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Analysis of Capsule W from the Southern Nuclear Operating Company, Vogtle Unit 2 Reactor Vessel Radiation Surveillance Program

Westinghouse

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Analysis of Capsule W from the Southern Nuclear Operating Company, Vogtle Unit 2 Reactor Vessel Radiation Surveillance Program

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PREFACE

This report has been technically reviewed and verified by:

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TABLE OF CONTENTS

PREFACE iii

LIST OF TABLES v

LIST OF FIGURES vii

EXECUTIVE SUMMARY ix

1 SUMMARY OF RESULTS 1-1

2 INTRODUCTION 2-1

3 BACKGROUND 3-1

4 DESCRIPTION OF PROGRAM 4-1

5 TESTING OF SPECIMENS FROM CAPSULE W 5-1
- 5.1 OVERVIEW 5-1
- 5.2 CHARPY V-NOTCH IMPACT TEST RESULTS 5-3
- 5.3 TENSILE TEST RESULTS 5-4
- 5.4 1/2T COMPACT TENSION SPECIMEN TESTS 5-5

6 RADIATION ANALYSIS AND NEUTRON DOSIMETRY 6-1
- 6.1 INTRODUCTION 6-1
- 6.2 DISCRETE ORDINATES ANALYSIS 6-2
- 6.3 NEUTRON DOSIMETRY 6-4
- 6.4 CALCULATIONAL UNCERTAINTIES 6-5

7 SURVEILLANCE CAPSULE REMOVAL SCHEDULE 7-1

8 REFERENCES 8-1

APPENDIX A VALIDATION OF THE RADIATION TRANSPORT MODELS BASED ON NEUTRON DOSIMETRY MEASUREMENTS A-0

APPENDIX B LOAD-TIME RECORDS FOR CHARPY SPECIMEN TESTS B-0

APPENDIX C CHARPY V-NOTCH PLOTS FOR EACH CAPSULE USING HYPERBOLIC TANGENT CURVE-FITTING METHOD C-0

APPENDIX D VOGTLE UNIT 2 SURVEILLANCE PROGRAM CREDIBILITY EVALUATION D-0

LIST OF TABLES

Table 4-1 Chemical Composition (wt %) of the Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 4-3

Table 4-2 Chemical Composition (wt %) of the Unirradiated Vogtle Unit 2 Reactor Vessel Beltline Region Weld Materials 4-4

Table 4-3 Heat Treatment of the Vogtle Unit 2 Reactor Vessel Surveillance Material 4-5

Table 5-1 Charpy V-Notch Data for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0 MeV) (*Longitudinal Orientation*) 5-6

Table 5-2 Charpy V-notch Data for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E> 1.0 MeV) (*Transverse Orientation*) 5-7

Table 5-3 Charpy V-notch Data for the Vogtle Unit 2 Surveillance Weld Metal Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0 MeV) 5-8

Table 5-4 Charpy V-notch Data for the Vogtle Unit 2 Heat Affected Zone Material Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0 MeV) 5-9

Table 5-5 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0 MeV) (*Longitudinal Orientation*) 5-10

Table 5-6 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0 MeV) (*Transverse Orientation*) 5-11

Table 5-7 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Surveillance Weld Metal Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0MeV) 5-12

Table 5-8 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Heat-Affected-Zone (*HAZ*) Metal Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E > 1.0MeV) 5-13

Table 5-9 Effect of Irradiation to 2.98×10^{19} n/cm^2 (E > 1.0 MeV) on the Notch Toughness Properties of the Vogtle Unit 2 Reactor Vessel Surveillance Materials 5-14

Table 5-10 Comparison of the Vogtle Unit 2 Surveillance Material 30 ft-lb Transition Temperature Shifts and Upper Shelf Energy Decreases with Regulatory Guide 1.99, Revision 2, Predictions 5-15

LIST OF TABLES (Cont.)

Table 5-11 Tensile Properties of the Vogtle Unit 2 Reactor Vessel Surveillance Materials Irradiated to 2.98 x 10^{19} n/cm^2 (E > 1.0MeV) 5-16

Table 6-1 Calculated Fast Neutron Exposure Rates and Integrated Exposures at the Surveillance Capsule Center 6-11

Table 6-2 Calculated Azimuthal Variation of Maximum Exposure Rates and Integrated Exposures at the Reactor Vessel Clad/Base Metal Interface 6-15

Table 6-3 Relative Radial Distribution of Neutron Fluence (E > 1.0 MeV) Within the Reactor Vessel Wall 6-19

Table 6-4 Relative Radial Distribution of Iron Atom Displacements (dpa) Within the Reactor Vessel Wall 6-19

Table 6-5 Calculated Fast Neutron Exposure of Surveillance Capsules Withdrawn from Alvin W. Vogtle Unit 2 6-20

Table 6-6 Calculated Surveillance Capsule Lead Factors 6-20

Table 7-1 Vogtle Unit 2 Reactor Vessel Surveillance Capsule Withdrawal Schedule 7-1

LIST OF FIGURES

Figure 4-1 Arrangement of Surveillance Capsules in the Vogtle Unit 2 Reactor Vessel 4-6

Figure 4-2 Capsule W Diagram Showing the Location of Specimens, Thermal Monitors, and Dosimeters 4-7

Figure 5-1 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)..................5-17

Figure 5-2 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)..................5-18

Figure 5-3 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)..................5-19

Figure 5-4 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)..................5-20

Figure 5-5 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)..................5-21

Figure 5-6 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)..................5-22

Figure 5-7 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Weld Metal 5-23

Figure 5-8 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Weld Metal..................5-24

Figure 5-9 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Weld Metal..................5-25

Figure 5-10 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Material..................5-26

Figure 5-11 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Material..................5-27

Figure 5-12 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Material..................5-28

LIST OF FIGURES (Cont.)

Figure 5-13 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*) 5-29

Figure 5-14 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*) 5-30

Figure 5-15 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Weld Metal 5-31

Figure 5-16 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Metal 5-32

Figure 5-17 Tensile Properties for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (Longitudinal Orientation) 5-33

Figure 5-18 Tensile Properties for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (Transverse Orientation) 5-34

Figure 5-19 Tensile Properties for Vogtle Unit 2 Reactor Vessel Weld Metal 5-35

Figure 5-20 Fractured Tensile Specimens from Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*) 5-36

Figure 5-21 Fractured Tensile Specimens from Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*) 5-37

Figure 5-22 Fractured Tensile Specimens from Vogtle Unit 2 Reactor Vessel Weld Metal 5-38

Figure 5-23 Engineering Stress-Strain Curves for Lower Shell Plate B8628-1 Tensile Specimens BL7, BL8 and BL9 (*Longitudinal Orientation*) 5-39

Figure 5-24 Engineering Stress-Strain Curves for Lower Shell Plate B8628-1 Tensile Specimen BT7, BT8 and BT9 (*Transverse Orientation*) 5-40

Figure 5-25 Engineering Stress-Strain Curves for Weld Metal Tensile Specimens BW7, BW8 and BW9 5-41

Figure 6-1 Alvin W. Vogtle Unit 2 r,θ Reactor Geometry 6-7

Figure 6-2 Alvin W. Vogtle Unit 2 r,z Reactor Geometry with Neutron Pad 6-10

EXECUTIVE SUMMARY

The purpose of this report is to document the results of the testing of surveillance Capsule W from Vogtle Unit 2. Capsule W was removed at 13.29 EFPY and post irradiation mechanical tests of the Charpy V-notch and tensile specimens were performed. A fluence evaluation utilizing the recently released neutron transport and dosimetry cross-section libraries was derived from the ENDF/B-VI data-base. Capsule W received a fluence of 2.98 x 10^{19} n/cm^2 (E > 1.0 MeV) after irradiation to 13.29 EFPY. The peak clad/base metal interface vessel fluence after 13.29 EFPY of plant operation was 7.20 x 10^{18} n/cm^2 (E > 1.0 MeV).

This evaluation lead to the following conclusions: 1) The measured 30 ft-lb transition temperature shift value for the lower shell plate B8628-1 (*longitudinal orientation*) is less than the Regulatory Guide 1.99, Revision 2, prediction. 2) The measured 30 ft-lb transition temperature shift value for the lower shell plate B8628-1 (*transverse orientation*) is greater than the Regulatory Guide 1.99, Revision 2, prediction. However, the shift value is less than the two sigma allowance by the Regulatory Guide 1.99, Revision 2, when calculating adjusted reference temperatures. 3) The measured 30 ft-lb transition temperature shift value for the surveillance weld metal is less than the Regulatory Guide 1.99, Revision 2, prediction. 4) The measured percent decrease in upper shelf energy for all the surveillance materials of Capsules W contained in the Vogtle Unit 2 surveillance program are less than the Regulatory Guide 1.99, Revision 2 predictions. 5) All beltline materials exhibit a more than adequate upper shelf energy level for continued safe plant operation and are predicted to maintain an upper shelf energy greater than 50 ft-lb throughout the current license (36 EFPY) and a potential license renewal date of 54 EFPY as required by 10CFR50, Appendix G [2]. 6) The Vogtle Unit 2 surveillance plate and weld data is credible. This evaluation can be found in Appendix D. 7) The PT Curves from WCAP-15161, Revision 3 are still acceptable for 26 EFPY and 36 EFPY.

Lastly, a brief summary of the Charpy V-notch testing can be found in Section 1. All Charpy V-notch data was plotted using a symmetric hyperbolic tangent curve fitting program.

1 SUMMARY OF RESULTS

The analysis of the reactor vessel materials contained in surveillance capsule W, the fourth capsule to be removed from the Vogtle Electric Generating Plant Unit 2 reactor pressure vessel, led to the following conclusions:

- The Capsule W results presented in this report were generated using CVGRAPH, Version 5.0.2, which is a hyperbolic tangent curve-fitting program. Appendix C presents the Capsule W CVGRAPH, Version 5.0.2, Charpy V-notch plots and the program input data.

- Capsule W received an average fast neutron fluence (E> 1.0 MeV) of 2.98 x 10^{19} n/cm^2 after 13.29 effective full power years (EFPY) of plant operation.

- Irradiation of the reactor vessel lower shell plate B8628-1 Charpy specimens, oriented with the longitudinal axis of the specimen parallel to the major rolling direction (*Longitudinal orientation*), to 2.98 x 10^{19} n/cm^2 (E> 1.0MeV) resulted in a 30 ft-lb transition temperature increase of 39°F and a 50 ft-lb transition temperature increase of 43.6°F. This results in an irradiated 30 ft-lb transition temperature of 47.8°F and an irradiated 50 ft-lb transition temperature of 89.0°F for the Longitudinal oriented specimens.

- Irradiation of the reactor vessel lower shell plate B8628-1 Charpy specimens, oriented with the longitudinal axis of the specimen perpendicular to the major rolling direction of the plate (*Transverse orientation*), to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) resulted in a 30 ft-lb transition temperature increase of 45.5°F and a 50 ft-lb transition temperature increase of 63.1°F. This results in an irradiated 30 ft-lb transition temperature of 74.1°F and an irradiated 50 ft-lb transition temperature of 133.2°F for Transverse oriented specimens.

- Irradiation of the weld metal Charpy specimens to 2.98 x 10^{19} n/cm^2 (E> 1.0MeV) resulted in a 30 ft-lb transition temperature increase of 31.4°F and a 50 ft-lb transition temperature increase of 47.9°F. This results in an irradiated 30 ft-lb transition temperature of 12.2°F and an irradiated 50 ft-lb transition temperature of 59.0°F.

- Irradiation of the weld Heat-Affected-Zone (HAZ) metal Charpy specimens to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) resulted in a 30 ft-lb transition temperature increase of 3.2°F and a 50 ft-lb transition temperature decrease of 4.6°F. This results in an irradiated 30 ft-lb transition temperature of -80.5°F and an irradiated 50 ft-lb transition temperature of -57°F.

- The average upper shelf energy of the lower shell plate B8628-1 (*Longitudinal orientation*) resulted in an average energy decrease of 5 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV). This results in an irradiated average upper shelf energy of 84 ft-lb for the Longitudinal oriented specimens.

- The average upper shelf energy of the lower shell plate B8628-1 (*Transverse orientation*) resulted in an average energy decrease of 1 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV). Hence, this results in an irradiated average upper shelf energy of 69 ft-lb for the Transverse oriented specimens.

- The average upper shelf energy of the weld metal Charpy specimens resulted an average energy decrease of 5 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV). Hence, this results in an irradiated average upper shelf energy of 87 ft-lb for the weld metal specimens.

- The average upper shelf energy of the weld HAZ metal Charpy specimens resulted in an average energy decrease of 6 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0MeV). This results in an irradiated average upper shelf energy of 100 ft-lb for the weld HAZ metal.

- A comparison of the Vogtle Electric Generating Plant Unit 2 reactor vessel beltline material test results with the Regulatory Guide 1.99, Revision 2[1] predictions led to the following conclusions:

  — The measured 30 ft-lb transition temperature shift value for the lower shell plate B8628-1 (*Longitudinal orientation*) is less than the Regulatory Guide 1.99, Revision 2, prediction.

  — The measured 30 ft-lb transition temperature shift value for the lower shell plate B8628-1 (*Transverse orientation*) is greater than the Regulatory Guide 1.99, Revision 2, prediction. However, the shift value is less than the two sigma allowance by the Regulatory Guide 1.99, Revision 2, when calculating adjusted reference temperatures.

  — The measured 30 ft-lb transition temperature shift value for the surveillance weld metal is less than the Regulatory Guide 1.99, Revision 2, prediction.

  — The measured percent decrease in upper shelf energy for all the surveillance materials for Capsule "W" is less than the Regulatory Guide 1.99, Revision 2, predictions.

- The credibility evaluation of the Vogtle Electric Generating Plant Unit 2 surveillance program presented in Appendix D of this report indicates that the surveillance results are credible.

- All beltline materials exhibit a more than adequate upper shelf energy level for continued safe plant operation and are predicted to maintain an upper shelf energy greater than 50 ft-lb throughout the end of the current license (36 EFPY) and a potential license renewal (54 EFPY) as required by 10CFR50, Appendix G [2].

- The calculated and best estimate end-of-license (36 EFPY) and 54 EFPY neutron fluence neutron fluence (E> 1.0 MeV) at the core midplane for the Vogtle Electric Generating Plant Unit 2 reactor vessel using the Regulatory Guide 1.99, Revision 2 attenuation formula (ie. Equation # 3) is as follows:

Calculated (36 EFPY):

Vessel inner radius* = 1.91 x 10^{19} n/cm^2

Vessel 1/4 thickness = 1.14 x 10^{19} n/cm^2

Vessel 3/4 thickness = 4.04 x 10^{18} n/cm^2

Calculated (54 EFPY):

Vessel inner radius* = 2.86 x 10^{19} n/cm^2

Vessel 1/4 thickness = 1.70 x 10^{19} n/cm^2

Vessel 3/4 thickness = 6.06 x 10^{18} n/cm^2

2 INTRODUCTION

This report presents the results of the examination of Capsule W, the fourth capsule removed from the reactor in the continuing surveillance program which monitors the effects of neutron irradiation on Southern Nuclear Vogtle Electric Generating Plant Unit 2 reactor pressure vessel materials under actual operating conditions.

The surveillance program for Southern Nuclear Vogtle Electric Generating Plant Unit 2 reactor pressure vessel materials was designed and recommended by the Westinghouse Electric Company. A description of the surveillance program and the pre-irradiation mechanical properties of the reactor vessel materials is presented in WCAP-11381, "Georgia Power Company Alvin W. Vogtle Unit No. 2 Reactor Vessel Radiation Surveillance Program[3]. The surveillance program was planned to cover the 40-year design life of the reactor pressure vessel and was based on ASTM E185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Reactor Vessels"[8]. Capsule W was removed from the reactor after 13.29 EFPY of exposure and shipped to the Westinghouse Science and Technology Center Hot Cell Facility, where the post-irradiation mechanical testing of the Charpy V-notch impact and tensile surveillance specimens was performed.

This report summarizes the testing of and the post-irradiation data obtained from surveillance capsule W removed from the Southern Nuclear Vogtle Electric Generating Plant Unit 2 reactor vessel and discusses the analysis of the data.

3 BACKGROUND

The ability of the large steel pressure vessel containing the reactor core and its primary coolant to resist fracture constitutes an important factor in ensuring safety in the nuclear industry. The beltline region of the reactor pressure vessel is the most critical region of the vessel because it is subjected to significant fast neutron bombardment. The overall effects of fast neutron irradiation on the mechanical properties of low alloy, ferritic pressure vessel steels such as A533 Grade B Class 1 (base material of the Vogtle Electric Generating Plant Unit 2 reactor pressure vessel beltline) are well documented in the literature. Generally, low alloy ferritic materials show an increase in hardness and tensile properties and a decrease in ductility and toughness during high-energy irradiation.

A method for ensuring the integrity of reactor pressure vessels has been presented in "Fracture Toughness Criteria for Protection Against Failure," Appendix G to Section XI of the ASME Boiler and Pressure Vessel Code[7]. The method uses fracture mechanics concepts and is based on the reference nil-ductility transition temperature (RT_{NDT}).

RT_{NDT} is defined as the greater of either the drop weight nil-ductility transition temperature (NDTT per ASTM E-208[21]) or the temperature 60°F less than the 50 ft-lb (and 35-mil lateral expansion) temperature as determined from Charpy specimens oriented perpendicular (transverse) to the major working direction of the plate. The RT_{NDT} of a given material is used to index that material to a reference stress intensity factor curve (K_{Ic} curve) which appears in Appendix G to the ASME Code[7]. The K_{Ic} curve is a lower bound of static fracture toughness results obtained from several heats of pressure vessel steel. When a given material is indexed to the K_{Ic} curve, allowable stress intensity factors can be obtained for this material as a function of temperature. Allowable operating limits can then be determined using these allowable stress intensity factors.

RT_{NDT} and, in turn, the operating limits of nuclear power plants can be adjusted to account for the effects of radiation on the reactor vessel material properties. The changes in mechanical properties of a given reactor pressure vessel steel, due to irradiation, can be monitored by a reactor vessel surveillance program, such as the Vogtle Unit 2 reactor vessel radiation surveillance program[3], in which a surveillance capsule is periodically removed from the operating nuclear reactor and the encapsulated specimens tested. The increase in the average Charpy V-notch 30 ft-lb temperature (ΔRT_{NDT}) due to irradiation is added to the initial RT_{NDT}, along with a margin (M) to cover uncertainties, to adjust the RT_{NDT} (ART) for radiation embrittlement. This ART (RT_{NDT} initial + M + ΔRT_{NDT}) is used to index the material to the K_{Ic} curve and, in turn, to set operating limits for the nuclear power plant that take into account the effects of irradiation on the reactor vessel materials.

4 DESCRIPTION OF PROGRAM

Six surveillance capsules for monitoring the effects of neutron exposure on the Vogtle Unit 2 reactor pressure vessel core region (beltline) materials were inserted in the reactor vessel prior to initial plant start-up. The six capsules were positioned in the reactor vessel between the neutron pads and the vessel wall as shown in Figure 4-1. The vertical center of the capsules is opposite the vertical center of the core. The capsules contain specimens made from lower shell plate B8628-1 (Heat No. C3500-2), weld metal fabricated with 3/16-inch Mil B-4 weld filler wire, heat number 87005 Linde 124 flux, lot number 1061, which is identical to that used in the actual fabrication of the intermediate to lower shell girth weld.

Capsule W was removed after 13.29 effective full power years (EFPY) of plant operation. This capsule contained Charpy V-notch, tensile, and 1/2T-CT fracture mechanics specimens made from lower shell plate B8628-1 and submerged arc weld metal identical to the closing girth seams. In addition, this capsule contained Charpy V-notch specimens from the weld Heat-Affected-Zone (HAZ) of lower shell plate B8628-1.

Test material obtained from lower shell plate (after the thermal heat treatment and forming of the plate) was taken at least one plate thickness from the quenched ends of the plate. All test specimens were machined from the 1/4 and 3/4 thickness locations of the plate after performing a simulated post-weld stress-relieving treatment on the test material. Specimens from weld metal and heat-affected-zone metal were machined from a stress-relieved weldment joining lower shell plate B8628-1 and adjacent lower shell plate B8825-1. All heat-affected-zone specimens were obtained from the weld heat-affected-zone of lower shell plate B8628-1.

Charpy V-notch impact specimens from lower shell plate B8628-1 were machined both in the longitudinal orientation (longitudinal axis of the specimen parallel to the major rolling direction) and transverse orientation (longitudinal axis of the specimen perpendicular to the major rolling direction). The core region weld Charpy impact specimens were machined from the weldment such that the long dimension of each Charpy specimen was perpendicular to the weld direction. The notch of the weld metal Charpy specimens were machined such that the direction of crack propagation in the specimen was in the welding direction.

Tensile specimens from lower shell plate B8628-1 were machined in both the longitudinal and transverse orientation. Tensile specimens from the weld metal were oriented with the long dimension of the specimen perpendicular to the weld direction.

Compact tension test specimens from plate B8628-1 were machined in both the longitudinal and transverse orientations. Compact tension test specimens from the weld metal were machined perpendicular to the weld direction with the notch oriented in the direction of the weld. All specimens were fatigue pre-cracked according to ASTM E399.

The chemical composition and heat treatment of the surveillance material is presented in Tables 4-1 through 4-3. The chemical analysis reported in Table 4-1 was obtained from unirradiated material used in the surveillance program[3] and irradiated material from capsules U[4] and Y[5].

Capsule W contained dosimeter wires of pure copper, iron, nickel, and aluminum 0.15 weight percent cobalt (cadmium-shielded and unshielded). In addition, cadmium shielded dosimeters of neptunium (Np^{237}) and uranium (U^{238}) were placed in the capsule to measure the integrated flux at specific neutron energy levels

The capsule contained thermal monitors made from two low-melting-point eutectic alloys and sealed in Pyrex tubes. These thermal monitors were used to define the maximum temperature attained by the test specimens during irradiation. The composition of the two eutectic alloys and their melting points are as follows:

2.5% Ag, 97.5% Pb	Melting Point: 579°F (304°C)
1.5% Ag, 1.0% Sn, 97.5% Pb	Melting Point: 590°F (310°C)

The arrangement of the various mechanical specimens, dosimeters and thermal monitors contained in Capsule W is shown in Figure 4-2.

Table 4-1 Chemical Composition (wt%) of the Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1[a]

Element	CE Analysis	Westinghouse Analysis	Capsule Y[a] Analysis (BL-62)
C	0.24	0.23	0.233
Mn	1.34	1.30	1.168
P	0.007	0.007	0.008
S	0.016	0.014	0.009
Si	0.25	0.23	0.185
Ni	0.59	0.59	0.549
Mo	0.59	0.50	0.51
Cr	0.02	0.07	0.064
Cu	0.05	0.05	0.049
Al	0.029	0.034	0.032
Co	0.004	0.008	0.008
Pb	not detected	<0.07	---
W	<0.01	<0.05	---
Ti	<0.01	0.005	<0.002
Zr	<0.001	<0.03	<0.01
V	0.004	<0.005	<0.004
Sn	0.017	0.007	<0.01
As	0.007	0.008	<0.02
Cb	<0.01	<0.05	---
N_2	0.008	0.007	---
B	<0.001	0.008	0.009

Notes:

a. Reprinted from Tables 4-2 and 4-4 of WCAP-14532.

Table 4-2[a] Chemical Composition (wt%) of the Unirradiated Vogtle Unit 2 Reactor Vessel Beltline Region Weld Materials

Element.	Inter. & Lower Shell Long. Welds[b]	Circ. Weld[c] (CE Analysis)	Circ Weld[d] (Westinghouse Analysis)	Capsule Y Analysis (BW-61)	Capsule Y Analysis (BW-63)	Capsule Y Analysis (BW-72)
C	0.15	0.075	0.099	0.084	0.089	0.097
Mn	1.34	1.27	1.25	1.046	0.983	1.110
P	0.007	0.007	0.008	0.010	0.008	0.011
S	0.011	0.010	0.013	0.006	0.006	0.008
Si	0.13	0.50	0.43	0.448	0.447	0.429
Ni	0.13	0.12	0.17	0.127	0.118	0.137
Mo	0.55	0.52	0.47	0.47	0.44	0.48
Cr	---	0.07	0.061	0.056	0.052	0.056
Cu	0.07	0.006	0.040	0.039	0.037	0.040
Al	---	---	0.015	<0.02	<0.02	<0.02
Co	---	---	0.002	0.008	0.008	0.009
Pb	---	---	<0.01	---	---	---
W	---	---	<0.01	---	---	---
Ti	---	---	<0.001	<0.002	<0.002	<0.002
Zr	---	---	<0.01	<0.01	<0.01	<0.01
V	0.005	0.004	<0.004	<0.004	<0.004	<0.004
Sn	---	---	<0.001	<0.01	<0.01	<0.01
As	---	---	0.003	<0.02	<0.02	<0.02
Cb	---	---	<0.002	---	---	---
N_2	---	---	0.002	---	---	---
B	---	---	0.009	0.009	0.008	0.008

Notes:
(a) Reprinted from Tables 4-3 and 4-4 of WCAP-14532. Note: the NIST Standards are Not reprinted herein.
(b) Weld Wire Heat # 87005, Linde 0091 Flux, Lot # 0145.
(c) Weld Wire Heat # 87005, Linde 124 Flux, Lot # 1061.
(d) Westinghouse Analysis of surveillance program test plate "D", identical to the inter. to lower shell circ. weld.

Table 4-3 Heat Treatment of the Vogtle Unit 2 Reactor Vessel Surveillance Material[a]			
Material	**Temperature (°F)**	**Time (hrs.)**	**Coolant**
Intermediate Shell Plates R4-1, R4-2 and R4-3	Austenitizing: 1600 ± 25 (871°C)	4	Water-quenched
	Tempered: 1225 ± 25 (663°C)	4	Air Cooled
	Stress Relief:(b) 1150± 50 (621°C)	16.5(b)	Furnace Cooled
Lower Shell Plates B8825-1, R8-1 and B8628-1	Austenitizing: 1600 ± 25 (871°C)	4	Water-quenched
	Tempered: 1225 ± 25 (663°C)	4	Air Cooled
	Stress Relief: 1150± 50 (621°C)	12.0(b)	Furnace Cooled
Intermediate Shell Longitudinal Seam Welds	Stress Relief: 1150± 50 (621°C)	16.5(b)	Furnace Cooled
Lower Shell Longitudinal Seam Welds		12.0(b)	Furnace Cooled
Intermediate Shell to Lower Shell Girth Weld	Local Stress Relief: 1150± 50 (621°C)	5.0	Furnace Cooled
Surveillance Program Weldment Test Plate "D" (Representative of Closing Girth Seam)	Post Weld Stress Relief: 1150 ± 50 (621°C)	6.0(c)	Furnace Cooled

(a) This Table was reprinted from Table 4-1 of WCAP-14532 and originally documented in WCAP-11381[3].
(b) Stress Relief includes the intermediate to lower shell closing girth seam post-weld heat treatment
(c) The stress relief heat treatment received by the surveillance test plate and weldment has been simulated.

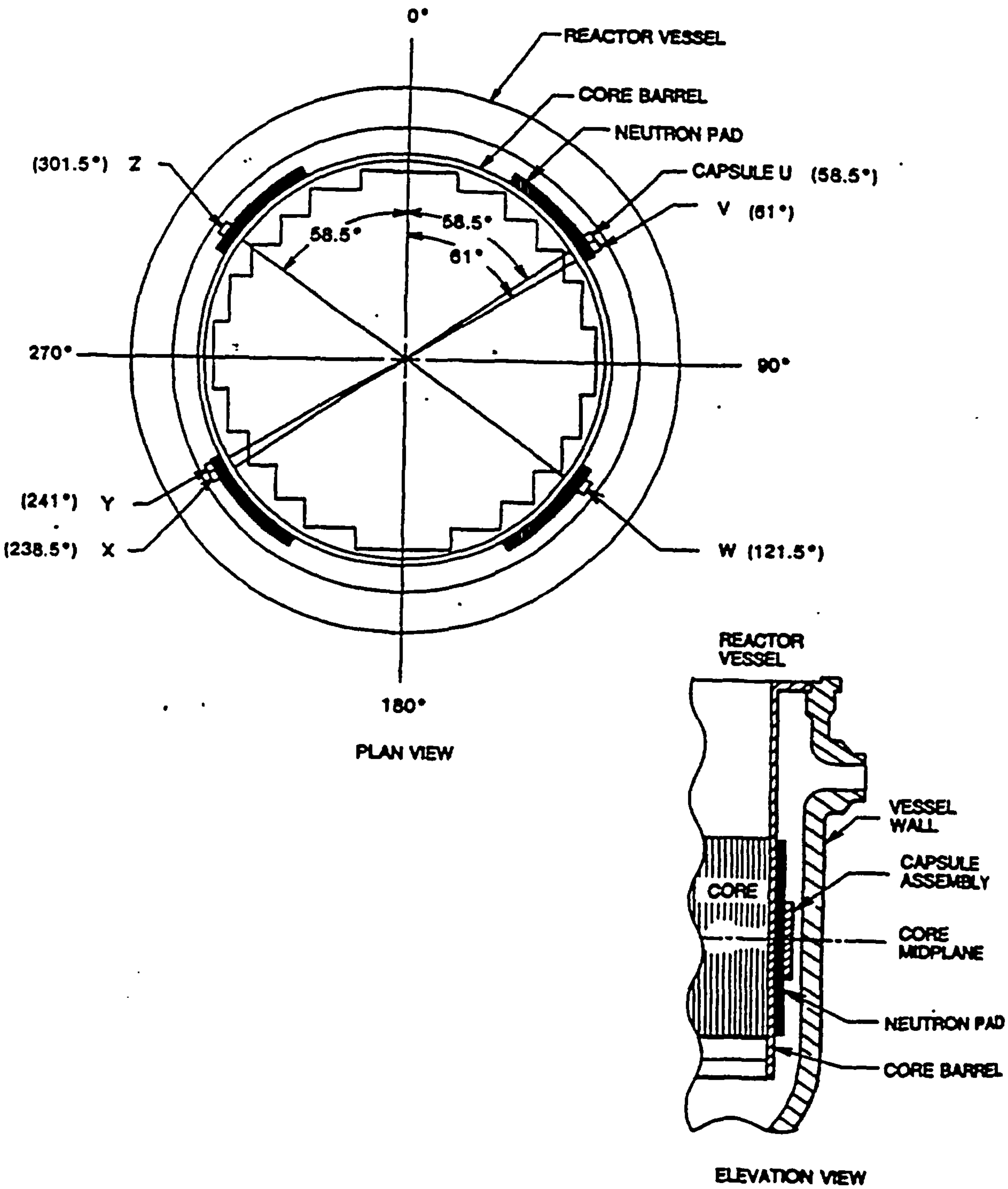


Figure 4-1 Arrangement of Surveillance Capsules in the Vogtle Unit 2 Reactor Vessel

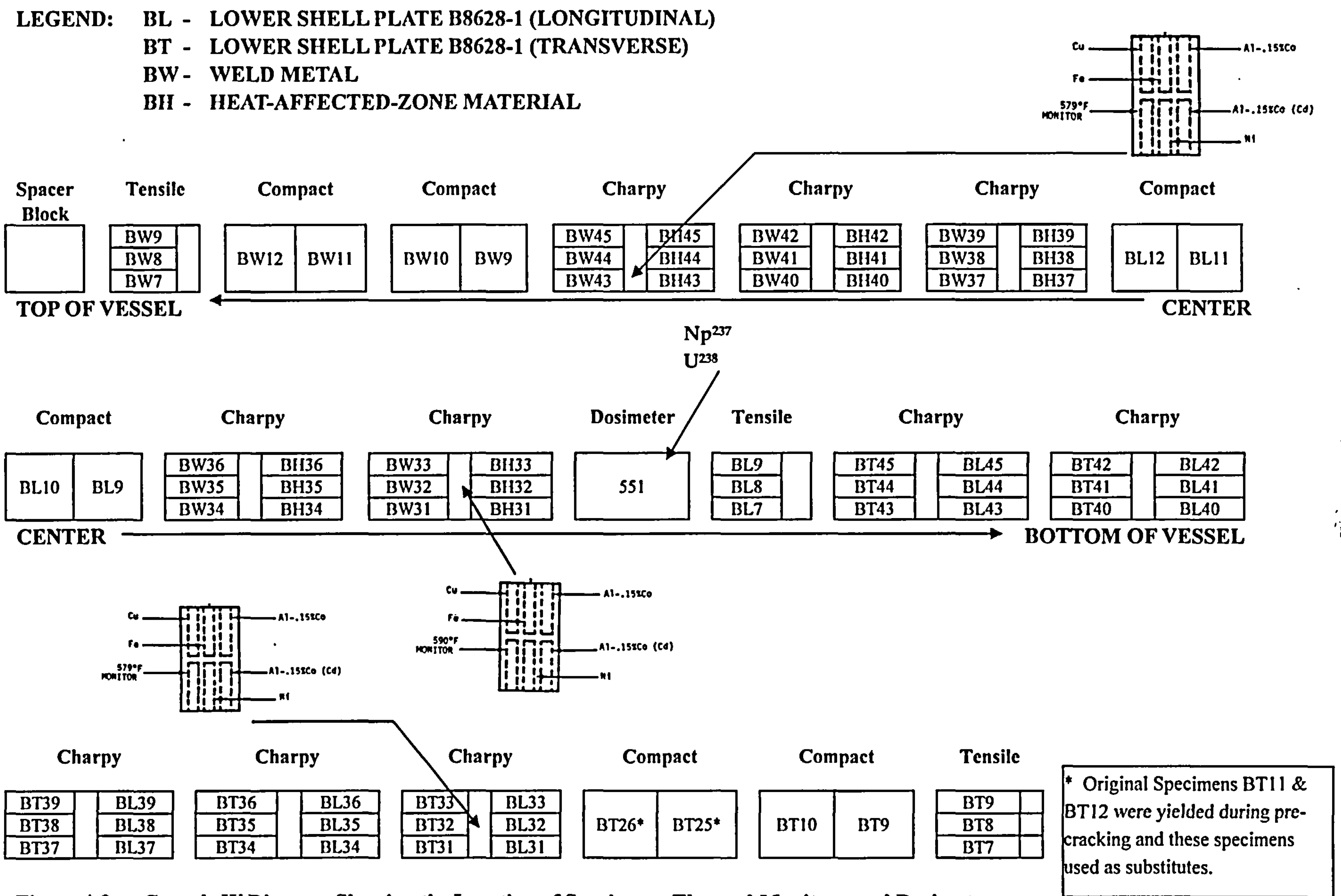


Figure 4-2 Capsule W Diagram Showing the Location of Specimens, Thermal Monitors, and Dosimeters

5 TESTING OF SPECIMENS FROM CAPSULE W

5.1 OVERVIEW

The post-irradiation mechanical testing of the Charpy V-notch impact specimens and tensile specimens was performed in the Remote Metallographic Facility (RMF) at the Westinghouse Research and Technology Park. Testing was performed in accordance with 10CFR50, Appendices G and H[2], ASTM Specification E185-82[8], and Westinghouse Procedure RMF 8402[9] Revision 2 as modified by Westinghouse RMF Procedures 8102[10], Revision 3, and 8103[11], Revision 2.

Upon receipt of the capsule at the hot cell laboratory was opened per Procedure RMF 8804[12]. The specimens and spacer blocks were carefully removed, inspected for identification number, and checked against the master list in WCAP-11381[3]. No discrepancies were found.

Examination of the two low-melting point 579°F (304°C) and 590°F (310°C) eutectic alloys indicated no melting of either type of thermal monitor. Based on this examination, the maximum temperature to which the test specimens were exposed was less than 579°F (304°C).

The Charpy impact tests were performed per ASTM Specification E23-02a[13] and Procedure RMF 8103 on a Tinius-Olsen Model 74, 358J machine. The tup (striker) of the Charpy machine is instrumented with an Instron Dynatup Impulse instrumentation system, feeding information into an IBM compatible computer. With this system, load-time and energy-time signals can be recorded in addition to the standard measurement of Charpy energy (E_D). From the load-time curve, the load of general yielding (P_{GY}), the time to general yielding (T_{GY}), the maximum load (P_M), and the time to maximum load (T_M) can be determined. Under some test conditions, a sharp drop in load indicative of fast fracture was observed. The load at which fast fracture was initiated is identified as the fast fracture load (P_F). If the fast load drop terminates well above zero load, the termination load is identified as the arrest load (P_A).

The energy at maximum load (E_M) was determined by comparing the energy-time record and the load-time record. The energy at maximum load is approximately equivalent to the energy required to initiate a crack in the specimen. Therefore, the propagation energy for the crack (E_P) is the difference between the total energy to fracture (E_D) and the energy at maximum load (E_M).

The yield stress (s_Y) was calculated from the three-point bend formula having the following expression:

$$\sigma_Y = P_{GY} \frac{L}{B(W-a)^2 C} \qquad (1)$$

where L = distance between the specimen supports in the impact testing machine; B = the width of the specimen measured parallel to the notch; W = height of the specimen, measured perpendicularly to the notch; a = notch depth. The constant C is dependent on the notch flank angle (φ), notch root radius (ρ) and the type of loading (i.e., pure bending or three-point bending). In three-point bending, for a Charpy specimen in which $\varphi = 45^\circ$ and $\rho = 0.010$ in., Equation 1 is valid with C = 1.21.

Therefore, (for L = 4W),

$$\sigma_Y = P_{GY}\frac{L}{B(W-a)^2 1.21} = \frac{3.305 P_{GY} W}{B(W-a)^2} \qquad (2)$$

For the Charpy specimen, B = 0.394 in., W = 0.394 in., and a = 0.079 in. Equation 2 then reduces to

$$\sigma_Y = 33.3 P_{GY} \qquad (3)$$

where s_Y is in units of psi and P_{GY} is in units of lbs. The flow stress was calculated from the average of the yield and maximum loads, also using the three-point bend formula.

Symbol 'A' in columns 4, 5, and 6 of Tables 5-5 through 5-8 is the cross-section area under the notch of the Charpy specimens:

$$A = B(W-a) = 0.1241 \text{ sq. in.} \qquad (4)$$

Percent shear was determined from post-fracture photographs using the ratio-of-areas methods in compliance with ASTM E23-02a[13] and A370-03a[14]. The lateral expansion was measured using a dial gage rig similar to that shown in the same specifications.

Tensile tests were performed on a 20,000 pound Instron, split console test machine (Model 1115) per ASTM Specification E8-04[15] and E21-03a[16] and Procedure RMF 8102[10].

Extension measurements were made with a linear variable displacement transducer (LVDT) extensometer. The extensometer gage length was 1.00 inch.

Elevated test temperatures were obtained with a three-zone electric resistance split-tube furnace with a 9-inch hot zone. All tests were conducted in air.

The yield load, ultimate load, fracture load, total elongation and uniform elongation were determined directly from the load-extension curve. The yield strength, ultimate strength and fracture strength were calculated using the original cross-sectional area. The final diameter and final gage length were determined from post-fracture photographs. The fracture area used to calculate the fracture stress (true stress at fracture) and percent reduction in area were computed using the final diameter measurement.

5.2 CHARPY V-NOTCH IMPACT TEST RESULTS

The results of the Charpy V-notch impact tests performed on the various materials contained in capsule W, which received a fluence of 2.98 x 10^{19} n/cm^2(E> 1.0 MeV) in 13.29 EFPY of operation, are presented in Tables 5-1 through 5-8 and are compared with unirradiated results[3] as shown in Figures 5-1 through 5-12.

The transition temperature increases and upper shelf energy decreases for the capsule W materials are summarized in Table 5-9. These results led to the following conclusions:

- Irradiation of the reactor vessel lower shell plate B8628-1 Charpy specimens, oriented with the longitudinal axis of the specimen parallel to the major rolling direction (*Longitudinal orientation*), to 2.98 x 10^{19} n/cm^2 (E> 1.0MeV) resulted in a 30 ft-lb transition temperature increase of 39°F and a 50 ft-lb transition temperature increase of 43.6°F. This results in an irradiated 30 ft-lb transition temperature of 47.8°F and an irradiated 50 ft-lb transition temperature of 89.0°F for the Longitudinal oriented specimens.

- Irradiation of the reactor vessel lower shell plate B8628-1 Charpy specimens, oriented with the longitudinal axis of the specimen perpendicular to the major rolling direction of the plate (*Transverse orientation*), to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) resulted in a 30 ft-lb transition temperature increase of 45.5°F and a 50 ft-lb transition temperature increase of 63.1°F. This results in an irradiated 30 ft-lb transition temperature of 74.1°F and an irradiated 50 ft-lb transition temperature of 133.2°F for Transverse oriented specimens.

- Irradiation of the weld metal Charpy specimens to 2.98 x 10^{19} n/cm^2 (E> 1.0MeV) resulted in a 30 ft-lb transition temperature increase of 31.4°F and a 50 ft-lb transition temperature increase of 47.9°F. This results in an irradiated 30 ft-lb transition temperature of 12.2°F and an irradiated 50 ft-lb transition temperature of 59.0°F.

- Irradiation of the weld Heat-Affected-Zone (*HAZ*) metal Charpy specimens to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) resulted in a 30 ft-lb transition temperature increase of 3.2°F and a 50 ft-lb transition temperature decrease of 4.6°F. This results in an irradiated 30 ft-lb transition temperature of -80.5°F and an irradiated 50 ft-lb transition temperature of -57°F.

- The average upper shelf energy of the lower shell plate B8628-1 (*Longitudinal orientation*) resulted in an average energy decrease of 5 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV). This results in an irradiated average upper shelf energy of 84 ft-lb for the Longitudinal oriented specimens.

- The average upper shelf energy of the lower shell plate B8628-1 (*Transverse orientation*) resulted in an average energy decrease of 1 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV). Hence, this results in an irradiated average upper shelf energy of 69 ft-lb for the Transverse oriented specimens.

- The average upper shelf energy of the weld metal Charpy specimens resulted an average energy decrease of 5 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV). Hence, this results in an irradiated average upper shelf energy of 87 ft-lb for the weld metal specimens.

- The average upper shelf energy of the weld HAZ metal Charpy specimens resulted in an average energy decrease of 6 ft-lb after irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0MeV). This results in an irradiated average upper shelf energy of 100 ft-lb for the weld HAZ metal.

- A comparison of the Vogtle Electric Generating Plant Unit 2 reactor vessel beltline material test results with the Regulatory Guide 1.99, Revision 2[1] predictions led to the following conclusions:

  — The measured 30 ft-lb transition temperature shift value for the lower shell plate B8628-1 (*Longitudinal orientation*) is less than the Regulatory Guide 1.99, Revision 2, prediction.

  — The measured 30 ft-lb transition temperature shift value for the lower shell plate B8628-1 (*Transverse orientation*) is greater than the Regulatory Guide 1.99, Revision 2, prediction. However, the shift value is less than the two sigma allowance by the Regulatory Guide 1.99, Revision 2, when calculating adjusted reference temperatures.

  — The measured 30 ft-lb transition temperature shift value for the surveillance weld metal is less than the Regulatory Guide 1.99, Revision 2, prediction.

  — The measured percent decrease in upper shelf energy for all the surveillance materials for Capsule "W" is less than the Regulatory Guide 1.99, Revision 2, predictions.

All beltline materials exhibit a more than adequate upper shelf energy level for continued safe plant operation and are predicted to maintain an upper shelf energy greater than 50 ft-lb throughout the end of the current license (36 EFPY) and a potential license renewal (54 EFPY) as required by 10CFR50, Appendix G [2].

The fracture appearance of each irradiated Charpy specimen from the various surveillance capsule W materials is shown in Figures 5-13 through 5-16 and shows an increasingly ductile or tougher appearance with increasing test temperature.

The load-time records for individual instrumented Charpy specimen tests are shown in Appendix B.

5.3 TENSILE TEST RESULTS

The results of the tensile tests performed on the various materials contained in Capsule W irradiated to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) are presented in Table 5-11 and are compared with unirradiated results[3] as shown in Figures 5-17 through 5-19.

The results of the tensile tests performed on the lower shell plate B8628-1 (*Longitudinal orientation*) indicated that irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) caused approximately a 3 to 11 ksi increase in the 0.2 percent offset yield strength and approximately a 5 to 10 ksi increase in the ultimate tensile strength when compared to unirradiated data[3] (Figure 5-17).

The results of the tensile tests performed on the lower shell plate B8628-1 (*Transverse orientation*) indicated that irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) caused an approximate increase of 4 to 12 ksi in the 0.2 percent offset yield strength and approximately a 4 to 9 ksi increase in the ultimate tensile strength when compared to unirradiated data[3] (Figure 5-18).

The results of the tensile tests performed on the surveillance weld metal indicated that irradiation to 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) caused approximately a 8 to 11 ksi increase in the 0.2 percent offset yield strength and approximately a 3 to 7 ksi increase in the ultimate tensile strength when compared to unirradiated data[3] (Figure 5-19).

The fractured tensile specimens for the lower shell plate B8628-1 material are shown in Figures 5-20 and 5-21, while the fractured tensile specimens for the surveillance weld metal are shown in Figure 5-22. The engineering stress-strain curves for the tensile tests are shown in Figures 5-23 through 5-25.

5.4 1/2T COMPACT TENSION SPECIMEN TESTS

Per the surveillance capsule testing contract, the 1/2T Compact Tension Specimens were not tested and are being stored at the Westinghouse Science and Technology Center Hot Cell facility.

Table 5-1 Charpy V-notch Data for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) (*Longitudinal Orientation*)

Sample	Temperature		Impact Energy		Lateral Expansion		Shear
Number	°F	°C	ft-lbs	Joules	mils	mm	%
BL31	-50	-46	7	9	6	0.15	2
BL34	-25	-32	11	15	8	0.20	5
BL40	0	-18	21	28	15	0.38	10
BL42	25	-4	15	20	11	0.28	15
BL44	40	4	27	37	24	0.61	20
BL33	50	10	42	57	39	0.99	25
BL39	50	10	22	30	17	0.43	20
BL38	75	24	42	57	30	0.76	40
BL32	100	38	52	71	45	1.14	60
BL41	125	52	61	83	52	1.32	75
BL36	150	66	*	*	*	*	*
BL45	150	66	77	104	61	1.55	90
BL43	175	79	85	115	65	1.65	100
BL35	200	93	81	110	65	1.65	100
BL37	225	107	85	115	64	1.63	100

* No Data

Table 5-2 Charpy V-notch Data for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV) (*Transverse Orientation*)

Sample Number	Temperature		Impact Energy		Lateral Expansion		Shear
	°F	°C	ft-lbs	Joules	mils	mm	%
BT32	-75	-59	5	7	4	0.10	2
BT41	-25	-32	8	11	5	0.13	5
BT44	0	-18	10	14	10	0.25	10
BT42	25	-4	21	28	18	0.46	15
BT43	50	10	26	35	23	0.58	20
BT37	75	24	29	39	28	0.71	30
BT36	75	24	24	33	23	0.58	25
BT40	100	38	40	54	37	0.94	50
BT33	125	52	42	57	42	1.07	65
BT39	150	66	60	81	52	1.32	90
BT38	200	93	61	83	45	1.14	95
BT45	225	107	72	98	56	1.42	100
BT31	250	121	74	100	61	1.55	100
BT35	275	135	61	83	53	1.35	100
BT34	275	135	70	95	52	1.32	100

Table 5-3 Charpy V-notch Data for the Vogtle Unit 2 Surveillance Weld Metal Irradiated to a Fluence of 2.98×10^{19} n/cm^2 (E> 1.0 MeV)							
Sample	Temperature		Impact Energy		Lateral Expansion		Shear
Number	°F	°C	ft-lbs	Joules	mils	mm	%
BW33	-50	-46	5	7	5	0.13	5
BW42	-25	-32	14	19	11	0.28	5
BW36	0	-18	36	49	28	0.71	15
BW35	0	-18	31	42	25	0.64	20
BW45	25	-4	22	30	22	0.56	25
BW41	50	10	38	52	34	0.86	30
BW37	75	24	71	96	47	1.19	55
BW40	75	24	64	87	49	1.24	50
BW31	100	38	64	87	52	1.32	65
BW34	140	60	71	96	57	1.45	80
BW38	175	79	73	99	63	1.60	90
BW32	200	93	77	104	61	1.55	95
BW39	225	107	88	119	74	1.88	100
BW43	250	121	79	107	67	1.70	100
BW44	250	121	93	126	72	1.83	100

Table 5-4 Charpy V-notch Data for the Vogtle Unit 2 Heat Affected Zone Material Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E> 1.0 MeV)

Sample Number	Temperature		Impact Energy		Lateral Expansion		Shear
	°F	°C	ft-lbs	Joules	mils	mm	%
BH44	-175	-115	3	4	2	0.05	2
BH31	-125	-87	17	23	8	0.20	5
BH33	-90	-68	31	42	19	0.48	15
BH43	-75	-59	43	58	25	0.64	20
BH42	-75	-59	17	23	12	0.30	15
BH38	-50	-46	57	77	32	0.81	55
BH37	-50	-46	57	77	34	0.86	60
BH34	-25	-32	67	91	36	0.91	50
BH32	0	-18	101	137	71	1.80	90
BH41	0	-18	92	125	59	1.50	70
BH39	25	-4	98	133	58	1.47	100
BH40	50	10	99	134	60	1.52	85
BH45	75	24	105	142	65	1.65	95
BH36	125	52	107	145	68	1.73	100
BH35	150	66	93	126	70	1.78	100

Table 5-5 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E>1.0 MeV) (*Longitudinal Orientation*)

Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2) Charpy E_D/A	Max. E_M/A	Prop. E_p/A	Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress S_Y (ksi)	Flow Stress (ksi)
BL31	-50	7	56	31	26	3196	0.13	3352	0.15	3352	0	106	109
BL34	-25	11	89	46	43	3274	0.14	3856	0.18	3856	0	109	119
BL40	0	21	169	72	97	3450	0.15	4249	0.23	4249	0	115	128
BL42	25	15	121	61	60	2885	0.13	3955	0.21	3942	0	96	114
BL44	40	27	218	131	87	2984	0.14	4194	0.35	4194	194	99	120
BL33	50	42	338	238	100	3368	0.14	4534	0.53	4488	182	112	132
BL39	50	22	177	66	111	3249	0.14	4070	0.22	4031	383	108	122
BL38	75	42	338	221	117	3290	0.15	4534	0.50	4523	725	110	130
BL32	100	52	419	216	203	2911	0.14	4259	0.52	4152	1035	97	119
BL41	125	61	491	225	267	3130	0.14	4278	0.52	4143	2047	104	123
BL36	150	*	*	*	*	*	*	*	*	*	*	*	*
BL45	150	77	620	300	320	3100	0.15	4356	0.67	3864	2023	103	124
BL43	175	85	685	224	461	2954	0.14	4296	0.53	n/a	n/a	98	121
BL35	200	81	653	282	370	2998	0.15	4159	0.65	n/a	n/a	100	119
BL37	225	85	685	209	476	2872	0.13	4157	0.51	n/a	n/a	96	117

* No Data

Table 5-6 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Lower Shell Plate B8628-1 Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E>1.0 MeV) (*Transverse Orientation*)

Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2) Charpy E_D/A	Max. E_M/A	Prop. E_p/A	Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress S_Y (ksi)	Flow Stress (ksi)
BT32	-75	5	40	21	19	2455	0.12	2491	0.13	2491	0	82	82
BT41	-25	8	64	33	31	3428	0.15	3485	0.16	3485	0	114	115
BT44	0	10	81	45	36	3578	0.15	3920	0.18	3920	0	119	125
BT42	25	21	169	109	60	3083	0.13	4170	0.3	4147	0	103	121
BT43	50	26	209	138	71	3195	0.14	4249	0.35	4239	155	106	124
BT37	75	29	234	133	101	2898	0.13	4140	0.35	4137	607	97	117
BT36	75	24	193	110	83	3210	0.14	4194	0.3	4176	452	107	123
BT40	100	40	322	196	127	3186	0.14	4251	0.46	4228	1388	106	124
BT33	125	42	338	155	184	2910	0.14	4117	0.4	4057	1704	97	117
BT39	150	60	483	207	277	3221	0.14	4317	0.48	3748	2644	107	126
BT38	200	61	491	186	305	2925	0.14	3987	0.47	2478	2021	97	115
BT45	225	72	580	224	356	3119	0.15	4362	0.52	n/a	n/a	104	125
BT31	250	74	596	190	407	2715	0.13	4216	0.47	n/a	n/a	90	115
BT35	275	61	491	158	333	2930	0.14	3892	0.42	n/a	n/a	98	114
BT34	275	70	564	183	381	2912	0.14	4166	0.46	n/a	n/a	97	118

Table 5-7 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Surveillance Weld Metal Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E>1.0 MeV)

Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2) Charpy E_D/A	Max. E_M/A	Prop. E_p/A	Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress S_Y (ksi)	Flow Stress (ksi)
BW33	-50	5	40	18	22	2042	0.1	2248	0.13	2248	0	68	71
BW42	-25	14	113	71	41	3119	0.13	4229	0.23	4229	0	104	122
BW36	0	36	290	232	58	3440	0.14	4527	0.51	4521	0	115	133
BW35	0	31	250	192	57	3379	0.14	4413	0.44	4387	0	113	130
BW45	25	22	177	113	64	2879	0.13	4002	0.31	3987	268	96	115
BW41	50	38	306	236	70	3151	0.14	4443	0.53	4419	182	105	126
BW37	75	71	572	237	335	3222	0.14	4639	0.52	3997	640	107	131
BW40	75	64	516	241	274	3160	0.14	4632	0.52	4261	1060	105	130
BW31	100	64	516	223	293	3031	0.14	4227	0.52	3970	1400	101	121
BW34	140	71	572	301	271	3113	0.14	4205	0.67	3703	2063	104	122
BW38	175	73	588	217	371	2960	0.14	4075	0.53	3549	1984	99	117
BW32	200	77	620	293	328	3002	0.15	4107	0.67	3320	2532	100	118
BW39	225	88	709	295	414	3043	0.14	4198	0.67	n/a	n/a	101	121
BW43	250	79	637	205	432	2764	0.14	3968	0.52	n/a	n/a	92	112
BW44	250	93	749	218	532	2899	0.14	4211	0.52	n/a	n/a	97	118

Table 5-8 Instrumented Charpy Impact Test Results for the Vogtle Unit 2 Heat-Affected-Zone (HAZ) Metal Irradiated to a Fluence of 2.98 x 10^{19} n/cm^2 (E>1.0 MeV)

Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2) Charpy E_D/A	Max. E_M/A	Prop. E_P/A	Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress S_Y (ksi)	Flow Stress (ksi)
BH44	-175	3	24	11	13	1198	0.08	1418	0.11	1418	0	40	44
BH31	-125	17	137	86	51	4299	0.15	5233	0.23	5227	0	143	159
BH33	-90	31	250	195	55	3472	0.14	4982	0.42	4963	0	116	141
BH43	-75	43	346	261	86	4027	0.15	5032	0.51	5026	637	134	151
BH42	-75	17	137	80	57	3659	0.14	4647	0.23	4647	0	122	138
BH38	-50	57	459	248	211	3482	0.14	4906	0.51	4655	551	116	140
BH37	-50	57	459	253	207	3538	0.14	4930	0.52	4735	1176	118	141
BH34	-25	67	540	346	194	3592	0.14	4836	0.68	4683	1660	120	140
BH32	0	101	814	351	463	3778	0.15	4838	0.69	3417	1712	126	143
BH41	0	92	741	338	403	3572	0.15	4802	0.67	2625	602	119	139
BH39	25	98	790	255	534	3542	0.14	4717	0.54	n/a	n/a	118	138
BH40	50	99	798	337	461	3437	0.14	4701	0.68	3271	1683	114	135
BH45	75	105	846	325	521	3181	0.14	4640	0.68	3401	1915	106	130
BH36	125	107	862	235	627	3226	0.14	4501	0.52	n/a	n/a	107	129
BH35	150	93	749	322	428	3307	0.14	4486	0.68	n/a	n/a	110	130

Table 5-9 Effect of Irradiation to 2.98 x 10^{19} n/cm^2 (E>1.0 MeV) on the Notch Toughness Properties of the Vogtle Unit 2 Reactor Vessel Surveillance Materials

Material	Average 30 (ft-lb)[a] Transition Temperature (°F)			Average 35 mil Lateral[b] Expansion Temperature (°F)			Average 50 ft-lb[a] Transition Temperature (°F)			Average Energy Absorption[a] at Full Shear (ft-lb)		
	Unirradiated	Irradiated	ΔT	Unirradiated	Irradiated	ΔT	Unirradiated	Irradiated	ΔT	Unirradiated	Irradiated	ΔE
Lower Shell Plate B8628-1 (*Longitudinal*)	8.8	47.8	39.0	36.4	74.7	38.3	45.4	89.0	43.6	89	84	-5
Lower Shell Plate B8628-1 (*Transverse*)	28.6	74.1	45.5	44.0	97.1	53.1	70.1	133.2	63.1	70	69	-1
Weld Metal	-19.2	12.2	31.4	-1.0	45.0	46.0	11.1	59.0	47.9	92	87	-5
HAZ Metal	-83.7	-80.5	3.2	-46.9	-46.5	0.4	-52.4	-57.0	-4.6	106	100	-6

a. "Average" is defined as the value read from the curve fit through the data points of the Charpy tests (see Figures 5-1, 5-4, 5-7 and 5-10).

b. "Average" is defined as the value read from the curve fit through the data points of the Charpy tests (see Figures 5-2, 5-5, 5-8 and 5-11)

Table 5-10 Comparison of the Vogtle Unit 2 Surveillance Material 30 ft-lb Transition Temperature Shifts and Upper Shelf Energy Decreases with Regulatory Guide 1.99, Revision 2, Predictions

Material	Capsule	Fluence ($x\ 10^{19}\ n/cm^2$)	30 ft-lb Transition Temperature Shift		Upper Shelf Energy Decrease	
			Predicted (°F) [(a)]	Measured (°F) [(b)]	Predicted (%) [(a)]	Measured (%)[(c)]
Lower Shell	U	0.356	22.2	2.0	15	0
Plate B8628-1	Y	1.12	31.9	5.8	19.5	0
(*Longitudinal*)	X	1.78	36.0	29.4	22	3
	W	2.98	40.0	39.0	25	6
Lower Shell	U	0.356	22.2	0.0[(d)]	15	0
Plate B8628-1	Y	1.12	31.9	1.9	19.5	0
(*Transverse*)	X	1.78	36.0	29.8	22	7
	W	2.98	40.0	45.5	25	1
Weld Metal	U	0.356	26.0	0.00[(d)]	15	0
	Y	1.12	37.5	18.7	19.5	7
	X	1.78	42.2	19.9	22	7
	W	2.98	47.0	31.4	25	5
HAZ Metal	U	0.356	---	0.00[(d)]	---	0
	Y	1.12	---	0.00[(d)]	---	0
	X	1.78	---	0.00[(d)]	---	7
	W	2.98	---	3.2	---	6

Notes:

(a) Based on Regulatory Guide 1.99, Revision 2, methodology using the mean weight percent values of copper and nickel of the surveillance material.

(b) Calculated using measured Charpy data plotted using CVGRAPH, Version 5.0.2 (See Appendix C)

(c) Values are based on the definition of upper shelf energy given in ASTM E185-82.

(d) Actual values for ΔRT_{NDT} are -7.1 (Plate), -17.3 (Weld), -24.3 (HAZ Cap. U), -10.1 (HAZ Cap. Y) and -2.5 (HAZ Cap. X). This physically should not occur, therefore for conservatism a value of zero will be reported (i.e. No Change in T_{30}).

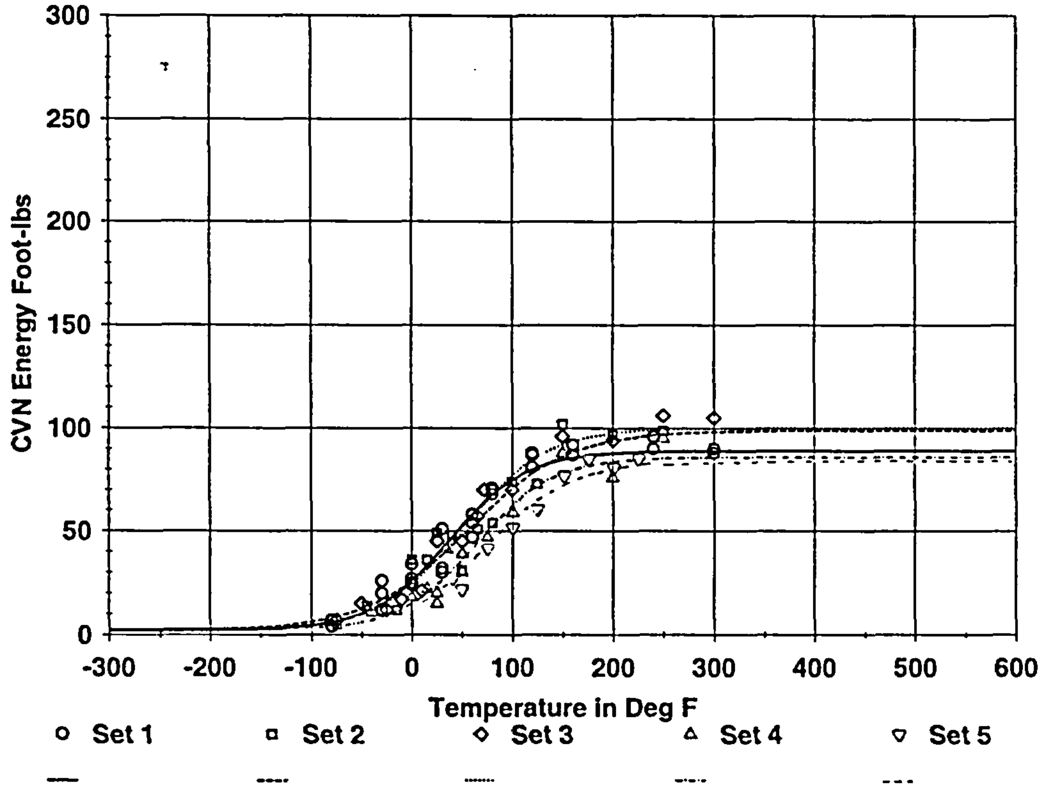
Table 5-11 Tensile Properties of the Vogtle Unit 2 Reactor Vessel Surveillance Materials Irradiated to 2.98 x 10^{19} n/cm^2 (E > 1.0 MeV)

Material	Sample Number	Test Temp. (°F)	0.2% Yield Strength (ksi)	Ultimate Strength (ksi)	Fracture Load (kip)	Fracture Stress (ksi)	Fracture Strength (ksi)	Uniform Elongation (%)	Total Elongation (%)	Reduction in Area (%)
Lower	BL-7	75	76.2	96.8	3.20	174.9	65.1	10.5	24.4	63
Plate B8628-1	BL-8	150	73.6	93.4	2.92	176.5	59.4	11.3	26.4	66
(*Longitudinal*)	BL-9	550	64.2	92.4	3.13	151.9	63.8	10.5	21.5	58
Lower	BT-7	75	73.3	95.5	3.34	127.5	67.9	12.0	22.5	47
Plate B8628-1	BT-8	150	73.8	91.7	3.21	141.4	65.4	11.3	21.6	54
(*Transverse*)	BT-9	550	66.2	91.6	3.63	135.3	73.9	10.5	18.6	45
Weld Metal	BW-7	75	73.5	90.0	2.90	181.8	59.1	12.0	26.7	68
	BW-8	175	73.2	85.2	2.76	193.1	56.3	11.0	24.6	71
	BW-9	550	71.0	86.4	3.18	154.0	64.7	12.0	21.3	58

LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:15 AM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	LT	C3500-2
2	Vogtle 2	U	SA533B1	LT	C3500-2
3	Vogtle 2	Y	SA533B1	LT	C3500-2
4	Vogtle 2	X	SA533B1	LT	C3500-2
5	Vogtle 2	W	SA533B1	LT	C3500-2



Results

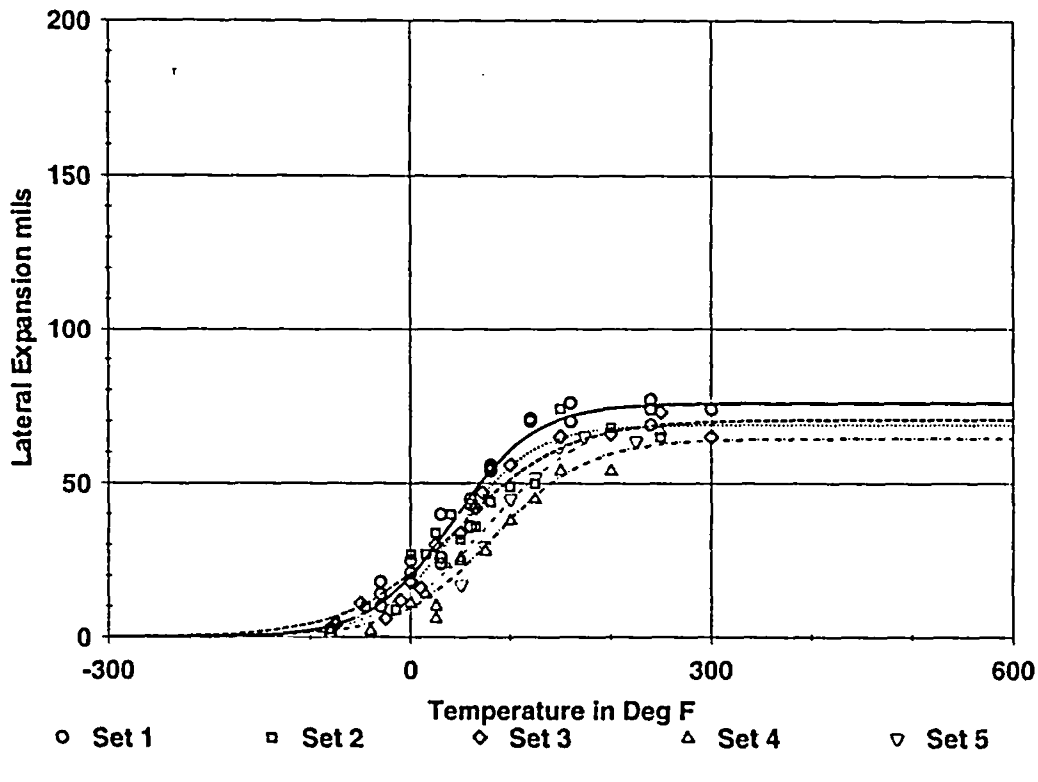
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	89.0	.0	8.8	.0	45.4	.0
2		2.2	99.0	10.0	10.8	2.0	54.9	9.5
3		2.2	100.0	11.0	14.6	5.8	50.5	5.1
4		2.2	86.0	-3.0	38.2	29.4	75.6	30.2
5		2.2	84.0	-5.0	47.8	39.0	89.0	43.6

Figure 5-1 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)

LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 02:31 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	LT	C3500-2
2	Vogtle 2	U	SA533B1	LT	C3500-2
3	Vogtle 2	Y	SA533B1	LT	C3500-2
4	Vogtle 2	X	SA533B1	LT	C3500-2
5	Vogtle 2	W	SA533B1	LT	C3500-2



Results

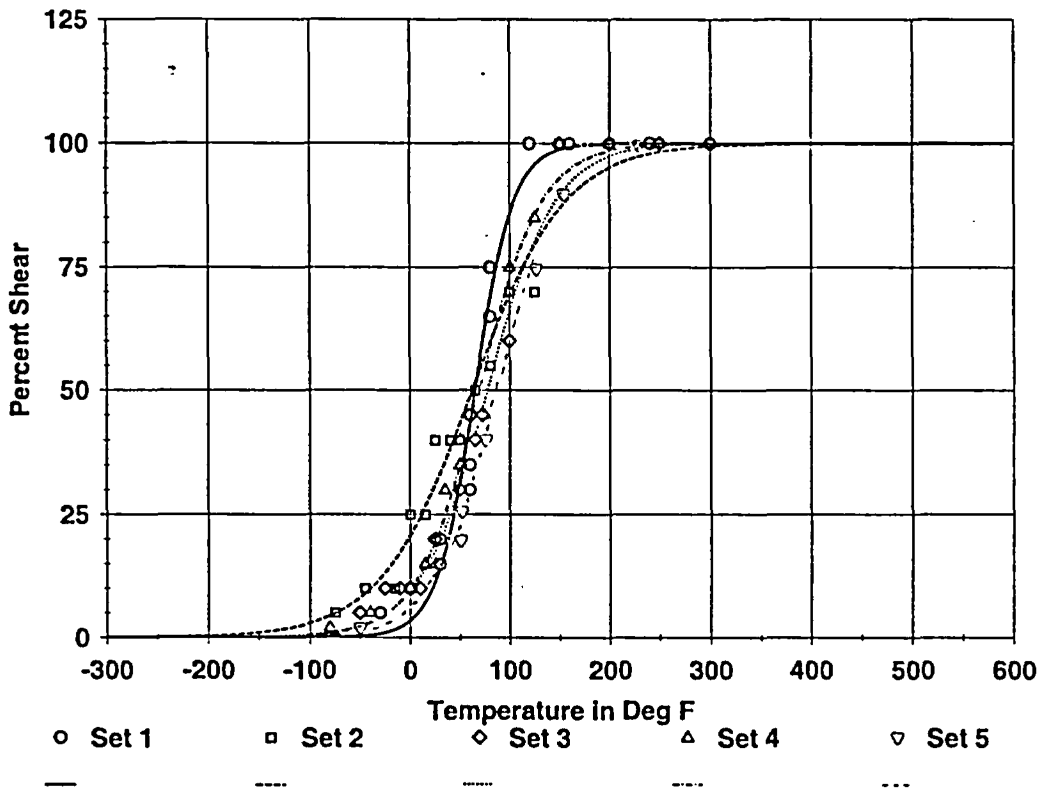
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	75.9	.0	36.4	.0
2		.0	70.6	-5.3	45.8	9.4
3		.0	68.9	-7.1	46.8	10.4
4		.0	64.6	-11.4	90.0	53.6
5		.0	69.4	-6.6	74.7	38.3

Figure 5-2 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)

LOWER SHELL PLATE 8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:36 AM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	LT	C3500-2
2	Vogtle 2	U	SA533B1	LT	C3500-2
3	Vogtle 2	Y	SA533B1	LT	C3500-2
4	Vogtle 2	X	SA533B1	LT	C3500-2
5	Vogtle 2	W	SA533B1	LT	C3500-2



Results

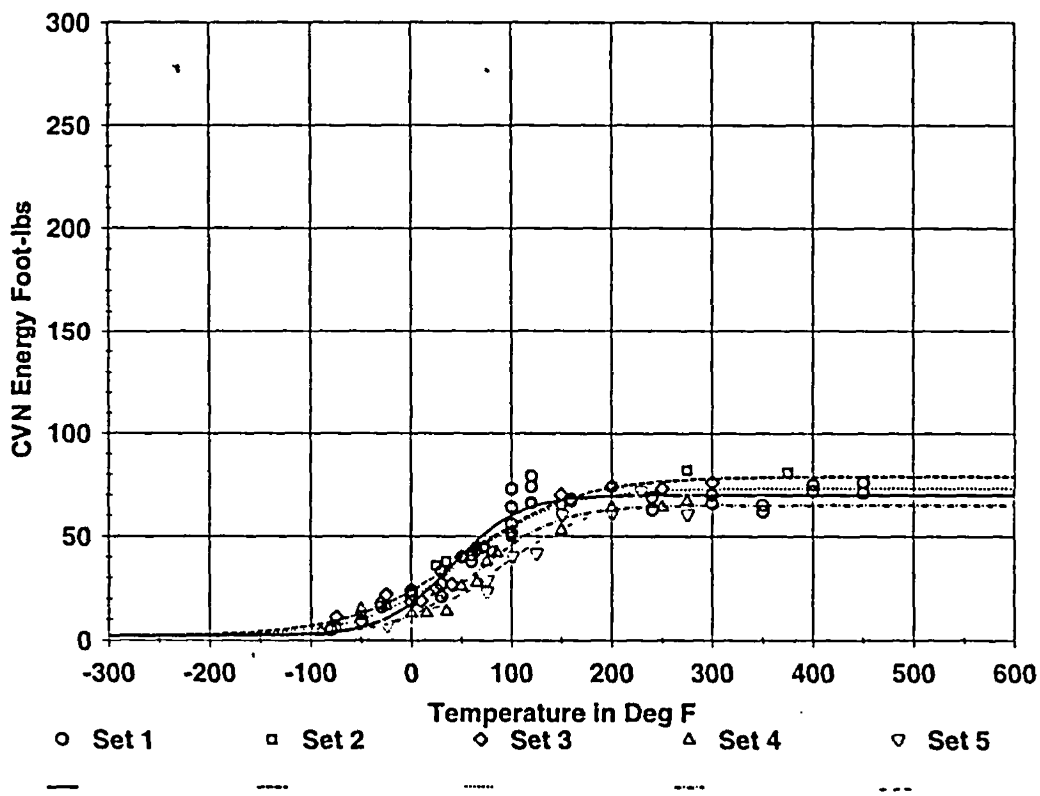
Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	65.0	.0
2		.0	100.0	.0	62.2	-2.8
3		.0	100.0	.0	77.8	12.8
4		.0	100.0	.0	69.3	4.3
5		.0	100.0	.0	86.5	21.5

Figure 5-3 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)

LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 01:11 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	TL	C3500-2
2	Vogtle 2	U	SA533B1	TL	C3500-2
3	Vogtle 2	Y	SA533B1	TL	C3500-2
4	Vogtle 2	X	SA533B1	TL	C3500-2
5	Vogtle 2	W	SA533B1	TL	C3500-2



Results

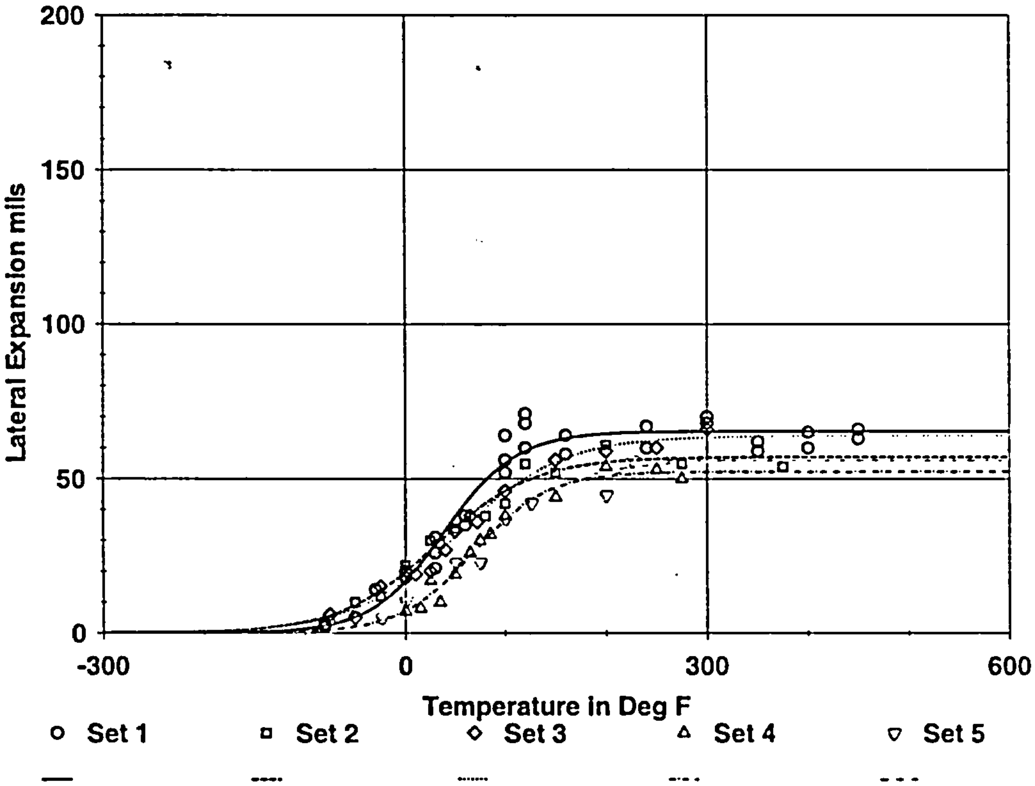
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	70.0	.0	28.6	.0	70.1	.0
2		2.2	79.0	9.0	21.5	-7.1	82.6	12.5
3		2.2	73.0	3.0	30.5	1.9	87.0	16.9
4		2.2	65.0	-5.0	58.4	29.8	113.5	43.4
5		2.2	69.0	-1.0	74.1	45.5	133.2	63.1

Figure 5-4 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)

LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 12/01/2004 01:44 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	TL	C3500-2
2	Vogtle 2	U	SA533B1	TL	C3500-2
3	Vogtle 2	Y	SA533B1	TL	C3500-2
4	Vogtle 2	X	SA533B1	TL	C3500-2
5	Vogtle 2	W	SA533B1	TL	C3500-2



