 2004-01, Inspection of Alloy 82/182/600 Materials Used in the Fabrication of Pressurizer Penetrations and Steam Space Piping Connections at Pressurized Water Reactors, to address degradation in pressurizer components fabricated from Alloy 82/182/600 materials. In this bulletin, the staff discussed the safety implications of recent pressurizer heater sleeve and steam space piping cracking events that had occurred both in U.S. and foreign PWRs and addressed the need for addressees to consider augmented bare metal visual (BMV) examinations, volumetric examinations, or surface examinations of their pressurizer penetrations and steam space piping connections. The staff also made the following recommendations with respect to inspection programs for pressurizer penetrations and steam space piping connections:

- (1) The implementation of a BMV inspection of 100% of all Alloy 82/182/600 pressurizer penetration and steam space piping connection locations in a manner that permits visual access to the bare metal 360° around the components.
- (2) The implementation of a non-destructive examination (NDE) to characterize the crack orientation associated with any pressurizer penetration or steam space piping connection in which a visual examination has demonstrated evidence of leakage.

- (3) If the NDE defines the flaw as potential circumferential cracking below the sleeve attachment weld, the NRC will be notified immediately and an appropriate inspection plan developed. The plan will define additional sleeves to be inspected by NDE sufficient to determine the extent of condition commensurate with the characterization of the flaw.

The staff requested that the addressees provide their plans for inspecting pressurizer penetrations and steam space piping connections made from Alloy 82/182/600 materials and provide justification why the inspection methods proposed for these components are considered to be capable of demonstrating compliance with the applicable regulatory requirements for the components. This TI provides inspection guidance for reviewing licensee examinations of Alloy 82/182/600 locations covered under the scope of Bulletin 2004-01.

## 2515/160-03 INSPECTION REQUIREMENTS

### 03.00 Implementation Requirements

Implementation of this TI is only required for those PWR light-water reactor facilities that include Alloy 600 base metal materials or Alloy 82/182 weld metal materials in the design of their pressurizer penetration nozzles, heater sleeves, or steam space piping components.

#### 03.01 Conformance with Licensee Response to NRC Bulletin 2004-01

- a. Inspectors assigned to the implementation of this TI will review the licensee's response to NRC Bulletin 2004-01 to familiarize themselves with the licensee's plan for the examination of Alloy 82/182/600 pressurizer penetrations and steam space piping connections. The inspector's objective will be to report on whether the inspections conducted by the licensee are consistent with the licensee's response to Bulletin 2004-01 and any subsequent, related correspondence between the licensee and the NRC staff.

#### 03.02 Bare Metal Visual Examination

A BMV examination is implemented to verify the absence of boric acid crystals, which, if otherwise detected, may provide evidence of a leak from an Alloy 82/182/600 pressurizer penetration nozzle or steam space piping connection. A BMV examination is also implemented to verify the integrity of the pressurizer shell. The inspection of BMV examinations within the scope of this TI may be conducted by either resident inspectors or Inservice Inspection (ISI) specialist inspectors at the discretion of Regional Management. If BMV examinations are performed, the inspection will consist of the following activities, as amended by the inspection guidance and options specified Section 04.00 of this TI:

