Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

July 7, 1992

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-259 50-327
Tennessee Valley Authority	)	50-260 50-328
	)	50-296 50-390
	)	50-391

BROWNS FERRY NUCLEAR PLANT (BFN), SEQUOYAH NUCLEAR PLANT (SQN), AND WATTS BAR NUCLEAR PLANT (WBN) - RESPONSE TO GENERIC LETTER 92-01 (REACTOR VESSEL STRUCTURAL INTEGRITY)

Enclosed is TVA's response to the subject generic letter. Enclosure 1 contains the response for BFN, Enclosure 2 for SQN, and Enclosure 3 for WBN. Commitments made in this letter are identified in Enclosure 4. The NUMARC recommended response guidelines have been utilized to the extent practical.

If you have any questions, please contact me at (615) 751-2687 in Chattanooga.

Sincerely,

Ralph H. Shell

Ralph H. Shell
Manager
Regulatory Licensing

Sworn to and subscribed before me
this 7 day of July 1992

Notary Public

My Commission Expires 12-23-95

Enclosures
cc: See page 2

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cc (Enclosures):

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ENCLOSURE 1

BROWNS FERRY NUCLEAR PLANT - RESPONSE TO GENERIC LETTER 92-01

1. The surveillance programs for Browns Ferry (BFN) Units 1, 2, and 3 reactor pressure vessels were developed to meet the requirements of ASTM E 185-66. The Browns Ferry surveillance program is described in NEDO-10115 and the core region materials information for all three units is given in BAW-1845. It is TVA's position that the surveillance program meets the requirements of Appendix H to 10 CFR Part 50. Three test capsules containing Charpy V-notch and tensile specimens of the base metal, heat-affected zone, and representation weld metal are currently installed in each vessel. In addition, a vessel wall dosimeter capsule was analyzed at the end of the first cycle by Southwest Research Institute (SwRI).

   The BFN pressure vessels were fabricated from plate material (supplied by Lukens Steel) which was rolled to contour, then each plate was welded together with longitudinal seams using the electroslag (ES) welding process and HiMnMo consumables. Subsequent to each shell being welded/assembled, each shell course was heat treated, prolongation material removed, and stress relieved. The circumferential weld seams to join the shell courses used the automatic submerged arc (ASA) welding process. The beltline shell courses, Mk-57 and Mk-58 were fabricated by Babcock & Wilcox (B&W) for all three Browns Ferry vessels. The Mk-57 to Mk-58 circumferential weld seam was completed by B&W for BFN Unit 1, and by Ishikawajima Heavy Industries (IHI) for BFN Units 2 and 3. A schematic of the BFN reactor vessel location of core region is given in figure 1. Detailed information may be found in BAW- 1845.

2.a. Upper Shelf Energy (USE) Predictions

   Fluence value achieved by BFN Units 1, 2, and 3 on December 16, 1991, and predicted for end-of-life at 32 effective full power years (EFPY) at the 1/4 thickness (1/4T) vessel wall position all fall below 1×10^{18} n/cm^2 (E > 1 MeV). Consequently, upper shelf prediction cannot be achieved through interpolation of Figure 2 of Regulatory Guide 1.99, Revision 2. Therefore, in order to determine predictions of upper shelf energies for this submittal, linear extrapolations of the curves to lower fluence values were made. Table 1 gives a summary of the predicted upper shelf energies. As shown by this table, no upper shelf energies are predicted to fall below 50 foot-pounds before the end-of-life (32 EFPY) for either of the three vessels, based on current fluence projections.

   No upper shelf energy was determined during vessel plate qualification. Therefore, a generic use of 120 ft-lbs was estimated based on the four surveillance plate material USEs and applied to all plate materials with no measured USE.

Figure 1 Browns Ferry Reactor Vessel
Core Region Location Elevation

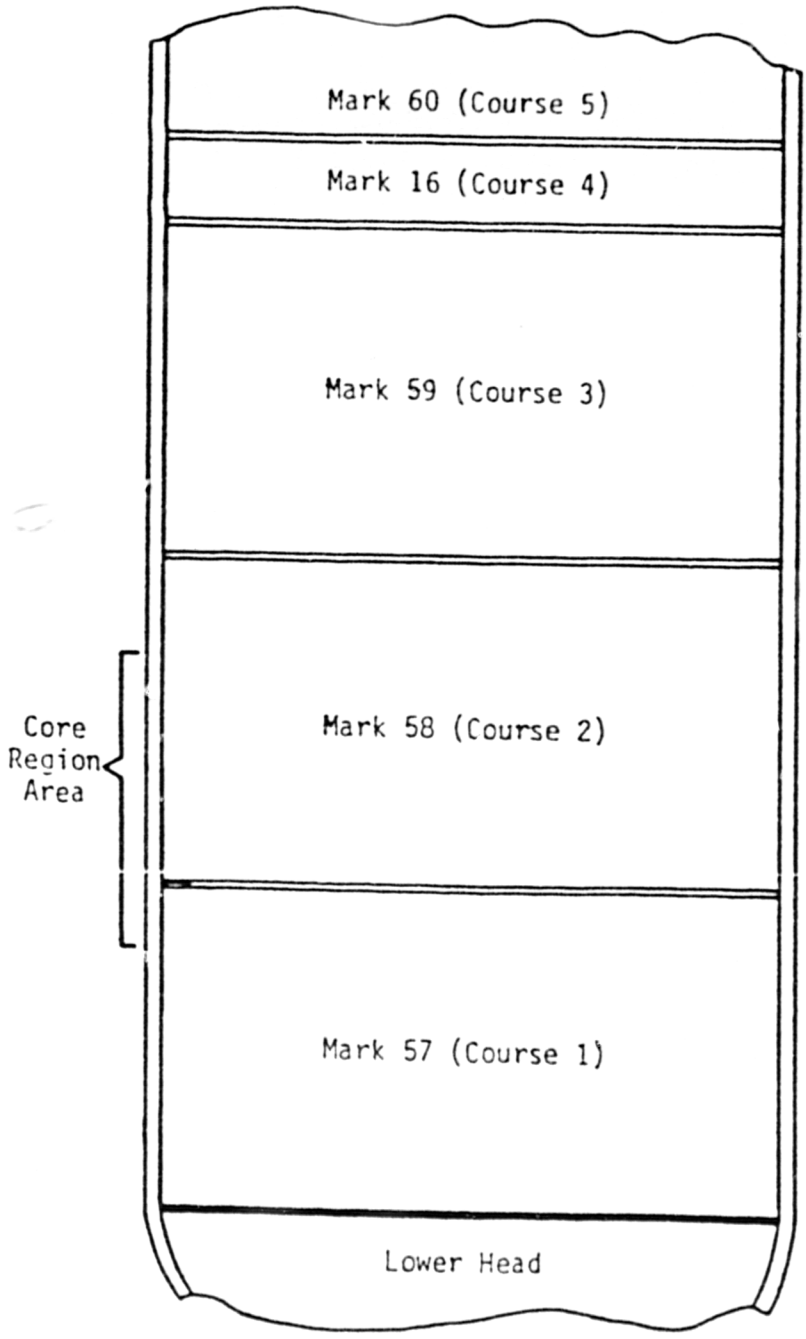

Table 1

UPPER SHELF ENERGY PREDICTIONS

Unit	Material	Copper Content wt/%	USE[1,2] Measured ft-lb	Predicted 1/4T Decrease at 12/16/91 %	Predicted 1/4T Decrease at EOL %	Predicted 1/4T USE at 12/16/91 ft-lb	Predicted 1/4T USE at EOL ft-lb
1	Intermediate Shell C-2868-2	0.09	144(93.6)	7	10	134(87.0)	130(84.2)
	Intermediate Shell C-2884-2	0.12	118(76.7)	8.2	11	108(85.9)	105(68.3)
	Intermediate Shell C-2753-1	0.08	120(78)	6.6	9.6	112(72.8)	108(70.5)
	Intermediate Shell ES welds (3)	0.25	95	15	22	80.8	74.1
	Circ. weld ASA weld-WF154	0.31	66	19	23[3]	53.5	50.8
	Lower Shell A1009-1	0.14	120(78)	9	13	109(71.0)	104(67.9)
	Lower Shell B5864-1	0.15	120(78)	9.5	13.5	109(71.0)	104(67.9)
	Lower Shell A0999-1	0.14	120(78)	9	13	109(71.0)	104(67.9)
	Lower Shell ES welds (3)	0.25	95	15	22	80.8	74.1
2	Intermediate Shell A0981-1	0.14	142(92.3)	9	13	129(84.0)	124(80.3)
	Intermediate Shell C2467-1	0.16	120(78)	10	13.5	108(70.2)	104(67.5)
	Intermediate Shell C2849-1	0.11	120(78)	7.8	10.5	111(71.9)	107(69.8)
	Intermediate Shell ES welds (3)	0.25	95	15	21.5	80.0	74.6
	Circ. weld ASA weld-D55733	0.09	145	7	10	134.8	130.5
	Lower Shell C2467-2	0.16	120(78)	10	14	108(70.2)	103(67.1)
	Lower Shell C2463-1	0.17	120(78)	10.5	14.5	107(69.8)	103(66.7)
	Lower Shell C2460-2	0.13	120(78)	8.6	12	110(71.3)	106(68.6)
	Lower Shell ES welds (3)	0.25	95	15	22	80.8	74.1
3	Intermediate Shell C3188-2	0.10	158(103)	7.4	10	146(95.4)	142(92.7)
	Intermediate Shell C3201-2	0.13	120(78)	8.6	12	110(71.3)	106(68.6)
	Intermediate Shell B7267-1	0.13	120(78)	8.6	12	110(71.3)	106(68.6)
	Intermediate Shell ES welds (3)	0.25	95	15	21.5	80.8	74.6
	Circ. weld ASA weld-D55733	0.09	195	7	9.8	181	176
	Lower Shell C3213-1	0.13	120(78)	8.6	12	110(71.3)	106(68.6)
	Lower Shell C3222-2	0.15	120(78)	9.5	13	109(70.6)	104(67.9)
	Lower Shell C3217-2	0.14	120(78)	9	12.5	109(70.0)	105(68.2)
	Lower Shell ES welds (3)	0.25	95	15	22	80.8	74.1