Results

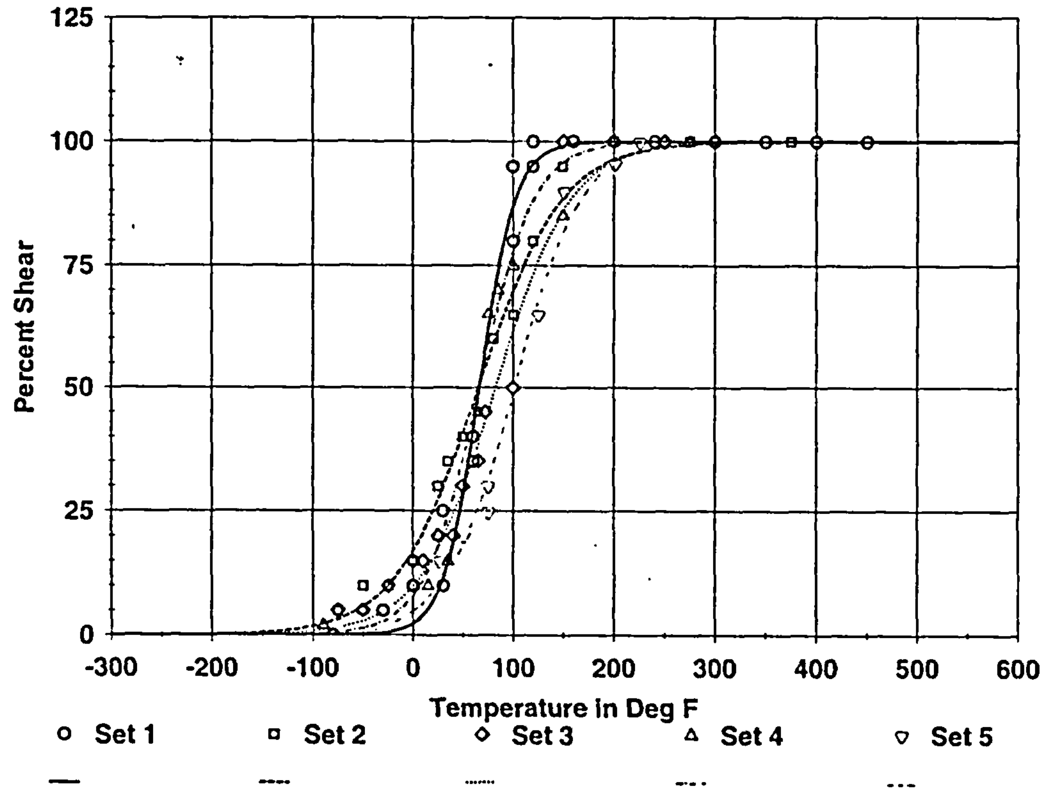
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	65.3	.0	44.0	.0
2		.0	57.1	-8.2	53.1	9.1
3		.0	63.8	-1.5	62.9	18.9
4		.0	52.4	-12.9	94.3	50.3
5		.0	55.8	-9.5	97.1	53.1

Figure 5-5 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)

LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:32 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	TL	C3500-2
2	Vogtle 2	U	SA533B1	TL	C3500-2
3	Vogtle 2	Y	SA533B1	TL	C3500-2
4	Vogtle 2	X	SA533B1	TL	C3500-2
5	Vogtle 2	W	SA533B1	TL	C3500-2



Results

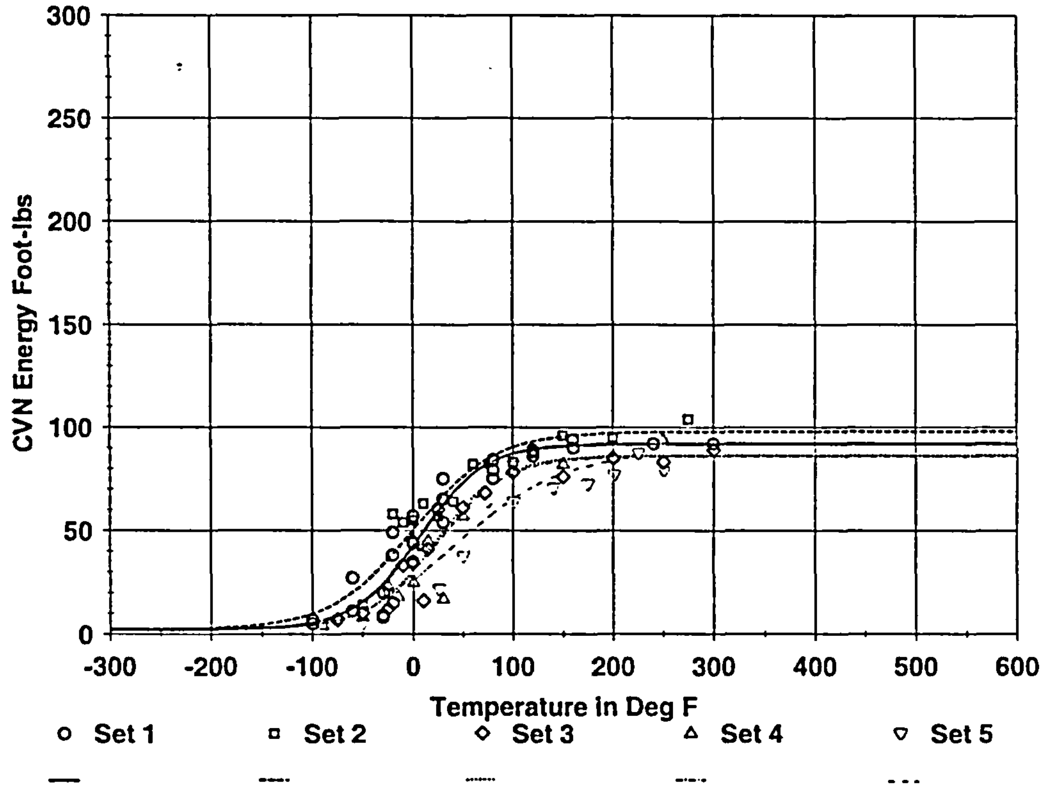
Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	66.5	.0
2		.0	100.0	.0	65.5	-1.0
3		.0	100.0	.0	83.0	16.5
4		.0	100.0	.0	66.2	-.3
5		.0	100.0	.0	100.4	33.9

Figure 5-6 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)

SURVEILLANCE PROGRAM WELD MATERIAL

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 01:23 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SMAW	NA	87005
2	Vogtle 2	U	SMAW	NA	87005
3	Vogtle 2	Y	SMAW	NA	87005
4	Vogtle 2	X	SMAW	NA	87005
5	Vogtle 2	W	SMAW	NA	87005



Results

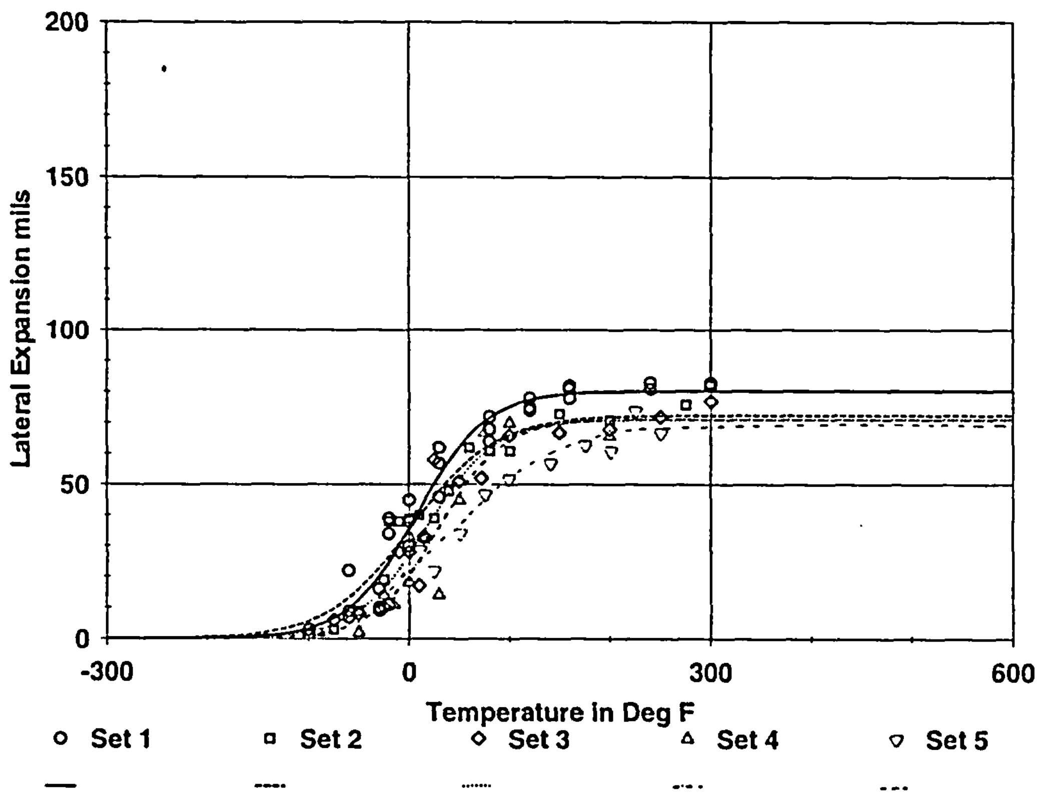
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	92.0	.0	-19.2	.0	11.1	.0
2		2.2	98.0	6.0	-36.5	-17.3	.0	-11.1
3		2.2	86.0	-6.0	-.5	18.7	32.0	20.9
4		2.2	87.0	-6.0	.7	19.9	34.5	23.4
5		2.2	87.0	-5.0	12.2	31.4	59.0	47.9

Figure 5-7 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Weld Metal

SURVEILLANCE PROGRAM WELD MATERIAL

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 04:17 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SMAW	NA	87005
2	Vogtle 2	U	SMAW	NA	87005
3	Vogtle 2	Y	SMAW	NA	87005
4	Vogtle 2	X	SMAW	NA	87005
5	Vogtle 2	W	SMAW	NA	87005



Results

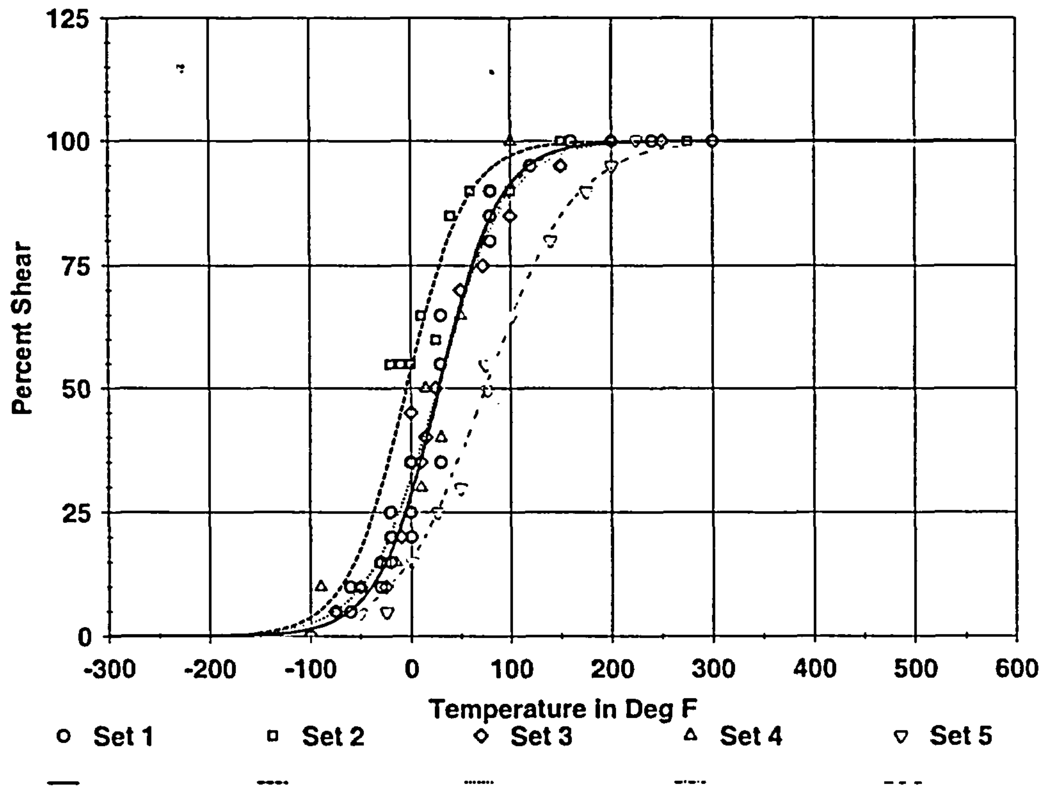
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	80.4	.0	-1.0	.0
2		.0	72.6	-7.9	-.3	.7
3		.0	71.0	-9.4	16.2	17.2
4		.0	71.2	-9.2	28.1	29.1
5		.0	70.0	-10.5	45.0	46.0

Figure 5-8 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Weld Metal

SURVEILLANCE PROGRAM WELD MATERIAL

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 03:51 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SMAW	NA	87005
2	Vogtle 2	U	SMAW	NA	87005
3	Vogtle 2	Y	SMAW	NA	87005
4	Vogtle 2	X	SMAW	NA	87005
5	Vogtle 2	W	SMAW	NA	87005



Results

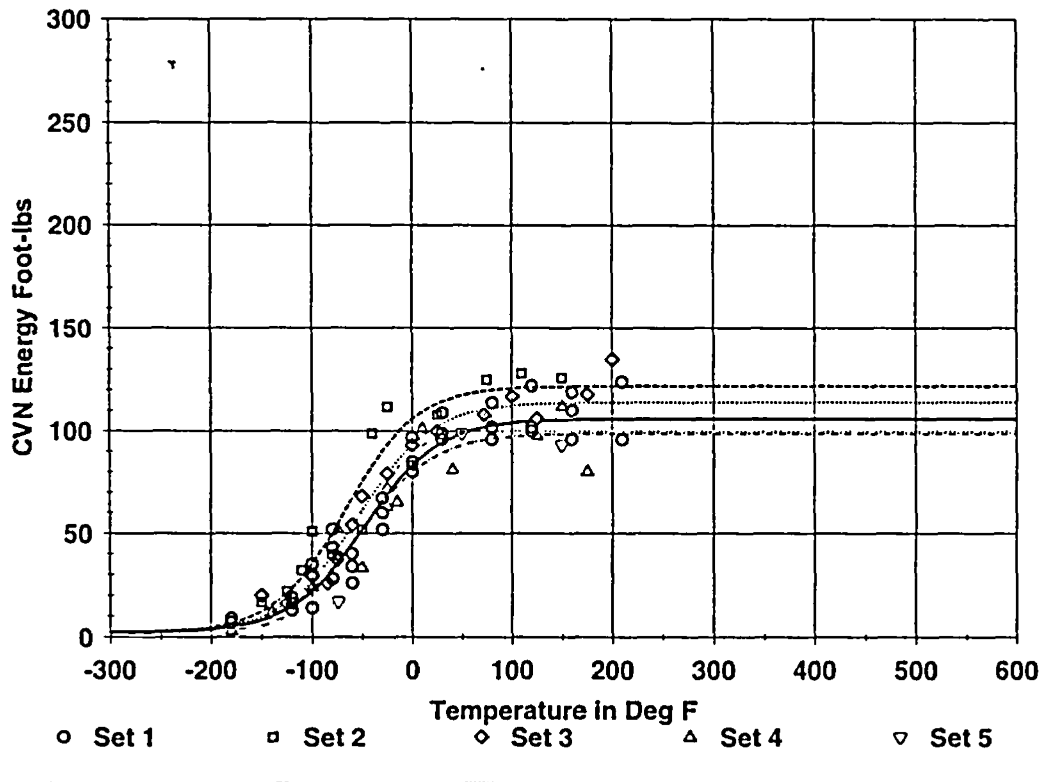
Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	28.1	.0
2		.0	100.0	.0	-4.1	-32.2
3		.0	100.0	.0	27.3	-.8
4		.0	100.0	.0	29.7	1.6
5		.0	100.0	.0	74.5	46.4

Figure 5-9 Charpy V-Notch Percent Shear vs Temperature for Vogtle Unit 2 Reactor Vessel Weld Metal

HEAT AFFECTED ZONE

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:21 AM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	NA	C3500-2
2	Vogtle 2	U	SA533B1	NA	C3500-2
3	Vogtle 2	Y	SA533B1	NA	C3500-2
4	Vogtle 2	X	SA533B1	NA	C3500-2
5	Vogtle 2	W	SA533B1	NA	C3500-2



Results

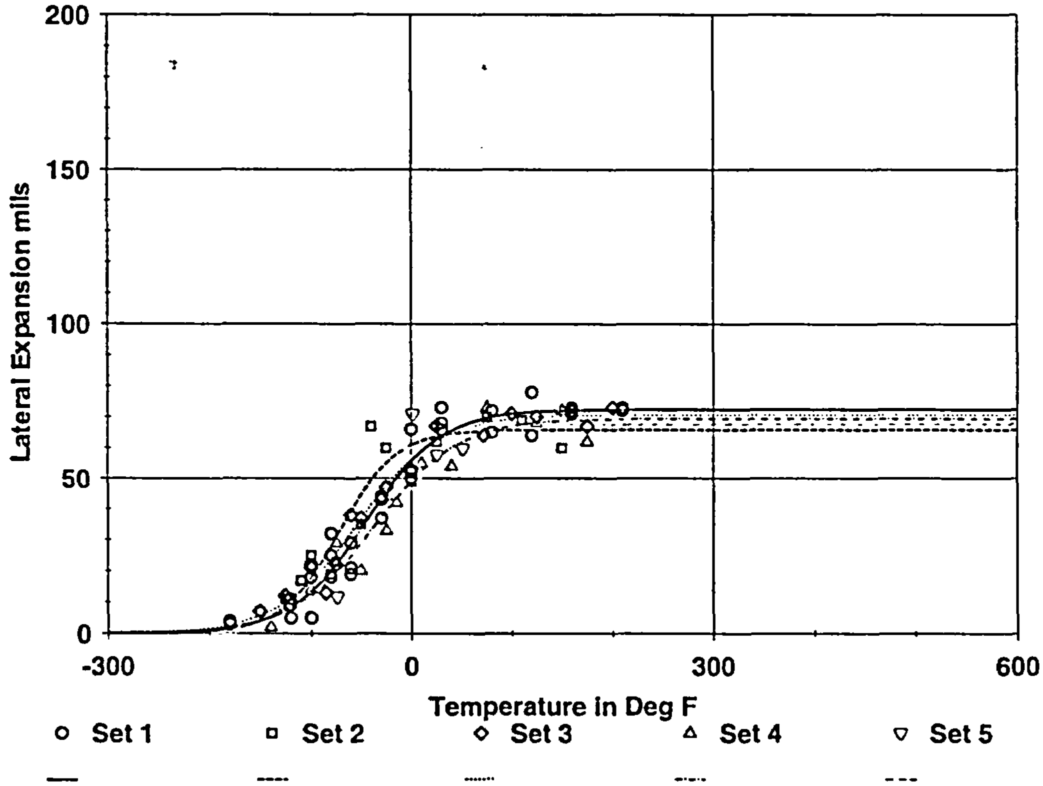
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	106.0	.0	-83.7	.0	-52.4	.0
2		2.2	122.0	16.0	-108.0	-24.3	-80.2	-27.8
3		2.2	114.0	8.0	-93.8	-10.1	-63.9	-11.5
4		2.2	99.0	-7.0	-86.2	-2.5	-53.2	-.8
5		2.2	100.0	-6.0	-80.5	3.2	-57.0	-4.6

Figure 5-10 Charpy V-Notch Impact Energy vs. Temperature for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Material

HEAT AFFECTED ZONE

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 12:26 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	NA	C3500-2
2	Vogtle 2	U	SA533B1	NA	C3500-2
3	Vogtle 2	Y	SA533B1	NA	C3500-2
4	Vogtle 2	X	SA533B1	NA	C3500-2
5	Vogtle 2	W	SA533B1	NA	C3500-2



Results

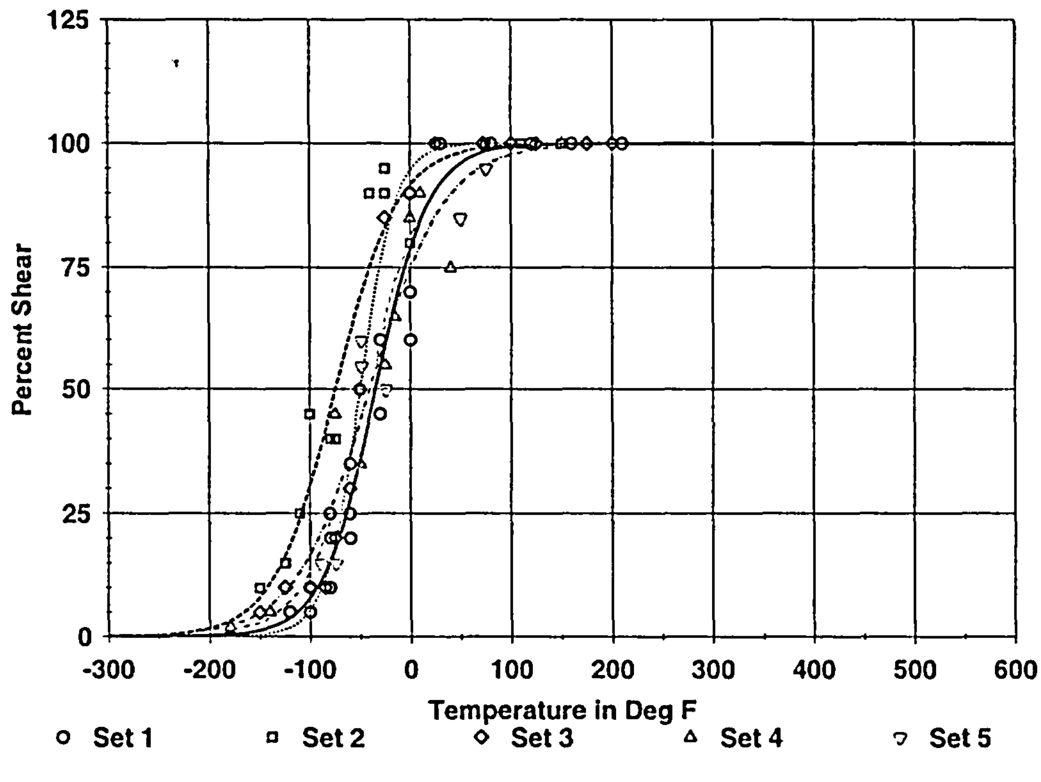
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	72.4	.0	-46.9	.0
2		.0	65.9	-6.5	-67.7	-20.8
3		.0	70.6	-1.9	-53.4	-6.5
4		.0	69.4	-3.0	-35.4	11.5
5		.0	68.0	-4.4	-46.5	.4

Figure 5-11 Charpy V-Notch Lateral Expansion vs. Temperature for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Material

HEAT AFFECTED ZONE

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:36 AM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Vogtle 2	UNIRR	SA533B1	NA	C3500-2
2	Vogtle 2	U	SA533B1	NA	C3500-2
3	Vogtle 2	Y	SA533B1	NA	C3500-2
4	Vogtle 2	X	SA533B1	NA	C3500-2
5	Vogtle 2	W	SA533B1	NA	C3500-2



Results

Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	-34.6	.0
2		.0	100.0	.0	-74.4	-39.8
3		.0	100.0	.0	-49.3	-14.7
4		.0	100.0	.0	-40.2	-5.6
5		.0	100.0	.0	-42.8	-8.2

Figure 5-12 Charpy V-Notch Percent Shear vs. Temperature for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Material

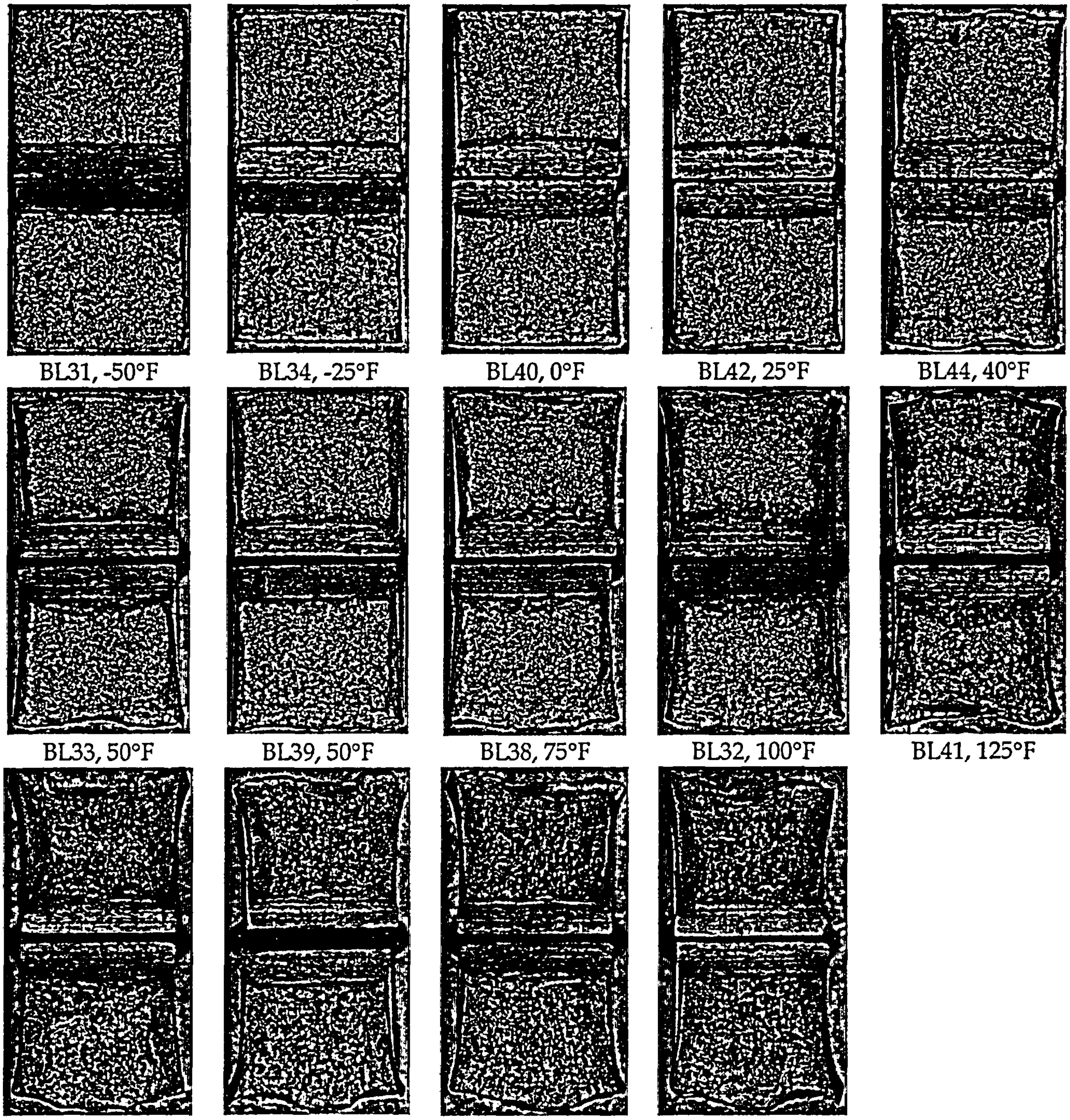


Figure 5-13 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)

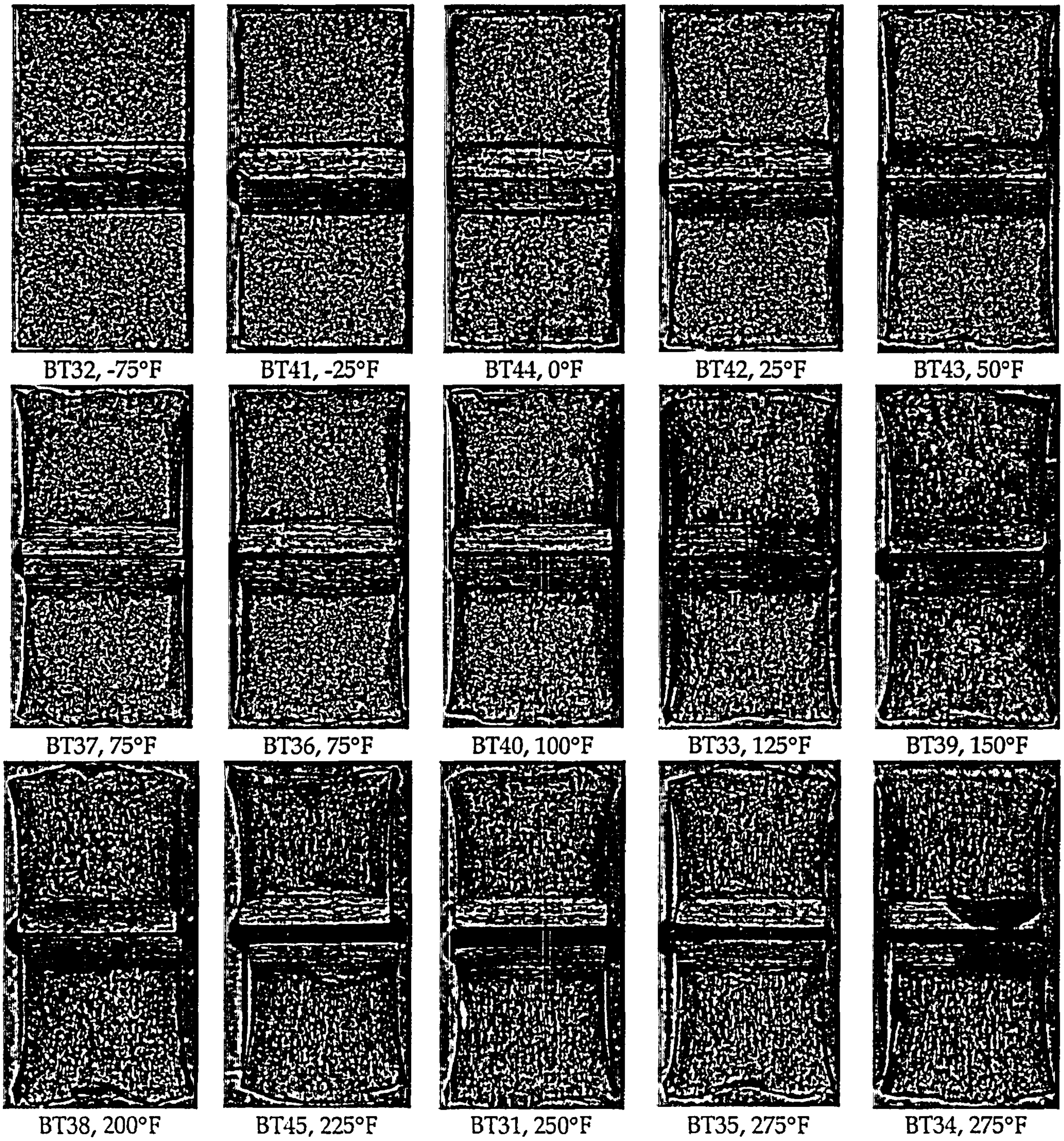


Figure 5-14 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)

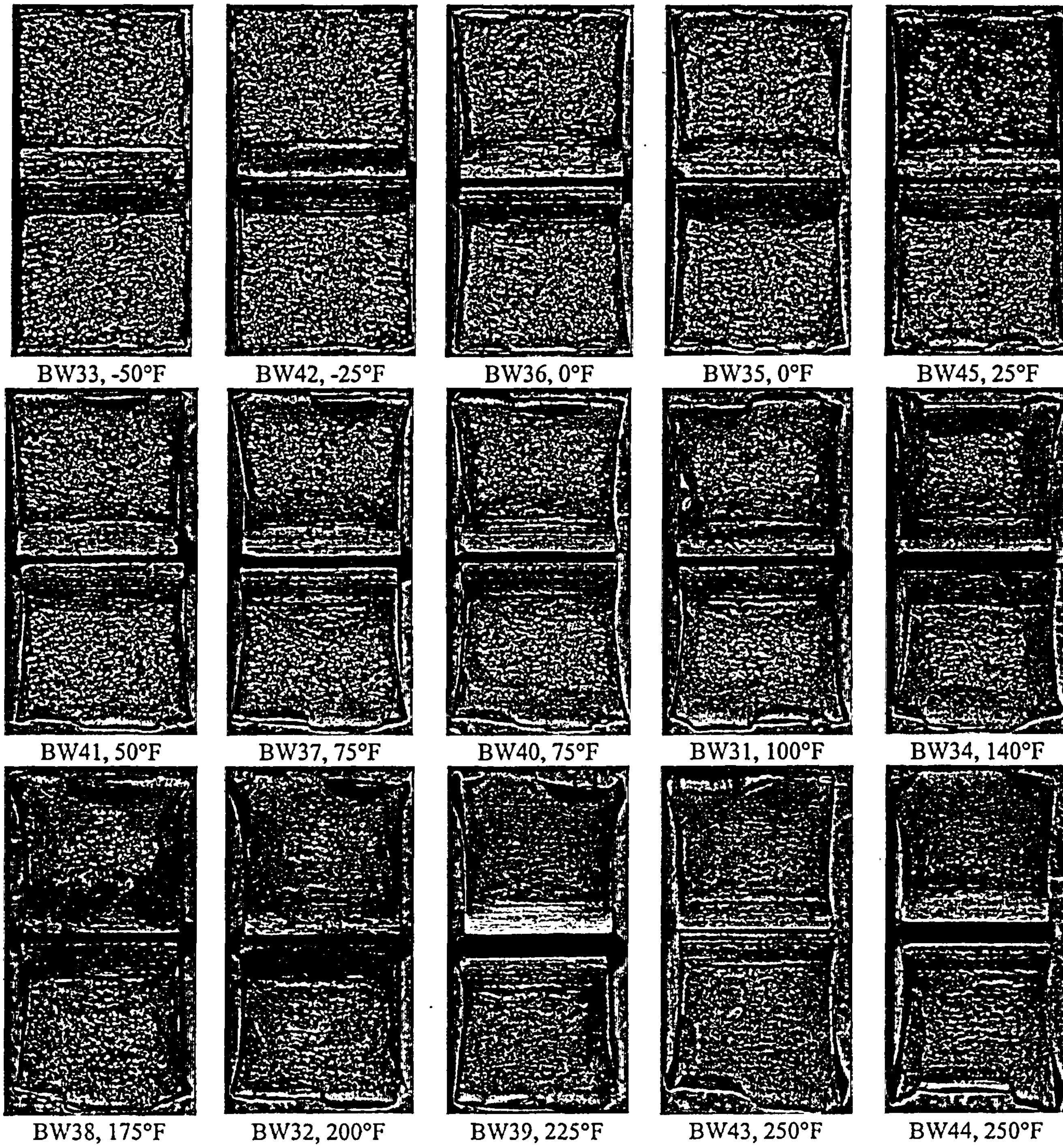


Figure 5-15 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Weld Metal

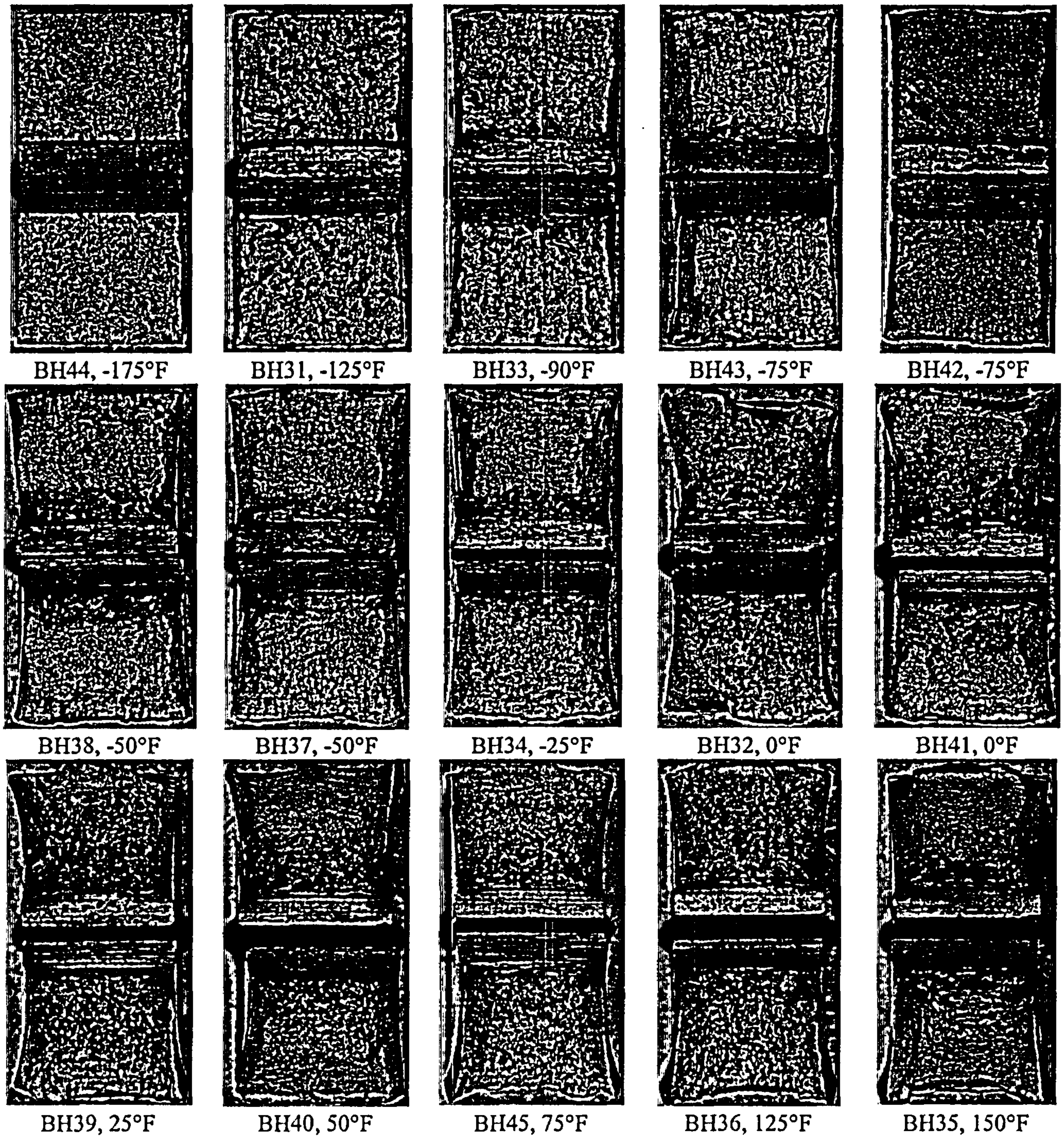
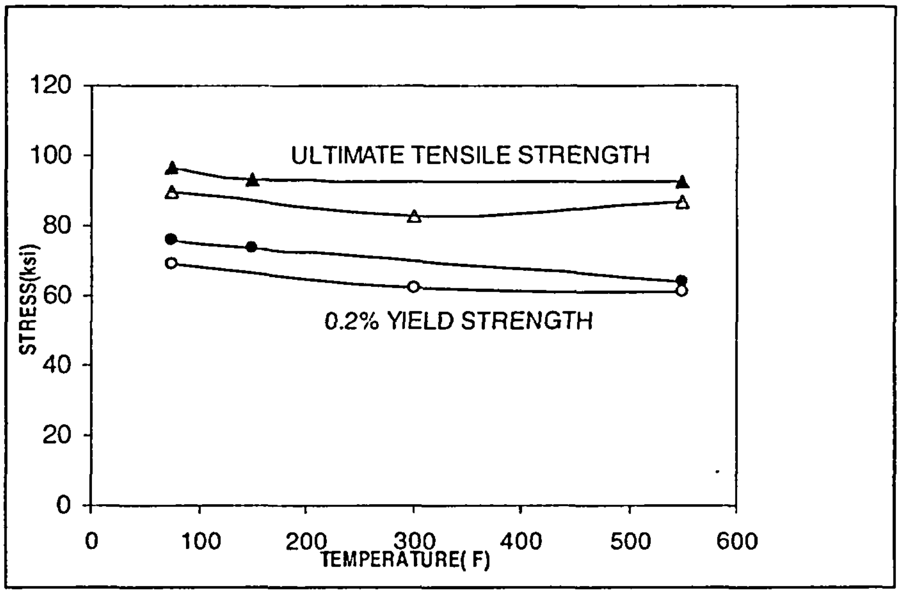


Figure 5-16 Charpy Impact Specimen Fracture Surfaces for Vogtle Unit 2 Reactor Vessel Heat-Affected-Zone Metal



Legend: Δ and ○ are Unirradiated
▲and ● are Irradiated to 2.98 x 10^{19} n/cm^2 (E > 1.0 MeV)

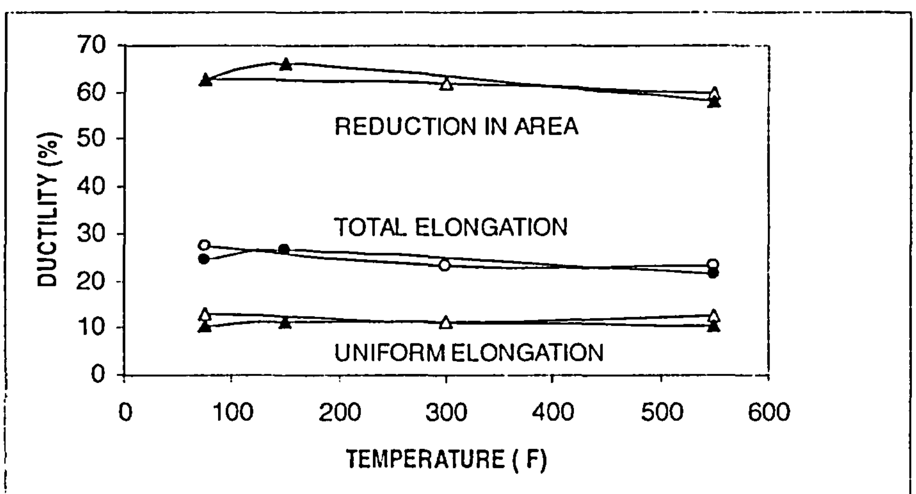
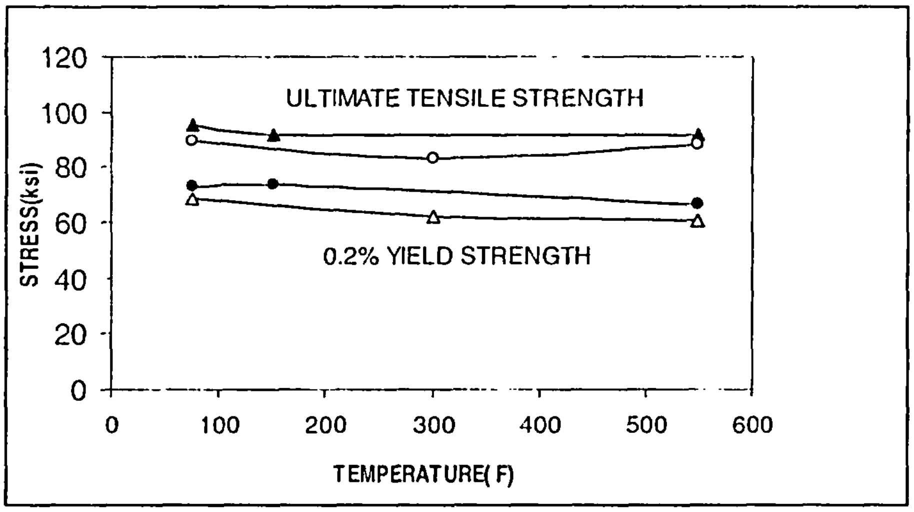


Figure 5-17 Tensile Properties for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)



Legend: Δ and ○ are Unirradiated
▲ and ● are Irradiated to 2.98 x 10^{19} n/cm^2 (E > 1.0 MeV)

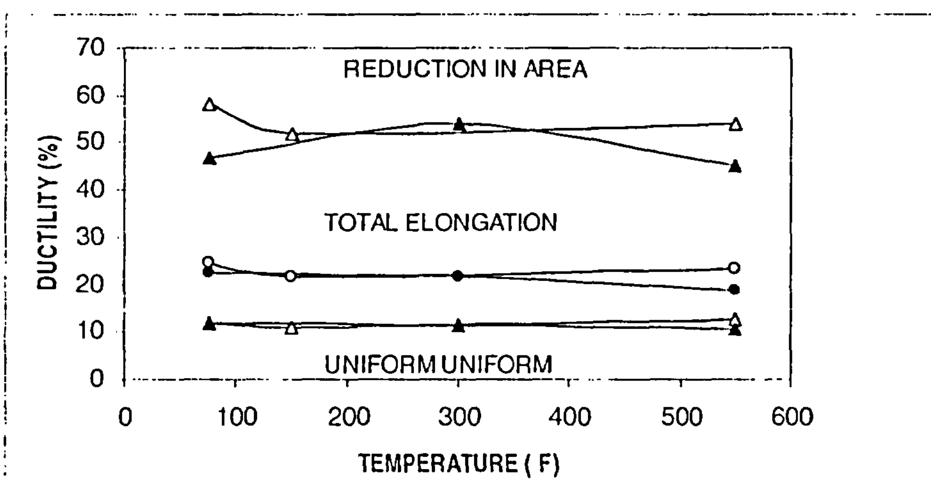
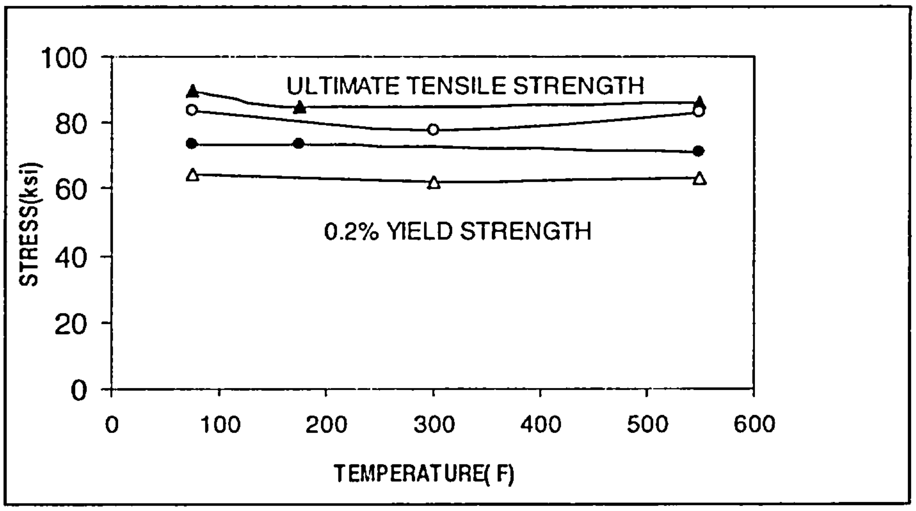


Figure 5-18 Tensile Properties for Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)



Legend: Δ and ○ are Unirradiated
▲ and ● are Irradiated to 2.98 x 10^{19} n/cm^2 (E > 1.0 MeV)

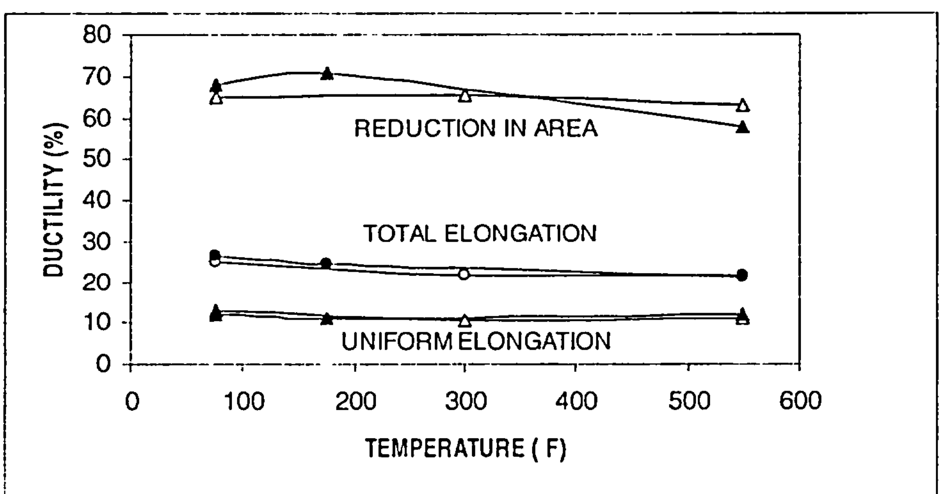
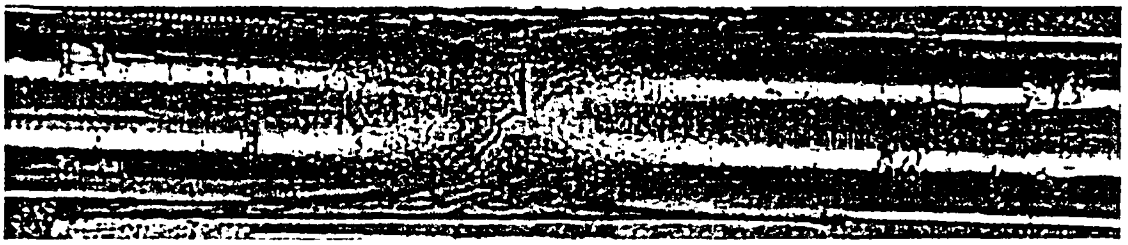


Figure 5-19 Tensile Properties for Vogtle Unit 2 Reactor Vessel Weld Metal

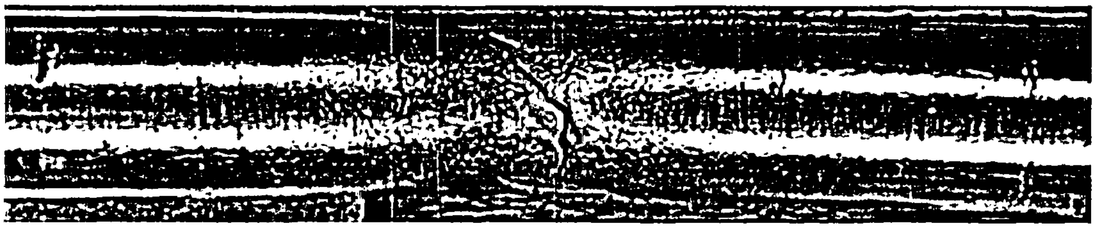


Specimen BL-7 Tested at 75°F

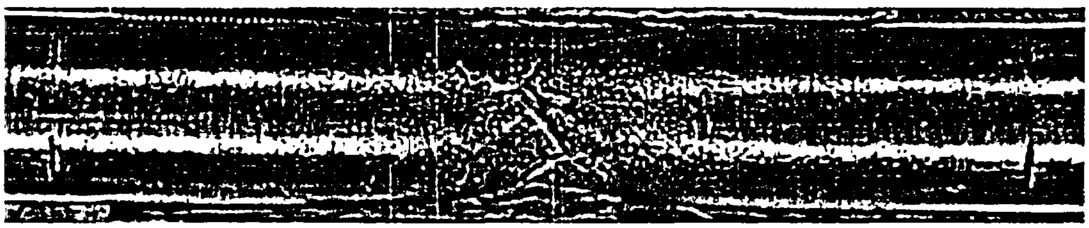
Specimen BL-8 Tested at 150°F

Specimen BL-9 Tested at 550°F

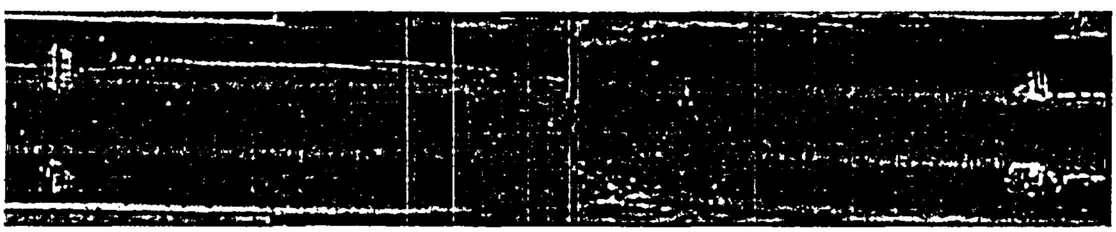
Figure 5-20 Fractured Tensile Specimens from Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Longitudinal Orientation*)



Specimen BT-7 Tested at 75°F

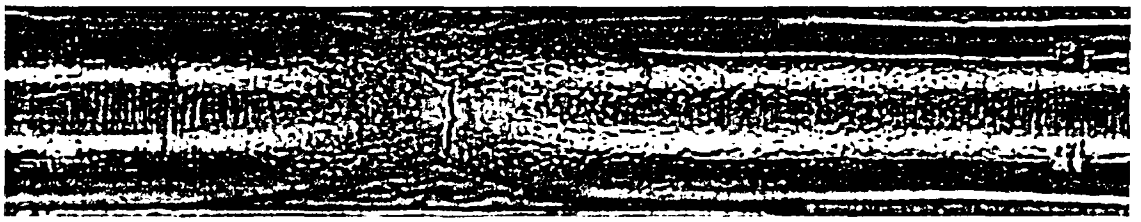


Specimen BT-8 Tested at 150°F



Specimen BT-9 Tested at 550°F

Figure 5-21 Fractured Tensile Specimens from Vogtle Unit 2 Reactor Vessel Lower Shell Plate B8628-1 (*Transverse Orientation*)



Specimen BW-7 Tested at 75°F

Specimen BW-8 Tested at 175°F

Specimen BW-9 Tested at 550°F

Figure 5-22 Fractured Tensile Specimens from Vogtle Unit 2 Reactor Vessel Weld Metal

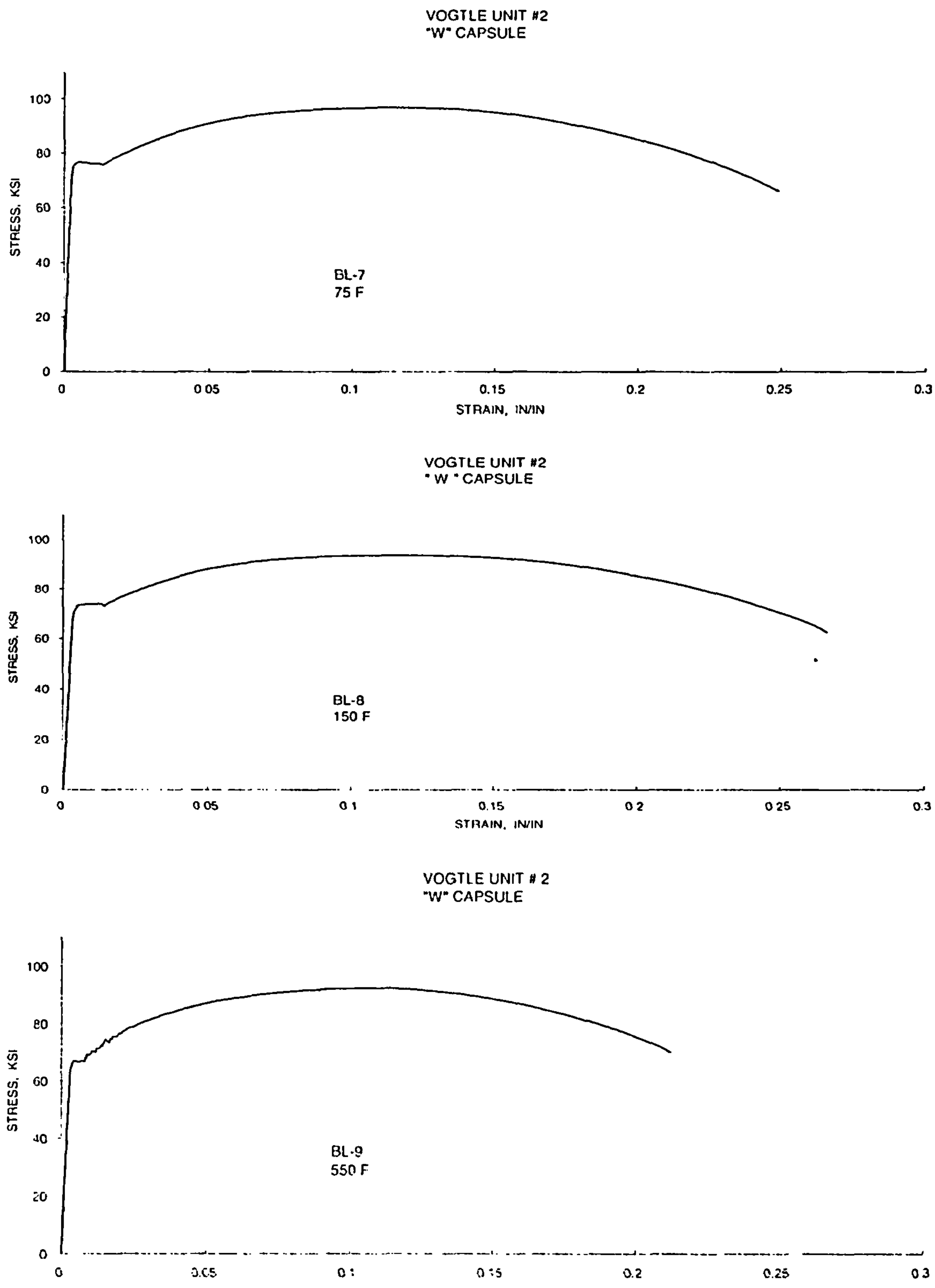


Figure 5-23 Engineering Stress-Strain Curves for Lower Shell Plate B8628-1 Tensile Specimens BL7, BL8 and BL9 (*Longitudinal Orientation*)

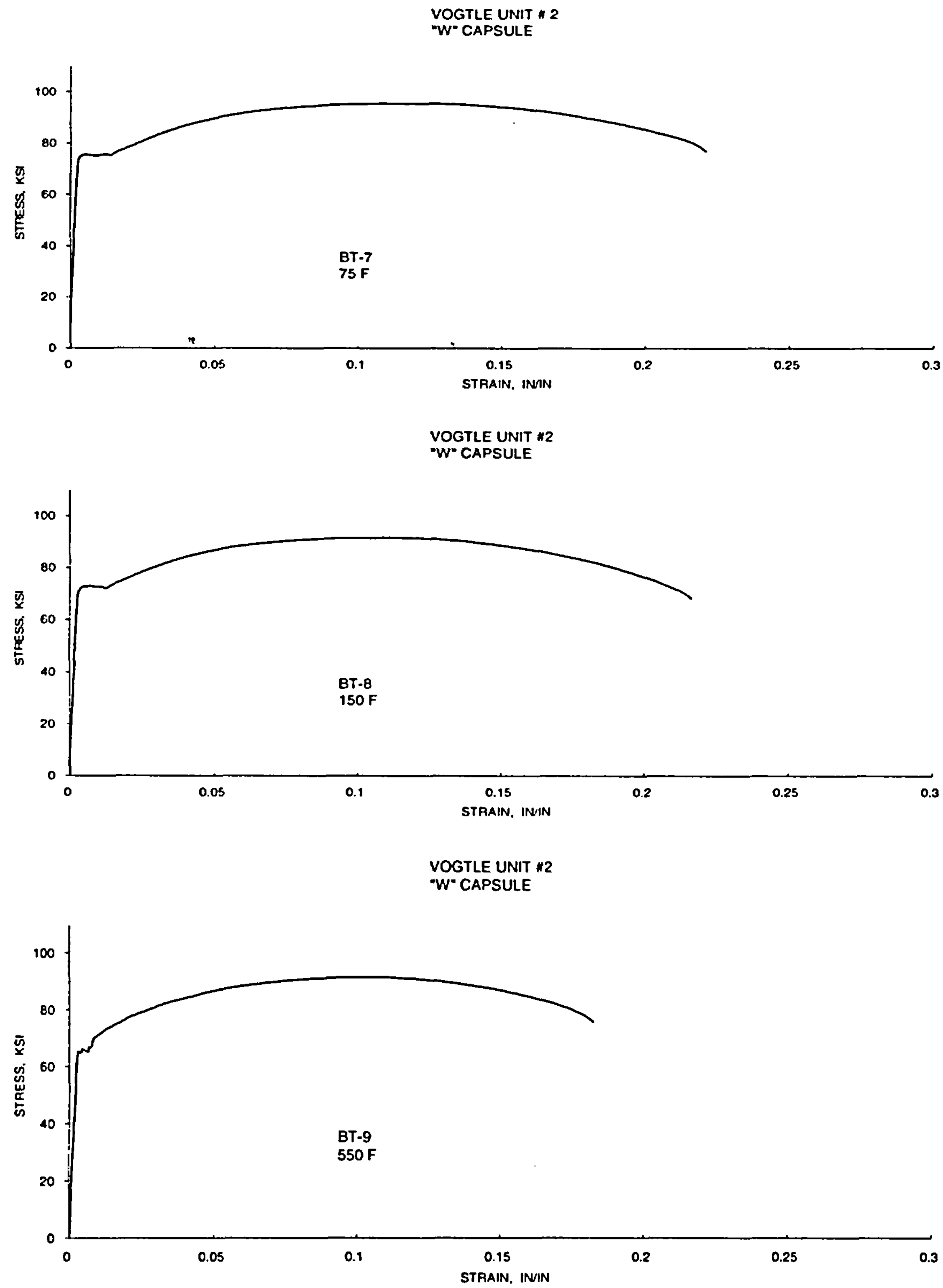


Figure 5-24 Engineering Stress-Strain Curves for Lower Shell Plate B8628-1 Tensile Specimens BT7, BT8 and BT9 (*Transverse Orientation*)

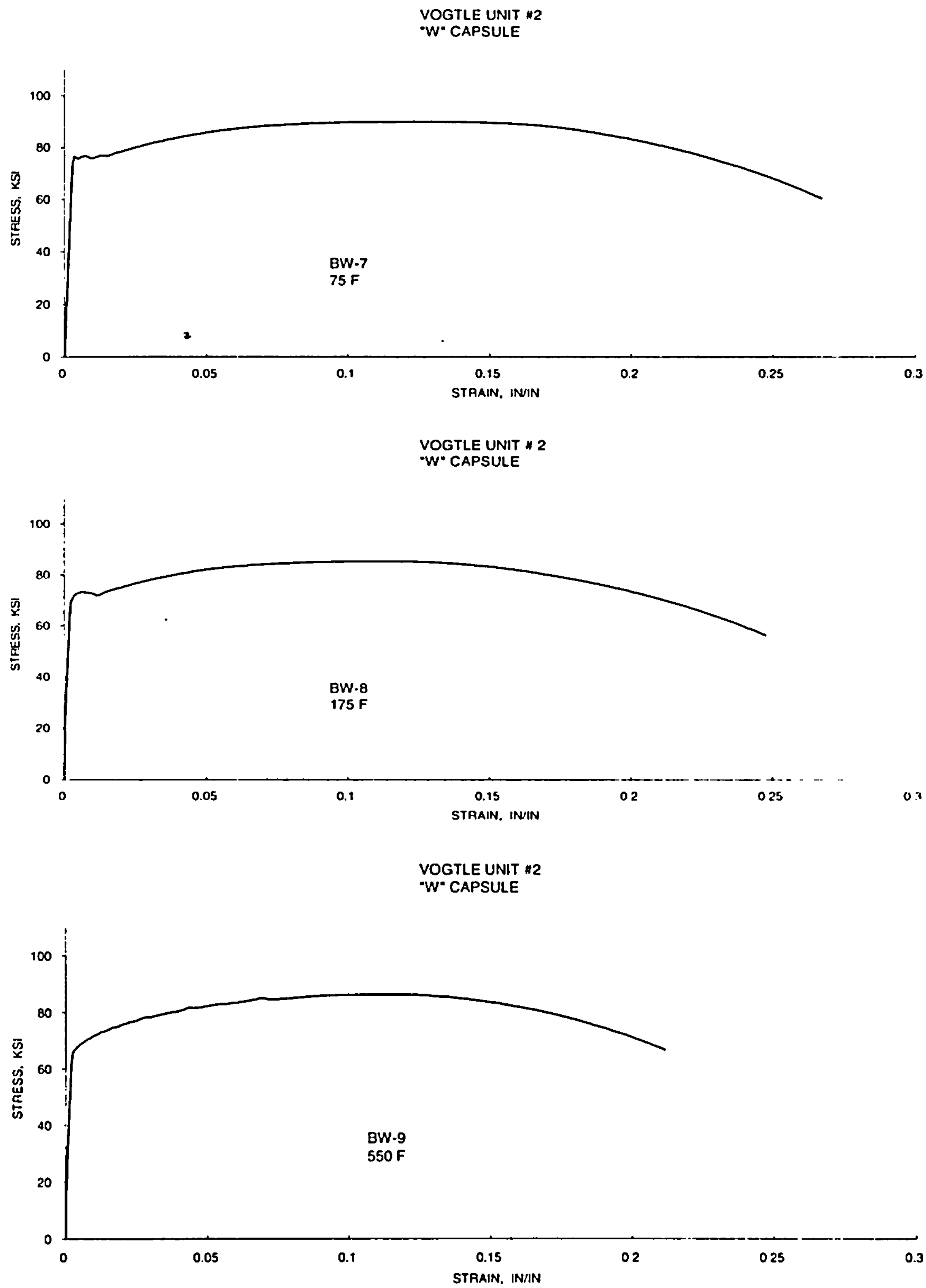


Figure 5-25 Engineering Stress-Strain Curves for Weld Metal Tensile Specimens BW7, BW8 and BW9

6 RADIATION ANALYSIS AND NEUTRON DOSIMETRY

6.1 INTRODUCTION

This section describes a discrete ordinates S_n transport analysis performed for the Alvin W. Vogtle Unit 2 reactor to determine the neutron radiation environment within the reactor pressure vessel and surveillance capsules. In this analysis, fast neutron exposure parameters in terms of fast neutron fluence (E > 1.0 MeV) and iron atom displacements (dpa) were established on a plant and fuel cycle specific basis. An evaluation of the most recent dosimetry sensor set from Capsule W, withdrawn at the end of the tenth plant operating cycle, is provided. In addition, to provide an up-to-date data base applicable to the Alvin W. Vogtle Unit 2 reactor, the sensor sets from the previously withdrawn capsules (U, Y, and X) were re-analyzed using the current dosimetry evaluation methodology. These dosimetry updates are presented in Appendix A of this report. Comparisons of the results from these dosimetry evaluations with the analytical predictions served to validate the plant specific neutron transport calculations. These validated calculations subsequently formed the basis for providing projections of the neutron exposure of the reactor pressure vessel for operating periods extending to 54 Effective Full Power Years (EFPY).

The use of fast neutron fluence (E > 1.0 MeV) to correlate measured material property changes to the neutron exposure of the material has traditionally been accepted for the development of damage trend curves as well as for the implementation of trend curve data to assess the condition of the vessel. In recent years, however, it has been suggested that an exposure model that accounts for differences in neutron energy spectra between surveillance capsule locations and positions within the vessel wall could lead to an improvement in the uncertainties associated with damage trend curves and improved accuracy in the evaluation of damage gradients through the reactor vessel wall.

Because of this potential shift away from a threshold fluence toward an energy dependent damage function for data correlation, ASTM Standard Practice E853, "Analysis and Interpretation of Light-Water Reactor Surveillance Results," recommends reporting displacements per iron atom (dpa) along with fluence (E > 1.0 MeV) to provide a database for future reference. The energy dependent dpa function to be used for this evaluation is specified in ASTM Standard Practice E693, "Characterizing Neutron Exposures in Iron and Low Alloy Steels in Terms of Displacements per Atom." The application of the dpa parameter to the assessment of embrittlement gradients through the thickness of the reactor vessel wall has already been promulgated in Revision 2 to Regulatory Guide 1.99, "Radiation Embrittlement of Reactor Vessel Materials."

All of the calculations and dosimetry evaluations described in this section and in Appendix A were based on the latest available nuclear cross-section data derived from ENDF/B-VI and made use of the latest available calculational tools. Furthermore, the neutron transport and dosimetry evaluation methodologies follow the guidance and meet the requirements of Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence."[17] Additionally, the methods used to develop the calculated pressure vessel fluence are consistent with the NRC approved methodology described in WCAP-14040-NP-A, "Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves," May 2004.[18]

6.2 DISCRETE ORDINATES ANALYSIS

A plan view of the Alvin W. Vogtle Unit 2 reactor geometry at the core midplane is shown in Figure 4-1. Six irradiation capsules attached to the neutron pad are included in the reactor design that constitutes the reactor vessel surveillance program. The capsules are located at azimuthal angles of 58.5°, 61°, 121.5°, 238.5°, 241°, and 301.5° as shown in Figure 4-1. These full core positions correspond to the following octant symmetric locations represented in Figure 6-1: 29° from the core cardinal axes (for the 61° and 241° dual surveillance capsule holder locations) and 31.5° from the core cardinal axes (for the 121.5° and 301.5° single surveillance capsule holder locations, and for the 58.5° and the 238.5° dual surveillance capsule holder locations). The stainless steel specimen containers are 1.182-inch by 1-inch and are approximately 56 inches in height. The containers are positioned axially such that the test specimens are centered on the core midplane, thus spanning the central 5 feet of the 12-foot high reactor core.

From a neutronic standpoint, the surveillance capsules and associated support structures are significant. The presence of these materials has a marked effect on both the spatial distribution of neutron flux and the neutron energy spectrum in the water annulus between the neutron pads and the reactor vessel. In order to determine the neutron environment at the test specimen location, the capsules themselves must be included in the analytical model.

In performing the fast neutron exposure evaluations for the Alvin W. Vogtle Unit 2 reactor vessel and surveillance capsules, a series of fuel cycle specific forward transport calculations were carried out using the following three-dimensional flux synthesis technique:

$$\phi(r,\theta,z) = \phi(r,\theta) * \frac{\phi(r,z)}{\phi(r)}$$

where $\phi(r,\theta,z)$ is the synthesized three-dimensional neutron flux distribution, $\phi(r,\theta)$ is the transport solution in r,θ geometry, $\phi(r,z)$ is the two-dimensional solution for a cylindrical reactor model using the actual axial core power distribution, and $\phi(r)$ is the one-dimensional solution for a cylindrical reactor model using the same source per unit height as that used in the r,θ two-dimensional calculation. This synthesis procedure was carried out for each operating cycle at Alvin W. Vogtle Unit 2.

For the Alvin W. Vogtle Unit 2 transport calculations, the r,θ models depicted in Figure 6-1 were utilized since, with the exception of the neutron pads, the reactor is octant symmetric. These r,θ models include the core, the reactor internals, the neutron pads – including explicit representations of octants not containing surveillance capsules and octants with surveillance capsules at 29° and 31.5°, the pressure vessel cladding and vessel wall, the insulation external to the pressure vessel, and the primary biological shield wall. These models formed the basis for the calculated results and enabled making comparisons to the surveillance capsule dosimetry evaluations. In developing these analytical models, nominal design dimensions were employed for the various structural components. Likewise, water temperatures, and hence, coolant densities in the reactor core and downcomer regions of the reactor were taken to be representative of full power operating conditions. The coolant densities were treated on a fuel cycle specific basis. The reactor core itself was treated as a homogeneous mixture of fuel, cladding, water, and miscellaneous core structures such as fuel assembly grids, guide tubes, et cetera. The geometric mesh description of the r,θ reactor models consisted of 183 radial by 99 azimuthal intervals. Mesh sizes were chosen to assure that proper convergence of the inner iterations was achieved on a pointwise basis. The pointwise inner iteration flux convergence criterion utilized in the r,θ calculations was set at a value of 0.001.

The r,z model used for the Alvin W. Vogtle Unit 2 calculations is shown in Figure 6-2 and extends radially from the centerline of the reactor core out to a location interior to the primary biological shield and over an axial span from an elevation below the lower core plate to above the upper core plate. As in the case of the r,θ models, nominal design dimensions and full power coolant densities were employed in the calculations. In this case, the homogenous core region was treated as an equivalent cylinder with a volume equal to that of the active core zone. The stainless steel former plates located between the core baffle and core barrel regions were also explicitly included in the model. The r,z geometric mesh description of these reactor models consisted of 153 radial by 188 axial intervals. As in the case of the r,θ calculations, mesh sizes were chosen to assure that proper convergence of the inner iterations was achieved on a point-wise basis. The point-wise inner iteration flux convergence criterion utilized in the r,z calculations was also set at a value of 0.001.

The one-dimensional radial models used in the synthesis procedure consisted of the same 153 radial mesh intervals included in the r,z models. Thus, radial synthesis factors could be determined on a meshwise basis throughout the entire geometry.

The core power distributions used in the plant specific transport analysis were provided by Southern Nuclear Co and the Nuclear Fuels Division of Westinghouse. for each of the first eleven fuel cycles at Alvin W. Vogtle Unit 2. Specifically, the data utilized included cycle dependent fuel assembly initial enrichments, burn-ups, and axial power distributions. This information was used to develop spatial and energy dependent core source distributions averaged over each individual fuel cycle. Therefore, the results from the neutron transport calculations provided data in terms of fuel cycle averaged neutron flux, which-h when multiplied by the appropriate fuel cycle length, generated the incremental fast neutron exposure for each fuel cycle. In constructing these core source distributions, the energy distribution of the source was based on an appropriate fission split for uranium and plutonium isotopes based on the initial enrichment and burn-up history of individual fuel assemblies. From these assembly dependent fission splits, composite values of energy release per fission, neutron yield per fission, and fission spectrum were determined.

All of the transport calculations supporting this analysis were carried out using the DORT discrete ordinates code Version 3.1[19] and the BUGLE-96 cross-section library.[20] The BUGLE-96 library provides a 67 group coupled neutron-gamma ray cross-section data set produced specifically for light water reactor (LWR) applications. In these analyses, anisotropic scattering was treated with a P_5 legendre expansion and angular discretization was modeled with an S_{16} order of angular quadrature. Energy and space dependent core power distributions, as well as system operating temperatures, were treated on a fuel cycle specific basis.

Selected results from the neutron transport analyses are provided in Tables 6-1 through 6-6. In Table 6-1, the calculated exposure rates and integrated exposures, expressed in terms of both neutron fluence (E > 1.0 MeV) and dpa, are given at the radial and azimuthal center of the octant symmetric surveillance capsule positions, i.e., for the 29° dual capsule, 31.5° dual capsule, and 31.5° single capsule. These results, representative of the axial midplane of the active core, establish the calculated exposure of the surveillance capsules withdrawn to date as well as projected into the future. Similar information is provided in Table 6-2 for the reactor vessel inner radius at four azimuthal locations. The vessel data given in Table 6-2 were taken at the clad/base metal interface, and thus, represent maximum calculated exposure levels on the vessel.

Both calculated fluence (E > 1.0 MeV) and dpa data are provided in Table 6-1 and Table 6-2. These data tabulations include both plant and fuel cycle specific calculated neutron exposures at the end of the tenth fuel cycle as well as future projections to 20, 24, 32, 40, 48, and 54 EFPY. The calculations for Cycle 4 account for an uprate from 3411 MWt to 3565 MWt. The projections were based on the assumption that the core power distributions and associated plant operating characteristics from Cycle 11 were representative of future plant operation. The future projections are also based on the current reactor power level of 3565 MWt.

Radial gradient information applicable to fast (E > 1.0 MeV) neutron fluence and dpa are given in Tables 6-3 and 6-4, respectively. The data, based on the cumulative integrated exposures from Cycles 1 through 10, are presented on a relative basis for each exposure parameter at several azimuthal locations. Exposure distributions through the vessel wall may be obtained by multiplying the calculated exposure at the vessel inner radius by the gradient data listed in Tables 6-3 and 6-4.

The calculated fast neutron exposures for the four surveillance capsules withdrawn from the Alvin W. Vogtle Unit 2 reactor are provided in Table 6-5. These assigned neutron exposure levels are based on the plant and fuel cycle specific neutron transport calculations performed for the Alvin W. Vogtle Unit 2 reactor.

Updated lead factors for the Alvin W. Vogtle Unit 2 surveillance capsules are provided in Table 6-6. The capsule lead factor is defined as the ratio of the calculated fluence (E > 1.0 MeV) at the geometric center of the surveillance capsule to the corresponding maximum calculated fluence at the pressure vessel clad/base metal interface. In Table 6-6, the lead factors for capsules that have been withdrawn from the reactor (U, Y, X and W) were based on the calculated fluence values for the irradiation period corresponding to the time of withdrawal for the individual capsules. For the capsules remaining in the reactor (V and Z), the lead factor corresponds to the calculated fluence values at the end of Cycle 11, the last completed fuel cycle for Alvin W. Vogtle Unit 2.

6.3 NEUTRON DOSIMETRY

The validity of the calculated neutron exposures previously reported in Section 6.2 is demonstrated by a direct comparison against the measured sensor reaction rates and via a least squares evaluation performed for each of the capsule dosimetry sets. However, since the neutron dosimetry measurement data merely serves to validate the calculated results, only the direct comparison of measured-to-calculated results for the most recent surveillance capsule removed from service is provided in this section of the report. For completeness, the assessment of all measured dosimetry removed to date, based on both direct and least squares evaluation comparisons, is documented in Appendix A.

The direct comparison of measured versus calculated fast neutron threshold reaction rates for the sensors from Capsule W, that was withdrawn from Alvin W. Vogtle Unit 2 at the end of the tenth fuel cycle, is summarized below.

