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Additional Information Related to Pilgrim Technical Specification Change Concerning Pressure-Temperature Limit Curves of Figures 3.6.1, 2, and 3

Reference: "Pilgrim Technical Specification Change Concerning Pressure-Temperature Limit Curves of Figures 3.6.1, 2, and 3", ENGC Letter No. 2.00.080, dated December 22, 2000.

The attached report provides additional information in support of the referenced Pilgrim Technical Specification Change that was requested by the NRC staff reviewer through the NRC Project Manager in a telephone conversation on January 24, 2001.

The report describes the updated evaluation of the fracture toughness characteristics of the reactor pressure vessel plate, forging and weld materials for the Pilgrim reactor vessel. The results of this report provide the material properties necessary to establish the pressure-temperature curves for the reactor vessel.

If you have any questions regarding the information contained in this letter, please contact P. M. Kahler at (508) 830-7939.

Mike Bellamy

A001

Commonwealth of Massachusetts)
County of Plymouth)

Then personally appeared before me, R.M. Bellamy, who being duly sworn, did state that he is Pilgrim Station Site Vice President and that he is duly authorized to execute and file the submittal contained herein in the name and on behalf of Entergy Nuclear Generation Company and that the statements in said submittal are true to the best of his knowledge and belief.

My commission expires: Sept 20, 2002
DATE

Peter M Kahler
NOTARY PUBLIC

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Attachment: Report No. SIR-00-082, "Updated Evaluation of Reactor Pressure Vessel Material Properties for Pilgrim Nuclear Power Station", dated August 2000.

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Updated Evaluation of Reactor Pressure Vessel Materials Properties for Pilgrim Nuclear Power Station

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Section	Pages	Revision	Date	Comments
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2.0	2-1 – 2-5			
3.0	3-1 – 3-32			
4.0	4-1			
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1.0 INTRODUCTION

This report describes an updated evaluation of the fracture toughness characteristics of the reactor pressure vessel plate, forging, and weld materials for the Pilgrim reactor vessel. In August 1994, Structural Integrity Associates (SI) performed an evaluation of the materials properties used in the Pilgrim RPV (Report No SIR-94-028 [1] and letter AFD-94-107[2]). Updated information is now available for some of the materials used in the RPV, especially the nozzle forging material and weld filler materials. This report incorporates the new and additional information on plate, forging and weld materials into a revision of SIR-94-028 and AFD-94-107.

The results of this report will provide the materials properties necessary to establish the pressure-temperature curves for the reactor vessel.

This report provides background for determining the fracture toughness of any portion of the vessel, including RPV nozzles and nozzle welds, as a function of the initial toughness, location in the vessel, and time of irradiation exposure.

2.0 BACKGROUND

2.1 Fracture Toughness and Flaw Evaluation

Pressure-temperature limit curves for reactor pressure vessel operations (e.g., heat-up and cool-down) and pressure tests are based on the limiting fracture toughness properties of the vessel material. Evaluation of any flaws detected during vessel inspection must also be based upon the fracture toughness of the vessel material where a flaw is located. Fracture toughness for the ferritic steels used for pressure vessels is a strong function of temperature. In addition, a reactor vessel is somewhat unique since a portion of it is exposed to irradiation by high energy neutrons throughout its lifetime. The resistance to fracture is decreased by this irradiation. In Appendices A [3] and G [4] to Section XI of the ASME Boiler and Pressure Vessel Code, fracture toughness is correlated with the "reference temperature" (RT_{NDT}), a characteristic temperature that defines a transition from ductile to brittle behavior. Those correlations are reproduced as Figure 2-1. K_{Ia} and K_{Ic} are the lower bound critical stress intensity factors for crack arrest and static crack initiation, respectively. The crack arrest or crack initiation fracture toughness can readily be determined from this relationship once the service temperature and RT_{NDT} are established. It can be seen from this figure that for a specific service temperature, the fracture toughness decreases as RT_{NDT} increases. In the beltline region of the vessel, accumulated fast neutron irradiation leads to an increase in the value of RT_{NDT}, thereby leading to a decrease in the toughness. The RT_{NDT} following neutron irradiation is characterized by a parameter called the adjusted reference temperature (ART). NRC Regulatory Guide (RG) 1.99 Revision 2 [5] provides guidelines for determining fracture toughness and the decrease in fracture toughness, characterized by the adjusted reference temperature (ART).

The correlations for K_{Ia}, the crack arrest toughness, in Appendix A, and K_{IR} (from Appendix G) are extremely conservative[1]. For example, the K_{IR} curve is derived from the lower bound static, dynamic, and crack arrest K_I values. That is, the curve is the lower bound of all of the data used to construct it.

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[1] The numerical values of K_{Ia}, as given in Appendix A, and K_{IR}, per Appendix G, are equal within 1%. Both are calculated as a function of the difference between the operating or test temperature and RT_{NDT}.

2.2 Adjusted Reference Temperature (ART)

Regulatory Guide 1.99, Revision 2 [5], describes general procedures to calculate the effects of neutron irradiation embrittlement of alloy steel used in the fabrication of reactor pressure vessels. Irradiation embrittlement increases the value of the reference temperature, RT_{NDT}, thereby reducing the fracture toughness. The adjusted reference temperature (ART) is used to determine the reduction in fracture toughness caused by irradiation embrittlement and uncertainties in the measured data. From Reference 5, ART is calculated using the following equation:

$$ART = \text{Initial } RT_{NDT} + \Delta RT_{NDT} + \text{Margin} \qquad \text{(Eq. 1)}$$

where:

ART	=	Adjusted Reference Temperature
RT_{NDT}	=	Reference Temperature
ΔRT_{NDT}	=	shift in the initial reference temperature (defined below)
Margin	=	$2\sqrt{\sigma_I^2 + \sigma_\Delta^2}$ (σ_I and σ_Δ defined below)

A discussion of the terms in Equation 1 is provided in the following paragraphs.

2.2.1 Initial Reference Temperature (RT_{NDT})

The initial reference temperature (initial RT_{NDT}) is a measure of the nil-ductility transition temperature of an unirradiated material. The guidelines for determining the initial reference temperature for new plants is specified in subparagraph NB-2331 of Section III of the ASME Code [6]. Subparagraph NB-2331 of Section III of the ASME Code [6], requires that a temperature, T_{NDT}, that is at or above the nil ductility transition temperature (NDTT), be determined by a drop-weight test (ASTM E208 [7]). The initial reference temperature (RT_{NDT}) will be equal to T_{NDT} provided that each specimen (transverse orientation) of a Charpy V-notch

(CVN) test exhibits no less than 50 ft-lbs absorbed impact energy and at least 35 mils lateral expansion (MLE) at a temperature of T_{NDT} + 60°F. If the CVN test at T_{NDT} + 60°F has not been performed, or if the 50 ft-lbs/35 MLE criterion has not been met at that temperature, then a transition temperature representing 50 ft-lbs and 35 MLE may be obtained from a full CVN curve developed from the minimum results of all the CVN tests performed. The reference temperature would then be this 50 ft-lbs/35 MLE transition temperature minus 60°F. In all cases, the reference temperature is defined by the greater of T_{NDT} determined by drop-weight testing or by the lower bound 50 ft-lbs/35 MLE transition temperature minus 60°F.

2.2.2 Reference Temperature Shift, ΔRT_{NDT}

The shift in the reference temperature, as a result of neutron irradiation, is the product of a chemistry factor (CF) and a fluence factor (FF) [5]:

$$\Delta RT_{NDT} = (CF) \bullet (FF) \qquad \text{(Eq. 2)}$$

The chemistry factor, a function of the copper and nickel content, is different for weld and wrought (base metal) materials. Regulatory Guide 1.99, Revision 2 [5], provides tables which give chemistry factor values that are based on measured values of Cu and Ni for the specific heat of material.

If two or more credible irradiated surveillance data sets are available for the reactor, Regulatory Position 2.1 of Reference 5 specifies a procedure to be used to calculate an adjusted CF.

The fluence factor is based upon the accumulated fast (E > 1 MeV) neutron exposure, typically corrected for the thickness at the location of interest. The fluence factor can be found using the following equation or from Figure 1 of Reference 5:

$$FF = f^{\,(0.28-0.10\bullet \log f)} \qquad \text{(Eq. 3)}$$

where: f = fast neutron fluence (in units of 10^{19} n/cm^2, E > 1MeV). The fluence decreases with distance into the vessel wall. To determine the fluence at a distance within the vessel wall, the calculated or measured fluence at the inside surface of the vessel is attenuated by the formula [5],

$$f = f_{surf} (e^{-0.24x}) \qquad \text{(Eq. 4)}$$

where:

f	=	fast neutron fluence (in units of 10^{19} n/cm^2, E > 1MeV),
f_{surf}	=	fast neutron fluence at the vessel inside surface, (same units as f),
x	=	depth into the vessel wall, (inches)

For ASME Code Section XI, Appendix G [4] evaluations, x is taken at one quarter of the base metal thickness (¼t). The stainless steel cladding at the inside surface of the vessel is, by design, treated purely as a lining and is not treated as a load-bearing member. However, the fast neutron flux can be attenuated through the cladding. For this evaluation, it will be assumed that the estimated inside surface fluence is given at the cladding-base metal interface. That is, no credit will be taken for attenuation of the fluence through the cladding.

2.2.3 Margin

Regulatory Guide 1.99, Revision 2 [5], also requires the addition of a margin term (M) that accounts for uncertainty in the initial reference temperature and for variance in the reference temperature shift. The margin term is calculated by Equation 5:

$$M = 2 \cdot (\sigma_I^2 + \sigma_\Delta^2)^{1/2} \qquad \text{(Eq. 5)}$$

where: σ_I = the standard deviation for the initial RT_{NDT} (°F) and

σ_Δ = the standard deviation for ΔRT_{NDT} (°F). Reference 5 states that σ_Δ is 28°F for welds and 17°F for base metal and that σ_Δ need not exceed 0.5 times the mean reference temperature shift (ΔRT_{NDT}).

The σ_I term is related to the uncertainty in the precision of the initial RT_{NDT}, either when determined by measurement or when default or generic values are used. Most of the estimation methods have established the initial RT_{NDT} value based upon analyses of measured data. The value of σ_I for each method may vary, depending upon the estimation method used.

2.2.4 Use of Surveillance Data

The use of surveillance material data for calculation of ART is permitted by Regulatory Guide 1.99, Revision 2 [5], subject to the condition that two or more credible sets of irradiated surveillance data from the subject reactor are available. Reference 5 provides a methodology for calculating revised chemistry factors based on the surveillance data to establish ART.

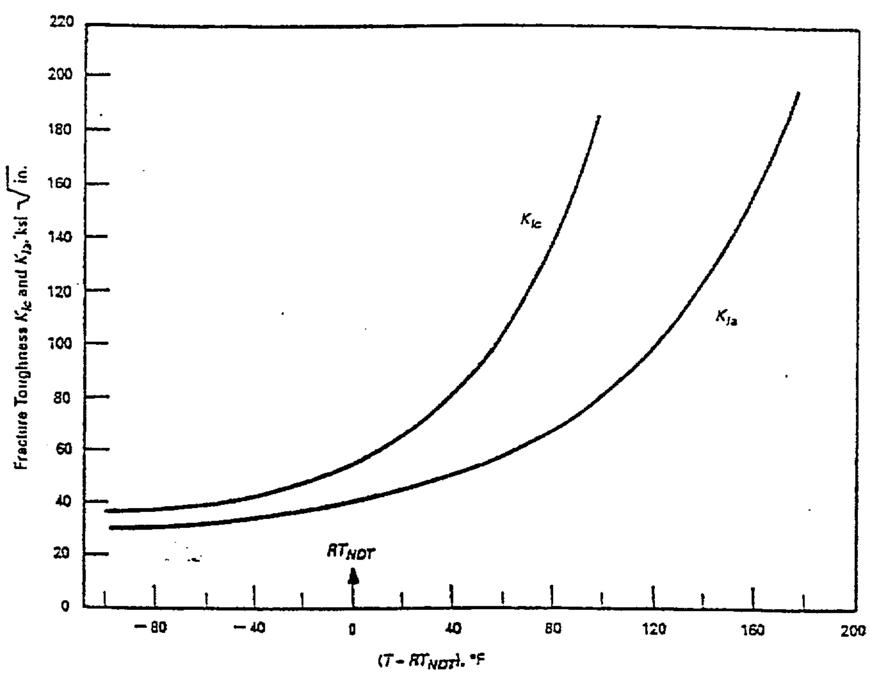


Figure 2-1. Lower Bound K_{Ia} and K_{Ic} Test Data for SA-533 Grade B Class 1, SA-508 Class 2, and SA-508 Class 3 Steels [3]

3.0 PILGRIM REACTOR VESSEL PROPERTIES

This analysis describes the methods required to determine the value of the adjusted reference temperature (ART), the key quantity used to define the fracture toughness for all areas of the Pilgrim reactor pressure vessel. As noted in the previous section, the ASME Code provides curves for lower bound K_{Ia} (K_{IR}) and K_{Ic} which are indexed to the difference between the temperature at which a stress is applied and the adjusted reference temperature (Figure 2-1).

3.1 Design and Materials

The Pilgrim reactor vessel is constructed from SA-533 Class B plates, joined by submerged arc weldments (B4 filler metal/Linde 1092 flux). Weld repairs to longitudinal and circumferential welds were performed by shielded metal arc welding (SMAW) using Type 8018 electrodes. Flanges, nozzles, and other formed parts were fabricated from SA-508, Class 2, forgings, and were joined to the vessel shell by shielded metal arc welding (SMAW) using Type 8018 electrodes.

A map of the Pilgrim reactor pressure vessel materials and welds is shown in Figures 3-1 and 3-2. Figure 3-1 shows the plate and forging material identification and associated code numbers, as well as the approximate locations of weld seams for all wrought products in the vessel shell and heads. Figure 3-2 lists all vessel shell and head welds, including weld numbers. Table 3-1 summarizes the piece numbers, code numbers (as identified in Figure 3-1), heat numbers, composition, and toughness properties for the plates and forgings that comprise the vessel shell, not including nozzles. Table 3-2 lists similar information for all vessel assembly weld metals. Detailed compositional information is not given for the SMAW electrodes. In the beltline, those electrodes are used only for root passes and for repairs. The root passes are at essentially the half-thickness position; a depth far in excess of the hypothesized ¼ t flaw. Further, at the half-thickness position, the attenuation of fast neutrons dramatically reduces the neutron fluence that that material would experience. Weld repairs constitute an extremely small volume of the overall weld. As such, the contribution of the SMAW electrodes to the effective chemistry

factor for the weld is considered to be insignificant. Tables 3-3 and 3-4 list similar information for the RPV nozzle forgings and nozzle-to-RPV welds.

Per ASTM E185-82 [24], **beltline materials** consist of "the irradiated region of the reactor vessel (shell material including weld regions and plates or forgings) that directly surrounds the effective height of the active core, and adjacent regions that are predicted to experience sufficient neutron damage to warrant consideration in the selection of surveillance material". The irradiation damage causes an increase in strength and hardness and a decrease in ductility and toughness. Also, it is well established that tramp or minor alloying elements, particularly copper and nickel, affect the radiation embrittlement response of the ferritic RPV material. Therefore, the fracture toughness properties of the beltline materials must be evaluated in accordance with the discussion of Section 2 of this report. Non-beltline materials are considered not to have experienced any embrittlement. For the Pilgrim RPV, the beltline materials include the lower intermediate shell, the lower shell, the three longitudinal weld seams in each of those shell courses, and the girth weld which connects the two courses to each other. Figure 3-3 includes a sketch of the Pilgrim RPV that shows the location of the beltline relative to the core region, and the vessel plate and weld components.

3.2 Reactor Vessel Fluence

Summaries of the flux distributions, and resulting axial and angular lead factors, are provided in Figures 3-3 and 3-4. Figure 3-3 is a plot of the axial distribution of fast flux in the Pilgrim vessel, and associated axial lead factors constructed from nodal data from Reference 13. It shows that significant portions of the lower intermediate shell and, especially, the lower shell will be irradiated to far less than the axial peak values. It also provides a method for determining the accumulated fast fluence at any axial position in the beltline. As an example, note that the axial lead factor for beltline girth weld 1-344, located at an elevation of 242.5 inches (from the bottom of the lower head, datum point "0") has a lead factor of 0.749 relative to the axial peak, determined by a linear interpolation of flux between nodes 5 and 6 in Figure 3-3 to yield a relative flux of 0.752 (relative to Node 12), ratioed to the axial flux peak factor of 1.004 at Node 13.

Irradiation effects are considered to be nil at elevations above about 367 inches and below 207 inches (i.e., about 10-15 inches above and below the active fuel where relative fast flux approaches zero, based upon an extrapolation of the profile shown in Figure 3-3). [2]

An additional refinement of the fluence predictions can also be made to account for circumferential variations in position. The BWR core has four-fold symmetry (Figure 3-4) so that peak fluence is accumulated at locations where the corner of a "flat" portion of the core plan is in closest proximity to the pressure vessel wall while the fluence will be less at an "edge" or the center of the "flat".

Figure 3-4 is a plot of the angular distribution of fast flux in the Pilgrim vessel, and associated angular distribution of lead factors, constructed from data of Reference 13. Figure 3-4 shows that significant portions of the lower intermediate shell will be irradiated to far less than the axial peak values, even though each plate has an axial lead factor of one. In similar manner, the lower/intermediate and lower plate longitudinal welds have maximum fluences determined by both the axial and angular lead factors. The combined effect of the axial and angular flux distribution on a specific RPV component is provided in the "Equiv. Lead Factor" term in Tables 3-7 and 3-8. These equivalent lead factors are used in the calculations of the 20, 32, and 48 EFPY fluence factors summarized in Tables 3-7 and 3-8.

Using the information in Reference 13, an estimate of the rate of fluence increase for the vessel ID surface was estimated. Reference 13 tabulates the estimated neutron flux and fluence at the middle and the end of several fuel cycles. From this information, the rate of increase in fluence per EFPY (Effective Full Power Years) can be estimated as shown in Table 3-5. The fluence

[2] The upper-most portions of the recirculation inlet nozzles (N2 nozzles) are just below the bottom of the active core, hence, would be considered to be in the beltline. However, the nozzles and nozzle welds are not evaluated in this report because the exposure is minimal (typically less than 10% of the peak fluence) and since impact properties for the weld metal and nozzles are very high. Therefore, their properties are clearly bounded by the properties of plates and welds (SAW) in the lower shell and lower intermediate shell.

rate up to 4.17 EFPY is much higher than for the other cycles summarized. Reference 13 states that an unusually large number of new fuel bundles were placed into the Pilgrim reactor at the start of Cycle 4. This higher power in the edge bundles of the core increased the neutron flux to the vessel. The fluence rates for each of the points in time after cycle 4 are assumed to be representative of the fluence rates after Cycle 7 (middle) and are assumed to be representative of the fluence rates that will be experienced up to the end of life. To be conservative, the highest fluence rate of 4.47 x 10^{16} n/cm^2/EFPY will be used as an estimate of the maximum vessel wall fluence rate opposite the core mid-plane height. The estimated maximum fluences at the vessel inside surface (clad to vessel interface) are estimated in Table 3-6. These values will be used in subsequent calculations of the ART.

3.3 Determination of ART

As noted in Section 2.2, the adjusted reference temperature (ART) is the sum of the Initial RT_{NDT}, the RT_{NDT} Shift and the margin.

The key chemical constituents relative to irradiation embrittlement are copper and nickel. Copper is considered an impurity in the grades of steel used for the vessel and, as such, was not routinely reported for plates and weld metals in plants of the vintage of Pilgrim. Fortunately, all of the plates in the vessel were procured from Lukens Steel so that most of the copper contents could be located for those products. As shown in Tables 3-1 and 3-3, the copper contents of the two flange forgings and all of the nozzle forgings are not available. Since no forgings are in the beltline, those copper contents are not required since a Chemistry Factor does not need to be computed to determine the end of life ART. Copper content is available for all of the SAW materials (Table 3-2). Tables 3-1 through 3-4 demonstrate that fairly complete background information was available on the reactor vessel components. Very complete information on beltline materials was available. As noted previously, the composition of the SMAW electrodes is not considered in the determination of the weld chemistry factor since those electrodes, used only for root passes and for repairs, constitute an extremely small volume of the overall weld.

As such, the contribution of the SMAW electrodes to the effective chemistry factor for the weld is considered to be insignificant.

3.3.1 *Initial RT_{NDT}*

The requirements of Subparagraph NB-2331 of Section III of the ASME Code [6] for the determination of the initial reference temperature (RT_{NDT}) were discussed in Section 2.2.1. The initial RT_{NDT} values for all of the vessel wrought materials, plate and forgings (flanges and nozzles), were determined per NB-2331. Drop weight tests were conducted on all of the wrought products to establish a NDTT value. Most of the Charpy V-notch impact tests were done over a range of temperatures, although not at the NDTT + 60°F temperature required by the Code. The CVN impact tests for nine nozzle forgings (N1A, N1B, N3A, N3B, N3C, N3D, N7A, N7B and N8) were performed at a single temperature of 10°F. Further, the specimen orientations were longitudinal rather than the required transverse orientation.

An initial evaluation of each plate or forging was performed to determine if the minimum required energy (50 ft-lb) and the minimum required lateral expansion (35 mils) were achieved at a CVN test temperature equal to or less than NDTT+60°F-20°F. The 20°F term is from MTEB 5-2 [15] and is an estimation of the adjustment in test temperature for longitudinally oriented specimens to be equivalent to transverse specimens (e.g., $T_{50T} = T_{50L} + 20°F$, where T_{50T} and T_{50L} are the temperatures required for the minimum energy value to exceed 50 ft-lb for transverse and longitudinal, respectively).

The value of NDTT+60°F-20°F is defined as the "CVN Check Temp" in Tables 3-1 and 3-3. From the CMTR tests results, a test temperature (column CVN TT °F) near or below the CVN Check Temp for each item was obtained and the energy and lateral expansion results were evaluated. As is shown in Table 3-1, most of the plate and flange forgings did not have sufficiently high minimum values at the available test temperatures to establish NDTT as the RT_{NDT} value. In the cases where the minimum energy and/or lateral expansion requirements were not satisfied, the minimum test results at each CVN test temperature were analyzed using a hyperbolic tangent (tanh) curve fitting routine. EPRI Reports MP-933 [19], NP 2428 [20], and

NP-4797 [21] have discussed the utilization of the hyperbolic tangent curve fitting procedure. This procedure estimates the value of impact energy (y) as a function of test temperature (T) as shown below:

$$Y = A+B \tanh [(T - T_o)/C]$$

where A,B,C and T_o are coefficients determined by non-linear regression.

A computer program, CVGRAPH [16], was developed for the analysis of Charpy V-notch impact test data by ATI Consulting for use by the utility members of the Westinghouse Owners Group. A licensed copy of CVGRAPH was obtained by Structural Integrity Associates to assist in the analyses of Charpy impact data for operating plants that do not have access to this program.

The results of the required CVGraph analyses are contained in Appendix A. In the cases where both the energy and lateral expansion data were evaluated, it was found that the 50 ft-lb temperature was always more limiting than the 35 mils temperature. The longitudinal 50 ft-lb temperatures (T_{50L}) for the analyzed test results are shown in Table 3-1. Using the results of those analyses, the RT_{NDT} values are defined as the NDTT or the T_{50L}-40°F (equivalent to T_{50T} + 60°F) value, whichever is greater, as shown in Table 3-1. For values of RT_{NDT} determined per the guidelines of NB-2331, the value of σ_I in the Margin is equal to 0.

For the nozzle forgings, as summarized in Table 3-3, the required energy and lateral expansion values were satisfied at test temperatures below the "CVN Check Temp" for all but three of the nozzles. For the nozzles that exhibited the required minimum impact properties the initial RT_{NDT} value is defined as the NDTT. For the three nozzles (N2K, N3B, and N3C) with less than the required energy or lateral expansion, an alternative method for the determination of the initial RT_{NDT} was required. GE developed a procedure to estimate the RT_{NDT} value using limited test data [17]. In this approach, if the minimum energy value is less than 50 ft-lb, the transition temperature to achieve 50 ft-lb is estimated by adding 2°F to the reported test temperature for each ft-lb that the minimum test result is less than 50 ft-lb. The value of T_{50L} determined by this procedure is converted to the equivalent T_{50T} value by adding 30°F to T_{50L}. It is assumed that the minimum lateral expansion values will exceed 35 mils at the T_{50T} temperature determined by this procedure. The values of T_{50T}-60°F for nozzles N2K and N3C are less than the NDTT value.

Therefore, the initial RT_{NDT} values equal the respective NDTT values. The T_{50T} - 60°F value for nozzle N3B equals 4°F. Since this value is higher than -10°F (NDTT) the intital RT_{NDT} value for nozzle N3B equals 4°F. This procedure uses the minimum test results and is, therefore, considered conservative, hence σ_I is equal to 0.

The Reference 17 procedure was used to estimate the limiting temperature for 50 ft-lb impact energy for welds. No correction for specimen orientation is required for welds.

