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Analysis of the Irradiation Data for A302B and A533B Correlation Monitor Materials

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Prepared for
U.S. Nuclear Regulatory Commission

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ABSTRACT

The results of Charpy V-notch impact tests for A302B and A533B-1 Correlation Monitor Materials (CMM) listed in the surveillance power reactor data base (PR-EDB) and material test reactor data base (TR-EDB) are analyzed. The shift of the transition temperature at 30 ft-lb (T_{30}) is considered as the primary measure of radiation embrittlement in this report. The hyperbolic tangent fitting model and uncertainty of the fitting parameters for Charpy impact tests are presented in this report. For the surveillance CMM data, the transition temperature shifts at 30 ft-lb (ΔT_{30}) generally follow the predictions provided by Revision 2 of Regulatory Guide 1.99 (R.G. 1.99). Difference in capsule temperatures is a likely explanation for large deviations from R.G. 1.99 predictions. Deviations from the R.G. 1.99 predictions are correlated to similar deviations for the accompanying materials in the same capsules, but large random fluctuations prevent precise quantitative determination. Significant scatter is noted in the surveillance data, some of which may be attributed to variations from one specimen set to another, or inherent in Charpy V-notch testing. The major contributions to the uncertainty of the R.G. 1.99 prediction model, and the overall data scatter are from mechanical test results, chemical analysis, irradiation environments, fluence evaluation, and inhomogeneous material properties. Thus in order to improve the prediction model, control of the above-mentioned error sources needs to be improved. In general, the embrittlement behavior of both the A302B and A533B-1 plate materials is similar. There is evidence for a fluence-rate effect in the CMM data irradiated in test reactors; thus its implication on power reactor surveillance programs deserves special attention.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

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1 INTRODUCTION

It is well known that the flux of energetic neutrons can displace significant numbers of atoms and thus alter physical and mechanical properties of reactor pressure vessel (RPV) steels. Property changes in materials due to neutron-induced displacement damage are a function of neutron energy, neutron flux, and temperature, as well as the material chemical composition and microstructure that determine how neutrons interact with atoms and how defects interact within the material.[1,2] The success of reactor design technology depends critically on the choice of material that has satisfactory material properties to resist the radiation damage. Presently, interest focuses on the radiation damage and its effect on RPV materials. It is generally accepted that radiation hardening and embrittlement in metals are caused by clusters of vacancies, interstitial and solute atoms that impede the motion of dislocations. The degree of embrittlement is conventionally correlated with fast neutron fluence or with total displacements per atom (dpa).

The aging and degradation of light-water-reactor (LWR) pressure vessels are of particular concern because of their importance to plant safety and the magnitude of the expected irradiation embrittlement. The radiation embrittlement of RPV materials depends on many different factors, primarily flux, fluence, neutron spectrum, irradiation temperature, pre-irradiation material history, and chemical composition.[3,4] These factors must be considered to reliably predict RPV embrittlement and to ensure the structural integrity of the reactor. Based on embrittlement predictions, decisions must be made concerning operating parameters, low-leakage-fuel management, possible life extension, and the need for annealing of the pressure vessel.[5]

Large amounts of data obtained from surveillance capsules and test reactor experiments and comprising many different materials and different irradiation conditions are needed to develop generally applicable damage prediction models that can be used for industry standards and regulatory guides. The U.S. Nuclear Regulatory Commission (NRC)/Oak Ridge National Laboratory (ORNL) embrittlement data base (EDB) is this comprehensive collection of data resulting from the merging of the Power Reactor Embrittlement Data Base (PR-EDB) and the Test Reactor Embrittlement Data Base (TR-EDB). Three major categories of data are included in the EDB, namely, pre-irradiation material history, irradiation environments, and mechanical test results. The following types of data are included:

1. fluence (E > 1.0 MeV, E > 0.1 MeV, and dpa), irradiation time, and irradiation temperature for each irradiated capsule;
2. Charpy test results before and after irradiation, both for individual specimen and evaluation of transition temperature and upper-shelf energies;
3. tensile test results before and after irradiation;
4. chemistry data for each material;
5. preirradiation heat treatment;
6. data concerning the fabrication of weld material; and
7. data related to the determination of the pressure-temperature limits.

The current version of the PR-EDB lists the test results of 98 heat-affected-zone (HAZ) materials, 105 weld materials, and 136 base materials that were irradiated in 252 capsules from 96 power reactors.[6] The current data collection of the TR-EDB contains 1230 different irradiated sets, 797 of which are from base materials, 378 from weld materials, and 55 from HAZ materials.[7] The EDB has been used in many radiation embrittlement studies of reactor vessels. This computerized data base for base material and weldments was compiled from surveillance reports of operating power reactors and available technical reports. All data are traceable to the reference sources, including page numbers. Most of the surveillance data have been verified by the reactor vendors responsible for the insertion of the material into surveillance capsules, and any changes and corrections have been documented in special files for future reference.

Generally, the surveillance programs of commercial power reactors include correlation monitor materials (CMM) in addition to base, weld, and HAZ of actual pressure vessel steels. These specimens are fabricated from standard reference steel plates that are similar in most cases in composition and heat treatment to the base material in the respective RPV and are supposed to serve as a reference for comparing the radiation embrittlement of the plant-specific material with the reference material and for detecting anomalies in the radiation environment of the surveillance capsules. In order to use these materials as a reference, the "normal" behavior in regard to fluence, flux, and irradiation temperature must be established first. This procedure requires the collection of data from a sufficient number of irradiations of the material at different irradiation environments, such as different fluxes and temperatures. Such data, obtained from irradiations in surveillance capsules and test reactors, are presently collected in the EDB, and the information is used for this study. The majority of surveillance programs use one or the other of two sources for the reference material, depending on the material in the pressure vessel. One source is the 6-in.-thick ASTM A302 grade B (A302B) reference plate by U.S. Steel, and the other source consists of three 12-in.-thick A533 grade B class 1 (A533B-1) plates fabricated by Lukens Steel and heat treated by Combustion Engineering (CE). These three plates were fabricated for the Heavy-Section Steel Technology (HSST) program in the late 1960s. Most surveillance data come from the second plate (HSST02); however, the first plate (HSST01) and third plate (HSTT03) are also used in surveillance capsules. The results obtained from the surveillance capsules and material test reactor experiments from these plates are included in this report. This report is restricted to A302B and A533B-1 materials. The detailed information of the heat treatments and chemistry compositions for the CMM are listed in Tables 1–5.

Table 1. Heat treatment of CMM

Plate ID	Heat No.	Mat. ID	Thickness	Heat treatment
ASTM	A0421	A302B	14.24 cm	Austenized at 1650°F 6 h, water quenched to 300°F; tempered at 1200°F 6 h, air cooled (heated to 1200°F at 63°F per hour maximum).
HSST01	A1008-1	A533B-1	30.48 cm	Normalized at 1670-1700°F 4h, air cooled; austenized at 1550-1650°F 4 h, water quenched to 300°F; tempered at 1200-1250°F 4 h, furnace cooled to 600°F; stress relieved at 1125-1175°F 40 h, furnace cooled to 600°F.
HSST02	A1195-1	A533B-1	30.48 cm	Normalized at 1650-1700°F 4 h, air cooled; austenized at 1575-1625°F 4 h, water quenched to 300°F; tempered at 1200-1250°F 4 h, furnace cooled to 500°F; stress relieved at 1125-1175°F 40 h, furnace cooled to 600°F.
HSST03	C2702	A533B-1	30.48 cm	Normalized at 1650-1700°F 12 h, air cooled; austenized at 1550-1650°F 12 h, water quenched to 400°F; tempered at 1200-1250°F 18 h, furnace cooled to 600°F; stress relieved at 1100-1150°F 40 h, furnace cooled to 600°F, at 1020-1035°F 12 h, furnace cooled to 600°F.

Table 2. A302B (ASTM) CMM chemical compositions

Plant/Exp				Chemistry Composition (wt %)								
ID	HEAT_ID	CHEM_LAB	SPEC_ID	C	Mn	P	S	Si	Cr	Mo	Ni	Cu
	SASTM	U.S. Steel	HEAT	0.240	1.340	0.011	0.023	0.230	0.110	0.510	0.180	0.200
GAR	SASTM S2		HEAT	0.220	1.390	0.016	0.017	0.260		0.600		0.230
IP2	SASTM	SWRI	R-60			0.010						0.170
IP2	SASTM	SWRI	R-62			0.020						0.190
IP2	SASTM	SWRI	R-33								0.280	0.350
IP2	SASTM	SWRI	R-2									0.250
IP2	SASTM	SWRI	R-36								0.270	0.310
IP2	SASTM	SWRI	R-40								0.210	0.210
IP2	SASTM	SWRI	R-56								0.180	0.200
IP2	SASTM	SWRI	R-52								0.270	0.180
NRL-1	SASTM	NRL		0.230	1.350	0.015	0.021	0.220	0.120	0.520	0.220	0.220
RRA	SASTM RRA		@3-11	0.243	1.420	0.014	0.021	0.230	0.110	0.490	0.170	0.182
SRM	SASTM	U.S. Steel	LADLE	0.200	1.310	0.013	0.023	0.230		0.480	0.180	0.180

Table 3. A533B (HSST01) CMM chemical compositions

Plant/Exp				Chemistry Composition (wt %)								
ID	HEAT_ID	CHEM_LAB	SPEC_ID	C	Mn	P	S	Si	Cr	Mo	Ni	Cu
	SHSS01	NRL	HEAT	0.220	1.370	0.008	0.008	0.220	0.150	0.540	0.660	0.180
	SHSS01	Lukens	CHECK	0.220	1.480	0.012	0.018	0.250		0.520	0.680	
	SHSS01	Lukens	LADLE	0.220	1.450	0.011	0.019	0.220		0.530	0.620	
MY	SHSS01	Westinghouse	61E	0.221	1.524	.0112	.0174	0.198	0.080	0.577	0.665	0.173
MY	SHSS01	Westinghouse	61D	0.215	1.487	.0104	.0174	0.077	0.080	0.556	0.654	0.170
HSST-0	SHSS01K 0T[a]	ORNL		0.230	1.430	0.012	0.013	0.240		0.550	0.810	
HSST-0	SHSS01K 12[a]	ORNL		0.260	1.240	0.021	0.012	0.240		0.550	0.730	
HSST-0	SHSS01K 14[a]	ORNL		0.230	1.440	0.010	0.015	0.230		0.540	0.840	
HSST-0	SHSS01K 18[a]	ORNL		0.220	1.410	0.010	0.014	0.230		0.520	0.830	
HSST-0	SHSS01K 1T[a]	ORNL		0.240	1.370	0.015	0.013	0.230		0.540	0.810	
HSST-0	SHSS01K 34[a]	ORNL		0.260	1.380	0.021	0.014	0.230		0.530	0.840	
HSST-0	SHSS01K 38[a]	ORNL		0.230	1.450	0.015	0.012	0.240		0.560	0.770	
HSST-0	SHSS01K 58[a]	ORNL		0.260	1.180	0.017	0.013	0.230		0.560	0.740	
HSST-0	SHSS01K 78[a]	ORNL		0.240	1.300	0.016	0.014	0.230		0.530	0.800	
HSST-0	SHSS01MU0T[a]	ORNL		0.230	1.440	0.014	0.014	0.260		0.540	0.670	
HSST-0	SHSS01MU12[a]	ORNL		0.200	1.380	0.010	0.011	0.220		0.520	0.670	
HSST-0	SHSS01MU14[a]	ORNL		0.230	1.390	0.010	0.012	0.260		0.530	0.680	

[a]The last two digits of HEAT_ID are used to specify the specimen locatino in parent material,

OT - inner surface, 12 - 1/2 thickness, 14 - 1/4 thickness, 18 - 1/8 thickness, 1T - outer surface, 34 - 3/4 thickness, 38 - 3/8 thickness, 58 - 5/8 thickness, 78 - 7/8 thickness.

Table 4. A533B (HSST02) CMM chemical compositions

Plant/Exp				Chemistry Composition (wt %)								
ID	HEAT_ID	CHEM_LAB	SPEC_ID	C	Mn	P	S	Si	Cr	Mo	Ni	Cu
	SHSS02		HEAT	0.230	1.390	0.013	0.013	0.210		0.500	0.640	0.170
	SHSS02	Lukens	LADLE	0.220	1.450	0.011	0.019	0.220		0.530	0.620	
DC1	SHSS02		R47	0.200	1.560	0.008	0.011	0.190	0.110	0.470	0.650	0.150
SA1	SHSS02	Westinghouse	HEAT	0.220	1.480	0.012	0.018	0.250	0.080	0.520	0.680	0.140
HSST-0	SHSS02	ORNL	CHECK	0.240	1.420	0.010	0.017	0.220	0.120	0.500	0.700	0.140
HSST-0	SHSS02FB0T[a]	ORNL		0.270	1.500	0.013	0.014	0.210		0.500	0.720	
HSST-0	SHSS02FB12[a]	ORNL		0.260	1.480	0.012	0.012	0.230		0.490	0.640	
HSST-0	SHSS02FB14[a]	ORNL		0.270	1.490	0.013	0.013	0.210		0.500	0.640	
HSST-4	SHSS02GA			0.230	1.550	0.009	0.014	0.200	0.040	0.530	0.670	0.140
NRL-2	SHSS02	NRL	HEAT	0.230	1.480	0.008	0.016	0.190	0.120	0.510	0.680	0.140
VDE	SHSS02A			0.220	1.440	0.012	0.008	0.300	0.120	0.510	0.630	0.120

[a]The last two digits of HEAT_ID are used to specify the specimen locatino in parent material,
OT - inner surface, 12 - 1/2 thickness, 14 - 1/4 thickness.

Table 5. A533B (HSST03) CMM chemical compositions

Plant/Exp				Chemistry Composition (wt %)								
ID	HEAT_ID	CHEM_LAB	SPEC_ID	C	Mn	P	S	Si	Cr	Mo	Ni	Cu
HSST-0	SHSS03	Lukens	CHECK	0.200	1.260	0.011	0.018	0.250	0.100	0.450	0.560	0.120
HSST-0	SHSS03	Lukens	LADLE	0.210	1.310	0.012	0.018	0.240	0.150	0.500	0.600	0.130
HSST-0	SHSS03E 0T[a]	ORNL		0.260	1.330	0.011	0.016	0.240		0.510	0.650	
HSST-0	SHSS03E 12[a]	ORNL		0.250	1.270	0.010	0.020	0.280		0.490	0.700	
HSST-0	SHSS03E 14[a]	ORNL		0.260	1.360	0.011	0.015	0.260		0.520	0.620	
HSST-0	SHSS03E 1T[a]	ORNL		0.250	1.410	0.010	0.016	0.280		0.500	0.610	
HSST-0	SHSS03E 34[a]	ORNL		0.260	1.370	0.010	0.019	0.250		0.430	0.620	

[a]The last two digits of HEAT_ID are used to specify the specimen locatino in parent material,
OT - inner surface, 12 - 1/2 thickness, 14 - 1/4 thickness, IT - outer surface, 34 - 3/4 thickness.

2 PROCEDURES USED IN EMBRITTLEMENT ANALYSIS

The CMMs are used in the surveillance program in the form of Charpy and tensile specimens. The majority of data are from the Charpy impact test, and only limited tensile test data are avail-able from General Electric's (GE) boiling-water-reactor (BWR) surveillance program. Thus only the Charpy test results are considered here, and the ΔT_{30} is considered as the primary measure for radiation embrittlement.

The computer curve fitting of Charpy V-notch transition temperature test data could promote more uniform analytical interpretation of Charpy data, particularly those obtained from reactor materials surveillance programs. The use of computerized methods is preferable to the hand fitting, which was widely practiced in the past. It eliminates some of the arbitrariness of the hand-fitted curve and allows calculation of the variance and covariance of the model parameters. Among the curve-fitting methods available are the four-parameter hyperbolic tangent method,[8] the four-parameter exponential curve method,[9] the five-parameter exponential term, the six-parameter Gauss-Integral method,[10] and the polynomial curve fit.[11] A mathematical expression of the hyperbolic tangent-shaped curves, typical of most Charpy impact energy, lateral expansion, and ductile fracture appearance vs test temperature data, requires at least four adjustable parameters to provide a useful characterization.

2.1 Description of the EDB Charpy Curve-Fitting Procedures

In order to have a uniform and consistent determination of the ΔT_{30} for the surveillance reference materials, the raw Charpy data are fitted to a hyperbolic tangent model. It relates impact energy E to the test temperature T according to the formula

$$E = (LSE + USE)/2 + [(USE - LSE)/2]^{*} \tanh(SLOPE(T-TM))$$

with USE and LSE the upper- and lower-shelf energy, respectively, with TM as the midpoint of the transition temperature region, and SLOPE as the slope of the curve at TM. This model is purely phenomenological but well characterizes the general shape of a Charpy curve in four basic parameters: USE, LSE, TM, and SLOPE. Currently, this hyperbolic tangent function is the most widely used fitting procedure next to hand (eyeball) fitting.

The fitting parameters in this report were obtained from the EDB data-fitting procedures, which use the IMSL subroutine ZXSSQ. This subroutine is based on the Levenberg-Marquardt algorithm to solve the nonlinear least-squares problems. In the EDB Charpy curve-fitting utility, the initial values for the fitting parameters were determined by first separating the two shelves from the transition region using fracture appearance and the relative magnitude of the impact energy as criteria. From the test data in the transition region, crude estimates are obtained for TM and SLOPE, respectively. In the fitting procedure, an additional constraint is introduced for USE, and LSE is assigned to 3 joules, which restrains the variation in these parameters. It avoids runaway values for USE and negative LSE if data points in these regions are missing. With these precautions, any reasonable set of Charpy data can be fitted as well and more consistently than by a human evaluator. The procedure is completely automated with no operator intervention required or allowed. However, visual inspection is made to ensure that the fitting is properly performed. When the procedure fails, it is generally the result of outliers which must be removed or the data are such that no reasonable fit can be made. The simplicity and appeal of the least-squares method brings with it the danger that it may be used inappropriately, which was pointed out in Ref. 12. In any use, the underlying assumption and limitations should be clearly kept in mind, and the "best estimates" are good only within the bounds of their statistical uncertainties.

Uncertainties for the fitting parameters are needed to determine accuracy and credibility of the transition temperature and upper shelf data. A covariance matrix of the fitting parameters is part of any least-squares procedure, but these covariances are not used for uncertainty analysis in the EDB fitting program. The unavoidable linearization used for the determination of the covariances disregards second-order effects, and there is no possibility to account for uncertainties in test temperature. A more reliable procedure is the use of random variations of the input data (Monte Carlo procedure); such variations can be applied to both impact energy and test temperature, and the results reflect more accurately the influences of nonlinearities. The generated fitting parameters with corresponding plots of the Charpy curves and uncertainty analyses are demonstrated in Appendix A. Both the hyperbolic tangent fit and hyperbolic tangent fit plus Monte Carlo procedure (which assigns 10 J uncertainty for the impact energy and 4°C uncertainty for the testing temperature) show good agreement in the determination of T_{30}. The trend curves of raw Charpy data generated by the hyperbolic tangent fit plus Monte Carlo procedure seem to be more representative than that of the hyperbolic tangent fit alone, especially for those data sets with large data scatter.

2.2 Determination of Trend Curves for Radiation Embrittlement

The dependency of the ΔT_{30} on the damage fluence (i.e., the trend curve) for the two materials needs to be determined. The transition temperature shift values predicted by Regulatory Guide 1.99 (R.G. 1.99) are used for the determination of the trend curve, which is given by the formula

$$\Delta RT_{NDT} = [CF] \cdot f^{(0.28-0.10 \log f)}$$

where [CF] is a "chemistry factor" which is given in tabular form, depending on the copper and nickel content, and separately for base material and welds. The symbol f stands for fluence, E > 1.0 MeV in 10^{19} n/cm^2. ΔRT_{NDT} is in degrees Fahrenheit at 30 ft-lb.

2.2.1 Background of Regulatory Guide 1.99, Rev. 2

According to Randall's paper, "Basis for Rev. 2 of the U. S. Nuclear Regulatory Commission's Regulatory Guide 1.99,"[13] there were two embrittlement models, Guthrie's[14] and Odette's,[15] involved in the development of R.G. 1.99, Rev. 2. Both models are based on the least-squares fitting scheme and adopted similar approaches in several areas: (1) separate welds and base metals; (2) the correlation is expressed as the product of a chemistry factor and a fluence factor; (3) the elements in the chemistry factor are copper and nickel; and (4) the fluence factor provides a trend curve slope of about 0.25 ~ 0.30 at 10^{19} n/cm^2.

Three major data bases were involved in the modeling of R.G. 1.99, Rev. 2. The data base and their influence on R.G. 1.99, Rev. 2, are described below:

177 Data Points Data Base

Fifty-one weld and 126 base metal data points were taken from surveillance reports by Randall and rechecked by Guthrie, where 41 of 126 base data are CMMs. The fluence contents are from Simon's[16] data when available. This data base is used in Guthrie's embrittlement model, which used an unconventional least-squares scheme and a Monte Carlo procedure in the model development.

The fluence factor (FF) of R.G. 1.99, Rev. 2, is determined primarily by Guthrie's fluence factor, with slight modifications.

For chemistry factor (CF) of the weld materials, Odette's model is chosen as the main guide for R.G. 1.99, Rev. 2; however, both models have good agreement on CF. For CF of the base metals, Guthrie's model is used, with two exceptions: first, when Guthrie's CF for base metals exceeds those for welds by Odette, the latter was used. Second, at very low copper levels, the CF is assigned as 20°F.

The 2σ margins for R.G. 1.99, Rev. 2, are based on the residual study of the 177 Data Points.

EPRI Data Base[17]

The Electric Power Research Institute's (EPRI) data base used in Odette's modeling contains 65 weld and 151 base metal data and was collected directly from surveillance reports where 37 of 151 base metal data are CMMs. The shift value was determined by a hyperbolic tangent fitting procedure. EPRI's data base overlapped the 177 Data Points almost completely.

For weld materials, Odette's CF is used, except for very low copper, and is assigned the value of 20 °F.

Test Reactor Data

For very low copper contents, there are not sufficient data from the above two data bases. Therefore, an additional judgment was made from test reactor data[18,19] for the determination of CF, which is assigned as 20°F.

2.3 Basis of CMM and Its Implication on Radiation Embrittlement

The use of CMMs is based on the idea that anomalous conditions with regard to fluence, fluence rate, and irradiation temperature can be detected by correspondingly anomalous behavior of the CMM. The difficulty is that it is not easy to determine whether anomalous embrittlement is caused by the radiation environment, such as neutron energy spectrum, flux, fluence, irradiation temperature, and reactor operation history; or by problems inherent in the reference material, such as inhomogeneous material properties of the CMM; or uncertainties in the determination of the trend curve for the reference material, and uncertainties in the determination of the ΔT_{30}. Significant errors in the trend curve determination will show up as systematic biases. These biases may be either independent of the fluence (e.g., due to an incorrect chemistry factor) or fluence dependent, indicating errors in the fluence factor. Such systematic biases can never be completely separated from random errors, but relatively large numbers of data will guard against neglecting large inconsistencies with the trend curve model.

The variation of material properties, such as mechanical test results and chemical compositions, within the reference material is a serious problem. Tests made from different sets of specimens for the unirradiated material reveal considerable differences in the baseline T_{30} for the ASTM A302B plate as well as the three HSST plates (HSST01, HSST02, and HSST03). The test specimens used for the baseline of the A302B reference material (LT orientation) have the range of T_{30} from 4 to 32 °F, and the range of chemistry composition for copper and nickel is 0.17–0.31wt % and 0.17–0.27 wt %, respectively. For the HSST01 plate, the LT baseline specimens have the range of T_{30} from -20 to 36 °F at one-quarter thickness; and the range of copper and nickel contents are 0.17–0.18 wt % and 0.62–0.84 wt %, respectively. For the HSST02 plate, the LT baseline specimens have the range of T_{30} from -3 to 47 °F; and the range of copper and nickel contents are 0.12–0.17 wt % and 0.62–0.72 wt %, respectively. For the HSST03 plate, the TL baseline specimens have the range of T_{30} from 31 to 42 °F at one-quarter thickness and from 17 to 29°F or LT orientation; and the range of copper and nickel contents are 0.12–0.13 wt % and 0.56–0.70 wt %, respectively. The possible fluctuations in the material properties from one specimen set to another can be detected only as random deviations, and these deviations cannot be clearly separated from other random errors.

The standard method used to determine the uncertainty for the T_{30} is based on the uncertainties in determining the fitting parameters in the least-squares fit and the mean-square difference between model and experimental data. However, this procedure does not consider possible deviations between the idealized model and the actual physical mechanism, and this may lead to serious underestimation of the uncertainties, the more so the more restrictive the model is. It can be assumed that the information for determining T_{30} is based on mean values and the slope of the relevant data regardless of what model is actually used, and that this information or the lack of it determines the uncertainties. However, the estimated values of T_{30} and USE as well as the experimental uncertainties are still based on a specific model. From past studies of several fitting models,[20] it appears that differences among selected fit models are mostly within uncertainty bounds.

Hyperbolic tangent fit results for CMM data are listed in Tables 6–8 for surveillance data, and Tables 9–12 for TR-EDB's CMM data, together with the values reported by the original investigation. The index transition temperature at the 30 ft-lb energy level is used in the study, which is the index temperature required by ASTM E-185 for the determination of the transition temperature shift. The 30 ft-lb energy level was used in preference to the old standard of 50 ft-lb

Table 6. Summary of A302B surveillance CMM

				Fluence E > 1 MeV	Flux E > 1 MeV	C_v transition temp. °F at 30-ft-lb, unirradiated				C_v transition temp. °F at 30-ft lb, irradiated				C_v transition temp. °F shift at 30-ft lb				
Tag	Reactor name	Capsule	Orient.	10^{19} n/cm²	10^{11} n/cm²s	R	T	MT	U	R	T	MT	U	R	P	T	MT	U
W	Beznau Unit 1	R	LT	0.572	0.682	36	32	33	6.1	144	135	135	11.5	108	84	103	102	13.0
W	Beznau Unit 1	V	LT	0.277	0.776	36	32	33	6.1	81	81	82	19.5	45	65	35	49	20.4
W	Jose Cabrera-Zorita	K	LT	1.400		40	32	33	6.1	160	131	128	20.2	120	109	99	95	21.1
W	Jose Cabrera-Zorita	N	LT	3.680	1.579	40	32	33	6.1	195	168	168	15.6	155	134	136	135	16.8
W	Jose Cabrera-Zorita	P	LT	1.430		40	32	33	6.1	178	164	163	12.0	138	110	132	130	13.5
W	Haddam Neck	A	LT	0.259	0.486	40	32	33	6.1	125	133	134	13.4	85	63	101	101	14.7
W	Haddam Neck	D	LT	2.280	0.665	40	32	33	6.1	180	170	165	17.3	140	122	138	132	18.3
W	Haddam Neck	F	LT	0.463	0.604	40	32	33	6.1	120	124	123	13.1	80	79	92	90	14.5
W	Haddam Neck	H	LT	1.550	0.646	40	32	33	6.1	167	169	166	12.0	127	112	137	133	13.5
G	Garigliano	113B	LT	1.100	0.414	27	32	33	6.1	153	140	140	12.5	126	103	108	107	13.9
G	Garigliano	113D	LT	0.737	0.547	27	32	33	6.1	133				106	91			
G	Garigliano	114A	LT	4.650	4.947	27	32	33	6.1	194				167	139			
G	Garigliano	114B	LT	2.210	5.725	27	32	33	6.1	142				115	121			
G	Garigliano	114C	LT	5.470	8.238	27	32	33	6.1	178				151	142			
W	R. E. Ginna Unit 1	R	LT	1.100	1.368	40	32	33	6.1	136	134	132	13.4	96	103	102	99	14.7
W	R. E. Ginna Unit 1	T	LT	1.910	0.880	40	32	33	6.1	180	167	165	16.7	140	118	135	132	17.8
W	R. E. Ginna Unit 1	V	LT	0.585	1.315	40	32	33	6.1	130	128	128	10.9	90	85	96	95	12.5
W	H. B. Robinson Unit 2	S	TL	0.506	1.253	64	64	64	13.0	141	138	142	20.0	77	81	74	78	23.9
W	H. B. Robinson Unit 2	T	TL	4.420	1.930	65	64	64	13.0	215	228	232	28.4	150	138	164	168	31.2
W	H. B. Robinson Unit 2	V	TL	0.601	0.595	64	64	64	13.0	169	135	135	20.0	105	86	71	71	23.9
W	Indian Point Unit 2	T	LT	0.243	0.542	38	32	33	6.1	110	106	107	11.7	72	62	74	74	13.2
W	Indian Point Unit 2	V	LT	0.506	0.186	38	32	33	6.1	128	132	132	13.5	90	81	100	99	14.8
W	Indian Point Unit 2	Y	LT	0.453	0.615	38	32	33	6.1	108	106	106	10.7	70	78	74	73	12.3
W	Indian Point Unit 2	Z	LT	1.080	0.663	38	32	33	6.1	138	120	117	16.6	100	102	88	84	17.7
W	Point Beach Unit 1	R	LT	2.360	1.466	40	32	33	6.1	150	156	154	10.3	110	123	124	121	12.0
W	Point Beach Unit 1	S	LT	0.798	0.700	40	32	33	6.1	135	126	126	13.8	95	94	94	93	15.1
W	Point Beach Unit 1	T	LT	2.370	0.809	40	32	33	6.1	160	162	162	13.1	120	123	130	129	14.5
W	Point Beach Unit 1	V	LT	0.524	1.117	40	32	33	6.1	135	132	131	11.3	95	82	100	98	12.8
W	San Onofre Unit 1	A	LT	1.750	2.986	40	32	33	6.1	155	148	146	11.8	115	115	116	113	13.3
W	San Onofre Unit 1	D	LT	3.480	3.910	40	32	33	6.1	190	186	187	13.7	150	133	154	154	15.0
W	San Onofre Unit 1	F	LT	3.850	1.584	40	32	33	6.1	170	162	160	14.3	130	135	130	127	15.5
W	Turkey Point Unit 3	S	LT	1.720	1.578	35	32	33	6.1	160	156	150	14.3	125	115	124	117	15.5
W	Turkey Point Unit 3	T	LT	0.739	2.041	35	32	33	6.1	117	118	115	15.4	82	92	86	82	16.6
W	Turkey Point Unit 3	V	LT	1.530	0.602	35	32	33	6.1	160	132	131	14.9	125	112	100	98	16.1
W	Yankee-Rowe	01		9.000	32.847	15	32	33	6.1	325				310	150			
W	Yankee-Rowe	02		9.000	30.928	15	32	33	6.1	325				310	150			
W	Yankee-Rowe	06		7.000	25.830	15	32	33	6.1	275				260	146			
W	Yankee-Rowe	08		5.000	17.007	15	32	33	6.1	240				225	140			

R - as reported; T - hyperbolic tangent model; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation); P - R.G. 1.99, Rev.2, prediction.
Tag field, W - Westinghouse; G - General Electric.
Westinghouse fluences obtained from "Westinghouse Surveillance Capsule Neutron Fluence Reevaluation," WCAP-14044.

Table 7. Summary of A533B, HSST01, surveillance CMM

Tag	Reactor Name	Capsule	Orient.	Fluence E > 1 MeV	Flux E > 1 MeV	C_v transition temp. °F at 30 ft-lb,unirradiated				C_v transition temp. °F at 30 ft-lb,irradiated				C_v transition temp. °F shift at 30 ft-lb				
				10^{19} n/cm^2	10^{11} n/cm^2*	R	T	Mt	U	R	T	Mt	U	R	P	T	Mt	U
C	Calvert Cliffs Unit 1	W263	LT	0.590	0.636	39	32	31	5.4	127	132	132	7.9	88	116	100	101	9.6
C	Calvert Cliffs Unit 2	W263	LT	0.814	0.564	25	24	23	6.7	153	151	153	8.5	128	128	127	130	10.8
C	Fort Calhoun Unit 1	W225	LT	0.583	0.711	27	14	13	7.4	151	147	146	8.6	124	115	133	133	11.3
C	Fort Calhoun Unit 1	W275	LT	1.280	0.298	27	14	13	7.4	168	186	186	19.5	141	145	172	173	20.9
C	Millstone Unit 2	W104	LT	0.884	0.282	24	30	30	7.7	165	165	163	8.8	141	131	135	133	11.7
C	Maine Yankee	A25	LT	1.300	4.348	15	14	13	7.4	165	169	168	11.3	150	146	155	155	13.5
C	Maine Yankee	W253	LT	1.250	0.339	15	14	13	7.4	175	180	179	8.6	160	144	166	166	11.3
C	Palo Verde Unit 2	W137	LT	0.407	0.284	3	14	13	7.4	120	110	110	14.5	117	102	96	97	16.3
C	Palisades	W110	LT	1.779	0.567	15	14	13	7.4	163	169	169	9.2	148	158	155	156	11.8
C	St. Lucie Unit 1	W104	LT	0.716	0.239	39	36	36	5.6	149	160	160	9.5	110	123	124	124	11.0

R - as reported; T - hyperbolic tangent model; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation).
P - predicted shift per Reg. Guide 199, Revison 2.
Tag field, C - Combustion Engineering.

Table 8. Summary of A 533B, HSST02, surveillance CMM

Tag	Reactor name	Capsule	Orient.	Fluence E > 1 MeV 10^{19} n/cm²	Flux E > 1 MeV 10^{11} n/cm² s	C_v transition temp. °F at 30 ft-lb,unirradiated R	T	MT	U	C_v transition temp. °F at 30 ft-lb,irradiated R	T	MT	U	C_v transition temp. °F at 30 ft-lb,unirradiated R	P	T	MT	U
B	Arkansas Unit 1	A	LT	1.030		48	47	46	5.1	94	121	116	16.1	46	129	74	70	16.9
B	Arkansas Unit 1	B	LT	0.428		48	47	46	5.1	98	97	98	10.4	50	98	50	52	11.6
B	Arkansas Unit 1	C	LT	1.460		48	47	46	5.1	116	122	121	12.7	68	141	75	75	13.7
B	Arkansas Unit 1	E	LT	0.073	0.244	56	47	46	5.1		75	73	12.4	40*	46	28	27	13.4
W	Donald C. Cook Unit 1	T	LT	0.269	0.673	45	47	46	5.1	105	106	105	13.1	60	82	59	59	14.1
W	Donald C. Cook Unit 1	U	LT	1.770	0.610	45	47	46	5.1	165	186	186	10.0	120	148	139	140	11.2
W	Donald C. Cook Unit 1	X	LT	0.813	0.760	45	47	46	5.1	145	148	149	9.6	100	121	101	103	10.9
W	Donald C. Cook Unit 1	Y	LT	1.230	0.788	45	47	46	5.1	155	156	156	10.7	110	135	109	110	11.9
B	Crystal River Unit 3	C	LT	0.656	0.513	48	47	46	5.1	121	130	129	13.8	73	113	83	83	14.7
B	Davis-Besse Unit 1	A	LT	1.290	1.230	48	47	46	5.1	154	160	160	13.9	106	137	113	114	14.8
W	Diablo Canyon Unit 1	S	LT	0.284	0.714	46	47	46	5.1	112	112	113	9.2	66	84	65	67	10.5
W	Diablo Canyon Unit 1	Y	LT	0.941	0.509	46	47	46	5.1	158	160	160	10.8	112	126	113	114	11.9
W	Indian Point Unit 3	Y	LT	0.724	0.690	50	47	46	5.1	190	194	191	11.4	140	116	147	145	12.5
W	Kewaunee	P	LT	2.840	0.809	45	47	46	5.1	200	201	201	10.8	155	164	154	155	11.9
W	Kewaunee	R	LT	1.900	1.301	45	47	46	5.1	185	202	194	10.3	140	150	155	148	11.5
W	Kewaunee	V	LT	0.608	1.498	45	47	46	5.1	140	143	141	11.8	95	110	96	95	12.9
B	Oconee Unit 1	A	LT	0.895		56	47	46	5.1	144	130	131	11.4	88	124	83	85	12.5
B	Oconee Unit 1	C	LT	0.986		48	47	46	5.1	116	122	121	12.6	68	194	75	75	13.6
B	Oconee Unit 1	E	LT	0.150	0.289	56	47	46	5.1		78	77	14.2	64*	64	31	31	15.1
B	Oconee Unit 1	F	LT	0.057	0.213	56	47	46	5.1		56	56	12.4	28*	40	9	10	13.4
B	Oconee Unit 2	A	LT	0.337		48	47	46	5.1	119	116	115	7.6	71	90	69	69	9.2
B	Oconee Unit 2	C	LT	0.094	0.248	56	47	46	5.1		74	73	11.4	42*	52	27	27	12.5
B	Oconee Unit 2	E	LT	1.210		48	47	46	5.1	143	170	168	16.9	95	135	123	122	17.7
B	Oconee Unit 3	B	LT	0.312		56	47	46	5.1	95	99	99	8.6	39	87	52	53	10.0
B	Oconee Unit 3	D	LT	1.450		32	47	46	5.1	151	153	150	16.5	119	141	106	104	17.3
W	Point Beach Unit 2	R	LT	2.520	1.537	49	47	46	5.1	200	201	200	12.0	151	160	154	154	13.0
W	Point Beach Unit 2	S	LT	3.760	0.807	49	47	46	5.1	194	198	197	12.5	145	172	151	151	13.5
W	Point Beach Unit 2	T	LT	1.010	0.927	49	47	46	5.1	154	168	168	13.3	105	128	121	122	14.2
W	Point Beach Unit 2	V	LT	0.585	1.216	45	47	46	5.1	135	141	141	10.7	90	109	94	95	11.9
W	Prairie Island Unit 1	P	LT	1.460	0.807	49	47	46	5.1	205	208	207	8.1	156	141	161	161	9.6
W	Prairie Island Unit 1	R	LT	3.950	1.463	49	47	46	5.1	235	241	240	9.9	186	173	194	194	11.1
W	Prairie Island Unit 1	V	LT	0.540	1.280	49	47	46	5.1	159	151	150	11.0	110	106	104	104	12.1
W	Prairie Island Unit 2	R	LT	4.050	1.457	45	47	46	5.1	225	230	229	10.3	180	174	183	183	11.5
W	Prairie Island Unit 2	T	LT	1.090	0.838	45	47	46	5.1	205	205	204	8.7	160	131	158	158	10.1
W	Prairie Island Unit 2	V	LT	0.578	1.314	45	47	46	5.1	170	170	169	11.1	125	108	123	123	12.2
W	Salem Unit 1	T	LT	0.256	0.738	50	47	46	5.1	110	113	114	11.9	60	81	66	68	12.9

Table 8 (continued)

Tag	Reactor name	Capsule	Orient.	Fluence E > 1 MeV 10^{19} n/cm^2	Flux E > 1 MeV 10^{11} n/cm^2 s	C_v transition temp. °F at 30 ft-lb, unirradiated R	T	MT	U	C_v transition temp. °F at 30 ft-lb, irradiated R	T	MT	U	C_v transition temp. °F at 30 ft-lb, unirradiated R	P	T	MT	U
W	Salem Unit 1	Y	LT	0.930	0.823	50	47	46	5.1	175	180	180	8.9	125	125	133	134	10.3
W	Salem Unit 1	Z	LT	1.230	0.644	50	47	46	5.1	185	182	182	8.4	135	135	135	136	9.8
W	Surry Unit 1	T	LT	0.282	0.834	45	47	46	5.1	115	119	117	10.9	70	84	72	71	12.0
W	Surry Unit 1	V	LT	1.970	0.779	45	47	46	5.1	190	189	189	10.2	145	152	142	143	11.4
W	Surry Unit 2	V	LT	1.750	0.663	45	47	46	5.1	165	152	150	12.2	120	148	105	104	13.2
W	Surry Unit 2	X	LT	0.294	0.797	40	47	46	5.1	100	109	108	9.8	60	85	62	62	11.0
B	Three Mile Island Unit 1	C	LT	0.866		48	47	46	5.1	125	126	125	9.9	77	123	79	79	11.1
B	Three Mile Island Unit 1	E	LT	0.107	0.263	56	47	46	5.1		90	89	9.2	44*	55	43	43	10.5
W	Turkey Point Unit 4	S	LT	1.430	1.324	45	47	46	5.1		152	151	9.2	115*	141	105	105	10.5
W	Turkey Point Unit 4	T	LT	0.708	1.914	45	47	46	5.1	135	136	136	12.1	90	116	89	90	13.1
W	Zion Unit 1	T	LT	0.325	0.846	42	47	46	5.1	108	113	113	8.8	66	88	66	67	10.2
W	Zion Unit 1	U	LT	0.964	0.853	42	47	46	5.1	172	175	170	12.6	130	127	128	124	13.6
W	Zion Unit 1	X	LT	1.330	0.816	42	47	46	5.1	162	166	165	10.1	120	138	119	119	11.3
W	Zion Unit 1	Y	LT	1.780	0.657	42	47	46	5.1	171	169	169	11.9	129	148	122	123	12.9
W	Zion Unit 2	T	LT	0.840	0.743	50	47	46	5.1	150	147	146	10.6	100	122	100	100	11.8
W	Zion Unit 2	U	LT	0.282	0.676	50	47	46	5.1	100	95	96	9.4	50	84	48	50	10.7
W	Zion Unit 2	Y	LT	1.670	0.576	50	47	46	5.1	185	183	183	8.6	135	146	136	137	10.0

R - as reported; T - hyperbolic tangent model; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation).

P - predicted shift per R.G. 1.99, Rev. 2.

* 50 ft-lb transition temperature shift

Tag Field, B - Babcock & Wilcox; W - Westinghouse

Westinghouse Fluences obtained from "Westinghouse Surveillance Capsule Neutron Fluence Reevaluation," WCAP-14044.

Table 9. Summary of A302B, ASTM, CMM per TR-EDB

Experiment	Reactor	Capsule	Heat	Orient.	Fluence E > 1 MeV	Flux E > 1 MeV	Irrad. temp.	C_v transition temp. °F at 30 ft-lb, unirradiated			C_v transition temp. °F at 30 ft-lb, irradiated			C_v transition temp. °F shift at 30 ft-lb			
Tag	ID		ID		10^{19} n/cm^2	10^{13} n/cm^2 s	°F	R	MT	U	R	MT	U	R	P	MT	U
HAW-AN	LITR	57 88A	SASTM F23	LT	1.080		500	30	13	6.6	210			180	102		
HAW-AN	LITR	57 88B	SASTM F23	LT	0.910		470	30	13	6.6	210			180	97		
MEA-RT	UBR	B4-65	SASTM F23	LT	0.560	1.008	550	7	4	9.1	88	84	6.8	81	84	80	11.4
MEA-RT	UBR	B4-76	SASTM F23	LT	2.230	1.006	550	7	4	9.1	132	130	7.4	125	122	126	11.7
MEA-RT	UBR	C2-75	SASTM F23	LT	1.040	0.937	550	7	4	9.1	113	110	9.1	106	101	106	12.9
MEA-RT	UBR	CE-44	SASTM F23	LT	0.790	0.079	550	7	4	9.1	110	110	8.8	103	93	106	12.7
MEA-RT	UBR	CE-45	SASTM F23	LT	3.850	0.096	550	7	4	9.1	139	131	8.1	132	135	127	12.2
MEA-RT	UBR	CE-46A	SASTM F23	LT	1.500	0.074	550	7	4	9.1	120	119	8.6	113	111	115	12.5
MEA-RT	UBR	RE-38	SASTM F23	LT	0.540	0.009	550	7	4	9.1	100	98	6.6	93	83	94	11.2
NRL-4	UBR	UB-01	SASTM F26	LT	0.120	0.700	550	0			40			40	45		
NRL-EP	BSR	7	SASTM N	TL	2.700	0.340	550	60	57	16.9	205	200	19.7	145	127	143	26.0
NRL-EP	UBR	UB-31	SASTM N	LT	3.600	0.899	550	20	16	4.4	195	182	9.1	175	133	166	10.1
ORRPSF	ORR	0-TF	SASTM F23	LT	5.400	0.105	550	25	25	8.3	171	161	8.5	146	142	136	11.9
ORRPSF	ORR	1/2 TF	SASTM F23	LT	1.400	0.027	550	25	25	8.3	115	114	8.4	90	109	89	11.8
ORRPSF	ORR	1/4 TF	SASTM F23	LT	2.800	0.055	550	25	25	8.3	145	127	8.8	121	127	102	12.1
ORRPSF	ORR	SSC1F	SASTM F23	LT	2.790	0.726	550	25	25	8.3	172	157	11.5	148	127	132	14.2
ORRPSF	ORR	SSC2F	SASTM F23	LT	5.400	0.695	550	25	25	8.3	194	185	8.1	169	142	160	11.6
PR-EDB	YR	8	SASTM D36	LT	5.000	0.170	490	15			240			225	140		
PR-EDB	YR	W1	SASTM D36	LT	0.220	0.003	490	35			120			85	59		
RRA	DIDO	2V4(9)	SASTM RRA	TL	0.475	0.228	482	21			174			153	79		
RRA	DIDO	2V4(9)	SASTM RRA	TL	1.020	0.251	482	21			228			185	101		
SM-2	LITR	X02	SASTM X		3.000	~0.500	550	15			170			155	129		
SRM	BGR	9	SASTM X		0.740		300							240	92		
SRM	BGR	10	SASTM X		0.550		300							205	83		
SRM	BR	122-3	SASTM F23	LT	7.100		585	30	13	6.6	195			165	147		
SRM	CVTR	10L	SASTM X		0.780		300							240	93		
SRM	ETR	XX	SASTM X		0.270		450							67	64		
SRM	ETR	XX	SASTM X		0.450		450							95	78		
SRM	ETR	XX	SASTM X		7.600		450							201	148		
SRM	IRL	1	SASTM X		0.035		300							35	24		
SRM	IRL	1	SASTM X		0.059		300							50	32		
SRM	IRL	1	SASTM X		0.099		300							50	41		
SRM	IRL	1	SASTM X		0.160		300							80	52		
SRM	IRL	1	SASTM X		0.260		300							105	63		
SRM	IRL	2	SASTM X		0.065		300							55	34		
SRM	IRL	2	SASTM X		0.114		300							70	44		
SRM	IRL	2	SASTM X		0.186		300							120	55		

Table 9 (continued)

Experiment Tag	Reactor ID	Capsule	Heat ID	Orient.	Fluence E > 1 MeV 10^{19} n/cm²	Flux E > 1 MeV 10^{13} n/cm² s	Irrad. temp. °F	C_v transition temp. °F at 30 ft-lb, unirradiated			C_v transition temp. °F at 30 ft-lb, irradiated			C_v transition temp. °F shift at 30 ft-lb			
								R	MT	U	R	MT	U	R	P	MT	U
SRM	IRL	2	SASTM X		0.310		300							150	68		
SRM	IRL	2	SASTM X		0.500		300							180	81		
SRM	IRL	3	SASTM X		0.008		300							0	9		
SRM	IRL	3	SASTM X		0.014		300							0	14		
SRM	IRL	3	SASTM X		0.036		300							20	24		
SRM	IRL	3	SASTM X		0.091		300							50	40		
SRM	IRL	3	SASTM X		0.140		300							80	49		
SRM	IRL	3	SASTM X		0.250		300							125	62		
SRM	IRL	3	SASTM X		0.630		300							165	87		
SRM	KE	1	SASTM X		0.470		300							205	79		
SRM	KE	1	SASTM X		0.480		300							205	80		
SRM	KE	1	SASTM X		0.570		300							230	84		
SRM	KE	2	SASTM X		0.890		300							265	97		
SRM	KE	2	SASTM X		0.910		300							265	97		
SRM	KE	2	SASTM X		1.100		300							275	103		
SRM	KE	3	SASTM X		2.300		300							360	123		
SRM	KE	3	SASTM X		2.500		300							310	125		
SRM	KE	3	SASTM X		2.800		300							360	127		
SRM	LITR	18 3	SASTM X		0.800	~0.500	300							200	94		
SRM	LITR	18 3	SASTM X		1.000	~0.500	300							250	100		
SRM	LITR	18 8	SASTM D36	LT	0.545	~0.500	550	15			80			65	83		
SRM	LITR	18 8	SASTM X		0.545	~0.500	300							170	83		
SRM	LITR	18 8	SASTM X		0.545	~0.500	400							130	83		
SRM	LITR	18 8	SASTM X		0.545	~0.500	450							140	83		
SRM	LITR	18 8	SASTM X		0.730	~0.500	465							191	91		
SRM	LITR	18 13	SASTM D36	LT	3.270	~0.500	550	15			180			165	131		
SRM	LITR	18 13	SASTM D36	LT	3.270	~0.500	650	15			125			110	131		
SRM	LITR	18 13	SASTM D36	LT	3.270	~0.500	750	15			80			65	131		
SRM	LITR	18 20H	SASTM D36	LT	4.250	~0.500	550	15			210			195	137		
SRM	LITR	18 42	SASTM F26	LT	1.700	~0.500	700	15			45			30	115		
SRM	LITR	18 45	SASTM F26	LT	3.597	~0.500	550	30			185			155	133		
SRM	LITR	18 62	SASTM X	LT	1.800	~0.500	300							255	116		
SRM	LITR	18105H	SASTM X	LT	2.289	~0.500	550	15			155			140	122		
SRM	LITR	28 49	SASTM X	LT	1.250		300							220	106		
SRM	LITR	43 72	SASTM X	LT	3.100	~0.690	300							310	130		
SRM	LITR	43 72	SASTM X	LT	3.100	~0.690	300							315	130		
SRM	LITR	43 86	SASTM S3SR	LT	3.373	~0.690	550	40			200			160	132		

Table 9 (continued)

Experiment Tag	Reactor ID	Capsule	Heat ID	Orient.	Fluence E > 1 MeV 10^{19} n/cm^2	Flux E > 1 MeV 10^{13} n/cm^2 s	Irrad. temp. °F	C_v transition temp. °F at 30 ft-lb, unirradiated			C_v transition temp. °F at 30 ft-lb, irradiated			C_v transition temp. °F shift at 30 ft-lb			
								R	MT	U	R	MT	U	R	P	MT	U
SRM	LITR	43 95	SASTM X	LT	4.100	~0.690	650	15			105			90	136		
SRM	LITR	43 98	SASTM X	LT	5.600	~0.690	750	15			80			65	142		
SRM	LITR	43108	SASTM X	LT	3.270	~0.690	550	15			170			155	131		
SRM	LITR	49 47	SASTM X	LT	0.750		300							205	92		
SRM	LITR	53 25	SASTM X	LT	2.000	~0.278	300							315	119		
SRM	LITR	53 25	SASTM X	LT	2.000	~0.278	300							295	119		
SRM	LITR	53 50	SASTM X	LT	1.200	~0.278	300							215	105		
SRM	LITR	53 68H	SASTM F23	LT	1.695	~0.278	550	30	13	7	185			155	115		
SRM	LITR	53 87	SASTM X		1.700	~0.278	300							300	115		
SRM	LITR	55 6	SASTM X		0.850	~0.358	300							230	95		
SRM	LITR	55 31	SASTM D36	LT	1.582	~0.358	490	15			215			200	113		
SRM	LITR	55 54H	SASTM F26	LT	3.503	~0.358	550	30			185			155	133		
SRM	LITR	55 61H	SASTM F26	LT	3.503	~0.358	550	30			200			170	133		
SRM	LITR	55 80	SASTM X	LT	2.938	~0.358	600	15			150			135	129		
SRM	LITR	55 84	SASTM X		2.100	~0.358	300							290	120		
SRM	LITR	55 85	SASTM X	LT	5.424	~0.358	550	15			210			195	142		
SRM	LITR	55 99H	SASTM F23	LT	2.599	~0.358	550	30	13	7	190			160	126		
SRM	LITR	55111	SASTM X	LT	1.921	~0.358	550	30			170			140	118		
SRM	LITR	57 88H	SASTM F23	LT	1.243		550	30	13	7	170			140	106		
SRM	MTR	S17	SASTM X	LT	1.800		300							300	116		
SRM	MTR	S17	SASTM X	ST	1.800		300							290	116		
SRM	MTR	S19	SASTM X	LT	1.300		300							265	107		
SRM	MTR	S20	SASTM X	LT	2.200		300							300	121		
SRM	MTR	S26	SASTM X	LT	7.000		300							405	146		
SRM	MTR	S30	SASTM X	LT	11.000		300							385	152		
SRM	MTR	S33	SASTM X	LT	10.000		300							385	151		
SRM	TRINO1	XX	SASTM X	LT	0.250		500	15			102			87	62		
SRM	UCRR	C3 1C	SASTM X	LT	0.750		300							170	92		
SRM	UCRR	D3 14H	SASTM X	LT	0.174		550	20			70			50	54		
SRM	WR1	XX	SASTM X	LT	0.300		550	15			95			80	67		
SRM	WR2	XX	SASTM X	LT	0.200		550	15			100			85	57		
SRM	XXX	EXP A	SASTM X		0.350		495							65	71		
SRM	XXX	EXP A	SASTM X		18.000		495							375	156		
SRM	YR	1	SASTM D36	LT	9.000	0.328	490	15			325			310	150		
SRM	YR	6	SASTM D36	LT	7.000	0.258	490	15			275			260	146		

R - as reported; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation).

P - predicted shift per R.G. 1.99, Rev. 2.

Table 10. Summary of A533B, HSST01, CMM per TR-EDB

Experiment ID	Reactor ID	Capsule	Heat ID[a]	Orient.	Fluence E > 1MeV 10^{19} n/cm²	Irrad. temp. °F	C_v transition temp. °F at 30 ft-lb, unirradiated R	MT	U	C_v transition temp. °F at 30 ft-lb, irradiated R	MT	U	C_v transition temp. °F shift at 30 ft lb R	P	MT	U
HSST-1	ORR	XX	SHSS01K 0T	LT	0.410	142	-145	-139	4.8	-15	-26	12.1	130	102	113	13.0
HSST-1	ORR	XX	SHSS01K 0T	LT	0.500	552	-145	-139	4.8	-75	-77	8.0	70	110	62	9.3
HSST-1	ORR	XX	SHSS01K 0T	LT	0.550	450	-145	-139	4.8	10	-11	10.0	155	113	128	11.1
HSST-1	ORR	XX	SHSS01K 0T	LT	1.000	143	-145	-139	4.8	5	-4	8.6	150	136	135	9.8
HSST-1	ORR	XX	SHSS01K 0T	LT	1.110	642	-145	-139	4.8	-90	-91	9.0	55	140	48	10.2
HSST-1	ORR	XX	SHSS01K 0T	LT	1.280	554	-145	-139	4.8	-50	-63	11.4	95	145	76	12.4
HSST-1	ORR	XX	SHSS01K 12	LT	0.470	130	15	-3	2.6	165	160	10.1	150	107	163	10.4
HSST-1	ORR	XX	SHSS01K 12	LT	0.580	139	15	-3	2.6	180	175	13.3	165	115	178	13.6
HSST-1	ORR	XX	SHSS01K 12	LT	0.680	147	15	-3	2.6	210	195	7.3	195	121	198	7.7
HSST-1	ORR	XX	SHSS01K 12	LT	0.740	455	15	-3	2.6	195	179	9.3	180	125	182	9.7
HSST-1	ORR	XX	SHSS01K 12	LT	0.920	458	15	-3	2.6	195	180	8.5	180	133	183	8.9
HSST-1	ORR	XX	SHSS01K 12	LT	0.980	661	15	-3	2.6	65	63	9.3	50	135	66	9.7
HSST-1	ORR	XX	SHSS01K 12	LT	1.060	561	15	-3	2.6	150	138	16.1	135	138	141	16.3
HSST-1	ORR	XX	SHSS01K 14	LT	0.460	146	0	-20	2.8	150	144	7.1	150	107	164	7.6
HSST-1	ORR	XX	SHSS01K 14	LT	0.600	155	0	-20	2.8	175	175	8.2	175	117	195	8.7
HSST-1	ORR	XX	SHSS01K 14	LT	0.660	454	0	-20	2.8	165	154	7.3	165	120	174	7.8
HSST-1	ORR	XX	SHSS01K 14	LT	0.880	556	0	-20	2.8	100	89	7.5	100	131	109	8.0
HSST-1	ORR	XX	SHSS01K 14	LT	0.970	143	0	-20	2.8	190	183	5.6	190	135	203	6.3
HSST-1	ORR	XX	SHSS01K 14	LT	1.240	550	0	-20	2.8	115	114	10.2	115	144	134	10.6
HSST-1	ORR	XX	SHSS01K 14	LT	1.340	655	0	-20	2.8	45	37	6.2	45	147	57	6.8
HSST-1	ORR	XX	SHSS01K 14	TL	0.660	130	25	20	8.0	180	170	7.7	155	120	150	11.1
HSST-1	ORR	XX	SHSS01K 14	TL	0.780	460	25	20	8.0	155	154	10.5	130	127	134	13.2
NRL-2	MTR	X01	SHSS01	TL	2.700	300	15			325			310	172		
NRL-2	UCRR	B3 51	SHSS01	TL	2.500	550	15			215			200	169		

R - as reported; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation).

P - predicted shift per R.G. 1.99, Rev. 2.

[a]The last two characters of Heat ID are used to specif the specimen position in the parent material.
OT - at surface, 12 - 1/2 thickness, 14 - 1/4 thickness.

Table 11. Sumary of A533B, HSST02, CMM per TR-EDB

Experiment Tag	Reactor ID	Capsule	Heat ID	Orient.	Fluence E > 1 MeV 10^{19} n/cm²	Flux E > 1 MeV 10^{13} n/cm² s	Irrad. temp. °F	C_v trnsition temp. °F at 30 ft-lb, unirradiated			C_v trnsition temp. °F at 30 ft-lb, irradiated			C_v transition temp. °F shift at 30 ft-lb			
								R	MT	U	R	MT	U	R	P	MT	U
HSST-1	ORR	XX	SHSS02FB13	LT	0.530		548	45	29	5.5	95	94	7.5	50	105	65	9.3
HSST-1	ORR	XX	SHSS02FB13	LT	1.060		150	45	29	5.5	235	214	8.5	190	130	185	10.1
HSST-1	ORR	XX	SHSS02FB13	LT	1.260		451	45	29	5.5	235	232	7.7	190	136	203	9.5
HSST-4	BSR	A4	SHSS02GA	TL	2.000	0.120	550	45	41	4.0	154	163	4.8	109	152	122	6.2
NRL-2	MTR	X02	SHSS02	LT	3.100		300	30			325			295	166		
NRL-2	MTR	X03	SHSS02	TL	2.800		300	45			360			315	163		
NRL-2	MTR	X04	SHSS02 0T	TL	3.300		300	-105			165			270	168		
NRL-2	UCRR	B3 45	SHSS02	LT	2.400		550	30			200			170	158		
NRL-2	UCRR	B3 45	SHSS02	TL	2.300		475	45			210			165	157		
VDE	FRJ-2	X01030	SHSS02A	LT	1.000	2.310	572	23	23	5.5	82	78	9.6	59	128	55	11.1
VDE	FRJ-2	X01030	SHSS02A	TL	1.000	2.310	572	34	38	7.0	73	73	7.7	40	128	35	10.4
VDE	FRJ-2	X01040	SHSS02A	LT	1.000	2.310	752	23	23	5.5	45	34	6.7	22	128	11	8.7
VDE	FRJ-2	X01040	SHSS02A	TL	1.000	2.310	752	34	38	7.0	46	42	6.6	13	128	4	9.6
VDE	FRJ-2	X05030	SHSS02A	LT	5.000	2.510	572	23	23	5.5	144	144	9.9	121	180	121	11.3
VDE	FRJ-2	X05030	SHSS02A	TL	5.000	2.510	572	34	38	7.0	138	135	10.3	104	180	97	12.5
VDE	FRJ-2	X05040	SHSS02A	LT	5.000	2.510	752	23	23	5.5	61	67	6.2	38	180	44	8.3
VDE	FRJ-2	X05040	SHSS02A	TL	5.000	2.510	752	34	38	7.0	75	74	8.6	41	180	36	11.1
VDE	FRJ-2	X10030	SHSS02A	LT	10.000	2.362	572	23	23	5.5	216	195	10.0	193	194	172	11.4
VDE	FRJ-2	X10030	SHSS02A	TL	10.000	2.362	572	34	38	7.0	225	211	8.8	191	194	173	11.2
VDE	FRJ-2	X10040	SHSS02A	LT	10.000	2.362	752	23	23	5.5	93	91	6.7	70	194	68	8.7
VDE	FRJ-2	X10040	SHSS02A	TL	10.000	2.362	752	34	38	7.0	104	96	9.8	70	194	58	12.0

R - as reported; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation).

P - predicted shift per R.G. 1.99, Rev. 2.

Table 12. Summary of A533B, HSST03, CMM per TR-EDB

Experiment Tag	Reactor ID	Capsule	Heat ID	Orient.	Fluence E > 1 MeV 10^{19} n/cm²	Flux E > 1 MeV 10^{13} n/cm² s	Irrad. temp. °F	C_v trnsition temp. °F at 30 ft-lb, unirradiated R	MT	U	C_v trnsition temp. °F at 30 ft-lb, irradiated R	MT	U	C_v trnsition temp. °F shift at 30 ft-lb R	P	MT	U
IAEAG	FRG-2	XX	SHSS03NR	LT	2.060	1.700	550	32	17	7.4	108			76	98		
IAEAG	FRG-2	XX	SHSS03NR	LT	9.450	1.700	545	32	17	7.4	216			184	124		
IAEAG	FRG-2	XX	SHSS03NR	TL	0.550	1.700	549	32	33	9.0	70			38	68		
IAEAG	FRG-2	XX	SHSS03NR	TL	1.730	1.700	554	32	33	9.0	100			68	95		
IAEAG	FRG-2	XX	SHSS03NR	TL	2.060	1.700	547	32	33	9.0	109			77	98		
IAEAG	FRG-2	XX	SHSS03NR	TL	2.680	1.700	549	32	33	9.0	124			90	104		
IAEAG	FRG-2	XX	SHSS03NR	TL	6.540	1.700	554	32	33	9.0	183			151	119		
IAEAG	FRG-2	XX	SHSS03NR	TL	6.970	1.700	549	32	33	9.0	243			211	120		
IAEAG	FRG-2	XX	SHSS03NR	TL	7.990	1.700	552	32	33	9.0	216			184	122		
IAEAG	FRG-2	XX	SHSS03NR	TL	9.450	1.700	543	32	33	9.0	244			212	124		
IAEAG	KKS	XX	SHSS03NR	TL	2.300	0.080	540	32	33	9.0	108			76	101		
IAEAG	VAK	XX	SHSS03NR	TL	2.400	0.300	545	32	33	9.0	145			113	102		
IAEAU	UBR	UB-23	SHSS03MUNE	TL	2.100	0.700	550	30	33	9.0	109			79	99		
KFA	FRJ-1	X00115	SHSS03LF	TL	0.150	0.200	302	32	33	9.0	129	127	6.6	97	41	94	11.2
KFA	FRJ-1	X00315	SHSS03LF	TL	0.350	0.200	302	32	33	9.0	189	179	6.8	157	58	146	11.3
KFA	FRJ-1	X00715	SHSS03LF	TL	0.700	0.200	302	32	33	9.0	230	221	5.7	198	74	188	10.7
KFA	FRJ-1	X01015	SHSS03LF-4	TL	1.000	0.200	302	32	33	9.0	304	316	16.1	272	82	283	18.4
KFA	FRJ-1	X01515	SHSS03LF	TL	1.500	0.200	302	32	33	9.0	282	273	6.0	250	91	240	10.8
KFA	FRJ-1	X01829	SHSS03GU	TL	1.800	0.200	550	32	33	9.0	118	100	10.0	86	95	67	13.5
KFA	FRJ-1	X03015	SHSS03LF	TL	3.000	0.200	302	32	33	9.0	297	297	4.6	265	106	264	10.1
KFA	FRJ-1	X07015	SHSS03LF	TL	7.000	0.200	302	32	33	9.0	358	345	13.0	326	120	312	15.8
KFA	FRJ-1	X08029	SHSS03GU	TL	8.000	0.200	550	32	33	9.0	268	252	8.0	236	122	219	12.0
KFA	FRJ-2	X06025	SHSS03LS	TL	6.000	3.000	491	32	33	9.0	313	299	12.9	281	118	266	15.7
KFA	FRJ-2	X06027	SHSS03LS	TL	6.000	3.000	518	32	33	9.0	261	252	11.6	229	118	219	14.7
KFA	FRJ-2	X06029	SHSS03LS	TL	6.000	3.000	554	32	33	9.0	207	193	16.1	175	118	160	18.4
KFA	FRJ-2	X06033	SHSS03LS	TL	6.000	3.000	626	32	33	9.0	126	124	10.2	94	118	91	13.6
KFA	FRJ-2	X06036	SHSS03LS	TL	6.000	3.000	689	32	33	9.0	95	93	14.5	63	118	60	17.1
KFA	HFR	X00220	SHSS03PL	TL	0.220	23.500	392	32	33	9.0	140	129	9.0	108	49	96	12.7
KFA	HFR	X00520	SHSS03PL	TL	0.470	21.050	392	32	33	9.0	183	188	8.1	151	65	155	12.1
KFA	HFR	X01120	SHSS03PL	TL	1.100	23.150	392	32	33	9.0	234	217	9.0	202	84	184	12.7
KFA	HFR	X02120	SHSS03PL	TL	2.100	22.970	392	32	33	9.0	262	259	7.5	230	99	226	11.7
KFA	HFR	X02120	SHSS03PL	TL	2.100	22.970	392	32	33	9.0	262	259	7.5	230	99	226	11.7
KFA	HFR	X09819	SHSS03PL	TL	9.800	26.350	374	32	33	9.0	397	399	7.0	365	124	366	11.4
NRL-4	UBR	UB-09	SHSS03MU	LT	1.700	0.700	550	30	33	9.0	110			80	94		
ORRPSF	ORR	0-TF	SHSS03PSF	TL	5.000	0.097	550	30	33	9.0	165	157	11.6	135	115	124	14.7
ORRPSF	ORR	1/2 TF	SHSS03PSF	TL	1.300	0.025	550	30	33	9.0	126	123	11.6	95	88	90	14.7
ORRPSF	ORR	1/4 TF	SHSS03PSF	TL	2.500	0.049	550	30	33	9.0	154	146	10.5	124	102	113	13.8
ORRPSF	ORR	SSC1F	SHSS03PSF	TL	2.550	0.664	550	30	33	9.0	140	156	10.6	110	103	123	13.9
ORRPSF	ORR	SSC2F	SHSS03PSF	TL	5.000	0.644	550	30	33	9.0	176	178	10.7	146	115	145	14.0

R - as reported; MT - hyperbolic tangent model plus Monte Carlo method; U - uncertainty (1 standard deviation).
P - predicted shift per R.G. 1.99, Rev. 2.

because the higher energy is too close to or above the upper shelf for some of the materials used. From the reported surveillance data, there are over 40 data points whose irradiated upper shelf are less than 50 ft-lb. In a few cases, suspect Charpy tests have been eliminated from the fitting and determination of uncertainties. This procedure is rather subjective, but the results are more reasonable (see the figures and tables in Appendix A, where the specimen identification of a rejected Charpy test is pre-affixed with a "*," and the rejected data are plotted with a solid symbol in the figure).

