Attachment A

San Onofre Nuclear Generating Station, Unit 2
Response to Generic Letter 92-01

Revision 2
May 19, 1994

Prepared by:

ATI Consulting
San Ramon, CA

and

Sartrex Corporation
Rockville, MD

Prepared for:

Southern California Edison
Irvine, CA

CONTENTS

CONTENTS (cont'd)

ILLUSTRATIONS

ILLUSTRATIONS (cont'd)

TABLES

Section 1

INTRODUCTION

The Nuclear Regulatory Commission (NRC) in Generic Letter 92-01 (GL 92-01) requested all holders of operating licenses or construction permits for nuclear power plants to submit information needed to assess compliance with requirements and commitments regarding reactor vessel integrity. Revision 0, June 24, 1992, of this report was prepared in response to GL 92-01 for San Onofre Nuclear Generating Station (SONGS), Unit 2. It identified additional information needed to resolve the following issues: (1) inconsistencies noted in copper (Cu) and nickel (Ni) contents for beltline Weld 9-203 and the surveillance weld, (2) locating material certification reports to confirm beltline weld properties, and (3) verifying the fluence at Weld 8-203.

Revision 1 of this report (dated January 22, 1993) incorporated additional materials data obtained from the SONGS, Unit 2 Nuclear Steam Supply System (NSSS) vendor, ABB-Combustion Engineering (ABB-CE), and the results of calculations performed by Southern California Edison Company (SCE) to better characterize fluence conditions at Weld 8-203, and the results from calculations performed to evaluate the upper shelf toughness for Weld 8-203. It also indicated that: (1) the beltline weld properties had been confirmed with the exception of beltline Welds 8-203 and 2-203 A, B, and C, and (2) additional information would be required to confirm heat numbers for the surveillance weld material and Welds 2-203 A, B, and C.

In previous versions of this report the initial RT_{NDT} for the vessel beltline material with the highest end of life adjusted reference temperature (i.e., the plate material used in the surveillance program) was determined using a combined data set obtained from the materials certification report (MCR) and the baseline surveillance program. In Revision 2, the initial RT_{NDT} for this material is determined using only the data from the MCR. This change was made to be consistent with SCE's interpretation of the Code requirement for defining initial RT_{NDT}, which is that data to be used in accordance with paragraph NB-2331 of Section III of the ASME Code are the data obtained by the vessel manufacturer to assess the toughness properties at the time of vessel fabrication. This MCR data thus established the initial RT_{NDT} by satisfying paragraph NB-2331(a)(3) of the ASME Code, Section III. This change also was made so that this initial RT_{NDT} is defined in a manner consistent with that for other beltline materials where surveillance baseline data were not available. Consistent with the previous revisions of this report, the combined set of MCR and surveillance data were used to establish the unirradiated upper shelf energy and the temperature at 30 ft-lb Charpy absorbed energy for purposes of assessing the irradiation effects on the surveillance plate material.

This revision (Revision 2) incorporates additional materials data and information obtained from the SONGS, Unit 2 NSSS vendor, ABB-CE. These data provide: (1) the heat number, chemistry and Charpy data for Welds 2-203 A, B, and C, (2) the weld wire and flux combinations, chemistry, and Charpy data for Weld 8-203, and (3) the weld wire and flux combinations for the surveillance weld. Based on a review of the information supplied by ABB-CE, the chemistry and

Charpy energies have been confirmed for the materials in the SONGS, Unit 2 pressure vessel beltline, and the response to GL 92-01 is now complete.

Section 2 of this report addresses compliance with 10 CFR Part 50 (10CFR50), Appendix H, for the surveillance program at SONGS, Unit 2. Compliance with 10CFR50, Appendix G, is described in Section 3 along with a description of the location, heat treatment, residual and alloying element contents, and upper shelf and transition temperature fracture toughness for the beltline materials in the SONGS, Unit 2, reactor vessel. Section 4 addresses embrittlement effects, including irradiation temperature and adjusted reference temperature for evaluation of the beltline materials relative to GL 88-11 and 10CFR50.61.

Section 2

REACTOR PRESSURE VESSEL SURVEILLANCE PROGRAM COMPLIANCE WITH APPENDIX H

The American Society of Mechanical Engineers (ASME) Code of record for the SONGS, Unit 2, reactor pressure vessel is the 1971 Edition through the Summer 1971 Addenda. Consequently, the applicable version of American Society for Testing and Materials (ASTM) E185 is the 1970 version (ASTM E185-70). However, the surveillance program for SONGS, Unit 2, was updated to the later 1973 version which is in more complete agreement with the intent of 10CFR50, Appendix H. Appendix A to this report provides a detailed review of ASTM E185-73 along with validation that ASTM E185-73 requirements were satisfied for the surveillance program design. With respect to capsule testing and reporting requirements, the latest version of ASTM E185 is required, and these requirements have been updated as listed in Appendix A following ASTM E185-82 (the current approved version).

As stated in the SONGS, Units 2 and 3 Final Safety Analysis Report (FSAR), Appendix H, requirements were met (with one exception) through compliance with ASTM E185-73. The one exception to meeting 10CFR50, Appendix H requirements had to do with the method of attachment of the holders for the six surveillance capsules in each SONGS unit. ABB-CE was the vessel manufacturer and the NSSS vendor; ABB-CE attached the capsule holders directly to the cladding on the inside of the vessel in the beltline region (as they did for all ABB-CE NSSS-designed vessels), and this approach violated the requirements in the early 1970's version of 10CFR50, Appendix H. NRC reviewed a ABB-CE Topical Report (CENPD-155-P, C-E Procedure for the Design, Fabrication, Installation, and Inspection of Surveillance Holder Assemblies) and found the practice and procedures acceptable.

The current version of 10CFR50, Appendix H does not treat this method of attachment of the capsule holders as a noncompliance issue. The wording in the current Appendix H, Section I.A.2, is:

> "If the capsule holders are attached to the vessel wall or to the vessel cladding, construction and in-service inspection of the attachments and the attachment welds must be done according to requirements for permanent structural attachments to reactor vessels given in Sections III and XI of the ASME Code. The design and location of the capsule holders shall permit insertion of replacement capsules."

This wording was derived from the ABB-CE Topical Report, and the SONGS units have met the additional ASME Code, Sections III and XI, design and inspection requirements. Therefore, there are no deviations or exceptions needed from the current Appendix H of 10CFR50.

The details of the SONGS, Unit 2, surveillance program have been described in the FSAR and subsequent surveillance program testing reports, baseline [1] and irradiated.[2] The first capsule results have been evaluated for a low fluence following ASTM E185-82 testing and reporting requirements. Later sections of this report will discuss these results as compared to regulatory prediction methods.

The update of ASTM E185 for 1992 (E185-93) is about to be approved and issued. One significant change from E185-82 is the removal of the requirements for testing heat-affected-zone (HAZ) material. This change has resulted from the difficulty in interpreting HAZ results due to the degree of scatter and the ability to define the usefulness of blunt notch Charpy V-notch absorbed energy (C_{VN}) HAZ data. NRC has been involved in making this change to E185 through ASTM standards participation. Because of this forthcoming change to ASTM E185, this report does not evaluate HAZ results for SONGS, Unit 2; however, the raw data from prior HAZ testing on the SONGS, Unit 2, beltline material has been reported previously,[1-2] and is provided for reference in a subsequent section of this report.

Section 3

FRACTURE MECHANICS

This section evaluates compliance with 10CFR50, Appendix G, and identifies the location, heat treatment, key residual and alloying element contents, and unirradiated fracture toughness properties for plates and welds in the SONGS, Unit 2, reactor pressure vessel beltline region.

The information presented in this section has been obtained from the materials certification reports (MCRs), welding materials certifications (WMCs), the FSAR for SONGS, Unit 2, and from additional information supplied by ABB-CE to prepare this response. In some instances, additional information was obtained from the unirradiated baseline surveillance material report,[1] and the irradiated material in the 97° location surveillance capsule (Capsule 97), which was removed from Unit 2 at the end of the third fuel cycle.[2]

3.1 COMPLIANCE WITH APPENDIX G

The materials in the beltline region of SONGS, Unit 2, comply with the requirements of Appendix G, 10CFR50. A summary of compliance with 10CFR50, Appendix G, as specified in the FSAR for SONGS, Units 2 and 3, and updated during preparation of this report, are listed in Table 3.1.

3.2 BELTLINE MATERIALS IN SONGS, UNIT 2

3.2.1 Location

Figure 3-1 is a representation of the SONGS, Unit 2, reactor pressure vessel, and identifies the plates and welds and their location in the beltline region.

The heat numbers for the beltline plates shown in Figure 3-1 are presented in Table 3.2. The weld wire and flux combination for the beltline welds shown in Figure 3-1 and the surveillance welds are presented in Table 3.3. Source documentation has been obtained to confirm the properties of all beltline plates and welds and the surveillance weld.

3.2.2 Heat Treatment

The heat treatment for the plate materials consisted of austenitization at 1575 ± 50°F for 4 hours; water quenched and tempered at 1225 ± 25°F for 4 hours. For ASME Code qualification, the plates were stress relieved at 1150 ± 25°F for 40 hours and then were furnace cooled to 600°F at a rate of 100°F/hr. The actual time at temperature for a specific weld or a

plate in the vessel depended upon the sequence of vessel fabrication; intermediate and final stress relief times were selected such that the total did not exceed 40 hours for any particular portion of the vessel. Longitudinal weld seams would see stress relief times near the 40 hour maximum, while the closing girth weld in the beltline region would see approximately half this amount of time maximum. All of the testing of plate materials was performed on pieces with essentially an identical heat treatment as the actual reactor vessel. The surveillance weldment received a final 42-hour and 15-minute stress relief at 1100°F to 1150°F.

3.2.3 Key Residual and Alloying Element Contents

The copper (Cu), nickel (Ni), phosphorus (P), and sulfur (S) contents reported for each beltline plate are presented in Table 3.4. The plate Cu, Ni, P, and S contents were obtained by averaging two measurements made by ABB-CE. The first measurement was made when ABB-CE received the plate from Lukens, and the second measurement was made when the surveillance program was defined. The bases for the Cu, Ni, P, and S contents are presented in Appendix B.

A second set of data is included for Plate C6404-2. This set was obtained from broken surveillance specimens when the first irradiated surveillance capsule from Unit 2 was tested.[2]

Table 3.5 contains the Cu, Ni, P, and S contents for the beltline welds. The source documents for the information in Table 3.5 are presented in Appendix C. Additional information from the WMCs for Welds 3-203 A, B, C, 8-203, and 9-203 is presented in Appendix D. Because Ni was not measured for Weld Seam 8-203, a value of 1.0 wt% has been assumed (see Regulatory Guide 1.99, Rev. 2). Two chemistry measurements have been made for the surveillance weld and also are reported in Table 3.5. The first chemistry measurement was made as part of the original baseline[1], while the second was obtained from a broken Charpy specimen from Capsule 97[2].

Tables 3.4 and 3.5 also include the chemistry factors determined for each reported set of Cu and Ni contents using Regulatory Guide 1.99, Revision 2.

3.3 FRACTURE TOUGHNESS RELATED DATA

This section presents the results from the C_{VN} tests and summarizes the upper shelf energies (USEs) and the results from the drop weight nil ductility temperature (NDT) tests for the unirradiated beltline plate and weld materials in SONGS, Unit 2. The unirradiated reference temperature (RT_{NDT}) values were determined from the C_{VN} and NDT test results in accordance with the most recent version of ASME Section III, NB-2331. The USEs were determined using the definition specified in ASTM E185-94 (to be issued). The data included in the USE determination were the C_{VN} values for those tests (at least 3) where the percent shear on the fracture surfaces was equal to and greater than 95%.

The fracture toughness data for the plates were obtained from the MCRs (see Appendix E of this report) and baseline surveillance program.[1] The source documents for Welds 2-203 A, B, C, 3-203 A, B, C, 8-203, and 9-203 are presented in Appendix D of this report. The data for the surveillance weld were obtained from the baseline surveillance program. For convenience, the C_{VN}, lateral expansion, and fracture appearance (% shear) data for the unirradiated beltline and surveillance plate and weld materials are listed in tabular form in Appendix F of this report.

As discussed earlier in Section 2, the results for HAZ material are not evaluated in this report because upcoming ASTM standard E185-94 will not require HAZ material to be part of the surveillance program. The raw C_{VN} data for the past HAZ testing are attached in Appendix G of this report.

3.3.1 Beltline Plate Material

Because fracture toughness requirements for reactor pressure vessels are based on requirements to test specimens oriented transverse to the rolling direction, the data presented here are for the transverse (TL) orientation with one exception. The exception is for the beltline Plate C6404-2, which was included in the surveillance program. Because the surveillance program for SONGS, Unit 2, also contains longitudinally (LT) oriented specimens, the unirradiated C_{VN} data are presented for completeness for the LT orientation.

The transverse C_{VN} data as a function of test temperature for beltline Plate numbers C6404-1, -2, -3, -4, -5, and -6 are presented in Figures 3-2 through 3-7, respectively. For convenience, an average curve through the data is also shown in each figure. The average curves were determined using a least squares fit to the data and a hyperbolic tangent functional form, where the lower shelf was fixed at 2.2 ft-lb and the upper shelf was fixed at the value determined using the definition in ASTM E185-94 for specimens having fracture surfaces with 95% and greater shear. For convenience, the figures also indicate the values of NDT, USE, the temperature at which a minimum C_{VN} equal to 50 ft-lb (T @ 50 ft-lb) is achieved consistent with the applicable method of ASME, Section III, NB-2331, and RT_{NDT}. As part of the surveillance program, additional C_{VN} versus temperature data were generated for Plate C6404-2;[1] these data are presented in Figure 3-8 along with a least squares fit curve.

The data obtained when the plate material was purchased (Figure 3-3) and the surveillance baseline data (Figure 3-8) were combined as shown in Figure 3-9. The average curve through the combined data set in Figure 3-9 was used as the unirradiated baseline to evaluate the results for the irradiated surveillance tests (see Section 4).

Table 3.6 is a summary of the unirradiated NDT, RT_{NDT}, and USE values for the TL orientation for each of the beltline plates in SONGS, Unit 2. The NDT for Plate C6404-2 also was determined twice. One value was measured when the material was purchased (-20°F), while

the second value was determined from the unirradiated baseline tests (+10°F). The value measured when the plate was purchased (i.e., the MCR data) is listed in Table 3.6.

The methods used to determine RT_{NDT} from the NDT and C_{VN} data also are identified in Table 3.6. The method of either NB-2331 (a)(2) or NB-2331 (a)(3) was used to determine RT_{NDT} for the plates.

Figure 3-10 shows the data and least squares fit line for the LT orientation for surveillance Plate C6404-2.[1] Figure 3-11 shows a comparison of the best fit line for the LT orientation for the surveillance plate (see Figure 3-10) with the data reported in the MCR for the LT orientation for Plate C6404-2. The information in Figure 3-11 indicates that the data for the LT orientation in Plate C6404-2 from the MCRs produce essentially the same C_{VN} versus temperature relationship as was obtained for the LT orientation surveillance plate material. Therefore, the baseline surveillance LT curve fit can be used to assess shift and upper shelf toughness changes.

3.3.2 Beltline Welds

A full C_{VN} versus temperature curve was obtained for the material in Weld Seam 9-203, and the data points and least squares hyperbolic tangent fit through the data are presented in Figure 3-12. The materials in the remaining beltline weld seams were tested to obtain three C_{VN} data points at 10°F. The results from these tests are presented in Table 3.7. Figure 3-13 presents the C_{VN} data and least squares hyperbolic tangent curve fit for the surveillance weld material. A comparison of the C_{VN} versus temperature curves for beltline Weld 9-203 and the surveillance weld in Figures 3-12 and 3-13, respectively, show that the impact energies as a function of temperature are essentially the same for both sets of data. Therefore, the baseline surveillance curve fit can be used to assess shift and upper shelf toughness changes.

Table 3.8 presents a summary of the unirradiated NDT, RT_{NDT}, and USE values for each of the beltline welds in SONGS, Unit 2. For Welds 3-203 A, B, C and 9-203, available C_{VN} data indicate that there is a minimum of 50 ft-lb absorbed energy at 60°F above NDT and, consequently, RT_{NDT} equals NDT. For Welds 2-203 A, B, C, the available C_{VN} data are 70°F above NDT; however, since the data all have absorbed energies greater than 100 ft-lb, RT_{NDT} was taken as equal to NDT because it is unlikely that the absorbed energy would be less than 50 ft-lb at 0°F when it is in excess of 100 ft-lb at 10°F. Since no NDT data are available for Weld 8-203, the initial RT_{NDT} was taken as the generic value of -56°F for ABB-CE fabricated vessels (see 10CFR50.61).

The USEs shown in Table 3.8 for Weld 9-203 and the surveillance weld were obtained by averaging the test results where 95% shear or greater was exhibited. The USEs for Welds 3-203 A, B, C and 8-203 were obtained from the data in Table 3.7 by averaging the three C_{VN} data points obtained at 10°F for each of the listed welds. The USEs for Welds 2-203 A, B, C

were obtained from the data in Table 3.7 by averaging the nine C_{VN} data points obtained at 0 and 10°F.

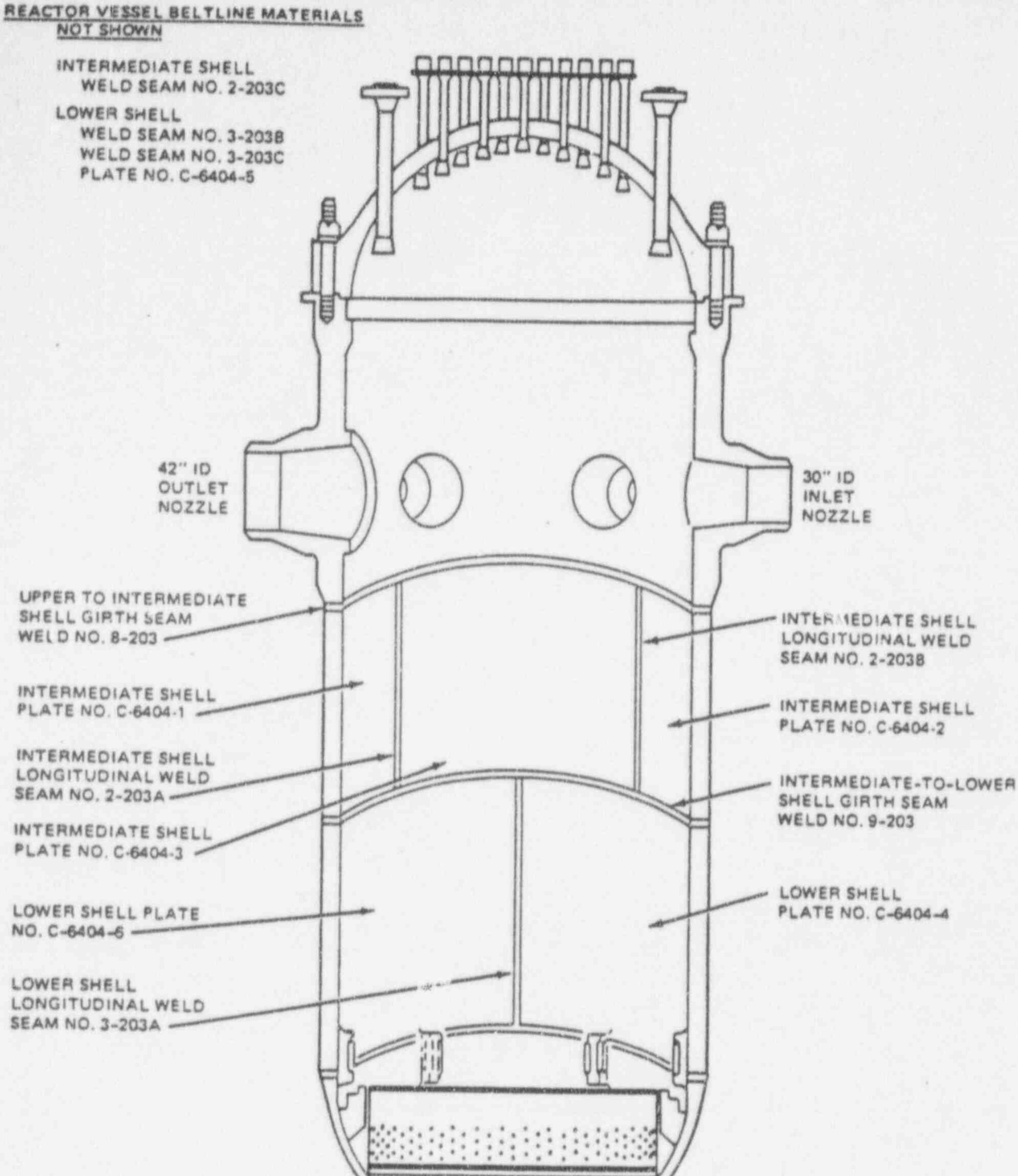

Figure 3-1. SONGS, Unit 2: Location and Identification of Beltline Plates and Welds.

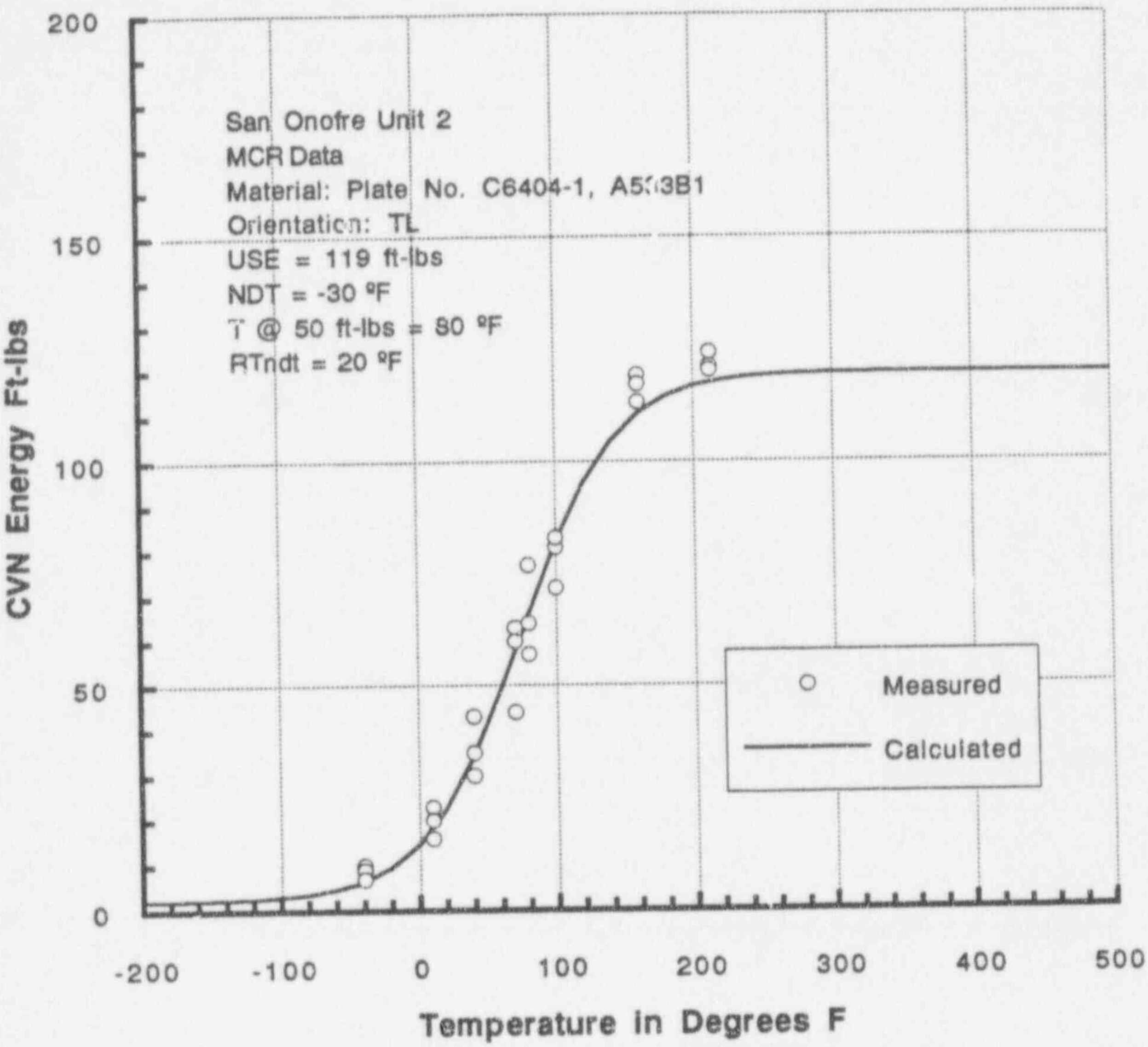

Figure 3-2. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-1, TL Orientation, MCR Data.

