

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
ON WELDED REINFORCING BAR SPLICES
FOR VOGTLE ELECTRIC GENERATING PLANT, UNITS 3 AND 4

1.0 INTRODUCTION

This safety evaluation addresses the inspection and testing necessary to provide reasonable assurance that welded reinforcing bar splices in safety-related reinforced concrete structures, other than containment structures, at the Vogtle Electric Generating Plant (VEGP), Units 3 and 4, are of acceptable quality. Based on information from Region II and the VEGP, Units 3 and 4, licensing basis, the Office of Nuclear Reactor Regulation (NRR) has identified the following:

- Section 3.8.4 of the VEGP, Units 3 and 4, updated final safety analysis report (UFSAR) addresses, “other Seismic Category I structures,” which are the shield building and the auxiliary building. Section 3.8.4, of the UFSAR, also provides, “[g]eneral criteria ... describing the loads, load combinations, materials, and quality control [that] are also applicable to the containment internal structures described in Subsection 3.8.3.”
- UFSAR, Section 3.8.4.6.1.2, states, “In areas where reinforcing steel splices are necessary and lap splices are not practical, mechanical connections (e.g., threaded splices, swaged sleeves or cadwelds) are used.” Welded reinforcing bar splices are neither a lap splice nor a mechanical connection.
- U.S. Nuclear Regulatory Commission (NRC) Integrated Inspection Report 05200025/2018001, 05200026/2018001, dated May 14, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18134A348) identified unresolved item (URI) 05200025/2018001-01 regarding the welded reinforcing steel hoops used in the north wall of the main steam east compartment of the Unit 3 auxiliary building, at column line 11, between elevations 117'-6" and 153'-0". The inspectors determined that the licensee was not performing destructive tests or nondestructive examination (NDE) of welded reinforcing joints in accordance with Section III, Division 2, “Code for Concrete Reactor Vessels and Containments,” of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC). Although Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a does not make ASME BPVC, Section III, Division 2, applicable to the welded splices in question, the inspection report notes that the licensee’s Nuclear Development Quality Assurance Manual (NDQAM) commits to Subpart 2.5 of ASME NQA-1-1994, without exception, and that Paragraph 7.13 of Subpart 2.5 states, “Welded reinforcing bar splices shall be subject to the requirements of para. 8.5, except that provisions of the ASME Boiler and Pressure Vessel Code, Section III, Division 2 (ACI Standard 359) shall also apply.”
- As documented in NRC Inspection Report 05200025/2019-010, the NRC has determined that the licensee committed a violation of 10 CFR Part 50, Appendix B, Criterion V, that is associated with the licensee using welded reinforcing bar splices in the auxiliary building without reviewing and reconciling licensing basis impacts (in particular, the statement in UFSAR Section 3.8.6.4.1.2 quoted above).
- As documented in NRC Inspection Report 05200025/2019-010, the NRC has determined that the licensee committed a violation of 10 CFR Part 50, Appendix B, Criterion II, by not following its quality assurance (QA) manual regarding adherence to ASME testing and NDE provisions for welded reinforcing bar splices.

In addition to the instances identified in Integrated Inspection Report 05200025/2018001, 05200026/2018001, the staff is aware that VEGP has used welded reinforcing bar splices in other safety-related reinforced concrete structures. The purpose of this safety evaluation (SE) is to evaluate whether the licensee's decision not to follow ASME testing and NDE provisions for welded reinforcing bar splices presents a safety concern in safety-related reinforced concrete structures at VEGP, Units 3 and 4.

2.0 REGULATORY EVALUATION

The reinforcement bar splices identified in Integrated Inspection Report 05200025/2018001, 05200026/2018001, are located in reinforcing steel hoops used in the north wall of the VEGP, Unit 3 main steam east compartment at column line 11, between elevations 117'-6" and 153'-0". Wall 11 is addressed in the VEGP, Units 3 and 4, UFSAR Tier 2, as mentioned in the Introduction, and Wall 11 is designated as a Critical Section per UFSAR Tier 2, Section 3.8.4.5.4, which also refers to UFSAR Tier 2, Appendix 3H.5.1.4 and Figure 3H.5-5.

