**UNITED STATES**
**NUCLEAR REGULATORY COMMISSION**
**WASHINGTON, D.C. 20555-0001**

November 7, 2008

Mr. Adam C. Heflin
Senior Vice President and
Chief Nuclear Officer
Union Electric Company
Post Office Box 620
Fulton, MO 65251

SUBJECT: CALLAWAY PLANT, UNIT 1 – RELIEF REQUEST I3R-10 APPROVED ON OCTOBER 31, 2008 FOR THIRD 10-YEAR INSERVICE INSPECTION INTERVAL - USE OF POLYETHYLENE PIPE IN LIEU OF CARBON STEEL PIPE IN BURIED ESSENTIAL SERVICE WATER PIPING SYSTEM (TAC NO. MD6792)

Dear Mr. Heflin:

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed and evaluated the information provided by Union Electric Company (the licensee) in its letter dated August 30, 2007, as supplemented by letters dated April 17, July 10, July 24, September 15, and October 9, 2008. The licensee requested approval of Relief Request I3R-10 under Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a for use of high-density polyethylene (HDPE) pipe in lieu of carbon steel pipe in buried essential service water (ESW) piping system.

The licensee proposed an alternative to certain requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) at the Callaway Plant, Unit 1 for its third 10-year inservice inspection interval, which is scheduled to end on December 18, 2014.

On October 31, 2008, the NRC staff responded to the licensee's request and issued a letter and safety evaluation approving the requested alternative.

By emails dated November 3-6, 2008, Mr. Thomas Elwood of your staff informed the NRC staff of some errors in the safety evaluation. The NRC staff has reviewed the information provided by Mr. Elwood, and agrees with the proposed changes to the safety evaluation supporting approval of the relief request.

The errors in the safety evaluation were caused inadvertently and have been corrected as marked on pages 4, 5, 6, 7, and 8, in the enclosed revised safety evaluation supporting the approval of above-described alternative. The corrections do not change the NRC staff's conclusions in the NRC letter dated October 31, 2008, approving the requested relief. Please replace the existing safety evaluation with the corrected safety evaluation.

We regret any inconvenience caused by the errors. If you have any questions, please contact Mohan Thadani at 301-415-1476 or by e-mail at mohan.thadani@nrc.gov.

Sincerely,

Michael T. Markley

Michael T. Markley, Chief
Plant Licensing Branch IV
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Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure:
As stated

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

# SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

## RELIEF REQUEST NO. I3R-10

## THIRD 10-YEAR INSERVICE INSPECTION INTERVAL

## UNION ELECTRIC COMPANY

## CALLAWAY PLANT, UNIT 1

## DOCKET NO. 50- 483

## 1.0 INTRODUCTION

By letter dated August 30, 2007, as supplemented by letters dated April 17, July 10, July 24, September 15, and October 9, 2008 (Agencywide Document Access and Management System (ADAMS) Accession Nos. ML072550488, ML081190648, ML082470210, and ML082140282, ML082630806, and ML082900027, respectively), Union Electric Company (the licensee) requested U.S. Nuclear Regulatory Commission (NRC) approval of Relief Request (RR) I3R-10 for Callaway Plant, Unit 1 (Callaway). The request for relief is associated with American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, Class 3 safety-related buried piping applications pertaining to the essential service water (ESW) system of Callaway. The licensee requested NRC approval to allow the replacement of the existing carbon steel piping with high-density polyethylene (HDPE) material, as an alternative to ASME Code, Section XI requirements under paragraph 50.55a(a)(3)(i) of Title 10 of the *Code of Federal Regulations* (10 CFR). The RR I3R-10 proposed to replace the following ESW trains A and B carbon steel piping:

- 30-inch diameter supply lines from pump house to control building with 36-inch diameter HDPE piping;
- 30-inch diameter return lines from control building to cooling tower with 36-inch diameter HDPE piping; and
- 4-inch diameter strainer backwash lines with 4-inch diameter HDPE piping.

The alternative proposed in the RR I3R-10 is for the third 10-year inservice inspection (ISI) interval for Callaway, which is currently scheduled to end on December 18, 2014.

## 2.0 REGULATORY REQUIREMENTS

In accordance with 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components must meet the requirements set forth in ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plants Components," to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that all inservice

Enclosure

examinations 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 ASME Code, Section XI, incorporated by reference in 10 CFR 50.55a(b) on the date 12 months prior to the start of the 10-year interval. For Callaway, the Code of record for the third 10-year ISI interval is the 1998 Edition through 2000 Addenda of Section XI of the ASME Code.

