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Nuclear Operations

February 21, 1991
NRC-90-0187

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

References:
1) Fermi 2
NRC Docket No. 50-341
NRC License No. NPF-43

2) "Effects of Residual Elements on Predicted Radiation Damage to Reactor Vessel Materials," USNRC Regulatory Guide 1.99, Revision 1, April 1977

3) "Radiation Embrittlement of Reactor Vessel Materials," USNRC Regulatory Guide 1.99, Revision 2, May 1988

4) "PVRC Recommendations on Toughness Requirements for Ferritic Materials," Welding Research Council Bulletin 175, August 1972

5) NRC Generic Letter No. 88-11, "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and Its Impact On Plant Operations, dated July 12, 1988.

6) Detroit Edison letter, NRC-88-0286, dated November 28, 1988

7) NRC Letter, (TAC No. 71493), dated March 29, 1989

Subject: Proposed Technical Specification Change (License Amendment) - Pressure-Temperature Limits

Pursuant to 10CFR50.90, Detroit Edison Company hereby proposes to amend Operating License NPF-43 for the Fermi 2 plant by incorporating the enclosed changes into the Plant Technical Specifications. The proposed change provides pressure-temperature (P-T) limits for the reactor coolant system and the reactor pressure vessel which conform to Regulatory Guide 1.99, Revision 2, as required by NRC Generic Letter 88-11 (Reference 5). This submittal fulfills Detroit Edison's commitment made in Reference 6 and documented as acceptable by the NRC in Reference 7 to propose revised P-T curves to Fermi 2 Technical Specifications and UFSAR sections using Regulatory Guide 1.99, Revision 2 methodology before the second refueling outage.

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Detroit Edison has evaluated the proposed Technical Specifications against the criteria of 10CFR50.92 and determined that no significant hazards consideration is involved. The Fermi 2 Onsite Review Organization has approved and the Nuclear Safety Review Group has reviewed the proposed Technical Specifications and concurs with the enclosed determinations. In accordance with 10CFR50.91, Detroit Edison has provided a copy of this letter to the State of Michigan.

If you have any questions, please contact Mr. Glen D. Ohlemacher at (313) 586-4275.

Sincerely,

Enclosure

cc: A. B. Davis
R. W. DeFayette
W. G. Rogers
J. F. Stang
Supervisor, Electric Operators, Michigan
Public Service Commission - J. R. Padgett

I, WILLIAM S. ORSER, do hereby affirm that the foregoing statements are based on facts and circumstances which are true and accurate to the best of my knowledge and belief.

William S. Orser

WILLIAM S. ORSER
Senior Vice President

On this 21st day of February, 1991, before me personally appeared William S. Orser, being first duly sworn and says that he executed the foregoing as his free act and deed.

Rosalie A. Armetta

Notary Public

ROSALIE A. ARMETTA
Notary Public, Monroe County, MI
My Commission Expires Jan. 11, 1992

INTRODUCTION

On July 12, 1988, the Nuclear Regulatory Commission issued Generic Letter GL 88-11 entitled, "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and Its Impact on Plant Operations." This Generic Letter implemented the requirements of Revision 2 of Regulatory Guide 1.99, "Radiation Embrittlement of Reactor Vessel Materials", dated May 1988 (Reference 3). These documents required Detroit Edison to evaluate the effect of the revised methodology of the Regulatory Guide on the plant pressure-temperature (P-T) limits for operation.

Since Fermi 2 was operating in its first fuel cycle, a two step process has been used. The first step was a response made to satisfy the NRC 180-day requirement to evaluate the Regulatory Guide, conduct a technical analysis of the new methodology, and to submit the Fermi 2 schedule for full implementation. This was completed on November 28, 1988 via letter NRC-88-0286 (Reference 6). The Fermi 2 response was accepted by the NRC in Reference 7. The second step is the submittal of this proposed Technical Specification (TS) change to implement the revised methodology. The TS change also incorporates recent analysis of the flux-wire dosimetry capsule.

In addition, the necessary Updated Final Safety Analysis Report (UFSAR) changes for the implementation of GL 88-11 are attached as Appendix E. These changes will be included in an annual UFSAR update following NRC approval of the proposed TS changes which implement the revised methodology.

EVALUATION

The pressure-temperature (P-T) curves in the Technical Specifications (TS) are established to the requirements of 10CFR50, Appendix G, to assure that brittle fracture of the reactor vessel is prevented. Part of the analysis involved in developing the P-T curves is to account for irradiation embrittlement effects in the core region, or beltline. In the past, Regulatory Guide 1.99, Revision 1 (Reference 2) has been used to predict the shift in nil-ductility reference temperature (RT_{NDT}) as a function of neutron fluence in the beltline region. Regulatory Guide 1.99, Revision 1 (Rev 1) was developed assuming that copper (Cu) and phosphorus (P) were the key chemical elements influencing embrittlement.

Regulatory Guide 1.99, Revision 2 (Rev 2) (Reference 3) was issued in May 1988. Rev 2 represents the results of statistical evaluation of commercial reactor surveillance test data accumulated through about 1984. The basic elements of the regulatory guide, a chemistry factor and a fluence factor, remained the same from Rev 1 to Rev 2. However, each factor is significantly different. The chemistry factor (CF) has been changed from an equation based on Cu and P in Rev 1 to tables of CF values based on Cu and nickel (Ni), with separate tables for plates and for welds. The fluence factor has been modified in Rev 2 to a somewhat more complex form. The overall effect of the changes from Rev 1 to Rev 2 has generally been to increase RT_{NDT} shift predictions for relatively low fluences (below 10^{19} n/cm^2) and to decrease RT_{NDT} shift predictions for higher fluences.

During Fermi 2's first refueling in the fall of 1989, the Reactor Pressure Vessel (RPV) dosimetry capsule containing "flux wires" was removed. The capsule was subsequently tested by General Electric to determine the fast neutron flux density and fluence specifically for the Fermi 2 RPV. Based on capsules removed from other similar size BWR vessels, the actual flux/fluence values were expected to be lower than the generic design values. The capsule analysis confirms this expectation and these lower values, projected for the life of the plant (32 EFPY), have been included in this evaluation. This has resulted in P-T curves that reflect the actual bounding conditions for safe operation of Fermi 2.

The following discussion provides a further review of the justification and basis for the proposed changes. After fully analyzing each of the materials and revising the P-T curves, it was determined that the vessel discontinuity limit curves of Appendix G of 10CFR 50 are more limiting than the curves developed from Regulatory Guide 1.99 Revision 2. The Appendix G curves will control until two further capsules are removed and tested for impact and tensile properties as outlined in the schedule of Technical Specification Table 4.4.6.1.3-1. As required by Specification 4.4.6.1.3, these examinations will be used to update the P-T curves.

REV 2 IMPACT EVALUATION

The beltline region in the Fermi 2 vessel consists of three lower shell plates, four lower-intermediate shell plates and the connecting longitudinal welds and girth weld. Appendix A shows the details of the impact evaluation. The process followed for analyzing each beltline material is described below.

