# APPENDIX A

# VALIDATION OF THE RADIATION TRANSPORT MODELS BASED ON NEUTRON DOSIMETRY MEASUREMENTS

## A.1 Neutron Dosimetry

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of measured dosimetry results to both the calculated and least squares adjusted values for the surveillance capsules withdrawn from Millstone Unit 2 are described herein.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

### A.1.1 Sensor Reaction Rate Determinations

In this section, the results of the evaluations of three neutron sensor sets withdrawn as part of the Millstone Unit 2 Reactor Vessel Materials Surveillance Program are presented.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

| Capsule ID | Equivalent Azimuthal Location | Withdrawal Time | Irradiation Time [EFPY] |
|---|---|---|---|
| W-97 | 7° | End of Cycle 3 | 3.0 |
| W-97 supplemental [1] | 7° | End of Cycle 10 | 5.0 |
| W-104 | 14° | End of Cycle 10 | 10.0 |
| W-83 | 7° | End of Cycle 14 | 15.3 |

[1] The W-97 supplemental capsule is a fourth dosimeter set that was first put into service at the beginning of the sixth fuel cycle. Since the W-97 supplemental capsule dosimetry differed substantially from the W-104 dosimetry measurements jointly described in Reference A-3, the W-97 supplemental capsule was not used to validate the Millstone Unit 2 transport calculations

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

The passive neutron sensors contained in the W-97, W-104, and W-83 surveillance capsules are summarized as follows:

| Sensor Material | Reaction Of Interest | Sensor Sets Evaluated Capsule W-97 | Capsule W-104 | Capsule W-83 |
|---|---|---|---|---|
| Copper [Cd] | $^{63}Cu(n,\alpha)^{60}Co$ | --- | --- | --- |
| Iron | $^{54}Fe(n,p)^{54}Mn$ | X | X | X |
| Nickel [Cd] | $^{58}Ni(n,p)^{58}Co$ | X | X | X |
| Titanium | $^{46}Ti(n,p)^{46}Sc$ | X | X | X |
| Uranium-238 | $^{238}U(n,f)^{137}Cs$ | --- | --- | --- |
| Uranium-238 [Cd] | $^{238}U(n,f)^{137}Cs$ | X | X | --- |
| Cobalt-Aluminum | $^{59}Co(n,\gamma)^{60}Co$ | X | --- | X |
| Cobalt-Aluminum [Cd] | $^{59}Co(n,\gamma)^{60}Co$ | X | --- | X |
| Sulfur | $^{32}S(n,p)^{32}P$ | --- | --- | --- |

In regards to the neutron sensors listed above, the cadmium-covered $^{63}Cu$ sensor reaction was not measured for capsule W-83 since the copper wire amalgamated with the cadmium. Similarly, the capsule W-97 $^{63}Cu$ sensor was also rejected on the basis of sample integrity since melting of the cadmium shield had also occurred. The cadmium-covered $^{63}Cu$ sensor reaction for capsule W-104 was also rejected based on previous performance issues with cadmium melting in the aforementioned capsules.

The bare uranium sensor measurements for capsules W-97 and W-83 were also excluded from this assessment. The bare $^{238}U(n,f)$ measurement is dominated by contributions from thermal neutron reactions in $^{235}U$ impurities. These thermal contributions add significant uncertainty to the determination of the $^{238}U(n,f)$ reaction rate. The bare $^{238}U(n,f)$ sensor reactions for capsule W-104 were not reported in Reference A-3.

The cadmium-covered $^{238}U$ sensor provides greater accuracy in the measurement of this fast neutron reaction and was therefore included in the reevaluation of capsules W-97 and W-104. However, the cadmium-covered $^{238}U$ sensors for Capsule W-83 were statistically inconsistent (in excess of $3\sigma$) with $^{238}U(n,f)^{137}Cs[Cd]$ measurements from other similar plants; hence, this sensor reaction rate was excluded from this assessment.

The sulfur sensor reaction was not measured for capsule W-83 due to the short half-life of $^{32}P$ (14.28 days); similarly, these sensors were not reevaluated for capsule W-97. Furthermore, the sulfur sensor reactions for capsule W-104 were not reported in Reference A-3. Therefore, the sulfur reaction was not utilized in the assessment of these capsules.

Pertinent physical and nuclear characteristics of the passive neutron sensors are listed in Table A-1. The use of passive monitors such as those listed above does not yield a direct measure of the energy dependent neutron flux at the point of interest. Rather, the activation or fission process is a measure of the integrated effect that the time and energy dependent neutron flux has on the target material over the course of the irradiation period. An accurate assessment of the average neutron flux level incident on the various monitors may be derived from the activation measurements only if the irradiation parameters are well known. In particular, the following variables are of interest:

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

The radiometric counting of the neutron sensors from capsule W-97 was reported by Combustion Engineering (C-E)[A-2]. The radiometric counting of the neutron sensors from capsule W-104 was reported by Babcock & Wilcox (B&W) [A-3]. The radiometric counting of the sensors from capsule W-83 was completed at the Pace Analytical Services Laboratory located at the Westinghouse Waltz Mill Site. The Pace radiometric counting followed established ASTM procedures. Following sample preparation and weighing, the specific activity of each sensor was determined by means of a high-resolution gamma spectrometer. For the iron, nickel, titanium, and cobalt-aluminum sensors, these analyses were

performed by direct counting of each of the individual samples. In the case of the uranium fission sensors, the analyses were carried out by direct counting preceded by dissolution and chemical separation of cesium from the sensor material.

The irradiation history of the reactor over the irradiation periods experienced by capsules W-97, W-104, and W-83 was based on the reported monthly power generation of Millstone Unit 2 from initial reactor criticality through the end of the dosimetry evaluation period. For the sensor sets utilized in the surveillance capsules, the half-lives of the product isotopes are long enough that a monthly histogram describing reactor operation has proven to be an adequate representation for use in radioactive decay corrections for the reactions of interest in the exposure evaluations. The irradiation history applicable to capsules W-97, W-104, and W-83 is given in Table A-2.

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

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

where:

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

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

In the equation describing the reaction rate calculation, the ratio $[P_j]/[P_{ref}]$ accounts for month-by-month variation of reactor core power level within any given fuel cycle as well as over multiple fuel cycles. The

ratio $C_j$, which was calculated for each fuel cycle using the transport methodology discussed in Section 6.2, accounts for the change in sensor reaction rates caused by variations in flux level induced by changes in core spatial power distributions from fuel cycle to fuel cycle. For a single-cycle irradiation, $C_j$ is normally taken to be 1.0. However, for multiple-cycle irradiations, particularly those employing low leakage fuel management, the additional $C_j$ term should be employed. The impact of changing flux levels for constant power operation can be quite significant for sensor sets that have been irradiated for many cycles in a reactor that has transitioned from non-low leakage to low leakage fuel management. The fuel cycle specific neutron flux values along with the computed values for $C_j$ are listed in Table A-3. These flux values represent the cycle dependent results at the radial and azimuthal center of the respective capsules at the axial elevation of the active fuel midplane.

Calculations for the reactions whose products have short half-lives indicated that $C_j$ factors based on cycle average flux values were appropriate for capsule W-97 but not appropriate for capsules W-104 and W-83 due to the change in the spectra over the life of the surveillance capsules resulting from the removal of the thermal shield at the end of the fifth fuel cycle. The effect of this spectral change was accounted for by determining $C_j$ factors based on individual reaction rates. As a result, the $C_j$ factors that were utilized in the final analyses for capsules W-104 and W-83 are based on individual reaction rates determined from the synthesized transport calculations as reported in Table A-3.

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

| Correction | Capsule W-97 | Capsule W-104 | Capsule W-83 [1] |
|---|---|---|---|
| $^{235}U$ Impurity/Pu Build-in | 0.872 | 0.848 | 0.819 |
| $^{238}U(\gamma,f)$ | 0.903 | 0.844 | 0.846 |
| Net $^{238}U$ Correction | 0.787 | 0.716 | 0.693 |

[1] The cadmium covered U foil from this dosimetry set was not used in the least squares evaluation for the W-83 capsule since it was statistically inconsistent with comparable measurement data obtained from similar plants.

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

Results of the sensor reaction rate determinations for capsules W-97, W-104 and W-83 are given in Table A-4. In Table A-4, the measured specific activities, decay corrected saturated specific activities, and computed reaction rates for each sensor indexed to the radial center of the capsule are listed. The fission sensor reaction rates are listed both with and without the applied corrections for $^{238}U$ impurities, plutonium build-in, and gamma ray induced fission effects.

### A.1.2 Least Squares Evaluation of Sensor Sets

Least squares adjustment methods provide the capability of combining the measurement data with the corresponding neutron transport calculations resulting in a Best Estimate neutron energy spectrum with

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

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

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

For the least squares evaluation of the Millstone Unit 2 surveillance capsule dosimetry, the FERRET code[A-4] was employed to combine the results of the plant specific neutron transport calculations and sensor set reaction rate measurements to determine best-estimate values of exposure parameters ($\phi(E > 1.0\ MeV)$ and dpa) along with associated uncertainties for the three in-vessel capsules considered herein.

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

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

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

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

For the Millstone Unit 2 application, the calculated neutron spectrum was obtained from the results of plant specific neutron transport calculations described in Section 6.2 of this report. The sensor reaction rates were derived from the measured specific activities using the procedures described in Section A.1.1. The dosimetry reaction cross-sections and uncertainties were obtained from the Sandia National Laboratory Radiation Metrology Laboratory (SNLRML) dosimeter cross-section library [A-5]. The SNLRML library is an evaluated dosimetry reaction cross-section compilation recommended for use in LWR evaluations by ASTM Standard E1018, "Application of ASTM Evaluated Cross-Section Data File, Matrix E 706 (IIB)".

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

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

Reaction Rate Uncertainties

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

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

| Reaction | Uncertainty |
|---|---|
| $^{63}Cu(n,\alpha)^{60}Co$ | 5% |
| $^{54}Fe(n,p)^{54}Mn$ | 5% |
| $^{58}Ni(n,p)^{58}Co$ | 5% |
| $^{46}Ti(n,p)^{46}Sc$ | 5% |
| $^{238}U(n,f)^{137}Cs$ | 10% |
| $^{59}Co(n,\gamma)^{60}Co$ | 5% |

These uncertainties are given at the $1\sigma$ level.

Dosimetry Cross-Section Uncertainties

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

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

| Reaction | Uncertainty |
|---|---|
| $^{63}Cu(n,\alpha)^{60}Co$ | 4.08-4.16% |
| $^{54}Fe(n,p)^{54}Mn$ | 3.05-3.11% |
| $^{58}Ni(n,p)^{58}Co$ | 4.49-4.56% |
| $^{46}Ti(n,p)^{46}Sc$ | 4.51-4.87% |
| $^{238}U(n,f)^{137}Cs$ | 0.54-0.64% |
| $^{59}Co(n,\gamma)^{60}Co$ | 0.79-3.59% |

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

Calculated Neutron Spectrum

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

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

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

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

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

where

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

The first term in the correlation matrix equation specifies purely random uncertainties, while the second term describes the short-range correlation's over a group range $\gamma$ ($\theta$ specifies the strength of the latter term). The value of $\delta$ is 1.0 when $g = g'$, and is 0.0 otherwise.

The set of parameters defining the input covariance matrix for the Millstone Unit 2 calculated spectra was as follows:

| | |
|---|---|
| Flux Normalization Uncertainty ($R_n$) | 15% |
| Flux Group Uncertainties ($R_g$, $R_{g'}$) | |
| (E > 0.0055 MeV) | 15% |
| (0.68 eV < E < 0.0055 MeV) | 29% |
| (E < 0.68 eV) | 52% |
| Short Range Correlation ($\theta$) | |
| (E > 0.0055 MeV) | 0.9 |
| (0.68 eV < E < 0.0055 MeV) | 0.5 |
| (E < 0.68 eV) | 0.5 |

| Flux Group Correlation Range ($\gamma$) | |
|---|---|
| (E > 0.0055 MeV) | 6 |
| (0.68 eV < E < 0.0055 MeV) | 3 |
| (E < 0.68 eV) | 2 |

### A.1.3 Comparisons of Measurements and Calculations

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

The data comparisons provided in Tables A-5 and A-6 show that the adjustments to the calculated spectra are relatively small and well within the assigned uncertainties for the calculated spectra, measured sensor reaction rates, and dosimetry reaction cross-sections. Further, these results indicate that the use of the least squares evaluation results in a reduction in the uncertainties associated with the exposure of the surveillance capsules. From Section 6.4 of this report, it may be noted that the uncertainty associated with the unadjusted calculation of neutron fluence (E > 1.0 MeV) and iron atom displacements at the surveillance capsule locations is specified as 12% at the $1\sigma$ level. From Table A-6, it is noted that the corresponding uncertainties associated with the least squares adjusted exposure parameters have been reduced to 6-7% for neutron flux (E > 1.0 MeV) and 6% for iron atom displacement rate. Again, the uncertainties from the least-squares evaluation are at the $1\sigma$ level.

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

It should be noted that although comparisons between the measured and calculated values for the $^{46}$Ti sensors are included in Table A-7, they were not used in determining the average measurement to calculation (M/C) ratios since a bias exists in the SNLRML cross section for the $^{46}$Ti(n,p) reaction. This bias may be observed in the data contained in ASTM Standard Practice E261, "Determining Neutron Fluence, Fluence Rate, and Spectra by Radioactivation Techniques." Specifically, Table 3 of ASTM E261 indicates that the sum in quadrature of the experimental uncertainty and the calculated uncertainty for $^{46}$Ti(n,p)$^{46}$Sc in the $^{235}$U thermal fission field is 6.86%. Also indicated in the same table is the ratio of the calculated cross-section to the experimentally measured cross section (C/E) that is given

as 0.899. Since the difference between the calculated and measured cross-section is greater than the uncertainties involved supports the hypothesis that the calculated cross-section is biased low.

In the case of the direct comparison of measured and calculated sensor reaction rates, the M/C comparisons for fast neutron reactions range from 0.87–1.15 for the 8 samples included in the data set. The overall average M/C ratio for the entire set of Millstone Unit 2 data is 1.00 with an associated standard deviation of 9.6%.

In the comparisons of best estimate and calculated fast neutron exposure parameters, the corresponding BE/C comparisons for the capsule data sets range from 0.94–1.12 for neutron flux (E > 1.0 MeV) and from 0.93 to 1.10 for iron atom displacement rate. The overall average BE/C ratios for neutron flux (E > 1.0 MeV) and iron atom displacement rate are 1.02 with a standard deviation of 9.1% and 1.01 with a standard deviation of 8.6%, respectively.

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

Table A-1

Nuclear Parameters Used In The Evaluation Of Neutron Sensors

| Monitor Material | Reaction of Interest | Target Atom Fraction[1] | 90% Response Range[2] (MeV) | Product Half-life | Fission Yield (%) |
|---|---|---|---|---|---|
| Copper | $^{63}Cu(n,\alpha)$ | 0.6917 | 5.0 – 12.0 | 5.271y | |
| Iron | $^{54}Fe$ (n,p) | 0.0585 | 2.3 – 8.8 | 312.3 d | |
| Nickel | $^{58}Ni$ (n,p) | 0.6808 | 1.9 – 8.8 | 70.82 d | |
| Titanium | $^{46}Ti$ (n,p) | 0.0800 | 4.0 – 10.5 | 83.81 d | |
| Uranium-238 | $^{238}U$ (n,f) | 1.0000 | 1.4 – 8.0 | 30.07 y | 6.02 |
| Cobalt-Aluminum | $^{59}Co$ (n,$\gamma$) | 0.0015 | non-threshold | 5.271 y | |

[1] The counting results identified by B&W for the capsule W-104 reactions were reported in Reference A-3 based on the weight of the target material in the sample rather than the total weight of the dosimeter material. As a result, the target atom fraction used in the analysis of the capsule W-104 sensors was unity.

[2] The 90% response range is defined such that, in the neutron spectrum characteristic of the Millstone Unit 2 surveillance capsules located at 7° and 14° from the core cardinal axes, approximately 90% of the sensor response is due to neutrons in the energy range specified with approximately 5% of the total response due to neutrons with energies below the lower limit and 5% of the total response due to neutrons with energies above the upper limit.

Table A-2

Monthly Thermal Generation During The First Fourteen Fuel Cycles of The Millstone Unit 2 Reactor

| Year | Month | Thermal Generation (MWt-hr) | Year | Month | Thermal Generation (MWt-hr) | Year | Month | Thermal Generation (MWt-hr) |
|---|---|---|---|---|---|---|---|---|
| 1975 | 10 | 0 | 1979 | 1 | 1662527 | 1982 | 1 | 0 |
| 1975 | 11 | 169382 | 1979 | 2 | 1692785 | 1982 | 2 | 0 |
| 1975 | 12 | 470151 | 1979 | 3 | 539470 | 1982 | 3 | 808939.7 |
| 1976 | 1 | 726120 | 1979 | 4 | 0 | 1982 | 4 | 1570359 |
| 1976 | 2 | 727079 | 1979 | 5 | 417578 | 1982 | 5 | 1982946 |
| 1976 | 3 | 993918 | 1979 | 6 | 1230123 | 1982 | 6 | 1935852 |
| 1976 | 4 | 1275861 | 1979 | 7 | 1989041 | 1982 | 7 | 1020076 |
| 1976 | 5 | 1161586 | 1979 | 8 | 745654 | 1982 | 8 | 1724588 |
| 1976 | 6 | 1534194 | 1979 | 9 | 1933841 | 1982 | 9 | 1703478 |
| 1976 | 7 | 1197834 | 1979 | 10 | 1991854 | 1982 | 10 | 1693915 |
| 1976 | 8 | 1373055 | 1979 | 11 | 0 | 1982 | 11 | 1644259 |
| 1976 | 9 | 1727678 | 1979 | 12 | 1613522 | 1982 | 12 | 1938553 |
| 1976 | 10 | 1787608 | 1980 | 1 | 2001005 | 1983 | 1 | 1801321 |
| 1976 | 11 | 1740007 | 1980 | 2 | 1683788 | 1983 | 2 | 1634909 |
| 1976 | 12 | 910583 | 1980 | 3 | 1740751 | 1983 | 3 | 806911 |
| 1977 | 1 | 1004692 | 1980 | 4 | 1831957 | 1983 | 4 | 1921628 |
| 1977 | 2 | 1697538 | 1980 | 5 | 499545 | 1983 | 5 | 1712695 |
| 1977 | 3 | 1849165 | 1980 | 6 | 404890 | 1983 | 6 | 0 |
| 1977 | 4 | 1348306 | 1980 | 7 | 1900317 | 1983 | 7 | 0 |
| 1977 | 5 | 368843 | 1980 | 8 | 958023 | 1983 | 8 | 0 |
| 1977 | 6 | 362122 | 1980 | 9 | 0 | 1983 | 9 | 0 |
| 1977 | 7 | 1329348 | 1980 | 10 | 659001 | 1983 | 10 | 0 |
| 1977 | 8 | 1885613 | 1980 | 11 | 1862268 | 1983 | 11 | 0 |
| 1977 | 9 | 1667984 | 1980 | 12 | 1995148 | 1983 | 12 | 0 |
| 1977 | 10 | 1516798 | 1981 | 1 | 782184 | 1984 | 1 | 809931 |
| 1977 | 11 | 1205392 | 1981 | 2 | 1752019 | 1984 | 2 | 1507373 |
| 1977 | 12 | 0 | 1981 | 3 | 2001106 | 1984 | 3 | 1971567 |
| 1978 | 1 | 0 | 1981 | 4 | 1934118 | 1984 | 4 | 1935357 |
| 1978 | 2 | 0 | 1981 | 5 | 987167 | 1984 | 5 | 1998215 |
| 1978 | 3 | 0 | 1981 | 6 | 1853185 | 1984 | 6 | 1877970 |
| 1978 | 4 | 107169 | 1981 | 7 | 1963023 | 1984 | 7 | 1903852 |
| 1978 | 5 | 1596598 | 1981 | 8 | 1904455 | 1984 | 8 | 1995846 |
| 1978 | 6 | 1752746 | 1981 | 9 | 1923108 | 1984 | 9 | 1910948 |
| 1978 | 7 | 1790474 | 1981 | 10 | 1869618 | 1984 | 10 | 2001607 |
| 1978 | 8 | 1806986 | 1981 | 11 | 1942822 | 1984 | 11 | 1524599 |
| 1978 | 9 | 1704986 | 1981 | 12 | 267821 | 1984 | 12 | 1935523 |
| 1978 | 10 | 1875411 | | | | | | |
| 1978 | 11 | 1839813 | | | | | | |
| 1978 | 12 | 1900976 | | | | | | |

Table A-2 cont'd

Monthly Thermal Generation During The First Fourteen Fuel Cycles
of The Millstone Unit 2 Reactor

| Year | Month | Thermal Generation (MWt-hr) | Year | Month | Thermal Generation (MWt-hr) | Year | Month | Thermal Generation (MWt-hr) |
|---|---|---|---|---|---|---|---|---|
| 1985 | 1 | 1994395 | 1988 | 1 | 0 | 1991 | 1 | 1323684 |
| 1985 | 2 | 900708 | 1988 | 2 | 439630 | 1991 | 2 | 1687526 |
| 1985 | 3 | 0 | 1988 | 3 | 2006818 | 1991 | 3 | 2008452 |
| 1985 | 4 | 0 | 1988 | 4 | 1494187 | 1991 | 4 | 1368599 |
| 1985 | 5 | 0 | 1988 | 5 | 956578 | 1991 | 5 | 803890 |
| 1985 | 6 | 0 | 1988 | 6 | 1400732 | 1991 | 6 | 0 |
| 1985 | 7 | 1247903 | 1988 | 7 | 2008427 | 1991 | 7 | 1352310 |
| 1985 | 8 | 1963363 | 1988 | 8 | 2008495 | 1991 | 8 | 540061 |
| 1985 | 9 | 1710661 | 1988 | 9 | 1936390 | 1991 | 9 | 1170466 |
| 1985 | 10 | 0 | 1988 | 10 | 1885985 | 1991 | 10 | 1708110 |
| 1985 | 11 | 1411904 | 1988 | 11 | 1943414 | 1991 | 11 | 342421 |
| 1985 | 12 | 1990411 | 1988 | 12 | 2008362 | 1991 | 12 | 160881 |
| 1986 | 1 | 1984099 | 1989 | 1 | 2008467 | 1992 | 1 | 1709024 |
| 1986 | 2 | 1813645 | 1989 | 2 | 201767 | 1992 | 2 | 975691 |
| 1986 | 3 | 2000735 | 1989 | 3 | 0 | 1992 | 3 | 2008454 |
| 1986 | 4 | 1940693 | 1989 | 4 | 2469 | 1992 | 4 | 1940643 |
| 1986 | 5 | 1809751 | 1989 | 5 | 1833467 | 1992 | 5 | 1872406 |
| 1986 | 6 | 1799531 | 1989 | 6 | 1938383 | 1992 | 6 | 0 |
| 1986 | 7 | 2007906 | 1989 | 7 | 2004115 | 1992 | 7 | 0 |
| 1986 | 8 | 1670198 | 1989 | 8 | 2001979 | 1992 | 8 | 0 |
| 1986 | 9 | 1121241 | 1989 | 9 | 1842429 | 1992 | 9 | 0 |
| 1986 | 10 | 0 | 1989 | 10 | 1189086 | 1992 | 10 | 0 |
| 1986 | 11 | 0 | 1989 | 11 | 454022 | 1992 | 11 | 0 |
| 1986 | 12 | 496285 | 1989 | 12 | 2008374 | 1992 | 12 | 0 |
| 1987 | 1 | 1772860 | 1990 | 1 | 2008226 | 1993 | 1 | 968933 |
| 1987 | 2 | 757661 | 1990 | 2 | 1813945 | 1993 | 2 | 1573593 |
| 1987 | 3 | 1990243 | 1990 | 3 | 2008300 | 1993 | 3 | 2008013 |
| 1987 | 4 | 1863177 | 1990 | 4 | 1870658 | 1993 | 4 | 1870993 |
| 1987 | 5 | 2006240 | 1990 | 5 | 455773 | 1993 | 5 | 1883361 |
| 1987 | 6 | 1942702 | 1990 | 6 | 945947 | 1993 | 6 | 1859045 |
| 1987 | 7 | 1936769 | 1990 | 7 | 2008021 | 1993 | 7 | 2008410 |
| 1987 | 8 | 1977157 | 1990 | 8 | 1869028 | 1993 | 8 | 1347720 |
| 1987 | 9 | 1792000 | 1990 | 9 | 901501 | 1993 | 9 | 902578 |
| 1987 | 10 | 2008169 | 1990 | 10 | 0 | 1993 | 10 | 1355882 |
| 1987 | 11 | 1840647 | 1990 | 11 | 1216781 | 1993 | 11 | 1848160 |
| 1987 | 12 | 1879773 | 1990 | 12 | 1822046 | 1993 | 12 | 1991761 |

Table A-2 cont'd

Monthly Thermal Generation During The First Fourteen Fuel Cycles
of The Millstone Unit 2 Reactor

| Year | Month | Thermal Generation (MWt-hr) | Year | Month | Thermal Generation (MWt-hr) | Year | Month | Thermal Generation (MWt-hr) |
|---|---|---|---|---|---|---|---|---|
| 1994 | 1 | 1987044 | 1997 | 1 | 0 | 2000 | 1 | 1793229 |
| 1994 | 2 | 1808654 | 1997 | 2 | 0 | 2000 | 2 | 803563.6 |
| 1994 | 3 | 2004989 | 1997 | 3 | 0 | 2000 | 3 | 1995614 |
| 1994 | 4 | 1420483 | 1997 | 4 | 0 | 2000 | 4 | 1353661 |
| 1994 | 5 | 0 | 1997 | 5 | 0 | 2000 | 5 | 0 |
| 1994 | 6 | 736521 | 1997 | 6 | 0 | 2000 | 6 | 1640187 |
| 1994 | 7 | 1715901 | 1997 | 7 | 0 | 2000 | 7 | 2002629 |
| 1994 | 8 | 0 | 1997 | 8 | 0 | 2000 | 8 | 2003897 |
| 1994 | 9 | 1743833 | 1997 | 9 | 0 | 2000 | 9 | 1923670 |
| 1994 | 10 | 8969 | 1997 | 10 | 0 | 2000 | 10 | 1984571 |
| 1994 | 11 | 0 | 1997 | 11 | 0 | 2000 | 11 | 1936391 |
| 1994 | 12 | 0 | 1997 | 12 | 0 | 2000 | 12 | 1996304 |
| 1995 | 1 | 0 | 1998 | 1 | 0 | 2001 | 1 | 2000397 |
| 1995 | 2 | 0 | 1998 | 2 | 0 | 2001 | 2 | 1809984 |
| 1995 | 3 | 0 | 1998 | 3 | 0 | 2001 | 3 | 1974906 |
| 1995 | 4 | 0 | 1998 | 4 | 0 | 2001 | 4 | 1809699 |
| 1995 | 5 | 0 | 1998 | 5 | 0 | 2001 | 5 | 1537819 |
| 1995 | 6 | 0 | 1998 | 6 | 0 | 2001 | 6 | 1934469 |
| 1995 | 7 | 0 | 1998 | 7 | 0 | 2001 | 7 | 1991596 |
| 1995 | 8 | 1127403 | 1998 | 8 | 0 | 2001 | 8 | 1802924 |
| 1995 | 9 | 1943543 | 1998 | 9 | 0 | 2001 | 9 | 1941279 |
| 1995 | 10 | 2008689 | 1998 | 10 | 0 | 2001 | 10 | 2002856 |
| 1995 | 11 | 1921802 | 1998 | 11 | 0 | 2001 | 11 | 1860739 |
| 1995 | 12 | 1594145 | 1998 | 12 | 0 | 2001 | 12 | 1976053 |
| 1996 | 1 | 2007749 | 1999 | 1 | 0 | 2002 | 1 | 1945747 |
| 1996 | 2 | 1232628 | 1999 | 2 | 0 | 2002 | 2 | 835263.3 |
| 1996 | 3 | 0 | 1999 | 3 | 0 | 2002 | 3 | 0 |
| 1996 | 4 | 0 | 1999 | 4 | 0 | | | |
| 1996 | 5 | 0 | 1999 | 5 | 712321.6 | | | |
| 1996 | 6 | 0 | 1999 | 6 | 1942647 | | | |
| 1996 | 7 | 0 | 1999 | 7 | 1989754 | | | |
| 1996 | 8 | 0 | 1999 | 8 | 1986803 | | | |
| 1996 | 9 | 0 | 1999 | 9 | 1432859 | | | |
| 1996 | 10 | 0 | 1999 | 10 | 2004610 | | | |
| 1996 | 11 | 0 | 1999 | 11 | 1897621 | | | |
| 1996 | 12 | 0 | 1999 | 12 | 1918186 | | | |

Table A-3

Calculated $C_j$ Factors at the Surveillance Capsule Center
Core Midplane Elevation

| Fuel Cycle | $\phi$(E > 1.0 MeV) [n/cm$^2$-s] | | | $C_j$ [1] | | |
|---|---|---|---|---|---|---|
| | Capsule W-97 | Capsule W-104 | Capsule W-83 | Capsule W-97 | Capsule W-104 | Capsule W-83 |
| 1 | 3.00E+10 | 2.10E+10 | 3.00E+10 | 0.89 | 0.70 | 0.83 |
| 2 | 3.35E+10 | 2.36E+10 | 3.35E+10 | 0.99 | 0.79 | 0.93 |
| 3 | 3.97E+10 | 2.80E+10 | 3.97E+10 | 1.18 | 0.93 | 1.10 |
| 4 | | 2.68E+10 | 3.84E+10 | | 0.90 | 1.07 |
| 5 | | 2.66E+10 | 3.79E+10 | | 0.89 | 1.05 |
| 6 | | 3.90E+10 | 5.45E+10 | | 1.30 | 1.51 |
| 7 | | 4.00E+10 | 5.58E+10 | | 1.34 | 1.55 |
| 8 | | 4.02E+10 | 5.59E+10 | | 1.34 | 1.55 |
| 9 | | 3.94E+10 | 5.48E+10 | | 1.31 | 1.52 |
| 10 | | 1.96E+10 | 2.46E+10 | | 0.65 | 0.68 |
| 11 | | | 2.81E+10 | | | 0.78 |
| 12 | | | 2.33E+10 | | | 0.65 |
| 13 | | | 2.47E+10 | | | 0.69 |
| 14 | | | 2.46E+10 | | | 0.68 |
| Average | 3.37E+10 | 2.99E+10 | 3.60E+10 | 1.00 | 1.00 | 1.00 |

[1] The $C_j$ factors based on the ratio of the cycle specific fast (E > 1 0 MeV) neutron flux divided by the average flux over the total irradiation period were deemed unsuitable for capsules W-104 and W-83 since individual reaction rates did not vary proportionally with the fast flux due to the removal of the thermal shield at the end of the fifth fuel cycle. As a result of this observation, the $C_j$ terms that were utilized in the final analyses for capsules W-104 and W-83 were based on the individual reaction rates determined from the synthesized transport calculations. The final $C_j$ which are based on individual reaction rates, are reported on the following pages of this table.

Table A-3 cont'd

Calculated $C_j$ Factors at the Surveillance Capsule Center
Core Midplane Elevation
(Capsule W-104)

| Fuel Cycle | Capsule W-104 Reaction Rates [rps/atom] | | | | |
|---|---|---|---|---|---|
| | $^{63}$Cu (n,α) | $^{54}$Fe (n,p) | $^{58}$Ni (n,p) | $^{46}$Ti (n,p) | $^{238}$U (n,f) |
| 1 | 2.36E-17 | 2.20E-15 | 2.92E-15 | 3.93E-16 | 8.60E-15 |
| 2 | 2.62E-17 | 2.46E-15 | 3.27E-15 | 4.38E-16 | 9.65E-15 |
| 3 | 3.07E-17 | 2.90E-15 | 3.85E-15 | 5.14E-16 | 1.14E-14 |
| 4 | 2.96E-17 | 2.79E-15 | 3.70E-15 | 4.95E-16 | 1.10E-14 |
| 5 | 2.94E-17 | 2.77E-15 | 3.68E-15 | 4.92E-16 | 1.09E-14 |
| 6 | 6.01E-17 | 5.27E-15 | 6.85E-15 | 9.99E-16 | 1.76E-14 |
| 7 | 6.15E-17 | 5.40E-15 | 7.03E-15 | 1.02E-15 | 1.80E-14 |
| 8 | 6.17E-17 | 5.43E-15 | 7.06E-15 | 1.03E-15 | 1.81E-14 |
| 9 | 6.06E-17 | 5.32E-15 | 6.92E-15 | 1.01E-15 | 1.77E-14 |
| 10 | 3.34E-17 | 2.77E-15 | 3.59E-15 | 5.43E-16 | 8.95E-15 |
| Average | 4.11E-17 | 3.68E-15 | 4.81E-15 | 6.83E-16 | 1.30E-14 |

| Fuel Cycle | Capsule W-104 $C_j$ | | | | |
|---|---|---|---|---|---|
| | $^{63}$Cu (n,α) | $^{54}$Fe (n,p) | $^{58}$Ni (n,p) | $^{46}$Ti (n,p) | $^{238}$U (n,f) |
| 1 | 0.57 | 0.60 | 0.61 | 0.58 | 0.66 |
| 2 | 0.64 | 0.67 | 0.68 | 0.64 | 0.74 |
| 3 | 0.75 | 0.79 | 0.80 | 0.75 | 0.88 |
| 4 | 0.72 | 0.76 | 0.77 | 0.72 | 0.84 |
| 5 | 0.72 | 0.75 | 0.76 | 0.72 | 0.84 |
| 6 | 1.46 | 1.43 | 1.42 | 1.46 | 1.35 |
| 7 | 1.50 | 1.47 | 1.46 | 1.50 | 1.39 |
| 8 | 1.50 | 1.48 | 1.47 | 1.50 | 1.39 |
| 9 | 1.48 | 1.45 | 1.44 | 1.48 | 1.37 |
| 10 | 0.81 | 0.75 | 0.75 | 0.79 | 0.69 |
| Average | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table A-3 cont'd

Calculated $C_j$ Factors at the Surveillance Capsule Center
Core Midplane Elevation
(Capsule W-83)

| Fuel Cycle | Capsule W-83 Reaction Rates [rps/atom] | | | | | |
|---|---|---|---|---|---|---|
| | $^{54}$Fe (n,p) | $^{58}$Ni (n,p) | $^{46}$Ti (n,p) | $^{238}$U (n,f) | $^{59}$Co (n,γ) | $^{59}$Co (n,γ) Cd |
| 1 | 3.07E-15 | 4.07E-15 | 5.34E-16 | 1.22E-14 | 2.90E-12 | 6.25E-13 |
| 2 | 3.41E-15 | 4.53E-15 | 5.92E-16 | 1.36E-14 | 3.26E-12 | 7.03E-13 |
| 3 | 4.01E-15 | 5.34E-15 | 6.94E-16 | 1.61E-14 | 3.89E-12 | 8.42E-13 |
| 4 | 3.90E-15 | 5.18E-15 | 6.75E-16 | 1.56E-14 | 3.77E-12 | 8.14E-13 |
| 5 | 3.84E-15 | 5.11E-15 | 6.65E-16 | 1.54E-14 | 3.71E-12 | 8.02E-13 |
| 6 | 7.17E-15 | 9.34E-15 | 1.33E-15 | 2.44E-14 | 2.50E-12 | 5.53E-13 |
| 7 | 7.33E-15 | 9.55E-15 | 1.36E-15 | 2.49E-14 | 2.56E-12 | 5.66E-13 |
| 8 | 7.35E-15 | 9.57E-15 | 1.36E-15 | 2.50E-14 | 2.56E-12 | 5.68E-13 |
| 9 | 7.21E-15 | 9.39E-15 | 1.33E-15 | 2.45E-14 | 2.51E-12 | 5.56E-13 |
| 10 | 3.37E-15 | 4.37E-15 | 6.44E-16 | 1.11E-14 | 1.07E-12 | 2.41E-13 |
| 11 | 3.82E-15 | 4.97E-15 | 7.28E-16 | 1.27E-14 | 1.24E-12 | 2.77E-13 |
| 12 | 3.19E-15 | 4.15E-15 | 6.12E-16 | 1.05E-14 | 1.02E-12 | 2.28E-13 |
| 13 | 3.38E-15 | 4.40E-15 | 6.47E-16 | 1.12E-14 | 1.08E-12 | 2.43E-13 |
| 14 | 3.38E-15 | 4.38E-15 | 6.46E-16 | 1.11E-14 | 1.08E-12 | 2.42E-13 |
| Average | 4.44E-15 | 5.82E-15 | 8.17E-16 | 1.57E-14 | 2.23E-12 | 4.89E-13 |

| Fuel Cycle | Capsule W-83 $C_j$ | | | | | |
|---|---|---|---|---|---|---|
| | $^{54}$Fe (n,p) | $^{58}$Ni (n,p) | $^{46}$Ti (n,p) | $^{238}$U (n,f) | $^{59}$Co (n,γ) | $^{59}$Co (n,γ) Cd |
| 1 | 0.69 | 0.70 | 0.65 | 0.78 | 1.30 | 1.28 |
| 2 | 0.77 | 0.78 | 0.72 | 0.87 | 1.46 | 1.44 |
| 3 | 0.90 | 0.92 | 0.85 | 1.03 | 1.75 | 1.72 |
| 4 | 0.88 | 0.89 | 0.83 | 0.99 | 1.69 | 1.66 |
| 5 | 0.86 | 0.88 | 0.81 | 0.98 | 1.66 | 1.64 |
| 6 | 1.61 | 1.61 | 1.62 | 1.55 | 1.12 | 1.13 |
| 7 | 1.65 | 1.64 | 1.66 | 1.59 | 1.15 | 1.16 |
| 8 | 1.65 | 1.65 | 1.66 | 1.59 | 1.15 | 1.16 |
| 9 | 1.62 | 1.62 | 1.63 | 1.56 | 1.13 | 1.14 |
| 10 | 0.76 | 0.75 | 0.79 | 0.71 | 0.48 | 0.49 |
| 11 | 0.86 | 0.85 | 0.89 | 0.81 | 0.55 | 0.57 |
| 12 | 0.72 | 0.71 | 0.75 | 0.67 | 0.45 | 0.47 |
| 13 | 0.76 | 0.76 | 0.79 | 0.71 | 0.49 | 0.50 |
| 14 | 0.76 | 0.75 | 0.79 | 0.71 | 0.48 | 0.49 |
| Average | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table A-4
Measured Sensor Activities and Reaction Rates

Surveillance Capsule W-97

| Reaction | Location | Measured Activity [1] (dps/g) | Saturated Activity (dps/g) | Reaction Rate (rps/atom) |
|---|---|---|---|---|
| $^{63}$Cu (n,α) $^{60}$Co (Cd) | Top | 1.12E+05 | 3.78E+05 | 5.76E-17 |
| | Middle | 1.10E+05 | 3.74E+05 | 5.71E-17 |
| | Bottom | 1.27E+05 | 4.28E+05 | 6.53E-17 |
| | Average | | | **6.00E-17** |
| $^{54}$Fe (n,p) $^{54}$Mn | Top | 1.87E+06 | 2.60E+06 | 4.13E-15 |
| | Middle | 1.76E+06 | 2.45E+06 | 3.88E-15 |
| | Bottom | 1.86E+06 | 2.59E+06 | 4.10E-15 |
| | Average | | | **4.04E-15** |
| $^{58}$Ni (n,p) $^{58}$Co (Cd) | Top | 3.01E+07 | 3.70E+07 | 5.30E-15 |
| | Middle | 2.78E+07 | 3.42E+07 | 4.90E-15 |
| | Bottom | 3.05E+07 | 3.75E+07 | 5.37E-15 |
| | Average | | | **5.19E-15** |
| $^{46}$Ti (n,p) $^{46}$Sc | Top | 6.15E+05 | 7.60E+05 | 7.55E-16 |
| | Middle | 5.48E+05 | 6.77E+05 | 6.73E-16 |
| | Bottom | 5.70E+05 | 7.07E+05 | 7.03E-16 |
| | Average | | | **7.10E-16** |
| $^{238}$U (n,f) $^{137}$Cs (Cd) | Top | 1.77E+05 | 2.75E+06 | 1.80E-14 |
| | Middle | 1.92E+05 | 2.98E+06 | 1.96E-14 |
| | Bottom | 1.87E+05 | 2.90E+06 | 1.91E-14 |
| | Average | | | 1.89E-14 |
| $^{238}$U (n,f) $^{137}$Cs (Cd) | Including $^{235}$U, $^{239}$Pu, and γ, fission corrections. | | | **1.49E-14** [2] |
| $^{59}$Co (n,γ) $^{60}$Co | Top | 2.22E+07 | 7.48E+07 | 4.88E-12 |
| | Middle | 2.52E+07 | 8.49E+07 | 5.54E-12 |
| | Bottom | 1.70E+07 | 5.73E+07 | 3.74E-12 |
| | Average | | | **4.72E-12** |
| $^{59}$Co (n,γ) $^{60}$Co (Cd) | Top | 2.93E+06 | 9.88E+06 | 6.44E-13 |
| | Middle | 3.02E+06 | 1.02E+07 | 6.64E-13 |
| | Bottom | 3.07E+06 | 1.04E+07 | 6.75E-13 |
| | Average | | | **6.61E-13** |

[1] Measured specific activities are decay corrected to time of reactor shutdown, i e., August 17, 1980
[2] The average $^{238}$U (n,f) reaction rate of 1.49E-14 includes a correction factor of 0 872 to account for plutonium build-in and an additional factor of 0.903 to account for photo-fission effects in the sensor.

Table A-4 cont'd
Measured Sensor Activities and Reaction Rates

Surveillance Capsule W-104

| Reaction | Location | Measured Activity [1] (dps/g) | Saturated Activity (dps/g) | Reaction Rate (rps/atom) |
|---|---|---|---|---|
| $^{63}$Cu (n,α) $^{60}$Co (Cd) | Top | 3.28E+05 | 4.87E+05 | 5.09E-17 |
| | Middle | 3.34E+05 | 4.96E+05 | 5.18E-17 |
| | Bottom | 3.50E+05 | 5.20E+05 | 5.43E-17 |
| | Average | | | **5.24E-17** |
| $^{54}$Fe (n,p) $^{54}$Mn | Top | 3.02E+07 | 4.09E+07 | 3.67E-15 |
| | Middle | 2.85E+07 | 3.86E+07 | 3.46E-15 |
| | Bottom | 2.90E+07 | 3.93E+07 | 3.52E-15 |
| | Average | | | **3.55E-15** |
| $^{58}$Ni (n,p) $^{58}$Co (Cd) | Top | 3.15E+07 | 5.07E+07 | 4.88E-15 |
| | Middle | 2.65E+07 | 4.27E+07 | 4.10E-15 |
| | Bottom | 3.03E+07 | 4.88E+07 | 4.69E-15 |
| | Average | | | **4.56E-15** |
| $^{46}$Ti (n,p) $^{46}$Sc | Top | 6.22E+06 | 9.55E+06 | 7.29E-16 |
| | Middle | 5.47E+06 | 8.40E+06 | 6.41E-16 |
| | Bottom | 5.75E+06 | 8.83E+06 | 6.74E-16 |
| | Average | | | **6.81E-16** |
| $^{238}$U (n,f) $^{137}$Cs (Cd) | Top | 4.77E+05 | 2.39E+06 | 1.57E-14 |
| | Middle | 4.77E+05 | 2.39E+06 | 1.57E-14 |
| | Bottom | 5.09E+05 | 2.55E+06 | 1.68E-14 |
| | Average | | | 1.61E-14 |
| $^{238}$U (n,f) $^{137}$Cs (Cd) | Including $^{235}$U, $^{239}$Pu, and γ, fission corrections. | | | **1.15E-14** [2] |

[1] Measured specific activities are assumed to be decay corrected to time of reactor shutdown, i e , September 14, 1990.
[2] The average $^{238}$U (n,f) reaction rate of 1.15E-14 includes a correction factor of 0 848 to account for plutonium build-in and an additional factor of 0.844 to account for photo-fission effects in the sensor.

Table A-4 cont'd
Measured Sensor Activities and Reaction Rates

Surveillance Capsule W-83

| Reaction | Location | Measured Activity [1] (dps/g) | Saturated Activity (dps/g) | Reaction Rate (rps/atom) |
|---|---|---|---|---|
| $^{54}$Fe (n,p) $^{54}$Mn | Top | 1.21E+06 | 3.02E+06 | 4.79E-15 |
| | Middle | 1.10E+06 | 2.75E+06 | 4.36E-15 |
| | Bottom | 1.10E+06 | 2.75E+06 | 4.36E-15 |
| | Average | | | **4.50E-15** |
| $^{58}$Ni (n,p) $^{58}$Co (Cd) | Top | 4.08E+06 | 4.28E+07 | 6.13E-15 |
| | Middle | 3.62E+06 | 3.80E+07 | 5.44E-15 |
| | Bottom | 3.80E+06 | 3.99E+07 | 5.71E-15 |
| | Average | | | **5.76E-15** |
| $^{46}$Ti (n,p) $^{46}$Sc | Top | 1.25E+05 | 9.14E+05 | 9.08E-16 |
| | Middle | 1.09E+05 | 7.97E+05 | 7.92E-16 |
| | Bottom | 1.10E+05 | 8.04E+05 | 7.99E-16 |
| | Average | | | **8.33E-16** |
| $^{238}$U (n,f) $^{137}$Cs (Cd) | Top | 1.55E+05 | 6.21E+05 | 4.08E-15 |
| | Middle | 1.80E+05 | 7.22E+05 | 4.74E-15 |
| | Bottom | 1.51E+05 | 6.05E+05 | 3.98E-15 |
| | Average | | | 4.27E-15 |
| $^{238}$U (n,f) $^{137}$Cs (Cd) | Including $^{235}$U, $^{239}$Pu, and $\gamma$, fission corrections. | | | **2.96E-15** [2] |
| $^{59}$Co (n,$\gamma$) $^{60}$Co | Top | 1.59E+07 | 5.05E+07 | 3.29E-12 |
| | Middle | 1.69E+07 | 5.36E+07 | 3.50E-12 |
| | Bottom | 1.12E+07 | 3.55E+07 | 2.32E-12 |
| | Average | | | **3.04E-12** |
| $^{59}$Co (n,$\gamma$) $^{60}$Co (Cd) | Top | 1.83E+06 | 5.72E+06 | 3.73E-13 |
| | Middle | 1.84E+06 | 5.76E+06 | 3.76E-13 |
| | Bottom | 1.82E+06 | 5.69E+06 | 3.71E-13 |
| | Average | | | **3.73E-13** |

[1] Measured specific activities are decay corrected to September 9, 2002.
[2] The average $^{238}$U (n,f) reaction rate of 2.96E-15 includes a correction factor of 0.819 to account for plutonium build-in and an additional factor of 0.846 to account for photo-fission effects in the sensor

Table A-5

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

Capsule W-97

| Reaction | Reaction Rate [rps/atom] Measured | Calculated | Best Estimate | M/C | M/BE |
|---|---|---|---|---|---|
| $^{54}Fe(n,p)^{54}Mn$ | 4.04E-15 | 3.50E-15 | 4.03E-15 | 1.15 | 1.00 |
| $^{58}Ni(n,p)^{58}Co$ (Cd) | 5.19E-15 | 4.66E-15 | 5.30E-15 | 1.11 | 0.98 |
| $^{46}Ti(n,p)^{46}Sc$ | 7.10E-16 | 5.70E-16 | 6.84E-16 | 1.25 | 1.04 |
| $^{238}U(n,f)^{137}Cs$ (Cd) | 1.49E-14 | 1.40E-14 | 1.56E-14 | 1.06 | 0.95 |
| $^{59}Co(n,\gamma)^{60}Co$ | 4.72E-12 | 3.28E-12 | 4.70E-12 | 1.44 | 1.01 |
| $^{59}Co(n,\gamma)^{60}Co$ (Cd) | 6.61E-13 | 6.78E-13 | 6.65E-13 | 0.98 | 0.99 |

Capsule W-104

| Reaction | Reaction Rate [rps/atom] Measured | Calculated | Best Estimate | M/C | M/BE |
|---|---|---|---|---|---|
| $^{54}Fe(n,p)^{54}Mn$ | 3.55E-15 | 3.76E-15 | 3.58E-15 | 0.94 | 0.99 |
| $^{58}Ni(n,p)^{58}Co$ (Cd) | 4.56E-15 | 4.92E-15 | 4.65E-15 | 0.93 | 0.98 |
| $^{46}Ti(n,p)^{46}Sc$ | 6.81E-16 | 6.57E-16 | 6.54E-16 | 1.04 | 1.04 |
| $^{238}U(n,f)^{137}Cs$ (Cd) | 1.15E-14 | 1.33E-14 | 1.23E-14 | 0.87 | 0.94 |

Capsule W-83

| Reaction | Reaction Rate [rps/atom] Measured | Calculated | Best Estimate | M/C | M/BE |
|---|---|---|---|---|---|
| $^{54}Fe(n,p)^{54}Mn$ | 4.50E-15 | 4.54E-15 | 4.53E-15 | 0.99 | 0.99 |
| $^{58}Ni(n,p)^{58}Co$ (Cd) | 5.75E-15 | 5.95E-15 | 5.89E-15 | 0.97 | 0.98 |
| $^{46}Ti(n,p)^{46}Sc$ | 8.33E-16 | 7.85E-16 | 8.07E-16 | 1.06 | 1.03 |
| $^{59}Co(n,\gamma)^{60}Co$ | 3.04E-12 | 2.23E-12 | 3.02E-12 | 1.36 | 1.01 |
| $^{59}Co(n,\gamma)^{60}Co$ (Cd) | 3.73E-13 | 4.67E-13 | 3.77E-13 | 0.80 | 0.98 |

Table A-6

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

| Capsule ID | $\phi(E > 1.0\ MeV)$ [n/cm$^2$-s] | | | |
|---|---|---|---|---|
| | Calculated [1] | Best Estimate | Uncertainty ($1\sigma$) | BE/C |
| W-97 | 3.37E+10 | 3.76E+10 | 6% | 1.12 |
| W-104 | 3.00E+10 | 2.80E+10 | 6% | 0.94 |
| W-83 | 3.60E+10 | 3.58E+10 | 7% | 0.99 |

[1] Calculated results are based on the synthesized transport calculations taken at the core midplane following the completion of each respective capsules irradiation period

| Capsule ID | Iron Atom Displacement Rate [dpa/s] | | | |
|---|---|---|---|---|
| | Calculated [1] | Best Estimate | Uncertainty ($1\sigma$) | BE/C |
| W-97 | 5.17E-11 | 5.70E-11 | 6 % | 1.10 |
| W-104 | 4.46E-11 | 4.15E-11 | 6 % | 0.93 |
| W-83 | 5.32E-11 | 5.26E-11 | 6 % | 0.99 |

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

Table A-7

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

| Reaction | M/C Ratio | | |
|---|---|---|---|
| | Capsule W-97 | Capsule W-104 | Capsule W-83 |
| $^{54}Fe(n,p)^{54}Mn$ | 1.15 | 0.94 | 0.99 |
| $^{58}Ni(n,p)^{58}Co$ (Cd) | 1.11 | 0.93 | 0.97 |
| $^{46}Ti(n,p)^{46}Sc$ | 1.25 [1] | 1.04 [1] | 1.06 [1] |
| $^{238}U(n,p)^{137}Cs$ (Cd) | 1.06 | 0.87 | N/A [2] |
| Average | 1.11 [3] | 0.91 [3] | 0.98 [3] |
| % Standard Deviation | 4.1 [3] | 4.1 [3] | 1.4 [3] |

[1] The M/C values for the $^{46}Ti$ sensors are listed but not used in the average M/C ratio due to a bias present in the SNLRML cross-section data as discussed in Section A.1.3 For additional information, these calculations were repeated using the $^{46}Ti$ dosimetry cross-section from the BUGLE-96 data library set. The results of these calculations were M/C ratios of 1 19, 1.00, and 1.02 for Capsules W-97, W-104, and W-83, respectively

[2] The cadmium-covered uranium measurement from Capsule W-83 was rejected

[3] The overall average M/C ratio for the set of 8 sensor measurements is 1.00 with an associated standard deviation of 9.6%

Table A-8

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

| Capsule ID | BE/C Ratio | |
|---|---|---|
| | $\phi(E > 1.0\ MeV)$ | dpa/s |
| W-97 | 1.12 | 1.10 |
| W-104 | 0.94 | 0.93 |
| W-83 | 0.99 | 0.99 |
| Average | 1.02 | 1.01 |
| % Standard Deviation | 9.1 | 8.6 |

## Appendix A References

A-1. Regulatory Guide RG-1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, March 2001.

