# REACTOR COOLANT SYSTEM DISSIMILAR METAL BUTT WELDS

CORNERSTONE: Barrier Integrity
Initiating Events

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

## 2515/172-01 OBJECTIVES

The objective of this TI is to:

a. Support NRC staff oversight of licensees' dissimilar metal butt weld (DMBW) mitigation and inspection activities that are being implemented in accordance with the industry guidelines of the Materials Reliability Program (MRP) -139, "Primary System Piping Butt Weld Inspection and Evaluation Guidelines," July 2005.

b. Verify that each pressurized water reactor (PWR) plant conforms to its commitments to conduct an inspection program consistent with the industry's MPR-139 guidelines.

c. Verify that mitigation techniques implemented by licensees are consistent with MRP-139 as discussed in the inspection requirements section of this TI.

d. Define and initiate information gathering so that NRC staff can identify and develop possible future regulatory positions, generic communications, and rulemaking in this area.

This TI pertains to primary system piping dissimilar metal butt welds 1" NPS or larger, including**:**

a. pressurizer nozzle dissimilar metal butt welds (DMBWs).

b. DMBWs less than or equal to 14 inches exposed to temperatures equivalent to the hot leg.

c. DMBWs larger than 14 inches exposed to temperatures equivalent to the hot leg.

d. DMBWs exposed to temperatures equivalent to the cold leg.

MRP-139 indicates that the initial or baseline volumetric inspections of butt welds in these four sets of locations are to be completed in 2007, 2008, 2009, and 2010, respectively.

2515/172-02 BACKGROUND

Operating experience has demonstrated that Alloy 600/82/182 materials exposed to primary coolant water (or steam) at the normal operating conditions of PWR plants have cracked due to primary water stress corrosion cracking (PWSCC). The NRC has issued several bulletins and an order since 2001 related to the occurrence of PWSCC in reactor coolant system components and welds containing Alloy 600/82/182.

Several methods have been used or are being considered by industry to address PWSCC. These methods include increased frequency of inspection, replacement of the Alloy 600/82/182 materials with Alloy 690/52/152 materials, structural weld overlays with Alloy 52/152 materials, stress improvement processes that place the susceptible materials in compression to prevent crack initiation and growth, and application of Alloy 52 cladding on the inside surface of the susceptible Alloy 82/182 material.

Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), which is incorporated into NRC regulations by 10 CFR 50.55a, "Codes and Standards," specifies examination requirements for reactor coolant system components and piping, including DMBWs. Volumetric, surface, and visual examinations are required to ensure the integrity of the reactor coolant pressure boundary and safe operation of the plant.

In September 2005, NEI issued MRP-139, “Material Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline,” with mandatory implementation for all PWRs under the industry’s proactive management of materials degradation initiative, NEI 03-08. MRP-139 provides industry’s guidance for the volumetric and visual inspections of butt welds in PWR primary systems. The MRP-139 inspections augment examinations of these locations already required by the ASME Code, Section XI. MRP-139 Section 1.2 on Implementation, Section 5 on Examination Requirements, and Section 6 on Examination Schedules were assigned the mandatory implementation category under NEI 03-08.

Based on recent experience with industry that arose from multiple flaws found in pressurizer nozzle welds at Wolf Creek, the staff concluded that it is essential that NRC staff monitor more closely the MRP-139 inspection programs and, in particular, the deviations utilities may be planning to take from the guidelines stated in MRP-139. This TI contains inspection and reporting requirements pertaining to deviations taken from MRP-139.

The NRC staff is relying on the industry MRP-139 program as a short term approach for addressing PWSCC, but the NRC staff needs to verify that each licensee has developed an inspection program and is implementing its commitments to conduct the inspections in accordance with MRP-139. As a long term approach for addressing

PWSCC, the NRC staff is working with the ASME Code to develop inspection requirements for dissimilar metal butt welds. These Code inspection requirements will be contained in an ASME code case that the NRC will endorse in its regulations if the code case is found acceptable.