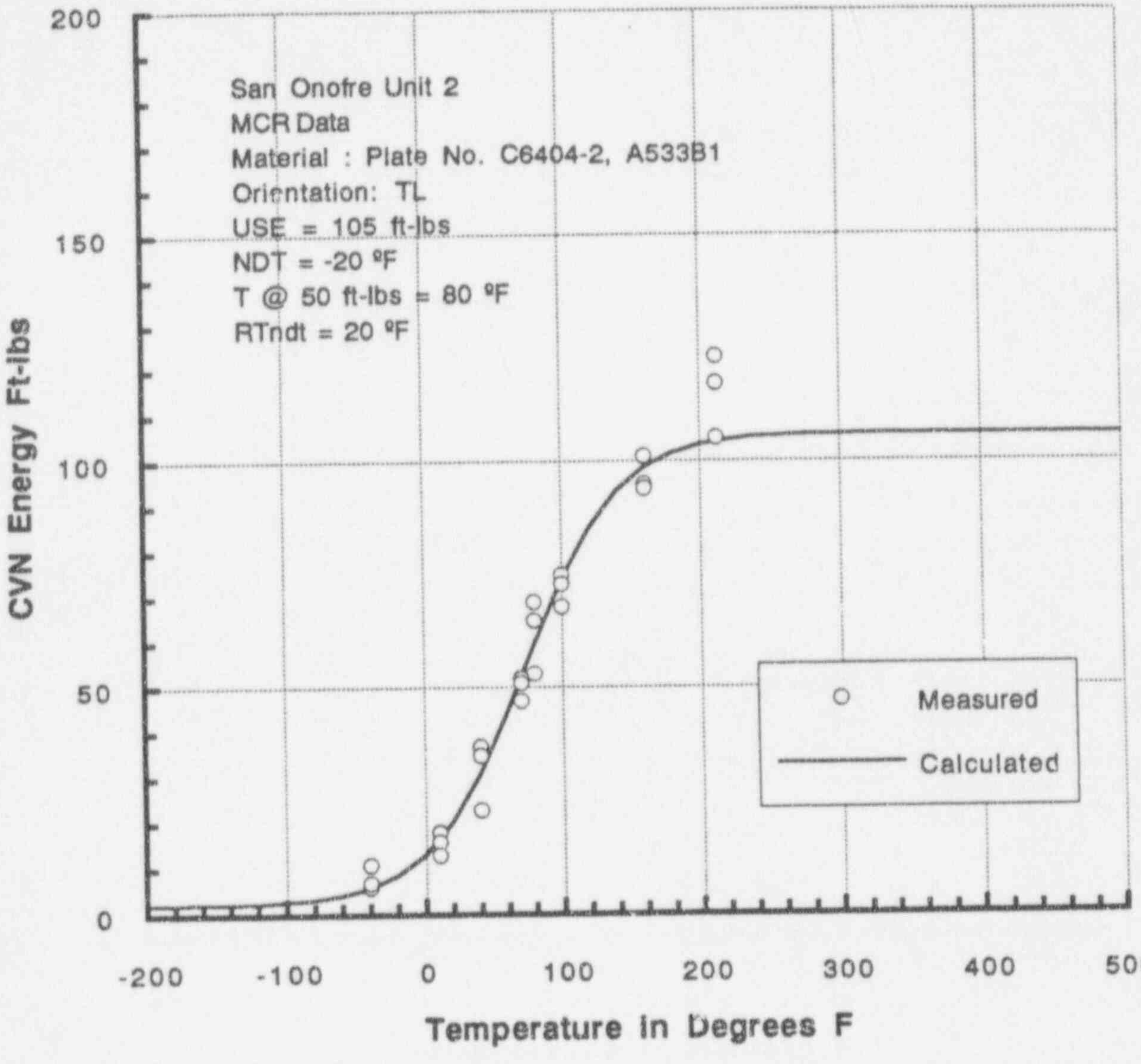

Figure 3-3. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-2, TL Orientation, MCR Data.

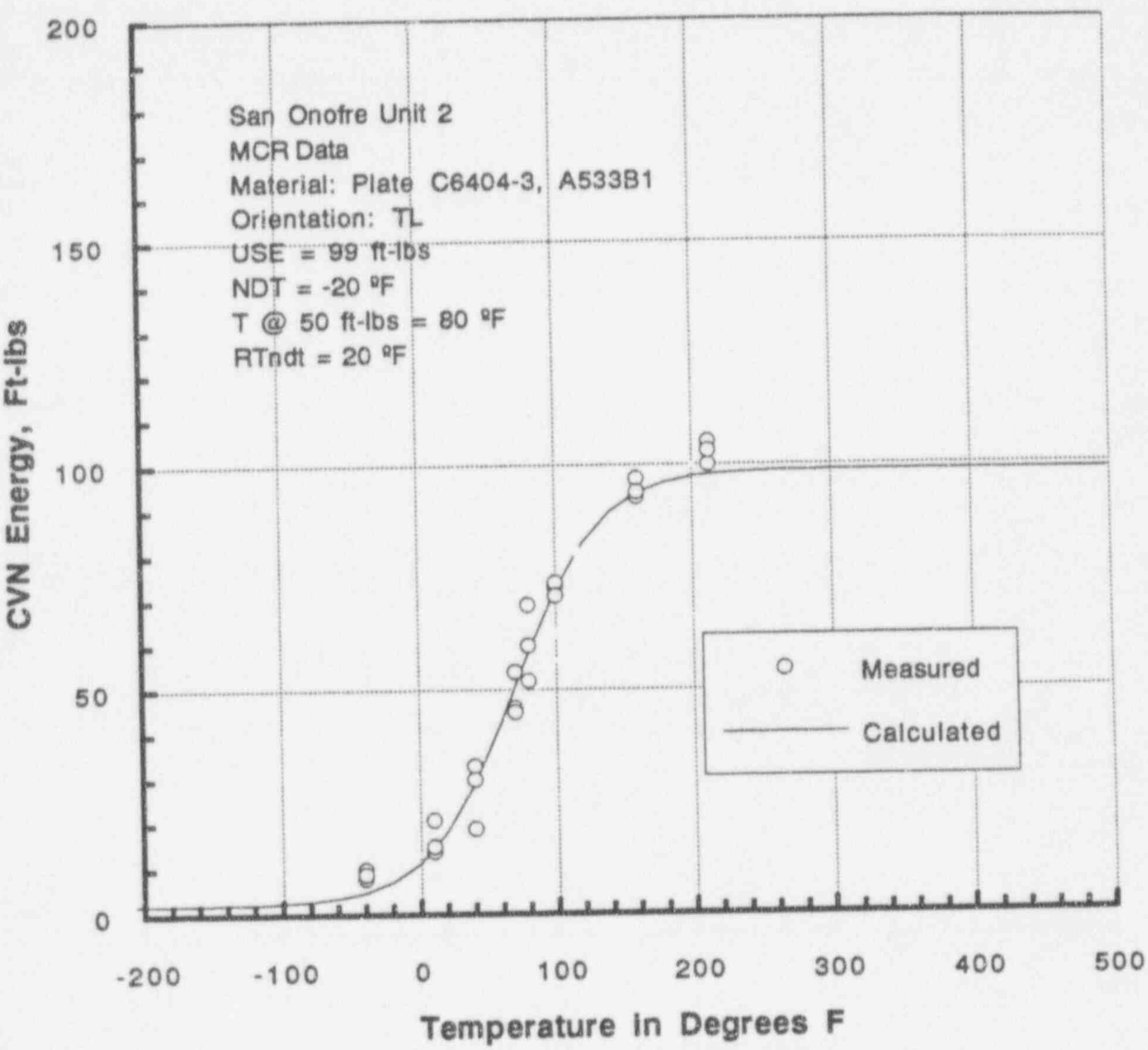

Figure 3-4. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-3, TL Orientation, MCR Data.

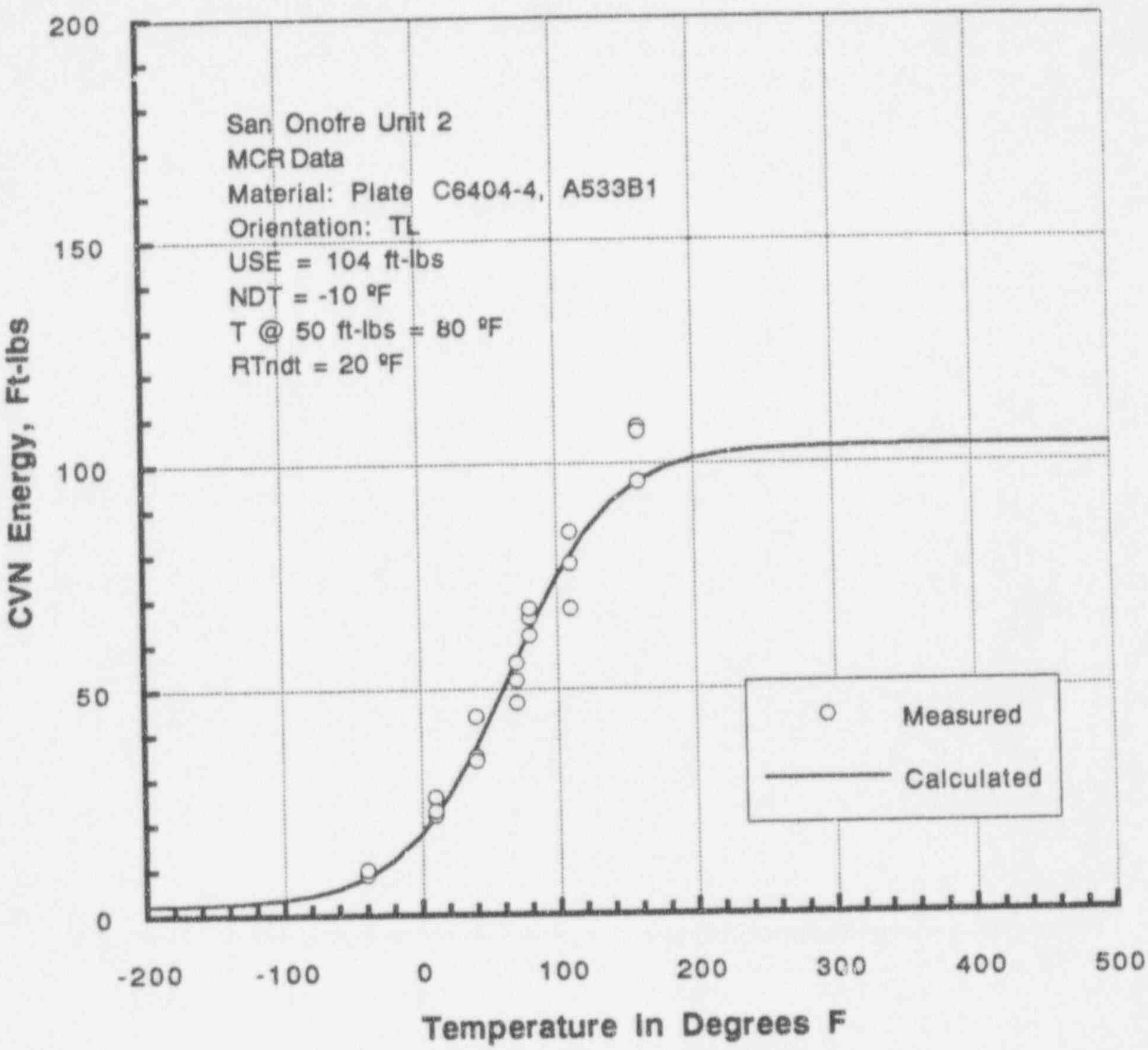

Figure 3-5. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-4, TL Orientation, MCR Data.

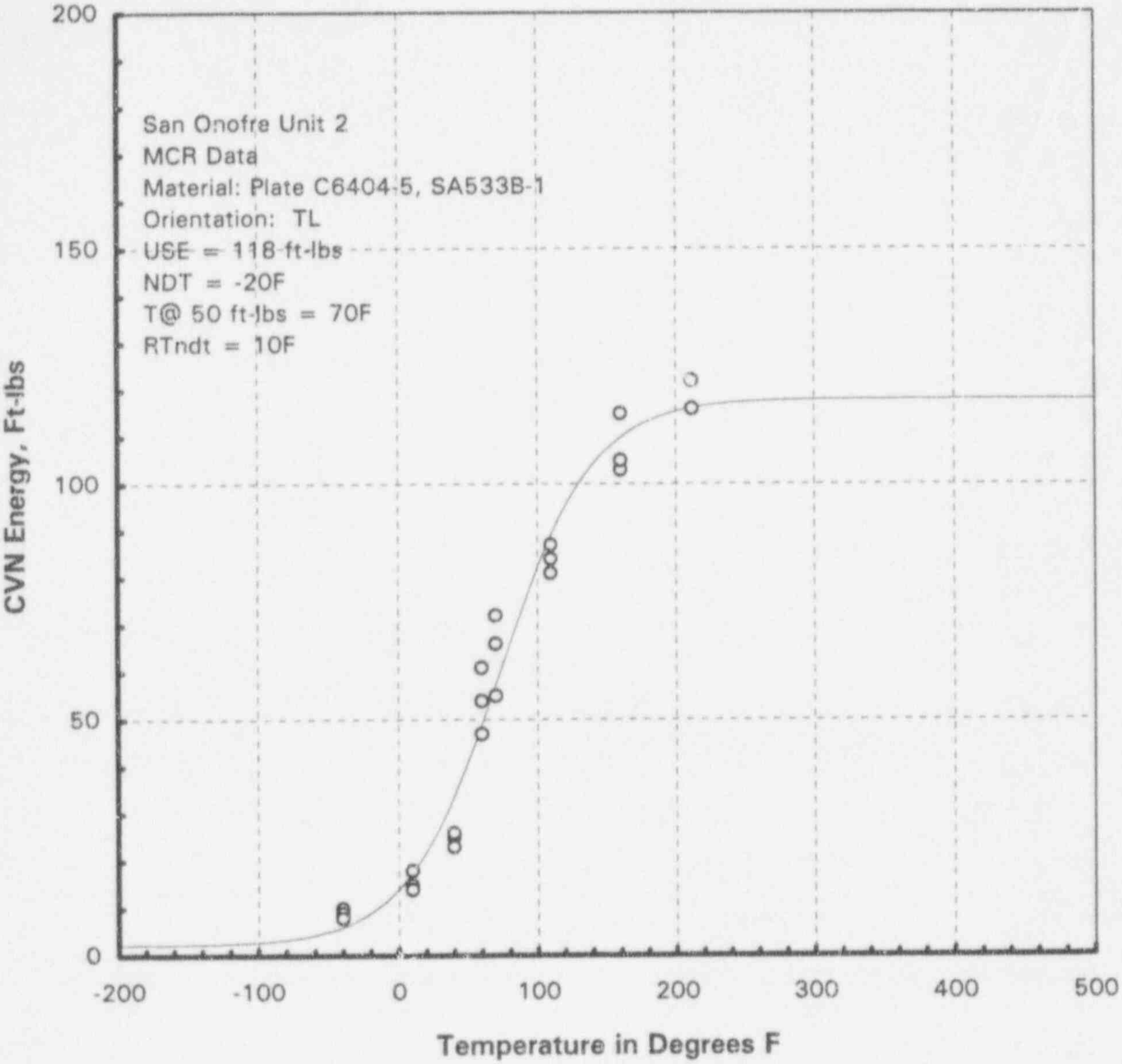

Figure 3-6. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-5, TL Orientation, MCR Data.

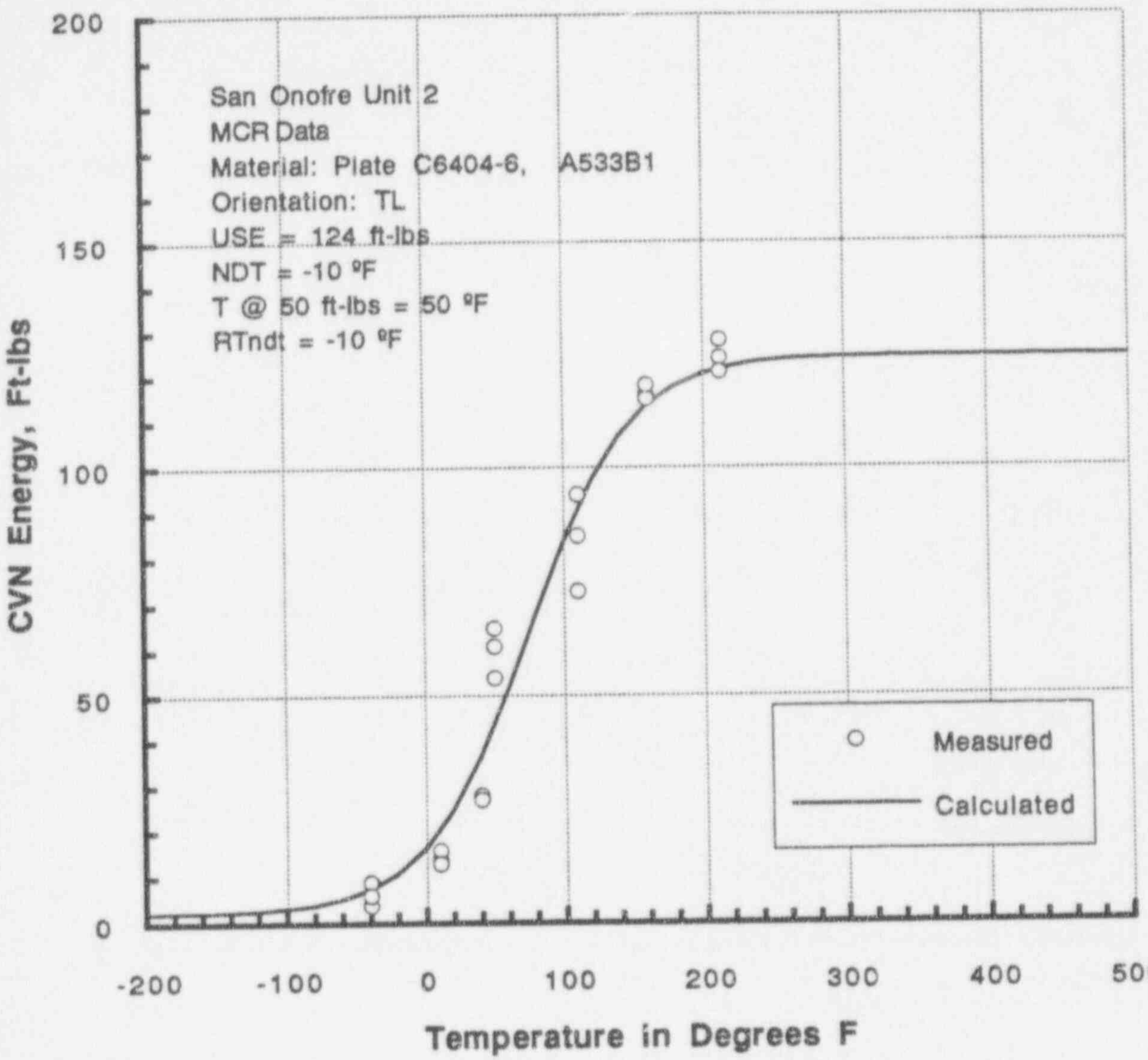

Figure 3-7. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-6, TL Orientation, MCR Data.

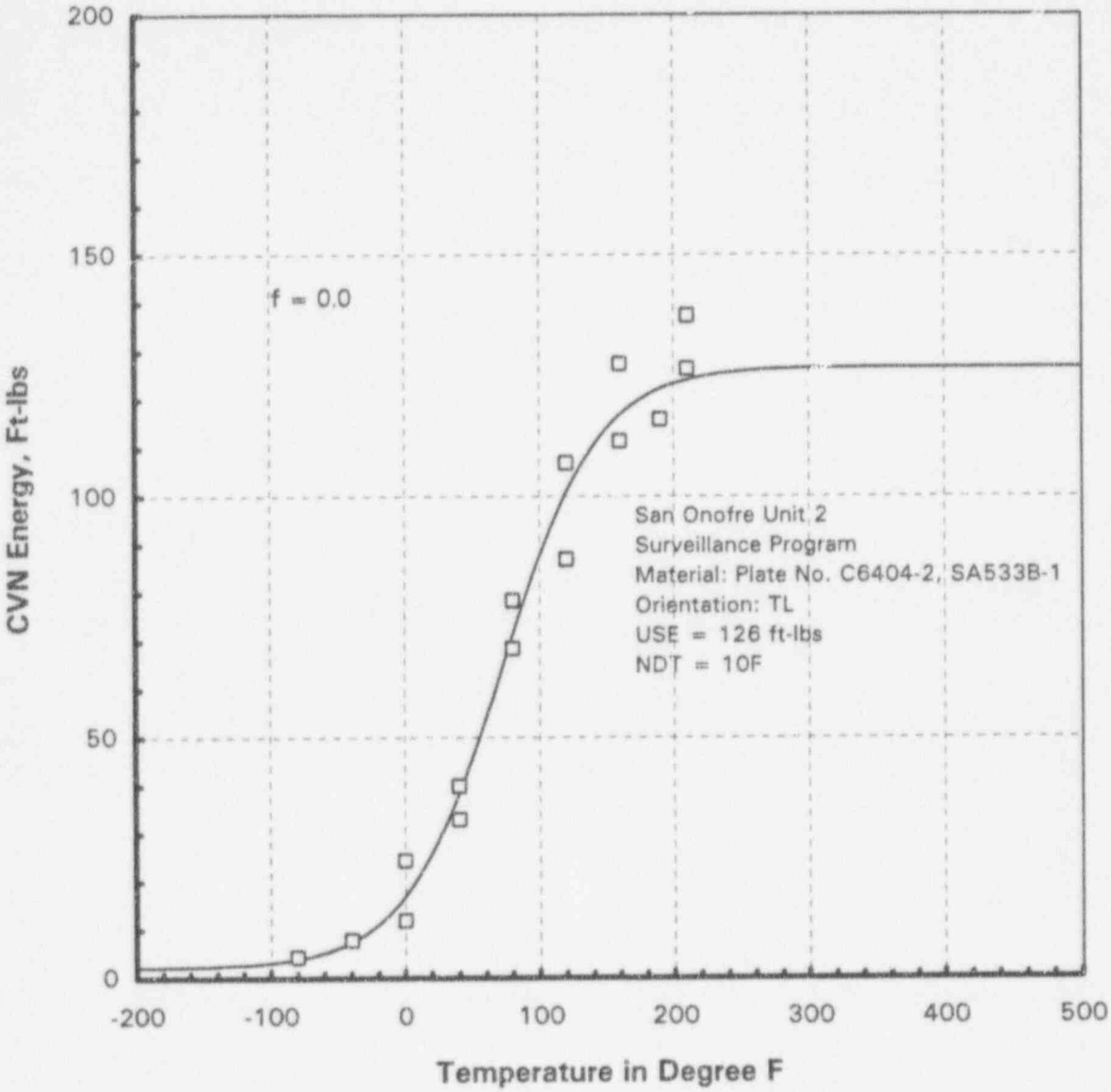

Figure 3-8. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-2, TL Orientation, Surveillance Baseline Data.