Reaction	Reaction Rates (rps/atom)		M/C Ratio
	Measured	Calculated	
$^{63}Cu(n,\alpha)^{60}Co$	4.21E-17	3.94E-17	1.07
$^{54}Fe(n,p)^{54}Mn$	4.15E-15	4.29E-15	0.97
$^{58}Ni(n,p)^{58}Co$	6.11E-15	6.00E-15	1.02
$^{238}U(n,p)^{137}Cs$ (Cd)	2.70E-14	2.27E-14	1.19
$^{237}Np(n,f)^{137}Cs$ (Cd)	2.35E-13	2.21E-13	1.06
		Average:	1.06
		% Standard Deviation:	8.2

The measured-to-calculated (M/C) reaction rate ratios for the Capsule W threshold reactions range from 0.97 to 1.19, and the average M/C ratio is 1.06 ± 8.2% (1σ). This direct comparison falls well within the ± 20% criterion specified in Regulatory Guide 1.190; furthermore, it is consistent with the full set of comparisons given in Appendix A for all measured dosimetry removed to date from the Alvin W. Vogtle Unit 2 reactor. These comparisons validate the current analytical results described in Section 6.2; therefore, the calculations are deemed applicable for Alvin W. Vogtle Unit 2.

6.4 CALCULATIONAL UNCERTAINTIES

The uncertainty associated with the calculated neutron exposure of the Alvin W. Vogtle Unit 2 surveillance capsule and reactor pressure vessel is based on the recommended approach provided in Regulatory Guide 1.190. In particular, the qualification of the methodology was carried out in the following four stages:

1 - Comparison of calculations with benchmark measurements from the Pool Critical Assembly (PCA) simulator at the Oak Ridge National Laboratory (ORNL).

2 - Comparisons of calculations with surveillance capsule and reactor cavity measurements from the H. B. Robinson power reactor benchmark experiment.

3 - An analytical sensitivity study addressing the uncertainty components resulting from important input parameters applicable to the plant specific transport calculations used in the neutron exposure assessments.

4 - Comparisons of the plant specific calculations with all available dosimetry results from the Alvin W. Vogtle Unit 2 surveillance program.

The first phase of the methods qualification (PCA comparisons) addressed the adequacy of basic transport calculation and dosimetry evaluation techniques and associated cross-sections. This phase, however, did not test the accuracy of commercial core neutron source calculations nor did it address uncertainties in operational or geometric variables that impact power reactor calculations. The second phase of the qualification (H. B. Robinson comparisons) addressed uncertainties in these additional areas that are primarily methods related and would tend to apply generically to all fast neutron exposure evaluations. The third phase of the qualification (analytical sensitivity study) identified the potential uncertainties introduced into the overall evaluation due to calculational methods approximations as well as to a lack of knowledge relative to various plant specific input parameters. The overall calculational uncertainty applicable to the Alvin W. Vogtle Unit 2 analysis was established from results of these three phases of the methods qualification.

The fourth phase of the uncertainty assessment (comparisons with Alvin W. Vogtle Unit 2 measurements) was used solely to demonstrate the validity of the transport calculations and to confirm the uncertainty estimates associated with the analytical results. The comparison was used only as a check and was not used in any way to modify the calculated surveillance capsule and pressure vessel neutron exposures previously described in Section 6.2. As such, the validation of the Alvin W. Vogtle Unit 2 analytical model based on the measured plant dosimetry is completely described in Appendix A.

The following summarizes the uncertainties developed from the first three phases of the methodology qualification. Additional information pertinent to these evaluations is provided in Reference 18.

	Capsule	Vessel IR
PCA Comparisons	3%	3%
H. B. Robinson Comparisons	3%	3%
Analytical Sensitivity Studies	10%	11%
Additional Uncertainty for Factors not Explicitly Evaluated	5%	5%
Net Calculational Uncertainty	12%	13%

The net calculational uncertainty was determined by combining the individual components in quadrature. Therefore, the resultant uncertainty was treated as random and no systematic bias was applied to the analytical results.

The plant specific measurement comparisons described in Appendix A support these uncertainty assessments for Alvin W. Vogtle Unit 2.

Figure 6-1

Alvin W. Vogtle Unit 2 r,θ Reactor Geometry with a 12.5° Neutron Pad at the Core Midplane

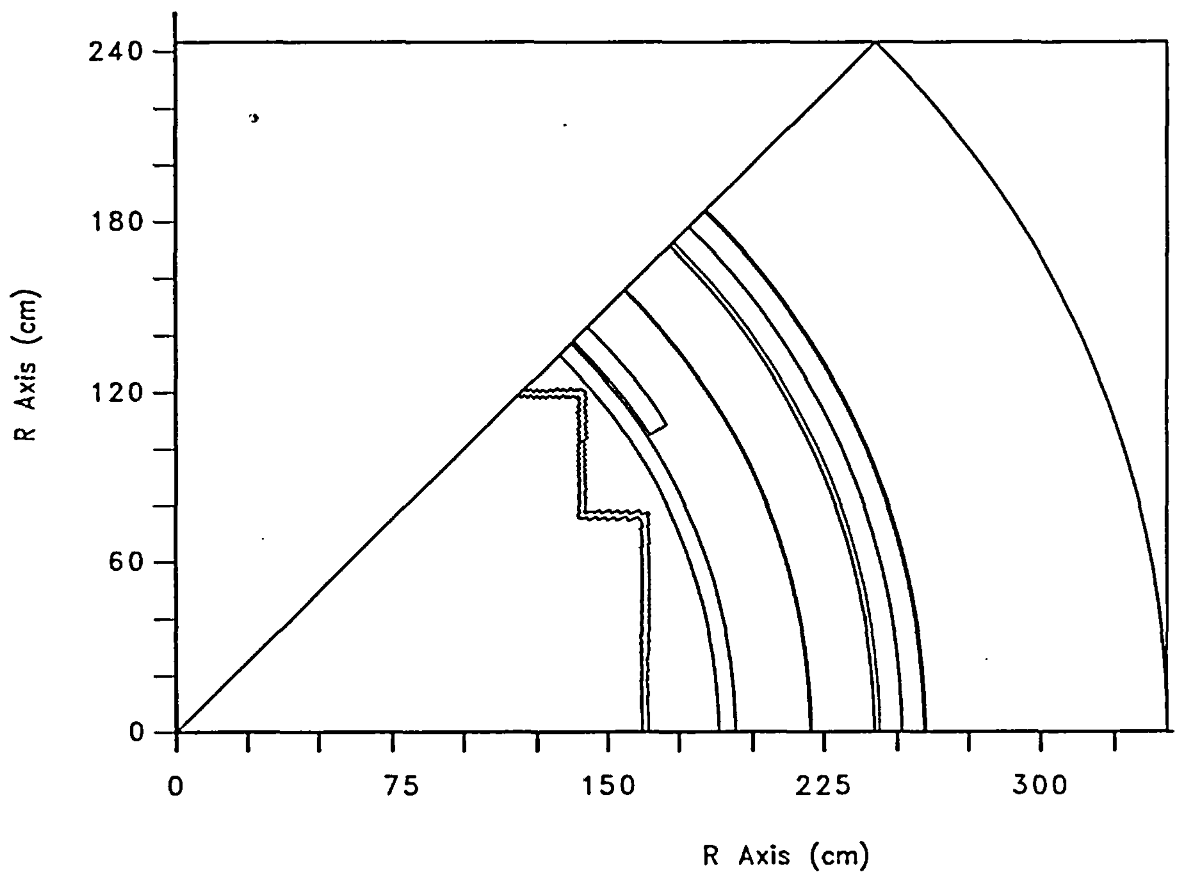


Figure 6-1 (continued)

Alvin W. Vogtle Unit 2 r,θ Reactor Geometry with a 20.0° Neutron Pad at the Core Midplane

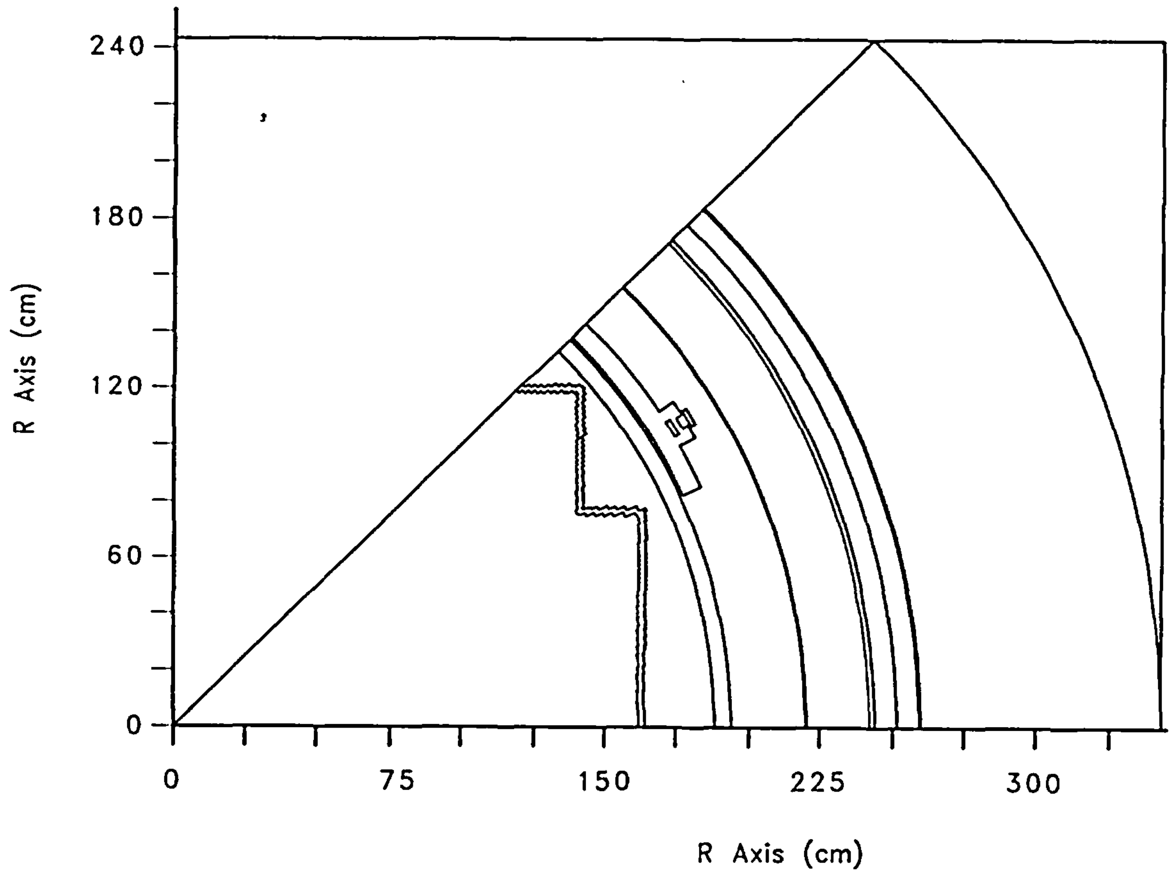


Figure 6-1 (continued)

Alvin W. Vogtle Unit 2 r,θ Reactor Geometry with a 22.5° Neutron Pad at the Core Midplane

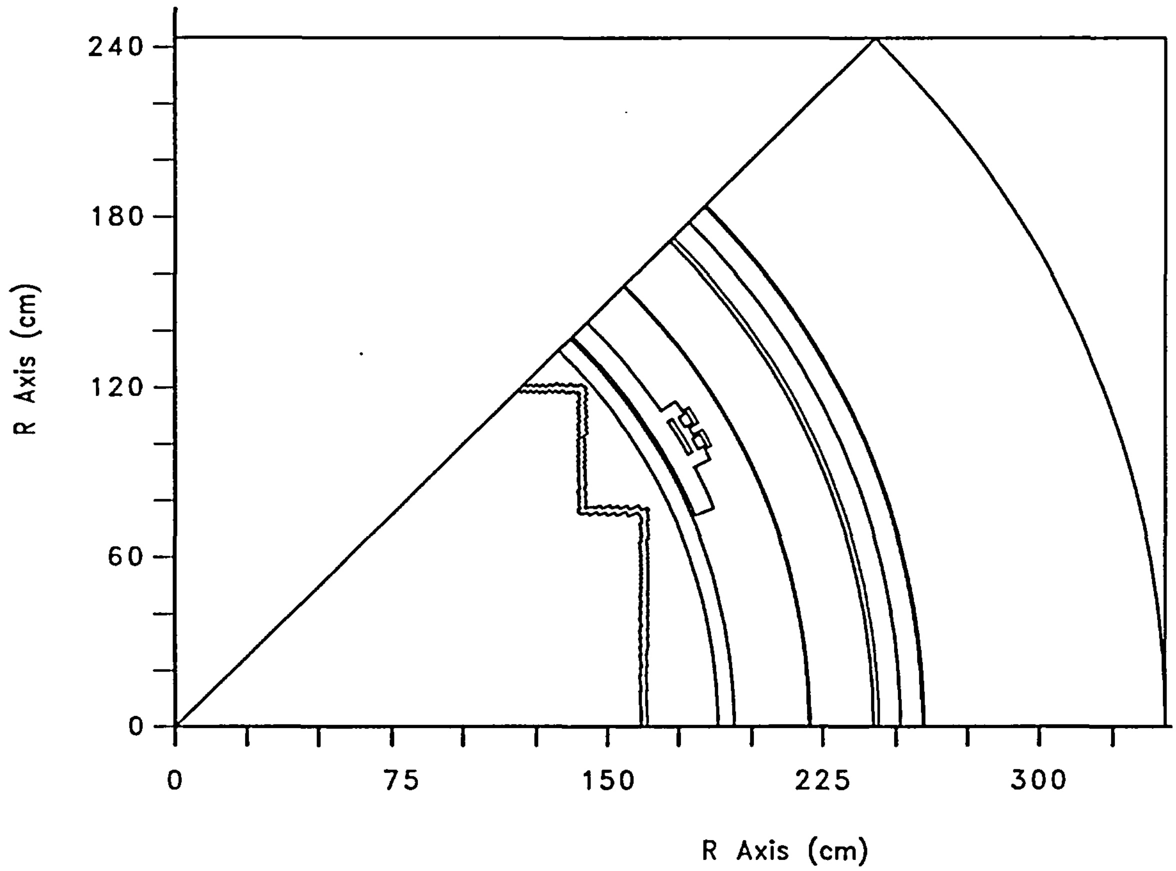


Figure 6-2

Alvin W. Vogtle Unit 2 r,z Reactor Geometry with Neutron Pad

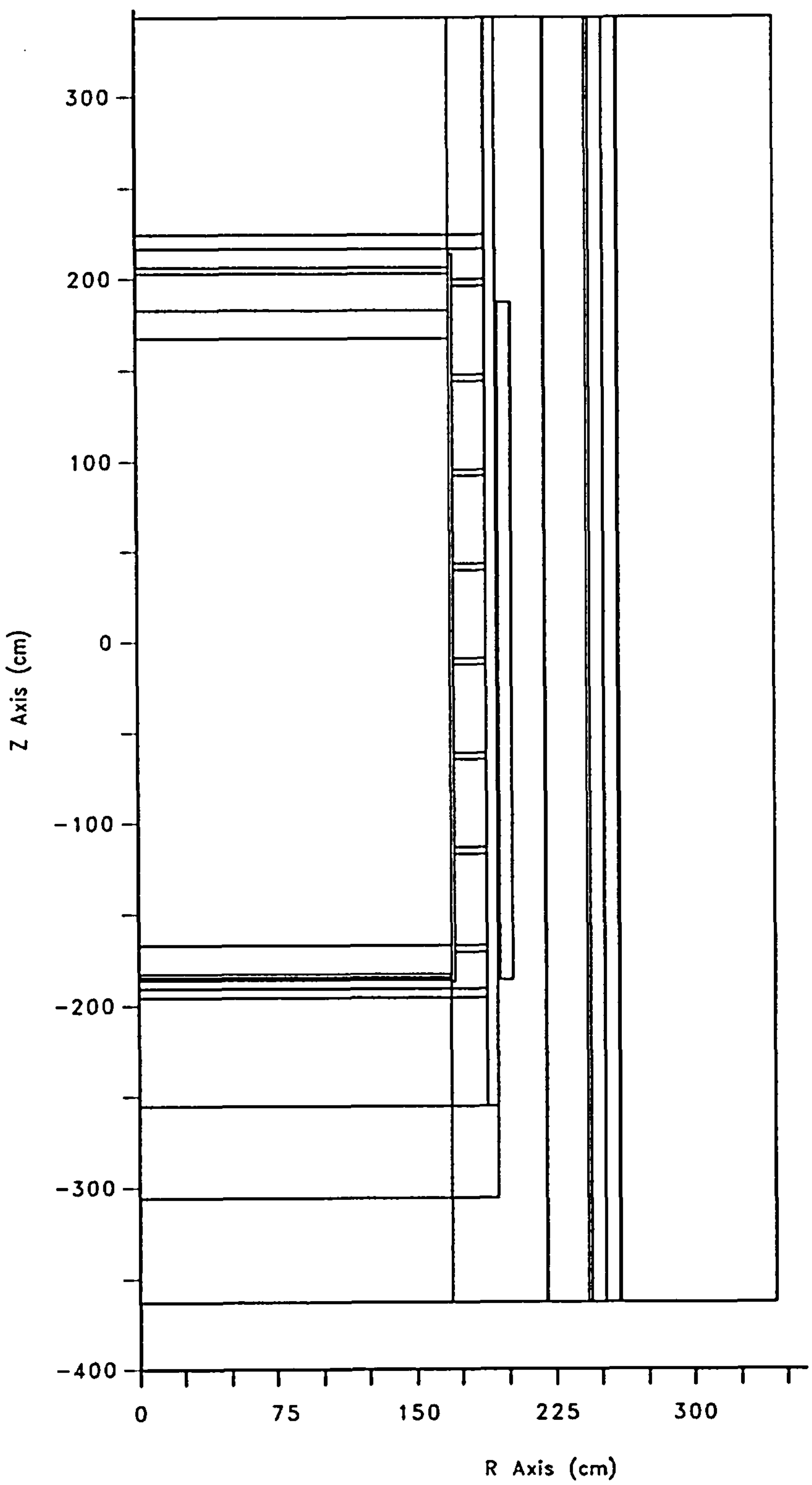


Table 6-1

Calculated Neutron Exposure Rates And Integrated Exposures
At The Surveillance Capsule Center

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Flux (E > 1.0 MeV) [n/cm²-s]		
				Dual 29°	Dual 31.5°	Single 31.5°
1	3.78E+07	3.78E+07	1.20	8.78E+10	9.43E+10	9.34E+10
2	3.86E+07	7.64E+07	2.42	7.30E+10	7.97E+10	7.89E+10
3	4.13E+07	1.18E+08	3.73	6.32E+10	6.82E+10	6.75E+10
4	3.96E+07	1.57E+08	4.98	6.08E+10	6.63E+10	6.57E+10
5	4.47E+07	2.02E+08	6.40	5.63E+10	6.17E+10	6.11E+10
6	4.35E+07	2.45E+08	7.78	6.27E+10	6.79E+10	6.73E+10
7	4.38E+07	2.89E+08	9.17	6.52E+10	7.08E+10	7.01E+10
8	4.43E+07	3.34E+08	10.57	6.53E+10	7.24E+10	7.17E+10
9	4.46E+07	3.78E+08	11.98	6.52E+10	6.95E+10	6.88E+10
10	4.11E+07	4.19E+08	13.29	6.41E+10	7.10E+10	7.04E+10
Future	4.11E+07	4.60E+08	14.59	6.04E+10	7.11E+10	7.04E+10
Future	1.71E+08		20.00	6.64E+10	7.11E+10	7.04E+10
Future	1.26E+08		24.00	6.64E+10	7.11E+10	7.04E+10
Future	2.52E+08		32.00	6.64E+10	7.11E+10	7.04E+10
Future	2.52E+08		40.00	6.64E+10	7.11E+10	7.04E+10
Future	2.52E+08		48.00	6.64E+10	7.11E+10	7.04E+10
Future	1.89E+08		54.00	6.64E+10	7.11E+10	7.04E+10

Note: Neutron exposure values reported for the surveillance capsules are centered at the core midplane.

Table 6-1 cont'd

Calculated Neutron Exposure Rates And Integrated Exposures
At The Surveillance Capsule Center

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Fluence (E > 1.0 MeV) [n/cm^2]		
				Dual 29°	Dual 31.5°	Single 31.5°
1	3.78E+07	3.78E+07	1.20	3.32E+18	3.56E+18	3.53E+18
2	3.86E+07	7.64E+07	2.42	6.14E+18	6.64E+18	6.58E+18
3	4.13E+07	1.18E+08	3.73	8.75E+18	9.45E+18	9.36E+18
4	3.96E+07	1.57E+08	4.98	1.12E+19	1.21E+19	1.20E+19
5	4.47E+07	2.02E+08	6.40	1.37E+19	1.48E+19	1.47E+19
6	4.35E+07	2.45E+08	7.78	1.64E+19	1.78E+19	1.76E+19
7	4.38E+07	2.89E+08	9.17	1.93E+19	2.09E+19	2.07E+19
8	4.43E+07	3.34E+08	10.57	2.22E+19	2.41E+19	2.39E+19
9	4.46E+07	3.78E+08	11.98	2.51E+19	2.72E+19	2.69E+19
10	4.11E+07	4.19E+08	13.29	2.77E+19	3.01E+19	2.98E+19
11	4.11E+07	4.60E+08	14.59	3.04E+19	3.30E+19	3.27E+19
Future	1.71E+08		20.00	4.18E+19	4.52E+19	4.48E+19
Future	1.26E+08		24.00	5.02E+19	5.42E+19	5.36E+19
Future	2.52E+08		32.00	6.69E+19	7.21E+19	7.14E+19
Future	2.52E+08		40.00	8.37E+19	9.01E+19	8.92E+19
Future	2.52E+08		48.00	1.01E+20	1.08E+20	1.07E+20
Future	1.89E+08		54.00	1.13E+20	1.22E+20	1.20E+20

Note: Neutron exposure values reported for the surveillance capsules are centered at the core midplane.

Table 6-1 cont'd

Calculated Neutron Exposure Rates And Integrated Exposures
At The Surveillance Capsule Center

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Iron Atom Displacement Rate [dpa/s]		
				Dual 29°	Dual 31.5°	Single 31.5°
1	3.78E+07	3.78E+07	1.20	1.72E-10	1.84E-10	1.82E-10
2	3.86E+07	7.64E+07	2.42	1.42E-10	1.54E-10	1.53E-10
3	4.13E+07	1.18E+08	3.73	1.22E-10	1.32E-10	1.31E-10
4	3.96E+07	1.57E+08	4.98	1.18E-10	1.28E-10	1.27E-10
5	4.47E+07	2.02E+08	6.40	1.09E-10	1.19E-10	1.18E-10
6	4.35E+07	2.45E+08	7.78	1.22E-10	1.32E-10	1.30E-10
7	4.38E+07	2.89E+08	9.17	1.26E-10	1.37E-10	1.36E-10
8	4.43E+07	3.34E+08	10.57	1.27E-10	1.41E-10	1.39E-10
9	4.46E+07	3.78E+08	11.98	1.27E-10	1.35E-10	1.33E-10
10	4.11E+07	4.19E+08	13.29	1.24E-10	1.38E-10	1.37E-10
11	4.11E+07	4.60E+08	14.59	1.29E-10	1.38E-10	1.36E-10
Future	1.71E+08		20.00	1.29E-10	1.38E-10	1.36E-10
Future	1.26E+08		24.00	1.29E-10	1.38E-10	1.36E-10
Future	2.52E+08		32.00	1.29E-10	1.38E-10	1.36E-10
Future	2.52E+08		40.00	1.29E-10	1.38E-10	1.36E-10
Future	2.52E+08		48.00	1.29E-10	1.38E-10	1.36E-10
Future	1.89E+08		54.00	1.29E-10	1.38E-10	1.36E-10

Note: Neutron exposure values reported for the surveillance capsules are centered at the core midplane.

Table 6-1 cont'd

Calculated Neutron Exposure Rates And Integrated Exposures
At The Surveillance Capsule Center

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Iron Atom Displacements [dpa]		
				Dual 29°	Dual 31.5°	Single 31.5°
1	3.78E+07	3.78E+07	1.20	6.49E-03	6.97E-03	6.89E-03
2	3.86E+07	7.64E+07	2.42	1.20E-02	1.29E-02	1.28E-02
3	4.13E+07	1.18E+08	3.73	1.70E-02	1.84E-02	1.82E-02
4	3.96E+07	1.57E+08	4.98	2.17E-02	2.35E-02	2.32E-02
5	4.47E+07	2.02E+08	6.40	2.66E-02	2.88E-02	2.85E-02
6	4.35E+07	2.45E+08	7.78	3.18E-02	3.45E-02	3.42E-02
7	4.38E+07	2.89E+08	9.17	3.74E-02	4.05E-02	4.01E-02
8	4.43E+07	3.34E+08	10.57	4.30E-02	4.67E-02	4.63E-02
9	4.46E+07	3.78E+08	11.98	4.86E-02	5.27E-02	5.22E-02
10	4.11E+07	4.19E+08	13.29	5.37E-02	5.84E-02	5.78E-02
11	4.11E+07	4.60E+08	14.59	5.90E-02	6.41E-02	6.34E-02
Future	1.71E+08		20.00	8.10E-02	8.76E-02	8.67E-02
Future	1.26E+08		24.00	9.73E-02	1.05E-01	1.04E-01
Future	2.52E+08		32.00	1.30E-01	1.40E-01	1.38E-01
Future	2.52E+08		40.00	1.62E-01	1.75E-01	1.73E-01
Future	2.52E+08		48.00	1.95E-01	2.09E-01	2.07E-01
Future	1.89E+08		54.00	2.19E-01	2.35E-01	2.33E-01

Note: Neutron exposure values reported for the surveillance capsules are centered at the core midplane.

Table 6-2

Calculated Azimuthal Variation Of Maximum Exposure Rates
And Integrated Exposures At The Reactor Vessel
Clad/Base Metal Interface

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Flux (E > 1.0 MeV) [n/cm²-s]			
				0°	15°	30°	45°
1	3.78E+07	3.78E+07	1.20	1.31E+10	1.94E+10	2.23E+10	2.30E+10
2	3.86E+07	7.64E+07	2.42	1.12E+10	1.53E+10	1.85E+10	1.78E+10
3	4.13E+07	1.18E+08	3.73	8.95E+09	1.36E+10	1.60E+10	1.60E+10
4	3.96E+07	1.57E+08	4.98	8.39E+09	1.24E+10	1.55E+10	1.58E+10
5	4.47E+07	2.02E+08	6.40	8.45E+09	1.23E+10	1.45E+10	1.47E+10
6	4.35E+07	2.45E+08	7.78	9.69E+09	1.39E+10	1.60E+10	1.62E+10
7	4.38E+07	2.89E+08	9.17	9.50E+09	1.42E+10	1.68E+10	1.70E+10
8	4.43E+07	3.34E+08	10.57	8.85E+09	1.35E+10	1.66E+10	1.84E+10
9	4.46E+07	3.78E+08	11.98	9.23E+09	1.40E+10	1.64E+10	1.62E+10
10	4.11E+07	4.19E+08	13.29	9.23E+09	1.34E+10	1.64E+10	1.78E+10
11	4.11E+07	4.60E+08	14.59	9.94E+09	1.48E+10	1.68E+10	1.66E+10
Future	1.71E+08		20.00	9.94E+09	1.48E+10	1.68E+10	1.66E+10
Future	1.26E+08		24.00	9.94E+09	1.48E+10	1.68E+10	1.66E+10
Future	2.52E+08		32.00	9.94E+09	1.48E+10	1.68E+10	1.66E+10
Future	2.52E+08		40.00	9.94E+09	1.48E+10	1.68E+10	1.66E+10
Future	2.52E+08		48.00	9.94E+09	1.48E+10	1.68E+10	1.66E+10
Future	1.89E+08		54.00	9.94E+09	1.48E+10	1.68E+10	1.66E+10

Table 6-2 cont'd

Calculated Azimuthal Variation Of Maximum Exposure Rates
And Integrated Exposures At The Reactor Vessel
Clad/Base Metal Interface

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Fluence (E > 1.0 MeV) [n/cm^2]			
				0°	15°	30°	45°
1	3.78E+07	3.78E+07	1.20	4.93E+17	7.31E+17	8.42E+17	8.69E+17
2	3.86E+07	7.64E+07	2.42	9.26E+17	1.32E+18	1.56E+18	1.56E+18
3	4.13E+07	1.18E+08	3.73	1.29E+18	1.87E+18	2.20E+18	2.20E+18
4	3.96E+07	1.57E+08	4.98	1.62E+18	2.36E+18	2.81E+18	2.83E+18
5	4.47E+07	2.02E+08	6.40	1.99E+18	2.91E+18	3.46E+18	3.48E+18
6	4.35E+07	2.45E+08	7.78	2.42E+18	3.52E+18	4.15E+18	4.19E+18
7	4.38E+07	2.89E+08	9.17	2.83E+18	4.14E+18	4.88E+18	4.93E+18
8	4.43E+07	3.34E+08	10.57	3.22E+18	4.74E+18	5.62E+18	5.74E+18
9	4.46E+07	3.78E+08	11.98	3.63E+18	5.36E+18	6.35E+18	6.46E+18
10	4.11E+07	4.19E+08	13.29	4.01E+18	5.91E+18	7.02E+18	7.20E+18
11	4.11E+07	4.60E+08	14.59	4.42E+18	6.52E+18	7.70E+18	7.87E+18
Future	1.71E+08		20.00	6.10E+18	9.02E+18	1.06E+19	1.07E+19
Future	1.26E+08		24.00	7.35E+18	1.09E+19	1.27E+19	1.28E+19
Future	2.52E+08		32.00	9.87E+18	1.46E+19	1.69E+19	1.70E+19
Future	2.52E+08		40.00	1.24E+19	1.84E+19	2.12E+19	2.11E+19
Future	2.52E+08		48.00	1.49E+19	2.21E+19	2.54E+19	2.53E+19
Future	1.89E+08		54.00	1.68E+19	2.49E+19	2.86E+19	2.85E+19

Table 6-2 cont'd

Calculated Azimuthal Variation Of Fast Neutron Exposure Rates
And Iron Atom Displacement Rates At The Reactor Vessel
Clad/Base Metal Interface

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Iron Atom Displacement Rate [dpa/s]			
				0°	15°	30°	45°
1	3.78E+07	3.78E+07	1.20	2.03E-11	2.97E-11	3.43E-11	3.64E-11
2	3.86E+07	7.64E+07	2.42	1.74E-11	2.36E-11	2.85E-11	2.82E-11
3	4.13E+07	1.18E+08	3.73	1.39E-11	2.09E-11	2.47E-11	2.52E-11
4	3.96E+07	1.57E+08	4.98	1.31E-11	1.91E-11	2.39E-11	2.50E-11
5	4.47E+07	2.02E+08	6.40	1.31E-11	1.90E-11	2.23E-11	2.32E-11
6	4.35E+07	2.45E+08	7.78	1.51E-11	2.13E-11	2.47E-11	2.56E-11
7	4.38E+07	2.89E+08	9.17	1.48E-11	2.19E-11	2.59E-11	2.69E-11
8	4.43E+07	3.34E+08	10.57	1.38E-11	2.08E-11	2.56E-11	2.91E-11
9	4.46E+07	3.78E+08	11.98	1.44E-11	2.16E-11	2.52E-11	2.55E-11
10	4.11E+07	4.19E+08	13.29	1.44E-11	2.06E-11	2.53E-11	2.81E-11
11	4.11E+07	4.60E+08	14.59	1.55E-11	2.28E-11	2.59E-11	2.62E-11
Future	1.71E+08		20.00	1.55E-11	2.28E-11	2.59E-11	2.62E-11
Future	1.26E+08		24.00	1.55E-11	2.28E-11	2.59E-11	2.62E-11
Future	2.52E+08		32.00	1.55E-11	2.28E-11	2.59E-11	2.62E-11
Future	2.52E+08		40.00	1.55E-11	2.28E-11	2.59E-11	2.62E-11
Future	2.52E+08		48.00	1.55E-11	2.28E-11	2.59E-11	2.62E-11
Future	1.89E+08		54.00	1.55E-11	2.28E-11	2.59E-11	2.62E-11

Table 6-2 cont'd

Calculated Azimuthal Variation Of Maximum Exposure Rates
And Integrated Exposures At The Reactor Vessel
Clad/Base Metal Interface

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Iron Atom Displacements [dpa]			
				0°	15°	30°	45°
1	3.78E+07	3.78E+07	1.20	7.65E-04	1.12E-03	1.30E-03	1.37E-03
2	3.86E+07	7.64E+07	2.42	1.44E-03	2.04E-03	2.40E-03	2.46E-03
3	4.13E+07	1.18E+08	3.73	2.00E-03	2.88E-03	3.39E-03	3.48E-03
4	3.96E+07	1.57E+08	4.98	2.51E-03	3.64E-03	4.34E-03	4.47E-03
5	4.47E+07	2.02E+08	6.40	3.10E-03	4.48E-03	5.33E-03	5.50E-03
6	4.35E+07	2.45E+08	7.78	3.75E-03	5.41E-03	6.40E-03	6.61E-03
7	4.38E+07	2.89E+08	9.17	4.40E-03	6.37E-03	7.53E-03	7.79E-03
8	4.43E+07	3.34E+08	10.57	5.01E-03	7.29E-03	8.67E-03	9.07E-03
9	4.46E+07	3.78E+08	11.98	5.65E-03	8.25E-03	9.79E-03	1.02E-02
10	4.11E+07	4.19E+08	13.29	6.24E-03	9.10E-03	1.08E-02	1.14E-02
11	4.11E+07	4.60E+08	14.59	6.87E-03	1.00E-02	1.19E-02	1.24E-02
Future	1.71E+08		20.00	9.49E-03	1.39E-02	1.63E-02	1.69E-02
Future	1.26E+08		24.00	1.14E-02	1.68E-02	1.95E-02	2.02E-02
Future	2.52E+08		32.00	1.53E-02	2.25E-02	2.61E-02	2.68E-02
Future	2.52E+08		40.00	1.93E-02	2.83E-02	3.26E-02	3.34E-02
Future	2.52E+08		48.00	2.32E-02	3.40E-02	3.92E-02	4.00E-02
Future	1.89E+08		54.00	2.61E-02	3.83E-02	4.41E-02	4.49E-02

Table 6-3

Relative Radial Distribution Of Neutron Fluence (E > 1.0 MeV)
Within The Reactor Vessel Wall

RADIUS	AZIMUTHAL ANGLE			
(cm)	0°	15°	30°	45°
220.11	1.000	1.000	1.000	1.000
225.59	0.571	0.566	0.561	0.557
231.06	0.282	0.277	0.272	0.269
236.54	0.134	0.130	0.127	0.125
242.01	0.064	0.059	0.057	0.056
Note:	Base Metal Inner Radius = 220.11 cm Base Metal 1/4T = 225.59 cm Base Metal 1/2T = 231.06 cm Base Metal 3/4T = 236.54 cm Base Metal Outer Radius = 242.01 cm			

Table 6-4

Relative Radial Distribution Of Iron Atom Displacements (dpa)
Within The Reactor Vessel Wall

RADIUS	AZIMUTHAL ANGLE			
(cm)	0°	15°	30°	45°
220.11	1.000	1.000	1.000	1.000
225.59	0.642	0.637	0.635	0.644
231.06	0.389	0.381	0.381	0.392
236.54	0.236	0.226	0.227	0.234
242.01	0.141	0.127	0.127	0.130
Note:	Base Metal Inner Radius = 220.11 cm Base Metal 1/4T = 225.59 cm Base Metal 1/2T = 231.06 cm Base Metal 3/4T = 236.54 cm Base Metal Outer Radius = 242.01 cm			

Table 6-5

Calculated Fast Neutron Exposure of Surveillance Capsules
Withdrawn from Alvin W. Vogtle Unit 2

Capsule	Irradiation Time [EFPY]	Fluence (E > 1.0 MeV) [n/cm^2]	Iron Displacements [dpa]
U	1.20	3.56E+18	6.97E-03
Y	4.98	1.12E+19	2.17E-02
X	7.78	1.78E+19	3.45E-02
W	13.29	2.98E+19	5.78E-02

Table 6-6

Calculated Surveillance Capsule Lead Factors

Capsule ID And Location	Status	Lead Factor
U (31.5° Dual)	Withdrawn EOC 1	4.10
Y (29.0° Dual)	Withdrawn EOC 4	3.95
X (31.5° Dual)	Withdrawn EOC 6	4.25
W (31.5° Single)	Withdrawn EOC 10	4.14
V (29.0° Dual)	In Reactor	3.86
Z (31.5° Single)	In Reactor	4.16

Note: Lead factors for capsules remaining in the reactor are based on cycle specific exposure calculations through the last completed fuel cycle, i.e., Cycle 11.

7 SURVEILLANCE CAPSULE REMOVAL SCHEDULE

The following surveillance capsule removal schedule meets the requirements of ASTM E185-82 and is recommended for future capsules to be removed from the Vogtle Unit 2 reactor vessel. This recommended removal schedule is applicable to 36 EFPY of operation.

Table 7-1 Vogtle Unit 2 Reactor Vessel Surveillance Capsule Withdrawal Schedule

Capsule	Location	Lead Factor[a]	Removal Time (EFPY)[b]	Fluence (n/cm^2, E>1.0 MeV)[a]
U	58.5°	4.10	1.20	3.56×10^{18} (c)
Y	241°	3.95	4.98	1.12×10^{19} (c)
X	238.5°	4.25	7.78	1.78×10^{19} (c)
W	121.5°	4.14	13.29	2.98×10^{19} (c, d)
Z	301.5°	4.16	17 (*Standby*)	3.82×10^{19} (e)
V	61°	3.86	Standby (f)	(f)

Notes:

(a) Updated in Capsule W dosimetry analysis.

(b) Effective Full Power Years (EFPY) from plant startup.

(c) Plant specific evaluation.

(d) This capsule was withdrawn at a fluence not less than once or greater than twice the peak EOL fluence for a standard license term of 40 years (36 EFPY). In addition, this capsule was withdrawn at a fluence not less than once or greater than twice the peak EOL fluence for an additional 20-year license renewal term to 60 years (54 EFPY).

(e) This projected fluence is not less than once or greater than twice the peak EOL fluence for an additional 20-year license renewal term to 80 years.

(f) This capsule will reach an EOL fluence for an additional 20-year license renewal term to 80 years at 18.3 EFPY.

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APPENDIX A

VALIDATION OF THE RADIATION TRANSPORT MODELS BASED ON NEUTRON DOSIMETRY MEASUREMENTS

A.1 Neutron Dosimetry

Comparisons of measured dosimetry results to both the calculated and least squares adjusted values for all surveillance capsules withdrawn from service to date at Alvin W. Vogtle Unit 2 are described herein. The sensor sets from these capsules have been analyzed in accordance with the current dosimetry evaluation methodology described in Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence."[A-1] One of the main purposes for presenting this material is to demonstrate that the overall measurements agree with the calculated and least squares adjusted values to within ± 20% as specified by Regulatory Guide 1.190, thus serving to validate the calculated neutron exposures previously reported in Section 6.2 of this report. This information may also be useful in the future, in particular, as least squares adjustment techniques become accepted in the regulatory environment.

A.1.1 Sensor Reaction Rate Determinations

In this section, the results of the evaluations of the four neutron sensor sets withdrawn to date as part of the Alvin W. Vogtle Unit 2 Reactor Vessel Materials Surveillance Program are presented. The capsule designation, location within the reactor, and time of withdrawal of each of these dosimetry sets were as follows:

Capsule ID	Azimuthal Location	Withdrawal Time	Irradiation Time [EFPY]
U	31.5° Dual	End of Cycle 1	1.20
Y	29.0° Dual	End of Cycle 4	4.98
X	31.5° Dual	End of Cycle 6	7.78
W	31.5° Single	End of Cycle 10	13.29

The azimuthal locations included in the above tabulation represent the first octant equivalent azimuthal angle of the geometric center of the respective surveillance capsules.

The passive neutron sensors included in the evaluations of Surveillance Capsules U, Y, V, and X are summarized as follows:

Sensor Material	Reaction Of Interest	Capsule U	Capsule Y	Capsule V	Capsule X
Copper	$^{63}Cu(n,\alpha)^{60}Co$	X	X	X	X
Iron	$^{54}Fe(n,p)^{54}Mn$	X	X	X	X
Nickel	$^{58}Ni(n,p)^{58}Co$	X	X	X	X
Uranium-238	$^{238}U(n,f)^{137}Cs$	X	X	X	X
Neptunium-237	$^{237}Np(n,f)^{137}Cs$	X	X	X	X
Cobalt-Aluminum*	$^{59}Co(n,\gamma)^{60}Co$	X	X	X	X

* The cobalt-aluminum measurements for this plant include both bare wire and cadmium-covered sensors.

Since all of the dosimetry monitors were accommodated within the dosimeter block centered at the radial, azimuthal, and axial center of the material test specimen array, gradient corrections were not required for these reaction rates. Pertinent physical and nuclear characteristics of the passive neutron sensors are listed in Table A-1.

The use of passive monitors such as those listed above does not yield a direct measure of the energy dependent neutron flux at the point of interest. Rather, the activation or fission process is a measure of the integrated effect that the time and energy dependent neutron flux has on the target material over the course of the irradiation period. An accurate assessment of the average neutron flux level incident on the various monitors may be derived from the activation measurements only if the irradiation parameters are well known. In particular, the following variables are of interest:

- the measured specific activity of each monitor,
- the physical characteristics of each monitor,
- the operating history of the reactor,
- the energy response of each monitor, and
- the neutron energy spectrum at the monitor location.

Results from the radiometric counting of the neutron sensors from Capsule U, Y, and X are documented in Reference A-2, A-5, and A-6. The radiometric counting of the sensors from Capsule W was carried out by Pace Analytical Services, Inc., located at the Westinghouse Waltz Mill Site. In all cases, the radiometric counting followed established ASTM procedures. Following sample preparation and weighing, the specific activity of each sensor was determined by means of a high-resolution gamma spectrometer. For the copper, iron, nickel, and cobalt-aluminum sensors, these analyses were performed by direct counting of each of the individual samples. In the case of the uranium and neptunium fission sensors, the analyses were carried out by direct counting preceded by dissolution and chemical separation of cesium from the sensor material.

The irradiation history of the reactor over the irradiation periods experienced by Capsules U, Y, X, and W was based on the monthly power generation of Alvin W. Vogtle Unit 2 from initial reactor criticality through the end of the dosimetry evaluation period. For the sensor sets utilized in the surveillance capsules, the half-lives of the product isotopes are long enough that a monthly histogram describing reactor operation has proven to be an adequate representation for use in radioactive decay corrections for the reactions of interest in the exposure evaluations. The irradiation history applicable to Capsules U, Y, X, and W is given in Table A-2.

Having the measured specific activities, the physical characteristics of the sensors, and the operating history of the reactor, reaction rates referenced to full-power operation were determined from the following equation:

$$R = \frac{A}{N_0 \, F \, Y \sum \frac{P_j}{P_{ref}} C_j \, [1 - e^{-\lambda t_j}] \, [e^{-\lambda t_d}]}$$

where:

R	=	Reaction rate averaged over the irradiation period and referenced to operation at a core power level of P_{ref} (rps/nucleus).
A	=	Measured specific activity (dps/gm).
N_0	=	Number of target element atoms per gram of sensor.
F	=	Weight fraction of the target isotope in the sensor material.
Y	=	Number of product atoms produced per reaction.
P_j	=	Average core power level during irradiation period j (MW).
P_{ref}	=	Maximum or reference power level of the reactor (MW).
C_j	=	Calculated ratio of $\phi(E > 1.0$ MeV) during irradiation period j to the time weighted average $\phi(E > 1.0$ MeV) over the entire irradiation period.
λ	=	Decay constant of the product isotope (1/sec).
t_j	=	Length of irradiation period j (sec).
t_d	=	Decay time following irradiation period j (sec).

and the summation is carried out over the total number of monthly intervals comprising the irradiation period.

In the equation describing the reaction rate calculation, the ratio $[P_j]/[P_{ref}]$ accounts for month-by-month variation of reactor core power level within any given fuel cycle as well as over multiple fuel cycles. The ratio C_j, which was calculated for each fuel cycle using the transport methodology discussed in Section 6.2, accounts for the change in sensor reaction rates caused by variations in flux level induced by changes in core spatial power distributions from fuel cycle to fuel cycle. For a single-cycle irradiation, C_j is normally taken to be 1.0. However, for multiple-cycle irradiations, particularly those employing low leakage fuel management, the additional C_j term should be employed. The impact of changing flux levels for constant power operation can be quite significant for sensor sets that have been irradiated for many cycles in a reactor that has transitioned from non-low leakage to low leakage fuel management or for sensor sets contained in surveillance capsules that have been moved from one capsule location to another. The fuel cycle specific neutron flux values along with the computed values for C_j are listed in Table A-3. These flux values represent the cycle dependent results at the radial and azimuthal center of the respective capsules at the axial elevation of the active fuel midplane.

Prior to using the measured reaction rates in the least-squares evaluations of the dosimetry sensor sets, additional corrections were made to the ^{238}U measurements to account for the presence of ^{235}U impurities in the sensors as well as to adjust for the build-in of plutonium isotopes over the course of the irradiation. Corrections were also made to the ^{238}U and ^{237}Np sensor reaction rates to account for gamma ray induced fission reactions that occurred over the course of the capsule irradiations. The correction factors applied to the Alvin W. Vogtle Unit 2 fission sensor reaction rates are summarized as follows:

Correction	Capsule U	Capsule Y	Capsule X	Capsule W
^{235}U Impurity/Pu Build-in	0.870	0.841	0.817	0.777
$^{238}U(\gamma,f)$	0.966	0.968	0.967	0.969
Net ^{238}U Correction	0.841	0.814	0.790	0.753
$^{237}Np(\gamma,f)$	0.990	0.990	0.990	0.991

These factors were applied in a multiplicative fashion to the decay corrected uranium and neptunium fission sensor reaction rates.

Results of the sensor reaction rate determinations for Capsules U, Y, X, and W are given in Table A-4. In Table A-4, the measured specific activities, decay corrected saturated specific activities, and computed reaction rates for each sensor indexed to the radial center of the capsule are listed. The fission sensor reaction rates are listed both with and without the applied corrections for ^{238}U impurities, plutonium build-in, and gamma ray induced fission effects.

A.1.2 Least Squares Evaluation of Sensor Sets

Least squares adjustment methods provide the capability of combining the measurement data with the corresponding neutron transport calculations resulting in a Best Estimate neutron energy spectrum with associated uncertainties. Best Estimates for key exposure parameters such as $\phi(E > 1.0\ MeV)$ or dpa/s along with their uncertainties are then easily obtained from the adjusted spectrum. In general, the least squares methods, as applied to surveillance capsule dosimetry evaluations, act to reconcile the measured sensor reaction rate data, dosimetry reaction cross-sections, and the calculated neutron energy spectrum within their respective uncertainties. For example,

$$R_i \pm \delta_{R_i} = \sum_g (\sigma_{ig} \pm \delta_{\sigma_{ig}})(\phi_g \pm \delta_{\phi_g})$$

relates a set of measured reaction rates, R_i, to a single neutron spectrum, ϕ_g, through the multigroup dosimeter reaction cross-section, σ_{ig}, each with an uncertainty δ. The primary objective of the least squares evaluation is to produce unbiased estimates of the neutron exposure parameters at the location of the measurement.

For the least squares evaluation of the Alvin W. Vogtle Unit 2 surveillance capsule dosimetry, the FERRET code[A-3] was employed to combine the results of the plant specific neutron transport calculations and sensor set reaction rate measurements to determine best-estimate values of exposure parameters ($\phi(E > 1.0\ MeV)$ and dpa) along with associated uncertainties for the four in-vessel capsules withdrawn to date.

The application of the least squares methodology requires the following input:

1 - The calculated neutron energy spectrum and associated uncertainties at the measurement location.

2 - The measured reaction rates and associated uncertainty for each sensor contained in the multiple foil set.

3 - The energy dependent dosimetry reaction cross-sections and associated uncertainties for each sensor contained in the multiple foil sensor set.

For the Alvin W. Vogtle Unit 2 application, the calculated neutron spectrum was obtained from the results of plant specific neutron transport calculations described in Section 6.2 of this report. The sensor reaction rates were derived from the measured specific activities using the procedures described in Section A.1.1. The dosimetry reaction cross-sections and uncertainties were obtained from the SNLRML dosimetry cross-section library[A-4]. The SNLRML library is an evaluated dosimetry reaction cross-section compilation recommended for use in LWR evaluations by ASTM Standard E1018, "Application of ASTM Evaluated Cross-Section Data File, Matrix E 706 (IIB)".

The uncertainties associated with the measured reaction rates, dosimetry cross-sections, and calculated neutron spectrum were input to the least squares procedure in the form of variances and covariances. The assignment of the input uncertainties followed the guidance provided in ASTM Standard E 944, "Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance."

The following provides a summary of the uncertainties associated with the least squares evaluation of the Alvin W. Vogtle Unit 2 surveillance capsule sensor sets.

Reaction Rate Uncertainties

The overall uncertainty associated with the measured reaction rates includes components due to the basic measurement process, irradiation history corrections, and corrections for competing reactions. A high level of accuracy in the reaction rate determinations is assured by utilizing laboratory procedures that conform to the ASTM National Consensus Standards for reaction rate determinations for each sensor type.

After combining all of these uncertainty components, the sensor reaction rates derived from the counting and data evaluation procedures were assigned the following net uncertainties for input to the least squares evaluation:

Reaction	Uncertainty
$^{63}Cu(n,\alpha)^{60}Co$	5%
$^{54}Fe(n,p)^{54}Mn$	5%
$^{58}Ni(n,p)^{58}Co$	5%
$^{238}U(n,f)^{137}Cs$	10%
$^{237}Np(n,f)^{137}Cs$	10%
$^{59}Co(n,\gamma)^{60}Co$	5%

These uncertainties are given at the 1σ level.

Dosimetry Cross-Section Uncertainties

The reaction rate cross-sections used in the least squares evaluations were taken from the SNLRML library. This data library provides reaction cross-sections and associated uncertainties, including covariances, for 66 dosimetry sensors in common use. Both cross-sections and uncertainties are provided in a fine multigroup structure for use in least squares adjustment applications. These cross-sections were compiled from the most recent cross-section evaluations and they have been tested with respect to their accuracy and consistency for least squares evaluations. Further, the library has been empirically tested for use in fission spectra determination as well as in the fluence and energy characterization of 14 MeV neutron sources.

For sensors included in the Alvin W. Vogtle Unit 2 surveillance program, the following uncertainties in the fission spectrum averaged cross-sections are provided in the SNLRML documentation package.

Reaction	Uncertainty
$^{63}Cu(n,\alpha)^{60}Co$	4.08-4.16%
$^{54}Fe(n,p)^{54}Mn$	3.05-3.11%
$^{58}Ni(n,p)^{58}Co$	4.49-4.56%
$^{238}U(n,f)^{137}Cs$	0.54-0.64%
$^{237}Np(n,f)^{137}Cs$	10.32-10.97%
$^{59}Co(n,\gamma)^{60}Co$	0.79-3.59%

These tabulated ranges provide an indication of the dosimetry cross-section uncertainties associated with the sensor sets used in LWR irradiations.

Calculated Neutron Spectrum

The neutron spectra input to the least squares adjustment procedure were obtained directly from the results of plant specific transport calculations for each surveillance capsule irradiation period and location. The spectrum for each capsule was input in an absolute sense (rather than as simply a relative spectral shape). Therefore, within the constraints of the assigned uncertainties, the calculated data were treated equally with the measurements.

While the uncertainties associated with the reaction rates were obtained from the measurement procedures and counting benchmarks and the dosimetry cross-section uncertainties were supplied directly with the SNLRML library, the uncertainty matrix for the calculated spectrum was constructed from the following relationship:

$$M_{gg'} = R_n^2 + R_g * R_{g'} * P_{gg'}$$

where R_n specifies an overall fractional normalization uncertainty and the fractional uncertainties R_g and $R_{g'}$ specify additional random group-wise uncertainties that are correlated with a correlation matrix given by:

$$P_{gg'} = [1-\theta]\delta_{gg'} + \theta\, e^{-H}$$

where

$$H = \frac{(g-g')^2}{2\gamma^2}$$

The first term in the correlation matrix equation specifies purely random uncertainties, while the second term describes the short-range correlations over a group range γ (θ specifies the strength of the latter term). The value of δ is 1.0 when g = g', and is 0.0 otherwise.

The set of parameters defining the input covariance matrix for the Alvin W. Vogtle Unit 2 calculated spectra was as follows:

Flux Normalization Uncertainty (R_n)	15%
Flux Group Uncertainties (R_g, $R_{g'}$)	
(E > 0.0055 MeV)	15%
(0.68 eV < E < 0.0055 MeV)	29%
(E < 0.68 eV)	52%
Short Range Correlation (θ)	
(E > 0.0055 MeV)	0.9
(0.68 eV < E < 0.0055 MeV)	0.5
(E < 0.68 eV)	0.5
Flux Group Correlation Range (γ)	
(E > 0.0055 MeV)	6
(0.68 eV < E < 0.0055 MeV)	3
(E < 0.68 eV)	2

A.1.3 Comparisons of Measurements and Calculations

Results of the least squares evaluations of the dosimetry from the Alvin W. Vogtle Unit 2 surveillance capsules withdrawn to date are provided in Tables A-5 and A-6. In Table A-5, measured, calculated, and best-estimate values for sensor reaction rates are given for each capsule. Also provided in this tabulation are ratios of the measured reaction rates to both the calculated and least squares adjusted reaction rates. These ratios of M/C and M/BE illustrate the consistency of the fit of the calculated neutron energy spectra to the measured reaction rates both before and after adjustment. In Table A-6, comparison of the calculated and best estimate values of neutron flux (E > 1.0 MeV) and iron atom displacement rate are tabulated along with the BE/C ratios observed for each of the capsules.

The data comparisons provided in Tables A-5 and A-6 show that the adjustments to the calculated spectra are relatively small and well within the assigned uncertainties for the calculated spectra, measured sensor reaction rates, and dosimetry reaction cross-sections. Further, these results indicate that the use of the least squares evaluation results in a reduction in the uncertainties associated with the exposure of the surveillance capsules. From Section 6.4 of this report, it may be noted that the uncertainty associated with the unadjusted calculation of neutron fluence (E > 1.0 MeV) and iron atom displacements at the surveillance capsule locations is specified as 12% at the 1σ level. From Table A-6, it is noted that the corresponding uncertainties associated with the least squares adjusted exposure parameters have been reduced to 6% for neutron flux (E > 1.0 MeV) and 8% for iron atom displacement rate. Again, the uncertainties from the least squares evaluation are at the 1σ level.

Further comparisons of the measurement results with calculations are given in Tables A-7 and A-8. These comparisons are given on two levels. In Table A-7, calculations of individual threshold sensor reaction rates are compared directly with the corresponding measurements. These threshold reaction rate comparisons provide a good evaluation of the accuracy of the fast neutron portion of the calculated energy spectra. In Table A-8, calculations of fast neutron exposure rates in terms of ϕ(E > 1.0 MeV) and dpa/s are compared with the best estimate results obtained from the least squares evaluation of the capsule dosimetry results. These two levels of comparison yield consistent and similar results with all measurement-to-calculation comparisons falling well within the 20% limits specified as the acceptance criteria in Regulatory Guide 1.190.

In the case of the direct comparison of measured and calculated sensor reaction rates, the M/C comparisons for fast neutron reactions range from 0.96 to 1.26 for the 20 samples included in the data set. The overall average M/C ratio for the entire set of Alvin W. Vogtle Unit 2 data is 1.11 with an associated standard deviation of 10.7%.

In the comparisons of best estimate and calculated fast neutron exposure parameters, the corresponding BE/C comparisons for the capsule data sets range from 0.99 to 1.20 for neutron flux (E > 1.0 MeV) and from 1.00 to 1.18 for iron atom displacement rate. The overall average BE/C ratios for neutron flux (E > 1.0 MeV) and iron atom displacement rate are 1.09 with a standard deviation of 7.7% and 1.10 with a standard deviation of 6.7%, respectively.

Based on these comparisons, it is concluded that the calculated fast neutron exposures provided in Section 6.2 of this report are validated for use in the assessment of the condition of the materials comprising the beltline region of the Alvin W. Vogtle Unit 2 reactor pressure vessel.

Table A-1

Nuclear Parameters Used In The Evaluation Of Neutron Sensors

Monitor Material	Reaction of Interest	Target Atom Fraction	90% Response Range (MeV)	Product Half-life	Fission Yield (%)
Copper	$^{63}Cu\ (n,\alpha)$	0.6917	4.9 – 11.9	5.271 y	
Iron	$^{54}Fe\ (n,p)$	0.0585	2.1 – 8.5	312.1 d	
Nickel	$^{58}Ni\ (n,p)$	0.6808	1.5 – 8.3	70.82 d	
Uranium-238	$^{238}U\ (n,f)$	1.0000	1.3 – 6.9	30.07 y	6.02
Neptunium-237	$^{237}Np\ (n,f)$	1.0000	0.3 – 3.8	30.07 y	6.17
Cobalt-Aluminum	$^{59}Co\ (n,\gamma)$	0.0015	non-threshold	5.271 y	

Note: The 90% response range is defined such that, in the neutron spectrum characteristic of the Alvin W. Vogtle Unit 2 surveillance capsules, approximately 90% of the sensor response is due to neutrons in the energy range specified with approximately 5% of the total response due to neutrons with energies below the lower limit and 5% of the total response due to neutrons with energies above the upper limit.

Table A-2

Monthly Thermal Generation During The First Eleven Fuel Cycles
Of The Alvin W. Vogtle Unit 2 Reactor
(Reactor power of 3411 MWt from startup through Cycle 4 (3/13/93) and
3565 MWt from Cycle 5 (4/27/93) through the End of Cycle 11)

Month-Year	Thermal Generation (MWt-hr)	Month-Year	Thermal Generation (MWt-hr)	Month-Year	Thermal Generation (MWt-hr)
Mar-89	0	Mar-92	605707	Mar-95	10688
Apr-89	475504	Apr-92	0	Apr-95	2438900
May-89	617966	May-92	1578601	May-95	2650425
Jun-89	2450888	Jun-92	2447254	Jun-95	2565303
Jul-89	2452023	Jul-92	2532424	Jul-95	2456584
Aug-89	2526703	Aug-92	2534744	Aug-95	2650678
Sep-89	2439109	Sep-92	2452670	Sep-95	2565249
Oct-89	2034639	Oct-92	2539098	Oct-95	2654328
Nov-89	2350213	Nov-92	2451426	Nov-95	2565212
Dec-89	2335572	Dec-92	2052686	Dec-95	2624729
Jan-90	2503482	Jan-93	2536193	Jan-96	2650834
Feb-90	2289775	Feb-93	2291024	Feb-96	2479725
Mar-90	2340854	Mar-93	2536217	Mar-96	2650787
Apr-90	2396650	Apr-93	2450906	Apr-96	2565415
May-90	2424191	May-93	2577663	May-96	2650735
Jun-90	2181332	Jun-93	2406365	Jun-96	2565158
Jul-90	1854770	Jul-93	2629330	Jul-96	2452545
Aug-90	1534544	Aug-93	2559359	Aug-96	2552746
Sep-90	585194	Sep-93	547977	Sep-96	489969
Oct-90	0	Oct-93	903906	Oct-96	1241612
Nov-90	1185372	Nov-93	2564027	Nov-96	2564798
Dec-90	2395968	Dec-93	2588183	Dec-96	2650604
Jan-91	2023180	Jan-94	2429440	Jan-97	2650701
Feb-91	1953887	Feb-94	2393295	Feb-97	2393844
Mar-91	1827085	Mar-94	2639006	Mar-97	2650728
Apr-91	2149993	Apr-94	2533075	Apr-97	2561147
May-91	2276659	May-94	2523585	May-97	2630761
Jun-91	2452835	Jun-94	1262082	Jun-97	2564816
Jul-91	2534141	Jul-94	1926053	Jul-97	2650622
Aug-91	2505776	Aug-94	2341001	Aug-97	2650268
Sep-91	2359978	Sep-94	2564313	Sep-97	2564794
Oct-91	2508529	Oct-94	2653771	Oct-97	2654064
Nov-91	2433457	Nov-94	2564454	Nov-97	2565321
Dec-91	2535003	Dec-94	2649055	Dec-97	2650576
Jan-92	2534130	Jan-95	2649874	Jan-98	2650913
Feb-92	2299840	Feb-95	2063517	Feb-98	2296803

Table A-2 cont'd

Monthly Thermal Generation During The First Eleven Fuel Cycles
Of The Alvin W. Vogtle Unit 2 Reactor
(Reactor power of 3411 MWt from startup through Cycle 4 (3/13/93) and
3565 MWt from Cycle 5 (4/27/93) through the End of Cycle 11)

Month-Year	Thermal Generation (MWt-hr)	Month-Year	Thermal Generation (MWt-hr)	Month-Year	Thermal Generation (MWt-hr)
Mar-98	491140	Mar-01	2626793	Mar-04	2650596
Apr-98	779588	Apr-01	541918	Apr-04	1435551
May-98	2068679	May-01	2212525		
Jun-98	2017178	Jun-01	2566207		
Jul-98	2630863	Jul-01	2651538		
Aug-98	2456507	Aug-01	2651538		
Sep-98	2412869	Sep-01	2536586		
Oct-98	2607668	Oct-01	2654480		
Nov-98	2565406	Nov-01	2564834		
Dec-98	2650912	Dec-01	2649576		
Jan-99	2650519	Jan-02	2648988		
Feb-99	2332866	Feb-02	2392406		
Mar-99	2503094	Mar-02	2649969		
Apr-99	2561474	Apr-02	2560911		
May-99	2650716	May-02	2649576		
Jun-99	2501128	Jun-02	2564442		
Jul-99	2650519	Jul-02	2649773		
Aug-99	2648554	Aug-02	2649969		
Sep-99	2508597	Sep-02	2537763		
Oct-99	149981	Oct-02	386049		
Nov-99	2051716	Nov-02	621071		
Dec-99	2300308	Dec-02	1421414		
Jan-00	2637192	Jan-03	2651478		
Feb-00	2480228	Feb-03	2395041		
Mar-00	2632679	Mar-03	2204085		
Apr-00	2562046	Apr-03	2562629		
May-00	2651123	May-03	2651185		
Jun-00	2565774	Jun-03	2565770		
Jul-00	2650927	Jul-03	2651185		
Aug-00	2650534	Aug-03	1785259		
Sep-00	2565185	Sep-03	2246890		
Oct-00	2654654	Oct-03	2654326		
Nov-00	2565381	Nov-03	2565378		
Dec-00	2650338	Dec-03	2650853		
Jan-01	2651123	Jan-04	2629328		
Feb-01	2394487	Feb-04	2379233		

Table A-3

Calculated C_j Factors at the Surveillance Capsule Center
Core Midplane Elevation

Fuel Cycle	φ(E > 1.0 MeV) [n/cm2-s]			
	Capsule U	Capsule Y	Capsule X	Capsule W
1	9.43E+10	8.78E+10	9.43E+10	9.34E+10
2		7.30E+10	7.97E+10	7.89E+10
3		6.32E+10	6.82E+10	6.75E+10
4		6.08E+10	6.63E+10	6.57E+10
5			6.17E+10	6.11E+10
6			6.79E+10	6.73E+10
7				7.01E+10
8				7.17E+10
9				6.88E+10
10				7.04E+10
Average	9.43E+10	7.09E+10	7.25E+10	7.12E+10

Fuel Cycle	C_j			
	Capsule U	Capsule Y	Capsule X	Capsule W
1	1.00	1.24	1.30	1.31
2		1.03	1.10	1.11
3		0.89	0.94	0.95
4		0.86	0.92	0.92
5			0.85	0.86
6			0.94	0.95
7				0.99
8				1.01
9				0.97
10				0.99
Average	1.00	1.00	1.00	1.00

Table A-4

Measured Sensor Activities And Reaction Rates

Surveillance Capsule U

Reaction	Location	Measured Activity (dps/g)	Saturated Activity (dps/g)	Radially Adjusted Saturated Activity (dps/g)	Radially Adjusted Reaction Rate (rps/atom)
^{63}Cu (n,α) ^{60}Co	Top	5.51E+04	3.96E+05	3.96E+05	6.04E-17
	Middle	4.96E+04	3.56E+05	3.56E+05	5.44E-17
	Bottom	4.86E+04	3.49E+05	3.49E+05	5.33E-17
	Average				**5.60E-17**
^{54}Fe (n,p) ^{54}Mn	Top	1.88E+06	3.98E+06	3.98E+06	6.31E-15
	Middle	1.65E+06	3.49E+06	3.49E+06	5.54E-15
	Bottom	1.67E+06	3.53E+06	3.53E+06	5.60E-15
	Average				**5.82E-15**
^{58}Ni (n,p) ^{58}Co	Top	1.86E+07	5.81E+07	5.81E+07	8.32E-15
	Middle	1.70E+07	5.31E+07	5.31E+07	7.60E-15
	Bottom	1.65E+07	5.16E+07	5.16E+07	7.38E-15
	Average				**7.77E-15**
^{238}U (n,f) ^{137}Cs (Cd)	Middle	1.83E+05	6.78E+06	6.78E+06	4.45E-14
^{238}U (n,f) ^{137}Cs (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**3.74E-14**
^{237}Np (n,f) ^{137}Cs (Cd)	Middle	1.56E+06	5.78E+07	5.78E+07	3.69E-13
^{237}Np (n,f) ^{137}Cs (Cd)			Including γ,fission correction:		**3.65E-13**
^{59}Co (n,γ) ^{60}Co	Top	1.13E+07	8.12E+07	8.12E+07	5.30E-12
	Middle	1.26E+07	9.05E+07	9.05E+07	5.91E-12
	Bottom	1.15E+07	8.26E+07	8.26E+07	5.39E-12
	Average				**5.53E-12**
^{59}Co (n,γ) ^{60}Co (Cd)	Top	5.99E+06	4.30E+07	4.30E+07	2.81E-12
	Middle	6.21E+06	4.46E+07	4.46E+07	2.91E-12
	Bottom	6.19E+06	4.45E+07	4.45E+07	2.90E-12
	Average				**2.87E-12**

Notes: 1) Measured specific activities are indexed to a counting date of 12/12/90.
2) The average ^{238}U (n,f) reaction rate of 3.74E-14 includes a correction factor of 0.870 to account for plutonium build-in and an additional factor of 0.966 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 3.65E-13 includes a correction factor of 0.990 to account for photo-fission effects in the sensor.

Table A-4 cont'd

Measured Sensor Activities And Reaction Rates

Surveillance Capsule Y

Reaction	Location	Measured Activity (dps/g)	Saturated Activity (dps/g)	Radially Adjusted Saturated Activity (dps/g)	Radially Adjusted Reaction Rate (rps/atom)
^{63}Cu (n,α) ^{60}Co	Top	1.33E+05	3.14E+05	3.14E+05	4.78E-17
	Middle	1.21E+05	2.85E+05	2.85E+05	4.35E-17
	Bottom	1.21E+05	2.85E+05	2.85E+05	4.35E-17
	Average				**4.50E-17**
^{54}Fe (n,p) ^{54}Mn	Top	1.54E+06	2.72E+06	2.72E+06	4.32E-15
	Middle	1.41E+06	2.49E+06	2.49E+06	3.95E-15
	Bottom	1.42E+06	2.51E+06	2.51E+06	3.98E-15
	Average				**4.09E-15**
^{58}Ni (n,p) ^{58}Co	Top	207.32	7.80E+06	4.26E+07	4.26E+07
	Middle	207.32	7.18E+06	3.92E+07	3.92E+07
	Bottom	207.32	7.03E+06	3.84E+07	3.84E+07
	Average				**5.73E-15**
^{238}U (n,f) ^{137}Cs (Cd)	Middle	4.71E+05	4.45E+06	4.45E+06	2.92E-14
^{238}U (n,f) ^{137}Cs (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**2.38E-14**
^{237}Np (n,f) ^{137}Cs (Cd)	Middle	3.78E+06	3.57E+07	3.57E+07	2.28E-13
^{237}Np (n,f) ^{137}Cs (Cd)			Including γ,fission correction:		**2.25E-13**
^{59}Co (n,γ) ^{60}Co	Top	2.39E+07	5.64E+07	5.64E+07	3.68E-12
	Middle	2.37E+07	5.59E+07	5.59E+07	3.65E-12
	Bottom	2.38E+07	5.61E+07	5.61E+07	3.66E-12
	Average				**3.66E-12**
^{59}Co (n,γ) ^{60}Co (Cd)	Top	1.22E+07	2.88E+07	2.88E+07	1.88E-12
	Middle	1.25E+07	2.95E+07	2.95E+07	1.92E-12
	Bottom	1.27E+07	2.99E+07	2.99E+07	1.95E-12
	Average				**1.92E-12**

Notes: 1) Measured specific activities are indexed to a counting date of 8/1/95.
2) The average ^{238}U (n,f) reaction rate of 2.38E-14 includes a correction factor of 0.841 to account for plutonium build-in and an additional factor of 0.968 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 2.25E-13 includes a correction factor of 0.990 to account for photo-fission effects in the sensor.

Table A-4 cont'd

Measured Sensor Activities And Reaction Rates

Surveillance Capsule X

Reaction	Location	Measured Activity (dps/g)	Saturated Activity (dps/g)	Radially Adjusted Saturated Activity (dps/g)	Radially Adjusted Reaction Rate (rps/atom)
$^{63}Cu\ (n,\alpha)\ ^{60}Co$	Top	1.96E+05	3.59E+05	3.59E+05	5.47E-17
	Middle	1.78E+05	3.26E+05	3.26E+05	4.97E-17
	Bottom	1.74E+05	3.18E+05	3.18E+05	4.86E-17
	Average				**5.10E-17**
$^{54}Fe\ (n,p)\ ^{54}Mn$	Top	1.78E+06	3.41E+06	3.41E+06	5.40E-15
	Middle	1.62E+06	3.10E+06	3.10E+06	4.92E-15
	Bottom	1.59E+06	3.05E+06	3.05E+06	4.83E-15
	Average				**5.05E-15**
$^{58}Ni\ (n,p)\ ^{58}Co$	Top	4.96E+06	5.50E+07	5.50E+07	7.87E-15
	Middle	4.41E+06	4.89E+07	4.89E+07	7.00E-15
	Bottom	4.44E+06	4.92E+07	4.92E+07	7.04E-15
	Average				**7.30E-15**
$^{238}U\ (n,f)\ ^{137}Cs$ (Cd)	Middle	9.00E+05	5.66E+06	5.66E+06	3.72E-14
$^{238}U\ (n,f)\ ^{137}Cs$ (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**2.94E-14**
$^{237}Np\ (n,f)\ ^{137}Cs$ (Cd)	Middle	6.84E+06	4.30E+07	4.30E+07	2.74E-13
$^{237}Np\ (n,f)\ ^{137}Cs$ (Cd)			Including γ,fission correction:		**2.72E-13**
$^{59}Co\ (n,\gamma)\ ^{60}Co$	Top				
	Middle	3.70E+07	6.77E+07	6.77E+07	4.42E-12
	Bottom	3.66E+07	6.70E+07	6.70E+07	4.37E-12
	Average				**4.39E-12**
$^{59}Co\ (n,\gamma)\ ^{60}Co$ (Cd)	Top				
	Middle	1.93E+07	3.53E+07	3.53E+07	2.30E-12
	Bottom	1.97E+07	3.60E+07	3.60E+07	2.35E-12
	Average				**2.33E-12**

Notes: 1) Measured specific activities are indexed to a counting date of 11/1/98.
2) The average ^{238}U (n,f) reaction rate of 2.94E-14 includes a correction factor of 0.817 to account for plutonium build-in and an additional factor of 0.967 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 2.72E-13 includes a correction factor of 0.990 to account for photo-fission effects in the sensor.
4) Top monitors for the ^{59}Co sensors were not present at the removal of the capsule.

Table A-4 cont'd

Measured Sensor Activities And Reaction Rates

Surveillance Capsule W

Reaction	Location	Measured Activity (dps/g)	Saturated Activity (dps/g)	Radially Adjusted Saturated Activity (dps/g)	Radially Adjusted Reaction Rate (rps/atom)
$^{63}Cu\ (n,\alpha)\ ^{60}Co$	Top	2.16E+05	2.98E+05	2.98E+05	4.54E-17
	Middle	1.94E+05	2.67E+05	2.67E+05	4.08E-17
	Bottom	1.90E+05	2.62E+05	2.62E+05	4.00E-17
	Average				**4.21E-17**
$^{54}Fe\ (n,p)\ ^{54}Mn$	Top	1.83E+06	2.80E+06	2.80E+06	4.43E-15
	Middle	1.67E+06	2.55E+06	2.55E+06	4.05E-15
	Bottom	1.64E+06	2.51E+06	2.51E+06	3.97E-15
	Average				**4.15E-15**
$^{58}Ni\ (n,p)\ ^{58}Co$	Top	1.00E+07	4.54E+07	4.54E+07	6.50E-15
	Middle	9.22E+06	4.18E+07	4.18E+07	5.99E-15
	Bottom	8.99E+06	4.08E+07	4.08E+07	5.84E-15
	Average				**6.11E-15**
$^{238}U\ (n,f)\ ^{137}Cs$ (Cd)	Middle	1.40E+06	5.47E+06	5.47E+06	3.59E-14
$^{238}U\ (n,f)\ ^{137}Cs$ (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**2.70E-14**
$^{237}Np\ (n,f)\ ^{137}Cs$ (Cd)	Middle	9.54E+06	3.72E+07	3.72E+07	2.38E-13
$^{237}Np\ (n,f)\ ^{137}Cs$ (Cd)			Including γ,fission correction:		**2.35E-13**
$^{59}Co\ (n,\gamma)\ ^{60}Co$	Top	4.00E+07	5.51E+07	5.51E+07	3.60E-12
	Middle	4.00E+07	5.51E+07	5.51E+07	3.60E-12
	Bottom	4.02E+07	5.54E+07	5.54E+07	3.62E-12
	Average				**3.60E-12**
$^{59}Co\ (n,\gamma)\ ^{60}Co$ (Cd)	Top	2.28E+07	3.14E+07	3.14E+07	2.05E-12
	Middle	2.35E+07	3.24E+07	3.24E+07	2.11E-12
	Bottom	2.29E+07	3.16E+07	3.16E+07	2.06E-12
	Average				**2.08E-12**

Notes: 1) Measured specific activities are indexed to a counting date of 9/16/04.

2) The average ^{238}U (n,f) reaction rate of 2.70E-14 includes a correction factor of 0.777 to account for plutonium build-in and an additional factor of 0.969 to account for photo-fission effects in the sensor.

3) The average ^{237}Np (n,f) reaction rate of 2.35E-13 includes a correction factor of 0.991 to account for photo-fission effects in the sensor.

Table A-5

Comparison of Measured, Calculated, and Best Estimate
Reaction Rates At The Surveillance Capsule Center

Capsule U

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	5.60E-17	4.90E-17	5.42E-17	1.14	1.03
$^{54}Fe(n,p)^{54}Mn$	5.82E-15	5.54E-15	5.93E-15	1.05	0.98
$^{58}Ni(n,p)^{58}Co$	7.77E-15	7.78E-15	8.21E-15	1.00	0.94
$^{238}U(n,f)^{137}Cs$ (Cd)	3.74E-14	3.00E-14	3.29E-14	1.25	1.14
$^{237}Np(n,f)^{137}Cs$ (Cd)	3.65E-13	2.95E-13	3.47E-13	1.24	1.05
$^{59}Co(n,\gamma)^{60}Co$	5.53E-12	4.23E-12	5.43E-12	1.31	1.02
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	2.87E-12	2.94E-12	2.92E-12	0.98	0.98

Capsule Y

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	4.50E-17	3.92E-17	4.28E-17	1.15	1.05
$^{54}Fe(n,p)^{54}Mn$	4.09E-15	4.28E-15	4.25E-15	0.96	0.96
$^{58}Ni(n,p)^{58}Co$	5.73E-15	5.98E-15	5.91E-15	0.96	0.97
$^{238}U(n,f)^{137}Cs$ (Cd)	2.38E-14	2.27E-14	2.23E-14	1.05	1.06
$^{237}Np(n,f)^{137}Cs$ (Cd)	2.25E-13	2.20E-13	2.21E-13	1.02	1.02
$^{59}Co(n,\gamma)^{60}Co$	3.66E-12	3.06E-12	3.59E-12	1.19	1.02
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	1.92E-12	2.15E-12	1.95E-12	0.89	0.98

Table A-5

Comparison of Measured, Calculated, and Best Estimate Reaction Rates At The Surveillance Capsule Center

Capsule X

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	5.10E-17	4.02E-17	4.97E-17	1.27	1.03
$^{54}Fe(n,p)^{54}Mn$	5.05E-15	4.38E-15	5.21E-15	1.15	0.97
$^{58}Ni(n,p)^{58}Co$	7.30E-15	6.13E-15	7.33E-15	1.19	1.00
$^{238}U(n,f)^{137}Cs$ (Cd)	2.94E-14	2.33E-14	2.77E-14	1.26	1.06
$^{237}Np(n,f)^{137}Cs$ (Cd)	2.72E-13	2.25E-13	2.68E-13	1.21	1.01
$^{59}Co(n,\gamma)^{60}Co$	4.39E-12	3.17E-12	4.31E-12	1.39	1.02
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	2.33E-12	2.20E-12	2.36E-12	1.06	0.99

Capsule W

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	4.21E-17	3.94E-17	4.12E-17	1.07	1.02
$^{54}Fe(n,p)^{54}Mn$	4.15E-15	4.29E-15	4.35E-15	0.97	0.95
$^{58}Ni(n,p)^{58}Co$	6.11E-15	6.00E-15	6.17E-15	1.02	0.99
$^{238}U(n,f)^{137}Cs$ (Cd)	2.70E-14	2.27E-14	2.38E-14	1.19	1.14
$^{237}Np(n,f)^{137}Cs$ (Cd)	2.35E-13	2.21E-13	2.36E-13	1.06	1.00
$^{59}Co(n,\gamma)^{60}Co$	3.60E-12	2.83E-12	3.54E-12	1.27	1.02
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	2.07E-12	2.00E-12	2.10E-12	1.04	0.99

Table A-6

Comparison of Calculated and Best Estimate Exposure Rates
At The Surveillance Capsule Center

Capsule ID	$\phi(E > 1.0\ MeV)$ [n/cm^2-s]			
	Calculated	Best Estimate	Uncertainty (1σ)	BE/C
U	9.43E+10	1.06E+11	6%	1.12
Y	7.09E+10	6.99E+10	6%	0.99
X	7.25E+10	8.67E+10	6%	1.20
W	7.12E+10	7.57E+10	6%	1.06

Note: Calculated results are based on the synthesized transport calculations taken at the core midplane following the completion of each respective capsules irradiation period.

