February 7, 2005

Mr. F. G. Burford , Director
Nuclear Safety & Licensing
Entergy Operations, Inc.
1340 Echelon Parkway
Jackson, MS 39213-8298

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT 2 (ANO-2) - RELAXATION REQUEST FROM U.S. NUCLEAR REGULATORY COMMISSION (NRC) FIRST REVISED ORDER EA-03-009 FOR THE CONTROL ELEMENT DRIVE MECHANISM (CEDM) NOZZLES (TAC NO. MC2303)

Dear Mr. Burford:

By letter dated March 11, 2004, as supplemented by letters dated October 7 and November 17, 2004, Entergy Operations, Inc. (Entergy, the licensee) requested relaxation to implement an alternative to certain requirements of the First Revised Order for CEDM nozzles at ANO-2.

Specifically, pursuant to the process specified in Section IV, Paragraph F of the First Revised Order, you requested relaxation from the requirements specified in Section IV, Paragraph C, Item (5)(b), to instead perform inspections using a three-step alternative, which involves the use of ultrasonic examination, analysis, and augmented inspection techniques.

The NRC staff has completed its review and concludes that the proposed alternative examination of the CEDM reactor pressure vessel (RPV) head penetration nozzles provides reasonable assurance of structural integrity of the RPV head. Further inspection of the CEDM 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. Thus, you have demonstrated good cause for the requested relaxation. Therefore, pursuant to Section IV, Paragraph F, of the First Revised Order, the NRC staff authorizes for one operating cycle commencing with the startup from the Spring 2005 refueling outage, the proposed alternative inspection for all CEDM head penetration nozzles at ANO-2, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in MRP-55, “Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material” is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 18 (following the upcoming refueling outage), this relaxation is rescinded and Entergy will, within 72 hours, submit to the NRC written justification for continued operation.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, Entergy 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 Operating Cycle 18 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the

NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for Operating Cycle 18 and future cycles for RPV head penetrations will be based on an NRC-acceptable crack growth rate formula.

The NRC staff's related Safety Evaluation (SE) is enclosed.

Be aware that when vessel head inspections are performed using American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements, acceptance criteria, or qualified personnel, those activities and all related activities fall within the jurisdiction of the ASME Code. Therefore, Order-related inspection activities may be subject to third party review, including those by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-368

Enclosure: Safety Evaluation

cc w/o encl: See next page

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Project Directorate IV
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELAXATION REQUEST FROM FIRST REVISED ORDER EA-03-009

REGARDING CONTROL ELEMENT DRIVE MECHANISM EXAMINATION

FACILITY OPERATING LICENSE NO. NPF-6

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE UNIT 2

DOCKET No. 50-368

1.0 INTRODUCTION

The NRC First Revised Order EA-03-009, 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 plants. Section IV, Paragraph F, of the First Revised Order states that a Project Director or higher management positions in the Division of Licensing Project Management of the Office of Nuclear Reactor Regulation, may, in writing, relax or rescind any of the conditions set forth in Section IV, Paragraph C of the First Revised Order upon demonstration by the licensee good cause. Section IV, Paragraph 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. In addition, Section IV, Paragraph F, of the First Revised Order states that requests for relaxation of the Order associated with specific penetration nozzles will be evaluated by the Nuclear Regulatory Commission (NRC) staff using its procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code) in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.55a(a)(3).

For Arkansas Nuclear One, Unit 2 (ANO-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 Section 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 360E 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 nonvisual NDE [nondestructive examination] (NDE) in accordance with either (I), (ii), or (iii):

(I) Ultrasonic testing [(UT)] 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 [(ECT)] or dye penetrant testing [(PT)] 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 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 examination 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 [(OD)] and inside diameter [(ID)] 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.

By letter, dated March 11, 2004, as supplemented by letters dated October 7 and November 17, 2004, Entergy Operations, Inc. (Entergy or 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 ANO-2.

