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SOUTHERN COMPANY
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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Joseph M. Farley Nuclear Plant – Unit 1
Reactor Vessel Surveillance Capsule V Results

Ladies and Gentlemen:

In accordance with the provisions of 10 CFR 50 Appendix H, Southern Nuclear Operating Company (SNC) hereby submits Westinghouse Report WCAP-16221-NP, Rev. 0, "Analysis of Capsule V from the Southern Nuclear Operating Company, Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program." This report presents the surveillance capsule test results from Capsule V, the 5th capsule removed from the reactor vessel. These test results were used to evaluate reactor vessel material properties following 20.16 effective full power years (EFPY) of plant operation (equivalent to about 61 EFPY of capsule fluence).

Based on the enclosed surveillance capsule test results, properties of the reactor beltline materials are predicted to remain more than adequate for continued safe plant operation through the end of the current license (about 34 EFPY) and a potential license renewal (to about 54 EFPY). Review of the capsule test results with respect to the FNP Unit 1 Pressure Temperature Limits Report (PTLR) shows no need for PTLR revision aside from normal updating of the heatup and cooldown pressure-temperature limit curves as they approach expiration.

This letter contains no new NRC commitments. If you have any questions, please advise.

Sincerely,

L. M. Stinson

LMS/DWD/sdl

Enclosure: WCAP-16221-NP, Rev. 0, "Analysis of Capsule V from the Southern Nuclear Operating Company, Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program"

A008

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Westinghouse Non-Proprietary Class 3

WCAP-16221-NP
Revision 0

March 2004

Analysis of Capsule V from the Southern Nuclear Operating Company, Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program

Westinghouse

WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-16221-NP, Revision 0

Analysis of Capsule V from the Southern Nuclear Operating Company, Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program

K.G. Knight
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March 2004

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF FIGURES (Cont.)

PREFACE

This report has been technically reviewed and verified by:

Reviewer:

Sections 1-5, 7, 8, and Appendices B, C, and D	T. J. Laubham	
Section 6 and Appendix A	S.L. Anderson	

EXECUTIVE SUMMARY

The purpose of this report is to document the results of the testing of surveillance Capsule V from Farley Unit 1. Capsule V was removed at 20.16 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 V received a fluence of 7.14×10^{19} n/cm^2 (E > 1.0 MeV) after irradiation to 20.16 EFPY. The peak clad/base metal interface vessel fluence after 20.16 EFPY of plant operation was 2.35×10^{19} n/cm^2 (E > 1.0 MeV).

This evaluation lead to the following conclusions: 1) 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 (34 EFPY) and a potential license renewal date of 54 EFPY as required by 10CFR50, Appendix G [2]. 2) The Farley Unit 1 surveillance plate data is not credible but the weld data is credible. This evaluation can be found in Appendix D.

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 V, the fifth capsule removed and tested from the Farley Unit 1 reactor pressure vessel, led to the following conclusions:

- The Charpy V-notch data presented in herein are based on a re-plot of unirradiated data from WCAP-8810[3] and all irradiated capsule data from WCAP-9717[4] (Capsule Y), WCAP-10474[5] (Capsule U), WCAP-11563 Rev. 1[6] (Capsule X), and WCAP-14196[7] (Capsule W) and STC Report (Capsule V)[8] using CVGRAPH, Version 4.1, which is a symmetric hyperbolic tangent curve-fitting program. The results presented in Section 5 are only for the Capsule V test results, which are also based on using CVGRAPH, Version 4.1. Appendix C presents all the CVGRAPH, Version 4.1, Charpy V-notch plots and the program input data, including that from the previous capsules.

- Capsule V received an average fast neutron fluence (E> 1.0 MeV) of 7.14 x10^{19} n/cm^2 after 20.16 effective full power years (EFPY) of plant operation.

- Irradiation of the reactor vessel lower shell plate B6919-1 Charpy specimens, oriented with the longitudinal axis of the specimen parallel to the major working direction (longitudinal orientation), resulted in an irradiated 30 ft-lb transition temperature of 154.9°F and an irradiated 50 ft-lb transition temperature of 194.77°F. This results in a 30 ft-lb transition temperature increase of 178.01°F and a 50 ft-lb transition temperature increase of 187.33°F for the longitudinal oriented specimens.

- Irradiation of the reactor vessel lower shell plate B6919-1 Charpy specimens, oriented with the longitudinal axis of the specimen perpendicular to the major working direction (transverse orientation), resulted in an irradiated 30 ft-lb transition temperature of 167.07°F and an irradiated 50 ft-lb transition temperature of 208.36°F. This results in a 30 ft-lb transition temperature increase of 161.87°F and a 50 ft-lb transition temperature increase of 152.99°F for the transverse oriented specimens.

- Irradiation of the weld metal (heat number 33A277) Charpy specimens resulted in an irradiated 30 ft-lb transition temperature of 40.83°F and an irradiated 50 ft-lb transition temperature of 71.33°F. This results in a 30 ft-lb transition temperature increase of 123.29°F and a 50 ft-lb transition temperature increase of 114.26°F.

- Irradiation of the weld Heat-Affected-Zone (HAZ) metal Charpy specimens resulted in an irradiated 30 ft-lb transition temperature of 9.64°F and an irradiated 50 ft-lb transition temperature of 70.92°F. This results in a 30 ft-lb transition temperature increase of 174.39°F and a 50 ft-lb transition temperature increase of 197.15°F.

- The average upper shelf energy of the lower shell plate B6919-1 (longitudinal orientation) resulted in an average energy decrease of 31 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 109 ft-lb for the longitudinal oriented specimens.

- The average upper shelf energy of the Lower Shell Plate B6919-1 (transverse orientation) resulted in an average energy decrease of 18 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 72 ft-lb for the longitudinal oriented specimens.

- The average upper shelf energy of the weld metal Charpy specimens resulted in an average energy decrease of 39 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 110 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 26 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 129 ft-lb for the weld HAZ metal.

- A comparison of the measured 30 ft-lb shift in transition temperature values for the Farley Unit 1 reactor vessel surveillance materials is presented in Table 5-10.

- 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 (34 EFPY) and a potential license renewal (54 EFPY) as required by 10CFR50, Appendix G [2].

- The calculated end-of-license (34 EFPY) neutron fluence (E> 1.0 MeV) at the core mid-plane for the Farley Unit 1 reactor vessel using the Regulatory Guide 1.99, Revision 2 attenuation formula (i.e., Equation #3 in the guide) are as follows:

  Calculated: Vessel inner radius* = 3.91×10^{19} n/cm^2
  Vessel 1/4 thickness = 2.44×10^{19} n/cm^2
  Vessel 3/4 thickness = 9.47×10^{18} n/cm^2

  *Clad/base metal interface. (Interpolated From Table 6-2)

2 INTRODUCTION

This report presents the results of the examination of Capsule V, the fifth capsule removed from the reactor in the continuing surveillance program, which monitors the effects of neutron irradiation on the Southern Nuclear Operating Company, Farley Unit 1 reactor pressure vessel materials under actual operating conditions.

The surveillance program for the Southern Nuclear Operating Company Farley Unit 1 reactor pressure vessel materials was designed and recommended by the Westinghouse Electric Corporation. A description of the surveillance program and the pre-irradiation mechanical properties of the reactor vessel materials are presented in WCAP-8810, "Southern Alabama Power Company Joseph M. Farley Nuclear Plant Unit No. 1 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 E185-73, "Standard Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels."[20] Capsule V was removed from the reactor after 20.16 EFPY of exposure and shipped to the Westinghouse Science and Technology Department 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 V removed from the Southern Nuclear Operating Company Farley Unit 1 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 SA533 Grade B Class 1 (base material of the Farley Unit 1 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 [10]. 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[9]) 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[10]. 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 Farley Unit 1 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 Farley Unit 1 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 B6919-1, and weld metal fabricated with weld wire Type B4, Heat Number 33A277 and Linde Type 0091 flux, Lot Number 3922.

Capsule V was removed after 20.16 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 B6919-1 and submerged arc weld metal representative of the intermediate shell longitudinal weld seams. In addition, this capsule contained Charpy V-notch specimens from the weld Heat-Affected-Zone (HAZ) metal of plate B6919-1.

Test material obtained from the intermediate shell course plate (after thermal heat treatment and forming of the plate) was taken at least one plate thickness from the quenched edges of the plate. All test specimens were machined from the ¼ thickness location of the plate after performing a simulated post-weld stress-relieved treatment on the test material. Test specimens were also removed from weld and heat-affected-zone metal of a stress-relieved weldment joining lower shell plate B6919-1. All heat-affected-zone specimens were obtained from the weld heat-affected-zone of the Lower Shell Plate B6919-1.

Charpy V-notch impact specimens from lower shell plate B6919-1 were machined in the longitudinal orientation (longitudinal axis of the specimen parallel to the major working direction) and also in the transverse orientation (longitudinal axis of the specimen perpendicular to the major working 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 was machined such that the direction of crack propagation in the specimen was in the welding direction.

Tensile specimens from lower shell plate B6919-1 were machined in both the longitudinal and transverse orientations. 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 lower shell plate B6919-1 were machined in 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 welding. All specimens were fatigue pre-cracked according to ASTM E399.

The chemical composition and heat treatment of the unirradiated surveillance materials are presented in Tables 4-1 and 4-2, respectively. The data in Table 4-1 and 4-2 was obtained from the unirradiated surveillance program report, WCAP-8810[3], Appendix A.

Capsule V contained dosimeter wires of pure iron, copper, 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: 580°F (304°C)
1.75% Ag, 0.75% Sn, 97.5% Pb	Melting Point: 590°F (310°C)

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

Table 4-1
Chemical Composition (Wt%) of the Farley Unit 1 Reactor Vessel Surveillance Materials (Unirradiated)[a]

Element	Lower Shell Plate B6919-1		Weld Metal
	Combustion Engineering Analysis	Westinghouse Analysis	Westinghouse Analysis
C	0.20	---	0.13
S	0.015	0.013	0.009
N_2	---	0.003	0.005
Co	0.008	0.016	0.018
Cu	0.14	0.10	0.14
Si	0.18	0.28	0.27
Mo	0.56	0.51	0.50
Ni	0.55	0.56	0.19
Mn	1.39	1.40	1.06
Cr	---	0.13	0.063
V	---	<0.001	0.003
P	0.015	0.015	0.016
Sn	---	0.008	0.005
Al	0.025	---	0.009

Notes:
(a) Data obtained from WCAP-8810[3] and duplicated herein for completeness.
(b) All elements not listed are less than 0.010 weight percent.

Table 4-2

Heat Treatment History of the Farley Unit 1 Reactor Vessel Surveillance Materials[a]

Material	Temperature (°F)	Time	Coolant
Lower Shell Plate	Austenitized @ 1550 - 1650	4 hrs.	Water-Quench
B6919-1	Tempered @ 1200 - 1250	4 hrs.	Air-cooled
	Stress Relieved @ 1125 - 1175	40 hrs.	Furnace Cooled to 600°F
Weld Metal (heat # 33A277)	Stress Relieved[b] @ 1125 - 1175	16 hrs.	Furnace Cooled

Notes:

(a) This table was taken from WCAP-8810[3].

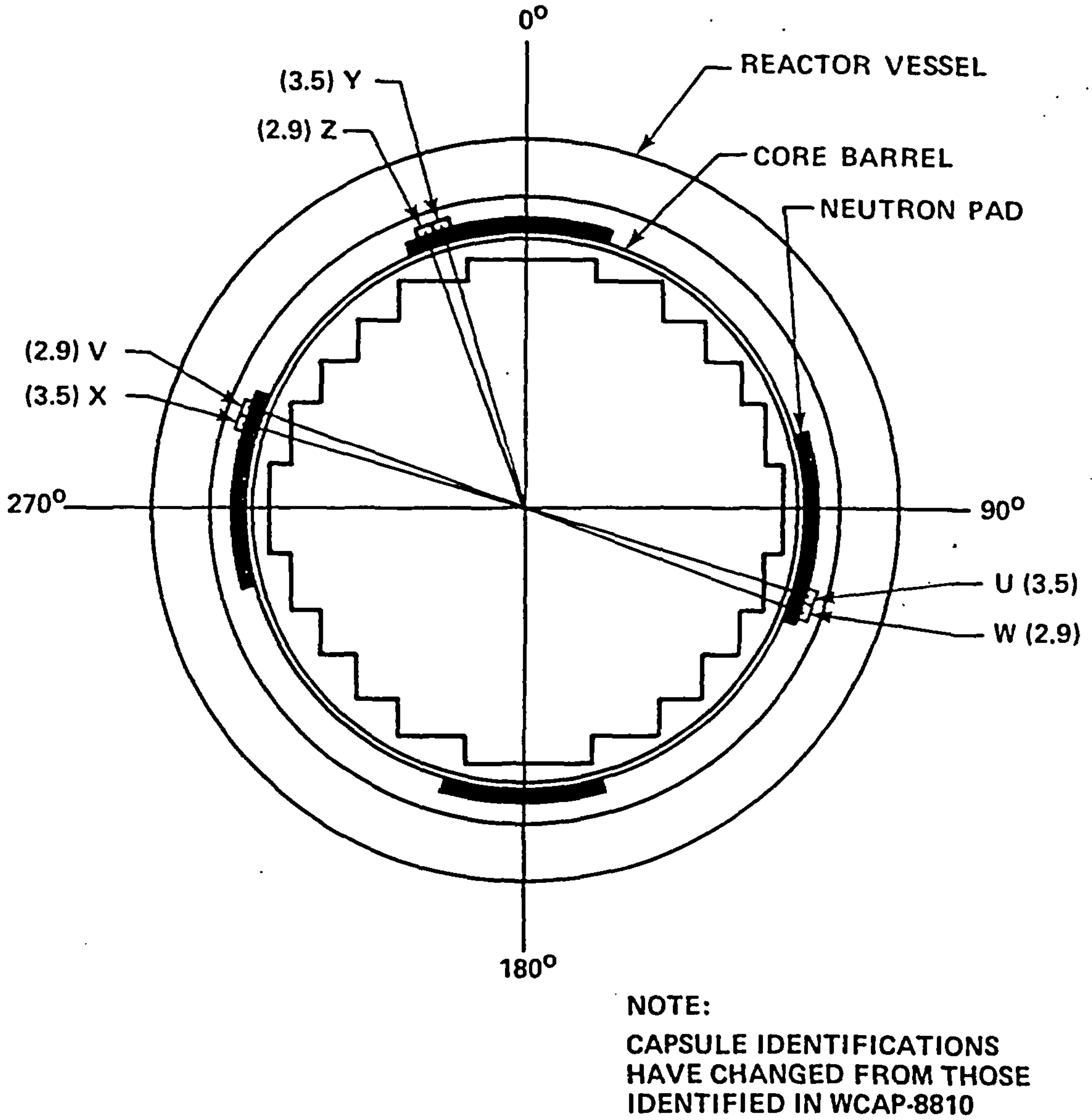


Figure 4-1 Arrangement of Surveillance Capsules in the Farley Unit 1 Reactor Vessel

SPECIMEN NUMBERING CODE

AT – PLATE B6919-1 TRANSVERSE
AL – PLATE B6919-1 LONGITUDINAL
AW – WELD METAL
AH – HEAT AFFECTED ZONE

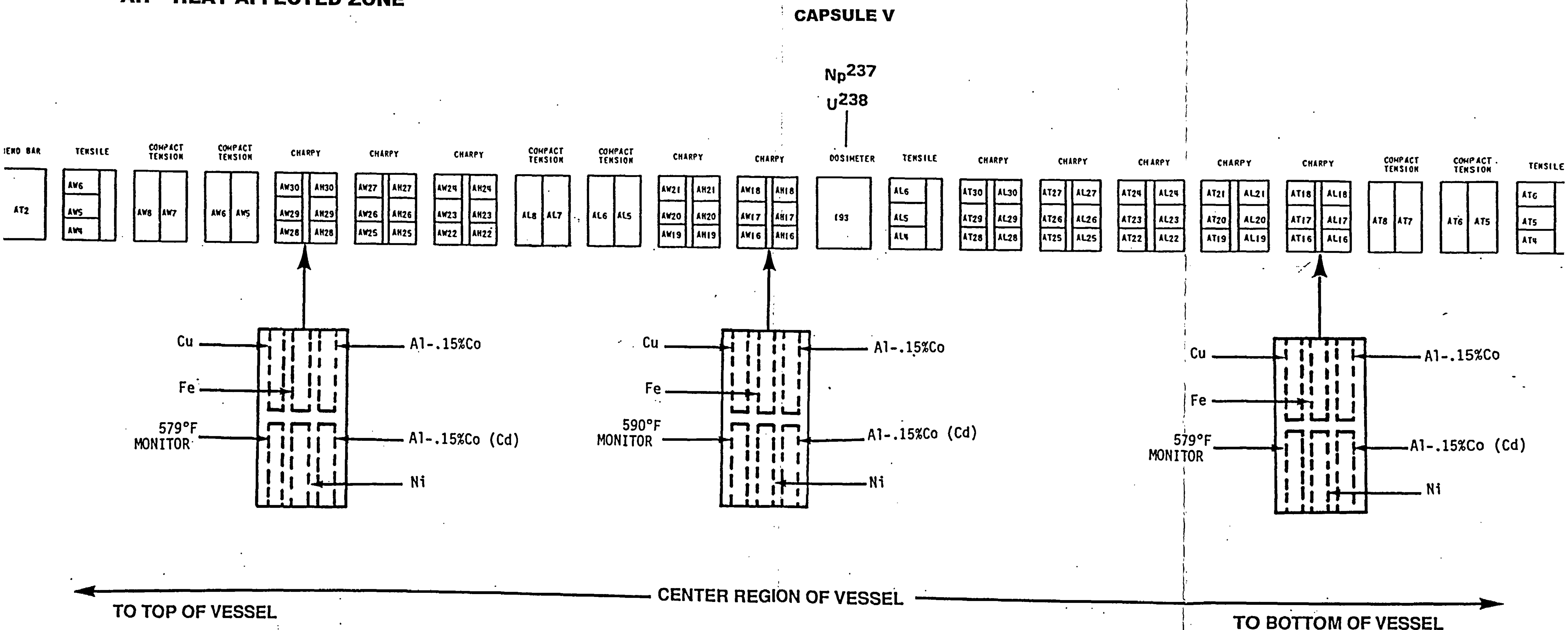


Figure 4-2 Capsule V Diagram Showing The Location of Specimens, Thermal Monitors, and Dosimeters

5 TESTING OF SPECIMENS FROM CAPSULE V

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[11], and Westinghouse Procedure RMF 8402[12] Revision 2 as modified by Westinghouse RMF Procedures 8102[13], Revision 1, and 8103[14], Revision 1.

Upon receipt of the capsule at the hot cell laboratory, the specimens and spacer blocks were carefully removed, inspected for identification number, and checked against the master list in WCAP-8810[3]. No discrepancies were found.

Examination of the two low-melting point 580°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 580°F (304°C).

The Charpy impact tests were performed per ASTM Specification E23-02a[15] and RMF Procedure 8103, Rev. 1, on a Tinius-Olsen Model 74, 358J machine. The tup (striker) of the Charpy impact test machine is instrumented with a 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 (Appendix B), 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), and the load at which fast fracture terminated 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 (σ_Y) was calculated from the three-point bend formula having the following expression:

$$\sigma_Y = (P_{GY} * L) / [B * (W - a)^2 * C] \tag{1}$$

where: L = distance between the specimen supports in the impact 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 ϕ = 45° and ρ = 0.010 inch, Equation 1 is valid with C = 1.21. Therefore, (for L = 4W),

$$\sigma_Y = (P_{GY} * L) / [B * (W - a)^2 * 1.21] = (3.305 * P_{GY} * W) / [B * (W - a)^2] \quad (2)$$

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

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

where σ_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.

The 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:

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

Percent shear was determined from post-fracture photographs using the ratio-of-areas methods in compliance with ASTM Specification E23-02a[15] and A370-97a[16]. The lateral expansion was measured using a dial gage rig similar to that shown in the same specification.

Tensile tests were performed on a 20,000-pound Instron, split-console test machine (Model 1115) per ASTM Specification E8-01[17] and E21-92 (1998)[18], and Procedure RMF 8102, Rev. 1[13]. All pull rods, grips, and pins were made of Inconel 718. The upper pull rod was connected through a universal joint to improve axiality of loading. The tests were conducted at a constant crosshead speed of 0.05 inches per minute throughout the test.

Extension measurements were made with a linear variable displacement transducer extensometer. The extensometer knife-edges were spring-loaded to the specimen and operated through specimen failure. The extensometer gage length was 1.00 inch. The extensometer is rated as Class B-2 per ASTM E83-93[19].

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. Because of the difficulty in remotely attaching a thermocouple directly to the specimen, the following procedure was used to monitor specimen temperatures. Chromel-Alumel thermocouples were positioned at the center and at each end of the gage section of a dummy specimen and in each tensile machine griper. In the test configuration, with a slight load on the specimen, a plot of specimen temperature versus upper and lower tensile machine griper and controller temperatures was developed over the range from room temperature to 550°F (288°C). During the actual testing, the grip temperatures were used to obtain desired specimen temperatures. Experiments have indicated that this method is accurate to ±2°F.

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 was 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 V, which received a fluence of 7.14 x 10^{19} n/cm^2(E> 1.0 MeV) in 20.16 EFPY of operation, are presented in Tables 5-1 through 5-8 and are compared with unirradiated results[4] as shown in Figures 5-1 through 5-12. The transition temperature increases and upper shelf energy decreases for the Capsule V materials are summarized in Table 5-9 and led to the following results:

- The Charpy V-notch data presented in WCAP-8810[3], WCAP-9717 [4], WCAP-10474[5], WCAP-11563[6], and WCAP-14169[7] were based on Charpy curves using a hyperbolic tangent curve-fitting routine. The results presented herein are only for the Capsule V test results using CVGRAPH, Version 4.1, which is a symmetric hyperbolic tangent curve-fitting program. This report also shows the composite plots that show the results from the previous capsules in Appendix C.

- Capsule V received an average fast neutron fluence (E> 1.0 MeV) of 7.14 x 10^{19} n/cm^2 after 20.16 effective full power years (EFPY) of plant operation.

- Irradiation of the reactor vessel intermediate shell plate B6919-1 Charpy specimens, oriented with the longitudinal axis of the specimen parallel to the major working direction (longitudinal orientation), resulted in an irradiated 30 ft-lb transition temperature of 154.9°F and an irradiated 50 ft-lb transition temperature of 194.77°F. This results in a 30 ft-lb transition temperature increase of 178.01°F and a 50 ft-lb transition temperature increase of 187.33°F for the longitudinal oriented specimens.

- Irradiation of the reactor vessel intermediate shell plate B6919-1 Charpy specimens, oriented with the longitudinal axis of the specimen perpendicular to the major working direction (transverse orientation), resulted in an irradiated 30 ft-lb transition temperature of 167.07°F and an irradiated 50 ft-lb transition temperature of 208.36°F. This results in a 30 ft-lb transition temperature increase of 161.87°F and a 50 ft-lb transition temperature increase of 152.99°F for the transverse oriented specimens.

- Irradiation of the weld metal (heat number 33A277) Charpy specimens resulted in an irradiated 30 ft-lb transition temperature of 40.83°F and an irradiated 50 ft-lb transition temperature of 71.33°F. This results in a 30 ft-lb transition temperature increase of 123.29°F and a 50 ft-lb transition temperature increase of 114.26°F.

- Irradiation of the weld Heat-Affected-Zone (HAZ) metal Charpy specimens resulted in an irradiated 30 ft-lb transition temperature of 9.64°F and an irradiated 50 ft-lb transition temperature of 70.92°F. This results in a 30 ft-lb transition temperature increase of 174.39°F and a 50 ft-lb transition temperature increase of 197.15°F.

- The average upper shelf energy of the intermediate shell plate B6919-1 (longitudinal orientation) resulted in an average energy decrease of 31 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 109 ft-lb for the longitudinal oriented specimens.

- The average upper shelf energy of the Intermediate Shell Plate B6919-1 (transverse orientation) resulted in an average energy decrease of 18 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 72 ft-lb for the longitudinal oriented specimens.

- The average upper shelf energy of the weld metal Charpy specimens resulted in an average energy decrease of 39 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 110 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 26 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 129 ft-lb for the weld HAZ metal.

- A comparison of the measured 30 ft-lb shift in transition temperature values for the Farley Unit 1 reactor vessel surveillance materials is presented in Table 5-10:

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 (34 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 V 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 V irradiated to 7.14 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 B6919-1 (longitudinal orientation) indicated that irradiation to 7.14 x 10^{19} n/cm^2 (E> 1.0 MeV) caused approximately a 22 to 44 ksi increase in the 0.2 percent offset yield strength and approximately a 18 to 23 ksi increase in the ultimate tensile strength when compared to unirradiated data[4]. See Figure 5-17 and Table 5-11.

The results of the tensile tests performed on the intermediate shell plate B6919-1 (transverse orientation) indicated that irradiation to 7.14 x 10^{19} n/cm^2 (E> 1.0 MeV) caused approximately a 14 to 23 ksi increase in the 0.2 percent offset yield strength and approximately a 10 to 19 ksi increase in the ultimate tensile strength when compared to unirradiated data[4]. See Figure 5-18 and Table 5-11.

The results of the tensile tests performed on the surveillance weld metal indicated that irradiation to 7.14 x 10^{19} n/cm^2 (E> 1.0 MeV) caused approximately a 10 to 11 ksi increase in the 0.2 percent offset yield strength and approximately a 7 to 10 ksi increase in the ultimate tensile strength when compared to unirradiated data[4]. See Figure 5-19 and Table 5-11.

The fractured tensile specimens for the intermediate shell plate B6919-1 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 Research and Technology Park Hot Cell facility.

Table 5-1

Charpy V-notch Data for the Farley Unit 1 Lower Shell Plate B6919-1 Irradiated to a Fluence of 7.14×10^{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	%
AL24	25	-4	6	8	0	0.00	2
AL19	50	10	4	5	2	0.05	5
AL20	75	24	16	22	5	0.13	10
AL22	100	38	11	15	3	0.08	15
AL16	125	52	23	31	10	0.25	20
AL18	140	60	26	35	14	0.36	20
AL23	150	66	34	46	20	0.51	25
AL25	175	79	28	38	13	0.33	30
AL30	190	88	48	65	31	0.79	40
AL21	200	93	58	79	41	1.04	70
AL27	250	121	65	88	45	1.14	75
AL17	275	135	86	117	59	1.50	85
AL26	300	149	107	145	75	1.91	100
AL28	325	163	113	153	72	1.83	100
AL29	325	163	106	144	67	1.70	100

Table 5-2
Charpy V-notch Data for the Farley Unit 1 Lower Shell Plate B6919-1 Irradiated to a Fluence of 7.14 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	%
AT20	25	-4	4	5	3	0.08	5
AT28	75	24	7	9	4	0.10	10
AT30	100	38	15	20	5	0.13	10
AT27	125	52	15	20	8	0.20	30
AT25	150	66	27	37	16	0.41	25
AT21	150	66	26	35	20	0.51	30
AT18	160	71	31	42	21	0.53	25
AT24	175	79	27	37	21	0.53	30
AT29	175	79	17	23	13	0.33	35
AT19	200	93	49	66	21	0.53	60
AT16	225	107	68	92	49	1.24	80
AT17	250	121	58	79	45	1.14	80
AT22	275	135	65	88	49	1.24	100
AT23	275	135	74	100	51	1.30	100
AT26	300	149	76	103	56	1.42	100

Table 5-3
Charpy V-notch Data for the Farley Unit 1 Surveillance Weld Metal Irradiated to a Fluence of 7.14×10^{19} n/cm^2 (E> 1.0 MeV)

Sample Number	Temperature		Impact Energy		Lateral Expansion		Shear
	°F	°C	ft-lbs	Joules	mils	mm	%
AW27	-50	-46	3	4	0	0.00	5
AW20	-25	-32	13	18	2	0.05	10
AW17	0	-18	8	11	7	0.18	10
AW21	25	-4	24	33	25	0.64	20
AW30	40	4	20	27	13	0.33	20
AW18	50	10	42	57	27	0.69	25
AW25	60	16	52	71	37	0.94	30
AW29	75	24	46	62	28	0.71	50
AW28	100	38	69	94	46	1.17	65
AW16	125	52	88	119	62	1.57	85
AW26	150	66	89	121	57	1.45	85
AW24	175	79	105	142	72	1.83	95
AW19	200	93	114	155	79	2.01	100
AW22	225	107	109	148	73	1.85	100
AW23	250	121	113	153	72	1.83	100

Table 5-4

Charpy V-notch Data for the Farley Unit 1 Heat-Affected-Zone (HAZ) Material Irradiated to a Fluence of 7.14 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	%
AH26	-75	-59	17	23	4	0.10	10
AH23	-50	-46	49	66	26	0.66	20
AH19	-50	-46	5	7	0	0.00	5
AH29	-25	-32	18	24	8	0.20	15
AH27	0	-18	63	85	30	0.76	30
AH21	0	-18	13	18	7	0.18	20
AH30	25	-4	34	46	15	0.38	25
AH16	50	10	31	42	16	0.41	35
AH22	75	24	31	42	25	0.64	40
AH20	100	38	69	94	38	0.97	50
AH28	150	66	74	100	50	1.27	80
AH18	200	93	92	125	75	1.91	90
AH17	225	107	103	140	62	1.57	95
AH24	250	121	107	145	73	1.85	100
AH25	275	135	151	205	75	1.91	100

Table 5-5

Instrumented Charpy Impact Test Results for the Farley Unit 1 Lower Shell Plate B6919-1 Irradiated to a Fluence of 7.14 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 σ_Y (ksi)	Flow Stress (ksi)
AL24	25	6	48	28	20	3259	0.13	3278	0.14	3273	0	109	109
AL19	50	4	32	11	22	1355	0.09	1496	0.10	1496	0	45	47
AL20	75	16	129	77	51	3953	0.15	4820	0.22	4769	0	132	146
AL22	100	11	89	48	40	4024	0.15	4338	0.18	4316	0	134	139
AL16	125	23	185	144	42	3723	0.14	4699	0.33	4696	0	124	140
AL18	140	26	209	168	42	3717	0.14	4789	0.37	4787	0	124	142
AL23	150	34	274	223	51	3674	0.15	4808	0.47	4798	0	122	141
AL25	175	28	226	163	63	3541	0.14	4611	0.38	4611	95	118	136
AL30	190	48	387	254	133	3625	0.15	4887	0.52	4811	73	121	142
AL21	200	58	467	249	218	3498	0.14	4804	0.52	4609	811	116	138
AL27	250	65	927	293	634	3081	0.14	4144	0.68	3038	1735	103	120
AL17	275	86	991	289	702	3047	0.14	4096	0.67	n/a	n/a	101	119
AL26	300	107	1072	344	728	3069	0.15	4187	0.78	n/a	n/a	102	121
AL28	325	113	1136	284	852	2863	0.14	4008	0.68	n/a	n/a	95	114
AL29	325	106	1023	282	742	2900	0.14	4042	0.67	n/a	n/a	97	116

Table 5-6

Instrumented Charpy Impact Test Results for the Farley Unit 1 Intermediate Shell Plate B6919-1 Irradiated to a Fluence of 7.14 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 σ_Y (ksi)	Flow Stress (ksi)
AT20	25	4	32	19	13	2309	0.11	2355	0.13	2339	0	77	78
AT28	75	7	56	29	28	3267	0.13	3343	0.14	3248	0	109	110
AT30	100	15	121	74	47	3352	0.15	4417	0.23	4392	0	112	129
AT27	125	15	121	61	60	3735	0.15	4425	0.20	4382	151	124	136
AT25	150	27	218	144	73	3434	0.14	4367	0.35	4342	817	114	130
AT21	150	26	209	69	140	3561	0.14	4348	0.21	4307	327	119	132
AT18	160	31	250	197	53	3578	0.14	4735	0.43	4729	0	119	138
AT24	175	27	218	142	76	3431	0.14	4333	0.35	4287	978	114	129
AT29	175	17	137	56	81	3735	0.15	4311	0.20	4305	632	124	134
AT19	200	49	395	193	202	3233	0.14	4626	0.45	4615	1468	108	131
AT16	225	68	548	244	303	3579	0.15	4880	0.51	4685	1934	119	141
AT17	250	58	467	230	238	3494	0.14	4636	0.50	4488	2816	116	135
AT22	275	65	524	195	329	3262	0.14	4379	0.45	n/a	n/a	109	127
AT23	275	74	596	237	359	3466	0.14	4725	0.51	n/a	n/a	115	136
AT26	300	76	612	226	386	3222	0.14	4412	0.52	n/a	n/a	107	127

Table 5-7

Instrumented Charpy Impact Test Results for the Farley Unit 1 Surveillance Weld Metal Irradiated to a Fluence of 7.14 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 σ_Y (ksi)	Flow Stress (ksi)
AW27	-50	3	24	11	13	1423	0.09	1496	0.11	1490	0	47	49
AW20	-25	13	105	62	43	4234	0.15	4806	0.20	4798	0	141	151
AW17	0	8	64	37	27	3622	0.17	3649	0.17	3639	0	121	121
AW21	25	24	193	73	120	3957	0.15	4728	0.22	4542	100	132	145
AW30	40	20	161	71	90	4022	0.15	4769	0.21	4623	22	134	146
AW18	50	42	338	251	88	3827	0.14	4805	0.51	4767	745	127	144
AW25	60	52	419	249	170	3790	0.15	4719	0.52	4660	948	126	142
AW29	75	46	371	257	113	3798	0.14	4930	0.52	4897	1192	126	145
AW28	100	69	556	248	308	3715	0.15	4674	0.52	4417	1507	124	140
AW16	125	88	709	336	373	3621	0.14	4682	0.67	3556	1659	121	138
AW26	150	89	717	333	384	3591	0.14	4594	0.68	3696	1882	120	136
AW24	175	105	846	325	521	3566	0.15	4519	0.68	3258	2526	119	135
AW19	200	114	919	335	583	3519	0.16	4654	0.69	n/a	n/a	117	136
AW22	225	109	878	339	540	3416	0.16	4652	0.70	n/a	n/a	114	134
AW23	250	113	910	324	587	3404	0.15	4590	0.67	n/a	n/a	113	133

Table 5-8

Instrumented Charpy Impact Test Results for the Farley Unit 1 Heat-Affected-Zone (HAZ) Metal Irradiated to a Fluence of 7.14 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 σ_Y (ksi)	Flow Stress (ksi)
AH26	-75	17	137	90	47	5036	0.17	5718	0.23	5697	0	168	179
AH23	-50	49	395	294	101	4600	0.16	5589	0.52	5400	0	153	170
AH19	-50	5	40	19	21	2241	0.10	2425	0.12	2401	0	75	78
AH29	-25	18	145	82	63	4610	0.16	5446	0.22	5444	0	154	167
AH27	0	63	508	286	221	4531	0.15	5543	0.51	5189	0	151	168
AH21	0	13	105	51	54	4545	0.16	4712	0.18	4699	0	151	154
AH30	25	34	274	219	55	4095	0.14	5317	0.42	5306	0	136	157
AH16	50	31	250	75	175	3855	0.14	4977	0.21	4617	1718	128	147
AH22	75	31	250	51	199	3439	0.13	4041	0.18	4036	1133	115	125
AH20	100	69	556	276	280	4128	0.15	5171	0.53	4876	543	137	155
AH28	150	74	596	269	327	3995	0.15	5207	0.52	5175	2275	133	153
AH18	200	92	741	348	393	3706	0.15	4911	0.68	4095	3423	123	143
AH17	225	103	830	335	495	3582	0.15	4784	0.67	n/a	n/a	119	139
AH24	250	107	862	256	606	3782	0.14	4972	0.51	n/a	n/a	126	146
AH25	275	151	1217	372	844	3951	0.15	5281	0.68	n/a	n/a	132	154

Table 5-9

Effect of Irradiation to 7.14 x 10^{19} n/cm^2 (E>1.0 MeV) on the Capsule V Notch Toughness Properties of the Farley Unit 1 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 B6919-1 (Long.)	-23.11	154.9	178.01	0.2	207	206.8	7.44	194.77	187.33	140	109	-31
Lower Shell Plate B6919-1 (Trans.)	5.19	167.07	161.87	42.67	215.69	173.02	55.37	208.36	152.99	90	72	-18
Weld Metal (Heat # 33A277)	-82.46	40.83	123.29	-48.69	73.83	122.52	-42.93	71.33	114.26	149	110	-39
HAZ Metal	-164.75	9.64	174.39	-106.89	95.47	202.37	-126.22	70.92	197.15	155	129	-26

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 Farley Unit 1 Surveillance Material 30 ft-lb Transition Temperature Shifts and Upper Shelf Energy Decreases with Regulatory Guide 1.99, Revision 2, Predictions

Material	Capsule	Fluence[d] (x 10^{19} n/cm^2, E > 1.0 MeV)	30 ft-lb Transition Temperature Shift		Upper Shelf Energy Decrease	
			Predicted (°F) [a]	Measured (°F) [b]	Predicted (%) [a]	Measured (%)[c]
Lower Shell Plate B6919-1 (Longitudinal)	Y	0.612	84.30	64.83	20	8.6
	U	1.73	112.57	110.34	25.5	22.9
	X	3.06	126.65	129.71	29	18.6
	W	4.75	136.14	145.57	33	22.1
	V	7.14	143.37	178.01	35	22.1
Lower Shell Plate B6919-1 (Transverse)	Y	0.612	84.30	70.45	20	0
	U	1.73	112.57	100.51	25.5	8.9
	X	3.06	126.65	110.72	29	11.1
	W	4.75	136.14	150.54	33	15.6
	V	7.14	143.37	161.87	35	20
Surveillance Program Weld Metal	Y	0.612	67.32	72.92	25	12.1
	U	1.73	89.89	81.13	32	29.5
	X	3.06	101.14	93.19	36	22.8
	W	4.75	108.72	104.17	40	26.2
	V	7.14	114.49	123.29	42.5	26.2
Heat Affected Zone Material	Y	0.612	---	32.55	---	10.3
	U	1.73	---	160.37	---	25.8
	X	3.06	---	136.91	---	21.9
	W	4.75	---	126.04	---	14.2
	V	7.14	---	174.39	---	16.8

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 4.1 (See Appendix C)

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

d) The fluence values presented here are the calculated values, not the best estimate values.

Table 5-11

Tensile Properties of the Farley Unit 1 Capsule V Reactor Vessel Surveillance Materials Irradiated to 7.14 x 10^{19} n/cm^2 (E > 1.0 MeV)

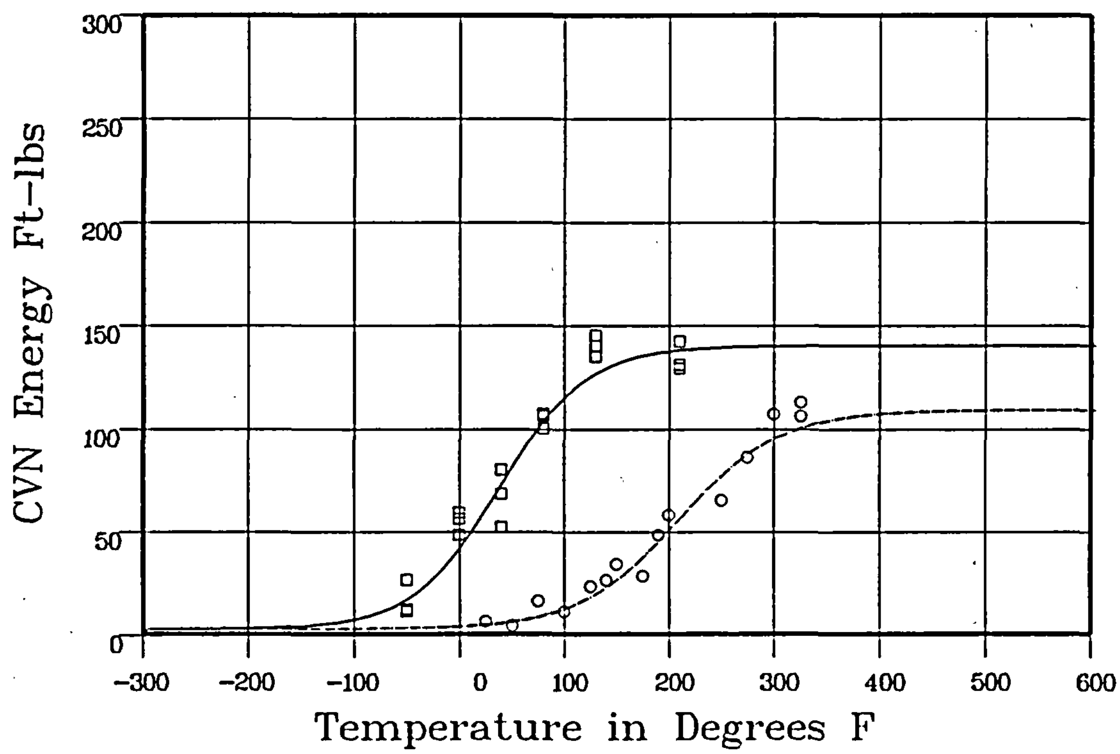
Material	Sample Number	Test Temp. (°F)	0.2% Yield Strength (ksi)	Ultimate Strength (ksi)	Fracture Load (kip)	Fracture Stress (ksi)	Fracture Strength (ksi)	Uniform Elongation (%)	Total Elongation (%)	Reduction in Area (%)
Lower Shell Plate B6919-1 (Long.)	AL-4	75	89.1	107.2	3.52	190.2	71.7	10.5	21.8	62
	AL-5	300	80.5	97.7	2.95	164.0	60.0	9.8	20.3	63
	AL-6	550	98.2	98.2	3.64	143.8	74.2	3.8	13.8	48
Lower Shell Plate B6919-1 (Trans.)	AT-5	75	89.6	106.5	3.81	158.8	77.6	9.8	19.5	51
	AT-4	300	80.0	97.4	3.78	166.3	77.0	10.5	20.1	54
	AT-6	550	73.3	95.2	3.17	98.3	64.5	8.3	13.9	34
Weld Metal	AW-6	75	88.8	99.8	3.08	188.6	62.6	10.5	23.4	67
	AW-5	300	81.1	91.8	3.18	188.4	64.7	9.0	21.0	66
	AW-4	550	78.9	94.1	3.15	170.2	64.2	9.0	20.3	62

LOWER SHELL PLATE (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:04:41 on 11-05-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	140	0	-23.11	0	7.44	0
2	0	2.19	0	109	-31	154.9	178.01	194.77	187.33



Curve Legend

1 □——— 2 ○---------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	LT	C6940-1
2	FA1	V	PLATE SA533B1	LT	C6940-1

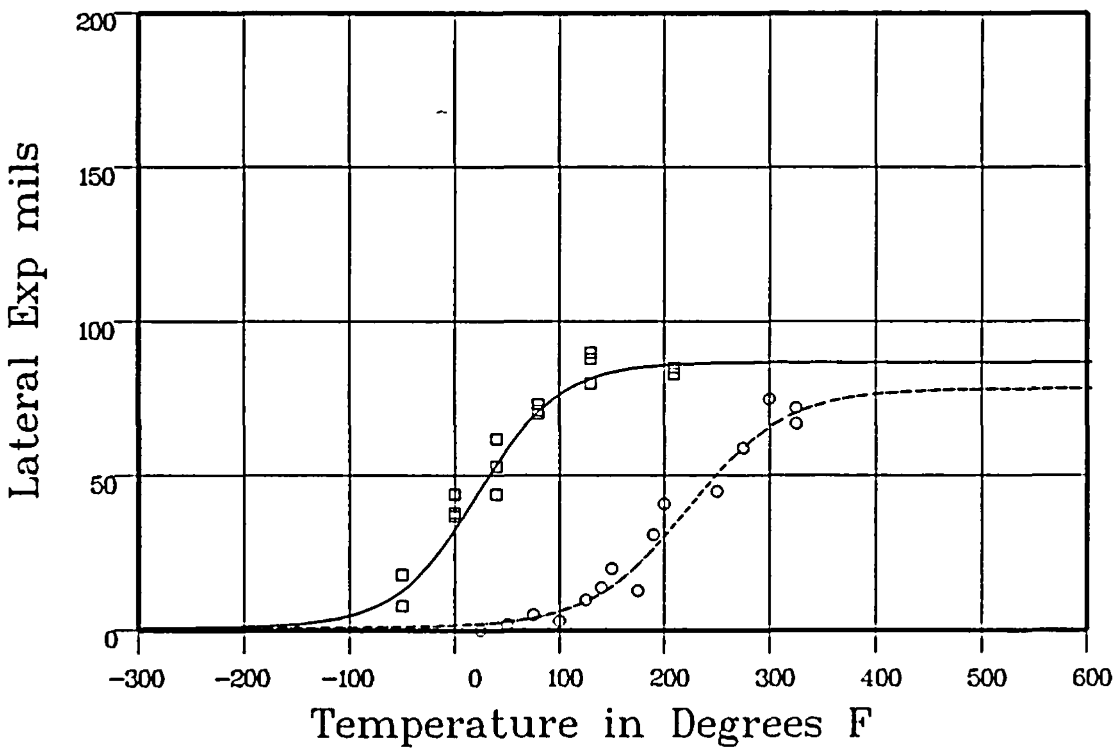
Figure 5-1 Charpy V-Notch Impact Energy vs. Temperature for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Longitudinal Orientation)

LOWER SHELL PLATE (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:07:39 on 11-05-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	86.8	0	2	0
2	0	78.27	-8.52	207	206.8



Curve Legend

1 □——— 2 ○---------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	LT	C6940-1
2	FA1	V	PLATE SA533B1	LT	C6940-1

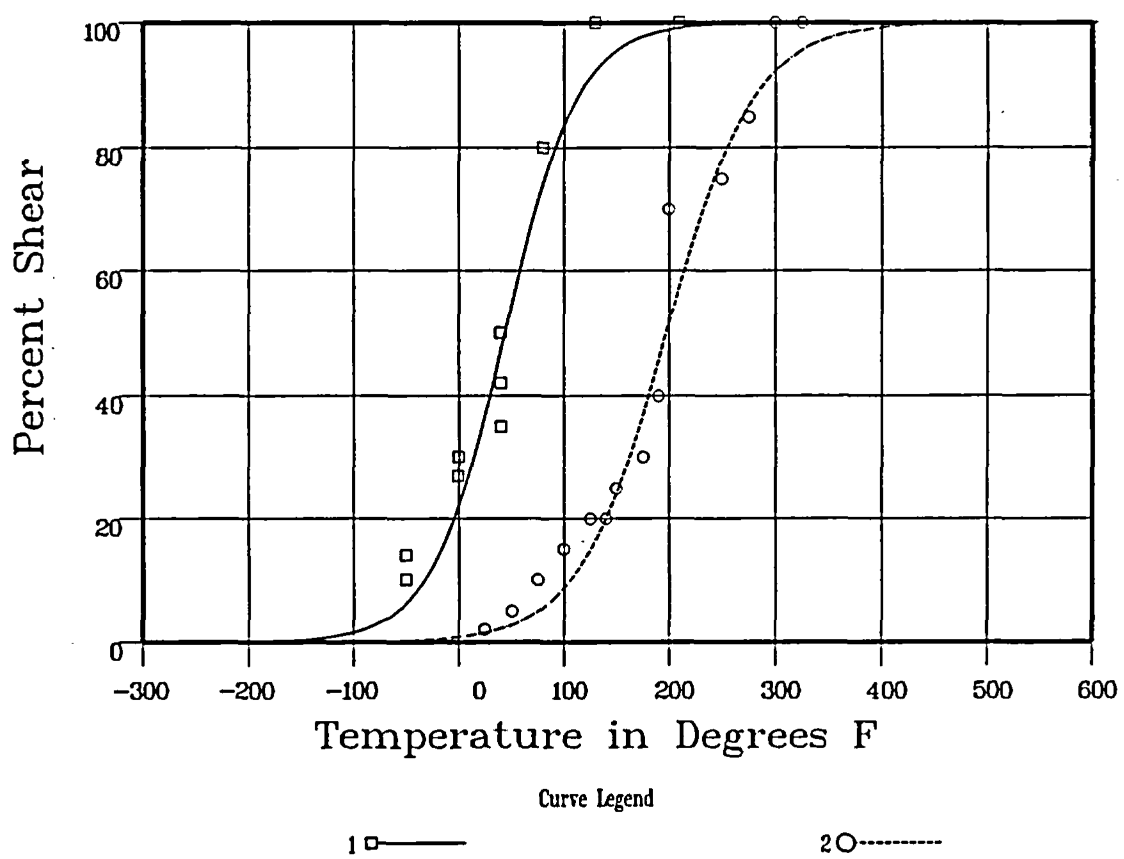
Figure 5-2 Charpy V-Notch Lateral Expansion vs. Temperature for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Longitudinal Orientation)

LOWER SHELL PLATE (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:10:08 on 11-05-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	39.21	0
2	0	192.74	153.53



Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	LT	C6940-1
2	FA1	V	PLATE SA533B1	LT	C6910-1

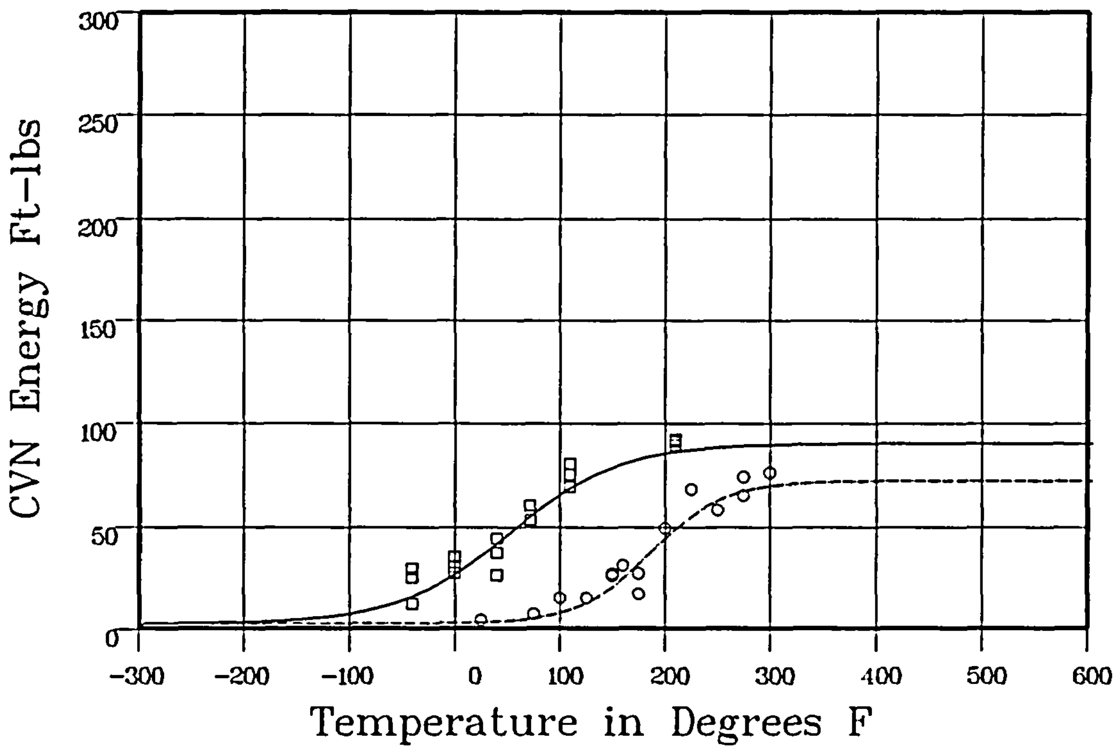
Figure 5-3 Charpy V-Notch Percent Shear vs. Temperature for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Longitudinal Orientation)

LOWER SHELL PLATE (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:18:33 on 11-05-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T o 30	d-T o 30	T o 50	d-T o 50
1	0	2.19	0	90	0	5.19	0	55.37	0
2	0	2.19	0	72	-18	167.07	161.87	208.36	152.99



Curve Legend

1 □——— 2 ○----------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	TL	C6940-1
2	FA1	V	PLATE SA533B1	TL	C6940-1

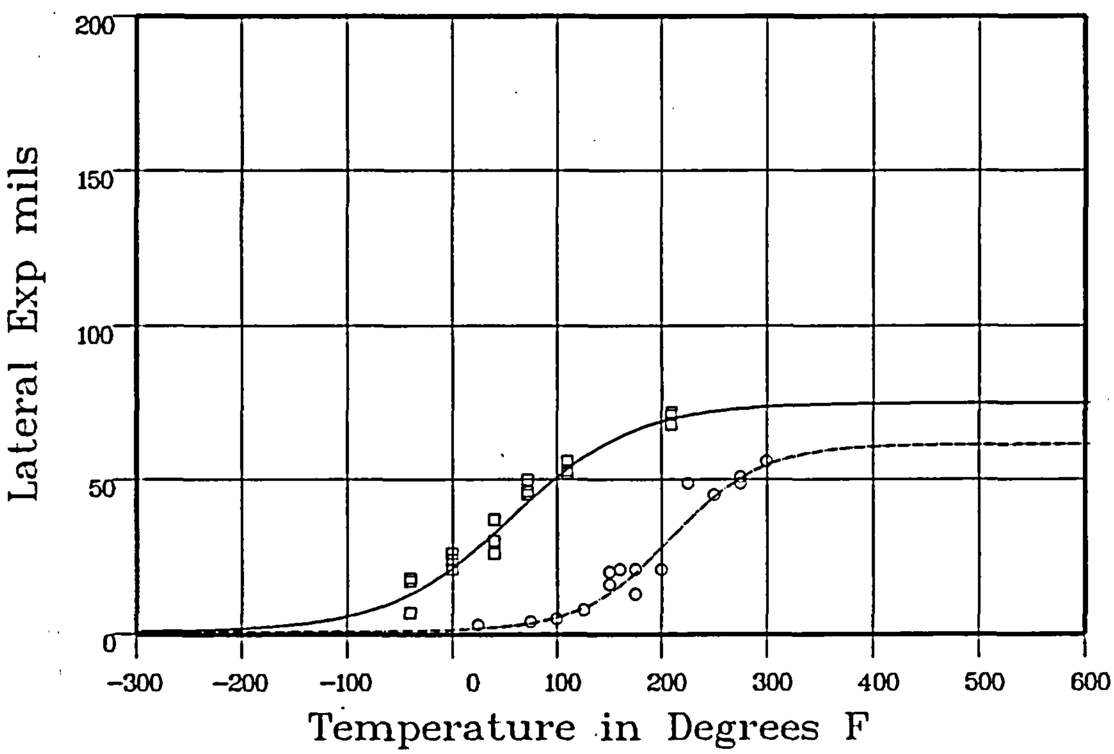
Figure 5-4 Charpy V-Notch Impact Energy vs. Temperature for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Transverse Orientation)

LOWER SHELL PLATE (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:28:07 on 11-05-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	75.15	0	42.67	0
2	0	61.55	-13.59	215.69	173.02



Curve Legend

1 □——— 2 ○----------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	TL	C6940-1
2	FA1	V	PLATE SA533B1	TL	C6940-1

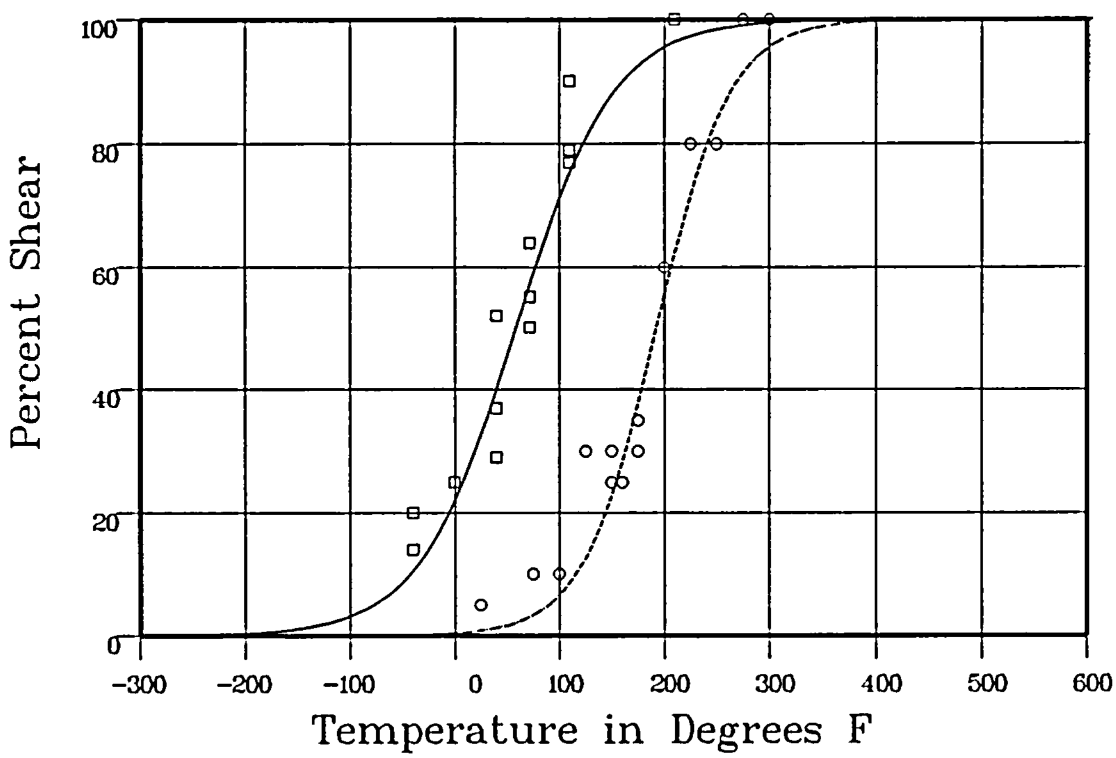
Figure 5-5 Charpy V-Notch Lateral Expansion vs. Temperature for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Transverse Orientation)

LOWER SHELL PLATE (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:30:18 on 11-05-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	53.9	0
2	0	187.96	134.06



Curve Legend

1 □——— 2 ○---------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	TL	C6940-1
2	FA1	V	PLATE SA533B1	TL	C6940-1

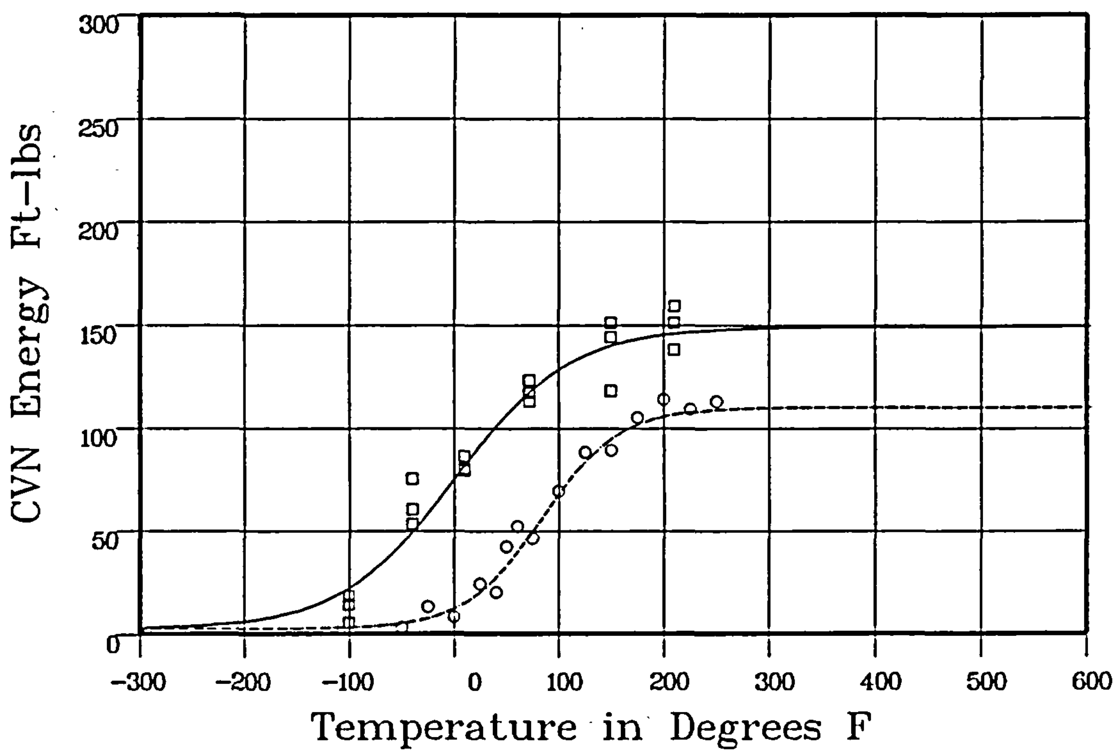
Figure 5-6 Charpy V-Notch Percent Shear vs. Temperature for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Transverse Orientation)

SURVEILLANCE PROGRAM WELD METAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 08:58:55 on 11-06-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	149	0	-82.46	0	-42.93	0
2	0	2.19	0	110	-39	40.83	123.29	71.33	114.26



Curve Legend

1 □——— 2 ○---------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	WELD LINDE 0091		33A277 FLUX LOT 3922
2	FA1	V	WELD LINDE 0091		33A277 FLUX LOT 3922

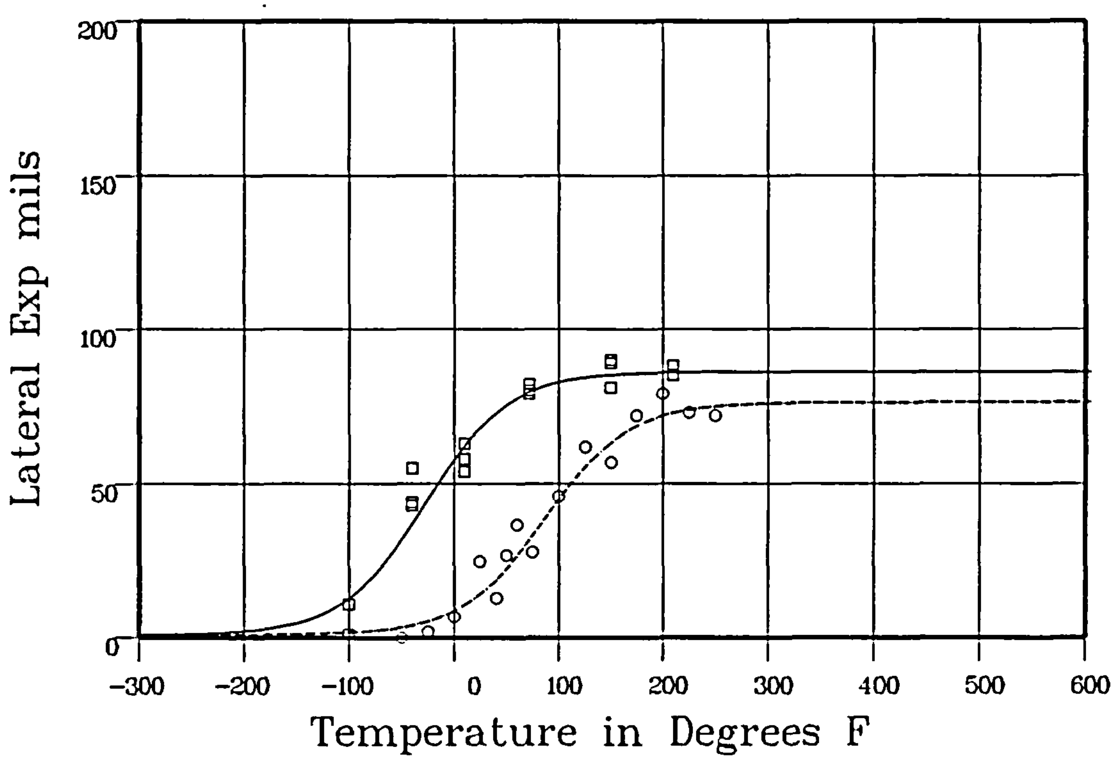
Figure 5-7 Charpy V-Notch Impact Energy vs. Temperature for Farley Unit 1 Reactor Vessel Weld Metal

SURVIELLANCE PROGRAM WELD METAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:01:05 on 11-06-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	86.12	0	-48.69	0
2	0	76.21	-9.91	73.83	122.52



Curve Legend

1 ☐———— 2 ○---------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	WELD LINDE 0091		33A277 FLUX LOT 3922
2	FA1	V	WELD LINDE 0091		33A277 FLUX LOT 3922

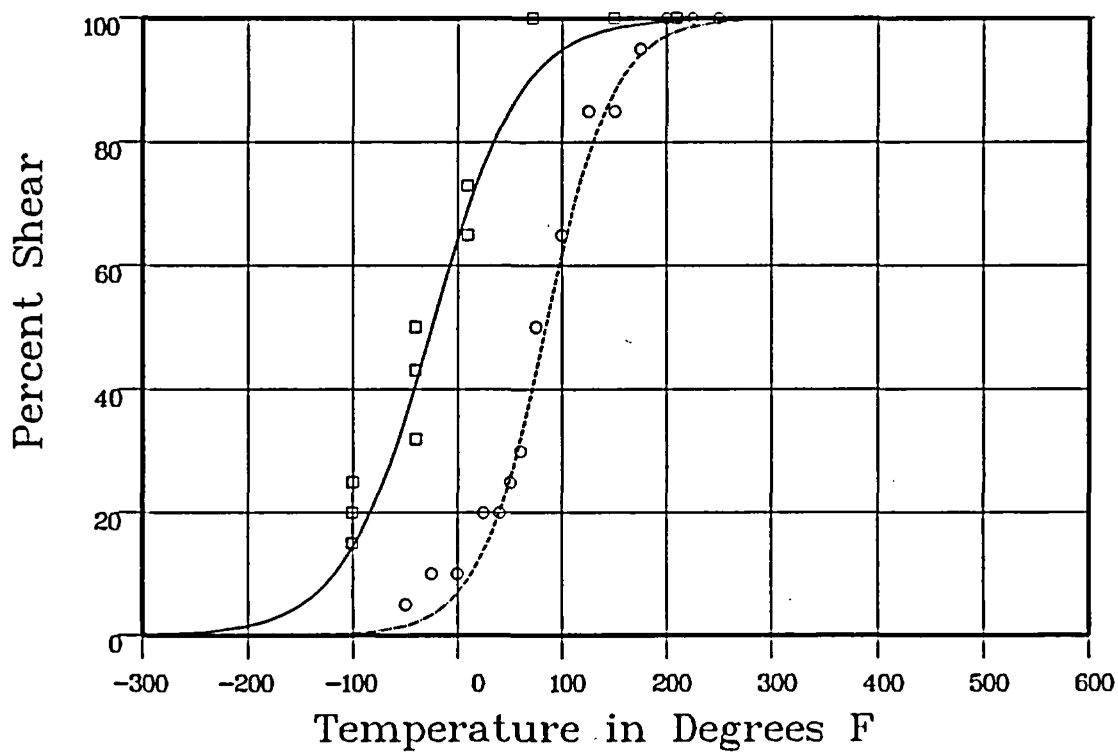
Figure 5-8 Charpy V-Notch Lateral Expansion vs. Temperature for Farley Unit 1 Reactor Vessel Weld Metal

SURVIELLANCE PROGRAM WELD METAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:02:54 on 11-06-2003

Results

Curve	Fluence	T o 50% Shear	d-T o 50% Shear
1	0	-29.06	0
2	0	79.99	109.06



Curve Legend

1 ——— 2 ----------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	WELD LINDE 0091		33A277 FLUX LOT 3922
2	FA1	V	WELD LINDE 0091		33A277 FLUX LOT 3922

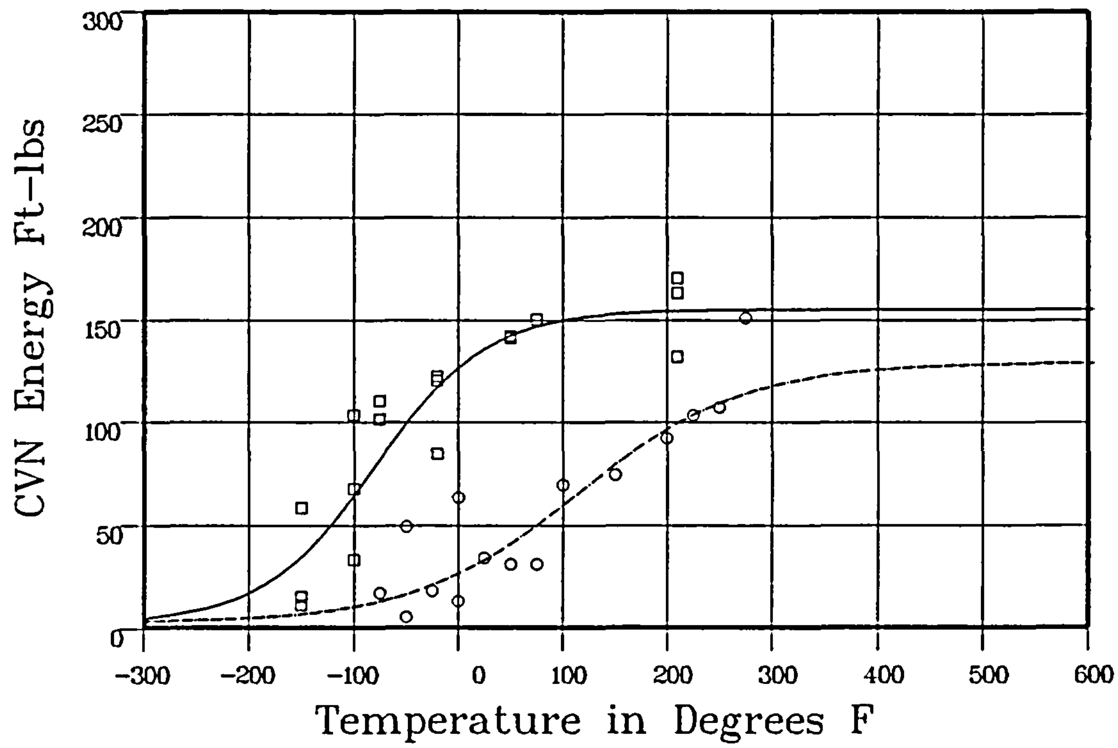
Figure 5-9 Charpy V-Notch Percent Shear vs. Temperature for Farley Unit 1 Reactor Vessel Weld Metal

HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:07:15 on 11-06-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	155	0	-164.75	0	-126.22	0
2	0	2.19	0	129	-26	9.64	174.39	70.92	197.15



Curve Legend

1 □———— 2 ○----------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	HEAT AFFD ZONE SA533B1		
2	FA1	V	HEAT AFFD ZONE SA533B1		

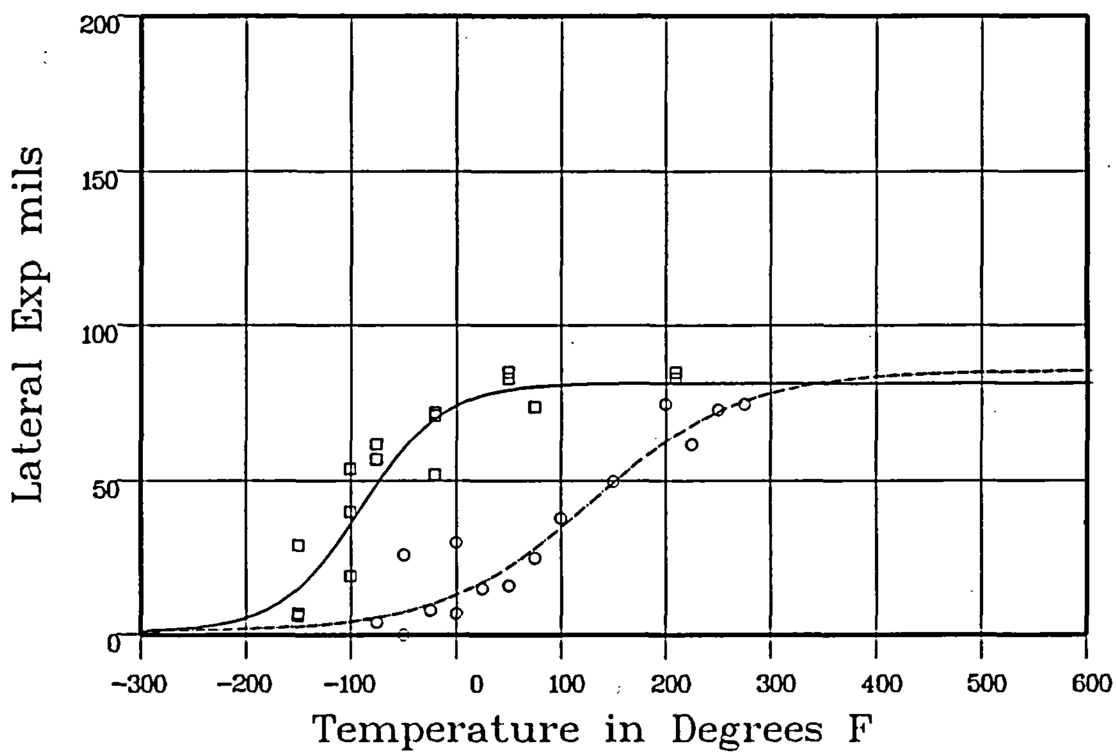
Figure 5-10 Charpy V-Notch Impact Energy vs. Temperature for Farley Unit 1 Reactor Vessel Heat-Affected-Zone Material

HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:09:23 on 11-06-2003

Results

Curve	Fluence	USE	d-USE	T o LE35	d-T o LE35
1	0	81.58	0	-106.89	0
2	0	85.5	3.92	95.47	202.37



Curve Legend

1 □——— 2 ○---------

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	HEAT AFFD ZONE SA533B1		
2	FA1	V	HEAT AFFD ZONE SA533B1		

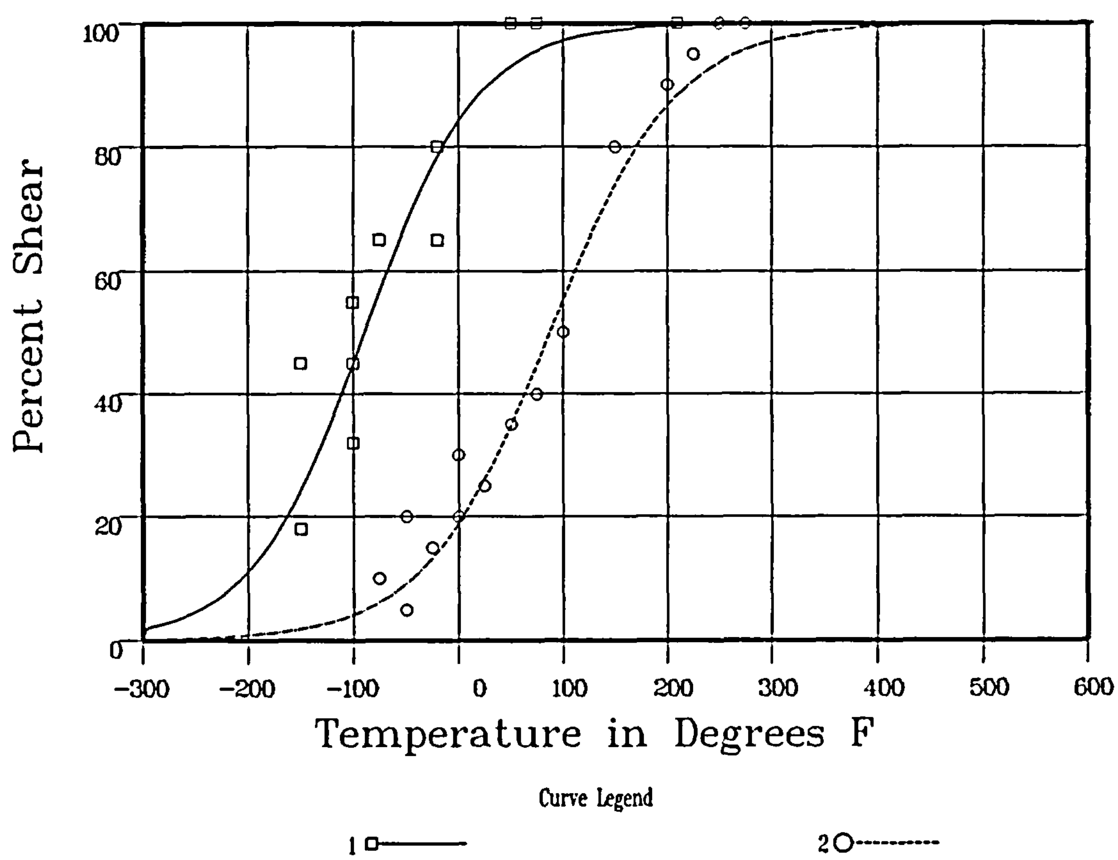
Figure 5-11 Charpy V-Notch Lateral Expansion vs. Temperature for Farley Unit 1 Reactor Vessel Heat-Affected-Zone Material

HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:11:04 on 11-06-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	-93.75	0
2	0	82.91	176.66



Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	HEAT AFFD ZONE SA533B1		
2	FA1	V	HEAT AFFD ZONE SA533B1		

Figure 5-12 Charpy V-Notch Percent Shear vs. Temperature for Farley Unit 1 Reactor Vessel Heat-Affected-Zone Material

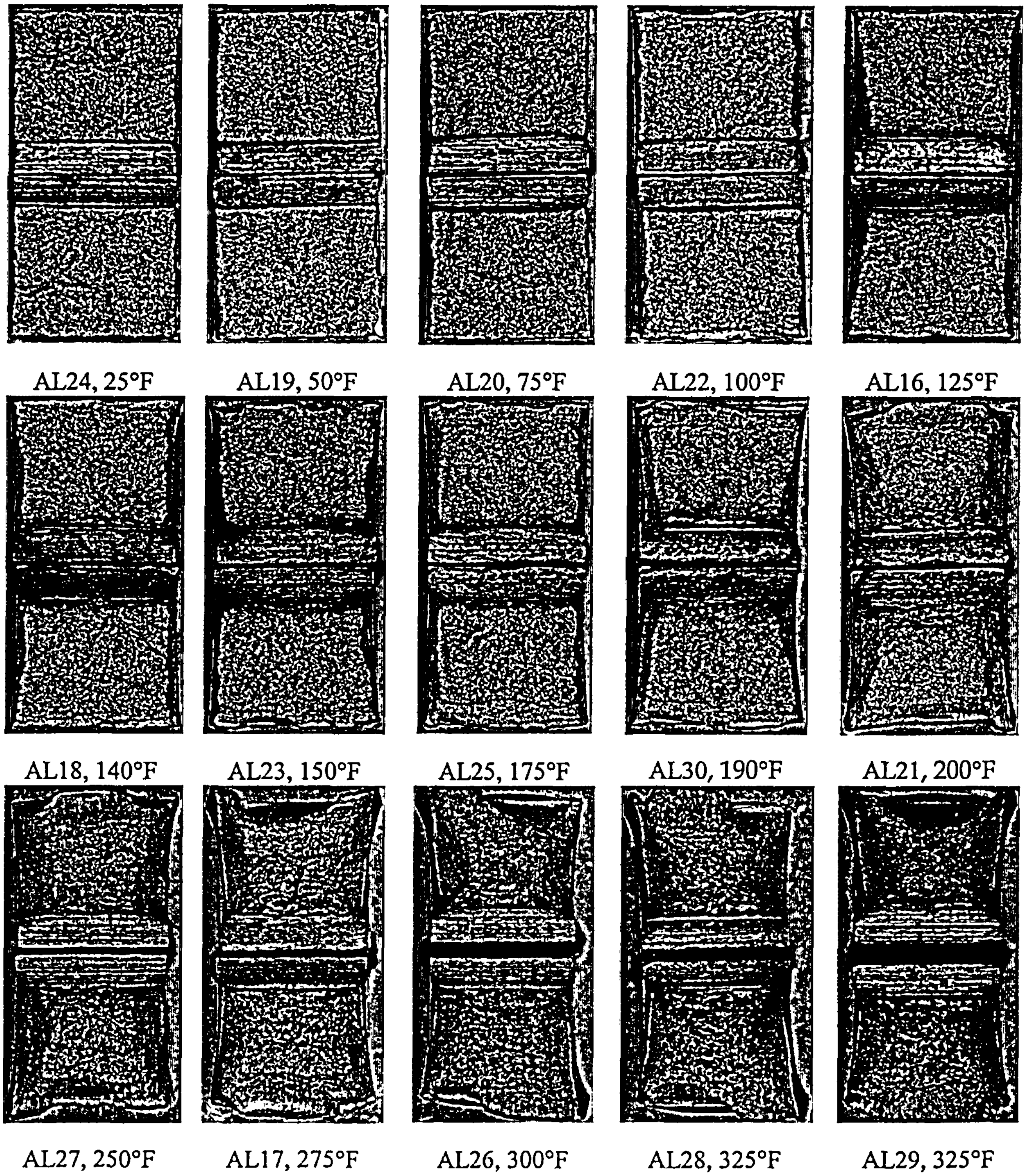
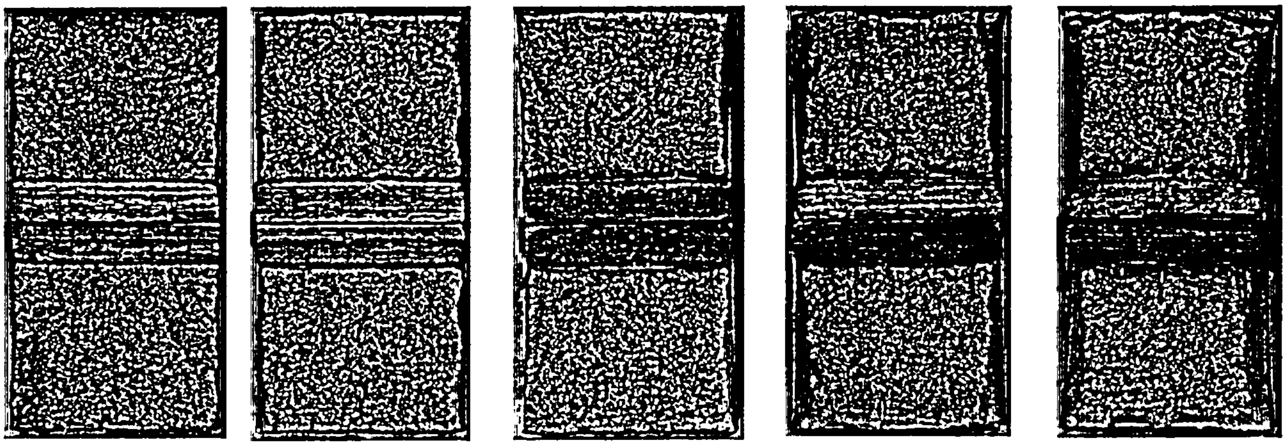
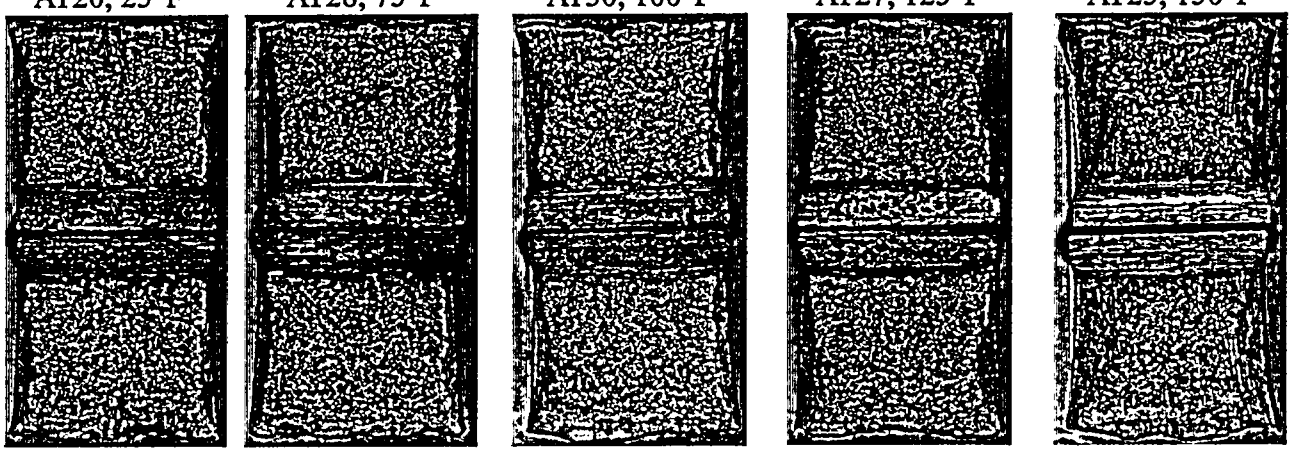


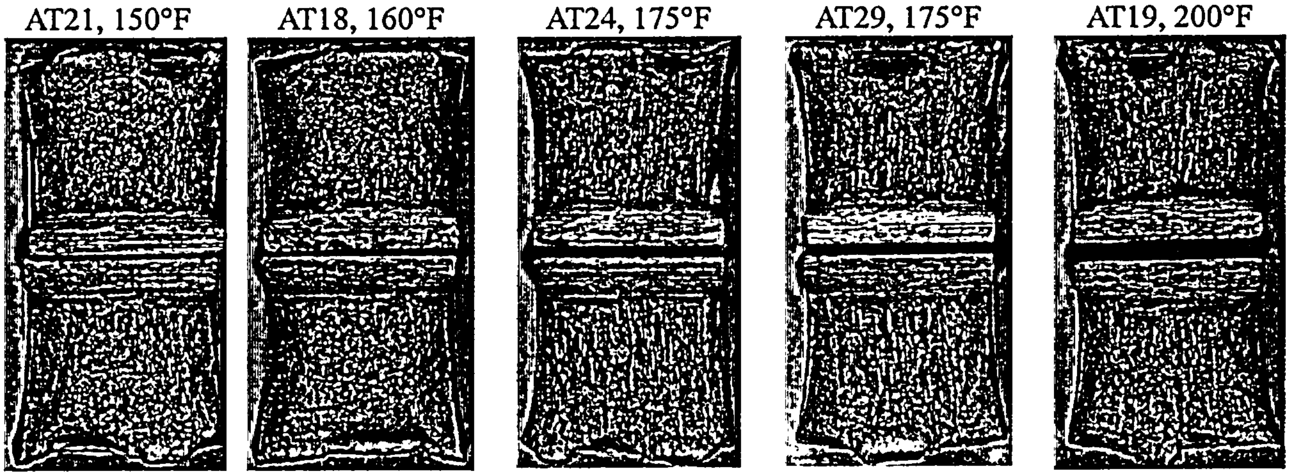
Figure 5-13 Charpy Impact Specimen Fracture Surfaces for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Longitudinal Orientation)



AT20, 25°F AT28, 75°F AT30, 100°F AT27, 125°F AT25, 150°F



AT21, 150°F AT18, 160°F AT24, 175°F AT29, 175°F AT19, 200°F



AT16, 225°F AT17, 250°F AT22, 275°F AT23, 275°F AT26, 300°F

Figure 5-14 Charpy Impact Specimen Fracture Surfaces for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Transverse Orientation)