Alternatives to requirements may be authorized or relief granted by the NRC pursuant to 10 CFR 50.55a(a)(3)(i), 10 CFR 50.55a(a)(3)(ii), or 10 CFR 50.55a(g)(6)(i). In proposing alternatives or requesting relief, the licensee must demonstrate that: the proposed alternatives provide an acceptable level or safety; compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety; or conformance is impractical for the facility. Pursuant to 10 CFR 50.55a(g)(4)(iv), ISI items may meet the requirements set forth in subsequent editions and addenda of the ASME Code that are incorporated by reference in 10 CFR 50.55a(b), subject to the limitations and modifications listed therein, and subject to Commission approval. Portions of editions and addenda may be used provided that related requirements of the respective editions and addenda are met.

## 3.0 TECHNICAL EVALUATION

### 3.1 Affected Components

ASME Code Class 3 buried ESW piping. The proposed alternative is 36-inch nominal outside diameter, Dimension Ration (DR) 9.5, and 4-inch nominal outside diameter, DR 9.0, HDPE piping.

### 3.2 Applicable Code Requirements

ASME Code, Section XI, IWA-4221(b) requires that "[a]n item to be used for repair/replacement activities shall meet the Construction Code specified in accordance with (1), (2), and (3)," and ASME Section XI, IWA-4221(b)(1) requires that "[w]hen replacing an existing item, the new item shall meet the Construction Code to which the original item was constructed."

The Construction Code of record for the ASME Code, Section XI, Class 3 ESW piping is ASME, Section III, Division 1, Subsection ND, 1974 Edition through Summer 1975 Addenda.

### 3.3 Proposed Alternative

The licensee requests to use Reference 7.1 titled, "Requirements for HDPE Piping for Nuclear Service," dated July 10, 2008, as supplemented in the licensee's responses to NRC's request for additional information, for material, design, fabrication, installation, examination, and testing of HDPE pipe for ASME Section III, Division 1, Class 3 buried piping.

### 3.4 Licensee Proposed Alternative and Basis for Use

The Callaway ESW system was originally designed with unlined carbon steel piping. Plant-specific and industry operating experience has shown that carbon steel piping is susceptible to fouling, corrosion, and microbiologically induced corrosion (MIC) for raw water applications.

The use of corrosion-resistant steel piping provides added resistance to such conditions, but does not eliminate susceptibility. Alternatively, the use of internal linings or coatings in carbon steel piping provides resistance to such conditions. However, degradation of and/or damage to the linings and coatings can cause exposure of the carbon steel piping to the raw water, resulting in piping degradation. Additionally, the linings and coatings can pose a potential foreign material concern, if they are released from the piping wall as a result of the degradation or damage.

HDPE piping will not rust, rot, corrode, tuberculate, or support biological growth. The use of HDPE piping in raw water applications will thus ensure long-term structural integrity and water flow reliability. Callaway has recently installed approximately 600 linear feet of 36-inch diameter buried HDPE piping in a non-safety-related blowdown application and has not experienced any significant problems. On a larger scale, Duke Power Company (DPC) has installed 20,000 linear feet of HDPE piping at Catawba Nuclear Station in non-safety-related raw water applications. Since the installations began in 1998, the DPC has reported that the material has had an excellent service history and has not experienced fouling or corrosion.

The Construction Code and later editions and addenda of this Construction Code do not provide rules for the material, design, fabrication, installation, examination, and testing of piping constructed with HDPE material. The licensee has requested to be allowed the replacement of buried carbon steel piping in the Callaway ESW system with HDPE piping. The replacement will be in accordance with the requirements for HDPE piping as outlined in Attachment 5 of Reference 7.1.

Engineering calculations and analytical evaluations were performed by the licensee utilizing the requirements and design rules described in Reference 7.1 of Callaway's RR I3R-10. Polyethylene piping is qualified for identical loading conditions (e.g. pressure, temperature, seismic) using similar design criteria as the original steel piping. Based on its evaluations for using polyethylene piping material in the proposed 36-inch supply line, 36-inch return line, and 4-inch strainer backwash lines of the ESW system, the licensee concluded that the use of polyethylene piping will result in improved system performance and enhanced system reliability, and the proposed alternative will provide an acceptable level of quality and safety. It was also mentioned by the licensee that the resistance of polyethylene pipe to corrosion and fouling and MIC ensures long-term reliability of the risk-significant ESW system.

