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

SAFETY EVALUATION

REACTOR VESSEL PRESSURIZED THERMAL SHOCK

DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2

INTRODUCTION

By letters dated January 22, 1986 and February 27, 1987, the Indiana and Michigan Electric Company, the licensee for the Donald C. Cook Nuclear Plant, Unit Nos. 1 and 2, submitted information on the material properties and the fast neutron fluence (E 1.0 MeV) of the reactor pressure vessel in compliance with the requirements of 10 CFR 50.61 (References 1, 2, and 3). This Safety Evaluation addresses our review for each unit.

EVALUATION

Unit 1

The controlling beltline material from the standpoint of PTS susceptibility was identified to be the intermediate to lower shell circumferential weld 9-442, weld wire heat No. IP3571.

The material properties of the controlling material and the associated margin and chemistry factor were reported to be:

	Utility Submittal	Staff Evaluation
Cu (copper content, %)	0.31	0.31
Ni (nickle content, %)	0.74	0.74
I (Initial RT_{NDT}, °F)	-56	-56
M (Margin, °F)	--	59
CF (Chemistry Factor, °F)	--	216.0

The controlling material has been properly identified. The justifications for the copper and nickel contents and the initial RT_{NDT}, given by reference to a submittal dated July 3, 1985, are acceptable. The margin has been derived from consideration of the bases for these values, following the PTS Rule, Section 50.61 of 10 CFR Part 50. The chemistry factor is shown above.

For D. C. Cook Unit 1, analysis of the fast neutron flux at the inside diameter of the pressure vessel was performed in connection with surveillance capsule X and capsule Y of Unit 2. The first calculations was performed using the DOT 3.5 code with P_1, S_8 approximations and a non ENDF/B based cross section set. The second calculation used the same approximation but a later version of DOT and an ENDF/B-IV based set of cross sections. The staff

noted that the P_1 approximation underestimates the value of the fluence incident on the inside surface of the pressure vessel. The licensee agreed and committed to revise the estimate of the fluence with the removal of the next surveillance capsule U which is scheduled for 1989 (Reference 3). In particular, the updated calculation will use the P_3 scattering cross section expansion approximation. The estimated underestimate of the end of license projected fluence is of the order of 15%. The sources taken into account were based on the low leakage loading instituted with cycle 9, which is conservative.

The controlling beltline material was identified as the lower shell circumferential weld 9-442 and, hence, the proper value of the fast neutron fluence for the estimation of the RT_{PTS} is the peak of the azimuthal distribution.

The equation specified in 10 CFR 50.61, as applicable for the D. C. Cook Unit 1 plant is:

$$RT_{PTS} = I+M+(-10+470xCu+350xCuxNi)xf^{0.27} \qquad (1)$$

where:

I	= Initial RT_{NDT}	= -56°F
M	= Uncertainty Margin	= 59°F
Cu	= w/o Copper in lower circumferential weld 9-442	= 0.31
Ni	= w/o Nickel in lower circumferential weld 9-442	= 0.74
f	= Peak Azimuthal Fluence (E 1.0 MeV) lower circumferential weld 9-442 in units of 10^{19} n/cm^2	= 1.66

Therefore, to the end of the current operating license:

$$RT_{PTS} = -56+59+(-10-470x0.31+350x0.31x0.74)x1.66^{0.27}$$
$$= 3+216.0x1.147 = 250.6°F$$

which is lower than 300°F the applicable PTS rule screening criterion.

Solving equation (1) for f, setting RT_{PTS} = 300°F one obtains:

$$300 = 3+216xf^{0.27}$$

$$0.27xlnf=ln1.375=.318 \qquad \text{and} \qquad f = 3.253$$

which is about 100% higher than the estimated end of license value of the fluence.

The projected revised value of the peak azimuthal value of the fluence is expected to yield an RT_{PTS} value well within the applicable 10 CFR 50.61 screening criterion. Therefore, the proposed value is acceptable subject to the revision committed to by the licensee with the removal and analysis of capsule U.

Unit 2

The controlling beltline material from the standpoint of PTS susceptibility was identified to be the intermediate shell plate C556-2.