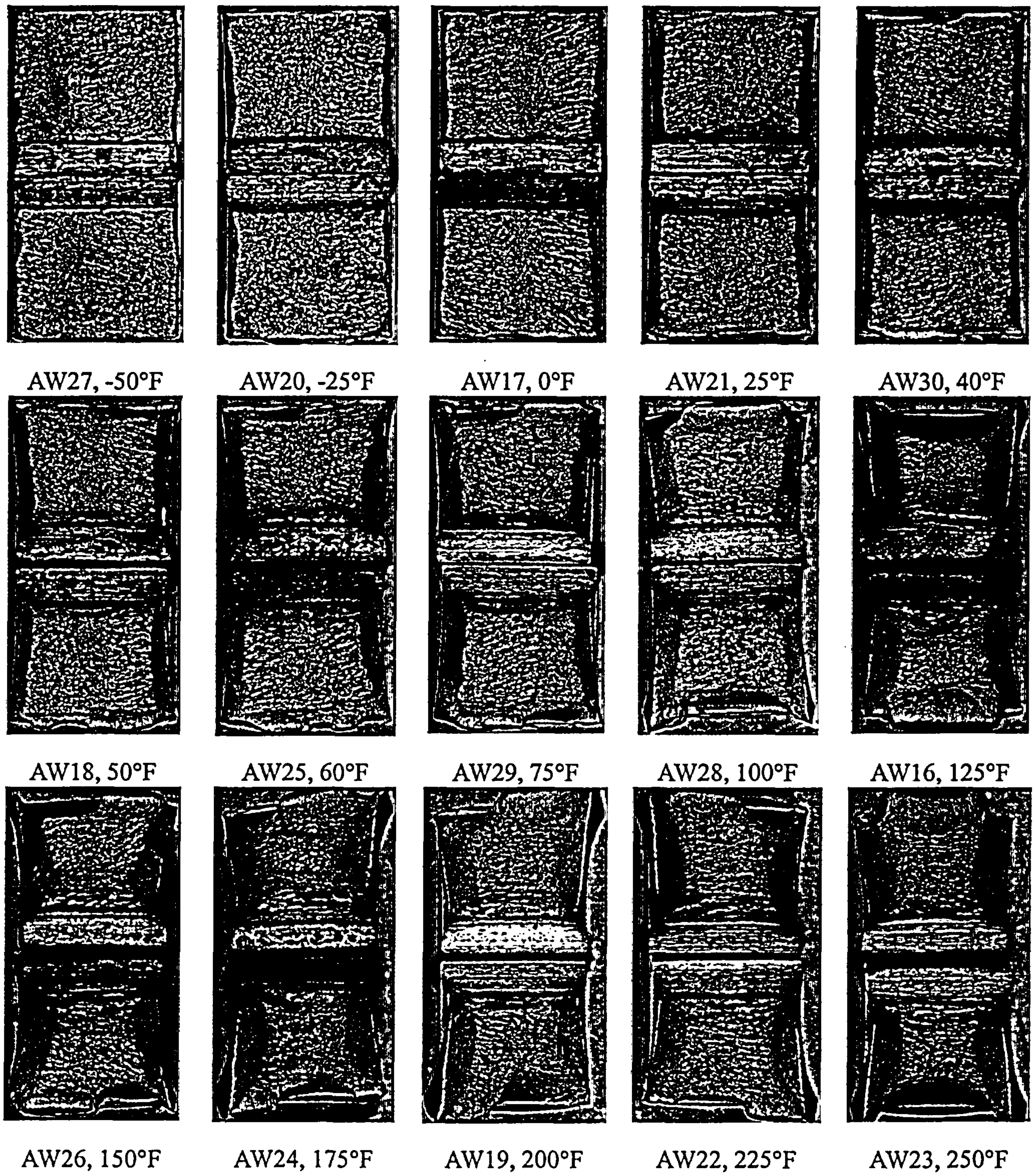


Figure 5-15 Charpy Impact Specimen Fracture Surfaces for Farley Unit 1 Reactor Vessel Weld Metal

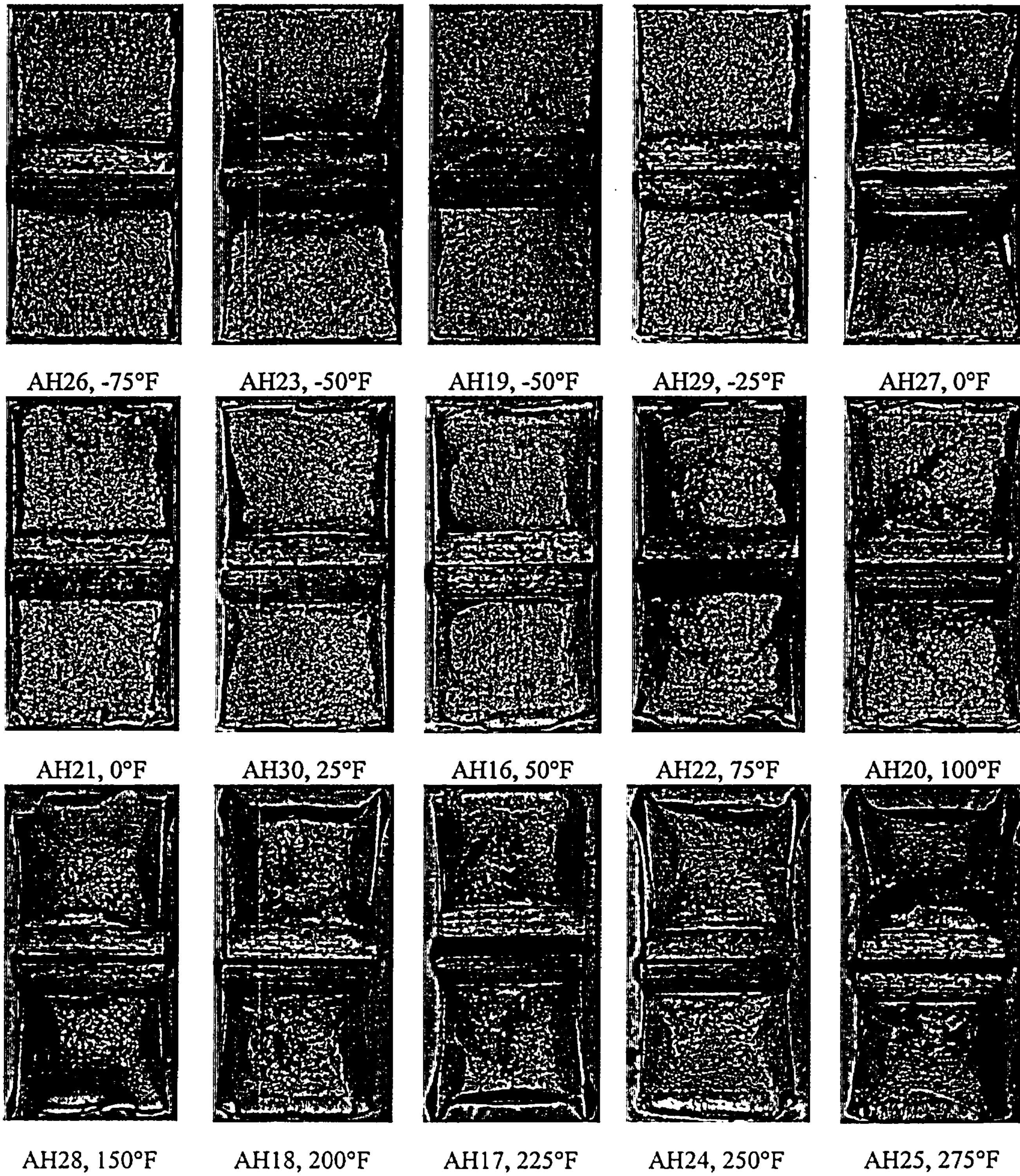


Figure 5-16 Charpy Impact Specimen Fracture Surfaces for Farley Unit 1 Reactor Vessel Heat-Affected-Zone Metal

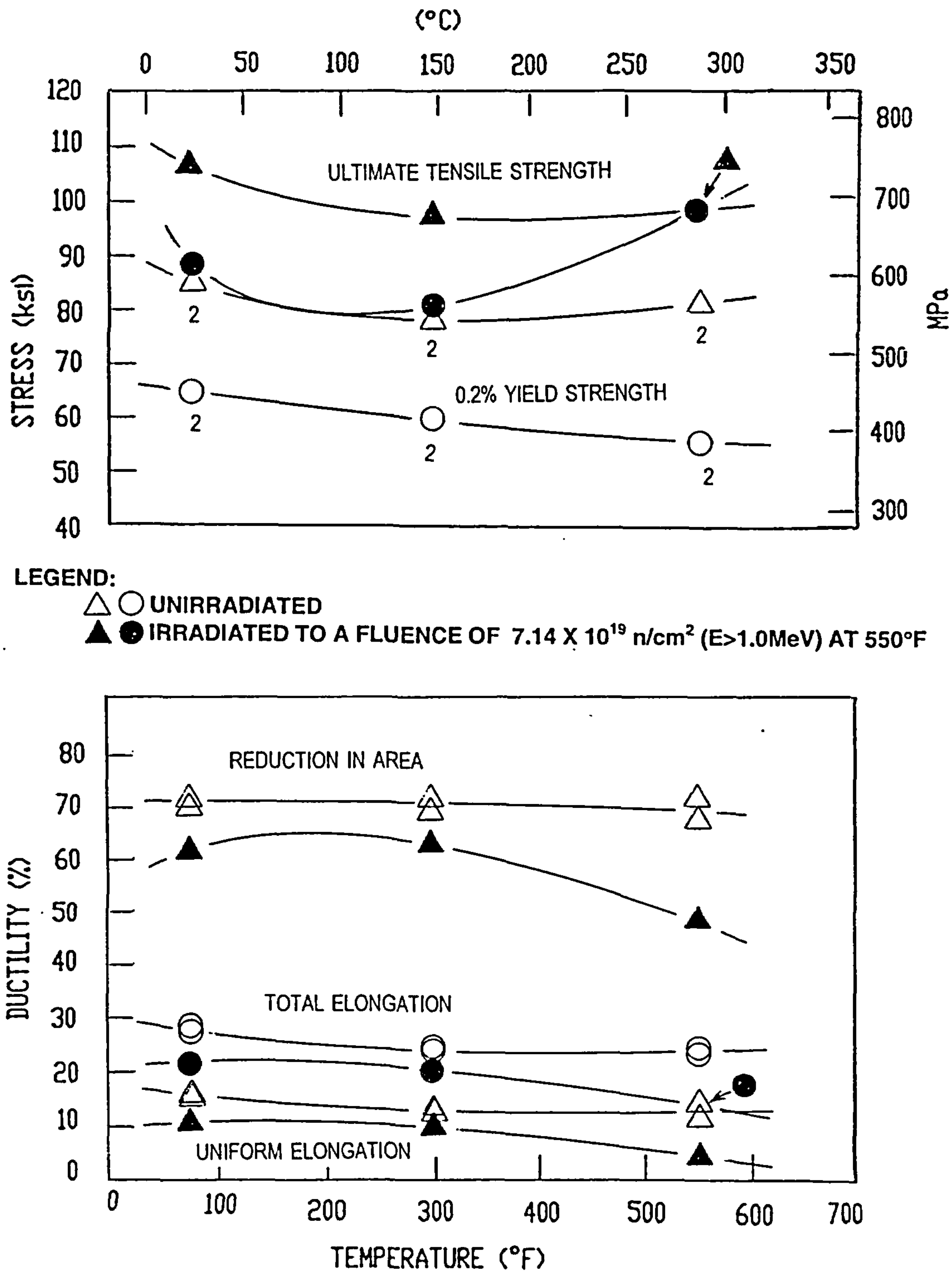


Figure 5-17 Tensile Properties for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Longitudinal Orientation)

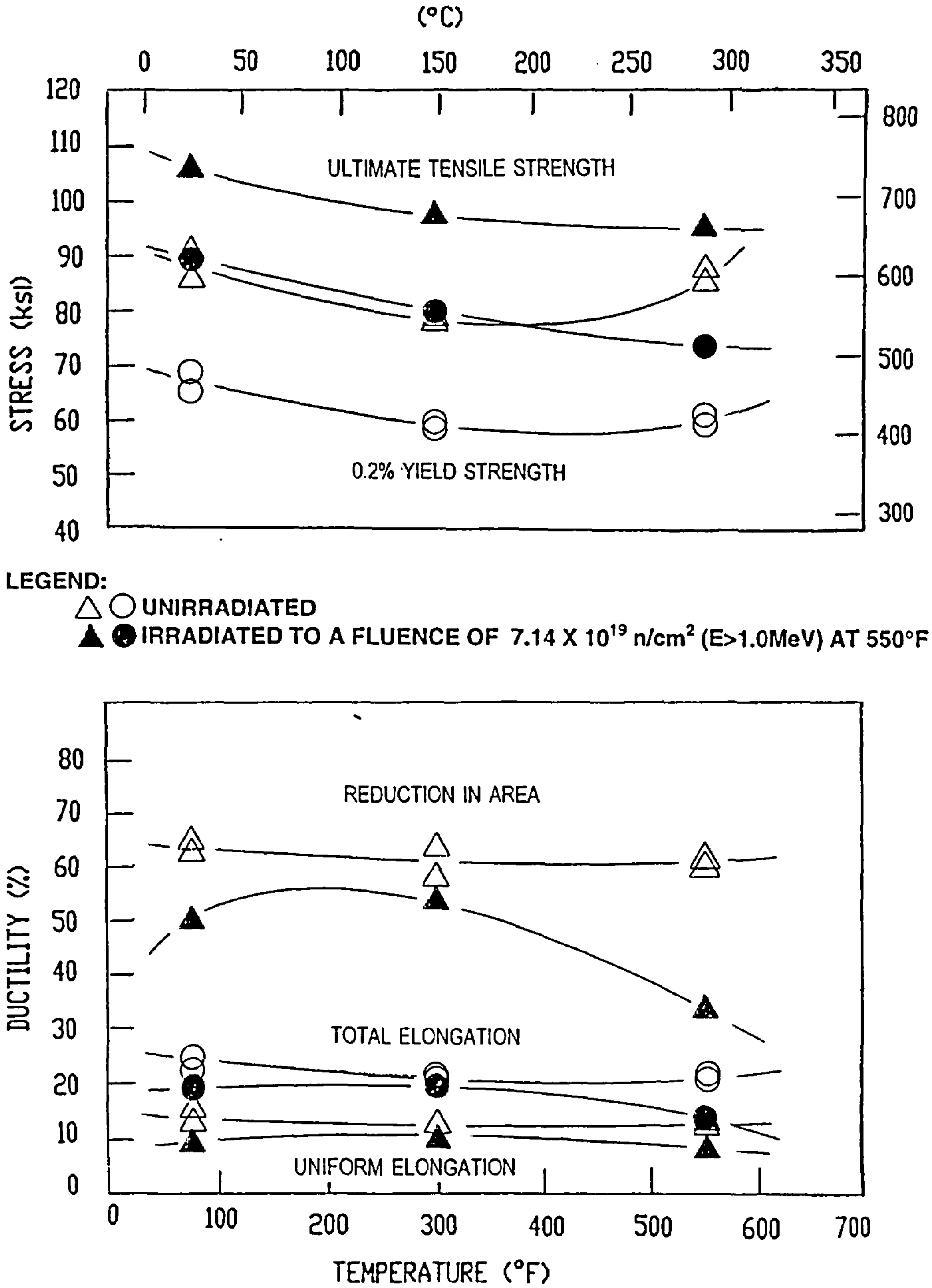


Figure 5-18 Tensile Properties for Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Transverse Orientation)

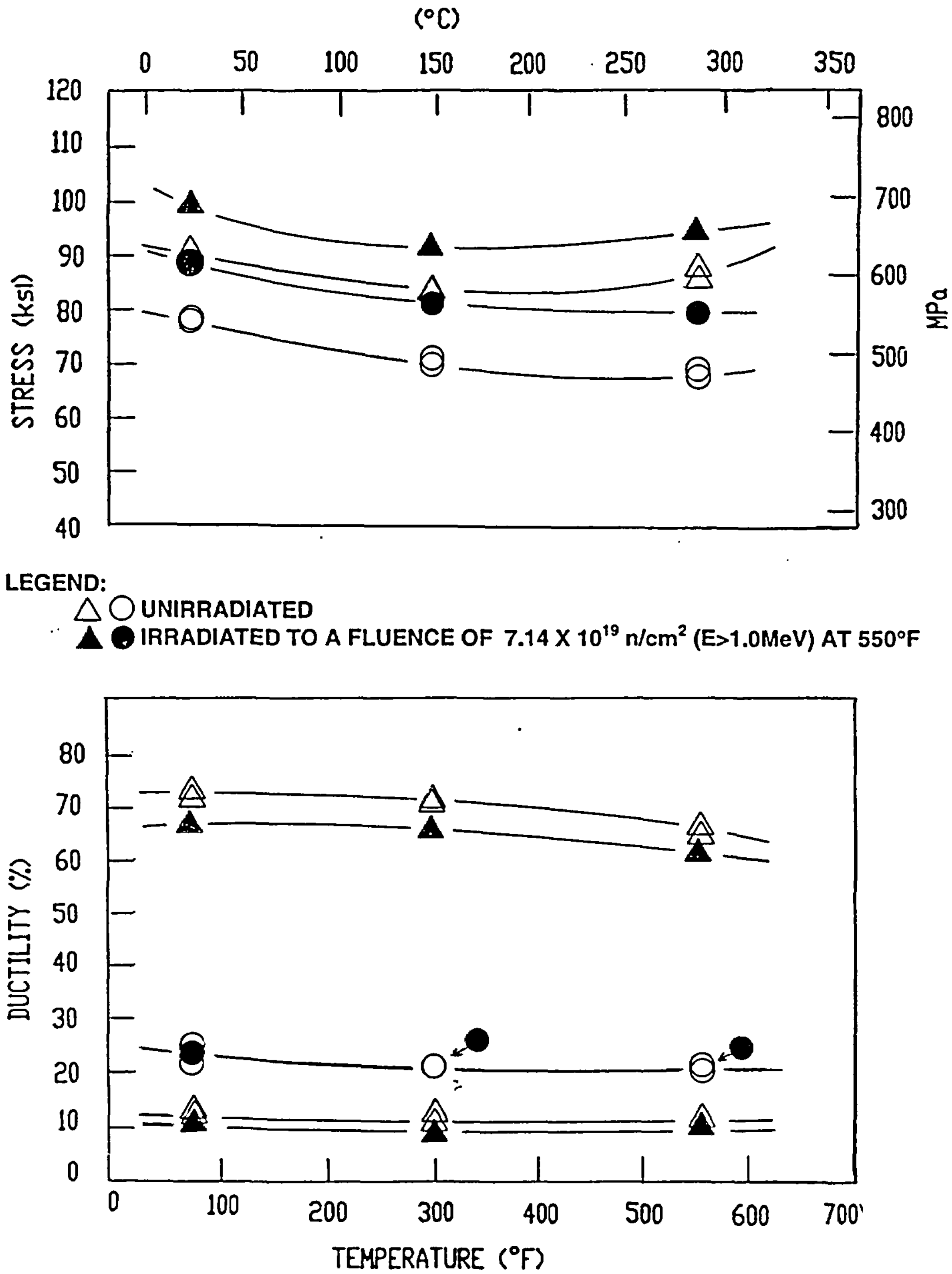
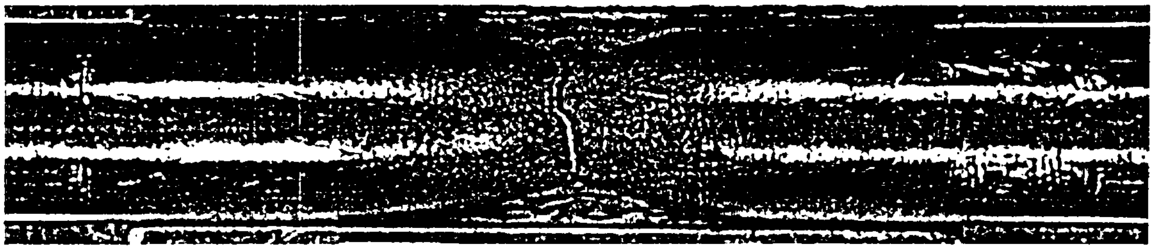
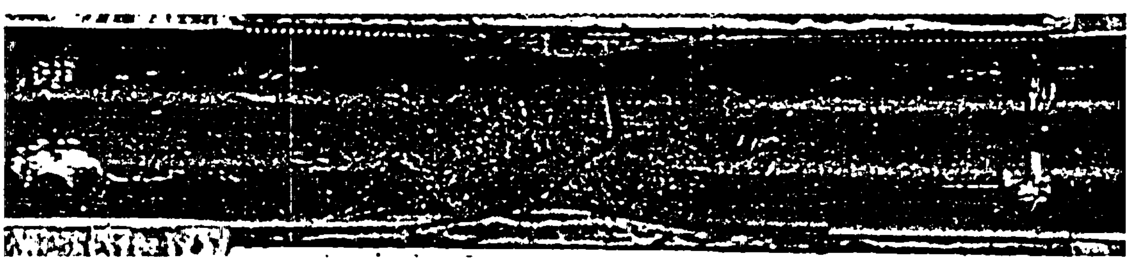


Figure 5-19 Tensile Properties for Farley Unit 1 Reactor Vessel Weld Metal



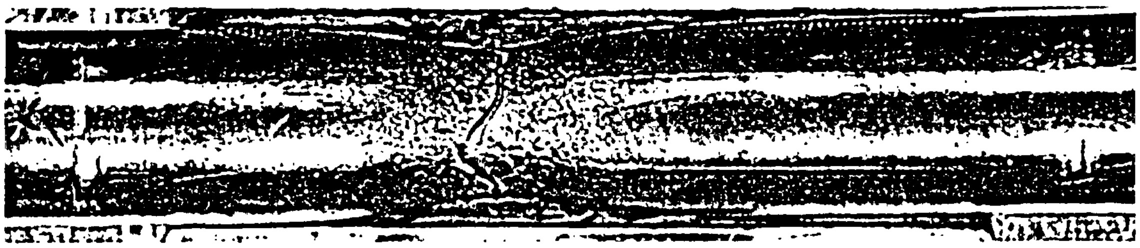
Specimen AL-4 Tested at 75°F

Specimen AL-5 Tested at 300°F

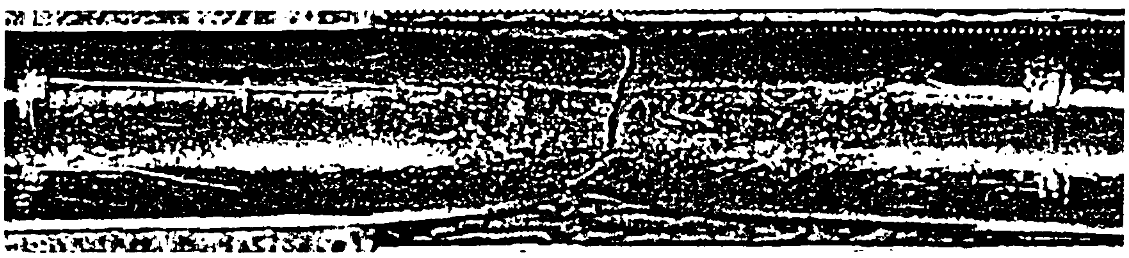


Specimen AL-6 Tested at 550°F

Figure 5-20 Fractured Tensile Specimens from Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Longitudinal Orientation)



Specimen AT-5 Tested at 75°F

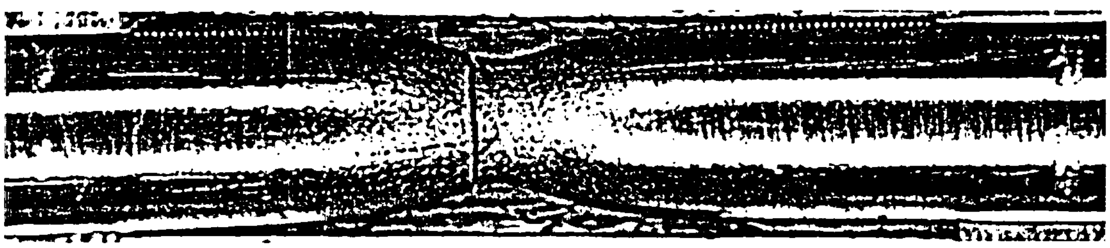


Specimen AT-4 Tested at 300°F

Specimen AT-6 Tested at 550°F

Figure 5-21 Fractured Tensile Specimens from Farley Unit 1 Reactor Vessel Lower Shell Plate B6919-1 (Transverse Orientation)

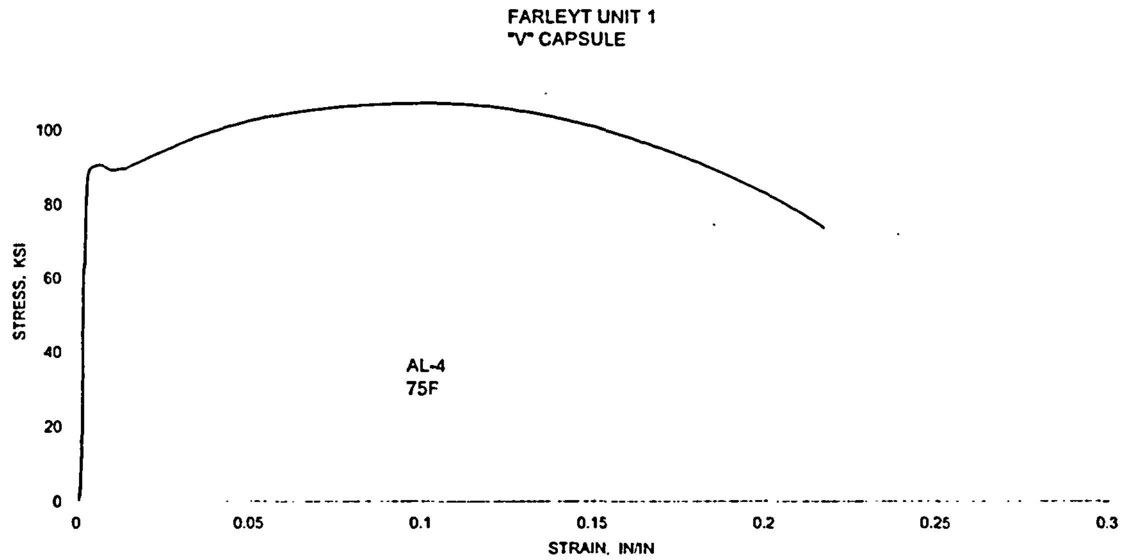
Specimen AW-6 Tested at 75°F



Specimen AW-5 Tested at 300°F

Specimen AW-4 Tested at 550°F

Figure 5-22 Fractured Tensile Specimens from Farley Unit 1 Reactor Vessel Weld Metal



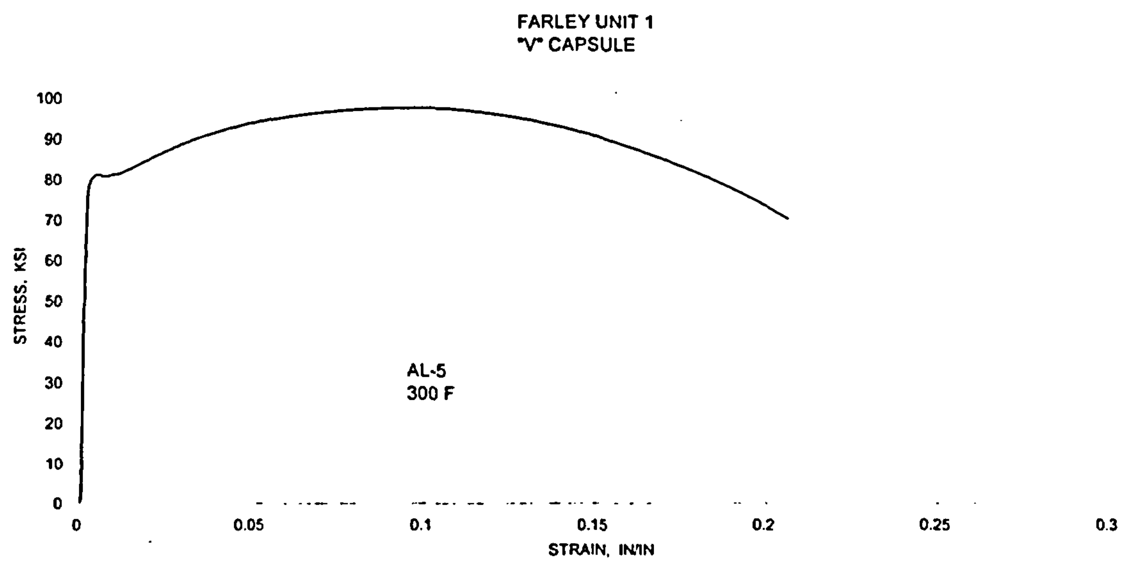


Figure 5-23 Engineering Stress-Strain Curves for Farley Unit 1 Lower Shell Plate B6919-1, Capsule V, Tensile Specimens AL-4, AL-5 (Longitudinal Orientation)

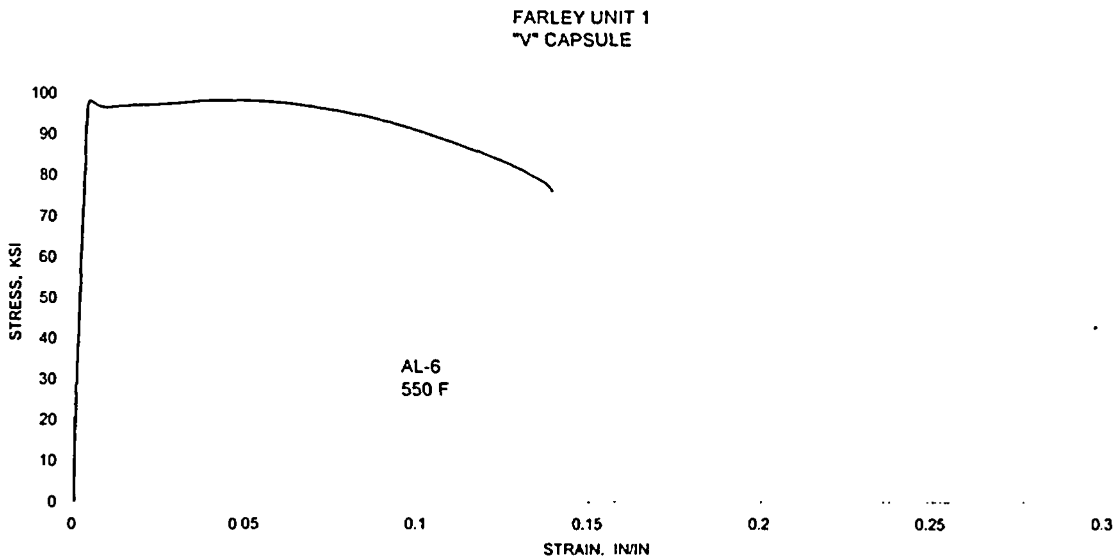
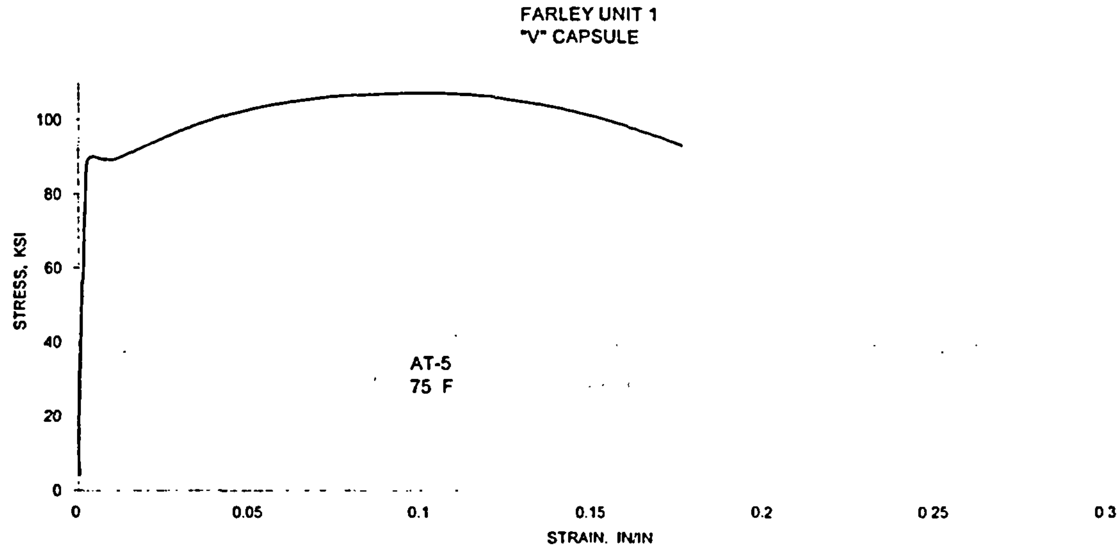


Figure 5-23 (cont.) Engineering Stress-Strain Curves for Farley Unit 1 Lower Shell Plate B6919-1, Capsule V, Tensile Specimen AL-6 (Longitudinal Orientation)



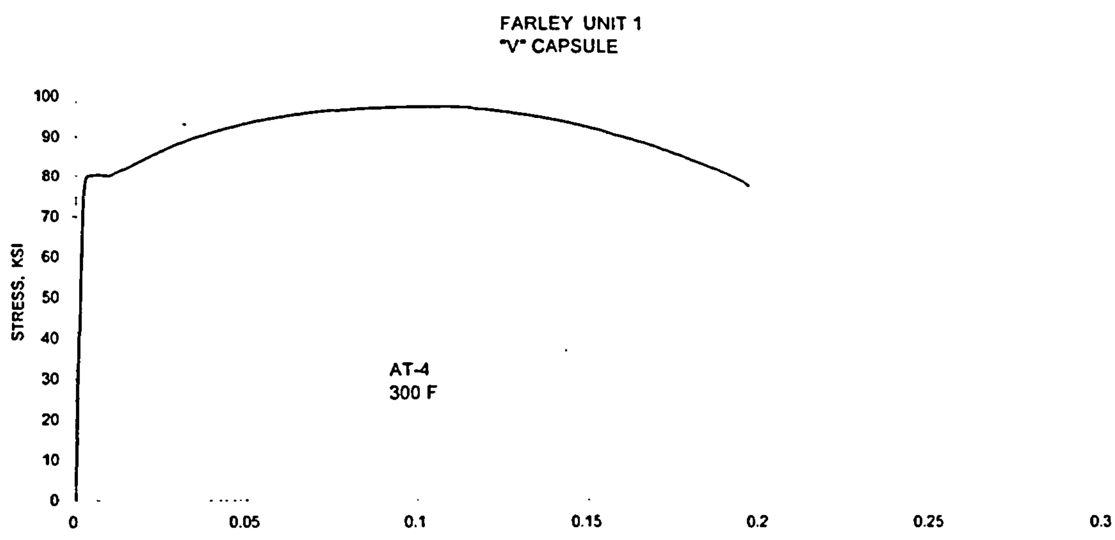


Figure 5-24 Engineering Stress-Strain Curves for Farley Unit 1 Lower Shell Plate B6919-1, Capsule V, Tensile Specimens AT-4, and AT-5 (Transverse Orientation)

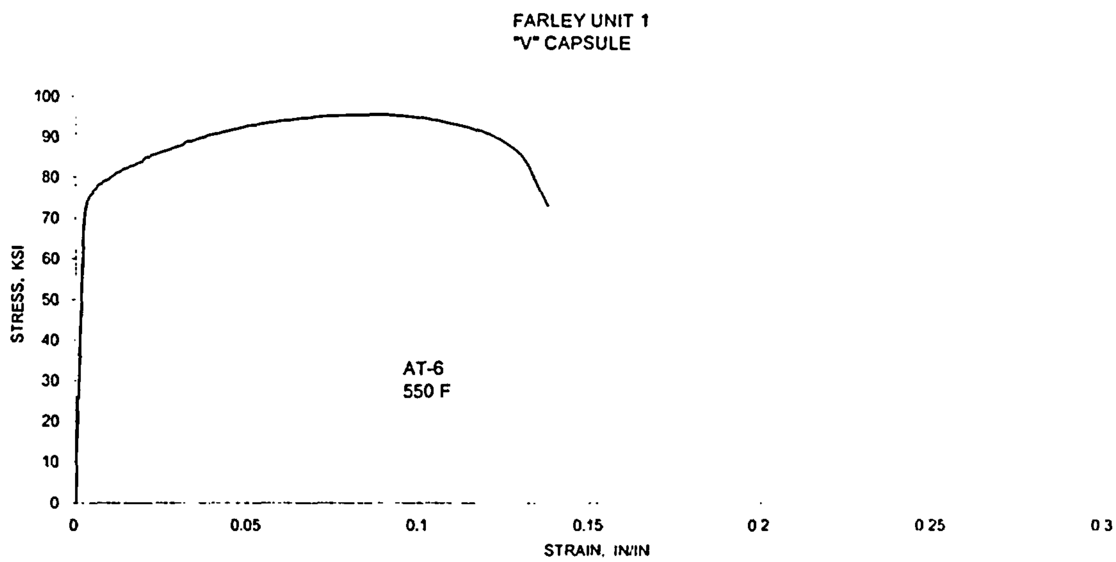
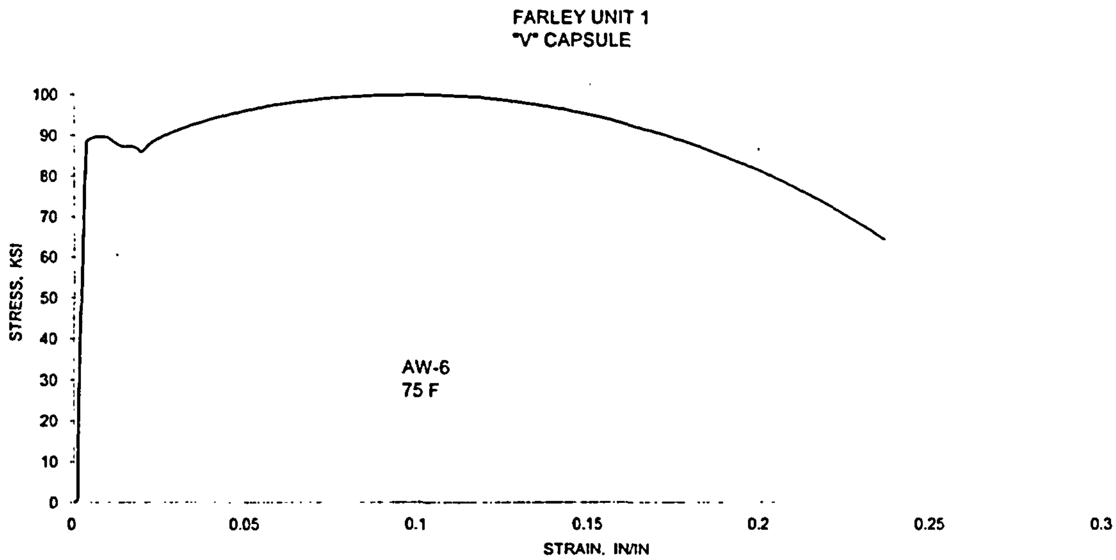


Figure 5-24 (cont.) Engineering Stress-Strain Curves for Farley Unit 1 Lower Shell Plate B6919-1, Capsule V, Tensile Specimen AT-6 (Transverse Orientation)



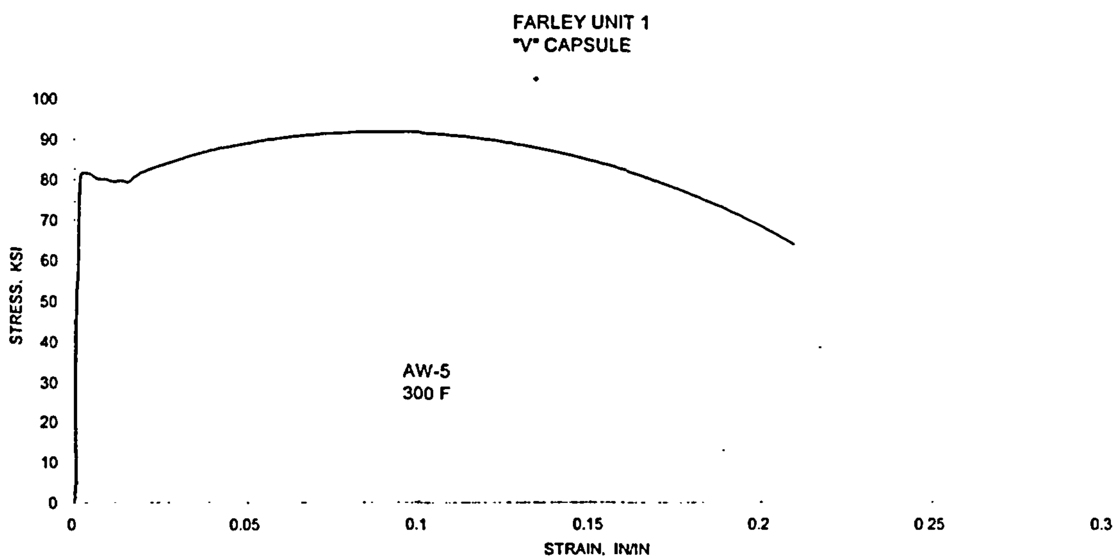


Figure 5-25 Engineering Stress-Strain Curves for Weld Metal, Capsule V, Tensile Specimens AW-4, and AW-5

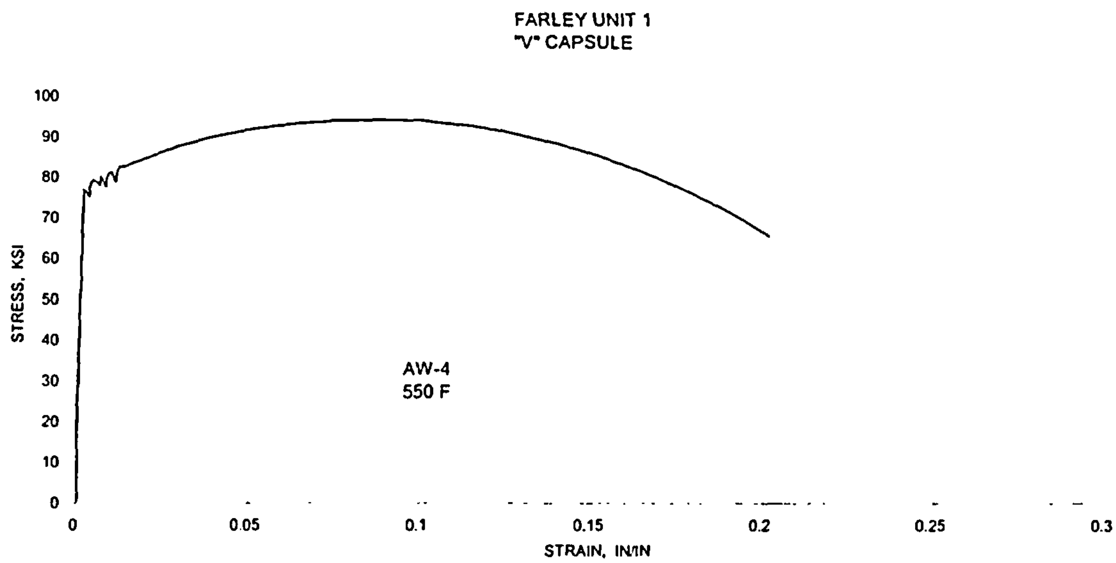


Figure 5-25 (cont.) Engineering Stress-Strain Curves for Weld Metal, Capsule V, Tensile Specimen GW-6

6 RADIATION ANALYSIS AND NEUTRON DOSIMETRY

6.1 INTRODUCTION

This section describes a discrete ordinates S_n transport analysis performed for the Farley Unit 1 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 V, withdrawn at the end of the eighteenth plant operating cycle, is provided. In addition, to provide an up-to-date data base applicable to the Farley Unit 1 reactor, sensor sets from previously withdrawn capsules (Y, U, X, and W) 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."[22] 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," January 1996.[23] The specific calculational methods applied are also consistent with those described in WCAP-15557, "Qualification of the Westinghouse Pressure Vessel Neutron Fluence Evaluation Methodology."[24]

6.2 DISCRETE ORDINATES ANALYSIS

A plan view of the Farley Unit 1 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 107°, 287°, 343° (17° from the core cardinal axes) and 110°, 290°, 340° (20° from the core cardinal axes). 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 Farley Unit 1 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 Farley Unit 1.

For the Farley Unit 1 transport calculations, two octant symmetric r,θ models were developed and are depicted in Figure 6-1. The first model contained the extended neutron pad (26° span) including the surveillance capsules, while the second contained the shortened neutron pad (15° span) with no surveillance capsules. The former model was used to perform surveillance capsule dosimetry evaluations and subsequent comparisons with calculated results, while the latter model was used to generate the maximum fluence at the pressure vessel wall. 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 185 radial by 92 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 Farley Unit 1 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 1-foot below the active fuel to approximately 1-foot above the active fuel. 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 149 radial by 178 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 149 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 taken from the appropriate Farley Unit 1 fuel cycle design reports. The data extracted from the design reports represented cycle dependent fuel assembly enrichments, burnups, 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 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 burnup 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[25] and the BUGLE-96 cross-section library.[26] 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 6-7. 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 two azimuthally symmetric surveillance capsule positions (17° and 20°). 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 Tables 6-2 and 6-3 for the reactor vessel inner radius. The vessel data given in Table 6-2 are representative of the axial location of the maximum neutron exposure at each of the four azimuthal locations, while Table 6-3 provides neutron exposure data for the intermediate shell course to nozzle shell course weld. It is also important to note that the data for the vessel inner radius were taken at the clad/base metal interface, and thus, represent the maximum calculated exposure levels of the vessel plates and welds.

Both calculated fluence (E > 1.0 MeV) and dpa data are provided in Table 6-1 through Table 6-3. These data tabulations include both plant and fuel cycle specific calculated neutron exposures at the end of the eighteenth operating fuel cycle as well as projections for the current operating fuel cycle, i.e., Cycle 19, and future projections to 25, 32, 36, 48, and 54 EFPY. The projections were based on the assumption that the core power distributions and associated plant operating characteristics from Cycle 19 were representative of future plant operation. The future projections are also based on the current reactor power level of 2775 MWt.

Radial gradient information applicable to fast (E > 1.0 MeV) neutron fluence and dpa are given in Tables 6-4 and 6-5, respectively. The data, based on the cumulative integrated exposures from Cycles 1 through 19, 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 6-4 and 6-5.

The calculated fast neutron exposures for the five surveillance capsules withdrawn from the Farley Unit 1 reactor are provided in Table 6-6. These assigned neutron exposure levels are based on the plant and fuel cycle specific neutron transport calculations performed for the Farley Unit 1 reactor.

Updated lead factors for the Farley Unit 1 surveillance capsules are provided in Table 6-7. 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 6-7, the lead factors for capsules that have been withdrawn from the reactor (Y, U, X, W, and V) were based on the calculated fluence values for the irradiation period corresponding to the time of withdrawal for the individual capsules. For the capsule remaining in the reactor (Z), the lead factor corresponds to the calculated fluence values at the end of Cycle 19, the current operating fuel cycle for Farley Unit 1.

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 V, that was withdrawn from Farley Unit 1 at the end of the eighteenth fuel cycle, is summarized below.

Reaction	Reaction Rates (rps/atom)		M/C Ratio
	Measured	Calculated	
$^{63}Cu(n,\alpha)^{60}Co$	6.04E-17	5.61E-17	1.08
$^{54}Fe(n,p)^{54}Mn$	5.55E-15	6.37E-15	0.87
$^{58}Ni(n,p)^{58}Co$	7.83E-15	8.97E-15	0.87
$^{238}U(n,p)^{137}Cs$ (Cd)	3.14E-14	3.49E-14	0.90
$^{237}Np(n,f)^{137}Cs$ (Cd)	3.34E-13	3.55E-13	0.94
		Average:	0.93
		% Standard Deviation:	9.2

The measured-to-calculated (M/C) reaction rate ratios for the Capsule V threshold reactions range from 0.87 to 1.08, and the average M/C ratio is 0.93 ± 9.2% (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 Farley Unit 1 reactor. These comparisons validate the current analytical results described in Section 6.2; therefore, the calculations are deemed applicable for Farley Unit 1.

6.4 CALCULATIONAL UNCERTAINTIES

The uncertainty associated with the calculated neutron exposure of the Farley Unit 1 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 Farley Unit 1 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 Farley Unit 1 analysis was established from results of these three phases of the methods qualification.

The fourth phase of the uncertainty assessment (comparisons with Farley Unit 1 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 Farley Unit 1 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 [24].

	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 Farley Unit 1.

Figure 6-1

Farley Unit 1 r,θ Reactor Geometry with a 15° Neutron Pad at the Core Midplane

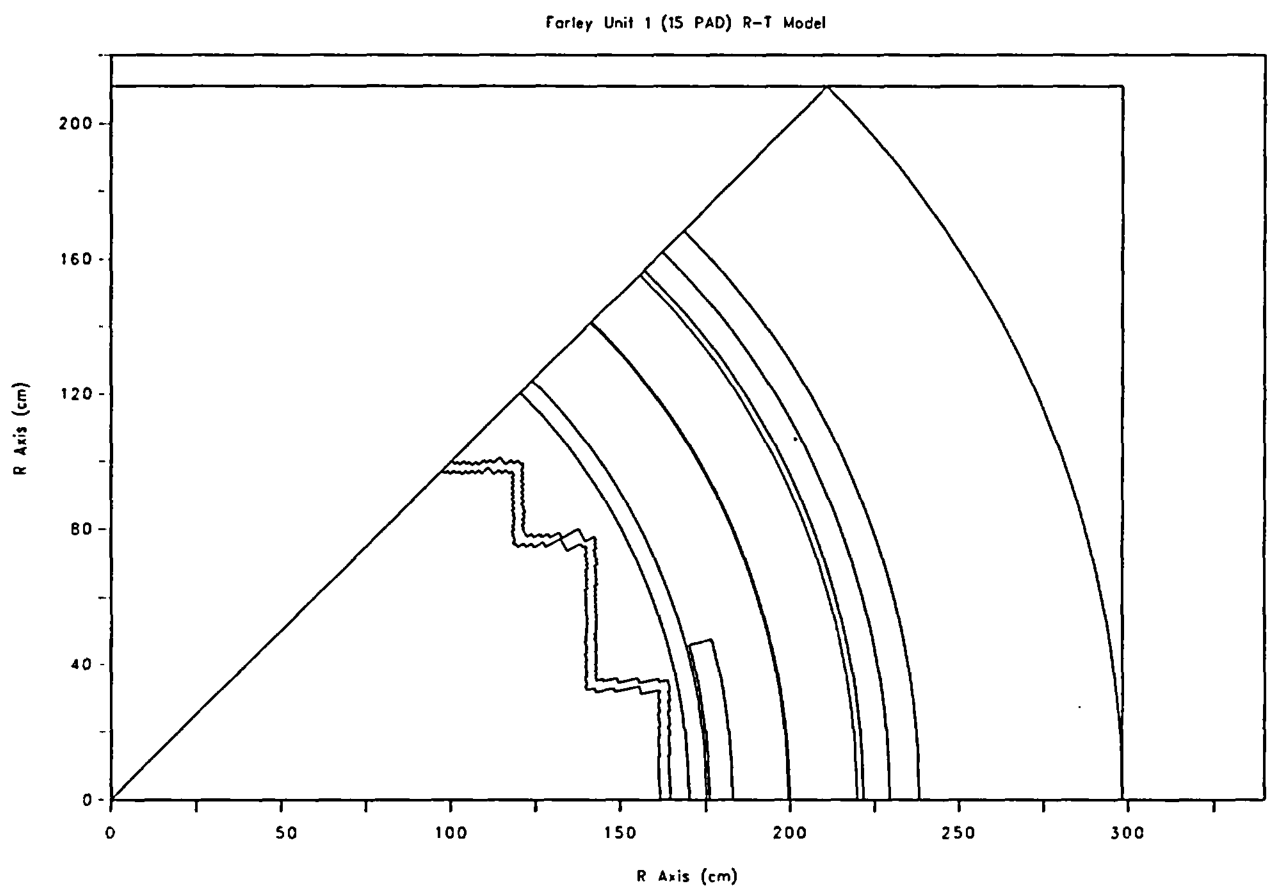


Figure 6-1 (continued)

Farley Unit 1 r,θ Reactor Geometry with a 26° Neutron Pad at the Core Midplane

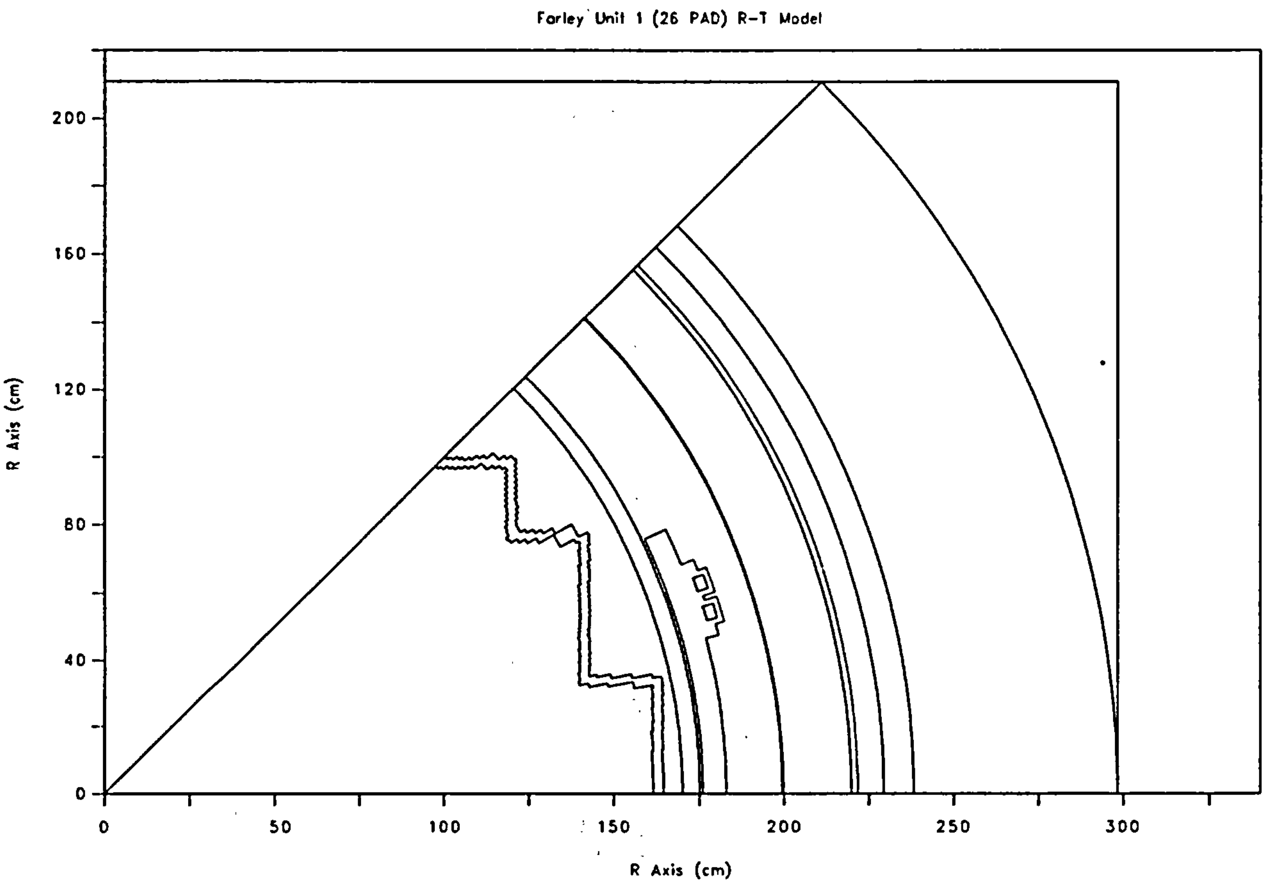


Figure 6-2

Farley Unit 1 r,z Reactor Geometry with Neutron Pad

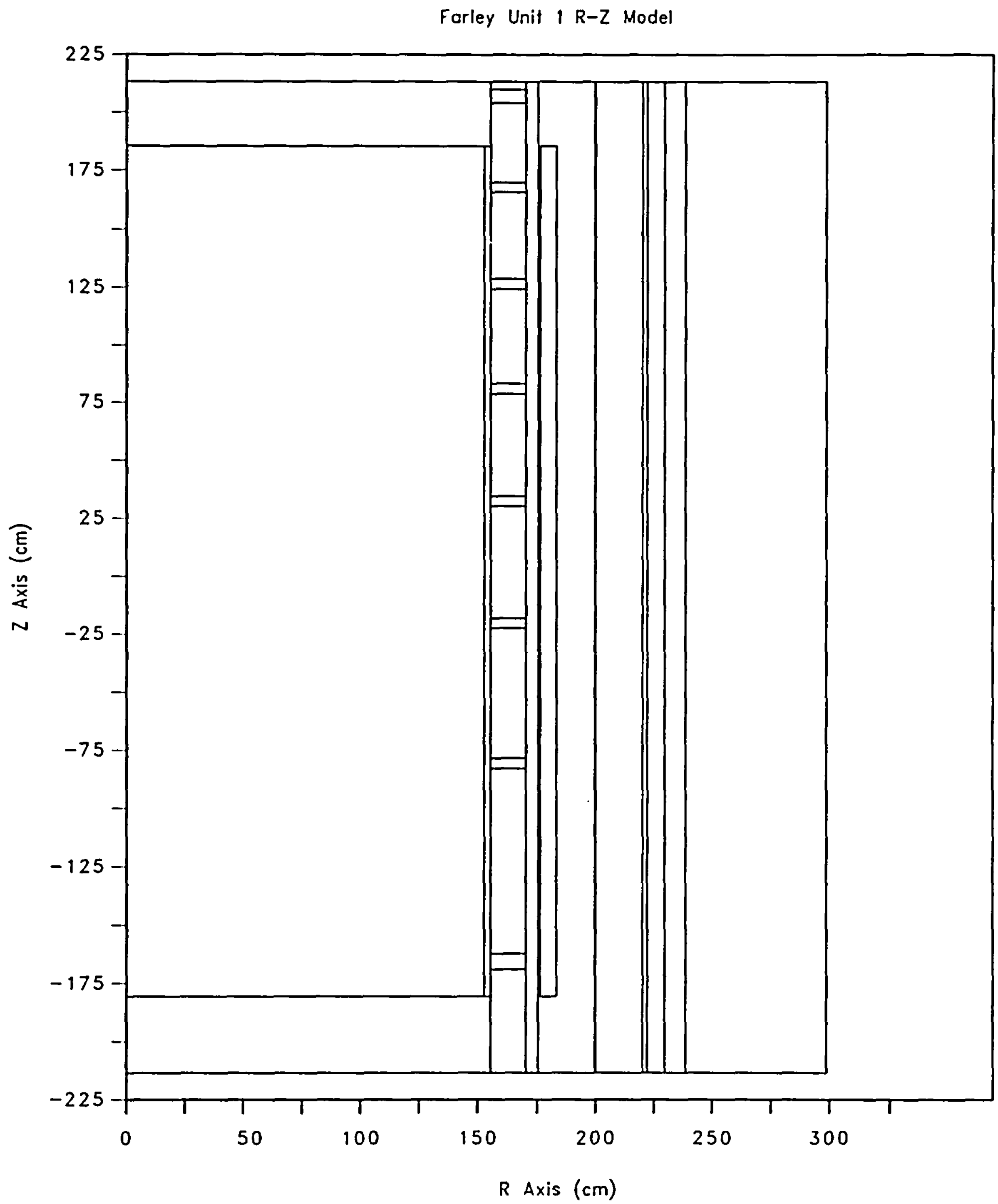


Table 6-1

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

Neutrons (E > 1.0 MeV)

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Flux (E > 1.0 MeV) [n/cm^2-s]	
				17°	20°
1	3.64E+07	3.64E+07	1.15	1.68E+11	1.45E+11
2	2.39E+07	6.03E+07	1.91	1.79E+11	1.54E+11
3	1.22E+07	7.24E+07	2.30	1.65E+11	1.42E+11
4	2.49E+07	9.73E+07	3.08	1.96E+11	1.63E+11
5	2.60E+07	1.23E+08	3.91	1.42E+11	1.25E+11
6	2.88E+07	1.52E+08	4.82	1.31E+11	1.14E+11
7	4.06E+07	1.93E+08	6.11	1.43E+11	1.25E+11
8	3.83E+07	2.31E+08	7.32	1.22E+11	1.06E+11
9	4.14E+07	2.73E+08	8.64	1.32E+11	1.19E+11
10	4.01E+07	3.13E+08	9.91	1.27E+11	1.07E+11
11	4.15E+07	3.54E+08	11.22	1.16E+11	1.02E+11
12	3.80E+07	3.92E+08	12.43	1.11E+11	9.45E+10
13	4.22E+07	4.34E+08	13.76	1.09E+11	9.13E+10
14	4.17E+07	4.76E+08	15.08	1.02E+11	9.17E+10
15	4.07E+07	5.17E+08	16.37	1.18E+11	1.03E+11
16	3.53E+07	5.52E+08	17.49	1.14E+11	9.70E+10
17	4.22E+07	5.94E+08	18.83	1.18E+11	1.05E+11
18	4.21E+07	6.36E+08	20.16	1.16E+11	9.99E+10
19(Prj.)	4.37E+07	6.80E+08	21.55	1.25E+11	1.06E+11
Future	1.09E+08	7.89E+08	25.00	1.25E+11	1.06E+11
Future	2.21E+08	1.01E+09	32.00	1.25E+11	1.06E+11
Future	1.26E+08	1.14E+09	36.00	1.25E+11	1.06E+11
Future	2.52E+08	1.51E+09	48.00	1.25E+11	1.06E+11
Future	1.89E+08	1.70E+09	54.00	1.25E+11	1.06E+11

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

Neutrons (E > 1.0 MeV)

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Fluence (E > 1.0 MeV) [n/cm^2]	
				17°	20°
1	3.64E+07	3.64E+07	1.15	6.12E+18	5.29E+18
2	2.39E+07	6.03E+07	1.91	1.04E+19	8.96E+18
3	1.22E+07	7.24E+07	2.30	1.24E+19	1.07E+19
4	2.49E+07	9.73E+07	3.08	1.73E+19	1.47E+19
5	2.60E+07	1.23E+08	3.91	2.10E+19	1.80E+19
6	2.88E+07	1.52E+08	4.82	2.48E+19	2.13E+19
7	4.06E+07	1.93E+08	6.11	3.06E+19	2.64E+19
8	3.83E+07	2.31E+08	7.32	3.53E+19	3.04E+19
9	4.14E+07	2.73E+08	8.64	4.07E+19	3.53E+19
10	4.01E+07	3.13E+08	9.91	4.58E+19	3.96E+19
11	4.15E+07	3.54E+08	11.22	5.06E+19	4.39E+19
12	3.80E+07	3.92E+08	12.43	5.48E+19	4.75E+19
13	4.22E+07	4.34E+08	13.76	5.94E+19	5.13E+19
14	4.17E+07	4.76E+08	15.08	6.36E+19	5.51E+19
15	4.07E+07	5.17E+08	16.37	6.84E+19	5.93E+19
16	3.53E+07	5.52E+08	17.49	7.24E+19	6.27E+19
17	4.22E+07	5.94E+08	18.83	7.74E+19	6.72E+19
18	4.21E+07	6.36E+08	20.16	8.23E+19	7.14E+19
19(Prj.)	4.37E+07	6.80E+08	21.55	8.78E+19	7.60E+19
Future	1.09E+08	7.89E+08	25.00	1.01E+20	8.76E+19
Future	2.21E+08	1.01E+09	32.00	1.29E+20	1.11E+20
Future	1.26E+08	1.14E+09	36.00	1.45E+20	1.24E+20
Future	2.52E+08	1.51E+09	48.00	1.92E+20	1.65E+20
Future	1.89E+08	1.70E+09	54.00	2.16E+20	1.85E+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

Iron Atom Displacements

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Displacement Rate [dpa/s]	
				17°	20°
1	3.64E+07	3.64E+07	1.15	3.46E-10	2.92E-10
2	2.39E+07	6.03E+07	1.91	3.69E-10	3.09E-10
3	1.22E+07	7.24E+07	2.30	3.39E-10	2.86E-10
4	2.49E+07	9.73E+07	3.08	4.07E-10	3.29E-10
5	2.60E+07	1.23E+08	3.91	2.88E-10	2.48E-10
6	2.88E+07	1.52E+08	4.82	2.68E-10	2.27E-10
7	4.06E+07	1.93E+08	6.11	2.92E-10	2.50E-10
8	3.83E+07	2.31E+08	7.32	2.49E-10	2.11E-10
9	4.14E+07	2.73E+08	8.64	2.67E-10	2.36E-10
10	4.01E+07	3.13E+08	9.91	2.58E-10	2.15E-10
11	4.15E+07	3.54E+08	11.22	2.34E-10	2.03E-10
12	3.80E+07	3.92E+08	12.43	2.25E-10	1.88E-10
13	4.22E+07	4.34E+08	13.76	2.20E-10	1.82E-10
14	4.17E+07	4.76E+08	15.08	2.05E-10	1.81E-10
15	4.07E+07	5.17E+08	16.37	2.39E-10	2.05E-10
16	3.53E+07	5.52E+08	17.49	2.31E-10	1.93E-10
17	4.22E+07	5.94E+08	18.83	2.39E-10	2.08E-10
18	4.21E+07	6.36E+08	20.16	2.35E-10	1.99E-10
19(Prj.)	4.37E+07	6.80E+08	21.55	2.55E-10	2.12E-10
Future	1.09E+08	7.89E+08	25.00	2.55E-10	2.12E-10
Future	2.21E+08	1.01E+09	32.00	2.55E-10	2.12E-10
Future	1.26E+08	1.14E+09	36.00	2.55E-10	2.12E-10
Future	2.52E+08	1.51E+09	48.00	2.55E-10	2.12E-10
Future	1.89E+08	1.70E+09	54.00	2.55E-10	2.12E-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

Iron Atom Displacements

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Displacements [dpa]	
				17°	20°
1	3.64E+07	3.64E+07	1.15	1.26E-02	1.06E-02
2	2.39E+07	6.03E+07	1.91	2.14E-02	1.80E-02
3	1.22E+07	7.24E+07	2.30	2.55E-02	2.15E-02
4	2.49E+07	9.73E+07	3.08	3.56E-02	2.97E-02
5	2.60E+07	1.23E+08	3.91	4.31E-02	3.62E-02
6	2.88E+07	1.52E+08	4.82	5.09E-02	4.27E-02
7	4.06E+07	1.93E+08	6.11	6.27E-02	5.29E-02
8	3.83E+07	2.31E+08	7.32	7.23E-02	6.09E-02
9	4.14E+07	2.73E+08	8.64	8.33E-02	7.07E-02
10	4.01E+07	3.13E+08	9.91	9.37E-02	7.93E-02
11	4.15E+07	3.54E+08	11.22	1.03E-01	8.77E-02
12	3.80E+07	3.92E+08	12.43	1.12E-01	9.49E-02
13	4.22E+07	4.34E+08	13.76	1.21E-01	1.03E-01
14	4.17E+07	4.76E+08	15.08	1.30E-01	1.10E-01
15	4.07E+07	5.17E+08	16.37	1.40E-01	1.18E-01
16	3.53E+07	5.52E+08	17.49	1.48E-01	1.25E-01
17	4.22E+07	5.94E+08	18.83	1.58E-01	1.34E-01
18	4.21E+07	6.36E+08	20.16	1.68E-01	1.42E-01
19(Prj.)	4.37E+07	6.80E+08	21.55	1.79E-01	1.52E-01
Future	1.09E+08	7.89E+08	25.00	2.07E-01	1.75E-01
Future	2.21E+08	1.01E+09	32.00	2.63E-01	2.22E-01
Future	1.26E+08	1.14E+09	36.00	2.95E-01	2.48E-01
Future	2.52E+08	1.51E+09	48.00	3.92E-01	3.29E-01
Future	1.89E+08	1.70E+09	54.00	4.40E-01	3.69E-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/cm^2-s]			
				0°	15°	30°	45°
1	3.64E+07	3.64E+07	1.15	5.19E+10	2.88E+10	2.13E+10	1.46E+10
2	2.39E+07	6.03E+07	1.91	5.69E+10	3.15E+10	2.31E+10	1.56E+10
3	1.22E+07	7.24E+07	2.30	4.88E+10	2.74E+10	2.01E+10	1.37E+10
4	2.49E+07	9.73E+07	3.08	5.80E+10	3.29E+10	2.18E+10	1.41E+10
5	2.60E+07	1.23E+08	3.91	4.32E+10	2.38E+10	1.70E+10	1.08E+10
6	2.88E+07	1.52E+08	4.82	3.76E+10	2.19E+10	1.58E+10	1.11E+10
7	4.06E+07	1.93E+08	6.11	4.29E+10	2.41E+10	1.76E+10	1.23E+10
8	3.83E+07	2.31E+08	7.32	3.57E+10	2.08E+10	1.52E+10	1.06E+10
9	4.14E+07	2.73E+08	8.64	3.28E+10	2.19E+10	1.65E+10	1.05E+10
10	4.01E+07	3.13E+08	9.91	3.56E+10	2.13E+10	1.45E+10	9.67E+09
11	4.15E+07	3.54E+08	11.22	3.14E+10	1.93E+10	1.51E+10	1.10E+10
12	3.80E+07	3.92E+08	12.43	3.14E+10	1.86E+10	1.30E+10	9.62E+09
13	4.22E+07	4.34E+08	13.76	3.11E+10	1.82E+10	1.18E+10	8.89E+09
14	4.17E+07	4.76E+08	15.08	2.80E+10	1.70E+10	1.35E+10	9.40E+09
15	4.07E+07	5.17E+08	16.37	3.26E+10	1.97E+10	1.52E+10	1.12E+10
16	3.53E+07	5.52E+08	17.49	3.52E+10	1.91E+10	1.34E+10	9.93E+09
17	4.22E+07	5.94E+08	18.83	3.03E+10	1.95E+10	1.58E+10	1.20E+10
18	4.21E+07	6.36E+08	20.16	3.33E+10	1.93E+10	1.46E+10	1.16E+10
19(Prj.)	4.37E+07	6.80E+08	21.55	3.61E+10	2.09E+10	1.46E+10	1.07E+10
Future	1.09E+08	7.89E+08	25.00	3.61E+10	2.09E+10	1.46E+10	1.07E+10
Future	2.21E+08	1.01E+09	32.00	3.61E+10	2.09E+10	1.46E+10	1.07E+10
Future	1.26E+08	1.14E+09	36.00	3.61E+10	2.09E+10	1.46E+10	1.07E+10
Future	2.52E+08	1.51E+09	48.00	3.61E+10	2.09E+10	1.46E+10	1.07E+10
Future	1.89E+08	1.70E+09	54.00	3.61E+10	2.09E+10	1.46E+10	1.07E+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	3.64E+07	3.64E+07	1.15	1.89E+18	1.05E+18	7.75E+17	5.29E+17
2	2.39E+07	6.03E+07	1.91	3.14E+18	1.74E+18	1.28E+18	8.72E+17
3	1.22E+07	7.24E+07	2.30	3.73E+18	2.07E+18	1.53E+18	1.04E+18
4	2.49E+07	9.73E+07	3.08	5.17E+18	2.89E+18	2.07E+18	1.39E+18
5	2.60E+07	1.23E+08	3.91	6.29E+18	3.51E+18	2.51E+18	1.67E+18
6	2.88E+07	1.52E+08	4.82	7.38E+18	4.14E+18	2.96E+18	1.99E+18
7	4.06E+07	1.93E+08	6.11	9.12E+18	5.12E+18	3.68E+18	2.49E+18
8	3.83E+07	2.31E+08	7.32	1.05E+19	5.92E+18	4.26E+18	2.89E+18
9	4.14E+07	2.73E+08	8.64	1.18E+19	6.82E+18	4.95E+18	3.33E+18
10	4.01E+07	3.13E+08	9.91	1.33E+19	7.68E+18	5.53E+18	3.72E+18
11	4.15E+07	3.54E+08	11.22	1.46E+19	8.48E+18	6.15E+18	4.17E+18
12	3.80E+07	3.92E+08	12.43	1.58E+19	9.18E+18	6.64E+18	4.54E+18
13	4.22E+07	4.34E+08	13.76	1.71E+19	9.94E+18	7.14E+18	4.91E+18
14	4.17E+07	4.76E+08	15.08	1.82E+19	1.07E+19	7.70E+18	5.30E+18
15	4.07E+07	5.17E+08	16.37	1.96E+19	1.15E+19	8.32E+18	5.76E+18
16	3.53E+07	5.52E+08	17.49	2.08E+19	1.21E+19	8.79E+18	6.11E+18
17	4.22E+07	5.94E+08	18.83	2.21E+19	1.30E+19	9.46E+18	6.61E+18
18	4.21E+07	6.36E+08	20.16	2.35E+19	1.38E+19	1.01E+19	7.10E+18
19(Prj.)	4.37E+07	6.80E+08	21.55	2.50E+19	1.47E+19	1.07E+19	7.56E+18
Future	1.09E+08	7.89E+08	25.00	2.89E+19	1.69E+19	1.23E+19	8.71E+18
Future	2.21E+08	1.01E+09	32.00	3.68E+19	2.15E+19	1.55E+19	1.11E+19
Future	1.26E+08	1.14E+09	36.00	4.14E+19	2.41E+19	1.73E+19	1.24E+19
Future	2.52E+08	1.51E+09	48.00	5.50E+19	3.20E+19	2.29E+19	1.64E+19
Future	1.89E+08	1.70E+09	54.00	6.18E+19	3.60E+19	2.56E+19	1.85E+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	3.64E+07	3.64E+07	1.15	8.24E-11	4.54E-11	3.26E-11	2.25E-11
2	2.39E+07	6.03E+07	1.91	9.03E-11	4.96E-11	3.54E-11	2.42E-11
3	1.22E+07	7.24E+07	2.30	7.74E-11	4.31E-11	3.09E-11	2.11E-11
4	2.49E+07	9.73E+07	3.08	9.21E-11	5.19E-11	3.34E-11	2.18E-11
5	2.60E+07	1.23E+08	3.91	6.84E-11	3.74E-11	2.60E-11	1.67E-11
6	2.88E+07	1.52E+08	4.82	5.96E-11	3.44E-11	2.43E-11	1.72E-11
7	4.06E+07	1.93E+08	6.11	6.81E-11	3.79E-11	2.71E-11	1.89E-11
8	3.83E+07	2.31E+08	7.32	5.67E-11	3.27E-11	2.34E-11	1.64E-11
9	4.14E+07	2.73E+08	8.64	5.21E-11	3.43E-11	2.53E-11	1.63E-11
10	4.01E+07	3.13E+08	9.91	5.65E-11	3.35E-11	2.23E-11	1.50E-11
11	4.15E+07	3.54E+08	11.22	4.98E-11	3.03E-11	2.32E-11	1.71E-11
12	3.80E+07	3.92E+08	12.43	4.99E-11	2.92E-11	2.00E-11	1.49E-11
13	4.22E+07	4.34E+08	13.76	4.94E-11	2.86E-11	1.82E-11	1.38E-11
14	4.17E+07	4.76E+08	15.08	4.43E-11	2.67E-11	2.07E-11	1.46E-11
15	4.07E+07	5.17E+08	16.37	5.18E-11	3.10E-11	2.33E-11	1.73E-11
16	3.53E+07	5.52E+08	17.49	5.58E-11	3.01E-11	2.06E-11	1.54E-11
17	4.22E+07	5.94E+08	18.83	4.81E-11	3.06E-11	2.43E-11	1.85E-11
18	4.21E+07	6.36E+08	20.16	5.29E-11	3.03E-11	2.25E-11	1.80E-11
19(Prj.)	4.37E+07	6.80E+08	21.55	5.72E-11	3.28E-11	2.25E-11	1.65E-11
Future	1.09E+08	7.89E+08	25.00	5.72E-11	3.28E-11	2.25E-11	1.65E-11
Future	2.21E+08	1.01E+09	32.00	5.72E-11	3.28E-11	2.25E-11	1.65E-11
Future	1.26E+08	1.14E+09	36.00	5.72E-11	3.28E-11	2.25E-11	1.65E-11
Future	2.52E+08	1.51E+09	48.00	5.72E-11	3.28E-11	2.25E-11	1.65E-11
Future	1.89E+08	1.70E+09	54.00	5.72E-11	3.28E-11	2.25E-11	1.65E-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	3.64E+07	3.64E+07	1.15	3.00E-03	1.65E-03	1.19E-03	8.17E-04
2	2.39E+07	6.03E+07	1.91	4.98E-03	2.74E-03	1.96E-03	1.35E-03
3	1.22E+07	7.24E+07	2.30	5.92E-03	3.26E-03	2.34E-03	1.61E-03
4	2.49E+07	9.73E+07	3.08	8.21E-03	4.55E-03	3.17E-03	2.15E-03
5	2.60E+07	1.23E+08	3.91	9.99E-03	5.53E-03	3.85E-03	2.58E-03
6	2.88E+07	1.52E+08	4.82	1.17E-02	6.52E-03	4.55E-03	3.08E-03
7	4.06E+07	1.93E+08	6.11	1.45E-02	8.06E-03	5.65E-03	3.84E-03
8	3.83E+07	2.31E+08	7.32	1.66E-02	9.31E-03	6.54E-03	4.47E-03
9	4.14E+07	2.73E+08	8.64	1.88E-02	1.07E-02	7.59E-03	5.15E-03
10	4.01E+07	3.13E+08	9.91	2.11E-02	1.21E-02	8.49E-03	5.75E-03
11	4.15E+07	3.54E+08	11.22	2.31E-02	1.33E-02	9.45E-03	6.46E-03
12	3.80E+07	3.92E+08	12.43	2.50E-02	1.44E-02	1.02E-02	7.02E-03
13	4.22E+07	4.34E+08	13.76	2.71E-02	1.56E-02	1.10E-02	7.60E-03
14	4.17E+07	4.76E+08	15.08	2.89E-02	1.67E-02	1.18E-02	8.20E-03
15	4.07E+07	5.17E+08	16.37	3.10E-02	1.80E-02	1.28E-02	8.90E-03
16	3.53E+07	5.52E+08	17.49	3.30E-02	1.91E-02	1.35E-02	9.45E-03
17	4.22E+07	5.94E+08	18.83	3.50E-02	2.04E-02	1.45E-02	1.02E-02
18	4.21E+07	6.36E+08	20.16	3.72E-02	2.16E-02	1.55E-02	1.10E-02
19(Prj.)	4.37E+07	6.80E+08	21.55	3.97E-02	2.30E-02	1.64E-02	1.17E-02
Future	1.09E+08	7.89E+08	25.00	4.59E-02	2.66E-02	1.89E-02	1.35E-02
Future	2.21E+08	1.01E+09	32.00	5.84E-02	3.38E-02	2.38E-02	1.71E-02
Future	1.26E+08	1.14E+09	36.00	6.57E-02	3.79E-02	2.66E-02	1.92E-02
Future	2.52E+08	1.51E+09	48.00	8.73E-02	5.04E-02	3.52E-02	2.55E-02
Future	1.89E+08	1.70E+09	54.00	9.81E-02	5.66E-02	3.94E-02	2.86E-02

Table 6-3

Calculated Azimuthal Variation Of Exposure Rates
And Integrated Exposures At
The Intermediate Shell Course to Nozzle Shell Course Weld

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Neutron Flux (E > 1.0 MeV) [n/cm^2-s]			
				0°	15°	30°	45°
1	3.64E+07	3.64E+07	1.15	5.66E+09	3.15E+09	2.33E+09	1.59E+09
2	2.39E+07	6.03E+07	1.91	1.09E+10	6.02E+09	4.41E+09	2.99E+09
3	1.22E+07	7.24E+07	2.30	6.36E+09	3.57E+09	2.62E+09	1.78E+09
4	2.49E+07	9.73E+07	3.08	7.49E+09	4.25E+09	2.81E+09	1.82E+09
5	2.60E+07	1.23E+08	3.91	5.26E+09	2.91E+09	2.07E+09	1.31E+09
6	2.88E+07	1.52E+08	4.82	5.64E+09	3.29E+09	2.37E+09	1.66E+09
7	4.06E+07	1.93E+08	6.11	6.09E+09	3.42E+09	2.50E+09	1.74E+09
8	3.83E+07	2.31E+08	7.32	4.62E+09	2.69E+09	1.97E+09	1.37E+09
9	4.14E+07	2.73E+08	8.64	5.09E+09	3.40E+09	2.56E+09	1.64E+09
10	4.01E+07	3.13E+08	9.91	5.61E+09	3.36E+09	2.29E+09	1.53E+09
11	4.15E+07	3.54E+08	11.22	4.67E+09	2.87E+09	2.25E+09	1.65E+09
12	3.80E+07	3.92E+08	12.43	5.51E+09	3.26E+09	2.28E+09	1.69E+09
13	4.22E+07	4.34E+08	13.76	5.28E+09	3.09E+09	2.01E+09	1.51E+09
14	4.17E+07	4.76E+08	15.08	4.78E+09	2.91E+09	2.30E+09	1.61E+09
15	4.07E+07	5.17E+08	16.37	5.71E+09	3.44E+09	2.65E+09	1.95E+09
16	3.53E+07	5.52E+08	17.49	5.56E+09	3.02E+09	2.12E+09	1.57E+09
17	4.22E+07	5.94E+08	18.83	4.88E+09	3.14E+09	2.55E+09	1.93E+09
18	4.21E+07	6.36E+08	20.16	5.39E+09	3.12E+09	2.36E+09	1.88E+09
19(Prj.)	4.37E+07	6.80E+08	21.55	5.98E+09	3.46E+09	2.43E+09	1.77E+09
Future	1.09E+08	7.89E+08	25.00	5.98E+09	3.46E+09	2.43E+09	1.77E+09
Future	2.21E+08	1.01E+09	32.00	5.98E+09	3.46E+09	2.43E+09	1.77E+09
Future	1.26E+08	1.14E+09	36.00	5.98E+09	3.46E+09	2.43E+09	1.77E+09
Future	2.52E+08	1.51E+09	48.00	5.98E+09	3.46E+09	2.43E+09	1.77E+09
Future	1.89E+08	1.70E+09	54.00	5.98E+09	3.46E+09	2.43E+09	1.77E+09

Table 6-3 cont'd

Calculated Azimuthal Variation Of Exposure Rates
And Integrated Exposures At
The Intermediate Shell Course to Nozzle Shell Course Weld

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	3.64E+07	3.64E+07	1.15	2.06E+17	1.15E+17	8.46E+16	5.78E+16
2	2.39E+07	6.03E+07	1.91	4.66E+17	2.59E+17	1.90E+17	1.29E+17
3	1.22E+07	7.24E+07	2.30	5.44E+17	3.02E+17	2.22E+17	1.51E+17
4	2.49E+07	9.73E+07	3.08	7.30E+17	4.08E+17	2.92E+17	1.96E+17
5	2.60E+07	1.23E+08	3.91	8.67E+17	4.84E+17	3.46E+17	2.30E+17
6	2.88E+07	1.52E+08	4.82	1.03E+18	5.78E+17	4.14E+17	2.78E+17
7	4.06E+07	1.93E+08	6.11	1.28E+18	7.17E+17	5.16E+17	3.49E+17
8	3.83E+07	2.31E+08	7.32	1.45E+18	8.20E+17	5.91E+17	4.01E+17
9	4.14E+07	2.73E+08	8.64	1.66E+18	9.61E+17	6.97E+17	4.69E+17
10	4.01E+07	3.13E+08	9.91	1.89E+18	1.10E+18	7.89E+17	5.30E+17
11	4.15E+07	3.54E+08	11.22	2.08E+18	1.22E+18	8.82E+17	5.99E+17
12	3.80E+07	3.92E+08	12.43	2.29E+18	1.34E+18	9.69E+17	6.63E+17
13	4.22E+07	4.34E+08	13.76	2.52E+18	1.47E+18	1.05E+18	7.26E+17
14	4.17E+07	4.76E+08	15.08	2.71E+18	1.59E+18	1.15E+18	7.93E+17
15	4.07E+07	5.17E+08	16.37	2.95E+18	1.73E+18	1.26E+18	8.73E+17
16	3.53E+07	5.52E+08	17.49	3.14E+18	1.84E+18	1.33E+18	9.28E+17
17	4.22E+07	5.94E+08	18.83	3.35E+18	1.97E+18	1.44E+18	1.01E+18
18	4.21E+07	6.36E+08	20.16	3.58E+18	2.10E+18	1.54E+18	1.09E+18
19(Prj.)	4.37E+07	6.80E+08	21.55	3.84E+18	2.25E+18	1.65E+18	1.17E+18
Future	1.09E+08	7.89E+08	25.00	4.49E+18	2.63E+18	1.91E+18	1.36E+18
Future	2.21E+08	1.01E+09	32.00	5.81E+18	3.39E+18	2.45E+18	1.75E+18
Future	1.26E+08	1.14E+09	36.00	6.56E+18	3.83E+18	2.75E+18	1.97E+18
Future	2.52E+08	1.51E+09	48.00	8.83E+18	5.14E+18	3.67E+18	2.64E+18
Future	1.89E+08	1.70E+09	54.00	9.96E+18	5.80E+18	4.13E+18	2.98E+18

Table 6-3 cont'd

Calculated Azimuthal Variation Of Exposure Rates
And Integrated Exposures At
The Intermediate Shell Course to Nozzle Shell Course Weld

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Iron Atom Displacement Rate [dpa/s]			
				0°	15°	30°	45°
1	3.64E+07	3.64E+07	1.15	8.83E-12	4.86E-12	3.50E-12	2.41E-12
2	2.39E+07	6.03E+07	1.91	1.69E-11	9.28E-12	6.62E-12	4.53E-12
3	1.22E+07	7.24E+07	2.30	9.91E-12	5.52E-12	3.95E-12	2.71E-12
4	2.49E+07	9.73E+07	3.08	1.17E-11	6.58E-12	4.24E-12	2.77E-12
5	2.60E+07	1.23E+08	3.91	8.20E-12	4.49E-12	3.12E-12	2.00E-12
6	2.88E+07	1.52E+08	4.82	8.78E-12	5.06E-12	3.57E-12	2.52E-12
7	4.06E+07	1.93E+08	6.11	9.47E-12	5.27E-12	3.77E-12	2.63E-12
8	3.83E+07	2.31E+08	7.32	7.20E-12	4.15E-12	2.97E-12	2.08E-12
9	4.14E+07	2.73E+08	8.64	7.93E-12	5.22E-12	3.86E-12	2.49E-12
10	4.01E+07	3.13E+08	9.91	8.73E-12	5.18E-12	3.45E-12	2.32E-12
11	4.15E+07	3.54E+08	11.22	7.27E-12	4.42E-12	3.38E-12	2.49E-12
12	3.80E+07	3.92E+08	12.43	8.56E-12	5.02E-12	3.43E-12	2.56E-12
13	4.22E+07	4.34E+08	13.76	8.20E-12	4.75E-12	3.03E-12	2.28E-12
14	4.17E+07	4.76E+08	15.08	7.42E-12	4.47E-12	3.46E-12	2.44E-12
15	4.07E+07	5.17E+08	16.37	8.86E-12	5.30E-12	3.99E-12	2.95E-12
16	3.53E+07	5.52E+08	17.49	8.64E-12	4.65E-12	3.19E-12	2.38E-12
17	4.22E+07	5.94E+08	18.83	7.60E-12	4.82E-12	3.84E-12	2.92E-12
18	4.21E+07	6.36E+08	20.16	8.38E-12	4.81E-12	3.56E-12	2.85E-12
19(Prj.)	4.37E+07	6.80E+08	21.55	9.30E-12	5.34E-12	3.66E-12	2.69E-12
Future	1.09E+08	7.89E+08	25.00	9.30E-12	5.34E-12	3.66E-12	2.69E-12
Future	2.21E+08	1.01E+09	32.00	9.30E-12	5.34E-12	3.66E-12	2.69E-12
Future	1.26E+08	1.14E+09	36.00	9.30E-12	5.34E-12	3.66E-12	2.69E-12
Future	2.52E+08	1.51E+09	48.00	9.30E-12	5.34E-12	3.66E-12	2.69E-12
Future	1.89E+08	1.70E+09	54.00	9.30E-12	5.34E-12	3.66E-12	2.69E-12

Table 6-3 cont'd

Calculated Azimuthal Variation Of Exposure Rates
And Integrated Exposures At
The Intermediate Shell Course to Nozzle Shell Course Weld

Cycle	Cycle Length [EFPS]	Cumulative Irradiation Time [EFPS]	Cumulative Irradiation Time [EFPY]	Iron Atom Displacements [dpa]			
				0°	15°	30°	45°
1	3.64E+07	3.64E+07	1.15	3.21E-04	1.77E-04	1.27E-04	8.76E-05
2	2.39E+07	6.03E+07	1.91	7.25E-04	3.99E-04	2.86E-04	1.96E-04
3	1.22E+07	7.24E+07	2.30	8.46E-04	4.66E-04	3.34E-04	2.29E-04
4	2.49E+07	9.73E+07	3.08	1.14E-03	6.30E-04	4.39E-04	2.98E-04
5	2.60E+07	1.23E+08	3.91	1.35E-03	7.47E-04	5.20E-04	3.50E-04
6	2.88E+07	1.52E+08	4.82	1.60E-03	8.92E-04	6.23E-04	4.22E-04
7	4.06E+07	1.93E+08	6.11	1.99E-03	1.11E-03	7.76E-04	5.29E-04
8	3.83E+07	2.31E+08	7.32	2.26E-03	1.27E-03	8.90E-04	6.09E-04
9	4.14E+07	2.73E+08	8.64	2.59E-03	1.48E-03	1.05E-03	7.12E-04
10	4.01E+07	3.13E+08	9.91	2.94E-03	1.69E-03	1.19E-03	8.05E-04
11	4.15E+07	3.54E+08	11.22	3.24E-03	1.87E-03	1.33E-03	9.08E-04
12	3.80E+07	3.92E+08	12.43	3.57E-03	2.06E-03	1.46E-03	1.01E-03
13	4.22E+07	4.34E+08	13.76	3.91E-03	2.26E-03	1.59E-03	1.10E-03
14	4.17E+07	4.76E+08	15.08	4.22E-03	2.45E-03	1.73E-03	1.20E-03
15	4.07E+07	5.17E+08	16.37	4.58E-03	2.67E-03	1.89E-03	1.32E-03
16	3.53E+07	5.52E+08	17.49	4.89E-03	2.83E-03	2.01E-03	1.41E-03
17	4.22E+07	5.94E+08	18.83	5.21E-03	3.03E-03	2.17E-03	1.53E-03
18	4.21E+07	6.36E+08	20.16	5.56E-03	3.24E-03	2.32E-03	1.65E-03
19(Prj.)	4.37E+07	6.80E+08	21.55	5.97E-03	3.47E-03	2.48E-03	1.77E-03
Future	1.09E+08	7.89E+08	25.00	6.98E-03	4.05E-03	2.88E-03	2.06E-03
Future	2.21E+08	1.01E+09	32.00	9.03E-03	5.23E-03	3.68E-03	2.65E-03
Future	1.26E+08	1.14E+09	36.00	1.02E-02	5.90E-03	4.15E-03	2.99E-03
Future	2.52E+08	1.51E+09	48.00	1.37E-02	7.92E-03	5.53E-03	4.01E-03
Future	1.89E+08	1.70E+09	54.00	1.55E-02	8.93E-03	6.22E-03	4.52E-03

Table 6-4

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

RADIUS (cm)	AZIMUTHAL ANGLE			
	0°	15°	30°	45°
199.79	1.000	1.000	1.000	1.000
204.79	0.587	0.601	0.600	0.603
209.79	0.301	0.316	0.314	0.318
214.79	0.148	0.159	0.158	0.161
219.79	0.068	0.078	0.078	0.082

Note:
Base Metal Inner Radius = 199.79 cm
Base Metal 1/4T = 204.79 cm
Base Metal 1/2T = 209.79 cm
Base Metal 3/4T = 214.79 cm
Base Metal Outer Radius = 219.79 cm

Table 6-5

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

RADIUS (cm)	AZIMUTHAL ANGLE			
	0°	15°	30°	45°
199.79	1.000	1.000	1.000	1.000
204.79	0.666	0.681	0.665	0.668
209.79	0.417	0.436	0.416	0.420
214.79	0.254	0.274	0.256	0.262
219.79	0.140	0.163	0.154	0.164

Note:
Base Metal Inner Radius = 199.79 cm
Base Metal 1/4T = 204.79 cm
Base Metal 1/2T = 209.79 cm
Base Metal 3/4T = 214.79 cm
Base Metal Outer Radius = 219.79 cm

Table 6-6

Calculated Fast Neutron Exposure of Surveillance Capsules
Withdrawn from Farley Unit 1

Capsule	Irradiation Time [EFPY]	Fluence (E > 1.0 MeV) [n/cm^2]	Iron Displacements [dpa]
Y	1.15	6.12E+18	1.26E-02
U	3.08	1.73E+19	3.56E-02
X	6.11	3.06E+19	6.27E-02
W	12.43	4.75E+19	9.49E-02
V	20.16	7.14E+19	1.42E-01

Table 6-7

Calculated Surveillance Capsule Lead Factors

Capsule ID And Location	Status	Lead Factor
Y (17°)	Withdrawn EOC 1	3.24
U (17°)	Withdrawn EOC 4	3.34
X (17°)	Withdrawn EOC 7	3.35
W (20°)	Withdrawn EOC 12	3.01
V (20°)	Withdrawn EOC 18	3.04
Z (20°)	In Reactor	3.04

Note: Lead factors for capsules remaining in the reactor are based on cycle specific exposure calculations through the current operating fuel reload, i.e., Cycle 19.