Pursuant to 10 CFR 50.55a(a)(3)(i), in lieu of the requirement of Section XI, IWA-4221(b)(1) for replacement of the ESW system piping, this alternative to the original Construction Code provides an acceptable level of quality and safety for repair and replacement activities for ASME Class 3 buried piping.

## 4.0 STAFF EVALUATION

The staff evaluation was based on assessment of the following aspects:

- Qualification, testing, examination, and some aspects of quality control, and
- Structural integrity and design evaluation

## 4.1 Qualification, testing, examination, and some aspects of quality control

The ASME Code, Sections III and XI predominately address application for metal piping, vessels, and components. The metal piping commonly used to hold and transport raw or service water in nuclear power plants is susceptible to corrosion, fouling, rusting, and MIC attacks. To mitigate these degradation mechanisms, a few nuclear power plants have selectively installed HDPE piping in non-safety related applications. To date, the HDPE piping applications have been free of these degradation mechanisms. The industry's experience indicates that selected ASME Code Class 3 water carrying systems would be suitable for HDPE piping as an alternative to the current metal piping.

The licensee is relying on the process described in Reference 7.1, in-house destructive and nondestructive testing, data published by the Plastic Pipe Institute (PPI), "Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, TR-33/2001," PPI, "Handbook of Polyethylene Pipe," and Reference 7.1. The licensee is butt fusing HDPE pipe joints autogenously using performance-based qualified procedures, equipment, and personnel. A portion of the ESW system is buried with access locations available for future ISI, if needed. The fusing process reviewed by the NRC staff covered qualifications, testing, examinations, and some aspects of quality control.

Although parts of the submittal referenced ASME Code Case N-755, "Use of Polyethylene PE Plastic Pipe Section III, Division 1 and Section XI," the NRC staff has based its conclusions on the engineering information provided by the licensee. Code Case N-755 is addressed in section 4.2.1 of this safety evaluation.

### 4.1.1 Fusion Procedure and Equipment Qualification

The licensee is using type PE4710 (cell classification 445574C) polyethylene material that is traceable to the resin supplier and pipe manufacturer. The resin manufacturer performed burst testing of its PE4710 material in accordance with American Society for Testing and Materials (ASTM) D 1599. The licensee prepared performance demonstration test coupons under its 10 CFR 50, Appendix B program. The testing of the performance demonstration coupons was witnessed by licensee's QA/QC personnel and included impact tensile testing of material traceable to the resin manufacturer and pipe manufacturer. The burst testing ensures that the piping will fail before a properly fabricated fused joint fails. The impact-tensile test is a quick go or no-go test on the fused joint's resistance to fracture. The impact-tensile test results that exhibit a ductile fracture are considered acceptable and those that exhibit a brittle fracture are rejectable.

The fusion procedure contains the essential variables necessary to make an acceptable joint and the "how to" process of fabricating the joint. The fusion procedure is specific to material, fusion process, component, configuration (diameter range, wall-thickness range), equipment, and essential variables. Essential variables affecting joint integrity are identified in Sections QF-221 and QF-222 of the licensee's submittal (Reference 7.1) as: pipe material (PE4710); heater surface temperature range (maximum/minimum); butt fusion interfacial pressure range (maximum/minimum); heater bead-up size (maximum/minimum) which is indirectly tied to pipe diameter in Table QF-221(a)-1; heater removal time (fast/slow) which is indirectly tied to pipe wall thickness in Table QF-221(a)-2; and cool-down time under fusion pressure (minimum). The NRC staff believes that equipment model used for the fusion process also affects joint integrity and that large ambient temperature differences will also affect the fusion process. The NRC staff considers both equipment and ambient temperature as essential variables.

The 10 CFR Part 50, Appendix B, Criterion III specifies, in part, that qualification testing be performed on a prototype under the most adverse design conditions. Applying this criterion to the fusion procedure, the essential variable extremes must be demonstrated. Instead of demonstrating the effects from each essential variable extreme (high and low value of a range), the licensee grouped essential variable extremes by their thermal affect on the fusion process. The essential variable group that maximized HDPE plasticity was maximum heater plate temperature, maximum joining force, and minimum joining dwell (heater removal) time. The essential variable group that minimized HDPE plasticity was minimum heater plate temperature, minimum joining force, and maximum joining dwell time. For the licensee's application, the high- and low-ambient temperatures during the fusion process of pipe (50 degrees Fahrenheit (°F) to 75 °F) and fitting (65 °F to 75 °F) had negligible thermal effect on the fusion process. Therefore, ambient temperature was considered a constant, and not considered by the licensee in the essential variable groupings.