The weld materials were not subjected to drop weight impact tests to determine the NDTT value, and the Charpy V-notch impact tests were conducted at a single temperature. If the minimum energy is equal to or greater than 50 ft-lb, T_{50} equals the test temperature. This procedure defines RT_{NDT} as T_{50} – 60°F. The GE procedure also states that if there is no drop weight data that the RT_{NDT} value may not be less than –50°F for welds. The results of the CVN tests of the weld materials and the estimated RT_{NDT} values are summarized in Tables 3-2 and 3-4 for the vessel shell/head welds and the nozzle attachment welds, respectively. This procedure uses the minimum test results and is, therefore, considered to be conservative, hence σ_I is equal to 0.

3.3.2 Adjusted Reference Temperature (ART)

Table 3-6 provides the anticipated RPV inner surface fluences for 20, 32, and 48 Effective Full Power Years (EFPY). Considering the Pilgrim RPV minimum wall thickness of 5.53 (5 17/32 inches per Reference 22) inches at the beltline, the ¼ t fluences can be calculated by the methodology of Regulatory Guide 1.99 Rev. 2 (equation 4 of section 2 of this report). Table 3-6 documents the RPV maximum calculated ¼ t fluences for 20, 32, and 48 EFPY for RPV beltline components.

Tables 3-7 and 3-8 summarize the calculations of 20, 32, and 48 EFPY fluence factors (FF), based on ¼ t vessel fluences for the vessel beltline plates and welds, respectively. In these and the following tables, not all beltline materials are assumed to be exposed to the peak neutron ¼ t fluence; both the angular and axial distribution of fluence is considered in the calculations of adjusted reference temperature (ART) given in Tables 3-9 and 3-10. These fluence factors are

uniquely calculated maximums for each beltline plate and weld of the Pilgrim RPV, and are based on the Pilgrim core axial and angular (azimuthal) flux patterns [13]. The fluences and fluence factors reported herein are conservative relative to those reported in the Reactor Vessel integrity Database (RVID), Version 2 [23].

Summary tables of toughness properties for the Pilgrim RPV are provided in Tables 3-9 through 3-12. These tables contain calculations of ART for 20, 32, and 48 EFPY for each RPV component, as well as the Initial RT_{NDT}, Chemistry Factor (CF) and Fluence Factor (FF) from the preceding tables. The tables contain transition temperature shift, margin, and adjusted reference temperature for both the beltline and non-beltline materials at the ¼t position. Table 3-9 summarizes toughness properties for the RPV plates and forgings, using the guidelines of Regulatory Guide 1.99, Rev 2. Table 3-10 contains similar information for the controlling weld heats (SAW welds with the highest CF). Tables 3-11 and 3-12 contain summary data for nozzle forgings and nozzle-to-RPV welds.

Table 3-1
Pilgrim Reactor Vessel Plates and Forgings [8, 9, 10]

Description	Piece No.	Code No.	Heat No.	DWT Temp °F (6)	NDTT °F	CVN Check Temp °F (1)	CVN TT °F (2)	Energy, ft-lbs (2) / Lat exp, mils	50 ft-lb Temp., Long T_{50L} °F (3)	RT_{NDT} °F	Cu	Ni
Bottom Head Dome	336-02	G-3114	C-2888-3	0 NB	-10	30	10	25, 23, 23 / 22, 21, 20	69	29	0.16	0.43
BH Lower Torus	336-03A, E	G-3113-3	A-2222-1	0 1 Break/ 1 NB	0	30	10	56, 75, 55 / 44, 56, 41	Not Determined	0	0.09	0.67
BH Lower Torus	336-03B, C	G-3113-1	C-2913-3	0 NB	-10	30	10	27, 33, 29 / 29, 28, 29 (4)	64	24	0.13	0.47
BH Lower Torus	336-03D, F	G-3113-2	A-2222-2	0 NB	-10	30	10	46, 31, 48 / 38, 24, 37	39	-1	0.11	0.65
BH Upper Torus	336-04A, C, D, F	G-3111-1	C-2851-2	0 NB	-10	30	10	90, 81, 78 / 63, 60, 56	Not Determined	-10	0.09	0.45
BH Upper Torus	336-04B, E, G, H	G-3111-2	C-2851-2	0 NB	-10	30	10	90, 81, 78 / 63, 60, 56	Not Determined	-10	0.09	0.45
Lower Shell	337-01A	G-3109-2	C-2957-2	0 NB	-10	30	10	45, 45, 31 / 37, 38, 28	40	0	0.10	0.47
Lower Shell	337-01B	G-3109-1	C-2957-1	0 NB	-10	30	10	37, 33, 37 / 31, 29, 31	37	-3	0.10	0.48
Lower Shell	337-01C	G-3109-3	C-2973-1	0 NB	-10	30	10	35, 50, 32 / 36, 40, 28	36	-4	0.11	0.63
Lower Int. Shell	337-03A	G-3108-3	C-2945-2	-10 NB	-20	20	10	45, 52, 50 / 35, 40, 39	28	-12	0.10	0.66
Lower Int. Shell	337-03B	G-3108-1	C-2921-2	-20 NB	-30	10	10	51, 52, 50 / 41, 43, 42	Not Determined	-30	0.14	0.60
Lower Int. Shell	337-03C	G-3108-2	C-2945-1	-30 NB	-40	0	10	43, 36, 39 / 34, 30, 31	33	-7	0.10	0.65
Upper Int. Shell	337-04A	G-3107-1	A-2094-1	0 NB	-10	30	10	46, 41, 47 / 36, 35, 35	24	-10	0.11	0.57
Upper Int. Shell	337-04B	G-3107-2	A-2094-2	0 NB	-10	30	10	56, 67, 48 / 43, 52, 40	9	-10	0.11	0.55

Table 3-1 (cont'd)

Description	Piece No.	Code No.	Heat No.	DWT Temp °F (6)	NDTT °F	CVN Check Temp °F (1)	CVN TT °F (2)	Energy, ft-lbs (2) / Lat exp, mils	50 ft-lb Temp., Long T_{50L} °F (3)	RT_{NDT} °F	Cu	Ni
Upper Int. Shell	337-04C	G-3107-3	C-2906-1	0 NB	-10	30	10	27, 59,45 / 24, 46, 38	26	-10	0.12	0.49
Upper Shell	337-02A	G-3109-5	C-2973-2	0 NB	-10	30	10	39, 47, 48 / 31, 37, 36	36	-4	0.11	0.61
Upper Shell	337-02B	G-3109-4	C-2561-2	0 NB	-10	30	10	62, 63, 61 / 46, 49, 46	Not Determined	-10	0.13	0.70
Upper Shell	337-02C	G-3109-6	C-3301-2	0 NB	-10	30	10	32, 43, 57 / 25, 35, 44	38	-2	0.18	0.57
Upper Shell Flange	339-02	G-3101	2V-545	20 NB	10	50	10	73, 45, 36 / 55, 34, 34	20	10	NR	0.81
Closure Head (CH) Flange	349-02	G-3102	5P-2003	20 NB	10	50	10	78.9, 94.5, 105.9 / 60, 70, 78	Not Determined	10	NR	0.77
CH Torus	349-03A, D, E, H	G-3178-1	C-3982-1	0 NB	-10	30	10	35, 37, 47 / 31, 32, 38	24	-10	0.14	0.60
CH Torus	349-03B, C, F, G	G-3178-2	C-3982-2	0 NB	-10	30	10	61, 84, 77 / 43, 59, 56	Not Determined	-10	0.14	0.60
CH Dome	349-04	G-3179-1	A-3121-3	0 NB	-10	30	10	73, 78, 72 / 52, 56, 54	Not Determined	-10	0.13	0.61

Notes:

1. Charpy V-notch maximum test temperature (CVN Check Temp) at which tests for longitudinally oriented specimens must demonstrate a minimum impact energy of 50 ft-lb and a minimum lateral expansion of 35 mils to satisfy the requirements of NB-2331 for RT_{NDT} to equal NDTT. The "CVN Check Temp" = NDTT + 60°F - 20°F (longitudinal to transverse correction).
2. "CVN TT" (test temperature) and results near or below the "CVN Check Temp" (specimens with longitudinal orientation).
3. Temperature at which 50 ft-lb energy and 35 mils lateral expansion requirements are satisfied for hyperbolic tangent curve fits through the minimum test results. If the 50 ft-lb/35 mils requirements are satisfied at the "CVN TT" no curve fits were performed.
4. On the CMTR is a note indicating that the lateral expansion results at 10 and 40°F are reversed. It is assumed that this is a correct assessment and the lower values are shown here.
5. NR = Not Reported
6. NB = No Break

Table 3-2
Pilgrim Reactor Vessel Welds [8, 9, 10, 11]

Weld Description	Seam No.	Weld Type	Heat No.	Flux Type & Lot No.	CVN Temp °F	Energy, ft-lbs	RT_{NDT} °F (1)	Cu (3)	Ni
Bottom Head Dome to Lower Torus – Circumferential Weld	5-336	SAW	13253	Linde 1092 #3774	10	74, 63, 82	-50	0.221	0.732
		SMAW	EOAG		10	173, 133, 135	-50	NR	1.04
			BBHH		10	116, 107, 109	-50	NR	0.95
BH Lower Torus – Long Welds of Segments	2-336A, B, C, D, E, F	SAW	51989	Linde 124 #3687	10	50, 60, 73	-50	0.17	0.165
		SMAW	EOAG		10	173, 133, 135	-50	NR	1.04
BH Lower Torus to BH Upper Torus – Circumferential Weld	6-336	SAW	13253	Linde 1092 #3774	10	74, 63, 82	-50	0.221	0.732
			13253	Linde 1092 #3791	10	85, 77, 81	-50	0.221	0.732
		SMAW	EOAG		10	173, 133, 135	-50	NR	1.04
BH Upper Torus – Long Welds of Segments	1-336A, B, C, D, E, F, G, H	SMAW	JBFG		10	40, 44, 31	-12	NR	1.29
BH Upper Torus to Lower Shell – Circumferential Weld	4-348	SMAW	LOEH		10	113, 123, 140	-50	NR	0.98
			LACH		10	125, 119, 119	-50	NR	0.90
Lower Shell to Bottom Head Girth Weld	9-338	SAW	20291	Linde 1092 #3854	10	60, 65, 59	-50	0.216	0.737
		SMAW	HADH		10	112, 110, 114	-50	NR	0.94
Lower Shell – Long Welds of Segments	2-338A, B, C	SAW	27204	Linde 1092 #3714	10	71, 57, 42	-34	0.203	1.018
		SMAW	EOAG		10	173, 133, 135	-50	NR	1.04
Lower Shell to Lower Intermediate Shell – Circumferential Weld	1-344	SAW	21935	Linde 1092 #3869	10	62, 59, 60	-50	0.183	0.704
		SMAW	LACH		10	125, 119, 119	-50	NR	0.90
Lower Intermediate Shell – Long Welds of Segments	1-338A, B, C	SAW	27204/12008	Linde 1092 #3774	10	63, 60, 49	-48	0.219	0.996
		SMAW	EOAG		10	173, 133, 135	-50	NR	1.04
			LODG		10	62, 83, 99	-50	NR	0.93
Lower Intermediate Shell to Upper Intermediate Shell – Circumferential Weld	3-339 B	SAW	13253	Linde 1092 #3833	10	79, 79, 82	-50	0.221	0.732
		SMAW	EAGH		10	119, 120, 127	-50	NR	0.97

Table 3-2 (cont'd)

Weld Description	Seam No.	Weld Type	Heat No.	Flux Type & Lot No.	CVN Temp °F	Energy, ft-lbs	RT_{NDT} °F (1)	Cu (3)	Ni
Upper Intermediate Shell – Long Welds of Segments	2-339A, B, C	SAW	27204/12008	Linde 1092 #3774	10	63, 60, 49	-48	0.219	0.996
			27204	Linde 1092 #3714	10	71, 57, 42	-34	0.203	1.018
		SMAW	JBFG		10	40, 44, 31	-12	NR	1.29
Upper Intermediate Shell to Upper Shell – Circumferential Weld	3-339A	SAW	13253	Linde 1092 #3791	10	85, 77, 81	-50	0.221	0.732
		SMAW	EAGH		10	119, 120, 127	-50	NR	0.97
			EOAG		10	173, 133, 135	-50	NR	1.04
Upper Shell – Long Welds of Segments	1-339A, B, C	SAW	27204/12008	Linde 1092 #3774	10	63, 60, 49	-48	0.219	0.996
		SMAW	JBFG		10	40, 44, 31	-12	NR	1.29
Upper Shell to Vessel Flange – Circumferential Weld	4-339	SAW	13253	Linde 1092 #3791	10	85, 77, 81	-50	0.221	0.732
		SMAW	EAGH		10	119, 120, 127	-50	NR	0.97
Closure Head (CH) Flange to CH Torus - Circumferential Weld	1-349	SAW	20291	Linde 1092 #3833	10	35, 50, 48	-20	0.216	0.737
		SMAW	LOEH		10	113, 123, 140	-50	NR	0.98
			EOAG		10	173, 133, 135	-50	NR	1.04
CH Torus – Long Welds of Segments	3-349A, B, C, D, E, F, G, H	SMAW	EAGH		10	119, 120, 127	-50	NR	0.97
CH Torus to CH Dome - Circumferential Weld	2-349	SAW	20291	Linde 1092 #3854	10	60, 65, 59	-50	0.216	0.737
			20291	Linde 1092 #3833	10	35, 50, 48	-20	0.216	0.737
		SMAW	CBBH		10	118, 142, 115	-50	NR	1.1
			LOEH		10	113, 123, 140	-50	NR	0.98

Notes:

1. For the Charpy specimen with the minimum reported energy, add 2°F to test temperature for each ft-lb below 50 ft-lb to determine T_{50}. Define $RT_{NDT} = T_{50}$-60°F. If the minimum reported energy is greater than 50 ft-lb, RT_{NDT} = T - 60°F
2. NR = Not Reported.
3. Cu was not reported for E8018 weld materials. It is assumed that the E8018 materials were used only for root passes and repair welds and do not constitute a significant volume of the welds. Therefore, the SMAW composition is not required to calculate a chemistry factor.

Table 3-3
Pilgrim Reactor Vessel Nozzle Forgings [10, 12]

NOZZLE Description	Piece No.	Code No.	Heat No.	DWT Temp °F	NDTT °F	CVN Check Temp °F (1)	CVN TT °F (2)	Energy, ft-lbs Lat exp, mils	RT_{NDT} °F (3)	Cu	Ni
Recirculation Outlet – N1A	345-04A	G-3115-1	EV-9794	10 NB	0	40	10	72, 85, 74 55, 65, 50	0	NR	0.83
Recirculation Outlet – N1B	345-04B	G-3115-2	EV-9784	10 NB	0	40	10	72, 83, 70 55, 62, 51	0	NR	0.79
Recirculation Inlet N2A – 30°	345-07A	G-3120-1	EV-9793	10 NB	0	40	-50	80, 78, 74 61, 57, 55	0	NR	0.72
Recirculation Inlet N2B – 60°	345-07B	G-3120-4	EV-9793	10 NB	0	40	-50	80, 78, 74 61, 57, 55	0	NR	0.72
Recirculation Inlet N2C – 90°	345-07C	G-3120-3	EV-9793	10 NB	0	40	-50	80, 78, 74 61, 57, 55	0	NR	0.72
Recirculation Inlet N2D – 120°	345-07D	G-3120-2	EV-9793	10 NB	0	40	-50	80, 78, 74 61, 57, 55	0	NR	0.72
Recirculation Inlet N2E – 150°	345-07E	G-3120-5	EV-9793	10 NB	0	40	-50	80, 78, 74 61, 57, 55	0	NR	0.72
Recirculation Inlet N2F – 210°	345-07F	G-3120-6	EV-9786	10 NB	0	40	10	94, 98, 106 65, 60, 69	0	NR	0.85
Recirculation Inlet N2G – 240°	345-07G	G-3120-7	EV-9786	10 NB	0	40	10	94, 98, 106 65, 60, 69	0	NR	0.85
Recirculation Inlet N2H – 270°	345-07H	G-3120-8	EV-9786	10 NB	0	40	10	94, 98, 106 65, 60, 69	0	NR	0.85
Recirculation Inlet N2J – 300°	345-07J	G-3120-9	EV-9786	10 NB	0	40	10	94, 98, 106 65, 60, 69	0	NR	0.85
Recirculation Inlet N2K – 330°	345-07K	G-3120-10	EV-9759	10 NB	0	40	10	41, 53, 44 33, 42, 37	0	NR	0.80
Steam Outlet N3A	347-10A	G-3116-1	EV-9813	0 NB	-10	30	10	59, 64, 64 42, 43, 43	-10	NR	0.80
Steam Outlet N3B	347-10B	G-3116-2	EV-9813	0 NB	-10	30	10	74, 38, 64 56, 33, 49	4	NR	0.78
Steam Outlet N3C	347-10C	G-3116-3	EV-9813	10 NB	0	40	10	66, 48, 58 36, 45, 44	0	NR	0.79

Table 3-3 (con't)

NOZZLE Description	Piece No.	Code No.	Heat No.	DWT Temp °F	NDTT °F	CVN Check Temp °F (1)	CVN TT °F (2)	Energy, ft-lbs Lat exp, mils	RT_{NDT} °F (3)	Cu	Ni
Steam Outlet N3D	347-10D	G-3116-4	EV-9806	10 NB	0	40	10	63, 50, 55 44, 45, 49	0	NR	0.80
Feedwater N4A	347-07A	G-3117-1	EV-9819	10 NB	0	40	10	82, 99, 78 62, 72, 57	0	NR	0.69
Feedwater N4B	347-07B	G-3117-2	EV-9819	10 NB	0	40	10	82, 99, 78 62, 72, 57	0	NR	0.69
Feedwater N4C	347-07C	G-3117-3	EV-9819	10 NB	0	40	10	82, 99, 78 62, 72, 57	0	NR	0.70
Feedwater N4D	347-07D	G-3117-4	AV-1809	10 NB	0	40	10	64, 84, 76 47, 72, 59	0	NR	0.73
Core Spray N6A	347-14A	G-3118-1	EV-9819	10 NB	0	40	10	82, 99, 78 62, 72, 57	0	NR	0.70
Core Spray N6B	347-14B	G-3118-2	EV-9819	10 NB	0	40	10	82, 99, 78 62, 72, 57	0	NR	0.70
Head Nozzle N7A	348-06A	G-3200-1	EV-9806 8G-6069A	50 NB	40	80	10	96, 99, 86 66, 74, 61	40	NR	0.82
Head Nozzle N7B (spare)	348-06B	G-3200-2	EV-9806 8G- 6060B	50 NB	40	80	10	96, 99, 86 66, 74, 61	40	NR	0.82
Head Vent N8	348-03	G-3199	EV-9806 8G-6068	50 NB	40	80	10	98, 82, 98 69, 71, 72	40	NR	0.82
Jet Pump Instru-mentation, N9A	345-10A	G-3122-1	EV-9792	10 NB	0	40	-40	92, 93, 87 46, 55, 39	0	NR	0.69
Jet Pump Instru-mentation, N9B	345-10B	G-3122-2	EV-9792	10 NB	0	40	-40	92, 93, 87 46, 55, 39	0	NR	0.69
CRD Hydraulic Return	346-11	G-3121	EV-9792	10 NB	0	40	-40	92, 93, 87 46, 55, 39	0	NR	0.72

Table 3-3 (concluded)

Notes:

1. Charpy V-notch maximum test temperature (CVN Check Temp) at which tests for longitudinally oriented specimens must demonstrate a minimum impact energy of 50 ft-lb and a minimum lateral expansion of 35 mils to satisfy the requirements of NB-2331 for RT_{NDT} to equal NDTT. The "CVN Check Temp" = NDTT + 60°F - 20°F (longitudinal to transverse correction).
2. The minimum "CVN TT"(test temperature) at which the minimum energy exeeds 50 ft-lb and the minimum lateral expansion exceeds 35 mils.
3. Since the "CVN TT" at which the 50 ft-lb/35 mils is met is less than the "CVN check temp" the initial RT_{NDT} – NDTT.
4. NR = Not Reported.
5. NB = No Break

Table 3-4
Pilgrim Reactor Nozzle-to-RPV Welds [8]

Weld Description	Seam No.	Weld Type	Heat No.	CVN Temp. (°F)	Energy, (ft-lbs)	RT_{NDT} °F (1)	Cu	Ni
Recirculation Outlet - N1A	4-345A	E-8018	CBBH	10	118, 142, 115	-50	NR	1.1
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Outlet - N1B	4-345B	E-8018	EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Inlet - N2A 30°	9-345A	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
Recirculation Inlet - N2B 60°	9-345B	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Inlet - N2C 90°	9-345C	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Inlet - N2D 120°	9-345D	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Inlet - N2E 150°	9-345E	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Inlet - N2F 210°	9-345F	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
Recirculation Inlet - N2G 240°	9-345G	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04

Table 3-4 (cont'd)

Weld Description	Seam No.	Weld Type	Heat No.	CVN Temp. (°F)	Energy, (ft-lbs)	RT_{NDT} °F (1)	Cu	Ni
Recirculation Inlet – N2H 270°	9-345H	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
Recirculation Inlet – N2J 300°	9-345J	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
Recirculation Inlet – N2K 330°	9-345K	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
Steam Outlet – N3A	14-347A	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
			HOKG	10	80, 86, 88	-50	NR	1.46
Steam Outlet – N3B	14-347B	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
			HOKG	10	80, 86, 88	-50	NR	1.46
Steam Outlet – N3C	14-347C	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
			HOKG	10	80, 86, 88	-50	NR	1.46
Steam Outlet – N3D	14-347D	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
			HOKG	10	80, 86, 88	-50	NR	1.46
Feedwater – N4A	9-347A	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
Feedwater – N4B	9-347B	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
Feedwater – N4C	9-347C	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			CBBH	10	118, 142, 115	-50	NR	1.1
Feedwater – N4D	9-347D	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04

Table 3-4 (cont'd)

Weld Description	Seam No.	Weld Type	Heat No.	CVN Temp. (°F)	Energy, (ft-lbs)	RT_{NDT} °F (1)	Cu	Ni
Core Spray - N6A	19-347A	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
Core Spray - N6B	19-347B	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EOAG	10	173, 133, 135	-50	NR	1.04
Head - N7A	8-348A	E-8018	LOEH	10	113, 123, 140	-50	NR	0.98
Head - N7B (spare)	8-348B	E-8018	LOEH	10	113, 123, 140	-50	NR	0.98
Head Vent - N8	3-348	E-8018	LOEH	10	113, 123, 140	-50	NR	0.98
Jet Pump - N9A	14-345A	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
Jet Pump - N9B	14-345B	E-8018	BBHH	10	116, 107, 109	-50	NR	0.95
			EAGH	10	119, 120, 127	-50	NR	0.97
			EOAG	10	173, 133, 135	-50	NR	1.04
			HOKG	10	80, 86, 88	-50	NR	1.46

1. For the Charpy specimen with the minimum reported energy, add 2°F to test temperature for each ft-lb below 50 ft-lb to determine T_{50}. Define $RT_{NDT} = T_{50}$-60°F. If the minimum reported energy is greater than 50 ft-lb, RT_{NDT} = T - 60°F
2. NR = Not Reported.

Table 3-5

Summary of the Fast Neutron Flux and Fluence per Fuel Cycle for Pilgrim

Cycle	Core Mid-plane RPV ID Flux [13] n/cm^2-sec	Core Mid-plane RPV ID Fluence [13] n/cm^2	Time of Cycle (Fluence/Flux) Seconds	EFPY/ Cycle (1)	Cumulative		
					EFPY	Fluence n/cm^2	Fluence Rate n/cm^2/EFPY
Through #4	Not Reported	$2.6x10^{17}$(2)	Not Reported		4.17	$2.60x10^{17}$	$6.24x10^{16}$
#5 Start to Midddle	$1.3x10^9$	$2.3x10^{16}$	$1.8x10^7$	0.57	4.74	$2.83x10^{17}$	$4.04x10^{16}$
#5 Middle to End	$1.1x10^9$	$2.0x10^{16}$	$1.8x10^7$	0.57	5.31	$3.03x10^{17}$	$3.51x10^{16}$
#6 Start to Midddle	$1.4x10^9$	$2.9x10^{16}$	$2.1x10^7$	0.67	5.98	$3.32x10^{17}$	$4.33x10^{16}$
#6 Middle to End	$1.2x10^9$	$2.6x10^{16}$	$2.2x10^7$	0.70	6.68	$3.58x10^{17}$	$3.71x10^{16}$
#7 Start to Midddle	$1.4x10^9$	$1.7x10^{16}$	$1.2x10^7$	0.38	7.06	$3.75x10^{17}$	$4.47x10^{16}$

Notes
1. Seconds per EFPY = 3600*24*365 = 31,536,000
2. Fluence value reported in Reference 14 at 4.17 EFPY.

