September 12, 2008

Mr. J. R. Morris
Site Vice President
Catawba Nuclear Station
Duke Energy Carolinas, LLC
4800 Concord Road
York, SC 29745

SUBJECT: CATAWBA NUCLEAR STATION, UNITS 1 AND 2, RELIEF 06-CN-003, USE OF POLYETHYLENE MATERIAL IN NUCLEAR SAFETY-RELATED PIPING APPLICATIONS (TAC NOS. MD3729 AND MD3730)

Dear Mr. Morris:

By letter dated October 26, 2006, as supplement by letters dated June 21, 2007, March 13, 2008, and May 29, 2008, Duke Energy Carolinas, LLC, the licensee, submitted a request for relief, RR-06-CN-003, from the American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code* (Code), Section XI, 1998 Edition through 2000 Addenda requirement pertaining to the use of high-density polyethylene (HDPE) pipe in lieu of the ASME Code requirement for Class 3 carbon steel piping, 12-inch nominal diameter supply and return buried piping to and from the diesel generator jacket water coolers for the third 10-year inservice inspection interval at Catawba Nuclear Station, Units 1 and 2 (Catawba 1 and 2). There are a total of 8 lines for which the licensee is seeking approval for the use of HDPE pipe. These lines are the 12-inch buried supply and return lines 1A, 1B, 2A and 2B. The Unit 1 third 10-year ISI interval is scheduled to end on June 29, 2015, and the Unit 2 third 10-year ISI interval is scheduled to end on August 19, 2016.

The enclosed safety evaluation contains the U.S. Nuclear Regulatory Commission (NRC) staff's evaluation and conclusions. The NRC staff has concluded that the licensee has provided sufficient information for the NRC staff to accept the use of HDPE pipe for the 1A and 2A supply lines to the diesel generator jacket water coolers. However, the NRC staff has identified that additional information is needed to complete its entire review of this relief request. The NRC staff is seeking information concerning supply lines 1B, 2B and return lines 1A, 1B, 2A, and 2B. By letter dated September 8, 2008, the NRC issued a request for this additional information. Based on the information provided in the licensee's request for relief, the NRC staff has determined that the use of HDPE pipe for ASME Code Class 3, 12-inch nominal diameter for the 1A and 2A supply lines buried piping to the diesel generator jacket water coolers will provide an acceptable level of quality and safety. Therefore, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.55a(a)(3)(i), the NRC staff authorizes the use of, joining of, inspection, testing, and quality assurance of HDPE pipe as an alternative to carbon steel pipe as required by the ASME Code, Section XI, IWA-4221(b) requirements, for the 1A and 2A supply lines Catawba 1 and 2 for the third 10-year ISI intervals. The evaluation of the remaining supply and return lines will be sent under separate cover when the licensee supplies the additional requested information.

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

Sincerely,

/RA/

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

Docket Nos. 50-413 and 50-414

Enclosure:
Safety Evaluation

cc w/encl: See next page

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

Sincerely,

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Enclosure:
Safety Evaluation

cc w/encl: See next page

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ADAMS Accession No: ML082240386 *SE input dated NRR-028

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF NO. 06-CN-003

CATAWBA NUCLEAR STATION, UNITS 1 AND 2

DUKE ENERGY CAROLINAS, LLC

DOCKET NOS. 50- 413 AND 50-414

1.0 INTRODUCTION

By letter dated October 26, 2006, to the U.S. Nuclear Regulator Commission (NRC) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML063120215), as supplemented by letters dated June 21, 2007 (ADAMS Accession No. ML071720400), March 13, 2008 (ADAMS Accession No. ML080790104), and May 29, 2008 (ADAMS Accession No. ML081550652), Duke Energy Carolinas, LLC, the licensee, proposed an alternative to certain requirements of the American Society of Mechanical Engineers (ASME), *Boiler and Pressure Vessel Code* (Code), Section XI, 1998 Edition through the 2000 Addenda requirement pertaining to the use of high-density polyethylene (HDPE) pipe in lieu of the ASME Code requirement, IWA-4221(b), carbon steel piping for the third 10-year inservice inspection (ISI) intervals at Catawba Nuclear Station, Units 1 and 2 (Catawba 1 and 2). There are a total of 8 lines for which the licensee is seeking approval for the use of HDPE pipe. Theses are the 12 inch buried supply and return lines 1A, 1B, 2A and 2B to the diesel generator jacket water coolers. The third 10-year interval for Catawba 1 started June 29, 2005, and ends June 29, 2015. The third 10-year interval for Catawba 2 started October 15, 2005, and ends August 19, 2016.