A-2. TR-N-MCM-008, "Northeast Utilities Service Company Millstone Nuclear Unit No. 2 Post-Irradiation Evaluation of Reactor Vessel Surveillance Capsule W-97," S. T. Byrne, Combustion Engineering Inc., April 1982.

A-3 BAW-2142, "Analysis of Capsule W-104 Northeast Nuclear Energy Company Millstone Nuclear Power Station, Unit No. 2 - Reactor Vessel Material Surveillance Program," A. L. Lowe, Jr., et al., B&W Nuclear Service Company, November 1991.

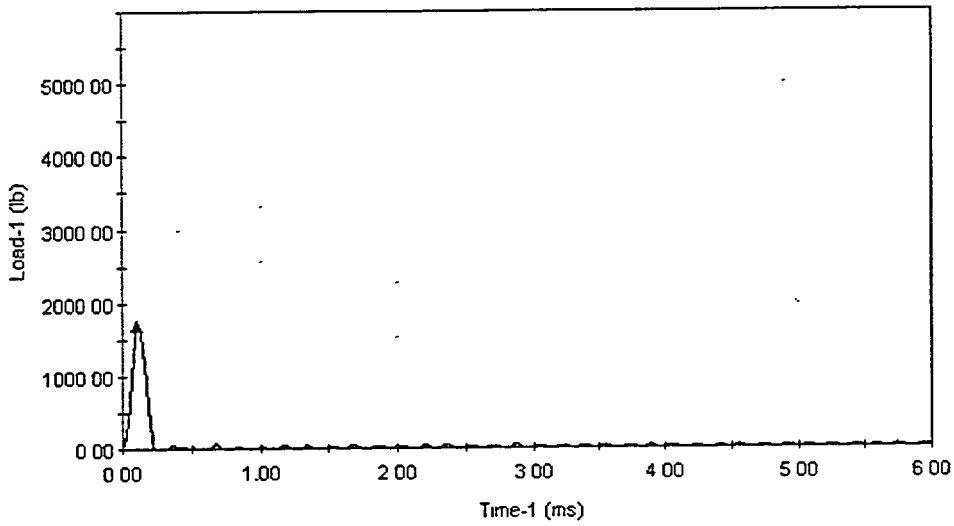
A-4. A. Schmittroth, *FERRET Data Analysis Core*, HEDL-TME 79-40, Hanford Engineering Development Laboratory, Richland, WA, September 1979.

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

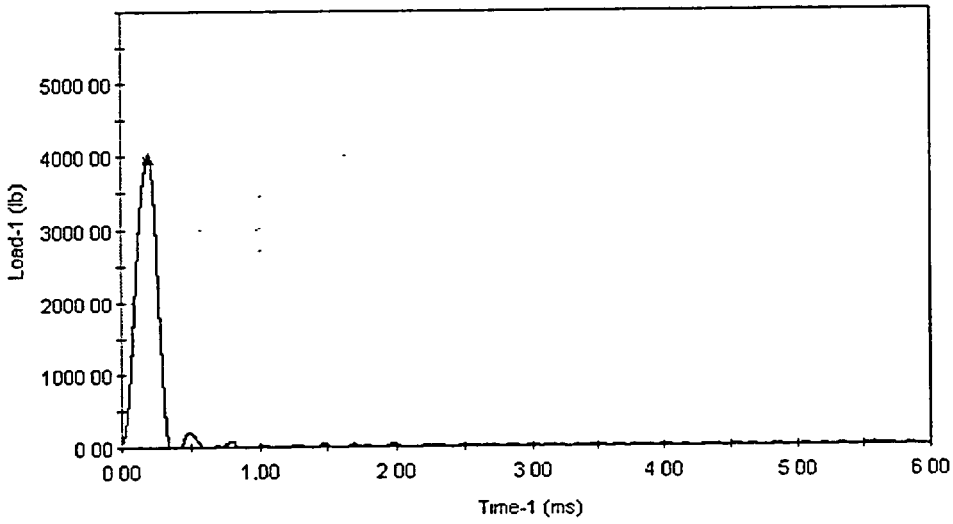
# APPENDIX B

## INSTRUMENTED CHARPY IMPACT TEST CURVES

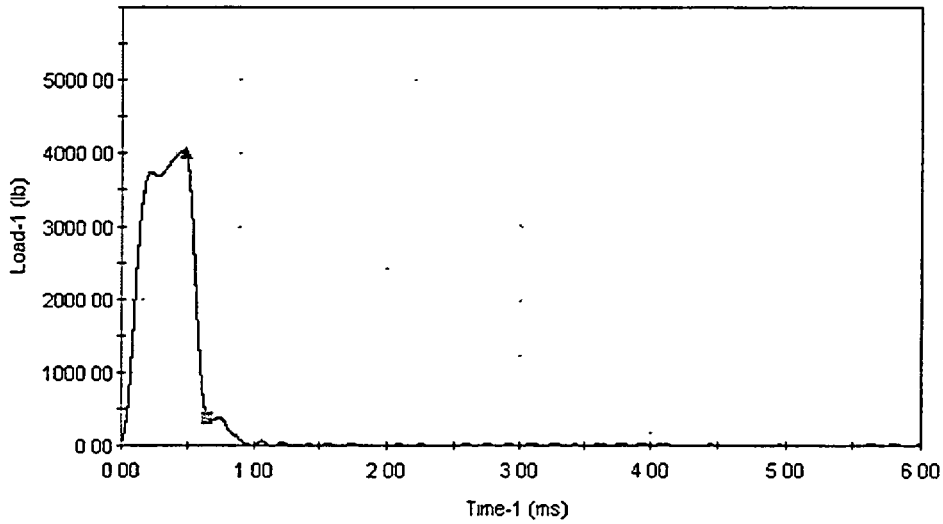
[Each of the following plots is titled as "Specimen Number, Test Temperature"]



