

TECHNICAL LETTER REPORT
ON THE THIRD 10-YEAR INTERVAL INSERVICE INSPECTION
REQUEST FOR RELIEF NO. RR-31
FOR
CAROLINA POWER AND LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2
DOCKET NUMBERS: 50-325 AND 50-324

1.0 INTRODUCTION

By letter dated July 16, 2002, the licensee, Carolina Power and Light (CP&L) Company, submitted Request for Relief RR-31, proposing an alternative to certain requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, *Rules for Inservice Inspection of Nuclear Power Plant Components*. This request is for the third 10-year inservice inspection (ISI) interval at Brunswick Steam Electric Plant, Units 1 and 2. In response to an NRC request, the licensee submitted supplemental information by letter dated February 11, 2003. The Pacific Northwest National Laboratory (PNNL) has evaluated the subject request for relief in the following section.

2.0 EVALUATION

The information provided by CP&L in support of the request for relief from Code requirements has been evaluated and the bases for disposition are documented below. The Code of record for Brunswick Steam Electric Plant, Units 1 and 2, third 10-year intervals, which began on May 11, 1998, and end on May 10, 2008, is the 1989 Edition of ASME Section XI, and is supplemented by ASME XI, 1995 Edition with 1996 Addenda for Appendix VIII, as required by 10 CFR 50.55a(b)(2)(xiv) through (xvi).

2.1 Request for Relief RR-31, Examination Category B-J, Item B9.11, Pressure Retaining Welds in Piping Subject to Appendix VIII, Supplement 11, Welded Overlay Examinations

Code Requirement: Performance demonstration requirements for qualifying procedures, personnel and equipment to inspect austenitic piping welds having structural overlays are listed in the 1995 Edition/1996 Addenda of ASME Section XI, Appendix VIII, Supplement 11. Licensees may 1) elect to use the requirements of Supplement 11 as listed, 2) seek NRC approval for new ASME code cases currently being reviewed by Code Committees, or 3) propose an alternative to Code requirements. The licensee proposed to use the industry's Performance Demonstration Initiative (PDI) program as an alternative to the following paragraphs of Supplement 11:

- Paragraph 1.1 (b) requires that qualification for the range of overlay thickness is valid when at least one specimen is used whose overlay thickness is within -0.10 inch to +0.25 inch of the maximum nominal overlay thickness for which the procedure is applicable.
- Paragraph 1.1(d)(1) requires that all base metal flaws be cracks.
- Paragraph 1.1 (d)(1)(a) requires that all flaws must be cracks and IGSCC when available.

ATTACHMENT

- Paragraph 1.1(e)(1) requires that at least 20% but not less than 40% of the flaws shall be oriented within ± 20 degrees of the pipe axial direction and that the rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws.
- Paragraph 1.1(e)(2)(a)(1) requires that a base grading unit shall include at least 3 inches of the length of the overlaid weld and the outer 25% of the overlaid weld and base metal on both sides.
- Paragraph 1.1(e)(2)(a)(3) requires that for unflawed base grading units, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit.
- Paragraph 1.1(e)(2)(b)(1) requires that an overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2 inches.
- Paragraph 2.3 requires that, for a depth sizing test, 80% of the flaws shall be sized at a specific location on the surface of the specimen identified to the candidate. For the remaining flaws, the regions of each specimen containing a flaw to be sized shall be identified to the candidate, and the candidate shall determine the maximum depth of the flaw in each region.
- Paragraph 3.1 calls for procedures, personnel and equipment to meet the acceptance criteria in Table VIII-S2-1 for both detection and false calls.
- Paragraph 3.2(b) requires that all extensions of base metal cracking into the overlay material by at least 0.1 inch are reported as being intrusions into the overlay material.

2.2 Licensee's Proposed Alternative to Code: Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposed using the PDI program in lieu of the requirements of ASME Section XI, 1995 Edition with 1996 Addenda, Appendix VIII, Supplement 11. The Electric Power Research Institute (EPRI) PDI program is described in the submittal, as supplemented.

2.3 Licensee's Bases for Alternative (as stated):

Paragraph 1.1(d)(1), requires that all base metal flaws be cracks. As illustrated [in the submittal], implanting a crack requires excavation of the base material on at least one side of the flaw. While this may be satisfactory for ferritic materials, it does not produce a useable axial flaw in austenitic materials because the sound beam, which normally passes only through base material, must now travel through weld material on at least one side, producing an unrealistic flaw response. To resolve this issue, the PDI program revised this paragraph to allow use of alternative flaw mechanisms under controlled conditions. For example, alternative flaws shall be limited to when implantation of cracks precludes obtaining an effective ultrasonic response, flaws shall be semi-elliptical with a tip width of less than or equal to 0.002 inches, and at least 70 percent of the flaws in the detection and sizing test shall be cracks and the remainder shall be alternative flaws.

