December 19, 2007

Mr. J. Randy Johnson
Vice President - Farley
Joseph M. Farley Nuclear Plant
7388 North State Highway 95
Columbia, AL 36319

SUBJECT: JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2, SAFETY EVALUATION OF PROPOSED MODIFICATION TO THE NUCLEAR REGULATORY COMMISSION-APPROVED ALTERNATIVE FOR WELD OVERLAY ON DISSIMILAR METAL WELDS OF PRESSURIZER NOZZLES (TAC NOS. MD6304 AND MD6305)

Dear Mr. Johnson:

By letter dated June 27, 2007, Southern Nuclear Operating Company (the licensee) requested the Nuclear Regulatory Commission (NRC) for approval to modify sections 3(a)2, 3(a)3, and Appendix 4, section 3.0(a) of Relief Request (RR) ISI-GEN-ALT-06-03, which require that when ambient temperature temper bead welding is used, the nondestructive examinations (NDEs) are required to be conducted at least 48 hours after the overlay reaches ambient temperature. The licensee proposed to allow performance of the NDEs 48 hours after the third temper bead weld layer is completed.

The NRC approved RR ISI-GEN-ALT-06-03 by letter dated March 8, 2007 (Agencywide Documents Access and Management System Accession No. ML070600246).
RR ISI-GEN-ALT-06-03 provides an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, to repair dissimilar metal butt welds using a full structural weld overlay in the pressurizer nozzles at Joseph M. Farley Nuclear Plant (FNP), Units 1 and 2.

As discussed in the enclosed safety evaluation, the NRC staff concludes that the proposed modification of the 48-hour hold time requirement provides an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations* Section 50.55a(a)(3)(i), the NRC authorizes the proposed modification to RR ISI-GEN-ALT-06-03. This authorization is applicable only when welding is performed in accordance with RR ISI-GEN-ALT-06-03 for the full structural weld overlay on the dissimilar metal welds of the pressurizer nozzles at FNP, Units 1 and 2.

Sincerely,

/RA/

Evangelos C. Marinos, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-348 and 50-364

cc w/encl: See next page

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SAFETY EVALUATION REPORT

PROPOSED MODIFICATION TO RELIEF REQUEST ISI-GEN-ALT-06-03

PRESSURIZER NOZZLE FULL STRUCTURAL WELD OVERLAYS

JOSEPH M. FARLEY NUCLEAR PLANT, UNITS 1 AND 2

SOUTHERN NUCLEAR OPERATING COMPANY

DOCKET NUMBERS 50-348 AND 364

1.0 INTRODUCTION

By letter dated June 27, 2007, Southern Nuclear Operating Company (the licensee) requested the Nuclear Regulatory Commission (NRC) for approval to modify the 48-hour hold time requirement defined in sections 3(a)2, 3(a)3, and Appendix 4, section 3.0(a) of Relief Request (RR) ISI-GEN-ALT-06-03. Currently, when ambient temperature temper bead welding is used in weld overlay of dissimilar metal butt welds, the nondestructive examinations (NDEs) are required to be conducted at least 48 hours after the completed overlay has returned to ambient temperature. The licensee proposed to change this requirement to allow performance of the NDEs 48 hours after the third temper bead weld layer is completed. The overall effect of the proposed change would reduce the time needed for weld overlay installation.

The NRC approved RR ISI-GEN-ALT-06-03 by letter dated March 8, 2007 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML070600246). RR ISI-GEN-ALT-06-03 provides an alternative to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, for the repair of dissimilar metal butt welds in the pressurizer nozzles at Joseph M. Farley Nuclear Plant (FNP), Units 1 and 2.

2.0 REGULATORY EVALUATION

Pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) must meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection (ISI) of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components.

Pursuant to 10 CFR 50.55a(a)(3), alternatives to requirements may be authorized by the NRC if the licensee demonstrates that (i) the proposed alternatives 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.

The licensee proposed to modify RR ISI-GEN-ALT-06-03 which the NRC has approved for FNP, Units 1 and 2 previously. The requirement of 10 CFR 50.55a(a)(3)(i) provides the suitable regulatory basis to evaluate the proposed modification.