Chemistry

The chemistry data for the beltline shell plate materials shown in Appendix A were taken from the General Electric (GE) design record file which supports Section 5.2 of the UFSAR. The information on the beltline weld materials was retrieved from GE Quality Assurance (QA) records and from some PWR material sources such as pressurized thermal shock (PTS) reports and a data base assembled by EPRI.

The beltline welds were fabricated by submerged arc welding with four heats of filler wire: a tandem arc of 13253 and 12008 in the lower shell longitudinal seams, 33A277 in the lower-intermediate shell longitudinal seams, and 10137 in the girth seam. Chemistry data for heats 33A277 and 10137 were available in GE QA records, but nickel (Ni) contents were not reported. No chemistry data was available for the tandem arc weld.

The weld heats above were Mil B4 type weld wire with a specified maximum Ni content of 0.50%. However, a modification was available to increase the nickel content to higher levels, in which case the wire was referred to as Mil B4 Modified. Heat 10137 was a Mil B4 Modified wire type, so it is necessary to assume the default Ni content of 1.0% for that heat. Heat 33A277 was not modified, so the Ni content is assumed to be the maximum allowable of 0.50%.

A search of PWR materials data and some calculations based on that data were completed with the objective of estimating a copper (Cu) and nickel (Ni) level for the tandem arc welds using filler metal heat numbers 13253 and 12008. The approach taken was to determine the estimated levels of Cu and Ni in each weld heat, and then combine them in a 50%-50% combination. Appendix B provides details of the calculations of these values. The resulting Cu and Ni values were used to establish the Rev 2 CF in Appendix A.

Initial RT_{NDT}

The values of initial RT_{NDT} shown in Appendix A were taken from the design record files supporting the materials information and the pressure-temperature (P-T) curves in the UFSAR. These values were based on 30 ft-lb impact energy verification testing, with longitudinal Charpy specimens used for plate, done at the time of vessel fabrication. A GE procedure was used to establish conservative values (compared to values that would be established with current test requirements) of RT_{NDT} from the fabrication test data for the P-T curves in the UFSAR.

For beltline materials, the methods of calculating adjusted RT_{NDT} in Rev 2 include a margin term to be added to the calculated value ΔRT_{NDT}. The margin term includes a component for uncertainty in initial RT_{NDT}, σ_I. Rev 2 discusses determination of σ_I for two categories of initial RT_{NDT}, measured values and generic mean values. For generic mean values, σ_I is simply the standard deviation calculated for the data set used to compute the mean. For measured values, requirements for determination of σ_I are somewhat vague. Rev 2 states, "If a measured value of initial RT_{NDT} for the material in question is available, σ_I is to be estimated from the precision of the test method."[a] GE's position for RT_{NDT} values derived from measured data, as is the case for the Fermi 2 beltline materials, is that σ_I is zero.

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[a] In the Rev 2 draft which was circulated <u>after</u> editing to incorporate public comments, the text stated, "σ_I, the standard deviation for the initial RT_{NDT}, may be taken as zero if a measured value of initial RT_{NDT} for the material in question is available."

The Charpy curves fit to surveillance data, which ultimately provided the ΔRT_{NDT} data for development of Rev 2, were best-estimate fits. An idealized example is provided as curve #1 in Figure 1. However, the ASME Code approach to determining RT_{NDT} is based on the lowest value of three specimens exceeding the required limits of impact energy and lateral expansion. A visualization of a Charpy curve drawn on the basis of the Code RT_{NDT} approach is shown as curve #2 in Figure 1. In comparing curves #1 and #2, it is clear that curve #2, which is based on the lowest value rather than the mean value, provides a conservative estimate of initial RT_{NDT}. Therefore, the ASME Code method of determining RT_{NDT} from measured data is conservative. Since the GE procedure was developed to be conservative relative to the ASME Code method, and the GE procedure also works with the lowest Charpy value rather than the average, $\sigma_I = 0^{\circ}F$ is appropriate.

Fluence

The 32 EFPY fluence used for the Rev 1 shift calculations in Appendix A is the value used in developing the current P-T curves, 1.1×10^{18} n/cm^2 at the 1/4 T. The best-estimate 32 EFPY inside surface fluence calculated from the flux-wire capsule dosimetry test results is described in Appendix C. This fluence was used in the Rev 2 shift calculations, as described below.

The Rev 2 method of calculating shift requires that the fluence at the vessel inside surface, f_{surf}, be calculated and then attenuated to the depth x according to the relationship:

$$f_x = f_{surf}(e^{-0.24x})$$

Surveillance Test Correction Factor

Rev 1 allows for consideration of credible surveillance data when it becomes available. Rev 2 requires that two sets of credible data be developed before considering their use. However; no surveillance testing has been performed yet, so surveillance test correction factors do not apply for either Rev 1 or Rev 2 calculations, and are set to 1.0 in Appendix A.

Shift and Adjusted Reference Temperature (ART)

The RT_{NDT} shift calculations in Appendix A are based on the procedures in Rev 1 and Rev 2. For Rev 1, the equation for SHIFT is:

$$SHIFT = (STF)*[40 + 1000(\%Cu - .08) + 5000(\%P - .008)]*(f)^{0.5}$$

where STF = surveillance test correction factor
f = fluence for the given EFPY / 10^{19}

For Rev 2, the SHIFT equation consists of two terms:

$$\text{SHIFT} = \Delta RT_{NDT} + \text{Margin}$$

$$\text{where } \Delta RT_{NDT} = [CF] * f^{(0.28 - 0.10 \log f)}$$

$$\text{Margin} = 2(\sigma_I^2 + \sigma_\Delta^2)^{.5}$$

Chemistry factors (CF) are tabulated for welds and plates in Tables 1 and 2, respectively, of Rev 2. The margin term σ_Δ has set values in Rev 2 of 17°F for plate and 28°F for weld. However, σ_Δ need not be greater than $0.5 * \Delta RT_{NDT}$.

The values of ART in Appendix A are computed by adding the SHIFT terms to the values of initial RT_{NDT}. Predicted ART values versus EFPY is plotted for the most limiting beltline conditions in Figure 2. As seen, the beltline plate with the highest initial RT_{NDT} and Cu content is limiting through about 10 EFPY. For operation beyond that time, the tandem arc beltline weld is limiting.

Results of Impact Evaluation

The impact of implementing Rev 2 simultaneously with use of the flux wire results is determined by comparing the ART values based on Rev 1 and Rev 2 from Appendix A. Table 1 shows the ART values at 32 EFPY for each beltline material. The following conclusions are drawn from the results in the table:

1. The Rev 2 ART values at 32 EFPY are below 200°F, which is the allowable limit in 10CFR50, Appendix G. Therefore, implementation of Rev 2 will not result in any additional requirements for analysis, testing or provisions for thermal annealing.

2. The tendency of Rev 2 to increase ART values is countered by the decreased fluence prediction resulting from the flux wire test results. Overall, the ART for the limiting weld material decreases slightly. The P-T curves currently in the Tech Spec are based on Rev 1 shift predictions for an earlier design predicted fluence of 1.4×10^{18} n/cm^2 (ART = 80°F). Therefore, the revision of the P-T curves in this amendment results in less restrictive limits than previously projected in the Technical Specification curves. But the ART curves still are restricted by the vessel discontinuity curves currently in the Technical Specifications.