If the deviations from the expected radiation damage exceed the uncertainties described above and the anomalies in the capsule environment (i.e., fluence), flux, irradiation temperature, or plant operation history must be suspected. Errors in fluence determination, which are large enough to significantly influence the damage prediction, are small in most cases, perhaps with the exception of very low fluences or very high fluences. For example, a 1.0×10^{19} n/cm² fluence with a large uncertainty (e.g., 35% uncertainty in the fluence evaluation) will result in only an 8% uncertainty in the fluence factor of R.G. 1.99, Rev. 2. From the present investigation of power reactor data, the dependency of radiation damage on the fluence rate cannot be confirmed nor ruled out. Whenever the radiation damage is larger or smaller than expected, fluence rates have not differed significantly from other capsules that behave normally. This leaves irradiation temperature as the most likely cause for variations with comparable fluence, excluding the very low and very high fluence range. Temperature monitors within the surveillance capsules give only the upper bound and, in case of melting, do not indicate whether any high temperature was transient or sustained. The investigation of the material test reactor data, which cover wider ranges of fluence, flux, and irradiation temperature compared with that of power reactor data, seems to reveal the fluence-rate effect and the synergistic effect of irradiation temperature and fluence and flux. Both the power reactor and test reactor data show the strong influence of the irradiation temperature on the radiation embrittlement.

It is a good indication that capsule anomalies are the cause for deviation from the expected radiation damage of the reference material if the other materials in the capsules show similar deviations. For this reason, the radiation damage for all materials in a given capsule from the reported surveillance data is investigated in this report, and the summary is listed in Tables 13–15; excluded were the HAZ materials and the materials where the copper and nickel content were not determined. Based on PR-EDB, Version 2, reported data, the new 2σ uncertainties per R.G. 1.99, Rev. 2, for base and weld metals, are determined as 56 and 63°F, respectively, but absolute residuals greater than 100°F were not included in the uncertainty study. Three plots of residual (with the 2σ bounds) vs fluence were generated for plate, forging, and weld materials, respectively (see Figs. 1–3). "Residual" is defined as the measured ΔT_{30} minus the R.G. 1.99, Rev. 2, prediction. The manufacturer's chemistry data were used in the residual study.

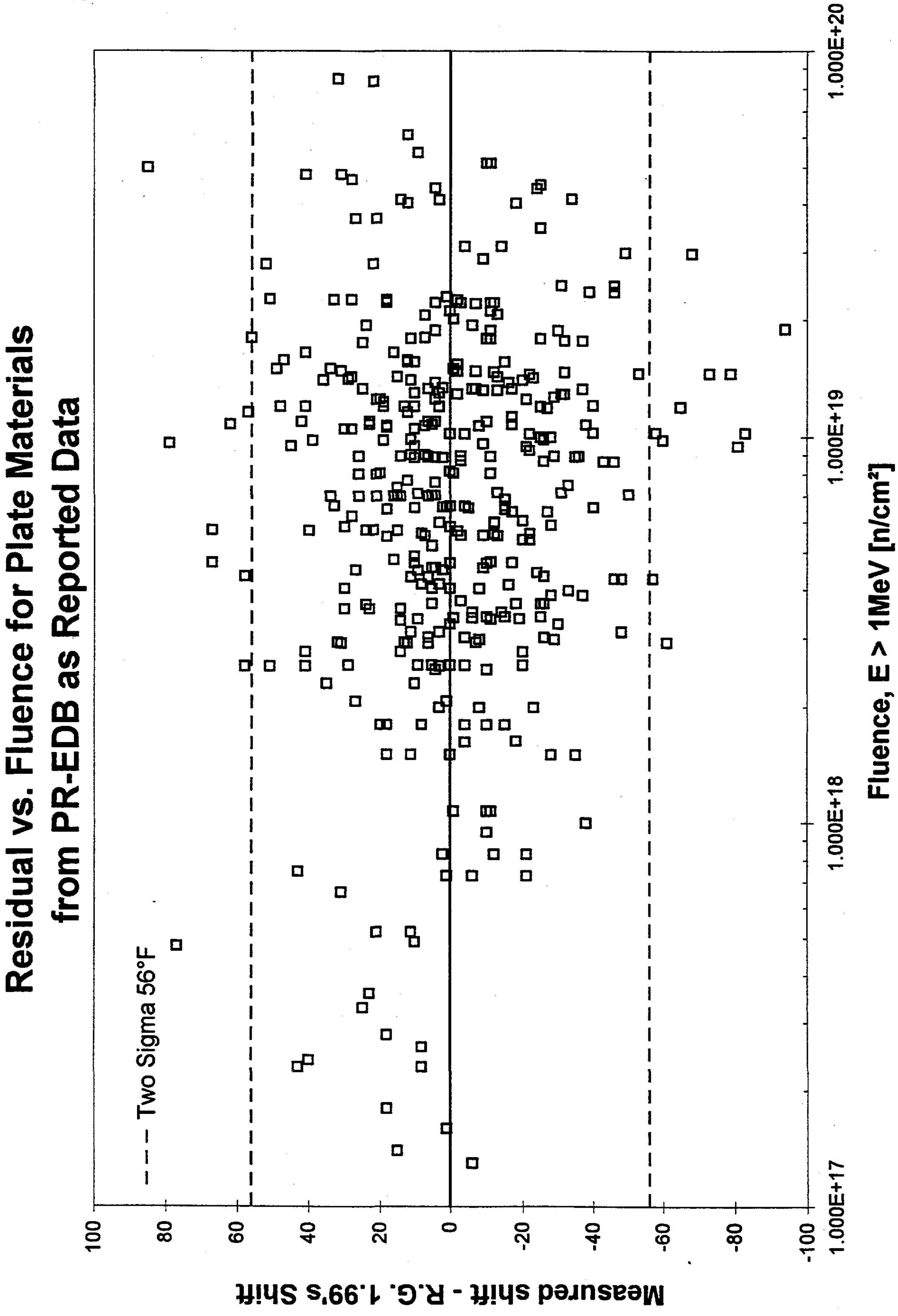


Figure 1 Embrittlement of surveillance plate materials relative to the R.G. 1.99, Rev. 2, prediction

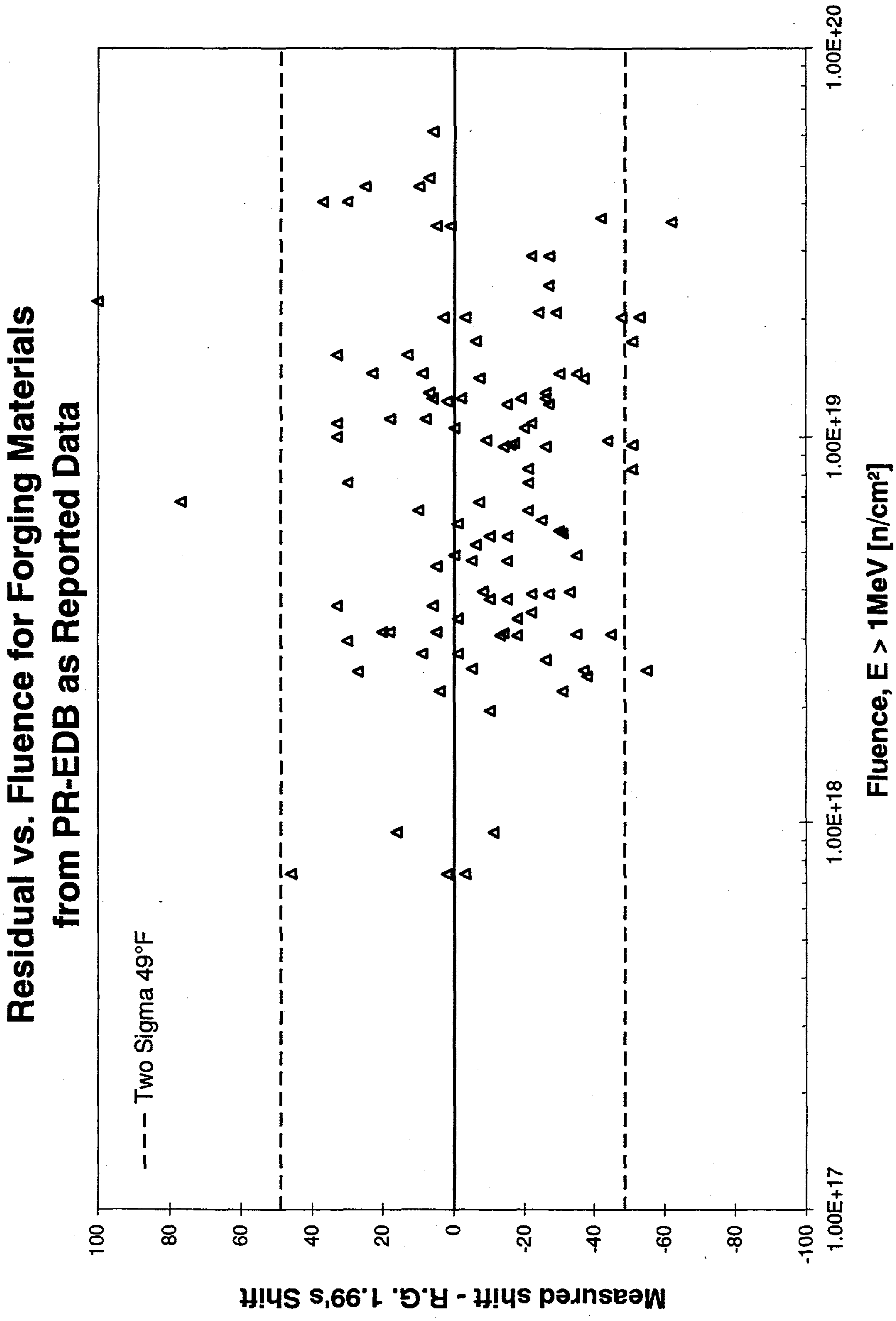


Figure 2 Embrittlement of surveillance forging materials relative to the R.G. 1.99, Rev. 2, prediction

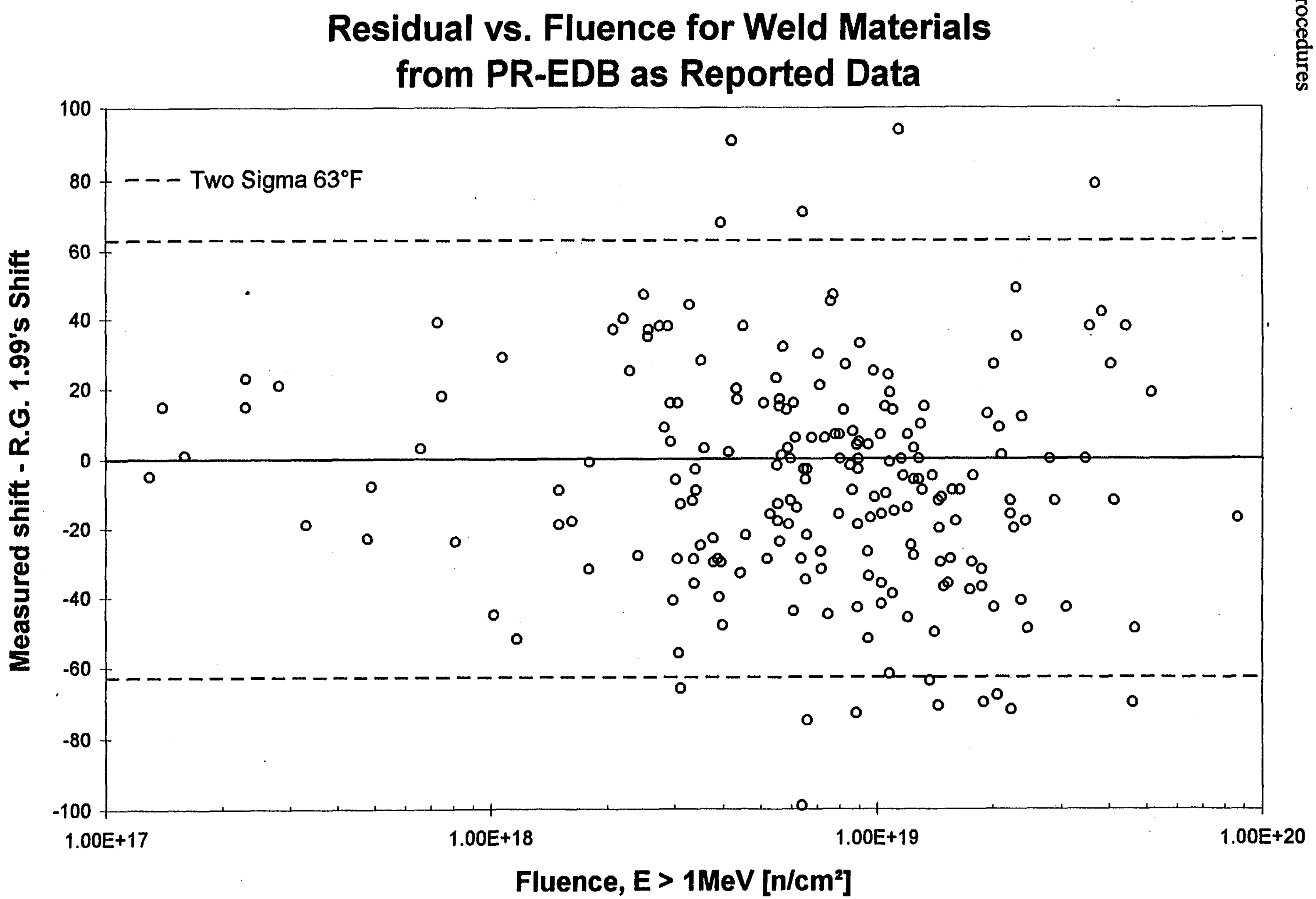


Figure 3 Embrittlement of surveillance weld relative to the R.G. 1.99, Rev. 2, prediction

3 RESULTS

The copper and nickel contents of CMM are listed in detail in Tables 1–3. The manufacturer's chemistry is used for the determination of the trend curves per R.G. 1.99, Rev. 2; the copper and nickel contents, and the chemistry factor according to R.G. 1.99, Rev. 2, are listed below.

Material	Cu (%)	Ni (%)	Chemistry factor(°F)
ASTM	0.200	0.180	100
HSST01	0.180	0.660	136
HSST02	0.170	0.640	128
HSST03	0.120	0.560	82

3.1 Power Reactor Surveillance Data

3.1.1 A302B (ASTM) CMM

The results from 33 capsules in 10 Westinghouse plants, and 5 capsules in 1 GE plant, have been investigated. The capsules in the H.B. Robinson Reactor contain specimens fabricated in the TL orientation; all others are fabricated in the LT orientation. The Yankee Rowe surveillance data exhibit a much greater shift than predicted by R.G. 1.99, Rev. 2, mainly due to the relative low operation temperature (450~525°F) and high flux ($1.7 \times 10^{12} \sim 3.2 \times 10^{12}$ n/cm²·s) compared with that of the data used to develop the R.G. 1.99, Rev. 2, and are excluded from the uncertainty study.

Compared to the R.G. 1.99, Rev. 2, the 1σ uncertainty of the data scatter band around the Regulatory Guide's trend curve is 15°F for EDB hyperbolic tangent fit results; and a bias of 6.1% is detected for CMM [i.e., the measured ΔT_{30} are on the average 6.1% larger than the Regulatory Guide predicted values (see Fig. 4)]. These values indicate that R.G. 1.99, Rev. 2, gave fairly good predictions for the radiation embrittlement of the ASTM CMM under different irradiation environments. However, this result may not be surprising since 41 out of the 126 base metal data points included in the initial sample used for the development of the R.G. 1.99, Rev. 2, were from CMM. In order to demonstrate this point, the shift data for ASTM CMM included in the R.G. 1.99, Rev. 2, data base (177 Data Points) are distinguished and identified by a solid symbol. As shown in Fig. 5, over 65% of Westinghouse's ASTM CMM were used in the development of R.G. 1.99, Rev. 2. Thus the characteristics of these CMM data are well incorporated into the R.G. 1.99, Rev. 2.

From Table 6, the comparison of reported shift and EDB hyperbolic tangent fit results, the average absolute difference between these two types of data is 12%. The bias and the 1σ uncertainty per R.G. 1.99's predictions determined by the reported shift data are 7.5% and 12°F, respectively. A similar bias, namely 6.9%, is found from all capsules that contain the A302B CMM per PR-EDB reported data, but with a relatively large data scatter band, a 1σ uncertainty of 25°F. For the A302B RPV steels, the majority of ASTM CMM shifts are greater than that of the base materials loaded in the same capsule due to the higher copper content of the CMM plate. This may serve as an upper bound for the irradiated A302B plate materials. One special case, Yankee Rowe, has a base metal that appears to be much more sensitive to the radiation embrittlement than ASTM CMM material and has less reported copper content, 0.18 wt %, compared with that of ASTM CMM, 0.20 wt %. However, the phosphorous content in Yankee Rowe's plate is higher than that of the ASTM CMM material.

Although the general underprediction of radiation damage for the CMM parallels the underprediction for companion materials in the same capsules, there are many exceptions to this rule. Only 12 out of 23 underpredicted surveillance capsules have good correlations between the behavior of the reference and plant- specific materials. This situation may be due to (1) deviation of the trend curve for plant-specific material from R.G. 1.99, Rev. 2, (2) uncertainties in the chemistry of the plant-specific material, (3) differences in temperature and fluence within the capsule, and (4) sample-to-sample variations in both plant-specific and CMM. Overall, 23 out of 37 surveillance capsules containing both CMM and A302B base metals show the same correlation towards the R.G. 1.99 predicted values; 14 out of 25 surveillance capsules contained both the CMM and weld metals show the same correlation towards the R.G. 1.99 predicted values. Where only 14 out of 37 surveillance capsules, the CMM and the accompanying materials in the same capsule show the same correlation towards the R.G.1.99 predicted values. Findings of large deviations from the R.G. 1.99, Rev. 2, trend curve are useful as warning flags that invite further investigation.

3.1.2 A533B (HSST) CMM

Results for the HSST01 plate in 10 capsules of 8 CE plates, and HSST02 plate in 53 capsules of 7 B&W plants and 13 Westinghouse plants were investigated.

The results of a comparison of HSST01 data with R.G. 1.99, Rev. 2, trend curves are demonstrated in Figs. 6 and 7 for EDB hyperbolic tangent fit results and reported shift data, respectively. On the average, R.G. 1.99, Rev. 2, underpredicted the experimental values for all surveillance capsules by 3.6% according to the EDB hyperbolic tangent fit results; and the 1σ uncertainty of the data scatter bands per the R.G. 1.99, Rev. 2, trend curve is 12.6°F.

A comparison of the HSST02 data with the R.G. 1.99, Rev. 2, trend curves is illustrated in Figs. 8 and 9 for EDB hyperbolic tangent fit results and reported data, respectively. It was found that R.G. 1.99 overpredicted the experimental values for all surveillance capsules by an average of 18% according to EDB hyperbolic tangent fit results; and the 1σ uncertainty of the data scatter bands per R.G. 1.99, Rev. 2, trend curve is 24°F. In order to determine whether this is capsule-specific (or vendor-specific), the biases are determined separately for the B&W and Westinghouse plants with the result that the average bias for B&W plants is –38% and –7.4% for Westinghouse (see Fig. 8). These values indicate a tendency for overprediction in the B&W capsules. The most likely reason is the capsule temperature. In the B&W capsules, significant melting of the thermal monitors is reported consistently and, even though this may well be due to transients, as stated in the reports, the average nominal capsule irradiation temperature is about 608°F, which is higher than that of the other vendors; also, the B&W plants follow a unique heatup curve for plant operation. Thus caution must be exercised in plant-specific, trend curve determinations from surveillance capsule results if the measured damage is substantially less than predicted. If similar overpredictions are found for the companion CMM, corrections must be made to the plant-specific trend curve to avoid nonconservative predictions for the pressure vessel material.

From Table 8, the mean absolute difference between EDB hyperbolic tangent fit results and reported shift data for B&W is 22% and 4% for Westinghouse. The large discrepancy of EDB hyper-bolic tangent fit results and reported shift data per B&W is demonstrated in Figs. 8 and 9. In Fig. 9, the data involved in the development of R.G. 1.99, Rev. 2, were identified by solid symbols. The majority of the B&W data are outside the 34°F 2σ uncertainty, whereas the B&W data near the trend curve of the R.G. 1.99, Rev. 2, are those samples used in the development of R.G. 1.99, Rev. 2.

Similar to the findings for the A302B CMM, large deviations between measured ΔT_{30} and their Regulatory Guide predictions for the CMM are correlated with similar deviations for the companion materials in the same capsules, for example, B&W's surveillance capsules. Overall, 13 out of 35 surveillance capsules contained both the CMM and A533B base metals and show the same correlation towards the R.G. 1.99 predicted values; 22 out of 31 surveillance capsules, containing both the CMM and weld metals, show the same correlation towards the R.G. 1.99 predicted values. Where there are only 10 out of 35 surveillance capsules, the CMM and the accompanying materials in the same capsule show the same correlation towards the R.G. 1.99 predicted values. The random fluctuations for the A533B-1 materials (including plate and weld materials) appear to be the same as those of the A302B material (including plate and weld materials); both have about 50°F 2σ uncertainty per the R.G. 1.99 prediction; and the biases are –9°F and 6°F for A533B-1 and A302B materials, respectively (see Figs. 10 and 11). These values indicate that, overall, R.G. 1.99, Rev. 2, underpredicted the A302B materials and overpredicted the A533B-1 materials.

3.1.3 Reactor Pressure Vessels Made of A302B Materials

The detailed summary of all the RPVs made of A302B materials with the corresponding CMM are listed in Table 13. The trend curves of ΔT_{30} vs fluence are illustrated in Figs. 12 and 13 for plate and weld materials, respectively, where the companion CMM were identified by solid dot symbols for comparison purposes. From Fig. 12, all the CMM shifts are greater than that of A302B plate materials, except those of Indian Point Unit 2. The majority of the CMM shift data are greater than that of the R.G. 1.99, Rev. 2, prediction, with the exceptions of B&W and GE's CMM data.

The mean chemistry contents with 1 standard deviation from all the A302B plate data, not including A302B CMM data, are 0.135 ± 0.043 and 0.315 ± 0.193 wt % for copper and nickel, respectively. The trend curve of R.G. 1.99, Rev. 2, for mean chemistry of the A302B plate materials and for ASTM A302B were both illustrated in Fig. 12 for comparison purposes. The mean chemistry contents with 1 standard deviation from the A302B weld materials are 0.245 ± 0.064 and 0.515 ± 0.322 wt % for copper and nickel, respectively. From Fig. 13, all the weld ΔT_{30} are greater than that of the companion CMM shifts except that of Haddam Neck capsule D.

3.1.4 Reactor Pressure Vessels Made of A533B-1 Materials

A detailed summary of all the RPVs made of A533B-1 materials with the corresponding CMM are listed in Table 14. The trend curves of ΔT_{30} vs fluence are illustrated in Figs. 14 and 15 for plate and weld materials, respectively, where the companion CMM were identified by solid dot symbols for comparison purposes. The mean chemistry contents with 1 standard deviation from the A533B-1 plate materials, not including A533B-1 CMM, are 0.141 ± 0.038 and 0.521 ± 0.038 wt % for copper and nickel, respectively. The trend curve of R.G. 1.99, Rev. 2, for mean chemistry of the A533B-1 plate materials and for HSST02 are both illustrated in Fig. 14 for comparison purposes. The mean chemistry contents with 1 standard deviation of the A533B-1 weld materials are 0.279 ± 0.062 and 0.559 ± 0.289 wt % for copper and nickel, respectively. From Fig. 15, all the weld ΔT_{30} values are greater than those of the companion CMM shifts except those of CE's and one of Westinghouse's data.

3.1.5 Reactor Pressure Vessels Made of Forging Materials

The detailed summary of all the RPVs made of A508 class 2 (A508-2), A508 class 3 (A508-3), and A336 as modified by the ASME code case 1236 forging materials with the corresponding CMM were listed in Table 15. The trend curves of ΔT_{30} vs fluence are illustrated in Fig. 16 for forging materials, where the companion CMM were identified by solid dot symbols for comparison purposes. The mean chemistry contents with 1 standard deviation from the A508-2 forging materials are 0.053 ± 0.020 and 0.72 ± 0.03 wt % for copper and nickel, respectively. The trend curve of R.G. 1.99, Rev. 2, for mean chemistry of the A508-2 forging materials and for HSST02 were both illustrated in Fig. 16 for comparison purposes. From Fig. 16, the forging materials are considerably less sensitive to radiation embrittlement compared with that of companion CMM, except the Garigliano A336 forging.

3.1.6 Comparison of the A302B and A533B-1 Plate Materials

Plate materials in all the RPVs of the U.S. commercial power plants are either A302B or A533B-1, where the older plants were made of A302B materials, and the newer plants were made of A533B-1 materials. The data trend of surveillance plates for the A302B and A533B-1 CMM, per Westinghouse and CE, are shown in Fig. 17, and the scatter bands of ΔT_{30} data for A302B and A533B CMM are completely overlapped. Therefore, the sensitivity of A302B materials to radiation embrittlement appears to be equivalent to that of A533B material). Further investigation was done on all A302B and A533B-1 materials from

Westinghouse surveillance capsules (see Fig. 18). Here, the ΔT_{30} data were further divided into three subgroups according to the three ranges of the copper contents, namely, Cu < = 0.1, 0.1 < Cu < 0.2, Cu > 0.2 wt %. A large data scatter appears on the figure for both the A302B and A533B-1 materials, and no distinct bias can be detected between A302B and A533B-1 materials for different ranges of chemistry. For example, at a range of 0.1 < Cu < 0.2, the scatter band of ΔT_{30} for A302B material is slightly larger than that of the A533B material, and the scatter band of A302B overlapped the scatter band of A533B almost completely. In Fig. 19, 3-D plots of ΔT_{30} vs fluence vs copper content for Westinghouse data also indicate that the radiation-induced ΔT_{30} of both the A302B and A533B-1 are similar.

3.2 Material Test Reactor Data

3.2.1 A302B (ASTM) CMM

The results of 113 irradiated data sets from the Charpy impact test have been investigated, and the summary is listed in Table 9. The trend curve and ΔT_{30} data are illustrated in Fig. 20; here, the trend curve of A302B ASTM CMM per R.G. 1.99, Rev. 2, was used as an index curve for ΔT_{30} at 550°F irradiation temperature. The ΔT_{30} data were divided into eight subgroups based on the different irradiation temperature ranges. Figure 20 clearly shows the effect of irradiation temperature. At the same fluence, the irradiated specimen with a lower irradiation temperature exhibits more radiation embrittlement. At a 550°F irradiation temperature and fluence greater than 1.5×10^{19} n/cm², a clear bias can be detected compared with the trend curve of A302B ASTM CMM per R.G. 1.99, Rev. 2. R.G. 1.99, Rev. 2, underpredicted the ΔT_{30} by about 19.3%. This effect may be a fluence-rate effect; higher fluence rates are expected to lead to higher values for the ΔT_{30} at high fluences[4,21,22]. The specimens irradiated in a material test reactor normally experience a 1- to 2-orders of magnitude higher fluence rate compared with that of commercial power reactors. However, fluence rate and spectral effects are difficult to separate experimentally. Variations in flux are usually obtained by varying the irradiation position in a reactor or by employing different reactors. These flux changes are invariably accompanied by changes in the neutron spectrum. A clearer picture for ASTM CMM data irradiated at 550°F with fluence greater than 1.5×10^{19} n/cm² is demonstrated in Fig. 21. The power reactor surveillance data are also included in the figure; the average fluence rate for these data is 1.55×10^{11} n/cm²·s, which shows that the R.G. 1.99, Rev. 2, underpredicted the ΔT_{30} for ASTM CMM data with higher fluence from power reactor surveillance capsules In Fig. 21, test reactor data were further subdivided into two subgroups for fluence rates less than 1.1×10^{11} n/cm²·s and fluence rates greater than 2.5×10^{11} n/cm²·s, respectively. From Fig. 21, it appears that the ΔT_{30} for lower fluence rates formed the lower bound for the test reactor data. This may indicate that the fluence-rate effect or the combined effect of fluence rate and spectral effect do exist in the test reactor data. In order to further investigate this issue, the test reactor data listed in Fig. 21 were subdivided into three subgroups, namely, test reactor data irradiated in-core position, test reactor data irradiated at core-edge position, and test reactor data from the simulated surveillance and through-wall specimen capsules irradiated at Oak Ridge Research Reactor Pool Side Facility (ORRPSF).[23] The data were plotted in Fig. 22. The ORRPSF data on Fig. 22 were not from the in-core positions, two ΔT_{30} data were from simulated surveillance capsule (SSC) positions, one ΔT_{30} data from wall surface (0T) capsule position, and one from a quarter thickness wall (1/4T) capsule position. The two SCC data (which have higher fluence rates) show larger ΔT_{30} compared with that of 0T and 1/4T data. The effect of the spectral difference between the SSC and 1/4T positions is negligible for the ORRPSF experiment. Thus the fluence-rate effect may be supported from the ORRPSF data.

From Fig. 22, three ΔT_{30} data have fluence at about 5.4×10^{19} n/cm²: two were from ORRPSF data, and one was a test reactor data irradiated in-core position with the fluence rate at about 4×10^{12} n/cm²·s. The test reactor data at in-core position gave the largest ΔT_{30}; however, its fluence rate was less than that of ORRPSF data at the SCC position, which has 6.95×10^{12} n/cm²·s fluence rate. The main cause of the above-mentioned situation may be due to the different physical locations of the irradiated specimens in the test reactors; in our case, one was at the in-core position and one was at the out-of-core position. There is a difference in neutron energy spectrum between the in-core and out-of-core positions. This specific example may imply that induced shift by the combined effect of the fluence rate and spectral effect of the test reactor data at in-core position are greater than the induced shift by the fluence-rate effect of ORRPSF data at out-of-core position.

Figure 23 is a duplicate of Fig. 20 with the fluence limited to a maximum of 4×10^{19} n/cm² to give a better picture of radiation embrittlement for the relatively low fluence data. From Fig. 23, at irradiation temperatures less than 300°F, embrittlement develops quite rapidly up to a fluence of about 1×10^{19} n/cm²; above 1×10^{19} n/cm², embrittlement buildup is less rapid, and some indication of embrittlement saturation appears.

3.2.2 A533B-1 (HSST01) CMM

The results of 24 irradiated Charpy sets, where 22 sets were irradiated in the Oak Ridge Research Reactor, have been investigated. The summary of HSST01 material is listed in Table 10. This shows a strong dependence for the unirradiated T_{30} on specimen location in the original parent plate; for example, the lowest T_{30} is from the specimen position near the surface (0T) of the parent plate. The ΔT_{30} data also show a similar dependence on the specimen position. Irradiated specimens originally located near the surface of the parent plate appear to be the least sensitive to radiation embrittlement. This specimen position effect on transition temperature shift is demonstrated in Fig. 24, where the ΔT_{30} of the 0T specimens were identified by solid symbols. The R. G. 1.99 prediction for the HSST01 plate is used as the trend curve of the 550°F irradiation temperature. The trend curve and measured shift data per PR-EDB reported data were plotted in Fig. 25. The mean absolute difference between reported ΔT_{30} data and EDB hyperbolic tangent fit results is 10.6%.

3.2.3 A533B-1 (HSST02) CMM

The results of 21 irradiated Charpy sets have been investigated. The summary of HSST02 materials is listed in Table 11. The R.G. 1.99, Rev. 2, prediction for the HSST02 plate is used as the trend curve for the 550°F irradiation temperature. The trend curve and reported ΔT_{30} data are illustrated in Fig. 26, where the reported ΔT_{30} data were divided into four subgroups for four ranges of irradiation temperatures. The data trend shows the strong influence of irradiation temperature on the ΔT_{30}. The ΔT_{30} data irradiated at 572°F and 752°F are from the German VDE experiments,[7] and the test specimens were experienced with high fluence rates at about 2.3×10^{13} n/cm²·s. The VDE ΔT_{30} data irradiated at 572°F appear to be less sensitive to radiation embrittlement at high fluence compared to the trend curve of R.G. 1.99, Rev. 2, for the HSST02 CMM with copper content of 0.17 wt %. The reason behind this situation is due to the difference in copper contents between the VDE HSST02 CMM, which has reported copper content as 0.12 wt %, and the copper content , 0.17 wt %, used in the evaluation of R.G. 1.99, Rev. 2. Thus in order to correct this bias caused by the difference in copper content, the normalized value of the VDE ΔT_{30} to copper content of 17 wt % is used in Fig. 27. The data trend of the normalized VDE data irradiated at 572°F seems to be more consistent with the conclusion drawn on the fluence-rate effect from ASTM CMM data irradiated at 550°F, and a higher irradiation temperature of the VDE experiment at 572°F seems to delay the incubation time of fluence-rate effect at higher fluence. From this section it may imply that the fluence-rate effect strongly depends on exposure neutron fluence, irradiation temperature, and material chemical compositions, such as copper content. There are indications that a higher fluence rate may lead to higher shifts at relatively high fluence, depending on copper content.[24]

3.2.4 A533B-1 (HSST03) CMM

The results of 39 irradiated Charpy sets have been investigated. The summary of HSST03 materials is listed in Table 12. The trend curve and ΔT_{30} data are illustrated in Fig. 28. The trend curve of HSST03 per R.G. 1.99, Rev. 2, was used as an index curve for ΔT_{30} at the 550°F irradiation temperature. The ΔT_{30} data were divided into five subgroups, based on four ranges of irradiation temperatures and two ranges of fluence rates. Figure 25 clearly shows the irradiation temperature effect, that is a specimen irradiated at a lower temperature will exhibit more radiation embrittlement. At 550°F irradiation temperature, a clear bias can be detected, compared with the trend curve of HSST03 CMM per R.G. 1.99, Rev. 2; that is, R.G. 1.99, Rev. 2, underpredicted the ΔT_{30} for fluences greater than 2.4×10^{19} n/cm^2 and overpredicted the ΔT_{30} for fluences less than 2.4×10^{19} n/cm^2, especially for fluence rates greater than 2.0×10^{12} n/cm^2·s. This may be a fluence-rate effect; higher fluence rates are expected to lead to higher values for the ΔT_{30} at relatively high fluences and lower values for the ΔT_{30} at relatively low fluences. In order to have a better picture for fluence-rate effect on the CMM data irradiated at 550°F, an additional plot was generated for the trend curve of HSST03 CMM with shift data irradiated at 550°F (see Fig. 29), where the ORRPSF and other test reactor data were identified with different symbols.

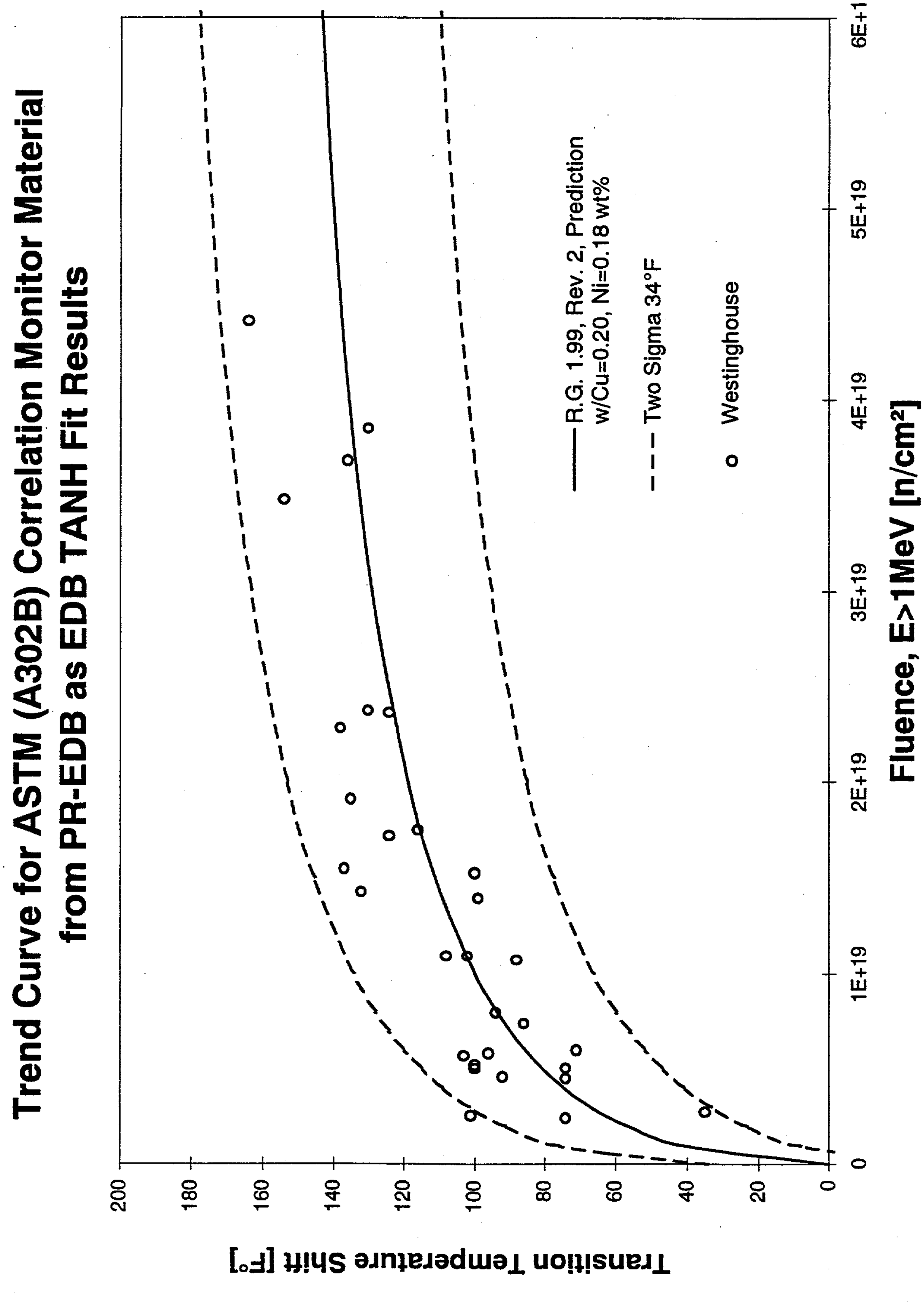


Figure 4 Embrittlement of the A302B ASTM CMM relative to the R.G. 1.99, Rev. 2, prediction

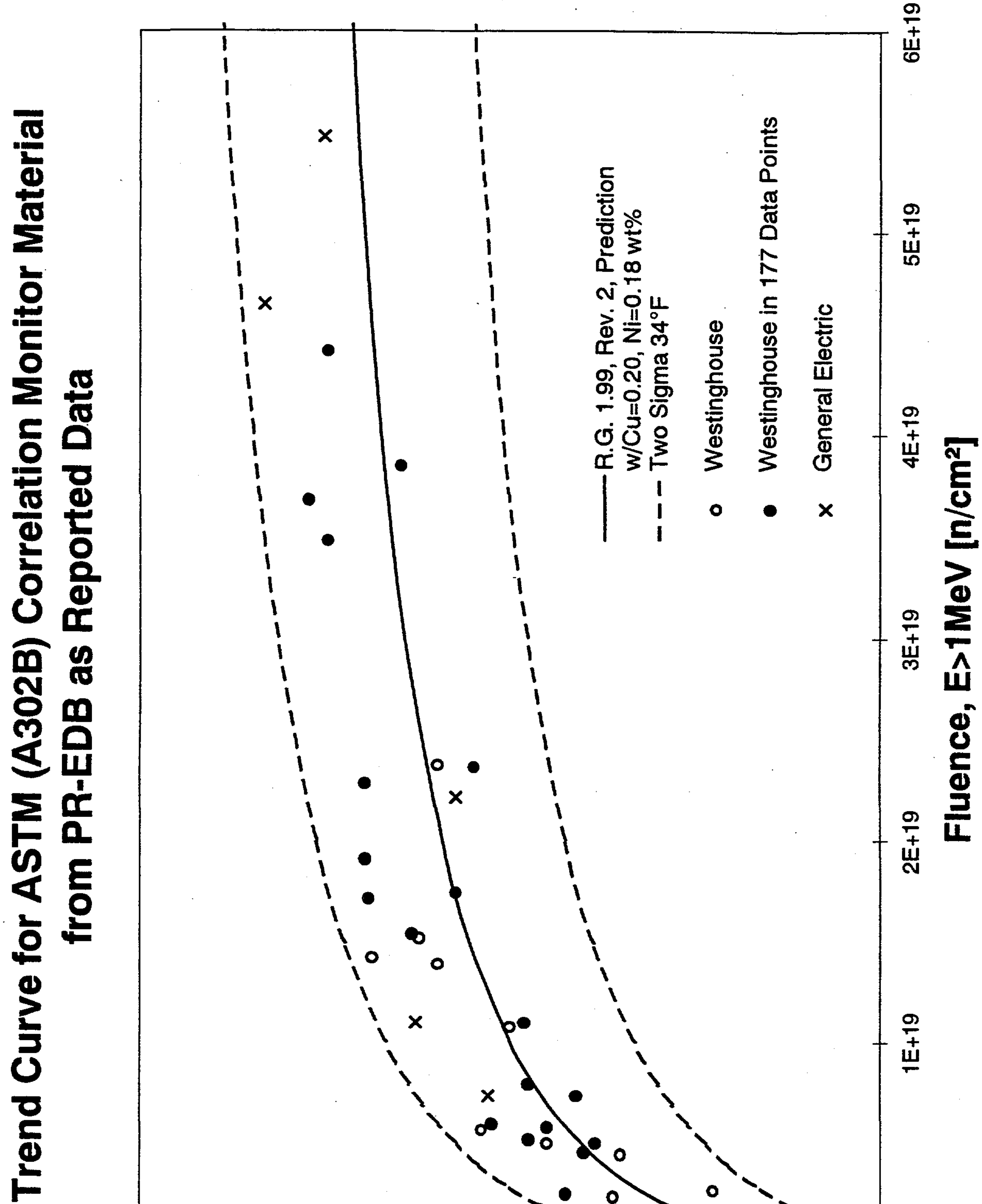


Figure 5 Embrittlement of the A302B ASTM CMM relative to the R.G. 1.99, Rev. 2, prediction

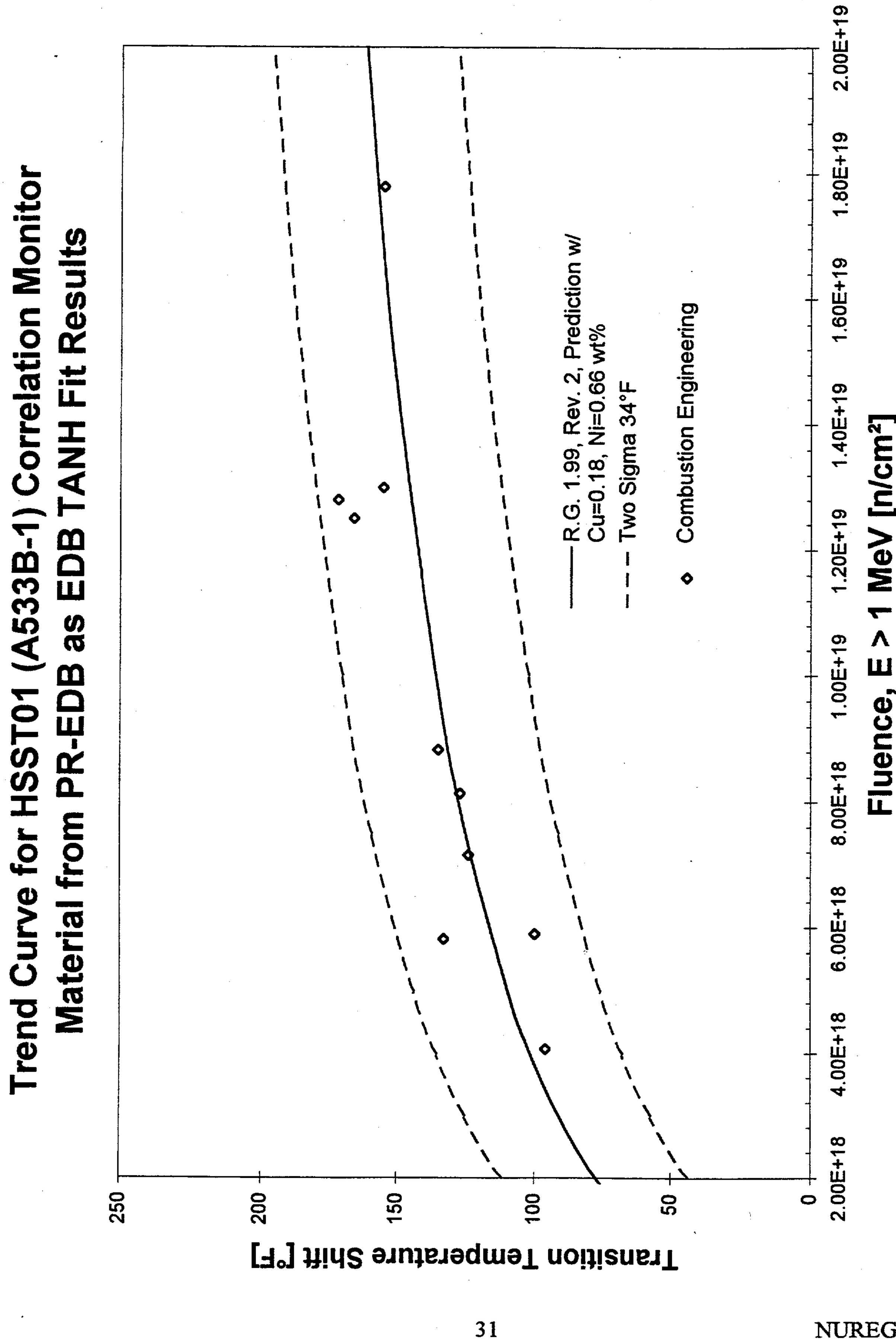


Figure 6 Embrittlement of the HSST01 CMM relative to the R.G. 1.99, Rev. 2, prediction

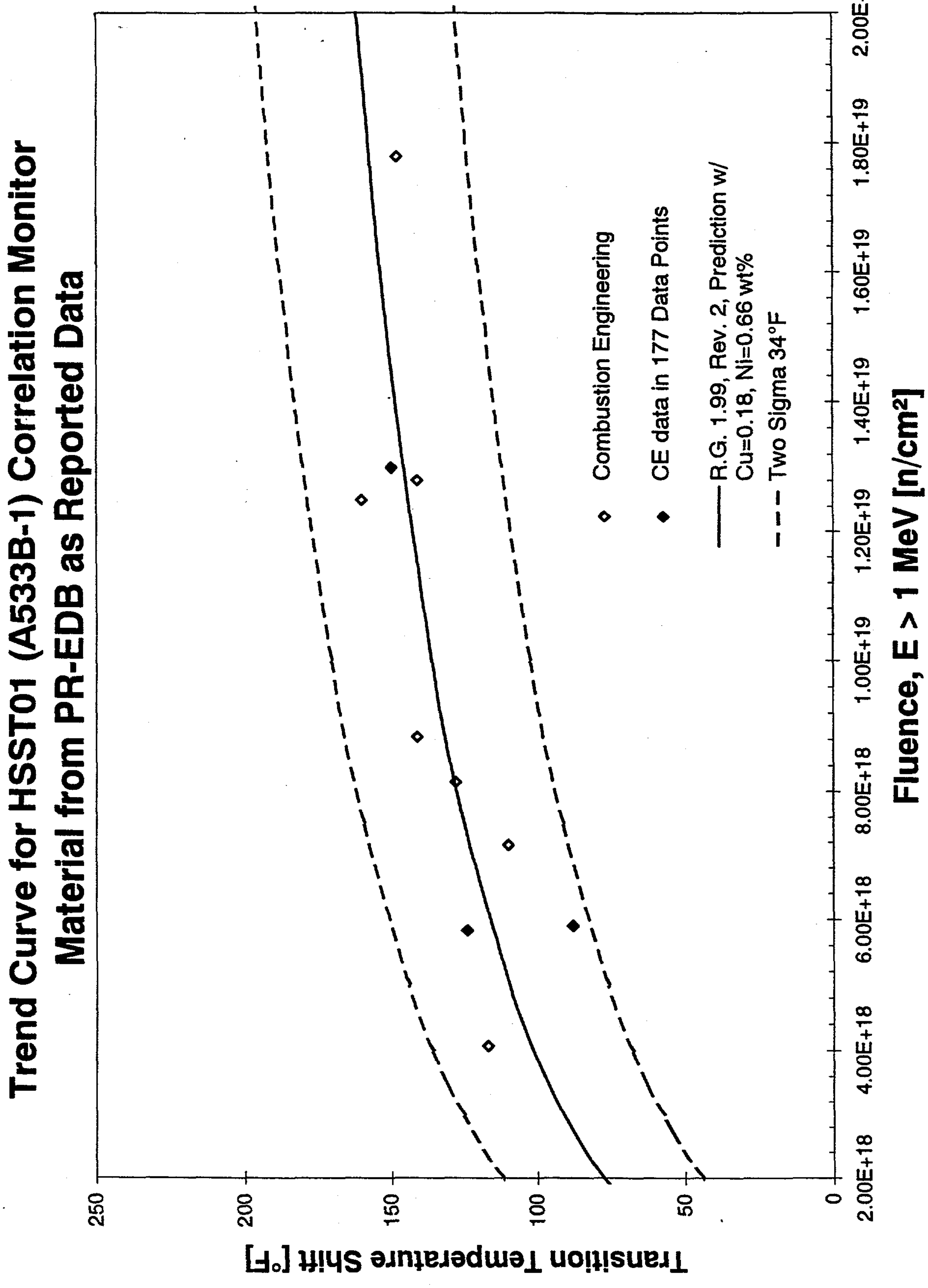


Figure 7 Embrittlement of the HSST01 CMM relative to the R.G. 1.99, Rev. 2, prediction

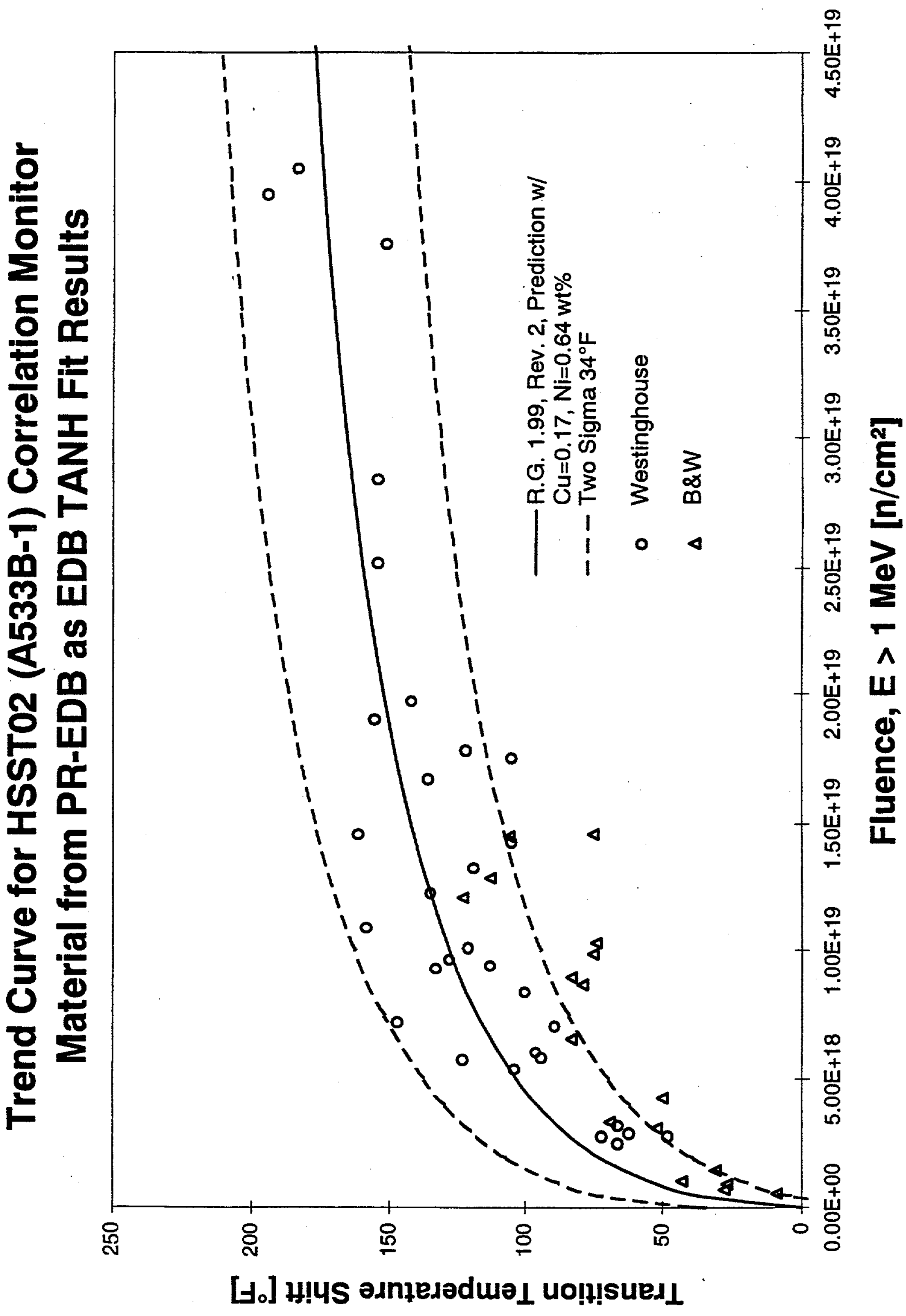


Figure 8 Embrittlement of the HSST02 CMM relative to R.G. 1.99, Rev. 2, prediction. Significant bias exists toward overprediction of the B&W surveillance data

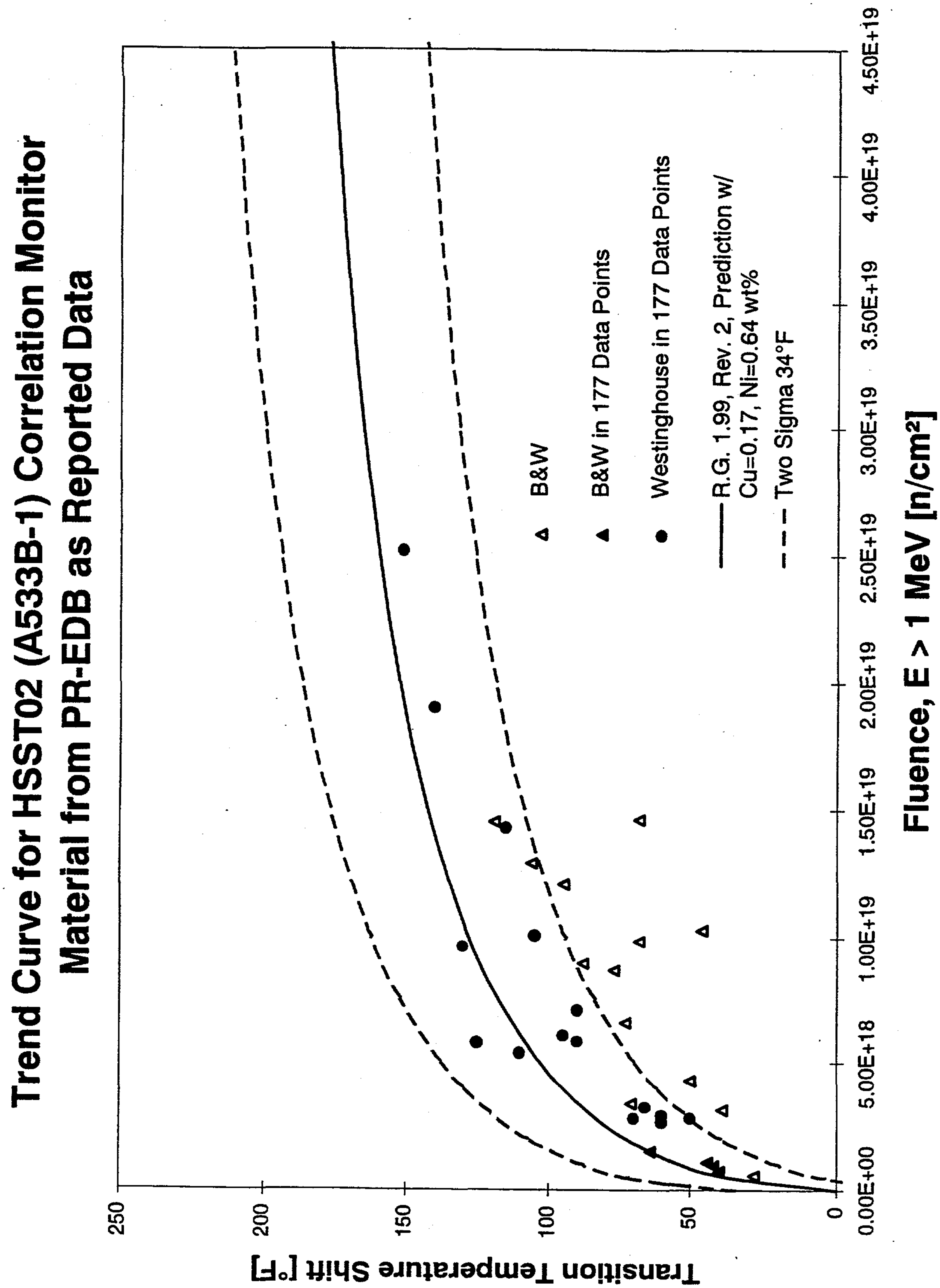


Figure 9. Embrittlement of the HSST02 CMM relative to the R.G. 1.99, Rev. 2, prediction. Significant bias exists toward overprediction of the B&W surveillance data

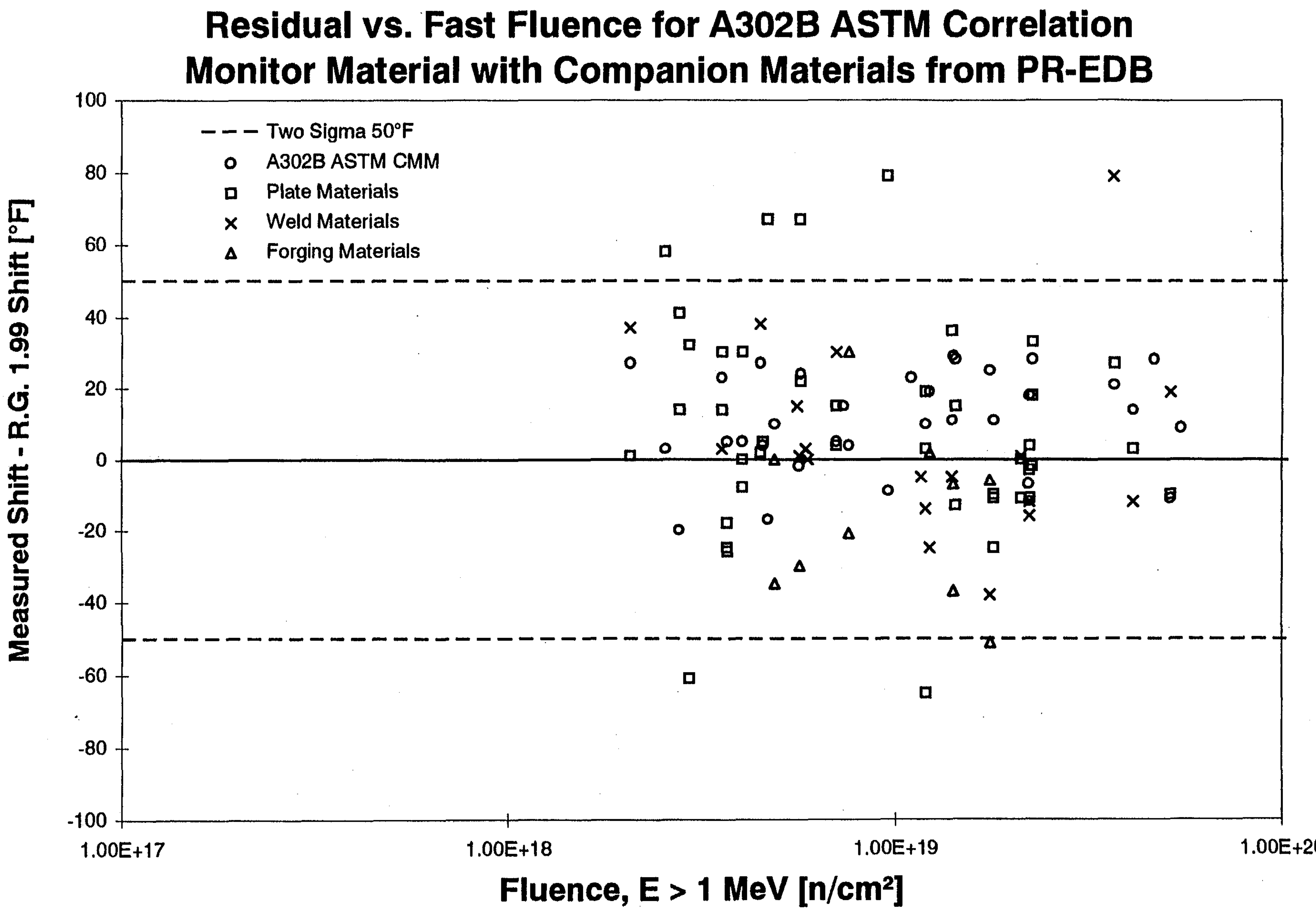


Figure 10 Plot of residual vs fast fluence for A302B ASTM CMM with companion materials, the overall two-sigma uncertainty is about 50°F. Garigliano A336 forgings and weld data, and Yankee Rowes' data were not included.