[1] Numbers in ( ) are longitudinal Charpy USE values from BAW-1845, reduced to 65%.

[2] A Generic USE value of 120 ft-lb, based on the four surveillance plate USEs, was asssigned to plate materials with no measured USE.

[3] Maximum 1/4T fluence at the circumferential weld seam in reference to the core centerline was used to make this USE prediction.

2.a. (continued):

Unit 1 circumferential weld WF-154, fabricated with Linde-80 flux and characterized by bounding chemical and mechanical parameters, is predicted to have an upper shelf of 50.8 ft-lbs at 32 EFPY based on Reg. Guide 1.99, Revision 2. The upper shelf energy when evaluated on the basis of an evaluation conducted by B&W on the "Effects of Neutron Irradiation on Linde-80 Weld Metal Upper Shelf Energy," (BAW-1803) predicts an upper shelf energy of 56.8 ft-lbs at the same fluence value. This calculation, shown below, involves the expression:

$$USE = -4.91\ (\mathrm{Log}_{10}F) - 68.35\ (\%Cu) + 164.96\ (\text{Std. Dev} = 1.5\ \text{ft-lb})$$

for 0.31% Cu and a fluence of 5.22×10^{17}:

$$USE = -4.91\ \mathrm{Log}\ (5.22 \times 10^{17}) - 68.35\ (0.31) + 164.96$$

$$= -87 - 21.2 + 164.96$$

$$= 56.8\ \text{ft-lbs @ 1 Std. Dev} = 1.5\ \text{ft-lbs}$$

Fluence values used in upper shelf predictions:

The results of analysis of the Browns Ferry vessel wall dosimeters at the end of the first cycle indicate the peak of the fast neutron flux incident on the reactor vessel wall to be:

Unit	Surface Fluence[1] (per EFPY)	1/4T Fluence (per EFPY)	1/4T Fluence (32 EFPY)	EFPY on 12/16/1991	1/4T Fluence 12/16/1991
	$\times 10^{16}$ n/cm^2	$\times 10^{16}$ n/cm^2	$\times 10^{17}$ n/cm^2	years	$\times 10^{17}$ n/cm^2
1	3.91	2.677	8.57	6.09	1.62
2	3.34	2.287	7.32	5.95	1.36
3	3.28	2.245	7.19	4.64	1.04

[1]Data from SwRI Projects 02-4884-001 (Unit 1), 02-4884-002 (Unit 2), and 02-4884-003 (Unit 3).

At 1/4 thickness, the fluence is given as:

$$\text{fluence}_{1/4T} = \text{fluence}_{surf.}(e^{-0.24X})$$
$$X_{1/4T} = 1/4\ (6.125 + 0.1875\ \text{in.}) = 1.578\ \text{in.}$$
$$\text{fluence}_{1/4T} = \text{fluence}_{surf.}(e^{-0.24 \times 1.578})$$
$$= \text{fluence}_{surf.}(e^{-0.379})$$
$$= \text{fluence}_{surf.} \times 0.6847$$

The circumferential weld seam between shell courses Mk-57 and Mk-58 is located 37.81 inches below the core midplane. The flux at this position is 0.755 x

10^9 nvt/sec versus a peak flux of 1.24 x 10^9 nvt/sec. The adjusted 1/4T fluence at 32 EFPY at the weld position for Unit 1 is:

$$(0.755/1.24) \times (8.57 \times 10^{17}) = 5.22 \times 10^{17}\ \text{n/cm}^2\ (32\ \text{EFPY})$$

This value was used to make end-of-life USE predictions for the Mk-57/Mk-58 circumferential weld seam for Unit 1.

2.b. The Browns Ferry Units 1, 2 and 3 reactor vessels were designed, fabricated, inspected, and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section III, 1965 edition, Summer 1965 addenda (Unit 3 vessel - Summer 1966 addenda). The surveillance programs for Browns Ferry Units 1, 2 and 3 reactor pressure vessels were developed to meet the requirements of ASTM E 185-66. The material properties requested are provided in Tables 2 through 12 which follow.

The reference nil-ductility temperature (RT_{NDT}) was determined in accordance with ASME Code, Section III, Subsection NB-2331 unless otherwise noted. The associated drop weight tests and Charpy tests were conducted in accordance with ASTM E208 and E23.

2.b. Continued

During the records review by B&W in the compilation of BAW-1845 entitled "Browns Ferry Core Region Materials Information (Units 1, 2, and 3)," neither specific weld materials nor test results for the ES weld consumables used on the longitudinal weld seams could be determined for any of the six weld seams on any of the three vessels. Consequently, a generic chemistry was developed for the vessel ES welds. B&W QA records from the time of construction of the BFN vessels show three ES weld qualifications and eight wire heat chemistries. Based on these values, a generic che try of 0.25% Cu, 0.35% Ni, and .016% P was chosen for the ES welds, and was applied to all vessel ES welds.

The Mk-57 to Mk-58 circumferential weld seam for Unit 1, identified as WF-154, was made by B&W. Although the Record of Filler Wire Qualification Test from B&W Mt. Vernon Works for the specific qualification of weld WF-154 provides both chemical analyses and mechanical tests, B&W's report detailing reactor vessel we chemistries (BAW-1799) lists a copper content considerably higher than the qualification report for weld WF-154. Since the higher copper value is part of B&W's licensing position, it was chosen by B&W in their assessment report, BAW-1845. TVA may choose to reexamine these conservative values at a future date. Similar problems with records do not exist for Units 2 and 3 circumferential welds fabricated by IHI.

Table 2

Plant Name: Browns Ferry Bar Nuclear Plant - Unit 1

Material Description: Intermediate Shell Course - Mk 58

Heat Numbers: Plates - C2884-2, C2368-2, C2753-1

Specification: ASME SA 302 Gr B

Supplier: Plate Material supplied by Lukens Steel; fabrication of shell course involving electroslag welding by B&W

Heat Treatment: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1725°F	1675°F	50°F	6 1/2 hr	BQ	Austenitizing
2	1650°F	1600°F	50°F	6 1/2 hr	BQ	Austenitizing
3	1225°F	1175°F	50°F	6 1/2 hr	BQ	Tempering
4	1150°F	1100°F	50°F	30 hr 31 min	FC	Stress Relief

Composition (wt %):

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
C2868-2[1]	0.22	1.39	0.007	0.009	0.23	0.52	0.07	0.48	0.09	0.032
C2884-2[1]	0.27	1.33	0.008	0.015	0.21	0.52	0.09	0.46	0.12	0.035
C2753-1[2]	0.22	1.32	0.009	0.014	0.22	0.50	N/A	0.47	0.08	N/A

[1]Analysis by Combustion Engineering
[2]Analysis by Babcock & Wilcox

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Longitudinal Charpy $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy USE
C2868-2	0°F	-14°F	0°F	144 ft-lb
C2884-2	0°F	+14°F	0°F	118 ft-lb
C2884-2 HAZ	N/A	+28°F	0°F[1]	97 ft-lb
C2753-1	-20°F	N/A	-20°F[2]	120 ft-lb[3]

[1]Established as 0°F based on Charpy T_{50} ft-lb/35 mils valves (BAW-1845)
[2]Value assigned as T_{NDT}, based on estimated Charpy properties (BAW-1845)
[3]Generic Value (BAW-1845)

Table 3

Plant Name: Browns Ferry Bar Nuclear Plant - Unit 1

Material Description: Lower Shell Course - Mk 57

Heat Numbers: Plates - A1009-1, B5864-1, A0999-1

Specification: ASME SA 302 Gr B

Supplier: Plate Material supplied by Lukens Steel; fabrication of shell course involving electroslag welding by B&W