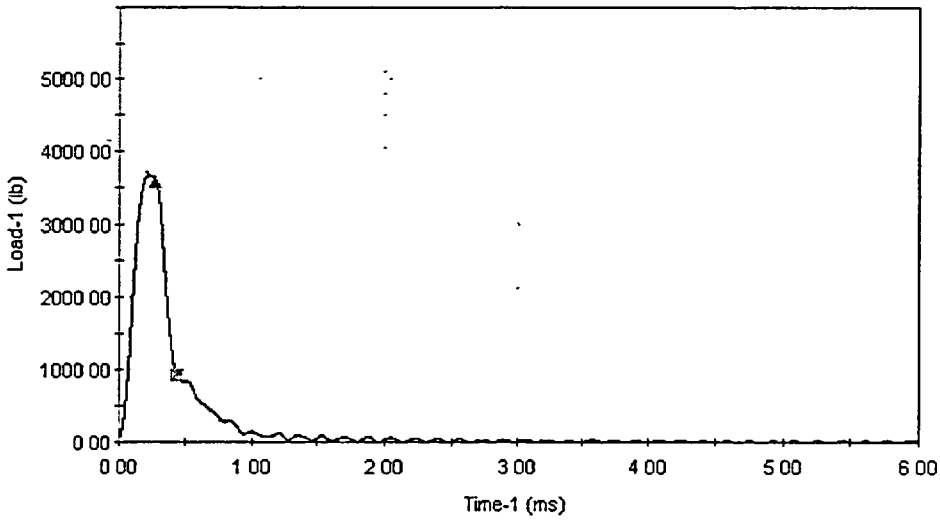

**132, 0°F**



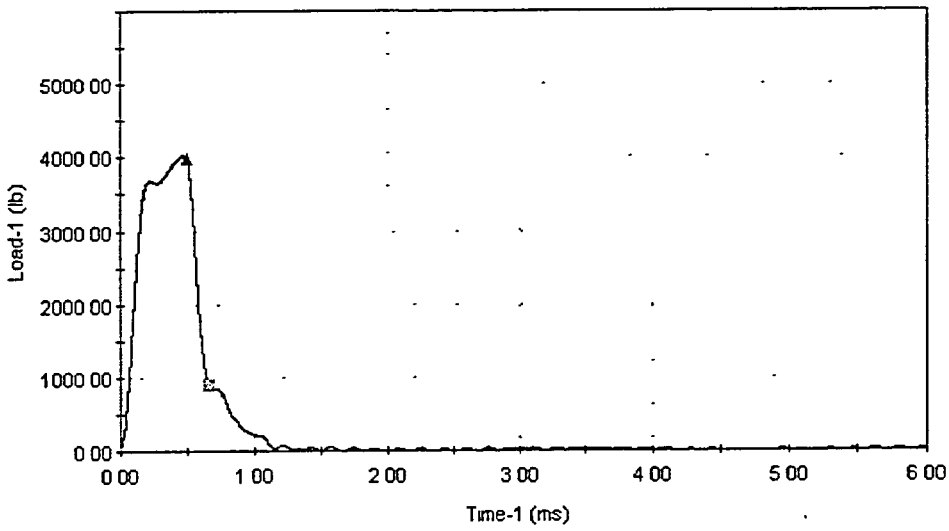

**146, 75°F**



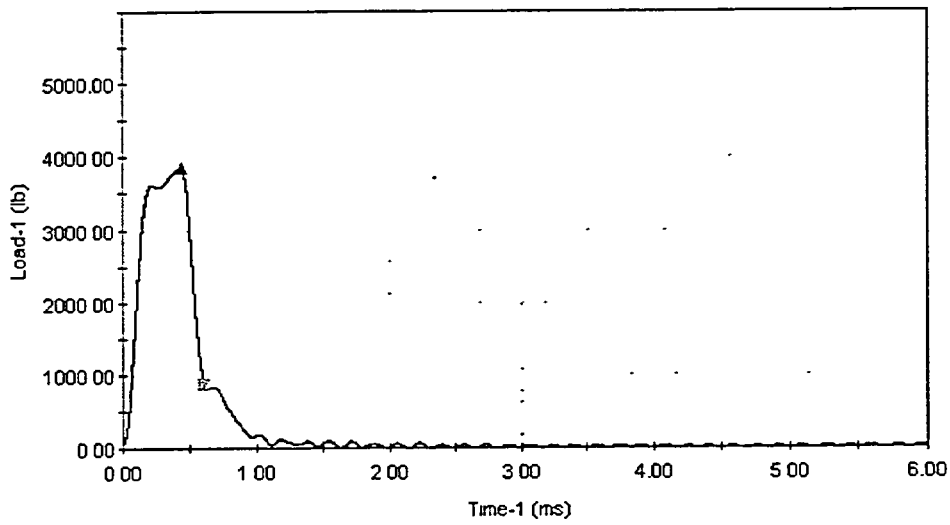

**117, 130°F**



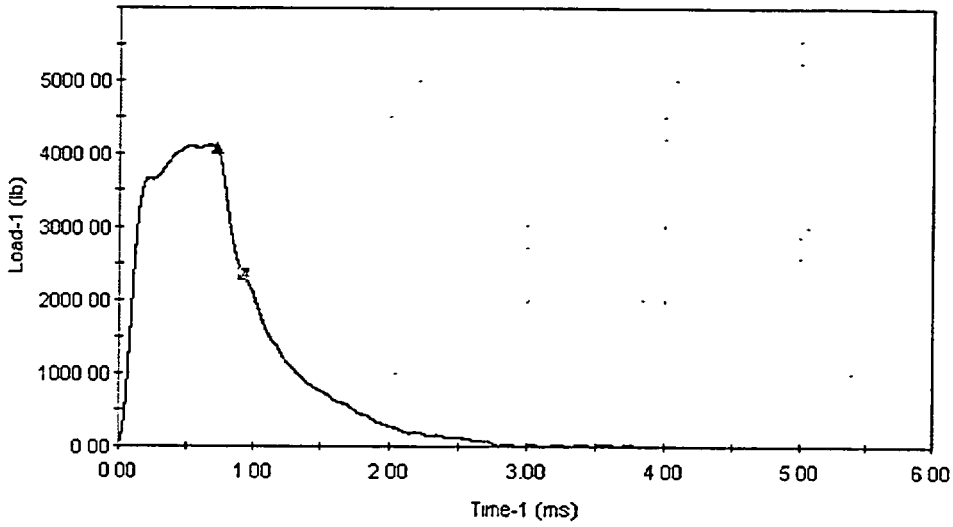

**13C, 175°F**



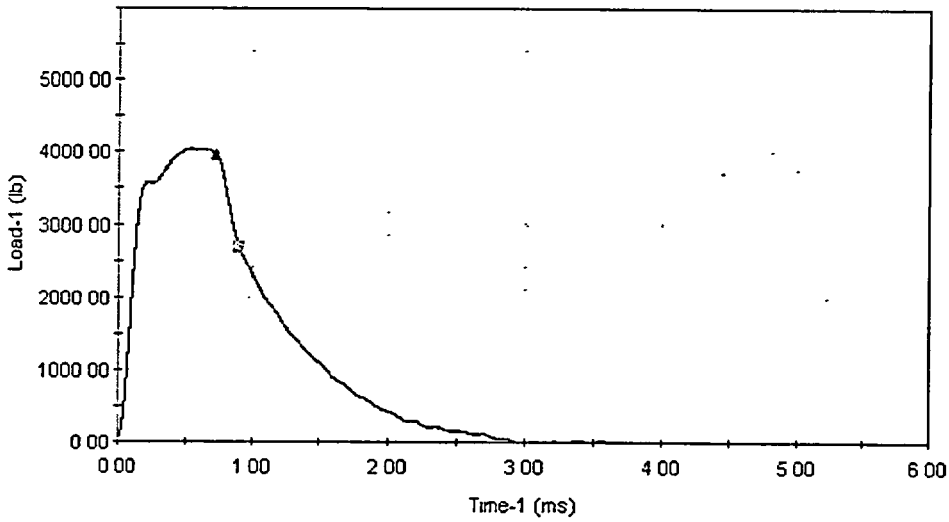

121, 175°F



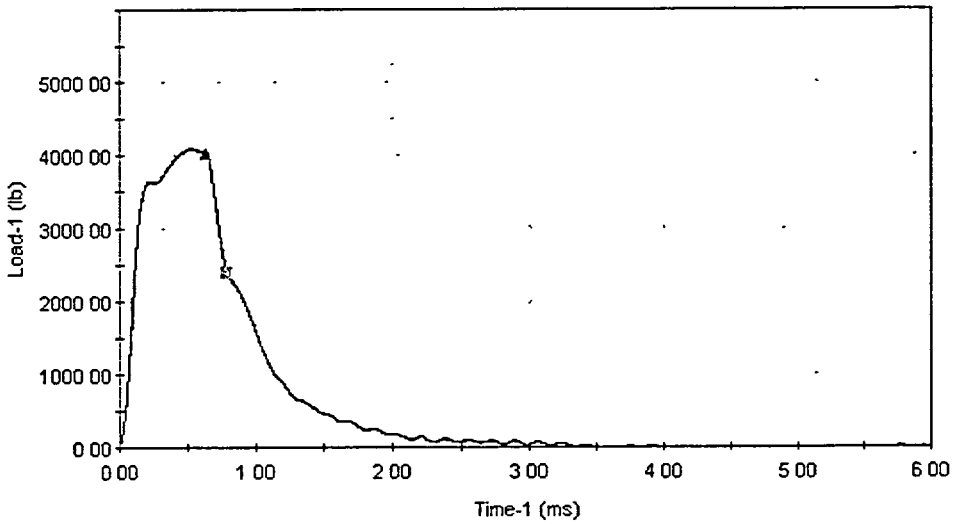

136, 200°F



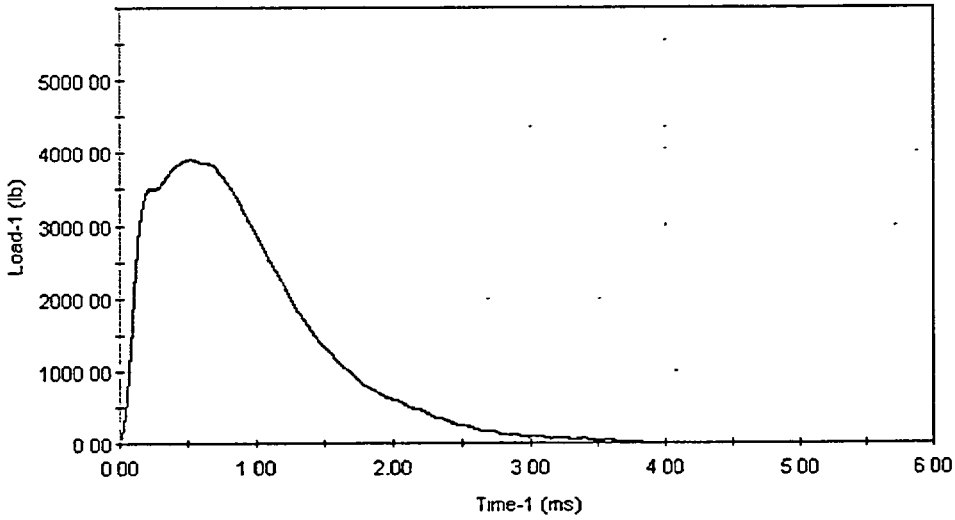

**156, 215°F**



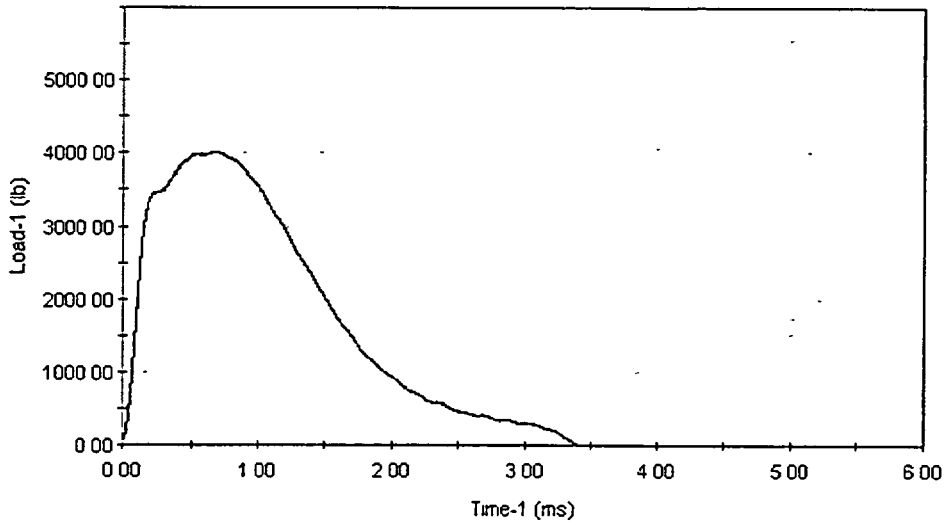

**165, 225°F**



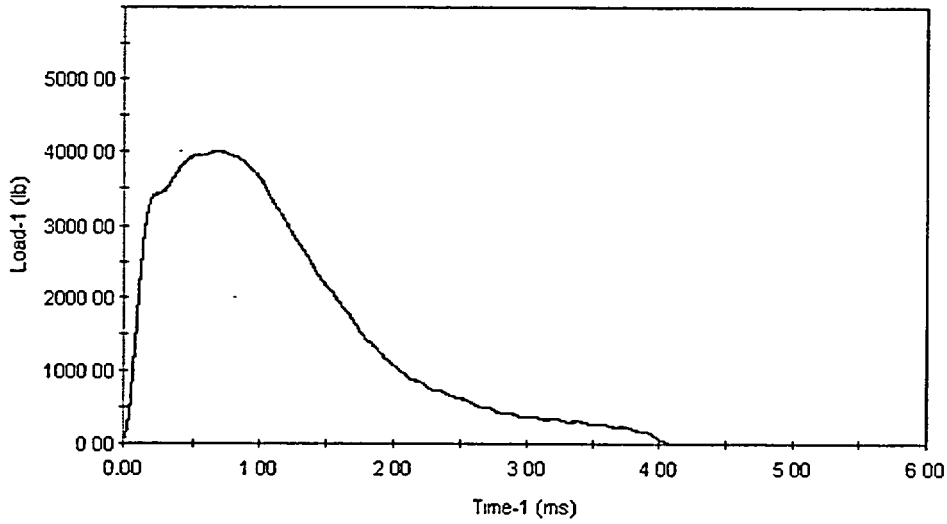

**131, 250°F**



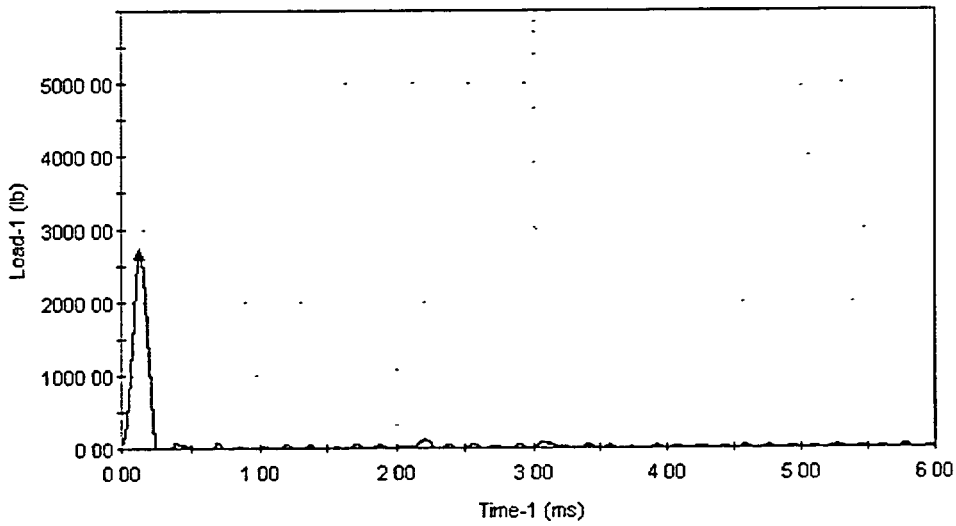

**12K, 300°F**



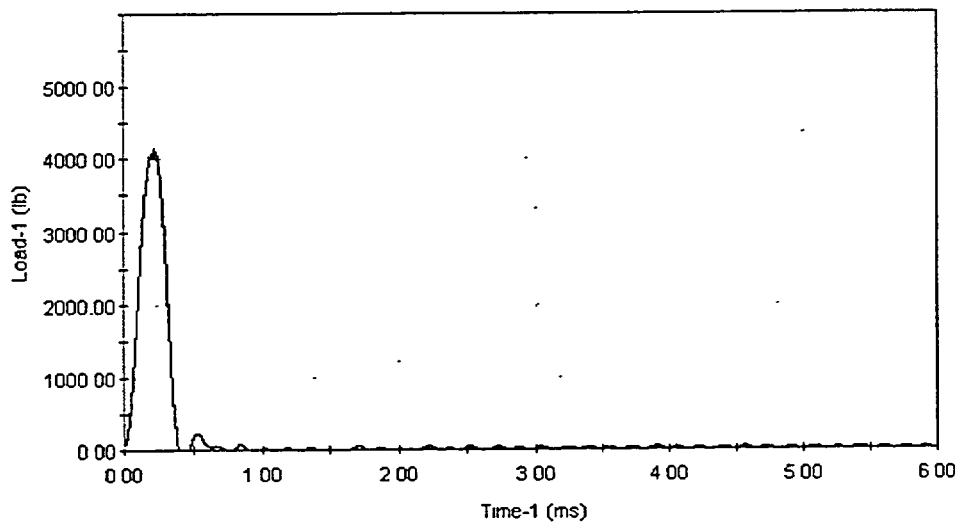

126, 325°F



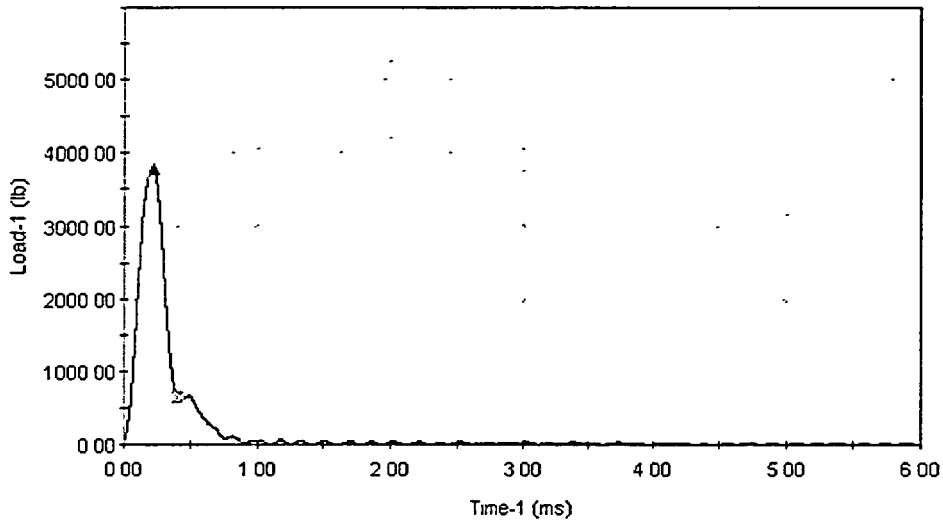

16D, 350°F



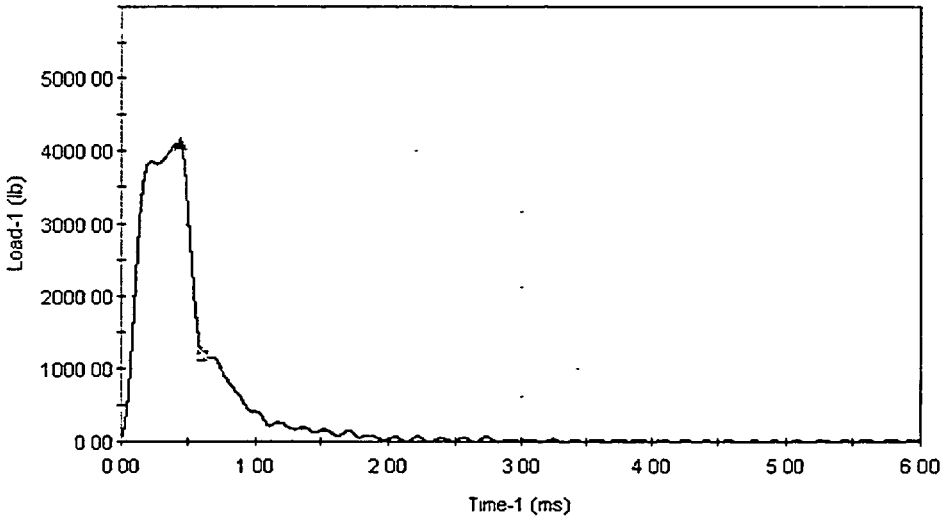

**224, 0°F**



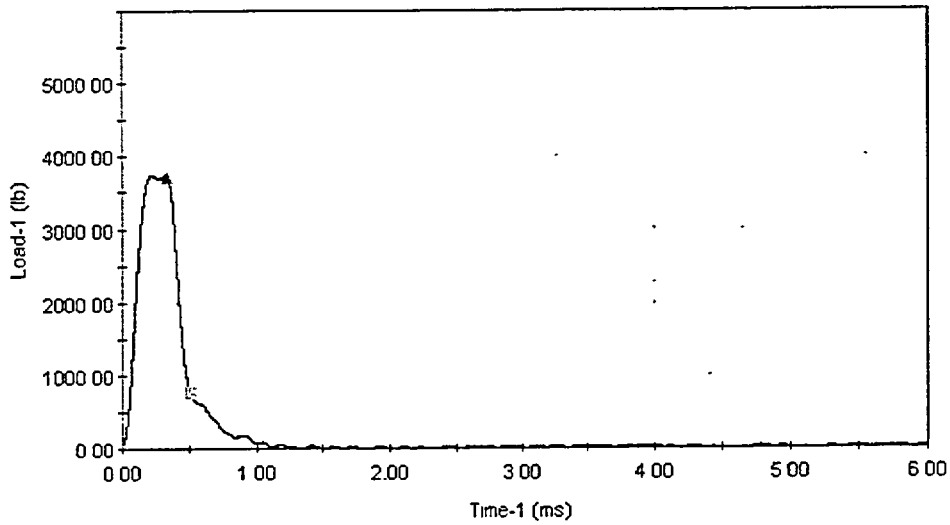

**231, 75°F**



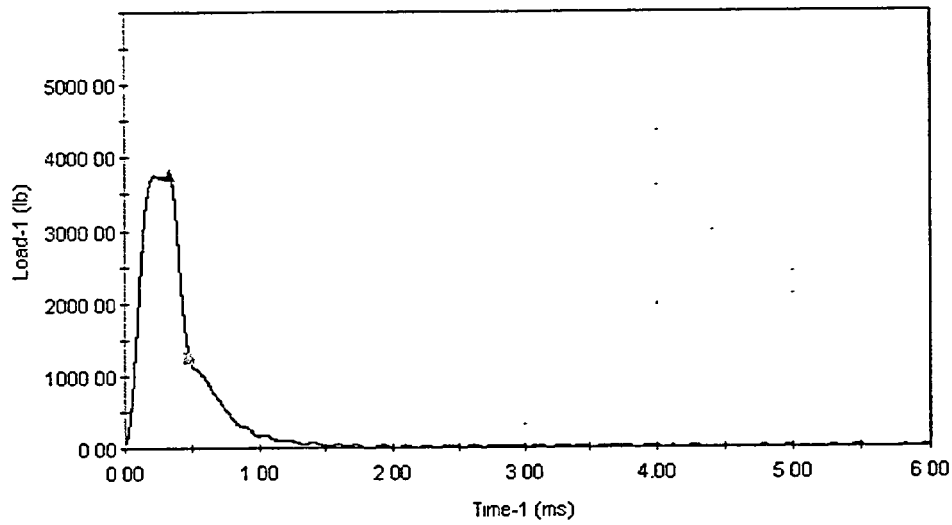

**21L, 130°F**



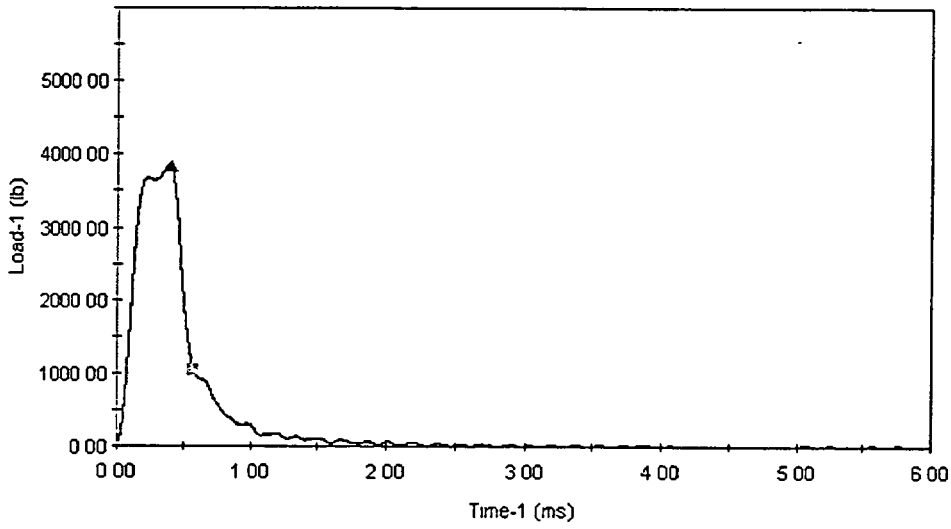

**253, 150°F**



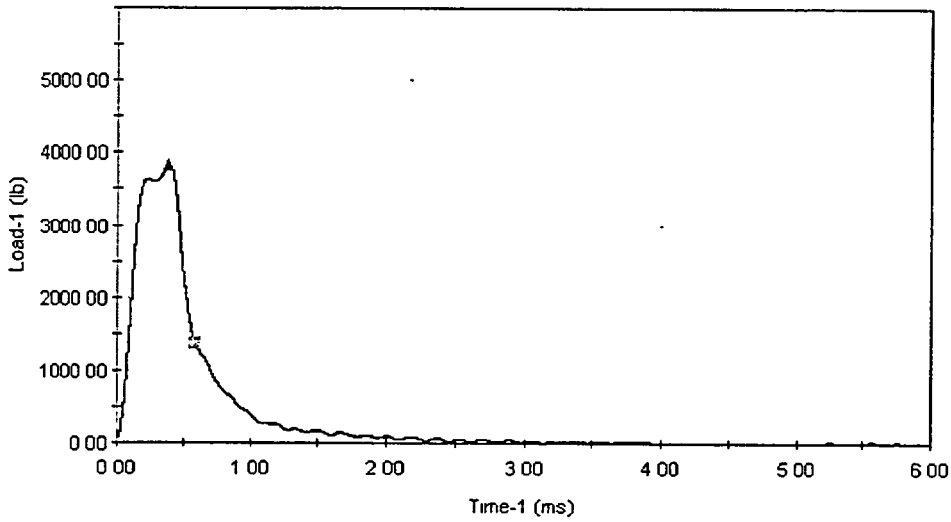

**213, 150°F**



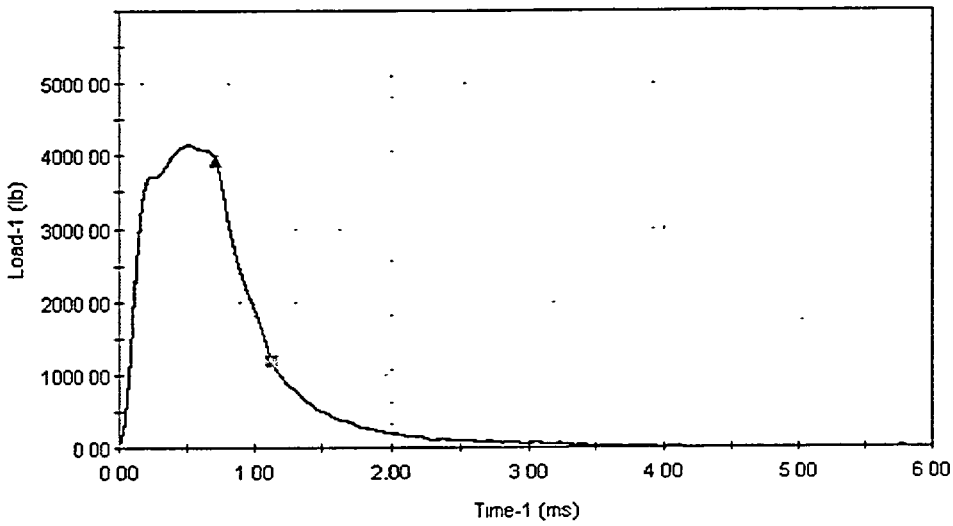

**245, 175°F**



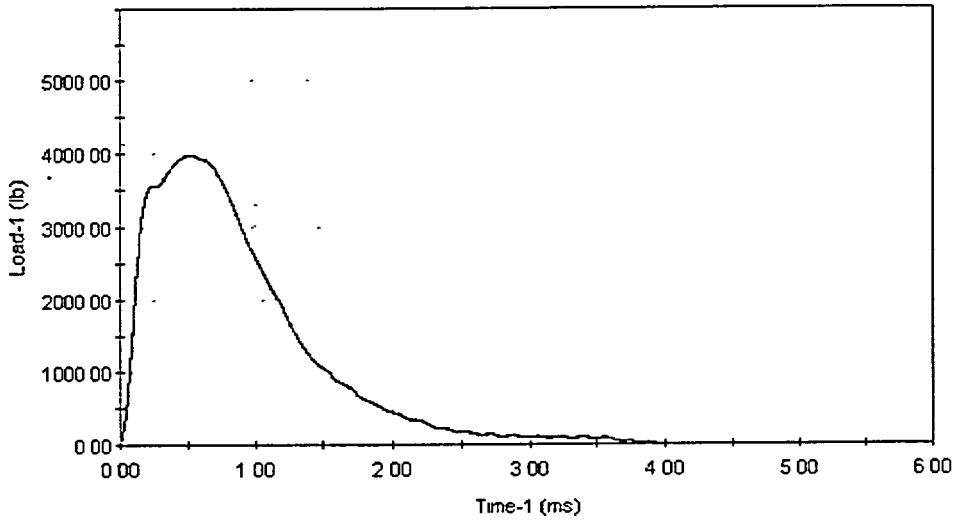

**212, 175°F**



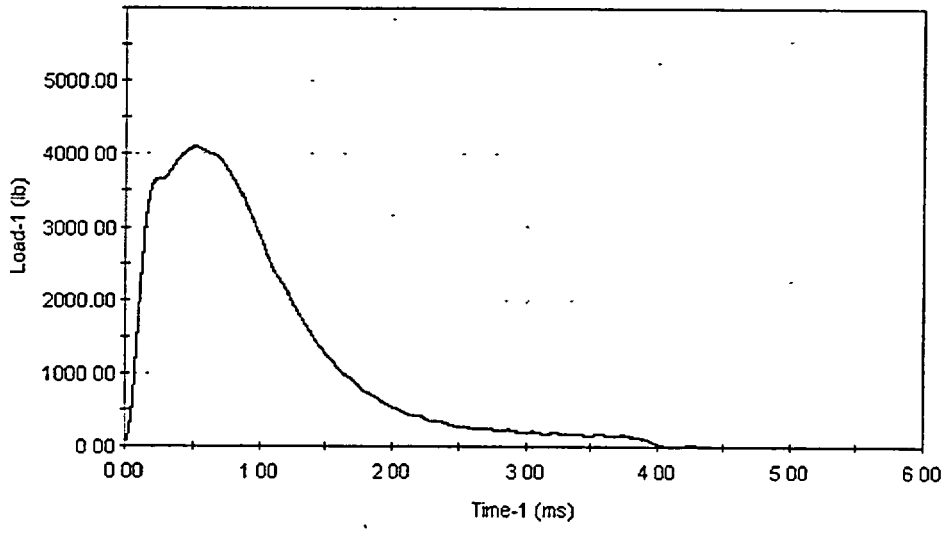

**211, 200°F**



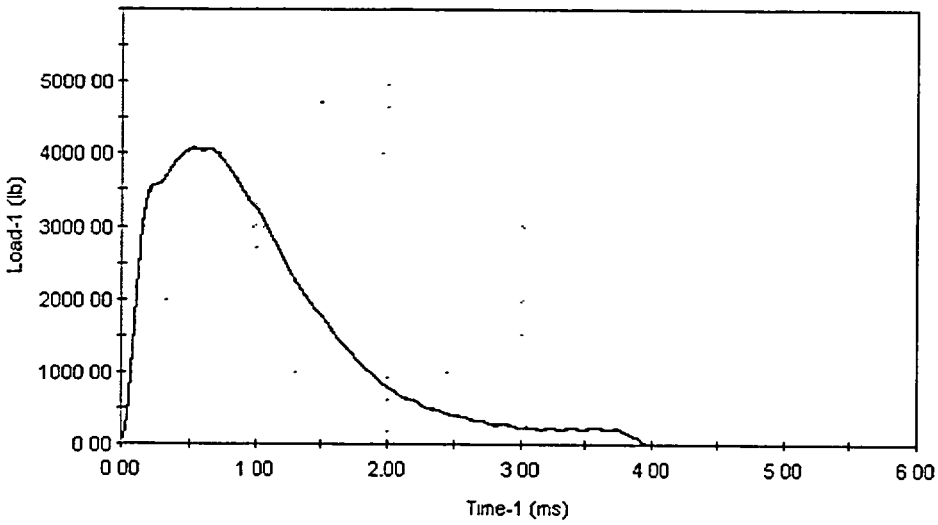

**23L, 225°F**



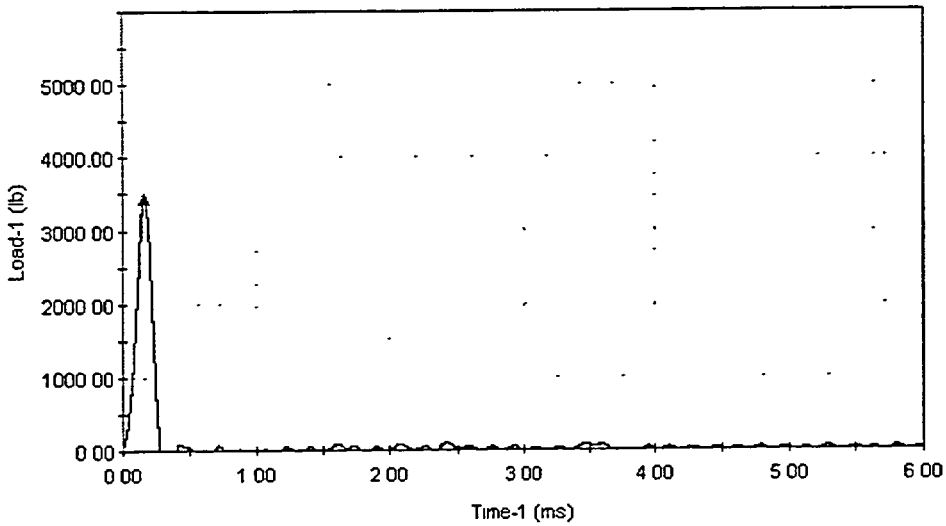

**214, 275°F**



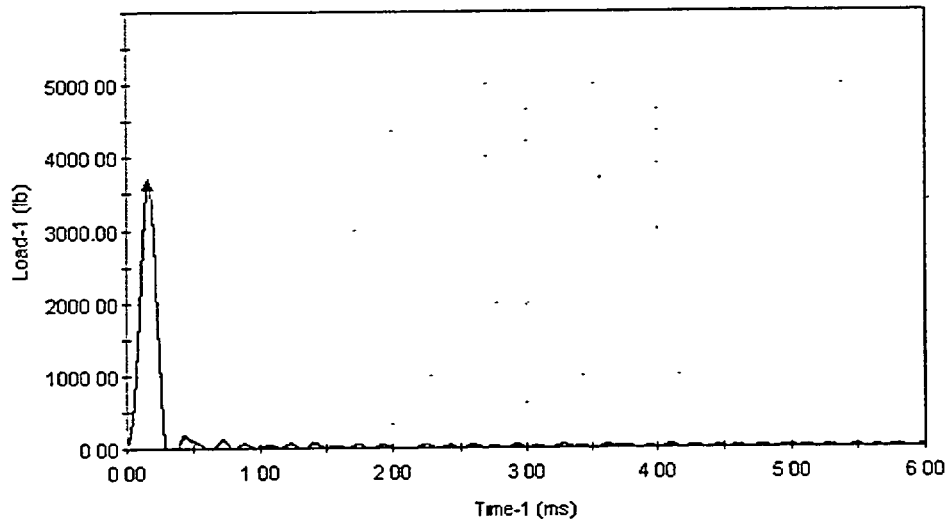

24K, 300°F



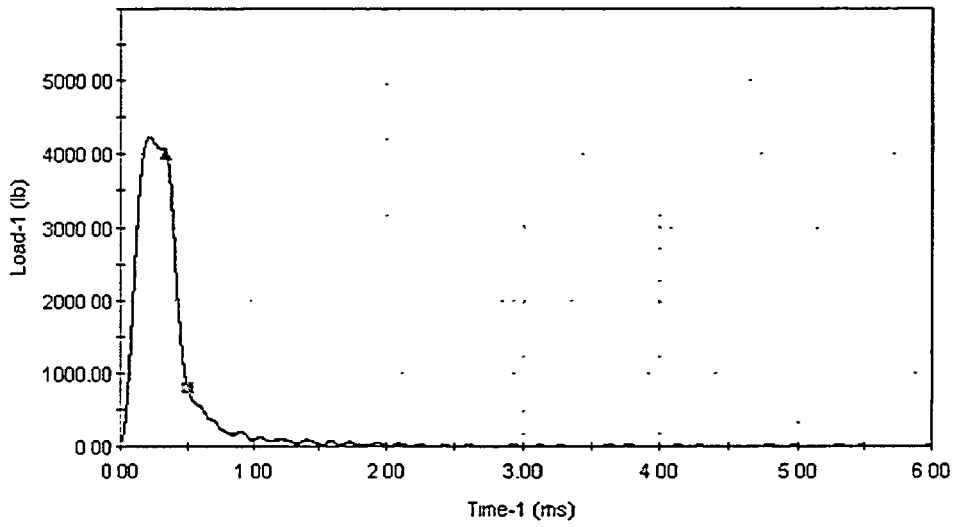

22A, 325°F



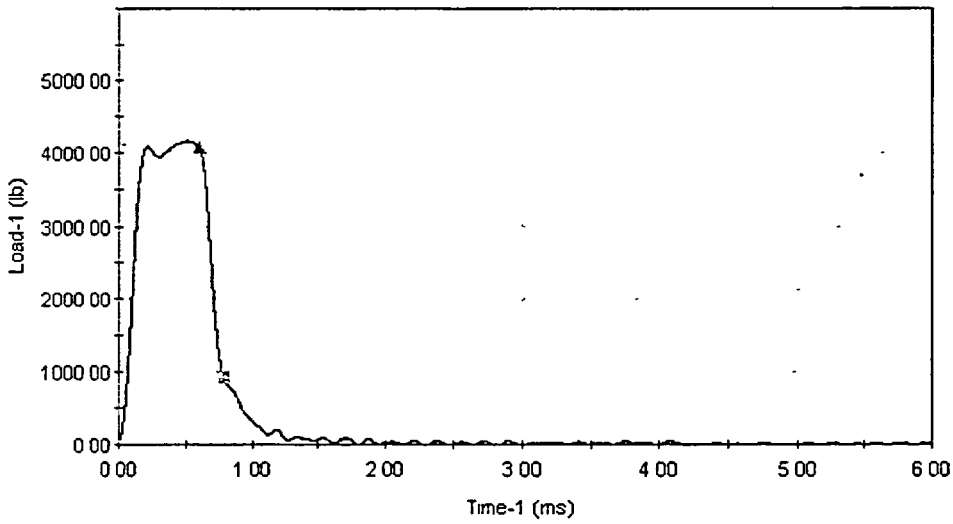

314, -50°F



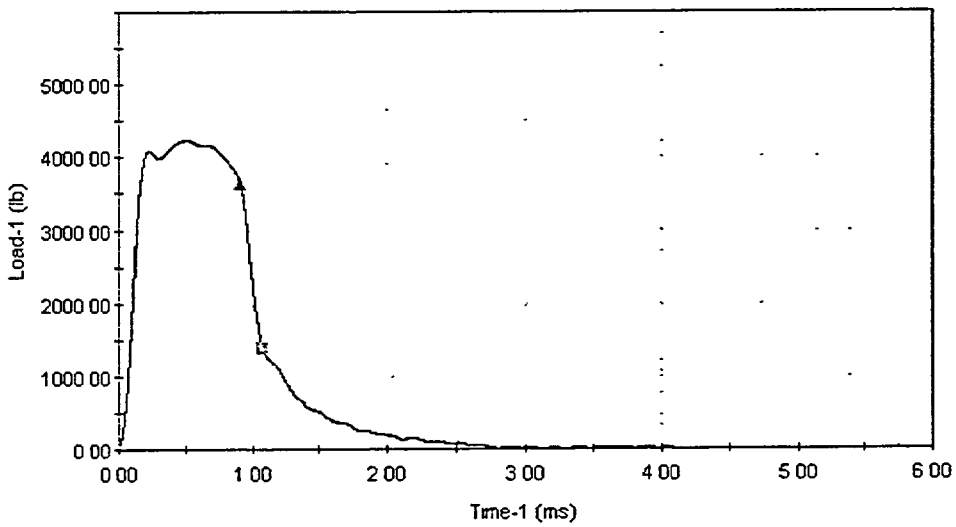

33K, 0°F



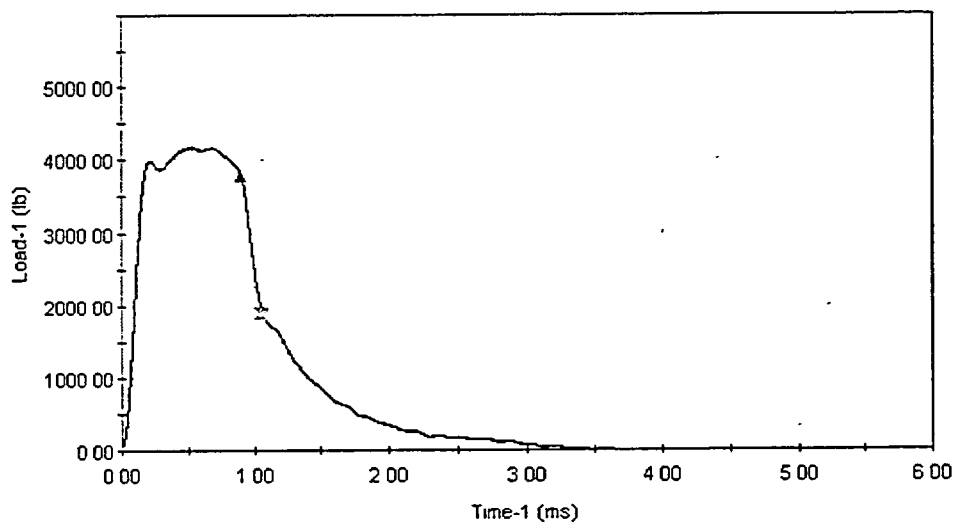

**34L, 30°F**



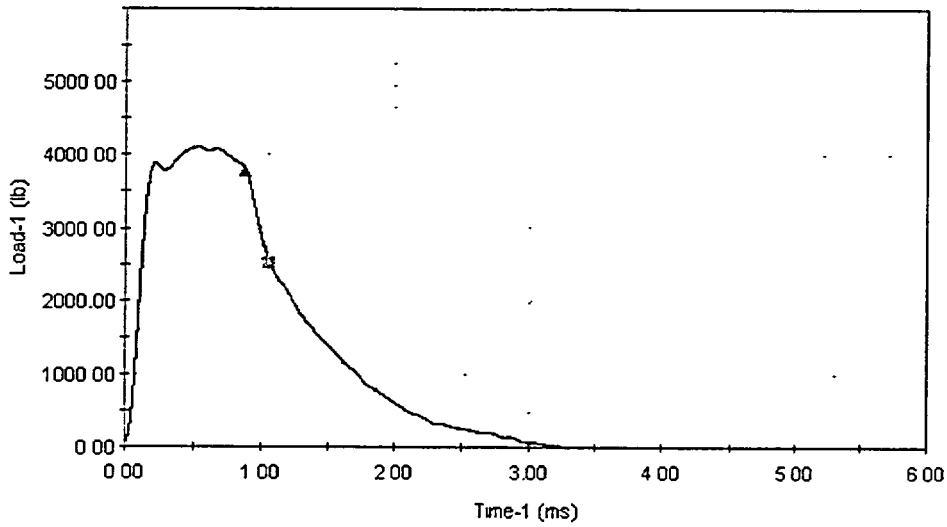

**311, 50°F**



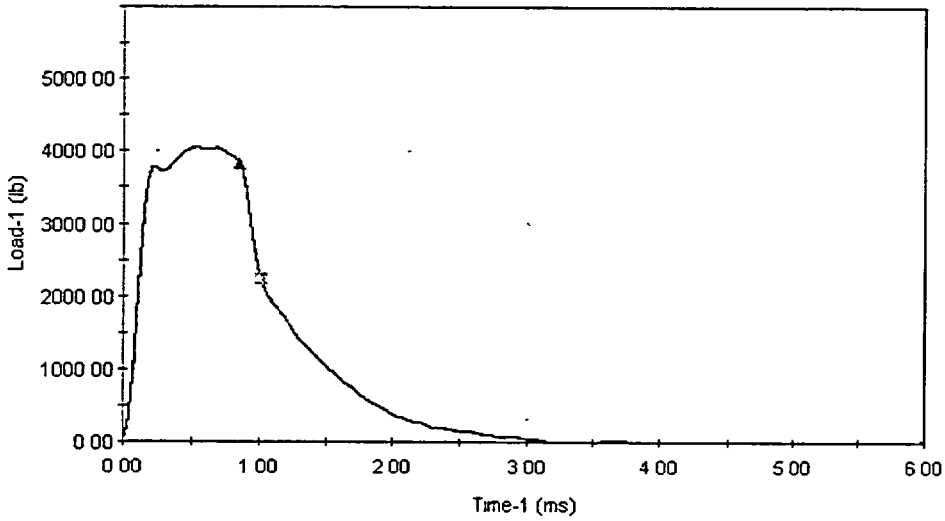

32A, 75°F



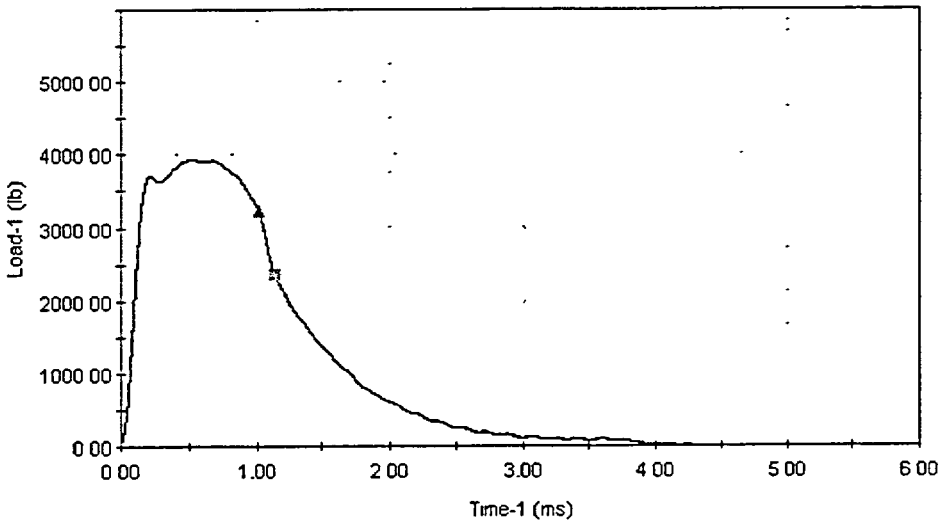

36D, 100°F



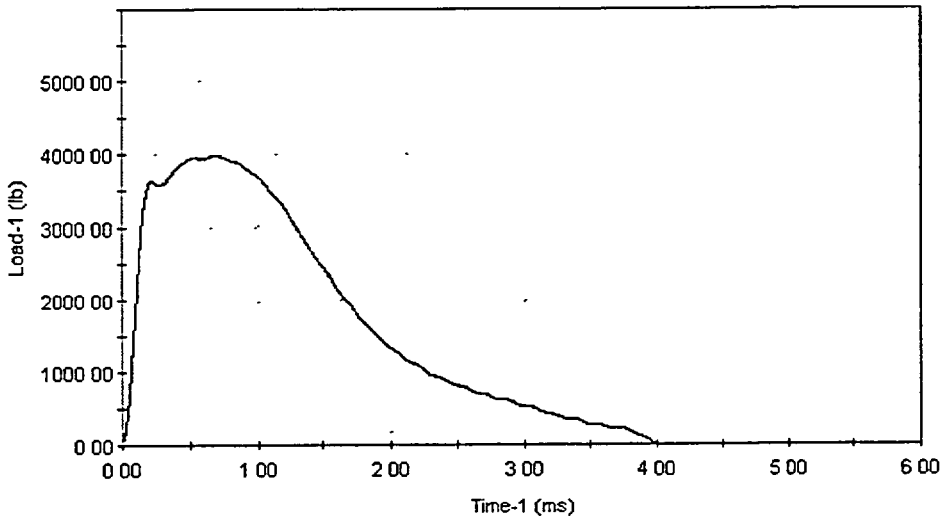

36E, 125°F



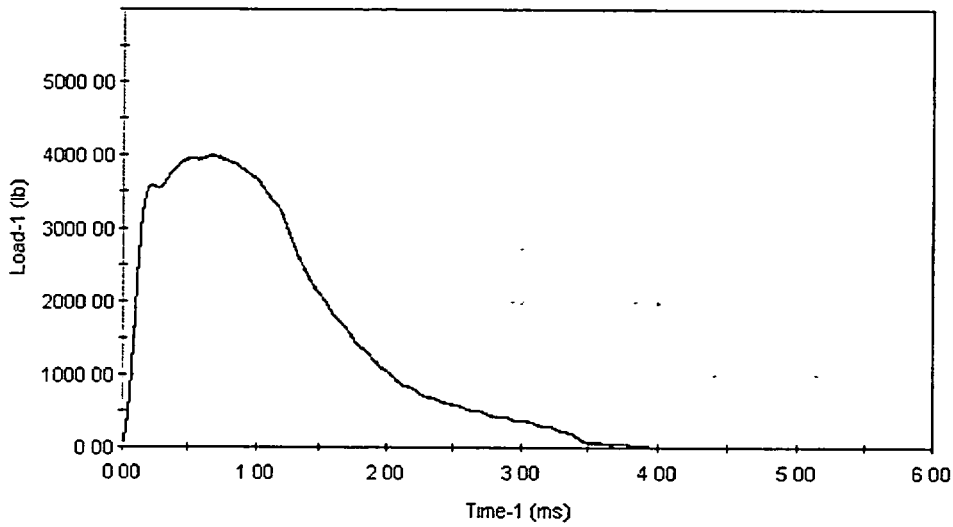

34C, 150°F



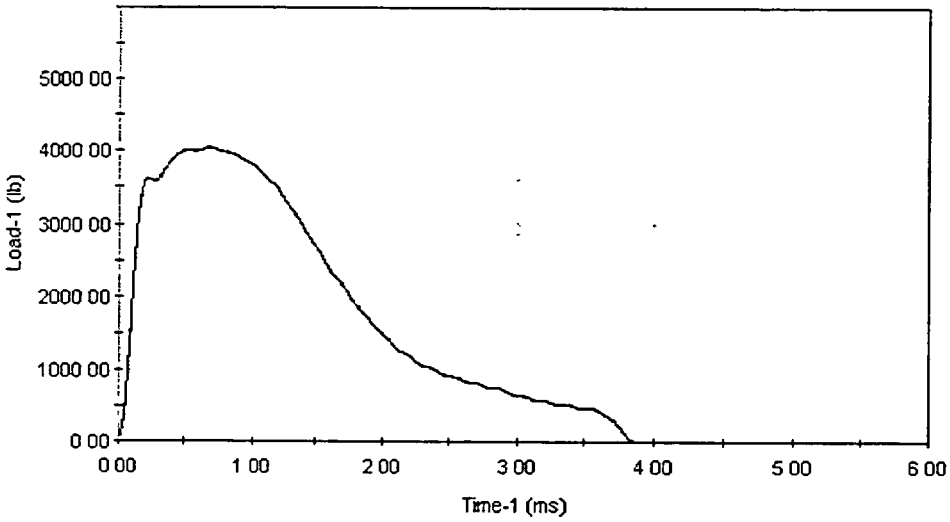

337, 200°F



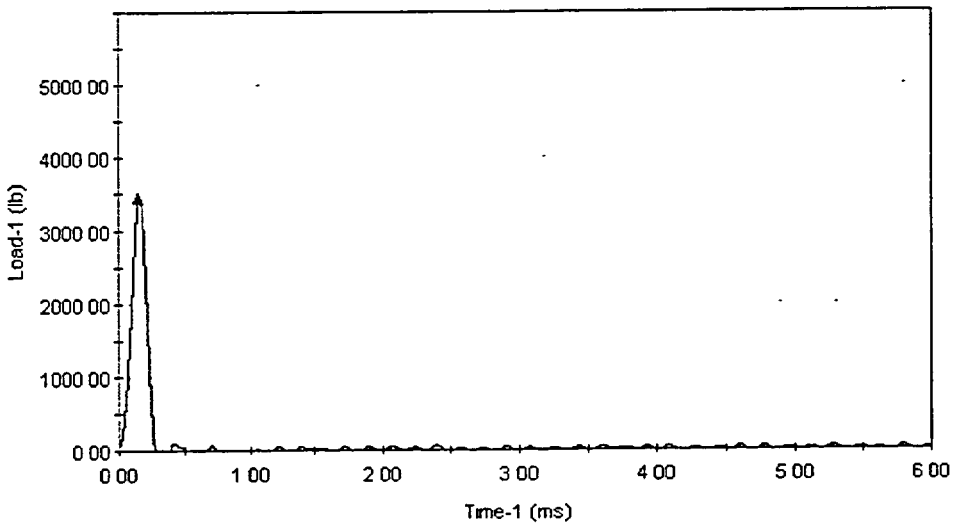

323, 225°F



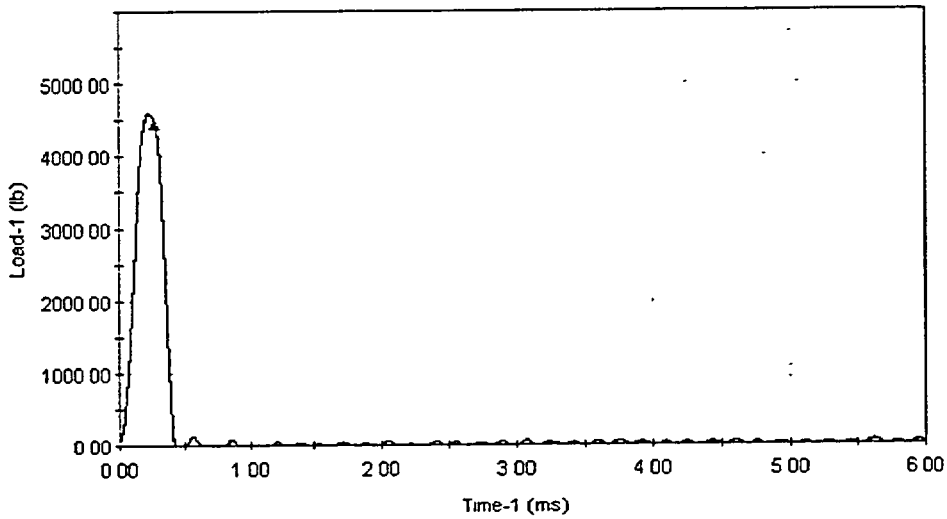

**336, 250°F**



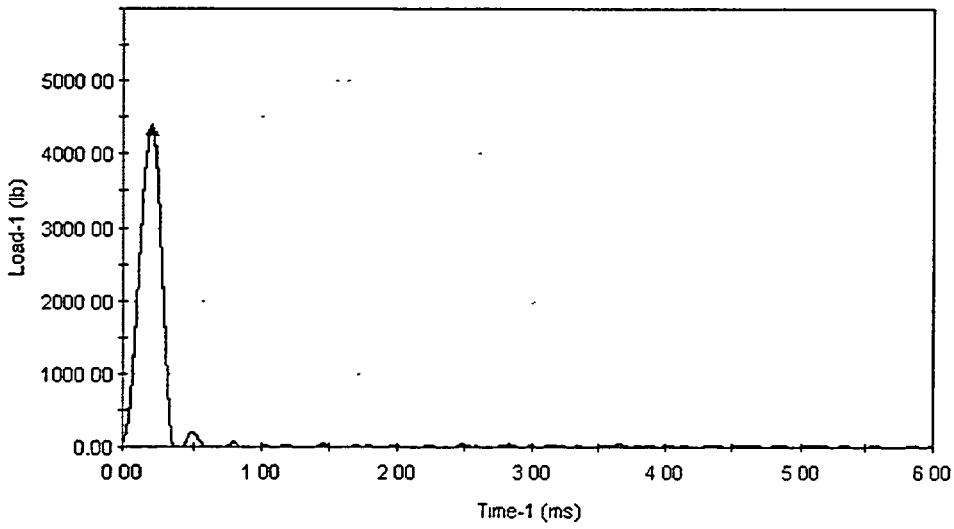

**312, 250°F**



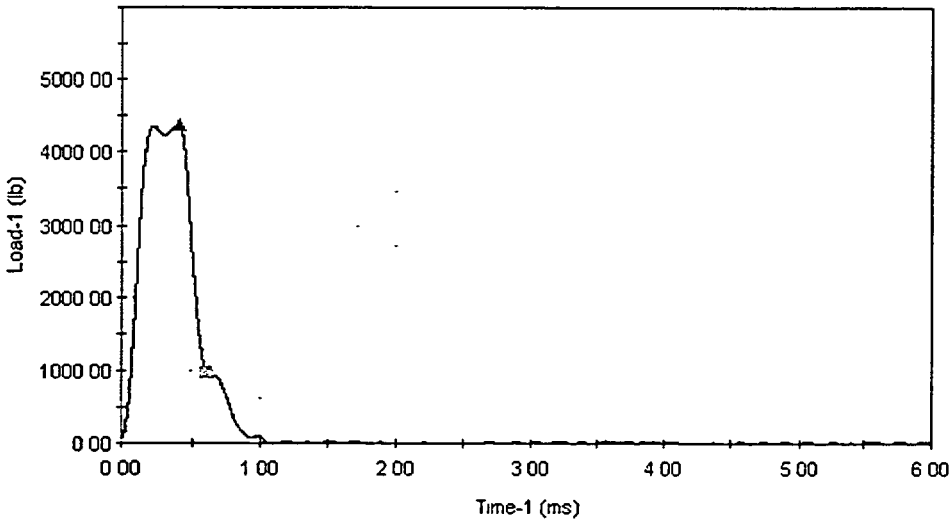

42T, -75°F



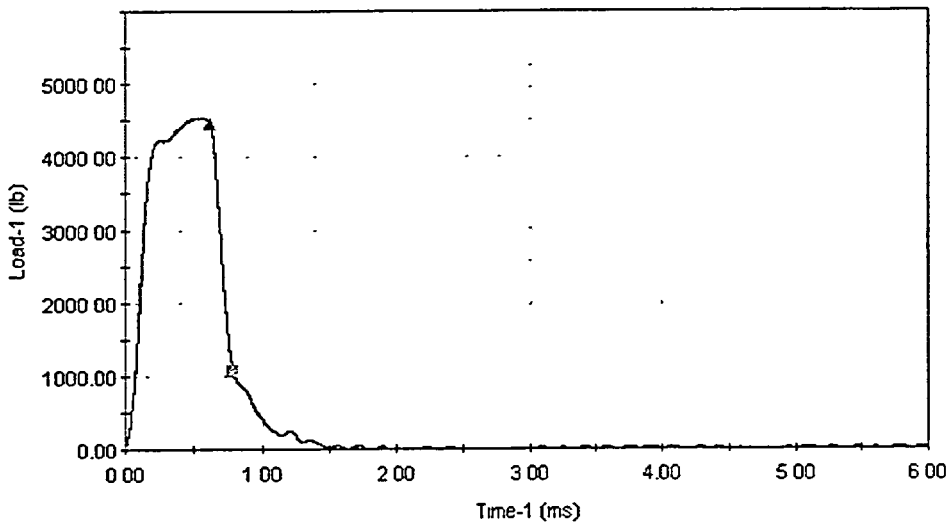

46E, -25°F



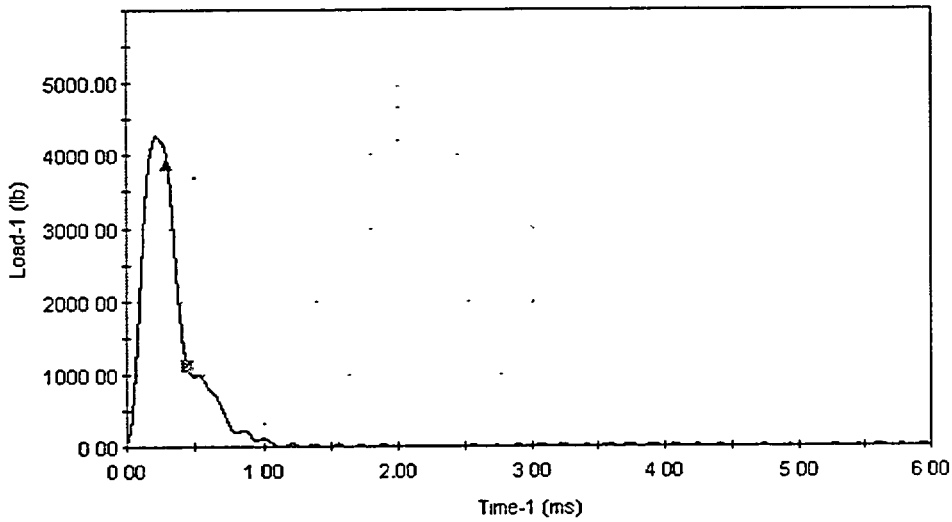

42P, 0°F



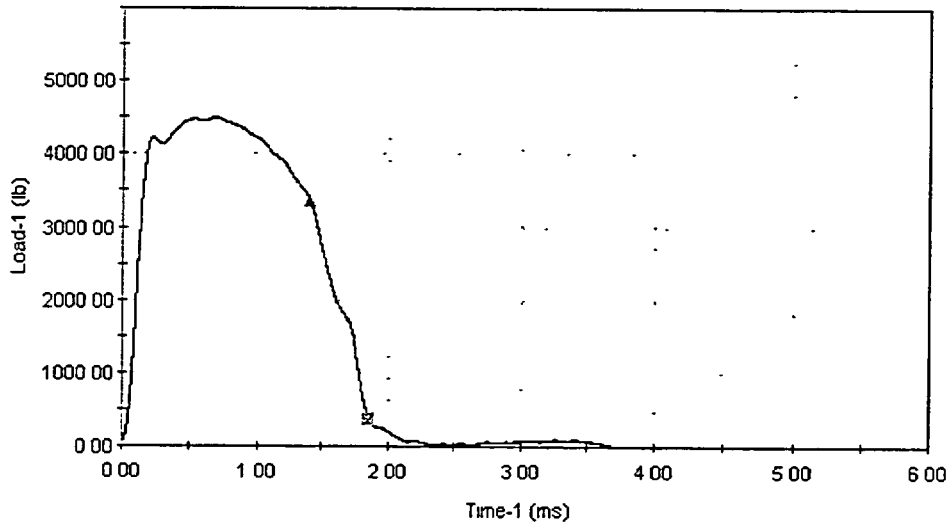

41E, 25°F



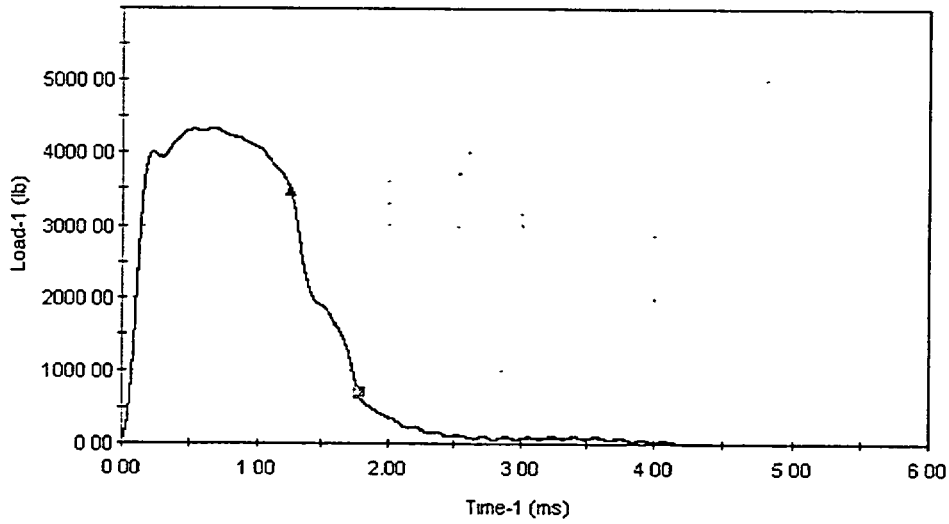

**41T, 50°F**



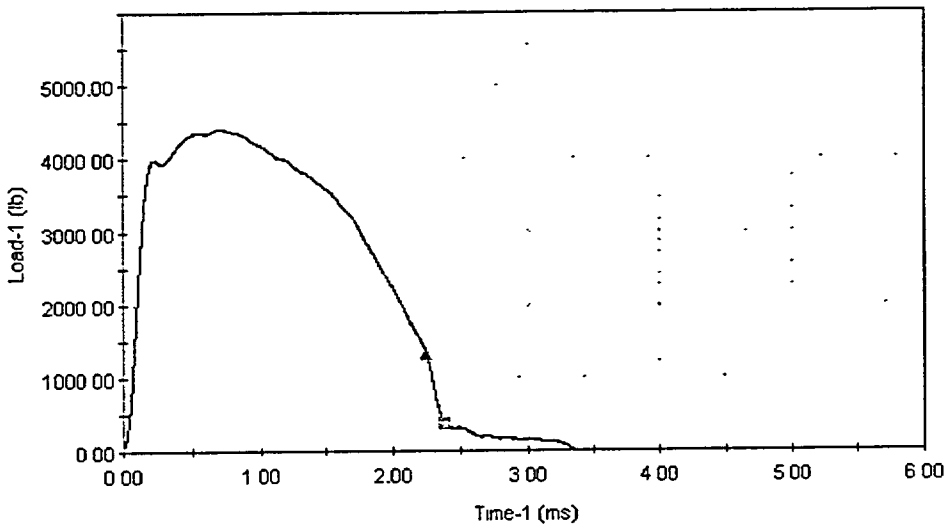

**42U, 75°F**



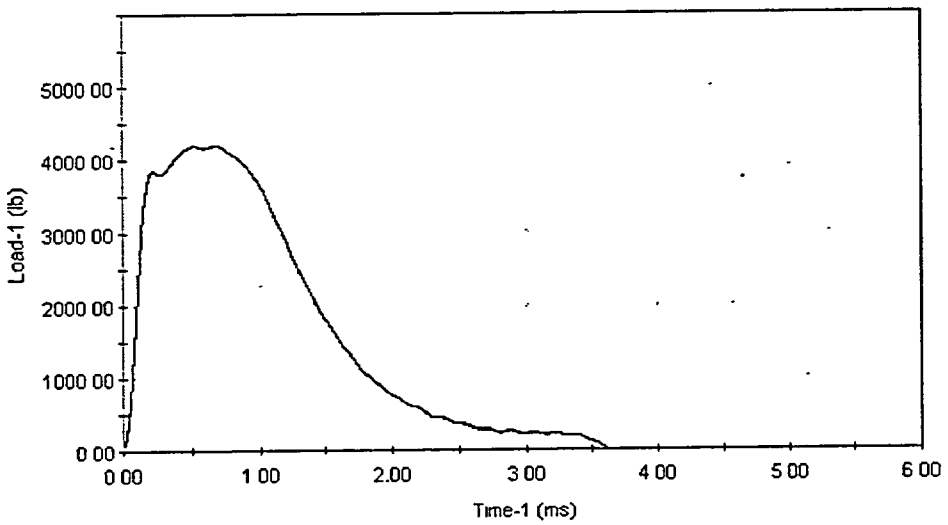

**427, 100°F**



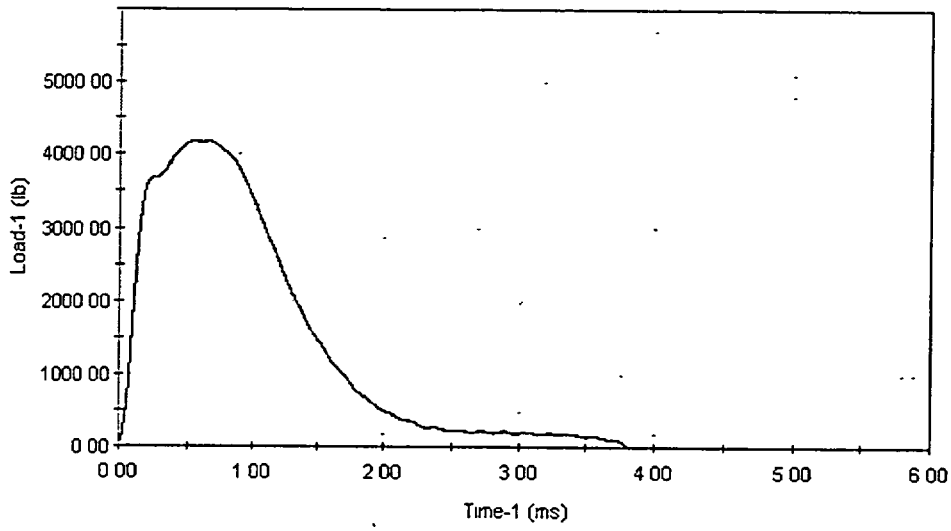

**43K, 150°F**



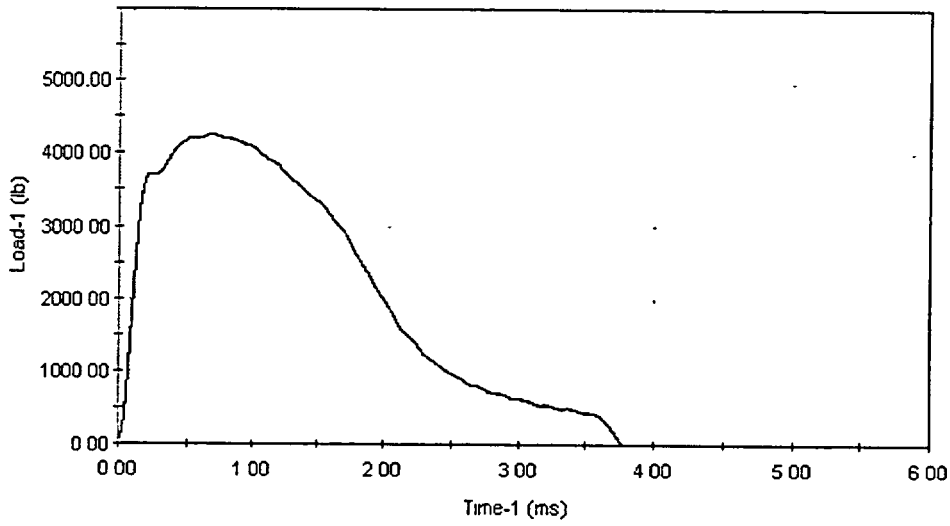

**41U, 200°F**




**46B, 250°F**




**45K, 300°F**




**44C, 325°F**

# APPENDIX C

## CHARPY V-NOTCH PLOTS FOR EACH CAPSULE

## USING HYPERBOLIC TANGENT CURVE-FITTING METHOG

# LOWER SHELL PLATE C-506-1 UNIRR (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:21:01 on 10-10-2002

Page 1

Coefficients of Curve 1

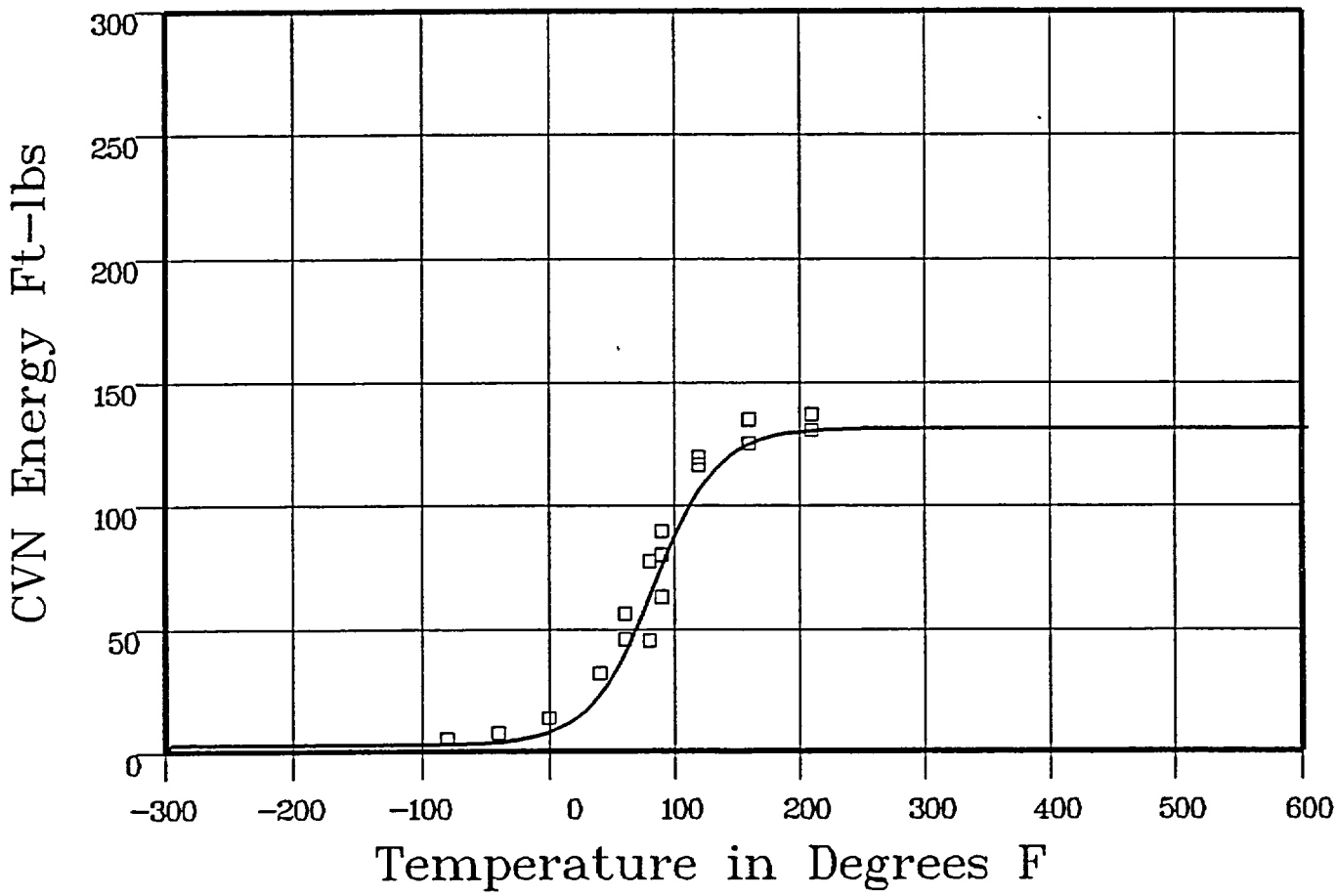
| A = 66.59 | B = 64.4 | C = 52.79 | T0 = 78.28 |
|---|---|---|---|

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

Upper Shelf Energy: 131 Fixed  Temp. at 30 ft-lbs: 44.2  Temp. at 50 ft-lbs: 64.3  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: LT

Capsule: UNIRR  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap.: UNIRR  Material: PLATE SA533B1  Ori: LT  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -80 | 4.5 | 2.51 | 1.98 |
| -40 | 7 | 3.64 | 3.35 |
| 0 | 13.5 | 8.51 | 4.98 |
| 40 | 32 | 26.66 | 5.33 |
| 60 | 45.5 | 45.15 | .34 |
| 60 | 56 | 45.15 | 10.84 |
| 80 | 45 | 68.69 | -23.69 |
| 80 | 77 | 68.69 | 8.3 |
| 90 | 79.5 | 80.66 | -1.16 |

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

# LOWER SHELL PLATE C-506-1 UNIRR (LONG)



Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 90 | 89 | 80.66 | 8.33 |
| 90 | 62.5 | 80.66 | -18.16 |
| 120 | 119 | 109 | 9.99 |
| 120 | 116 | 109 | 6.99 |
| 160 | 124.5 | 125.42 | -.92 |
| 160 | 134.5 | 125.42 | 9.07 |
| 210 | 130 | 130.12 | -.12 |
| 210 | 136.5 | 130.12 | 6.37 |

SUM of RESIDUALS = 31.84

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:21:01 on 10-10-2002

Page 1

Coefficients of Curve 2

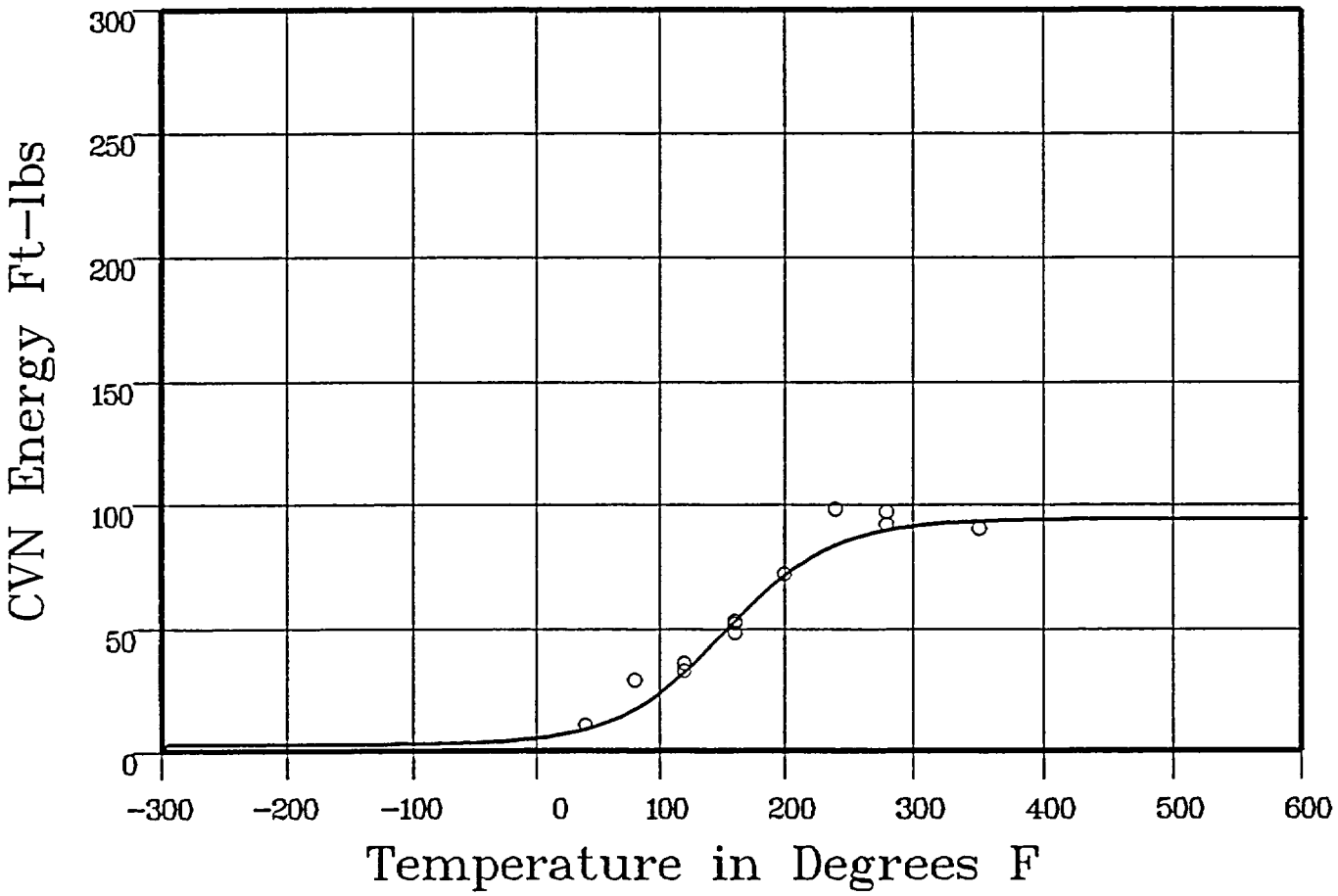
| A = 48.09 | B = 45.9 | C = 87.56 | T0 = 146.48 |
|---|---|---|---|

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

Upper Shelf Energy: 94 Fixed  Temp. at 30 ft-lbs: 109.9  Temp. at 50 ft-lbs: 150.1  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: LT

Capsule: W-97  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: W-97  Material: PLATE SA533B1  Ori: LT  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 40 | 11 | 9.61 | 1.38 |
| 80 | 29 | 18.69 | 10.3 |
| 120 | 33 | 34.62 | -1.62 |
| 120 | 36 | 34.62 | 1.37 |
| 160 | 53 | 55.12 | -2.12 |
| 160 | 52 | 55.12 | -3.12 |
| 160 | 48 | 55.12 | -7.12 |
| 200 | 72 | 73.11 | -1.11 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 240 | 98 | 84.3 | 13.69 |
| 280 | 97 | 89.84 | 7.15 |
| 280 | 92 | 89.84 | 2.15 |
| 350 | 90 | 93.12 | -3.12 |

SUM of RESIDUALS = 17.81

# LOWER SHELL PLATE C-506-1 CAPSULE 104 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:21:01 on 10-10-2002

Page 1

Coefficients of Curve 3

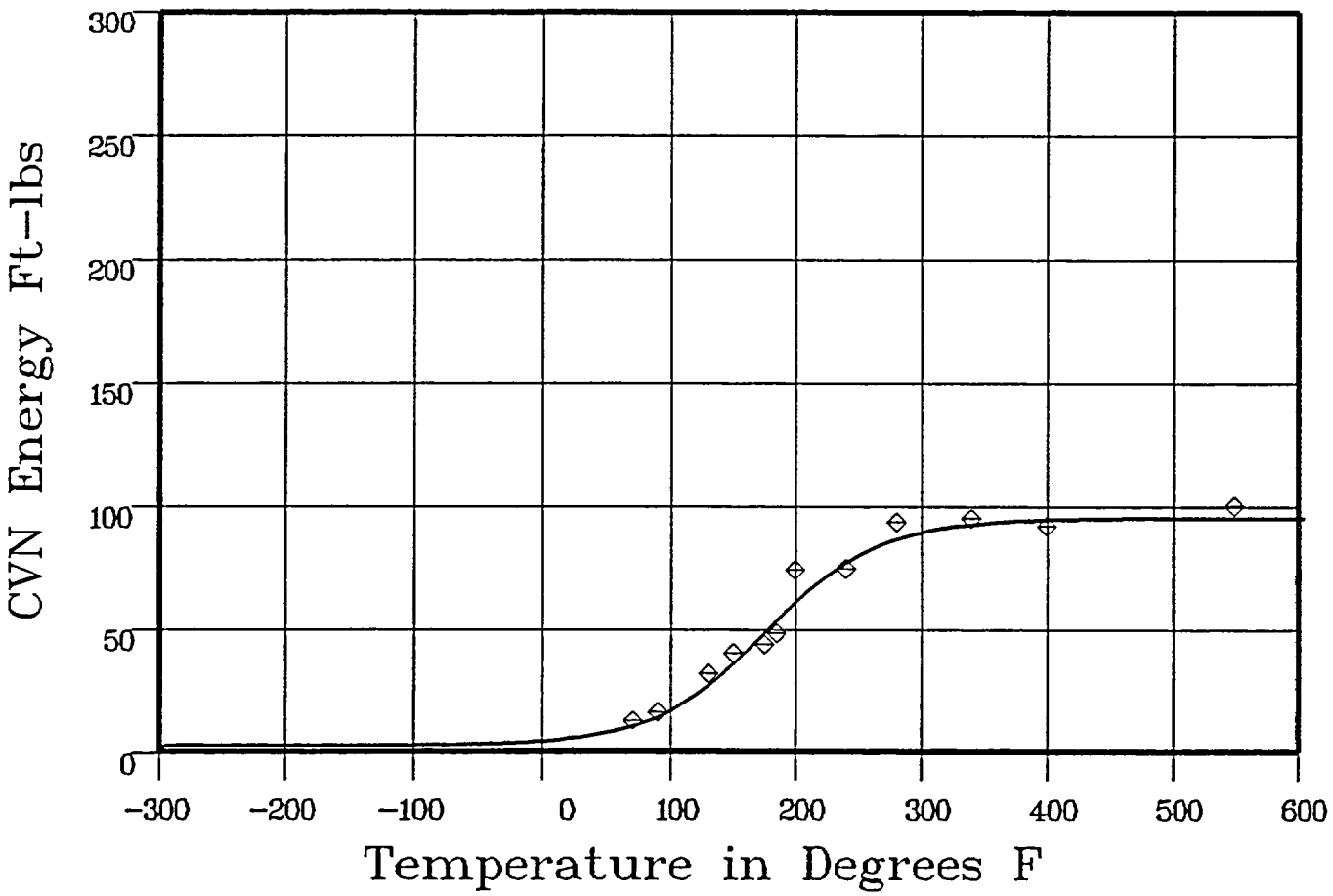
| A = 48.59 | B = 46.4 | C = 91.59 | T0 = 170.8 |
|---|---|---|---|

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

Upper Shelf Energy: 95 Fixed  Temp. at 30 ft-lbs: 131.9  Temp. at 50 ft-lbs: 173.5  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: LT

Capsule: W-104  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: W-104  Material: PLATE SA533B1  Ori: LT  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 70 | 13 | 11.44 | 1.55 |
| 90 | 16.5 | 15.77 | .72 |
| 130 | 32 | 29.19 | 2.8 |
| 150 | 40 | 38.24 | 1.75 |
| 175 | 43.5 | 50.72 | -7.22 |
| 185 | 48 | 55.73 | -7.73 |
| 200 | 74 | 62.91 | 11.08 |
| 240 | 74.5 | 78.22 | -3.72 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 104 (LONG)



Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 280 | 93.5 | 87.17 | 6.32 |
| 340 | 95 | 92.74 | 2.25 |
| 400 | 92 | 94.38 | -2.38 |
| 550 | 100 | 94.97 | 5.02 |