Table 3-6

Pilgrim RPV Maximum Calculated Fluences
(Based on Methodology of RG.1.99 Rev. 2)

EFPY	Inner Surface Max Fluence (1) n/cm^2	¼t Fluence n/cm^2
20	9.54×10^{17}	6.85×10^{17}
32	1.49×10^{18}	1.07×10^{18}
48	2.21×10^{18}	1.59×10^{18}

Notes

1. Based upon the fluence rate of 4.47×10^{16} n/cm^2/EFPY for mid cycle 7 from Table 3-5.
2. Vessel minimum wall thickness = 5.53 inches
   Fluence attenuation = $(e^{-0.24x})$ where x is the distance from ID vessel/clad interface.
   ¼ t = 1.38 inches

Table 3-7

Fluence Factors (FF) for ART Calculations - Beltline Plates and Forgings (Per Reg. Guide 1.99, Rev. 2)
(based on ¼t vessel fluences) [9, 10, 13]

Description	Code No.	Heat No.	RPV Azimuth Location	Peak Circ. Lead Factor (1)	Peak Axial Lead Factor (2)	Plate Equiv. Lead Factor	20 EFPY Fluence @¼ t n/cm^2 (3)	32 EFPY Fluence @¼ t n/cm^2 (3)	48 EFPY Fluence @¼ t n/cm^2 (3)	FF @20 EFPY	FF @32 EFPY	FF @48 EFPY
Lower Shell	G-3109-2	C-2957-2	318° to 78°	1.0	0.749	0.749	$5.13x10^{17}$	$8.01x10^{17}$	$1.19x10^{18}$	0.30	0.37	0.45
Lower Shell	G-3109-1	C-2957-1	78° to 198°	1.0	0.749	0.749	$5.13x10^{17}$	$8.01x10^{17}$	$1.19x10^{18}$	0.30	0.37	0.45
Lower Shell	G-3109-3	C-2973-1	198° to 318°	1.0	0.749	0.749	$5.13x10^{17}$	$8.01x10^{17}$	$1.19x10^{18}$	0.30	0.37	0.45
Lower Int. Shell	G-3108-3	C-2945-2	300° to 60°	1.0	1.0	1.0	$6.85x10^{17}$	$1.07x10^{18}$	$1.59x10^{18}$	0.35	0.43	0.52
Lower Int. Shell	G-3108-1	C-2921-2	60° to 180°	1.0	1.0	1.0	$6.85x10^{17}$	$1.07x10^{18}$	$1.59x10^{18}$	0.35	0.43	0.52
Lower Int. Shell	G-3108-2	C-2945-1	180° to 300°	1.0	1.0	1.0	$6.85x10^{17}$	$1.07x10^{18}$	$1.59x10^{18}$	0.35	0.43	0.52

Notes
1. From Figure 3-4, Azimuthal Lead Factors.
2. From Figure 3-3, Axial Lead Factors.
3. From Table 3-6.

Table 3-8
Fluence Factors (FF) for ART Calculations - Beltline Welds (Per Reg. Guide 1.99, Rev. 2)
(based on ¼t Vessel Fluence) [8, 9, 10, 13]

Description	Seam No.	RPV Azimuth Location	Peak Circ. Lead Factor(1)	Peak Axial Lead Factor (2)	Weld Equiv. Lead Factor	20 EFPY Fluence @¼ t n/cm^2 (3)	32 EFPY Fluence @¼ t n/cm^2 (3)	48 EFPY Fluence @¼ t n/cm^2 (3)	FF @20 EFPY	FF @32 EFPY	FF @48 EFPY
L. Int. Shell Long. Weld	1-338A	60°	0.93	1.0	0.93	$6.37x10^{17}$	$9.95x10^{17}$	$1.48x10^{18}$	0.33	0.42	0.50
L. Int. Shell Long. Weld	1-338B	180°	0.39	1.0	0.39	$2.67x10^{17}$	$4.17x10^{17}$	$6.20x10^{17}$	0.21	0.26	0.33
L. Int. Shell Long. Weld	1-338C	300°	0.93	1.0	0.93	$6.37x10^{17}$	$9.95x10^{17}$	$1.48x10^{18}$	0.33	0.42	0.50
L.Int./ L. Shell Girth Weld	1-344	Full Circle	1.00	0.749	0.75	$5.14x10^{17}$	$8.03x10^{17}$	$1.19x10^{18}$	0.30	0.37	0.45
Lower.Shell Long. Weld	2-338 A	78°	0.55	0.749	0.41	$2.81x10^{17}$	$4.39x10^{17}$	$6.52x10^{17}$	0.21	0.27	0.34
Lower.Shell Long. Weld	2-338 B	198°	0.78	0.749	0.58	$3.97x10^{17}$	$6.21x10^{17}$	$9.22x10^{17}$	0.26	0.33	0.40
Lower.Shell Long. Weld	2-338 C	318°	0.58	0.749	0.43	$2.95x10^{17}$	$4.60x10^{17}$	$6.84x10^{17}$	0.22	0.28	0.34

Notes
1. From Figure 3-4, Azimuthal Lead Factors.
2. From Figure 3-3, Axial Lead Factors.
3. From Table 3-6.

Table 3-9 (cont'd)

Description Piece No.	Heat No.	Initial RT_{NDT} °F (1)	Chemistry Factor, °F	20 EFPY ART Fluence Factor, @ ¼t (2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F	32 EFPY ART Fluence Factor, @ ¼t (2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F	48 EFPY ART Fluence Factor, @ ¼t (2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F
Vessel	2V-545	10	Non Beltline	Non Beltline	0	0	10	0	0	0	10	0	0	0	10
Closure Head Flange 349-02	5P-2003	10	Non Beltline	Non Beltline	0	0	10	0	0	0	10	0	0	0	10
Closure Head Torus 349-03A	C-3982-1	-10	Non Beltline	Non Beltline	0	0	-10	0	0	0	-10	0	0	0	-10
Closure Head Torus 349-03C	C-3982-2	-10	Non Beltline	Non Beltline	0	0	-10	0	0	0	-10	0	0	0	-10

Notes:
1. From Table 3-1.
2. From Table 3-7
3. $\Delta RT_{NDT} = FF \times CF$

Table 3-10
Toughness Properties for Controlling Weld Heats (SAW welds with highest RT_{NDT} unless noted)
(Per Reg. Guide 1.99, Rev. 2)

Description	Seam No.	Heat No.	Initial RT_{NDT} °F (1)	Chemistry Factor, °F	20 EFPY ART				32 EFPY ART				48 EFPY ART			
					Fluence Factor, @¼t(2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F	Fluence Factor, @¼t(2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F	Fluence Factor, @¼t(2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F
B.Head Dome / L. Torus Weld	5-336	13253	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
B.Head L. Torus Long Welds	2-336A,B, C,D,E & F	51989	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
B.Head L Torus / U. Torus Weld	6-336	13253	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
B.Head U. Torus Long Welds	1-336A, B,C,D,E, F,G & H	SMAW JBFG	-12	Non Beltline	Non Beltline	0	0	-12	0	0	0	-12	0	0	0	-12
L. Shell / B. Head Weld – 2 Seam Nos.	4-348	SMAW 2 Heats	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
	9-338	20291	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
L. Shell Long. Weld	2-338A	27204	-34	227	.21	48	48	62	0.27	56	61	83	0.34	56	77	99
L. Shell Long. Weld	2-338B	27204	-34	227	.26	56	59	81	0.33	56	75	97	0.40	56	91	113
L. Shell Long. Weld	2-338C	27204	-34	227	.22	50	50	66	0.28	56	64	86	0.34	56	77	99
L.Int./L.Shell Weld	1-344	21935	-50	172	.30	52	52	54	0.37	56	64	70	0.45	56	77	83
L. Int. Long. Weld	1-338A	27204/ 12008	-48	231	.33	56	76	84	0.42	56	97	105	0.50	56	116	124
L. Int. Long. Weld	1-338B	27204/ 12008	-48	231	.21	49	49	50	0.26	56	60	68	0.33	56	76	84
L. Int. Long. Weld	1-338C	27204/ 12008	-48	231	.33	56	76	84	0.42	56	97	105	0.50	56	116	124
U. Int./L. Int. Weld	3-339B	13253	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
U. Int. Long. Weld	2-339A,B &C	27204	-34	Non Beltline	Non Beltline	0	0	-34	0	0	0	-34	0	0	0	-34
U. Shell/U. Int. Weld	3-339A	13253	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
U. Shell Long. Weld	1-339A,B &C	27204/ 12008	-48	Non Beltline	Non Beltline	0	0	-48	0	0	0	-48	0	0	0	-48

Table 3-10 (continued)

Description Piece No.	Seam No.	Heat No.	Initial RT_{NDT} °F (1)	Chemistry Factor, °F	20 EFPY ART				32 EFPY ART				48 EFPY ART			
					Fluence Factor, @¼t(2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F	Fluence Factor, @¼t(2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F	Fluence Factor, @¼t(2)	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F
U. Shell/Flange Weld	4-339	13253	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
C. Head/Flange Weld	1-349	20291	-20	Non Beltline	Non Beltline	0	0	-20	0	0	0	-20	0	0	0	-20
C. Head Torus Long Welds	3-349A, B,C,D,E, F,G & H	SMAW EAGH	-50	Non Beltline	Non Beltline	0	0	-50	0	0	0	-50	0	0	0	-50
C. Head Dome / Torus Weld	2-349	20291	-20	Non Beltline	Non Beltline	0	0	-20	0	0	0	-20	0	0	0	-20

Notes:

1. From Table 3-2. For welds made with both SAW and SMAW materials, it is assumed that the SAW material will constitute almost all of the weld volume and will be the controlling material.
2. From Table 3-8.
3. $\Delta RT_{NDT} = FF \times CF$

Table 3-11
Toughness Properties for Nozzle Forgings (Per Reg. Guide 1.99, Rev. 2)

Description Piece No.	Heat No.	Initial RT_{NDT} °F (1)	20, 32 and 48 EFPY ART Fluence Factor, @¼t	Margin $2 \cdot \sigma_\Delta$ °F	ΔRT_{NDT} @¼t °F	ART @ ¼t °F
Recirculation Outlet – N1A 345-04A	EV-9794	0	Non Beltline	0	0	0
Recirculation Outlet – N1B 345-04B	EV-9784	0	Non Beltline	0	0	0
Recirculation Inlet N2A – 30° 345-07A	EV-9793	0	Non Beltline	0	0	0
Recirculation Inlet N2B – 60° 345-07B	EV-9793	0	Non Beltline	0	0	0
Recirculation Inlet N2C – 90° 345-07C	EV-9793	0	Non Beltline	0	0	0
Recirculation Inlet N2D – 120° 345-07D	EV-9793	0	Non Beltline	0	0	0
Recirculation Inlet N2E – 150° 345-07E	EV-9793	0	Non Beltline	0	0	0
Recirculation Inlet N2F – 210° 345-07F	EV-9786	0	Non Beltline	0	0	0
Recirculation Inlet N2G – 240° 345-07G	EV-9786	0	Non Beltline	0	0	0
Recirculation Inlet N2H – 270° 345-07H	EV-9786	0	Non Beltline	0	0	0
Recirculation Inlet N2J – 300° 345-07J	EV-9786	0	Non Beltline	0	0	0
Recirculation Inlet N2K – 330° 345-07K	EV-9759	0	Non Beltline	0	0	0
Steam Outlet N3A 347-10A	EV-9813	-10	Non Beltline	0	0	-10
Steam Outlet N3B 347-10B	EV-9813	4	Non Beltline	0	0	4
Steam Outlet N3C 347-10C	EV-9813	0	Non Beltline	0	0	0
Steam Outlet N3D 347-10D	EV-9806	0	Non Beltline	0	0	0
Feedwater N4A 347-07A	EV-9819	0	Non Beltline	0	0	0
Feedwater N4B 347-07B	EV-9819	0	Non Beltline	0	0	0
Feedwater N4C 347-07C	EV-9819	0	Non Beltline	0	0	0
Feedwater N4D 347-07D	AV-1809	0	Non Beltline	0	0	0
Core Spray N6A 347-14A	EV-9819	0	Non Beltline	0	0	0
Core Spray N6B 347-14B	EV-9819	0	Non Beltline	0	0	0
Head Nozzle N7A 348-06A	EV-9806 8G-6069A	40	Non Beltline	0	0	40
Head Nozzle N7B (spare) 348-06B	EV-9806 8G- 6060B	40	Non Beltline	0	0	40
Head Vent N8 348-03	EV-9806 8G-6068	40	Non Beltline	0	0	40
Jet Pump Instrumentation, N9A 345-10A	EV-9792	0	Non Beltline	0	0	0
Jet Pump Instrumentation, N9B 345-10B	EV-9792	0	Non Beltline	0	0	0
CRD Hydraulic Return 346-11	EV-9792	0	Non Beltline	0	0	0

Note 1. From Table 3-3.

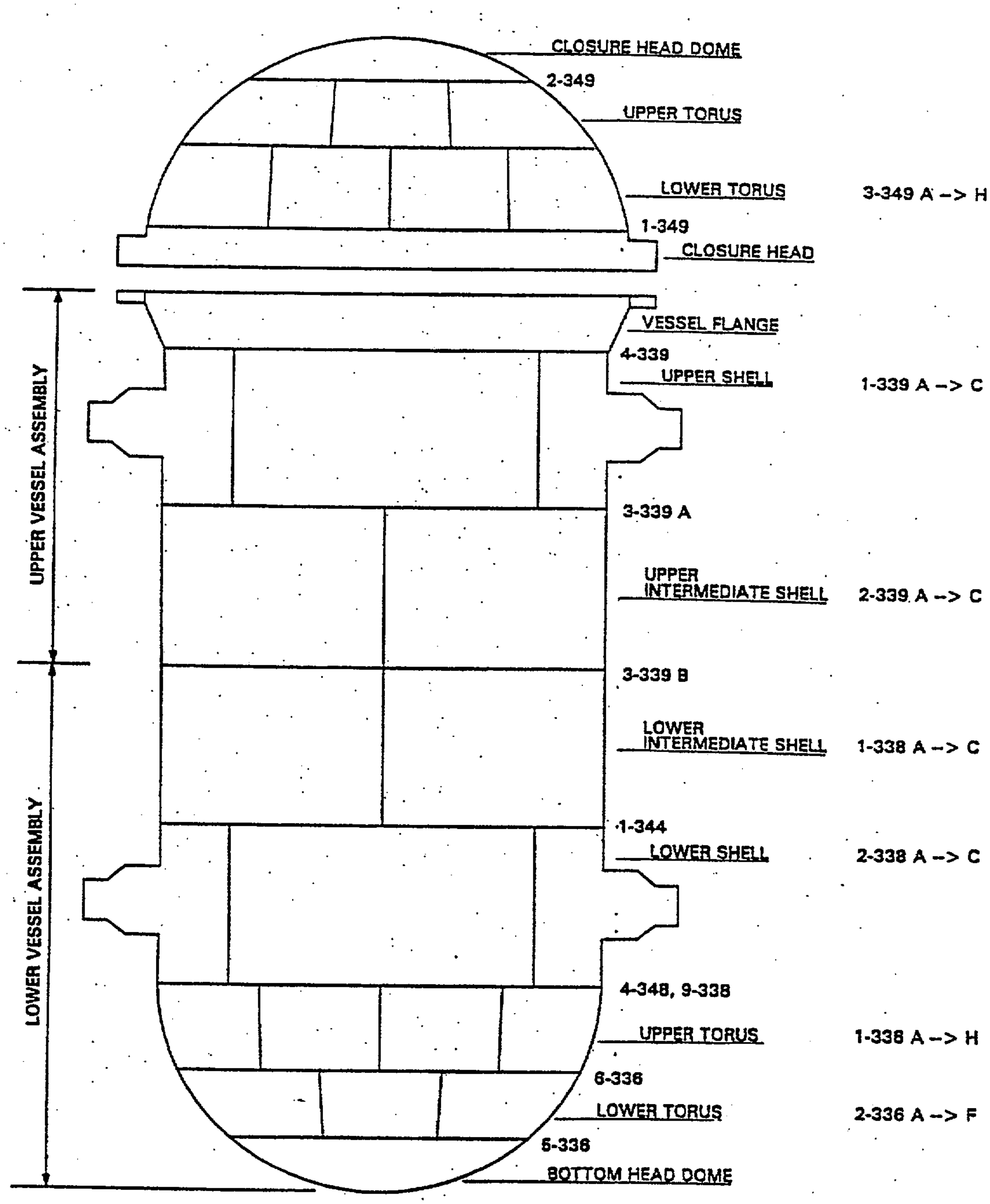


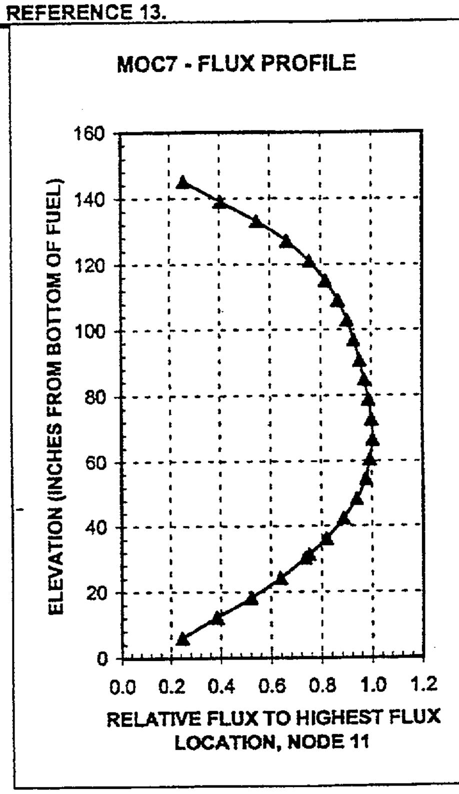
Figure 3-2. Pilgrim Reactor Vessel Shell Weld Identification Map [8]

AXIAL RELATIVE FLUX PROFILE FROM REFERENCE 13.

Node	Axial Flux Profile for MOC 7				
	Inches	Elev., (in)	Weld Seam	Relative Flux (1)	Normalized Relative Flux (2)
Bottom of Fuel	0	211.1			
1	6.05	217.15	2-338	0.246	0.245
2	12.20	223.30	2-338	0.385	0.383
3	18.16	229.26	2-338	0.521	0.519
4	24.21	235.31	2-338	0.638	0.635
5	30.25	241.35	2-338	0.736	0.733
5A	**31.4**	**242.50**	**1-344**	**0.752**	**0.749**
6	36.31	247.41	1-338	0.819	0.816
7	42.36	253.46	1-338	0.887	0.883
8	48.41	259.51	1-338	0.940	0.936
9	54.47	265.57	1-338	0.977	0.973
10	60.52	271.62	1-338	0.993	0.989
11	66.56	277.66	1-338	1.004	1.000
12	72.62	283.72	1-338	1.000	0.996
13	78.67	289.77	1-338	0.989	0.985
14	84.72	295.82	1-338	0.972	0.968
15	90.77	301.87	1-338	0.953	0.949
16	96.82	307.92	1-338	0.930	0.926
17	102.87	313.97	1-338	0.902	0.898
18	108.93	320.03	1-338	0.867	0.864
19	114.98	326.08	1-338	0.819	0.816
20	121.03	332.13	1-338	0.755	0.752
21	127.09	338.19	1-338	0.666	0.663
22	133.14	344.24	1-338	0.547	0.545
23	139.19	350.29	1-338	0.404	0.402
24	145.24	356.34	Top of Fuel	0.257	0.256

Notes

1. Flux normalized to 1.00 at Node 12 [13].
2. Relative flux normalized to 1.000 at Node 11, location of maximum flux.



AXIAL LEAD FACTORS TO BE USED IN EVALUATION

ITEM	ELEV. Inches	NODE	MAX NORM AXIAL LEAD FACTOR (1)
Bottom Head ID	0	N/A	0
Lower Shell Weld 2-338A, B, C	106.38 to 242.5	1 to 5A	0.749
Girth Weld 1-344	242.5	5A	0.749
Lower Int. Shell Weld 1-338A, B, C	242.5 to 398	5A to 24	1.0

Note

1. From normalized relative flux, normalized to Node 11.

PILGRIM REACTOR VESSEL OUTLINE / WELD MAP [18]

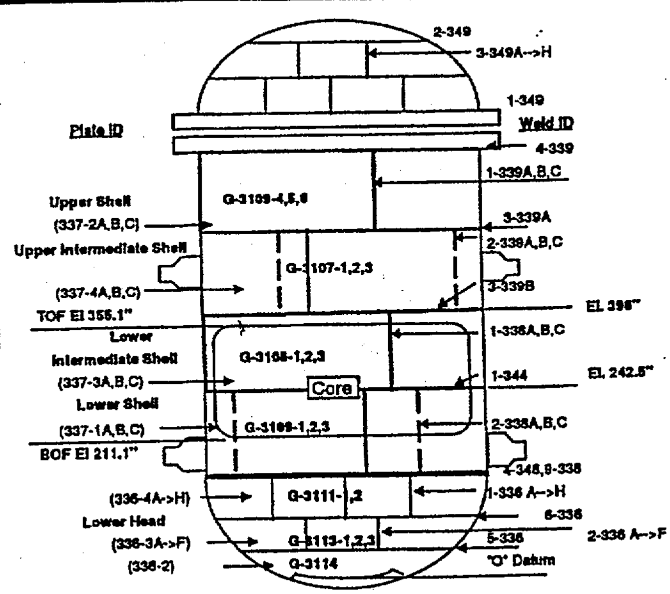


Figure 3-3. Pilgrim RPV Axial Flux Profile and Axial Lead Factors [13, 18]

4.0 SUMMARY

- Documentation for the wrought products(Tables 3-1 → 3-4) is excellent. The documentation for the weld materials is limited to CVN tests at one temperature. Best estimate chemistries for copper and nickel are available for the beltline SAW materials.

- A strict interpretation of the rules from NB-2331 and MTEB 5-2 was applied for determining the initial RT_{NDT} values for the plate and forging materials.

- Initial RT_{NDT} values for the welds were determined using the GE procedures described in Reference 17.

- The limiting materials for the non-beltline locations are the Bottom Head Upper Torus longitudinal welds 1-336A to H (ART = -12°F, Table 3-10); the Bottom Head plate 336-02 (ART = 29°F, Table 3-9); and the N7A, N7B and N8 nozzles (ART = 40°F, Table 3-11). It should be noted that the high nozzle ART is determined by the high dropweight test temperature. The actual ART may be significantly lower.

- The limiting material for the irradiated, beltline locations are the Lower Intermediate Shell longitudinal welds 1-338A & C (ART @ 32 EFPY = 105°F, Table 3-10) and the Lower Shell plate 337-01C (ART @ 32 EFPY = 50°F, Table 3-9).

List of Acronyms

CVN – Charpy V-Notch impact
SAW – Submerged arc welding
SMAW – Shielded metal arc welding
RT_{NDT} – Nil ductility reference temperature
ART – Adjusted reference temperature
EFPY – Effective Full Power Years
RPV – Reactor pressure vessel
NDTT – Nil ductility transition temperature (from drop weight tests)

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2. A. F. Deardorff, "Additional Evaluations of Reactor Pressure Vessel Materials Properties for Pilgrim," Structural Integrity Associates Letter Report AFD-94-107, prepared for P.K. Shah, Altran Corporation, November 8, 1994.

3. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, Appendix A, "Analysis of Flaws," 1989.

4. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, Appendix G, "Protection Against Nonductile Failure," 1989.

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

6. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, 1989.

7. ASTM E208-87a, "Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels," 1990 Annual Book of ASTM Standards.

8. "The Reactor Vessel Group Records Evaluation Program, Phase II Final Report for the Pilgrim 1 Reactor Pressure Vessel Plates, Forgings, Welds, and Cladding," MISC-PENG-ER-009, Rev. 00; Volumes 1, 2, and 3; October 1996. SI File PNPS-03Q-212P.

9. Notebook containing identification of Pilgrim RPV shell and head plates, flange forgings and welds; and CMTRs and correspondence on the materials prepared by J. S. Roberts at the Pilgrim plant. SI File PNPS-03Q-211.

10. Material Identification for 224" I.D. BWR, CE Drawing Number 232-370-3, Rev. 3, 1-19-70. SI File PNPS-03Q-203P.

11. "Best Estimte Copper and Nickel Values in CE Fabricated Reactor Vessel Welds," CEOG Task 902, CE NPSD-1039, Revision 02, Final Report, June 1997. SI File PNPS-03Q-231.

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14. E. B. Norris, "Pilgrim Nuclear Power Station Unit 1 Reactor Vessel Irradaition Surveillance Program," Final Report SwRI Project No. 02-5951, July 1981. SI File PNPS-03Q-207

15. Branch Technical Position – MTEB 5-2, "Fracture Toughness Requirements," Revision 1, July 1981.

16. CVGRAPH – Hyperbolic Tangent Curve-Fitting Program, Version 4.1, developed by ATI Consulting, March, 1996.

17. GE Nuclear Energy, "Methods for Establishing Reference Temperatures (RT_{NDT}) for Vessel Steels for Certain Plants," Y1006A006, Revision 1, 1/25/79.