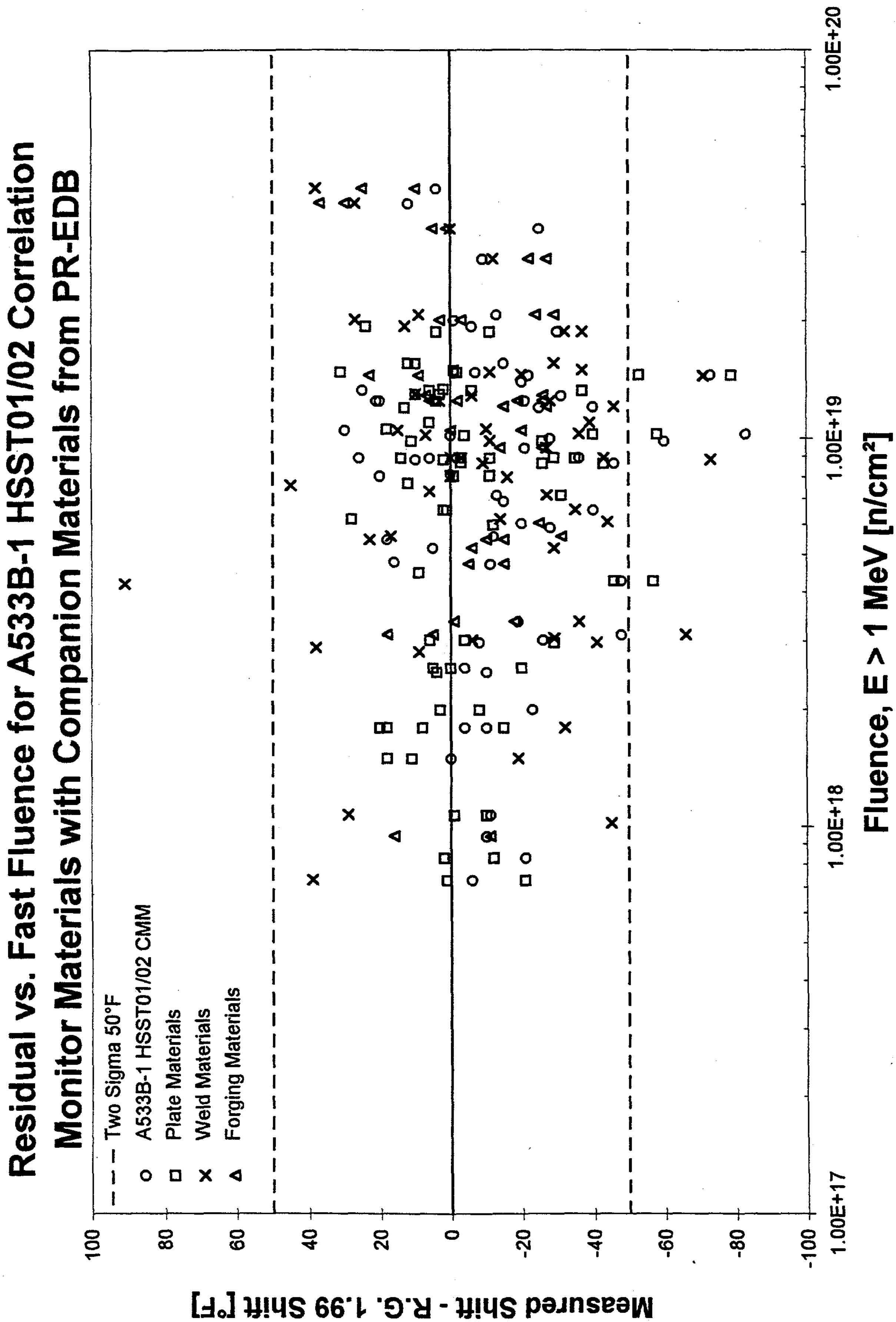


Figure 11 Plot of residual vs fast fluence for A533B-1 HSST01/HSST02 CMM with companion materials, the overall two sigma is 50°F

Table 13. Summary of A302B reactor pressure vessel steels per PR-EDB reported data

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence $E > 1$ MeV n/cm^2	C_v transition temp. at 30 ft-lb, °F		C_v transition temp. Shift at 30 ft-lb, °F			Chemistry, wt %		
							Unirradiated	Irradiated	Measured	R.G. 1.99	Residual	P	NI	CU
Big Rock Point Reactor, Capsule 119														
G	20192-2	A302B	SHM3	SRM	LT	1.500e+18	0	15	15	50	-35	0.016	0.180	0.200
G	192462/3	A302B	PBR_01	Plate	TL	1.500e+18	-5	-5	0	28	-28	0.016	0.180	0.100
G	192462/3	A302B	WBR_01	Weld	TS	1.500e+18	-70	-15	55	64	-9	0.014	0.100	0.270
Big Rock Point Reactor, Capsule 127														
G	20192-2	A302B	SHM3	SRM	LT	7.100e+18	0	40	40	90	-50	0.016	0.180	0.200
G	192462/3	A302B	PBR_01	Plate	TL	7.100e+18	-5	55	60	51	9	0.016	0.180	0.100
G	192462/3	A302B	WBR_01	Weld	TS	7.100e+18	-70	65	135	114	21	0.014	0.100	0.270
Haddam Neck, Capsule A														
W	A0421	A302B	SASTM	SRM	LT	2.070e+18	40	125	85	58	27	0.011	0.180	0.200
W	A5892	A302B	PCTY02	Plate	LT	2.070e+18	-30	5	35	34	1	0.010	0.200	0.100
W	86054B	A302B	WCTY01	Weld	TL	2.070e+18	-50	45	95	58	37	0.020	0.046	0.220
Haddam Neck, Capsule D														
W	A0421	A302B	SASTM	SRM	LT	2.220e+19	40	180	140	122	18	0.011	0.180	0.200
W	A5877	A302B	PCTY04	Plate	LT	2.220e+19	-24	54	78	81	-3	0.010	0.200	0.120
W	86054B	A302B	WCTY01	Weld	TL	2.220e+19	-50	60	110	122	-12	0.020	0.046	0.220
Haddam Neck, Capsule F														
W	A0421	A302B	SASTM	SRM	LT	4.04e+18	40	120	80	75	5	0.011	0.180	0.200
W	A5892	A302B	PCTY02	Plate	LT	4.04e+18	-30	5	35	43	-8	0.010	0.200	0.100
W	A5877	A302B	PCTY04	Plate	LT	4.04e+18	-20	60	80	50	30	0.010	0.200	0.120
W	A5911	A302B	PCTY07	Plate	LT	4.04e+18	-25	25	50	50	0	0.013	0.200	0.120
Haddam Neck, Capsule H														
W	A0421	A302B	SASTM	SRM	LT	1.790e+19	40	167	127	116	11	0.011	0.180	0.200
W	A5892	A302B	PCTY02	Plate	LT	1.790e+19	-50	7	57	67	-10	0.010	0.200	0.100
W	A5877	A302B	PCTY04	Plate	LT	1.790e+19	-24	43	67	78	-11	0.010	0.200	0.120
W	A5911	A302B	PCTY07	Plate	LT	1.790e+19	-30	23	53	78	-25	0.013	0.200	0.120

Table 13 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb, °F Unirradiated	Irradiated	C_v transition temp. Shift at 30 ft-lb, °F Measured	R.G. 1.99	Residual	Chemistry, wt % P	NI	CU
Dresden Nuclear Plant Station Unit 1, Capsule CORE-5														
G	20192-2	A302B	SHM3 O	SRM	TS	1.300e+20	10	165	155	154	1	0.016	0.180	0.200
G	19716	A302B	PDR101O	Plate	LS	1.300e+20	60	190	130	126	4	0.018	0.540	0.120
H. B. Robinson Unit 2, Capsule S														
W	A0421	A302B	SASTM	SRM	TL	3.690e+18	64	141	77	72	5	0.011	0.180	0.200
W	A6604-1	A302B	PHB201	Plate	LT	3.690e+18	-18	13	31	49	-18	0.007	0.200	0.120
W	B1256-1	A302B	PHB202	Plate	LT	3.690e+18	11	27	16	42	-26	0.010	0.200	0.100
W	B1250-1	A302B	PHB203	Plate	LT	3.690e+18	28	41	13	38	-25	0.010	0.200	0.090
H. B. Robinson Unit 2, Capsule T														
W	A0421	A302B	SASTM	SRM	TL	4.110e+19	65	215	150	136	14	0.011	0.180	0.200
W	B1250-1	A302B	PHB203	Plate	LT	4.110e+19	30	105	75	72	3	0.010	0.200	0.090
W	W5214	A302B	WHB201	Weld	TL	4.110e+19	-60	225	285	297	-12	0.021	0.660	0.340
H. B. Robinson Unit 2, Capsule V														
W	A0421	A302B	SASTM	SRM	TL	4.510e+18			105	78	27	0.011	0.180	0.200
W	B1256-1	A302B	PHB202	Plate	LT	4.510e+18	11	58	47	45	2	0.010	0.200	0.100
W	W5214	A302B	WHB201	Weld	TL	4.510e+18	-87	120	207	169	38	0.021	0.660	0.340
Humboldt Bay Power Plant Unit 3, Capsule 4														
G	20192-2	A302B	SHM3	SRM	LT	3.000e+19	0	80	80	129	-49	0.016	0.180	0.200
Indian Point Unit 2, Capsule T														
W	A0421	A302B	SASTM	SRM	LT	2.550e+18			72	69	3	0.010	0.270	0.200
W	B4688-2	A302B	PIP201	Plate	LT	2.930e+18			54	115	-61	0.010	0.580	0.250
W	B4701-2	A302B	PIP202	Plate	LT	2.930e+18			94	62	32	0.014	0.460	0.140
W	B4922-1	A302B	PIP203	Plate	LT	2.550e+18			120	62	58	0.011	0.570	0.140
Indian Point Unit 2, Capsule V														
W	A0421	A302B	SASTM	SRM	LT	4.570e+18			90	86	4	0.010	0.270	0.200
W	B4701-2	A302B	PIP202	Plate	LT	4.570e+18			78	73	5	0.014	0.460	0.140
W	W5214	A302B	WIP201	Weld	TL	5.590e+18			204	189	15	0.010	1.020	0.200

Table 13 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb, °F Unirradiated	Irradiated	C_v transition temp. Shift at 30 ft-lb, °F Measured	R.G. 1.99	Residual	Chemistry, wt % P	NI	CU
Indian Point Unit 2, Capsule Y														
W	A0421	A302B	SASTM	SRM	LT	4.720e+18			70	87	-17	0.010	0.270	0.200
W	B4922-1	A302B	PIP203	Plate	LT	4.720e+18			145	78	67	0.011	0.570	0.140
W	W5214	A302B	WIP201	Weld	TL	5.890e+18			195	192	3	0.010	1.020	0.200
Indian Point Unit 2, Capsule Z														
W	A0421	A302B	SASTM	SRM	LT	9.620e+18			100	109	-9	0.010	0.270	0.200
W	B4688-2	A302B	PIP201	Plate	LT	1.200e+19			117	182	-65	0.010	0.580	0.250
W	B4701-2	A302B	PIP202	Plate	LT	1.200e+19			117	98	19	0.014	0.460	0.140
W	B4922-1	A302B	PIP203	Plate	LT	9.620e+18			177	98	79	0.011	0.570	0.140
Indian Point Unit 3, Capsule Y														
W	A1195-1	A533B-1	SHSS02	SRM	LT	8.050e+18	50	190	140	120	20	0.010	0.640	0.170
W	A0512-2	A302B	PIP304	Plate	TL	8.050e+18	60	210	150	151	-1	0.012	0.520	0.240
W	W5214	A302B	WIP301	Weld	TL	8.050e+18	-55	125	180	180	0	0.019	1.020	0.150
Lacrosse Boiling Water Reactor (Genoa-2), Capsule 1A/1B														
A	N31438	A302B	SLAC01	SRM	LT	4.350e+18	-60	30	90	32	58	0.017	0.180	0.070
A	A5848	A302B	PLAC02	Plate	LT	4.350e+18	-75	-45	30	56	-26	0.009	0.180	0.140
A	3C2B	A302B	WLAC01	Weld	TL	4.350e+18	-30	55	85	68	17	0.016	0.120	0.180
Lacrosse Boiling Water Reactor (Genoa-2), Capsule 2A/7B														
A	N31438	A302B	SLAC01	SRM	LT	1.100e+19	-60	25	85	43	42	0.017	0.180	0.070
A	A5848	A302B	PLAC02	Plate	LT	1.100e+19	-75	-10	65	75	-10	0.009	0.180	0.140
A	3C2B	A302B	WLAC01	Weld	TL	1.100e+19	-20	85	105	91	14	0.016	0.120	0.180
Lacrosse Boiling Water Reactor (Genoa-2), Capsule 38AB														
A	N31438	A302B	SLAC01	SRM	LT	1.080e+19	-60	45	105	43	62	0.017	0.180	0.070
A	A5848	A302B	PLAC02	Plate	LT	1.080e+19	-75	5	80	75	5	0.009	0.180	0.140
A	3C2B	A302B	WLAC01	Weld	TL	1.080e+19	-20	90	110	91	19	0.016	0.120	0.180

Table 13 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb, °F Unirradiated	Irradiated	C_v transition temp. Shift at 30 ft-lb, °F Measured	R.G. 1.99	Residual	Chemistry, wt % P	NI	CU
Lacrosse Boiling Water Reactor (Genoa-2), Capsule 9A/9B														
A	N31438	A302B	SLAC01	SRM	LT	6.600e+18	-60	10	70	37	33	0.017	0.180	0.070
A	A5848	A302B	PLAC02	Plate	LT	6.600e+18	-75	-10	65	65	0	0.009	0.180	0.140
A	3C2B	A302B	WLAC01	Weld	TL	6.600e+18	-20	55	75	78	-3	0.016	0.120	0.180
Oconee Nuclear Station Unit 1, Capsule A														
B	A1195-1	A533B-1	SHSS02	SRM	LT	8.950e+18	56	144	88	124	-36	0.010	0.640	0.170
B	C3265-1	A302B	POC102	Plate	LT	8.950e+18	-5	55	60	63	-3	0.015	0.500	0.100
B	C3265-1	A302B	POC102	Plate	TL	8.950e+18	5	39	34	63	-29	0.015	0.500	0.100
B	406L44	A302B	WOC101	Weld	TL	8.950e+18	-5	186	191	191	0	0.024	0.590	0.310
Oconee Nuclear Station Unit 1, Capsule C														
B	A1195-1	A533B-1	SHSS02	SRM	LT	9.860e+18	48	116	68	128	-60	0.010	0.640	0.170
B	C3265-1	A302B	POC102	Plate	LT	9.860e+18	-5	34	76	65	11	0.015	0.500	0.100
B	C3265-1	A302B	POC102	Plate	TL	9.860e+18	18	94	39	65	-26	0.015	0.500	0.100
B	406L44	A302B	WOC101	Weld	TL	9.860e+18	-5	180	185	196	-11	0.024	0.590	0.310
Oconee Nuclear Station Unit 1, Capsule E														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.500e+18	56		64*	64	0	0.010	0.640	0.170
B	C3265-1	A302B	POC102	Plate	LT	1.500e+18	-11	40	51	33	18	0.015	0.500	0.100
B	C3265-1	A302B	POC102	Plate	TL	1.500e+18	7	51	44	33	11	0.015	0.500	0.100
B	406L44	A302B	WOC101	Weld	TL	1.500e+18	-5	75	80	99	-19	0.024	0.590	0.310
Oconee Nuclear Station Unit 1, Capsule F														
B	C2800-2	A302B	POC101	Plate	LT	8.300e+17	0	16	16	28	-12	0.012	0.630	0.110
B	A1195-1	A533B-1	SHSS02	SRM	LT	8.300e+17	56		28*	49	-21	0.010	0.640	0.170
B	C2800-2	A302B	POC101	Plate	TL	8.300e+17	-2	28	30	28	2	0.012	0.630	0.110
Palisades, Capsule W110														
C	A1008-1	A533B-1	SHSS01	SRM	LT	1.779e+19	15	163	148	158	-10	0.0112	0.665	0.173
C	C1279-3	A302BM	PPAL01	Plate	LT	1.779e+19	0	180	180	192	-12	0.011	0.53	0.25
C	3277	A302BM	WPAL01	Weld	TL	1.779e+19	-85	229	314	267	47	0.011	0.95	0.24
Point Beach Nuclear Plant Unit 1, Capsule R														
W	A0421	A302B	SASTM	SRM	LT	2.220e+19	40	150	110	122	-12	0.011	0.180	0.200
W	A9811	A302B	PPB101	Plate	LT	2.220e+19	-45	60	105	101	4	0.010	0.056	0.190
W	C1423	A302B	PPB102	Plate	LT	2.220e+19	-30	20	50	61	-11	0.014	0.065	0.110
W	72445	A302B	WPB101	Weld	TL	2.220e+19	-45	120	165	181	-16	0.019	0.570	0.180

Table 13 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence $E > 1$ MeV n/cm^2	C_v transition temp. at 30 ft-lb, °F		C_v transition temp. Shift at 30 ft-lb, °F			Chemistry, wt %		
							Unirradiated	Irradiated	Measured	R.G. 1.99	Residual	P	NI	CU
Point Beach Nuclear Plant Unit 1, Capsule S														
W	A0421	A302B	SASTM	SRM	LT	7.050e+18	40	135	95	90	5	0.011	0.180	0.200
W	A9811	A302B	PPB101	Plate	LT	7.050e+18	-45	45	90	75	15	0.010	0.056	0.190
W	C1423	A302B	PPB102	Plate	LT	7.050e+18	-30	20	50	46	4	0.014	0.065	0.110
W	72445	A302B	WPB101	Weld	TL	7.050e+18	-45	120	165	135	30	0.019	0.570	0.180
Point Beach Nuclear Plant Unit 1, Capsule T														
W	A0421	A302B	SASTM	SRM	LT	2.110e+19	40	160	120	120	0	0.011	0.180	0.200
W	A9811	A302B	PPB101	Plate	LT	2.110e+19	-45	55	100	100	0	0.010	0.056	0.190
W	C1423	A302B	PPB102	Plate	LT	2.110e+19	-30	20	50	61	-11	0.014	0.065	0.110
W	72445	A302B	WPB101	Weld	TL	2.110e+19	-45	135	180	179	1	0.019	0.570	0.180
Point Beach Nuclear Plant Unit 1, Capsule V														
W	A0421	A302B	SASTM	SRM	LT	3.580e+18	40	135	95	72	23	0.011	0.180	0.200
W	A9811	A302B	PPB101	Plate	LT	3.580e+18	-45	45	90	60	30	0.010	0.056	0.190
W	C1423	A302B	PPB102	Plate	LT	3.580e+18	-30	20	50	36	14	0.014	0.065	0.110
W	72445	A302B	WPB101	Weld	TL	3.580e+18	-45	65	110	107	3	0.019	0.570	0.180
San Onofre Unit 1, Capsule A														
W	A0421	A302B	SASTM	SRM	LT	1.200e+19	40	155	115	105	10	0.011	0.180	0.200
W	A3119	A302B	PSO103	Plate	LT	1.200e+19			100	97	3	0.014	0.200	0.180
W		A302B	WSO101	Weld	TL	1.200e+19	-20	100	80	94	-14	0.017	0.080	0.190
San Onofre Unit 1, Capsule D														
W	A0421	A302B	SASTM	SRM	LT	2.260e+19	40	190	150	122	28	0.011	0.180	0.200
W	19585	A302B	PSO101	Plate	LT	2.260e+19			140	107	33	0.013	0.200	0.170
W	A3099	A302B	PSO102	Plate	LT	2.260e+19			110	112	-2	0.012	0.200	0.180
W	A3119	A302B	PSO103	Plate	LT	2.260e+19			130	112	18	0.014	0.200	0.180
San Onofre Unit 1, Capsule F														
W	A0421	A302B	SASTM	SRM	LT	5.140e+19	40	170	130	141	-11	0.011	0.180	0.200
W	A3099	A302B	PSO102	Plate	LT	5.140e+19	10	130	120	130	-10	0.012	0.200	0.180
W		A302B	WSO101	Weld	TL	5.140e+19	-20	125	145	126	19	0.017	0.080	0.190
Three Mile Island Nuclear Station Unit 1, Capsule C														
B	A1195-1	A533B-1	SHSS02	SRM	LT	8.660e+18	48	125	77	123	-46	0.010	0.640	0.170
B	C2789-2	A302B	PTM101	Plate	LT	8.660e+18	-27	3	30	56	-26	0.010	0.570	0.090
B	C2789-2	A302B	PTM101	Plate	TL	8.660e+18	28	41	13	56	-43	0.010	0.570	0.090
B	299L44	A302B	WTM101	Weld	TL	8.660e+18	-56	147	203	212	-9	0.019	0.710	0.330

Table 13 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb, °F Unirradiated	Irradiated	C_v transition temp. Shift at 30 ft-lb, °F Measured	R.G. 1.99	Residual	Chemistry, wt % P	NI	CU
Three Mile Island Nuclear Station Unit 1, Capsule E														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.070e+18	56		44*	55	-11	0.010	0.640	0.170
B	C2789-2	A302B	PTM101	Plate	LT	1.070e+18	-11	13	24	25	-1	0.010	0.570	0.090
B	C2789-2	A302B	PTM101	Plate	TL	1.070e+18	24	-29	-53	25	-10	0.010	0.570	0.090
B	299L44	A302B	WTM101	Weld	TL	1.070e+18	-56	68	124	95	29	0.019	0.710	0.330
Yankee-Rowe, Capsule 01														
W	A0421	A302B	SASTM S1	SRM		9.000e+19	15	325	310	150	160	0.011	0.180	0.200
W	19281-2	A302B	PYR_01	Plate	LT	9.000e+19	10	410	400	135	265	0.020	0.180	0.180
Yankee-Rowe, Capsule 02														
W	A0421	A302B	SASTM S1	SRM		9.000e+19	15	325	310	150	160	0.011	0.180	0.200
W	19281-2	A302B	PYR_01	Plate	LT	9.000e+19	10	410	400	135	265	0.020	0.180	0.180
Yankee-Rowe, Capsule 06														
W	A0421	A302B	SASTM S1	SRM		7.000e+19	15	275	260	146	114	0.011	0.180	0.200
W	19281-2	A302B	PYR_01	Plate	LT	7.000e+19	10	370	360	132	228	0.020	0.180	0.180
Yankee-Rowe, Capsule 08														
W	A0421	A302B	SASTM S1	SRM		5.000e+19	15	240	225	140	85	0.011	0.180	0.200
W	19281-2	A302B	PYR_01	Plate	LT	5.000e+19	10	330	320	126	194	0.020	0.180	0.180

* 50 ft-lb transition temperature shift

Residual is defined as measured shift - R.G. 1.99, Rev. 2, shift.

Tag Field, A - Allis Chalmers; B - Babcock & Wilcox; C - Combustion Engineering; G - General Electric; W- Westinghouse.

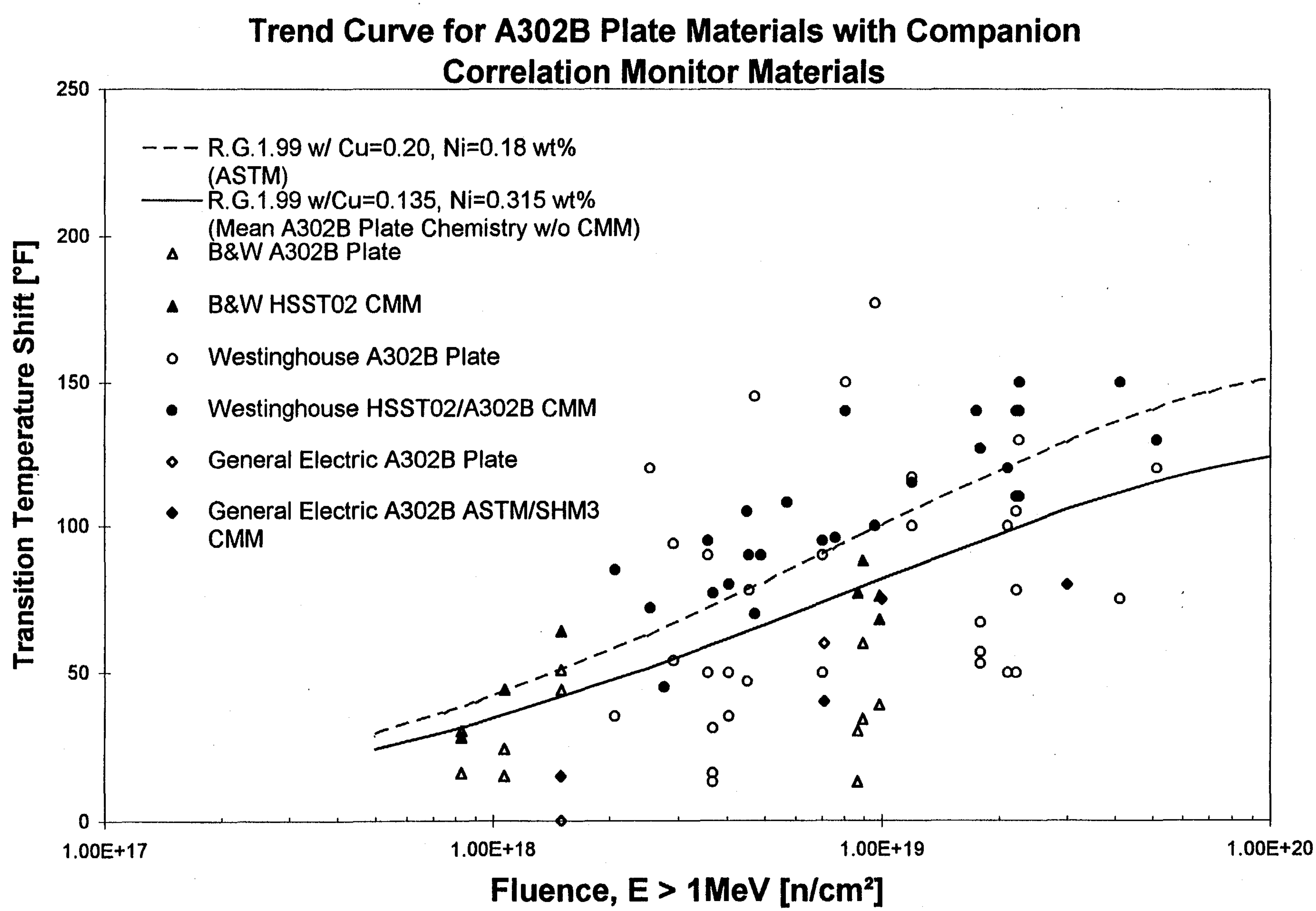


Figure 12 Trend curve for A302B plate materials and the corresponding CMMs (The SRM data are identified with a solid symbol, the corresponding A302B plate is identified with a hollow symbol)

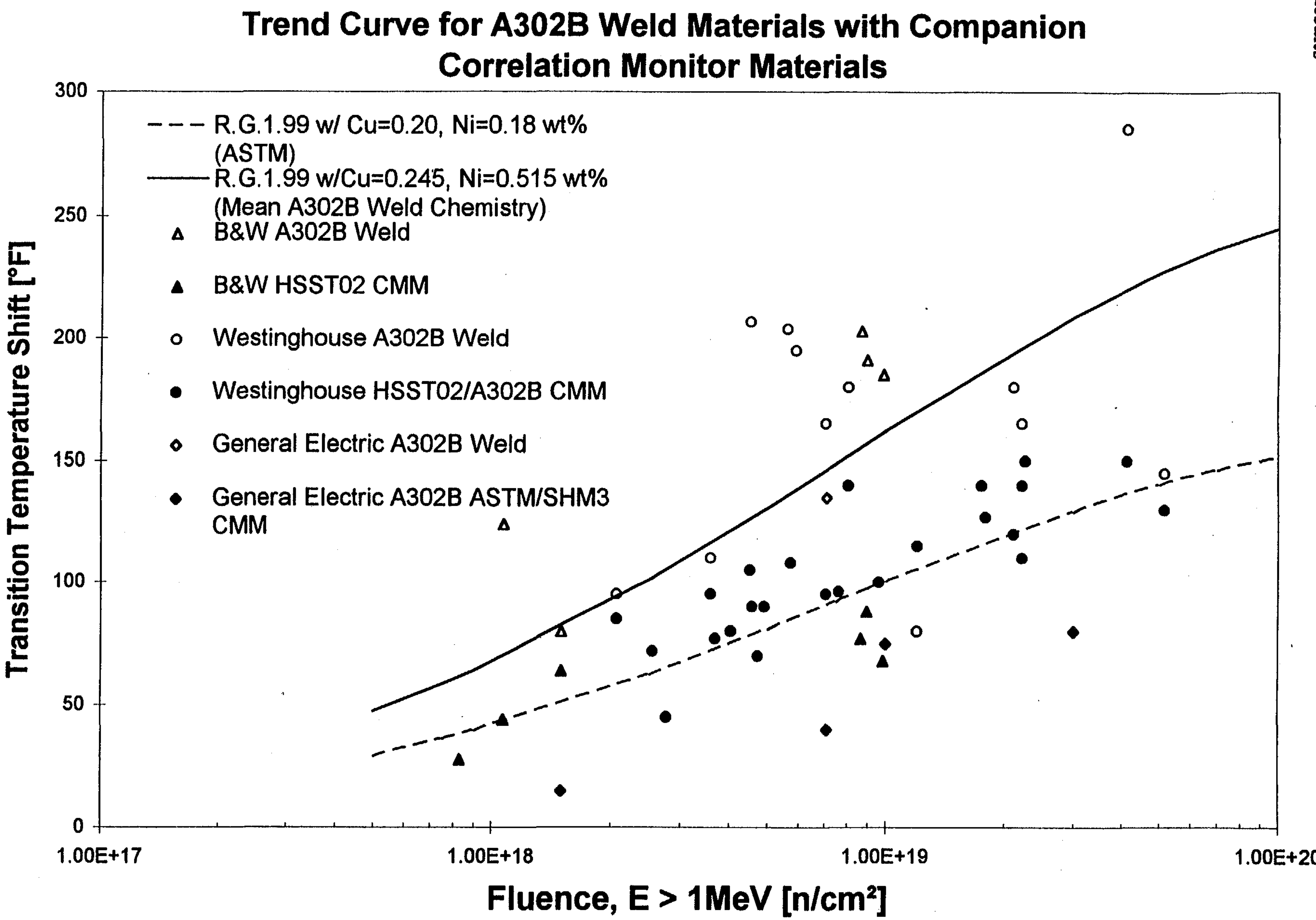


Figure 13 Trend curve for A302B weld materials and the corresponding CMM(The CMM data are identified with a solid symbol, the corresponding A302B weld data are identified with a hollow symbol)

Table 14. Summary of A533B reactor pressure vessel steels per PR-EDB reported data

							C_v transition temp. at 30 ft-lb		C_v transition temp. Shift at 30 ft-lb			Chemistry		
Tag	Heat No.	Material ID	HEAT ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	Unirradiated	Irradiated	Measured	R.G. 1.99	Residual	P	NI	CU
Arkansas Nuclear One, Unit 1, Capsule A														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.030e+19	48	94	46	129	-83	0.010	0.640	0.170
B	C5114-1	A533B-1	PAN101	Plate	LT	1.030e+19	-31	17	48	106	-58	0.010	0.520	0.150
B	C5114-1	A533B-1	PAN101	Plate	TL	1.030e+19	17	83	66	106	-40	0.010	0.520	0.150
B	406L44	A533B-1	WAN101	Weld	TL	1.030e+19	5	156	151	187	-36	0.016	0.590	0.280
Arkansas Nuclear One, Unit 1, Capsule B														
B	A1195-1	A533B-1	SHSS02	SRM	LT	4.280e+18	48	98	50	98	-48	0.010	0.640	0.170
B	C5114-2	A533B-1	PAN102	Plate	LT	4.280e+18	-13	22	35	81	-46	0.010	0.520	0.150
B	C5114-2	A533B-1	PAN102	Plate	TL	4.280e+18	19	15	24*	81	-57	0.010	0.520	0.150
Arkansas Nuclear One, Unit 1, Capsule C														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.460e+19	48	116	68	141	-73	0.010	0.640	0.170
B	C5114-1	A533B-1	PAN101	Plate	LT	1.460e+19	-31	33	64	117	-53	0.010	0.520	0.150
B	C5114-1	A533B-1	PAN101	Plate	TL	1.460e+19	17	55	38	117	-79	0.010	0.520	0.150
B	406L44	A533B-1	WAN101	Weld	TL	1.460e+19	5	190	185	205	-20	0.016	0.590	0.280
Arkansas Nuclear One, Unit 1, Capsule E														
B	A1195-1	A533B-1	SHSS02	SRM	LT	7.270e+17	56		40*	46	-6	0.010	0.640	0.170
B	C5114-1	A533B-1	PAN101	Plate	LT	7.270e+17	-21	-4	17	38	-21	0.010	0.520	0.150
B	C5114-1	A533B-1	PAN101	Plate	TL	7.270e+17	7	46	39	38	1	0.010	0.520	0.150
B	406L44	A533B-1	WAN101	Weld	TL	7.270e+17	5	110	105	66	39	0.016	0.590	0.280
Jose Cabrera-Zorita Reactor, Capsule K														
W	A0421	A302B	SASTM	SRM	LT	1.400e+19	40	160	120	109	11	0.011	0.180	0.200
W	A8312-1	A533B-1	PCAB01	Plate	LT	1.400e+19	-50	90	140	104	36	0.013	0.500	0.140
W	1248	A533B-1	WCAB01	Weld	TL	1.400e+19	-20	90	110	115	-5	0.015	0.110	0.220
Jose Cabrera-Zorita Reactor, Capsule N														
W	A0421	A302B	SASTM	SRM	LT	3.680e+19	40	195	155	134	21	0.011	0.180	0.200
W	A8312-1	A533B-1	PCAB01	Plate	LT	3.680e+19	-50	105	155	128	27	0.013	0.500	0.140
W	1248	A533B-1	WCAB01	Weld	TL	3.680e+19	-20	200	220	141	79	0.015	0.110	0.220

Table 14 (continued)

Tag	Heat No.	Material ID	HEAT ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb		C_v transition temp. Shift at 30 ft-lb			Chemistry		
							Unirradiated	Irradiated	Measured	R.G. 1.99	Residual	P	NI	CU
Jose Cabrera-Zorita Reactor, Capsule P														
W	A0421	A302B	SASTM	SRM	LT	1.430e+19	40	178	138	110	28	0.011	0.180	0.200
W	A8312-1	A533B-1	PCAB01	Plate	LT	1.430e+19	-50	70	120	105	15	0.013	0.500	0.140
W	B3170-1	A533B-1	PCAB02	Plate	LT	1.430e+19	-24	44	68	81	-13	0.011	0.530	0.110
Calvert Cliffs Unit 1, Capsule W263														
C	A1008-1	A533B-1	SHSS01	SRM	LT	5.900e+18	39	127	88	116	-28	0.008	0.660	0.180
C	C4441-1	A533B-1	PCC103	Plate	LT	6.000e+18	8	68	60	72	-12	0.011	0.640	0.120
C	33A277	A533B-1	WCC101	Weld	TL	6.100e+18	-50	9	59	103	-44	0.040	0.180	0.240
Calvert Cliffs Unit 2, Capsule W263														
C	A1008-1	A533B-1	SHSS01	SRM	LT	8.140e+18	25	153	128	128	0	0.008	0.660	0.180
C	C5286-1	A533B-1	PCC202	Plate	LT	8.060e+18	9	93	84	95	-11	0.005	0.660	0.140
C	10137	A533B-1	WCC201	Weld	TL	7.970e+18	-50	19	69	85	-16	0.016	0.040	0.200
Donald C. Cook Unit 1, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.800e+18	45	105	60	70	-10	0.010	0.640	0.170
W	C3506-1	A533B-1	PCK101	Plate	LT	1.800e+18	5	65	60	52	8	0.009	0.490	0.140
W	C3506-1	A533B-1	PCK101	Plate	TL	1.800e+18	20	90	70	52	18	0.009	0.490	0.140
W	13253	A533B-1	WCK101	Weld		1.800e+18	-90	-10	80	112	-32	0.023	0.740	0.270
Donald C. Cook Unit 1, Capsule U														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.880e+19	45	165	120	150	-30	0.010	0.640	0.170
W	C3506-1	A533B-1	PCK101	Plate	LT	1.880e+19	5	120	115	111	4	0.009	0.490	0.140
W	C3506-1	A533B-1	PCK101	Plate	TL	1.880e+19	15	130	115	111	4	0.009	0.490	0.140
W	13253	A533B-1	WCK101	Weld		1.880e+19	-90	115	205	242	-37	0.023	0.740	0.270
Donald C. Cook Unit 1, Capsule X														
W	A1195-1	A533B-1	SHSS02	SRM	LT	6.900e+18	45	145	100	115	-15	0.010	0.640	0.170
W	C3506-1	A533B-1	PCK101	Plate	LT	7.700e+18	5	105	100	88	12	0.009	0.490	0.140
W	C3506-1	A533B-1	PCK101	Plate	TL	6.200e+18	15	125	110	82	28	0.009	0.490	0.140
W	13253	A533B-1	WCK101	Weld	TL	6.200e+18	-90	255	165	179	-14	0.023	0.740	0.270

Table 14 (continued)

Tag	Heat No.	Material ID	HEAT ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm^2	C_v transition temp. at 30 ft-lb: Unirradiated	C_v transition temp. at 30 ft-lb: Irradiated	C_v transition temp. Shift at 30 ft-lb: Measured	C_v transition temp. Shift at 30 ft-lb: R.G. 1.99	C_v transition temp. Shift at 30 ft-lb: Residual	Chemistry: P	Chemistry: NI	Chemistry: CU
Donald C. Cook Unit 1, Capsule Y														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.200e+19	45	155	110	135	-25	0.010	0.640	0.170
W	C3506-1	A533B-1	PCK101	Plate	LT	1.340e+19	5	110	105	103	2	0.009	0.490	0.140
W	C3506-1	A533B-1	PCK101	Plate	TL	1.060e+19	15	130	115	97	18	0.009	0.490	0.140
W	13253	A533B-1	WCK101	Weld		1.060e+19	-90	290	200	210	-10	0.023	0.740	0.270
Crystal River Unit 3, Capsule C														
B	A1195-1	A533B-1	SHSS02	SRM	LT	6.560e+18	48	121	73	113	-40	0.010	0.640	0.170
B	C4344-1	A533B-1	PCR301	Plate	TL	6.560e+18	16	142	126	125	1	0.008	0.540	0.200
B	C4344-2	A533B-1	PCR302	Plate	TL	6.560e+18	16	143	127	125	2	0.008	0.540	0.200
B		A533B-1	WCR301	Weld	TL	6.560e+18	36	158	122	157	-35	0.021	0.100	0.390
Diablo Canyon Unit 1, Capsule S														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.980e+18	46	112	66	74	-8	0.008	0.650	0.150
W	C2793-1	A533B-1	PDC103	Plate	LT	2.980e+18	5	3	4*	33	-29	0.011	0.460	0.077
W	27204	A533B-1	WDC101	Weld	TL	2.980e+18	-67	43	110	151	-41	0.016	0.980	0.210
Diablo Canyon Unit 1, Capsule Y														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.020e+19	46	158	112	112	0	0.008	0.650	0.150
W	C2793-1	A533B-1	PDC103	Plate	LT	1.020e+19	5	52	47	51	-4	0.010	0.466	0.079
W	27204	A533B-1	WDC101	Weld	TL	1.020e+19	-67	167	234	227	7	0.016	0.980	0.210
Fort Calhoun Station Unit 1, Capsule W225														
C	A1008-1	A533B-1	SHSS01	SRM	LT	4.800e+18	27	151	124	108	16	0.008	0.660	0.180
C	A1768-1	A533B-1	PFC101	Plate	LT	4.500e+18	22	82	60	51	9	0.013	0.480	0.100
C	305414	A533B-1	WFC101	Weld	TL	4.200e+18	-28	210	238	147	91	0.012	0.600	0.300
Millstone Nuclear Power Station Unit 2, Capsule W104														
C	A1008-1	A533B-1	SHSS01	SRM	LT	8.840e+18	24	165	141	131	10	0.008	0.660	0.180
C	C5667-1	A533B-1	PML201	Plate	LT	8.840e+18	38	137	99	97	2	0.006	0.610	0.140
C	90136	A533B-1	WML201	Weld	TL	8.840e+18	-30	28	58	131	-73	0.014	0.060	0.300
Maine Yankee Nuclear Plant, Capsule A25														
C	A1008-1	A533B-1	SHSS01	SRM	LT	1.300e+19	15	165	150	140	10	0.011	0.665	0.173
C	B7955-1	A533B-1	PMY_01	Plate	LT	1.300e+19	0	120	120	117	3	0.013	0.590	0.150
C	IP3571	A533B-1	WMY_01	Weld	TL	1.300e+19	-30	240	270	260	10	0.015	0.780	0.360

Table 14 (continued)

Tag	Heat No.	Material ID	HEAT ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb Unirradiated	C_v transition temp. at 30 ft-lb Irradiated	C_v transition temp. Shift at 30 ft-lb Measured	C_v transition temp. Shift at 30 ft-lb R.G. 1.99	C_v transition temp. Shift at 30 ft-lb Residual	Chemistry P	Chemistry NI	Chemistry CU
Maine Yankee Nuclear Plant, W253														
C	A1008-1	A533B-1	SHSS01	SRM	LT	1.250e+19	15	175	160	139	21	0.011	0.665	0.173
C	B7955-1	A533B-1	PMY_01	Plate	LT	1.250e+19	0	120	120	116	4	0.013	0.590	0.150
C	IP3571	A533B-1	WMY_01	Weld	TL	1.250e+19	-30	230	260	257	3	0.015	0.780	0.360
Salem Unit 1, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.560e+18	50	110	60	64	-4	0.012	0.680	0.140
W	C1354-1	A533B-1	PSA101	Plate	LT	2.560e+18	-20	80	100	95	5	0.010	0.530	0.220
W	C1354-2	A533B-1	PSA102	Plate	LT	2.560e+18	-25	75	100	100	0	0.010	0.540	0.230
W	C1397-2	A533B-1	PSA103	Plate	LT	2.560e+18	-50	25	75	95	-20	0.011	0.520	0.220
Salem Unit 1, Capsule Y														
W	A1195-1	A533B-1	SHSS02	SRM	LT	8.910e+18	50	175	125	99	26	0.012	0.680	0.140
W	C1397-2	A533B-1	PSA103	Plate	LT	8.910e+18	-50	60	110	145	-35	0.011	0.520	0.220
W	39B196	A533B-1	WSA101	Weld	TL	8.910e+18	-135	30	165	208	-43	0.019	1.260	0.160
Salem Unit 1, Capsule Z														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.330e+19	50	185	135	110	25	0.012	0.680	0.140
W	C1354-1	A533B-1	PSA101	Plate	LT	1.330e+19	-20	150	170	164	6	0.010	0.530	0.220
W	C1354-2	A533B-1	PSA102	Plate	LT	1.330e+19	-25	140	165	171	-6	0.010	0.540	0.230
W	C1397-2	A533B-1	PSA103	Plate	LT	1.330e+19	-50	75	125	162	-37	0.011	0.520	0.220
St. Lucie Unit 1, Capsule W104														
C	A1008-1	A533B-1	SHSS01	SRM	LT	7.160e+18	39	149	110	123	-13	0.008	0.660	0.180
C	C5935-2	A533B-1	PSL101	Plate	LT	7.160e+18	8	75	67	98	-31	0.006	0.570	0.150
C	90136	A533B-1	WSL101	Weld	TL	7.160e+18	-53	20	73	100	-27	0.013	0.110	0.230
Surry Unit 1, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.500e+18	45	115	70	80	-10	0.010	0.640	0.170
W	C4415-1	A533B-1	PSU101	Plate	LT	2.500e+18	-10	40	50	46	4	0.014	0.500	0.110
W	299L44	A533B-1	WSU101	Weld	TL	2.880e+18	-15	150	165	127	38	0.011	0.700	0.250
Surry Unit 1, Capsule V														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.940e+19	45	190	145	151	-6	0.010	0.640	0.170
W	C4415-1	A533B-1	PSU101	Plate	LT	1.940e+19	-10	100	110	86	24	0.014	0.500	0.110
W	299L44	A533B-1	WSU101	Weld	TL	1.940e+19	-15	225	240	227	13	0.011	0.700	0.250

Table 14 (continued)

Tag	Heat No.	Material ID	HEAT ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb Unirradiated	Irradiated	C_v transition temp. Shift at 30 ft-lb Measured	R.G. 1.99	Residual	Chemistry P	NI	CU
Surry Unit 2, Capsule V														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.880e+19	45	165	120	150	-30	0.010	0.640	0.170
W	C4339-1	A533B-1	PSU201	Plate	LT	1.880e+19	-5	70	75	86	-11	0.012	0.540	0.110
W	C4339-1	A533B-1	PSU201	Plate	TL	1.880e+19	5	80	75	86	-11	0.012	0.540	0.110
W	227	A533B-1	WSU201	Weld	TL	1.880e+19	-20	125	145	177	-32	0.017	0.560	0.190
Surry Unit 2, Capsule X														
W	A1195-1	A533B-1	SHSS02	SRM	LT	3.020e+18	40	100	60	86	-26	0.010	0.640	0.170
W	C4339-1	A533B-1	PSU201	Plate	LT	3.020e+18	-5	50	55	49	6	0.012	0.540	0.110
W	C4339-1	A533B-1	PSU201	Plate	TL	3.020e+18	5	50	45	49	-4	0.012	0.540	0.110
W	227	A533B-1	WSU201	Weld	TL	3.020e+18	-20	75	95	101	-6	0.017	0.560	0.190
Zion Nuclear Plant Reactor Unit 1, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.800e+18	42	108	66	70	-4	0.010	0.640	0.170
W	B7835-1	A533B-1	PZN101	Plate	LT	1.800e+18	-5	55	60	40	20	0.010	0.490	0.110
W	B7835-1	A533B-1	PZN101	Plate	TL	1.800e+18	25	50	25	40	-15	0.010	0.490	0.110
W	72105	A533B-1	WZN101	Weld	TL	3.060e+18	4	116	112	141	-29	0.020	0.570	0.350
Zion Nuclear Plant Reactor Unit 1, Capsule U														
W	A1195-1	A533B-1	SHSS02	SRM	LT	8.920e+18	42	172	130	124	6	0.010	0.640	0.170
W	B7835-1	A533B-1	PZN101	Plate	LT	8.920e+18	-5	80	85	71	14	0.010	0.490	0.110
W	B7835-1	A533B-1	PZN101	Plate	TL	8.920e+18	25	85	60	71	-11	0.010	0.490	0.110
W	72105	A533B-1	WZN101	Weld	TL	8.920e+18	4	203	199	202	-3	0.020	0.570	0.350
Zion Nuclear Plant Reactor Unit 1, Capsule X														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.400e+19	42	162	120	140	-20	0.010	0.640	0.170
W	B7835-1	A533B-1	PZN101	Plate	LT	1.200e+19	-5	95	90	77	13	0.010	0.490	0.110
W	B7835-1	A533B-1	PZN101	Plate	TL	1.500e+19	25	105	80	81	-1	0.010	0.490	0.110
W	72105	A533B-1	WZN101	Weld	TL	1.500e+19	4	199	195	232	-37	0.020	0.570	0.350
Zion Nuclear Plant Reactor Unit 1, Capsule Y														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.560e+19	42	171	129	144	-15	0.010	0.640	0.170
W	B7835-1	A533B-1	PZN101	Plate	LT	1.560e+19	-5	87	92	82	10	0.010	0.490	0.110
W	B7835-1	A533B-1	PZN101	Plate	TL	1.560e+19	25	119	94	82	12	0.010	0.490	0.110
W	72105	A533B-1	WZN101	Weld	TL	1.560e+19	4	209	205	234	-29	0.020	0.570	0.350

Table 14 (continued)

Tag	Heat No.	Material ID	HEAT ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb Unirradiated	C_v transition temp. at 30 ft-lb Irradiated	C_v transition temp. Shift at 30 ft-lb Measured	C_v transition temp. Shift at 30 ft-lb R.G. 1.99	C_v transition temp. Shift at 30 ft-lb Residual	Chemistry P	Chemistry NI	Chemistry CU
Zion Nuclear Plant Reactor Unit 2, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.000e+19	50	150	100	128	-28	0.010	0.640	0.170
W	C4007-1	A533B-1	PZN201	Plate	LT	8.700e+18	37	112	75	78	-3	0.010	0.530	0.120
W	C4007-1	A533B-1	PZN201	Plate	TL	1.100e+19	49	139	90	84	6	0.010	0.530	0.120
W	72105	A533B-1	WZN201	Weld	LT	1.100e+19	4	179	175	214	-39	0.020	0.570	0.350
Zion Nuclear Plant Reactor Unit 2, Capsule U														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.000e+18	50	100	50	73	-23	0.010	0.640	0.170
W	C4007-1	A533B-1	PZN201	Plate	LT	2.000e+18	37	75	38	46	-8	0.010	0.530	0.120
W	C4007-1	A533B-1	PZN201	Plate	TL	2.000e+18	49	98	49	46	3	0.010	0.530	0.120
W	72105	A533B-1	WZN201	Weld	LT	2.820e+18	-23	122	145	136	9	0.020	0.570	0.350
Zion Nuclear Plant Reactor Unit 2, Capsule Y														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.480e+19	50	185	135	142	-7	0.010	0.640	0.170
W	C4007-1	A533B-1	PZN201	Plate	LT	1.480e+19	37	125	88	90	-2	0.010	0.530	0.120
W	C4007-1	A533B-1	PZN201	Plate	TL	1.480e+19	49	170	121	90	31	0.010	0.530	0.120
W	72105	A533B-1	WZN201	Weld	LT	1.480e+19	-10	210	220	231	-11	0.020	0.570	0.350

* 50 ft-lb transition temperature shift.

Residual is defined as measured shift - R.G. 1.99, Rev. 2, shift.

Tag Field, B - Babcock & Wilcox; C - Combustion Engineering; W- Westinghouse.

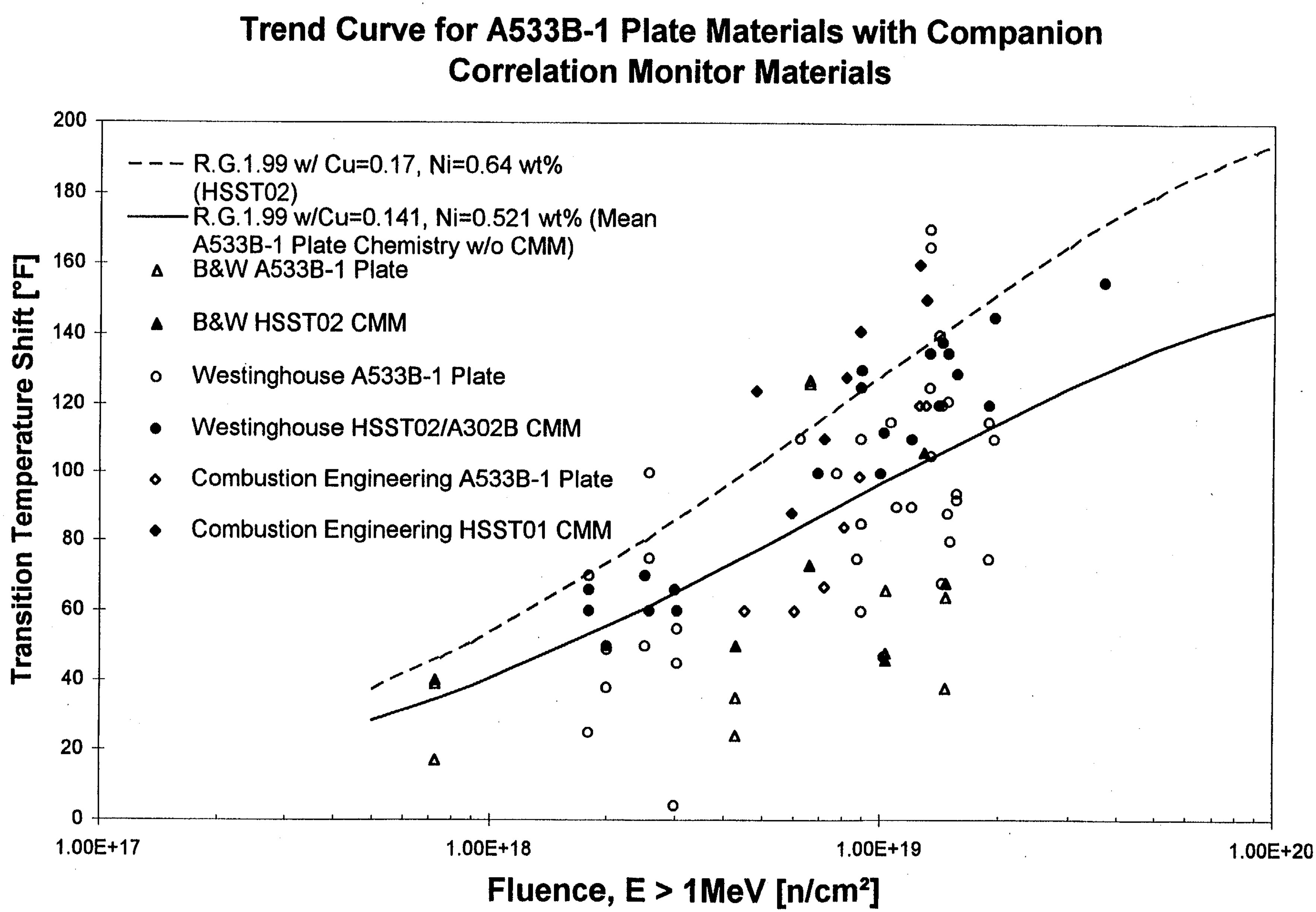


Figure 14 Trend curve for A533B-1 plate materials and the corresponding CMMs. The SRM data are identified with a solid symbol, and the corresponding A533B-1 plate is identified with a hollow symbol

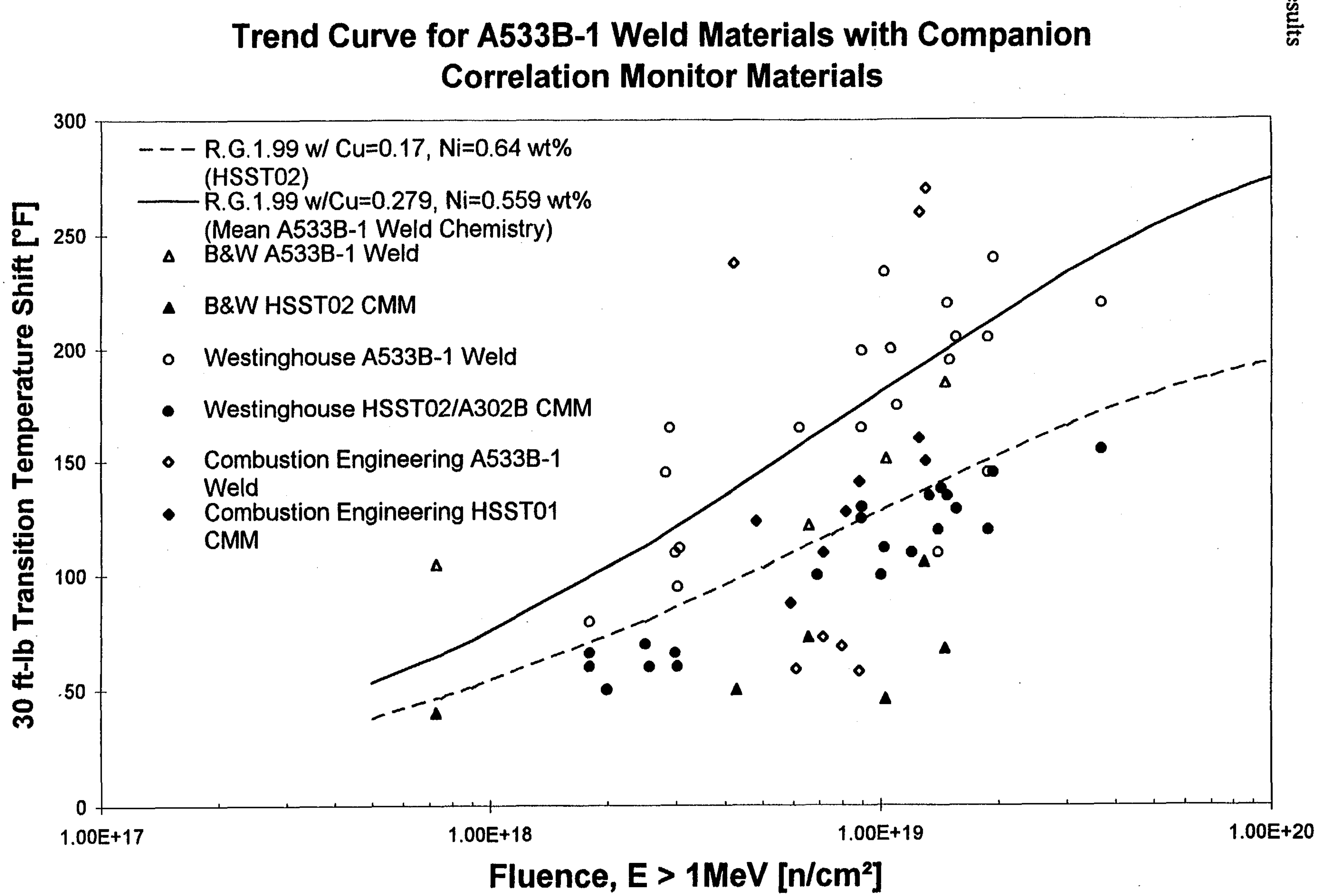


Figure 15 Trend curves for A533B-1 weld materials and the corresponding CMMs. The SRM data are identified with a solid symbol, and the corresponding weld is identified with a hollow symbol

Table 15. Summary of forging reactor pressure vessel steels per PR-EDB reported data

							C_v transition temp. at 30 ft-lb		C_v transition temp. at 30 ft-lb			Chemistry		
Tag	Number	ID	ID.	ID.	Orient.	Fluence E > 1 MeV n/cm²	Unirradiated	Irradiated	Measured	R.G. 1.99	Residual	P	NI	CU
Davis-Besse Nuclear Power Station Unit 1, Capsule A														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.29e+19	48	154	106	137	-31	0.010	0.640	0.170
B	123X244	A508-2	FDB101	Forging	TL	1.29e+19	-26	-24	2	28	-26	0.004	0.770	0.040
B	5P4086	A508-2	FDB102	Forging	TL	1.29e+19	16	44	28	21	7	0.011	0.810	0.020
Garigliano, Capsule 113B														
G	A0421	A302B	SASTM S2	SRM	LT	1.10e+19	27	153	126	103	23	0.016	0.180	0.200
G	1675	A336	FGAR01OD	Forging	LT	9.20e+18	-69	109	178	50	128	0.025	0.800	0.080
G	2120	A336	FGAR02OD	Forging	TL	1.00e+19	-8	257	265	232	33	0.020	0.860	0.300
Garigliano, Capsule 113D														
G	A0421	A302B	SASTM S2	SRM	LT	7.37e+18	27	133	106	91	15	0.016	0.180	0.200
G	1675	A336	FGAR01ID	Forging	LT	6.76e+18	-53	70	122	45	77	0.025	0.800	0.080
G	2120	A336	FGAR02ID	Forging	TL	6.76e+18	23	223	200	207	-7	0.020	0.860	0.300
Garigliano, Capsule 114A														
G	A0421	A302B	SASTM S2	SRM	LT	4.65e+19	27	194	167	139	28	0.016	0.180	0.200
G	1675	A336	FGAR01ID	Forging	LT	4.48e+19	-53	225	277	70	207	0.025	0.800	0.080
G	2120	A336	FGAR02ID	Forging	TL	4.65e+19	23	352	329	322	7	0.020	0.860	0.300
Garigliano, Capsule 114B														
G	A0421	A302B	SASTM S2	SRM	LT	2.21e+19	27	142	115	122	-7	0.016	0.180	0.200
G	1675	A336	FGAR01ID	Forging	LT	2.21e+19	-53	109	162	62	100	0.025	0.800	0.080
G	2120	A336	FGAR02ID	Forging	TL	2.43e+19	23	284	261	288	-27	0.020	0.860	0.300
Garigliano, Capsule 114C														
G	A0421	A302B	SASTM S2	SRM	LT	5.47e+19	27	178	151	142	9	0.016	0.180	0.200
G	1675	A336	FGAR01ID	Forging	LT	6.64e+19	-53	217	270	74	196	0.025	0.800	0.080
G	2120	A336	FGAR02ID	Forging	TL	6.12e+19	23	363	340	334	6	0.020	0.860	0.300

Table 15 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb Unirradiated	C_v transition temp. at 30 ft-lb Irradiated	C_v transition temp. at 30 ft-lb Measured	C_v transition temp. at 30 ft-lb R.G. 1.99	C_v transition temp. at 30 ft-lb Residual	Chemistry P	Chemistry NI	Chemistry CU
Robert E. Ginna Nuclear Plant Unit 1, Capsule R														
W	A0421	A302B	SASTM	SRM	LT	7.60e+18	40	136	96	92	4	0.011	0.180	0.200
W	125P666	A508-2	FGIN01	Forging	LT	7.60e+18	-48	11	59	29	30	0.010	0.690	0.050
W	125S255	A508-2	FGIN02	Forging	LT	7.60e+18	-29	-9	20	41	-21	0.010	0.690	0.070
Robert E. Ginna Nuclear Plant Unit 1, Capsule T														
W	A0421	A302B	SASTM	SRM	LT	1.75e+19	40	180	140	115	25	0.011	0.180	0.200
W	125P666	A508-2	FGIN01	Forging	LT	1.75e+19	-40	-10	30	36	-6	0.010	0.690	0.050
W	125S255	A508-2	FGIN02	Forging	LT	1.75e+19	-25	-25	0	51	-51	0.010	0.690	0.070
Robert E. Ginna Nuclear Plant Unit 1, Capsule V														
W	A0421	A302B	SASTM	SRM	LT	4.90e+18	40	130	90	80	10	0.011	0.180	0.200
W	125P666	A508-2	FGIN01	Forging	LT	4.90e+18	-40	-15	25	25	0	0.010	0.690	0.050
W	125S255	A508-2	FGIN02	Forging	LT	4.90e+18	-25	-25	0	35	-35	0.010	0.690	0.070
Kewaunee Nuclear Power Plant, Capsule P														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.89e+19	45	200	155	164	-9	0.010	0.640	0.170
W	122X208VA1	A508-2	FKWE01	Forging	LT	2.89e+19	-25	0	25	47	-22	0.010	0.710	0.060
W	123X167VA1	A508-2	FKWE02	Forging	LT	2.89e+19	-50	-30	20	47	-27	0.010	0.750	0.060
Kewaunee Nuclear Power Plant, Capsule R														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.07e+19	45	185	140	153	-13	0.010	0.640	0.170
W	122X208VA1	A508-2	FKWE01	Forging	LT	2.07e+19	-25	-10	15	44	-29	0.010	0.710	0.060
W	123X167VA1	A508-2	FKWE02	Forging	LT	2.07e+19	-50	-30	20	44	-24	0.010	0.750	0.060
Kewaunee Nuclear Power Plant, Capsule V														
W	A1195-1	A533B-1	SHSS02	SRM	LT	5.59e+18	45	140	95	107	-12	0.010	0.640	0.170
W	122X208VA1	A508-2	FKWE01	Forging	LT	5.59e+18	-25	-25	0	31	-31	0.010	0.710	0.060
W	123X167VA1	A508-2	FKWE02	Forging	LT	5.59e+18	-50	-50	0	31	-31	0.010	0.750	0.060
Oconee Nuclear Station Unit 2, Capsule A														
B	A1195-1	A533B-1	SHSS02	SRM	LT	3.37e+18	48	119	71	90	-19	0.010	0.640	0.170
B	3P2359	A508-2	FOC201	Forging	LT	3.37e+18	-24	-30	0	18	-18	0.006	0.750	0.040
B	3P2359	A508-2	FOC201	Forging	TL	3.37e+18	-28	-11	17	18	-1	0.006	0.750	0.040

Table 15 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb Unirradiated	C_v transition temp. at 30 ft-lb Irradiated	C_v transition temp. at 30 ft-lb Measured	R.G. 1.99	Residual	Chemistry P	NI	CU
Oconee Nuclear Station Unit 2, Capsule C														
B	A1195-1	A533B-1	SHSS02	SRM	LT	9.43e+17	56		42*	52	-10	0.010	0.640	0.170
B	3P2359	A508-2	FOC201	Forging	LT	9.43e+17	-31	-4	27	11	16	0.006	0.750	0.040
B	3P2359	A508-2	FOC201	Forging	TL	9.43e+17	-31	-74	0	11	-11	0.006	0.750	0.040
Oconee Nuclear Station Unit 2, Capsule E														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.21e+19	48	143	95	135	-40	0.010	0.640	0.170
B	3P2359	A508-2	FOC201	Forging	LT	1.21e+19	-24	-12	12	27	-15	0.006	0.750	0.040
B	3P2359	A508-2	FOC201	Forging	TL	1.21e+19	-28	-30	0	27	-27	0.006	0.750	0.040
Oconee Nuclear Station Unit 3, Capsule B														
B	A1195-1	A533B-1	SHSS02	SRM	LT	3.12e+18	56	95	39	87	-48	0.010	0.640	0.170
B	522194	A508-2	FOC301	Forging	TL	3.12e+18	-9	12	32	14	18	0.014	0.760	0.020
B	522314	A508-2	FOC302	Forging	TL	3.12e+18	-9	10	19	14	5	0.011	0.730	0.010
Oconee Nuclear Station Unit 3, Capsule D														
B	A1195-1	A533B-1	SHSS02	SRM	LT	1.45e+19	32	151	119	141	-22	0.010	0.640	0.170
B	522194	A508-2	FOC301	Forging	TL	1.45e+19	-9	22	31	22	9	0.014	0.760	0.020
B	522314	A508-2	FOC302	Forging	TL	1.45e+19	-9	36	45	22	23	0.011	0.730	0.010
Point Beach Nuclear Plant Unit 2, Capsule R														
W	A1195-1	A533B-1	SHSS02	SRM	LT	2.01e+19	49	200	151	152	-1	0.010	0.640	0.170
W	122W195VA1	A508-2	FPB201	Forging	LT	2.01e+19	-45	-10	35	38	-3	0.010	0.700	0.051
W	123V500VA1	A508-2	FPB202	Forging	LT	2.01e+19	-80	-10	70	67	3	0.009	0.710	0.088
Point Beach Nuclear Plant Unit 2, Capsule S														
W	A1195-1	A533B-1	SHSS02	SRM	LT	3.47e+19	49	194	145	170	-25	0.010	0.640	0.170
W	122W195VA1	A508-2	FPB201	Forging	LT	3.47e+19	-45	2	47	42	5	0.010	0.700	0.051
W	123V500VA1	A508-2	FPB202	Forging	LT	3.47e+19	-80	-4	76	75	1	0.009	0.710	0.088
Point Beach Nuclear Plant Unit 2, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	9.45e+18	49	154	105	126	-21	0.010	0.640	0.170
W	122W195VA1	A508-2	FPB201	Forging	LT	9.45e+18	-45	-28	17	31	-14	0.010	0.700	0.051
W	123V500VA1	A508-2	FPB202	Forging	LT	9.45e+18	-80	-50	30	56	-26	0.009	0.710	0.088

Table 15 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb Unirradiated	C_v transition temp. at 30 ft-lb Irradiated	C_v transition temp. at 30 ft-lb Measured	C_v transition temp. at 30 ft-lb R.G. 1.99	C_v transition temp. at 30 ft-lb Residual	Chemistry P	Chemistry NI	Chemistry CU
Point Beach Nuclear Plant Unit 2, Capsule V														
W	A1195-1	A533B-1	SHSS02	SRM	LT	4.74e+18	45	135	90	101	-11	0.010	0.640	0.170
W	122W195VA1	A508-2	FPB201	Forging	LT	4.74e+18	-55	-35	20	25	-5	0.010	0.700	0.051
W	123V500VA1	A508-2	FPB202	Forging	LT	4.74e+18	-80	-50	30	45	-15	0.009	0.710	0.088
Prairie Island Unit 1, Capsule P														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.25e+19	49	205	156	136	20	0.010	0.640	0.170
W	21918	A508-3	FPI101	Forging	LT	1.25e+19	-25	-5	20	39	-19	0.013	0.720	0.060
W	21918	A508-3	FPI101	Forging	TL	1.25e+19	-27	10	37	39	-2	0.013	0.720	0.060
Prairie Island Unit 1, Capsule R														
W	A1195-1	A533B-1	SHSS02	SRM	LT	4.03e+19	49	235	186	174	12	0.010	0.640	0.170
W	21918	A508-3	FPI101	Forging	LT	4.03e+19	-25	55	80	50	30	0.013	0.720	0.060
W	21918	A508-3	FPI101	Forging	TL	4.03e+19	-27	60	87	50	37	0.013	0.720	0.060
Prairie Island Unit 1, Capsule V														
W	A1195-1	A533B-1	SHSS02	SRM	LT	5.21e+18	49	159	110	105	5	0.010	0.640	0.170
W	21918	A508-3	FPI101	Forging	TL	5.21e+18	-27	-3	24	30	-6	0.013	0.720	0.060
Prairie Island Unit 2, Capsule R														
W	A1195-1	A533B-1	SHSS02	SRM	LT	4.42e+19	45	225	180	176	4	0.010	0.640	0.170
W	22642	A508-3	FPI201	Forging	LT	4.42e+19	-25	75	100	75	25	0.011	0.700	0.085
W	22642	A508-3	FPI201	Forging	TL	4.42e+19	0	85	85	75	10	0.011	0.700	0.085
Prairie Island Unit 2, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.05e+19	45	205	160	130	30	0.010	0.640	0.170
W	22642	A508-3	FPI201	Forging	LT	1.05e+19	-25	30	55	55	0	0.011	0.700	0.085
W	22642	A508-3	FPI201	Forging	TL	1.05e+19	0	35	35	55	-20	0.011	0.700	0.085
Prairie Island Unit 2, Capsule V														
W	A1195-1	A533B-1	SHSS02	SRM	LT	5.49e+18	45	170	125	107	18	0.010	0.640	0.170
W	22642	A508-3	FPI201	Forging	LT	5.49e+18	-25	10	35	45	-10	0.011	0.700	0.085
W	22642	A508-3	FPI201	Forging	TL	5.49e+18	0	30	30	45	-15	0.011	0.700	0.085

Table 15 (continued)

Tag	Heat No.	Material ID	Heat ID	Prod. ID	Orient.	Fluence E > 1 MeV n/cm²	C_v transition temp. at 30 ft-lb		C_v transition temp. at 30 ft-lb			Chemistry		
							Unirradiated	Irradiated	Measured	R.G. 1.99	Residual	P	NI	CU
Turkey Point Nuclear Power Station Unit 3, Capsule S														
W	A0421	A302B	SASTM	SRM	LT	1.41e+19	35		139*	110	29	0.011	0.180	0.200
W	123P461VA1	A508-2	FTP301	Forging	LT	1.41e+19	-47	-45	2	39	-37	0.010	0.700	0.058
W	123S266VA1	A508-2	FTP302	Forging	LT	1.41e+19	-63	-15	48	55	-7	0.010	0.680	0.079
Turkey Point Nuclear Power Station Unit 3, Capsule T														
W	A0421	A302B	SASTM	SRM	LT	5.68e+18	35	117	82	84	-2	0.011	0.180	0.200
W	123P461VA1	A508-2	FTP301	Forging	LT	5.68e+18	-47	-47	0	30	-30	0.010	0.700	0.058
Turkey Point Nuclear Power Station Unit 3, Capsule V														
W	A0421	A302B	SASTM	SRM	LT	1.23e+19	35	160	125	106	19	0.011	0.180	0.200
W	123S266VA1	A508-2	FTP302	Forging	LT	1.23e+19	-50	5	55	53	2	0.010	0.680	0.079
Turkey Point Nuclear Power Station Unit 4, Capsule S														
W	A1195-1	A533B-1	SHSS02	SRM	LT	1.25e+19	45		115*	136	-21	0.010	0.640	0.170
W	122S180VA1	A508-2	FTP401	Forging	LT	1.25e+19	-29	-53	-24	37	-26	0.011	0.700	0.056
W	123P481VA1	A508-2	FTP402	Forging	LT	1.25e+19	-12	29	41	35	6	0.010	0.710	0.054
Turkey Point Nuclear Power Station Unit 4, Capsule T														
W	A1195-1	A533B-1	SHSS02	SRM	LT	6.05e+18	45	135	90	110	-20	0.010	0.640	0.170
W	122S180VA1	A508-2	FTP401	Forging	LT	6.05e+18	-29	-24	5	30	-25	0.011	0.700	0.056

* 50 ft-lb transition temperature shift.

