April 2, 2004

Mr. L. M. Stinson
Vice President - Farley Project
Southern Nuclear Operating
Company, Inc.
Post Office Box 1295
Birmingham, Alabama 35201-1295

SUBJECT: JOSEPH M. FARLEY NUCLEAR PLANT, UNIT 2 RE: RELAXATION OF REQUIREMENTS ASSOCIATED WITH FIRST REVISED ORDER (EA-03-009) REGARDING ALTERNATE EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES (TAC NO. MC2441)

Dear Mr. Stinson:

The First Revised NRC Order EA-03-009 (First Revised Order), issued on February 20, 2004, requires specific examinations of the reactor pressure vessel head and vessel head penetration nozzles of all pressurized water reactor plants. By letter dated March 25, 2004, as supplemented by letter dated April 1, 2004, Southern Nuclear Operating Company, Inc. (the licensee) requested relaxation to implement an alternative to the requirements of Section IV.C.(5)(b) of the First Revised Order for reactor pressure vessel (RPV) head penetration nozzles at Joseph M. Farley Nuclear Plant, Unit 2.

The licensee requested relaxation from the First Revised Order for one 18-month operating cycle, where inspection coverage is limited by inaccessible areas of five control rod drive mechanism penetration nozzles, with respect to nondestructive examination.

The Nuclear Regulatory Commission (NRC) staff has reviewed and evaluated the information provided by the licensee in support of this request and concludes that the licensee has demonstrated good cause for the requested relaxation and the licensee's proposed alternative examination of the five vessel head penetration (VHP) nozzles provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections of these VHP nozzles in accordance with Section IV.C.(5)(b), of the First Revised Order would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV.F of the First Revised Order, the NRC staff authorizes the proposed alternative inspection at Joseph M. Farley, Unit 2, for one 18-month operating cycle, 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 First Revised Order dated February 20, 2004, 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 analyses has been revised. Any future crack growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack growth rate formula.

The NRC staff review is provided in the enclosed Safety Evaluation. If you have any questions concerning this approval, please contact Sean Peters at (301) 415-1842.

Sincerely,

/RA/

Edwin M. Hackett, Director
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-364

Enclosure: As stated

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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 analyses has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack growth rate formula.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FIRST REVISED ORDER (EA-03-009) RELAXATION REQUEST

ALTERNATE EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD

PENETRATION NOZZLES

JOSEPH M. FARLEY NUCLEAR PLANT, UNIT 2

SOUTHERN NUCLEAR OPERATING COMPANY, INC., ET AL.

DOCKET NO. 50-364

1.0 INTRODUCTION

The First Revised NRC Order EA-03-009 (First Revised Order), issued on February 20, 2004, requires specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized water reactor (PWR) plants. By letter dated March 25, 2004, as supplemented by letter dated April 1, 2004, Southern Nuclear Operating Company, Inc. (SNC, the licensee) requested relaxation to implement an alternative to the requirements of Section IV.C.(5)(b) of the First Revised Order for RPV head penetration nozzles at Joseph M. Farley Nuclear Plant (FNP), Unit 2.

The licensee seeks relaxation from the First Revised Order for one 18-month operating cycle, where inspection coverage is limited by inaccessible areas of five control rod drive mechanism (CRDM) penetration nozzles, with respect to non-destructive examination (NDE), including ultrasonic testing (UT), eddy current testing (ET), and dye penetrant testing (PT).

2.0 REGULATORY EVALUATION

The First Revised NRC Order EA-03-009 (First Revised Order), issued on February 20, 2004, requires specific examinations of the RPV head and VHP nozzles of all PWR plants. Section IV.F. of the First Revised Order states that requests for relaxation of the First Revised 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 Code in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50.55a(a)(3). Section IV.F. of the First Revised 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 First Revised Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For FNP, Unit 2, and similar plants determined to have a high susceptibility to primary water stress corrosion cracking (PWSCC) in accordance with Sections IV.A and IV.B of the First

Revised Order, the following inspections are required to be performed every refueling outage in accordance with Sections IV.C.(5)(a) and IV.C.(5)(b) of the First Revised Order:

(a) Bare metal visual examination of 100 percent of the RPV head surface (including 360° around each RPV head penetration nozzle). For RPV heads with the surface obscured by support structure interferences which are located at RPV head elevations downslope from the outermost RPV head penetration, a bare metal visual inspection of no less than 95 percent of the RPV head surface may be performed provided that the examination shall include those areas of the RPV head upslope and downslope from the support structure interference to identify any evidence of boron or corrosive product. Should any evidence of boron or corrosive product be identified, the licensee shall examine the RPV head surface under the support structure to ensure that the RPV head is not degraded.

