Southern California Edison
San Onofre Nuclear Generating Station, Unit 3
Response to Generic Letter 92-01

(Non-Proprietary Version)

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San Onofre Nuclear Generating Station, Unit 3
Response to Generic Letter 92-01

Final Report
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Section 1

INTRODUCTION

The Nuclear Regulatory Commission (NRC) in Generic Letter 92-01 (GL92-01) 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. This report has been prepared in response to GL92-01 for San Onofre Nuclear Generating Station (SONGS), Unit 3.

Section 2 of this report addresses compliance with 10 CFR Part 50 (10CFR50), Appendix H for the surveillance program at SONGS, Unit 3. 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 3 reactor vessel. Section 4.0 addresses embrittlement effects, including irradiation temperature and adjusted reference temperature for evaluation of the beltline materials relative to GL88-11 and 10CFR50.61.

Additional information is needed to complete the response to GL92-01 for SONGS, Unit 3. This information includes: (1) resolving inconsistencies in Cu and Ni contents and Charpy impact properties reported for beltline weld 9-203 and the surveillance weld, which have been reported to have been fabricated using some of the same consumables, (2) obtaining material certification reports to confirm beltline weld properties, (3) identifying the Charpy impact properties, chemistry, and fluence for weld 8-203, and (4) resolving inconsistencies between Charpy impact properties reported in the materials certification report and the materials surveillance program for the longitudinal orientation in plate C6802-1.

Section 2

REACTOR PRESSURE VESSEL SURVEILLANCE PROGRAM COMPLIANCE WITH APPENDIX H

The ASME Code of record for the San Onofre Nuclear Generating Station (SONGS), Unit 3 reactor pressure vessel is the 1971 Edition through the Summer 1971 Addenda. Consequently, the applicable version of ASTM E185 is the 1970 version (ASTM E185-70). However, the surveillance program for SONGS, Unit 3 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 Appendix H requirements had to do with the method of attachment of the holders for the six surveillance capsules in each SONGS unit. Combustion Engineering (CE) was the vessel manufacturer and the nuclear steam supply system (NSSS) vendor; CE attached the capsule holders directly to the cladding on the inside of the vessel in the beltline region (as they did for all CE NSSS-designed vessels), and this approach violated the requirements in the early 1970's version of 10CFR50, Appendix H. The NRC reviewed a 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 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 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 3 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 (E185-92) 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 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 3; however, the raw data from prior HAZ testing on the SONGS, Unit 3 beltline material has been reported previously,[1-3] 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 3 reactor pressure vessel beltline region.

Generally, the information presented in this section has been obtained from the materials certification reports (MCRs) and the FSAR for SONGS, Unit 3, and from additional information supplied by Combustion Engineering (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 3 at the end of the fourth fuel cycle.[2]

3.1 COMPLIANCE WITH APPENDIX G

Generally, the materials in the beltline region of SONGS, Unit 3 comply with the requirements of Appendix G, 10CFR50. Areas of non compliance with Appendix G, 10CFR50, 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 3

3.2.1 Location

Figure 3-1 is a representation of the SONGS, Unit 3 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.

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 the identical heat treatment as the actual reactor vessel. The surveillance weldment received a final 41-hour and 45-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 and Ni contents were obtained by averaging two measurements made by CE. The first measurement was made when CE received the plate from Lukens and the second measurement was made when the surveillance program was defined. The bases for the Cu and Ni contents reported by CE and listed in Table 3.4 are presented in Appendix B. The plate P and S contents were obtained from the MCRs, which are included as Appendix C.

A second set of data is included for plate C6802-1. This set was obtained from broken surveillance specimens when the first irradiated surveillance capsule from Unit 3 was tested.[2]

Table 3.5 contains the Cu, Ni, P and S contents reported in the FSAR for the beltline welds. Two additional chemistry measurements are reported for beltline weld 9-203. One additional value was obtained from the welding material certification (WMC) for Type Mil B-4 Wire, Heat No. 90069, Linde Type 124 Flux, Lot No. 0951 (see Appendix C), while a second preliminary value has been provided by CE[4] for Type Mil B-4 Wire, Heat No. 90144, Linde Type 124 Flux, Lot No. 1061. Three 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 and third were obtained from broken Charpy specimens from Capsule 97[2]. Because Cu was not measured for beltline weld 8-203, a value of 0.35 wt% has been assumed (see Regulatory Guide 1.99, Revision 2). Because Ni was not measured for beltline welds 8-203 and 2-203, a value of 1.0 wt % has been assumed (see Regulatory Guide 1.99, Revision 2).

The surveillance weld was reported by CE to have been fabricated using one of the weld wire and flux combinations in weld 9-203 (see Table 3.3). The information in Table 3.5 indicates a distinct difference between the Cu and Ni contents reported for the surveillance weld and weld 9-203. Because of the differences in reported Cu and Ni contents and differences in the C_{VN} curves (see Section 3.3.2) the surveillance weld and beltline weld 9-203 are listed and evaluated separately in the report. CE is continuing their investigation to resolve these inconsistencies.

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 Charpy V-notch absorbed energy (C_{VN}) tests, and summarizes the upper shelf energies (USE) and the results from the drop weight nil ductility temperature (NDT) tests for the unirradiated beltline plate and weld materials in SONGS, Unit 3. 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 upper shelf energies were determined using the definition specified in ASTM E185-92 (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 plate were obtained from the MCRs (see Appendix C) and baseline surveillance program. The data for weld 9-203 were obtained from the WMC (see Appendix C). The fracture toughness data for the remaining beltline welds were obtained from the FSAR, and the data for the surveillance weld was 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 D.

As discussed earlier in Section 2, the results for heat affected zone (HAZ) material are not evaluated in this report because upcoming ASTM standard E185-92 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 E.

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 C6802-1, which was included in the surveillance program. Because the surveillance program for SONGS, Unit 3 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 C6802-1, -2, -3, -4, -5, and -6 are presented in Figures 3-2 through 3-7, respectively. For convenience, an average curve through the data also is 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 E185-92 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-lbs) is achieved consistent with the applicable method of ASME, Section III, NB 2331, and RT_{NDT}.

As part of the surveillance program additional Charpy absorbed energy versus temperature data were generated for plate C6802-1;[1] these data are presented in Figure 3-8 along with a least squares fit curve. Because there was a relatively wide gap in the test temperatures near the 50 ft-lb level for the surveillance baseline data set in Figure 3-8, the graphical method of NB-2331 (a)(4) was used to determine RT_{NDT}. The 50 ft-lb temperature was determined by the intersection of the dashed line and the 50 ft-lb level as shown in Figure 3-8. The dashed line was drawn parallel to the least squares fit line at 50 ft-lb so that it was on, or to the right of, all data points in the transition region.

The data obtained when the plate material was purchased (Figure 3-2) and the surveillance baseline data (Figure 3-8) were combined as shown in Figure 3-9. The combined data set presented in Figure 3-9 was used to determine RT_{NDT} and the USE for the transverse orientation in Plate C6802-1. The average curve through the combined data set in Figure 3-9 also 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 transverse orientation for each of the beltline plates in SONGS, Unit 3. The NDT for plate C6802-1 also was determined twice. One value was measured when the material was purchased, while the second value was determined from the unirradiated baseline tests. The higher of these values 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 NB-2331 (a)(3) was used to determine RT_{NDT} for all plates except for the combined data set of plate C6802-1 (see Figure 3-9), where the graphical method of NB-2331 (a)(4) was used because there is a relatively wide spread in the test temperatures near the 50 ft-lb level.

Figure 3-10 shows the data and least squares fit line for the longitudinal (LT) orientation for surveillance plate C6802-1,[1] while Figure 3-11 shows the data and least squares fit line for the LT orientation reported in the MCR for plate C6802-1. A comparison of the information in Figures 3-10 and 3-11 indicate a significant difference in the C_{VN} versus temperature curves obtained from the MCR and surveillance program for the LT orientation for plate C6802-1. CE is continuing their investigation to resolve this inconsistency.

3.3.2 Beltline Welds

A full C_{VN} versus temperature curve was obtained for the material in weld seam 3-203, and the data points and least squares hyperbolic tangent fit through the data are presented in Figure 3-12. A full C_{VN} versus temperature curve was obtained for the Type Mil B-4 Wire, Heat No. 90069, Linde Type 124 Flux, Lot No. 0951 combination in beltline weld seam 9-203; the C_{VN} data and least squares hyperbolic tangent fit through the data are presented in Figure 3-13. The material in beltline weld seam 2-203 was tested to obtain three C_{VN} data points at 20°F. The results from these tests are presented in Table 3.7.

Figure 3-14 presents the C_{VN} data and least squares hyperbolic tangent curve fit for the surveillance weld material. A comparison of Figures 3-13 and 3-14 indicates a significant difference in the C_{VN} versus temperature curves for the surveillance weld and beltline weld 9-203. This difference is not consistent with what would be expected from independent testing of the same weld wire heat. The source of this inconsistency is under investigation by CE.

Table 3.8 presents a summary of the unirradiated NDT, RT_{NDT} and USE values for each of the beltline welds in SONGS, Unit 3. For welds 2-203, 3-203, 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. No NDT data are available for weld 8-203, and RT_{NDT} was taken as the generic value of -56°F for CE fabricated vessels (see 10CFR50.61).

Because fewer than three specimens were tested at each temperature the graphical method of NB-2331 (a)(4) was used to determine RT_{NDT} for the surveillance weld as shown by the intersection of the dashed line and the 50 ft-lb C_{VN} level in Figure 3-14.

The upper shelf energies listed in Table 3.8 for welds 3-203, 9-203 (Heat 90069), and the surveillance weld were obtained by averaging the test results where 95% shear or greater was exhibited. The upper shelf energy for weld 2-203 was obtained from the data in Table 3.7 by averaging the three C_{VN} data points obtained at 20°F. Currently, no C_{VN} data have been identified for welds 9-203 (Heat 90144) and 8-203, and CE is continuing their investigation to identify the C_{VN} values.

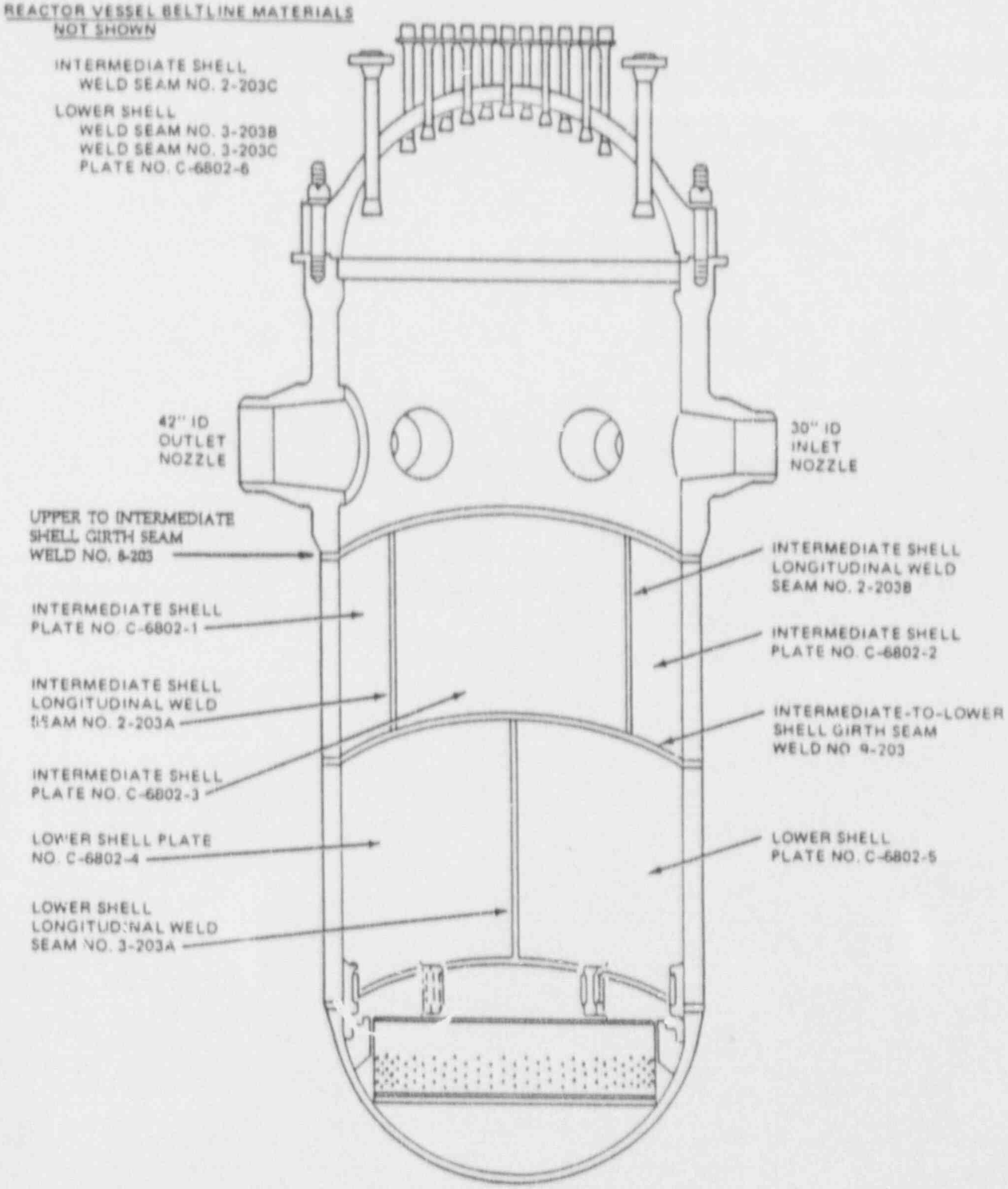

Figure 3-1. SONGS, Unit 3: Location and Identification of Beltline Plates and Welds.