Wall 11 is designated in the VEGP, Units 3 and 4 UFSAR as, "Wall at Column Line 11," and is described in UFSAR Section 3H.5.1.4, as follows:

The north wall of the [main steam isolation valve] MSIV east compartment, at column line 11 (Wall 11) between elevation 117'-6" and elevation 153'-0", has been identified as a critical section.

The segment of the wall between elevation 117'-6" and elevation 135'-3" is 4 feet thick, and several pipes such as the main steam line, main feed water line, and the start-up feed water line are anchored to this wall at the interface with the turbine building. The wall segment from elevation 135'-3" to elevation 153'-0" does not provide support to any high energy lines, and is 2 feet thick. This portion does not have to withstand reactions from high energy line breaks.

VEGP, Units 3 and 4, UFSAR, Section 3.8.4.6, gives the materials, quality control, and special construction techniques for construction of reinforced concrete structures. Subsection 3.8.4.6.1.2 specifies the provisions for reinforcing steel including stating that in areas where reinforcing steel splices are necessary and lap splices are not practical, mechanical connections (e.g., threaded splices, swaged sleeves or cadwelds) are used.

The regulatory requirement for inspection is set forth in Criterion X, "Inspection," of Appendix B to 10 CFR Part 50. Criterion X requires, in part, a program for inspection of activities affecting quality to be established and executed by or for the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. Examinations, measurements, or tests of material or products processed shall be performed for each work operation where necessary to assure quality.

The VEGP, Units 3 and 4, NDQAM was developed following the guidance of Nuclear Energy Institute 06-14, "Quality Assurance Program Description," which the staff found through a safety evaluation to be acceptable as a method for complying with the provisions of Appendix B to 10 CFR Part 50. Additionally, VEGP, Units 3 and 4, NDQAM commitments encompass Basic Requirement 10, and Supplement 10S-1 of NQA-1-1994. Basic Requirement 10 states, "Characteristics to be inspected and inspection methods to be employed shall be specified." Supplement 10S-1, Section 2, states, "Inspection requirements and acceptance criteria shall

include specified requirements contained in the applicable design documents approved by the responsible design organization.” Subsection 4.0, “NQA-1-1994 Commitment/Exceptions,” of Section 10 of the NDQAM, “commits to compliance with the requirements of Subparts 2.5 and 2.8 for establishing appropriate inspection requirements,” such as for the final acceptance of fabricated and/or installed items during construction. The staff notes that although NQA-1-1994, Subpart 2.5, Paragraph 7.13, is an acceptable way to meet Criterion X of Appendix B to 10 CFR Part 50, it is not the only possible way.

3.0 TECHNICAL EVALUATION

Background

The focus of the SE is the adequacy of the full penetration butt welded splices of reinforcing rebar. The primary structure addressed in this safety evaluation is Wall 11 of the auxiliary building at VEGP, Unit 3. The discussion in this SE is not limited to this structure and is also applicable all to other safety-related reinforced concrete structures at VEGP, Units 3 and 4. The design details for Wall 11 specify closed hoops. These hoops could not be fabricated from one continuous piece of reinforcing steel. As a result, the design drawings specified for them to be fabricated from two pieces joined together with mechanical splices. During construction, butt welded splices were used in place of mechanical splices.

The licensee for VEGP, Units 3 and 4, committed to portions of ASME NQA-1-1994 to meet the requirements of 10 CFR Part 50, Appendix B for its QA program. ASME NQA-1 has provisions for the development and implementation of Appendix B requirements that are included in the VEGP, Units 3 and 4, QA program. Specifically, NQA-1, Subpart 2.5, “Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete, Structural Steel, Soils, and Foundations for Nuclear Power Plants,” Paragraph 7.13, “Welded Reinforcing Bar Splices,” states that welding reinforcement bar splices shall be subject to paragraph 8.5 of the subpart except that the provisions of ASME Section III, Division 2 shall also apply.