The NRC staff has identified that additional information is needed to complete its entire review of this relief request. The NRC staff is seeking information concerning supply lines 1B, 2B and return lines 1A, 1B, 2A, and 2B. By letter dated September 8, 2008 (ADAMS Accession No. ML082480700), the NRC issued a request for this additional information. The following safety evaluation is limited to the review and approval of the 1A and 2A supply lines to the diesel generator jacket water coolers.

2.0 BACKGROUND

Both corrosion and fouling problems have occurred in the nuclear service water (RN) system piping at Catawba 1 and 2. The RN system piping was originally designed using carbon steel material with no internal coating or lining. The licensee has stated that HDPE piping offers advantages in corrosion protection over a design where corrosion protection of the system is provided by a coating or liner. The licensee also indicated that the primary advantage in using HDPE pipe versus carbon steel pipe materials is its resistance to fouling, corrosion, and microbiologically induced corrosion (MIC). HDPE piping is also not susceptible to galvanic attack. The licensee further stated that portions of Catawba 1 and 2 RN piping replaced with corrosion resistant steel has experienced accelerated microbiological attack and developed

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pinhole leaks during service. In contrast, some 20,000 linear feet of the Catawba 1 and 2 non-safety-related service water system HDPE piping in sizes up to 32 inches, has been performing well with excellent service history since 1998. The licensee included additional supporting information about the successful performance of a limited amount of HDPE piping in the above ground safety-related ASME Code, Section III Class 3 service water piping at British Energy's Sizewell B plant. Sizewell B is the first plant in the world to install HDPE piping in nuclear safety-related seismically qualified systems. The licensee also stated that the resistance of the HDPE pipe to corrosion and fouling (tubercle formation and MIC) ensures long-term reliability from a structural integrity and flow standpoint.

3.0 REGULATORY EVALUATION

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 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 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 Catawba 1 and 2, the code of record for the third 10-year ISI intervals is the 1998 Edition through the 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 NRC approval. Portions of editions and addenda may be used provided that related requirements of the respective editions and addenda are met.

4.0 TECHNICAL EVALUATION

4.1 Affected Components

ASME Code Class 3, 12-inch nominal diameter supply and return buried piping to and from the diesel generator jacket water coolers.

4.2 Applicable Code Requirements

ASME Code, Section XI, IWA-4221(b) requires that an item to be used for repair/replacement activities shall meet the Construction Code specified and IWA-4221(b)(1) requires that when 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 buried ASME Code, Section XI, Class 3 piping is the ASME Code, Section III, Subsection ND, 1974 Edition through Summer 1974 Addenda.

4.3 Proposed Alternative

Pursuant to 10 CFR 50.55(a)(3)(i), in lieu of Section XI, IWA-4221(b)(1) the licensee requested approval to replace steel piping with HDPE piping. In the licensee's letters dated October 26, 2006, June 21, 2007, and March 13, 2008, the licensee provided the rules that will be used in lieu of the original Construction Code for the design, fabrication, installation, examination, and testing of the HDPE piping.

4.4 Licensee Basis for the Alternative

The Construction Code and later editions and addenda of the Construction Code do not provide rules for the design, fabrication, installation, examination, and testing of HDPE piping. The primary advantage with using HDPE piping versus other carbon steel piping is its resistance to fouling, corrosion, and MIC. The HDPE piping does not experience fouling or corrosion and is not susceptible to galvanic or microbiological attack. The HDPE piping's resistance to corrosion and fouling ensures long-term reliability from a structural integrity and liquid flow standpoint. The 20,000 linear feet of HDPE piping in service in the Catawba 1 and 2 nonsafety-related service water system in sizes up to 32 inches National Piping Standard (NPS) has demonstrated the acceptability of polyethylene material for service.

At Catawba 1 and 2, the low-pressure service water (RL) system supplies cooling water to the containment chilled water (YV) system chiller condensers. Prior to replacing the carbon steel piping with HDPE piping, monitoring of the RL flow control valve position and YV condenser pressures showed the valves to be fully open during the summer months and condenser pressures up to 150 pounds per square inch gage (psig) which is a few psig away from the system trip set point. After replacing the carbon steel with polyethylene piping and operating for two cycles, the control valves have been operating at less than 50 percent open and condenser pressures have been running around 125 psig during the summer months. This is a clear indication that the use of HDPE piping will result in improved system performance and enhanced system reliability. Since the installation of HDPE piping at Catawba 1 and 2 in nonsafety-related applications, there has not been a failure or leakage of the HDPE piping or joints.