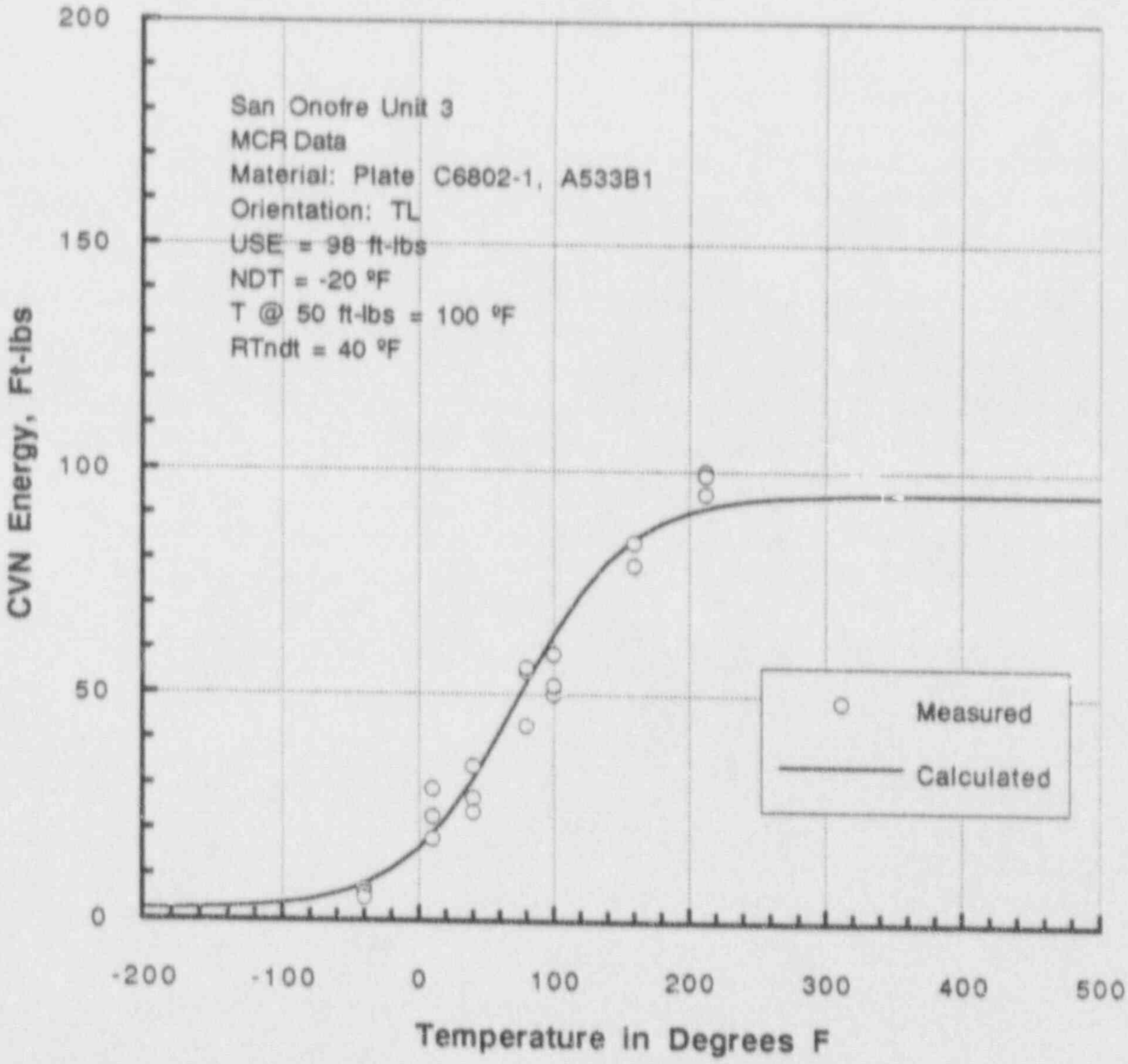

Figure 3-2. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-1, TL Orientation, MCR Data.

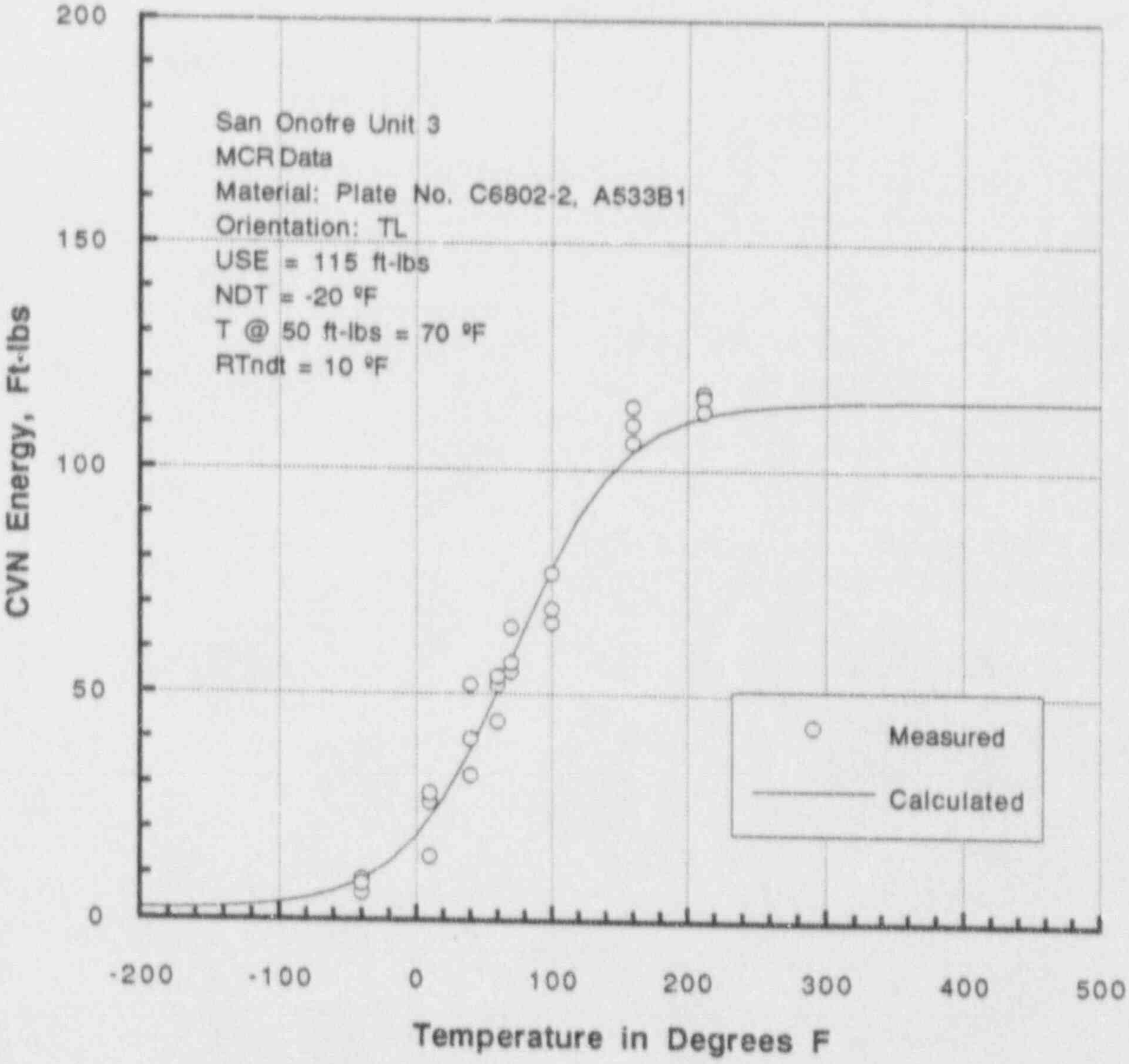

Figure 3-3. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-2, TL Orientation, MCR Data.

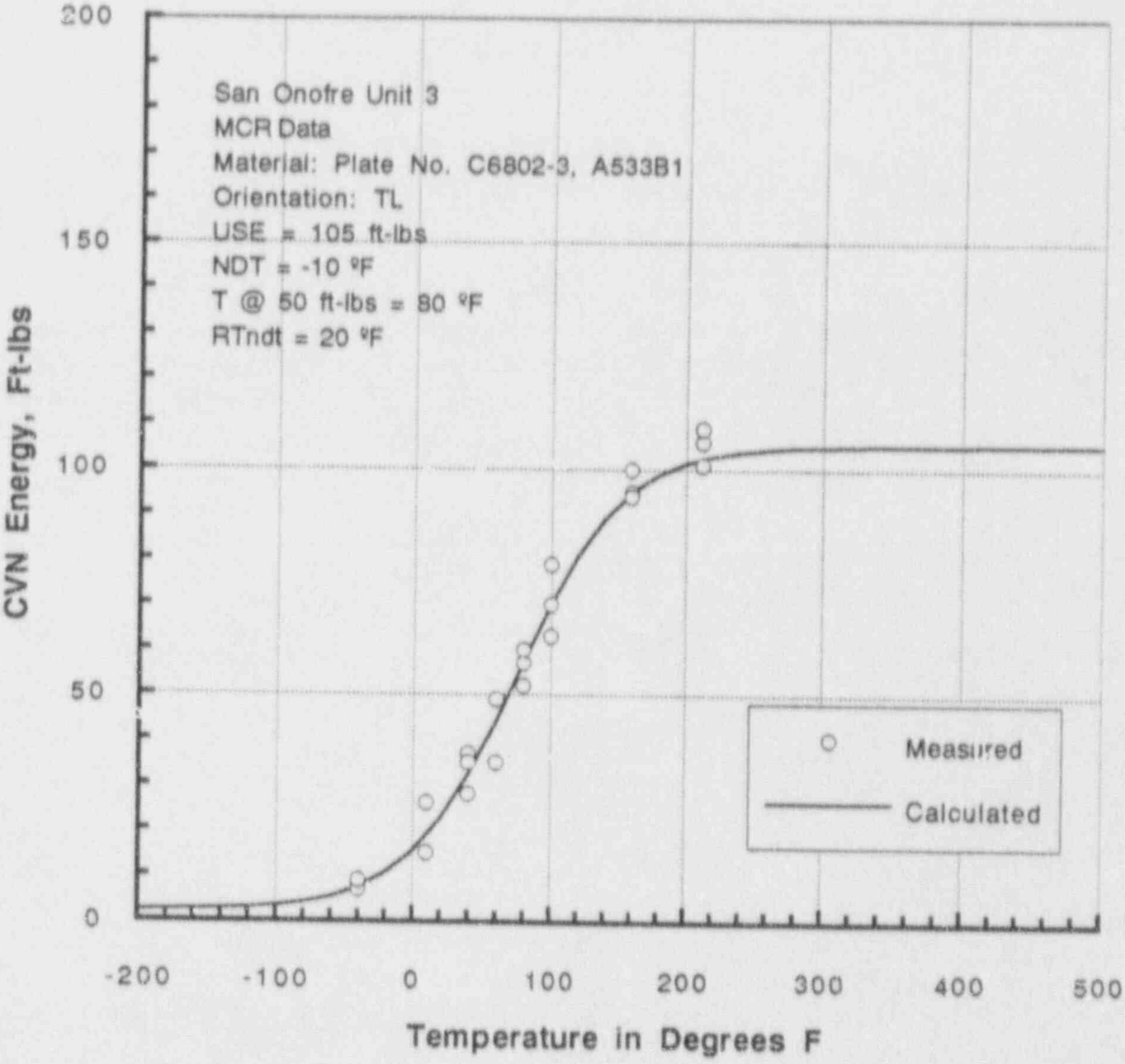

Figure 3-4. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-3, TL Orientation, MCR Data.

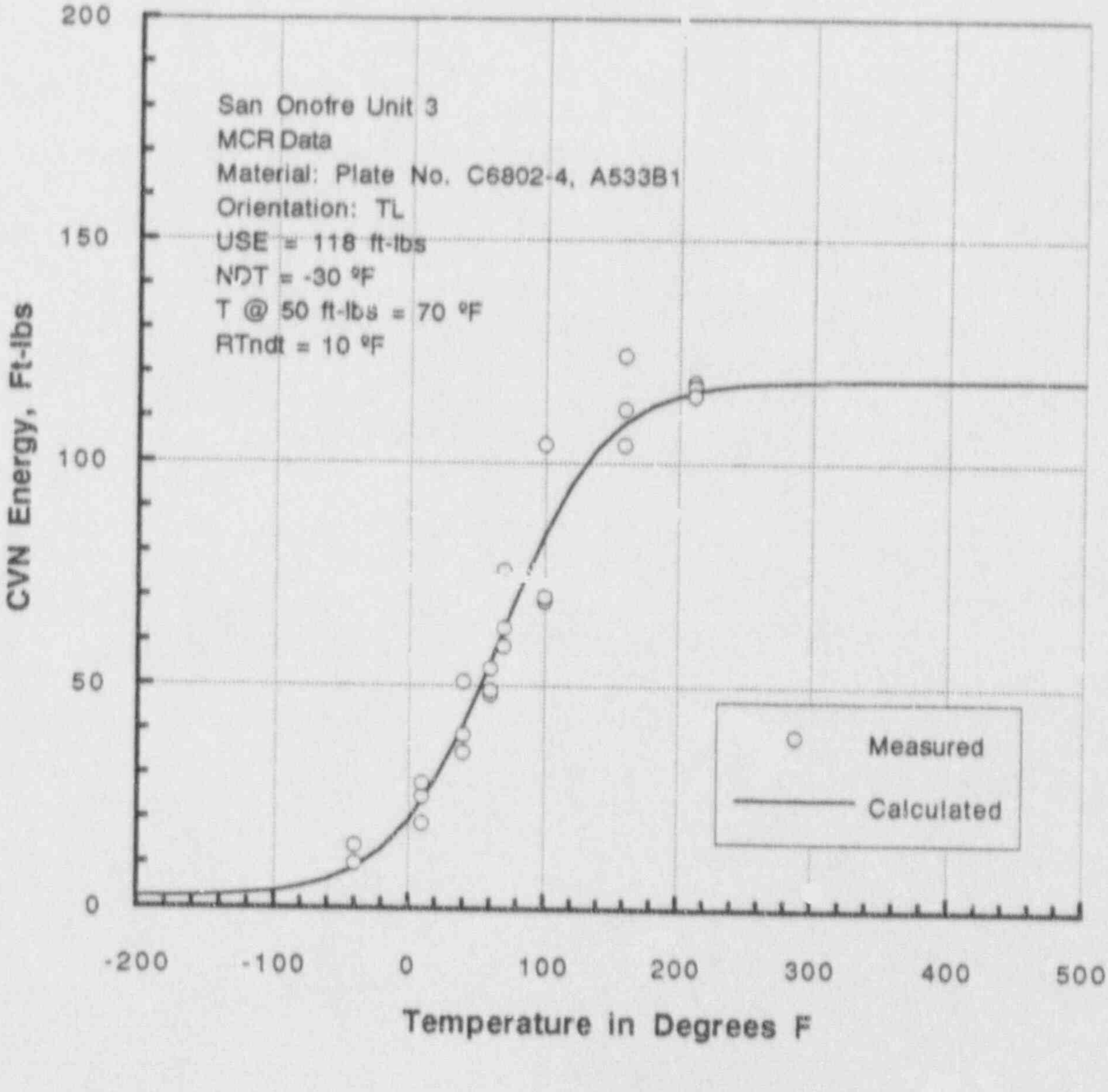

Figure 3-5. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-4, TL Orientation, MCR Data.