3.0 STAFF EVALUATION

Sections 3(a)2, 3(a)3, and Appendix 4 section 3.0(a) of RR ISI-GEN-ALT-06-03 requires that when ambient temper bead welding is used over ferritic materials that surface and ultrasonic examinations be performed when the completed weld has been at ambient temperature for least 48 hours. The 48-hour delay was required to allow sufficient time for hydrogen cracking to occur (if it is to occur) in the heat affected zone (HAZ) of ferritic materials prior to performing examinations, to ensure detection of hydrogen cracking by NDEs. The licensee has referenced an Electric Power Research Institute (EPRI) report as a technical basis for starting the 48-hour hold after completion of the third temper bead weld layer rather than waiting for the completed weld overlay to cool to ambient temperature.

Although the proposed 48-hour hold time is the same as in the approved relief request, the total time is reduced when the starting point of the 48-hour hold starts from the third layer instead of from the completion of the entire weld overlay. The staff's concern is on the potential for hydrogen cracking or cold cracking resulting from welding. The staff identified four potential contributors to cracking. They are changes in the microstructure of the base metal, sources for hydrogen introduction, tensile stress and temperature, and diffusivity and solubility of hydrogen in the P-3 material (i.e., pressurizer nozzles).

EPRI has documented their technical basis in Technical Update Report 1013558, "Repair and Replacement Applications Center: Temper Bead Welding Applications 48-Hour Hold Requirements for Ambient Temperature Temper Bead Welding" (ADAMS Accession No. ML070670060). The data in the EPRI report is based on testing performed on SA-508, Class 2 low-alloy ferritic steels, which is the material of the FNP pressurizer nozzles.

After evaluating all of the issues relevant to hydrogen cracking such as microstructure of susceptible materials, availability of hydrogen, applied stresses, temperature, and diffusivity and solubility of hydrogen in steels, EPRI concluded that "there appears to be no technical basis for waiting the 48 hours after cooling to ambient temperature before beginning the NDE of the completed weld. There should be no hydrogen present, and even if it were present, the temper bead welded component should be very tolerant of the moisture." EPRI also notes that over 20 weld overlays and 100 repairs have been performed using temper bead techniques on low alloy steel components over the last 20 years. During this time, there has never been an indication of hydrogen cracking by the NDEs performed after the 48-hour hold or by subsequent inservice inspections.

As indicated in the EPRI report, the microstructure in the P-3 material directly beneath the temper bead weld overlay consists of a tempered martensite or tempered bainite that has excellent toughtness, combined with a modest maximum hardness of the order of Rc [Rockwell C Hardness] 30 or lower. This hardness level is below the threshold for hydrogen cracking in the low alloy steels in water environment. Hydrogen cracking would most likely to occur at a hardness of Rc 36 or higher. However, EPRI found that the microstructure at the toe of the temper bead weld overlay in the P-3 weld HAZ at the outside diameter surface where tempering is somewhat limited may have a very small HAZ with a maximum hardness of the order of

Rc 36, at a distance of about 40 mils from the toe of the weld overlay. Therefore, at the toe of the temper bead weld overlay in the P-3 material on the outside surface, it is possible for the hardness to reach a threshold for hydrogen cracking to occur. EPRI stated that even in the very unlikely case that cracking was to occur, it would not be structurally significant. In addition, at a depth of about 2 to 2.5 mm beneath the toe of the weld overlay the hardness is reduced to less than Rc 29, a hardness level well below that required to cause hydrogen cracking. On the basis of hardness tests, the staff finds that microstructure of the base metal is not affected by the welding significantly. The staff finds that hydrogen cracking would most likely not to occur in the weld overlay based on hardness determination. If hydrogen cracking does occur at the toe of the weld overlay, the staff believes that it will not be structurally significant.

Hydrogen in the weld may come from moisture, poor shielding gas, and contamination. It is noted that moisture in the shielding gas or high humidity is not a problem for gas tungsten arc weld because of its welding procedures. Contamination will affect the weld, and should be identified either during the welding process or during the subsequent NDE of the overlay. Good welding practice should eliminate this problem for the temper bead weld overlay. The licensee's RR ISI-GEN-ALT-06-03 requires specific welding practice for the temper bead weld overlay to minimize the presence of hydrogen. The staff finds that hydrogen content in the weld overlay will be minimized as part of temper bead ambient temperature welding procedures.