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 Farley Unit 1 reactor vessel. This recommended removal schedule is applicable to 34 EFPY of operation.

Table 7-1 Recommended Surveillance Capsule Withdrawal Schedule

Capsule	Capsule Location	Lead Factor [a]	Withdrawal EFPY [a, b]	Fluence (n/cm^2) [a]
Y	343°	3.24	1.15	6.12×10^{18} (c)
U	107°	3.34	3.08	1.73×10^{19} (c)
X	287°	3.35	6.11	3.06×10^{19} (c)
W	110°	3.01	12.43 (EOL)	4.75×10^{19} (c)
V	290°	3.04	20.16 (e) (License Renewal)	7.14×10^{19} (c)
Z	340°	3.04	~24.0 (Standby)	8.44×10^{19} (d)

Notes:

(a) Updated in Capsule V dosimetry analysis.
(b) Effective Full Power Years (EFPY) from plant startup.
(c) Plant specific evaluation.
(d) 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.
(e) In the event that Farley Unit 1 obtains license renewal approval, then this capsule will serve as the "new" end of life capsule.

8 REFERENCES

1. Regulatory Guide 1.99, Revision 2, *Radiation Embrittlement of Reactor Vessel Materials,* U.S. Nuclear Regulatory Commission, May, 1988.

2. Code of Federal Regulations, 10CFR50, Appendix G, *Fracture Toughness Requirements*, and Appendix H, *Reactor Vessel Material Surveillance Program Requirements*, U.S. Nuclear Regulatory Commission, Washington, D.C.

3. WCAP-8810, "*Southern Alabama Power Company Joseph M. Farley Nuclear Plant Unit No. 1 Reactor Vessel Radiation Surveillance Program,*" J.A. Davidson, et.al., December 1976.

4. WCAP-9717, "*Analysis of Capsule Y from the Alabama Power Company Farley Unit No. 1 Reactor Vessel Radiation Surveillance Program,*" S.E. Yanichko, et. al., June 1980.

5. WCAP-10474, "*Analysis of Capsule U from the Alabama Power Company Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program*", S.E. Yanichko, et. al., February 1984.

6. WCAP-11563, Rev. 1, "*Analysis of Capsule X from the Alabama Power Company Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program.*" S.E. Yanichko, et. al., September 1987.

7. WCAP-14196, "*Analysis of Capsule W from the Alabama Power Company Farley Unit 1 Reactor Vessel Radiation Surveillance Program.*" P.A. Peters, et. al., February 1995.

8. STD-MCE-03-53, "Farley Unit 1 Capsule V Test Results," J. Conermann, 10/30/03.

9. ASTM E208, *Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA.

10. Section XI of the ASME Boiler and Pressure Vessel Code, Appendix G, *Fracture Toughness Criteria for Protection Against Failure*

11. ASTM E185-82, *Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA.

12. Procedure RMF 8402, *Surveillance Capsule Testing Program*, Revision 2.

13. Procedure RMF 8102, *Tensile Testing*, Revision 1.

14. Procedure RMF 8103, *Charpy Impact Testing*, Revision 1.

15. ASTM E23-02a, *Standard Test Method for Notched Bar Impact Testing of Metallic Materials*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA, 2002.

16. ASTM A370-97a, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA, 1997.

17. ASTM E8-01, *Standard Test Methods for Tension Testing of Metallic Materials*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA, 2001.

18. ASTM E21-92 (1998), *Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA, 1998.

19. ASTM E83-93, *Standard Practice for Verification and Classification of Extensometers*, in ASTM Standards, Section 3, American Society for Testing and Materials, Philadelphia, PA, 1993.

20. ASTM E185-73, *Standard Recommended Practice for Surviellance Tests for Nuclear Reactor Vessels.*

21. WCAP-14370, *Use of the Hyperbolic Tangent Function for Fitting Transition Temperature Toughness Data*, T. R. Mager, et al, May 1995.

22. 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 2001.

23. WCAP-14040-NP-A, Revision 2, *Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves*, January 1996.

24. WCAP-15557, Revision 0, *Qualification of the Westinghouse Pressure Vessel Neutron Fluence Evaluation Methodology*, August 2000.

25. RSICC Computer Code Collection CCC-650, *DOORS 3.1, One, Two- and Three-Dimensional Discrete Ordinates Neutron/Photon Transport Code System*, August 1996.

26. RSIC Data Library Collection DLC-185, "BUGLE-96, Coupled 47 Neutron, 20 Gamma-Ray Group Cross Section Library Derived from ENDF/B-VI for LWR Shielding and Pressure Vessel Dosimetry Applications," March 1996.

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 Farley Unit 1 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 five neutron sensor sets withdrawn to date as part of the Farley Unit 1 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]
Y	17°	End of Cycle 1	1.15
U	17°	End of Cycle 4	3.08
X	17°	End of Cycle 7	6.11
W	20°	End of Cycle 12	12.43
V	20°	End of Cycle 18	20.16

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 Y, U, X, W, and V are summarized as follows:

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

* The cobalt-aluminum measurements for this plant include both bare wire and cadmium-covered sensors.
** The bare cobalt-aluminum wires for this capsule were not recovered.

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 Capsules Y, U, X, and W are documented in References A-2 through A-5, respectively. The radiometric counting of the sensors from Capsule V 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 Y, U, X, W, and V was based on the reported monthly power generation of Farley Unit 1 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 Y, U, X, W, and V 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 Farley Unit 1 fission sensor reaction rates are summarized as follows:

Correction	Capsule Y	Capsule U	Capsule X	Capsule W	Capsule V
^{235}U Impurity/Pu Build-in	0.861	0.818	0.774	0.719	0.654
$^{238}U(\gamma,f)$	0.976	0.976	0.976	0.978	0.978
Net ^{238}U Correction	0.840	0.798	0.755	0.703	0.640
$^{237}Np(\gamma,f)$	0.994	0.994	0.994	0.994	0.994

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 Y, U, X, W, and V 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 $\phi(E > 1.0\text{ MeV})$ 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 Farley Unit 1 surveillance capsule dosimetry, the FERRET code[A-6] 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 (ϕ(E > 1.0 MeV) and dpa) along with associated uncertainties for the five 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 Farley Unit 1 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-7]. 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 Farley Unit 1 surveillance capsule sensor sets.

<u>Reaction Rate Uncertainties</u>

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 Farley Unit 1 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 groupwise 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 Farley Unit 1 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 Farley Unit 1 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 0.80–1.08 for the 25 samples included in the data set. The overall average M/C ratio for the entire set of Farley Unit 1 data is 0.94 with an associated standard deviation of 9.8%.

In the comparisons of best estimate and calculated fast neutron exposure parameters, the corresponding BE/C comparisons for the capsule data sets range from 0.81–0.97 for neutron flux (E > 1.0 MeV) and from 0.84 to 0.97 for iron atom displacement rate. The overall average BE/C ratios for neutron flux (E > 1.0 MeV) and iron atom displacement rate are 0.91 with a standard deviation of 6.8% and 0.94 with a standard deviation of 6.3%, 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 Farley Unit 1 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 – 11.8	5.271 y	
Iron	$^{54}Fe\ (n,p)$	0.0585	2.1 – 8.4	312.3 d	
Nickel	$^{58}Ni\ (n,p)$	0.6808	1.5 – 8.2	70.82 d	
Uranium-238	$^{238}U\ (n,f)$	1.0000	1.2 – 6.8	30.07 y	6.02
Neptunium-237	$^{237}Np\ (n,f)$	1.0000	0.4 – 3.6	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 Farley Unit 1 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 Eighteen Fuel Cycles
Of The Farley Unit 1 Reactor
(Reactor Power of 2652 MWt for Cycles 1 through 15,
and 2775MW for Cycles 16 through 18)

Year	Month	Thermal Generation (MWt-hr)	Year	Month	Thermal Generation (MWt-hr)	Year	Month	Thermal Generation (MWt-hr)
1977	8	67513	1980	8	1694628	1983	8	1971688
1977	9	864971	1980	9	1398265	1983	9	1909440
1977	10	355140	1980	10	1933931	1983	10	1789981
1977	11	1131938	1980	11	382570	1983	11	1909228
1977	12	1304003	1980	12	0	1983	12	1973088
1978	1	1354896	1981	1	0	1984	1	1729356
1978	2	1426824	1981	2	0	1984	2	631428
1978	3	1884641	1981	3	0	1984	3	0
1978	4	1662759	1981	4	1134435	1984	4	124058
1978	5	1650988	1981	5	1639348	1984	5	1807741
1978	6	1784321	1981	6	1836579	1984	6	1908735
1978	7	1830416	1981	7	1889655	1984	7	1973062
1978	8	1797336	1981	8	1902225	1984	8	1973088
1978	9	941142	1981	9	552776	1984	9	1904651
1978	10	1501768	1981	10	0	1984	10	1949788
1978	11	1896861	1981	11	0	1984	11	1898355
1978	12	1787293	1981	12	0	1984	12	1898787
1979	1	1558383	1982	1	0	1985	1	1973088
1979	2	1616052	1982	2	0	1985	2	1782144
1979	3	381913	1982	3	1254038	1985	3	1708471
1979	4	0	1982	4	1523773	1985	4	329500
1979	5	0	1982	5	1955244	1985	5	85286
1979	6	0	1982	6	1875911	1985	6	1655389
1979	7	0	1982	7	1968060	1985	7	1844333
1979	8	0	1982	8	1679390	1985	8	1958242
1979	9	0	1982	9	1812488	1985	9	1871312
1979	10	0	1982	10	1710147	1985	10	1954081
1979	11	457481	1982	11	1909130	1985	11	1865690
1979	12	1760937	1982	12	1856957	1985	12	1943431
1980	1	1721418	1983	1	794698	1986	1	1877709
1980	2	639186	1983	2	0	1986	2	1741224
1980	3	1800910	1983	3	33094	1986	3	1812234
1980	4	1870270	1983	4	1489953	1986	4	1872495
1980	5	1927148	1983	5	1956770	1986	5	1853814
1980	6	822411	1983	6	1810449	1986	6	1888407
1980	7	1201139	1983	7	1973088	1986	7	1846629

Table A-2 cont'd

Monthly Thermal Generation During The First Eighteen Fuel Cycles
Of The Farley Unit 1 Reactor
(Reactor Power of 2652 MWt for Cycles 1 through 15,
and 2775MW for Cycles 16 through 18)

Year	Month	Thermal Generation (MWt-hr)	Year	Month	Thermal Generation (MWt-hr)	Year	Month	Thermal Generation (MWt-hr)
1986	8	1775600	1989	8	1969301	1992	8	1971823
1986	9	1890035	1989	9	1383665	1992	9	1564342
1986	10	181323	1989	10	0	1992	10	0
1986	11	0	1989	11	855994	1992	11	257
1986	12	1716656	1989	12	1968102	1992	12	1560307
1987	1	1751070	1990	1	1970192	1993	1	1928568
1987	2	1768852	1990	2	1652567	1993	2	1775604
1987	3	1955044	1990	3	1962103	1993	3	1293224
1987	4	1216358	1990	4	1906730	1993	4	1905594
1987	5	1906563	1990	5	1846696	1993	5	1971444
1987	6	1909366	1990	6	1758695	1993	6	1908087
1987	7	1973035	1990	7	1690942	1993	7	1972236
1987	8	1748771	1990	8	1971720	1993	8	1972212
1987	9	1909437	1990	9	1867822	1993	9	1907885
1987	10	1812021	1990	10	1974496	1993	10	1975209
1987	11	1909437	1990	11	1906403	1993	11	1909034
1987	12	1235697	1990	12	1971698	1993	12	1972228
1988	1	1973088	1991	1	1970245	1994	1	1969966
1988	2	1845755	1991	2	1780012	1994	2	1763942
1988	3	1581648	1991	3	488986	1994	3	227593
1988	4	0	1991	4	0	1994	4	275479
1988	5	388449	1991	5	467378	1994	5	1840449
1988	6	1773947	1991	6	1777930	1994	6	1887519
1988	7	1973088	1991	7	1919659	1994	7	1946860
1988	8	1970025	1991	8	1725229	1994	8	1972995
1988	9	1909440	1991	9	1890966	1994	9	1909440
1988	10	1884883	1991	10	1879448	1994	10	1966909
1988	11	1908164	1991	11	1909440	1994	11	1909440
1988	12	1951416	1991	12	1961350	1994	12	1972720
1989	1	1964305	1992	1	1971348	1995	1	1668639
1989	2	1757472	1992	2	1844169	1995	2	1772517
1989	3	1932709	1992	3	1972001	1995	3	1971635
1989	4	1892334	1992	4	1860541	1995	4	1904131
1989	5	1973088	1992	5	1971974	1995	5	1969707
1989	6	1906099	1992	6	1907928	1995	6	1432290
1989	7	1967625	1992	7	1971762	1995	7	1972982

Table A-2 cont'd

Monthly Thermal Generation During The First Eighteen Fuel Cycles
Of The Farley Unit 1 Reactor
(Reactor Power of 2652 MWt for Cycles 1 through 15,
and 2775MW for Cycles 16 through 18).

Year	Month	Thermal Generation (MWt-hr)	Year	Month	Thermal Generation (MWt-hr)	Year	Month	Thermal Generation (MWt-hr)
1995	8	1926386	1998	8	1018288	2001	8	2064600
1995	9	791505	1998	9	1485916	2001	9	1991229
1995	10	0	1998	10	1012640	2001	10	304001
1995	11	1237397	1998	11	0	2001	11	840437
1995	12	1971468	1998	12	87524	2001	12	1932288
1996	1	1973107	1999	1	2011070	2002	1	2064600
1996	2	1745785	1999	2	1864800	2002	2	1863579
1996	3	1973088	1999	3	1956375	2002	3	2063629
1996	4	1906788	1999	4	1995225	2002	4	1995197
1996	5	1798799	1999	5	1838715	2002	5	1922145
1996	6	1897153	1999	6	1996712	2002	6	1998000
1996	7	1930947	1999	7	2064580	2002	7	2064600
1996	8	1972107	1999	8	2063601	2002	8	2063657
1996	9	1909440	1999	9	1998000	2002	9	1997556
1996	10	1975740	1999	10	2067375	2002	10	1950242
1996	11	1908591	1999	11	1960982	2002	11	1998000
1996	12	1973088	1999	12	2038432	2002	12	1958762
1997	1	1841734	2000	1	1909754	2003	1	2064461
1997	2	1782144	2000	2	1214534	2003	2	1864800
1997	3	887754	2000	3	118437	2003	3	1848289
1997	4	0	2000	4	0			
1997	5	0	2000	5	125347			
1997	6	1466264	2000	6	1863884			
1997	7	1938745	2000	7	2047728			
1997	8	1973088	2000	8	2040180			
1997	9	1908697	2000	9	1997889			
1997	10	1975740	2000	10	1989203			
1997	11	1909440	2000	11	1998000			
1997	12	1882761	2000	12	2058800			
1998	1	1973008	2001	1	2064600			
1998	2	1764296	2001	2	1824868			
1998	3	1972425	2001	3	2064544			
1998	4	1892971	2001	4	1995225			
1998	5	1966882	2001	5	2063740			
1998	6	1908432	2001	6	1940780			
1998	7	1932875	2001	7	2064717			

Table A-3

Calculated C_j Factors at the Surveillance Capsule Center
Core Midplane Elevation

Fuel Cycle	$\phi(E > 1.0\ MeV)$ [n/cm^2-s]				
	Capsule Y	Capsule U	Capsule X	Capsule W	Capsule V
1	1.68E+11	1.68E+11	1.68E+11	1.45E+11	1.45E+11
2		1.79E+11	1.79E+11	1.54E+11	1.54E+11
3		1.65E+11	1.65E+11	1.42E+11	1.42E+11
4		1.96E+11	1.96E+11	1.63E+11	1.63E+11
5			1.42E+11	1.25E+11	1.25E+11
6			1.31E+11	1.14E+11	1.14E+11
7			1.43E+11	1.25E+11	1.25E+11
8				1.06E+11	1.06E+11
9				1.19E+11	1.19E+11
10				1.07E+11	1.07E+11
11				1.02E+11	1.02E+11
12				9.45E+10	9.45E+10
13					9.13E+10
14					9.17E+10
15					1.03E+11
16					9.70E+10
17					1.05E+11
18					9.99E+10
Average	1.68E+11	1.775E+11	1.586E+11	1.210E+11	1.122E+11

Fuel Cycle	C_j				
	Capsule Y	Capsule U	Capsule X	Capsule W	Capsule V
1	1.000	0.947	1.060	1.202	1.296
2		1.007	1.127	1.269	1.370
3		0.929	1.040	1.176	1.269
4		1.106	1.238	1.343	1.449
5			0.894	1.029	1.110
6			0.828	0.940	1.015
7			0.903	1.036	1.117
8				0.874	0.942
9				0.983	1.060
10				0.888	0.958
11				0.842	0.909
12				0.781	0.843
13					0.814
14					0.817
15					0.918
16					0.865
17					0.934
18					0.891
Average	1.000	1.000	1.000	1.000	1.000

Table A-4

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	6.59E+04	5.10E+05	5.10E+05	7.78E-17
	Middle	6.28E+04	4.86E+05	4.86E+05	7.41E-17
	Bottom	6.81E+04	5.27E+05	5.27E+05	8.04E-17
	Average				**7.74E-17**
^{54}Fe (n,p) ^{54}Mn	Top	1.95E+06	5.33E+06	5.33E+06	8.44E-15
	Middle	1.90E+06	5.19E+06	5.19E+06	8.23E-15
	Bottom	1.99E+06	5.44E+06	5.44E+06	8.62E-15
	Average				**8.43E-15**
^{58}Ni (n,p) ^{58}Co	Top	1.01E+07	8.04E+07	8.04E+07	1.15E-14
	Middle	9.63E+06	7.66E+07	7.66E+07.	1.10E-14
	Bottom	1.04E+07	8.28E+07	8.28E+07	1.19E-14
	Average				**1.14E-14**
^{238}U (n,f) ^{137}Cs (Cd)	Middle	2.59E+05	1.00E+07	1.00E+07	6.58E-14
^{238}U (n,f) ^{137}Cs (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**5.53E-14**
^{237}Np (n,f) ^{137}Cs (Cd)	Middle	1.82E+06	7.05E+07	7.05E+07	4.49E-13
^{237}Np (n,f) ^{137}Cs (Cd)			Including γ,fission correction:		**4.47E-13**
^{59}Co (n,γ) ^{60}Co	Top	1.44E+07	1.11E+08	1.11E+08	7.27E-12
	Middle	1.50E+07	1.16E+08	1.16E+08	7.57E-12
	Bottom	1.46E+07	1.13E+08	1.13E+08	7.37E-12
	Average				**7.40E-12**
^{59}Co (n,γ) ^{60}Co (Cd)	Top	8.11E+06	6.27E+07	6.27E+07	4.09E-12
	Middle	8.22E+06	6.36E+07	6.36E+07	4.15E-12
	Bottom	8.14E+06	6.30E+07	6.30E+07	4.11E-12
	Average				**4.12E-12**

Notes: 1) Measured specific activities are indexed to a counting date of September 18, 1979.
2) The average ^{238}U (n,f) reaction rate of 5.53E-14 includes a correction factor of 0.861 to account for plutonium build-in and an additional factor of 0.976 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 4.47E-13 includes a correction factor of 0.994 to account for photo-fission effects in the sensor.

Table A-4 cont'd

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	1.35E+05	5.08E+05	5.08E+05	7.75E-17
	Middle	1.34E+05	5.05E+05	5.05E+05	7.70E-17
	Bottom	1.42E+05	5.35E+05	5.35E+05	8.16E-17
	Average				**7.87E-17**
^{54}Fe (n,p) ^{54}Mn	Top	1.88E+06	5.39E+06	5.39E+06	8.54E-15
	Middle	1.86E+06	5.33E+06	5.33E+06	8.45E-15
	Bottom	1.94E+06	5.56E+06	5.56E+06	8.81E-15
	Average				**8.60E-15**
^{58}Ni (n,p) ^{58}Co	Top	4.16E+06	8.59E+07	8.59E+07	1.23E-14
	Middle	4.03E+06	8.33E+07	8.33E+07	1.19E-14
	Bottom	4.33E+06	8.95E+07	8.95E+07	1.28E-14
	Average				**1.23E-14**
^{238}U (n,f) ^{137}Cs (Cd)	Middle	7.00E+05	1.06E+07	1.06E+07	6.99E-14
^{238}U (n,f) ^{137}Cs (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**5.58E-14**
^{237}Np (n,f) ^{137}Cs (Cd)	Middle	6.05E+06	9.20E+07	9.20E+07	5.87E-13
^{237}Np (n,f) ^{137}Cs (Cd)			Including γ,fission correction:		**5.83E-13**
^{59}Co (n,γ) ^{60}Co	Top	3.56E+07	1.34E+08	1.34E+08	8.74E-12
	Middle	3.57E+07	1.34E+08	1.34E+08	8.77E-12
	Bottom	3.60E+07	1.36E+08	1.36E+08	8.84E-12
	Average				**8.79E-12**
^{59}Co (n,γ) ^{60}Co (Cd)		1.92E+07	7.23E+07	7.23E+07	**4.72E-12**

Notes: 1) Measured specific activities are indexed to a counting date of November 11, 1983.
2) The average ^{238}U (n,f) reaction rate of 5.58E-14 includes a correction factor of 0.818 to account for plutonium build-in and an additional factor of 0.976 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 5.83E-13 includes a correction factor of 0.994 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	2.13E+05	4.74E+05	4.74E+05	7.23E-17
	Middle	2.12E+05	4.71E+05	4.71E+05	7.19E-17
	Bottom	2.22E+05	4.94E+05	4.94E+05	7.53E-17
	Average				**7.32E-17**
$^{54}Fe\ (n,p)\ ^{54}Mn$	Top	2.27E+06	4.61E+06	4.61E+06	7.31E-15
	Middle	2.24E+06	4.55E+06	4.55E+06	7.21E-15
	Bottom	2.40E+06	4.87E+06	4.87E+06	7.73E-15
	Average				**7.41E-15**
$^{58}Ni\ (n,p)\ ^{58}Co$	Top	7.83E+06	7.33E+07	7.33E+07	1.05E-14
	Middle	7.55E+06	7.07E+07	7.07E+07	1.01E-14
	Bottom	8.05E+06	7.54E+07	7.54E+07	1.08E-14
	Average				**1.05E-14**
$^{238}U\ (n,f)\ ^{137}Cs$ (Cd)	Middle	1.28E+06	1.02E+07	1.02E+07	6.67E-14
$^{238}U\ (n,f)\ ^{137}Cs$ (Cd)	Including ^{235}U, ^{239}Pu, and γ,fission corrections:				**5.04E-14**
$^{237}Np\ (n,f)\ ^{137}Cs$ (Cd)	Middle	9.88E+06	7.84E+07	7.84E+07	5.00E-13
$^{237}Np\ (n,f)\ ^{137}Cs$ (Cd)		Including γ,fission correction:			**4.97E-13**
$^{59}Co\ (n,\gamma)\ ^{60}Co$	Top	5.11E+07	1.14E+08	1.14E+08	7.41E-12
	Middle	5.24E+07	1.17E+08	1.17E+08	7.60E-12
	Bottom	4.76E+07	1.06E+08	1.06E+08	6.91E-12
	Average				**7.31E-12**
$^{59}Co\ (n,\gamma)\ ^{60}Co$ (Cd)	Top	2.84E+07	6.32E+07	6.32E+07	4.12E-12
	Bottom	2.64E+07	5.87E+07	5.87E+07	3.83E-12
	Average				**3.98E-12**

Notes: 1) Measured specific activities are indexed to a counting date of May 4, 1987.
2) The average ^{238}U (n,f) reaction rate of 5.04E-14 includes a correction factor of 0.774 to account for plutonium build-in and an additional factor of 0.976 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 4.97E-13 includes a correction factor of 0.994 to account for photo-fission effects in the sensor.

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,α) ^{60}Co	Top	2.36E+05	3.74E+05	3.74E+05	5.71E-17
	Middle	2.35E+05	3.73E+05	3.73E+05	5.69E-17
	Bottom	2.49E+05	3.95E+05	3.95E+05	6.02E-17
	Average				**5.81E-17**
^{54}Fe (n,p) ^{54}Mn	Top	1.73E+06	3.43E+06	3.43E+06	5.43E-15
	Middle	1.70E+06	3.37E+06	3.37E+06	5.34E-15
	Bottom	1.84E+06	3.64E+06	3.64E+06	5.78E-15
	Average				**5.51E-15**
^{58}Ni (n,p) ^{58}Co	Top	8.46E+06	5.59E+07	5.59E+07	8.00E-15
	Middle	8.08E+06	5.34E+07	5.34E+07	7.64E-15
	Bottom	8.79E+06	5.81E+07	5.81E+07	8.32E-15
	Average				**7.99E-15**
^{238}U (n,f) ^{137}Cs (Cd)	Middle	1.54E+06	6.52E+06	6.52E+06	4.28E-14
^{238}U (n,f) ^{137}Cs (Cd)	Including ^{235}U, ^{239}Pu, and γ,fission corrections:				**3.01E-14**
^{237}Np (n,f) ^{137}Cs (Cd)	Middle	1.15E+07	4.87E+07	4.87E+07	3.11E-13
^{237}Np (n,f) ^{137}Cs (Cd)	Including γ,fission correction:				**3.09E-13**
^{59}Co (n,γ) ^{60}Co (Cd)	Top	4.15E+07	6.58E+07	6.58E+07	4.29E-12
	Middle	4.12E+07	6.53E+07	6.53E+07	4.26E-12
	Bottom	4.15E+07	6.58E+07	6.58E+07	4.29E-12
	Average				**4.28E-12**

Notes: 1) Measured specific activities are indexed to a counting date of August 17, 1994.

2) The average ^{238}U (n,f) reaction rate of 3.01E-14 includes a correction factor of 0.719 to account for plutonium build-in and an additional factor of 0.978 to account for photo-fission effects in the sensor.

3) The average ^{237}Np (n,f) reaction rate of 3.09E-13 includes a correction factor of 0.994 to account for photo-fission effects in the sensor.

Table A-4 cont'd

Measured Sensor Activities And Reaction Rates
Surveillance Capsule V

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	2.49E+05	3.90E+05	3.90E+05	5.95E-17
	Middle	2.48E+05	3.89E+05	3.89E+05	5.93E-17
	Bottom	2.61E+05	4.09E+05	4.09E+05	6.24E-17
	Average				**6.04E-17**
^{54}Fe (n,p) ^{54}Mn	Top	1.84E+06	3.50E+06	3.50E+06	5.54E-15
	Middle	1.81E+06	3.44E+06	3.44E+06	5.45E-15
	Bottom	1.88E+06	3.57E+06	3.57E+06	5.66E-15
	Average				**5.55E-15**
^{58}Ni (n,p) ^{58}Co	Top	6.05E+06	5.50E+07	5.50E+07	7.88E-15
	Middle	5.82E+06	5.29E+07	5.29E+07	7.58E-15
	Bottom	6.18E+06	5.62E+07	5.62E+07	8.04E-15
	Average				**7.83E-15**
^{238}U (n,f) ^{137}Cs (Cd)	Middle	2.42E+06	7.46E+06	7.46E+06	4.90E-14
^{238}U (n,f) ^{137}Cs (Cd)		Including ^{235}U, ^{239}Pu, and γ,fission corrections:			**3.14E-14**
^{237}Np (n,f) ^{137}Cs (Cd)	Middle	1.71E+07	5.27E+07	5.27E+07	3.36E-13
^{237}Np (n,f) ^{137}Cs (Cd)			Including γ,fission correction:		**3.34E-13**
^{59}Co (n,γ) ^{60}Co	Top	4.56E+07	7.14E+07	7.14E+07	4.66E-12
	Middle	4.55E+07	7.13E+07	7.13E+07	4.65E-12
	Bottom	4.24E+07	6.64E+07	6.64E+07	4.33E-12
	Average				**4.55E-12**
^{59}Co (n,γ) ^{60}Co (Cd)	Top	2.48E+07	3.89E+07	3.89E+07	**2.53E-12**

Notes: 1) Measured specific activities are indexed to a counting date of October 30, 2003.
2) The average ^{238}U (n,f) reaction rate of 3.14E-14 includes a correction factor of 0.654 to account for plutonium build-in and an additional factor of 0.978 to account for photo-fission effects in the sensor.
3) The average ^{237}Np (n,f) reaction rate of 3.34E-13 includes a correction factor of 0.994 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 Y

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	7.74E-17	7.32E-17	7.53E-17	1.06	1.03
$^{54}Fe(n,p)^{54}Mn$	8.43E-15	8.86E-15	8.55E-15	0.95	0.99
$^{58}Ni(n,p)^{58}Co$	1.14E-14	1.26E-14	1.19E-14	0.90	0.96
$^{238}U(n,f)^{137}Cs$ (Cd)	5.53E-14	5.10E-14	4.83E-14	1.08	1.14
$^{237}Np(n,f)^{137}Cs$ (Cd)	4.46E-13	5.49E-13	4.81E-13	0.81	0.93
$^{59}Co(n,\gamma)^{60}Co$	7.40E-12	5.42E-12	7.18E-12	1.37	1.03
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	4.12E-12	4.18E-12	4.20E-12	0.99	0.98

Capsule U

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	7.87E-17	7.66E-17	7.68E-17	1.03	1.02
$^{54}Fe(n,p)^{54}Mn$	8.60E-15	9.31E-15	8.87E-15	0.92	0.97
$^{58}Ni(n,p)^{58}Co$	1.23E-14	1.33E-14	1.26E-14	0.92	0.98
$^{238}U(n,f)^{137}Cs$ (Cd)	5.58E-14	5.38E-14	5.18E-14	1.04	1.08
$^{237}Np(n,f)^{137}Cs$ (Cd)	5.83E-13	5.81E-13	5.79E-13	1.00	1.01
$^{59}Co(n,\gamma)^{60}Co$	8.78E-12	5.76E-12	8.50E-12	1.52	1.03
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	4.72E-12	4.45E-12	4.81E-12	1.06	0.98

Capsule X

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	7.32E-17	7.04E-17	7.02E-17	1.04	1.04
$^{54}Fe(n,p)^{54}Mn$	7.41E-15	8.44E-15	7.74E-15	0.88	0.96
$^{58}Ni(n,p)^{58}Co$	1.05E-14	1.20E-14	1.09E-14	0.88	0.96
$^{238}U(n,f)^{137}Cs$ (Cd)	5.04E-14	4.82E-14	4.47E-14	1.05	1.13
$^{237}Np(n,f)^{137}Cs$ (Cd)	5.00E-13	5.17E-13	4.96E-13	0.97	1.01
$^{59}Co(n,\gamma)^{60}Co$	7.31E-12	5.06E-12	7.08E-12	1.44	1.03
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	3.97E-12	3.90E-12	4.05E-12	1.02	0.98

Table A-5 cont'd

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

Capsule W

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	5.81E-17	5.95E-17	5.58E-17	0.98	1.04
$^{54}Fe(n,p)^{54}Mn$	5.51E-15	6.82E-15	5.73E-15	0.81	0.96
$^{58}Ni(n,p)^{58}Co$	7.99E-15	9.62E-15	8.08E-15	0.83	0.99
$^{238}U(n,f)^{137}Cs$ (Cd)	3.01E-14	3.75E-14	3.07E-14	0.80	0.98
$^{237}Np(n,f)^{137}Cs$ (Cd)	3.09E-13	3.84E-13	3.14E-13	0.80	0.98
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	4.28E-12	2.71E-12	4.21E-12	1.58	1.02

Capsule V

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	6.04E-17	5.61E-17	5.73E-17	1.08	1.05
$^{54}Fe(n,p)^{54}Mn$	5.55E-15	6.37E-15	5.78E-15	0.87	0.96
$^{58}Ni(n,p)^{58}Co$	7.83E-15	8.97E-15	8.08E-15	0.87	0.97
$^{238}U(n,f)^{137}Cs$ (Cd)	3.14E-14	3.49E-14	3.10E-14	0.90	1.01
$^{237}Np(n,f)^{137}Cs$ (Cd)	3.34E-13	3.55E-13	3.27E-13	0.94	1.02
$^{59}Co(n,\gamma)^{60}Co$	4.55E-12	3.21E-12	4.40E-12	1.42	1.03
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	2.53E-12	2.49E-12	2.59E-12	1.02	0.98

Table A-6

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

	ϕ(E > 1.0 MeV) [n/cm^2-s]			
Capsule ID	**Calculated**	**Best Estimate**	**Uncertainty (1σ)**	**BE/C**
Y	1.68E+11	1.58E+11	6%	0.942
U	1.78E+11	1.73E+11	6%	0.977
X	1.59E+11	1.49E+11	6%	0.937
W	1.21E+11	9.87E+10	6%	0.815
V	1.12E+11	9.97E+10	6%	0.889

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

	Iron Atom Displacement Rate [dpa/s]			
Capsule ID	**Calculated**	**Best Estimate**	**Uncertainty (1σ)**	**BE/C**
Y	3.46E-10	3.24E-10	8%	0.938
U	3.66E-10	3.64E-10	8%	0.994
X	3.25E-10	3.13E-10	8%	0.961
W	2.42E-10	2.03E-10	8%	0.838
V	2.24E-10	2.05E-10	8%	0.915

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 Y	Capsule U	Capsule X	Capsule W	Capsule V
$^{63}Cu(n,\alpha)^{60}Co$	1.06	1.03	1.04	0.98	1.08
$^{54}Fe(n,p)^{54}Mn$	0.95	0.92	0.88	0.81	0.87
$^{58}Ni(n,p)^{58}Co$	0.90	0.92	0.88	0.83	0.87
$^{238}U(n,p)^{137}Cs$ (Cd)	1.08	1.04	1.05	0.80	0.90
$^{237}Np(n,f)^{137}Cs$ (Cd)	0.81	1.00	0.97		0.94
Average	0.96	0.98	0.96	0.84	0.93
% Standard Deviation	11.6	5.6	8.7	8.8	9.2

Note: The overall average M/C ratio for the set of 25 sensor measurements is 0.94 with an associated standard deviation of 9.8%.

Table A-8

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

Capsule ID	BE/C Ratio	
	$\phi(E > 1.0\ MeV)$	dpa/s
Y	0.94	0.94
U	0.97	1.00
X	0.93	0.97
W	0.81	0.84
V	0.88	0.92
Average	0.91	6.8
% Standard Deviation	0.94	6.3

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 2001.

A-2. WCAP-9717, Revision 0, "Analysis of Capsule Y from the Alabama Power Company Farley Unit 1 Reactor Vessel Radiation Surveillance Program," June 1980.

A-3. WCAP-10474, Revision 0, "Analysis of Capsule U from the Alabama Power Company Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program," February 1984.

A-4 WCAP-11563, Revision 1, "Analysis of Capsule X from the Alabama Power Company Joseph M. Farley Unit 1 Reactor Vessel Radiation Surveillance Program," September 1987.

A-5 WCAP-14196, Revision 0, "Analysis of Capsule W from the Alabama Power Company Farley Unit 1 Reactor Vessel Radiation Surveillance Program," February 1995.

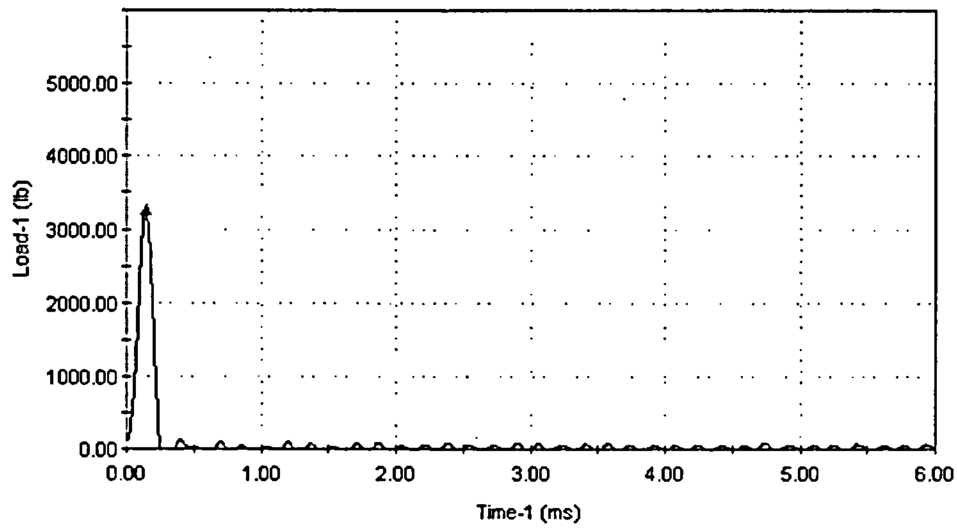
A-4. A. Schmittroth, *FERRET Data Analysis Core*, HEDL-TME 79-40, Hanford Engineering Development Laboratory, Richland, WA, September 1979.

A-5. RSIC Data Library Collection DLC-178, "SNLRML Recommended Dosimetry Cross-Section Compendium", July 1994.

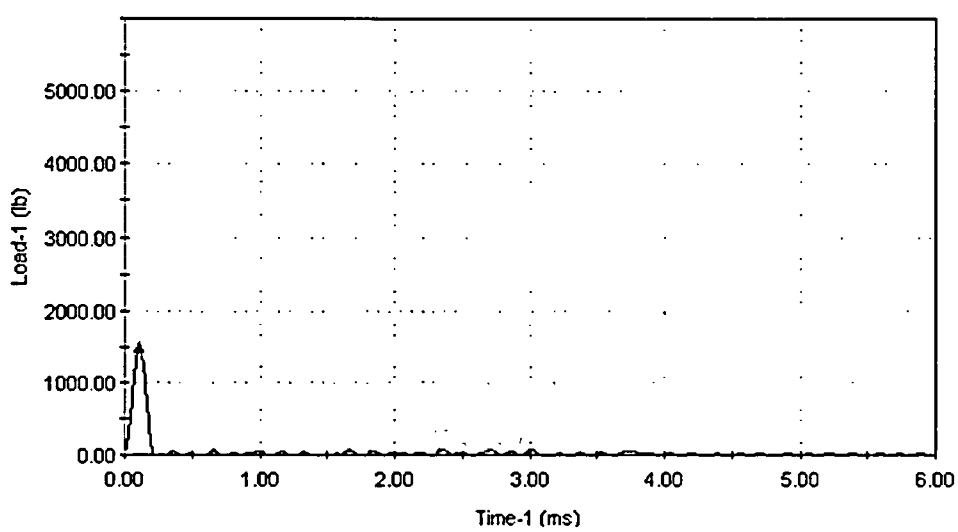
APPENDIX B

LOAD-TIME RECORDS FOR CHARPY SPECIMEN TESTS

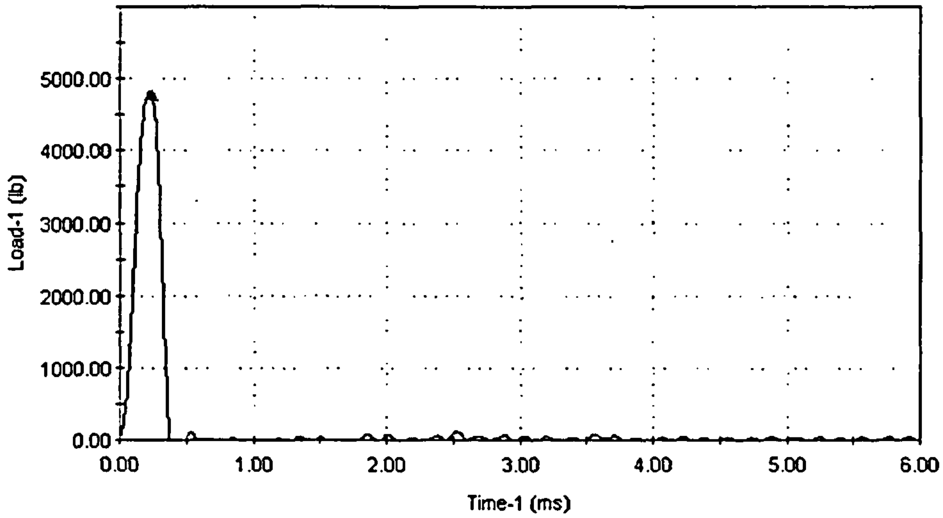
- Specimen prefix "AL" denotes Intermediate Shell Plate, Longitudinal Orientation
- Specimen prefix "AT" denotes Intermediate Shell Plate, Transverse Orientation
- Specimen prefix "AW" denotes Weld Material
- Specimen prefix "AH" denotes Heat-Affected Zone material
- Load (1) is in units of lbs
- Time (1) is in units of milli-seconds



