October 31, 2000

Mr. Charles M. Dugger
Vice President Operations
Entergy Operations, Inc.
17265 River Road
Killona, LA 70066-0751

SUBJECT: WATERFORD STEAM ELECTRIC STATION, UNIT 3 - RELIEF REQUEST RELATED TO PRESSURE-RETAINING BOLTED CONNECTIONS IN CLASS 1, 2, AND 3 BORATED SYSTEMS (TAC NO. MB0010)

Dear Mr. Dugger:

By letter dated September 15, 2000, Entergy Operations, Inc. (Entergy), submitted a relief request (PWR-ISI-001, Revision 0) for Waterford Steam Electric Station, Unit 3 (Waterford 3) from use of certain provisions of Section XI of the American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code (Code). Specifically, Entergy requested relief from the requirements of the 1992 Edition of the ASME Code, Section XI, Subarticle IWA-5242(a) for pressure-retaining bolted connections in Class 1, 2, and 3 borated systems.

The staff has completed its review of the relief request and proposed alternative and has determined that the proposed alternative provides an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(3)(i), Entergy's proposed alternative is authorized, for the bolting material listed in the relief request except SA-193 Grade B16, for the second 10-year inspection interval at Waterford 3. The basis for this conclusion is described in the enclosed staff's Safety Evaluation.

If you have questions regarding this response, please contact N. Kalyanam, at (301) 415-1480.

Sincerely,

/RA/

Robert A. Gramm, Chief, Section 1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Enclosure: Safety Evaluation

Docket No. 50-382

cc: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE SECOND 10-YEAR INSERVICE INSPECTION INTERVAL

REQUEST FOR RELIEF AND PROPOSED ALTERNATIVE (PWR-ISI-001, REVISION 0)

ENTERGY OPERATIONS INC.

WATERFORD STEAM ELECTRIC STATION, UNIT 3

DOCKET NO. 50-382

1.0 INTRODUCTION

By letter dated September 15, 2000, Entergy Operations Inc. (Entergy, the licensee), submitted a request for relief from and approval of an alternative to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section XI requirements for inservice inspection (ISI) at Waterford Steam Electric Station, Unit 3 (Waterford 3). The information provided by the licensee in support of the request for relief from Code requirements has been evaluated and the basis for disposition is documented below.

2.0 BACKGROUND

The ISI of the ASME Code Class 1, 2, and 3 components shall be performed in accordance with Section XI of the ASME Code and applicable addenda as required by 10 CFR 50.55a(g), except where specific written relief has been granted by the Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 50.55a(6)(g)(i). The regulations at 10 CFR 50.55a(a)(3) state that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, “Rules for Inservice Inspection of Nuclear Power Plant Components,” to the extent practical within the limitations of design, geometry, and materials of construction of the components. The regulations require that inservice examination of components 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 Section XI of the ASME Code incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. For the second 10-year interval at Waterford 3, which started in July 1997, the applicable edition of the ASME Code is the 1992 Edition with portions of the 1993 Addenda as specified in its ISI program.

3.0 LICENSEE'S EVALUATION

Components for Which Relief is Requested

Class 1, 2, and 3 pressure retaining bolted connections in systems borated for controlling reactivity when the bolting material is resistant to boric acid degradation.

Code Requirement from Which Relief is Requested (as stated)

> "ASME Section XI, Subarticle IWA-5242(a) states that for systems borated for the purpose of controlling reactivity, insulation shall be removed from pressure-retaining bolted connections for a direct VT-2 visual examination."

Requested Authorization (as stated)

> "Pursuant to 10 CFR 50.55a(a)(3)(i), Entergy proposes to implement ASME Code Case N-616 in lieu of removing insulation for VT-2 visual examinations of bolted connections in ASME Code Class 1, 2, and 3 systems borated for the purpose of reactivity control during system pressure tests, as required by IWA-5242(a)."

The applicable time period for which relief is requested is the second 10-year ISI interval.