The heater bead-up size is the result of thermal expansion of the HDPE pipe, without an applied load, against the heater plate. As the material acquires heat from the heater plate, it expands. Both the pipe and heater plate are stationary, thus the material flows along the heater plate and beads up on the inside diameter (ID) and outside diameter (OD) surfaces. The bead width on the pipe surface is a combination of material flow and thermal expansion. Intuitively, heater bead-up size should be associated with wall thickness because greater material volume flows to the surface. The licensee is using two specific pipe diameters with similar DR numbers (DR 9.0 and DR 9.5) which require a larger bead for the thicker wall pipe, i.e., 4-inch diameter, 0.5-inch wall, with a minimum bead size of 0.125 inches and 36-inch diameter, 4-inch wall, with a minimum bead size of 0.56 inches. Although, the bead-up size essential variable is expressed as a minimum and maximum, the minimum value indicates sufficient heat has been conducted into the pipe. The maximum value is for practical reasons because the heater plate and pipe approach a thermal equilibrium and the bead may sag from gravity.

The licensee's qualification process for the fusion procedure consisted of demonstrating capability, reliability, and effectiveness. To show capability, the licensee used the essential variable group extremes to produce joints from 4-inch nominal, DR 9.0 and 36-inch nominal DR 9.5, type PE4710 pipe. To show reliability, the licensee made three joints for each essential variable group or each pipe size. To show effectiveness, the licensee subjected each joint to a minimum of four impact-tensile tests with each test taken approximately 90-degrees apart around the circumference. From the 36-inch nominal DR 9.5 pipe at each test location, the licensee will take several impact-tensile tests to examine the effects of the thicker wall on the joint integrity. In the event that the impact-tensile test data from the 36-inch pipe is inconclusive, the licensee will perform a full-section tensile test.

The licensee used three different pieces of equipment (identified by manufacturer and model number) for fusing 36-inch and 4-inch piping and their associated fittings. Each piece of equipment was performance demonstrated using equipment-specific essential variables.

Based on the above, the NRC staff concluded that the licensee's process for demonstrating the capability, reliability, and joint effectiveness to qualify the fabrication procedure is, therefore, acceptable.

### 4.1.2 Fusion Operator Qualification

Technical Report TR-33/2006, "Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe," by PPI references Title 49 of the *Code of Federal Regulations* (49 CFR) Part 192 for fusion operator qualifications. Pursuant to 49 CFR 192.285(b)(2), joints are required to be ultrasonically tested or sectioned longitudinally in three locations and visually examined for voids or discontinuities on the cut surface.

The licensee qualified the fusion operators using the same model equipment (McElroy Manufacturing and Ritmo America) and fusion procedure that will be used for making joints in the ESW piping. Bend coupons consisted of fusion joints on 6-inch diameter 3/4-inch wall pipe or 36-inch diameter 4-inch wall pipe, depending on the size being qualified. The qualification testing consisted of cutting two full-section bend-test specimens from each coupon, bending one such that the ID was in tension and the other such that the OD was in tension. The 6-inch diameter specimens were bent until the ends touched, and the 36-inch diameter specimens were bent over a mandrel to achieve a bend radius of 2 times the wall thickness at the joint. For such testing, the test is acceptable if no cracks are observed in the bend region. As part of test preparation, the specimens are visually examined for evidence of voids and discontinuities. The making of fused joints using representative material, pipe diameter, and wall thicknesses, and the examination and bend testing of the joints demonstrate the fusion operator's ability to following the fusion procedure and make acceptable joints. Based on the above, the NRC staff concluded that the demonstration used by the licensee to qualify fusion operators is, therefore, acceptable.

