September 20, 2001

Mr. Randall K. Edington
Vice President - Operations
Entergy Operations, Inc.
River Bend Station
P. O. Box 220
St. Francisville, LA 70775

SUBJECT: RIVER BEND STATION, UNIT 1 - EXEMPTION FROM THE REQUIREMENTS OF 10 CFR PART 50, SECTION 50.60 (TAC NO. MB1153)

Dear Mr. Edington:

The Nuclear Regulatory Commission (the Commission) has approved the enclosed exemption from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.60 for the River Bend Station, Unit 1 (RBS). This action is in response to your letter dated January 24, 2001, as supplemented by letters dated July 2, and August 6 and 20, 2001, that submitted new pressure-temperature (P-T or P/T) limits for RBS. The new P/T limits were developed using the methodology in American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code (the Code) Case N-640, "Alternative Requirement Fracture Toughness for Development of P-T Limit Curves for ASME B&PV Code Section XI, Division 1," in lieu of the methodology in 10 CFR Part 50, Appendix G.

Your letter of January 24, 2001, also included a request to amend your license to change the reactor vessel P/T limits specified in Technical Specification (TS) 3.4.11, "RCS [Reactor Coolant System] Pressure and Temperature (P/T) Limits," and the current RCS P/T limits in TS Figure 3.4-11, "Minimum Temperature Required Vs. RCS Pressure," would be replaced with recalculated RCS P/T limits, based, in part, on an alternative methodology. That request is being handled concurrently with your exemption request, but as a separate action.

A copy of the exemption and the supporting safety evaluation are enclosed. The exemption has been forwarded to the Office of the Federal Register for publication.

Sincerely,
***/RA by R. Gramm for/***

Robert E. Moody, Project Manager, Section 1
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-458
Enclosures: As stated
cc w/encls: See next page

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River Bend Station

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ENTERGY OPERATIONS, INC.

RIVER BEND STATION, UNIT 1

DOCKET NO. 50-458

EXEMPTION

## 1.0 BACKGROUND

Entergy Operations, Inc. (the licensee) is the holder of Facility Operating License No. NPF-47 which authorizes operation of the River Bend Station, Unit 1 (RBS). The license provides, among other things, that the facility is subject to all rules, regulations, and orders of the U.S. Nuclear Regulatory Commission (NRC or the Commission) now or hereafter in effect.

The facility consists of a boiling water reactor located in West Felciana Parish in Louisiana.

## 2.0 REQUEST/ACTION

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Appendix G requires that pressure-temperature (P-T or P/T) limits be established for reactor pressure vessels (RPVs) during normal operating and hydrostatic or leak rate testing conditions. Specifically, 10 CFR Part 50, Appendix G, Section IV.2.a states that "...[t]he appropriate requirements on both the pressure-temperature limits and the minimum permissible temperature must be met for all conditions." Pursuant to 10 CFR Part 50, Appendix G, Section IV.2.b, the requirements for these limits are the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Section XI, Appendix G Limits.

To address provisions of amendments to Technical Specification (TS) 3.4.11, "RCS [Reactor Coolant System] Pressure and Temperature (P/T) Limits," and the RCS P/T limits in TS Figure 3.4-11, "Minimum Temperature Required Vs. RCS Pressure," in the submittal dated January 24, 2001, as supplemented by letters dated July 2, and August 6 and 20, 2001, the licensee requested that the staff exempt RBS from application of specific requirements of 10 CFR Part 50, Section 50.60(a) and Appendix G, and substitute use of ASME Code Case N-640. Code Case N-640 permits the use of an alternate reference fracture toughness ($K_{Ic}$ fracture toughness curve instead of $K_{Ia}$ fracture toughness curve) for reactor vessel materials in determining the P-T limits. Since the $K_{Ic}$ fracture toughness curve shown in ASME Code Section XI, Appendix A, Figure A-2200-1 provides greater allowable fracture toughness than the corresponding $K_{Ia}$ fracture toughness curve of ASME Code Section XI, Appendix G, Figure G-2210-1, using the $K_{Ic}$ fracture toughness, as permitted by Code Case N-640, in establishing the P-T limits would be less conservative than the methodology currently endorsed by 10 CFR Part 50, Appendix G. Considering this, an exemption to apply the Code Case would be required by 10 CFR 50.60.

The licensee has proposed to revise the P-T limits for RBS using the $K_{Ic}$ fracture toughness curve, in lieu of the $K_{Ia}$ fracture toughness curve, as the lower bound for fracture toughness.