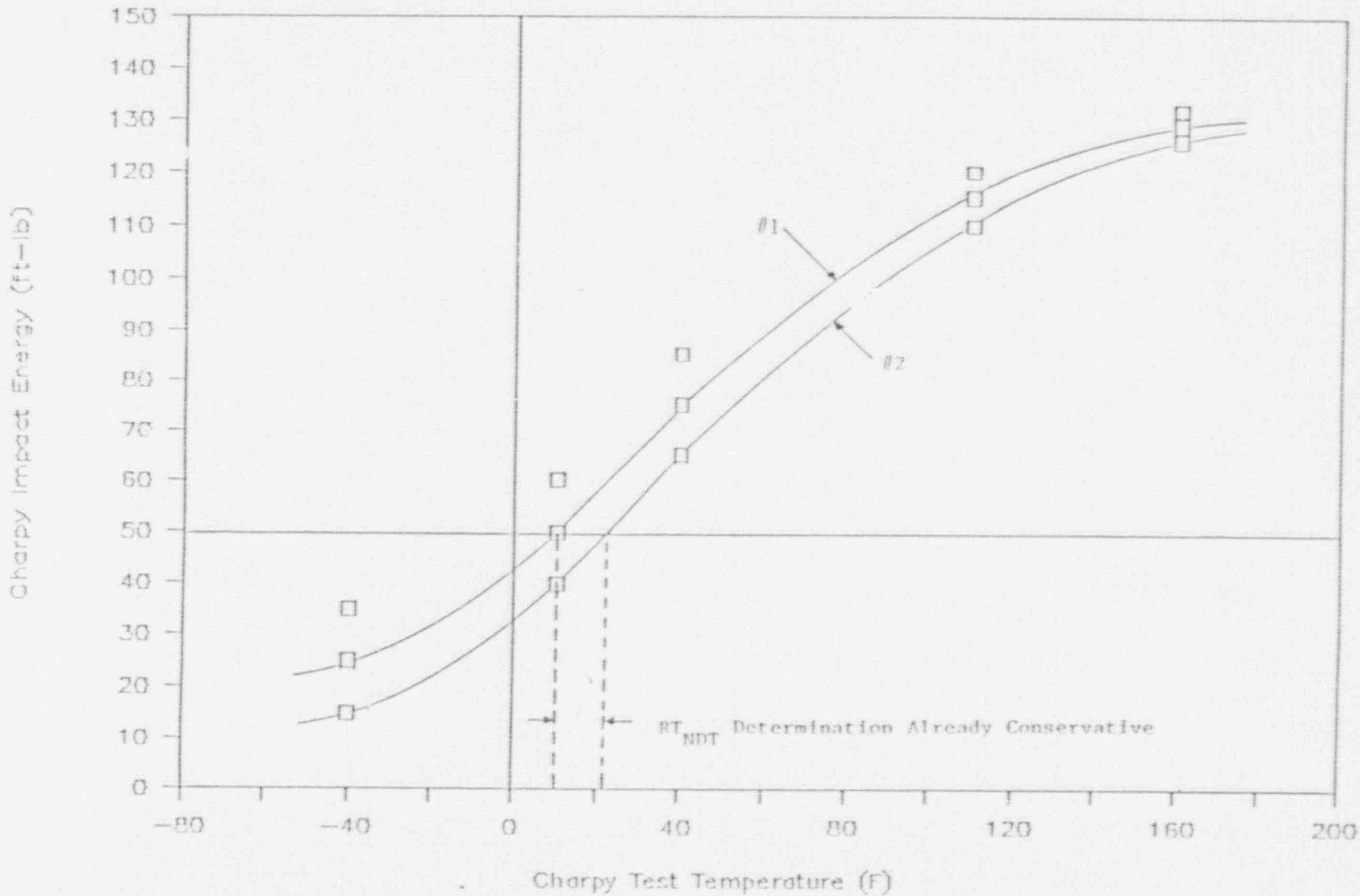

Figure 1. Comparison of Surveillance Fit and RT_{NDT} Approach

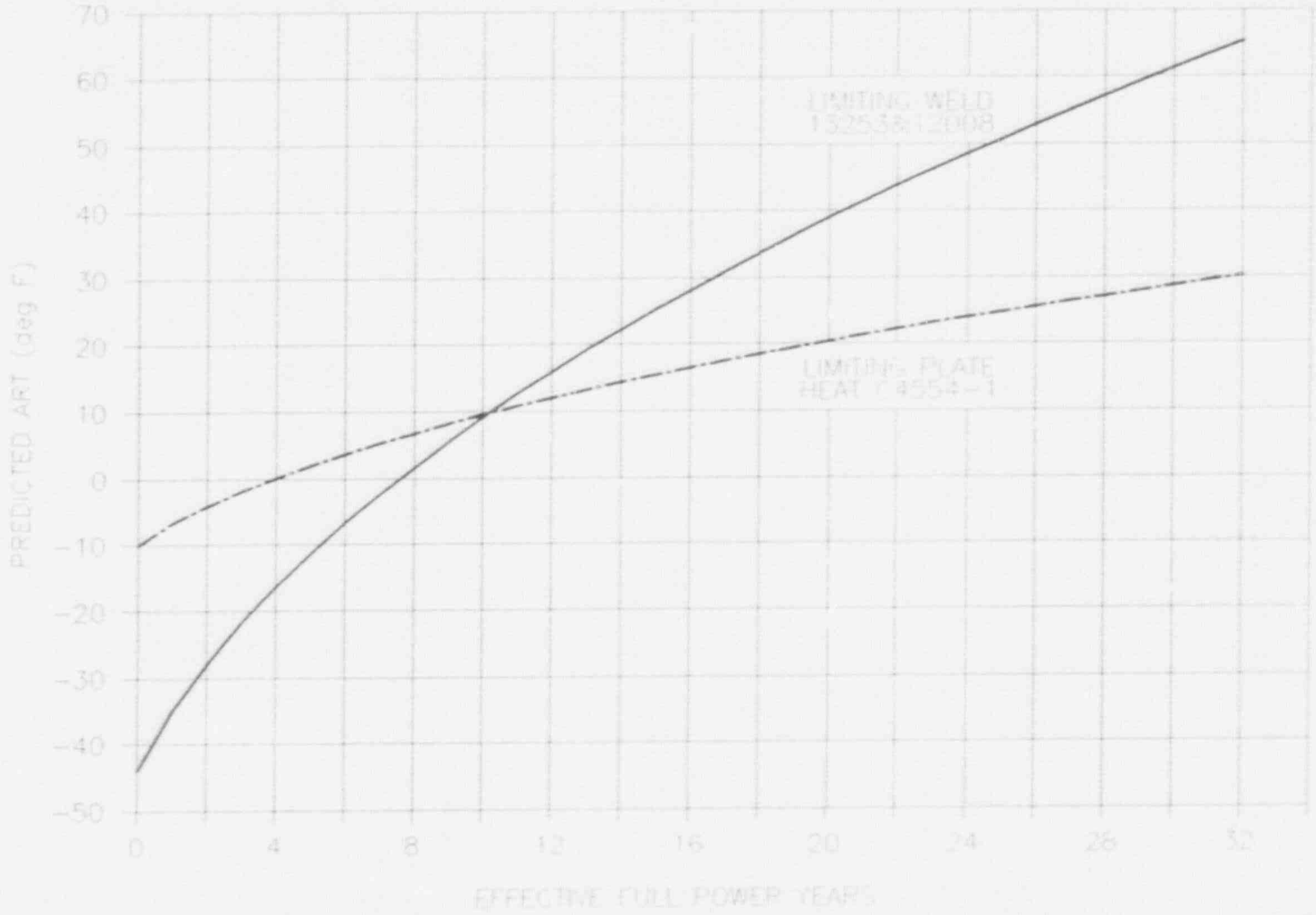

Figure 2. Limiting Beltline ART versus EFPY

Table 1

COMPARISON OF REV 1 AND REV 2 ART VALUES

FOR FERMI 2

	32 EFPY	
	Rev 1	Rev 2
Beltline Component	ART (^{o}F)	ART (^{o}F)
Plates:		
C4564-1	7.9	16.3
B8614-1	11.5	20.6
C4574-2	13.8	15.7
C4568-2	21.2	28.6
C4540-2	6.6	14.9
C4560-1	16.5	26.0
C4554-1	21.5	30.1
Welds:		
13253 & 12008	67.1	65.3
33A277	56.1	42.0
10137	26.3	63.6

PRESSURE-TEMPERATURE CURVES

Background

Operating limits for pressure and temperature are required for three categories of operation: (a) hydrostatic pressure tests and leak tests, referred to as Curve A; (b) non-nuclear heatup/cooldown and low-level physics tests, referred to as Curve B; and (c) core critical operation, referred to as Curve C. There are three vessel regions that affect the operating limits: the closure flange region; the core beltline region; and the remainder of the vessel, or non-beltline regions. The closure flange region limits are controlling at lower pressures primarily because of 10CFR50 Appendix G requirements. The non-beltline and beltline region operating limits are evaluated according to procedures in 10CFR50 Appendix G, Appendix G of the ASME Code and Welding Research Council (WRC) Bulletin 175 (Reference 4) with the beltline region minimum temperature limits adjusted to account for vessel irradiation.

Proposed TS Figure 3.4.6.1-1 presents the curves as revised by Regulatory Guide 1.99, Rev 2, for 32 EFPY of operation. The requirements for each vessel region influencing the P-T curves are discussed below.

Non-Beltline Regions

Non-beltline regions are those locations that receive too little fluence to cause any RT_{NDT} increase. Non-beltline components include the nozzles, the closure flanges, some shell plates, top and bottom head plates and the control rod drive (CRD) penetrations. Detailed stress analyses, specifically for the purpose of fracture toughness analysis, of the non-beltline components were performed for the BWR/6. The BWR/6 vessel is representative of large BWR Reactor Vessels, including the one at Fermi 2. The analyses took into account all mechanical loadings and thermal transients anticipated. Detailed stresses were used according to WRC Bulletin 175 to develop plots of allowable pressure (P) versus temperature relative to the reference temperature ($T - RT_{NDT}$). Plots were developed for the two most limiting regions; the feedwater nozzle and the CRD penetration regions. All other non-beltline regions are categorized under one of these two regions.

The generic BWR/6 non-beltline region results were applied to Fermi 2 by adding the highest RT_{NDT} for the non-beltline discontinuities to the appropriate P versus ($T - RT_{NDT}$) curves for the BWR/6 CRD penetration or feedwater nozzle. The limiting RT_{NDT} values are $40^{o}F$ for the CRD penetration limits and feedwater nozzle limits. The non-beltline limits in proposed TS Figure 3.4.6.1-1 are the same as those shown in the current Tech Spec curves except that the new Curve A is more conservative. Rev 2 and fluence changes only affect the beltline limits.