Residual is defined as measured shift - Reg. Guide 199 Rev. 2's shift.

Tag Field, B - Babcock & Wilcox; G - General Electric; W- Westinghouse.

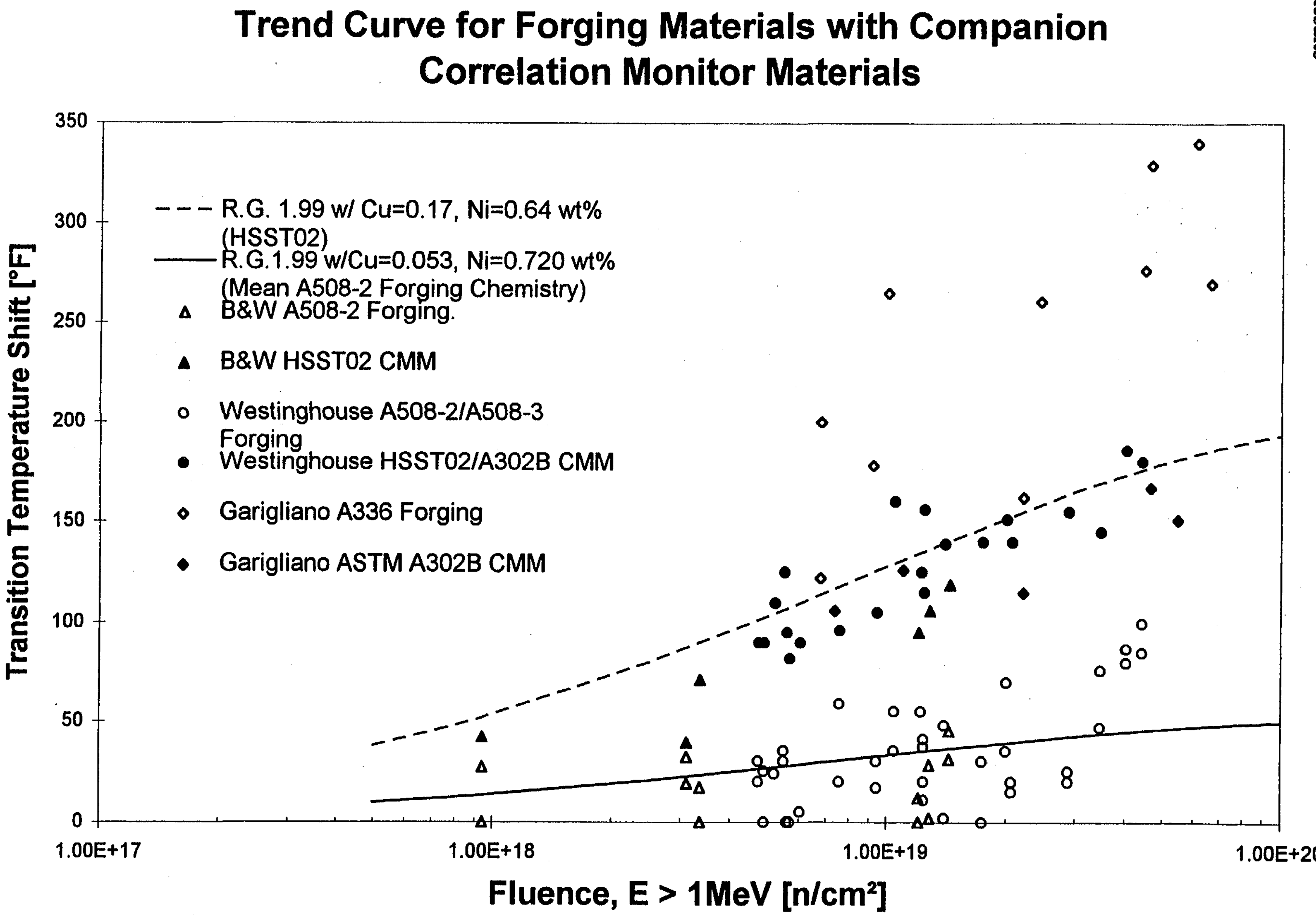


Figure 16 Trend curve for forging materials and the corresponding CMMs. The SRM data are identified with a solid symbol, and the corresponding forging is identified with a hollow symbol

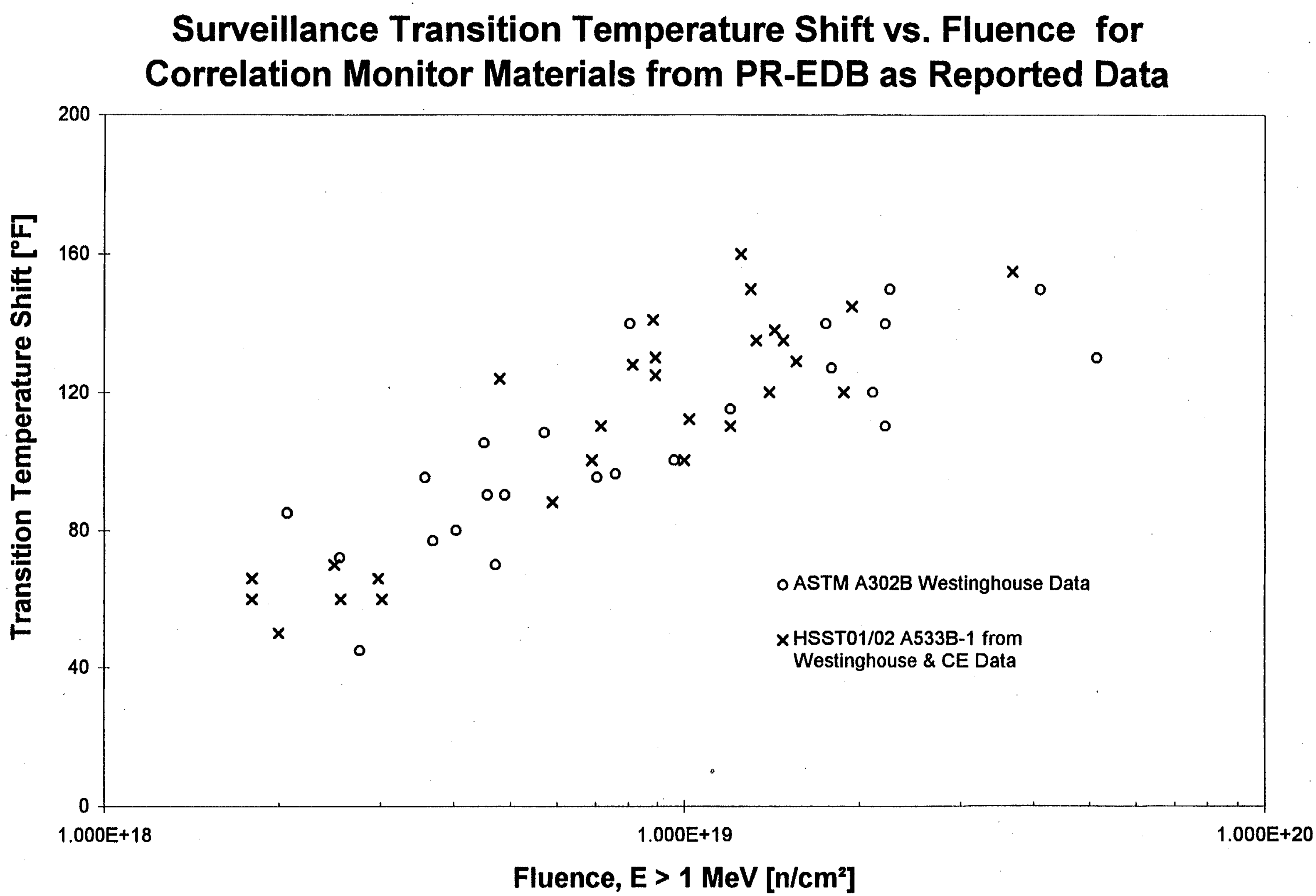


Figure 17 Plot of surveillance NDT shift vs fluence for ASTM A302B and HSST01/02 A533B-1 CMMs per PR-EDB reported data

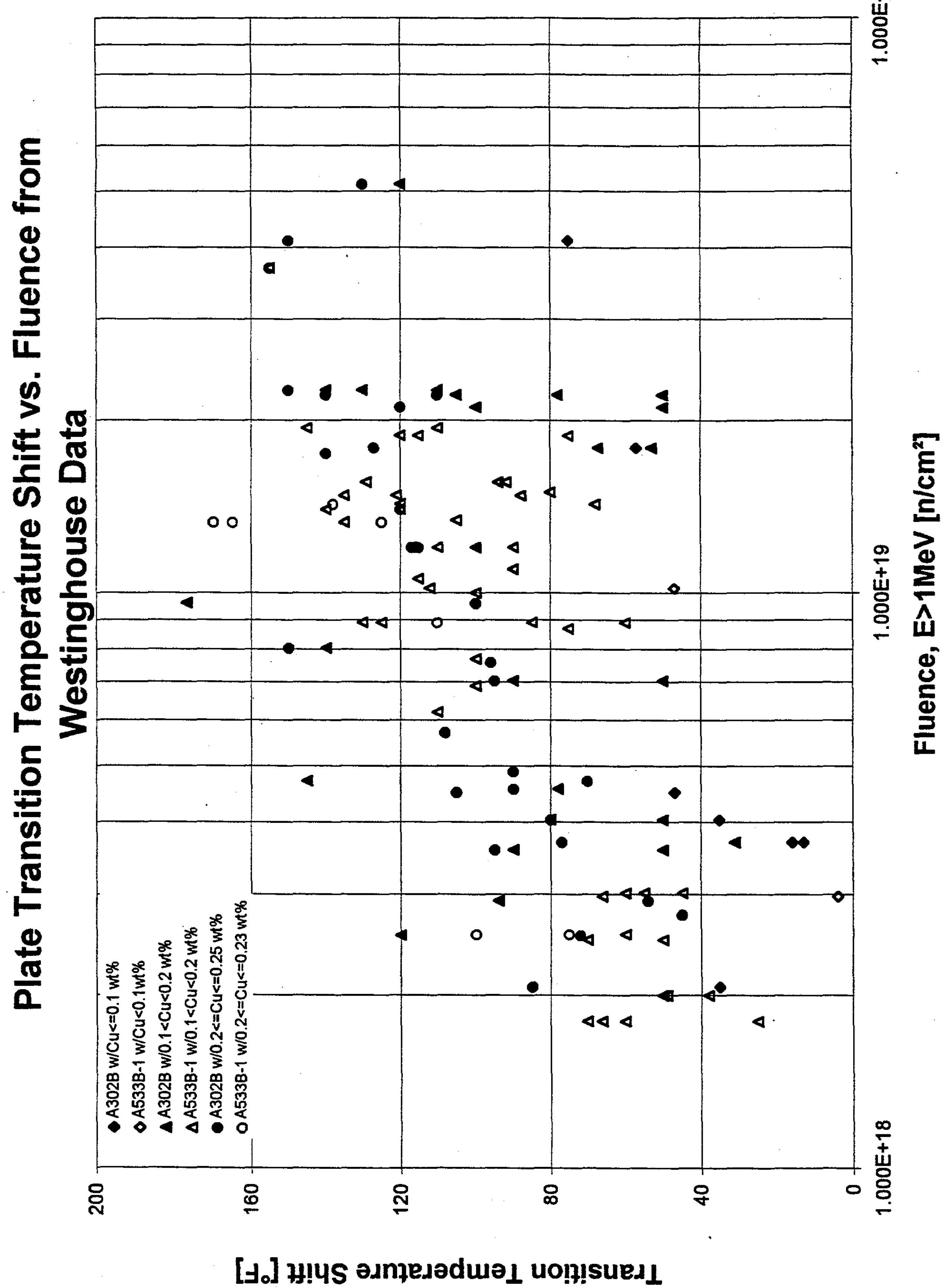
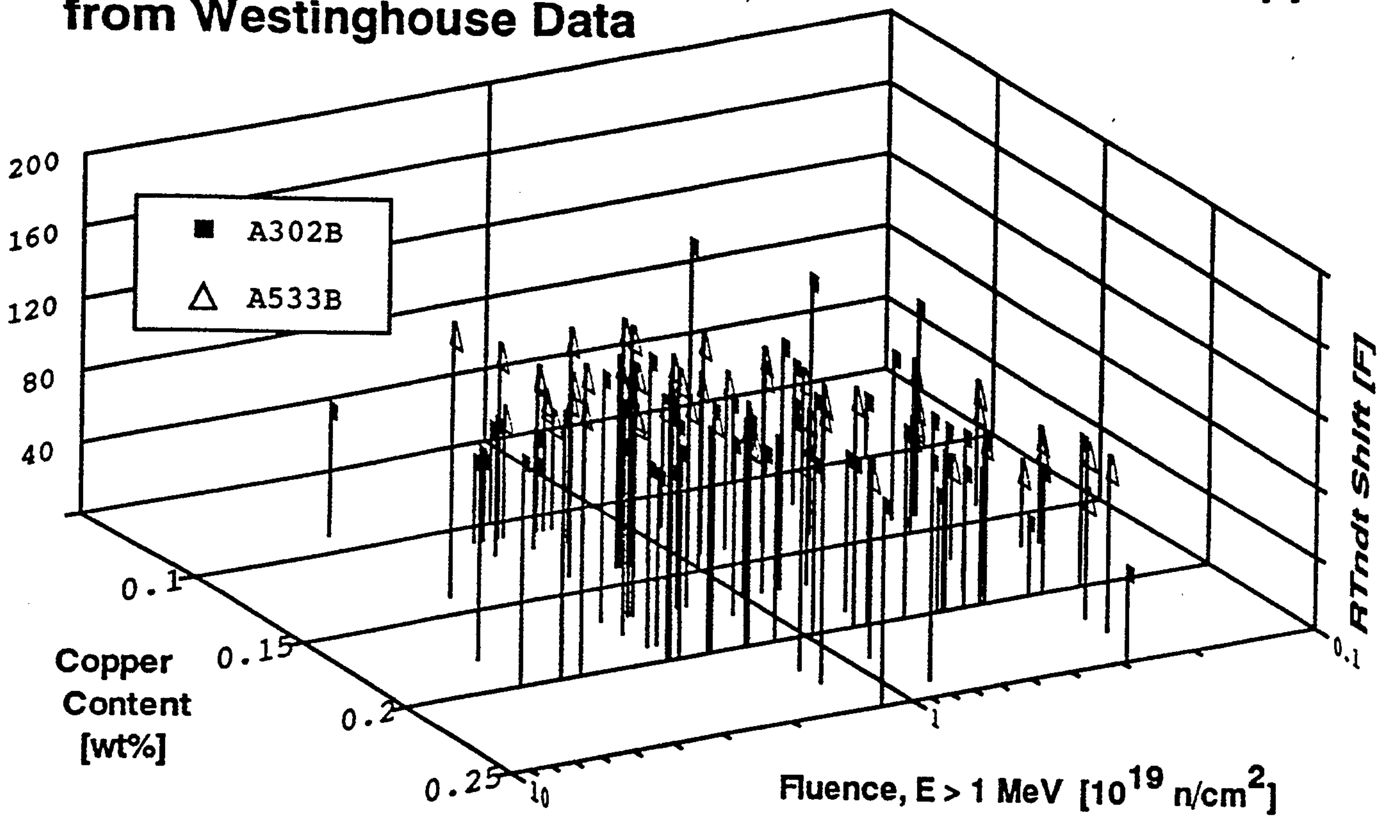


Figure 18 Plot of transition temperature shift vs fast fluence for A302B and A533B-1 plate materials from Westinghouse.

Plate Transition Temperature Shift vs Fluence vs Copper from Westinghouse Data



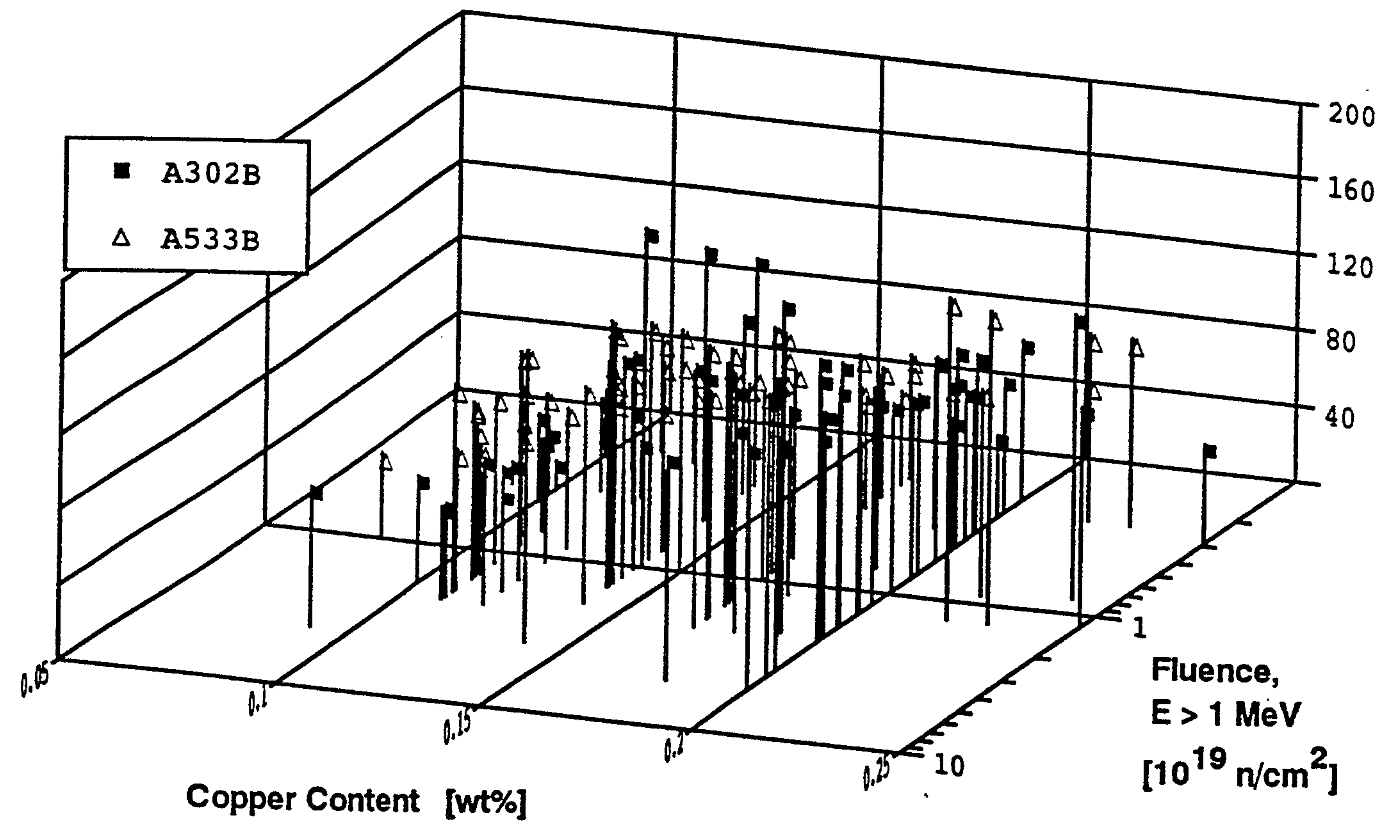


Figure 19 3-D plots of RT_{NDT} shift vs fluence vs copper content for A302B and A533B-1 materials per Westinghouse data

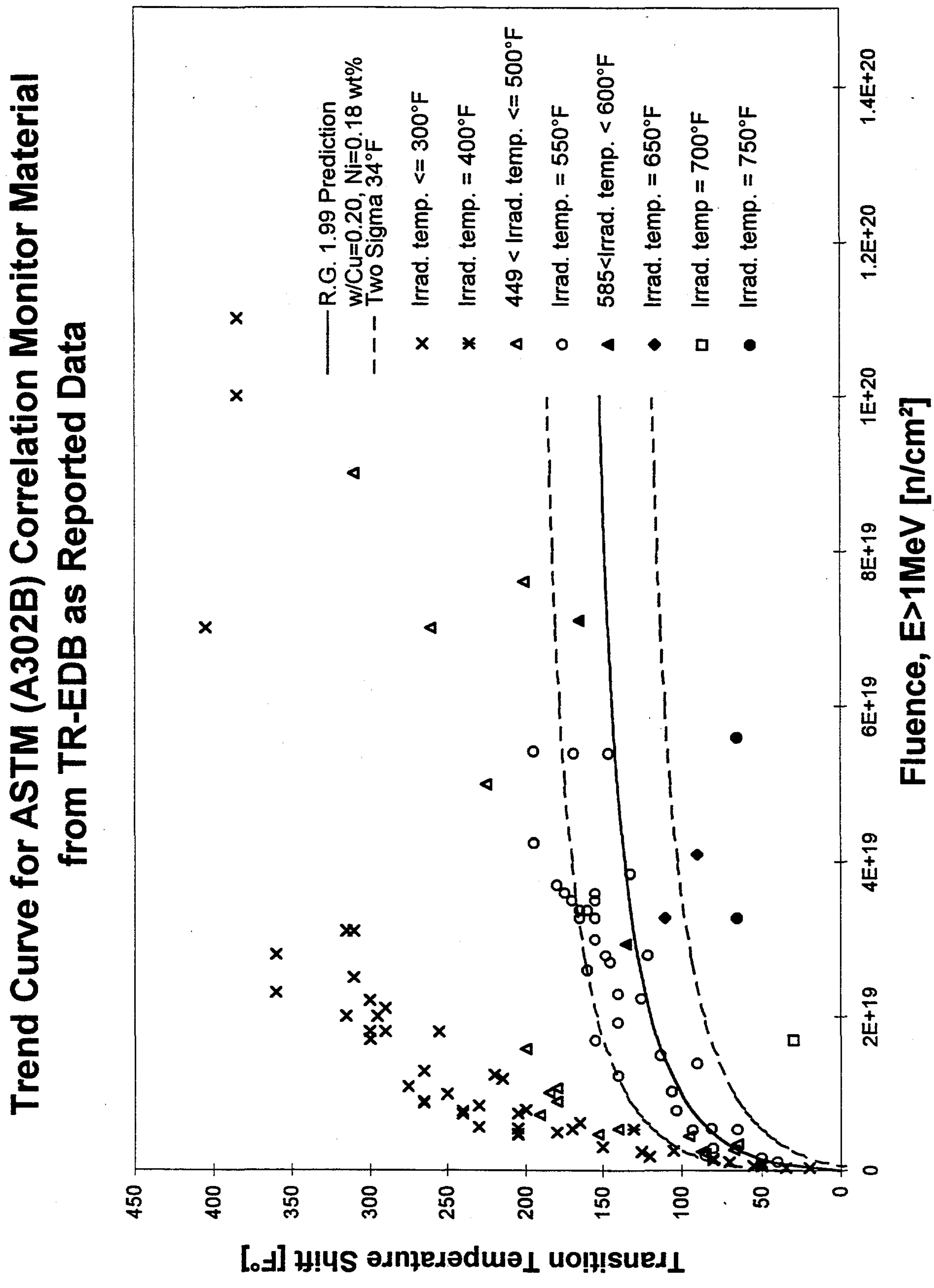


Figure 20 Embrittlement of the A302B ASTM CMM relative to the R.G. 1.99, Rev. 2, prediction

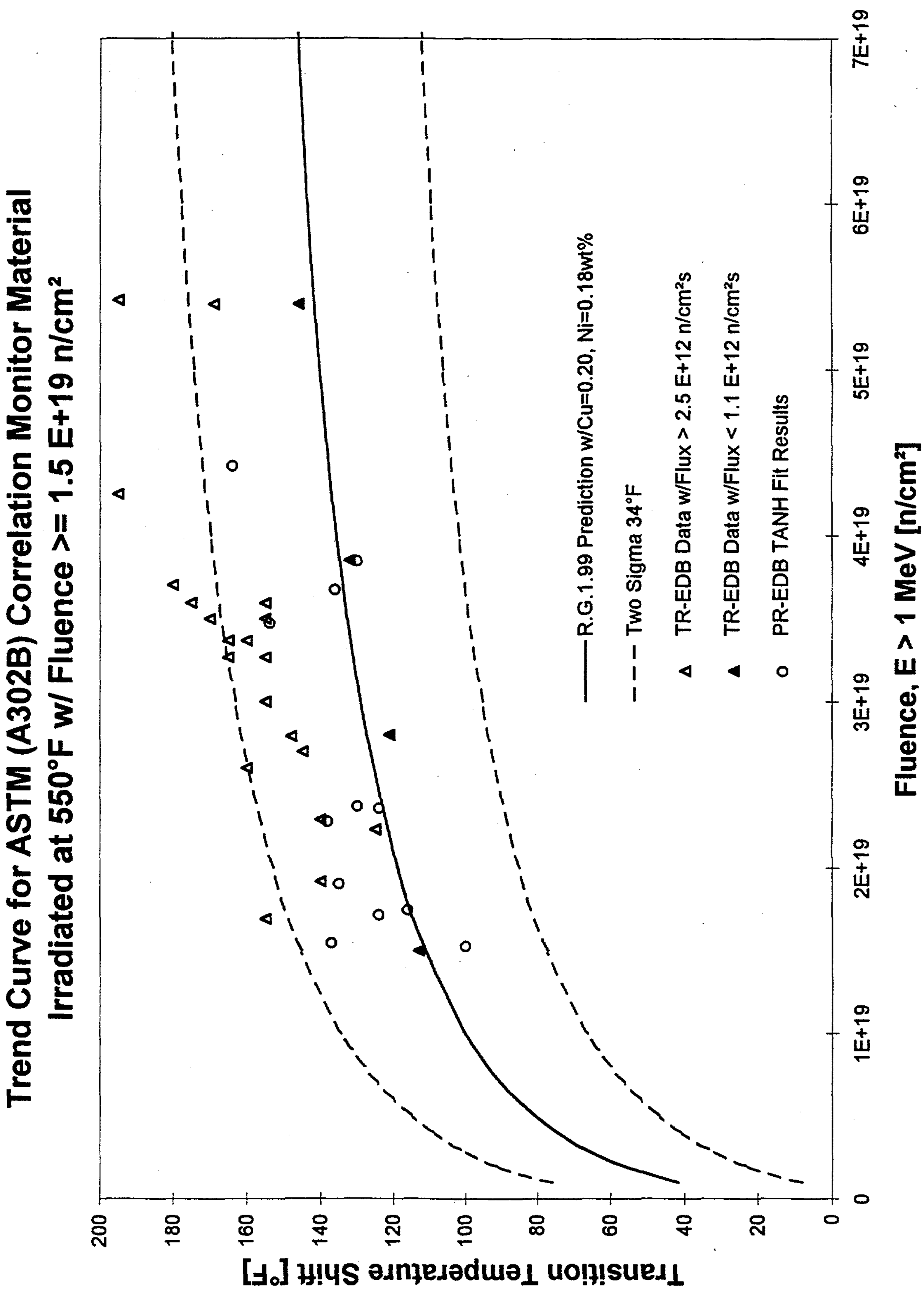


Figure 21 Embrittlement of the A302B ASTM CMM relative to the R.G. 1.99, Rev. 2, prediction for fluence > 1.5E+19 n/cm²

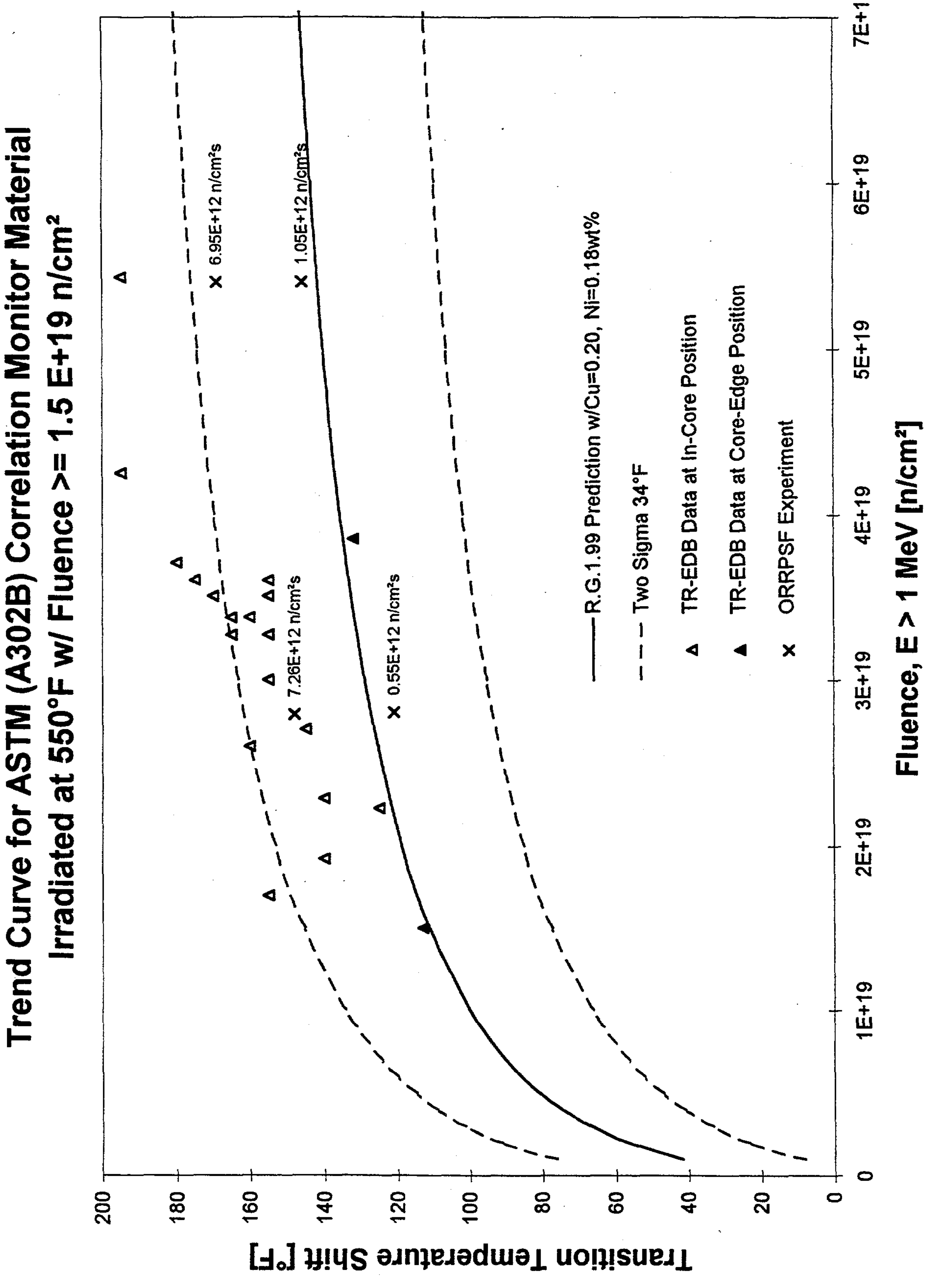


Figure 22 Embrittlement of the HSST01 CMM relative to the R.G. 1.99, Rev. 2, prediction

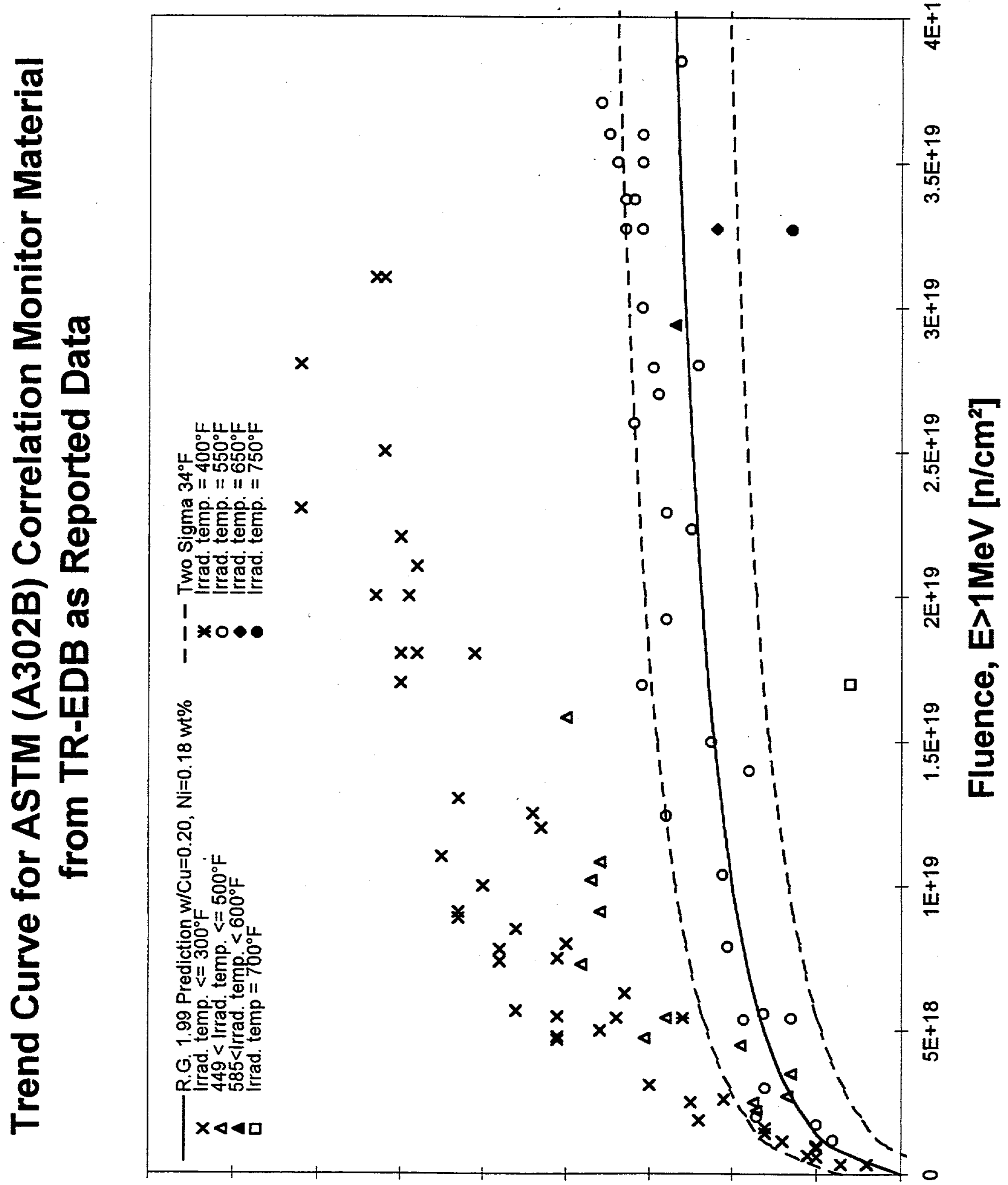


Figure 23. Embrittlement of the HSST01 CMM relative to the R.G. 1.99, Rev. 2, prediction

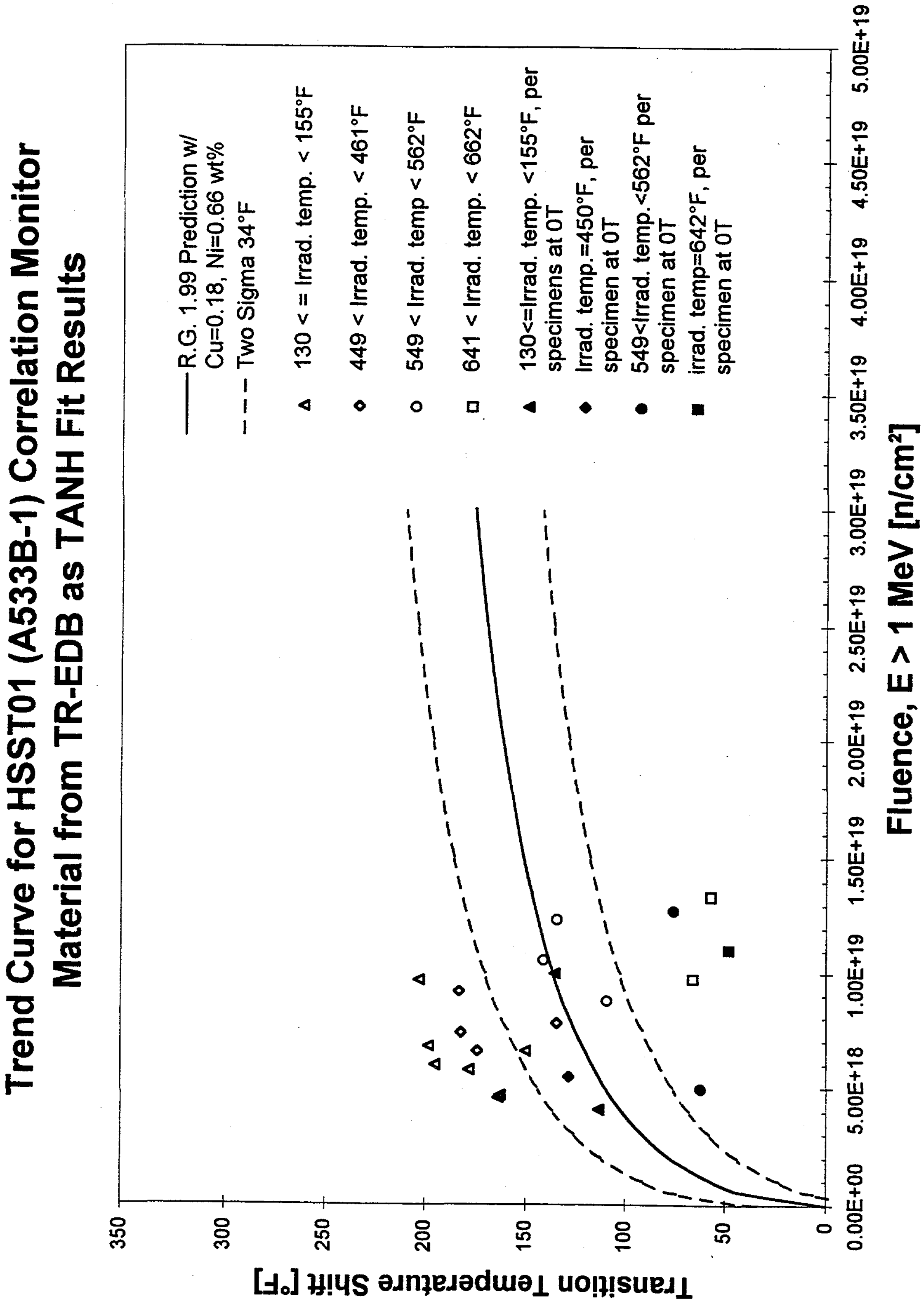


Figure 24 Embrittlement of the HSST02 CMM relative to R.G. 1.99, Rev. 2, prediction

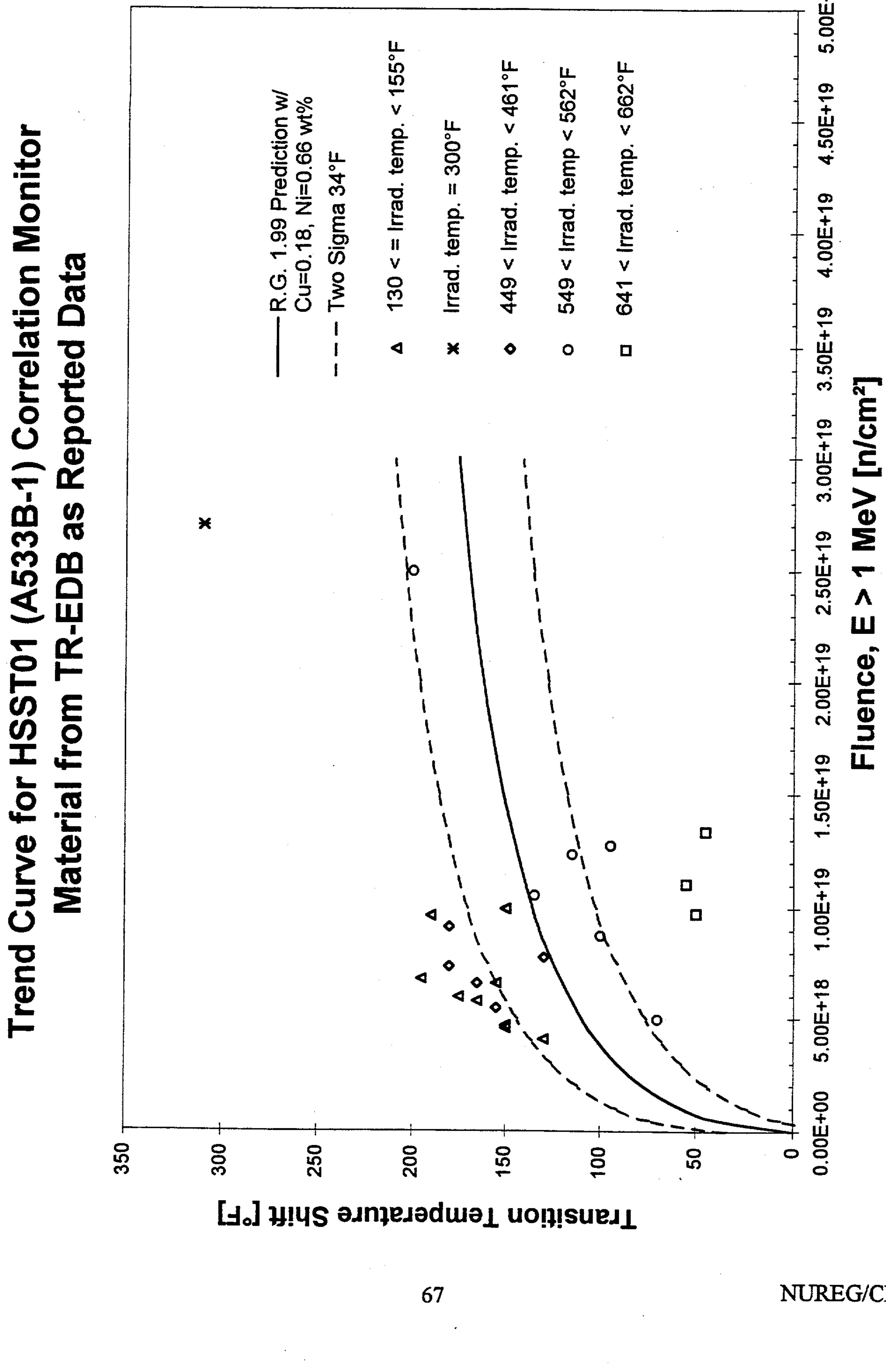


Figure 25 Embrittlement of the HSST03 CMM relative to R.G. 1.99, Rev. 2, prediction

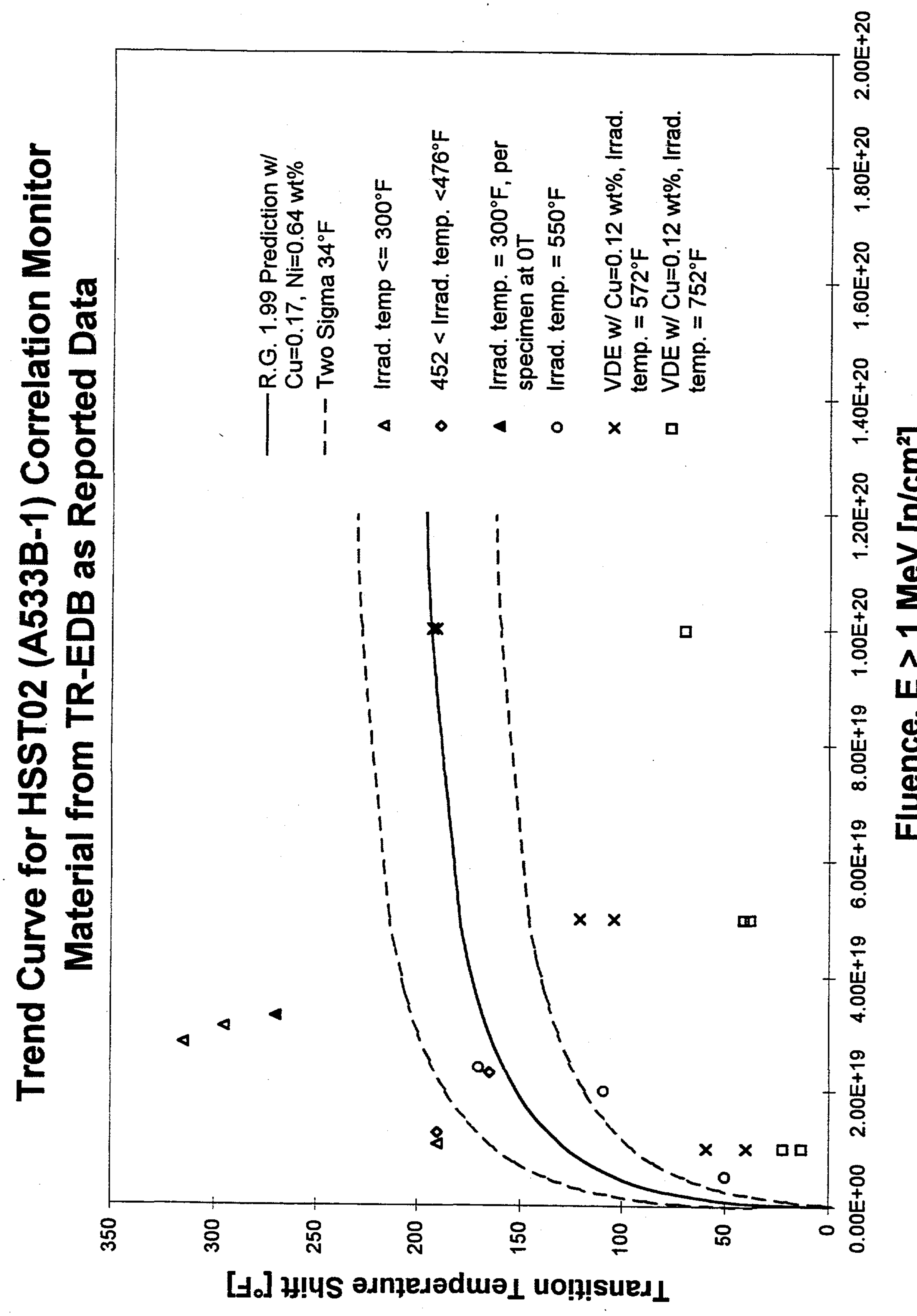


Figure 26 Embrittlement of the HSST02 CMM relative to R.G. 1.99, Rev. 2, prediction

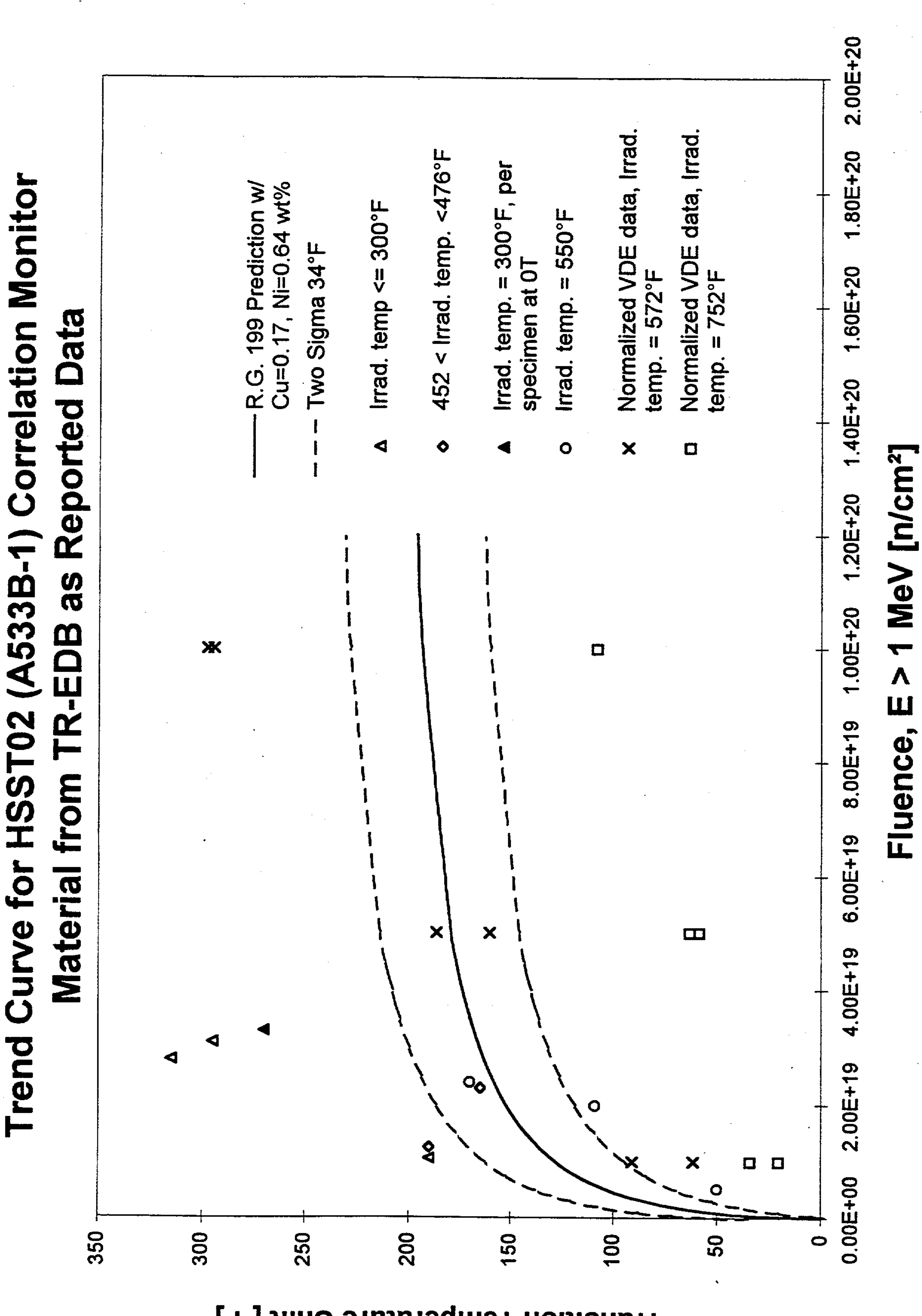


Figure 27 Embrittlement of the HSST02 CMM relative to R.G. 1.99, Rev. 2. VDE data were normalized to 17 wt % copper content

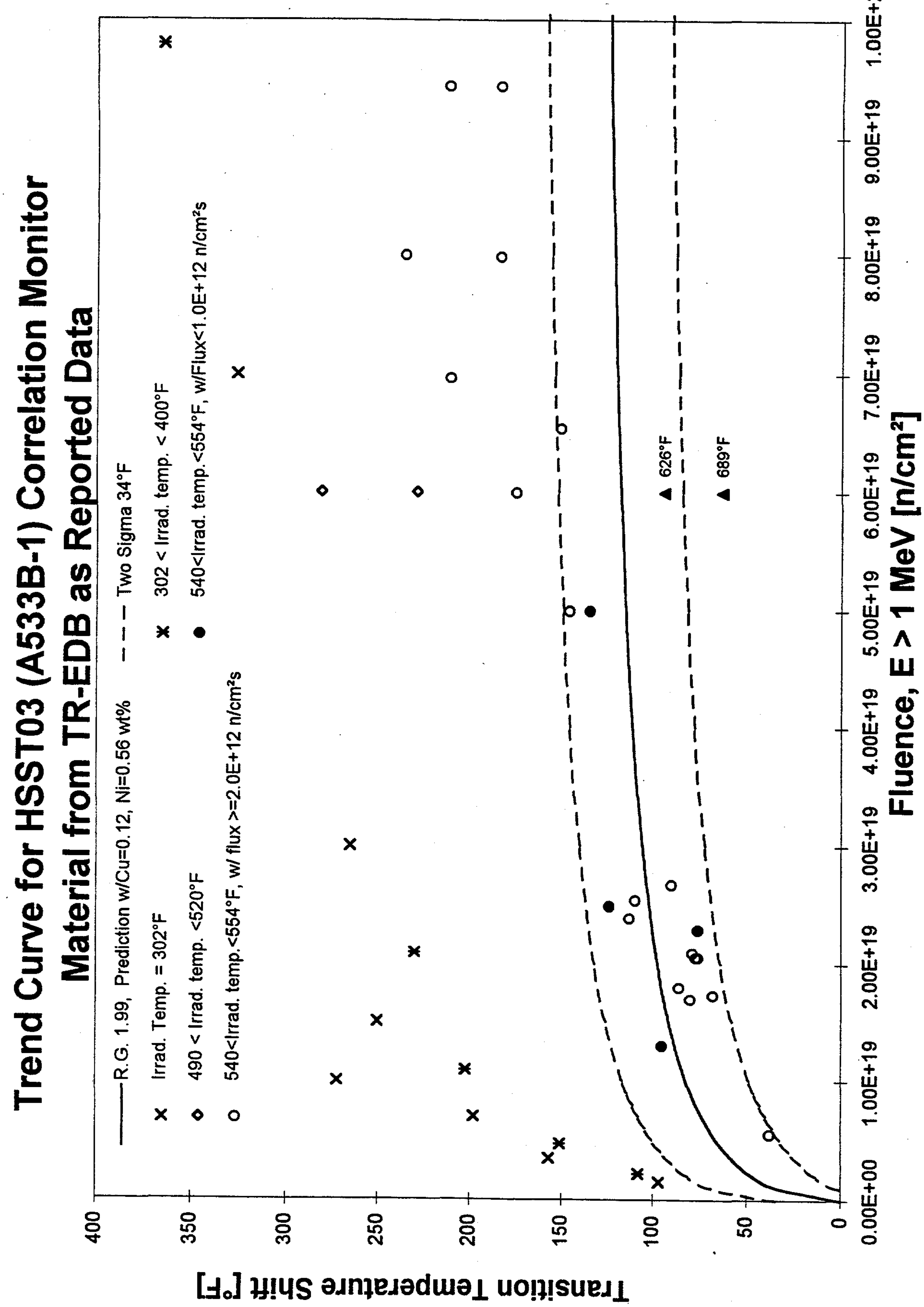


Figure 28 Embrittlement of the HSST03 CMM relative to R.G. 1.99, Rev. 2, prediction

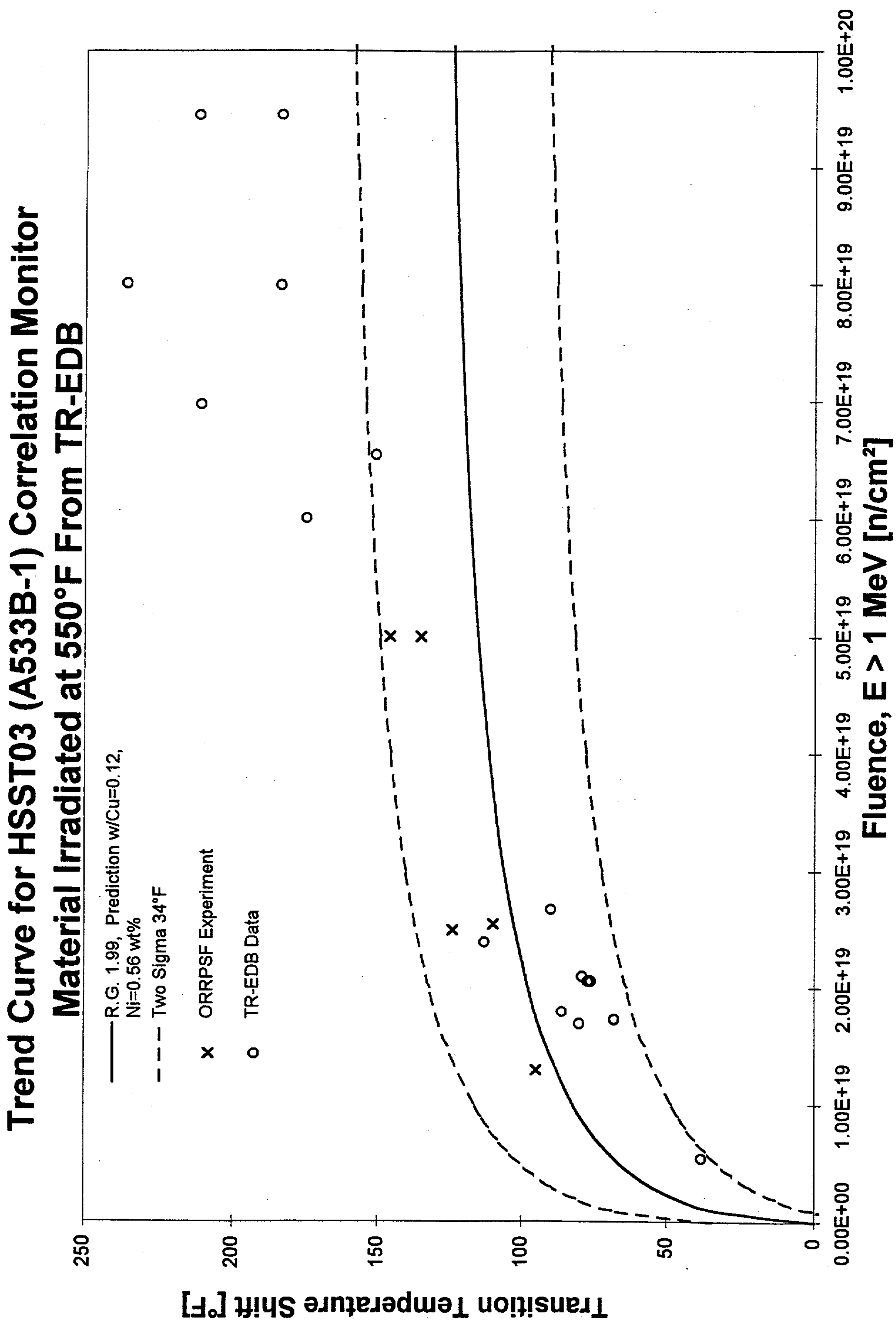


Figure 29 Embrittlement of the HSST03 CMM irradiated at 550°F relative to R.G. 1.99, Rev. 2, prediction

4 CONCLUSIONS

The results from the surveillance capsules show that the trend curves for the A302B (ASTM) and A533B (HSST) CMM closely follow the model of the R.G. 1.99, Rev. 2. Significant scatter is noted in the data, some of which may be attributed to variations from one specimen set to another. The major contributions to the uncertainty of the R.G. 1.99 prediction model and the overall data scatter are from mechanical test results, chemical analysis, irradiation environments, fluence evaluation, and inhomogeneous material properties. Thus in order to improve the prediction model, control of the above-mentioned error sources needs to be improved. Thus properly documented information on mechanical testing procedures, material properties and material history, irradiation environments, reactor power-time history, and neutronic analysis are vital for the development of an embrittlement model. For example, information as to the exact location of the test specimens within the parent material should be provided.

In this report, the data fitting procedure was also demonstrated to be another independent source contributing to the uncertainty. For example, the mean absolute difference between EDB hyperbolic tangent fit results and reported ΔT_{30} for B&W data can be up to 22%. Thus a unified data-fitting procedure is essential to generate consistent results among different laboratories, such as EDB data fitting procedures demonstrated in this report.. When the greater inhomogeneity of specific test sets are known (for example, additional chemical compositions are available for the individual test specimen), further constraints need to be added into the Charpy curve-fitting model, such as copper and nickel contents in addition to the impact energy and test temperature, to account for the material inhomogeneity.

For surveillance data, significant deviations of the measured shift from the trend curve (i.e., more or less than 34 °F for plate materials) should be considered as a warning flag pointing to a possible anomalous capsule environment. The most likely reason for deviations from the trend curve is the capsule temperature; fluence and fluence rate can be determined fairly accurately, and possible effects from these sources are relatively small in a power reactor environment. A quantitative relation between irradiation temperature and ΔT_{30} has been established in the past,[20] based on the nominal capsule temperature determined by the melt wires loaded in the irradiated capsule. This shows that the weld materials are the most sensitive and the forging materials are the least sensitive to the irradiation temperature. However, a more detailed investigation needs to be done on the issue related to the irradiation temperature of surveillance capsules. These effects must be considered if material- and reactor-specific trend curves are established.

The investigation shows that results from CMMs can indeed be used to detect anomalies in the surveillance capsule irradiation. Nominal values for the ΔT_{30} in the CMM for a given fluence can be determined from R.G. 1.99, Rev. 2. Any significant deviation from the trend curve should be investigated as to the possible causes. The exact location of the test samples within the plate should be ascertained, if possible, and variations in the baseline values between samples should be considered. If the material inhomogeneity is a suspect for a particular test set, the detailed chemical compositions from the broken specimens are needed to generate a more accurate embrittlement index from a more realistic curve-fitting model, which incorporates the chemistry constraints into the regression analysis. Influence of irradiation temperature may be inferred from the results of the CMM and should be considered whenever material- and reactor-specific trend curves are to be established.

There is some evidence for a fluence-rate effect in the CMM data irradiated in test reactors. The existence of a fluence-rate effect has important implications for the U.S. commercial power industries, since accelerated locations have almost invariably been used in RPV surveillance programs. For example, the GE surveillance data have a large range of fluxes, ranging from 2.0×10^8 to 4.6×10^{12} n/cm²·s, whereas for B&W data it ranges from 2.4×10^{10} to 9.66×10^{11} n/cm²·s, for CE data, 2.3×10^{10} to 6.31×10^{11} n/cm²·s, and for Westinghouse data (not including Yankee Rowe data)

7.5×10^9 to 2.47×10^{11} n/cm^2·s. Thus, the implication of a fluence-rate effect in a nuclear commercial power reactor environment deserves special attention, especially for GE BWR surveillance data. The current embrittlement models are based on surveillance data without accounting for fluence-rate effects. If the fuence-rate effect is significant over the range of interest, use of surveillance data with a high lead factor may result in a conservative or nonconservative prediction of vessel embrittlement, depending on the particular fluence range. Thus, depending on the lead factor involved, it may be prudent to apply some correction to the surveillance data in application to the prediction of vessel embrittlement. Based on the available data, however, definition of a "high" lead factor and the development of such correction factors are not yet practicable. Additional data from the CMMs irradiated over a range of fluence rates are needed to establish the fluence-rate effects with confidence.