Use of the $K_{Ic}$ curve in determining the lower bound fracture toughness in the development of P-T operating limits curve is more technically correct than the $K_{Ia}$ curve since the rate of loading during a heatup or cooldown is slow and is more representative of a static condition than a dynamic condition. The $K_{Ic}$ curve appropriately implements the use of static initiation fracture toughness behavior to evaluate the controlled heatup and cooldown process of a reactor vessel. The staff has required use of the initial conservatism of the $K_{Ia}$ curve since 1974 when the curve was codified. This initial conservatism was necessary due to the limited knowledge of RPV materials. Since 1974, additional knowledge has been gained about RPV materials, which demonstrates that the lower bound on fracture toughness provided by the $K_{Ia}$ curve is well beyond the margin of safety required to protect the public health and safety from potential RPV failure.

In summary, the ASME Code Section XI, Appendix G, procedure was conservatively developed based on the level of knowledge existing in 1974 concerning RPV materials and the estimated effects of operation. Since 1974, the level of knowledge about these topics has been greatly expanded. The NRC staff concludes that this increased knowledge permits relaxation of the ASME Code Section XI, Appendix G requirements by applying the $K_{Ic}$ fracture toughness, as permitted by Code Case N-640, while maintaining, pursuant to 10 CFR 50.12(a)(2)(ii), the underlying purpose of the ASME Code and the NRC regulations to ensure an acceptable margin of safety.

## 3.0 DISCUSSION

Pursuant to 10 CFR 50.12, the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of 10 CFR Part 50, when (1) the exemptions are authorized by law, will not present an undue risk to public health or safety, and are consistent with the common defense and security; and (2) when special circumstances are present. The staff accepts the licensee's determination that an exemption would be required to approve the use of Code Case N-640.

The staff examined the licensee's rationale to support the exemption request and concluded that the use of the Code Case would meet the underlying purpose of 10 CFR Part 50. Based upon a consideration of the conservatism that is explicitly incorporated into the methodologies of 10 CFR Part 50, Appendix G; Appendix G of the Code; and Regulatory Guide 1.99, Revision 2, the staff concluded that application of Code Case N-640 as described would provide an adequate margin of safety against brittle failure of the RPV. This is also consistent with the determination that the staff has reached for other licensees under similar conditions based on the same considerations.

The safety evaluation may be examined, and/or copied for a fee, at the NRC's Public Document Room, located at One White Flint North, 11555 Rockville Pike (first floor), Rockville, Maryland. Publicly available records will be accessible electronically from the ADAMS Public Library component on the NRC website, http://www.nrc.gov (the Electronic Reading Room).

Therefore, the staff concludes that requesting exemption under the special circumstances of 10 CFR 50.12(a)(2)(ii) is appropriate and that the methodology of Code Case N-640 may be used to revise the P-T limits for RBS, subject to the limitation of 16 EFPYs.

## 4.0 CONCLUSION

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12(a), the exemption is authorized by law, will not endanger life or property or common defense and security, and is, otherwise, in the public interest. Also, special circumstances are present. Therefore, the Commission hereby grants Entergy Operations, Inc., an exemption from the requirements of 10 CFR Part 50, Section 50.60(a) and 10 CFR Part 50, Appendix G, for River Bend Station, Unit 1.

Pursuant to 10 CFR 51.32, the Commission has determined that the granting of this exemption will not have a significant effect on the quality of the human environment (66 FR 48069, published on September 17, 2001).

This exemption is effective upon issuance.

Dated at Rockville, Maryland, this 20th day of September, 2001.

FOR THE NUCLEAR REGULATORY COMMISSION

***/RA/***

John A. Zwolinski, Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST TO AMEND THE PRESSURE TEMPERATURE LIMITS

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-458

## 1.0 INTRODUCTION

By application dated January 24, 2001, as supplemented by letters dated July 2, and August 6 and 20, 2001, Entergy Operations, Inc., (the licensee), submitted a request to amend their license for River Bend Station, Unit 1 (RBS), to change the reactor vessel pressure/temperature (P-T or P/T) limits specified in Technical Specification (TS) 3.4.11, "RCS [Reactor Coolant System] Pressure and Temperature (P/T) Limits," and replace the RCS P/T limits in TS Figure 3.4-11, "Minimum Temperature Required Vs. RCS Pressure," with recalculated RCS P/T limits, based, in part, on an alternative methodology. The submittal also contained a request for an exemption from applying specific requirements of 10 CFR 50.60(a) and Appendix G of 10 CFR Part 50, and to substitute use of the 1995 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (Code), Code Case N-640, which permits the use of the plane strain fracture toughness ($K_{IC}$) curve instead of the crack arrest fracture toughness ($K_{Ia}$) curve for reactor pressure vessel (RPV) materials, in determining the P-T limits.

