April 25, 2003

Mr. J. B. Beasley, Jr.
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: RELAXATION OF REQUIREMENTS ASSOCIATED WITH ORDER (EA-03-009) REGARDING REACTOR PRESSURE VESSEL HEADS INSPECTIONS (TAC NOS. MB8007 AND MB8008)

Dear Mr. Beasley:

The Nuclear Regulatory Commission (NRC) Order EA-03-009 (Order), issued February 11, 2003, established interim inspection requirements for reactor pressure vessel heads and associated penetrations at pressurized water reactors. By a letter dated March 3, 2003, as supplemented by letters dated April 11 and 18, 2003, Southern Nuclear Operating Company (SNC) requested relaxation of the Order, specifically, item IV.C.(1)(a) with respect to bare metal visual examination of the reactor pressure vessel (RPV) head and item IV.C.(1)(b)(i) with respect to performing ultrasonic testing (UT) extending to the bottom of each penetration nozzle at the Joseph M. Farley Nuclear Plant (Farley), Units 1 and 2. Less than 1 percent of the RPV head surface is inaccessible for bare metal visual examination due to reflective metal insulation and the shroud support structure. In addition, the physical configuration of the lower ends of the 4-inch diameter nozzles at the Farley units limits the extent of UT examination. Your request was made based on Section IV.F of the Order.

We have reviewed and evaluated the information provided by you in support of your request for relaxation of item IV.C.(1)(a) with respect to bare metal visual examination of the RPV head and item IV.C.(1)(b)(i) of the Order with respect to performing UT extending to the bottom of each penetration nozzle at Farley, Units 1 and 2, as stated in your March 3, 2003, letter, and supplemented on April 11 and 18, 2003. The staff has found that SNC has demonstrated good cause for the requested relaxation. The licensee has demonstrated that compliance with the Order for specific nozzles would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV.F of the Order and 10 CFR 50.55a(a)(3), the NRC staff approves your request for relaxation and authorizes the proposed alternative to item IV.C.(1)(a) with respect to bare metal visual examination of the RPV head and item IV.C.(1)(b)(i) of the Order with respect to performing UT extending to the bottom of each penetration nozzle at Farley, Units 1 and 2, contingent upon the following condition:

> If the NRC staff finds that the crack growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If the licensee's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance

criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised.

This action completes our review of the Order EA-03-009 relaxation requests for Farley, Units 1 and 2 under TAC Nos. MB8007 and MB8008. Also, your letter of March 3, 2003, provided a similar request for the Vogtle Electric Generating Plant (Vogtle), Units 1 and 2. A separate review will be performed by the staff to evaluate the Order EA-03-009 relaxation request for Vogtle, Units 1 and 2, under TAC Nos. MB8009 and MB8010.

The details of the staff review are provided in the enclosed Safety Evaluation. If there are any questions concerning this approval, please contact Frank Rinaldi at (301) 415-1447.

Sincerely,

/RA/

Scott W. Moore, Acting Director
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

the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELAXATION OF FEBRUARY 11, 2003, ORDER (EA-03-009)

REACTOR PRESSURE VESSEL HEAD INSPECTIONS

JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2

SOUTHERN NUCLEAR OPERATING COMPANY, INC.

DOCKET NOS. 50-348 AND 50-364

1.0 INTRODUCTION

Nuclear Regulatory Commission (NRC) Order EA-03-009, issued February 11, 2003, established interim inspection requirements for reactor pressure vessel heads and associated penetrations at pressurized water reactors. By letter dated March 3, 2003, as supplemented by letters dated April 11 and 18, 2003, Southern Nuclear Company (SNC, the licensee), requested relaxation of the Order to implement an alternative to the requirements of Section IV, paragraphs C.(1)(a) for bare metal visual examination and C.(1)(b)(i) for the vessel head penetration (VHP) nozzles at Farley, Units 1 and 2. The physical configuration of the lower ends of the 4-inch diameter nozzles at the Farley units limits the extent of such examination. The specific relaxations requested are from the requirements to conduct a bare metal visual examination of 100 percent of the reactor pressure vessel (RPV) head surface and to perform non-destructive examination (NDE) of the RPV head penetration nozzle base material to the bottom of the nozzle. Relaxation was requested for Farley, Units 1 and 2, for one 18-month operating cycle. SNC's request was made based on Section IV.F of the Order.

2.0 REGULATORY REQUIREMENTS

NRC Order EA-03-009, issued on February 11, 2003, requires specific examinations of the RPV head and VHP nozzles of all pressurized water reactor (PWR) plants. Section IV, paragraph F, of the Order states that requests for relaxation of the Order associated with specific penetration nozzles will be evaluated by the NRC staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers Boiler Pressure and Vessel Code (ASME Code) in accordance with 10 CFR 50.55a(a)(3). Section IV, paragraph F, of the Order states that a request for relaxation regarding inspection of specific nozzles shall address the following criteria: (1) the proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or (2) compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For Farley, Units 1 and 2, and similar plants determined to have a high susceptibility to primary water stress corrosion cracking (PWSCC) in accordance with Section IV, paragraphs A and B,

of the Order, the following inspections are required to be performed during every refueling outage in accordance with Section IV, paragraph C.(1), of the Order:

(a) Bare metal visual (BMV) examination of 100 percent of the RPV head surface (including 360° around each RPV head penetration nozzle), AND

(b) Either:

(i) Ultrasonic testing (UT) of each RPV head penetration nozzle (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone, OR

(ii) Eddy current testing or dye penetrant testing of the wetted surface of each J-Groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-groove weld.