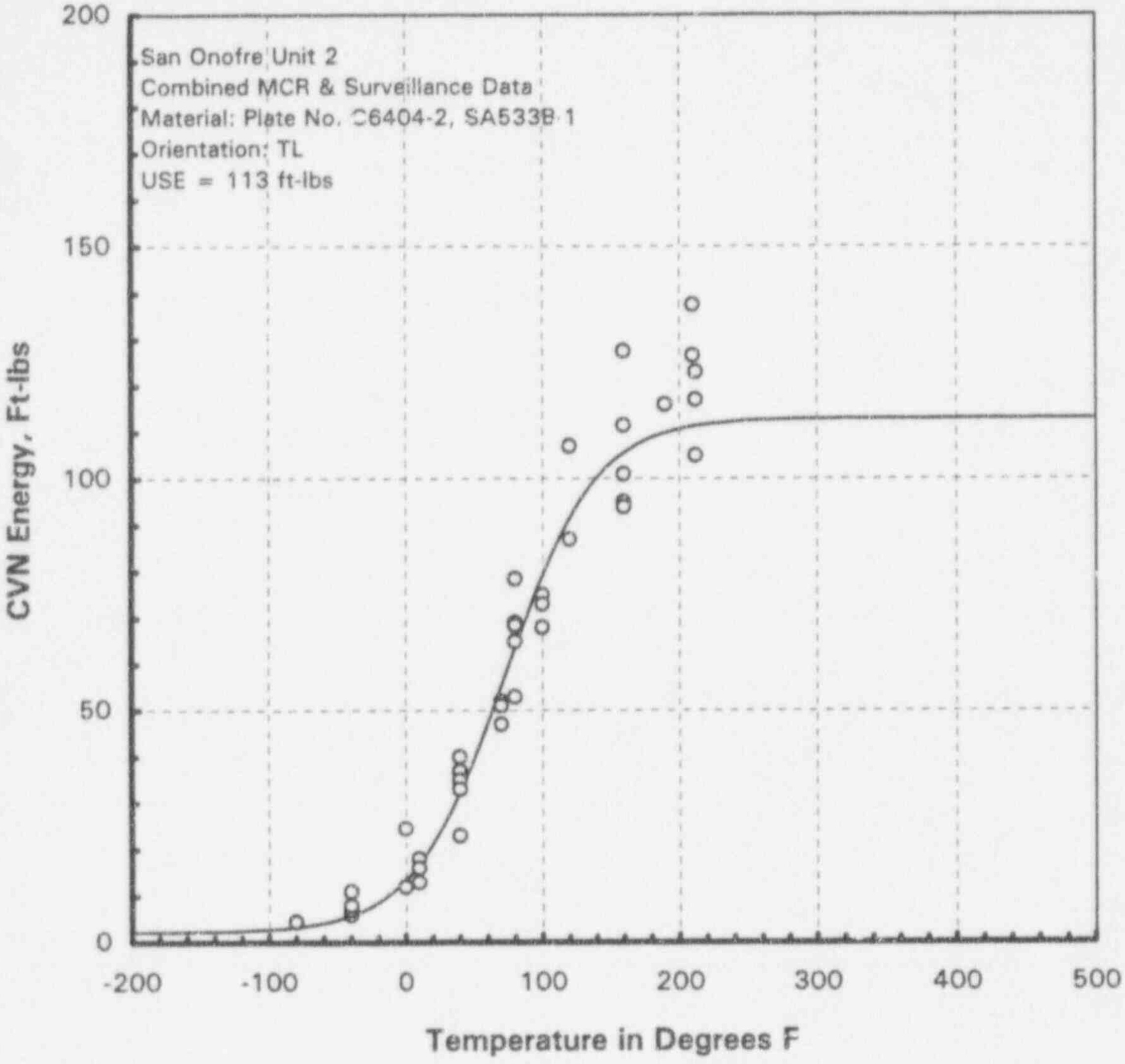

Figure 3-9. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-2, TL Orientation, Combined MCR and Surveillance Baseline Data.

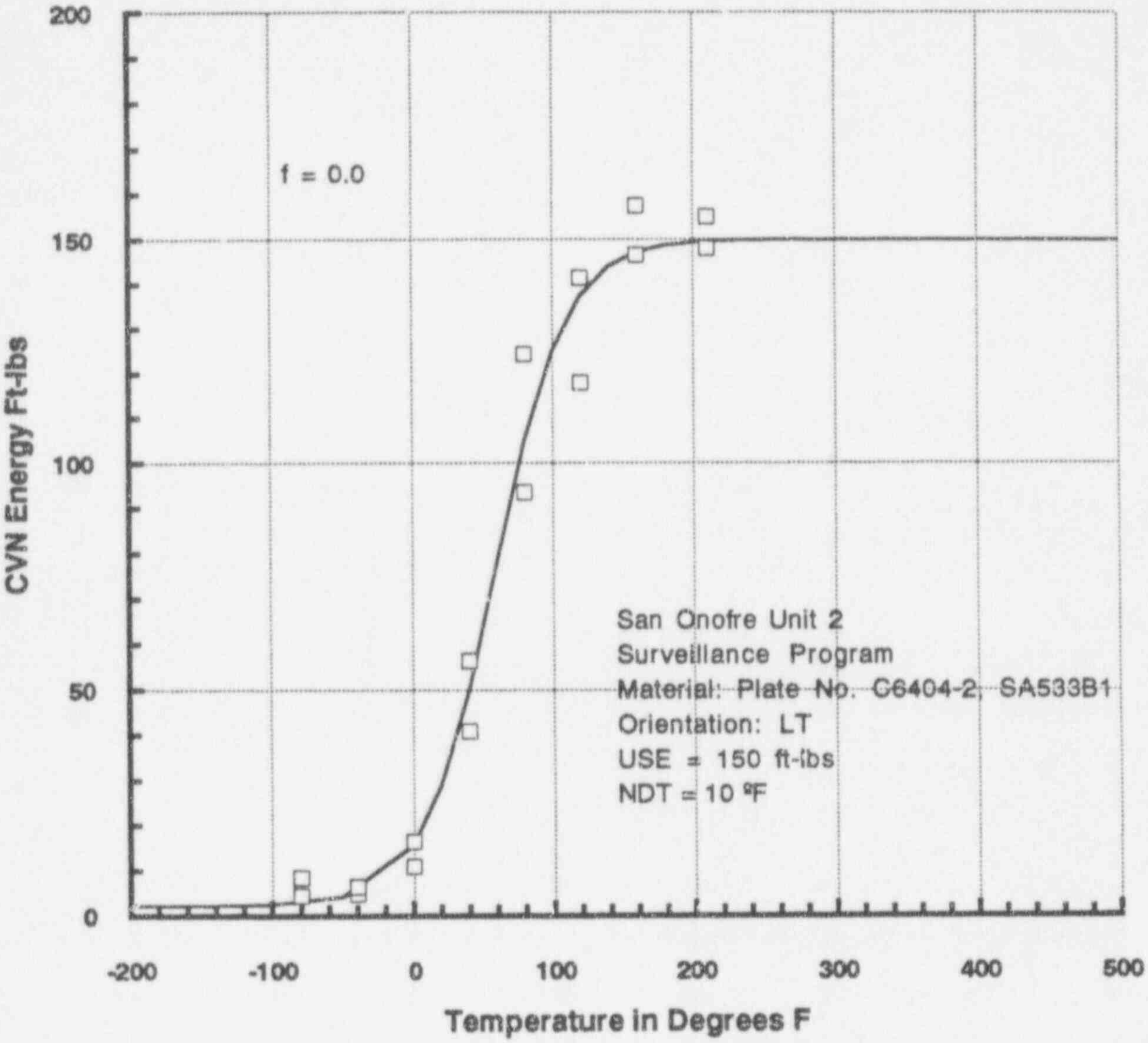

Figure 3-10. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6404-2, LT Orientation, Surveillance Baseline Data.

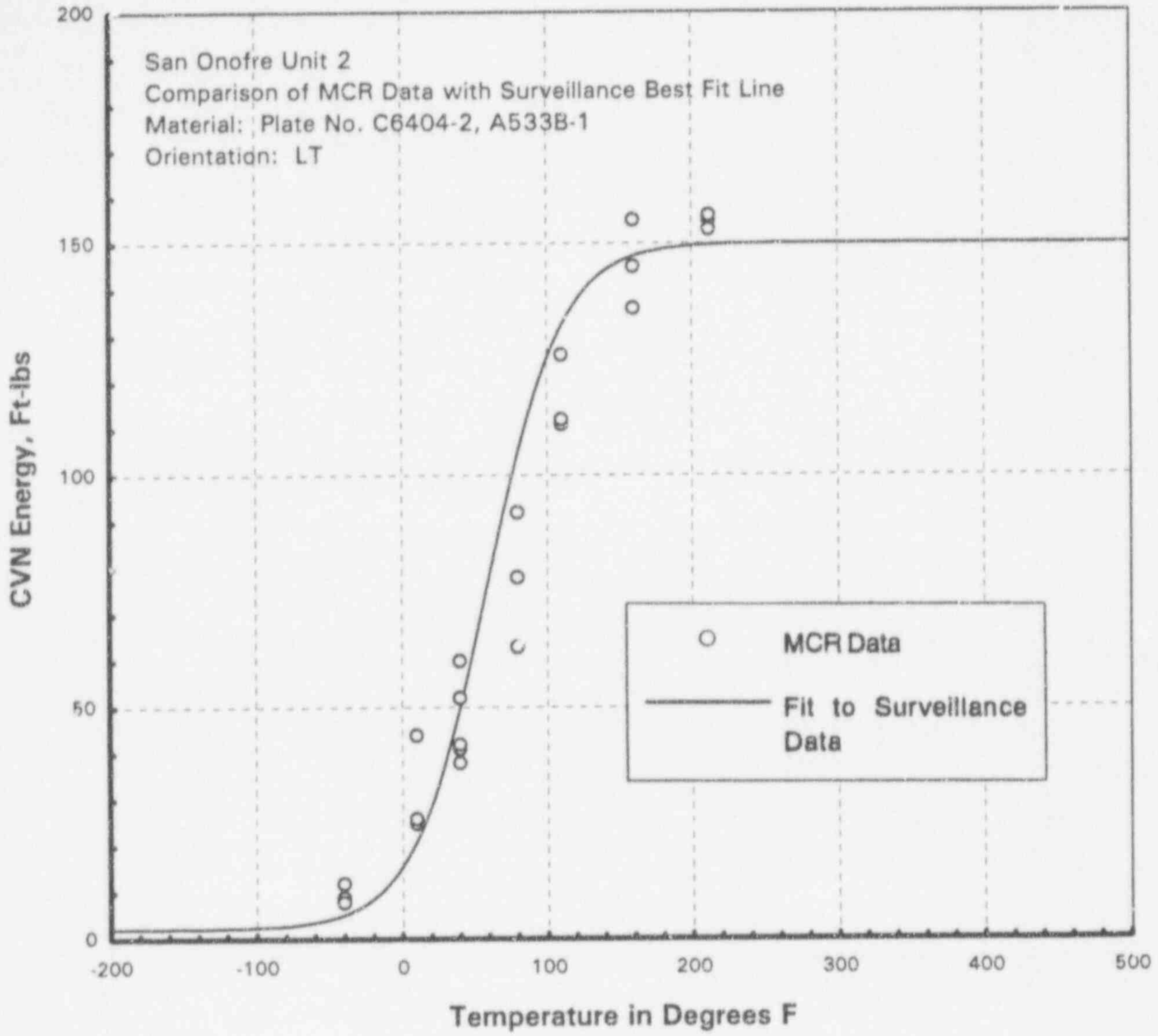

Figure 3-11. SONGS, Unit 2: Comparison of Least Squares Fit C_{VN} versus Temperature Curve for the Surveillance Plate with MCR Data for Plate C6404-2, LT Orientation.

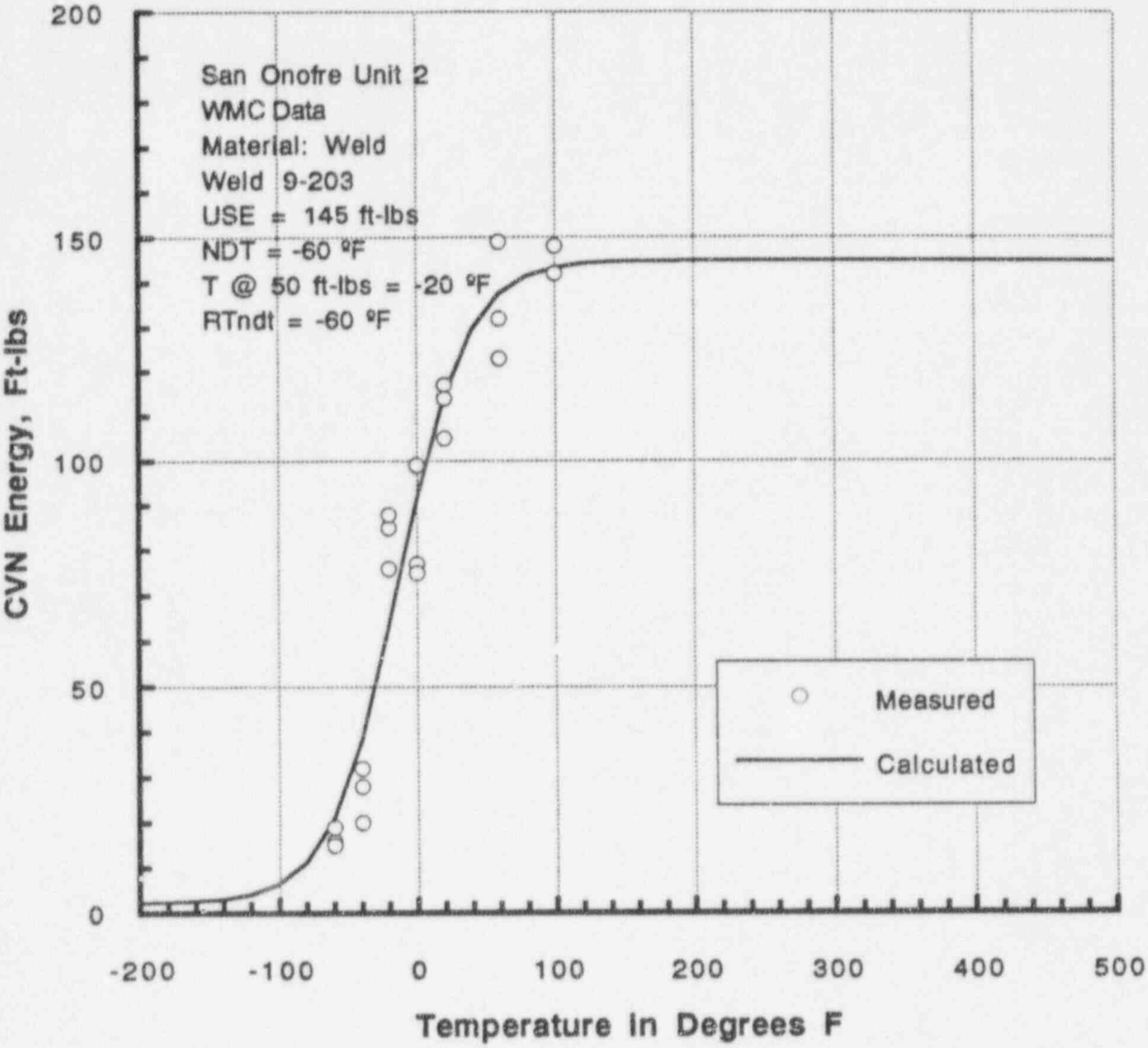

Figure 3-12. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Weld 9-203, WMC Data.

Table 3.1 SONGS, Unit 2: Compliance with 10CFR50, Appendix G.

Paragraph	Description of Non-Compliance	Comment
II.B	Series 4xx stainless steels are purchased and treated to Code requirements. No RT_{NDT} or drop weight T_{NDT} temperatures are determined.	Consistent with ASME Code in effect.
III.B.5.a	Records of fracture toughness testing do not include a certification that tests were performed in accordance with Appendix G.	Appendix G was not applicable at the time tests were performed. Certification to the applicable ASME Code is included. The intent of Appendix G is met.
III.C.	"Reactor Vessel Beltline", as defined by Paragraph II.H, includes the weld heat-affected-zones. Section III.C is not complied with in that only base plate and representative welds in the beltline region were considered for the required testing.	The baseline tests of the surveillance program include weld and HAZ material from the most limiting plate. Results available for SONGS Unit 2 indicate that the intent of Appendix G has been met. (Note: the HAZ results are not presented in this report)
III.C.1	Only single-temperature testing was performed for some weld materials.	Consistent with ASME Code in effect.
	Only the heat-affected-zone from the most limiting plate was tested over an extended temperature range.	
III.C.2	Excess material for test specimen weldment is not necessarily from the actual production plate, although it is the same P-number. (Section IX, ASME Code)	The same combinations of a specific heat of filler wire and a specific lot of flux welded under the same production conditions as those used in joining the corresponding shell materials were used.

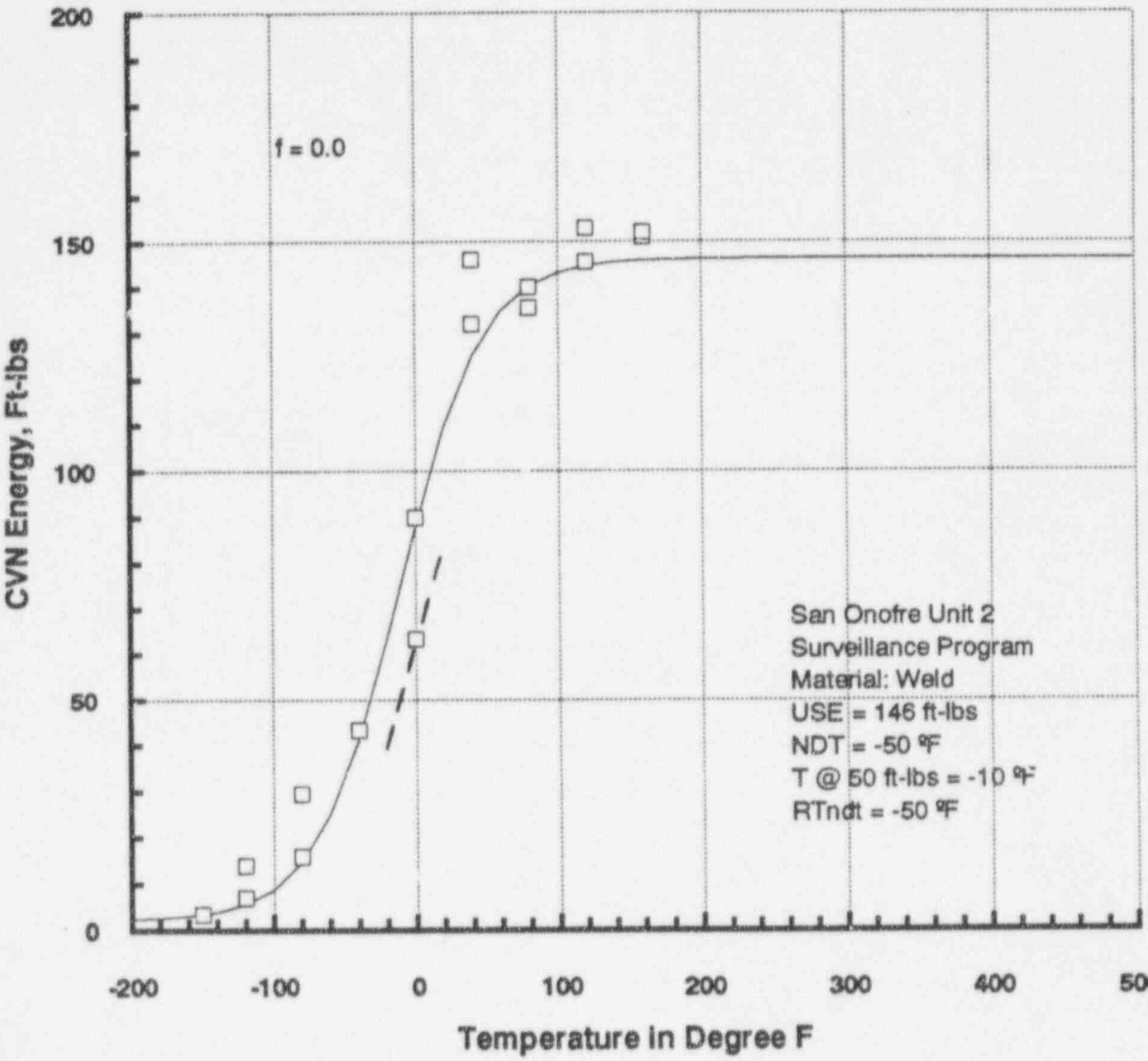

Figure 3-13. SONGS, Unit 2: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Surveillance Weld, Surveillance Baseline Data.

Table 3.1 (Continued)

Paragraph	Description of Non-Compliance	Comment
IV.A.4	Charpy V-notch tests were not conducted at "the preload temperature or at the lowest service temperature, whichever is lower".	The ASME Code in effect required test temperature of 60°F below the lowest service temperature. All bolting material was tested at 10°F and met the 35 ft-lb minimum requirement of the applicable ASME Code. All beltline plate materials and one beltline weld were tested to meet the current (1989) Code requirements in NB-2331. The remaining beltline welds were tested at 10°F and/or 0°F and have an average C_{VN} in excess of 90 ft-lb. These results indicate that the intent of Appendix G has been met.

Table 3.2 SONGS, Unit 2: Plate and Corresponding Heat Numbers for the Beltline Plates.

Plate Number	Lukens Heat Number
C6404-1	C7596-1
C6404-2	C7595-2
C6404-3	C7595-1
C6404-4	A6735-1
C6404-5	C7585-1
C6404-6	C7596-2

Table 3.3 SONGS, Unit 2: Weld Wire and Flux Combinations for Beltline and Surveillance Welds.

Weld Seam	Weld Wire and Flux
2-203 A, B, C[a]	E8018 C-3 Electrodes, Lot No. BOLA
3-203 A, B, C[b]	Type Mil B-4 Wire, Heat No. 83637, Linde Type 0091 Flux, Lot No. 1122
8-203[c]	Combination of (1) Type Mil B-4 Wire, Heat No. 10137, Linde Type 0091 Flux, Lot No. 3999 and (2) Type Mil B-4 Wire, Heat No. 90136, Linde Type 0091 Flux, Lot. No. 3999
9-203[b]	Type Mil B-4 Wire, Heat No. 90130, Linde Type 0091 Flux, Lot No. 0842
Surveillance[a]	Same consumables as Weld 9-203

a. Weld wire heat number and flux type confirmed by ABB-CE letter dated November 4, 1993 contained in Appendix D.

b. Basis is SONGS Unit 2 FSAR and is consistent with handwritten note in Appendix D.

c. Weld wire heat number and flux type confirmed by ABB-CE letter dated January 4, 1994. The applicable data are contained in App. C and D.

Table 3.4 SONGS, Unit 2: Key Residual and Alloying Element Contents for Beltline Plates.[a]

Plate Number	ABB-CE Lab. No.	Cu	Ni	P	S	CF[b]
C6404-1	P14445 P16921	0.10	0.56	0.007	0.009	65
C6404-2	P14446 P16922	0.10	0.59	0.008	0.010	65
C6404-2[c]		0.10	0.59	0.011	N/A	65
C6404-3	P14447 P16923	0.10	0.56	0.008	0.011	65
C6404-4	P14105 P17110	0.10	0.62	0.006	0.009	65
C6404-5	P14068 P17405	0.11	0.64	0.007	0.010	75
C6404-6	P14106 P17111	0.10	0.58	0.006	0.010	65

a. Average values (see Appendix B)

b. Chemistry factors from Regulatory Guide 1.99, Revision 2

c. Measured when the surveillance tests were performed for Capsule 97[2]

Table 3.5 SONGS, Unit 2: Key Residual and Alloying Element Contents for Beltline Welds.

