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 $3.26 \times 10^{17}$ 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 $1.10 \times 10^{18}$ n/cm$^2$ (E > 1.0 Mev) and at one quarter of the vessel thickness is $7.63 \times 10^{17}$ 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 (mills) | 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 - - | 8, - - | 2, - - | |
| | | | | ≥+195 (1) | 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 Test Temp. (°F) | Charpy Impact Toughness: 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 |
| | | | | | | +10 | 98.4 87.0 92.2 | 65, 66, 65 | 50, 50, 50 |
| | | SAW[3] | 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 | | | | | +10 | 102.9 69.0 88.7 | 86, 57, 70 | 70, 40, 50 |
| | 138° | | | | | +10 | 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 | | | | | +40[1] | 113.9, 112.5 96.3 | 83, 79, 72 | 80, 80, 45 |
| | 258° | | | | | >+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) | Absorbed Energy (ft-lb) | Lateral Expansion (mills) | Shear percent |
|---|---|---|---|---|---|---|---|---|---|
| LPCI nozzle welds (4 total) | W179 | SMAW | 504-01205 | - | ------------------Same as W6 ---------------------------- | | | | |
| | 45° | SMAW | 001-01205 | - | -40 | +10 | 127.5, 98.0, 102.0 | 88, 77, 79 | 80, 60, 60 |
| | W179 | | 504-01205 | - | ------------------Same as W6---------------------------- | | | | |
| | 135° | | 519-01205 | - | ------------------Same as W6---------------------------- | | | | |
| | W179 | | 001-01205 | - | ------------------Same as W179-------------------------- | | | | |
| | 225° | | 519-01205 | - | ------------------Same as W6---------------------------- | | | | |
| | W179 | | 504-01205 | - | ------------------Same as W6---------------------------- | | | | |
| | 315° | | 519-01205 | - | ------------------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) | Elongation, (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 | 99.0 | 28.5 | 7.5 |
| | | | | | | | | | | | 68.5 | 87.3 | 25.5 | |
| 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 | 85.0 | 26.9 | 7.0 |
| | | | | | | | | | | | 60.5 | 85.5 | 26.9 | |
| 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 | 89.4 | 26.7 | 7.5 |
| | | | | | | | | | | | 65.1 | 87.5 | 27.1 | |
| 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 | 91.7 | 27.0 | 8.0 |
| | | | | | | | | | | | 69.3 | 91.8 | 25.0 | |
| 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 | 87.5 | 27.5 | 6.0 |
| | | | | | | | | | | | 62.1 | 85.3 | 26.7 | |
| 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 | 89.4 | 24.6 | 7.5 |
| | | | | | | | | | | | 65.3 | 87.7 | 27.5 | |
| 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 | 90.5 | 25.6 | 7.5 |
| | | | | | | | | | | | 73.3 | 93.8 | 25.2 | |

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 = $7.63 \times 10^{17}$ 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 = $3.68 \times 10^{17}$ 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 = $7.63 \times 10^{17}$ 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 |

| Heat Number/Lot | Chemistry Cu (Wt) Percent | Chemistry Ni (Wt) Percent | $RT_{NDT}$ (F) Initial Value | $RT_{NDT}$ (F) from Reg. Guide 1.99, R2 | $RT_{NDT}$ (F) Estimated EOL |
|---|---|---|---|---|---|
| Girth Weld Material between Shell Courses 3 and 4 | | | | | |
| Peak EOL Fluence(2) (Shell Course 3) at 1/4T = 3.68 x $10^{17}$ 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 x $10^{17}$ 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

| Heat Number[1] | Chemistry: Cu (Wt) Percent | Chemistry: Ni (Wt) Percent | $NDT_{NDT}$ (F): Initial Value | $NDT_{NDT}$ (F): from Reg. Guide 1.99,R2 | $NDT_{NDT}$ (F): 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 = $3.26 \times 10^{17}$ $n/cm^2$