2515/172-03 INSPECTION REQUIREMENTS

03.01 Licensee's Implementation of the MRP-139 Baseline Inspections.

Verify the following:

a. The licensee's inspection program includes inspections of the pressurizer, hot leg and cold leg temperature DMBWs and that the schedules for these baseline inspections are consistent with the requirements stated in MRP-139. If any baseline inspection schedules deviate from MRP-139 guidelines, determine what deviations are planned and what is the general basis for the deviation.

b. The licensees (except for the nine plants specified below) have completed their MRP-139 baseline inspections of all pressurizer DMBWs by December 31, 2007. For nine PWR plants (Braidwood Unit 2, Comanche Peak Unit 2, Diablo Canyon Unit 2, Palo Verde Unit 2, Seabrook, South Texas Station Unit 1, V.C. Summer, Vogtle Unit 1 and Waterford Unit 3), verify that the baseline pressurizer DMBWs are completed during the spring 2008 outages.

03.02 Volumetric Examinations.

Licensees perform volumetric examinations as part of the inspection/mitigation activities as described in MRP-139. Inspectors should use Inspection Procedure (IP) 57080, "Ultrasonic Testing Examination" and ASME Code Section XI, Appendix VIII, "Performance Demonstrations for Ultrasonic Examination Systems" as guidance when observing or reviewing the volumetric examinations performed by the licensee. Perform the following inspections through either direct observation (preferred method) or records review. If no examinations are being performed during the current outage, perform a records review of an examination during the previous outage.

a. Observe or review at least one examination of a weld (for example, an examination of a weld that is categorized as not being mitigated, an examination of a weld prior to mitigation by either weld overlay or mechanical stress improvement, or an examination of a weld after mitigation by mechanical stress improvement). Verify that the inspection is performed in accordance with the guidelines in MRP-139, Section 5.1.

b. Observe or review at least one weld overlay volumetric examination. Verify that the inspection performed is consistent with the NRC staff relief request authorization for the weld overlay. If the inspection coverage warrants further evaluation, review the licensee's documentation of the basis for achieving the required inspection coverage.

c. Verify that the examinations were performed by qualified personnel.

d. Verify that any deficiencies identified were appropriately dispositioned and resolved.

03.03 Weld Overlays.

MRP-139 addresses inspection of dissimilar metal welds mitigated by weld overlays as part of the strategy to address the DMBW issue. Inspectors should use guidance contained in IP 55050, "Nuclear Welding General Inspection Procedure," when performing their review of licensee's weld overlay techniques. Perform the following inspections to verify that the proper weld overlay techniques were used. If no examinations are being performed during the current outage, perform a records review of an examination during the previous outage.

a. For at least one weld overlay verify that the welding activities were performed consistent with ASME Code requirements as modified by NRC staff relief request authorizations.

b. Verify that the licensee has submitted a relief request and obtained NRR staff authorization to install the weld overlays, whether full structural or optimized weld overlays.

c. Verify that welding was performed by qualified personnel.

d. Verify that any deficiencies identified were appropriately dispositioned, and resolved.

03.04 Mechanical Stress Improvement.

MRP-139 addresses inspection of dissimilar metal welds mitigated by stress improvement (SI) as part of the strategy to address the DMBW issue. For each application of SI used, inspectors should review the SI qualification report that describes the essential parameters of the SI process (e.g., the location radial loading is applied and the applied load, as well as the inspection requirements). Inspectors should verify the following for each location where SI was applied:

a. The nozzle, weld, safe end, and pipe configurations, as applicable, are consistent with the configuration addressed in the SI qualification report.

b. The SI qualification report addresses the location radial loading is applied, the applied load, and the effect that plastic deformation of the pipe configuration may have on the ability to conduct volumetric examinations.

c. The licensee's inspection procedure records document that a volumetric examination per the ASME Code, Section XI, Appendix VIII was performed prior to and after the application of the SI.

d. The SI qualification report addresses limiting flaw sizes that may be found during pre-SI and post-SI inspections and that any flaws identified during the volumetric examination are to be within the limiting flaw sizes established by the SI qualification report.

e. Verify that any deficiencies identified were appropriately dispositioned, and resolved.