Relief is requested to allow closer spacing of flaws provided they didn't interfere with detection or discrimination. The existing specimens used to date for qualifications to the Tri-party (NRC/BWROG/EPRI) agreement have a flaw population density greater than allowed by the current Code requirements. These samples have been used successfully for all previous qualifications under the Tri-party agreement program to Supplement 11. The PDI Program has merged the Tri-party test specimens into their weld overlay program. For example: the requirement for using IWA-3300 for proximity flaw evaluation in paragraph 1.1(e)(1) was excluded, instead indications will be sized based on their individual merits; paragraph 1.1(d)(1) includes the statement that intentional overlay fabrication flaws shall not interfere with ultrasonic detection or characterization of the base metal flaws; paragraph 1.1(e)(2)(a)(1) was modified to require that a base metal grading unit include at least 1 inch of the length of the overlaid weld, rather than 3 inches; paragraph 1.1(e)(2)(a)(3) was modified to require sufficient unflawed overlaid weld and base metal to exist on all sides of the grading unit to preclude interfering reflections from adjacent flaws, rather than the 1 inch requirement of Supplement 11; paragraph 1.1(e)(2)(b)(1) was modified to define an overlay fabrication grading unit as including the overlay material and the base metal-to-overlay interface for a length of at least 1 inch rather than the 6 square inches requirement of Supplement 11; and paragraph 1.1(e)(2)(b)(2) states that overlay fabrication grading units designed to be unflawed shall be separated by unflawed overlay material and unflawed base metal-to-overlay interface for at least 1 inch at both ends, rather than around its entire perimeter.

Additionally, the requirement for axially oriented overlay fabrication flaws in paragraph 1.1(e)(1) was excluded from the PDI Program as an improbable scenario. Weld overlays are typically applied using automated gas tungsten arc welding techniques with the filler metal being applied in a circumferential direction. Because resultant fabrication induced discontinuities would also be expected to have major dimensions oriented in the circumferential direction axial overlay fabrication flaws are unrealistic.

The requirement in paragraph 3.2(b) for reporting all extensions of cracking into the overlay is omitted from the PDI Program because it is redundant to the (root mean square) RMS calculations performed in paragraph 3.2(c) and it's presence adds confusion and ambiguity to depth sizing as required by paragraph 3.2(c). This also makes the weld overlay program consistent with the Supplement 2 depth sizing criteria.

The PDI Program omits the phrase "and base metal on both sides", in paragraph 1.1(e)(2)(a)(1) because some of the qualification samples included flaws on both sides of the weld. To avoid confusion, several instances of the term "cracks" or "cracking" were changed to the term "flaws" because of the use of alternative flaw mechanisms.

2.4 Response to Request for Additional Information (as stated):

In response to an NRC request for additional information, the licensee, in consultation with EPRI PDI, provided the following supplemental information in its letter dated February 11, 2003. The questions are the same as those sent to Edwin I. Hatch Nuclear Plant dated October 4, 2002 (ADAMS Accession Number **ML022820026**).

Response 1: The specimen set shall include specimens with overlays not thicker than 0.1 in. more than the minimum thickness, nor thinner than 0.25 in. of the maximum nominal overlay thickness for which the examination procedure is applicable.

According to the PDI, their intent has always been to provide an allowance to examine overlays that were slightly larger than the maximum that was qualified. Also, according to the PDI, the Appendix VIII Committee concluded that 0.25 inch was adequate and any deviation greater than that would require additional qualification. Progress Energy Carolinas, Inc. [CP&L] agrees with the PDI clarification and will adopt the change made to the PDI Program alternative.

Response 2: The use of alternative flaws shall be limited to when the implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws. Progress Energy Carolinas, Inc. [CP&L] agrees with the PDI clarification and will adopt the change made to the PDI Program alternative.

Response 3: The base metal grading unit includes the overlay material and outer 25% of the overlaid weld. The base metal grading unit shall extend circumferentially for at least 1 inch and shall start at the weld centerline and be wide enough in the axial direction to encompass one half of the original weld crown and a minimum of 0.50 inches of the adjacent base material.

