February 20, 2001

Mr. D. N. Morey
Vice President - Farley Project
Southern Nuclear Operating
Company, Inc.
Post Office Box 1295
Birmingham, Alabama 35201-1295

SUBJECT: JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2 RE: BOLTED-CONNECTION INSERVICE INSPECTION RELIEF REQUEST NOS. 41 THROUGH 43 (TAC NOS. MA9669 AND MA9670)

Dear Mr. Morey:

Your letter of July 28, 2000, submitted Unit 1 and Unit 2 relief requests RR-41, RR-42, and RR-43 to us. The relief requests involved visual inspection of bolted connections. Based on our review of the information you provided, we authorize your proposed RR-41, RR-42, and RR-43 alternatives pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i) for Farley Units 1 and 2 for the third 10-year interval ending on November 30, 2007.

The Enclosure contains our Safety Evaluation. Please contact me at (301) 415-1423 if you have any questions.

Sincerely,

/RA/

Maitri Banerjee, Acting Chief, Section 1
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-348 and 50-364

Enclosure: As stated

cc w/encl: See next page

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REVIEW BY THE OFFICE OF NUCLEAR REACTOR REGULATION

OF RELIEF REQUESTS NOS. 41 THROUGH 43

JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2

SOUTHERN NUCLEAR OPERATING COMPANY

DOCKET NOS. 50-348 AND 50-364

1.0 INTRODUCTION

Inservice inspection (ISI) of American Society of Mechanical Engineers (ASME) Code Class 1, 2, and 3 components is performed in accordance with Section XI of the ASME Boiler and Pressure Vessel Code and applicable addenda as required by 10 CFR 50.55a(g), except where the Commission grants specific written relief pursuant to 10 CFR 50.55a(g)(6)(i). 10 CFR 50.55a(a)(3) states that licensees may use alternatives to the requirements of paragraph (g) when authorized by the NRC if (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements, except the design and access provisions and the pre-service examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that ISI of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The Code of record for the Farley, Units 1 and 2, third 10-year ISI interval is the 1989 of the ASME Boiler and Pressure Vessel Code.

Southern Nuclear Operating Company's (SNC's) letter of July 28, 2000, proposed three alternatives to the ISI requirements of Section XI of the ASME Code for its J. M. Farley Nuclear Plant (FNP), Units 1 and 2. The NRC's evaluations are discussed below.

2.0 EVALUATIONS

2.1 Relief Request RR-41 (As stated)

2.1.1 System/Component(s) for Which Alternative Rules are Requested:

Corrective actions associated with leakage at Class 1, 2, and 3 bolted connections as prescribed by IWA-5250, "Corrective Measures."

2.1.2 Code Requirements

Subparagraph IWA-5250(a)(2) of the 1989 Edition of ASME Section XI states "if leakage occurs at a bolted connection, the bolting shall be removed, VT-3 visually examined for corrosion, and evaluated in accordance with IWA-3100. " In addition, subparagraph IWA-5250(a)(2) of the 1992 Edition of ASME states "if leakage occurs at a bolted connection, one of the bolts shall be removed, VT-3 examined, and evaluated in accordance with IWA-3100."

2.1.3. Specific Relief Requested

Alternative rules are requested from the requirement to remove, and VT-3 examine any bolting from a bolted connection which shows evidence of leakage.

2.1.4. SNC's Basis for Requesting Relief

Several issues associated with the current requirements of IWA 5250(a)(2) are summarized as follows:

1. The Code requires that bolting be removed from the bolted connection without regard to the severity of the leakage. However, the Code does not specify that leakage be stopped, but does require that the leakage be evaluated. SNC has developed and incorporated into the ISI Pressure Test Plan, generic structural integrity evaluations for the various plant systems which establish acceptable administrative leakage limits for these systems. The ISI Pressure Test Plan specifies that leakage exceeding these administrative limits must be evaluated for structural integrity. In addition, the increased leakage must be approved by plant management.

