

September 24, 2009

MEMORANDUM TO: John A. Grobe, Associate Director
for Engineering and Safety Systems
Office of Nuclear Reactor Regulation

FROM: Michele G. Evans, Director **/RA/**
Division of Component Integrity
Office of Nuclear Reactor Regulation

SUBJECT: POSITION PAPER ON REGULATORY REQUIREMENTS FOR
APPLICATION OF WELD OVERLAYS IN PIPING SYSTEMS
APPROVED FOR LEAK-BEFORE-BREAK (LBB)

The purpose of this memorandum is to provide a position paper developed by Division of Component Integrity (DCI) at the request of the Office of Nuclear Reactor Regulation (NRR) Executive Team. The paper addresses the regulatory requirements for application of weld overlays in piping systems previously approved for LBB in accordance with General Design Criterion-4 (GDC-4).

When LBB was approved in the 1980s and 1990s for the current operating fleet of pressurized water reactor (PWR), reactor coolant system (RCS) butt welds had not exhibited corrosion and the staff concluded that PWR RCS piping was not susceptible to corrosion. Since 2000, primary water stress corrosion cracking (PWSCC) has occurred in the RCS systems of a number of PWRs. A discussion of PWSCC in reactor coolant system piping butt welds is contained in RIS 2008-25, "Regulatory Approach for Primary Water Stress Corrosion Cracking of Dissimilar Metal Butt Welds in Pressurized Water Reactor Primary Coolant System Piping."

Industry has developed a number of techniques to mitigate welds against PWSCC, including application of weld overlays that cause compressive stresses to be applied to the inside region of piping welds. These stresses are intended to prevent crack initiation and propagation of existing cracks in this region. Some licensees plan to install weld overlays in piping systems approved for leak-before-break. Other licensees may have already installed weld overlays in piping systems approved for LBB. Installation of weld overlays on piping previously approved by the NRC staff for LBB would affect the prior LBB evaluation. The enclosed draft position paper discusses the applicable regulatory requirements for updating LBB analyses when licensees plan to install or have already installed weld overlays.

CONTACT: Edmund J. Sullivan, NRR/DCI
(301) 415-2796

J. Grobe

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NRR Divisions with a stake in this issue as well as the Office of Enforcement have concurred on the enclosed position paper. The Office of General Counsel has no legal objections to the public release of this position paper. On September 30, 2009, the staff plans to hold a public meeting to discuss the draft position paper, which will be made publicly available prior to the meeting.

Enclosure:

Draft Position Paper on Weld Overlays

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Enclosure:
Draft Position Paper on Weld Overlays

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DRAFT POSITION PAPER ON REGULATORY REQUIREMENTS FOR APPLICATION OF WELD OVERLAYS IN PIPING SYSTEMS APPROVED FOR LEAK-BEFORE-BREAK

1. Governing Requirements for Leak-Before-Break (LBB)

The governing requirement for LBB is General Design Criterion 4 (GDC-4)—Environmental and dynamic effects design bases. GDC 4 requires that structures, systems, and components be designed to accommodate the environmental and dynamic effects of postulated pipe ruptures. A limited scope revision of GDC-4 was issued in July 1986 to include the provision to allow exclusion of dynamic effects from the design basis for certain piping with Commission review and approval-- *“dynamic effects of postulated pipe ruptures of primary coolant loop piping in pressurized water reactors may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.”*

GDC-4 was revised again in October 1987 to broaden the scope of piping eligible for LBB beyond the primary coolant loop. The revision included the provision that, *“dynamic effects of postulated pipe ruptures may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.”* This was referred to as the broad scope revision of GDC-4.

The revised GDC-4 was based on advances in fracture mechanics technology. Acceptable technical procedures and criteria for using LBB are documented in NUREG-1061, Volume 3, “Report of the U. S. Nuclear Regulatory Commission Piping Review Committee, Evaluation of Potential for Pipe Breaks,” November 1984. The procedures and criteria of NUREG-1061, Volume 3, were subsequently incorporated in draft Standard Review Plan (SRP) 3.6.3 issued in August 1987. SRP 3.6.3, Revision 1, was issued in March 2007.

SRP 3.6.3, “Leak-Before-Break” (LBB) specifies that, *“The reviewer should evaluate the potential for degradation by erosion, erosion/corrosion, and erosion/cavitation due to unfavorable flow conditions and water chemistry. Industry experience for specific piping systems plays an important role in the evaluation of these degradation mechanisms... These evaluations must demonstrate that these mechanisms are not potential sources of pipe rupture.”*

2. Systems Approved for LBB

After a review of supporting analyses, the staff issued approvals to exclude the dynamic effects of postulated pipe ruptures from the design basis for the reactor coolant loop (RCL) piping for all PWRs and for certain RCL branch piping for some PWRs.