03.05 Inservice Inspection Program.

MRP-139 contains industry mandatory requirements for baseline and inservice inspection. In accordance with MRP-139, inservice inspections are performed based on the categorization of the weld configuration, which are classified as Categories A–I for volumetric examinations and Categories J and K for visual examinations. The inspectors will perform an inspection to verify that the licensee has prepared an MRP-139 inservice inspection program applicable welds are included in a category consistent with MRP-139 guidelines. The inspectors will verify that the licensee's inspection program and procedures specify inspection frequencies consistent with Tables 6-1 and 6-2 of MRP-139. The inspectors will determine if any welds are categorized as H or I and review the licensee's basis for the categorization and the licensee's plans for addressing potential PWSCC. The inspector will determine if any deviations are planned from the inspection guidelines in MRP-139, i.e., frequencies, examination volumes, methods.

2515/172-04 GUIDANCE

Certain inspection requirements will have to take place during plant outages when the activities occur. For inspection activities related to programs and reports, it may be necessary to perform inspection onsite during a non-outage period to obtain adequate support from the licensee's staff. Additionally, if nondestructive testing performed at a licensee's facility by an inspection vendor is not directly observed (preferred method), a records review may require that portion of the inspection be performed at the vendor's facility since the data may not available at the plant.

04.01 Licensee's Implementation of the MRP-139 Baseline Inspections.

MRP-139 establishes an industry mandatory requirement for licensees to complete baseline inspections of DMBWs in the reactor coolant system. The licensee's baseline inspections may be performed on a number of different weld configurations based on their MRP-139 categorization. Regardless of licensee's plans to mitigate a particular weld, the MRP-139 baseline inspections must be performed using ASME, Section XI, Appendix VIII, qualified methods.

MRP-139 Table 2-1 contains a listing of locations involving Alloy 82/182 piping butt welds in Westinghouse, Combustion Engineering and Babcox & Wilcox design plants. This listing can be used to determine if the licensee appropriately placed these DMBWs into the MRP-139 inspection program. A complete listing of Alloy 82/182 welds should also be contained in licensee documentation prepared in response to MRP-126.

It is the NRC staff's view that if the licensee plans to mitigate a weld by a mechanical stress improvement, the licensee has to conduct a pre-stress improvement inspection, and this pre-stress improvement inspection is the MRP-139 baseline inspection. This view is generally consistent with the code case being prepared by ASME Section XI on inspection of dissimilar metal butt welds.

There are nine plants scheduled to perform the pressurizer DMBW inspections in the spring 2008 time frame. This schedule for inspection of the pressurizer weld connections was the subject of extensive NRC staff review and evaluation as documented in the NRC staff's safety assessment on this issue which can be obtained in Agency Documents Access and Management System (ADAMS) using accession number ML072400199.

04.02 Volumetric Examinations.

Examination of a weld prior to application of a full structural weld overlay (FSWO) is not required by either MRP-139 or the ASME code cases pertaining to weld overlays. While such an examination is not required to be performed prior to application of a FSWO, some licensees may choose to perform this type of examination.

04.03 Weld Overlays.

ASME Section XI does not presently contain inspection requirements for weld overlays. Section XI has issued Code Cases N-504-3, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping" and N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique." These two code cases are listed in Regulatory Guide (RG) 1.147, Revision 15, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," with limitations. Although these code cases are approved with limitations in RG 1.147, their use for a weld overlay on an Alloy 82/182 weld requires a relief request, since they were not written for this application. ASME Section XI has issued N-740 and N-740-1, "Dissimilar Metal Weld Overlay for Repair of Class 1, 2, and 3 Items," and is working on the second revision to this code case. When the NRC staff approves code case N-740-X in RG 1.147 and endorses this regulatory guide in an update to 10 CFR 50.55a, application of weld overlays will no longer require NRR approval through authorization of a relief request.

04.04 Mechanical Stress Improvement.

Mechanical stress improvement is generally applied through a proprietary process referred to as the Mechanical Stress Improvement Process or MSIP™. This process was originally employed in the nuclear power industry to boiling water reactor piping susceptible to intergranular stress corrosion cracking. Each application of the process is expected to be accompanied by a qualification report that documents the specific stress improvement parameters to be applied to the weld, the basis for the parameters, and the inspection requirements. While SI has been through MSIP™ in the past, industry intends to also use what is referred to as optimized weld overlays. Optimized weld overlays are not as thick as full structural weld overlays, but are designed to obtain

essentially the same stress improvement benefits as an MSIP™. ASME Code, Section XI, Appendix VIII volumetric examination must be performed prior to and after the application of stress improvement whether by an MSIP™ or an optimized weld overlay.