EPRI reported that tensile stresses should not be an issue for cold cracking as the thermal stresses diminish with each weld overlay layer. Following the final weld layer, it is expected that the maximum surface temperature at the toe of the weld overlay in the P-3 HAZ would reach temperatures only on the order of 400 degrees Fahrenheit (°F) to 500 °F. Slow cooling to ambient temperature from these temperatures would be expected to produce relatively small stresses. This implies that waiting 48 hours after the third weld layer would not produce high stresses and reduce the likelihood of cold cracking. The staff finds that tensile stresses are not an issue if 48-hour hold time is implemented after completion of the third layer.

In case hydrogen is introduced during the welding, the staff's concern is whether hydrogen would be entrapped in the P-3 material of the pressurizer nozzles and produce cracking. EPRI report stated that the diffusion rate for hydrogen is greater in ferritic materials than in austenitic materials, but the solubility of hydrogen in austenitic is from five to seven times greater in the austenite than in the ferrite or martensite. Consequently, due to the temperatures expected during the welding of the temper bead layers, and during the welding of the non-temper bead weld overlays, the temperature should be sufficient for the hydrogen to diffuse out of the P-3 material, either escaping the structure or diffusing into the austenite, where it can be held in much greater quantities. Thus even if hydrogen is produced, a large hydrogen inventory in the P-3 material is not expected.

The licensee also referenced an ASME technical basis paper (ADAMS Accession No. ML070790679) which indicates that the introduction of hydrogen to the ferritic HAZ is limited to the first weld layer because this is the only weld layer that makes contact with the ferritic base material. The technical basis paper states that while the potential for the introduction of hydrogen to the ferritic HAZ is negligible during subsequent weld layers, these layers provide a heat source that accelerates the dissipation of hydrogen from the ferritic HAZ in non-water backed applications. The staff agrees with the licensee that large hydrogen inventory in the P-3 material is not expected due to the diffusivity and solubility of hydrogen in the austenitic weld and ferritic base metal.

On the basis of information submitted, the staff finds that it is not necessary to wait until 48 hours after the completed overlay has reached ambient temperature because any delayed hydrogen cracking, were it to occur, is expected to occur within the 48 hours following completion of the third temper bead weld layer. Therefore, the staff concludes that NDE of the weld overlay 48 hours after completion of the third temper bead weld layer is acceptable.

4.0 CONCLUSIONS

The NRC staff has reviewed the licensee's submittal and determined that the proposed modification to perform NDE of the weld overlay 48 hours after completion of the third temper bead weld layer will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC authorizes the modification of the 48-hour hold time requirement to be incorporated in sections 3(a)2, 3(a)3, and Appendix 4, section 3.0(a) of RR ISI-GEN-ALT-06-03.

This authorization is applicable only when welding is performed in accordance with RR ISI-GEN-ALT-06-03 for the full structural weld overlay of the dissimilar metal butt welds of the pressurizer nozzles at FNP, Units 1 and 2.

All other ASME Code, Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

Principal Contributor: John Tsao

Date: December 19, 2007

Joseph M. Farley Nuclear Plant, Units 1 & 2

cc:

Mr. J. Randy Johnson
Vice President - Farley
Joseph M. Farley Nuclear Plant
7388 North State Highway 95
Columbia, AL 36319

Mr. B. D. McKinney, Licensing Manager
Southern Nuclear Operating Company, Inc.
P.O. Box 1295
Birmingham, AL 35201-1295

Mr. M. Stanford Blanton
Balch and Bingham Law Firm
P.O. Box 306
1710 Sixth Avenue North
Birmingham, AL 35201

Mr. Jeffrey T. Gasser
Executive Vice President
Southern Nuclear Operating Company, Inc.
P.O. Box 1295
Birmingham, AL 35201

State Health Officer
Alabama Department of Public Health
434 Monroe St.
Montgomery, AL 36130-1701

Chairman
Houston County Commission
P.O. Box 6406
Dothan, AL 36302

Resident Inspector
U.S. Nuclear Regulatory Commission
7388 N. State Highway 95
Columbia, AL 36319

William D. Oldfield
SAER Supervisor
Southern Nuclear Operating Company, Inc.
P.O. Box 470
Ashford, AL 36312