SUM of RESIDUALS = 10.46

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:21:01 on 10-10-2002

Page 1

Coefficients of Curve 4

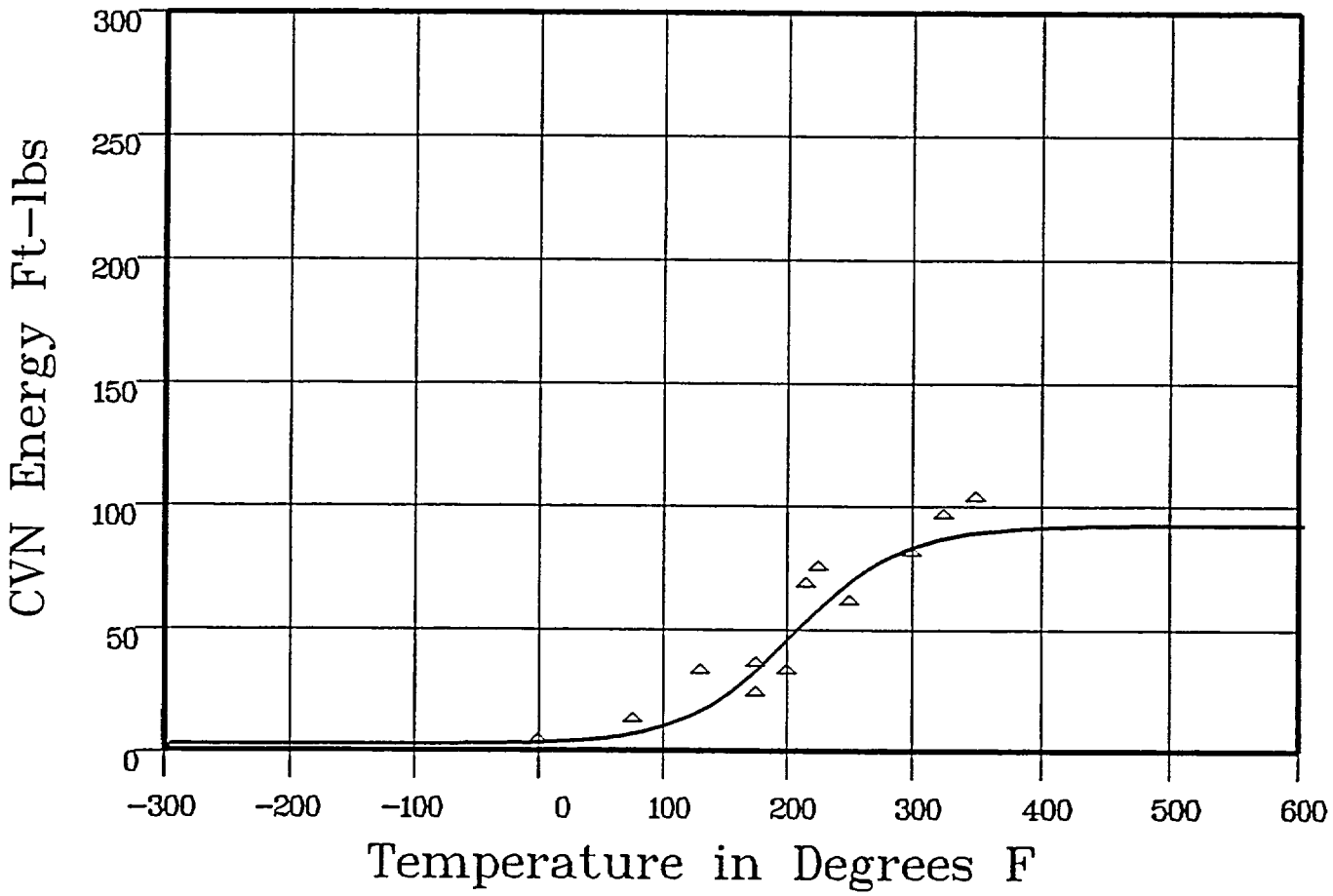
| A = 47.09 | B = 44.9 | C = 88.27 | T0 = 198.75 |
|---|---|---|---|

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

Upper Shelf Energy: 92 Fixed  Temp. at 30 ft-lbs: 163.3  Temp. at 50 ft-lbs: 204.4  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: LT

Capsule: W-83  Total Fluence:




Data Set(s) Plotted

Plant: M12  Cap: W-83  Material: PLATE SA533B1  Ori: LT  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 0 | 3 | 3.18 | -.18 |
| 75 | 12 | 7.32 | 4.67 |
| 130 | 32 | 17.82 | 14.17 |
| 175 | 35 | 35.3 | -.3 |
| 175 | 23 | 35.3 | -12.3 |
| 200 | 32 | 47.73 | -15.73 |
| 215 | 67 | 55.27 | 11.72 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 225 | 74 | 60.07 | 13.92 |
| 250 | 60 | 70.58 | -10.58 |
| 300 | 80 | 83.77 | -3.77 |
| 325 | 95 | 87.13 | 7.86 |
| 350 | 102 | 89.17 | 12.82 |

SUM of RESIDUALS = 22.3

# LOWER SHELL PLATE C-506-1 UNIRR (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:30:01 on 10-10-2002

Page 1

Coefficients of Curve 1

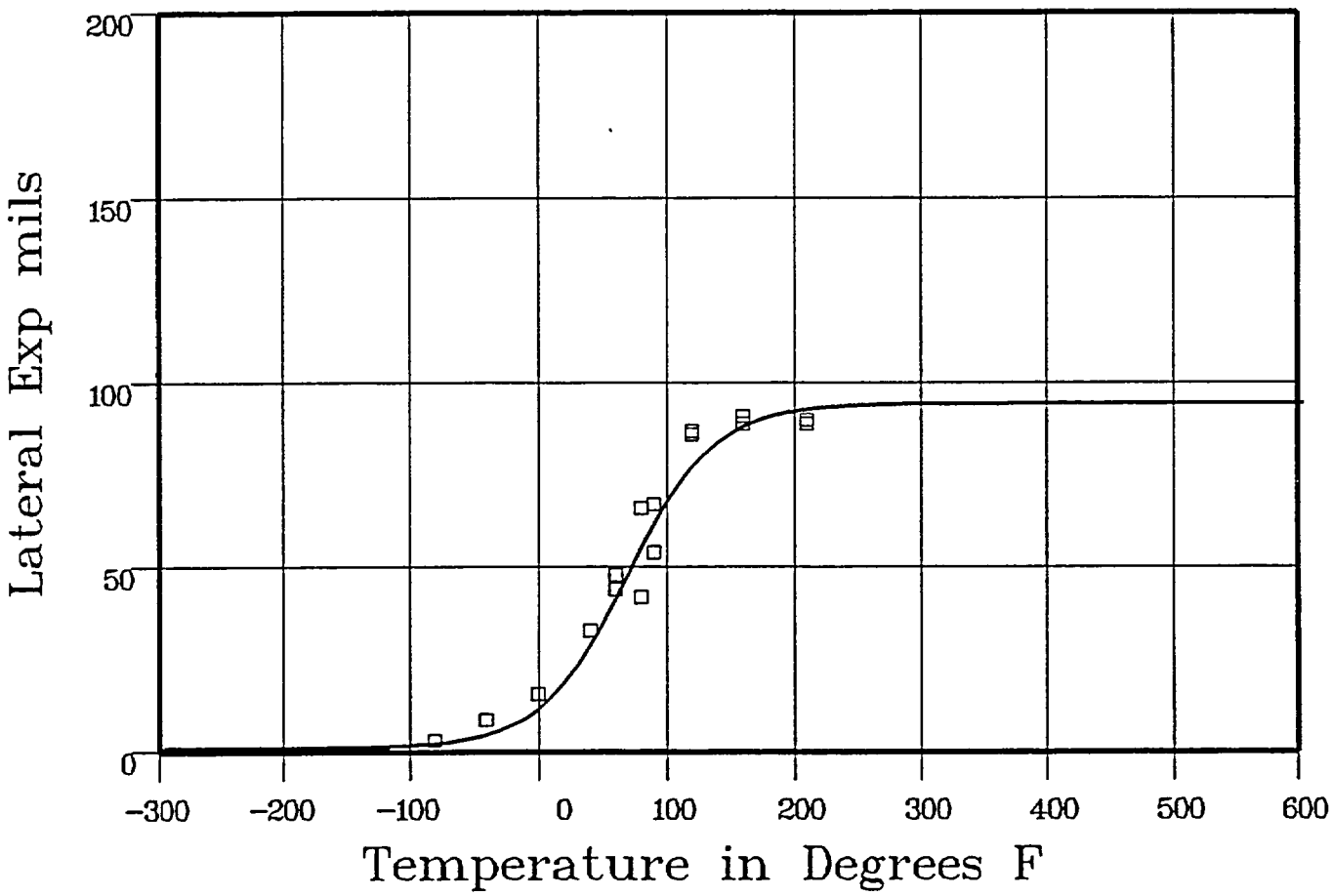
| A = 47.72 | B = 46.72 | C = 68.85 | T0 = 64.21 |
|---|---|---|---|

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

Upper Shelf L.E.: 94.44 Temperature at L.E. 35: 44.9 Lower Shelf L.E.: 1 Fixed

Material. PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: M12 Cap.: UNIRR Material: PLATE SA533B1 Ori.: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -80 | 3 | 2.39 | .6 |
| -40 | 9 | 5.31 | 3.68 |
| 0 | 16 | 13.52 | 2.47 |
| 40 | 33 | 31.93 | 1.06 |
| 60 | 44 | 44.86 | -.86 |
| 60 | 48 | 44.86 | 3.13 |
| 80 | 42 | 58.24 | -16.24 |
| 80 | 66 | 58.24 | 7.75 |
| 90 | 67 | 64.44 | 2.55 |

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

# LOWER SHELL PLATE C-506-1 UNIRR (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 90 | 67 | 64.44 | 2.55 |
| 90 | 54 | 64.44 | -10.44 |
| 120 | 86 | 79.01 | 6.98 |
| 120 | 87 | 79.01 | 7.98 |
| 160 | 89 | 88.99 | 0 |
| 160 | 91 | 88.99 | 2 |
| 210 | 90 | 93.11 | -3.11 |
| 210 | 89 | 93.11 | -4.11 |

SUM of RESIDUALS = 6.03

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:30:01 on 10-10-2002

Page 1

Coefficients of Curve 2

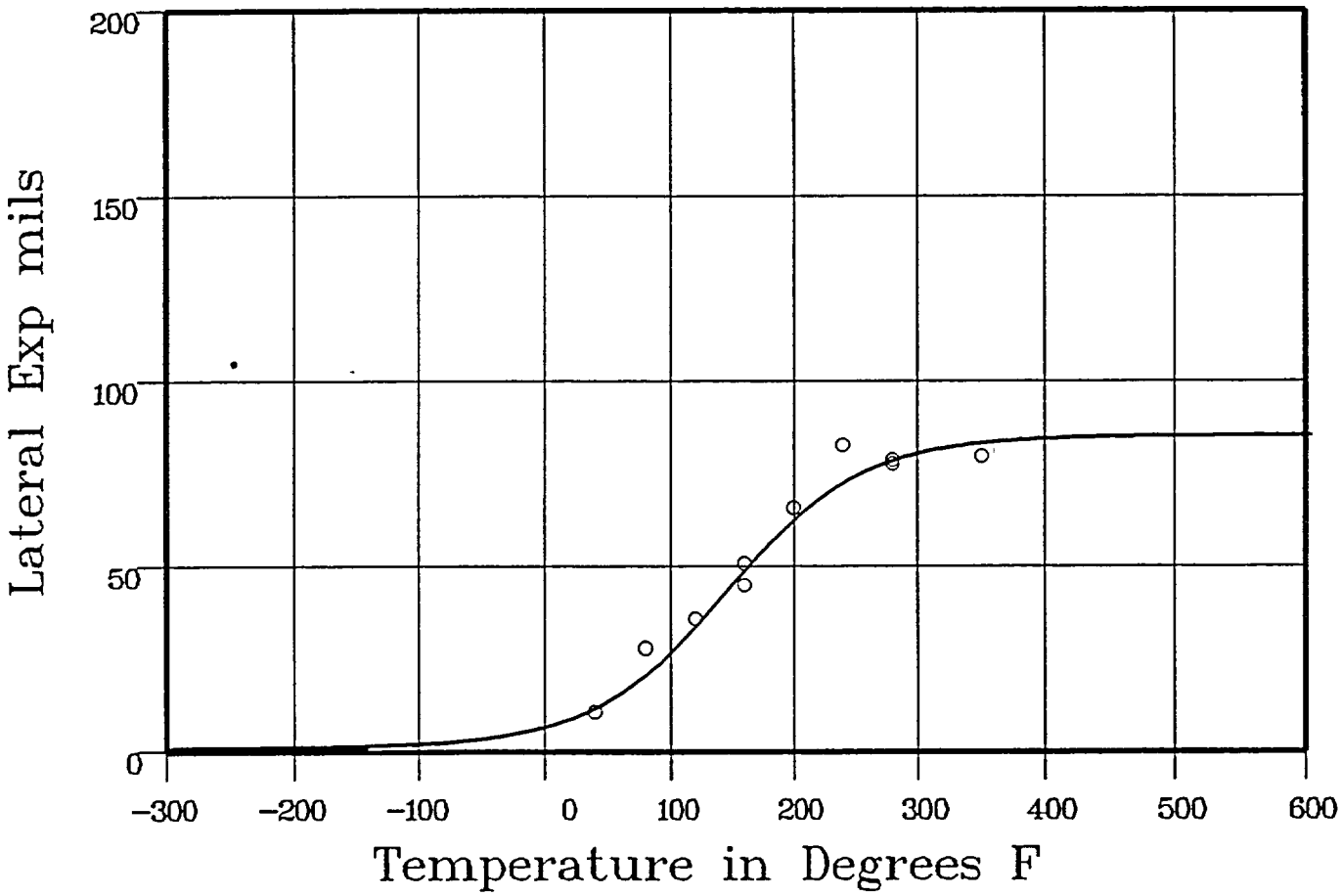
| A = 43.28 | B = 42.28 | C = 110.42 | T0 = 140.91 |
|---|---|---|---|

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

Upper Shelf L.E.: 85.56 Temperature at L.E. 35: 119 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: MI2 Cap: W-97 Material: PLATE SA533B1 Ori: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 40 | 11 | 12.71 | -1.71 |
| 80 | 28 | 22.06 | 5.93 |
| 120 | 36 | 35.36 | .63 |
| 120 | 36 | 35.36 | .63 |
| 160 | 51 | 50.51 | .48 |
| 160 | 45 | 50.51 | -5.51 |
| 160 | 45 | 50.51 | -5.51 |
| 200 | 66 | 63.96 | 2.03 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 240 | 83 | 73.51 | 9.48 |
| 280 | 79 | 79.26 | -.26 |
| 280 | 78 | 79.26 | -1.26 |
| 350 | 80 | 83.69 | -3.69 |

SUM of RESIDUALS = 1.24

# LOWER SHELL PLATE C-506-1 CAPSULE 104 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:30:01 on 10-10-2002

Page 1

Coefficients of Curve 3

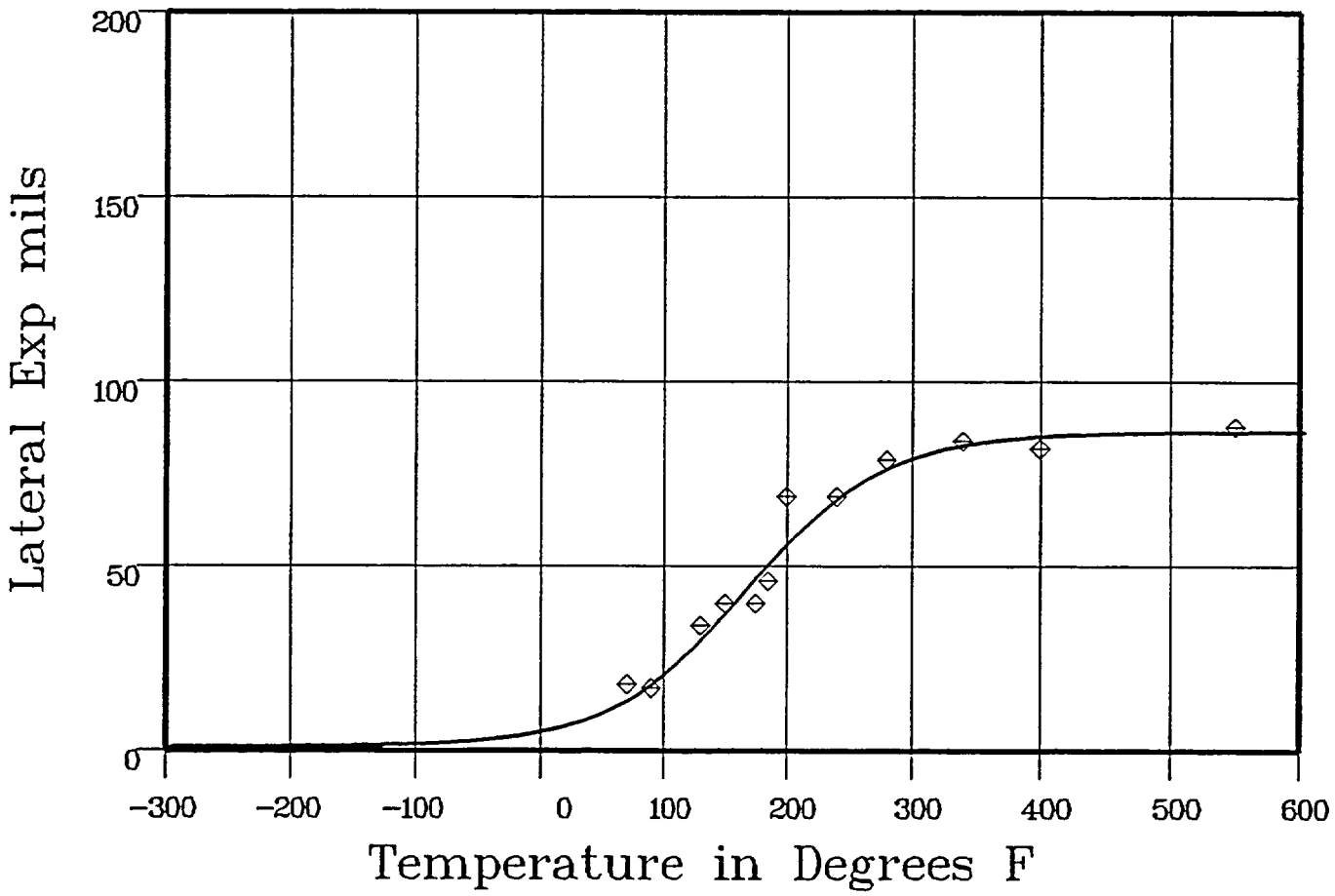
| A = 43.78 | B = 42.78 | C = 111.2 | T0 = 162.89 |
|---|---|---|---|

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

Upper Shelf L.E.: 86.57 Temperature at L.E. 35: 139.7 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-104 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap.: W-104 Material: PLATE SA533B1 Ori.: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 70 | 18 | 14.55 | 3.44 |
| 90 | 17 | 19.17 | -2.17 |
| 130 | 34 | 31.48 | 2.51 |
| 150 | 40 | 38.84 | 1.15 |
| 175 | 40 | 48.42 | -8.42 |
| 185 | 46 | 52.18 | -6.18 |
| 200 | 69 | 57.55 | 11.44 |
| 240 | 69 | 69.46 | -.46 |

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

# LOWER SHELL PLATE C–506–1 CAPSULE 104 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-104 Total Fluence:

## Charpy V–Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 280 | 79 | 77.28 | 1.71 |
| 340 | 84 | 83.17 | .82 |
| 400 | 82 | 85.38 | -3.38 |
| 550 | 88 | 86.49 | 1.5 |

SUM of RESIDUALS = 1.95

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:30:01 on 10-10-2002

Page 1

Coefficients of Curve 4

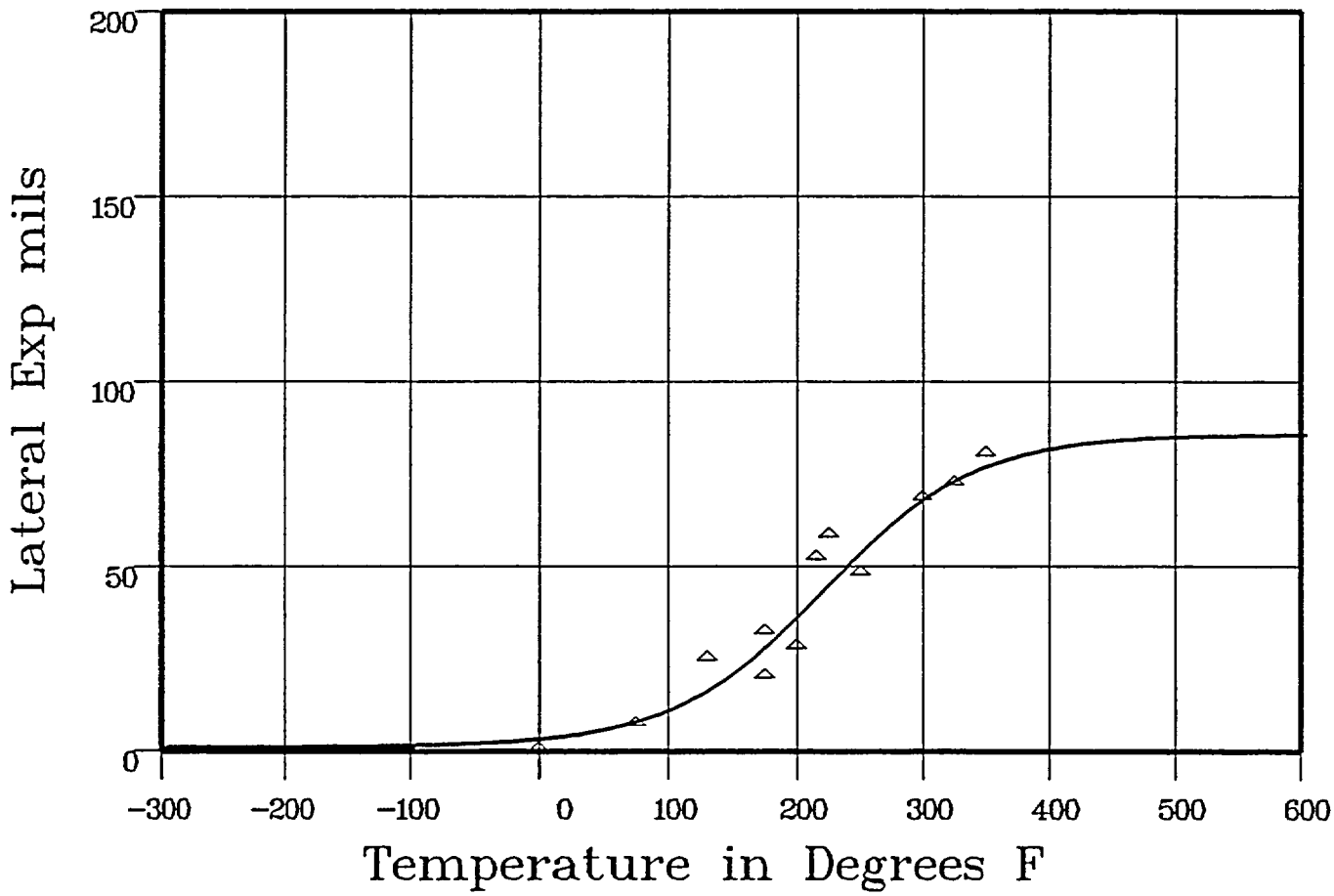
| A = 43.34 | B = 42.34 | C = 120.32 | T0 = 215.33 |
|---|---|---|---|

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

Upper Shelf L.E.: 85.68 Temperature at L.E. 35: 191.3 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-83 Total Fluence:




Data Set(s) Plotted

Plant: M12 Cap: W-83 Material: PLATE SA533B1 Ori: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 0 | 0 | 3.29 | -3.29 |
| 75 | 7 | 8.49 | -1.49 |
| 130 | 25 | 17.5 | 7.49 |
| 175 | 32 | 29.65 | 2.34 |
| 175 | 20 | 29.65 | -9.65 |
| 200 | 28 | 37.97 | -9.97 |
| 215 | 52 | 43.22 | 8.77 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 225 | 58 | 46.73 | 11.26 |
| 250 | 48 | 55.21 | -7.21 |
| 300 | 68 | 69.03 | -1.03 |
| 325 | 72 | 73.9 | -1.9 |
| 350 | 80 | 77.52 | 2.47 |

SUM of RESIDUALS = -2.24

# LOWER SHELL PLATE C-506-1 UNIRR (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:36:10 on 10-10-2002

Page 1

Coefficients of Curve 1

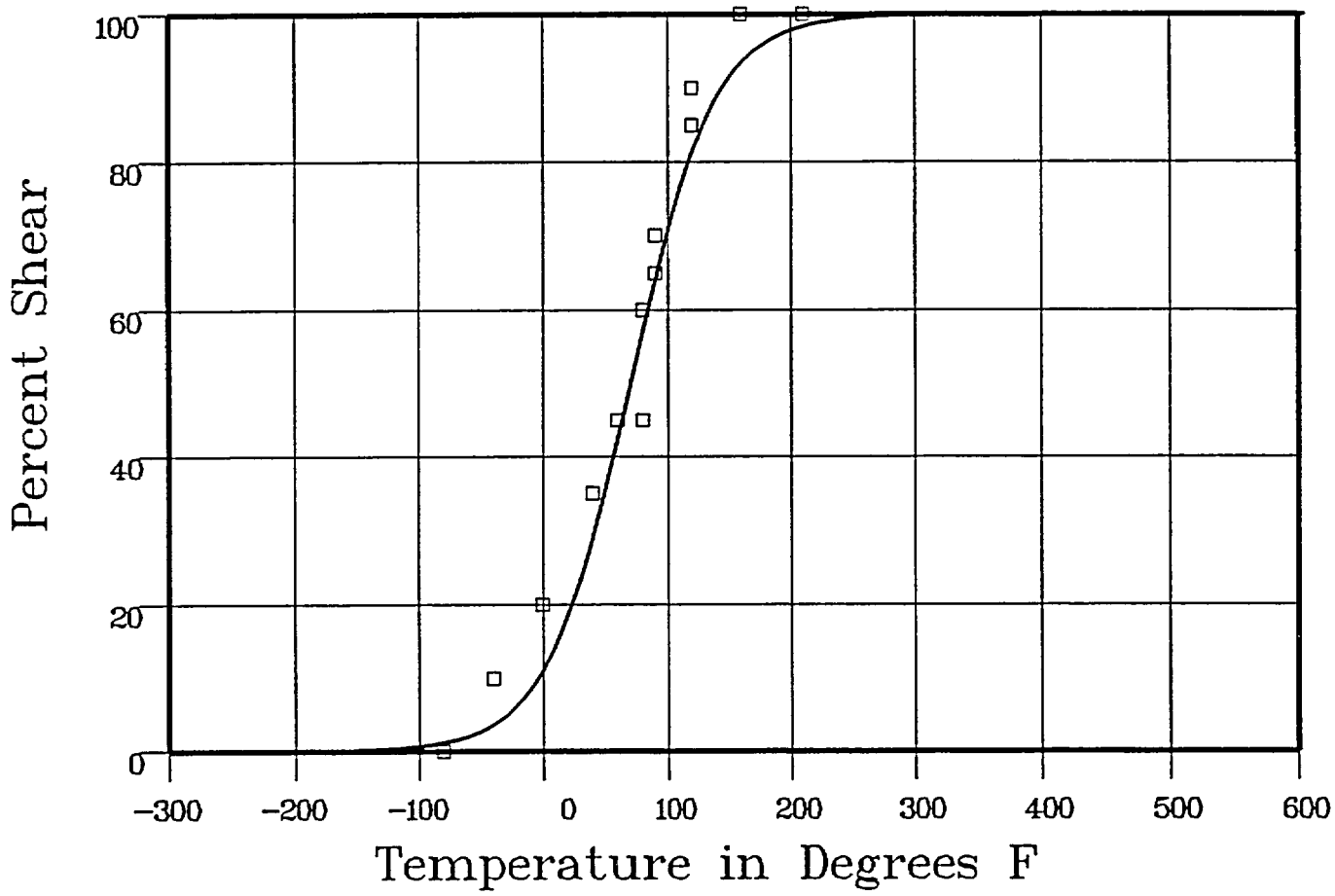
| A = 50 | B = 50 | C = 67.59 | T0 = 65.62 |
|---|---|---|---|

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

Temperature at 50% Shear: 65.6

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: UNIRR Material: PLATE SA533B1 Ori: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -80 | 0 | 1.32 | -1.32 |
| -40 | 10 | 4.2 | 5.79 |
| 0 | 20 | 12.54 | 7.45 |
| 40 | 35 | 31.9 | 3.09 |
| 60 | 45 | 45.84 | -.84 |
| 60 | 45 | 45.84 | -.84 |
| 80 | 45 | 60.47 | -15.47 |
| 80 | 60 | 60.47 | -.47 |
| 90 | 70 | 67.28 | 2.71 |

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

# LOWER SHELL PLATE C-506-1 UNIRR (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 90 | 70 | 67.28 | 2.71 |
| 90 | 65 | 67.28 | -2.28 |
| 120 | 90 | 83.32 | 6.67 |
| 120 | 85 | 83.32 | 1.67 |
| 160 | 100 | 94.22 | 5.77 |
| 160 | 100 | 94.22 | 5.77 |
| 210 | 100 | 98.62 | 1.37 |
| 210 | 100 | 98.62 | 1.37 |

SUM of RESIDUALS = 23.14

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:36:10 on 10-10-2002

Page 1

Coefficients of Curve 2

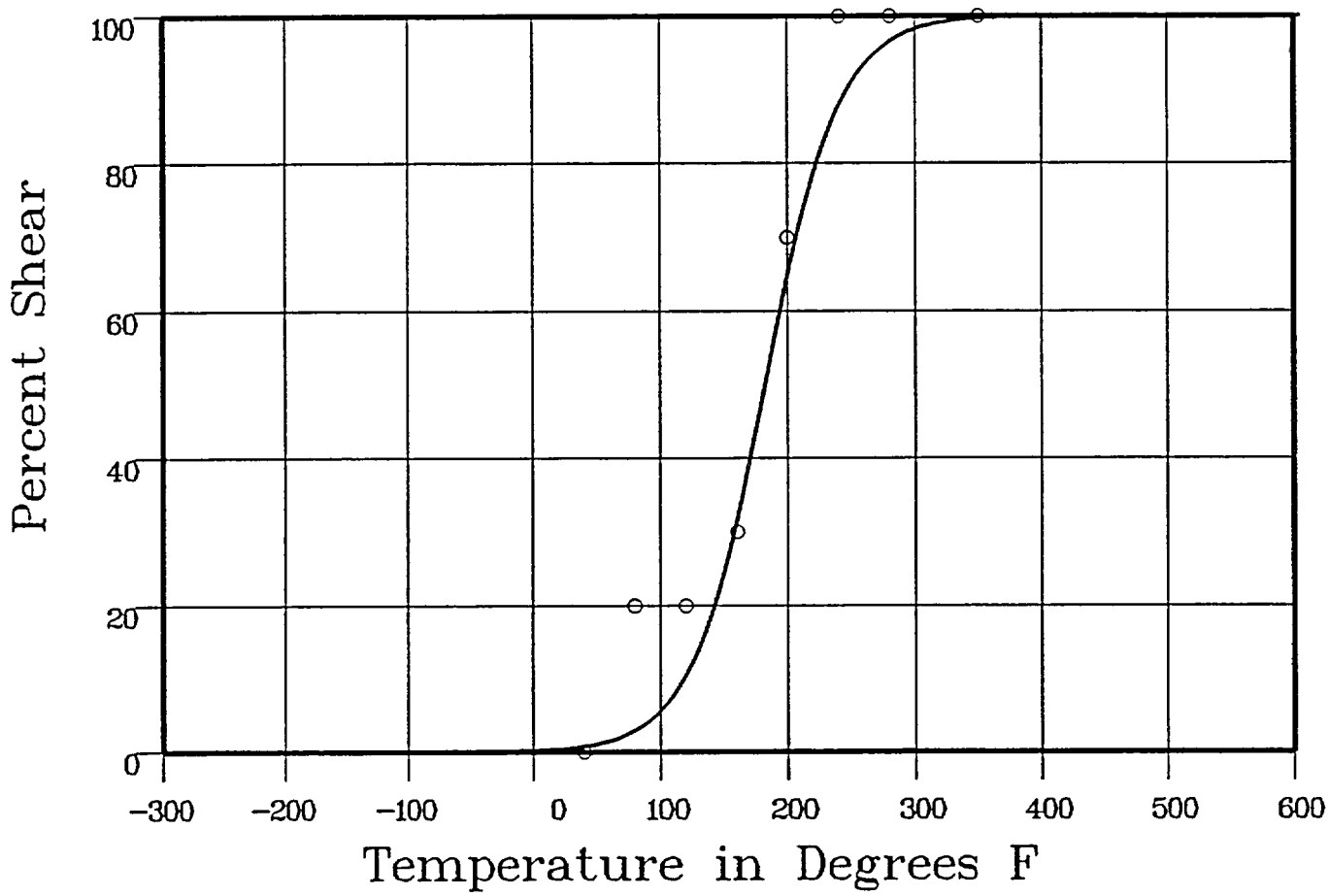
| A = 50 | B = 50 | C = 58.22 | T0 = 177.65 |
|---|---|---|---|

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

Temperature at 50% Shear: 177.6

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: M12 Cap: W-97 Material: PLATE SA533B1 Ori: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 40 | 0 | .87 | -.87 |
| 80 | 20 | 3.37 | 16.62 |
| 120 | 20 | 12.12 | 7.87 |
| 120 | 20 | 12.12 | 7.87 |
| 160 | 30 | 35.28 | -5.28 |
| 160 | 30 | 35.28 | -5.28 |
| 160 | 30 | 35.28 | -5.28 |
| 200 | 70 | 68.29 | 1.7 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (LONG)



Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 240 | 100 | 89.48 | 10.51 |
| 280 | 100 | 97.11 | 2.88 |
| 280 | 100 | 97.11 | 2.88 |
| 350 | 100 | 99.73 | .26 |

SUM of RESIDUALS = 33.89

# LOWER SHELL PLATE C-506-1 CAPSULE 104 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:36:10 on 10-10-2002

Page 1

Coefficients of Curve 3

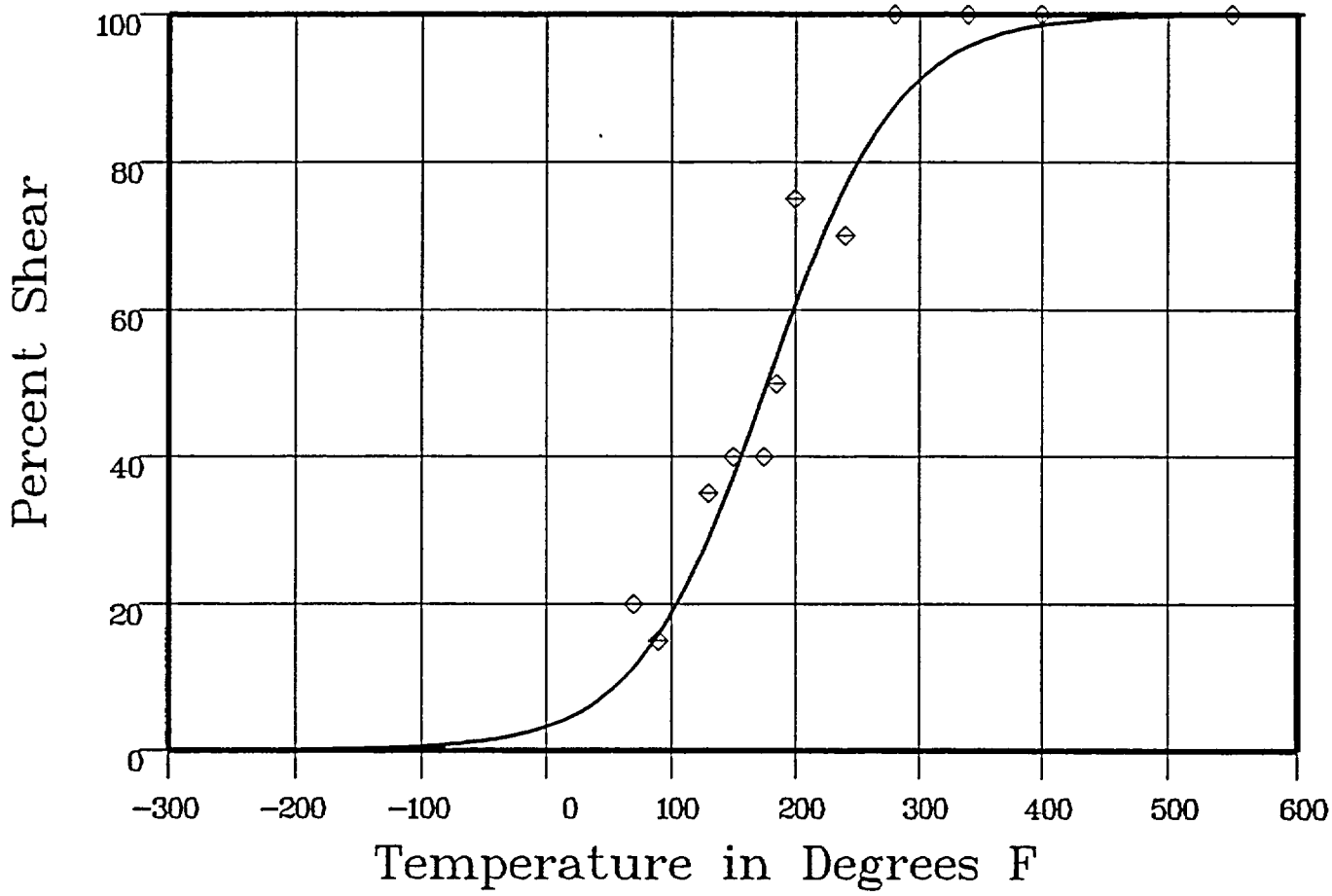
| A = 50 | B = 50 | C = 104.92 | T0 = 172.55 |
|---|---|---|---|

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

Temperature at 50% Shear: 172.5

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-104 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-104 Material: PLATE SA533B1 Ori: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 70 | 20 | 12.4 | 7.59 |
| 90 | 15 | 17.16 | -2.16 |
| 130 | 35 | 30.76 | 4.23 |
| 150 | 40 | 39.41 | .58 |
| 175 | 40 | 51.16 | -11.16 |
| 185 | 50 | 55.9 | -5.9 |
| 200 | 75 | 62.78 | 12.21 |
| 240 | 70 | 78.33 | -8.33 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 104 (LONG)



Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 280 | 100 | 88.57 | 11.42 |
| 340 | 100 | 96.05 | 3.94 |
| 400 | 100 | 98.7 | 1.29 |
| 550 | 100 | 99.92 | .07 |

SUM of RESIDUALS = 13.8

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:36:10 on 10-10-2002

Page 1

Coefficients of Curve 4

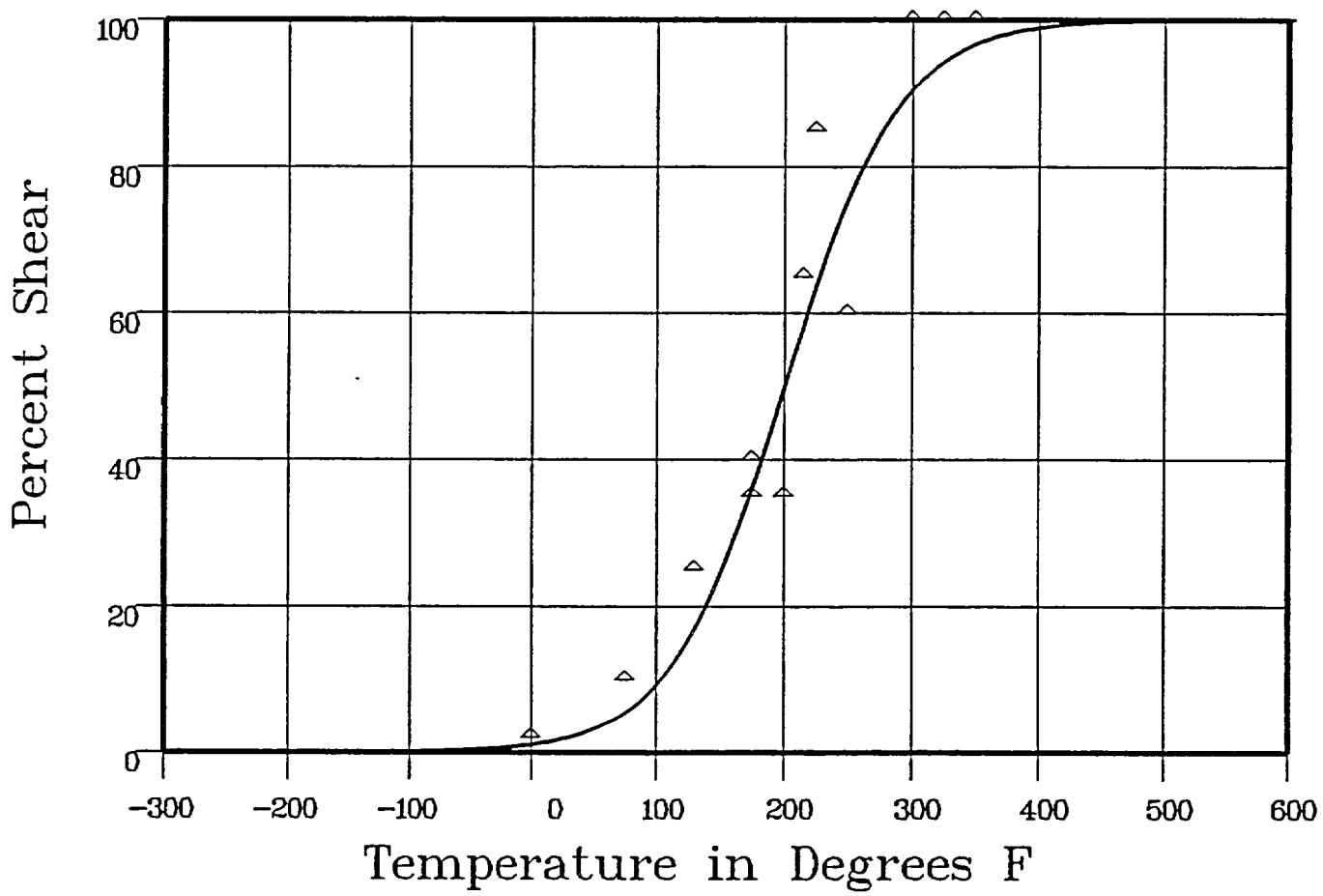
| A = 50 | B = 50 | C = 88.42 | T0 = 196.02 |
|---|---|---|---|

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

Temperature at 50% Shear: 196

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-83 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-83 Material: PLATE SA533B1 Ori: LT Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 0 | 2 | 1.17 | .82 |
| 75 | 10 | 6.08 | 3.91 |
| 130 | 25 | 18.34 | 6.65 |
| 175 | 35 | 38.33 | -3.33 |
| 175 | 40 | 38.33 | 1.66 |
| 200 | 35 | 52.24 | -17.24 |
| 215 | 65 | 60.56 | 4.43 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (LONG)



Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: LT

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 225 | 85 | 65.82 | 19.17 |
| 250 | 60 | 77.22 | -17.22 |
| 300 | 100 | 91.3 | 8.69 |
| 325 | 100 | 94.86 | 5.13 |
| 350 | 100 | 97.01 | 2.98 |

SUM of RESIDUALS = 15.68

# LOWER SHELL PLATE C-506-1 UNIRR (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:43:52 on 10-14-2002

Page 1

Coefficients of Curve 1

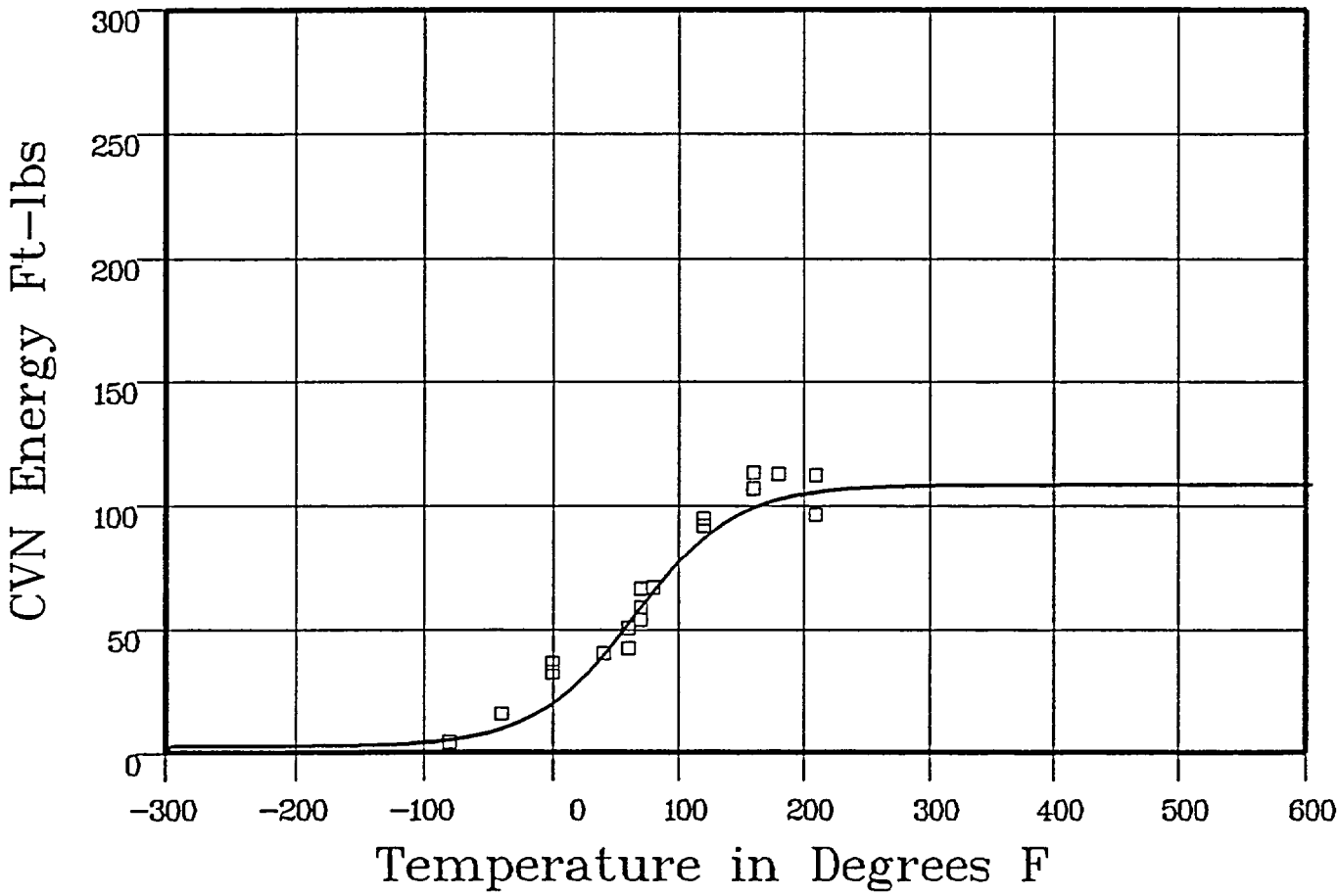
| A = 55.09 | B = 52.9 | C = 80.63 | T0 = 60 |
|---|---|---|---|

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

Upper Shelf Energy: 108 Fixed  Temp. at 30 ft-lbs: 18.4  Temp. at 50 ft-lbs: 52.2  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: TL

Capsule: UNIRR  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: UNIRR  Material: PLATE SA533B1  Ori: TL  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -80 | 4 | 5.38 | -1.38 |
| -40 | 15.5 | 10.37 | 5.12 |
| 0 | 32.5 | 21.68 | 10.81 |
| 0 | 36 | 21.68 | 14.31 |
| 40 | 40 | 42.24 | -2.24 |
| 60 | 50 | 55.09 | -5.09 |
| 60 | 42 | 55.09 | -13.09 |
| 70 | 58.5 | 61.62 | -3.12 |
| 70 | 66 | 61.62 | 4.37 |

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

# LOWER SHELL PLATE C-506-1 UNIRR (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 70 | 53.5 | 61.62 | -8.12 |
| 80 | 66.5 | 67.95 | -1.45 |
| 120 | 94.5 | 88.51 | 5.98 |
| 120 | 91.5 | 88.51 | 2.98 |
| 160 | 113 | 99.82 | 13.17 |
| 160 | 106.5 | 99.82 | 6.67 |
| 180 | 112.5 | 102.86 | 9.63 |
| 210 | 112 | 105.49 | 6.5 |
| 210 | 96 | 105.49 | -9.49 |