Heat Treatment: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1725°F	1675°F	50°F	6 1/2 hr	BQ	Austenitizing
2	1650°F	1600°F	50°F	6 1/2 hr	BQ	Austenitizing
3	1225°F	1175°F	50°F	6 1/2 hr	BQ	Tempering
4	1150°F	1100°F	50°F	36 hr 35 min	FC	Stress Relief

Composition (wt %): (Analysis by Babcock & Wilcox in BAW-1845)

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
A1009-1	0.22	1.37	0.009	0.010	0.18	0.50	N/A	0.46	0.14	N/A
B5864-1	0.21	1.29	0.005	0.016	0.17	0.44	N/A	0.49	0.15	N/A
A0999-1	0.22	1.32	0.010	0.014	0.19	0.60	N/A	0.50	0.14	N/A

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Longitudinal Charpy[1] $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy[2] USE
A1009-1	-10°F	+10°F	-10°F	120 ft-lb
B5864-1	-20°F	+10°F	-20°F	120 ft-lb
A0999-1	-20°F	+10°F	-20°F	120 ft-lb

[1]Test temperature of three Charpy tests conducted at a single temperature which exceeded 50 ft-lbs and 35 mils.
[2]Generic value (BAW-1845)

Table 4

Plant Name: Browns Ferry Bar Nuclear Plant - Units 1, 2, and 3

Description: Axial Welds Joining Rolled Plate to Form Shell Courses Mk-57 and Mk-58

Wire Heat No.: Records of Specific Consumables not Available

Weld Type: Electroslag

Wire Type: Raco HiMnMo

Flux Type: Linde 124

Flux Lot: Records of Specific Consumables not Available

Fabricator: Babcock & Wilcox

Heat Treatment following Welding: (from BAW-1845)

Unit	Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
Same as that listed for individual shell courses in previous tables							

Composition (wt %): (Generic Chemistry from BAW-1799 given in BAW-1845)

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
All ES Welds	N/A	N/A	0.016	N/A	N/A	0.35	N/A	N/A	0.25	N/A

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Charpy $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Upper Shelf Energy USE
All ES Welds (production)	N/A	N/A[1]	10°F[2]	95 ft-lb[3]

[1]Specific data not available for production welds, but data is available from surveillance welds, given in Table 12. (BAW-1845)

[2]Established by SER supporting Amendment No. 121 to License No. DPR-33 dated December 16, 1985.

[3]Generic Estimated USE for all ES welds based on surveillance weld USEs (BAW-1845)

Table 5

Plant Name: Browns Ferry Bar Nuclear Plant Unit 1

Description: Circumferential Weld WF-154 Joining Mk-57 to Mk-58

Wire Heat No.: 406L44

Weld Type: Automatic Submerged Arc

Wire Type: Union Carbide Mn-Mo-Ni

Flux Type: Linde 80

Flux Lot: 8720

Fabricator: Babcock & Wilcox

Heat Treatment following Welding: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1150°F	1100°F	50°F	13 hr 55 min	FC	Stress Relief

Composition as Welded (wt %):

From Record of Filler Wire Qualification Test for WF-154 in BAW-1845:

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
0.072	1.50	0.015	0.021	0.45	0.59	N/A	0.30	0.20	N/A

Generic Chemistry reported in BAW-1799 for weld WF-154

P	Ni	Cu
0.013	0.59	0.31

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Charpy $T_{50ft\text{-}lb/35mils}$	Reference Temperature RT_{NDT}	Upper Shelf Energy USE
Circumferential ASA Weld	N/A	N/A	+20°F[1]	66 ft-lb[2]

[1]Upper bound unirradiated RT_{NDT} for this material reported in BAW-10046 and adapted by BAW-1845.

[2]From BAW-1845, the generic value for B&W submerged arc weld material as described in BAW-10046.

Table 6

Plant Name: Browns Ferry Bar Nuclear Plant - Unit 2

Material Description: Lower Shell Course - Mk 57

Heat Numbers: Plates - C2467-2, C2463-1, C2460-2

Specification: ASME SA 302 Gr B

Supplier: Plate Material supplied by Lukens Steel; fabrication of shell course involving electroslag welding by B&W

Heat Treatment: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1725°F	1675°F	50°F	6 1/2 hr	BQ	Austenitizing
2	1650°F	1600°F	50°F	6 1/2 hr	BQ	Austenitizing
3	1225°F	1175°F	50°F	6 1/2 hr	BQ	Tempering
4	1150°F	1100°F	50°F	29 hr 52 min	FC	Stress Relief

Composition (wt %): (Analysis by Babcock & Wilcox in BAW-1845)

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
C2467-2	0.20	1.36	0.008	0.013	0.20	0.52	N/A	0.47	0.16	N/A
C2463-1	0.21	1.33	0.008	0.015	0.16	0.48	N/A	0.47	0.17	N/A
C2460-2	0.21	1.29	0.012	0.014	0.17	0.51	N/A	0.45	0.13	N/A

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Longitudinal Charpy[1] $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy[2] USE
C2467-2	-20°F	+10°F	-20°F	120 ft-lb
C2463-1	-20°F	+10°F	-20°F	120 ft-lb
C2460-2	-20°F	+10°F	-20°F	120 ft-lb

[1]Test temperature of three Charpy tests conducted at a single temperature which exceeded 50 ft-lbs and 35 mils

[2]Generic values (BAW-1845)

Table 7

Plant Name: Browns Ferry Bar Nuclear Plant - Unit 2

Material Description: Intermediate Shell Course - Mk 58

Heat Numbers: Plates - A0981-1, C2467-1, C2849-1

Specification: ASME SA 302 Gr B

Supplier: Plate Material supplied by Lukens Steel; fabrication of shell course involving electroslag welding by B&W

Heat Treatment: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1725°F	1675°F	50°F	6 1/2 hr	BQ	Austenitizing
2	1650°F	1600°F	50°F	6 1/2 hr	BQ	Austenitizing
3	1225°F	1175°F	50°F	6 1/2 hr	BQ	Tempering
4	1150°F	1100°F	50°F	34 hr 37 min	FC	Stress Relief

Composition (wt %):

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
A0981-1[1]	0.20	1.35	0.007	0.011	0.19	0.55	0.11	0.49	0.14	0.025
C2467-1[2]	0.20	1.36	0.008	0.013	0.20	0.52	N/A	0.47	0.16	N/A
C2849-1[2]	0.21	1.30	0.010	0.015	0.23	0.50	N/A	0.46	0.11	N/A

[1]Analysis by Combustion Engineering
[2]Analysis by Babcock & Wilcox

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Longitudinal Charpy $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy USE
A0981-1	-10°F	+10°F[1]	-10°F	142 ft-lb
A0981-1 HAZ	N/A	<-40°F	-10°F	123 ft-lb
C2467-1	-10°F	+10°F[1]	-10°F	120 ft-lb[2]
C2849-1	-10°F	+10°F[1]	-10°F	120 ft-lb[2]

[1]Test temperature of three Charpy tests conducted at a single temperature which exceeded 50 ft-lbs and 35 mils
[2]Generic values (BAW-1845)

Table 8

Plant Name: Browns Ferry Bar Nuclear Plant Unit 2

Description: Circumferential Welds Joining Mk-57 to Mk-58

Wire Heat No.: D55733

Weld Type: Automatic Submerged Arc

Wire Type: Y-204

Flux Type: YF-200

Flux Lot: 1210-02037

Fabricator: Ishikawajima-Harima Heavy Industries Co.

Heat Treatment following Welding: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1150°F	1100°F	50°F	13 hr 02 min	FC	Stress Relief

Composition Filler Wire (wt %): (Baw-1845)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
0.10	2.23	0.010	0.009	0.16	0.72	N/A	0.45	0.09	N/A

Composition as Welded (wt %): (Baw-1845)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
0.08	1.70	0.014	0.005	0.40	0.65	N/A	0.45	0.09	N/A

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Charpy $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Upper Shelf Energy USE
Circumferential ASA Weld	N/A	-40°F	-40°F[1]	145 ft-lb

[1]Based on the higher value of $T_{50ft-lb/35mils}$ for Units 2 and 3 (BAW-1845).

