APPENDIX 5A

COMPLIANCE WITH 10CFR50, APPENDIX G AND APPENDIX H

5A.1 REACTOR PRESSURE VESSEL BELTLINE PLATE AND WELD INFORMATION

Available dropweight and Charpy V-Notch (CVN) data for the Hope Creek Generating Station (HCGS) beltline plates and welds are presented in Tables 5A-1 and 5A-2. These materials were impact tested in accordance with the ASME B&PV Code, 1968 Edition through the Winter 1969 Addenda and to the applicable General Electric reactor pressure vessel (RPV) purchase specification requirements.

Estimated values of RT_{NDT} (reference temperature, nil ductility transition) for the unirradiated beltline plates and welds are presented in Table 5A-4. These estimates were made using the data in Tables 5A-1 and 5A-2 in accordance with GE procedure Y1006A006, which meets the intent of paragraph NB2300 of the ASME B&PV Code. For the three plates that comprise shell course number 3 (heats 5K3025, 5K2608, and 5K2698), adequate toughness data are not available to determine their inherent RT_{NDT} values. However, in comparing these three heats with the other beltline plate materials (Table 5A-3), certain variables that affect toughness properties (i.e., heat treatment, C content, Mn content, sulfur and phosphorus levels, mechanical strength, and grain size) are essentially the same. In addition, longitudinal +40°F CVN data for shell course number 3 plates are equivalent to longitudinal +40°F data for the other beltline plate materials. Therefore, it appears appropriate and conservative to estimate the initial RT_{NDT} value (+19°F) for the shell course number 3 plates as the highest RT_{NDT} value determined for the other beltline plate materials.

The applicability of General Electric Procedure Y 1006A006, Revision 1 (submitted under separate cover) to the Hitachi-fabricated HCGS

Unit 1 reactor pressure vessel (RPV) is demonstrated by Tables 5A-20 and 5A-21. These tables compare the chemistries, heat treatments, and mechanical properties of the materials that form the data base for the application of Y1006A006 with the properties of the HCGS RPV materials. Table 5A-20 provides data for plate materials, and Table 5A-21 provides data for forgings. The comparisons indicate that for both plates and forgings there are no significant differences in these properties between the Y1006A006 materials and the HCGS materials.

Further evidence of the compatibility of the HCGS RPV material is presented in Tables 5A-22 and 5A-23, which compare Charpy V-notch test results. As shown in Table 5A-22, the plates fabricated by Japan Steel/Hitachi have toughness properties equivalent to Y1006A006 data-base materials, although they were evaluated at test temperatures 10°F lower. Similarly, as shown in Table 5A-23, the Japan Steel/Hitachi forgings demonstrate a -10°F notch toughness comparable to results for the Y1006A006 forgings, which were tested at +50°F.

Evidence of the equivalence of the Y1006A006 and Hitachi weld materials is given in Table 5A-24, which compares their respective chemistries, tensile properties, and thermal treatments. Except for the Ni content, these materials are very similar, although the Hitachi weld metals are generally lower in phosphorus and sulfur content.

Table 5A-25 compares the Charpy V-notch impact-test results for Y1006A006 and Hitachi weld materials. The Hitachi materials correspond well with the notch toughness values for the Y1006A006 materials and, in fact, are generally superior. The submerged-arc weld materials used for fabrication of the HCGS RPV are not presented because of their toughness properties are suitable to meet the requirements of Appendix G of 10CFR50 for establishing reference temperatures, and it was not necessary to apply procedure Y1006A006.

Copper and nickel values, used to estimate the effects of irradiation on toughness, are presented in Table 5A-4.

Estimated end of life (EOL) RT_{NDT} values, including the shift for beltline materials, determined for the (1/4)T thickness location from the vessel I.D., are also given in Table 5A-4 and are in accordance with Regulatory Guide 1.99, Revision 2.

Transverse CVN upper shelf toughness testing was not required at the time the HCGS vessel was manufactured. Therefore, upper shelf data are not available for some of the beltline plates and welds.

Except for shell course 3 material, the beltline plates were transverse CVN impact tested at several relatively low Charpy test temperatures ranging from -76° to 104°F. For three of the six plates tested (heats 5K2963, 6C45, 5K2530), the 75 ft-lb minimum transverse upper shelf requirement was met, although for two of these heats less than three specimens were tested at the temperatures where the 75 ft-lb requirement was met.

To initially demonstrate HCGS beltline plate materials had adequate toughness to meet the 75 ft-lb transverse upper shelf requirement, plots of the fracture appearance versus the corresponding CVN absorbed energy were prepared for each of the six heats tested at the low temperature regime as mentioned above. Least squares linear regressions and the 95 percent confidence limits were obtained. The data are shown in Figures 5A-1 through 5A-6.

The value of the lower confidence limit at 100 percent fracture appearance was then used to infer the upper shelf energy. This procedure is validated by Reference 5A-1. In brief, this paper showed, for ferritic steels (all of which were related to light water nuclear reactors), there is a linear relationship between fracture appearance and CVN energy.

Figures 5A-1 through 5A-6 indicate that all six heats have inferred transverse upper-shelf energies in excess of 75 ft-lbs. One of

these heats, No. 5K3238, is used in the HCGS surveillance program. Hence, extra CVN specimens were available, and supplemental CVN upper shelf tests were run at >190°F. The results, given in Table 5A-1, confirm that the upper shelf energy for this heat is in excess of 75 ft-lbs, further substantiating the validity of the least-squares linear regression technique to infer upper-shelf energy.

For the shell course number 3 plates, low temperature CVN data are not available to infer the upper shelf energies. However, as outlined in the discussions on determining starting RT_{NDT} values, these plates are considered essentially the same as the shell courses 4 and 5 plates. Therefore, it is consistent to assume that their upper shelf energies are equivalent as well and to predict minimum transverse upper shelf energies in excess of 75 ft-lbs.

Unirradiated and end-of-life RT_{NDT} values are given in Table 5A-4 along with values for the shifts in RT_{NDT} calculated by Ref. 5A-6. The radiation shift values used for the pressure-temperature vessel discontinuity limit curves presented in Figures 5.3-1A, B, & C are those derived from shifts calculated according to the formula given in Revision 2 of Regulatory Guide 1.99.

Unirradiated and end-of-life upper shelf energies are given in Table 5A-19. Based on the results listed in Table 5A-19, it is expected that the beltline materials will have upper shelf energy values above 50 ft-lb at 32 EFPY, as required in 10CFR50, Appendix G. Moreover, Hope Creek is a participant in a program to perform analyses to demonstrate equivalent margin in cases where the upper shelf energy drops below 50 ft-lb. This analysis shows equivalent margin at upper shelf energy values as low as 35 ft-lb. The calculations in Tables B-1 and B-2 in Appendix B of Ref. 5A-4 show that the equivalent margin analysis is applicable.

Beltline weld materials were CVN impact tested solely at +10°F. However, most of these materials exceeded the 75 ft-lb upper shelf requirement at this temperature. Only two heats had test results that were less than the minimum required upper shelf energy. Table 5A-2 indicates that material from heat 510-01205 is capable of meeting the 75-ft-lb requirement as evidenced by four out of six test results exceeding this value. One value that did not meet the requirement evidenced 48.1 ft-lbs of absorbed energy. However, the corresponding fracture appearance was only 30 percent ductile whereas the upper-shelf by one definition is considered 100 percent ductile fracture. This margin suggests that

at much higher test temperatures, the material would evidence correspondingly higher impact properties and meet the upper-shelf limits.

This same argument holds for material from heat flux D55733/1810-02205 where a low value of 64.3 ft-lbs was determined but with a fracture appearance of only 40 percent ductile. Again, considerable margin exists to infer an upper-shelf energy in excess of 75 ft-lbs.

5A.2 REACTOR PRESSURE VESSEL NONBELTLINE INFORMATION

The following initial estimated reference temperatures were derived in accordance with GE procedure Y1006A006, which meets the intent of paragraph NB2300 of the ASME B&PV code.

The top head flange (SA508 Class 2) and the shell flange (SA508 Class 2) both have an initial estimated reference temperature, RT_{NDT}, of 10°F.

Plates connected to vessel flanges (SA533, Gr. B, Class 1) have reference temperatures conservatively assumed to +19°F based on no-break dropweight test results at +10°F and an argument similar to that used in predicting the reference temperature for shell course number 3 beltline material (see Section 5A-1). Available data on these plates are presented in Table 5A-17.

Available drop-weight and Charpy V-notch test results for the HCGS Unit 1 closure flange region materials are provided in Table 5A-26.

The nozzles for the Low Pressure Coolant Injection (LPCI) System have a starting estimated reference temperature of -20°F. Because of the design of the HCGS vessel, these nozzles are predicted to experience an EOL fluence at 1/4T of the vessel thickness of 3.26×10^{17} n/cm^2. Based on a copper content of 0.14 percent and a nickel content of 0.82 percent, this fluence yields an estimated EOL RT_{NDT} of 28°F (see Table 5A-5). This estimate is in accordance with NRC Regulatory Guide 1.99, Rev. 2.

The feedwater nozzles (SA508 Class 2) have an estimated reference temperature of -20°F. Since CVN data are not available for these nozzles, this estimate was derived by assuming the feedwater nozzle materials have toughness properties comparable to the LPCI nozzle materials. One feedwater nozzle was made from material of heat number 19468, which was used to fabricate two of the four LPCI nozzles. Table 5A-6, which compares the chemistry, mechanical properties, grain sizes, and heat treatments of both nozzle materials, supports this assumption and shows that these materials are essentially equivalent.

Moreover, the feedwater nozzles were dropweight tested at -20°F, and no breaks were reported; this suggests that the nil ductility transition temperature (NDTT) is at least -30°F and that the assumed NDTT of -20°F for the LPCI nozzle material is conservative.

Closure studs (SA540 Grade B24 material) met the CVN test requirement of 45 ft-lbs of absorbed energy and 25 mils of lateral expansion at 10°F.

5A.3 FERRITIC PRESSURE BOUNDARY PIPING AND VALVES

The HCGS main steam piping is in compliance with 10CFR50, Appendix G, since the material was toughness tested at +70°F in accordance with the ASME B&PV Code, 1971 Edition with Summer 1972 Addenda.

The HCGS flued head fitting material is in compliance with 10CFR50, Appendix G, since the material was toughness tested at 0°F in accordance with the ASME B&PV Code, 1971 Edition with Winter 1973 Addenda.

The safety/relief valves (SRVs) are in compliance with 10CFR50, Appendix G, since they are exempted by the ASME B&PV Code from toughness testing because of their 6-inch size.

The HCGS main steam isolation valves (MSIVs) were built to the 1968 ASME B&PV Code, Addenda Draft for Pumps and Valves, Class 1, and were exempt from toughness testing at time of purchase. These valves are exposed to less than 20 percent of design pressure at temperatures less than +250°F.

The typical available information on the HCGS MSIV body materials is presented in Table 5A-7. The thickness of the MSIV bodies is 1.925 inches. Toughness data on similar materials for MSIV bodies on other projects, where toughness testing was done, are presented in Tables 5A-8 through 5A-13. In most cases, the valve vendor and the material supplier are the same as for the HCGS MSIVs (Atwood and Morrill and Quaker Alloy Casting Co., respectively). In all cases, these materials were heat treated generally in the same manner. A typical heat treatment cycle was: Normalize at 1700°F and air cool plus temper at 1350°F and air cool plus postweld heat treatment at 1200°F and/or stress relief at 1100°F and air cool. By inference, the data in Tables 5A-8 through 5A-13 demonstrate the capability of the HCGS MSIV body materials (Table 5A-7) to meet current toughness requirements (i.e., 25 mils of lateral expansion at a temperature lower than or equal to the lowest service temperature).