5 REFERENCES

1. L. K. Mansur, “Mechanisms and Kinetics of Radiation Effects in Metals and Alloys,” *Kinetics ofNohomogeneous Processes*, ed. by Gorden R. Freeman, 1987.

2. K. C. Russell, "Phase Stability Under Irradiation," *Progress in Materials Science*, ed. by B. Chalmers, J. Christian, T. B. Massalski, Pergamon Press, Oxford, 1982.

3. G. R. Odette, P. M. Lombrozo, and R. A. Wullaert, "Relationship Between Irradiation Hardening and Embrittlement of Pressure Vessel Steels," *Effects of Radiation on Materials, Twelfth International Symposium*, ASTM STP 870, eds. F. A. Garner and J. S. Perrin, American Society for Testing and Materials, Philadelphia, pp.840-860, 1985.

4. G. E. Lucas, G. R. Odette, P. M. Lombrozo, and J. W. Sheckherd, "Effects of Composition, Microstructure, and Temperature on Irradiation Harding of Pressure Vessel Steels," *Effects of Radiation on Materials, Twelfth International Symposium*, ASTM STP 870, eds. A. Garner, and J. Perrin, American Society for Testing and Materials, Philadelphia, pp. 900-930, 1985.

5. V. N. Shah, W. L. Sever, G. R. Odette, and A. S. Amar, "Residual Life Assessment of Light Water Reactor Pressure Vessels," *Effects of Radiation on Materials*, ASTM STP 1011, pp. 161-175, 1989.

6. F. W. Stallmann, J. A. Wang, F. B. K. Kam, and B. J. Taylor, *PR-EDB: Power Reactor Embrittlement Data Base, Version 2*, NUREG/CR-4816 (ORNL/TM-10328/R2), U.S. Nuclear Regulatory Commission, 1994.

7. F. W. Stallmann, J. A. Wang, and F. B. K. Kam, *TR-EDB: Test Reactor Embrittlement Data Base, Version 1*, NUREG/CR-6076 (ORNL/ TM-12415), U.S. Nuclear Regulatory Commission, 1994.

8. W. Oldfield, “Fitting Curves to Toughness Data,” *ASTM J. Testing and Evaluation* **7(6)** (November 1979).

9. D. Pachur, “Radiation Annealing Mechanisms of Low-Alloy Reactor Pressure Vessel Steels Dependent on Irradiation Temperature and Neutron Fluence,” *Nucl. Technol.* 59, 463-475 (1982).

10. G. Hofer, C. C. Hung, U. Guenews, “A Mathematical Function for Describing the Results of Charpy Impact Tests,” *Zeitscrift Fuer Wekstoffenhnick J. Fo Mat. Tech.* **8(4)**, 109-111 (April 1977).

11. William G. Hood, “Polynomial Curve Fitter,” *Byte*, pp. 155, June 1987.

12. F. W. Stallmann, *Theory and Practice of General Adjustment and Model Fitting Procedures*, NUREG/CR-2222 (ORNL/TM-7896), U.S. Nuclear Regulatory Commission, December 1981.

13. Pryor N. Randall, “Basis for Revision 2 of the U.S. Nuclear Regulatory Commission’‘s Regulatory Guide 199,” *Radiation Embrittlement of Nuclear Reactor Pressure Vessel Steels: An International Review (Second Volume)*, ASTM STP 909, L.E. Steele, Ed., pp. 149-162, 1986.

14. G. L. Guthrie, “Charpy Trend Curves Based on 177 PWR Data Points,” *LWR Pressure Vessel Surveillance Dosimetry Improvement Program, Quarterly Report April 1983-June 1983*, NUREG/CR-3391, Vol. 2, (HEDL-TME 83-22), U.S. Nuclear Regulatory Commission, April 1984.

15. G. R. Odette, P. M. Lombrozo, J. F. Perrin, and R. A. Wullaert, *Physical Based Regression Correlations of Embrittlement Data from Reactor Pressure Vessel Surveillance Programs,* EPRI NP-3319, Electric Power Research Institute, January 1984.

16. W. N. McElroy, Ed., *LWR Pressure Vessel Surveillance Dosimetry Improvement Program: LWR Power Reactor Surveillance Physics-Dosimetry Data Base Compendium*, NUREG/CR-3319 (HEDL-TME 85-3), U.S. Nuclear Regulatory Commission, August 1985.

17. W. Oldfield, P. McConnell, W. Server, and E. Oldfield, *Irradiated Nuclear Pressure Vessel Steel Data Base*, EPRI NP 2428, Electric Power Research Institute, June 1982.

18. Pierre Petrequin, *Irradiation Embrittlement of Pressure Vessel Steels: A Review of Activities in France*, ASTM STP 819, pp. 29-52, 1983.

19. C. Guionnet, B. Houssin, D. Brasseur, A., Lefort, D. Gros, and R. Perdreau, *Radiation Embrittlement of PWR Reactor Vessel Weld Metals: Nickel and Copper Synergism Effects*, ASTM STP 782, H.B. Brager and J. S. Perrin Eds., pp. 392-411, 1982.

20. F. W. Stallmann, *Analysis of the A302B and A533B Standard Reference Materials in Surveillance Capsules of Commercial Power Reactors*," NUREG/CR-4947 (ORNL/TM-10459), U.S. Nuclear Regulatory Commission, January 1988.

21. W. N. McElroy, R. Gold, R. L. Simons, and J. H. Roberts, "Trend Curve Data Development and Testing," *Influence of Radiation on Material Properties: 13th International Symposium*, ASTM STP 956, F. A. Garner, C. H. Henager, and N. Igata, Eds., American Society for Testing and Materials, Philadelphia, 1987, pp. 505-534.

22. R. L. Simons, "Damage Rate and Spectrum Effects in Ferritic Steel ΔNDTT Data," *Influence of Radiation on Material Properties: 13th International Symposium*, ASTM STP 956, F. A. Garner, C. H. Henager, and N. Igata, Eds., American Society for Testing and Materials, Philadelphia, 1987, pp. 535-551.

23. J. R. Hawthorne, B. K. Menke, *Light Water Reactor Pressure Vessel Surveillance Dosimetry Improvement Program: Postirradiation Notch Ductility and Tensile Strength Determinations for PSF Simulated Surveillance and Through-Wall Specimen Capsules*, NUREG/CR-3295 (MEA-2017), U.S. Nuclear Regulatory Commission, April 1984.

24. G. R. Odette, E. V. Mader, G. E. Lucas, W. J. Phythian, C. A. English, "The Effect of Flux on the Irradiation Hardening of Pressure Vessel Steels," *Effects of Radiation on Materials: 16th International Symposium*, ASTM STP 1175, A. S. Kumar, D. S. Gelles, R. K. Nanstad, and E. A. Litle, Eds., American Society for Testing and Materials, Philadelphia, 1993, pp. 373-393.

25. J. A. Wang, F. B. K. Kam, F. W. Stallmann, "The Embrittlement Data Base (EDB) and Its Applications," *Effects of Radiation on Materials: 17th Symposium*, ASTM STP 1270, David S. Gelles, Randy K. Nanstad, Arvind S. Kumar, and Edward A. Little, Editors, American Society for Testing and Materials, Philadelphia, 1996.

APPENDIX A

HYPERBOLIC TANGENT FITS AND UNCERTAINTY STUDY FOR A302B AND A533B SURVEILLANCE REFERENCE MATERIALS

In this appendix, CMM is referred to as reference material.

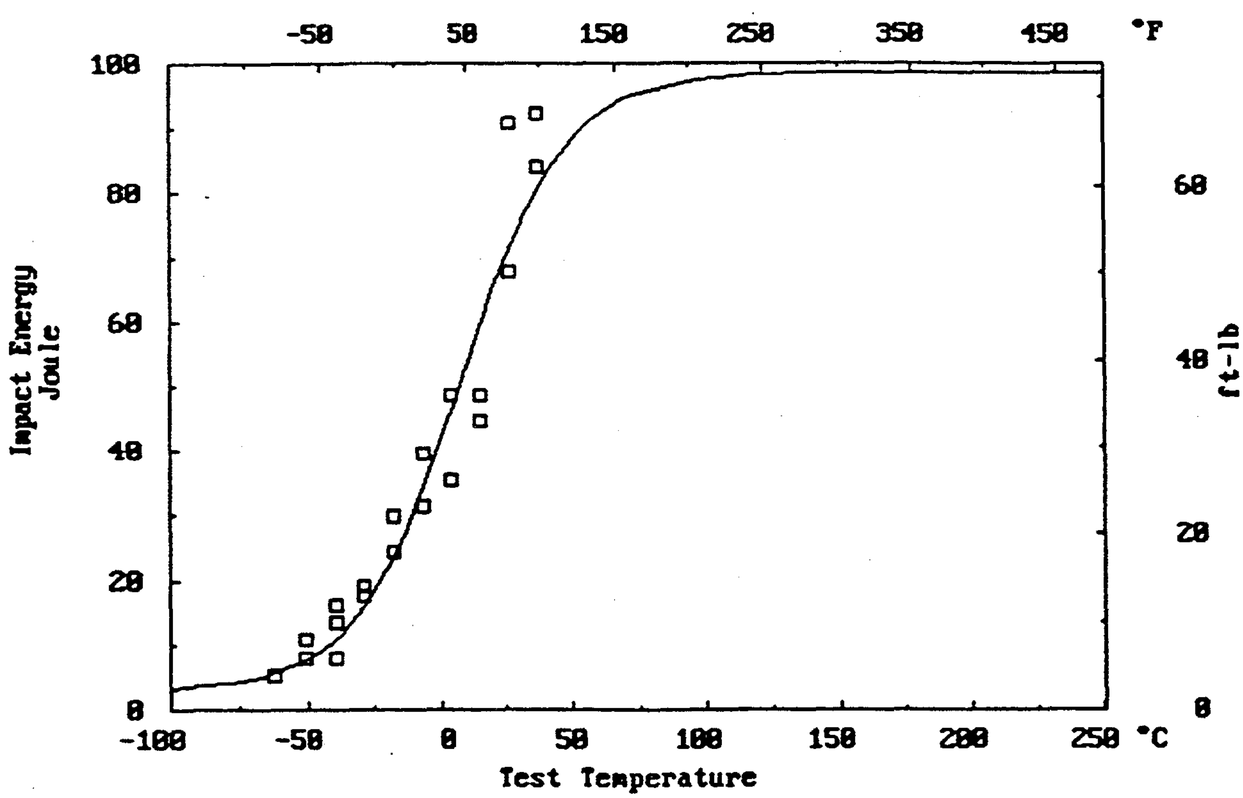
A302B REFERENCE MATERIAL, Baseline (Longitudinal Direction)

USE= 98.8 J, LSE= 3.1 J, CVT(1/2)= 8.C , Slope = 0.0250
Unirradiated Charpy Specimen, CVT(41J) = 0. C , CVT(68J) = 23. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
	-62.	-80.	5.	4.	0.15	6.	2.
	-62.	-80.	5.	4.	0.15	6.	2.
	-51.	-60.	11.	8.	0.15	6.	3.
	-51.	-60.	8.	6.	0.15	6.	3.
	-40.	-40.	16.	12.	0.36	14.	10.
	-40.	-40.	14.	10.	0.25	10.	5.
	-40.	-40.	8.	6.	0.18	7.	5.
	-29.	-20.	19.	14.	0.36	14.	15.
	-29.	-20.	18.	13.	0.36	14.	15.
	-18.	0.	30.	22.	0.56	22.	30.
	-18.	0.	24.	18.	0.46	18.	25.
	-7.	20.	39.	29.	0.71	28.	35.
	-7.	20.	31.	23.	0.58	23.	35.
	4.	40.	49.	36.	0.84	33.	45.
	4.	40.	35.	26.	0.66	26.	45.
	16.	60.	49.	36.	1.02	40.	50.
	16.	60.	45.	33.	0.89	35.	45.
	27.	80.	91.	67.	1.52	60.	100.
	27.	80.	68.	50.	1.22	48.	70.
	38.	100.	92.	68.	1.52	60.	98.
	38.	100.	84.	62.	1.47	58.	85.

A302B Reference Material

SASTM Baseline LT



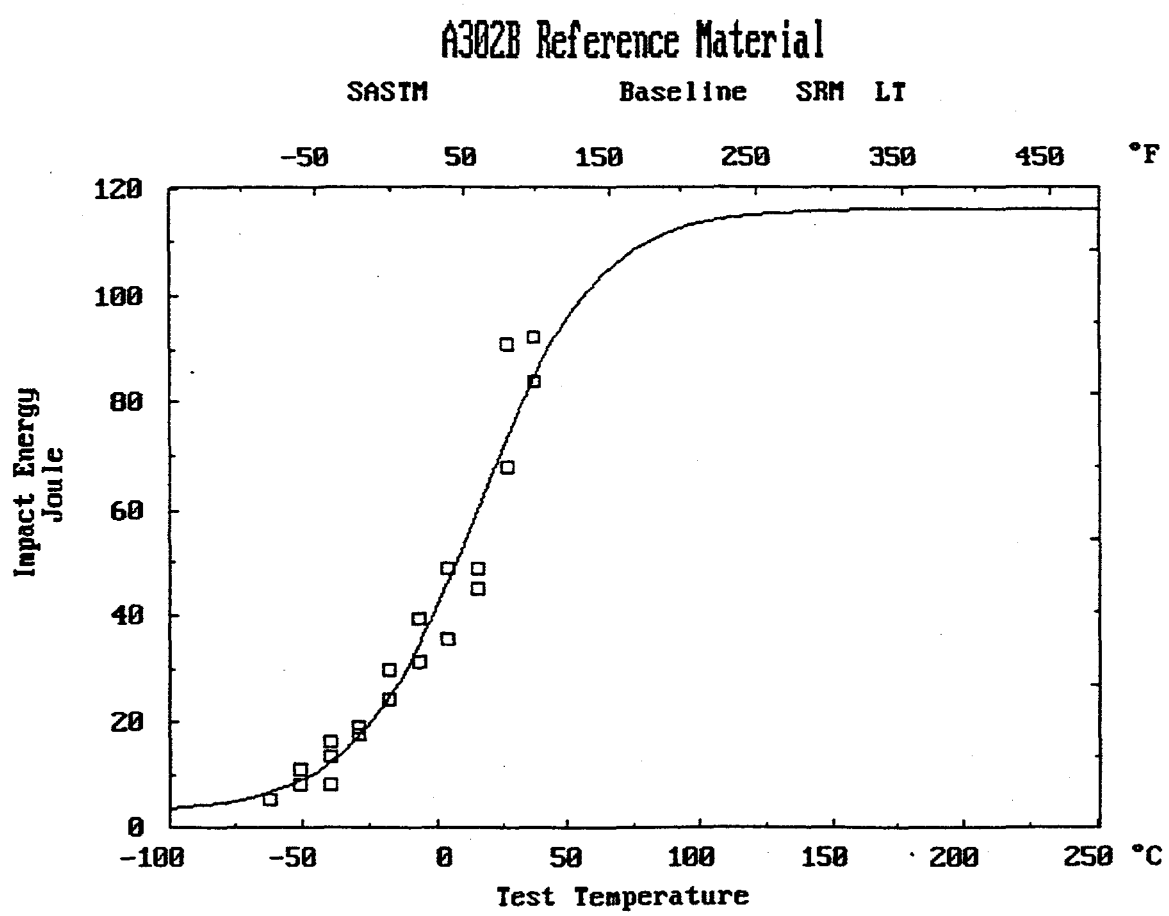
A302B REFERENCE MATERIAL

Baseline (Longitudinal Direction)

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SASTM Baseline SRM LT

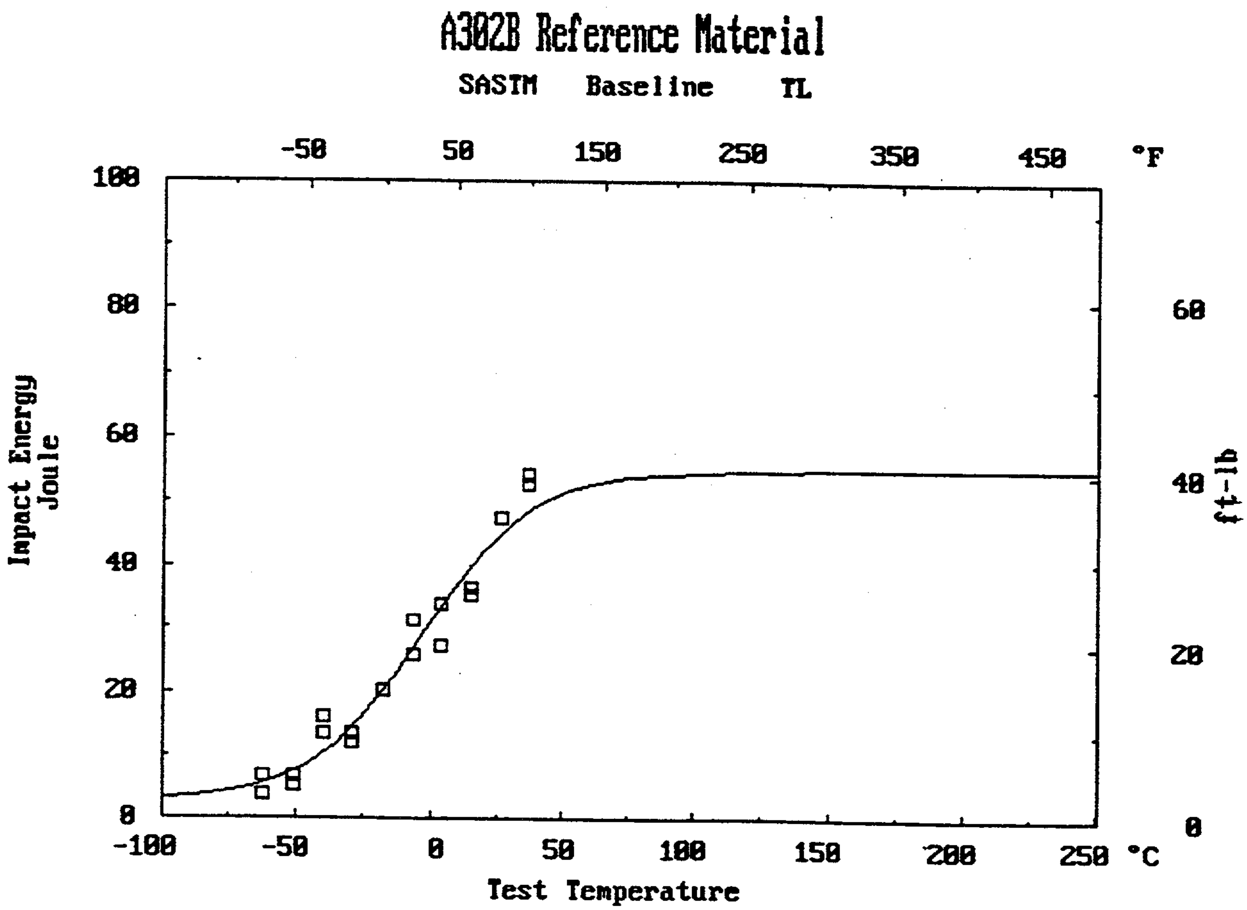
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	116.1	21.5	0.105				
CVT at Midpoint (C)	15.5	9.6	0.118	0.951			
1/slope (C)	45.5	7.0	-0.239	0.615	0.650		
CVT at 41 Joule (C)	0.3	3.3	0.289	0.381	0.582	-0.026	
CVT at 68 Joule (C)	23.6	3.6	-0.097	-0.094	0.164	0.317	0.508



A302B REFERENCE MATERIAL, Baseline (Transverse Direction)

USE= 55.1 J, LSE= 3.0 J, CVT(1/2)= -3.C , Slope = 0.0244
Unirradiated Charpy Specimen, CVT(41J) = 18. C , CVT(68J) =****** C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
	-62.	-80.	4.	3.	0.15	6.	2.
	-62.	-80.	7.	5.	0.18	7.	2.
	-51.	-60.	5.	4.	0.15	6.	3.
	-51.	-60.	7.	5.	0.18	7.	3.
	-40.	-40.	14.	10.	0.25	10.	5.
	-40.	-40.	16.	12.	0.30	12.	10.
	-29.	-20.	12.	9.	0.30	12.	20.
	-29.	-20.	14.	10.	0.30	12.	20.
	-18.	0.	20.	15.	0.41	16.	25.
	-18.	0.	20.	15.	0.43	17.	25.
	-7.	20.	26.	19.	0.51	20.	40.
	-7.	20.	31.	23.	0.66	26.	40.
	4.	40.	27.	20.	0.76	30.	45.
	4.	40.	34.	25.	0.79	31.	45.
	16.	60.	35.	26.	0.74	29.	60.
	16.	60.	37.	27.	0.74	29.	70.
	27.	80.	47.	35.	0.94	37.	70.
	27.	80.	47.	35.	1.02	40.	85.
	38.	100.	53.	39.	1.07	42.	98.
	38.	100.	54.	40.	1.17	46.	100.



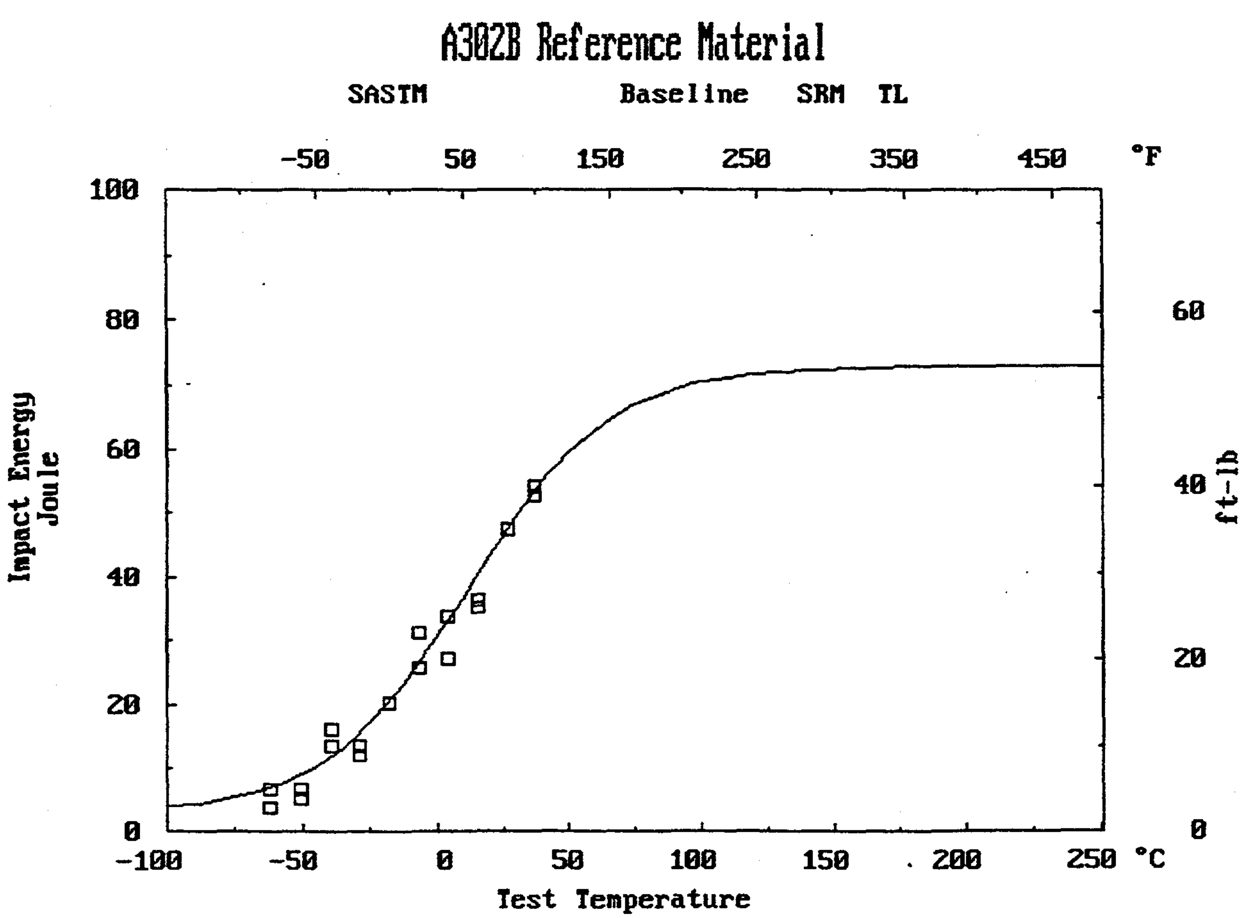
A302B REFERENCE MATERIAL

Baseline (Transverse Direction)

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

SASTM Baseline SRM TL

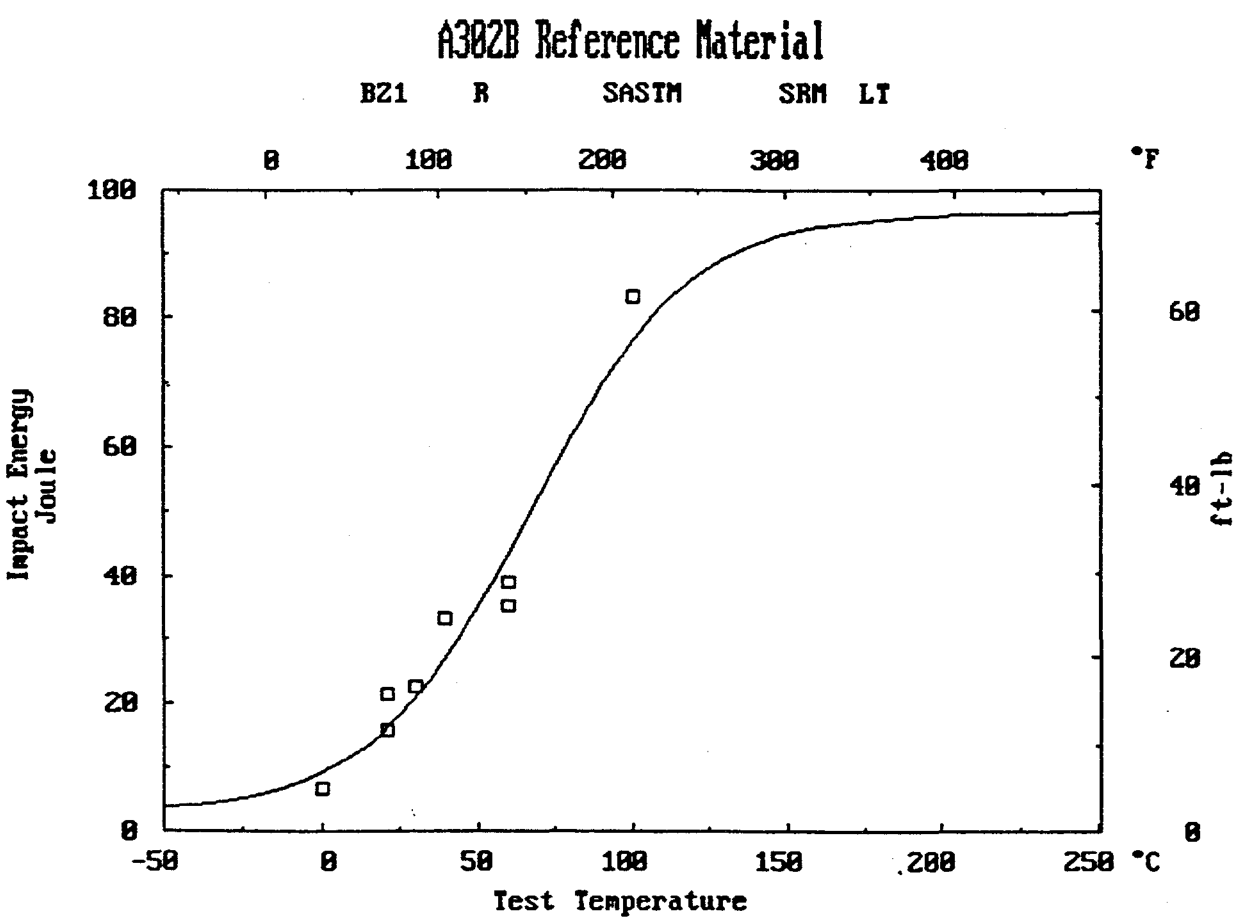
Parameter	Mean	Std.Dev.	Correlation Coefficients			
Lower Shelf Energy (J)	3.0	0.0				
Upper Shelf Energy (J)	72.9	14.7	0.206			
CVT at Midpoint (C)	11.8	12.8	0.222	0.919		
1/slope (C)	53.5	12.6	-0.160	0.498	0.548	
CVT at 41 Joule (C)	17.8	5.5	-0.038	0.023	0.340	0.425



A302B REFERENCE MATERIAL
Beznau Unit 1, Capsule R

USE= 96.6 J, LSE= 3.0 J, CVT(1/2)= 67.C , Slope = 0.0197
CVT(41J) = 57. C , CVT(68J) = 88. C ,
Fluence = 5.720E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R14	0.	32.	7.	5.	0.20	8.	3.
R13	21.	70.	21.	16.	0.43	17.	17.
R9	21.	70.	16.	12.	0.28	11.	15.
R15	30.	86.	23.	17.	0.48	19.	19.
R16	40.	104.	33.	25.	0.69	27.	32.
R10	60.	140.	39.	29.	0.63	25.	37.
R12	60.	140.	35.	26.	0.63	25.	31.
R11	100.	212.	83.	62.	1.32	52.	100.



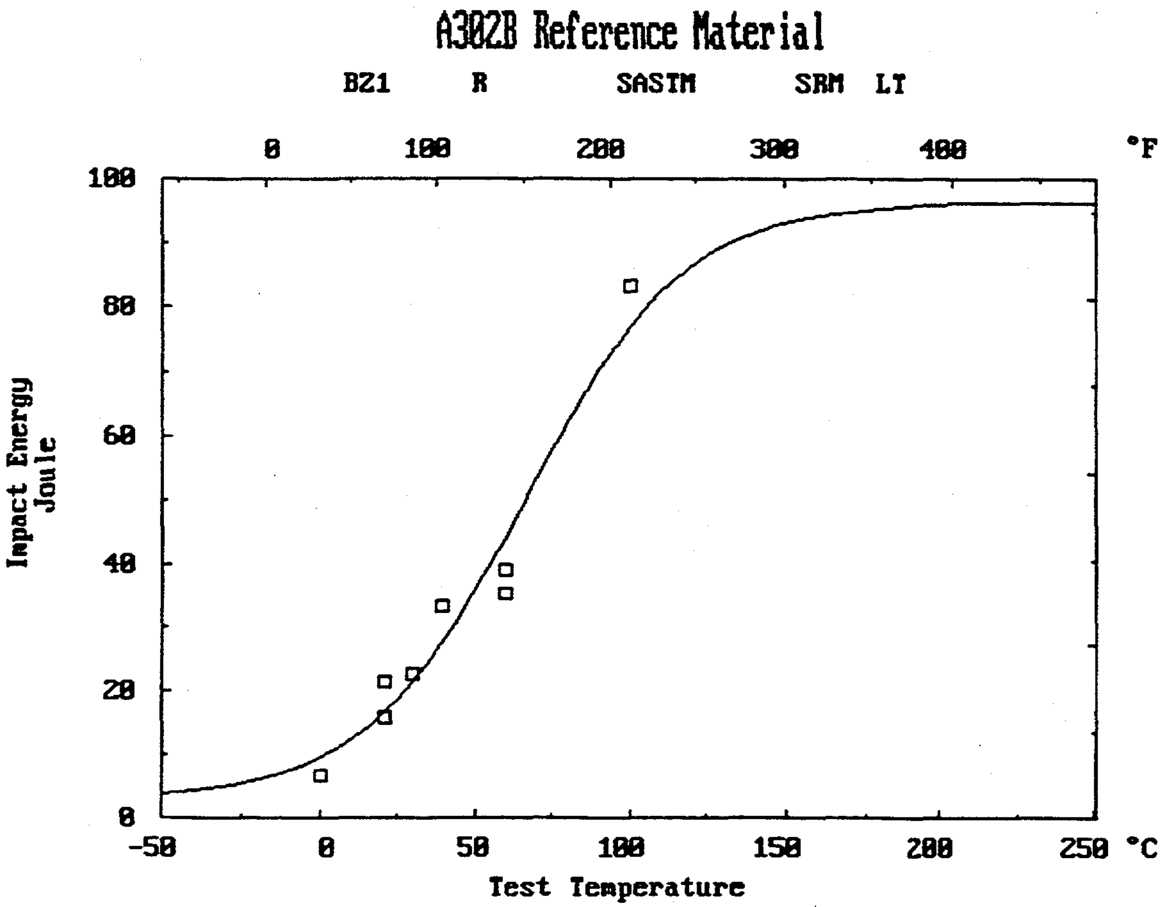
A302B REFERENCE MATERIAL

Beznau Unit 1, Capsule R

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

BZ1 R SASTM SRM LT : Fluence = 5.720E+18 , Irr. Temp. = 288

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	96.6	13.8	0.480				
CVT at Midpoint (C)	66.1	8.1	0.599	0.661			
1/slope (C)	51.0	10.9	-0.085	-0.034	0.089		
CVT at 41 Joule (C)	57.3	6.4	0.343	-0.163	0.579	-0.091	
CVT at 68 Joule (C)	91.5	16.5	-0.130	-0.643	-0.129	0.458	0.504

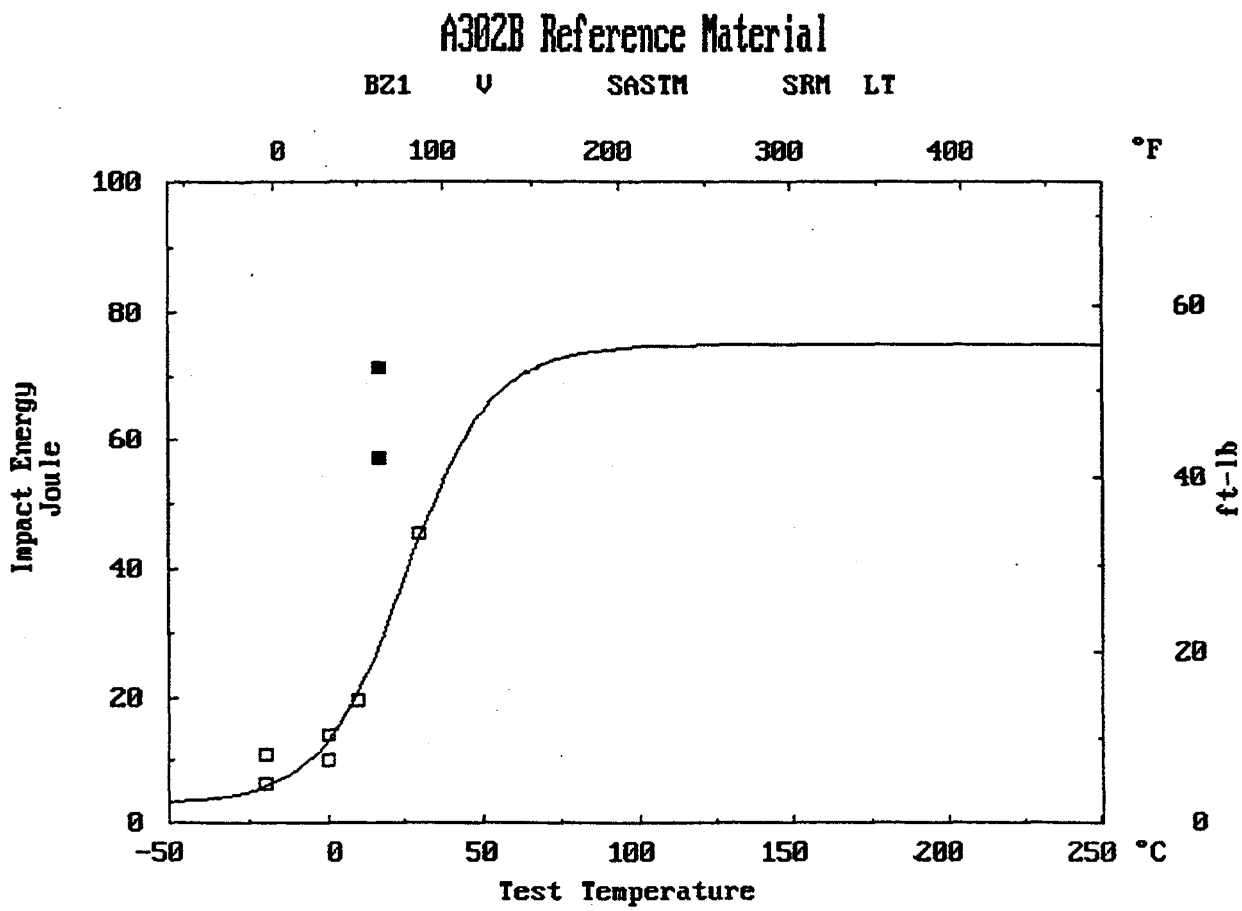


A302B REFERENCE MATERIAL
Beznau Unit 1, Capsule V

USE= 75.1 J, LSE= 3.0 J, CVT(1/2)= 26.C , Slope = 0.0357
CVT(41J) = 27. C , CVT(68J) = 57. C ,
Fluence = 2.770E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R5	0.	32.	14.	10.	0.28	11.	
R6	0.	32.	10.	8.	0.30	12.	
R8	10.	50.	20.	14.	0.38	15.	
*R1	17.	62.	57.	42.	0.51	20.	
*R2	17.	62.	71.	53.	0.41	16.	
R7	30.	86.	45.	33.	0.74	29.	
R3	-20.	-4.	11.	8.	0.18	7.	
R4	-20.	-4.	6.	5.	0.13	5.	

** The initial USE is assigned as 53 ft-lb.



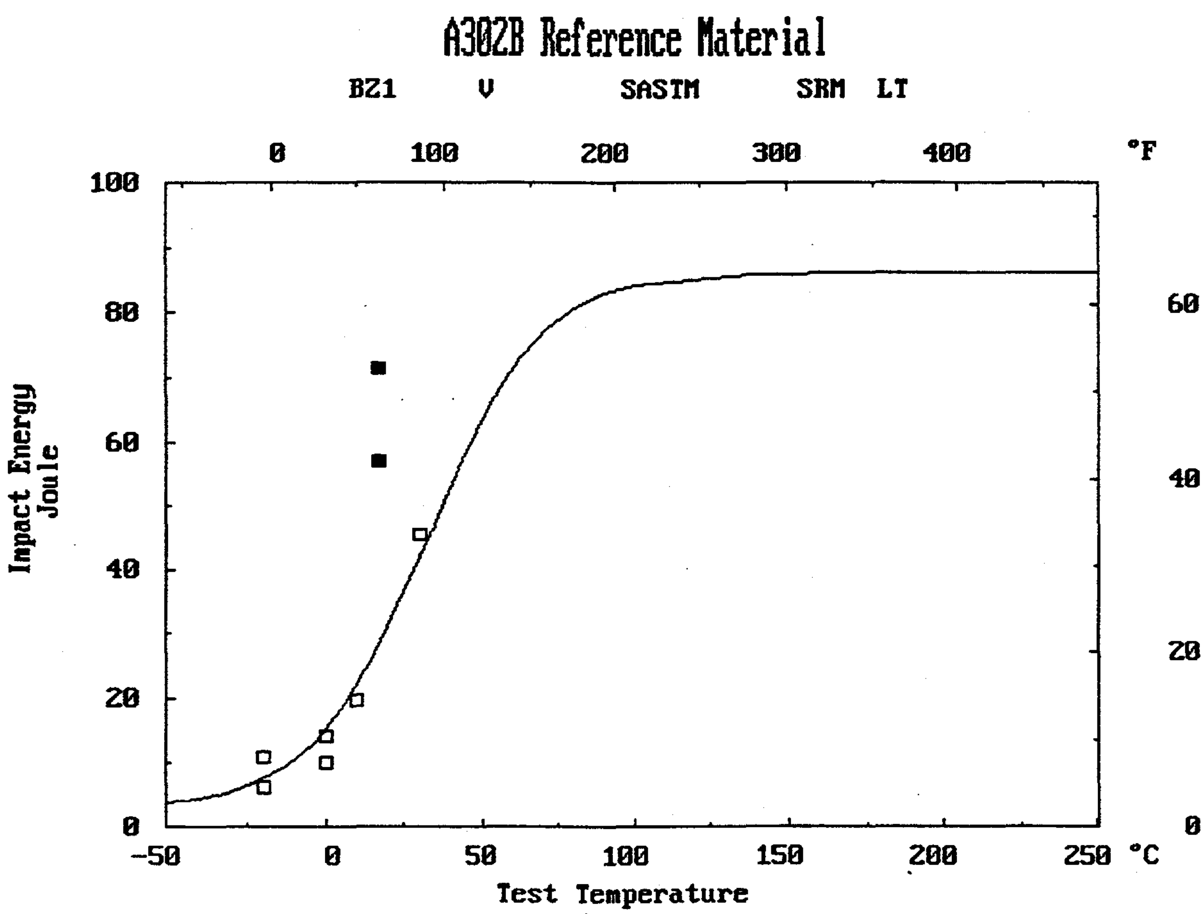
A302B REFERENCE MATERIAL

Beznau Unit 1, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
BZ1   V     SASTM     SRM  LT : Fluence = 2.770E+18 , Irr. Temp. =  288
```

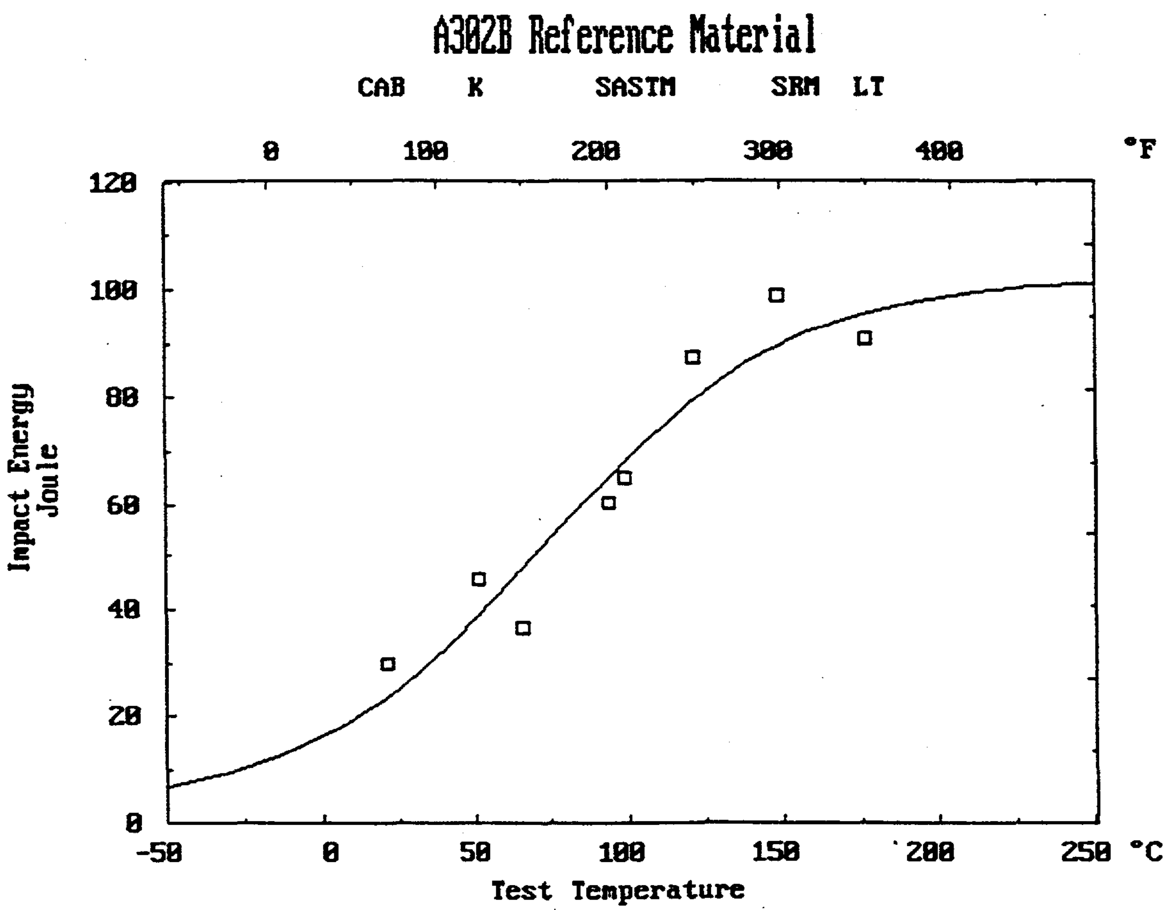
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	86.2	12.6	0.110				
CVT at Midpoint (C)	32.2	9.2	0.075	0.672			
1/slope (C)	36.2	11.0	-0.182	0.352	0.587		
CVT at 41 Joule (C)	29.2	6.8	0.037	0.134	0.806	0.435	
CVT at 68 Joule (C)	58.8	15.5	-0.143	-0.298	0.335	0.601	0.685



A302B REFERENCE MATERIAL
Jose Cabrera-Zorita, Capsule K

USE= 102.1 J, LSE= 3.0 J, CVT(1/2)= 73.C , Slope = 0.0130
CVT(41J) = 55. C , CVT(68J) = 98. C ,
Fluence = 1.400E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R57	21.	70.	30.	22.	0.46	18.	20.
R60	52.	125.	45.	33.	0.63	25.	35.
R62	66.	150.	37.	27.	0.66	26.	30.
R58	93.	200.	60.	44.	0.99	39.	60.
R59	99.	210.	65.	48.	1.12	44.	85.
R63	121.	250.	87.	64.	1.19	47.	100.
R64	149.	300.	99.	73.	1.37	54.	100.
R61	177.	350.	91.	67.	1.32	52.	100.



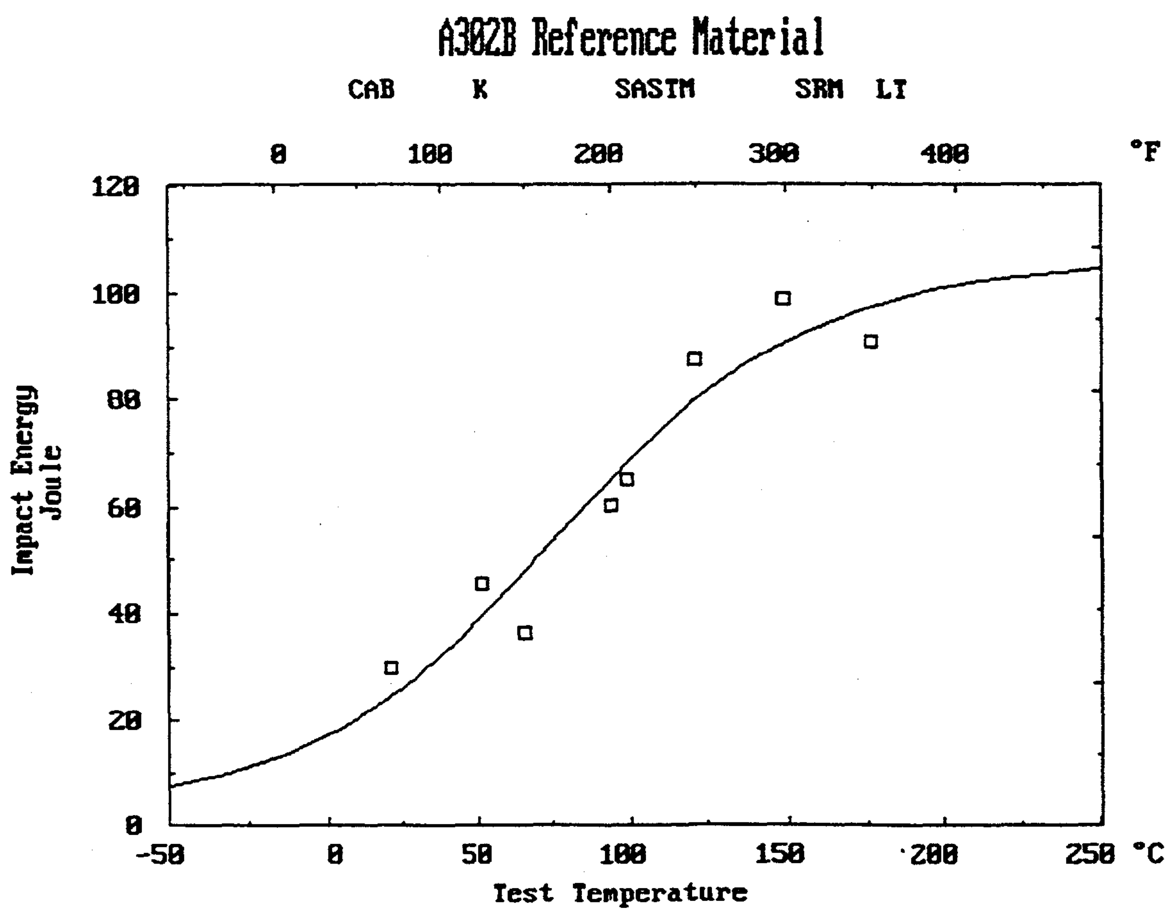
A302B REFERENCE MATERIAL

Jose Cabrera-Zorita, Capsule K

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000

CAB   K     SASTM     SRM  LT : Fluence = 1.400E+19 , Irr. Temp. =  304
```

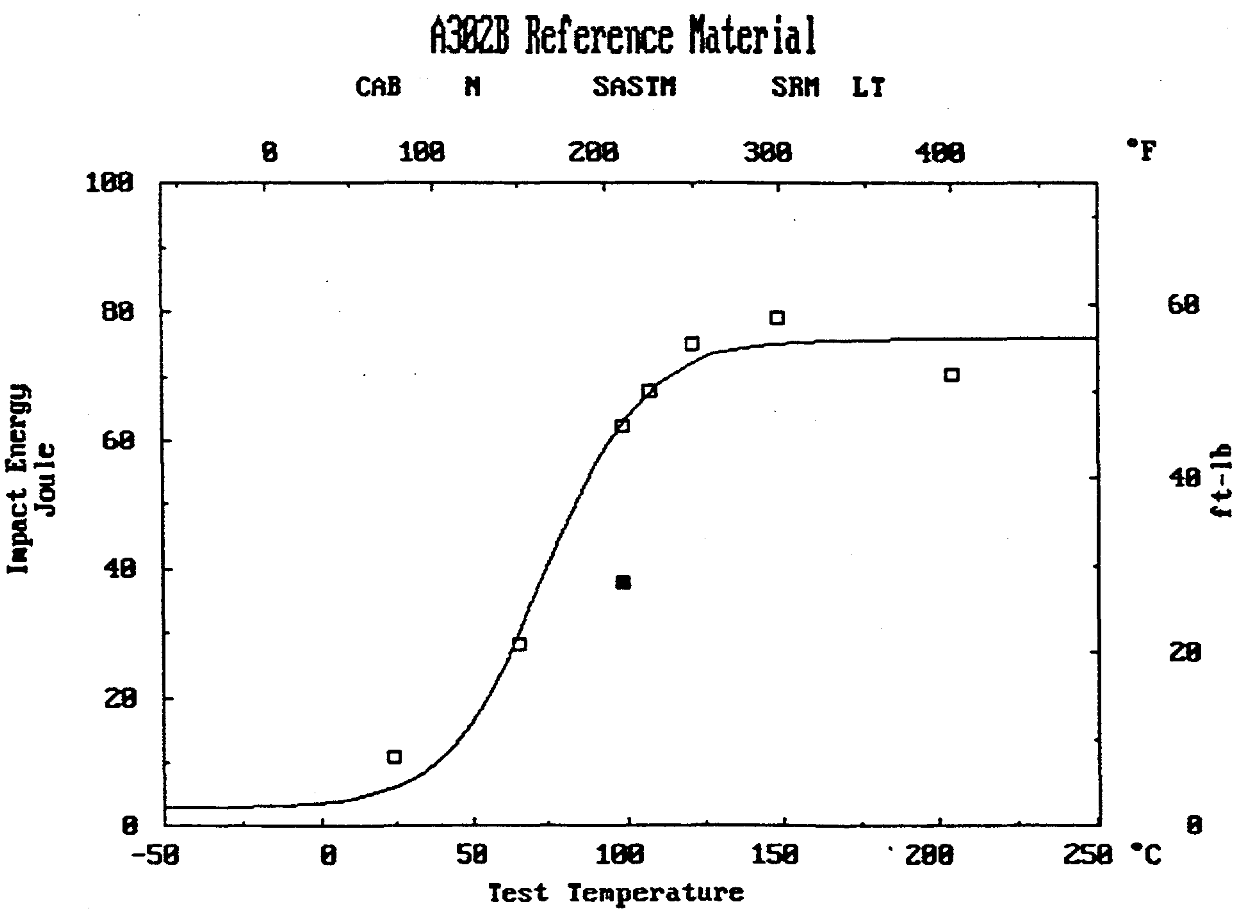
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	105.8	13.5	0.157				
CVT at Midpoint (C)	76.1	15.4	0.330	0.818			
1/slope (C)	82.3	22.4	-0.250	0.615	0.374		
CVT at 41 Joule (C)	53.6	11.1	0.481	-0.014	0.499	-0.541	
CVT at 68 Joule (C)	98.6	8.6	0.132	0.121	0.563	0.265	0.531



A302B REFERENCE MATERIAL
Jose Cabrera-Zorita, Capsule N

USE= 76.0 J, LSE= 3.0 J, CVT(1/2)= 74.C , Slope = 0.0313
CVT(41J) = 76. C , CVT(68J) = 108. C ,
Fluence = 3.680E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	F	Impact Energy J	ft-lb	Lat. Exp. mm	mil	% Shear
R47	24.	76.	11.	8.	0.28	11.	5.
R46	66.	150.	28.	21.	0.56	22.	21.
R41	99.	210.	62.	46.	1.02	40.	78.
*R48	99.	210.	38.	28.	0.51	20.	48.
R43	107.	225.	68.	50.	1.42	56.	94.
R45	121.	250.	75.	55.	1.45	57.	100.
R42	149.	300.	79.	58.	1.40	55.	100.
R44	204.	400.	70.	52.	1.47	58.	100.



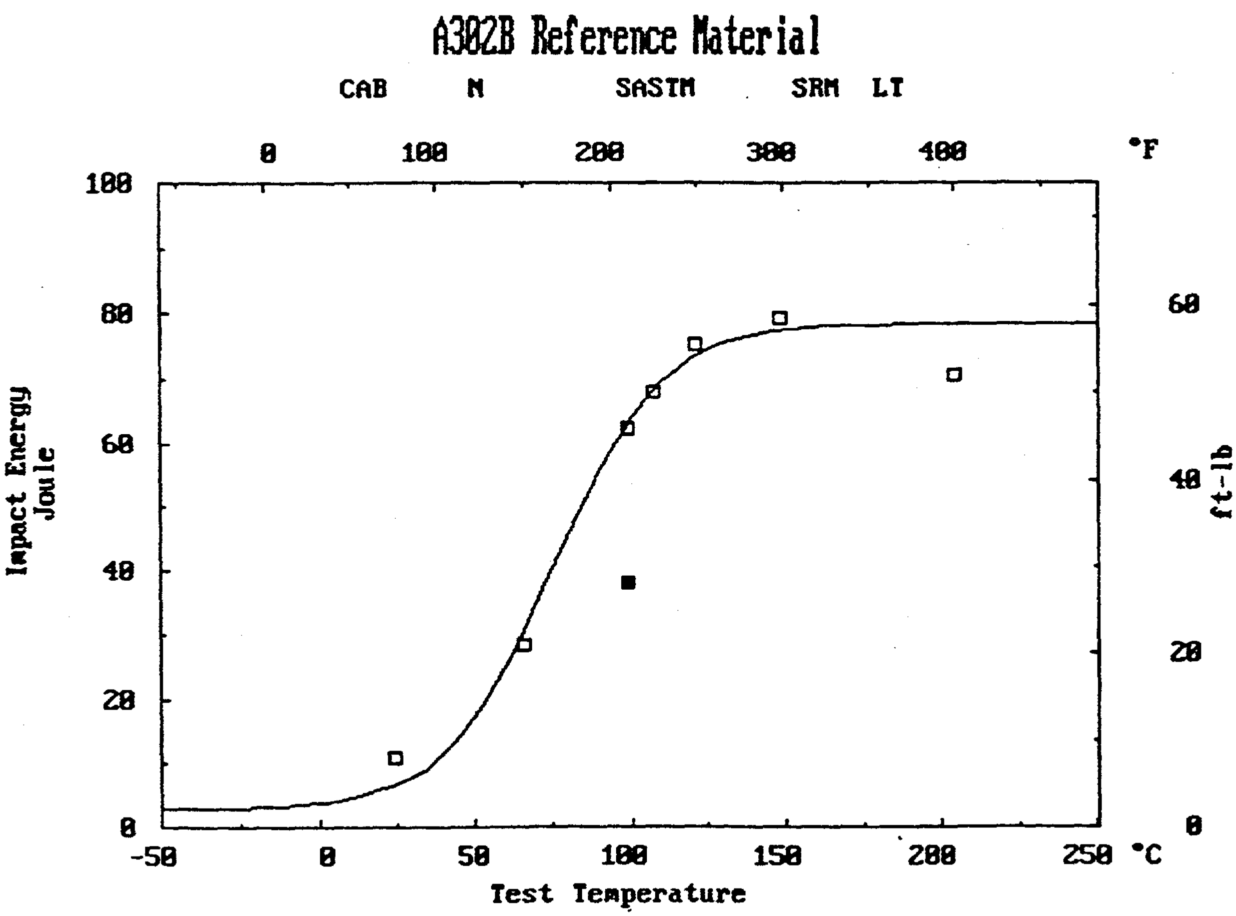
A302B REFERENCE MATERIAL

Jose Cabrera-Zorita, Capsule N

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =    4.0 Degree C
Number of Successful Iterations =   200, Maximum = 1000
```

CAB N SASTM SRM LT : Fluence = 3.680E+19 , Irr. Temp. = 304

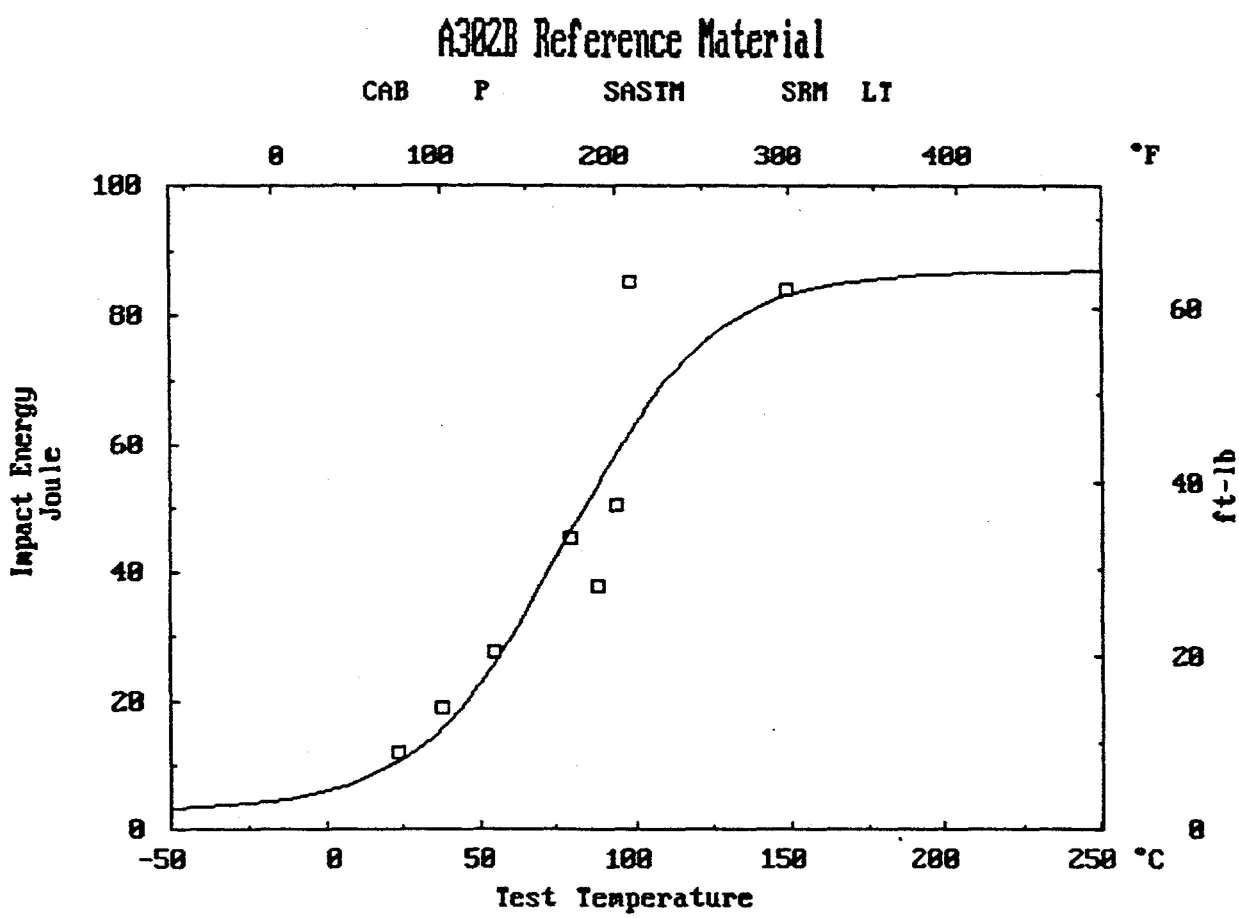
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	78.3	5.4	-0.094				
CVT at Midpoint (C)	75.3	9.3	0.283	0.371			
1/slope (C)	34.0	10.6	-0.182	0.385	-0.136		
CVT at 41 Joule (C)	75.4	8.6	0.316	0.095	0.956	-0.260	
CVT at 68 Joule (C)	108.0	11.3	0.117	-0.226	0.381	0.453	0.489



A302B REFERENCE MATERIAL
Jose Cabrera-Zorita, Capsule P

USE= 87.0 J, LSE= 3.0 J, CVT(1/2)= 78.C , Slope = 0.0215
CVT(41J) = 73. C , CVT(68J) = 106. C ,
Fluence = 1.430E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R13	23.	74.	12.	9.	0.10	4.	5.
R16	38.	100.	19.	14.	0.30	12.	20.
R12	54.	130.	28.	20.	0.36	14.	25.
R14	79.	175.	45.	33.	0.76	30.	40.
R9	88.	190.	38.	28.	0.66	26.	40.
R10	93.	200.	51.	37.	0.81	32.	60.
R11	98.	209.	85.	63.	1.12	44.	100.
R15	149.	300.	84.	62.	1.32	52.	100.



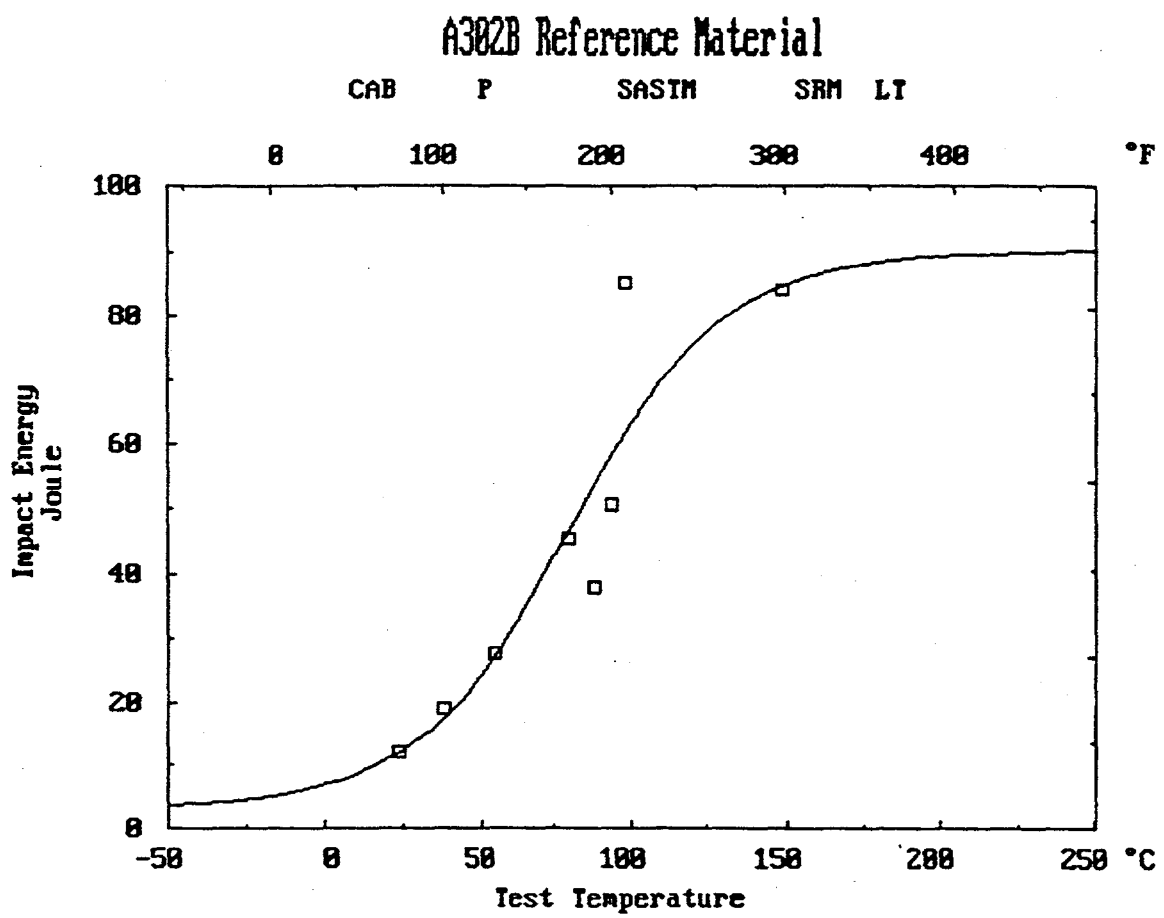
A302B REFERENCE MATERIAL

Jose Cabrera-Zorita, Capsule P

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

CAB P SASTM SRM LT : Fluence = 1.430E+19 , Irr. Temp. = 304

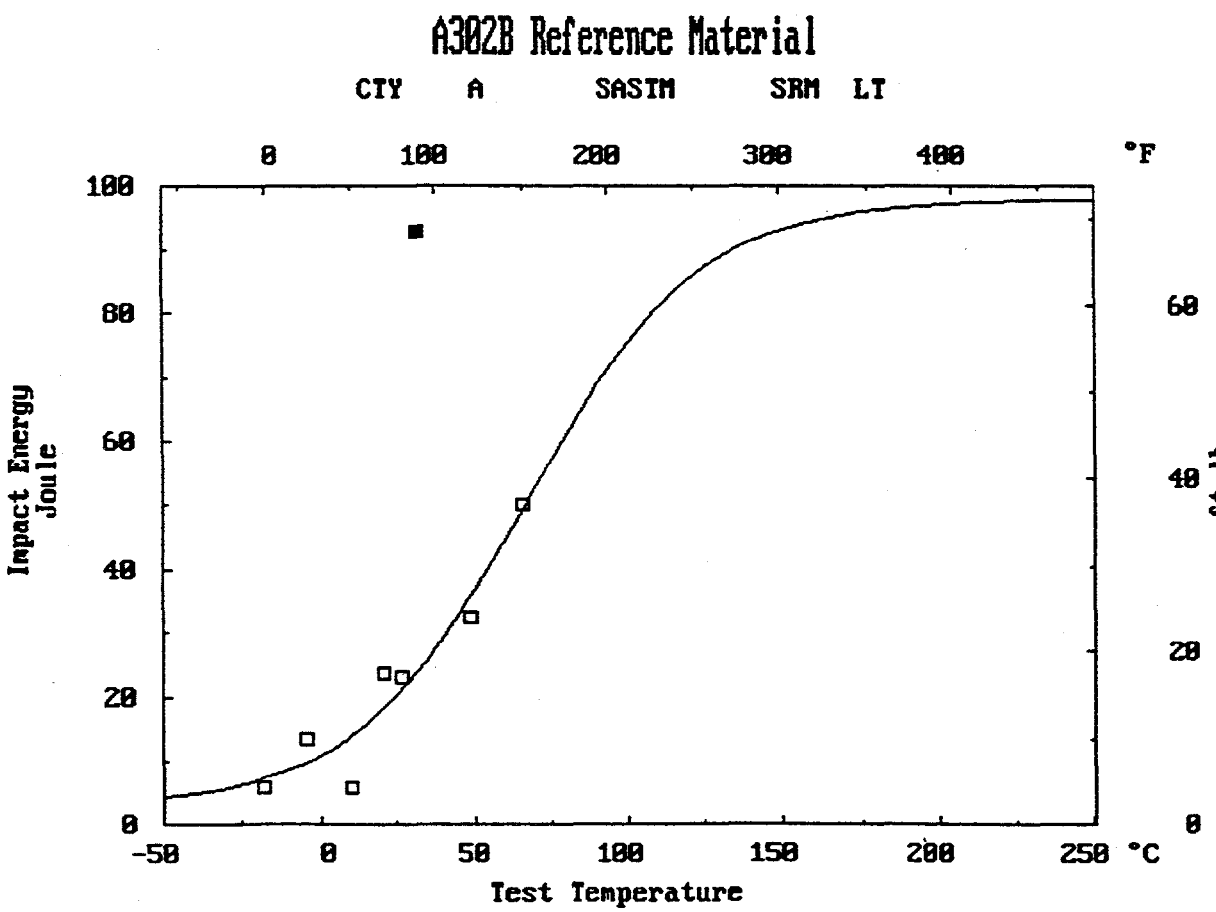
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	90.3	11.4	0.106				
CVT at Midpoint (C)	79.6	9.5	0.173	0.746			
1/slope (C)	51.1	14.8	-0.211	0.384	0.202		
CVT at 41 Joule (C)	73.0	6.7	0.220	0.024	0.646	-0.332	
CVT at 68 Joule (C)	109.5	12.2	-0.137	-0.392	-0.049	0.439	0.238



A302B REFERENCE MATERIAL
Haddam Neck, Capsule A

USE= 98.0 J, LSE= 3.0 J, CVT(1/2)= 67.C , Slope = 0.0178
CVT(41J) = 56. C , CVT(68J) = 89. C ,
Fluence = 2.070E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R44	-18.	0.	6.	4.	0.10	4.	0.
R42	-4.	25.	14.	10.	0.25	10.	5.
R46	10.	50.	6.	4.	0.15	6.	0.
R47	21.	70.	24.	17.	0.48	19.	5.
R41	27.	80.	23.	17.	0.46	18.	5.
*R43	32.	90.	93.	68.	1.22	48.	100.
R45	49.	120.	33.	24.	0.61	24.	40.
R48	66.	150.	50.	37.	1.02	40.	60.



A302B REFERENCE MATERIAL

Haddam Neck, Capsule A

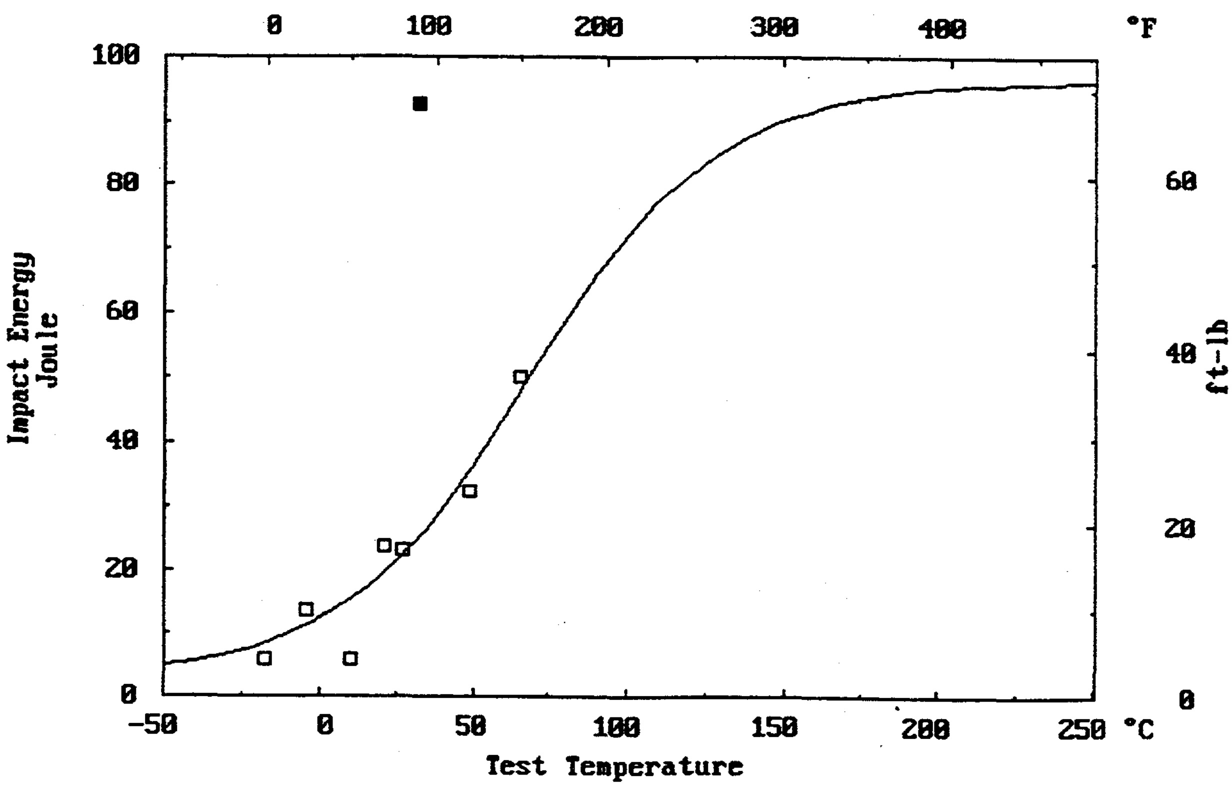
```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CTY A SASTM SRM LT : Fluence = 2.070E+18 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	96.7	11.0	0.180				
CVT at Midpoint (C)	68.4	14.2	0.199	0.664			
1/slope (C)	61.8	19.5	0.059	0.359	0.718		
CVT at 41 Joule (C)	56.5	8.8	0.157	0.202	0.816	0.457	
CVT at 68 Joule (C)	94.8	16.9	0.044	-0.037	0.656	0.800	0.760