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<br>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<br>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<br>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<br>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<br>+ Temper 1380°F (6 hr, 15 min.) air cool<br>+ 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 |

---

(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<br>+ Temper 1345°F (6 hr, 45 min) air cool<br>+ 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<br>+ Temper 1350/1360°F (6 hr) air cool<br>+ 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 |

---

(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<br>+ Temper 1225°F (7.5 hr) air cool<br>+ 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<br>+ Temper 1150°/1250°F (8 hr) air cool<br>+ 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 ($^oC$) | | | Chemistry (wt. percent) | | | | | | | Mechanical Properties | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Austenitize | Temper | Postweld | C | Mn | P | S | Si | Ni | Mo | Yield, (ksi) | U.T.S. (ksi) | Elongation, (%) | 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 $7.63 \times 10^{17}$ n/cm$^2$, for Low. and Low-Int. shells; $3.68 \times 10^{17}$ n/cm$^2$, for Int. shell; and $3.26 \times 10^{17}$ n/cm$^2$, for LPCI Nozzle. A fluence of $7.63 \times 10^{17}$ n/cm$^2$ was used for the welds identified as vertical and $3.68 \times 10^{17}$ 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.<br>Tran. | 69.2<br>66.0 | 90.4<br>88.4 | 27.9<br>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-BHr.-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.<br>Long. | 66.4<br>66.2 | 86.3<br>87.4 | 24.3<br>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.<br>Tran. | 66.7<br>67.8 | 87.3<br>86.9 | 26.2<br>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

| | | | 1/4T Charpy V-Notch Test Results | | | | |
|---|---|---|---|---|---|---|---|
| Grade | Thickness (in.) | Source | 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<br>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)