SUM of RESIDUALS = 35.53

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:43:52 on 10-14-2002

Page 1

Coefficients of Curve 2

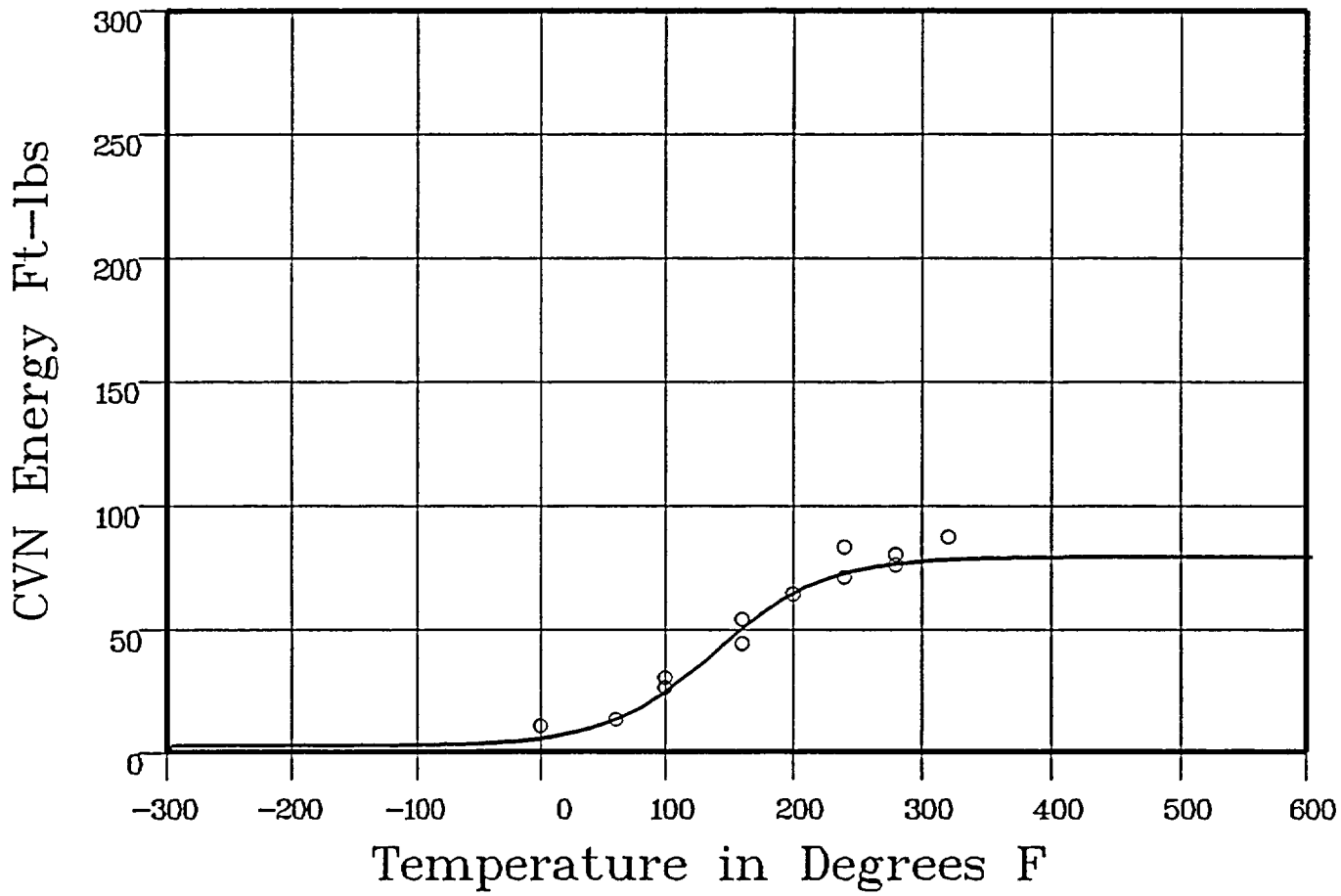
| A = 40.59 | B = 38.4 | C = 85.91 | T0 = 133.59 |
|---|---|---|---|

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

Upper Shelf Energy: 79 Fixed  Temp. at 30 ft-lbs: 109.2  Temp. at 50 ft-lbs: 155  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: TL

Capsule: W-97  Total Fluence:




Data Set(s) Plotted

Plant: M12  Cap: W-97  Material: PLATE SA533B1  Ori.: TL  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 0 | 10 | 5.47 | 4.52 |
| 60 | 13 | 13.93 | -.93 |
| 100 | 26 | 26.3 | -.3 |
| 100 | 30 | 26.3 | 3.69 |
| 160 | 44 | 52.04 | -8.04 |
| 160 | 54 | 52.04 | 1.95 |
| 200 | 64 | 65.5 | -1.5 |
| 240 | 83 | 73.04 | 9.95 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 240 | 71 | 73.04 | -2.04 |
| 280 | 76 | 76.53 | -.53 |
| 280 | 80 | 76.53 | 3.46 |
| 320 | 87 | 78.01 | 8.98 |

SUM of RESIDUALS = 19.19

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:43:52 on 10-14-2002

Page 1

Coefficients of Curve 3

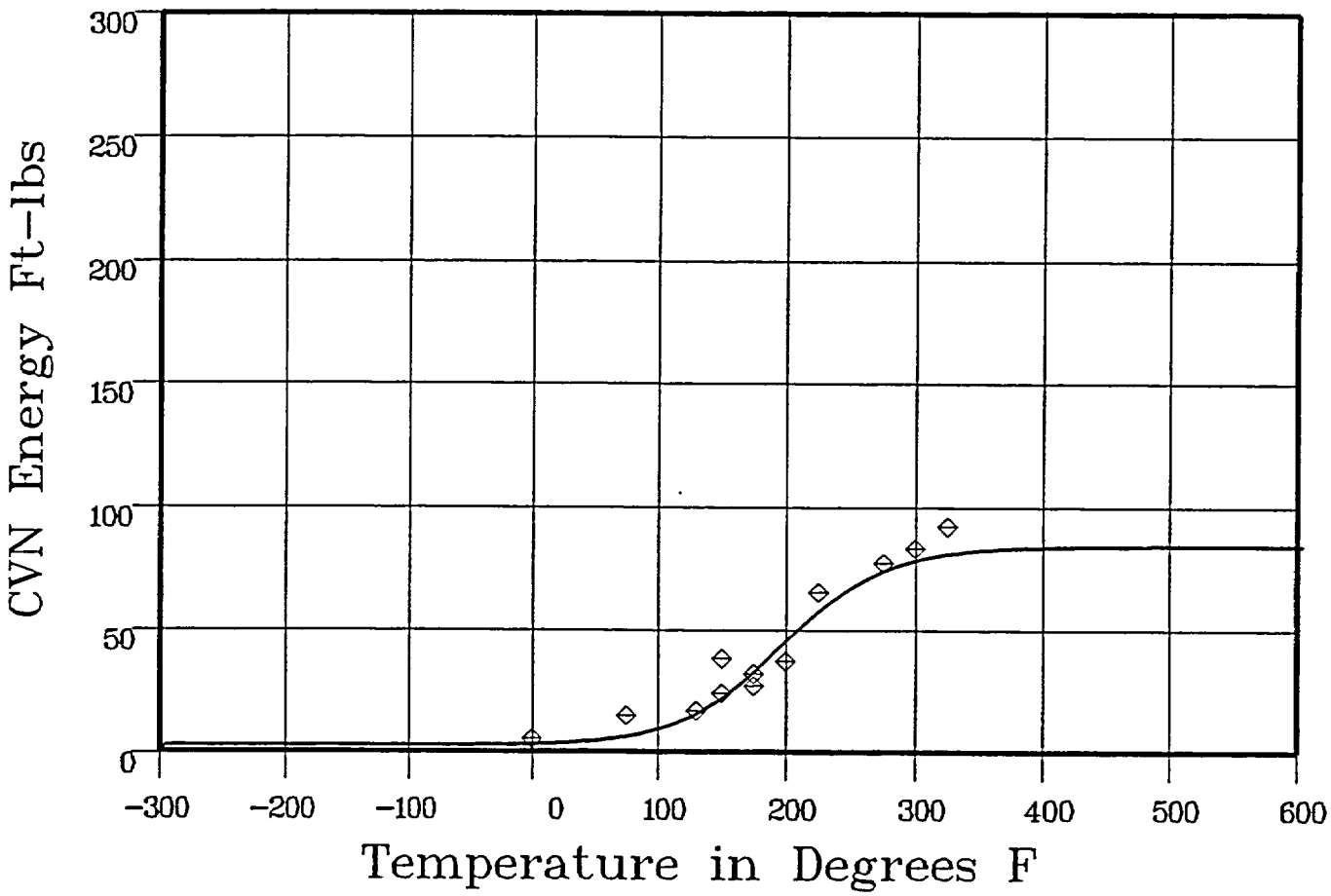
| A = 43.09 | B = 40.9 | C = 81.51 | T0 = 191.25 |
|---|---|---|---|

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

Upper Shelf Energy: 84 Fixed  Temp. at 30 ft-lbs: 164.1  Temp. at 50 ft-lbs: 205.1  Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1  Heat Number: C-5667-1  Orientation: TL

Capsule: W-83  Total Fluence:




Data Set(s) Plotted

Plant: MI2  Cap: W-83  Material: PLATE SA533B1  Ori: TL  Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 0 | 5 | 2.94 | 2.05 |
| 75 | 15 | 6.66 | 8.33 |
| 130 | 17 | 17.08 | -.08 |
| 150 | 24 | 24 | 0 |
| 150 | 38 | 24 | 13.99 |
| 175 | 27 | 35.05 | -8.05 |
| 175 | 32 | 35.05 | -3.05 |
| 200 | 37 | 47.47 | -10.47 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 225 | 65 | 59.12 | 5.87 |
| 275 | 77 | 74.7 | 2.29 |
| 300 | 83 | 78.69 | 4.3 |
| 325 | 92 | 81.03 | 10.96 |

SUM of RESIDUALS = 26.14

# LOWER SHELL PLATE C-506-1 UNIRR (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:04:01 on 10-14-2002

Page 1

Coefficients of Curve 1

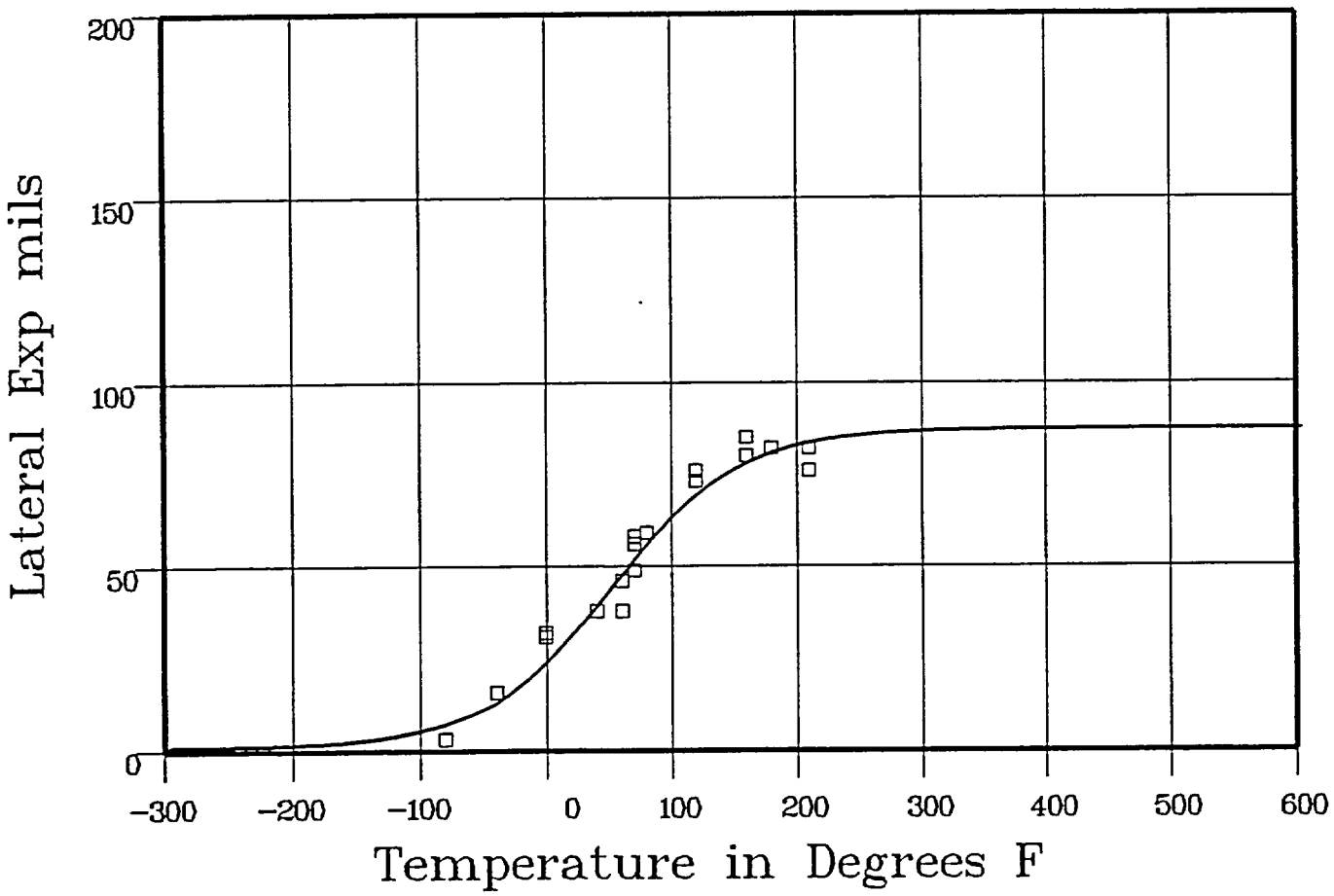
| A = 44.2 | B = 43.2 | C = 102.74 | T0 = 46.87 |
|---|---|---|---|

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

Upper Shelf L.E.: 87.4 Temperature at L.E. 35: 24.6 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: M12 Cap.: UNIRR Material: PLATE SA533B1 Ori.: TL Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -80 | 3 | 7.74 | -4.74 |
| -40 | 16 | 14.44 | 1.55 |
| 0 | 31 | 25.75 | 5.24 |
| 0 | 32 | 25.75 | 6.24 |
| 40 | 38 | 41.31 | -3.31 |
| 60 | 46 | 49.69 | -3.69 |
| 60 | 38 | 49.69 | -11.69 |
| 70 | 56 | 53.76 | 2.23 |
| 70 | 58 | 53.76 | 4.23 |

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

# LOWER SHELL PLATE C-506-1 UNIRR (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 70 | 49 | 53.76 | -4.76 |
| 80 | 59 | 57.66 | 1.33 |
| 120 | 73 | 70.63 | 2.36 |
| 120 | 76 | 70.63 | 5.36 |
| 160 | 85 | 78.8 | 6.19 |
| 160 | 80 | 78.8 | 1.19 |
| 180 | 82 | 81.38 | .61 |
| 210 | 82 | 83.93 | -1.93 |
| 210 | 76 | 83.93 | -7.93 |

SUM of RESIDUALS = -1.48

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:04:01 on 10-14-2002

Page 1

Coefficients of Curve 2

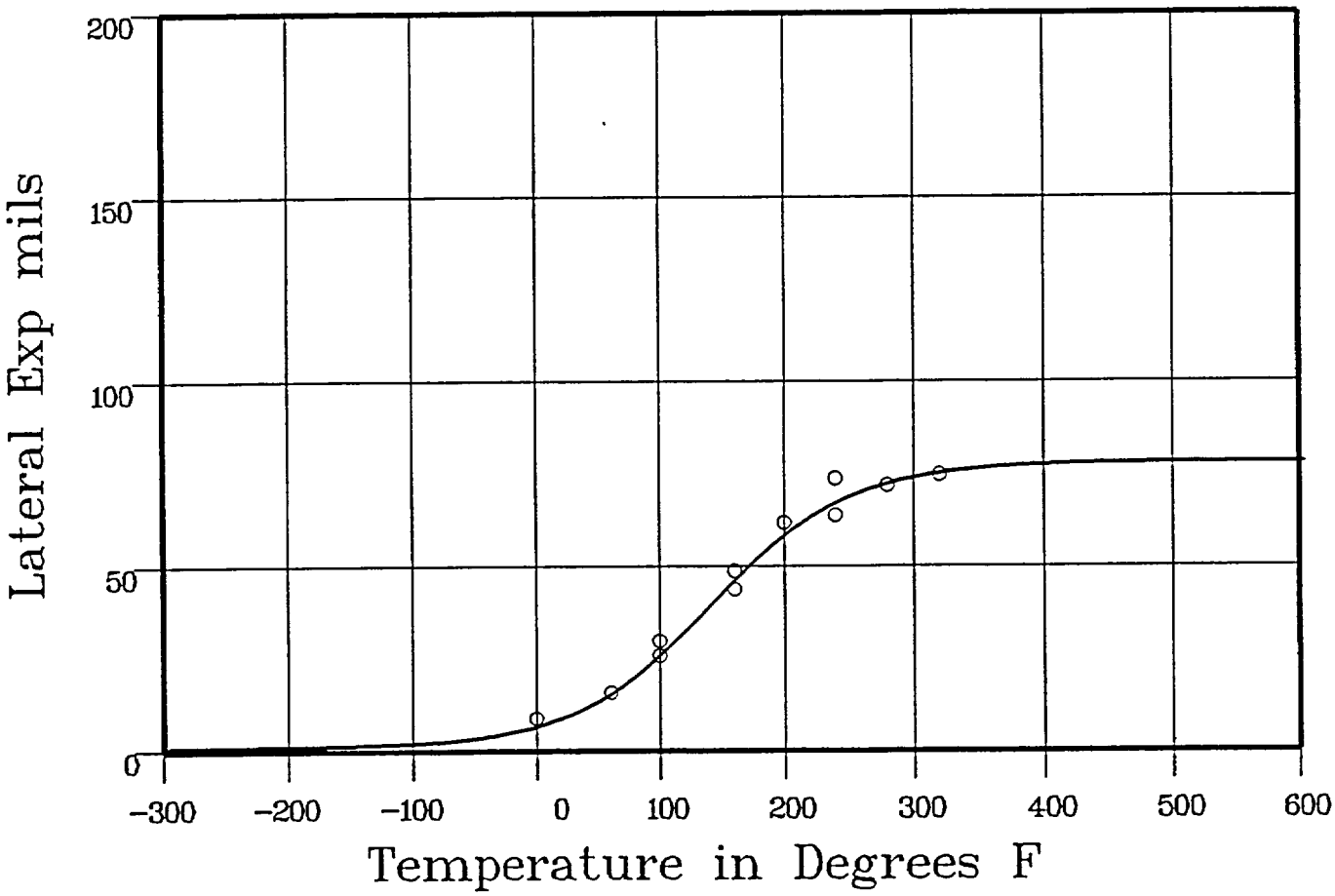
| A = 39.62 | B = 38.62 | C = 110.69 | T0 = 135.93 |
|---|---|---|---|

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

Upper Shelf LE: 78.24 Temperature at LE 35: 122.6 Lower Shelf LE: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-97 Material: PLATE SA533B1 Ori: TL Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed LE | Differential |
|---|---|---|---|
| 0 | 9 | 7.1 | 1.89 |
| 60 | 16 | 16.62 | -.62 |
| 100 | 26 | 27.5 | -1.5 |
| 100 | 30 | 27.5 | 2.49 |
| 160 | 44 | 47.88 | -3.88 |
| 160 | 49 | 47.88 | 1.11 |
| 200 | 62 | 59.77 | 2.22 |
| 240 | 74 | 68.01 | 5.98 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 240 | 64 | 68.01 | -4.01 |
| 280 | 72 | 72.91 | -.91 |
| 280 | 72 | 72.91 | -.91 |
| 320 | 75 | 75.55 | -.55 |

SUM of RESIDUALS = 1.3

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:04:01 on 10-14-2002

Page 1

Coefficients of Curve 3

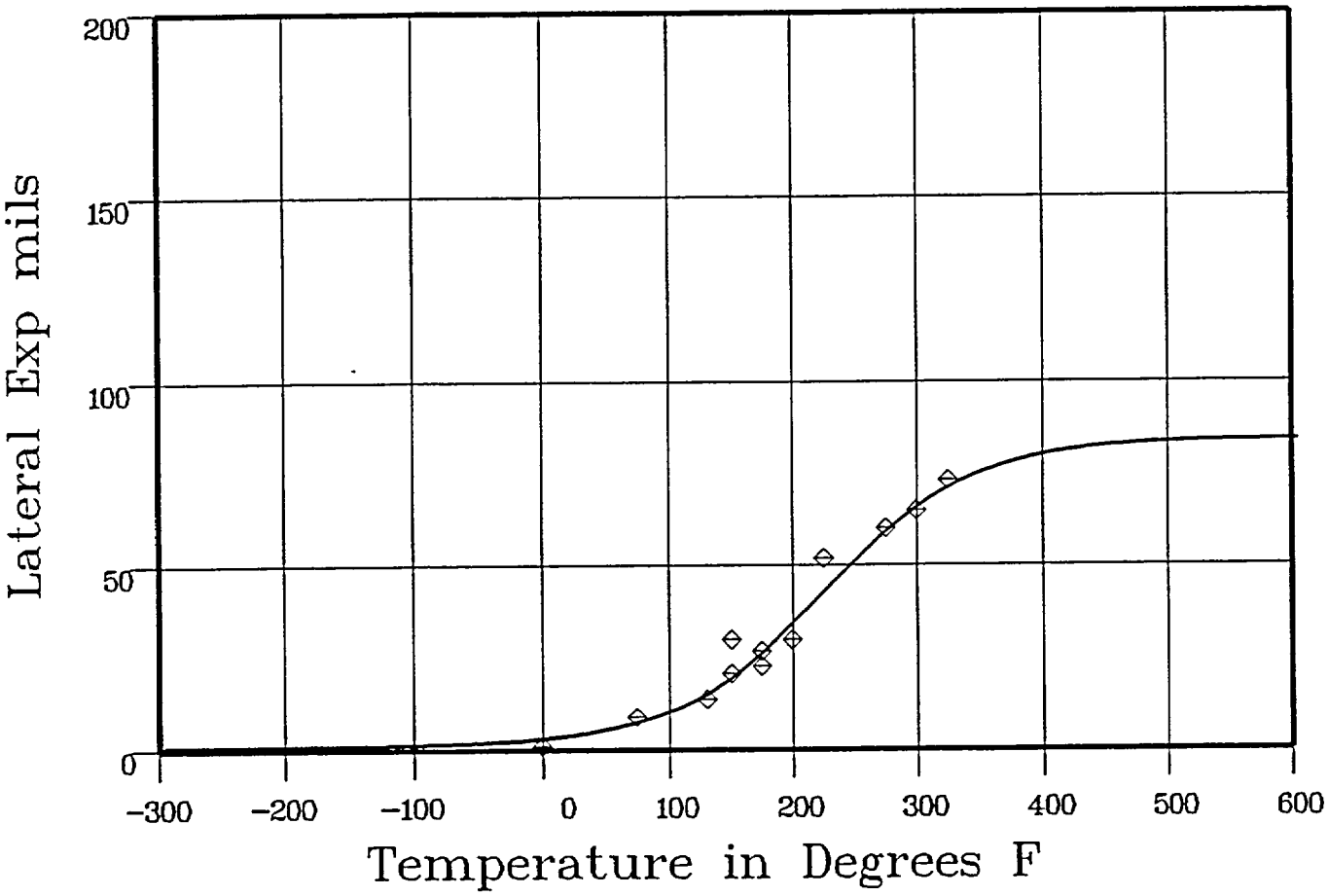
| A = 42.61 | B = 41.61 | C = 120.45 | T0 = 219.14 |
|---|---|---|---|

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

Upper Shelf L.E.: 84.22 Temperature at L.E. 35: 196.8 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-83 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap.: W-83 Material: PLATE SA533B1 Ori.: TL Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 0 | 1 | 3.13 | -2.13 |
| 75 | 9 | 7.96 | 1.03 |
| 130 | 14 | 16.43 | -2.43 |
| 150 | 21 | 21.04 | -.04 |
| 150 | 30 | 21.04 | 8.95 |
| 175 | 23 | 28.01 | -5.01 |
| 175 | 27 | 28.01 | -1.01 |
| 200 | 30 | 36.05 | -6.05 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 83 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 225 | 52 | 44.63 | 7.36 |
| 275 | 60 | 60.63 | -.63 |
| 300 | 65 | 66.99 | -1.99 |
| 325 | 73 | 71.98 | 1.01 |

SUM of RESIDUALS = -.96

# LOWER SHELL PLATE C-506-1 UNIRR (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:13:13 on 10-14-2002

Page 1

Coefficients of Curve 1

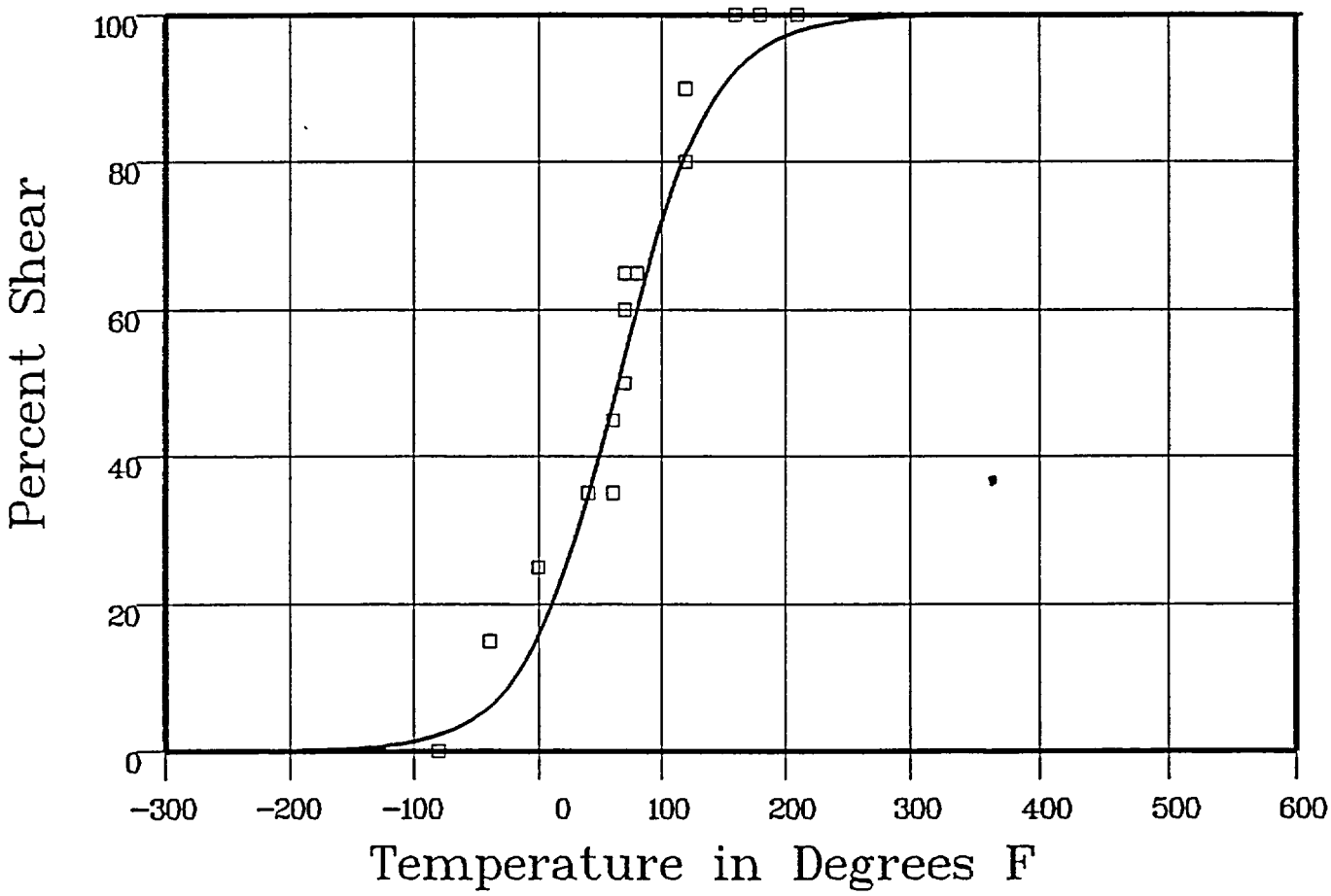
| A = 50 | B = 50 | C = 76.64 | T0 = 59.53 |
|---|---|---|---|

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

Temperature at 50% Shear: 59.5

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: UNIRR Material: PLATE SA533B1 Ori: TL Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -80 | 0 | 2.55 | -2.55 |
| -40 | 15 | 6.93 | 8.06 |
| 0 | 25 | 17.45 | 7.54 |
| 0 | 25 | 17.45 | 7.54 |
| 40 | 35 | 37.52 | -2.52 |
| 60 | 45 | 50.3 | -5.3 |
| 60 | 35 | 50.3 | -15.3 |
| 70 | 60 | 56.78 | 3.21 |
| 70 | 65 | 56.78 | 8.21 |

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

# LOWER SHELL PLATE C-506-1 UNIRR (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 70 | 50 | 56.78 | -6.78 |
| 80 | 65 | 63.04 | 1.95 |
| 120 | 80 | 82.89 | -2.89 |
| 120 | 90 | 82.89 | 7.1 |
| 160 | 100 | 93.22 | 6.77 |
| 160 | 100 | 93.22 | 6.77 |
| 180 | 100 | 95.86 | 4.13 |
| 210 | 100 | 98.06 | 1.93 |
| 210 | 100 | 98.06 | 1.93 |

SUM of RESIDUALS = 29.81

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:13:13 on 10-14-2002

Page 1

Coefficients of Curve 2

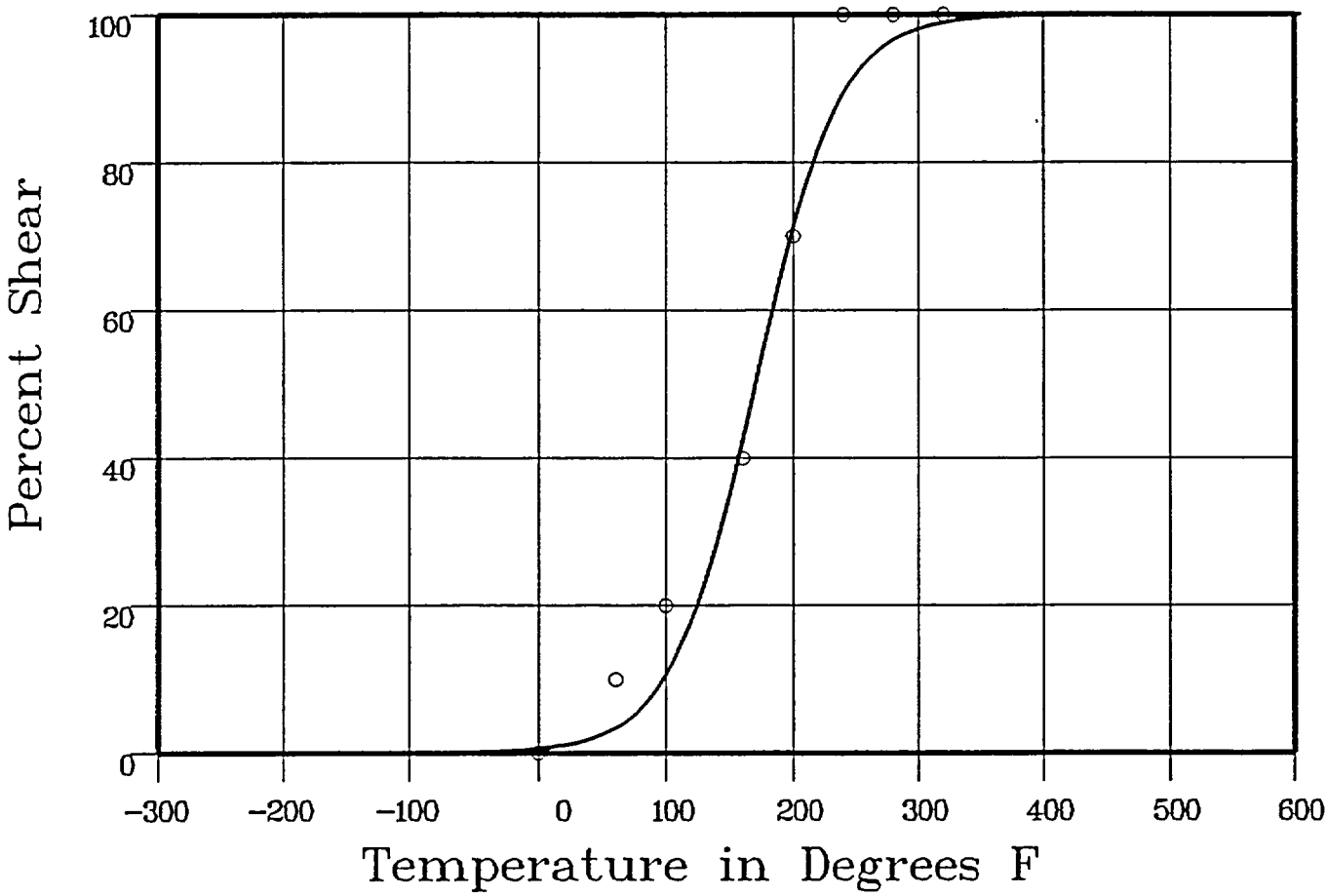
| A = 50 | B = 50 | C = 65.94 | T0 = 165.52 |
|---|---|---|---|

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

Temperature at 50% Shear: 165.5

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-97 Material: PLATE SA533B1 Ori: TL Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 0 | 0 | .65 | -.65 |
| 60 | 10 | 3.91 | 6.08 |
| 100 | 20 | 12.05 | 7.94 |
| 100 | 20 | 12.05 | 7.94 |
| 160 | 40 | 45.81 | -5.81 |
| 160 | 40 | 45.81 | -5.81 |
| 200 | 70 | 73.99 | -3.99 |
| 240 | 100 | 90.54 | 9.45 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)



Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 240 | 100 | 90.54 | 9.45 |
| 280 | 100 | 96.98 | 3.01 |
| 280 | 100 | 96.98 | 3.01 |
| 320 | 100 | 99.08 | .91 |

SUM of RESIDUALS = 31.55

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:13:13 on 10-14-2002

Page 1

Coefficients of Curve 3

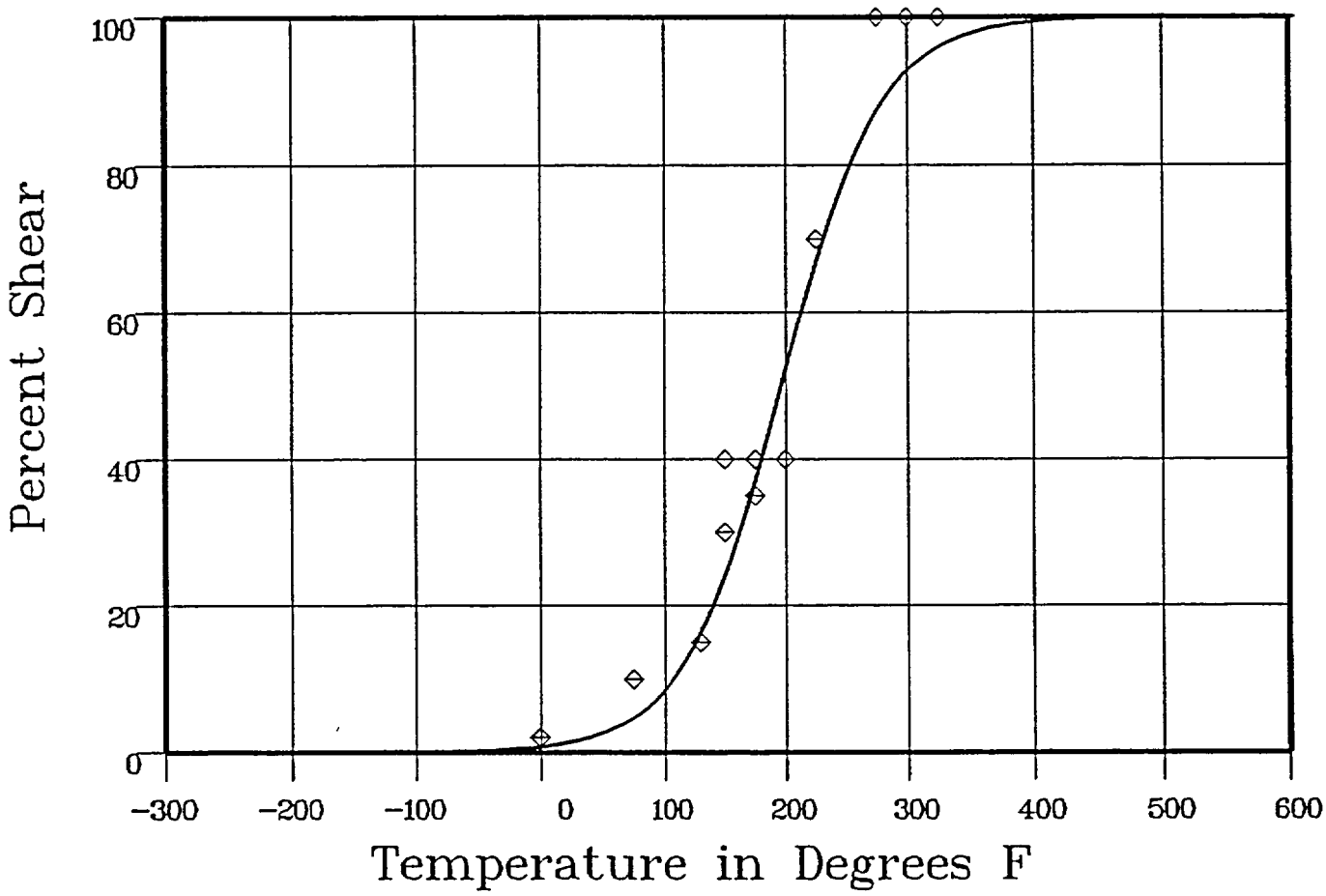
| A = 50 | B = 50 | C = 81.2 | T0 = 191.71 |
|---|---|---|---|

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

Temperature at 50% Shear: 191.7

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-83 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-83 Material: PLATE SA533B1 Ori: TL Heat #: C-5667-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 0 | 2 | .88 | 1.11 |
| 75 | 10 | 5.34 | 4.65 |
| 130 | 15 | 17.94 | -2.94 |
| 150 | 30 | 26.35 | 3.64 |
| 150 | 40 | 26.35 | 13.64 |
| 175 | 35 | 39.84 | -4.84 |
| 175 | 40 | 39.84 | .15 |
| 200 | 40 | 55.08 | -15.08 |

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

# LOWER SHELL PLATE C-506-1 CAPSULE 97 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C-5667-1 Orientation: TL

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 225 | 70 | 69.41 | .58 |
| 275 | 100 | 88.6 | 11.39 |
| 300 | 100 | 93.5 | 6.49 |
| 325 | 100 | 96.38 | 3.61 |

SUM of RESIDUALS = 22.42

# UNIRRADIATED (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:50:19 on 10-14-2002

Page 1

Coefficients of Curve 1

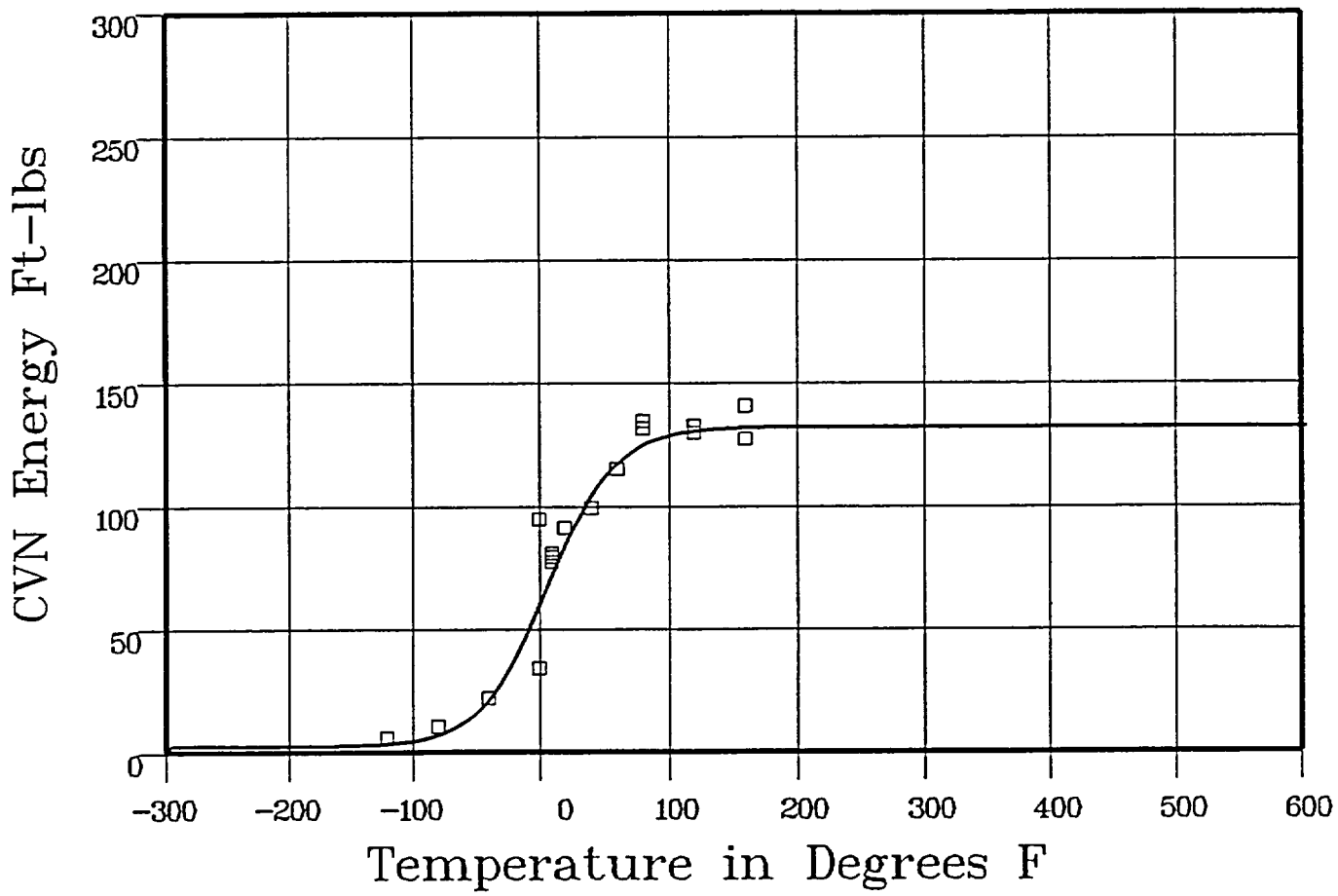
| A = 67.09 | B = 64.9 | C = 52.34 | T0 = 1.87 |
|---|---|---|---|

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

Upper Shelf Energy: 132 Fixed  Temp. at 30 ft-lbs: -32.1  Temp. at 50 ft-lbs: -12.2  Lower Shelf Energy: 2.19 Fixed

Material. WELD L 124/0091  Heat Number: 90136/10137  Orientation:

Capsule: UNIRR  Total Fluence:




Data Set(s) Plotted

Plant: M12  Cap: UNIRR  Material: WELD L 124/0091  Ori:  Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -120 | 5.5 | 3.42 | 2.07 |
| -80 | 10 | 7.64 | 2.35 |
| -40 | 22 | 24 | -2 |
| 0 | 34 | 64.77 | -30.77 |
| 0 | 94.5 | 64.77 | 29.72 |
| 10 | 77 | 77.09 | -.09 |
| 10 | 79 | 77.09 | 1.9 |
| 10 | 80.5 | 77.09 | 3.4 |
| 20 | 91 | 88.71 | 2.28 |

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

# UNIRRADIATED (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 40 | 99 | 107.46 | -8.46 |
| 60 | 115 | 119.29 | -4.29 |
| 80 | 134.5 | 125.75 | 8.74 |
| 80 | 131.5 | 125.75 | 5.74 |
| 120 | 132.5 | 130.59 | 1.9 |
| 120 | 129.5 | 130.59 | -1.09 |
| 160 | 140.5 | 131.69 | 8.8 |
| 160 | 127 | 131.69 | -4.69 |

SUM of RESIDUALS = 15.54

# CAPSULE 97 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:11:31 on 11-21-2002
Page 1
Coefficients of Curve 2

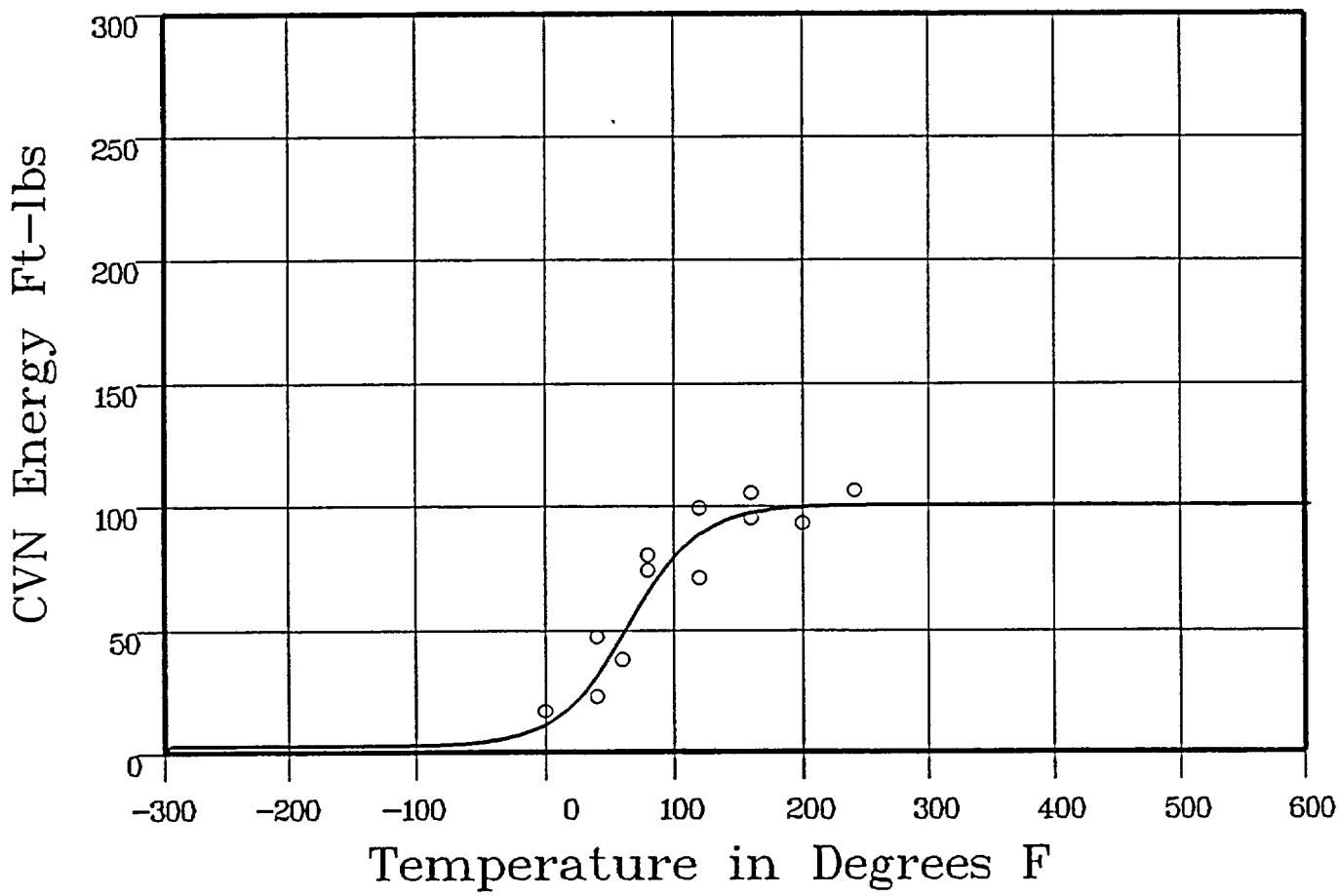
| A = 51.09 | B = 48.9 | C = 55.76 | T0 = 59.53 |
|---|---|---|---|

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

Upper Shelf Energy: 100 Fixed  Temp. at 30 ft-lbs: 33.7  Temp. at 50 ft-lbs: 58.2  Lower Shelf Energy: 2.19 Fixed

Material: WELD L 124/0091  Heat Number: 90136/10137  Orientation:

Capsule: W-97  Total Fluence:




Data Set(s) Plotted
Plant: M12  Cap: W-97  Material: WELD L 124/0091  Ori:  Heat #: 90136/10137

**Charpy V-Notch Data**

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 0 | 17 | 12.54 | 4.45 |
| 40 | 23 | 34.64 | -11.64 |
| 40 | 47 | 34.64 | 12.35 |
| 60 | 38 | 51.51 | -13.51 |
| 80 | 74 | 68.28 | 5.71 |
| 80 | 80 | 68.28 | 11.71 |
| 120 | 99 | 89.96 | 9.03 |
| 120 | 71 | 89.96 | -18.96 |

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

# CAPSULE 97 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 160 | 95 | 97.4 | -2.4 |
| 160 | 105 | 97.4 | 7.59 |
| 200 | 93 | 99.36 | -6.36 |
| 240 | 106 | 99.84 | 6.15 |