Core Beltline Region

The pressure-temperature (P-T) limits for the beltline region are determined according to the methods in ASME Code Appendix G. As the beltline fluence increases during operation, these curves shift by an amount discussed previously. Typically, the beltline curves shift to become more limiting than the non-beltline curves at some point during operating life. However, using the updated fluence estimate for Fermi 2, the non-beltline curves remain limiting for 32 EFPY of operation.

The stress intensity factors (K_I), calculated for the beltline region according to ASME Appendix G procedures, were based on a combination of pressure and thermal stresses for a 1/4 T flaw in a flat plate. The pressure stresses were calculated using thin-walled cylinder equations. Thermal stresses were calculated assuming the through-wall temperature distribution of a flat plate subjected to a $100^{\circ}F$/hr thermal gradient. A 32 EFPY ART of $65^{\circ}F$ was used to adjust the ($T - RT_{NDT}$) values from Figure G-2210-1 of ASME Code Appendix G.

The curves resulting from shifting the beltline limits are shown as A', B' and C' in proposed TS Figure 3.4.6.1-1 for 32 EFPY of operation. As seen there, these curves are less limiting than the non-beltline curves A, B and C, and are shown for information only.

Closure Flange Region

10CFR50, Appendix G, sets several minimum requirements for pressure and temperature, in addition to those outlined in the ASME Code, based on the closure flange region RT_{NDT}. In some cases, the results of analysis for other regions exceed these requirements and they do not affect the shape of the P-T curves. However, some closure flange requirements do impact the curves. In addition, General Electric recommends $60^{\circ}F$ margin on the required bolt preload temperature.

As stated in Paragraph G-2222(c) of ASME Appendix G, for application of full bolt preload and reactor pressure up to 20% of hydrostatic test pressure, the RPV metal temperature must be at RT_{NDT} or greater. The standard practice is to require ($RT_{NDT} + 60^{\circ}F$) for boltup, because ($RT_{NDT} + 60^{\circ}F$) assures ductility in the closure flange region materials, which are highly stressed during boltup. Furthermore, the flaw size assumed in that region (0.24 inches) is less than 1/4 T. This flaw size is detectable using ultrasonic testing (UT) techniques. For Fermi 2, the closure flange and attached shell values of ($RT_{NDT} + 60^{\circ}F = 71^{\circ}F$) are consistent with the allowable lowest service temperature for the bolting material.

10CFR50 Appendix G, paragraph IV.A.2, sets minimum temperature requirements for pressure above 20% hydrotest pressure based on the RT_{NDT} of the closure region. Curve A temperature must be no less than (RT_{NDT} + 90°F) and Curve B temperature no less than (RT_{NDT} + 120°F). These requirements cause the step in curve A at 20% hydrotest pressure (312 psig) shown in proposed TS Figure 3.4.6.1-1. However, the feedwater nozzle limits for curve B result in limits greater than (RT_{NDT} + 120°F), so a similar step at 312 psig is not seen.

