VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

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U. S. Nuclear Regulatory Commission
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Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
UPPER SHELF ENERGY OF REACTOR VESSEL MATERIALS

Virginia Electric and Power Company submits the following information in response to requests from the NRC staff currently involved in the review of an amendment request to modify the heatup and cooldown curves contained in the Surry Power Station Technical Specifications. A discussion of the anticipated date at which the lead material in the beltline region will reach 50 ft-lbs at the 1/4T position is provided in Attachment 1. Longer term actions being taken by the Company to address this issue include: membership in the Babcock and Wilcox (B&W) reactor vessel working group and a flux reduction program. This information is provided in Attachment 2.

The flux reduction program is proceeding toward a targeted implementation date in 1991. Because the associated design effort is in preliminary stages, it would be premature to identify a preferred method to be used to achieve flux reduction. Details of the project plan are provided in Attachment 2.

The B&W owners group reactor vessel working group is a collection of utilities that have reactor vessels fabricated by Babcock and Wilcox. The membership of this group includes utilities with B&W designed NSSS and seven Westinghouse utilities. The primary goal of this group is to provide a sound technical basis for the continued operability of the B&W fabricated reactor vessels. As a member of this group, the Company intends to participate in the course of action outlined in Attachment 2.

The information presented in Attachments 1 and 2 shows that the predicted Surry Unit 1 vessel upper shelf energy is not expected to go below 50 ft-lbs until 1998. Therefore, the subject license amendment is not impacted by this issue. In addition, the Company is involved in two independent programs to reduce flux and to demonstrate the continued operability of the reactor vessel with an upper shelf energy below 50 ft-lbs.

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During a recent conversation with the NRC staff it was indicated that upper shelf energy was the only unresolved issue pertaining to the amendment request. We believe the information contained herein answers your questions on this issue. Should you have further questions, please contact us.

Very truly yours,

W. L. Stewart
Senior Vice President - Nuclear

Attachments

cc: U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, N. W.
Suite 2900
Atlanta, Georgia 30323

Mr. W. E. Holland
NRC Senior Resident Inspector
Surry Power Station

Mr. Donald Howell
c/o Babcock & Wilcox
P. O. Box 10935
Lynchburg, Virginia 24506-0935

Mr. Michael F. Moylan
c/o Wisconsin Electric Power Company
231 W. Michigan
P. O. Box 2046
Milwaukee, Wisconsin 53201

ATTACHMENT 1

Upper Shelf Toughness Of Surry Reactor Vessel Materials

Of the four Virginia Electric and Power Company reactor vessels, the Surry Unit 1 vessel weld material is exhibiting the most pronounced radiation embrittlement. Although there are no significant operating differences between the four units, there is a distinct difference between the manufacturing processes and materials used to fabricate the four vessels. The reactor vessel fabrication was originally subcontracted by Westinghouse to Babcock and Wilcox. The work was transferred to Rotterdam Dockyard Company after the Unit 1 vessel was nearly completed. The Unit 2 vessel components were forged and the longitudinal welds were completed by B&W. However, the circumferential welding of the components were not completed by B&W. Most of the Surry Unit 1 vessel welds are B&W welds. The Surry Unit 2 vessel is comprised of Rotterdam and B&W welds.

The Linde 80 welds used in B&W manufactured vessels are characterized by relatively high copper and nickel impurity content. This relatively high impurity content results in a greater susceptibility to neutron induced embrittlement and consequently high shifts in RT_{NDT}. Furthermore, these welds have a relatively low initial upper shelf toughness. Therefore, the Surry Unit 1 vessel program must address both pressurized thermal shock and upper shelf toughness. Surry Unit 2 has some B&W welds but they are in low fluence regions so there is no anticipated PTS or upper shelf problem.

The fluence at which the limiting Surry Unit 1 reactor vessel weld is predicted to drop below 50 ft-lb has been calculated in accordance with the methods presented in Regulatory Guide 1.99, Revision 2, Section 2. Surveillance data for these calculations are obtained from the Wisconsin Electric and Power Company's reactor vessel surveillance program (1), which includes a surrogate weld material (SA-1263) for the limiting Surry Unit 1 weld (SA-1585).

10 CFR 50 Appendix H specifies that an integrated surveillance program may be considered for a set of reactors that have similar design and operating features. The design and operating features of the reactors in the set must be sufficiently similar to permit accurate comparisons of the predicted amount of radiation damage as a function of total power output. In order to show that there are no significant differences in operating conditions among the plants represented in the B&W integrated reactor vessel surveillance program, B&W has compared the flux spectra among participating B&W and Westinghouse reactors.