2. IWA-3100 does not provide an acceptance standard for a VT-3 bolt examination.

3. Removing bolts from a leaking connection, even one bolt at a time, may increase the leakage.

2.1.5 Proposed Alternate Examination

Farley Nuclear Plant will perform one of the following when evidence of leakage is found at bolted connections in borated and non-borated systems:

1. The leakage will be stopped or reduced to acceptable limits as established by the Farley Nuclear Plant ISI Pressure Test Plan. The bolts and component material will then be evaluated for joint integrity. This evaluation will be documented and included as part of the ISI outage report and sent to the NRC within 90 days of the conclusion of each refueling outage.

2. If the leakage is not stopped or reduced to acceptable administrative limits, the joint will be evaluated for integrity. This evaluation will determine the

susceptibility of the bolts to corrosion and failure and will include the following:

a. The number and service age of the bolts,
b. Bolt and component material,
c. Corrosiveness of process fluid,
d. Leakage location and system function,
e. Leakage history at the connection or other system components, [and]
f. Visual evidence of corrosion at the assembled connection.

This evaluation will be documented and included as part of the ISI outage report and sent to the NRC within 90 days of the conclusion of each refueling outage.

3. If the evaluation is unable to justify joint integrity, the bolted connection will be repaired/replaced.

2.1.6 SNC's Justification for Requesting Relief

The ASME Code Committees have evaluated alternatives similar to those proposed herein and determined that they are acceptable corrective action for leakage at bolted connections. These alternatives resolve the implementation problems associated with IWA-5250(a)(2) and provide acceptable corrective actions for evidence of leakage at bolted connections.

The use of these alternatives will not affect the level of quality and safety, nor decrease the margin of public health and safety. Therefore, it is requested that the proposed alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(i).

2.1.7 Staff Evaluation of RR-41

IWA-5250(a)(2) of the 1989 Edition of ASME Code Section XI states that if leakage occurs at a bolted connection, the bolting shall be removed, VT-3 visually examined for corrosion, and evaluated in accordance with IWA-3100. Pursuant to 10 CFR 50.55a(a)(3)(i), SNC proposed an alternative to the requirements of IWA-5250(a)(2) described in section 2.1.5 above regarding corrective actions for leakage at bolted connections.

In accordance with IWA-5250(a)(2), if leakage occurs at a bolted connection, the bolting must be removed, VT-3 visually examined for corrosion, and evaluated in accordance with IWA-3100. In lieu of this requirement, the licensee has proposed to perform one of three other actions. One proposed action is for SNC to stop or reduced the leakage to acceptable limits established by the Farley Nuclear Plant ISI Pressure Test Plan. SNC would then evaluate the bolts and component material for joint integrity. SNC would document this evaluation and include it in their ISI outage report. SNC will send this report to the NRC within 90 days of the end of each refueling outage. Another action SNC could take is to evaluate the bolting to determine its susceptibility to corrosion. SNC's proposed evaluation would consider, as a minimum, items 2.a. through f. described in section 2.1.5 above. The third proposed action is for SNC to repair or replace the bolted connection if their evaluation is unable to justify joint integrity. In a phone call between the staff and SNC on January 30, 2001, SNC clarified the

third proposed action. SNC said that when applying RR-41 in lieu of performing a VT-3 on degraded bolting, SNC would replace the bolting under the plant repair/replacement program. SNC commented that this would provide a greater level of quality and safety than performing the Code-specified VT-3 examination based on the quality control associated with replacement Code materials. SNC further said that if it were only necessary to replace a degraded gasket, the normal Section XI corrective action, including VT-3 of bolting, would apply rather than this relief request.

