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AUTH.NAME AUTHOR AFFILIATION
CURTIS,N.W. Pennsylvania Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
SCHWENCER,A. Licensing Branch 2

SUBJECT: Forwards revs to FSAR Section 53 re stainless steel weld cladding & fracture toughness. Revs show conformance w/10cfr50 Apps G & H & will be incorporated in next FSAR amend.

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PP&L Pennsylvania Power & Light Company
Two North Ninth Street • Allentown, PA 18101 • 215 / 770-5151

Norman W. Curtis
Vice President-Engineering & Construction-Nuclear
215/770-7501

SEP 29 1983

Director of Nuclear Reactor Regulation
Attention: Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUSQUEHANNA STEAM ELECTRIC STATION
FSAR SECTION 5.3
ER 100508 FILE 841-1
PLA-1847 Docket No. 50-388

Dear Mr. Schwencer:

In order to support obtaining an operating license for Susquehanna SES Unit 2, enclosed are revisions to Section 5.3 of the Susquehanna SES FSAR. These revisions show the conformance of Unit 2 with 10CFR50 Appendices G and H. These revisions will be incorporated in the next amendment to the FSAR.

Very truly yours,

N. W. Curtis
Vice President-Engineering & Construction-Nuclear

Enclosure

cc: R. L. Perch NRC

B001
1/1

5.3.1.4.1.3 Regulatory Guide 1.43, (5/73) Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components

Reactor pressure vessel specifications require that all low alloy steel be produced to fine grain practice. The requirements of this regulatory guide are not applicable to BWR vessels.

5.3.1.4.1.4 Regulatory Guide 1.44, (5/73) Control of the Use of Sensitized Stainless Steel

Controls to avoid severe sensitization are discussed in Subsection 5.2.3.4.1.1.

5.3.1.4.1.5 Regulatory Guide 1.50 (5/73), Control of Preheat Temperature for Welding Low-Alloy Steel

Preheat controls are discussed in Subsection 5.2.3.3.2.1.

5.3.1.4.1.6 Regulatory Guide 1.71, (12/73) Welder Qualification for Areas of Limited Accessibility

Qualification for areas of limited accessibility is discussed in Subsection 5.2.3.3.2.3.

5.3.1.4.1.7 Regulatory Guide 1.99, (Rev. 1) Effects of Residual Elements on Predicted Radiation Damage to Reactor Pressure Vessel Materials

Predictions for changes in transition temperature and upper shelf energy were made in accordance with the requirements of Regulatory Guide 1.99.

5.3.1.5 Fracture Toughness

5.3.1.5.1 Compliance with 10CFR50 Appendix G

A major condition necessary for full compliance to Appendix G is satisfaction of the requirements of the Summer 1972 Addenda to Section III. This is not possible with components which were purchased to earlier Code requirements. For the extent of the compliance, see Tables 5.3-1a and 5.3-2a.

Ferritic material complying with 10 CFR 50, Appendix G, must have both drop weight tests and Charpy V-notch (CVN) tests with the CVN specimens oriented transverse to the principal material working direction to establish the RT_{NDT}. The CVN tests must be evaluated against both an absorbed energy and lateral expansion criteria. The maximum acceptable RT_{NDT} must be determined in accordance with the analytical procedures of ASME Code Section III, Appendix G. Appendix G of 10 CFR 50 requires a minimum of 75 ft-lb upper shelf CVN energy for beltline material. It also requires at least 45 ft-lb CVN energy and 25 mils lateral expansion for bolting material at the lower of the preload or lowest service temperature.

By comparison, material for the Susquehanna SES reactor vessels was qualified by either drop weight tests and/or longitudinally oriented CVN tests (both not required), confirming that the material nil-ductility transition temperature (NDTT) is at least 60°F below the lowest service temperature. When the CVN test was applied, a 30 ft-lb energy level was used in defining the NDTT. There was no upper shelf CVN energy requirement on the beltline material. The bolting material was qualified to a 30 ft-lb energy requirement at 60°F below the minimum preload temperature.