Core Critical Operation Requirements of 10CFR50, Appendix G

Curves C and C', the core critical operation curves shown in proposed TS Figure 3.4.6.1-1, are generated from the requirements of 10CFR50 Appendix G, paragraph IV.A.3. Essentially paragraph IV.A.3 requires that core critical P-T limits be 40°F above any Curve A or B limits. Curve B is more limiting than Curve A, so Curve C is Curve B plus 40°F.

Another provision of IV.A.3 concerns minimum temperature for initial criticality in a Boiling Water Reactor (BWR) in a startup. The BWR is allowed critical operations at pressures below 312 psig. This allows plant startup and is restricted to when reactor water level is in the normal range and closure flange region temperature is greater than RT_{NDT} + 60°F. Above 312 psig, the temperature required for critical operations must be at least that required for the hydrostatic pressure test (Curve A' at 1100 psig). Curve C is restrictive enough to meet this requirement.

PROPOSED TECHNICAL SPECIFICATION CHANGES

The proposed Technical Specification change pages are attached as Appendix D. Each proposed change is discussed below:

(a) The Limiting Condition for Operation (LCO), Specification 3.4.6.1, and the Surveillance Requirements, Specifications 4.4.6.1.1 through 4.4.6.1.4, are modified by removing reference to curves A', B' and C'. As discussed above, these curves are no longer limiting and are included in Figure 3.4.6.1-1 for information only. Therefore, it is appropriate to eliminate them from the LCO and Surveillance Requirements.

(b) A revised TS Figure 3.4.6.1-1 is provided as discussed in the previous evaluation.

(c) Table 4.4.6.1.3-1 is modified to reflect the lead factor used for the updated P-T curves. As discussed in Appendix C, this lead factor better reflects the variation between the peak fluence location and the capsule location.

Changes to the TS Bases section are also proposed to reflect the Regulatory Guide 1.99, Revision 2, methodology. Detailed information concerning test results and neutron fluence vs. time, which has previously been included in Bases Figure B 3/4.4.6-1 and Bases Table 3/4.4.6-1, has been deleted. Material of this level of detail is typically not found in the Bases. The former Bases Table B 3/4.4.6-1 has been revised to include the brittle fracture sensitive materials relevant to curves A, B, and C of TS Figure 3.4.6.1-1 and is being located in the UFSAR. The existing reference to the FSAR has been updated to the UFSAR section. A change is proposed to clarify that the tensile stresses thermally induced during heatup adds to the already existing pressure stresses. It is also proposed to clarify that the P-T curve limits were developed based upon a heatup rate at the 100°F per hour limit. The fact that nickel content instead of phosphorus content is of concern is reflected as well as the conclusion that P-T Curves A, B and C are more limiting than Curves A', B' and C'. These Bases changes are acceptable since they are either consistent with the revised methodology or editorial in nature.

SIGNIFICANT HAZARDS CONSIDERATION

In accordance with 10CFR50.92, Detroit Edison has made a determination that the proposed amendment involves no significant hazards considerations. To make this determination, Detroit Edison must establish that operation in accordance with the proposed amendment would not: 1) involve a significant increase in the probability or consequences of an accident previously evaluated, or 2) create the possibility of a new or different kind of accident from any accident previously evaluated, or 3) involve a significant reduction in a margin of safety.

The proposed change provides pressure/temperature limits for the reactor coolant system and the reactor pressure vessel which conform to Regulatory Guide 1.99, Revision 2, as required by NRC Generic Letter 88-11. The proposed amendment does not:

1) Involve a significant increase in the probability or consequences of an accident previously evaluated. The proposed amendment incorporates the required changes to the reactor vessel (RPV) irradiation embrittlement sections pertaining to the RPV heat-up and cool-down curves. The analysis resulting in these revisions was requested by the NRC in Generic Letter 88-11 which implemented Revision 2 of Regulatory Guide 1.99.

The proposed amendment of the Technical Specifications does not increase the probability or consequences of an accident. This amendment invokes the more accurate analysis of neutron irradiation effect on RPV beltline materials as required by the NRC in Generic Letter 88-11 and Regulatory Guide 1.99 Rev. 2. No physical changes to the Fermi 2 plant will be made and no change to the normal operation of the plant will be made through implementation of this amendment, except that the curve used for hydrostatic and leak testing has been made more restrictive to better protect the reactor vessel.

2) Create the possibility of a new or different kind of accident from any accident previously evaluated. The proposed amendment revises the technical specification heat-up and cool-down curves as affected by long-term RPV beltline material neutron irradiation. Based upon more accurate methods, described in Regulatory Guide 1.99 Rev. 2, and actual fluence data the need for more restrictive limits later in plant life has been eliminated. The hydrostatic test curve was made more restrictive based on a more conservative fracture mechanics analysis. No changes are being made to the design or functional characteristics of any system or component. No components will be added, deleted, or modified by this amendment. None of the UFSAR Chapter 15 Accident Analyses are being altered. Therefore, this amendment does not create the possibility of a new or different kind of accident than previously evaluated in the UFSAR.

3) Involve a significant reduction in a margin of safety. The proposed amendment does not reduce the margin of safety as defined in the bases of the Technical Specifications. The proposed amendment incorporates the analysis of the Fermi 2 RPV for irradiation embrittlement into the TS curves. The analysis conforms to the NRC guidance contained in Regulatory Guide 1.99 Revision 2 as requested by Generic Letter 88-11.

Implementation of this amendment conforms to the latest and most accurate predictive model accepted by the NRC. Additional accuracy has been achieved by the inclusion of the results of the flux wire dosimetry capsule analysis for prediction of neutron fluence on the RPV beltline materials. This analysis was completed by General Electric on the flux wires from the capsule removed from the RPV inner wall beltline region during the first refueling outage. More restrictive limits for hydrostatic testing have been included by the use of a more conservative fracture mechanics analysis. The cumulative effect of these changes does not significantly reduce the margin of safety.

Based on the above, Detroit Edison has determined that the proposed amendment does not involve a significant hazards consideration.

ENVIRONMENTAL IMPACT

Detroit Edison has reviewed the proposed Technical Specification changes against the criteria of 10CFR51.22 for environmental considerations. The proposed change does not involve a significant hazards consideration, nor significantly change the types or significantly increase the amounts of effluents that may be released offsite, nor significantly increase individual or cumulative occupational radiation exposures. Based on the foregoing, Detroit Edison concludes that the proposed Technical Specifications do meet the criteria given in 10CFR51.22(c) (9) for a categorical exclusion from the requirements for an Environmental Impact Statement.

CONCLUSION

Based on the evaluation above: 1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and 2) such activities will be conducted in compliance with the Commission's regulations, and the proposed amendment will not be inimical to the common defense and security or to the health and safety of the public.