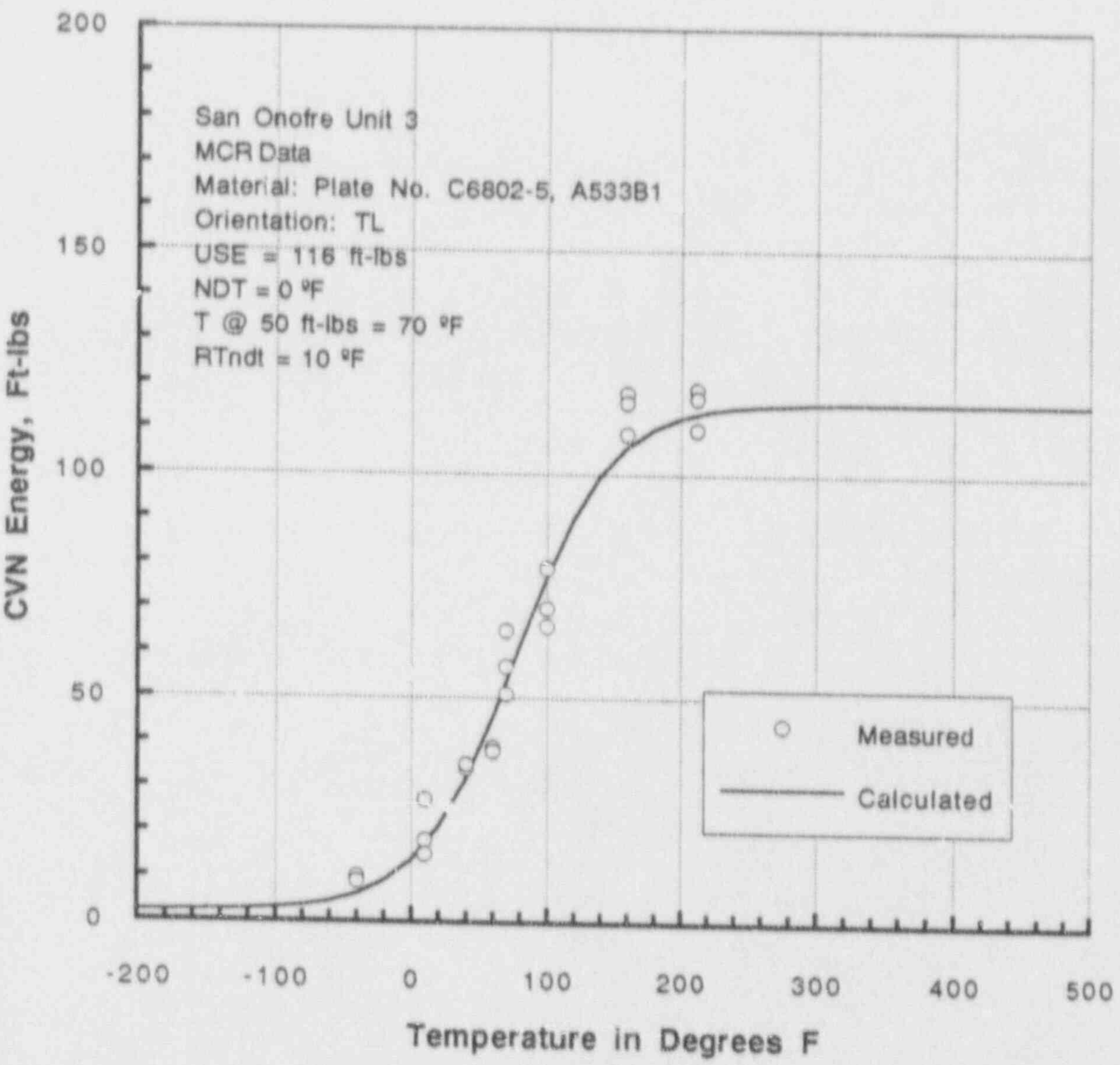

Figure 3-6. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-5, TL Orientation, MCR Data.

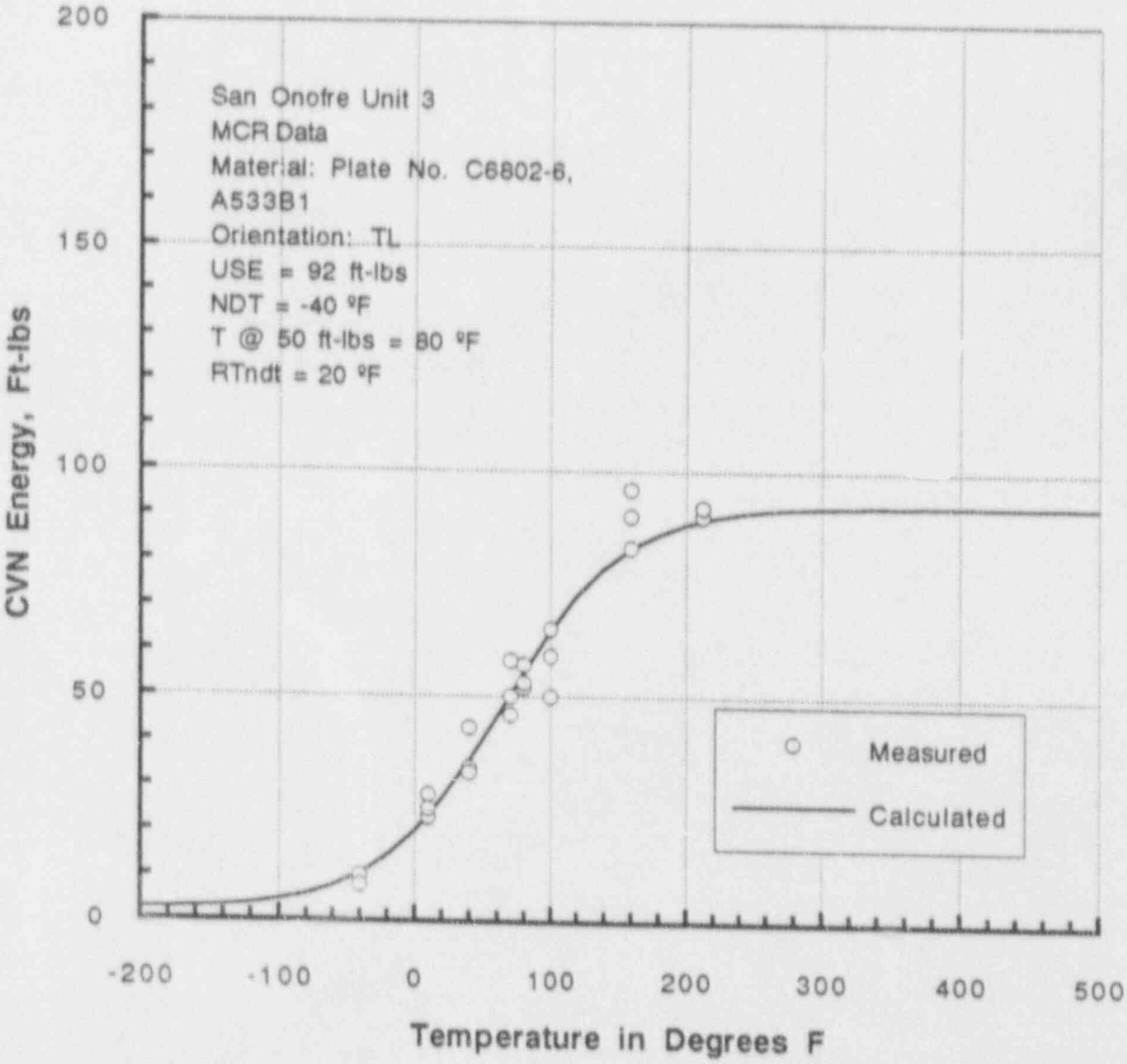

Figure 3-7. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-6, TL Orientation, MCR Data.

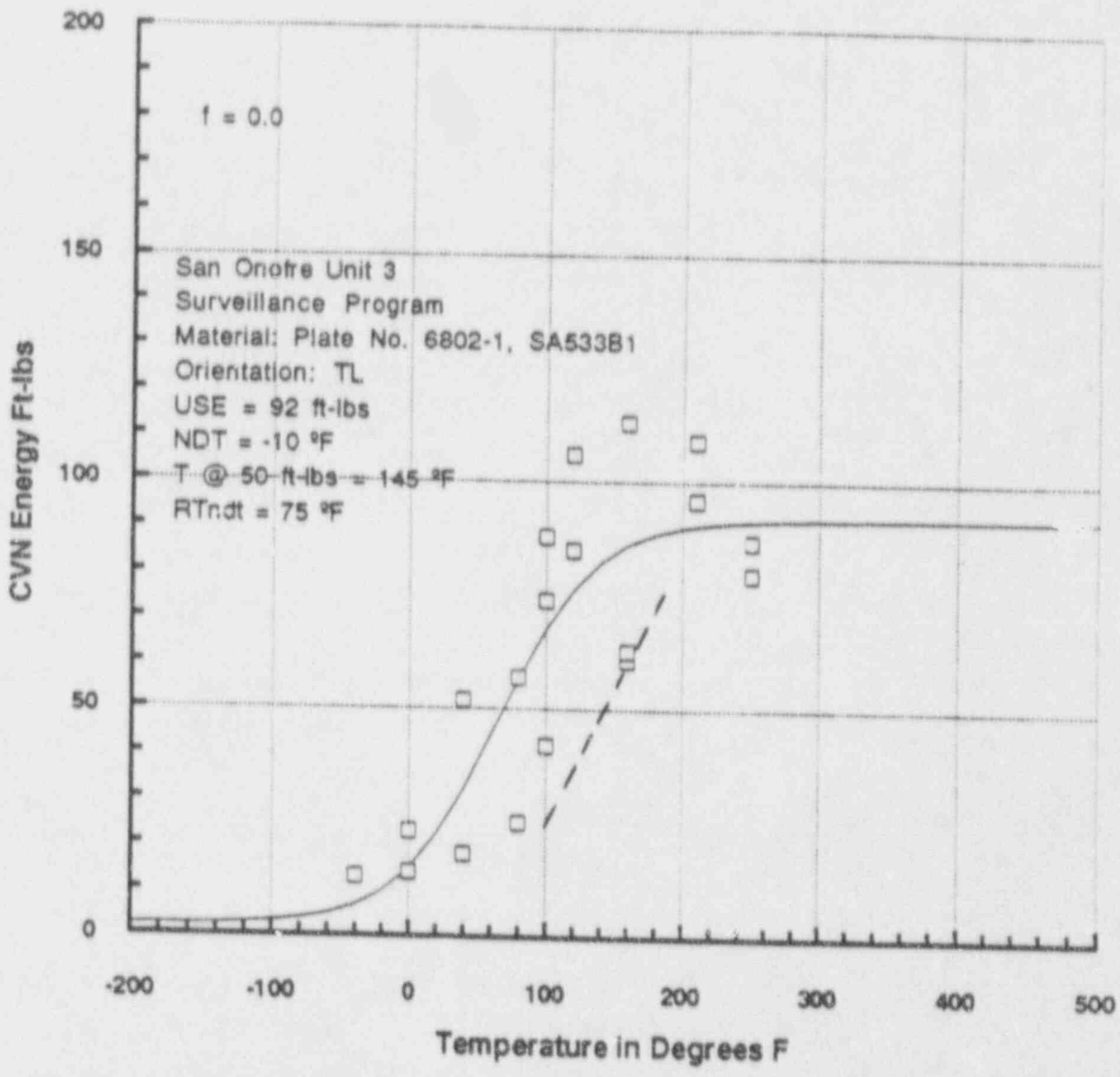

Figure 3-8. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-1, TL Orientation, Surveillance Baseline Data.