Basis for Alternative (as stated)

> "The intent of the insulation removal requirement was to look for evidence of leakage due to the specific concern of boric acid corrosion of bolting materials. It is not required for non-borated systems since there is no borated water degradation mechanism present. Similarly, it should not be required for connections in borated systems having non-susceptible bolting materials (no boric acid degradation mechanism).
>
> Insulation removal was prescribed primarily because boric acid corrosion is a concern for low chromium steels (<10%). In instances where higher chromium steels are used, Entergy believes insulation removal is inappropriate since the degradation mechanism (boric acid corrosion) is not present or occurs at a greatly reduced rate. The bolting material typically used in the subject areas at Waterford 3 is shown in the table below.

Bolting Material

Material	Grade
SA-193	B8
	B8M
	B16
SA-194	6
	B8
	B8M
SA-453	660
SA-564	630

Entergy maintains [that] removing insulation to inspect for corrosion of bolting material that was specifically installed due to its corrosion-resistant properties is unwarranted. Such actions add unnecessary radiation exposure and waste resources needed to erect and remove scaffolds and remove and install insulation. Entergy believes these actions do not enhance the safety or quality of the plant."

Proposed Alternative Criteria (as stated)

> "Where insulation is not removed from bolted connections in systems borated for the purpose of controlling reactivity, Entergy proposes to use Code Case N-616, "Alternative Requirements for VT-2 Visual Examination of Classes 1, 2, and 3 Insulated Pressure Retaining Bolted Connections," as an alternative to IWA-5242(a). In addition to Code Case N-616, Entergy will continue to remove insulation, as discussed in Relief Request CEP-ISI-002[1], at connections that have the following material conditions:
>
> 1. 17-4 PH stainless steel or 410 stainless steel studs or bolts aged at a temperature below 1100 ^{o}F or with hardness above Rc [Rockwell Hardness C Scale] 30;
>
> 2. A-286 stainless steel studs or bolts with a preload above 100 ksi [kilo-pounds per square inch].
>
> Entergy will continue to follow ASME Section XI IWA-5213, which specifies test condition hold times after pressurization."

4.0 STAFF EVALUATION

The Code requires the removal of all insulation from pressure-retaining bolted connections in systems borated for the purpose of controlling reactivity when performing VT-2 visual examinations during system pressure tests. The Code requires this examination to be performed each refueling outage for Class 1 systems, and each inspection period for Class 2 and 3 systems.

Entergy submitted Relief Request CEP-ISI-002, Rev. 0, on April 24, 2000, as amended by letter dated August 24, 2000, for the second 10-year ISI interval for Waterford 3. Article IWA-5242(a) of the ASME Code, Section XI, 1992 Edition requires removal of insulation from pressure-retaining bolted connections in borated systems for VT-2 visual examination during system pressure tests. Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee proposed an alternative to IWA-5242(a). The alternative consists of the following:

1. System pressure tests will be performed in accordance with the hold time requirements specified in IWA-5213(a). The visual examination of the insulated components will be performed as required by IWA-5242(a), with the exception that the insulation need not be removed. If leakage is detected during testing, insulation will be removed for

[1]Entergy Letter CNRO-2000-00027, "Alternative to ASME Code Requirements," dated August 24, 2000.

examination, and the effects of the leakage will be evaluated in accordance with the previously NRC-approved Relief Request ISI2-08[2].

2. VT-2 visual examination with removal of insulation will be performed once during each refueling outage for ASME Class 1 systems, and once during each ISI period for Class 2 and 3 systems. The examination may be conducted at cold ambient temperature and non-pressurized conditions. Any evidence of leakage shall be evaluated per approved Relief Request ISI2-08.

The staff found that once the Code-specified hold time requirements during pressure tests were followed, significant leakage, if any, would penetrate the insulation and be detected. In addition, periodic removal of the insulation for VT-2 examination, even under cold and non-pressurized conditions, should allow for detection of even minor leakage in a timely manner via the presence of boric acid crystals or residue. Thus the two-phased approach of the licensee's proposed alternative provided an acceptable level of quality and safety for bolted connections in borated systems.

Based on the alternative described above, by letter dated October 13, 2000, NRC approved the use of Relief Request CEP-ISI-002, Revision 0, for Waterford 3[3].