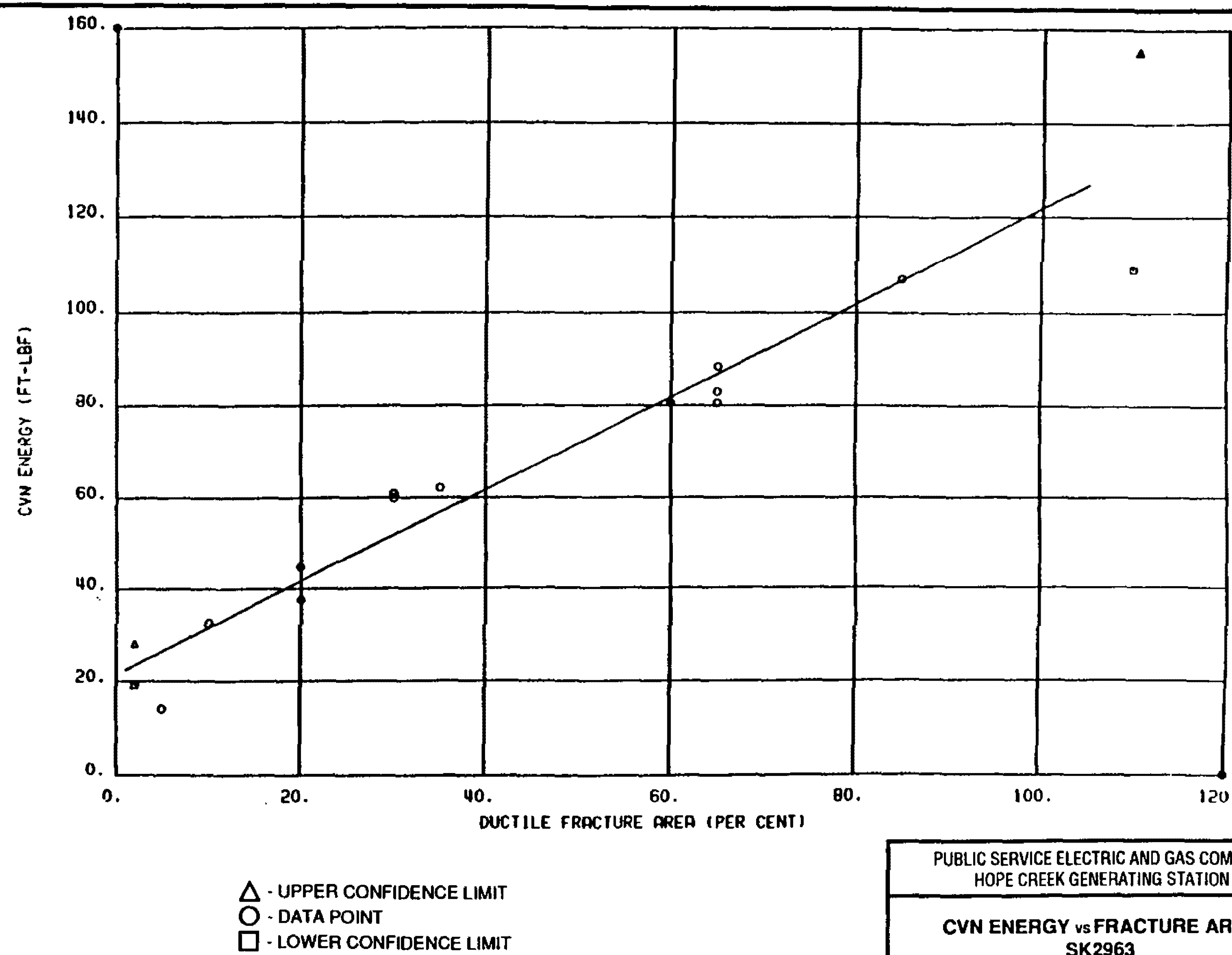
CLOSURE FLANGE REGION MATERIALS

| 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<br>66.7,73.2,62.4 | 59,39,53<br>52,58,49 |
| (Piece S2A) | Longitudinal | | 10 | 74.5,87.8,53.0<br>65.4,74.5,79.8 | 57,74,45<br>52,55,65 |
| (Piece S2C) | Longitudinal | | 10 | 84.7,95.8,95.8<br>90.0,55.2,89.1 | 65,75,79<br>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.