18. J. S. Roberts, "Determine the ASME Sect. III App. G Adjusted Reference Temperature for the Reactor Vessel Beltline Materials," Pilgrim Nuclear Power Station, Calc. No. M-980, Rev 0 (Draft), Mechanical (MESG), Dated 4/12/00. SI File PNPS-03Q-209.

19. W.L. Server and W. Oldfield, "Nuclear Pressure Vessel Steel Data Base," EPRI Report NP-933, Topical Report, December 1978.

20. P. McConnell, et.al.,"Irradiated Nuclear Pressure Vessel Steel Data Base," EPRI Report NP-2428, Topical Report, June, 1982.

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22. BECO Dwg. No. 1979-216-6, Rev. E2, General Arrangement Elevation, (CE Dwg. No. 232-334-4), SI File PNPS-02Q-233-11.

23. Reactor Vessel Integrity Database (RVID), Developed by the Nuclear Regulatory commission (NRC), version 2 (2.05) (Last data update 6/9/99).

24. ASTM E185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels, E706(IF)," American Society for Testing and Materials.

APPENDIX A

CVGRAPH ANALYSES OF MINIMUM CHARPY V-NOTCH TEST IMPACT DATA FOR SELECTED PILGRIM PRESSURE VESSEL PLATES AND FORGING

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1
CAPSULE ID :
PRODUCT CODE : PLATE
MATERIAL ID : SA533B1
ORIENTATION : LT Lateral-Transverse
HEAT NO : C-2888-3 (G-3114)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	9.00	7.00	0.00		0.00
2	10.00	23.00	20.00	0.00		0.00
3	40.00	34.00	27.00	0.00		0.00
4	110.00	74.00	57.00	0.00		0.00
5	160.00	112.00	70.00	0.00		0.00
6	212.00	110.00	79.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:09:03 on 06-28-2000

Page 1

Coefficients of Curve 1

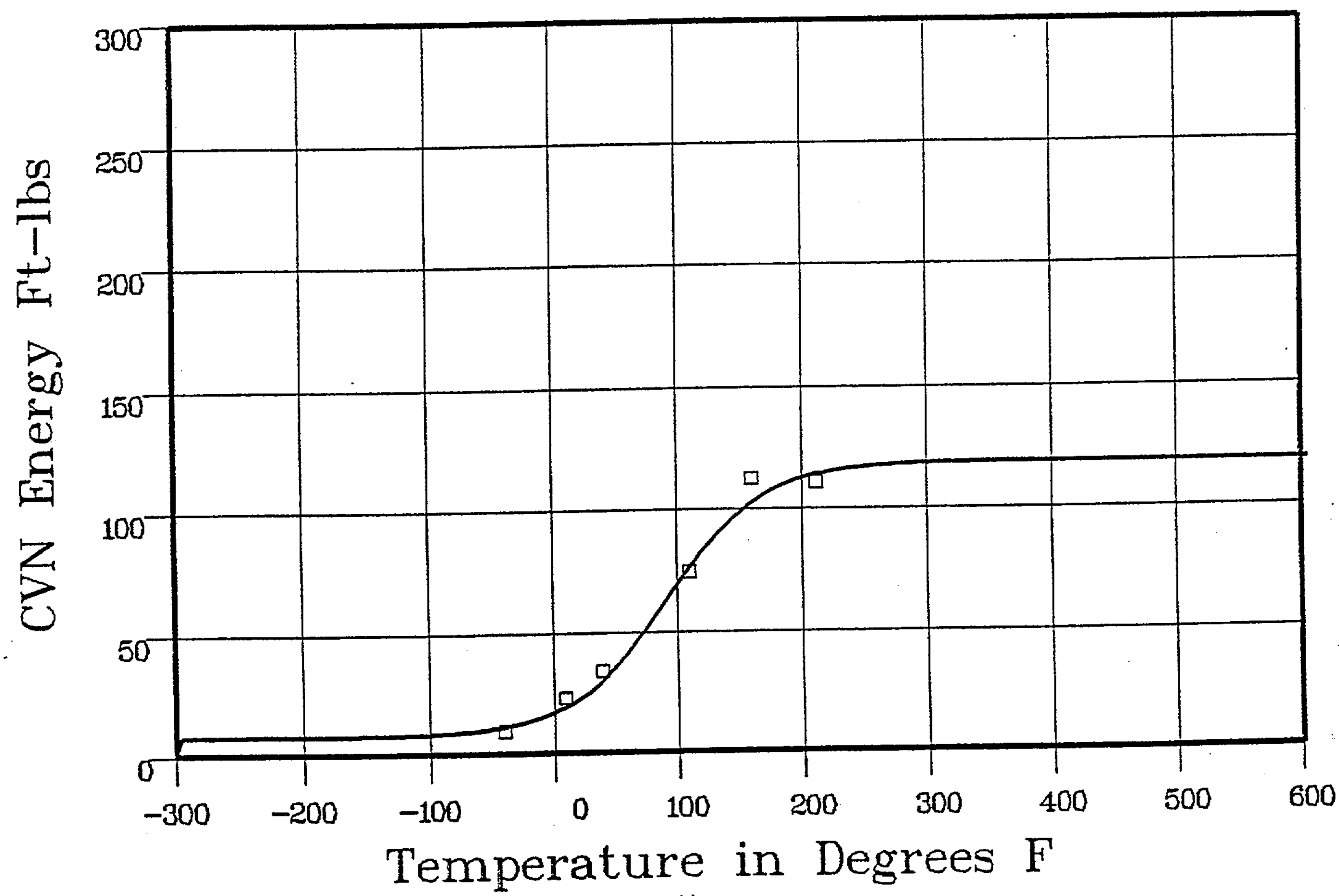
A = 62.93	B = 55.62	C = 77.13	T0 = 87

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

Upper Shelf Energy: 118.56 Temp. at 30 ft-lbs: 34.4 Temp. at 50 ft-lbs: 68.7 Lower Shelf Energy: 7.3

Material: PLATE SA533B1 Heat Number: C-2888-3 (G-3114) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2888-3 (G-3114)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	9	11.28	-2.28
10	23	20.6	2.39
40	34	32.69	1.3
110	74	79.04	-5.04
160	112	103.99	8
212	110	114.37	-4.37

SUM of RESIDUALS = 0

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1
CAPSULE ID :
PRODUCT CODE : PLATE
MATERIAL ID : SA533B1
ORIENTATION : LT Lateral-Transverse
HEAT NO : C-2913-3 (G-3113-1)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	10.00	8.00	0.00		0.00
2	10.00	27.00	28.00	0.00		0.00
3	40.00	33.00	48.00	0.00		0.00
4	110.00	88.00	68.00	0.00		0.00
5	160.00	128.00	70.00	0.00		0.00
6	212.00	132.00	74.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:04:55 on 06-28-2000

Page 1

Coefficients of Curve 1

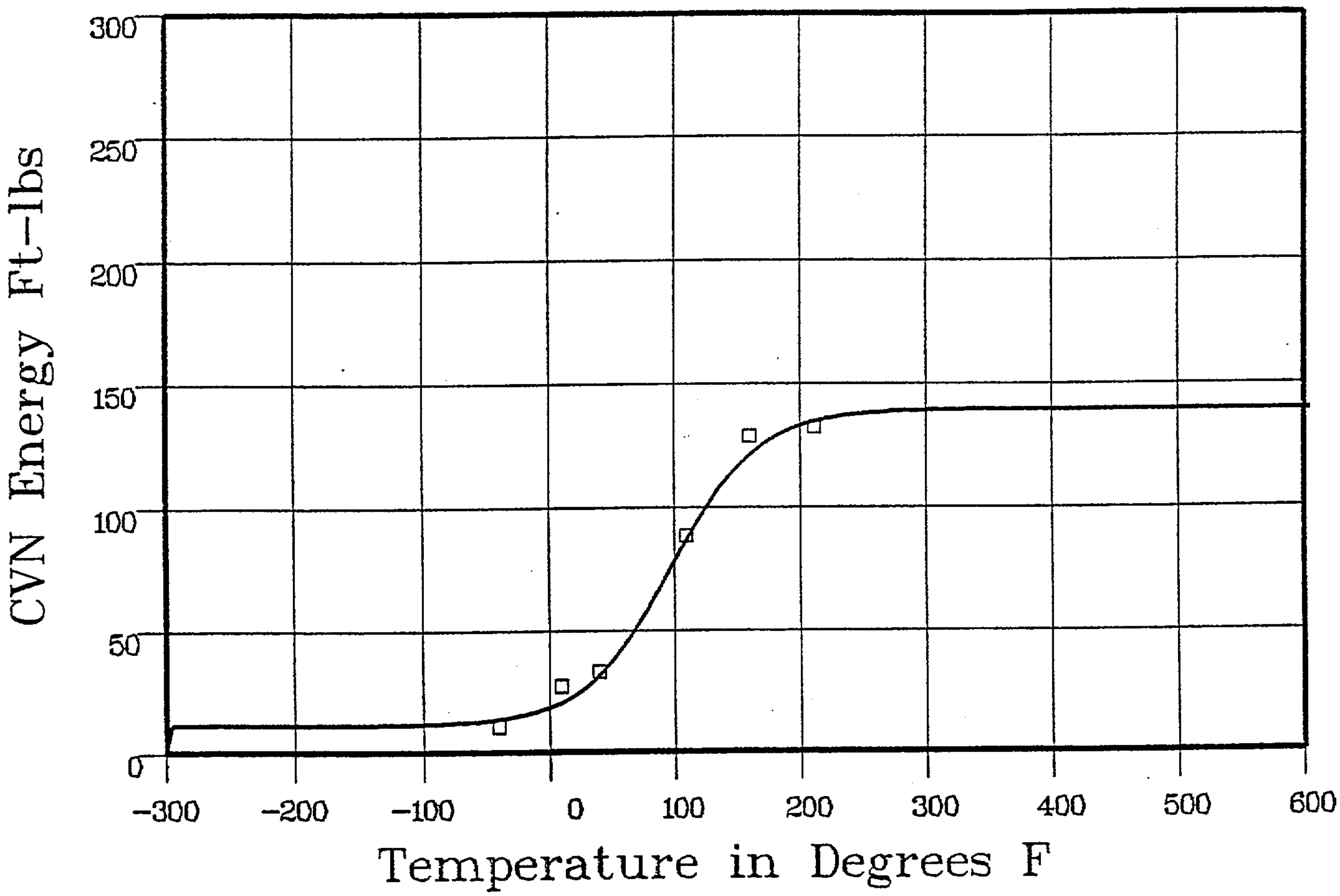
A = 74.82	B = 64.22	C = 69.9	T0 = 92.25

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

Upper Shelf Energy: 139.04   Temp. at 30 ft-lbs: 31.9   Temp. at 50 ft-lbs: 63.7   Lower Shelf Energy: 10.59

Material: PLATE SA533B1   Heat Number: C-2913-3 (G-3113-1)   Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1   Cap: Material: PLATE SA533B1   Ori.: LT   Heat #: C-2913-3 (G-3113-1)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	10	13.45	-3.45
10	27	21.74	5.25
40	33	34.12	-1.12
110	88	90.78	-2.78
160	128	122.88	5.11
212	132	135	-3

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:34:48 on 06-28-2000

Page 1

Coefficients of Curve 1

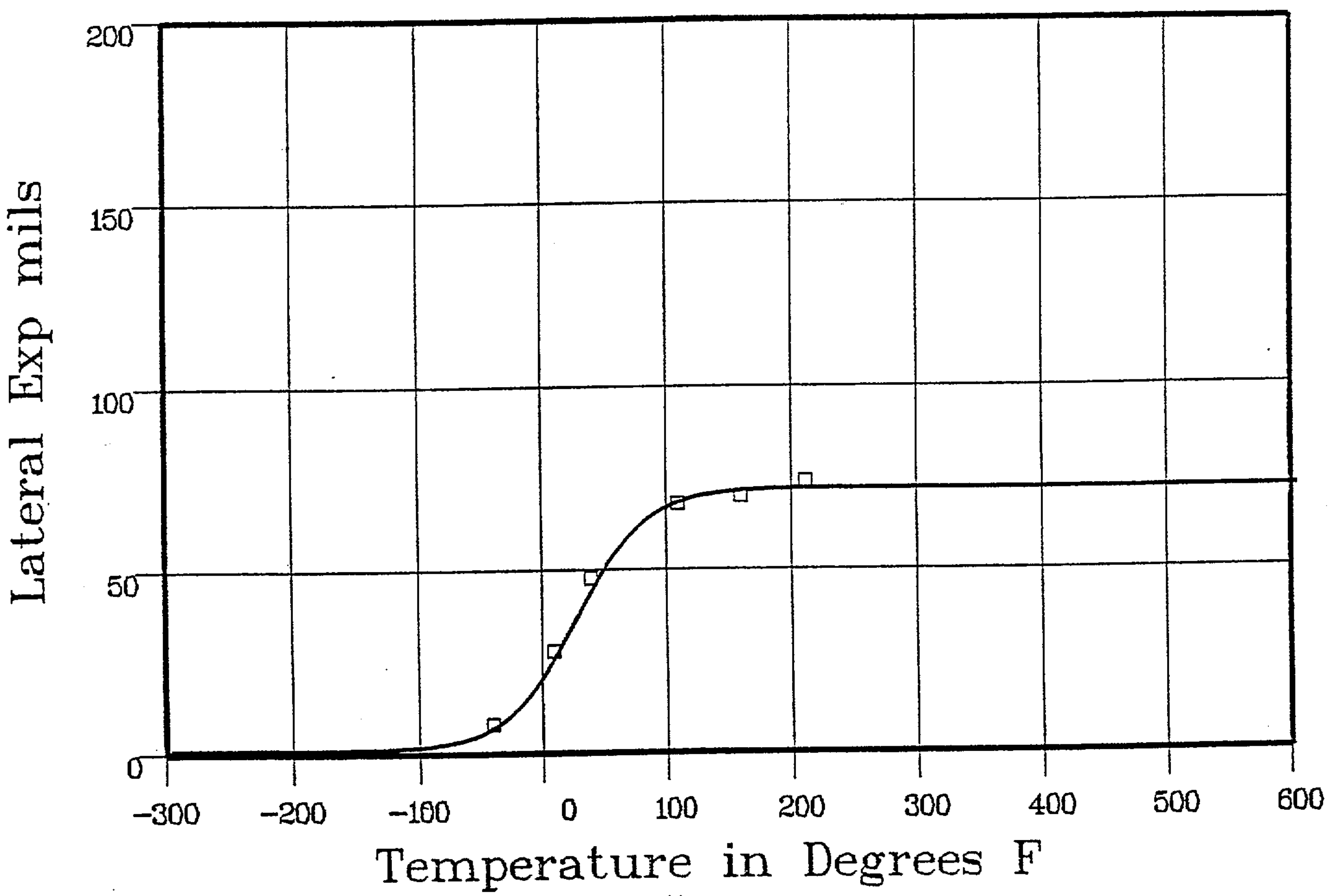
A = 36.57	B = 35.57	C = 56.38	T0 = 22.6

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

Upper Shelf L.E.: 72.14 Temperature at L.E. 35: 20.1 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2913-3 (G-3113-1) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2913-3 (G-3113-1)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	8	7.96	.03
10	28	28.74	-.74
40	48	47.2	.79
110	68	69.07	-1.07
160	70	71.6	-1.6
212	74	72.05	1.94

SUM of RESIDUALS = -.66

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1
CAPSULE ID :
PRODUCT CODE : PLATE
MATERIAL ID : SA533B1
ORIENTATION : LT Lateral-Transverse
HEAT NO : A-2222-2 (G-3113-2)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	9.00	8.00	0.00		0.00
2	10.00	31.00	24.00	0.00		0.00
3	40.00	52.00	42.00	0.00		0.00
4	110.00	110.00	87.00	0.00		0.00
5	160.00	148.00	87.00	0.00		0.00
6	212.00	152.00	84.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 19:04:51 on 06-27-2000

Page 1

Coefficients of Curve 1

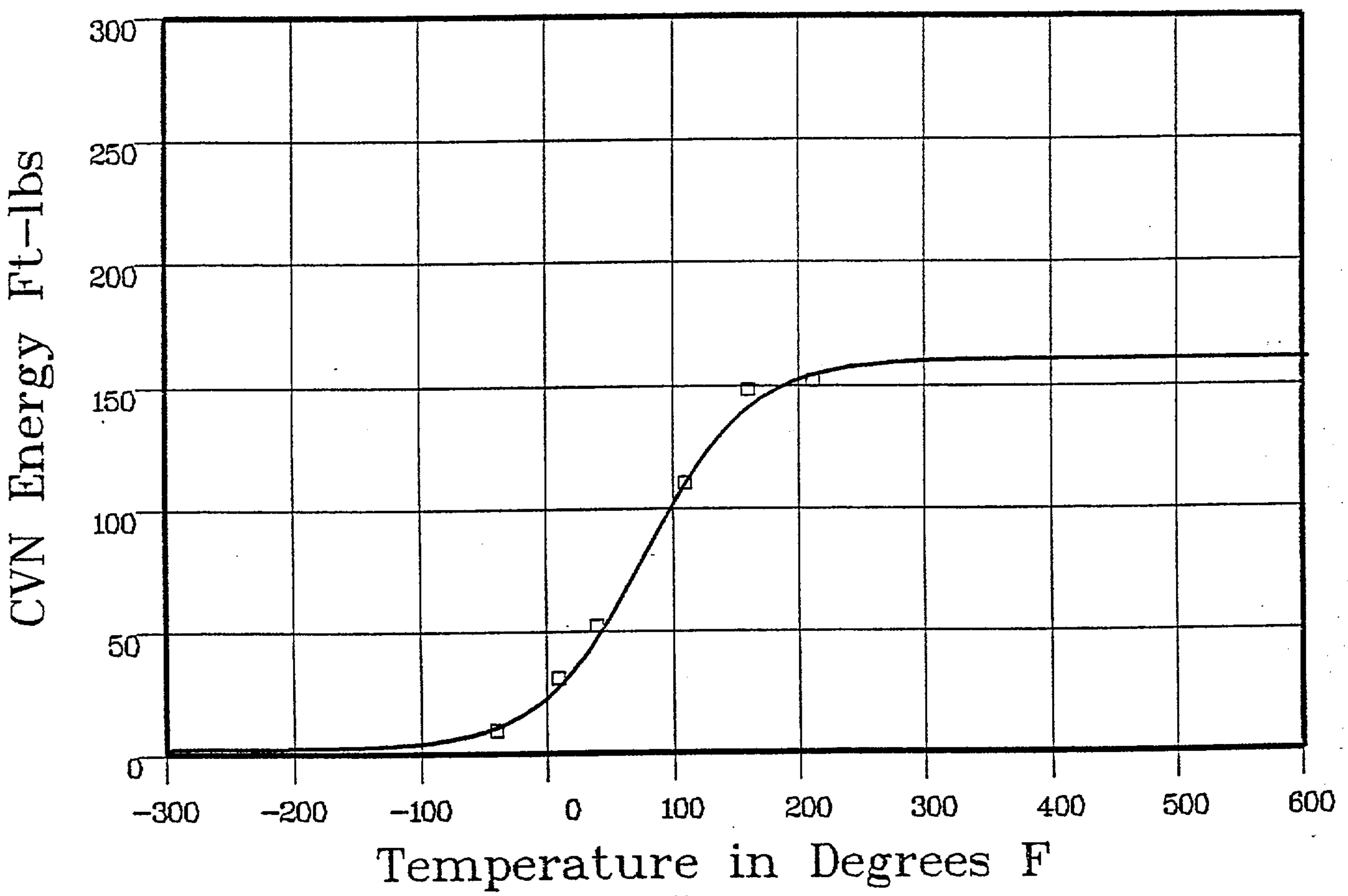
A = 81.14	B = 79.14	C = 82.7	T0 = 73.77

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

Upper Shelf Energy: 160.29 Temp. at 30 ft-lbs: 10.1 Temp. at 50 ft-lbs: 39.3 Lower Shelf Energy: 2 Fixed

Material: PLATE SA533B1 Heat Number: A-2222-2 (G-3113-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: A-2222-2 (G-3113-2)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	9	11.49	-2.49
10	31	29.89	1.1
40	52	50.51	1.48
110	110	113.75	-3.75
160	148	142.79	5.2
212	152	154.89	-2.89

SUM of RESIDUALS = -1.34

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 19:05:25 on 06-27-2000

Page 1

Coefficients of Curve 1

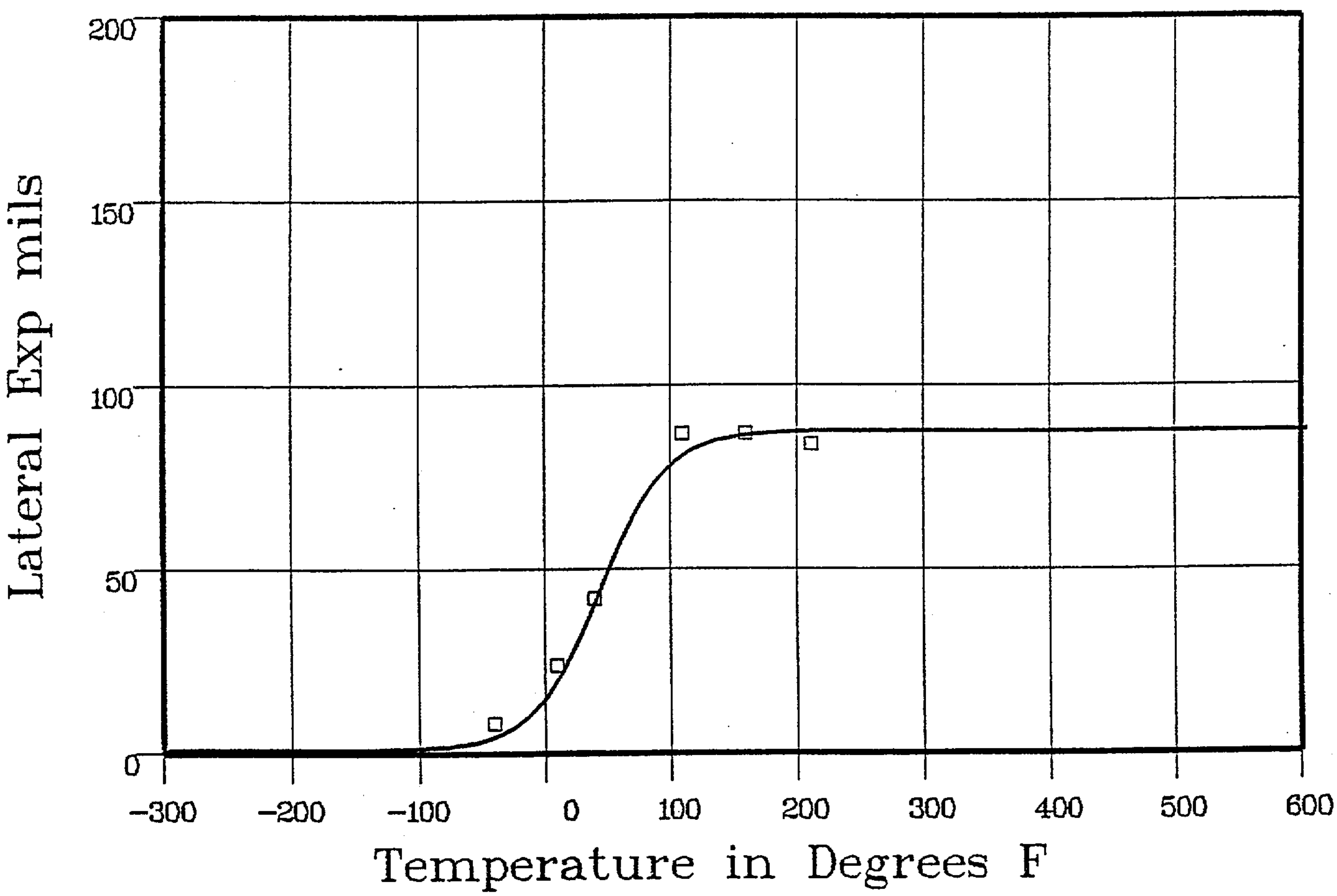
A = 44.33	B = 43.33	C = 52.69	T0 = 39.37

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

Upper Shelf L.E.: 87.67 Temperature at L.E. 35: 27.8 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: A-2222-2 (G-3113-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: A-2222-2 (G-3113-2)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	8	5.06	2.93
10	24	22.4	1.59
40	42	44.85	-2.85
110	87	82.11	4.88
160	87	86.79	2
212	84	87.54	-3.54

SUM of RESIDUALS = 3.22

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-2957-2 (G-3109-2)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	10.00	11.00	0.00		0.00
2	10.00	31.00	28.00	0.00		0.00
3	40.00	51.00	41.00	0.00		0.00
4	110.00	98.00	74.00	0.00		0.00
5	160.00	127.00	93.00	0.00		0.00
6	195.00	120.00	86.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:44:08 on 06-27-2000