Capsule ID	Iron Atom Displacement Rate [dpa/s]			
	Calculated	Best Estimate	Uncertainty (1σ)	BE/C
U	1.84E-10	2.07E-10	8%	1.13
Y	1.37E-10	1.37E-10	8%	1.00
X	1.40E-10	1.65E-10	8%	1.18
W	1.37E-10	1.46E-10	8%	1.07

Note: Calculated results are based on the synthesized transport calculations taken at the core midplane following the completion of each respective capsules irradiation period.

Table A-7

Comparison of Measured/Calculated (M/C) Sensor Reaction Rate Ratios Including all Fast Neutron Threshold Reactions

Reaction	M/C Ratio			
	Capsule U	Capsule Y	Capsule X	Capsule W
$^{63}Cu(n,\alpha)^{60}Co$	1.14	1.15	1.27	1.07
$^{54}Fe(n,p)^{54}Mn$	1.05	0.96	1.15	0.97
$^{58}Ni(n,p)^{58}Co$	1.00	0.96	1.19	1.02
$^{238}U(n,p)^{137}Cs$ (Cd)	1.25	1.05	1.26	1.19
$^{237}Np(n,f)^{137}Cs$ (Cd)	1.24	1.02	1.21	1.06
Average	1.14	1.03	1.22	1.06
% Standard Deviation	11.1	7.9	5.0	8.2

Note: The overall average M/C ratio for the set of 20 sensor measurements is 1.11 with an associated standard deviation of 10.7%.

Table A-8

Comparison of Best Estimate/Calculated (BE/C) Exposure Rate Ratios

Capsule ID	BE/C Ratio	
	ϕ(E > 1.0 MeV)	dpa/s
U	1.12	1.13
Y	0.99	1.00
X	1.20	1.18
W	1.06	1.07
Average	1.09	1.10
% Standard Deviation	7.7	6.7

Appendix A References

A-1. Regulatory Guide RG-1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, March 1995.

A-2. WCAP-13007, "Analysis of Capsule U from the Georgia Power Company Vogtle Unit 2 Reactor Vessel Radiation Surveillance Program," January 1991.

A-3. A. Schmittroth, *FERRET Data Analysis Core*, HEDL-TME 79-40, Hanford Engineering Development Laboratory, Richland, WA, September 1979.

A-4. RSIC Data Library Collection DLC-178, "SNLRML Recommended Dosimetry Cross-Section Compendium", July 1994.

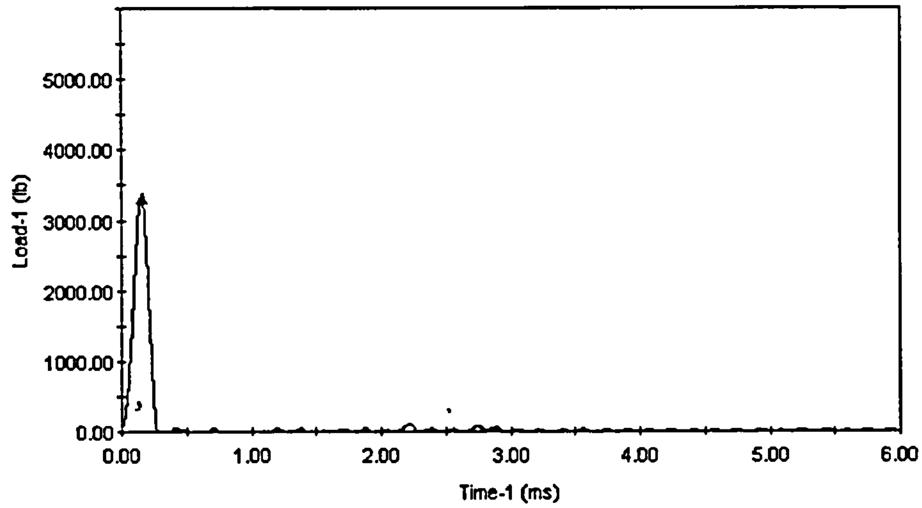
A-5 WCAP-14532, "Analysis of Capsule Y from the Georgia Power Company Vogtle Electric Generating Plant (VEGP) Unit 2 Reactor Vessel Radiation Surveillance Program," February 1996.

A-6 WCAP-15159, "Analysis of Capsule X From the Southern Nuclear Vogtle Electric Generating Plant Unit 2 Reactor Vessel Radiation Surveillance Program," March 1999.

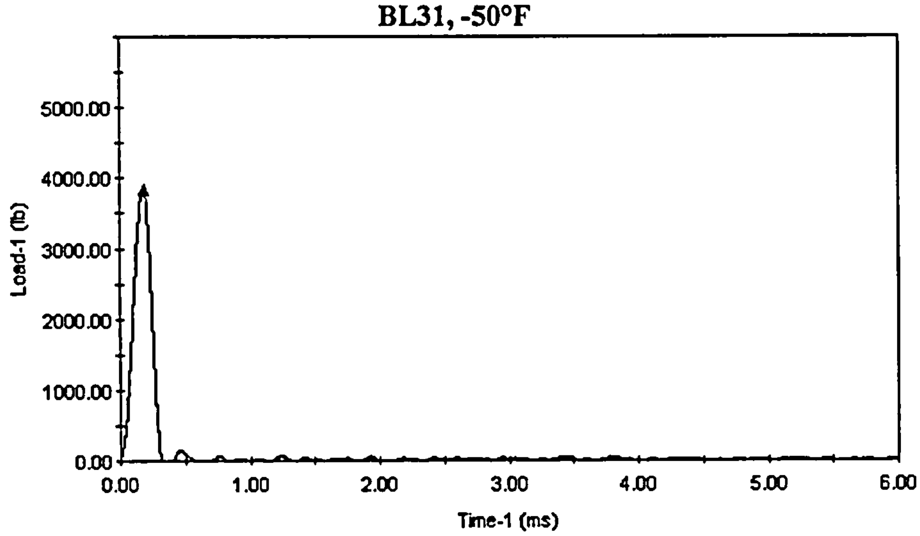
APPENDIX B

LOAD-TIME RECORDS FOR CHARPY SPECIMEN TESTS

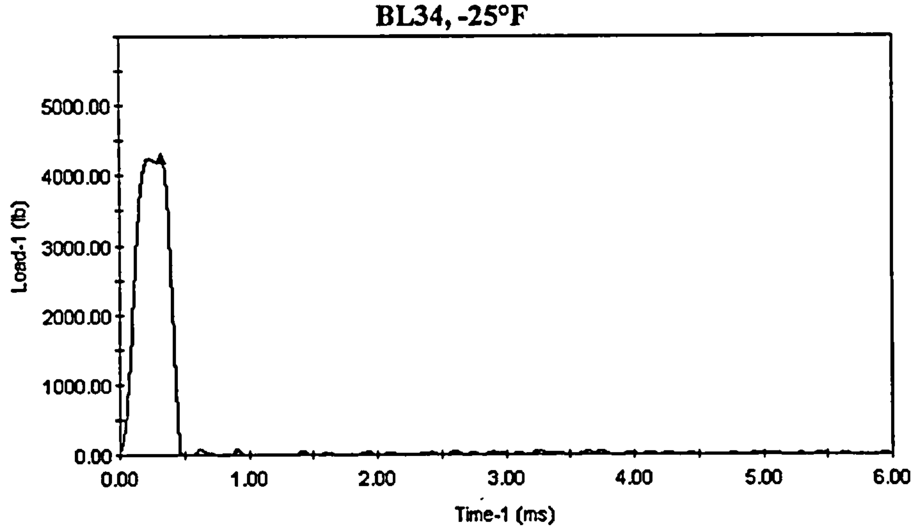
- Specimen prefix "BL" denotes Lower Plate, Longitudinal Orientation
- Specimen prefix "BT" denotes Lower Plate, Transverse Orientation
- Specimen prefix "BW" denotes Weld Material
- Specimen prefix "BH" denotes Heat-Affected Zone material