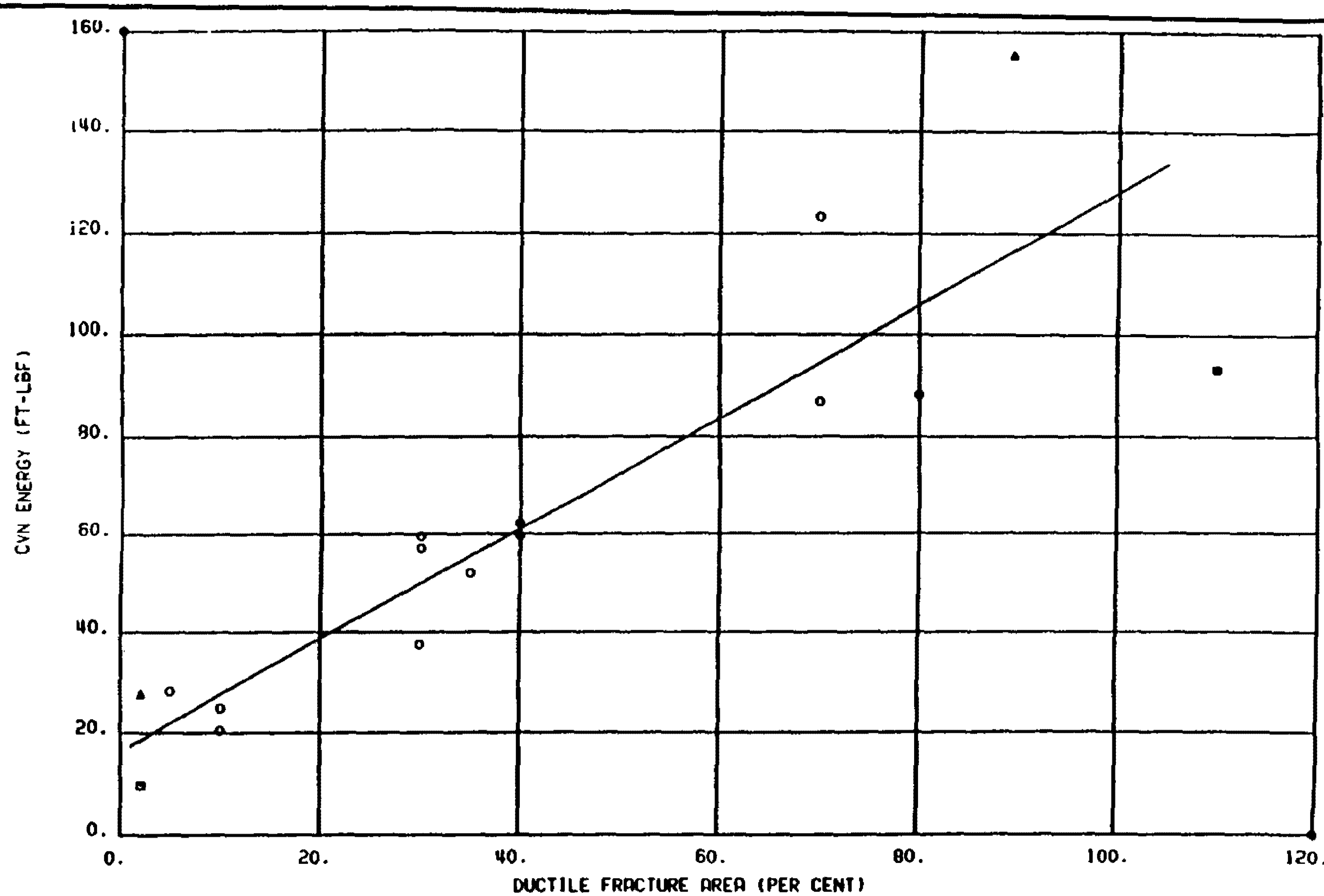



PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

**CVN ENERGY vs FRACTURE AREA**
**SK2963**

Updated FSAR
Revision 5, May 11, 1993