According to the PDI, base material flaws are located in the base material contained within the original weld heat affected zone. Because the width of the weld crown and heat affected zone vary from pipe to pipe, latitude must be given in the Code to allow the user to vary the width of the grading units. Therefore, the PDI has concluded that the words provided above allow sufficient latitude. Progress Energy Carolinas, Inc. [CP&L] agrees with the PDI clarification and will adopt the changes made to the PDI Program alternative.

PDI also stated that the below clarification has been made to the PDI Program alternative.

Response 4: Depth Sizing Test

- (a) The depth sizing test may be conducted separately or in conjunction with the detection test.
- (b) When the depth sizing test is conducted in conjunction with the detection test and the detected flaws do not satisfy the requirements of 1.1(f), additional specimens shall be provided to the candidate. The regions containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.
- (c) For a separate depth sizing test, the regions of each specimen containing a flaw to be sized shall be identified to the candidate. The candidate shall determine the maximum depth of the flaw in each region.

Grading units are not associated with length or depth sizing. Candidates are instructed to find the maximum flaw height in a specific region of the sample. The region is large enough to encompass the flaw to be sized but small enough that they do not size the wrong flaw. Progress Energy Carolinas, Inc. [CP&L] agrees with PDI clarification and will adopt the changes made to the PDI Program alternative.

Response 5: Detection Acceptance Criteria

- (a) Examination procedures are qualified for detection when;

- (1) All flaws within the scope of the procedure are detected and the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for false calls.
 - (2) At least one successful personnel demonstration has been performed meeting the acceptance criteria defined in (b).
- (b) Examination equipment and personnel are qualified for detection when the results of the performance demonstration satisfy the acceptance criteria of Table VIII-S2-1 for both detection and false calls.
- (c) The criteria in (a), (b) shall be satisfied separately by the demonstration results for base metal grading units and for overlay fabrication grading units.

The three times procedure qualification requirements identified above are in addition to the ASME Code; a request for relief is not required for its use. Except as noted elsewhere in the request for relief (e.g., alternative flaws, etc.), the proposed PDI Program alternative for personnel and equipment qualifications is identical to and in full compliance with the current Code requirements for procedures, personnel and equipment. Progress Energy Carolinas, Inc. [CP&L] agrees with the PDI response and the clarification made to the PDI Program alternative.

Response 6: The minimum number of flaws (for sizing specimens) shall be ten. At least 30% of the flaws shall be overlay fabrication flaws. At least 40% of the flaws shall be open to the inside surface. Sizing sets shall contain a distribution of flaw dimensions to assess sizing capabilities. For initial procedure qualification, sizing sets shall include the equivalent of three personnel qualification sets. To qualify new values of essential variables, at least one personnel qualification set is required.

Grading units are not associated with length or depth sizing. Flawed grading units are a minimum of one inch, but the flaw can be shorter than the size of the grading unit. For flaws greater than one inch the grading unit includes the entire flaw. The examination contains many flaws greater than 3 or 4 inches long. The inclusion of too much detail on the minimum and maximum size of the flaws could encourage testmanship, not stop it. Progress Energy Carolinas, Inc. [CP&L] agrees with the PDI clarification and will adopt the changes made to the PDI Program alternative.

- 2.5 Evaluation: The nuclear power industry tasked PDI with the implementation of a Section XI, Appendix VIII, Supplement 11 performance demonstration program. The PDI program is routinely assessed by the staff for consistency with Code and proposed Code changes. In order to meet the scheduled implementation date of November 22, 2001, specified in 10 CFR 50.55a(g)(6)(ii)(C), PDI evaluated the applicability of using test specimens from an existing weld overlay program¹ for the Supplement 11 performance demonstration program. Their evaluation identified differences with Supplement 11 Paragraphs 1.1(b), 1.1(d)(1), 1.1(d)1(a), 1.1(e)(1), 1.1(e)(2)(a)(1), 1.1(e)(2)(a)(3), 1.1(e)(2)(b)(1), 2.3, 3.1 and 3.2(b).