The Nuclear Regulatory Commission (NRC) has established requirements in 10 CFR Part 50 to protect the integrity of the reactor coolant pressure boundary in nuclear power plants. The NRC staff evaluates the P-T limit curves based on the following NRC regulations and guidance: 10 CFR Part 50, Appendix G; Generc Letter (GL) 88-11; GL 92-01, Revision 1 (Rev. 1); GL 92-01, Rev. 1, Supplement 1; Regulatory Guide (RG) 1.99, Revision 2 (Rev. 2); and Standard Review Plan (SRP) Section 5.3.2. GL 88-11 advised licensees that the NRC staff would use RG 1.99, Rev. 2, to review P-T limit curves. RG 1.99, Rev. 2, contains methodologies for determining the increase in transition temperature and the decrease in upper-shelf energy resulting from neutron radiation. GL 92-01, Rev. 1, requested that licensees submit their RPV data for their plants to the NRC staff for review. GL 92-01, Rev. 1, Supplement 1, requested that licensees provide and assess data from other licensees that could affect their RPV integrity evaluations. These data are used by the staff as the basis for the staff's review of P-T limit curves and as the basis for the staff's review of pressurized thermal shock assessments (10 CFR 50.61 assessments). Appendix G to 10 CFR Part 50 requires that P-T limit curves for the RPV be at least as conservative as those obtained by applying the methodology of Appendix G to Section XI of the ASME Code.

SRP Section 5.3.2 provides an acceptable method of determining the P-T limit curves for ferritic materials in the beltline of the RPV based on the linear elastic fracture mechanics methodology of Appendix G to Section XI of the ASME Code. The basic parameter of this methodology is the stress intensity factor $K_I$, which is a function of the stress state and flaw configuration. Appendix G to Section XI also requires a safety factor of 2.0 on stress intensities resulting from reactor pressure during normal and transient operating conditions, and a safety factor of 1.5 for hydrostatic testing curves. The methods of Appendix G of Section XI postulate the existence of a sharp surface flaw in the RPV that is normal to the direction of the maximum stress. This flaw is postulated to have a depth that is equal to 1/4 thickness (1/4T) of the RPV beltline thickness and a length equal to 1.5 times the RPV beltline thickness. The critical locations in the RPV beltline region for calculating heatup and cooldown P-T curves are the 1/4T and 3/4 thickness (3/4T) locations, which correspond to the maximum depth of the postulated inside surface and outside surface defects, respectively.

The Appendix G ASME Code methodology requires that licensees determine the adjusted reference temperature (ART or adjusted $RT_{NDT}$). ART is defined as the sum of the initial (unirradiated) reference temperature (initial $RT_{NDT}$), the mean value of the adjustment in reference temperature caused by irradiation ($\Delta RT_{NDT}$), and a margin term.

The $\Delta RT_{NDT}$ is a product of a chemistry factor and a fluence factor. The chemistry factor is dependent upon the amount of copper and nickel in the material and may be determined from tables in RG 1.99, Rev. 2, or from surveillance data. The fluence factor is dependent upon the neutron fluence at the maximum postulated flaw depth. The margin term is dependent upon whether the initial $RT_{NDT}$ is a plant-specific or a generic value and whether the chemistry factor was determined using the tables in RG 1.99, Rev. 2, or surveillance data. The margin term is used to account for uncertainties in the values of the initial $RT_{NDT}$, the copper and nickel contents, the fluence and the calculational procedures. RG 1.99, Rev. 2, describes the methodology to be used in calculating the margin term.