(b) For each penetration, perform a non-visual NDE in accordance with either (i), (ii), or (iii):

(i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-1]); or from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-2). In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [see Figure IV-3]); or from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces, and

leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

2.1 First Revised Order Requirements for which Relaxation is Requested

The First Revised Order, Section IV.C requires, in part, that inspections of Section IV.C.(5)(b) of the First Revised Order be performed every refueling outage for high susceptibility plants similar to FNP, Unit 2, with the condition of Footnote 2.

Footnote 2 in Section IV.C allows licensees with previously NRC-approved inspection plans to continue under the plan's requirements for the first outage after February 11, 2003, provided discrepancies between the inspection plan and the First Revised Order requirements were documented in a submittal to the NRC. SNC had a previously NRC-approved inspection plan for FNP, Unit 2, approved by an April 25, 2003, NRC safety evaluation report (SER) (ML031150594).

The licensee has requested relaxation from Section IV.C(5)(b) of the First Revised Order within the scope of Footnote 2 of the First Revised Order. The specific relaxation requested is identified below.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Proposed Alternative

The licensee seeks relaxation from the First Revised NRC Order EA-03-009, dated February 20, 2004, where inspection coverage is limited by inaccessible areas of 5 CRDM penetration nozzles for FNP, Unit 2, with respect to NDE, UT, ET, and PT.

The licensee proposes to achieve NDE coverage by means of UT to at least 1 inch below the lowest point of the toe of the J-groove weld in accordance with the April 25, 2003, NRC SER for 64 of the 69 4-inch diameter nozzles for FNP, Unit 2. But for the other five nozzles (#62, 63, 65, 66 and 69), the licensee proposes to achieve UT coverage to as far below the weld as can be achieved (i.e.; to the shoulder of the area machined for threading).

The coverage achieved at each of these five nozzles is listed in Table 1 below:

Table 1 - Farley, Unit 2, Spring 2004 RPV Head Inspection Nozzles with UT Coverage Less than 1 Inch Below the Lowest Point of the Toe of the J-Groove Weld (i.e. downhill side)			
Nozzle #	Weld Angle	Minimum UT Coverage Achieved Below J-Groove Weld	Hoop Stress at Lowest Point of Coverage[1]
62	42.6 degrees	0.76 inches	5000 psi
63	42.6 degrees	0.92 inches	zero to compressive
65	42.6 degrees	0.92 inches	zero to compressive
66	42.6 degrees	0.96 inches	zero to compressive
69	42.6 degrees	0.76 inches	5000 psi

3.2 Licensee's Basis for Proposed Alternative

NDE coverage to at least 1 inch below the J-groove weld is unnecessary for the cited nozzles because UT examination to the lower limit physically achievable provides an acceptable level of quality and safety, as described below.

In a previous response to an NRC question regarding growth of postulated cracks in unexamined portions of the nozzle below the J-groove weld (Question 3 in Enclosure 1 of the SNC's letter of April 11, 2003), the licensee described flaw evaluations performed using FNP, Unit 1's, plant-specific penetration nozzle stresses. These stresses and evaluations also apply to FNP, Unit 2. A through-wall axial flaw was postulated in the nozzle material growing upwards towards the bottom of the weld. Since the stresses for the unexamined portion of the nozzle below the weld are too low to propagate an axial flaw, the flaw evaluations started at 0.5 inches below the weld (well within the zone examined by UT for the five cited nozzles), and the time to propagate the flaw in the nozzle to the toe of the J-groove weld was determined.

As stated in the licensee's letter dated April 11, 2003, this assumed through-wall axial flaw would take approximately 5 years of operation to grow from 0.5 inches below the weld up to the point of contact with the weld, and even longer to grow from the bottom of the weld upwards through the pressure boundary. This 5-year period was a limiting case based on the most highly stressed nozzles. For the postulated crack to propagate up to the weld from the downhill side of a nozzle with a 42.6 degree weld angle (typical for the 5 nozzles at issue), an even longer period is required; approximately 6.8 operating years per Figure 6-11 of WCAP-15925-P, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Farley Units 1 and 2" (Proprietary, transmitted by the licensee's April 11, 2003 letter).