5.0 NRC STAFF'S EVALUATION

The ASME Code, Section III, Subsection ND, 1974 Edition including Summer 1974 Addendum, which is the Construction Code for Catawba 1 and 2, 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 reviewed the licensee's supporting technical documentation for the use of HDPE piping at Catawba 1 and 2. The NRC staff evaluation is presented below.

5.1 Acceptance of HDPE Material PE 4710 for Class 3 Piping

The evaluations performed by the licensee were based on the properties of polyethylene (PE) 3408 material. The NRC staff requested additional information concerning clarification on whether the PE material is PE 3408 or PE4710 that would be used to replace existing carbon steel piping. The licensee stated that it intends to use HDPE PE 4710 material to replace the steel piping in ASME Code, Section III Class 3 nuclear safety related buried piping to and from the diesel generator jacket water coolers. The licensee submitted additional documentation from ISCO industries showing the comparison of the physical and mechanical properties of PE 3408 and PE 4710 materials concluding that the differences are not very significant, and PE 4710 has greater resistance to slow crack growth. The licensee stated that PE 4710 material properties meet or exceed PE 3408 material properties. The sample analyses presented by the licensee justifying the use of HDPE piping is based on PE 3408 properties. The licensee also stated that the sample analyses will be developed into a design calculation during project implementation, and the analyses will be revised to reference only PE 4710 material. Based on its review the NRC staff finds this acceptable.

5.2 HDPE Flaw Depth Allowance

During its review the NRC staff raised concerns on the issue of flaws of 10 percent wall thickness and premature leaks or failures in the HDPE piping of PE 4710 material due to slow crack growth. The NRC staff requested additional supporting test data. The licensee stated that there is insufficient test data to support the allowance of scratches with a depth of up to 10 percent of the wall thickness for extended service life for all pipe sizes and design temperatures. Testing is being planned by the industry but will not be completed in a time frame to support the Catawba 1 and 2 schedule for piping replacement. Based on the examination of the existing test data available to date, the licensee made modifications for the allowance on scratch depth as follows: (a) for piping less than or equal to 4 inches with a standard dimension ratio (SDR) greater than 11, scratch depth allowance of no more than 10 percent of the nominal wall thickness is permitted, (b) for piping less than or equal to 4 inches with an SDR less than 11, scratch depth allowance of the smaller of either 10 percent of the nominal wall thickness or 0.041 inches is permitted, (c) for piping greater than 4 inches, scratch depth allowance of the smaller of either 10 percent of the nominal wall thickness or 0.041 inches is permitted. The licensee further stated that any unacceptable scratches or damage to the HDPE piping will be cut out and replaced or scratches removed by blending smoothly. The NRC staff perform an independent analysis and finds the licensee scratch depth analysis and flaw depth limits acceptable.

The licensee provided information with regard to the unacceptability of the inclusions, and cold fusion in HDPE piping fused joints. The licensee has taken several measures to ensure a high confidence that flaws are not incorporated into the fused joints. The measures include fusion process controls, requirements on essential joining parameters (fusion temperature, pressure, and time of pressure application), personnel training and qualifications, procedure requirements to avoid contamination or moisture introduction into the joint, visual inspection of the bead profile, and hydrostatic testing. Based on the above the NRC staff finds the measures taken by the licensee to prevent unacceptable inclusions, and cold fusion in HDPE piping fused joints acceptable.

5.3 HDPE Piping Flange Joint Interface

In response to a request for additional information concerning the evaluation of the flanged joint interface between metallic piping and polyethylene piping, the licensee stated that as a part of the ongoing Electric Power Research Institute's (EPRI'S) test program, the HDPE flanges are tested until they leak. The results of these tests are summarized in the Interim EPRI Report 1014902, "Fatigue and Capacity Testing of High Density Polyethylene Pipe Material," the report shows that with adequate bolt preload, the flange's capacity is greater than that of the attached pipe. If stresses in the fusion butt joints connecting the flange adapter to the pipe meet the design procedure limits, then the moment loading transmitted to the flanged joint will be below that which is necessary to cause flange leakage. Based on this additional information provided by the licensee, the NRC staff finds that specific analysis and design requirements for the HDPE flange to steel flange connection is not required.