The HCGS MSIV valve cover, i.e., bonnet materials are SA105 Grade 2 forgings, normalized at 1650°F and air cooled (Table 5A-14). Some evidence of toughness for SA105 forgings can be found in Reference 5A-2, which shows CVN toughness in excess of 25 mils of lateral expansion at +40°F and NDTT values no greater than -10°F for SA-105 material normalized at 1565°F for four hours and air cooled. The thickness of the MSIV valve covers is 5.095 inches.

Further evidence of toughness for SA105 forging material is presented in Tables 5A-15 and 5A-16, which show toughness data for River Bend Unit 1 pipe fittings. These materials were normalized at 1650°F for four hours and air cooled. The toughness data given are for longitudinally oriented specimens, whereas the ASME B&PV Code requirements are for transverse specimens. However, prior GE impact

test experience with carbon steel material indicates it is appropriate to approximate transverse properties at about 40 percent of the corresponding longitudinal properties. On this basis the data in Tables 5A-15 and 5A-16 predict that the transverse properties meet the requirements for 25 mils of lateral expansion.

5A.4 REACTOR PRESSURE VESSEL SURVEILLANCE SPECIMENS

The HCGS vessel was built to the 1968 Edition of Section III of the ASME B&PV Code with Winter 1969 Addenda prior to the promulgation of 10CFR50 Appendix H and ASTM E185-73. Therefore, the HCGS surveillance program is designed to conform to the requirements applicable at the time the vessel was fabricated.

Table 5A-4 indicates that the HCGS beltline materials are generally resistant to irradiation degradation of impact properties. The highest predicted EOL reference temperature, RT_{NDT}, is 75°F for heat 5K3025-1 material.

The surveillance test plate weld materials consist of heat/lot 510-01205 stick electrode and heat/lot D53040/1125-02205 bare wire and flux via submerged arc welding (SAW).

The Babcock-Hitachi K.K. weld procedure used to prepare the surveillance test plate is provided as Figure 5A-7. Available information concerning the plate weld indicates the root of the weld consists of stick electrode heat/lot 510-01205, whereas the remainder of the weld if essentially heat/lot D53040/1125-02205 SAW filler. Documentation submitted by Babcock-Hitachi K.K. detailing the location and numbering of surveillance specimens

shows weld metal surveillance specimens to have been fabricated away from the root of the weld. Therefore, it is assumed that weld metal surveillance specimens represent only heat/lot D53040/1125-02205 material.

The number of surveillance specimen capsules and the number of specimens are in compliance with ASTM E185-73. The capsule holders inside the vessel are located at 30°, 120°, and 300° azimuths. The capsule located at the 30° azimuth was removed during the fifth refueling outage. Capsule contents, including number and orientation of specimens, are given in Table 5A-18.

The withdrawal schedule for the surveillance program capsules as specified in section 5.3.1.6.1 meet the requirements of ASTM Standard E 185-82. The lead factors for the HCGS surveillance capsules are 1.05 at the inside surface of the vessel and 1.52 at one-quarter of the way through the vessel wall measured from the inside surface. These lead factors were calculated assuming that the vessel is symmetrical. This assumption was made because the vessel qualification program did not provide for measurements of vessel radii to identify any angular locations where the inside diameter of the vessel is larger than nominal. Hence, it is possible that a surveillance capsule could be located at an extended radius position. This would provide surveillance sample test results lower than calculated and nonconservative values for the peak fluence when it is estimated from the capsule data using the aforementioned lead factors.

The orientations of the surveillance specimens are acceptable since the data indicate that radiation embrittlement is independent of specimen orientation. Longitudinally oriented CVN specimens from the heat affected zone (HAZ) simulate the conditions of longitudinal production weld joints.

The End-of-Life (EOL) calculated peak fluence at the inside diameter of the vessel is 1.10×10^{18} n/cm^2 ($E > 1.0$ Mev) and at one quarter of the vessel thickness is 7.63×10^{17} n/cm^2 ($E > 1.0$ Mev). The

withdrawal of the capsules will be according to the criteria found in the BWR Vessel and Internals Project (BWRVIP) Integrated Surveillance Program (ISP), reference 5.3-12.

The construction tolerances on the reactor vessel required that the minimum (nominal) radius of the vessel be maintained. The applicable version of the ASME B&PV Code did allow for areas of the vessel to have larger radii. The measurement acceptance techniques for the vessel were either the use of a template to test the minimum diameter or a series of measurements to determine the diameter at various points. The measurement technique did not require the identification of the locations where the vessel diameter is longer than nominal. Hence the lead factors were calculated for the nominal dimension.

If an area of increased vessel diameter were to coincide with a location of the surveillance sample specimens, the correct fluence at the samples would be less than that predicted from measurements on the samples. If these data were used to preduct the peak fluences, the values would be less than the calculated peak

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fluences. The calculated peak fluences using nominal dimensions will be conservative.

5A.5 REFERENCES

5A-1 Oldfield, W., "Statistical Relationships between Charpy V-Notch Energy and Fracture Appearance," Res Mechanica Letters 1, (1981) pp 149 - 154.

5A-2 Becker, J.R. and C. Stead, "Closed-Die Forgings for Nuclear Applications, Metal Progress," pages 35-39, July 1978.

5A-3 General Electric Company, "RPV Surveillance Materials Testing and Fracture Toughness and Analysis," GE-NE-A164-1294, R1, DRF 137-0010-7, December 1997.

5A-4 General Electric Company, "10CFR50 Appendix G Equivalent Margin Analysis for Low Upper Shelf Energy in BWR/2 through BWR/6 Vessels," NEDO-32205-A, Rev. 1, February 1994.

5A-5 General Electric Company, "Basis for GE RTNDT Estimation Method," NEDC-32399-P, September 1994.

5A-6 Structural Integrity Associates, Inc., "Revised Pressure-Temperature Curves for Hope Creek," SIR-00-136, Rev. 1, March 23, 2004.

TABLE 5A-1

BELTLINE PLATE TOUGHNESS DATA
(SA-533, GRADE B, Class 1 Plate)

Shell Course	Heat#/ Slab#	NDT (Top/Bottom) (°F)	Charpy V-Notch Toughness: Orientation Longitudinal (L) or Transverse (T)	Charpy Test Temp. (°F)	Energy (ft-lb)	Lateral Expansion (mils)	Shear, percent
No. 5 (lower)	5K3230/1	-10	Transverse	+10	48.2, 59.5, 39.7	40, 42, 38	25, 30, 25
				+40	59.5, 64.6, 68.5	49, 51, 51	30, 35, 40
				+68	65.9, - -	48, - -	45, - -
				-22	30.3, 31.5, -	24, 22, -	10, 10, -
				-49	21.3, 13.9, -	14, 9, -	5, 5, -
				-76	12.8, - -	9, - -	5, - -
			Longitudinal (top)	+40	72, 56, 72		
			(bot)	+40	114, 61, 104		
	6C35/1	-20	Transverse	+10	33.8, 33.8, 32.6	29, 28, 25	25, 20, 15
				+40	56.9, 47.3, 58.2	43, 30, 46	35, 25, 30
				+68	58.3, - -	46, - -	30, - -
				-22	24.7, 28.0, -	24, 37, -	5, 10, -
				-49	18.1, 17.0, -	13, 12, -	5, 5, -
				-76	19.2, - -	5, - -	3, - -
			Longitudinal (top)	+40	67, 113, 59		
			(bot)	+40	49, 58, 51		
No. 5 (lower)	6C45/1	-20	Transverse	+10	40.9, 38.5, 45.7	26, 31, 33	20, 20, 20
				+40	62, 50.7, 43.3	48, 42, 33	45, 30, 25
				+68	62, - -	48, - -	30, - -
				+104	85.4, - -	69, - -	60, - -
				-22	40.9, 37.3, -	27, 36, -	10, 10, -
				-49	10.8, - -	7, - -	3, - -
				-76	9.7, - -	10, - -	0, - -
			Longitudinal (top)	+40	72, 68, 54		
			(bot)	+40	58, 78, 76		
No. 4 (lower intern.)	5K2963/1	-10	Transverse	+10	62.0, 59.7, 60.7	38, 45, 46	35, 30, 30
				+40	80.3, 82.9, 80.3	56, 58, 58	60, 65, 60
				+68	88.2, - -	64, - -	65, - -
				+104	107.1, - -	71, - -	85, - -
				-22	44.5, 37.3, -	36, 29, -	20, 20, -
				-49	32.6, - -	14, - -	10, - -
				-76	13.9 - -	25, - -	5, - -
			Longitudinal (top)	+40	66, 120, 79		
			(bot)	+40	63, 72, 75		

TABLE 5A-1 (Cont)

Shell Course	Heat#/ Slab#	NDT (Top/Bottom) (°F)	Charpy V-Notch Toughness: Orientation Longitudinal (L) or Transverse (T)	Charpy Test Temp. (°F)	Energy (ft-lb)	Lateral Expansion (mils)	Shear, percent	
No. 4 (Lower intern.)	5K2530/1	-10	Transverse	+10	59.5, 62.0, 56.9	43, 48, 44	30, 40, 30	
				+40	37.3, 59.5, 51.9	29, 45, 40	30, 40, 35	
				+68	123.3, 86.9, -	52, 71, -	70, 70, -	
				+104	88.2, - -	71, - -	80, - -	
				-22	24.7, 20.3, -	16, 16, -	10, 10, -	
				-49	28.0, - -	20, - -	5, - -	
			Longitudinal (top)	+40	120, 97, 111			
			(bot)	+40	138, 117, 103			
	5K3238/1[2]	0	Transverse	+10	31.5, 30.3, 30.3	20, 22, 22	15, 20, 15	
				+40	40.9, 48.2, 43.3	36, 33, 33	45, 40, 25	
				+68	62.0, - -	46, - -	40, - -	
				+104	62.0 - -	50, - -	50, - -	
				-22	20.3, 21.3, -	17, 18, -	10, 10, -	
				-49	20.3, - -	12, - -	10, - -	
				-76	12.8 - - [1]	8, - -	2, - -	
				≥+195	88.0, 94.5, 91.0	69, 78, 73	99, 99, 99	
			Longitudinal (top)	+10	58, 58, 62			
			(bot)	+10	35, 37, 43			
No. 3 (Interm)	5K3025/1	+40 (no break)	Longitudinal (top)	+40	75.8, 87.8, 61.5	52, 66, 48	30, 50, 30	
			(bot)	+40		94.5, 77.1, 69.3		74, 86, 54 50, 40, 30
	5K2608/1	+40 (no break)	Longitudinal (top)	+40	71.9, 74.5, 85.1	52, 59, 57	30, 30, 30	
			(bot)	+40		66.7, 51.4, 70.6		47, 37, 48 30, 20, 20
	5K2698/1	+40 (no break)	Longitudinal (top)	+40	98.5, 79.8, 85.1	72, 58, 58	50, 40, 40	
			(bot)	+40		74.5, 91.8, 93.1		51, 69, 62 30, 30, 40

(1) Supplemental test results of surveillance program spares.
(2) Surveillance test plate material.