Based on the above, the staff concludes that the actions SNC proposes present a sound engineering approach to assure the integrity of the bolting materials. Based on the actions contained in SNC's proposed alternative, the staff concludes that SNC's proposed alternative to the requirements of IWA-5250(a)(2) is a technically sound engineering approach to detect significant patterns of degradation and will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the licensee's proposed alternative is authorized. This alternative applies to pressure testing performed during the third 10-year interval ending on November 30, 2007, using the 1989 or 1992 Editions of the ASME Code Section XI.

2.2 Relief Request RR-42 (As stated)

2.2.1 Code Requirement

The 1989 Edition of ASME Section XI, IWA-5242(a) requires that, for systems borated for the purpose of controlling reactivity, insulation shall be removed from pressure-retaining bolted connections for visual examination VT-2. Table IWB-2500-1, Examination Category B-P, requires this be accomplished once each refueling outage for Class I components. Table IWC-2500-1, Examination Category C-H, requires this be accomplished once each inspection period for Class 2 components. Table IWD-2500-1, Examination Categories D-A, D-B, and D-C, requires this be accomplished once each inspection period for Class 3 components.

2.2.2 Specific Relief Requested

Alternatives are requested from removing insulation from corrosion-resistant, pressure-retaining bolted connections in borated systems for VT-2 visual examination at the Code required frequencies.

2.2.3 SNC's Basis for Requesting Relief

The requirement to remove insulation prior to performing VT-2 examinations was added to the 1989 Section XI of the ASME Code after events occurred in the nuclear industry where bolt degradation was observed as a result of boric acid corrosion attack caused by leaks at bolted connections. At sufficiently high bolt surface temperatures, borated water leakage may concentrate through evaporation and subsequently corrode carbon steel or low alloy steel bolts. However, high chromium content stainless steels are not significantly affected by the concentrated boric acid.

The resistance of high chromium content stainless steels to boric acid corrosion is discussed in several studies, including EPRI's "Boric Acid Corrosion Guidebook". This guidebook indicates that one remedial measure to preventing future degradation is to replace carbon and low-alloy steel fasteners with corrosion resistant materials, such as 304, 316, 410, and 17-4 PH stainless steels or Inconel Alloy 718 and X-750. Recent experience at Farley Nuclear Plant with 410 stainless steel (SA-193 Grade B6) bolts supports this conclusion. Stainless steel (410) bolts, which had been in service for more than 20 years exposed to boric acid leakage, showed no evidence of wastage or other corrosion damage when cleaned and visually examined.

Under certain conditions some grades of corrosion-resistant bolts have exhibited stress-corrosion cracking (both intergranular and transgranular) when exposed to high stress levels in a boric acid environment. SA-453 Grade 660 (also known as A-286 stainless steel) has been found to be susceptible to stress corrosion cracking if preloaded above 100 ksi. However, a study by Piascik and Moore of Babcock & Wilcox found that SA-453 Grade 660 bolts preloaded below 100 ksi showed no failures. Other studies have shown that SA-453 Grade 660 stress relieved at a temperature of 1100 °F or higher or material that has a hardness of 30 RC or lower does not experience stress corrosion cracking. An Electricite' de France (EDF) study that heated A-286 stainless steel (SA-453 Grade 660) at 212 °F in a concentrated boric acid solution showed no evidence of stress corrosion cracking after 3000 hours.

Two grades of corrosion-resistant bolts are used by Farley. These are [American Society for Testing and Materials (ASTM)] SA-453 Grade 660 (A-286 stainless steel) and ASTM SA-193 B6 Type 410 stainless steel. The yield strength of both these grades is 85 ksi. An evaluation (Log. No. 00-MT-009) performed for plant Farley by Southern Company Services has shown that the corrosion-resistant bolts in use at Farley Nuclear Plant are not susceptible to stress-corrosion cracking when exposed to plant operating conditions.