The licensee stated that the strain limits for the HDPE piping are based on standard manufacturers' HDPE pipe curvature. The allowable pipe bending radius of greater than 30 outside diameters (OD) is based on the licensee's experience with the installation HDPE piping, and the allowable ring deflection values listed in the Plastic Pipe Institute (PPI) Handbook for HDPE piping. The licensee also stated that the long-term and short-term Poisson's ratio values of 0.35 and 0.45, respectively, for HDPE material are reasonable values based on industry recommendations. In addition, the NRC staff raised concerns about offset or surface mismatch in a fused joint. The licensee performed a finite element analysis to justify a 10-percent offset or mismatch. The NRC staff reviewed the analysis and found that the element size was the same throughout the analysis. The NRC staff requested further justification of the 10-percent offset or mismatch. The licensee performed an additional finite element analysis with finer size elements. This analysis also indicated the acceptability of 10-percent mismatch or offset in the fused joints. The NRC staff reviewed the information and finds it acceptable.

5.4 Stress Intensification Factor Values for Fusion Butt Joints and Miter Bends

The NRC staff requested additional information concerning the stress intensification factor (SIF or i) values for fusion butt joints and miter bends versus SIF values used by the licensee in justifying the proposed alternative. The licensee used SIF values of 1 for the fusion butt weld joint stress and 2 for mitered elbow stress. SIF values of 1.0 for fusion butt joints and 2.0 for miter bends are recommended in the Code Case for the use of HDPE piping. At the time the licensee submitted the relief request, EPRI had not completed the testing of HDPE piping to determine the appropriated SIF valves. The NRC staff considered higher SIF values are reasonable for use until the test results were available for HDPE piping. The NRC staff performed an independent calculation of the stresses in buried HDPE piping using higher SIF values of 2.0 for a fusion butt joint and 3.0 for a miter bend. Based on the calculation, the NRC staff concludes that the re-computed stress for the fusion butt joints and miter bends results is still acceptable as shown in the table below. Stresses calculated by the NRC staff were higher than those calculated by the licensee, however, they are below the allowable stresses. EPRI has completed final SIF testing for HDPE piping. The test results are documented in EPRI Report 1015062, "Fatigue and Capacity Testing of High-Density PE Pipe and Pipe Components Fabricated from PE 4710." The Mark I approach to design was used to assign a SIF of 1 for straight pipe butt fused joints and SIFs for other fittings are then related based on test data. The SIF of 1 for a butt fused joint was qualified by testing and this data was used to construct fatigue curves in the report. The SIF of 2 for 5 segment mitered elbows was determined from fatigue testing of 12-inch mitered elbows with SIFs of 1.83 and 1.84. The data from this final EPRI report substantiates the SIFs that were used by the licensee to justify the proposed alternative. Based on the above the, NRC staff finds the SIF values used by the licensee adequate for HDPE piping with PE 4710 material.

In addition, the NRC staff requested additional information concerning the licensee's combining certain load cases by square root sum of squares (SRSS) rather than absolute sum for seismic results for buried pipe. The licensee stated in the response to the request for additional information that the above ground steel piping, and the buried piping can be considered as two separate spectral groups and can be combined by SRSS in accordance with the guidance in Regulatory Guide (RG) 1.92, "Combining Modal Responses And Spatial Components in Seismic Response Analysis," Appendix N of Section III. However the NRC staff considered that some conservatism is appropriate due to uncertainties in the behavior and interaction of the buried HDPE piping and above ground steel piping. The NRC staff performed an independent calculation of the seismic stresses using the absolute sum for the above ground and buried pipe interaction and the results are shown in the table below. The NRC staff finds the results acceptable.

	Fusion Butt Weld Stress		**Mitered Elbow Stress**		**Allowable Stress**
	i=1	**i=2**	**i=2**	**i=3**	
	Licensee's Stress Calculation	**NRC Staff's Stress Calculation**	**Licensee's Stress Calculation**	**NRC Staff's Stress Calculation**	
Diesel Generator Building 1A					
Thermal Expansion Load	51 psi	76 psi	148 psi	205 psi	1100 psi
Seismic Load	501 psi	967 psi*	88 psi	127 psi*	1100 psi
Diesel Generator Building 2A					
Thermal Expansion Load	64 psi	84 psi	138 psi	195 psi	1100 psi
Seismic Load	338 psi	644 psi*	503 psi	750 psi*	1100 psi

Notes: 1. For fusion butt weld stress, straight piping section stresses used.
2. * Seismic, stresses for governing load cases are combined by absolute sum and not SRSS.