SUM of RESIDUALS = 4.13

# CAPSULE 104 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:50:19 on 10-14-2002

Page 1

Coefficients of Curve 3

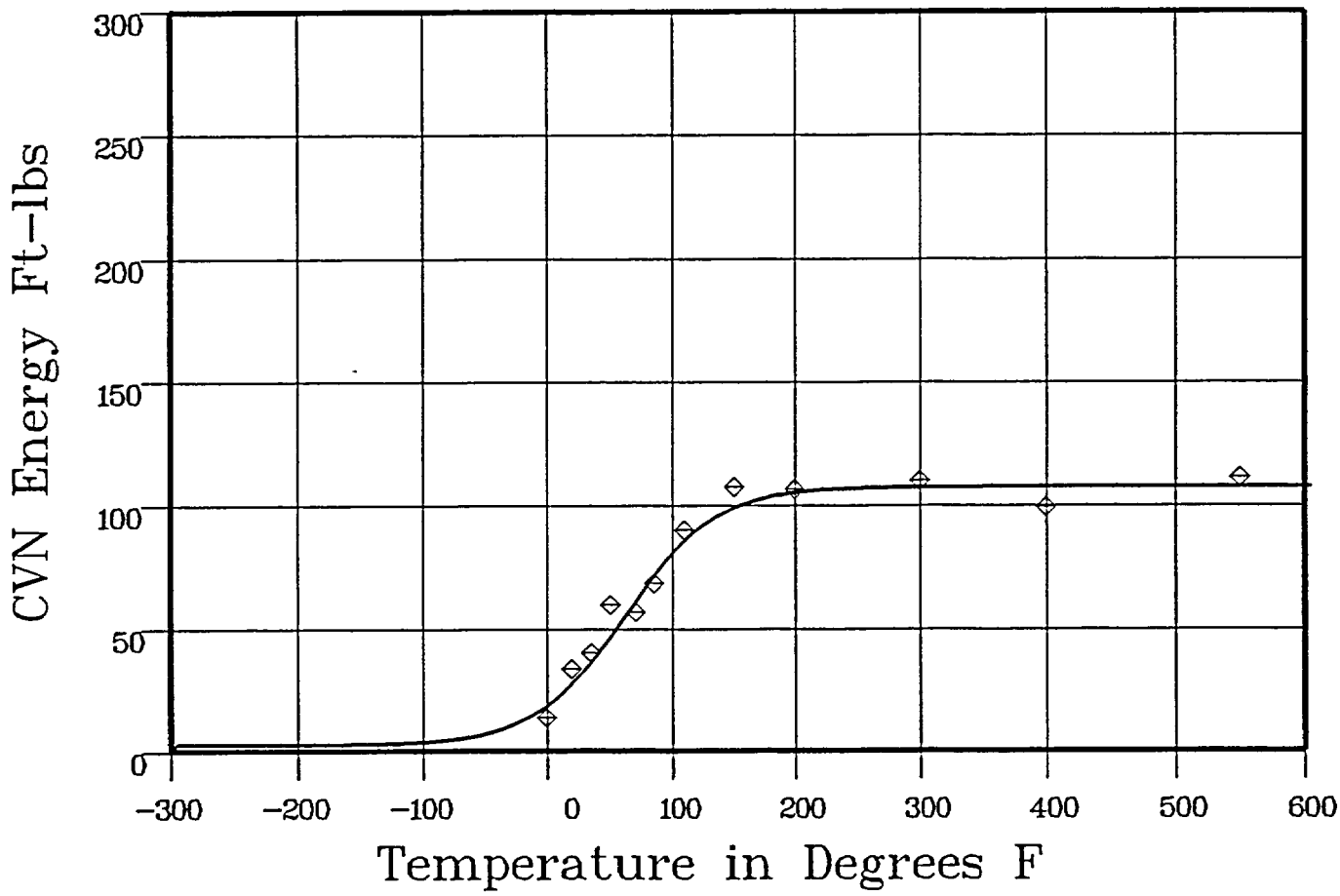
| A = 54.59 | B = 52.4 | C = 72.12 | T0 = 56.71 |
|---|---|---|---|

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

Upper Shelf Energy: 107 Fixed  Temp. at 30 ft-lbs: 19.9  Temp. at 50 ft-lbs: 50.3  Lower Shelf Energy: 2.19 Fixed

Material: WELD L 124/0091  Heat Number: 90136/10137  Orientation:

Capsule: W-104  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: W-104  Material: WELD L 124/0091  Ori:  Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 0 | 13.5 | 20.2 | -6.7 |
| 20 | 33.5 | 30.01 | 3.48 |
| 35 | 40 | 39.28 | .71 |
| 50 | 59.5 | 49.73 | 9.76 |
| 70 | 56.5 | 64.14 | -7.64 |
| 85 | 68 | 74.15 | -6.15 |
| 110 | 89.5 | 87.52 | 1.97 |
| 150 | 107 | 99.66 | 7.33 |

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

# CAPSULE 104 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 200 | 106 | 105.06 | .93 |
| 300 | 109.5 | 106.87 | 2.62 |
| 400 | 99 | 106.99 | -7.99 |
| 550 | 111 | 106.99 | 4 |

SUM of RESIDUALS = 2.34

# CAPSULE 83 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:50:19 on 10-14-2002
Page 1
Coefficients of Curve 4

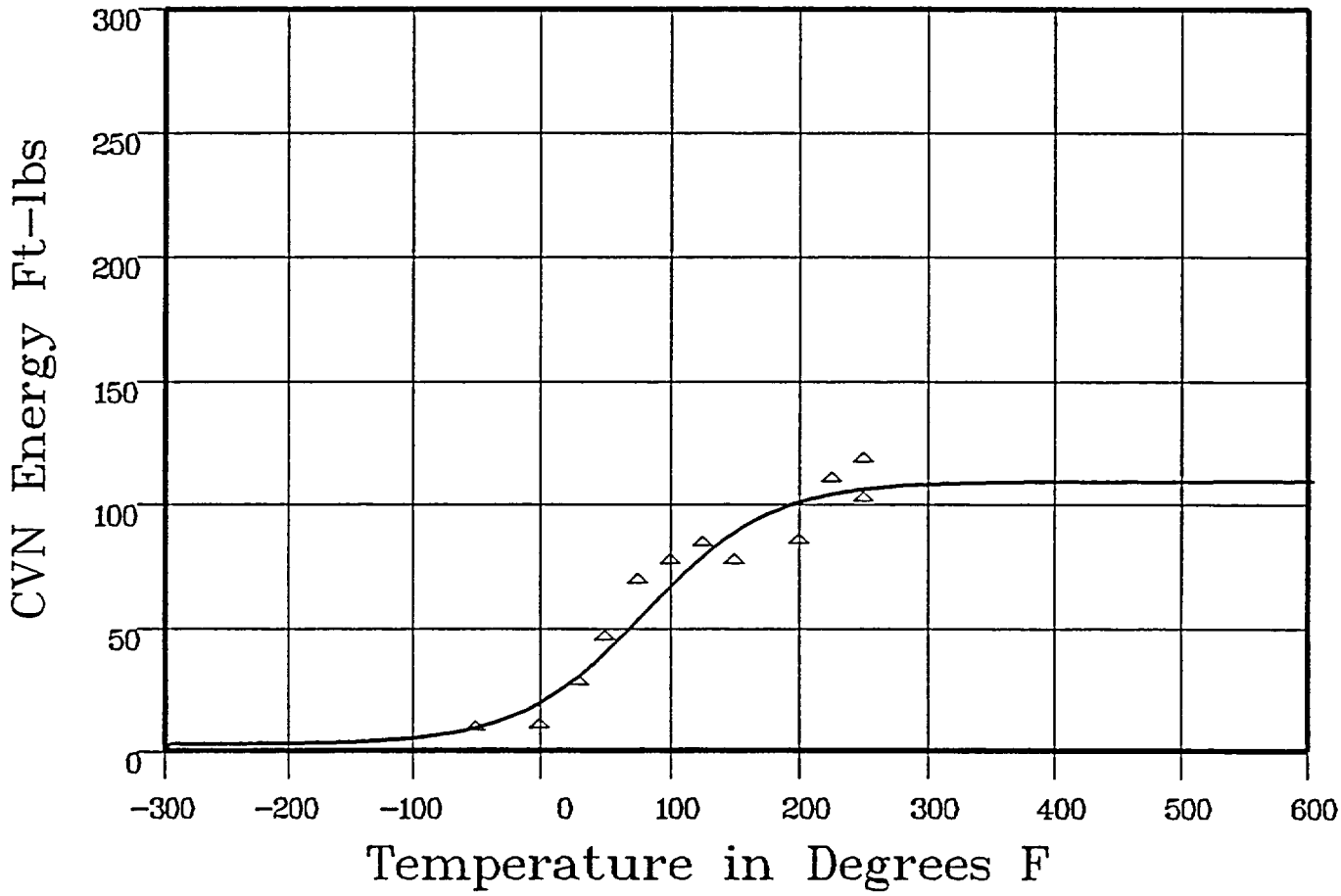
| A = 55.59 | B = 53.4 | C = 97.76 | T0 = 75 |
|---|---|---|---|

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

Upper Shelf Energy: 109 Fixed  Temp. at 30 ft-lbs: 23.9  Temp. at 50 ft-lbs: 64.7  Lower Shelf Energy: 2.19 Fixed

Material: WELD L 124/0091  Heat Number: 90136/10137  Orientation:

Capsule: W-83  Total Fluence:




Data Set(s) Plotted
Plant: M12  Cap: W-83  Material: WELD L 124/0091  Ori:  Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -50 | 8 | 9.88 | -1.88 |
| 0 | 9 | 21.14 | -12.14 |
| 30 | 27 | 32.62 | -5.62 |
| 50 | 45 | 42.23 | 2.76 |
| 75 | 68 | 55.59 | 12.4 |
| 100 | 76 | 68.96 | 7.03 |
| 125 | 83 | 80.75 | 2.24 |

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

# CAPSULE 83 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 150 | 76 | 90.05 | -14.05 |
| 200 | 84 | 101.31 | -17.31 |
| 225 | 109 | 104.25 | 4.74 |
| 250 | 101 | 106.1 | -5.1 |
| 250 | 117 | 106.1 | 10.89 |

SUM of RESIDUALS = -16.03

# UNIRRADIATED (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:20:58 on 10-14-2002

Page 1

Coefficients of Curve 1

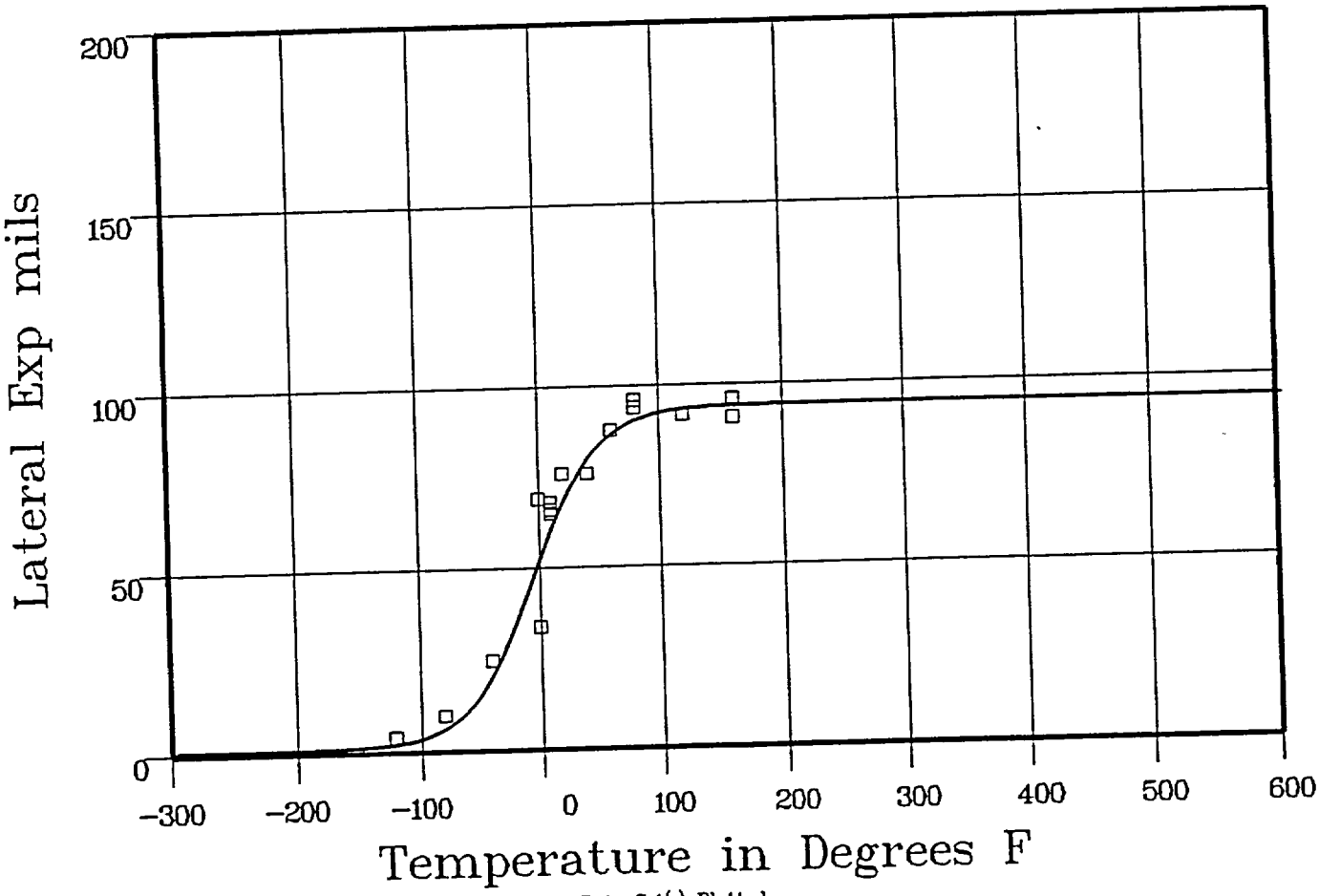
| A = 47.66 | B = 46.66 | C = 53.35 | T0 = -9.66 |
|---|---|---|---|

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

Upper Shelf L.E.: 94.33 Temperature at L.E. 35: -24.5 Lower Shelf L.E.: 1 Fixed

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap.: UNIRR Material: WELD L 124/0091 Ori: Heat #: 90136/10137

Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -120 | 4 | 2.46 | 1.53 |
| -80 | 10 | 7.23 | 2.76 |
| -40 | 25 | 23.66 | 1.33 |
| 0 | 34 | 56.03 | -22.03 |
| 0 | 69 | 56.03 | 12.96 |
| 10 | 68 | 64.13 | 3.86 |
| 10 | 66 | 64.13 | 1.86 |
| 10 | 65 | 64.13 | .86 |
| 20 | 76 | 71.23 | 4.76 |

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

# CAPSULE 97 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:20:58 on 10-14-2002

Page 1

Coefficients of Curve 2

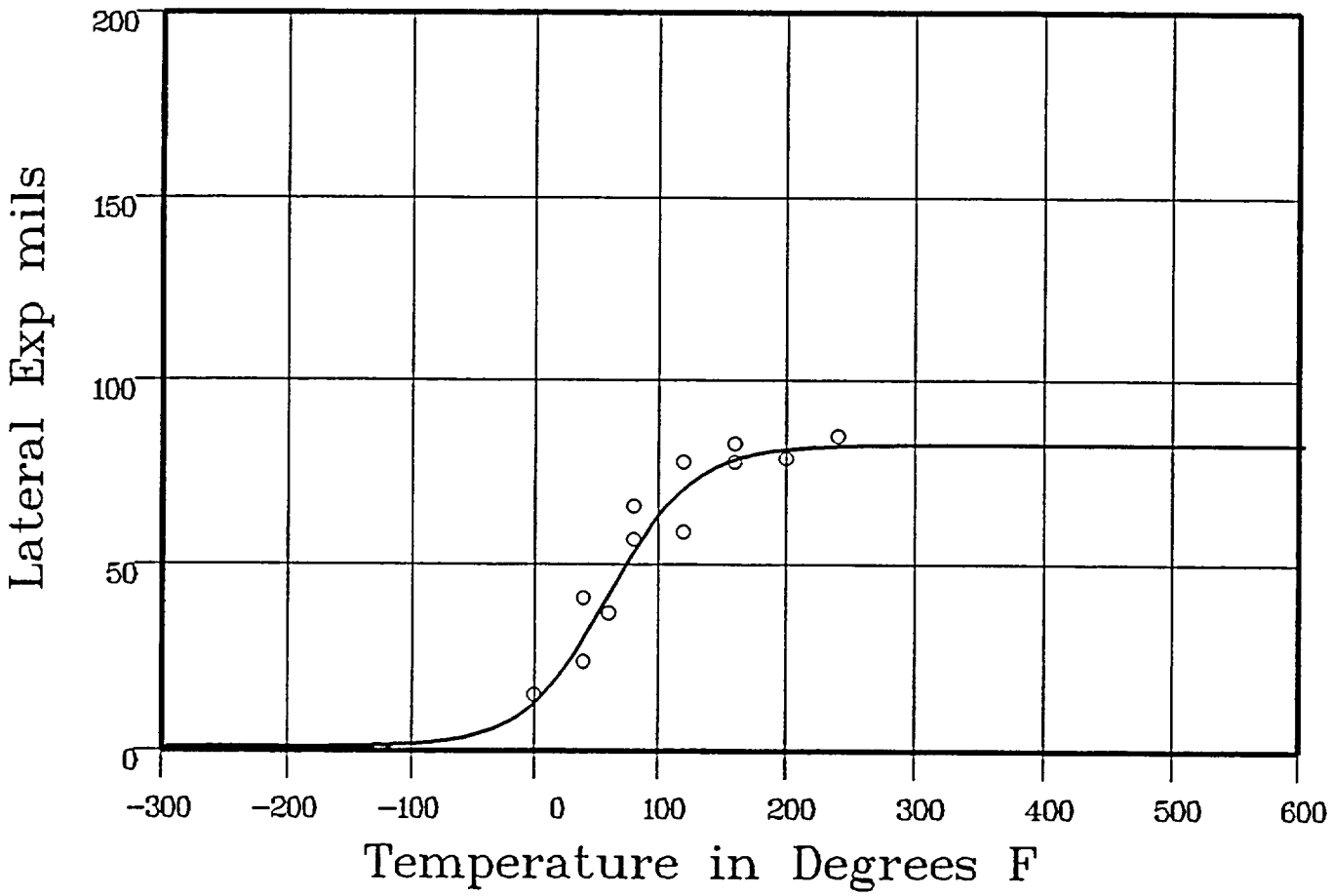
| A = 41.86 | B = 40.86 | C = 67.98 | T0 = 55.78 |
|---|---|---|---|

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

Upper Shelf L.E: 82.72 Temperature at L.E. 35: 44.2 Lower Shelf L.E: 1 Fixed

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: MI2 Cap: W-97 Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 0 | 15 | 14.26 | .73 |
| 40 | 24 | 32.54 | -8.54 |
| 40 | 41 | 32.54 | 8.45 |
| 60 | 37 | 44.39 | -7.39 |
| 80 | 57 | 55.83 | 1.16 |
| 80 | 66 | 55.83 | 10.16 |
| 120 | 78 | 71.99 | 6 |
| 120 | 59 | 71.99 | -12.99 |

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

# CAPSULE 97 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 160 | 78 | 79.08 | -1.08 |
| 160 | 83 | 79.08 | 3.91 |
| 200 | 79 | 81.56 | -2.56 |
| 240 | 85 | 82.36 | 2.63 |

SUM of RESIDUALS = .48

# CAPSULE 104 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:20:58 on 10-14-2002
Page 1
Coefficients of Curve 3

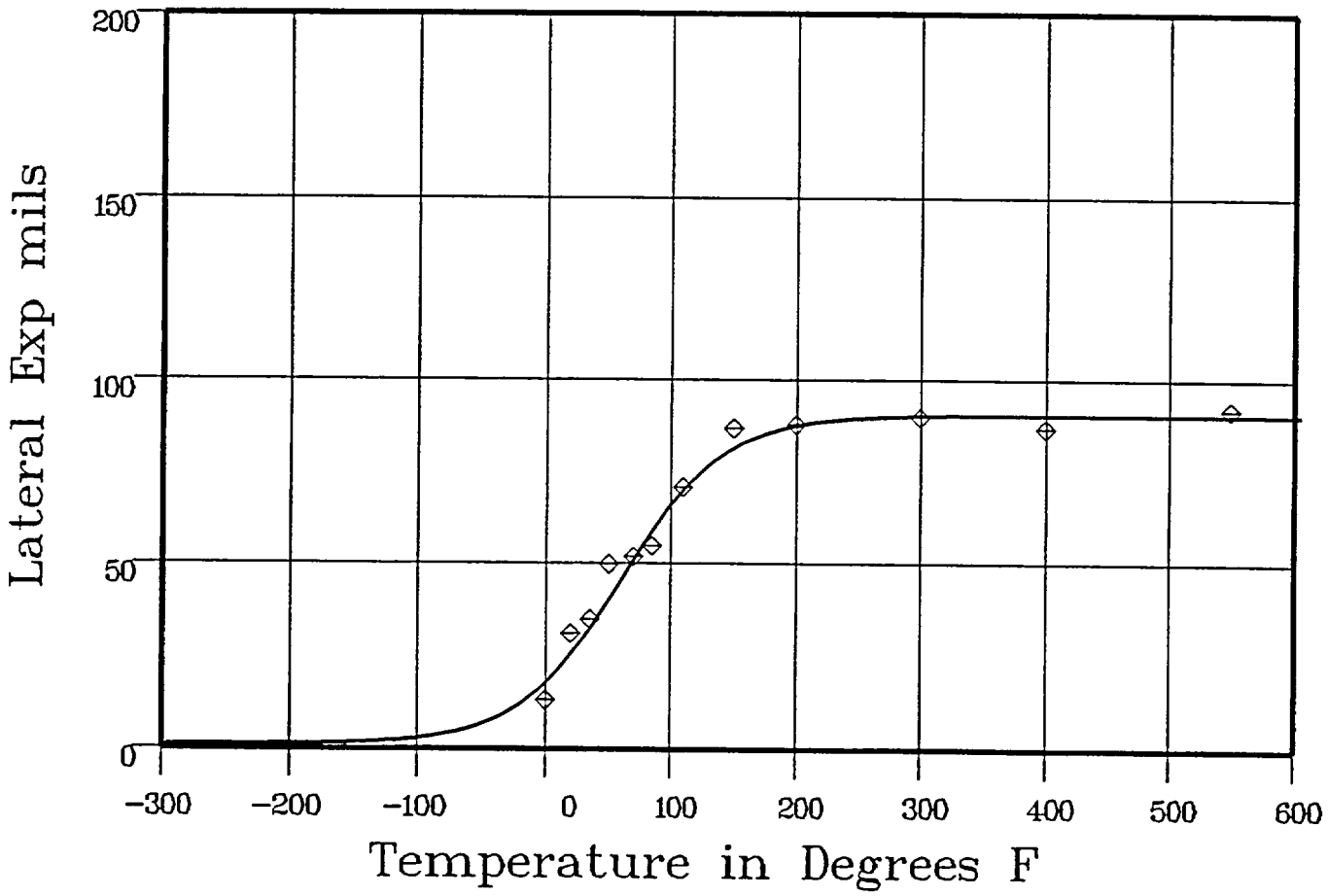
| A = 45.77 | B = 44.77 | C = 81.91 | T0 = 55.31 |
|---|---|---|---|

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

Upper Shelf LE: 90.54 Temperature at LE 35: 35.2 Lower Shelf LE: 1 Fixed

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-104 Total Fluence:




Data Set(s) Plotted
Plant: ML2 Cap: W-104 Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed LE | Differential |
|---|---|---|---|
| 0 | 13 | 19.42 | -6.42 |
| 20 | 31 | 27.58 | 3.41 |
| 35 | 35 | 34.89 | .1 |
| 50 | 50 | 42.87 | 7.12 |
| 70 | 52 | 53.71 | -1.71 |
| 85 | 55 | 61.32 | -6.32 |
| 110 | 71 | 71.89 | -.89 |
| 150 | 87 | 82.47 | 4.52 |

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

# CAPSULE 104 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 200 | 88 | 88 | 0 |
| 300 | 90 | 90.31 | -.31 |
| 400 | 87 | 90.52 | -3.52 |
| 550 | 92 | 90.54 | 1.45 |

SUM of RESIDUALS = -2.57

# CAPSULE 83 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:20:58 on 10-14-2002
Page 1
Coefficients of Curve 4

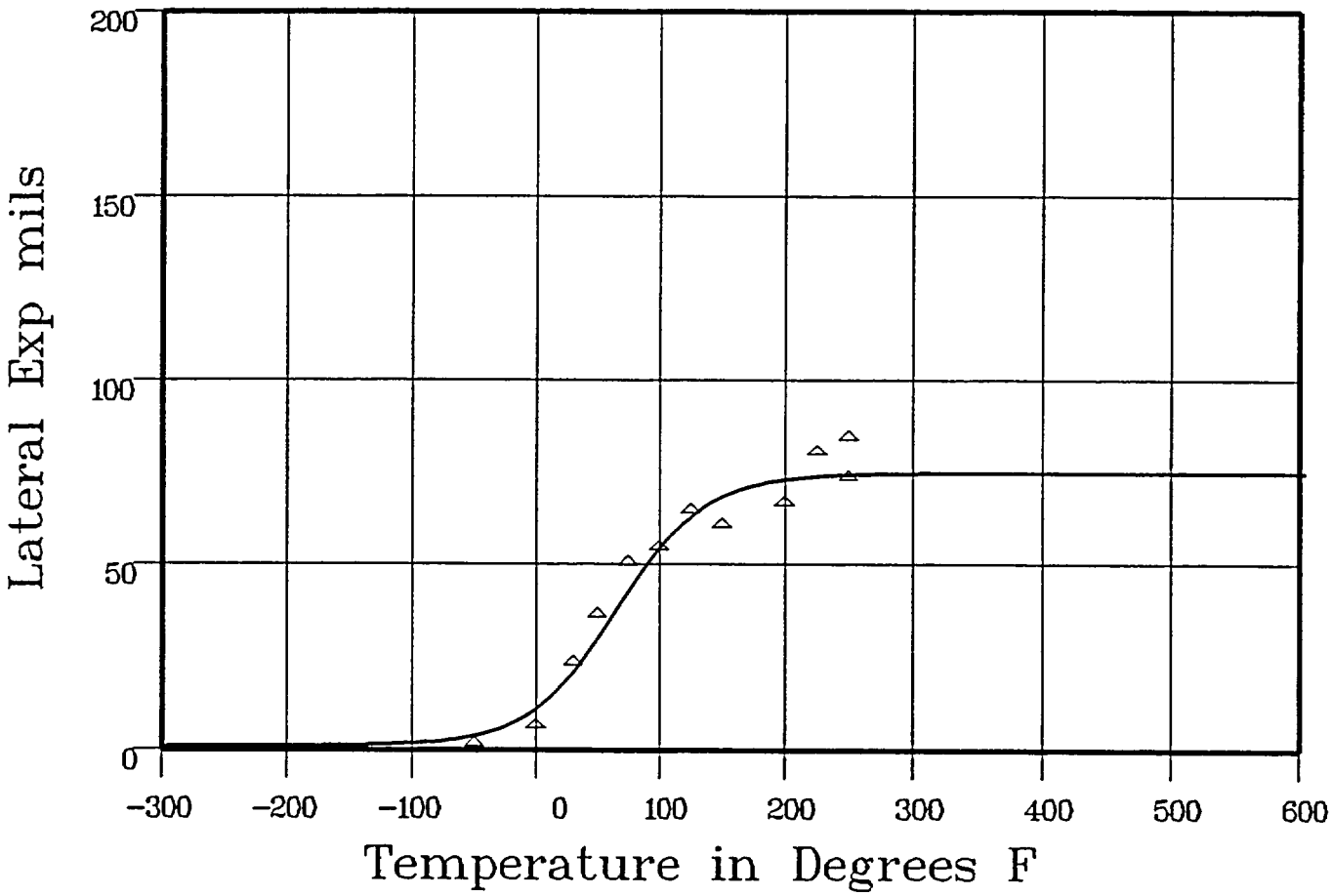
| A = 37.89 | B = 36.89 | C = 71.98 | T0 = 60.93 |
|---|---|---|---|

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

Upper Shelf L.E: 74.78 Temperature at L.E. 35: 55.2 Lower Shelf L.E: 1 Fixed

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-83 Total Fluence:




Data Set(s) Plotted
Plant: ML2 Cap: W-83 Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -50 | 1 | 4.23 | -3.23 |
| 0 | 6 | 12.46 | -6.46 |
| 30 | 23 | 22.94 | .05 |
| 50 | 36 | 32.32 | 3.67 |
| 75 | 50 | 45 | 4.99 |
| 100 | 54 | 56.15 | -2.15 |
| 125 | 64 | 64.13 | -.13 |

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

# CAPSULE 83 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 150 | 60 | 69.05 | -9.05 |
| 200 | 66 | 73.26 | -7.26 |
| 225 | 80 | 74.01 | 5.98 |
| 250 | 73 | 74.4 | -1.4 |
| 250 | 84 | 74.4 | 9.59 |

SUM of RESIDUALS = -5.41

# UNIRRADIATED (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:28:54 on 10-14-2002

Page 1

Coefficients of Curve 1

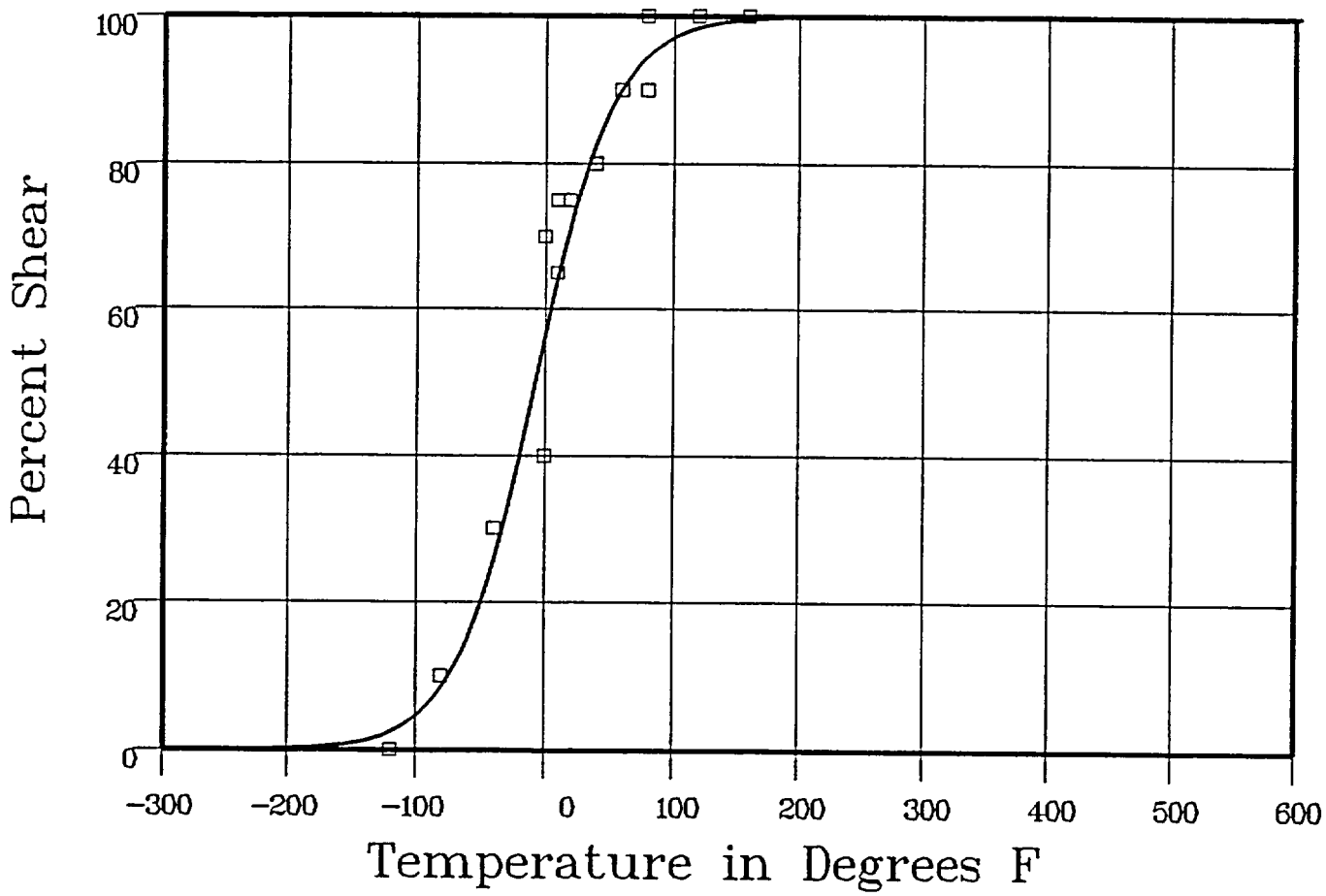
| A = 50 | B = 50 | C = 61.03 | T0 = -12.18 |
|---|---|---|---|

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

Temperature at 50% Shear: -12.1

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: UNIRR Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -120 | 0 | 2.83 | -2.83 |
| -80 | 10 | 9.77 | .22 |
| -40 | 30 | 28.67 | 1.32 |
| 0 | 40 | 59.85 | -19.85 |
| 0 | 70 | 59.85 | 10.14 |
| 10 | 65 | 67.41 | -2.41 |
| 10 | 75 | 67.41 | 7.58 |
| 10 | 75 | 67.41 | 7.58 |
| 20 | 75 | 74.16 | .83 |

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

# UNIRRADIATED (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 40 | 80 | 84.68 | -4.68 |
| 60 | 90 | 91.41 | -1.41 |
| 80 | 90 | 95.34 | -5.34 |
| 80 | 100 | 95.34 | 4.65 |
| 120 | 100 | 98.7 | 1.29 |
| 120 | 100 | 98.7 | 1.29 |
| 160 | 100 | 99.64 | .35 |
| 160 | 100 | 99.64 | .35 |
| | | SUM of RESIDUALS = | -.9 |

# CAPSULE 97 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:28:54 on 10-14-2002
Page 1
Coefficients of Curve 2

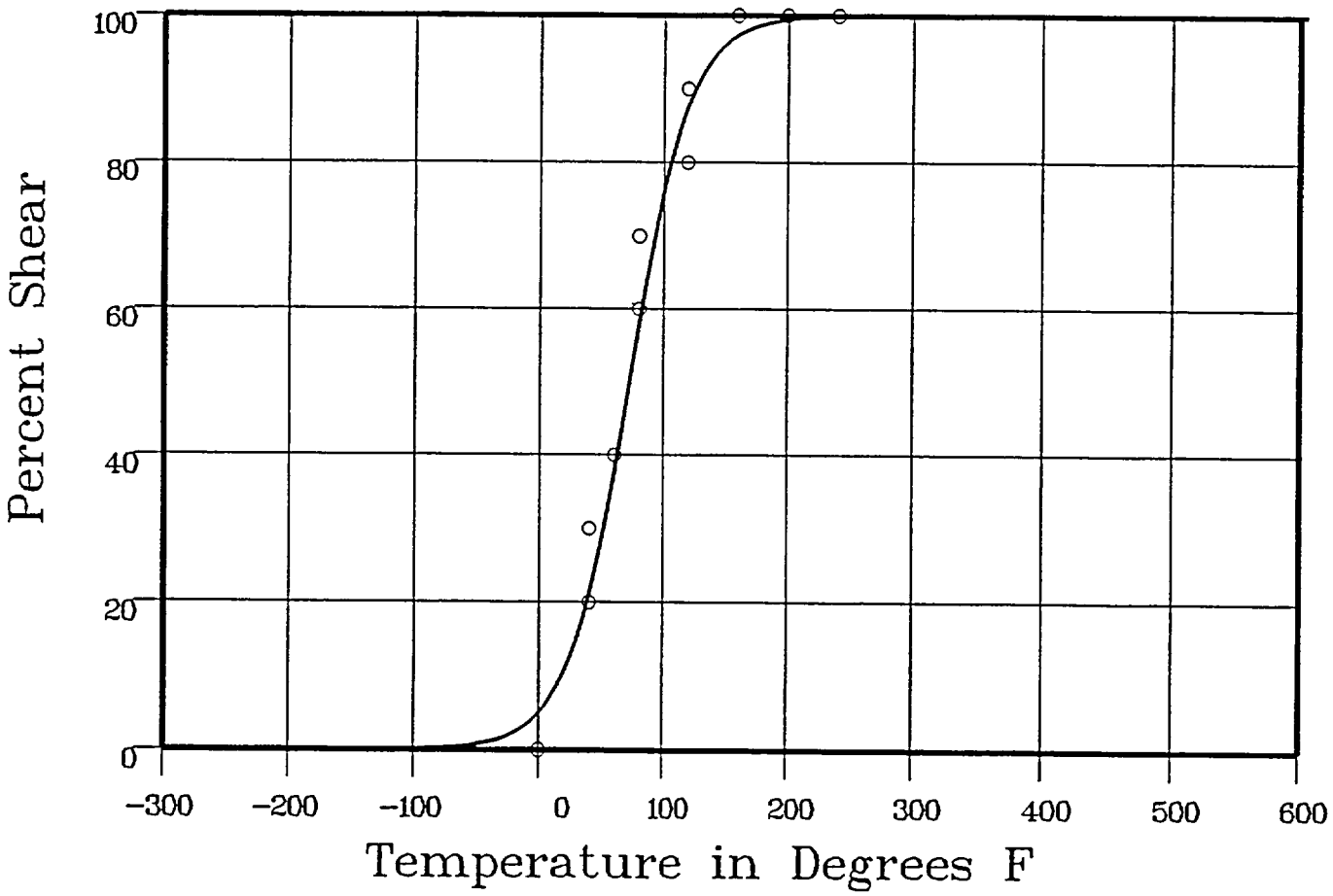
| A = 50 | B = 50 | C = 48.87 | T0 = 67.7 |
|---|---|---|---|

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

Temperature at 50% Shear: 67.7

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-97 Total Fluence:




Data Set(s) Plotted
Plant: ML2 Cap: W-97 Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 0 | 0 | 5.89 | -5.89 |
| 40 | 20 | 24.34 | -4.34 |
| 40 | 30 | 24.34 | 5.65 |
| 60 | 40 | 42.18 | -2.18 |
| 80 | 60 | 62.32 | -2.32 |
| 80 | 70 | 62.32 | 7.67 |
| 120 | 90 | 89.47 | .52 |
| 120 | 80 | 89.47 | -9.47 |

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

# .CAPSULE 97 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 160 | 100 | 97.76 | 2.23 |
| 160 | 100 | 97.76 | 2.23 |
| 200 | 100 | 99.55 | .44 |
| 240 | 100 | 99.91 | .08 |

SUM of RESIDUALS = -5.35

# CAPSULE 104 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:28:54 on 10-14-2002
Page 1
Coefficients of Curve 3

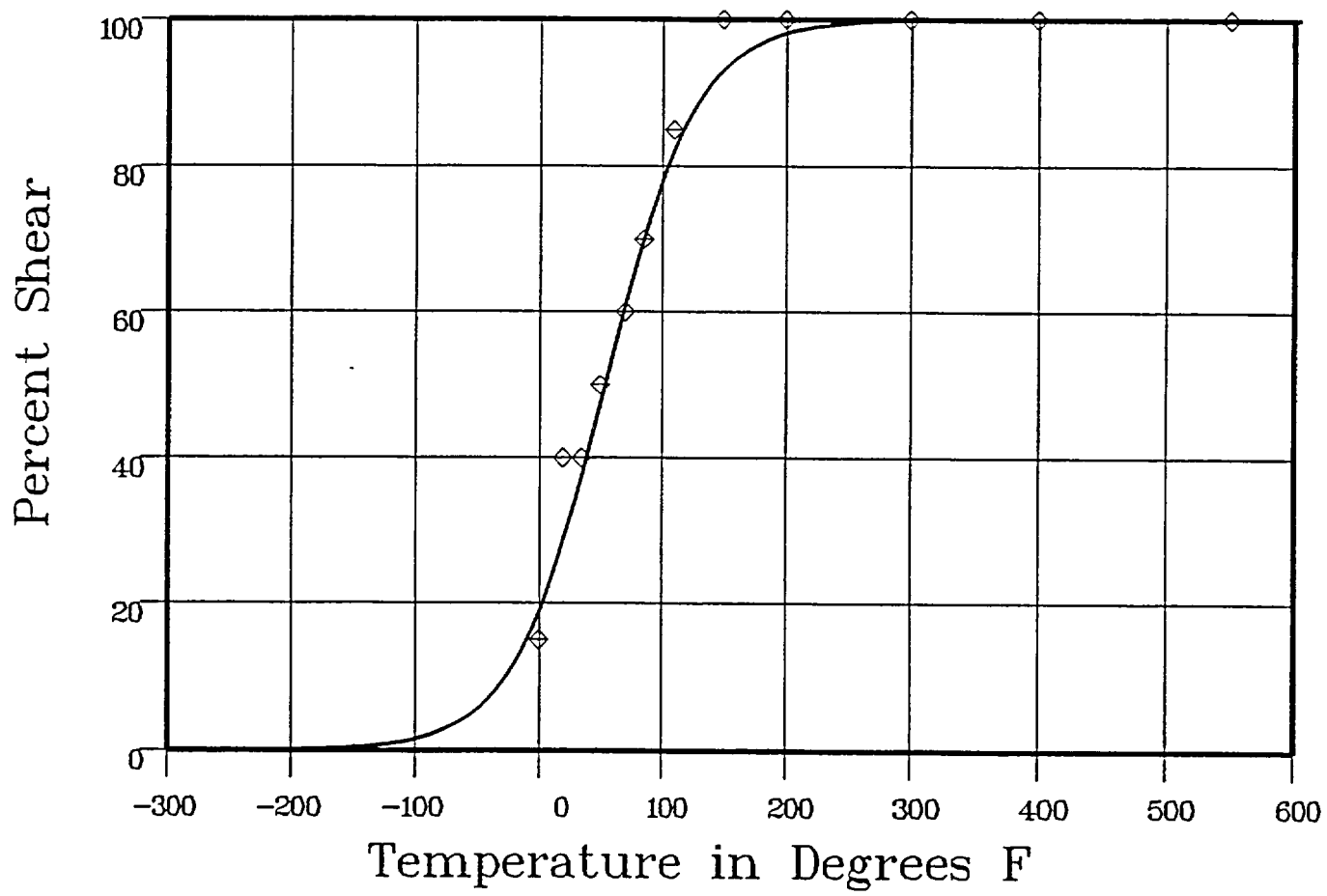
| A = 50 | B = 50 | C = 73.56 | T0 = 49.21 |
|---|---|---|---|

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

Temperature at 50% Shear: 49.2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-104 Total Fluence:




Data Set(s) Plotted
Plant: M12 Cap: W-104 Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 0 | 15 | 20.78 | -5.78 |
| 20 | 40 | 31.12 | 8.87 |
| 35 | 40 | 40.45 | -.45 |
| 50 | 50 | 50.53 | -.53 |
| 70 | 60 | 63.76 | -3.76 |
| 85 | 70 | 72.56 | -2.56 |
| 110 | 85 | 83.92 | 1.07 |
| 150 | 100 | 93.93 | 6.06 |

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

# CAPSULE 104 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 200 | 100 | 98.36 | 1.63 |
| 300 | 100 | 99.89 | .1 |
| 400 | 100 | 99.99 | 0 |
| 550 | 100 | 99.99 | 0 |

SUM of RESIDUALS = 4.67

# CAPSULE 83 (WELD)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:28:54 on 10-14-2002
Page 1
Coefficients of Curve 4

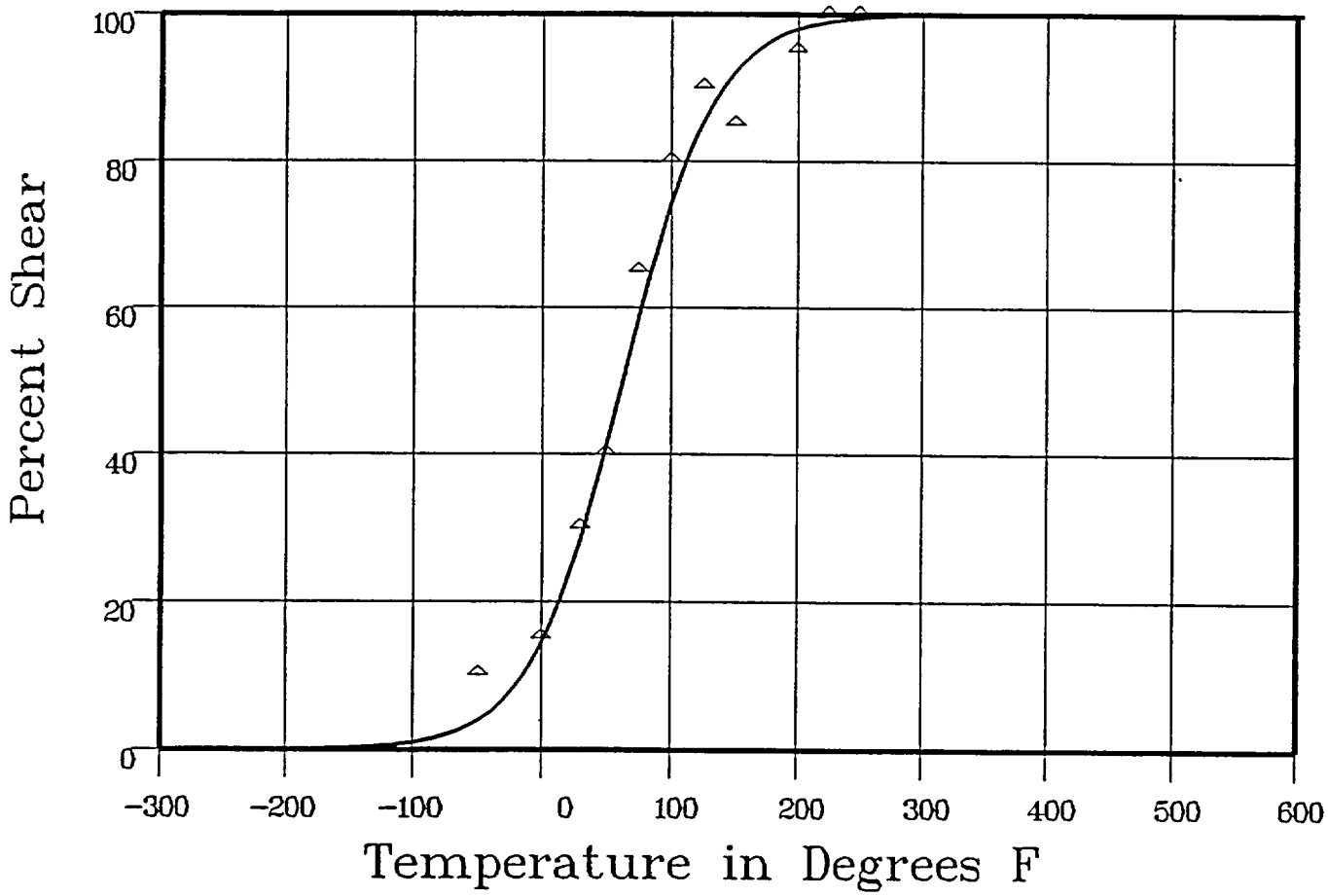
| A = 50 | B = 50 | C = 70.42 | T0 = 58.12 |
|---|---|---|---|

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

Temperature at 50% Shear: 581

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-83 Total Fluence:




Data Set(s) Plotted
Plant: ML2 Cap: W-83 Material: WELD L 124/0091 Ori: Heat #: 90136/10137

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -50 | 10 | 4.43 | 5.56 |
| 0 | 15 | 16.1 | -1.1 |
| 30 | 30 | 31.02 | -1.02 |
| 50 | 40 | 44.25 | -4.25 |
| 75 | 65 | 61.75 | 3.24 |
| 100 | 80 | 76.66 | 3.33 |
| 125 | 90 | 86.98 | 3.01 |

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

# CAPSULE 83 (WELD)

Page 2

Material: WELD L 124/0091 Heat Number: 90136/10137 Orientation:

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 150 | 85 | 93.14 | -8.14 |
| 200 | 95 | 98.25 | -3.25 |
| 225 | 100 | 99.13 | .86 |
| 250 | 100 | 99.57 | .42 |
| 250 | 100 | 99.57 | .42 |