TABLE 5A-2

BELTLINE WELD METAL

Weld Identity	Weld No. & Azimuth Location	Process	Heat No.	Flux Lot	NDT (°F)	Charpy Impact Toughness: Charpy Test Temp. (°F)	Absorbed Energy (ft-lb)	Lateral Expansion (mills)	Shear percent
Shell course No. 5 longitudinal seams (all seams)	W15-1 18°	SMAW	510-01205	-	-40	+10	90.1 73.2 48.1	70, 64, 38	60, 40, 30
		SAW(3)				+10	98.4 87.0 92.2	65, 66, 65	50, 50, 50
			D53040	1125-02205	-30	+10	88.4 67.6 51.5	62, 55, 41	50, 40, 40
						+10	63.9 51.8 66.6	45, 44, 55	50, 40, 50
	W15-2 138°					+10	102.9 69.0 88.7	86, 57, 70	70, 40, 50
						+10(1)	85.3, 73.2 77.3	58, 51, 57	50, 50, 40
						+10(1)	64.6, 77.6 73.7	52, 62, 55	40, 45, 40
	W15-3 258°					+40(2)	113.9, 112.5 96.3	83, 79, 72	80, 80, 45
						>+200(2)	133.0 144.5 148.0	90, 87, 85	99, 99, 99
Girth weld between shell courses 4 and 5	W7	SMAW & SAW	----------Same as W15----------						
Shell course No. 4 longitudinal seams (all seams)	W14-1 90°	SMAW & SAW	----------Same as W15----------						
	W14-2 210°								
	W14-3 330°								
Girth weld between shell courses 3 and 4	W6	SMAW	519-01205	-	-49	+10	109.8, 109.8, 107.1	87, 78, 70	75, 75, 80
		SMAW	504-01205	-	-31	+10	130.1, 120.6, 123.3	89, 84, 92	75, 80, 75
		SMAW	510-01205		----------Same as W15-1----------				
		SAW	D55733	1810-02205	-40	+10	72.6, 64.3, 66.7	62, 69, 62	50, 40, 50
		SAW	D53040	1810-02205	-49	+10	89.6, 88.2, 107.1	82, 71, 89	60, 60, 75
Shell course No. 3 longitudinal seams (all seams)	W13-1 35°	SMAW	510-01205	-	----------Same as W15-1----------				
	W13-2 155°	SAW	D53040	1125-02205	----------Same as W15-1----------				
	W13-3 275°								

TABLE 5A-2 (Cont)

Weld Identity	Weld No. & Azimuth Location	Process	Heat No.	Flux Lot	NDT (°F)	Charpy Impact Toughness: Charpy Test Temp. (°F)	Charpy Impact Toughness: Absorbed Energy (ft-lb)	Charpy Impact Toughness: Lateral Expansion (mils)	Charpy Impact Toughness: Shear percent
LPCI nozzle welds (4 total)	W179 45°	SMAW	504-01205 001-01205	- -	-40	+10	Same as W6 127.5, 98.0, 102.0	88, 77, 79	80, 60, 60
	W179 135°		504-01205 519-01205	- -			Same as W6 Same as W6		
	W179 225°		001-01205 519-01205	- -			Same as W179 Same as W6		
	W179 315°		504-01205 519-01205	- -			Same as W6 Same as W6		

(1) Surveillance sample records.
(2) Supplemental test results of surveillance program spares.
(3) Surveillance weld material.

TABLE 5A-3

HEAT TREATMENT AND CHEMICAL MECHANICAL PROPERTIES OF BELTLINE PLATE MATERIAL

Japan Steel Plate Heat Number	Heat Treatment (°C)			Chemistry, wt. percent							Mechanical Properties			
	Austenitize	Temper	Postweld	C	Mn	P	S	Si	Ni	Mo	Yield (ksi)	U.T.S. (ksi)	Elong-ation, (percent)	Grain Size
5K3025	3.6HR@(860-890)	3.3HR@(650-670)	42.8HR@(595-605)	0.17	1.46	0.012	0.009	0.30	0.71	0.52	67.0 68.5	99.0 87.3	28.5 25.5	7.5
5K2608	3.3HR@(860-870)	3.5HR@(650-660)	40.0HR@(595-605)	0.19	1.46	0.009	0.014	0.30	0.58	0.52	61.0 60.5	85.0 85.5	26.9 26.9	7.0
5K2698	3.6HR@(860-875)	3.9HR@(650-670)	40.0HR@(595-605)	0.21	1.41	0.010	0.010	0.30	0.58	0.56	68.2 65.1	89.4 87.5	26.7 27.1	7.5
5K3238	3.4HR@(860-890)	3.3HR@(650-670)	40.5HR@(600-610)	0.20	1.45	0.012	0.008	0.31	0.63	0.56	70.2 -	92.5 -	26.5 -	7.5
5K2530	3.3HR@(860-895)	3.3HR@(650-670)	40.5HR@(600-610)	0.20	1.43	0.010	0.008	0.30	0.56	0.54	70.8 -	92.3 -	25.1 -	6.5
5K2963	3.5HR@(860-870)	3.3HR@(660-670)	40.5HR@(600-610)	0.22	1.43	0.009	0.008	0.29	0.58	0.59	70.6 69.3	91.7 91.8	27.0 25.0	8.0
5K3230	3.5HR@(860-880)	3.6HR@(650-680)	40.5HR@(600-610)	0.19	1.44	0.010	0.012	0.30	0.56	0.50	62.7 62.1	87.5 85.3	27.5 26.7	6.0
6C35	3.3HR@(860-890)	3.7HR@(650-680)	40.5HR@(600-610)	0.20	1.46	0.010	0.011	0.27	0.54	0.51	66.2 65.3	89.4 87.7	24.6 27.5	7.5
6C45	3.4HR@(860-880)	3.7HR@(650-680)	40.5HR@(600-610)	0.18	1.49	0.008	0.010	0.31	0.57	0.50	68.6 73.3	90.5 93.8	25.6 25.2	7.5

TABLE 5A-4

RADIATION RT_{NDT} AND EOL RT_{NDT} FOR BELTLINE MATERIALS

	Chemistry		RT_{NDT} (F)		
Heat Number/Lot	Cu (Wt) Percent	Ni (Wt) Percent	Initial Value	from Reg. Guide 1.99, R2	Estimated EOL
Vessel Plate Material (SA533, Gr. B, Cl-1) for Shell Courses 4 and 5					
Peak EOL Fluence at 1/4T = 7.63×10^{17} n/cm^2					
5K2963-1-2	0.07	0.58	-10	32	+22
5K2530-1-2	0.08	0.56	+19	37	+56
5K3238-1-2 (1)	0.09	0.64	+7	42	+49
5K3230-1-2	0.07	0.56	-10	32	+22
6C35-1-2	0.09	0.54	-11	42	+31
6C45-1-2	0.08	0.57	+1	37	+38
Vessel Plate Material (SA533, Gr. B, Cl-1) for Shell Course 3					
Peak EOL Fluence (2) at 1/4T = 3.68×10^{17} n/cm^2					
5K3025-1	0.15	0.71	+19	56	+75
5K2608-1	0.09	0.58	+19	29	+48
5K2698-1	0.10	0.58	+19	32	+51
Material for Girth and Longitudinal Welds for Shell Courses 4 and 5					
Peak EOL Fluence at 1/4T = 7.63×10^{17} n/cm^2					
510-01205 (3)	0.09	0.54	-40	80	+40
D53040/1125-02205 (3,5)	0.081	0.611 (6)	-30	78	+48

TABLE 5A-4 (Cont)

	Chemistry		RT_{NDT} (F)		
Heat Number/Lot	Cu (Wt) Percent	Ni (Wt) Percent	Initial Value	from Reg. Guide 1.99, R2	Estimated EOL
Girth Weld Material between Shell Courses 3 and 4					
Peak EOL Fluence(2) (Shell Course 3) at 1/4T = 3.68×10^{17} n/cm^2					
519-01205(4)	0.01	0.53	-49	10	-39
504-01205(4)	0.01	0.51	-31	10	-21
D55733/1810-02205	0.10	0.68	-40	62	+22
D53040/1810-02205(6)	0.081	0.611	-49	53	+4
LPCI Nozzle Weld Material (Bottom of Nozzles)					
Peak EOL Fluence(2) at 1/4T - 3.26×10^{17} n/cm^2					
001-01205	0.02	0.51	-40	13	-27

(1) Surveillance test plate material.

(2) Axial and radial distributions included.

(3) These materials were also used in the longitudinal seams of shell course 3 and in the girth welds between shell courses 3 and 4.

(4) These materials were also used for the LPCI nozzle welds.

(5) Surveillance weld material.

(6) Average chemistry of this weld material, surveillance weld material, and mechanical test weld material. From Ref. 5.3-12, Table 3-5.

TABLE 5A-5

RADIATION RT_{NDT} AND EOL RT_{NDT} FOR CORE REGION NOZZLES

	Chemistry		NDT_{NDT} (F)		
Heat Number(1)	Cu (Wt) Percent	Ni (Wt) Percent	Initial Value	from Reg. Guide 1.99,R2	Estimated EOL
19468-1-4,5	0.12	0.80	-20	40	+20
10024-1-2,3	0.14	0.82	-20	48	+29

(1) LPCI Nozzles (SA508, Cl2)

(2) Peak EOL Fluence at 1/4T of vessel thickness = 3.26×10^{17} n/cm^2

TABLE 5A-6

HEAT TREATMENT AND CHEMICAL MECHANICAL PROPERTIES OF NOZZLE MATERIAL

Nozzle Type Heat Number	Heat Treatment (°C)			Chemistry (wt. percent)							Mechanical Properties			
	Austenitize	Temper	Postweld	C	Mn	P	S	Si	Ni	Mo	Yield, (ksi)	U.T.S. (ksi)	Elongation, (percent)	Grain Size
12 in. LPCI Heat 19468	690 min.@ 910°C	1200 min @ 665°C	2400 min @ 625°C	0.15	0.74	0.008	0.011	0.28	0.80	0.62 0.35	-	-	-	7.5
12 in. LPCI Heat 10024	545 min. @ 895°C	1200 min. @ 660°C	2400 min. @ 620°C	0.15	0.73	0.010	0.009	0.29	0.82	0.64 0.40	71.0	88.0	-	8.5
12 in. feed-water Heat 19432	640 min. @ 900°C	1140 min. @ 670°C	2400 min. @ 620°C	0.16	0.77	0.009	0.008	0.30	0.83	0.67 0.36	73.0	90.0	-	8.0
12 in. feed-water Heat 19468	600 min. @ 900°C	1040 min. @ 665°C	2400 min. @ 620°C	(Date provided above for LPCI nozzle material)										8.0
12 in. feed-water Heat 19346	540 min. @ 900°C	1020 min. @ 678°C	2400 min. @ 620°C	0.16	0.59	0.006	0.007	0.25	0.91	0.65 0.34	64.0	81.0	-	8.0

TABLE 5A-7

TYPICAL HCGS MSIV BODY MATERIAL INFORMATION

Applicable Code:	1968 ASME B&PV Code, Addenda draft for pumps and valves, Class 1
Vendor:	Atwood and Morrill Co.
Material Vendor:	Quaker Alloy Casting Co.
Material Specification:	ASTM SA 216 WCB
Heat Number:	R9070

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.24	0.83	0.49	0.015	0.02	NA(1)

Grain Size (ASTM No.):	NA(1)
Heat Treatment:	Normalize 1690°F to 1710°F (7 hr, 5 min.) air cool + Temper 1380°F (6 hr, 15 min.) air cool + Postweld 1140°F to 1165°F (6 hr, 50 min.) air cool

Charpy V-Notch Impact Toughness:

Test Temperature:	NA
Energy, ft-lb:	NA
Lateral Expansion, mils:	NA
Shear, percent:	NA

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(1) NA = Not Available.