Page 1

Coefficients of Curve 1

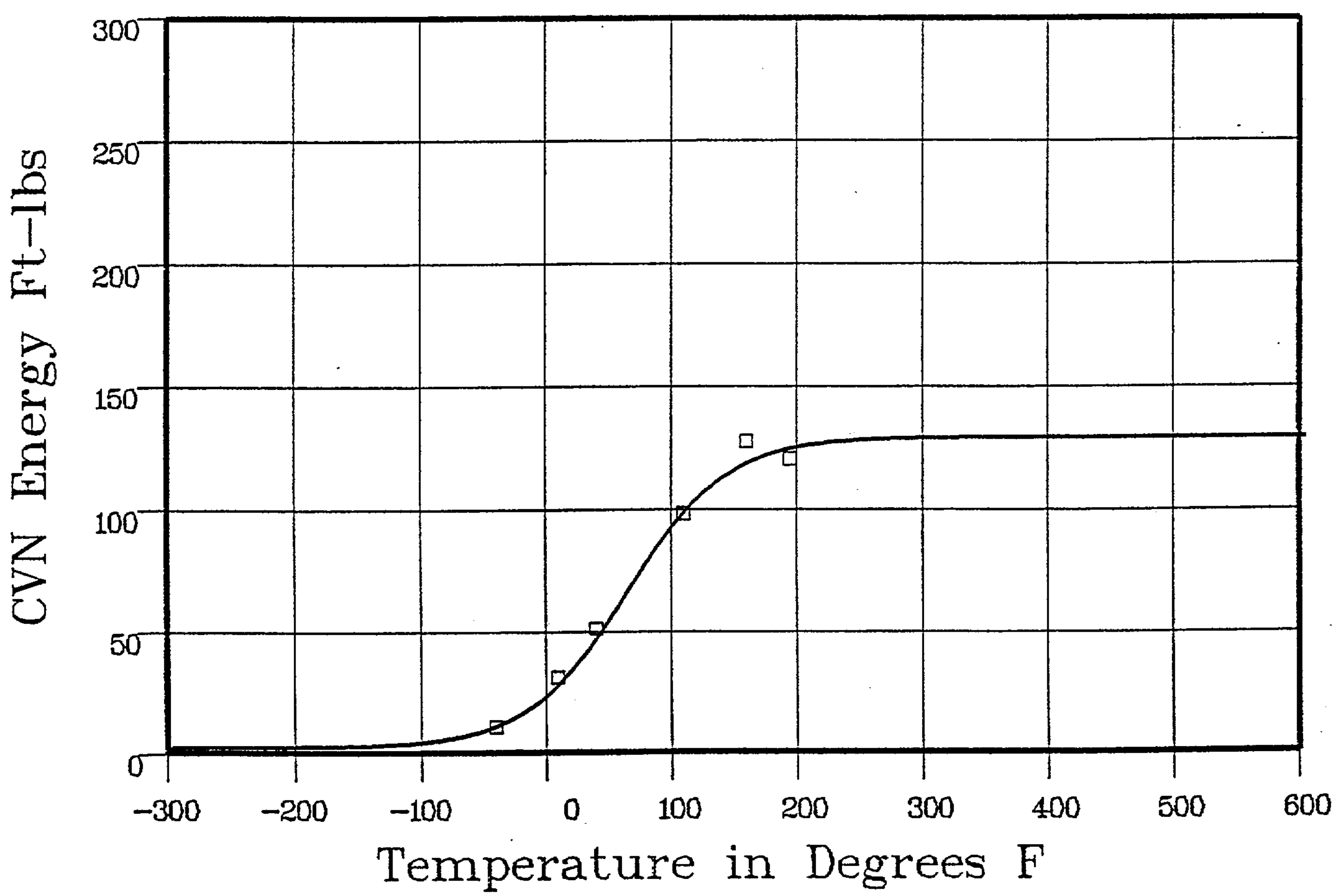
A = 65.44	B = 63.44	C = 79.29	T0 = 59.53

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

Upper Shelf Energy: 128.89 Temp. at 30 ft-lbs: 9.5 Temp. at 50 ft-lbs: 39.8 Lower Shelf Energy: 2 Fixed

Material: PLATE SA533B1 Heat Number: C-2957-2 (G-3109-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2957-2 (G-3109-2)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	10	11.53	-1.53
10	31	30.27	.72
40	51	50.12	.87
110	98	101.13	-3.13
160	127	119.56	7.43
195	120	124.86	-4.86

SUM of RESIDUALS = -5

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:44:48 on 06-27-2000

Page 1

Coefficients of Curve 1

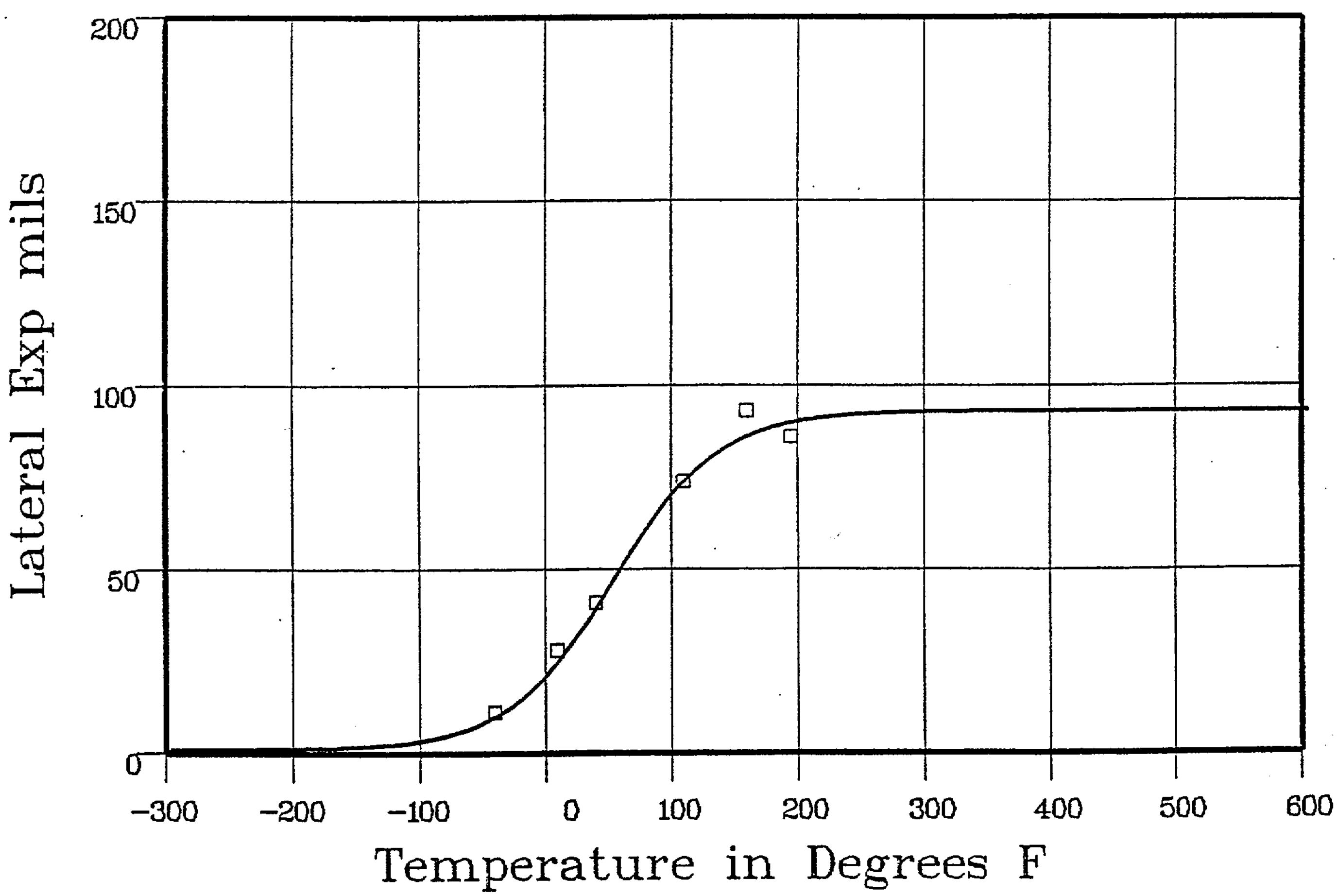
A = 47.01	B = 46.01	C = 83.65	T0 = 49.13

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

Upper Shelf L.E.: 93.02 Temperature at L.E. 35: 26.7 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2957-2 (G-3109-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2957-2 (G-3109-2)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	11	10.76	.23
10	28	26.93	1.06
40	41	42.01	-1.01
110	74	75.61	-1.61
160	93	86.95	6.04
195	86	90.29	-4.29

SUM of RESIDUALS = .42

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-2957-1 (G-3109-1)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	7.00	7.00	0.00		0.00
2	10.00	33.00	29.00	0.00		0.00
3	40.00	50.00	42.00	0.00		0.00
4	110.00	102.00	78.00	0.00		0.00
5	160.00	120.00	86.00	0.00		0.00
6	195.00	111.00	87.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:39:18 on 06-27-2000

Page 1

Coefficients of Curve 1

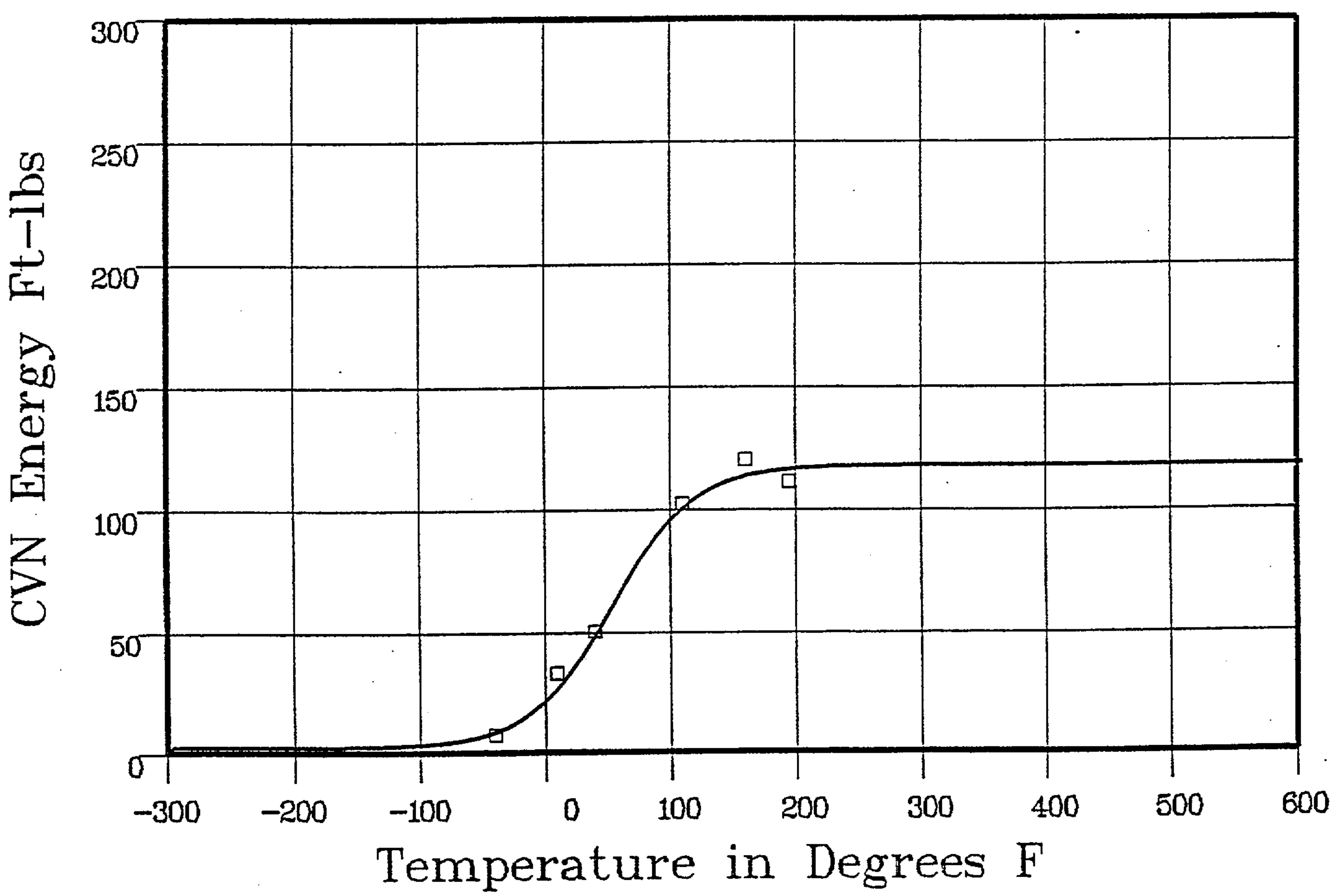
A = 59.85	B = 57.85	C = 65.46	T0 = 48.28

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

Upper Shelf Energy: 117.7 Temp. at 30 ft-lbs: 10.9 Temp. at 50 ft-lbs: 37 Lower Shelf Energy: 2 Fixed

Material: PLATE SA533B1 Heat Number: C-2957-1 (G-3109-1) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap: Material: PLATE SA533B1 Ori.: LT Heat #: C-2957-1 (G-3109-1)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	7	9.3	-2.3
10	33	29.41	3.58
40	50	52.57	-2.57
110	102	102.45	-.45
160	120	114.01	5.98
195	111	116.4	-5.4

SUM of RESIDUALS = -1.16

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:40:04 on 06-27-2000

Page 1

Coefficients of Curve 1

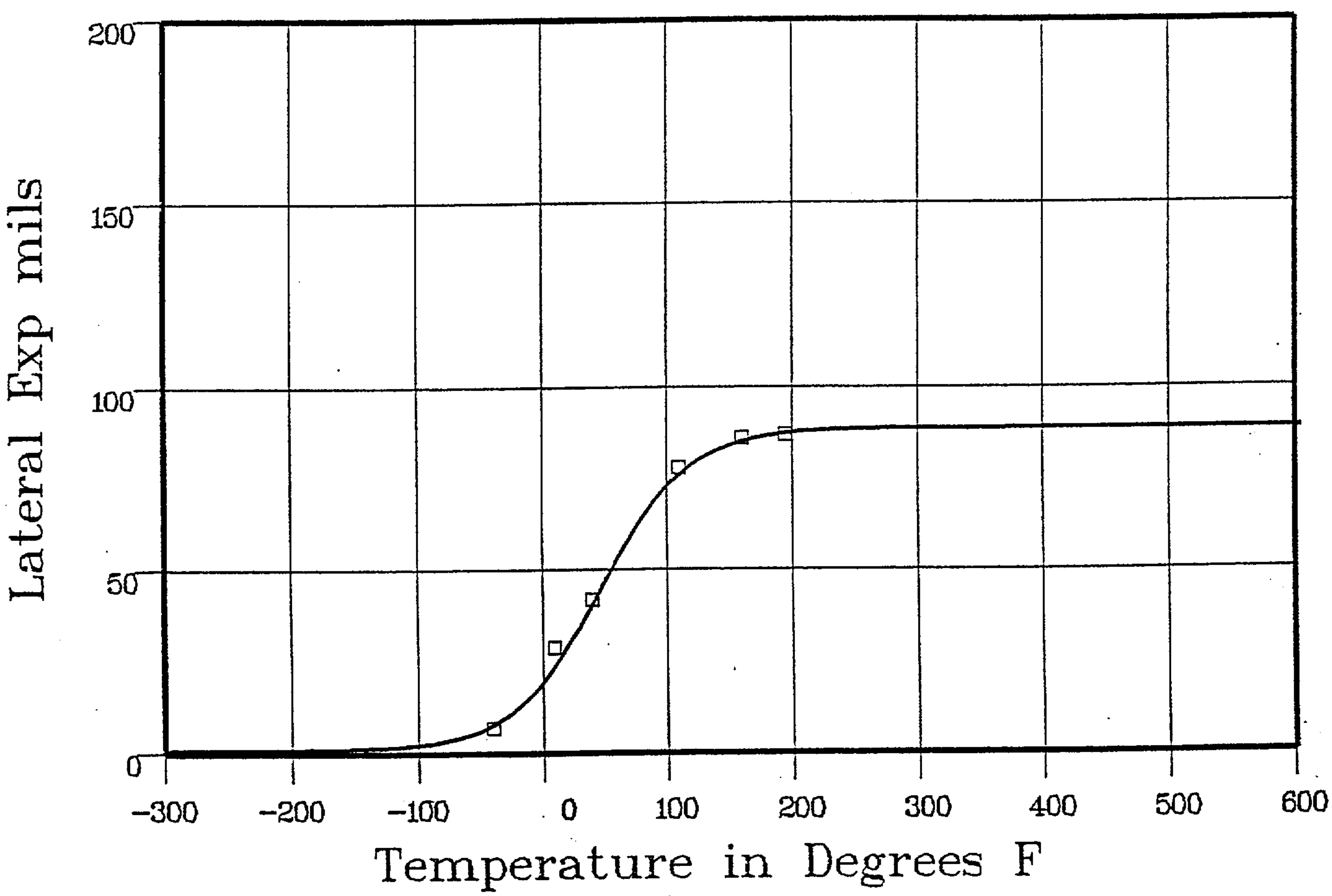
A = 44.85	B = 43.85	C = 70.56	T0 = 41.71

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

Upper Shelf L.E.: 88.7 Temperature at L.E. 35: 25.5 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2957-1 (G-3109-1) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2957-1 (G-3109-1)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	7	8.87	-1.87
10	29	26.36	2.63
40	42	43.78	-1.78
110	78	77.63	.36
160	86	85.73	.26
195	87	87.57	-.57

SUM of RESIDUALS = -.97

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1
CAPSULE ID :
PRODUCT CODE : PLATE
MATERIAL ID : SA533B1
ORIENTATION : LT Lateral-Transverse
HEAT NO : C-2973-1 (G-3109-3)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	12.00	12.00	0.00		0.00
2	10.00	32.00	28.00	0.00		0.00
3	40.00	52.00	43.00	0.00		0.00
4	110.00	102.00	78.00	0.00		0.00
5	160.00	112.00	86.00	0.00		0.00
6	195.00	110.00	85.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:48:55 on 06-27-2000

Page 1

Coefficients of Curve 1

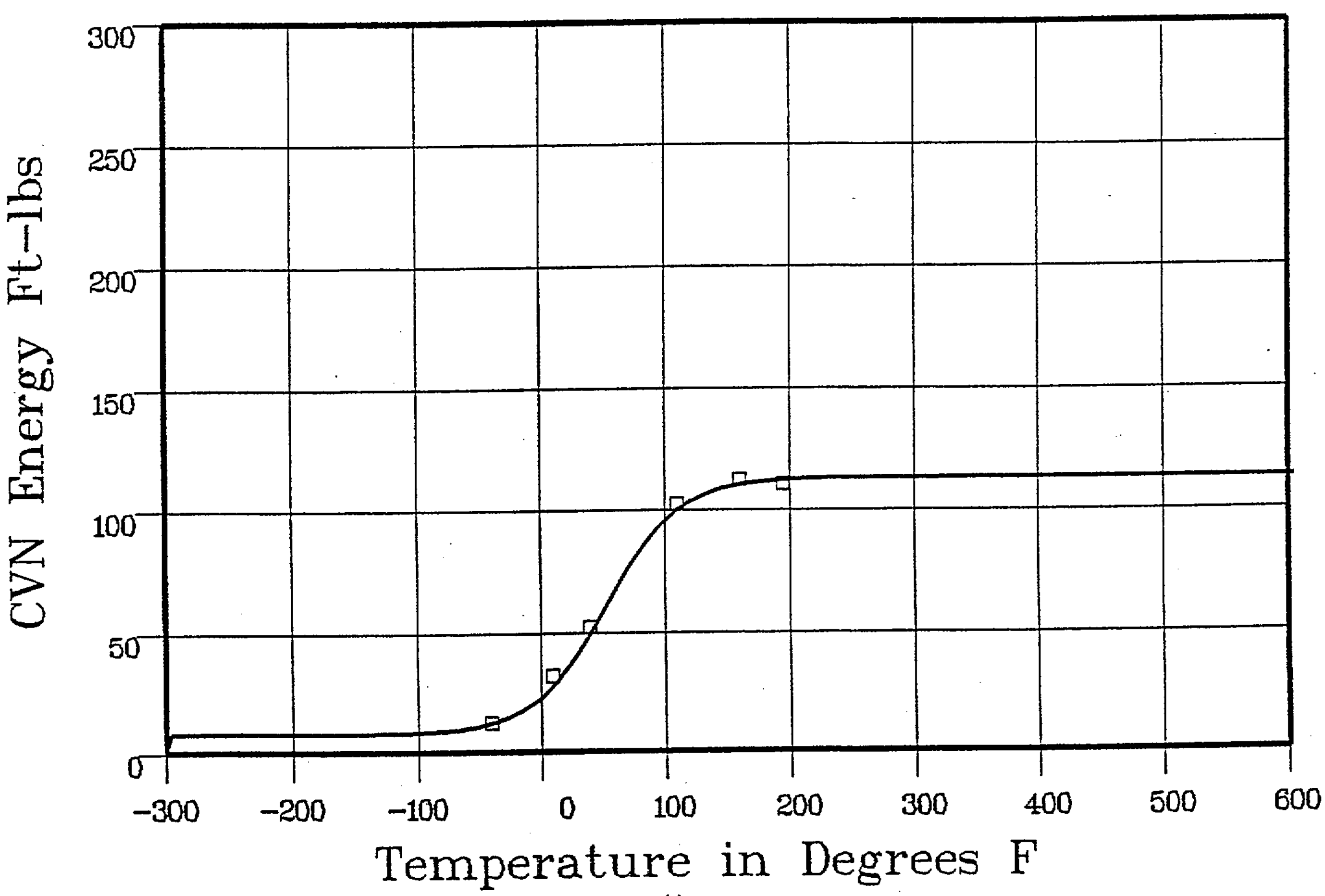
A = 60.05	B = 52.49	C = 58.57	T0 = 47.5

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

Upper Shelf Energy: 112.54 Temp. at 30 ft-lbs: 9.3 Temp. at 50 ft-lbs: 36.1 Lower Shelf Energy: 7.56

Material: PLATE SA533B1 Heat Number: C-2973-1 (G-3109-3) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap: Material: PLATE SA533B1 Ori.: LT Heat #: C-2973-1 (G-3109-3)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	12	12.59	-.59
10	32	30.39	1.6
40	52	53.36	-1.36
110	102	101.43	.56
160	112	110.33	1.66
195	110	111.86	-1.86

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:49:35 on 06-27-2000

Page 1

Coefficients of Curve 1

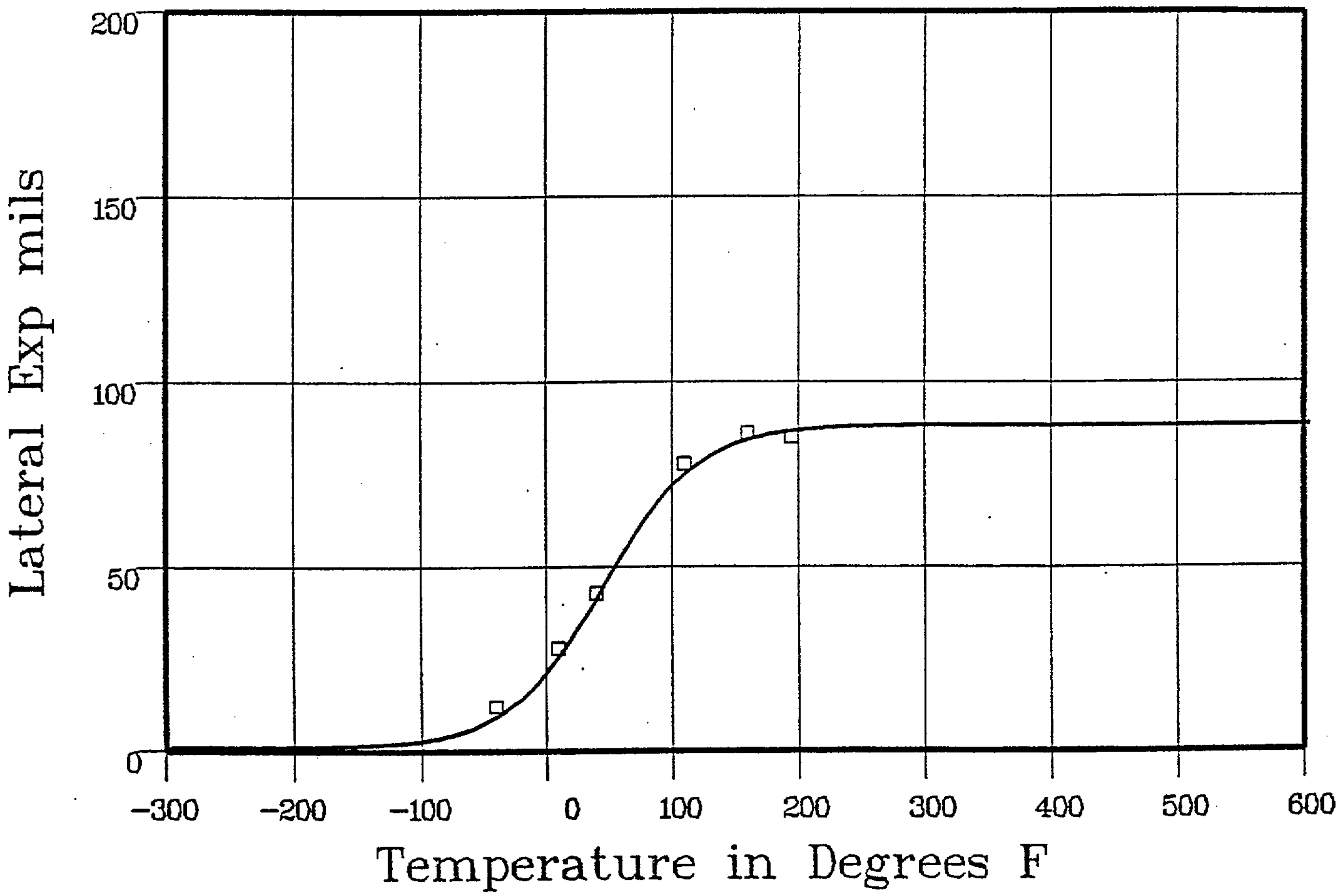
A = 44.66	B = 43.66	C = 74.95	T0 = 40.31

