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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RESPONSE TO THE 1991 PRESSURIZED THERMAL SHOCK RULE, 10 CFR 50.61

BALTIMORE GAS AND ELECTRIC COMPANY

CALVERT CLIFFS NUCLEAR POWER PLANTS, UNITS 1 AND 2

DOCKET NOS. 50-317 AND 50-318

1.0 BACKGROUND

The Pressurized Thermal Shock (PTS) rule, 10 CFR 50.61, adopted on July 23, 1985, establishes a screening criterion that is a measure of a limiting level of embrittlement beyond which operation cannot continue without further plant-specific evaluation. The screening criterion is given in terms of reference temperature, RT_{PTS}. The screening criterion is 270 °F for plates and axial welds and 300 °F for the circumferential weld. The RT_{PTS} value is defined as the sum of (a) the unirradiated reference temperature, (b) the margin to be added to cover uncertainties in the initial properties, and (c) the adjusted reference temperature, ΔRT_{PTS}, caused by irradiation. The amount of ΔRT_{PTS} is based on the amount of neutron irradiation and the amount of copper and nickel in the material. The greater the amounts of copper, nickel, and neutron fluence; the greater the ΔRT_{PTS} for the material and the lower its fracture resistance.

The PTS rule was amended on May 15, 1991. The amended rule requires licensees to consider the effect of reactor vessel operating temperature and surveillance results on the calculated RT_{PTS} value. In addition, the amended rule requires licensees to submit an assessment by December 16, 1991, if the RT_{PTS} for any material in the beltline is projected to exceed the PTS screening criterion before expiration of the operating license.

By letter dated December 13, 1991, the Baltimore Gas and Electric Company (BG&E) (the licensee) submitted an assessment of the projected RT_{PTS} for the Calvert Cliffs Nuclear Power Plant, Units 1 and 2 (Calvert Cliffs 1 and 2) reactor vessel beltline materials. Additional information was provided in correspondence dated May 22, 1992.

2.0 EVALUATION

The Calvert Cliffs 1 and 2 reactor vessels were fabricated by Combustion Engineering (CE). Each reactor vessel beltline consists of six axially-oriented welds, one circumferentially-oriented weld and six plates. The axially-oriented welds were fabricated using a submerged arc process with tandem electrodes. The circumferentially-oriented weld was fabricated using a submerged arc process with a single electrode. CE maintained adequate records to determine the heat numbers of all plates and weld wire used in the fabrication of the beltline welds and plates.

2.1 Chemical Composition of Plates

The amount of copper and nickel in each plate was determined from either chemical analysis of each plate by the plate fabricator or from analysis of surveillance material. These data indicate that the plates will not be limiting with respect to embrittlement.

2.2 Chemical Composition of Welds

The amount of copper and nickel in each weld was determined from measurements of weld deposits that were fabricated using the same heat number of weld wire as used in the fabrication of the beltline welds in the Calvert Cliffs 1 and 2 reactor vessels. The limiting welds in the Calvert Cliffs 1 reactor vessel are the axial welds, which are reported to contain 0.21 percent copper and 0.88 percent nickel. The limiting welds in the Calvert Cliffs 2 reactor vessel are the axial welds, which are reported to contain 0.12 percent copper and 1.01 percent nickel.

All welds contain multiple data except for the limiting weld in Calvert Cliffs 2. Its chemistry was determined from a single data source, which did not include the amount of nickel. The staff is concerned that a single data point does not represent a best estimate value for this heat of wire because of the variability in the amount of copper observed in the other beltline welds.

2.3 Estimate of Embrittlement

The licensee estimates that with a flux reduction of 50 percent beginning with Cycle 11, the Calvert Cliffs 1 reactor vessel will reach the PTS screening criteria in 2005. The licensee estimates that the Calvert Cliffs 2 reactor vessel will reach the PTS screening criteria after the end of a 20-year license renewal period.

2.4 Surveillance Material Test Results

The Calvert Cliffs 1 and 2 reactor vessel material surveillance program contains weld metal and plate material. The surveillance plate materials were removed from plates that are in the beltlines and the surveillance welds were removed from welds that were fabricated using the same heat of weld wire as used to fabricate the circumferential welds in the beltlines. The test results from the surveillance welds and plates indicate that the measured increase in reference temperature resulting from neutron irradiation is less than the calculated ΔRT_{PTS} using the methodology in the amended PTS rule. Hence, the test results indicate that the methodology in the amended PTS rule is applicable to the Calvert Cliffs 1 and 2 reactor vessels.

In addition, the licensee reported test results from the Farley 1 and McGuire 1 surveillance programs, which contain weld samples that were fabricated using heats of weld wire used to fabricate welds in the Calvert Cliffs 1 and 2 reactor vessel beltline. The McGuire 1 surveillance weld represents the limiting weld in the Calvert Cliffs 1 reactor vessel. The test results from the McGuire

surveillance weld indicate that the ΔRT_{PTS} calculated using the methodology in the amended PTS rule is conservative for the limiting weld in the Calvert Cliffs 1 reactor vessel.

2.5 Irradiation Temperature

The method of calculating the RT_{PTS} was empirically derived from surveillance data from U.S. commercially-operated nuclear reactor vessels. The method is valid for a nominal irradiation temperature of 550 °F and irradiation below 525 °F is considered to produce embrittlement greater than the value predicted in the PTS rule.