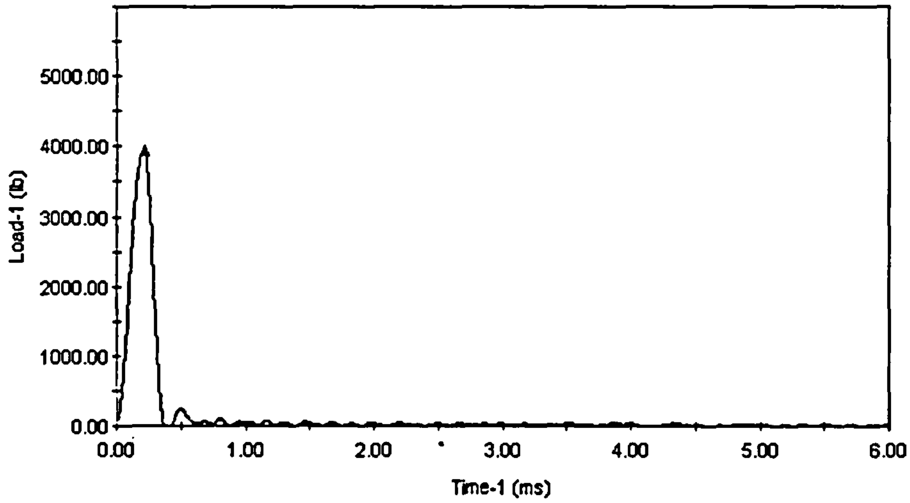
BL31, -50°F



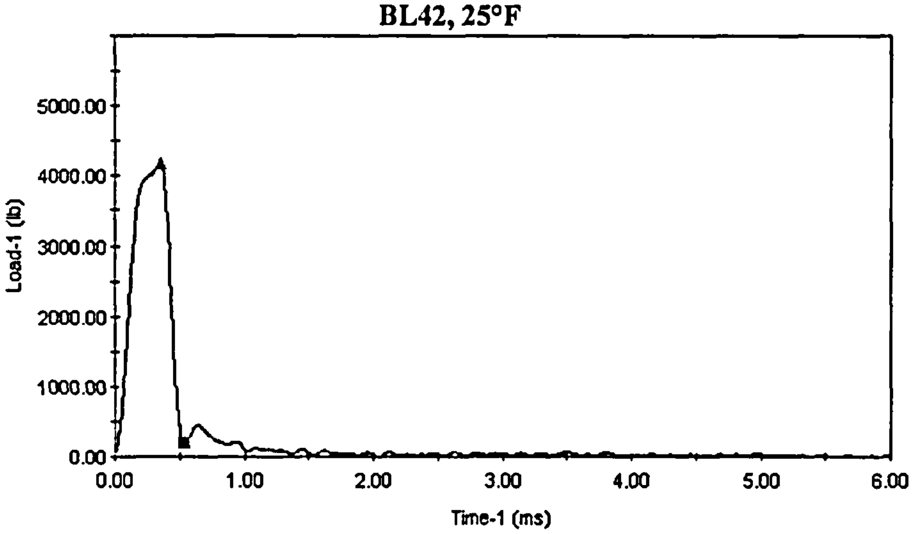
BL34, -25°F



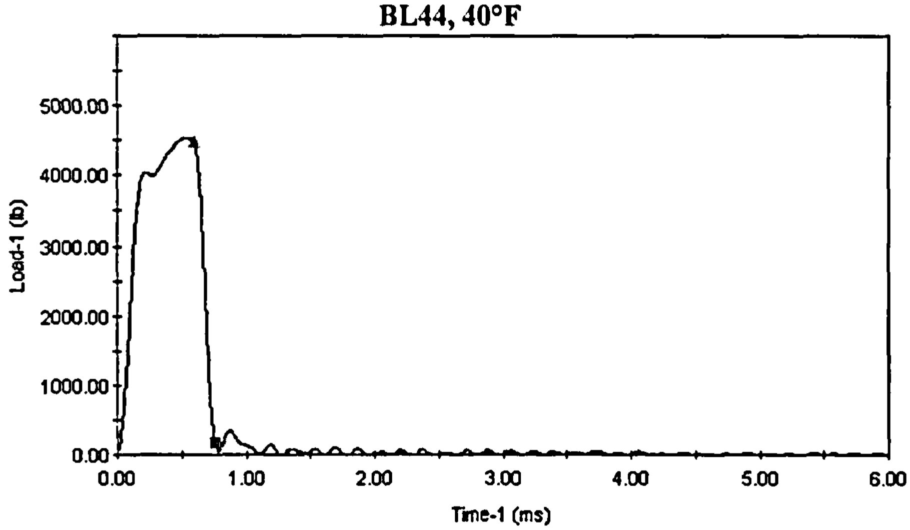
BL40, 0°F



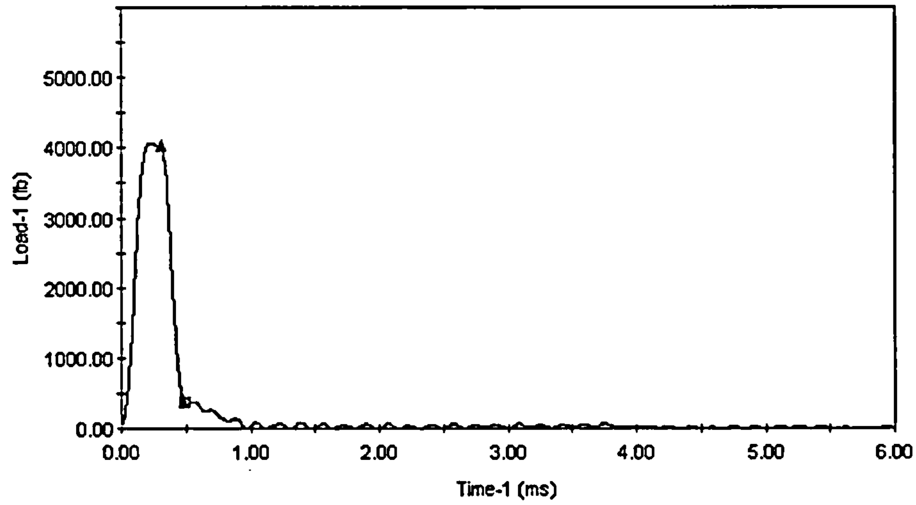
BL42, 25°F



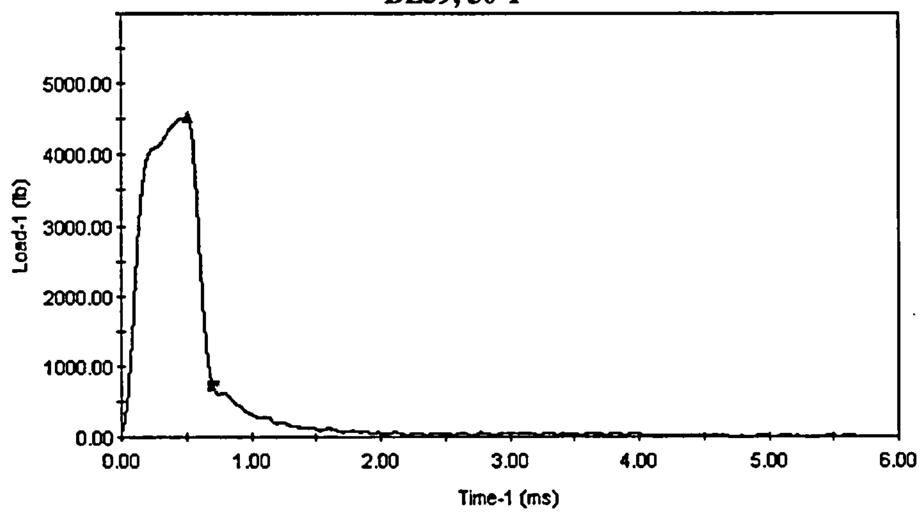
BL44, 40°F



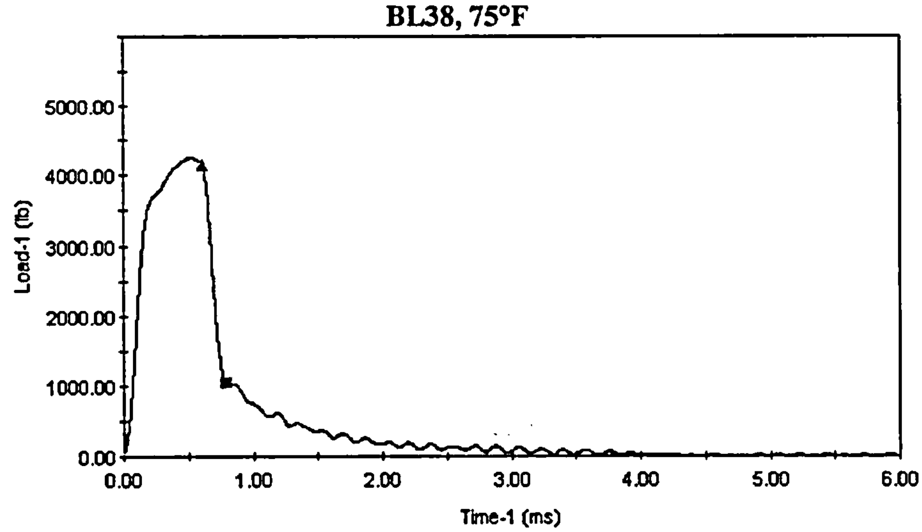
BL33, 50°F



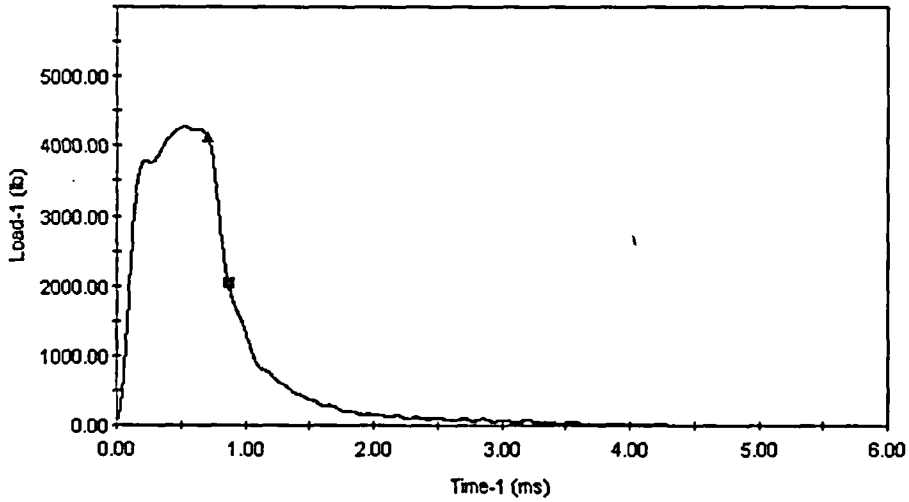
BL39, 50°F



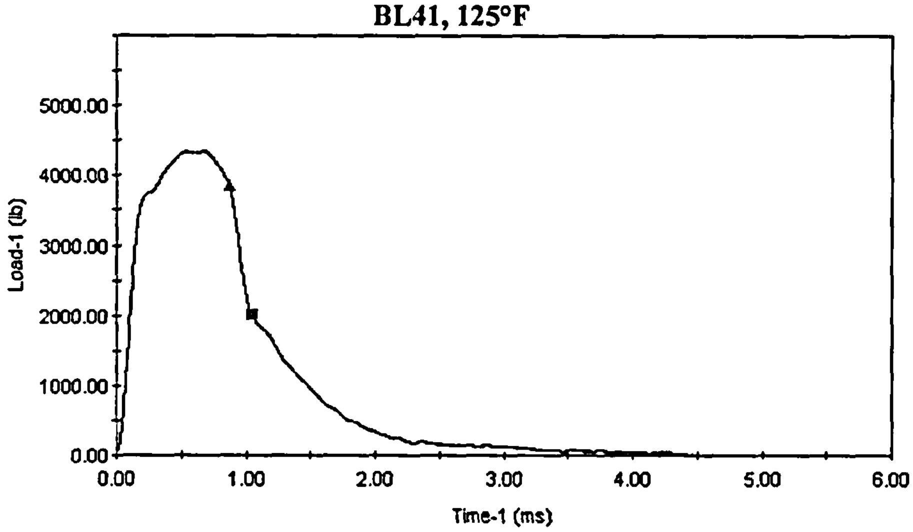
BL38, 75°F



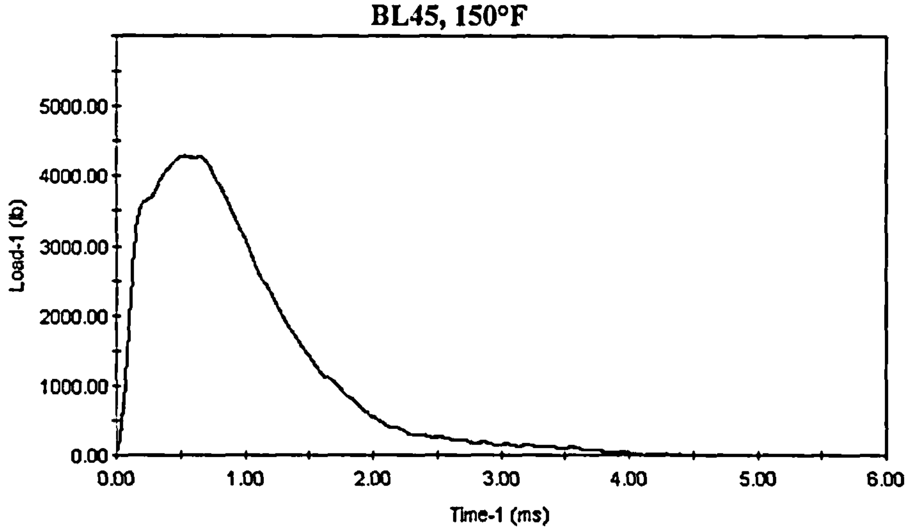
BL32, 100°F



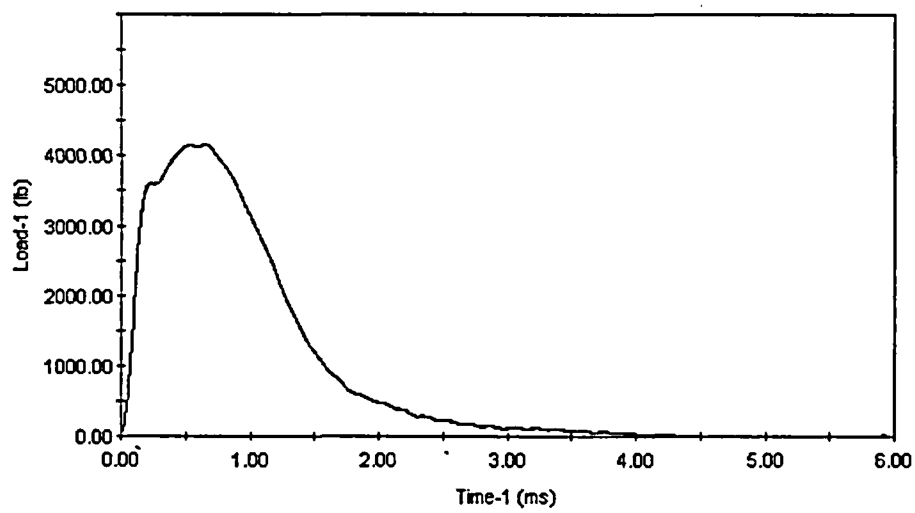
BL41, 125°F



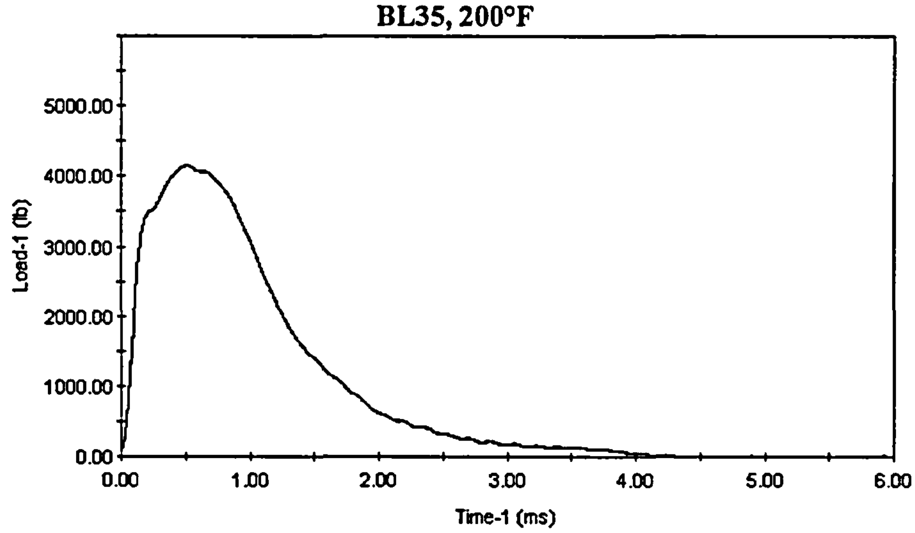
BL45, 150°F



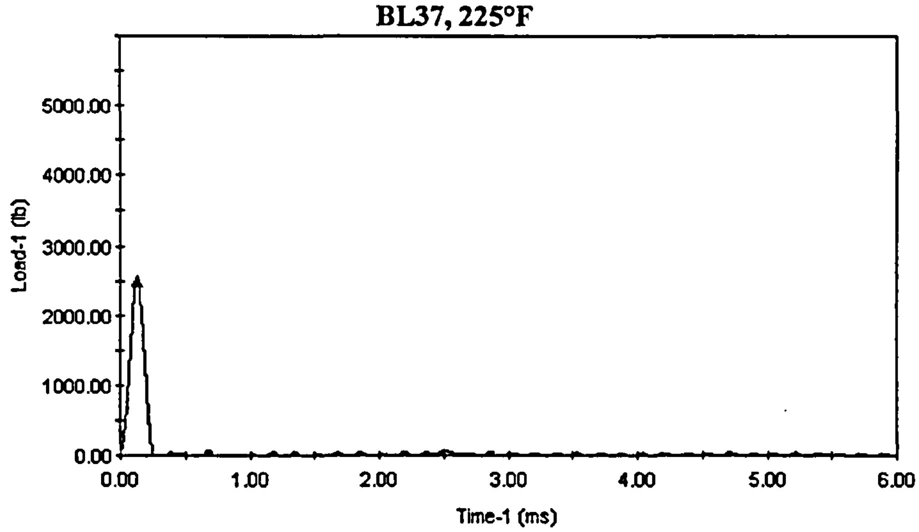
BL43, 175°F



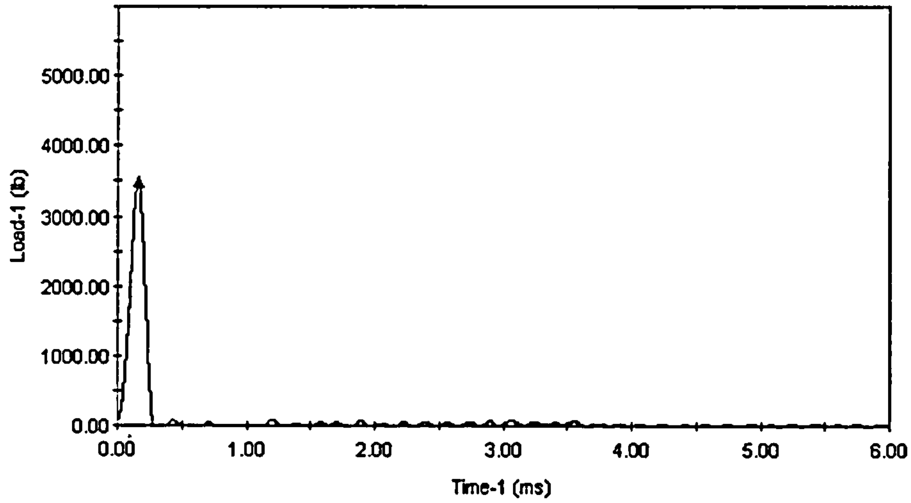
BL35, 200°F



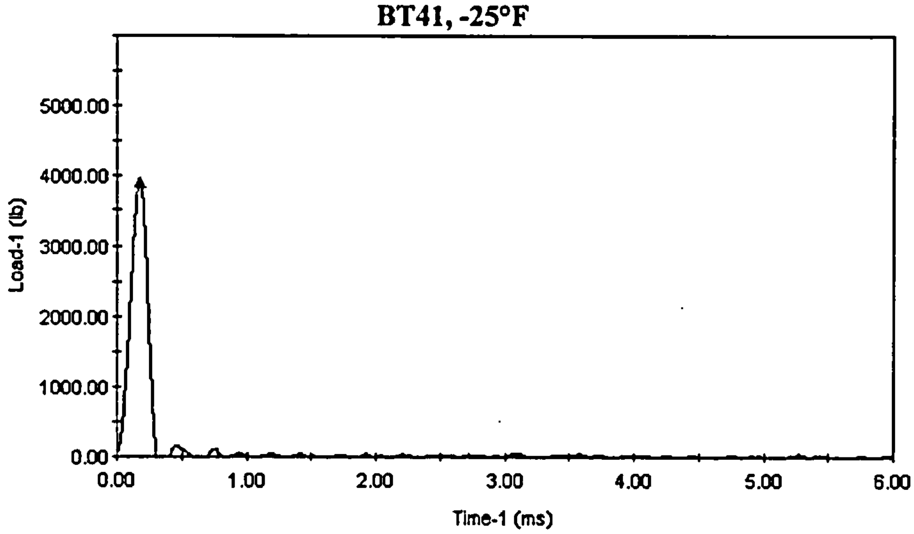
BL37, 225°F



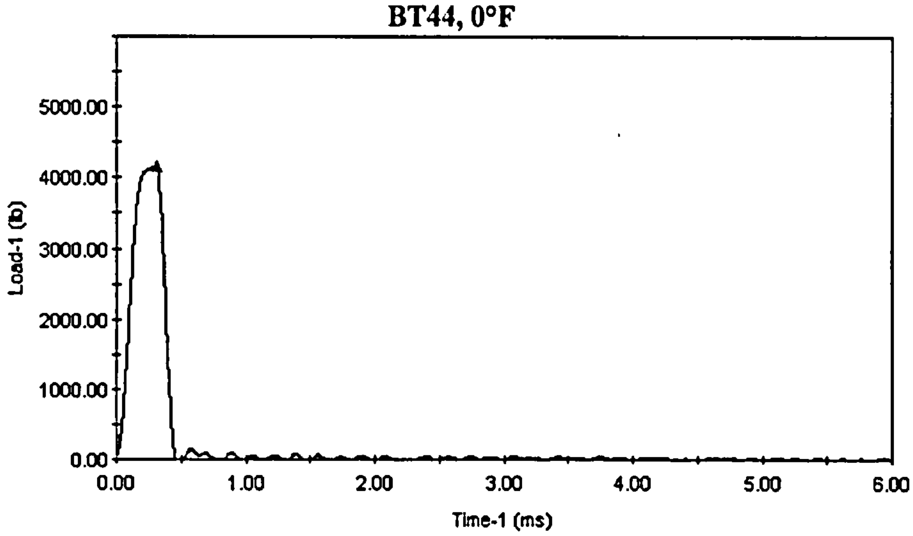
BT32, -75°F



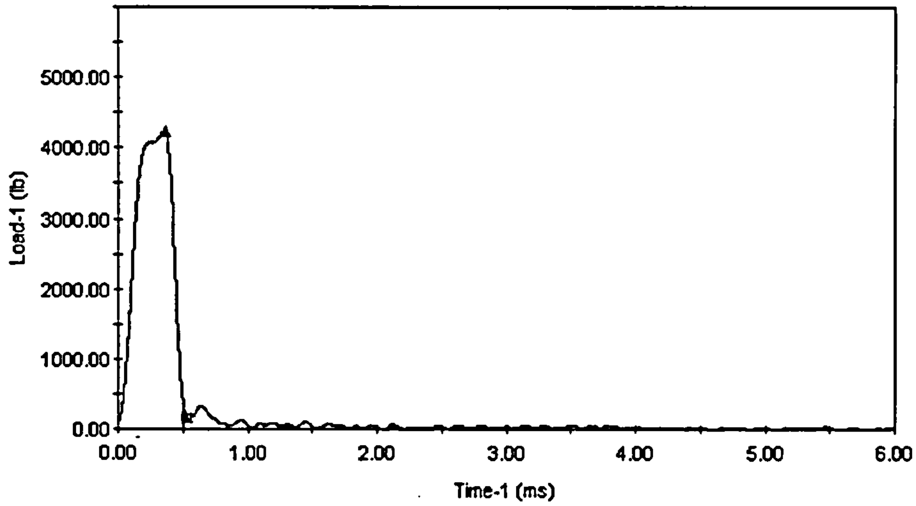
BT41, -25°F



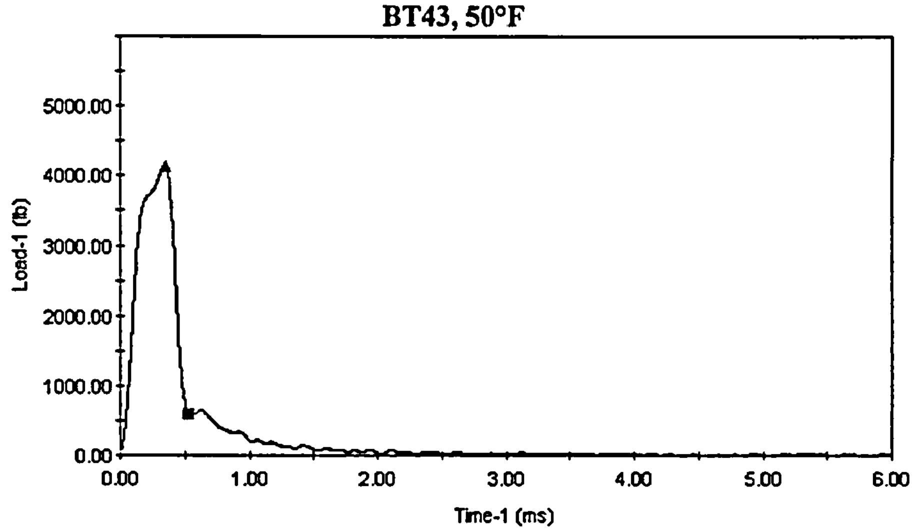
BT44, 0°F



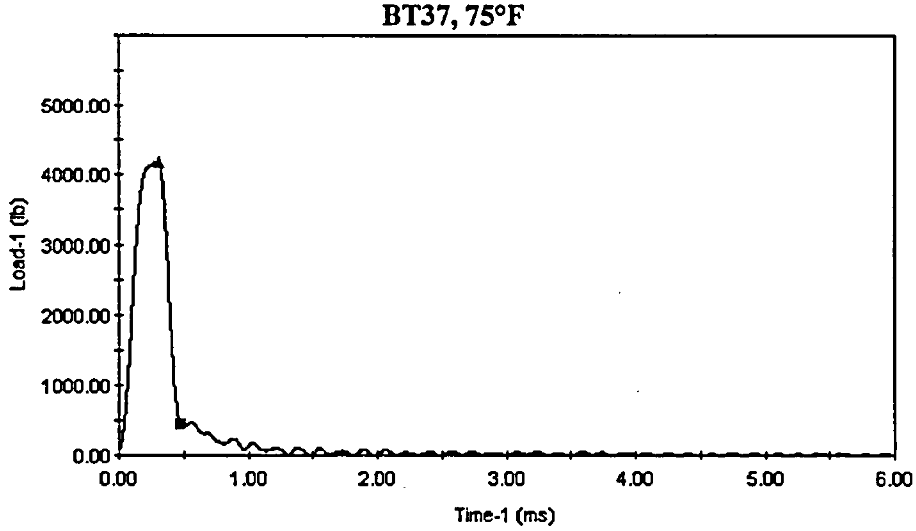
BT42, 25°F



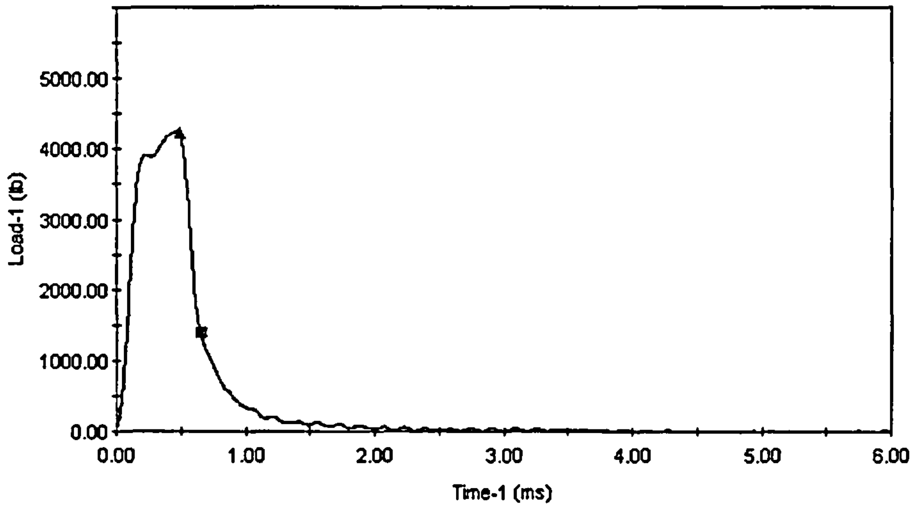
BT43, 50°F



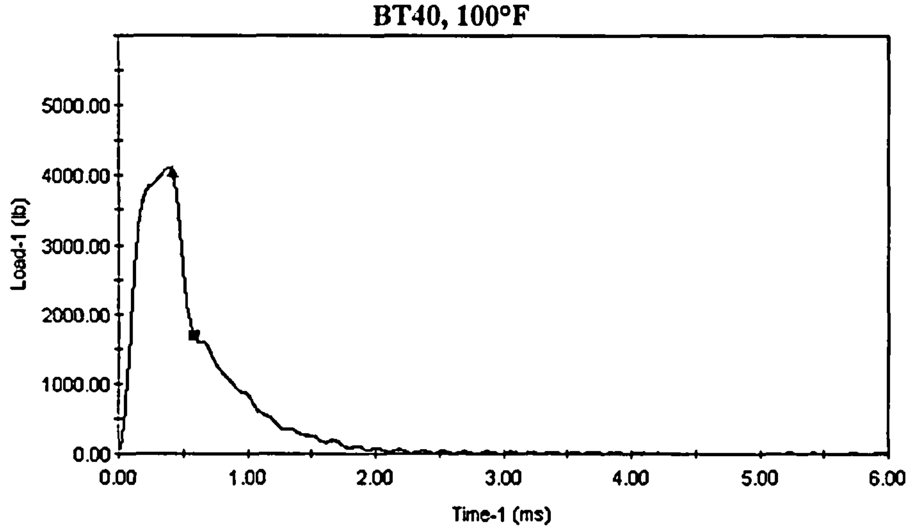
BT37, 75°F



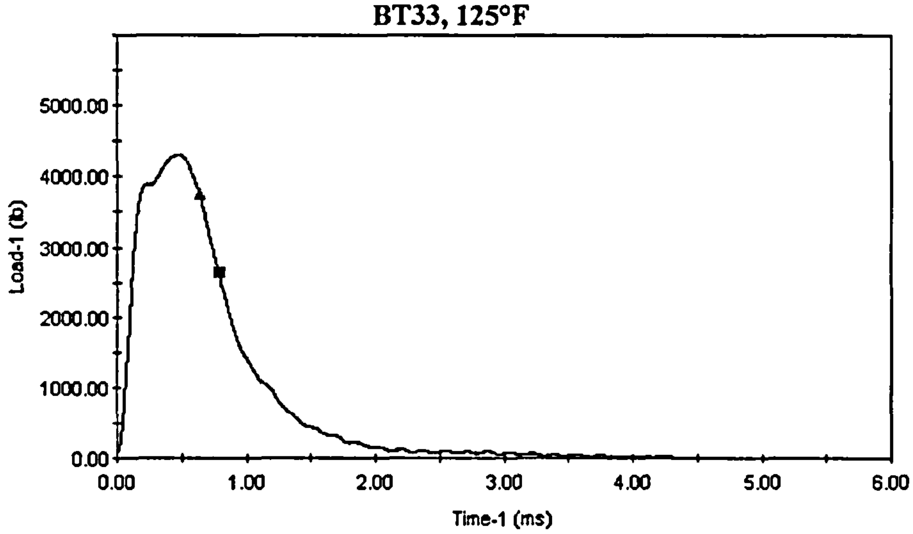
BT36, 75°F



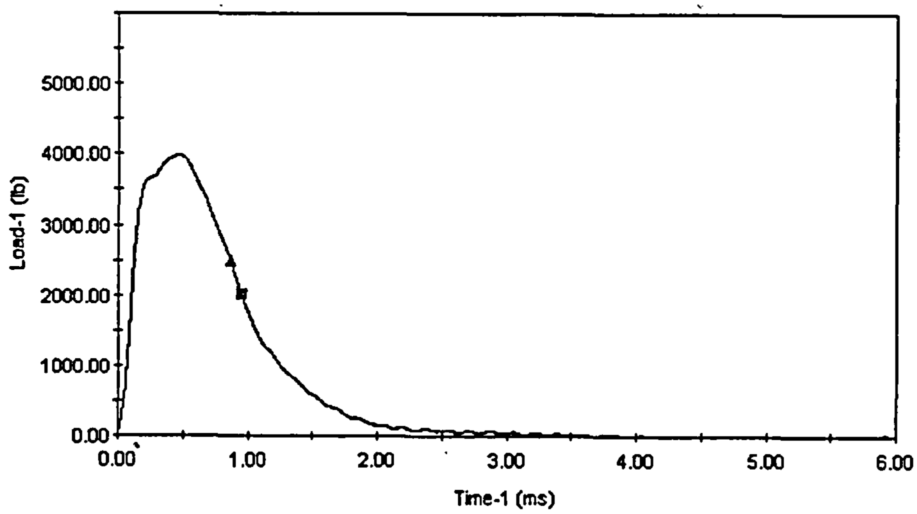
BT40, 100°F



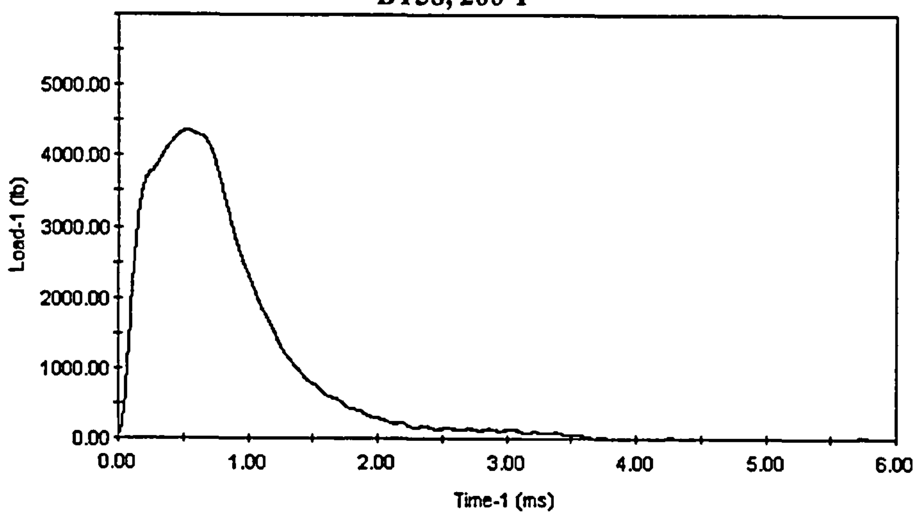
BT33, 125°F



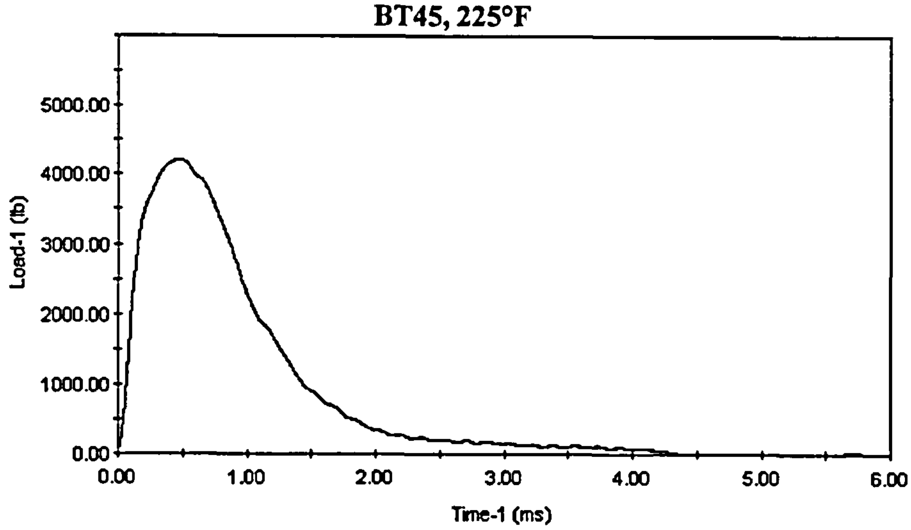
BT39, 150°F



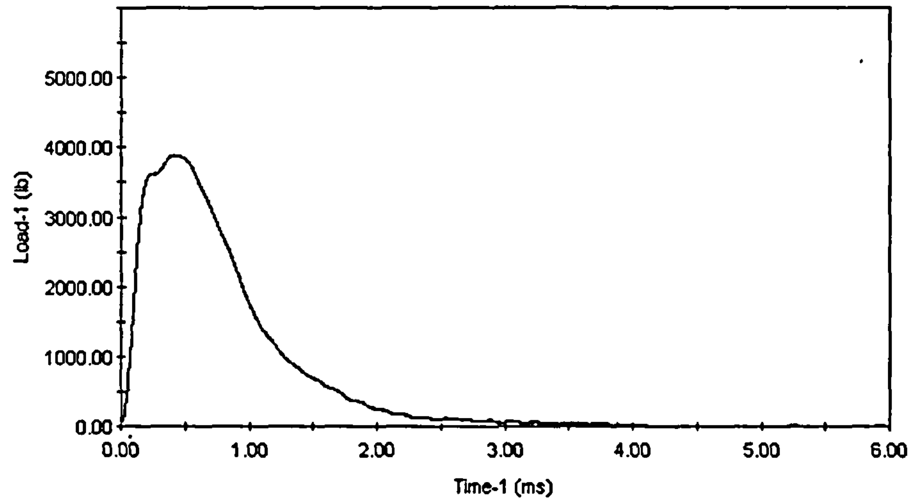
BT38, 200°F



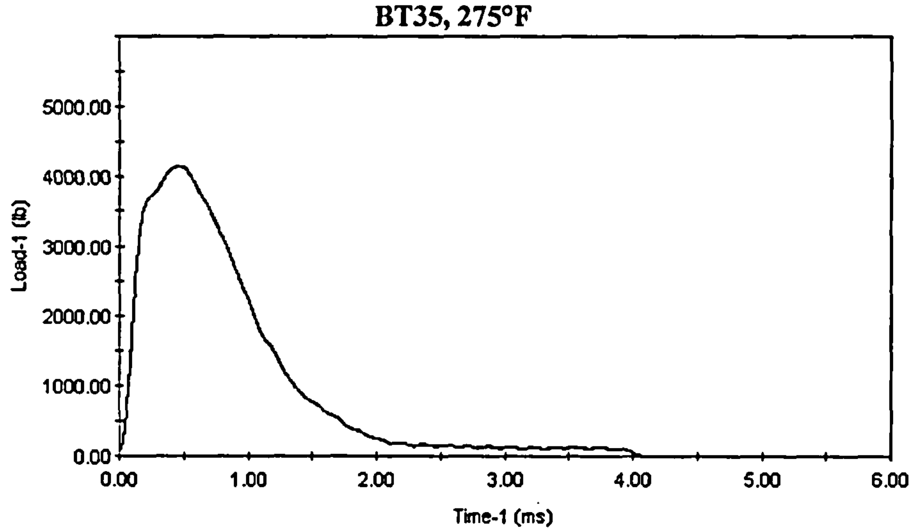
BT45, 225°F



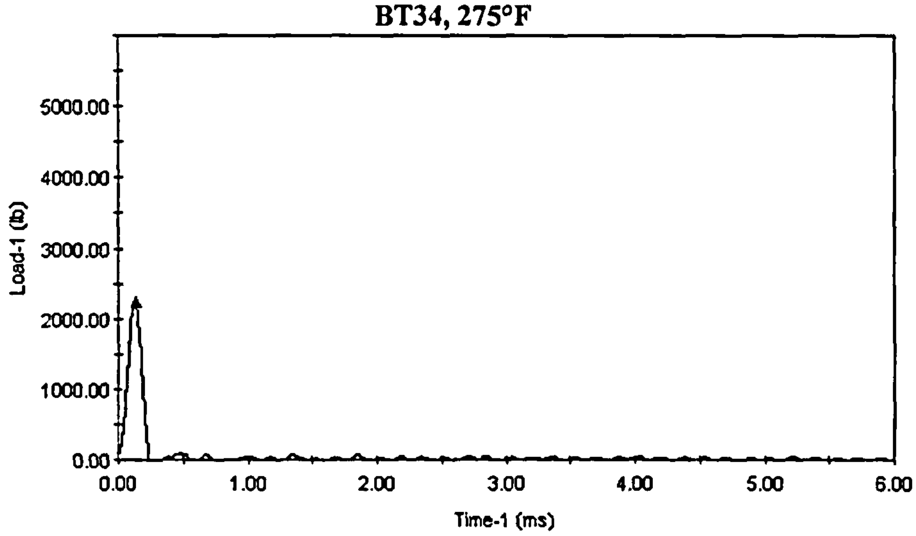
BT31, 250°F



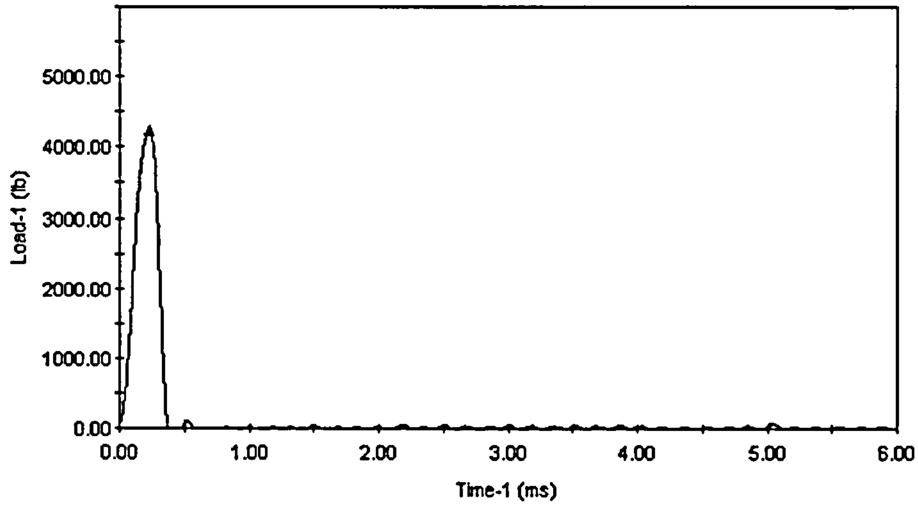
BT35, 275°F



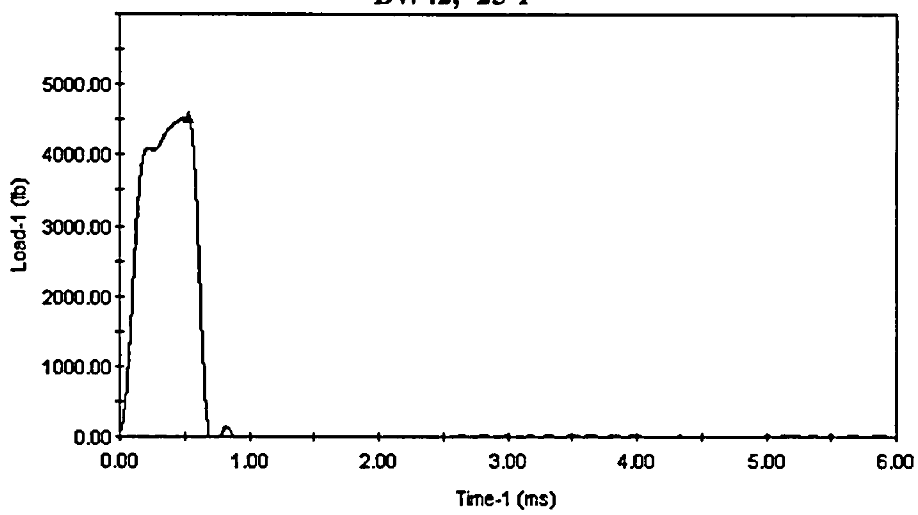
BT34, 275°F



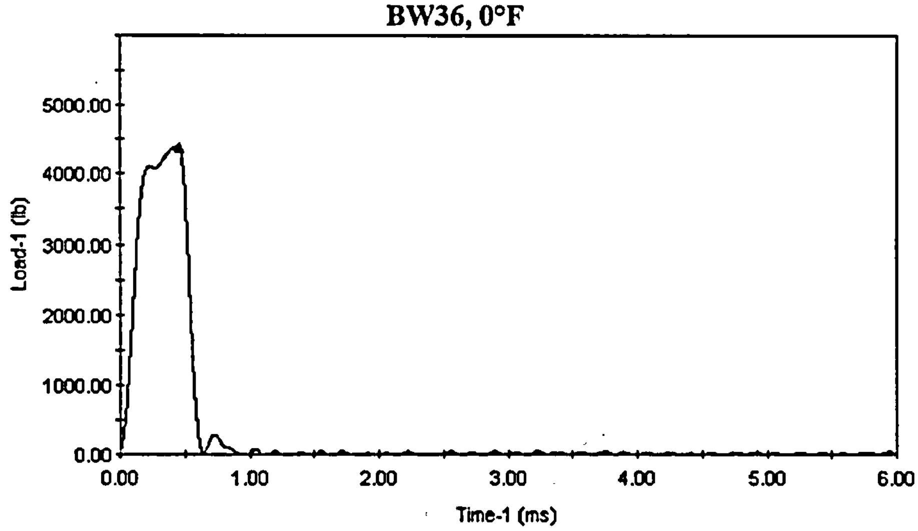
BW33, -50°F



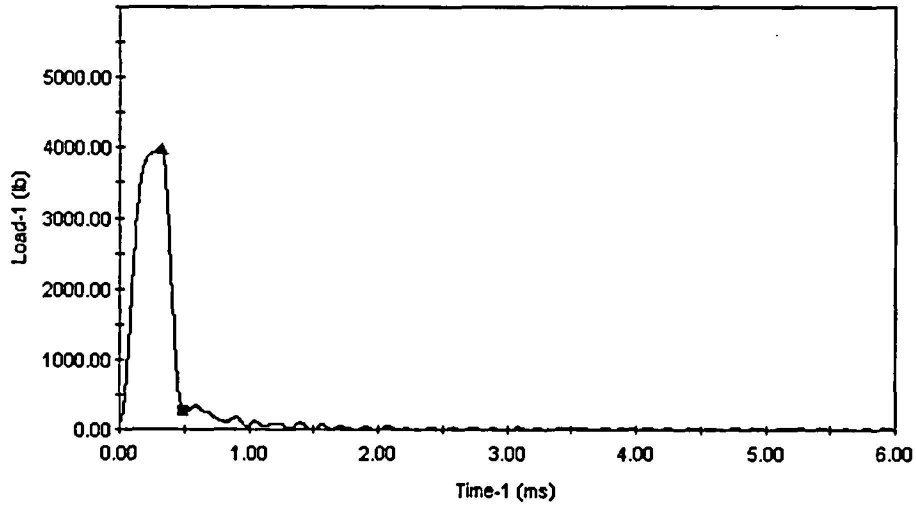
BW42, -25°F



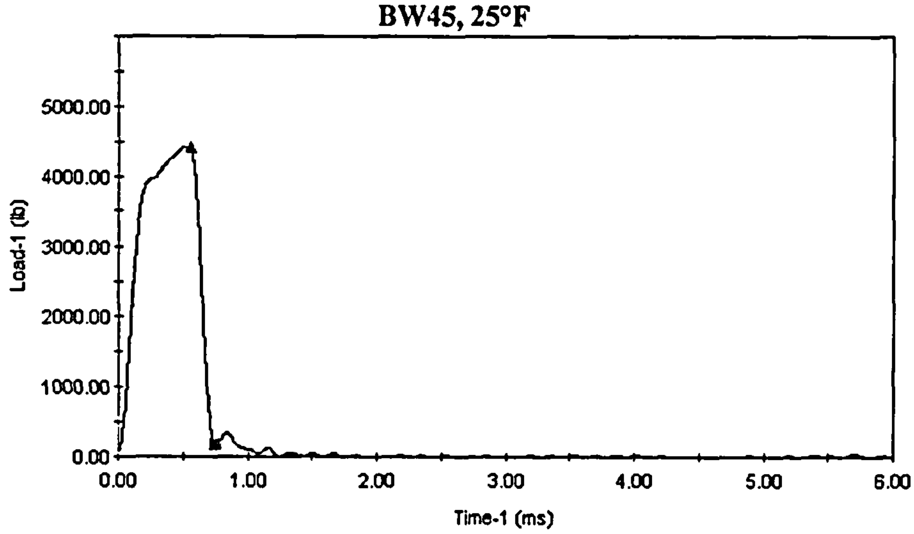
BW36, 0°F



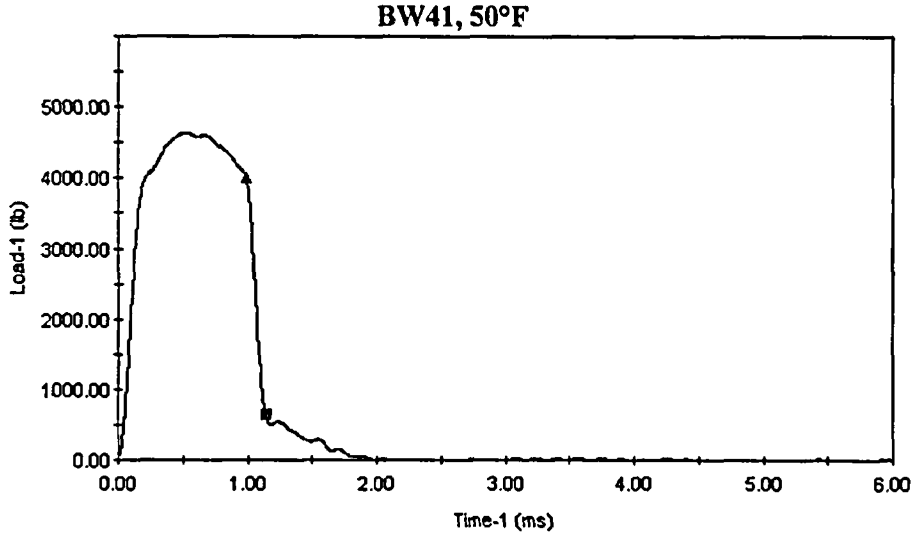
BW35, 0°F



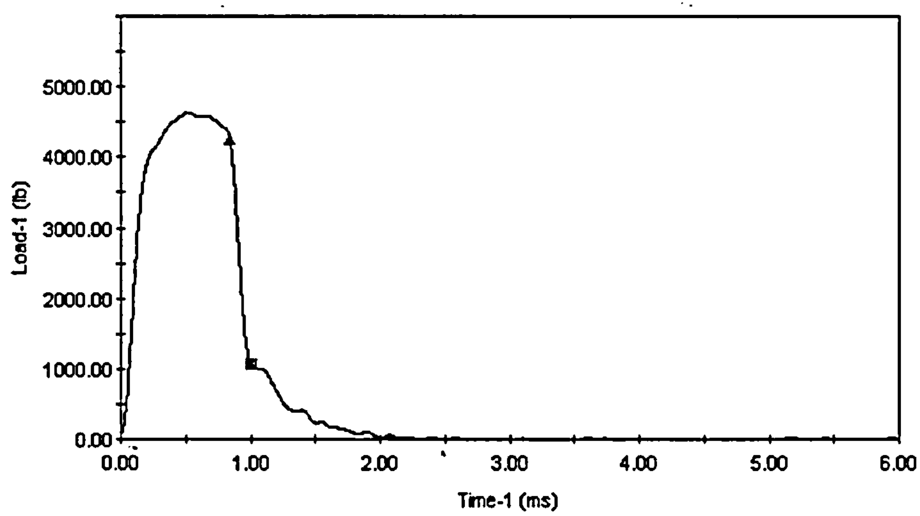
BW45, 25°F



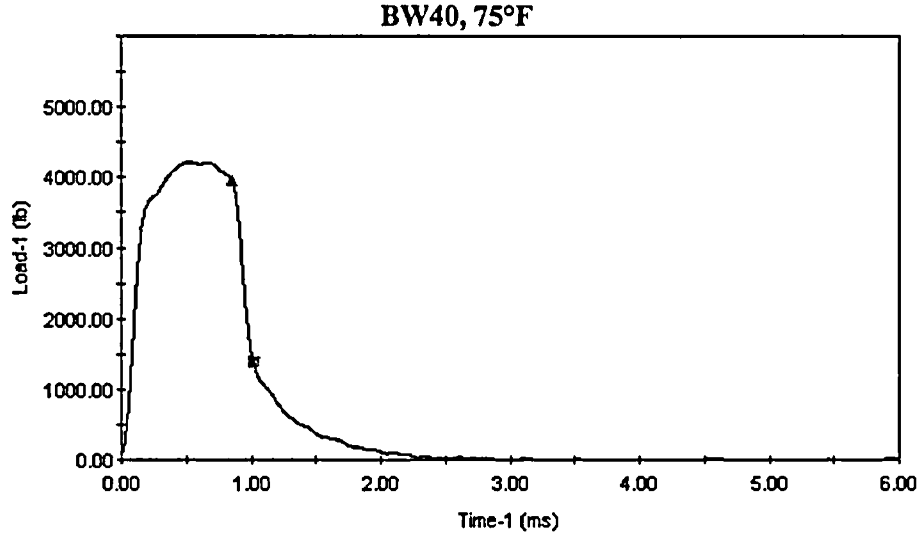
BW41, 50°F



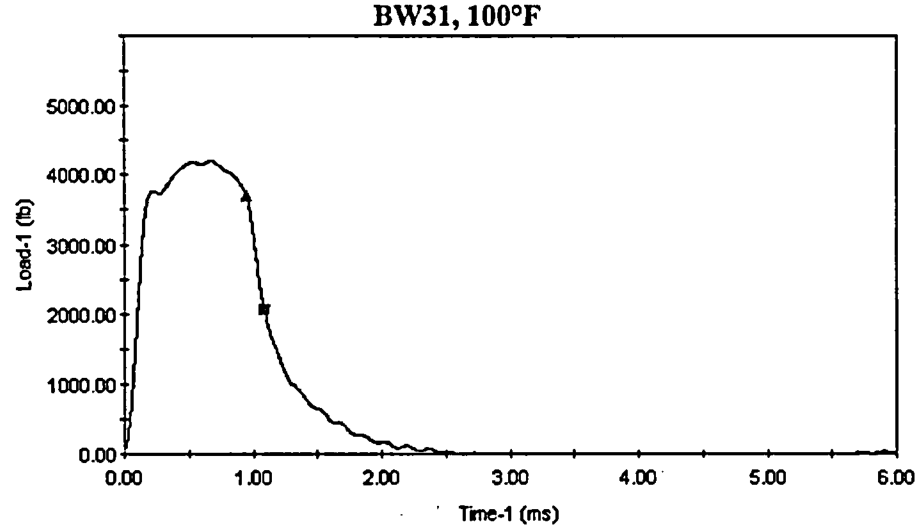
BW37, 75°F



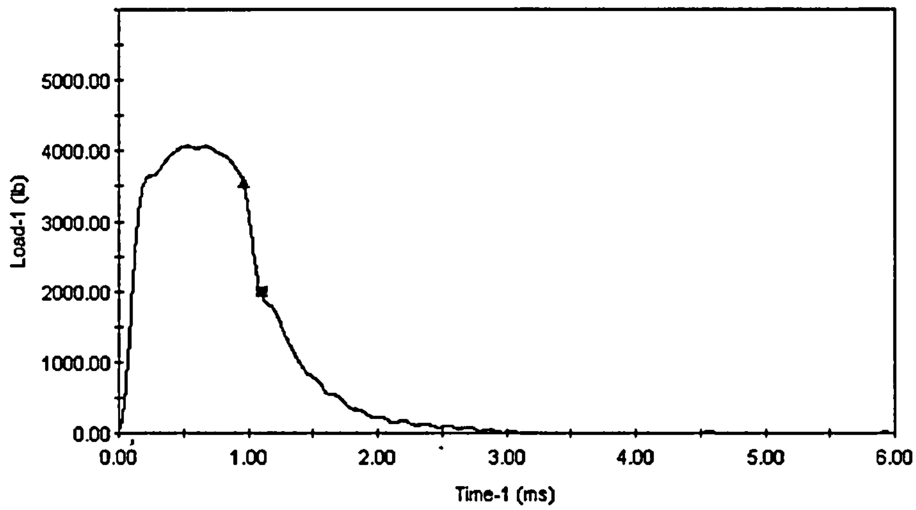
BW40, 75°F



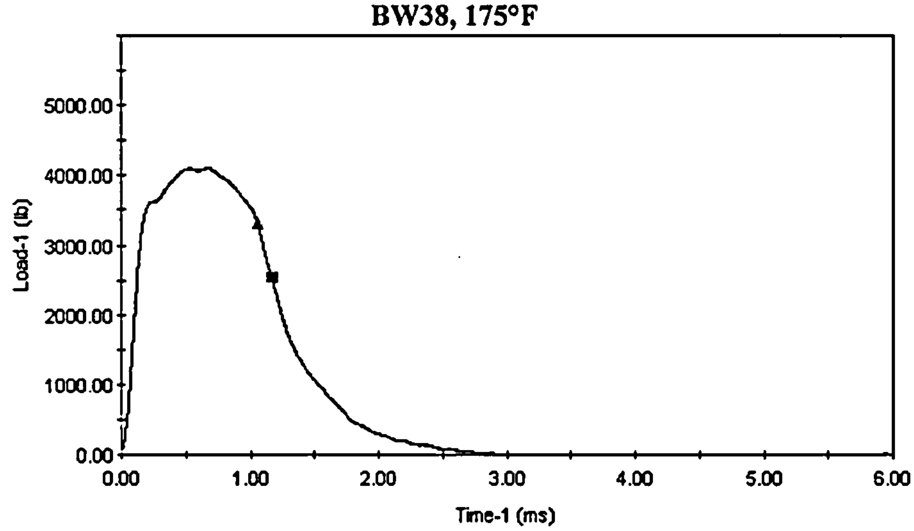
BW31, 100°F



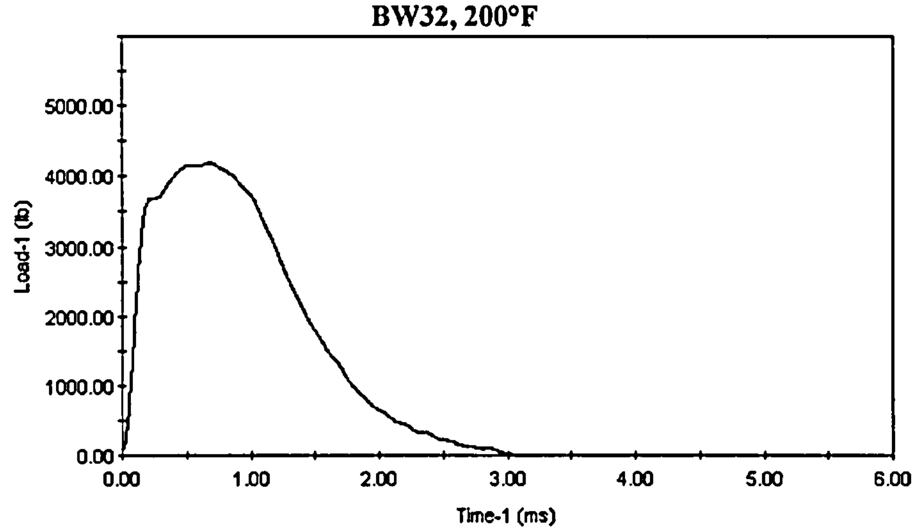
BW34, 140°F



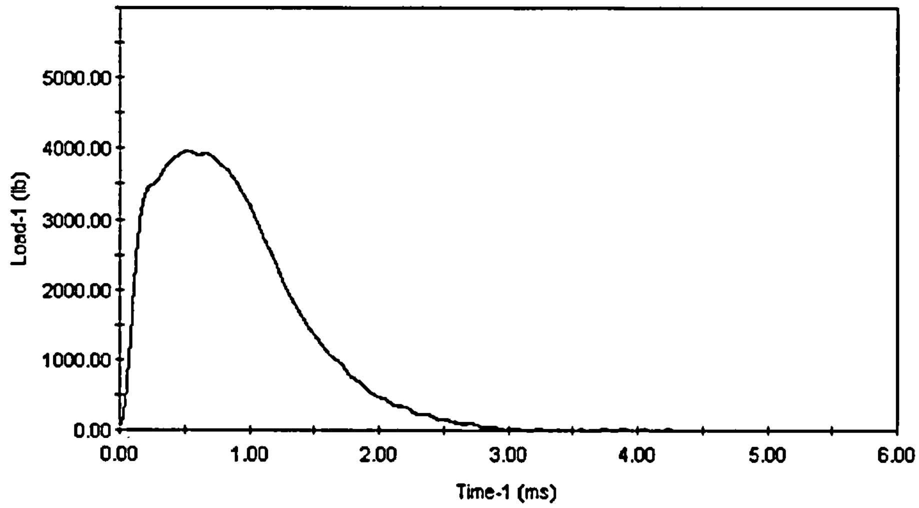
BW38, 175°F



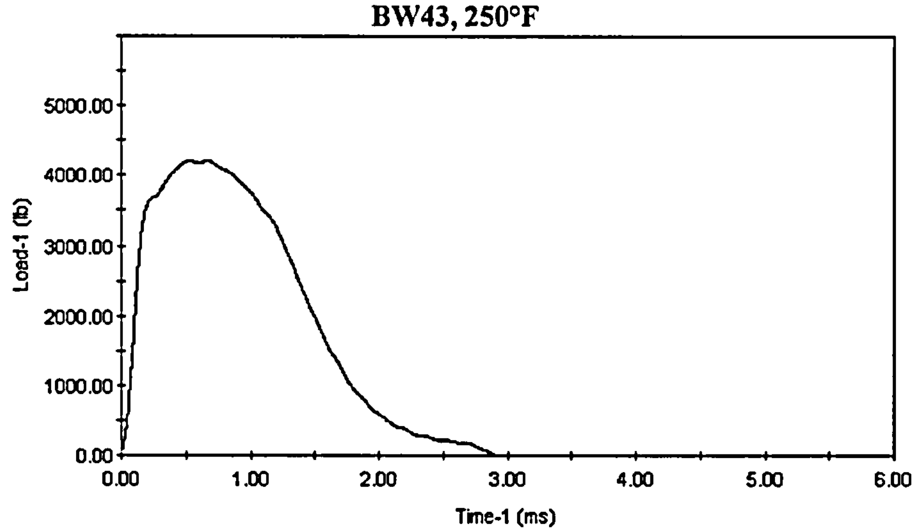
BW32, 200°F



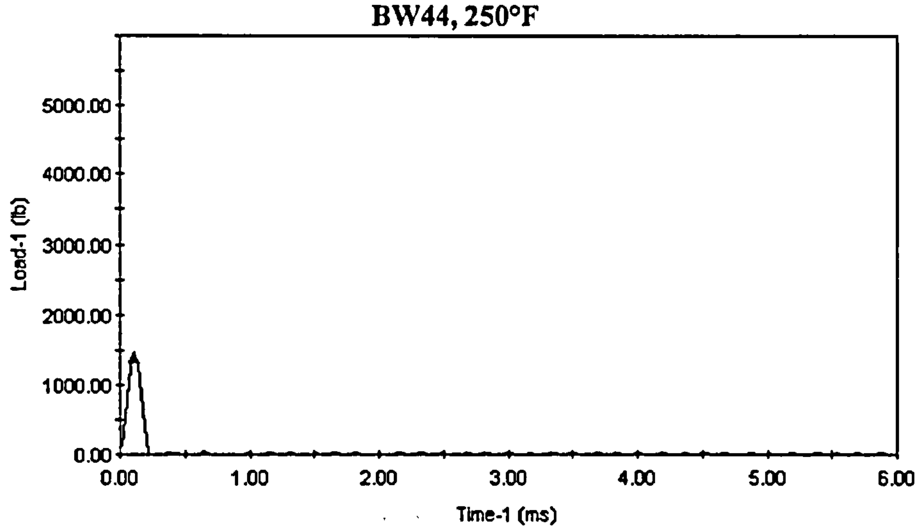
BW39, 225°F



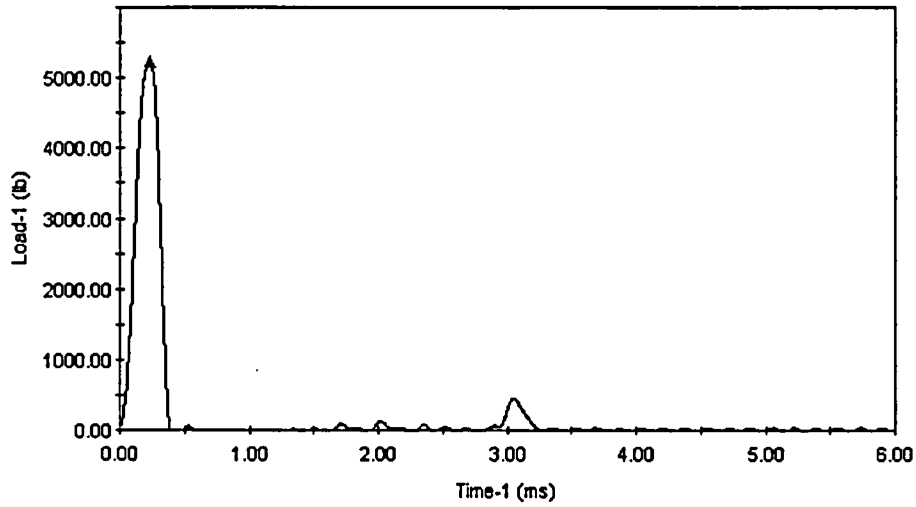
BW43, 250°F



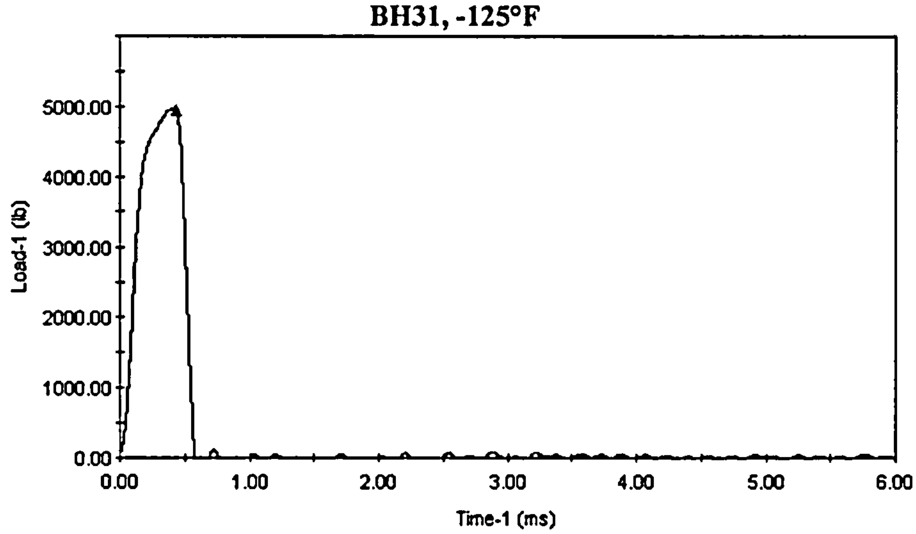
BW44, 250°F



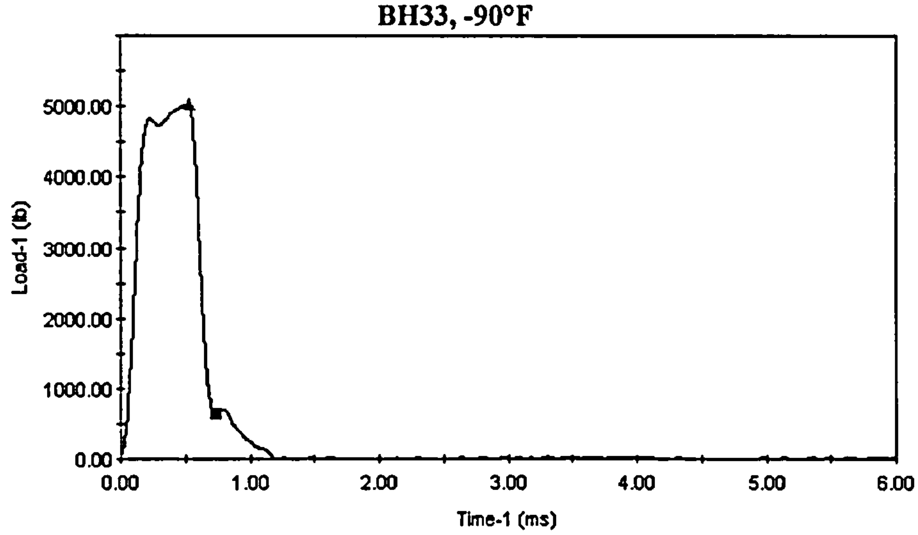
BH44, -175°F



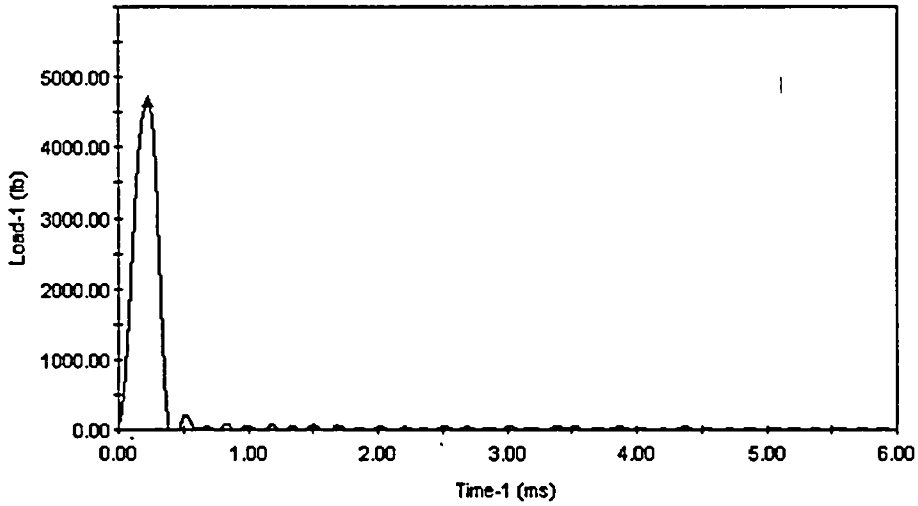
BH31, -125°F



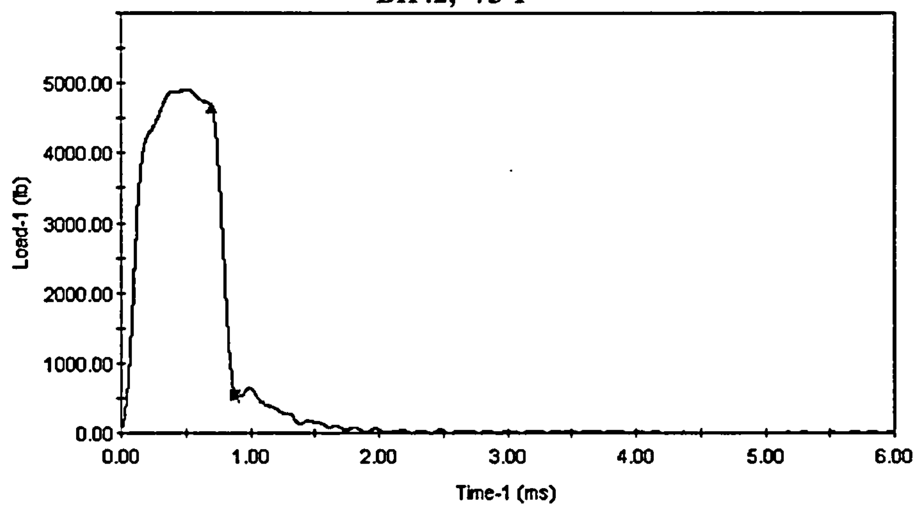
BH33, -90°F



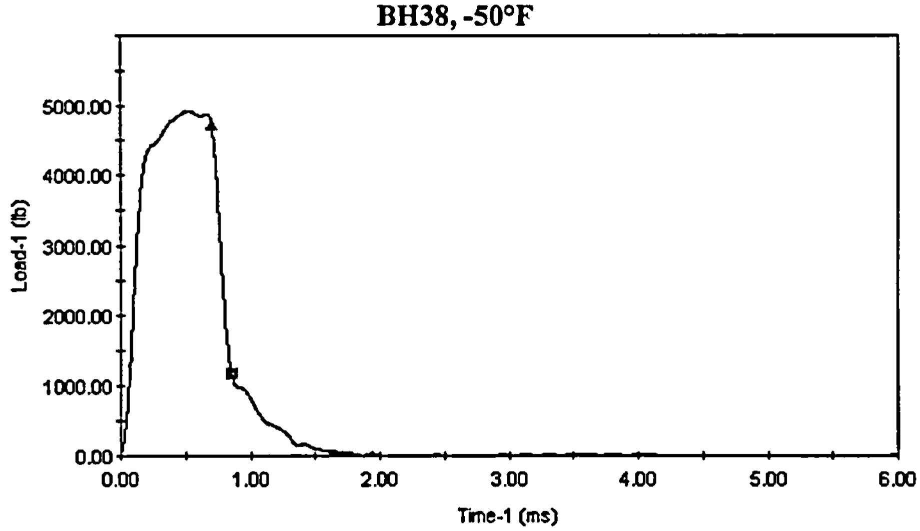
BH43, -75°F



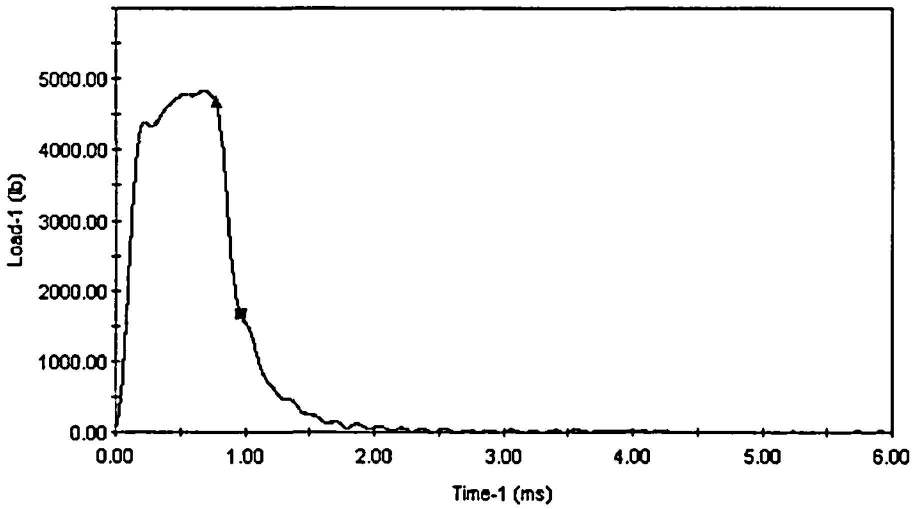
BH42, -75°F



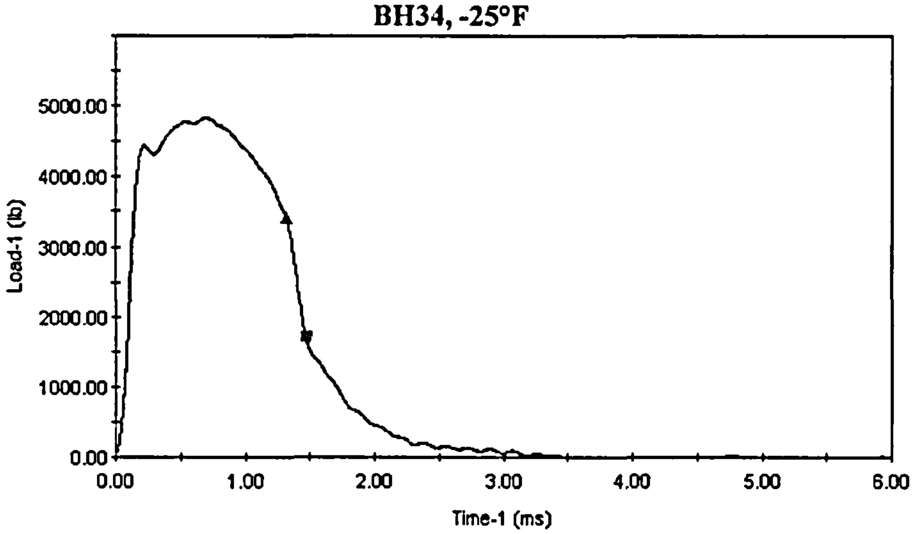
BH38, -50°F



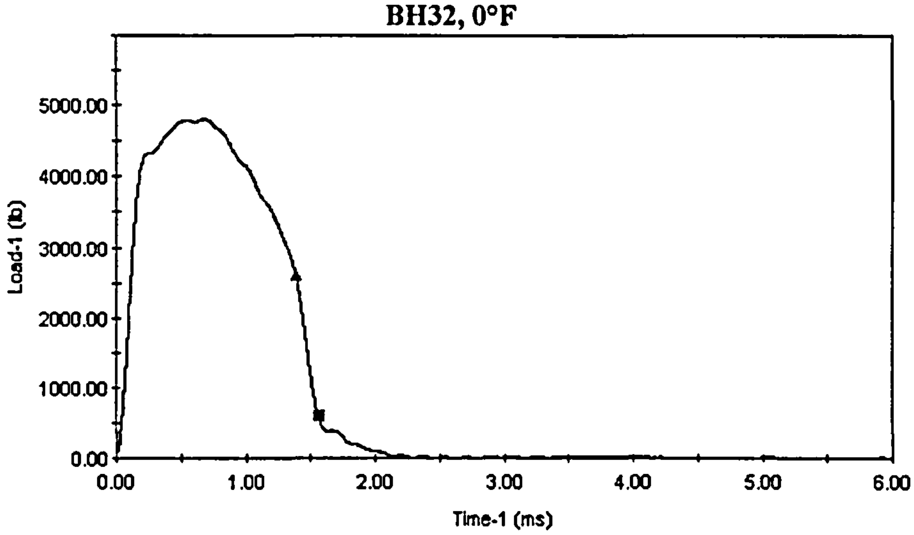
BH37, -50°F



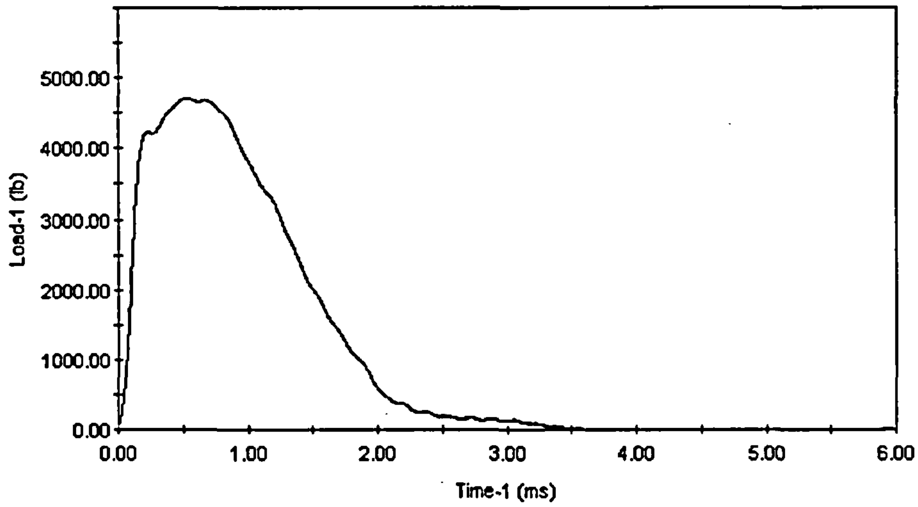
BH34, -25°F



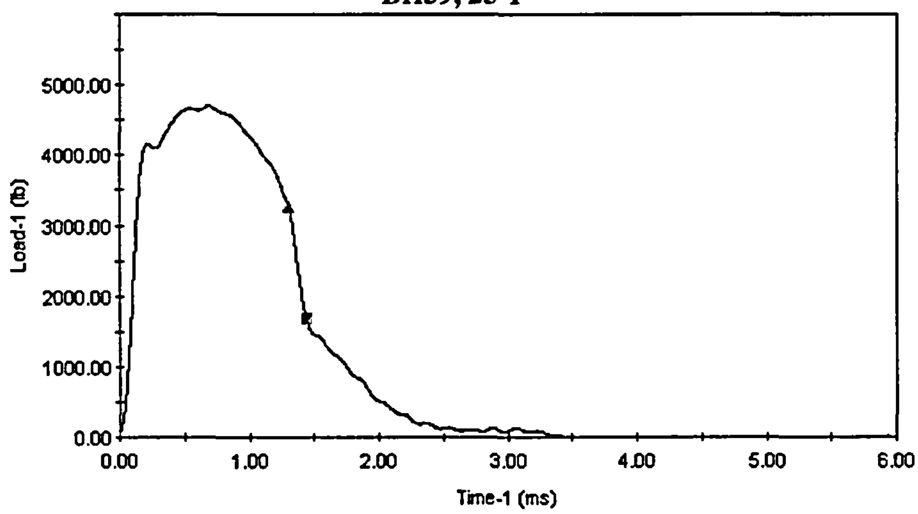
BH32, 0°F



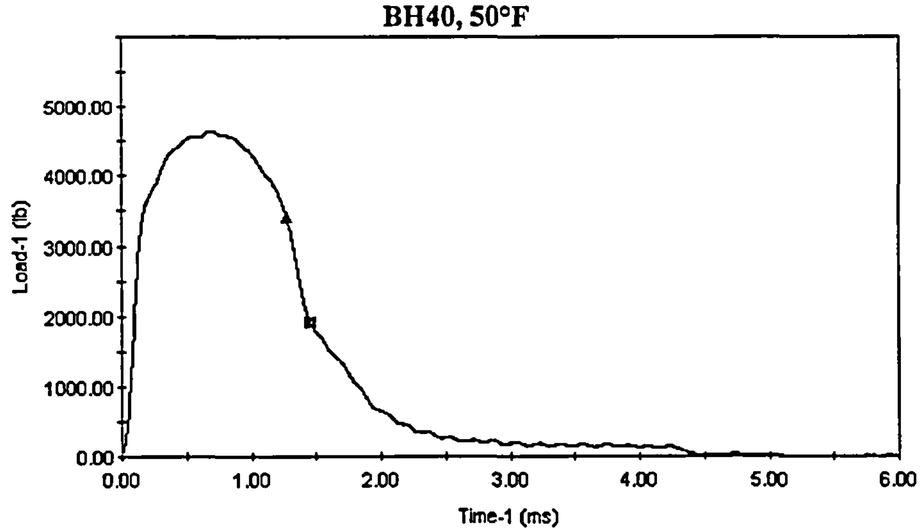
BH41, 0°F



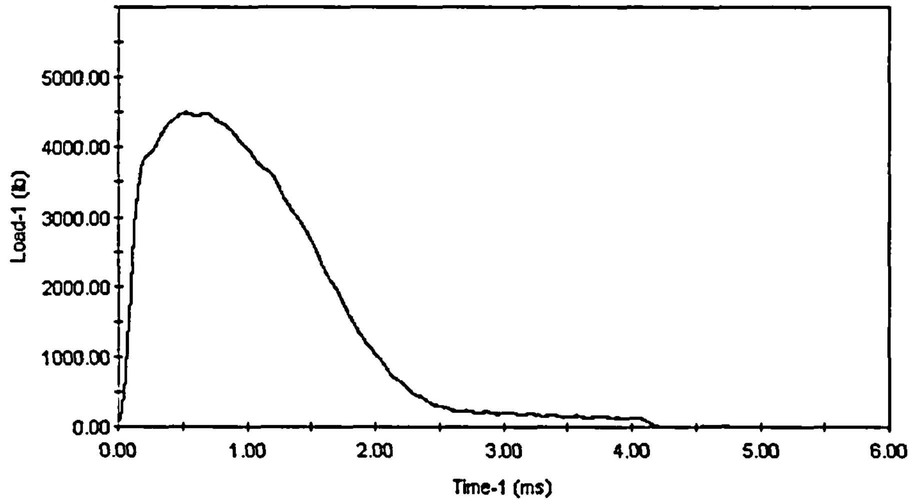
BH39, 25°F



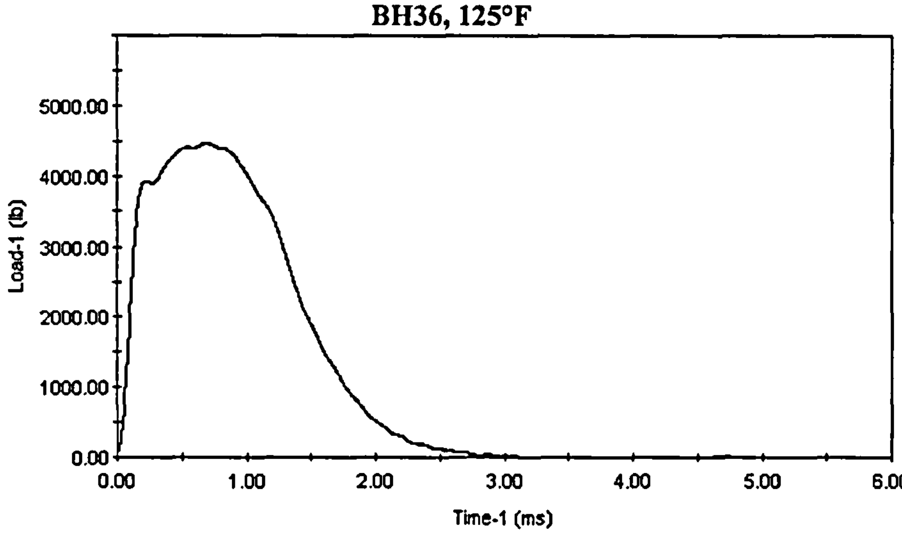
BH40, 50°F



BH45, 75°F



BH36, 125°F



BH35, 150°F

APPENDIX C

CHARPY V-NOTCH PLOTS FOR EACH CAPSULE USING HYPERBOLIC TANGENT CURVE-FITTING METHOD

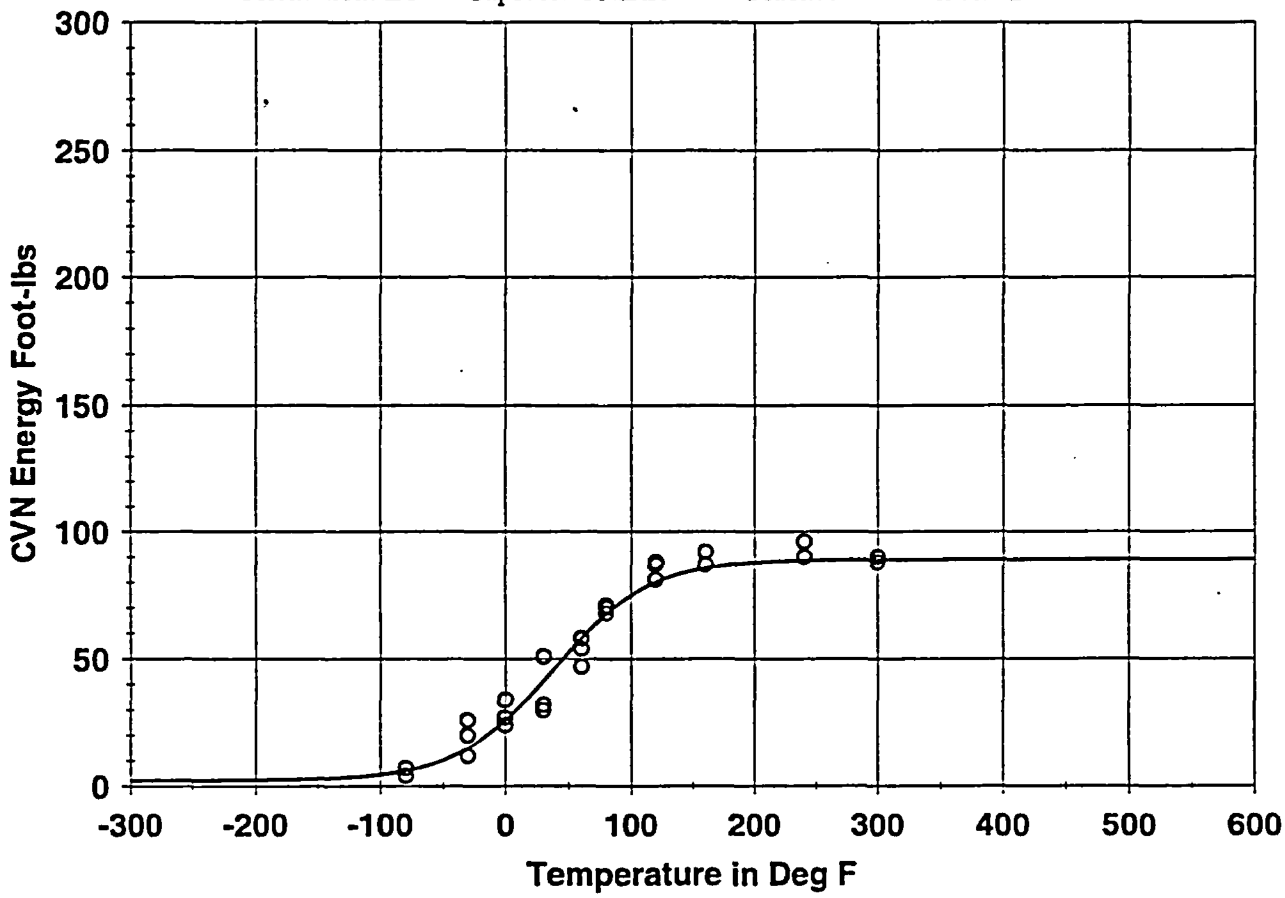
Contained in Table C-1 are the upper shelf energy values used as input for the generation of the Charpy V-notch plots using CVGRAPH, Version 4.1. Lower shelf energy values were fixed at 2.2 ft-lb. The unirradiated and irradiated upper shelf energy values were calculated per the ASTM El 85-82 definition of upper shelf energy.

Table C-1 Upper Shelf Energy Values Fixed in CVGRAPH

Material	Unirradiated	Capsule U	Capsule Y	Capsule X	Capsule W
Lower Shell Plate B8628-1 (Longitudinal Orientation)	89 ft-lb	99 ft-lb	100 ft-lb	86 ft-lb	84 ft-lb
Lower Shell Plate B8628-1 (Transverse Orientation)	70 ft-lb	79 ft-lb	73 ft-lb	65 ft-lb	69 ft-lb
Weld Metal (Heat # 87005)	92 ft-lb	98 ft-lb	86 ft-lb	87 ft-lb	87 ft-lb
HAZ Material	106 ft-lb	122 ft-lb	114 ft-lb	99 ft-lb	100 ft-lb

UNIRRADIATED LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:12 AM
Page 1
Coefficients of Curve 1
A = 45.6 B = 43.4 C = 76.43 T0 = 37.56 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf Energy=89.0(Fixed) Lower Shelf Energy=2.2(Fixed)
Temp@30 ft-lbs=8.8 Deg F Temp@50 ft-lbs=45.4 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-80.00	4.00	6.03	-2.03
-80.00	7.00	6.03	.97
-30.00	12.00	14.86	-2.86
-30.00	20.00	14.86	5.14
-30.00	26.00	14.86	11.14
.00	24.00	25.84	-1.84
.00	27.00	25.84	1.16
.00	34.00	25.84	8.16
30.00	30.00	41.32	-11.32

UNIRRADIATED LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
30.00	32.00	41.32	-9.32
30.00	51.00	41.32	9.68
60.00	47.00	57.99	-10.99
60.00	54.00	57.99	-3.99
60.00	58.00	57.99	.01
80.00	68.00	67.49	.51
80.00	71.00	67.49	3.51
80.00	70.00	67.49	2.51
120.00	81.00	80.00	1.00
120.00	87.00	80.00	7.00
120.00	88.00	80.00	8.00
160.00	87.00	85.61	1.39
160.00	92.00	85.61	6.39
240.00	90.00	88.57	1.43
240.00	90.00	88.57	1.43
240.00	96.00	88.57	7.43
300.00	88.00	88.91	-.91
300.00	90.00	88.91	1.09

Correlation Coefficient = .982

UNIRRADIATED LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 02:29 PM

Page 1

Coefficients of Curve 1

A = 37.97 B = 37.97 C = 82.49 T0 = 42.82 D = 0.00E+00

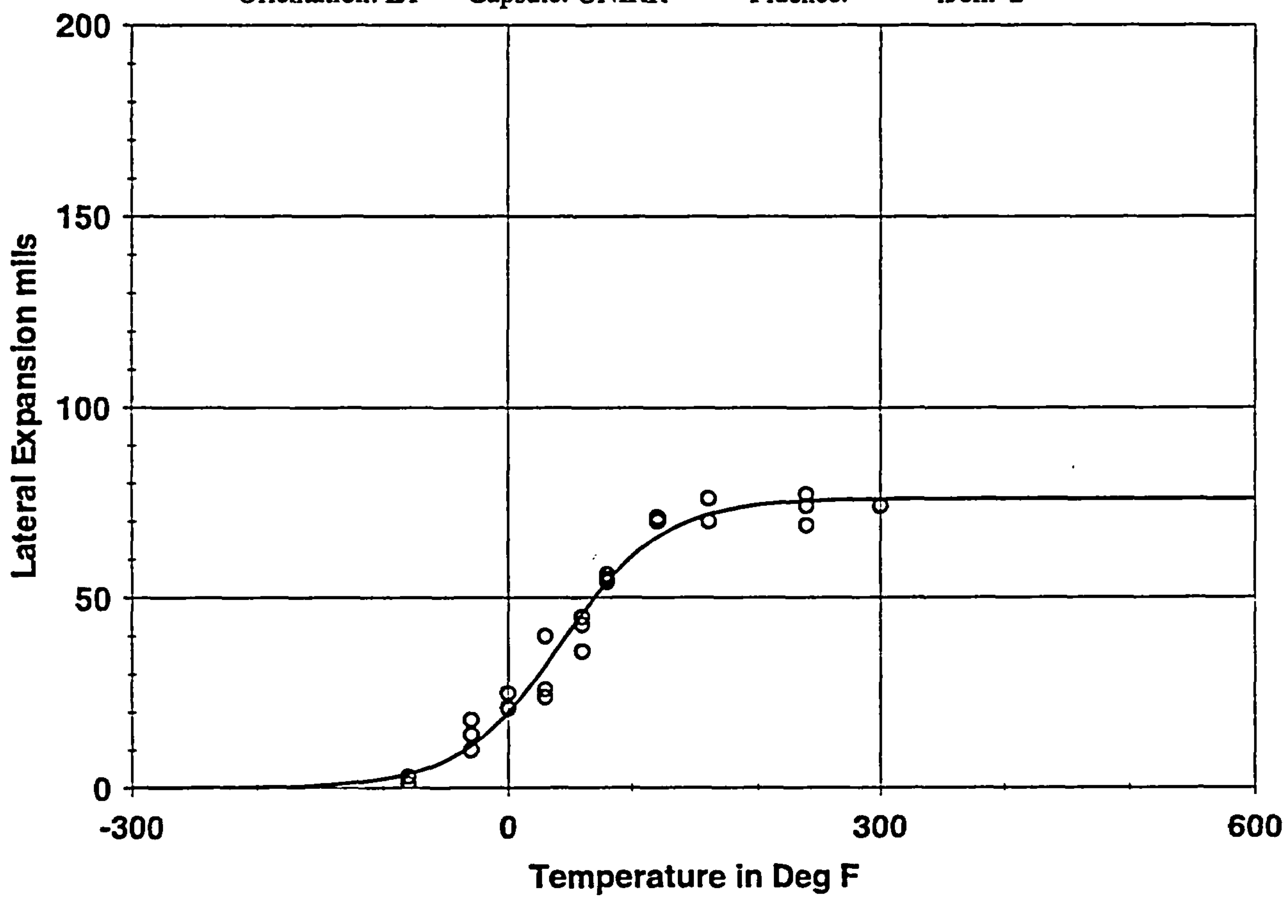
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=75.9 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=36.4 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-80.00	1.00	3.68	-2.68
-80.00	3.00	3.68	-.68
-30.00	10.00	11.10	-1.10
-30.00	14.00	11.10	2.90
-30.00	18.00	11.10	6.90
.00	21.00	19.86	1.14
.00	21.00	19.86	1.14
.00	25.00	19.86	5.14
30.00	24.00	32.12	-8.12

UNIRRADIATED LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: UNIRR Fluence: n/cm^2

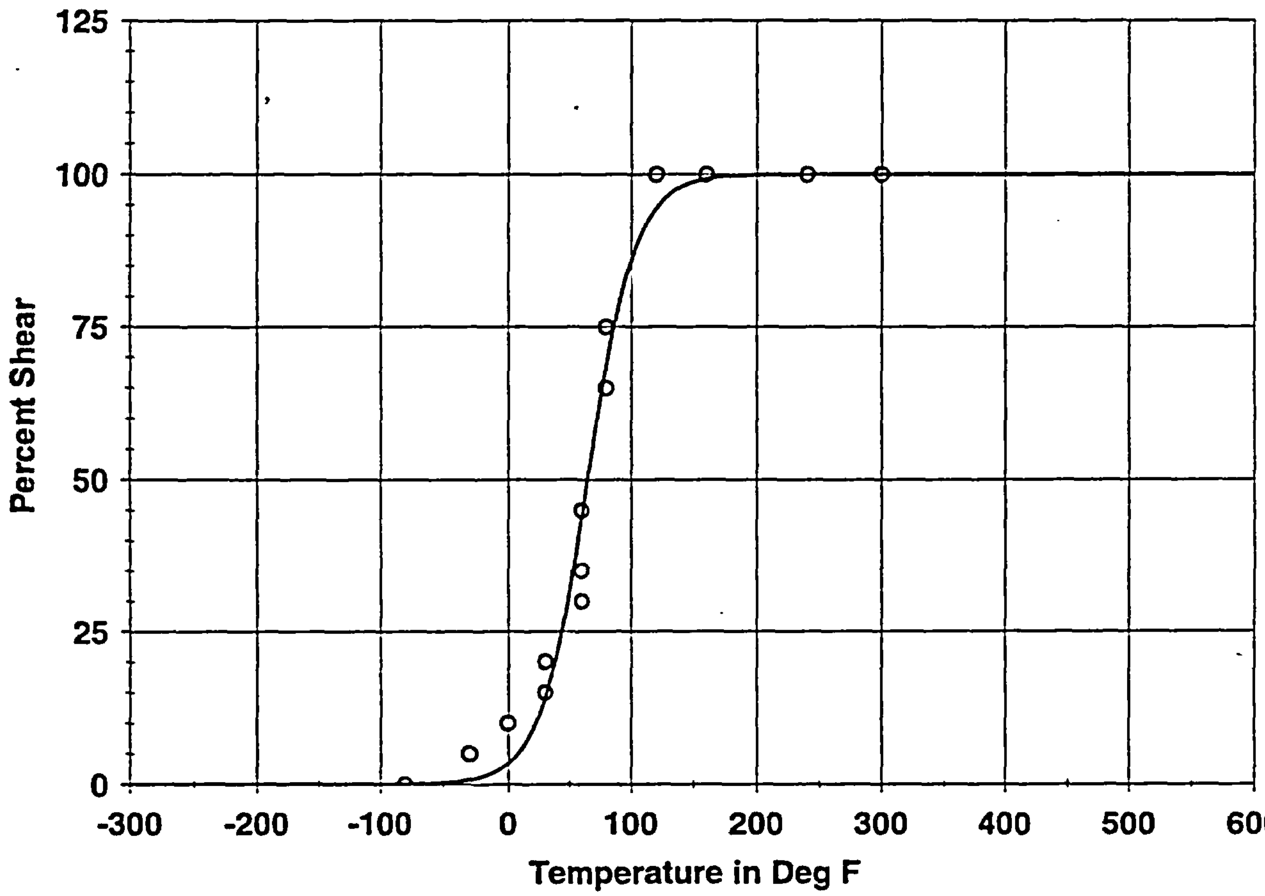
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
30.00	26.00	32.12	-6.12
30.00	40.00	32.12	7.88
60.00	36.00	45.77	-9.77
60.00	43.00	45.77	-2.77
60.00	45.00	45.77	-.77
80.00	56.00	54.01	1.99
80.00	54.00	54.01	-.01
80.00	55.00	54.01	.99
120.00	71.00	65.81	5.19
120.00	70.00	65.81	4.19
120.00	71.00	65.81	5.19
160.00	70.00	71.75	-1.75
160.00	76.00	71.75	4.25
240.00	77.00	75.31	1.69
240.00	74.00	75.31	-1.31
240.00	69.00	75.31	-6.31
300.00	74.00	75.79	-1.79
300.00	74.00	75.79	-1.79

Correlation Coefficient = .985

UNIRRADIATED LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:35 AM
Page 1
Coefficients of Curve 1
A = 50. B = 50. C = 38.73 T0 = 64.93 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 65.0
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-80.00	.00	.06	-.06
-80.00	.00	.06	-.06
-30.00	5.00	.74	4.26
-30.00	5.00	.74	4.26
-30.00	5.00	.74	4.26
.00	10.00	3.38	6.62
.00	10.00	3.38	6.62
.00	10.00	3.38	6.62
30.00	20.00	14.14	5.86

UNIRRADIATED LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
30.00	20.00	14.14	5.86
30.00	15.00	14.14	.86
60.00	30.00	43.67	-13.67
60.00	35.00	43.67	-8.67
60.00	45.00	43.67	1.33
80.00	75.00	68.53	6.47
80.00	75.00	68.53	6.47
80.00	65.00	68.53	-3.53
120.00	100.00	94.50	5.50
120.00	100.00	94.50	5.50
120.00	100.00	94.50	5.50
160.00	100.00	99.27	.73
160.00	100.00	99.27	.73
240.00	100.00	99.99	.01
240.00	100.00	99.99	.01
240.00	100.00	99.99	.01
300.00	100.00	100.00	.00
300.00	100.00	100.00	.00

Correlation Coefficient = .994

CAPSULE U LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:13 AM

Page 1

Coefficients of Curve 2

A = 50.6 B = 48.4 C = 99.74 T0 = 56.04 D = 0.00E+00

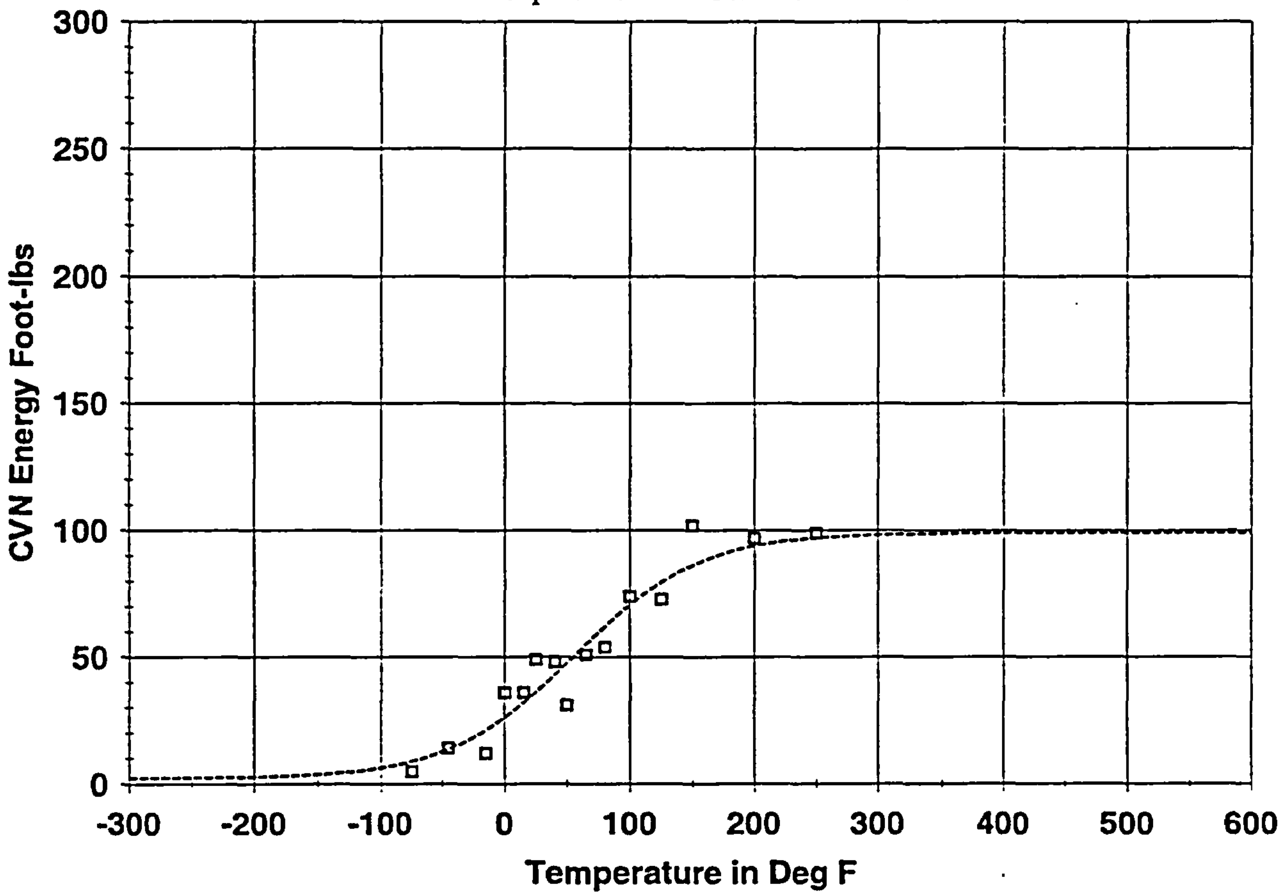
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=99.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=10.8 Deg F Temp@50 ft-lbs=54.9 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	5.00	8.72	-3.72
-45.00	14.00	13.48	.52
-15.00	12.00	20.98	-8.98
.00	36.00	25.95	10.05
15.00	36.00	31.74	4.26
25.00	49.00	36.01	12.99
40.00	48.00	42.88	5.12
50.00	31.00	47.67	-16.67
65.00	51.00	54.94	-3.94

CAPSULE U LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
80.00	54.00	62.01	-8.01
100.00	74.00	70.65	3.35
125.00	73.00	79.58	-6.58
150.00	102.00	86.23	15.77
200.00	97.00	93.89	3.11
250.00	99.00	97.06	1.94

Correlation Coefficient = .961

CAPSULE U LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 02:29 PM

Page 1

Coefficients of Curve 2

A = 35.31 B = 35.31 C = 108.65 T0 = 46.71 D = 0.00E+00

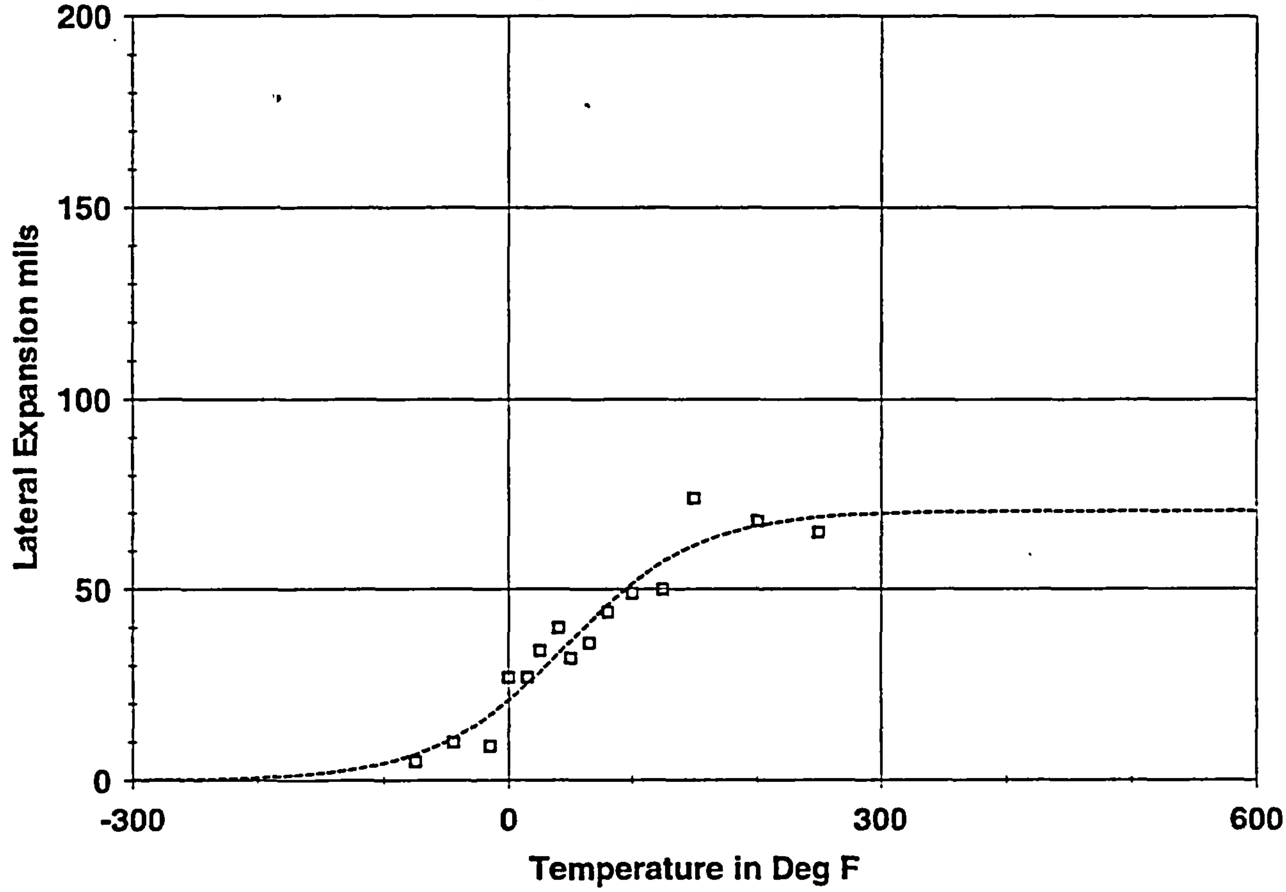
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=70.6 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=45.8 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	5.00	6.79	-1.79
-45.00	10.00	11.02	-1.02
-15.00	9.00	17.16	-8.16
.00	27.00	21.00	6.00
15.00	27.00	25.28	1.72
25.00	34.00	28.34	5.66
40.00	40.00	33.13	6.87
50.00	32.00	36.37	-4.37
65.00	36.00	41.19	-5.19

CAPSULE U LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
80.00	44.00	45.80	-1.80
100.00	49.00	51.36	-2.36
125.00	50.00	57.10	-7.10
150.00	74.00	61.44	12.56
200.00	68.00	66.65	1.35
250.00	65.00	68.98	-3.98

Correlation Coefficient = .962

CAPSULE U LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:35 AM

Page 1

Coefficients of Curve 2

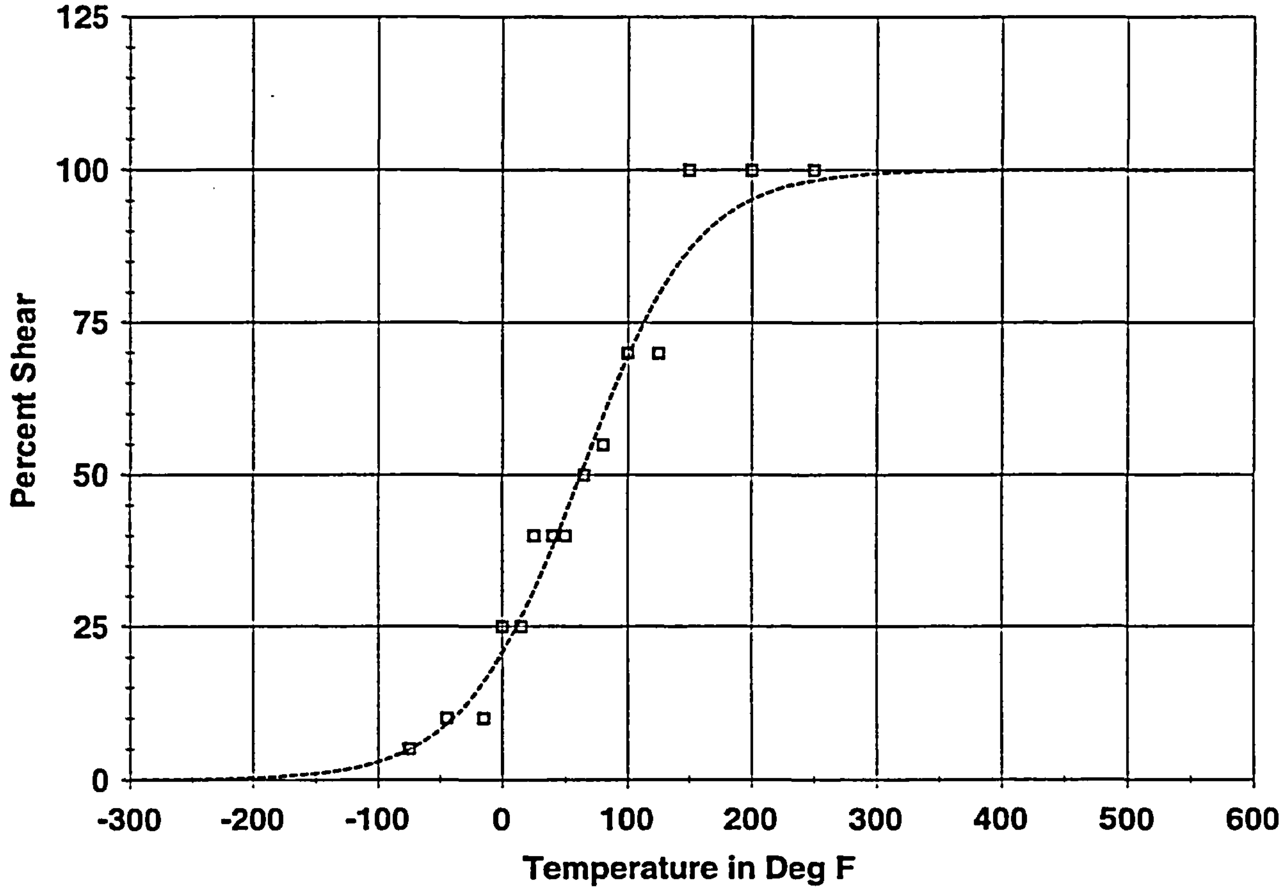
A = 50. B = 50. C = 92.4 T0 = 62.1 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 62.2

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	5.00	4.89	.11
-45.00	10.00	8.96	1.04
-15.00	10.00	15.86	-5.86
.00	25.00	20.68	4.32
15.00	25.00	26.51	-1.51
25.00	40.00	30.94	9.06
40.00	40.00	38.26	1.74
50.00	40.00	43.49	-3.49
65.00	50.00	51.57	-1.57

CAPSULE U LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
80.00	55.00	59.56	-4.56
100.00	70.00	69.43	.57
125.00	70.00	79.60	-9.60
150.00	100.00	87.02	12.98
200.00	100.00	95.19	4.81
250.00	100.00	98.32	1.68

Correlation Coefficient = .985

CAPSULE Y LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:13 AM

Page 1

Coefficients of Curve 3

A = 51.1 B = 48.9 C = 81.88 T0 = 52.33 D = 0.00E+00

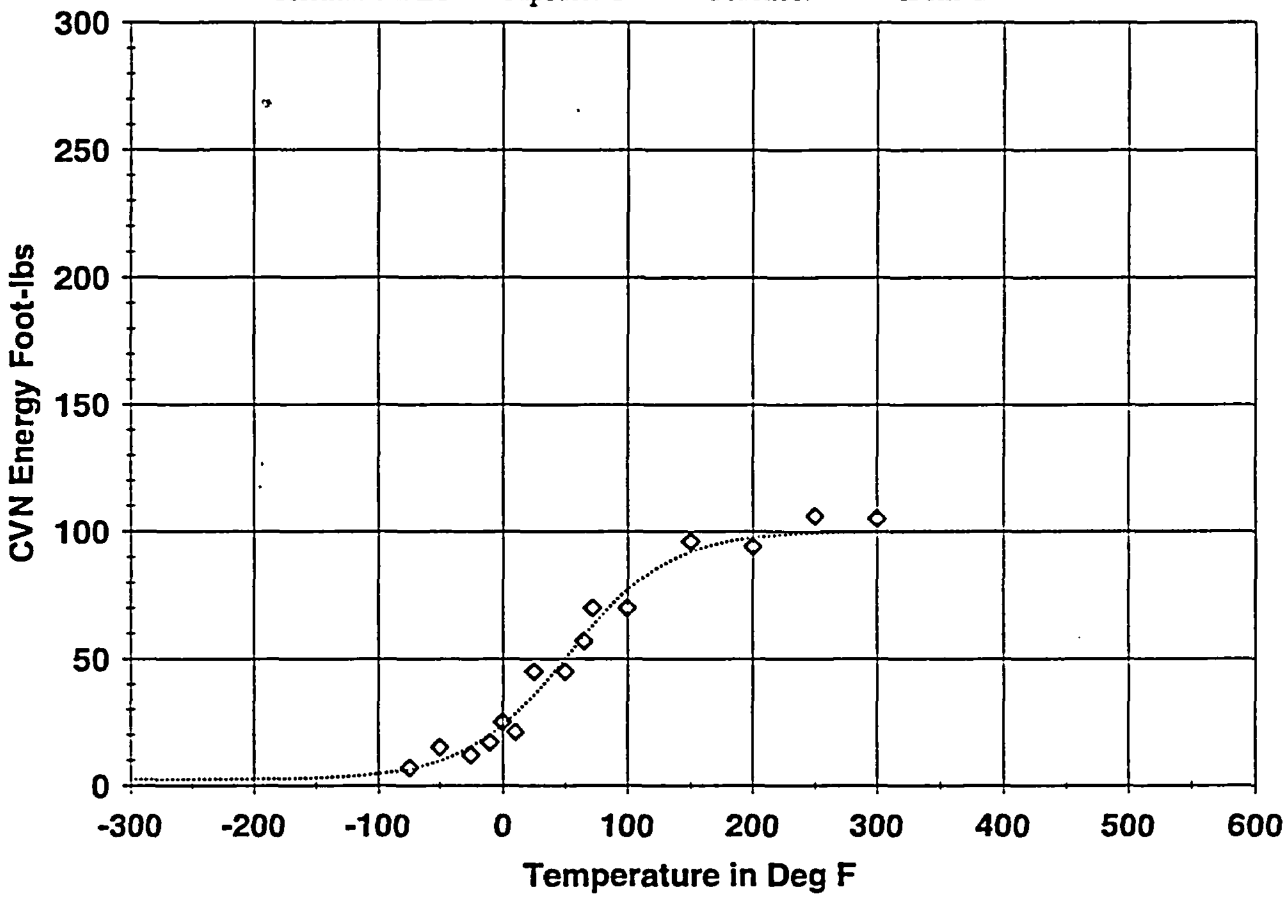
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=100.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=14.6 Deg F Temp@50 ft-lbs=50.5 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	7.00	6.37	.63
-50.00	15.00	9.62	5.38
-25.00	12.00	15.05	-3.05
-10.00	17.00	19.72	-2.72
.00	25.00	23.51	1.49
10.00	21.00	27.85	-6.85
25.00	45.00	35.36	9.64
50.00	45.00	49.71	-4.71
65.00	57.00	58.61	-1.61

CAPSULE Y LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
72.00	70.00	62.63	7.37
100.00	70.00	76.74	-6.74
150.00	96.00	91.76	4.24
200.00	94.00	97.42	-3.42
250.00	106.00	99.22	6.78
300.00	105.00	99.77	5.23

Correlation Coefficient = .989

CAPSULE Y LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 02:30 PM

Page 1

Coefficients of Curve 3

A = 34.43 B = 34.43 C = 77.76 T0 = 45.5 D = 0.00E+00

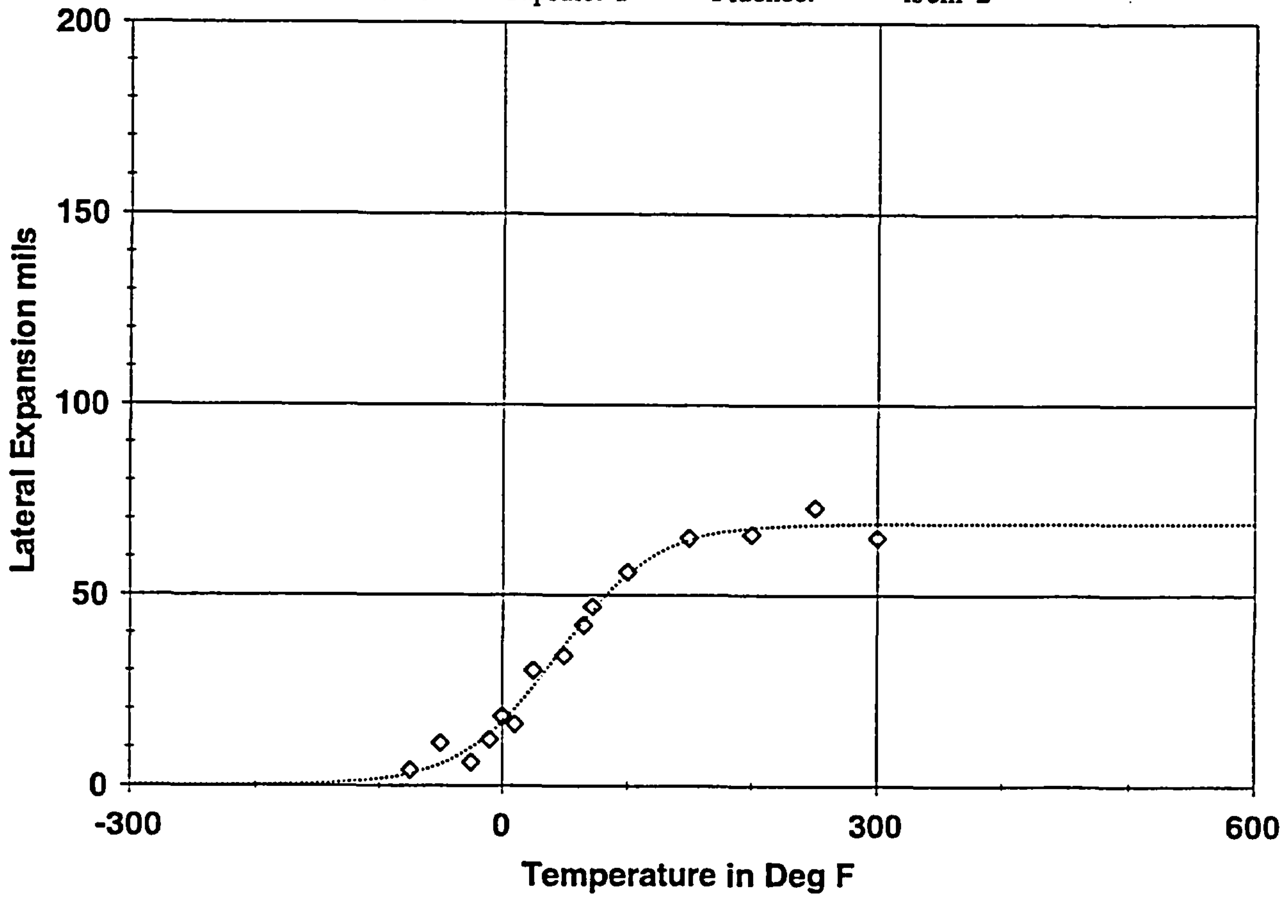
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=68.9 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=46.8 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	4.00	2.97	1.03
-50.00	11.00	5.44	5.56
-25.00	6.00	9.66	-3.66
-10.00	12.00	13.32	-1.32
.00	18.00	16.30	1.70
10.00	16.00	19.72	-3.72
25.00	30.00	25.55	4.45
50.00	34.00	36.42	-2.42
65.00	42.00	42.88	-.88

CAPSULE Y LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
72.00	47.00	45.72	1.28
100.00	56.00	55.25	.75
150.00	65.00	64.47	.53
200.00	66.00	67.58	-1.58
250.00	73.00	68.50	4.50
300.00	65.00	68.75	-3.75

Correlation Coefficient = .992

CAPSULE Y LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:35 AM

Page 1

Coefficients of Curve 3

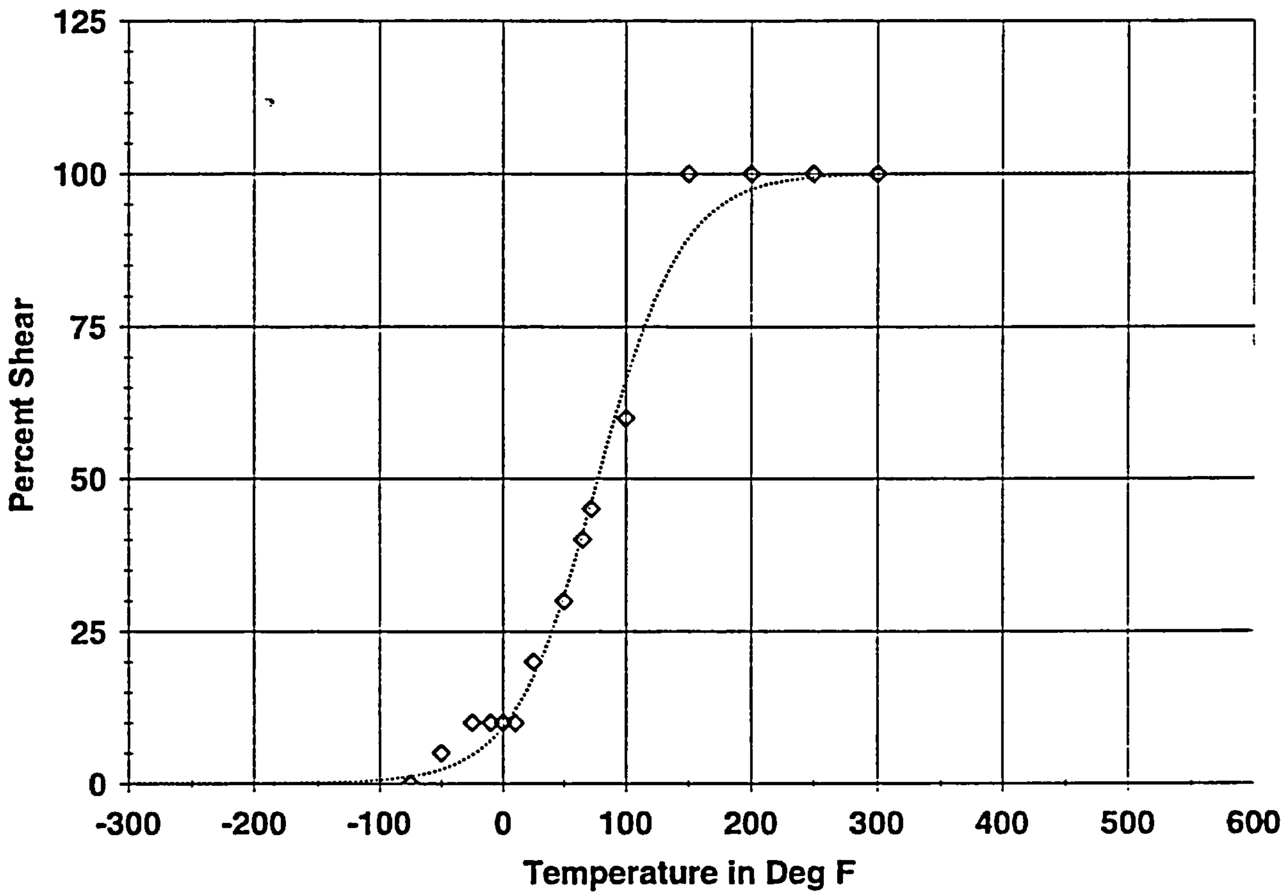
A = 50. B = 50. C = 67.76 T0 = 77.75 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 77.8

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	.00	1.09	-1.09
-50.00	5.00	2.25	2.75
-25.00	10.00	4.60	5.40
-10.00	10.00	6.98	3.02
.00	10.00	9.15	.85
10.00	10.00	11.92	-1.92
25.00	20.00	17.41	2.59
50.00	30.00	30.59	-.59
65.00	40.00	40.70	-.70

CAPSULE Y LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72.00	45.00	45.76	-.76
100.00	60.00	65.85	-5.85
150.00	100.00	89.40	10.60
200.00	100.00	97.36	2.64
250.00	100.00	99.38	.62
300.00	100.00	99.86	.14

Correlation Coefficient = .996

CAPSULE X LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:13 AM

Page 1

Coefficients of Curve 4

A = 44.1 B = 41.9 C = 75.94 T0 = 64.75 D = 0.00E+00

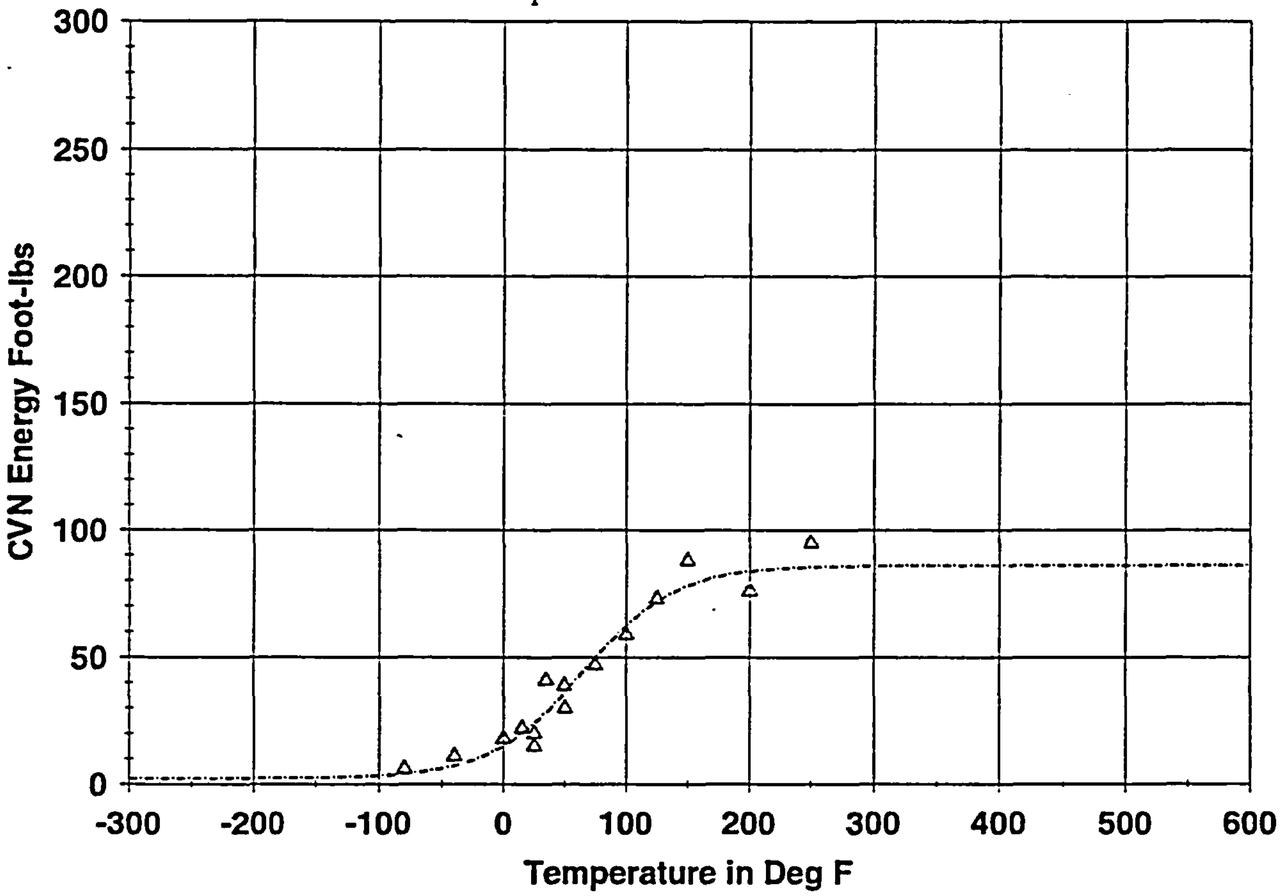
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=86.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=38.2 Deg F Temp@50 ft-lbs=75.6 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-80.00	6.00	4.01	1.99
-40.00	11.00	7.19	3.81
.00	18.00	15.09	2.91
15.00	22.00	20.00	2.00
25.00	15.00	23.97	-8.97
25.00	20.00	23.97	-3.97
35.00	41.00	28.48	12.52
50.00	30.00	36.06	-6.06
50.00	39.00	36.06	2.94

CAPSULE X LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: X Fluence: n/cm^2

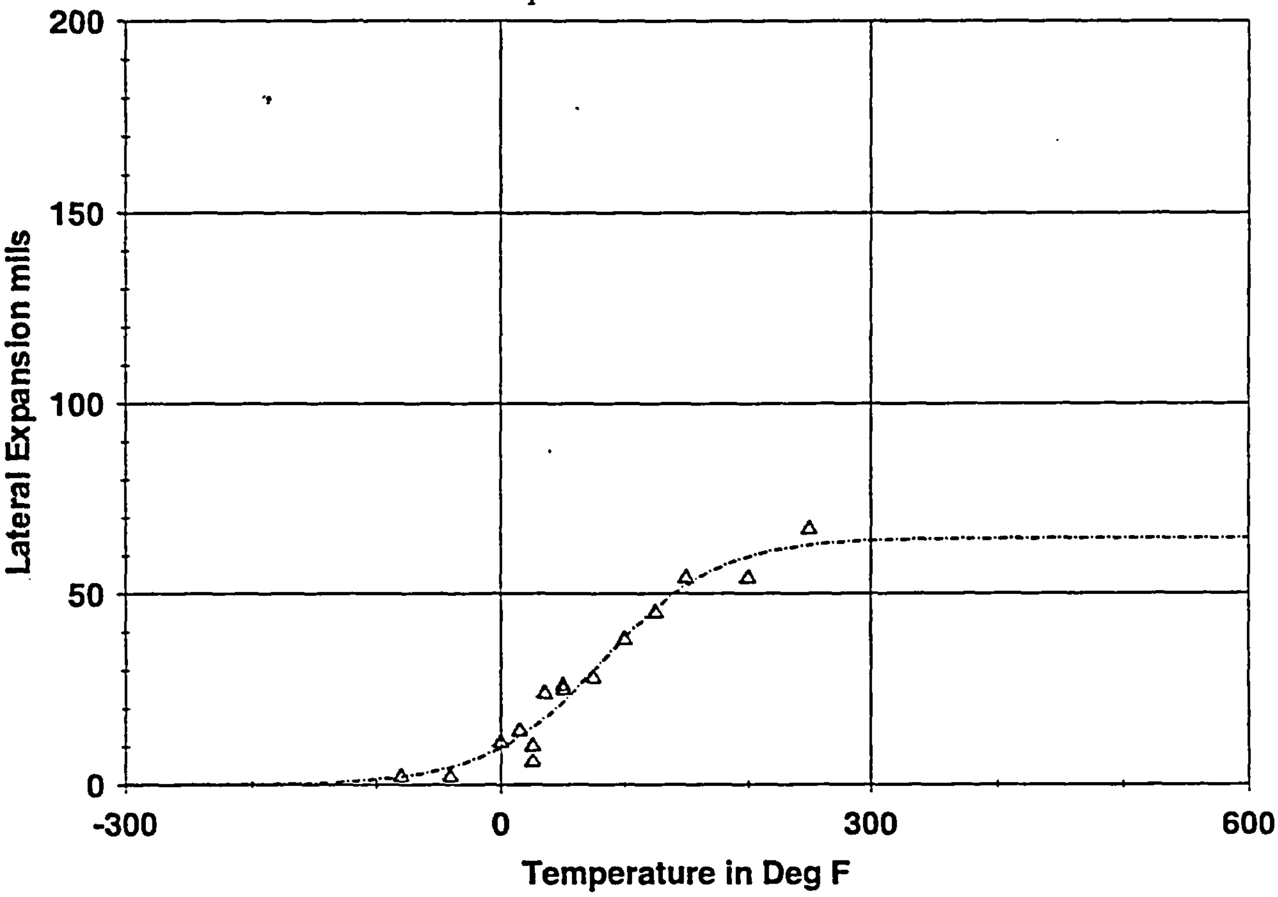
Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
75.00	47.00	49.72	-2.72
100.00	59.00	62.26	-3.26
125.00	73.00	71.77	1.23
150.00	88.00	77.97	10.03
200.00	76.00	83.69	-7.69
250.00	95.00	85.37	9.63

Correlation Coefficient = .975

CAPSULE X LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 02:30 PM
Page 1
Coefficients of Curve 4
A = 32.28 B = 32.28 C = 94.48 T0 = 82. D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf L.E.=64.6 Lower Shelf L.E.=.0(Fixed)
Temp.@L.E. 35 mils=90.0 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-80.00	2.00	2.03	-.03
-40.00	2.00	4.54	-2.54
.00	11.00	9.67	1.33
15.00	14.00	12.58	1.42
25.00	6.00	14.87	-8.87
25.00	10.00	14.87	-4.87
35.00	24.00	17.42	6.58
50.00	26.00	21.74	4.26
50.00	25.00	21.74	3.26

CAPSULE X LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
75.00	28.00	29.89	-1.89
100.00	38.00	38.35	-.35
125.00	45.00	46.03	-1.03
150.00	54.00	52.18	1.82
200.00	54.00	59.64	-5.64
250.00	67.00	62.76	4.24

Correlation Coefficient = .979

CAPSULE X LOWER SHELL PLATE B8628 -1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:35 AM

Page 1

Coefficients of Curve 4

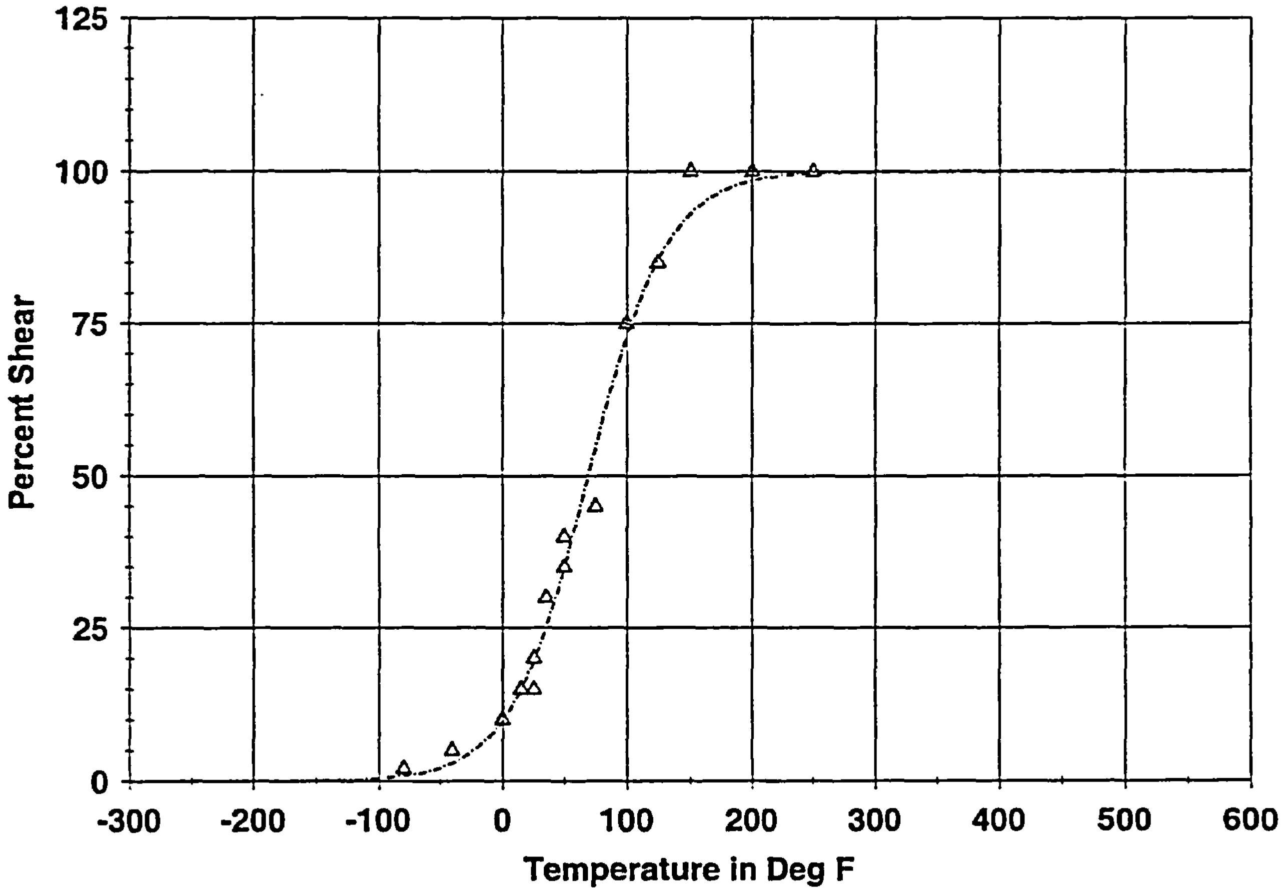
A = 50. B = 50. C = 62.44 T0 = 69.29 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 69.3

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-80.00	2.00	.83	1.17
-40.00	5.00	2.93	2.07
.00	10.00	9.80	.20
15.00	15.00	14.95	.05
25.00	15.00	19.49	-4.49
25.00	20.00	19.49	.51
35.00	30.00	25.01	4.99
50.00	35.00	35.03	-.03
50.00	40.00	35.03	4.97

CAPSULE X LOWER SHELL PLATE B8628 -1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: X Fluence: n/cm^2

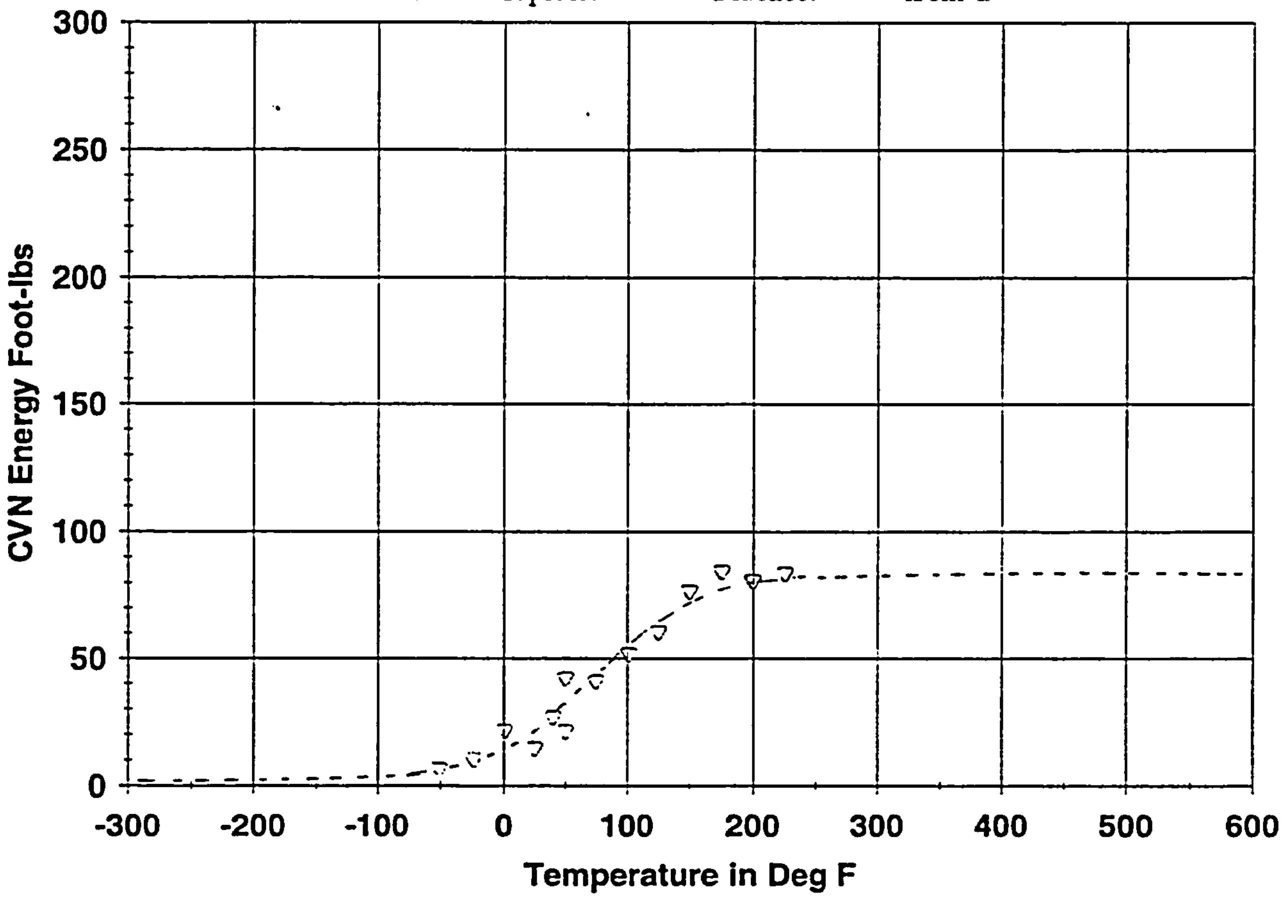
Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
75.00	45.00	54.56	-9.56
100.00	75.00	72.78	2.22
125.00	85.00	85.62	-.62
150.00	100.00	92.99	7.01
200.00	100.00	98.50	1.50
250.00	100.00	99.69	.31