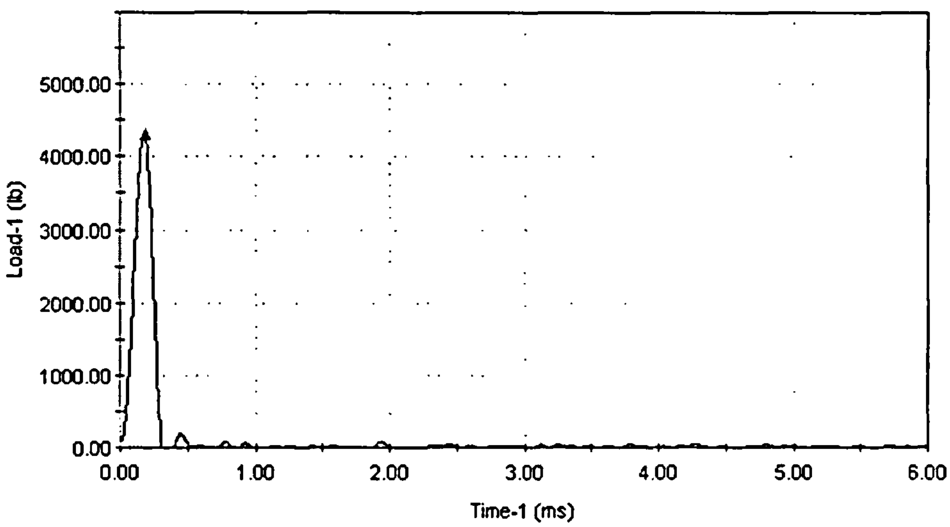
AL24, 25°F



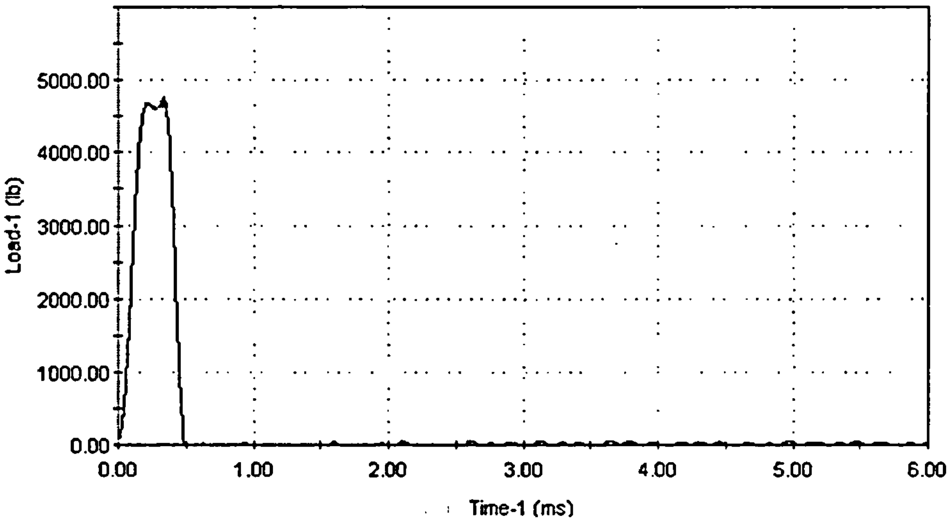
AL19, 50°F



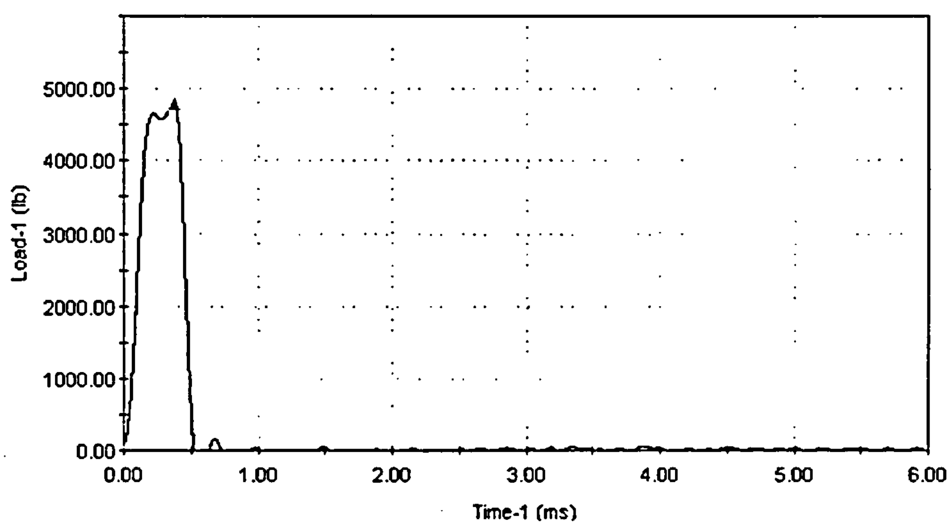
AL20, 75°F



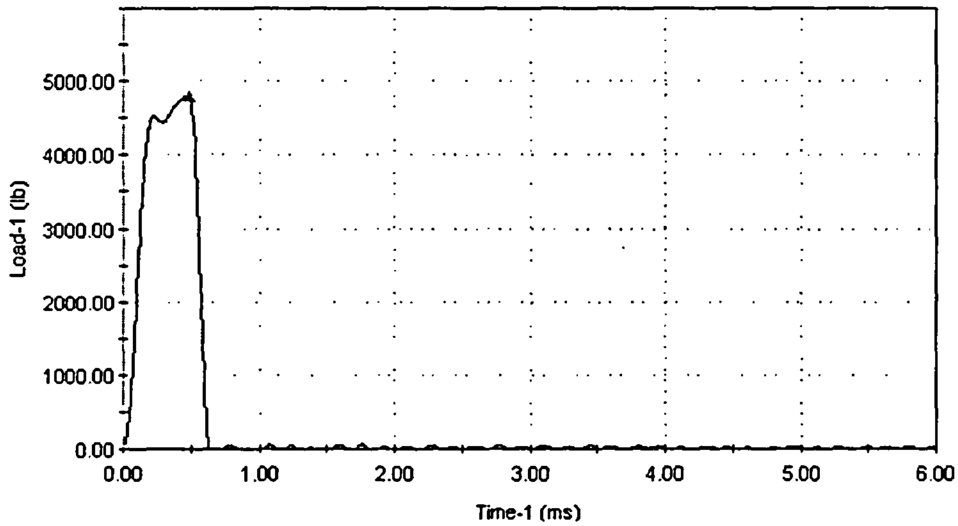
AL22, 100°F



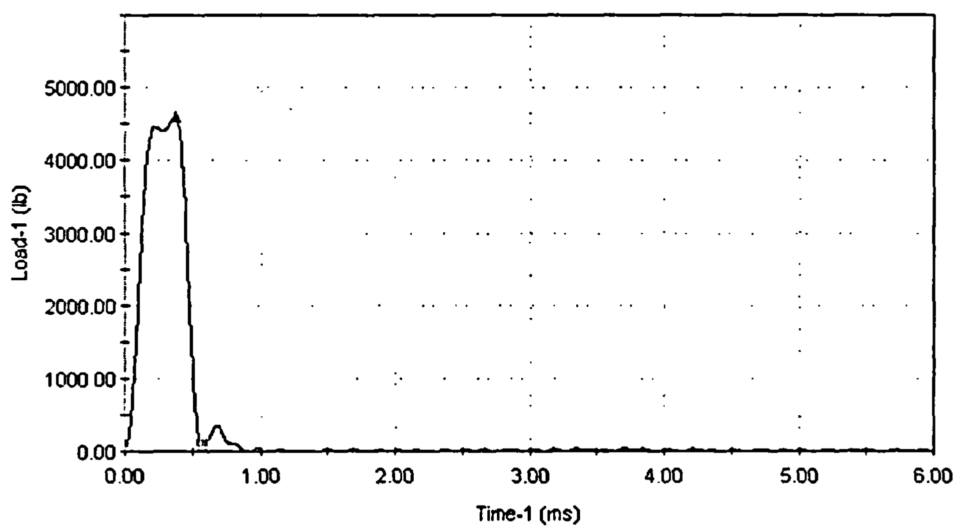
AL16, 125°F



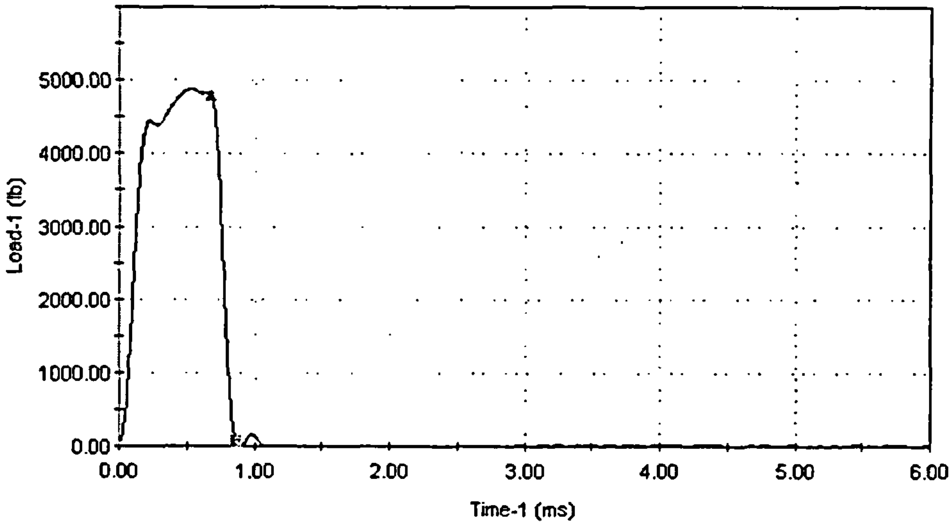
AL18, 140°F



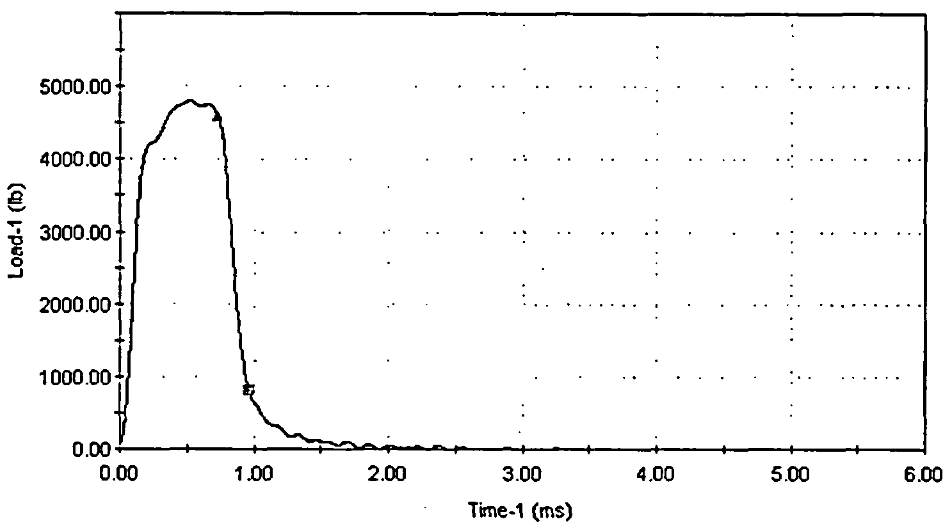
AL23, 150°F



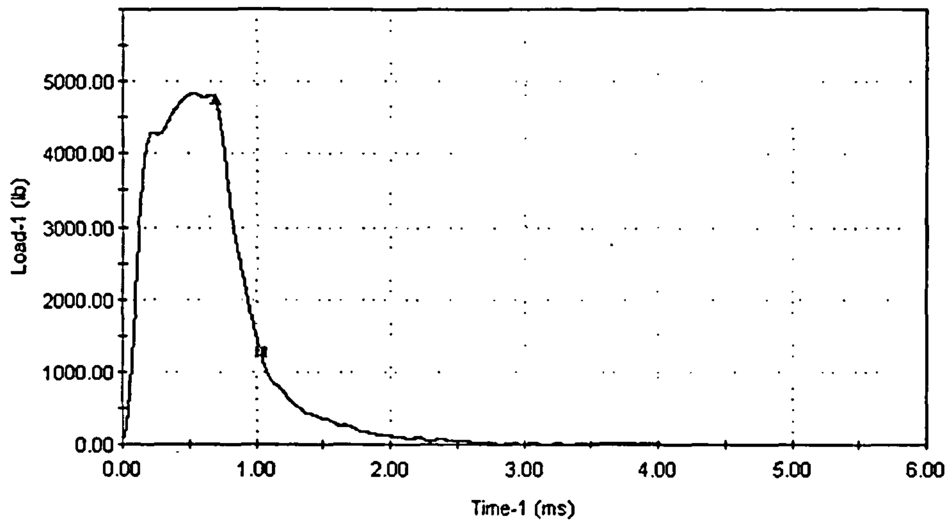
AL25, 175°F



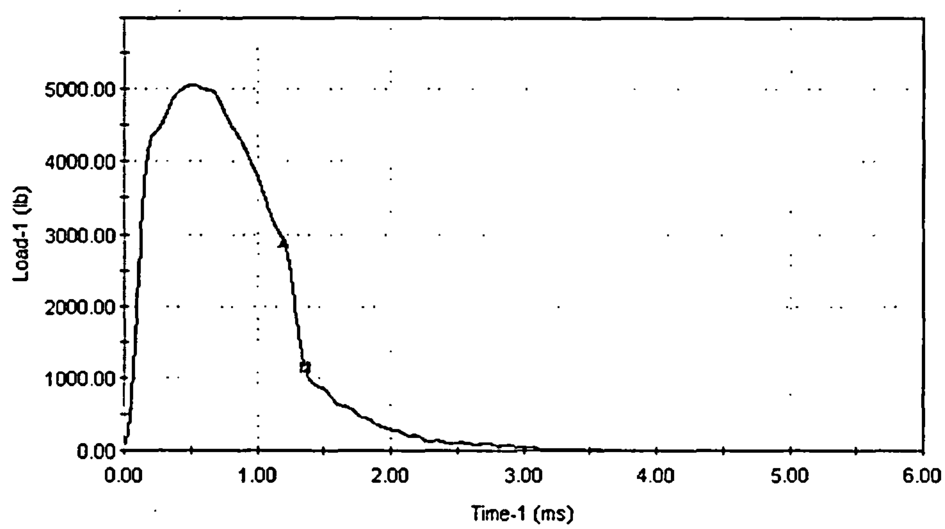
AL30, 190°F



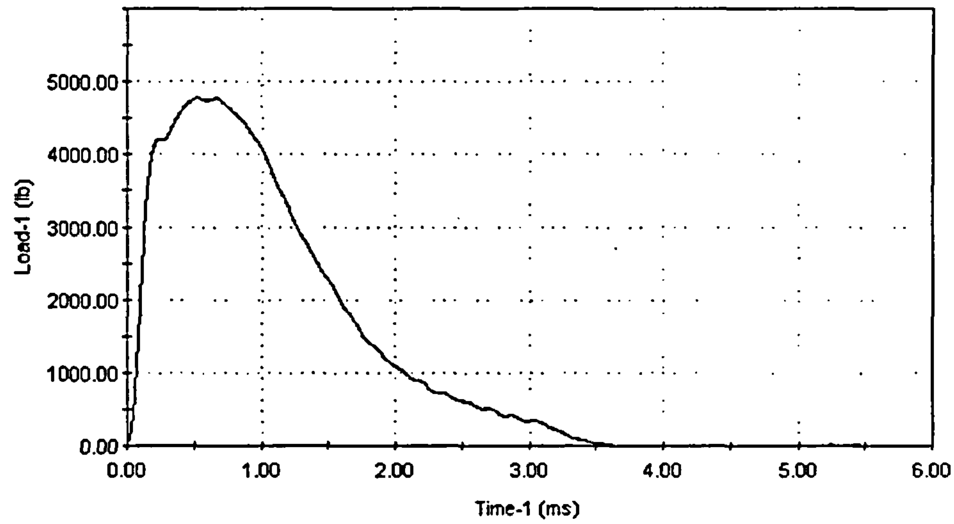
AL21, 200°F



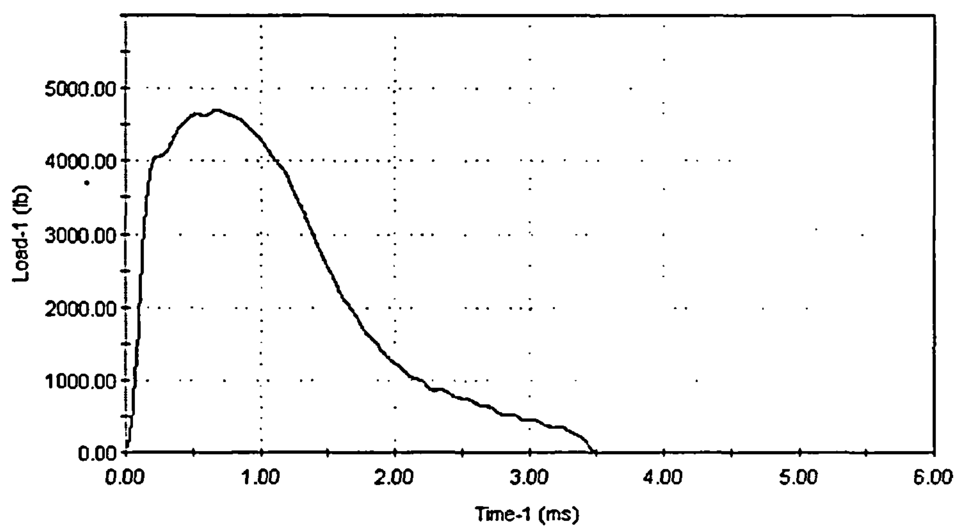
AL27, 250°F



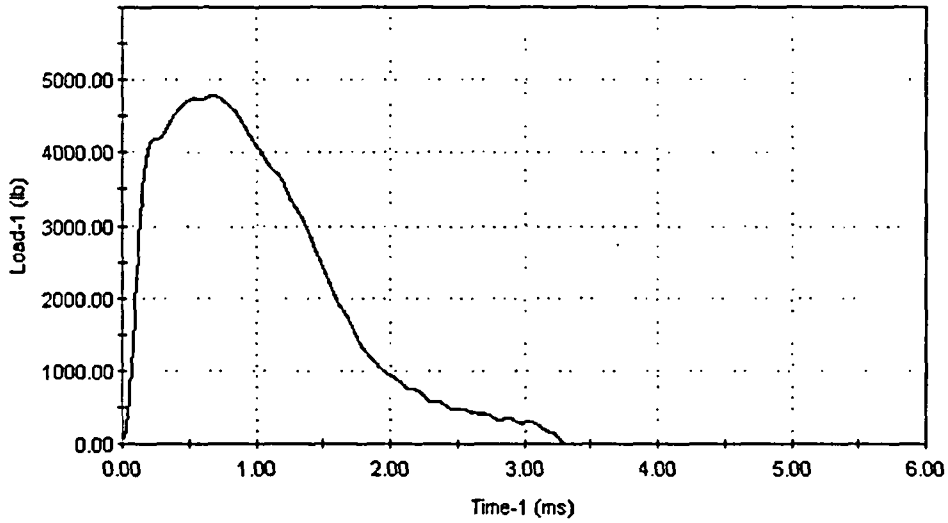
AL17, 275°F



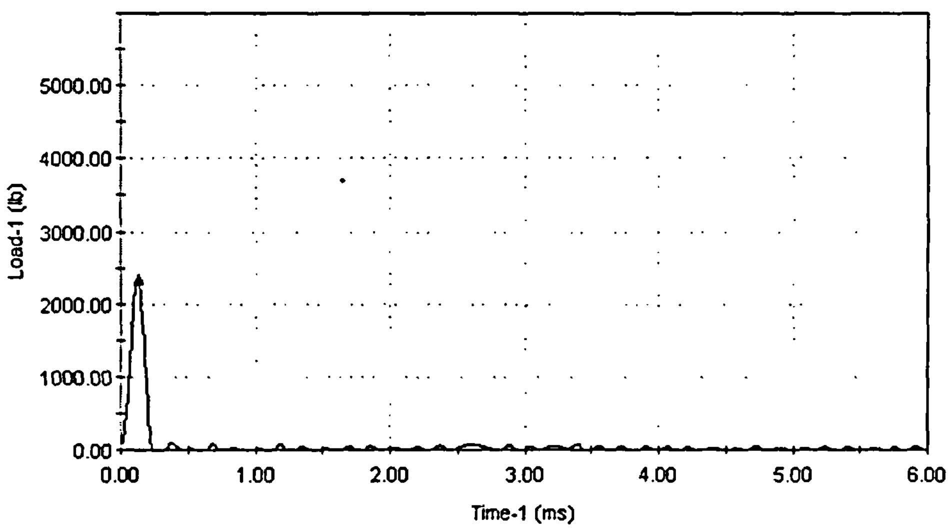
AL26, 300°F



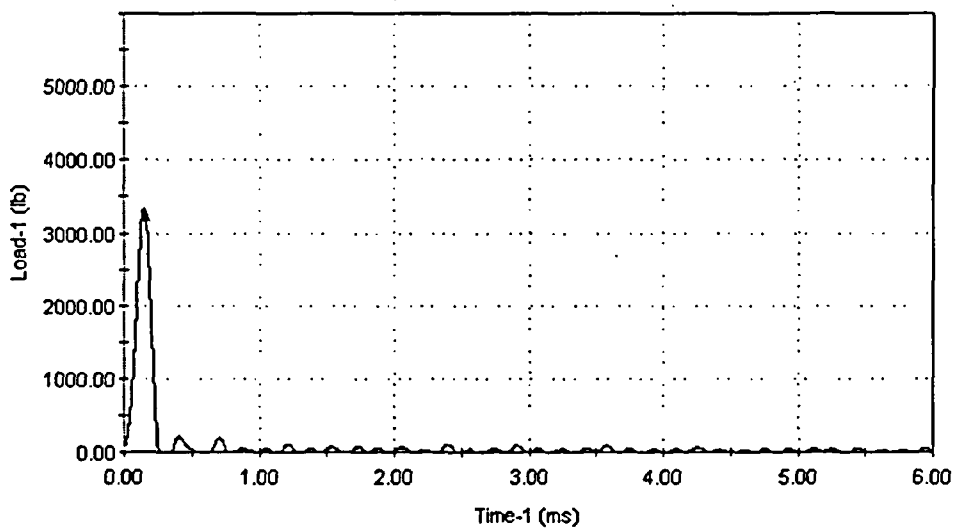
AL28, 325°F



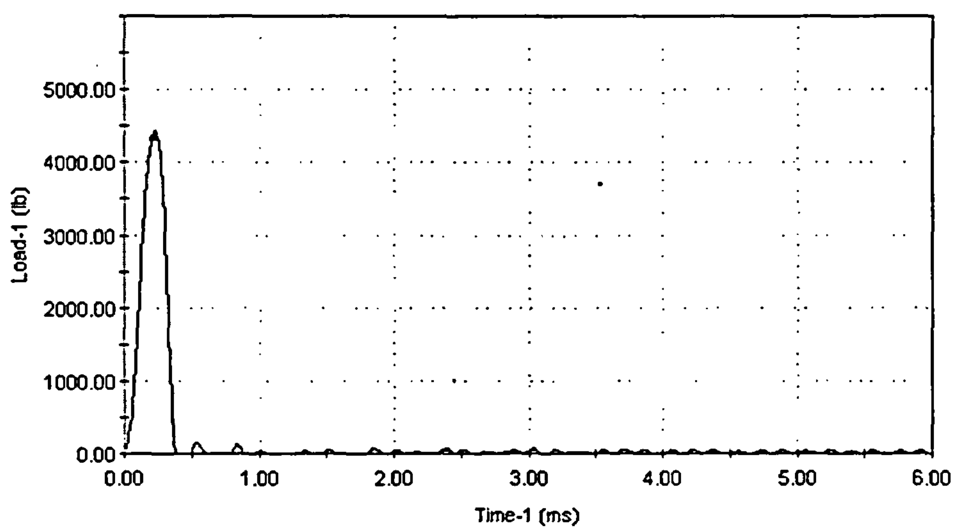
AL29, 325°F



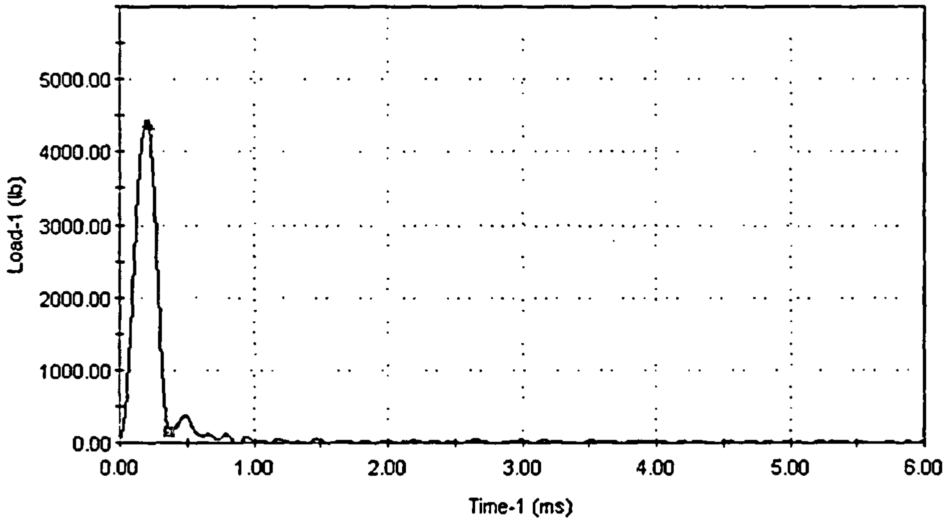
AT20, 25°F



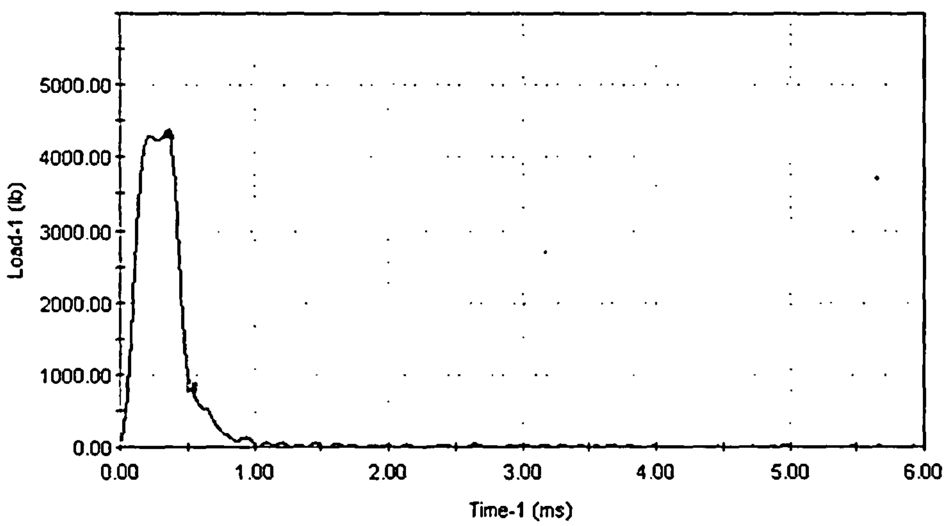
AT28, 75°F



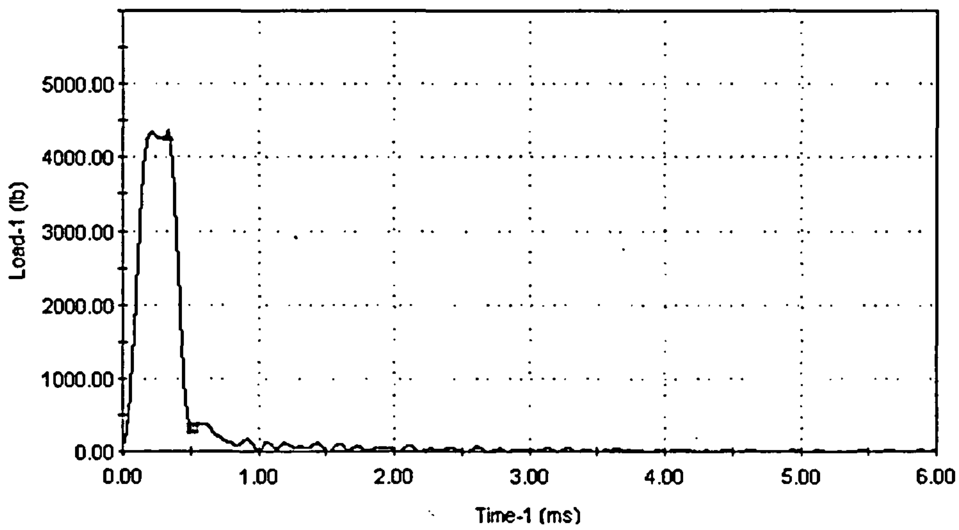
AT30, 100°F



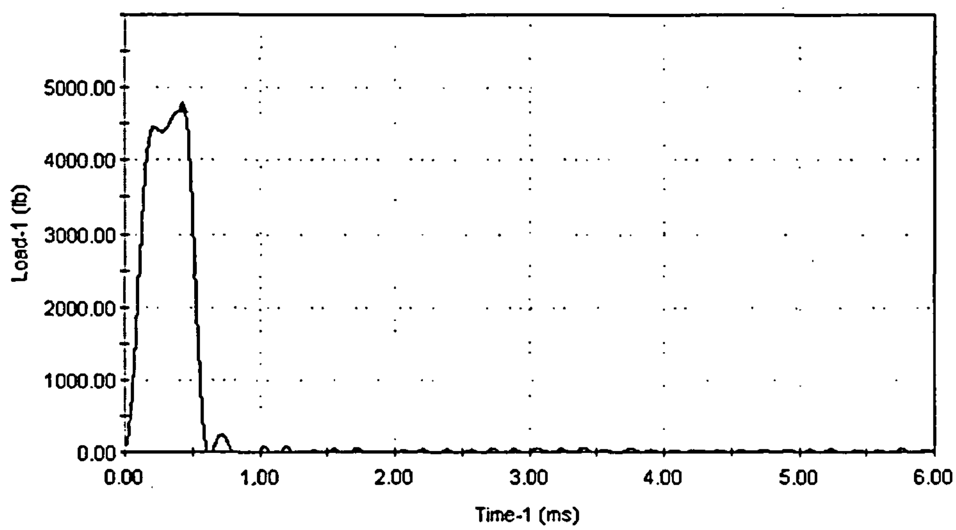
AT27, 125°F



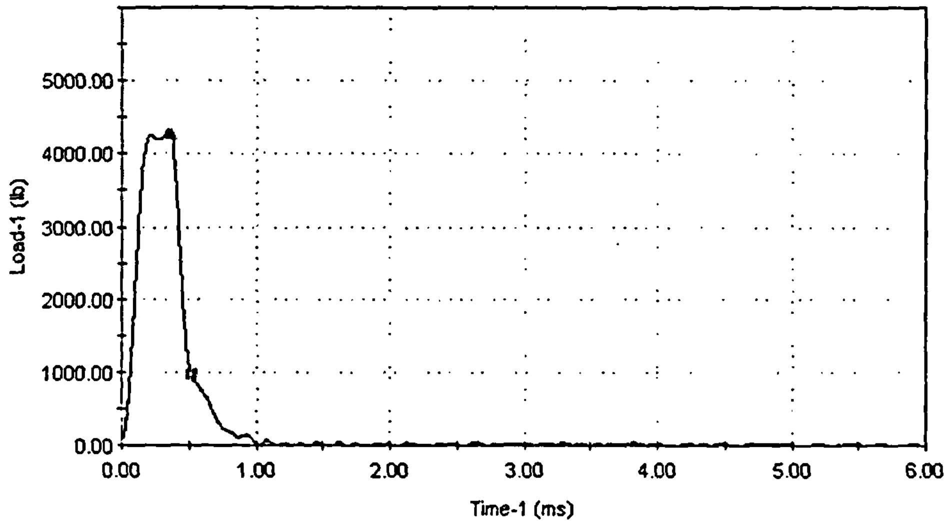
AT25, 150°F



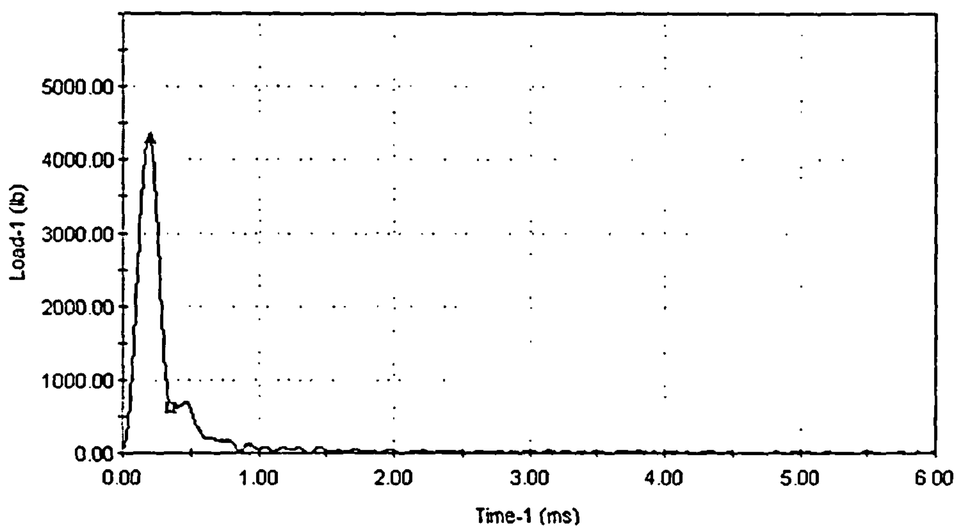
AT21, 150°F



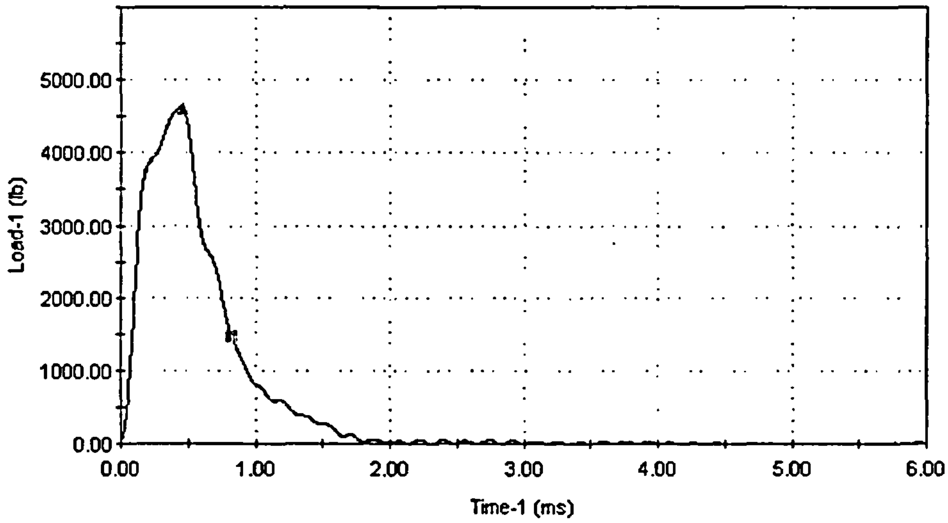
AT18, 160°F



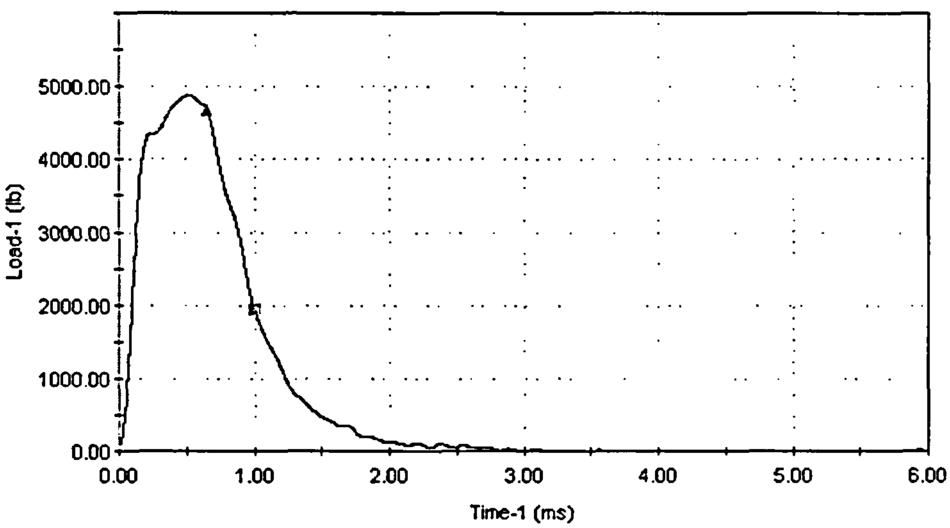
AT24, 175°F



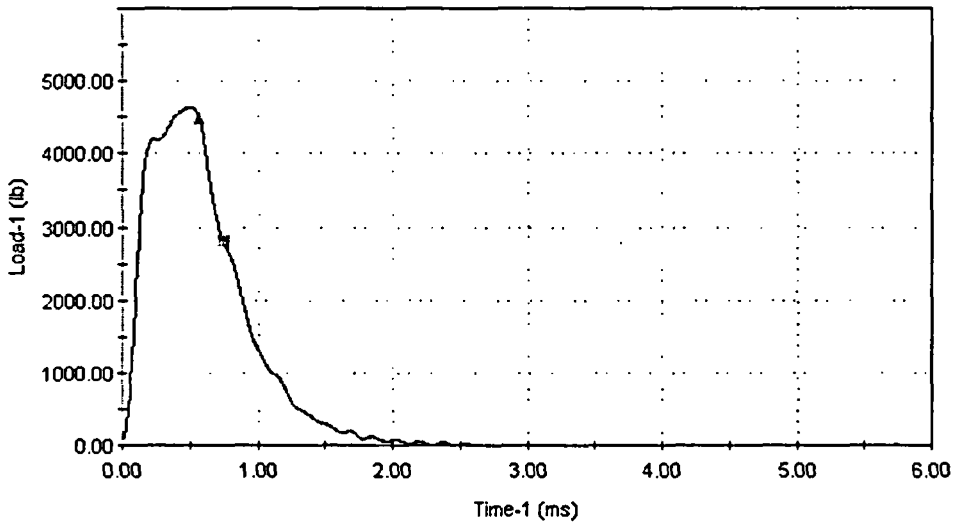
AT29, 175°F



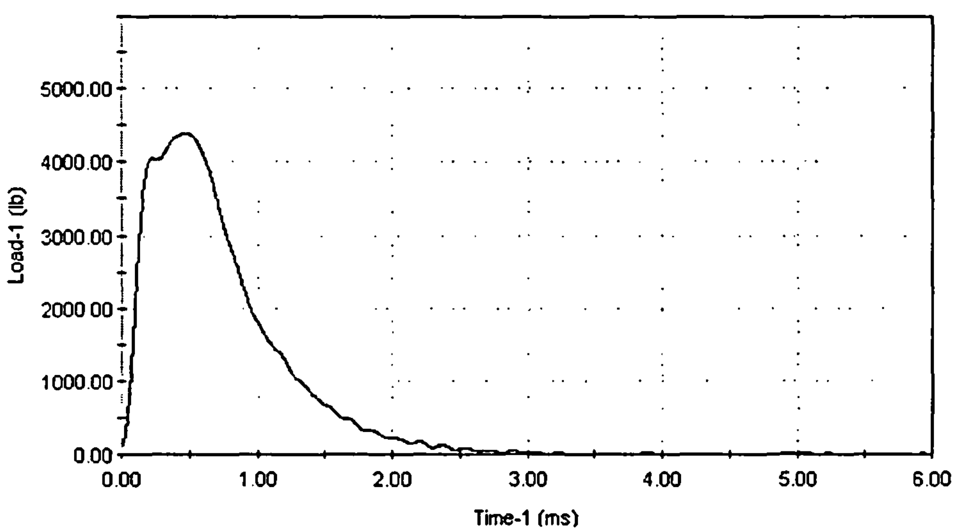
AT19, 200°F



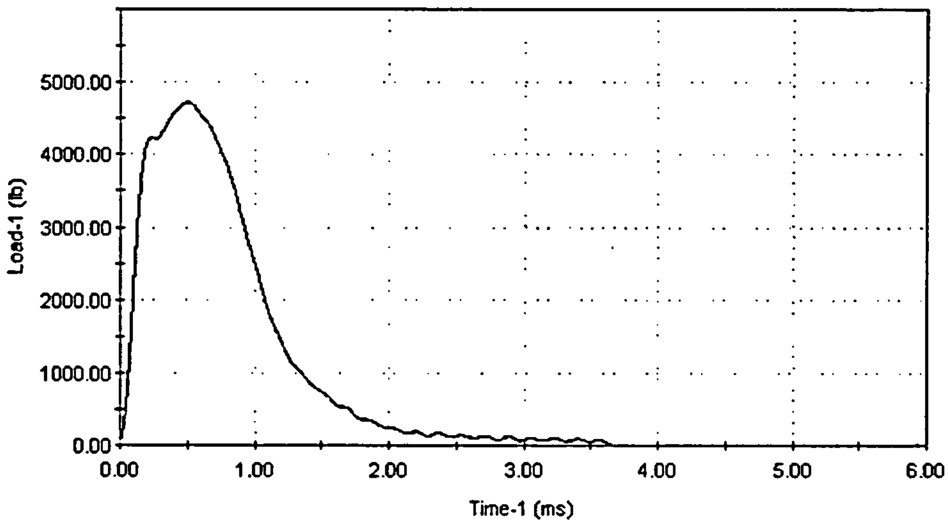
AT16, 225°F



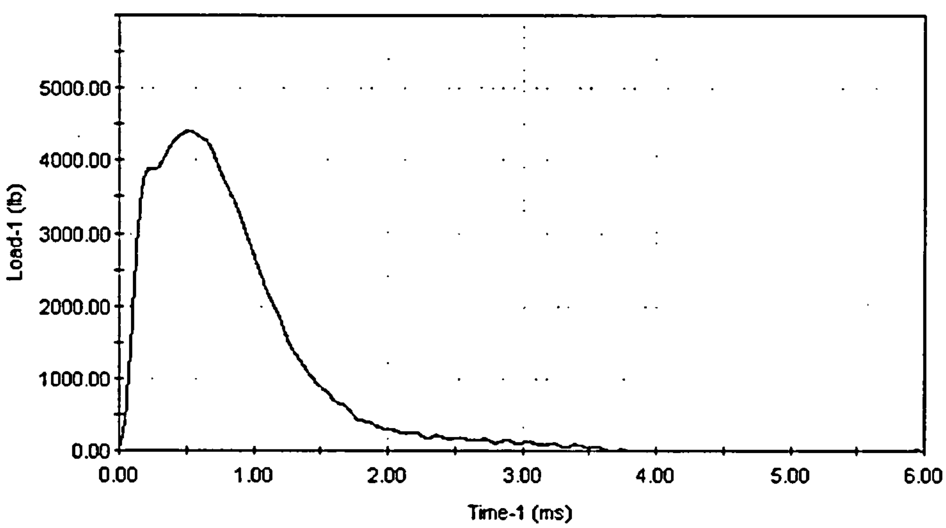
AT17, 250°F



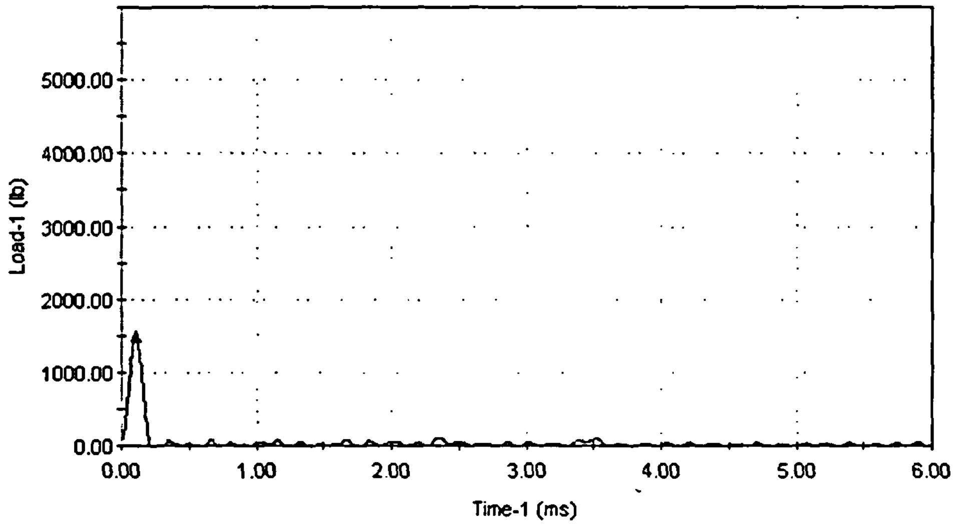
AT22, 275°F



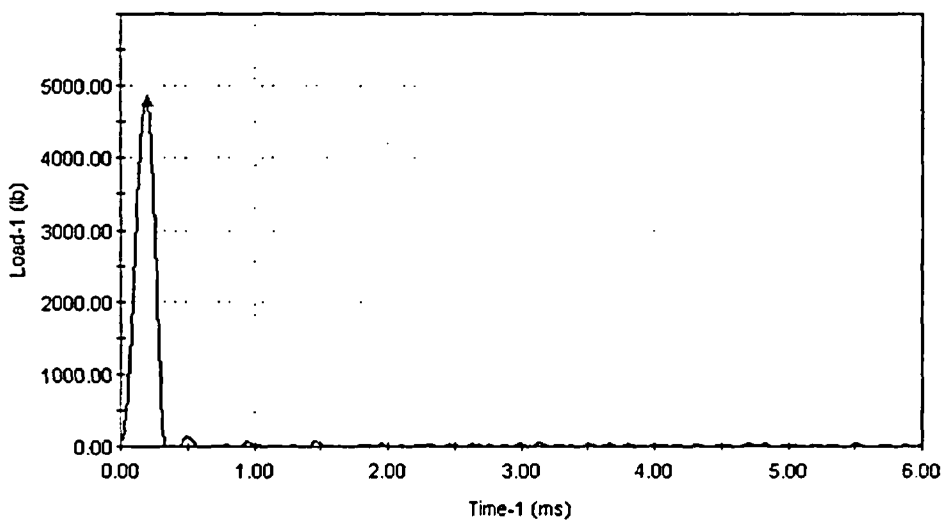
AT23, 275°F



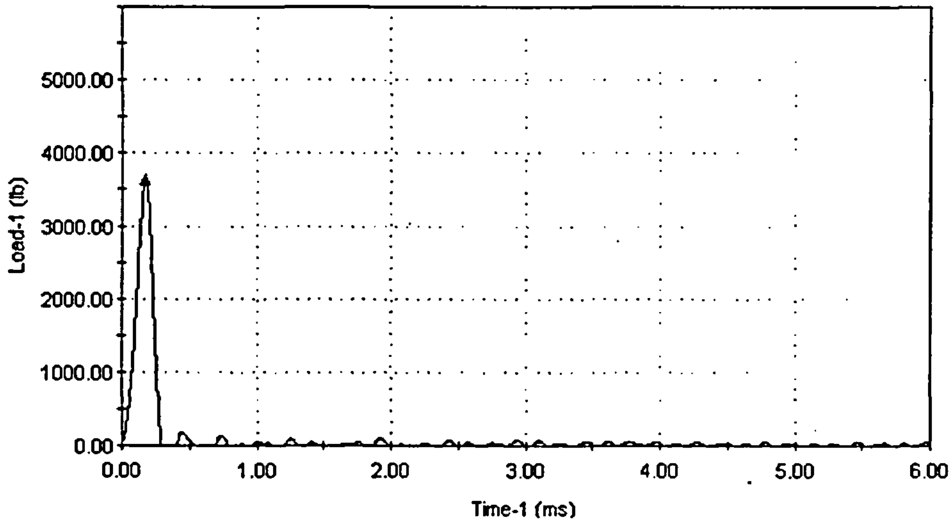
AT26, 300°F



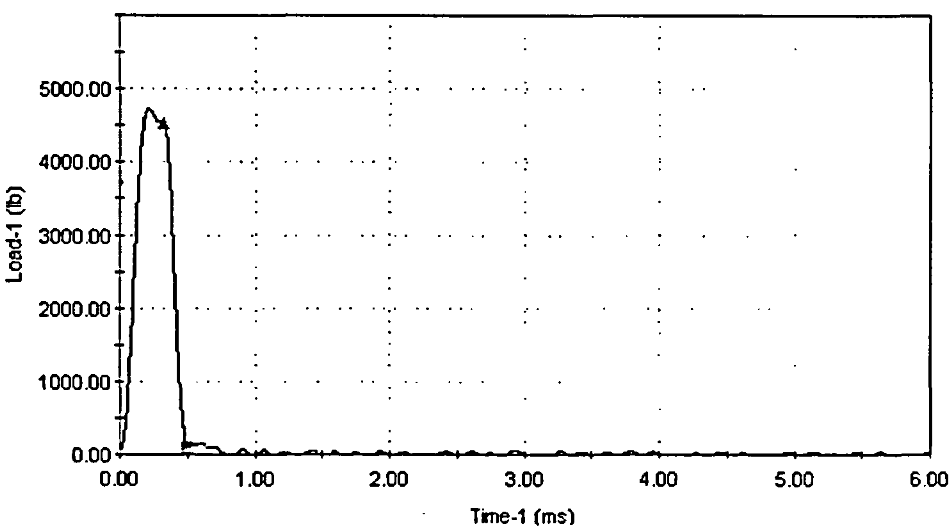
AW27, -50°F



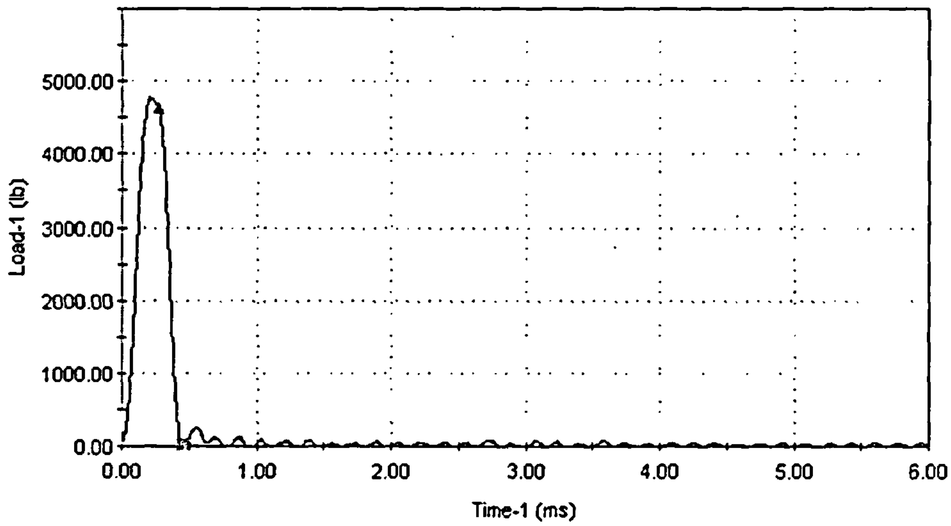
AW20, -25°F



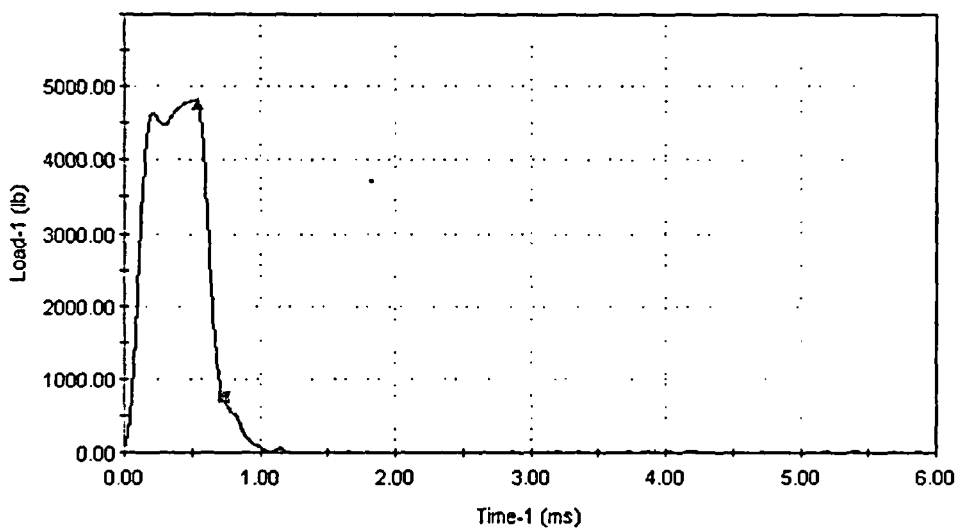
AW17, 0°F



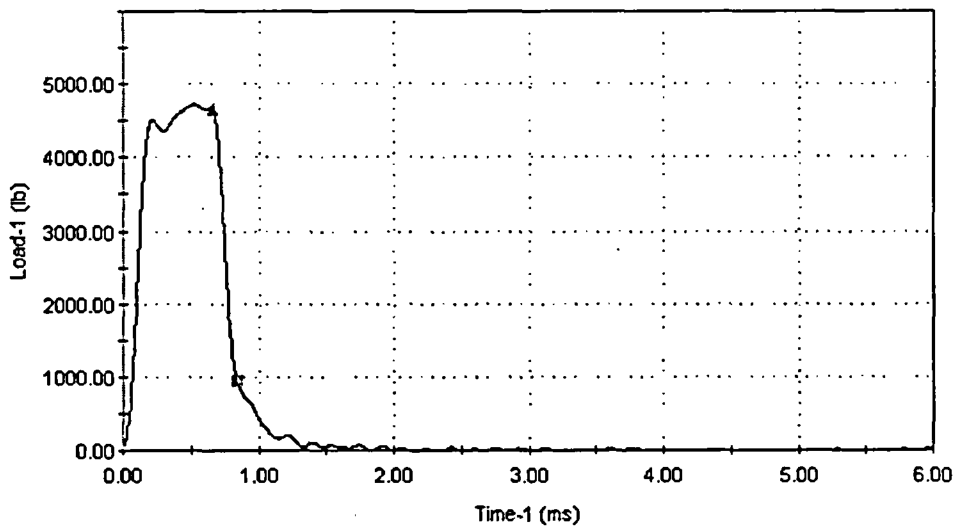
AW21, 25°F



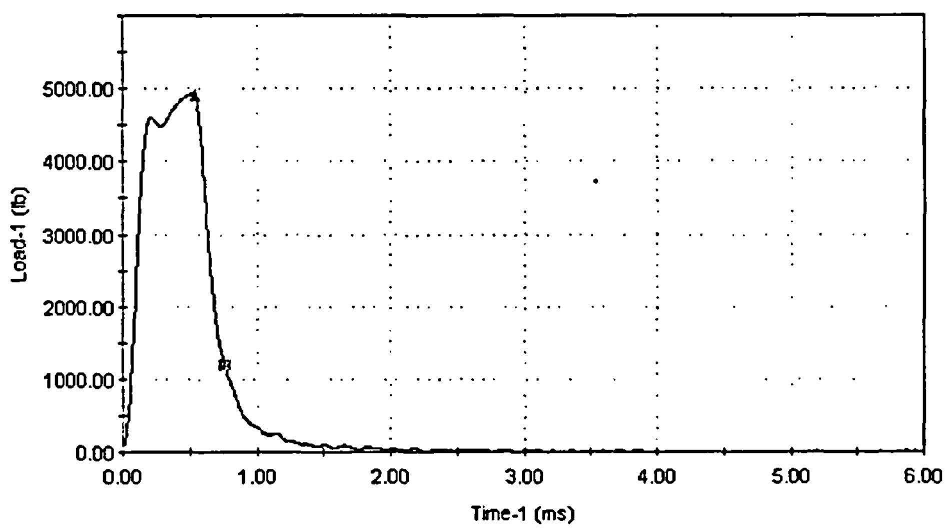
AW30, 40°F



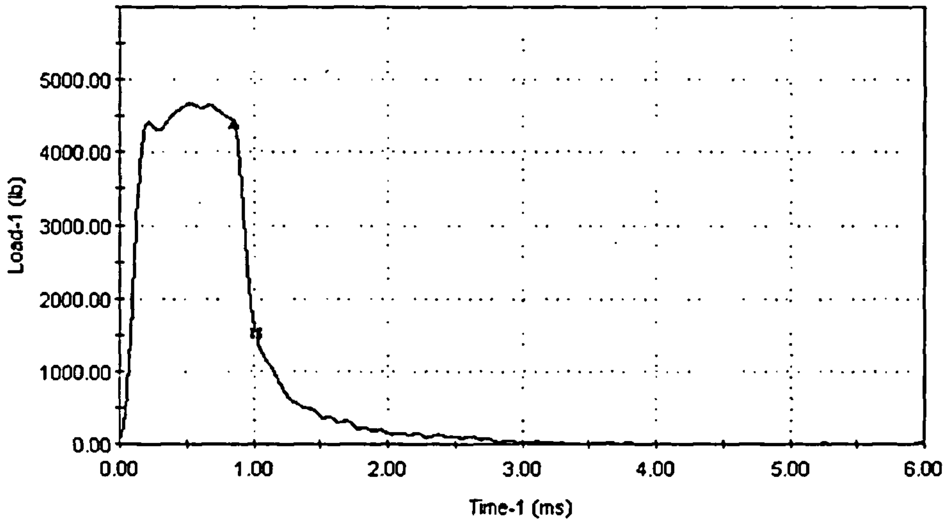
AW18, 50°F



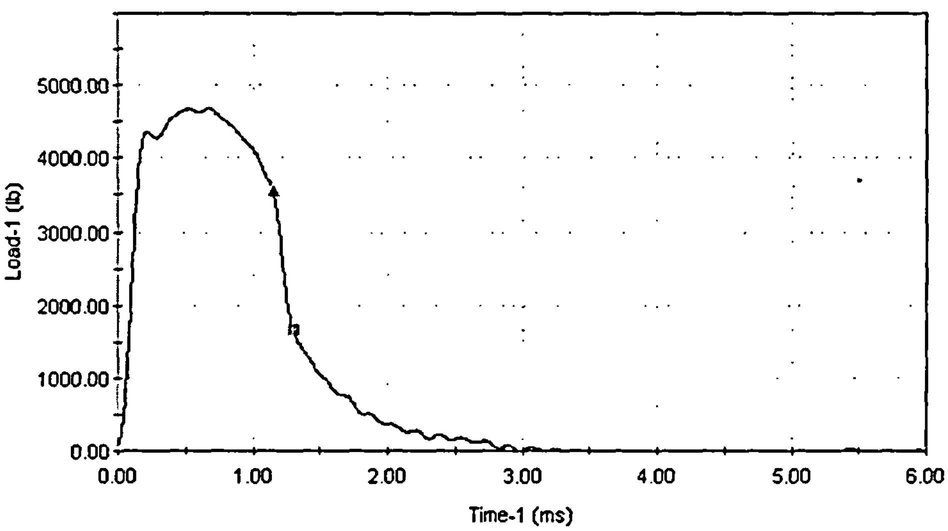
AW25, 60°F



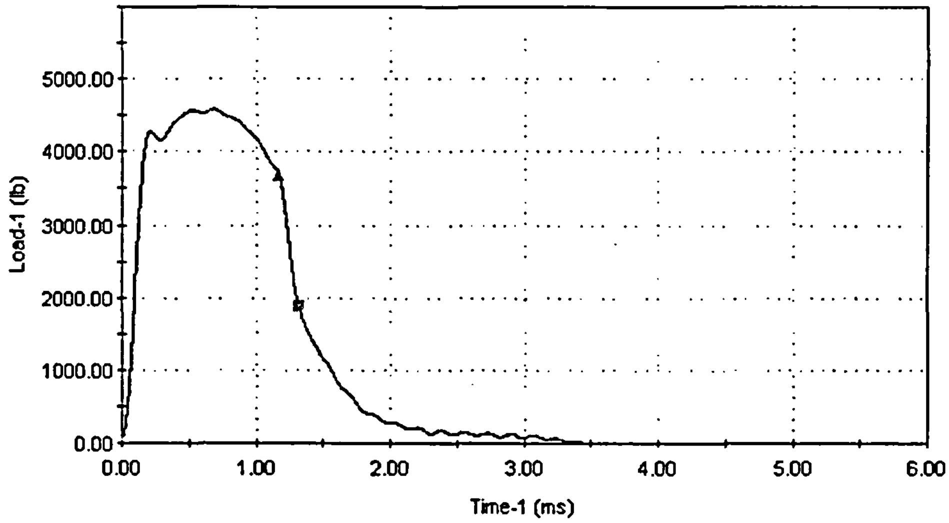
AW29, 75°F



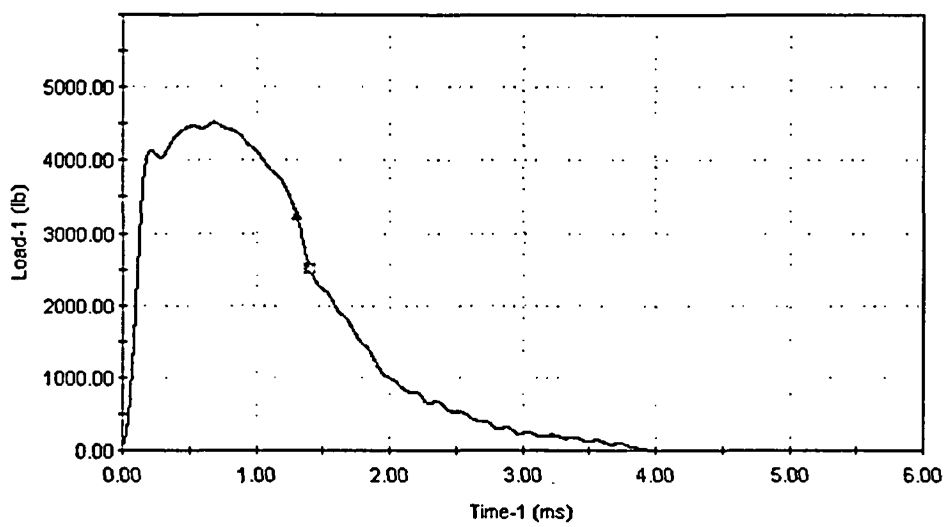
AW28, 100°F



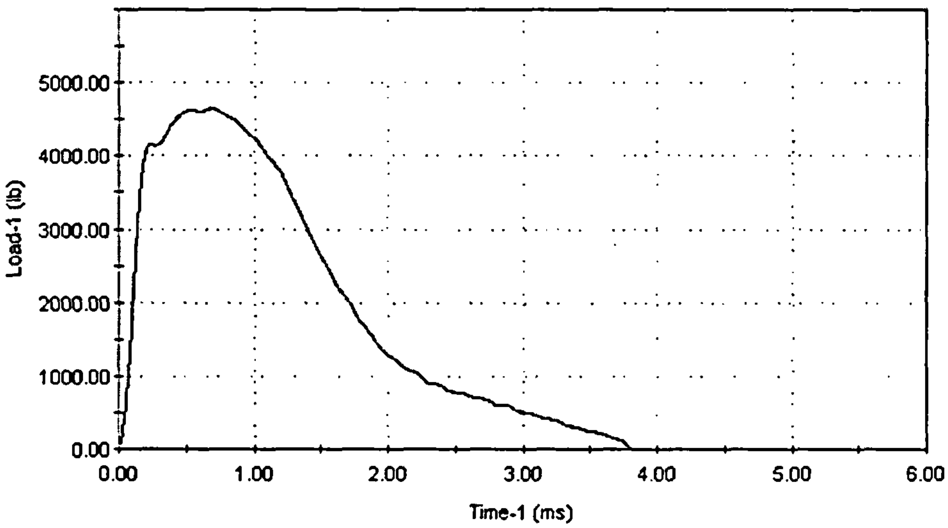
AW16, 125°F



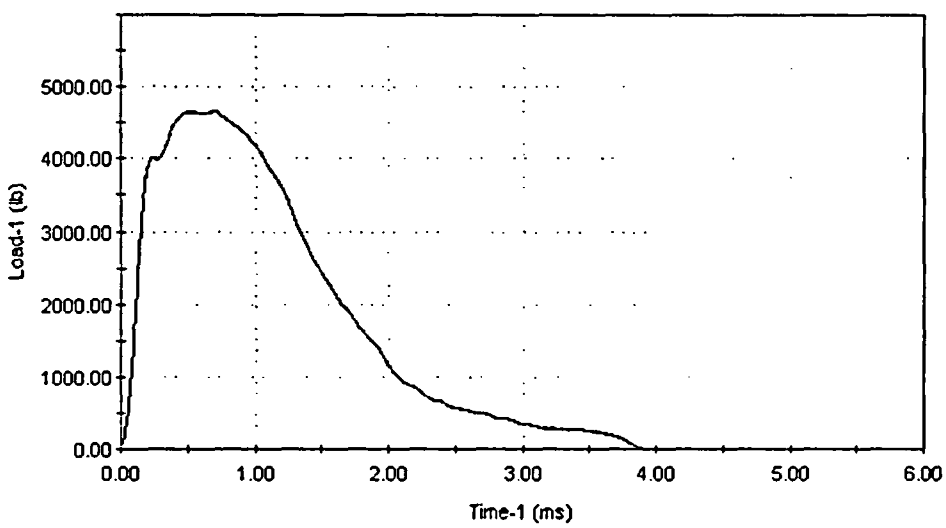
AW26, 150°F



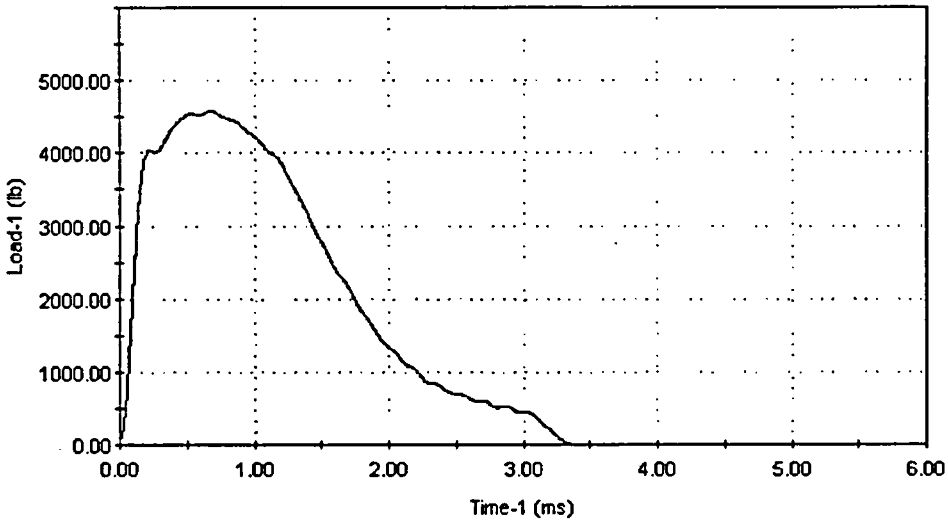
AW24, 175°F



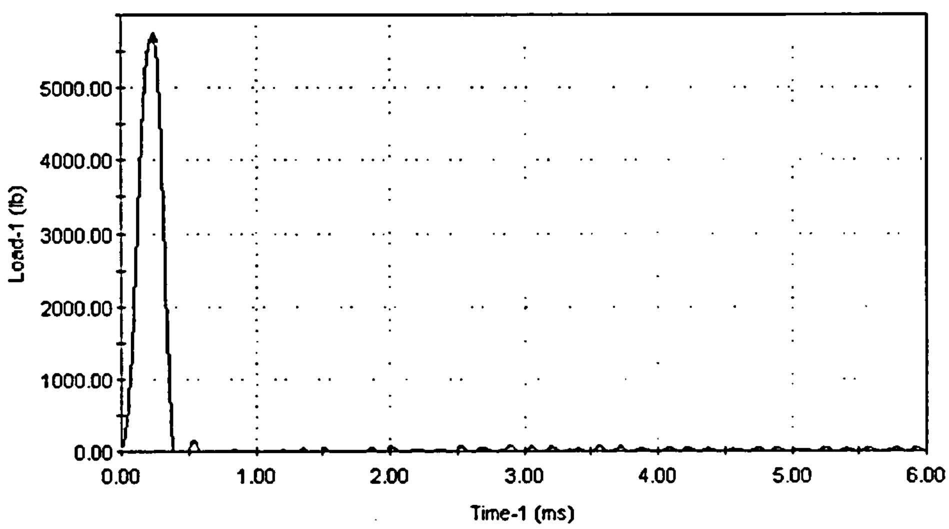
AW19, 200°F



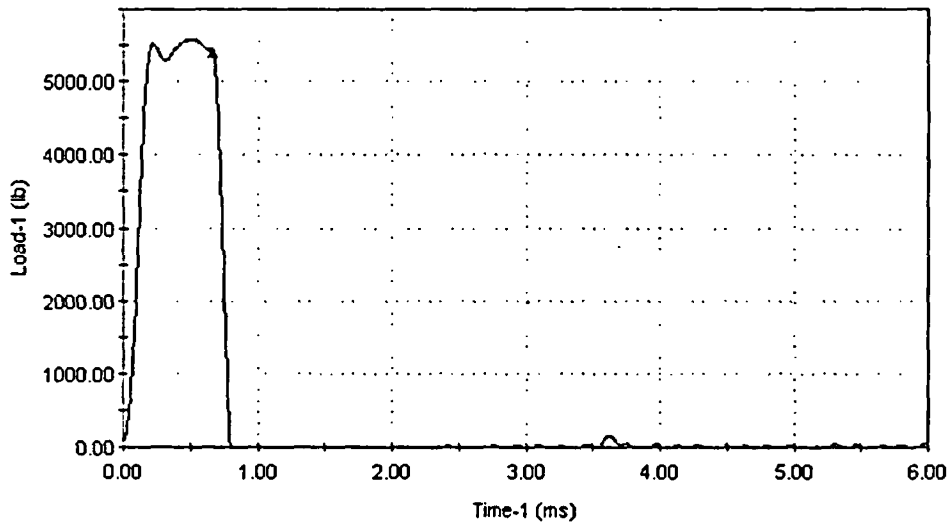
AW22, 225°F



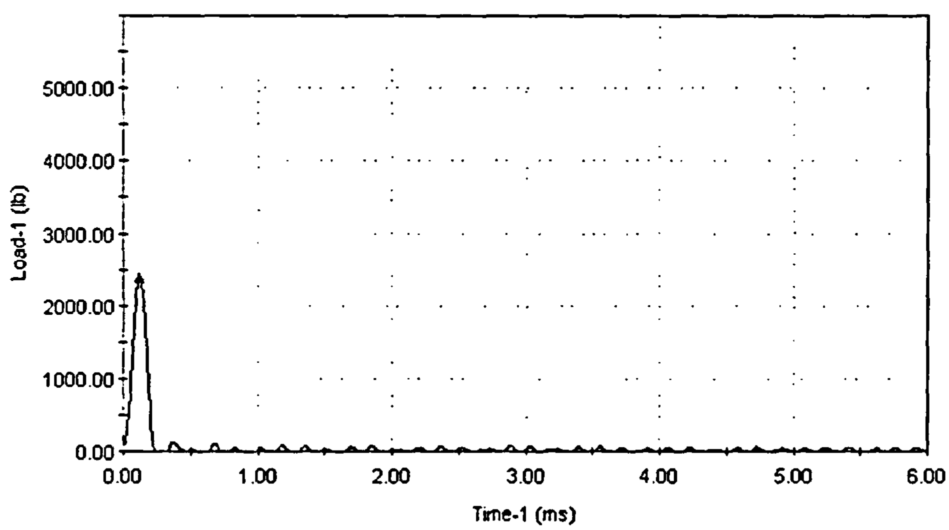
AW23, 250°F



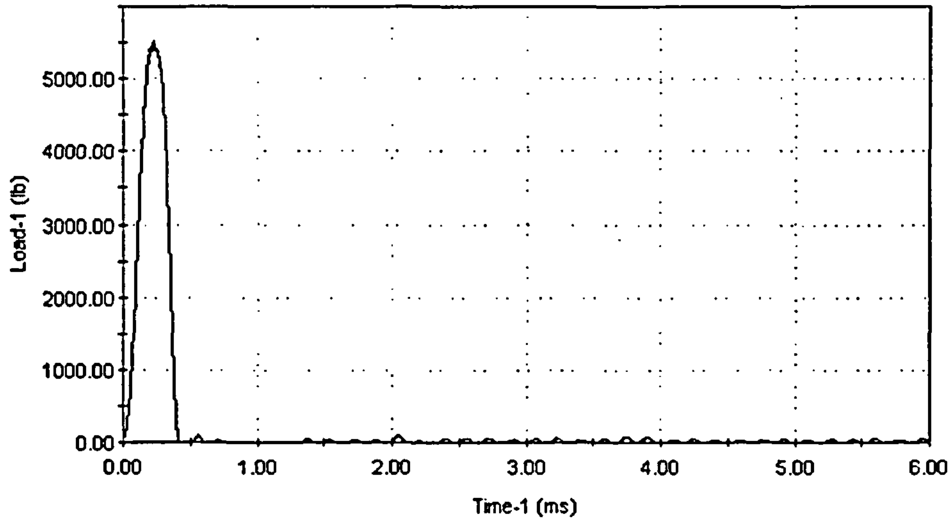
AH26, -75°F



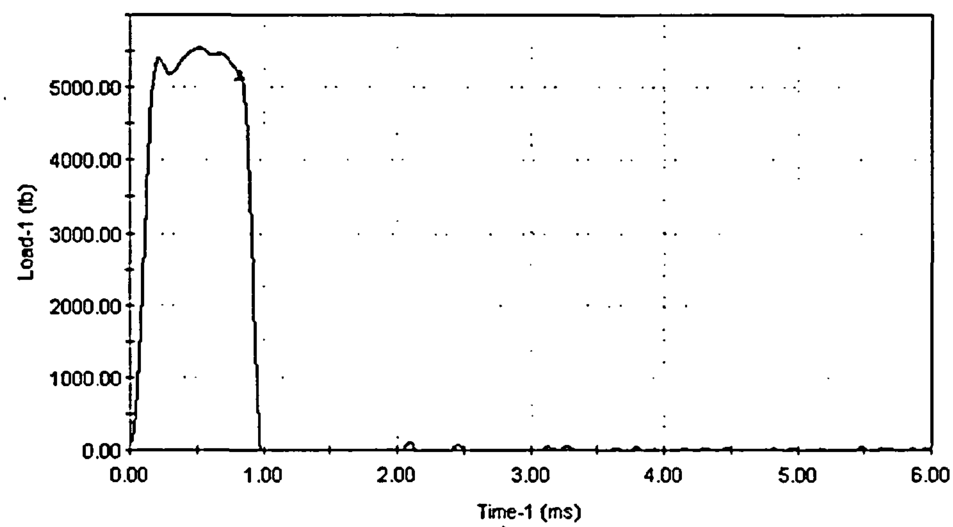
AH23, -50°F



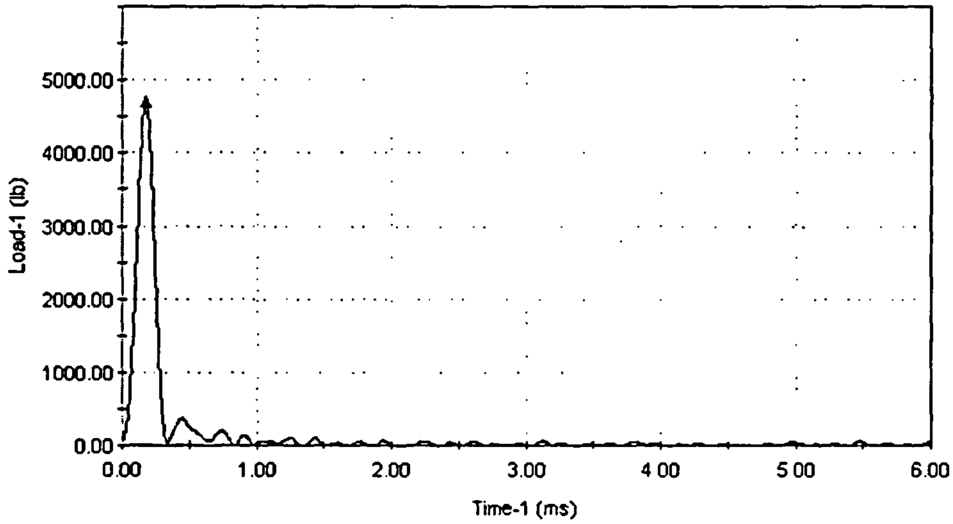
AH19, -50°F



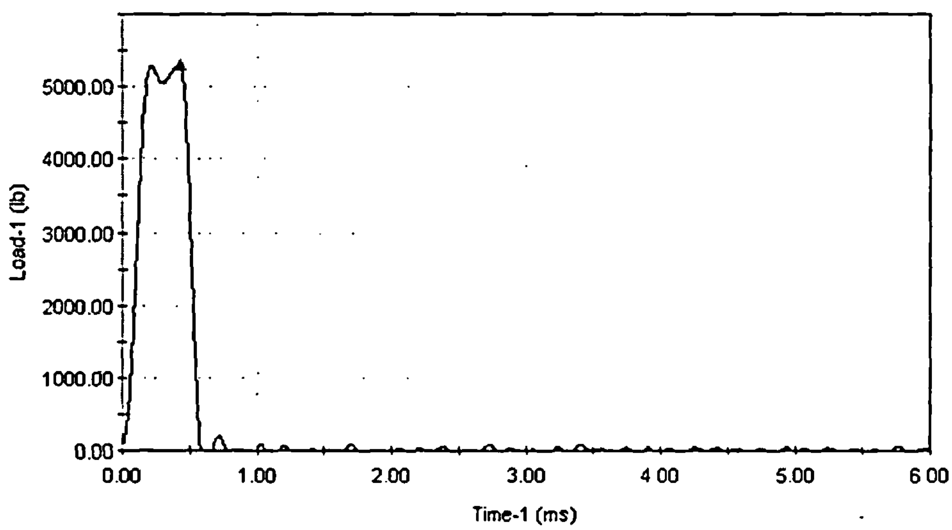
AH29, -25°F



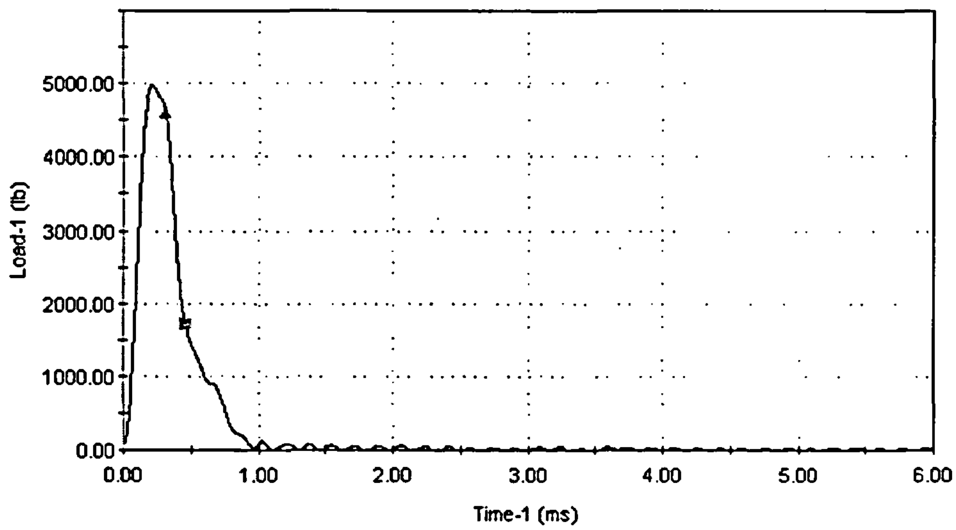
AH27, 0°F



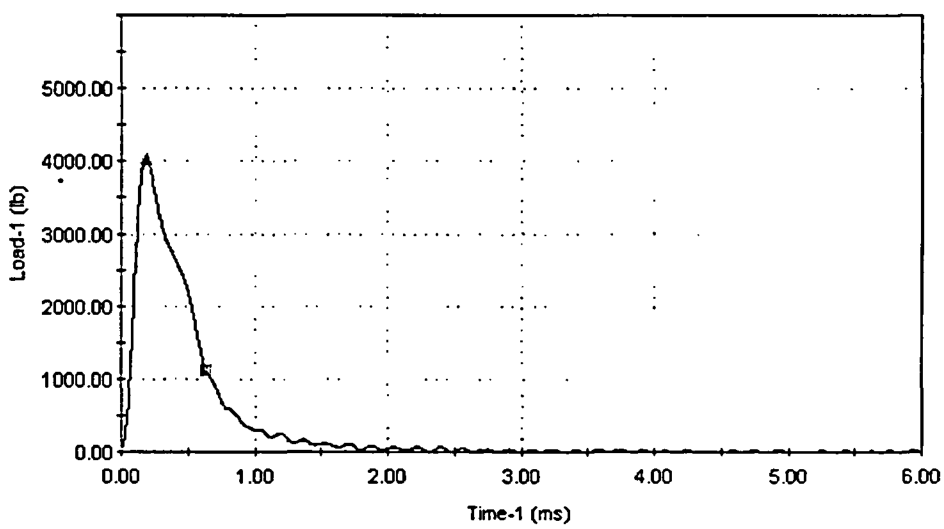
AH21, 0°F



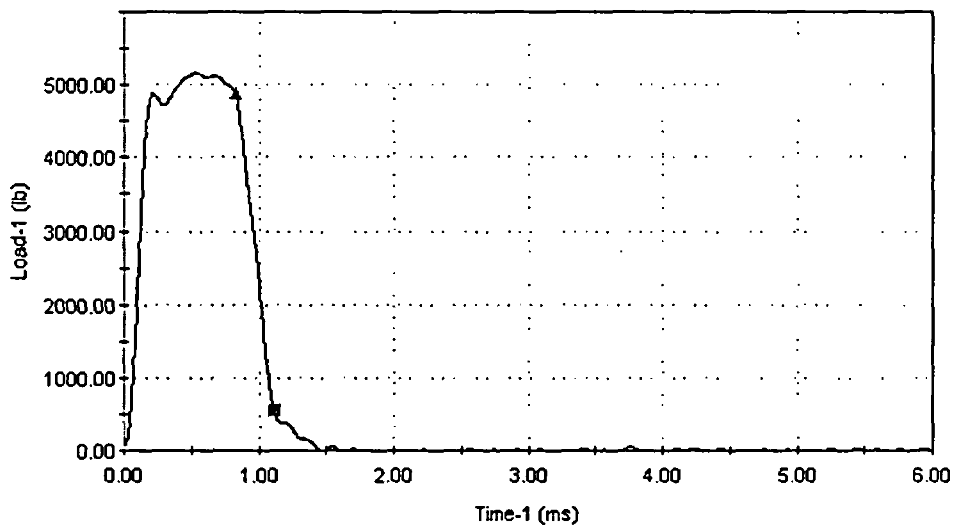
AH30, 25°F



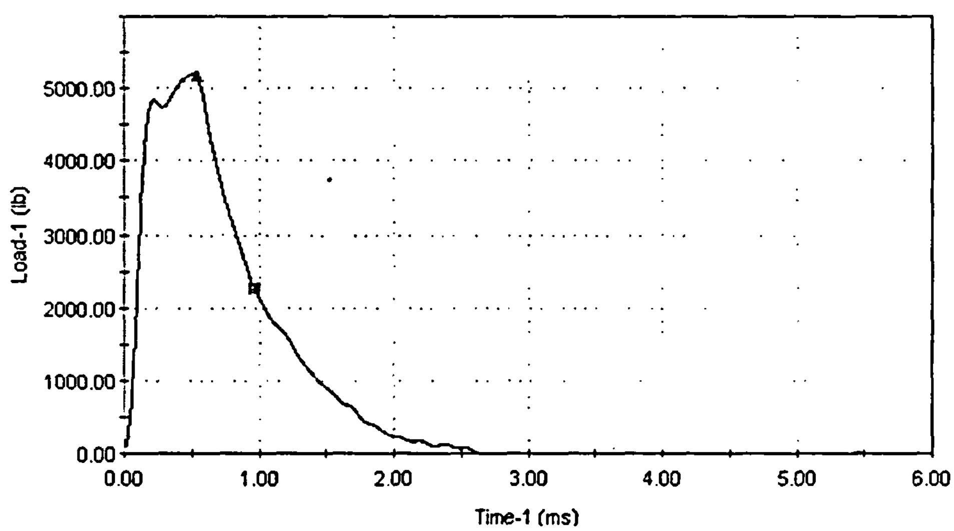
AH16, 50°F



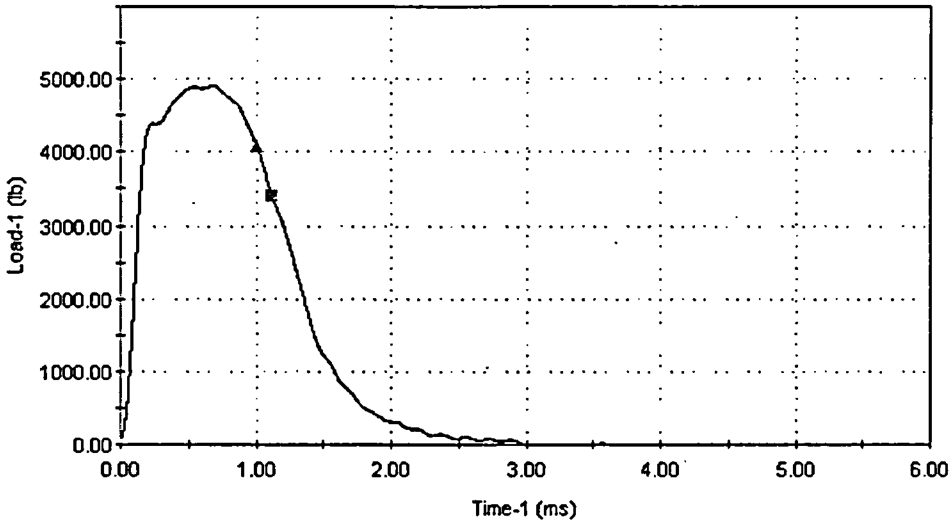
AH22, 75°F



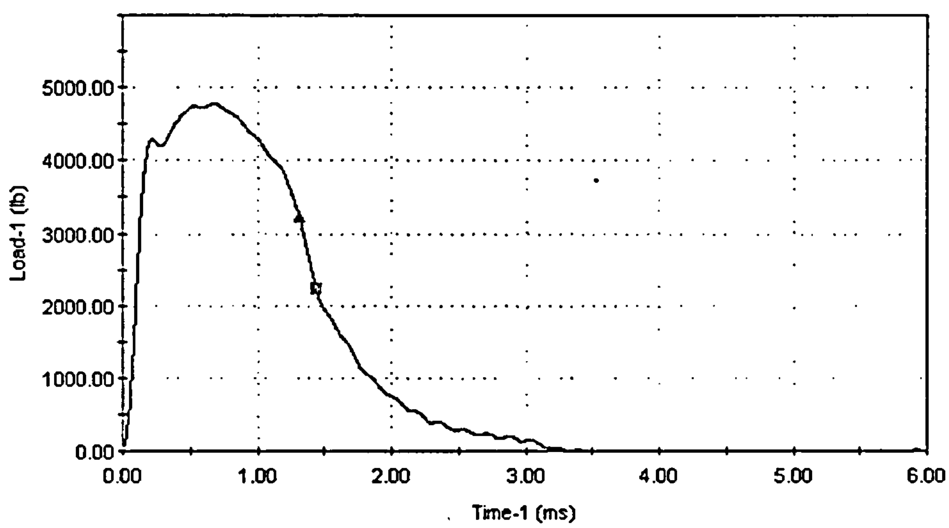
AH20, 100°F



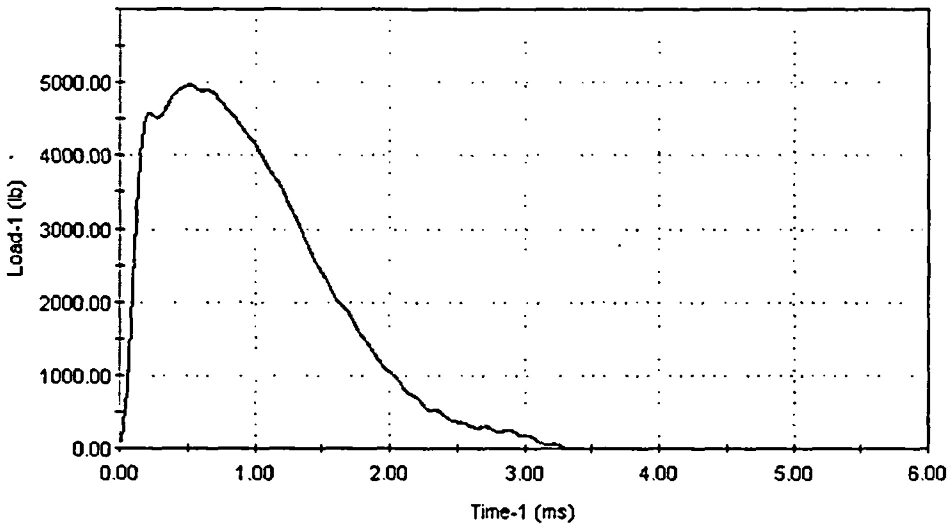
AH28, 150°F



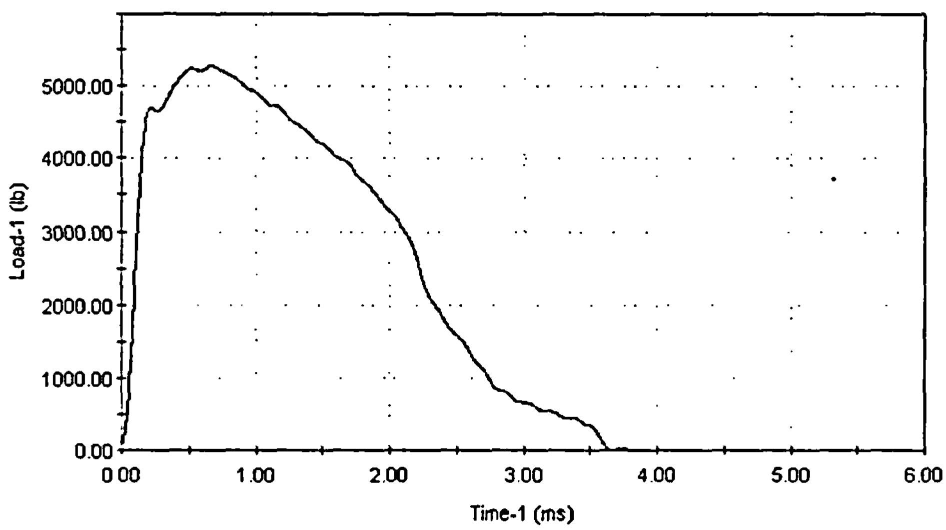
AH18, 200°F



AH17, 225°F



AH24, 250°F



AH25, 275°F

APPENDIX C

CHARPY V-NOTCH PLOTS FOR CAPSULE V USING SYMMETRIC 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. The definition for Upper Shelf Energy (USE) is given in ASTM E185-82, Section 4.18, and reads as follows:

> "*upper shelf energy level* – the average energy value for all Charpy specimens (normally three) whose test temperature is above the upper end of the transition region. For specimens tested in sets of three at each test temperature, the set having the highest average may be regarded as defining the upper shelf energy."

If there are specimens tested in set of three at each temperature Westinghouse reports the set having the highest average energy as the USE (usually unirradiated material). If the specimens were not tested in sets of three at each temperature Westinghouse reports the average of all 100% shear Charpy data as the USE. Hence, the USE values reported in Table C-1 and used to generate the Charpy V-notch curves were determined utilizing this methodology.

The lower shelf energy values were fixed at 2.2 ft-lb for all cases.

Table C-1 Upper Shelf Energy Values Fixed in CVGRAPH [ft-lb]

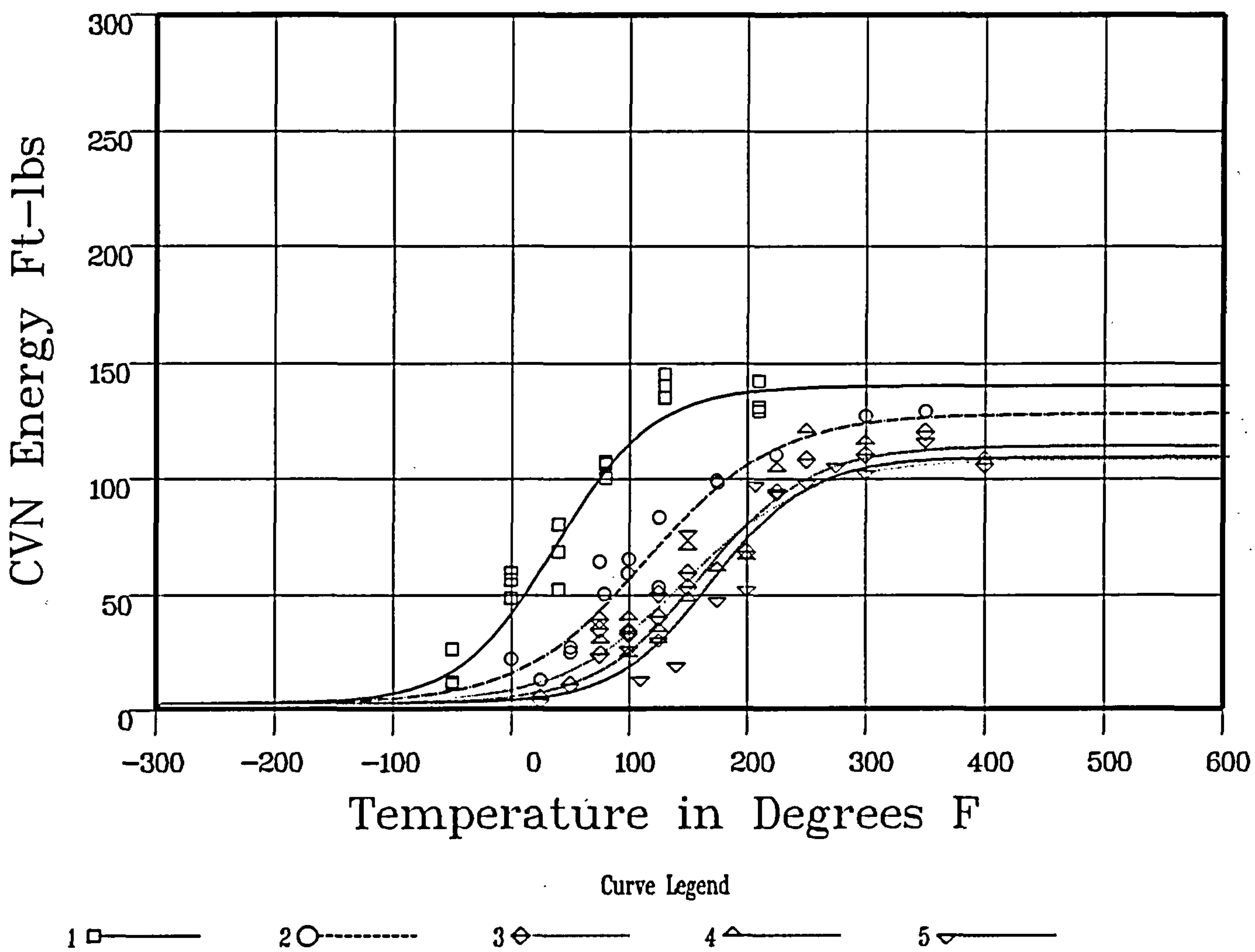
Material	Unirradiated (ft-lbs)	Capsule Y (ft-lbs)	Capsule U (ft-lbs)	Capsule X (ft-lbs)	Capsule W (ft-lbs)	Capsule V (ft-lbs)
Lower Shell Plate B6919-1 (Long.)	140	128	108	114	109	109
Lower Shell Plate B6919-1 (Trans.)	90	90	82	80	76	72
Weld Metal (heat # V89476)	149	131	105	115	110	110
HAZ Material	155	139	115	121	133	129

LOWER SHELL PLATE (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:10:20 on 11-06-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	140	0	-23.11	0	7.44	0
2	0	2.19	0	128	-12	41.72	64.83	83.91	76.47
3	0	2.19	0	108	-32	87.22	110.34	131.81	124.37
4	0	2.19	0	114	-26	106.59	129.71	143.93	136.49
5	0	2.19	0	109	-31	122.46	145.57	157.08	149.63



Data Set(s) Plotted

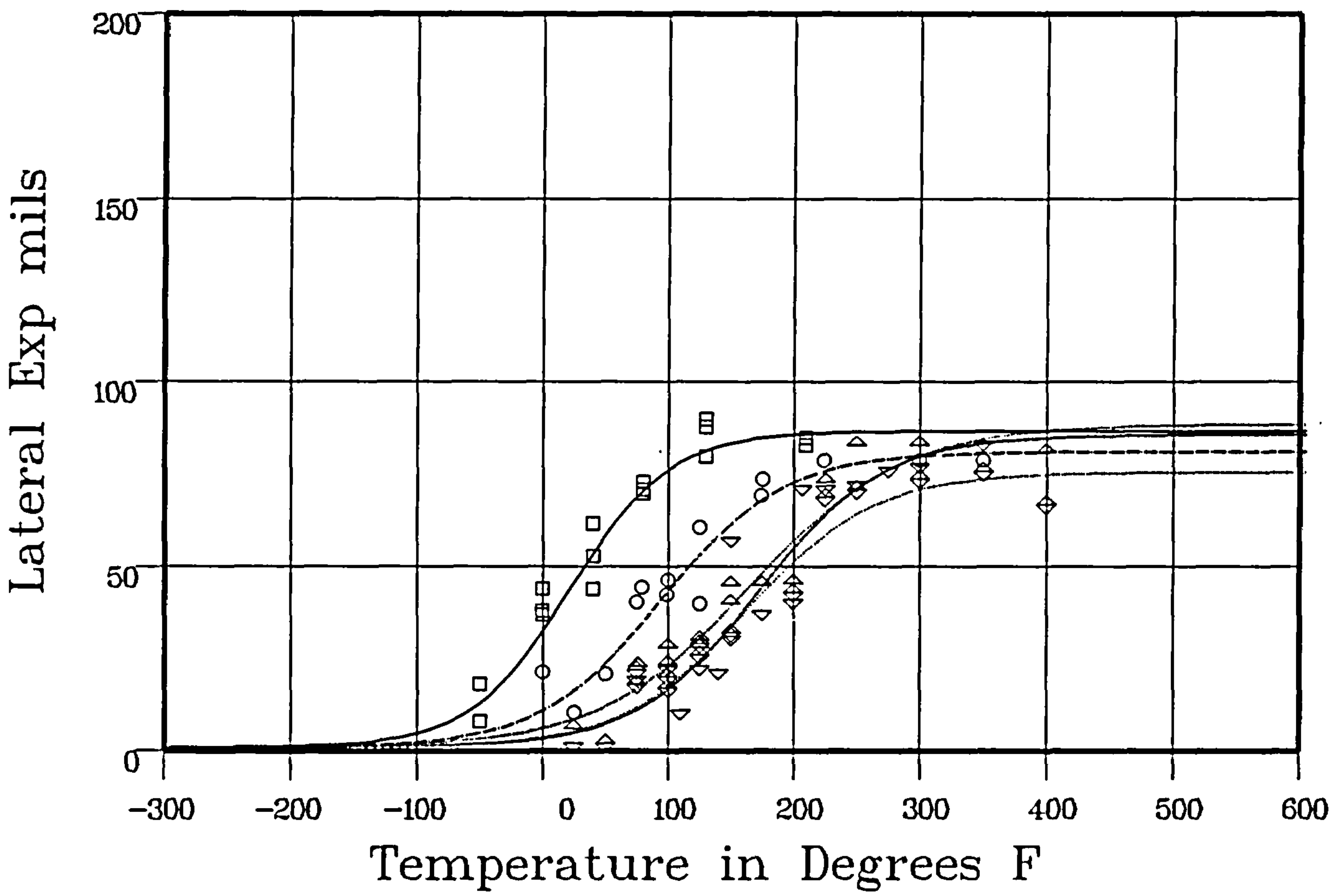
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	LT	C6940-1
2	FA1	Y	PLATE SA533B1	LT	C6940-1
3	FA1	U	PLATE SA533B1	LT	C6940-1
4	FA1	X	PLATE SA533B1	LT	C6940-1
5	FA1	W	PLATE SA533B1	LT	C6940-1

LOWER SHELL PLATE (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:16:42 on 11-06-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	86.8	0	2	0
2	0	81.26	-5.54	75.06	74.86
3	0	75.7	-11.1	149.31	149.1
4	0	88.57	1.76	133.12	132.92
5	0	85.77	-1.03	147.95	147.75



Curve Legend

1 □ — 2 ○ ---- 3 ◇ — 4 △ — 5 ▽ —

Data Set(s) Plotted

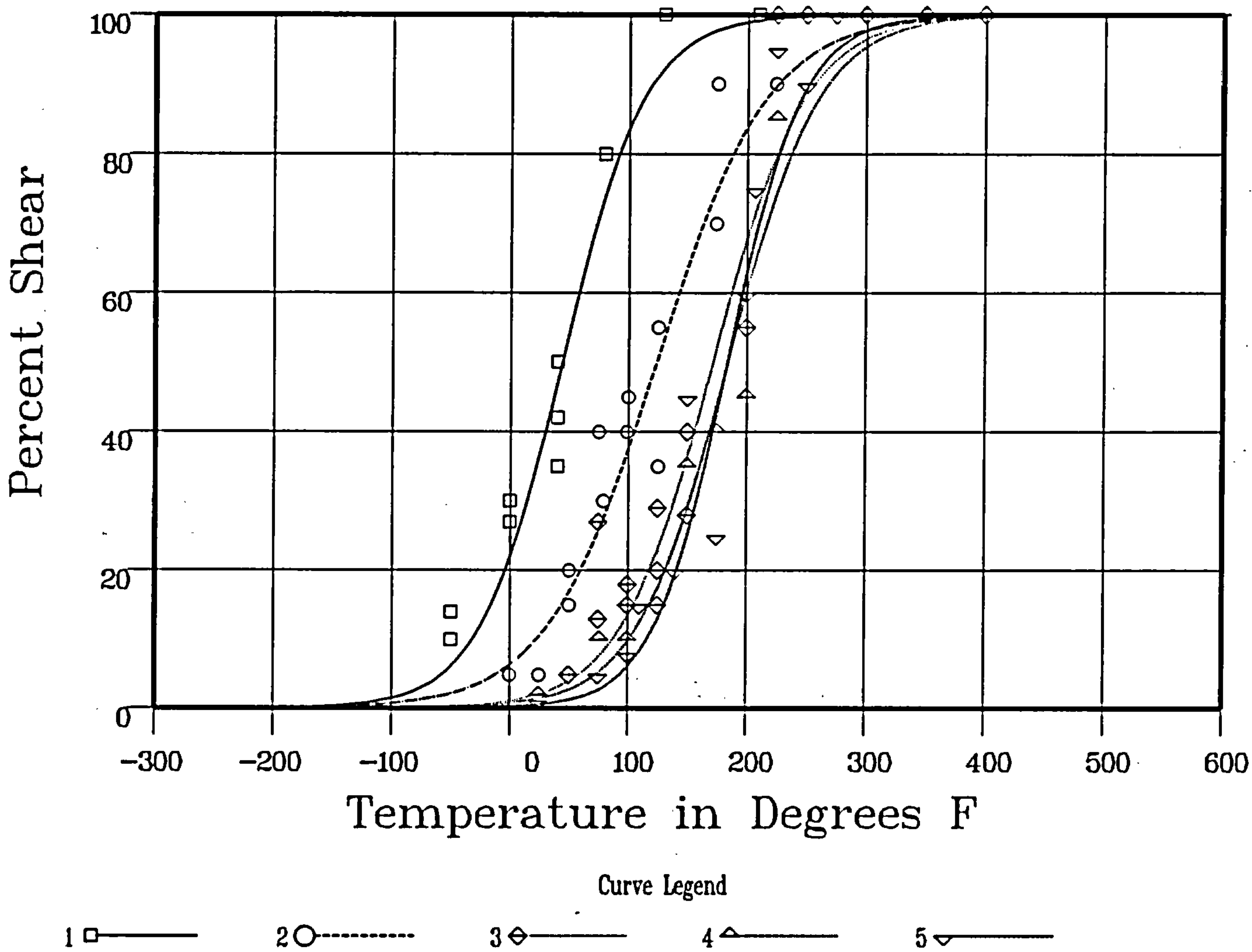
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	LT	C6940-1
2	FA1	Y	PLATE SA533B1	LT	C6940-1
3	FA1	U	PLATE SA533B1	LT	C6940-1
4	FA1	X	PLATE SA533B1	LT	C6940-1
5	FA1	W	PLATE SA533B1	LT	C6940-1

LOWER SHELL PLATE (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:21:14 on 11-06-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	39.21	0
2	0	119.23	80.02
3	0	166.87	127.66
4	0	179.53	140.32
5	0	179.18	139.97



Data Set(s) Plotted

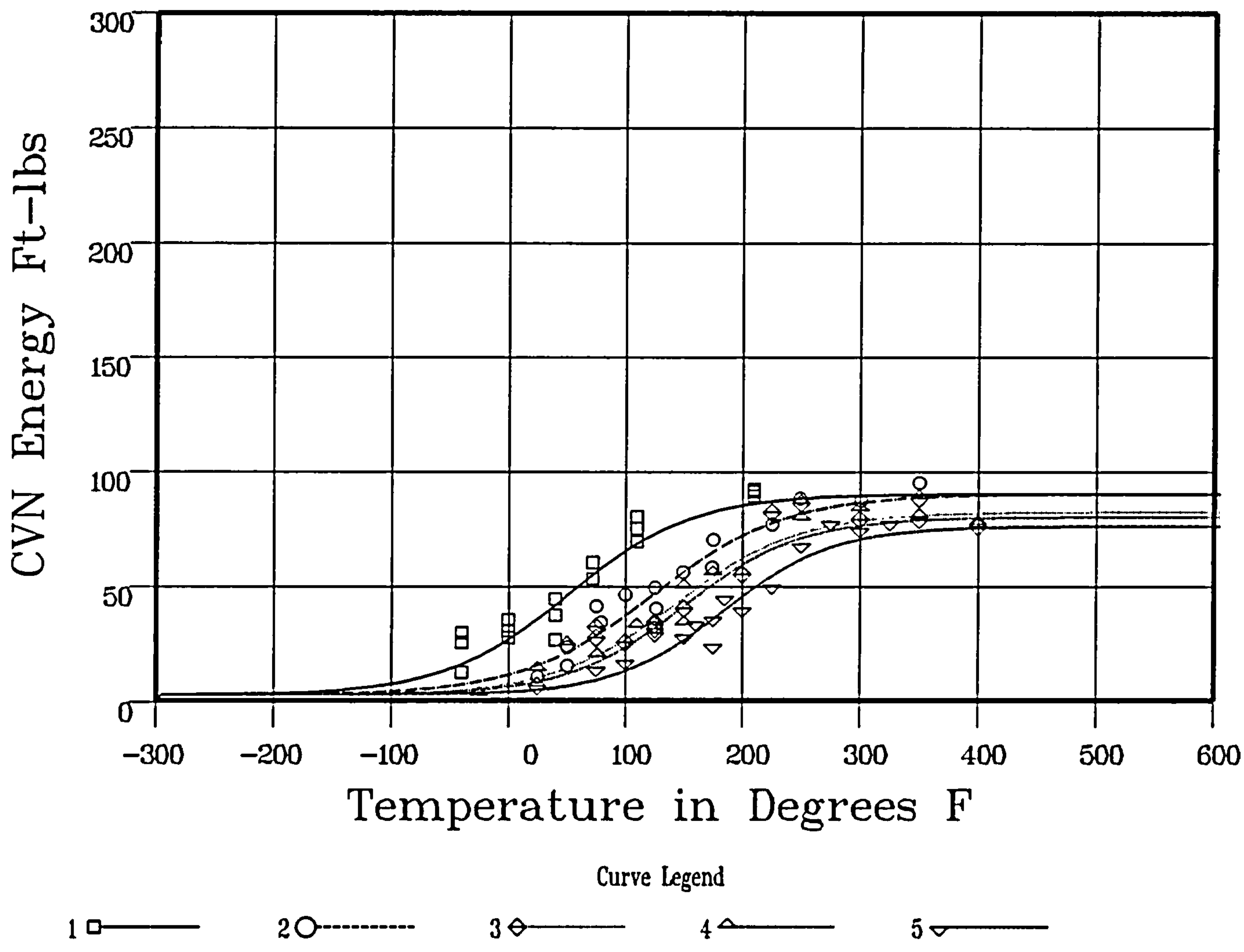
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	LT	C6940-1
2	FA1	Y	PLATE SA533B1	LT	C6940-1
3	FA1	U	PLATE SA533B1	LT	C6940-1
4	FA1	X	PLATE SA533B1	LT	C6940-1
5	FA1	W	PLATE SA533B1	LT	C6940-1

LOWER SHELL PLATE (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:45:39 on 11-06-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	90	0	5.19	0	55.37	0
2	0	2.19	0	90	0	75.64	70.45	128.97	73.59
3	0	2.19	0	82	-8	105.7	100.51	159.15	103.78
4	0	2.19	0	80	-10	115.91	110.72	168.11	112.74
5	0	2.19	0	76	-14	155.73	150.54	207.65	152.28



Data Set(s) Plotted

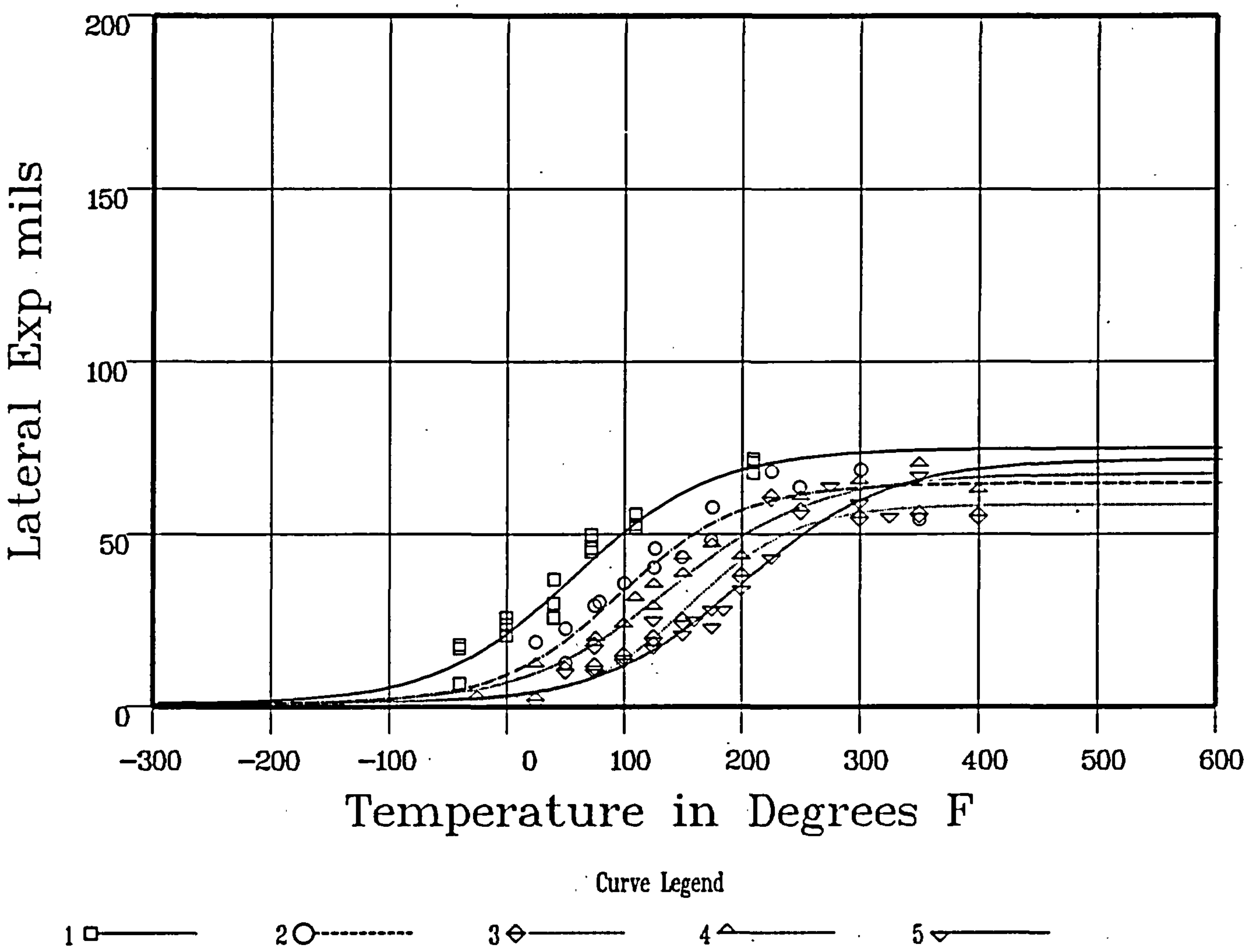
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	TL	C6940-1
2	FA1	Y	PLATE SA533B1	TL	C6940-1
3	FA1	U	PLATE SA533B1	TL	C6940-1
4	FA1	X	PLATE SA533B1	TL	C6940-1
5	FA1	W	PLATE SA533B1	TL	C6940-1

LOWER SHELL PLATE (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:27:34 on 11-06-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	75.09	0	42.74	0
2	0	65.01	-10.07	98.45	55.71
3	0	58.78	-16.3	168	125.26
4	0	67.71	-7.38	136.45	93.71
5	0	71.87	-3.22	191.91	149.17



Data Set(s) Plotted

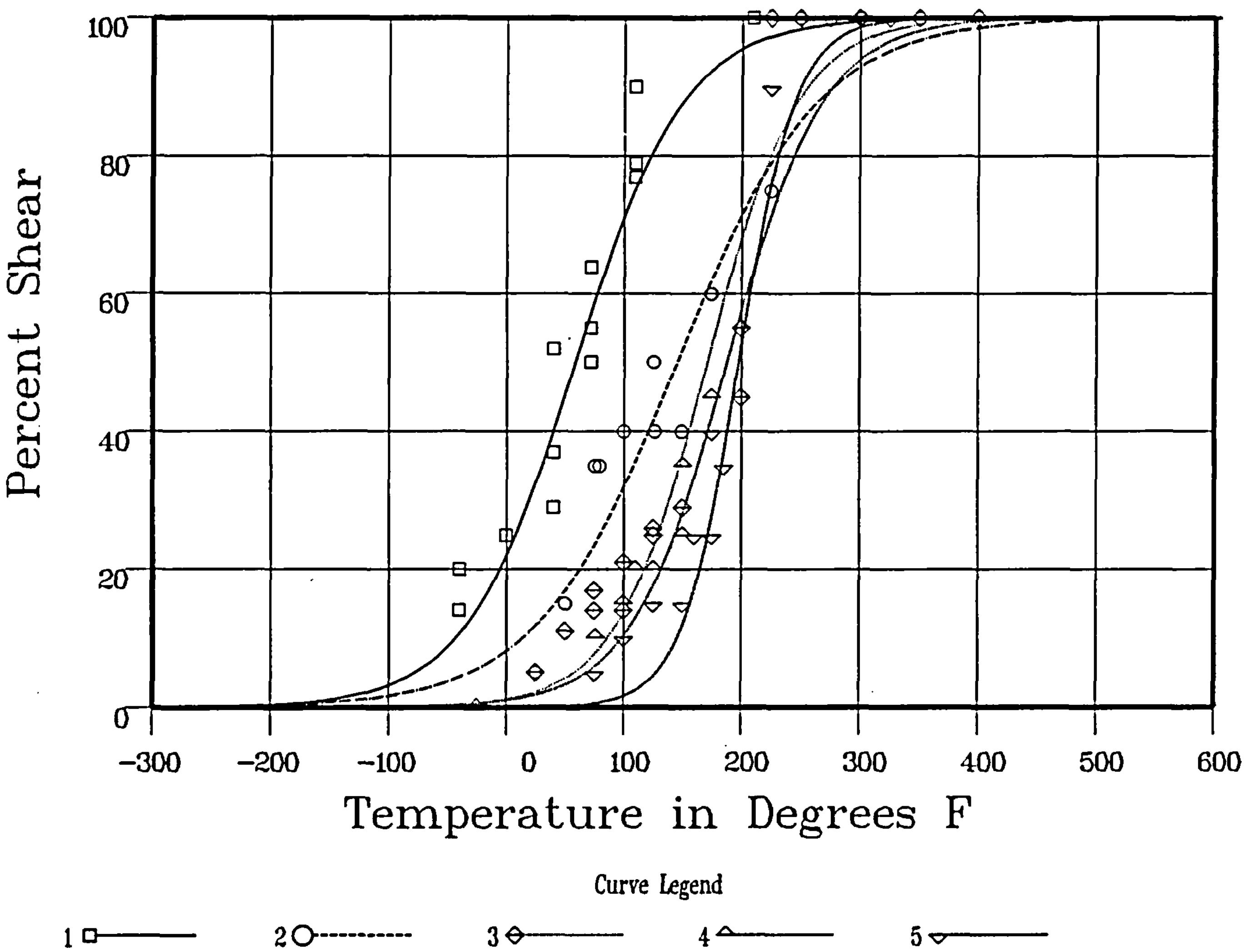
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	TL	C6940-1
2	FA1	Y	PLATE SA533B1	TL	C6940-1
3	FA1	U	PLATE SA533B1	TL	C6940-1
4	FA1	X	PLATE SA533B1	TL	C6940-1
5	FA1	W	PLATE SA533B1	TL	C6940-1

LOWER SHELL PLATE (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:34:17 on 11-06-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	53.9	0
2	0	140.64	86.73
3	0	166.4	112.5
4	0	183.16	129.26
5	0	193.12	139.21



Data Set(s) Plotted

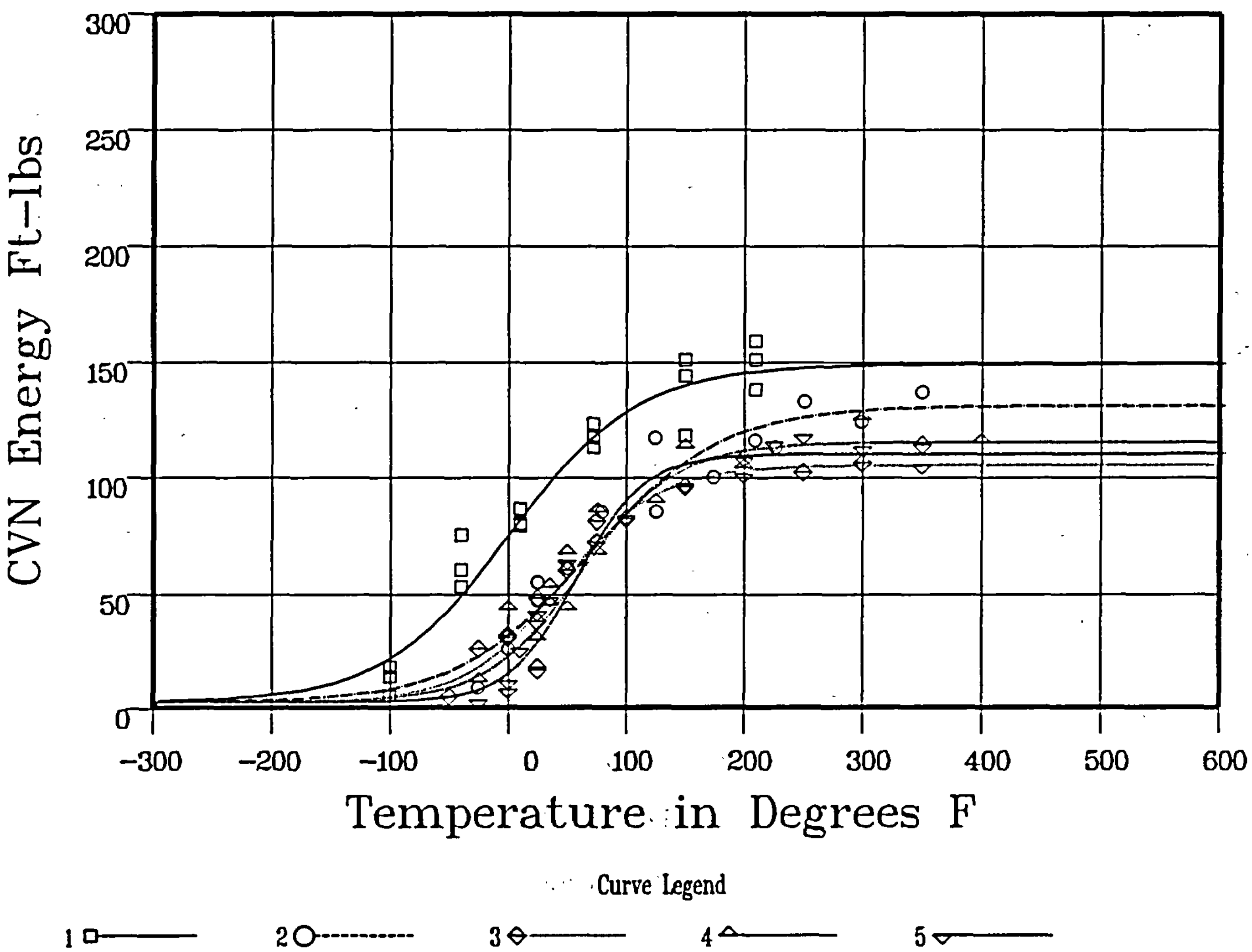
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	PLATE SA533B1	TL	C6940-1
2	FA1	Y	PLATE SA533B1	TL	C6940-1
3	FA1	U	PLATE SA533B1	TL	C6940-1
4	FA1	X	PLATE SA533B1	TL	C6940-1
5	FA1	W	PLATE SA533B1	TL	C6940-1

SURVIELLANCE PROGRAM WELD METAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:43:49 on 11-06-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	149	0	-82.46	0	-42.93	0
2	0	2.19	0	131	-18	-9.54	72.92	33.5	76.43
3	0	2.19	0	105	-44	-1.33	81.13	33.75	76.68
4	0	2.19	0	115	-34	10.72	93.19	43.7	86.63
5	0	2.19	0	110	-39	21.71	104.17	45.87	88.81



Data Set(s) Plotted

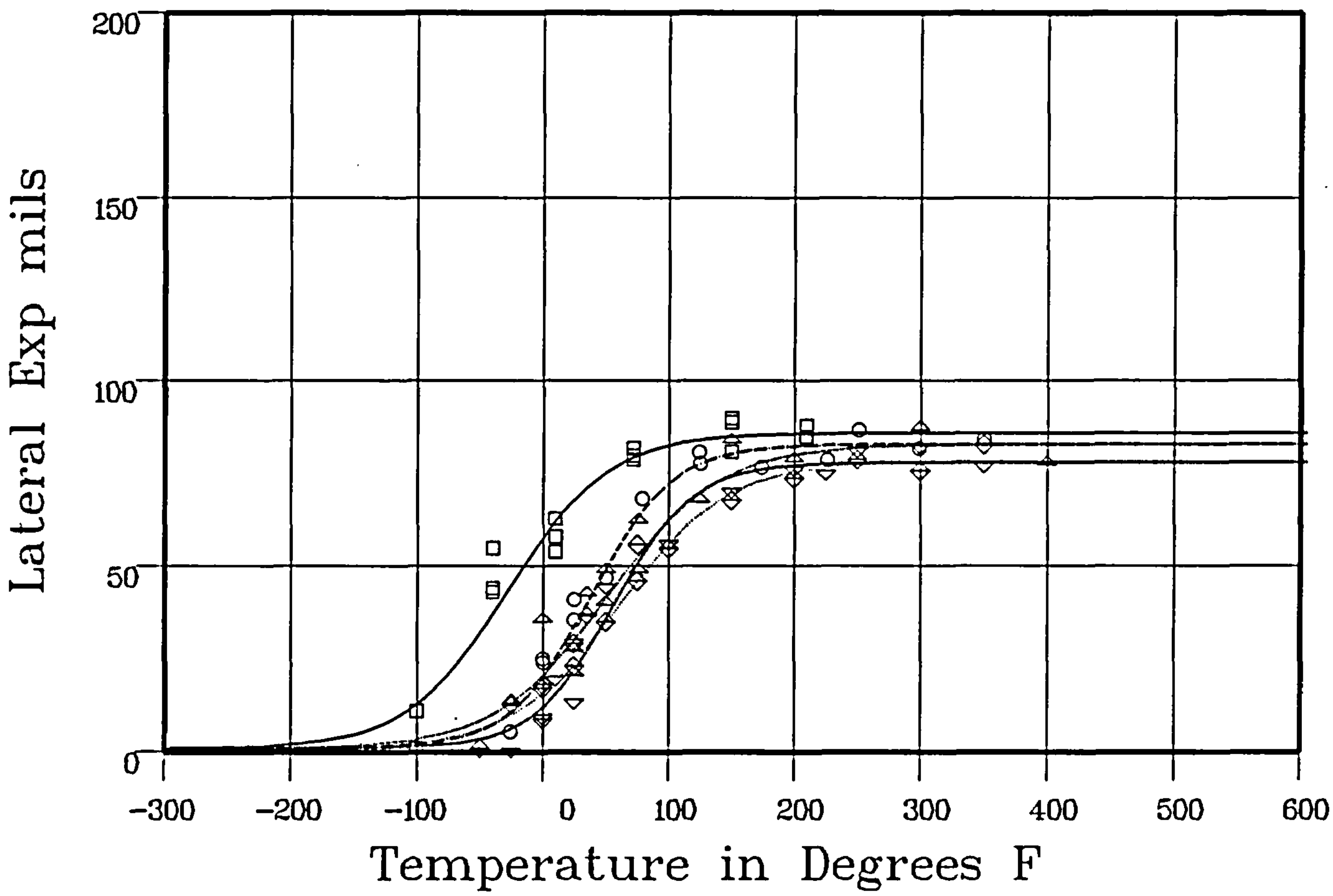
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	WELD LINDE 0091		33A277 FLUX LOT 3922
2	FA1	Y	WELD LINDE 0091		33A277 FLUX LOT 3922
3	FA1	U	WELD LINDE 0091		33A277 FLUX LOT 3922
4	FA1	X	WELD LINDE 0091		33A277 FLUX LOT 3922
5	FA1	W	WELD LINDE 0091		33A277 FLUX LOT 3922

SURVIELLANCE PROGRAM WELD METAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:48:15 on 11-06-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	86.12	0	-48.69	0
2	0	83.06	-3.05	22.64	71.33
3	0	78.56	-7.56	46.11	94.8
4	0	83.02	-3.09	31.61	80.3
5	0	78.19	-7.93	44.02	92.71



