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August 26, 1977

Mr. Donald K. Davis, Acting Chief
Operating Reactors - Branch 2
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad-Cities Station Units 1 and 2
Request for Information Concerning
Reactor Vessel Material
NRC Docket Nos. 50-237/249 and 50-254/265

References (a): D. K. Davis letter to R. L. Bolger, dated May 20, 1977.

(b): D. E. O'Brien letter to D. K. Davis, dated August 9, 1977.

Dear Mr. Davis:

This letter and the enclosure contain Commonwealth Edison's response to Reference (a) requesting information concerning the Dresden and Quad-Cities reactor vessel material surveillance programs. Dresden Units 2 and 3 and Quad-Cities Units 1 and 2 are addressed in this response. Dresden Unit 1 information will be transmitted by October 26, 1977, as indicated in Reference (b).

The attached generic report prepared by General Electric presents a position that radiation damage differences between material repæesented in the metal surveillance program and other beltline materials are very small. The relatively low end of life fluence and the expected compositional variations contribute to this position. Based on this, we consider the requested detailed information in Reference (a) to be unnecessary for the NRC Staff to judge the adequacy of the Dresden Units 2 and 3 and Quad-Cities Units 1 and 2 material surveillance programs.

The following information specific to Dresden Units 2 and 3 and Quad-Cities Units 1 and 2 reactor vessels is provided to further aid the Staff in its review.

1. The end of life fluence at the inner wall is 2.4 x 10^{17} nvt (>1 MeV) based on 40 years at 80% capacity factor.

2. The beltline regions of the reactor pressure vessels contain a circumferential submerged arc weld and longitudinal electroslag welds.

3. The metal surveillance program for each vessel is described in GE Report NEDO 10115, Class 1, dated July, 1969, entitled "Mechanical Property Surveillance of General Electric BWR Vessels".

4. Chemical analyses of materials in the Dresden Unit 3 and Quad-Cities Units 1 and 2 surveillance programs determined the Cu, P, and S contents to be as given in the attached table. Chemical analyses have not been made on Dresden Unit 2 materials.

5. Unirradiated charpy v-notch and tensile properties of materials in the Dresden Units 2 and 3 and Quad-Cities Units 1 and 2 surveillance programs are given in the attached table.

Please direct any additional questions concerning this matter to this office.

One (1) signed original and 59 copies of this letter are provided for your use.

Very truly yours,

for [signature]

M. S. Turbak
Nuclear Licensing Administrator
Boiling Water Reactors

Attachment

Table - Chemical Composition and Mechanical Properties of Materials Included in the Material Surveillance Programs

		Composition (Weight Percent)			Charpy Data		Tensile Data[2]			
		Cu	P	S	30Ft-Lb. Temp.(°F)	Upper Shelf (Ft-Lbs.)	YS (psi)	TS (psi)	Elong. (%in 2")	Red. A (%)
D2	Base Material	ND[1]	ND	ND	0	153	61,400	82,800	22.6	63.5
	Subarc Weld				-13	71	65,400	83,200	18.5	53.6
	Electroslag Weld				-10	101	ND	ND	ND	ND
D3	Base Material	0.14	0.009	0.013	-10	135	58,150	84,320	21.1	68.2
	Subarc Weld	0.35	0.013	0.013	-45	65	63,430	81,720	19.4	47.5
	Electroslag Weld	0.20	0.011	0.015	40	70	54,570	80,120	18.7	57.1
QC1	Base Material	0.22	0.010	0.021	-30	105	61,210	87,980	21.5	60.4
	Subarc Weld	0.31	0.010	0.014	-30	72	62,220	81,260	17.0	51.9
	Electroslag Weld	0.17	0.011	0.017	10	100	56,160	79,190	16.3	52.5
QC2	Base Material	0.10	0.007	0.009	-15	135	60,400	87,370	22.2	58.8
	Subarc Weld	0.26	0.013	0.014	15	95	55,510	77,960	21.0	51.9
	Electroslag Weld	0.18	0.011	0.013	-30	125	55,220	77,310	19.1	59.6