TABLE 5A-8

GRAND GULF MSIV BODY MATERIAL INFORMATION

Applicable Code:	ASME B&PV Code, Section III, 1974
Valve Vendor:	Atwood and Morrill, Co.
Material Vendor:	Quaker Alloy Casting Co.
Material Specification:	ASME SA216 Grade WCB
Heat Number:	F6406

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.23	0.89	0.53	0.019	0.012	NA(1)

Grain Size (ASTM No.): NA(1)

Heat Treatment: Normalize 1680/1710°F (5 hr, 30 min) air cool
+ Temper 1350°F (5 hr, 30 min) air cool
+ Postweld 1200°F (6 hr) air cool

Charpy V-Notch Impact Toughness:

Test Temperature:	+60°F
Energy, ft-lb:	32, 31, 34
Lateral Expansion, mils:	33, 32, 31
Shear, percent:	40, 40, 40

(1) NA = Not Available.

TABLE 5A-9

TVA X20 MSIV BODY MATERIAL INFORMATION

Applicable Code:	ASME B&PV Code, Section III, 1975 with Summer 1975 Addenda
Valve Vendor:	Atwood & Morrill Co.
Material Vendor:	Quaker Alloy Casting Co.
Material Specification:	ASME SA216 Grade WCB
Heat Number:	F3547

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.23	0.88	0.38	0.016	0.015	NA(1)

Grain Size (ASTM No.):	NA
Heat Treatment:	Normalize 1700°/1725°F (6 hr, 20 min) air cool + Temper 1345°F (6 hr, 45 min) air cool + Postweld 1200°/1225°F (6 hr, 30 min) air cool

Charpy V-Notch Impact Toughness

Test Temperature:	+60°F
Energy, ft-lb:	66, 56, 54
Lateral Expansion, mils:	53, 50, 53
Shear, percent:	40, 40, 40

(1) NA = Not Available.

TABLE 5A-10

CLINTON 1 MSIV BODY MATERIAL INFORMATION

Applicable Code:	ASME B&PV Code, Section III, 1974
Valve Vendor:	Atwood and Morrill Co.
Material Vendor:	Quaker Alloy Casting Co.
Material Specification:	ASME SA216 Grade WCB
Heat Number:	F7516

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.25	0.78	0.53	0.018	0.013	NA(1)

Grain Size (ASTM No.):	NA(1)
Heat Treatment:	Normalize 1690/1710°F (6 hr 5 min) air cool + Temper 1350/1360°F (6 hr) air cool + Postweld 1200°F (6 hr, 5 min)air cool

Charpy V-Notch Impact Toughness

Test Temperature:	+60°F
Energy, ft-lb:	30, 24, 34
Lateral Expansion, mils:	37, 27, 33
Shear, percent:	40, 40, 40

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(1) NA = Not Available.

TABLE 5A-11

CNV MSIV BODY MATERIAL INFORMATION

Applicable Code:	ASME B&PV Code, Section III, 1971 with S73 Addenda
Valve Vendor:	Rockwell International
Material Vendor:	Rockwell International
Material Specification:	SA216 Grade WCC
Heat Number:	3760171

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.17	1.09	0.50	0.008	0.011	0.060

Grain Size (ASTM No.): NA(1)

Heat Treatment: Normalize 1700°F (8 hr) air cool
Temper 1275°F (8 hr) air cool
Postweld 1100°F (6 hr) air cool

Charpy V-Notch Impact Toughness

Test Temperature:	+40°F
Energy, ft-lb:	35.0, 38.0, 29.0
Lateral Expansion, mils:	32.0, 36.0, 29.0
Shear, percent:	20, 20, 20

---

(1) NA = Not Available.

TABLE 5A-12

LAGUNA VERDE 1 MSIV-BODY MATERIAL INFORMATION

Applicable Code:	ASME B&PV Code, Section III, 1971 with Summer 1973 Addenda
Valve Vendor:	Rockwell International
Material Vendor:	NA(1)
Material Specification:	SA216 Grade WCC
Heat Number:	1750262

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.21	1.19	0.43	0.011	0.009	0.043

Grain Size (ASTM No.):	NA(1)
Heat Treatment:	Normalize 1700°F (10 hr) air cool + Temper 1225°F (7.5 hr) air cool + Postweld 1100°F (6 hr) air cool

Charpy V-Notch Impact Toughness

Test Temperature:	+40°F
Energy, ft-lb:	29.0, 33.0, 35.0
Lateral Expansion, mils:	25.0, 26.0, 30.0
Shear, percent:	15, 15, 15

---

(1) NA = Not Available.

TABLE 5A-13

RIVER BEND 1 MSIV BODY MATERIAL INFORMATION

Applicable Code:	ASME B&PV Code, Section III, 1974
Valve Vendor:	Atwood & Morrill Co.
Material Vendor:	Atwood & Morrill, Ltd.
Material Specification:	SA216 Grade WCB
Heat Number:	35

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.24	0.82	0.46	0.022	0.013	NA(1)

Grain Size (ASTM No.):	NA(1)
Heat Treatment:	Normalize 1650°F - 1800°F (8 hr) air cool to 400°F + Temper 1150°/1250°F (8 hr) air cool + Postweld 1095°/1195°F (18 hr) furnace cool to 800°F (100°F/hr) air cool

Charpy V-Notch Impact Toughness

Test Temperature:	+60°F
Energy, ft-lb:	31.5, 37.5, 39.5
Lateral Expansion, mils:	33, 41, 40
Shear, percent:	10, 10, 10

---

(1) NA = Not Available.

TABLE 5A-14

HCGS MSIV COVER MATERIAL INFORMATION

Applicable Code:	1968 ASME B&PV Code, Addenda Draft for Pumps (Valves, Cl.1)
Valve Vendor:	Atwood & Morrill Co.
Material Vendor:	Cann & Saul Steel Co.
Material Specification:	ASTM A105 Grade 2
Heat Number:	229076

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.35	0.76	0.20	0.010	0.017	NA(1)

Grain Size (ASTM No.): NA(1)

Heat Treatment: 1650°F (12 hr) cool in still air

Charpy V-Notch Impact Toughness

Test Temperature:	NA
Energy, ft-lb:	NA
Lateral Expansion, mils:	NA
Shear, percent:	NA

---

(1) NA = Not Available.

TABLE 5A-15

RIVERBEND 1 PIPE FITTING MATERIAL INFORMATION
(HEAT NUMBER 631218)

Applicable Code:	ASME B&PV Code, Section III, 1974 Edition S74 Addendum
Vendor:	Bonney Forge Division, Gulf & Western Manufacturing
Material Vendor:	Sharon Steel
Material Specification:	SA105N
Heat Number:	631218 (Sharon Steel)

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.28	0.87	0.22	0.014	0.015	NA(1)

Grain Size (ASTM No.): NA(1)

Heat Treatment: Normalize 1650°F (4 hr) air cool

Charpy V-Notch Impact Toughness (Longitudinal):

Test Temperature:	+70°F
Energy, ft-lb:	68.2, 83.5, 76.0
Lateral Expansion, mils:	64, 71, 69
Shear, percent:	80, 80, 80

(1) NA = Not Available.

TABLE 5A-16

RIVER BEND 1 PIPE FITTINGS MATERIAL INFORMATION
(HEAT NUMBER 630614)

Applicable Code:	ASME B&PV Code, Section III, 1974 Edition S74 Addendum
Vendor:	Bonney Forge Division, Gulf & Western Manufacturing
Material Vendor:	Sharon Steel
Material Specification:	SA105N
Heat Number:	630614 (Sharon Steel)

Chemical Composition (Wt. percent):	C	Mn	Si	P	S	Al
	0.26	0.86	0.16	0.022	0.017	NA(1)

Grain Size (ASTM No.): NA(1)

Heat Treatment: Normalize 1650°F (4 hr) air cool

Charpy V-Notch Impact Toughness (Longitudinal):

Test Temperature:	+70°F					
Energy, ft-lb:	76.6,	74.9,	62.0	107.7,	108.5,	109.3
Lateral Expansion, mils:	68,	69,	63	75,	84,	85
Shear, percent:	80,	90,	80	100,	100,	100

(1) NA = Not Available.

TABLE 5A-17

HEAT TREATMENT AND CHEMICAL MECHANICAL PROPERTIES OF PLATES CONNECTING TO CLOSURE FLANGES

Japan Steel Plate Heat Number	Heat Treatment (°C)			Chemistry (wt. percent)							Mechanical Properties			
	Austenitize	Temper	Postweld	C	Mn	P	S	Si	Ni	Mo	Yield, (ksi)	U.T.S. (ksi)	Elong-ation, (%)	Grain Size
(SHELL COURSE NUMBER 1 PLATES)														
5K3015	3.7HR@(860-890)	3.4HR@(650-670)	40.0HR@(595-605)	0.20	1.41	0.009	0.010	0.26	0.58	0.53	68.0	92.0	26.0	7.5
5K3101	3.5HR@(860-880)	3.3HR@(660-680)	40.5HR@(595-605)	0.19	1.47	0.012	0.010	0.29	0.57	0.55	72.0	95.0	25.3	7.5
5K3150	3.4HR@(860-890)	3.6HR@(650-675)	40.0HR@(595-605)	0.19	1.47	0.010	0.007	0.29	0.57	0.54	68.0	90.0	28.3	7.5
(TOP HEAD PETAL PLATE MATERIAL)														
6C35	2.3HR@(860-890)	2.4HR@(650-670)	20.7HR@(595-620)	0.19	1.44	0.011	0.010	0.28	0.55	0.52	72.0	95.0	24.8	6.5
	2.8HR@(860-890)	2.3HR@(650-695)	20.0HR@(600-630)	0.19	1.44	0.011	0.010	0.28	0.55	0.52	68.0	90.0	25.8	7.0
6C102	2.3HR@(860-890)	2.3HR@(650-675)	20.0HR@(600-630)	0.19	1.44	0.012	0.011	0.29	0.57	0.52	69.0	90.0	24.6	7.5
	2.3HR@(860-890)	2.2HR@(650-670)	20.3HR@(595-610)	0.19	1.44	0.012	0.011	0.29	0.57	0.52	73.0	91.0	26.8	7.0

TABLE 5A-18

RPV SURVEILLANCE SPECIMEN INFORMATION

Capsule Holder No.	Charpy V-Notch	Tensile
1	12 Long. Base	2 Long. Base
	12 Long. HAZ	2 Long. HAZ
	12 Weld Material	2 Weld Material
2	12 Trans. Base	2 Long. Base
	12 Trans. HAZ	2 Long. HAZ
	12 Weld Material	2 Weld Material
3	12 Long. Base	2 Long. Base
	12 Long. HAZ	2 Long. HAZ
	12 Weld Material	2 Weld Material

TABLE 5A-19

UPPER SHELF ENERGY ANALYSIS FOR HOPE CREEK 1 BELTLINE MATERIAL

LOCATION	HEAT	INITIAL.[1] TRANS. USE	%Cu	%DECR.[2] USE	32 EFPY TRANS. USE
PLATES:					
Lower	5K3230/1	121	0.07	8.5	111
	6C35/1	107	0.09	10	96
	6C45/1	97	0.08	9.5	88
Low-Int.	5K2963/1	102	0.07	8.5	93
	5K2530/1	86	0.08	9.5	78
	5K3238/1	76	0.09	10	68
Unirradiated[3] Surveillance	5K3238/1	91	0.09	10	82
Int.	5K3025/1	75	0.15	11.5	66
	5K2608/1	75	0.09	8.5	69
	5K2698/1	75	0.10	9	68
LPCI Nozzle					
	19468/1	>79	0.12	10	71
	10024/1	>70	0.14	10.5	63
WELD:					
Vertical	510-01205	>92.5	0.09	13	80
	D53040	135	0.081	12.5	118
Unirradiated[3] Surveillance	D53040	164	0.08	12.5	144
LPCI Nozzle	001-01205	>109	0.02	6.5	102
Girth	519-01205	>109	0.01	5.5	103
	504-01205	>125	0.01	5.5	118
	D53040	>95	0.081	12.5	83
	D55733	>68	0.10	11.5	60

(1) Transverse plate values are conservatively estimated as described in the UFSAR; test temperatures for plate materials were not available. Weld values are conservatively based on data taken at 10°F.