Table 9

Plant Name: Browns Ferry Bar Nuclear Plant - Unit 3

Material Description: Lower Shell Course - Mk 57

Heat Numbers: Plates - C3213-1, C3222-2, C3217-2

Specification: ASME SA 302 Gr B

Supplier: Plate Material supplied by Lukens Steel; fabrication of shell course involving electroslag welding by B&W

Heat Treatment: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1725°F	1675°F	50°F	6 1/2 hr	BQ	Austenitizing
2	1650°F	1600°F	50°F	6 1/2 hr	BQ	Austenitizing
3	1225°F	1175°F	50°F	6 1/2 hr	BQ	Tempering
4	1150°F	1100°F	50°F	25 hr 41 min	FC	Stress Relief

Composition (wt %): (Analysis by Babcock & Wilcox in BAW-1845)

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
C3213-1	0.21	1.29	0.009	0.015	0.24	0.58	N/A	0.49	0.13	N/A
C3222-2	0.21	1.38	0.015	0.015	0.28	0.52	N/A	0.50	0.15	N/A
C3217-2	0.21	1.38	0.009	0.013	0.24	0.66	N/A	0.46	0.14	N/A

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Longitudinal Charpy[1] $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy[2] USE
C3213-1	-30°F	+10°F	-30°F	120 ft-lb
C3222-2	-20°F	+10°F	-20°F	120 ft-lb
C3217-2	-50°F	+10°F	-50°F	120 ft-lb

[1]Test temperature of three Charpy tests conducted at a single temperature which exceeded 50 ft-lbs and 35 mils
[2]Generic values (BAW-1845)

Table 10

Plant Name: Browns Ferry Bar Nuclear Plant - Unit 3

Material Description: Intermediate Shell Course - Mk 58

Heat Numbers: Plates - C3188-2, C3201-2, B7267-1

Specification: ASME SA 302 Gr B

Supplier: Plate Material supplied by Lukens Steel; fabrication of shell course involving electroslag welding by B&W

Heat Treatment: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1725°F	1675°F	50°F	6 1/2 hr	BQ	Austenitizing
2	1650°F	1600°F	50°F	6 1/2 hr	BQ	Austenitizing
3	1225°F	1175°F	50°F	6 1/2 hr	BQ	Tempering
4	1150°F	1100°F	50°F	30 hr 25 min	FC	Stress Relief

Composition (wt %): (Analysis by Babcock & Wilcox in BAW-1845)

Heat No.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
C3188-2[1]	0.18	1.27	0.007	0.007	0.22	0.51	0.08	0.47	0.10	0.015
C3201-2[2]	0.20	1.40	0.007	0.017	0.21	0.60	N/A	0.49	0.13	N/A
B7267-1[2]	0.21	1.33	0.010	0.015	0.24	0.51	N/A	0.47	0.13	N/A

[1]Analysis by Combustion Engineering
[2]Analysis by Babcock & Wilcox

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Longitudinal Charpy $T_{50ft\text{-}lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy USE
C3188-2	-30°F	+10°F[1]	-30°F	158 ft-lb
C3188-2 HAZ	N/A	-1°F	0°F	128 ft-lb
C3201-2	-30°F	+10°F[1]	-30°F	120 ft-lb[2]
B7267-1	-20°F	+10°F[1]	-20°F	120 ft-lb[2]

[1]Test temperature of three Charpy tests conducted at a single temperature which exceeded 50 ft-lbs and 35 mils
[2]Generic values (BAW-1845)

Table 11

Plant Name: Browns Ferry Bar Nuclear Plant Unit 3

Description: Circumferential Welds Joining Mk-57 to Mk-58

Wire Heat No.: D51852/D55733

Weld Type: Automatic Submerged Arc

Wire Type: Y-204

Flux Type: YF-200

Flux Lot: 1325-02037

Fabricator: Ishikawa[illegible]ma Heavy Industries Co.

Heat Treatment following Welding: (from BAW-1845)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1150°F	1100°F	50°F	11 hr 50 min	FC	Stress Relief

Composition Filler Wire (wt %): (BAW-1845)

Heat	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
D51852	0.09	2.14	0.012	0.007	0.17	0.72	N/A	0.45	0.09	N/A
D55733	0.10	2.23	0.010	0.009	0.16	0.72	N/A	0.45	0.09	N/A

Composition as Welded (wt %): (Baw-1845)

Heat	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al
D51852	0.09	1.68	0.012	0.005	0.40	0.67	N/A	0.45	0.09	N/A
D55733	0.08	1.72	0.013	0.006	0.39	0.66	N/A	0.45	0.09	N/A

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

	Drop Weight T_{NDT}	Charpy $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Upper Shelf Energy USE
Circumferential ASA Weld	N/A	-58°F	-40°F[1]	195 ft-lb

[1]Based on the higher value of $T_{50ft-lb/35mils}$ for Units 2 and 3.

Table 12

SURVEILLANCE MATERIAL

The surveillance weldments for Browns Ferry Units 1, 2, and 3 involved base metal from the rolled plates used in the fabrication of the beltline shell courses and electroslag welds. Since specific data concerning the electroslag welds of the vessels is not available, use of the same weld consumables in the surveillance samples as the vessels cannot be established. The surveillance material and the reactor vessel material had the same heat treatment except for the stress relief time. All surveillance test materials received a 30 hour stress relief at 1100 to 1150°F followed by furnace cooling. A summary of the mechanical and chemical parameters for the surveillance samples is as follows:

Composition (wt %): (Analysis by Combustion Engineering reported in BAW-1845)

Surveillance Material	C	Mn	P	S	Si	Ni	Cr	Mo	Cu
Unit 1 C2868-2	0.22	1.39	0.007	0.009	0.23	0.52	0.07	0.48	0.09
C2884-2	0.27	1.33	0.008	0.015	0.21	0.52	0.09	0.46	0.12
C2884-2 HAZ	0.27	1.33	0.008	0.015	0.21	0.52	0.09	0.46	0.12
ES Weld	0.17	1.45	0.012	0.013	0.09	0.30	0.06	0.48	0.10
Unit 2 A0981-1	0.20	1.35	0.007	0.011	0.19	0.55	0.11	0.49	0.14
A0981-1 HAZ	0.20	1.35	0.007	0.011	0.19	0.55	0.11	0.49	0.14
ES Weld	0.15	1.49	0.010	0.011	0.09	0.33	0.08	0.49	0.20
Unit 3 C3188-2	0.18	1.27	0.007	0.007	0.22	0.51	0.08	0.47	0.11
C3188-2 HAZ	0.18	1.27	0.007	0.007	0.22	0.51	0.08	0.47	0.11
ES Weld	0.16	1.50	0.011	0.012	0.10	0.28	0.08	0.49	0.11

Fracture Toughness: (Analysis by Babcock & Wilcox in BAW-1845)

Surveillance Material ID	Drop Weight T_{NDT}	Longitudinal Charpy $T_{50ft-lb/35mils}$	Reference Temperature RT_{NDT}	Longitudinal Upper Shelf Energy USE
Unit 1 C2868-2	0°F	-14°F	0°F	144 ft-lb
C2884-2	0°F	+14°F	0°F	118 ft-lb
C2884-2 HAZ	N/A	+28°F	0°F[1]	97 ft-lb
ES Weld	10°F[2]	+33°F	10°F	93 ft-lb
Unit 2 A0981-1	-10°F	+10°F	-10°F	142 ft-lb
A0981-1 HAZ	N/A	<-40°F	0°F[1]	123 ft-lb
ES Weld	10°F[2]	+10°F	10°F	116 ft-lb
Unit 3 C3188-2	-30°F	-36°F	-30°F	158 ft-lb
C3188-2 HAZ	N/A	-1°F	0°F[1]	128 ft-lb
ES Weld	10°F[2]	-21°F	10°F	124 ft-lb

[1]Established on the basis of Charpy $T_{50ft-lb/35mils}$ values as 0°F for base metal HAZs (BAW-1845).

[2]Upper bound T_{NDT} values from four weld procedure qualification tests.

3.a. Browns Ferry Nuclear Plant is designed with a recirculation suction temperature of 529°F. A review of current operating procedures and temperature data for Unit 2 indicates that recirculation suction temperatures on individual loops may be below 525°F for some periods of operation. Verification and quantization of the time and accumulated fluence during these intervals is being pursued. A summary of this evaluation will be submitted by December 1, 1992.

However, consideration of the effect of lower radiation temperature on the reference temperature and the Charpy upper-shelf energy, should it exist, is incorporated in the Browns Ferry surveillance program. Three surveillance capsules are contained in each vessel, mounted against the ID vessel surface at the core midplane (GE NEDO-10115). The temperature and neutron flux encountered by the surveillance samples is the same as that seen by the vessel ID surface. Base metal and heat-affected zone specimens contained in the capsules of each vessel were fabricated from actual beltline materials and weld specimens were fabricated from electroslag welds representative of the consumables used to fabricate the vessel shell courses. The surveillance program as currently implemented will provide an evaluation of the actual versus predicted changes in reference temperature and upper shelf energies of beltline materials. With this configuration, any effects of lower irradiation temperatures should be readily discernable.

3.b. Neither of the three Units at Browns Ferry Nuclear Plant have achieved 8 effective full power years of operation, which is the scheduled time for removal of the first surveillance capsules. Therefore, no surveillance data exists for consideration of the predicted amount of embrittlement at this time.

3.c. Neither of the three Units at Browns Ferry Nuclear Plant have achieved 8 effective full power years of operation, which is the scheduled time for removal of the first surveillance capsules. Therefore, surveillance data does not exist for comparison between the measured and predicted reference temperature and upper shelf energy.