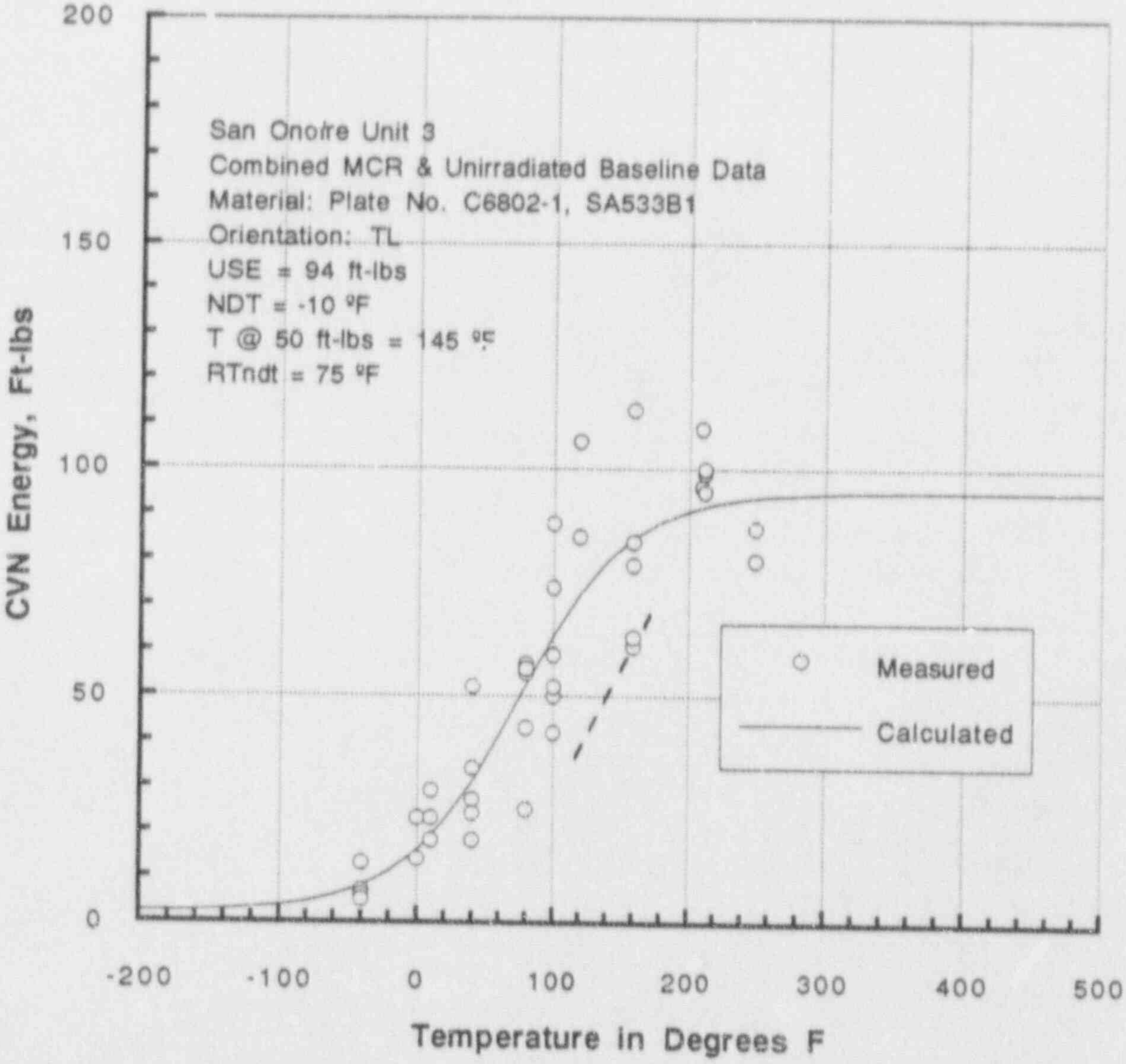

Figure 3-9. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-1, TL Orientation, Combined MCR and Surveillance Baseline Data.

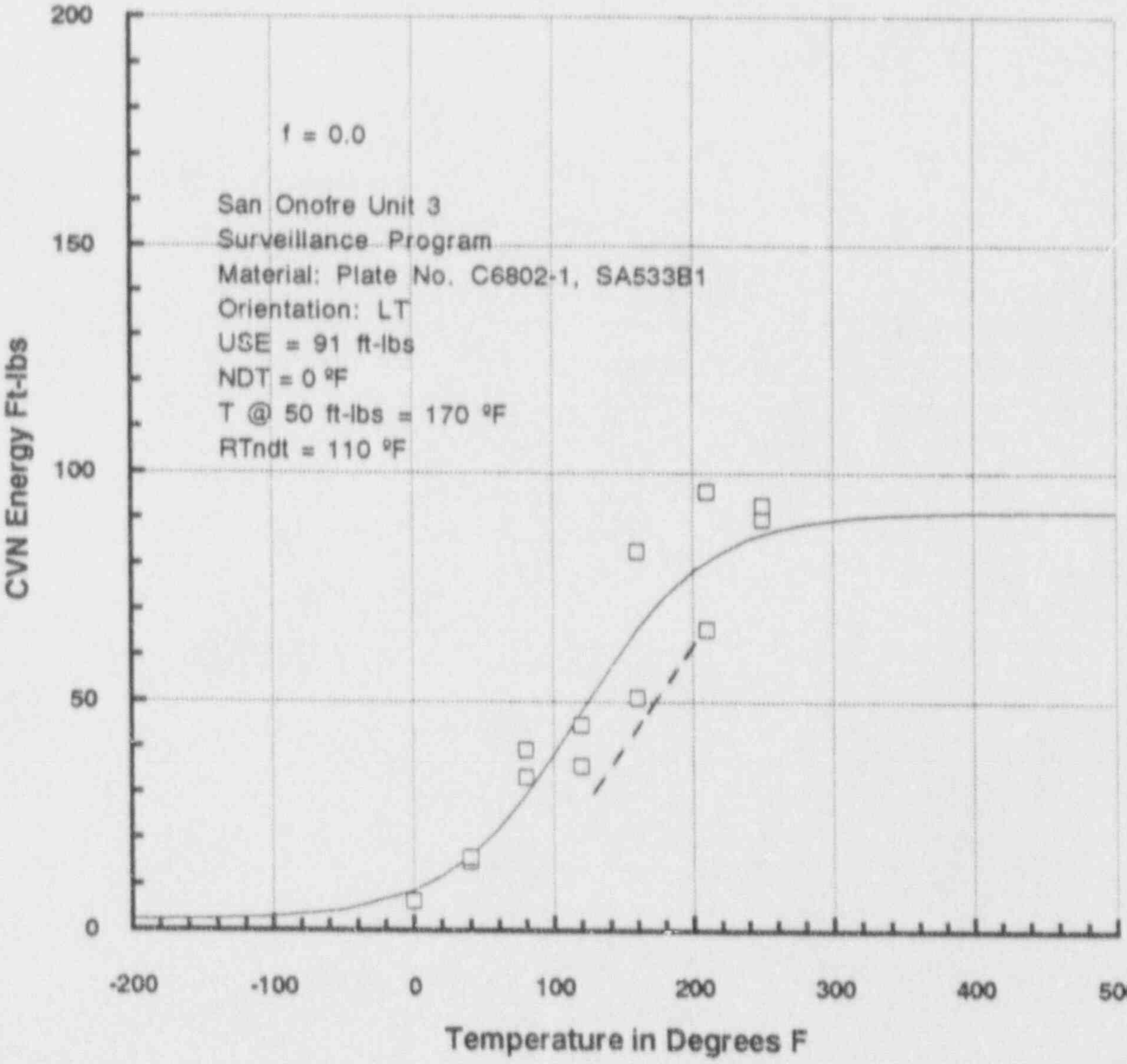

Figure 3-10. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate Co802-1, LT Orientation, Surveillance Baseline Data.

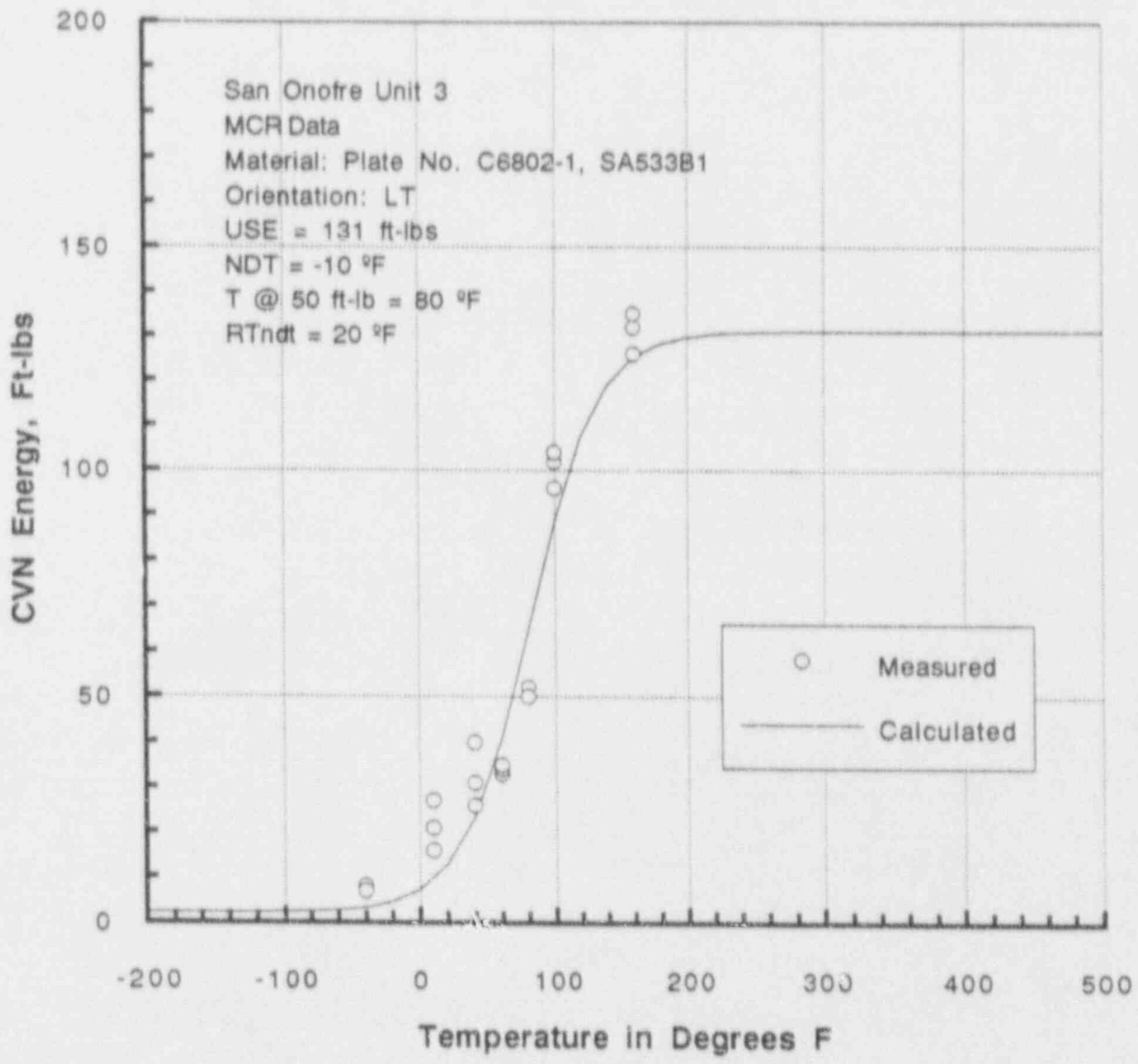

Figure 3-11. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Plate C6802-1, LT Orientation, MCR Data.

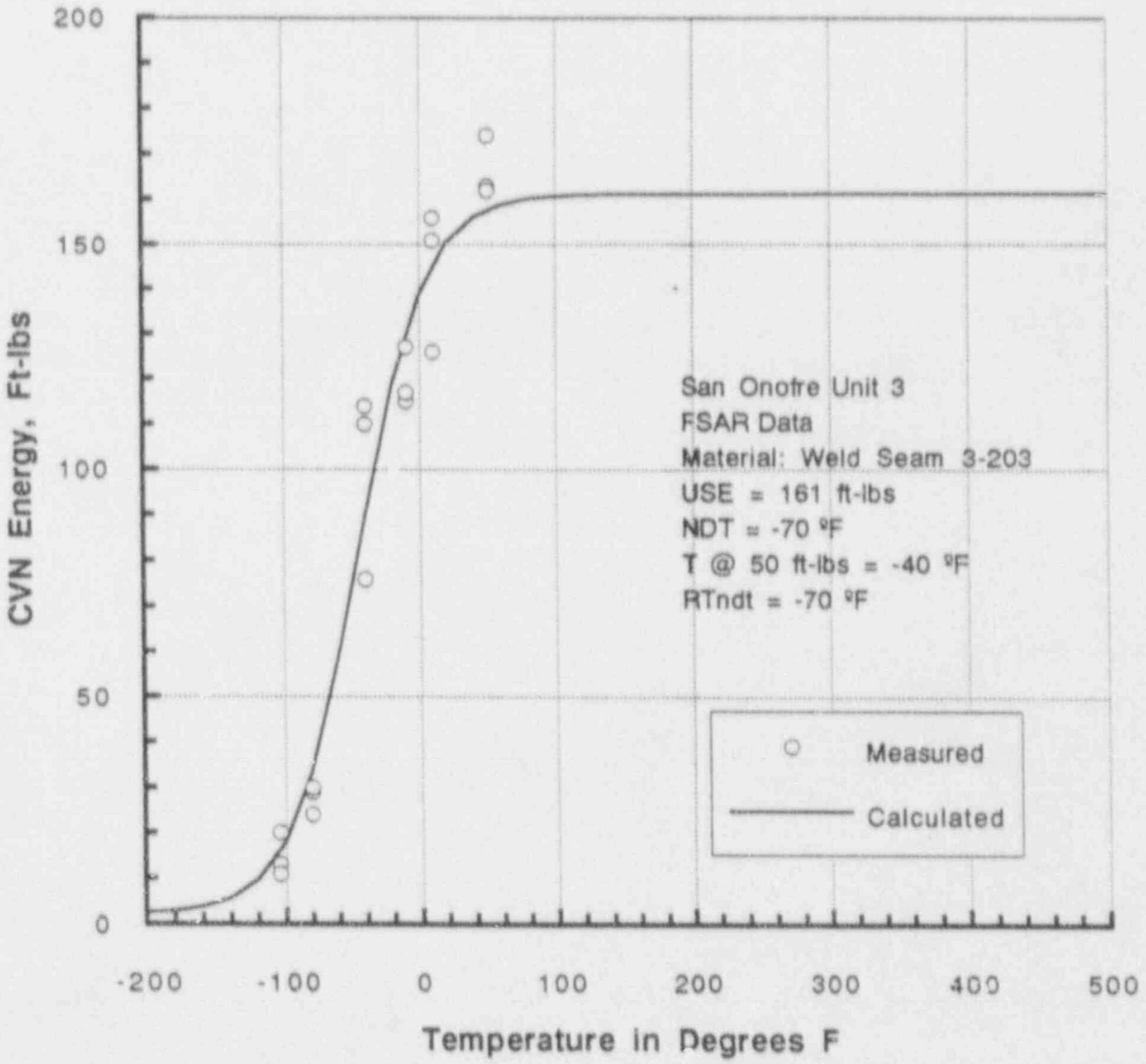

Figure 3-12. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Weld 3-203, FSAR Data