2.0 FIRST REVISED NRC ORDER EA-03-009 RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

2.1 First Revised Order Requirements for Which Relaxation is Requested

Section IV.C. of the First Revised NRC Order EA-03-009 dated February 20, 2004, requires, in part, that inspections in accordance with Section IV.C.(5)(b) of the First Revised Order be performed every refueling outage for high susceptibility plants. ANO-2 is a high susceptibility plant.

The licensee has requested relaxation from Section IV.C.(5)(b) of the First Revised NRC Order EA-03-009. The specific relaxation requested is identified below.

Relaxation was requested for the upcoming ANO-2 refueling outage in the Spring of 2005.

2.2 Licensee's Proposed Alternative Method

Ultrasonic Examination

The licensee states that the ID surface of each CEDM nozzle (i.e., nozzle base material) shall be UT examined from two (2) inches above the J-weld to 1.544 inches above the bottom of the nozzle. The licensee will also perform an assessment to determine if leakage has occurred into the interference fit zone, as currently specified in Section IV.C.(5)(b)(I) of the First Revised Order. Figure 1 is from the licensee's submittal and shows the inspection areas of a CEDM nozzle as defined by the licensee.

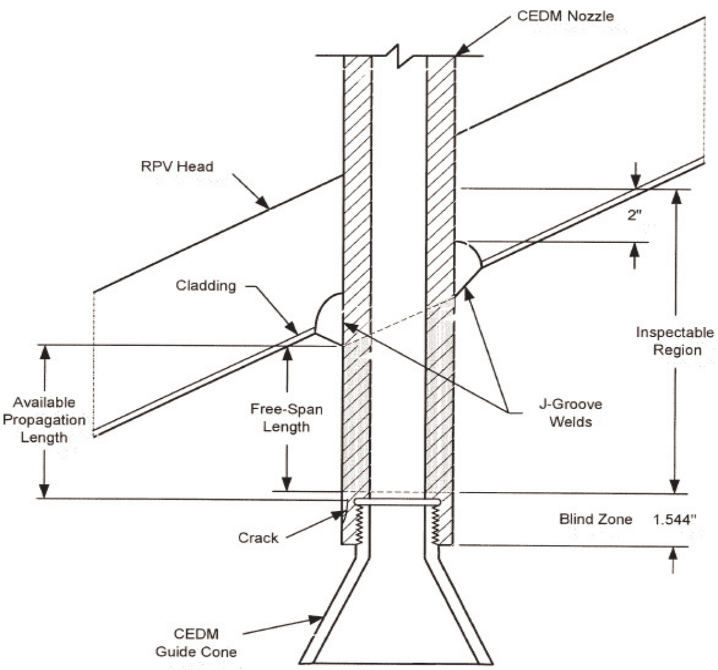

Figure 1

Augmented Inspection

The licensee states that CEDM nozzles that have been demonstrated by analysis to have inadequate free-span to facilitate crack growth for one cycle will be inspected. These nozzles and their associated augmented inspection areas are identified in Table 2 of the licensee's March 11, 2004, letter. Specifically, an augmented inspection of the OD will be performed on that portion of the nozzle that has been determined by analysis as necessary to prevent a crack from reaching the J-groove weld in less than one operating cycle. The augmented inspection will utilize either ECT or PT, or a combination of both techniques.

2.3 Licensee's Basis for Relaxation

Nozzle Configuration Limitation

The licensee states that the guide cones are attached to the bottom of the ANO-2 CEDM nozzles via threaded connections. The guide cones screw into the end of the CEDM nozzles with a welded set screw and two tack welds at the cone-nozzle interface to secure the guide cone to the nozzle. There is a 45E chamfer at the top of the threaded region that is 0.094 inch in length. The length of the threaded region is 1.25 inches.