SUM of RESIDUALS = -.89

# UNIRRADIATED (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:57:39 on 10-15-2002

Page 1

Coefficients of Curve 1

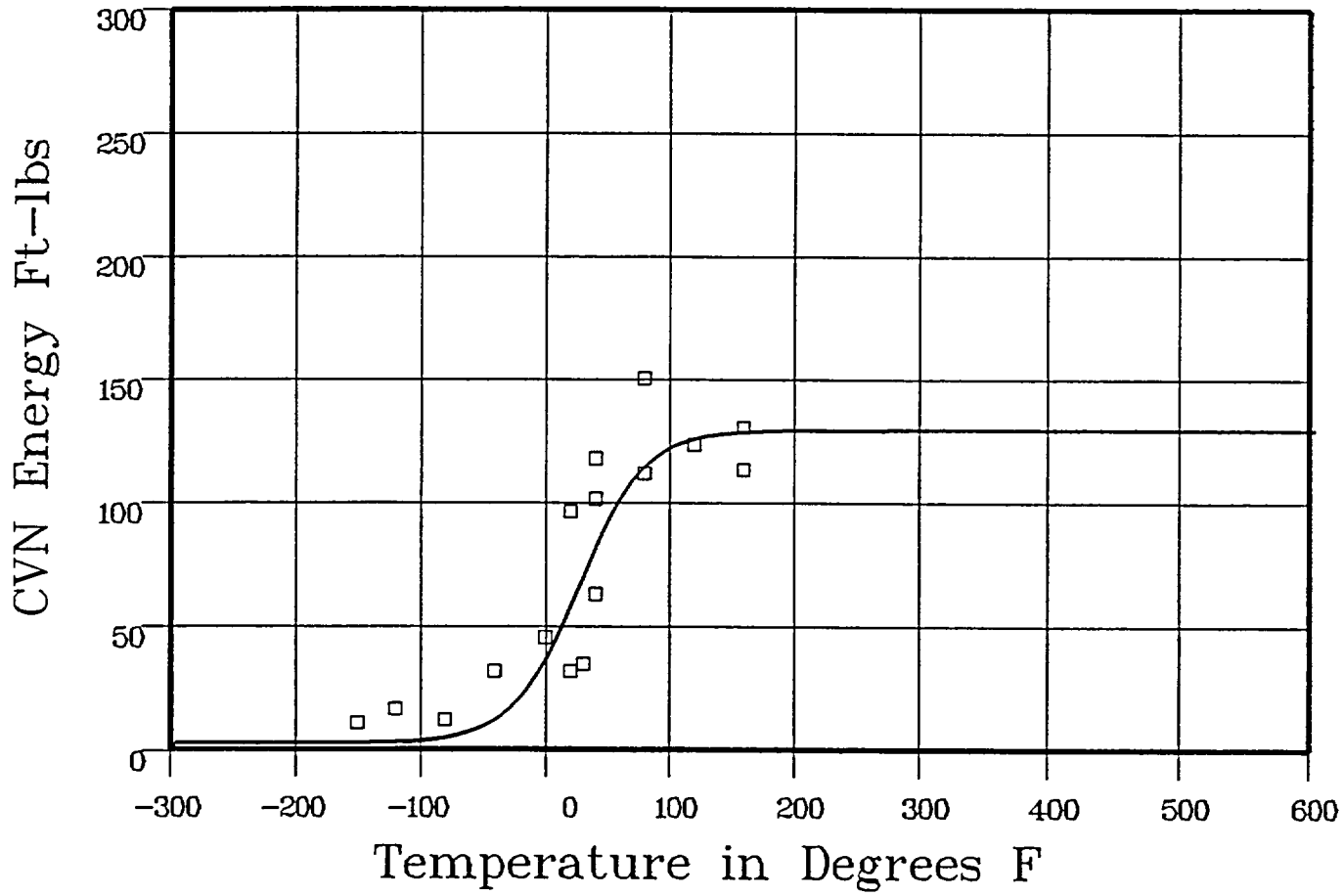
| A = 65.59 | B = 63.4 | C = 52.83 | T0 = 22.03 |
|---|---|---|---|

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

Upper Shelf Energy: 129 Fixed  Temp. at 30 ft-lbs: -11.5  Temp. at 50 ft-lbs: 8.7  Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE SA533B1  Heat Number: C-506-1  Orientation:

Capsule: UNIRR  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap.: UNIRR  Material: HEAT AFFD ZONE SA533B1  Ori.:  Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -150 | 10 | 2.38 | 7.61 |
| -120 | 16 | 2.78 | 13.21 |
| -80 | 11.5 | 4.81 | 6.68 |
| -40 | 31.5 | 13.26 | 18.23 |
| 0 | 45 | 40.59 | 4.4 |
| 20 | 96 | 63.16 | 32.83 |
| 20 | 31.5 | 63.16 | -31.66 |
| 30 | 34.5 | 75.08 | -40.58 |
| 40 | 62.5 | 86.36 | -23.86 |

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

# UNIRRADIATED (HEAT AFFECTED ZONE)



Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 40 | 117.5 | 86.36 | 31.13 |
| 40 | 101 | 86.36 | 14.63 |
| 80 | 111.5 | 116.28 | -4.78 |
| 80 | 150 | 116.28 | 33.71 |
| 120 | 123 | 125.96 | -2.96 |
| 160 | 113 | 128.31 | -15.31 |
| 160 | 130 | 128.31 | 1.68 |

SUM of RESIDUALS = 44.96

# CAPSULE 97 (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:57:39 on 10-15-2002

Page 1

Coefficients of Curve 2

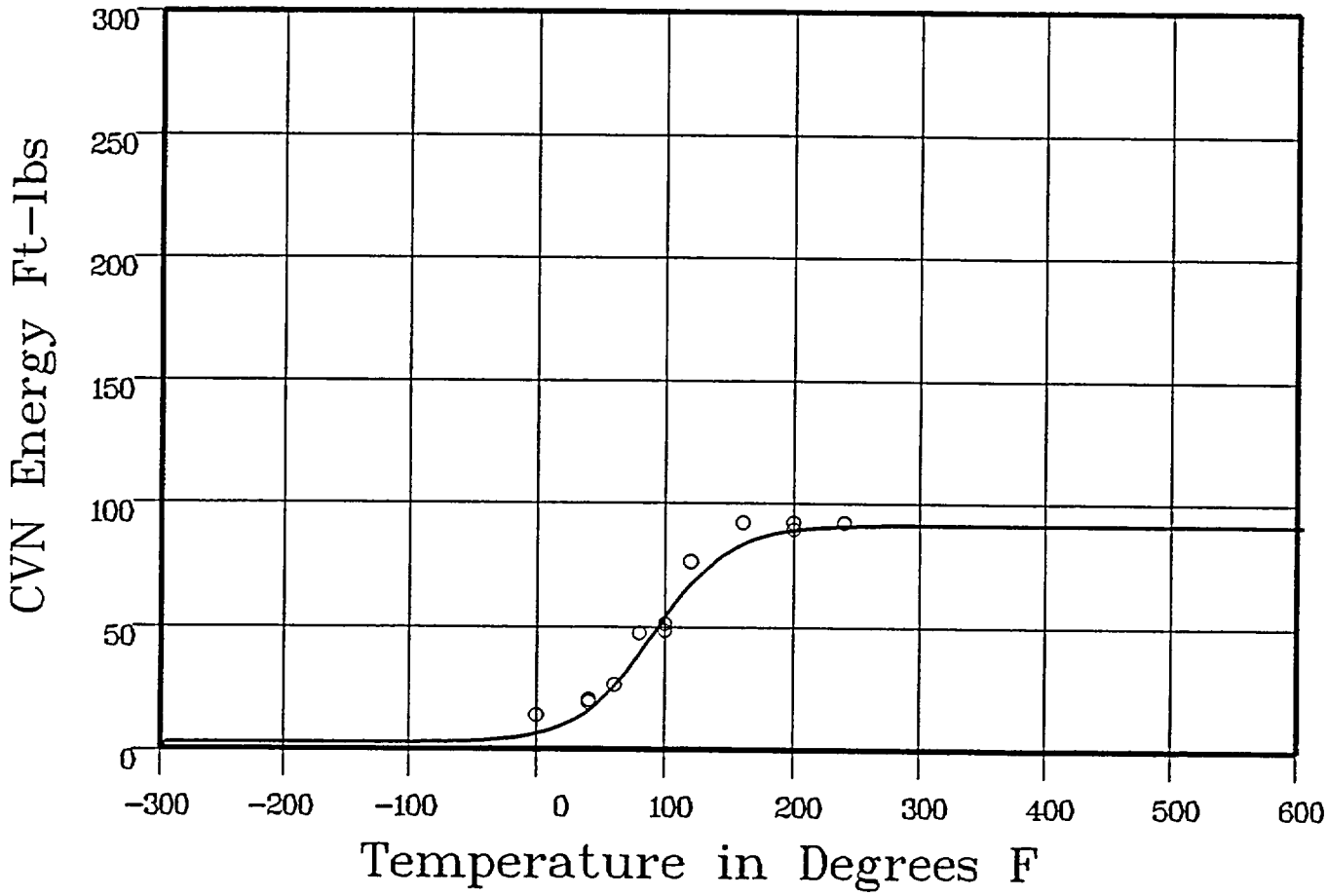
| A = 46.59 | B = 44.4 | C = 59.81 | T0 = 86.24 |
|---|---|---|---|

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

Upper Shelf Energy: 91 Fixed  Temp. at 30 ft-lbs: 62.7  Temp. at 50 ft-lbs: 90.8  Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFF'D ZONE SA533B1  Heat Number: C-506-1  Orientation:

Capsule: W-97  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: W-97  Material: HEAT AFF'D ZONE SA533B1  Ori:  Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 0 | 14 | 6.9 | 7.09 |
| 40 | 19 | 17.79 | 1.2 |
| 40 | 20 | 17.79 | 2.2 |
| 60 | 26 | 28.27 | -2.27 |
| 80 | 47 | 41.97 | 5.02 |
| 100 | 51 | 56.63 | -5.63 |
| 100 | 48 | 56.63 | -8.63 |
| 120 | 76 | 69.29 | 6.7 |

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

# CAPSULE 97 (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 160 | 92 | 84.04 | 7.95 |
| 200 | 89 | 89.06 | -.06 |
| 200 | 92 | 89.06 | 2.93 |
| 240 | 92 | 90.48 | 1.51 |

SUM of RESIDUALS = 18.03

# CAPSULE 83 (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:57:39 on 10-15-2002

Page 1

Coefficients of Curve 3

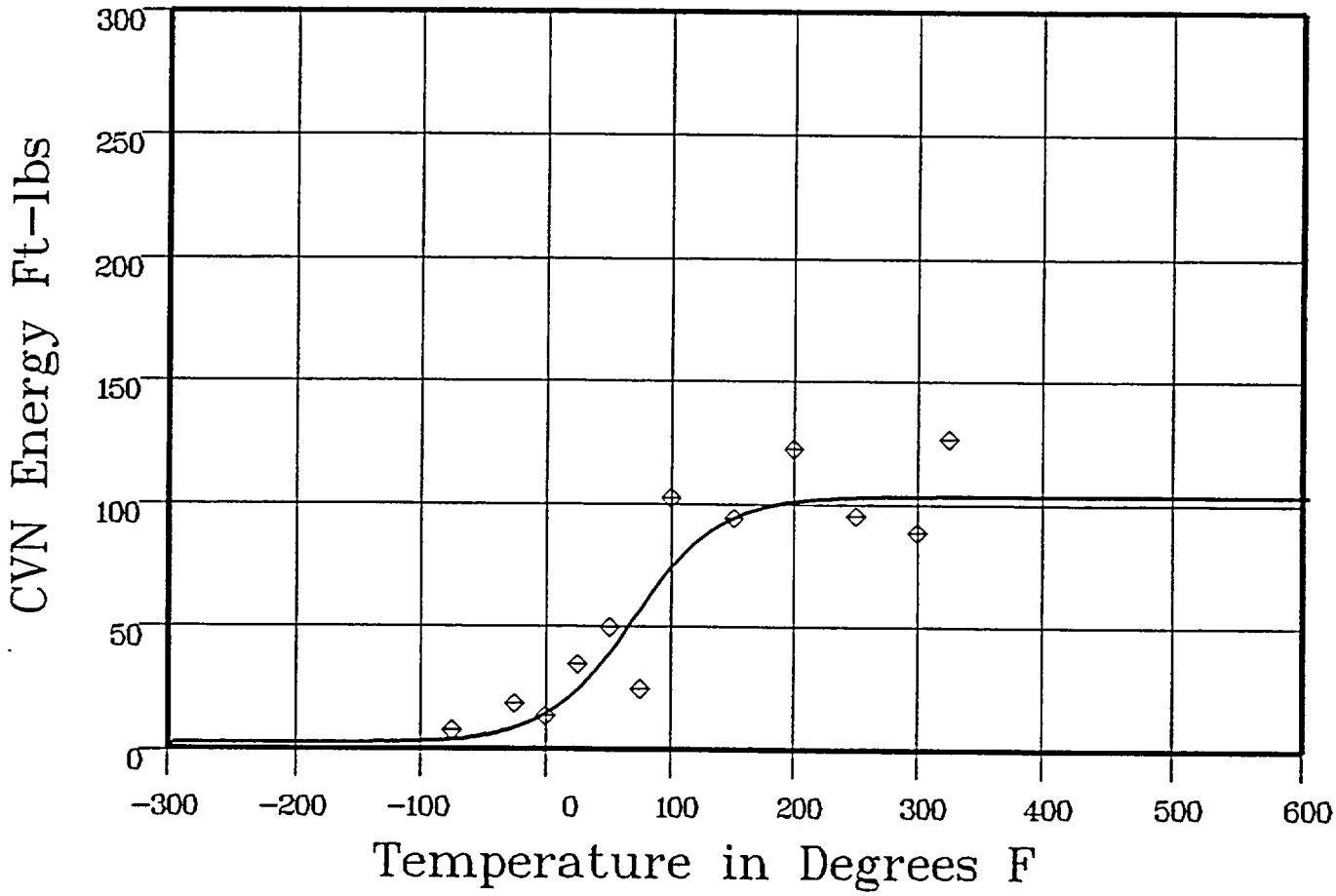
| A = 52.59 | B = 50.4 | C = 68.85 | T0 = 64.9 |
|---|---|---|---|

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

Upper Shelf Energy: 103 Fixed  Temp. at 30 ft-lbs: 31.6  Temp. at 50 ft-lbs: 61.3  Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFF'D ZONE SA533B1  Heat Number: C-506-1  Orientation:

Capsule: W-83  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: W-83  Material: HEAT AFF'D ZONE SA533B1  Ori:  Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -75 | 7 | 3.9 | 3.09 |
| -25 | 18 | 9.09 | 8.9 |
| 0 | 13 | 15.48 | -2.48 |
| 25 | 34 | 26.27 | 7.72 |
| 50 | 49 | 41.85 | 7.14 |
| 75 | 24 | 59.93 | -35.93 |
| 100 | 102 | 76.27 | 25.72 |
| 150 | 94 | 95.15 | -1.15 |

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

# CAPSULE 83 (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 200 | 122 | 101.04 | 20.95 |
| 250 | 95 | 102.53 | -7.53 |
| 300 | 88 | 102.89 | -14.89 |
| 325 | 126 | 102.94 | 23.05 |

SUM of RESIDUALS = 34.59

# UNIRRADIATED (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:01:12 on 10-15-2002

Page 1

Coefficients of Curve 1

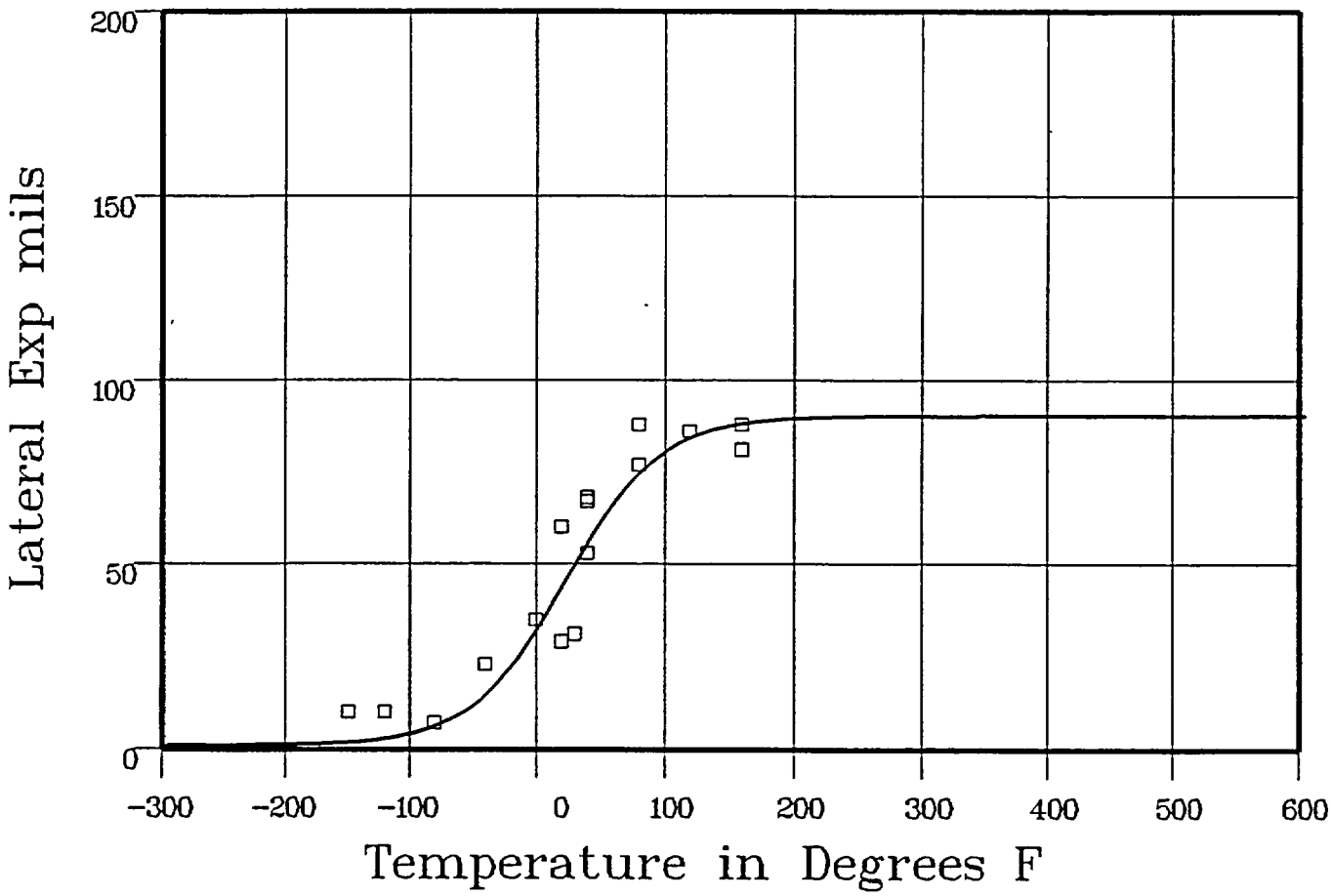
| A = 45.69 | B = 44.69 | C = 73.87 | T0 = 18.75 |
|---|---|---|---|

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

Upper Shelf L.E: 90.39 Temperature at L.E. 35: .7 Lower Shelf L.E: 1 Fixed

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: UNIRR Material: HEAT AFF'D ZONE SA533B1 Ori: Heat #: C-506-1

**Charpy V-Notch Data**

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -150 | 10 | 1.91 | 8.08 |
| -120 | 10 | 3.04 | 6.95 |
| -80 | 7 | 6.77 | .22 |
| -40 | 23 | 16.13 | 6.86 |
| 0 | 35 | 34.58 | .41 |
| 20 | 60 | 46.45 | 13.54 |
| 20 | 29 | 46.45 | -17.45 |
| 30 | 31 | 52.45 | -21.45 |
| 40 | 53 | 58.21 | -5.21 |

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

# UNIRRADIATED (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 40 | 68 | 58.21 | 9.78 |
| 40 | 67 | 58.21 | 8.78 |
| 80 | 77 | 76.09 | .9 |
| 80 | 88 | 76.09 | 11.9 |
| 120 | 86 | 84.97 | 1.02 |
| 160 | 81 | 88.48 | -7.48 |
| 160 | 88 | 88.48 | -.48 |

SUM of RESIDUALS = 16.42

# CAPSULE 97 (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:01:12 on 10-15-2002

Page 1

Coefficients of Curve 2

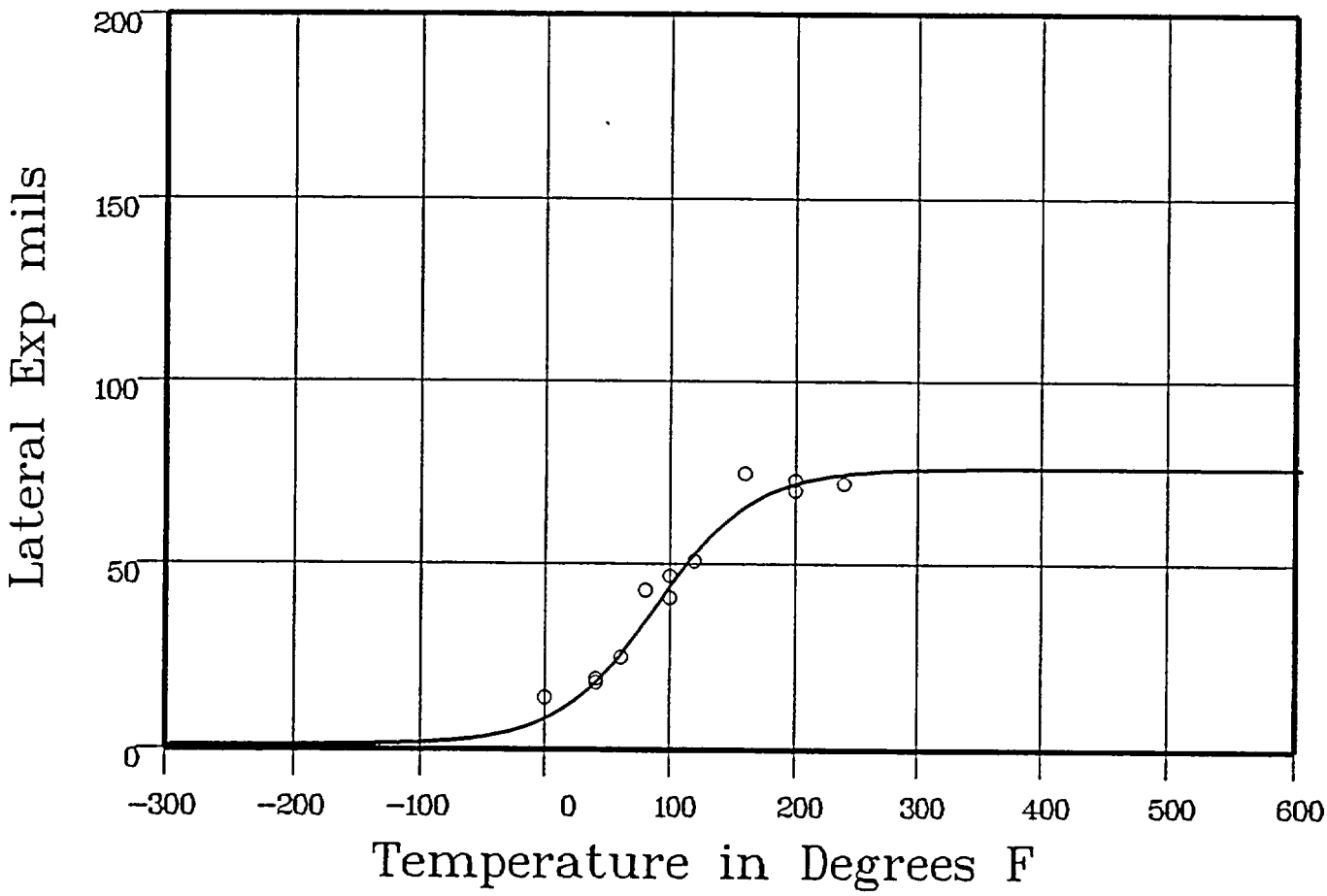
| A = 38.67 | B = 37.67 | C = 79.81 | T0 = 84.17 |
|---|---|---|---|

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

Upper Shelf L.E.: 76.34 Temperature at L.E. 35: 76.3 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-97 Material: HEAT AFF'D ZONE SA533B1 Ori: Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 0 | 14 | 9.15 | 4.84 |
| 40 | 18 | 19.71 | -1.71 |
| 40 | 19 | 19.71 | -.71 |
| 60 | 25 | 27.59 | -2.59 |
| 80 | 43 | 36.7 | 6.29 |
| 100 | 47 | 46.04 | .95 |
| 100 | 41 | 46.04 | -5.04 |
| 120 | 51 | 54.52 | -3.52 |

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

# CAPSULE 97 (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 160 | 75 | 66.53 | 8.46 |
| 200 | 70 | 72.42 | -2.42 |
| 200 | 73 | 72.42 | .57 |
| 240 | 72 | 74.85 | -2.85 |

SUM of RESIDUALS = 2.26

# CAPSULE 83 (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:01:12 on 10-15-2002

Page 1

Coefficients of Curve 3

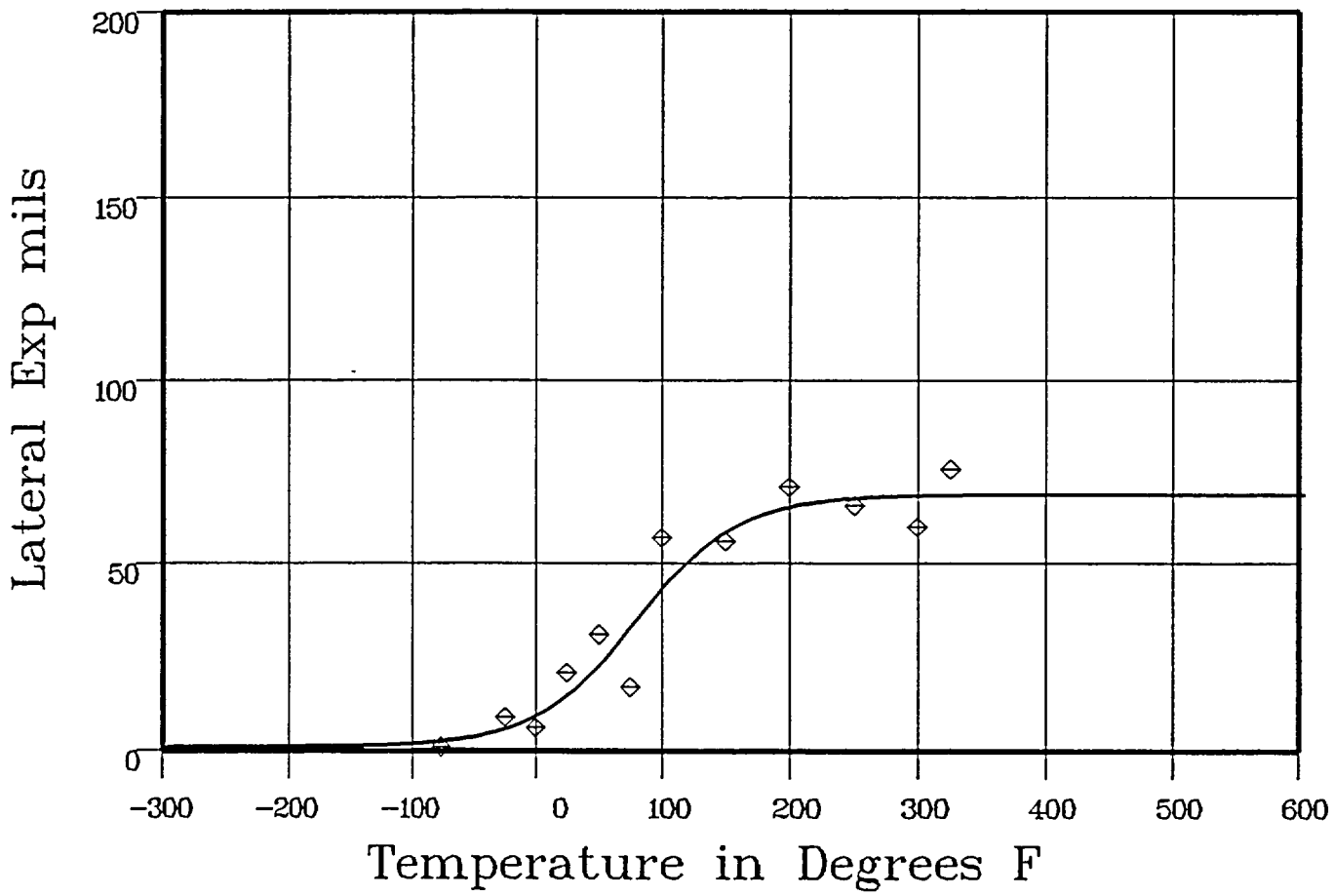
| A = 34.95 | B = 33.95 | C = 81.03 | T0 = 75.29 |
|---|---|---|---|

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

Upper Shelf L.E.: 68.9 Temperature at L.E. 35: 75.4 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-83 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap.: W-83 Material: HEAT AFFD ZONE SA533B1 Ori.: Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -75 | 1 | 2.62 | -1.62 |
| -25 | 9 | 6.26 | 2.73 |
| 0 | 6 | 10.16 | -4.16 |
| 25 | 21 | 16.22 | 4.77 |
| 50 | 31 | 24.68 | 6.31 |
| 75 | 17 | 34.82 | -17.82 |
| 100 | 57 | 44.99 | 12 |
| 150 | 56 | 59.62 | -3.62 |

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

# CAPSULE 83 (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 200 | 71 | 65.91 | 5.08 |
| 250 | 66 | 68 | -2 |
| 300 | 60 | 68.64 | -8.64 |
| 325 | 76 | 68.76 | 7.23 |

SUM of RESIDUALS = .26

# UNIRRADIATED (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:04:13 on 10-15-2002

Page 1

Coefficients of Curve 1

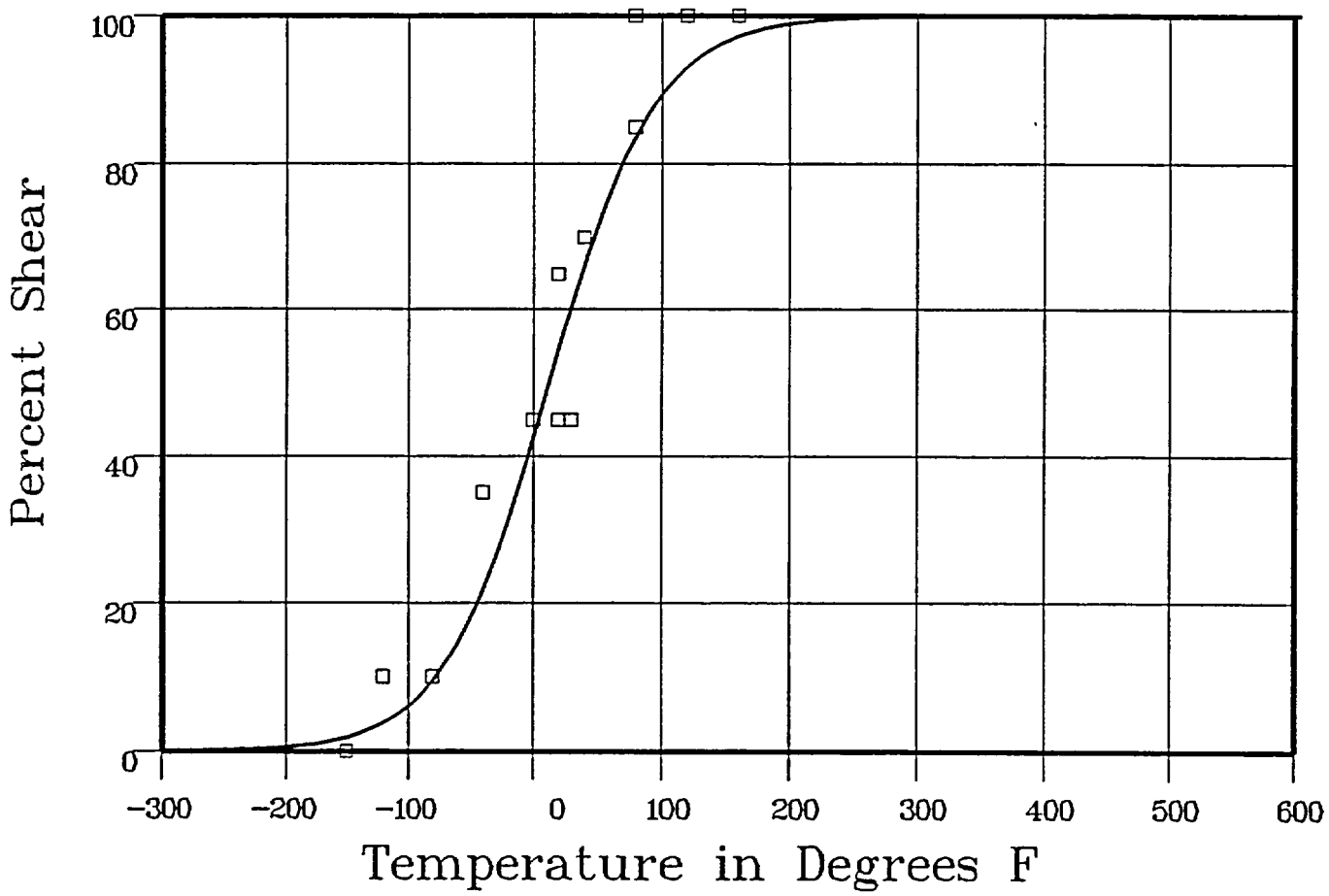
| A = 50 | B = 50 | C = 82.38 | T0 = 7.96 |
|---|---|---|---|

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

Temperature at 50% Shear: 7.9

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: UNIRR Material: HEAT AFFD ZONE SA533B1 Ori: Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -150 | 0 | 2.11 | -2.11 |
| -120 | 10 | 4.28 | 5.71 |
| -80 | 10 | 10.56 | -.56 |
| -40 | 35 | 23.78 | 11.21 |
| 0 | 45 | 45.17 | -.17 |
| 20 | 65 | 57.25 | 7.74 |
| 20 | 45 | 57.25 | -12.25 |
| 30 | 45 | 63.06 | -18.06 |
| 40 | 70 | 68.51 | 1.48 |

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

# UNIRRADIATED (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 40 | 70 | 68.51 | 1.48 |
| 40 | 70 | 68.51 | 1.48 |
| 80 | 85 | 85.17 | -.17 |
| 80 | 100 | 85.17 | 14.82 |
| 120 | 100 | 93.81 | 6.18 |
| 160 | 100 | 97.56 | 2.43 |
| 160 | 100 | 97.56 | 2.43 |

SUM of RESIDUALS = 21.65

# CAPSULE 97 (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:04:13 on 10-15-2002

Page 1

Coefficients of Curve 2

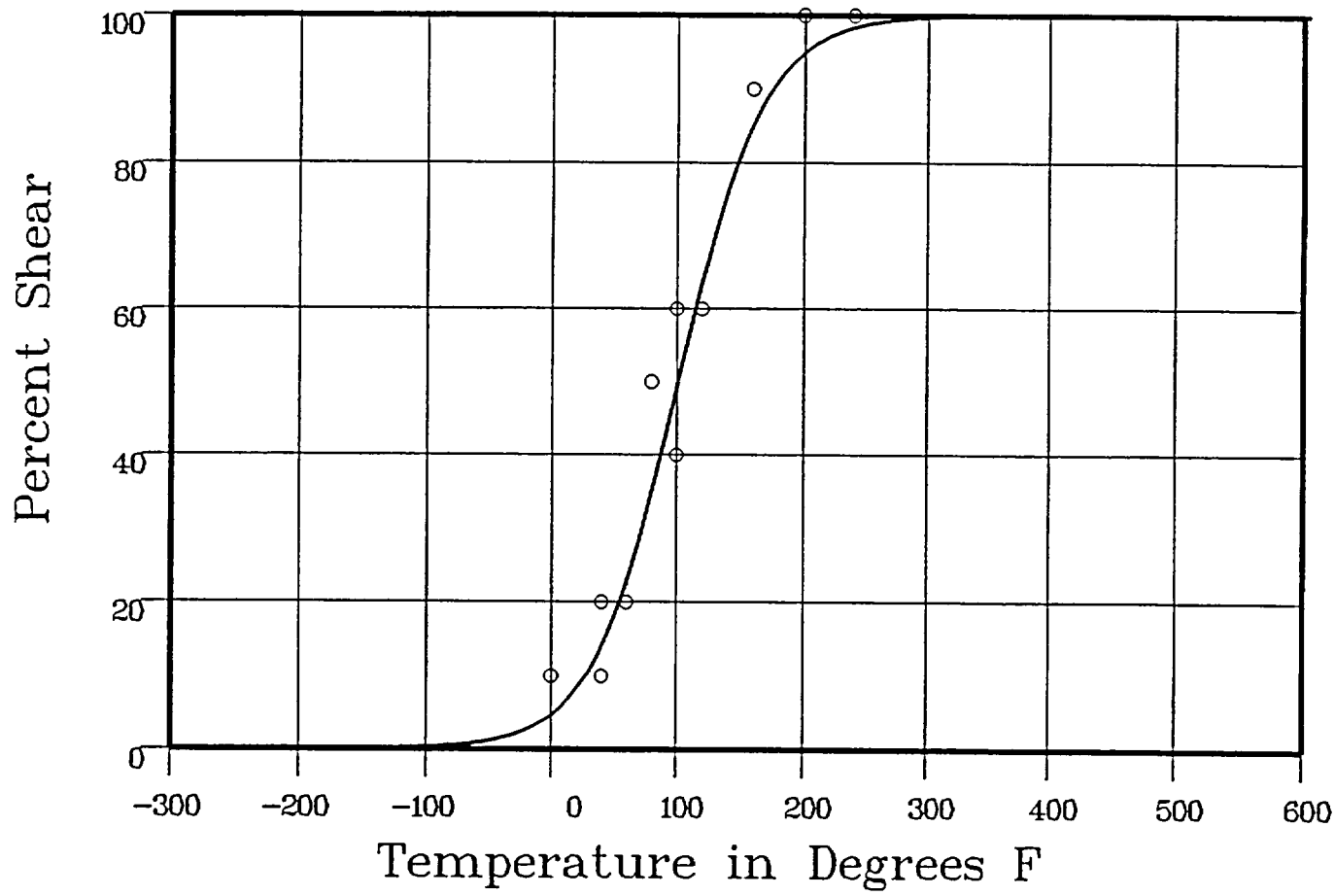
| A = 50 | B = 50 | C = 67.46 | T0 = 96.67 |
|---|---|---|---|

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

Temperature at 50% Shear: 96.6

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-97 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-97 Material: HEAT AFF'D ZONE SA533B1 Ori: Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 0 | 10 | 5.38 | 4.61 |
| 40 | 20 | 15.7 | 4.29 |
| 40 | 10 | 15.7 | -5.7 |
| 60 | 20 | 25.21 | -5.21 |
| 80 | 50 | 37.88 | 12.11 |
| 100 | 60 | 52.45 | 7.54 |
| 100 | 40 | 52.45 | -12.45 |
| 120 | 60 | 66.62 | -6.62 |

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

# CAPSULE 97 (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-97 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 160 | 90 | 86.72 | 3.27 |
| 200 | 100 | 95.53 | 4.46 |
| 200 | 100 | 95.53 | 4.46 |
| 240 | 100 | 98.59 | 1.4 |

SUM of RESIDUALS = 12.17

# CAPSULE 83 (HEAT AFFECTED ZONE)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:04:13 on 10-15-2002

Page 1

Coefficients of Curve 3

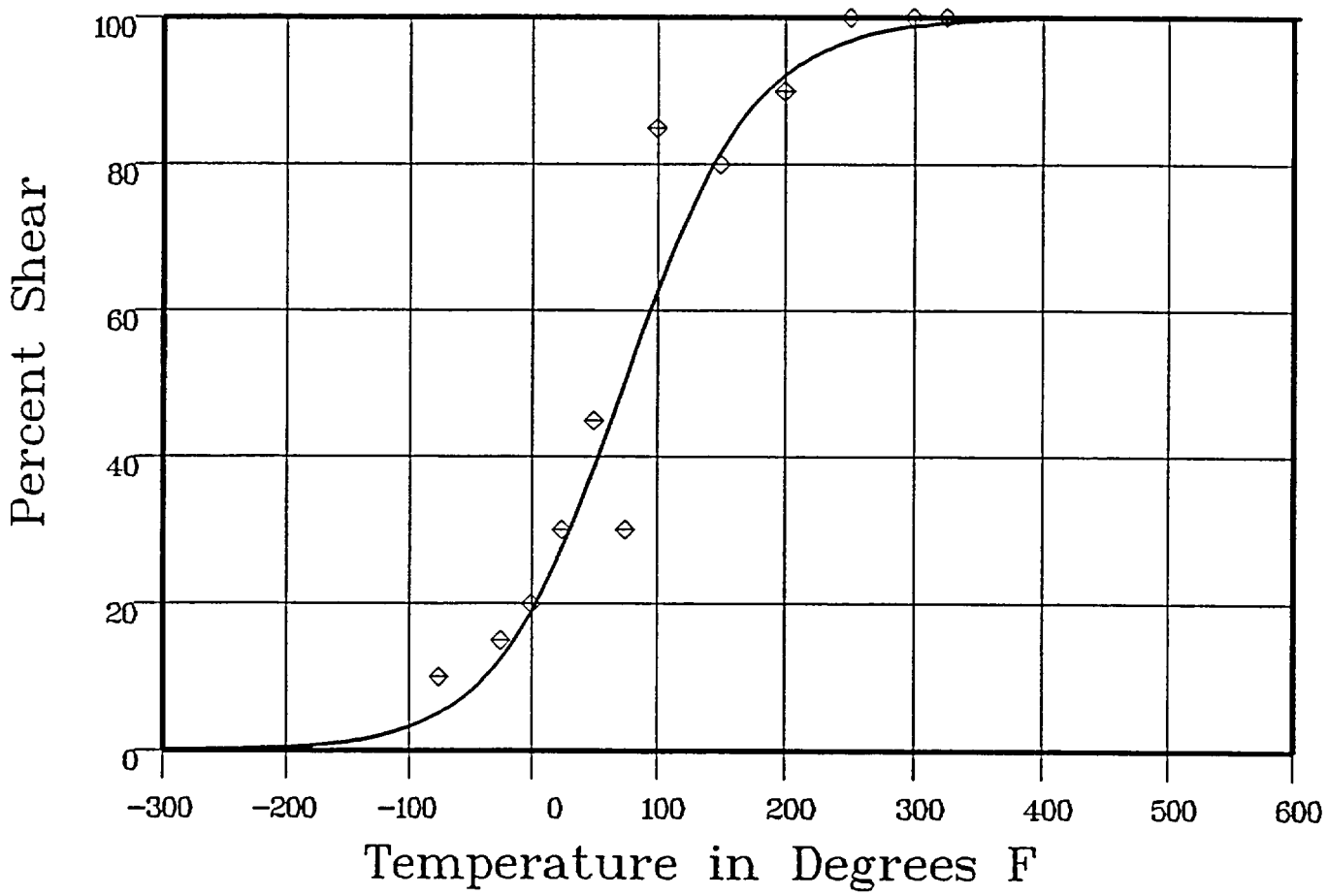
| A = 50 | B = 50 | C = 101.88 | T0 = 69.37 |
|---|---|---|---|

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

Temperature at 50% Shear: 69.3

Material: HEAT AFFD ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-83 Total Fluence:




Data Set(s) Plotted

Plant: M12 Cap: W-83 Material: HEAT AFFD ZONE SA533B1 Ori: Heat #: C-506-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -75 | 10 | 5.55 | 4.44 |
| -25 | 15 | 13.55 | 1.44 |
| 0 | 20 | 20.39 | -.39 |
| 25 | 30 | 29.5 | .49 |
| 50 | 45 | 40.6 | 4.39 |
| 75 | 30 | 52.75 | -22.75 |
| 100 | 85 | 64.59 | 20.4 |
| 150 | 80 | 82.95 | -2.95 |

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

# CAPSULE 83 (HEAT AFFECTED ZONE)

Page 2

Material: HEAT AFF'D ZONE SA533B1 Heat Number: C-506-1 Orientation:

Capsule: W-83 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 200 | 90 | 92.85 | -2.85 |
| 250 | 100 | 97.19 | 2.8 |
| 300 | 100 | 98.93 | 1.06 |
| 325 | 100 | 99.34 | .65 |

SUM of RESIDUALS = 6.76

# UNIRRADIATED (STANDARD REFERENCE MATERIAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:08:44 on 10-15-2002

Page 1

Coefficients of Curve 1

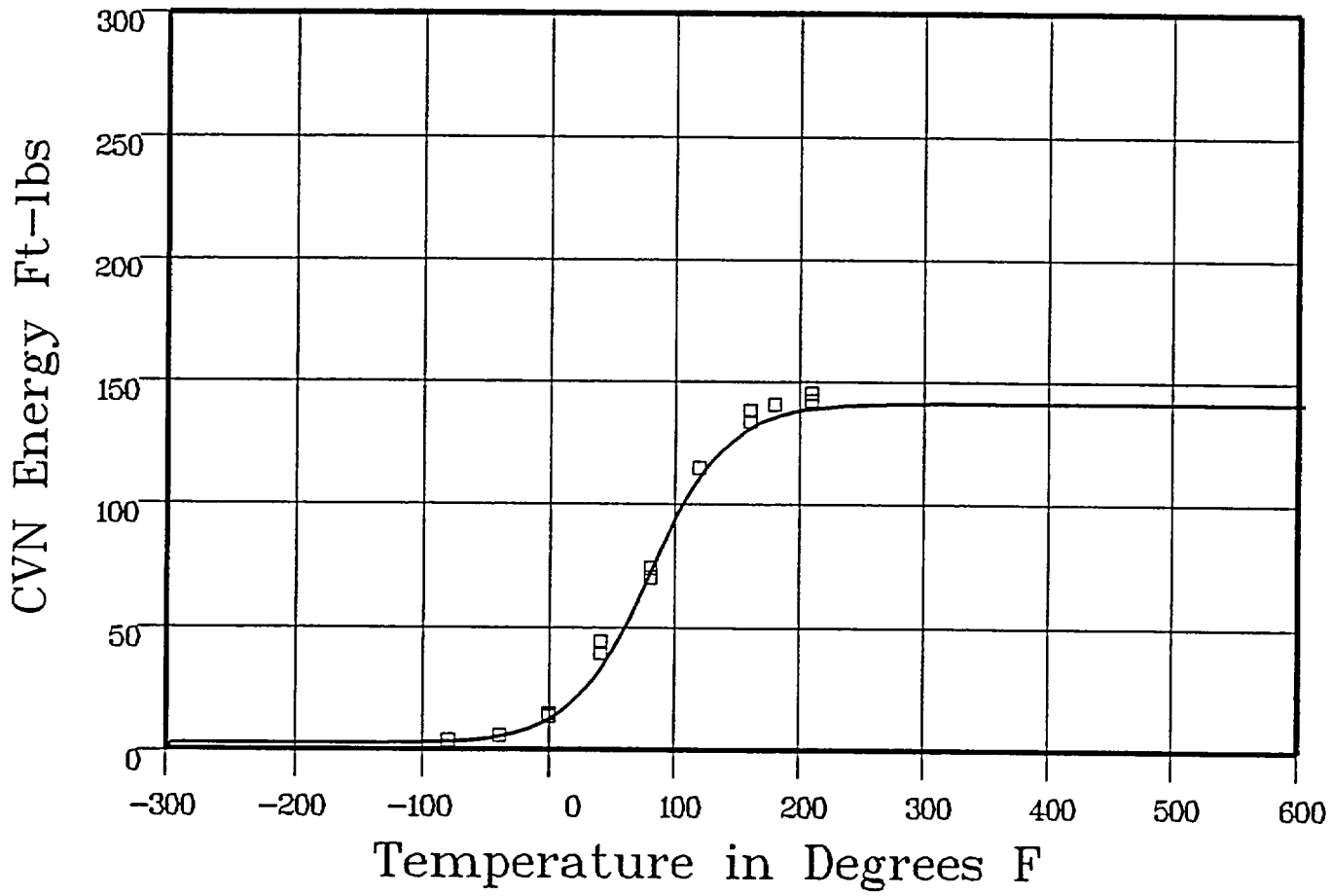
| A = 71.59 | B = 69.4 | C = 63.23 | T0 = 75.29 |
|---|---|---|---|

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

Upper Shelf Energy: 141 Fixed  Temp. at 30 ft-lbs: 31.5  Temp. at 50 ft-lbs: 54.9  Lower Shelf Energy: 2.19 Fixed

Material: SRM HSST01  Heat Number: A1008-1  Orientation: LT

Capsule: UNIRR  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: UNIRR  Material: SRM HSST01  Ori: LT  Heat #: A1008-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| -80 | 3.5 | 3.21 | .28 |
| -40 | 5.5 | 5.72 | -.22 |
| 0 | 13.5 | 13.94 | -.44 |
| 0 | 14.5 | 13.94 | .55 |
| 40 | 39 | 36.44 | 2.55 |
| 40 | 43.5 | 36.44 | 7.05 |
| 80 | 73.5 | 76.75 | -3.25 |
| 80 | 69.5 | 76.75 | -7.25 |
| 120 | 114.5 | 113.84 | .65 |

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

# UNIRRADIATED (STANDARD REFERENCE MATERIAL)



Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 120 | 114.5 | 113.84 | .65 |
| 160 | 138 | 132.08 | 5.91 |
| 160 | 133.5 | 132.08 | 1.41 |
| 180 | 140.5 | 136.11 | 4.38 |
| 210 | 145 | 139.06 | 5.93 |
| 210 | 142 | 139.06 | 2.93 |