(2) Values obtained from Figure 2 of R.G. 1.99 Rev. 2 for 32 EFPY 1/4 T fluences equal to 7.63×10^{17} n/cm^2, for Low. and Low-Int. shells; 3.68×10^{17} n/cm^2, for Int. shell; and 3.26×10^{17} n/cm^2, for LPCI Nozzle. A fluence of 7.63×10^{17} n/cm^2 was used for the welds identified as vertical and 3.68×10^{17} n/cm^2 for the welds identified as girth.

(3) Initial USE data taken from Table 5-4 and chemistry data from Table 3-5 of Ref. 5.3-12.

TABLE 5A-20

COMPARISON OF SA 533 PLATE MATERIAL
USED AS THE DATA BASE FOR GE PROCEDURE Y1006A006 VERSUS SA533 MATERIAL
MANUFACTURED BY JAPAN STEEL WORKS FOR HOPE CREEK UNIT 1 REACTOR PRESSURE VESSEL

Grade	Thickness (in.)	Source	No.(1)	Average Composition of Materials (Wt %) C	Mn	P	S	Si	Ni	Cr	Mo	Heat Treatment	Orient.	Yield Strength (Ksi)	Ultimate Tensile Strength (Ksi)	Percent Elongation (%)
A533	6-6.5	GE	5	0.21	1.32	0.009	0.014	0.18	0.51	-	0.48	1625F-6Hr.-Agitated Brine-Q+1200F-6Hr.-Brine -Q+1125F-30Hr.-FC to 600F	Long. Tran.	69.2 66.0	90.4 88.4	27.9 26.6
A533	7-7.5	Comb.	6	0.22	1.36	0.011	0.014	0.19	0.53	-	0.49	1675F-4Hr.-AC+1600F-4Hr.-Agitated WQ+1225F-4Hr.-FC+1150F-40Hr.-FC	-	-	-	-
A533	8-8.5	GE	4	0.22	1.39	0.011	0.018	0.20	0.54	0.11	0.49	1775F-8.5Hr.-Agitated Brine-Q+1200F-8Hr.-Brine-Q+1125F-30Hr.-FC	-	-	-	-
A533	8.5-9	Comb.	1	0.22	1.38	0.011	0.013	0.21	0.44	-	0.49	1675F-4Hr.-AC+1600F-4Hr. Agitated WQ+1225F-4Hr. FC-1150F-40Hr.-FC		Tran	68.3	88.6 25.4
A533	9.5-10	West.	6	0.21	1.31	0.011	0.017	0.22	0.57	0.14	0.47	1600F-4Hr.-Agitated WQ-1225F-4Hr.-AC+1150F-40Hr.-FC	Tran. Long.	66.4 66.2	86.3 87.4	24.3 26.0
A533	11.5-12	Comb.	3	0.23	1.31	0.010	0.015	0.19	0.55	-	0.58	1675F-4Hr.-AC+1600F-4Hr.Agitated WQ+1225F-4Hr.-FC+1150F-40Hr.-FC	Tran.	64.4	86.7	26.5
A533	11.5-12	West.	4	0.21	1.35	0.013	0.022	0.24	0.51	-	0.48	1600F-4Hr.-Agitated WQ+1225F-4Hr.-AC+1150F-27Hr.-FC	Long. Tran.	66.7 67.8	87.3 86.9	26.2 26.0
A533(2)	6-6.5	Japan Steel		0.20	1.45	0.012	0.008	0.31	0.63	-	0.56	(1580F-1634F)-3.4Hr.-Q+(1202F-1238F)-3.3Hr. (1112F-1130F)-40.5Hr.	-	70.2	92.5	26.5
A533	6-6.5	Japan Steel		0.20	1.43	0.010	0.008	0.30	0.56	-	0.54	"	-	70.8	92.3	25.1
A533	6-6.5	Japan Steel		0.22	1.43	0.009	0.008	0.29	0.58	-	0.59	"	-	69.3	91.8	25.0
A533	6-6.5	Japan Steel		0.19	1.44	0.010	0.012	0.30	0.56		0.50	"	-	62.7	87.5	27.5
A533	6-6.5	Japan Steel		0.20	1.46	0.010	0.011	0.27	0.54	-	0.51	"	-	66.2	89.4	24.6
A533	6-6.5	Japan Steel		0.18	1.49	0.008	0.010	0.31	0.57		0.50	"	-	68.6	90.5	25.6

(1)No. = Number of plates tested.
(2) = SA533, Gr. B, Cl.1

Table 5A-21

Comparison of SA 508 Forging Material

Used as the Data Base for GE Procedure Y1006A006 Versus SA508 Material

Manufactured by Japan Steel Works for Hope Creek Unit 1 Reactor Pressure Vessel

Grade	Thickness (in.)	Source	No.(1)	Average Composition of Materials (Wt %) C	Mn	P	S	Si	Ni	Cr	Mo	V	Heat Treatment	Orient.	Yield Strength (Ksi)	Ultimate Tensile Strength (Ksi)	Reduction of Area (%)
A508 Cl.2	8-8.5	West.	1	0.19	0.65	0.010	0.007	0.23	0.69	0.33	0.60	0.02	1550F-9Hr.-WQ+1210F--12Hr.-AC+1125F-11Hr.-FC	Tang.	72.1	91.3	69.1
A508 Cl.2	9-9.5	West.	1	0.22	0.63	0.009	0.011	0.24	0.68	0.34	0.59	0.02	1185F-11Hr.-Double WQ-1220F-22Hr.-AC+1110F-6Hr. +50°/Hr. to 600F	Tang.	58.9	82.1	70.8
A508 Cl.2	15-20	GE	1	0.21	0.60	0.010	0.007	0.24	0.67	0.33	0.58	0.04	1615F-9Hr.Agitated WQ+1230F-20Hr.-WQ+1125F-30Hr.-100°/Hr. to 600F-AC	Tang.	60.0	82.1	73.5
A508 Cl.2	20-25	Ladish	4	0.23	0.63	0.009	0.010	0.26	0.78	0.35	0.63	0.045	1650F-8Hr.-AC+1650F-8Hr.-WQ+1275F-24Hr.-WQ+1150F-30Hr.-FC to 600F-AC	Tang.	62.5	87.0	66.9
A508 Cl.2	6.7	Japan Steel		0.16	0.72	0.010	0.009	0.32	0.84	0.39	0.62	-	(1634F-1643F) Austenitize-9.1Hr. +(1211F-1220F)Temper-16Hr.+1144F-PWHT-40Hr.	-	71.0	88.4	70.0
A508 Cl.2	6.7	Japan Steel		0.15	0.70	0.011	0.011	0.32	0.81	0.38	0.63	Tr.	(1652-1670F) Austenitize-11Hr.+(1220-1230F)-Temper-16.5Hr.+1156F-PWHT-40Hr.	-	65.1	82.5	72.1

(1) No. = Number of forgings tested

TABLE 5A-22

COMPARISON OF NOTCH TOUGHNESS INFORMATION FOR JAPAN STEEL AND Y1006A006 PLATE MATERIAL

Grade	Thickness (in.)	Source	1/4T Charpy V-Notch Test Results				
			Orientation	No.(1)	Test Temperature (°F)	Average Absorbed Energy (ft-lb)	Average Lateral Expansion (mils)
A533	6-6.5	GE	Transverse	5	+50	60	44
A533	7-7.5	Comb.	Transverse	6	+50	56	45
A533	8-8.5	GE	Transverse	4	+50	60	40
A533	8.5-9	Comb.	Transverse	1	+50	53	40
A533	11.5-12	Comb.	Transverse	3	+50	47	36
A533	11.5-12	West.	Transverse	4	+50	44	40
SA533, Gr.B, Cl.1	6.2-6.8	Japan Steel	Transverse	See below(2)	+40	44	34
SA533, Gr.B, Cl.1	6.2-6.8	Japan Steel	Transverse		+40	50	38
SA533, Gr.B, Cl.1	6.2-6.8	Japan Steel	Transverse		+40	81	57
SA533, Gr.B, Cl.1	6.2-6.8	Japan Steel	Transverse		+40	64	50
SA533, Gr.B, Cl.1	6.2-6.8	Japan Steel	Transverse		+40	54	40
SA533, Gr.B, Cl.1	6.2-6.8	Japan Steel	Transverse		+40	52	41

(1) No = Number of plates tested

(2) Each row of data represents a heat of material used in the beltline region of the Hope Creek Unit 1 RPV.

TABLE 5A-23

COMPARISON OF NOTCH TOUGHNESS INFORMATION FOR JAPAN STEEL AND Y1006A006 FORGINGS

Grade	Thickness (in.)	Source	1/4 Charpy V-Notch Test Results				
			Orientation	No.[1]	Test Temperature (°F)	Average Absorbed Energy (ft-lb)	Average Lateral Expansion (mils)
A508 Class 2	8-8.5	West.	Tang.	1	+50	81	60
A508 Class 2	9-9.5	West.	Tang.	1	+50	96	64
A508 Class 2	15-20	GE	Long.	1	+50	96	55
A508 Class 2	20-25	Ladish	N.R.	4	+50	48	NR
ASME SA508, Class 2	6.7	Japan Steel/ Katsuta Works, Hitachi Ltd.	Long.	See below[2]	-10	80	66
ASME SA508, Class 2	6.7	Japan Steel/ Katsuta Works, Hitachi Ltd.	Long.		-10	77	62

(1) No. = Number of forgings tested

(2) Each row of data represents a heat of material used in the fabrication of the low pressure core injection nozzles for Hope Creek Unit 1 RPV.