3. Prior Approval

GDC-4 provides a clear requirement for prior approval of LBB as a condition to implementing designs that exclude the dynamic effects associated with postulated pipe ruptures. GDC-4 states that, “dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions

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consistent with the design basis for the piping.” The Federal Register Notice for the proposed broad scope rule states in Section IV, Summary of Acceptance Criteria, that, “The Commission will review and approve the various plant specific evaluations before authorizing the removal of hardware which mitigates the dynamic effects of postulated high energy pipe ruptures.”

4. Applicability of the Revised GDC 4

Licensees and applicants were not required to make any changes as a result of the amendments to GDC 4. Rather, GDC 4 provided licensees and applicants with an option not previously available without an exemption. As explained below, licensees (including non-GDC licensees) and applicants implemented the option of performing LBB analysis provided by the revised GDC-4.

5. LBB Approvals by Scheduler Exemption Prior to Revision of GDC 4

Approval to exclude the dynamic effects of postulated pipe ruptures was issued for some plants via scheduler exemptions prior to completion of the revision of GDC-4. NRC Generic Letter 84-04, “Safety Evaluation of Westinghouse Topical Reports Dealing with Elimination of Postulated Pipe Breaks in PWR Primary Main Loops,” informed applicants and licensees that authorization by NRC to remove or not to install protection against asymmetric dynamic loads (e.g., certain pipe whip restraints) in the primary main coolant loop would require an exemption from the then existing GDC-4. Approval for LBB via a scheduler exemption led to changes in plant licenses that included statements like, “This exemption will expire when the current GDC-4 rulemaking changes have been completed.” All of the exemption requests involved NRC staff review and approval of analyses in accordance with the technical procedures and criteria of NUREG-1061, Volume 3. Since the exemptions were scheduler or temporary, upon expiration of the exemption the requirement in effect for each of these licensees was the Revised GDC-4, which these licensees would automatically satisfy by virtue of the staff review and approval of the plants’ LBB analyses.

6. LBB Approvals during Operating License (OL) Reviews

Approval to use LBB for some plants occurred during the later stages of the OL reviews. The application to use LBB for these plants was made based upon the revised GDC-4 via an amendment to the operating license application. In these cases the staff reviewed and approved analyses that demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping. The approved analyses are discussed in the plant safety evaluation reports.

7. LBB Approvals for Non-GDC Plants

The GDC are not applicable to plants with construction permits issued prior to May 21, 1971. At the time of the promulgation of Appendix A to 10 CFR 50, the Commission stressed that the GDC were not new requirements and were promulgated to more clearly articulate the licensing requirements and practice in effect at that time. Each plant licensed before the GDC were formally adopted was evaluated on a plant specific basis, determined to be safe, and licensed by the Commission. Although the applicability of the GDC varies among facilities, in all cases, the plant-specific current licensing basis (CLB) governs. With respect to GDC-4, non-GDC plants sought and received Commission approval to remove dynamic effects from design bases. For

such plants, the CLB would be GDC-4 since LBB would have been approved by the NRC staff based upon the revised GDC-4.

8. Operating Experience

In 2000, a large accumulation of boric acid deposits observed during a refueling outage at V.C. Summer led to the discovery of cracking in the "A" hot leg pipe-to-reactor-pressure-vessel (RPV) nozzle Alloy 82/182 butt weld. The weld had a through-wall axial flaw with a small circumferential component and other small part-through-wall axial flaws. Based on destructive examinations of the piping and the weld material that was removed, the licensee determined that primary water stress-corrosion cracking (PWSCC) caused the flaws.

In September 2005, the industry issued MRP-139, "Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline," that all PWR plants agreed to implement. MRP-139 provides industry guidance for the volumetric and visual inspections of butt welds in PWR primary systems. These inspections augment inspections of these locations already required by Section XI of the ASME Code.

Prior to the issuance of MRP-139, the staff evaluated how PWSCC impacted compliance with GDC-4. The conclusion was that, based on operating experience, there was no basis for the staff to conclude on a generic basis that an extremely low probability of pipe rupture no longer existed; by extension, licensees were still in compliance with GDC-4.

The staff continues to believe that, while PWSCC is an active degradation mechanism in Alloy 82/182 butt welds, the operating experience to date along with the actions that industry has been undertaking lead the staff to conclude that the bases for GDC-4 compliance are still valid. The staff plans to document this point in a generic communication, e.g., a RIS, on LBB of weld overlays.