Weld Number	ABB-CE Lab No.	Cu	Ni	P	S	CF[a]
2-203A	D18153	0.03	0.90	0.009	0.017	41
2-203B	D18154	0.03	0.91	0.009	0.016	41
2-203C	D18155	0.03	0.95	0.010	0.016	41
3-203A	D17025	0.05	0.12	0.011	0.011	40
3-203B	D17026	0.04	0.06	0.010	0.011	30
3-203C	D17027	0.06	0.11	0.010	0.011	42
8-203 (90136)	D10255	0.31	1[b]	0.012	0.010	260
(10137)	D10600	0.23	1[b]	0.016	0.010	236
9-203	D23227	0.07	0.29	0.009	0.007	69
Surveillance[c]	D26761	0.03	0.12	0.003	0.009	30
Surveillance[d]		0.03	0.15	<0.005	N/A	32

a. Chemistry Factors determined from Regulatory Guide 1.99, Revision 2

b. Ni content was not obtained and 1.0 wt% has been assumed (per Regulatory Guide 1.99, Rev. 2)

c. Measured when surveillance program was developed[1]

d. Measured when the surveillance tests were performed for Capsule 97[2]

Table 3.6 SONGS, Unit 2: Beltline Plate Material Unirradiated Fracture Toughness Tests Results Summary, TL Orientation.

Plate Number	NDT (°F)	Initial RT_{NDT} (°F)	Procedure to Determine RT_{NDT}	USE (ft-lbs)
C6404-1	-30	20	NB-2331 (a)(3)	119
C6404-2[a]	-20[b]	20	NB-2331 (a)(3)	113
C6404-3	-20	20	NB-2331 (a)(3)	99
C6404-4	-10	20	NB-2331 (a)(3)	104
C6404-5	-20	10	NB-2331 (a)(3)	118
C6404-6	-10	-10	NB-2331 (a)(2)	124

a. This plate is included in the surveillance program. RT_{NDT} is based on the MCR data (see Figure 3-3) and the USE value is based on the combined data sets from the MCRs and unirradiated surveillance baseline (see Figure 3-9)

b. An NDT value of -20°F was determined when the plate was purchased (+10°F was determined from the surveillance baseline program).

Table 3.7 SONGS, Unit 2: Charpy Absorbed Energy Values for Weld Seams 2-203 A, B, and C; 3-203 A, B, and C; and 8-203.

Weld Seam	Test Temperature (°F)	Charpy Energy (ft-lb)
2-203 A, B, C	10	69, 87, 74
	10	106, 108, 105
	0	82, 101, 108
3-203 A, B, C	10	153, 131, 125
8-203 (90136)	10	108, 112, 119
(10137)	10	101, 108, 107

Table 3.8 SONGS, Unit 2: Beltline Weld Material Unirradiated Fracture Toughness Tests Results Summary.

Weld Seam	NDT (°F)	Initial RT_{NDT} (°F)	Procedure to Determine RT_{NDT}	USE (ft-lbs)
2-203 A, B, C	-60	-60	NB-2331 (a)(2)	93[b]
3-203 A, B, C	-50[a]	-50	NB-2331 (a)(2)	136[d]
8-203 (10137)	N/A	-56	c	105[d]
8-203 (90136)	N/A	-56	c	113[d]
9-203	-60[a]	-60	NB-2331 (a)(2)	145
Surveillance	-50	-50	NB-2331 (a)(4)	146

a. NDT values were obtained from the FSAR and documented in Appendix D

b. Estimated using the average of C_{VN} values obtained at +10°F and 0°F (see Table 3.7)

c. Generic value for ABB-CE fabricated vessels using Linde 0091, 1092, and 124 fluxes (see 10CFR50.61)

d. Estimated using the average of C_{VN} values obtained at +10°F (see Table 3.7)

Section 4

ISSUES RELATED TO GENERIC LETTER 88-11

NRC issued Generic Letter 88-11 (GL 88-11) in July 1988. GL 88-11 revised the methodology used for estimating radiation embrittlement of reactor pressure vessel materials to be consistent with the guidelines in Regulatory Guide 1.99, Revision 2. Several technical issues have recently emerged which indicate a need to address some of the application assumptions used in Regulatory Guide 1.99, Revision 2. The pertinent issues brought out in GL 92-01 are addressed in this section.

4.1 VESSEL TEMPERATURE DURING OPERATION

The methodology in Regulatory Guide 1.99, Revision 2, is specified to be applicable for operating temperatures in the range of 525 to 590°F. Concern is expressed in GL 92-01 that power operation may occur at temperatures below 525°F. For SONGS, Unit 2, the reactor coolant cold leg temperature (T_c) is maintained above the Technical Specification limiting condition for operation of 535°F which applies above 30% power. The normal operating band of T_c ranges from 545°F at zero power to 553°F at 100% power with a tolerance of $\pm$ 2°F. Thus, there is no time during normal power operation that the SONGS, Unit 2, vessel or surveillance capsules experience temperatures below 525°F.

4.2 APPLICABILITY OF SURVEILLANCE DATA

To properly assess the measured surveillance results and to project irradiation embrittlement trends for the vessel, fluence projections, validated through the dosimetry contained in the surveillance capsules tested to date, are needed. Both SONGS, Units 2 and 3, have identical core designs and essentially the same past and projected operation history. Therefore, the fluence projections from Units 2 and 3 surveillance data will be used for each unit. The fluence as a function of effective full power years (EFPY) was obtained from the results of the first capsules pulled from Units 2 and 3.

The Unit 2 capsule was pulled at the end of the third fuel cycle which corresponds to 2.85 EFPY.[2] These data represent the original core for both units, and the best estimate value of peak fluence at the vessel inner surface is 4.34×10^{18} n/cm^2 (E > 1 MeV); the capsule fluence was about 20% higher at 5.07×10^{18} n/cm^2.

At the start of the fourth cycle for each unit, the core was reconfigured in a low leakage loading pattern which reduced the vessel and capsule fluxes. The first capsule taken out of Unit 3 was after the fourth fuel cycle at 4.33 EFPY and represents the combined results of the standard and low leakage core designs.[3] The peak fluence value for the vessel inner surface is 6.6×10^{18} n/cm^2, and the associated capsule fluence is 8.0×10^{18} n/cm^2.

The projection of fluence forward in time is based upon an extrapolation of the dosimetry information obtained from the two SONGS capsules. The projected peak fluence at the vessel inner surface at the end of 32 EFPY is 4.2 x 10^{19} n/cm^2.[3] At the point in time of December 16, 1991, the estimated EFPY is 5.63, and the projected peak fluence at the vessel inner surface is 8.5 x 10^{18} n/cm^2.

As indicated in Figure 3-1, there is a weld identified as 8-203 which is well outside the core region of the vessel (i.e., approximately 2 feet above the top of the core). This weld is conservatively considered a beltline material because of a large chemistry factor associated with the high reported Cu content (0.31 wt%) in combination with a 1.0 wt% Ni content, which was conservatively assumed because Ni was not reported. The fluence at this location above the core was reported in the FSAR to be about 1/37 that of the peak fluence location within the vessel. Recent calculations performed at SCE[4] indicate that the fluence at Weld 8-203 is 1/108 that of the peak fluence location within the vessel. The SCE fluence calculations have been used in the evaluation of Weld 8-203.

Within Regulatory Guide 1.99, Revision 2, there are five credibility criteria that must be met in order to utilize surveillance data in adjusting the predicted embrittlement trends and/or reducing the assigned margin terms. Three of the criteria are met (proper limiting materials, definitive measurements of shift and upper shelf, and a match between the capsule and vessel temperatures within ±25°F), but the other two have not been satisfied since only one capsule from each vessel has been pulled and evaluated. To satisfy these last two requirements, the second capsules (which will not be pulled until about 15 EFPY) must be evaluated to supply two valid data sets for the vessel surveillance materials, and testing of the correlation monitor material contained in the second capsules must be evaluated against the available data for that material.

In the subsequent portion of this section, the available results from the first capsules will be compared to the regulatory prediction approaches, and projections based upon the regulatory approaches will be made.

4.3 SHIFTS AT THE CHARPY V-NOTCH 30 FT-LB ENERGY LEVEL

Capsule 97 from the SONGS Unit 2 surveillance program was tested in 1988. The C_{VN} results from this capsule are shown in Figures 4-1 (Plate C6404-2/LT), 4-2 (Plate C6404-2/TL), and 4-3 (surveillance weld). Appendix H contains, in tabular form, the absorbed energy, lateral expansion, and fracture appearance (% shear) for the irradiated surveillance materials.

The results computed during this work for the shift at the 30 ft-lb energy level are tabulated in Table 4.1 as "current" and compared to the Regulatory Guide 1.99, Revision 2, mean shift predictions (RG1.99R2):

RG1.99R2 = CF (chemistry factor) x ff (fluence function).

The results obtained by Battelle[2] are also shown for comparison. The differences between the current values for shift versus those from Battelle are due to small differences in the curve fit to the C_{VN} data and the different data set used for unirradiated Plate C6404-2/TL (i.e., Figure 3-8 for Battelle and Figure 3-9 in the current study).

All of the measured shift results are less than the mean prediction from Regulatory Guide 1.99, Revision 2. Until another capsule is tested, there is no way to definitively evaluate that CFs should be adjusted to reflect measured behavior, rather than that predicted from the Regulatory Guide.

Table 4.2 lists the predicted estimates of adjusted RT_{NDT} (ART) at the vessel inner surface for the two time periods of December 16, 1991 (as requested in GL 92-01) and at the end of the current license (32 EFPY). Note that the Regulatory Guide 1.99, Revision 2, shift (CF x ff) with the appropriate margin terms have been used; the initial RT_{NDT}s were taken from Tables 3.6 and 3.8. The results in Table 4.2 show that the adjusted RT_{NDT} is essentially the same for all beltline plates, and that the plate material is the limiting material in the vessel beltline. Finally, the results in Table 4.2 show that the degree of radiation embrittlement in the SONGS, Unit 2, reactor vessel beltline materials is relatively low even at end-of-design life fluence.

4.4 UPPER SHELF ENERGY DROP

Capsule 97 from the SONGS, Unit 2, surveillance program was evaluated in 1988. The USE results are shown in Figures 4-1, 4-2, and 4-3, and are tabulated in Table 4.3 as absolute drop in USE (ft-lb). Also listed in Table 4.3 are the predicted drops from Regulatory Guide 1.99, Revision 2. All of the measured drops in USE are below those predicted by the Regulatory Guide.

Predictions of USE levels at the quarter-thickness location after neutron irradiation exposure are shown in Table 4.4 for all the SONGS, Unit 2, beltline materials. At the end of 32 EFPY, none of the materials are projected to even approach the NRC screening limit of 50 ft-lb specified in 10CFR50, Appendix G.

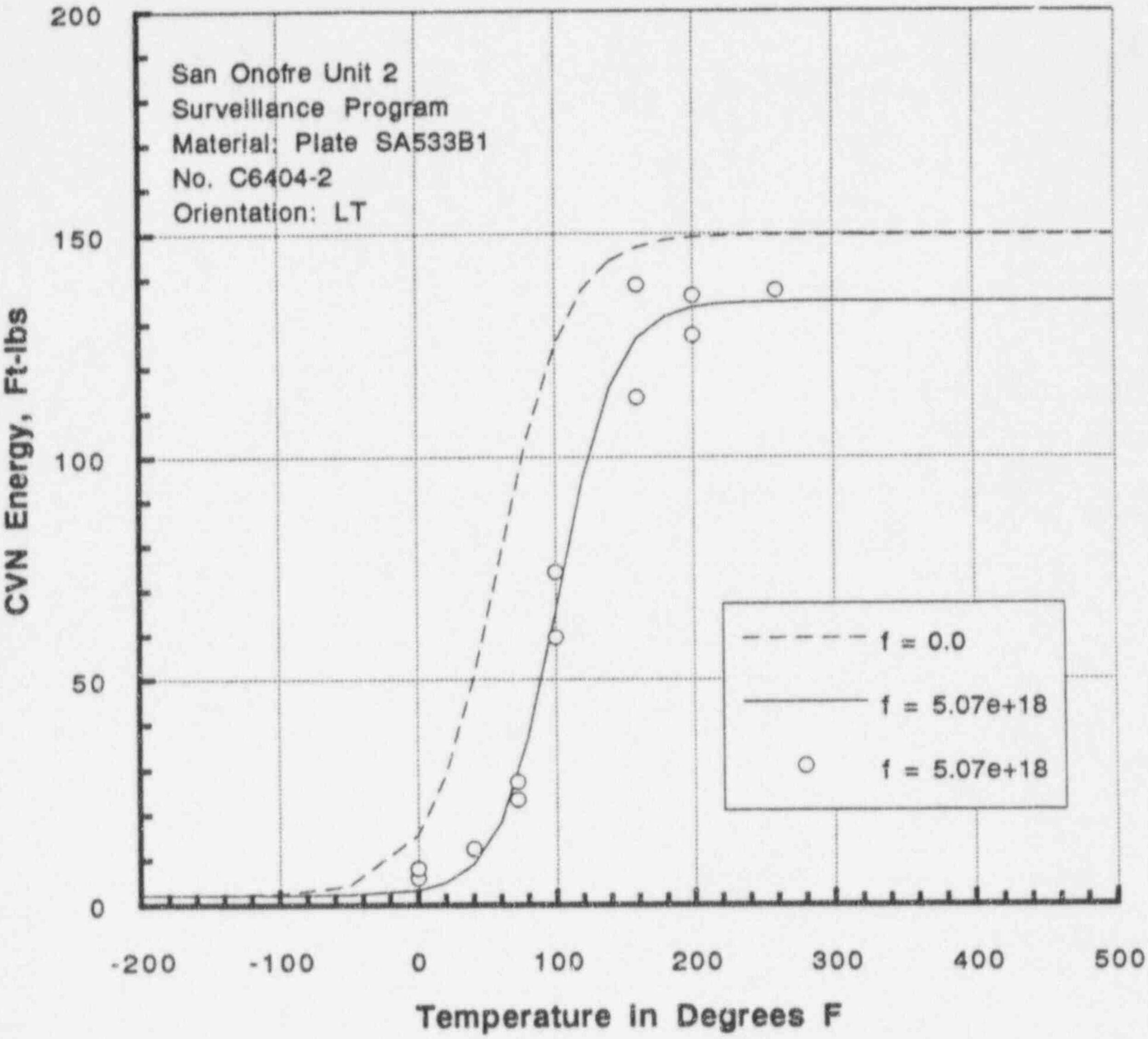

Figure 4-1. SONGS, Unit 2: Comparison of the Least Squares Fit for the Unirradiated Baseline Data with the Irradiated C_{VN} Data and Least Squares Fit for the Data from Capsule 97, Plate C6404-2, LT Orientation.

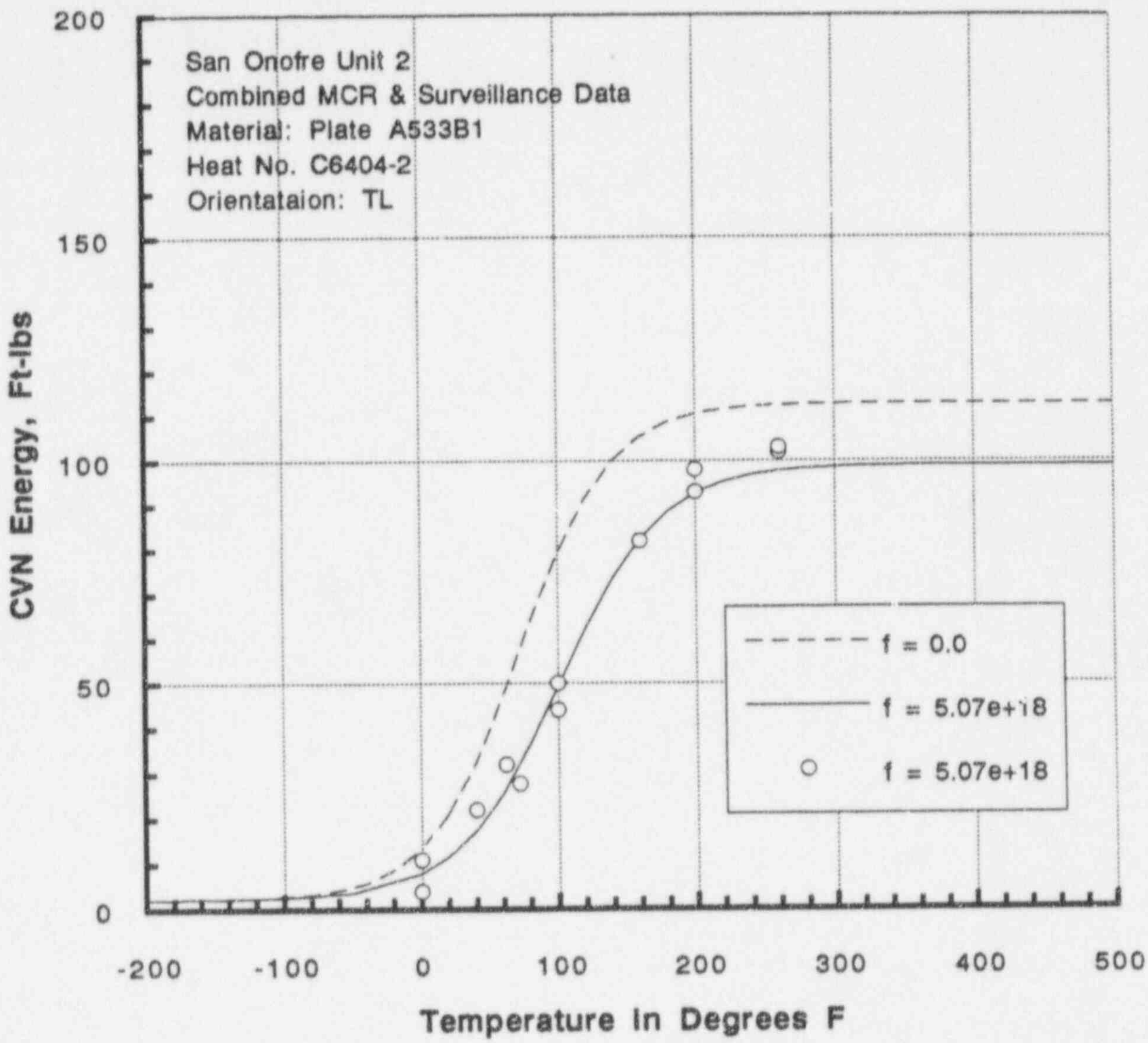

Figure 4-2. SONGS, Unit 2: Comparison of the Least Squares Fit for the Combined MCR and Unirradiated Baseline Data with the Irradiated C_{VN} Data and Least Squares Fit for the Data from Capsule 97, Plate C6404-2, TL Orientation.

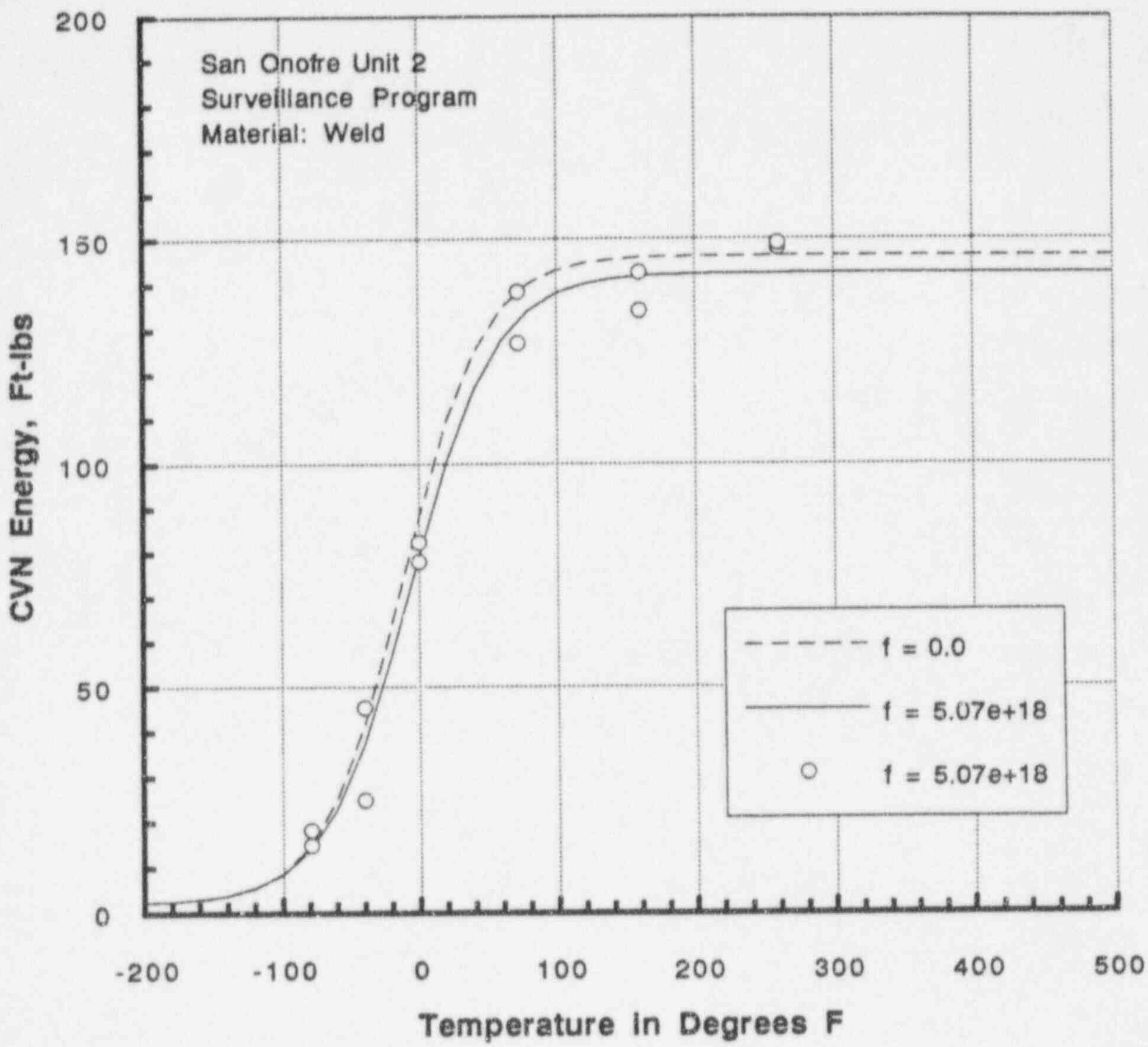

Figure 4-3. SONGS, Unit 2: Comparison of the Least Squares Fit for the Unirradiated Baseline Data with the Irradiated C_{VN} Data and Least Squares Fit for the Data from Capsule 97, Surveillance Weld.

Table 4.1. SONGS, Unit 2: Surveillance Capsule Shift Results.

Material/ Orientation	CF	ff	30 ft-lb Shift (°F)		
			Battelle	RG1.99R2	Current
C6404-2/LT	65[a]	0.81	51	53	52[c]
C6404-2/TL	65[a]	0.81	45	53	33[d]
Surveillance Weld	69[b]	0.81	7	56	4[e]

a. See Table 3.4 (Cu = .10; Ni = .59)

b. Based upon the conservative 9-203 weld chemistry -- see Table 3.5

c. Based on the baseline surveillance data, see Figure 3-10

d. Based on the combined data set from the MCR and baseline surveillance program, see Figure 3-9

e. Based on the baseline surveillance data, see Figure 3-13

Table 4.2. SONGS, Unit 2: ART Estimates at the Inner Surface Location for Beltline Materials on 12/16/91 and at 32 EFPY.