The axial crack growth prediction shown in Figure 6-11 of WCAP-15925 can be conservatively

[1] Approximate values taken from Figure 9 hoop stress curves provided in Enclosure 1 of April 11, 2003, licensee letter to the NRC.

applied to possible undetected flaws in the 42.6 degrees penetration nozzles where less than 1-inch of UT coverage was achieved below the weld. That is, it can be shown that more than the 6.8 years indicated by Figure 6-11 would be required for an undetected axial through-wall flaw to propagate up to the weld. From Table 1 above, the most limiting inspection coverage is 0.76 inches below the lowest point of the toe of the J-groove weld. Referring to Enclosure 1, Figure 9 of the licensee's letter dated April 11, 2003, a flaw with the upper crack tip located at the boundary of the examined area (i.e. 0.76 inches below the weld) and the lower crack tip located at the point where the hoop stress becomes compressive will only be about 0.2 inches long. Also from Figure 9, the hoop stress at the upper crack tip will only be about 5000 psi. In contrast, the crack growth curve in WCAP-15925, Figure 6-11 was generated assuming an initial through-wall flaw 0.474 inches long (required to achieve a crack tip stress intensity factor that exceeds 9 MPa$\sqrt{m}$, the threshold assumed for propagation), with the upper crack tip located 0.5 inches below the weld where the hoop stress is about 15,000 psi. Therefore, it is clear that Figure 6-11, which assumes a larger crack with higher stress located closer to the weld, conservatively bounds possible undetected flaws in the five nozzles for which UT coverage relaxation is sought.

Since the FNP, Unit 2, RPV head is scheduled to be replaced after just one more operating cycle (in fall 2005), the predicted time period for possible undetected flaws to grow up to the weld is far greater than the remaining planned service life of the RPV head. Accordingly, the proposed alternative will provide an acceptable level of quality and safety.

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.

SNC has a previously approved inspection plan for FNP, Unit 2, documented by an NRC SER report dated April 25, 2003. The approved inspection plan requires the inspection of each RPV head penetration nozzle to a minimum of 1 inch below the bottom of the J-groove weld. However, full coverage is not achievable at FNP, Unit 2, for five nozzles (#62, 63, 65, 66 and 69) 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 including increased personnel radiation dose due to possible surface examination options. 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 inspection proposed by the licensee for these five nozzles (#62, 63, 65, 66 and 69) is to volumetrically examine each nozzle to as far below the weld as can be achieved as identified in Table 1 above. In support of this request, the licensee documented that preliminary assessment of the inspection results from the current March 2004 inspections had disclosed no evidence of head material wastage or of leaking or cracked nozzles. FNP, Unit 2, has not identified leakage or PWSCC in penetration nozzles in past inspections. In addition, the NRC staff took into consideration the licensee's documented head replacement for FNP, Unit 2,

which is scheduled to take place in Fall 2005. The NRC staff also reviewed 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 CRDM penetrations at FNP, Unit 2, show that the residual stresses decrease significantly at distances identified in Table 1 above for minimum UT coverage achieved. 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 this low, initiation of a crack is very unlikely. Operating experience also indicates that locations with this low stress level have been much less 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 also unlikely.

An analysis provided by the licensee demonstrates that if an axial crack initiates from the minimum UT coverage achieved locations, it will take more than 5 years of operation for this postulated crack to propagate to the point of contact with the J-groove weld. This analysis used the approach described in Footnote 1 of the First Revised Order as the criteria to set the necessary height of the examination. As the current RPV upper head is expected to remain in service for only one additional operational cycle and is then scheduled for replacement in Fall 2005, the coverage addressed by this request provides reasonable assurance of structural integrity of the component. However, this analysis incorporates a crack growth formula 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 approval of the proposed relaxations (as noted in Section 4.0 below).

The safety issues that are addressed by the inspections mandated by the First Revised 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 the five nozzles (#62, 63, 65, 66 and 69) to the minimum UT coverage achievable below the J-groove weld, as documented in Table 1 above, will provide reasonable assurance of structural integrity.

Based upon the information above, the NRC staff finds that the licensee's proposed alternative examination is acceptable as it provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Further inspections to comply with the First Revised Order requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative examination of the five VHP nozzles (#62, 63, 65, 66 and 69) provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles and welds. Thus the NRC staff concludes that the licensee has demonstrated good cause for the requested relaxation in that the proposed alternative provides an acceptable level of quality and safety. Further inspections of these VHP nozzles in accordance with Section IV.C(5)(b), of the First Revised Order would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV.F of the First Revised Order, the NRC staff authorizes the proposed alternative inspection for the five VHP nozzles (#62, 63, 65, 66 and 69) at FNP, Unit 2, for one 18-month operating cycle, 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 First Revised Order dated February 20, 2004, 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 analyses has been revised. Any future crack growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack growth rate formula.

Principal Contributor: J. Collins, NRR

Date: April 2, 2004

Joseph M. Farley Nuclear Plant

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