ASME Section III, Division 2, “Code for Concrete Reactor Vessels and Containments,” is a standard for construction of concrete containments and vessels and not for other safety-related reinforced concrete structures for which American Concrete Institute ACI-349, “Code Requirements for Nuclear Safety-Related Concrete Structures,” is the standard for design, detailing, and construction. NQA-1-1994, Paragraph 8.5, “Welding,” of Subpart 2.5 states that inspection of structural steel welding shall be performed in accordance with the provisions of Section 6.0 of American Welding Society (AWS) D1.1, “Structural Welding Code - Steel.” Paragraph 8.5 further provides that this inspection shall include visual examination of preparation, welding processes, post-welding operations, and if deemed necessary, some NDE inspections if appropriate to the application. However, AWS D1.1 is not a standard for the welding of reinforcement but for steel structural shapes such as tubes, plates, and angles. Therefore, NQA-1-1994 referenced ASME Section III, Division 2. The provisions in ASME Section III, Division 2, refer to AWS D1.4, “Structural Welding Code-Steel Reinforcing Bars,” pertaining, in part, to the qualification of the welding procedure specification (WPS) and the qualification of the welders. ASME Section III, Division 2, augments AWS D1.4 (no edition identified) with provisions for NDE and tensile testing on a sampling basis of the splices.

The licensee for VEGP, Units 3 and 4, committed to certain regulatory positions in NRC Regulatory Guide 1.142, Revision 2, “Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments),” with the exception that ACI-349-97 is

updated to the 2001 edition of ACI-349 (ACI 349-01). ACI 349-01, Section 12.14.3.2, provides that all welding conforms to AWS D1.4-98. The ACI 349-01, Section 1.5, "Quality assurance program," provides that the user shall develop its QA program prior to starting work, and that Appendix B to 10 CFR Part 50 establishes the requirements for the QA program. The welded reinforcing bar splices were visually examined in accordance with AWS D1.4-98. AWS D1.4 is a generic code and can be used for both nuclear and non-nuclear commercial construction. AWS D1.4 does not mandate NDE other than visual examination unless specified in the bidding documents or subsequently requested by the owner. ACI 349-01, Section 12.14.3.6, states, "Where it is deemed necessary, the engineer shall be permitted to require the destructive tests of production splices to assure the compliance with Sections 12.14.3.3 and 12.14.3.4," and Section 12.14.3.3 provides that a full welded splice shall develop at least 125 percent of the specified yield strength of the bar. In the standard itself, ACI 349-01 does not specify additional non-destructive inspections and destructive tests such as those in the ASME Code, Section III, Division 2.

This SE is evaluating the safety of safety-related reinforced concrete structures at VEGP, Units 3 and 4, based on the plant-specific design and practices. The staff has identified that the current licensing basis for VEGP, Units 3 and 4, includes commitments to Regulatory Guide 1.142, Revision 2, with exceptions; however, Revision 2 does not provide a regulatory position on inspections and testing for welded reinforcement bar splices. The staff acknowledges general statements, in the NRC Standard Review Plan, Section 3.8.4, and Regulatory Guide 1.142, Revision 3, for example, suggesting that welding of reinforcing bars should conform with ASME Code, Section III, Division 2, but this guidance also explicitly recognizes that exceptions to this position may be justified. Discussions of generally applicable national codes and standards, herein, is not intended to imply that this evaluation is broader in scope than VEGP, Units 3 and 4.

Evaluation

The staff determined through NRC inspections that the licensee has conformed with the provisions in ACI 349-01 for qualification of the WPS and welders as well as visual examination of welded splices in VEGP, Units 3 and 4, even though conformance with the ACI 349-01 provisions endorsing AWS D1.4-98 does not address the additional QA provisions for field sampling and testing of ASME Code, Section III, Division 2.

The staff confirmed that there were no regulatory findings of safety significance that have been identified for actual weld failures of welded reinforcing bar splices at VEGP, Units 3 and 4, because of site-specific factors, such as application of the quality program, welder qualifications, or qualified procedures. In addition, although they are not identical weld joints, experience at VEGP, Units 3 and 4, for tested coupler welds and embed plate welds of similar carbon steel material showed that the welds achieved tensile strengths in excess of 125 percent of the specified yield strength, even with defects found in the tested welds.