Plate No./ Weld Seam	CF	Fluence Function at the Inner Surface		ART (°F)[a] at the Inner Surface	
		12/16/91	32 EFPY	12/16/91	32 EFPY
C6404-1	65	0.95	1.37	116	143
C6404-2	65[b]	0.95	1.37	116	143
C6404-3	65	0.95	1.37	116	143
C6404-4	65	0.95	1.37	116	143
C6404-5	75	0.95	1.37	115	147
C6404-6	65	0.95	1.37	86	113
2-203 A, B, C	41[c]	0.95	1.37	18	52
3-203 A, B, C	38[d]	0.95	1.37	22	54
8-203 (10137)	236	0.09[e]	0.25[e]	5[f]	68[f]
8-203 (90136)	260	0.09[e]	0.25[e]	8[f]	74[f]
9-203	69	0.95	1.37	62	90

a. ART is the adjusted reference temperature equal to the predicted shift (CF x ff) plus the initial RT_{NDT} plus a margin term equal to 34°F for plates or 56°F for welds (unless the predicted shift is less than the margin term, in which case the margin is equal to the predicted shift)

b. Based upon average chemistries for this plate (.10 Cu/.59 Ni)--see Tables 3.4 and 4.1

c. Based upon average chemistries for these welds (.03 Cu/.92 Ni)--see Table 3.5

d. Based upon average chemistries for these welds (.05 Cu/.10 Ni)--see Table 3.5

e. Fluence function is based upon the peak vessel fluence divided by 108[4]

f. Since there is not a measured initial RT_{NDT}, an additional margin associated with the standard deviation (17°F) of the initial RT_{NDT} has been used as described in Regulatory Guide 1.99, Rev. 2

Table 4.3. SONGS, Unit 2: Surveillance Capsule Upper Shelf Results

Material/ Orientation	Cu (wt%)	Fluence ($x\ 10^{19}\ n/cm^2$)	Upper Shelf Drop (ft-lb)		
			Battelle	RG1.99R2	Current
C6404-2/LT	0.10[a]	0.507	17	24	15[d]
C6404-2/TL	0.10[a]	0.507	21	18	14[e]
Surveillance Weld	0.07[b]	0.507	5	26[c]	4[f]

a. See Table 3.4

b. See Table 3.5 for weld 9-203

c. Based upon interpolation of the Regulatory Guide 1.99, Rev. 2 curves.

d. Based on the baseline surveillance data, see Figure 3-10

e. Based on the combined data set from the MCR and baseline surveillance program, see Figure 3-9

f. Based on the baseline surveillance data, see Figure 3-13

Table 4.4. SONGS, Unit 2: Upper Shelf Estimates at the Quarter-Thickness Location for Beltline Materials on 12/16/91 and at 32 EFPY.

Plate No./ Weld Seam	Cu (wt%)	Fluence (x 10^{19} n/cm^2) at Quarter-Thickness 12/16/91	32 EFPY	Upper Shelf Energy (ft-lb)[a] at Quarter-Thickness 12/16/91	32 EFPY
C6404-1	0.10	0.51	2.5	100	91
C6404-2	0.10[b]	0.51	2.5	95	87
C6404-3	0.10	0.51	2.5	83	76
C6404-4	0.10	0.51	2.5	87	80
C6404-5	0.11	0.51	2.5	98	89
C6404-6	0.10	0.51	2.5	104	95
2-203 A, B, C	0.03[c]	0.51	2.5	78	71
3-203 A, B, C	0.05[d]	0.51	2.5	114	103
8-203 (10137)	0.23	0.005	0.023	94[e]	89[e]
8-203 (90136)	0.31	0.005	0.023	97[e]	88[e]
9-203	0.07	0.51	2.5	119	107

a. The upper shelf energy is estimated from Regulatory Guide 1.99, Rev. 2, taking into account the projected fluences and measured chemistry

b. Based upon average chemistry for this plate--see Table 3.4

c. Based upon average chemistry for this weld and the lowest measured upper shelf--see Tables 3.5 and 3.8

d. Based upon average chemistry for this weld--see Table 3.5

e. Based upon an extrapolation of the curves in Regulatory Guide 1.99, Rev. 2

Section 5

REFERENCES

[1] A. Ragl, Southern California Edison San Onofre Unit 2, Evaluation of Baseline Specimens, Reactor Vessel Materials Irradiation Surveillance Program, Combustion Engineering S-TR-MCS-002, May 27, 1978.

[2] M. P. Manahan, L. M. Lowry, and E. O. Fromm, Examination, Testing, and Evaluation of Irradiated Pressure Vessel Surveillance Specimens from the San Onofre Nuclear Generating Station Unit 2 (SONGS-2), Battelle Columbus, December 1988.

[3] E. Terek, E. P. Lippincott, A. Madeyski, and M. Ramirez, Analysis of the Southern California Edison Company San Onofre Unit 3 Reactor Vessel Surveillance Capsule Removed from the 97° Location, Westinghouse WCAP-12920, Revision 2, May 1994.

[4] R. Chang, "SONGS 2/3 RPV Fluence Ratio at Weld 8-203", SCE Calculation No. N-1020-065, December 1992.

APPENDIX A

SONGS, UNIT 2: EVALUATION OF COMPLIANCE WITH ASTM E185-73 AND E185-82

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
1.2 Surveillance tests are divided according to application into two cases:	Compliance
1.2.1 Case A - Where both the predicted increase in transition temperature of the reactor vessel steel is 100°F or less and the calculated peak neutron fluence (E > 1 MeV) of the reactor vessel is 5 X 10^{18} n/cm^2 or less.	
1.2.2 Case B - Where the predicted increase in transition temperature of the reactor vessel steel is greater than 100°F or where the calculated peak neutron fluence (E > 1 MeV) of the reactor vessel is greater than 5 X 10^{18} n/cm^2	
4.1 Test Material - Test specimens shall be prepared from the actual materials used in fabricating the irradiated region of the reactor vessel.	Compliance
4.1 Samples shall represent minimum of one heat of the base metal and one butt weld and one weld heat-affected-zone (HAZ) if a weld occurs in the irradiated region.	Compliance
4.1 The base metal and weld metal to be included in the program should represent the material that may limit the operation of the reactor during its lifetime.	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
4.1.1 Vessel Material Sampling - A minimum test program shall consist of specimens taken from the following locations: (1) base metal of one heat used in the irradiated region, (2) weld metal, fully representative of the fabrication practice used for a weld in the irradiated region (weld wire of rod, must come from one of the heats used in the irradiated region of the reactor vessel) and the same type of flux, and (3) the heat-affected-zone associated with the base metal noted above.	Compliance
4.1.1 Representative test stock to provide two additional sets of test specimens of the base metal, weld and heat-affected-zone shall be retained with full documentation and identification.	Compliance
4.1.2 Fabrication History - The test material shall receive a fabrication history (austenitizing, quench and tempering, and post-weld heat treatment) fully representative of the fabrication received by the material in the irradiated region of the reactor vessel.	Compliance
4.1.3 Chemical Requirements - The chemical composition required by the material specifications for the test materials (base metal and as deposited weld metal) shall be obtained and include, but not be limited to phosphorus (P), sulfur (S), copper (Cu), and vanadium (V).	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
4.2 Charpy V-notch impact specimens corresponding to the Type A specimen described in Methods E 23 shall be employed unless material thickness does not permit. Both irradiated and unirradiated types of specimens shall be of the same size and shape.	Compliance
4.3 Specimen Orientation and Location - For both tension and impact specimens from base metal, the major axis of the specimen shall be machined normal to the principal rolling direction for plates and normal to the major working direction for forgings. The length of the notch of the Charpy impact specimen shall be normal to the surface of the material. The recommended orientation of the impact and tension specimens with respect to the weld are shown in Fig. 1. Weld metal tension specimens may be oriented in the same direction as the Charpy specimens provided that the gage length consists of all weld metal. No specimens are to be removed within 1/2 in. of the root or the surfaces of the welds. Sections of the weldment shall be etched to define the weld heat affected zones. Care shall be taken that the impact specimens from the weld heat affected zones have their notch roots in the heat affected zone at a standard distance of approximately 1/32 in. from the fusion line. Specimens representing the base metal (tension and impact) and the weld heat-affected zone shall be removed from the quarter thickness location. (per NB2300 of ASME Code Section III)	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
4.4 Number of Specimens - The minimum number of test specimens for each exposure shall be as follows:	Compliance
4.4 At least 15 Charpy impact specimens shall be used to establish an unirradiated transition curve for each material.	Compliance
4.4 For Case B (see above), three tension test specimens shall be used to establish unirradiated tensile properties.	Not Applicable
5.1.1 Vessel Wall Specimens (Required) - Specimens shall be irradiated at a location in the reactor that duplicates as closely as possible the neutron-flux spectrum, temperature history, and maximum accumulated neutron fluence experienced by the reactor vessel.	Compliance
5.1.1 The instantaneous neutron flux at the location of the specimens shall not exceed three times the calculated maximum neutron flux at the inside wall of the reactor vessel.	Compliance

Table for 4.4 Number of Specimens:

	Case A	Case B	
	Charpy	Charpy	Tension
Base Metal	12	12	2
Weld Metal	12	12	2
HAZ	12	12	-

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
5.1.2 Accelerated Irradiation Specimens (Optional) - Test specimens may be positioned at locations other than (5.1.1) for accelerated irradiation at a rate exceeding three times the calculated maximum neutron flux at the inside wall of the reactor vessel.	Not Applicable
5.2 Flux Measurements - Provisions shall be made to measure the neutron fluence as follows: 5.2.1 Dosimeters with the vessel wall specimens (5.1.1).	Compliance
5.2.2 Where accelerated irradiation specimens are used (5.1.2), dosimeters with the test specimens and dosimeters either in a separate flux monitor capsule adjacent to the vessel wall or in a vessel wall capsule.	Compliance
5.3 Test Capsules - To prevent deterioration of the surface of the specimens during test, the specimens should be maintained in an inert environment within a corrosion-resistant capsule.	Compliance
5.3 The temperature history of the specimens shall duplicate as closely as possible the temperature experienced by the reactor vessel.	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
5.3 Surveillance capsules should be sufficiently rigid to prevent damage to the capsules by coolant pressure or coolant flow thus hindering specimen removal or causing inadvertent deformation of the specimens.	Compliance
5.3 Irradiated capsules must not be bouyant to preclude serious radiation exposure to personnel if under water handling is employed.	Compliance
5.3 Consideration should be given to the design of the capsule and capsule attachments to permit insertion of replacement capsules into the reactor at a later time in the lifetime of the vessel.	Compliance
5.4 Specimen Withdrawal - A minimum surveillance program shall consist of three capsules for Case A and five capsules for Case B. It is recommended that capsules be withdrawn as described in Table 1. (See Table 1 of ASTM E185-73.)	Compliance
6.1 Radiation Environment - The neutron flux, neutron energy spectrum, and irradiation temperature of surveillance specimens and the method of determination shall be documented.	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 2 Program
6.2 Neutron Flux Dosimeters - Flux dosimeters for a particular program shall be determined by referring to Method E 261.	Compliance

END

END

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
8.1 Temperature Environment - The maximum exposure temperature of the surveillance capsule materials shall be determined. If a discrepancy (>14°C or 25°F) occurs between the observed and the expected capsule exposure temperatures, an analysis of the operating conditions shall be conducted to determine the magnitude and duration of these differences.	Compliance
8.2 Neutron Irradiation Environment: 8.2.1 The neutron flux density, neutron energy spectrum, and neutron fluence of the surveillance specimens and the corresponding maximum values for the reactor vessel shall be determined in accordance with the guidelines in Guide E 482 and Recommended Practice E 560. 8.2.2 The specific method of determination shall be determined and recorded using both a calculated spectrum and an assumed fission spectrum.	Compliance
9.1 Tension Tests: 9.1.1 Method - Tension testing shall be conducted in accordance with Methods E 8 and Recommended Practice E 21. 9.1.2 Test Temperature: 9.1.2.1 Unirradiated - The test temperatures for each material shall include room temperature, service temperature, and one intermediate temperature to define the strength versus temperature relationship.	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
9.1.2.2 Irradiated - One specimen from each material shall be tested at a temperature in the vicinity of the upper end of the Charpy energy transition region. The remaining specimens from each material shall be tested at the service temperature and the midtransition temperature.	Compliance
9.1.3 Measurements - For both unirradiated and irradiated materials, determine yield strength, tensile strength, fracture load, fracture strength, fracture stress, total and uniform elongation, and reduction of area.	Compliance
9.2 Charpy Tests: 9.2.1 Method - Charpy tests shall be conducted in accordance with Method E 23 and A370.	Compliance
9.2.2 Test Temperature: 9.2.2.1 Unirradiated - Test temperature for each material shall be selected to establish a full transition temperature curve. One specimen per test temperature may be used to define the overall shape of the curve. Additional tests should be performed in the region where the measurements described in 9.2.3 are made.	Compliance
9.2.2.2 Irradiated - Specimens for each material will be tested at temperatures selected to define the full energy transition curve. Particular emphasis should be placed on defining the 41-J (30 ft-lb), 68-J (50 ft-lb), and 0.89-mm (35 mil) lateral expansion index temperatures and the upper shelf energy.	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
9.2.3 Measurements - For each test specimen, measure the impact energy, lateral expansion, and percent shear fracture appearance. From the unirradiated and irradiated transition temperature curves determine the 41-J (30 ft-lb), 68-J (50 ft-lb), and 0.89 mm (35 mil) lateral expansion index temperatures and the upper shelf energy. The index temperatures and the upper shelf energy shall be determined from the average curves.	Compliance
9.2.3.1 Obtain from the material qualification test report the initial reference temperature (RT_{NDT}) as defined in ASME Code, Section III, Subarticle NB 230 for unirradiated materials.	Compliance
9.3 Hardness Tests (Optional) - Hardness tests may be performed on unirradiated and irradiated Charpy specimens. The measurements shall be taken in areas away from the fracture zone or the edges of the specimens. The tests shall be conducted in accordance with Methods A 370.	Compliance
9.4 Supplemental Tests (Optional) - If supplemental fracture toughness tests are conducted (in addition to tests conducted on tension and Charpy specimens as described in 6.1) the test procedures shall be documented.	Not Applicable

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
9.5 Calibration of Equipment - Procedures shall be employed assuring that tools, gages, recording instruments, and other measuring and testing devices are calibrated and properly adjusted periodically to maintain accuracy within necessary limits. Whenever possible calibration shall be conducted with standards traceable to the National Bureau of Standards. Calibration status shall be maintained in records traceable to the equipment.	Compliance
10.1 Tension Test Data: 10.1.1 Determine the amount of radiation strengthening by comparing unirradiated test results with irradiated test results at the temperature specified in 9.1.2. 10.1.2 The tensile strength data can be verified using the results from the hardness test (optional) described in 9.3.	Compliance
10.2 Charpy Test Data: 10.2.1 Determine the radiation induced transition temperature shifts by measuring the difference in the 41-J (30 ft-lb), 68-J (50 ft-lb), and 0.89 mm (35 mil) lateral expansion index temperatures before and after irradiation. The index temperatures shall be obtained from the average curves.	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
10.2.2 Determine the adjusted reference temperature by adding the shift corresponding to the 41-J (30 ft-lb) index determined in 10.2.1 to the initial reference temperature obtained in 9.2.3.1.	Compliance
10.2.3 Determine the radiation induced change in the upper shelf energy (USE) from the measurements made before and after irradiation using average value curves.	Compliance
10.2.4 (Optional) - Determine the radiation induced change in temperature corresponding to 50% of the upper shelf energy before and after irradiation from average value curves.	Not Applicable
10.3 Supplemental Test Data (Optional) - If additional, supplemental tests are performed (9.4), the data shall be recorded to supplement the information from the tensile and Charpy tests.	Not Applicable
10.4 Retention of Test Specimens - It is recommended that all broken test specimens be retained until released by the owner in the event that additional analyses are required to explain anomalous results.	Compliance
11.1 Where applicable, both SI units and conventional units shall be reported.	

Summary of Requirements per ASTM E185-82	**San Onofre Unit 2 Program**
11.2 Surveillance Program Description - Description of the reactor vessel including the following:	Compliance
11.2.1 Location of the surveillance capsules with respect to the reactor vessel, reactor vessel internals, and the reactor core.	
11.2.2 Location in the vessel of the plates or forgings and the welds.	
11.2.3 Location(s) of the peak vessel fluence.	
11.2.4 Lead factors between the specimen fluence and the peak vessel fluence at the I.D. and the 1/4T locations.	
11.2.5 Surveillance Material Selection:	Compliance
11.2.5.1 Description of all beltline materials including chemical analysis, fabrication history, Charpy data, tensile data, drop-weight data, and initial RT_{NDT}.	
11.2.5.2 Describe the basis for selection of surveillance materials.	

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
11.3 Surveillance Material Characterization:	Compliance
11.3.1 Description of the surveillance material including fabrication history, material source (heat or lot), and any differences between the surveillance material history and that of the reactor vessel material history.	
11.3.2 Location and orientation of the test specimens in the parent material.	
------------------	------------------
11.3.3 Test Specimen Design:	Compliance
11.3.3.1 Description of the test specimens (tension, Charpy, and any other types of specimens used), neutron dosimeters, and temperature monitors.	
11.3.3.2 Certification of calibration of all equipment and instruments used in conducting the tests.	

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
11.4.1 Tension Tests:	Compliance
11.4.1.1 Trade name and model of the testing machine, gripping devices, extensometer, and recording devices used in the test.	
11.4.1.2 Speed of testing and method of measuring the controlling testing speed.	
11.4.1.3 Complete stress-strain curve (if a group of specimens exhibits similar stress-strain curves, a typical curve may be reported for the group).	
11.4.1.4 Test Data from each specimen as follows: (1) Test temperature; (2) Yield strength or yield point and method of measurement; (3) Tensile strength; (4) Fracture load, fracture strength, and fracture stress; (5) Uniform elongation and method of measurement; (6) Total elongation; (7) Reduction of area; and (8) Specimen identification.	

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
11.4.2 Charpy Tests:	Compliance
11.4.2.1 Trade name and model of the testing machine, available hammer energy capacity and striking velocity, temperature conditioning and measuring devices, and a description of the procedure used in the inspection and calibration of the testing machine.	
11.4.2.2 Test data from each specimen as follows: (1) Temperature of test; (2) Energy absorbed by the specimen in breaking, reported in joules (and foot-pound-force); (3) Fracture appearance; (4) Lateral expansion; and (5) Specimen identification.	
11.4.2.3 Test data for each material as follows: (1) Charpy 41-J (30 ft-lb), 68-J (50 ft-lb), and 0.89 mm (35 mil) lateral expansion index temperature of unirradiated material and of each set of irradiated specimens, along with the corresponding temperature increases for these specimens; (2) Upper shelf energy (USE) absorbed before and after irradiation; (3) Initial reference temperature; and (4) Adjusted reference temperature.	
------------------	------------------
11.4.3 Hardness Tests (Optional):	Compliance
11.4.3.1 Trade name and model of the testing machine.	
11.4.3.2 Hardness data.	

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
11.4.4 Other Fracture Toughness Tests: 11.4.4.1 If additional tests are performed, the test data shall be reported together with the procedure used for conducting the tests and analysis of the data.	Not Applicable
------------------	------------------
11.4.5 Temperature and Neutron Radiation Environment Measurements: 11.4.5.1 Temperature monitor results and an estimate of maximum capsule exposure temperature. 11.4.5.2 Neutron dosimeter measurements, analysis techniques, and calculated results including the following: (1) Neutron flux density, neutron energy spectrum, and neutron fluence in terms of neutrons per square metre and neutrons per square centimetre (>0.1 and 1 MeV) for the surveillance specimens using both calculated spectrum and assumed fission spectrum assumptions. (2) Description of the methods used to verify the procedures including calibrations, cross sections, and other pertinent nuclear data.	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 2 Program
11.5 Application of Test Results:	Compliance
11.5.1 Extrapolation of the neutron flux and fluence results to the surface and 1/4T locations of the reactor vessel at the peak fluence location.	
11.5.2 Comparison of fluence determined from dosimetry analysis with original predicted values.	
11.5.3 Extrapolation of fracture toughness properties to the surface and 1/4T locations of the reactor vessel at the peak fluence location.	
------------------	------------------
11.6 Deviations - Deviations or anomalies in procedure from this practice shall be identified and described fully in the report.	Compliance
------------------	------------------
END	**END**

APPENDIX B

SONGS UNIT 2: BASES FOR PLATE CHEMISTRY MEASUREMENTS

ABB

June 8, 1992
S-MECH-92-050

Mr. Steve Gosselin
Southern California Edison
23 Parker Street
Irvine, CA 92718

SUBJECT: VESSEL PLATE CHEMICAL ANALYSIS SOURCES

Dear Mr. Gosselin:

The purpose of this letter is to provide background information pertaining to beltline material chemistry data for the plates which were used in the fabrication of the SONGS Units 2 and 3 reactor vessel. Recently, differences were noted in the chemical analysis results reported for the SONGS 2 and 3 reactor vessel beltline plates. A review has been performed which identified that these differences arose from the fact that different source information was used. The source information is noted below:

SONGS 2

"CMTR" - Lukens Steel Mill analysis
"FSAR" and "CEN-189" - Chattanooga analyses dated 3/20/70 and 11/26/73

SONGS 3

"CMTR" - Lukens Steel Mill analysis
"FSAR" - Chattanooga analysis dated 1/25/74 and 3/20/74
"CEN-189" - RPV surveillance program Chattanooga analyses dated 7/16/75 and 5/4/78

In order to respond to the plate chemistry questions of NRC Generic Letter 92-01, pertinent background information is provided followed by a specific recommendation.

First, the Lukens chemical analysis data was provided with the CMTR for information only, whereas Chattanooga analyses were used as the basis for licensing transmittals. This was done as a matter of C-E practice to maintain consistency of results. (Lukens used both different equipment and analysis standards, which could yield different reported chemical contents than the Chattanooga laboratory.)

Secondly, for both SONGS Unit 2 and 3, chemical analyses were required by both the C-E reactor pressure vessel specification and C-E surveillance program specification. Since these analyses were performed in two separate instances by the Chattanooga facility on the same material, it is ABB C-E's position that the average of these two analyses would be most representative of the plate chemical content. (Note: For both units, the "CE Analysis" value is an average of the chemical contents aquired in accordance with the vessel and surveillance program specification.)

Therefore, the recommended chemical composition for both SONGS vessels is the average of the two Chattanooga chemical analyses, provided in Table 1, and titled "CE Analysis".

Should there be any additional questions, please do not hesitate to contact me at (203) 285-3469.

Sincerely,

COMBUSTION ENGINEERING, INC.

Craig D. Stewart for

S. T. Byrne
Supervisor, Reactor Vessel Integrity

STB/CDS:cds

cc: D. Pilmer (SCE)
B. Chang
W. Gahwiller
C. Stewart
M. Wade

STB060.WP

TABLE 1

U23 RV BELTLINE REGION PLATE COPPER AND NICKEL CONTENT				
Plate No.	Cu Content (wt %)		Ni Content (wt %)	
	CMTR	CE Analysis	CMTR	CE Analysis
Unit 2				
C-6404-1	0.11	0.10	0.51	0.56
C-6404-2	0.12	0.10	0.61	0.59
C-6404-3	0.12	0.10	0.62	0.56
C-6404-4	0.12	0.10	0.63	0.62
C-6404-5	0.12	0.11	0.63	0.64
C-6404-6	0.12	0.10	0.54	0.58
Unit 3				
C-6802-1	0.06	0.06	0.58	0.58
C-6802-2	0.04	0.04	0.58	0.57
C-6802-3	0.06	0.06	0.57	0.58
C-6802-4	0.05	0.05	0.58	0.56
C-6802-5	0.04	0.04	0.52	0.55
C-6802-6	0.06	0.06	0.65	0.62

COMBUSTION DIVISION

Mr. S. R. Moss

Analyses of Core Region Plates
To Specification 00000-PE-110
Job No. A-98006
Contract 71170
Project No. 960001

Metallurgical R & D
Department
Chattanooga

Mr. R. E. Lorentz, Jr.
Mr. R. D. Bradford
Mr. H. N. Dinwiddie
Mr. P. C. Kiefer
Mr. S. R. Lewis

March 20, 1974

Material was purchased from Lukens Steel on our P. O. Number 40-82066 to SA-533, Grade B, Class I and to C. E. Purchase Specification P3F12(d). The three intermediate shell plates were purchased to specified size of 220-3/4" x 109-5/16" x 9-11/16".