Correlation Coefficient = .994

CAPSULE W LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:13 AM
Page 1
Coefficients of Curve 5
A = 43.1 B = 40.9 C = 81.94 T0 = 74.98 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf Energy=84.0(Fixed) Lower Shelf Energy=2.2(Fixed)
Temp@30 ft-lbs=47.8 Deg F Temp@50 ft-lbs=89.0 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-50.00	7.00	5.90	1.10
-25.00	11.00	8.76	2.24
.00	21.00	13.51	7.49
25.00	15.00	20.85	-5.85
40.00	27.00	26.63	.37
50.00	42.00	31.00	11.00
50.00	22.00	31.00	-9.00
75.00	42.00	43.11	-1.11
100.00	52.00	55.22	-3.22

CAPSULE W LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: W Fluence: n/cm^2

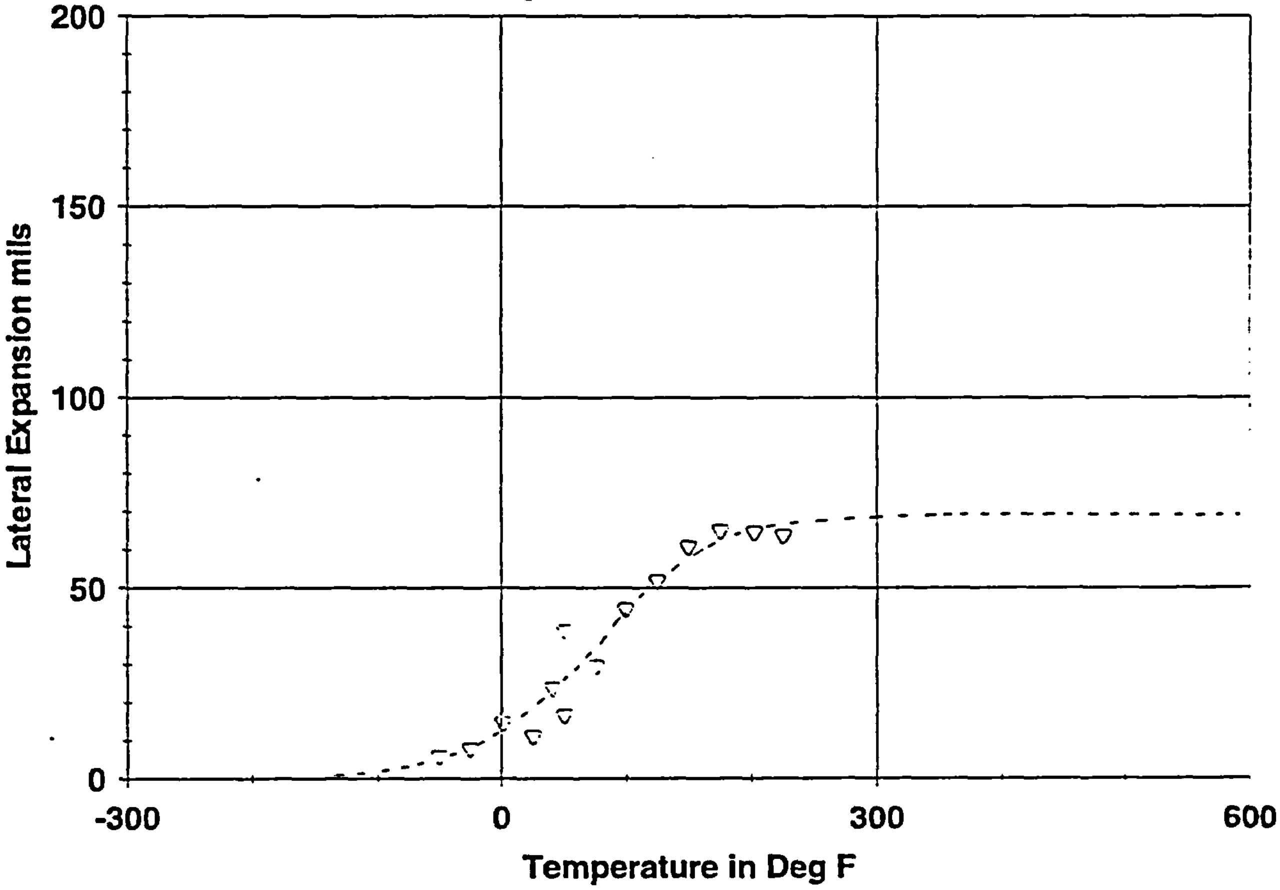
Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
125.00	61.00	65.37	-4.37
150.00	77.00	72.70	4.30
175.00	85.00	77.45	7.55
200.00	81.00	80.31	.69
225.00	85.00	81.95	3.05

Correlation Coefficient = .981

CAPSULE W LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 02:30 PM
Page 1
Coefficients of Curve 5
A = 34.69 B = 34.69 C = 91.2 T0 = 73.83 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf L.E.=69.4 Lower Shelf L.E.=.0(Fixed)
Temp.@L.E. 35 mils=74.7 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-50.00	6.00	4.31	1.69
-25.00	8.00	7.13	.87
.00	15.00	11.47	3.53
25.00	11.00	17.71	-6.71
40.00	24.00	22.38	1.62
50.00	39.00	25.83	13.17
50.00	17.00	25.83	-8.83
75.00	30.00	35.14	-5.14
100.00	45.00	44.38	.62

CAPSULE W LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: W Fluence: n/cm^2

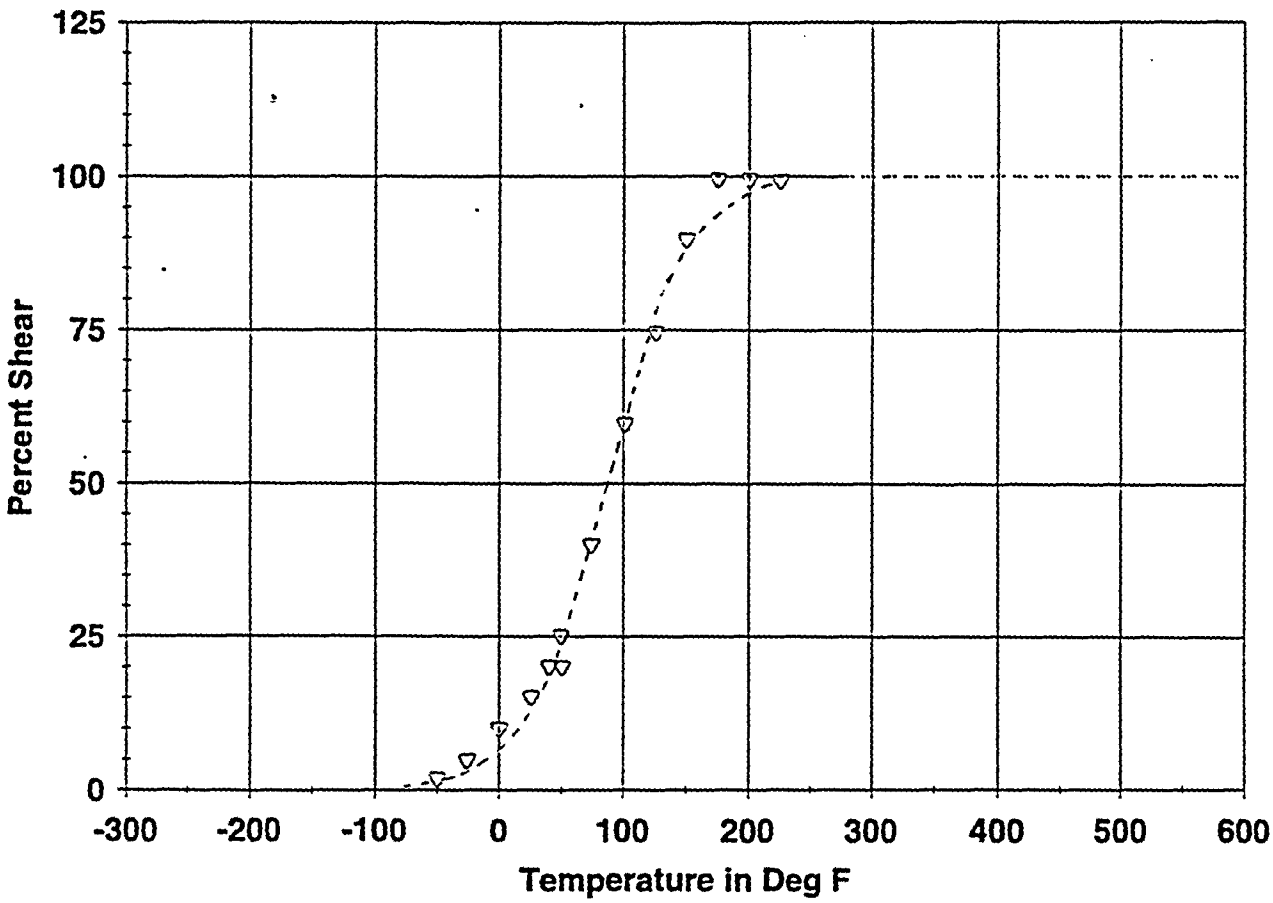
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
125.00	52.00	52.34	-.34
150.00	61.00	58.40	2.60
175.00	65.00	62.58	2.42
200.00	65.00	65.28	-.28
225.00	64.00	66.95	-2.95

Correlation Coefficient = .973

CAPSULE W LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/17/2004 11:35 AM
Page 1
Coefficients of Curve 5
A = 50. B = 50. C = 63.08 T0 = 86.41 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 86.5
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: LT Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differentia'
-50.00	2.00	1.31	.69
-25.00	5.00	2.84	2.16
.00	10.00	6.07	3.93
25.00	15.00	12.49	2.51
40.00	20.00	18.67	1.33
50.00	25.00	23.97	1.03
50.00	20.00	23.97	-3.97
75.00	40.00	41.06	-1.06
100.00	60.00	60.61	-.61

CAPSULE W LOWER SHELL PLATE B8628-1 (LONGITUDINAL)

Page 2

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: LT Capsule: W Fluence: n/cm^2

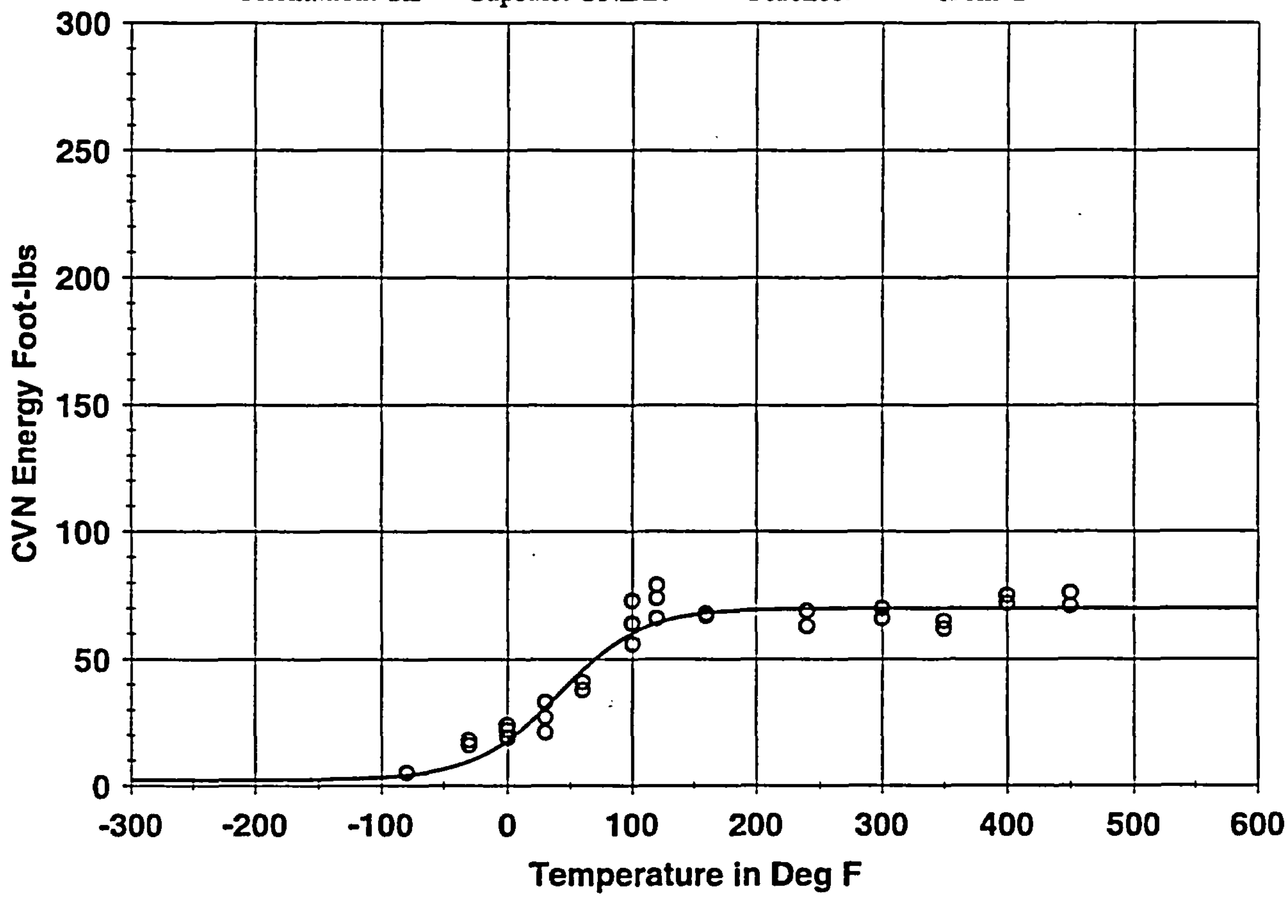
Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
125.00	75.00	77.27	-2.27
150.00	90.00	88.25	1.75
175.00	100.00	94.32	5.68
200.00	100.00	97.34	2.66
225.00	100.00	98.78	1.22

Correlation Coefficient = .998

UNIRRADIATED LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 01:36 PM
Page 1
Coefficients of Curve 1
A = 36.1 B = 33.9 C = 67.14 T0 = 40.81 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf Energy=70.0(Fixed) Lower Shelf Energy=2.2(Fixed)
Temp@30 ft-lbs=28.6 Deg F Temp@50 ft-lbs=70.1 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-80.00	5.00	4.01	.99
-80.00	5.00	4.01	.99
-30.00	16.00	9.54	6.46
-30.00	18.00	9.54	8.46
.00	19.00	17.71	1.29
.00	22.00	17.71	4.29
.00	24.00	17.71	6.29
30.00	21.00	30.69	-9.69
30.00	27.00	30.69	-3.69

UNIRRADIATED LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
30.00	33.00	30.69	2.31
60.00	38.00	45.54	-7.54
60.00	38.00	45.54	-7.54
60.00	41.00	45.54	-4.54
100.00	56.00	60.08	-4.08
100.00	64.00	60.08	3.92
100.00	73.00	60.08	12.92
120.00	66.00	64.15	1.85
120.00	74.00	64.15	9.85
120.00	79.00	64.15	14.85
160.00	67.00	68.11	-1.11
160.00	68.00	68.11	-.11
160.00	68.00	68.11	-.11
240.00	63.00	69.82	-6.82
240.00	69.00	69.82	-.82
300.00	66.00	69.97	-3.97
300.00	70.00	69.97	.03
350.00	62.00	69.99	-7.99
350.00	65.00	69.99	-4.99
400.00	72.00	70.00	2.00
400.00	75.00	70.00	5.00
450.00	71.00	70.00	1.00
450.00	76.00	70.00	6.00

Correlation Coefficient = .968

UNIRRADIATED LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:49 PM

Page 1

Coefficients of Curve 1

A = 32.67 B = 32.67 C = 72.88 T0 = 38.79 D = 0.00E+00

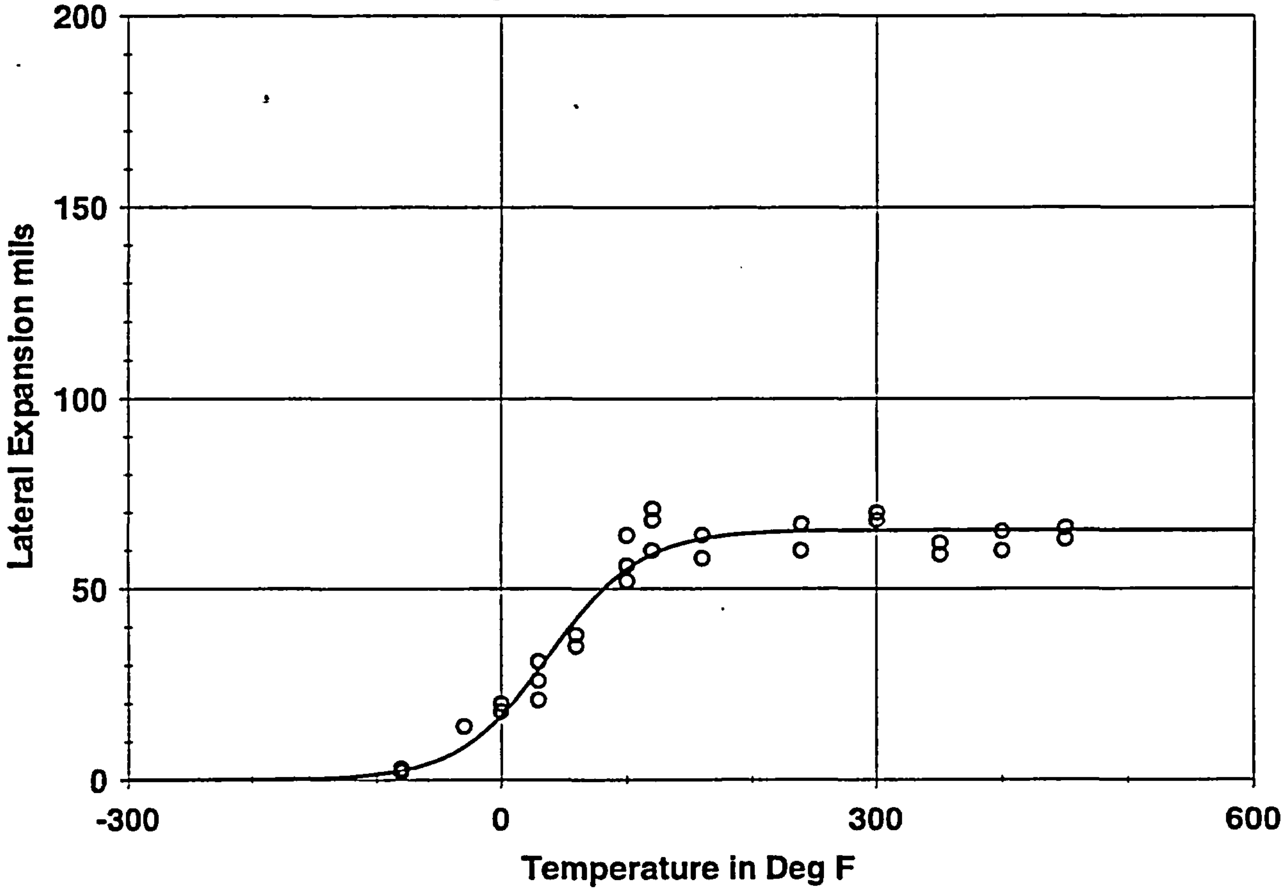
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=65.3 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=44.0 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-80.00	2.00	2.42	-.42
-80.00	3.00	2.42	.58
-30.00	14.00	8.59	5.41
-30.00	14.00	8.59	5.41
.00	18.00	16.76	1.24
.00	20.00	16.76	3.24
.00	20.00	16.76	3.24
30.00	21.00	28.75	-7.75
30.00	26.00	28.75	-2.75

UNIRRADIATED LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: UNIRR Fluence: n/cm^2

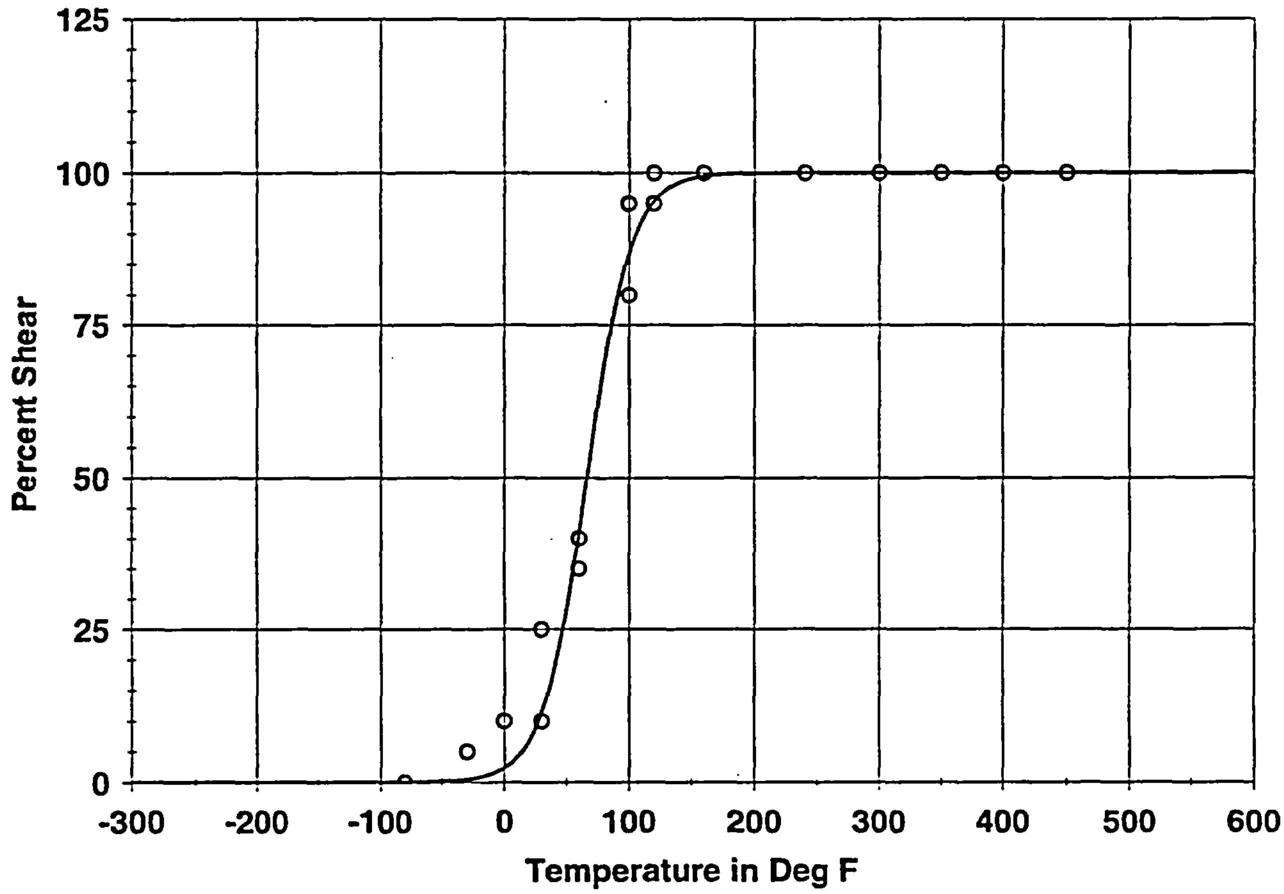
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
30.00	31.00	28.75	2.25
60.00	35.00	41.92	-6.92
60.00	38.00	41.92	-3.92
60.00	38.00	41.92	-3.92
100.00	52.00	55.08	-3.08
100.00	56.00	55.08	.92
100.00	64.00	55.08	8.92
120.00	60.00	58.99	1.01
120.00	68.00	58.99	9.01
120.00	71.00	58.99	12.01
160.00	58.00	63.08	-5.08
160.00	64.00	63.08	.92
160.00	64.00	63.08	.92
240.00	60.00	65.08	-5.08
240.00	67.00	65.08	1.92
300.00	68.00	65.29	2.71
300.00	70.00	65.29	4.71
350.00	59.00	65.33	-6.33
350.00	62.00	65.33	-3.33
400.00	65.00	65.34	-.34
400.00	60.00	65.34	-5.34
450.00	63.00	65.34	-2.34
450.00	66.00	65.34	.66

Correlation Coefficient = .977

UNIRRADIATED LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:31 PM
Page 1
Coefficients of Curve 1
A = 50. B = 50. C = 35.5 T0 = 66.46 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 66.5
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-80.00	.00	.03	-.03
-80.00	.00	.03	-.03
-30.00	5.00	.43	4.57
-30.00	5.00	.43	4.57
.00	10.00	2.31	7.69
.00	10.00	2.31	7.69
.00	10.00	2.31	7.69
30.00	25.00	11.36	13.64
30.00	10.00	11.36	-1.36

UNIRRADIATED LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
30.00	10.00	11.36	-1.36
60.00	35.00	40.99	-5.99
60.00	40.00	40.99	-.99
60.00	35.00	40.99	-5.99
100.00	80.00	86.87	-6.87
100.00	95.00	86.87	8.13
100.00	95.00	86.87	8.13
120.00	95.00	95.33	-.33
120.00	100.00	95.33	4.67
120.00	100.00	95.33	4.67
160.00	100.00	99.49	.51
160.00	100.00	99.49	.51
160.00	100.00	99.49	.51
240.00	100.00	99.99	.01
240.00	100.00	99.99	.01
300.00	100.00	100.00	.00
300.00	100.00	100.00	.00
350.00	100.00	100.00	.00
350.00	100.00	100.00	.00
400.00	100.00	100.00	.00
400.00	100.00	100.00	.00
450.00	100.00	100.00	.00
450.00	100.00	100.00	.00

Correlation Coefficient = .995

CAPSULE U LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 01:36 PM

Page 1

Coefficients of Curve 2

A = 40.6 B = 38.4 C = 114.67 T0 = 53.93 D = 0.00E+00

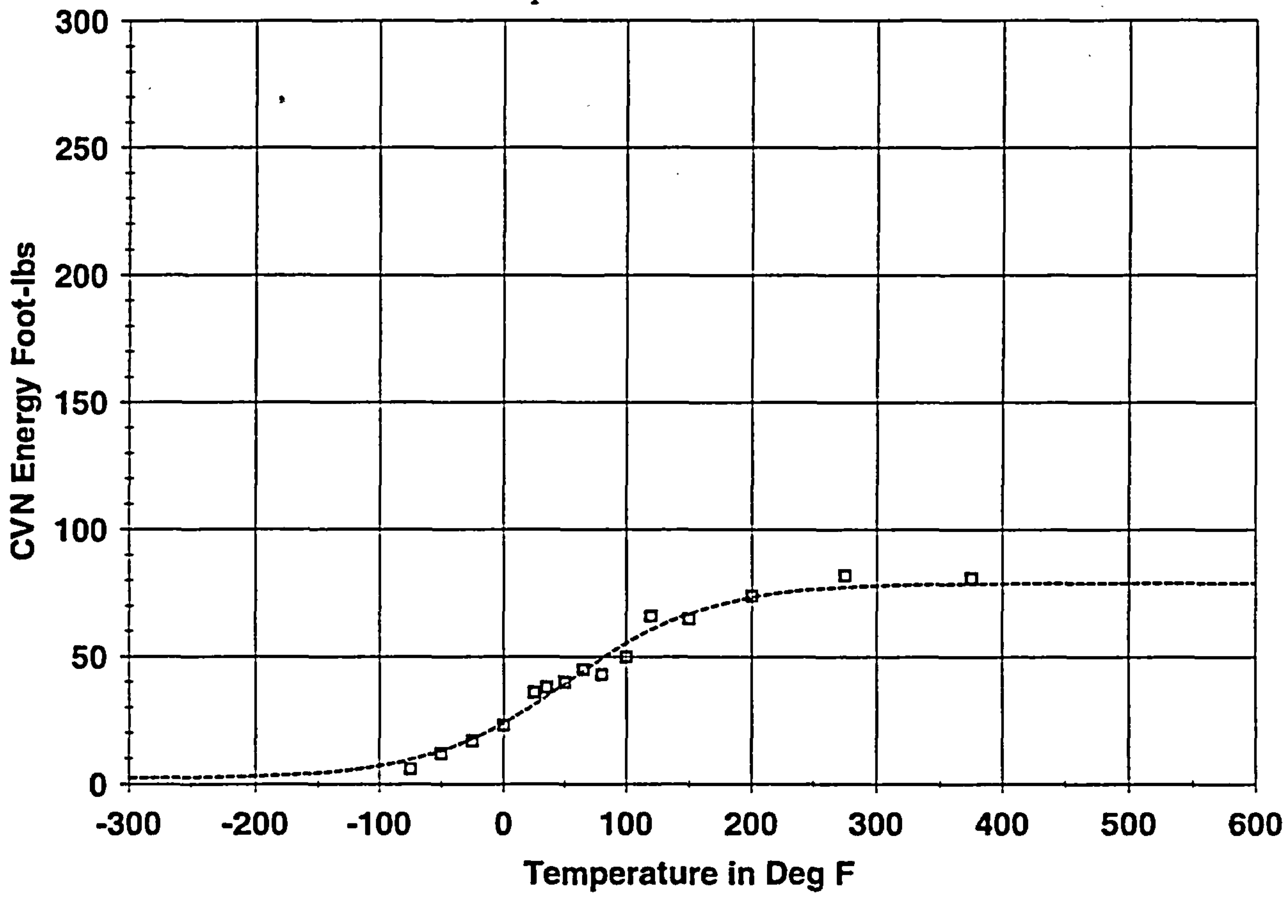
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=79.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=21.5 Deg F Temp@50 ft-lbs=82.6 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	6.00	9.53	-3.53
-50.00	12.00	12.98	-.98
-25.00	17.00	17.68	-.68
.00	23.00	23.77	-.77
25.00	36.00	31.11	4.89
35.00	38.00	34.32	3.68
50.00	40.00	39.29	.71
65.00	45.00	44.30	.70
80.00	43.00	49.18	-6.18

CAPSULE U LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
100.00	50.00	55.25	-5.25
120.00	66.00	60.56	5.44
150.00	65.00	66.89	-1.89
200.00	74.00	73.43	.57
275.00	82.00	77.41	4.59
375.00	81.00	78.72	2.28

Correlation Coefficient = .990

CAPSULE U LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:49 PM

Page 1

Coefficients of Curve 2

A = 28.55 B = 28.55 C = 97.06 T0 = 30.7 D = 0.00E+00

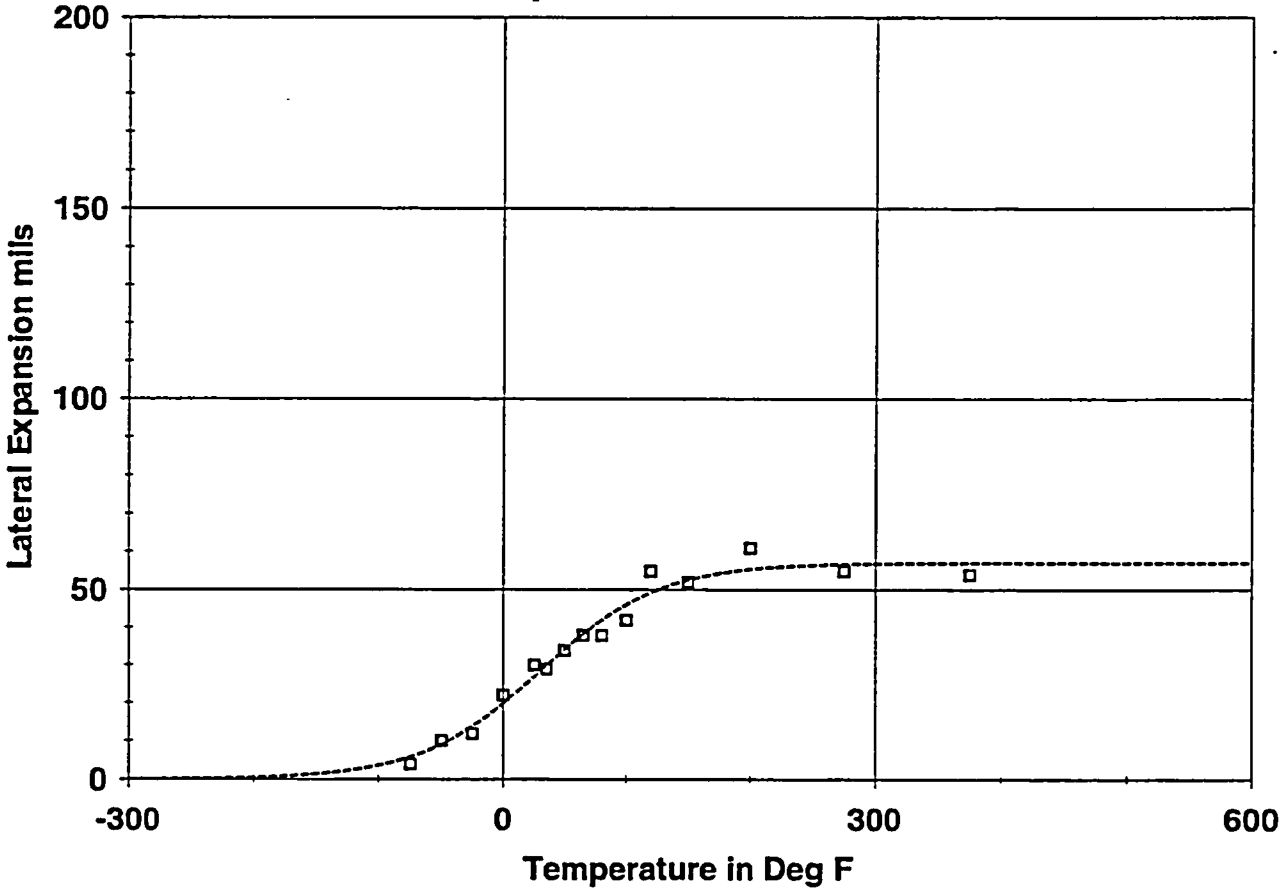
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=57.1 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=53.1 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	4.00	5.81	-1.81
-50.00	10.00	9.10	.90
-25.00	12.00	13.76	-1.76
.00	22.00	19.81	2.19
25.00	30.00	26.88	3.12
35.00	29.00	29.81	-.81
50.00	34.00	34.15	-.15
65.00	38.00	38.24	-.24
80.00	38.00	41.92	-3.92

CAPSULE U LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
100.00	42.00	46.05	-4.05
120.00	55.00	49.27	5.73
150.00	52.00	52.60	-.60
200.00	61.00	55.41	5.59
275.00	55.00	56.73	-1.73
375.00	54.00	57.05	-3.05

Correlation Coefficient = .985

CAPSULE U LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:31 PM

Page 1

Coefficients of Curve 2

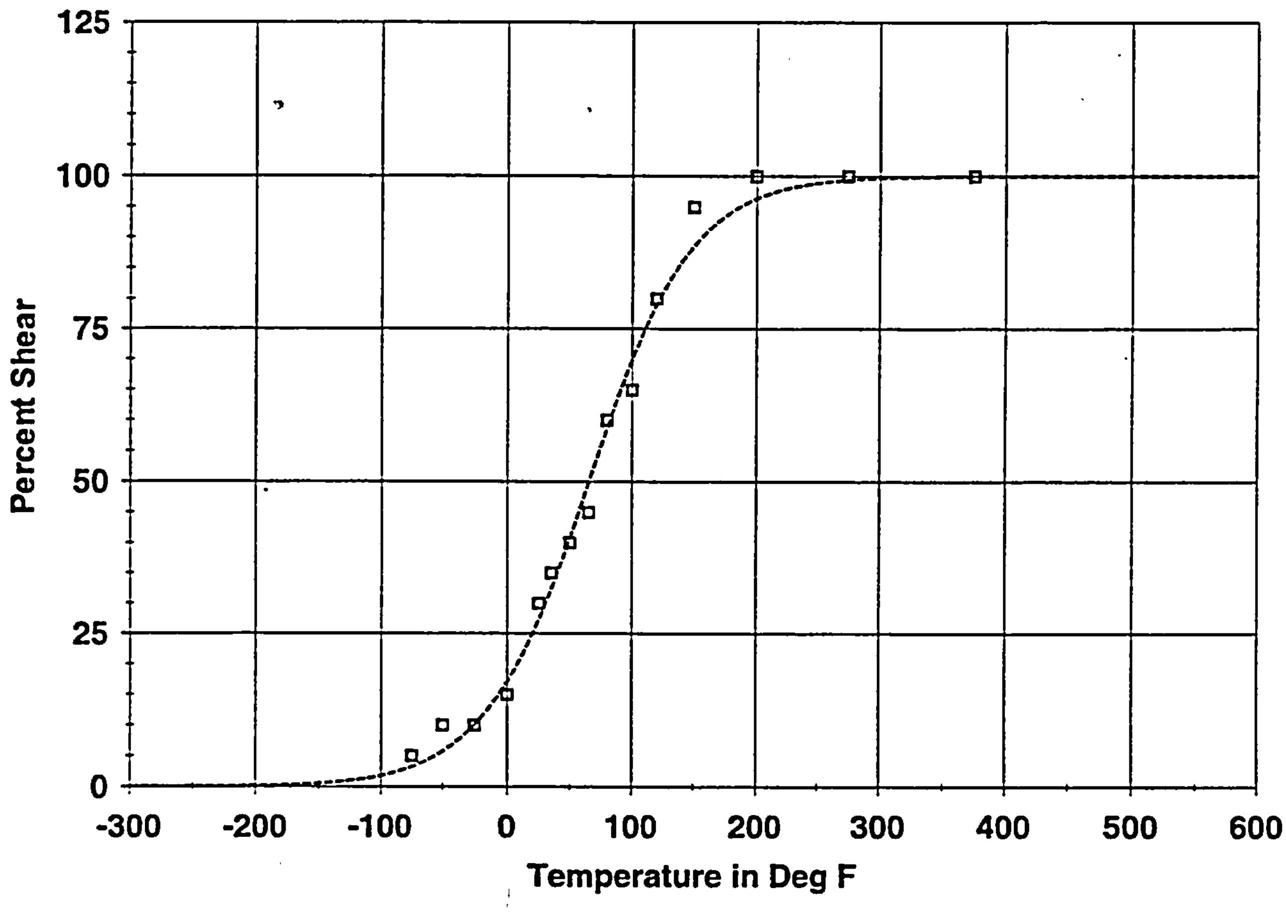
A = 50. B = 50. C = 82.49 T0 = 65.43 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 65.5

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	5.00	3.21	1.79
-50.00	10.00	5.74	4.26
-25.00	10.00	10.04	-.04
.00	15.00	16.99	-1.99
25.00	30.00	27.28	2.72
35.00	35.00	32.35	2.65
50.00	40.00	40.75	-.75
65.00	45.00	49.74	-4.74
80.00	60.00	58.74	1.26

CAPSULE U LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
100.00	65.00	69.81	-4.81
120.00	80.00	78.97	1.03
150.00	95.00	88.60	6.40
200.00	100.00	96.31	3.69
275.00	100.00	99.38	.62
375.00	100.00	99.95	.05

Correlation Coefficient = .996

CAPSULE Y LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 01:36 PM
Page 1
Coefficients of Curve 3

A = 37.6 B = 35.4 C = 96.69 T0 = 51.57 D = 0.00E+00

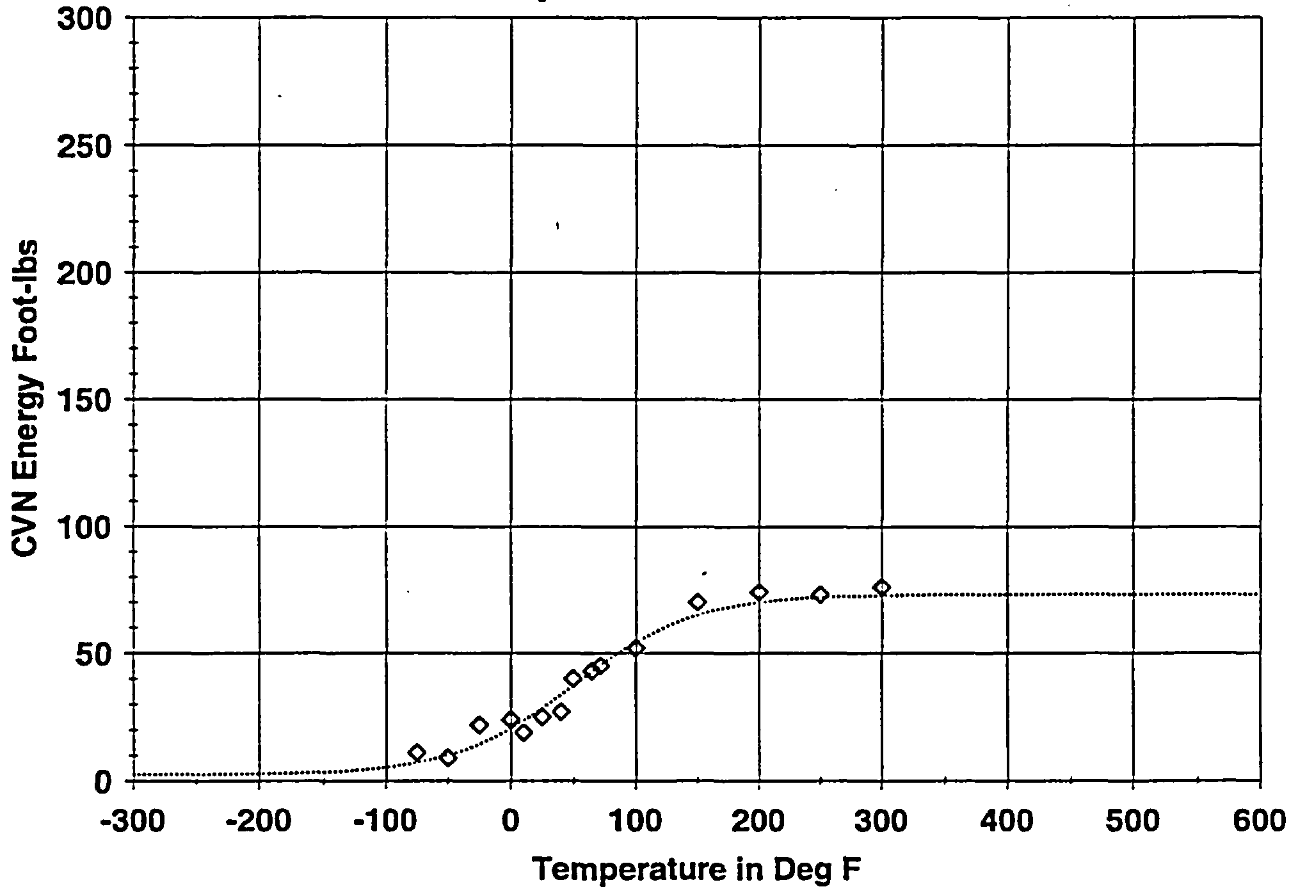
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=73.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=30.5 Deg F Temp@50 ft-lbs=87.0 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	11.00	7.01	3.99
-50.00	9.00	9.92	-.92
-25.00	22.00	14.26	7.74
.00	24.00	20.33	3.67
10.00	19.00	23.26	-4.26
25.00	25.00	28.11	-3.11
40.00	27.00	33.39	-6.39
50.00	40.00	37.03	2.97
65.00	43.00	42.49	.51

CAPSULE Y LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
72.00	45.00	44.97	.03
100.00	52.00	53.98	-1.98
150.00	70.00	64.82	5.18
200.00	74.00	69.86	4.14
250.00	73.00	71.85	1.15
300.00	76.00	72.59	3.41

Correlation Coefficient = .987

CAPSULE Y LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:49 PM

Page 1

Coefficients of Curve 3

A = 31.92 B = 31.92 C = 104.1 T0 = 52.77 D = 0.00E+00

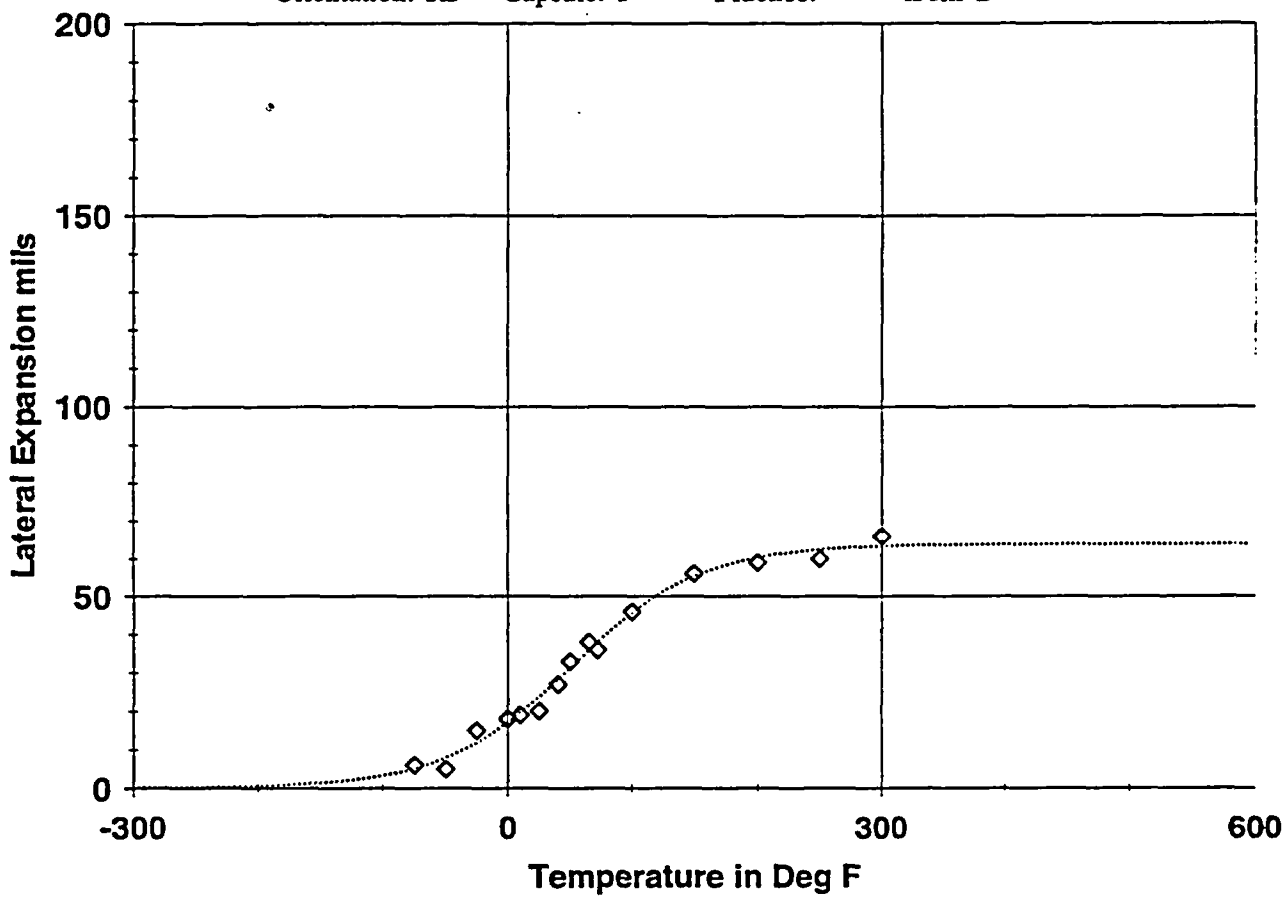
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=63.8 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=62.9 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	6.00	5.05	.95
-50.00	5.00	7.78	-2.78
-25.00	15.00	11.70	3.30
.00	18.00	16.99	1.01
10.00	19.00	19.49	-.49
25.00	20.00	23.60	-3.60
40.00	27.00	28.02	-1.02
50.00	33.00	31.07	1.93
65.00	38.00	35.65	2.35

CAPSULE Y LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
72.00	36.00	37.75	-1.75
100.00	46.00	45.48	.52
150.00	56.00	55.30	.70
200.00	59.00	60.27	-1.27
250.00	60.00	62.42	-2.42
300.00	66.00	63.29	2.71

Correlation Coefficient = .994

CAPSULE Y LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:31 PM

Page 1

Coefficients of Curve 3

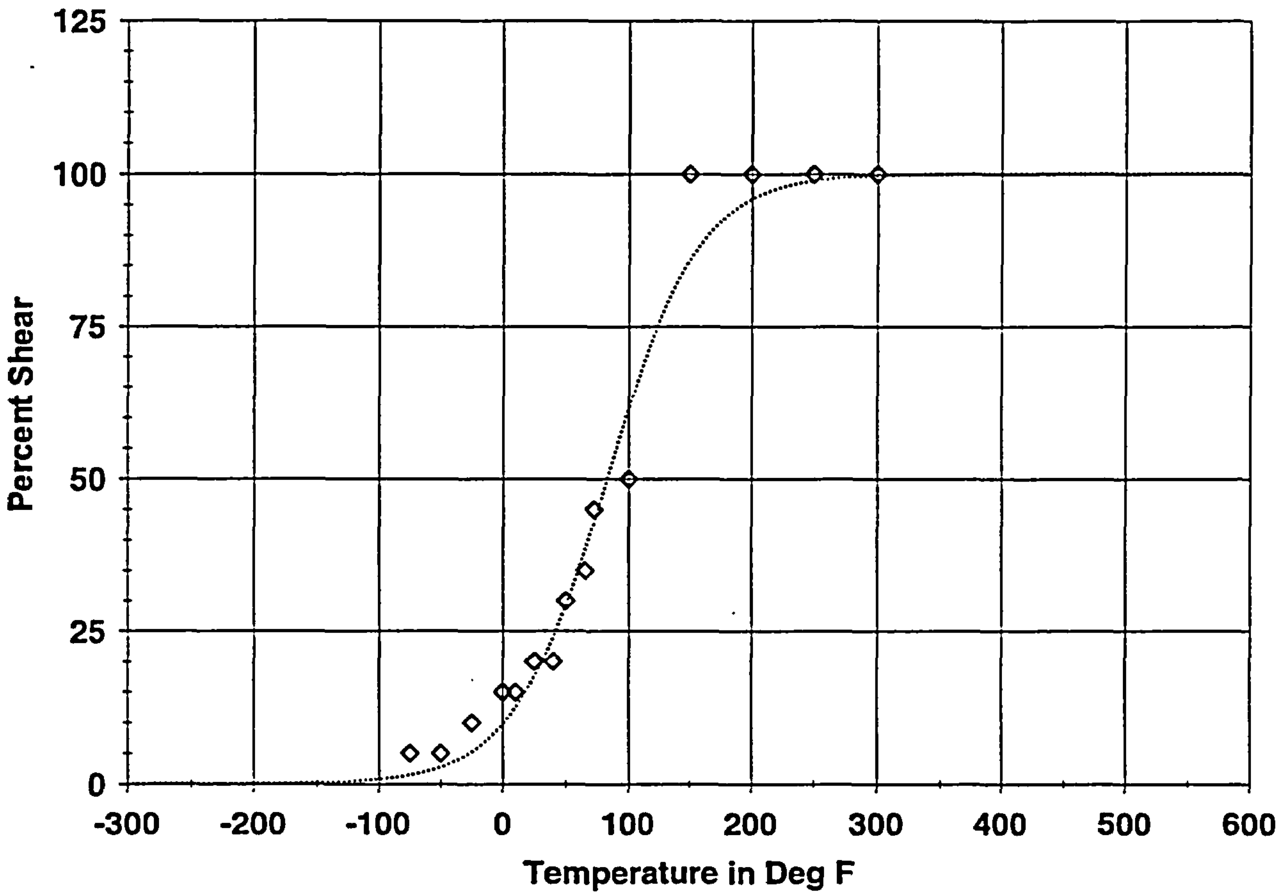
A = 50. B = 50. C = 74.35 T0 = 83. D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 83.0

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	5.00	1.41	3.59
-50.00	5.00	2.72	2.28
-25.00	10.00	5.19	4.81
.00	15.00	9.69	5.31
10.00	15.00	12.31	2.69
25.00	20.00	17.36	2.64
40.00	20.00	23.93	-3.93
50.00	30.00	29.16	.84
65.00	35.00	38.13	-3.13

CAPSULE Y LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72.00	45.00	42.66	2.34
100.00	50.00	61.24	-11.24
150.00	100.00	85.84	14.16
200.00	100.00	95.88	4.12
250.00	100.00	98.89	1.11
300.00	100.00	99.71	.29

Correlation Coefficient = .990

CAPSULE X LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 01:36 PM
Page 1
Coefficients of Curve 4

A = 33.6 B = 31.4 C = 79.36 T0 = 67.47 D = 0.00E+00

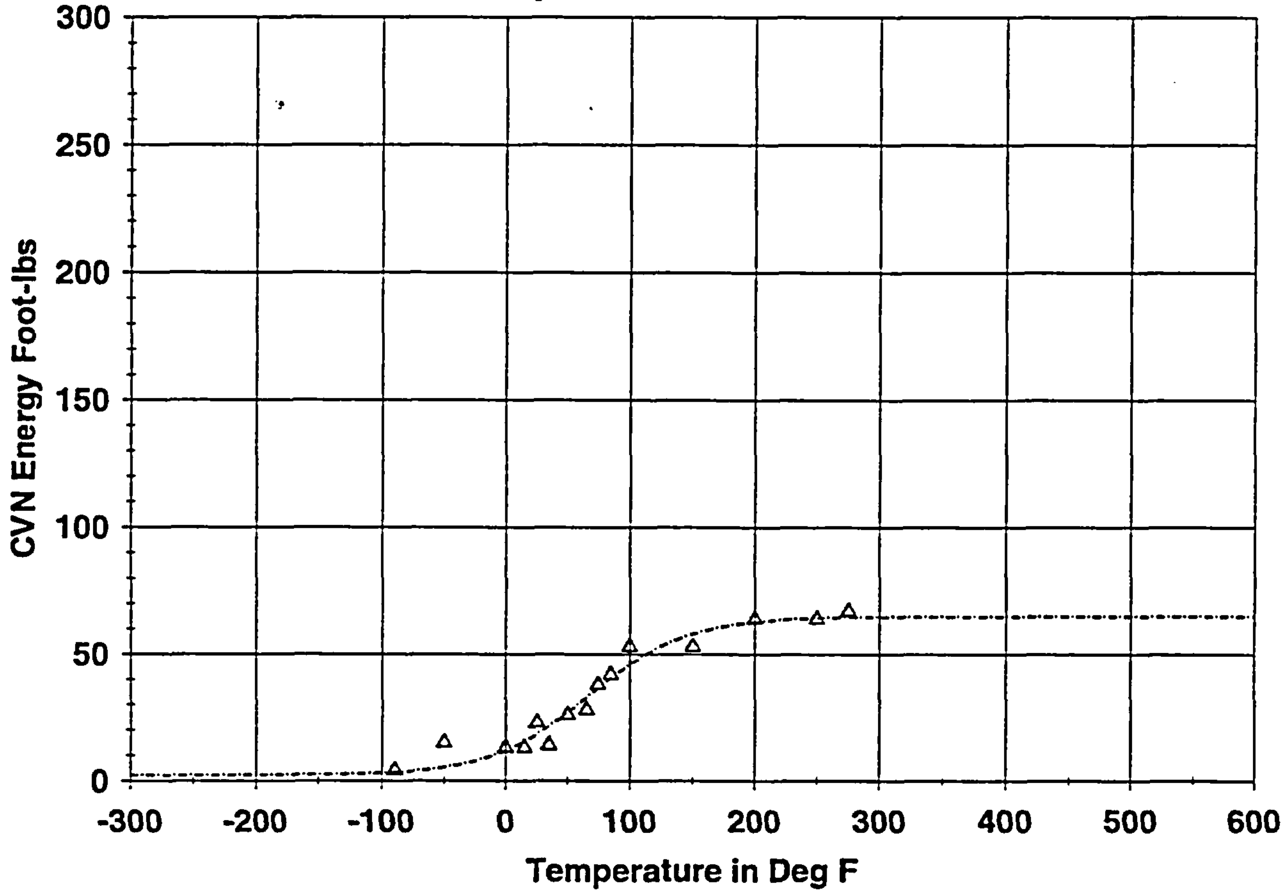
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=65.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=58.4 Deg F Temp@50 ft-lbs=113.5 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-90.00	4.00	3.36	.64
-50.00	15.00	5.29	9.71
.00	13.00	11.90	1.10
15.00	13.00	15.42	-2.42
25.00	23.00	18.24	4.76
35.00	14.00	21.43	-7.43
50.00	26.00	26.80	-.80
65.00	28.00	32.62	-4.62
75.00	38.00	36.57	1.43

CAPSULE X LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: X Fluence: n/cm^2

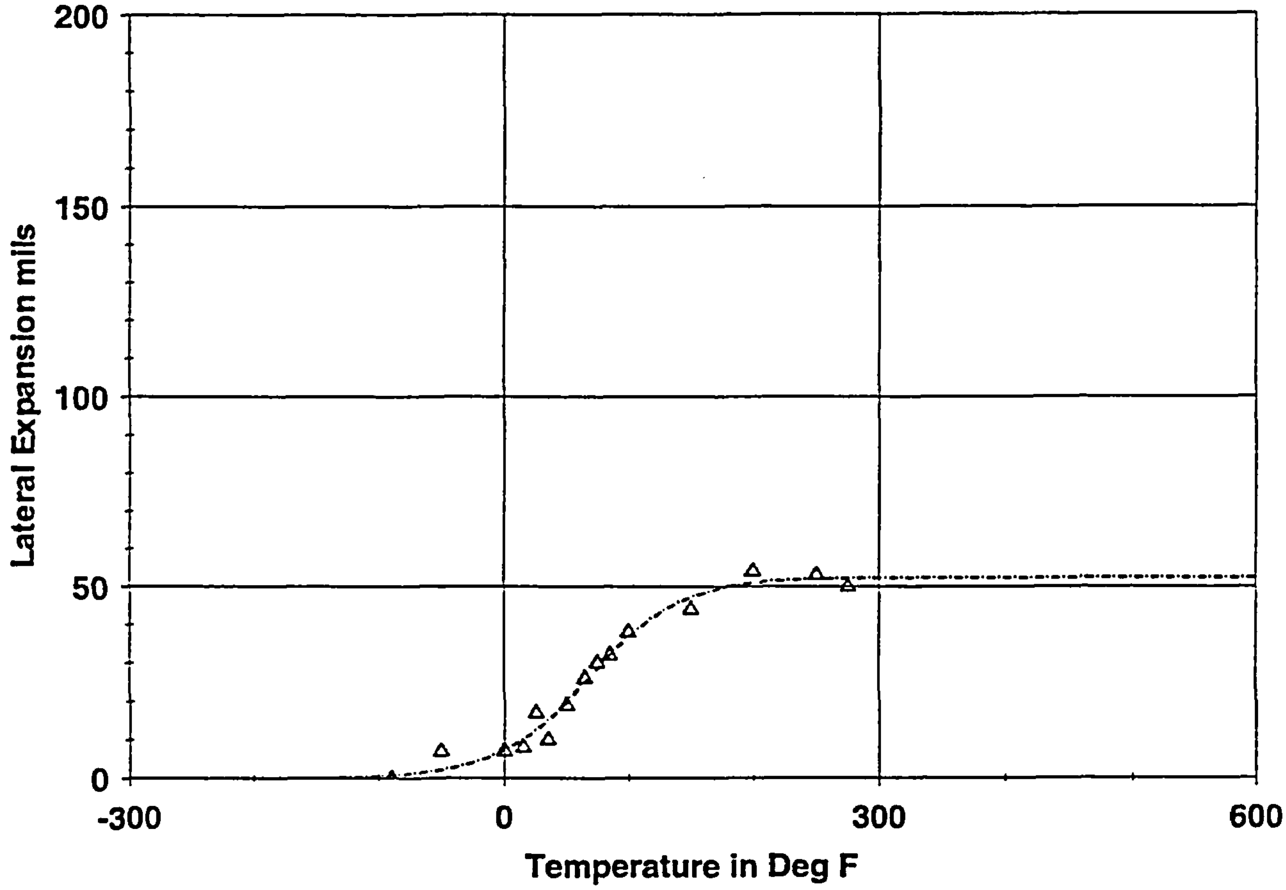
Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
85.00	42.00	40.43	1.57
100.00	53.00	45.80	7.20
150.00	53.00	58.03	-5.03
200.00	64.00	62.85	1.15
250.00	64.00	64.38	-.38
275.00	67.00	64.67	2.33

Correlation Coefficient = .978

CAPSULE X LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:49 PM
Page 1
Coefficients of Curve 4
A = 26.2 B = 26.2 C = 74.38 T0 = 68.23 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf L.E.=52.4 Lower Shelf L.E.=.0(Fixed)
Temp.@L.E. 35 mils=94.3 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-90.00	.00	.73	-.73
-50.00	7.00	2.09	4.91
.00	7.00	7.21	-.21
15.00	8.00	10.11	-2.11
25.00	17.00	12.48	4.52
35.00	10.00	15.22	-5.22
50.00	19.00	19.90	-.90
65.00	26.00	25.06	.94
75.00	30.00	28.58	1.42

CAPSULE X LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: X Fluence: n/cm^2

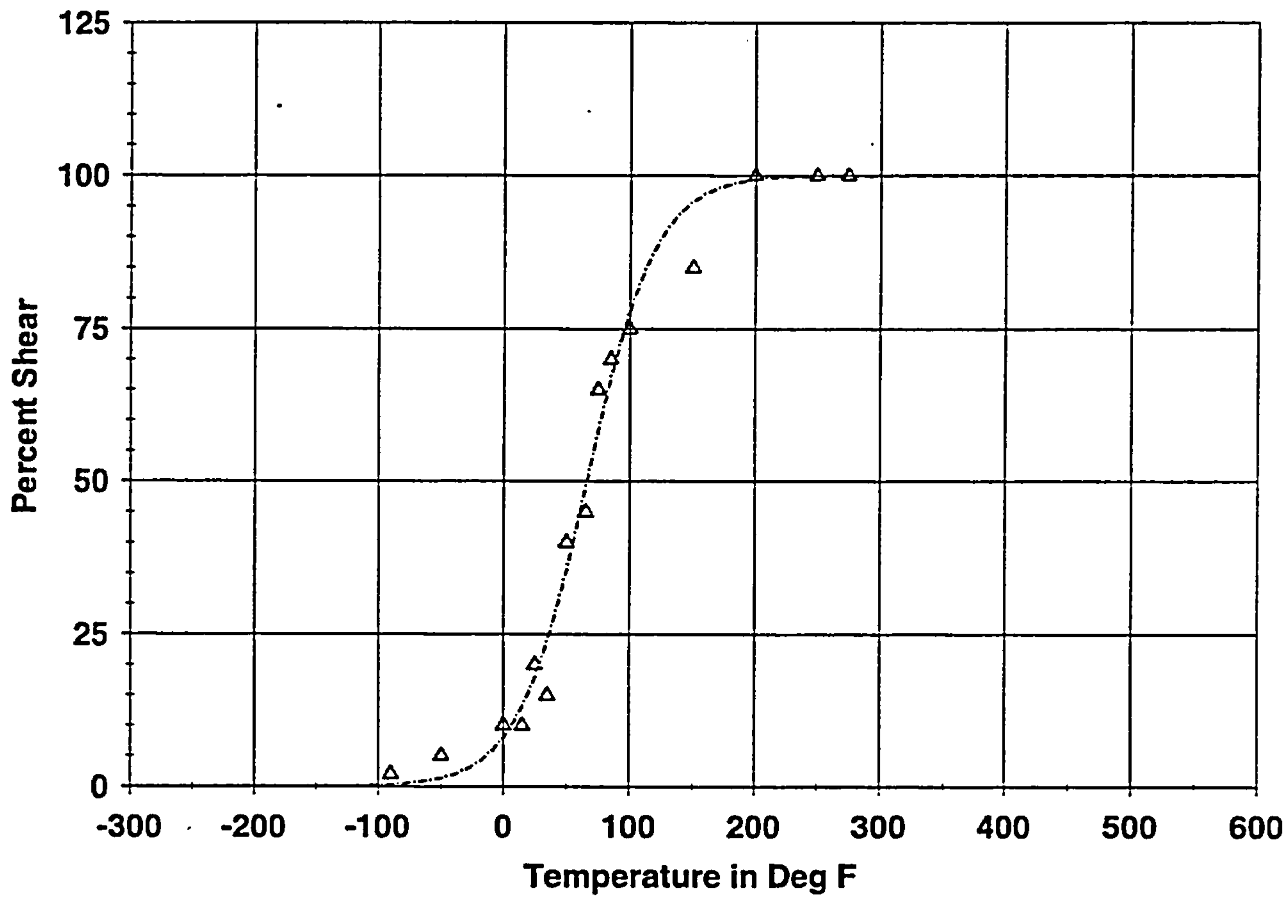
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
85.00	32.00	32.01	-.01
100.00	38.00	36.76	1.24
150.00	44.00	47.16	-3.16
200.00	54.00	50.92	3.08
250.00	53.00	52.01	.99
275.00	50.00	52.20	-2.20

Correlation Coefficient = .989

CAPSULE X LOWER SHELL PLATE B8628-2 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:31 PM
Page 1
Coefficients of Curve 4
A = 50. B = 50. C = 53.99 T0 = 66.11 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 66.2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-90.00	2.00	.31	1.69
-50.00	5.00	1.34	3.66
.00	10.00	7.95	2.05
15.00	10.00	13.09	-3.09
25.00	20.00	17.90	2.10
35.00	15.00	24.01	-9.01
50.00	40.00	35.51	4.49
65.00	45.00	48.98	-3.98
75.00	65.00	58.16	6.84

CAPSULE X LOWER SHELL PLATE B8628-2 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
85.00	70.00	66.82	3.18
100.00	75.00	77.83	-2.83
150.00	85.00	95.72	-10.72
200.00	100.00	99.30	.70
250.00	100.00	99.89	.11
275.00	100.00	99.96	.04

Correlation Coefficient = .992

CAPSULE W LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 01/18/2005 03:14 PM

Page 1

Coefficients of Curve 1

A = 35.6 B = 33.4 C = 93.76 T0 = 89.91 D = 0.00E+00

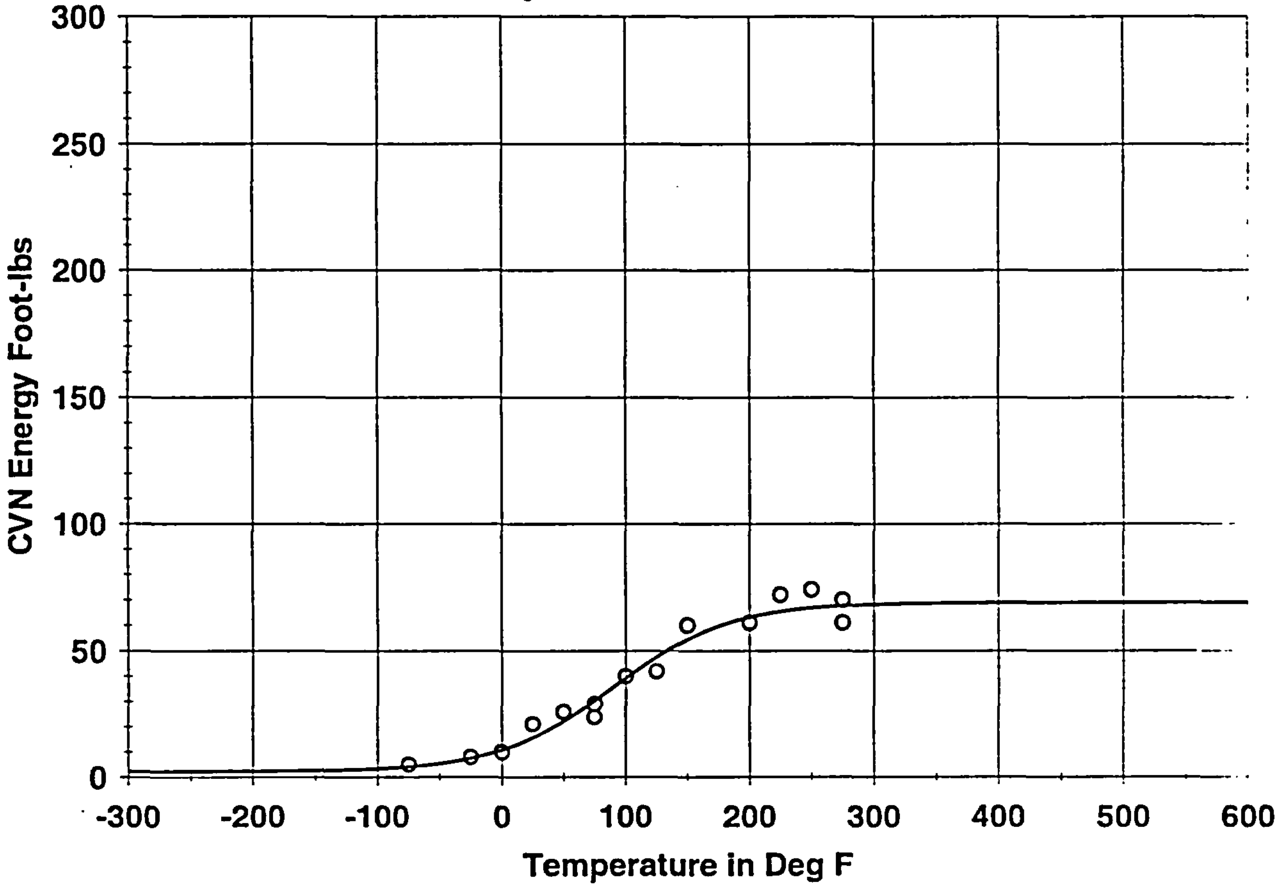
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=69.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=74.1 Deg F Temp@50 ft-lbs=133.2 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	5.00	4.12	.88
-25.00	8.00	7.50	.50
.00	10.00	10.76	-.76
25.00	21.00	15.58	5.42
50.00	26.00	22.18	3.82
75.00	29.00	30.33	-1.33
75.00	24.00	30.33	-6.33
100.00	40.00	39.18	.82
125.00	42.00	47.55	-5.55

CAPSULE W LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: W Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
150.00	60.00	54.49	5.51
200.00	61.00	63.18	-2.18
225.00	72.00	65.46	6.54
250.00	74.00	66.87	7.13
275.00	61.00	67.74	-6.74
275.00	70.00	67.74	2.26

Correlation Coefficient = .983

CAPSULE W LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:50 PM
Page 1
Coefficients of Curve 5

A = 27.92 B = 27.92 C = 95.34 T0 = 72.36 D = 0.00E+00

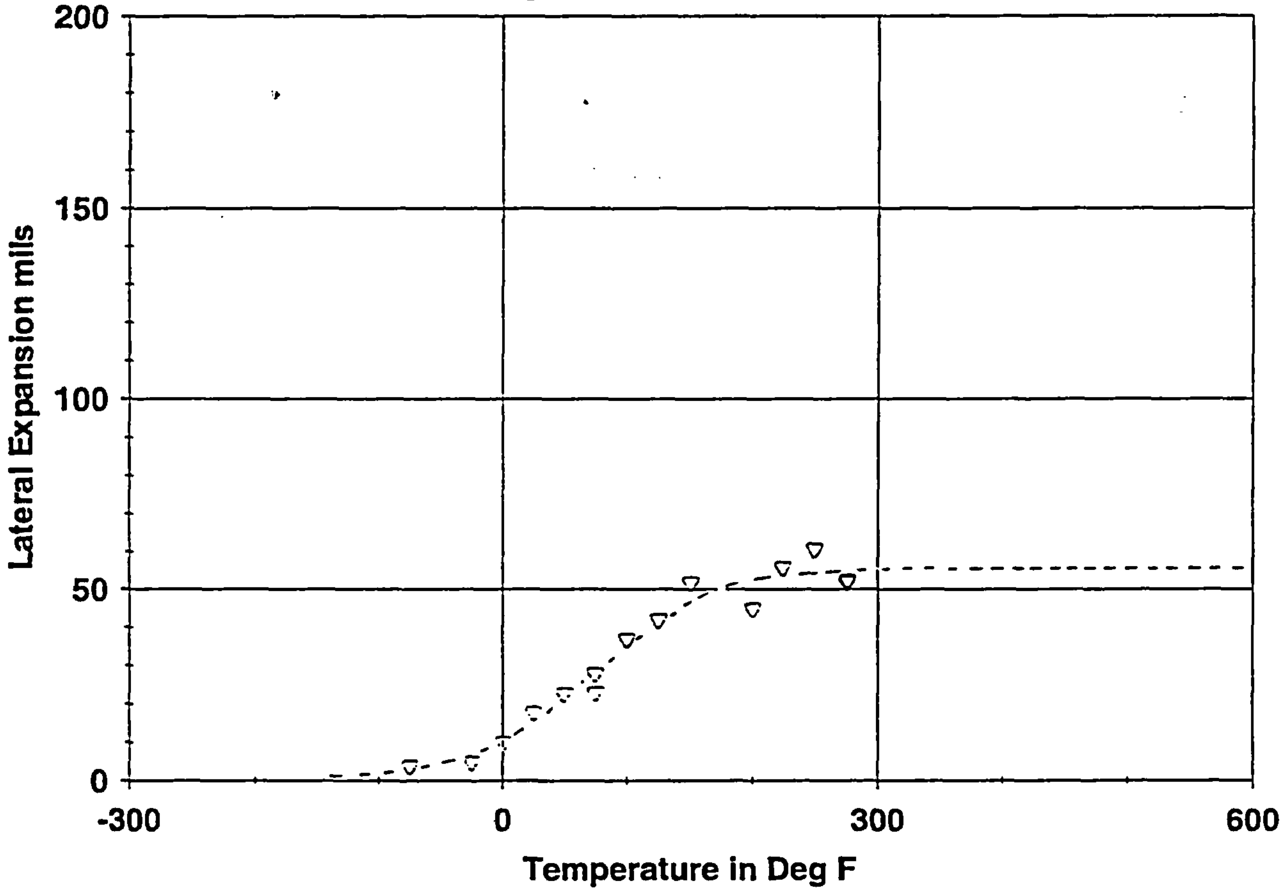
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=55.8 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=97.1 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: TL Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	4.00	2.43	1.57
-25.00	5.00	6.41	-1.41
.00	10.00	10.04	-.04
25.00	18.00	15.09	2.91
50.00	23.00	21.49	1.51
75.00	28.00	28.69	-.69
75.00	23.00	28.69	-5.69
100.00	37.00	35.80	1.20
125.00	42.00	41.94	.06

CAPSULE W LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: W Fluence: n/cm^2