5.5 HDPE Piping Elastic Modulus

The NRC staff requested additional information concerning clarification on whether an adjustment due to an elastic modulus change is needed for the 1100 pounds per square inch (psi) allowable alternating stress amplitude used for the buried HDPE piping for thermal expansion stresses and seismic stresses evaluated using equivalent thermal approach. The licensee provided clarification and rationale by stating that the fatigue tests reported in EPRI 1014902 were displacement (strain) controlled tests and the resulting stress capacities were based on the actual modulus of elasticity the specimen was experiencing while under load. Two sets of data were provided by the licensee. One set with the elastic modulus that existed during the initial load cycle, and the second with the lower bound modulus that is experienced after a prolonged period of cycling at 1 Hertz. The failures are based on the load and modulus that pipe experienced under load. The test results in the EPRI report bound the 1100 psi cyclic stress range with a margin of at least 2 for all temperatures reported. The licensee stated that since the effect of the elastic modulus is accounted for by using the accurate modulus in the structural analysis to determine the applied load, there is no need to reduce the capacities (1100 psi allowable alternating stress) determined from actual tests. Based on its review the NRC staff finds this rationale acceptable.

5.6 HDPE Piping Sidewall Stress

The NRC staff questioned the allowable stress used by the licensee in the calculation for the circumferential compressive stress in the sidewalls of the HDPE piping. In response, the licensee stated that for elevated temperature service, the allowable compressive stress in the sidewalls can be reduced in accordance with the PPI Handbook. Using the formula in the PPI Handbook, the required allowable stress of 1000 psi for HDPE piping can be reduced to 500 psi at 140°F. The licensee's computed sidewall compression stress for the HDPE piping at Catawba 1 and 2 is 112 psi which is less than the allowable stress of 500 psi at 140°F. The NRC staff finds the sidewall compression stress of the buried HDPE piping acceptable when using the reduced allowable stress.

5.7 Test Program for HDPE Piping for Application in ASTM Class 1, 2 and 3 Piping

The industry is engaged in an extensive ongoing testing program to establish the full range of properties for the specific grade of PE 4710 material to be utilized at Catawba 1 and 2**.** The licensee provided information outlining the tasks in the planned EPRI testing of HDPE piping with PE 4710 material. The testing will include: (1) slow crack growth associated with a code allowable of 10-percent scratch depth, and development of SIFs and fatigue failure (FF) data for commonly used fittings, (2) long-term creep rupture tests for PE 4710 including allowable stresses for temperatures greater than 120 °F and life greater than 20 years, (3) full range of stress - strain properties for PE 4710, (4) fatigue curves for PE 4710, (5) SIFs and FFs for 5-mitered bends using PE 4710 material. Based on its review, the NRC staff finds the proposed test program for the HDPE piping using PE 4710 material acceptable.

Techniques to ensure the structural integrity of the fusion joints are still evolving. There is no performance or operating history regarding the use of HDPE piping in nuclear safety-related applications only nonsafety applications. The licensee made the following regulatory commitments to address this issue:

> 1. Prior to submitting Catawba 1 and 2 fourth 10-year ISI interval, the licensee, will submit information obtained from the above referenced testing program to the NRC. If the information supports operation of the HDPE piping using PE 4710 material for the remainder of the plant life, this information will be submitted to the NRC for information only.
>
> 2. If the results from the testing program do not support the operation using HDPE piping with PE 4710 material for the remainder of the plant life, this information will be submitted to the NRC as a part of the subsequent request for alternative for the fourth 10-year ISI Interval.

5.8 Evaluation of Proposed Fabrication, Examination, and Testing

Division 1 of the ASME Code Section III and Section XI predominately address applications for metal piping and metal components. The metal piping commonly used in nuclear power plants to transport water are susceptible to corrosion, fouling, rusting, and microbiological attack. The licensee must continually maintain, repair, and replace the degraded metal. Also buried pipe creates potentially unseen hazards to the activities taking place above the pipe. To mitigate the degradation mechanisms affecting metal pipe, the nuclear power industry has selectively installed HDPE piping in nonsafety-related applications. To date, the nonsafety-related HDPE piping applications have been free of these degradation mechanisms. The industry's experience indicates that selected ASME Code Class 3 water carrying systems should be suitable for HDPE piping as an alternative to the current metal piping.