04.05 Inservice Inspection Program.

MRP-139 categorizes welds according to their mitigation status. Mitigation techniques noted in MRP-139 are full structural weld overlays and stress improvement. MRP-139 requires less frequent inspection of welds that have been mitigated. These categories also relate to the condition of the weld as cracked or uncracked. Categories H and I pertain to welds for which a qualified ASME examination can not be performed. NRR is aware of some welds for which a qualified examination may not be possible without taking additional measures. Category H and I welds may include welds joined to cast austenitic stainless steel piping.

## 2515/172-05 REPORTING REQUIREMENTS

Each refueling cycle for each unit document inspection results in section 4OA5 of the routine resident inspectors' integrated inspection report and send a copy of the inspection report to NRR/DCI, Attention: Edmund Sullivan or e-mail the electronic file of the inspection report to EJS@NRC.gov. In addition, forward the electronic file(s) that documents the results of this TI to Mr. Edmund Sullivan when the TI is completed. Mr. Sullivan can also be reached by telephone at (301) 415-2796.

The purpose of this TI is to support NRR/DCI by inspecting and reporting on the licensees' performance on implementing MRP-139. Specifically, the inspectors should provide a qualitative description of the effectiveness of the licensees' DMBW inspection and mitigation program. As a minimum, the inspectors shall document the following aspects in an inspection report:

a. For MRP-139 baseline inspections:

    1. Have the baseline inspections been performed or are they scheduled to be performed in accordance with MRP-139 guidance? Were the baseline inspections of the pressurizer temperature DMBWs of the nine plants listed in 03.01.b completed during the spring 2008 outages.

    2. Is the licensee planning to take any deviations from the MRP-139 baseline inspection requirements of MRP-139? If so, what deviations are planned and what is the general basis for the deviation? If inspectors determine that a licensee is planning to deviate from any MRP-139 baseline inspection requirements, NRR should be informed by email as soon as possible.

b. For each examination inspected, was the activity:

1. Performed in accordance with the examination guidelines in MRP-139 Section 5.1 for unmitigated welds or mechanical stress improved welds and consistent with NRC staff relief request authorization for weld overlaid welds?

2. Performed by qualified personnel? (Briefly describe the personnel training/qualification process used by the licensee for this activity.)

3. Performed such that deficiencies were identified, dispositioned, and resolved?

c. For each weld overlay inspected, was the activity:

1. Performed in accordance with ASME Code welding requirements and consistent with NRC staff relief requests authorizations? Has the licensee submitted a relief request and obtained NRR staff authorization to install the weld overlays?

2. Performed by qualified personnel? (Briefly describe the personnel training/qualification process used by the licensee for this activity.)

3. Performed such that deficiencies were identified, dispositioned, and resolved?

d. For each mechanical stress improvement used by the licensee during the outage, was the activity performed in accordance with a documented qualification report for stress improvement processes and in accordance with demonstrated procedures? Specifically,

1. Are the nozzle, weld, safe end, and pipe configurations, as applicable, consistent with the configuration addressed in the SI qualification report?

2. Does the SI qualification report address the location radial loading is applied, the applied load, and the effect that plastic deformation of the pipe configuration may have on the ability to conduct volumetric examinations?

3. Do the licensee's inspection procedure records document that a volumetric examination per the ASME Code, Section XI, Appendix VIII was performed prior to and after the application of the SI?

4. Does the SI qualification report address limiting flaw sizes that may be found during pre-SI and post-SI inspections and that any flaws identified during the volumetric examination are to be within the limiting flaw sizes established by the SI qualification report.

5. Performed such that deficiencies were identified, dispositioned, and resolved?

e. For the inservice inspection program:

1. Has the licensee prepared an MRP-139 inservice inspection program? If not, briefly summarize the licensee's basis for not having a documented program and when the licensee plans to complete preparation of the program.

2. In the MRP-139 inservice inspection program, are the welds appropriately categorized in accordance with MRP-139? If any welds are not appropriately categorized, briefly explain the discrepancies.

3. In the MRP-139 inservice inspection program, are the inservice inspection frequencies, which may differ between the first and second 10-year intervals after the MRP-139 baseline inspection, consistent with the inservice inspection frequencies called for by MRP-139?