[1]ND - not determined

[2]Tested at 550F

REACTOR VESSEL MATERIAL SURVEILLANCE PROGRAM

The NRC requested Commonwealth Edison Company to provide a detailed list of information relative to the Dresden and Quad Cities reactor vessels. The staff's concern is that the materials used in reactor vessel fabrication may have a wider variation in sensitivity to radiation damage than originally anticipated. In addition, some reactor vessels incorporate more than one heat of materials, including weld materials in their belt line region, but all of these heats may not be included in the reactor vessel material surveillance program. The purpose of this paper is to show that General Electric's program of reactor vessel surveillance is completely responsive to 10CFR50, Appendix H. Further, it will be shown that the effect on adjusted reference temperature for the most adverse materials in BWR/2 through BWR/4 plants irradiated to the maximum 40-year fluence observed is very small.

General Electric has addressed the problem of obtaining representative surveillance specimens since the beginning of its reactor pressure vessel surveillance program. The material for base metal specimens has been taken from a plate used in the vessel beltline region or from a plate of the same heat of material. The same plate used for base metal specimens is used for production of heat-affected zone specimens, and the weld specimens are produced by the identical weld practice and procedures used in the vessel fabrication. For vessels constructed from plate, the vessel longitudinal welds are represented; while for vessels fabricated from forged rings, the girth welds are represented. When widely varying weld practices such as submerged metal arc and electroslag welding are used jointly in a vessel, both are represented in the surveillance program material. Thus, the surveillance specimens do represent the materials and processing of the vessel beltline region.

The procedures described above were used to select surveillance materials and to prepare specimens for all operating BWR 2 through 4 plants. Examination of this method of selection, even in light of the most recent data, reveals that the reactor pressure vessel surveillance specimens currently in use still provide a reasonable representation of the limiting materials in the reactor vessel beltline region.

The production of the vessel beltline region is generally accomplished by the welding of several plates and, most often, several heats of steel are involved. The vessel surveillance specimens are produced from one of these heats. The possible variation of the other beltline heats, however, is limited by the characteristic range of compositions resulting from the material production practices. Consultation with the domestic heavy-section pressure vessel steel mill, Lukens Steel, concerning process capability and a survey of 10 BWR vessels reveals that the residual element of major importance, copper, lies consistently within the 0.15 to 0.20 weight percent range when special low-copper scrap selection procedures are not invoked on the mill process.

Examination of the predicted effect of residual element composition on the irradiation behavior of pressure vessel steels as provided in Regulatory Guide 1.99 and a preliminary analysis of GE data in the BWR fluence range from 10 operating BWR's representing copper contents in the range .01 to 0.30 weight percent and phosphorous contents in the range .007 to 0.02 weight percent reveals a minimal impact due to the possible variation in base metal composition that could be present in the vessel beltline. Data at the upper end of the copper range (0.30%) was obtained from an atypical source. It represents a foreign plant with a forged ring produced by foreign practice. It does, however, provide additional support for predicting the maximum effect of elevated copper contents.

For most operating BWR 2 through 4 vessels, with some exceptions, the predicted end of 40-year life fluence at the vessel wall 1/4T location is below 2×10^{18} nvt (> 1 MeV). For this fluence range, an estimated end of life variance of approximately 15°F in transition temperature shift would be indicated for a copper composition range of 0.15 to 0.20

weight percent copper. This variance represents the expected deviation in predicted transition temperature shift due to compositional differences. That is, at the end of life fluence, the predicted shift in transition temperature could vary by 15°F depending on the composition of the heat of plate material in question. Thus, even with the maximum predicted variability of copper content for the beltline plate material, a minimal variation in predicted transition temperature shift is expected.

For the one plant with a predicted 1/4T fluence value of 3×10^{18} nvt (>1 MeV) at the end of life, the effect of the maximum expected variation of copper content would be approximately a 30°F variation in predicted transition temperature shift. This variation, while larger than that expected for all other operating BWR/2 through 4 plants is not prohibitively large, particularly since it represents the worst case of surveillance specimens with 0.15% Cu while other heats in the beltline contain 0.20% copper.