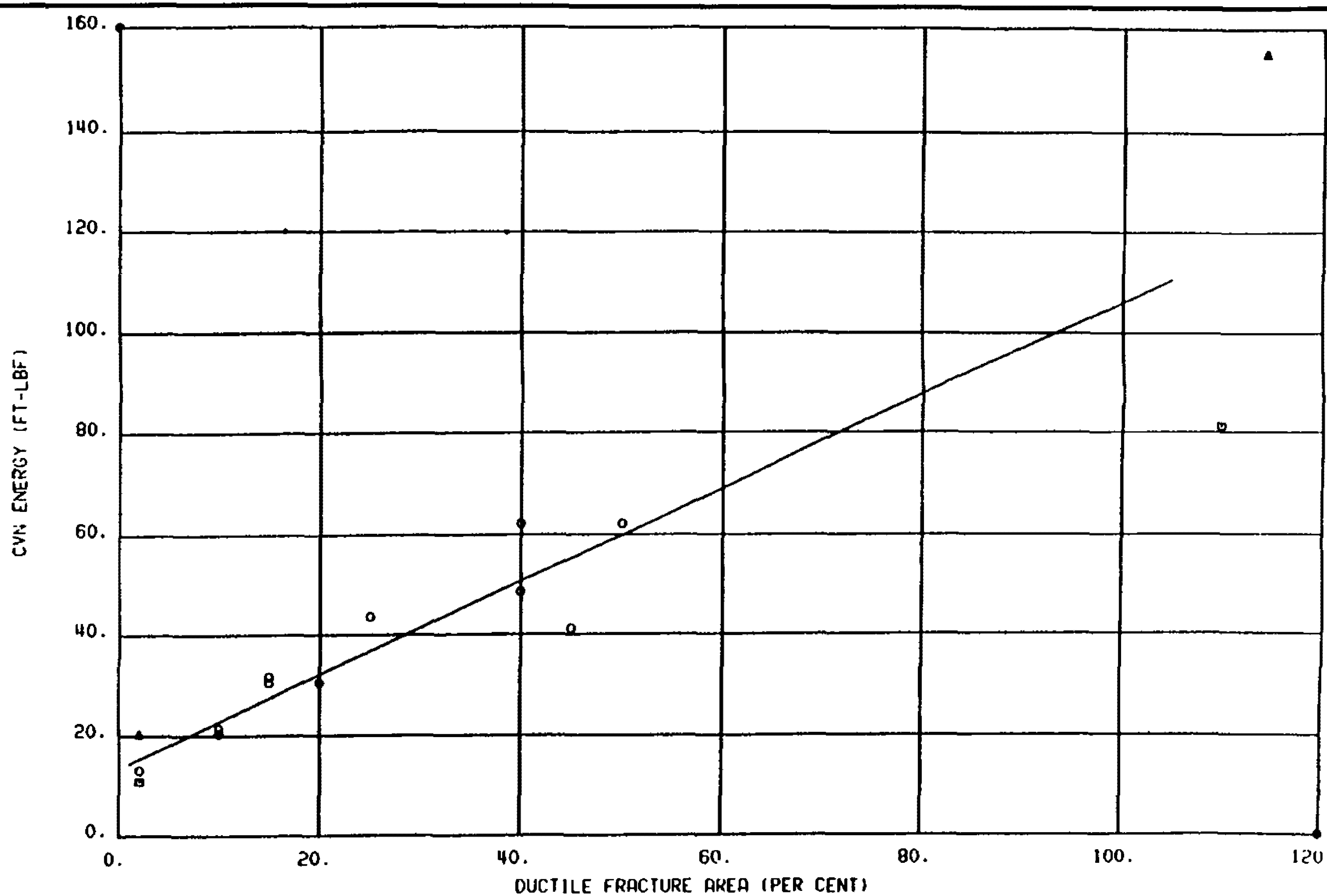
Sheet 1 of 1
Figure 5A-1




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

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
HOPE CREEK GENERATING STATION