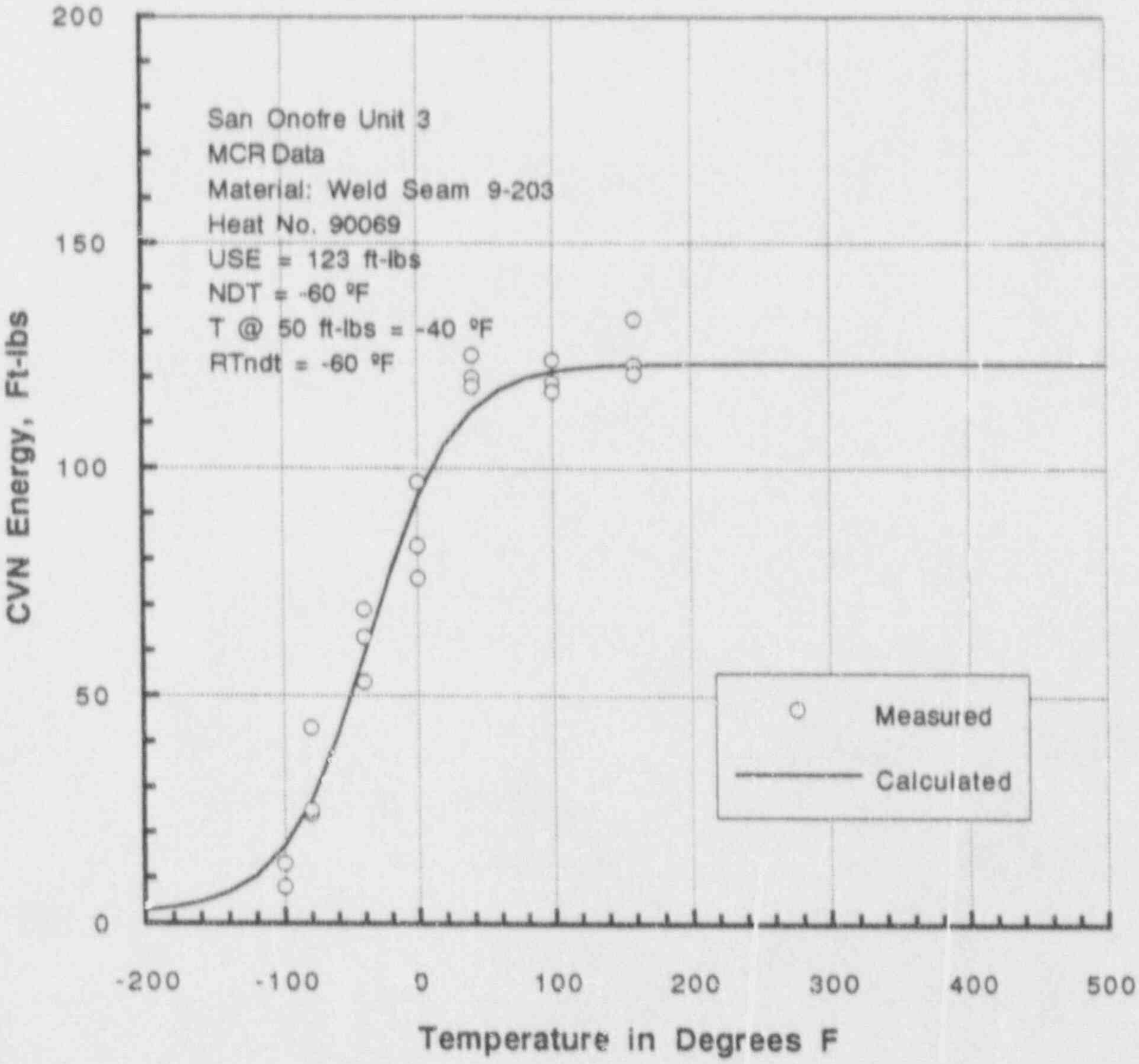

Figure 3-13. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Weld 9-203, MCR Data.

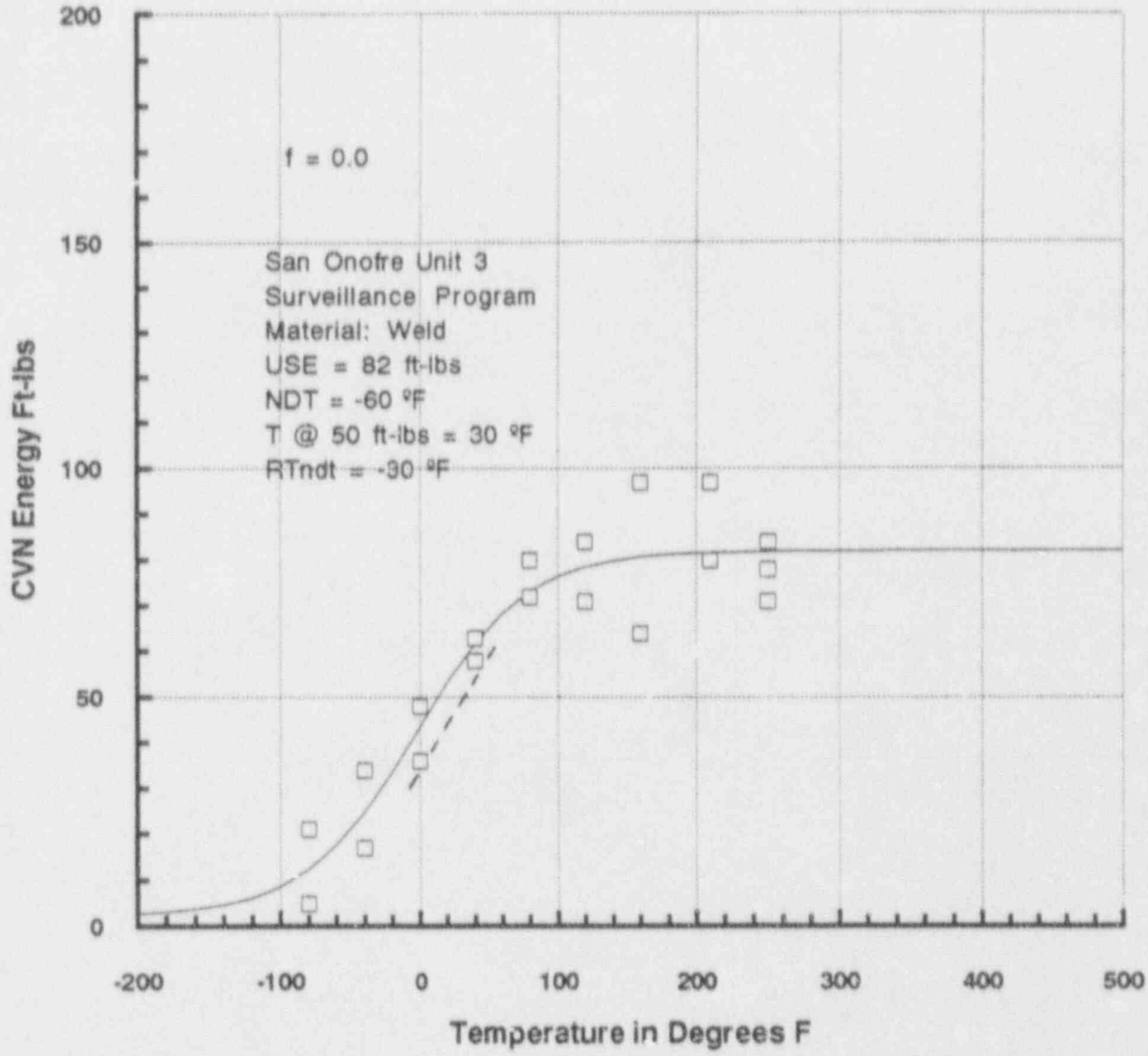

Figure 3-14. SONGS, Unit 3: Data and Least Squares Fit Curve for C_{VN} versus Temperature, Surveillance Weld, Surveillance Baseline Data.

Table 3.1 SONGS, Unit 3: 10CFR50 Appendix G - Areas of Non-Compliance.

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 represent-active 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. Only the heat-affected-zone from the most limiting plate was tested over an extended temperature range.	Consistent with ASME Code in effect.
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.

Table 3.1 (Continued)

Paragraph	Description of Non-Compliance	Comment
IV.A.4	Charpy V-notch test 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 60F below the lowest service temperature. All bolting material was tested at 10F and met the 35 ft-lb minimum requirement of the applicable ASME Code. All beltline plate materials and two beltline welds were tested to meet the current (1989) Code requirements in NB-2331. One beltline weld as tested at 20F and has C_{VN} in excess of 100 ft-lb. These results indicate that the intent of Appendix G has been met. One weld located away from the core region has been classified as a beltline weld because the Cu and Ni contents are currently not documented and high values have been assumed; these assumed Cu and Ni values result in the second largest shift, for the beltline materials. In addition, no C_{VN} data are currently available for this weld. Additional chemistry, fluence, and C_{VN} energy data will be required to complete the evaluation of weld 8-203 for compliance with Appendix G.

Table 3.2 SONGS, Unit 3: Plate and Corresponding Heat Numbers for the Beltline Plates.

Plate Number	Lukens Heat Number
C6802-1	C9195-2
C6802-2	C9218-2
C6802-3	C9195-1
C6802-4	C9220-1
C6802-5	C9218-1
C6802-6	B3388-1

Table 3.3 SONGS, Unit 3: Weld Wire and Flux Combinations for Beltline and Surveillance Welds.

Weld Seam	Weld Wire and Flux
2-203 A, B, and C	Type Mil B-4 Wire, Heat No. 83650 Linde Type 0091 Flux, Lot No. 1122
3-203 A, B, and C	Type Mil B-4 Wire, Heat No. 88114, Linde Type 0091 Flux, Lot No. 0145
9-203	Combination of (1) Type Mil B-4 Wire, Heat No. 90069, Linde Type 124 Flux, Lot No. 0951, and (2) Type Mil B-4 Wire, Heat No. 90144, Linde Type 124 Flux, Lot No. 1061
8-203	Presently not available
Surveillance	Presently not available. Currently reported by CE to be one of the weld wire heats used to fabricate beltline weld 9-203 [4].

Table 3.4 SONGS, Unit 3: Key Residual and Alloying Element Contents for Beltline Plates.

Plate Number	Cu[a]	Ni[a]	P[b]	S[b]	CF[c]
C6802-1	0.06	0.58	0.011	0.013	37
C6802-1	0.06[d]	0.58[d]	0.009[d]	0.014[d]	37
C6802-2	0.04	0.57	0.010	0.013	26
C6802-3	0.06	0.58	0.011	0.012	37
C6802-4	0.05	0.56	0.011	0.013	31
C6802-5	0.04	0.55	0.012	0.013	26
C6802-6	0.06	0.62	0.011	0.014	37

a. Average values reported by CE in Appendix B.

b. Values reported in the MCR.

c. Chemistry factors from Regulatory Guide 1.99, Revison 2

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

Table 3.5 SONGS, Unit 3: Key Residual and Alloying Element Contents for Beltline Welds

Weld Seam	Cu	Ni	P	S	CF[a]
2-203A,B,C[b]	0.05	1[c]	0.006	0.010	68
3-203A,B,C[b]	0.04	0.16	0.007	0.005	39
9-203[b]	0.05	0.04	0.007	0.011	31
9-203[d]	0.06	0.04	0.010	0.009	34
9-203[e]	0.05	0.04	N/A	N/A	31
8-203	0.35[f]	1[c]	N/A	N/A	272
Surveillance [g]	0.03	0.08	0.004	0.009	27
Surveillance [h]	0.03	0.11	0.014	0.008	29
Surveillance [h]	0.03	0.09	0.011	0.008	28

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

b. Values from FSAR

c. Ni content was not measured and 1 wt% has been assumed

d. Values from WMC for Type Mil B-4 Wire, Heat No. 90069, Linde Type 124 Flux, Lot No. 0951.

e. Preliminary information from CE for Type Mil B-4 Wire, Heat No. 90144, Linde Type 124 Flux, Lot No. 1061[4].

f. Cu content was not measured and 0.35% has been assumed

g. Measured when surveillance program was developed[1]

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

Table 3.6 SONGS, Unit 3: 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)
C6802-1[a]	-10[b]	75	NB2331 (a)(4)	94
C6802-2	-20	10	NB2331 (a)(3)	115
C6802-3	-10	20	NB2331 (a)(3)	105
C6802-4	-30	10	NB2331 (a)(3)	118
C6802-5	0	10	NB2331 (a)(3)	116
C6802-6	-40	20	NB2331 (a)(3)	92

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

b. Higher of 2 transverse values (i.e., -20°F determined when plate was purchased, and -10°F from surveillance baseline)

Table 3.7 SONGS, Unit 3: Charpy Absorbed Energy Values at 20°F for Weld Seams 2-203 A, B and C.

Weld Seam	Charpy Energy (ft-lb)
2-203 A, B, and C	125, 138, 145

Table 3.8 SONGS, Unit 3: 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	-40[a]	-40	NB-2331 (a)(2)	136[b]
3-203 A, B, C	-70[a]	-70	NB-2331 (a)(2)	161
8-203	N/A	-56	c	N/A
9-203	-60[d]	-60	NB-2331 (a)(2)	123
9-203[e]	-50	-50	--	N/A
Surveillance	-60	-30	NB-2331 (a)(4)	82

a. Values obtained from the FSAR

b. Estimated using the average of C_{VN} values obtained at +20°F (see Table 3.7)

c. Generic value for CE fabricated vessels using Linde 009, 1097, and 124 fluxes (see 10CFR50.61)

d. Value obtained from the WMC, for Type Mil B-4 Wire, Heat No. 90069, Linde Type 124 Flux, Lot No. 0951.

e. Preliminary values obtained from CE for Type Mil B-4 Wire, Heat No. 90144, Linde Type 124 Flux, Lot No. 1061[4].