A302B Reference Material

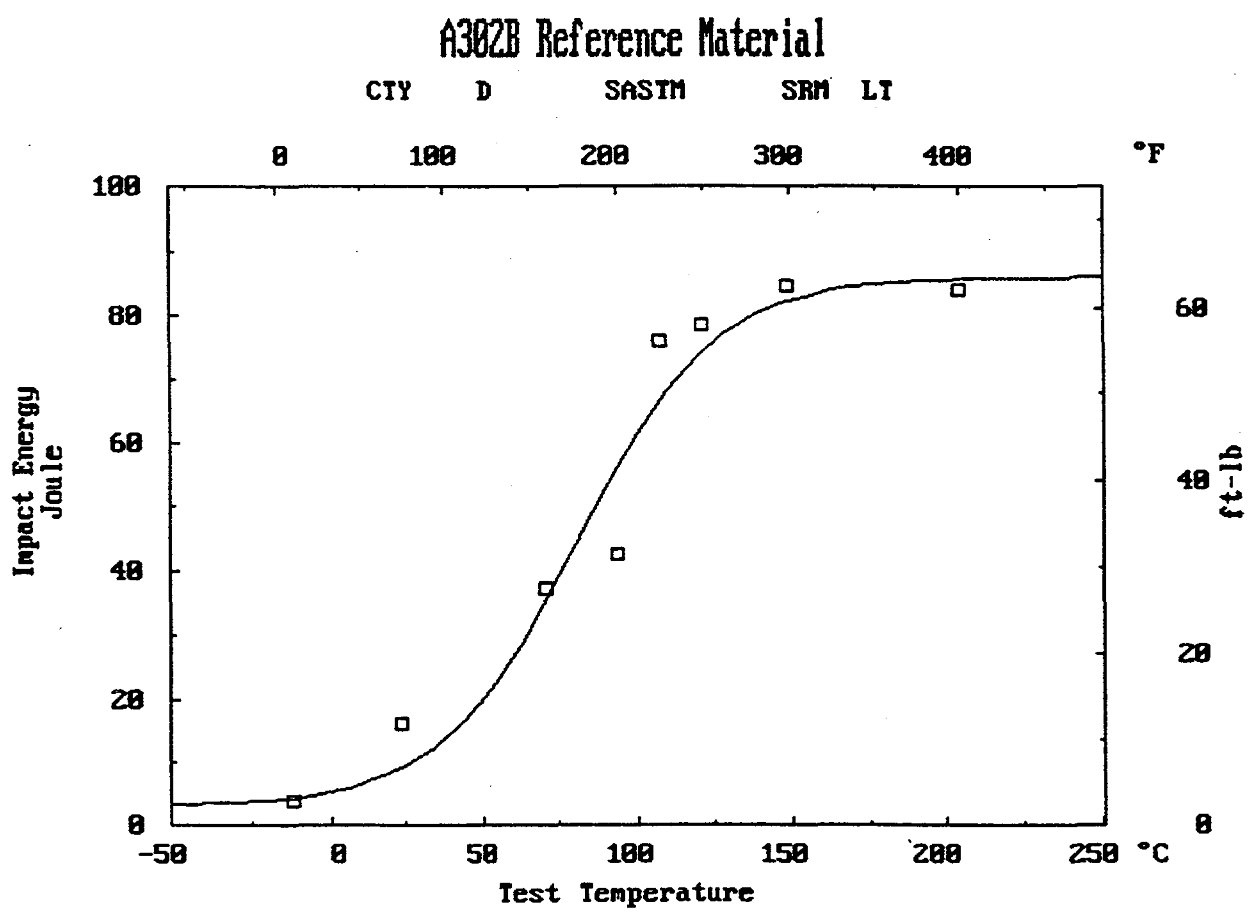
CTY A SASTM SRM LT



A302B REFERENCE MATERIAL
Haddam Neck, Capsule D

USE= 86.1 J, LSE= 3.0 J, CVT(1/2)= 81.C , Slope = 0.0224
CVT(41J) = 77. C , CVT(68J) = 109. C ,
Fluence = 2.220E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R49	-12.	10.	4.	3.	0.30	12.	1.
R50	24.	75.	16.	12.	0.38	15.	14.
R53	71.	160.	37.	27.	0.61	24.	27.
R51	93.	200.	43.	32.	1.07	42.	51.
R54	107.	225.	76.	56.	1.04	41.	93.
R55	121.	250.	79.	58.	1.09	43.	100.
R52	149.	300.	85.	62.	1.14	45.	100.
R56	204.	400.	84.	62.	1.27	50.	100.



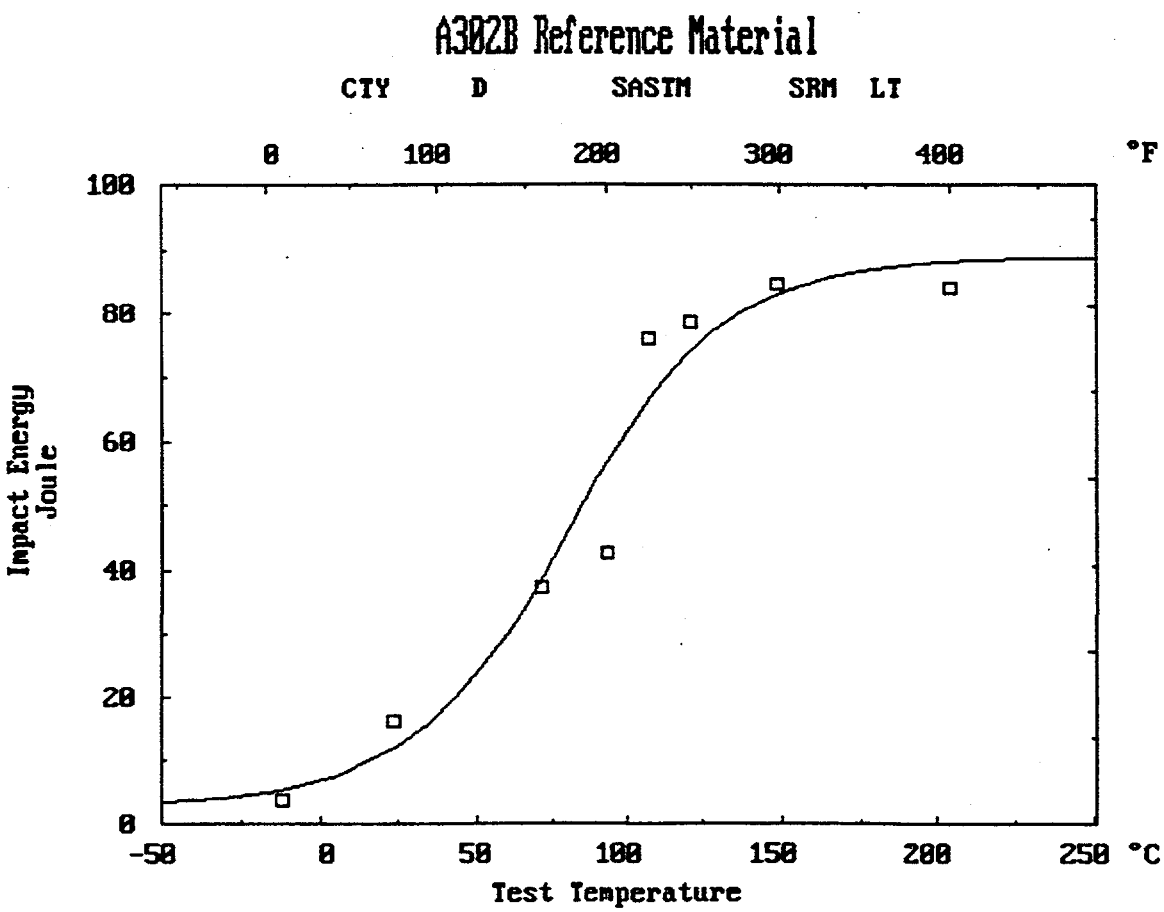
A302B REFERENCE MATERIAL

Haddam Neck, Capsule D

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

CTY D SASTM SRM LT : Fluence = 2.220E+19 , Irr. Temp. = 304

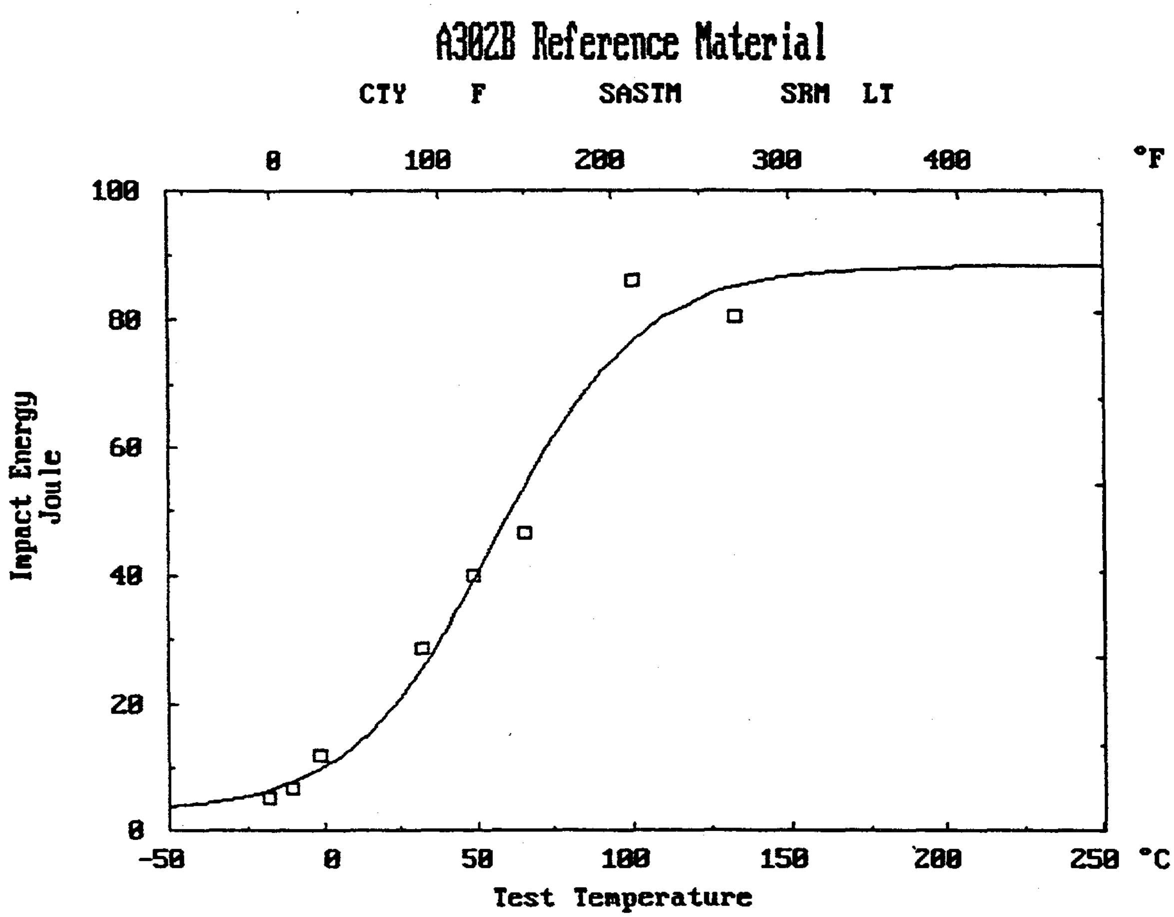
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	89.0	8.5	-0.171				
CVT at Midpoint (C)	80.2	10.9	0.274	0.563			
1/slope (C)	52.1	16.2	-0.432	0.485	-0.043		
CVT at 41 Joule (C)	73.8	9.6	0.462	0.031	0.825	-0.491	
CVT at 68 Joule (C)	110.5	9.5	0.042	-0.104	0.353	0.374	0.381



A302B REFERENCE MATERIAL
Haddam Neck, Capsule F

USE= 88.5 J, LSE= 3.0 J, CVT(1/2)= 56.C , Slope = 0.0212
CVT(41J) = 51. C , CVT(68J) = 84. C ,
Fluence = 4.040E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R21	-18.	0.	5.	4.	0.03	1.	0.
R24	-10.	14.	7.	5.	0.05	2.	3.
R20	-1.	30.	12.	9.	0.13	5.	2.
R22	32.	90.	29.	21.	0.53	21.	15.
R18	49.	120.	40.	29.	0.66	26.	25.
R19	66.	150.	47.	34.	0.76	30.	40.
R23	100.	212.	86.	63.	1.40	55.	95.
R17	132.	270.	81.	59.	1.27	50.	97.



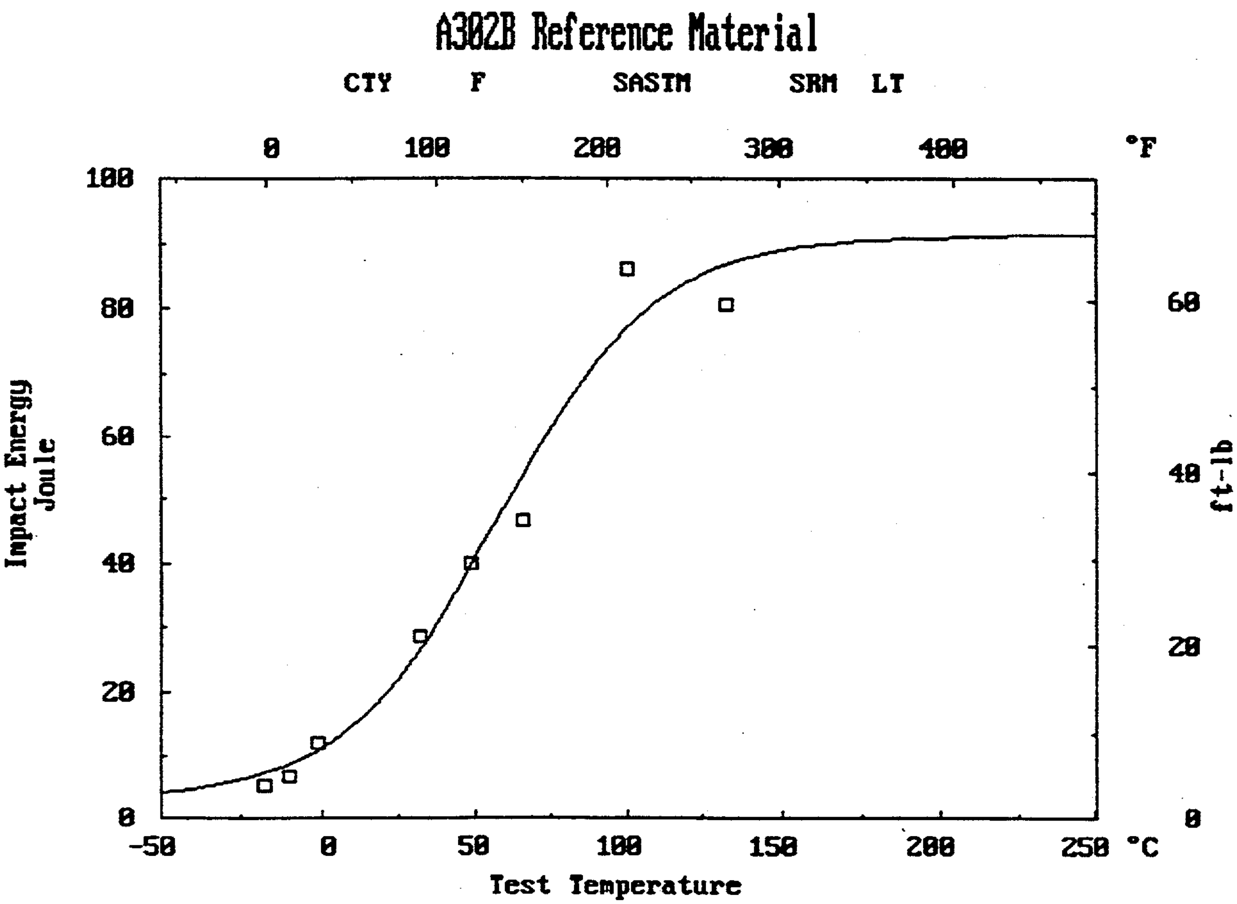
A302B REFERENCE MATERIAL

Haddam Neck, Capsule F

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CTY F SASTM SRM LT : Fluence = 4.040E+18 , Irr. Temp. = 304

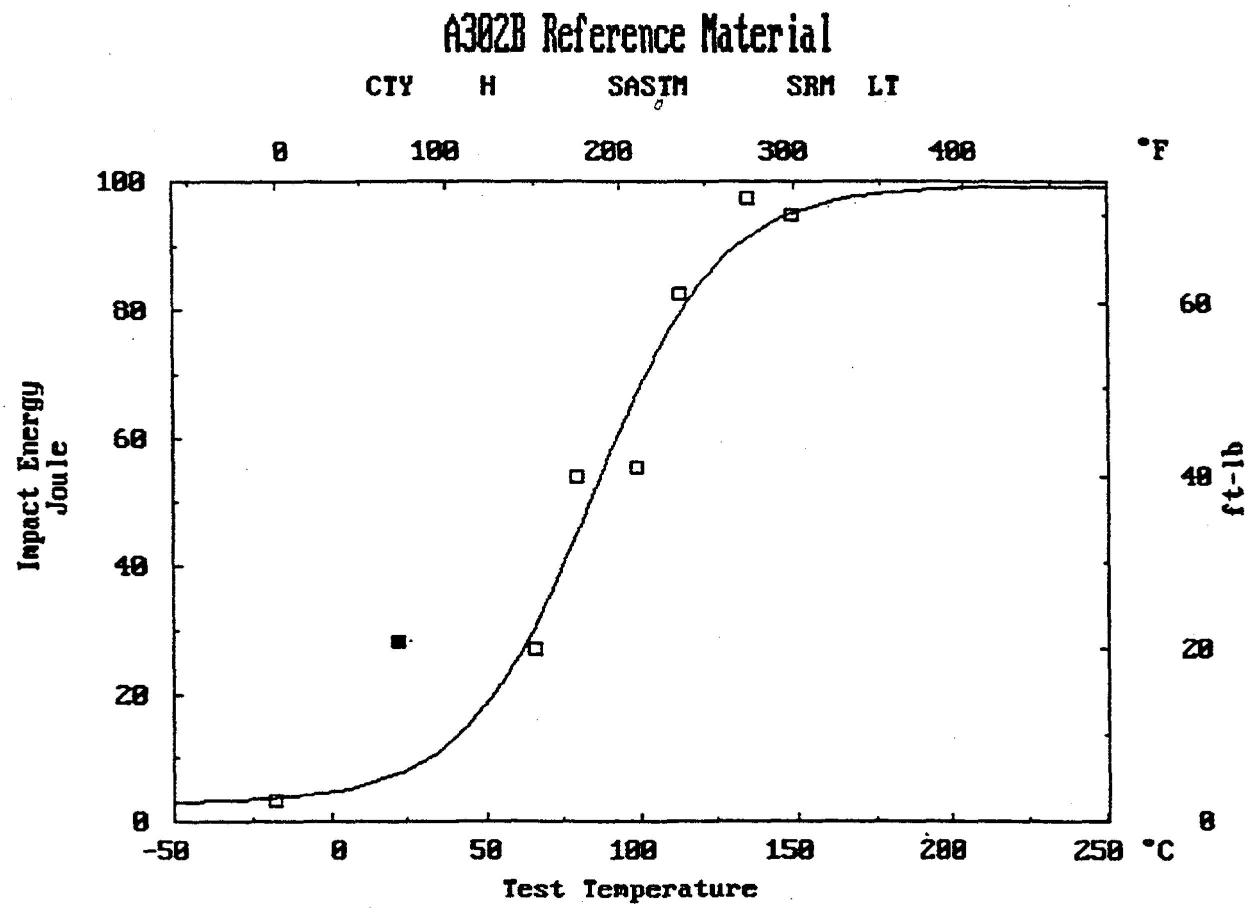
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	91.4	11.2	0.210				
CVT at Midpoint (C)	57.9	11.2	0.274	0.778			
1/slope (C)	51.0	12.7	-0.155	0.458	0.432		
CVT at 41 Joule (C)	50.7	7.3	0.326	0.264	0.784	0.027	
CVT at 68 Joule (C)	86.2	11.4	-0.007	-0.207	0.256	0.471	0.475



A302B REFERENCE MATERIAL
Haddam Neck, Capsule H

USE= 99.3 J, LSE= 3.0 J, CVT(1/2)= 85.C , Slope = 0.0242
CVT(41J) = 76. C , CVT(68J) = 100. C ,
Fluence = 1.790E+19 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	F	Impact Energy J	ft-lb	Lat. Exp. mm	mil	% Shear
R38	-18.	0.	3.	2.	0.05	2.	1.
*R40	22.	72.	28.	21.	0.36	14.	15.
R33	66.	150.	27.	20.	0.41	16.	35.
R39	79.	175.	54.	40.	0.69	27.	55.
R37	99.	210.	56.	41.	0.66	26.	60.
R36	113.	235.	83.	61.	0.94	37.	95.
R34	135.	275.	98.	72.	1.35	53.	100.
R35	149.	300.	95.	70.	1.32	52.	100.



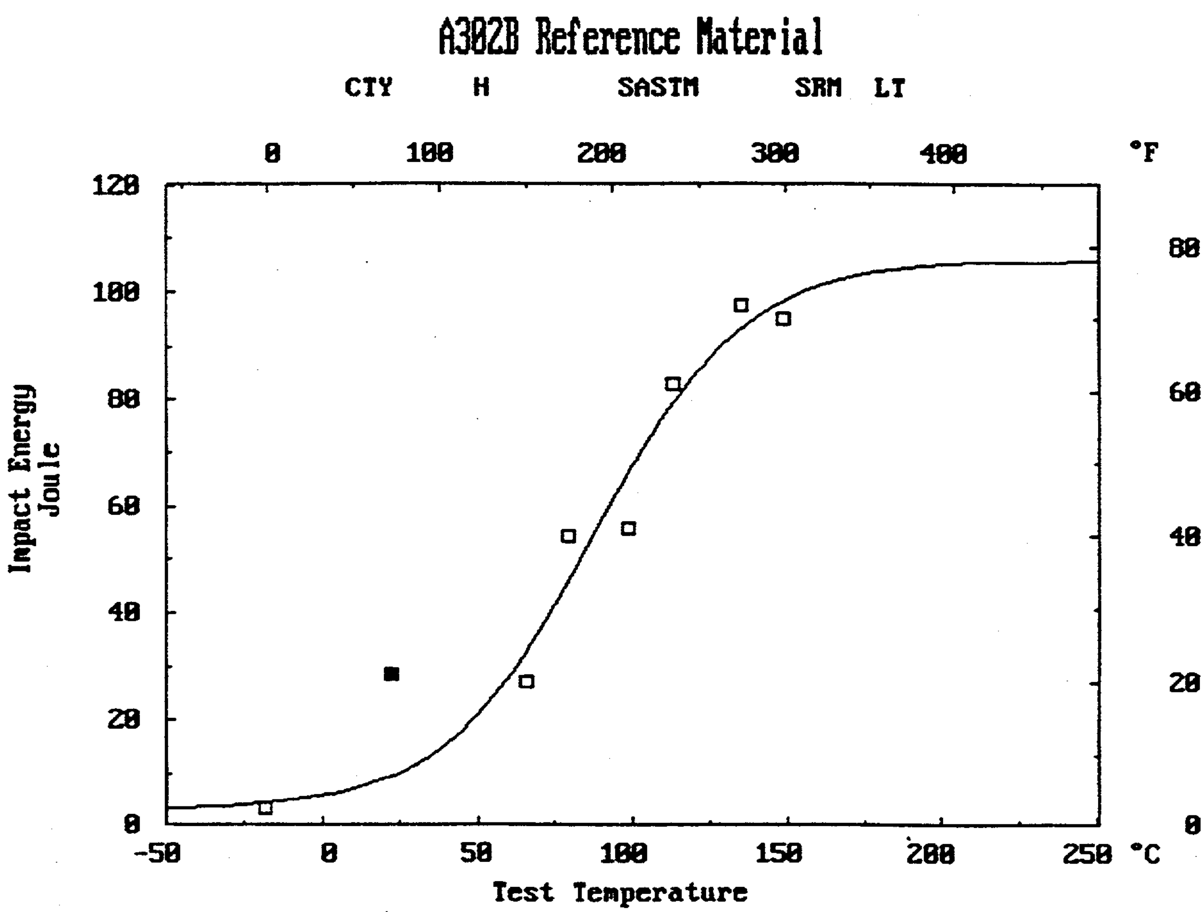
A302B REFERENCE MATERIAL

Haddam Neck, Capsule H

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CTY H SASTM SRM LT : Fluence = 1.790E+19 , Irr. Temp. = 288

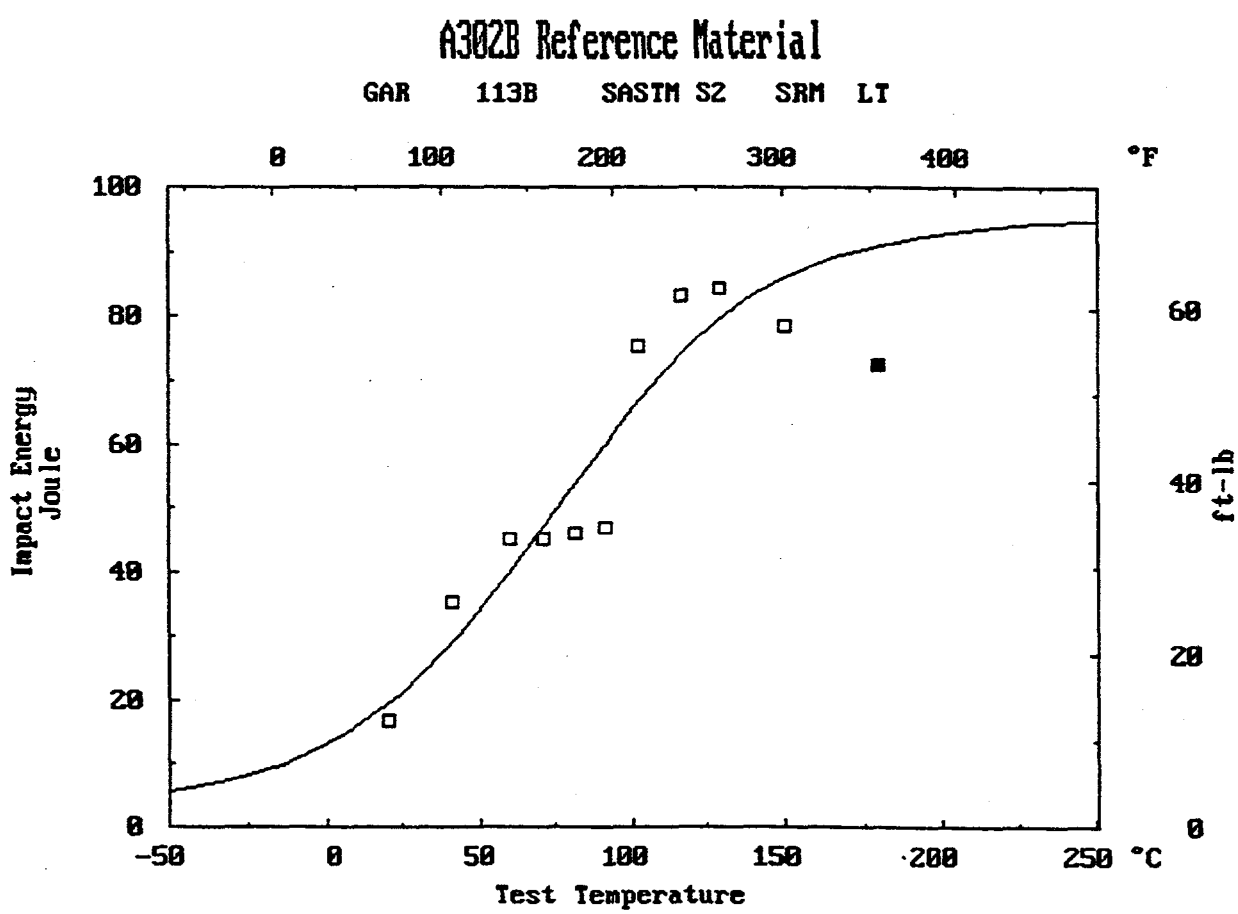
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	105.9	13.5	0.015				
CVT at Midpoint (C)	87.6	9.8	0.147	0.810			
1/slope (C)	48.0	14.6	0.006	0.714	0.514		
CVT at 41 Joule (C)	74.2	6.7	0.183	-0.041	0.486	-0.424	
CVT at 68 Joule (C)	100.2	6.1	0.197	0.279	0.707	0.403	0.572



A302B REFERENCE MATERIAL
Garigliano, Capsule 113B

```
USE=  95.5 J, LSE=   3.0 J, CVT(1/2)=   74.C , Slope = 0.0144
CVT(41J) =   61. C , CVT(68J) =  104. C ,
Fluence = 1.100E+19 , Irr. Temp. = -17 C
```

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
Y7E	21.	69.	17.	12.	0.30	12.	10.
Y7B	41.	106.	35.	26.	0.51	20.	20.
Y7M	60.	140.	45.	33.	0.86	34.	30.
Y7T	71.	160.	45.	33.			30.
Y7Y	81.	178.	46.	34.	0.66	26.	40.
Y7L	91.	196.	47.	35.	0.91	36.	40.
Y7K	102.	216.	76.	56.	1.17	46.	70.
Y7P	116.	241.	83.	62.	1.22	48.	80.
Y7J	129.	264.	84.	62.			60.
Y7U	150.	302.	78.	58.	1.30	51.	50.
*Y7C	180.	356.	73.	53.	1.24	49.	50.



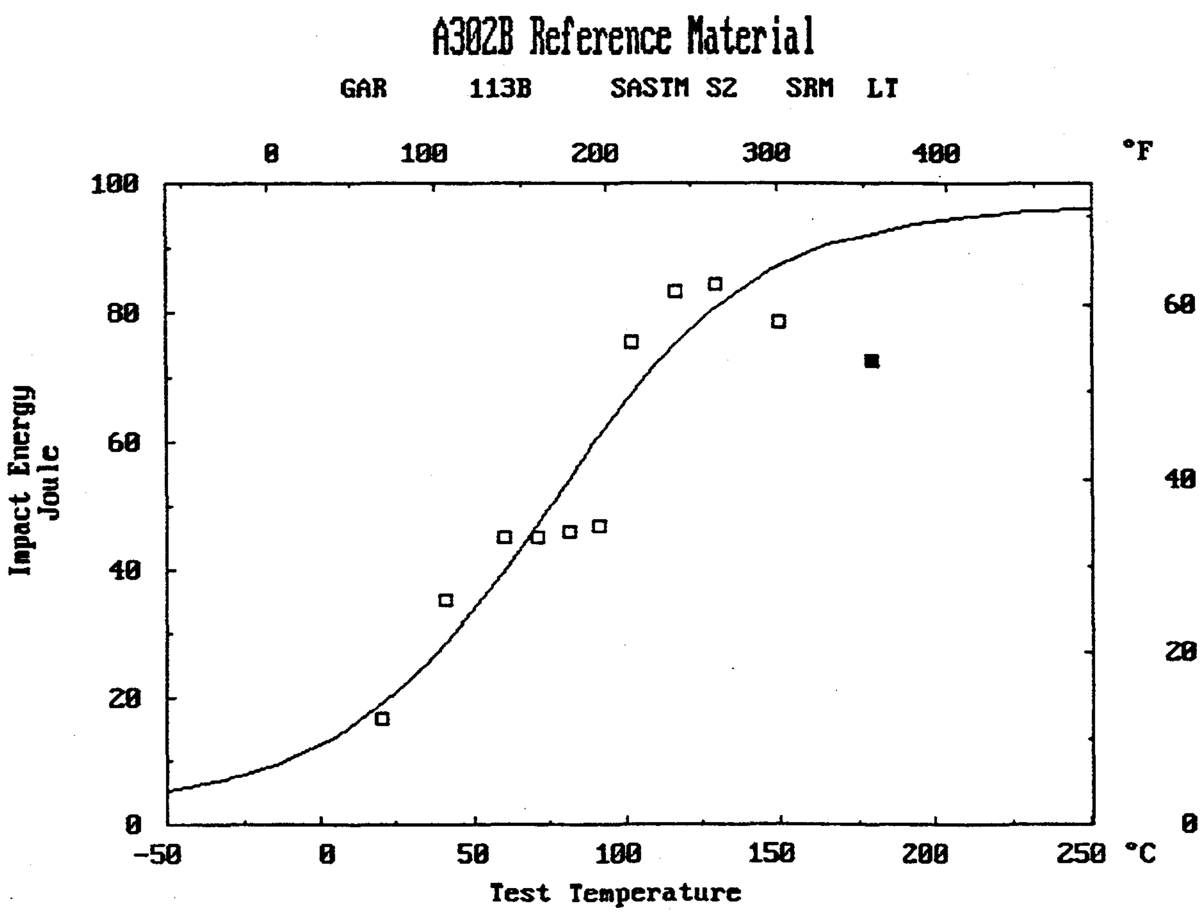
A302B REFERENCE MATERIAL

Garigliano, Capsule 113B

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

GAR 113B SASTM S2 SRM LT : Fluence = 1.100E+19 , Irr. Temp. = -17

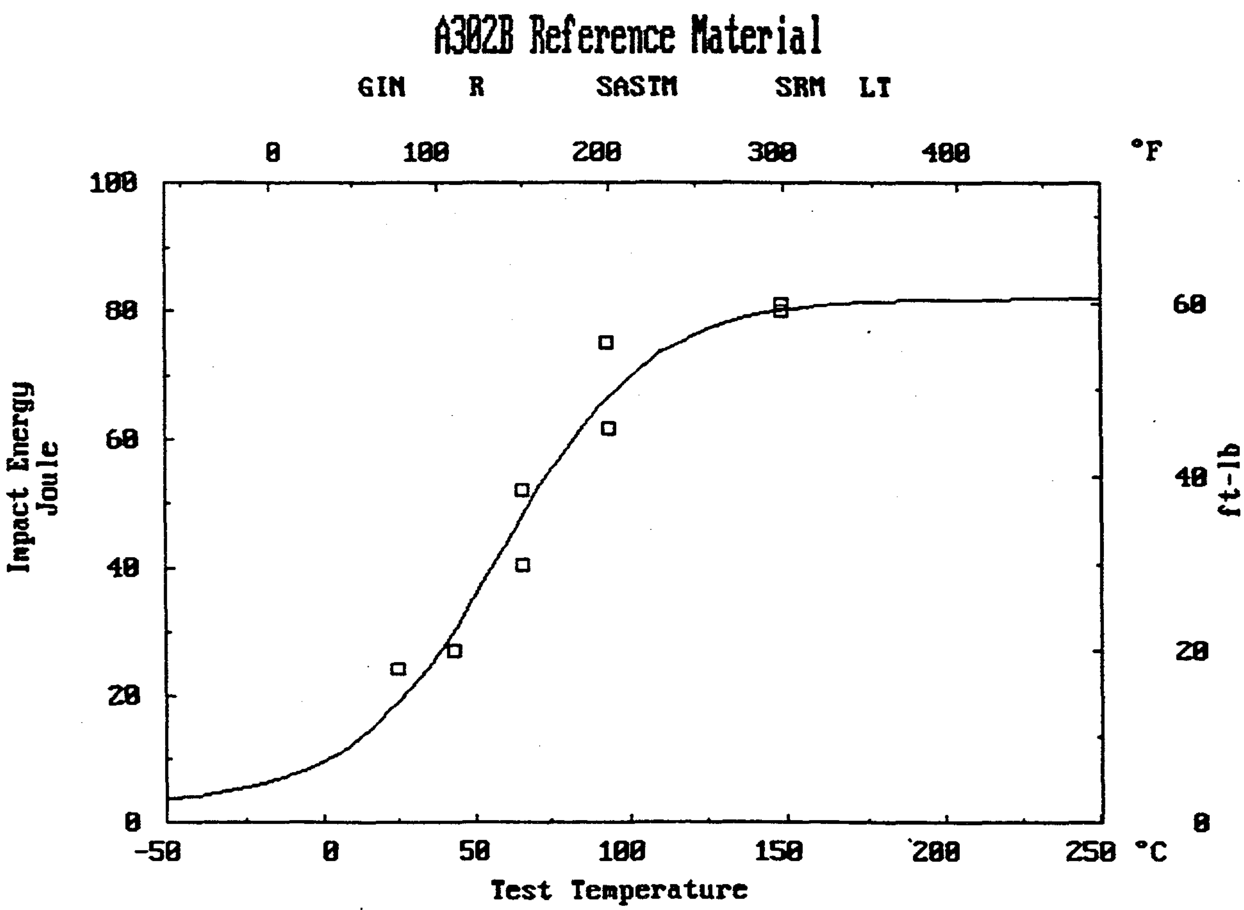
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	96.6	14.9	0.113				
CVT at Midpoint (C)	74.7	15.2	0.230	0.891			
1/slope (C)	68.5	20.1	-0.068	0.677	0.539		
CVT at 41 Joule (C)	61.1	7.9	0.357	0.175	0.557	-0.280	
CVT at 68 Joule (C)	104.5	8.9	0.004	-0.031	0.214	0.372	0.266



A302B REFERENCE MATERIAL
R. E. Ginna Unit 1, Capsule R

USE= 82.1 J, LSE= 3.0 J, CVT(1/2)= 59.C , Slope = 0.0204
CVT(41J) = 57. C , CVT(68J) = 96. C ,
Fluence = 7.600E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R12	25.	77.	24.	18.	0.43	17.	15.
R10	43.	110.	27.	20.	0.53	21.	20.
R11	66.	150.	52.	38.	0.91	36.	40.
R16	66.	150.	41.	30.	0.69	27.	40.
R9	93.	199.	75.	55.	1.27	50.	75.
R14	93.	200.	62.	45.	1.07	42.	70.
R13	149.	300.	80.	59.	1.55	61.	99.
R15	149.	300.	81.	60.	1.47	58.	100.



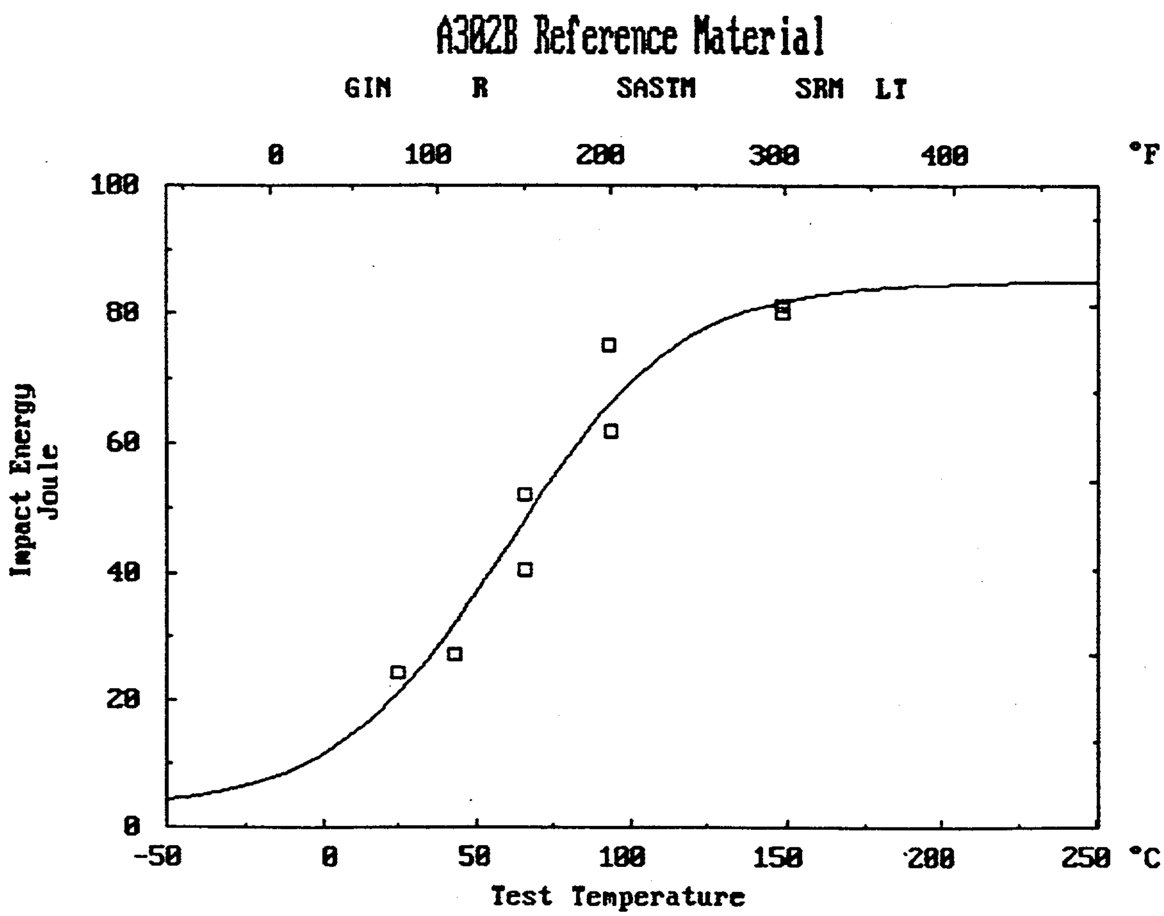
A302B REFERENCE MATERIAL

R. E. Ginna Unit 1, Capsule R

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

GIN R SASTM SRM LT : Fluence = 7.600E+18 , Irr. Temp. = 288

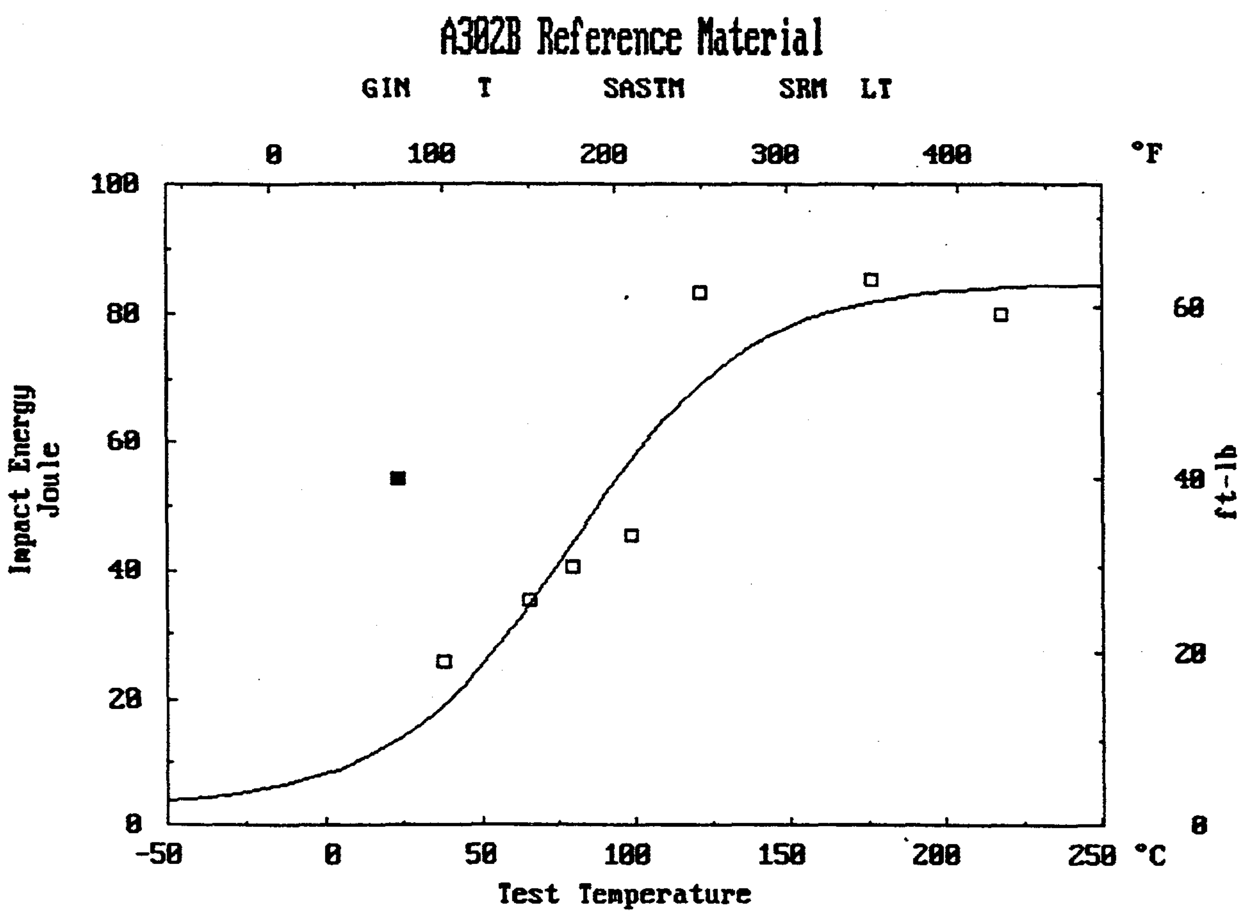
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	85.2	8.4	0.011				
CVT at Midpoint (C)	60.1	9.5	0.217	0.678			
1/slope (C)	55.7	17.9	-0.178	0.562	0.175		
CVT at 41 Joule (C)	55.4	7.4	0.299	0.024	0.731	-0.372	
CVT at 68 Joule (C)	98.5	11.5	-0.032	-0.149	0.120	0.503	0.200



A302B REFERENCE MATERIAL
R. E. Ginna Unit 1, Capsule T

USE= 84.8 J, LSE= 3.0 J, CVT(1/2)= 79.C , Slope = 0.0171
CVT(41J) = 75. C , CVT(68J) = 119. C ,
Fluence = 1.750E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
*R20	24.	75.	54.	40.	0.63	25.	53.
R24	38.	100.	26.	19.	0.33	13.	15.
R22	66.	150.	35.	26.	0.74	29.	41.
R23	79.	175.	41.	30.	0.71	28.	44.
R19	99.	210.	45.	33.	0.63	25.	48.
R18	121.	250.	83.	62.	1.22	48.	100.
R17	177.	350.	85.	63.	1.24	49.	100.
R21	218.	425.	80.	59.	1.09	43.	100.



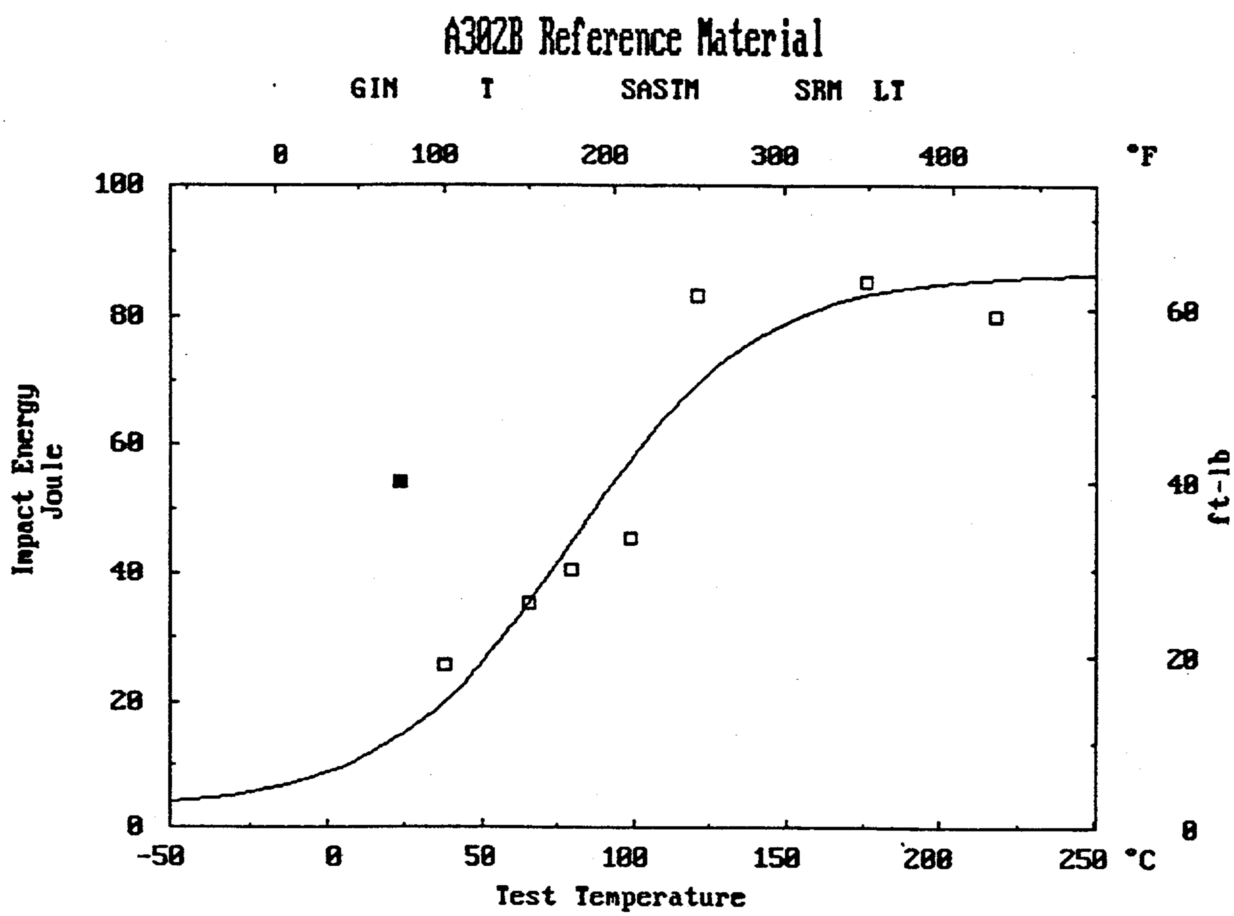
A302B REFERENCE MATERIAL

R. E. Ginna Unit 1, Capsule T

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

GIN T SASTM SRM LT : Fluence = 1.750E+19 , Irr. Temp. = 304

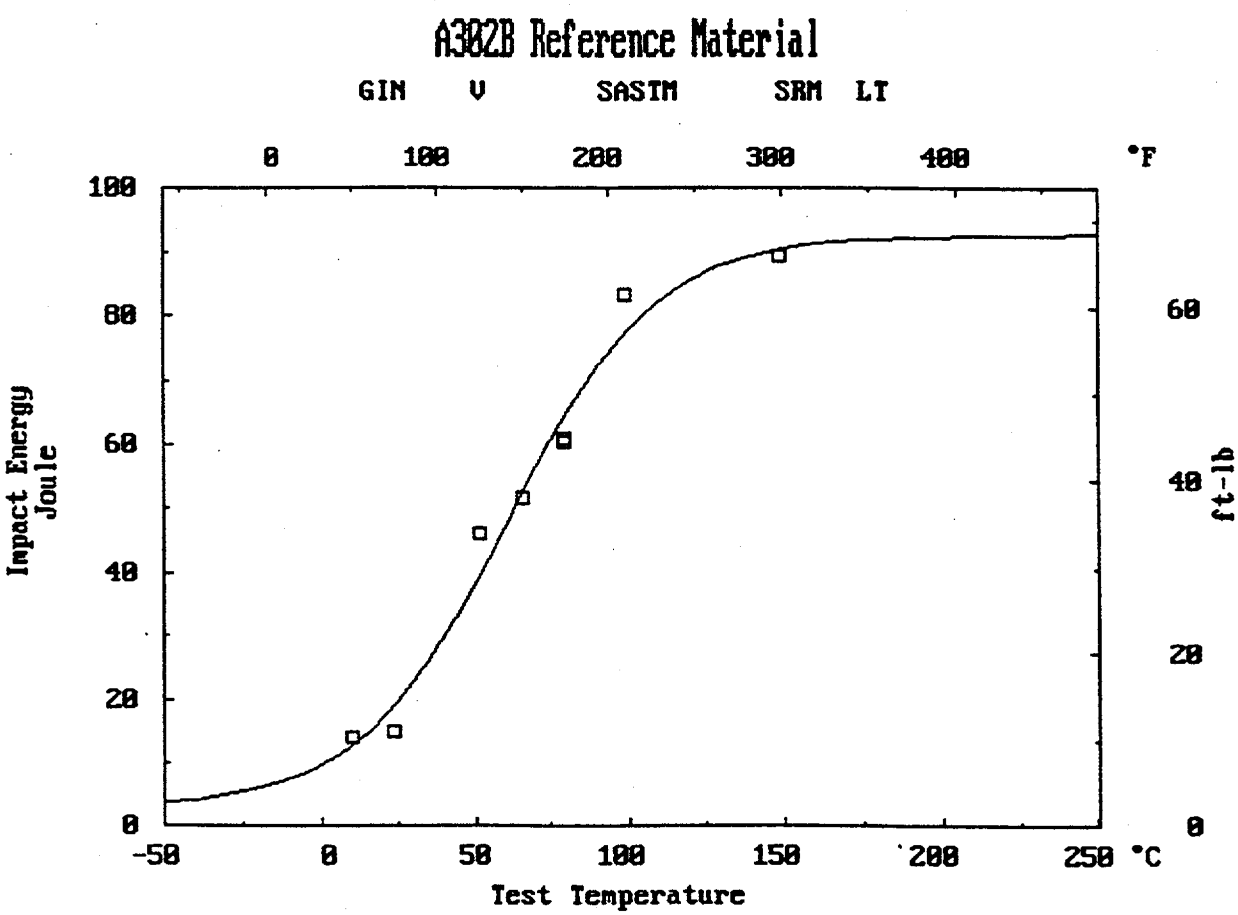
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	86.7	7.4	0.242				
CVT at Midpoint (C)	79.7	11.3	0.310	0.625			
1/slope (C)	60.7	19.5	-0.246	0.228	-0.137		
CVT at 41 Joule (C)	74.1	9.3	0.317	0.132	0.832	-0.477	
CVT at 68 Joule (C)	119.7	14.5	-0.204	-0.350	-0.109	0.620	-0.004



A302B REFERENCE MATERIAL
R. E. Ginna Unit 1, Capsule V

USE= 92.8 J, LSE= 3.0 J, CVT(1/2)= 61.C , Slope = 0.0207
CVT(41J) = 53. C , CVT(68J) = 84. C ,
Fluence = 4.900E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	F	Impact Energy J	ft-lb	Lat. Exp. mm	mil	% Shear
R3	10.	50.	14.	10.	0.25	10.	
R1	24.	75.	15.	11.	0.28	11.	
R5	52.	125.	46.	34.	0.76	30.	
R4	66.	150.	52.	38.	0.84	33.	
R7	79.	175.	61.	45.	1.07	42.	
R8	79.	175.	60.	44.	1.04	41.	
R2	99.	210.	83.	62.	1.30	51.	
R6	149.	300.	89.	66.	1.30	51.	