TABLE 5A-24

COMPARISONS OF Y1006A006 AND HITACHI SHIELDED METAL ARC WELD MATERIAL

Heat/Lot	Chemical Composition (wt. %) C	Ni	Mn	Si	P	S	Mo	V	Cu	Yield Strength (ksi)	Ultimate Tensile Strength (ksi)	Reduction of Area (%)	Heat Treatment
Y1006A006 DATA BASE:													
402P3162/H426B27AE	0.066	0.83	1.06	0.46	0.02	0.018	0.49	0.019	0.03	78.7	90.7	42.8	1150°F 20° for 50 hours
401P2871/H430B27AF	0.06	0.98	1.09	0.36	0.013	0.017	0.52	0.02	0.03	73.5	83.5	71.2	1150°F 20° for 50 hours
03L048/B525B27AF	0.04	0.96	1.23	0.40	0.014	0.014	0.53	0.02	0.09	78.0	91.0	64.7	1150°F 20° for 50 hours
L83978/J414B27AD	0.08	1.06	1.15	0.51	0.017	0.014	0.54	0.02	0.02	83.7	94.5	69.5	1150°F 20° for 50 hours
401S0371/B504B27AE	0.05	1.04	1.18	0.37	0.012	0.012	0.56	0.02	0.03	84.2	94.4	68.2	1150°F 20° for 50 hours
492L4871/A421B27AE	0.07	0.95	1.06	0.37	0.018	0.025	0.50	0.02	0.04	72.0	84.5	72.7	1150°F 20° for 50 hours
422K8511/G313A27AD	0.06	1.00	1.21	0.31	0.016	0.013	0.54	0.02	0.01	81.3	91.5	74.5	1150°F 20° for 50 hours
640892/J424B27AE	0.08	1.00	1.20	0.44	0.015	0.018	0.55	0.02	0.09	76.5	90.0	71.0	1150°F 20° for 50 hours
07R458/B503B27AG	0.06	0.97	1.14	0.35	0.020	0.021	0.51	0.02	0.04	68.0	80.5	71.4	1150°F 20° for 50 hours
HITACHI:													
510-01205	0.072	0.54	1.20	0.42	0.010	0.011	0.45	---	0.09	85.6	94.6	67.9	1112-1170°F 40 hours
519-01205	0.051	0.53	1.17	0.26	0.010	0.007	0.45	---	0.01	73.0	85.5	71.7	1112-1170°F 40 hours
504-01205	0.06	0.51	1.30	0.26	0.011	0.005	0.41	---	0.01	69.8	83.3	68.2	1112-1170°F 40 hours

TABLE 5A-25

COMPARISON OF CVN TEST RESULTS OF Y1006A006 AND HITACHI WELD MATERIALS

Source	Heat/Flux	Process	Test Temp (°F)	Absorbed Energy (ft-lb)	Lateral Expansion (mils)	Shear (%)
Y1006A006	03L048/B525B27AF	SMAW	0	61, 75, 79	44, 58, 59	50, 60, 60
			+ 40	104, 108	75, 77	80, 80
			+130	122, 123, 126	89, 83, 91	100, 100, 100
	02R486/J404B27AG	SMAW	- 10	52, 64, 66	39, 45, 46	40, 40, 40
			+ 40	84, 87	63, 68	60, 60
			+130	121, 124, 129	91, 96, 95	100, 100, 100
	L83978/J414B27AD	SMAW	- 20	51, 52, 81	37, 40, 63	35, 50, 40
			+ 40	120, 123	72, 73	80, 80
			+ 72	128, 140	78, 81	90, 90
	401S0371/B504B27AE	SMAW	0	80, 85, 82	63, 62, 60	35, 50, 35
			+ 40	95, 97	71, 76	40, 75
			+ 70	111, 107, 109,	87, 85, 77	80, 90, 80
	402P3162/H426B27AE	SMAW	- 10	60, 54, 68	44, 37, 53	40, 30, 30
			+ 40	96, 99	57, 68	60, 60
			+212	119, 122, 124	93, 90, 68	100, 100, 100
	492L4871/A421B27AE	SMAW	0	50, 51, 57	36, 38, 40	30, 40, 45
			+ 40	135, 137	84, 80	90, 80
	422K85AA/G313A27AD	SMAW	- 20	65, 74, 127	44, 48, 76	40, 50, 60
			+ 25	107, 108	74, 80	80, 70
	640892/J424B27AE	SMAW	0	55, 62, 62	38, 44, 48	35, 40, 40
			+ 40	56, 75	42, 55	50, 60
			+130	118, 122, 130	87, 89, 82	100, 100, 100
	401P2871/H430B27AE	SMAW	0	27, 50, 56	25, 42, 46	40, 45, 45
			+ 10	75, 76, 107	60, 62, 74	60, 50, 80
			+ 40	90, 100	71, 76	70, 80
	07R458/S403B27AG	SMAW	0	59, 61, 70	51, 52, 58	50, 50, 60
			+ 40	99, 101	77, 78	80, 75
			+ 72	106, 110	85, 87	80, 80
Hitachi	510-01205	SMAW	+ 10	90, 73, 48	70, 64, 38	60, 40, 30
				98, 87, 92	65, 66, 65	50, 50, 50
	519-01205	SMAW	+ 10	110, 110, 107	87, 78, 70	75, 75, 80
	504-01205	SMAW	+ 10	130, 120, 123	89, 84, 92	75, 80, 75

TABLE 5A-26

DROP WEIGHT AND CHARPY V-NOTCH TEST RESULTS[1]

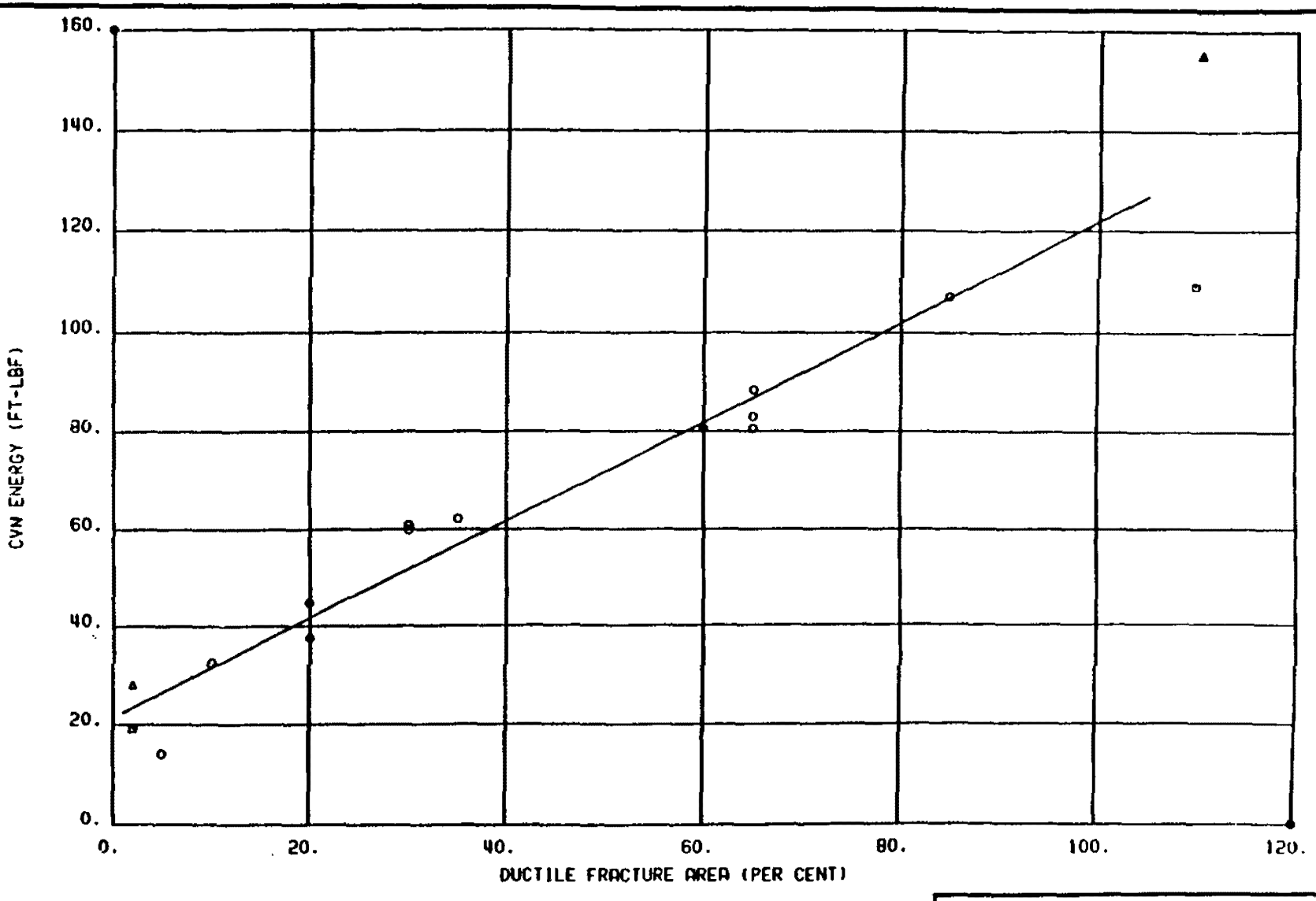
CLOSURE FLANGE REGION MATERIALS

Material	Orientation	NDT Temp. (°F)	Test Temp. (°F)	Absorbed Energy (ft-lbs)	Lateral Expansion (Mils)
SA508, Cl.2 (Head Flange)	Longitudinal	-20/ -10 @180° AWAY	-40	64.1,70.6,20.8,77.1	48,51,11,58
			-10	93.1,114.7,106.6, 87.8,97.1,71.9	64,78,62,55, 64,49
			10	81.1,108,133.6, 137.6, 165.1	49,68,78,95, 68,74
			40	157.4,121.5,137.6, 134.9,144.3,137.6	89,73,77,86, 79,85
			60	199.9,154.8,159.9 195.4,144.3,170.1	77,69,88,87, 82,73
SA508, Cl.1 (Shell Flange)	Longitudinal	-10	10	120.1,122.8,130.9 130.9,132.3,116.1	77,81,83,81, 77,64
			-10	120.1,95.8,128.2, 109.3,101.2,87.8	72,58,80,74 59,57
			+40	141.6,134.9,141.6, 145.6,167.6,182.4	81,77,84,82, 85,89
			-40	13.4,69.3,59.0,55.2 74.5,101.2	7,48,41,38, 54,68
SA533, Gr. B, Cl.1 (Top Petal Plate connected to Head Flange)					
(Piece T2A)	Longitudinal		10	46.5,39.2,39.2 103.9,81.1,75.8	36,34,33, 73,57,54
(Piece T2B)	Longitudinal		10	77.1,70.6,79.8 74.5,71.9,61.5	55,55,64 57,55,50
(Piece T2C)	Longitudinal		10	85.1,70.6,81.1 95.8,85.1,85.1	67,53,62 70,65,70
(Piece T2D)	Longitudinal		10	69.3,73.2,87.8 61.5,66.7,85.1	57,57,72 59,63,72

TABLE 5A-26 (Cont)

Material	Orientation	NDT Temp. (°F)	Test Temp. (°F)	Absorbed Energy (ft-lbs)	Lateral Expansion (Mils)
SA533,GR.B, Cl.1 (Upper Shell Connected to Shell Flange)					
(Piece S1C)	Longitudinal		10	71.8,46.9,61.5 66.7,73.2,62.4	59,39,53 52,58,49
(Piece S2A)	Longitudinal		10	74.5,87.8,53.0 65.4,74.5,79.8	57,74,45 52,55,65
(Piece S2C)	Longitudinal		10	84.7,95.8,95.8 90.0,55.2,89.1	65,75,79 70,44,71