### 4.1.3 Visual Examination Personnel Qualification

The licensee will provide a minimum of 16 hours of additional training to certify qualified VT-1 (visual examination) personnel for reviewing recorded fusion joining data and performing bead-appearance examinations. The licensee will give VT-1 personnel hands-on practice in operating HDPE fabrication equipment and in making fused butt joints. The VT-1 personnel must successfully pass a licensee-administered performance demonstration consisting of a combination of acceptable and unacceptable fused joints. A minimum of five flawed samples will be used for the VT procedure demonstration, and a minimum of five flawed samples will be used for personnel demonstrations using the VT procedure. In addition, inside surface examples of visually acceptable and unacceptable joints will be available to provide supplemental visual comparison standards for VTs. Based on the above, the NRC staff concluded that personnel successfully demonstrating their skills on representative mockups of acceptable and rejectable fused joints assures their proficiency and is, therefore, acceptable.

### 4.1.4 Ultrasonic Testing Personnel Qualification

The licensee will use contractor personnel with demonstrated ultrasonic testing (UT) skills in detecting volumetric flaws in the fused joint area of HDPE pipe. The contractor personnel will be under the licensee's 10 CFR 50, Appendix B program. The licensee will verify the personnel skills and UT technique with representative mockups containing ten flaws of varying shapes, dimensions, and relative locations in the fused joints. The current acceptance criterion is that any unbonded area in the joint that is detected with UT is rejected. Based on the above, the

NRC staff concluded that the performance demonstration provides verification of personnel skills and procedure effectiveness in detecting volumetric flaws and is, therefore, acceptable.

### 4.1.5 Visual and Ultrasonic Testing Examinations

The visual examiner will perform a VT-1 examination on the OD of the fusion joint bead and verify that the recorded data in the data logger is within the fusion procedure pressure and fusion time ranges. The UT examiner will use the time of flight diffraction technique to verify an absence of volumetric flaws in the joint region (a portion of the pipe end and the fused joint). Joints not conducive to UT examinations will be examined visually on both the ID and OD surfaces by the VT-1 examiner. Based on the above, the NRC staff concluded that the examinations for verifying joint integrity should detect detrimental flaws, if any, in the joint region and are, therefore, acceptable.

### 4.1.6 Process Control Criteria

The licensee is relying on guidance published in TR-33/2006 to identify the key variables that affect joint integrity and to identify the essential variables for fabrication process control. The licensee will be recording the essential variables (fusion time and pressure) with a data logger during the fusion process and recording the measured heater-plate temperature immediately before insertion. The data being recorded is viewed by the fusion operator and VT-1 inspector. The recorded data from the data logger (pressure and fusion time) are reviewed for acceptance before the licensee buries the joint. If any variables deviate outside the acceptable ranges, the joint is cut out. In addition to the process control, the fused joint will be ultrasonically examined as described in section 4.1.5 of this safety evaluation. The licensee will maintain the data logger information and inspection results. Based on the above, the NRC staff concluded that proposed process control is, therefore, acceptable.

### 4.1.7 Pressure Testing

The licensee will perform a hydrostatic test at 150 percent of the system design pressure plus 10 psig. The licensee will provide the VT-2 personnel with 4 additional hours of training on HDPE fusion pipe joints. The hydrostatic test is effective in detecting existing though-wall flaws. However, because HDPE material flows over time, the hydrostatic test gives little, if any, information on embedded flaws which may grow over time. The HDPE portion of the ESW system will be tested and maintained, including Inservice System Leakage Tests and System Hydrostatic Tests, in accordance with ASME Code, Section XI. Based on the above, the NRC staff concluded that the proposed pressure testing is, therefore, acceptable.

### 4.1.8 Access for Future Testing

The use of HDPE pipe in ASME Code Class 3 piping systems is new to the U.S. nuclear power industry. To address unknown integrity issues that may appear after burying the piping, the licensee committed to provide access points in the ESW system for future examinations from the inside surface. Based on the above, the NRC staff concluded that the provision for the accessibility of the pipe inside surface examination is therefore, acceptable.

### 4.1.9 Fittings

For gas pipe lines, TR-33/2006 requires that fused joints satisfy 49 CFR 192.283 which states that the procedure must be qualified by subjecting specimen joints made according to the following two criteria: (1) the burst test requirements of a sustained pressure test, minimum hydrostatic burst test or sustained static pressure test, and (2) the lateral pipe connection tests which subject the pipe and 90-degree fitting to a force until failure or a tensile test. The licensee intends on performing testing similar to the 49 CFR Part 192 requirements. The fittings are made from type PE4710 material, the same as the piping. For criterion (1), the licensee will subject the HDPE pipe to a system pressure test at 150 percent of design pressure plus 10 psig. For criterion (2), the licensee will use fittings with thicker walls than the system pipe. Since the fusion process and equipment have been performance-demonstrated by impact-tensile testing as discussed in Section 4.1.1 of this safety evaluation, the pipe side of the fitting to pipe should fail before the fitting joints fail. Based on the above, the NRC staff concluded that the test program for the fittings is, therefore, acceptable.