Footnote 3 of the Order provides specific criteria for the examination of repaired VHP nozzles.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposed Alternative Method

For Item (a), the proposed alternative examination is to achieve substantial compliance with the requirement by conducting a BMV examination of the RPV head surface to the extent possible (over 99 percent) including 100 percent of coverage of surface areas adjacent to each of the head penetration nozzles. In addition, this alternative will examine the head surface immediately upslope and downslope of the inaccessible area.

For item (b), the proposed alternate examination is to perform a UT examination of the nozzles as close as possible to the bottom of the nozzle, but to a minimum of 1 inch from the bottom of the J-groove weld.

3.2 Licensee's Basis for Relaxation

Item (a):

The licensee stated that a small percentage (less than 1 percent) of the head surface is inaccessible due to reflective metal insulation (RMI) and the shroud support structure. Access to this area would require major disassembly of the RMI and shroud. The licensee stated that obtaining the additional information would result in substantial radiation exposure to personnel and increased costs. Since the proposed examination includes more than 99 percent of the area, including all areas adjacent to each of the head penetration nozzles, the licensee contended that the additional work would not provide any increase in the level of quality and safety commensurate with the hardship involved.

Item (b):

The licensee stated that it is unable to completely comply with the requirement to UT to the bottom of the penetration nozzle due to the physical configuration of the nozzles. Specifically, the bottom end of these nozzles are externally threaded, or internally tapered, or both. This configuration prevents UT data acquisition in a zone extending to approximately 1 and 1.5 inches from the bottom of each nozzle.

The licensee stated that the coverage of at least 1 inch below the weld would provide an acceptable level of quality and safety. Specifically, the licensee stated that,

1) UT coverage to the bottom of the nozzles is not necessary in that the limitation does not preclude examination of the portions of these nozzles that are of primary interest.

2) UT of the high stressed portion of the nozzle (the weld and its adjacent area) is unaffected by this limitation. Beyond 1 inch from the bottom of the weld, the operating stresses are very low, less than 5 ksi as determined by a stress analysis, and are unlikely to cause crack initiation.

3) UT of the interference fit zone above the weld for leakage assessment is not affected.

4) The nozzle is essentially an open-ended tube and the inaccessible portion of the nozzle is not part of the reactor coolant system pressure boundary.

5) Cracks initiating from this portion would be of minimal safety significance with respect to pressure boundary leakage or nozzle ejection because this portion is at least an inch below the pressure boundary and any cracks would have to grow through a significantly examined portion of the tube to reach the pressure boundary.

The licensee supported its request with a crack growth analysis that determined it would take a hypothetical axial crack with a crack tip 0.5 inch below the weld approximately 5 years of operation to grow to the point of contact with the weld. This analysis used the approach described in footnote 1 of the Order as the criteria to set the necessary height of the examination. However, this analysis incorporates a crack growth formula different from that described in footnote 1 of the Order, as provided in the Electric Power Research Institute (EPRI) Report, "Material Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1."

3.3 Evaluation

The NRC staff's review of this request was based on criterion (2) of Section IV.F of the Order, which states:

Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Relaxation Request Item (a)

Order EA-03-009 requires, in part, that BMV examination of 100 percent of the RPV head surface (including 360° around each RPV head penetration nozzle) should be performed.

For item (a), the alternative examination proposed by the licensee is to achieve a BMV examination of the RPV head surface to the extent possible, more than 99 percent, including 100 percent coverage of surface areas adjacent to each of the head penetration nozzles.

The specific configuration over the RPV head at Farley, Units 1 and 2, consists of RMI and the shroud support structure. As a result, a small percentage, less than 1 percent as determined by the licensee, of the head surface is inaccessible for BMV examination. To achieve 100 percent of coverage as required by the Order, the licensee would have to physically remove the RMI and the shroud support structure. Specifically, the RMI and the shroud support structure would have to be disassembled to allow BMV inspection. When the inspection is completed, new RMI and the shroud support structure would have to be reinstalled on the RPV head. This additional work would result in hardship to the licensee. Thus, the RMI and the shroud support structure make a complete inspection in accordance with Order EA-03-009 very difficult and would involve a hardship. This evaluation focuses on the issue of whether there is a compensating increase in the level of quality and safety such that 100 percent of the vessel head surface area should be inspected despite this hardship.