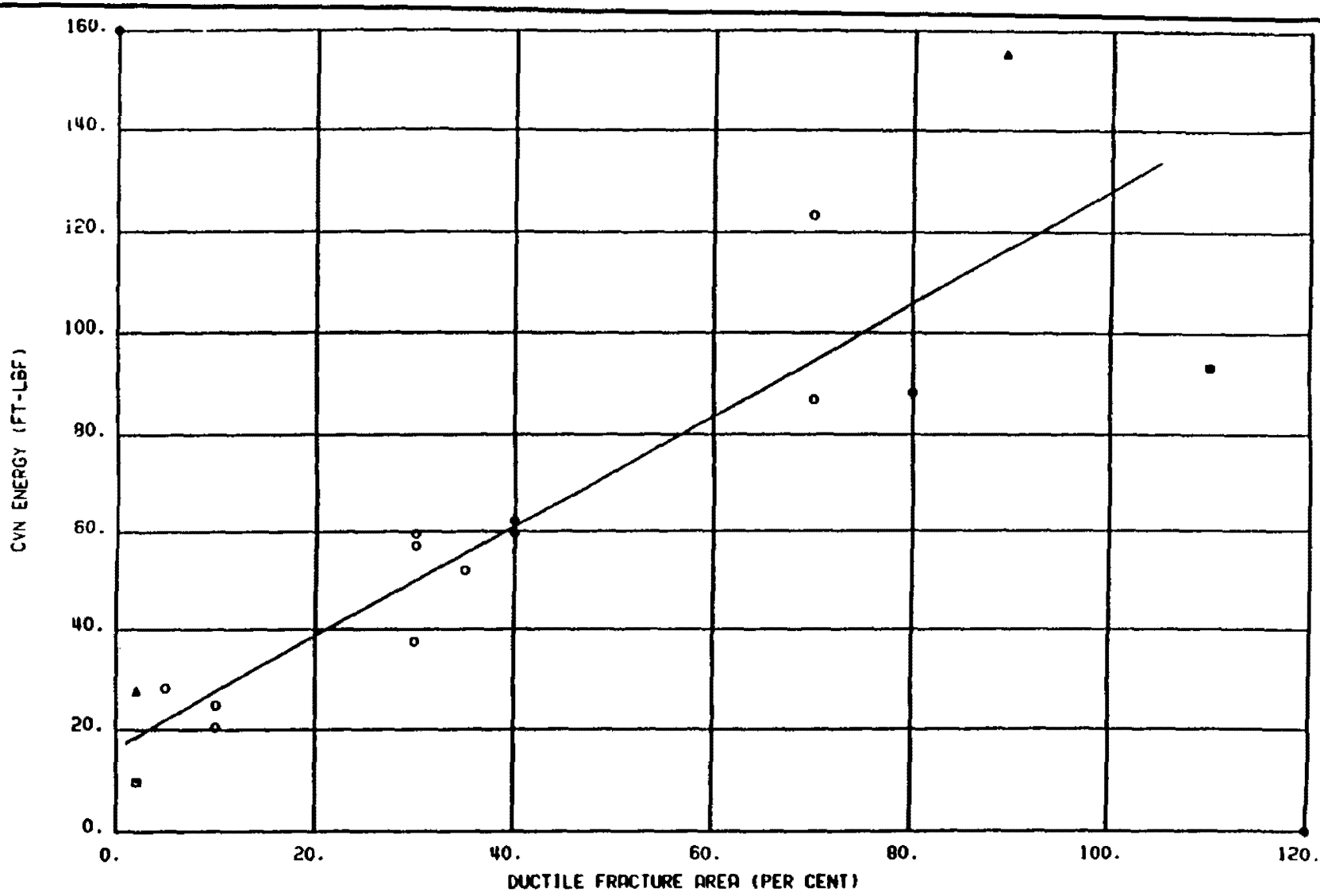
(1) In accordance with the ASME Code and GE specification requirements, the weld metals joining the flange region materials have CVN absorbed energy values of at least 30 ft-lbs at +10°F.



△ - UPPER CONFIDENCE LIMIT
○ - DATA POINT
□ - LOWER CONFIDENCE LIMIT

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

CVN ENERGY vs FRACTURE AREA
SK2963



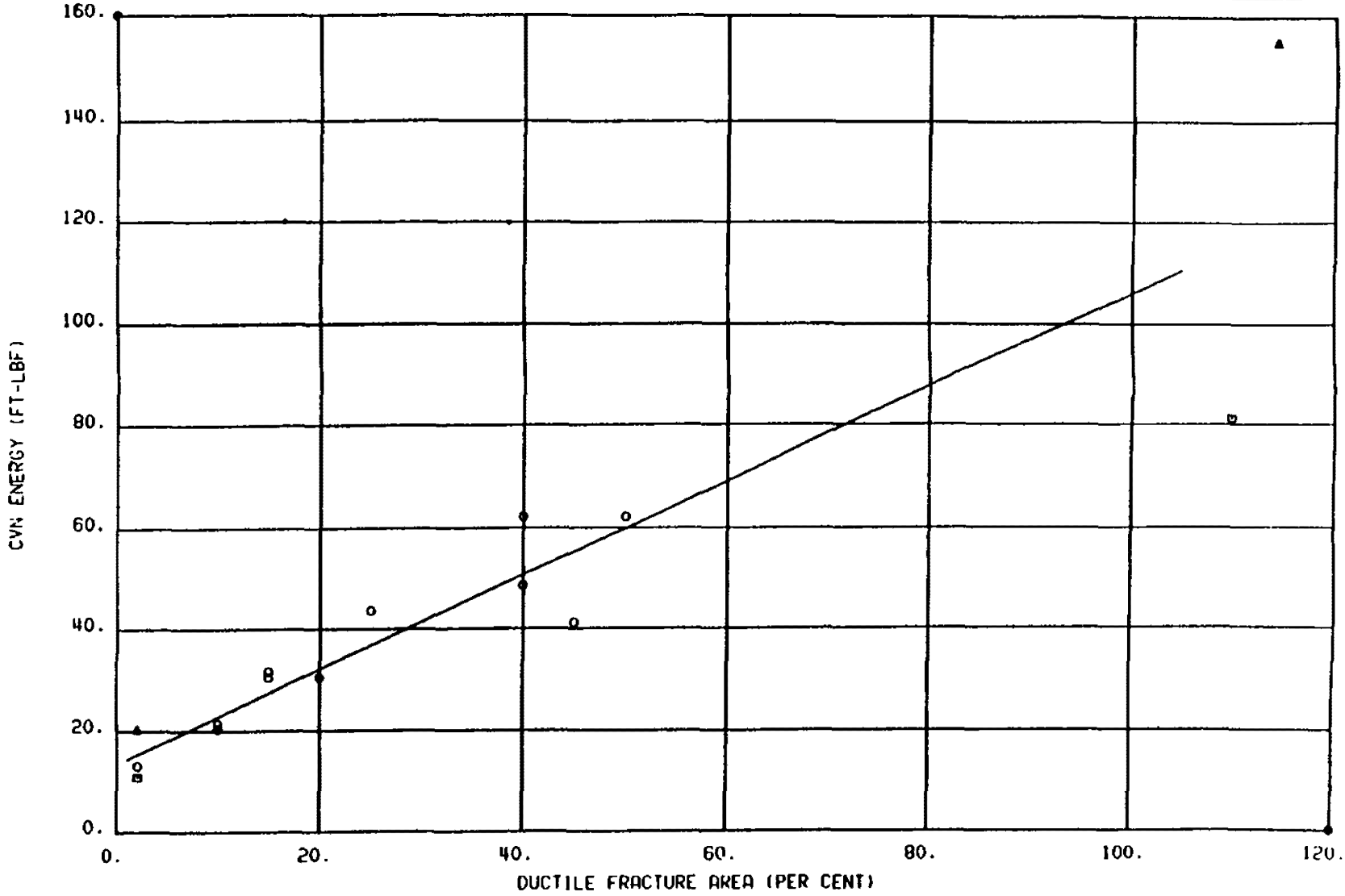
△ - UPPER CONFIDENCE LIMIT
○ - DATA POINT
□ - LOWER CONFIDENCE LIMIT

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

CVN ENERGY vs FRACTURE AREA
SK2530

Updated FSAR
Revision 5, May 11, 1993

Sheet 1 of 1
Figure 5A-2



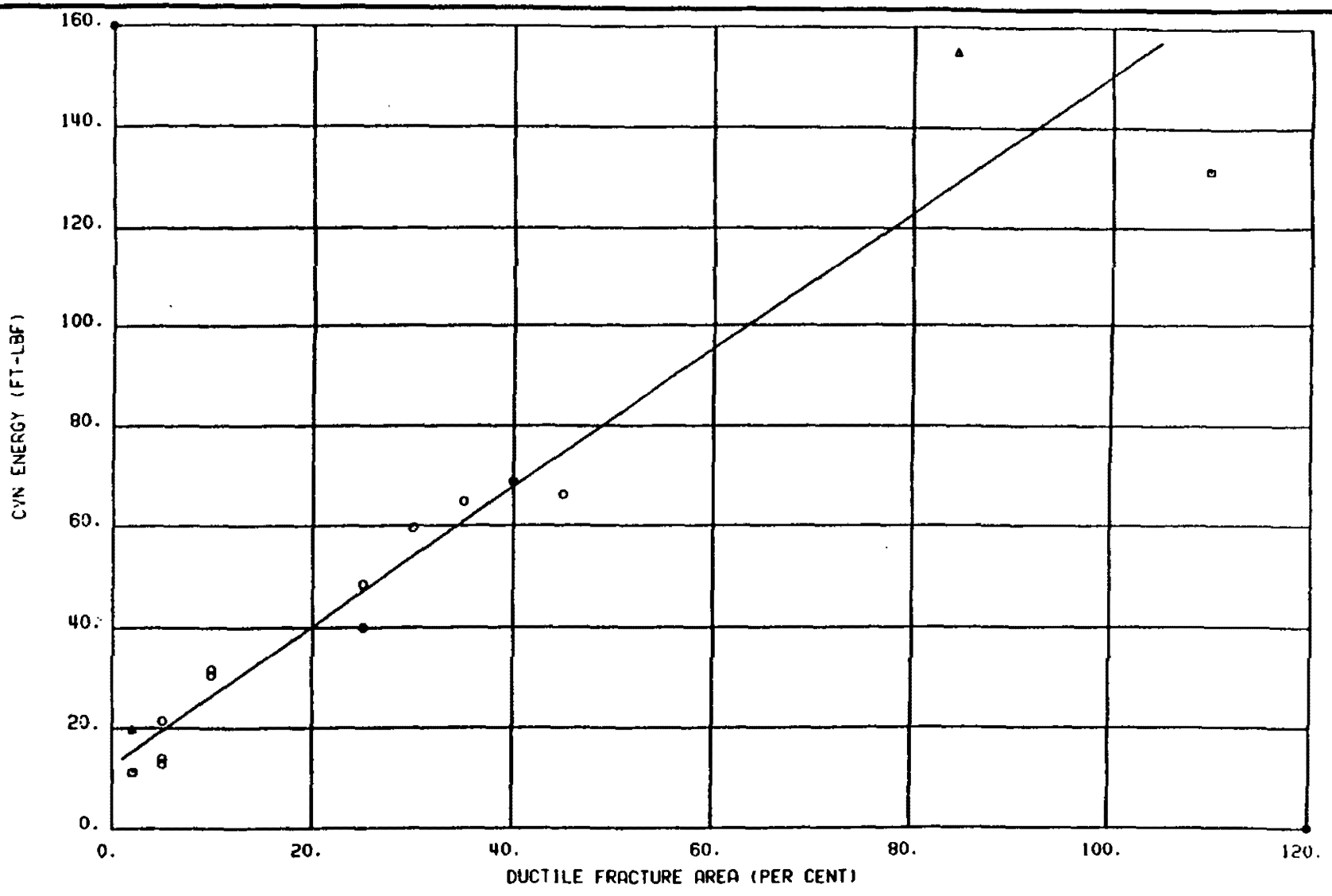
△ - UPPER CONFIDENCE LIMIT
○ - DATA POINT
□ - LOWER CONFIDENCE LIMIT