APPENDIX A

COMPARISON OF IRRADIATION EMBRITTLEMENT PREDICTIONS OF REGULATORY GUIDE 1.99, REVISIONS 1 AND 2

FOR

FERMI UNIT 2

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Intermediate Plate: G-3703-5 Thickness 6.13 inches

Material Heat: C4564-1

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.21	1.3	0.01	0.015	0.25	0.09	0.55	0.48

Initial RTndt: RTndt-I = -12 F, Sigma-I = 0 F

32 EFPY Fluence (f):
Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 58

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	3.6	3.6	7.2	-4.8	7.0	-5.0
8	5.9	5.9	11.8	-0.2	9.9	-2.1
12	7.8	7.8	15.5	3.5	12.2	0.2
16	9.3	9.3	18.7	6.7	14.1	2.1
20	10.7	10.7	21.5	9.5	15.7	3.7
24	12.0	12.0	23.9	11.9	17.2	5.2
28	13.1	13.1	26.2	14.2	18.6	6.6
32	14.1	14.1	28.3	16.3	19.9	7.9

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Intermediate Plate: G-3705-1 Thickness 6.13 inches

Material Heat: B8614-1

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.23	1.22	0.011	0.015	0.27	0.12	0.61	0.62

Initial RTndt: RTndt-I = -20 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 83.2

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	5.2	5.2	10.3	-9.7	11.1	-8.9
8	8.5	8.5	17.0	-3.0	15.8	-4.2
12	11.1	11.1	22.3	2.3	19.3	-0.7
16	13.4	13.4	26.8	6.8	22.3	2.3
20	15.4	15.4	30.8	10.8	24.9	4.9
24	17.2	17.2	34.3	14.3	27.3	7.3
28	18.8	18.8	37.6	17.6	29.5	9.5
32	20.3	20.3	40.6	20.6	31.5	11.5

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Intermediate Plate: G-3705-2 Thickness 6.13 inches

Material Heat: C4574-2

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.22	1.36	0.014	0.016	0.24	0.1	0.55	0.54

Initial RTndt: RTndt-I = -16 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 65

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	4.0	4.0	8.1	-7.9	10.6	-5.4
8	6.6	6.6	13.3	-2.7	14.9	-1.1
12	8.7	8.7	17.4	1.4	18.3	2.3
16	10.5	10.5	20.9	4.9	21.1	5.1
20	12.0	12.0	24.0	8.0	23.6	7.6
24	13.4	13.4	26.8	10.8	25.9	9.9
28	14.7	14.7	29.4	13.4	27.9	11.9
32	15.9	15.9	31.7	15.7	29.8	13.8

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Intermediate Plate: G-3705-3 Thickness 6.13 inches

Material Heat: C4568-2

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.23	1.32	0.012	0.016	0.24	0.12	0.61	0.56

Initial RTndt: RTndt-I = -12 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 83.2

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	5.2	5.2	10.3	-1.7	11.7	-0.3
8	8.5	8.5	17.0	5.0	16.6	4.6
12	11.1	11.1	22.3	10.3	20.3	8.3
16	13.4	13.4	26.8	14.8	23.5	11.5
20	15.4	15.4	30.8	18.8	26.2	14.2
24	17.2	17.2	34.3	22.3	28.7	16.7
28	18.8	18.8	37.6	25.6	31.0	19.0
32	20.3	20.3	40.6	28.6	33.2	21.2

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Shell Plate: G-3706-1 Thickness 6.13 inches

Material Heat: C4540-2

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.24	1.3	0.01	0.01	0.21	0.08	0.62	0.54

Initial RTndt: RTndt-I = -10 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 51

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	3.2	3.2	6.3	-3.7	5.9	-4.1
8	5.2	5.2	10.4	0.4	8.3	-1.7
12	6.8	6.8	13.7	3.7	10.2	0.2
16	8.2	8.2	16.4	6.4	11.7	1.7
20	9.4	9.4	18.9	8.9	13.1	3.1
24	10.5	10.5	21.1	11.1	14.4	4.4
28	11.5	11.5	23.0	13.0	15.5	5.5
32	12.4	12.4	24.9	14.9	16.6	6.6

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Shell Plate: G-3706-2 Thickness 6.13 inches

Material Heat: C4560-1

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.22	1.3	0.01	0.015	0.25	0.11	0.57	0.5

Initial RTndt: RTndt-I = -10 F, Sigma-I = 0 F

32 EFPY Fluence (f):
Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 73.7

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	4.6	4.6	9.1	-0.9	9.4	-0.6
8	7.5	7.5	15.0	5.0	13.3	3.3
12	9.9	9.9	19.7	9.7	16.2	6.2
16	11.9	11.9	23.7	13.7	18.8	8.8
20	13.6	13.6	27.3	17.3	21.0	11.0
24	15.2	15.2	30.4	20.4	23.0	13.0
28	16.7	16.7	33.3	23.3	24.8	14.8
32	18.0	18.0	36.0	26.0	26.5	16.5

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Lower Shell Plate: G-3706-3 Thickness 6.13 inches

Material Heat: C4554-1

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.22	1.27	0.011	0.018	0.22	0.12	0.56	0.48

Initial RTndt: RTndt-1 = -10 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 82.2

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	5.1	5.1	10.2	0.2	11.1	1.1
8	8.4	8.4	16.8	6.8	15.8	5.8
12	11.0	11.0	22.0	12.0	19.3	9.3
16	13.2	13.2	26.5	16.5	22.3	12.3
20	15.2	15.2	30.4	20.4	24.9	14.9
24	17.0	17.0	33.9	23.9	27.3	17.3
28	18.6	18.6	37.1	27.1	29.5	19.5
32	20.1	20.1	40.1	30.1	31.5	21.5

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Beltline Weld 2-307 A,B,C Thickness 6.13 inches

Material Heat: TANDEM 13253,12008 1092 LOT 3833

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
			0.013			0.26	0.87	

Initial RTndt: RTndt-I = -44 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 224

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	13.9	13.9	27.8	-16.2	39.3	-4.7
8	22.9	22.9	45.7	1.7	55.6	11.6
12	30.0	30.0	60.0	16.0	68.0	24.0
16	36.1	36.1	72.2	28.2	78.6	34.6
20	41.4	41.4	82.9	38.9	87.8	43.8
24	46.2	46.2	92.5	48.5	96.2	52.2
28	50.6	50.6	101.2	57.2	103.9	59.9
32	54.6	54.6	109.3	65.3	111.1	67.1

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Beltline Weld 15-308 A,B,C,D Thickness 6.13 inches

Material Heat: 33A277 124 LOT 3878

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.073	1.29	0.016	0.011	0.33	0.32	0.5	0.52

Initial RTndt: RTndt-I = -50 F, Sigma-I = 0 F

32 EFPY Fluence (f):
Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 188.5

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	11.7	11.7	23.4	-26.6	37.5	-12.5
8	19.2	19.2	38.5	-11.5	53.1	3.1
12	25.2	25.2	50.5	0.5	65.0	15.0
16	30.4	30.4	60.7	10.7	75.0	25.0
20	34.9	34.9	69.7	19.7	83.9	33.9
24	38.9	38.9	77.8	27.8	91.9	41.9
28	42.6	42.6	85.2	35.2	99.3	49.3
32	46.0	46.0	92.0	42.0	106.1	56.1