ENCLOSURE 2

SEQUOYAH NUCLEAR PLANT - RESPONSE TO GENERIC LETTER 92-01

1. The surveillance programs for Sequoyah Units 1 and 2 reactor pressure vessels were developed to meet the requirements of ASTM E 185-73. These programs are described in Westinghouse WCAPs -8233 and -8513. It is TVA's position that both surveillance programs meet the requirements of Appendix H to 10 CFR Part 50. Contained within eight material test capsules located in each reactor between the thermal shield and vessel wall are Charpy V-notch specimens, tensile specimens, and wedge-opening-loading (WOL) samples from the limiting shell forging material and associated weld metal, and Charpy V-notch impact specimens of HAZ metal.

2.a. Upper Shelf Energy Predictions

Unit 1

Material	Copper Content	USE Measured	Predicted 1/4T Decrease at 12/16/91	Predicted 1/4T Decrease at EOL	Predicted 1/4T USE at 12/16/91	Predicted 1/4T USE at EOL
	wt/%	%	%	%	ft-lb	ft-lb
Lower Shell Forging 04 (tangential)	0.13	116	17.5	26.6	96	85
Lower Shell Forging 04 (axial)	0.13	71.5	17.5	26.6	59	52.5
Lower Forging 04 - HAZ	0.13	86	17.5	26.6	71	63
Intermediate Shell Forging 05	0.15	74	19.2	29	60	52.5
Circumferential Weld 04/05	0.33	111	37	48	70	57.7

Unit 2

Lower Shell Forging 04	0.14	100	15.5	23	84	79
Intermediate Forging 05 (tangential)	0.13	138	15	22	117	108
Intermediate Forging 05 (axial)	0.13	88	15	22	75	69
Intermediate Shell Forging 05 - HAZ	0.13	118	15	22	100	92
Circumferential Weld	0.13	105	18.5	27	86	77

SEQUOYAH NUCLEAR PLANT - RESPONSE TO GENERIC LETTER 92-01

Fluence values used in upper shelf predictions:

Unit 1

The fluence for Sequoyah Nuclear Plant Unit 1:

At RPV surface: $f_{surf} = 3.5 \times 10^{18}$ n/cm^2 for 2.919 EFPY
(SwRI Project 06-8851, Table 4.17)

$= 1.20 \times 10^{18}$ n/cm^2 for 1 EFPY

At 1/4 thickness: $f_{depth\ x} = f_{surf}(e^{-0.24x})$

thickness = 8.608 inches at beltline

$f_{1/4T} = f_{surf}(e^{-0.5164}) = f_{surf}(0.5967)$

$f_{1/4T} = 0.715 \times 10^{18}$ n/cm^2 for 1 EFPY

$= 2.29 \times 10^{19}$ n/cm^2 for 32 EFPY

$= 3.79 \times 10^{18}$ n/cm^2 for 5.3 EFPY
(On December 16, 1991, the estimated operating time for Unit 1 was 5.3 EFPY)

Unit 2

The fluence for Sequoyah Nuclear Plant Unit 2:

At RPV surface: $f_{surf} = 2.034 \times 10^{18}$ n/cm^2 for 2.9 EFPY +
0.5036×10^{18} n/cm^2 for each EFPY thereafter
(SwRI Project 17-8851, Table 20)

$= 1.669 \times 10^{19}$ n/cm^2 for 32 EFPY

$= 3.34 \times 10^{18}$ n/cm^2 for 5.5 EFPY
(On December 16, 1991, the estimated operating time for Unit 2 was 5.5 EFPY)

At 1/4 thickness: $f_{depth\ x} = f_{surf}(e^{-0.24x})$

thickness = 8.608 inches at beltline

$f_{1/4T} = 9.96 \times 10^{18}$ n/cm^2 for 32 EFPY

$= 1.99 \times 10^{18}$ n/cm^2 for 5.5 EFPY

2.a. Upper Shelf Energy Predictions (Continued)

As given in the tables above, the Charpy upper shelf energies for all beltline materials in both Sequoyah Units 1 and 2 are projected to remain above 50 ft-lb at end-of life calculated fluences at 1/4T.

2.b. The construction of Sequoyah Units 1 and 2 reactor vessels by Rotterdam Dockyard Company complied with the requirements of the 1968 ASME Boiler and Pressure Vessel Code Section III for Class "1" vessels. However, the surveillance programs for Sequoyah Units 1 and 2 reactor pressure vessels were developed to meet the requirements of ASTM E 185-73 (Westinghouse WCAPs 8233 and 8513. It is our position that compliance with the fracture toughness requirements of Appendix G of 10 CFR Part 50 has been met. Material properties requested are provided in tables 1 through 9 which follow.

The reference nil-ductility temperatures (RT_{NDT}) were determined in accordance with ASME Code, Section III, Subsection NB-2331, unless otherwise noted. The associated drop weight tests and Charpy V-notch tests were conducted in accordance with ASTM E208 and E23.

Table 1

Plant Name: Sequoyah Nuclear Plant - Unit 1

Material Description: Lower Shell Forging 04

Heat Number: 980919/281587

Specification: ASTM A 508 cl. 2

Supplier: Rheinstahl Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1710°F	1580°F	130°F	4hr	WQ	Austenitizing
2	1240°F	1200°F	40°F	6hr	FC	Tempering
3	1155°F	1105°F	50°F	20hr 23min	FC	Stress Relief

Composition (wt %): (Analyses by Westinghouse - WCAP-8233)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.17	0.62	0.020	0.016	0.22	0.76	0.37	0.56	0.13	N/A	0.009

Fracture Toughness:

Drop Weight T_{NDT} +5°F (drop weight tests by Rotterdam Dockyard Company)

Tangential Orientation:

Charpy $T_{50ft-lb/35mils}$ +10°F (longitudinal Charpy data of WCAP-8233)

RT_{NDT} +5°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)

Upper Shelf Energy (USE) 116 ft-lb (longitudinal Charpy data of WCAP-8233)

Axial Orientation

Charpy $T_{50ft-lb/35mils}$ +133°F (transverse Charpy curve of WCAP-8233)[1]

RT_{NDT} +73°F (T_{NDT} + 60°F is less than $T_{50ft-lb/35mils}$)

Upper Shelf Energy (USE) 71.5 ft-lb (transverse Charpy data of WCAP-8233)

[1]Lower bound Charpy curve value reported in WCAP.

Table 2

Plant Name: Sequoyah Nuclear Plant - Unit 1

Material Description: Intermediate Shell Forging 05

Heat Number: 980807/281489

Specification: ASTM A 508 cl. 2

Supplier: Rheinstahl Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)[1]

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1724°F	1616°F	108°F	3-1/2hr	WQ	Austenitizing
2	1292°F	1202°F	90°F	5-1/4hr	FC	Tempering
3	1155°F	1105°F	50°F	27hr 24min	FC	Stress Relief

[1]Run 1 and 2 values are required limits, not actual results.

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.20	0.70	0.011	0.019	0.23	0.86	0.40	0.53	0.15	N/A	N/A

Fracture Toughness:

Drop Weight T_{NDT}	-4°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	+14°F (longitudinal Charpy data from Rotterdam Dockyard Company reduced to 65%)
RT_{NDT}	-4°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	74 ft-lb (longitudinal Charpy data from Rotterdam Dockyard Company reduced to 65%)

Table 3

Plant Name: Sequoyah Nuclear Plant - Unit 1

Material Description: Lower Shell Forging 04 - Heat Affected Zone (HAZ)

Heat Number: 980919/281587

Specification: ASTM A 508 cl. 2

Supplier: Rheinstahl Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1710°F	1580°F	130°F	4 hr	WQ	Austenitizing
2	1240°F	1200°F	40°F	6 hr	FC	Tempering
3	1155°F	1105°F	50°F	7hr 13min	FC	Stress Relief
4	Submerged Arc Welded					
5	1155°F	1105°F	50°F	13 hr 10 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.17	0.62	0.020	0.016	0.22	0.76	0.37	0.56	0.13	N/A	0.009

Fracture Toughness:

Drop Weight T_{NDT}	-22°F (Dropweight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	+15°F (transverse Charpy curve of WCAP-8233)
RT_{NDT}	-22°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	86 ft-lb (transverse Charpy data of WCAP-8233)

Table 4

Plant Name: Sequoyah Nuclear Plant - Unit 1

Material Description: Circumferential Weld Seam 04/05

Wire Heat Number: Lot No. 25295

Weld Type: Submerged Arc Weld

Wire Type: Wire 40 (Linde)

Flux Type: SAF 89

Flux Lot: 2275

Fabricator: Rotterdam Dockyard Company

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1155 °F	1105 °F	50 °F	13 hr 10 min	FC	Stress Relief

Composition (As welded, wt %): (Analyses by Westinghouse - WCAP-8233)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.058	1.40	0.021	0.009	0.42	0.17	0.068	0.53	0.33	N/A	0.008

Fracture Toughness:

Drop Weight T_{NDT}	-40°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	-27°F (Charpy data of WCAP-8233)
RT_{NDT}	-40°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	111 ft-lb (Charpy data of WCAP-8233)

Table 5

Plant Name: Sequoyah Nuclear Plant - Unit 2

Material Description: Lower Shell Forging 04

Heat Number: 990469/293323

Specification: ASTM A 508 cl. 2

Supplier: Rheinstahl Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)[1]

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1724°F	1616°F	108°F	3-1/2hr	WQ	Austenitizing
2	1292°F	1202°F	90°F	5-1/4hr	FC	Tempering
3	1155°F	1105°F	50°F	19hr 16min	FC	Stress Relief

[1]Run 1 and 2 are required limits, not actual results.