- a. Inspectors will follow IP 57050, "Visual Testing Examination." Inspection requirements; however, guidance associated with inspection objective 01.01 in IP 57050 will be excluded from the inspection scope.
- b. Review the qualifications and certification of the inspection personnel and the inspection techniques to assess the licensee's ability to detect or identify small boric acid deposits on the subject locations.
- c. Review the examination procedure to determine whether it provides adequate guidance and examination criteria to implement the licensee's examination plan.
- d. Conduct a performance-based inspection to verify that the licensee properly performed the procedure. Pay particular attention to ensure that the visual clarity of the examination process was adequate; the method used to track identification of the locations being inspected is effective; and that prior (pre-existing) boric acid deposits, debris, and insulation were effectively identified and evaluated. Also, review the inspection procedure to verify that it provides specific actions to be implemented should boric acid deposits (or other interfering deposits) be identified on the subject locations or related insulation.
- e. Independently review a sample of the visual examinations of the Alloy 82/182/600 pressurizer penetrations and steam space piping connections. The sample should consist of a representative sample of all types of locations covered under the scope of Bulletin 2004-01 which are being examined by BMV. The number of specific BMV examinations reviewed by the inspector should be sufficient to meet the requirements and guidance provided in IP 57050-02, Section 02.02 and IP 57050-03. The sample should also allow for assessment of the physical difficulties in conducting the examination. The inspection of the licensee's examinations may be considered part of the sample required by IP 71111.08, "Inservice Inspection Activities," Section 71111.08-02, Subsections 02.01 and 02.03, as subject to the additional guidance in Section 04.00 of this TI..
- f. If an inspection opportunity is available, inspectors will independently examine a sample of Alloy 82/182/600 pressurizer penetrations and steam space piping connections and assess the conditions of the pressurizer shell. In particular, inspectors should look for evidence of possible leakage from the subject locations and for conditions such as debris, insulation, dirt, boric acid deposits from preexisting leaks, coatings, physical layout, and viewing obstructions (e.g., pressurizer heater cables). If an opportunity to independently review the subject locations does not become available, inspectors will briefly describe the circumstances (i.e., is this a routine outage condition that does not permit viewing) and what they could independently review.
- g. If boric acid deposits are identified on the surface of any of the subject locations or related insulation, the inspector will review the licensee's actions for verifying the integrity of the affected penetrations and/or steam space piping connections. These activities should be performed before returning the plant to operation. The inspection of these licensee activities will consist of the following:

1. A review of the process the licensee follows for resolving the source of any boric acid deposits identified.
  2. A review of the scope of the licensee's plan to examine the pressure retaining components above the locations which the deposits were identified to ensure that all possible sources of boric acid leakage have been identified.
  3. A review of the licensee's corrective actions in response to the identification of boric acid deposits on the subject locations or related insulation.
- h. Inspection Option: If boric acid deposits are attributed to a source other than leakage through the pressure boundary and if supplemental non-visual nondestructive examination (NDE) is not performed of the area, inspectors will review the process used by the licensee to determine the source of the boric acid deposits (this is to ensure that the boric acid deposits are not the result of reactor coolant leakage from a throughwall or through-weld crack in a reactor coolant pressure boundary component). Inspectors should review reports of any chemical analyses to ensure that the conclusions are logical and supported by the analysis. Questions regarding detailed aspects of chemical analyses of boric acid deposits may be referred to the Materials and Chemical Engineering Branch contacts for this Temporary Instruction.
- i. Inspectors will report anomalies, deficiencies, and discrepancies associated with the RCS structures or the examination process including those identified by the licensee. Verify they are placed in the licensee's corrective action process. The inspectors will report lower-level issues concerning data collection and analysis, as well as any issues that are deemed to be significant to the phenomenon described in the bulletin or when such problems are judged to be significant enough to potentially impede the examination process. These items should be reported in accordance with the reporting instructions of this TI.

### 03.03 Volumetric Examination

Licensees may perform volumetric examinations in accordance with their response to Bulletin 2004-01 under two specific circumstances. First, licensees may perform volumetric examinations of butt welded joints (e.g., in lines connecting safety or relief valves to the pressurizer) as part of their scheduled ASME Code inservice inspection program or in accordance with commitments made in response to Bulletin 2004-01. Second, licensees may perform volumetric examinations if boric acid deposits are identified on any pressurizer penetrations or steam space piping connections. If volumetric examinations are performed, the NRC inspection will consist of the following activities:

- a. Inspectors will follow Inspection Procedure (IP) 57080, "Ultrasonic Testing Examination." The inspection of the licensee's volumetric examinations may be considered part of the sample required by IP 71111.08, "Inservice Inspection

Activities,” Section 71111.08-02, Subsections 02.01 and 02.03, as subject to the additional guidance in Section 04.00 of this TI. The inspection scope will consist of:

1. If volumetric inspections are being conducted consistent with the licensee’s ASME Code inservice inspection program, the scope of examinations reviewed by the inspector should be consistent with the requirements and guidance provided in IP 57080-02, Section 02.02 and IP 57080-03.
  2. If volumetric inspections are being conducted to further evaluate the material conditions of pressurizer penetrations or steam space piping connections which show evidence of reactor coolant leakage, or to expand the scope of volumetric examinations performed if circumferential PWSCC has been identified, all licensee examinations should be reviewed by the inspector.
- b. The inspector will independently review the licensee’s implementation of the chosen method to volumetrically inspect the subject locations.
- c. Identify any anomalies, deficiencies, and discrepancies associated with the RCS structures or the examination process including those identified by the licensee and then verify they are placed in the licensee’s corrective action process. The inspectors will report lower-level issues concerning data collection and analysis, as well as any issues that are judged to be significant enough to potentially impede the examination process. The inspector will report whether the demonstrated examination procedures were implemented properly. These items should be reported in accordance with the reporting instructions of this TI.

#### 03.04 Surface Examination

Licensees may perform surface examinations in accordance with their response to Bulletin 2004-01 under two specific circumstances. First, licensees may perform surface examinations of butt welded joints (e.g., in lines connecting safety or relief valves to the pressurizer) as part of their scheduled ASME Code inservice inspection program or in accordance with commitments made in response to Bulletin 2004-01. Second, licensees may perform surface examinations if boric acid deposits are identified on any pressurizer penetrations or steam space piping connections. If a surface examination is performed, the NRC inspection will consist of the following activities:

- a. Inspectors will follow Inspection Procedure (IP) 57060, “Liquid Penetrant Testing Examination.” The inspection of the licensee’s surface examinations may be considered part of the sample required by IP 71111.08, Section 71111.08-02, Subsections 02.01 and 02.03, as subject to the additional guidance in Section 04.00 of this TI. The inspection sample will consist of:
  1. If surface examinations are being conducted consistent with the licensee’s ASME Code inservice inspection program, the scope of examinations

reviewed by the inspector should be consistent with the requirements and guidance provided in IP 57060-02, Section 02.02 and IP 57060-03.

2. If surface examinations are being conducted to further evaluate the material conditions of pressurizer penetrations or steam space piping connections which show evidence of reactor coolant leakage, or to expand the scope of surface examinations performed if circumferential PWSCC has been identified, all licensee examinations should be reviewed by the inspector.
  - b. The inspector will independently review the licensee's implementation of the chosen method to inspect relevant surface conditions in the subject locations.
  - c. Identify any anomalies, deficiencies, and discrepancies associated with the RCS structures or the examination process including those identified by the licensee and then verify they are placed in the licensee's corrective action process. The inspectors will report lower-level issues concerning data collection and analysis, as well as any issues that are judged to be significant enough to potentially impede the examination process. The inspector will report whether the demonstrated examination procedures were implemented properly. These items should be reported in accordance with the reporting instructions of this TI.

#### 2515/160-04 GUIDANCE

##### 04.00 Implementation Guidance

Implementation of this TI may be accomplished either resident inspector personnel or by Regional inspectors specializing in inservice inspections (ISI specialist inspectors). The staff of the Division of Inspection Program Management (DIPM), Office of Nuclear Reactor Regulation (NRR) estimates that it will take between 10 hours and 60 hours of inspection time to complete this TI per PWR facility. Regional managers shall be responsible for assigning the type of inspectors that shall be used for fulfillment of this TI and for scheduling the number of hours allocated for implementation of this TI per facility. The following guidance may be applied to the implementation of this TI:

- a. The requirements of this TI may be accomplished either by Resident Inspector or ISI Specialist Inspector personnel. It is expected that inspectors assigned to the implementation of this TI will be familiar with the BMV, volumetric, and surface examination techniques that are within the scope of this TI. However, it is not a prerequisite of this TI that the inspectors be qualified to Level II or Level III certificates on the applicable augmented BMV, volumetric, or surface examination techniques selected for the pressurizer component examinations.
- b. Option: Implementation of this TI may be used as an alternative for satisfying Regional Core Inspection Requirements for IP 71111.08, Section 71111.08-02, Subsections 02.01 and 02.03. If this option is selected, the review of augmented examinations activities under this TI will count as a review sample credited to the fulfillment of IP 71111.08 in lieu of the ASME Code required ISI

samples required for fulfillment of the IP, other than the ISI volumetric examination sample required for inspections of steam generator (SG) tube examinations. In this case, the ISI review sample for the SG tube examinations remains that specified in IP 71111.08.