NQA-1, Subpart 2.5 Paragraph 7.13, refers to ASME Section III, Division 2, which in turn provides additional inspection and testing, including radiography and destructive testing on a sampling basis of the reinforcing splice welds to provide additional assurance of the reinforcing splice welds. From a safety perspective, the staff finds the non-conformance with NQA-1, Subpart 2.5, could have reduced the likelihood of identifying potential weld defects. However the staff has determined that any potentially undetected weld defects would be an issue of minor safety significance in terms of potential weld capacity reduction. In conjunction with

the site-specific factors listed in the previous paragraph, several factors, listed below, contribute to the robustness of the relevant structures and the conclusion of minor safety significance:

- There are numerous built-in conservatisms in the design, (e.g., material properties, load factors, actual state of stress), that provide additional margin in the design.
- Consistent with the provisions of ACI 349-01 and those in AWS D1.4-98, the application of these codes provides reasonable assurance that the welding procedures for the welded splices and the welders themselves are adequately qualified to produce welds capable of withstanding 125 percent of the specified yield strength of the reinforcement.
- Per AWS D1.4-98, welding procedures and welders are qualified by welding mockups that simulate the production weld joint designs, that are then inspected and tested, to ensure the welders can produce acceptable welds consistently.
- Welding reinforcement splices in carbon steel use relatively basic welding techniques as compared to other alloys such as nickel based alloys or dissimilar metals that use advanced welding techniques.
- The welding procedures specified that if welders are found to be producing unacceptable welds consistently, then retraining and requalification of the welders is required. Unacceptable welds are repaired in accordance with AWS D1.4-98.
- Weld design for 125 percent of the specified yield strength of the bar provides margin to ensure that the weld does not fail before the reinforcing bar.
- Visual examinations have been found by the NRC staff to be sufficient for the site for inspecting weld quality through assurance that approved processes are being followed and that the weld is being implemented as designed and therefore assuring the weld capacity is adequate.
- Visual examination, in accordance with the standards provides reasonable assurance that welds are acceptable because full access to the weld can be achieved to ensure defects are found and repaired, if necessary.
- There are many loads accounted for in the design including static, dynamic, seismic, high energy line break, and thermal loads. The most significant contribution to overall risk is seismic loads. In relation to seismic loads, Section 19.55.6.3 of the VEGP, Units 3 and 4, UFSAR states, "in regards to seismic demand for the [nuclear island] NI structures, systems, and components, it can be concluded that the Seismic Margin Assessment analysis documented in Section 19.55 of the DCD is applicable to the VEGP site." The seismic margin assessment in the design control document (DCD) shows that the reinforced concrete building structures at the site have a high confidence low probability of failure (HCLPF) peak ground acceleration that ranges from 0.67g for the shield building circular RC wall to 0.88g and 0.97g for the auxiliary building (Wall 1 and Wall 11). These values are considerably greater than the controlling HCLPF for the plant in terms of peak ground acceleration (0.5g), which is about 1.67 times greater than the peak ground acceleration for the site-specific safe-shutdown earthquake of about 0.3g. Therefore, there is sufficient margin in the seismic design that the relevant structures will perform their design basis function.

Evaluation Conclusion

- Based on the evaluation above, the staff concludes that despite the non-conformance with NQA-1-1994, Subpart 2.5, Paragraph 7.13, the actual programs, processes, procedures, training, and inspections for the welded splices are otherwise sufficient to satisfy Appendix B to 10 CFR Part 50. In particular, the NRC staff has determined that

the VEGP Units 3 and 4, QA program implementation met the requirements of Criterion X, "Inspection," of Appendix B to 10 CFR Part 50 because a program for inspection of activities affecting quality was established and executed to verify conformance with the design. Thus, the staff concludes that it has no safety concern that the welded splices, as implemented for Wall 11 or in safety-related reinforced concrete structures at the site, challenges reasonable assurance of adequate protection of the public health and safety as a result of the licensee not performing additional testing.

- VEGP, Units 3 and 4, inspections, tests, analyses, and acceptance criteria (ITAAC) verifying the structural integrity of safety-related reinforced concrete structures are ITAAC 3.3.00.02a.i.c and 3.3.00.02a.i.d. These ITAAC are broadly stated and do not specifically invoke ASME destructive testing and NDE for welded splices in safety-related reinforced concrete structures. Also, as explained above, ASME NDE and testing is not necessary to provide reasonable assurance of adequate protection for welded splices in safety-related reinforced concrete structures at VEGP, Units 3 and 4. Thus, performing the ASME destructive testing and NDE is not necessary to successfully complete the ITAAC for safety-related reinforced concrete structures.