The licensee states that meaningful UT data cannot be collected in the threaded area or the chamfer region. The chamfer region geometry causes sporadic signals while, once the guide cone is reached, sound cannot pass into the CEDM nozzle base material because of the gap that exists between the guide cone and the nozzle at the threaded connection. This leaves a length of 1.344 inches (1.25 + 0.094) at the bottom of the CEDM nozzle that cannot be inspected by UT examination due to nozzle configuration.

The licensee contends that resolving the UT limitations due to nozzle configuration would require eliminating the CEDM nozzle-to-guide cone threaded connection. This would require cutting off the top of the nozzle thread region and changing it to a welded socket design for attachment of the guide cone. The licensee states that the aforementioned modification would result in a total personnel radiation exposure of approximately 100 man-Rem and a reduction in the inspection region between the blind zone and the J-groove weld. Installing the new guide cones would result in high residual stresses in the weld heat affected zone, which would increase the probability of PWSCC.

Inspection Probe Limitation Design

In addition to the limitations of inspecting the chamfer and threaded area of the bottom of the CEDM nozzles, there are limitations regarding the inspection probe's ability to collect data 0.2 inches above the chamfer area. The licensee states that the inspection probe that is to be used for the ANO-2 CEDM nozzles consists of seven (7) individual transducers. The transducers consist of one pair used for circumferential scanning using the time of flight diffraction (TOFD), one pair for axial scanning using TOFD, one standard zero-degree scan transducer and two ECT transducers. These transducers are slightly recessed into the probe holder that must be filled with water to provide coupling between the transducers and the nozzle wall. The licensee states that prior UT examinations performed on the CEDM nozzles at ANO-2 indicate that the circumferential-scanning TOFD transducer pair only collects data down to a point 0.200 inch above the chamfer. This makes the total distance at the bottom of the nozzle that cannot be UT inspected equal to 1.544 inches (1.25 in threads + 0.094 inch chamfer + 0.2 inch). This area is referred to as the "blind zone." The licensee states that it knows of no UT equipment currently available that resolves the blind zone limitation, and therefore, new UT equipment would have to be developed and appropriately qualified. The licensee also states that the time and resources required to develop this equipment is unknown.

The licensee states that it evaluated the feasibility of inspecting the blind zone (ID and OD surfaces) using the PT or ECT method as specified in Section IV.C.(5)(b)(ii) of the Order. The licensee states that in order to perform a PT examination, it would be required to remove all 81 of the CEDM nozzle guide cones, perform a PT examination and reinstall all 81 CEDM nozzle guide cones, which would result in a total personnel radiation exposure of approximately 200 man-Rem. Furthermore, performing a ECT examination, as with a UT inspection, would not yield results in the 1.344-inch threaded region.

The licensee believes that removing the CEDM nozzle guide cones and reinstalling new nozzle guide cones in order to remove the threaded area, or removing and reinstalling the existing nozzle guide cones to conduct additional inspections, would impose hardships and unusual difficulties without a compensating increase in the level of quality and safety.

Crack Growth Analysis

As a result of the aforementioned NDE limitations, the licensee performed an analysis to determine if sufficient free-span length exists between the blind zone and the weld that would allow one operating cycle of crack growth without the postulated crack reaching the weld. For nozzles or portions of nozzles that did not have sufficient free span length to accommodate one operating cycle of crack growth, the licensee determined how much propagation length is required before a postulated crack in the blind zone would reach the weld within one operating cycle. The licensee's analysis shows that seventy-five (75) of eighty-one (81) CEDM nozzles do not have sufficient free span length to accommodate one operating cycle of crack growth. The licensee plans to perform augmented inspection on all 75 CEDM nozzles that do not have enough free-span length to accommodate one operating cycle of crack growth.

The licensee's analysis is detailed in Entergy Engineering Report M-EP-2003-002, Rev. 1 "Fracture Mechanics Analysis For The Assessments Of The Potential For Primary Water Stress Corrosion Crack (PWSCC) Growth in Uninspected Regions Of The Control Element Mechanism (CEDM) Nozzles At Arkansas Nuclear One Unit 2."