From the previous comparison it can be seen that the fracture toughness testing performed on the SSES reactor vessel material in some cases cannot be shown to comply with 10 CFR 50, Appendix G. However, to determine operating limits in accordance with 10 CFR 50, Appendix G, estimates of the beltline material RT_{NDT} and the highest RT_{NDT} of all other material were made, as explained in Subsection 5.3.1.5.1.2. The method for developing these operating limits is also described therein.

On the basis of the last paragraph on page 19013 of the July 17, 1973, Federal Register, the following is considered an appropriate method of complaince.

5.3.1.5.1.1 Intent of Proposed Approach

The intent of the proposed special method of compliance with Appendix G for this vessel is to provide operating limitations on pressure and temperature based on fracture toughness. These operating limits assure that a margin of safety against a nonductile failure of this vessel is nearly the same as that for a vessel built to the Summer 1972 Addenda.

The specific temperature limits for operation when the core is critical are based on 10 CFR 50, Appendix G, August 1973 revision (Unit 1), 10 CFR 50, Appendix G, July 1983 revision (Unit 2), and GE Licensing Topical Report, NEDO-21778-A.

5.3.1.5.1.2 Operating Limits Based on Fracture Toughness

Operating limits which define minimum reactor vessel metal temperatures vs reactor pressure during normal heatup and cooldown and, during in-service hydrostatic testing, were established using the methods of Appendix G of Section III of the ASME Boiler and Pressure Vessel Code, 1971 Edition, including the summer 1972 Addenda. The results are shown in Figure 5.3-4a for Unit 1 and 5.3-4b for Unit 2.

Estimated RT_{NDT} values and temperature limits are given in this section for the limiting locations in the reactor vessel.

All the vessel shell and head areas remote from discontinuties, all other shell and head areas, flanges plus the feedwater nozzles were evaluated, and the operating limit curves are based on the limiting location. The boltup limits for the flange and adjacent shell region are based on a minimum metal temperature of RT_{NDT} + 60°. The maximum through-wall temperature gradient from continuous heating or cooling at 100°F per hour was considered. The safety factors applied were as specified in ASME Code, Appendix G.

For the purpose of setting these operating limits, the reference temperature, RT_{NDT}, is determined from the toughness test data taken in accordance with requirements of the Code to which this vessel is designed and manufactured. This toughness test data, Charpy V-notch (CVN) and/or drop-weight nil-ductility transition temperature (NDT) is analyzed to permit compliance with the intent of 10 CFR 50, Appendix G. Because all toughness testing needed for strict compliance with Appendix G was not required at the time of vessel procurement, some toughness results are not available. For example, longitudinal CVN's, instead of transverse, were tested, usually at a single test temperature of +10°F or +40°F, for absorbed energy. Also, at the time either

CVN or NDT testing was permitted; therefore, in some cases both tests were not performed as is currently required. To substitute for this absence of certain data, toughness property correlations were derived for the vessel materials in order to operate upon the available data to give a conservative estimate of RT_{NDT}, compliant with the intent of Appendix G criteria.

These toughness correlations vary, depending upon the specific material analyzed, and were derived from the results of WRC Bulletin 217, "Properties of Heavy Section Nuclear Reactor Steels", and from toughness data from the Susquehanna SES vessels and other reactors. In the case of vessel plate material (SA-533 Grade B, Class 1), the predicted limiting toughness property is either NDT or transverse CVN 50 ft-lb temperature minus 60°F. CVN and NDT data are available for all the beltline plates. Where NDT results are missing, NDT is estimated as the longitudinal CVN 35 ft-lb transition temperature. The transverse CVN 50 ft-lb transition temperature is estimated from longitudinal CVN data in the following manner. The lowest longitudinal CVN ft-lb value is adjusted to derive a longitudinal CVN 50 ft-lb transition temperature by adding 2°F per ft-lb to the test temperature. If the actual data equal or exceed 50 ft-lb, the test temperature is derived by interpolation or conservatively taken as the transition temperature. Once the longitudinal 50 ft-lb temperature is derived, an additional 30°F is added to account for orientation effects and to estimate the transverse CVN 50 ft-lb temperature minus 60°F, estimated in the preceding manner.