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.18	0.68	0.012	0.014	0.22	0.75	0.33	0.66	0.14	N/A	N/A

Fracture Toughness:

Drop Weight T_{NDT}	-40°F (Drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft\text{-}lb/35mils}$	+29°F (longitudinal Charpy testing by Rotterdam Dockyard Company reduced to 65%)
RT_{NDT}	-31°F (T_{NDT} + 60°F is less than $T_{50ft\text{-}lb/35mils}$)
Upper Shelf Energy (USE)	100 ft-lb (longitudinal Charpy testing by Rotterdam Dockyard Company reduced to 65%)

Table 6

Plant Name: Sequoyah Nuclear Plant - Unit 2

Material Description: Intermediate Shell Forging 05

Heat Number: 288757/981057

Specification: ASTM A 508 cl. 2

Supplier: Rheinstahl Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1700°F	1650°F	50°F	3-1/2 hr	WQ	Austenitizing
2	1250°F	1200°F	50°F	9 hr	FC	Tempering
3	1155°F	1105°F	50°F	23 hr 12 min	FC	Stress Relief

Composition (wt %): (Analyses by Westinghouse as reported in WCAP-8513)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	V	Al
0.18	0.72	0.018	0.018	0.27	0.74	0.33	0.64	0.13	0.022	0.027

Fracture Toughness:

Drop Weight T_{NDT} -22°F (drop weight tests by Rotterdam Dockyard Company)

Tangential Orientation:

Charpy $T_{50ft-lb/35mils}$ -30°F (longitudinal Charpy data of WCAP-8513)

RT_{NDT} -22°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)

Upper Shelf Energy (USE) 138 ft-lb (longitudinal Charpy data of WCAP-8513)

Axial Orientation

Charpy $T_{50ft-lb/35mils}$ +70°F (transverse Charpy curve of WCAP-8513)[1]

RT_{NDT} +10°F (T_{NDT} + 60°F is less than $T_{50ft-lb/35mils}$)

Upper Shelf Energy (USE) 88 ft-lb (transverse Charpy data of WCAP-8513)

[1]Lower bound Charpy curve value reported in WCAP.

Table 7

Plant Name: Sequoyah Nuclear Plant - Unit 2

Material Description: Intermediate Shell Forging 05 - Heat Affected Zone (HAZ)

Heat Number: 288757/981057

Specification: ASTM A 508 cl. 2

Supplier: Rheinstahl Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1700°F	1650°F	50°F	3-1/2 hr	WQ	Austenitizing
2	1250°F	1200°F	50°F	9 hr	FC	Tempering
3	1155°F	1105°F	50°F	8 hr 56 min	FC	Stress Relief
4	Submerged Arc Welded					
5	1155°F	1105°F	50°F	14 hr 16 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	V	Al
0.18	0.72	0.018	0.018	0.27	0.74	0.33	0.64	0.13	0.022	0.027

Fracture Toughness:

Drop Weight T_{NDT}	-13°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	+14°F (transverse Charpy curve of WCAP-8513)
RT_{NDT}	-13°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	118 ft-lb (transverse Charpy data of WCAP-8513)

Table 8

Plant Name: Sequoyah Nuclear Plant - Unit 2

Material Description: Circumferential Weld Seam 04/05

Wire Heat Number: 4278 (Arco Chemie)

Weld Type: Submerged Arc Weld

Wire Type: S4 MO

Flux Type: Poeder 89 (Smit)

Flux Lot: 1211

Fabricator: Rotterdam Dockyard Company

Heat Treatment:

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1155 °F	1100 °F	50 °F	14 hr 16 min	FC	Stress Relief

Composition (As welded, wt %): (Analyses by Westinghouse as reported in WCAP-8513)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	V	Al
0.095	1.50	0.016	0.013	0.41	0.11	0.085	0.53	0.13	0.002	0.009

Fracture Toughness:

Drop Weight T_{NDT}	-4°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	+14°F (Charpy data of WCAP-8513)
RT_{NDT}	-4°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	105 ft-lb (Charpy data of WCAP-8513)

Table 9

HEAT TREATMENT OF SURVEILLANCE WELDMENT

The surveillance weldments for Sequoyah Units 1 and 2 were identical to the closing girth seam weldments between forgings 04 and 05 of the reactor vessels with the exception of the flux lot number for Unit 1. The surveillance base materials from forgings 04 and 05 were heat treated identical to the respective forgings up to welding the final seam for both units. A summary of additional heat treatments following fabrication of the ring forgings is as follows:

Unit 1

Material	Run No.	Time	Temp.	Run ID
forging 04	1	7 hr 13 min	1130 ± 25°F	stress relief before weld 04/05
	2	13 hr 10 min	1130 ± 25°F	stress relief after weld 04/05
	Total	20 hr 23 min		
forging 05	1	14 hr 14 min	1130 ± 25°F	stress relief before weld 04/05
	2	13 hr 10 min	1130 ± 25°F	stress relief after weld 04/05
	Total	27 hr 24 min		
Weld 04/05	1	13 hr 10 min	1130 ± 25°F	stress relief after weld 04/05

Unit 2

Material	Run No.	Time	Temp.	Run ID
forging 04	1	5 hr 0 min	1130 ± 25°F	stress relief before weld 04/05
	2	14 hr 16 min	1130 ± 25°F	stress relief after weld 04/05
	Total	19 hr 16 min		
forging 05	1	8 hr 56 min	1130 ± 25°F	stress relief before weld 04/05
	2	14 hr 16 min	1130 ± 25°F	stress relief after weld 04/05
	Total	23 hr 12 min		
Weld 04/05	1	14 hr 16 min	1130 ± 25°F	stress relief after weld 04/05

3.a. Normal operation of the cold leg does not occur below 525°F while the reactors are critical. The minimum RCS loop average temperature (T_{avg}) is required by the Sequoyah Technical Specification to be ≥ 541°F within 15 minutes prior to achieving criticality. At 0 power T_{Hot} and T_{Cold} are at essentially the same temperature. The operation of the reactor is such that T_{Cold} remains essentially constant, while T_{Hot} increases to meet the power requirements.

Since cold leg temperatures do not fall below 525°F while the reactors are critical, no predictions need to be made concerning the effects of low temperature embrittlement.

3.b. The surveillance results from two capsules from each unit were used to reevaluate the adjusted reference temperatures and recalculate operating parameters to comply with RG 1.99, Revision 2. These data, given in WCAP-12970 and WCAP-12971, were used to prepare the recent TS submittals for SQN 1 and 2.

3.c. The mean-plus-two standard deviation predicted by Regulatory Guide 1.99, Revision 2, exceed the measured increase in reference temperature for all Unit 1 beltline materials. For Sequoyah Unit 2 weld metal, the measured chemistry factors for capsules T and U, taken individually, are each less than the predicted mean-plus-two standard deviations. However, when the method of Section 2.1 of the Reg. Guide is used to determine the adjusted reference temperature for two sets of creditable surveillance data, i.e., "calculating the chemistry factor, CF, for the best fit by multiplying each adjusted RT_{NDT} by its corresponding fluence factor, summing the products, and dividing by the sum of the squares of the fluence factors," the combined "measured" chemistry factor increases. This increase results in a "measured" reference temperature which exceeds the predicted mean-plus-two standard deviations at the higher fluence levels. The predicted and measured comparisons for the capsules directly and for the combined value which minimizes the sum of the square of the errors are given below in Tables 10 and 11.

Table 10

Comparison of Measured and Predicted Reference Temperature Increases for Unit 2 Weld from Capsules T and U

	Capsule T		Capsule U	As
	Irradiated		As Irradiated	
Parameter	Predicted	Measured	Predicted	Measured
Chemistry Factor, CF (°F)	68	80	68	130
Fluence, f (10^{19} n/cm^2)	0.220	0.220	0.643	0.643
Fluence factor, ff	0.592	0.592	0.876	0.876
ΔRT_{NDT} (°F) = CF x ff	40.3	47.4	59.6	113.9
Margin, 2σ (°F)	56	-	56	-
Comparison of ΔRT_{NDT} (°F)	96.3	47.4	115.6	113.9

The combined capsule T and U chemistry factor for the Unit 2 weld metal is 144°F (WCAP-12971).