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

CVN ENERGY vs FRACTURE AREA
SK3238

Updated FSAR
Revision 5, May 11, 1993

Sheet 1 of 1
Figure 5A-3

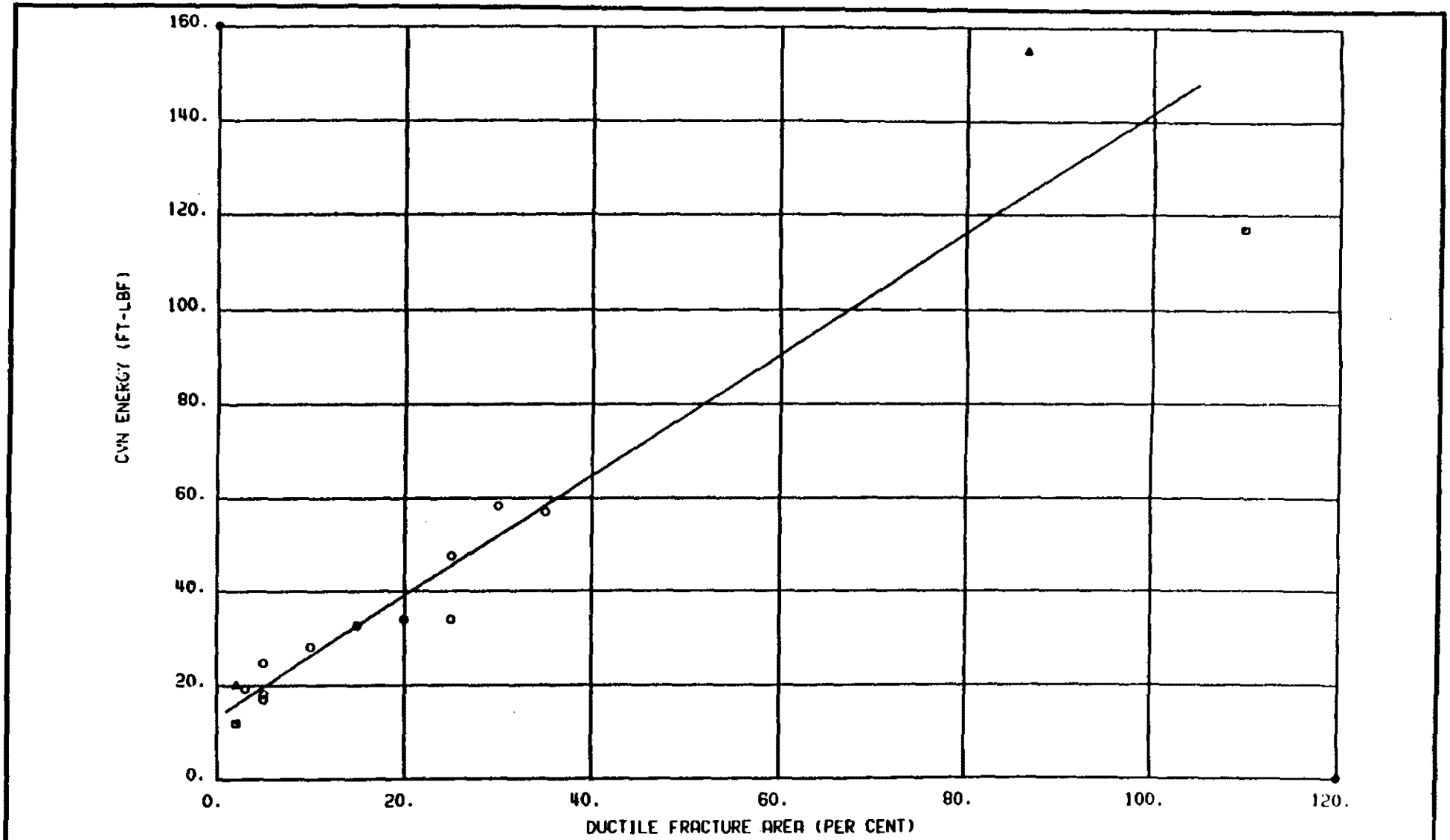


PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

CVN ENERGY vs FRACTURE AREA
SK3230

Updated FSAR
Revision 5, May 11, 1993

Sheet 1 of 1
Figure 5A-4

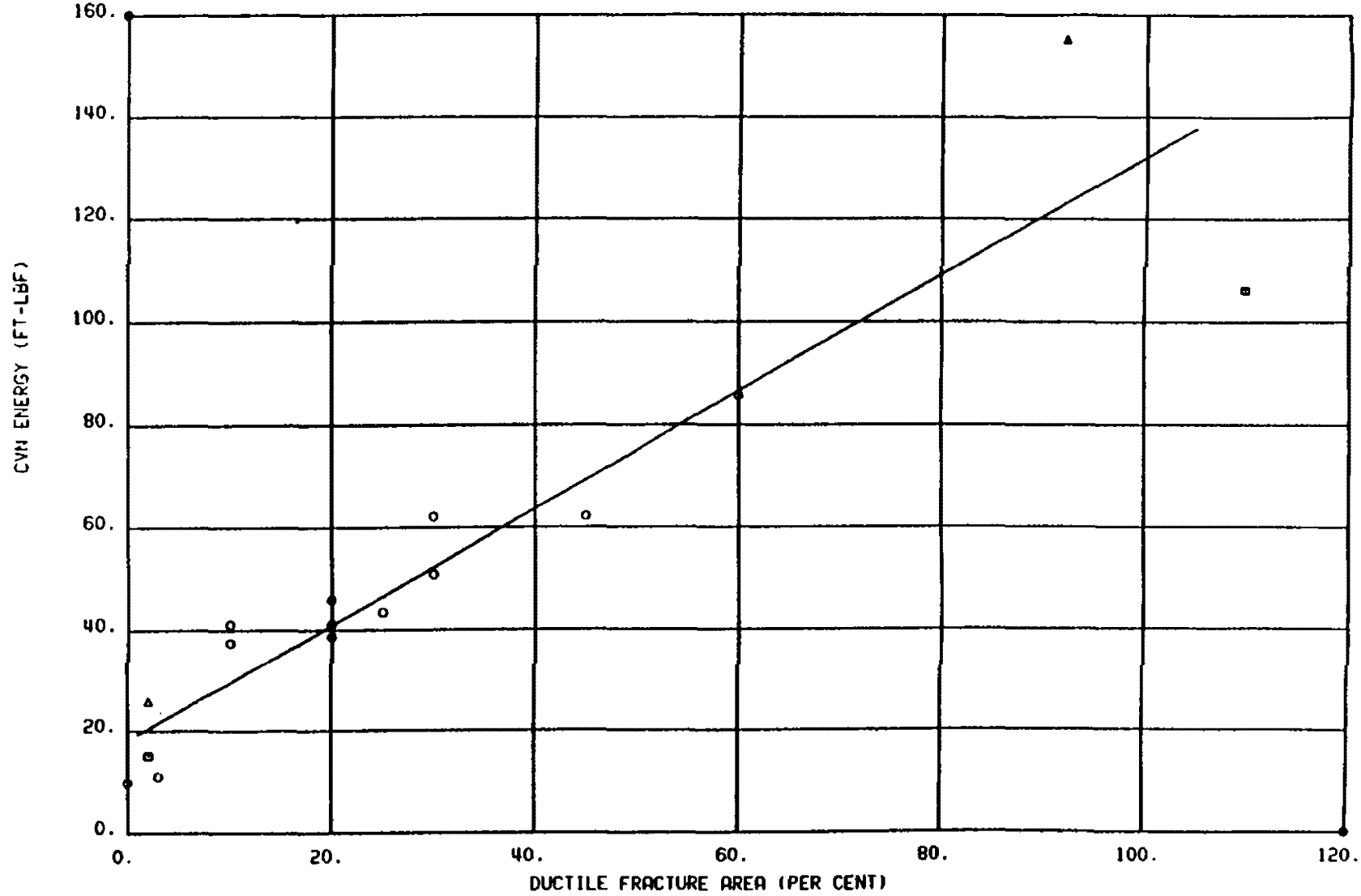


PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

CVN ENERGY vs FRACTURE AREA
6C35

Updated FSAR
Revision 5, May 11, 1993

Sheet 1 of 1
Figure 5A-5



PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

CVN ENERGY vs FRACTURE AREA
6C45

Updated FSAR
Revision 5, May 11, 1993

Sheet 1 of 1
Figure 5A-6

Revised portion is marked by ⚠ Oct. 22 '73
Revised portions are indicated by ⚠ Nov. 3, '72 (EDS-2383-E-330-B)

BABCOCK-HITACHI K.K

DETAIL WELDING PROCEDURE (DWP)

DWP. NO.	HBW-001-1 REV. 2
※ GROUPING	P-NO. 28-S TO P-NO. 128-S
※ PROCESS	SMAW / SAW (MANUAL OR MACHINE)
※ TYPE OF JOINT	GROOVE (PLATE OR PIPE)

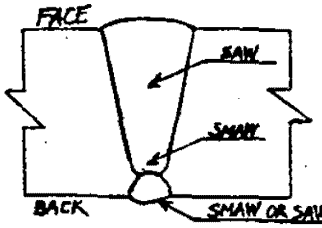
GENERAL WELDING PROC SPEC. NO. RS-0576 PROC. QUAL. TEST SPEC. NO. RS-9551-1 ⚠
RECORD OF PROC. QUAL. TEST NO. HPR-001 ※THICKNESS RANGE 3/16 TO 8 IN
※POSITION F & H (SMAW) F (SAW) PROGRESSION — PIPE SIZE — TO — IN
TYPE OF ELECTRODE 1ST LAYER CONSUMABLE SUBSEQUENT CONSUMABLE
※FILLER METAL F-NO. 4 (SMAW) ※TYPE OR TRADE NAME OF FLUX YF-200
※WELD METAL A-NO. 2 ※TYPE OR TRADE NAME OF FILLER METAL Y-204 (SAW)
COMPOSITION OF INERT GAS — FLOW RATE — L/MIN.
※BACK SHIELD (YES, NO) ※PASS (SINGLE, MULTIPLE) (FACE, BACK) ※RETAINER (YES, NO)
※BACKING STRIP (YES, NO) ※CONSUMABLE INSERT (YES, NO) ※ARC (SINGLE, MULTIPLE)
※POLARITY (STRAIGHT, REVERSE) ※CURRENT DC (SMAW) AC (SAW) OSCILLATION (~~YES~~ NO)
※PREHEAT & INTERPASS TEMP. 393 TO 500 °F. WIRE (~~SINGLE MULTIPLE~~)
INTERSTAGE POST WELD HEAT TREATMENT—15 MIN. MINIMUM
FINAL POST WELD HEAT TREATMENT—1 HR./IN. OF BASE METAL THICKNESS

APPLICABLE SPEC. OF BASE METAL & FILLER METAL

※BASE METAL SA-508CL-2 / SA-533GRB CL.1 TO SA-533GR.B CL.1
FILLER METAL AWS A5.17 Y-204 / AWS A5.5 NiCrMo-2 FLUX AWS A5.17 YF-200

※IMPACT TEST (AT 10 °F)
DBPO (YES, NO)
HAZ (YES, NO)

SKETCH OF JOINT



NOTE:
1) ITEMS WITH THE ASTERISK ARE ESSENTIAL VARIABLES FOR THIS PROCEDURE QUALIFICATION

WELDING CONDITION

POSITION	SIZE (IN)	AMPERAGE (A) ※	VOLTAGE (V) ※	TRAVEL SPEED (IN/MIN) ※
LAYER — (N-3) WELDING PROCESS SMAW				
※F & ※H	1/8"	DC 100~150	19~25	1/64 ~ 4 3/64
	5/32"	150~200	20~26	2 7/64 ~ 9 1/16
	3/16"	200~250	20~26	3 17/64 ~ 10 9/16
LAYER — (Y204+YF200) WELDING PROCESS SAW				
※F	5/32"	A.C 550~650	FOR APPROVAL 28~37	10~13 3/4
	3/16"	650~750	28~37	10~13 3/4

REVISION 0
APRIL 11, 1988

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK NUCLEAR GENERATING STATION

WELD PROCEDURE FOR SURVEILLANCE TEST PLATE

UPDATED FSAR FIGURE 5A-7