For forgings (SA-508 Class 2), the predicted limiting property is the same as for vessel plates. CVN and NDT values are available for the vessel flange, closure head flange, and feedwater nozzle materials for Susquehanna SES. RT_{NDT} is estimated in the same way as for vessel plates.

For the vessel weld metal, the predicted limiting property is the CVN 50 ft-lb transition temperature minus 60°F, as the NDT values are -50°F or lower for these materials. This temperature is derived in the same way as for the vessel plate material, except the 30°F addition for orientation effects is omitted since there is no principal working direction. When NDT values are available, they are also considered and the RT_{NDT} is taken as the higher of NDT or the 50 ft-lb temperature minus 60°F. When NDT is not available, the RT_{NDT} shall not be less than -50°F, since lower values are not supported by the correlation data.

For vessel weld heat affected zone (HAZ) material, the RT_{NDT} is assumed the same as for the base material as ASME Code weld procedure qualification test requirements, and post weld heat treatment indicates this assumption is valid.

Closure bolting material (SA-540 Grade B24) toughness test requirements for Units 1 and 2 were for 30 ft-lb at 60°F below the bolt-up temperature. Current Code requirements are for 45 ft-lb and 25 mils lateral expansion (MLE) at the preload or lowest service temperature, including bolt-up. The reactor vessel closure studs for Unit 1 have a minimum Charpy impact energy of 40 ft-lbs and a 25-mil lateral expansion at 10°F. The lowest service temperature for the closure studs is 70°F for Unit 1. For Unit 2, the closure studs have a minimum Charpy impact energy of 48 ft-lb and a 27-mil lateral expansion at 10°F; therefore, the lowest service temperature for the Unit 2 closure studs is +10°F.

Using the above general approach, an initial RT_{NDT} of +18°F was established for the core beltline region for Unit 1 and +10°F for Unit 2.

The effect of the main closure discontinuity was considered by adding 60°F to the RT_{NDT} to establish the minimum temperature for boltup and pressurization. The minimum bolt-up temperature of +70°F for Units 1 and 2, which is shown on Figures 5.3-4a and 5.3-4b, is based on an initial RT_{NDT} of +10°F for the closure flange forgings.

The effect of the feedwater nozzle discontinuities was considered by adjusting the results of a BWR/6 reactor discontinuity analysis to the Susquehanna reactors. The adjustment was made by increasing the minimum temperatures required by the difference between the Susuehanna SES and BWR/6 feedwater nozzle forging RT NDT's. The feedwater nozzle adjustment was based on an RT_{NDT} of -16°F for Unit 1 and the maximum allowed RT_{NDT} of 40°F for Unit 2.

5.3.1.5.1.3 Operating Limits During Heatup, Cooldown and Core Operation

The fracture toughness analysis was done for the normal heatup or cooldown rate of 100°F/hour. The temperature gradients and thermal stress effects corresponding to this rate were included. The results of the analyses are a set of operating limits for non-nuclear heatup or cooldown shown as curves labeled B on Figures 5.3-4a and 5.3-4b. Curves labeled C on these figures apply whenever the core is critical.