#### 04.01 Guidance on Conformance with NRC Bulletin 2004-01

In response to Bulletin 2004-01, each licensee will submit their own plans for inspecting locations addressed within the scope of their bulletin response. However, the staff expects that, at a minimum, licensees will perform a 100 percent BMV examination of each Alloy 82/182/600 pressurizer penetration and steam space piping connection. If a licensee has elected to follow an examination program which is more aggressive (e.g., using volumetric or surface examination techniques in lieu of BMVs), this should be documented in the licensee's bulletin response and the inspector should review the actual inspections performed by that licensee against the scope of the inspections committed to in the licensee's bulletin response. As noted previously, a licensee may also need to perform inspections beyond BMV examinations in order to adequately evaluate pressurizer penetrations and steam space piping connections which show evidence of leakage, or butt welded connections which may require surface and volumetric inspection per the licensee's ASME Code ISI program.

For the purpose of completing the inspection activities associated with this TI, adequate guidance on the inspection of licensee visual (including BMV), surface, and/or volumetric examinations has been provided previously in IP 71111.08, IP 57050, IP 57060, IP 57070, IP 57080, IP 57090, TI 2515/150, Revision 2, and TI 2515/152, Revision 1. Inspectors should review the guidance provided in these IPs and TIs, as they deem necessary given the scope of activities undertaken by a particular licensee, for them to complete their inspections.

#### 04.02 Guidance on Examinations of Alloy 82/182/600 Pressurizer Locations on a Sampling Basis

Some licensees may have committed to perform BMV or non-visual examinations of their Alloy 82/182/600 pressurizer penetration nozzle and steam space piping components during each refueling outage but may opt to perform the examinations on a sampling basis. For example, a licensee may determine that based upon a review of original construction records, that some of the Alloy 82/182/600 penetration nozzle or steam space piping components have experienced weld repairs that could impart large residual tensile stresses on the inside surfaces of the components. These residual stresses, when considered with the high operating temperatures for the components, could make the components the most likely to crack first. Thus, a licensee's BMV inspections at these locations each outage could be used as an indication of the potential of remaining Alloy 82/182/600 penetration nozzle or steam space piping components to crack and for not performing BMV examinations of the remaining locations during the current or subsequent outages. If the licensee is using a sample of the Alloy 82/182/600 penetration nozzle and steam space piping components as the basis for scheduling its BMV or non-visual examinations or has other justifications for not continuing with BMV examinations at each outage, the inspector should contact the

NRR/DE/EMCB staff member listed in Section 2515/160-05 of this TI and forward the licensee's bases/justification.

## 2515/160-05 REPORTING REQUIREMENTS

Document the inspection results in a routine inspection report from the Region's Division of Reactor Projects if a resident inspector was assigned to the TI (i.e., in a DRP quarterly inspection report) or a routine inspection report from the Region's Division of Reactor Safety if an ISI specialist was assigned to the TI. The Regional Offices should either send a copy of the applicable sections to the Materials and Chemical Engineering Branch, Division of Engineering, Office of Nuclear Reactor Regulation (NRR/DE/EMCB), Attention: Edward Andruszkiewicz, or e-mail a copy of the report to Mr. Andruszkiewicz at EVA@NRC.gov. Mr. Andruszkiewicz can also be reached by telephone at (301) 415-1994. In addition, as soon as it is finalized, a copy of the feeder to the inspection report should be sent to NRR/DE/EMCB, to the attention of Mr. Andruszkiewicz as indicated above.