Table 11

Comparison of "Measured" and Predicted Reference Temperature Increases for Unit 2 Weld Metal from Combined Capsule T and U Chemistry Factor

Parameter	On December 16, 1991 Predicted	On December 16, 1991 Measured	At EOL (32 EFPY) Predicted	At EOL (32 EFPY) Measured
Chemistry Factor, CF (^{o}F)	68	144	68	144
Fluence, f (10^{19} n/cm^2)	0.199	0.199	0.996	0.996
Fluence factor, ff	0.567	0.567	0.999	0.999
ΔRT_{NDT} (^{o}F) = CF x ff	38.6	81.7	67.9	143.8
Margin, 2σ (^{o}F)	56	-	56	-
Comparison of ΔRT_{NDT} (^{o}F)	94.6	81.7	123.9	143.8

The weld metal is the controlling Unit 2 beltline material. The adjusted reference temperature from the surveillance data has been used to generate heatup and cooldown curves.

All Charpy upper shelf energies (USE) for Sequoyah Units 1 and 2 beltline materials exceed the predicted values using Regulatory Guide 1.99, Revision 2, guidelines with the exception of the lower forging 04 heat-affected zone of Unit 1. Data from the first two capsules (T and U) removed from Unit 1 reactor vessel indicate USE values slightly lower than predicted by Figure 2 of Regulatory Guide 1.99, Revision 2. However, preliminary data from capsule X, currently being evaluated by Westinghouse, provides measurements which indicate the upper shelf energy to be greater than predicted, even when the data is treated conservatively. [Capsule X has been subjected to a fluence that exceeds the maximum end-of-life (32 EFPY) neutron fluence at the 1/4T position.] These data, given in table 12 below, are based on Charpy measurements which exhibit significant scatter in both the irradiated and unirradiated condition. In view of the more recent data of capsule X, it is concluded that the anomalous behavior in upper shelf values of capsules T and U of unit 1 forging 04 HAZ are due to the inherent data scatter.

Table 12

Unit 1 Forging 04 Heat-Affected Zone

Material Condition	Fluence x 10^{19}	Upper Shelf Energy (USE)
Unirradiated	0	86
Irradiated (Capsule T)	0.274	69
Irradiated (predicted)	0.274	72 (predicted value > measured)
Irradiated (Capsule U)	1.08	64
Irradiated (predicted)	1.08	67 (predicted value > measured)
Irradiated (Capsule X)[1]	1.61	82.5(68)[2]
Irradiated (predicted)	1.61	63.6 (predicted value < measured)

[1]Preliminary data obtained under Shop Order TJIP-S003 with Westinghouse for analysis of capsule X

[2]Value in ( ) is obtained by excluding extraneously high upper shelf data point

ENCLOSURE 3

WATTS BAR NUCLEAR PLANT - RESPONSE TO GENERIC LETTER 92-01

1. The surveillance programs for Watts Bar Units 1 and 2 reactor pressure vessels were developed to meet the requirements of ASTM E 185-73. These programs are descibed in Westinghouse WCAPs 9298 and 9455. It is TVA's position that both surveillance programs meet the requirements of Appendix H to 10 CFR Part 50. Six test capsules containing transverse Charpy specimens, tensiles, and compact tension samples of the limiting forging material, the weld metal, and the HAZ are currently installed in each vessel.

2.a. Upper Shelf Energy Predictions

Unit	Material	Copper Content wt/%	USE Measured ft-lb	Predicted USE Decrease %	Predicted USE at EOL ft-lb
1	Lower Shell Forging 04	0.08	88	20	70
	Intermediate Shell Forging 05 (Tangential)	0.17	132	30	92
	Intermediate Shell Forging 05 (Axial)	0.17	62	30	43.4
	Intermediate Forging 05 HAZ	0.17	89	30	62
	Circumferential Weld Seam	0.05	131	22	102
2	Lower Shell Forging 04	0.05	105	17	87
	Intermediate Shell Forging 05 (Tangential)	0.05	175	17	145
	Intermediate Shell Forging 05 (Axial)	0.05	110	17	91
	Intermediate Forging 05 HAZ	0.05	130	17	108
	Circumferential Weld Seam	0.05	139	22	108

Fluence values used in upper shelf predictions:

The design basis fluence (32 EFPY) for Watts Bar Nuclear Plant Units 1 and 2 is:

$$3.18 \times 10^{19}\ n/cm^2 \quad (E > 1\ MeV)$$

At 1/4 thickness, the fluence is given as:

$$\text{fluence}_{1/4T} = \text{fluence}_{surf.}(e^{-0.24X})$$

$$X_{1/4T} = 1/4\ (8.46 + 0.156\ \text{in.}) = 2.154\ \text{in.}$$

$$\text{fluence}_{1/4T} = 3.18 \times 10^{19}\ (e^{-0.24 \times 2.154})$$

$$= 3.18 \times 10^{19} \times (0.5963)$$

$$= 1.896 \times 10^{19}\ \text{n/cm}^2\ (E > 1\ \text{MeV})$$

As shown above, the Charpy upper shelf energy for Watts Bar Unit 1 intermediate shell forging 05, heat 527536, based on the design basis fluence and indicated copper levels, is predicted to fall below 50 ft-lb prior to end of life (32 EFPY). Actions to be taken in regard to Paragraphs IV.A.1 and V.C of Appendix G to 10 CFR Part 50 will be submitted by January 29, 1993.

The Charpy upper shelf energy predicted for December 16, 1991 is the same as the unirradiated USE.

2.b. The construction of Watts Bar Units 1 and 2 reactor vessels by Rotterdam Dockyard Company complied with the requirements of the 1971 ASME Boiler and Pressure Vessel Code Section III for Class "1" vessels and addenda up to and including the Winter 1971. However, the surveillance programs for Watts Bar Units 1 and 2 reactor pressure vessels were developed to meet the requirements of ASTM E 185-73. With the exception of the low upper shelf energy discussed in Section 2.a. above, it is our position that compliance with the fracture toughness requirements of Appendix G of 10 CFR Part 50 has been met. Material properties requested are provided in tables 1 through 9 which follow.

Table 1

Plant Name: Watts Bar Nuclear Plant - Unit 1

Material Description: Lower Shell Forging 04

Heat Number: 528522

Specification: ASTM A 508 cl. 2

Supplier: Fried. Krupp Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1688°F	1616°F	72°F	6 2/3 hr	WQ	Austenitizing
2	1229°F	1202°F	27°F	6 hr	FC	Tempering
3	1175°F	1103°F	72°F	18 hr 02 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.20	0.69	0.006	0.010	0.32	0.83	0.34	0.57	0.08	N/A	0.01

Fracture Toughness:

Drop Weight T_{NDT}	+5°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	-26°F (longitudinal Charpy testing by Rotterdam Dockyard Company reduced to 65%)
RT_{NDT}	+5°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	88 ft-lb (longitudinal Charpy testing by Rotterdam Dockyard Company reduced to 65%)

Table 2

Plant Name: Watts Bar Nuclear Plant - Unit 1

Material Description: Intermediate Shell Forging 05

Heat Number: 527536

Specification: ASTM A 508 cl. 2

Supplier: Fried. Krupp Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1697°F	1616°F	81°F	3 1/2 hr	WQ	Austenitizing
2	1238°F	1202°F	36°F	6 hr	FC	Tempering
3	1175°F	1103°F	72°F	24 hr 06 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.20	0.73	0.012	0.016	0.25	0.80	0.32	0.57	0.17	N/A	<0.02

Fracture Toughness:

Drop Weight T_{NDT} -22°F (drop weight tests by Rotterdam Dockyard Company)

Tangential orientation:

Charpy $T_{50ft-lb/35mils}$ -5°F (longitudinal Charpy data of WCAP-9298)

RT_{NDT} -22°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)

Upper Shelf Energy (USE) 132 ft-lb (longitudinal Charpy data of WCAP-9298)

Axial orientation:

Charpy $T_{50ft-lb/35mils}$ +107°F (transverse Charpy curve of WCAP-9298)

RT_{NDT} +47°F ($T_{50ft-lb/35mils}$ less 60°F is greater than T_{NDT})

Upper Shelf Energy (USE) 62 ft-lb (transverse Charpy data of WCAP-9298)

Table 3

Plant Name: Watts Bar Nuclear Plant - Unit 1

Material Description: Intermediate Shell Forging 05 - Heat Affected Zone (HAZ)

Heat Number: 527536

Specification: ASTM A 508 cl. 2

Supplier: Fried. Krupp Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1697°F	1616°F	81°F	3 1/2 hr	WQ	Austenitizing
2	1238°F	1202°F	36°F	6 hr	FC	Tempering
3	1155°F	1105°F	50°F	10 hr 56 min	FC	Stress Relief
4	Submerged Arc Welded					
5	1175°F	1103°F	72°F	14 hr 20 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.20	0.73	0.012	0.016	0.25	0.80	0.32	0.57	0.17	N/A	<0.01