Corrosion resistant bolts in use at Farley Nuclear Plant, purchased to the above mentioned ASTM specifications, requires a minimum heat treating (tempering) temperature of 1100 °F or higher for the SA-193 Grade B6 and a minimum hardening temperature of 1325 °F for the SA-453 Grade 660. Bolts are torqued to values permitted by FNP General Maintenance Procedure FNP-0-GMP-80.0 and vendor manuals. FNP-0-GMP-80.0 permits no torquing above 85% of the bolt yield strength. Most torque values are considerably below this maximum value.

At Farley Nuclear Plant, a minor leak which may not be detectable with the insulation in place, will not affect the structural integrity of the corrosion resistant bolted connection through either wastage, other types of corrosion, or stress-corrosion cracking. The primary issue is the potential for a minor leak to increase such that it jeopardizes other non-corrosion resistant component, or equipment important to safety. Implementation of the Alternate Examination in lieu of the Code requirements will detect such conditions and continue to assure that the structural integrity of the bolted connections will be maintained.

2.2.4 Proposed Alternate Examination

Perform the VT-2 examination with the insulation in place after the system containing the affected bolted connection has been at pressure for a minimum of four (4) hours. This will allow adequate time for any leakage to penetrate the insulation which provides a means for detecting any significant leakage with the insulation in place. If evidence of leakage is observed at a bolted connection during the VT-2 examination, the insulation will then be removed from that bolted connection and the connection re-examined with the insulation removed. In addition, during each inspection period, the insulation will be removed from approximately 1/3 of the corrosion resistant Class 1, 2, or 3 bolted connections (on a rotating basis), and each of these connections will be VT-2 examined with the insulation removed. This will permit each corrosion resistant bolted connections to be VT-2 examined on an ongoing basis, with the insulation removed, at least once during each ten-year interval.

2.2.5 SNC's Justification for Requesting Relief

The proposed alternative will provide adequate assurance that the level of quality and safety for corrosion resistant bolting will be maintained. Therefore, the proposed alternative should be [authorized] pursuant to I0CFR50.55a(a)(3)(i).

2.2.6 Staff Evaluation of RR-42

The Code requires removing all insulation from pressure-retaining bolted connections in systems borated for the purpose of controlling reactivity when performing VT-2 visual examinations during system pressure tests. The Code requires SNC to perform this examination each refueling outage for Class 1 systems, and each inspection period for Class 2 and 3 systems. Pursuant to 10 CFR 50.55a(a)(3)(i), SNC proposed an alternative to the requirements of IWA-5242(a) described in section 2.2.4 above regarding removing insulation from corrosion-resistant, pressure-retaining bolted connections in borated systems for VT-2 visual examination performed during pressure tests.

The staff has developed a position over the years on the use of ASTM SA-193 B6 Type 410 stainless steel (SA-193 Grade 6) and A-286 stainless steel (SA-453 Grade 660) fasteners. Type 410 stainless steel is suitable for use in contact with primary water if it is aged at a temperature of 1100 °F or higher. It becomes susceptible to primary water stress corrosion cracking if it is aged at a lower temperature. The hardness of this alloy should be below Rc 30 if it is properly heat treated. A-286 stainless steel is susceptible to stress corrosion cracking in primary water, particularly if preloaded above 100 ksi. NUREG/CR-3604, "Bolting Applications," states that A-286 stainless steel is not suitable for use as a reactor structural material because much safer materials are available. However, there are a large number of A-286 bolting currently in nuclear service, both in boiling-water reactors (BWRs) and pressurized-water reactors (PWRs). Bengtsson and Korhonen of ASEA-ATOM, Vasteras, Sweden, examined the behavior of A-286 in a BWR environment as reported in the *Proceedings of the International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors*, August 22-25, 1983, Myrtle Beach, South Carolina sponsored by National Association of Corrosion Engineers, the Metallurgical Society of AIME, and the American Nuclear Society. They found the A-286 was the most susceptible material to intergranular

stress corrosion cracking in BWR water that they tested. They also found that A-286 is less likely to crack as the applied stress is reduced. Piascik and Moore from Babcock & Wilcox reported a number of vessel internals bolt failures of A-286 bolts in *Nuclear Technology*, Vol. 75, December 1986 in PWR water. They correlated the failures with bolt fillet peak stress and found that bolts preloaded below 100 ksi showed no failures.