4. If any welds are categorized as H or I, briefly explain the licensee's basis for the categorization and the licensee's plans for addressing potential PWSCC.

5. If the licensee is planning to take deviations from the inservice inspection "requirements" of MRP-139, what are the deviations and what are the general bases for the deviations? Was the NEI 03-08 process for filing deviations followed?

Any issues identified during this inspection should be processed and documented in accordance with NRC Inspection Manual Chapter (IMC) 0612, "Power Reactor Inspection Reports." The significance of inspection findings should be evaluated in accordance with applicable appendices of IMC 0609, "Significance Determination Process." Any noncompliance with NRC requirements resulting from this inspection should be evaluated and documented in accordance with NRC Enforcement Policy (NUREG -1600) and Section 3.12 of the NRC Enforcement Manual. Also, licensees are required to address the findings resulting from the MRP-139 inspections (i.e., perform analyses and repairs) in accordance with existing requirements in the ASME code and 10 CFR 50.55a.

## 2515/172-06 COMPLETION SCHEDULE

Up to three outages may be needed to complete the inspections associated with this issue. The inspection activities identified in this TI should be completed within one cycle of the last MRP-139 baseline inspections. Inspectors may perform inspection of record-related aspects of the TI at any time and, if an inspection opportunity is available, perform inspections of mitigation and examination activities in this TI during the refueling outages.

2515/172-07 EXPIRATION

This TI will expire on June 30, 2011, or upon completion of the MRP-139 baseline inspections for all DMBWs in the PWR fleet. This TI will be in effect for more than 24 months because the mitigation and MRP-139 baseline inspection of DMBWs potentially affected by PWSCC will not be fully addressed by all licensees for all affected components until at least the end of calendar year 2010.

2515/172-08 CONTACT

For questions regarding the performance of this TI and emergent issues, contact Ted Sullivan at (301) 415-2796 or e-mail Ted Sullivan at EJS@NRC.GOV.

2515/172-09 STATISTICAL DATA REPORTING

All direct inspection effort expended on this TI is to be charged to 2515/172 for reporting by the Regulatory Information Tracking System (RITS) reporting with an IPE code of TI.

2515/172-10 ORIGINATING ORGANIZATION INFORMATION

10.01 Organizational Responsibility.

This TI was initiated by the Division of Component Integrity (NRR/DCI).

10.02 Resource Estimate.

The estimated direct inspection effort to perform this TI is estimated to be 40 to 60 hours per PWR unit per refueling cycle.

10.03 Training.

No formal training is proposed for the performance of this TI. However, if technical support is needed during the inspection of licensees' weld mitigations, volumetric examinations or MRP-139 program, contact DCI through IRIB at least 30 days before the anticipated need for technical support.

2515/172-11 REFERENCES

Primary System Piping Butt Weld Inspection and Evaluation Guidelines, MRP-139, EPRI, Palo Alto, CA, July 2005. [ML052150196]

Safety Assessment on the Advanced Finite Element Analysis Related to Growth of Postulated Primary Water Stress Corrosion Cracking Flaws in Pressurizer Nozzle Dissimilar Metal Butt Welds, August 2007. [ML072400199]

Mayfield, M.E. letter to Marion, A., NRC Staff Comments on MRP-139, October 12, 2005 [ML052720290]

MRP 2006-018 MRP-139 Interim Guidance on Implementation Schedules, August 11, 2006 [ML080300470 ]

MRP 2007-039 MRP-139 Interim Guidance on Bare Metal Visual Inspection, November 1, 2007 [ML080300474]

MRP 2007-038 MRP-139 Interim Guidance on Small Bore Volumetric Inspection, November 1, 2007 [ML080300478]

Attachment 1

Revision History for TI 2515/172

| Commitment Tracking Number | Issue Date | Description of Change | Training Needed | Training Completion Date | Comment Resolution Accession Number |
|---|---|---|---|---|---|
| N/A | 02/21/08<br>CN 08-009 | Support NRC staff oversight of licensees' dissimilar metal butt weld (DMBW) mitigation and inspection activities that are being implemented in accordance with the industry guidelines of the Materials Reliability Program (MRP) -139. | N/A | N/A | ML080390335 |
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