TABLE 5.3-2a

APPENDIX G MATRIX FOR SUSQUEHANNA SES UNIT 2#

Appendix G Par. No.	Topic	Comply Yes/No Or N.A.	Alternate Actions Or Comments
I, II	Introduction; Definitions	--	
III.A	Compliance With ASME Code, Section NB-2300	Yes	See Subsection 5.3.1.5.1.2 for discussion.
III.B.1	Location & Orientation of Impact Test Spec	Yes	See III.A, above.
III.B.2	Materials Used to Prepare Test Specimens	No	Compliance except for CVN orientation and CVN upper shelf.
III.B.3	Calibration of Temp. Inst. and Charpy Test Machines	No.	Paragraph NB-2360 of the ASME B&PV code, Section IV, was not in existence at the time of purchase of the Susquehanna SES Unit 2 reactor pressure vessel. However, the requirements of the 1971 edition of the ASME B&PV Section III Code, Summer 1971 addenda, were met. For the discussions of the GE interpretations of compliance and NRC acceptance see References 1 and 2. The temperature instruments and Charpy Test Machines calibration data are retained until the next recalibration. This is in accordance with Reg. Guide 1.88 Rev. 2, GE Alternative Position 1.88, and ANSI N45.2.9, 1974. Therefore, the instrument calibration data for Susquehanna SES Unit 2 would not be currently available.
III.B.4	Qualification of Testing Personnel	No	No written procedures were in existence as required by the Regulation; however, the individuals were qualified by on-the-job training and past experience. For the discussion of the GE interpretation of compliance and NRC acceptance see References 1 and 2.
III.B.5	Test Results Recording and Certification	Yes	See References 1 and 2.
III.C.1	Test Conditions	No	See III.A, III.B.2, above.
III.C.2	Materials Used to Prepare Test Specimens for Reactor Vessel Beltline	Yes	Compliance on base metal and weld metal tests. Test weld not made on same heat of base plate, necessarily.
IV.A.1	Acceptance Standard of Materials	--	--
IV.A.2.a	Calculated Stress Intensity Factor	Yes	
IV.A.2.b	Requirements for Nozzles, Flanges and Shell Region Near Geometric Discontinuities	Yes	Plus 60°F was added to the RT_{NDT} for the reactor vessel flanges. For other nozzles and discontinuities the results of the BWR/6 analysis were adjusted to Susquehanna Unit 2 RT_{NDT} conditions.

Appendix G Par. No.	Topic	Comply Yes/No Or N.A.	Alternate Actions Or Comments
IV.A.2.c	RPV Metal Temperature Requirement When Core is Critical	Yes	
IV.A.2.d	Minimum Permissible Temp. During Hydro Test	Yes	
IV.A.3	Materials for Piping, Pumps and Valves	No	Main steamline piping is in compliance. See Subsection 5.2.3.3.1 for discussions on pumps and valves.
IV.A.4	Materials for Bolting and Other Fasteners	Yes	Current toughness requirements for closure head studs are met at 10°F.
IV.B	Minimum Upper Shelf Energy For RPV Beltline	No	No upper shelf tests run. However, recommend acceptance based upon lowest longitudinal CVN's for plates at +10°F of 45 ft-lb (50% shear) for heat C2421-3 (0.10% Cu), 50 ft-lb (50% shear) for heat C2929-1 (0.13% Cu), and 39 ft-lb (40% shear) for heat C2433-2 (0.10% Cu). Lowest CVN's for welds are 22, 30, 31, 43, 55 ft-lb (no % shear records) at -20°F with 0.06% Cu. The scatter in energy data at -20°F indicates transition behavior and the probability that upper shelf is in excess of 50 ft-lb (for 100% shear). End-of-life upper shelf values (100% shear) are predicted to be in excess of 50 ft-lb, based upon preceding data and Regulatory Guide 1.99.
IV.C	Requirement for Annealing When RT_{NDT} 200°F	N/A	
V.A	Requirements for Material Surveillance Program	See App. H	
V.B	Conditions for Continued Operation	Yes	See Sections 5.3.1.5.1.1, 5.3.1.5.1.2, 5.3.1.5.1.3, 5.3.1.5.1.4, 5.3.1.5.1.6, 5.3.1.6 and Table 5.3-2b
V.C.	Alternative If V.B Cannot Be Satisfied	--	--
V.D.	Requirement For RPV Thermal Annealing If V.C Cannot Be Met	N/A	
V.E	Reporting Requirement For V.C and V.D	N/A	

