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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 224 TO FACILITY OPERATING LICENSE NO. DPR-49

IES UTILITIES INC.

CENTRAL IOWA POWER COOPERATIVE

CORN BELT POWER COOPERATIVE

DUANE ARNOLD ENERGY CENTER

DOCKET NO. 50-331

1.0 INTRODUCTION

By letter dated October 17, 1997, IES Utilities Inc. (the licensee) submitted the "Duane Arnold Reactor Pressure Vessel (RPV) Surveillance Materials Testing and Analysis." By letter dated April 15, 1998, the licensee submitted a request to amend the pressure-temperature (P-T) limit curves in the technical specifications (TS) for Duane Arnold based on the October 17, 1997, report. The amendment was intended to extend the validity of the Duane Arnold P-T limit curves to 32 effective full power years (EFPY). The current P-T limit curves are valid for a service period of 16 EFPY. In addition, the licensee included P-T limit curves valid for up to 18, 20, 24, and 28 EFPY.

The staff evaluates the P-T limits based on the following NRC regulations and guidance: 10 CFR Part 50, Appendix G; Generic Letter (GL) 88-11; GL 92-01, Revision 1; GL 92-01, Revision 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 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 (USE) resulting from neutron radiation. GL 92-01, Rev. 1, requested that licensees submit their reactor pressure vessel (RPV) data for their plants to the 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 (PTS) 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 American Society of Mechanical Engineers Boiler and Pressure Vessel (ASME) Code.

SRP 5.3.2 provides an acceptable method of calculating the P-T limits for ferritic materials in the beltline of the RPV based on the linear elastic fracture mechanics (LEFM) 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 requires a safety factor of 2.0 on stress intensities resulting from reactor pressure during normal and transient operating conditions; for hydrostatic testing curves, Appendix G requires a safety factor of 1.5.

The methods of Appendix G 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 one-fourth 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 limit curves are the 1/4 thickness (1/4T) and 3/4 thickness (3/4T) locations, which correspond to the depth of the maximum postulated flaw, if initiated and grown from the inside and outside surfaces of the RPV, respectively.

The Appendix G, ASME Code methodology requires that licensees determine the adjusted reference temperature (ART or RT_{NDT}). The 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 (ΔRT_{NDT}), and a margin (M) term.

The ΔRT_{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 initial RT_{NDT}, copper and nickel contents, fluence and calculational procedures. RG 1.99, Rev. 2 describes the methodology to be used in calculating the margin term.

2.0 EVALUATION

As stated above, the licensee submitted ART calculations and P-T limit curves valid for up to 18, 20, 24, 28, and 32 EFPY. The staff independently verified the accuracy of the licensee's ART calculations. In addition, the staff independently generated P-T curves for normal operations and hydrostatic test pressures effective to 32 EFPY. The details of this evaluation are provided below.

For the Duane Arnold reactor vessel, the licensee determined that the most limiting material at the 1/4T and 3/4T locations is the shell #2 ring plate (1-21). This plate was fabricated using plate heat B0673-1. The licensee calculated an ART of 106°F at the 1/4T location and 92°F at the 3/4T location at 32 EFPY. The neutron fluence used in the ART calculation was 1.9×10^{18} n/cm^2 at the 1/4T location and 1.1×10^{18} n/cm^2 at the 3/4T location. The initial RT_{NDT} for the limiting plate was 10°F. The margin term used in calculating the ART for the limiting plate was

34 at the 1/4T and 3/4 T locations, as permitted by Position 1.1 of RG 1.99, Revision 2. The licensee's limiting ART for the vessel flange, head flange, and upper shell plate and weld material is 14°F.

The ART is determined using the chemistry values for each beltline material of Duane Arnold. The Reactor Vessel Integrity Database (RVID) contains chemistry values for each beltline material for all light water reactors in the U.S. The licensee provided updated chemistry data for the beltline materials of Duane Arnold in the submittal of October 17, 1997. It should be noted that the staff used the updated chemistry values in the review for Duane Arnold.

The staff performed an independent calculation of the ART values for the limiting material using the methodology in RG 1.99, Revision 2. Based on these calculations, the staff verified that the licensee's limiting material for the Duane Arnold reactor vessel is the shell #2 ring plate (1-21) that was fabricated using plate heat B0673-1. The staff's calculated ART values for the limiting material agreed with the licensee's calculated ART values at 32 EFPY. Substituting the ART values for the Duane Arnold limiting plate into the equations in SRP 5.3.2, the staff verified that the proposed P-T limits satisfy the requirements in Paragraph IV.A.2 of Appendix G of 10 CFR Part 50. The staff independently generated P-T curves for normal operations and hydrostatic test pressures effective to 32 EFPY. In comparing the staff's generated curves to the licensee's generated curves, the staff determined that the P-T curves for Duane Arnold meet the requirements of Appendix G of Section XI of the ASME Code. It should be noted that the P-T limit curves valid for up to 18, 20, 24, and 28 EFPY were generated by the licensee using the same methodology as the 32 EFPY P-T limit curves; therefore, the staff also determined that these curves meet the requirements of Appendix G of Section XI of the ASME Code.

In addition to beltline materials, 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. Based on the RT_{NDT} of 14°F for the limiting flange and upper shell materials, the staff has determined that the proposed P-T limits satisfy the requirement for the closure flange region during normal operation and hydrostatic pressure test and leak test.

3.0 SUMMARY

The staff concludes that the proposed P-T limits for the reactor coolant system for heatup, cooldown, leak test, and criticality satisfy the requirements in Appendix G to Section XI of the ASME Code and Appendix G of 10 CFR Part 50 for 32 EFPY. The proposed P-T limits also satisfy Generic Letter 88-11 because the method in RG 1.99, Rev. 2 was used to calculate the ART. Hence, the proposed P-T limits may be incorporated into the Duane Arnold technical specifications.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Iowa State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATIONS

This amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 or changes a surveillance requirement. The staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluent that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration and there has been no public comment on such finding (63 FR 25110). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The staff has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: M. Khanna

Date: October 1, 1998

7.0 REFERENCES

1. Regulatory Guide 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Revision 2, May 1988.

2. NUREG-0800, Standard Review Plan, Section 5.3.2: "Pressure-Temperature Limits."

3. Code of Federal Regulations, Title 10, Part 50, Appendix G, "Fracture Toughness Requirements."

4. Generic Letter 88-11, "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and its Impact on Plant Operations," July 12, 1988.

5. ASME Boiler and Pressure Vessel Code, Section XI, Appendix G for Nuclear Power Plant Components, Division 1, "Protection Against Non-ductile Failure."

6. October 17, 1997, letter from Kenneth E. Peveler (IES Utilities, Inc.) to U.S. NRC Document Control Desk, Subject: "Reactor Pressure Vessel Surveillance Materials Testing and Analysis."

7. April 15, 1998, letter from John F. Franz (IES Utilities, Inc.) to U.S. NRC Document Control Desk, Subject: "Application for Amend to License DPR-49, Revising TS re: 'Reactor Vessel Pressure-Temp Curve Update'."