Paragraph 1.1(b) of Supplement 11 states limitations to the maximum thickness for which a procedure may be qualified. The Code states that "The specimen set must

¹ The existing weld overlay program is the industry's response to Generic Letter 88-01 which resulted in a Tri-party Agreement between NRC, EPRI, and the Boiling Water Reactor Owners Group (BWROG), "Coordination Plan for NRC/EPRI/BWROG Training and Qualification Activities of NDE Personnel," July 3, 1984

include at least one specimen with overlay thickness within minus 0.10-inch to plus 0.25-inch of the maximum nominal overlay thickness for which the procedure is applicable." The Code requirement addresses the specimen thickness tolerance for a single specimen set, but is confusing when multiple specimen sets are used. The PDI proposed alternative states that "the specimen set shall include specimens with overlay not thicker than 0.10-inch more than the minimum thickness, nor thinner than 0.25-inch of the maximum nominal overlay thickness for which the examination procedure is applicable." The proposed alternative provides clarification on the application of the tolerance. The tolerance is unchanged for a single specimen set, however, it clarifies the tolerance for multiple specimen sets by providing tolerances for both the minimum and maximum thicknesses. The proposed wording eliminates confusion while maintaining the intent of the overlay thickness tolerance. Therefore, the staff finds this PDI Program revision acceptable.

Paragraph 1.1(d)(1) requires that all base metal flaws be cracks. PDI determined that certain Supplement 11 requirements pertaining to location and size of cracks would be extremely difficult to achieve. For example, flaw implantation requires excavating a volume of base material to allow a pre-cracked coupon to be welded into this area. This process would add weld material to an area of the specimens that typically consists of only base material, and could potentially make ultrasonic examination more difficult and not representative of actual field conditions. In an effort to satisfy the requirements, PDI developed a process for fabricating flaws that exhibit crack like reflective characteristics. Instead of all flaws being cracks as required by Paragraph 1.1(d)(1), the PDI weld overlay performance demonstrations contain at least 70 percent cracks with the remainder being fabricated flaws exhibiting crack-like reflective characteristics. The fabricated flaws are semi-elliptical with tip widths of less than 0.002-inches. The licensee provided further information describing a revision to the PDI Program alternative to clarify when real cracks, as opposed to fabricated flaws, will be used; "Flaws shall be limited to the cases where implantation of cracks produces spurious reflectors that are uncharacteristic of actual flaws." The NRC has reviewed the flaw fabrication process, compared the reflective characteristics between actual cracks and PDI-fabricated flaws, and found the fabricated flaws acceptable for this application.^{2,3}

Paragraph 1.1(e)(1) requires that at least 20% but not less than 40% of the flaws shall be oriented within ± 20 degrees of the axial direction [of the piping test specimen]. Flaws contained in the original base metal heat-affected zone satisfy this requirement, however, PDI excludes axial fabrication flaws in the weld overlay material. PDI has concluded that axial flaws in the overlay material are improbable because the overlay filler material is applied in the circumferential direction (parallel to the girth weld), therefore fabrication anomalies would also be expected to have major dimensions in the circumferential direction. The NRC finds this approach to implantation of fabrication flaws to be reasonable, therefore, PDI's application of flaws oriented in the axial direction is acceptable.

² NRC memorandum, "Summary of Public Meeting Held January 31 - February 2, 2001," with PDI Representatives, March 2, 2001. ML010940402

³ NRC memorandum, "Summary of Public Meeting Held June 12 through June 14, 2001," with PDI Representatives, November 29, 2001 ML013330156

Paragraph 1.1(e)(1) also requires that the rules of IWA-3300 shall be used to determine whether closely spaced flaws should be treated as single or multiple flaws. PDI treats each flaw as an individual flaw and not as part of a system of closely spaced flaws. PDI controls the flaws going into a test specimen set such that the flaws are free of interfering reflections from adjacent flaws. In some cases this permits flaws to be spaced closer than what is allowed for classification as a multiple set of flaws by IWA-3300, thus potentially making the performance demonstration more challenging. Hence, PDI's application for closely spaced flaws is acceptable.

Paragraph 1.1(e)(2)(a)(1) requires that a base grading unit shall include at least 3-inches of the length of the overlaid weld, and the base grading unit includes the outer 25% of the overlaid weld and base metal on both sides. The PDI program reduced the criteria to 1-inch of the length of the overlaid weld and eliminated from the grading unit the need to include both sides of the weld. The proposed change permits the PDI program to continue using test specimens from the existing weld overlay program which have flaws on both sides of the welds. These test specimens have been used successfully for testing the proficiency of personnel for over 16-years. The weld overlay qualification is designed to be a near-side [relative to the weld] examination, and it is improbable that a candidate would detect a flaw on the opposite side of the weld due to the sound attenuation and re-direction caused by the weld microstructure. However, the presence of flaws on both sides of the original weld (outside the PDI grading unit) may actually provide a more challenging examination, as candidates must determine the relevancy of these flaws, if detected. Therefore, PDI's use of the 1-inch length of the overlaid weld base grading unit and elimination from the grading unit the need to include both sides of the weld, as described in the revised PDI Program alternative, is acceptable.