COMPARISON OF REG. GUIDE 1.99 REVISIONS 1 AND 2
FOR FERMI 2 BELTLINE MATERIALS

Beltline Girth Weld 1-313 Thickness 6.13 inches

Material Heat: 10137, 0091 Lot 3999

Chemistry:	C	Mn	P	S	Si	Cu	Ni	Mo
	0.2	1.13	0.016	0.01	0.14	0.23	1	0.49

Initial RTndt: RTndt-I = -50 F, Sigma-I = 0 F

32 EFPY Fluence (f): Calculated Peak 1/4T f = 1.1E+18 n/cm^2 (used with Rev 1)
Calculated Peak I.D. f = 5.2E+17 n/cm^2
Rev 2 Attenuated 1/4T f = 3.6E+17 n/cm^2 (basis for Rev 2 delta RT)

Surveillance Testing Affecting Rev 1 Shift Calculation:

Surveillance testing not yet done.
Correction factor applied = 1

Chemistry Factor for Rev 2 Shift: CF= 236

Comparison of Rev 1 and Rev 2 SHIFT and ART (degrees F) versus EFPY:

EFPY	Rev 2 Delta RT	Rev 2 Margin	Rev 2 SHIFT	Rev 2 ART	Rev 1 SHIFT	Rev 1 ART
4	14.6	14.6	29.2	-20.8	27.0	-23.0
8	24.1	24.1	48.1	-1.9	38.1	-11.9
12	31.6	31.6	63.2	13.2	46.7	-3.3
16	38.0	38.0	76.0	26.0	53.9	3.9
20	43.6	43.6	87.3	37.3	60.3	10.3
24	48.7	48.7	97.4	47.4	66.1	16.1
28	53.3	53.3	106.6	56.6	71.4	21.4
32	57.6	56.0	113.6	63.6	76.3	26.3

APPENDIX B

ESTIMATE OF COPPER AND NICKEL CONTENT FOR THE 13253 & 12008 TANDEM ARC BELTLINE WELD

WELD 2-307

There are various means to reach a best-estimate chemistry for 13253 and 12008 tandem weld with 1092 Flux Lot 3833:

1. Maine Yankee PTS report gives average values for eight tests of 13253 and 12008 with flux lots 3774, 3791 and 3833. Results are:

.22% Cu, .84% Ni

2. Separate data for 13253 and 12008 can be combined:

13253:	.25% Cu,	.73% Ni	EPRI Data Base, Salem 2 & Cook 1
	.25% Cu,	.72% Ni	Salem 1 & 2 PTS Report
	.25% Cu,	.73% Ni	Diablo Canyon 1 PTS Report

Assume 13253: 0.25% Cu, 0.73% Ni

12008: No separate Cu data; must deduce chemistry from other combinations. EPRI data base shows 12008-1.0% Ni

Two cases found in PTS reports:

	Cu	Ni
21935/3889 only	.18	.68
21935 + 12008/3889	.20	.86
21935/3869 only	.18	.68
21935 + 12008/3869	.22	.85

Given the value of 1.0% Ni, a 50-50 tandem weld is credible

1.00 ---|
        |--- 0.84 Ni
0.68 ---|

Assuming this is the case, the ⌐u for 12008 can be calculated

for Lot 3889

x / 0.18	0.20	x = 0.22% Cu 12008

for Lot 3869

y / 0.18	0.22	y = 0.26% Cu 12008

Assume <u>12008: 0.26% Cu, 1.0% Ni</u>

Now combine 12008 + 13253 in a 50-50 weld:

12008	0.26	0.26% Cu	1.0	Ni	0.87% Ni
13253	0.25		0.73	Ni	

The calculated combination is:

0.26% Cu, 0.87% Ni for 13253 & 12008

APPENDIX C

PEAK

FLUENCE

DETERMINATION

FROM

FLUX

WIRE

TEST

FLUENCE FACTOR DETERMINATION

INTRODUCTION

In September 1989, Fermi 2 completed its first fuel cycle. During the outage that followed, the flux wire dosimeter attached to the surveillance capsule at the vessel 30° azimuth was removed. The dosimeter was shipped to the General Electric Vallecitos Nuclear Center (VNC) in Pleasanton, CA for testing. The test results and the associated determination of peak vessel flux and fluence are presented in this appendix.

The surveillance program for Fermi 2 consists of three surveillance capsules and one separate flux wire dosimeter. Each surveillance capsule contains Charpy specimens of the beltline base, weld and HAZ materials, and a set of flux wires used to determine the fluence experienced by the capsule. The surveillance capsules are scheduled to be withdrawn periodically during plant life (the current schedule for Fermi 2 is shown in TS Table 4.4.6.1.3-1). In addition to the flux wires in the surveillance capsules, a flux wire dosimeter was attached to the capsule at 30° for removal after the first fuel cycle. Since the vessel fluence is proportional to thermal power produced, the results of the flux wire dosimeter test are used to provide a calibration point of vessel fluence versus accumulated thermal power. A linear extrapolation provides an estimate of the fluence at 32 effective full power years (EFPY).

The determination of the peak 32 EFPY fluence is basically a two-step process. First, the flux wires are analyzed to determine the flux and fluence at the dosimeter location. Then, lead factors are calculated which relate the flux magnitude at the dosimeter location to that at the location of peak flux.

The flux wire dosimeter was disassembled at VNC and the iron and copper flux wires were cleaned and weighed. Gamma spectrometry was used to determine the rate of disintegrations. The daily power history of the first fuel cycle was used, along with cross-section data developed for BWRs to transform the disintegration data into rates of irradiation, or flux (n/cm^2-s).

The dosimeter lead factor is presented in TS Table 4.4.6.1.3-1 as 0.7 for the peak 1/4 T location. However, this lead factor was based on one-dimensional transport calculations done at the time of FSAR preparation, and includes an uncertainty safety factor of 2. More recent pseudo-three dimensional computations of lead factor have been done for 251 inch vessels with 764 fuel bundles, the same configuration as Fermi 2. The inside surface (ID) lead factor reported for Peach Bottom 2 was 0.95. For Susquehanna 1, the ID lead factor was computed to be 0.94. The lead factors are primarily dependent upon geometry and fuel bundle configuration. All three vessels have their dosimeters at the 30° azimuth and at the core midplane. Therefore, the lead factors mentioned above provide the best available prediction of peak 32 EFPY fluence from the Fermi 2 flux wire data.

The methods used to calculate the Peach Bottom 2 lead factor are summarized below.

Determination of the lead factors for the RPV peak location at the ID was done using a combination of two-dimensional and one-dimensional computer analyses. The two-dimensional analysis established the relative fluence in the azimuthal direction at the vessel ID. A series of one-dimensional analyses were done to determine the core height of the axial flux peak and its relationship to the surveillance capsule height. The combination of azimuthal and axial distribution results provides the lead factor between the dosimeter location and the peak flux location.

The two-dimensional DOT computer program was used to solve the Boltzman transport equation using the discrete ordinate method on an (R,Θ) geometry, assuming a fixed source. One quarter core symmetry was used with periodic boundary conditions at 0° and 90°. Neutron cross sections were determined for 26 energy groups, with angular scattering approximated by a third-order Legendre expansion. Flux as a function of azimuth was calculated, establishing the azimuth of the peak flux and its magnitude relative to the flux at the dosimeter location of 30°.