Curve Legend

1 □——— 2 ○-------- 3 ◇——— 4 △——— 5 ▽———

Data Set(s) Plotted

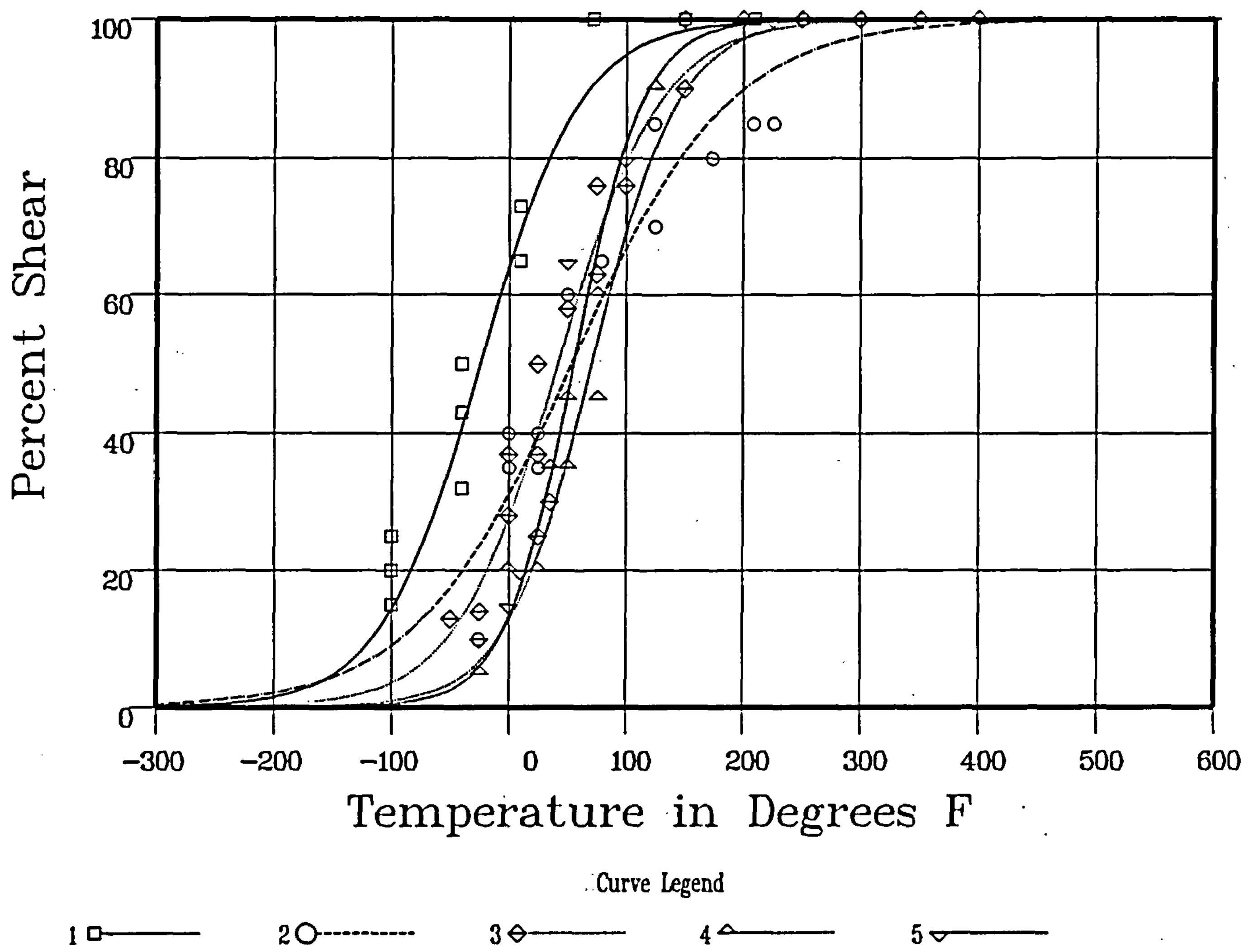
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	WELD LINDE 0091		33A277 FLUX LOT 3922
2	FA1	Y	WELD LINDE 0091		33A277 FLUX LOT 3922
3	FA1	U	WELD LINDE 0091		33A277 FLUX LOT 3922
4	FA1	X	WELD LINDE 0091		33A277 FLUX LOT 3922
5	FA1	W	WELD LINDE 0091		33A277 FLUX LOT 3922

SURVIELLANCE PROGRAM WELD METAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:51:43 on 11-06-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	-29.06	0
2	0	48.75	77.81
3	0	37.03	66.09
4	0	66.09	95.15
5	0	50.62	79.68



Data Set(s) Plotted

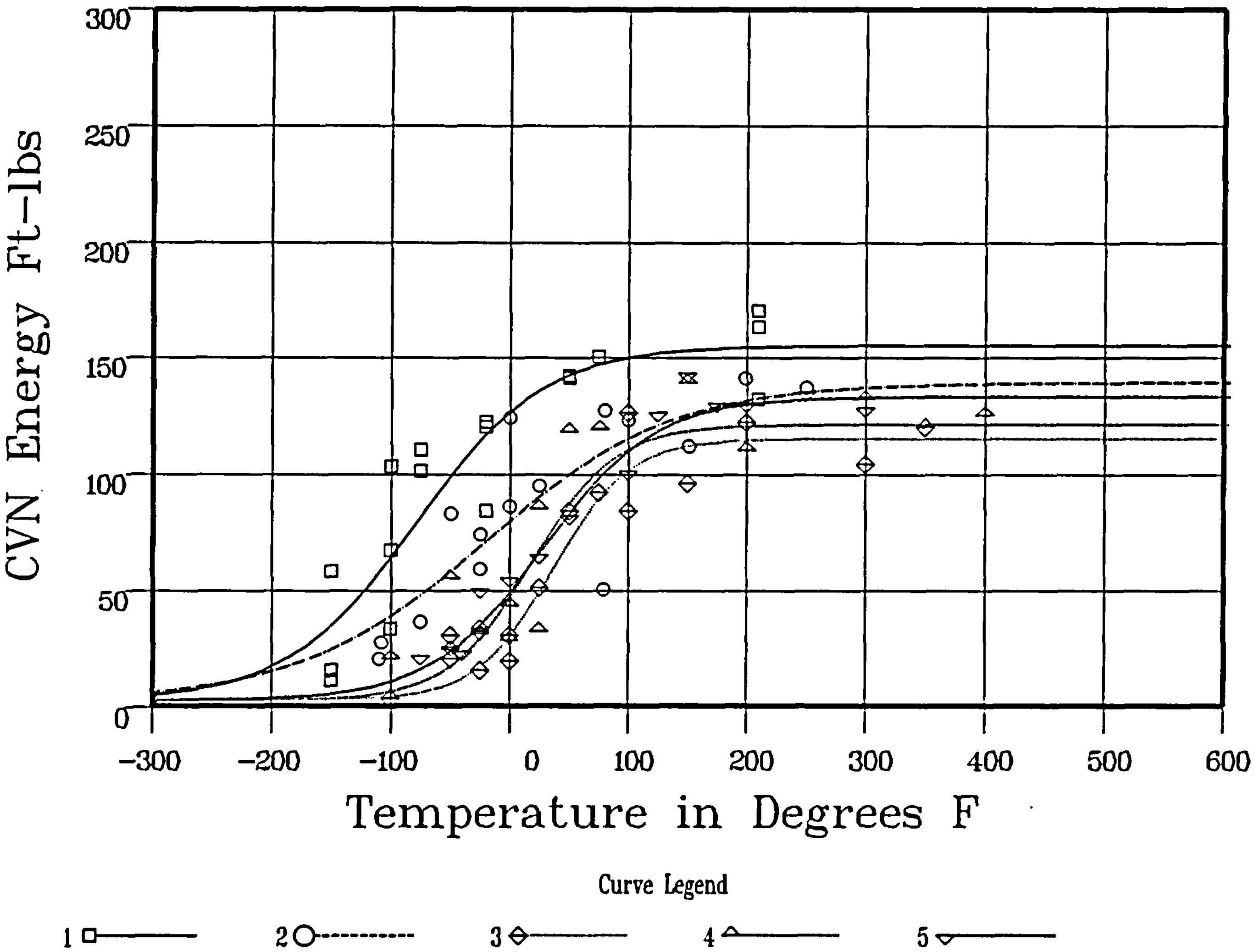
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	WELD LINDE 0091		33A277 FLUX LOT 3922
2	FA1	Y	WELD LINDE 0091		33A277 FLUX LOT 3922
3	FA1	U	WELD LINDE 0091		33A277 FLUX LOT 3922
4	FA1	X	WELD LINDE 0091		33A277 FLUX LOT 3922
5	FA1	W	WELD LINDE 0091		33A277 FLUX LOT 3922

HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:01:16 on 11-06-2003

Results

Curve	Fluence	LSE	d-LSE	USE	d-USE	T @ 30	d-T @ 30	T @ 50	d-T @ 50
1	0	2.19	0	155	0	-164.75	0	-126.22	0
2	0	2.19	0	139	-16	-132.19	32.55	-74.19	52.03
3	0	2.19	0	115	-40	-4.37	160.37	21.56	147.79
4	0	2.19	0	121	-34	-27.83	136.91	-23	125.99
5	0	2.19	0	133	-22	-38.7	126.04	-3.01	123.21



Data Set(s) Plotted

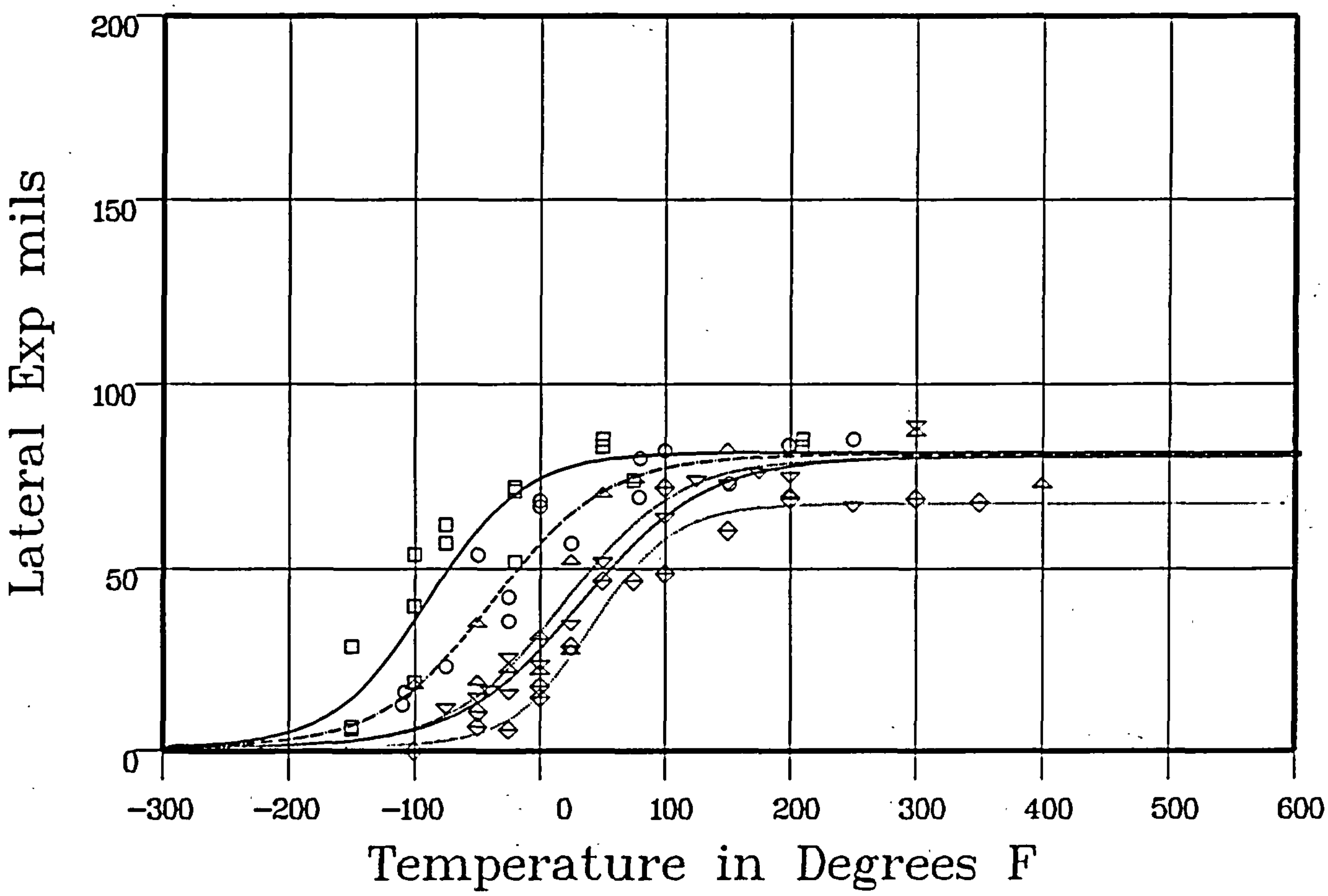
Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	HEAT AFFD ZONE SA533B1		C6940-1
2	FA1	Y	HEAT AFFD ZONE SA533B1		C6940-1
3	FA1	U	HEAT AFFD ZONE SA533B1		C6940-1
4	FA1	X	HEAT AFFD ZONE SA533B1		C6940-1
5	FA1	W	HEAT AFFD ZONE SA533B1		C6940-1

HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:04:43 on 11-06-2003

Results

Curve	Fluence	USE	d-USE	T @ LE35	d-T @ LE35
1	0	81.58	0	-106.78	0
2	0	80.96	-.62	-57.2	49.58
3	0	67.7	-13.88	37.37	144.15
4	0	80.15	-1.42	.59	107.37
5	0	80.31	-1.27	13.01	119.8



Curve Legend

1 □——— 2 ○-------- 3 ◇——— 4 △——— 5 ▽———

Data Set(s) Plotted

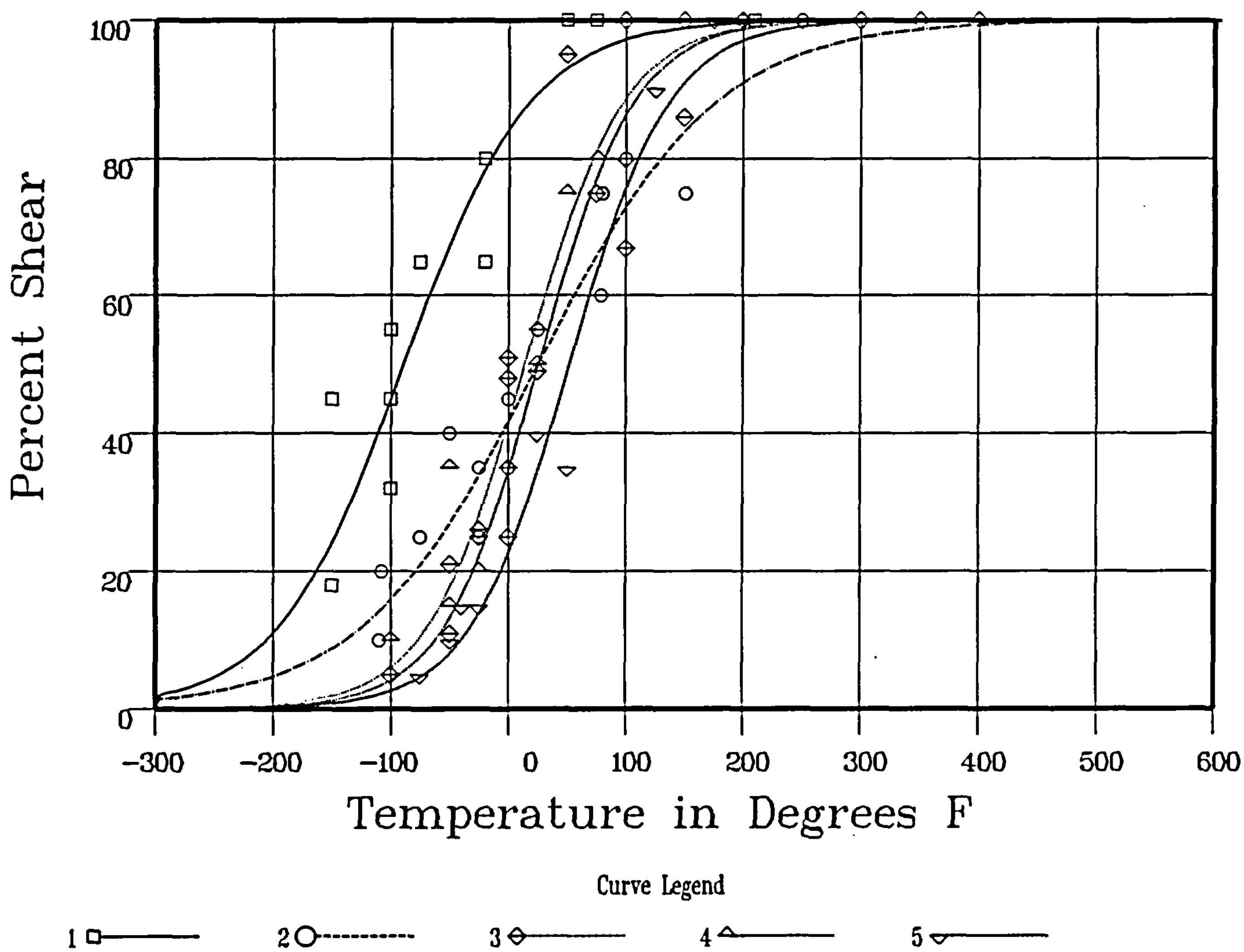
Curve	Plant	Capsule	Material		Ori.	Heat#
1	FA1	UNIRR	HEAT AFFD ZONE	SA533B1		C6940-1
2	FA1	Y	HEAT AFFD ZONE	SA533B1		C6940-1
3	FA1	U	HEAT AFFD ZONE	SA533B1		C6940-1
4	FA1	X	HEAT AFFD ZONE	SA533B1		C6940-1
5	FA1	W	HEAT AFFD ZONE	SA533B1		C6940-1

HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:44 on 11-06-2003

Results

Curve	Fluence	T @ 50% Shear	d-T @ 50% Shear
1	0	-93.75	0
2	0	20.62	114.37
3	0	9.52	103.27
4	0	21.09	114.84
5	0	47.34	141.09



Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat#
1	FA1	UNIRR	HEAT AFFD ZONE SA533B1		C6940-1
2	FA1	Y	HEAT AFFD ZONE SA533B1		C6940-1
3	FA1	U	HEAT AFFD ZONE SA533B1		C6940-1
4	FA1	X	HEAT AFFD ZONE SA533B1		C6940-1
5	FA1	W	HEAT AFFD ZONE SA533B1		C6940-1

UNIRRADIATED (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:10:20 on 11-06-2003

Page 1

Coefficients of Curve 1

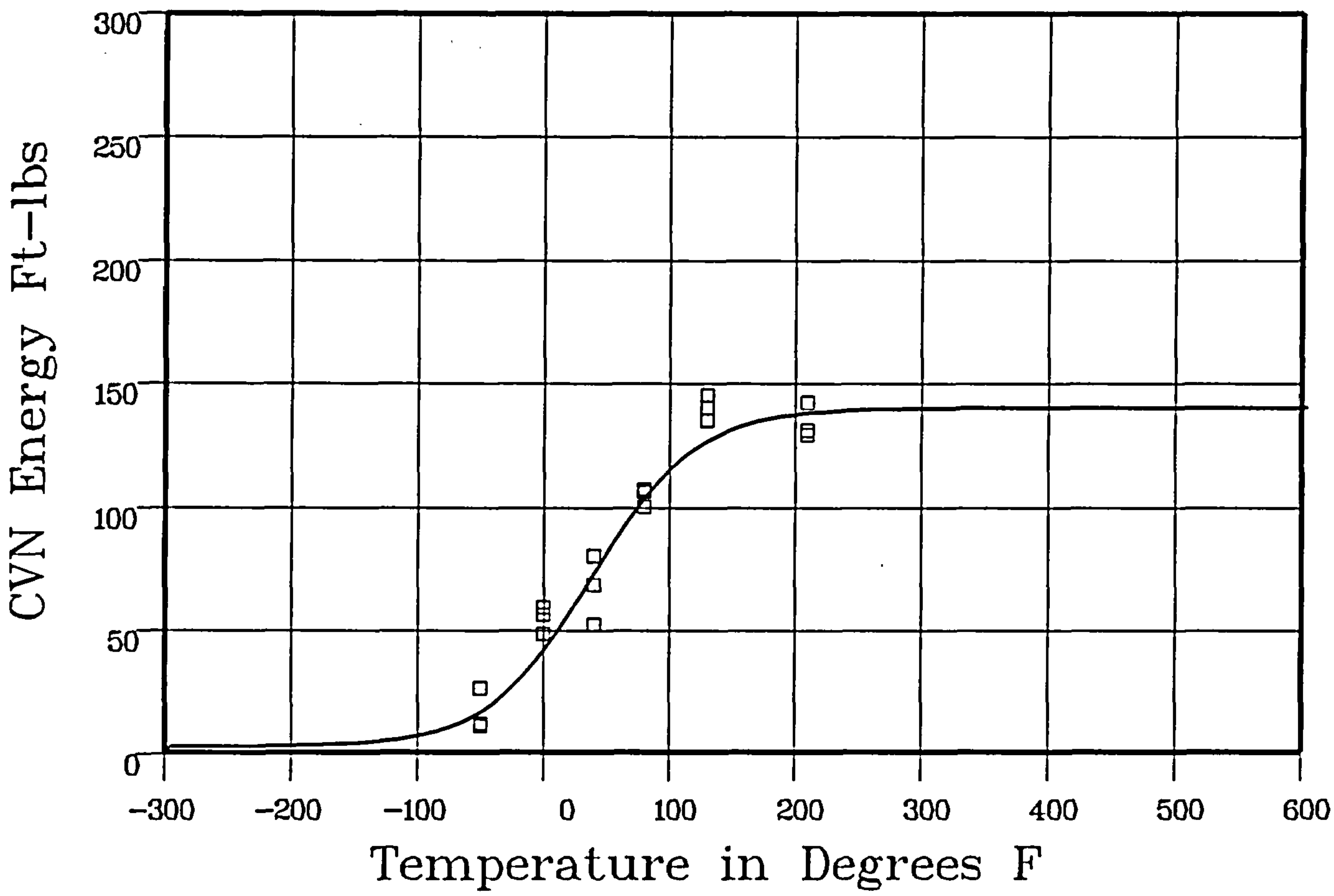
A = 71.09	B = 68.9	C = 82.3	T0 = 33.48

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 140 Fixed Temp. at 30 ft-lbs: -23.1 Temp. at 50 ft-lbs: 7.4 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: UNIRR Material: PLATE SA533B1 Ori: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	12	18.21	-6.21
-50	11	18.21	-7.21
-50	26	18.21	7.78
0	56	44.51	11.48
0	59	44.51	14.48
0	48	44.51	3.48
40	80	76.54	3.45
40	52	76.54	-24.54
40	68	76.54	-8.54

**** Data continued on next page ****

UNIRRADIATED (LONGITUDINAL)

Page 2

Material: PLATE SA533B1   Heat Number: C6940-1   Orientation: LT

Capsule: UNIRR   Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
80	107	106.36	.63
80	100	106.36	-6.36
80	106	106.36	-.36
130	145	127.95	17.04
130	135	127.95	7.04
130	140	127.95	12.04
210	129	138.13	-9.13
210	142	138.13	3.86
210	131	138.13	-7.13

SUM of RESIDUALS = 11.83

UNIRRADIATED (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:16:42 on 11-06-2003

Page 1

Coefficients of Curve 1

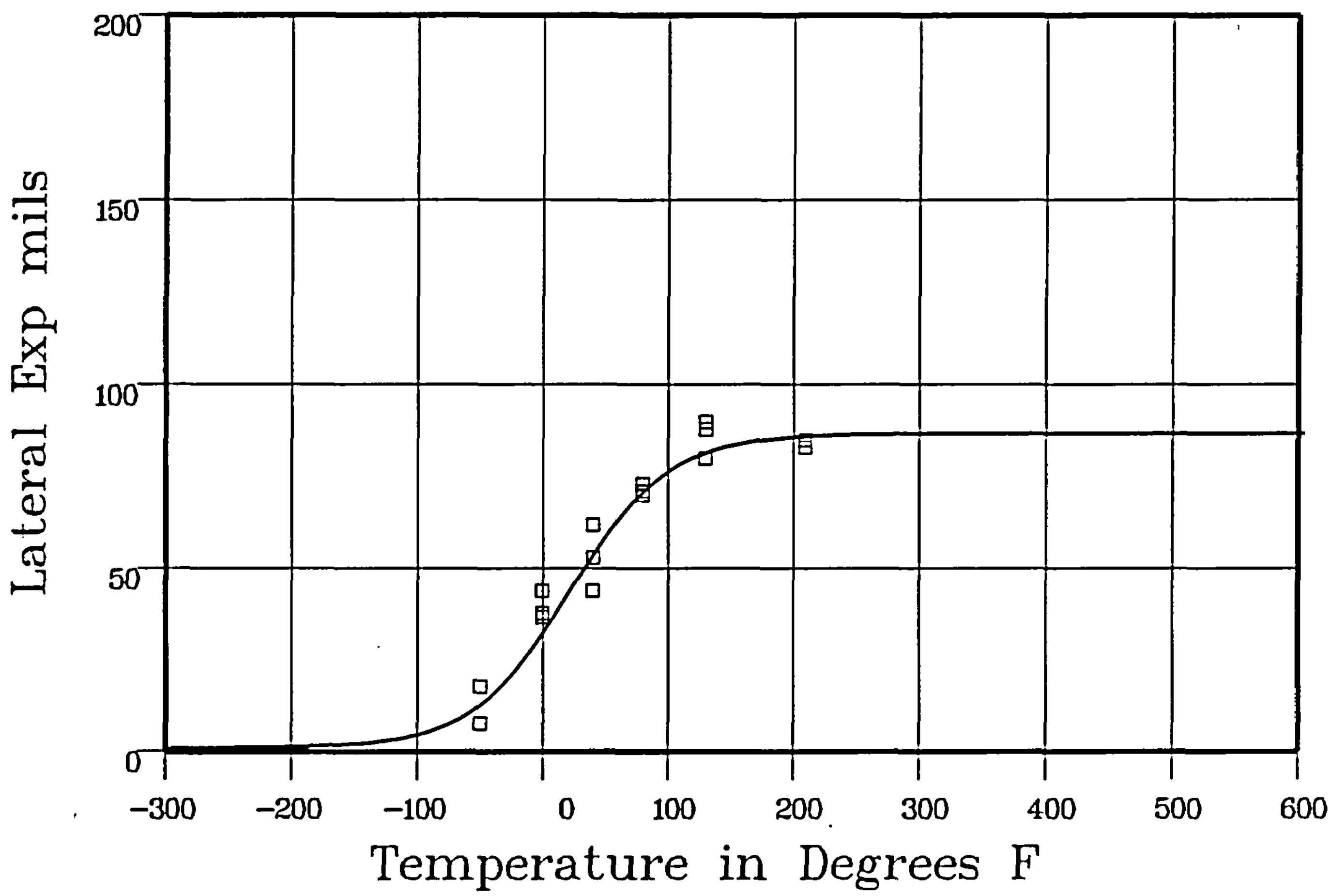
A = 43.9	B = 42.9	C = 79.16	T0 = 16.87

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 86.8 Temperature at L.E. 35: .2 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	8	14.37	-6.37
-50	8	14.37	-6.37
-50	18	14.37	3.62
0	38	34.89	3.1
0	44	34.89	9.1
0	37	34.89	2.1
40	62	56.09	5.9
40	44	56.09	-12.09
40	53	56.09	-3.09

**** Data continued on next page ****

UNIRRADIATED (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
80	70	72.33	-2.33
80	73	72.33	.66
80	71	72.33	-1.33
130	88	82.15	5.84
130	80	82.15	-2.15
130	90	82.15	7.84
210	85	86.16	-1.16
210	85	86.16	-1.16
210	83	86.16	-3.16

SUM of RESIDUALS = -1

UNIRRADIATED (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:21:14 on 11-06-2003

Page 1

Coefficients of Curve 1

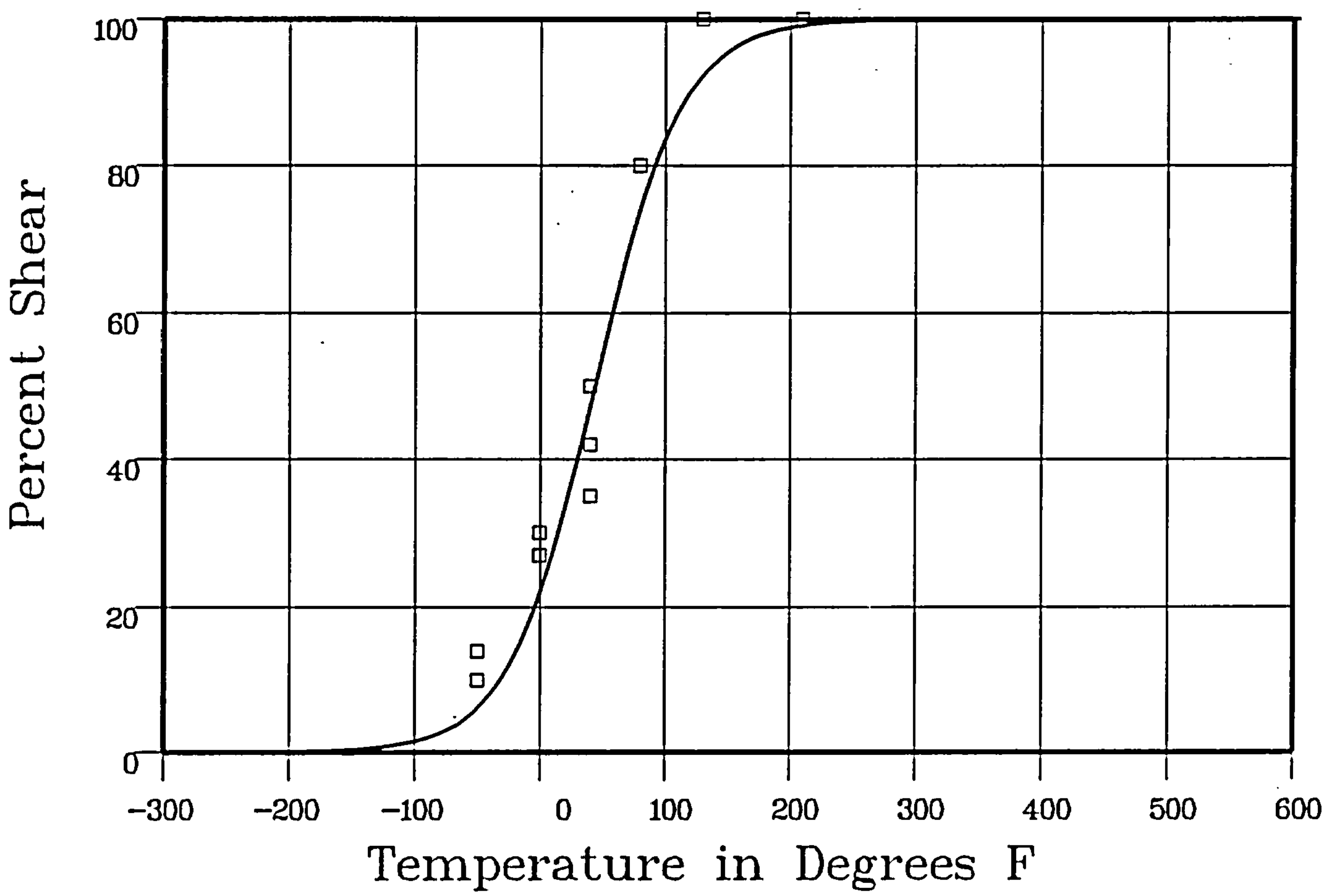
A = 50	B = 50	C = 69.21	T0 = 39.21

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 39.2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	10	7.05	2.94
-50	14	7.05	6.94
-50	14	7.05	6.94
0	27	24.35	2.64
0	30	24.35	5.64
0	27	24.35	2.64
40	50	50.57	-.57
40	35	50.57	-15.57
40	42	50.57	-8.57

**** Data continued on next page ****

UNIRRADIATED (LONGITUDINAL)

.Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
80	80	76.47	3.52
80	80	76.47	3.52
80	80	76.47	3.52
130	100	93.23	6.76
130	100	93.23	6.76
130	100	93.23	6.76
210	100	99.28	.71
210	100	99.28	.71
210	100	99.28	.71

SUM of RESIDUALS = 36.05

CAPSULE Y (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:10:20 on 11-06-2003

Page 1

Coefficients of Curve 2

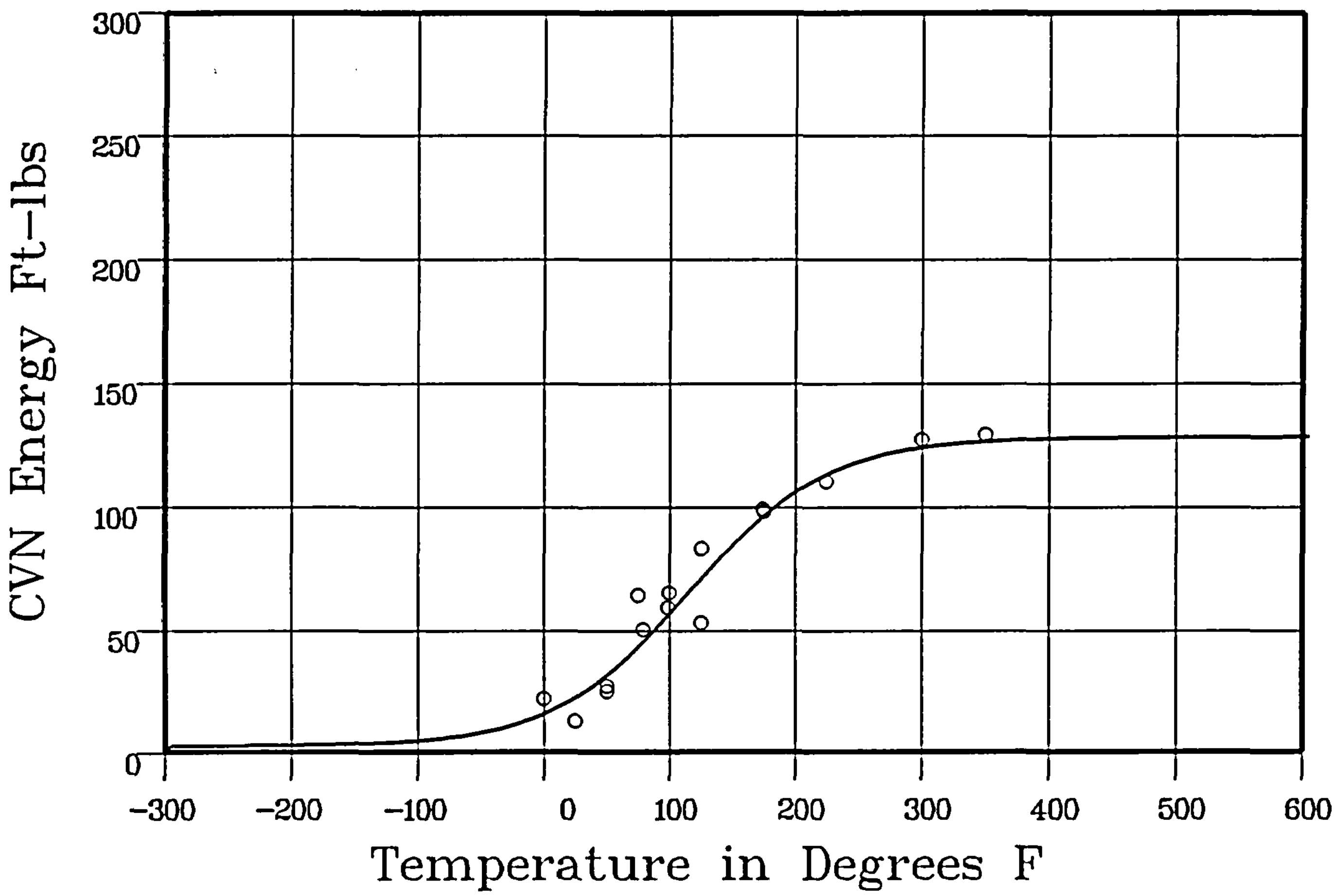
A = 65.09	B = 62.9	C = 109.56	T0 = 110.74

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 128 Fixed Temp. at 30 ft-lbs: 41.7 Temp. at 50 ft-lbs: 83.9 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
0	22	16.91	5.08
25	13	23.95	-10.95
50	27	33.41	-6.41
50	25	33.41	-8.41
75	64	45.27	18.72
79	50	47.37	2.62
99	59	58.38	.61
100	65	58.95	6.04

**** Data continued on next page ****

CAPSULE Y (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
125	83	73.23	9.76
125	53	73.23	-20.23
174	99	97.85	1.14
175	98	98.27	-.27
224	110	113.87	-3.87
300	127	124.14	2.85
350	129	126.42	2.57

SUM of RESIDUALS = -.72

CAPSULE Y (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:16:42 on 11-06-2003

Page 1

Coefficients of Curve 2

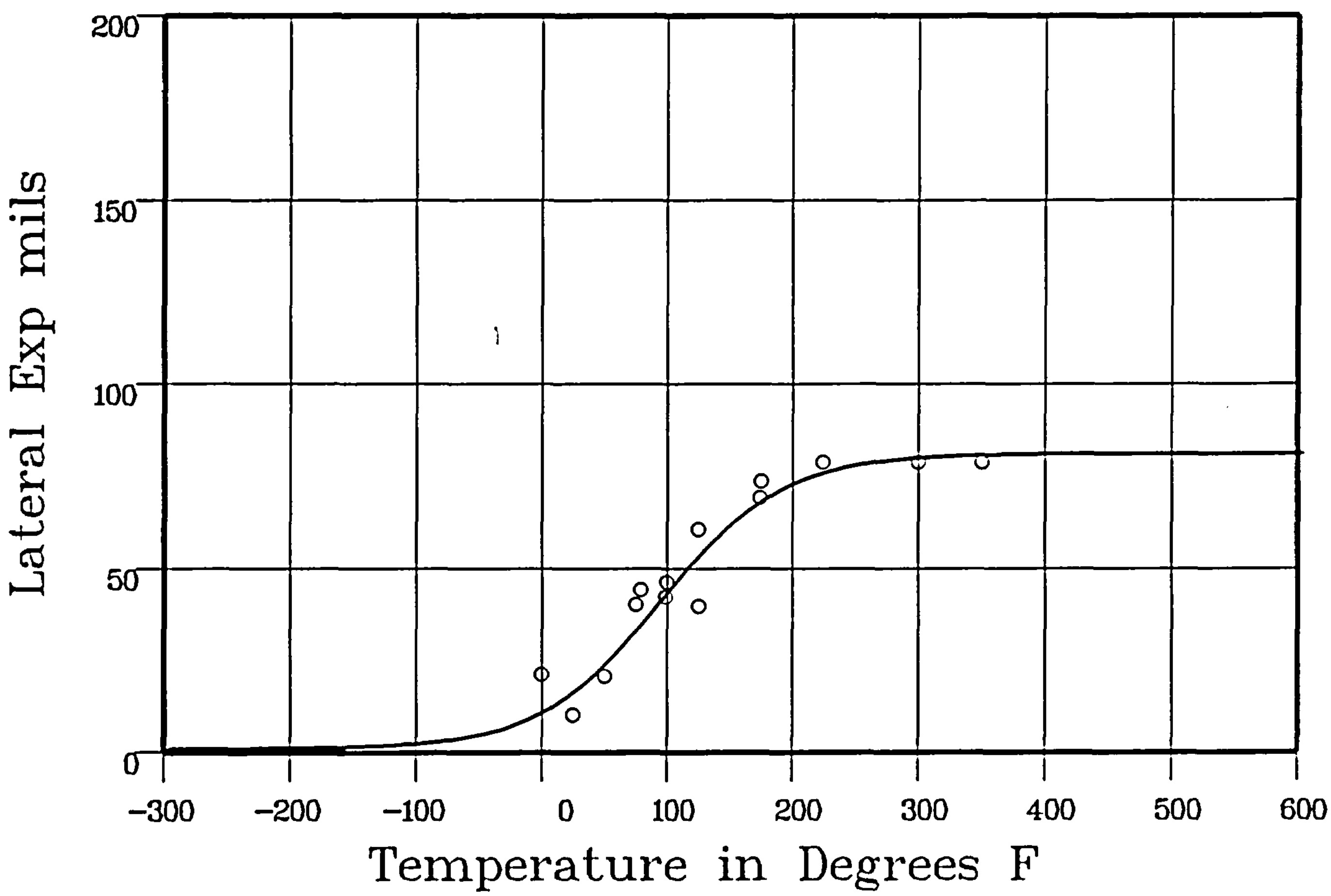
A = 41.13	B = 40.13	C = 96.96	T0 = 90

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 81.26 Temperature at L.E. 35: 75 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
0	21.5	11.84	9.65
25	10.5	17.64	-7.14
50	21	25.45	-4.45
50	21	25.45	-4.45
75	40.5	34.97	5.52
79	44.5	36.59	7.9
99	42.5	44.84	-2.34
100	46.5	45.25	1.24

**** Data continued on next page ****

CAPSULE Y (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
125	61	55.01	5.98
125	40	55.01	-15.01
174	69.5	69.2	.29
175	74	69.41	4.58
224	79	76.5	2.49
300	79	80.22	-1.22
350	79	80.88	-1.88

SUM of RESIDUALS = 1.15

CAPSULE Y (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:21:14 on 11-06-2003

Page 1

Coefficients of Curve 2

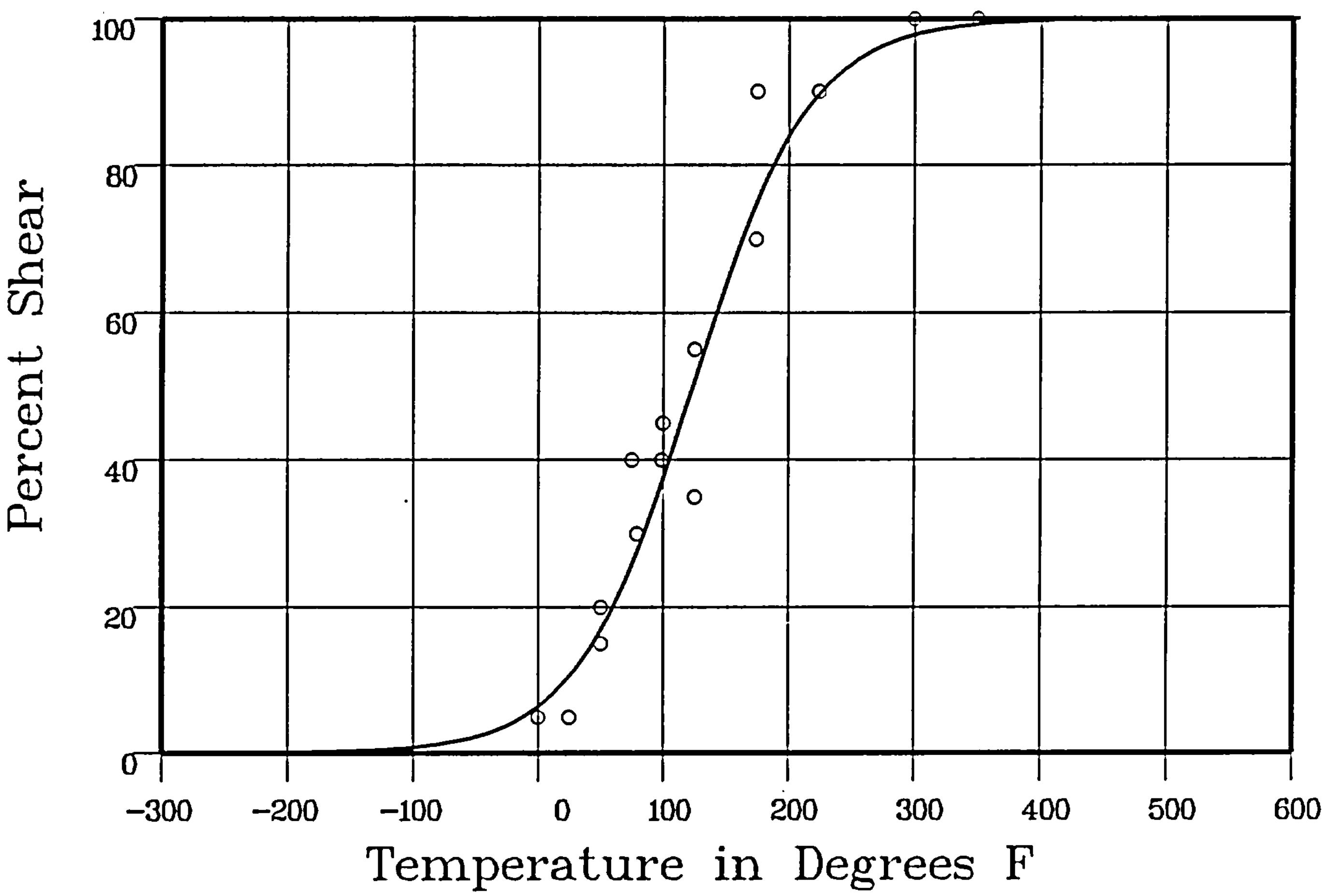
A = 50	B = 50	C = 92.6	T0 = 119.23

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 119.2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
0	5	7.07	-2.07
25	5	11.55	-6.55
50	20	18.31	1.68
50	15	18.31	-3.31
75	40	27.78	12.21
79	30	29.54	.45
99	40	39.24	.75
100	45	39.75	5.24

**** Data continued on next page ****

CAPSULE Y (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
125	55	53.1	1.89
125	35	53.1	-18.1
174	70	76.54	-6.54
175	90	76.92	13.07
224	90	90.57	-.57
300	100	98.02	1.97
350	100	99.31	.68

SUM of RESIDUALS = .81

CAPSULE U (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:10:20 on 11-06-2003

Page 1

Coefficients of Curve 3

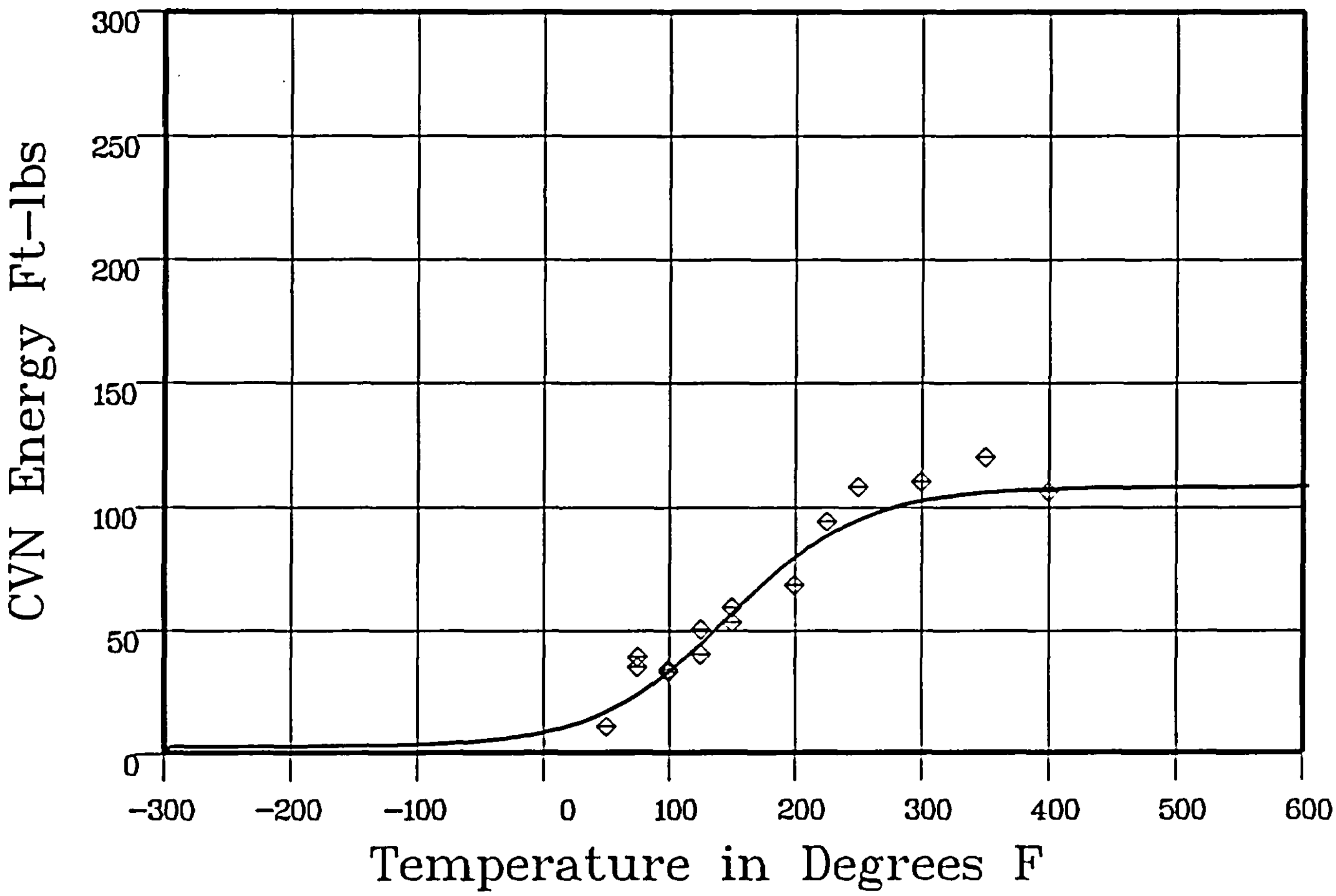
A = 55.09	B = 52.9	C = 106.38	T0 = 142.1

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 108 Fixed Temp. at 30 ft-lbs: 87.2 Temp. at 50 ft-lbs: 131.8 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: U Material: PLATE SA533B1 Ori: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
50	11	18.11	-7.11
75	39	25.55	13.44
75	35	25.55	9.44
100	33	35.19	-2.19
100	34	35.19	-1.19
125	50	46.66	3.33
125	40	46.66	-6.66
150	53	59.01	-6.01

**** Data continued on next page ****

CAPSULE U (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
150	59	59.01	-.01
200	68	81.34	-13.34
225	94	89.6	4.39
250	108	95.7	12.29
300	110	102.82	7.17
350	120	105.91	14.08
400	106	107.17	-1.17

SUM of RESIDUALS = 26.45

CAPSULE U (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:16:42 on 11-06-2003

Page 1

Coefficients of Curve 3

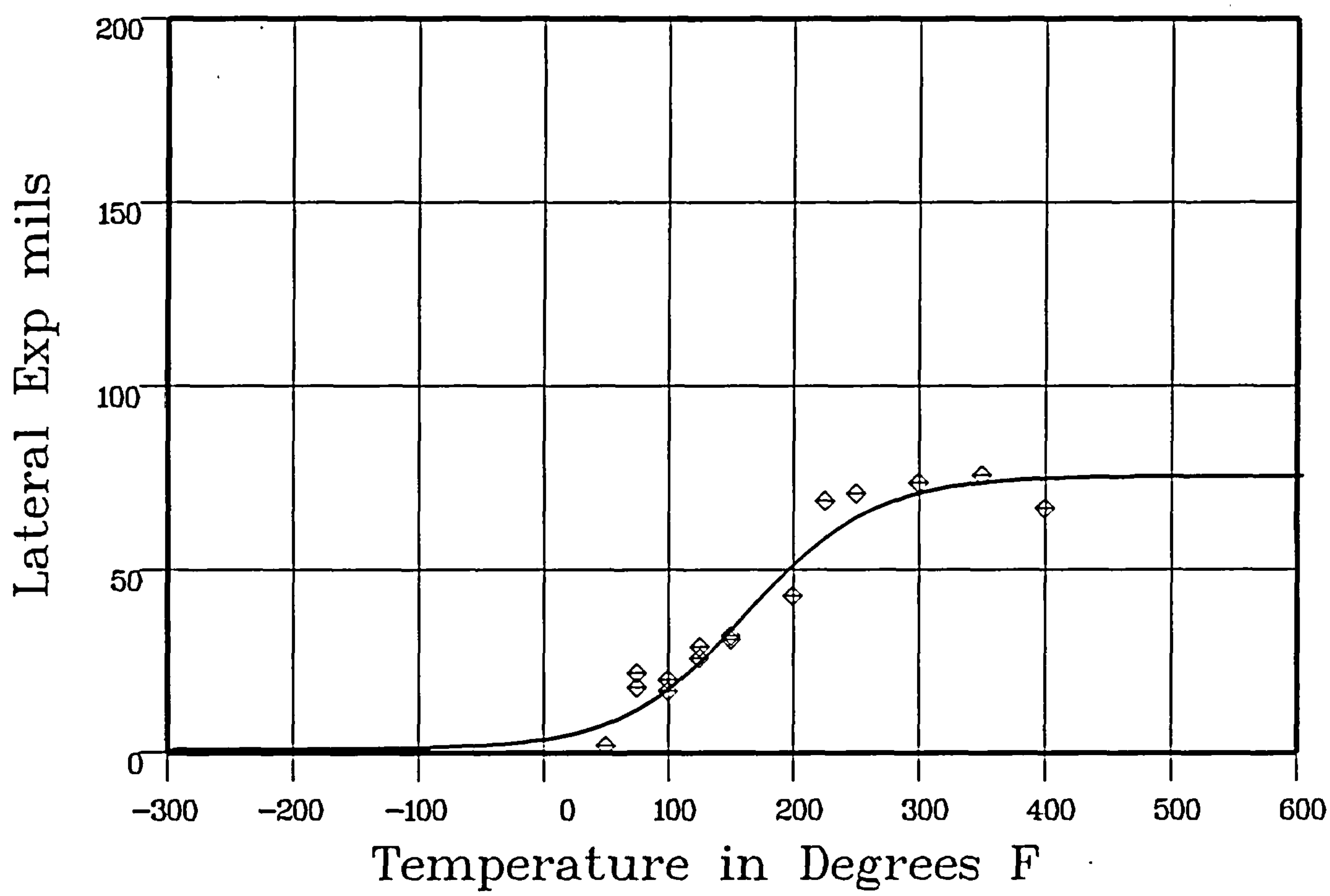
A = 38.35	B = 37.35	C = 100.48	T0 = 158.35

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 75.7 Temperature at L.E. 35: 149.3 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: U Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
50	2	8.74	-6.74
75	22	12.94	9.05
75	18	12.94	5.05
100	17	18.8	-1.8
100	20	18.8	1.19
125	29	26.38	2.61
125	26	26.38	-.38
150	32	35.25	-3.25

**** Data continued on next page ****

CAPSULE U (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
150	31	35.25	-4.25
200	43	53	-10
225	69	60.03	8.96
250	71	65.32	5.67
300	74	71.5	2.49
350	76	74.09	1.9
400	67	75.1	-8.1

SUM of RESIDUALS = 2.38

CAPSULE U (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:21:14 on 11-06-2003

Page 1

Coefficients of Curve 3

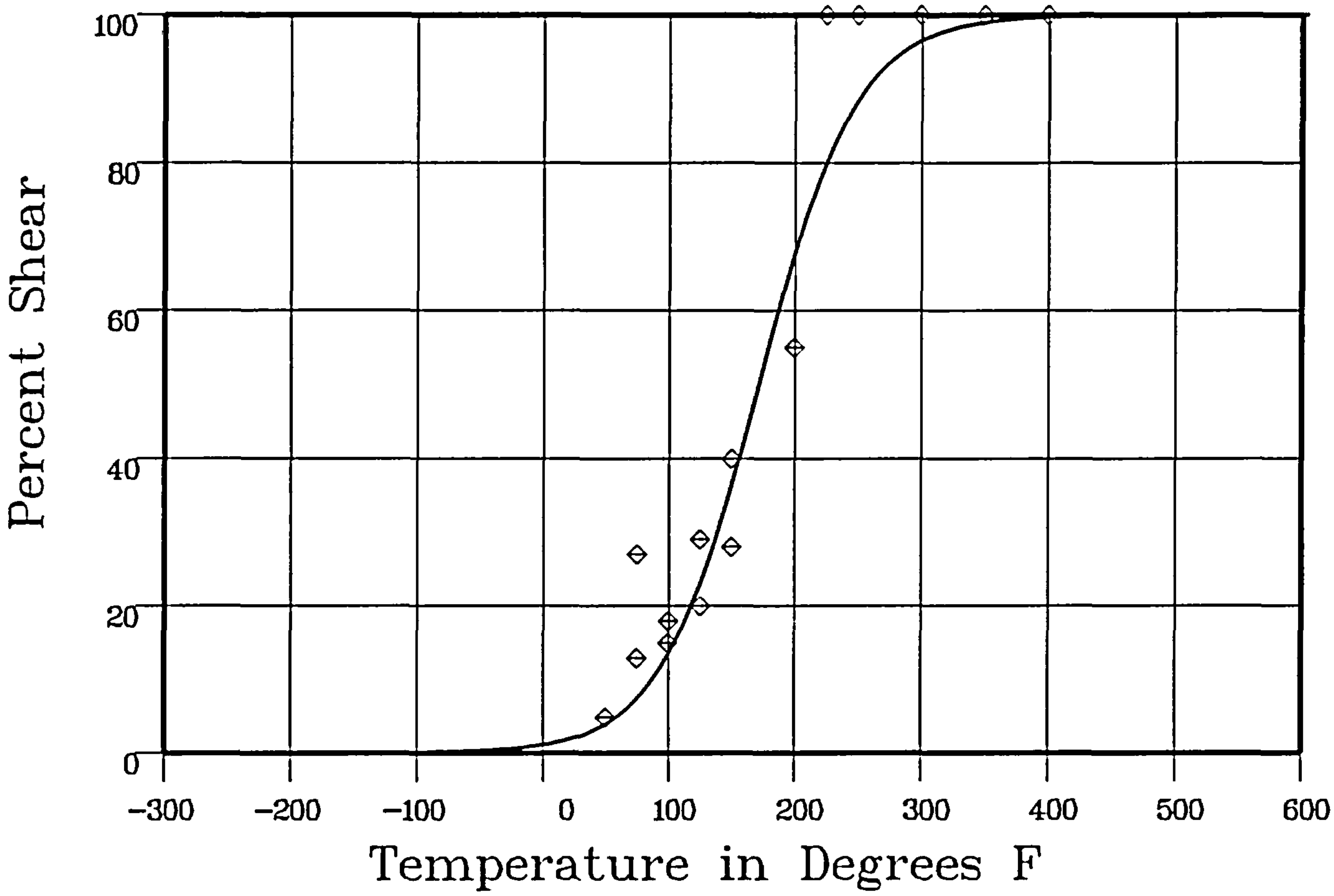
A = 50	B = 50	C = 77.11	T0 = 166.87

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 166.8

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: U Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
50	5	4.6	.39
75	27	8.44	18.55
75	13	8.44	4.55
100	18	15	2.99
100	15	15	0
125	29	25.23	3.76
125	20	25.23	-5.23
150	28	39.22	-11.22

**** Data continued on next page ****

CAPSULE U (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
150	40	39.22	.77
200	55	70.24	-15.24
225	100	81.86	18.13
250	100	89.62	10.37
300	100	96.93	3.06
350	100	99.14	.85
400	100	99.76	.23

SUM of RESIDUALS = 31.98

CAPSULE X (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:10:20 on 11-06-2003

Page 1

Coefficients of Curve 4

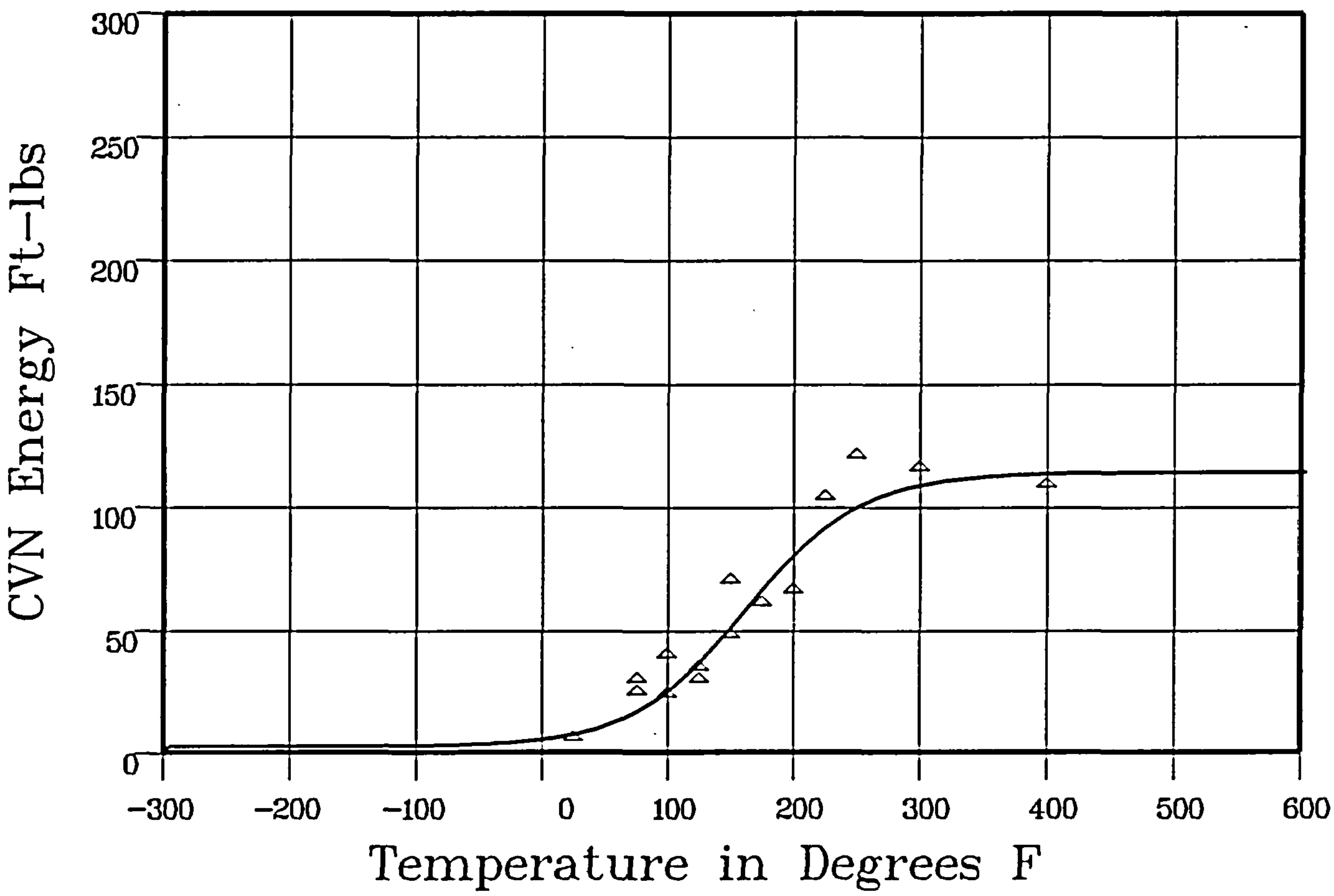
A = 58.09	B = 55.9	C = 91.74	T0 = 157.32

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 114 Fixed Temp. at 30 ft-lbs: 106.5 Temp. at 50 ft-lbs: 143.9 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	5	8.11	-3.11
76	24	18.43	5.56
76	29	18.43	10.56
100	23	27.1	-4.1
100	39	27.1	11.89
125	34	39.18	-5.18
125	29	39.18	-10.18

**** Data continued on next page ****

CAPSULE X (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
150	69	53.64	15.35
150	47	53.64	-6.64
175	60	68.73	-8.73
200	65	82.37	-17.37
225	103	93.18	9.81
250	120	100.9	19.09
300	115	109.22	5.77
400	108	113.43	-5.43

SUM of RESIDUALS = 17.27

CAPSULE X (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:16:42 on 11-06-2003

Page 1

Coefficients of Curve 4

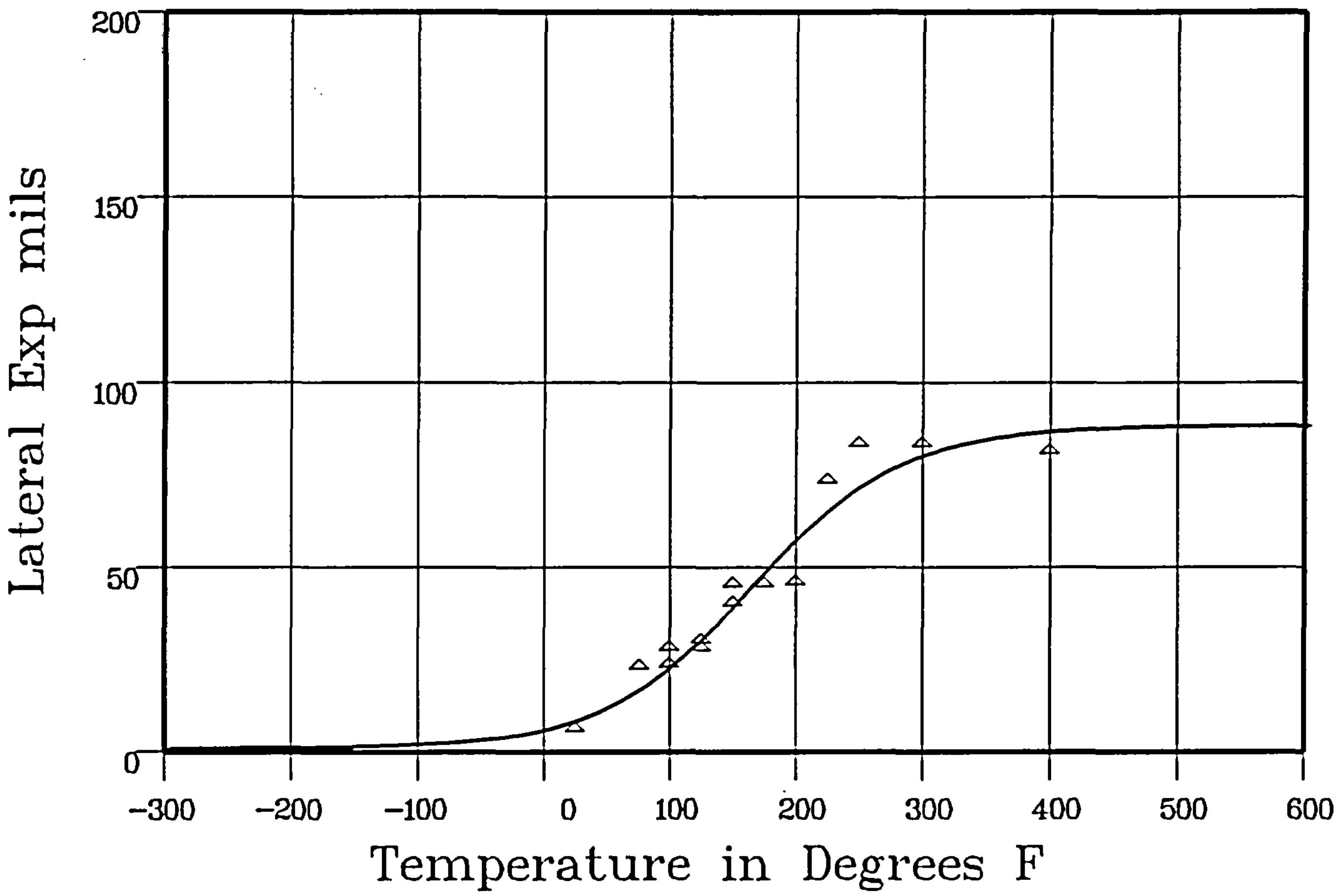
A = 44.78	B = 43.78	C = 119.58	T0 = 160.31

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 88.57 Temperature at L.E. 35: 133.1 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	6	9.25	-3.25
76	23	18.18	4.81
76	23	18.18	4.81
100	23.5	24.4	-.9
100	28	24.4	3.59
125	30	32.22	-2.22
125	28	32.22	-4.22

**** Data continued on next page ****

CAPSULE X (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
150	45	41.02	3.97
150	40	41.02	-1.02
175	45	50.13	-5.13
200	45.5	58.8	-13.3
225	73	66.4	6.59
250	83	72.59	10.4
300	83	80.85	2.14
400	81	87.01	-6.01

SUM of RESIDUALS = .27

CAPSULE X (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:21:14 on 11-06-2003

Page 1

Coefficients of Curve 4

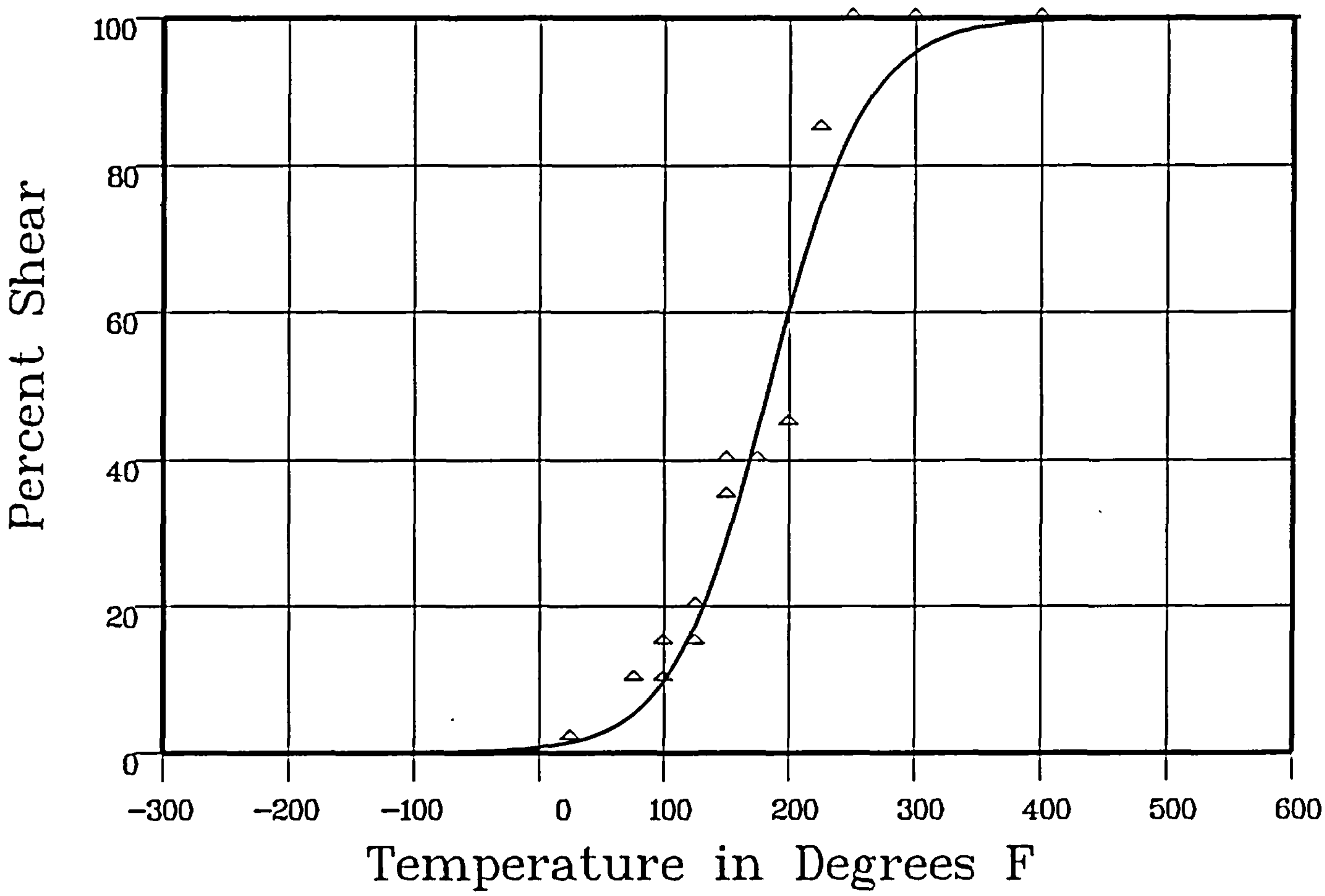
A = 50	B = 50	C = 76.2	T0 = 179.53

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 179.5

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	2	1.7	.29
76	10	6.19	3.8
76	10	6.19	3.8
100	10	11.03	-1.03
100	15	11.03	3.96
125	20	19.29	.7
125	15	19.29	-4.29

**** Data continued on next page ****

CAPSULE X (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
150	40	31.53	8.46
150	35	31.53	3.46
175	40	47.03	-7.03
200	45	63.11	-18.11
225	85	76.73	8.26
250	100	86.4	13.59
300	100	95.93	4.06
400	100	99.69	.3

SUM of RESIDUALS = 20.25

CAPSULE W (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:10:20 on 11-06-2003
Page 1
Coefficients of Curve 5

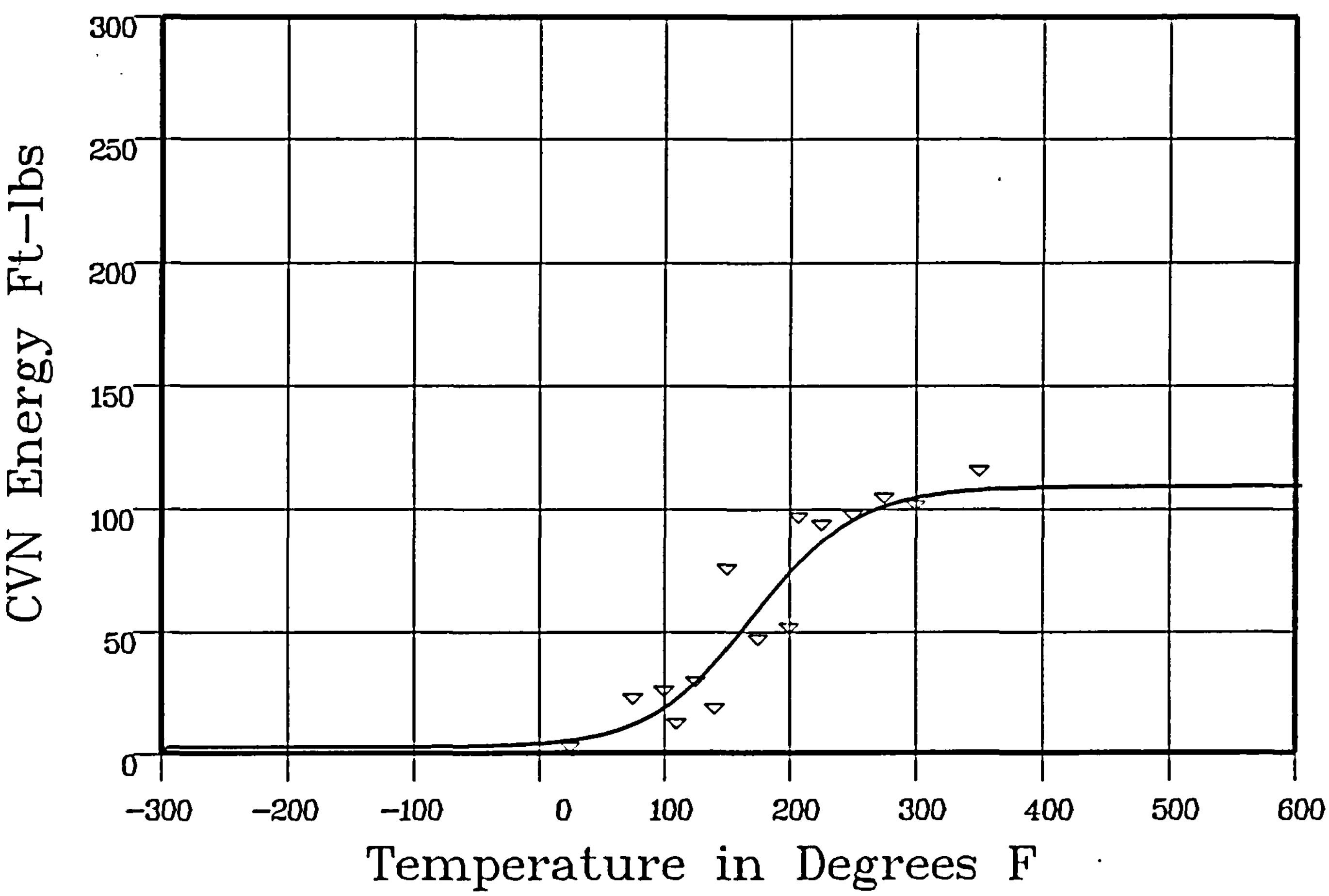
A = 55.59	B = 53.4	C = 83.03	T0 = 165.82

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 109 Fixed Temp. at 30 ft-lbs: 122.4 Temp. at 50 ft-lbs: 157 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: W Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap.: W Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	4	5.67	-1.67
75	24	12.97	11.02
100	27	20.35	6.64
110	14	24.28	-10.28
125	31	31.27	-.27
140	20	39.5	-19.5

**** Data continued on next page ****

CAPSULE W (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
150	77	45.54	31.45
175	48	61.47	-13.47
200	53	76.41	-23.41
207	98	80.1	17.89
225	95	88.3	6.69
250	99	96.57	2.42
275	106	101.81	4.18
300	103	104.94	-1.94
350	117	107.75	9.24

SUM of RESIDUALS = 18.98

CAPSULE W (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:16:42 on 11-06-2003

Page 1

Coefficients of Curve 5

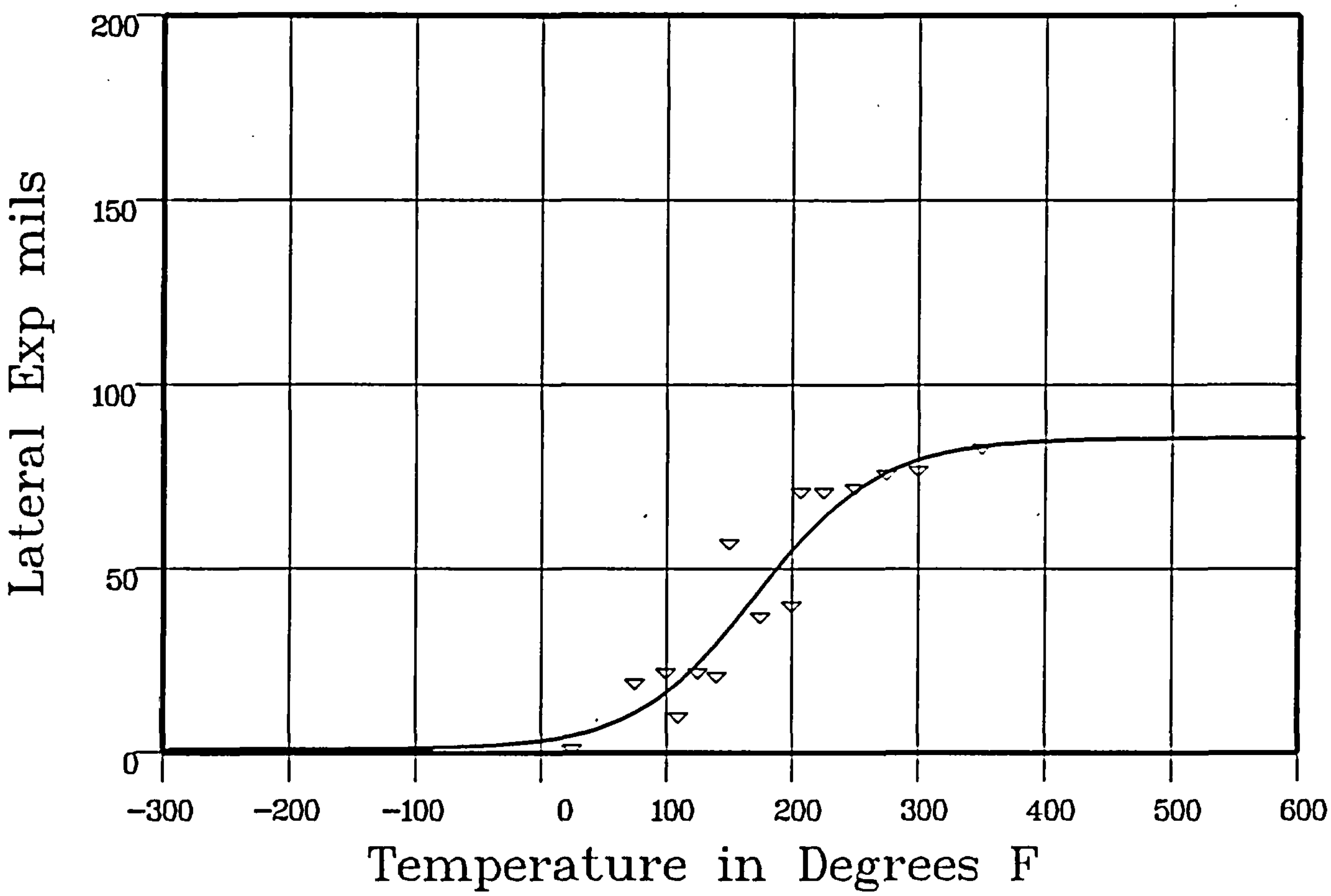
A = 43.38	B = 42.38	C = 97.85	T0 = 167.57

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 85.77 Temperature at L.E. 35: 147.9 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	2	5.36	-3.36
75	20	12.1	7.89
100	23	18.02	4.97
110	11	20.97	-9.97
125	23	26.02	-3.02
140	22	31.74	-9.74

**** Data continued on next page ****

CAPSULE W (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
150	58	35.85	22.14
175	38	46.59	-8.59
200	41	56.93	-15.93
207	72	59.59	12.4
225	72	65.74	6.25
250	73	72.5	.49
275	77	77.28	-.28
300	78	80.46	-2.46
350	84	83.78	.21

SUM of RESIDUALS = .98

CAPSULE W (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:21:14 on 11-06-2003

Page 1

Coefficients of Curve 5

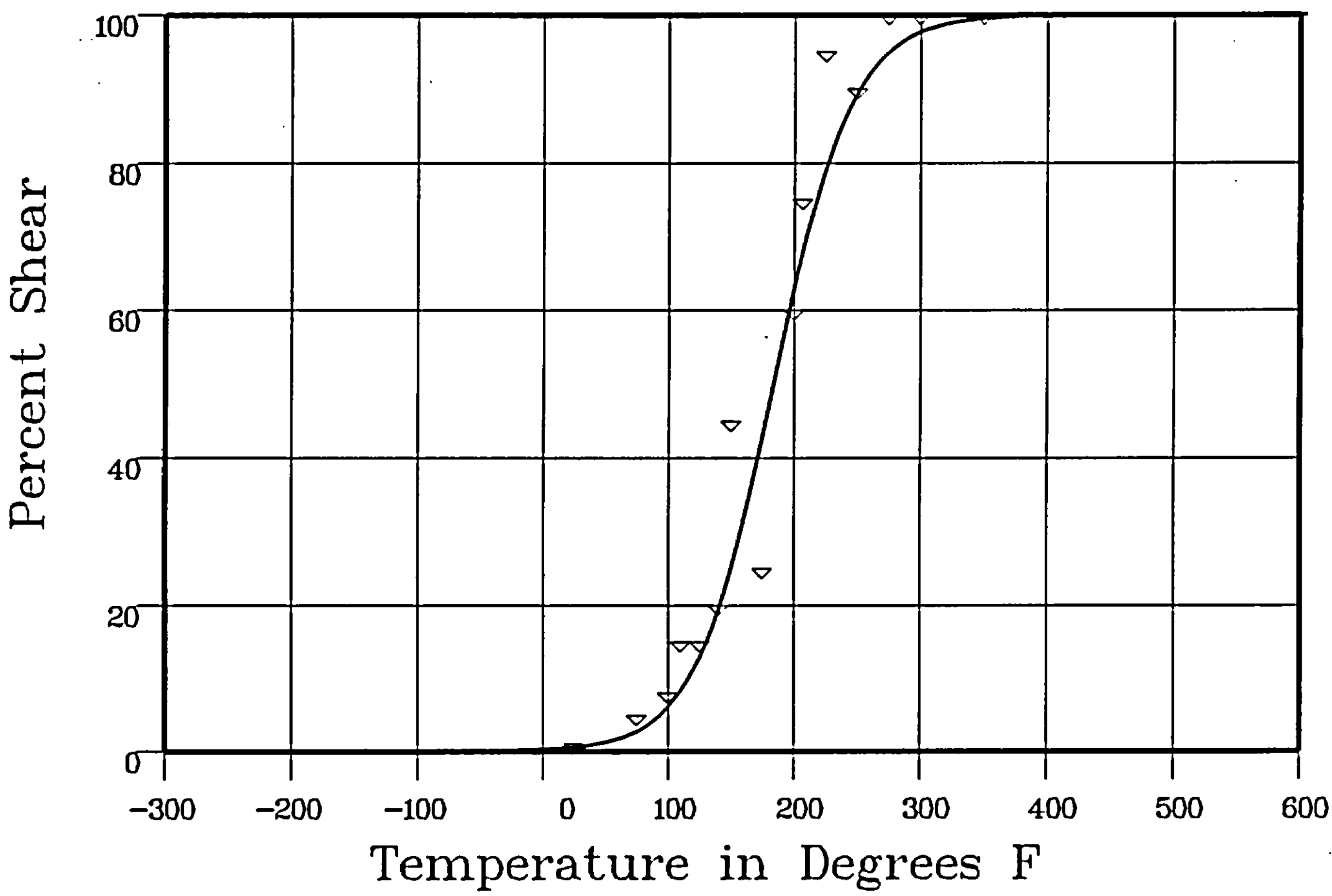
A = 50	B = 50	C = 61.72	T0 = 179.18

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 179.1

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	1	.67	.32
75	5	3.3	1.69
100	8	7.13	.86
110	15	9.6	5.39
125	15	14.73	.26
140	20	21.93	-1.93

**** Data continued on next page ****

CAPSULE W (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
150	45	27.98	17.01
175	25	46.61	-21.61
200	60	66.25	-6.25
207	75	71.12	3.87
225	95	81.52	13.47
250	90	90.84	-.84
275	100	95.7	4.29
300	100	98.04	1.95
350	100	99.6	.39

SUM of RESIDUALS = 18.89

CAPSULE V (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:04:41 on 11-05-2003

Page 1

Coefficients of Curve 2

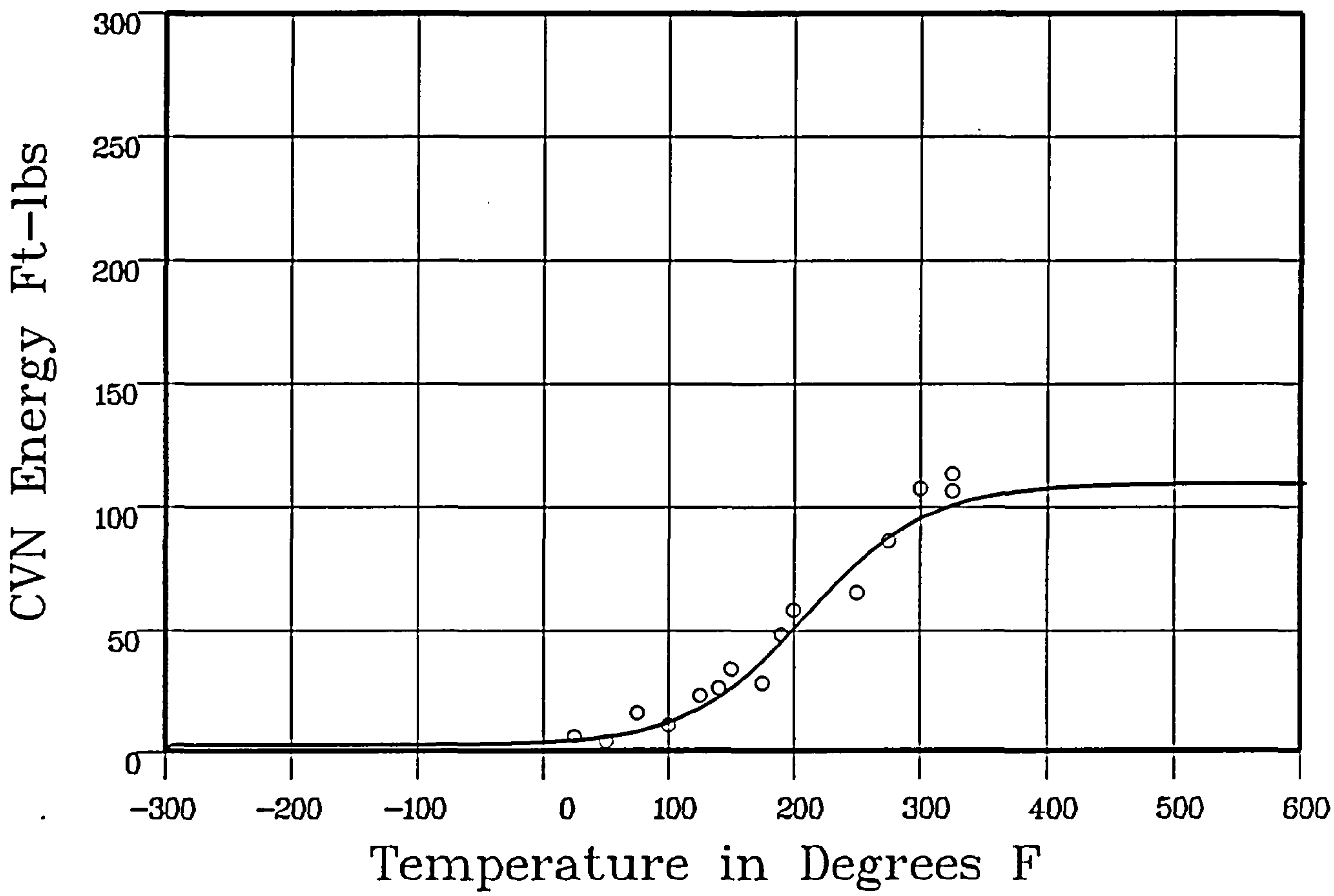
A = 55.59	B = 53.4	C = 95.63	T0 = 204.84