9. Mitigation of PWSCC

The industry has used several methods to mitigate PWSCC. These methods include structural weld overlays fabricated with Alloy 52/152 materials. Alloy 52/152 materials are considered more resistant to PWSCC than Alloy 82/182 materials.

Leak-before-break is applicable only to an entire piping system or analyzable portion thereof. Analyzable portions are typically segments located between anchor points. An LBB analysis examines or calculates the leakage and stability margins for each weld in the analyzed segment, and typically, the margins for the limiting locations in each segment are reported in the analysis summary. A structural weld overlay changes the weld geometry of the original weld upon which the LBB analysis was based, which makes the original SRP 3.6.3 LBB analysis obsolete. Updating the LBB analysis entails a recalculation of the leakage and stability margins for the new geometry at the overlaid location which may or may not cause the summary results to change.

10. NRC Review and Approval of LBB Analyses

In each of the cases discussed above in Sections 5, 6 and 7, the applicable requirements for LBB are contained in GDC-4. If a licensee decides to mitigate a weld by a weld overlay and the weld is part of a piping segment approved for LBB, the CLB for LBB has to be revised

regardless of the process under which the original approval was obtained. Application of the criteria of 10 CFR 50.59 to the weld overlay situation will likely result in the determination that a license amendment is required. Paragraph (c)(2)(viii) indicates that a license amendment is required if the change (e.g., LBB analysis of a weld overlay) would result in a departure from a method of evaluation described in the FSAR used in establishing the design bases or in the safety analysis. The staff believes that the LBB method of evaluation for piping systems with weld overlays represents a departure from the original LBB analysis methodology reviewed and approved by the NRC. For example, with an LBB analysis of a weld overlay, the leakage crack has different crack morphologies in the original weld and in the overlay. The methodology for leakage analysis will have to be based on calculated equivalent crack morphology parameters which was not necessary with the original approved analysis.

11. Existing Weld Overlays of Welds in LBB Approved Systems

There are no technical specification (TS) requirements directly applicable to LBB. In addition, there are no ASME Code requirements that would be violated by applying a weld overlay provided the weld overlay was reviewed and approved by the staff as an alternative to the requirements of the ASME Code. (If Code Cases on overlays are approved in Regulatory Guide 1.147, licensees will be permitted to install weld overlays via ASME Code Case rules.) There may be license conditions applicable to LBB. In such cases, licensees are responsible for ensuring that a weld overlay would not violate any license conditions or seek necessary regulatory approvals.

Some licensees may have already applied weld overlays to piping systems approved by the staff for LBB. Licensees who have already applied weld overlays to piping systems without NRC prior approval for LBB for the weld overlays should address the licensing basis non-conforming condition and take prompt corrective action in accordance with 10 CFR Part 50, Appendix B, Criterion XVI. Corrective action would include (a) performing a 10 CFR 50.59 evaluation, (b) performing an operability determination for the non-conforming condition and (c) updating the LBB analysis and submitting a license amendment to the NRC in a timely manner. The staff has not received any such analyses for review and approval.

Licensees in this situation may be subject to enforcement for operating in non-conformance with the plant's CLB.

12. Future Application of Weld Overlays in LBB Approved Systems

Some licensees may decide in an upcoming outage to apply a weld overlay to address inspection results or a potential PWSCC flaw in a pipe weld. Licensees understand that the weld overlays have to be reviewed and approved by the staff as an alternative to the requirements of the ASME Code in order to remain in compliance with NRC regulations. However, licensees that decide to apply a weld overlay may not have updated the LBB analysis or submitted the analysis to the NRC.

Licensees that decide to apply weld overlays to LBB piping systems during an outage without NRC prior approval for LBB for the weld overlays are required by 10 CFR Part 50, Appendix B, Criterion XVI, to take prompt corrective action. Corrective action would include (a) performing a 10 CFR 50.59 evaluation, (b) performing an operability determination for the non-conforming condition and (c) updating the LBB analysis and submitting a license amendment to the NRC in a timely manner. The need to obtain NRC approval for this change to resolve the

nonconforming conditions would not affect the licensee's authority to operate the plant or restart from outages provided that operation of the plant does not violate the technical specifications or the license. Licensees in this situation may be subject to enforcement for the nonconforming condition because they would have installed weld overlays without obtaining prior approval as required by GDC-4.

For future outages, licensees are expected to make appropriate plans to avoid placing plants in nonconformance with the CLB. Such plans include performing a 10 CFR 50.59 evaluation for the planned weld overlay, updating the LBB analysis and submitting a license amendment to the NRC with sufficient time for NRC to complete the licensing action prior to plant startup.