**CVN ENERGY vs FRACTURE AREA**
**SK2530**



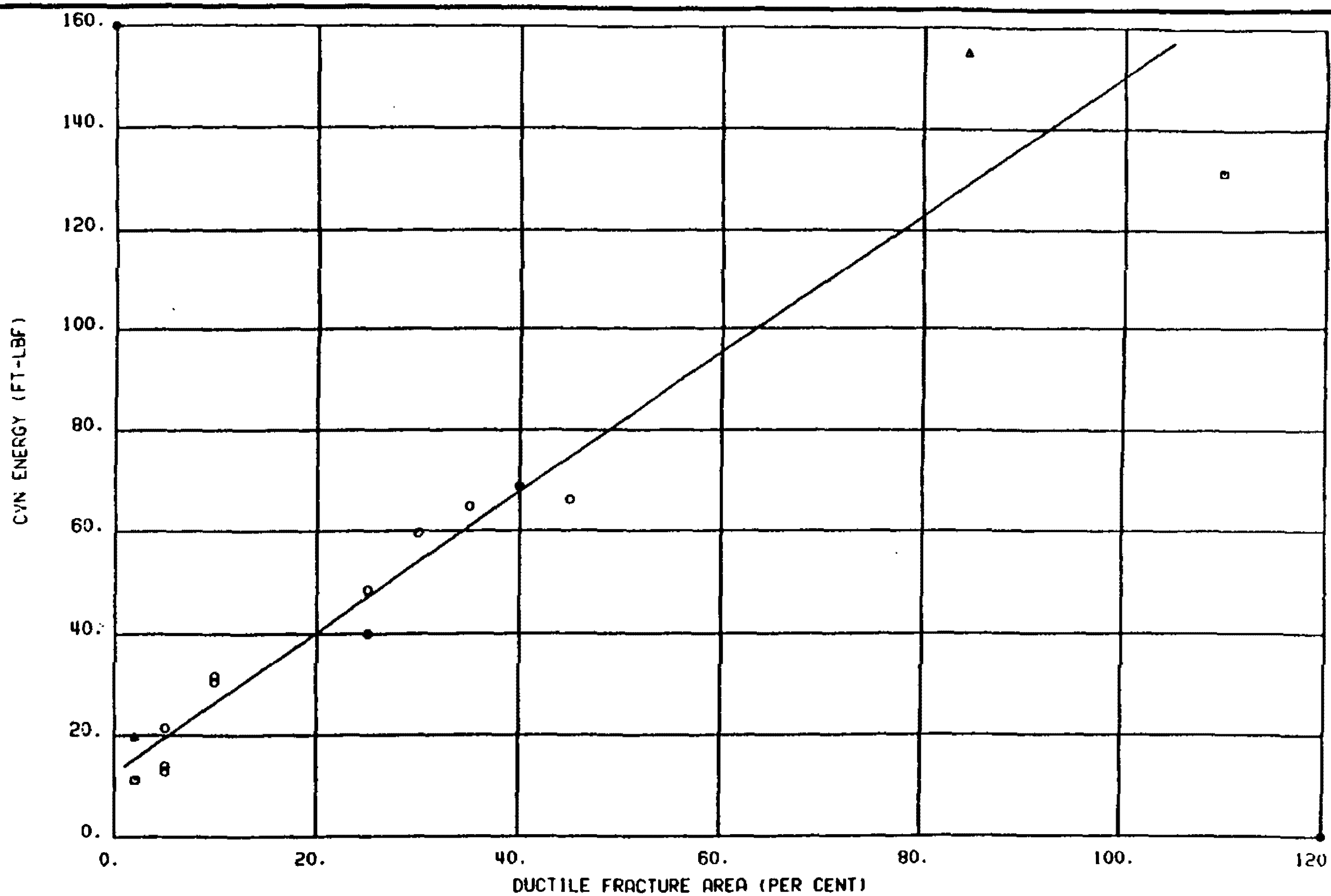

△ - UPPER CONFIDENCE LIMIT
○ - DATA POINT
□ - LOWER CONFIDENCE LIMIT

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



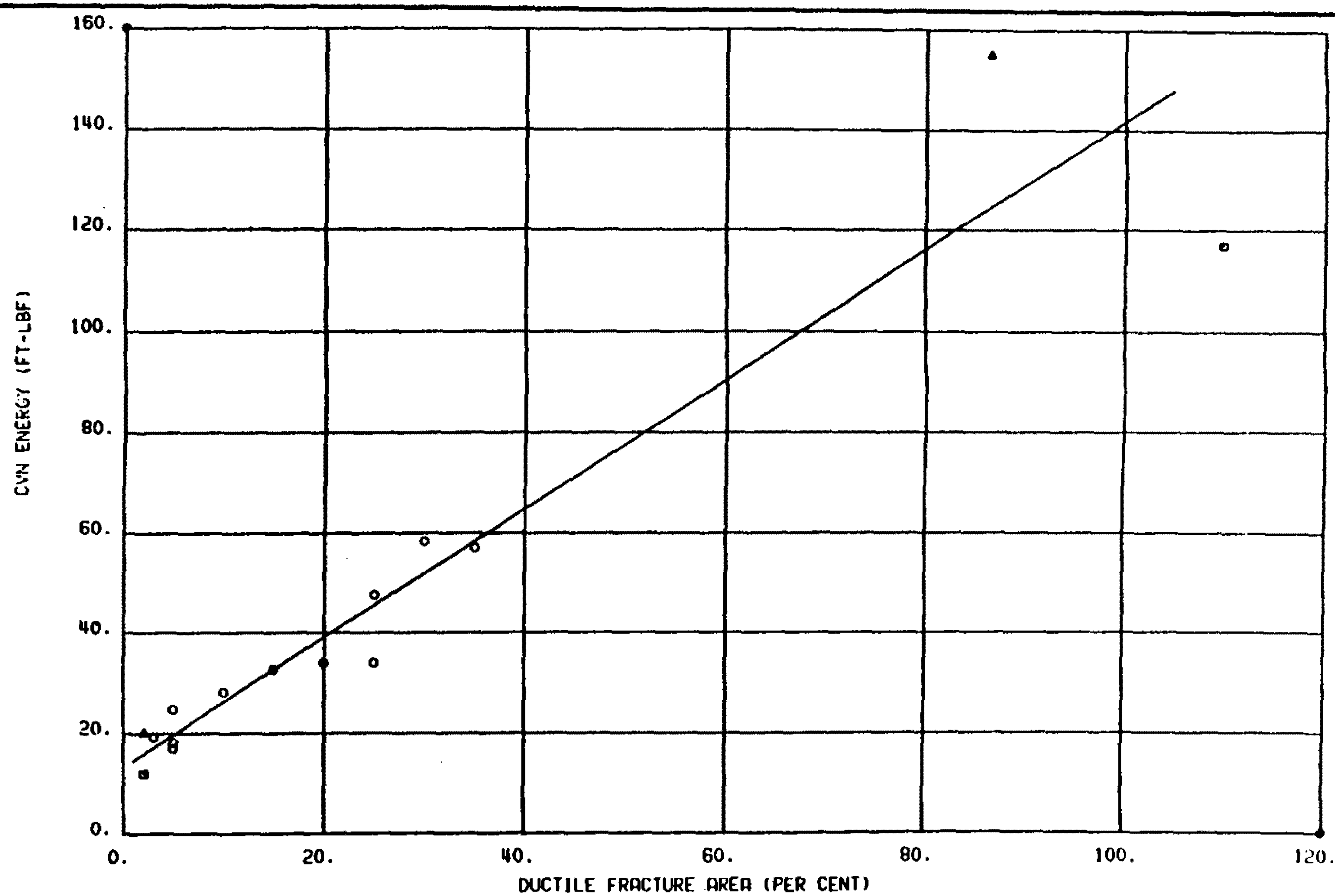

△ - UPPER CONFIDENCE LIMIT
○ - DATA POINT
□ - LOWER CONFIDENCE LIMIT

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



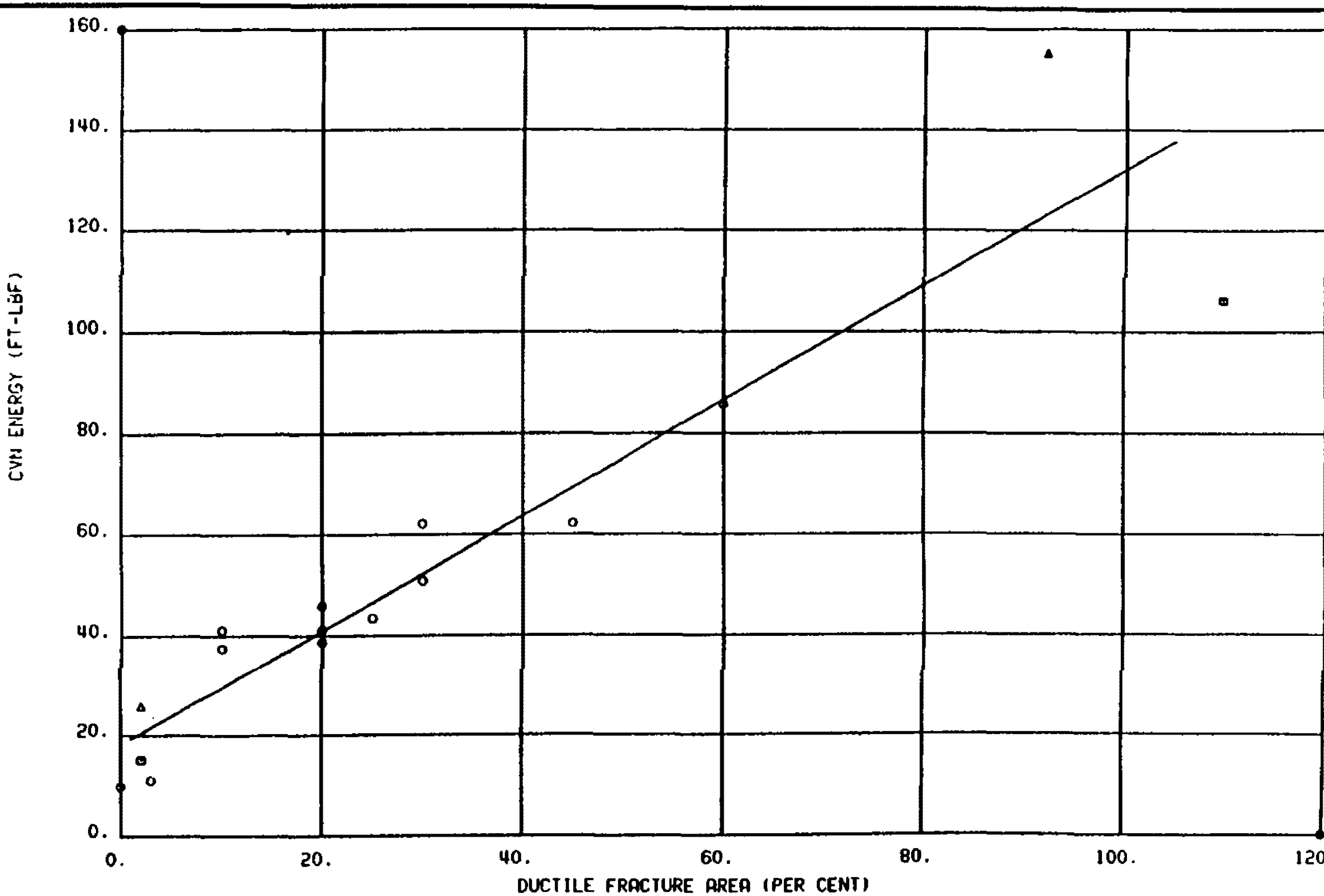

△ - UPPER CONFIDENCE LIMIT
○ - DATA POINT
□ - LOWER CONFIDENCE LIMIT

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