Augmented Inspection

The licensee indicates that manual ECT will be the primary inspection method for the augmented inspections but the PT method or a combination of PT and ECT may also be used. The licensee provided a table listing the minimum inspection areas, axial length and circumferential extent, required to allow one operating cycle of growth for all 75 nozzles requiring augmented inspection. The maximum axial length that is required to be inspected, according to the analyses, is 0.661 inch and the minimum axial length to be inspected is 0.320 inch below the top of the blind zone for the 75 CEDM nozzles that require augmented inspection. The licensee states that it understands that the NRC staff's expectation is that inspections be performed to the maximum extent possible. According to the licensee, the ECT inspection tool is limited to inspecting an axial length from 0.20 inch above the blind zone to 0.80 inch below the top of the blind zone.

Although Table 2 in the licensee's March 11, 2004, submittal indicates an axial length to be inspected ranging from 0.320 inch to 0.661 inch below the top of the blind zone, the licensee will be inspecting to an axial distance of 0.8 inch below the top of the blind zone. The ECT inspection equipment was specifically designed by Westinghouse to perform the required augmented inspections of the CEDM nozzles. The licensee states that the equipment was designed with the following objectives:

a. Inspection coverage bounds the portion of the blind zone identified by analysis.
b. The equipment can be consistently applied to all CEDM nozzle locations.
c. The equipment setup and operation minimizes radiation exposure.
d. The equipment setup and operation minimizes operator error.

The ECT inspection tool is designed with an array of transducer coils that allow a single scan to be performed without multiple setups. A one-inch scan length (0.2 inch above the blind zone + 0.8 inch below the blind zone) was chosen to envelop the areas identified by analysis (maximum axial length of 0.661 inch), and to prevent interference issues associated with the guide cones and steep angles on the outer nozzle rows. The licensee explained that the scan length is fixed by the design of the inspection tool and the size of the ECT coil block.

3.0 EVALUATION

The NRC staff's review of this request was based on criterion (2) of Paragraph F of Section IV 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.

Within the context of the licensee's proposed alternative examination of the RPV penetration nozzles, the licensee has demonstrated the hardship that would result from implementing examinations far enough down on the CEDM nozzles to meet the requirements of Section IV.C.(5)(b) of the Order. The hardship identified by the licensee includes the nozzle configuration, limitation of the UT probe used for nozzle examination and radiation exposure to perform UT examination in accordance with the Order. The NRC staff agrees that the nozzles' threaded area that mates with guide cones makes inspection of these nozzles in accordance with the Order 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 these nozzles should be inspected despite this hardship.

The licensee sought and received approval of an identical relaxation request for its Fall 2003 outage. The prior request was based on the requirements of Order EA-03-009. The differences between the requirements of the current First Revised Order EA-03-009 and Order EA-03-009 do not have an impact on the licensee's current relaxation request pertaining to the inspection of the bottom of the CEDM nozzles.

The licensee's current request is based on the fracture mechanics methodology detailed in Entergy Engineering Report M-EP-2003-002 Rev. 1 which was submitted to the NRC on August 27, 2003, in support of its Fall 2003 outage relaxation request. The licensee's prior request for its Fall 2003 outage, based on the aforementioned Engineering Report, was approved by the NRC staff by letter dated October 9, 2003, to the licensee.

Since the boundaries for the proposed augmented inspection, as defined in Table 1 of the licensee's March 11, 2004 submittal are based on an acceptable fracture mechanics methodology, and the approach of inspecting the area below the top of the blind zone to ensure adequate propagation length for all assumed flaws to grow in one fuel cycle is reasonable, the NRC staff accepts the results summarized in Table 1.