The staff has developed a position over the years on the use of American Iron and Steel Institute (AISI) Type 17-4 PH stainless steel (SA-564 Grade 630), AISI Type 410 stainless steel (SA-193 Grade B6), and A-286 stainless steel (SA-453 Grade 660) fasteners. The Type 17-4 PH stainless steel and the AISI Type 410 stainless steel are suitable for use in contact with primary water if they are aged at a temperature of 1100 °F or higher. If they are aged at a lower temperature, they become susceptible to primary water stress corrosion cracking (PWSCC). The hardness of these alloys should be below Rc 30 if they are properly heat treated. A-286 stainless steel is susceptible to PWSCC, particularly if preloaded above 100 ksi. NUREG/CR-3604, "Bolting Applications," states that A-286 stainless steel is not suitable for use as a reactor structural material because much safer materials are available. However, there are a large number of A-286 stainless steel bolting currently in nuclear service, both in Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs). Bengtsson and Korhonen of ASEA-ATOM, Vasteras, Sweden, examined the behavior of A-286 stainless steel in a BWR environment as reported in the Proceedings of the International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, August 22-25, 1983, Myrtle Beach, South Carolina, sponsored by National Association of Corrosion Engineers, the Metallurgical Society of American Institute of Metallurgical Engineers, and the American Nuclear Society. They found the A-286 stainless steel in comparison to other tested

[2]NRC Letter "RELIEF AUTHORIZATION FOR ALTERNATIVE TO THE REQUIREMENTS OF ASME SECTION XI, SUBARTICLE IWA-5250 BOLTING EXAMINATION FOR ARKANSAS NUCLEAR ONE, UNITS 1 AND 2, GRAND GULF SATION, UNIT 1, RIVER BEND STATION, AND WATERFORD STEAM ELECTRIC STATION, UNIT 3 (TAC NOS. MA0825, MA0826, MA0806, MA0824, AND MA 0809), dated April 7, 1998.

[3]NRC Letter "RELIEF REQUEST RELATED TO THE REMOVAL OF INSULATION ON AMERICAN SOCIETY OF MECHANICAL ENGINEERS BOILER & PRESSURE VESSELS CODE CLASS 1, 2, AND 3 SYSTEMS DURING INSERVICE INSPECTION FOR ARKANSAS NUCLEAR ONE, UNIT 1, ARKANSAS NUCLEAR ONE, UNIT 2, AND WATERFORD STEAM ELECTRIC STATION, UNIT 3 (TAC NOS. MA8773, MA8788, AND MA8778), dated October 13, 2000.

materials, was the most susceptible material they tested to intergranular stress corrosion cracking in BWR water. They also found that A-286 stainless steel is less likely to crack as the applied stress is reduced. Piascik and Moore from Babcock & Wilcox reported a number of vessel internals bolt failures of A-286 stainless steel bolts in Nuclear Technology, Vol. 75, December 1986, in PWR water. They correlated the failures with bolt fillet peak stress and found that bolts preloaded below 100 ksi showed no failures.

The staff position is that any Type 17-4 PH stainless steel or AISI Type 410 stainless steel stud or bolt aged at a temperature below 1100 °F or with hardness above Rc 30 must have the thermal insulation removed for VT-2 examination during the system pressure test. For A-286 stainless steel studs or bolts, the preload must be verified to be below 100 ksi or the thermal insulation must be removed and the joint visually inspected. For nuts conforming to SA-194, experience indicates it would not be necessary to remove the thermal insulation for visual inspection.

Entergy will implement ASME Code Case N-616 for performance of VT-2 visual examination at all of the locations where corrosive resistant bolting is installed without removal of the insulation. The following restrictions will apply to those locations where this relief is used:

1. A four-hour hold time at system normal operating pressure will be utilized prior to examination.

2. This relief will not apply to :

    a. A-286 stainless steel (SA-453 Grade 660) bolting with a pre-load above 100 ksi.
    b. Bolts made from Grade 410 stainless steel (SA-193 Grade B6) tempered at a temperature below 1100 °F or with a hardness above Rc 30.
    c. Bolts made from SA-564 Grade 630 (Type 17-4 PH stainless steel) tempered at a temperature below 1100 °F or with a hardness above Rc 30.