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

Upper Shelf L.E.: 88.33 Temperature at L.E. 35: 23.4 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2973-1 (G-3109-3) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap: Material: PLATE SA533B1 Ori: LT Heat #: C-2973-1 (G-3109-3)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	12	10.16	1.83
10	28	27.91	.08
40	43	44.48	-1.48
110	78	76.56	1.43
160	86	84.89	1.1
195	85	86.95	-1.95

SUM of RESIDUALS = 1.01

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-2973-2 (G-3109-5)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	13.00	14.00	0.00		0.00
2	10.00	39.00	31.00	0.00		0.00
3	40.00	49.00	39.00	0.00		0.00
4	110.00	96.00	71.00	0.00		0.00
5	160.00	121.00	75.00	0.00		0.00
6	212.00	122.00	89.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:54:15 on 06-27-2000

Page 1

Coefficients of Curve 1

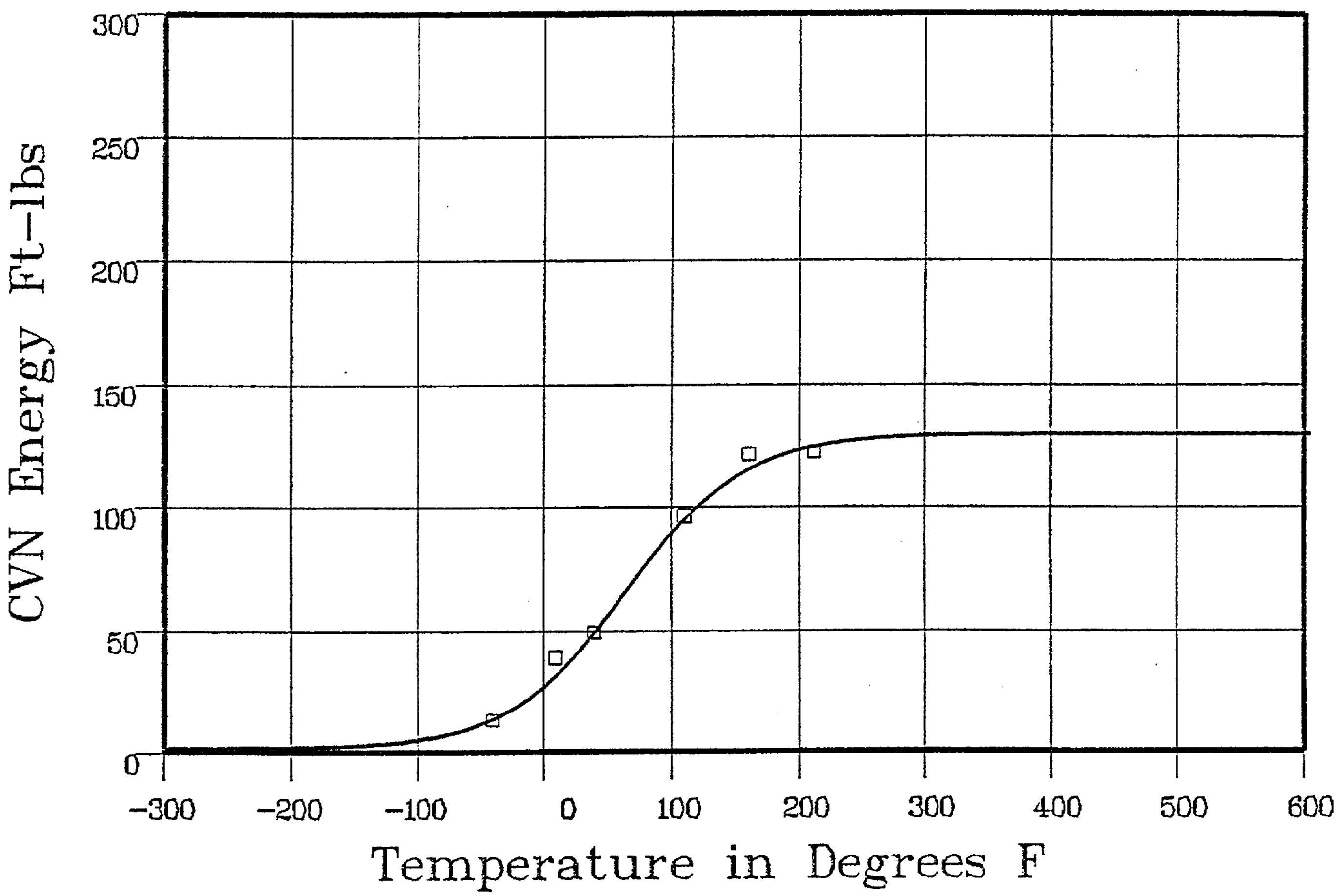
A = 65.31	B = 64.06	C = 92.47	T0 = 59

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

Upper Shelf Energy: 129.37 Temp. at 30 ft-lbs: 1.6 Temp. at 50 ft-lbs: 36.4 Lower Shelf Energy: 1.25

Material: PLATE SA533B1 Heat Number: C-2973-2 (G-3109-5) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap: Material: PLATE SA533B1 Ori: LT Heat #: C-2973-2 (G-3109-5)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	13	14.72	-1.72
10	39	34.22	4.77
40	49	52.33	-3.33
110	96	97.44	-1.44
160	121	116.41	4.58
212	122	124.85	-2.85

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:54:56 on 06-27-2000

Page 1

Coefficients of Curve 1

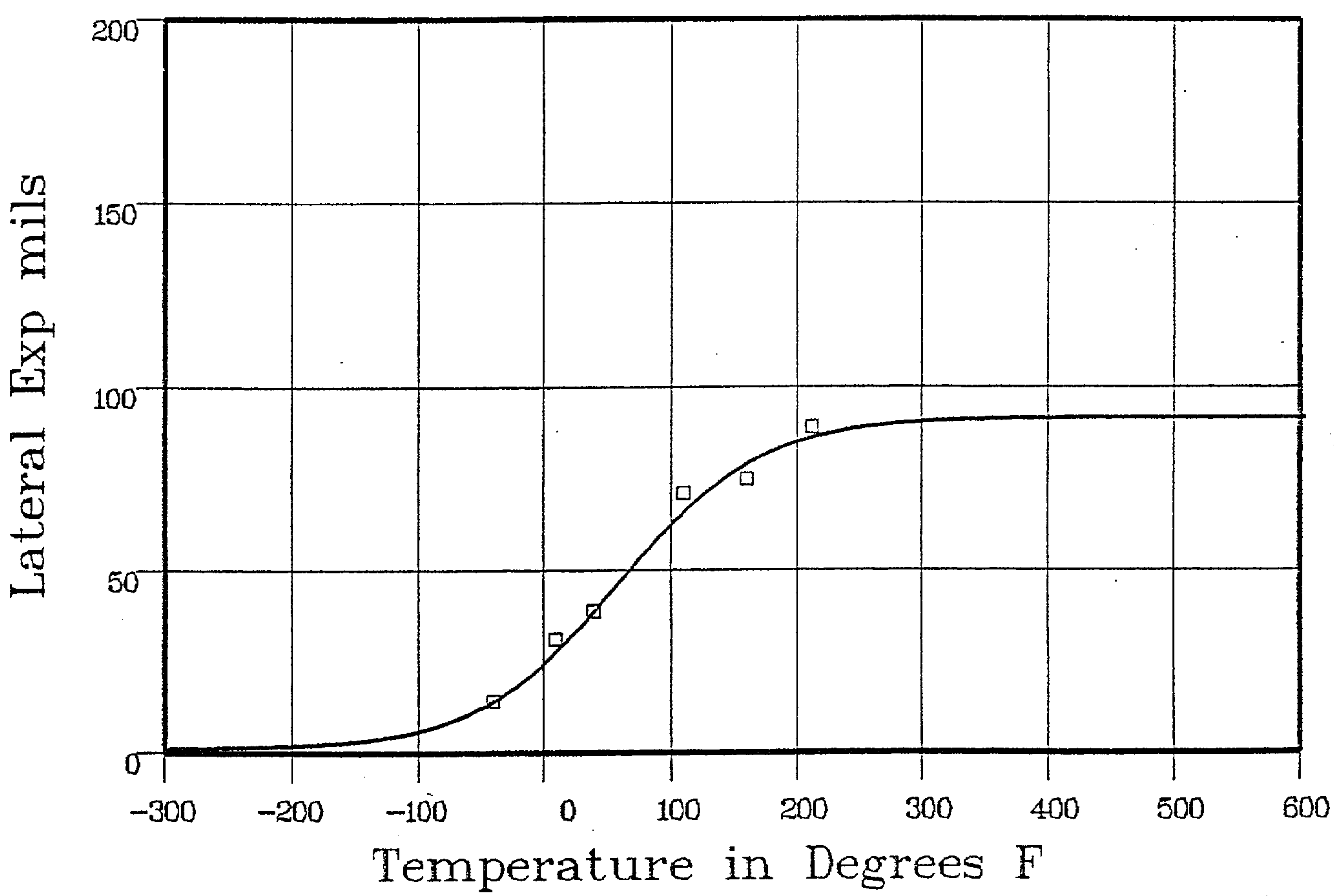
A = 46.27	B = 45.27	C = 110.47	T0 = 53.43

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

Upper Shelf L.E.: 91.55 Temperature at L.E. 35: 25.3 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2973-2 (G-3109-5) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2973-2 (G-3109-5)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	14	15.08	-1.08
10	31	29.33	1.66
40	39	40.79	-1.79
110	71	67.62	3.37
160	75	80.06	-5.06
212	89	86.69	2.3

SUM of RESIDUALS = -.6

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-3301-2 (G-3109-6)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	16.00	15.00	0.00		0.00
2	10.00	32.00	25.00	0.00		0.00
3	40.00	52.00	43.00	0.00		0.00
4	110.00	108.00	83.00	0.00		0.00
5	160.00	127.00	87.00	0.00		0.00
6	210.00	133.00	80.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:58:31 on 06-27-2000

Page 1

Coefficients of Curve 1

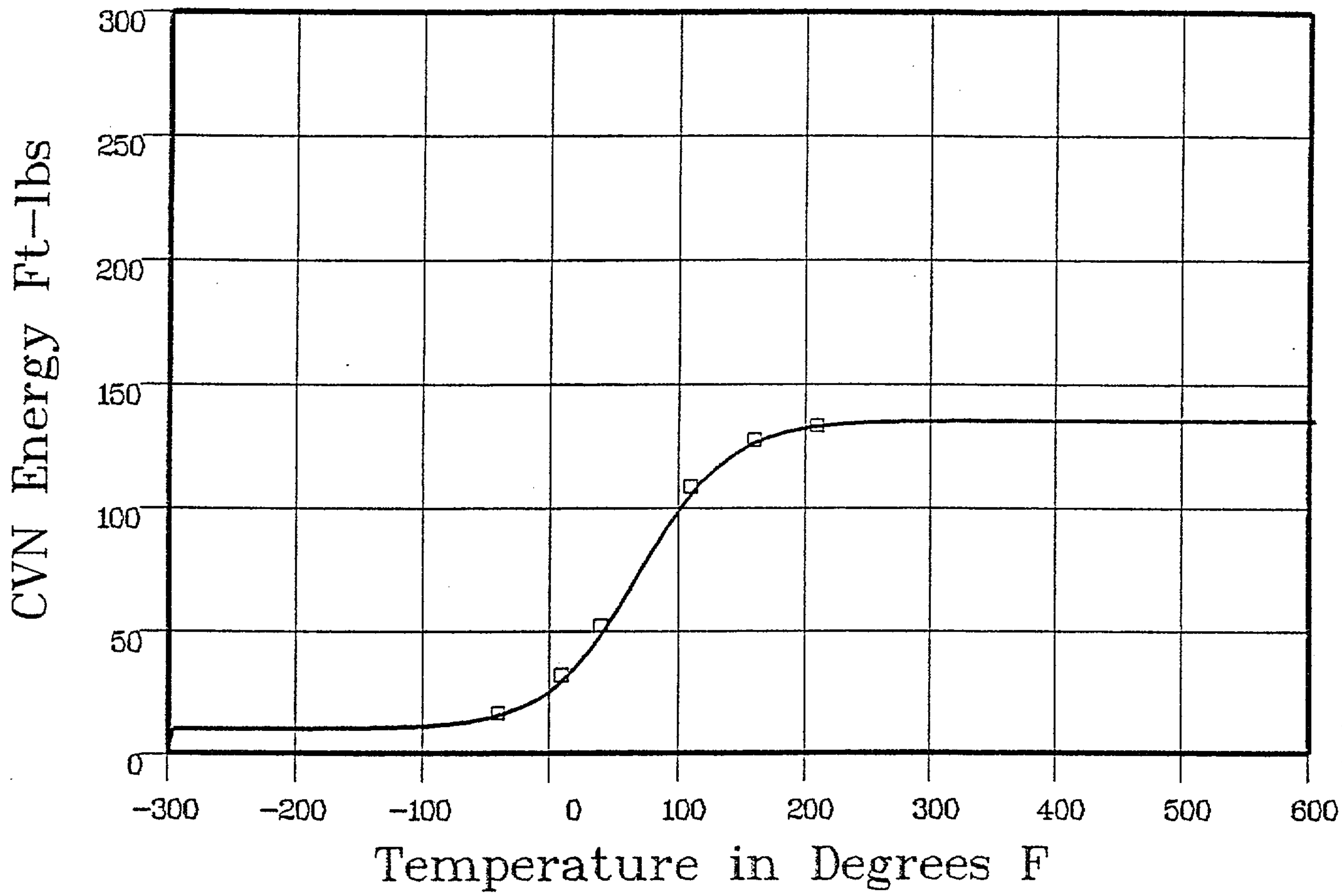
A = 72.29	B = 62.63	C = 70.95	T0 = 64.01

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

Upper Shelf Energy: 134.93 Temp. at 30 ft-lbs: 5.8 Temp. at 50 ft-lbs: 37.6 Lower Shelf Energy: 9.66

Material: PLATE SA533B1 Heat Number: C-3301-2 (G-3109-6) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-3301-2 (G-3109-6)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	16	15.99	0
10	32	32.09	-.09
40	52	51.87	.12
110	108	108.02	-.02
160	127	127.08	-.08
210	133	132.92	.07

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:59:16 on 06-27-2000

Page 1

Coefficients of Curve 1

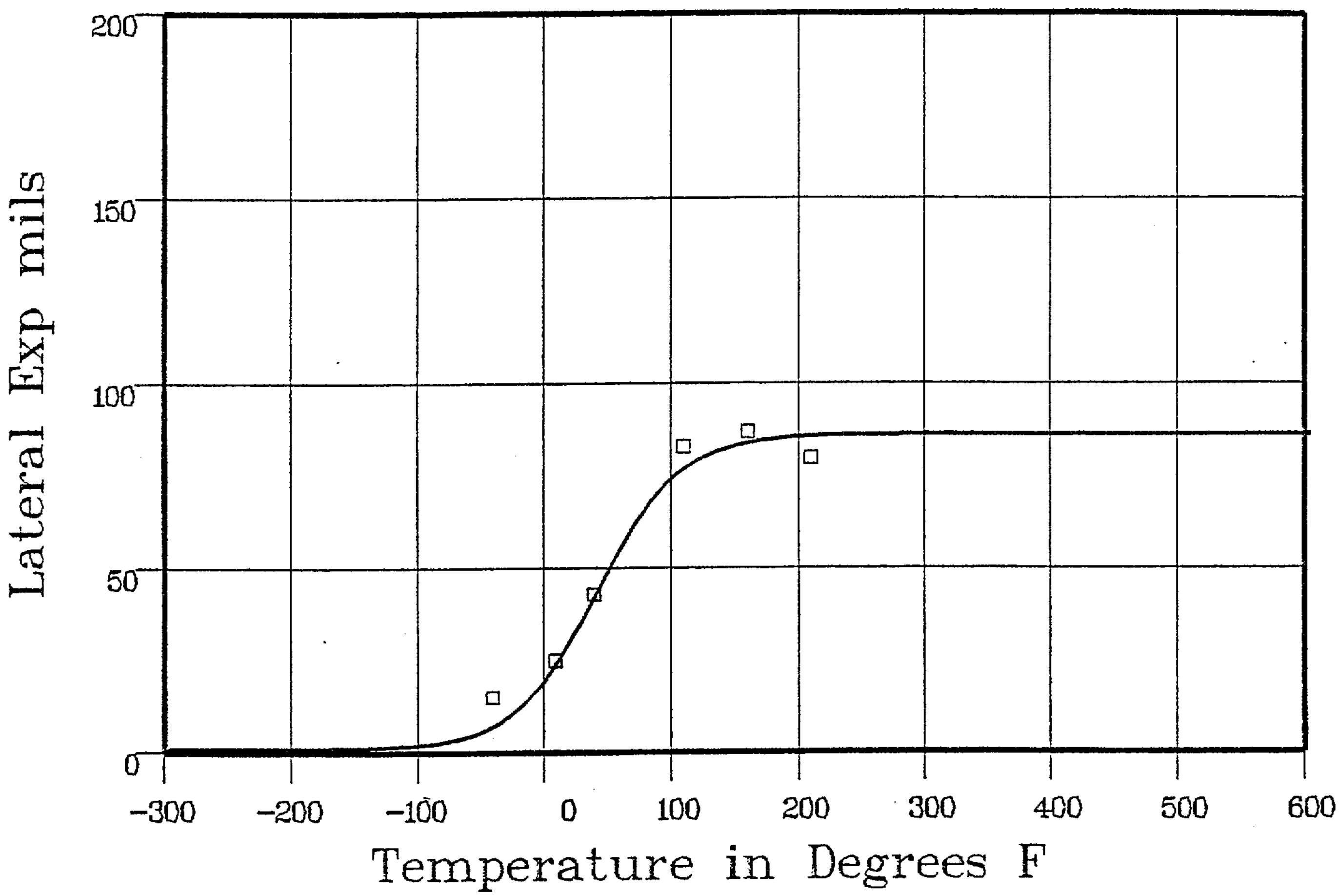
A = 43.6	B = 42.6	C = 63.99	T0 = 37.2

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

Upper Shelf L.E.: 86.21 Temperature at L.E. 35: 24 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-3301-2 (G-3109-6) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-3301-2 (G-3109-6)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	15	8	6.99
10	25	26.51	-1.51
40	43	45.46	-2.46
110	83	78.27	4.72
160	87	84.41	2.58
210	80	85.83	-5.83

SUM of RESIDUALS = 4.49

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-2945-2 (G-3108-3)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	14.00	14.00	0.00		0.00
2	10.00	45.00	35.00	0.00		0.00
3	40.00	53.00	38.00	0.00		0.00
4	110.00	114.00	76.00	0.00		0.00
5	160.00	122.00	85.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:34:04 on 06-27-2000

Page 1

Coefficients of Curve 1

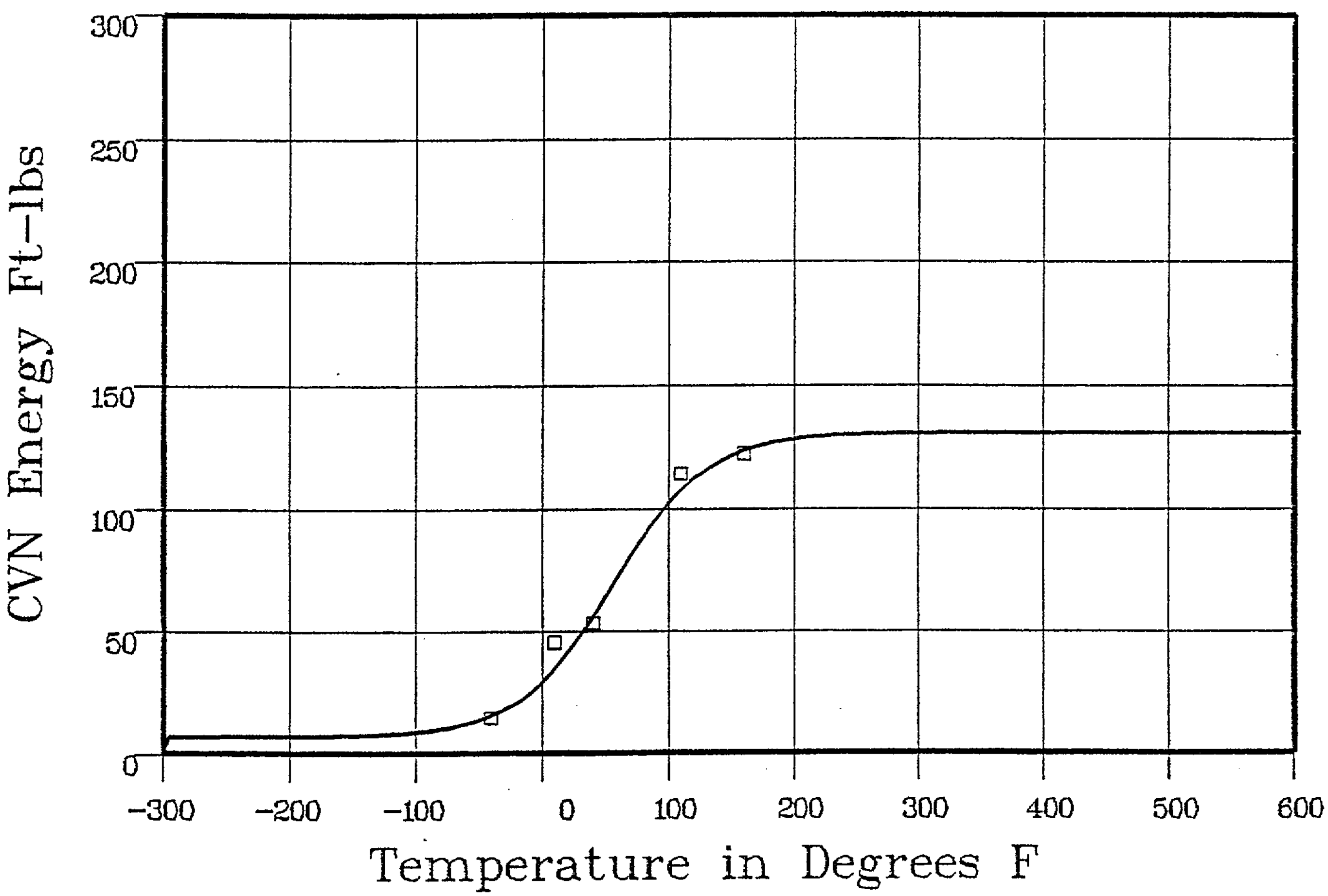
A = 68.39	B = 61.96	C = 73.96	T0 = 50.25

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

Upper Shelf Energy: 130.36 Temp. at 30 ft-lbs: -3.3 Temp. at 50 ft-lbs: 27.6 Lower Shelf Energy: 6.42

Material: PLATE SA533B1 Heat Number: C-2945-2 (G-3108-3) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2945-2 (G-3108-3)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	14	16.36	-2.36
10	45	37.65	7.34
40	53	59.86	-6.86
110	114	109.81	4.18
160	122	124.3	-2.3

SUM of RESIDUALS = 0

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1
CAPSULE ID :
PRODUCT CODE : PLATE
MATERIAL ID : SA533B1
ORIENTATION : LT Lateral-Transverse
HEAT NO : C-2945-1 (G-3108-2)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	13.00	12.00	0.00		0.00
2	10.00	36.00	30.00	0.00		0.00
3	40.00	54.00	42.00	0.00		0.00
4	110.00	108.00	77.00	0.00		0.00
5	160.00	120.00	81.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:13:57 on 06-27-2000