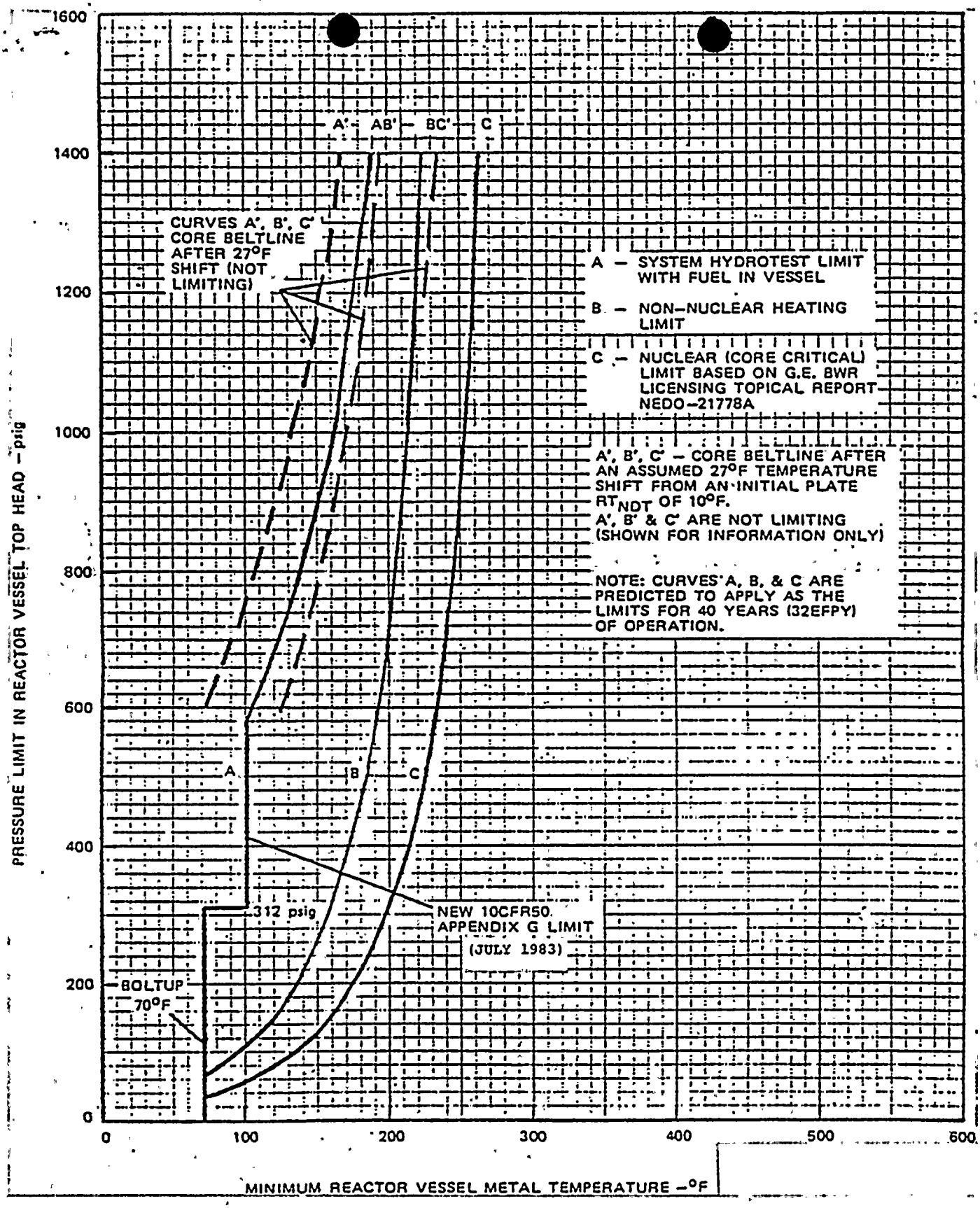
References

1. Letter MFN-414-77, G. G. Sherwood (GE) to Edson G. Case (NRC) dated October 17, 1977.

Appendix G Par. No.	Topic	Comply Yes/No Or N.A.	Alternate Actions Or Comments

2., Letter, Robert B. Minogue (NRC) to G. G. Sherwood (GE) dated February 14, 1978.

This table references the 1980 10CFR50 Appendices G and H requirements. The engineering rational used to meet the 10CFR50 Appendices G and H requirements of 1980 are equally applicable to meeting the 10CFR50 Appendices G and H requirements of 1983.



SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

MINIMUM TEMPERATURE REQUIRED vs. REACTOR PRESSURE SUSQUEHANNA UNIT 2

FIGURE 5.3-5