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 109 Fixed   Temp. at 30 ft-lbs: 154.9   Temp. at 50 ft-lbs: 194.7   Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1   Heat Number: C6940-1   Orientation: LT

Capsule: V   Total Fluence:



Data Set(s) Plotted

Plant: FA1   Cap.: V   Material: PLATE SA533B1   Ori.: LT   Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	6	4.62	1.37
50	4	6.23	-2.23
75	16	8.82	7.17
100	11	12.92	-1.92
125	23	19.12	3.87
140	26	24.08	1.91
150	34	27.94	6.05
175	28	39.45	-11.45

**** Data continued on next page ****

CAPSULE V (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
190	48	47.37	.62
200	58	52.89	5.1
250	65	79.09	-14.09
275	86	88.98	-2.98
300	107	96.15	10.84
325	106	100.99	5
325	113	100.99	12

SUM of RESIDUALS = 21.27

CAPSULE V (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:07:39 on 11-05-2003

Page 1

Coefficients of Curve 2

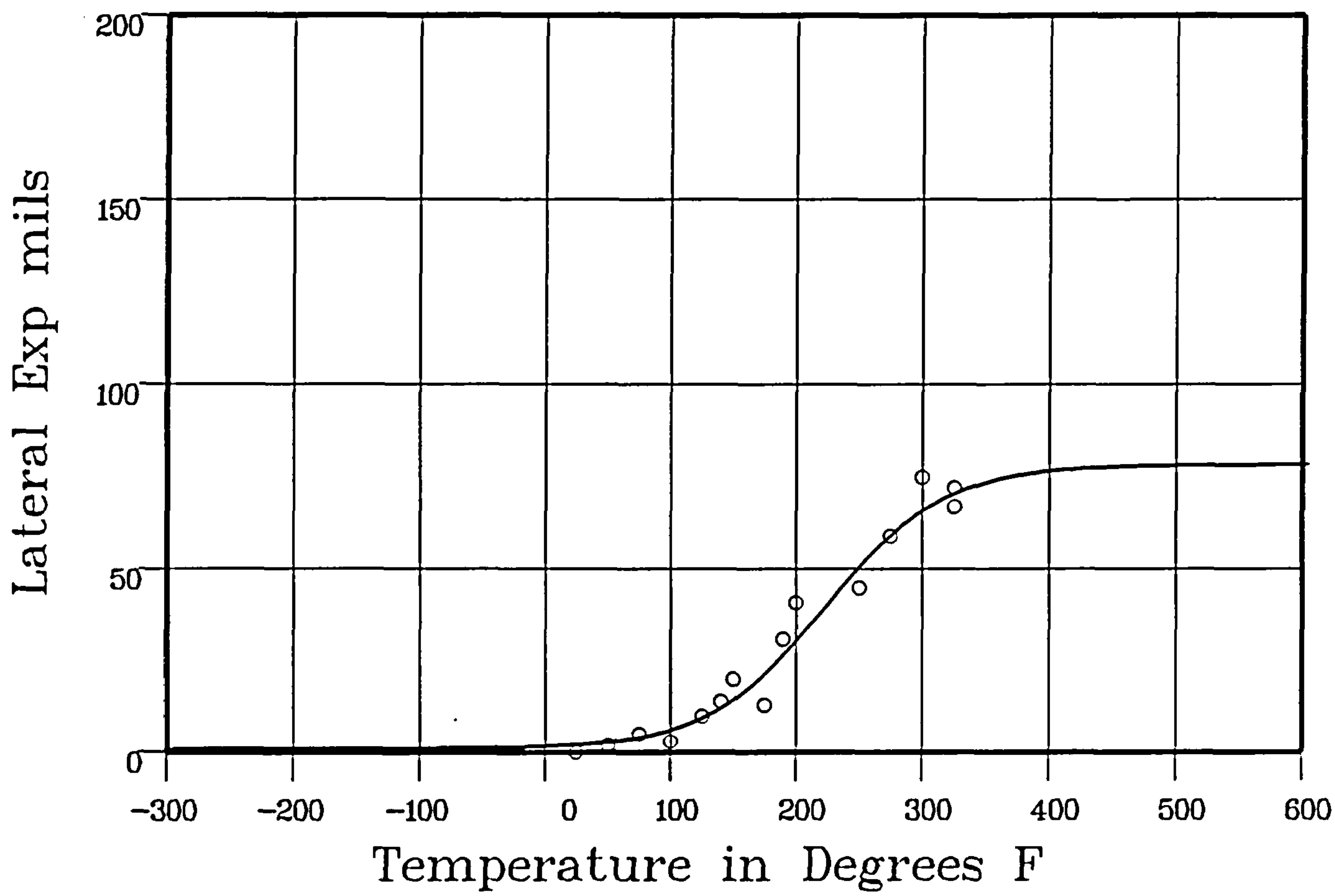
A = 39.63	B = 38.63	C = 93.31	T0 = 218.26

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 78.27 Temperature at L.E. 35: 207 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	0	2.2	-2.2
50	2	3.04	-1.04
75	5	4.42	.57
100	3	6.67	-3.67
125	10	10.22	-.22
140	14	13.16	.83
150	20	15.52	4.47
175	13	22.9	-9.9

**** Data continued on next page ****

CAPSULE V (LONGITUDINAL)

Page 2

Material: PLATE SA533B1   Heat Number: C6940-1   Orientation: LT

Capsule: V   Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
190	31	28.28	2.71
200	41	32.17	8.82
250	45	52.29	-7.29
275	59	60.6	-1.6
300	75	66.85	8.14
325	67	71.15	-4.15
325	72	71.15	.84

SUM of RESIDUALS = -3.71

CAPSULE V (LONGITUDINAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:10:08 on 11-05-2003

Page 1

Coefficients of Curve 2

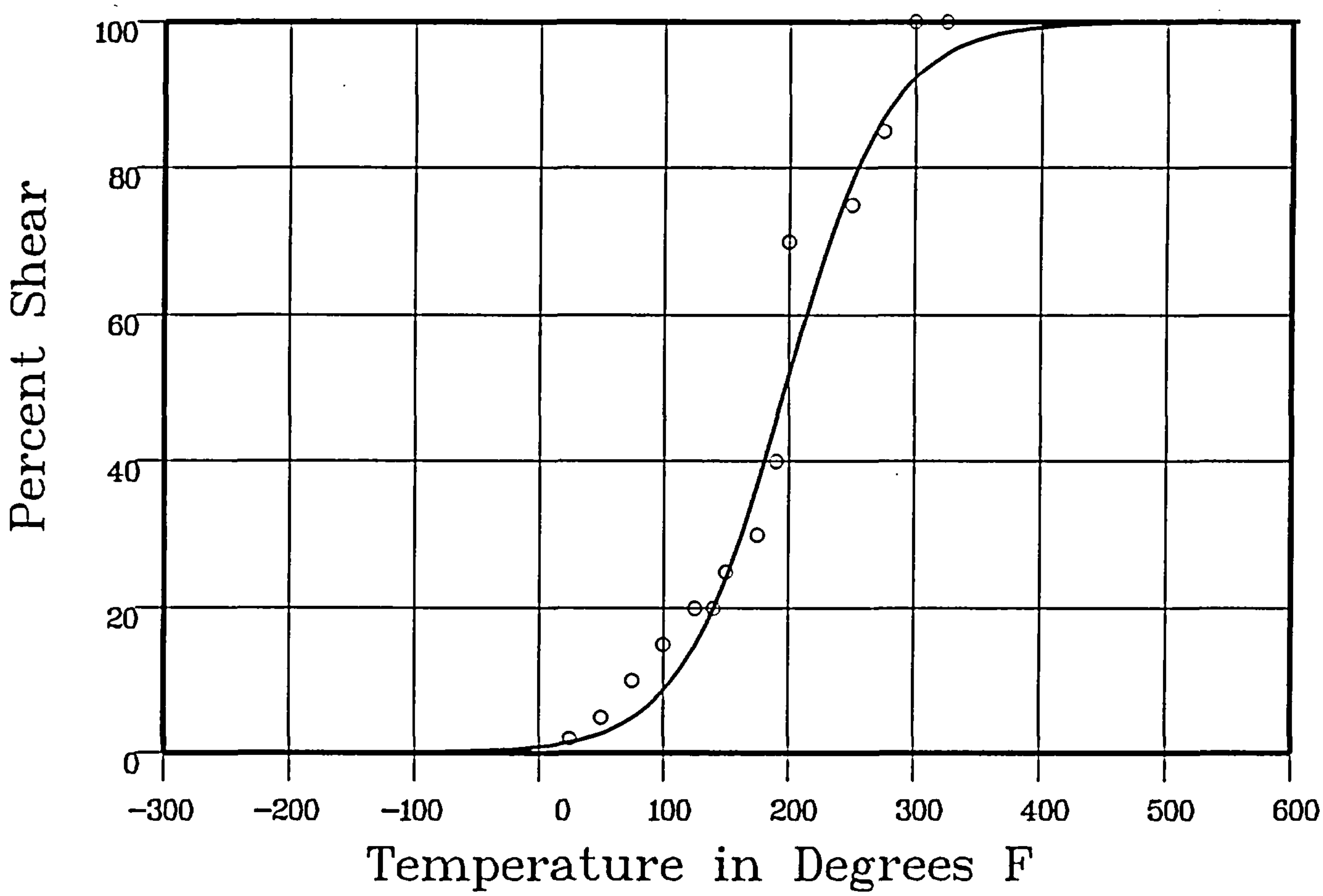
A = 50	B = 50	C = 82.66	T0 = 192.74

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 192.7

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: PLATE SA533B1 Ori.: LT Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	2	1.69	.3
50	5	3.06	1.93
75	10	5.47	4.52
100	15	9.58	5.41
125	20	16.25	3.74
140	20	21.82	-1.82
150	25	26.22	-1.22
175	30	39.42	-9.42

**** Data continued on next page ****

CAPSULE V (LONGITUDINAL)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: LT

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
190	40	48.33	-8.33
200	70	54.37	15.62
250	75	79.98	-4.98
275	85	87.97	-2.97
300	100	93.05	6.94
325	100	96.08	3.91
325	100	96.08	3.91

SUM of RESIDUALS = 17.55

UNIRRADIATED (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:45:39 on 11-06-2003

Page 1

Coefficients of Curve 1

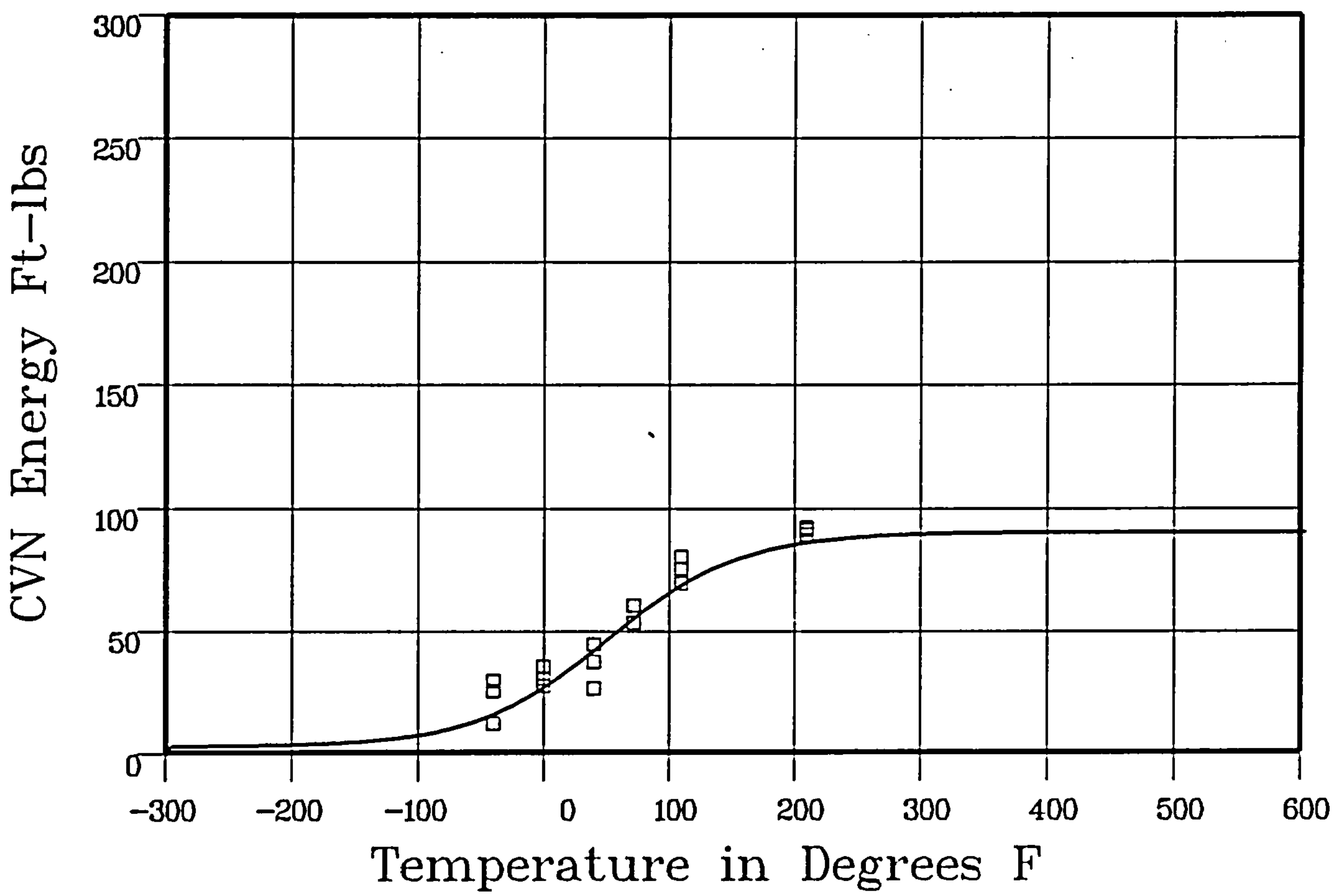
A = 46.09	B = 43.9	C = 105.92	T0 = 45.93

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 90 Fixed Temp. at 30 ft-lbs: 5.1 Temp. at 50 ft-lbs: 55.3 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	25	16.67	8.32
-40	29	16.67	12.32
-40	12	16.67	-4.67
0	27	28.17	-1.17
0	35	28.17	6.82
0	30	28.17	1.82
40	26	43.64	-17.64
40	37	43.64	-6.64
40	44	43.64	.35

**** Data continued on next page ****

UNIRRADIATED (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
72	53	56.68	-3.68
72	53	56.68	-3.68
72	60	56.68	3.31
110	80	69.82	10.17
110	69	69.82	-.82
110	75	69.82	5.17
210	89	86.2	2.79
210	91	86.2	4.79
210	92	86.2	5.79

SUM of RESIDUALS = 23.37

UNIRRADIATED (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:27:34 on 11-06-2003

Page 1

Coefficients of Curve 1

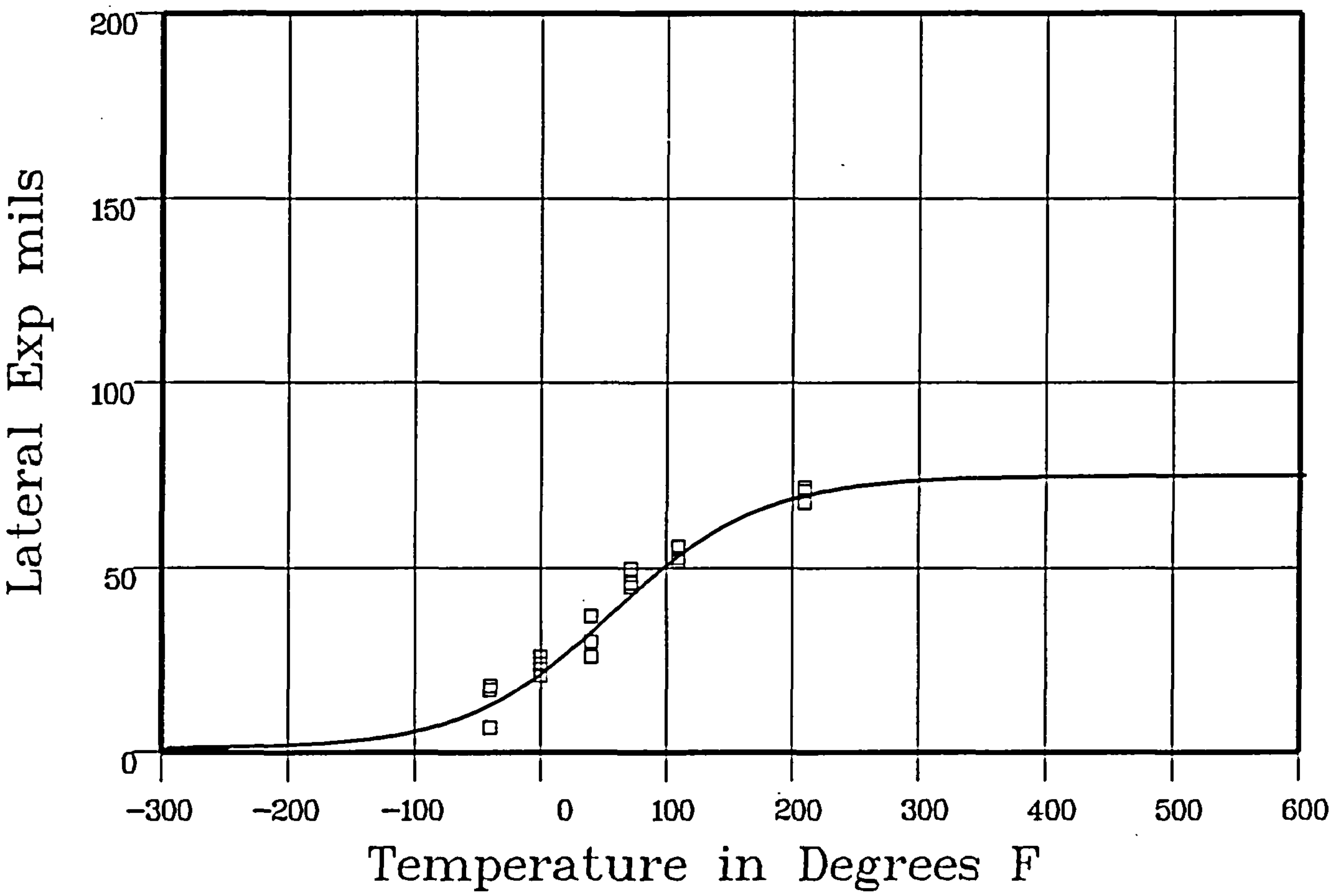
A = 38.04	B = 37.04	C = 118.3	T0 = 52.5

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 75.09 Temperature at L.E. 35: 42.7 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	17	13.82	3.17
-40	18	13.82	4.17
-40	7	13.82	-6.82
0	24	22.6	1.39
0	26	22.6	3.39
0	21	22.6	-1.6
40	26	34.14	-8.14
40	30	34.14	-4.14
40	37	34.14	2.85

**** Data continued on next page ****

UNIRRADIATED (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
72	45	44.1	.89
72	46	44.1	1.89
72	50	44.1	5.89
110	52	54.76	-2.76
110	53	54.76	-1.76
110	56	54.76	1.23
210	68	70.26	-2.26
210	72	70.26	1.73
210	71	70.26	.73

SUM of RESIDUALS = -.14

UNIRRADIATED (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:34:17 on 11-06-2003

Page 1

Coefficients of Curve 1

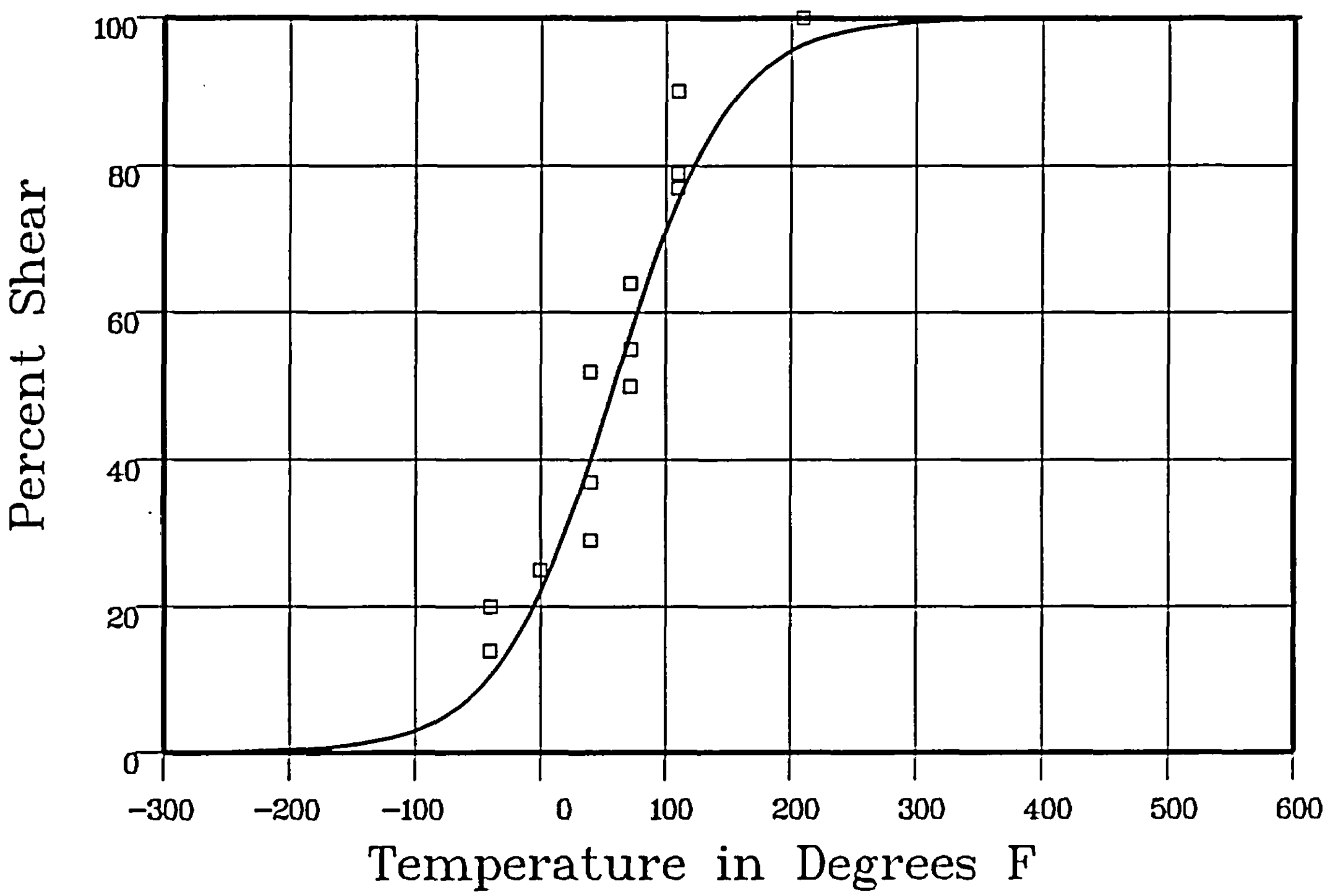
A = 50	B = 50	C = 92.47	T0 = 53.9

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 53.9

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-40	14	11.59	2.4
-40	20	11.59	8.4
-40	14	11.59	2.4
0	25	23.75	1.24
0	25	23.75	1.24
0	25	23.75	1.24
40	37	42.53	-5.53
40	29	42.53	-13.53
40	52	42.53	9.46

**** Data continued on next page ****

UNIRRADIATED (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72	64	59.66	4.33
72	50	59.66	-9.66
72	55	59.66	-4.66
110	90	77.08	12.91
110	79	77.08	1.91
110	77	77.08	-.08
210	100	96.69	3.3
210	100	96.69	3.3
210	100	96.69	3.3

SUM of RESIDUALS = 21.98

CAPSULE Y (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:45:39 on 11-06-2003

Page 1

Coefficients of Curve 2

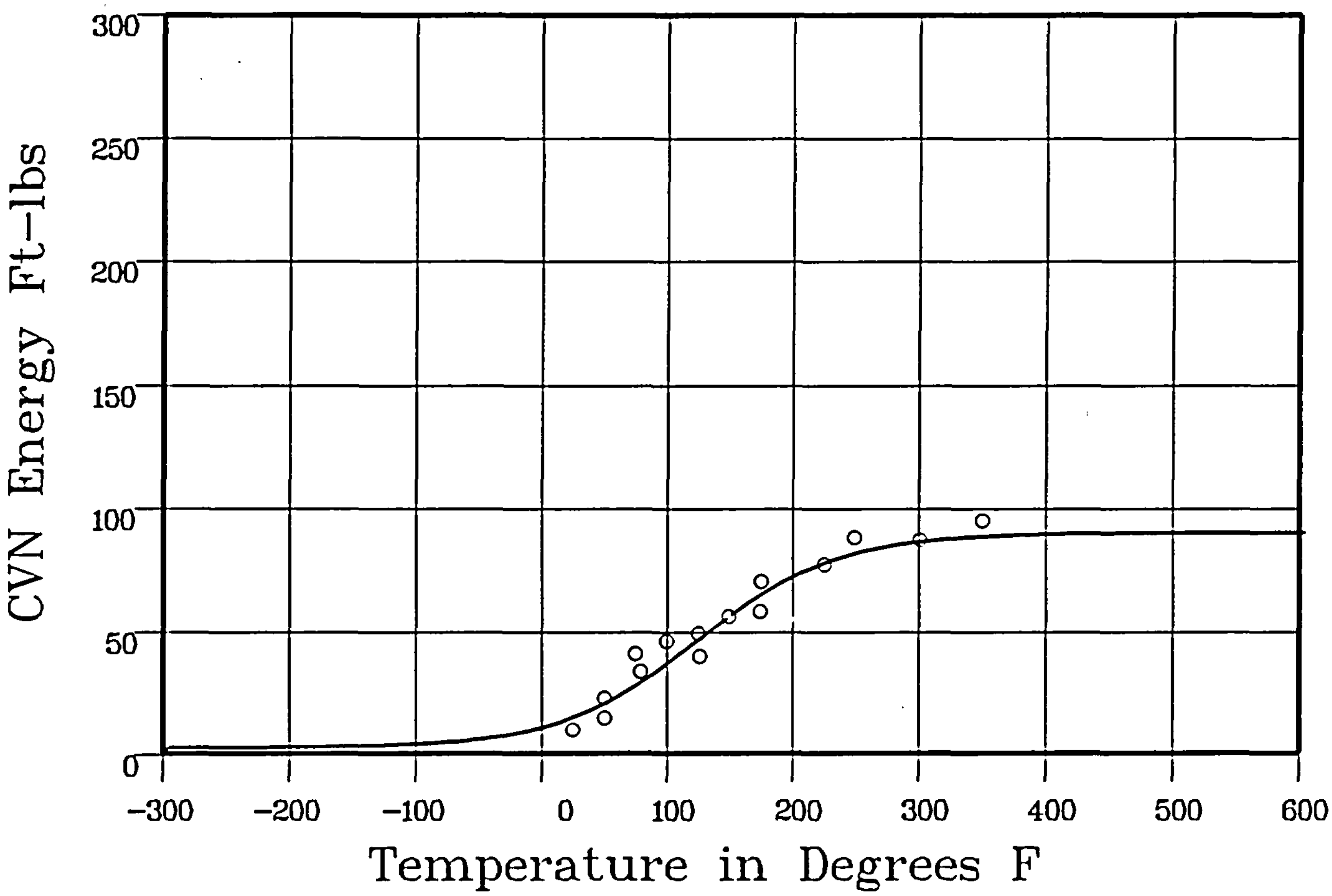
A = 46.09	B = 43.9	C = 112.57	T0 = 118.94

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 90 Fixed   Temp. at 30 ft-lbs: 75.6   Temp. at 50 ft-lbs: 128.9   Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1   Heat Number: C6940-1   Orientation: TL

Capsule: Y   Total Fluence:



Data Set(s) Plotted

Plant: FA1   Cap: Y   Material: PLATE SA533B1   Ori: TL   Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	10	16.12	-6.12
50	23	22.13	.86
50	15	22.13	-7.13
75	41	29.78	11.21
79	34	31.14	2.85
100	46	38.78	7.21
125	49	48.45	.54
126	40	48.84	-8.84

**** Data continued on next page ****

CAPSULE Y (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
149	56	57.54	-1.54
174	58	66	-8
175	70	66.31	3.68
225	77	78.41	-1.41
249	88	82.07	5.92
301	87	86.67	.32
350	95	88.57	6.42

SUM of RESIDUALS = 5.97

CAPSULE Y (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:27:34 on 11-06-2003
Page 1
Coefficients of Curve 2

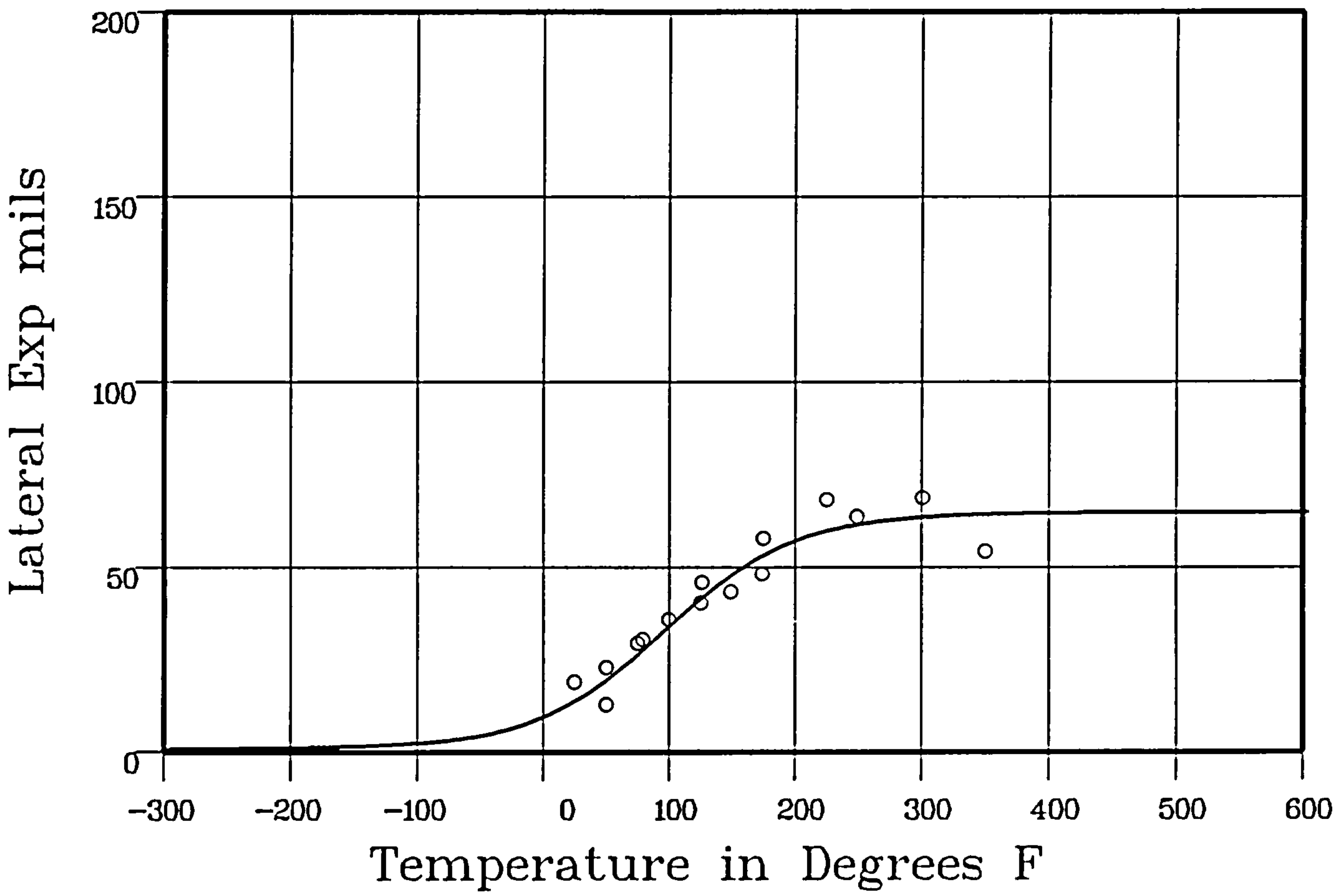
A = 33	B = 32	C = 103.89	T0 = 91.99

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 65.01 Temperature at L.E. 35: 98.4 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: Y Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap: Y Material: PLATE SA533B1 Ori: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	19	14.82	4.17
50	23	20.73	2.26
50	13	20.73	-7.73
75	29.5	27.82	1.67
79	30.5	29.02	1.47
100	36	35.47	.52
125	40.5	42.85	-2.35
126	46	43.12	2.87

**** Data continued on next page ****

CAPSULE Y (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
149	43.5	49	-5.5
174	48.5	54.07	-5.57
175	58	54.24	3.75
225	68.5	60.42	8.07
249	64	62.04	1.95
301	69	63.89	5.1
350	54.5	64.57	-10.07

SUM of RESIDUALS = .64

CAPSULE Y (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:34:17 on 11-06-2003

Page 1

Coefficients of Curve 2

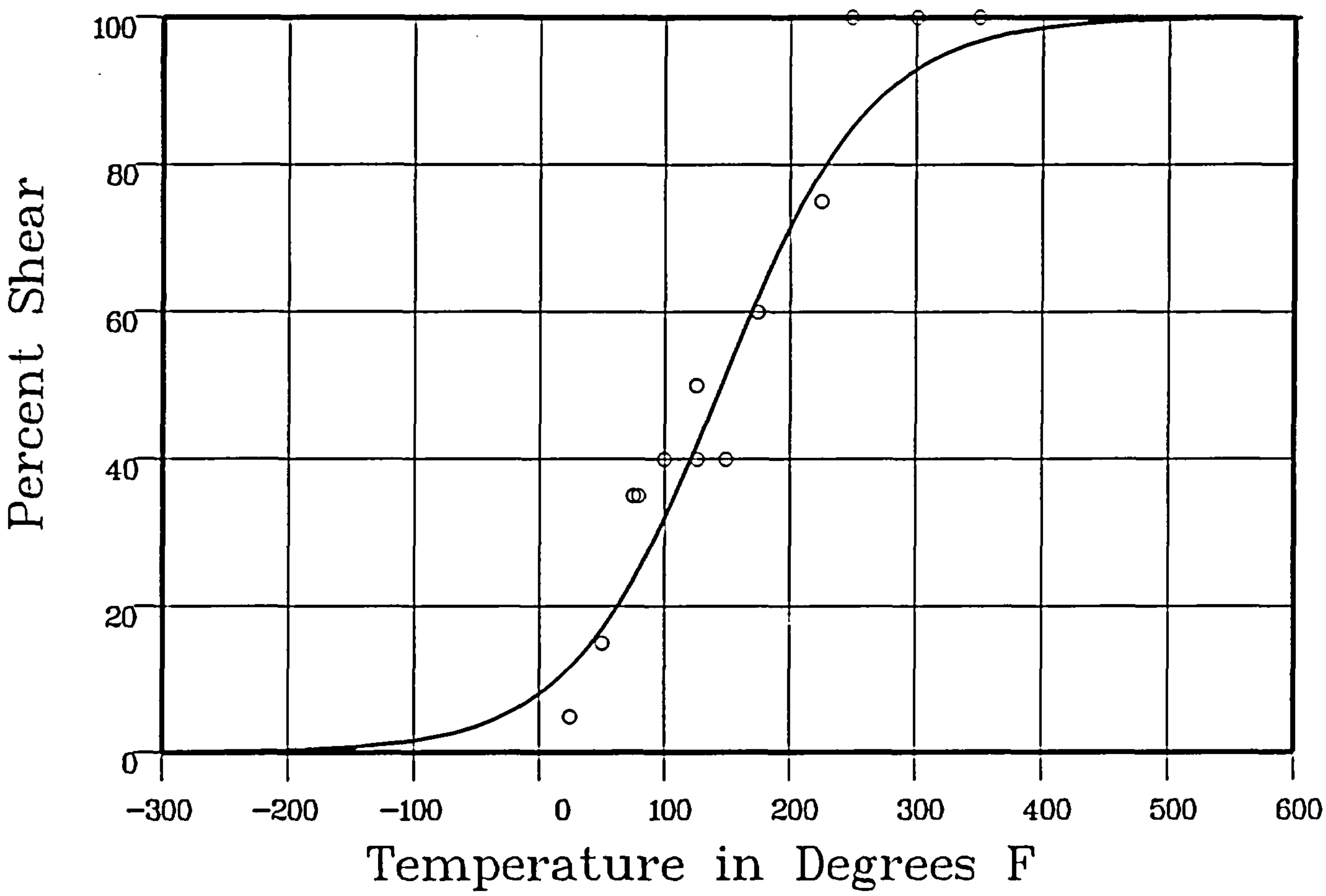
A = 50	B = 50	C = 119.71	T0 = 140.64

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 140.6

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: Y Material: PLATE SA533B1 Ori: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	5	12.65	-7.65
50	15	18.02	-3.02
50	15	18.02	-3.02
75	35	25.03	9.96
79	35	26.31	8.68
100	40	33.64	6.35
125	50	43.5	6.49
126	40	43.91	-3.91

**** Data continued on next page ****

CAPSULE Y (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
149	40	53.48	-13.48
174	60	63.58	-3.58
175	60	63.96	-3.96
225	75	80.36	-5.36
249	100	85.93	14.06
301	100	93.57	6.42
350	100	97.06	2.93

SUM of RESIDUALS = 10.89

CAPSULE U (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:45:39 on 11-06-2003

Page 1

Coefficients of Curve 3

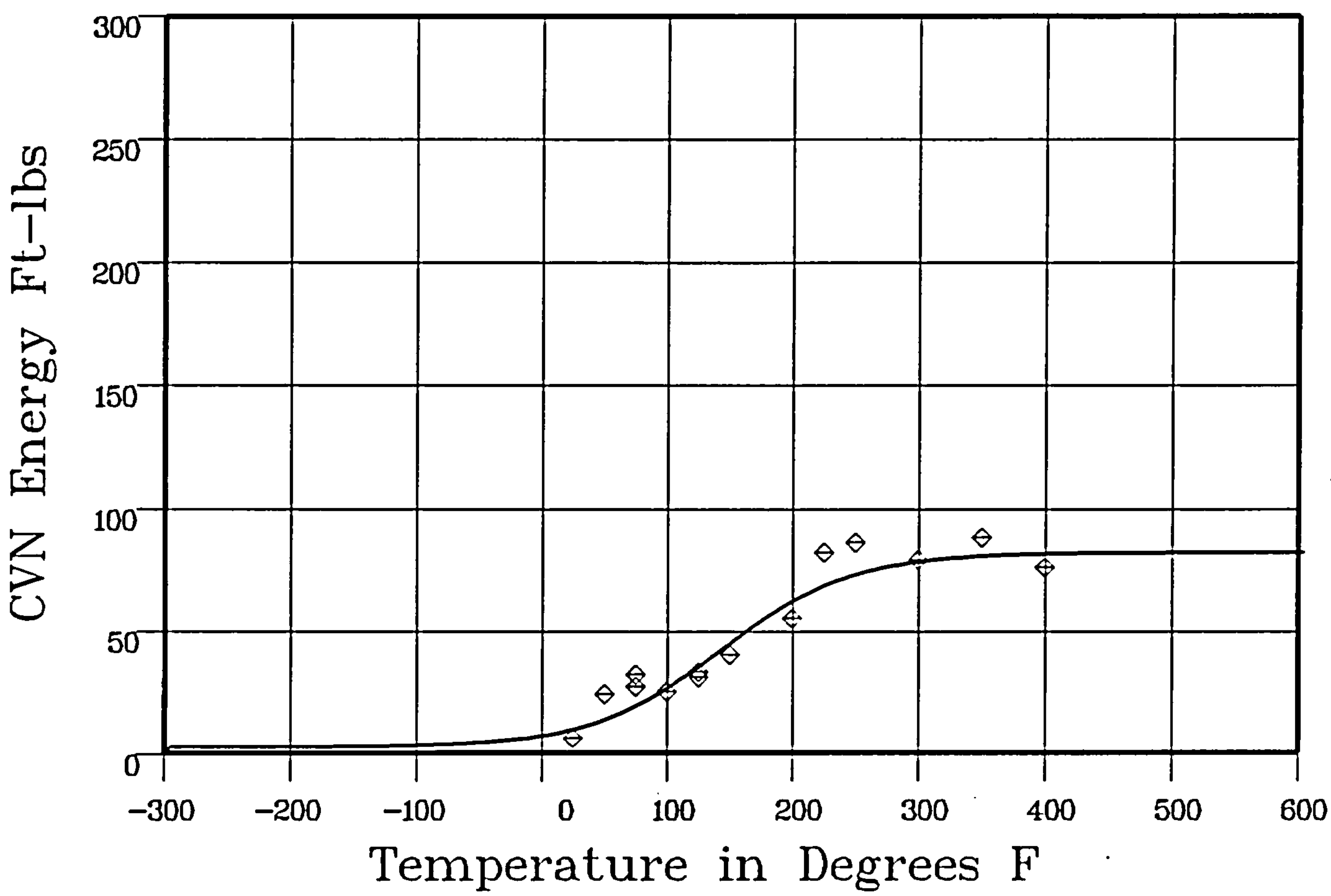
A = 42.09	B = 39.9	C = 104.04	T0 = 138.28

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 82 Fixed Temp. at 30 ft-lbs: 105.7 Temp. at 50 ft-lbs: 159.1 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: U Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	6	10.32	-4.32
50	24	14.55	9.44
75	32	20.44	11.55
75	27	20.44	6.55
100	25	28.04	-3.04
100	25	28.04	-3.04
125	31	37.03	-6.03
125	33	37.03	-4.03

**** Data continued on next page ****

CAPSULE U (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
150	40	46.57	-6.57
200	55	63.33	-8.33
225	82	69.32	12.67
250	86	73.65	12.34
300	79	78.58	.41
350	88	80.65	7.34
400	76	81.48	-5.48

SUM of RESIDUALS = 19.45

CAPSULE U (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:27:34 on 11-06-2003

Page 1

Coefficients of Curve 3

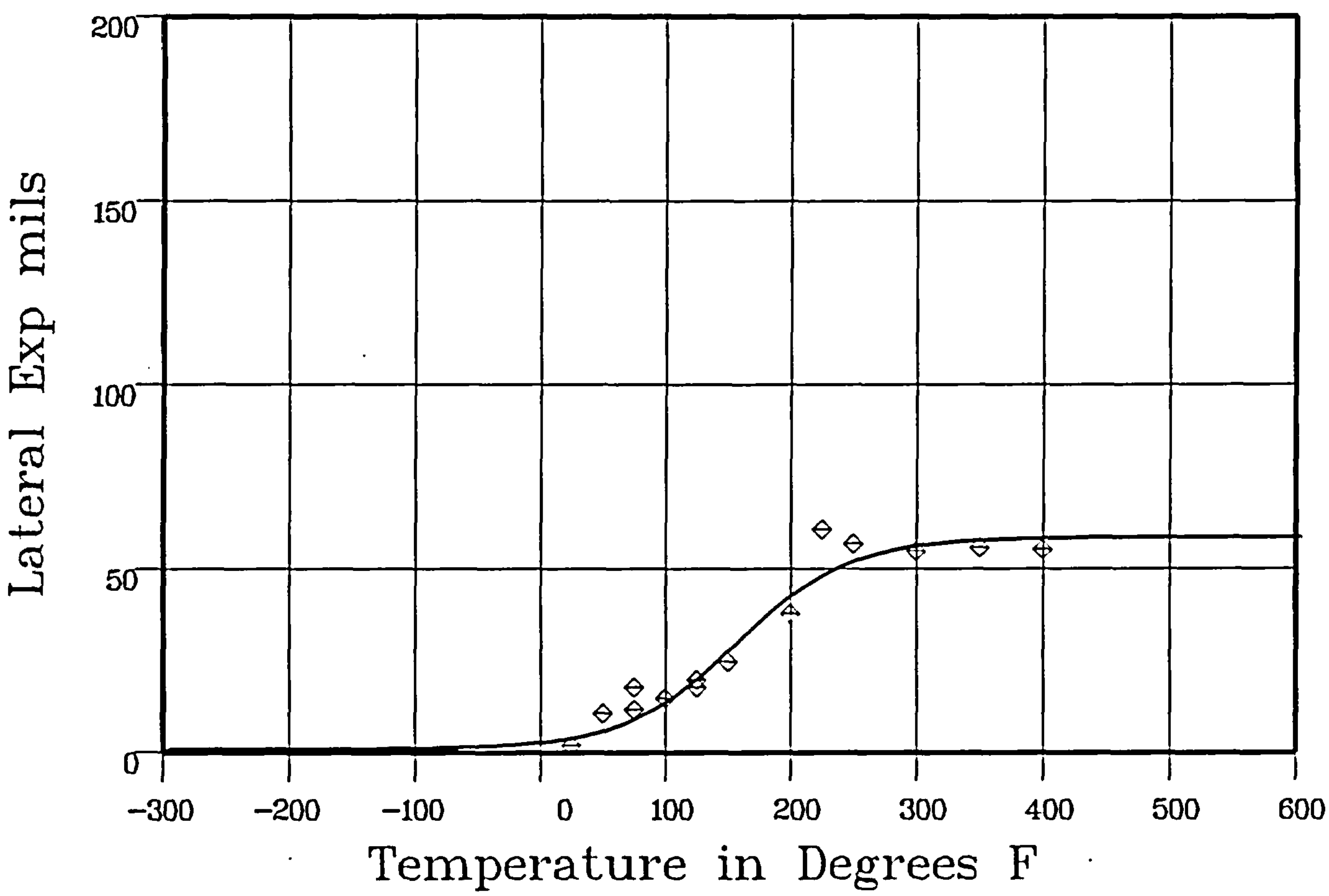
A = 29.89	B = 28.89	C = 91.28	T0 = 151.7

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 58.78 Temperature at L.E. 35: 168 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: U Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	2	4.38	-2.38
50	11	6.61	4.38
75	18	10.07	7.92
75	12	10.07	1.92
100	15	15.08	-.08
100	15	15.08	-.08
125	18	21.67	-3.67
125	20	21.67	-1.67

**** Data continued on next page ****

CAPSULE U (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
150	25	29.35	-4.35
200	38	43.89	-5.89
225	61	49.12	11.87
250	57	52.77	4.22
300	55	56.63	-1.63
350	56	58.04	-2.04
400	55.5	58.53	-3.03

SUM of RESIDUALS = 5.44

CAPSULE U (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:34:17 on 11-06-2003
Page 1
Coefficients of Curve 3

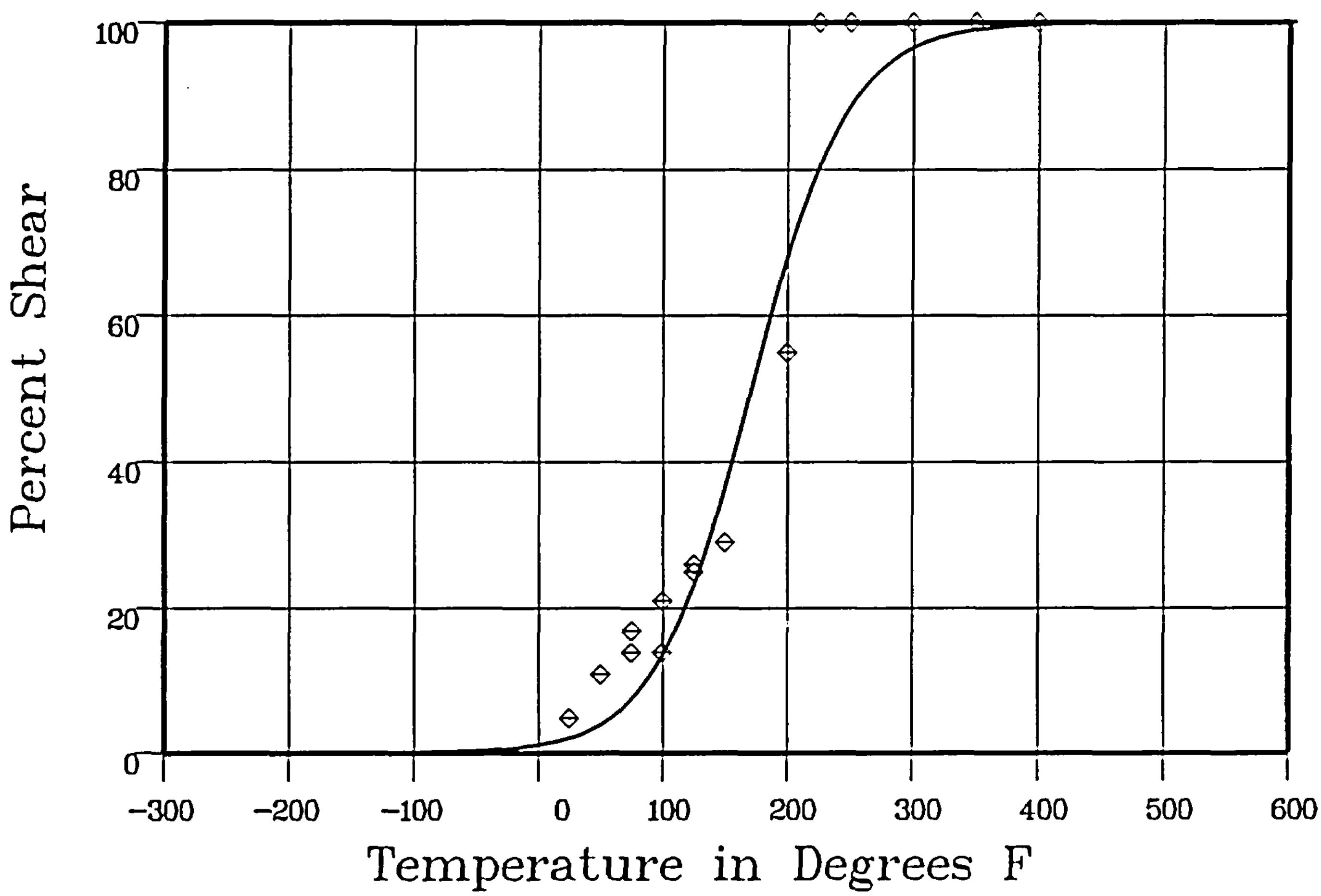
A = 50	B = 50	C = 76.98	T0 = 166.4

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 166.4

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: U Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap.: U Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	5	2.47	2.52
50	11	4.63	6.36
75	17	8.51	8.48
75	14	8.51	5.48
100	14	15.11	-1.11
100	21	15.11	5.88
125	25	25.43	-.43
125	26	25.43	.56

**** Data continued on next page ****

CAPSULE U (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
150	29	39.5	-10.5
200	55	70.53	-15.53
225	100	82.08	17.91
250	100	89.76	10.23
300	100	96.98	3.01
350	100	99.15	.84
400	100	99.76	.23

SUM of RESIDUALS = 33.96

CAPSULE X (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:45:39 on 11-06-2003

Page 1

Coefficients of Curve 4

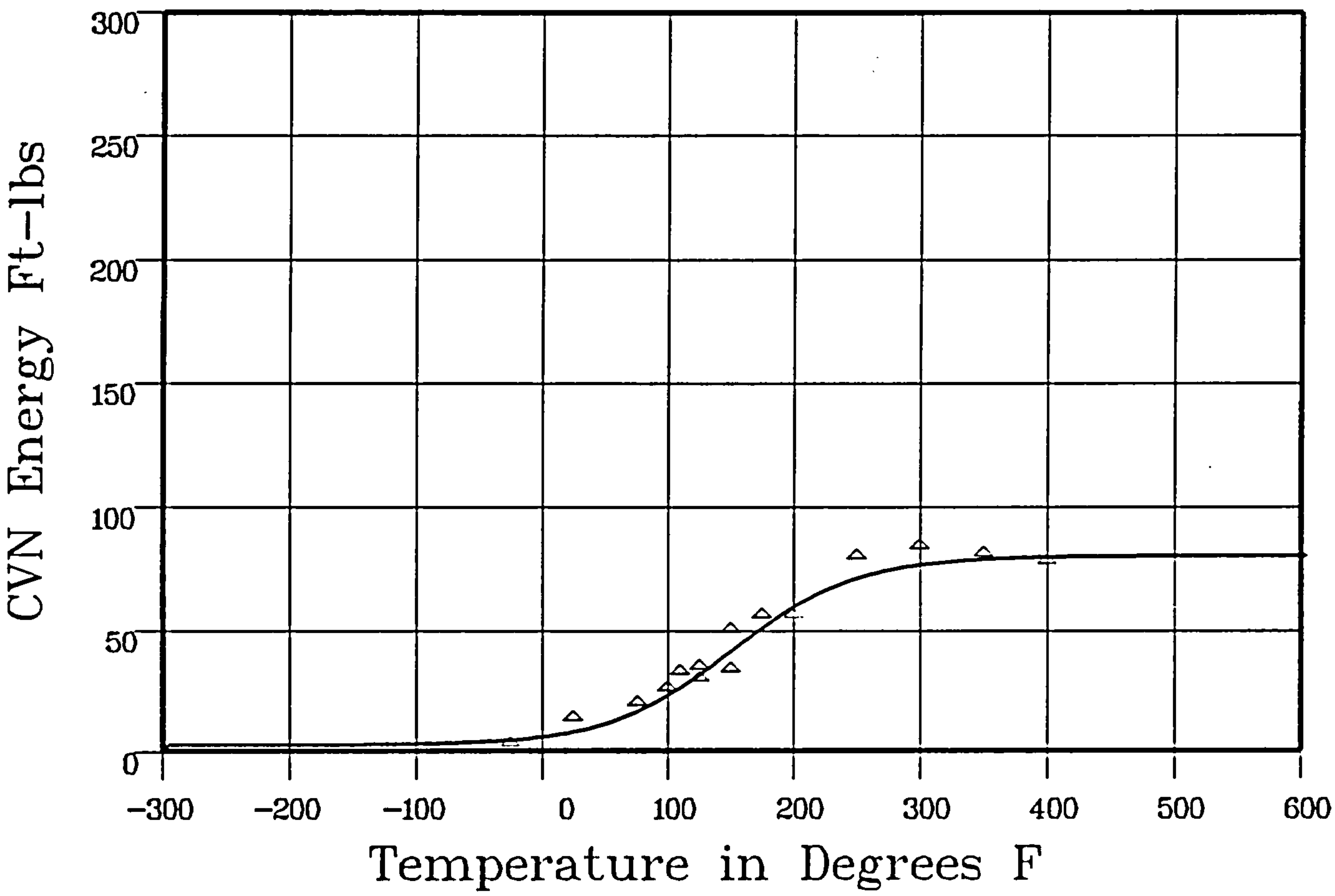
A = 41.09	B = 38.9	C = 99.15	T0 = 145.01

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 80 Fixed Temp. at 30 ft-lbs: 115.9 Temp. at 50 ft-lbs: 168.1 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-25	2	4.64	-2.64
25	13	8.54	4.45
76	19	17.68	1.31
100	25	24.55	.44
110	32	27.9	4.09
125	29	33.35	-4.35
125	34	33.35	.64

**** Data continued on next page ****

CAPSULE X (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
150	49	43.05	5.94
150	33	43.05	-10.05
175	55	52.51	2.48
200	55	60.7	-5.7
250	79	71.64	7.35
300	83	76.72	6.27
350	80	78.77	1.22
400	77	79.54	-2.54

SUM of RESIDUALS = 8.93

CAPSULE X (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:27:34 on 11-06-2003

Page 1

Coefficients of Curve 4

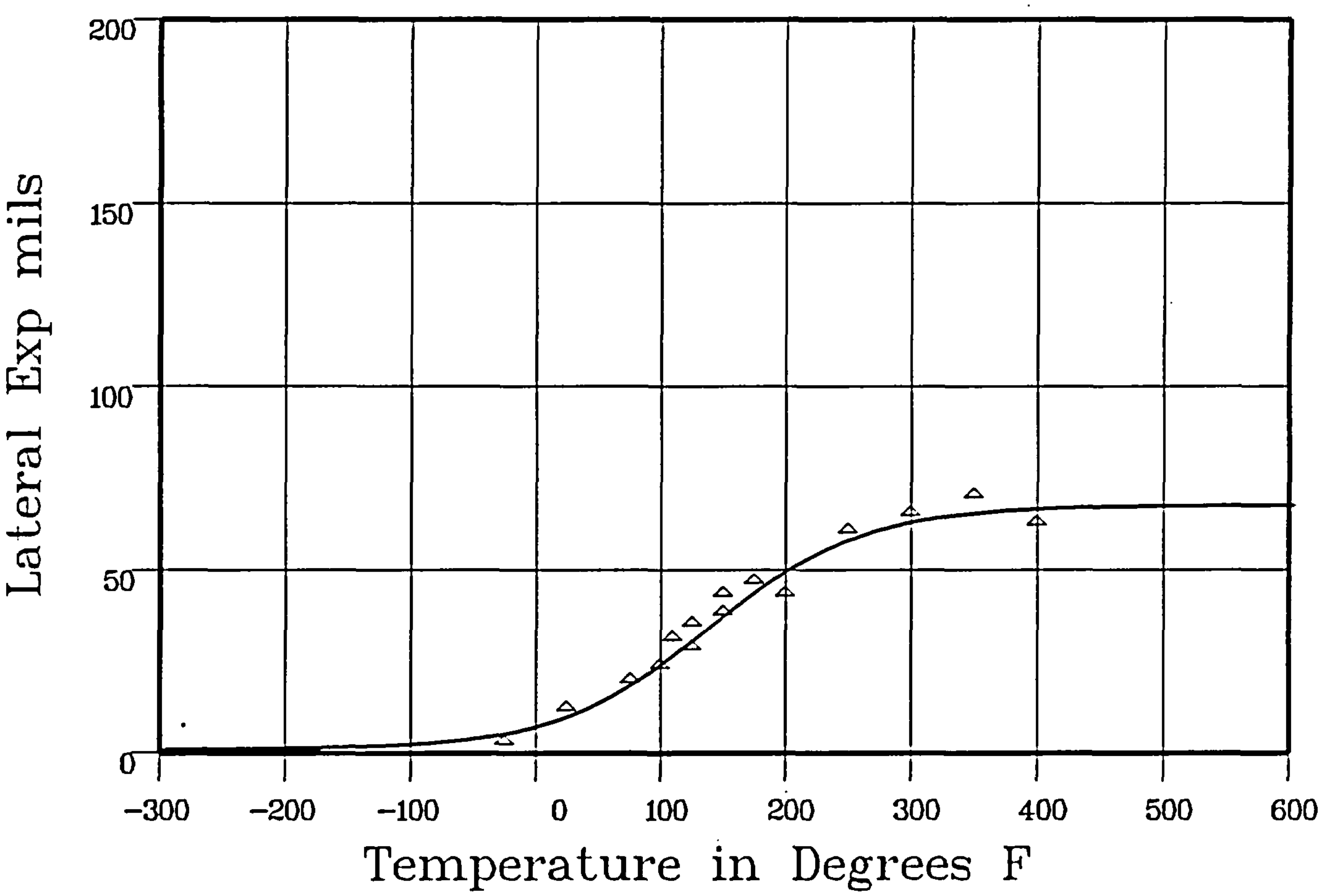
A = 34.35	B = 33.35	C = 123.88	T0 = 134.06

Equation is: $L.E. = A + B * [\tanh((T - T0)/C)]$

Upper Shelf L.E.: 67.71 Temperature at L.E. 35: 136.4 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-25	2.5	5.75	-3.25
25	12	10.78	1.21
76	19.5	19.77	-.27
100	23.5	25.4	-1.9
110	31	27.95	3.04
125	28.5	31.91	-3.41
125	35	31.91	3.08

**** Data continued on next page ****

CAPSULE X (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
150	43	38.62	4.37
150	38	38.62	-.62
175	46.5	44.99	1.5
200	43	50.6	-7.6
250	60.5	58.81	1.68
300	65	63.42	1.57
350	70	65.72	4.27
400	62.5	66.81	-4.31

SUM of RESIDUALS = -.64

CAPSULE X (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:34:17 on 11-06-2003

Page 1

Coefficients of Curve 4

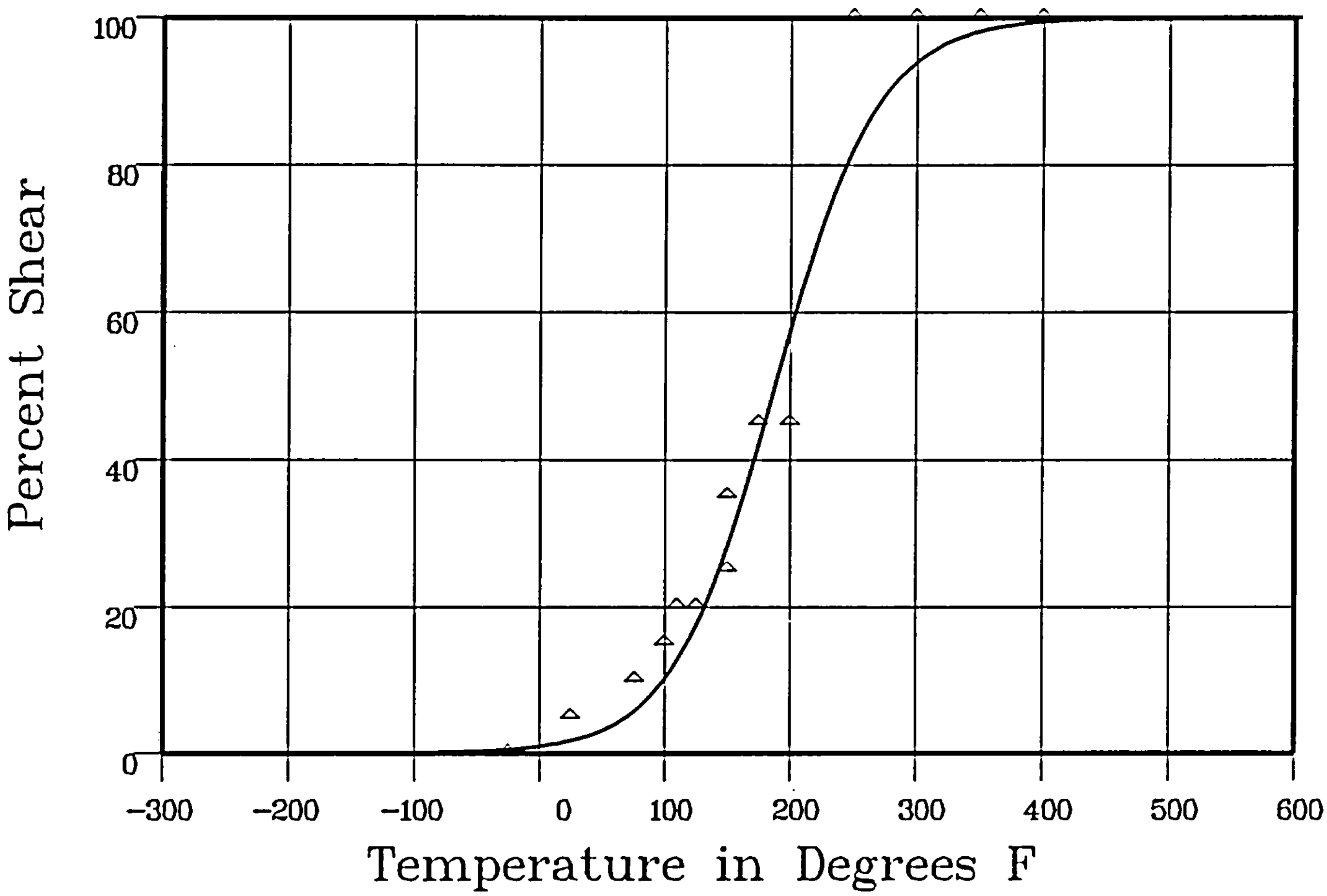
A = 50	B = 50	C = 81.25	T0 = 183.16

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 183.1

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: X Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-25	0	.59	-.59
25	5	1.99	3
76	10	6.67	3.32
100	15	11.43	3.56
110	20	14.17	5.82
125	20	19.28	.71
125	20	19.28	.71

**** Data continued on next page ****

CAPSULE X (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
150	35	30.65	4.34
150	25	30.65	-5.65
175	45	44.98	.01
200	45	60.21	-15.21
250	100	83.82	16.17
300	100	94.66	5.33
350	100	98.37	1.62
400	100	99.52	.47

SUM of RESIDUALS = 23.67

CAPSULE W (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:45:39 on 11-06-2003

Page 1

Coefficients of Curve 5

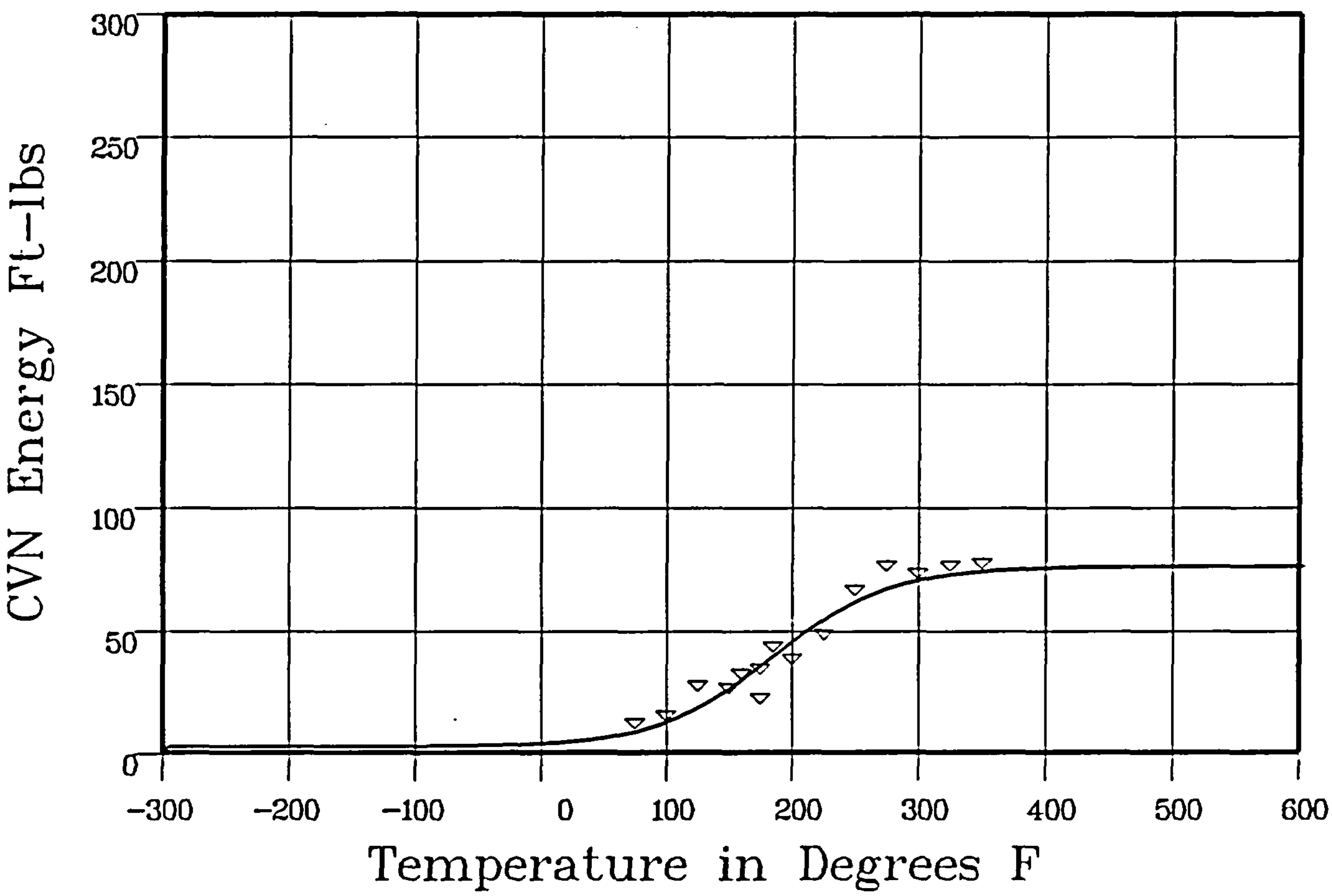
A = 39.09	B = 36.9	C = 93.34	T0 = 179.23

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 76 Fixed Temp. at 30 ft-lbs: 155.7 Temp. at 50 ft-lbs: 207.6 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
75	14	9.34	4.65
100	17	13.62	3.37
125	29	19.78	9.21
150	28	27.9	.09
160	34	31.6	2.39
175	36	37.42	-1.42

**** Data continued on next page ****

CAPSULE W (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
175	24	37.42	-13.42
185	45	41.37	3.62
200	40	47.17	-7.17
225	50	55.86	-5.86
250	68	62.71	5.28
275	78	67.59	10.4
300	75	70.83	4.16
325	78	72.88	5.11
350	79	74.14	4.85

SUM of RESIDUALS = 25.29

CAPSULE W (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:27:34 on 11-06-2003

Page 1

Coefficients of Curve 5

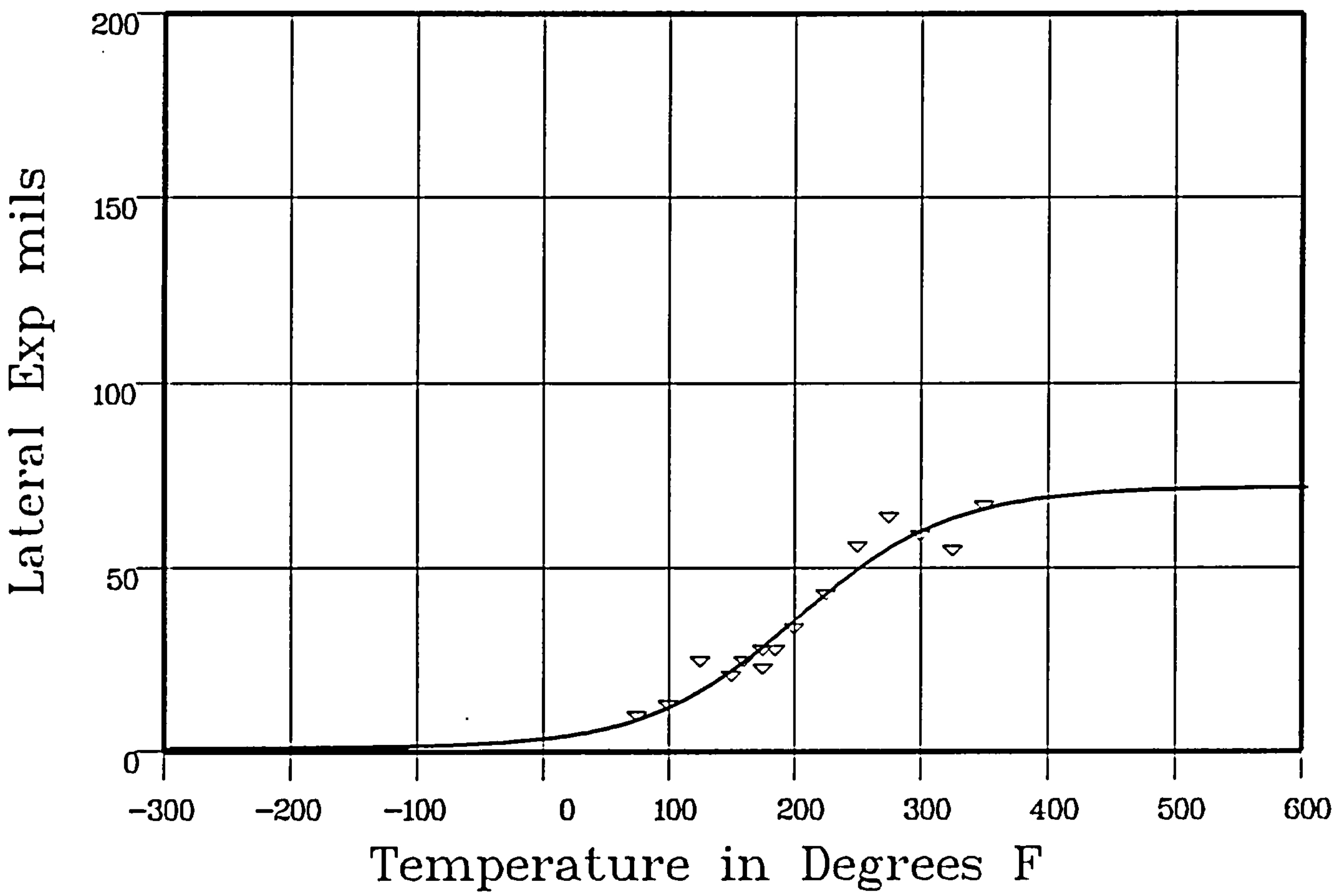
A = 36.43	B = 35.43	C = 121.99	T0 = 196.87

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 71.87 Temperature at L.E. 35: 191.9 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
75	11	9.46	1.53
100	14	13.02	.97
125	26	17.68	8.31
150	22	23.45	-1.45
160	26	26.04	-.04
175	29	30.15	-1.15

**** Data continued on next page ****

CAPSULE W (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
175	24	30.15	-6.15
185	29	33	-4
200	35	37.34	-2.34
225	44	44.46	-.46
250	57	50.96	6.03
275	65	56.46	8.53
300	60	60.84	-.84
325	56	64.14	-8.14
350	68	66.55	1.44

SUM of RESIDUALS = 2.24

CAPSULE W (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 13:34:17 on 11-06-2003

Page 1

Coefficients of Curve 5

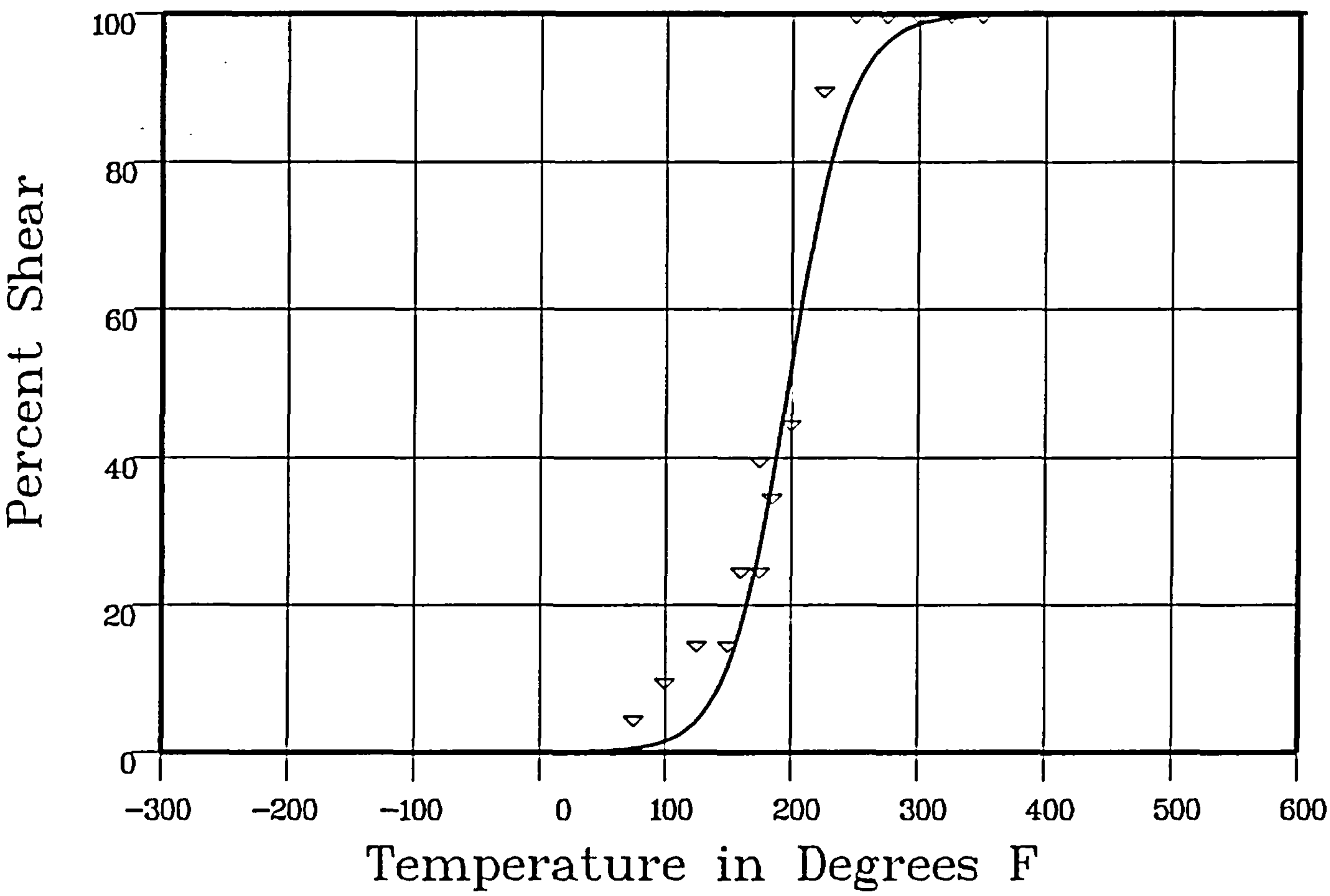
A = 50	B = 50	C = 47.58	T0 = 193.12

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 193.1

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
75	5	.69	4.3
100	10	1.95	8.04
125	15	5.4	9.59
150	15	14.03	.96
160	25	19.9	5.09
175	25	31.82	-6.82

**** Data continued on next page ****

CAPSULE W (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
175	40	31.82	8.17
185	35	41.54	-6.54
200	45	57.17	-12.17
225	90	79.24	10.75
250	100	91.6	8.39
275	100	96.89	3.1
300	100	98.89	1.1
325	100	99.6	.39
350	100	99.86	.13

SUM of RESIDUALS = 34.52

CAPSULE V (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:18:33 on 11-05-2003

Page 1

Coefficients of Curve 2

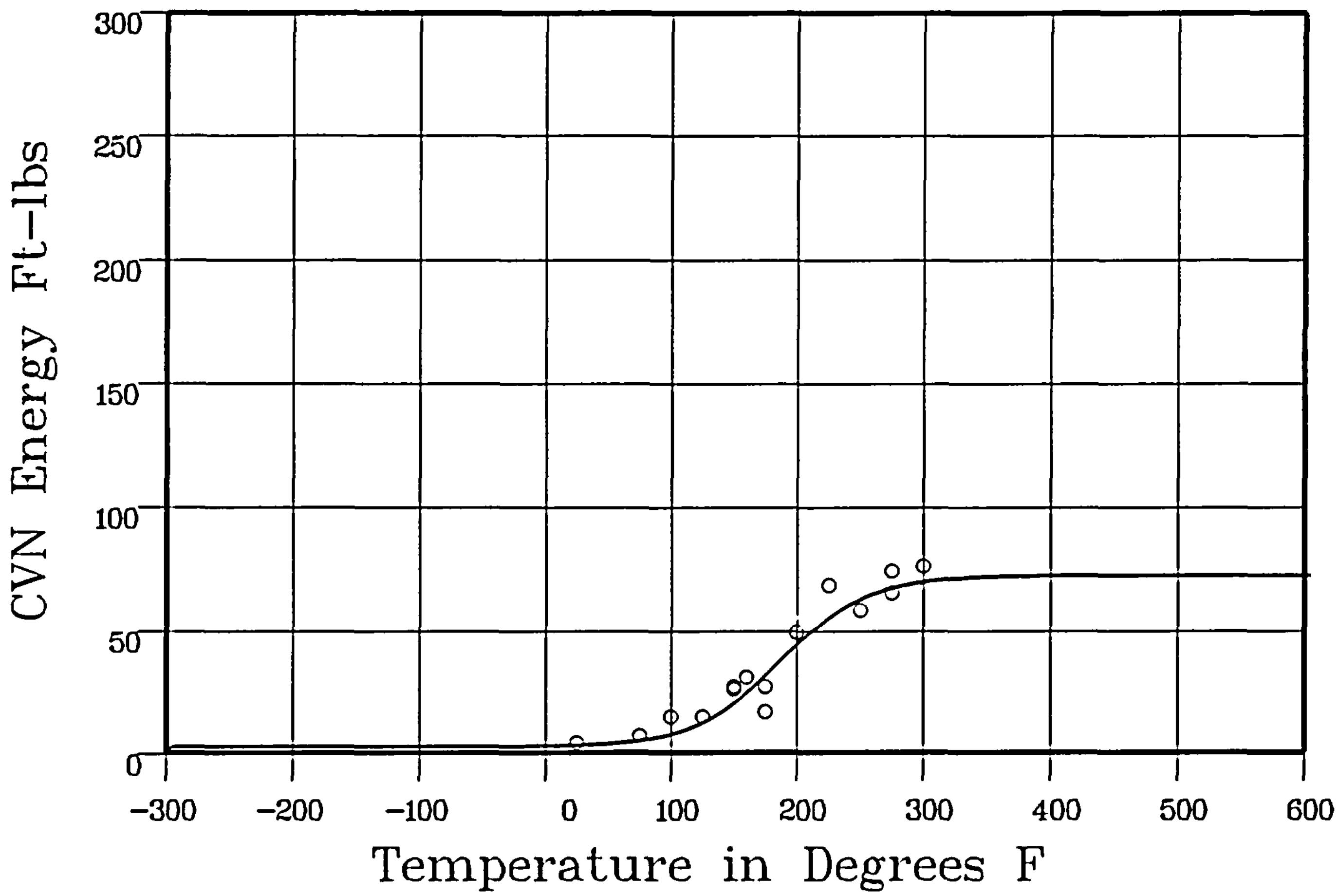
A = 37.09	B = 34.9	C = 69.48	T0 = 181.4

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 72 Fixed Temp. at 30 ft-lbs: 167 Temp. at 50 ft-lbs: 208.3 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: V Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	4	2.96	1.03
75	7	5.31	1.68
100	15	8.31	6.68
125	15	13.69	1.3
150	27	22.31	4.68
150	26	22.31	3.68
160	31	26.67	4.32
175	27	33.89	-6.89

**** Data continued on next page ****

CAPSULE V (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
175	17	33.89	-16.89
200	49	46.22	2.77
225	68	56.51	11.48
250	58	63.48	-5.48
275	74	67.57	6.42
275	65	67.57	-2.57
300	76	69.77	6.22

SUM of RESIDUALS = 18.44

CAPSULE V (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:28:07 on 11-05-2003

Page 1

Coefficients of Curve 2

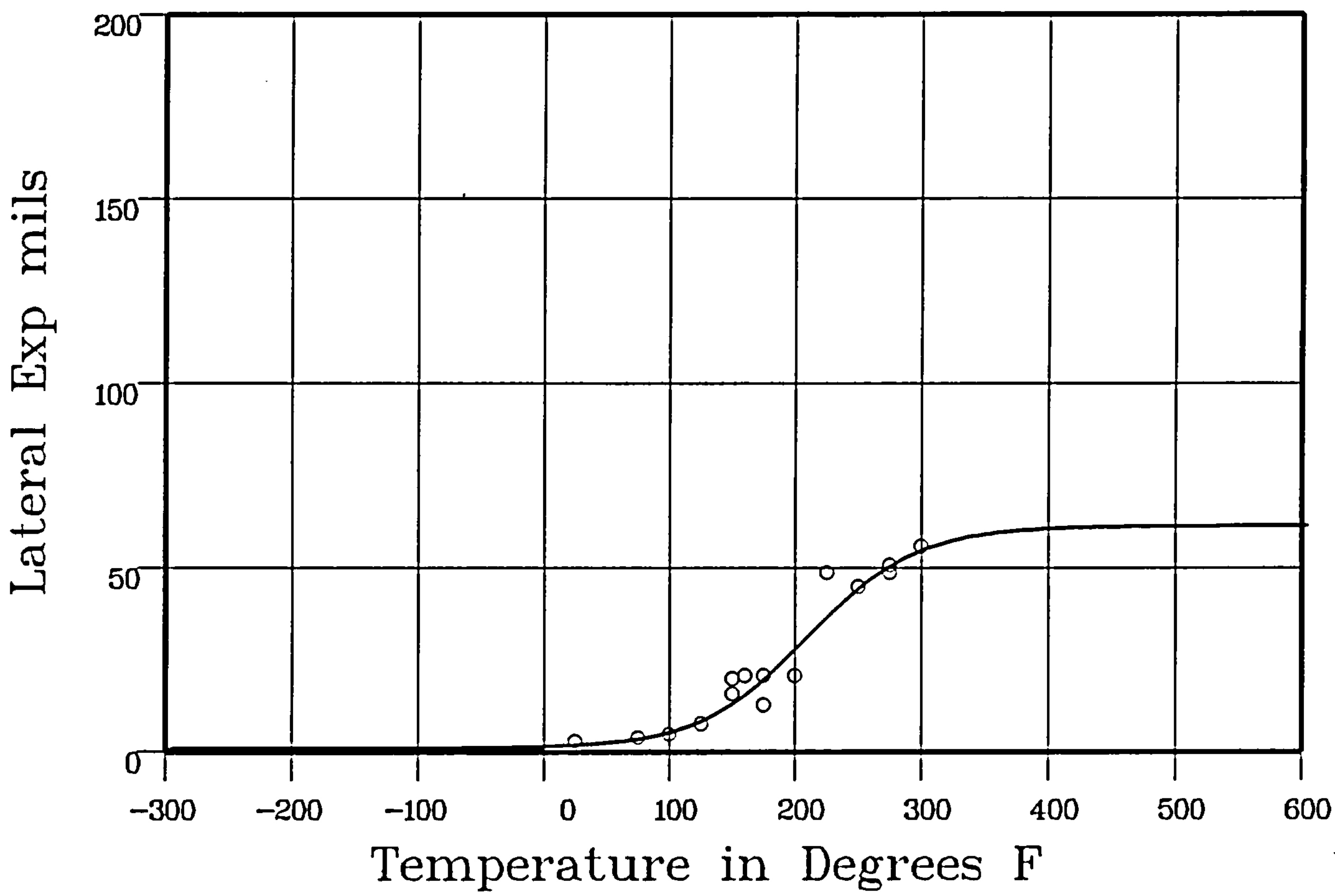
A = 31.27	B = 30.27	C = 86.91	T0 = 204.96

Equation is: LE = A + B * [tanh((T - T0)/C)]

Upper Shelf LE: 61.55 Temperature at LE 35: 215.6 Lower Shelf LE: 1 Fixed

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: V Material: PLATE SA533B1 Ori: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed LE	Differential
25	3	1.94	1.05
75	4	3.89	.1
100	5	5.96	-.96
125	8	9.29	-1.29
150	16	14.33	1.66
150	20	14.33	5.66
160	21	16.87	4.12
175	21	21.23	-.23

**** Data continued on next page ****

CAPSULE V (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
175	13	21.23	-8.23
200	21	29.55	-8.55
225	49	38.13	10.86
250	45	45.7	-.7
275	51	51.48	-.48
275	49	51.48	-2.48
300	56	55.44	.55