Similarly, the variability of weld metal properties within the beltline region does not present a major obstacle to their effective representation by the current surveillance specimens. Typically, the range of residual element compositions present in weld metal falls within several major bands determined by weld process, electrode coating, and flux type. This variability inherent to process characteristic is already taken into account by the fact that the identical weld process and procedures used in vessel manufacture are used to produce the surveillance weld specimens. The copper content range resulting strictly from heat to heat variations of filler metal composition within a given process, however, would still require the surveillance specimens to adequately represent a limited range of weld metal composition which could be present in the vessel beltline region when more than one heat of filler metal was used for fabrication of this region.

Discussions with the major reactor pressure vessel fabricators and a survey of weld practices used in 10 BWR pressure vessels has characterized the ranges of copper contents expected for the weld metal in the vessel beltline. The copper content range for electroslag welds and submerged arc welds made without copper coated electrodes is expected to be 0.15 to 0.20 weight per cent copper. For shielded metal arc welds, a copper content of less than 0.15 weight percent should result; while for submerged metal arc welds made with copper coated electrodes, a typical range of 0.25 to 0.30 weight percent copper with maximum outside limits of 0.20 to 0.40 weight percent would be expected.

The net effect of the characteristic variations in copper content for each of these weld procedures can be estimated by the prediction methods of Regulatory Guide 1.99 and by the preliminary analysis of extensive GE data in the BWR fluence range. The shielded metal arc welds, electroslag welds, and submerged metal arc welds made without copper coated electrodes would exhibit approximately a 10 to 15°F variation in transition temperature response due to residual element composition at the maximum 1/4 T end-of-life fluence expected for BWR/2, 3 and 4 plants.

For submerged metal arc welds made with copper coated electrodes, a larger variation is expected. The typical copper content of 0.25 to 0.3 weight percent exhibited by these welds would result in a 25° F variation in transition temperature shift at 2×10^{18} nvt (> 1 mev). The maximum range of copper contents exhibited by this process (0.20 to 0.40 weight percent) would result in approximatey a 50° F variation in transition temperature shift at the 2×10^{18} nvt 1/4 T end-of-life fluence value. Because of the steps taken to assure duplication of the exact vessel weld procedure and welding parameters in making the surveillance weld, however, the typical range of 0.25 to 0.30 weight percent rather than the maximum process range of 0.20 to 0.40 weight percent should be expected to characterize the variation between surveillance samples and vessel welds for any given vessel. Thus, a variation of approximately 25° F would be the best-estimate of the variation in transition temperature response for submerged metal arc welds made with copper coated filler wires at end-of-life due to compositional variations between the weld metal in the surveillance samples and the actual welds in the pressure vessel.

Based on the preceding discussion, the selection of materials for the reactor pressure vessel surveillance programs in BWR 2, 3 and 4's does reasonably represent the materials in the beltline region of the vessel. The steps taken by General Electric to assure adequate representation of the welds process and all subsequent material processing steps seen by the vessel materials limits the only possible variation between surveillance specimens and vessel material to the heat to heat variability of base metal and weld metal. The net, end of 40-year life effect of these possible variations, is projected to be only a 10°to 25° F variability in the predicted transition temperature shift for the BWR fluence range. Included in the analysis of the behavioral variations due to compositional variations is a major factor of conservatism. The maximum expected composition range for each material condition is used as a basis for the estimated effects of composition. Rarely will the heat of surveillance sample material happen to fall at the exact bottom of the expected copper content range while the vessel materials from the other heats in the beltline fall at the top of the same copper range. Thus, the estimated effects projected in this paper will tend to be minimized by the actual conditions in the field.

Although it is still important to know the residual element composition of the vessel steel and surveillance specimens for complete analysis of surveillance test results, this information can easily be obtained by chemical analysis of archive material and analysis of specimens at the time of testing. General Electric believes that the steps taken during the production of BWR pressure vessel surveillance specimens adequately assure reasonable representation of the vessel material and that any variations in irradiation behavior between the surveillance materials and additional heats of vessel materials would be minimal in the BWR fluence range.