## 2.0 EVALUATION

### 2.1 Licensee Evaluation

The licensee submitted material data and detailed methodologies for generating P-T limits for 32 effective full power years (EFPY) for the beltline, upper vessel, and bottom head material for RBS. The material information includes the initial $RT_{NDT}$ values for all materials in the three geometric classifications mentioned above. For the beltline material, the licensee determined that the most limiting material for P-T curves is the axial weld that was manufactured with the weld wire of heat 5P6756 and Linde 124 flux. The licensee employed the methodology in RG 1.99, Rev. 2 and calculated an ART of 102 °F at the 1/4T fluence of 0.57E19 n/cm$^2$ (32 EFPYs) for this limiting material based on a $\Delta RT_{NDT}$ value of 96 °F, an initial $RT_{NDT}$ of -50 °F, and a margin term of 56 °F ($\sigma_I$ = 0 °F and $\sigma_\Delta$ = 28 °F). The $\Delta RT_{NDT}$ value for this material was determined using the chemistry table of RG 1.99, Rev. 2. The licensee did not perform similar calculations for the limiting upper vessel and bottom head material because these non-beltline materials only experienced insignificant fluence.

Based on the ART of 102 °F for the limiting beltline material and the highest initial $RT_{NDT}$ value of 10 °F for both the upper vessel and the bottom head materials, the licensee used the methodology of Appendix G in the 1995 Edition of Section XI of the ASME Code, as modified by Code Case N-640, to calculate the P-T limits for RBS. For the bottom head P-T limits, the licensee's Appendix G analyses used the results from a detailed stress analysis for a generic 251-inch boiling water reactor (BWR)/6 vessel. For the upper vessel P-T limits, the licensee's WRC-175 analyses used the Appendix G stress formula for the pressure test curves and results from the detailed stress analysis for a generic 251-inch BWR/6 vessel for the heatup and cooldown curves. The results for the generic vessel were then adjusted for the initial $RT_{NDT}$ values and the vessel geometry of RBS.

2.2 NRC Staff Evaluation

The licensee's proposed methodology for determining the P-T limits includes an assessment of the RPV beltline, upper vessel, and bottom head materials. The licensee's proposed methodology includes Code Case N-640 and two plant-specific deviations. The plant-specific deviations are discussed in the evaluations for beltline materials and the bottom head that follow.

For beltline materials, the NRC staff compared the licensee's material information in Table 4.4 of the submittal with that in the NRC's reactor vessel integrity database (RVID) and found that, except for the initial $RT_{NDT}$ values for plates C-3054-2 and C-3138-2 and the chemistry data for weld 5P6756 (the limiting material), the material data for the reactor vessel is consistent with those in the RVID. The NRC staff determined that the Charpy test data in Table 4-1 of the submittal had provided sufficient justification for the revision of the initial $RT_{NDT}$ values for plates C-3054-2 and C-3138-2 from 2°F and 9°F to 10°F and 0°F, respectively. Also, the copper and nickel values of 0.084% and 0.938% from the Certified Materials Test Report (CMTR) are acceptable because the licensee uses a more conservative chemistry factor than that based on the best-estimate copper and nickel values from BWRVIP-46, "Update of Bounding Assessment of BWR/2-6 Reactor Pressure Vessel Integrity Issues." The NRC staff performed an independent calculation of the ART value for the limiting beltline material using the methodology in RG 1.99, Revision 2, and verified the licensee's identification of the limiting material and its ART value for 32 EFPYs for RBS. In addition to Code Case N-640, the licensee's P-T limit methodology contains a plant-specific deviation from the Appendix G methodology, which applies to all P-T limits. In this deviation, the licensee employed an approximate approach to generate the heatup P-T limits. Instead of performing an analysis at 3/4T, the licensee performed a thermal gradient analysis at 1/4T using the ART at 1/4T and treating compressive stresses at this location as tensile stresses. The NRC staff examined $K_{It}$ values at 1/4T and 3/4T due to a typical heatup thermal gradient and confirmed that the absolute value of $K_{It}$ at 1/4T is always larger than the $K_{It}$ at 3/4T during a heatup period of 5 hours. Considering this and the fact that the licensee also uses the much higher fluence at 1/4T in calculating the ART at 3/4T, the NRC staff determined that the licensee's approximate approach for beltline heatup curves is more conservative than the corresponding part of Appendix G and therefore the resulting beltline P-T limits satisfy regulatory requirements.

For the upper vessel, the licensee used the highest initial $RT_{NDT}$ value for the upper vessel materials and the NRC approved WRC-175 methodology for analyzing upper vessel nozzles using stresses from the detailed stress analysis for a generic 251-inch BWR/6 vessel to supplement the Appendix G methodology. The NRC staff finds this approach for the upper vessel P-T limits is rigorous and acceptable.