### 4.2 Structural integrity and design evaluation

Union Electric Company is the first licensee to request utilizing PE4710 material HDPE piping in a safety-related ASME Code, Section III Class 3 application at its Callaway plant with temperatures higher than 140 °F (degrees Fahrenheit), pressures higher than 150 psig (pounds per square inch gauge), and diameters larger than 12.75 inches. As the ASME Code, Section III, Subsection ND, 1974 Edition through Summer 1975 Addenda, which is the Construction Code, as well as later editions and addenda, do not provide rules for the design, fabrication, installation, examination, and testing of piping constructed using polyethylene material, the NRC staff performed a review of the licensee's analyses. T he results of the NRC staff's evaluations are provided in the following sections of this safety evaluation.

### 4.2.1 ASME Code Case N-755

The licensee was requested by the NRC staff to supplement the RR I3R-10 to address specific aspects of ASME Code Case N-755 not endorsed by the NRC staff. NRC's review of the methodology utilized in the RR I3R-10 is specific for the Callaway application only. The industry is engaged in an extensive ongoing testing program to establish the full range of properties, fatigue data, stress-intensification factors, long-term creep rupture data, and slow crack-growth characteristics for the specific grade of PE material (PE4710) to be utilized in the requested Callaway application. The current test data that support a fatigue allowable of 1100 psi for PE4710 material is very limited. More investigations are needed to confirm the short-duration (30 days) stress allowables and applicable design factors. Furthermore, techniques to ensure the structural integrity of fusion joints are still evolving. Finally, there is currently no domestic performance or operating experience history regarding PE4710 piping's use in nuclear safety-related applications.

In the letter dated July 10, 2008, the licensee made a regulatory commitment to evaluate future investigations performed by the industry to confirm the short-duration (30-day) stress allowables and applicable design factors for PE4710 piping. The licensee also committed to evaluate future refinement of the fusion technique to confirm structural integrity of the installed fusion joints. The results will be submitted to the NRC staff prior to submittal of Callaway's fourth

10-year ISI interval, and will include, if necessary, a fourth 10-year ISI interval alternative request. The NRC staff reviewed the supplemental information and the regulatory commitment made by the licensee and finds them reasonable.

### 4.2.2. Acceptability of Flaws

In its letter dated July 10, 2008, the licensee responded to the NRC staff's question on acceptability of any flaws that may be present in HDPE piping. In that letter, the licensee provided the following information on how it will address the flaws in polyethylene piping within the scope of the RR I3R-10:

- For 4-inch diameter ESW backwash piping, any section with a flaw exceeding 10 percent of the wall thickness shall be cut out and replaced. For 36-inch diameter ESW supply and return piping, any section with a flaw exceeding 7 percent of the wall thickness shall be cut out and replaced. Any section of piping with a flaw not exceeding 5 percent of the wall thickness may be left as-is.

- All other flaws shall be removed by blending. The depression after flaw elimination is blended uniformly into the surrounding surface with a maximum taper not to exceed width to height ratio of 3 to 1. After flaw elimination, the area will be examined by VT to ensure that the flaw has been removed. If the elimination of the flaw reduces the thickness of the section below the minimum required design thickness, the section of piping containing the flaw shall be cut out and replaced.

Based on the above, t he NRC staff concluded that the approach provided by the licensee to address the damage to the polyethylene piping due to the presence of any flaws indicated is acceptable, as the minimum required design thickness will be maintained.

### 4.2.3 Design Factor

Design factors are used to enhance safety in engineering calculation of acceptable strength of materials. The preliminary stress calculations reviewed by the NRC staff are based on a design factor of 0.5. With regard to the design factor, the staff reiterated that the use of a design factor greater than 0.5 in HDPE piping stress evaluations is not acceptable. The licensee committed to use a design factor of 0.5 in the final calculations which the staff finds acceptable.