Section 4

ISSUES RELATED TO GENERIC LETTER 88-11

NRC issued Generic Letter 88-11 (GL88-11) in July 1988. GL88-11 letter 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 Generic Letter 92-01 (GL92-01) 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 from 525 to 590°F. Concern is expressed in GL92-01 that power operation may occur at temperatures below 525°F. For SONGS, Unit 3 the reactor coolant cold leg temperature (T_c) is never below 545°F during power operation and rises to about 553°F at full power. Thus, there is no time during normal power operation that the SONGS, Unit 3 vessel or surveillance capsules experience temperatures below 545°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 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.[5] 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.[2] The peak fluence value at 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 4.2×10^{19} n/cm^2.[2] 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 8.5×10^{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 considered a beltline material because of a large chemistry factor associated with the unreported Cu and Ni contents. Because Cu was not reported, 0.35 wt % was conservatively assumed; and, because Ni was not reported, Ni was assumed at 1 wt %. The fluence at this location above the core has reported in the FSAR to be about 1/37 that of the peak fluence location within the vessel. Preliminary calculations performed at SCE indicate that the fluence at this weld location may be considerably lower than that indicated in the FSAR. Prior to final verification of the SCE fluence calculation at weld 8-203, the factor of 1/37 has been assumed to perform the evaluations in this report.

Within Regulatory Guide 1.99, Revision 2 there are five credibiiity 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 $\pm 25°F$), 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 3 surveillance program was tested in 1991. The C_{VN} results from this capsule are shown in Figures 4-1 (Plate C6802-1/LT), 4-2 (Plate C6802-1/TL), and 4-3 (surveillance weld). Appendix F 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 Westinghouse[2] are also shown for comparison. The differences between the current values for shift versus those from Westinghouse are due to small differences in the curve fit to the C_{VN} data and the different data set used for Plate C6802-1/TL (i.e., Figure 3-8 for Westinghouse and Figure 3-9 in the current study).

The measured shift result for plate C6802-1 are higher than the mean prediction from Regulatory Guide 1.99, Revision 2, but are within the mean plus two standard deviation value of 69°F (i.e., 35°F + 34°F = 69°F as compared to 45 - 58°F). The measured shift for the surveillance weld is much less than the mean shift prediction using Regulatory Guide 1.99, Revision 2. Until another capsule is tested, there is no way to definitively evaluate that the chemistry factors (CF) 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 GL92-01) 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 plate material C6802-1 which is the plate material in the surveillance program, is the limiting material in the vessel beltline. For weld seam 9-203 the properties from the weld wire heat 90069 was used for the predictions in Table 4-2; if the other weld wire heat (90144) was evaluated, the results would be 10°F higher due to the higher initial RT_{NDT}. Note the low levels of ART for all welds. The results in Table 4.2 show that the degree of radiation embrittlement in the SONGS, Unit 3 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 3 surveillance program was evaluated in 1991. The upper shelf energy results are shown in Figures 4-1, 4-2, and 4-3, and are tabulated in Table 4.3 as an absolute drop in upper shelf energy (ft-lb). Also listed in Table 4.3 are the predicted drops from Regulatory Guide 1.99, Revision 2. The measured drop for the surveillance weld is slightly below the value predicted using Regulatory Guide 1.99, Revision 2. The two measured upper shelf drops for plate C6802-1 are slightly higher than those predicted using the regulatory guide. The difference will be reassessed when additional surveillance capsule results are available (at about 15 EFPY); however, as shown in the following paragraph, current trends indicate an USE well above 50 ft-lb at 32 EFPY.

Predictions of upper shelf energy levels at the quarter-thickness location after neutron irradiation exposure are shown in Table 4.4 for all the SONGS, Unit 3 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. Because there are no upper shelf values for welds 8-203 and 9-203 (Heat 90144), these welds were not evaluated for drop in upper shelf. Since both of these welds were fabricated by CE using materials and procedures which produce initial upper shelves above 80 ft-lb, the upper shelf is projected to never drop below 50 ft-lb.

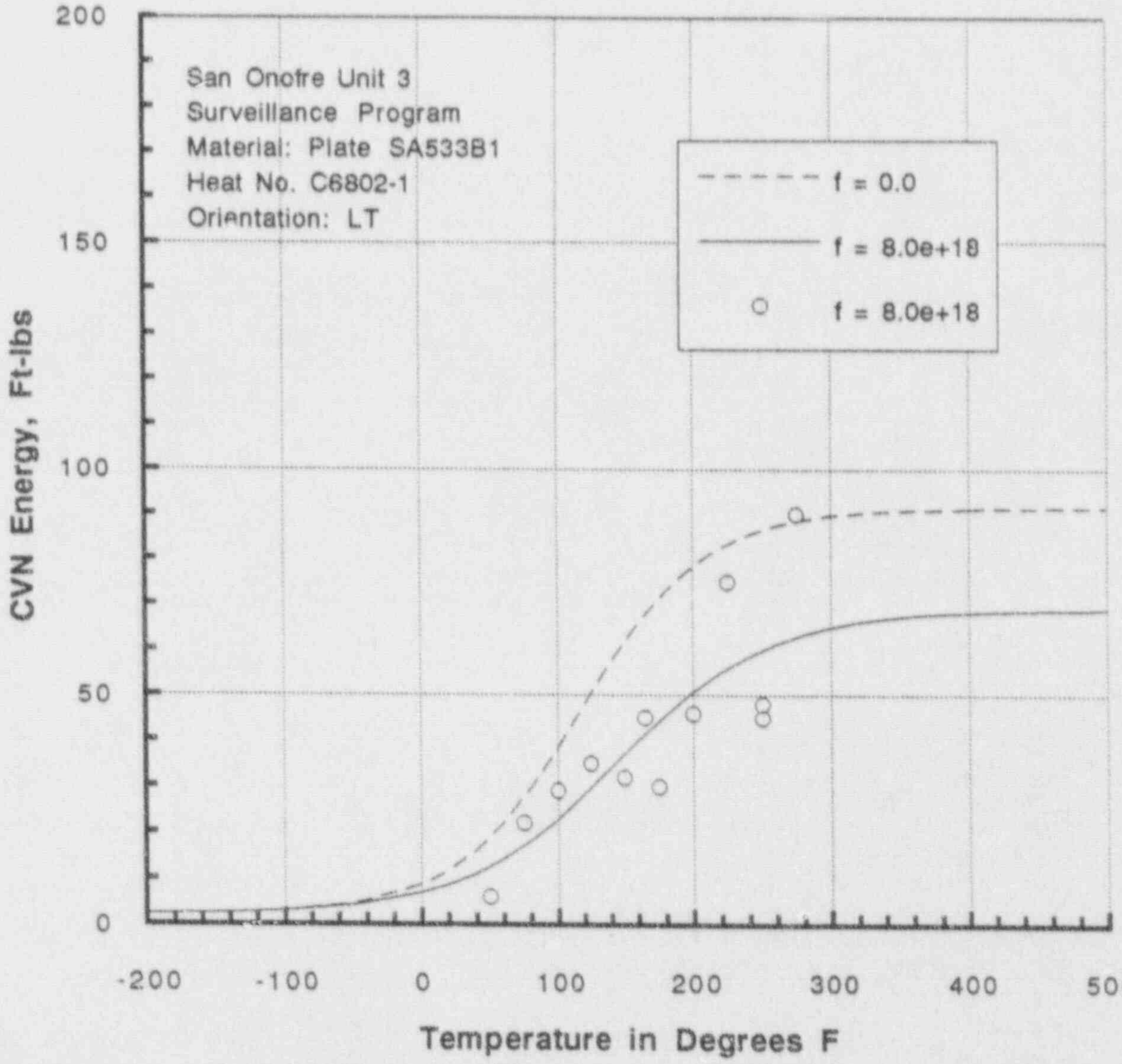

Figure 4-1. SONGS, Unit 3: Comparison of Irradiated C_{VN} Data from Capsule 97 with Unirradiated Baseline Data, Plate C6802-1, LT Orientation.

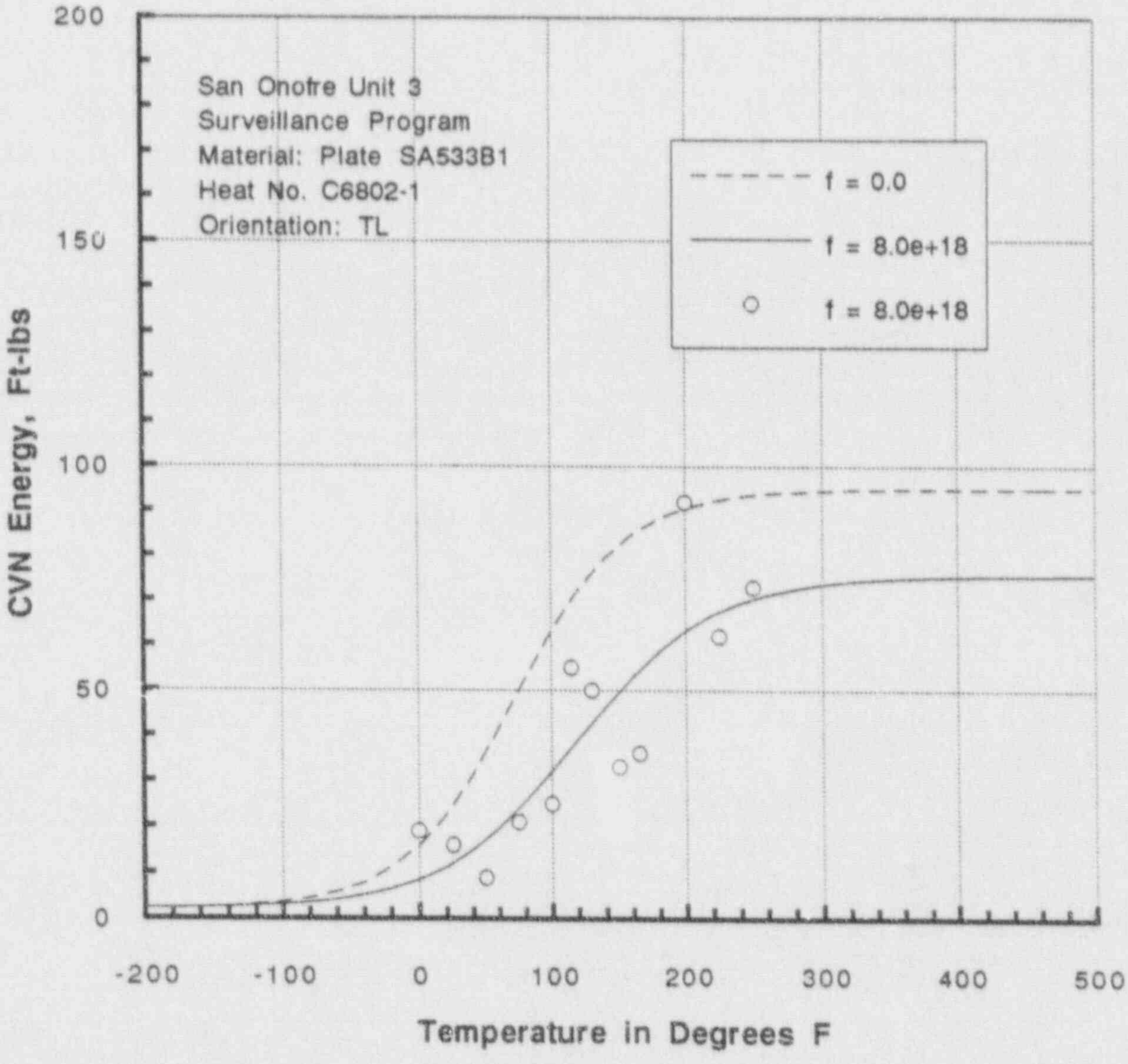

Figure 4-2. SONGS, Unit 3: Comparison of Irradiated C_{VN} Data from Capsule 97 with Unirradiated Baseline Data, Plate C6802-1, TL Orientation.