For the bottom head, the licensee's P-T limit methodology is not as rigorous as those for the upper vessel and beltline P-T limits. The bottom head P-T limits for pressure testing were derived specifically for pressure and did not include the thermal stresses associated with the 20°F/hr heatup/cooldown. Further, the bottom head P-T limits for heatup and cooldown were derived indirectly from the bottom head P-T limits for pressure testing and may not be conservative for heatup and cooldown conditions. This is the second deviation from the Appendix G methodology. The NRC staff has evaluated the information in the original submittal and the response to NRC staff's request for additional information and determined that the information is not sufficient for the NRC staff to accept the methodology outright. However, the NRC staff approves the proposed P-T limits in the RBS TS since the proposed limits are based on the beltline P-T limits which are more limiting than the upper vessel and bottom head P-T limits by a margin large enough to bound the uncertainties associated with the licensee's methodology for calculating the bottom head P-T limits. Since the beltline P-T limits conform to Appendix G requirements, the P-T limits in the RBS TS meets Appendix G requirements.

Appendix G of 10 CFR Part 50 also imposes a minimum temperature at the closure head flange based on the reference temperature for the flange material. Section IV.A.2 of Appendix G states that when the pressure exceeds 20% of the preservice system hydrostatic test pressure, the temperature of the closure flange regions highly stressed by the bolt preload must exceed the reference temperature of the material in those regions by at least 120 °F for normal operation and by 90 °F for hydrostatic pressure tests and leak tests. When the pressure is less than or equal to 20% of the preservice system hydrostatic test pressure, the temperature of the closure flange regions highly stressed by the bolt preload must exceed the highest reference temperature of the material in the closure flange region. Based on the flange $RT_{NDT}$ of -10 °F, the staff has determined that the straight-line segments for the beltline P-T curves, 80 °F (-10 °F+90 °F) line for pressure test and 110 °F (-10 °F+120 °F) line for heatup and cooldown, have satisfied the requirement for the closure flange region during normal operation and inservice leak and hydrostatic testing. The straight-line segment of 68 °F for the P-T limits is not required by Appendix G. However, it is a more conservative limit that is based on a water temperature of 68 °F that is assumed in the licensee's calculation of the shutdown margin for when the head is off while fuel is in the vessel.

The fluence calculation in the submittal was based on an early evaluation which did not satisfy the recommendations of RG 1.190. In the supplemental letter dated July 2, 2001, the licensee agreed with staff comments regarding the acceptability of the vessel fluence and proposed to reevaluate the fluence with a staff approved code. The licensee requested staff approval for the proposed pressure temperature curves, subject to the limitation for up to 16 EFPYs.

The staff finds that the proposed fluence value (and the resulting pressure temperature curves) to be conservative because: (1) By the end of the requested period of applicability the vessel will have accumulated about 16 EFPYs while the P-T curve calculation assumed the estimated 32 EFPY fluence. This results in a factor of conservatism of about or greater than two. (2) The increased neutron leakage due to the 5% power uprate has been accounted for in GE-NE-A22-00081-12, Rev. 0, “105% Power Uprate Evaluation Report for Entergy Operations, Inc. River Bend Station” by General Electric-Nuclear Energy, San Jose CA, February 1999. Depending on the assumptions in this calculation, the factor of two conservatism may stay the same or may decrease by a small amount. In either case, the conservatism is adequate for a staff finding of reasonable assurance of safety. Therefore, the staff finds the proposed P-T curves to be acceptable, subject to the limitation of 16 EFPYs.

Also, the fluence methodology for BWR vessels is currently under a generic review by the NRC staff, and the fluence values reported in the licensee's submittal will not be considered final until the review is completed.

## 3.0 CONCLUSIONS

Except for the fluence aspects, the NRC staff concludes that the licensee's proposed P-T limits for heatup, cooldown, hydrotest, and criticality, which are derived using a methodology based on Appendix G of the Code, as modified by Code Case N-640 and two plant-specific deviations, satisfies the underlying purpose of Appendix G of 10 CFR 50. The proposed P-T limit curves also satisfy GL 88-11, because the method in RG 1.99, Revision 2 was used by the licensee to calculate the ART. However, since the fluence methodology for BWR vessels is currently under generic review by the NRC, the proposed P-T limit curves are acceptable, subject to the limitation of 16 EFPYs.

Principal Contributors: S. Sheng
L. Lois

Date: September 20, 2001