The following information is relative to purchased material:

Lab No.	Heat No.	Item Code No.	Piece No.
P14445	C-7596-1	C-6404-1	215-03
P14446	C-7595-2	C-6404-2	215-03
P14447	C-7595-1	C-6404-3	215-03

Analytical samples were obtained at 1/4T below ID surface. Table I shows chemistry of submitted samples.

J. A. Kosik

JAK:mc

attachment

TABLE I

Chemistry of submitted Plates

	C.1414-1	C.6414-2	C.1414-3
	Lab No. P14445	Lab No. P14446	Lab No. P14447
Si	.20	.26	.27
Sul	.010	.011	.011
P	.009	.010	.009
Mn	1.33	1.39	1.40
C	.22	.20	.22
Cr	.15	.16	.15
Ni	.55	.58	.53
Mo	.57	.62	.63
B	.0001	.0002	.0002
Cb	<.01	<.01	<.01
Ti	<.01	<.01	<.01
Co	.012	.012	.011
Cu	.10	.10	.10
Al	.049	.046	.054
N_2	.009	.007	.006
V	.006	.005	.005
W	<.01	<.01	<.01
As	.013	.013	.012
Sn	.006	.006	.005
Zr	.001	.001	.001

Intermediate Shell Plates

COMBUSTION DIVISION

Mr. Bill Moss

Material Certification
Customer Requirement
Job No. A-98006
Contract No. 71170
Project No. 960001

Metallurgical R & D
Department
Chattanooga

cc: Mr. R. E. Lorentz, Jr.
Mr. S. R. Lewis
Mr. R. D. Bradford
Mr. H. N. Dinwiddie
Mr. P. C. Kiefer

S.T.B. FEB 2 4 1976

November 26, 1973

Lower shell material for the core region was purchased from Lukens Steel on our P. O. No. 40-82066 to ASME SA-533, Grade B, Class I Specification and to C. E. I. Purchase Specification P3F12(d).

Data relative to the purchased plates:

Lab No.	Heat No.	Item Code	Piece No.
P-14068	C-7585-1	C-6404-5	215-02
P-14105	A-6735-1	C-6404-4	215-02
P-14106	C-7596-2	C-6404-6	215-02

The above plates were purchased to size 9-11/16" x 109-5/16" x 220-3/4". Analytical sample was obtained from a location of 2" below ID surface of the plate thickness. Chemistry of above material is shown in Table I.

J. A. Kosik

JAK:mc

attachment

TABLE I

	C-6404-5 Lab No. P14068	C-6404-4 Lab No. P14105	C-6404-6 Lab No. P14106
Si	.22	.25	.21
Sul	.008	.009	.011
Phos	.006	.006	.007
Mn	1.27	1.43	1.38
Car	.20	.24	.20
Cr	.20	.09	.15
Ni	.62	.60	.57
Mo	.57	.59	.59
B	.0001	.0002	.0002
Cb	<.01	<.01	<.01
V	.003	.003	.004
Co	.016	.016	.015
Cu	.11	.09	.10
Al	.046	.037	.027
N2	.007	.010	.008
Ti	<.01	<.01	<.01
W	<.01	<.01	<.01
As	.005	.006	.010
Sn	.004	.005	.005
Zr	.001	.001	.001

[illegible]

- CheH. Chemistry for Interm. Shell (Surv.) & Surv. Weld

J.J.K. DEC 0 3 1976

Interoffice Correspondence

POWER SYSTEMS

S.T.B. DEC 0 8 1976

TO: A. D. Emery

cc: R. W. DeVane
D. B. Grogan
J. J. Koziol
R. G. Williams

SCE II
Reactor Vessel
Core Region Chemistry

Design Engineering

DRV-76-1405

November 30, 1976

KC
SMS
STB

The attached analyses (2 sheets), W. A. House to R. Dion Bradford, dated November 19, 1976 represent the chemical compositions of surveillance material of Codes C-6404-1, C-6404-2 and C-6404-3 and their weld seams. The only SCE II analyses not yet submitted are those of surveillance material for Codes C-6404-4, C-6404-5 and C-6404-6.

Dion Bradford
Dion Bradford

RDB/dl

Interoffice Correspondence

POWER SYSTEMS

R. Dion Bradford

Subject

Surveillance Program Analysis
Southern California Edison II
Contract No. 71170
Job No. B-38069
Project No. 960001

From

Metallurgical & Materials
Laboratory - Chattanooga

November 19, 1976

Chemical Analysis

Lab No.	P16921	P16922	P16923
Shell	Intermediate	Intermediate	Intermediate
Code	C6404-1	C6404-2	C6404-3
Heat	C7596-1	C7595-2	C7595-1
Car	0.23	0.23	0.25
Mn	1.38	1.43	1.45
P	0.004	0.005	0.006
S	0.008	0.009	0.010
Si	0.21	0.26	0.27
Ni	0.58	0.60	0.60
Cr	0.18	0.18	0.17
Mo	0.52	0.58	0.58
V	0.004	0.003	0.003
Cb	<.01	<.01	<.01
Ti	<.01	<.01	<.01
Co	0.013	0.012	0.012
Cu	0.10	0.10	0.10
Al Sol	0.026	0.033	0.032
Al Ins	0.002	0.001	0.001
Al Total	0.028	0.034	0.033
B	<.001	<.001	<.001
W	<.01	<.01	<.01
As	0.002	0.001	0.002
Sn	0.004	0.003	0.004
Zr	<.001	<.001	<.001
Pb	<.001	<.001	<.001
Sb	0.0025	0.0025	0.0025
N	0.007	0.005	0.005

W. A. House

W. A. House

WAH/sh

Interoffice Correspondence

POWER SYSTEMS

J.J.K. JUL 2 0 1977

S.T.B. JUL 2 5 1977

To: Mr. J. J. Koziol ✓

cc: Mr. D. B. Grogan

Contract 71170
Surveillance Program
Plate Chemistry

Design Engineering

DRV-77-831

July 18, 1977

XC
SMS
S-TV
ADE

Attachment (1): Memo, W. A. House to D. Bradford, dated 3/14/77.

Attachment (2): Memo, W. A. House to D. Bradford, dated 6/08/77.

The chemical analyses given by Attachments (1) and (2) are from the lower shell plates. This completes all contract chemistry requirements except for data from a special weldment which will supplement the surveillance program. That data will be forwarded when the weldment is completed.

Bill R. Moss
B. R. Moss

BRM:mo

Interoffice Correspondence

POWER SYSTEMS

To	Subject	From
To: D. Bradford cc: Elaine White	Surveillance Program Analysis Contract No. 71170 Job No. B-38069 Project No. 960001	Metallurgical & Materia Laboratory - Chattanoog June 8, 1977

Description: Plate Code C-6404-5
Heat No. C-7585-1
Lab No. P-17405

Analysis:

~~A~~ C	0.21	Co	0.014
Mn	1.33	Cu	0.11
P	0.008	Al	0.041
S	0.011	B	< .001
Si	0.24	W	< .01
Ni	0.67	Sb	0.0016
Cr	0.25	As	0.003
Mo	0.57	Sn	0.007
V	0.003	Zr	< .001
Cb	< .01	Pb	< .001
Ti	< .01	N2	0.009

W A House
W. A. House

WAH/sh

POWER SYSTEMS

To	Subject	From - Date
D. G. Binegar R. E. Lorentz, Jr. S. R. Lewis N. Wamack S. A. Lewis	Welding Material Certification To Requirements of ASME Section III Job Number K-32255 Project Number 960009	Metallurgical & Materials Laboratory Chattanooga April 8, 1975

Weld Seam 9-203
SoCal 2

The following test data is for 3/16" diameter bare wire, Type Lo-Co-Phos, Heat No. 90130, Flux Type 0091, Lot No. 0842 (Test No. 1389).

A weld deposit was made using the above heat of wire and lot of flux. Welding was done in accordace with SAA-SMA-12.12-102. The completed weldment was given a post weld heat treatment of 1150°F for 40 hours and furnace cooled to 600°F.

IMPACT AND/OR FRACTURE TESTS									
TYPE	TEMP. °F	VALUES			TEMP. °F	VALUES			NDT
CVN		Ft/Lbs	%Shear	MilsLatExp		Drop Weight			
	-60	16	0	9	-60	1 F			-60°F
	-60	15	0	7	-50	2 NF			
	-60	19	0	11	-40	1 NF			
	-40	20	5	11					
	-40	28	10	16					
	-40	32	15	22					
	-20	85	50	53	+60	132	80	77	
	-20	88	50	56	+60	149	100	84	
	-20	76	40	47	+60	123	80	74	
	0	77	40	47	+100	142	100	82	
	0	75	40	45	+100	148	100	84	
	0	99	60	52	+100	140	100	82	
	+20	117	70	74					
	+20	105	60	65					
	+20	114	70	74					

ALL WELD METAL .505 TENSILE

Lab Code	Yield Strength ksi	Ultimate Tensile Strength ksi	Elongation in 2"%	Reduction of Area %
10	78.4	91.5	27.0	70.0

J. M. Arnold

JMA:gb

D3.2

Interoffice Correspondence

POWER SYSTEMS

To: Dion Bradford

cc: Peggy Webb

Subject

Surveillance Test
Project No. 960001
Job No. B-38069
Contract No. 71170

From

Metallurgical & Materi
Laboratory - Chattanoo

March 14, 1977

Description: Southern California Edison II, 9-11/16" Lukens Plate

Analysis:

Lab No.	P-17110 (Ref. P-14105)	P-17111 (Ref. P-14106)
Heat No.	C-6735-1	C-7596-2
Code No.	C-6404-4	C-6404-6
C	0.25	0.21
Mn	1.47	1.37
P	0.006	0.005
S	0.008	0.009
Si	0.25	0.20
Ni	0.63	0.58
Cr	0.12	0.19
Mo	0.57	0.53
V	0.003	0.003
Cb	<.01	<.01
Ti	<.01	<.01
Co	0.013	0.011
Cu	0.10	0.10
Al	0.036	0.026
B	<.001	<.001
W	<.01	<.01
Sb	0.0025	0.0022
As	0.002	0.002
Sn	0.006	0.005
Zr	<.001	<.001
Pb	<.001	<.001
N2	0.011	0.009

W. A. House

W. A. House

WAH/sh

APPENDIX C

SONGS UNIT 2: BASES FOR WELD CHEMISTRY MEASUREMENTS

Chatt Chemistry For Beltline Welds

Interoffice Correspondence

POWER SYSTEMS

S.T.B. APR 13 1976

XC SMS STL EC

TO: J. J. Koziol

cc: D. B. Grogan
R. W. DeVane
R. G. Williams

SCE II
Reactor Vessel
Core Region Chemistry

Design Engineering

DRV-76-434

April 6, 1976

Results are attached of the core region as-deposited weld and chemical analyses required by General Specification No. 00000-PE-110.

Seam No.	Seam	Plate Codes
2-203A	Intermediate Long.	C-6404-2 to -3
B	Intermediate Long.	C-6404-1 to -2
C	Intermediate Long.	C-6404-1 to -3
9-203	Closing Girth	C-6404-1, -2, -3 to C-6404-4, -5, -
3-203A	Lower Long.	C-6404-4 to -6
B	Lower Long.	C-6404-5 to -6
C	Lower Long.	C-6404-4 to -5

R. D. Bradford
R. D. Bradford

RDB/dl

Lab No.	D-18153	D-18154	D-18155	D-23227	D-17025	D-17026	D-170
Seam No.	2-203A	2-203B	2-203C	9-203	3-203A	3-203B	3-203
Mn	.84	.91	.88	1.34	1.27	1.17	1.33
Cr	<.01	<.01	<.01	.15	.05	.05	.06
Ni	.90	.91	.95	.29	.12	.06	.11
Mo	.23	.24	.25	.58	.52	.39	.54
Cb	<.01	.01	<.01	.01	<.01	<.01	<.01
Cu	.03	.03	.03	.07	.05	.04	.06
Phos	.009	.009	.010	.009	.011	.010	.010
Car	.065	.077	.074	.17	.14	.17	.18
Co	.014	.017	.015	.016	.009	.007	.009
Si	.32	.36	.36	.20	.13	.10	.12
Sul	.017	.016	.016	.007	.011	.011	.011
B	.0005	.0005	.0005	<.001	.0004	.0004	.0004
Ti	.01	.02	.01	<.01	<.01	<.01	<.01
Al	.001	.003	.002	.017	.004	.002	.004
N2	.017	.010	.008	.040	.008	.006	.005
V	.007	.008	.008	.006	.006	.004	.006
W	.01	.01	.01	.02	.01	.01	.01
As	.012	.012	.011	.007	.013	.011	.014
Sn	.005	.005	.005	.004	.007	.005	.006
Zr	.002	.003	.003	<.001	.002	.002	.002
Pb	ND	ND	ND	<.001	ND	ND	ND

- Chatt. Chemistry for Interm. Shell (Surv.) & Surv. Weld

J.J.K. DEC 0 3 1976

Interoffice Correspondence

POWER SYSTEMS

S.T.B. DEC 0 8 1976

TO: A. D. Emery

cc: R. W. DeVane
D. B. Grogan
J. J. Koziol
R. G. Williams

SCE II
Reactor Vessel
Core Region Chemistry

Design Engineering

DRV-76-1405

November 30, 1976

KC
SMS
STB

The attached analyses (2 sheets), W. A. House to R. Dion Bradford, dated November 19, 1976 represent the chemical compositions of surveillance material of Codes C-6404-1, C-6404-2 and C-6404-3 and their weld seams. The only SCE II analyses not yet submitted are those of surveillance material for Codes C-6404-4, C-6404-5 and C-6404-6.

Dion Bradford

Dion Bradford

RDB/dl

Lab No.	D26761	D26762
Seam	2-236A	2-236B
Plates Codes	C6404-1 & 3	C6404-2 & 3
Car	0.17	0.17
Mn	1.34	1.38
P	0.003	0.004
S	0.009	0.009
Si	0.21	0.22
Ni	0.12	0.07
Cr	0.09	0.10
Mo	0.52	0.54
V	0.005	0.005
Cb	<.01	<.01
Ti	<.01	<.01
Co	0.012	0.019
Cu	0.03	0.04
Al Sol	0.010	0.009
Al Ins	0.002	0.009
Al Total	0.012	0.012
B	<.001	<.001
W	<.01	<.01
As	<.001	0.003
Sn	0.001	0.002
Zr	<.001	<.001
Pb	<.001	<.001
Sb	0.0013	-0.0014
N	0.004	0.005

W. A. House

W. A. House

WAH/sh

DATE 6-8-71

METALLURGICAL RESEARCH AND DEVELOPMENT

TO: NUCLEAR WELDING APPLICATIONS SECTION

ATTENTION: Larry [illegible]

CC: J.A. [illegible], Ron Lee, Paul Kiefer

JOB NUMBER 5 32255

CHEMICAL ANALYSIS OF WIRE-FLUX TEST WELD COUPON

SAMPLE NO.	8.6
LAB NO.	D10600
TYPE WIRE	B-4
SIZE WIRE	3/16"
HEAT NO.	10137
FLUX	0091
LOT NO.	3999
SI	.14
S	.010
P	.016
MN	1.13
C	.20
MO	.47
CU	.23
NI	

Don Bruce

DATE 3-22-71

METALLURGICAL RESEARCH AND DEVELOPMENT

TO: NUCLEAR WELDING APPLICATIONS SECTION

ATTENTION: LARRY ROSE

CC: J.A. Kosik, DAVID HUMBLE, Paul Kiefer

JOB NUMBER B 32255

INFO

CHEMICAL ANALYSIS OF WIRE-FLUX TEST WELD COUPON

SAMPLE NO.	764
LAB NO.	B10255
TYPE WIRE	B-4
SIZE WIRE	3/16"
HEAT NO.	90136
FLUX	0091
LOT NO.	3999
SI	.16
S	.010
P	.012
MN	1.00
C	.11
MO	.47
CU	.31
NI	

Al Nation

APPENDIX D

SONGS UNIT 2: WMCs FOR BELTLINE MATERIALS

COMBUSTION DIVISION

Nuclear Manufacturing Superintendent
Nuclear Welding Applications
Bay 29 Rod Room
Inventory Control
Welding Inspection
~~Rod Room (Met. Lab. Section)~~
~~B&AP Inspection~~

Welding Material Certification and Release for Section III

Nuclear Quality Engineering

FEBRUARY 22, 1973

The following welding material has been tested in accordance with the requirements of SOP #100-23.31 and meets the requirements of the latest Addenda to Section III of the ASME Code and is released for use on ASME Code work only:

I. Coated Electrodes (MA)

TYPE	SIZE	HEAT #	LOT #	CONTROL #	BRAND

II. Bare Electrodes (GTA & GMA)

TYPE	SIZE	HEAT #	BRAND

III. Flux Electrode Combination (SAA)

TYPE ELECTRODE		SIZE	HEAT #	TYPE FLUX	LOT #
B-4 *	PAGE	3/16"ϕ	83640	LINDE 0091	1122
B-4 *	PAGE	3/16"ϕ	83637	}	}
B-4 *	PAGE	3/16"ϕ	83650		

PCK/ft

Q1.49

* LOW COPPER PHOS

SINGLE ARC

[signature]

CORRESPONDENCE

COMBUSTION DIVISION

	Subject	From - Date
Mr. P. C. Kiefer Mr. R. Jay Mr. S. A. Lewis Mr. S. R. Lewis Mr. R. E. Lorentz, Jr. Mr. G. Porter Mr. R. E. Smith	Welding Material Qualification to Requirements of ASME Section III Job Number D-32255 Project Number 960009	Metallurgical Research and Development Department Chattanooga February 8, 1973

Weld 3-203

PAGE

The following test data is for 3/16" diameter bare wire, type low Cu-Phos., Heat No. 83637, Flux Type 0091, Lot No. 1122.

A weld deposit was made using the above heat of wire and lot of flux. Welding was done in accordance with C-E Welding Procedure Specification SA-33-34. The completed weldment was given a post weld heat treatment of 1150°F ± 25°F for 40 hours and furnace cooled to 600°F.

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft./Lbs.	VALUES Mils Lat.Exp.	TEMP. °F	VALUES Drop Weights	NDT
CVN	+10	153	85	-50	1 F	
	+10	131	81	-40	2 NF	
	+10	125	77			-50°F

OK

ALL WELD METAL .505 TENSILE

Lab Code	Yield Strength KSI	Ultimate Tensile Strength, KSI	Elongation in 2", %	Reduction of Area, %
I	77.2	89.1	29.5	73.1

[signature]

DATE 1-22-73

METALLURGICAL RE[illegible]ARCH AND DEVELOPMEN[illegible]

TO: NUCLEAR WELDING APPLICATIONS SECTION

ATTENTION: GLENN PORTER

CC: RALPH JAY, PAUL KIEFER

JOB NUMBER D32255

CHEMICAL ANALYSIS OF WIRE-FLUX TEST WELD COUPON

SAMPLE NO.	1059	1060				
LAB NO.	D14054	D14055				
TYPE WIRE	Low Cu-Phos	Low Cu-Phos				
SIZE WIRE	3/16"	3/16"				
[illegible]T NO.	PAGE 83637	PAGE 83650				
FLUX	0091	0091				
LOT NO.	1122	1122				
SI	.15	.15				
S	.007 ✓	.010 ✓				
P	.006 ✓	.006 ✓				
MN	1.32	1.24				
C	.16	.15				
MO	.62	.61				
CU	.04 ✓	.05 ✓				
V	.007 ✓	.006 ✓				

Al Nation

INTER-OFFICE CORRESPONDENCE

POWER SYSTEMS

Nuclear Manufacturing Superintendent
Nuclear Welding Applications
Bay 29 Rod Room
Welding Material Control (c/o R. N. Fry)
Welding Inspection
~~Rod Room (Met Lab Section)~~

Nuclear Quality Assurance

4-14-75

WELDING MATERIAL CERTIFICATION
AND RELEASE FOR A.S.M.E.
Section III

The following welding material has been tested in accordance with the requirements of SOP #100-23.31 and meets the requirements of the latest Addenda to Section III of the ASME Code and is released for use on ASME Code work only:

I. Coated Electrodes (MA)

TYPE	SIZE	HEAT #	LOT #	CONTROL #	BRAND

II. Bare Electrodes (GTA & GMA)

TYPE	SIZE	HEAT #	BRAND

III. Flux Electrode Combination (SAA)

TYPE ELECTRODE	SIZE	HEAT #	TYPE FLUX	LOT #
B-4 LoCu LoPhos	3/16	90130	0091	0842

D. G. Binegar
D. G. Binegar

D 3.2

DGB/ap

A.S.M.E.
Section III

(G207)

DATE 3-25-75

METALLURGICAL RESEARCH AND DEVELOPMENT

... Turner, Don Binegar

... NUMBER K32255

CHEMICAL ANALYSIS OF WIRE-FLUX TEST WELD SAMPLE

SAMPLE NO.	1389				
LAB NO.	D19895				
TYPE WIRE	Low Cu-Phos				
SIZE WIRE	3/16"				
HEAT NO.	70130				
FLUX	0091				
LOT NO.	0842				
SI	.18				
S	.010				
P	.006				
MN	1.15				
C	.16				
CR	.05				
NI	.04				
MO	.50				
CB/TA					
TI					
CO					
CU	.04				
V	.006				
N_2					
FE					

[illegible] B.2

DATE 3-13-75

REQUEST FORM
NCM QUALITY ASSURANCE

TO: WAYNE TURNER, DON BINEGAR

JOB NO.: E32255

WET CHEMICAL ANALYSIS OF WIRE SAMPLE

R No.			3780	
Type Mat'l.	Lo Cu – Lo Phos – B 4			
Size			3/16	
Heat			90130	
Si			.06	
S			.010	
P			.007	
Mn			2.04	
C			.18	
Cr			.09	
Ni			.06	
Mo			.57	
Cb/Ta				
Ti				
Co				
Cu			.04	
V			.007	
N2				
Fe				
AL			.030	

DB.2

J. H. McMinn

Mr. Keith Reeser
Southern California Edison Company
Irvine Operations Center
23 Parker Street, MD 345
Irvine, CA 92718

November 4, 1993
S-MECH-93-062

Subject: **Material Information for SONGS 2 and 3 Reactor Vessel Welds**

References: 1) ABB/CE Letter No. S-MECH-93-049, "Proposal No. 93-241-C1A; Additional Reactor Vessel Material Information for SONGS 2 & 3", C. Gimbrone, dated September 8, 1993.

2) ABB/CE Letter No. S-MECH-93-059, "Weld Fabrication Records for SONGS Units 2 and 3", D. Walker, dated November 2, 1993.

Dear Mr. Reeser:

This letter provides weld wire heat numbers and flux types for the following welds as proposed in Reference 1:

1) The surveillance weld for SONGS Unit 2.
2) Welds 2-203 A, B, and C for the SONGS Unit 2 reactor vessel.
3) The surveillance weld for SONGS Unit 3.
4) Weld No. 8-203 for the SONGS Unit 3 reactor vessel.