The staff's position is that any Type 410 stainless steel stud or bolt aged at a temperature below 1100 °F or with hardness above Rc 30 must have the thermal insulation removed for VT-2 examination during the system pressure test. For A-286 stainless steel studs or bolts, the preload must be verified to be below 100 ksi or the thermal insulation must be removed and the joint visually inspected.

For nuts conforming to SA-194, experience indicates that it would not be necessary to remove the thermal insulation to perform visual inspection.

In their submittal, SNC stated that these types of corrosion resistant bolts in use at FNP have a minimum heat treating temperature of 1100 °F or higher for the SA-193 Grade B6 (410 stainless steel) and a minimum hardening temperature of 1325 °F (meets RC 30 hardness criteria) for the SA-453 Grade 660 (A-286 stainless steel). Further, SNC procedures do not permit torquing bolts above 85% of the bolt yield strength. SNC stated that most torque values are considerably below this maximum value. This is consistent with the staff position previously described in this safety evaluation report. Specifically, the heat treating temperature for 410 stainless steel is 1100 °F or higher, and the bolt preload of all bolting, including the A-286 bolts, is below 100 ksi (Farley procedures do not allow torquing above 85% of the bolt yield strength of 85 ksi).

The ASME approved Code Case N-616, "Alternative Requirements for VT-2 Visual Examination of Class 1, 2, and 3 Insulated Pressure-Retaining Bolted Connections," Section XI, Division 1 on May 7, 1999, but the NRC staff has not reviewed it for general applicability. Code Case N-616 eliminated the requirement to remove the insulation at any time if corrosion resistant bolting is used. But, Code Case N-616 did not address the possibility that Type 410 stainless steel or A-286 fasteners could fail in service under insulation and the failure could go unnoticed. It also does not specifically require a 4-hour hold time at operating temperature and pressure prior to conducting the VT-2 examination. However, SNC's proposed alternative is to perform the VT-2 examination with the insulation in place after the system containing the affected bolted connection has been at pressure for a minimum of 4 hours. If SNC observes evidence of leakage at a bolted connection during the VT-2 examination, they will then remove the insulation from that bolted connection and re-examine the connection with the insulation removed. In addition, during each inspection period, SNC will remove the insulation from approximately 1/3 of the corrosion resistant Class 1, 2, or 3 bolted connections (on a rotating basis) during pressure tests. SNC will then VT-2 examine each of these connections with the insulation removed. This will permit each corrosion-resistant bolted connection to be VT-2 examined on an ongoing basis, with the insulation removed, at least once during each 10-year interval.

The staff finds this relief request acceptable based on the above. This alternative applies to ISI examinations performed during the third ISI interval ending on November 30, 2007, using the 1989 Edition of Section XI.

2.3 Relief Request RR-43 (As stated)

2.3.1 Code Requirements

ASME Section XI, 1989 Edition, Paragraph IWA-5242(a) requires that, for systems borated for the purpose of controlling reactivity, insulation shall be removed from pressure retaining bolted connections prior to performing the visual examination. Table IWC-2500-1 requires a system pressure test and corresponding VT-2 visual examination be performed on Class 2 components once each inspection period and a system hydrostatic test and corresponding VT-2 visual examination be performed on Class 2 components once each inspection interval. Table IWD-2500-1 requires a system pressure test and corresponding VT-2 visual examination be performed on Class 3 components once each inspection period and a system hydrostatic test and corresponding VT-2 visual examination be performed on Class 3 components once each inspection interval.