Page 1

Coefficients of Curve 1

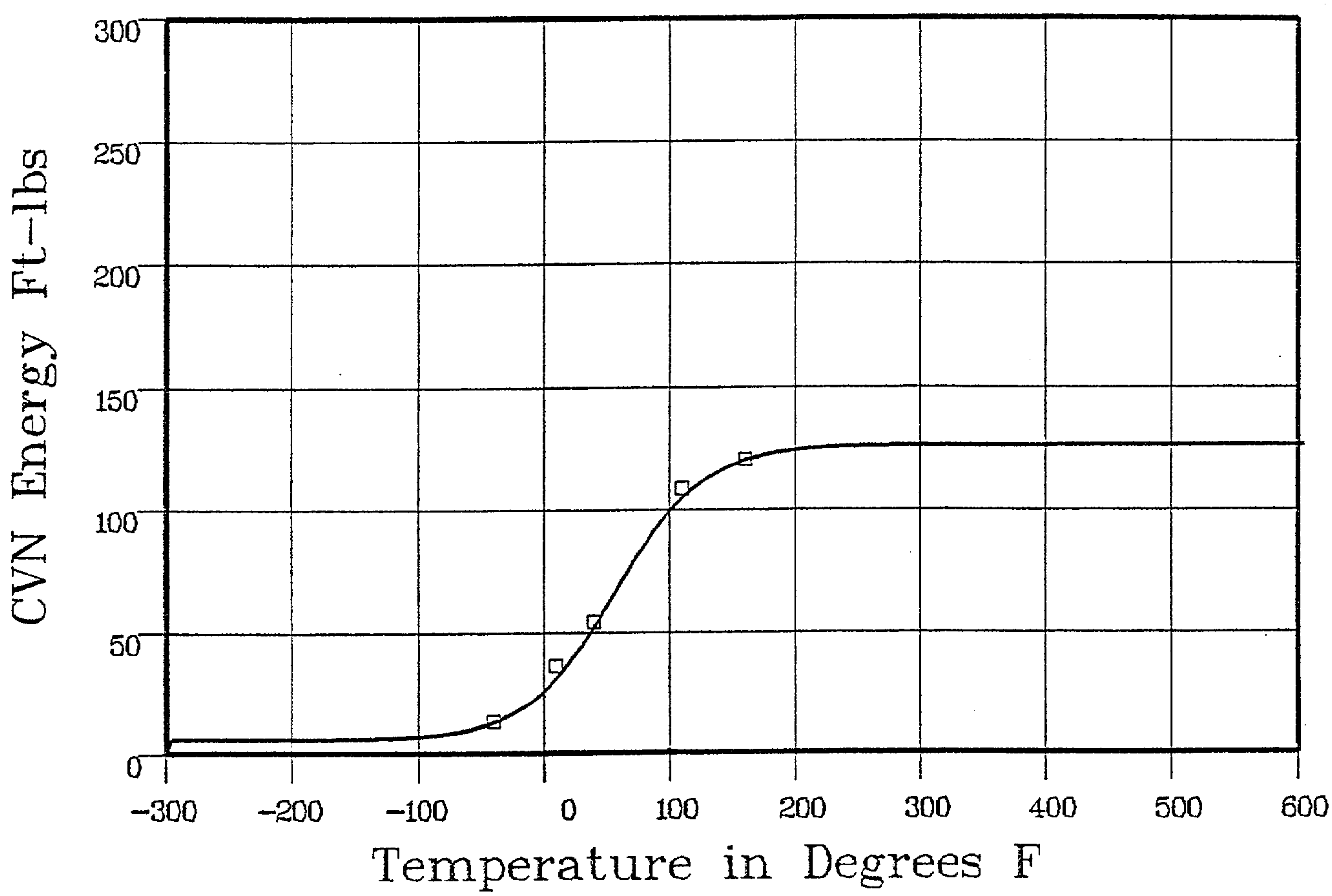
A = 65.72	B = 60.23	C = 70.27	T0 = 51.5

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

Upper Shelf Energy: 125.95 Temp. at 30 ft-lbs: 3.5 Temp. at 50 ft-lbs: 32.7 Lower Shelf Energy: 5.48

Material: PLATE SA533B1 Heat Number: C-2945-1 (G-3108-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2945-1 (G-3108-2)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	13	13.78	-.78
10	36	33.77	2.22
40	54	55.95	-1.95
110	108	106.78	1.21
160	120	120.7	-.7

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:14:58 on 06-27-2000

Page 1

Coefficients of Curve 1

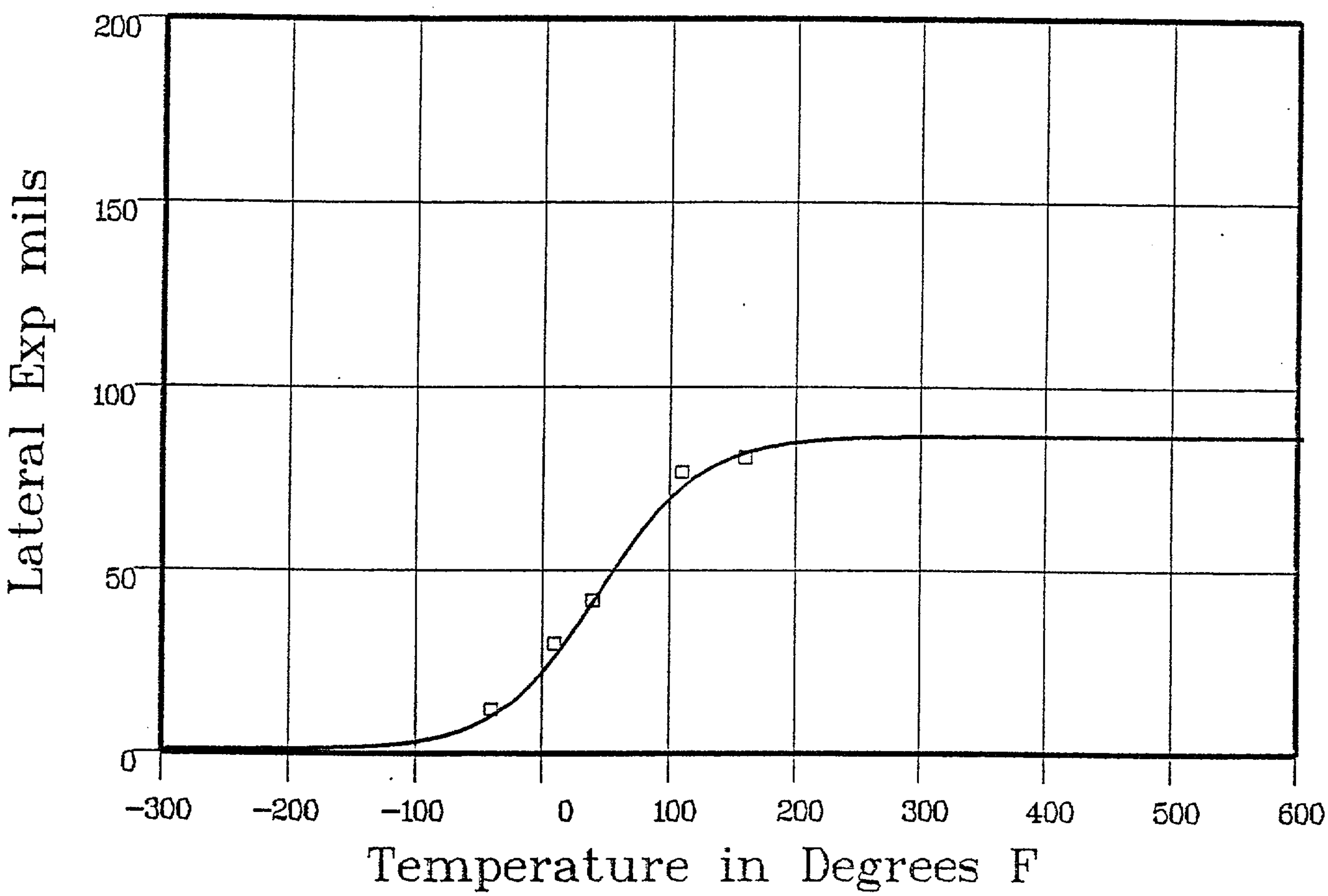
A = 43.86	B = 42.86	C = 79.47	T0 = 39.37

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

Upper Shelf L.E.: 86.72 Temperature at L.E. 35: 22.7 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2945-1 (G-3108-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2945-1 (G-3108-2)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	12	11.24	.75
10	30	28.7	1.29
40	42	44.19	-2.19
110	77	74.32	2.67
160	81	82.79	-1.79

SUM of RESIDUALS = .74

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : A2094-1(G-3107-1)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	18.00	16.00	0.00		0.00
2	10.00	41.00	35.00	0.00		0.00
3	40.00	62.00	48.00	0.00		0.00
4	110.00	113.00	83.00	0.00		0.00
5	160.00	130.00	86.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 17:57:40 on 06-27-2000

Page 1

Coefficients of Curve 1

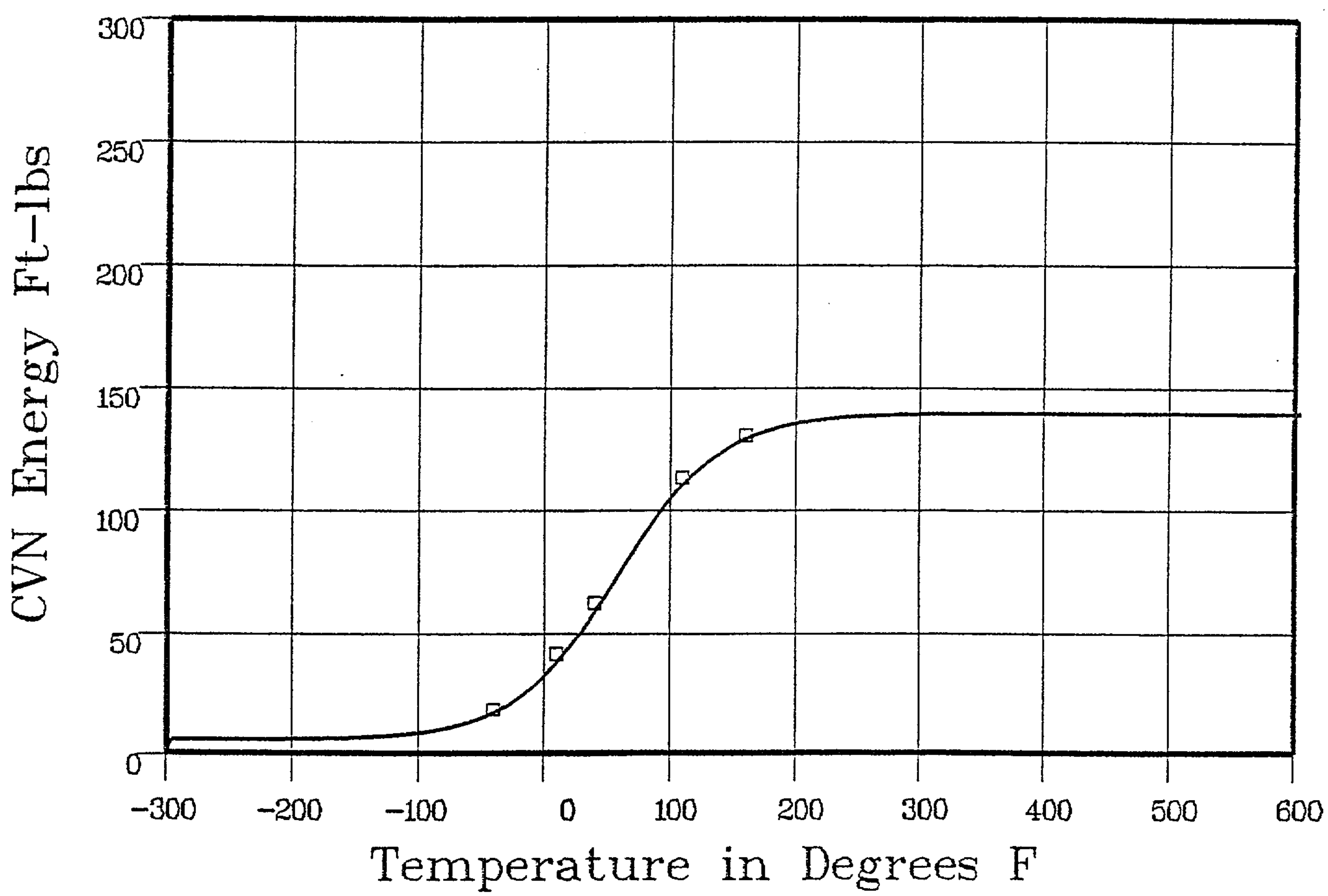
A = 72.24	B = 67.02	C = 82.41	T0 = 52.25

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

Upper Shelf Energy: 139.26 Temp. at 30 ft-lbs: -8.8 Temp. at 50 ft-lbs: 23.8 Lower Shelf Energy: 5.22

Material: PLATE SA533B1 Heat Number: A2094-1(G-3107-1) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: A2094-1(G-3107-1)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	18	18.13	-.13
10	41	40.6	.39
40	62	62.35	-.35
110	113	112.78	.21
160	130	130.12	-.12

SUM of RESIDUALS = 0

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : A-2094-2 (G-3107-2)

COMMENT

MIN DATA EACH TEMPERATURE

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm^2	Capsule Temperature °F
1	-40.00	24.00	19.00	0.00		0.00
2	10.00	48.00	40.00	0.00		0.00
3	40.00	75.00	56.00	0.00		0.00
4	110.00	104.00	78.00	0.00		0.00
5	160.00	122.00	88.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 18:02:29 on 06-27-2000

Page 1

Coefficients of Curve 1

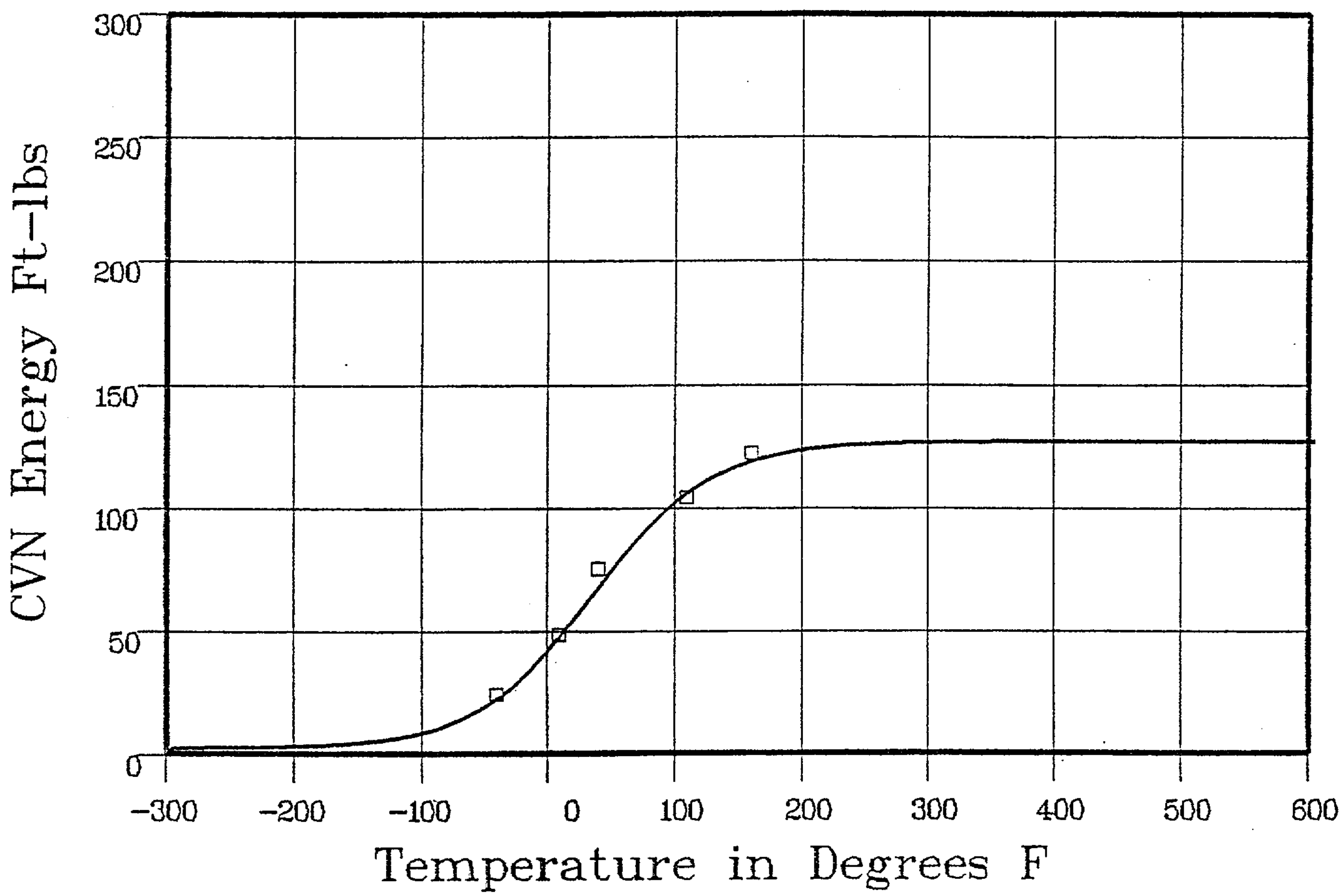
A = 64.42	B = 62.42	C = 92.33	T0 = 30.93

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

Upper Shelf Energy: 126.85 Temp. at 30 ft-lbs: -26.3 Temp. at 50 ft-lbs: 9.2 Lower Shelf Energy: 2 Fixed

Material: PLATE SA533B1 Heat Number: A-2094-2 (G-3107-2) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap: Material: PLATE SA533B1 Ori.: LT Heat #: A-2094-2 (G-3107-2)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	24	24.1	-.1
10	48	50.5	-2.5
40	75	70.53	4.46
110	104	107.77	-3.77
160	122	119.66	2.33

SUM of RESIDUALS = .41

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-2906-1 (G-3107-3)

COMMENT

MIN POINTS EACH TEMPERATURE

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	12.00	12.00	0.00		0.00
2	10.00	27.00	24.00	0.00		0.00
3	40.00	78.00	55.00	0.00		0.00
4	110.00	115.00	82.00	0.00		0.00
5	160.00	134.00	89.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:37:22 on 06-28-2000

Page 1

Coefficients of Curve 1

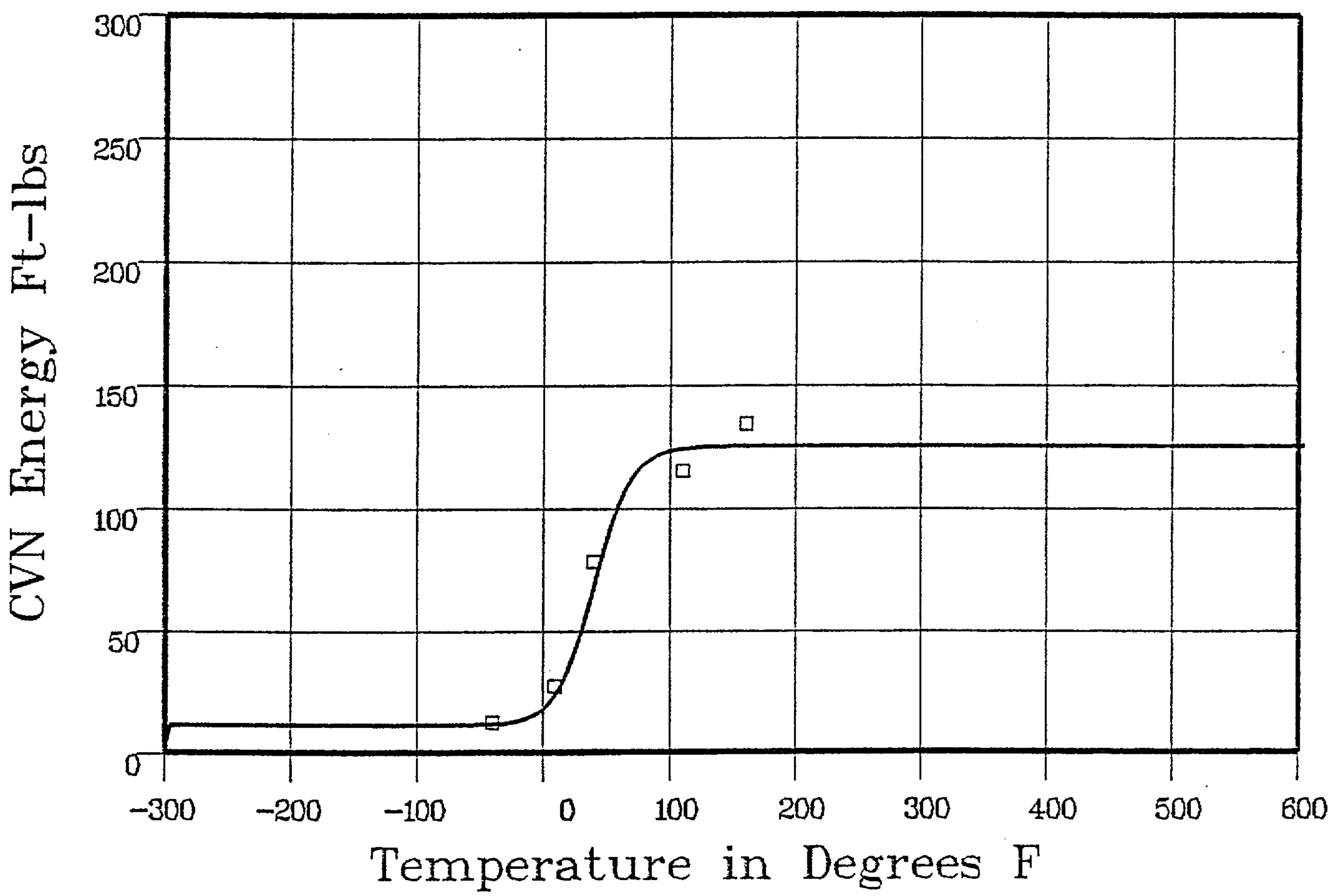
A = 67.95	B = 57.07	C = 29	T0 = 35.25

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

Upper Shelf Energy: 125.02 Temp. at 30 ft-lbs: 12 Temp. at 50 ft-lbs: 25.8 Lower Shelf Energy: 10.87

Material: PLATE SA533B1 Heat Number: C-2906-1 (G-3107-3) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2906-1 (G-3107-3)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	12	11.5	.49
10	27	27.9	-.9
40	78	77.21	.78
110	115	124.37	-9.37
160	134	125	8.99

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:38:50 on 06-28-2000

Page 1

Coefficients of Curve 1

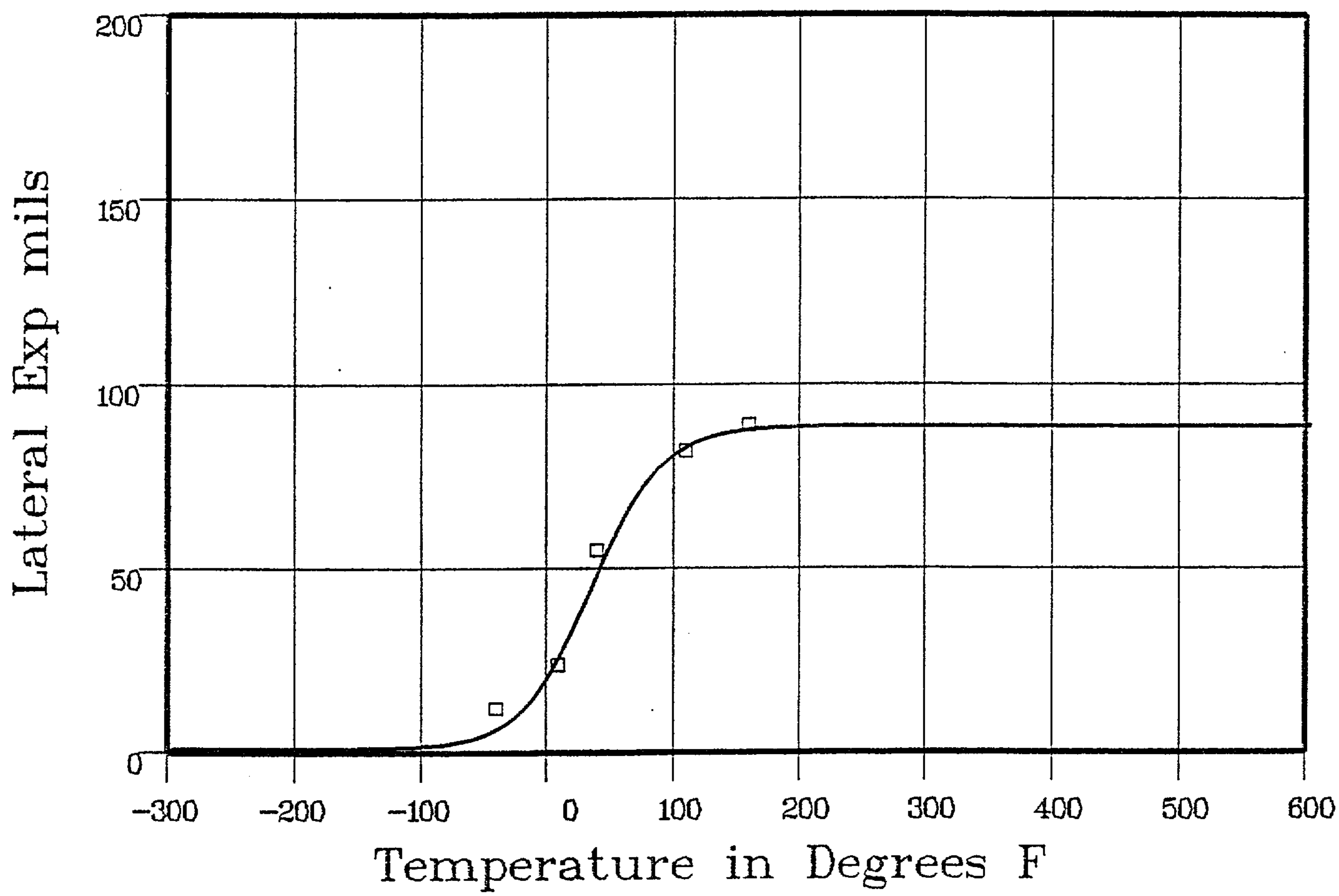
A = 44.83	B = 43.83	C = 55	T0 = 30.93

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

Upper Shelf L.E.: 88.67 Temperature at L.E. 35: 18.3 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2906-1 (G-3107-3) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2906-1 (G-3107-3)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	12	7.18	4.81
10	24	28.91	-4.91
40	55	51.99	3
110	82	83.98	-1.98
160	89	87.87	1.12