The above information was researched using all of the available original fabrication records for these welds which were obtained from the Chattanooga facility (Ref. 2). The requested information is found in Table 1, and two major results of this effort are noted below:

1) The above welds consisted of either filler metal type Mil-B4 or E8018 electrodes as noted under "Filler Metal".

2) It was determined that repairs were made to welds 2-203A and 8-203. Information regarding the consumables for the repair welds is included in Table 1. However, an investigation regarding the extent of these weld repairs was not within the scope of this effort.

ABB Combustion Engineering Nuclear Power

Combustion Engineering, Inc.
P.O. Box 500
1000 Prospect Hill Road
Windsor, Connecticut 0695-0500
Telephone (203) 688-1911
Fax (230) 285-9512

Table 1 - Weld Consumables for SONGS 2 and 3 Reactor Vessel Welds

Vessel	Weld	Filler metal	Heat No.	Flux type	Lot No.
SONGS Unit 2	surveillance	[Mil-B4]	90130	Linde 0091	0842
		[E8018]	AA0HP	--	--
	2-203 A,B,C	[E8018]	BOLA	--	--
	2-203 A (repair)	[E8018]	EOBC	--	--
SONGS Unit 3	surveillance	[Mil-B4]	90069	Linde 124	0951
	8-203	[Mil-B4]	88118	Linde 0091	0145
		[E8018]	HAAID	--	--
	8-203 (repair)	[E8018]	GABFE and FAOJE	--	--

This effort was performed in accordance with the CE Nuclear Services Quality Assurance Manual for Quality Class 1 work. The contents of this report have been reviewed to insure the accuracy of its contents. If you should have any questions regarding this report, please contact me at (203)-285-5911 or Mr. Craig Stewart at (203)-285-2294.

Sincerely,
Combustion Engineering, Inc.

Daniel Walker
Staff Engineer

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of:

X Design Review using Checklist(s) #9 of QAM-101.
___ Alternate Analysis - Copy attached.
___ Verification Testing - Test Report No. ______

Woodilla D.J. 10/nov/15
Independent Reviewer: Name/Signature/Date

Table 1 - Weld Consumables for SONGS 2 and 3 Reactor Vessel Welds

Vessel	Weld	Filler metal	Heat No.	Flux type	Lot No.
SONGS Unit 2	surveillance	Mil-B4	90130	Linde 0091	0842
	2-203 A,B,C	E8018	BOLA	--	--
	2-203 A (repair)	E8018	EOBC	--	--
SONGS Unit 3	surveillance	Mil-B4	90069	Linde 124	0951
	8-203	Mil-B4	88118	Linde 0091	0145
	8-203 (repair)	E8018	GABFE and FAOJE	--	--

This effort was performed in accordance with the CE Nuclear Services Quality Assurance Manual for Quality Class 1 work. The contents of this report have been reviewed to insure the accuracy of its contents. If you should have any questions regarding this report, please contact me at (203)-285-5911 or Mr. Craig Stewart at (203)-285-2294.

Sincerely,
Combustion Engineering, Inc.

Daniel Walker
Staff Engineer

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of:

✓ Design Review using Checklist(s) # 9 of QAM-101.
___ Alternate Analysis - Copy attached.
___ Verification Testing - Test Report No. ____

Woodilla, D.J. [signature] 10/Nov/93
Independent Reviewer: Name/Signature/Date

COMBUSTION DIVISION

To	Subject	From - Date
Mr. P. C. Kiefer cc: Mr. R. Jay Mr. S. A. Lewis Mr. S. R. Lewis Mr. R. E. Lorentz, Jr. Mr. G. Porter Mr. R. E. Smith	Welding Material Qualification to Requirements of ASME Section III Job Number E-32255 Project Number 960009	Metallurgical Research and Development Department Chattanooga April 26, 1973

The following test data is for 1/4" Electrode, Type 8018, Lot No. BOLA.

A weld deposit was made using the above lot of electrodes. Welding was done in accordance with C-E Welding Procedure Specification MA-33B4. The completed weldment was given a post weld heat treatment of 1150°F ± 25°F for 40 Hours and furnace cooled to 600°F.

IMPACT AND/OR FRACTURE TESTS						
TYPE	TEMP. °F	VALUES		TEMP. °F	VALUES	NDT
CVN		FT/Lb	MilsLatExp.		Drop Weight	
	+10	106	66	-60	1 F	
	+10	108	72	-50	2 NF	
	+10	105	71	-40	1 NF	-60°F
	0	82	58	-20	1 NF	
	0	101	70			
	0	108	75			

ALL WELD METAL .505 TENSILE

Lab Code	Yield Strength KSI	Ultimate Tensile Strength, KSI	Elongation in 2", %	Reduction of Area, %
FW	66.0	80.5	31.0	72.0

J. M. Arnold

COMBUSTION DIVISION

Mr. P. C. Kiefer

cc: Mr. R. E. Lorentz, Jr.
Mr. S. A. Lewis
Mr. S. R. Lewis
Mr. L. Rose
Mr. R. Bryant

Welding Material Qualification to Requirements of ASME Section III
B-32255
810556

Metallurgical Research a[nd] Development Department
Chattanooga

March 16, 1971

The following test data is for 1/4" diameter electrodes, type 8018, lot number BOLA.

A weld deposit was made using the above lot of electrodes. Welding was done in accordance with C-E Welding Procedure Specification MA-33B4. The completed weldment was given a post weld heat treatment of 1150°F ±25°F for 40 hours and furnace cooled to 600°F.

Charpy V-Notch Impacts

Test Code	Ft/Lbs. @ +10°F	Requirements
JD	69, 87, 74	30 Ft/Lbs @ + 10°F

ok

All Weld Metal .505 Tensile

Yield Strength KSI	Ultimate Tensile Strength, KSI	Elongation in 2", %	Reduction of Area, %
73.1	85.6	27.5	69.5

NUCLEAR
QUALITY ENGR.
MAR 17 1971
P. C. K.

J. M. Arnold
J. M. Arnold

JMA:sl

INTER-OFFICE CORRESPONDENCE

COMBUSTION DIVISION

Mr. P. C. Kiefer

cc: Mr. R. E. Lorentz, Jr.
Mr. S. A. Lewis
Mr. S. R. Lewis
Mr. L. Rose
Mr. R. Bryant

Welding Material Qualification
to Requirements of ASME
Section III
B-32255
810556

Metallurgical Research and
Development Department
Chattanooga

June 8, 1971

The following test data is for 3/16" diameter bare wire, type B-4, heat number 10137, flux type 0091, lot number 3999.

A weld deposit was made using the above heat of wire and lot of flux. Welding was done in accordance with C-E Welding Procedure Specification SAA-33-34. The completed weldment was given a post weld heat treatment of 1150°F ±25°F for 40 hours and furnace cooled to 600°F.

Charpy V-Notch Impacts

Test Code	Ft/Lbs. @ +10°F	Requirements
NZ	101, 108, 107	30 Ft/Lbs @ +10°F

All Weld Metal .505 Tensile

Yield Strength KSI	Ultimate Tensile Strength, KSI	Elongation in 2", %	Reduction of Area, %
73.9	87.2	28.5	71.1

J. M. Arnold

JMA:sl

INTER-OFFICE CORRESPONDENCE

C-E COMBUSTION DIVISION

Mr. P. C. Kiefer

cc: Mr. R. E. Lorentz, Jr.
Mr. S. A. Lewis
Mr. S. R. Lewis
Mr. L. Rose
Mr. D. Humble

Welding Material Qualification
to Requirements of ASME
Section III
B-32255
810556

Metallurgical Research and
Development Department
Chattanooga

March 23, 1971

The following test data is for 3/16" diameter bare wire, type B-4, heat number 90136, flux type 0091, lot number 3999.

A weld deposit was made using the above heat of wire and lot of flux. Welding was done in accordance with C-E Welding Procedure Specification SAA-33-34. SINGLE ARC The completed weldment was given a post weld heat treatment of 1150°F ±25°F for 40 hours and furnace cooled to 600°F.

Charpy V-Notch Impacts

Test Code	Ft/Lbs. @ +10°F	Requirements
JE	108, 112, 119	30 Ft./Lbs. @ + 10°F

All Weld Metal .505 Tensile

Yield Strength KSI	Ultimate Tensile Strength, KSI	Elongation in 2", %	Reduction of Area, %
67.9	81.1	30.0	73.4

W. O. Norman (signature)

W. O. Norman

WON:sl

APPENDIX E

SONGS UNIT 2: MCRs FOR BELTLINE MATERIALS

J. W. Rogers

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97986-001 BS

HEAT NO. C7596-1 CODE NO. C-6404-1

MATERIAL DESCRIPTION 220-3/4" x 109-5/16" x 9-11/16" Intermediate Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.21	1.30	.009	.013	.21	.51		.47		.11	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2"%	REDUCTION OF AREA %
EDT-A	.505	R. T.	66.5	86.5	25.0	61.6
EDT-B	.505	R. T.	65.9	86.3	26.0	65.6

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	Ft/Lbs	% Shear	Mils Lat. Exp.	TEMP. °F	VALUES	NDT
CVN Impacts	- 40	7	0	10			
	- 40	11	0	14			
	- 40	12	0	15			
	+ 10	56	30	38		Drop Weights	
	+ 10	60	30	42			
	+ 10	56	30	39	0	1 F	
	+ 40	39	25	36	+10	1 F	+10°F
	+ 40	68	35	54	+20	2 NF	
	+ 40	70	35	54			
	+110	105	60	74			
	+110	104	60	76			
	+110	117	80	83			
	+160	145	100	88			
	+160	134	90	84			
	+160	153	100	90			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(A) 1600°F ±25°F 4 hours. Water quenched.

(B) 1225°F ±25°F 4 hours.

(C) 1150°F ±25°F 40 hours. Furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4 T level and notched perpendicular to the plate surface.

The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: P. Webb (2)
S. R. Lewis
T. B. Burton
R. E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY (H. M. Arnold)

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MOSS.

MATERIALS CERTIFICATION REPORT

ERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

ENDOR Lukens Steel Company JOB NO. A-97986-028

HEAT NO. C7596-1 CODE NO. C-6404-1

MATERIAL DESCRIPTION 220-3/4" X 109-5/16" X 9-11/16" Intermediate Shell (Test Plate "

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.21	1.30	.009	.013	.21	.51		.47		.11	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2"%	REDUCTION OF AREA %
AY-TA	.505	R. T.	66.2	86.3	27.0	65.2
AY-TB	.505	R. T.	65.3	86.6	27.0	65.4

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES Drop Weights	NDT
Charpy Impacts	+30	46	25	34	-30	1 F	-30°F
	+30	37	15	26	-20	2 NF	
	+30	41	20	30	-10	1 NF	
	+80	58	30	43			
	+80	79	45	55			
	+80	64	35	47			
	+212	143	100	84			
	+212	147	100	86			
	+212	156	100	87			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.

(b) 1225°F ± 25°F 4 hours.

(c) 1150°F ±25 °F 40 hours furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a). and Shop Order A97986 Supplement No. 17.

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold

J.M. Arnold

DATE March 21, 1974

B. R. Moss

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT
MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3T12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97986-028

HEAT NO. C7596-1 CODE NO. C-6404-1

MATERIAL DESCRIPTION 220-3/4" X 109-5/16" X 9-11/16" Intermediate Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.21	1.30	.009	.013	.21	.51		.47		.11	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
AY-TA	.505	R. T.	66.2	86.3	27.0	65.2
AY-TB	.505	R. T.	65.3	86.6	27.0	65.4

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES			NDT
Charpy Impacts						Drop Weights			
	-40	10	0	5	-30	1 F			-30°F
	-40	9	0	4	-20	2 NF			
	-40	7	0	3	-10	1 NF			
	+10	23	10	19					
	+10	16	5	14		Ft/Lbs	%Shear	Mils Lat Exp	
	+10	20	10	15					
	+40	30	15	21	+100	81	50	58	
	+40	35	15	25	+100	72	50	56	
	+40	43	20	30	+100	83	50	62	
	+70	63	35	48	+160	119	95	74	
	+70	60	35	46	+160	113	95	76	
	+70	44	20	31	+160	117	90	78	
	+80	77	50	55	+212	121	100	75	
	+80	64	40	44	+212	120	100	75	
	+80	57	35	42	+212	124	100	79	

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25 °F 40 hours furnace cooled to 600°F.

The impacts were taken transverse to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a). and Shop Order A97986 Supplement No. 17.

Form E-2170

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
J.M. Arnold

DATE March 21, 1974

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

B. R. Moss

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company. JOB NO. A-97986-026

HEAT NO. C7595-2 CODE NO. C-6404-2

MATERIAL DESCRIPTION 220-3/4" X 109-5/16" X 9-11/16" Intermediate Shell (Test Plate "

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.20	1.34	.010	.015	.29	.61		.58		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
AZ-TA	.505	R. T.	66.8	88.0	26.0	67.0
AZ-TB	.505	R. T.	67.2	88.0	25.0	66.8

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES			NDT
Charpy Impacts						Drop Weights			
	-40	6	0	3	-20	1 F			-20°F
	-40	7	0	3	-10	2 NF			
	-40	11	0	6					
	+10	18	10	13					
	+10	16	5	11		Ft/Lbs	%Shear	Mils Lat Exp	
	+10	13	5	8					
	+40	37	15	25	+100	75	50	55	
	+40	23	10	17	+100	68	50	52	
	+40	35	15	24	+100	73	50	53	
	+70	52	25	38	+160	101	99	71	
	+70	47	25	34	+160	95	95	66	
	+70	51	25	40	+160	94	95	67	
	+80	65	40	47	+212	105	100	74	
	+80	69	40	48	+212	123	100	80	
	+80	53	30	38	+212	117	100	76	

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ±25 °F 40 hours furnace cooled to 600°F.

The impacts were taken transverse to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a). and Shop Order A97986 Supplement No. 17.

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold
J.M. Arnold

DATE March 21, 1974

L. W. Rogers

C[illegible]BUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(d) — CONTRACT NO. 71170

VENDOR Lukens Steel Company — JOB NO. A-97986-003 BS

HEAT NO. C7595-2 — CODE NO. C-6404-2

MATERIAL DESCRIPTION 220-3/4" x 109-5/16" x 9-11/16" Intermediate Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.20	1.34	.010	.015	.29	.61		.58		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
EET-A	.505	R. T.	70.1	90.5	25.0	66.4
EET-B	.505	R. T.	69.2	89.8	25.0	66.4

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	Ft/Lbs	% Shear	Mils Lat.Exp.	TEMP. °F	VALUES	NDT
CVN Impacts	- 40	9	0	11		Drop Weights	
	- 40	12	0	18			
	- 40	8	0	10			
	+ 10	25	10	19			
	+ 10	44	25	30			
	+ 10	26	15	21			
	+ 40	42	25	31	0	1 F 1 NF	
	+ 40	60	40	44	-10	1 NF	0°F
	+ 40	52	30	46	+10	2 NF	
	+110	126	80	85			
	+110	111	70	78			
	+110	112	70	74			
	+160	145	95	85			
	+160	136	90	84			
	+160	155	100	90			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(A) 1600°F ±25°F 4 hours. Water quenched.

(B) 1225°F ±25°F 4 hours.

(C) 1150°F ±25°F 40 hours. Furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4 T level and notched perpendicular to the plate surface.

The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: P. Webb (2)
S. R. Lewis
T. B. Burton
R. E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY [signature]
(J. M. Arnold)

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

B. R. Moss

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3I'12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97986-026

HEAT NO. C7595-2 CODE NO. C-6404-2

MATERIAL DESCRIPTION 220-3/4" X 109-5/16" X 9-11/16" Intermediate Shell (Test Plate "

MILL CHEMICAL ANALYSIS											
TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.20	1.34	.010	.015	.29	.61		.58		.12	

MECHANICAL TESTS						
TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
AZ-TA	.505	R. T.	66.8	88.0	26.0	67.0
AZ-TB	.505	R. T.	67.2	88.0	25.0	66.8

IMPACT AND/OR FRACTURE TESTS							
TYPE	TEMP. °F	VALUES			TEMP. °F	VALUES	NDT
Charpy Impacts		Ft/Lbs	%Shear	Mils Lat Exp		Drop Weights	
	+40	41	20	30	-20	1 F	-20°F
	+40	42	20	32	-10	2 NF	
	+40	38	15	27			
	+80	63	40	45			
	+80	92	60	62			
	+80	78	50	54			
	+212	155	100	87			
	+212	156	100	88			
	+212	153	100	82			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25 °F 40 hours furnace cooled to 600°F.

The Impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a). and Shop Order A97986 Supplement No. 1

Form E-2170

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
J.M. Arnold

DATE March 21, 1974

J. W. Rogers

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(d)

CONTRACT NO. 71170

VENDOR Lukens Steel Company

JOB NO. A-97986-005 BS

HEAT NO. C7595-1

CODE NO. C-6404-3

MATERIAL DESCRIPTION 220-3/4" x 109-5/16" x 9-11/16" Intermediate Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.38	.008	.014	.29	.62		.58		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
EFT-A	.505	R. T.	73.1	93.3	24.0	64.8
EFT-B	.505	R. T.	73.1	94.0	25.0	65.2

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	Ft/Lbs	% Shear	Mils Lat. Exp.	TEMP. °F	VALUES	NDT
CVN Impacts	- 40	13	0	14		Drop Weights	
	- 40	15	0	10			
	- 40	44	20	31			
	+ 10	45	25	31			
	+ 10	30	15	20			
	+ 10	41	25	26	0	1 F	0°F
	+ 40	63	40	43	+10	2 NF	
	+ 40	45	30	32			
	+ 40	72	45	49			
	+110	115	80	79			
	+110	100	60	73			
	+110	116	80	80			
	+160	131	100	83			
	+160	136	100	82			
	+160	148	100	83			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(A) 1600°F ±25°F 4 hours. Water quenched.

(B) 1225°F ±25°F 4 hours.

(C) 1150°F ±25°F 40 hours. Furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4 T level and notched perpendicular to the plate surface.

The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: P. Webb (2)
S. R. Lewis
T. B. Burton
R. E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY (J. M. Arnold)

R. Moss

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97986-027

HEAT NO. C7595-1 CODE NO. C-6404-3

MATERIAL DESCRIPTION 220-3/4" X 109-5/16" X 9-11/16" Intermediate Shell (Test Plate "

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.38	.008	.014	.29	.62		.58		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2"%	REDUCTION OF AREA %
BA-TA	.505	R. T.	72.5	93.8	25.0	64.3
BA-TB	.505	R. T.	71.3	92.8	25.5	63.8

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES Drop Weights	NDT
Charpy Impacts	-80	10	0	9	-30	1 F	
	-80	7	0	7	-20	1 NF 1 F	-20°F
	-80	9	0	7	-10	2 NF	
	+40	39	25	35			
	+40	41	25	34			
	+40	42	25	35			
	+80	98	70	67			
	+80	75	50	54			
	+80	51	30	38			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ±25 °F 40 hours furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a). and Shop Order A97986 Supplement No. 17.

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
J.M. Arnold

DATE March 21, 1974

DATE December 30, 1970

r. Moss

MATERIALS CERTIFICATION REPORT

TERIAL SPECIFICATION P3F17 (d) CONTRACT NO. 71170

NDOR Lukens Steel Company JOB NO. A-97986-027

AT NO. C7595-1 CODE NO. C-6404-3

TERIAL DESCRIPTION 220-3/4" X 109-5/16" X 9-11/16" Intermediate Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.38	.008	.014	.29	.62		.58	.	.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
BA-TA	.505	R. T.	72.5	93.8	25.0	64.3
BA-TB	.505	R. T.	71.3	92.8	25.5	63.8

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES			TEMP. °F	VALUES			NDT
Charpy Impacts		Ft/Lbs	%Shear	Mils Lat Exp		Drop Weights			
	-40	8	0	5	-30	1 F			
	-40	10	0	6	-20	1 NF 1 F			-20°F
	-40	9	0	5	-10	2 NF			
	+10	14	5	9					
	+10	21	10	15		Ft/Lbs	%Shear	Mils Lat Exp	
	+10	15	5	13					
	+40	19	10	14	+100	73	50	55	
	+40	33	20	22	+100	74	50	54	
	+40	30	15	18	+100	71	50	50	
	+70	46	25	35	+160	97	99	62	
	+70	54	30	42	+160	94	95	64	
	+70	45	25	35	+160	93	95	61	
	+80	69	50	49	+212	105	100	69	
	+80	60	50	44	+212	100	100	66	
	+80	52	50	36	+212	103	100	64	

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ±25°F 40 hours furnace cooled to 600°F.

The impacts were taken transverse to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a). and Shop Order A97986 Supplement No. 17.

Form E-2120

P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold

DATE March 21, 1974

J. W. Rogers

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-001 B.S.

HEAT NO. A 6735-1 CODE NO. C-6404-4

MATERIAL DESCRIPTION 220-3/4" x 109-5/16" x 9-11/16" Lower Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.46	.013	.013	.28	.63		.55		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
MR-TA	.505	R. T.	70.5	93.0	25.0	64.7
MR-TB	.505	R. T.	70.8	93.0	25.0	65.2

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	Ft/Lbs	% Shear	Mils Lat. Exp.	TEMP. °F	VALUES	NDT
CVN Impacts	- 40	11	0	6		Drop Weights	
	- 40	17	0	9			
	- 40	10	0	5			
	+ 10	46	25	32			
	+ 10	42	20	29			
	+ 10	50	25	35	0	1F	0°F
	+ 40	67	40	45	+10	2NF	
	+ 40	58	30	41			
	+ 40	63	35	42			
	+110	101	70	72			
	+110	105	60	74			
	+110	102	70	70			
	+160	124	100	80			
	+160	139	100	88			
	+160	133	100	84			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(A) 1600°F ±25°F 4 hours. Water quenched.
(B) 1225°F ±25°F 4 hours.
(C) 1150°F ±25°F 40 hours. Furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4 T level and notched perpendicular to the plate surface.

The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: P. Webb (2)
S. R. Lewis
N. Wamack
R. E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
(J. M. Arnold)

DATE 5-26-71

B.R. Moss

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) — CONTRACT NO. 71170

VENDOR Lukens Steel Company — JOB NO. A-97987-001

HEAT NO. A6735-1 — CODE NO. C-6404-4

MATERIAL DESCRIPTION 220 3/4" X 109 5/16" X 9 11/16" Lower Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.46	.013	.013	.28	.63		.55		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
TS-TA	.505	R. T.	68.3	91.0	26.0	64.4
TS-TB	.505	R. T.	70.1	91.3	26.0	67.2

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES	NDT
Charpy Impacts						Drop Weights	
	+50	39	25	28	0	2 NF	-10°F
	+50	52	30	38	-10	1 F	
	+50	48	30	35			
	+60	58	40	41			
	+60	53	40	37			
	+60	62	50	44			
	+70	58	40	41			
	+70	69	50	48			
	+70	82	60	54			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a).

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold

DATE November 20, 1973

METALLURG L RESEARCH AND DEVELOPMEN DEPT
MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170
VENDOR Lukens Steel Company JOB NO. A-97987-001
HEAT NO. A6735-1 CODE NO. C-6404-4
MATERIAL DESCRIPTION 220 3/4" X 109 5/16" X 9 11/16" Lower Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.22	1.46	.013	.013	.28	.63		.55		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
TS-TA	.505	R. T.	68.3	91.0	26.0	64.4
TS-TB	.505	R. T.	70.1	91.3	26.0	67.2

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES			NDT
Charpy Impacts						Drop Weights			
	-40	9	0	6	-10	1 F			-10°F
	-40	9	0	7	0	2 NF			
	-40	10	0	8					
	+10	26	15	20					
	+10	22	10	17					
	+10	23	10	20					
	+40	35	15	25		Ft/Lbs	%Shear	Mils Lat Exp	
	+40	34	15	25					
	+40	44	20	33	+110	68	50	51	
	+70	47	30	36	+110	78	50	56	
	+70	52	35	40	+110	85	60	60	
	+70	56	40	41	+160	108	100	78	
	+80	62	40	48	+160	107	100	75	
	+80	66	40	50	+160	96	100	71	
	+80	68	40	53					

ADDITIONAL DATA INCLUDING HEAT TREATMENT:
(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The impacts were taken transverse to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a).