4.0 CONCLUSION

Based on the above evaluation, the staff has concluded, that there is reasonable assurance that the health and safety of the public will not be endangered by the welded reinforcing bar splices in safety-related reinforced concrete structures at VEGP, Units 3 and 4.

5.0 REFERENCES

1. Vogtle Electric Generating Plant, Unit 3, Current Facility Combined License NPF-91, Revised June 23, 2020 (ADAMS Accession No. ML14100A106).
2. Vogtle Electric Generating Plant, Unit 4, Current Facility Combined License NPF-92, Revised June 23, 2020 (ADAMS Accession No. ML14100A135).
3. Vogtle Electric Generating Plant, Units 3 and 4, Revision 8, Updated Final Safety Analysis Report, Chapter 3, "Design of Structures, Components, Equipment and Systems," Section 3.8, "Design of Category I Structures," March 21, 2019 (ADAMS Accession No. ML19171A058).
4. Vogtle Electric Generating Plant, Units 3 and 4, Revision 8, Updated Final Safety Analysis Report, Chapter 3, "Design of Structures, Components, Equipment and Systems," Appendix 3H, "Auxiliary and Shield Building Critical Sections," March 21, 2019 (ADAMS Accession No. ML19171A061).
5. Vogtle Electric Generating Plant, Units 3 and 4, Revision 8, Updated Final Safety Analysis Report, Chapter 17, "Quality Assurance," March 21, 2019 (ADAMS Accession No. ML19171A076).
6. Vogtle Electric Generating Plant, Units 3 and 4, Plant Specific DCD Tier 1, Revision 7, March 21, 2019 (ADAMS Accession No. ML19171A045).

7. Regulatory Guide 1.142, Revision 3, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)," April 2019 (ADAMS Accession No. ML16172A240).
8. Regulatory Guide 1.142, Revision 2, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)," November 2001 (ADAMS Accession No. ML013100274).
9. American Concrete Institute ACI 349-01, "Code Requirements for Nuclear Safety-Related Concrete Structures."
10. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (BPVC) Section III, Division 2, "Code for Concrete Containments."
11. American Society of Mechanical Engineers, NQA-1-1994, "Quality Assurance Requirements for Nuclear Facility Applications."
12. American Welding Society AWS D1.1, "Structural Welding Code - Steel."
13. American Welding Society AWS D1.4-1998, "Structural Welding Code-Steel Reinforcing Bars."
14. Nuclear Regulatory Commission (NRC) Integrated Inspection Report 05200025/2018001, 05200026/2018001, dated May 14, 2018 (ADAMS Accession No. ML18134A348)
15. Regulatory Guide 1.142, Revision 2, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)," November 2001 (ADAMS Accession No. ML013100274).
16. American Concrete Institute ACI 349-01, "Code Requirements for Nuclear Safety-Related Concrete Structures."
17. American Society of Mechanical Engineers Boiler and Pressure Vessel Code (BPVC) Section III, Division 2, "Code for Concrete Containments."
18. American Society of Mechanical Engineers NQA-1-1994, "Quality Assurance Requirements for Nuclear Facility Applications."
19. American Welding Society AWS D1.1, "Structural Welding Code - Steel."
20. American Welding Society AWS D1.4-1998, "Structural Welding Code-Steel Reinforcing Bars."

ADAMS Accession No.: ML20178A132 (SE)

*via e-mail

NRR-100

OFFICE	NRR/VPO:PM	NRR/VPO:LA	NRR/VPO:BC	NRR/DEX
NAME	WGleaves*	RButler*	VHall*	KManoly*
DATE	7/1/20	7/1/20	7/1/20	7/1/20
OFFICE	NRR/DNRL	NRR/DRO	NRR/DRO	NRR/DRO:BC
NAME	JHoncharik*	PPrescott*	JOrtega-Luciano*	KKavanagh*
DATE	7/1/20	7/1/20	7/1/20	7/2/20
OFFICE	NRR/DNRL:BC	RES/DE	NRR/DRO	NRR/VPO
NAME	MMitchell*	LLund*	CMiller*	MKing*
DATE	7/1/20	7/2/20	7/2/20	7/2/20
OFFICE	NRR/DNRL	NRR/DEX	OGC	NRR:OD
NAME	BCaldwell* for ABradford	MSampson* for EBenner	MASpencer* NLO	HNieh*
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