If evidence of leakage is detected at locations where corrosive resistant bolting material is used, either by discovery of active leakage or evidence of boric acid crystals, the insulation will be removed and the bolted connection will be reexamined. If necessary, the bolted connection will be evaluated in accordance with the corrective measures of subarticle IWA-5250.

The bolting materials SA-193 Grade B8, SA-193 Grade B8M, SA-194 Grade 6, SA-194 Grade B8, SA-194 Grade B8M, SA-453 Grade 660, and SA-564 Grade 630, listed in the Bolting Material table contained in this Safety Evaluation, have a chromium content of greater than 10% and meet the requirements of Code Case N-616 for VT-2 examination without insulation removal.

The licensee also has included within the Bolting Material table, SA-193 Grade B16, as one of the bolting materials typically used in borated systems. The chromium content of SA-193 Grade B16 is in the range of 0.80% to 1.15%, which is below the requirements of Code Case N-616 of a chromium content of 10% or greater for bolting material. Therefore, the relief request will not apply for bolting of material SA-193 Grade B16.

In summary, Entergy's proposed alternative to IWA-5242(a), consists of the following:

1. System pressure tests will be performed in accordance with the hold time requirements specified in IWA-5213(a). The visual examination of the insulated components will be performed as required by IWA-5242(a), with the exception that the insulation need not be removed. If leakage is detected during testing, insulation will be removed for examination, and the effects of the leakage will be evaluated in accordance with the previously NRC-approved Relief Request ISI2-08.

2. VT-2 visual examination with removal of insulation will be performed once during each refueling outage for ASME Class 1 systems, and once during each ISI period for Class 2 and 3 systems. This applies to the bolted joints in borated systems with bolting of less than 10% chromium, or other bolting to which the relief does not apply, as outlined on page 5 of this Safety Evaluation (SE). The examination may be conducted at cold ambient temperature and non-pressurized conditions. Any evidence of leakage shall be evaluated per approved Relief Request ISI2-08.

The staff finds that once the Code-specified hold time requirements during pressure tests are followed, significant leakage, if any, will penetrate the insulation and be detected. In addition, for those bolted joints in borated systems with bolting of less than 10% chromium, or other bolting to which the relief does not apply, as outlined on page 5 of this SE, periodic removal of the insulation for VT-2 examination, even under cold and non-pressurized conditions, should allow for detection of even minor leakage in a timely manner via the presence of boric acid crystals or residue. Thus the two-phased approach of the licensee's proposed alternative provides an acceptable level of quality and safety for bolted connections in borated systems.

Code Case N-616 has eliminated the requirement to remove the insulation at any time if corrosion resistant bolting is used. In addition, the code case does not include the requirement to hold the system at operating pressure and temperature for a minimum of four hours. However, as discussed, the licensee will perform system pressure tests in accordance with the hold-time requirements (four hour hold time) specified in IWA-5213(a).

The staff finds this relief request acceptable for the bolted connections in systems borated for the purposes of reactivity control, with all bolting material listed in the Bolting Material table, with the exception of SA-193 Grade B16.

5.0 CONCLUSION

The staff concludes that the use of Code Case N-616 for Class 1, 2, and 3 systems, borated for the purposes of reactivity control, is acceptable because it provides an acceptable level of quality and safety for examination of insulated joints containing corrosion resistant bolting (chromium content equal to greater than 10%). Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), relief is granted for the second 10-year ISI interval at Waterford 3.

Principal Contributor: N. Kalyanam

Date: October 31, 2000

cc:

Administrator
Louisiana Department of Environmental Quality
P. O. Box 82215
Baton Rouge, LA 70884-2215

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

Director
Nuclear Safety Assurance
Entergy Operations, Inc.
17265 River Road
Killona, LA 70066-0751

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

General Manager Plant Operations
Waterford 3 SES
Entergy Operations, Inc.
17265 River Road
Killona, LA 70066-0751

Licensing Manager
Entergy Operations, Inc.
17265 River Road
Killona, LA 70066-0751

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

Resident Inspector/Waterford NPS
P. O. Box 822
Killona, LA 70066-0751

Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, TX 76011

Parish President Council
St. Charles Parish
P. O. Box 302
Hahnville, LA 70057

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

Chairman
Louisiana Public Services Commission
Baton Rouge, LA 70825-1697