SUM of RESIDUALS = 21.14

# CAPSULE 104 (STANDARD REFERENCE MATERIAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:08:44 on 10-15-2002

Page 1

Coefficients of Curve 2

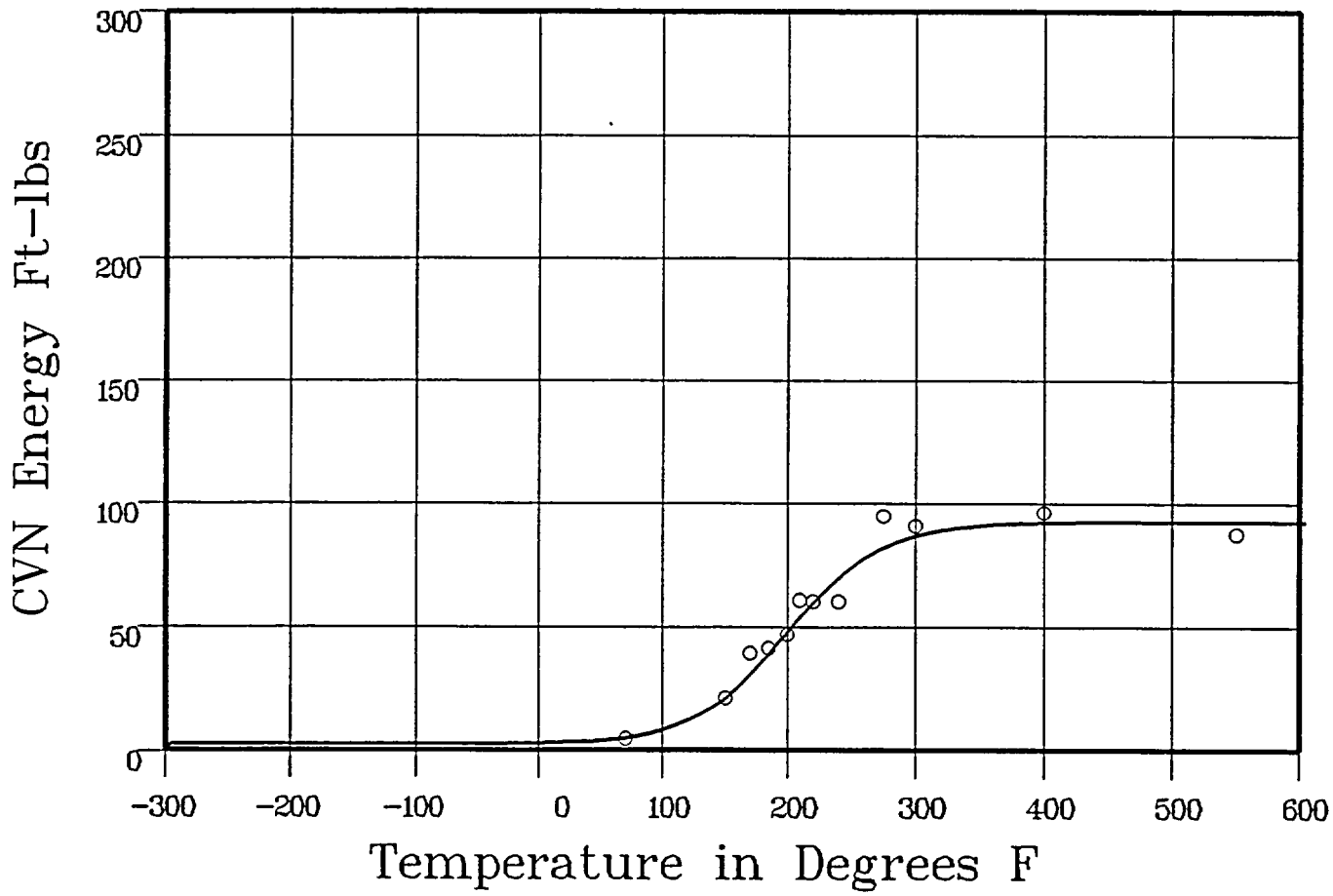
| A = 47.09 | B = 44.9 | C = 74.52 | T0 = 194.82 |
|---|---|---|---|

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

Upper Shelf Energy: 92 Fixed  Temp. at 30 ft-lbs: 164.9  Temp. at 50 ft-lbs: 199.6  Lower Shelf Energy: 2.19 Fixed

Material: SRM HSST01  Heat Number: A1008-1  Orientation: LT

Capsule: W-104  Total Fluence:




Data Set(s) Plotted

Plant: ML2  Cap: W-104  Material: SRM HSST01  Ori: LT  Heat #: A1008-1

## Charpy V-Notch Data

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 70 | 4.5 | 5.24 | -.74 |
| 150 | 21 | 22.94 | -1.94 |
| 170 | 39 | 32.67 | 6.32 |
| 185 | 41 | 41.21 | -.21 |
| 200 | 46.5 | 50.21 | -3.71 |
| 210 | 60.5 | 56.11 | 4.38 |
| 220 | 60 | 61.71 | -1.71 |
| 240 | 60 | 71.4 | -11.4 |

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

# CAPSULE 104 (STANDARD REFERENCE MATERIAL)

Page 2

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input CVN Energy | Computed CVN Energy | Differential |
|---|---|---|---|
| 275 | 94.5 | 82.64 | 11.85 |
| 300 | 90.5 | 86.96 | 3.53 |
| 400 | 96 | 91.63 | 4.36 |
| 550 | 87 | 91.99 | -4.99 |

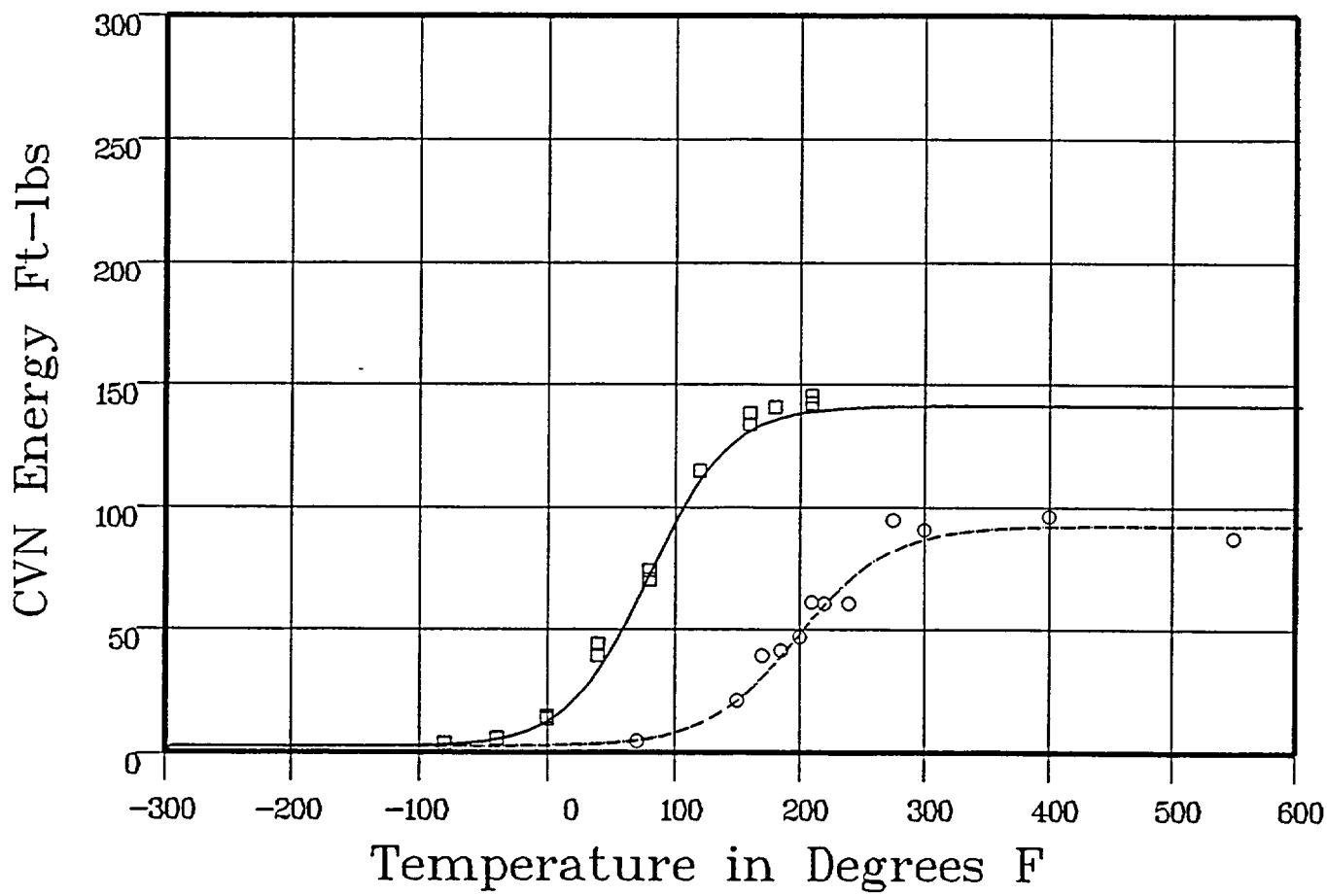
SUM of RESIDUALS = 5.73

# STANDARD REFERENCE MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:08:44 on 10-15-2002

Results

| Curve | Fluence | LSE | d-LSE | USE | d-USE | T @ 30 | d-T @ 30 | T @ 50 | d-T @ 50 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 2.19 | 0 | 141 | 0 | 31.51 | 0 | 54.93 | 0 |
| 2 | 0 | 2.19 | 0 | 92 | -49 | 164.93 | 133.41 | 199.64 | 144.7 |




Curve Legend

1 □———— 2 ○----------

Data Set(s) Plotted

| Curve | Plant | Capsule | Material | Ori. | Heat# |
|---|---|---|---|---|---|
| 1 | ML2 | UNIRR | SRM HSST01 | LT | A1008-1 |
| 2 | ML2 | W-104 | SRM HSST01 | LT | A1008-1 |

# UNIRRADIATED (STANDARD REFERENCE MATERIAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:12:01 on 10-15-2002

Page 1

Coefficients of Curve 1

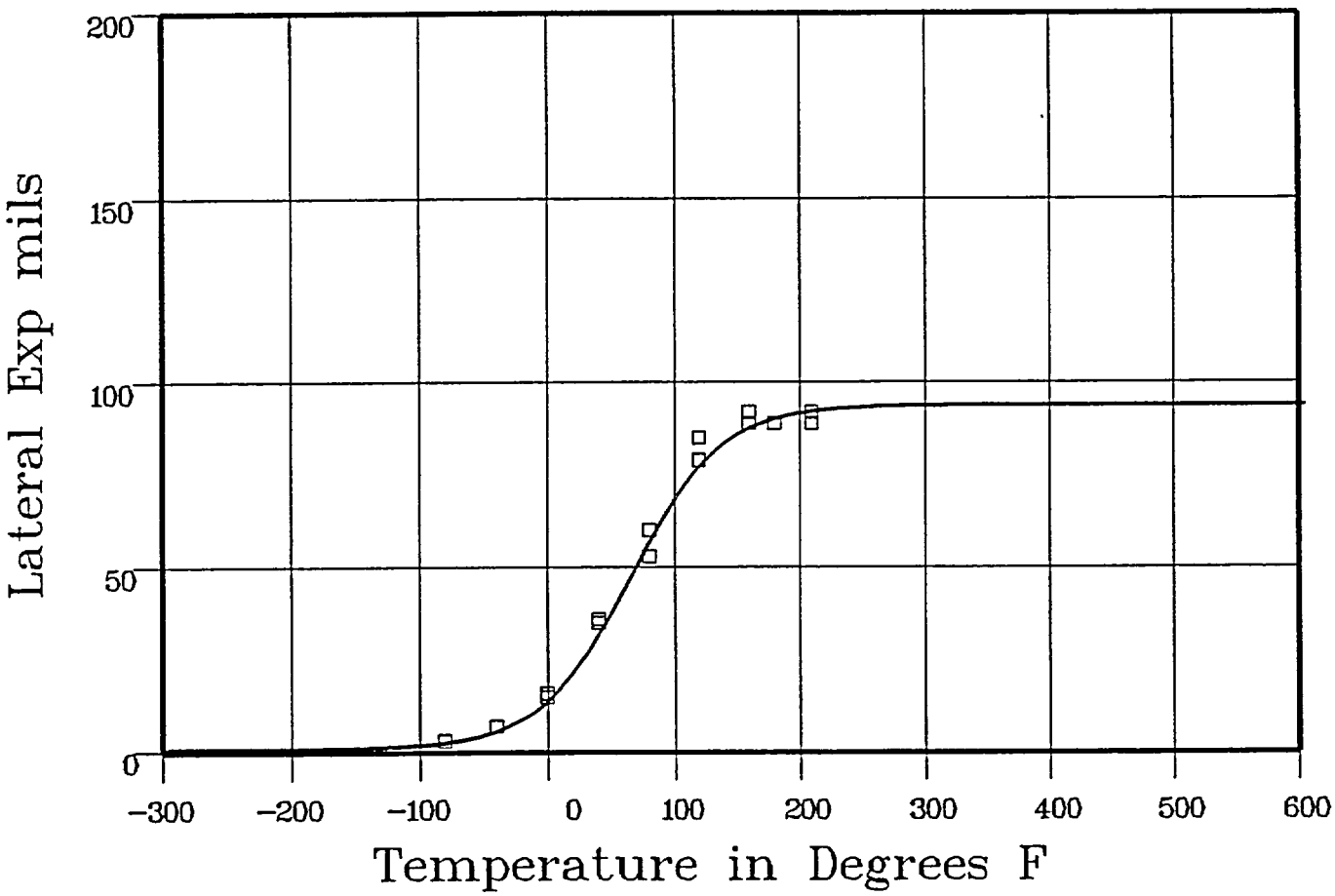
| A = 47.42 | B = 46.42 | C = 71.51 | T0 = 60.46 |
|---|---|---|---|

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

Upper Shelf L.E.: 93.84 Temperature at L.E. 35: 40.8 Lower Shelf L.E.: 1 Fixed

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap.: UNIRR Material: SRM HSST01 Ori: LT Heat #: A1008-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| -80 | 3 | 2.79 | .2 |
| -40 | 7 | 6.27 | .72 |
| 0 | 15 | 15.44 | -.44 |
| 0 | 16 | 15.44 | .55 |
| 40 | 35 | 34.48 | .51 |
| 40 | 36 | 34.48 | 1.51 |
| 80 | 60 | 59.79 | .2 |
| 80 | 53 | 59.79 | -6.79 |
| 120 | 85 | 79.07 | 5.92 |

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

# UNIRRADIATED (STANDARD REFERENCE MATERIAL)

Page 2

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 120 | 79 | 79.07 | -.07 |
| 160 | 89 | 88.43 | .56 |
| 160 | 92 | 88.43 | 3.56 |
| 180 | 89 | 90.67 | -1.67 |
| 210 | 92 | 92.44 | -.44 |
| 210 | 89 | 92.44 | -3.44 |
| | | SUM of RESIDUALS = | .87 |

# CAPSULE 104 (STANDARD REFERENCE MATERIAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:12:01 on 10-15-2002

Page 1

Coefficients of Curve 2

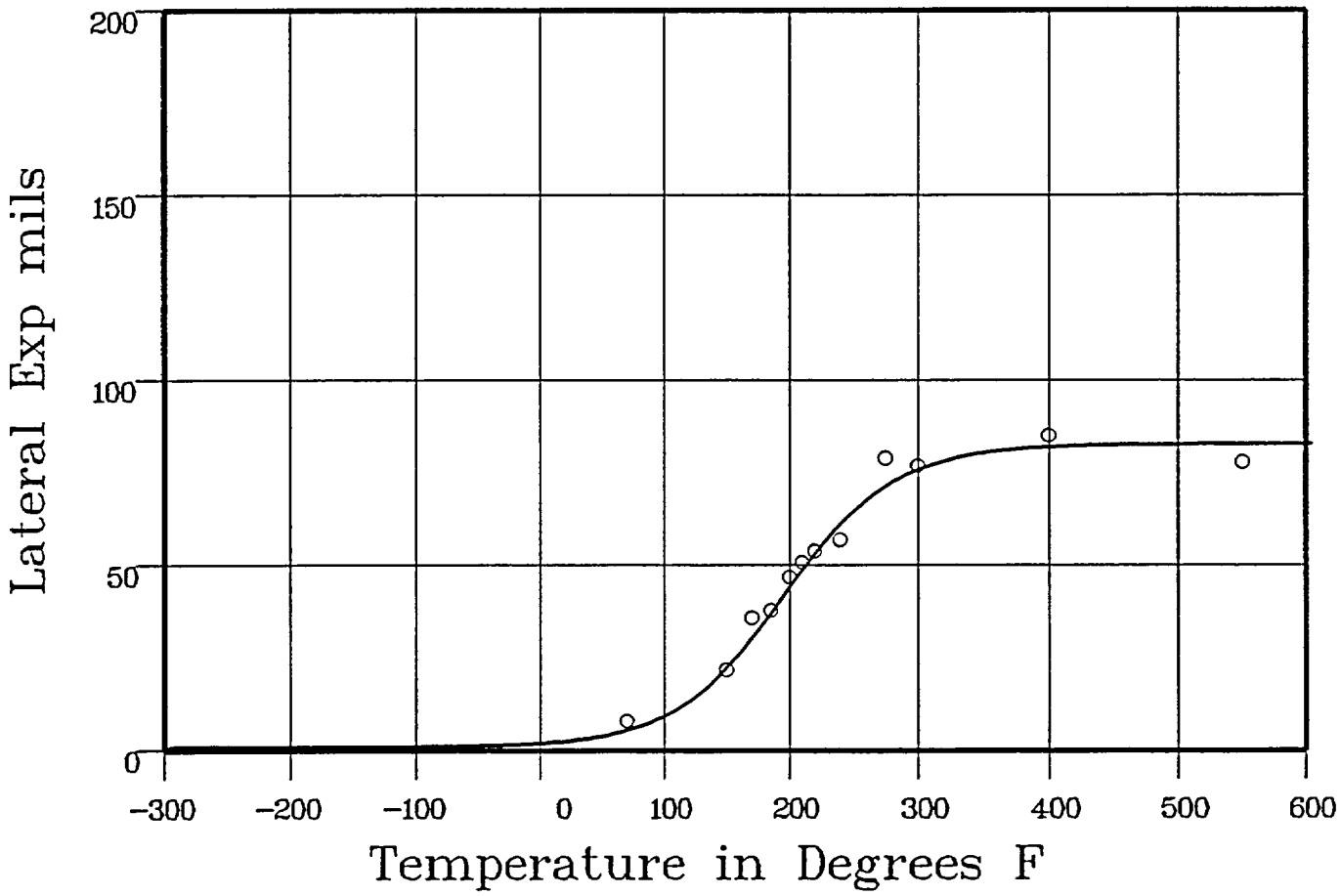
| A = 41.83 | B = 40.83 | C = 87.26 | T0 = 190.72 |
|---|---|---|---|

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

Upper Shelf L.E.: 82.67 Temperature at L.E. 35: 175.9 Lower Shelf L.E.: 1 Fixed

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: W-104 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap.: W-104 Material: SRM HSST01 Ori.: LT Heat #: A1008-1

## Charpy V-Notch Data

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 70 | 8 | 5.83 | 2.16 |
| 150 | 22 | 24.05 | -2.05 |
| 170 | 36 | 32.31 | 3.68 |
| 185 | 38 | 39.16 | -1.16 |
| 200 | 47 | 46.16 | .83 |
| 210 | 51 | 50.71 | .28 |
| 220 | 54 | 55.04 | -1.04 |
| 240 | 57 | 62.72 | -5.72 |

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

# CAPSULE 104 (STANDARD REFERENCE MATERIAL)

Page 2

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Lateral Expansion | Computed L.E. | Differential |
|---|---|---|---|
| 275 | 79 | 72.33 | 6.66 |
| 300 | 77 | 76.5 | .49 |
| 400 | 85 | 82 | 2.99 |
| 550 | 78 | 82.65 | -4.65 |

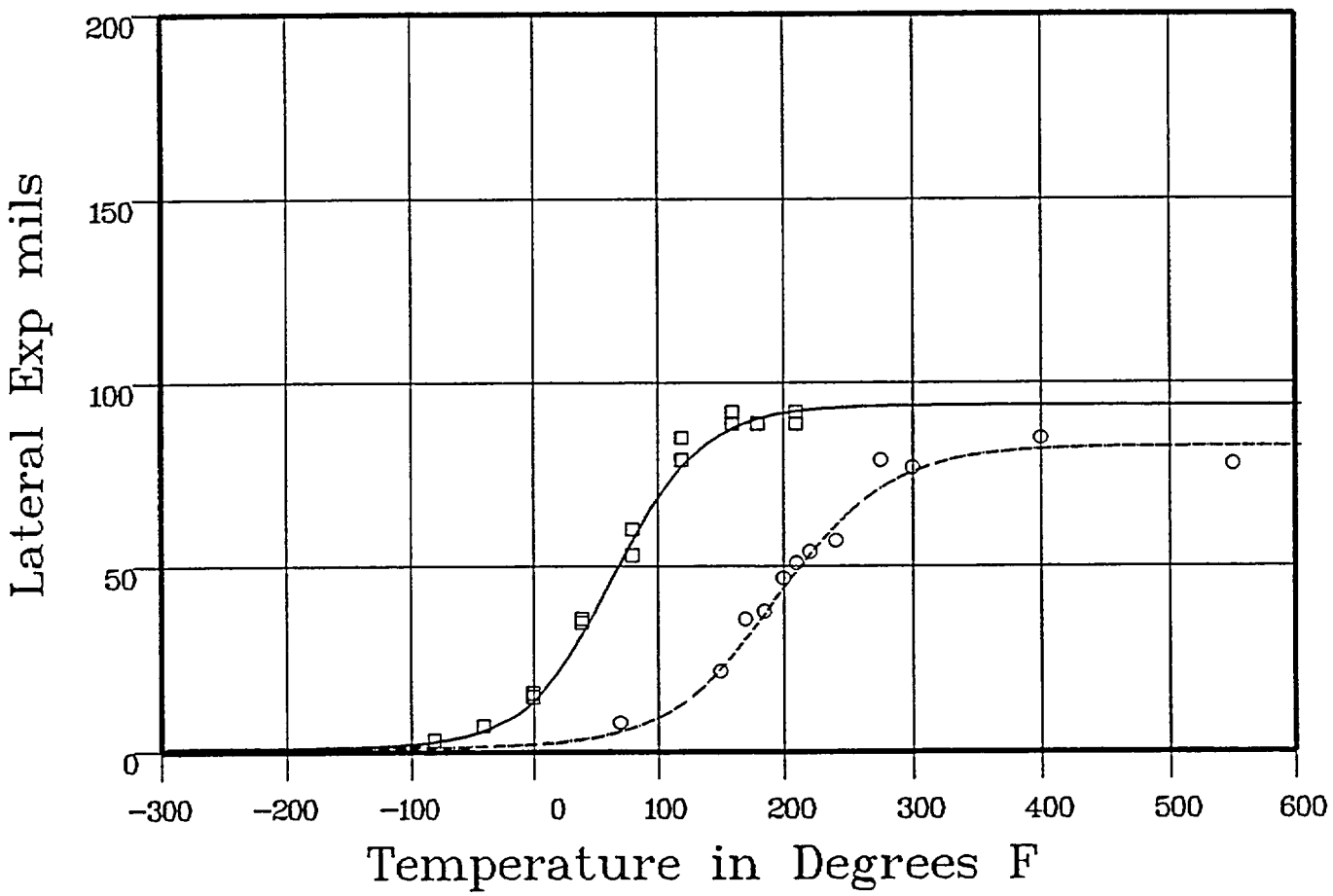
SUM of RESIDUALS = 2.5

# STANDARD REFERENCE MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:12:01 on 10-15-2002

Results

| Curve | Fluence | USE | d-USE | T @ LE35 | d-T @ LE35 |
|---|---|---|---|---|---|
| 1 | 0 | 93.84 | 0 | 40.85 | 0 |
| 2 | 0 | 82.67 | -11.17 | 175.97 | 135.11 |




Curve Legend

1 □———  2 ○---------

Data Set(s) Plotted

| Curve | Plant | Capsule | Material | Ori. | Heat# |
|---|---|---|---|---|---|
| 1 | M12 | UNIRR | SRM HSST01 | LT | A1008-1 |
| 2 | M12 | W-104 | SRM HSST01 | LT | A1008-1 |

# UNIRRADIATED (STANDARD REFERENCE MATERIAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:14:42 on 10-15-2002

Page 1

Coefficients of Curve 1

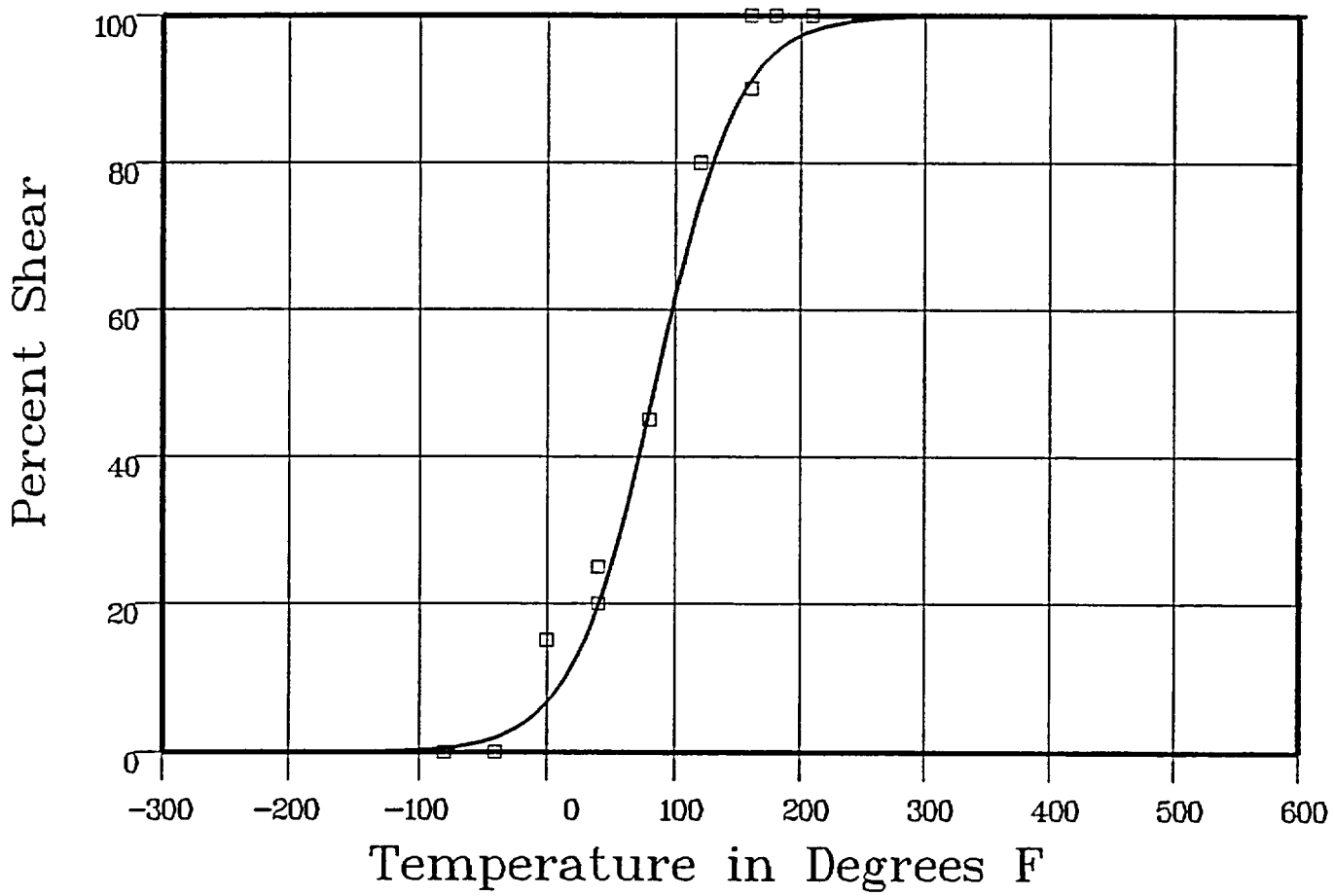
| A = 50 | B = 50 | C = 64.08 | T0 = 80.15 |
|---|---|---|---|

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

Temperature at 50% Shear: 80.1

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: UNIRR Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: UNIRR Material: SRM HSST01 Ori: LT Heat #: A1008-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| -80 | 0 | .67 | -.67 |
| -40 | 0 | 2.29 | -2.29 |
| 0 | 15 | 7.57 | 7.42 |
| 0 | 15 | 7.57 | 7.42 |
| 40 | 20 | 22.21 | -2.21 |
| 40 | 25 | 22.21 | 2.78 |
| 80 | 45 | 49.87 | -4.87 |
| 80 | 45 | 49.87 | -4.87 |
| 120 | 80 | 77.61 | 2.38 |

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

# UNIRRADIATED (STANDARD REFERENCE MATERIAL)

Page 2

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: UNIRR Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 120 | 80 | 77.61 | 2.38 |
| 160 | 100 | 92.35 | 7.64 |
| 160 | 90 | 92.35 | -2.35 |
| 180 | 100 | 95.75 | 4.24 |
| 210 | 100 | 98.29 | 1.7 |
| 210 | 100 | 98.29 | 1.7 |

SUM of RESIDUALS = 20.41

# CAPSULE 104 (STANDARD REFERENCE MATERIAL)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:14:42 on 10-15-2002

Page 1

Coefficients of Curve 2

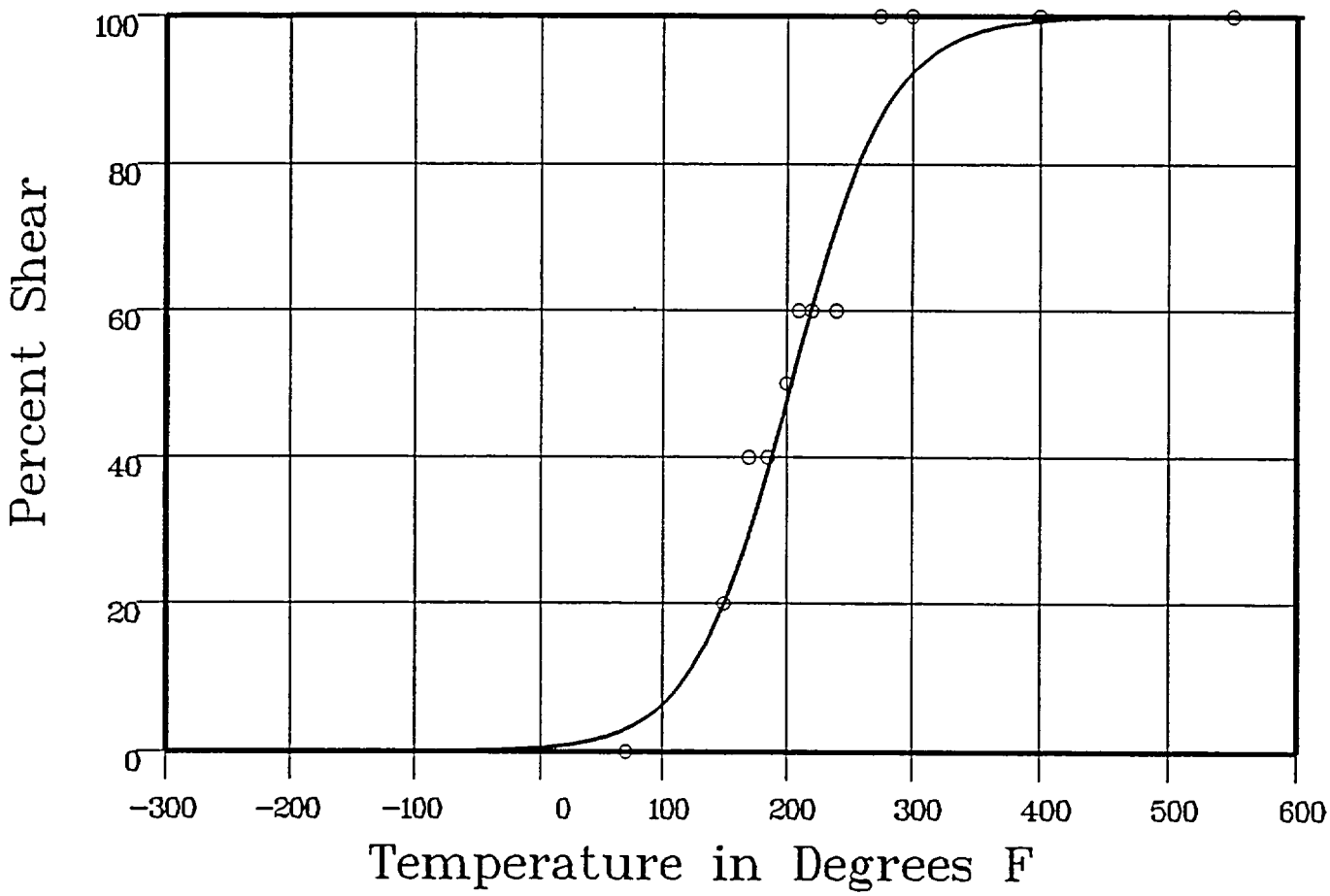
| A = 50 | B = 50 | C = 77.3 | T0 = 199.21 |
|---|---|---|---|

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

Temperature at 50% Shear: 199.2

Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: W-104 Total Fluence:




Data Set(s) Plotted

Plant: ML2 Cap: W-104 Material: SRM HSST01 Ori: LT Heat #: A1008-1

## Charpy V-Notch Data

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 70 | 0 | 3.41 | -3.41 |
| 150 | 20 | 21.86 | -1.86 |
| 170 | 40 | 31.95 | 8.04 |
| 185 | 40 | 40.9 | -.9 |
| 200 | 50 | 50.5 | -.5 |
| 210 | 60 | 56.92 | 3.07 |
| 220 | 60 | 63.12 | -3.12 |
| 240 | 60 | 74.17 | -14.17 |

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

# CAPSULE 104 (STANDARD REFERENCE MATERIAL)



Material: SRM HSST01 Heat Number: A1008-1 Orientation: LT

Capsule: W-104 Total Fluence:

## Charpy V-Notch Data (Continued)

| Temperature | Input Percent Shear | Computed Percent Shear | Differential |
|---|---|---|---|
| 275 | 100 | 87.65 | 12.34 |
| 300 | 100 | 93.13 | 6.86 |
| 400 | 100 | 99.44 | .55 |
| 550 | 100 | 99.98 | .01 |

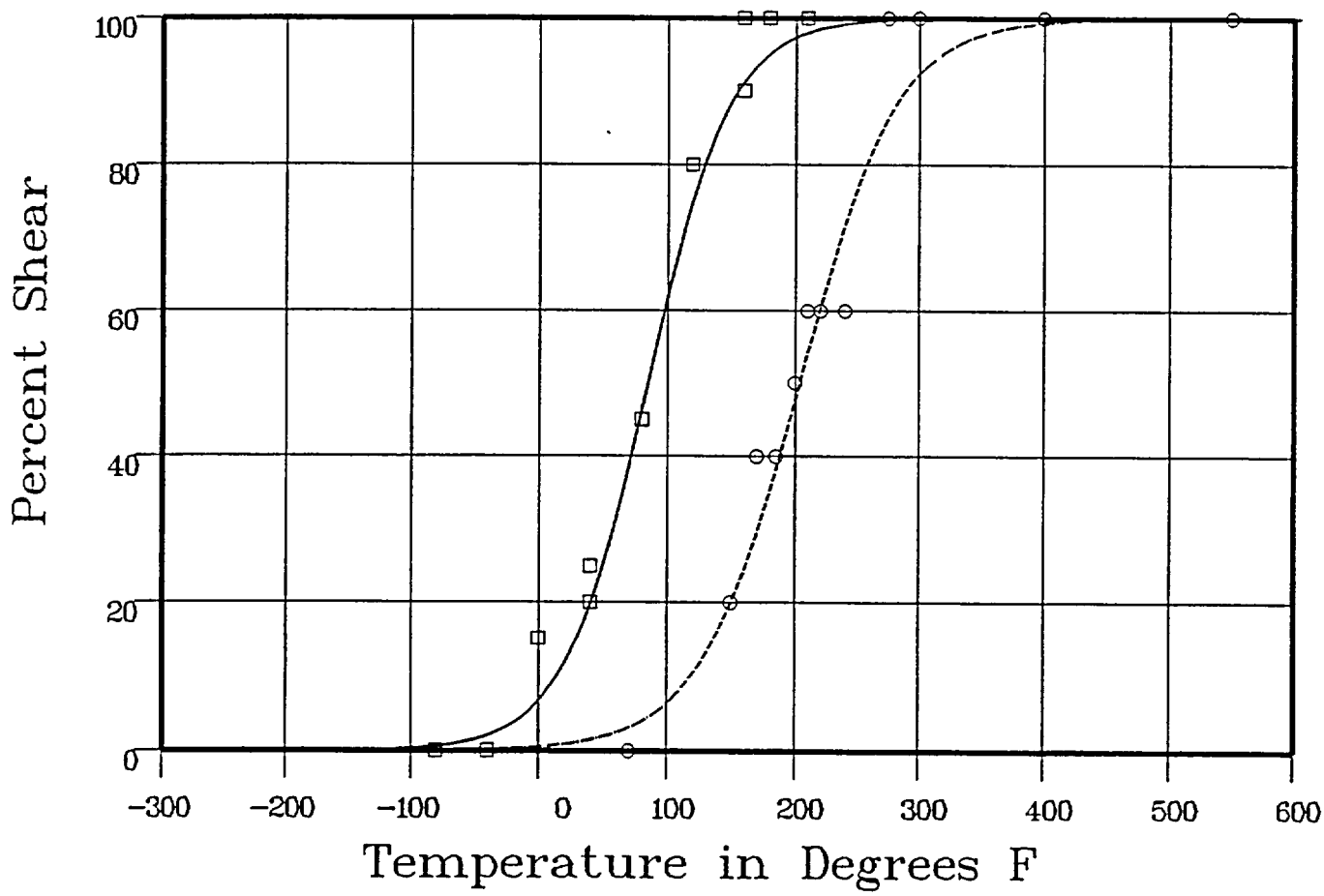
SUM of RESIDUALS = 6.89

# STANDARD REFERENCE MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:14:42 on 10-15-2002

Results

| Curve | Fluence | T @ 50% Shear | d-T @ 50% Shear |
|---|---|---|---|
| 1 | 0 | 80.15 | 0 |
| 2 | 0 | 199.21 | 119.06 |




Curve Legend

1 □———— 2 ○----------

Data Set(s) Plotted

| Curve | Plant | Capsule | Material | Ori. | Heat# |
|---|---|---|---|---|---|
| 1 | ML2 | UNIRR | SRM HSST01 | LT | A1008-1 |
| 2 | ML2 | W-104 | SRM HSST01 | LT | A1008-1 |

# APPENDIX D

# MILLSTONE UNIT 2 SURVEILLANCE PROGRAM

# CREDIBILITY ANALYSIS

## SURVEILLANCE DATA CREDIBLITY EVALUATION

### INTRODUCTION:

Regulatory Guide 1.99, Revision 2, describes general procedures acceptable to the NRC staff for calculating the effects of neutron radiation embrittlement of the low-alloy steels currently used for light-water-cooled reactor vessels. Position C.2 of Regulatory Guide 1.99, Revision 2, describes the methodology for calculating the adjusted reference temperature and Charpy upper-shelf energy of reactor vessel beltline materials using surveillance capsule data. The methods of Position C.2 can only be applied when two or more credible surveillance data sets become available from the reactor in question.

To date there have been three surveillance capsules removed from Millstone Unit 2. To use these surveillance data sets, they must be shown to be credible. In accordance with Regulatory Guide 1.99, Revision 2, there are five requirements that must be met for the surveillance data to be judged credible. The purpose of this evaluation is to apply these credibility requirements to the reactor vessel surveillance data obtained from Millstone Unit 2 and determine if these surveillance data sets are credible.

### EVALUATION

*Criterion 1:Materials in the capsules should be those judged most likely to be controlling with regard to radiation embrittlement. The beltline region of the reactor vessel is defined in Appendix G to 10 CFR Part 50, "Fracture Toughness Requirements", December 19, 1995 to be:*

*"the reactor vessel (shell material including welds, heat affected zones, and plates or forgings) that directly surrounds the effective height of the active core and adjacent regions of the reactor vessel that are predicted to experience sufficient neutron radiation damage to be considered in the selection of the most limiting material with regard to radiation damage."*

The Millstone Unit 2 reactor vessel consists of the following beltline region materials:

- Intermediate Shell Plate C-506-1, -2, -3 (Heats C-5843-1, -2 , -3)
- Lower Shell Plate C-506-1, -2, -3 (Heats C-5667-1, -2 ,-3)
- Intermediate to Lower Girth Seam 9-203 (Heats 10137 and 90136)
- Intermediate and Lower Shell Longitudinal Seams 2-203 and 3-203 (Heat A-8746)

The Millstone Unit 2 surveillance programs was based on ASTM E-185-70 and utilizes test specimens from Lower Shell Plate C-506-1 and Intermediate to Lower Girth Seam 9-203 Heat # 10137/90136 Flux Type Linde 0091.

At the time when the surveillance program material was selected it was believed that copper and phosphorus were the elements most important to embrittlement of reactor vessel steels. Lower Shell Plate C-506-1 had the highest Copper content (0.15%) and one of the highest Initial $RT_{NDT}$ values and was selected as the surveillance program base metal. It should be noted that the lower shell plate C-506-1 is currently the limiting beltline material on the Millstone Unit 2 Reactor Vessel.

The Intermediate to Lower Girth Seam 9-203 was fabricated from 2 heats of weld wire; Heat # 10137 (OD of weld) and 90136 (ID of weld). The surveillance weld was made from the same heat and the same manner as the Intermediate to Lower Shell Girth Weld, i.e. 2 heats. The average Cu/Ni between the two heats would be 0.25 Cu and 0.06 Ni, which is the highest Cu value of all beltline welds and was therefore selected as the surveillance program weld material.

Since the base metal and weld metal selected for the Millstone Unit 2 Surveillance Program represent the limiting plate and weld in the beltline region, this criterion is met.

***Criterion 2: Scatter in the plots of Charpy energy versus temperature for the irradiated and unirradiated conditions should be small enough to permit the determination of the 30 ft-lb temperature and upper shelf energy unambiguously.***

Plots of Charpy energy versus temperature for the unirradiated and irradiated condition are presented in Appendix C of this calcnote.

Based on engineering judgment, the scatter in the data presented in these plots is small enough to permit the determination of the 30 ft-lb temperature and the upper shelf energy of the Millstone Unit 2 surveillance materials unambiguously. Therefore, the Millstone Unit 2 surveillance program meets this criterion.

***Criterion 3: When there are two or more sets of surveillance data from one reactor, the scatter of $\Delta RT_{NDT}$ values about a best-fit line drawn as described in Regulatory Position 2.1 normally should be less than 28°F for welds and 17°F for base metal. Even if the fluence range is large (two or more orders of magnitude), the scatter should not exceed twice those values. Even if the data fail this criterion for use in shift calculations, they may be credible for determining decrease in upper shelf energy if the upper shelf can be clearly determined, following the definition given in ASTM E185-82.***

The functional form of the least squares method as described in Regulatory Position 2.1 will be utilized to determine a best-fit line for this data and to determine if the scatter of these $\Delta RT_{NDT}$ values about this line is less than 28°F for welds and less than 17°F for the plate.

Following is the calculation of the best fit line as described in Regulatory Position 2.1 of Regulatory Guide 1.99, Revision 2.

Table D-1
Millstone Unit 2 Chemistry Factors Based on Surveillance Data
(Reg. Guide1.99, Rev. 2, Position 2.1)

| Material | Capsule | Capsule f [(a)] | FF [(b)] | $\Delta RT_{NDT}$ [(c)] | $FF*\Delta RT_{NDT}$ | $FF^2$ |
|---|---|---|---|---|---|---|
| Lower Shell Plate C-506 Longitudinal (Heat # C-5667-1) | W-97 | 0.324 | 0.69 | 65.75 | 45.37 | 0.476 |
| | W-104 | 0.949 | 0.99 | 87.67 | 86.79 | 0.98 |
| | W-83 | 1.74 | 1.15 | 119.12 | 136.99 | 1.323 |
| Lower Shell Plate C-506 Transverse (Heat # C-5667-1) | W-97 | 0.324 | 0.69 | 90.83 | 62.67 | 0.476 |
| | W-83 | 1.74 | 1.15 | 145.78 | 167.65 | 1.323 |
| | Sum = | | | | 499.47 | 4.578 |
| | $CF = \Sigma(FF * RT_{NDT}) \div \Sigma(FF^2) = (499.47) \div (4.578) = 109.1$ °F | | | | | |
| Intermediate to Lower Girth Seam 9-203 (Heat # 10137 & 90136) | W-97 | 0.324 | 0 69 | 65.93 | 45 49 | 0.476 |
| | W-104 | 0.949 | 0.99 | 52.12 | 51.59 | 0.98 |
| | W-83 | 1.74 | 1.15 | 56.09 | 64.50 | 1.323 |
| | Sum = | | | | 161.58 | 2.779 |
| | $CF = \Sigma(FF * RT_{NDT}) - \Sigma(FF^2) = (161.58) \div (2.779) = 58.14$ °F | | | | | |

Notes:

(a) f = best estimate fluence values. ($1 \times 10^{19}$ n/cm$^2$, E > 1.0 MeV).

(b) FF = fluence factor = $f^{(0.28 - 0.1*\log f)}$.

(c) $\Delta RT_{NDT}$ values are the measured 30 ft-lb shift values taken from App. C

The scatter of $\Delta RT_{NDT}$ values about the functional form of a best-fit line drawn as described in Regulatory Position 2.1 is presented in Table B-2.

Table D-2:
Turkey Point Unit 3 Surveillance Capsule Data Scatter about the Best-Fit Line for Surveillance Forging Materials.

| Material | Capsule | CF[(a)] ($Slope_{best\ fit}$) | FF[(b)] | $\Delta RT_{NDT}$[(c)] | $\Delta RT_{NDT}$ (°F) | Scatter $\Delta RT_{NDT}$ (°F) | <17°F (Base Metals) <28°F (Weld) |
|---|---|---|---|---|---|---|---|
| Lower Shell Plate C-506 Longitudinal (Heat # C-5667-1) | W-97 | 109.1 | 0.69 | 65.75 | 75.28 | 9.53 | Yes |
| | W-104 | 109.1 | 0.99 | 87.67 | 108 | 20.33 | No |
| | W-83 | 109.1 | 1.15 | 119.12 | 125.47 | 6 35 | Yes |
| Lower Shell Plate C-506 Transverse (Heat # C-5667-1) | W-97 | 109.1 | 0.69 | 90.83 | 75.28 | -15.55 | Yes |
| | W-83 | 109.1 | 1.15 | 145.78 | 125.47 | -20.31 | No |
| Intermediate to Lower Girth Seam 9-203 (Heat # 10137 & 90136) | W-97 | 58.14 | 0.69 | 65.93 | 40.12 | -25.81 | Yes |
| | W-104 | 58.14 | 0.99 | 52.12 | 57.55 | 5.43 | Yes |
| | W-83 | 58.14 | 1.15 | 56.09 | 66.86 | 10.77 | Yes |

Notes:

(a) f = Calculated fluence from capsule W-83 dosimetry analysis results (x $10^{19}$ n/cm$^2$, E > 1.0 MeV) See Section 6.

(b) FF = fluence factor = $f^{(0.28 - 0.1 * \log f)}$.

(c) $\Delta RT_{NDT}$ values are the measured 30 ft-lb. shift values (Appendix C) and do not include the adjustment ratio procedure of Reg. Guide 1.99 Revisión 2, Position 2.1, since this calculation is based on the actual surveillance weld metal measured shift values

$$\text{Best Fit } \Delta RT_{NDT} = (Slope_{best\ fit}) * (\text{Fluence Factor})$$

CONCLUSION:

Table D-2 indicates that two of the five measured plate $\Delta RT_{NDT}$ values are outside the 1$\sigma$ scatter band. Therefore the plate data is not credible. Table D-2 also indicates that all of the measured weld $\Delta RT_{NDT}$ values are within the 1$\sigma$ scatter band. Therefore the weld data meets this criteria.

*Criterion 4: The irradiation temperature of the Charpy specimens in the capsule should match the vessel wall temperature at the cladding/base metal interface within +/- 25°F.*

The location of the specimens with respect to the reactor vessel beltline provides assurance that the reactor vessel wall and the specimens experience equivalent operating conditions such that the temperatures will not differ by more than 25°F.

*Criterion 5: The surveillance data for the correlation monitor material in the capsule should fall within the scatter band of the database for that material.*

The Millstone Unit 2 surveillance program does contain correlation monitor material. According to Table 14 of NUREG/CR-6413[12], Millstone Unit 2 Correlation Monitor Material for Capsule 104 had a residual value of 10°F, which is less than the ± 34 (2 Sigma) scatter band allowance for plate HSST02 (A533B-1) material (per figure 9 of the NUREG report). Note: The fluence & $\Delta RT_{NDT}$ has been updated since the issue of the NUREG Report, however, these changes would not cause the Correlation Monitor Material to exceed the scatter band.

**CONCLUSION:**

Based on the preceding responses to all five criteria of Regulatory Guide 1.99, Revision 2, Section B and 10CFR 50.61, the Millstone Unit 2 surveillance weld data is credible. However due not meeting criterion 3 the Millstone Unit 2 surveillance plate data is not credible.