A one-dimensional computer code (SN1D) was used to calculate flux for various elevations at the peak azimuth angle. The elevation of the peak flux was determined, as well as its magnitude relative to the flux at the dosimeter elevation. This factor is the axial component of the lead factor. The lead factor between the peak and dosimeter locations was calculated as the azimuthal component times the axial component.

RESULTS

A summary of the >1 MeV flux and fluence values for the dosimeter are presented in Table 1. In the GE flux wire analysis report, there is an estimated 2σ uncertainty of $\pm 25\%$ on the >1 MeV flux and fluence. Table 1 shows the upper bound values with the nominal values.

The lead factor used for the peak location inside surface is presented in Table 1 with the dosimeter test results. The lead factor is used to predict the peak fluence (f) according to the following equation:

$$\text{Peak } f = (\text{Dosimeter } f * 32 \text{ EFPY})/(\text{Dosimeter EFPY} * \text{Lead Factor})$$

The first fuel cycle for Fermi 2 consisted of 1066 days of operation with an average capacity factor of 0.428. This is equivalent to 456.2 days at full power, or 1.25 EFPY. This value is used with the fluence value at the end of cycle one (EOC1) to calculate the 32 EFPY fluence shown in Table 1. The lead factor used is 0.94, from Susquehanna 1 since it is slightly more conservative than the 0.95 lead factor from Peach Bottom 2. The fluence at the peak location ID is plotted as a function of EFPY in Figure 1.

As some of the 10 year surveillance capsules at other BWRs are being tested, the 10 year dosimetry in these capsules are consistently testing at lower flux values than the first cycle dosimetry tests. This is expected to be caused by the atypical operation of the first fuel cycle compared to the subsequent 10 years of operation. Therefore, it is expected that the flux values determined for Fermi 2 in this test are higher than will typically be experienced in future operation.

CONCLUSIONS

The flux wire test results summarized in Table 1 show a nominal peak fluence on the vessel ID at 32 EFPY of 5.2×10^{17} n/cm^2. The fluence determined by dosimetry is significantly lower than the original design fluence value of 1.7×10^{18} n/cm^2 (which included a safety factor of 2 on lead factor). This lower trend is consistent with the results of dosimetry tests at other plants. The 32 EFPY fluence value determined from the flux wire testing results was used to modify the Rev 2 impact analysis and the pressure-temperature curves as presented in this proposed amendment.

Table 1

FLUENCE DETERMINATION FOR THE PEAK LOCATION
IN THE FERMI 2 VESSEL

Time at Power:		
	EOC1 - 2.92 years at 42.8% CF:	1.25 EFPY
	Design - 40 years at 80% CF:	32 EFPY
Lead Factor:		
	Peak Location ID:	0.94
Dosimeter Flux:		
	Measured Value:	4.9×10^{8} n/cm²·s
	Upper Bound:	6.1×10^{8} n/cm²·s
Dosimeter Fluence:		
	Measured Value:	1.9×10^{16} n/cm²
	Upper Bound:	2.4×10^{16} n/cm²
Peak Vessel ID 32 EFPY Fluence:		
	Nominal Prediction:	5.2×10^{17} n/cm²
	Upper Bound:	6.5×10^{17} n/cm²

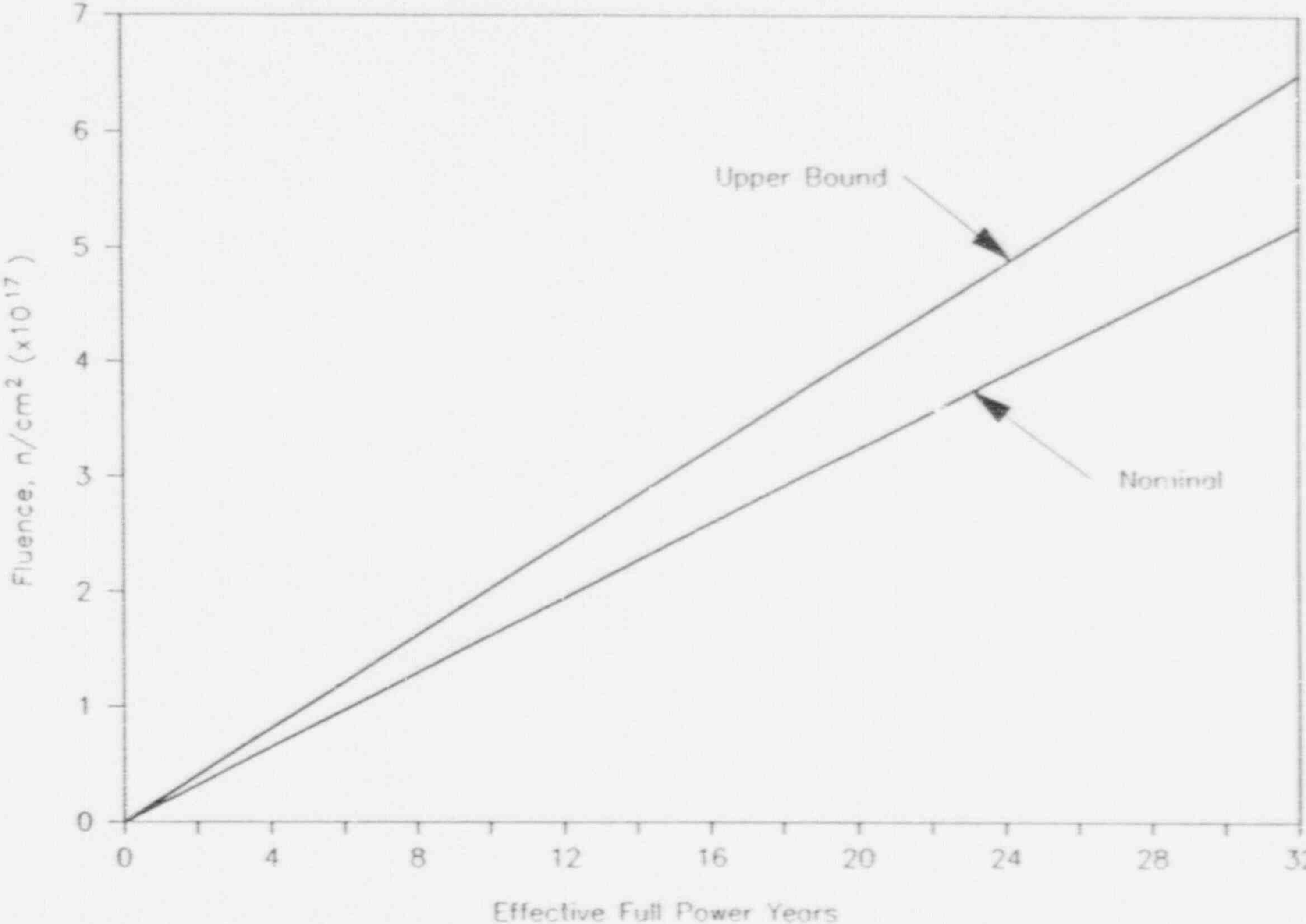

Figure 1 . Predicted Peak ID Fluence Based on Flux Wire Results