SUM of RESIDUALS = 1.07

CAPSULE V (TRANSVERSE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:30:18 on 11-05-2003

Page 1

Coefficients of Curve 2

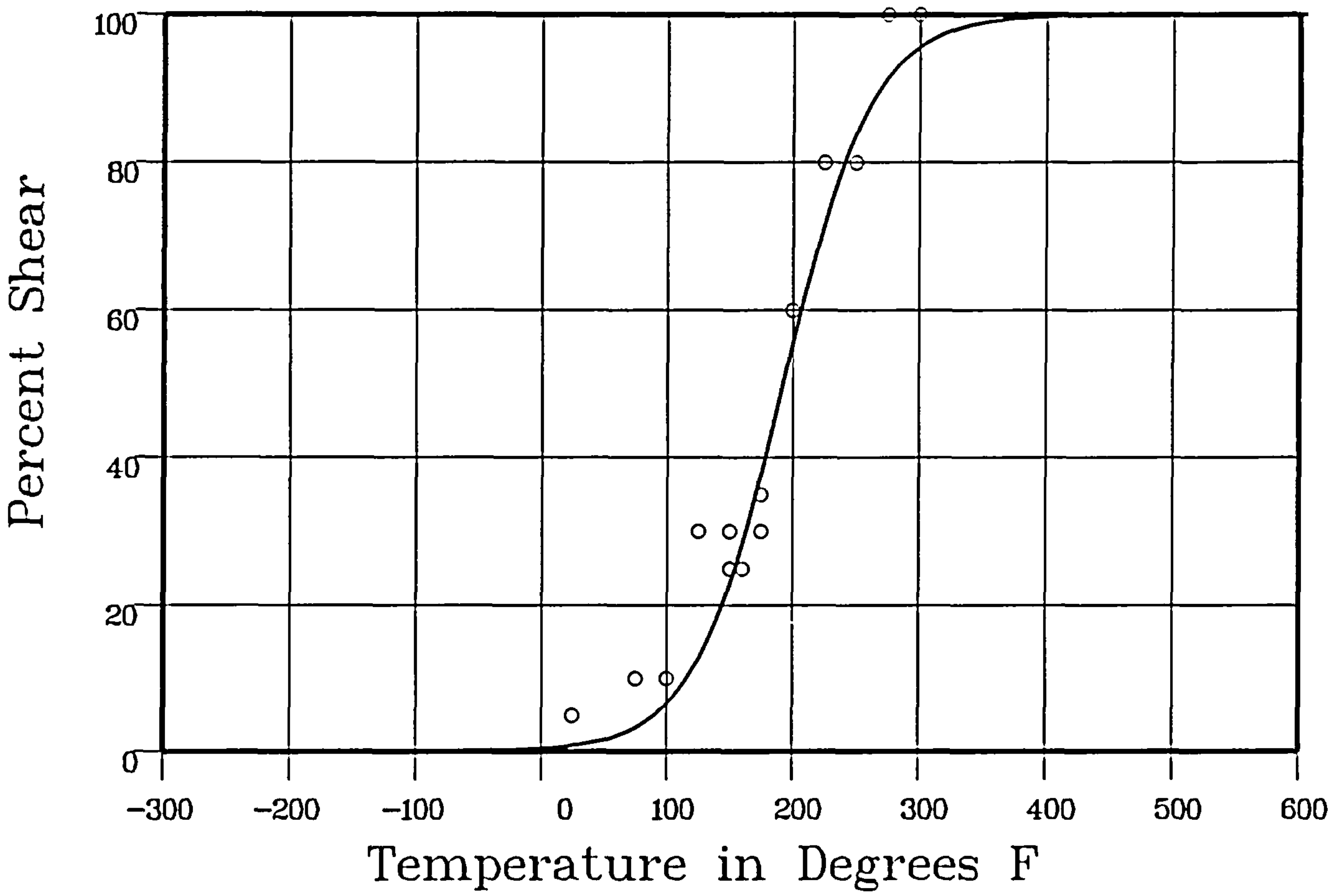
A = 50	B = 50	C = 69.89	T0 = 187.96

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 187.9

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: PLATE SA533B1 Ori.: TL Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	5	.93	4.06
75	10	3.79	6.2
100	10	7.46	2.53
125	30	14.16	15.83
150	25	25.23	-.23
150	30	25.23	4.76
160	25	30.99	-5.99
175	30	40.82	-10.82

**** Data continued on next page ****

CAPSULE V (TRANSVERSE)

Page 2

Material: PLATE SA533B1 Heat Number: C6940-1 Orientation: TL

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
175	35	40.82	-5.82
200	60	58.52	1.47
225	80	74.26	5.73
250	80	85.5	-5.5
275	100	92.34	7.65
275	100	92.34	7.65
300	100	96.1	3.89

SUM of RESIDUALS = 31.43

UNIRRADIATED (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:43:49 on 11-06-2003

Page 1

Coefficients of Curve 1

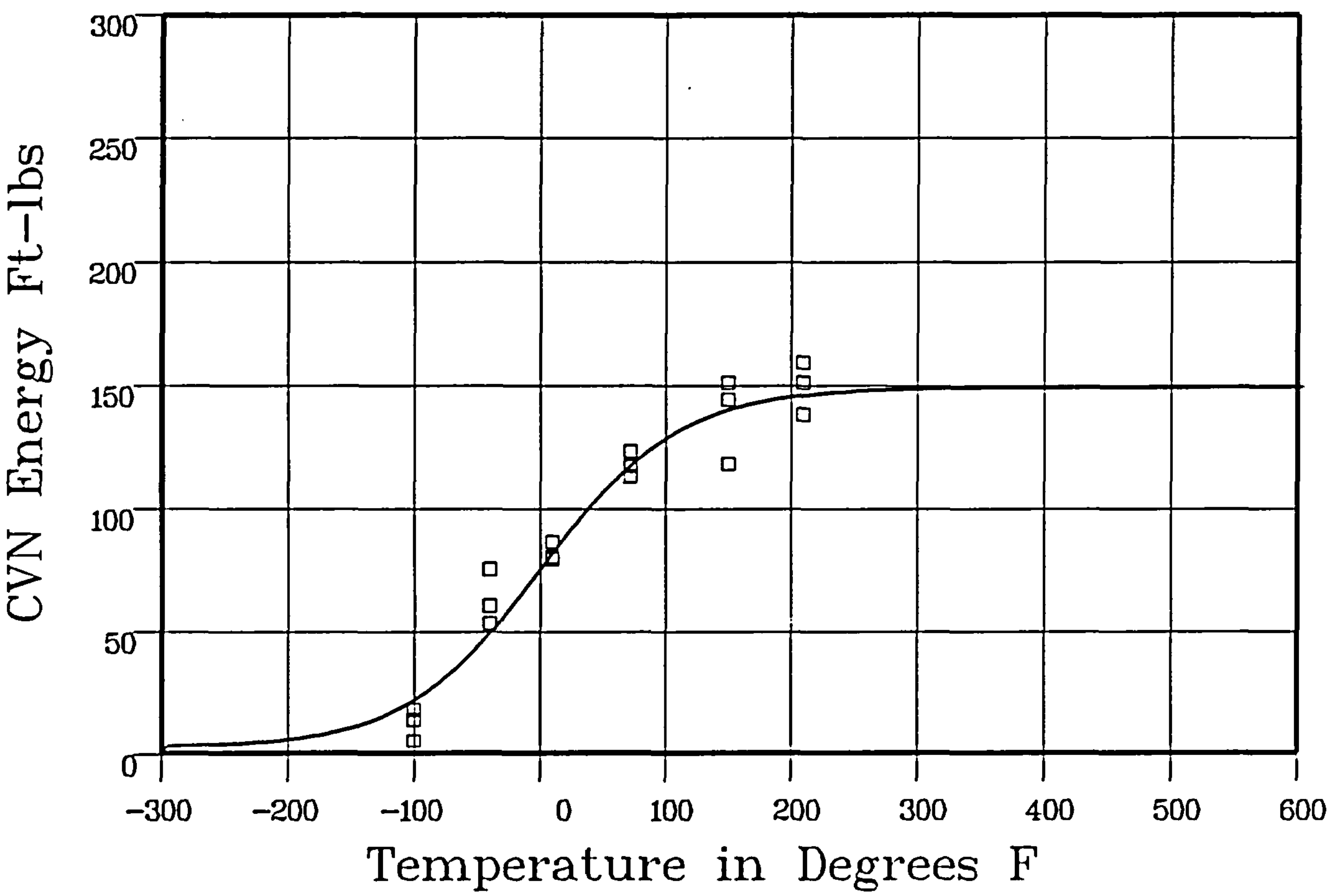
A = 75.59	B = 73.4	C = 108.91	T0 = -3.28

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 149 Fixed Temp. at 30 ft-lbs: -82.4 Temp. at 50 ft-lbs: -42.9 Lower Shelf Energy: 2.19 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-100	18	23.45	-5.45
-100	14	23.45	-9.45
-100	5	23.45	-18.45
-40	75	51.75	23.24
-40	53	51.75	1.24
-40	60	51.75	8.24
10	86	84.5	1.49
10	80	84.5	-4.5
10	79	84.5	-5.5

**** Data continued on next page ****

UNIRRADIATED (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
72	117	119.54	-2.54
72	113	119.54	-6.54
72	123	119.54	3.45
150	118	140.7	-22.7
150	144	140.7	3.29
150	151	140.7	10.29
210	159	146.13	12.86
210	138	146.13	-8.13
210	151	146.13	4.86
			SUM of RESIDUALS = -14.28

UNIRRADIATED (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:48:15 on 11-06-2003

Page 1

Coefficients of Curve 1

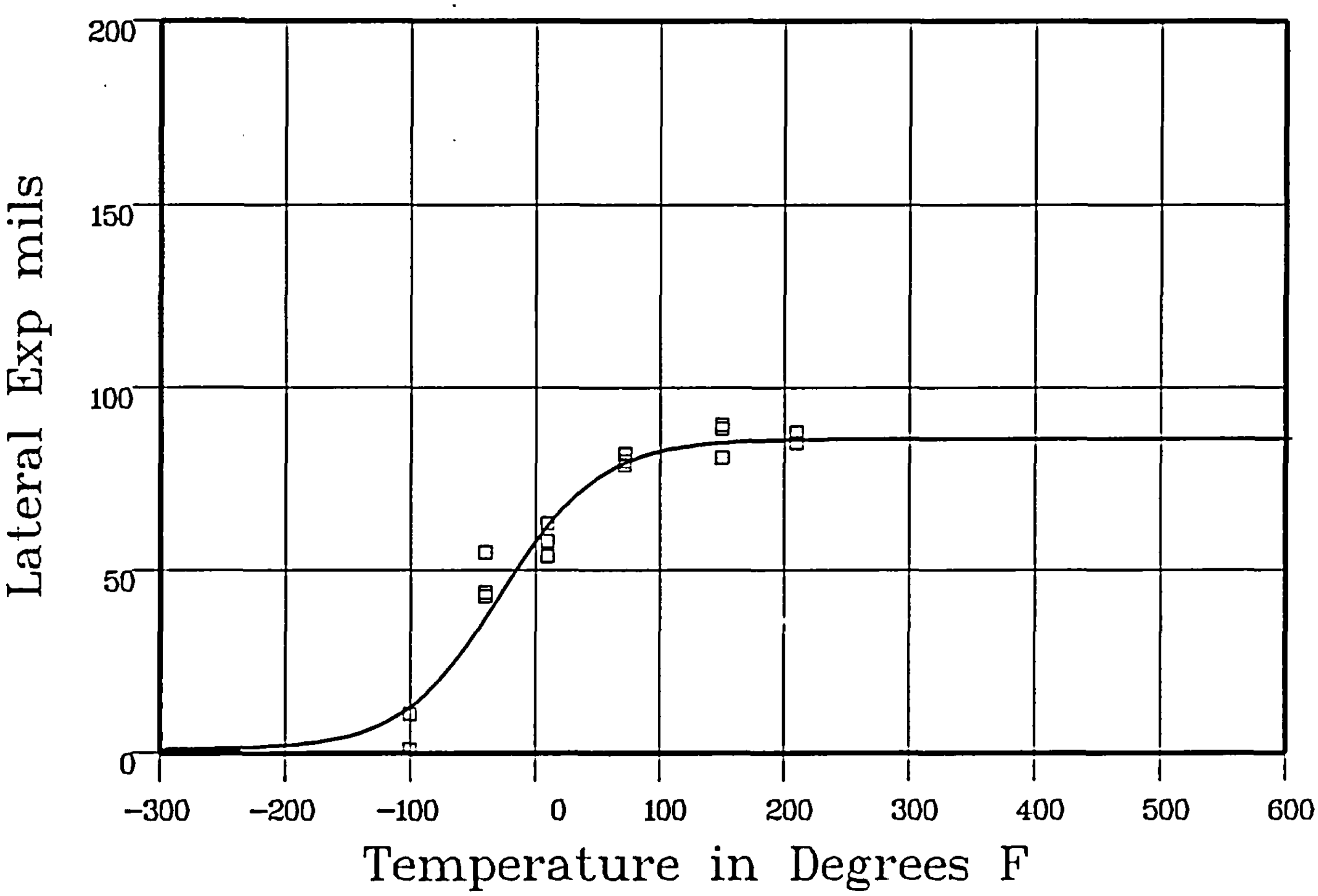
A = 43.56	B = 42.56	C = 79.96	T0 = -32.38

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 86.12 Temperature at L.E. 35: -48.6 Lower Shelf L.E.: 1 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-100	11	14.24	-3.24
-100	11	14.24	-3.24
-100	1	14.24	-13.24
-40	55	39.52	15.47
-40	43	39.52	3.47
-40	44	39.52	4.47
10	63	64.22	-1.22
10	58	64.22	-6.22
10	54	64.22	-10.22

**** Data continued on next page ****

UNIRRADIATED (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
72	82	80.29	1.7
72	79	80.29	-1.29
72	80	80.29	-.29
150	81	85.24	-4.24
150	89	85.24	3.75
150	90	85.24	4.75
210	85	85.92	-.92
210	88	85.92	2.07
210	85	85.92	-.92

SUM of RESIDUALS = -9.39

UNIRRADIATED (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:51:43 on 11-06-2003

Page 1

Coefficients of Curve 1

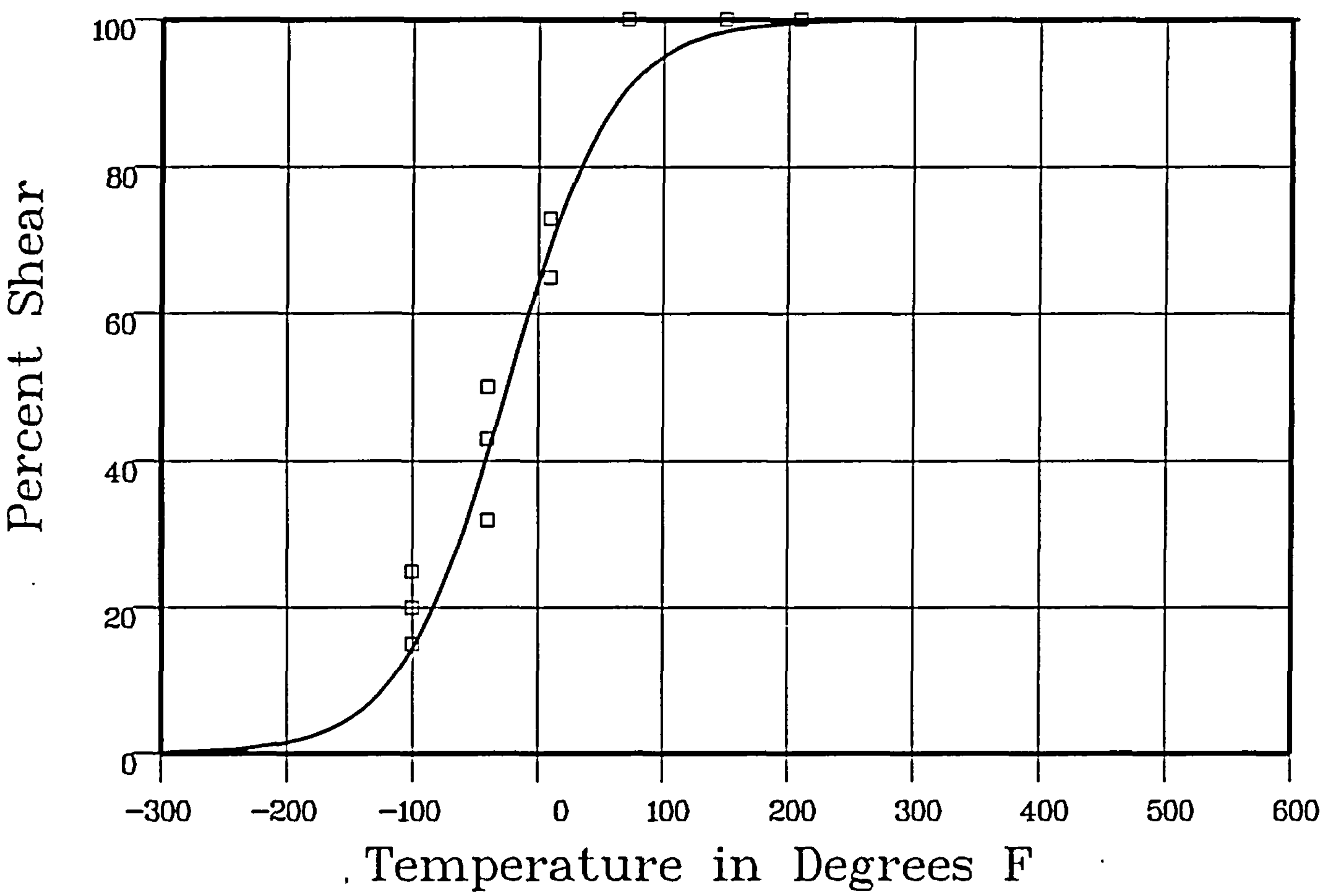
A = 50	B = 50	C = 84.86	T0 = -29.06

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: -29

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: UNIRR Material: WELD LINDE 0091 Ori: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-100	20	15.81	4.18
-100	25	15.81	9.18
-100	15	15.81	-.81
-40	50	43.59	6.4
-40	43	43.59	-.59
-40	32	43.59	-11.59
10	73	71.51	1.48
10	65	71.51	-6.51
10	65	71.51	-6.51

**** Data continued on next page ****

UNIRRADIATED (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72	100	91.54	8.45
72	100	91.54	8.45
72	100	91.54	8.45
150	100	98.55	1.44
150	100	98.55	1.44
150	100	98.55	1.44
210	100	99.64	.35
210	100	99.64	.35
210	100	99.64	.35
		SUM of RESIDUALS =	26

CAPSULE Y (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:43:49 on 11-06-2003
Page 1
Coefficients of Curve 2

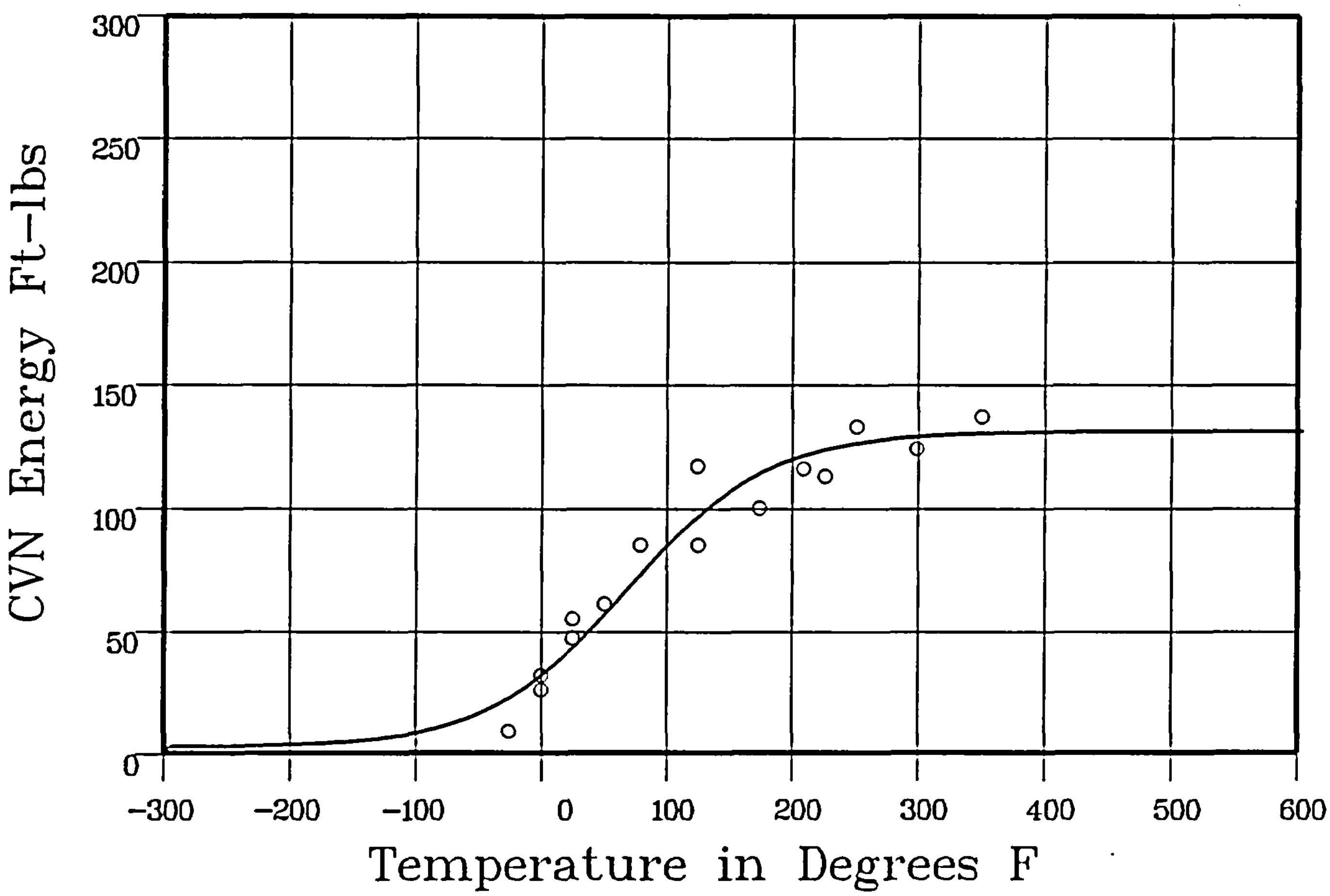
A = 66.59	B = 64.4	C = 112.89	T0 = 63.27

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 131 Fixed Temp. at 30 ft-lbs: -9.5 Temp. at 50 ft-lbs: 33.5 Lower Shelf Energy: 2.19 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap.: Y Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-26	9	24.16	-15.16
0	32	33.86	-1.86
0	26	33.86	-7.86
25	47	45.56	1.43
25	55	45.56	9.43
50	61	59.06	1.93
79	85	75.51	9.48
124	117	98.24	18.75

**** Data continued on next page ****

CAPSULE Y (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
125	85	98.67	-13.67
174	100	115.11	-15.11
209	116	121.94	-5.94
226	113	124.17	-11.17
251	133	126.53	6.46
299	124	129.05	-5.05
350	137	130.2	6.79

SUM of RESIDUALS = -21.53

CAPSULE Y (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:48:15 on 11-06-2003
Page 1
Coefficients of Curve 2

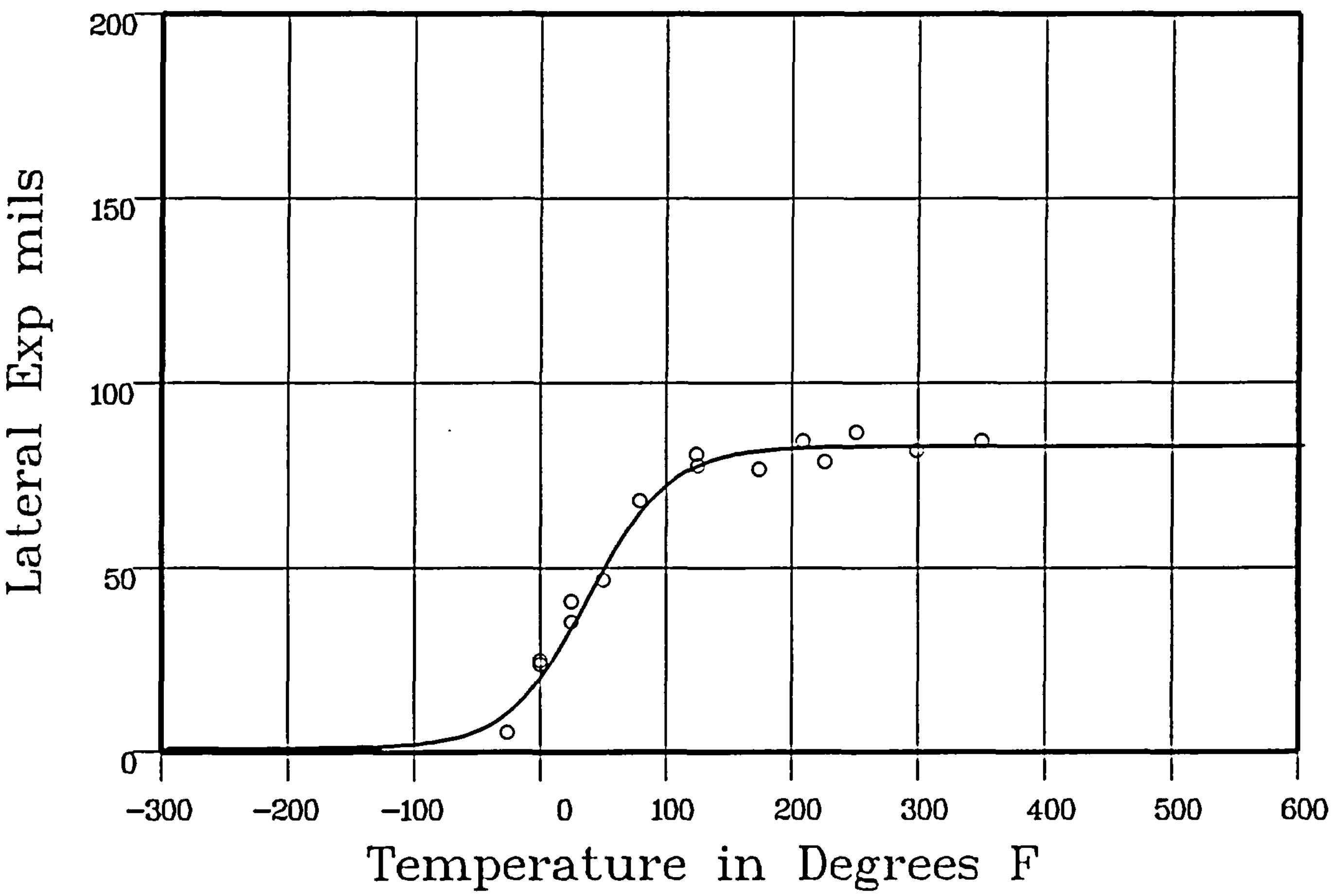
A = 42.03	B = 41.03	C = 64.16	T0 = 33.75

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 83.06 Temperature at L.E. 35: 22.6 Lower Shelf L.E.: 1 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap: Y Material: WELD LINDE 0091 Ori: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-26	5.5	12.03	-6.53
0	24	22.24	1.75
0	25	22.24	2.75
25	35.5	36.47	-.97
25	41	36.47	4.52
50	47	52.21	-5.21
79	68.5	66.97	1.52
124	81	78.42	2.57

**** Data continued on next page ****

CAPSULE Y (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
125	78	78.55	-.55
174	77	82.04	-5.04
209	84.5	82.72	1.77
226	79	82.86	-3.86
251	87	82.97	4.02
299	82	83.04	-1.04
350	84.5	83.06	1.43

SUM of RESIDUALS = -2.84

CAPSULE Y (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:51:43 on 11-06-2003

Page 1

Coefficients of Curve 2

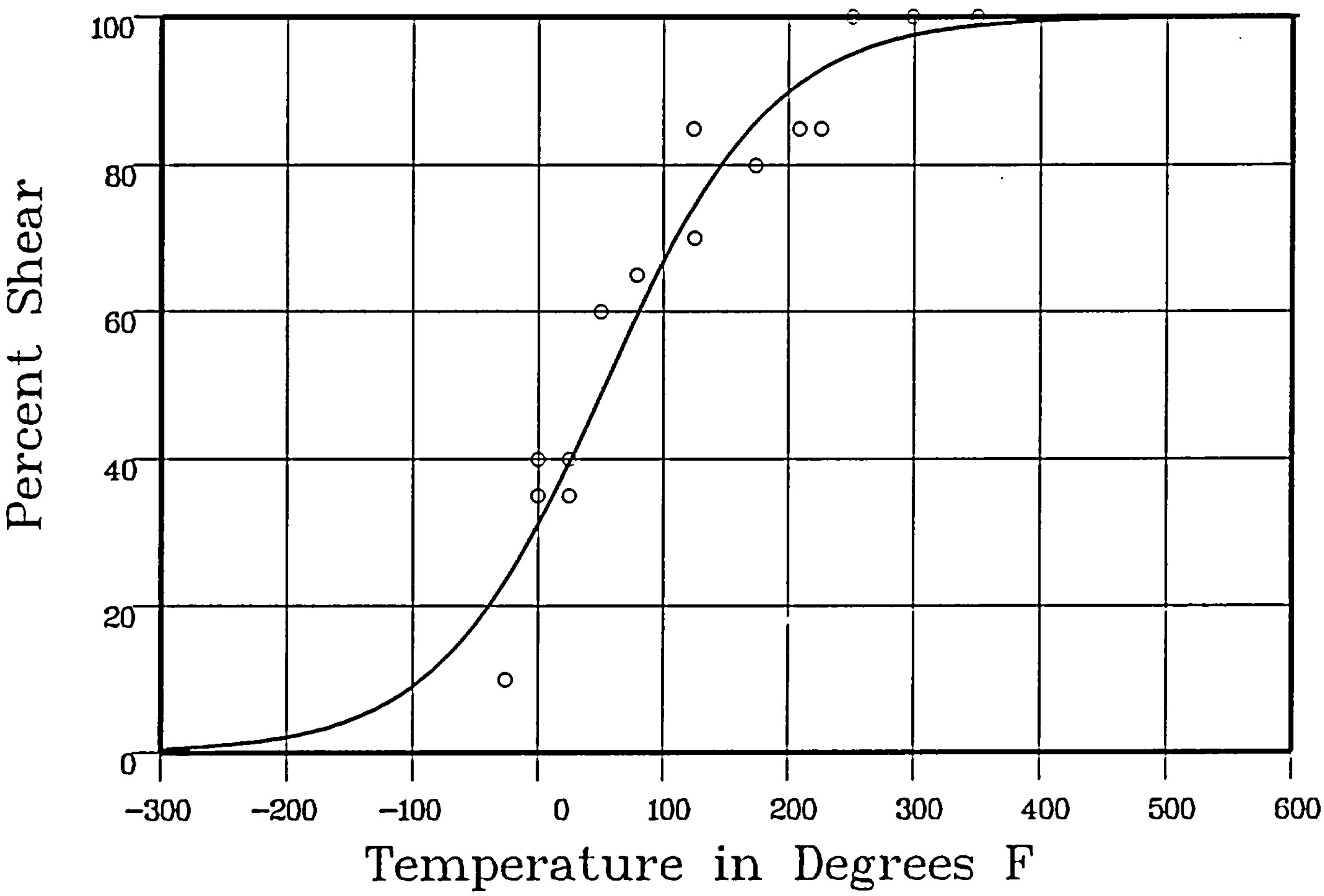
A = 50	B = 50	C = 133.83	T0 = 48.75

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 48.7

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-26	10	24.65	-14.65
0	40	32.55	7.44
0	35	32.55	2.44
25	35	41.21	-6.21
25	40	41.21	-1.21
50	60	50.46	9.53
79	65	61.11	3.88
124	85	75.48	9.51

**** Data continued on next page ****

CAPSULE Y (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
125	70	75.75	-5.75
174	80	86.66	-6.66
209	85	91.64	-6.64
226	85	93.39	-8.39
251	100	95.35	4.64
299	100	97.67	2.32
350	100	98.9	1.09
			SUM of RESIDUALS = -8.65

CAPSULE U (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:43:49 on 11-06-2003

Page 1

Coefficients of Curve 3

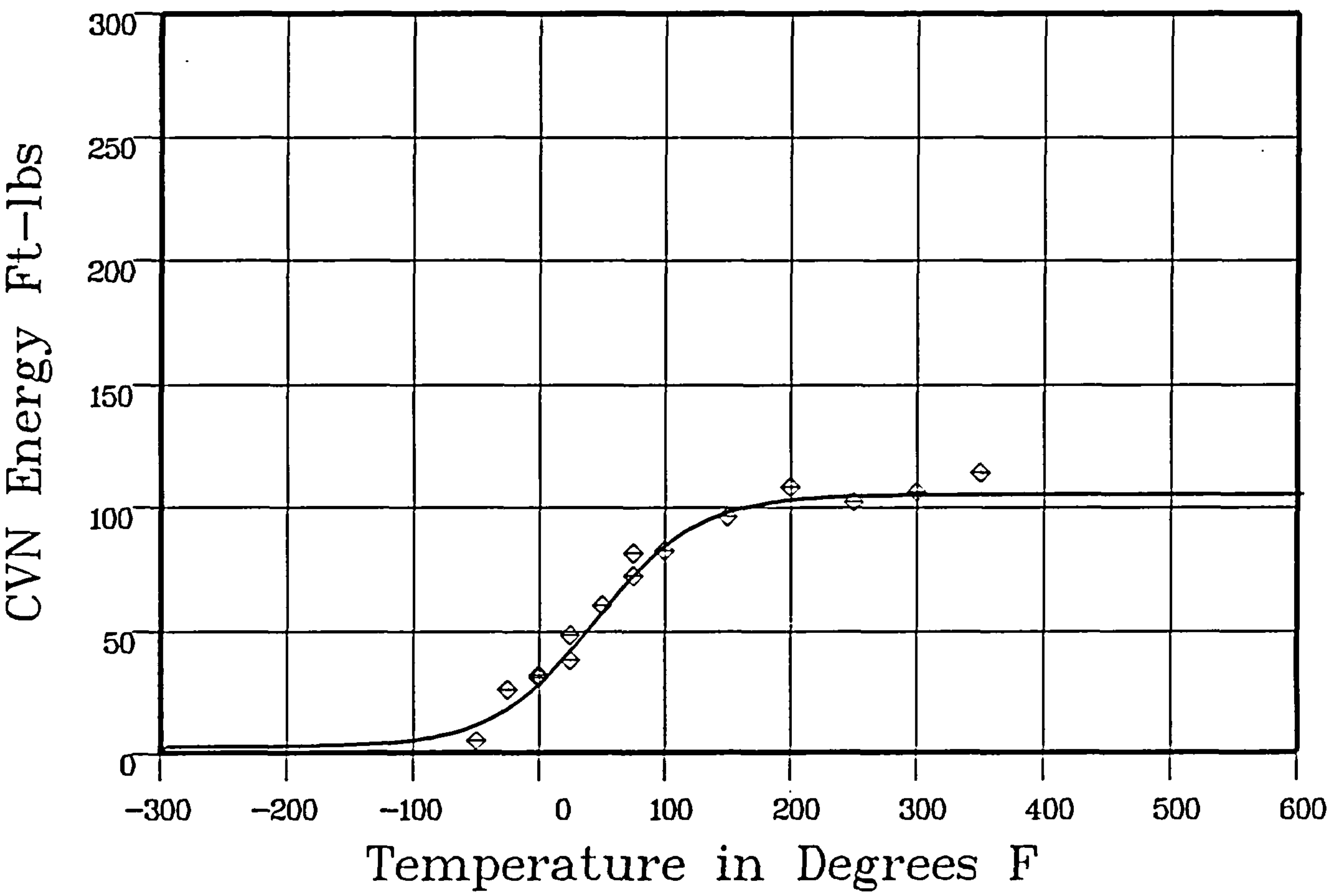
A = 53.59	B = 51.4	C = 82.35	T0 = 39.53

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 105 Fixed   Temp. at 30 ft-lbs: -1.3   Temp. at 50 ft-lbs: 33.7   Lower Shelf Energy: 2.19 Fixed

Material: WELD LINDE 0091   Heat Number: 33A277 FLUX LOT 3922   Orientation:

Capsule: U   Total Fluence:



Data Set(s) Plotted

Plant: FA1   Cap: U   Material: WELD LINDE 0091   Ori: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	5	12.69	-7.69
-25	26	19.94	6.05
0	32	30.66	1.33
0	31	30.66	.33
25	48	44.62	3.37
25	38	44.62	-6.62
50	60	60.09	-.09
75	72	74.46	-2.46

**** Data continued on next page ****

CAPSULE U (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
75	81	74.46	6.53
100	82	85.75	-3.75
150	96	98.42	-2.42
200	108	102.95	5.04
250	102	104.38	-2.38
300	106	104.81	1.18
350	114	104.94	9.05

SUM of RESIDUALS = 7.48

CAPSULE U (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:48:15 on 11-06-2003

Page 1

Coefficients of Curve 3

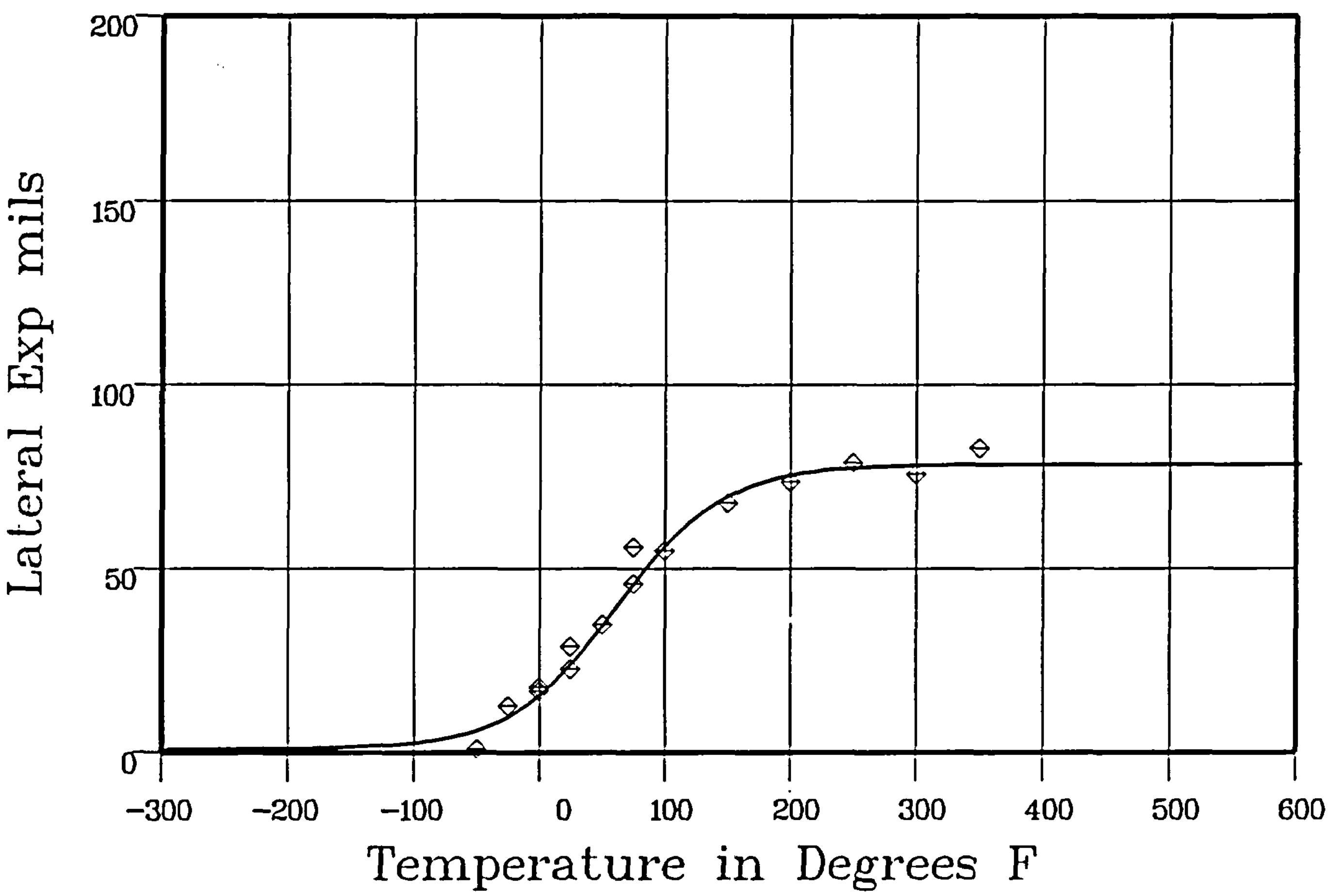
A = 39.78	B = 38.78	C = 85.58	T0 = 56.71

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 78.56 Temperature at L.E. 35: 46.1 Lower Shelf L.E.: 1 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: U Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	1	6.91	-5.91
-25	13	11	1.99
0	18	17.28	.71
0	17	17.28	-.28
25	29	26.03	2.96
25	23	26.03	-3.03
50	35	36.74	-1.74
75	46	47.94	-1.94

**** Data continued on next page ****

CAPSULE U (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
75	56	47.94	8.05
100	55	57.87	-2.87
150	68	70.68	-2.68
200	74	75.92	-1.92
250	79	77.72	1.27
300	76	78.29	-2.29
350	83	78.48	4.51

SUM of RESIDUALS = -3.16

CAPSULE U (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:51:43 on 11-06-2003
Page 1
Coefficients of Curve 3

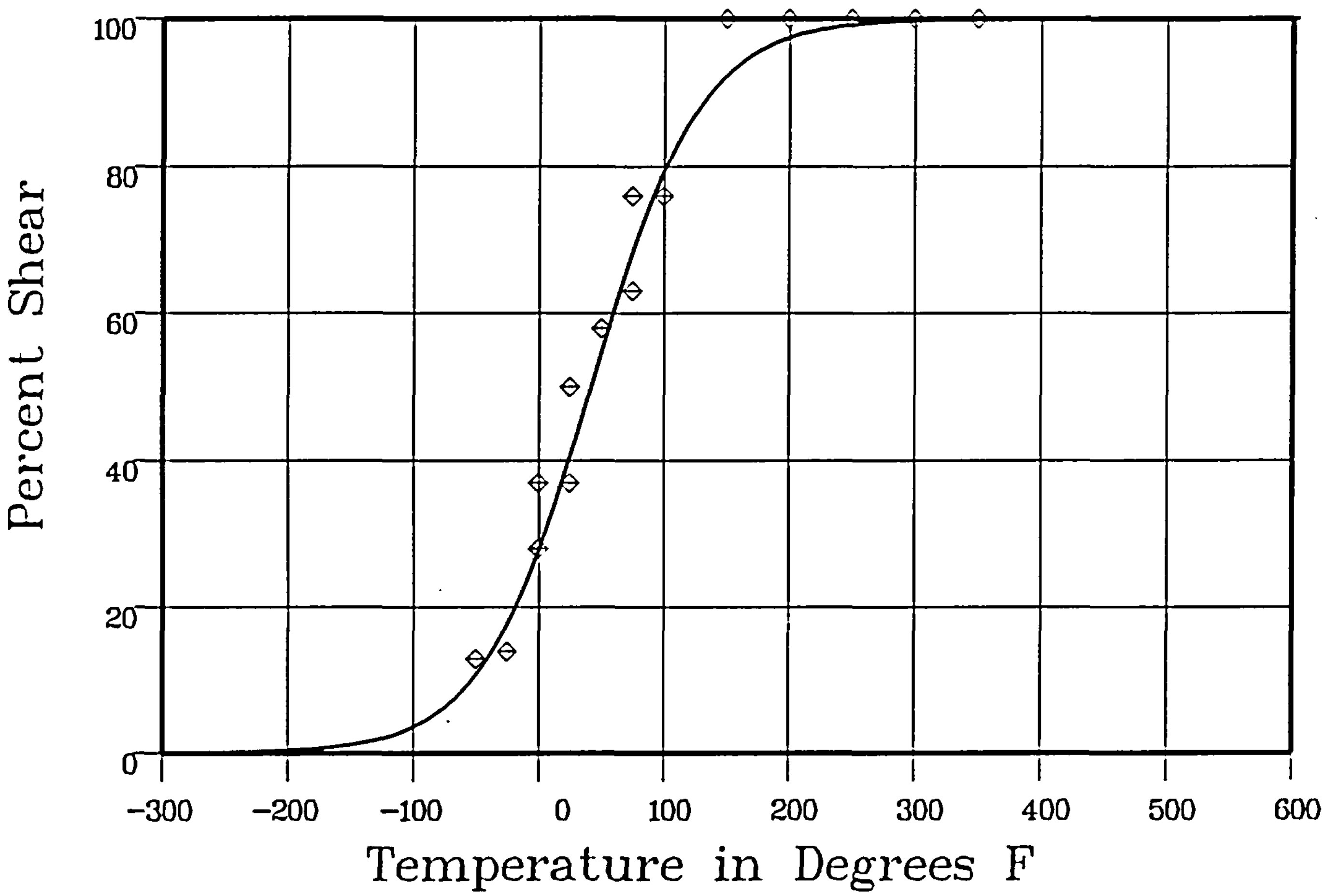
A = 50	B = 50	C = 87.03	T0 = 37.03

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 37

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: U Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap.: U Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	13	11.92	1.07
-25	14	19.38	-5.38
0	28	29.92	-1.92
0	37	29.92	7.07
25	50	43.13	6.86
25	37	43.13	-6.13
50	58	57.39	.6
75	63	70.52	-7.52

**** Data continued on next page ****

CAPSULE U (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
75	76	70.52	5.47
100	76	80.95	-4.95
150	100	93.06	6.93
200	100	97.69	2.3
250	100	99.25	.74
300	100	99.76	.23
350	100	99.92	.07

SUM of RESIDUALS = 5.49

CAPSULE X (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve   Printed at 14:43:49 on 11-06-2003

Page 1

Coefficients of Curve 4

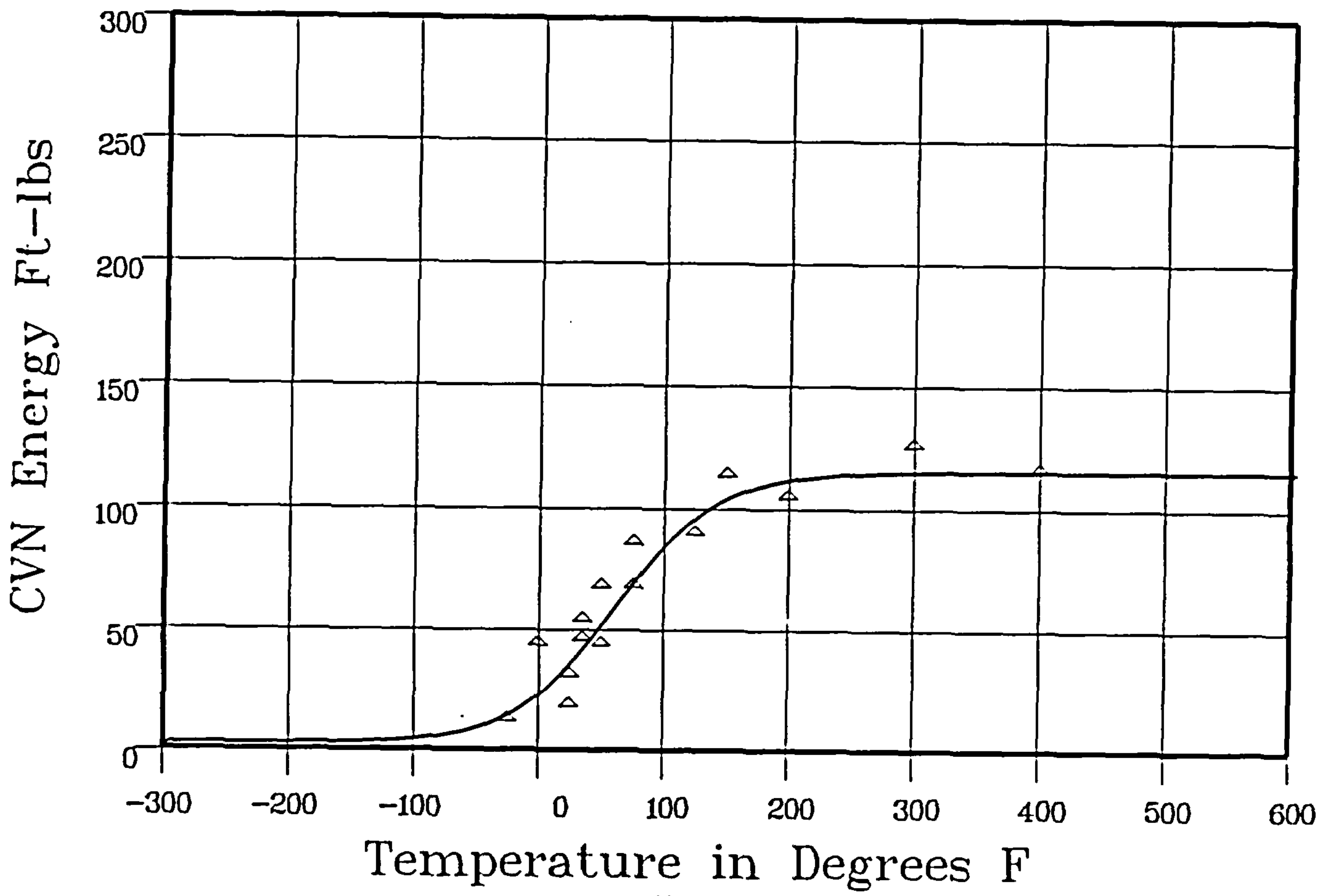
A = 58.59	B = 56.4	C = 81.41	T0 = 56.21

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 115 Fixed   Temp. at 30 ft-lbs: 10.7   Temp. at 50 ft-lbs: 43.7   Lower Shelf Energy: 2.19 Fixed

Material: WELD LINDE 0091   Heat Number: 33A277 FLUX LOT 3922   Orientation:

Capsule: X   Total Fluence:



Data Set(s) Plotted

Plant: FA1   Cap.: X   Material: WELD LINDE 0091   Ori.:   Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-25	12	15.7	-3.7
0	43	24.85	18.14
25	30	37.97	-7.97
25	18	37.97	-19.97
35	45	44.22	.77
35	53	44.22	8.77
50	67	54.3	12.69

**** Data continued on next page ****

CAPSULE X (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
50	43	54.3	-11.3
76	67	72.04	-5.04
76	85	72.04	12.95
125	89	97.42	-8.42
150	113	104.75	8.24
200	104	111.79	-7.79
300	125	114.71	10.28
400	115	114.97	.02

SUM of RESIDUALS = 7.68

CAPSULE X (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:48:15 on 11-06-2003

Page 1

Coefficients of Curve 4

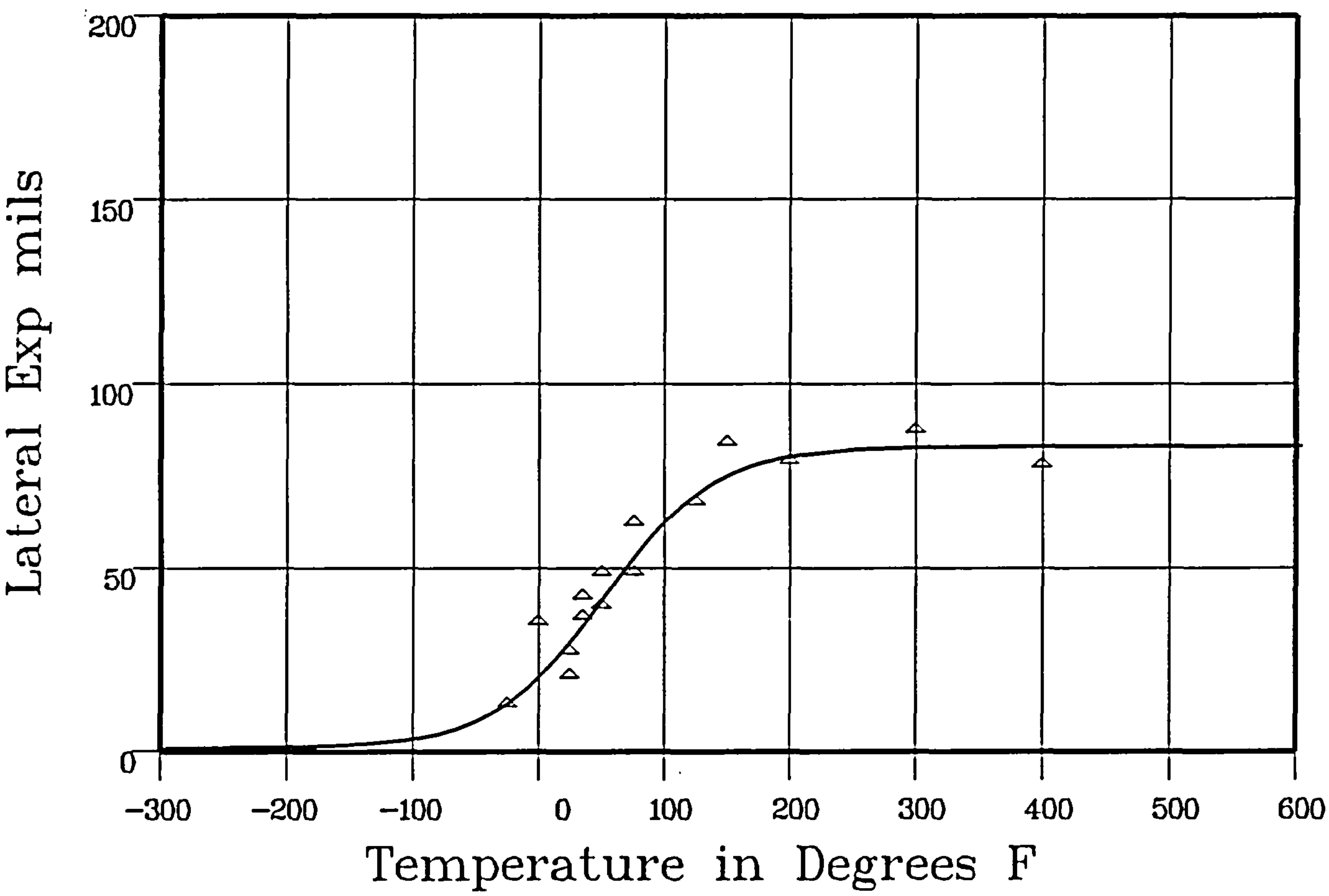
A = 42.01	B = 41.01	C = 88.36	T0 = 46.87

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 83.02 Temperature at L.E. 35: 31.6 Lower Shelf L.E.: 1 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-25	12.5	14.47	-1.97
0	35	22.09	12.9
25	27	32.06	-5.06
25	20.5	32.06	-11.56
35	36.5	36.53	-.03
35	42	36.53	5.46
50	48.5	43.46	5.03

**** Data continued on next page ****

CAPSULE X (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
50	39.5	43.46	-3.96
76	48.5	55.06	-6.56
76	62	55.06	6.93
125	67.5	71.07	-3.57
150	83.5	75.78	7.71
200	78.5	80.54	-2.04
300	87	82.76	4.23
400	77.5	83	-5.5

SUM of RESIDUALS = 2.02

CAPSULE X (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:51:43 on 11-06-2003
Page 1
Coefficients of Curve 4

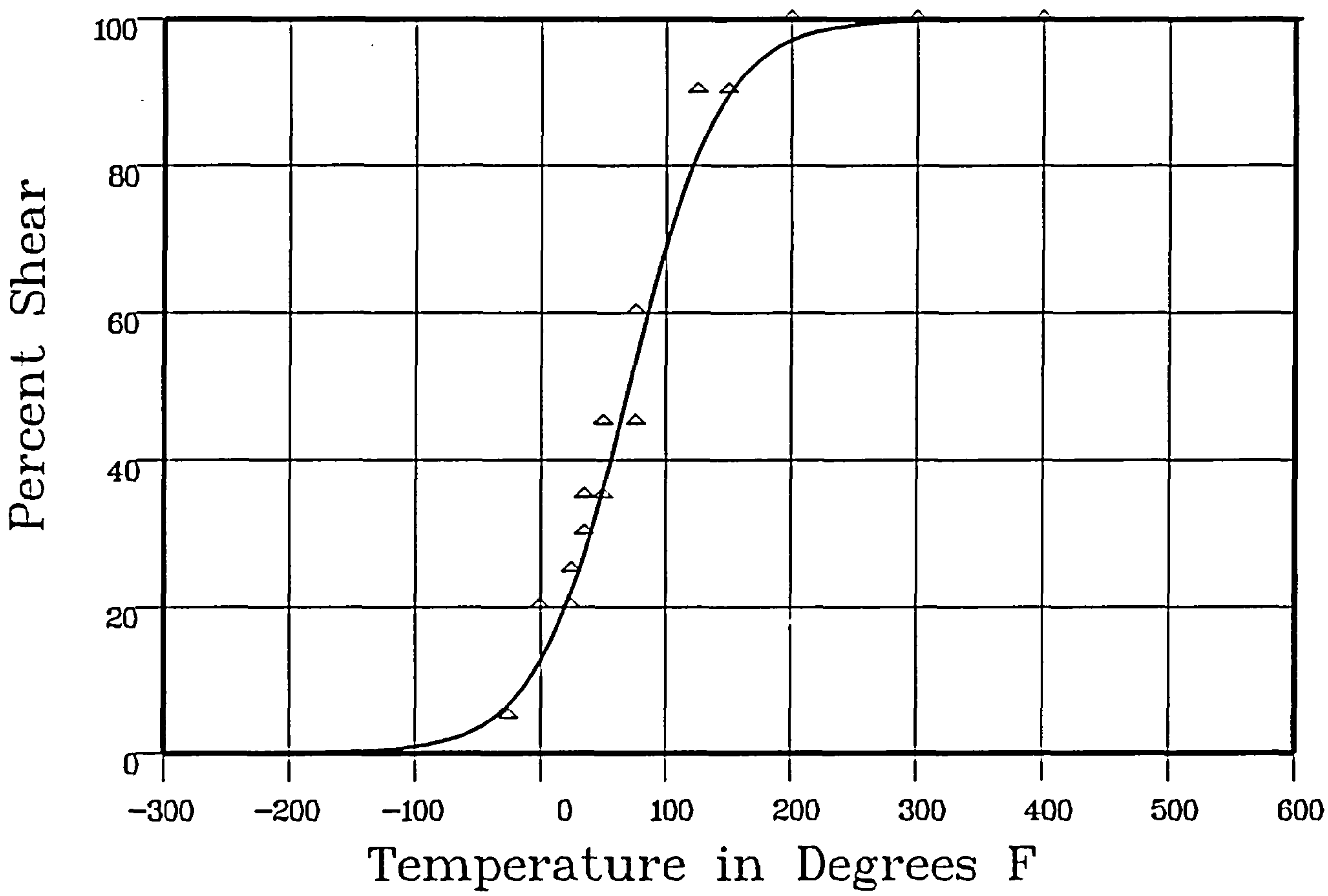
A = 50	B = 50	C = 73.3	T0 = 66.09

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 66

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap: X Material: WELD LINDE 0091 Ori: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-25	5	7.68	-2.68
0	20	14.14	5.85
25	25	24.58	.41
25	20	24.58	-4.58
35	30	29.97	.02
35	35	29.97	5.02
50	45	39.19	5.8

**** Data continued on next page ****

CAPSULE X (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
50	35	39.19	-4.19
76	45	56.71	-11.71
76	60	56.71	3.28
125	90	83.3	6.69
150	90	90.79	-.79
200	100	97.47	2.52
300	100	99.83	.16
400	100	99.98	.01

SUM of RESIDUALS = 5.82

CAPSULE W (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:43:49 on 11-06-2003

Page 1

Coefficients of Curve 5

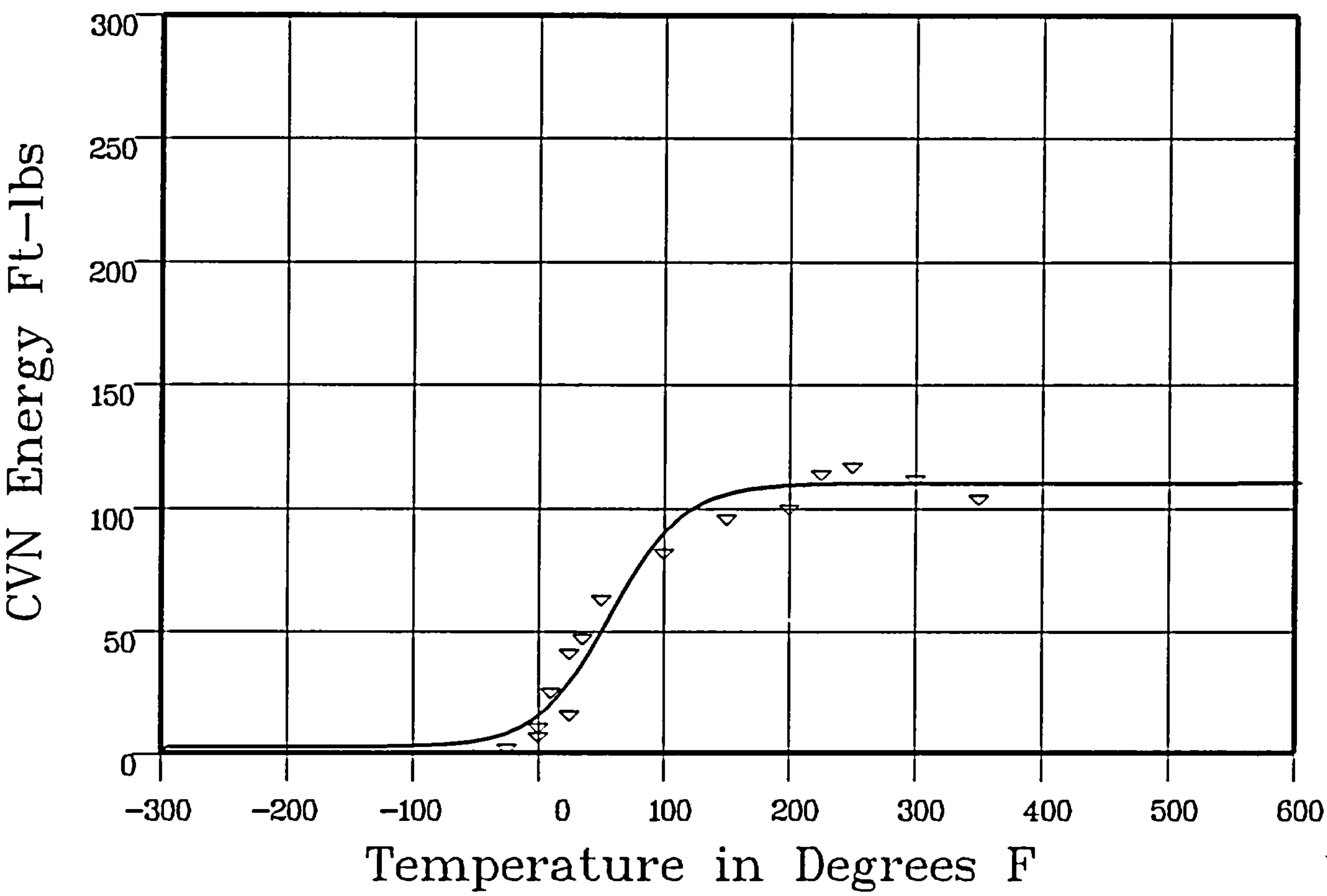
A = 56.09	B = 53.9	C = 58.25	T0 = 52.5

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 110 Fixed Temp. at 30 ft-lbs: 21.7 Temp. at 50 ft-lbs: 45.8 Lower Shelf Energy: 2.19 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: W Material: WELD LINDE 0091 Ori: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-25	3	9.24	-6.24
0	12	17.46	-5.46
0	8	17.46	-9.46
10	26	22.53	3.46
25	17	32.39	-15.39
25	42	32.39	9.6

**** Data continued on next page ****

CAPSULE W (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
35	48	40.37	7.62
50	64	53.78	10.21
100	83	92.34	-9.34
150	97	106.33	-9.33
200	101	109.32	-8.32
225	115	109.71	5.28
250	118	109.87	8.12
300	113	109.97	3.02
350	105	109.99	-4.99

SUM of RESIDUALS = -21.22

CAPSULE W (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:48:15 on 11-06-2003

Page 1

Coefficients of Curve 5

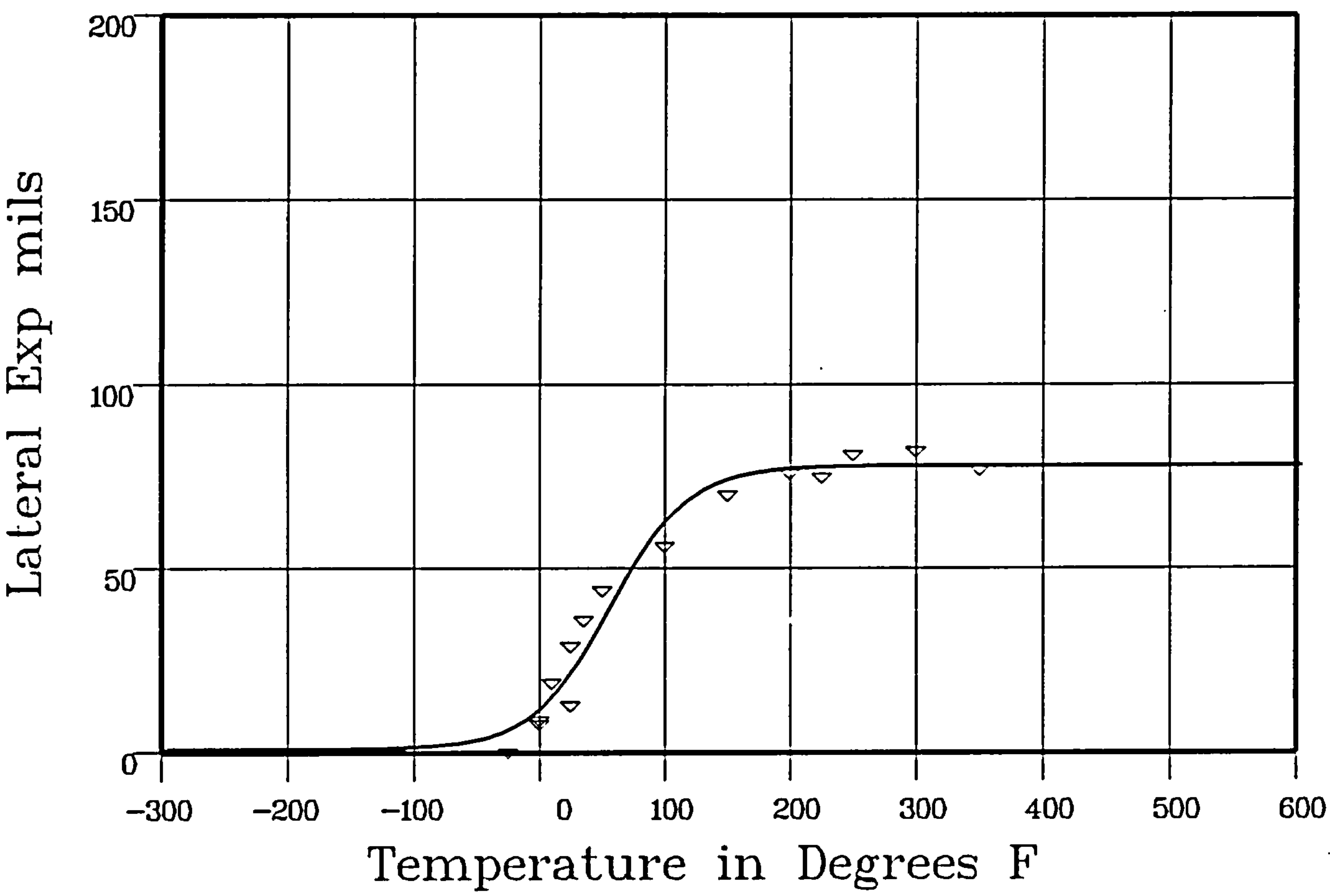
A = 39.59	B = 38.59	C = 63.02	T0 = 51.56

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 78.19 Temperature at L.E. 35: 44 Lower Shelf L.E.: 1 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-25	1	7.24	-6.24
0	9	13.57	-4.57
0	10	13.57	-3.57
10	20	17.28	2.71
25	14	24.22	-10.22
25	30	24.22	5.77

**** Data continued on next page ****

CAPSULE W (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
35	37	29.67	7.32
50	45	38.63	6.36
100	57	64.53	-7.53
150	71	74.93	-3.93
200	77	77.5	-.5
225	76	77.87	-1.87
250	82	78.04	3.95
300	83	78.16	4.83
350	78	78.18	-.18

SUM of RESIDUALS = -7.71

CAPSULE W (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:51:43 on 11-06-2003
Page 1
Coefficients of Curve 5

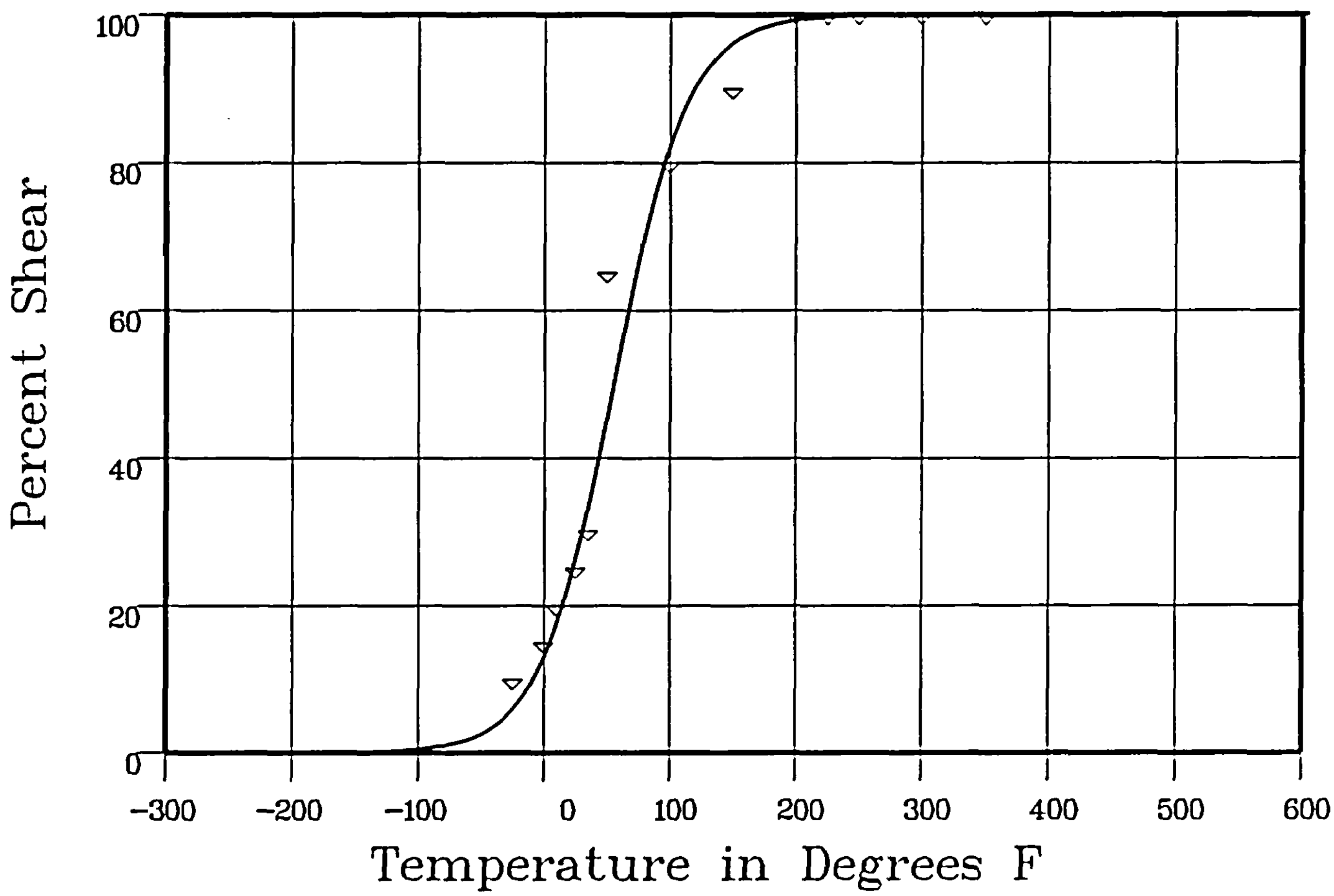
A = 50	B = 50	C = 58.55	T0 = 50.62

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 50.6

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: W Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap.: W Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-25	10	7.02	2.97
0	15	15.07	-.07
0	15	15.07	-.07
10	20	19.98	.01
25	25	29.41	-4.41
25	25	29.41	-4.41

**** Data continued on next page ****

CAPSULE W (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
35	30	36.96	-6.96
50	65	49.46	15.53
100	80	84.37	-4.37
150	90	96.75	-6.75
200	100	99.39	.6
225	100	99.74	.25
250	100	99.88	.11
300	100	99.98	.01
350	100	99.99	0

SUM of RESIDUALS = -7.54

CAPSULE V (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 08:58:55 on 11-06-2003

Page 1

Coefficients of Curve 2

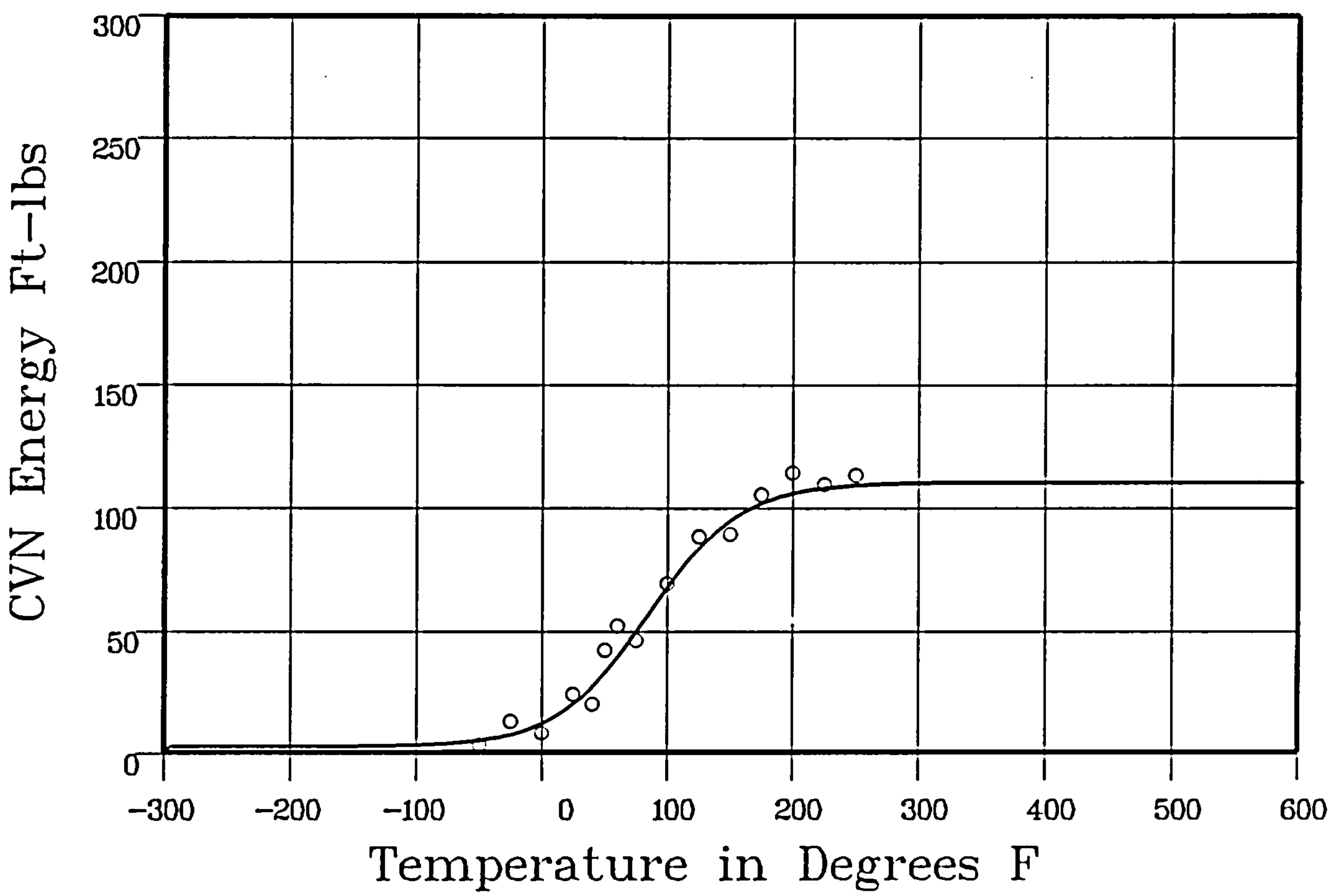
A = 56.09	B = 53.9	C = 73.52	T0 = 79.68

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 110 Fixed   Temp. at 30 ft-lbs: 40.8   Temp. at 50 ft-lbs: 71.3   Lower Shelf Energy: 2.19 Fixed

Material: WELD LINDE 0091   Heat Number: 33A277 FLUX LOT 3922   Orientation:

Capsule: V   Total Fluence:



Data Set(s) Plotted

Plant: FA1   Cap: V   Material: WELD LINDE 0091   Ori: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	3	5.27	-2.27
-25	13	8.1	4.89
0	8	13.27	-5.27
25	24	22.06	1.93
40	20	29.53	-9.53
50	42	35.44	6.55
60	52	42	9.99
75	46	52.66	-6.66

**** Data continued on next page ****

CAPSULE V (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
100	69	70.62	-1.62
125	88	85.66	2.33
150	89	96.12	-7.12
175	105	102.49	2.5
200	114	106.06	7.93
225	109	107.96	1.03
250	113	108.96	4.03

SUM of RESIDUALS = 8.71

CAPSULE V (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:01:05 on 11-06-2003
Page 1
Coefficients of Curve 2

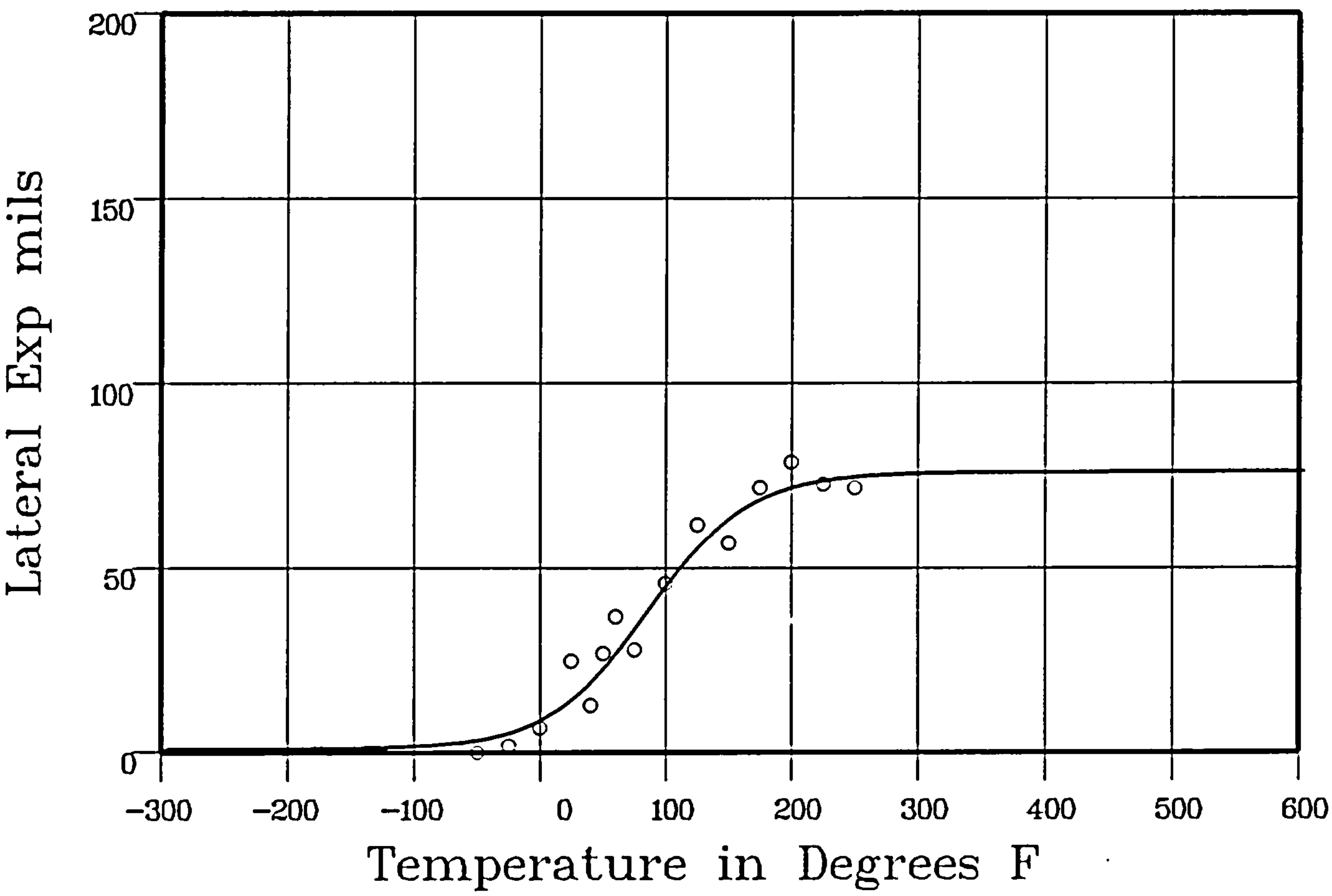
A = 38.6	B = 37.6	C = 80.38	T0 = 81.56

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 76.21 Temperature at L.E. 35: 73.8 Lower Shelf L.E.: 1 Fixed

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted
Plant: FA1 Cap.: V Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	0	3.74	-3.74
-25	2	5.95	-3.95
0	7	9.73	-2.73
25	25	15.79	9.2
40	13	20.72	-7.72
50	27	24.55	2.44
60	37	28.75	8.24
75	28	35.54	-7.54

**** Data continued on next page ****

CAPSULE V (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed LE.	Differential
100	46	47.08	-1.08
125	62	57.15	4.84
150	57	64.61	-7.61
175	72	69.5	2.49
200	79	72.45	6.54
225	73	74.14	-1.14
250	72	75.08	-3.08

SUM of RESIDUALS = -4.87

CAPSULE V (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:02:54 on 11-06-2003

Page 1

Coefficients of Curve 2

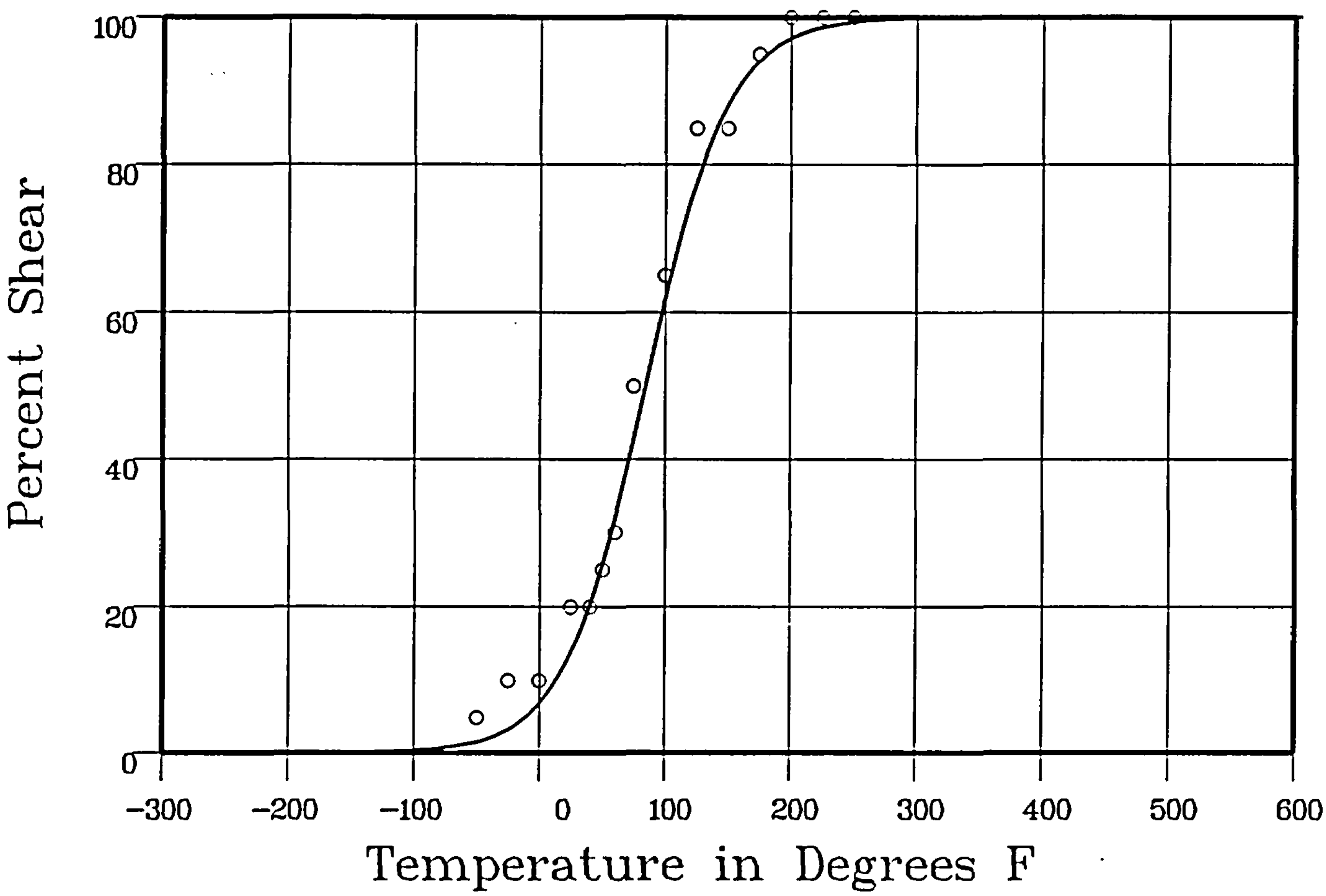
A = 50	B = 50	C = 65.13	T0 = 79.99

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 79.9

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: WELD LINDE 0091 Ori.: Heat #: 33A277 FLUX LOT 3922

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	5	1.81	3.18
-25	10	3.82	6.17
0	10	7.89	2.1
25	20	15.59	4.4
40	20	22.64	-2.64
50	25	28.47	-3.47
60	30	35.11	-5.11
75	50	46.17	3.82

**** Data continued on next page ****

CAPSULE V (WELD)

Page 2

Material: WELD LINDE 0091 Heat Number: 33A277 FLUX LOT 3922 Orientation:

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
100	65	64.88	.11
125	85	79.92	5.07
150	85	89.56	-4.56
175	95	94.86	.13
200	100	97.55	2.44
225	100	98.84	1.15
250	100	99.46	.53

SUM of RESIDUALS = 13.35

UNIRRADIATED (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:01:16 on 11-06-2003