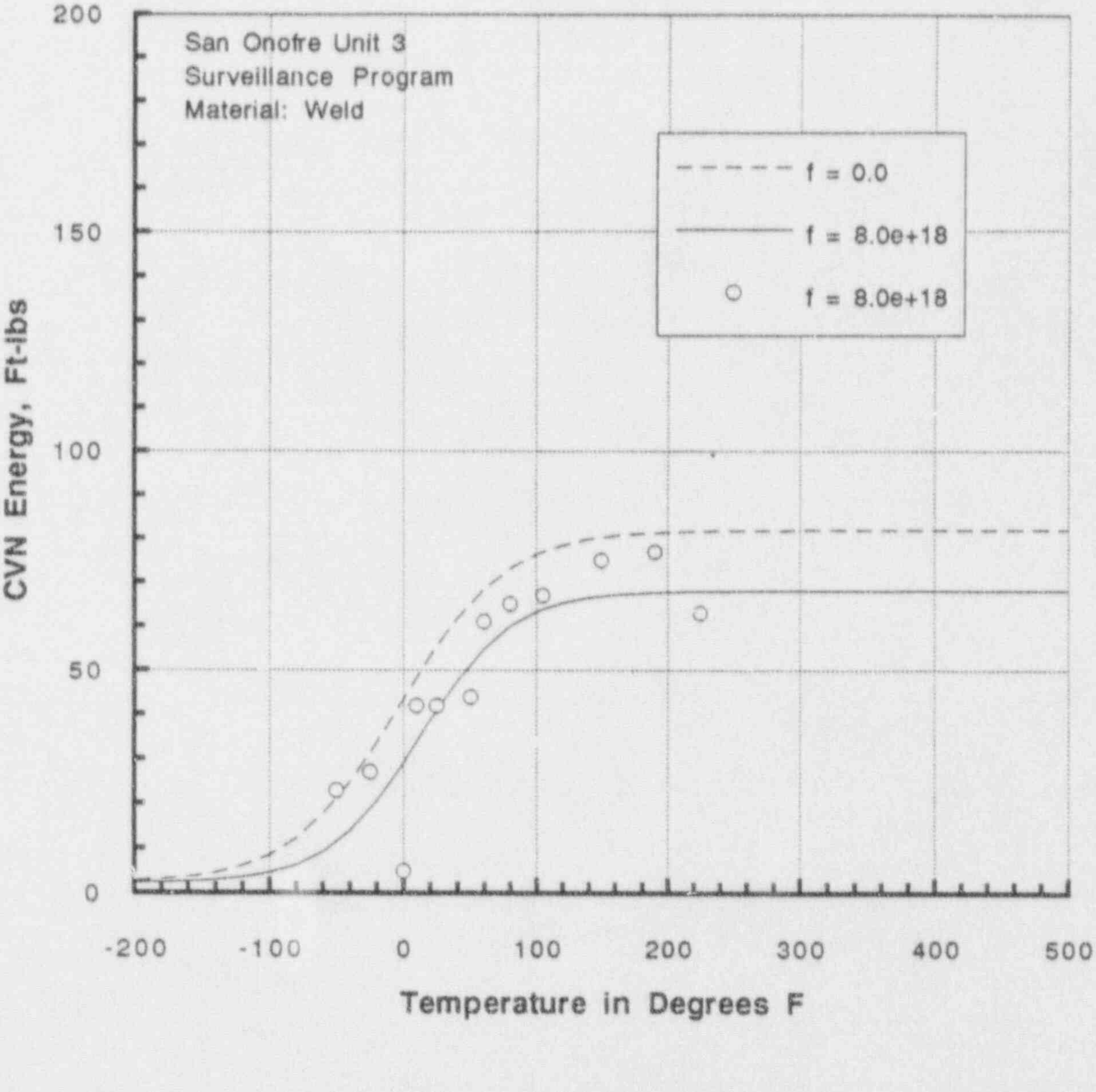

Figure 4-3. SONGS, Unit 3: Comparison of Irradiated C_{VN} data from Capsule 97 with Unirradiated Baseline Data, Surveillance Weld.

Table 4.1. SONGS, Unit 3: Surveillance Capsule Shift Results

Material/ Orientation	CF	ff	30 ft-lb Shift (°F)		
			W	RG1.99R2	Current
C6802-1/LT	37[a]	0.94	50	35	45[c]
C6802-1/TL	37[a]	0.94	55	35	58[d]
Surveillance Weld	28[b]	0.94	32	26	2[e]

[a] See Table 3.4 (Cu = .06; Ni = .58)

[b] Based upon the average chemistries -- see Table 3.5 (Cu = .03; Ni = .09)

[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 3-14.

Table 4.2. SONGS, Unit 3: ART Estimates at the Inner Surface Location for Beltline Materials on 12/16/91 and at 32 EFPY

Plate No./ Weld Seam	CF	ff at the Inner Surface		ART (F) [a] at the Inner Surface	
		12/16/91	32 EFPY	12/16/91	32 EFPY
C6802-1	37[b]	0.95	1.37	144	160
C6802-2	26	0.95	1.37	60	80
C6802-3	37	0.95	1.37	89	105
C6802-4	31	0.95	1.37	69	86
C6802-5	26	0.95	1.37	60	80
C6802-6	37	0.95	1.37	89	105
2-203	68	0.95	1.37	81	109
3-203	39	0.95	1.37	4	37
8-203	272	0.19[c]	0.42[c]	56[d]	130[d]
9-203	34	0.95	1.37	5	33

[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 34F for plates or 56F 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 measured chemistries for this plate (.06 Cu / .58 Ni) -- see Tables 3.4 and 4.1.

[c] ff is based upon the peak vessel fluence divided by 37 (as indicated in the FSAR)

[d] Since there is no 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 3: Surveillance Capsule Upper Shelf Results

Material/ Orientation	Cu (wt%)	Fluence ($\times 10^{19}$ n/cm)	Upper Shelf Drop (ft-lb) Battelle	RG1.99R2	Current
C6802-1/LT	0.06[a]	0.80	22	17	22[d]
C6802-1/TL	0.06[a]	0.80	16	17	18[e]
Surveillance Weld	0.03[b]	0.80	12	15[c]	14[f]

a See Table 3.4

b See Table 3.5

c Based upon the Regulatory Guide 1.99, Rev. 2 lowest percentage drop (18%) curve at the specified fluence times the measured unirradiated upper shelf determined in this report

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 3-14

Table 4.4. SONGS, Unit 3: Upper Shelf Estimates at the Quarter-Thickness Location for Beltline Materials on 12/16/91 and 32 EFPY

Plate No./ Weld Seam	Cu (wt%)	fluence (x 10^{19} n/cm) at Quarter-Thickness 12/16/91	fluence (x 10^{19} n/cm) at Quarter-Thickness 32 EFPY	Upper Shelf Energy (ft-lb)[a] at Quarter-Thickness 12/16/91	Upper Shelf Energy (ft-lb)[a] at Quarter-Thickness 32 EFPY
C6802-1	0.06[b]	0.51	2.5	79	72
C6802-2	0.04	0.51	2.5	96	88
C6802-3	0.06	0.51	2.5	88	80
C6802-4	0.05	0.51	2.5	99	90
C6802-5	0.04	0.51	2.5	97	89
C6802-6	0.06	0.51	2.5	77	70
2-203	0.05	0.51	2.5	114	104
3-203	0.04	0.51	2.5	135	123
9-203	0.06	0.51	2.5	102	92

[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 measured chemistry for this plate -- see Table 3.4

Section 5

REFERENCES

1. A. Ragl, Southern California Edison San Onofre Unit 3, Evaluation of Baseline Specimens, Reactor Vessel Materials Irradiation Surveillance Program, Combustion Engineering TR-S-MCS-004, November 30, 1979.

2. 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 1, November 1991.

3. M. P. Manahan and J. Garrabrandt, Testing and Analysis of Unirradiated Heat Effected-Zone (HAZ) Material from the San Onofre Nuclear Generating Station Unit 3 (SONGS-3), Battelle Columbus, May 31, 1989.

4. Telephone communication between S. Byrne and C. Stewart, CE, and D. Pilmer and S. Gosselin, SCE, June 15, 1992.

5. 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.

APPENDIX A

SONGS, UNIT 3: EVALUATION OF COMPLIANCE WITH ASTM E185-73 AND E185-82

Summary of Requirements per ASTM E185-73	San Onofre Unit 3 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 that 5 X 10^{18} n/cm^2	
4.1 Test Material - Test specimens shall be preparedfrom the actual materials used in fabricating the irradiated region of the reactor vessel.	To be confirmed based on resolving inconsistencies in: (1) Cu and Ni contents and C_{VN} curves reported for beltline and surveillance welds, and (2) C_{VN} curves reported for the LT orientation in beltline and surveillance plate materials.
4.1 Samples shall represent a 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 3 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.	To be confirmed based on resolving inconsistencies in: (1) Cu and Ni contents reported for beltline and surveillance welds, and (2) C_{VN} curves reported for the LT orientation in beltline and surveillance plates.
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	Compliance

Summary of Requirements per ASTM E185-73	**San Onofre Unit 3 Program**
obtained and include, but not be limited to phosphorus (P), sulfur (S), copper (Cu), and vanadium (V).	Compliance
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	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 3 Program
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)	
4.4 Number of Specimens - The minimum number of test specimens for each exposure shall be as follows:	Compliance

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

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	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 3 Program
closely as possible the neutron-flux spectrum, temperature history, and maximum accumulated neutron fluence experienced by the reactor vessel.	
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
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	Compliance

Summary of Requirements per ASTM E185-73	San Onofre Unit 3 Program
capsule.	
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
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

Summary of Requirements per ASTM E185-73	San Onofre Unit 3 Program
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.)	
6.1 Radiation Environment - The neutron flux, neutron energy spectrum, and irradiation temperature of surveillance specimens and the method of determination shall be documented.	
6.2 Neutron Flux Dosimeters - Flux dosimeters for a particular program shall be determined by referring to Method E 261.	

END

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 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
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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
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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	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
define the strength versus temperature relationship.	
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	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
where the measurements described in 9.2.3 are made.	
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
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) -	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
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
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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
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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
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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	Compliance

Summary of [illegible]quirements per ASTM E185-82	San Onofre Unit 3 Program
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.	
10.2 Charpy Test Data:	Compliance
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.	
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

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
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
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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
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11.1 Where applicable, both SI units and conventional units shall be reported.	
----------------	----------------
11.2 Surveillance Program Description - Description of the reactor vessel including the following: 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	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
the 1/4T locations.	
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11.2.5 Surveillance Material Selection: 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.	Compliance
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11.3 Surveillance Material Characterization: 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.	Compliance
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11.3.3 Test Specimen Design: 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	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
and instruments used in conducting the tests.	
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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.	
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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	

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
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.	
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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.	
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11.4.4 Other Fracture Toughness Tests:	Not Applicable

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
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
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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
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11.5 Application of Test Results: 11.5.1 Extrapolation of the neutron flux and fluence results to the surface and 1/4T locations of the reactor vessel	Compliance

Summary of Requirements per ASTM E185-82	San Onofre Unit 3 Program
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.	
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11.6 Deviations - Deviations or anomalies in procedure from this practice shall be identified and described fully in the report.	Compliance
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END

APPENDIX B

SONGS, UNIT 3: BASES FOR PLATE

CHEMISTRY MEASUREMENTS

ABB
ASEA BROWN BOVERI

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.)

ABB Combustion Engineering Nuclear Power

Combustion Engineering, Inc.
1000 Prospect Hill Road
Post Office Box 500
Windsor, Connecticut 06095-0500
Telephone (203) 688-1911
Fax (203) 285-9512
Telex 99297 COMBEN WSOR

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

APPENDIX C

SONGS, UNIT 3: MCRs FOR BELTLINE MATERIALS (Proprietary)

APPENDIX D

SONGS, UNIT 3: UNIRRADIATED C_{VN} DATA FOR PLATES AND WELDS

Table D-1 Charpy V-Notch Test Results
For Unit 3 Plate C6802-1 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	7.00	5.00	0.00
2	-40.00	6.00	4.00	0.00
3	-40.00	5.00	4.00	0.00
4	10.00	29.00	20.00	10.00
5	10.00	23.00	17.00	10.00
6	10.00	18.00	14.00	5.00
7	40.00	34.00	21.00	15.00
8	40.00	27.00	19.00	10.00
9	40.00	24.00	17.00	5.00
10	80.00	43.00	34.00	25.00
11	80.00	55.00	45.00	30.00
12	80.00	56.00	44.00	30.00
13	100.00	50.00	37.00	25.00
14	100.00	52.00	40.00	25.00
15	100.00	59.00	45.00	30.00
16	160.00	79.00	60.00	80.00
17	160.00	79.00	63.00	80.00
18	212.00	95.00	70.00	100.00
19	212.00	99.00	72.00	100.00
20	160.00	84.00	62.00	80.00
21	212.00	100.00	74.00	100.00

Table D-2 Charpy V-Notch Test Results
For Unit 3 Plate C6802-2 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	9.00	4.00	0.[illegible]
2	-40.00	6.00	3.00	0.00
3	-40.00	8.00	4.00	0.00
4	10.00	26.00	19.00	10.00
5	10.00	14.00	11.00	5.00
6	10.00	28.00	24.00	10.00
7	40.00	32.00	26.00	15.00
8	40.00	40.00	30.00	20.00
9	40.00	52.00	37.00	25.00
10	60.00	44.00	34.00	25.00
11	60.00	52.00	36.00	30.00
12	60.00	54.00	37.00	30.00
13	70.00	55.00	38.00	30.00
14	76.00	57.00	39.00	35.00
15	70.00	65.00	45.00	40.00
16	100.00	66.00	50.00	40.00
17	100.00	77.00	59.00	50.00
18	100.00	69.00	54.00	40.00
19	160.00	114.00	77.00	90.00
20	160.00	110.00	75.00	90.00
21	160.00	106.00	75.00	90.00
22	212.00	117.00	80.00	100.00
23	212.00	116.00	82.00	100.00
24	212.00	113.00	79.00	100.00

Table D-3 Charpy V-Notch Test Results
For Unit [illegible] Plate C6802-3 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	8.00	4.00	0.00
2	-40.00	7.00	3.00	0.00
3	-40.00	9.00	3.00	0.00
4	10.00	26.00	20.00	10.00
5	10.00	26.00	20.00	10.00
6	10.00	15.00	11.00	5.00
7	40.00	37.00	27.00	15.00
8	40.00	28.00	22.00	10.00
9	40.00	35.00	26.00	15.00
10	60.00	35.00	26.00	15.00
11	60.00	49.00	34.00	25.00
12	60.00	35.00	30.00	20.00
13	80.00	57.00	47.00	30.00
14	80.00	52.00	40.00	25.00
15	80.00	60.00	46.00	40.00
16	100.00	79.00	60.00	60.00
17	100.00	70.00	54.00	50.00
18	100.00	63.00	46.00	40.00
19	160.00	100.00	71.00	90.00
20	160.00	95.00	69.00	90.00
21	160.00	94.00	67.00	90.00
22	212.00	106.00	76.00	100.00
23	212.00	109.00	78.00	100.00
24	212.00	101.00	72.00	100.00