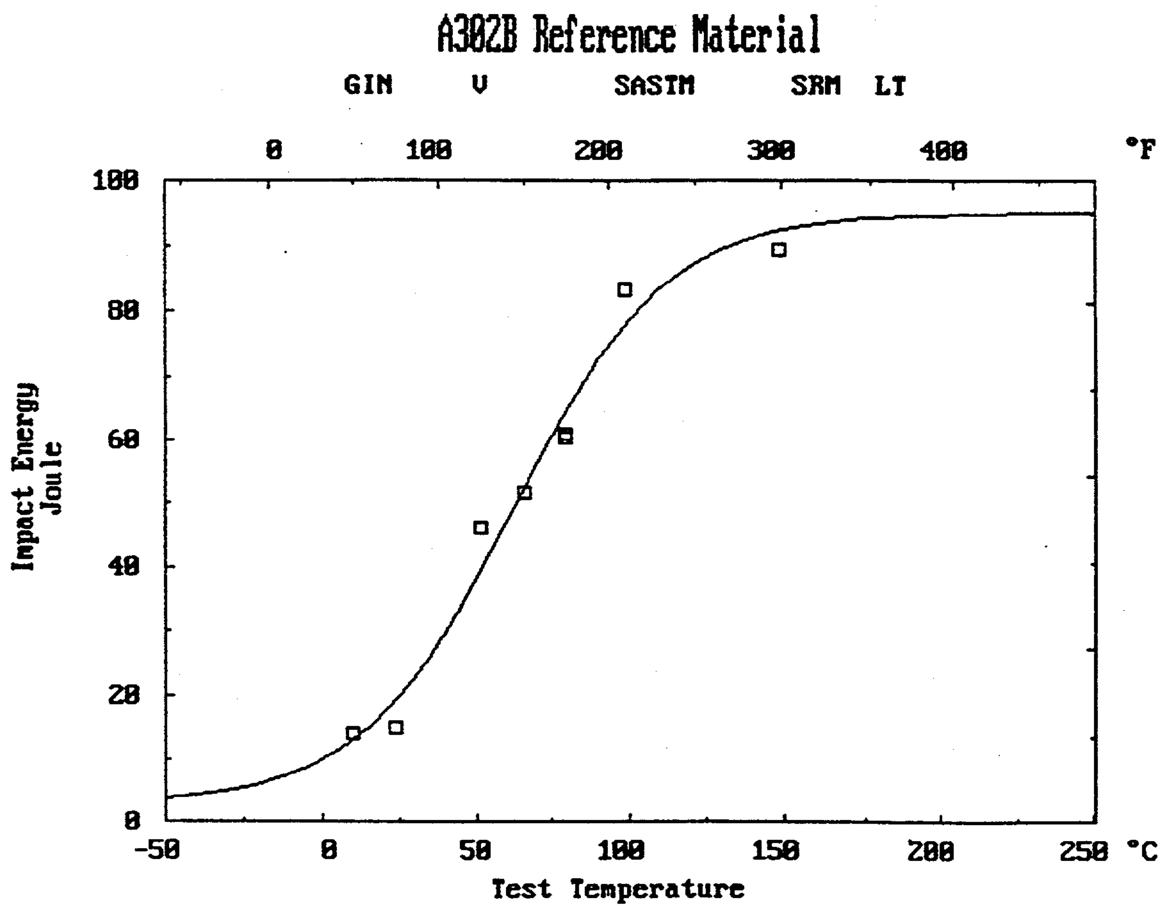
A302B REFERENCE MATERIAL

R. E. Ginna Unit 1, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

GIN V SASTM SRM LT : Fluence = 4.900E+18 , Irr. Temp. = 288

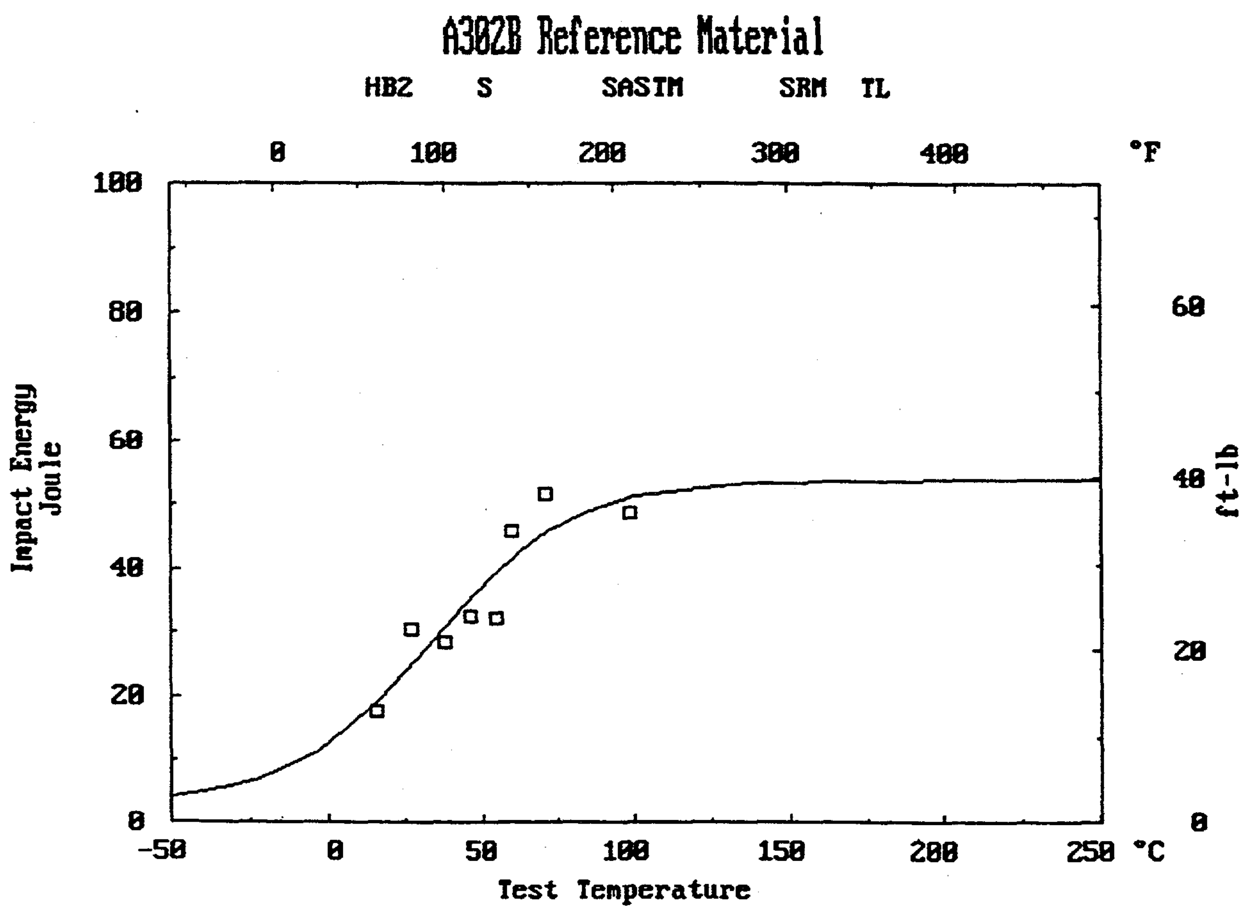
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	95.2	11.1	0.095				
CVT at Midpoint (C)	62.2	9.1	0.174	0.770			
1/slope (C)	49.6	13.5	0.046	0.464	0.361		
CVT at 41 Joule (C)	53.3	6.1	0.181	0.096	0.651	-0.279	
CVT at 68 Joule (C)	85.1	9.1	0.115	-0.202	0.184	0.466	0.305



A302B REFERENCE MATERIAL
H. B. Robinson Unit 2, Capsule S

USE= 53.9 J, LSE= 3.0 J, CVT(1/2)= 34.C , Slope = 0.0217
CVT(41J) = 59. C , CVT(68J) =****** C ,
Fluence = 3.690E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R1	16.	60.	18.	13.	0.28	11.	
R3	27.	80.	30.	22.	0.51	20.	
R6	38.	100.	28.	21.	0.51	20.	
R4	46.	115.	33.	24.	0.58	23.	
R7	54.	130.	32.	24.	0.61	24.	
R5	60.	140.	46.	34.	0.74	29.	
R2	71.	160.	52.	38.	1.02	40.	
R8	99.	210.	49.	36.	0.97	38.	



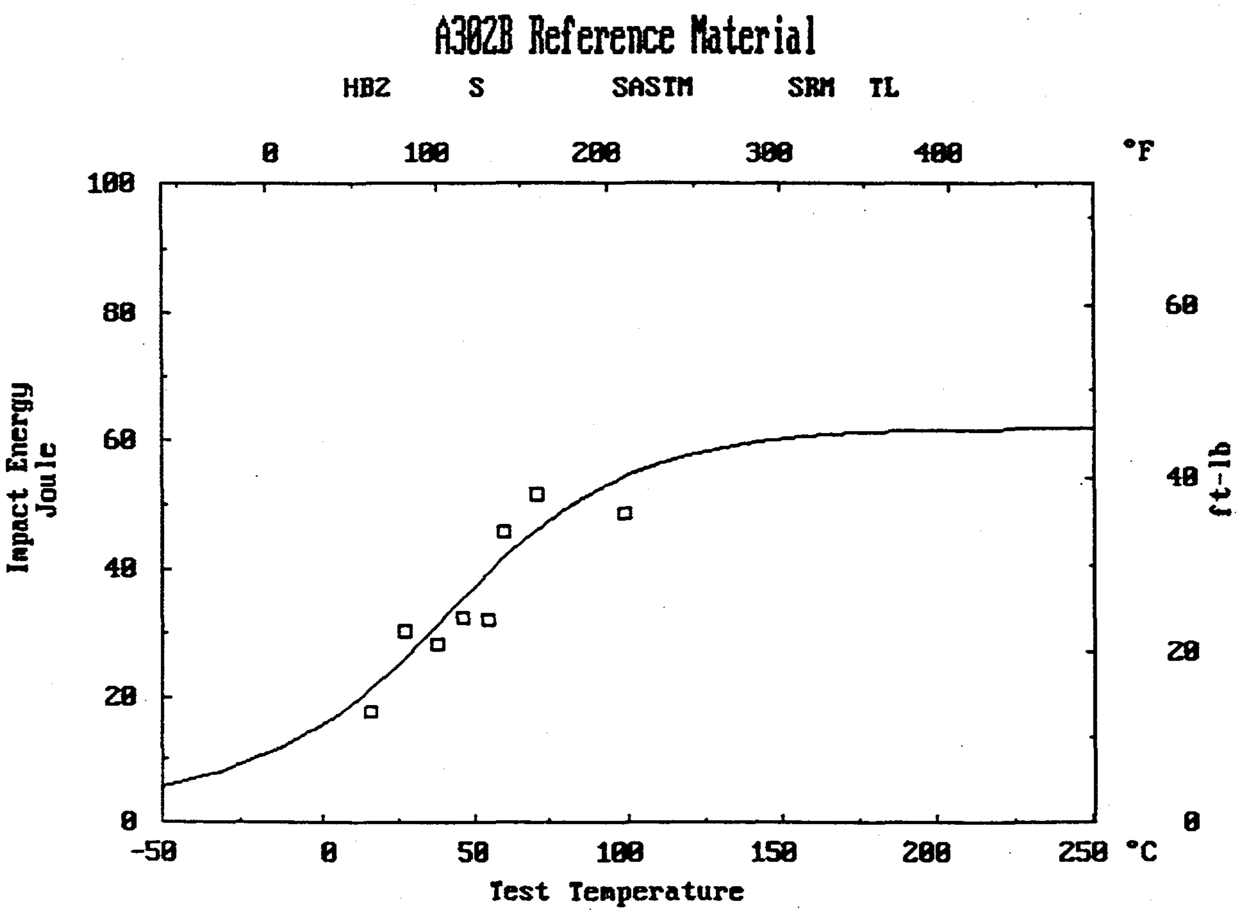
A302B REFERENCE MATERIAL

H. B. Robinson Unit 2, Capsule S

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
HB2   S     SASTM     SRM  TL : Fluence = 3.690E+18 , Irr. Temp. =  304
```

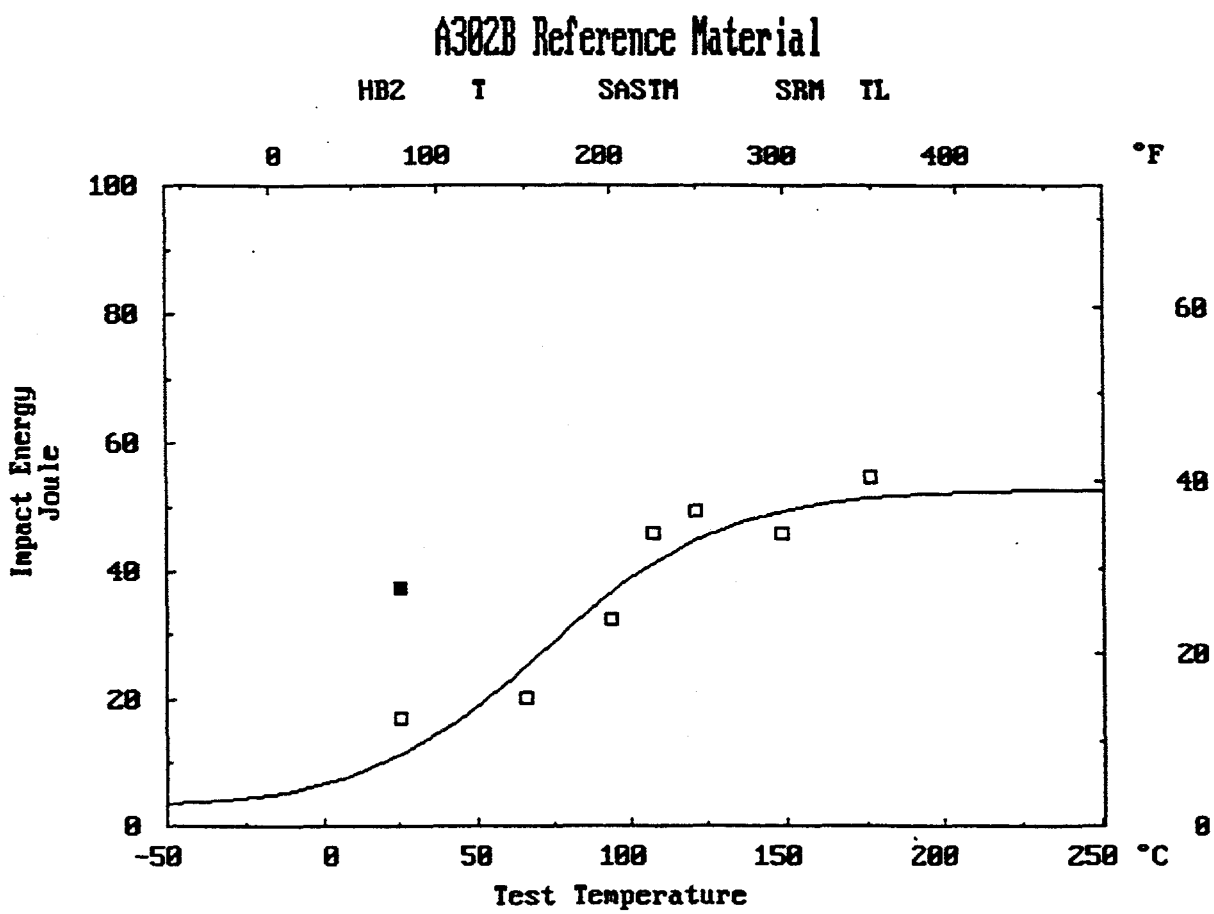
Parameter	Mean	Std.Dev.	Correlation Coefficients			
Lower Shelf Energy (J)	3.0	0.0				
Upper Shelf Energy (J)	61.7	10.1	0.284			
CVT at Midpoint (C)	40.2	13.7	0.344	0.789		
1/slope (C)	60.0	21.1	-0.006	0.273	0.098	
CVT at 41 Joule (C)	61.0	11.1	0.010	-0.249	0.119	0.416



A302B REFERENCE MATERIAL
H. B. Robinson Unit 2, Capsule T

USE= 53.0 J, LSE= 3.0 J, CVT(1/2)= 73.C , Slope = 0.0174
CVT(41J) = 106. C , CVT(68J) =****** C ,
Fluence = 4.110E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R59	26.	78.	17.	12.	0.25	10.	10.
*R63	26.	78.	37.	27.	0.56	22.	15.
R62	66.	150.	20.	15.	0.28	11.	35.
R64	93.	200.	33.	24.	0.53	21.	45.
R58	107.	225.	46.	34.	0.81	32.	96.
R60	121.	250.	49.	36.	0.89	35.	99.
R61	149.	300.	46.	34.	0.81	32.	100.
R57	177.	350.	55.	40.	0.94	37.	100.



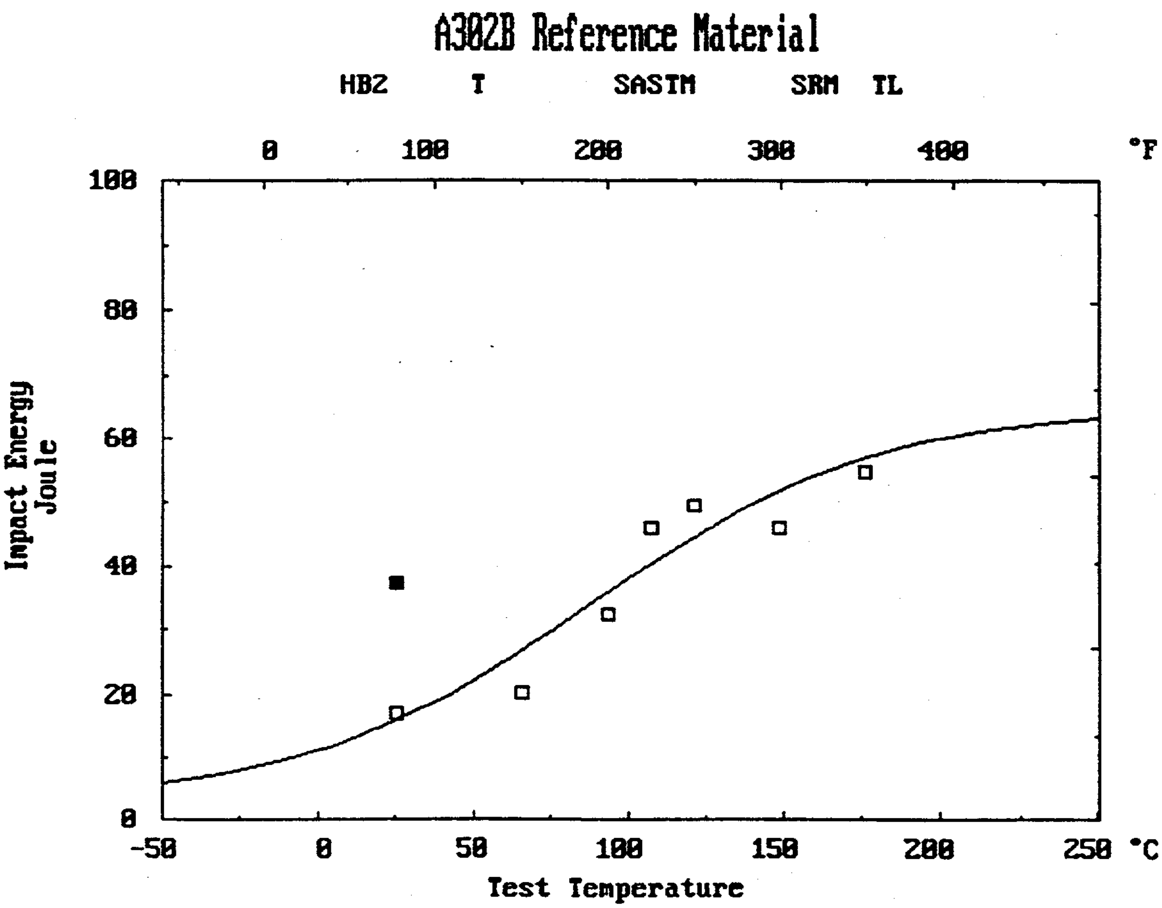
A302B REFERENCE MATERIAL

H. B. Robinson Unit 2, Capsule T

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
HB2    T     SASTM     SRM  TL : Fluence = 4.110E+19 , Irr. Temp. =  304
```

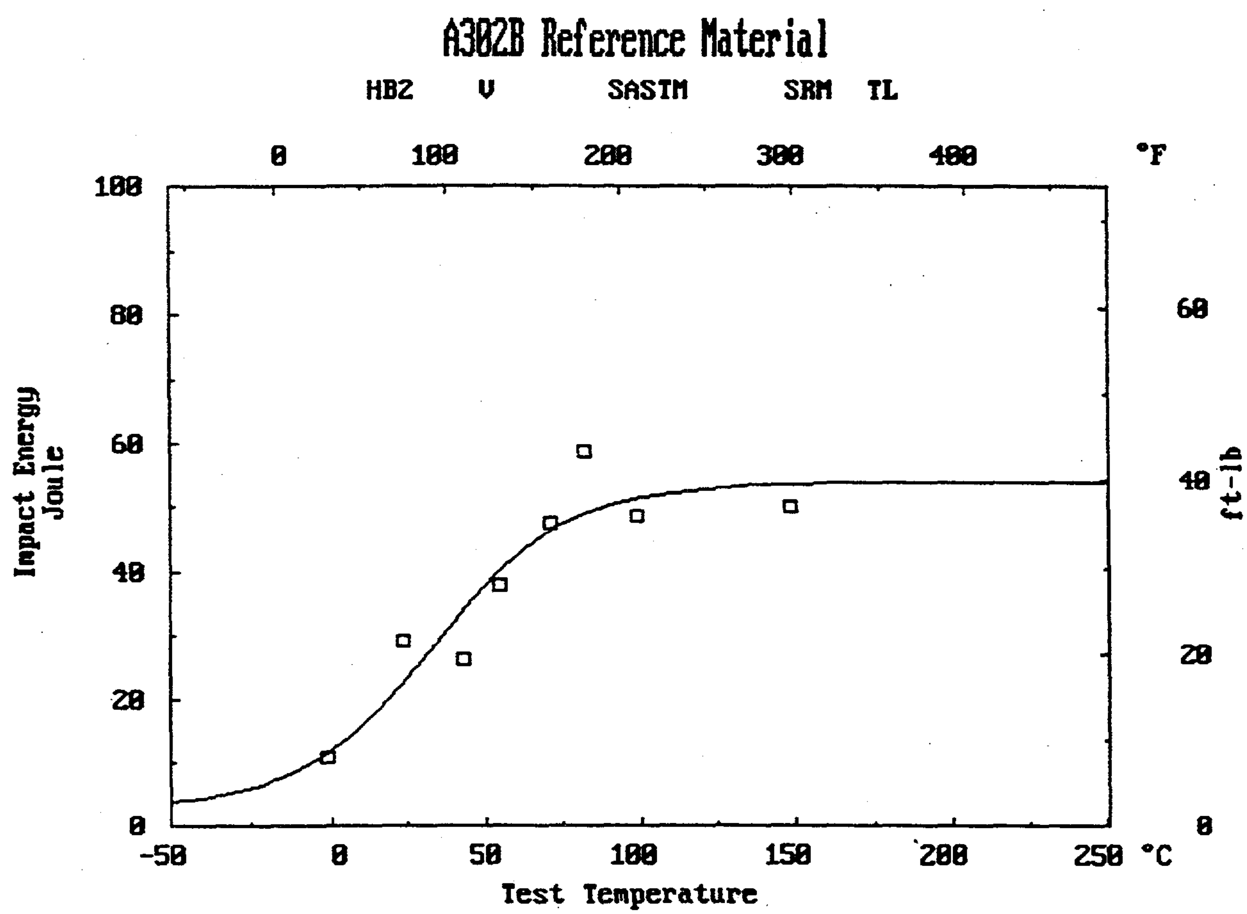
Parameter	Mean	Std.Dev.	Correlation Coefficients			
Lower Shelf Energy (J)	3.0	0.0				
Upper Shelf Energy (J)	65.0	11.8	0.256			
CVT at Midpoint (C)	87.5	22.9	0.324	0.787		
1/slope (C)	92.2	29.5	-0.070	0.424	0.292	
CVT at 41 Joule (C)	111.3	15.8	0.074	-0.133	0.384	0.271



A302B REFERENCE MATERIAL
H. B. Robinson Unit 2, Capsule V

USE= 53.9 J, LSE= 3.0 J, CVT(1/2)= 33.C , Slope = 0.0232
CVT(41J) = 57. C , CVT(68J) =****** C ,
Fluence = 4.510E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R51	-1.	30.	11.	8.	0.15	6.	0.
R55	24.	75.	29.	21.	0.48	19.	5.
R54	43.	110.	26.	19.	0.48	19.	5.
R52	54.	130.	38.	28.	0.66	26.	10.
R56	71.	160.	47.	35.	0.84	33.	15.
R49	82.	180.	59.	43.	1.09	43.	100.
R53	99.	210.	49.	36.	0.86	34.	20.
R50	149.	300.	50.	37.	1.04	41.	100.



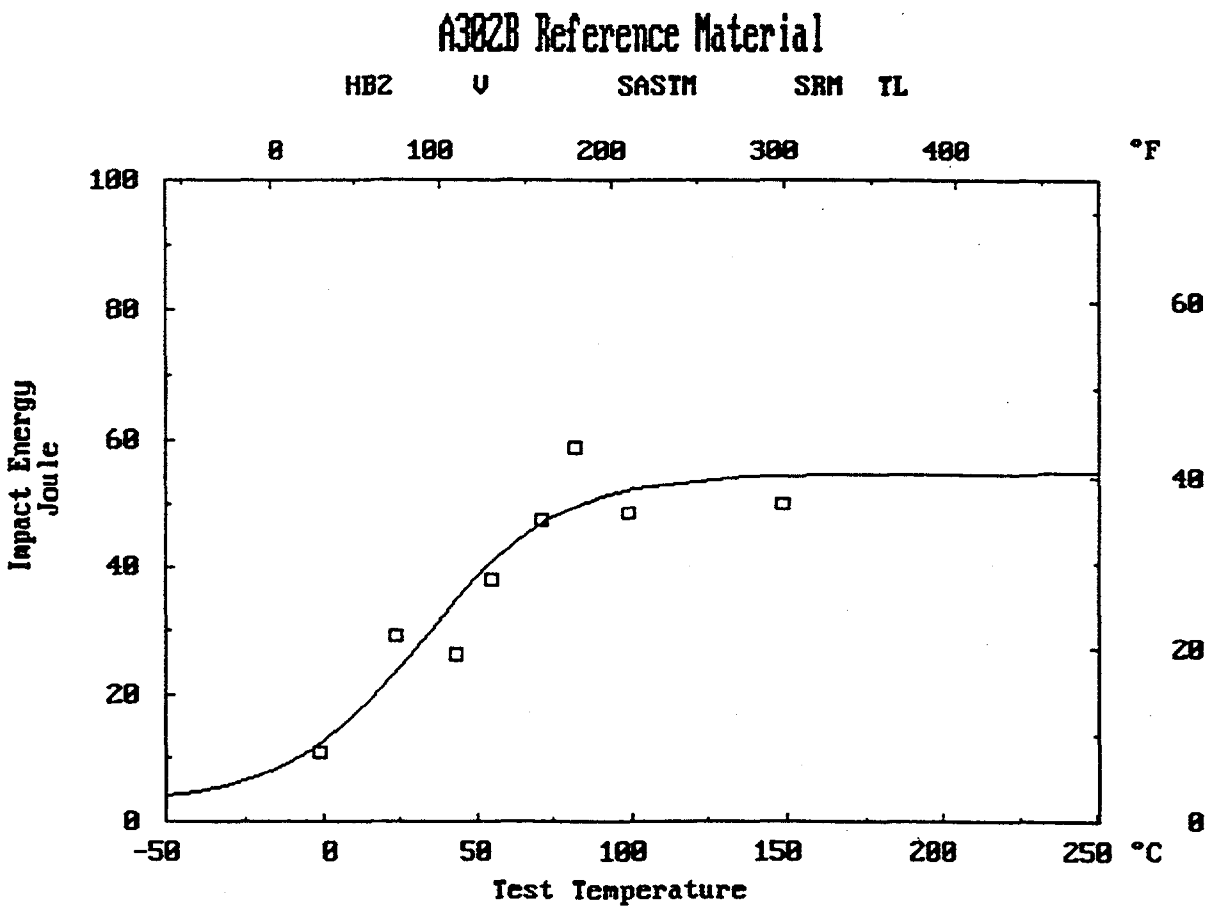
A302B REFERENCE MATERIAL

H. B. Robinson Unit 2, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

HB2 V SASTM SRM TL : Fluence = 4.510E+18 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients			
Lower Shelf Energy (J)	3.0	0.0				
Upper Shelf Energy (J)	55.0	6.8	0.177			
CVT at Midpoint (C)	33.0	14.0	0.285	0.659		
1/slope (C)	44.4	14.5	-0.072	0.363	-0.003	
CVT at 41 Joule (C)	57.2	11.1	0.152	-0.070	0.443	0.316



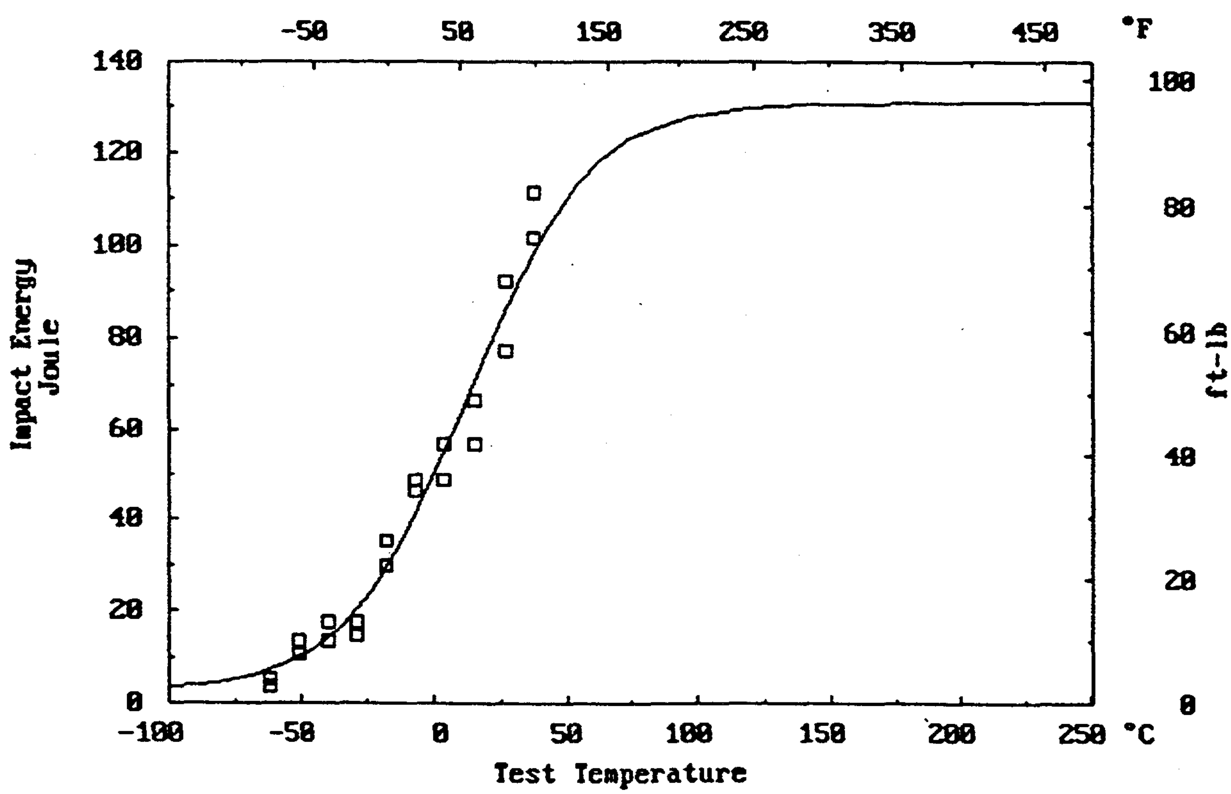
A302B REFERENCE MATERIAL, Humbolt Unit 3, Baseline (Longitudinal Direction)

USE= 130.8 J, LSE= 3.0 J, CVT(1/2)= 13.C , Slope = 0.0221
Unirradiated Charpy SpecimenCVT(41J) = -7. C , CVT(68J) = 14. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
	-62.	-80.	4.	3.	0.15	6.	2.
	-62.	-80.	5.	4.	0.20	8.	2.
	-51.	-60.	11.	8.	0.18	7.	3.
	-51.	-60.	14.	10.	0.20	8.	3.
	-40.	-40.	14.	10.	0.28	11.	10.
	-40.	-40.	18.	13.	0.28	11.	10.
	-29.	-20.	15.	11.	0.38	15.	20.
	-29.	-20.	18.	13.	0.46	18.	20.
	-18.	0.	30.	22.	0.56	22.	35.
	-18.	0.	35.	26.	0.66	26.	35.
	-7.	20.	46.	34.	0.81	32.	40.
	-7.	20.	49.	36.	0.86	34.	40.
	4.	40.	49.	36.	0.86	34.	45.
	4.	40.	57.	42.	0.97	38.	45.
	16.	60.	57.	42.	0.94	37.	50.
	16.	60.	66.	49.	1.09	43.	50.
	27.	80.	77.	57.	1.30	51.	65.
	27.	80.	92.	68.	1.45	57.	80.
	38.	100.	102.	75.	1.63	64.	98.
	38.	100.	111.	82.	1.83	72.	100.

A302B Reference Material

HM3 SASTM M SRM LT



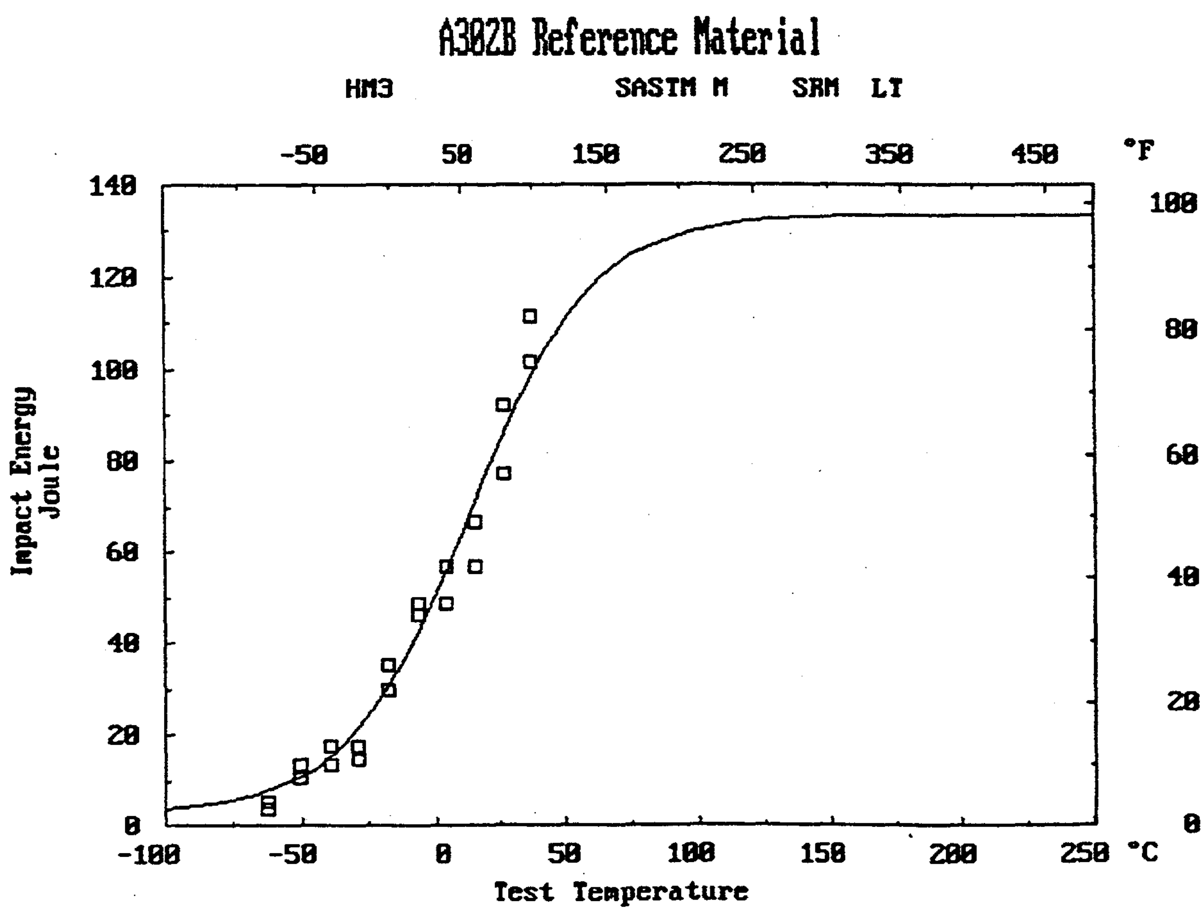
A302B REFERENCE MATERIAL

Humbolt Unit 3, Baseline (Longitudinal Direction)

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

HM3 SASTM M SRM LT

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	133.4	23.2	0.136				
CVT at Midpoint (C)	13.5	9.6	0.179	0.948			
1/slope (C)	47.0	7.2	-0.013	0.694	0.741		
CVT at 41 Joule (C)	-7.3	3.2	0.312	0.316	0.520	-0.016	
CVT at 68 Joule (C)	13.9	3.2	0.185	0.256	0.531	0.479	0.702



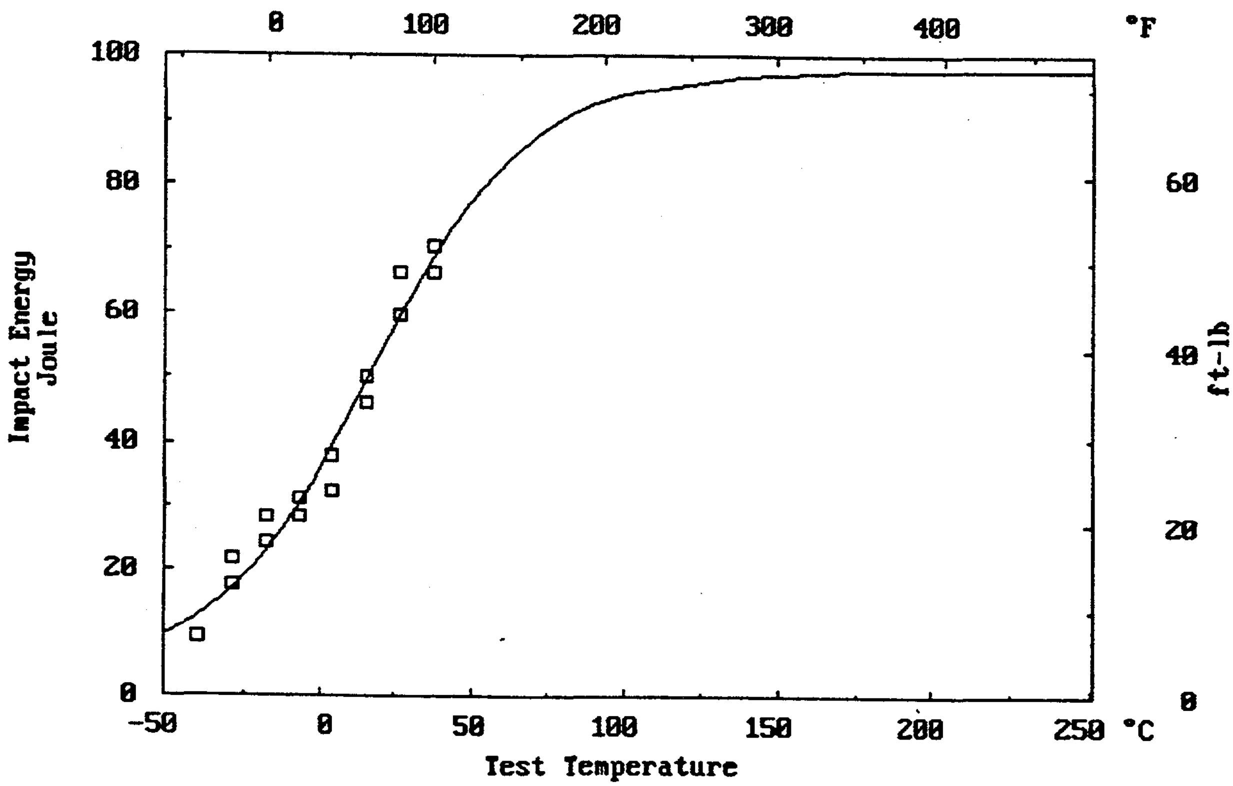
A302B REFERENCE MATERIAL
Humbolt Unit 3, Baseline (Transverse Direction)

USE= 97.9 J, LSE= 3.0 J, CVT(1/2)= 17.C , Slope = 0.0193
Unirradiated Charpy SpecimenCVT(41J) = 6. C , CVT(68J) = 37. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
	-40.	-40.	9.	7.	0.23	9.	10.
	-40.	-40.	9.	7.	0.28	11.	10.
	-29.	-20.	18.	13.	0.36	14.	15.
	-29.	-20.	18.	13.	0.41	16.	15.
	-29.	-20.	22.	16.	0.43	17.	25.
	-18.	0.	24.	18.	0.51	20.	30.
	-18.	0.	28.	21.	0.56	22.	35.
	-7.	20.	28.	21.	0.66	26.	40.
	-7.	20.	31.	23.	0.76	30.	40.
	4.	40.	33.	24.	0.76	30.	50.
	4.	40.	38.	28.	0.76	30.	50.
	16.	60.	46.	34.	0.89	35.	60.
	16.	60.	50.	37.	0.99	39.	75.
	27.	80.	60.	44.	1.24	49.	75.
	27.	80.	66.	49.	1.32	52.	90.
	38.	100.	66.	49.	1.27	50.	95.
	38.	100.	70.	52.	1.30	51.	95.

A302B Reference Material

HM3 SASTM M SRM TL



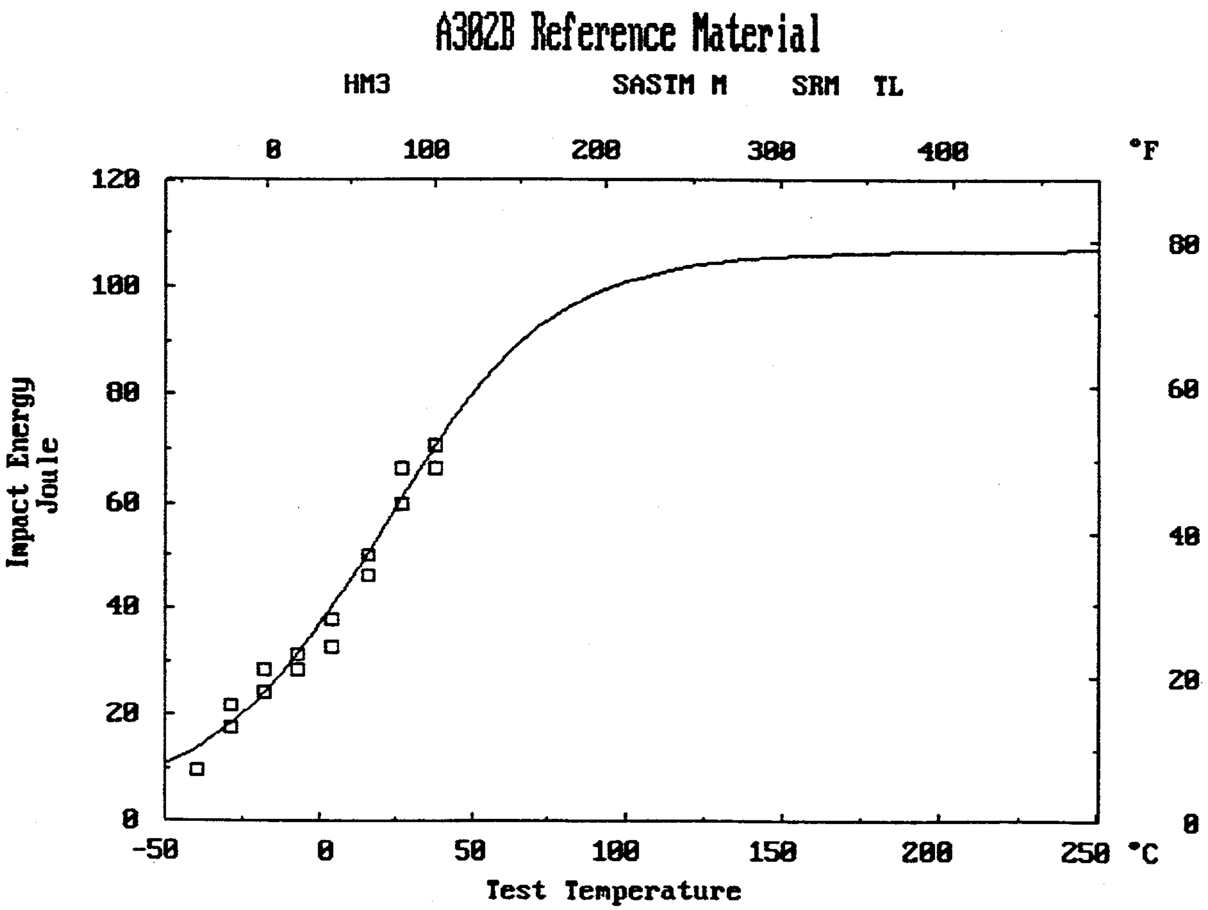
A302B REFERENCE MATERIAL

Humbolt Unit 3, Baseline (Transverse Direction)

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

HM3 SASTM M SRM TL

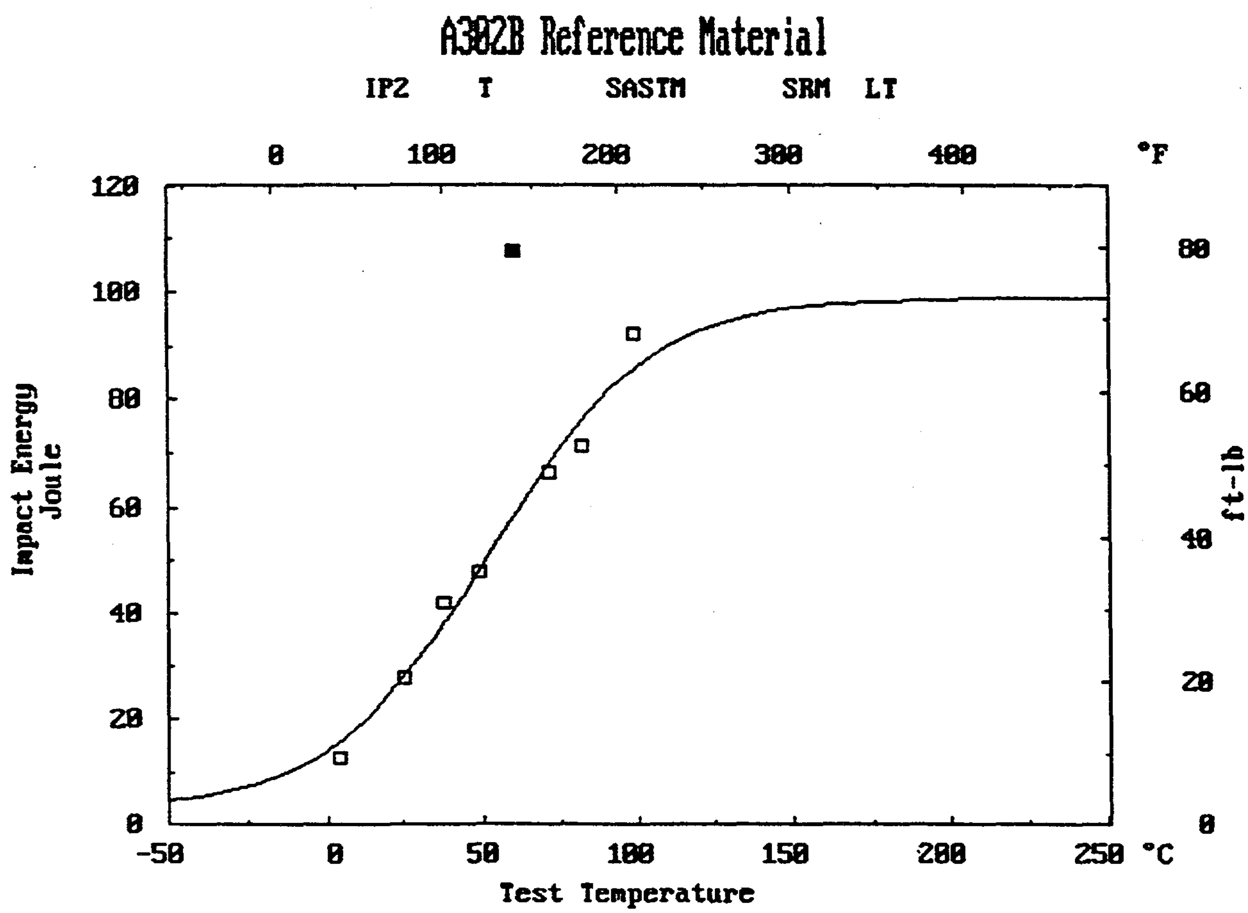
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	106.8	23.0	0.413				
CVT at Midpoint (C)	20.3	13.6	0.405	0.936			
1/slope (C)	55.8	12.2	0.147	0.570	0.700		
CVT at 41 Joule (C)	5.5	3.8	0.256	0.313	0.537	0.185	
CVT at 68 Joule (C)	38.6	8.7	-0.160	-0.458	-0.258	0.238	0.202



A302B REFERENCE MATERIAL
Indian Point Unit 2, Capsule T

USE= 98.9 J, LSE= 3.0 J, CVT(1/2)= 52.C , Slope = 0.0197
CVT(41J) = 41. C , CVT(68J) = 71. C ,
Fluence = 2.020E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	F	Impact Energy J	ft-lb	Lat. Exp. mm	mil	% Shear
R5	4.	40.	13.	9.	0.23	9.	0.
R1	26.	78.	28.	20.	0.46	18.	5.
R6	38.	100.	42.	31.	0.69	27.	10.
R4	49.	120.	48.	35.	0.81	32.	15.
*R7	60.	140.	108.	79.	1.68	66.	100.
R3	71.	160.	66.	49.	1.04	41.	70.
R8	82.	180.	71.	52.	1.02	40.	60.
R2	99.	210.	92.	68.	1.52	60.	100.



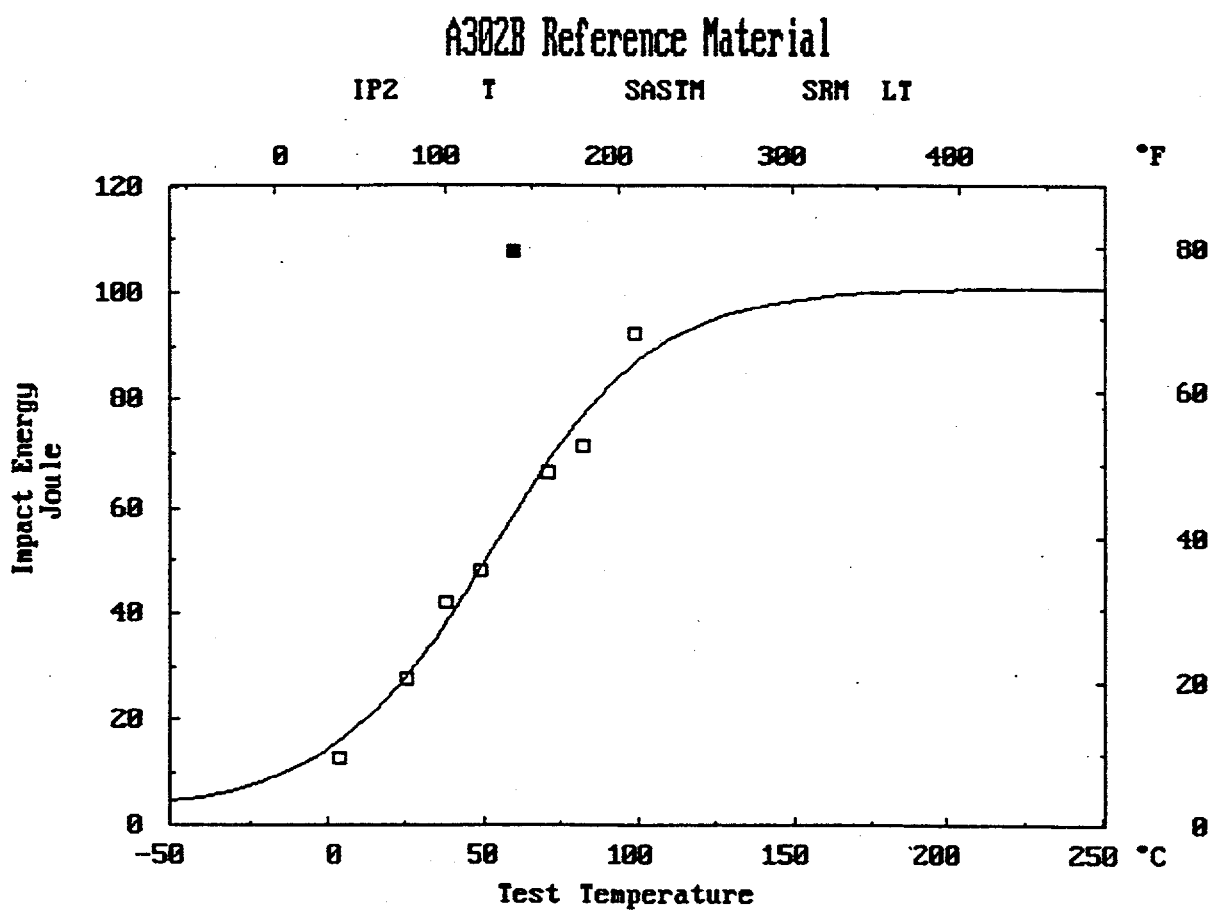
A302B REFERENCE MATERIAL

Indian Point Unit 2, Capsule T

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

IP2 T SASTM SRM LT : Fluence = 2.020E+18 , Irr. Temp. = 304

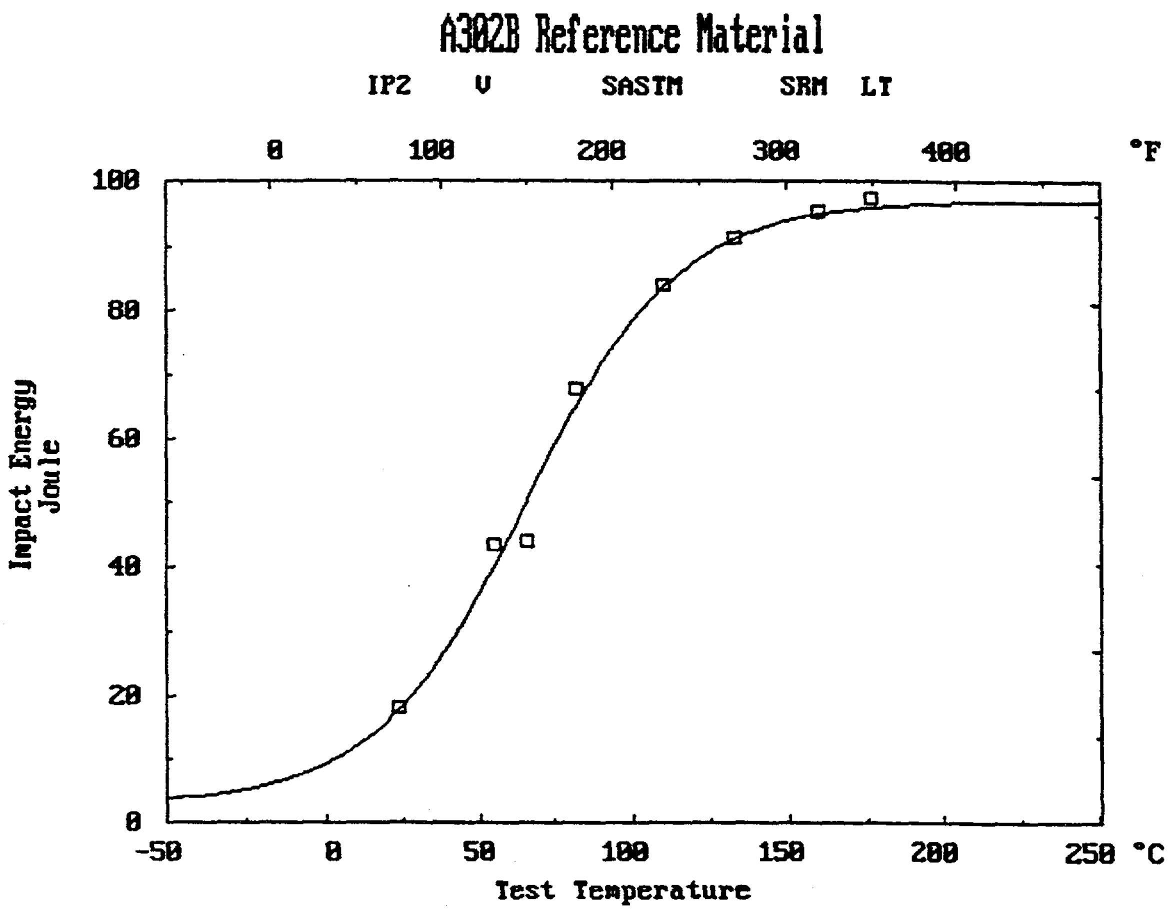
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	100.7	14.7	0.355				
CVT at Midpoint (C)	52.8	10.6	0.340	0.818			
1/slope (C)	51.5	12.2	0.155	0.432	0.392		
CVT at 41 Joule (C)	41.2	6.5	0.131	0.211	0.687	-0.154	
CVT at 68 Joule (C)	72.3	8.7	-0.014	-0.222	0.218	0.383	0.477



A302B REFERENCE MATERIAL
Indian Point Unit 2, Capsule V

USE= 97.1 J, LSE= 3.0 J, CVT(1/2)= 65.C , Slope = 0.0202
CVT(41J) = 56. C , CVT(68J) = 85. C ,
Fluence = 4.570E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R49	23.	74.	18.	13.	0.36	14.	5.
R50	54.	130.	43.	32.	1.04	41.	20.
R56	66.	150.	44.	32.	0.84	33.	30.
R51	82.	180.	68.	50.	1.12	44.	75.
R52	110.	230.	84.	62.	1.47	58.	95.
R53	132.	270.	92.	67.	1.50	59.	100.
R54	160.	320.	96.	70.	1.63	64.	100.
R55	177.	350.	98.	72.	1.57	62.	100.



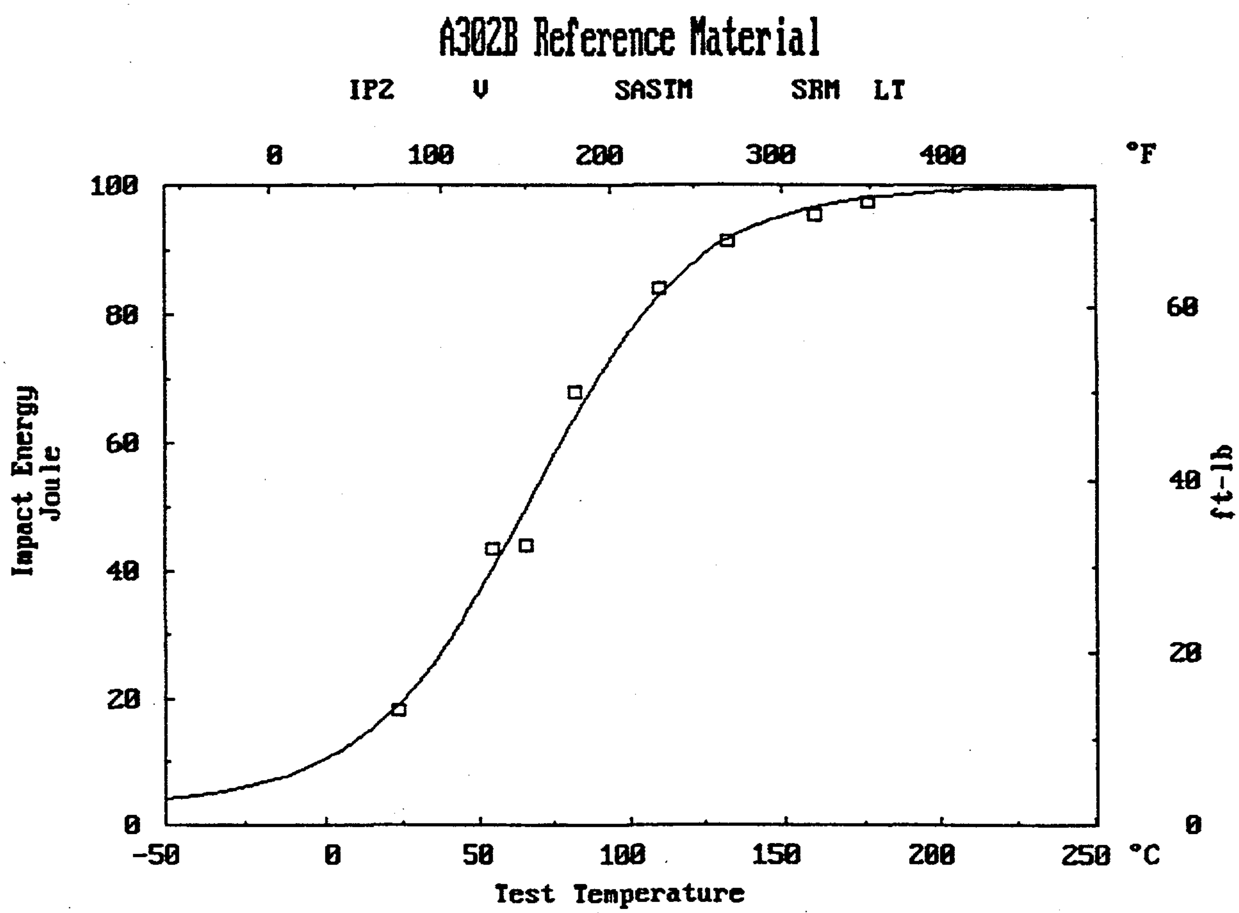
A302B REFERENCE MATERIAL

Indian Point Unit 2, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

IP2 V SASTM SRM LT : Fluence = 4.570E+18 , Irr. Temp. = 304

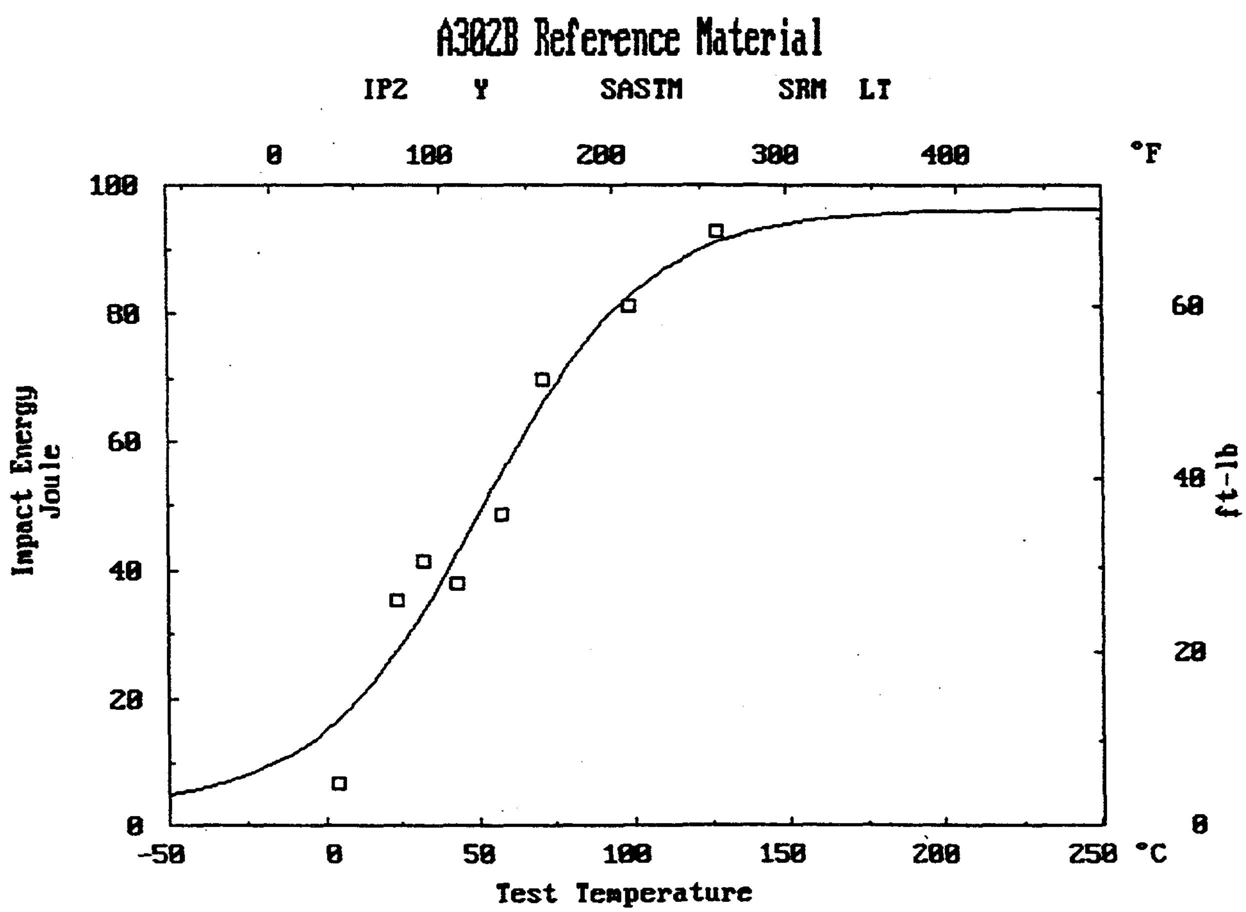
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	99.9	8.8	0.073				
CVT at Midpoint (C)	67.5	9.2	0.086	0.667			
1/slope (C)	54.3	16.4	-0.026	0.626	0.403		
CVT at 41 Joule (C)	55.2	7.5	0.072	-0.065	0.634	-0.361	
CVT at 68 Joule (C)	86.5	8.4	-0.005	0.212	0.723	0.542	0.511



A302B REFERENCE MATERIAL
Indian Point Unit 2, Capsule Y

USE= 96.4 J, LSE= 3.0 J, CVT(1/2)= 51.C , Slope = 0.0186
CVT(41J) = 41. C , CVT(68J) = 74. C ,
Fluence = 4.720E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R60	4.	40.	7.	5.	0.10	4.	0.
R57	23.	74.	35.	26.	0.56	22.	5.
R62	32.	90.	41.	30.	0.66	26.	10.
R58	43.	110.	38.	28.	0.66	26.	15.
R59	57.	135.	49.	36.	0.81	32.	20.
R63	71.	160.	70.	51.	1.09	43.	40.
R64	99.	210.	81.	60.	1.35	53.	90.
R61	127.	260.	93.	68.	1.47	58.	100.