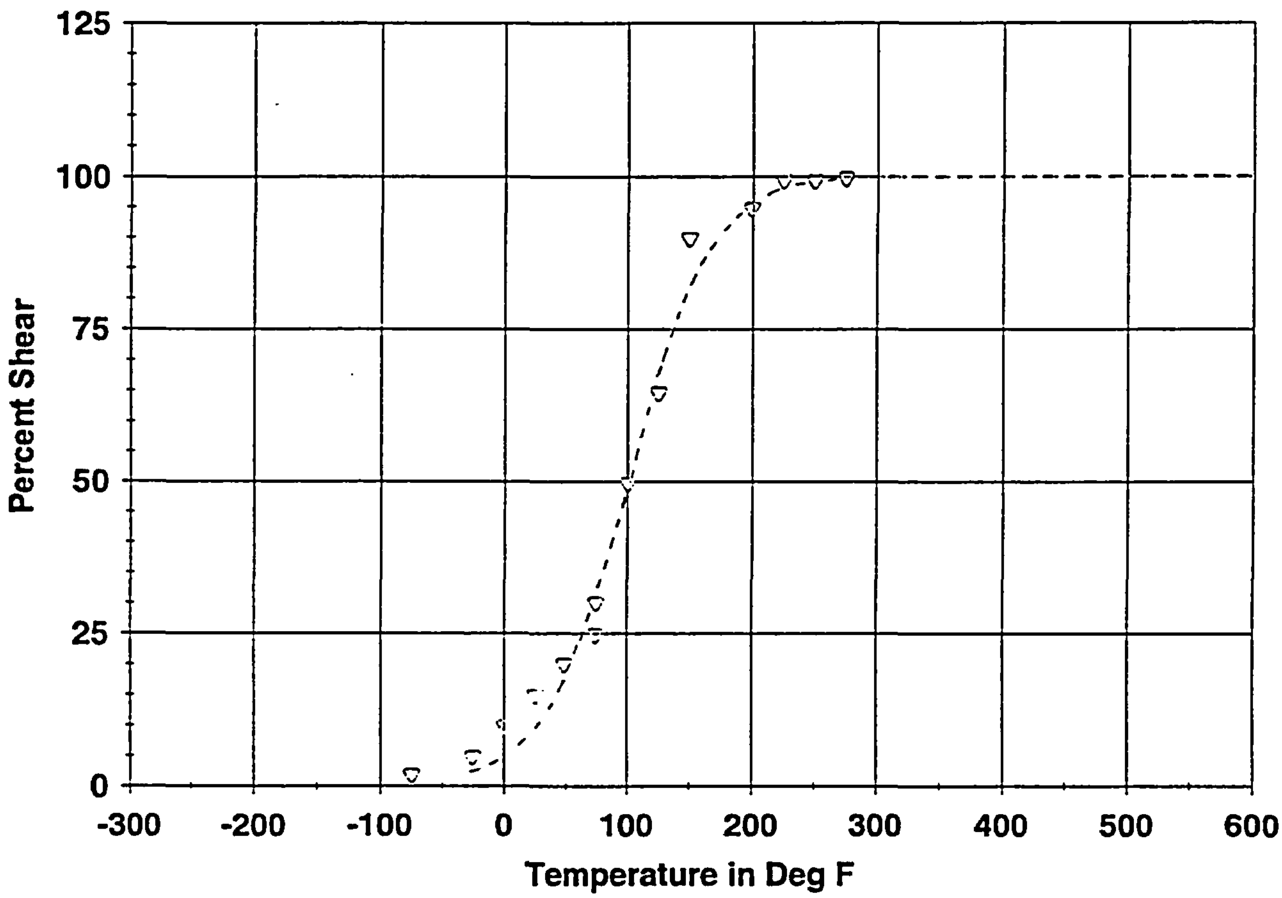
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
150.00	52.00	46.68	5.32
200.00	45.00	52.25	-7.25
225.00	56.00	53.66	2.34
250.00	61.00	54.53	6.47
275.00	53.00	55.06	-2.06
275.00	52.00	55.06	-3.06

Correlation Coefficient = .982

CAPSULE W LOWER SHELL PLATE B8628-1 (TRANSVERSE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/18/2004 03:31 PM
Page 1
Coefficients of Curve 5
A = 50. B = 50. C = 64.89 T0 = 100.3 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 100.4
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: TL Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	2.00	.45	1.55
-25.00	5.00	2.06	2.94
.00	10.00	4.35	5.65
25.00	15.00	8.94	6.06
50.00	20.00	17.50	2.50
75.00	30.00	31.43	-1.43
75.00	25.00	31.43	-6.43
100.00	50.00	49.77	.23
125.00	65.00	68.16	-3.16

CAPSULE W LOWER SHELL PLATE B8628-1 (TRANSVERSE)

Plant: Vogtle 2   Material: SA533B1   Heat: C3500-2
Orientation: TL   Capsule: W   Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
150.00	90.00	82.22	7.78
200.00	95.00	95.58	-.58
225.00	100.00	97.90	2.10
250.00	100.00	99.02	.98
275.00	100.00	99.54	.46
275.00	100.00	99.54	.46

Correlation Coefficient = .996

UNIRRADIATED (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 01:20 PM

Page 1

Coefficients of Curve 1

A = 47.1 B = 44.9 C = 65.02 T0 = 6.8 D = 0.00E+00

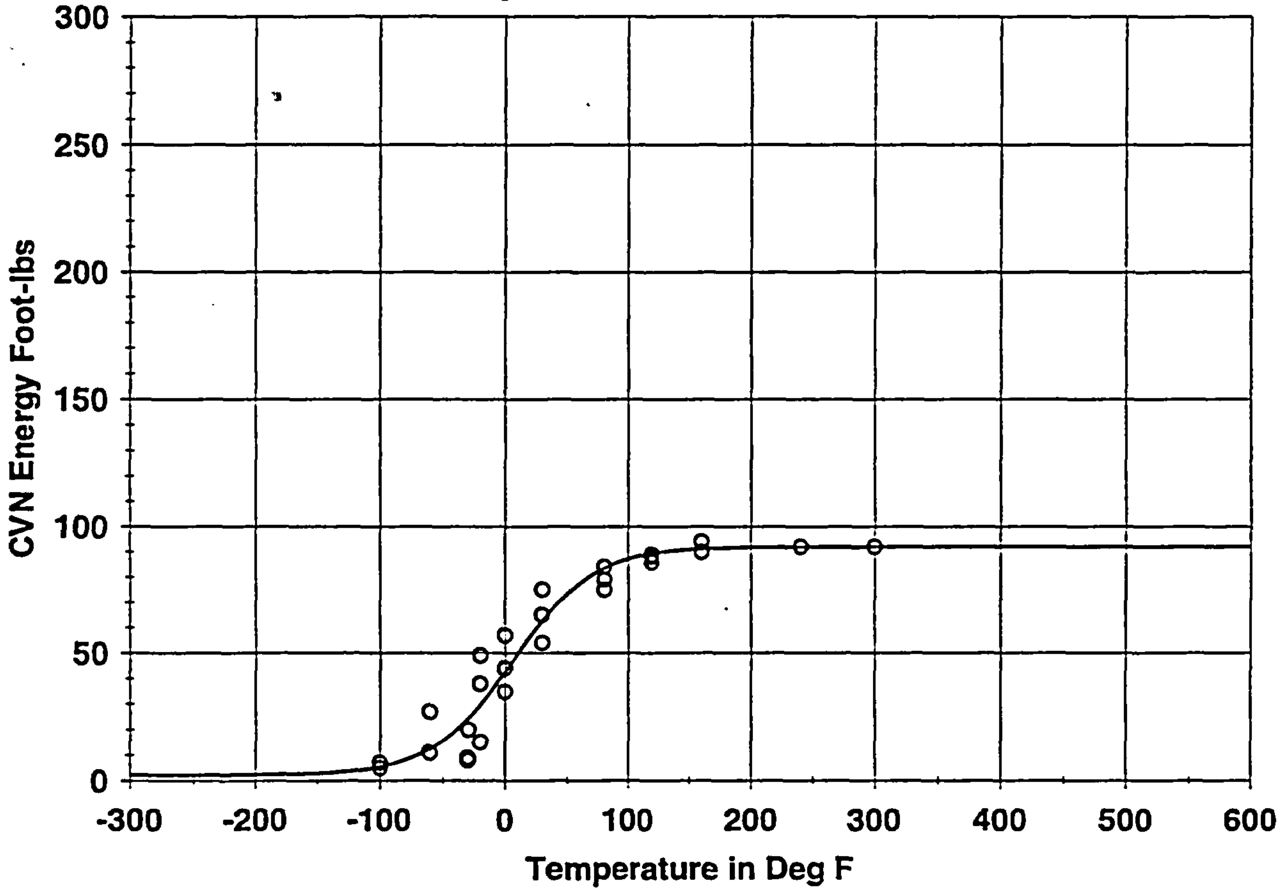
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=92.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=-19.2 Deg F Temp@50 ft-lbs=11.1 Deg F

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-100.00	5.00	5.44	-.44
-100.00	7.00	5.44	1.56
-100.00	7.00	5.44	1.56
-60.00	11.00	12.40	-1.40
-60.00	11.00	12.40	-1.40
-60.00	27.00	12.40	14.60
-30.00	8.00	24.09	-16.09
-30.00	9.00	24.09	-15.09
-30.00	20.00	24.09	-4.09

UNIRRADIATED (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-20.00	15.00	29.57	-14.57
-20.00	38.00	29.57	8.43
-20.00	49.00	29.57	19.43
.00	35.00	42.42	-7.42
.00	44.00	42.42	1.58
.00	57.00	42.42	14.58
30.00	54.00	62.47	-8.47
30.00	65.00	62.47	2.53
30.00	75.00	62.47	12.53
80.00	75.00	83.45	-8.45
80.00	79.00	83.45	-4.45
80.00	84.00	83.45	.55
120.00	86.00	89.32	-3.32
120.00	88.00	89.32	-1.32
120.00	89.00	89.32	-.32
160.00	90.00	91.20	-1.20
160.00	90.00	91.20	-1.20
160.00	94.00	91.20	2.80
240.00	92.00	91.93	.07
240.00	92.00	91.93	.07
300.00	92.00	91.99	.01
300.00	92.00	91.99	.01

Correlation Coefficient = .971

UNIRRADIATED (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 04:15 PM

Page 1

Coefficients of Curve 1

A = 40.21 B = 40.21 C = 68.68 T0 = 7.85 D = 0.00E+00

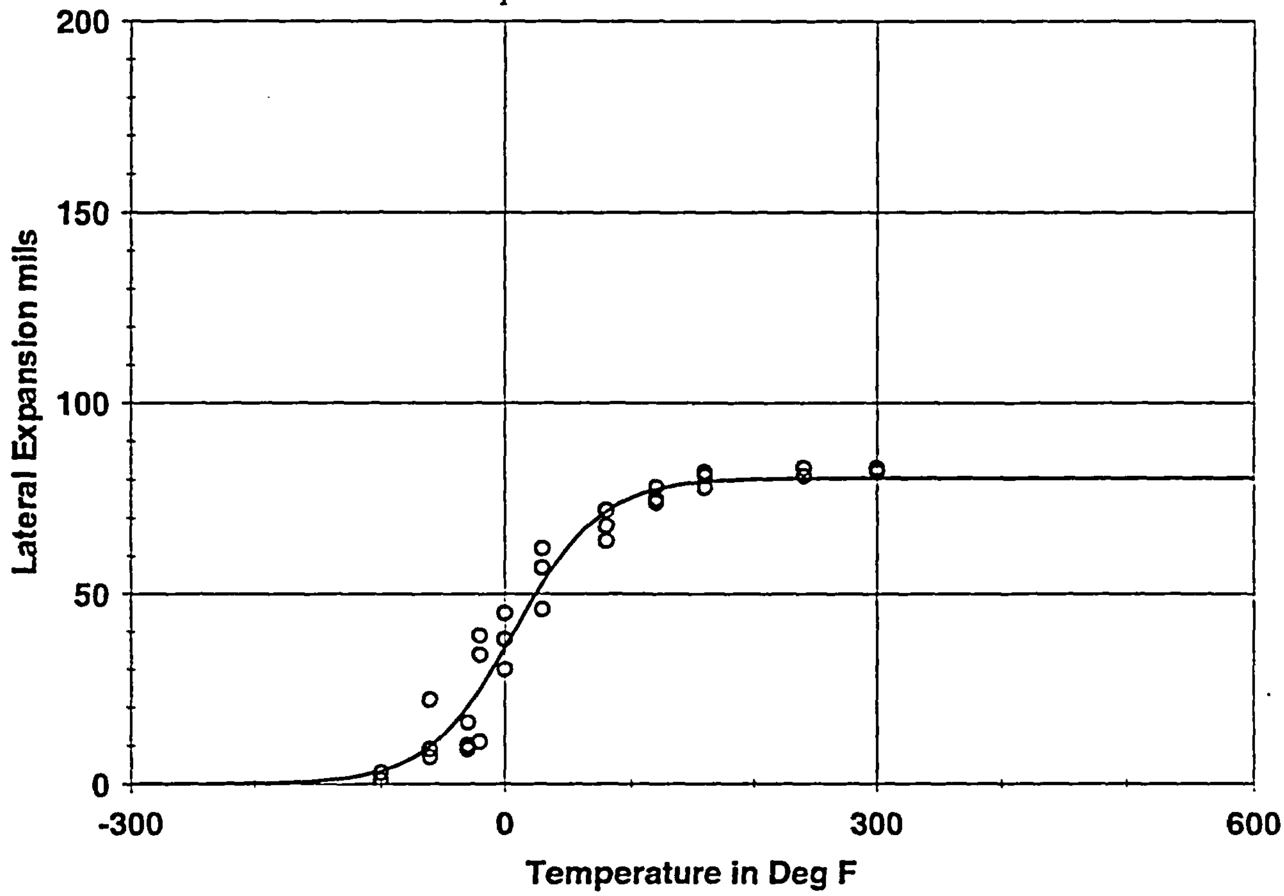
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=80.4 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=-1.0 Deg F

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-100.00	1.00	3.33	-2.33
-100.00	3.00	3.33	-.33
-100.00	3.00	3.33	-.33
-60.00	9.00	9.79	-.79
-60.00	7.00	9.79	-2.79
-60.00	22.00	9.79	12.21
-30.00	9.00	20.05	-11.05
-30.00	10.00	20.05	-10.05
-30.00	16.00	20.05	-4.05

UNIRRADIATED (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: UNIRR Fluence: n/cm^2

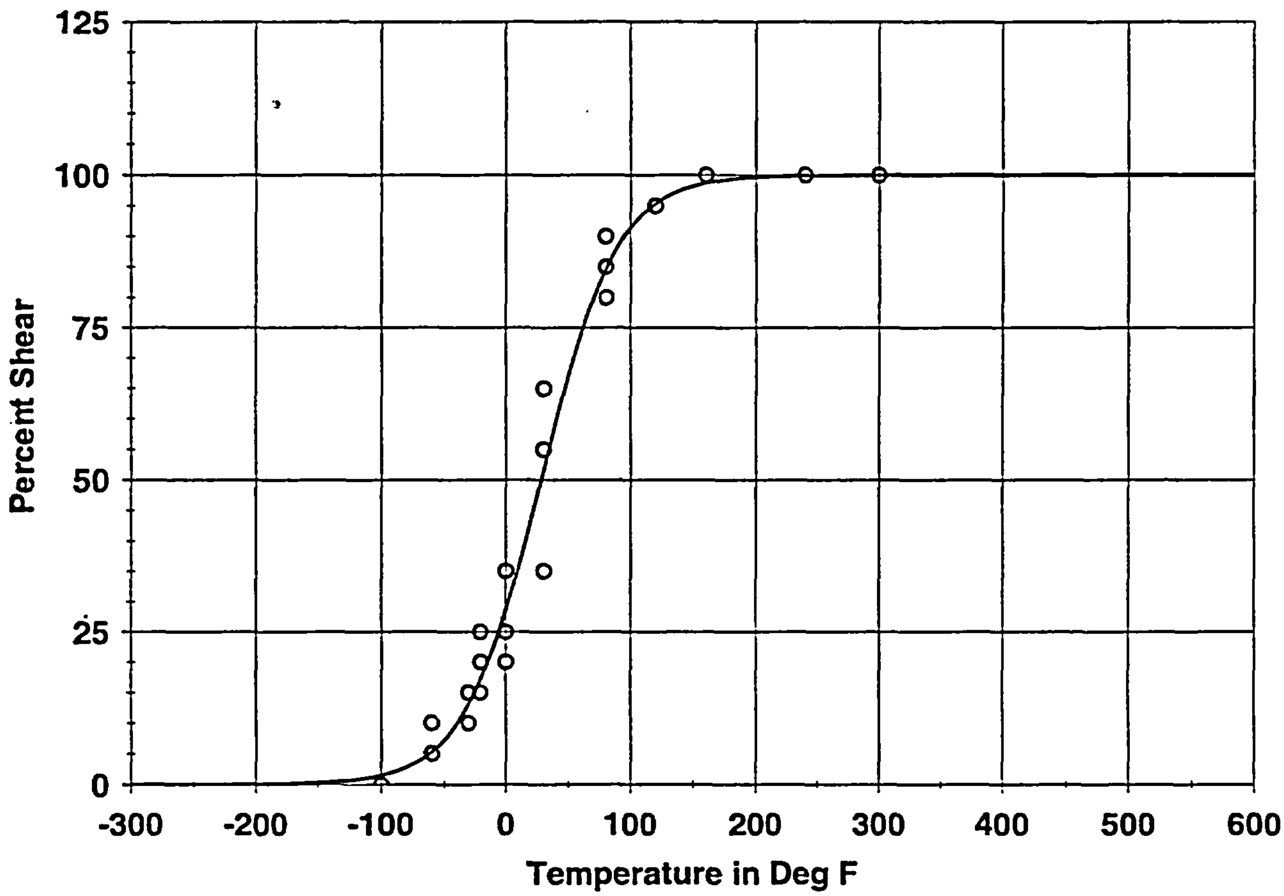
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-20.00	11.00	24.74	-13.74
-20.00	34.00	24.74	9.26
-20.00	39.00	24.74	14.26
.00	30.00	35.63	-5.63
.00	38.00	35.63	2.37
.00	45.00	35.63	9.37
30.00	46.00	52.74	-6.74
30.00	57.00	52.74	4.26
30.00	62.00	52.74	9.26
80.00	64.00	71.65	-7.65
80.00	68.00	71.65	-3.65
80.00	72.00	71.65	.35
120.00	74.00	77.46	-3.46
120.00	75.00	77.46	-2.46
120.00	78.00	77.46	.54
160.00	81.00	79.47	1.53
160.00	78.00	79.47	-1.47
160.00	82.00	79.47	2.53
240.00	81.00	80.32	.68
240.00	83.00	80.32	2.68
300.00	82.00	80.40	1.60
300.00	83.00	80.40	2.60

Correlation Coefficient = .977

UNIRRADIATED (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 03:49 PM
Page 1
Coefficients of Curve 1
A = 50. B = 50. C = 61.01 T0 = 28.04 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 28.1
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-100.00	.00	1.48	-1.48
-100.00	.00	1.48	-1.48
-100.00	.00	1.48	-1.48
-60.00	5.00	5.28	-.28
-60.00	5.00	5.28	-.28
-60.00	10.00	5.28	4.72
-30.00	10.00	12.98	-2.98
-30.00	15.00	12.98	2.02
-30.00	10.00	12.98	-2.98

UNIRRADIATED (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-20.00	15.00	17.15	-2.15
-20.00	20.00	17.15	2.85
-20.00	25.00	17.15	7.85
.00	25.00	28.51	-3.51
.00	20.00	28.51	-8.51
.00	35.00	28.51	6.49
30.00	35.00	51.60	-16.60
30.00	55.00	51.60	3.40
30.00	65.00	51.60	13.40
80.00	80.00	84.60	-4.60
80.00	85.00	84.60	.40
80.00	90.00	84.60	5.40
120.00	95.00	95.32	-.32
120.00	95.00	95.32	-.32
120.00	95.00	95.32	-.32
160.00	100.00	98.70	1.30
160.00	100.00	98.70	1.30
160.00	100.00	98.70	1.30
240.00	100.00	99.90	.10
240.00	100.00	99.90	.10
300.00	100.00	99.99	.01
300.00	100.00	99.99	.01

Correlation Coefficient = .992

CAPSULE U (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 01:20 PM

Page 1

Coefficients of Curve 2

A = 50.1 B = 47.9 C = 82.01 T0 = .14 D = 0.00E+00

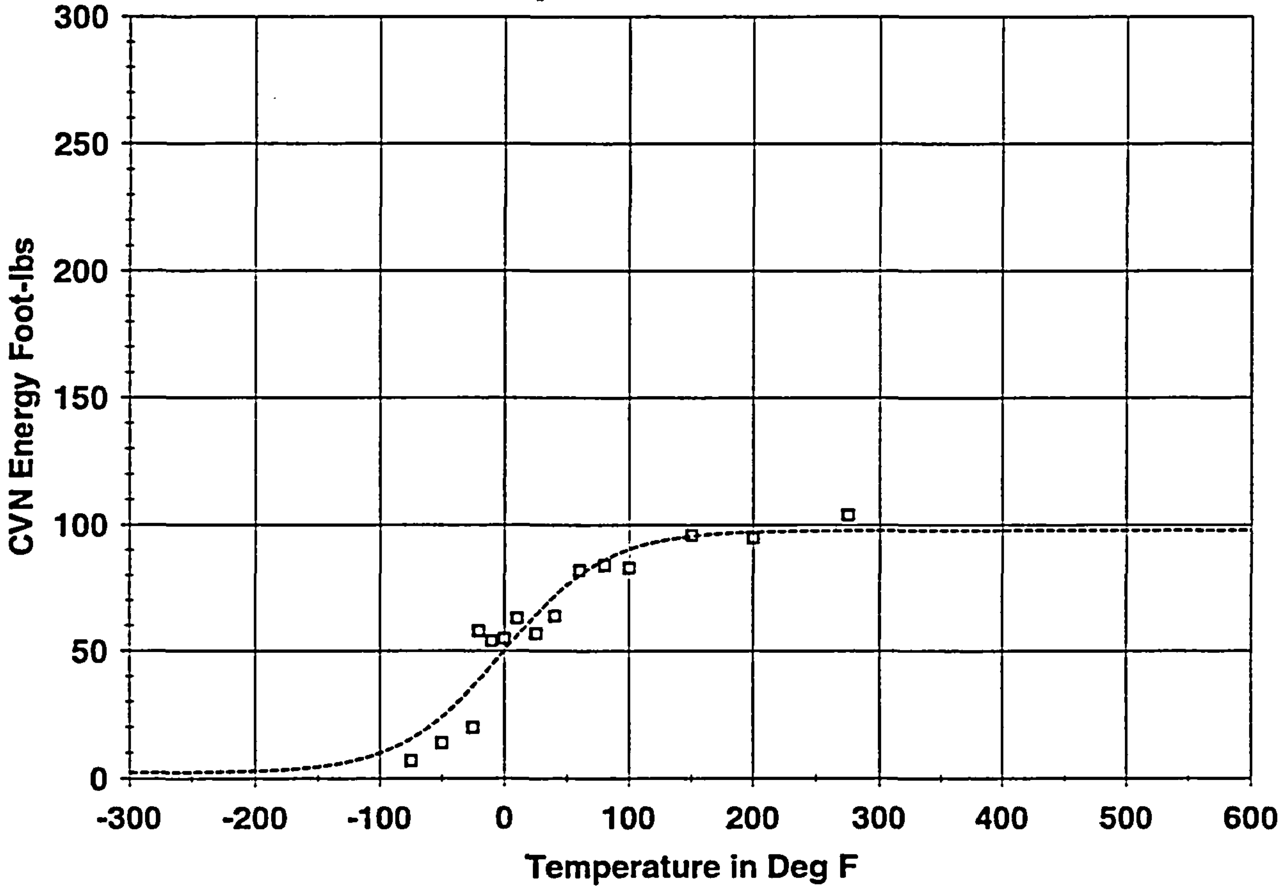
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=98.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=-36.5 Deg F Temp@50 ft-lbs=.0 Deg F

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	7.00	15.42	-8.42
-50.00	14.00	23.99	-9.99
-25.00	20.00	35.86	-15.86
-20.00	58.00	38.57	19.43
-10.00	54.00	44.21	9.79
.00	55.00	50.02	4.98
10.00	63.00	55.83	7.17
25.00	57.00	64.19	-7.19
40.00	64.00	71.71	-7.71

CAPSULE U (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: U Fluence: n/cm^2

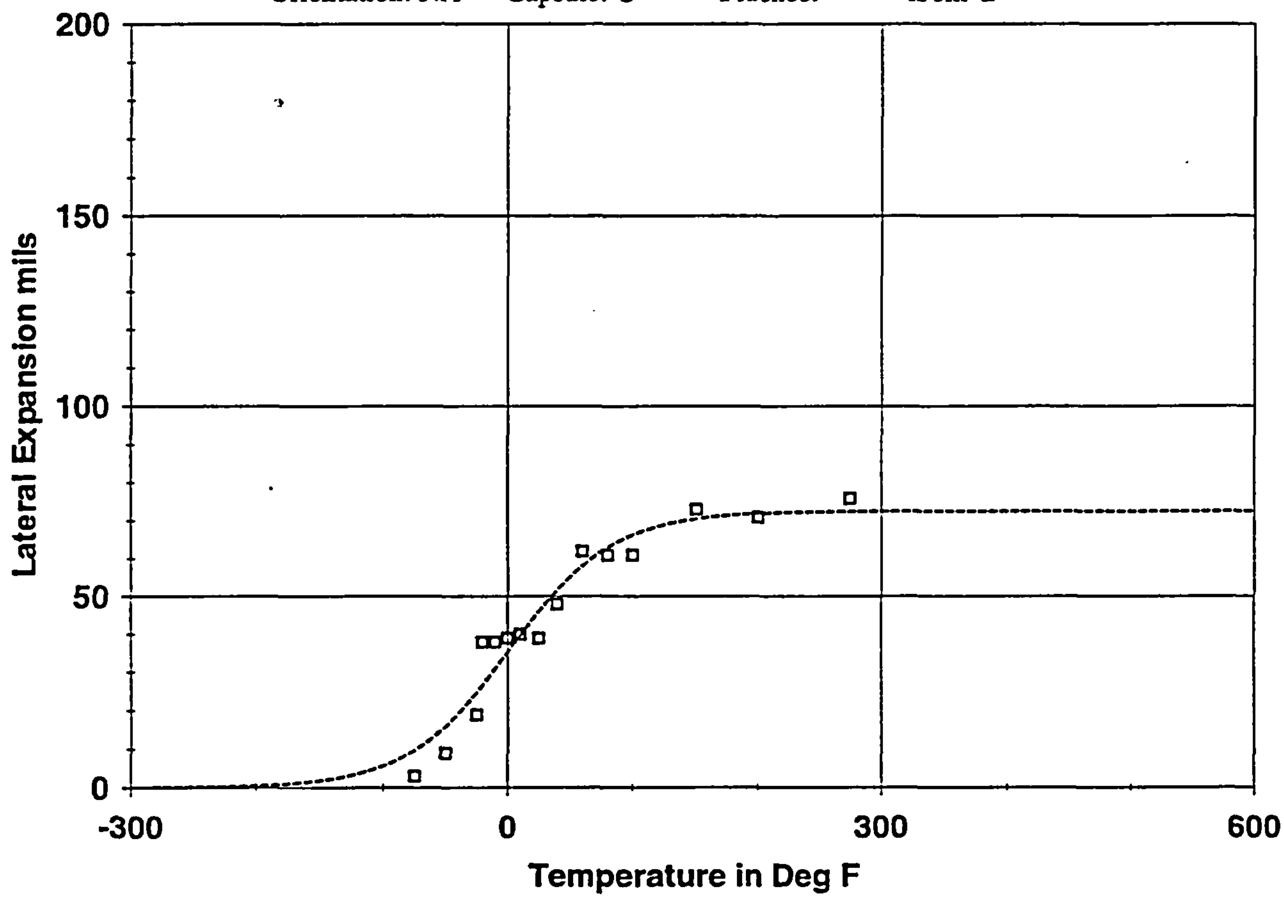
Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
60.00	82.00	79.94	2.06
80.00	84.00	86.04	-2.04
100.00	83.00	90.29	-7.29
150.00	96.00	95.58	.42
200.00	95.00	97.27	-2.27
275.00	104.00	97.88	6.12

Correlation Coefficient = .952

CAPSULE U (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 04:15 PM
Page 1
Coefficients of Curve 2
A = 36.28 B = 36.28 C = 82.97 T0 = 2.59 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf L.E.=72.6 Lower Shelf L.E.=.0(Fixed)
Temp.@L.E. 35 mils=-.3 Deg F
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	3.00	9.69	-6.69
-50.00	9.00	15.94	-6.94
-25.00	19.00	24.64	-5.64
-20.00	38.00	26.64	11.36
-10.00	38.00	30.81	7.19
.00	39.00	35.14	3.86
10.00	40.00	39.51	.49
25.00	39.00	45.84	-6.84
40.00	48.00	51.61	-3.61

CAPSULE U (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
60.00	62.00	58.01	3.99
80.00	61.00	62.83	-1.83
100.00	61.00	66.22	-5.22
150.00	73.00	70.53	2.47
200.00	71.00	71.93	-.93
275.00	76.00	72.45	3.55

Correlation Coefficient = .969

CAPSULE U (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 03:49 PM

Page 1

Coefficients of Curve 2

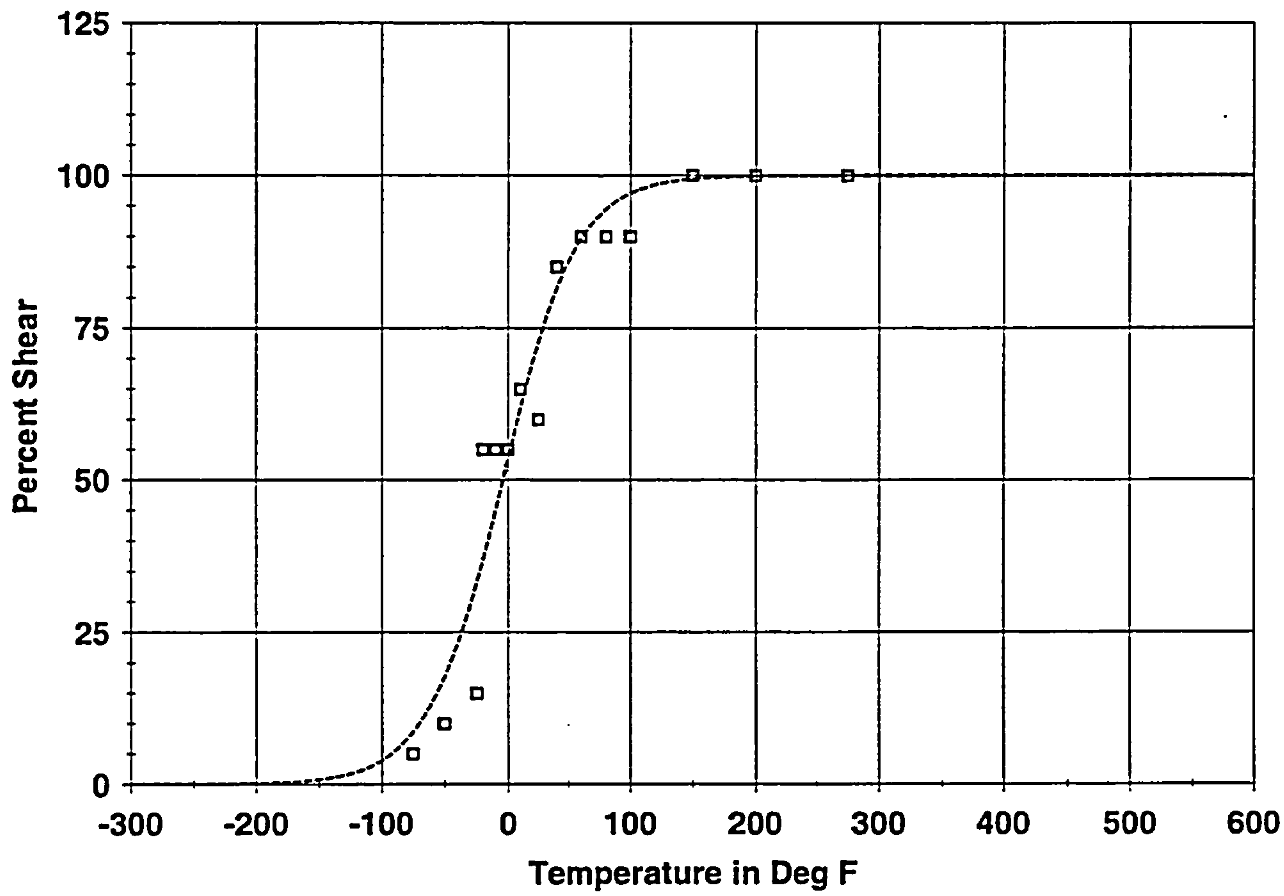
A = 50. B = 50. C = 59.67 T0 = -4.16 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = -4.1

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	5.00	8.52	-3.52
-50.00	10.00	17.71	-7.71
-25.00	15.00	33.21	-18.21
-20.00	55.00	37.03	17.97
-10.00	55.00	45.12	9.88
.00	55.00	53.48	1.52
10.00	65.00	61.65	3.35
25.00	60.00	72.66	-12.66
40.00	85.00	81.46	3.54

CAPSULE U (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
60.00	90.00	89.57	.43
80.00	90.00	94.38	-4.38
100.00	90.00	97.04	-7.04
150.00	100.00	99.43	.57
200.00	100.00	99.89	.11
275.00	100.00	99.99	.01

Correlation Coefficient = .965

CAPSULE Y (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 01:20 PM

Page 1

Coefficients of Curve 3

A = 44.1 B = 41.9 C = 66.07 T0 = 22.56 D = 0.00E+00

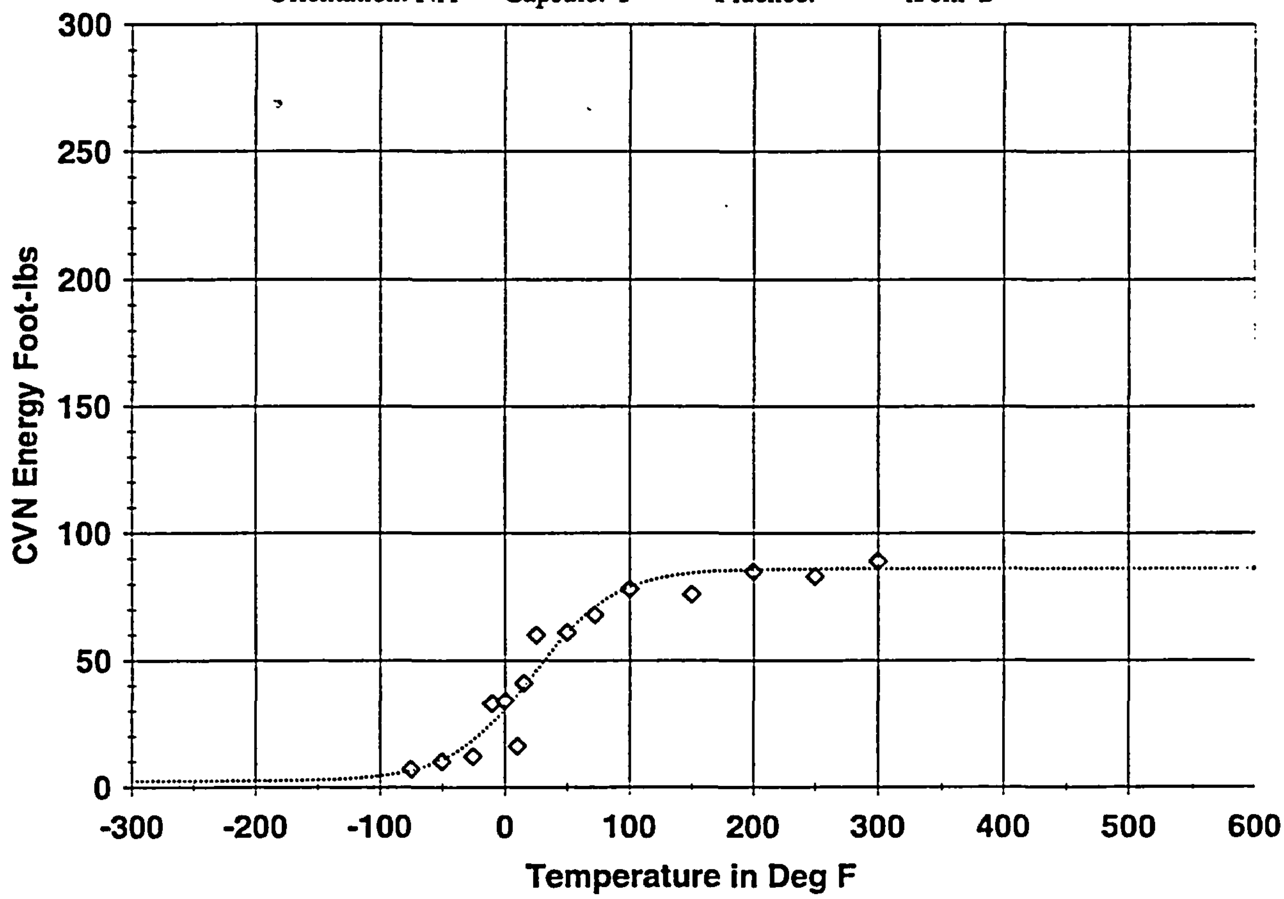
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=86.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=-.5 Deg F Temp@50 ft-lbs=32.0 Deg F

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-75.00	7.00	6.36	.64
-50.00	10.00	10.59	-.59
-25.00	12.00	18.26	-6.26
-10.00	33.00	24.98	8.02
.00	34.00	30.32	3.68
10.00	16.00	36.23	-20.23
15.00	41.00	39.33	1.67
25.00	60.00	45.65	14.35
50.00	61.00	60.57	.43

CAPSULE Y (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: Y Fluence: n/cm^2

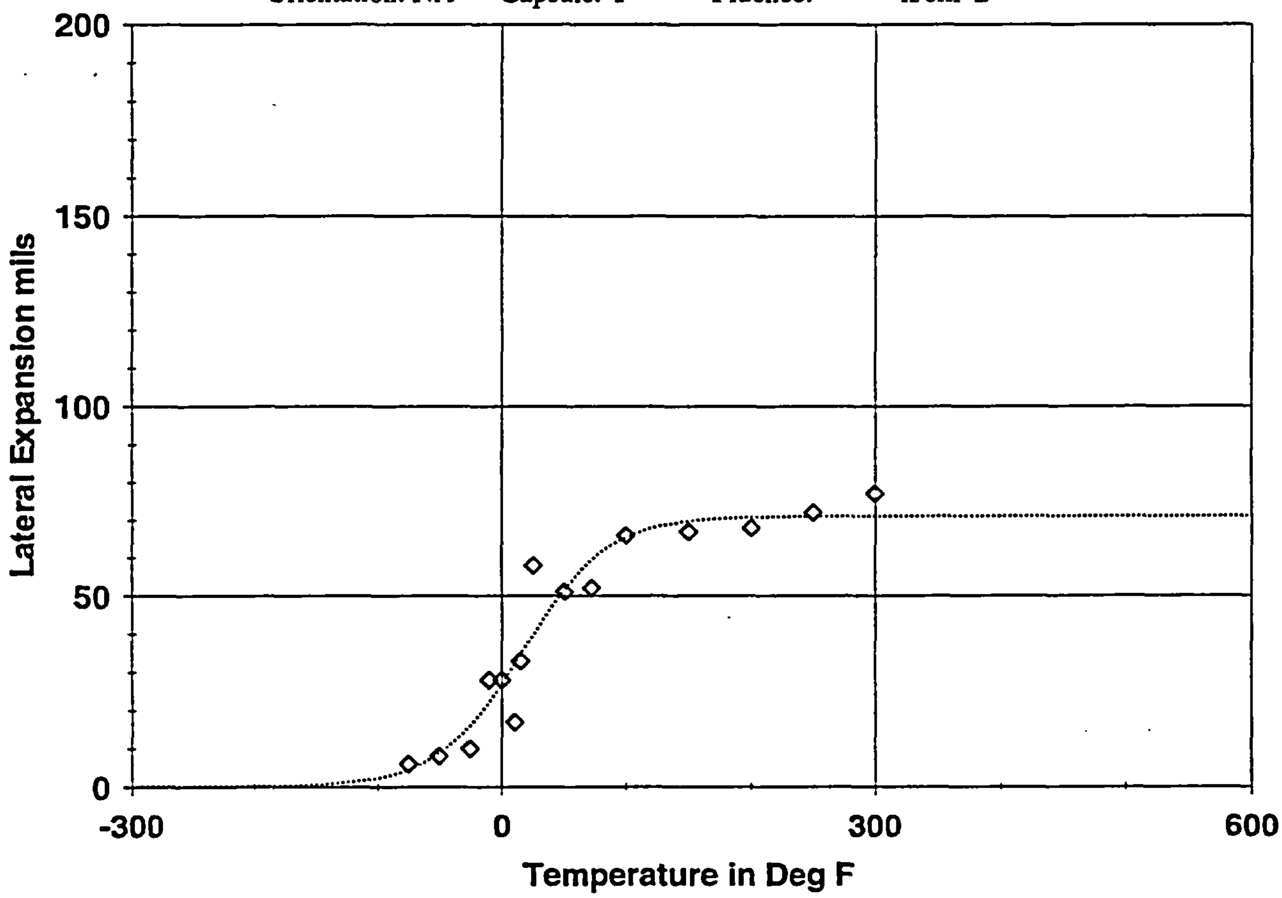
Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
72.00	68.00	70.67	-2.67
100.00	78.00	78.67	-.67
150.00	76.00	84.27	-8.27
200.00	85.00	85.61	-.61
250.00	83.00	85.91	-2.91
300.00	89.00	85.98	3.02

Correlation Coefficient = .967

CAPSULE Y (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 04:15 PM
Page 1
Coefficients of Curve 3
A = 35.51 B = 35.51 C = 67.92 T0 = 17.15 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf L.E.=71.0 Lower Shelf L.E.=.0(Fixed)
Temp.@L.E. 35 mils=16.2 Deg F
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-75.00	6.00	4.42	1.58
-50.00	8.00	8.64	-.64
-25.00	10.00	15.93	-5.93
-10.00	28.00	22.03	5.97
.00	28.00	26.73	1.27
10.00	17.00	31.79	-14.79
15.00	33.00	34.39	-1.39
25.00	58.00	39.60	18.40
50.00	51.00	51.46	-.46

CAPSULE Y (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: Y Fluence: n/cm^2

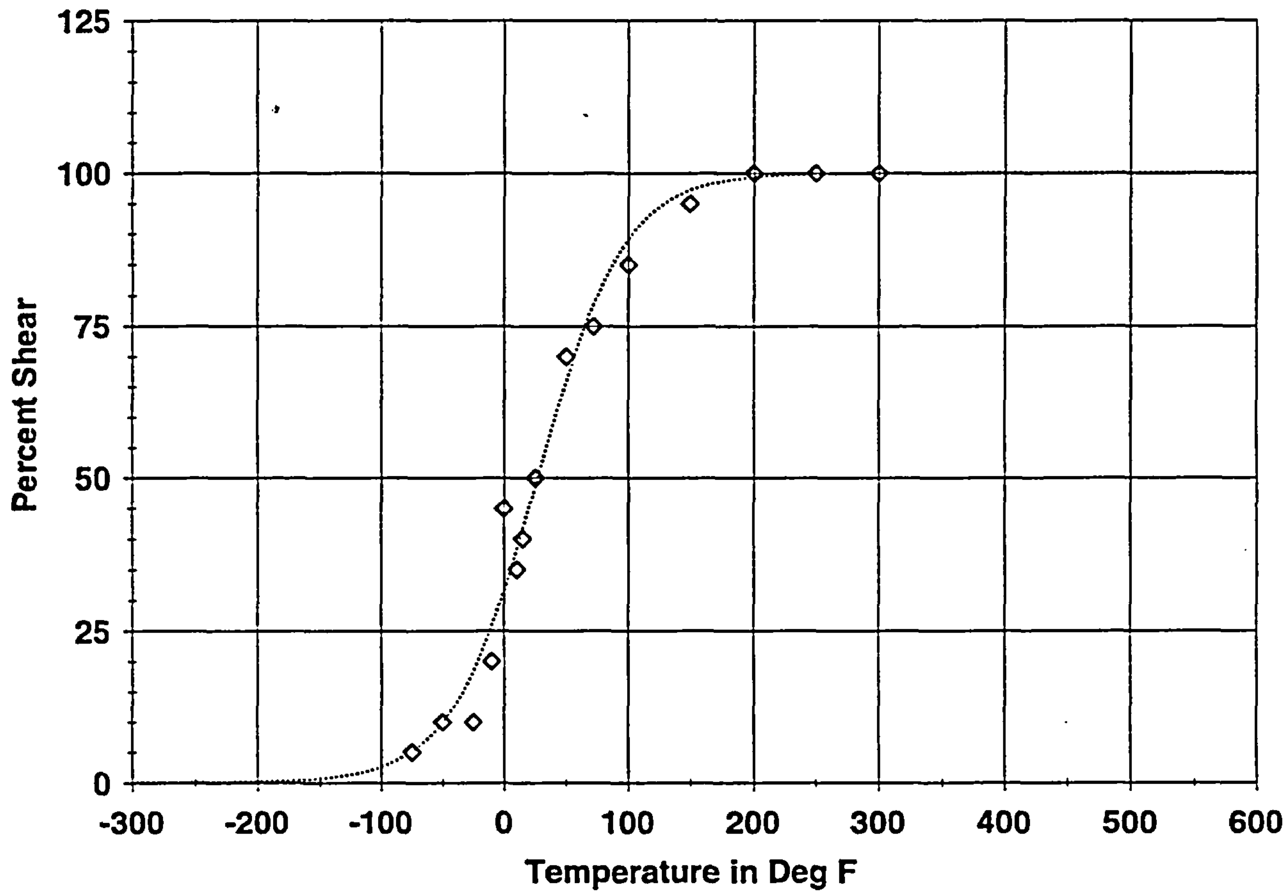
Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
72.00	52.00	59.24	-7.24
100.00	66.00	65.33	.67
150.00	67.00	69.63	-2.63
200.00	68.00	70.70	-2.70
250.00	72.00	70.95	1.05
300.00	77.00	71.01	5.99

Correlation Coefficient = .958

CAPSULE Y (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 03:49 PM
Page 1
Coefficients of Curve 3
A = 50. B = 50. C = 69.74 T0 = 27.24 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Temperature at 50% Shear = 27.3
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75.00	5.00	5.06	-.06
-50.00	10.00	9.84	.16
-25.00	10.00	18.27	-8.27
-10.00	20.00	25.58	-5.58
.00	45.00	31.40	13.60
10.00	35.00	37.88	-2.88
15.00	40.00	41.31	-1.31
25.00	50.00	48.39	1.61
50.00	70.00	65.76	4.24

CAPSULE Y (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: Y Fluence: n/cm^2

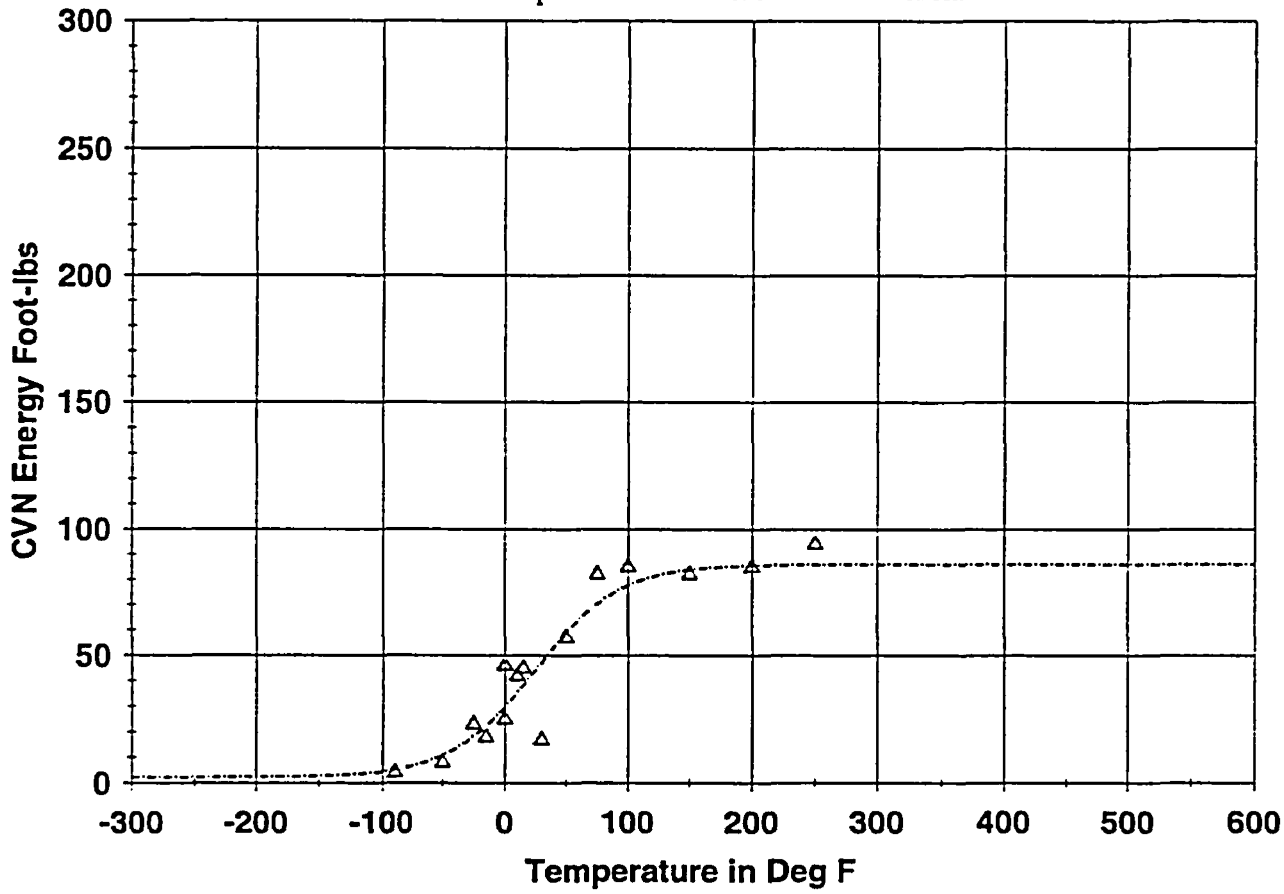
Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72.00	75.00	78.31	-3.31
100.00	85.00	88.96	-3.96
150.00	95.00	97.13	-2.13
200.00	100.00	99.30	.70
250.00	100.00	99.83	.17
300.00	100.00	99.96	.04

Correlation Coefficient = .990

CAPSULE X (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 01:20 PM
Page 1
Coefficients of Curve 4
A = 44.1 B = 41.9 C = 68.71 T0 = 24.7 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf Energy=87.0(Fixed) Lower Shelf Energy=2.2(Fixed)
Temp@30 ft-lbs=.7 Deg F Temp@50 ft-lbs=34.5 Deg F
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-90.00	4.00	5.07	-1.07
-50.00	8.00	10.76	-2.76
-25.00	23.00	18.17	4.83
-15.00	18.00	22.27	-4.27
.00	25.00	29.66	-4.66
.00	46.00	29.66	16.34
10.00	42.00	35.27	6.73
15.00	45.00	38.23	6.77
30.00	17.00	47.33	-30.33

CAPSULE X (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
50.00	57.00	58.87	-1.87
75.00	82.00	70.26	11.74
100.00	85.00	77.58	7.42
150.00	82.00	83.87	-1.87
200.00	85.00	85.49	-.49
250.00	94.00	85.88	8.12

Correlation Coefficient = .941

CAPSULE X (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 04:15 PM
Page 1
Coefficients of Curve 4

A = 35.61 B = 35.61 C = 63.83 T0 = 29.18 D = 0.00E+00

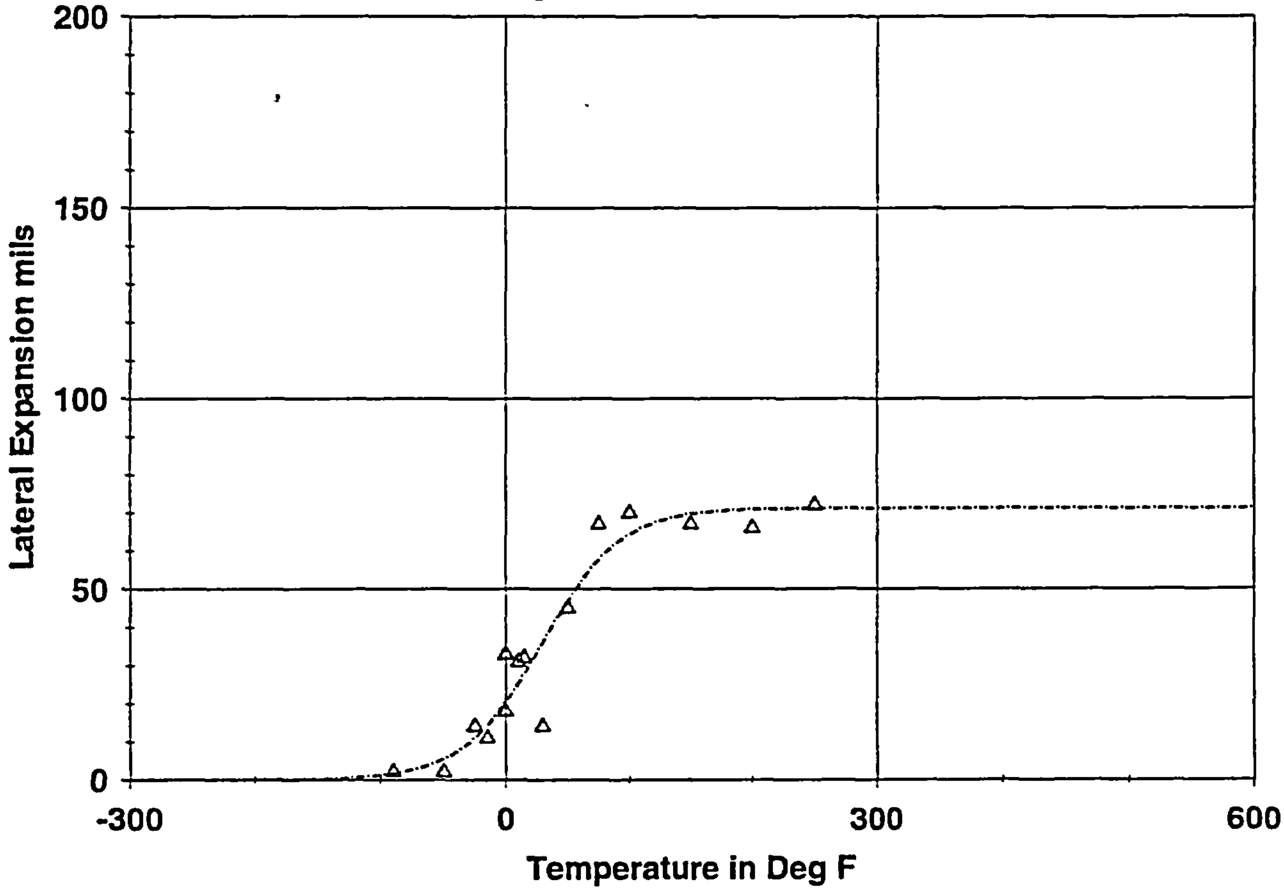
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=71.2 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=28.1 Deg F

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-90.00	2.00	1.66	.34
-50.00	2.00	5.50	-3.50
-25.00	14.00	11.02	2.98
-15.00	11.00	14.27	-3.27
.00	18.00	20.38	-2.38
.00	33.00	20.38	12.62
10.00	31.00	25.22	5.78
15.00	32.00	27.83	4.17
30.00	14.00	36.07	-22.07

CAPSULE X (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
50.00	45.00	46.83	-1.83
75.00	67.00	57.53	9.47
100.00	70.00	64.24	5.76
150.00	67.00	69.64	-2.64
200.00	66.00	70.89	-4.89
250.00	72.00	71.15	.85

Correlation Coefficient = .953

CAPSULE X (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 03:50 PM

Page 1

Coefficients of Curve 4

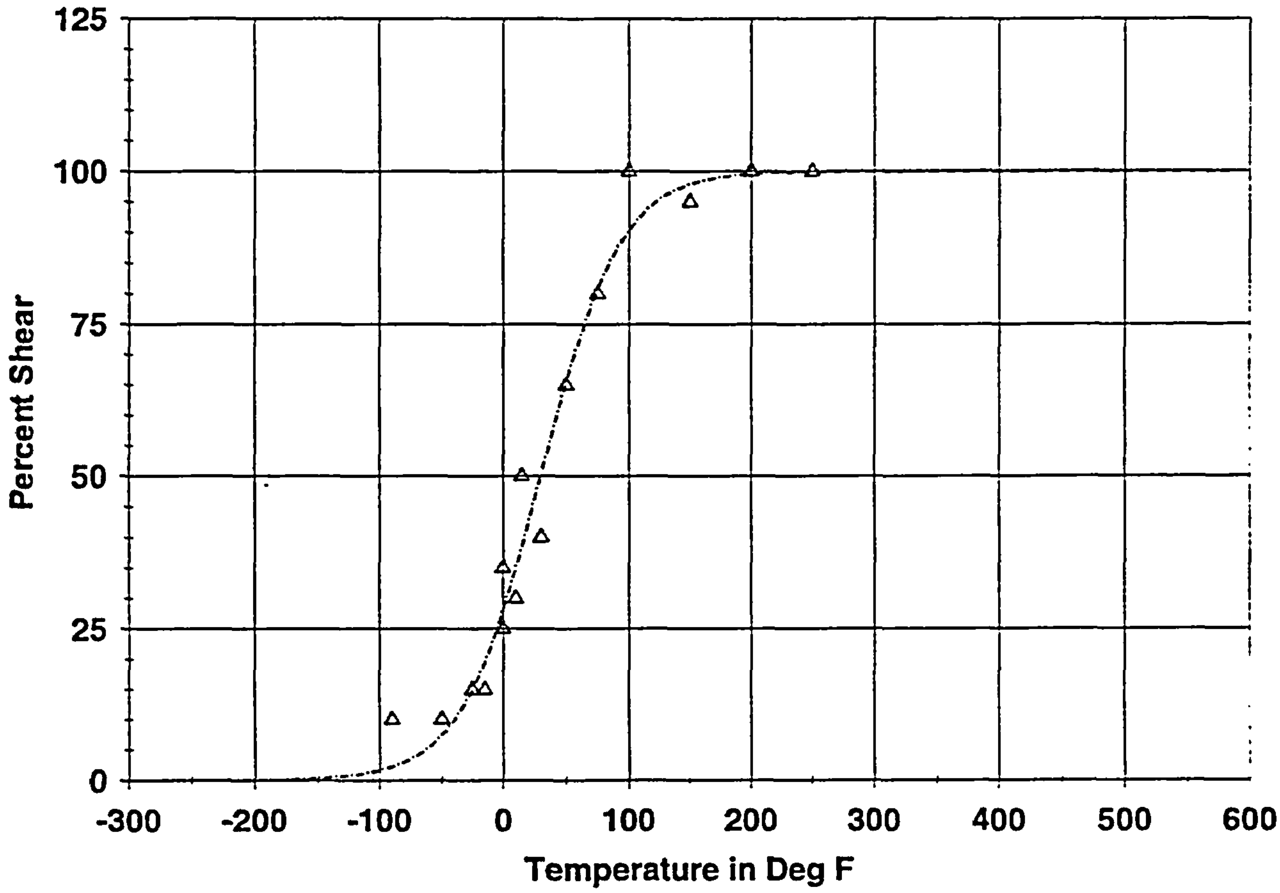
A = 50. B = 50. C = 63.06 T0 = 29.69 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 29.7

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-90.00	10.00	2.20	7.80
-50.00	10.00	7.40	2.60
-25.00	15.00	15.00	.00
-15.00	15.00	19.51	-4.51
.00	25.00	28.06	-3.06
.00	35.00	28.06	6.94
10.00	30.00	34.88	-4.88
15.00	50.00	38.56	11.44
30.00	40.00	50.25	-10.25

CAPSULE X (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
50.00	65.00	65.57	-.57
75.00	80.00	80.80	-.80
100.00	100.00	90.29	9.71
150.00	95.00	97.85	-2.85
200.00	100.00	99.55	.45
250.00	100.00	99.91	.09

Correlation Coefficient = .986

CAPSULE W (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 01/18/2005 03:13 PM

Page 1

Coefficients of Curve 1

A = 44.6 B = 42.4 C = 96.14 T0 = 46.66 D = 0.00E+00

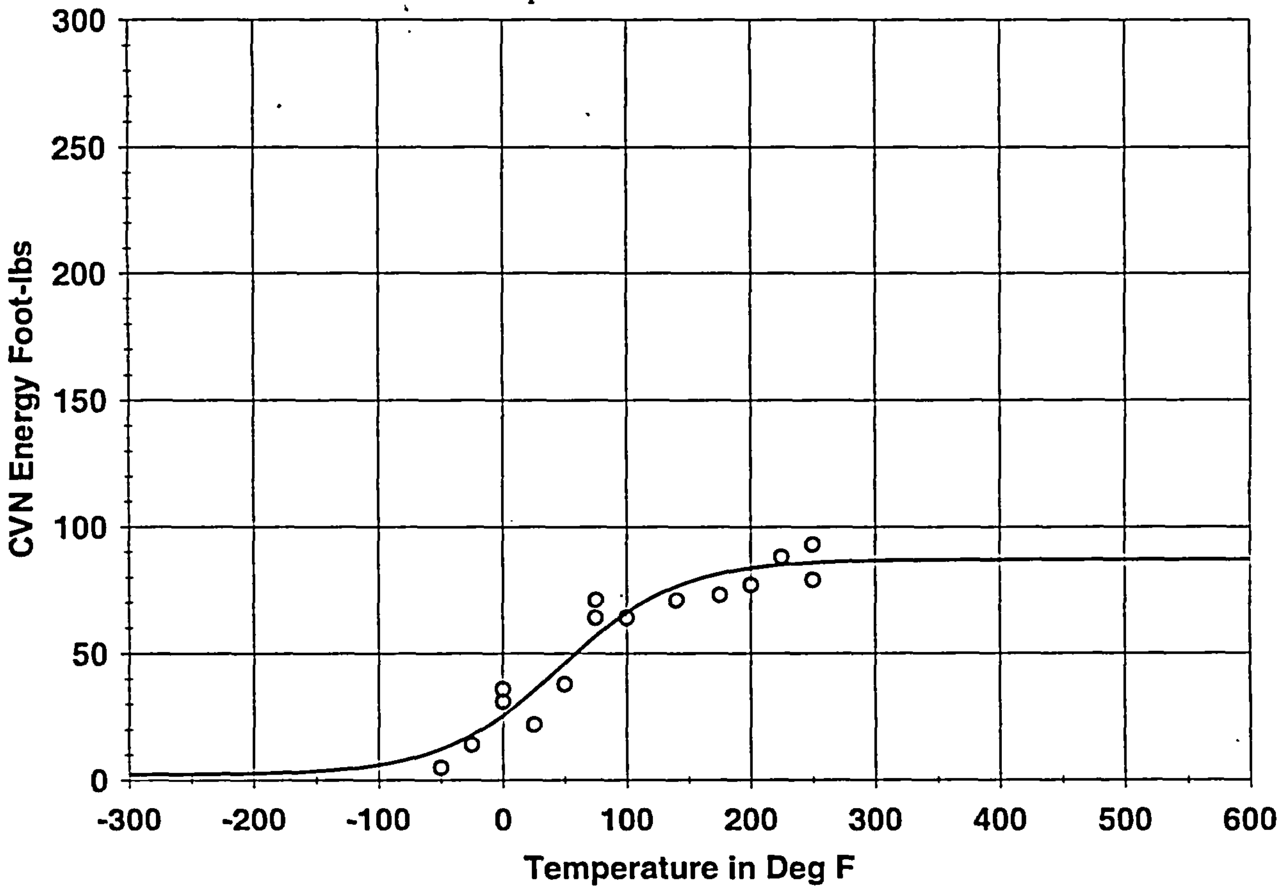
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=87.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=12.2 Deg F Temp@50 ft-lbs=59.0 Deg F

Plant: Vogtle 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-50.00	5.00	12.21	-7.21
-25.00	14.00	17.79	-3.79
.00	36.00	25.50	10.50
.00	31.00	25.50	5.50
25.00	22.00	35.21	-13.21
50.00	38.00	46.07	-8.07
75.00	71.00	56.75	14.25
75.00	64.00	56.75	7.25
100.00	64.00	65.98	-1.98

CAPSULE W (WELD)

Page 2
Plant: Vogtle 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: W Fluence: n/cm^2

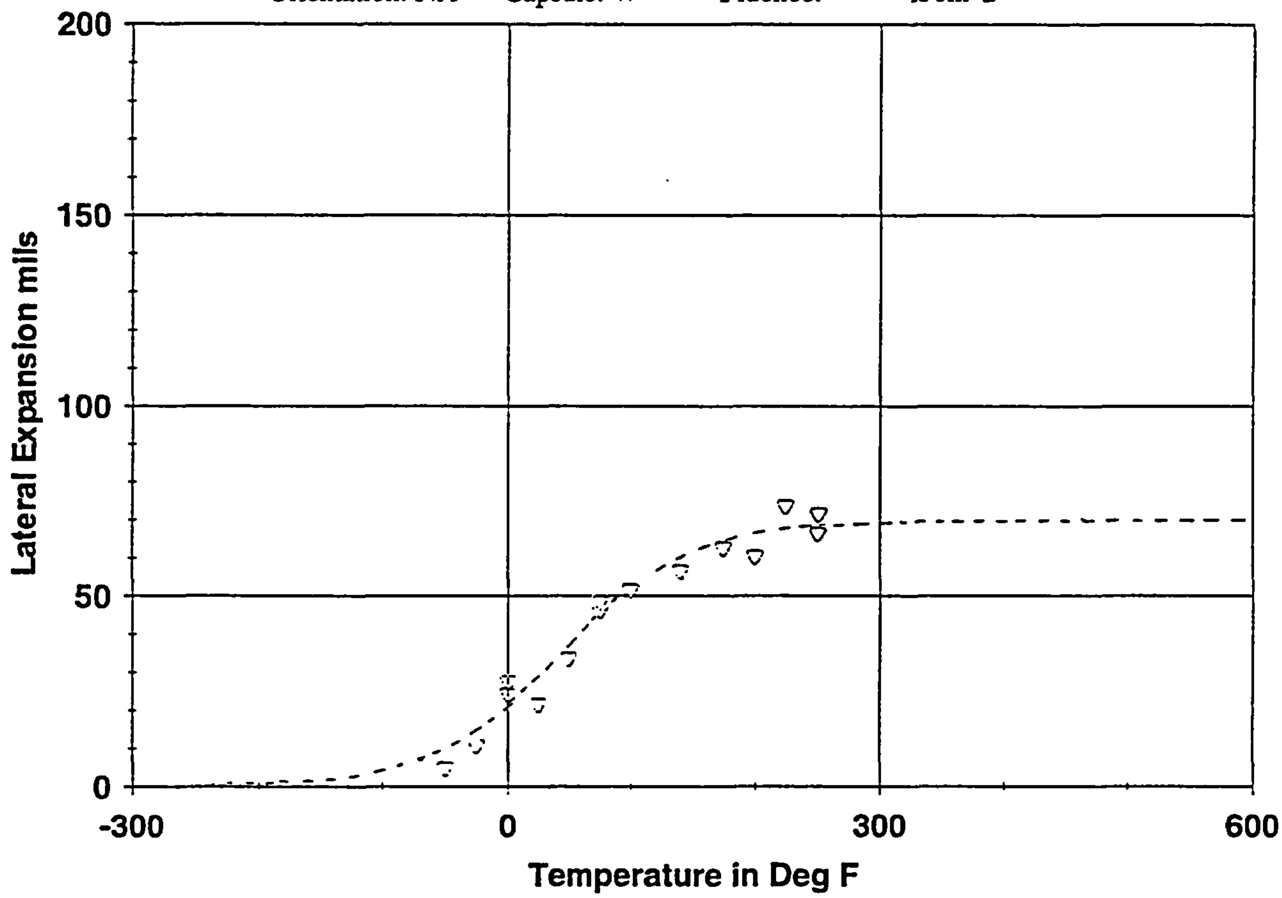
Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
140.00	71.00	76.36	-5.36
175.00	73.00	81.51	-8.51
200.00	77.00	83.65	-6.65
225.00	88.00	84.97	3.03
250.00	79.00	85.78	-6.78
250.00	93.00	85.78	7.22

Correlation Coefficient = .956

CAPSULE W (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 04:15 PM
Page 1
Coefficients of Curve 5
A = 34.98 B = 34.98 C = 103.68 T0 = 44.94 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf L.E.=70.0 Lower Shelf L.E.=.0(Fixed)
Temp.@L.E. 35 mils=45.0 Deg F
Plant: VOGTLE 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-50.00	5.00	9.66	-4.66
-25.00	11.00	14.41	-3.41
.00	28.00	20.70	7.30
.00	25.00	20.70	4.30
25.00	22.00	28.34	-6.34
50.00	34.00	36.69	-2.69
75.00	47.00	44.85	2.15
75.00	49.00	44.85	4.15
100.00	52.00	51.99	.01

CAPSULE W (WELD)

Page 2
Plant: VOGTLE 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: W Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
140.00	57.00	60.32	-3.32
175.00	63.00	64.70	-1.70
200.00	61.00	66.62	-5.62
225.00	74.00	67.86	6.14
250.00	67.00	68.65	-1.65
250.00	72.00	68.65	3.35

Correlation Coefficient = .980

CAPSULE W (WELD)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/19/2004 03:50 PM

Page 1

Coefficients of Curve 5

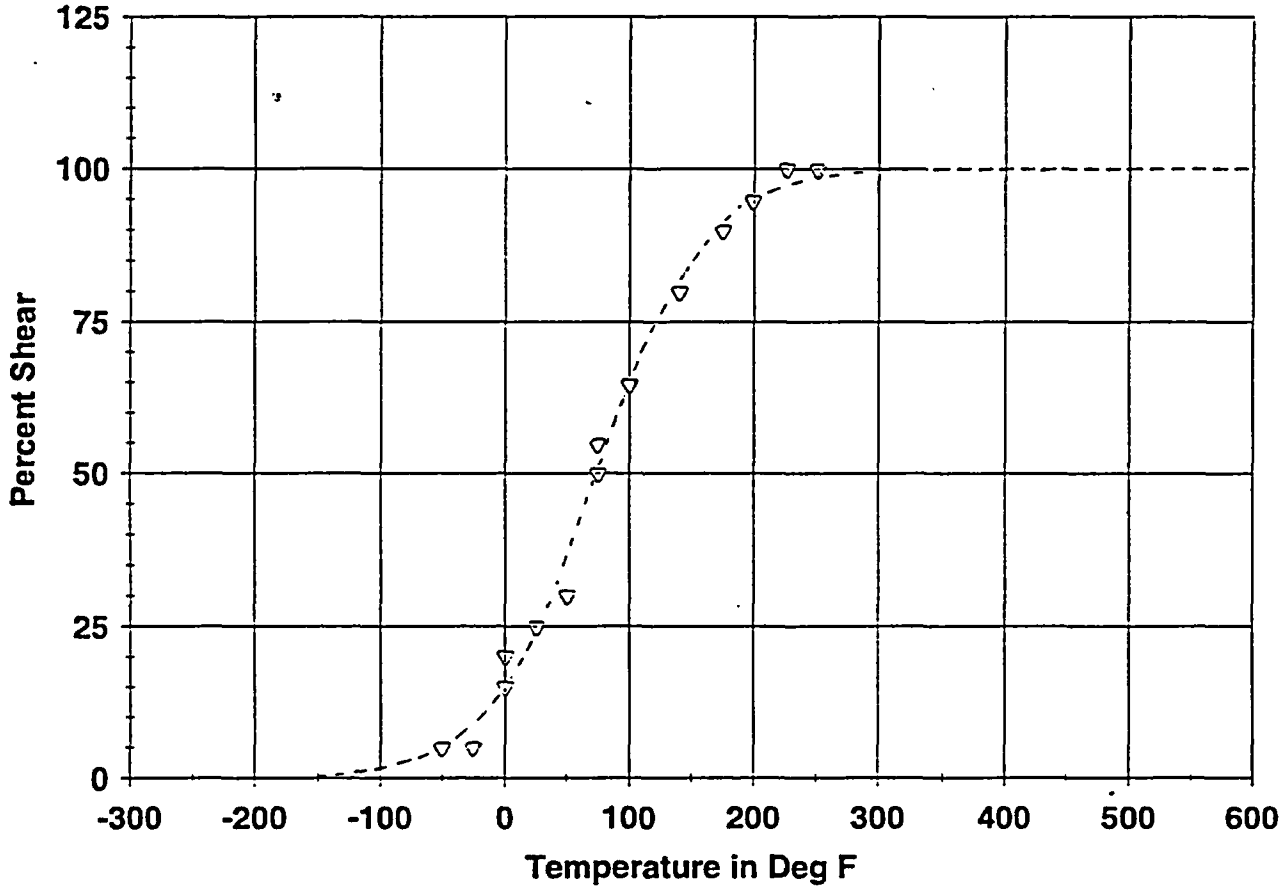
A = 50. B = 50. C = 85.44 T0 = 74.41 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = 74.5

Plant: VOGTLE 2 Material: SMAW Heat: 87005

Orientation: NA Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50.00	5.00	5.16	-.16
-25.00	5.00	8.89	-3.89
.00	15.00	14.91	.09
.00	20.00	14.91	5.09
25.00	25.00	23.93	1.07
50.00	30.00	36.09	-6.09
75.00	55.00	50.35	4.65
75.00	50.00	50.35	-.35
100.00	65.00	64.54	.46

CAPSULE W (WELD)

Page 2
Plant: VOGTLE 2 Material: SMAW Heat: 87005
Orientation: NA Capsule: W Fluence: n/cm^2

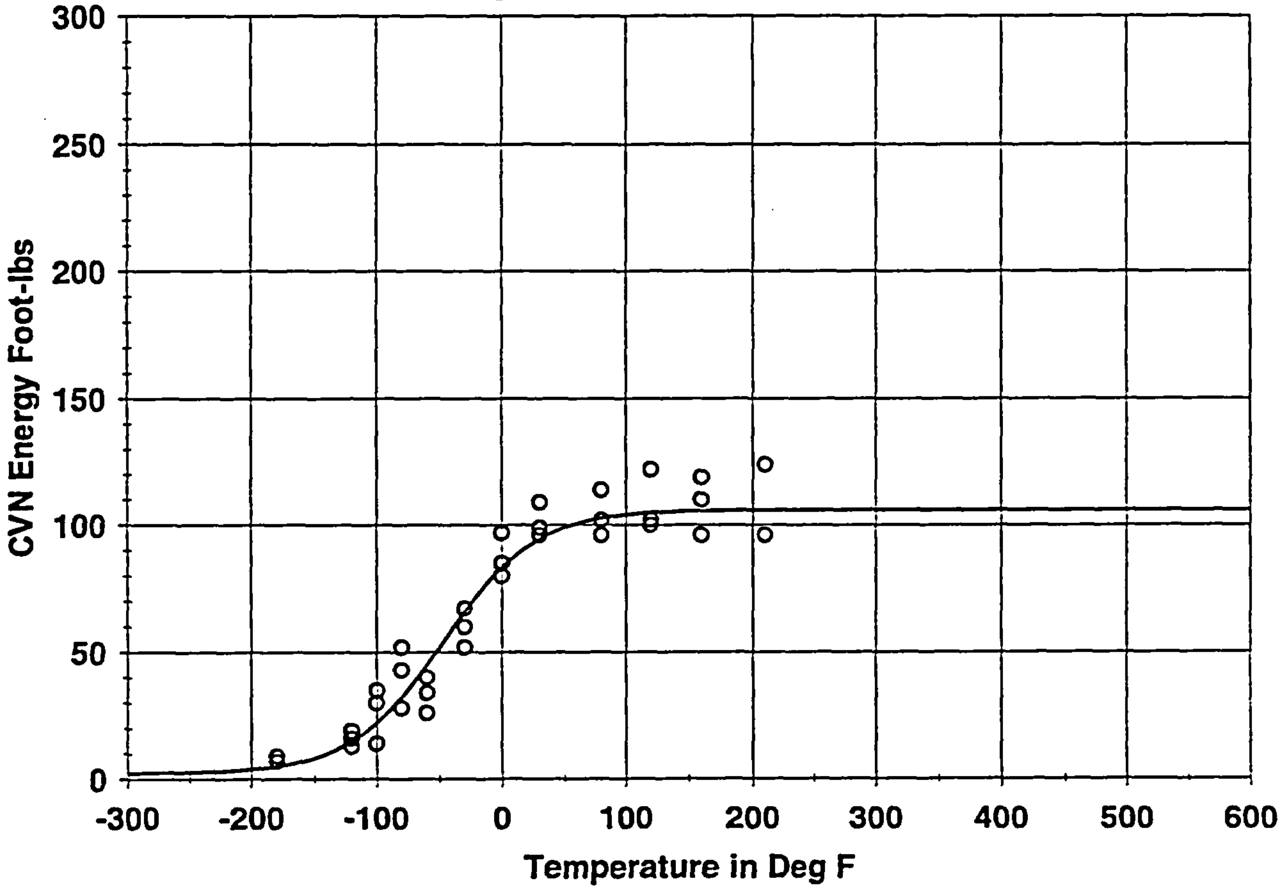
Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
140.00	80.00	82.28	-2.28
175.00	90.00	91.33	-1.33
200.00	95.00	94.98	.02
225.00	100.00	97.14	2.86
250.00	100.00	98.39	1.61
250.00	100.00	98.39	1.61

Correlation Coefficient = .997

UNIRRADIATED (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:17 AM
Page 1
Coefficients of Curve 1
A = 54.1 B = 51.9 C = 73.87 T0 = -46.61 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf Energy=106.0(Fixed) Lower Shelf Energy=2.2(Fixed)
Temp@30 ft-lbs=-83.7 Deg F Temp@50 ft-lbs=-52.4 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-180.00	7.00	4.93	2.07
-180.00	9.00	4.93	4.07
-120.00	13.00	14.72	-1.72
-120.00	16.00	14.72	1.28
-120.00	19.00	14.72	4.28
-100.00	14.00	22.00	-8.00
-100.00	30.00	22.00	8.00
-100.00	35.00	22.00	13.00
-80.00	28.00	32.12	-4.12