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the dat furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold
J.M. Arnold

DATE November 20, 1973

I. W. Rogers

COMBUSTION ENGINEERING, INC.

CORRECTED COPY

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT May 25, 1971

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-003 B.S

HEAT NO. C-7585-1 CODE NO. C-6404-5

MATERIAL DESCRIPTION 220-3/4" x 109-5/16" x 9-11/16" Lower Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.19	1.35	.015	.013	.23	.63		.56		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
MS-TA	.505	R. T.	72.0 ✓	92.3 ✓	25.0 ✓	67.4
MS-TB	.505	R. T.	71.6 ✓	92.0 ✓	25.0 ✓	67.2

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	% Shear	Mils Lat.Exp.	TEMP. °F	VALUES	NDT
CVN Impacts	- 40	9	0	6			✓
	- 40	15	0	10		Drop Weights	
	- 40	11	0	7			
	+ 10	26	15	18			
	+ 10	35	20	24	-20	1F	
	+ 10	24	15	19	-10	1F	-10°F
	+ 40	62 ✓	35	44	0	2NF	
	+ 40	83 ✓	40	58			
	+ 40	84 ✓	40	60			
	+110	126	80	75			
	+110	116	70	74			
	+110	112	70	72			
	+160	141	100	84			
	+160	134	100	82			
	+160	127	95	80			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(A) 1600°F ±25°F 4 hours. Water quenched.
(B) 1225°F ±25°F 4 hours.
(C) 1150°F ±25°F 40 hours. Furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4 T level and notched perpendicular to the plate surface.

The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: P. Webb (2)
S. R. Lewis
N. Wamack
R. E. Lorentz, Jr.

RJX 5-21-93

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
(J. M. Arnold)

May 25, 1971

B.R. Moss

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-002

HEAT NO. C7585-1 CODE NO. C-6404-5

MATERIAL DESCRIPTION 220 3/4" X 109 5/16" X 9 11/16" Lower Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.19	1.35	.015	.013	.23	.63		.56		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2"%	REDUCTION OF AREA %
TT-TA	.505	R. T.	68.3	89.1	26.0	68.9
TT-TB	.505	R. T.	68.3	88.6	27.5	66.9

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES Drop Weights	NDT
Charpy Impacts	+40	33	15	20	-30	1 F	
	+40	38	20	21	-20	1 F 1 NF	-20°F
	+40	47	25	34	-10	2 NF	
	+60	54	25	39			
	+60	50	25	37			
	+60	62	30	42			
	+70	70	40	46			
	+70	93	50	64			
	+70	83	45	54			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a).

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold

DATE November 20, 1973

B.K. Moss

METALLURGI L RESEARCH AND DEVELOPMEN DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-002

HEAT NO. C7585-1 CODE NO. C-6404-5

MATERIAL DESCRIPTION 220 3/4" X 109 5/16" X 9 11/16" Lower Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.19	1.35	.015	.013	.23	.63		.56		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
TT-TA	.505	R. T.	68.3	89.1	26.0	68.9
TT-TB	.505	R. T.	68.3	88.6	27.5	66.9

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES			NDT
Charpy Impacts						Drop Weights			
	-40	10	0	5	-30	1 F			
	-40	9	0	5	-20	1 NF / 1 F			-20°F
	-40	8	0	4	-10	2 NF			
	+10	18	5	18					
	+10	15	5	13		Ft/Lbs	%Shear	Mils Lat Exp	
	+10	14	5	14					
	+40	25	15	20	+110	81	50	60	
	+40	26	15	22	+110	84	50	59	
	+40	23	15	19	+110	87	50	61	
	+60	47	30	36	+160	103	90	65	
	+60	54	35	42	+160	105	90	70	
	+60	61	35	50	+160	115	90	72	
	+70	66	40	48	+212	122	100	81	
	+70	72	45	53	+212	116	100	74	
	+70	55	35	44	+212	116	100	71	

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.

(b) 1225°F ± 25°F 4 hours.

(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The impacts were taken transverse to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a).

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from test performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold

DATE November 20, 1973

J. W. Rogers

C[illegible]BUSTION ENGINEERING, INC.
METALLURGICAL RESEARCH AND DEVELOPMENT DEPT
MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-005 B.S.

HEAT NO. C 7596-2 CODE NO. C-6404-6

MATERIAL DESCRIPTION 220-3/4" x 109-5/16" x 9-11/16" Lower Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.19	1.31	.008	.012	.23	.54		.52		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2"%	REDUCTION OF AREA %
MT-TA	.505	R. T.	66.7	87.0	26.0	66.4
MT-TB	.505	R. T.	67.3	87.4	26.0	66.8

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	% Shear	Mils Lat.Exp.	TEMP. °F	VALUES		NDT
CVN Impacts	- 40	9	0	8		Drop Weights		
	- 40	12	0	12				
	- 40	19	0	14				
	+ 10	70	30	48				
	+ 10	61	25	41				
	+ 10	64	25	44	-10	1F		
	+ 40	56	30	42	0	1F	1NF	0°F
	+ 40	84	40	58	+10	2NF		
	+ 40	84	40	60				
	+110	136	80	85				
	+110	126	70	80				
	+110	128	80	82				
	+160	151	100	89				
	+160	167	100	92				
	+160	161	100	90				

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(A) 1600°F ±25°F 4 hours. Water quenched.

(B) 1225°F ±25°F 4 hours.

(C) 1150°F ±25°F 40 hours. Furnace cooled to [illegible]°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4 T level and notched perpendicular to the plate surface.

The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: P. Webb (2)
S. R. Lewis
N. Wamack
R. E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
J. M. Arnold

.G1) 4E)

B.R. Moss

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-003

HEAT NO. C7596-2 CODE NO. C-6404-6

MATERIAL DESCRIPTION 220 3/4" X 109 5/16" X 9 11/16" Lower Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.19	1.31	.008	.012	.23	.54		.52		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
TU-TA	.505	R. T.	64.9	84.7	27.0	66.9
TU-TB	.505	R. T.	63.9	83.2	27.0	66.1

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES Drop Weights	NDT
Charpy Impacts	+50	83	40	56	-20	1 F	-10°F
	+50	76	35	51	-10	1 NF 1 F	
	+50	61	30	44	0	2 NF	
	+70	102	50	68			
	+70	66	30	44			
	+70	88	40	60			

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a).

Form E-2170

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J. M. Arnold
J.M. Arnold

DATE November 20, 1973

B.R. Moss

COMBUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12 (d) CONTRACT NO. 71170

VENDOR Lukens Steel Company JOB NO. A-97987-003

HEAT NO. C7596-2 CODE NO. C-6404-6

MATERIAL DESCRIPTION 220 3/4" X 109 5/16" X 9 11/16" Lower Shell (Test Plate "C")

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.19	1.31	.008	.012	.23	.54		.52		.12	

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
TU-TA	.505	R. T.	64.9	84.7	27.0	66.9
TU-TB	.505	R. T.	63.9	83.2	27.0	66.1

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES Ft/Lbs	%Shear	Mils Lat Exp	TEMP. °F	VALUES			NDT
Charpy Impacts						Drop Weights			
	-40	4	0	4	-20	1 F			
	-40	9	0	6	-10	1 NF	1F		-10°F
	-40	6	0	5	0	2 NF			
	+10	14	5	13					
	+10	16	5	14					
	+10	13	5	12					
	+40	28	15	23					
	+40	27	15	22		Ft/Lbs	%Shear	Mils Lat Exp	
	+40	27	15	24					
	+50	61	30	46	+160	116	90	78	
	+50	54	25	40	+160	115	90	75	
	+50	65	30	47	+160	118	90	78	
	+110	85	60	61	+212	128	100	80	
	+110	73	50	52	+212	124	100	76	
	+110	94	70	59	+212	121	100	77	

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1600°F ± 25°F 4 hours. Water quenched.
(b) 1225°F ± 25°F 4 hours.
(c) 1150°F ± 25°F 40 hours furnace cooled to 600°F.

The impacts were taken transverse to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface.
The dropweights and tensiles were taken transverse to the major rolling direction.
Testing was done in accordance with M&P Specification N-5.5.2.11(b) Add. 1 (a).

Form E-2120

cc: P. Webb
H. Dinwiddie
R.E. Smith
S.R. Lewis
R.E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY J.M. Arnold

DATE November 20, 1973

APPENDIX F

SONGS, UNIT 2: UNIRRADIATED C_{VN} DATA FOR PLATES AND WELDS

Table F-1 Charpy V-Notch Test Results For Unit 2 Plate C6404-1 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	10.00	5.00	0.00
2	-40.00	9.00	4.00	0.00
3	-40.00	7.00	3.00	0.00
4	10.00	23.00	19.00	10.00
5	10.00	16.00	14.00	5.00
6	10.00	20.00	15.00	10.00
7	40.00	30.00	21.00	15.00
8	40.00	35.00	25.00	15.00
9	40.00	43.00	30.00	20.00
10	70.00	63.00	~~35.00~~ 48.00	~~40.00~~ 35.00 BB 5/19/94
11	70.00	60.00	46.00	35.00
12	70.00	44.00	31.00	20.00
13	80.00	77.00	55.00	50.00
14	80.00	64.00	44.00	40.00
15	80.00	57.00	42.00	35.00
16	100.00	81.00	58.00	50.00
17	100.00	72.00	56.00	50.00
18	100.00	83.00	62.00	50.00
19	160.00	119.00	74.00	95.00
20	160.00	113.00	76.00	95.00
21	160.00	117.00	78.00	90.00
22	212.00	121.00	75.00	100.00
23	212.00	120.00	75.00	100.00
24	212.00	124.00	79.00	100.00

Table F-2 Charpy V-Notch Test Results
For Unit 2 Plate C6404-2 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	6.00	3.00	0.00
2	-40.00	7.00	3.00	0.00
3	-40.00	11.00	6.00	0.00
4	10.00	18.00	13.00	10.00
5	10.00	16.00	11.00	5.00
6	10.00	13.00	8.00	5.00
7	40.00	37.00	25.00	15.00
8	40.00	23.00	17.00	10.00
9	40.00	35.00	24.00	15.00
10	70.00	52.00	38.00	25.00
11	70.00	47.00	34.00	25.00
12	70.00	51.00	40.00	25.00
13	80.00	65.00	47.00	40.00
14	80.00	69.00	48.00	40.00
15	80.00	53.00	38.00	30.00
16	100.00	75.00	55.00	50.00
17	100.00	68.00	52.00	50.00
18	100.00	73.00	53.00	50.00
19	160.00	101.00	71.00	99.00
20	160.00	95.00	66.00	95.00
21	160.00	94.00	67.00	95.00
22	212.00	105.00	74.00	100.00
23	212.00	123.00	80.00	100.00
24	212.00	117.00	76.00	100.00

Table F-3 Charpy V-Notch Test Results
For Unit 2 Plate C6404-3 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)	
1	-40.00	8.00	5.00	0.00	
2	-40.00	10.00	6.00	0.00	
3	-40.00	9.00	~~8.00~~ 5.00	0.00	BB 5/19/94
4	10.00	14.00	9.00	5.00	
5	10.00	21.00	15.00	10.00	
6	10.00	15.00	13.00	5.00	
7	40.00	19.00	~~24.00~~ 14.00	~~30.00~~ 10.00	BB 5/19/94
8	40.00	33.00	22.00	20.00	
21	160.00	93.00	61.00	95.00	
10	70.00	46.00	35.00	25.00	
11	70.00	54.00	42.00	30.00	
12	70.00	45.00	35.00	25.00	
13	80.00	69.00	49.00	50.00	
14	80.00	60.00	44.00	50.00	
15	80.00	52.00	36.00	50.00	
16	100.00	73.00	55.00	50.00	
17	100.00	74.00	54.00	50.00	
18	100.00	71.00	50.00	50.00	
19	160.00	97.00	62.00	99.00	
20	160.00	94.00	64.00	95.00	
9	40.00	30.00	18.00	~~35.00~~ 15.00	BB 5/19/94
22	212.00	105.00	69.00	100.00	
23	212.00	100.00	66.00	100.00	
24	212.00	103.00	64.00	100.00	

Table F-4 Charpy V-Notch Test Results
For Unit 2 Plate C6404-4 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	9.00	6.00	0.00
2	-40.00	9.00	7.00	0.00
3	-40.00	10.00	8.00	0.00
4	10.00	26.00	20.00	15.00
5	10.00	22.00	17.00	10.00
6	10.00	23.00	20.00	10.00
7	40.00	35.00	25.00	15.00
8	40.00	34.00	25.00	15.00
9	40.00	44.00	33.00	20.00
10	70.00	47.00	36.00	30.00
11	70.00	52.00	40.00	35.00
12	70.00	56.00	41.00	40.00
13	80.00	62.00	48.00	40.00
14	80.00	66.00	50.00	40.00
15	80.00	68.00	53.00	40.00
16	110.00	68.00	51.00	50.00
17	110.00	78.00	56.00	50.00
18	110.00	85.00	60.00	60.00
19	160.00	108.00	78.00	100.00
20	160.00	107.00	75.00	100.00
21	160.00	96.00	71.00	100.00

Table F-5 Charpy V-Notch Test Results For Unit 2 Plate C6404-5 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	10.00	5.00	0.00
2	-40.00	9.00	5.00	0.00
3	-40.00	8.00	4.00	0.00
4	10.00	18.00	18.00	5.00
5	10.00	15.00	13.00	5.00
6	10.00	14.00	14.00	5.00
7	40.00	25.00	20.00	15.00
8	40.00	26.00	22.00	15.00
9	40.00	23.00	19.00	15.00
10	~~50.00~~ 60.00	47.00	36.00	30.00
11	~~50.00~~ 60.00	54.00	42.00	35.00
12	~~50.00~~ 60.00	61.00	50.00	35.00
13	70.00	66.00	48.00	40.00
14	70.00	72.00	53.00	45.00
15	70.00	55.00	44.00	35.00
16	110.00	81.00	60.00	50.00
17	110.00	84.00	59.00	50.00
18	110.00	87.00	61.00	50.00
19	160.00	103.00	65.00	90.00
20	160.00	105.00	70.00	90.00
21	160.00	115.00	72.00	90.00
22	212.00	122.00	81.00	100.00
23	212.00	116.00	74.00	100.00
24	212.00	116.00	~~74.00~~ 71.00	100.00

JD 5/19/94

JD 5/19/94

Table F-6 Charpy V-Notch Test Results
For Unit 2 Plate C6404-6 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	4.00	4.00	0.00
2	-40.00	9.00	6.00	0.00
3	-40.00	6.00	5.00	0.00
4	10.00	14.00	13.00	5.00
5	10.00	16.00	14.00	5.00
6	10.00	13.00	12.00	5.00
7	40.00	28.00	23.00	15.00
8	40.00	27.00	22.00	15.00
9	40.00	27.00	24.00	15.00
10	50.00	61.00	46.00	30.00
11	50.00	54.00	40.00	25.00
12	50.00	65.00	47.00	30.00
13	110.00	85.00	61.00	60.00
14	110.00	73.00	52.00	50.00
15	110.00	94.00	59.00	70.00
16	160.00	116.00	78.00	90.00
17	160.00	115.00	75.00	90.00
18	160.00	118.00	78.00	90.00
19	212.00	128.00	80.00	100.00
20	212.00	124.00	76.00	100.00
21	212.00	121.00	77.00	100.00

Table F-7 Charpy V-Notch Test Results
For Unit 2 Weld Seam 9-203 (Heat #90130), ~~FSAR~~ WMC Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-60.00	16.00	9.00	0.00
2	-60.00	15.00	7.00	0.00
3	-60.00	19.00	11.00	0.00
4	-40.00	20.00	11.00	5.00
5	-40.00	28.00	16.00	10.00
6	-40.00	32.00	22.00	15.00
7	-20.00	85.00	53.00	50.00
8	-20.00	88.00	56.00	50.00
9	-20.00	76.00	47.00	40.00
10	0.00	77.00	47.00	40.00
11	0.00	75.00	45.00	40.00
12	0.00	99.00	52.00	60.00
13	20.00	117.00	74.00	70.00
14	20.00	105.00	65.00	60.00
15	20.00	114.00	74.00	70.00
16	60.00	132.00	77.00	80.00
17	60.00	149.00	84.00	100.00
18	60.00	123.00	74.00	80.00
19	100.00	142.00	82.00	100.00
20	100.00	148.00	84.00	100.00
21	100.00	140.00	82.00	100.00

Table F-8 Charpy V-Notch Test Results
For Unit 2 Plate C6404-2 (LT), CE Baseline Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
154	-80.00	4.50	2.00	0.00
136	-80.00	8.50	10.00	0.00
122	-40.00	5.00	6.00	0.00
132	-40.00	6.50	6.00	0.00
143	0.00	11.00	13.00	15.00
147	0.00	16.50	18.00	15.00
114	40.00	41.00	38.00	25.00
11A	40.00	56.50	48.00	25.00
12K	80.00	93.50	72.00	65.00
14A	80.00	124.50	83.00	75.00
156	120.00	118.00	78.00	80.00
11E	120.00	141.50	96.00	90.00
13T	160.00	146.50	90.00	100.00
11T	160.00	157.50	95.00	90.00
157	210.00	148.00	96.00	100.00
14L	210.00	155.00	94.00	100.00

Table F-9 Charpy V-Notch Test Results
For Unit 2 Plate C6404-2 (TL), CE Baseline Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
264	-80.00	4.50	2.00	0.00
25A	-40.00	8.00	8.00	0.00
23D	-40.00	8.00	9.00	0.00
21T	0.00	12.00	15.00	10.00
21Y	0.00	24.50	24.00	10.00
262	40.00	33.00	32.00	20.00
22B	40.00	40.00	35.00	25.00
24J	80.00	68.50	58.00	30.00
24E	80.00	78.50	62.00	40.00
21E	120.00	87.00	66.00	75.00
24A	120.00	107.00	72.00	80.00
245	160.00	111.50	78.00	85.00
24T	160.00	127.50	84.00	90.00
216	190.00	116.00	80.00	100.00
24U	210.00	126.50	87.00	100.00
231	210.00	137.50	91.00	100.00

Table F-10 Charpy V-Notch Test Results For Unit 2 Surveillance Weld, CE Baseline Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
34A	-150.00	3.50	1.00	0.00
31M	-120.00	7.00	6.00	15.00
333	-120.00	14.00	12.00	15.00
346	-80.00	16.00	15.00	25.00
37A	-80.00	29.50	25.00	30.00
31K	-40.00	43.50	37.00	35.00
35T	0.00	63.50	53.00	65.00
34T	0.00	90.00	68.00	75.00
33B	40.00	132.00	90.00	90.00
324	40.00	146.00	97.00	100.00
35L	80.00	135.50	95.00	100.00
326	80.00	140.00	96.00	100.00
331	120.00	145.50	95.00	100.00
34J	120.00	153.00	98.00	100.00
35J	160.00	151.00	96.00	100.00
335	160.00	152.00	100.00	100.00

Table F-11 Charpy V-Notch Test Results
For Unit 2 Plate C6404-2 (LT), MCR Data

Test Temperature (°F)	Impact Energy (ft-lbs)	Lateral Expansion (mils)	Fracture Appearance (% Shear)
-40	9	11	0
-40	12	18	0
-40	8	10	0
10	25	19	10
10	44	30	25
10	26	21	15
40	42	31	25
40	60	44	40
40	52	46	30
110	126	85	80
110	111	78	70
110	112	74	70
160	145	85	95
160	136	84	90
160	155	90	100

APPENDIX G

SONGS, UNIT 2: HAZ TEST RESULTS

CE Baseline Tests[1]

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
45J	-150.00	5.00	3.00	0.00
43C	-120.00	9.50	6.00	0.00
41M	-80.00	23.50	19.00	25.00
415	-80.00	35.00	28.00	30.00
466	-40.00	30.00	24.00	30.00
46K	-40.00	40.00	34.00	30.00
47B	0.00	82.00	56.00	50.00
41Y	0.00	101.00	70.00	70.00
44C	40.00	104.50	71.00	90.00
432	40.00	115.50	88.00	100.00
461	80.00	135.50	86.00	90.00
42B	80.00	153.00	92.00	100.00
43K	120.[illegible]	108.00	79.00	90.00
421	120.00	144.50	88.00	100.00
451	160.00	139.00	85.00	100.00
442	160.00	151.50	86.00	100.00

Battelle Capsule 97[2]

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)	CHARPY FLUENCE (n/cm2)	IRRAD TEMP. (F)
476	-79.00	12.00	9.80	17.00	5.07E+18	580.00
41A	-79.00	14.10	10.20	13.00	5.07E+18	580.00
41C	-40.00	20.00	14.00	27.00	5.07E+18	580.00
413	-40.00	28.20	26.80	38.00	5.07E+18	580.00
43U	0.00	38.30	30.40	46.00	5.07E+18	580.00
42J	0.00	77.50	54.80	54.00	5.07E+18	580.00
42Y	72.00	103.80	81.20	89.00	5.07E+18	580.00
42C	72.00	114.20	84.40	93.00	5.07E+18	580.00
444	160.00	130.00	87.00	100.00	5.07E+18	580.00
412	160.00	132.60	85.60	100.00	5.07E+18	580.00
44P	260.00	133.70	82.20	100.00	5.07E+18	580.00
424	260.00	145.30	89.80	100.00	5.07E+18	580.00

APPENDIX H

SONGS, UNIT 2: IRRADIATED C_{VN} DATA FROM CAPSULE 97

Table H-1 Charpy V-Notch Test Results
For Unit 2 Plate C6404-2 (LT)
Irradiated (f = 5.07 x 10^{18})

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
141	0.00	6.00	6.80	4.00
111	0.00	8.10	6.40	5.00
15M	40.00	12.50	7.80	11.00
14T	72.00	23.50	23.60	9.00
13M	72.00	27.40	26.60	13.00
123	100.00	59.50	53.60	18.00
13E	100.00	74.20	58.80	20.00
11M	160.00	113.40	83.00	77.00
15E	160.00	138.50	99.40	100.00
11U	200.00	127.30	93.40	100.00
124	200.00	136.20	105.80	100.00
137	260.00	137.30	95.40	100.00

Table H-2 Charpy V-Notch Test Results
For Unit 2 Plate C6404-2 (TL)
Irradiated (f = 5.07×10^{18})

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
214	0.00	4.00	10.00	4.00
23J	0.00	11.00	11.00	6.00
223	40.00	22.00	19.60	11.00
22K	72.00	27.90	32.80	15.00
22T	62.00	32.10	31.80	15.00
25U	100.00	44.10	42.80	42.00
23P	100.00	50.00	44.00	49.00
21B	160.00	82.00	68.40	85.00
221	200.00	93.00	71.00	100.00
25L	200.00	98.00	68.60	100.00
256	260.00	101.90	83.40	100.00
211	260.00	103.00	83.80	100.00

Table H-3 Charpy V-Notch Test Results
For Unit 2 Surveillance Weld
Irradiated (f = 5.07 x 10^{18})

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
37M	-79.00	15.00	14.40	18.00
37L	-79.00	18.40	20.00	13.00
3A3	-40.00	25.00	23.60	36.00
36M	-40.00	45.40	36.60	40.00
36P	0.00	78.00	65.20	68.00
36K	0.00	82.40	64.60	70.00
31E	72.00	126.90	95.00	92.00
33P	72.00	138.20	102.20	100.00
342	160.00	134.00	99.80	100.00
36E	160.00	142.50	97.80	100.00
32P	260.00	147.90	97.60	100.00
341	260.00	149.00	100.40	100.00