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

| |
|---|
| PUBLIC SERVICE ELECTRIC AND GAS COMPANY<br>HOPE CREEK GENERATING STATION |
| **CVN ENERGY vs FRACTURE AREA<br>6C45** |
| Updated FSAR<br>Revision 5, May 11, 1993 — Sheet 1 of 1<br>Figure 5A-6 |

Revised portion is marked by △ Oct. 22 '73
Revised portions are indicated by △ Nov. 3, '72 (EDS-2383-2-330-B)

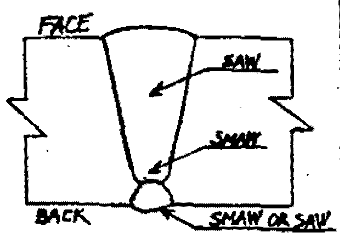
| BABCOCK-HITACHI K.K<br>DETAIL WELDING PROCEDURE<br>(DWP) | DWP. NO. | HDW-001-1 REV. 2 |
|---|---|---|
| | ※ GROUPING | P-NO.2B-S TO P-NO.12B-S |
| | ※ PROCESS | SMAW / SAW (MANUAL OR MACHINE) |
| | ※ TYPE OF JOINT | GROOVE (PLATE OR PIPE) |

GENERAL WELDING PROC SPEC. NO. RS-9576 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-508 CL-2 SA-533 GR.B cl.1 TO SA-533 GR.B cl.1
FILLER METAL AWS A5.17 Y-204 AWS A5.5 ~~?~~ FLUX AWS A5.17 YF-200

※IMPACT TEST (AT 10 °F)
DEPO (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 | 28~37 | 10~13 3/4 |
| | 3/16 | 650~750 | 28~37 | 10~13 3/4 |

FOR APPROVAL

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