The licensee will autogenously fuse the HDPE pipe joints together. The methods being used to ensure joint integrity are fabrication operator qualification, visual testing personnel qualifications, procedure qualifications, destructive testing, process controls, visual examinations, and pressure testing.

The licensee has performed a 10 CFR Part 50, Appendix B audit of its HDPE pipe and pipe fitting supplier. The audit included visual examination of the joining process and a review of the destructive testing data performed by the supplier. The licensee will be performing independent receipt inspection and testing of the purchased HDPE piping. The application of 10 CFR Part 50, Appendix B on material suppliers is a license requirement.

5.9 Procedure Qualification

For procedure qualification, the licensee is relying on in-house destructive and nondestructive testing, and data published by the PPI, "Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe, Technical Report (TR)-33/2006." The licensee's selection of essential variables is for the 12-inch nominal diameter, SDR 11, HDPE pipe. TR-33/2006 lists as essential variables time, temperature, and pressure for fused joints. TR-33/2006 provides approximate heater bead melt size based on pipe diameter (12-inch nominal diameter). The licensee performed in-house testing to validate the ranges for selected variables and will record the values of the TR-33/2006 essential variables during the fusion process. The recorded variables will be reviewed for acceptance before burying the pipe segment. If any variables deviate outside the accepted ranges, the fused joint will be removed.

For gas pipe lines, TR-33/2006 requires that fused joints satisfy 49 CFR Part 192, Section 192.283 which states that the procedure must be qualified by subjecting specimen joints made according to: (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 49 CFR Part 192 requirements. For the first (1) criterion, the licensee will subject the HDPE pipe to a system pressure test at 150 percent above design pressure. For the second (2) criterion, the licensee is using fittings with thicker walls than the pipe and subjecting pipe joints to routine impact tensile tests. The pipe joints should fail before the fitting joints fail.

The licensee's proposed alternative is specifically for 12-inch diameter, SDR 11, type PE 4710 HDPE pipe with joints made using the butt fusion process; pipe fusibility is verified at the extremes of the temperature and pressure essential variable ranges. Besides the limited application, the procedure effectiveness will be constantly checked with in-process testing, thus assuring satisfactory joints. Based on its review, the NRC staff finds the licensee's procedure as applied acceptable.

5.10 Fusion Operator Qualification

TR-33/2006 references 49 CFR Part 192 for fusion operator qualifications. Section 192.285(b)(2) requires that joints be ultrasonically tested or sectioned longitudinally in three locations and visually examined for voids or discontinuities on the cut surface. The licensee is using an in-process approach for satisfying this criterion by performing daily and performing random in-house impact tensile testing of joints. This testing will be performed during the entire duration of the piping system construction. The impact tensile test specimens are taken from the longitudinal direction through the fused joint. During impact tensile test specimen preparation, obvious internal defects would be exposed and detectable. Impact tensile specimens with internal defects may also display an unusual failure appearance. The visual examination of in-process test specimen will detect internal void and discontinuities. Based on its review the NRC staff finds the qualifications for a fusion operator acceptable.

5.11 Volumetric Testing (VT)-1 HDPE Piping Qualifications

The licensee will provide a minimum of 16 hours of additional training to certify qualified VT-1 personnel for reviewing recorded fusion joining data and perform bead appearance examinations. The licensee will give VT-1 personnel hands-on-practice in operating HDPE fabrication equipment and making fused butt joints. The VT-1 personnel must successfully pass a licensee administered performance demonstration consisting of a combination of 10 or more acceptable and unacceptable fused joints. In addition, inside surface examples of visually acceptable and unacceptable joints will be available to provide supplemental visual comparison standards for visual examinations. Personnel successfully demonstrating their skills on representative mockups of acceptable and rejectable fused joints assures proficiency. The NRC staff finds the qualifications of the VT-1 testing personnel acceptable.