On September 19, 2008, the NRC staff conducted a phone call with the licensee. During that phone call, the NRC staff asked the licensee to provide its calculation for thermal gradient stress analysis. In its October 9, 2008, response (Reference 7.4), the licensee provided a calculation addressing the thermal gradient stresses. The NRC staff concluded that the results of the calculation are acceptable. In the October 9, 2008, response, the licensee's calculation was based on a design factor (DF) of 0.5, and another calculation was based on a DF of 0.56, which had a notation "for information only." The NRC staff does not accept the use of DF of 0.56. The NRC staff 's evaluation of the relief request is based only on results corresponding to a DF of 0.50.

### 4.2.4 Stress Evaluation

The NRC staff conducted an independent evaluation to verify the hoop stress in polyethylene pipe from internal pressure and equivalent external pressure based on thick pressure vessel formulas provided in References 7.1 and 7.2 (thin-pressure vessel formulas). Because the wall thickness of the polyethylene piping is much larger than carbon steel piping and the diameter to thickness ratio of the HDPE piping associated with the RR I3R-10 is much less than 20, the staff considers thick vessel formulas more appropriate for calculating the pressure stresses. The circumferential or hoop stress ($\sigma$) due to pressure calculated based on thin vessel formula ($P.D_{avg}/2.t$) used for minimum required wall thickness ($t_{min}$) calculation from internal pressure in section 3021.1, and circumferential compressive stress in the side walls due to external pressure in section 3032 of Reference 7.1, are not conservative compared to the more accurate thick vessel formulas listed below.

Circumferential or hoop stress due to internal pressure:

$P$ = Internal design pressure; $D_o$ = outside diameter; $t$ = wall thickness; $D_{avg}$ = average diameter
$a$ = outside radius; $b$=inside radius; $\sigma$ = Circumferential stress for thin vessel = $P.D_{avg}/(2.t)$
$\sigma$ = Circumferential stress for thick vessel from internal pressure = $P(a^2+b^2)/(a^2-b^2)$

| | P psig | $D_o$ inch | t inch | $D_{avg}$ inch | $D_{avg}/t$ | a inch | b inch | Thin σ psi | Thick σ psi | Allowable psi |
|---|---|---|---|---|---|---|---|---|---|---|
| ESW Supply | 165 | 36 | 3.85 | 32.15 | 8.35 | 18 | 14.15 | 689 | 699* | 695 |
| ESW Return | 45 | 36 | 3.85 | 32.15 | 8.35 | 18 | 14.15 | 188 | 191 | 340 |
| Backwash | 160 | 4.5 | 0.50 | 4.0 | 8 | 2.25 | 1.75 | 640 | 650 | 695 |

* The hoop stress of 699 pounds per square inch (psi) due to internal pressure based on thick vessel formula slightly exceeds the allowable stress of 695 psi for the supply line, which is based on a design factor (DF=0.5) or factor of safety of 2. This very slight excedance raises the design factor from 0.5 to 0.503 or lowers the factor of safety from 2.0 to 1.989. As this reduction in factor of safety is extremely small, the NRC staff finds it to be acceptable.

Circumferential compressive stress in side walls of pipe due to external pressure:

$\sigma$ = Circumferential stress for thick vessel from external pressure = $2P(a^2)/(a^2-b^2)$
$P$ = Equivalent external pressure

| | P psig | $D_o$ inch | t inch | $D_{avg}$ inch | $D_{avg}/t$ | a inch | b inch | Thin σ psi | Thick σ psi | Allowable psi |
|---|---|---|---|---|---|---|---|---|---|---|
| ESW Supply | 15.8 | 36 | 3.85 | 32.15 | 8.35 | 18 | 14.15 | 66 | 83 | 695 |
| ESW Return | 15.8 | 36 | 3.85 | 32.15 | 8.35 | 18 | 14.15 | 66 | 83 | 340 |
| Backwash | 8.25 | 4.5 | 0.50 | 4.0 | 8 | 2.25 | 1.75 | 33 | 42 | 695 |

The circumferential compressive stress in the side walls due to external pressure from thick vessel formula is higher than the one from the thin vessel formula, but it is still acceptable because the margin is sufficient.

In response to a question regarding the constant 1000 psi allowable stress used in checking the circumferential compressive stress in the side walls of HDPE pipe, the licensee agreed to use the temperature-dependent stress allowable in lieu of 1000 psi in the final stress calculation. In letter dated September 15, 2008 (Reference 7.3), the licensee stated that the final stress calculations include the temperature-dependent stress allowable. Based on the above, the NRC staff concludes this is acceptable.