Table D-4 Charpy V-Notch Test Results
For Unit 3 Plate C6802-4 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	10.00	6.00	0.00
2	-40.00	14.00	8.00	0.00
3	-40.00	10.00	6.00	0.00
4	10.00	25.00	18.00	10.00
5	10.00	28.00	20.00	10.00
6	10.00	19.00	13.00	5.00
7	40.00	35.00	30.00	20.00
8	40.00	39.00	32.00	20.00
9	40.00	51.00	37.00	25.00
10	60.00	48.00	35.00	20.00
11	60.00	54.00	39.00	25.00
12	60.00	49.00	34.00	20.00
13	70.00	76.00	53.00	50.00
14	70.00	63.00	47.00	40.00
15	70.00	59.00	44.00	35.00
16	100.00	104.00	65.00	60.00
17	100.00	69.00	52.00	40.00
18	100.00	70.00	54.00	40.00
19	160.00	124.00	80.00	95.00
20	160.00	112.00	71.00	90.00
21	160.00	104.00	70.00	90.00
22	212.00	118.00	78.00	100.00
23	212.00	117.00	81.00	100.00
24	212.00	115.00	77.00	100.00

Table D-5 Charpy V-Notch Test Results
For Unit 3 Plate C6802-5 (TL), MCR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-40.00	9.00	4.00	0.00
2	-40.00	10.00	5.00	0.00
3	-40.00	9.00	3.00	0.00
4	10.00	18.00	12.00	5.00
5	10.00	27.00	20.00	10.00
6	10.00	15.00	11.00	5.00
7	40.00	34.00	23.00	15.00
8	40.00	35.00	24.00	15.00
9	40.00	35.00	25.00	15.00
10	60.00	39.00	26.00	15.00
11	60.00	39.00	28.00	15.00
12	60.00	38.00	27.00	15.00
13	70.00	65.00	43.00	30.00
14	70.00	57.00	40.00	30.00
15	70.00	51.00	37.00	25.00
16	100.00	66.00	47.00	30.00
17	100.00	70.00	49.00	35.00
18	100.00	79.00	56.00	40.00
19	160.00	118.00	78.00	100.00
20	160.00	116.00	75.00	100.00
21	160.00	109.00	65.00	90.00
22	212.00	119.00	78.00	100.00
23	212.00	110.00	72.00	100.00
24	212.00	117.00	74.00	100.00

Table D-6 Charpy V-Notch Test Results
For Unit 3 Plate C6802-6 (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	10.00	4.00	0.00
3	-40.00	8.00	4.00	0.00
4	10.00	23.00	17.00	10.00
5	10.00	28.00	20.00	10.00
6	10.00	25.00	18.00	10.00
7	40.00	34.00	26.00	15.00
8	40.00	43.00	34.00	20.00
9	40.00	33.00	26.00	15.00
10	70.00	50.00	39.00	25.00
11	70.00	46.00	35.00	20.00
12	70.00	58.00	45.00	30.00
13	80.00	52.00	40.00	25.00
14	80.00	57.00	45.00	30.00
15	80.00	53.00	41.00	25.00
16	100.00	50.00	42.00	30.00
17	100.00	65.00	51.00	50.00
18	100.00	59.00	46.00	40.00
19	160.00	96.00	72.00	95.00
20	160.00	90.00	69.00	90.00
21	160.00	83.00	65.00	90.00
22	212.00	90.00	70.00	100.00
23	212.00	92.00	71.00	100.00
24	212.00	92.00	70.00	100.00

Table D-7 Charpy V-Notch Test Results
For Unit 3 Weld Seam 9-203 (Heat #90067), WMC Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-100.00	13.00	8.00	0.00
2	-100.00	8.00	4.00	0.00
3	-100.00	13.00	5.00	0.00
4	-80.00	24.00	15.00	5.00
5	-80.00	43.00	31.00	20.00
6	-80.00	25.00	17.00	5.00
7	-40.00	53.00	36.00	25.00
8	-40.00	69.00	50.00	40.00
9	-40.00	63.00	44.00	35.00
10	0.00	83.00	60.00	50.00
11	0.00	76.00	52.00	40.00
12	0.00	97.00	67.00	60.00
13	40.00	120.00	82.00	90.00
14	40.00	118.00	80.00	90.00
15	40.00	125.00	82.00	100.00
16	100.00	119.00	78.00	100.00
17	100.00	117.00	78.00	100.00
18	100.00	124.00	83.00	100.00
19	160.00	123.00	82.00	100.00
20	160.00	121.00	81.00	100.00
21	160.00	133.00	82.00	100.00

Table D-8 Charpy V-Notch Test Results
For Unit 3 Weld Seam 3-203 (Heat #88114), FSAR Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
1	-104.00	13.00	7.00	0.00
2	-104.00	11.00	6.00	0.00
3	-104.00	20.00	13.00	5.00
4	-80.00	29.00	22.00	10.00
5	-80.00	30.00	21.00	10.00
6	-80.00	24.00	13.00	10.00
7	-40.00	110.00	66.00	60.00
8	-40.00	76.00	48.00	40.00
9	-40.00	114.00	68.00	60.00
10	-10.00	127.00	70.00	80.00
11	-10.00	115.00	64.00	70.00
12	-10.00	117.00	68.00	70.00
13	10.00	126.00	78.00	80.00
14	10.00	151.00	81.00	100.00
15	10.00	156.00	84.00	100.00
16	50.00	174.00	86.00	100.00
17	50.00	163.00	85.00	100.00
18	50.00	162.00	83.00	100.00

Table D-9 Charpy V-Notch Test Results
For Unit 3 Plate C6802-1 (TL), CE Baseline Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
252	-40.00	13.00	12.00	0.00
23E	0.00	14.00	12.00	10.00
26J	0.00	23.00	24.00	5.00
22P	40.00	18.00	17.00	10.00
26D	40.00	52.00	45.00	20.00
22K	80.00	25.00	25.00	20.00
263	80.00	57.00	50.00	40.00
23Y	100.00	42.00	40.00	30.00
25M	100.00	74.00	60.00	40.00
24T	100.00	88.00	65.00	50.00
25E	120.00	85.00	73.00	50.00
267	120.00	106.00	80.00	80.00
23A	160.00	61.00	60.00	60.00
221	160.00	63.00	58.00	70.00
25Y	160.00	113.00	81.00	90.00
23P	210.00	96.00	74.00	90.00
255	210.00	109.00	82.00	100.00
21K	250.00	80.00	71.00	100.00
22A	250.00	87.00	73.00	100.00

Table D-10 Charpy V-Notch Test Result
For Unit 3 Plate C6802-1 (LT), CE Baseline Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
151	0.00	6.50	5.00	0.00
146	40.00	15.00	13.00	10.00
127	40.00	16.00	15.00	10.00
11U	80.00	33.50	30.00	30.00
13H	80.00	39.50	36.00	30.00
14C	120.00	36.00	37.00	40.00
126	120.00	45.00	41.00	40.00
14B	160.00	51.00	47.00	60.00
13U	160.00	83.00	70.00	80.00
13E	210.00	66.00	62.00	70.00
14T	210.00	96.00	81.00	80.00
11L	250.00	90.00	80.00	100.00
11C	250.00	93.00	87.00	100.00

Table D-11 Charpy V-Notch Test Results
For Unit 3 Surveillance Weld, CE Baseline Data

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
31Y	-80.00	5.00	5.00	0.00
37C	-80.00	21.00	19.00	20.00
32C	-40.00	17.00	18.00	20.00
36M	-40.00	34.00	31.00	30.00
36C	0.00	36.00	34.00	30.00
36T	0.00	48.00	45.00	40.00
37E	40.00	58.00	53.00	40.00
3A2	40.00	63.00	56.00	60.00
35Y	80.00	72.00	65.00	80.00
34M	80.00	80.00	82.00	100.00
376	120.00	71.00	65.00	80.00
33K	120.00	84.00	79.00	90.00
316	160.00	64.00	67.00	70.00
344	160.00	97.00	90.00	100.00
32K	210.00	80.00	85.00	90.00
31C	210.00	97.00	84.00	90.00
35M	250.00	71.00	69.00	100.00
372	250.00	78.00	73.00	100.00
34E	250.00	84.00	82.00	100.00

Table D-12 Charpy V-Notch Test Results
For Unit 3 Plate C6802-1 (LT), MCR Data

Test Temperature (°F)	Impact Energy (ft-lbs)	Lateral Expansion (mils)	Fracture Appearance (% Shear)
-40	8	3	0
-40	7	2	0
-40	7	2	0
10	16	10	5
10	21	13	5
10	27	18	10
40	40	27	15
40	26	17	10
40	31	23	10
60	33	25	15
60	34	25	15
60	35	24	15
80	50	39	20
80	52	40	25
80	50	38	20
100	102	65	70
100	104	61	70
100	96	63	60
160	126	81	100
160	132	84	100
160	135	83	100

APPENDIX E

SONGS, UNIT 3: HAZ TEST RESULTS

CE Baseline Tests[1]

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
47L	-80.00	6.00	4.00	0.00
45B	-80.00	6.00	4.00	0.00
42Y	-40.00	30.00	26.00	10.00
436	-40.00	30.00	26.00	10.00
45J	0.00	30.00	25.00	20.00
45Y	0.00	46.00	37.00	30.00
42J	40.00	33.00	34.00	20.00
42K	40.00	35.00	32.00	20.00
42U	80.00	73.00	48.00	80.00
454	80.00	79.00	63.00	50.00
471	120.00	42.00	41.00	60.00
475	120.00	50.00	49.00	70.00
43C	160.00	61.00	62.00	80.00
43K	160.00	87.00	72.00	90.00
46K	210.00	57.00	57.00	70.00
444	210.00	105.00	73.00	100.00
46A	250.00	63.00	66.00	100.00
42T	250.00	75.00	68.00	100.00
46Y	250.00	98.00	80.00	100.00

Westinghouse Capsule 97[2]

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)	CHARPY FLUENCE (n/cm2)	IRRAD TEMP. (F)
441	-75.00	9.00	8.00	5.00	8.00E+18	550.00
42L	-50.00	18.00	16.00	15.00	8.00E+18	550.00
45C	-20.00	3.00	4.00	5.00	8.00E+18	550.00
43P	0.00	26.00	23.00	35.00	8.00E+18	550.00
464	25.00	35.00	37.00	45.00	[illegible] 00E+18	550.00
[illegible]	[illegible].00	33.00	33.00	50.[illegible]	8.00E+18	550.00
[illegible]	[illegible]	43.00	44.00	75.00	8.[illegible]E+18	550.00
46[illegible]	[illegible]	41.00	38.00	70.00	8.00E+18	550.00
[illegible]	[illegible]	45.00	44.00	80.00	8.00E+18	550.00
[illegible]	[illegible]	63.00	61.00	100.00	8.00E+18	550.00
[illegible]	[illegible].00	84.00	68.00	100.00	8.00E+18	550.00
434	250.00	75.00	65.00	100.00	8.00E+18	550.00

Battelle Columbus Additional Unirradiated HAZ Results[3]

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
3S1	-120.00	7.50	5.00	11.00
3S3	-120.00	9.50	3.20	9.30
1S11	-80.00	23.50	13.00	12.40
1S12	-80.00	26.00	16.60	17.80
1S17	-40.00	27.50	21.80	13.10
3S4	-40.00	57.00	36.20	31.10
3S5	0.00	39.50	31.80	49.20
1S9	0.00	64.50	43.20	55.40
1S16	20.00	61.50	46.60	52.00
1S5	20.00	76.00	49.80	54.70
1S3	20.00	82.00	50.60	56.30
1S18	40.00	93.00	63.80	63.10
1S10	40.00	99.00	64.00	73.40
1S13	40.00	105.00	64.40	72.90
1S8	80.00	113.00	72.60	100.00
1S6	80.00	115.00	65.00	100.00
1S4	120.00	122.00	83.40	100.00
1S14	120.00	160.00	86.60	100.00
1S7	160.00	128.00	87.20	100.00
1S2	160.00	153.00	82.20	100.00
3S6	210.00	118.00	78.80	100.00
1S15	210.00	132.00	75.80	100.00

APPENDIX F

SONGS, UNIT 3: IRRADIATED C_{VN} DATA FROM CAPSULE 97

Table F-1 Charpy V-Notch Test Results
For Unit 3 Plate C6802-1 (LT)
Irradiated ($f = 8 \times 10^{18}\ n/cm^2$)

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
147	50.00	6.00	5.00	5.00
153	75.00	22.00	15.00	15.00
15K	100.00	29.00	24.00	25.00
113	125.00	35.00	32.00	30.00
14Y	150.00	32.00	26.00	30.00
15B	165.00	45.00	43.00	45.00
14A	175.00	30.00	27.00	45.00
14E	200.00	46.00	46.00	55.00
11T	225.00	75.00	66.00	80.00
12K	250.00	45.00	48.00	80.00
12L	250.00	48.00	46.00	95.00
14M	275.00	90.00	76.00	100.00

Table F-2 Charpy V-Notch Test Results
For Unit 3 Plate C6802-1 (TL)
Irradiated ($f = 8 \times 10^{18}$ n/cm^2)

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
25U	0.00	19.00	18.00	10.00
23K	25.00	16.00	11.00	10.00
21A	50.00	9.00	12.00	10.00
23L	75.00	21.00	20.00	15.00
22B	100.00	25.00	25.00	20.00
25J	115.00	55.00	48.00	45.00
25L	130.00	50.00	41.00	50.00
247	150.00	33.00	33.00	50.00
223	165.00	36.00	37.00	65.00
25C	200.00	92.00	73.00	100.00
245	225.00	62.00	59.00	100.00
23M	250.00	73.00	77.00	100.00

Table F-3 Charpy V-Notch Test Results
For Unit 3 Surveillance Weld
Irradiated ($f = 8 \times 10^{18}$ n/cm^2)

SPECIMEN ID	TEMP TEST (F)	ENERGY IMPACT (ft-lb)	LATERAL EXP (mil)	FRACT APPEAR (%)
363	-50.00	23.00	20.00	15.00
33L	-25.00	27.00	25.00	20.00
31D	0.00	5.00	6.00	5.00
37B	10.00	42.00	34.00	60.00
367	25.00	42.00	44.00	65.00
331	50.00	44.00	44.00	70.00
37U	60.00	61.00	57.00	95.00
371	80.00	65.00	59.00	95.00
365	105.00	67.00	60.00	100.00
34P	150.00	75.00	73.00	100.00
33D	190.00	77.00	76.00	100.00
377	225.00	63.00	58.00	100.00