2.3.2 Specific Relief Requested

Insulation will not be removed from pressure-retaining Class 2 and 3 bolted connections prior to performing VT-2 visual examinations during the conduct of pressure tests.

2.3.3 SNC's Basis for Requesting Relief

ASME has approved Code Case N-533-1 to require a system pressure test and VT-2 visual examination be performed each period for Class 2 and 3 bolted connections without removal of insulation *[only in systems borated for the purposes of controlling reactivity]*[1]. The connections are not required to be pressurized during this pressure test. Further, the insulation is required to be removed from bolted connections each period and a VT-2 visual examination is required to be performed during a subsequent pressure test with the system at nominal operating pressure. Evidence of leakage is required to be evaluated in accordance with IWA-5250.

2.3.4 Proposed Alternate Examination

Insulated Class 2 and 3 pressure-retaining bolted connections will be uninsulated and VT-2 examined as scheduled per the ISI Pressure Test Plan while the connection are at atmospheric or static pressure. The bolted connections will also be examined (with insulation installed) during the regularly scheduled system pressure test conducted at nominal operating pressure. This re-examination will be conducted no earlier than 4 hours after reaching nominal system operating pressure.

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[1]Italicized text was added by NRC for clarity.

2.3.5 SNC's Justification for Requesting Relief

The pressure test with the 4-hour hold time will allow adequate time for any leakage to penetrate the insulation, thereby, providing a means of detecting any significant leakage with the insulation in place. Secondly, by removing the insulation at the prescribed intervals, any boric acid residue can be detected. This two-phase approach provides an acceptable level of quality and safety for Class 2 and 3 bolted connections; therefore, the proposed alternative should be authorized pursuant to 10CFR50.55a(a)(3)(i).

2.3.6 Staff Evaluation of RR-43

ASME Section XI, Subparagraph IWA-5242(a) requires SNC to remove insulation from pressure-retaining bolted connections prior to performing visual examination on borated systems that control reactivity. Pursuant to 10 CFR 50.55a(a)(3)(i), SNC proposed an alternative to the requirements of IWA-5242(a) described in section 2.3.4 above to perform VT-2 visual examinations with insulation in place for pressure-retaining Class 2 and 3 bolted connections when conducting pressure tests.

SNC's proposed alternative is essentially equivalent to ASME Code Case N-533-1 which specifies performing a system pressure test and VT-2 visual examination each period for Class 2 and 3 bolted connections without removing insulation. The NRC staff is currently reviewing Code Case N-533-1 but has not yet approved it for use. SNC's proposed alternative provides a systematic approach to assure leak-tight integrity of systems borated for the purpose of controlling reactivity. Initially, when performing leakage tests at operating pressure with the insulation in place, any significant leakage will be visible when the leakage penetrates the insulation or appears at joints or low points. Also, SNC will remove the insulation from bolted connections each period and will perform a VT-2 visual examination with the system at normal operating pressure. SNC will then be able to detect minor leakage by noting the presence of boric acid crystals or residue. This two-phase approach will provide an acceptable level of quality and safety for bolted connections in borated systems. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), SNC's proposed alternative is authorized for Class 2 and 3 systems. The use of this alternative is authorized for pressure testing performed during the third 10-year interval which ends on November 30, 2007, using the 1989 Edition of Section XI or until the NRC publishes Code Case N-533-1 for general use in a future version of NRC Regulatory Guide (RG) 1.147. At that time, if SNC intends to continue implementing the alternative, it must follow all provisions of Code Case N-533-1 with limitations or conditions specified in RG 1.147, if any.

3.0 CONCLUSION

The staff has reviewed SNC's submittal and concludes that SNC's proposed alternatives specified in RR-41, RR-42, and RR-43, provide acceptable levels of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), SNC's proposed alternatives contained in these requests for relief are authorized for FNP, Units 1 and 2, for the third 10-year interval ending on November 30, 2007.

Principal Contributor: M. Padovan

Date: February 20, 2001