The licensee indicates that except for fleeting excursions during transients at low power, the cold leg temperature was above 525 °F during power operation with the reactor critical. The licensee estimates that no more than 5 effective full-power hours (EFPH) of critical operation occurred with cold leg temperatures below 525 °F. The low power, low temperature transitory events correspond to a resultant fluence substantially below 10^{16} n/cm^2. The licensee indicates that the effect of such minimal low temperature irradiation on the RT_{PTS} value is negligible. The Calvert Cliffs 1 and 2 surveillance program support this conclusion because the measured increase in RT_{PTS} is less than the predicted value for both plates and welds.

2.6 Fast Neutron Fluence Estimates

The neutron fluence estimate was performed by Southwest Research Institute (SwRI) for Calvert Cliffs 1 and 2, using the two dimensional discrete ordinates transport code DOT and pin-wise source distribution. The SAILOR cross section library is based on ENDF/B-IV and the fission neutron spectrum was derived from ENDF/B-V. The $\varnothing(r,0)$ and $\varnothing(r,z)$ forward solutions were used with a three-dimensional flux synthesis. An S_8 quadrature and a P_3 scattering approximations were used for the solution. The source data were derived from the plant operating history.

The limiting elements for Calvert Cliffs 1 are the axial welds 2-203 (A, B and C) which are at the peak locations of the azimuthal distribution, thus, the peak value is the applicable value for the critical elements. No azimuthal distribution data was provided for Calvert Cliffs. However, the axial welds 2-203 (A, B and C) are also identified as the critical elements, thus, we assure them to be subject to the peak azimuthal fluence value.

The methodology and results comply with all the NRC staffs recommendations for fluence estimates.

3.0 CONCLUSIONS

Based on our review of the BG&E submittals, as detailed above, we have concluded:

a. The surveillance test results indicate that the value of RT_{PTS} calculated using the methodology in the PTS rule is applicable to the Calvert Cliffs 1 and 2 reactor vessels.

b. The methodology, approximations, and the source and cross sections used satisfy staff recommendation, therefore, the fluence estimates are acceptable.

c. Based on the reported material chemistry, irradiation temperature, and neutron fluence, the NRC staff determines that Calvert Cliffs 1 with a flux reduction of 50 percent beginning with Cycle 11 will each the PTS screening criteria in 2005. Additional information on material chemistry is needed for Calvert Cliffs 2.

d. As noted in Section 2.2 above, all welds contain multiple data relating to the chemical composition except for the limiting weld in Calvert Cliffs 2. The NRC staff has determined that the additional information identified in Enclosure 2 is needed to complete their review of Calvert Cliffs 2.

Principal Contributors:
B. Elliot
L. Lois

Date: July 15, 1992

Enclosure 2

Request for Additional Information
Calvert Cliffs 2

Paragraph (b)(2)(iv) in the amended PTS rule states, "weight percent copper and weight nickel are the best estimate values for the material, which will normally be the mean of measured values for a plate or forging or for weld samples made with the weld wire heat number that matches the critical weld. If these values are not available, the upper limiting values given in the materials specification to which the vessel was built may be used. If not available, conservative estimates (mean plus one standard deviation) based on generic data[1] may be used if justification is provided. If none of these alternatives are available, 0.35 percent copper and 1.0 percent nickel must be assumed."

The staff requests that the licensee provide additional information that demonstrates that the reported weight percent of copper and nickel for weld seams 2-203-A,B,C in the reactor vessel of Calvert Cliffs 2 comply with the requirements in paragraph (b)(2)(iv) of the amended PTS rule.

(1) The licensee should provide: a) the number and source of weld samples made with weld wire heat 8746 and b) the amount of copper reported from each sample.

(2) If the reported value of copper (0.12 percent) is not a mean value from weld samples, the licensee is requested to provide a best estimate of the amount of copper based on: (a) an upper limit from the material specification, (b) a conservative estimate based on generic data, or (c) the default value reported in the amended PTS rule. If generic data is utilized, provide the data and identify its source (i.e., vessel and weld wire heat identity, material specification, and date of its fabrication relative to Calvert Cliffs 2).

(3) Since the amount of nickel is unknown for weld wire heat 8746, the licensee is requested to provide a best estimate of the amount of nickel based method (a), (b), or (c) in the previous paragraph.

(4) Based on the best estimate of weight percent copper and nickel for weld seams 2-203-A, B, C, the licensee is requested to determine when the Calvert Cliff 2 reactor vessel is projected to reach the PTS screening criteria documented in 10 CFR 50.61.

---

[1]Generic data is data from reactor vessels fabricated in the same time period to the same material specification and the same shop as the Calvert Cliffs 2 reactor vessel.

This requirement affects on respondent and, therefore, is not subject to the Office of Management and Budget review under P.L. 96-511.

Sincerely,

Original Signed By:

Daniel G. McDonald, Senior Project Manager
Project Directorate I-1
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Enclosures:
1. Safety Evaluation
2. Request for Additional Information - Unit 2

cc w/enclosures:
See next page

DISTRIBUTION:
Docket File
NRC & Local PDRs
PDI-1 Reading
SVarga
JCalvo
RACapra
CVogan
DMcDonald
OGC
BElliot, 7/D/4
LLois, 8/E/23
RJones, 8/E/23
WBateman, 17/G/21
ACRS (10)
CCowgill, RGN-1
Plant File

OFFICE	PDI-1:LA	PDI-1:PM	PDI-1:D		
NAME	CVogan	DMcDonald:avl	RACapra		
DATE	7/15/92	07/15/92	7/15/92	/ /	/ /

OFFICIAL RECORD COPY
FILENAME: A:\CC82504.LTR