5.12 Hydrostatic Testing

The licensee will perform a hydrostatic test at 150 percent above the system design pressure to verify leak tightness. The piping will be examined for leakage using ASME Code, Section XI qualified VT-2 personnel. The licensee will provide the VT-2 personnel with 4 additional hours of training on HDPE fused pipe joints. The hydrostatic test is effective in detecting existing though-wall flaws. However, because HDPE material is viscoelastic and flows over time, the hydrostatic test gives little, if any, information on embedded flaws which may grow over time. The hydrostatic test is an effective method of validating system leak tightness at the time of testing. The NRC staff finds the hydrostatic testing that will be performed on the HDPE piping acceptable.

5.13 Volumetric Flaws

During the fusion process, the licensee will be examining the pipe ends for defects, such as foreign material, voids, and porosity. If any defects are detected, the licensee will initiate their problem investigation process. The visual examinations being performed on the bead joint should indicate gross internal joint unsoundness.

While typical volumetric flaws and internal cracks with wide opening dimensions are readily detectable with current nondestructive examination (NDE) methods, “cold fusion” flaws resulting from inadequacies in the joining process are elusive to detection. Cold fusion is unique to PE fused joints. Efforts are on-going to identify NDE methods that can reliability detect cold fusion. In time, improvements in volumetric examination methods may be capable of reliably detecting cold fusion flaws or operating flaws that might occur during plant operations.

Since volumetric examinations would provide increased confidence in piping system structural integrity, the licensee is providing access to the inside surface of the HDPE piping for future NDE examinations. Providing access to the piping system for future examinations, if needed, adds monitoring flexibility to the system. Based on its review the NRC staff finds this acceptable.

5.14 Process Control

In some instances, cold fusion can be detected from the bead appearance that is formed during the fusion process. TR-33/2006 states that the fusion beads should be approximately 2 to 2.5 times the bead height above the pipe and should be rounded and uniformly sized all around the pipe. The bead appearance is also affected by typical volumetric defects and by environmental influences. The bead appearance can provide useful information on a fused joint’s internal soundness. The licensee will visually examine both the inside diameter and outside diameter bead appearance for acceptability.

A fused joint with a good appearance is an indicator but does not guarantee sound joints. The licensee provided information on fused joints made from 12-inch diameter SDR 11 HDPE pipe. The licensee varied the fusion temperatures and pressures beyond the acceptable essential variable ranges of the procedure. The results indicated that very low temperatures with high or low pressures produced visually unacceptable joints, and misaligned pipe ends produced visually unacceptable joints. Looking at the cross sections, the joints appeared to be sound; however, visual examination alone is not sufficient to detect “cold fusion.” The absence of or an insufficient crystalline structure weakens the joint, thus making it more susceptible to failure than the pipe itself.

The licensee is using in-process destructive testing to verify fusion equipment operability and internal pipe/joint soundness. A least 10 percent of each field joint from each fusion machine will be tested during a production shift, and at least one blind random field joint will be selected for impact tensile testing within a 4 shift period. If any weakness is detected, the licensee will remove the joints produced since the last successful impact tensile test. The in-process testing during installation of the pipe system provides an effective means for assuring joint functionality.

Although efforts are still underway to improve HDPE pipe and examination of HDPE pipe, its application may greatly improve the reliability of specific piping systems. The licensee's use of fabrication process controls, subsequent VT-1 examinations, hydrostatic testing, and random impact tensile testing provides a means for detecting flaws that may have the potential for through-wall growth. The use of HDPE pipe has the potential of improving pipe system reliability in corrosive environments that are challenging to metal pipe. Although the ASME Code does not currently provide rules for HDPE pipe applications that are acceptable to the NRC staff, the supporting information submitted by the licensee in the relief request has demonstrated to the NRC staff reasonable assurance in maintaining structural integrity of the HDPE piping. For the licensee's specified application in the submittal, the use of HDPE piping as an alternative to the ASME Code-required metal piping will provide an acceptable level of quality and safety for the length of time supported by long-term testing.

6.0 CONCLUSION

The NRC staff reviewed the licensee's supporting technical information for the proposed alternative of HDPE buried pipe in nuclear safety-related piping applications. Based on the above evaluation, and the regulatory commitments made by the licensee as stated above, the NRC staff concludes that the use of HDPE pipe for ASME Code Class 3, 12-inch nominal diameter supply buried piping line 1A and 2A to and from the diesel generator jacket water coolers as described in the relief request, with supplements, will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the NRC staff authorizes the joining inspection, testing, and quality assurance aspects of the proposed alternative to ASME Code, Section XI, IWA-4221(b) requirements, for Catawba 1 and 2 for the third 10-year ISI intervals.

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

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Dated September 12, 2008