It has been concluded that the reactor vessels in the B&W integrated reactor vessel surveillance program comply with the assumptions and bases for an integrated surveillance program per 10 CFR 50 Appendix H. Therefore, it is appropriate to use applicable data from other reactors in the program to meet the plant specific data requirements of Regulatory Guide 1.99, Revision 2.

The following data pertaining to the surveillance weld material were taken from Table 5-9 and 5-10 of Reference (1):

	Fluence n/cm^2 $(x10^{19})$	USE* ft-lb	USE Decrease ft-lb	% Decrease in USE
Unirradiated:	0.0	65	n/a	n/a
Capsule				
V	5.44	53	12	18.5
S	7.55	52	13	20.0
R	20.80	51	14	21.5
T	21.10	55	10	15.4

*Upper Shelf Energy

These data were plotted and bounded by a line in accordance with the procedure of Reg. Guide 1.99 Rev. 2. The fluence at which the predicted percent decrease in USE energy equals 23.1% (corresponding to a reduction from 65 ft-lbs to 50 ft-lbs) was determined from this line to be 1.3×10^{19} n/cm^2. This is the fluence which must be attained at the 1/4-T location to reduce the predicted USE to 50 ft-lbs.

The 1/4-T fluence may be converted to a vessel inner-surface fluence by using Equation 3 from RG 1.99 Rev. 2. (The 1/4-T thickness, x, is 2.0125 inches.) The surface fluence is calculated to be 2.11×10^{19} n/cm^2. By interpolating this value against the data of Table 6-3 in Reference (2), it is estimated that the 50 ft-lb level will be reached at approximately 14.9 EFPY, which presently is projected as sometime during the year 1995. This calculation assumes that Cycle 10 ends as scheduled in October of 1990.

The data presented in Table 6-3 (2) assume that the flux to the reactor vessel at the 0° beltline weld location will be the same in cycles 9 and 10 as it was in cycle 8. This assumption results in a predicted fluence as a function of time greater than that which is indicated by actual cycle data. According to cycle design data, a reduction of greater than 30% in the relative power distribution of the three assemblies facing the 0° weld has been achieved for cycles 9 and 10 relative to cycle 8. (The three assemblies nearest the 0° weld location contribute over 90% of the flux to that location.) The relative power distributions in the three assemblies facing the 0° weld are expected to be maintained at values comparable to those of cycle 10 for future cycles.

Accounting for actual and expected fluences to the beltline welds at the 0° location, the limiting Surry Unit 1 weld is expected to drop below 50 ft-lb USE at approximately 17.8 EFPY sometime near the end of 1998. Implementation of a flux reduction program would push this date farther into the future.

Although the upper shelf energy is conservatively predicted to reach the 50 ft-lb action level during 1995, it is expected that the operability of the Surry Unit 1 reactor vessel may be demonstrated up to, and perhaps beyond, the end of its currently licensed life. Results of fracture toughness tests with Linde 80 welds indicate that even at upper shelf energies below 50 ft-lbs, the welds will retain sufficient fracture toughness to allow demonstration of adequate margins of safety against failure with fluences up to 2.5 x 10^{19} n/cm^2, which will not occur on Unit 1 during its licensed period of operation. Additional testing is planned to allow more extensive characterization of the elastic/plastic behavior of the Linde 80 class of weld metals exposed to greater fluences. Characterization of the shift in transition temperature will make it possible to define heatup and cooldown curves meeting the requirements of Appendix G at fluences greater than 2.5 x 10^{19} n/cm^2.

REFERENCES

1. "Analysis of Capsule T from the Wisconsin Electric Power Company Point Beach Nuclear Plant Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-10736, dated December, 1984.

2. "Analysis of Capsule V from the Virginia Electric and Power Company Surry Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-11415, dated February, 1987.

ATTACHMENT 2

Long Term Actions In Response To The Low Upper Shelf Toughness Issue

MEMBERSHIP IN THE B&WOG

The B&WOG has historically been proactive in addressing the reactor vessel embrittlement issue. For instance, the B&WOG has already acquired NRC approval of fracture toughness testing procedures(1), a fracture mechanics analysis procedure(2), and an integrated reactor vessel surveillance program(3). These items are necessary to demonstrate that it is feasible to continue to operate a reactor vessel with materials that have fallen below the 10 CFR 50 Appendix G limit of 50 ft-lbs on upper shelf toughness. Based on their proactive approach, and the fact that the reactor vessels for Surry Units 1 and 2 were partially fabricated by B&W, Virginia Electric and Power Company decided to join the B&WOG. Four other utilities with Westinghouse nuclear steam supply systems utilizing B&W fabricated reactor vessels also decided to participate in the vessel operability activities of the B&WOG. The participating utilities with Westinghouse NSSS plants include Commonwealth Edison Company, Florida Power & Light Company, Rochester Gas & Electric Corporation, and Wisconsin Electric Power Company. The B&WOG Materials Committee, which includes six utilities with B&W supplied NSSS and the four Westinghouse utilities, has formed the Reactor Vessel Working Group. The purpose of the Reactor Vessel Working Group as stated in its charter is, "...To identify problems and solutions to problems related to the materials and structural integrity of B&W manufactured reactor vessels in nuclear power plants in order to improve safety, achieve high plant availability, and reduce costs." Four of the projects being undertaken by the working group to fulfill the objectives of the group are:

1. Expansion of the integrated reactor vessel materials surveillance program, BAW-1543, to include the five Westinghouse owners and better share and utilize pertinent materials property data for the Linde 80 welds.

2. Fabrication of eight new surveillance capsules to be inserted in two B&W reactors and Surry Unit 2 (1 capsule) to acquire additional material property data for several representative weld metals to support continued operability and life extension.

3. Revision of BAW-10046 to provide applicability of these fracture mechanics procedures to the participating Westinghouse owners.

4. Submittal to the NRC of a new procedure, BAW-2086, for testing wedge open loading (WOL) fracture mechanics specimens which have been irradiated in the Westinghouse owner's plants and which can supply valuable information about the fracture toughness of Linde 80 weld metals at higher fluences than have been achieved in the B&W integrated surveillance program to date.

The projects listed above are currently underway. The submission of reports BAW-1543, BAW-2086, and BAW-10046 has already occurred with anticipated NRC approval pending. The fabrication of new surveillance capsules is underway at B&W.

An aspect of the new capsule fabrication and testing activities is the potential use of previously irradiated WOL specimens. This would involve recovery of previously irradiated capsule materials from Westinghouse, Southwest Research Institute, and Battelle Columbus Laboratories where they had been initially tested. These materials would then be transferred to B&W for possible reconstitution of some specimens for use in the new capsules and testing of the previously unbroken WOL specimens. This work is proceeding with materials already having been recovered from Southwest Research Institute. Plans for transfer are underway with Westinghouse and Battelle. Completion of this task in the near term will facilitate fabrication of the new surveillance capsules and acquisition of materials testing data for Linde 80 welds of interest.

FLUX REDUCTION PROGRAM

The Company is about midway through a flux reduction study for Surry Unit 1. The intent of the program is to reduce the neutron flux at the critical locations (i.e. certain welds) in order to maintain the neutron fluence below levels that violate regulatory limits (e.g. 50 ft-lbs USE and PTS Screening Criteria). The study has considered both fuel assembly modifications and vessel internals modifications.

Preliminary design calculations indicate that the desired level of flux reduction can be achieved using part length absorber in the control rod guide tubes of the peripheral assemblies located near the critical locations. Fuel assembly inserts also appear to be the most economical means of achieving the desired flux reduction. By inserting absorbers that are approximately half the length of a fuel rod, the neutron flux at the critical locations can be effectively reduced with a minimum impact on fuel cycle design or economics.

Surry Unit 1 has operated with a low leakage core design for the past three cycles. Therefore, it is not necessary to reduce the neutron leakage as much as it is to shape the escape flux. We are presently assessing whether or not to provide the part length absorbers as part of the Surry 1, Cycle 13 design. This cycle is currently scheduled to begin operation toward the end of 1992.

The reduced fluence goal was selected based on several criteria. Most important is the goal of demonstrating continued operability of the vessel throughout the license period. Next, is the goal of maintaining the option for plant life extension beyond the forty year design limit. Based on the results shown in Attachment 1 and the WCAP-11015[5], flux reduction is only necessary for the latter goal. Finally, these goals must be achieved using design strategies that lead to the safe and efficient operation of the Surry Power Station.

REFERENCES

1. J. D. Aadland et al, "Babcock & Wilcox J-R Procedure for Compact Fracture Toughness Specimens," B&W-1808, Babcock & Wilcox, Lynchburg, Virginia, December 1984.

2. "Methods of Compliance With Fracture Toughness and Operational Requirements of 10CFR50, Appendix G," B&W-10046, Rev. 2, Babcock & Wilcox, Lynchburg, Virginia, December 1984.

3. A. L. Lowe, Jr., et al., "Integrated Reactor Vessel Material Surveillance Program," B&W-1543A, Rev. 2, Babcock & Wilcox, Lynchburg, Virginia, May 1985.

4. Yanichko, S. E. and Perone, V. A., "Analysis of Capsule V From The Virginia Electric and Power Company Surry Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-11415, February 1987.

5. Perone, V. A., et al, "Surry Units 1 and 2 Reactor Vessel Fluence and RT_{pts} Evaluations," WCAP-11015, Rev. 1, April 1987.