The material properties of the controlling material and the associated margin and chemistry factor were reported to be:

	Utility Submittal	Staff Evaluation
Cu (copper content, %)	0.15	0.15
Ni (nickle content, %)	0.58	0.58
I (Initial RT_{NDT}, °F)	+58	+58
M (Margin, °F)	--	59
CF (Chemistry Factor, °F)	--	91.0

The controlling material has been properly identified. The justifications for the copper and nickel contents and the initial RT_{NDT}, given by reference to the FSAR, are acceptable. The margin has been derived from consideration of the bases for these values, following the PTS Rule, Section 50.61 of 10 CFR Part 50. The chemistry factor is as shown above.

For D. C. Cook Unit 2 analysis of the fast neutron fluence to the pressure vessel was performed in connection with the removal of surveillance capsule Y at the end of cycle 3. Cycle 1 had new assemblies but cycle 2 was a transition cycle to low leakage. Therefore, the analyses included calculations for the cycle 1 and 2 loadings was well for cycle 3. The calculations used the P_1 and S_8 approximations in the DOT 3.5 code with ENDF/B-IV based cross section sets. Future cycle loadings will use even lower leakage loadings but cycle 3 was used for the estimation of the extrapolation to the end of the current license which is conservative as far as the neutron sources are concerned. However, the staff noted that the P_1 approximation underestimates the value of the fluence incident on the inside surface of the pressure vessel. The licensee agreed and committed to revise the estimate of the fluence with the removal of the next surveillance capsule X which is scheduled for mid-1987 (Reference 3). In particular the updated calculation will use the P_3 scattering cross section expansion approximation. The underestimate of the end of license projected fluence is of the order of 15%.

The controlling beltline material from the standpoint of PTS susceptibility was identified to be the intermediate shell plate C5556-2. Therefore the applicable value of the fluence for the estimation of RT_{PTS} is the peak azimuthal value. It is estimated that at the end of the current license and at an 80% load factor

for the remaining time, the D. C. Cook Unit 2 will accumulate 21.38 effective full power years of operation and a peak (azimuthal) fluence of 1.36×10^{19} n/cm^2. The equation specified in 10 CFR 50.61, as applicable for the D. C. Cook Unit 2 is:

$$RT_{PTS} = I+M+(-10+470xCu+350xCuxNi)xf^{0.27} \quad (1)$$

where:
- I = Initial RT_{NDT} = 58°F
- M = Uncertainty Margin = 59°F
- Cu = w/o Copper in shell plate C5556-2 = 0.15
- Ni = w/o Nickel in shell plate C5556-2 = 0.58
- f = Peak Azimuthal Fluence on shell Plate C5556-2 ($E > 1.0$ MeV) in Units of 10^{19} n/cm^2 = 1.36

Therefore, to the end of the current operating license:

$$RT_{PTS} = 58+59+(-10-470x0.15+350x0.15x0.58)x1.36^{0.27}$$
$$= 117+91x1.087 = 215.8°F$$

which is considerably lower than the 270°F i.e., the applicable 10 CFR 50.61 screening criterion.

Solving equation (1) for f, setting RT_{PTS} = 270°F, one obtains:

$$270 = 117 + 91xf^{0.27}$$

$$\text{or } f = 6.85$$

Since 6.85/1.36 = 5.03, the projected fluence at the end of the current license required to reach the screening criterion is about 500% higher than the projected actual fluence. Therefore, the proposed value is acceptable, subject to the revision committed to by the licensee with the removal and analysis of capsule X.

REFERENCES

1. Letter from M. P. Alexich Indiana and Michigan Electric Company to Director, NRR dated January 22, 1986.

2. SwRI-7244-001/1, "Reactor Vessel Material Surveillance Program for D. C. Cook Unit No. 1 Analysis of Capsule Y" E. B. Norris, dated January 1986.

   SwRI-7244-002/1, "Reactor Vessel Material Surveillance Program for D. C. Cook Unit No. 2 Analysis of Capsule Y" E. B. Norris, dated February 1984.

3. Letter from M. P. Alexich, Indiana and Michigan Electric Company to NRC dated February 27, 1987.