UNIRRADIATED (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-80.00	43.00	32.12	10.88
-80.00	52.00	32.12	19.88
-60.00	26.00	44.80	-18.80
-60.00	34.00	44.80	-10.80
-60.00	40.00	44.80	-4.80
-30.00	52.00	65.58	-13.58
-30.00	60.00	65.58	-5.58
-30.00	67.00	65.58	1.42
.00	80.00	83.10	-3.10
.00	85.00	83.10	1.90
.00	97.00	83.10	13.90
30.00	96.00	94.41	1.59
30.00	99.00	94.41	4.59
30.00	109.00	94.41	14.59
80.00	96.00	102.74	-6.74
80.00	102.00	102.74	-.74
80.00	114.00	102.74	11.26
120.00	100.00	104.87	-4.87
120.00	102.00	104.87	-2.87
120.00	122.00	104.87	17.13
160.00	96.00	105.62	-9.62
160.00	110.00	105.62	4.38
160.00	119.00	105.62	13.38
210.00	96.00	105.90	-9.90
210.00	124.00	105.90	18.10

Correlation Coefficient = .968

UNIRRADIATED (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 12:25 PM

Page 1

Coefficients of Curve 1

A = 36.21 B = 36.21 C = 74.44 T0 = -44.47 D = 0.00E+00

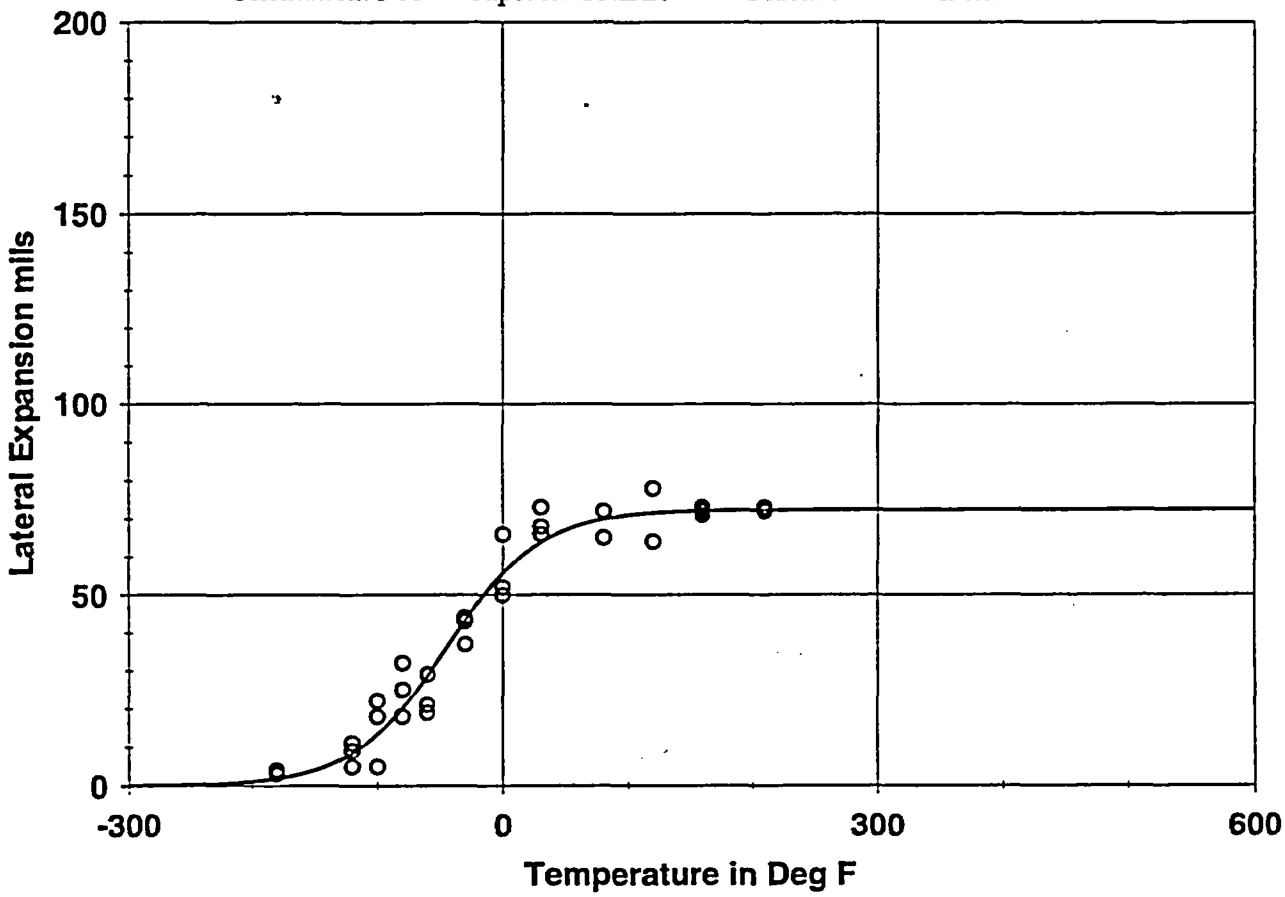
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=72.4 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=-46.9 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-180.00	4.00	1.85	2.15
-180.00	3.00	1.85	1.15
-120.00	5.00	8.41	-3.41
-120.00	9.00	8.41	.59
-120.00	11.00	8.41	2.59
-100.00	5.00	13.30	-8.30
-100.00	18.00	13.30	4.70
-100.00	22.00	13.30	8.70
-80.00	18.00	20.13	-2.13

UNIRRADIATED (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-80.00	25.00	20.13	4.87
-80.00	32.00	20.13	11.87
-60.00	19.00	28.77	-9.77
-60.00	21.00	28.77	-7.77
-60.00	29.00	28.77	.23
-30.00	37.00	43.17	-6.17
-30.00	43.00	43.17	-.17
-30.00	44.00	43.17	.83
.00	52.00	55.60	-3.60
.00	50.00	55.60	-5.60
.00	66.00	55.60	10.40
30.00	68.00	63.80	4.20
30.00	66.00	63.80	2.20
30.00	73.00	63.80	9.20
80.00	72.00	69.96	2.04
80.00	65.00	69.96	-4.96
80.00	72.00	69.96	2.04
120.00	64.00	71.57	-7.57
120.00	64.00	71.57	-7.57
120.00	78.00	71.57	6.43
160.00	73.00	72.13	.87
160.00	71.00	72.13	-1.13
160.00	72.00	72.13	-.13
210.00	72.00	72.35	-.35
210.00	73.00	72.35	.65

Correlation Coefficient = .978

UNIRRADIATED (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:35 AM

Page 1

Coefficients of Curve 1

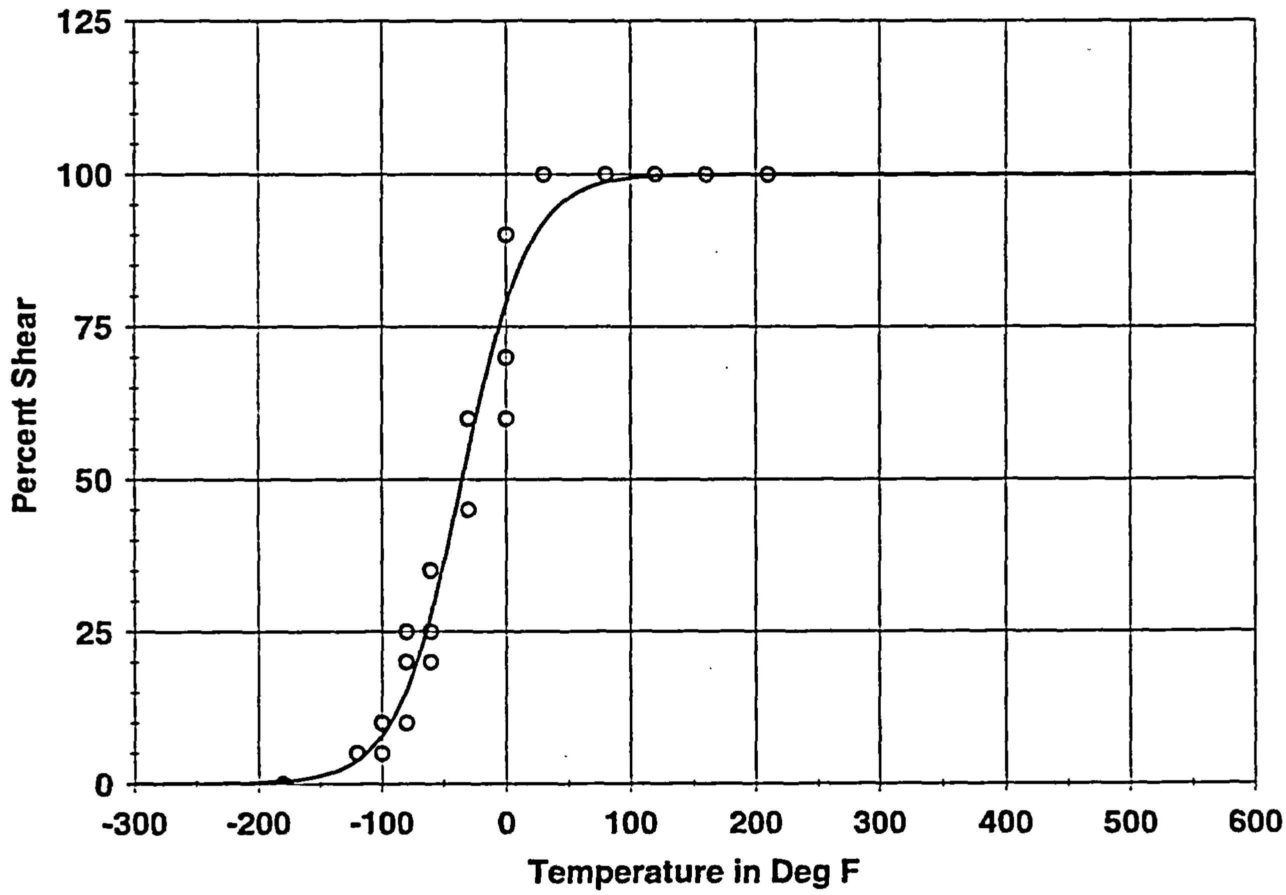
A = 50. B = 50. C = 53.04 T0 = -34.64 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = -34.6

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: UNIRR Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-180.00	.00	.41	-.41
-180.00	.00	.41	-.41
-120.00	5.00	3.85	1.15
-120.00	5.00	3.85	1.15
-120.00	5.00	3.85	1.15
-100.00	5.00	7.84	-2.84
-100.00	5.00	7.84	-2.84
-100.00	10.00	7.84	2.16
-80.00	10.00	15.31	-5.31

UNIRRADIATED (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: UNIRR Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-80.00	20.00	15.31	4.69
-80.00	25.00	15.31	9.69
-60.00	20.00	27.77	-7.77
-60.00	25.00	27.77	-2.77
-60.00	35.00	27.77	7.23
-30.00	60.00	54.36	5.64
-30.00	45.00	54.36	-9.36
-30.00	60.00	54.36	5.64
.00	70.00	78.69	-8.69
.00	60.00	78.69	-18.69
.00	90.00	78.69	11.31
30.00	100.00	91.96	8.04
30.00	100.00	91.96	8.04
30.00	100.00	91.96	8.04
80.00	100.00	98.69	1.31
80.00	100.00	98.69	1.31
80.00	100.00	98.69	1.31
120.00	100.00	99.71	.29
120.00	100.00	99.71	.29
120.00	100.00	99.71	.29
160.00	100.00	99.94	.06
160.00	100.00	99.94	.06
160.00	100.00	99.94	.06
210.00	100.00	99.99	.01
210.00	100.00	99.99	.01

Correlation Coefficient = .990

CAPSULE U (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:17 AM

Page 1

Coefficients of Curve 2

A = 62.1 B = 59.9 C = 70.83 T0 = -65.7 D = 0.00E+00

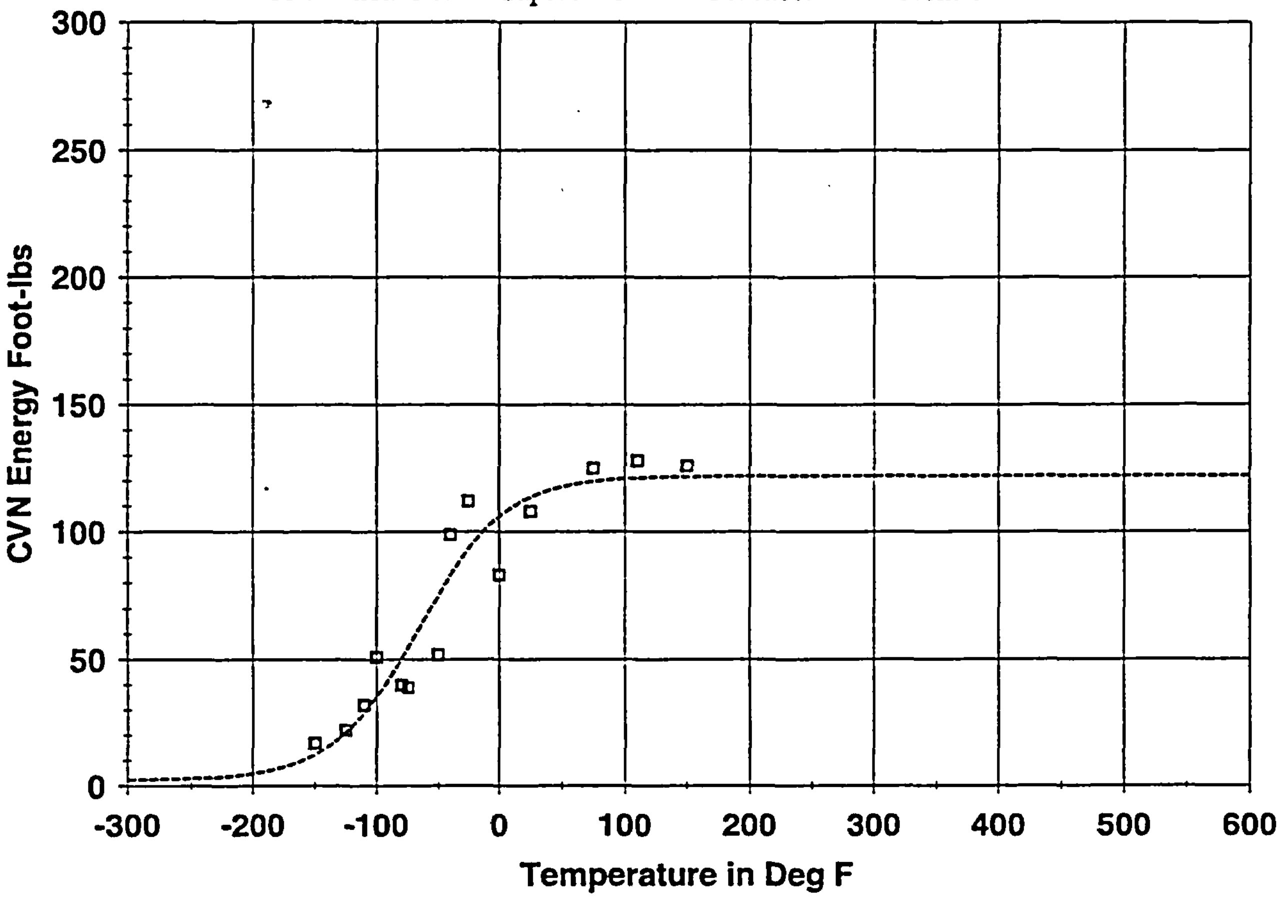
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=122.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=-108.0 Deg F Temp@50 ft-lbs=-80.2 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-150.00	17.00	12.35	4.65
-125.00	22.00	21.11	.89
-110.00	32.00	28.86	3.14
-100.00	51.00	35.17	15.83
-80.00	40.00	50.17	-10.17
-75.00	39.00	54.28	-15.28
-50.00	52.00	75.17	-23.17
-40.00	99.00	82.93	16.07
-25.00	112.00	93.18	18.82

CAPSULE U (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2   Material: SA533B1   Heat: C3500-2
Orientation: NA   Capsule: U   Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-25.00	112.00	93.18	18.82
.00	83.00	105.80	-22.80
25.00	108.00	113.41	-5.41
75.00	125.00	119.79	5.21
110.00	128.00	121.17	6.83
150.00	126.00	121.73	4.27

Correlation Coefficient = .941

CAPSULE U (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 12:25 PM

Page 1

Coefficients of Curve 2

A = 32.95 B = 32.95 C = 57.44 T0 = -71.33 D = 0.00E+00

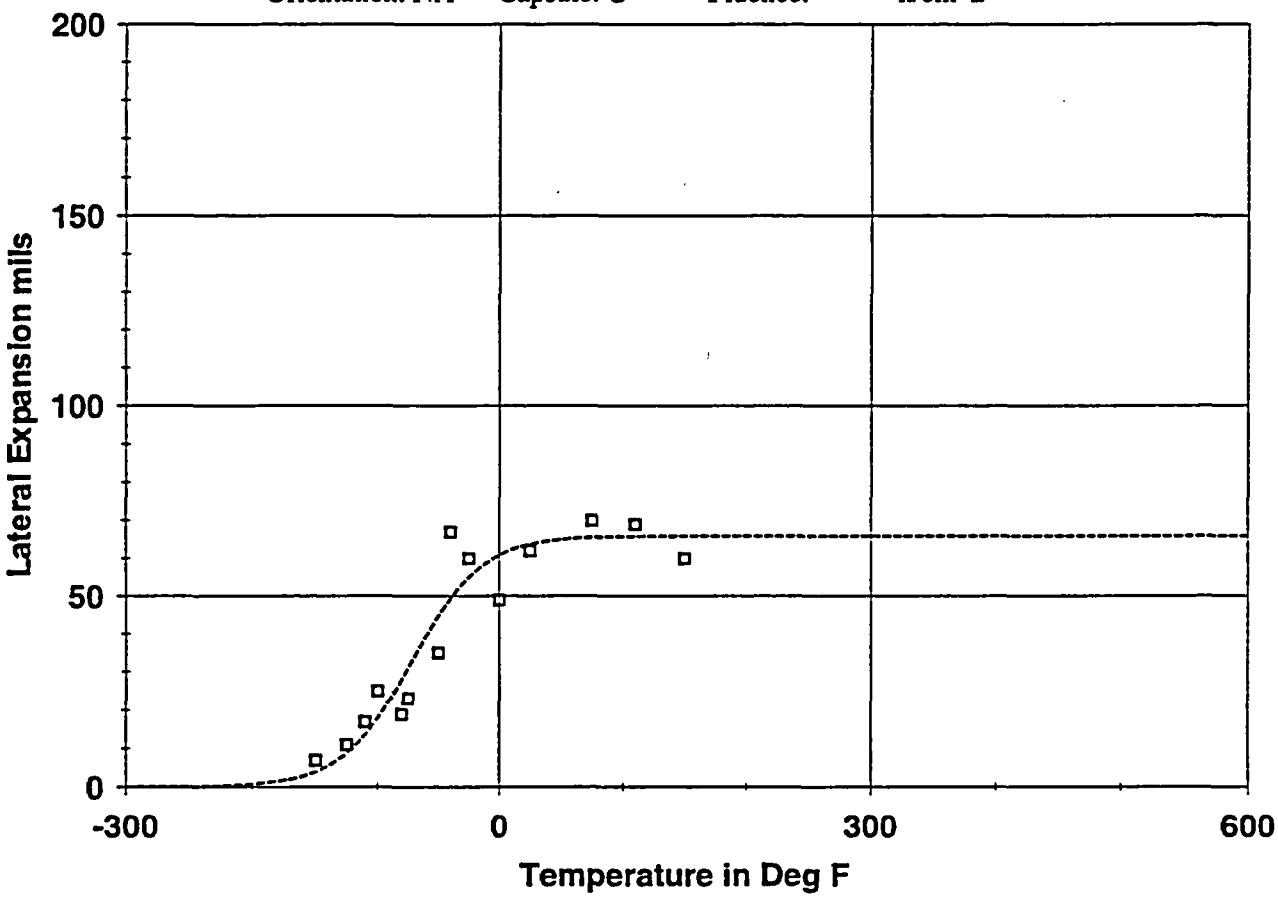
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=65.9 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=-67.7 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-150.00	7.00	4.00	3.00
-125.00	11.00	8.81	2.19
-110.00	17.00	13.61	3.39
-100.00	25.00	17.75	7.25
-80.00	19.00	28.02	-9.02
-75.00	23.00	30.85	-7.85
-50.00	35.00	44.65	-9.65
-40.00	67.00	49.33	17.67
-25.00	60.00	54.95	5.05

CAPSULE U (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-25.00	60.00	54.95	5.05
.00	49.00	60.83	-11.83
25.00	62.00	63.68	-1.68
75.00	70.00	65.50	4.50
110.00	69.00	65.78	3.22
150.00	60.00	65.87	-5.87

Correlation Coefficient = .941

CAPSULE U (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:35 AM

Page 1

Coefficients of Curve 2

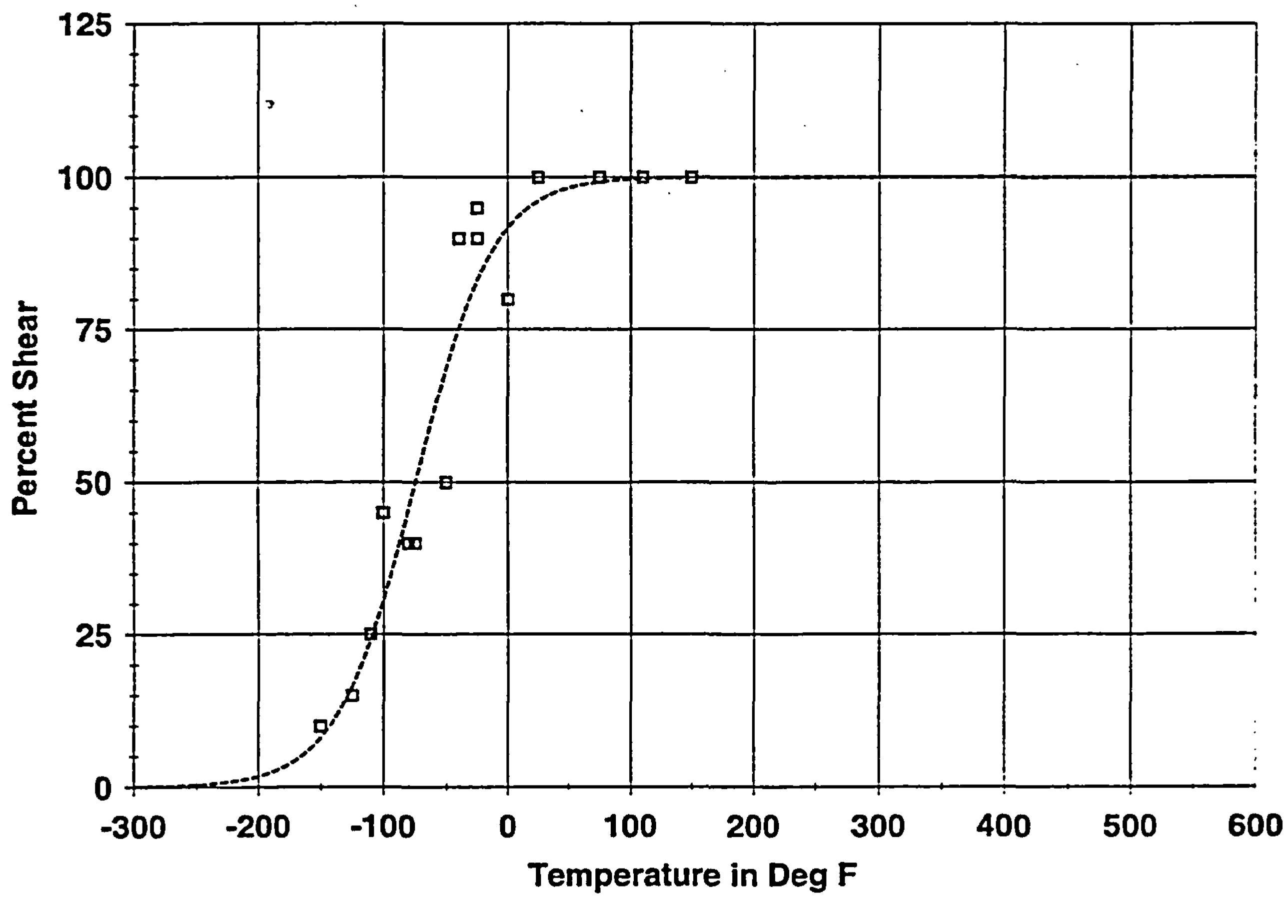
A = 50. B = 50. C = 62.09 T0 = -74.49 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = -74.4

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: U Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-150.00	10.00	8.08	1.92
-125.00	15.00	16.43	-1.43
-110.00	25.00	24.17	.83
-100.00	45.00	30.54	14.46
-80.00	40.00	45.58	-5.58
-75.00	40.00	49.59	-9.59
-50.00	50.00	68.76	-18.76
-40.00	90.00	75.23	14.77
-25.00	95.00	83.12	11.88

CAPSULE U (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: U Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-25.00	90.00	83.12	6.88
.00	80.00	91.68	-11.68
25.00	100.00	96.10	3.90
75.00	100.00	99.20	.80
110.00	100.00	99.74	.26
150.00	100.00	99.93	.07

Correlation Coefficient = .961

CAPSULE Y (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:17 AM

Page 1

Coefficients of Curve 3

A = 58.1 B = 55.9 C = 73.59 T0 = -53.18 D = 0.00E+00

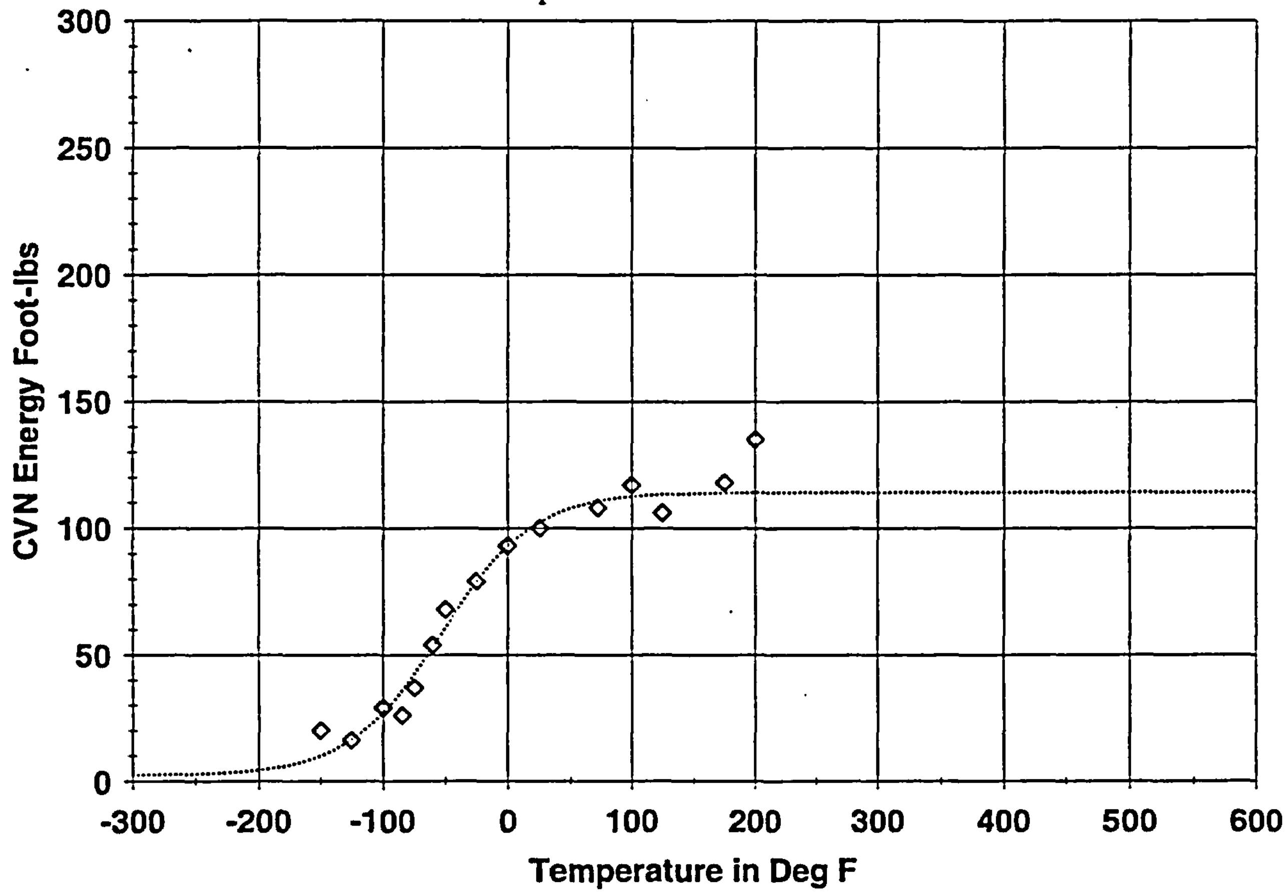
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=114.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=-93.8 Deg F Temp@50 ft-lbs=-63.9 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-150.00	20.00	9.71	10.29
-125.00	16.00	16.10	-.10
-100.00	29.00	26.67	2.33
-85.00	26.00	35.33	-9.33
-75.00	37.00	42.00	-5.00
-60.00	54.00	52.94	1.06
-50.00	68.00	60.52	7.48
-25.00	79.00	78.52	.48
.00	93.00	92.68	.32

CAPSULE Y (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
25.00	100.00	102.07	-2.07
72.00	108.00	110.40	-2.40
100.00	117.00	112.29	4.71
125.00	106.00	113.13	-7.13
175.00	118.00	113.77	4.23
200.00	135.00	113.89	21.11

Correlation Coefficient = .983

CAPSULE Y (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 12:25 PM

Page 1

Coefficients of Curve 3

A = 35.29 B = 35.29 C = 78.8 T0 = -52.82 D = 0.00E+00

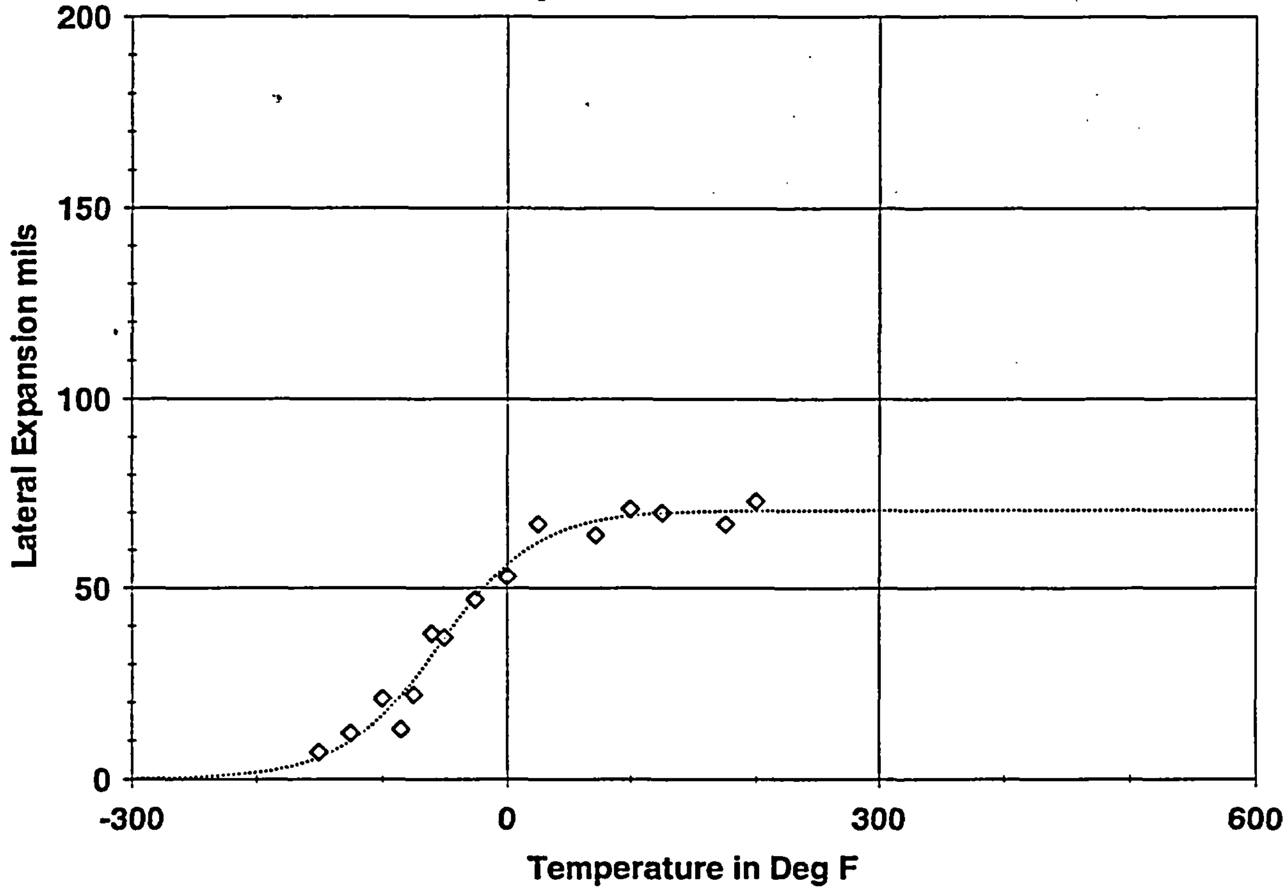
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=70.6 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=-53.4 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-150.00	7.00	5.52	1.48
-125.00	12.00	9.74	2.26
-100.00	21.00	16.37	4.63
-85.00	13.00	21.63	-8.63
-75.00	22.00	25.61	-3.61
-60.00	38.00	32.08	5.92
-50.00	37.00	36.55	.45
-25.00	47.00	47.25	-.25
.00	53.00	55.94	-2.94

CAPSULE Y (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: Y Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
25.00	67.00	61.98	5.02
72.00	64.00	67.73	-3.73
100.00	71.00	69.15	1.85
125.00	70.00	69.81	.19
175.00	67.00	70.36	-3.36
200.00	73.00	70.46	2.54

Correlation Coefficient = .987

CAPSULE Y (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:35 AM

Page 1

Coefficients of Curve 3

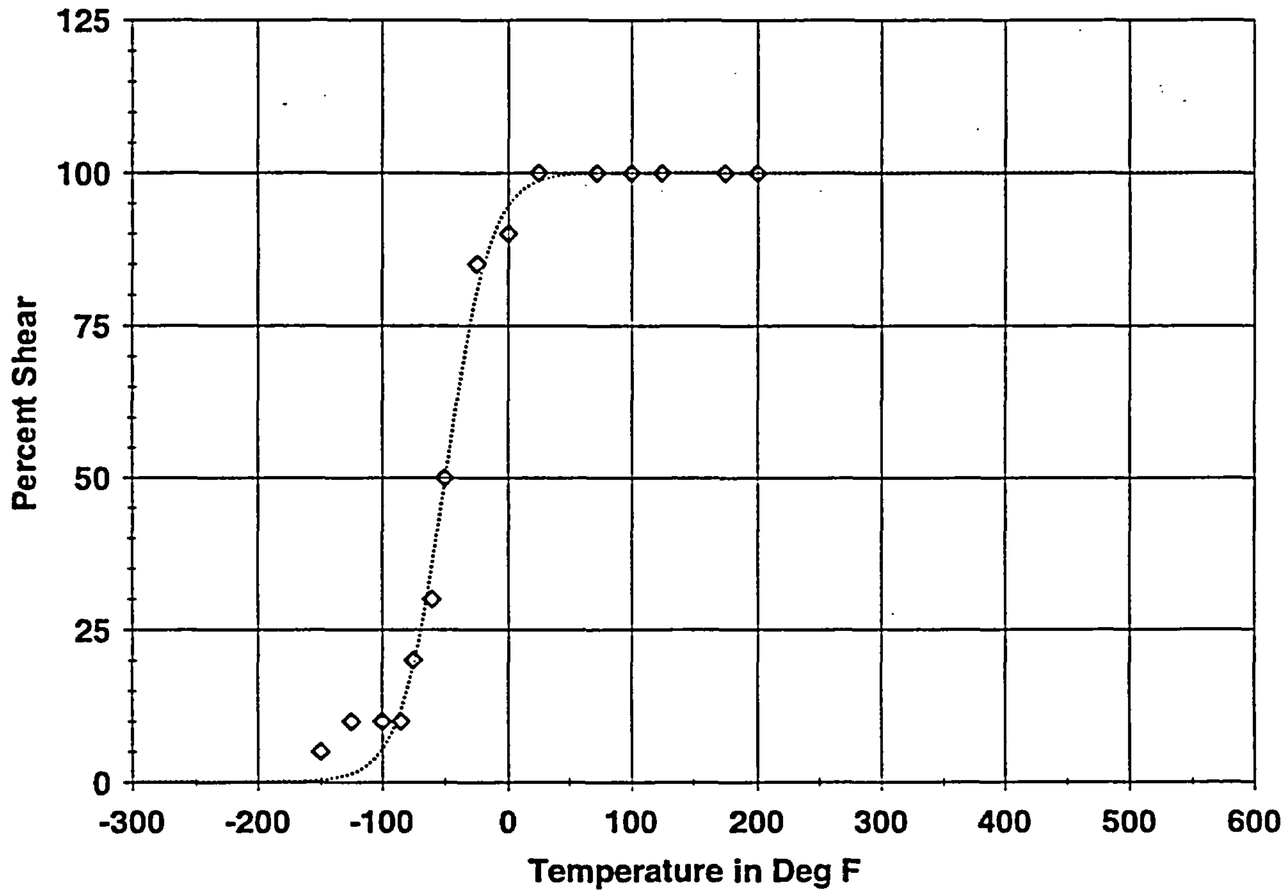
A = 50. B = 50. C = 34.94 T0 = -49.36 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = -49.3

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: Y Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-150.00	5.00	.31	4.69
-125.00	10.00	1.30	8.70
-100.00	10.00	5.22	4.78
-85.00	10.00	11.51	-1.51
-75.00	20.00	18.73	1.27
-60.00	30.00	35.23	-5.23
-50.00	50.00	49.08	.92
-25.00	85.00	80.13	4.87
.00	90.00	94.40	-4.40

CAPSULE Y (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: Y Fluence: n/cm^2

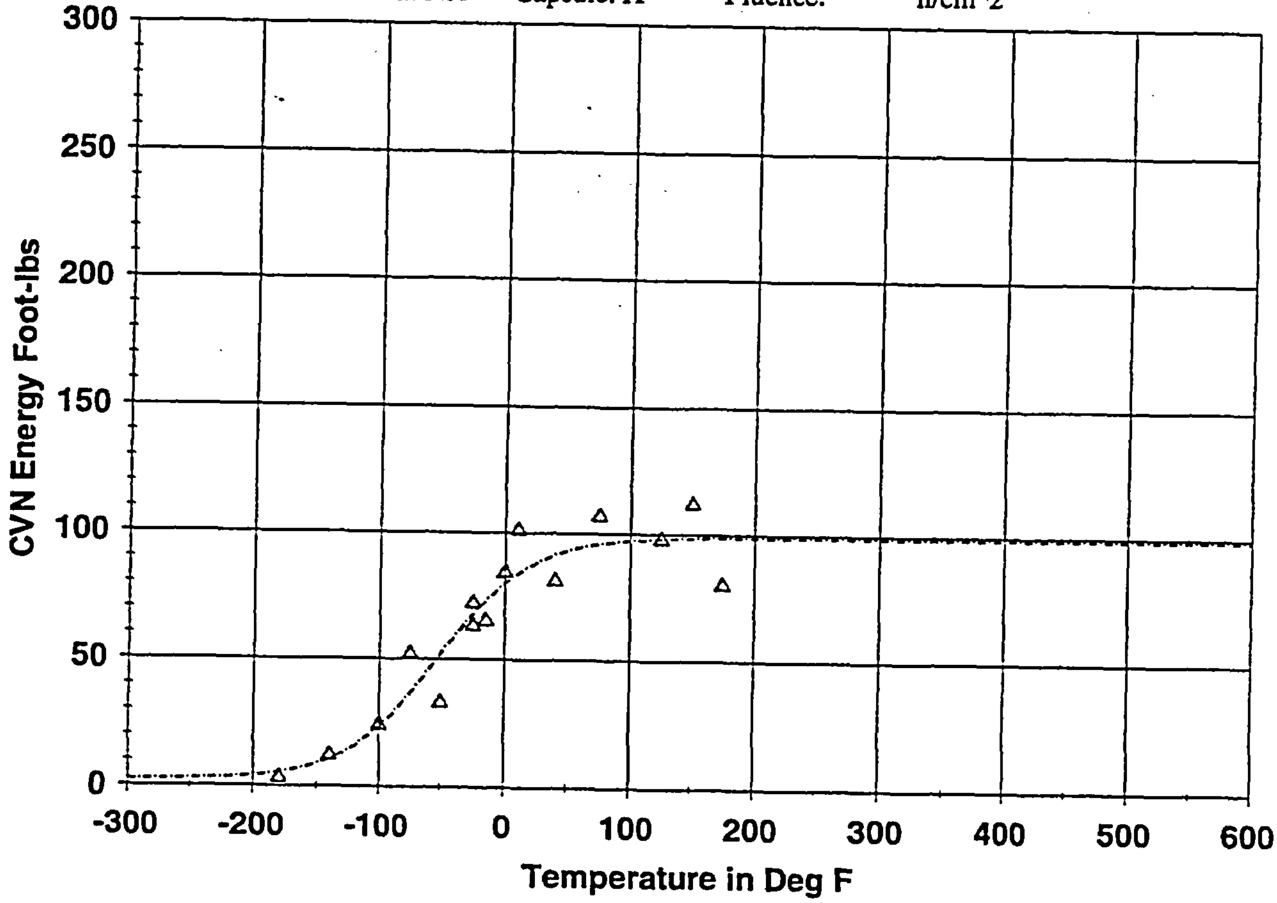
Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25.00	100.00	98.60	1.40
72.00	100.00	99.90	.10
100.00	100.00	99.98	.02
125.00	100.00	100.00	.00
175.00	100.00	100.00	.00
200.00	100.00	100.00	.00

Correlation Coefficient = .997

CAPSULE X (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:18 AM
Page 1
Coefficients of Curve 4
A = 50.6 B = 48.4 C = 74.79 T0 = -52.28 D = 0.00E+00
Equation is A + B * [Tanh((T-To)/(C+DT))]
Upper Shelf Energy=99.0(Fixed) Lower Shelf Energy=2.2(Fixed)
Temp@30 ft-lbs=-86.2 Deg F Temp@50 ft-lbs=-53.2 Deg F
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-180.00	3.00	5.28	-2.28
-140.00	12.00	10.66	1.34
-100.00	24.00	23.32	.68
-75.00	52.00	36.33	15.67
-50.00	33.00	52.08	-19.08
-25.00	72.00	67.51	4.49
-25.00	63.00	67.51	-4.51
-15.00	65.00	72.91	-7.91
.00	84.00	79.82	4.18

CAPSULE X (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
10.00	101.00	83.61	17.39
40.00	81.00	91.44	-10.44
75.00	107.00	95.89	11.11
125.00	98.00	98.16	-.16
150.00	112.00	98.57	13.43
175.00	80.00	98.78	-18.78

Correlation Coefficient = .945

CAPSULE X (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 12:25 PM

Page 1

Coefficients of Curve 4

A = 34.72 B = 34.72 C = 81.9 T0 = -36.15 D = 0.00E+00

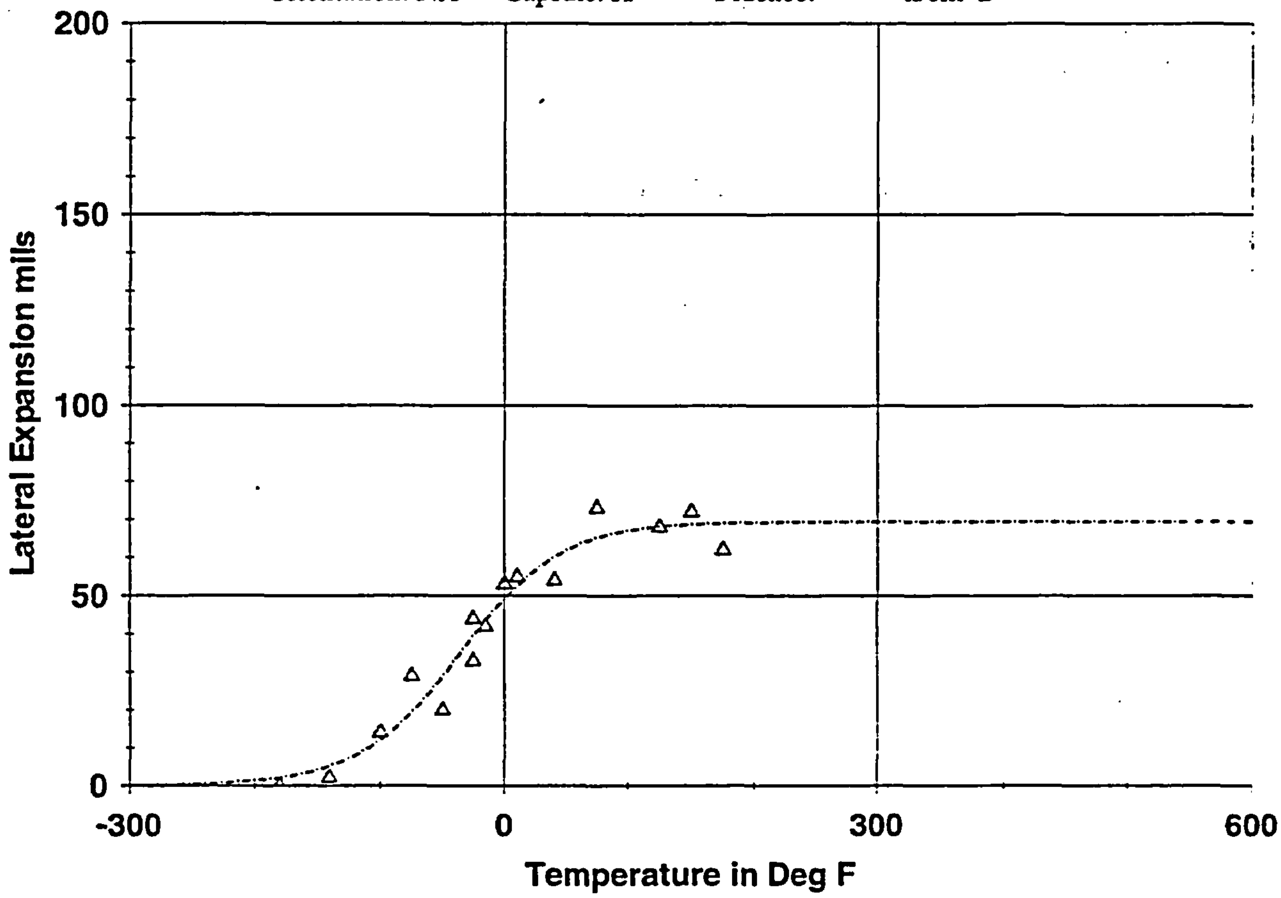
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=69.4 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=-35.4 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-180.00	.00	2.01	-2.01
-140.00	2.00	5.09	-3.09
-100.00	14.00	12.07	1.93
-75.00	29.00	19.38	9.62
-50.00	20.00	28.90	-8.90
-25.00	44.00	39.42	4.58
-25.00	33.00	39.42	-6.42
-15.00	42.00	43.49	-1.49
.00	53.00	49.12	3.88

CAPSULE X (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
10.00	55.00	52.45	2.55
40.00	54.00	60.08	-6.08
75.00	73.00	65.12	7.88
125.00	68.00	68.11	-.11
150.00	72.00	68.71	3.29
175.00	62.00	69.04	-7.04

Correlation Coefficient = .973

CAPSULE X (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:35 AM

Page 1

Coefficients of Curve 4

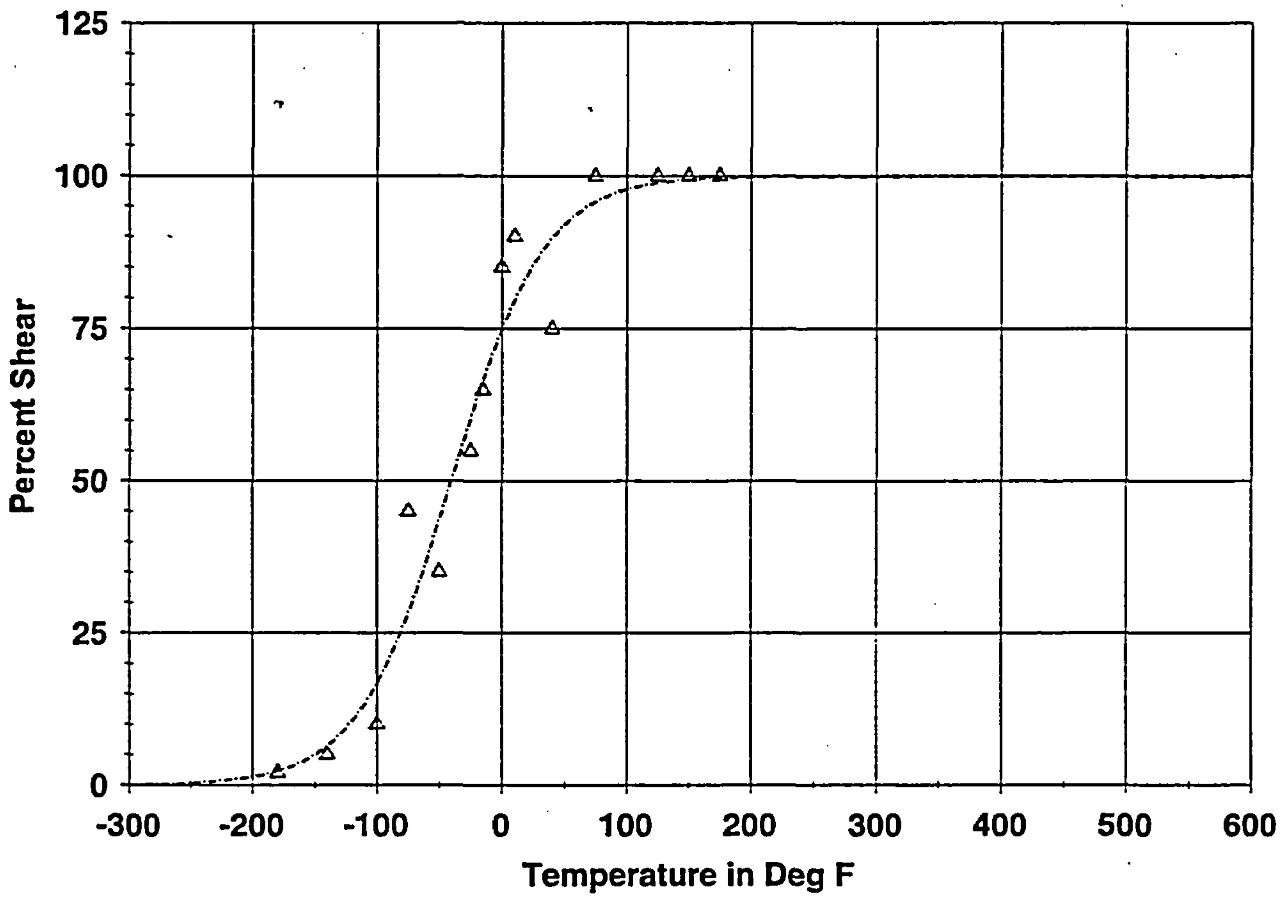
A = 50. B = 50. C = 74.29 T0 = -40.29 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = -40.2

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: X Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-180.00	2.00	2.27	-.27
-140.00	5.00	6.39	-1.39
-100.00	10.00	16.70	-6.70
-75.00	45.00	28.20	16.80
-50.00	35.00	43.50	-8.50
-25.00	55.00	60.15	-5.15
-25.00	55.00	60.15	-5.15
-15.00	65.00	66.39	-1.39
.00	85.00	74.74	10.26

CAPSULE X (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: X Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
10.00	90.00	79.48	10.52
40.00	75.00	89.68	-14.68
75.00	100.00	95.71	4.29
125.00	100.00	98.85	1.15
150.00	100.00	99.41	.59
175.00	100.00	99.70	.30

Correlation Coefficient = .974

CAPSULE W (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:18 AM

Page 1

Coefficients of Curve 5

A = 51.1 B = 48.9 C = 53.34 T0 = -55.88 D = 0.00E+00

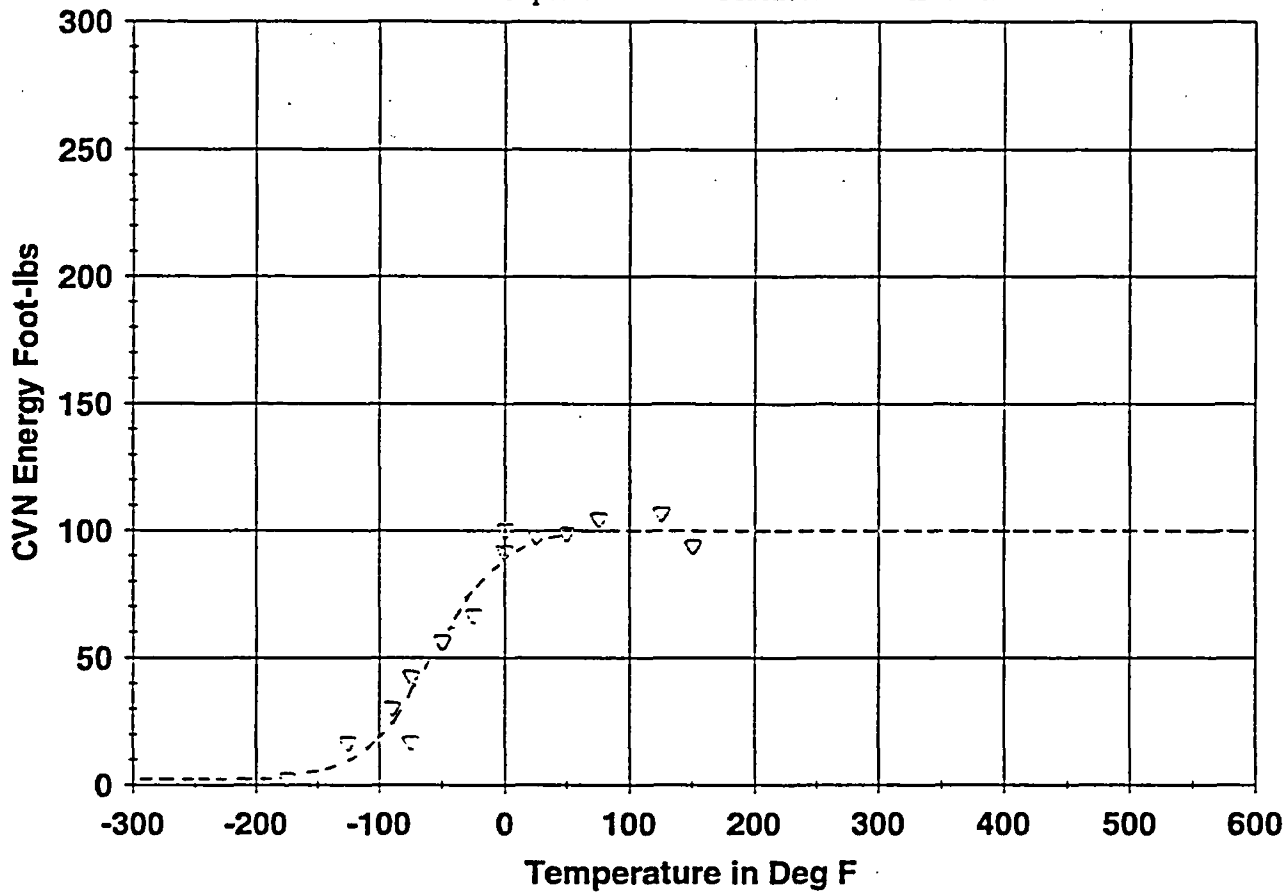
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf Energy=100.0(Fixed) Lower Shelf Energy=2.2(Fixed)

Temp@30 ft-lbs=-80.5 Deg F Temp@50 ft-lbs=-57.0 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
-175.00	3.00	3.31	-.31
-125.00	17.00	9.01	7.99
-90.00	31.00	23.49	7.51
-75.00	43.00	34.28	8.72
-75.00	17.00	34.28	-17.28
-50.00	57.00	56.46	.54
-50.00	57.00	56.46	.54
-25.00	67.00	76.62	-9.62
.00	101.00	89.28	11.72

CAPSULE W (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: W Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input CVN	Computed CVN	Differential
.00	92.00	89.28	2.72
25.00	98.00	95.50	2.50
50.00	99.00	98.19	.81
75.00	105.00	99.28	5.72
125.00	107.00	99.89	7.11
150.00	93.00	99.96	-6.96

Correlation Coefficient = .977

CAPSULE W (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 12:25 PM

Page 1

Coefficients of Curve 5

A = 34.01 B = 34.01 C = 62.8 T0 = -48.33 D = 0.00E+00

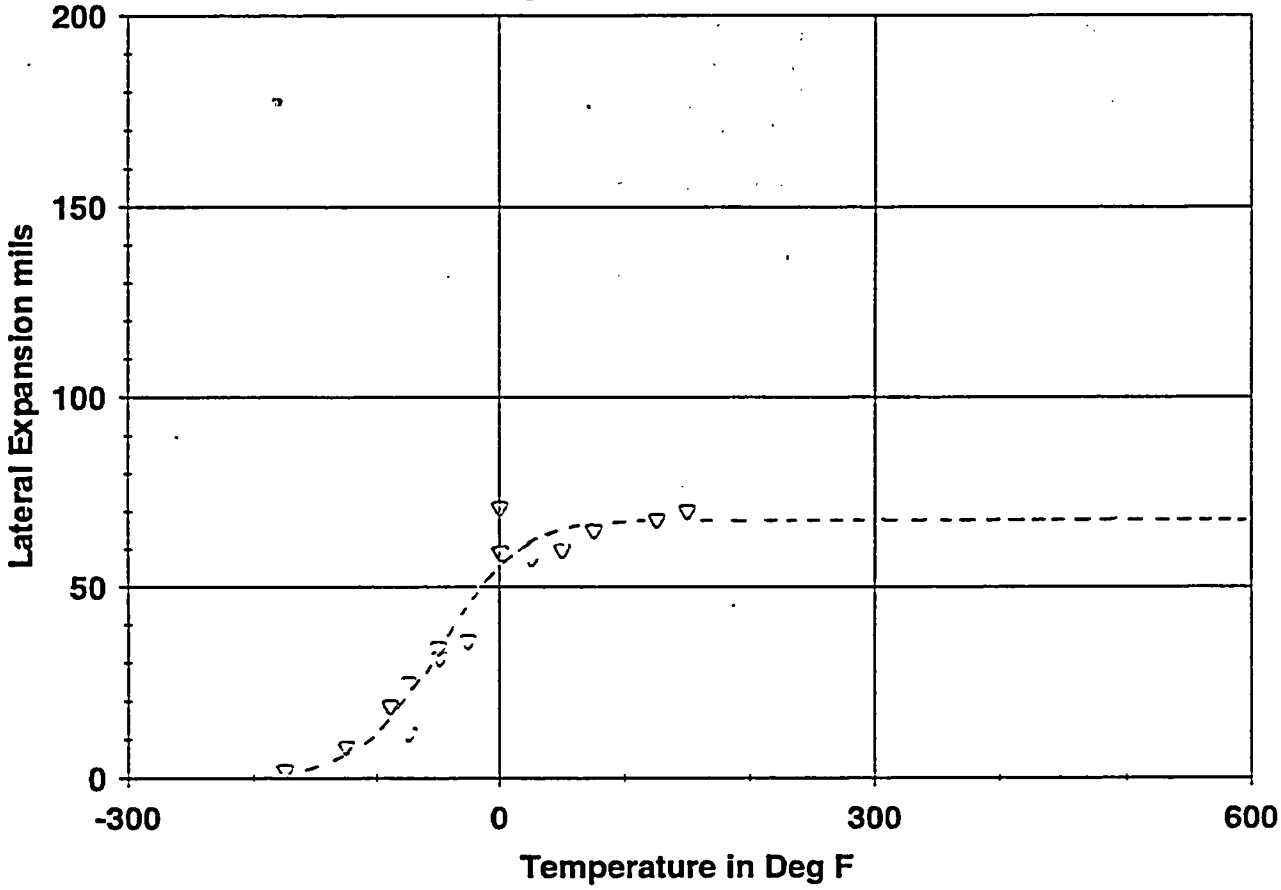
Equation is A + B * [Tanh((T-To)/(C+DT))]

Upper Shelf L.E.=68.0 Lower Shelf L.E.=.0(Fixed)

Temp.@L.E. 35 mils=-46.5 Deg F

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
-175.00	2.00	1.18	.82
-125.00	8.00	5.45	2.55
-90.00	19.00	14.26	4.74
-75.00	25.00	20.38	4.62
-75.00	12.00	20.38	-8.38
-50.00	32.00	33.11	-1.11
-50.00	34.00	33.11	.89
-25.00	36.00	46.09	-10.09
.00	71.00	56.00	15.00

CAPSULE W (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: W Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input L.E.	Computed L.E.	Differential
.00	59.00	56.00	3.00
25.00	58.00	62.02	-4.02
50.00	60.00	65.18	-5.18
75.00	65.00	66.71	-1.71
125.00	68.00	67.75	.25
150.00	70.00	67.90	2.10

Correlation Coefficient = .969

CAPSULE W (HEAT AFFECTED ZONE)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 11/22/2004 11:36 AM

Page 1

Coefficients of Curve 5

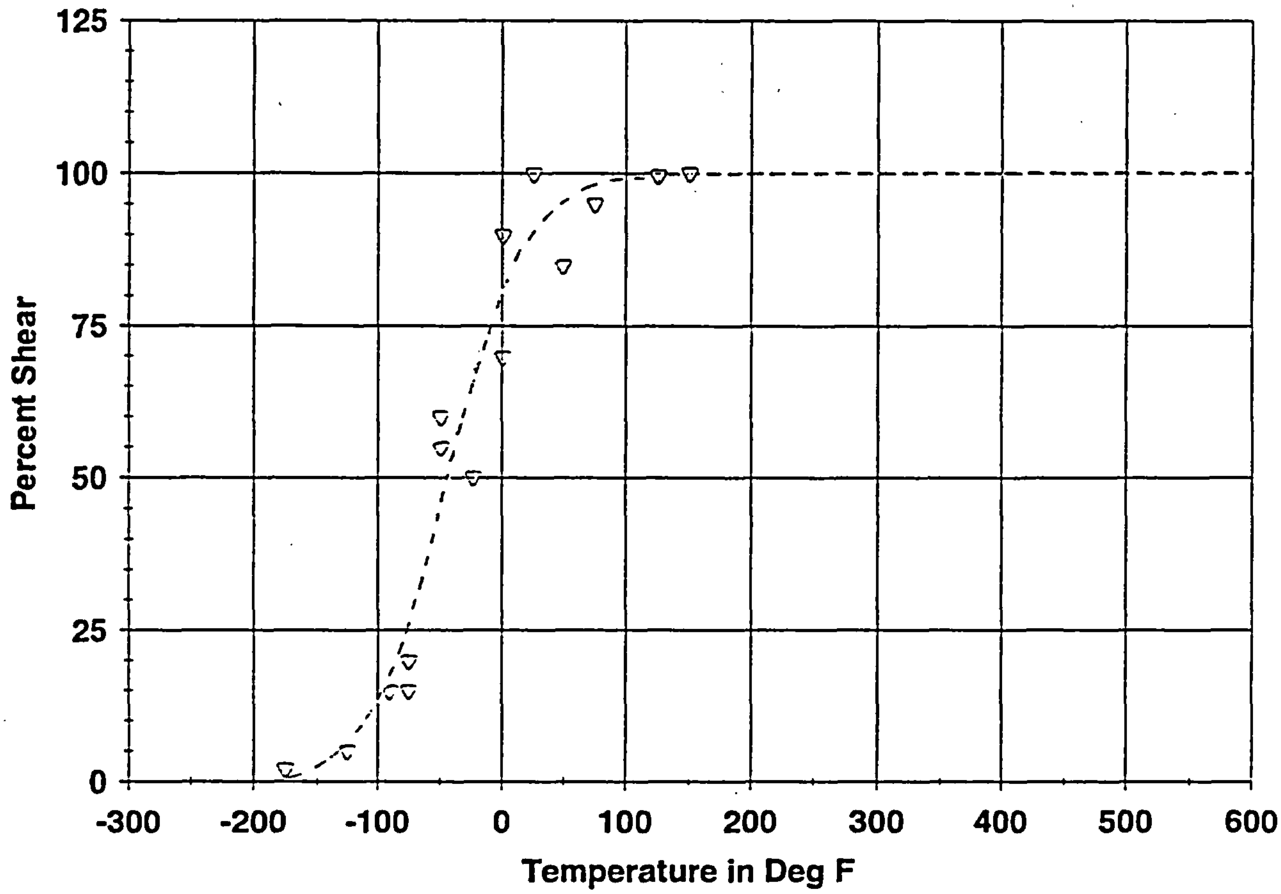
A = 50. B = 50. C = 59.52 T0 = -42.89 D = 0.00E+00

Equation is A + B * [Tanh((T-To)/(C+DT))]

Temperature at 50% Shear = -42.8

Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2

Orientation: NA Capsule: W Fluence: n/cm^2



Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-175.00	2.00	1.17	.83
-125.00	5.00	5.96	-.96
-90.00	15.00	17.04	-2.04
-75.00	20.00	25.37	-5.37
-75.00	15.00	25.37	-10.37
-50.00	55.00	44.05	10.95
-50.00	60.00	44.05	15.95
-25.00	50.00	64.59	-14.59
.00	90.00	80.86	9.14

CAPSULE W (HEAT AFFECTED ZONE)

Page 2
Plant: Vogtle 2 Material: SA533B1 Heat: C3500-2
Orientation: NA Capsule: W Fluence: n/cm^2

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
.00	70.00	80.86	-10.86
25.00	100.00	90.73	9.27
50.00	85.00	95.78	-10.78
75.00	95.00	98.13	-3.13
125.00	100.00	99.65	.35
150.00	100.00	99.85	.15

Correlation Coefficient = .971

APPENDIX D

VOGTLE UNIT 2 SURVEILLANCE PROGRAM CREDIBILITY EVALUATION

INTRODUCTION:

Regulatory Guide 1.99, Revision 2, describes general procedures acceptable to the NRC staff for calculating the effects of neutron radiation embrittlement of the low-alloy steels currently used for light-water-cooled reactor vessels. Position C.2 of Regulatory Guide 1.99, Revision 2, describes the method for calculating the adjusted reference temperature and Charpy upper-shelf energy of reactor vessel beltline materials using surveillance capsule data. The methods of Position C.2 can only be applied when two or more credible surveillance data sets becomes available from the reactor in question.

To date there have been four surveillance capsules removed from the Vogtle Electric Generating Plant Unit 2 reactor vessel. To use these surveillance data sets, they must be shown to be credible. In accordance with the discussion of Regulatory Guide 1.99, Revision 2, there are five requirements that must be met for the surveillance data to be judged credible.

The purpose of this evaluation is to apply the credibility requirements of Regulatory Guide 1.99, Revision 2, to the Vogtle Electric Generating Plant Unit 2 reactor vessel surveillance data and determine if the Vogtle Electric Generating Plant Unit 2 surveillance data is credible.

EVALUATION:

CRITERION 1: Materials in the capsules should be those judged most likely to be controlling with regard to radiation embrittlements.

The beltline region of the reactor vessel is defined in Appendix G to 10CFR Part 50, "Frature Toughness Requirements", as follows:

> "the reactor vessel (shell material including welds, heat affected zones, and plates or forgings) that directly surrounds the effective height of the active core and adjacent regions of the reactor vessel that are predicted to experience sufficient neutron radiation damage to be considered in the selection of the most limiting material with regard to radiation damage."

The Vogtle Electric Generating Plant Unit 2 reactor vessel consists of the following beltline region materials:

- Intermediate shell plates R4-1, R4-2 and R4-3
- Lower shell plates B8825-1, R8-1 and B8628-1
- The intermediate shell longitudinal weld seams 101-124A,B,C, lower shell longitudinal weld seams 101-142A,B,C were all fabricated with weld wire heat number 87005, Linde 0091 Flux, Lot 0145.
- The intermediate to lower shell girth weld seam 101-171 was fabricated with weld wire heat number 87005, Linde 124 Flux, Lot 1061.

The Vogtle Unit 2 surveillance program utilizes longitudinal, transverse test specimens from lower shell plate B8628-1. The surveillance weld metal was fabricated with weld wire heat number 87005, Flux Type Linde 124 Lot Number 1061.

At the time when the surveillance program material was selected it was believed that copper and phosphorus were the elements most important to embrittlement of reactor vessel steels. Lower shell plate B8628-1 had the highest initial RT_{NDT} and one of the lowest initial USE values of all plate materials in the beltline region. In addition, lower shell plate B8628-1 had approximately the same copper and phosphorous content of the other beltline plate materials. Hence, based on the highest initial RT_{NDT} and one of the lowest initial USE of all plate materials, the lower shell plate B8628-1 was chosen for the surveillance program. The girth weld, on the other hand, has the same heat as all the beltline welds but a different flux. The girth weld had a lower initial RT_{NDT} of the two flux types. However, both welds had low initial RT_{NDT} values and the same copper/phosphorus content. The initial USE of the girth weld used in the surveillance program was 50 to 60 ft-lbs lower than the weld wire & flux used in the longitudinal weld seams. Hence, the girth weld was selected based on the lower USE value.

Based on the above discussion and the methodology in use at the time the program was developed, the Vogtle Unit 2 surveillance material meets the intent of this criterion.

CRITERION 2: Scatter in the plots of Charpy energy versus temperature for the irradiated and unirradiated conditions should be small enough to permit the determination of the 30 ft-lb temperature and upper shelf energy unambiguously.

Plots of the Charpy energy versus temperature for the unirradiated and irradiated condition are presented in Section 5 and Appendix C of this Report.

Based on engineering judgment, the scatter in the data presented in these plots is small enough to permit the determination of the 30 ft-lb temperature and the upper shelf energy of the Vogtle Electric Generating Plant Unit 2 surveillance materials unambiguously. Therefore, the Vogtle Electric Generating Plant Unit 2 surveillance program meets the intent of this criterion.

CRITERION 3: When there are two or more sets of surveillance data from one reactor, the scatter of ΔRT_{NDT} values about a best-fit line drawn as described in Regulatory Position 2.1 normally should be less than 28°F for welds and 17°F for base metal Even if the fluence range is large (two or more orders of magnitude), the scatter should not exceed twice those values. Even if the data fails this criterion for use in shift calculations, they may be credible for determining decrease in upper shelf energy if the upper shelf can be clearly determined, following the definition given in ASTM E185-82.

The functional form of the least squares method as described in Regulatory Position 2.1 will be utilized to determine a best-fit line for this data and to determine if the scatter of these ΔRT_{NDT} values about this line is less than 28°F for welds and less than 17°F for the plate.

Following is the calculation of the best-fit line as described in Regulatory Position 2.1 of Regulatory Guide 1.99, Revision 2. In addition, the recommended NRC methods for determining credibility will be followed. The NRC methods were presented to industry at a meeting held by the NRC on February 12 and 13, 1998. At this meeting the NRC presented five cases. Of the five cases, Case 1 ("Surveillance data available from plant but no other source") most closely represents the situation listed above for Vogtle Unit 2 surveillance weld metal and plate materials.

TABLE D-1

Calculation of Chemistry Factors using Vogtle Unit 2 Surveillance Capsule Data

Material	Capsule	Capsule f[a]	FF[b]	ΔRT_{NDT}[c]	FF*ΔRT_{NDT}	FF^2
Lower Shell Plate B8628-1 (*Longitudinal*)	U	0.356	0.715	2.0	1.43	0.511
	Y	1.12	1.03	5.8	5.97	1.06
	X	1.78	1.16	29.4	34.10	1.35
	W	2.98	1.29	39.0	50.31	1.66
Lower Shell Plate B8628-1 (*Transverse*)	U	0.356	0.715	0.0[d]	0.00	0.511
	Y	1.12	1.03	1.9	1.96	1.06
	X	1.78	1.16	29.8	34.57	1.35
	W	2.98	1.29	45.5	58.70	1.66
				SUM:	187.04	9.162
	$CF_{B8628\text{-}1} = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (187.04) \div (9.162) = 20.4°F$					
Surveillance Weld Material	U	0.356	0.715	0.0[d]	0.00	0.511
	Y	1.12	1.03	18.7	19.3	1.06
	X	1.78	1.16	19.9	23.1	1.35
	W	2.98	1.29	31.4	40.5	1.66
				SUM:	82.9	4.581
	$CF_{Surv.\ Weld} = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (82.9) \div (4.581) = 18.1°F$					

Notes:

(a) f = fluence. See Section 6, [x 10^{19} n/cm^2, E > 1.0 MeV].

(b) FF = fluence factor = $f^{(0.28 - 0.1 * \log f)}$.

(c) ΔRT_{NDT} values are the measured 30 ft-lb shift values taken from Appendix C, herein [°F].

(d) Actual values for ΔRT_{NDT} are -7.1 (*Plate*) and -17.3 (*Weld*). This physically should not occur, therefore for conservatism a value of zero will be used.

The scatter of ΔRT_{NDT} values about the functional form of a best-fit line drawn as described in Regulatory Position 2.1 is presented in Table D-2.

Table D-2

Vogtle Unit 2 Surveillance Capsule Data Scatter about the Best-Fit Line for Surveillance Forging Materials.

Material	Capsule	CF	FF	Measured ΔRT_{NDT}	Predicted ΔRT_{NDT}	Scatter ΔRT_{NDT} (°F)	<17°F (*Base Metals*) <28°F (*Weld*)
Lower Shell Plate B8628-1 (*Longitudinal*)	U	20.4	0.715	2.0	14.6	12.6	Yes
	Y	20.4	1.03	5.8	21.0	15.2	Yes
	X	20.4	1.16	29.4	23.7	-5.7	Yes
	W	20.4	1.29	39.0	26.3	-12.7	Yes
Lower Shell Plate B8628-1 (*Transverse*)	U	20.4	0.715	0.0	14.6	14.6	Yes
	Y	20.4	1.03	1.9	21.0	19.1	No
	X	20.4	1.16	29.8	23.7	-6.1	Yes
	W	20.4	1.29	45.5	26.3	-19.2	No
Vessel Beltline Welds (*Heat # 87005*)	U	18.1	0.715	0.0	12.9	12.9	Yes
	Y	18.1	1.03	18.7	18.6	-0.1	Yes
	X	18.1	1.16	19.9	21.0	1.1	Yes
	W	18.1	1.29	31.4	23.3	-8.1	Yes

Table D-2 indicates that one measured plate ΔRT_{NDT} value is below the lower bound 1σ of -17°F and one measured plate ΔRT_{NDT} value is above the upper bound 1σ of 17°F. Both are less the 2.2 °F from the upper and lower limits. From a statistical point of view, +/-1σ (17°F) would be expected to encompass 68% of the data. In this case 80% is within the scatter band of +/- 1σ. The fact that two plate data points are out by 2.2°F or less can be attributed to several factors, such as 1) the inherent uncertainty in the Charpy test data, 2) the use of a plotting program versus hand drawn plots using engineering judgment, 3) Symmetric plots versus asymmetric plots, and/or rounding errors.

Looking at the data in Table D-2, all the measured plate ΔRT_{NDT} values are below or within the upper bound 1σ of 17°F except for one. The one data point is above 1σ by only 2.2°F. Hence based on the evaluation above, the plate data meets the intent of this criterion.

As for the surveillance weld, all the scatter is within the acceptable range for credible data.

CRITERION 4: The irradiation temperature of the Charpy specimens in the capsule should match the vessel wall temperature at the cladding/base metal interface within +/- 25 °F.

The capsule specimens are located in the reactor between the core barrel and the vessel wall and are positioned opposite the center of the core. The test capsules are in baskets attached to the neutron pads. The location of the specimens with respect to the reactor vessel beltline provides assurance that the reactor vessel wall and the specimens experience equivalent operating conditions such that the temperature will not differ by more than 25°F. Hence, this criterion is met.

CRITERION 5: The surveillance data for the correlation monitor material in the capsule should fall within the scatter band of the data base for that material.

The Vogtle Electric Generating Plant Unit 2 surveillance program does not contain correlation monitor material. Therefore, this criterion is not applicable to the Vogtle Electric Generating Plant Unit 2 surveillance program.

CONCLUSION:

Based on the preceding responses to all five criteria of Regulatory Guide 1.99, Revision 2, Section B and 10CFR 50.61, the Vogtle Electric Generating Plant Unit 2 surveillance data is Credible.