One purpose of this TI is to support NRR/DE/EMCB by inspecting and reporting on the licensees' performance of pressurizer penetration nozzle and steam space piping component examinations. Specifically, the inspectors should provide a qualitative description of the effectiveness of the licensees' examinations. At a minimum, the inspectors should be able to briefly answer the following questions (with a description of inspection scope and results) in Section 40A5, "Other," of the next integrated inspection report:

- a. For each of the examination methods used during the outage, was the examination:
  1. Performed by qualified and knowledgeable personnel? (Briefly describe the personnel training/qualification process used by the licensee for this activity.)
  2. Performed in accordance with demonstrated procedures?
  3. Able to identify, disposition, and resolve deficiencies?
  4. Capable of identifying the leakage in pressurizer penetration nozzle or steam space piping components, as discussed in NRC Bulletin 2004-01?
- b. What was the physical condition of the penetration nozzle and steam space piping components in the pressurizer system (e.g., debris, insulation, dirt, boron from other sources, physical layout, viewing obstructions)?
- c. How was the visual inspection conducted (e.g., with video camera or direct visual by the examination personnel)?

- d. How complete was the coverage (e.g., 360° around the circumference of all the nozzles)?
- e. Could small boron deposits, as described in the Bulletin 2004-01, be identified and characterized?
- f. What material deficiencies (i.e., cracks, corrosion, etc.) were identified that required repair?
- g. What, if any, impediments to effective examinations, for each of the applied methods, were identified (e.g., centering rings, insulation, thermal sleeves, instrumentation, nozzle distortion)?
- h. If volumetric or surface examination techniques were used for the augmented inspections examinations, what process did the licensee use to evaluate and dispose any indications that may have been detected as a result of the examinations?
- i. Did the licensee perform appropriate follow-on examinations for indications of boric acid leaks from pressure-retaining components in the pressurizer system?

Any issues identified during this inspection should be processed and documented in accordance with NRC Inspection Manual Chapter (IMC) 0612, "Power Reactor Inspection Reports." Significance of inspection findings should be evaluated in accordance with applicable appendices of IMC 0609, "Significance Determination Process." Although a licensee's implementation of augmented examinations on pressurizer penetration nozzle and steam space piping components is outside the scope of Section XI of the ASME Code, licensees are still required to report any pressure boundary leakage from the components or relevant indications in the components in accordance with existing requirements in the Section XI of the ASME code and 10 CFR 50.55a, and to take appropriate corrective action pursuant to Criterion XVI of 10 CFR Part 50, Appendix B. Failure to meet these requirements must be identified as violations of these requirements.

2515/160-06          COMPLETION SCHEDULE

This TI should be completed by October 2006.

2515/160-07          EXPIRATION

This TI will expire two years from the date of issuance.

2515/160-08          CONTACT

For questions regarding the performance of this TI, contact either Mr. Edward V. Andruszkiewicz at (301) 415-1994 (E-mail: EVA@nrc.gov) or Mr. James Medoff at 301-415-2715 (E-mail: JXM@nrc.gov), NRR/DE/EMCB. For questions on NRC Bulletin 2004-01 or a licensee's commitments made in response to NRC Bulletin 2004-01, contact Mr. Edward V. Andruszkiewicz at the phone number or E-mail address listed above.

#### 2515/160-09 STATISTICAL DATA REPORTING

All direct inspection effort expanded on this TI is to be charged to 2515/160 for reporting by the STARFIRE/HRMS system with an IPE code of SI.

#### 2515/160-10 ORIGINATING ORGANIZATION INFORMATION

10.01 Organizational Responsibility. This TI was initiated by the Materials and Chemical Engineering Branch of the Division of Engineering, Office of Nuclear Reactor Regulation.

10.02 Resource Estimate. The staff estimates that the amount of direct inspection effort to perform this TI is 10 to 60 hours per PWR unit. Refer to the implementation guidance in Section 04.00 for further clarification on the resource estimate.

10.03 Other. Parallel inspection procedures that can be satisfied by the performance of this TI are IP 71111.08, IP 57050, IP 57060, IP 57070, IP 57080, and IP 57090.

10.04 Training. No specialized training is needed to perform inspection requirements in this TI beyond basic training for inspectors (specified in IMC 1245, "Inspector Qualifications"). However, if technical support is needed during the inspection, contact EMCB technical contact stated in this TI.

END