The licensee's crack growth analysis used the approach described in Footnote 1 of the Order, with the exception of the crack growth rate, as the criteria to set the necessary height of the surface 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 Electric Power Research Institute (EPRI) Report MRP-55, "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material." Entergy is aware that the NRC staff has not yet completed a final assessment regarding the acceptability of the EPRI report.

Augmented inspection

According to the licensee, 75 of the 81 CEDM nozzles at ANO-2, will not receive enough UT coverage of nozzle material below the J-groove weld to correspond to crack growth of a postulated flaw for one operating cycle. The aforementioned nozzles will receive an augmented inspection to a minimum distance as shown in Table 1 in the licensee's March 11, 2004, letter. The licensee's analysis shows that these minimum distances will accommodate one operating cycle of crack growth. Although the licensee's analysis shows an axial length to be inspected ranging from 0.320 inch to 0.661 inch below the top of the blind zone, Entergy states that it will be inspecting an axial length of 0.8 inches below the top of the blind zone. The licensee stated that augmented examinations will be performed using ECT, PT or a combination of both inspection methods. It must be noted that UT examination is a volumetric examination of the base metal and gives a higher level of interrogation than an ECT or PT examination which inspects the surface only. According to the licensee's analysis, through-wall and OD originating part through-wall flaws are the limiting flaws as established by analysis. The ECT and PT examination methods are very effective in locating surface flaws. It is very likely that ECT or PT will locate surface flaws in the inspection area if they are present.

Based on the results from the crack growth analysis and the proposed augmented inspections, there is reasonable assurance of structural integrity for the uninspected portions of the nozzles. Therefore, performance of UT to the requirements of Section IV.C.(5)(b)(I) would result in hardship 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 CEDM RPV head penetration nozzles using UT from 2 inches above the J-groove weld to 1.544 inches above the bottom of the CEDM nozzles, and the augmented examination of nozzles without sufficient free-span length for one cycle of postulated flaw growth, provide reasonable assurance of the structural integrity of the RPV head, vessel head penetration nozzles, and welds. Further, inspection of the CEDM nozzles in accordance with Section IV.C.(5)(b) of the First Revised 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 First Revised Order EA-03-009, good cause has been shown for relaxation of the Order, and the NRC staff authorizes, for one operating cycle commencing with the startup from the Spring 2005 refueling outage, the proposed alternative inspection for all CEDM head penetration nozzles at ANO-2, subject to the following condition as stated in the licensee's submittal dated March 11, 2004:

> If the NRC staff finds that the crack-growth formula in MRP-55 is unacceptable, Entergy shall revise its analysis that justifies relaxation of the Order within 30 days after the NRC informs Entergy of an NRC-approved crack-growth formula. If Entergy's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of Operating Cycle 18 (following the upcoming refueling outage), this relaxation is rescinded and Entergy will, 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, Entergy 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 Operating Cycle 18 or the subsequent operating cycle, Entergy shall, within 30 days, submit a letter to the

NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for Operating Cycle 18 and future cycles for RPV head penetrations will be based on an NRC-acceptable crack growth rate formula.

Principal Contributor: R. Davis

Date: February 7, 2005

cc:

Executive Vice President
& Chief Operating Officer
Entergy Operations, Inc.
P. O. Box 31995
Jackson, MS 39286-1995

Director, Division of Radiation
Control and Emergency Management
Arkansas Department of Health
4815 West Markham Street, Slot 30
Little Rock, AR 72205-3867

Winston & Strawn
1400 L Street, N.W.
Washington, DC 20005-3502

Mr. Mike Schoppman
Framatome ANP, Richland, Inc.
Suite 705
1911 North Fort Myer Drive
Rosslyn, VA 22209

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P. O. Box 310
London, AR 72847

Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

County Judge of Pope County
Pope County Courthouse
Russellville, AR 72801

Vice President, Operations Support
Entergy Operations, Inc.
P. O. Box 31995
Jackson, MS 39286-1995

Wise, Carter, Child & Caraway
P. O. Box 651
Jackson, MS 39205