Page 1

Coefficients of Curve 1

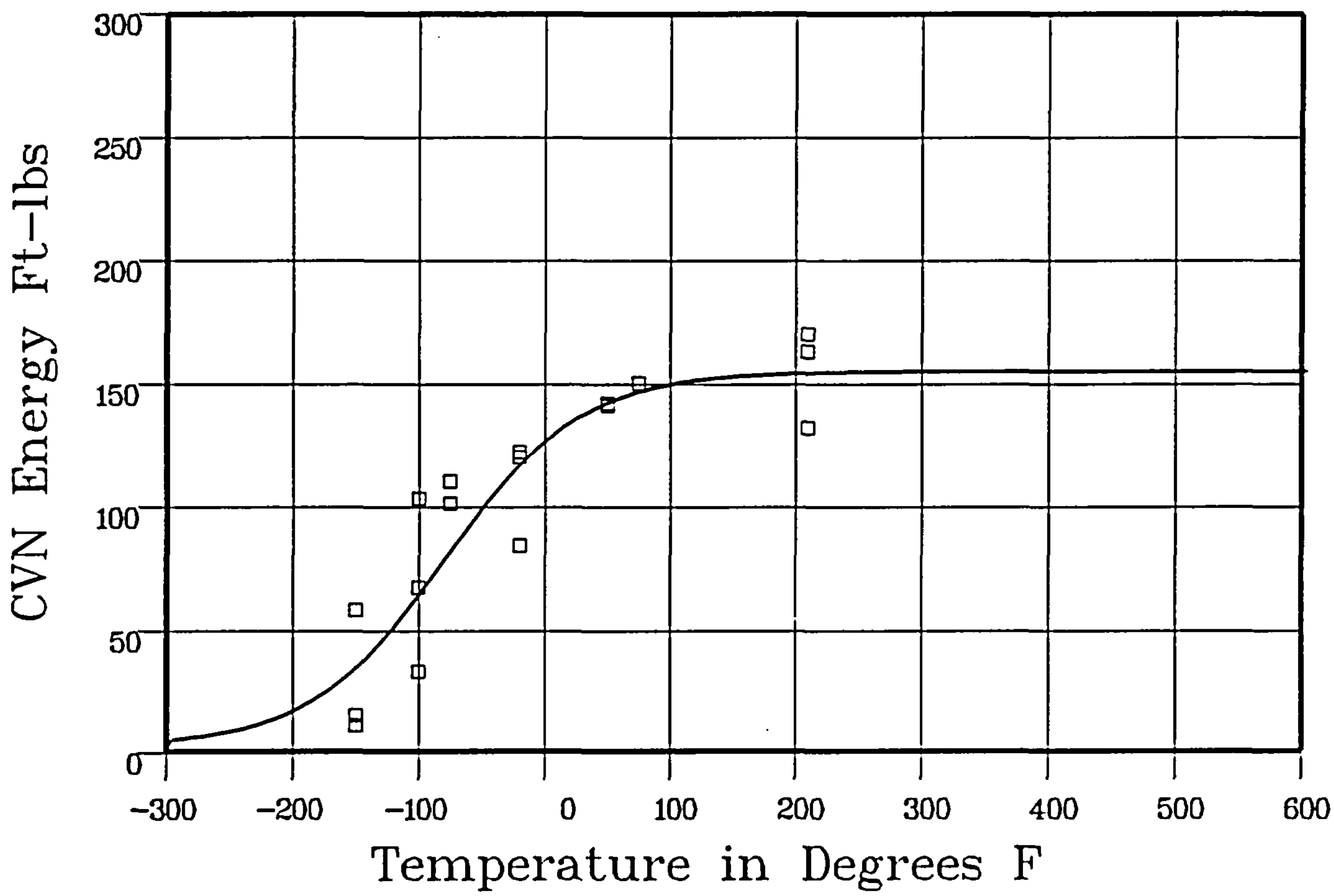
A = 78.59	B = 76.4	C = 107.56	T0 = -83.9

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 155 Fixed Temp. at 30 ft-lbs: -164.7 Temp. at 50 ft-lbs: -126.2 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: UNIRR Material: HEAT AFFD ZONE SA533B1 Ori: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-150	11	36.78	-25.78
-150	58	36.78	21.21
-150	15	36.78	-21.78
-100	67	67.25	-.25
-100	33	67.25	-34.25
-100	103	67.25	35.74
-75	110	84.91	25.08
-75	101	84.91	16.08
-20	122	119.31	2.68

**** Data continued on next page ****

UNIRRADIATED (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-20	84	119.31	-35.31
-20	120	119.31	.68
50	141	143.29	-2.29
50	142	143.29	-1.29
75	150	147.43	2.56
210	132	154.35	-22.35
210	170	154.35	15.64
210	163	154.35	8.64

SUM of RESIDUALS = -14.98

UNIRRADIATED (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:04:43 on 11-06-2003

Page 1

Coefficients of Curve 1

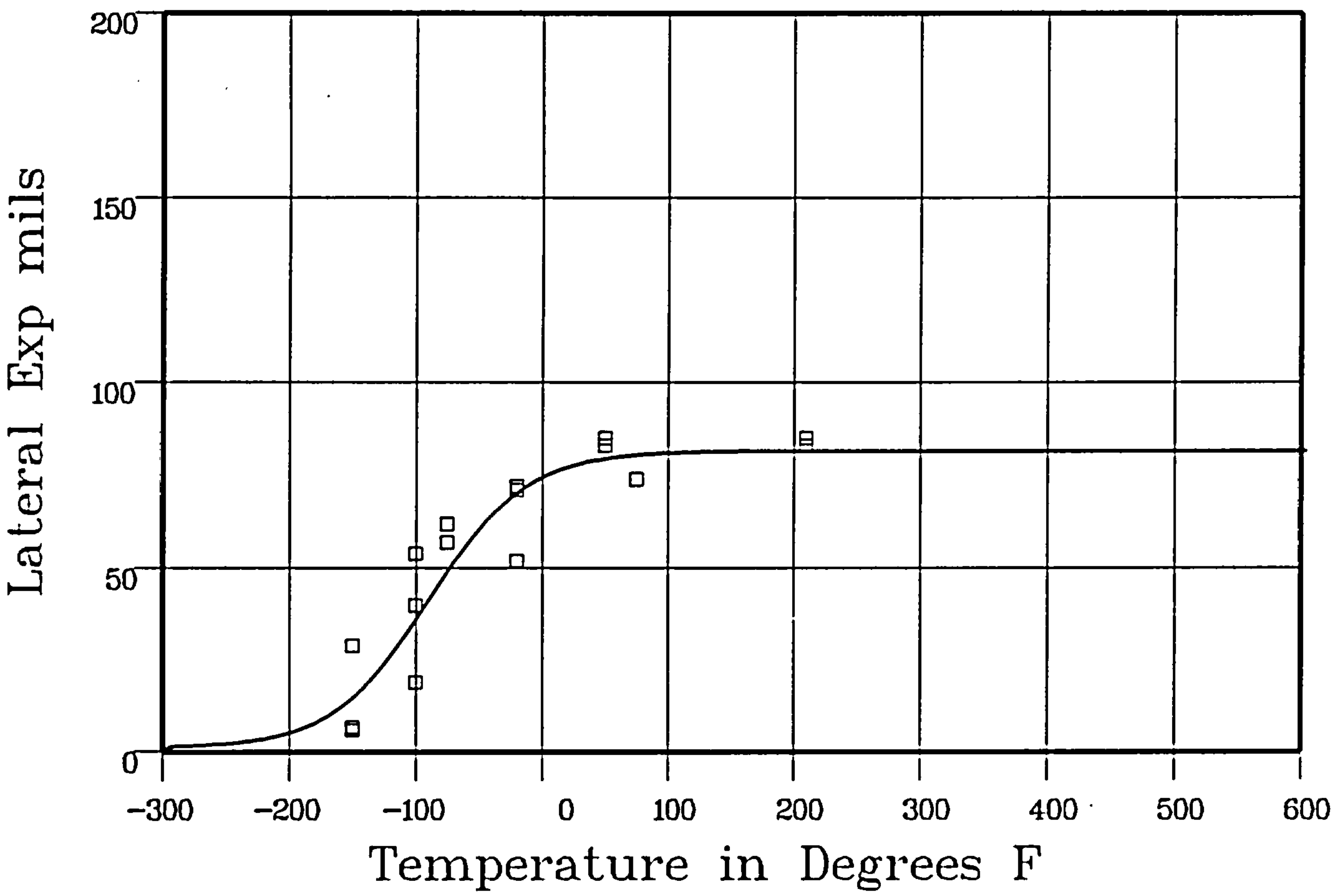
A = 41.29	B = 40.29	C = 76.82	T0 = -94.68

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 81.58 Temperature at L.E. 35: -106.7 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-150	6	16.43	-10.43
-150	29	16.43	12.56
-150	7	16.43	-9.43
-100	40	38.51	1.48
-100	19	38.51	-19.51
-100	54	38.51	15.48
-75	57	51.39	5.6
-75	62	51.39	10.6
-20	72	71.49	.5

**** Data continued on next page ****

UNIRRADIATED (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-20	52	71.49	-19.49
-20	71	71.49	-.49
50	83	79.76	3.23
50	85	79.76	5.23
75	74	80.62	-6.62
210	85	81.55	3.44
210	83	81.55	1.44
210	85	81.55	3.44

SUM of RESIDUALS = -2.95

UNIRRADIATED (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:44 on 11-06-2003

Page 1

Coefficients of Curve 1

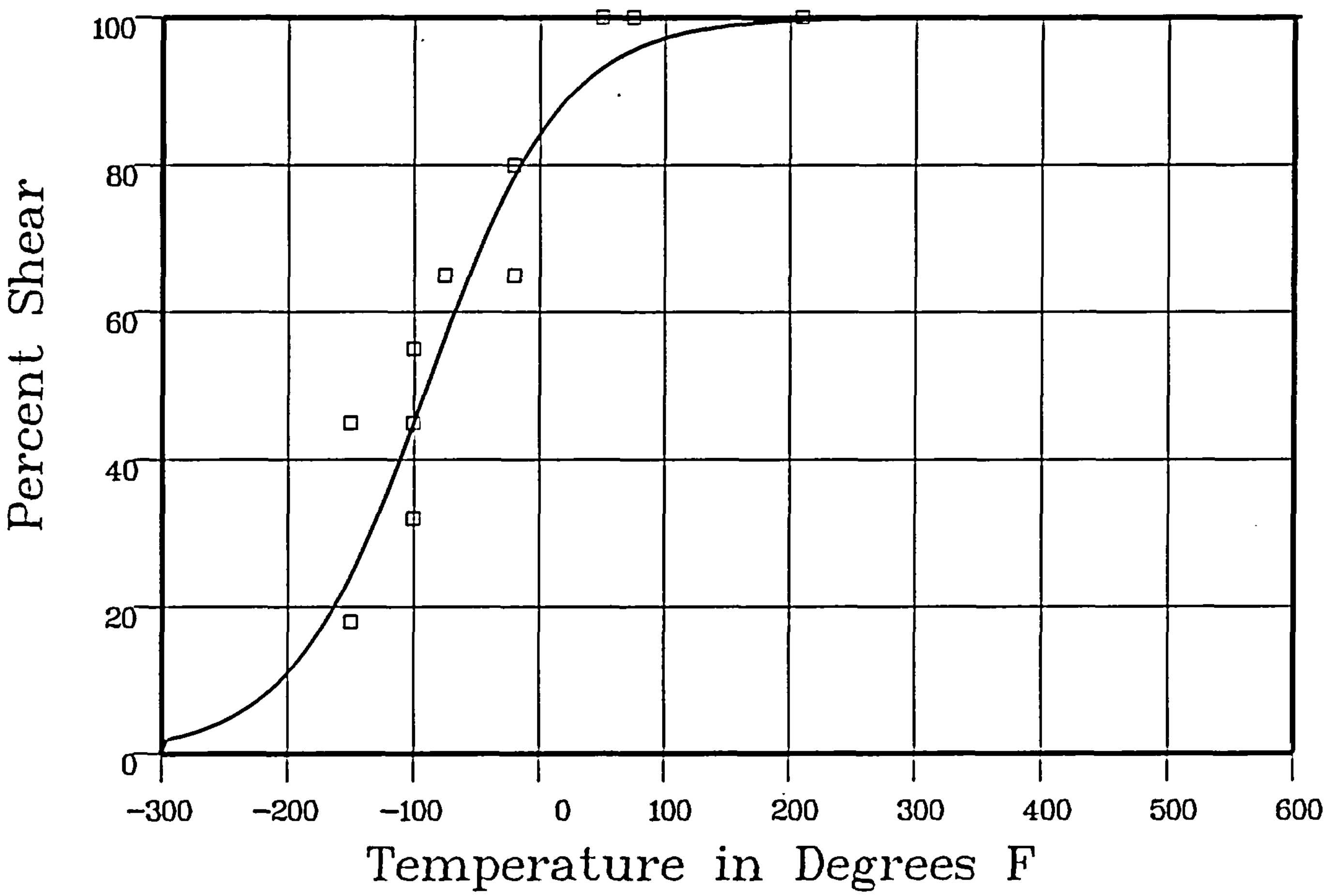
A = 50	B = 50	C = 106.64	T0 = -93.75

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: -93.7

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: UNIRR Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-150	18	25.82	-7.82
-150	45	25.82	19.17
-150	18	25.82	-7.82
-100	45	47.07	-2.07
-100	32	47.07	-15.07
-100	55	47.07	7.92
-75	65	58.7	6.29
-75	65	58.7	6.29
-20	80	79.94	.05

**** Data continued on next page ****

UNIRRADIATED (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1   Heat Number: C6940-1   Orientation:

Capsule: UNIRR   Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-20	65	79.94	-14.94
-20	80	79.94	.05
50	100	93.67	6.32
50	100	93.67	6.32
75	100	95.94	4.05
210	100	99.66	.33
210	100	99.66	.33
210	100	99.66	.33

SUM of RESIDUALS = 9.74

CAPSULE Y (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:01:16 on 11-06-2003

Page 1

Coefficients of Curve 2

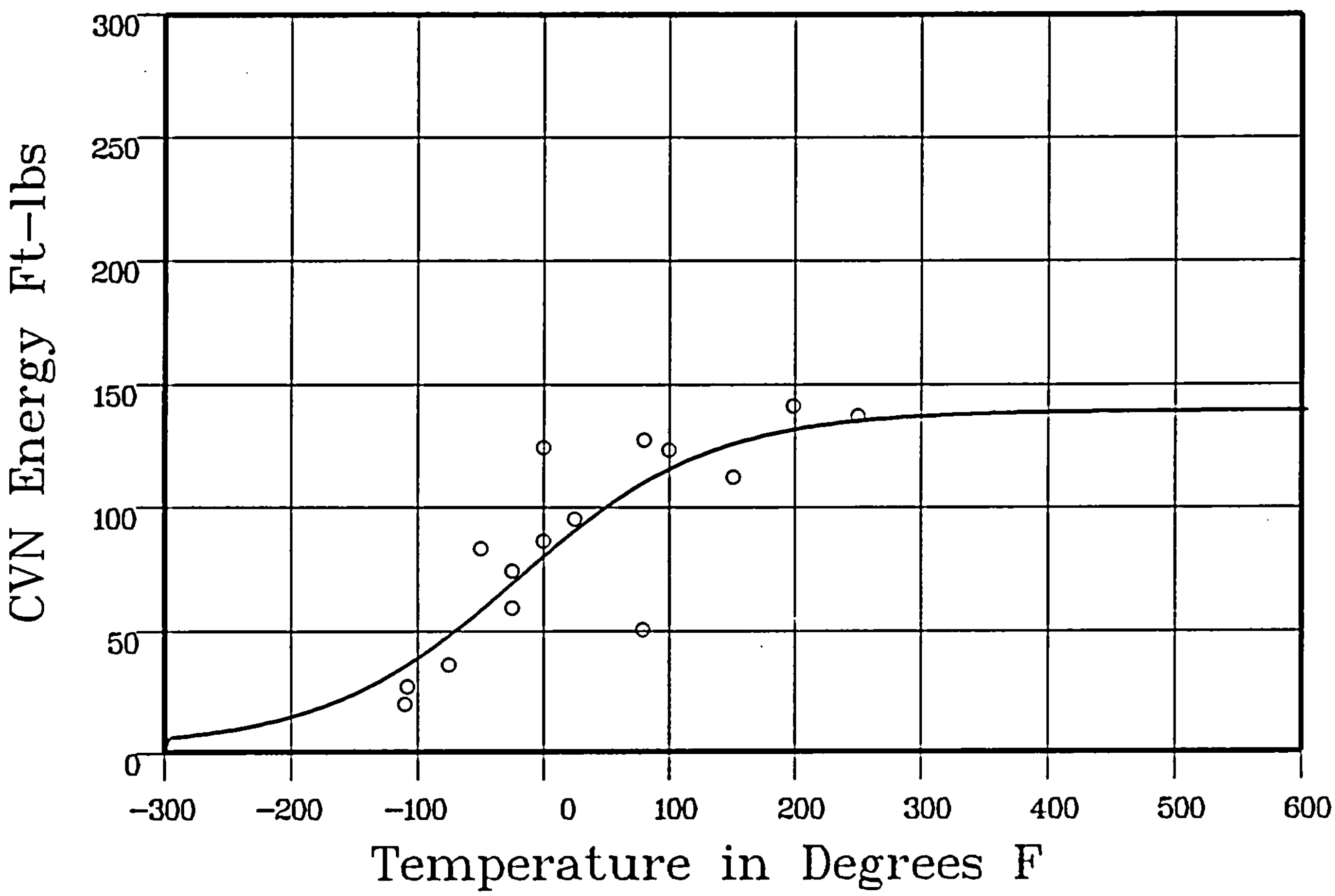
A = 70.59	B = 68.4	C = 155.77	T0 = -25.78

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 139 Fixed Temp. at 30 ft-lbs: -132.1 Temp. at 50 ft-lbs: -74.1 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-110	20	36.84	-16.84
-108	27	37.51	-10.51
-75	36	49.67	-13.67
-50	83	60.05	22.94
-25	74	70.94	3.05
-25	59	70.94	-11.94
0	124	81.81	42.18
0	86	81.81	4.18

**** Data continued on next page ****

CAPSULE Y (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	95	92.14	2.85
79	50	110.73	-60.73
80	127	111.01	15.98
100	123	116.3	6.69
151	112	126.18	-14.18
199	141	131.76	9.23
250	137	135.14	1.85

SUM of RESIDUALS = -18.91

CAPSULE Y (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:04:43 on 11-06-2003

Page 1

Coefficients of Curve 2

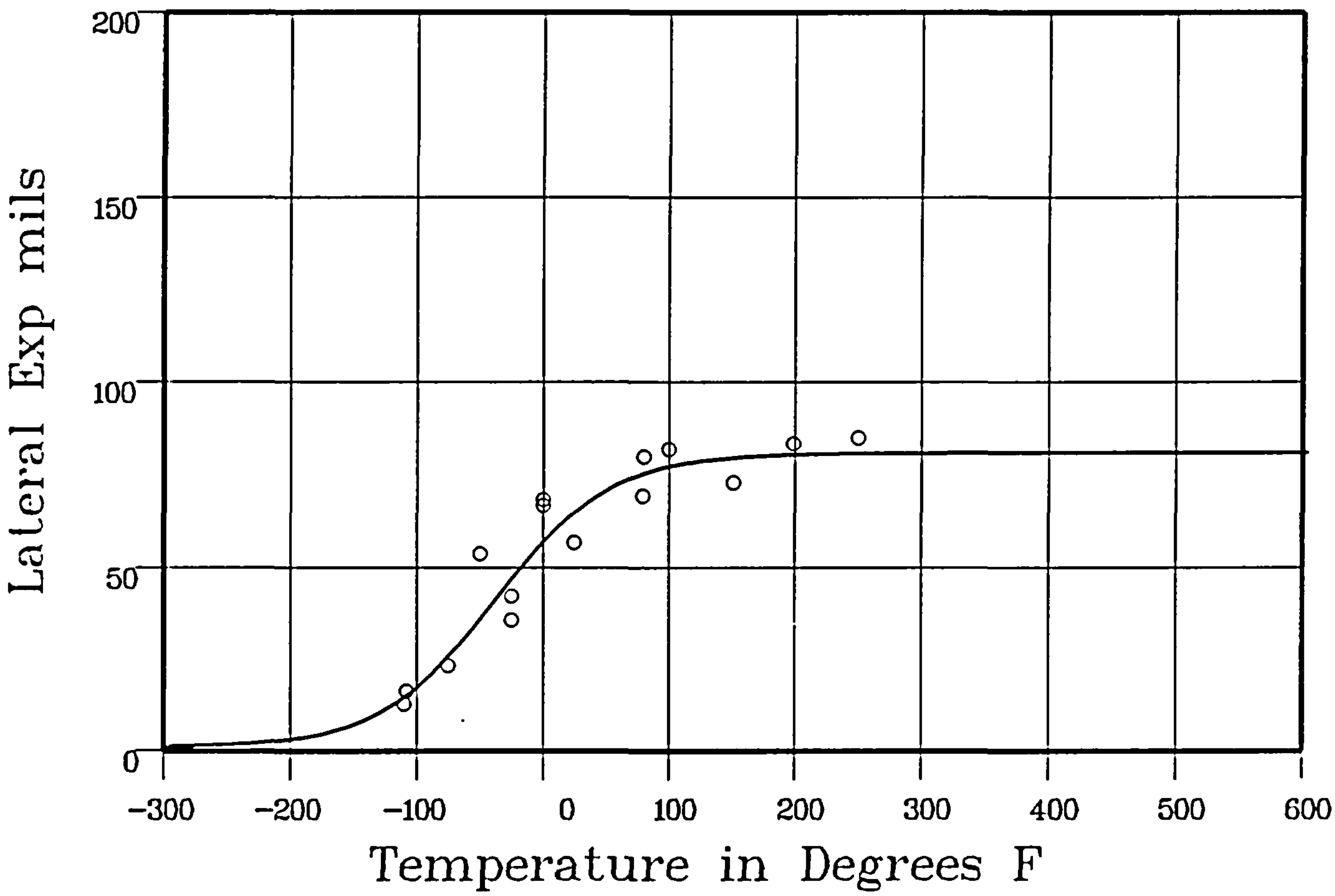
A = 40.98	B = 39.98	C = 91.16	T0 = -43.46

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 80.96 Temperature at L.E. 35: -57.2 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-110	13	16.07	-3.07
-108	16.5	16.61	-.11
-75	23.5	27.67	-4.17
-50	54	38.11	15.88
-25	42.5	48.96	-6.46
-25	36	48.96	-12.96
0	67	58.71	8.28
0	68.5	58.71	9.78

**** Data continued on next page ****

CAPSULE Y (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	57	66.39	-9.39
79	69.5	75.86	-6.36
80	80	75.96	4.03
100	82	77.66	4.33
151	73	79.85	-6.85
199	83.5	80.57	2.92
250	85	80.83	4.16

SUM of RESIDUALS = 0

CAPSULE Y (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:44 on 11-06-2003

Page 1

Coefficients of Curve 2

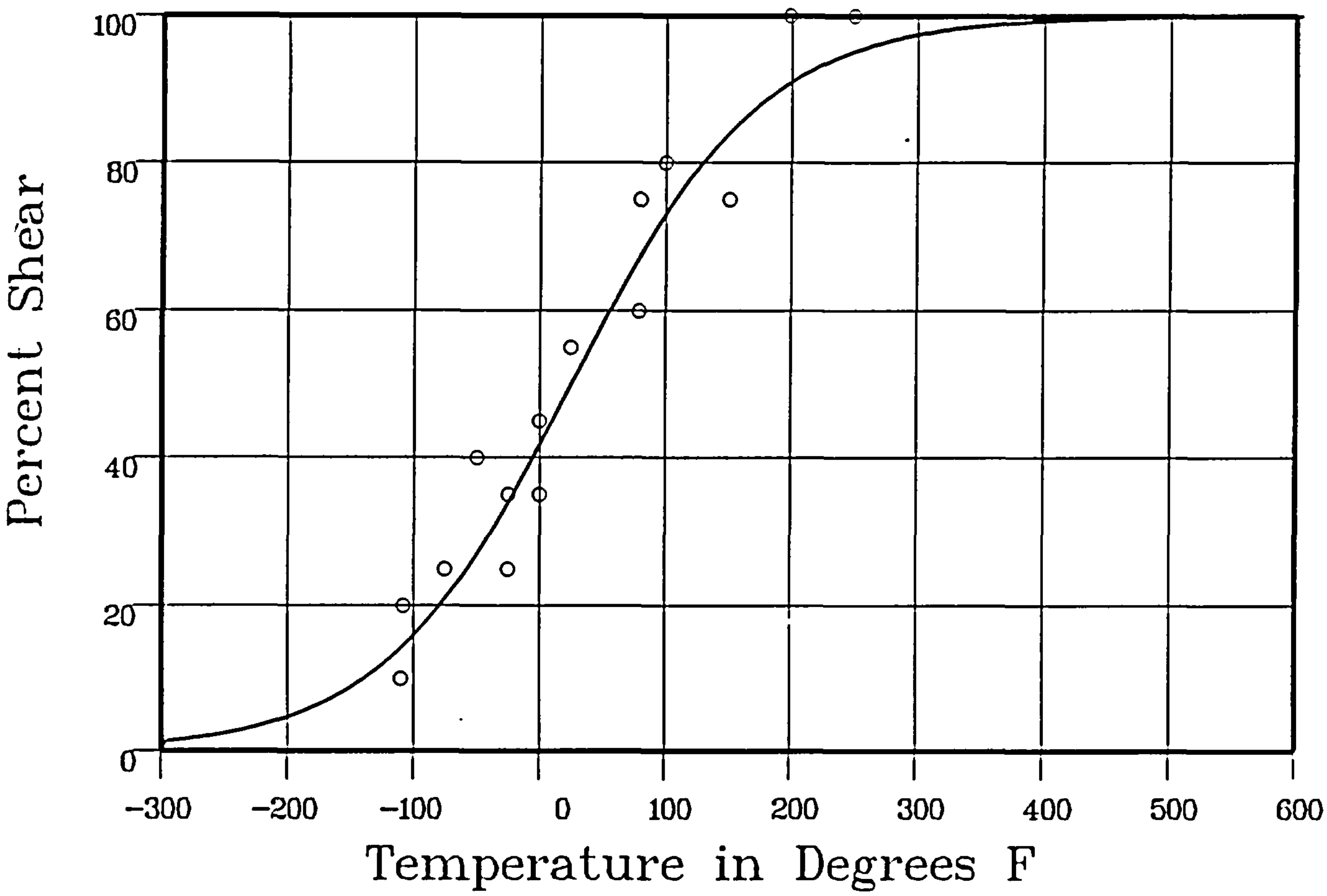
A = 50	B = 50	C = 150.69	T0 = 20.62

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 20.6

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: Y Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-110	10	15.01	-5.01
-108	20	15.35	4.64
-75	25	21.94	3.05
-50	40	28.14	11.85
-25	35	35.3	-.3
-25	25	35.3	-10.3
0	45	43.19	1.8
0	35	43.19	-8.19

**** Data continued on next page ****

CAPSULE Y (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	55	51.45	3.54
79	60	68.45	-8.45
80	75	68.74	6.25
100	80	74.14	5.85
151	75	84.94	-9.94
199	100	91.43	8.56
250	100	95.45	4.54

SUM of RESIDUALS = 7.91

CAPSULE U (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:01:16 on 11-06-2003

Page 1

Coefficients of Curve 3

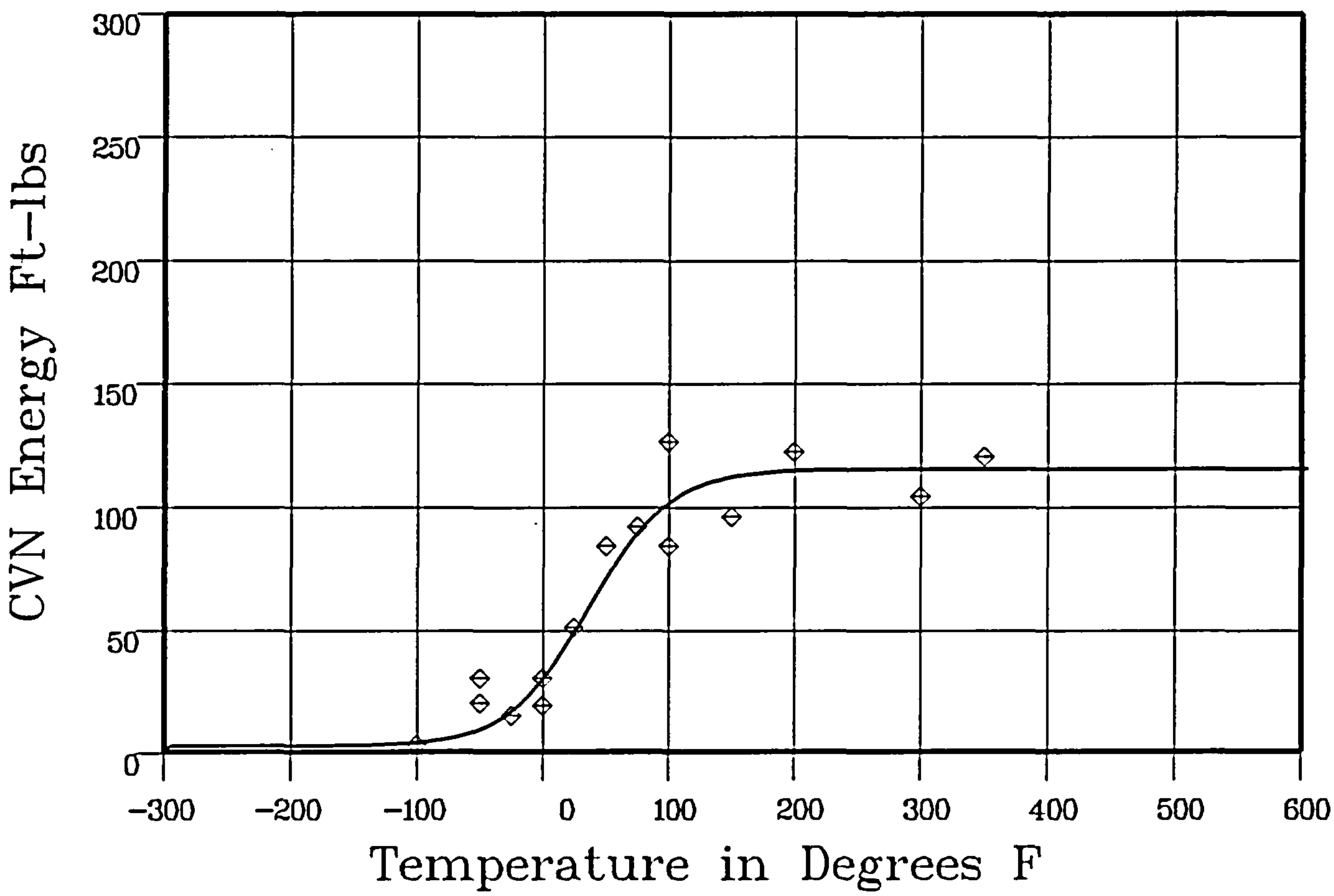
A = 58.59	B = 56.4	C = 64.03	T0 = 31.4

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 115 Fixed Temp. at 30 ft-lbs: -4.3 Temp. at 50 ft-lbs: 21.5 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: U Material: HEAT AFFD ZONE SA533B1 Ori: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-100	3	4.03	-1.03
-50	30	10.42	19.57
-50	20	10.42	9.57
-25	15	18.73	-3.73
0	19	32.96	-13.96
0	30	32.96	-2.96
25	51	52.97	-1.97
50	84	74.53	9.46

**** Data continued on next page ****

CAPSULE U (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
75	92	91.98	.01
100	126	103.15	22.84
100	84	103.15	-19.15
150	96	112.28	-16.28
200	122	114.42	7.57
300	104	114.97	-10.97
350	120	114.99	5

SUM of RESIDUALS = 3.98

CAPSULE U (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:04:43 on 11-06-2003

Page 1

Coefficients of Curve 3

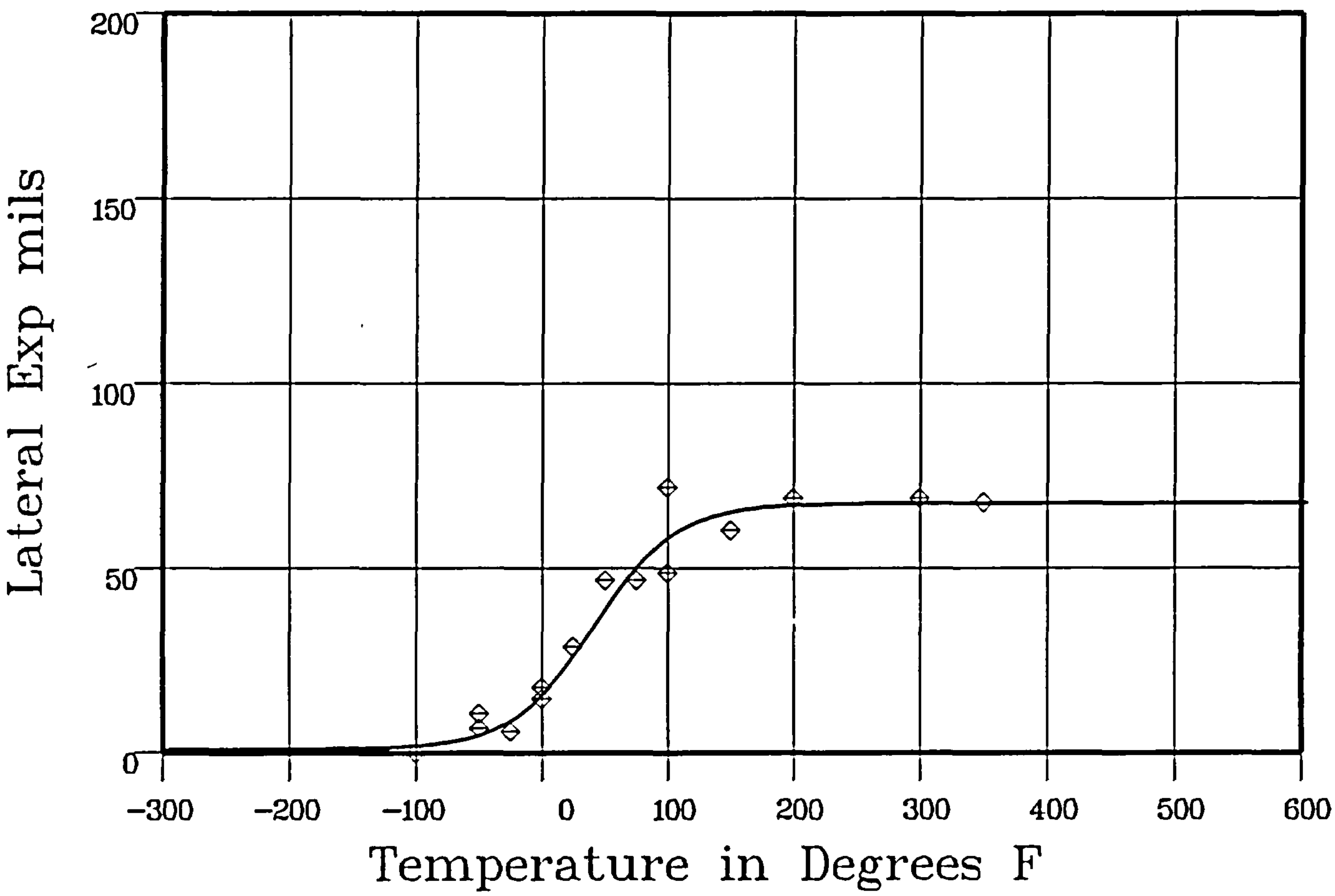
A = 34.35	B = 33.35	C = 65.82	T0 = 36.09

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 67.7 Temperature at L.E. 35: 37.3 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: U Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-100	0	2.05	-2.05
-50	11	5.54	5.45
-50	7	5.54	1.45
-25	6	10.01	-4.01
0	15	17.7	-2.7
0	18	17.7	.29
25	29	28.78	.21
50	47	41.29	5.7

**** Data continued on next page ****

CAPSULE U (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed LE	Differential
75	47	52.04	-5.04
100	72	59.33	12.66
100	49	59.33	-10.33
150	60.5	65.67	-5.17
200	69	67.24	1.75
300	69	67.68	1.31
350	68	67.69	.3

SUM of RESIDUALS = -.15

CAPSULE U (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:44 on 11-06-2003
Page 1
Coefficients of Curve 3

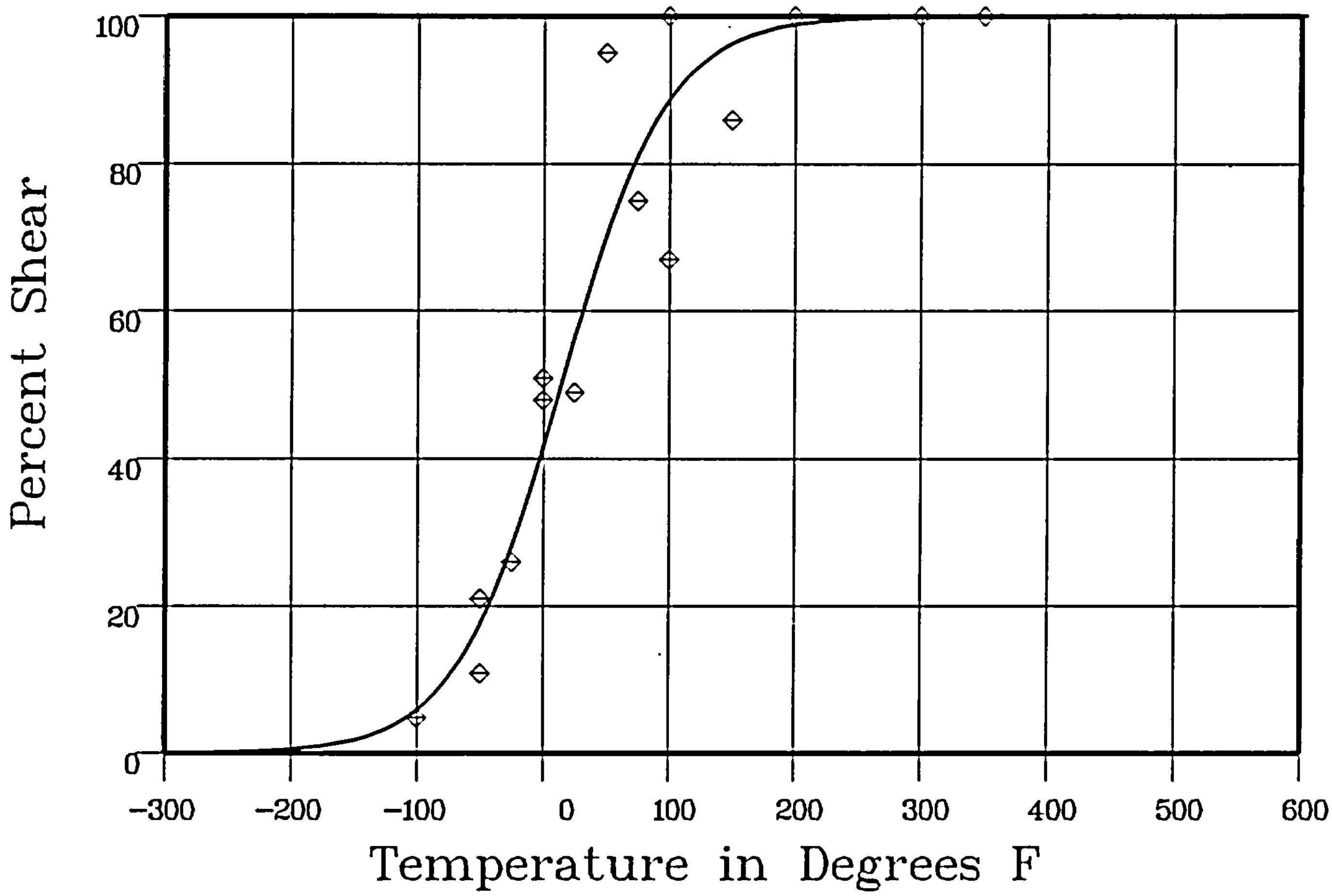
A = 50	B = 50	C = 83.26	T0 = 9.52

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 9.5

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: U Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: U Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-100	5	6.71	-1.71
-50	21	19.31	1.68
-50	11	19.31	-8.31
-25	26	30.37	-4.37
0	48	44.3	3.69
0	51	44.3	6.69
25	49	59.18	-10.18
50	95	72.55	22.44

**** Data continued on next page ****

CAPSULE U (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: U Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
75	75	82.81	-7.81
100	100	89.78	10.21
100	67	89.78	-22.78
150	86	96.68	-10.68
200	100	98.97	1.02
300	100	99.9	.09
350	100	99.97	.02

SUM of RESIDUALS = -19.99

CAPSULE X (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:01:16 on 11-06-2003

Page 1

Coefficients of Curve 4

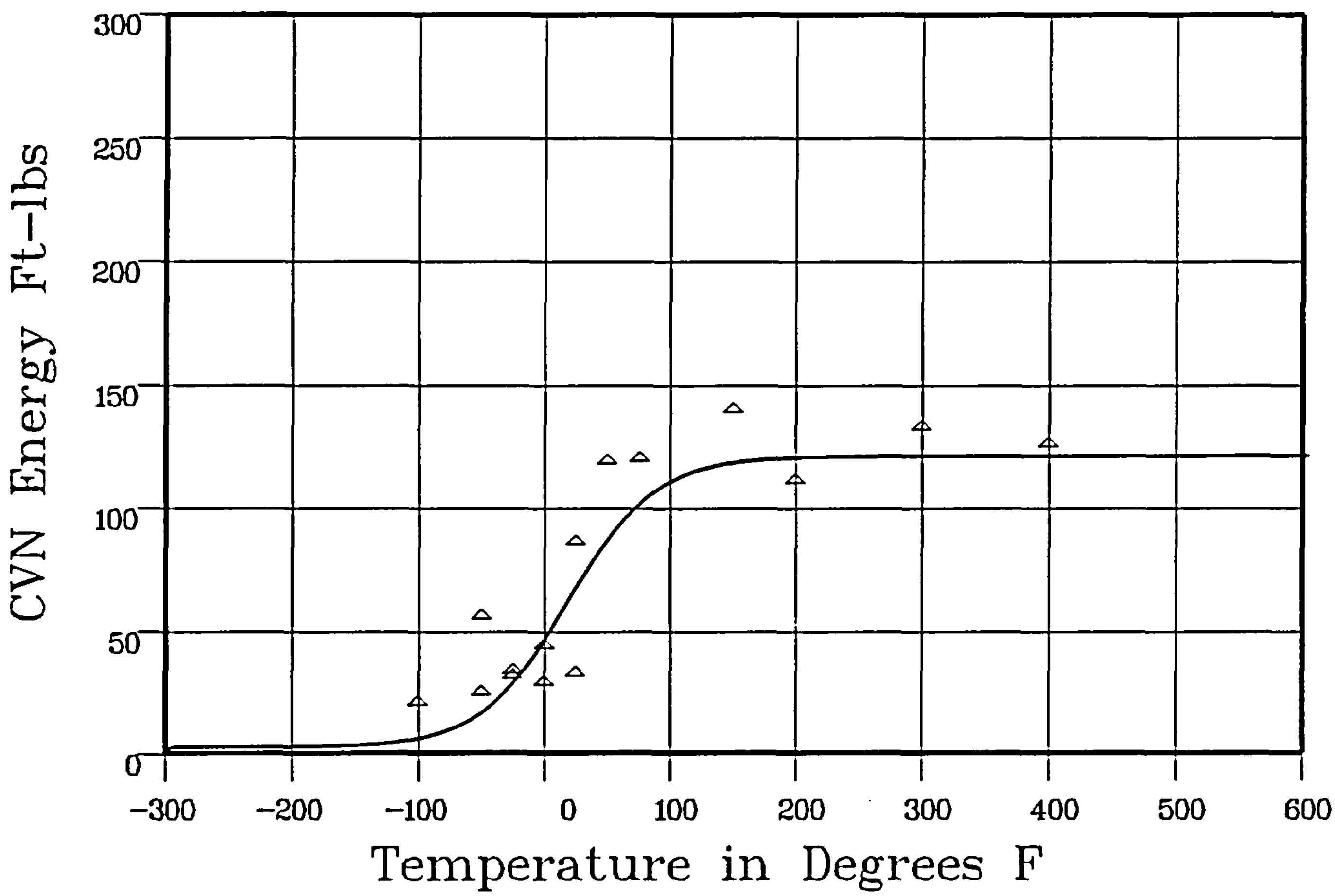
A = 61.59	B = 59.4	C = 69.87	T0 = 13.59

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 121 Fixed   Temp. at 30 ft-lbs: -27.8   Temp. at 50 ft-lbs: -2   Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1   Heat Number: C6940-1   Orientation:

Capsule: X   Total Fluence:



Data Set(s) Plotted

Plant: FA1   Cap.: X   Material: HEAT AFFD ZONE SA533B1   Ori.:   Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-100	20	6.62	13.37
-50	24	18.76	5.23
-50	55	18.76	36.23
-25	33	31.76	1.23
-25	31	31.76	-.76
0	28	50.18	-22.18
0	43	50.18	-7.18

**** Data continued on next page ****

CAPSULE X (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1   Heat Number: C6940-1   Orientation:

Capsule: X   Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	32	71.21	-39.21
25	85	71.21	13.78
50	118	90.02	27.97
76	119	103.94	15.05
150	139	118.65	20.34
200	110	120.43	-10.43
300	132	120.96	11.03
400	125	120.99	4

SUM of RESIDUALS = 68.49

CAPSULE X (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:04:43 on 11-06-2003

Page 1

Coefficients of Curve 4

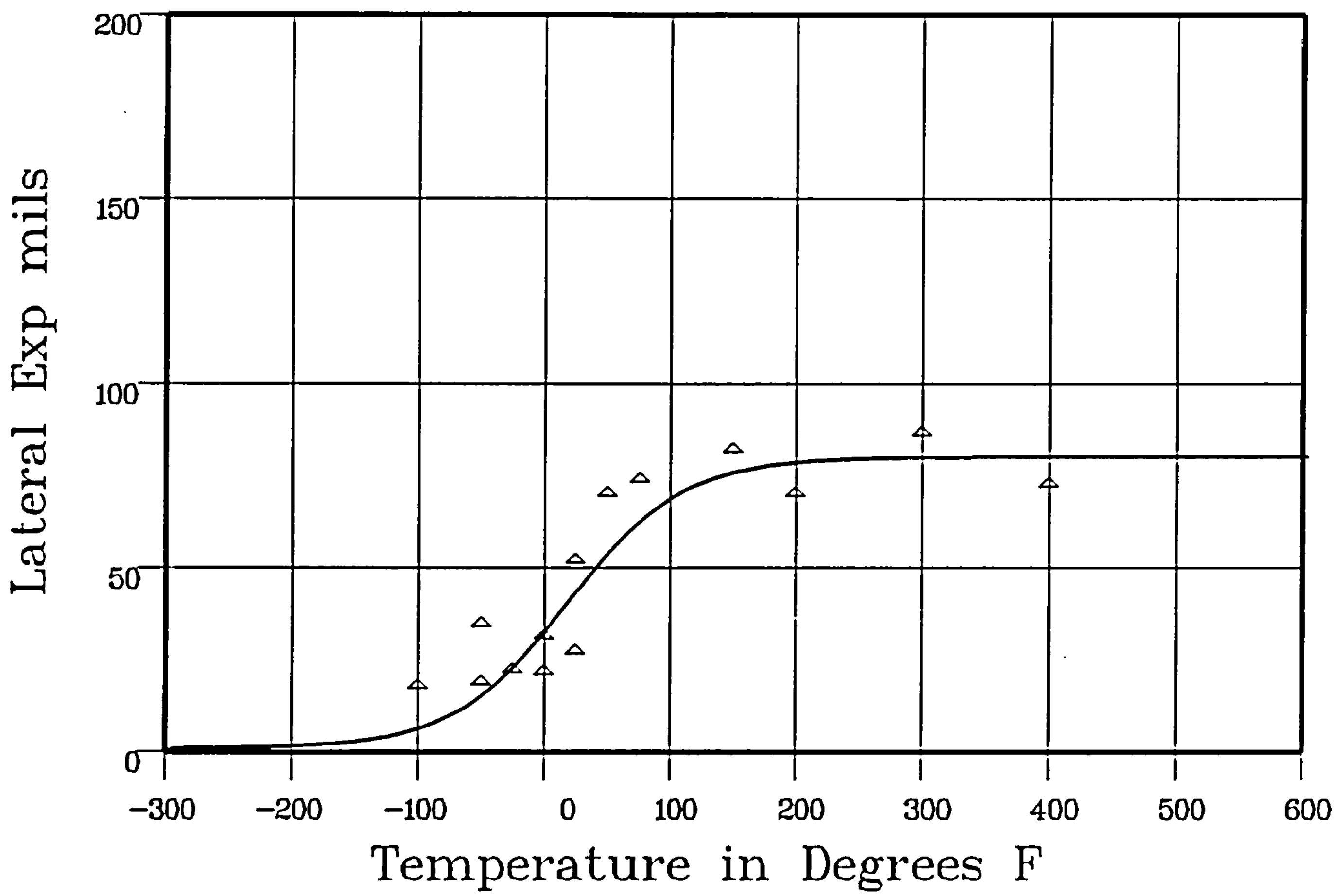
A = 40.57	B = 39.57	C = 91.62	T0 = 13.59

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 80.15 Temperature at L.E. 35: .5 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-100	17.5	7.12	10.37
-50	18.5	16.8	1.69
-50	34.5	16.8	17.69
-25	22	24.82	-2.82
-25	22	24.82	-2.82
0	21.5	34.75	-13.25
0	31	34.75	-3.75

**** Data continued on next page ****

CAPSULE X (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	27	45.48	-18.48
25	51.5	45.48	6.01
50	69.5	55.52	13.97
76	73.5	64.01	9.48
150	81.5	76.32	5.17
200	69.5	78.82	-9.32
300	86	80	5.99
400	72	80.14	-8.14

SUM of RESIDUALS = 11.79

CAPSULE X (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:44 on 11-06-2003

Page 1

Coefficients of Curve 4

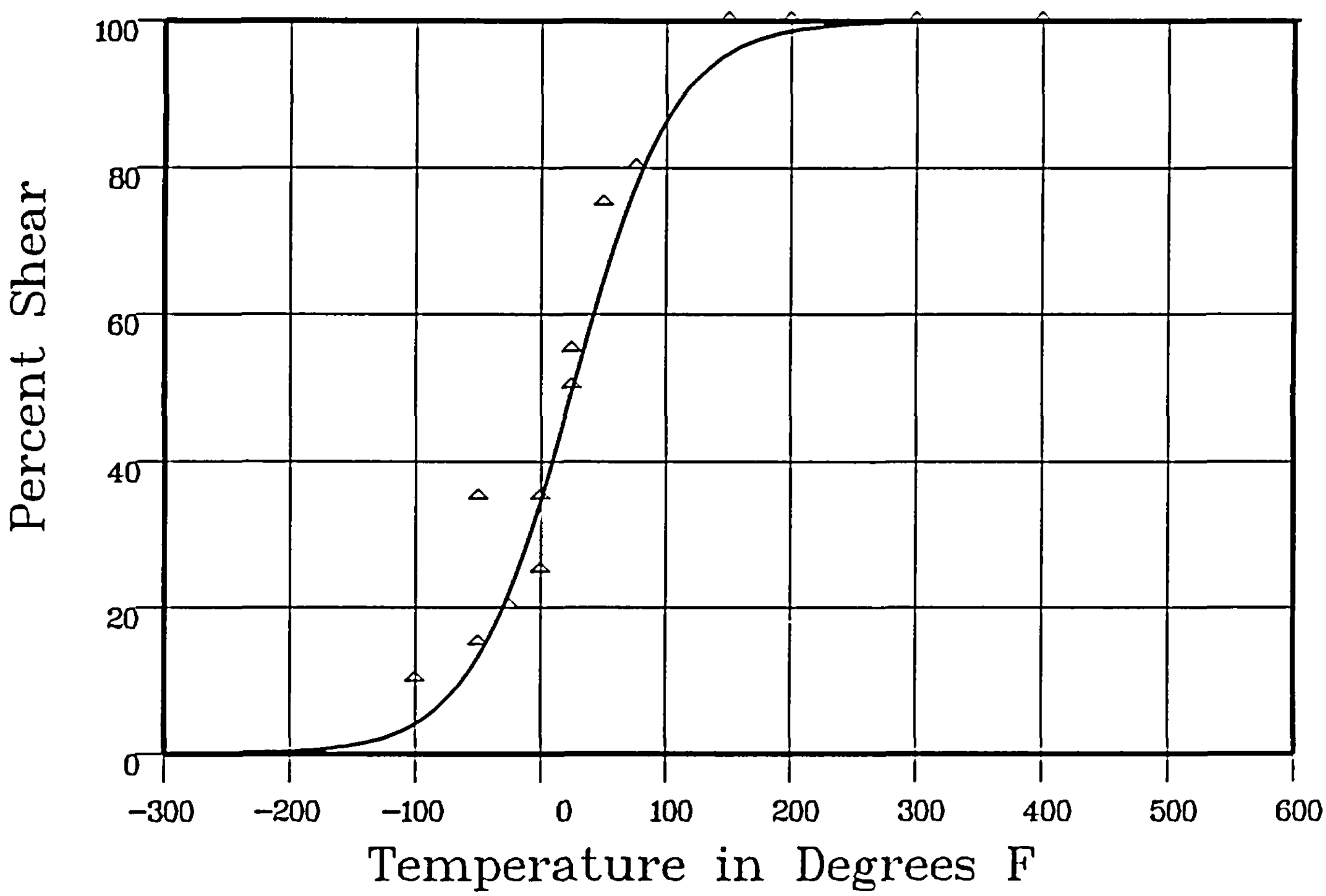
A = 50	B = 50	C = 80.73	T0 = 21.09

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: .21

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: X Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-100	10	4.74	5.25
-50	15	14.66	.33
-50	35	14.66	20.33
-25	20	24.19	-4.19
-25	20	24.19	-4.19
0	25	37.22	-12.22
0	35	37.22	-2.22

**** Data continued on next page ****

CAPSULE X (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1   Heat Number: C6940-1   Orientation:

Capsule: X   Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	50	52.41	-2.41
25	55	52.41	2.58
50	75	67.17	7.82
76	80	79.57	.42
150	100	96.05	3.94
200	100	98.82	1.17
300	100	99.9	.09
400	100	99.99	0

SUM of RESIDUALS = 16.72

CAPSULE W (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:01:16 on 11-06-2003

Page 1

Coefficients of Curve 5

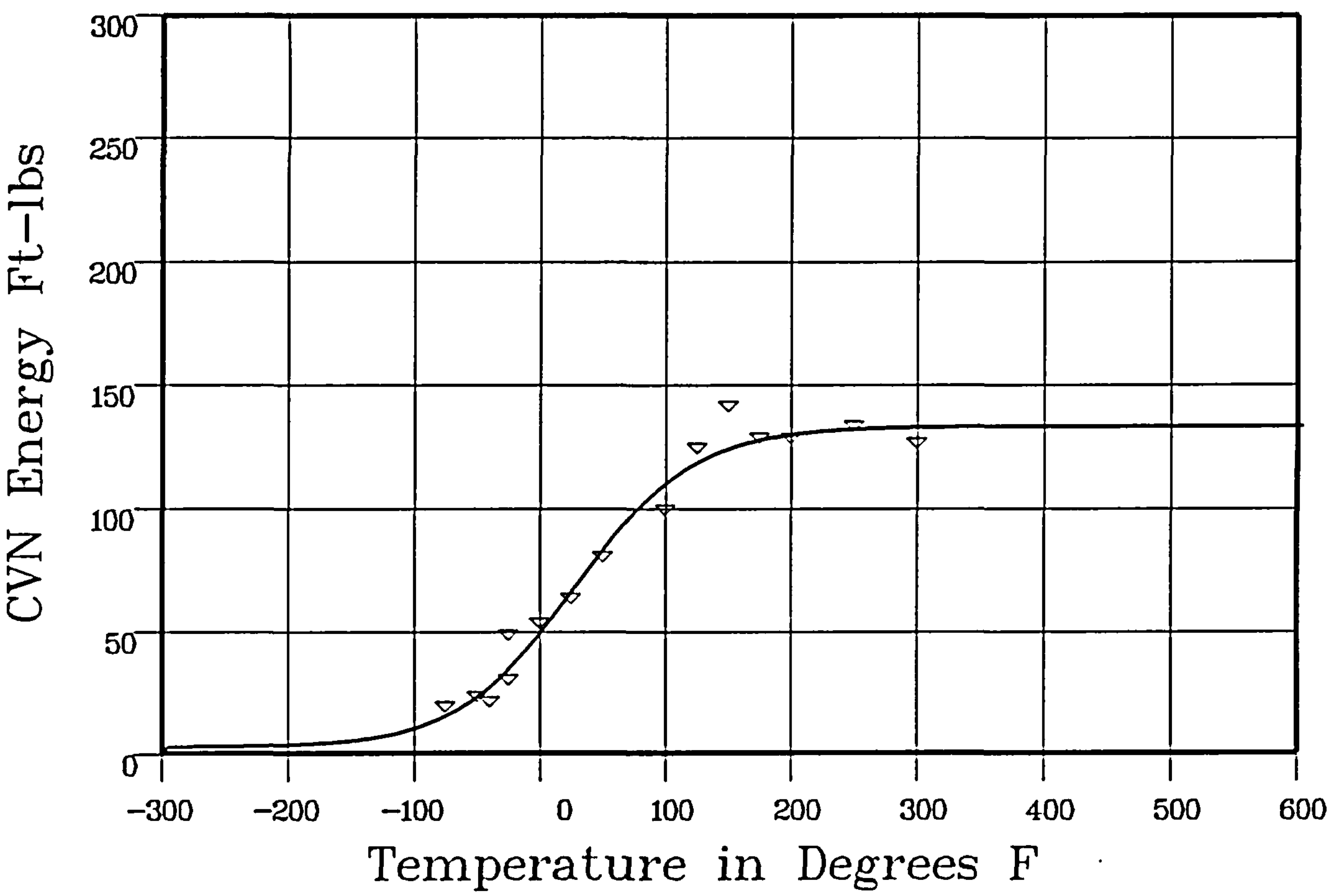
A = 67.59	B = 65.4	C = 94.18	T0 = 22.96

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 133 Fixed Temp. at 30 ft-lbs: -38.7 Temp. at 50 ft-lbs: -3 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: W Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-75	21	16.72	4.27
-50	25	25.11	-.11
-40	23	29.4	-6.4
-25	32	36.9	-4.9
-25	50	36.9	13.09
0	55	51.95	3.04

**** Data continued on next page ****

CAPSULE W (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
25	65	69.01	-4.01
50	82	85.87	-3.87
100	101	111.67	-10.67
125	126	119.55	6.44
150	143	124.74	18.25
175	130	128.01	1.98
200	130	130.02	-.02
250	135	131.95	3.04
300	128	132.63	-4.63

SUM of RESIDUALS = 15.52

CAPSULE W (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:04:43 on 11-06-2003

Page 1

Coefficients of Curve 5

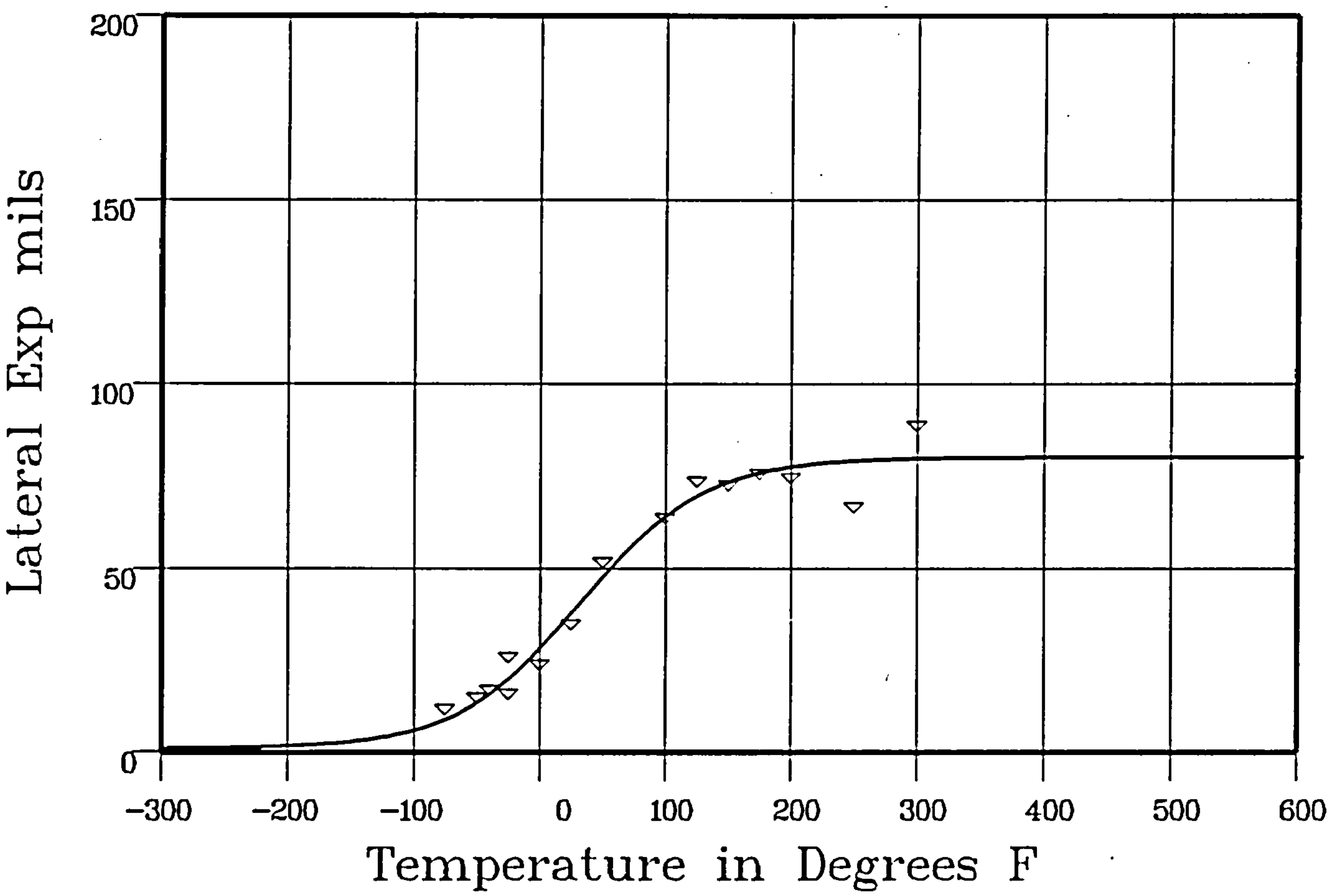
A = 40.65	B = 39.65	C = 98.64	T0 = 27.18

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 80.31 Temperature at L.E. 35: 13 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: W Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-75	13	9.87	3.12
-50	16	14.71	1.28
-40	18	17.17	.82
-25	17	21.43	-4.43
-25	27	21.43	5.56
0	25	29.99	-4.99

**** Data continued on next page ****

CAPSULE W (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
25	36	39.77	-3.77
50	53	49.66	3.33
100	65	65.56	-.56
125	75	70.71	4.28
150	74	74.24	-.24
175	77	76.54	.45
200	76	77.99	-1.99
250	68	79.45	-11.45
300	90	80	9.99
			SUM of RESIDUALS = 1.39

CAPSULE W (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:44 on 11-06-2003

Page 1

Coefficients of Curve 5

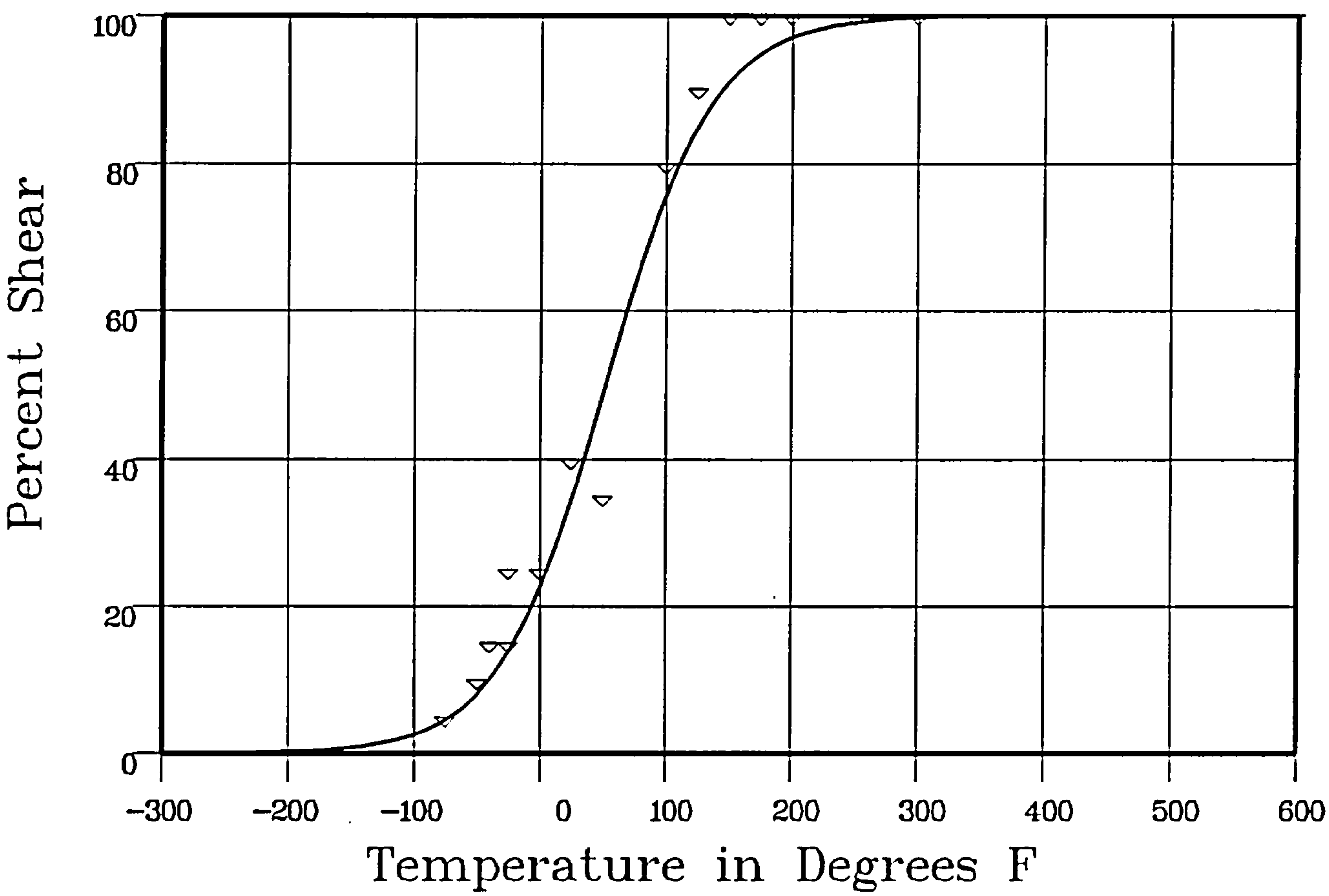
A = 50	B = 50	C = 84.46	T0 = 47.34

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 47.3

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: W Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap: W Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C6940-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75	5	5.22	-.22
-50	10	9.07	.92
-40	15	11.22	3.77
-25	15	15.27	-.27
-25	25	15.27	9.72
0	25	24.58	.41

**** Data continued on next page ****

CAPSULE W (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C6940-1 Orientation:

Capsule: W Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
25	40	37.07	2.92
50	35	51.57	-16.57
100	80	77.67	2.32
125	90	86.28	3.71
150	100	91.91	8.08
175	100	95.35	4.64
200	100	97.37	2.62
250	100	99.18	.81
300	100	99.74	.25

SUM of RESIDUALS = 23.15

CAPSULE V (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:07:15 on 11-06-2003

Page 1

Coefficients of Curve 2

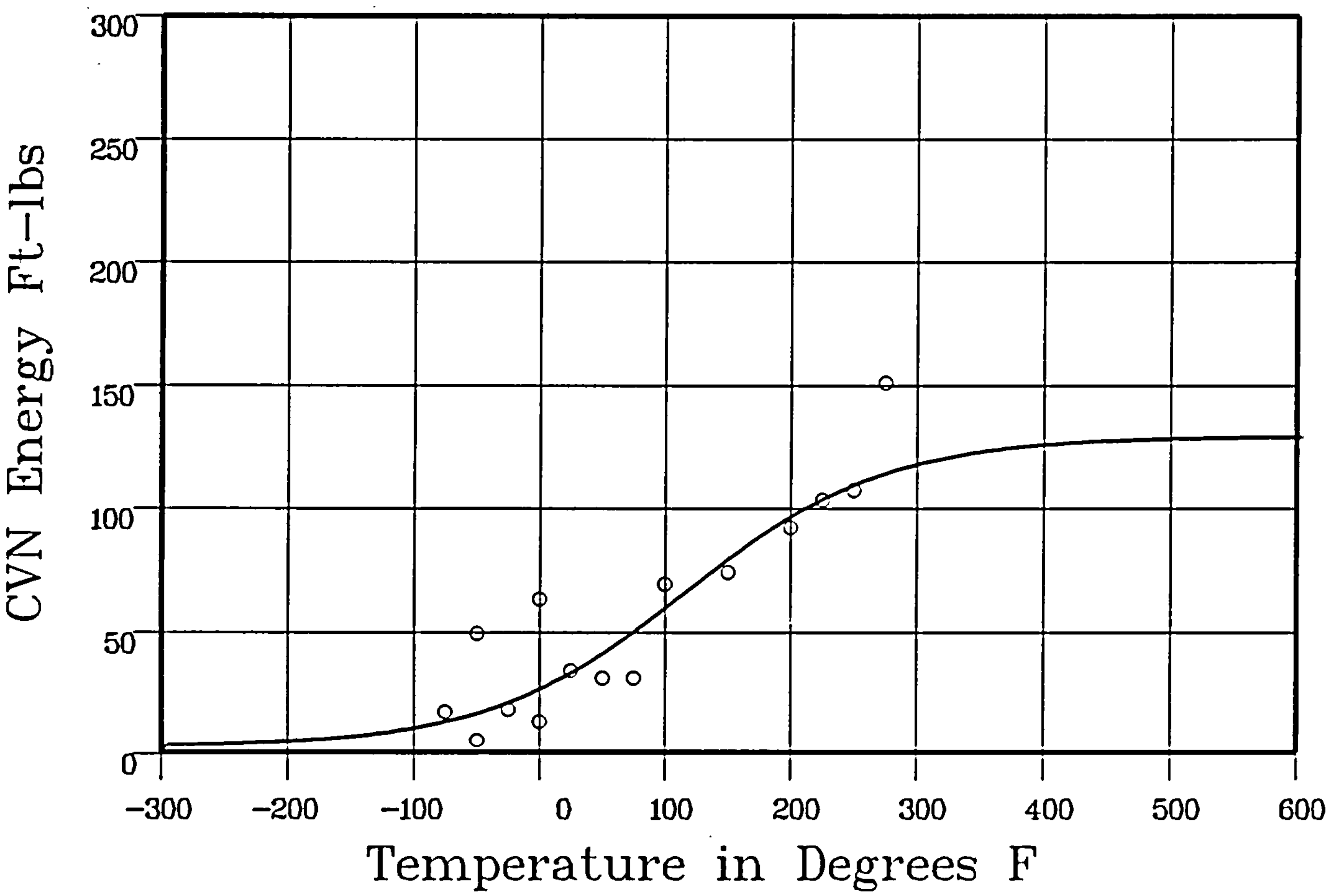
A = 65.59	B = 63.4	C = 159.65	T0 = 111.03

Equation is: CVN = A + B * [tanh((T - T0)/C)]

Upper Shelf Energy: 129 Fixed Temp. at 30 ft-lbs: 9.6 Temp. at 50 ft-lbs: 70.9 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #:

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-75	17	13.43	3.56
-50	5	17.08	-12.08
-50	49	17.08	31.91
-25	18	21.71	-3.71
0	63	27.46	35.53
0	13	27.46	-14.46
25	34	34.39	-.39
50	31	42.47	-11.47

**** Data continued on next page ****

CAPSULE V (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: Orientation:

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
75	31	51.52	-20.52
100	69	61.22	7.77
150	74	80.77	-6.77
200	92	97.67	-5.67
225	103	104.46	-1.46
250	107	110.07	-3.07
275	151	114.58	36.41

SUM of RESIDUALS = 35.51

CAPSULE V (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:09:23 on 11-06-2003

Page 1

Coefficients of Curve 2

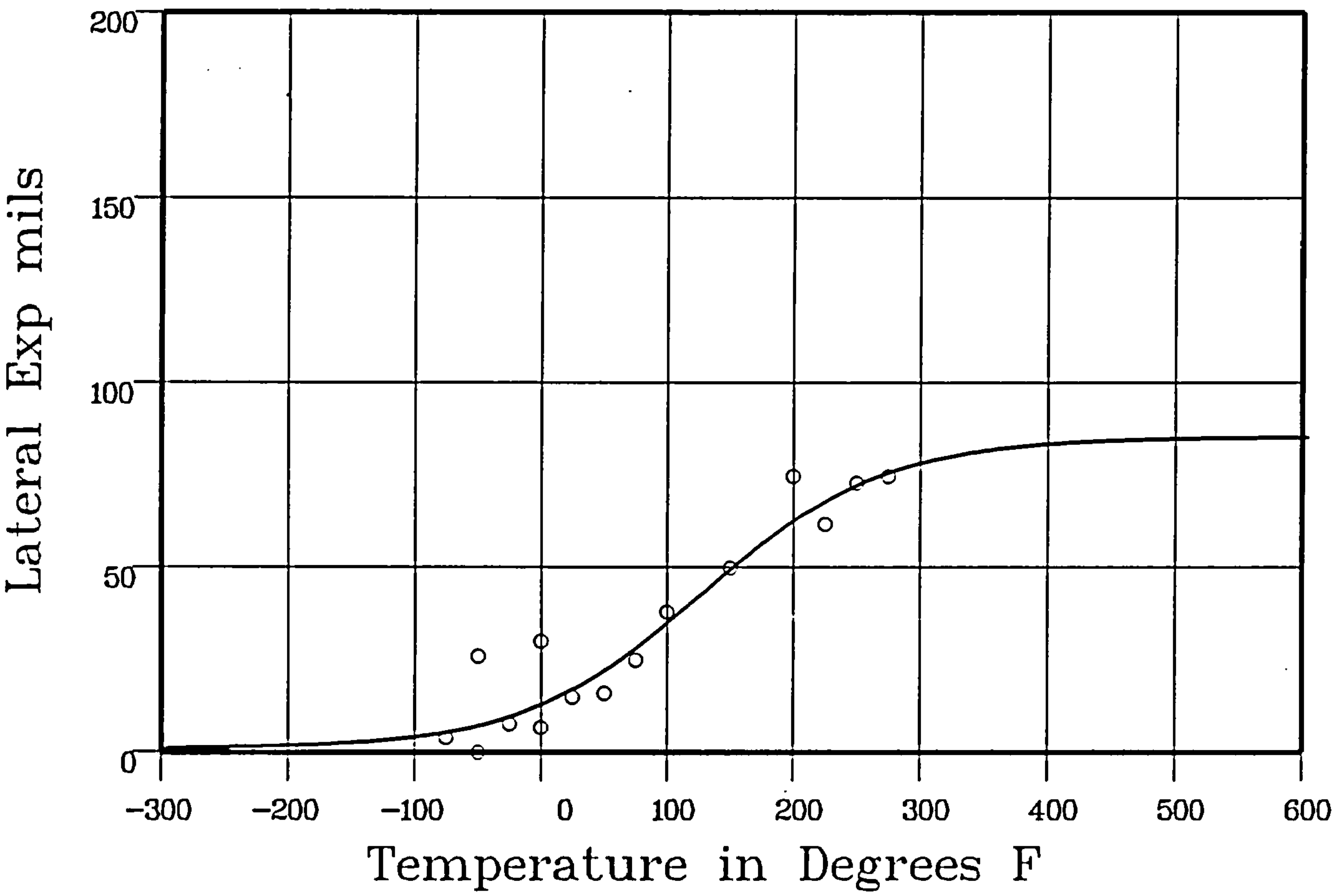
A = 43.25	B = 42.25	C = 142.87	T0 = 123.75

Equation is: L.E. = A + B * [tanh((T - T0)/C)]

Upper Shelf L.E.: 85.5 Temperature at L.E. 35: 95.4 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #:

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-75	4	5.92	-1.92
-50	0	7.82	-7.82
-50	26	7.82	18.17
-25	8	10.36	-2.36
0	30	13.7	16.29
0	7	13.7	-6.7
25	15	17.95	-2.95
50	16	23.19	-7.19

**** Data continued on next page ****

CAPSULE V (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1   Heat Number: Orientation:

Capsule: V   Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
75	25	29.37	-4.37
100	38	36.29	1.7
150	50	50.93	-.93
200	75	63.88	11.11
225	62	69.02	-7.02
250	73	73.17	-.17
275	75	76.42	-1.42

SUM of RESIDUALS = 4.39

CAPSULE V (HAZ)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:11:04 on 11-06-2003

Page 1

Coefficients of Curve 2

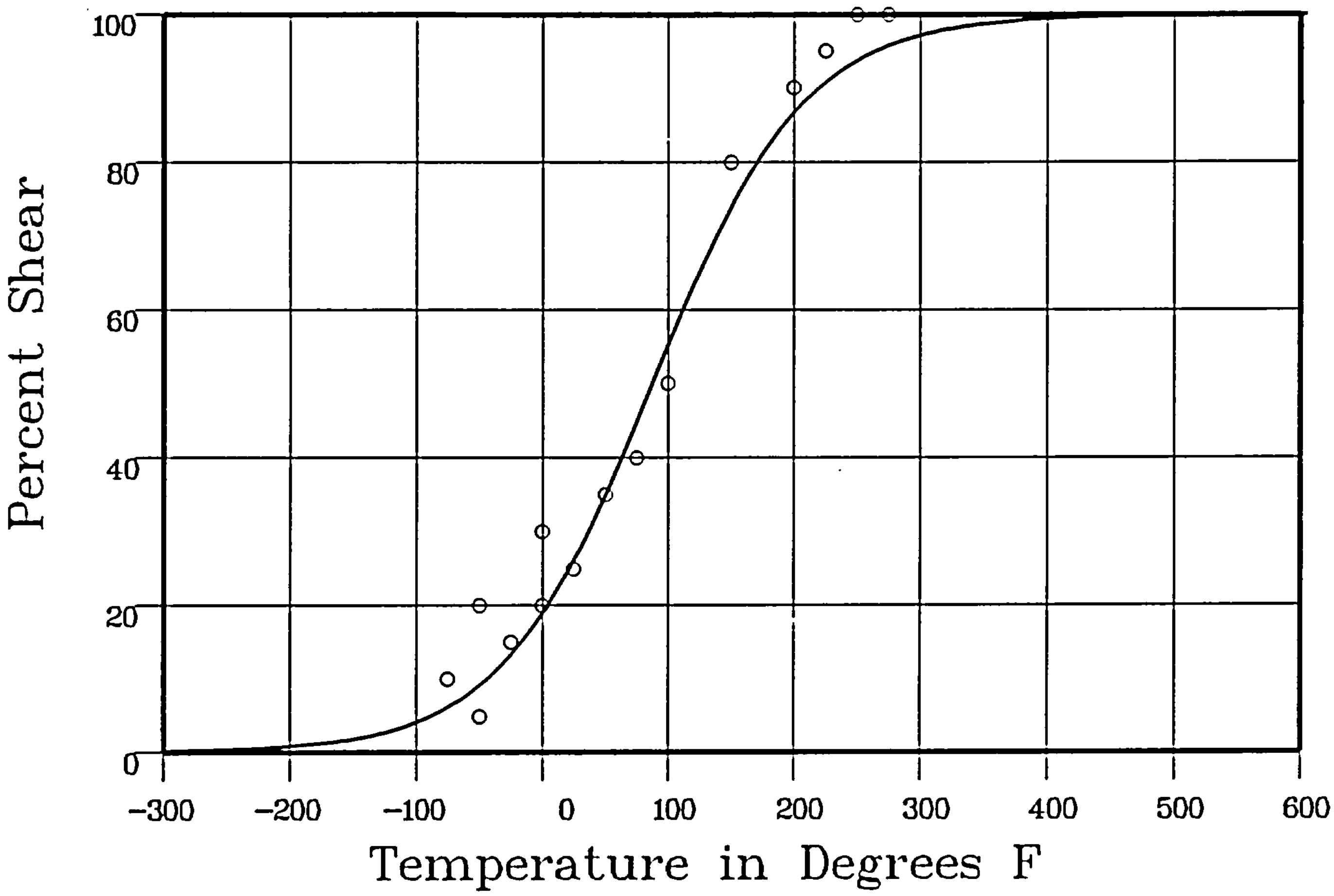
A = 50	B = 50	C = 120.21	T0 = 82.91

Equation is: Shear% = A + B * [tanh((T - T0)/C)]

Temperature at 50% Shear: 82.9

Material: HEAT AFFD ZONE SA533B1 Heat Number: Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: FA1 Cap.: V Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #:

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-75	10	6.74	3.25
-50	5	9.87	-4.87
-50	20	9.87	10.12
-25	15	14.24	.75
0	30	20.11	9.88
0	20	20.11	-.11
25	25	27.61	-2.61
50	35	36.64	-1.64

**** Data continued on next page ****

CAPSULE V (HAZ)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: Orientation:

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
75	40	46.71	-6.71
100	50	57.06	-7.06
150	80	75.32	4.67
200	90	87.52	2.47
225	95	91.4	3.59
250	100	94.15	5.84
275	100	96.06	3.93

SUM of RESIDUALS = 21.52

APPENDIX D

FARLEY UNIT 1 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 become available from the reactor in question.

To date there has been three surveillance capsules removed from the Farley Unit 1 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 Farley Unit 1 reactor vessel surveillance data and determine if the Indian Point Unit 1 surveillance data is credible.

EVALUATION:

Criterion 1: Materials in the capsules should be those judged most likely to be controlling with regard to radiation embrittlement.

The Farley Unit 1 reactor vessel consists of the following beltline region materials:

- Intermediate Shell Plates B6903-2, 3,
- Lower Shell Plates B6919-1, 2,
- Intermediate Shell Longitudinal Weld Seams 19-894 A & B (Heat # 33A277),
- Circumferential Weld Seam 11-894 (Heat # 6329637),
- Lower Shell Weld Seam 20-894 A & B (Heat #90099)

At the time when the Farley Unit 1 surveillance program material was selected it was believed that copper and phosphorus were the elements most important to embrittlement of the reactor vessel steels. The intermediate shell plate B6919-1 had one of the highest initial RT_{NDT} and the lowest USE of all plate materials in the beltline region. In addition, the intermediate shell plate B6919-1 had approximately the same copper and phosphorus content as the other beltline plate materials. Therefore, based on the highest initial RT_{NDT} and the lowest USE, the intermediate shell plate B6919-1 was chosen for the surveillance program.

The weld material in the Farley Unit 1 surveillance program was made of weld wire (Heat #33A277), the same as the Intermediate Shell Longitudinal Weld Seams 19-894 A&B. This weld had the highest copper content, thus it was chosen as the surveillance weld material.

Hence, Criterion 1 is met for the Farley Unit 1 reactor vessel.

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.

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 Farley Unit 1 surveillance materials unambiguously. Hence, the Farley Unit 1 surveillance program meets 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 fail 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 Farley Unit 1 surveillance weld metal and plate materials.

TABLE D-1

Calculation of Chemistry Factors using Farley Unit 1 Surveillance Capsule Data

Material	Capsule	Capsule f[a]	FF[b]	ΔRT_{NDT}[c]	FF*ΔRT_{NDT}	FF^2
Lower Shell Plate B6919-1 (Longitudinal)	Y	0.612	0.862	64.83	55.883	0.744
	U	1.73	1.151	110.34	127.001	1.324
	X	3.06	1.295	129.71	167.974	1.678
	W	4.75	1.392	145.57	202.633	1.938
	V	7.14	1.466	178.01	260.963	2.149
Lower Shell Plate B6919-1 (Transverse)	Y	0.612	0.862	70.45	60.728	0.744
	U	1.73	1.151	100.51	115.687	1.324
	X	3.06	1.295	110.72	143.382	1.678
	W	4.75	1.392	150.54	209.552	1.938
	V	7.14	1.466	161.87	237.301	2.149
	SUM:				1581.104	15.666
	$CF_{B6919-1} = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (1581.104) \div (15.666) = 100.9°F$					
Surveillance Weld Material	Y	0.612	0.862	72.92	62.857	0.744
	U	1.73	1.151	81.13	93.381	1.324
	X	3.06	1.295	93.19	120.681	1.678
	W	4.75	1.392	104.17	145.005	1.938
	V	7.14	1.466	123.29	180.743	2.149
	SUM:				602.667	7.833
	$CF_{Surv. Weld} = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (602.667) \div (7.833) = 76.9°F$					

Notes:

(a) f = fluence. Calculated fluence from Section 6 of this report, [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].

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:
Farley Unit 1 Surveillance Capsule Data Scatter about the Best-Fit Line for Surveillance Forging Materials.

Material	Capsule	CF ($Slope_{best\ fit}$)	FF	Measured ΔRT_{NDT}	Predicted ΔRT_{NDT}	Scatter ΔRT_{NDT} (°F)	<17°F (Base Metals) <28°F (Weld)
Lower Shell Plate B6919-1 (Longitudinal)	Y	100.9	0.862	64.83	86.98	-22.2	No
	U	100.9	1.151	110.34	116.14	-5.8	Yes
	X	100.9	1.295	129.71	130.67	-1.0	Yes
	W	100.9	1.392	145.57	140.45	5.1	Yes
	V	100.9	1.466	178.01	147.92	30.1	No
Lower Shell Plate B6919-1 (Transverse)	Y	100.9	0.862	70.45	86.98	-16.5	Yes
	U	100.9	1.151	100.51	116.14	-15.6	Yes
	X	100.9	1.295	110.72	130.67	-20.0	No
	W	100.9	1.392	150.54	140.45	10.1	Yes
	V	100.9	1.466	161.87	147.92	14.0	Yes
Vessel Beltline Welds (Heat # 33A277)	Y	76.9	0.862	72.92	66.29	6.6	Yes
	U	76.9	1.151	81.13	88.51	-7.4	Yes
	X	76.9	1.295	93.19	99.59	-6.4	Yes
	W	76.9	1.392	104.17	107.04	-2.9	Yes
	V	76.9	1.466	123.29	112.74	10.6	Yes

Table D-2 indicates that 3 of 10 data point falls outside the +/- 1σ of 17°F scatter band for the lower shell plate B6919-1 surveillance data. Therefore, the surveillance plate data is deemed "not credible".

No data points fall outside the +/- 1σ of 28°F scatter band for the surveillance weld data. Therefore, the weld data is deemed credible per the third criterion.

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 pad. 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 temperatures 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 database for that material.

The Farley Unit 1 surveillance program does not contain correlation monitor material. Therefore, this criterion is not applicable to the Farley Unit 1 surveillance program.

CONCLUSION:

Based on the preceding responses to all five criteria of Regulatory Guide 1.99, Revision 2, Section B and 10 CFR 50.61, the Farley Unit 1 surveillance plate is not credible but the weld data is credible.