The NRC staff noted that the stress evaluations and summaries included in the preliminary stress calculation were for straight pipe locations only and did not include critical miter bend locations with the applicable stress indices and stress intensification factors. The licensee agreed to include stress summaries for miter bend locations in the final stress calculations. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations summarize the stresses at critical miter bend locations. Based on the above, the NRC staff concludes this is acceptable.

The NRC staff questioned the validity of not considering the torsional moment in the HDPE piping stress evaluations. In its response, the licensee stated that the final stress calculations will consider all three moment components including the torsional moment. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations include all three moment components including torsion. Based on the above, the NRC staff concludes this is acceptable.

In a request for additional information, the NRC staff stated that the alternative thermal stress evaluation should be based on the maximum range of all thermal load cases rather than stress check based on individual load cases. In its response the licensee stated that in the final calculations, the alternative thermal stress will be based on maximum range of all thermal load cases. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations are based on the maximum range of all thermal load cases. Based on the above, the NRC staff concludes this is acceptable.

In the preliminary calculations reviewed by the NRC staff, the upward buoyant force in flotation analysis of the buried HDPE pipe was based on the ID of the pipe. The staff pointed that it should be based on the OD of the pipe. In its response, the licensee indicated that in the final calculations, the buoyant force will be calculated based on the OD of the buried pipe. In a follow-up submittal (Reference 7.3), the licensee stated that the final stress calculations utilize the OD of the pipe for the upward buoyant force computation. Based on the above, the NRC staff concludes this is acceptable.

## 5.0 REGULATORY COMMITMENT

In its letter dated July 10, 2008 (Reference 7.1, Enclosure 7), the licensee made the following regulatory commitment:

| COMMITMENT | Due Date/Event |
|---|---|
| AmerenUE will evaluate future investigations performed by the industry to confirm the short-duration (30-day) stress allowables and applicable design factors for PE4710 piping. AmerenUE will also evaluate future evolution of the fusion technique to validate structural integrity of the installed fusion joints. The results of the evaluations will be submitted to the NRC prior to submittal of Callaway's fourth 10-year interval ISI plan, and will include, if necessary, a fourth 10-year ISI interval alternative request. | Prior to submittal of Callaway's inservice inspection plan for the fourth 10-year interval. |

## 6.0 CONCLUSION

Based on the above evaluation, the NRC staff concludes that the use of HDPE pipe for the buried section of the ESW system, (ASME Code Class 3, 4-inch DR 9.0 and 36-inch DR 9.5 piping) as described in the RR I3R-10 will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the use of HDPE pipe for the buried section of the ESW system in lieu of the carbon steel piping for Callaway's third 10-year ISI interval which is scheduled to end on December 18, 2014.

All other requirements of the ASME Code, Section XI for which relief has not been specifically requested remain applicable, including third-party review by the Authorized Nuclear Inservice Inspector.

## 7.0 REFERENCES

7.1 Luke H. Graessle, AmerenEU, Letter to NRC, "10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated July 10, 2008 (ADAMS Accession No. ML082470210).

7.2 Luke H. Graessle, Ameren EU, Letter to NRC, "Follow-up Information Regarding 10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated April 17, 2008 (ADAMS Accession No. ML081190648).

7.3 L. H. Graessle, AmerenEU, Letter to NRC, "Additional Information Regarding 10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated September 15, 2008 (ADAMS Accession No. ML082630806).

7.4 Luke H. Graessle, AmerenEU, Letter to NRC, "Follow-up Information Regarding 10CFR50.55a Request: Proposed Alternative to ASME Section XI Requirements for Replacement of Class 3 Buried Piping (TAC No. MD6792)," dated October 9, 2008 (ADAMS Accession No. ML082900027).

Principal Contributors: D. Naujock
C. Basavaraju

Date: October 31, 2008

We regret any inconvenience caused by the errors. If you have any questions, please contact Mohan Thadani at 301-415-1476 or by e-mail at mohan.thadani@nrc.gov.

Sincerely,

/RA/

Michael T. Markley, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure:
As stated

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| DATE | 11/6/08 | 11/5/08 | 11/6/08 | 11/7/08 | 11/7/08 |

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We regret any inconvenience caused by the errors.

Sincerely,

Mohan C. Thadani, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure:
As stated

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