Fracture Toughness:

Drop Weight T_{NDT}	-22°F (drop weight tests for base metal assumed for HAZ. This is conservative since HAZ shows improved impact properties)
Charpy $T_{50ft-lb/35mils}$	+34°F (transverse Charpy curve of WCAP 9298)
RT_{NDT}	-22°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	89 ft-lb (transverse Charpy data of WCAP 9298)

Table 4

Plant Name:	Watts Bar Nuclear Plant - Unit 1	
Material Description:	Circumferential Weld Seam 04/05	
Wire Heat Number:	895075	Data from WCAP-9298
Weld Type:	Submerged Arc Weld	
Wire Type:	S3 NiMo of Hoesch	
Flux Type:	Grau L.O. (LW 320)	
Flux Lot:	p.46	
Fabricator:	Rotterdam Dockyard Company	

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1175 °F	1103 °F	72 °F	14 hr 20 min	FC	Stress Relief

Composition (As welded, wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.069	1.97	0.01	0.01	0.22	0.70	0.05	0.56	0.05	N/A	N/A

Fracture Toughness:

Drop Weight T_{NDT}	-67°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft\text{-}lb/35mils}$	+17°F (Charpy curve of WCAP 9298)
RT_{NDT}	-43°F (T_{NDT} + 60°F is less than $T_{50ft\text{-}lb/35mils}$)
Upper Shelf Energy (USE)	131 ft (Charpy data of WCAP 9298)

Table 5

Plant Name: Watts Bar Nuclear Plant - Unit 2

Material Description: Lower Shell Forging 04

Heat Number: 528658

Specification: ASTM A 508 cl. 2

Supplier: Fried. Krupp Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1706°F	1616°F	90°F	2 2/3 hr	WQ	Austenitizing
2	1238°F	1202°F	36°F	5 1/2 hr	FC	Tempering
3	1152°F	1103°F	49°F	15 hr 34 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.20	0.72	0.006	0.010	0.26	0.81	0.29	0.58	0.05	N/A	<0.01

Fracture Toughness:

Drop Weight T_{NDT}	+5°F (transverse drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	+38°F (longitudinal Charpy testing by Rotterdam Dockyard Company reduced to 65%)
RT_{NDT}	+5°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	105 ft-lb (longitudinal Charpy testing by Rotterdam Dockyard Company reduced to 65%)

Table 6

Plant Name: Watts Bar Nuclear Plant - Unit 2

Material Description: Intermediate Shell Forging C5

Heat Number: 527828

Specification: ASTM A 508 cl. 2

Supplier: Fried. Krupp Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1697°F	1616°F	81°F	4 hr	WQ	Austenitizing
2	1238°F	1202°F	36°F	6 hr	FC	Tempering
3	1152°F	1103°F	49°F	19 hr 30 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.21	0.72	0.012	0.012	0.28	0.78	0.28	0.55	0.05	N/A	<0.01

Fracture Toughness:

Drop Weight T_{NDT}	+14°F (drop weight tests by Rotterdam Dockyard Company)
Tangential orientation:	
Charpy $T_{50ft-lb/35mils}$	0°F (longitudinal Charpy data of WCAP-9455)
RT_{NDT}	+14°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	175 ft-lb (longitudinal Charpy data of WCAP-9455)
Axial orientation:	
Charpy $T_{50ft-lb/35mils}$	+40°F (transverse Charpy curve of WCAP-9455)
RT_{NDT}	+14°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	110 ft-lb (transverse Charpy data of WCAP 9455)

Table 7

Plant Name: Watts Bar Nuclear Plant - Unit 2

Material Description: Intermediate Shell Forging 05 - Heat Affected Zone (HAZ)

Heat Number: 527828

Specification: ASTM A 508 cl. 2

Supplier: Fried. Krupp Huttenwerke

Heat Treatment: (from Rotterdam Dockyards Company records)

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1697°F	1616°F	81°F	4 hr	WQ	Austenitizing
2	1238°F	1202°F	36°F	6 hr	FC	Tempering
3	1152°F	1103°F	49°F	6 hr 9 min	FC	Stress Relief
4	Submerged Arc Welded					
5	1152°F	1103°F	49°F	13 hr 21 min	FC	Stress Relief

Composition (wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.21	0.72	0.012	0.012	0.28	0.78	0.28	0.55	0.05	N/A	<0.01

Fracture Toughness:

Drop Weight T_{NDT}	-67°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	-50°F (transverse Charpy curve of WCAP 9455)
RT_{NDT}	-67°F (T_{NDT} + 60°F is greater than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	130 ft-lb (transverse Charpy data of WCAP 9455)

Table 8

Plant Name:	Watts Bar Nuclear Plant - Unit 2	
Material Description:	Circumferential Weld Seam 04/05	
Wire Heat Number:	895075	Data from WCAP-9455
Weld Type:	Submerged Arc Weld	
Wire Type:	S3 NiMo of Hoesch	
Flux Type:	Grau L.O. (LW 320)	
Flux Lot:	p.46	
Fabricator:	Rotterdam Dockyard Company	

Heat Treatment:

Run No.	Max Temp	Min Temp	Temp Range	Time	Quench	Run ID
1	1152 ^{o}F	1103 ^{o}F	49 ^{o}F	13 hr 21 min	FC	Stress Relief

Composition (As welded, wt %): (Analyses by Rotterdam Dockyard Company)

C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Cb	Al
0.069	1.97	0.01	0.01	0.22	0.70	0.05	0.56	0.05	N/A	N/A

Fracture Toughness:

Drop Weight T_{NDT}	-76°F (drop weight tests by Rotterdam Dockyard Company)
Charpy $T_{50ft-lb/35mils}$	+10°F (transverse Charpy data of WCAP 9455)
RT_{NDT}	-50°F (T_{NDT} + 60°F is less than $T_{50ft-lb/35mils}$)
Upper Shelf Energy (USE)	139 ft-lb (transverse Charpy data of WCAP 9455)

Table 9

HEAT TREATMENT OF SURVEILLANCE WELDMENT

The surveillance weldments for Watts Bar Units 1 and 2 were identical to the closing girth seam weldments between forgings 04 and 05. The base materials from forgings 04 and 05 were heat treated identical to the respective forgings up to welding the final seam for both units. A summary of additional heat treatments following fabrication of the ring forgings is as follows (from Rotterdam records):

Unit 1

Material	Run No.	Time	Temp.	Run ID
forging 04	1	3 hr 42 min	1130 ± 25°F	stress relief before weld 04/05
	2	14 hr 56 min	1130 ± 25°F	stress relief after weld 04/05
	Total	18 hr 38 min		
forging 05	1	10 hr 56 min	1130 ± 25°F	stress relief before weld 04/05
	2	14 hr 56 min	1130 ± 25°F	stress relief after weld 04/05
	Total	25 hr 52 min		
Weld 04/05	1	14 hr 56 min	1130 ± 25°F	stress relief after weld 04/05

Unit 2

Material	Run No.	Time	Temp.	Run ID
forging 04	1	2 hr 13 min	1130 ± 25°F	stress relief before weld 04/05
	2	13 hr 21 min	1130 ± 25°F	stress relief after weld 04/05
	Total	15 hr 34 min		
forging 05	1	6 hr 09 min	1130 ± 25°F	stress relief before weld 04/05
	2	13 hr 21 min	1130 ± 25°F	stress relief after weld 04/05
	Total	19 hr 30 min		
Weld 04/05	1	13 hr 21 min	1130 ± 25°F	stress relief after weld 04/05

3.a. Normal operation of the cold leg does not occur below 525°F while the reactors are critical. The minimum RCS loop average temperature (T_{avg}) is proposed by the draft Watts Bar Technical Specification to be ≥ 551°F within 15 minutes prior to achieving criticality. At 0 power T_{Hot} and T_{Cold} are at essentially the same temperature. The operation of the reactor is such that T_{Cold} remains essentially constant, while T_{Hot} increases to meet the power requirements. Since cold leg temperatures do not fall below 525°F while the reactors are critical, no predictions need to be made concerning the effects of low temperature embrittlement.

3.b. No surveillance results exist for Watts Bar.

3.c. Watts Bar Nuclear Plant is still under construction. Therefore no surveillance data exist for changes in the reference temperature or upper shelf.

ENCLOSURE 4

WATTS BAR NUCLEAR PLANT COMMITMENT

Actions to be taken in regard to Paragraphs IV A.1 and V.C of Appendix G to 10 CFR Part 50 will be submitted by January 29, 1993.

ENCLOSURE 4

COMMITMENTS

1. Actions to be taken in regard to Paragraphs IV A.1 and V.C of Appendix G to 10 CFR Part 50 for WBN will be submitted by January 29, 1993.

2. Submit by December 1, 1992, a summary evaluation of the time and accumulated fluence during intervals of BFN operation below 525°F and its effect on the reference temperature and on the Charpy upper shelf energy.