SUM of RESIDUALS = 2.04

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : FORGING

MATERIAL ID : SA508CL2

ORIENTATION : LT Lateral-Transverse

HEAT NO : 2V-545 (G-3101)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	10.00	36.00	34.00	0.00		0.00
2	-70.00	5.00	3.00	0.00		0.00
3	-40.00	26.00	21.00	0.00		0.00
4	70.00	103.00	72.00	0.00		0.00
5	100.00	125.00	41.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:37:55 on 06-28-2000

Page 1

Coefficients of Curve 1

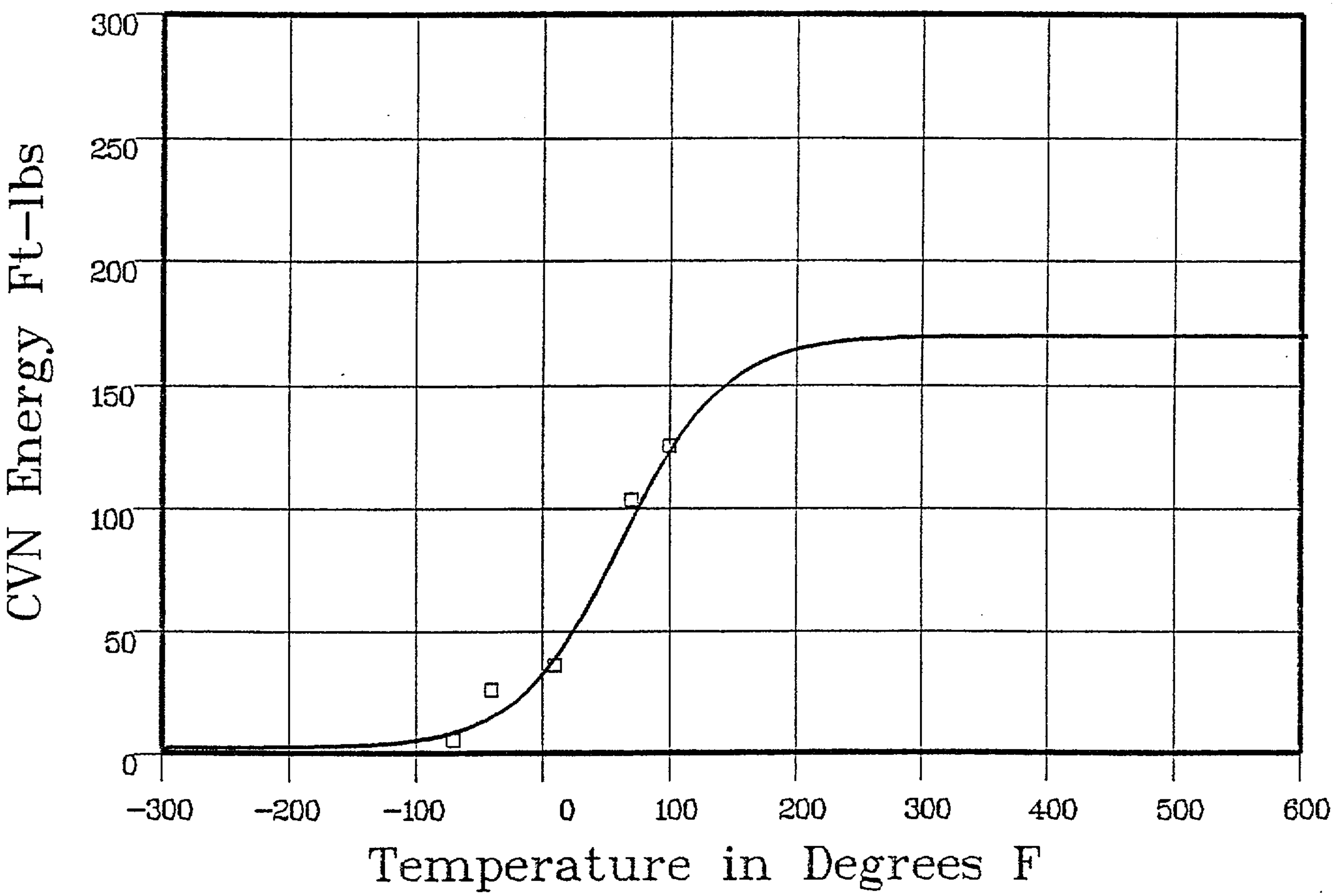
A = 85.78	B = 83.78	C = 81.13	T0 = 56.68

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

Upper Shelf Energy: 169.57 Temp. at 30 ft-lbs: -8.4 Temp. at 50 ft-lbs: 19.6 Lower Shelf Energy: 2 Fixed

Material: FORGING SA508CL2 Heat Number: 2V-545 (G-3101) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: FORGING SA508CL2 Ori.: LT Heat #: 2V-545 (G-3101)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-70	5	9.06	-4.06
-40	26	16.15	9.84
10	36	42.27	-6.27
70	103	99.41	3.58
100	125	126.7	-1.7

SUM of RESIDUALS = 1.39

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:38:54 on 06-28-2000

Page 1

Coefficients of Curve 1

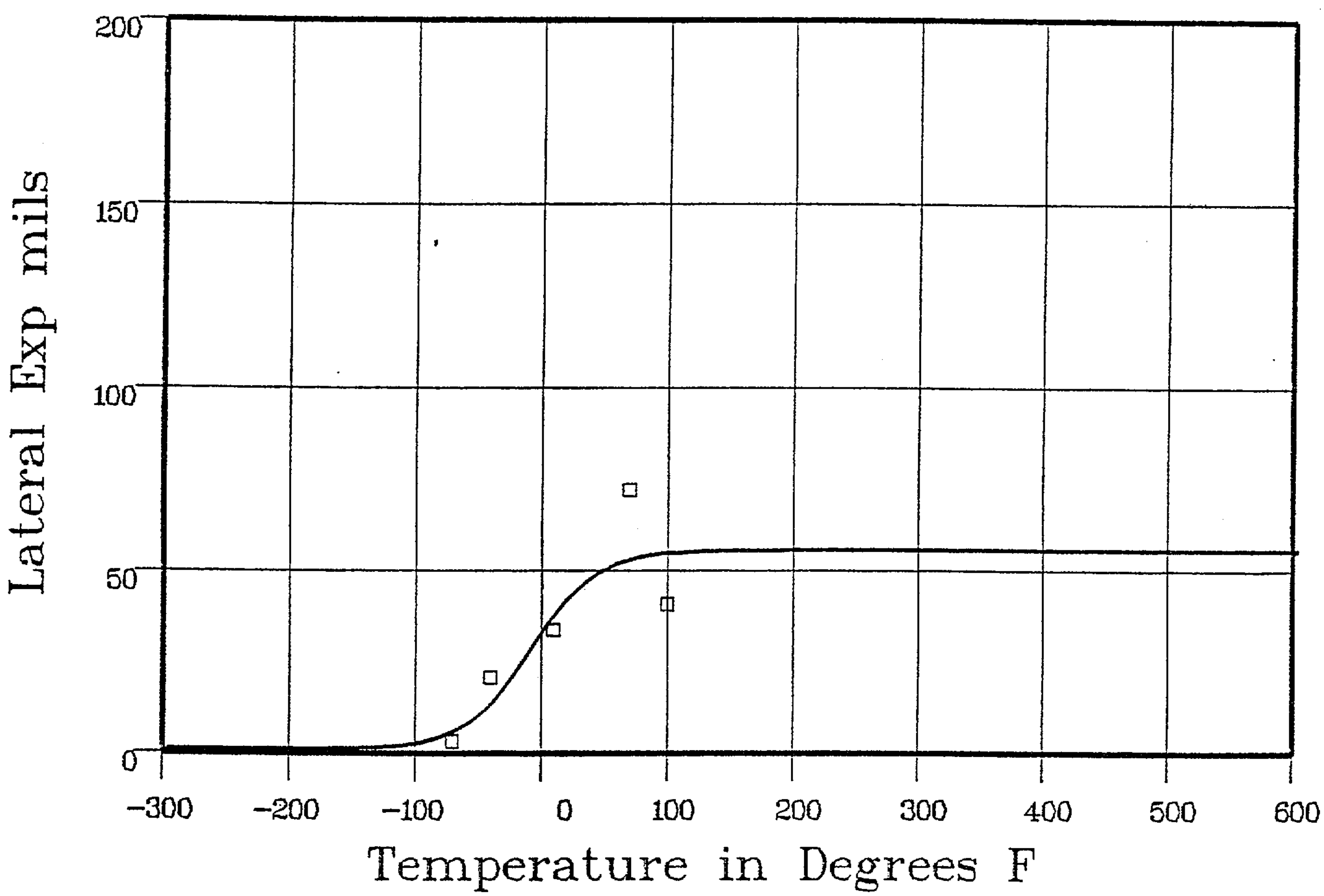
A = 28.4	B = 27.4	C = 52.26	T0 = -13.59

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

Upper Shelf L.E.: 55.8 Temperature at L.E. 35: -.7 Lower Shelf L.E.: 1 Fixed

Material: FORGING SA508CL2 Heat Number: 2V-545 (G-3101) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: FORGING SA508CL2 Ori.: LT Heat #: 2V-545 (G-3101)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-70	3	6.67	-3.67
-40	21	15.62	5.37
10	34	39.99	-5.99
70	72	53.65	18.34
100	41	55.1	-14.1

SUM of RESIDUALS = -.05

CHARPY V-NOTCH DATA REPORT

PLANT : PL1 PILGRIM UNIT 1

CAPSULE ID :

PRODUCT CODE : PLATE

MATERIAL ID : SA533B1

ORIENTATION : LT Lateral-Transverse

HEAT NO : C-3982-1 (G-3178-1)

SPECIMEN INFORMATION

Specimen ID	Test Temperature °F	Impact Energy ft-lb	Lateral Expansion mil	% Shear	Fluence n/cm²	Capsule Temperature °F
1	-40.00	16.00	14.00	0.00		0.00
2	10.00	35.00	31.00	0.00		0.00
3	40.00	68.00	50.00	0.00		0.00
4	110.00	103.00	76.00	0.00		0.00
5	160.00	120.00	88.00	0.00		0.00

End of Report

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 19:24:11 on 06-27-2000

Page 1

Coefficients of Curve 1

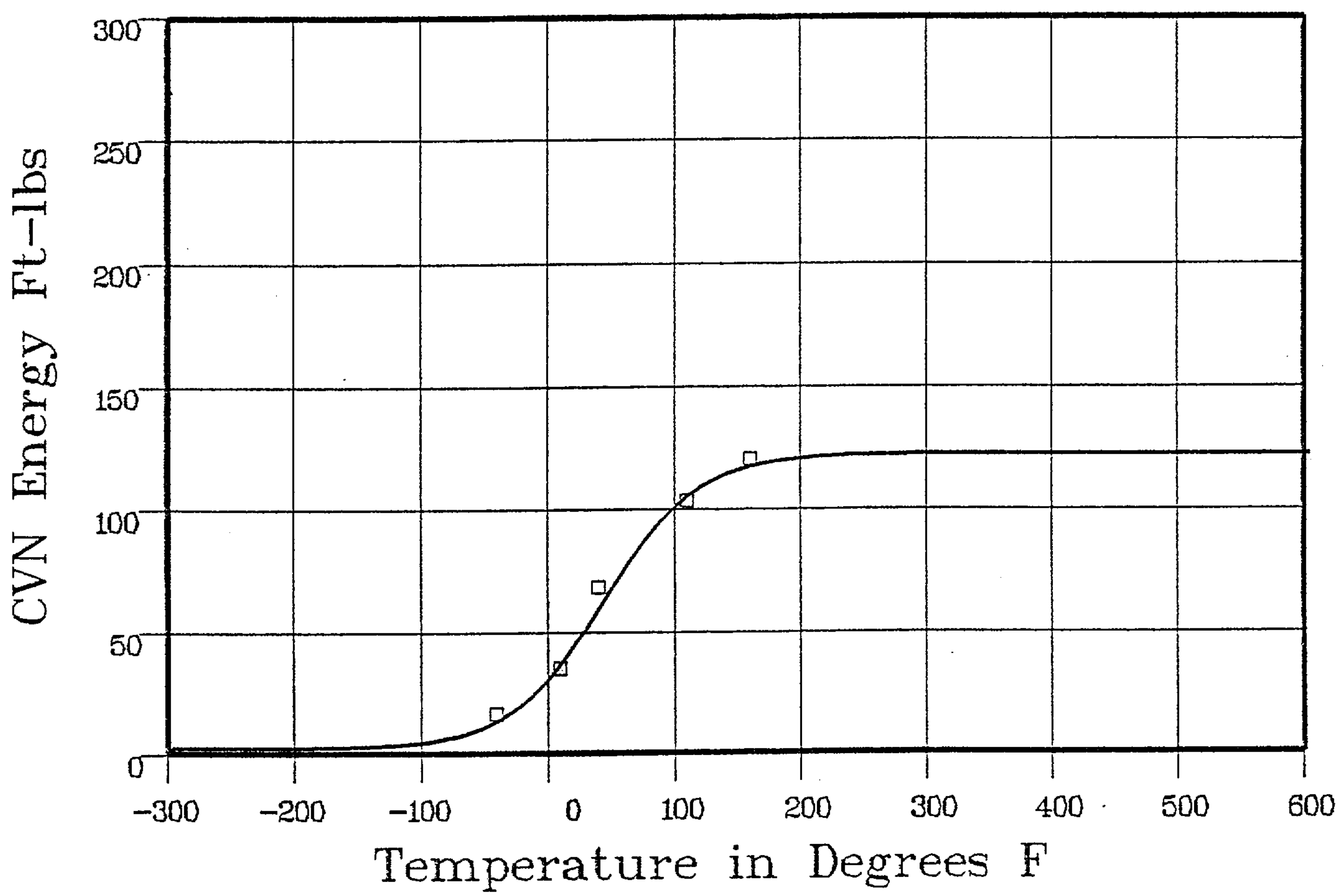
A = 62	B = 60.08	C = 73.87	T0 = 38.75

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

Upper Shelf Energy: 122.09 Temp. at 30 ft-lbs: -5.1 Temp. at 50 ft-lbs: 23.7 Lower Shelf Energy: 1.91

Material: PLATE SA533B1 Heat Number: C-3982-1 (G-3178-1) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-3982-1 (G-3178-1)

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	16	14.65	1.34
10	35	39.73	-4.73
40	68	63.02	4.97
110	103	106.84	-3.84
160	120	117.74	2.25

SUM of RESIDUALS = 0

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 19:24:51 on 06-27-2000

Page 1

Coefficients of Curve 1

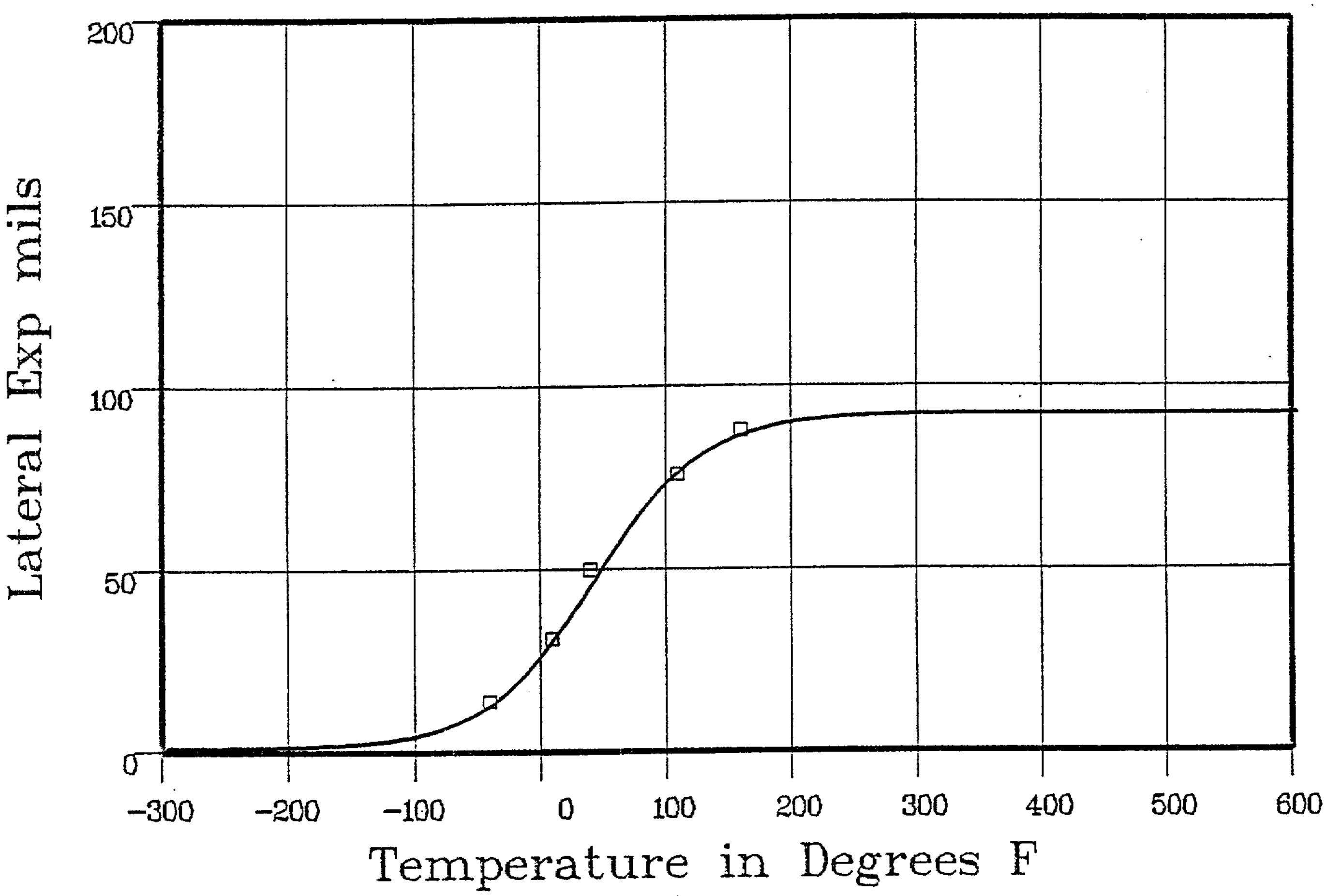
A = 46.68	B = 45.68	C = 86.8	T0 = 37.5

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

Upper Shelf L.E.: 92.36 Temperature at L.E. 35: 14.7 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-3982-1 (G-3178-1) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-3982-1 (G-3178-1)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	14	14.12	-.12
10	31	32.67	-1.67
40	50	47.99	2
110	76	77.89	-1.89
160	88	87.23	.76

SUM of RESIDUALS = -.92

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:09:38 on 06-28-2000

Page 1

Coefficients of Curve 1

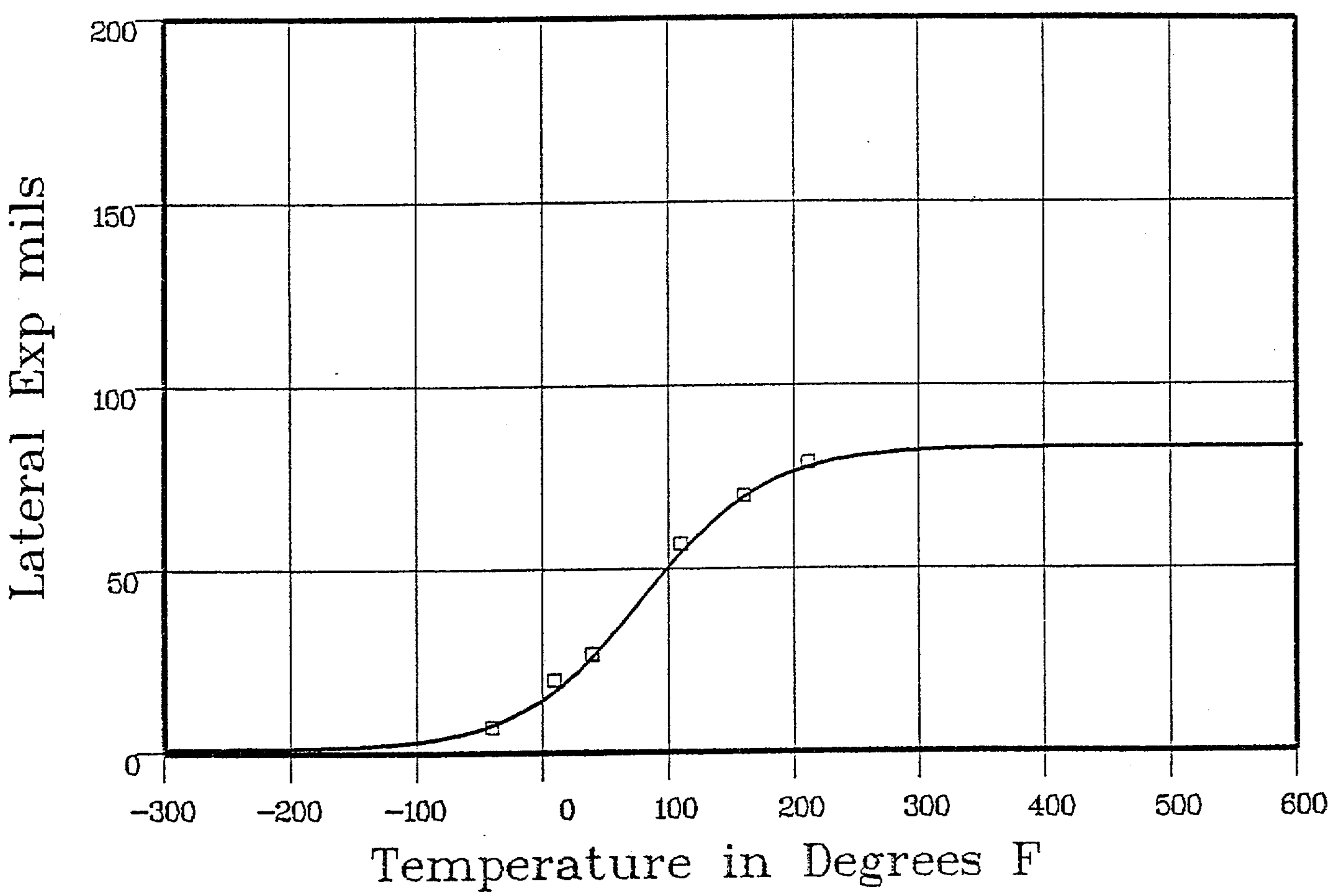
A = 42.03	B = 41.03	C = 98.17	T0 = 74.41

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

Upper Shelf L.E.: 83.07 Temperature at L.E. 35: 57.4 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-2888-3 (G-3114) Orientation: LT

Capsule: Total Fluence:



Data Set(s) Plotted

Plant: PL1 Cap.: Material: PLATE SA533B1 Ori.: LT Heat #: C-2888-3 (G-3114)

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	7	8.27	-1.27
10	20	18.41	1.58
40	27	28.21	-1.21
110	57	56.29	.7
160	70	70.85	-.85
212	79	78.38	.61

SUM of RESIDUALS = -.43