The purpose of the BMV examination is to inspect evidence of head penetration nozzle leakage as well as evidence of degradation on the vessel head surface. Since the examination covers more than 99 percent of the head surface including all areas adjacent to each of the head penetration nozzles, any evidence of nozzle leaks would be detected. In addition, the licensee's inspection covers those portions of the RPV head that are immediately upslope and downslope of the inaccessible area. Evidence of boric acid leaks would be visible in the examined areas. Therefore, the proposed alternative provides reasonable assurance of the structural integrity of the RPV head.

Because the proposed alternative provides reasonable assurance of structural integrity of the component, the licensee has demonstrated hardship without a compensating increase in the level of quality and safety.

Relaxation Request Item (b)

Order EA-03-009 requires, in part, that UT of each RPV head penetration nozzle extend from 2 inches above the J-groove weld to the end of the nozzle. However, full coverage is not achievable at Farley because of nozzle end geometry. Specifically, the bottom end of these nozzles are externally threaded, or internally tapered, or both. Thus, the geometry of the nozzle ends makes inspection in accordance with Order EA-03-009 difficult and would involve a hardship. This evaluation focuses on the issue of whether there is a compensating increase in the level of quality and safety such that these nozzles should be inspected despite this hardship.

The alternative proposed by the licensee is to examine at least 1 inch below the bottom of the J-groove weld instead of the end of the nozzles as required by the Order. According to the licensee, most of the nozzles will receive extensive examination coverage. For a limited

number of nozzles, the inaccessible portion is at least 1 inch from the bottom of the J-groove weld on the "downhill" side of the penetration. The NRC staff reviewed various evaluations and analyses performed by the licensee in support of this request, as described below.

Stress profiles, based on the licensee's finite element analysis of control rod drive mechanism (CRDM) penetrations at Farley, Units 1 and 2, show that the residual stresses decrease significantly at distances beyond 1 inch below the bottom of the J-groove weld. The evaluation shows that the worst case occurred on the "downhill" side of the nozzle where UT coverage is most limited due to the curvature of the RPV head. The maximum operating stress level for the nozzle base material beyond the UT coverage, as determined by the licensee, is less than 5 ksi. The nominal yield strength of the CRDM penetration base material is from 32.7 to 48.5 ksi. Since the stress level at the unexamined area is so low, initiation of a crack is very unlikely. Operating experience also indicates that locations with this low stress level have not been susceptible to cracking. In addition, if examination of the high stress locations of these nozzles and the high stress locations in other nozzles (i.e., nozzle locations adjacent to the J-groove weld and associated heat affected zone areas) finds no cracks, then cracking at these low stress locations is unlikely.

An analysis provided by the licensee demonstrates that even if an axial crack initiates from this location, it will take more than 5 years of operation for this hypothetical crack to propagate to the point of contact with the J-groove weld. This analysis used the approach described in footnote 1 of the Order as the criteria to set the necessary height of the examination. Therefore, the coverage addressed by this request provides reasonable assurance of structural integrity of the component. However, this analysis incorporates a crack growth formula different from that described in footnote 1 of the Order, as provided in the EPRI Report, "Material Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1." The NRC staff has completed a preliminary review of the crack growth formula, but has not yet made a final assessment regarding the acceptability of the report. Therefore, a condition has been included regarding the proposed relaxations (as noted in Section 4.0 below).

The safety issues that are addressed by the inspections mandated by Order EA-03-009 are degradation (corrosion) of the low-alloy steel RPV head, reactor coolant pressure boundary integrity and ejection of the VHP nozzle due to circumferential cracking of the nozzle above the J-groove weld. The proposed alternative, as conditioned, provides reasonable assurance that these safety issues are addressed. Based on the above discussion, the alternative proposed by the licensee to inspect a minimum of 1 inch below the bottom of the J-groove weld will provide an acceptable level of quality and safety.

Because the proposed alternatives for Item (a) and Item (b), as conditioned below, provide reasonable assurance of structural integrity of the component, the licensee has demonstrated good cause for relaxation of the Order in that compliance would result in hardship without a compensating increase in the level of quality and safety.

4.0 CONCLUSION

The staff concludes that: (a) the licensee's proposed alternative examination of at least 99 percent of the RPV head including 100 percent of the area adjacent to the RPV head penetration nozzles and excluding areas inaccessible due to RMI and the shroud support

structure, and (b) the licensee's proposed alternative examination of the RPV head penetration nozzles to at least 1 inch below the bottom of the J-groove weld, provide reasonable assurance of the structural integrity of the RPV head, VHP nozzles, and associated J-groove welds at Farley, Units 1 and 2. Further inspection of these VHP nozzles in accordance with Section IV, paragraph C.(1), of Order EA-03-009 would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, paragraph F, of Order EA-03-009, the licensee has demonstrated good cause and the staff authorizes the proposed relaxations for VHP head penetration nozzles for Farley, Units 1 and 2,subject to the following condition:

> If the NRC staff finds that the crack growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If the licensee's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised.

Principal Contributors: Z. Fu, NRR
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Date: April 25, 2003

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