Paragraph 1.1(e)(2)(a)(3) requires that for unflawed base grading units, at least 1 inch of unflawed overlaid weld and base metal shall exist on either side of the base grading unit. This is to minimize the number of false identifications of extraneous reflectors. The PDI program stipulates that unflawed overlaid weld and base metal exists on all sides of the grading unit and flawed grading units must be free of interfering reflections from adjacent flaws which addresses the same concerns as Code. Hence, PDI's application of the variable flaw-free area adjacent to the grading unit is acceptable.

Paragraph 1.1(e)(2)(b)(1) requires that an overlay grading unit shall include the overlay material and the base metal-to-overlay interface of at least 6 square inches. The overlay grading unit shall be rectangular, with minimum dimensions of 2-inch. The PDI program reduces the base metal-to-overlay interface to at least 1-inch (in lieu of a minimum of 2 inches) and eliminates the minimum rectangular dimension. This criterion is necessary to allow use of existing examination specimens that were fabricated in order to meet NRC Generic Letter 88-01 (Tri-party Agreement, July 1984)¹. This criterion may be more challenging than Code because of the variability associated with the shape of the grading unit. Hence, PDI's application of the grading unit is acceptable.

Paragraph 2.3 states that, for depth sizing tests, 80% of the flaws shall be sized at a specific location on the surface of the specimen to the candidate. This requires detection and sizing tests to be separate. PDI revised the weld overlay program to allow sizing to be conducted either in conjunction with, or separately from, the flaw detection test. If performed in conjunction with detection, and the detected flaws do not meet the

Supplement 11 range criteria, additional specimens will be presented to the candidate with the regions containing flaws identified. Each candidate will be required to determine the maximum depth of flaw in each region. For separate sizing tests, the regions of interest will also be identified and the maximum depth and length of each flaw in the region will similarly be determined. In addition, PDI stated that grading units are not applicable to sizing tests, and that each sizing region will be large enough to contain the target flaw, but small enough such that candidates will not attempt to size a different flaw. The above clarification provides a basis for implementing sizing tests in a systematic, consistent manner that meets the intent of Supplement 11. As such, this method is acceptable to the staff.

Paragraphs 3.1 and 3.2 of Supplement 11 state that procedures, equipment and personnel [as a complete ultrasonic system] are qualified for detection or sizing of flaws, as applicable, when certain criteria are met. The PDI program allows procedure qualification to be performed separately from personnel and equipment qualification. Historical data indicate that, if ultrasonic detection or sizing procedures are thoroughly tested, personnel and equipment using those procedures have a higher probability of successfully passing a qualification test. In an effort to increase this passing rate, PDI has elected to perform procedure qualifications separately in order to assess and modify essential variables that may affect overall system capabilities. For a procedure to be qualified, the PDI program requires three times as many flaws to be detected (or sized) as shown in Supplement 11 for the entire ultrasonic system. The personnel and equipment are still required to meet Supplement 11, therefore the PDI program exceeds ASME requirements for personnel, procedures, and equipment qualification.

Paragraph 3.2(b) requires that all extensions of base metal cracking into the overlay material by at least 0.10-inch are reported as being intrusions into the overlay material. The PDI program omits this criterion because of the difficulty in actually fabricating a flaw with a 0.10-inch minimum extension into the overlay, while still knowing the true state of the flaw dimensions. However, the PDI program requires that cracks be depth-sized to the tolerance specified in Code which is 0.125-inches. Since the Code tolerance is close to the 0.10-inch value of Paragraph 3.2(b), any crack extending beyond 0.10-inch into the overlay material would be identified as such from the characterized dimensions. The reporting of an extension in the overlay material is redundant for performance demonstration testing because of the flaw sizing tolerance. Therefore, PDI's omission of highlighting a crack extending beyond 0.10-inch into the overlay material is acceptable.

3.0 CONCLUSION

Based on the above evaluation, it is concluded that the licensee's proposed alternative to use the EPRI PDI program as described in the submittal as supplemented, in lieu of ASME Appendix VIII, Supplement 11 qualification requirements, will provide an acceptable level of quality and safety. Therefore, it is recommended that pursuant to 10 CFR 50.55a(a)(3)(i), Request for Relief No. RR-31 be authorized for the third 10-year intervals at Brunswick Steam Electric Plant, Units 1 and 2, which are scheduled to conclude on May 10, 2008.