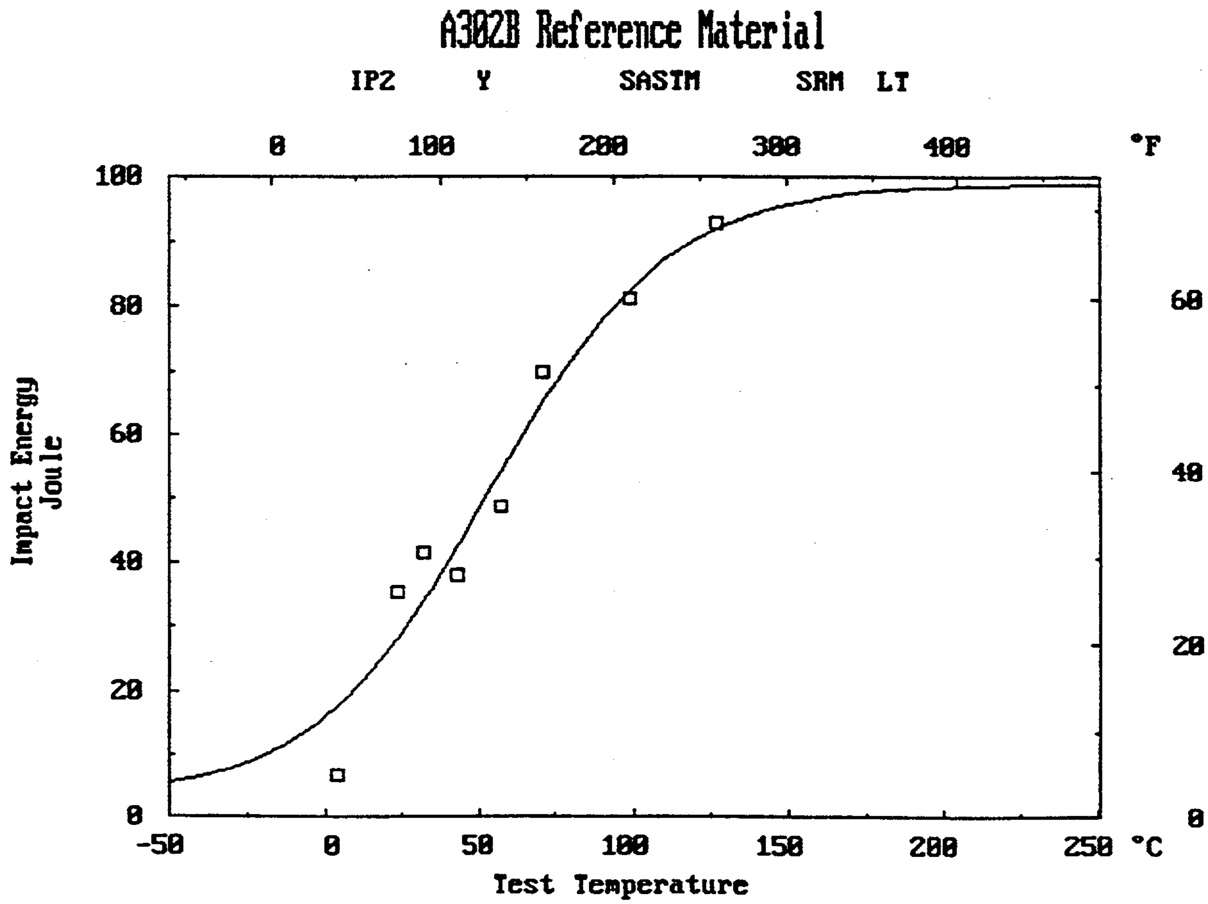
A302B REFERENCE MATERIAL

Indian Point Unit 2, Capsule Y

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
IP2   Y     SASTM     SRM  LT : Fluence = 4.720E+18 , Irr. Temp. =  304
```

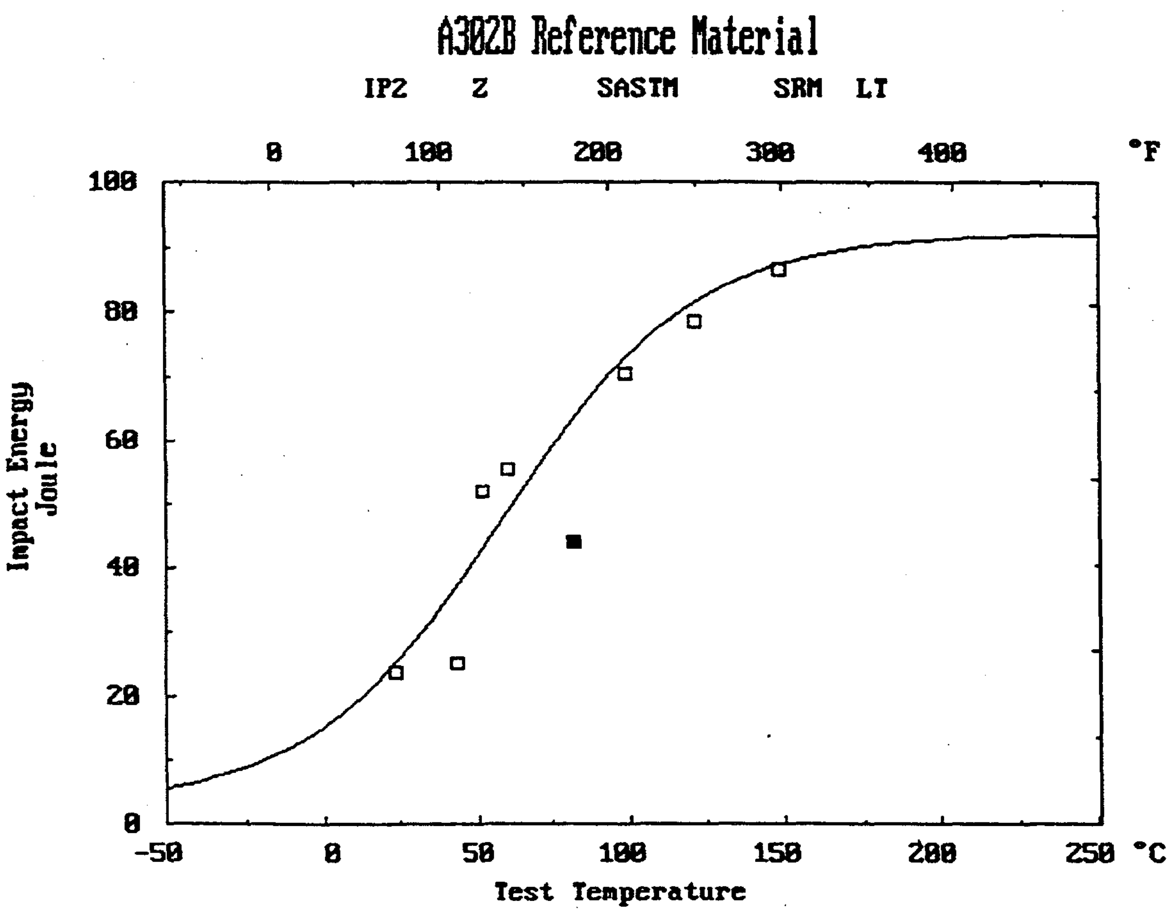
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	99.2	12.6	0.277				
CVT at Midpoint (C)	53.7	11.5	0.367	0.861			
1/slope (C)	57.7	15.1	0.316	0.605	0.640		
CVT at 41 Joule (C)	41.1	5.9	0.257	0.288	0.682	0.077	
CVT at 68 Joule (C)	75.5	9.0	0.319	0.143	0.536	0.652	0.578



A302B REFERENCE MATERIAL
Indian Point Unit 2, Capsule Z

```
USE=  92.3 J, LSE=   3.0 J, CVT(1/2)=    58.C , Slope = 0.0160
CVT(41J) =    49. C , CVT(68J) =    89. C ,
Fluence = 9.620E+18 , Irr. Temp. = 304 C
```

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R-33	24.	75.	24.	17.	0.25	10.	16.
R-36	43.	110.	25.	18.	0.13	5.	16.
R-40	52.	125.	52.	38.	0.63	25.	35.
R-37	60.	140.	56.	41.	1.27	50.	39.
*R-38	82.	180.	44.	32.	0.51	20.	34.
R-34	99.	210.	70.	52.	2.54	100.	49.
R-39	121.	250.	79.	58.	2.54	100.	57.
R-35	149.	300.	87.	64.	2.54	100.	55.



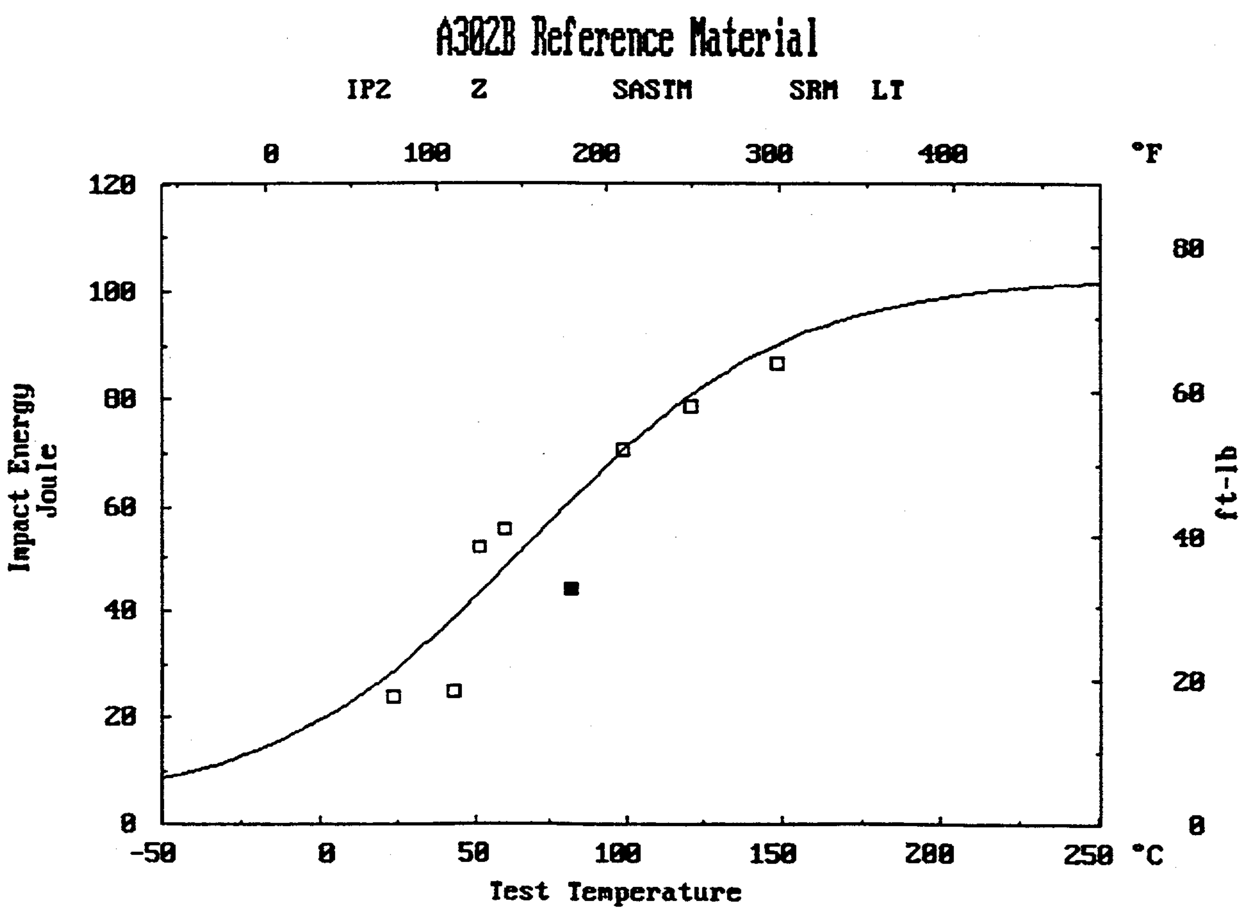
A302B REFERENCE MATERIAL

Indian Point Unit 2, Capsule Z

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

IP2 Z SASTM SRM LT : Fluence = 9.620E+18 , Irr. Temp. = 304

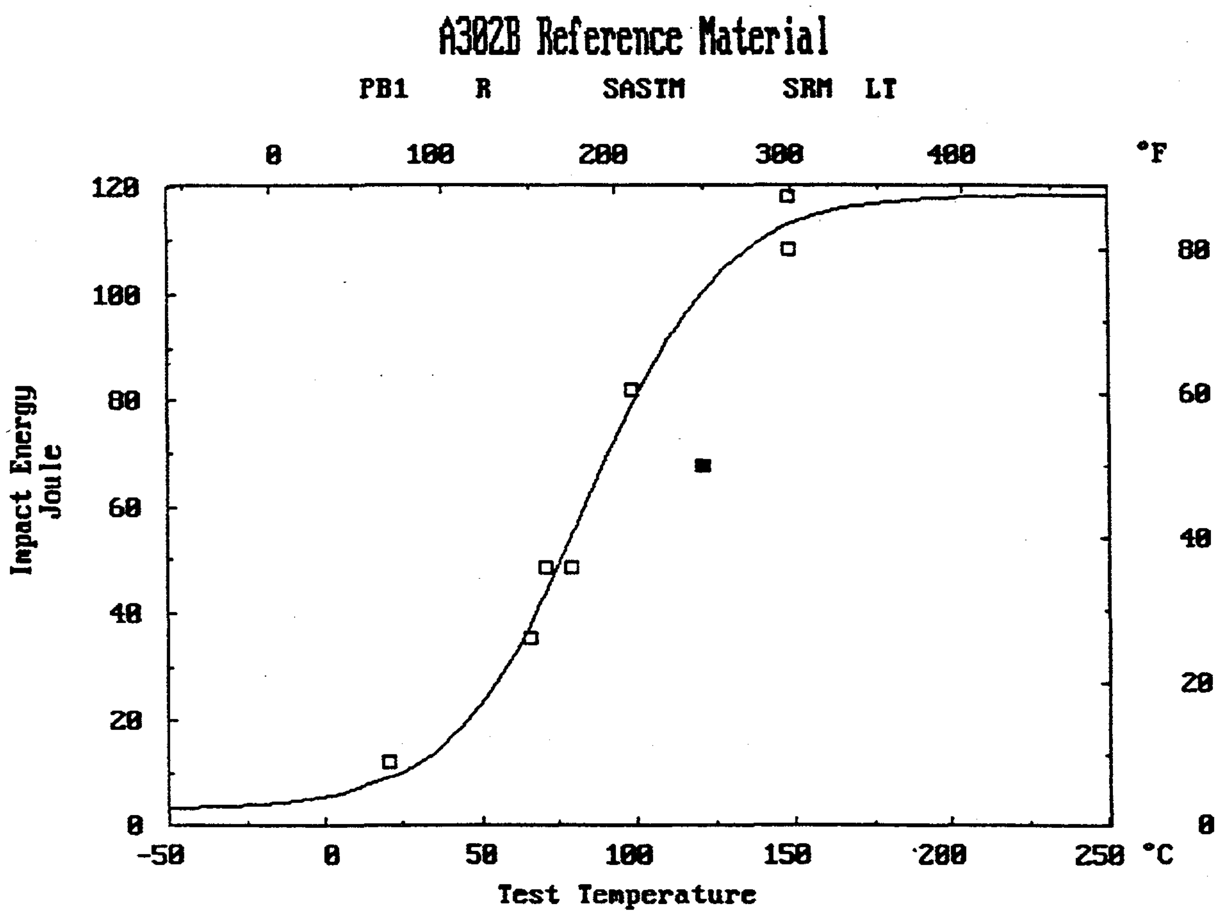
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	102.9	14.6	-0.100				
CVT at Midpoint (C)	67.9	15.9	-0.103	0.856			
1/slope (C)	83.1	21.7	0.072	0.543	0.460		
CVT at 41 Joule (C)	47.5	9.2	-0.172	0.036	0.459	-0.422	
CVT at 68 Joule (C)	95.0	10.0	-0.019	-0.076	0.310	0.429	0.375



A302B REFERENCE MATERIAL
Point Beach Unit 1, Capsule R

USE= 118.5 J, LSE= 3.0 J, CVT(1/2)= 84.C , Slope = 0.0230
CVT(41J) = 69. C , CVT(68J) = 90. C ,
Fluence = 2.220E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R10	21.	70.	12.	9.	0.10	4.	10.
R13	66.	150.	35.	26.	0.53	21.	30.
R15	71.	160.	49.	36.	0.69	27.	40.
R9	79.	175.	49.	36.	0.71	28.	40.
R11	99.	210.	82.	60.	1.07	42.	85.
*R12	121.	250.	68.	50.	1.07	42.	80.
R14	149.	300.	118.	87.	1.47	58.	100.
R16	149.	300.	108.	80.	1.27	50.	100.



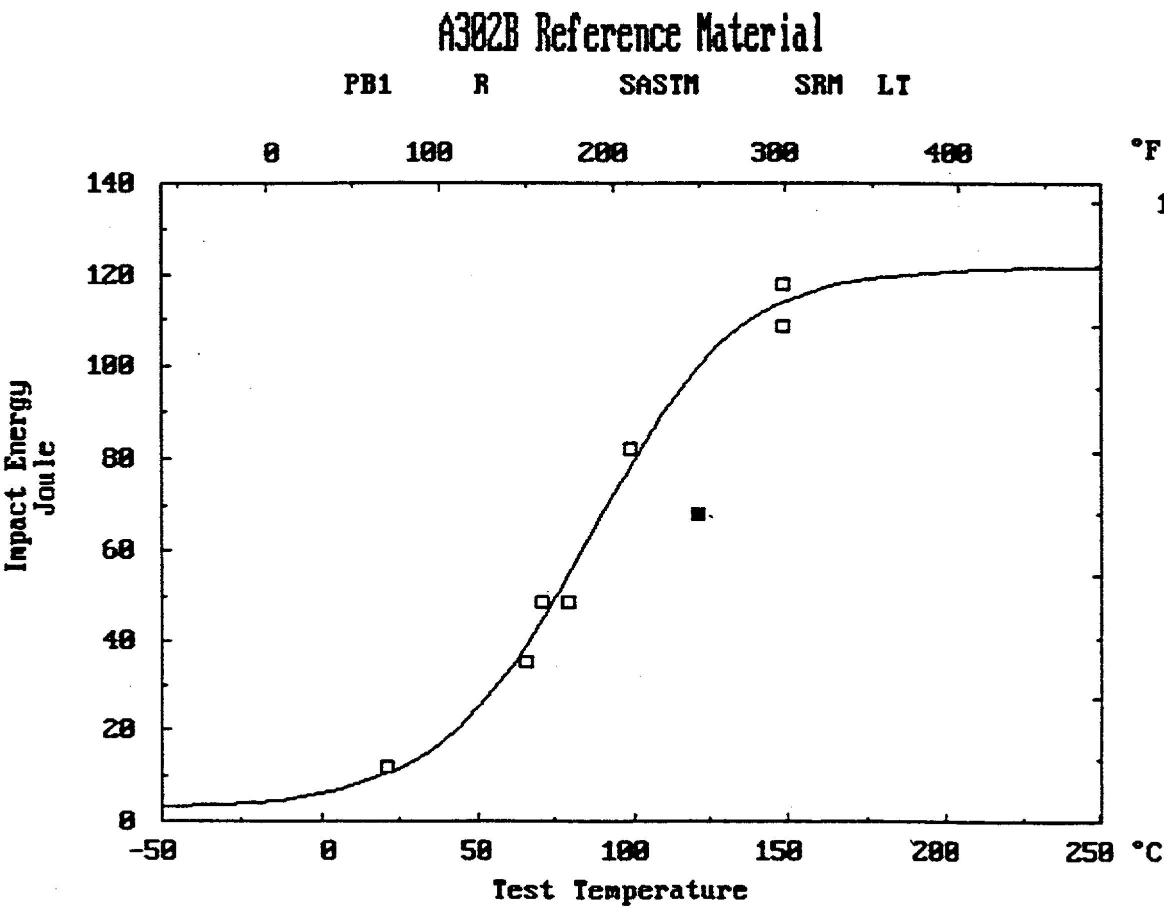
A302B REFERENCE MATERIAL

Point Beach Unit 1, Capsule R

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PB1 R SASTM SRM LT : Fluence = 2.220E+19 , Irr. Temp. = 304

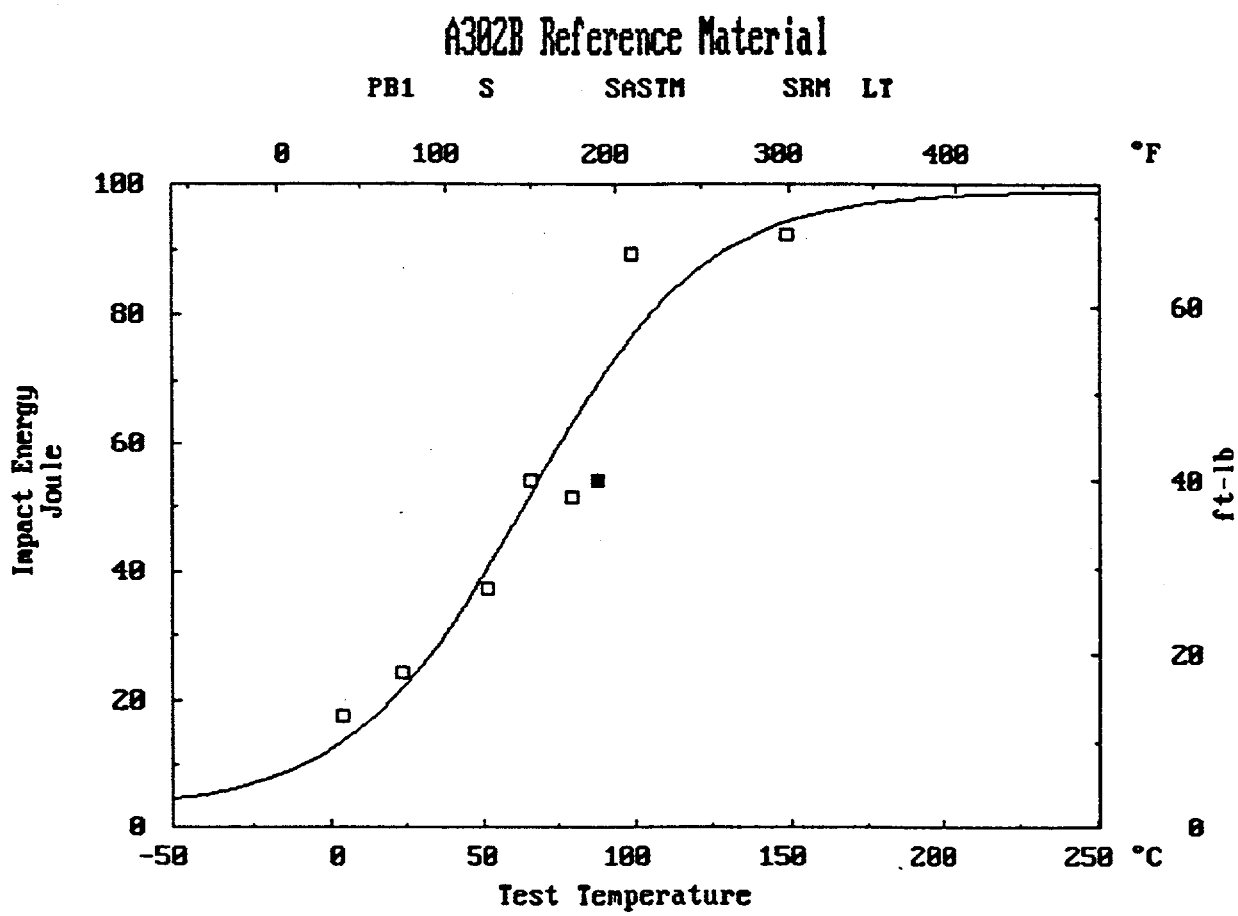
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	121.7	11.5	0.068				
CVT at Midpoint (C)	85.8	7.9	0.002	0.771			
1/slope (C)	47.3	12.7	-0.066	0.541	0.536		
CVT at 41 Joule (C)	67.7	5.7	-0.005	-0.065	0.399	-0.472	
CVT at 68 Joule (C)	90.1	5.5	-0.111	0.200	0.754	0.437	0.548



A302B REFERENCE MATERIAL
Point Beach Unit 1, Capsule S

USE= 99.3 J, LSE= 3.0 J, CVT(1/2)= 65.C , Slope = 0.0173
CVT(41J) = 52. C , CVT(68J) = 86. C ,
Fluence = 7.050E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R28	4.	40.	18.	13.	0.15	6.	5.
R26	24.	75.	24.	18.	0.30	12.	20.
R25	52.	125.	37.	27.	0.51	20.	30.
R27	66.	150.	54.	40.	0.76	30.	40.
R29	79.	175.	52.	38.	0.81	32.	45.
*R31	88.	190.	54.	40.	0.97	38.	99.
R32	99.	210.	89.	66.	1.24	49.	95.
R30	149.	300.	92.	68.	1.42	56.	100.



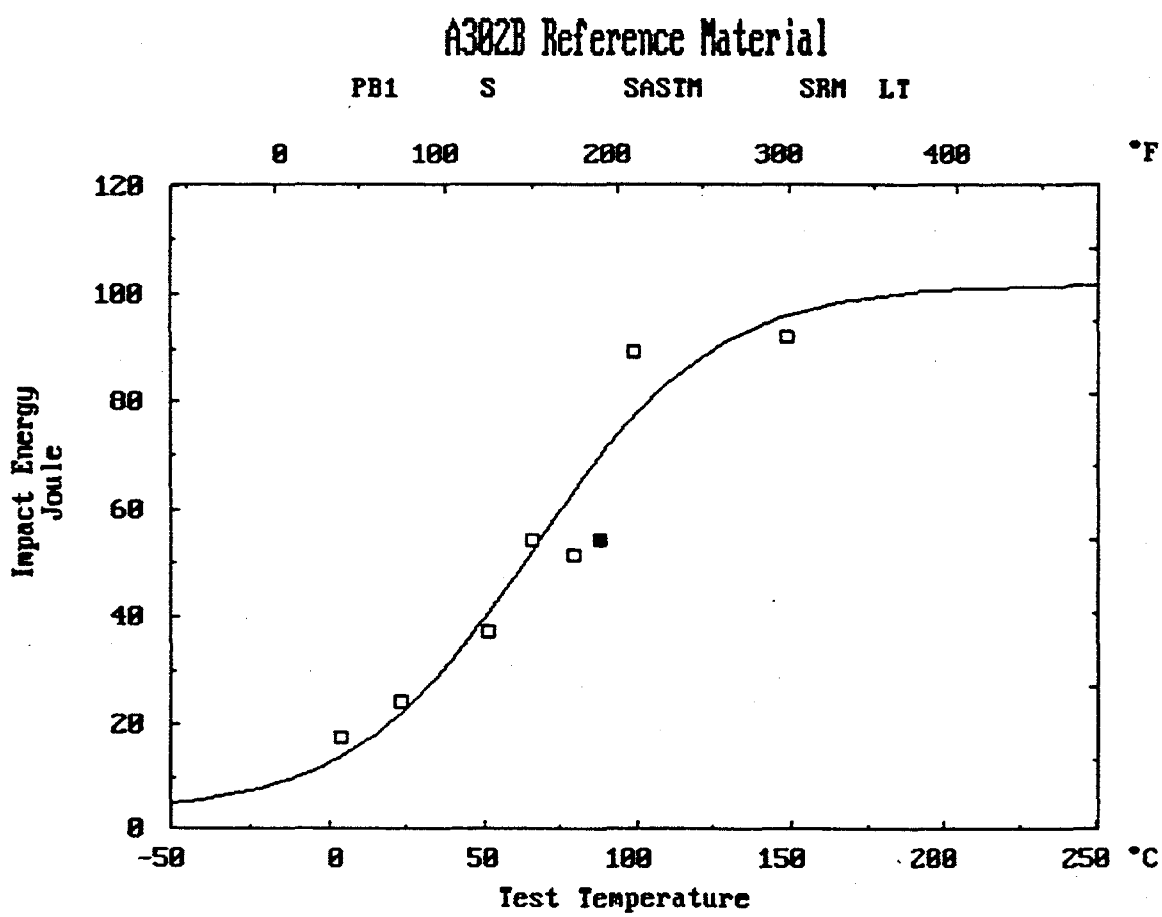
A302B REFERENCE MATERIAL

Point Beach Unit 1, Capsule S

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =    4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

PB1 S SASTM SRM LT : Fluence = 7.050E+18 , Irr. Temp. = 304

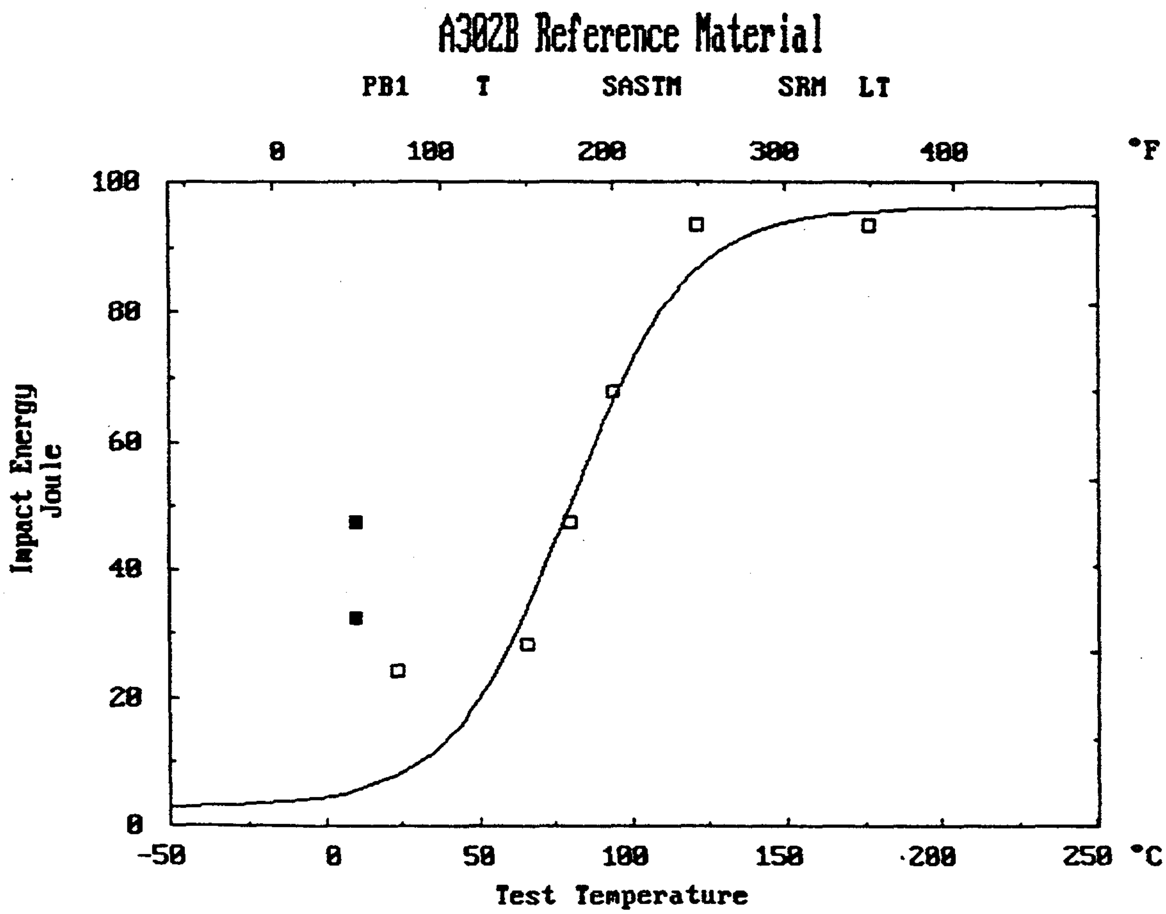
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	101.8	13.1	0.184				
CVT at Midpoint (C)	66.1	10.7	0.318	0.792			
1/slope (C)	59.7	17.1	-0.212	0.434	0.297		
CVT at 41 Joule (C)	52.0	7.6	0.420	0.037	0.562	-0.452	
CVT at 68 Joule (C)	86.5	8.5	0.026	-0.104	0.331	0.479	0.358



A302B REFERENCE MATERIAL
Point Beach Unit 1, Capsule T

```
USE=  96.2 J, LSE=   3.1 J, CVT(1/2)=    79.C , Slope = 0.0261
CVT(41J) =    72. C , CVT(68J) =    95. C ,
Fluence = 2.110E+19 , Irr. Temp. = 304 C
```

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
*R17	10.	50.	33.	24.	0.51	20.	44.
*R24	10.	50.	47.	35.	0.63	25.	33.
R19	23.	74.	24.	18.	0.36	14.	21.
R20	66.	150.	28.	21.	0.51	20.	32.
R18	79.	175.	47.	35.	0.71	28.	40.
R23	93.	200.	68.	50.	0.81	32.	57.
R22	121.	250.	94.	69.	1.30	51.	98.
R21	177.	350.	94.	69.	1.30	51.	100.



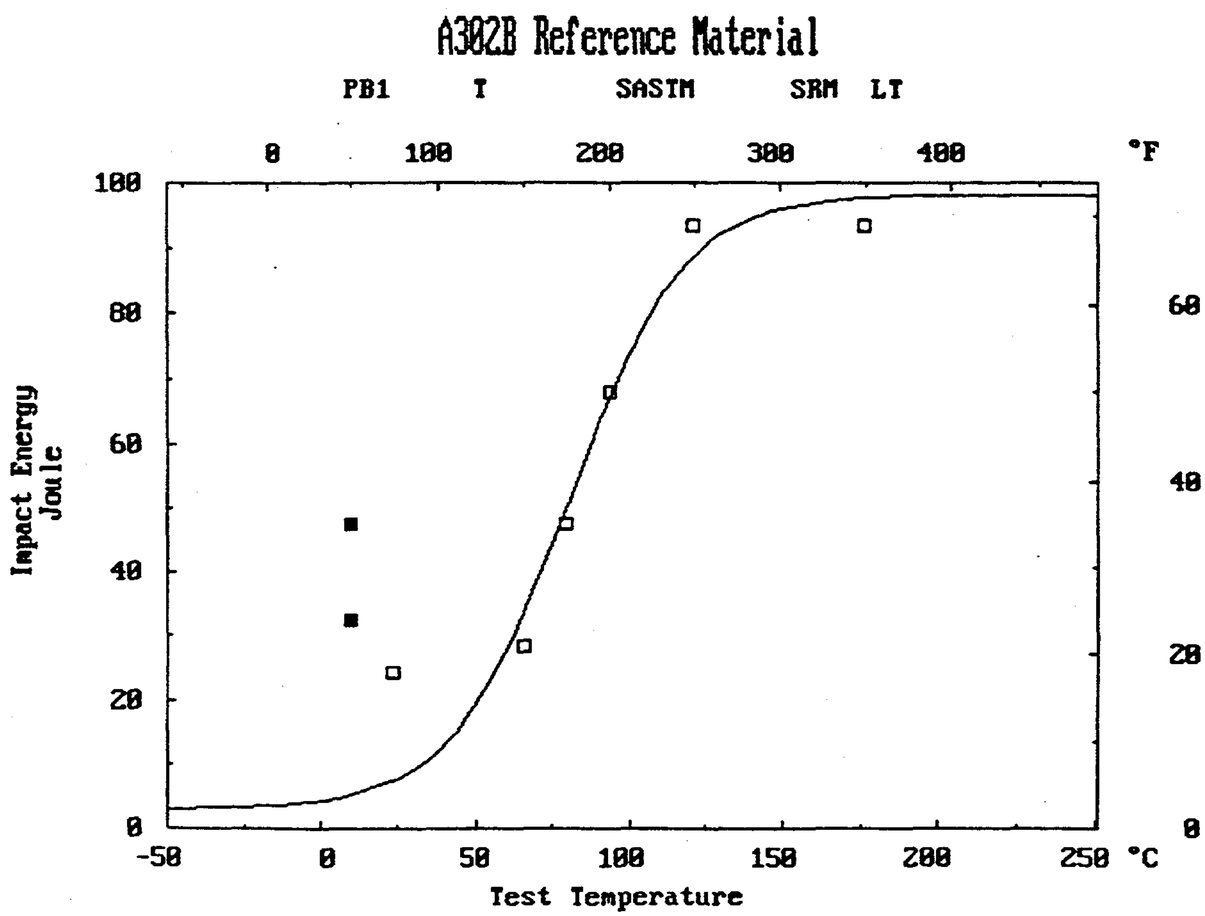
A302B REFERENCE MATERIAL

Point Beach Unit 1, Capsule T

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PB1 T SASTM SRM LT : Fluence = 2.110E+19 , Irr. Temp. = 304

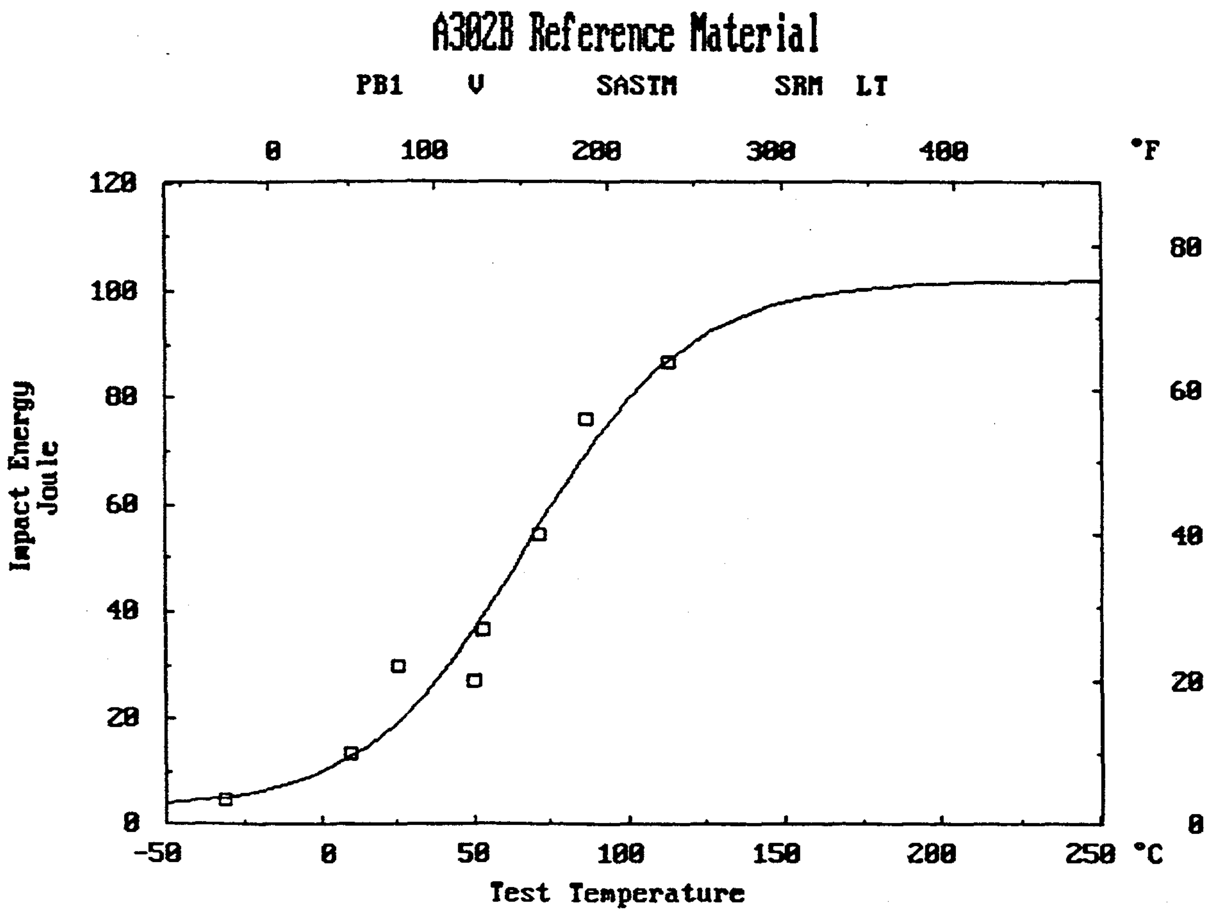
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.0					
Upper Shelf Energy (J)	98.2	8.0	0.086				
CVT at Midpoint (C)	80.0	7.2	0.317	0.523			
1/slope (C)	37.2	13.4	-0.520	0.233	-0.126		
CVT at 41 Joule (C)	72.3	7.3	0.482	0.036	0.810	-0.586	
CVT at 68 Joule (C)	94.5	6.8	-0.133	-0.074	0.492	0.478	0.352



A302B REFERENCE MATERIAL
Point Beach Unit 1, Capsule V

USE= 102.0 J, LSE= 3.0 J, CVT(1/2)= 68.C , Slope = 0.0192
CVT(41J) = 56. C , CVT(68J) = 85. C ,
Fluence = 3.580E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R6	-32.	-25.	5.	3.	0.05	2.	2.
R1	10.	50.	14.	10.	0.20	8.	10.
R7	26.	78.	30.	22.	0.48	19.	15.
R5	50.	122.	27.	20.	0.53	21.	30.
R4	53.	127.	37.	27.	0.66	26.	40.
R2	72.	161.	54.	40.	0.91	36.	55.
R3	87.	188.	76.	56.	1.30	51.	75.
R8	113.	236.	87.	64.	1.37	54.	98.



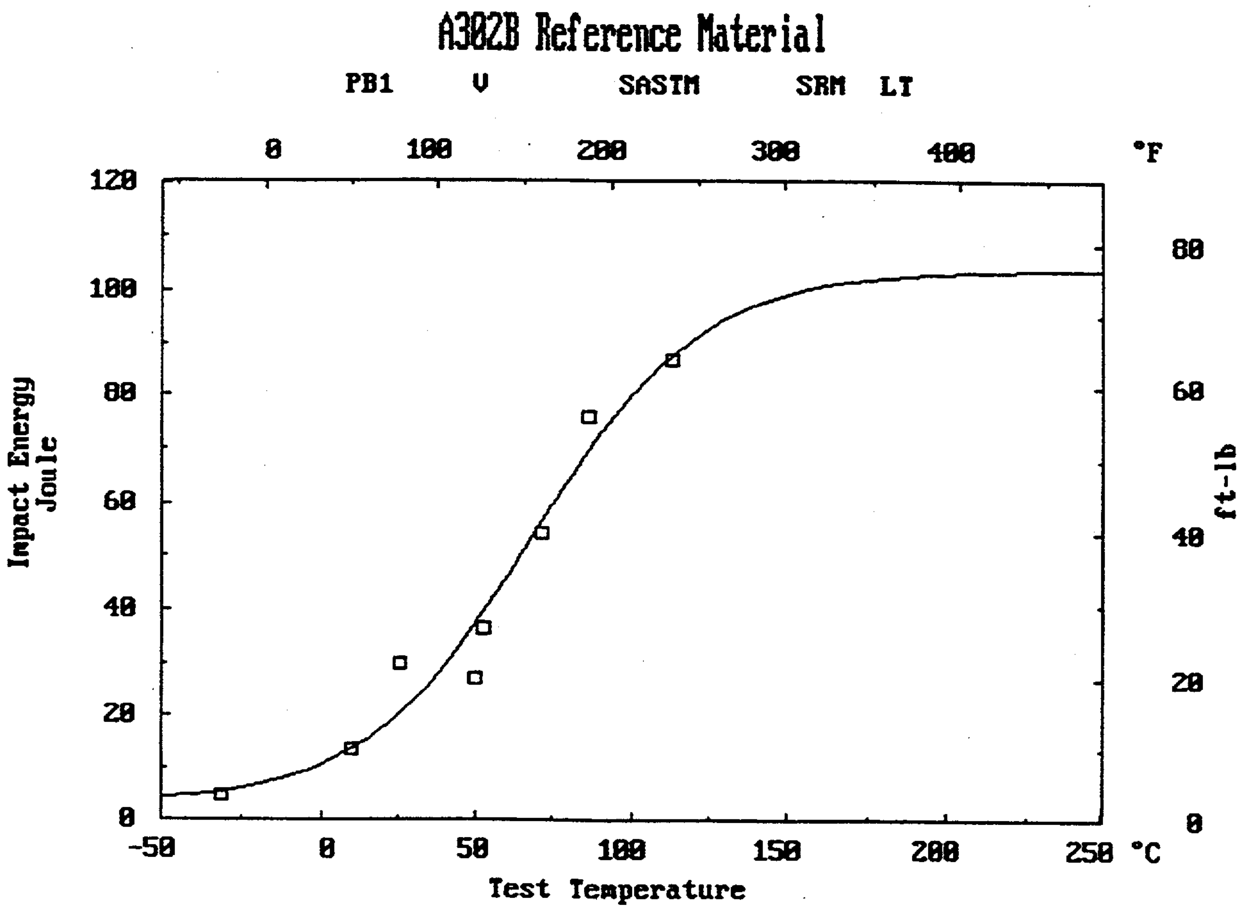
A302B REFERENCE MATERIAL

Point Beach Unit 1, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

PB1 V SASTM SRM LT : Fluence = 3.580E+18 , Irr. Temp. = 304

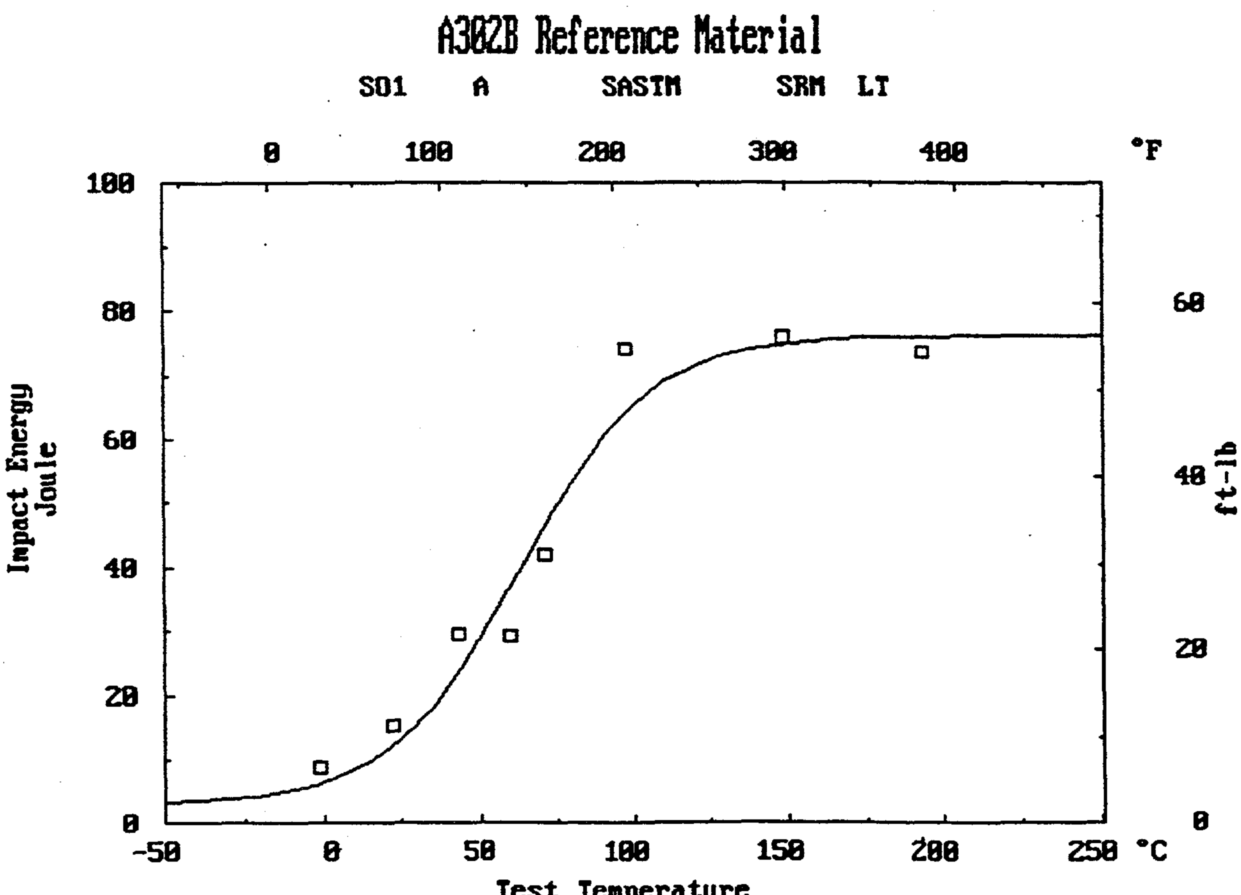
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	103.9	15.5	0.176				
CVT at Midpoint (C)	68.5	10.9	0.310	0.854			
1/slope (C)	54.1	14.0	-0.197	0.438	0.386		
CVT at 41 Joule (C)	54.9	6.3	0.434	0.171	0.571	-0.348	
CVT at 68 Joule (C)	86.1	7.8	0.031	-0.210	0.114	0.395	0.265



A302B REFERENCE MATERIAL
San Onofre Unit 1, Capsule A

USE= 76.3 J, LSE= 3.0 J, CVT(1/2)= 63.C , Slope = 0.0239
CVT(41J) = 65. C , CVT(68J) = 106. C ,
Fluence = 1.200E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R48	-1.	30.	9.	6.	0.15	6.	2.
R43	22.	72.	15.	11.	0.30	12.	5.
R45	43.	110.	30.	22.	0.46	18.	5.
R44	60.	140.	29.	21.	0.56	22.	10.
R41	71.	160.	42.	31.	0.74	29.	20.
R47	97.	207.	74.	55.	1.24	49.	95.
R42	149.	300.	76.	56.	1.19	47.	100.
R46	193.	380.	74.	54.	1.40	55.	100.



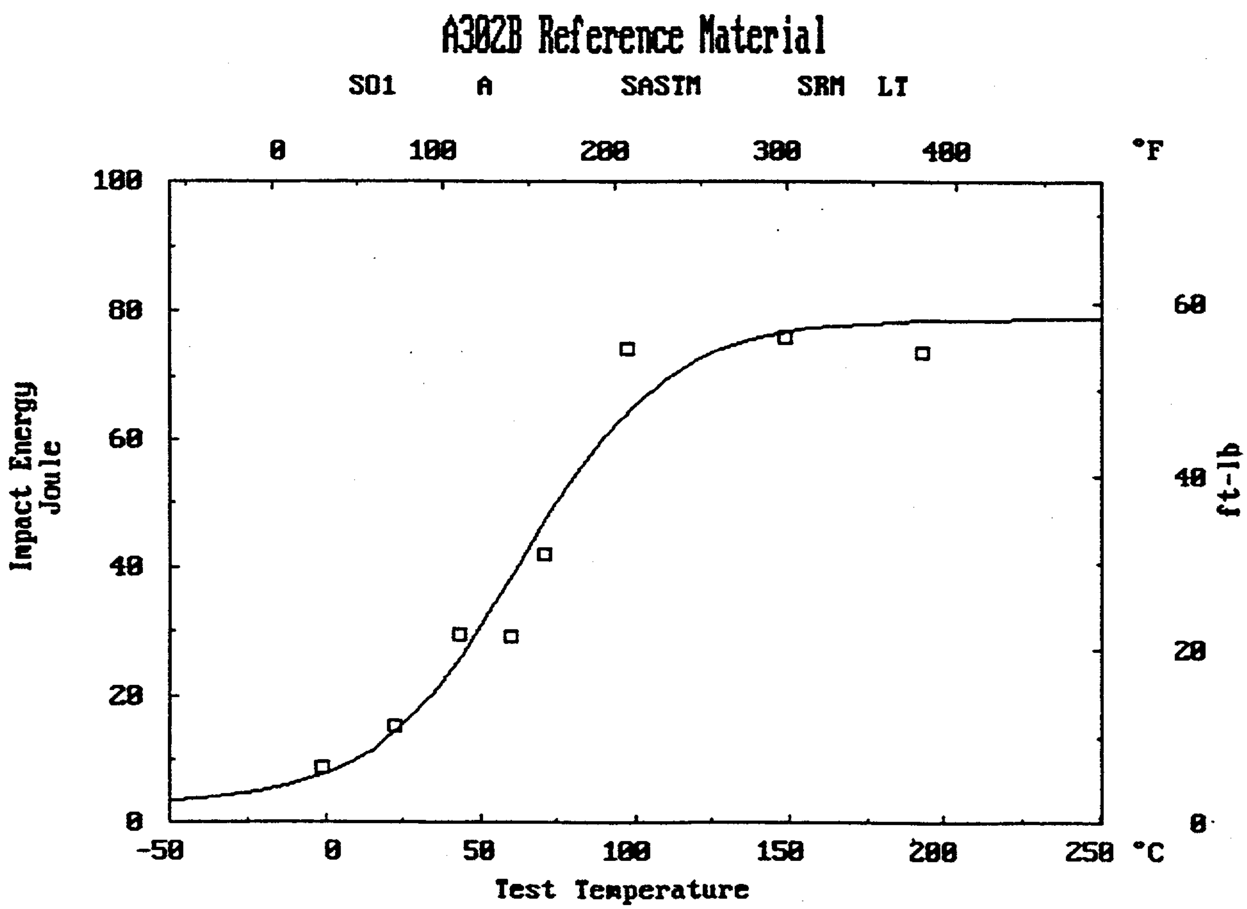
A302B REFERENCE MATERIAL

San Onofre Unit 1, Capsule A

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
SO1    A     SASTM    SRM  LT : Fluence = 1.200E+19 , Irr. Temp. =  304
```

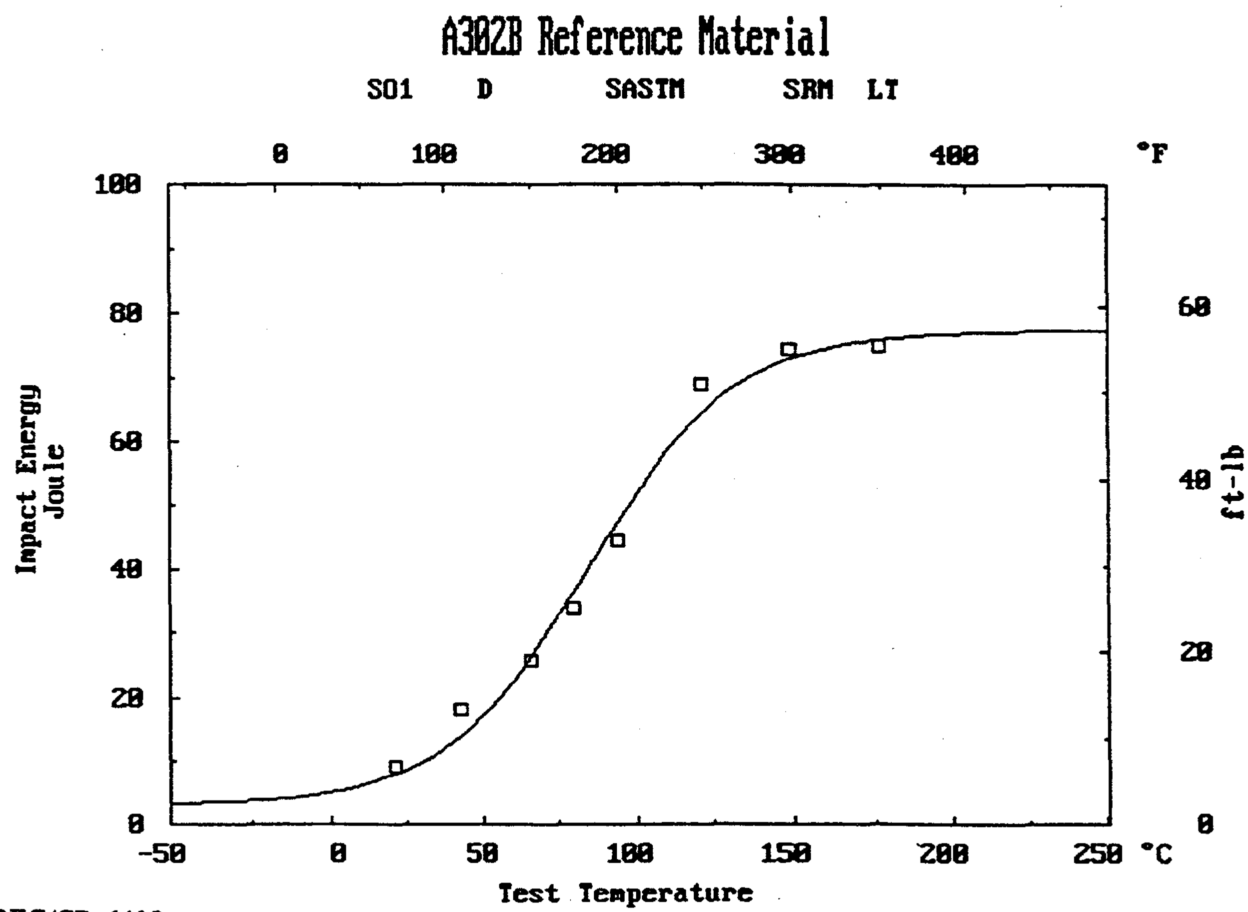
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	78.9	5.5	0.074				
CVT at Midpoint (C)	63.3	7.5	0.302	0.468			
1/slope (C)	47.2	13.6	-0.364	0.182	-0.060		
CVT at 41 Joule (C)	63.5	6.6	0.302	-0.043	0.853	-0.151	
CVT at 68 Joule (C)	108.9	18.4	-0.212	-0.491	-0.061	0.627	0.262



A302B REFERENCE MATERIAL
San Onofre Unit 1, Capsule D

USE= 77.6 J, LSE= 3.0 J, CVT(1/2)= 84.C , Slope = 0.0213
CVT(41J) = 85. C , CVT(68J) = 129. C ,
Fluence = 2.360E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R13	21.	70.	9.	7.	0.13	5.	2.
R10	43.	110.	18.	13.	0.30	12.	5.
R11	66.	150.	26.	19.	0.41	16.	20.
R9	79.	175.	34.	25.	0.58	23.	20.
R16	93.	200.	45.	33.	0.76	30.	40.
R12	121.	250.	69.	51.	1.27	50.	100.
R15	149.	300.	75.	55.	1.42	56.	90.
R14	177.	350.	75.	55.	0.91	36.	100.



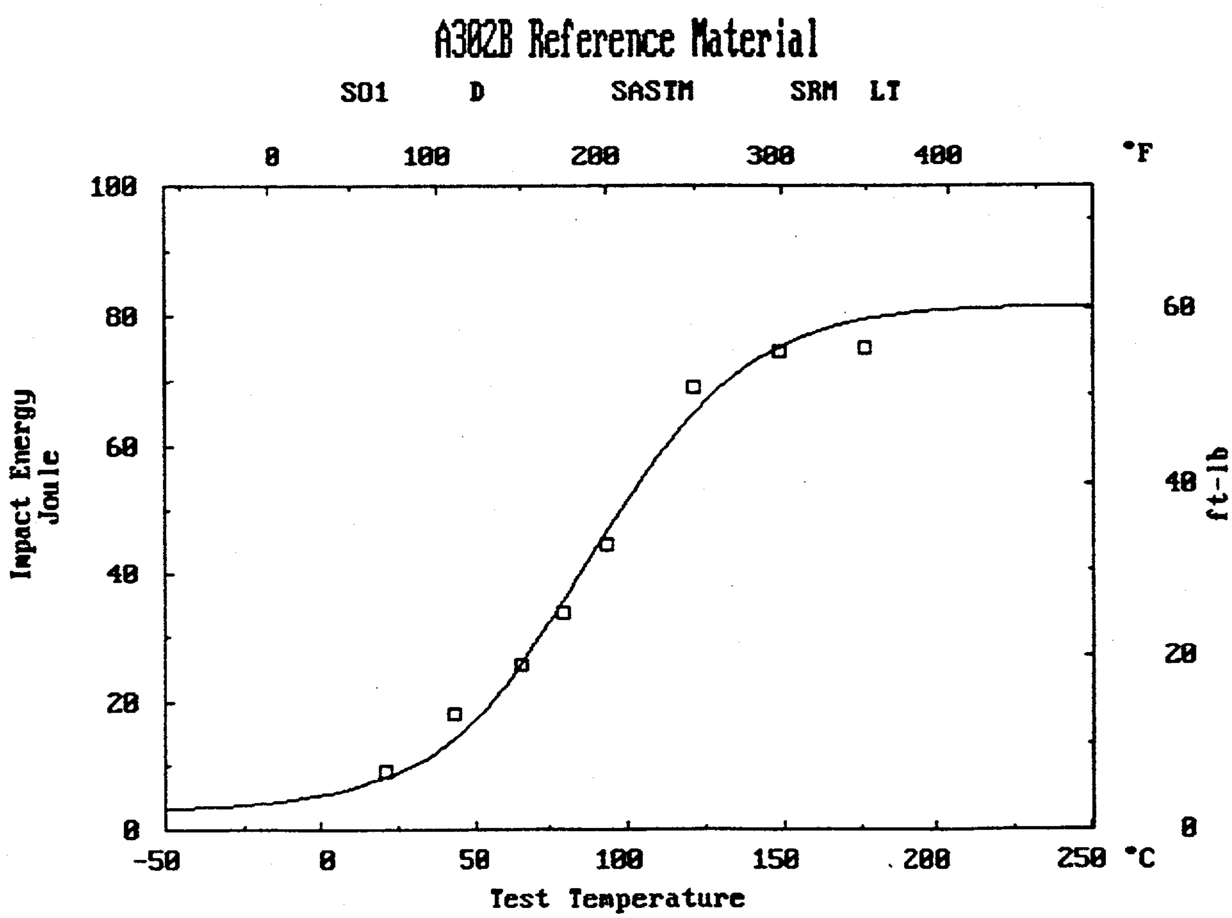
A302B REFERENCE MATERIAL

San Onofre Unit 1, Capsule D

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SO1 D SASTM SRM LT : Fluence = 2.360E+19 , Irr. Temp. = 304

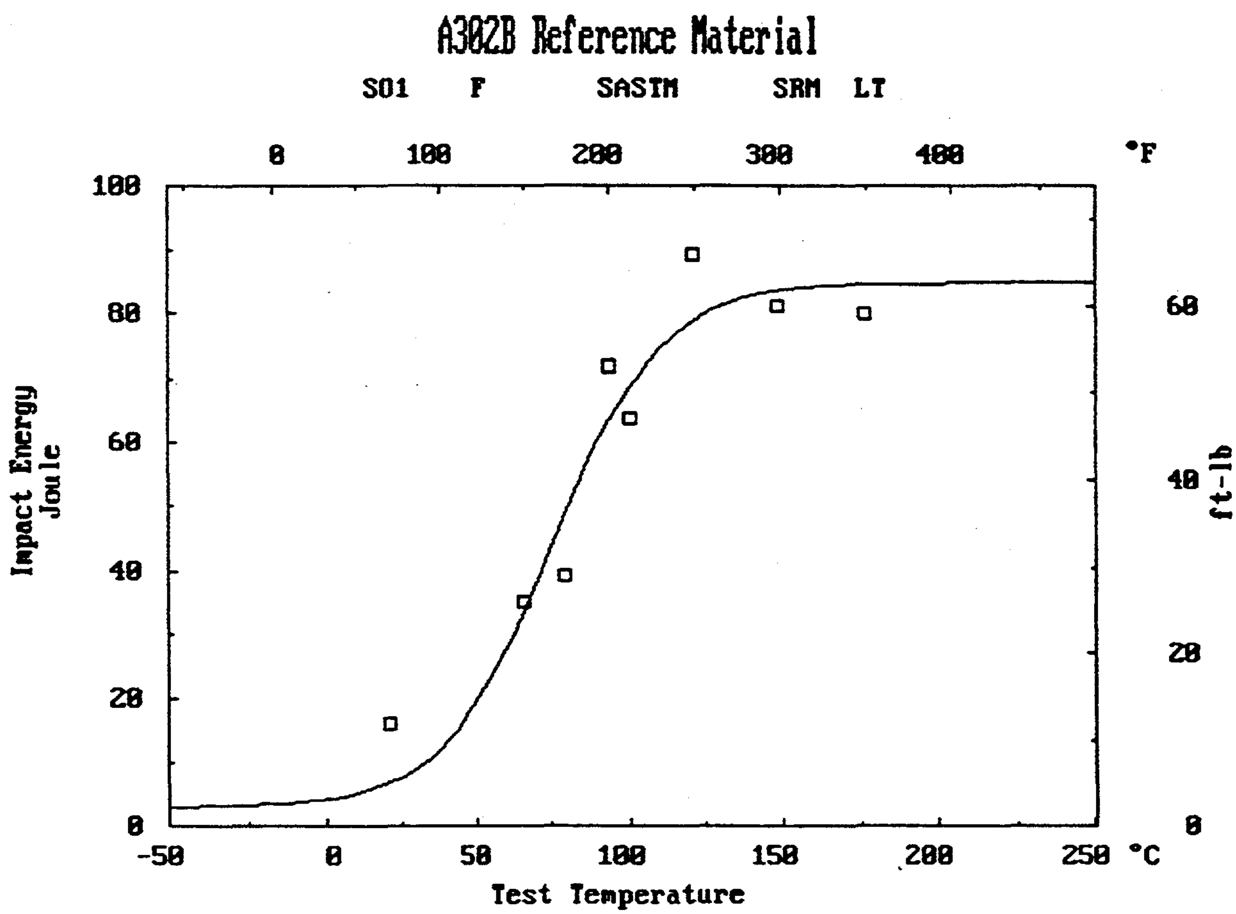
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	81.7	8.5	-0.113				
CVT at Midpoint (C)	88.0	10.8	0.081	0.717			
1/slope (C)	49.9	15.7	-0.341	0.589	0.394		
CVT at 41 Joule (C)	85.9	7.6	0.210	0.249	0.843	0.058	
CVT at 68 Joule (C)	129.6	14.9	-0.155	-0.175	0.212	0.485	0.407



A302B REFERENCE MATERIAL
San Onofre Unit 1, Capsule F

USE= 85.0 J, LSE= 3.0 J, CVT(1/2)= 75.C , Slope = 0.0281
CVT(41J) = 72. C , CVT(68J) = 99. C ,
Fluence = 5.140E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R57	21.	70.	16.	12.	0.41	16.	10.
R63	66.	150.	35.	26.	0.61	24.	20.
R58	79.	175.	39.	29.	0.71	28.	25.
R61	93.	200.	72.	53.	1.12	44.	80.
R60	100.	212.	64.	47.	1.02	40.	85.
R62	121.	250.	89.	66.	1.32	52.	100.
R64	149.	300.	81.	60.	1.19	47.	100.
R59	177.	350.	80.	59.	1.30	51.	100.



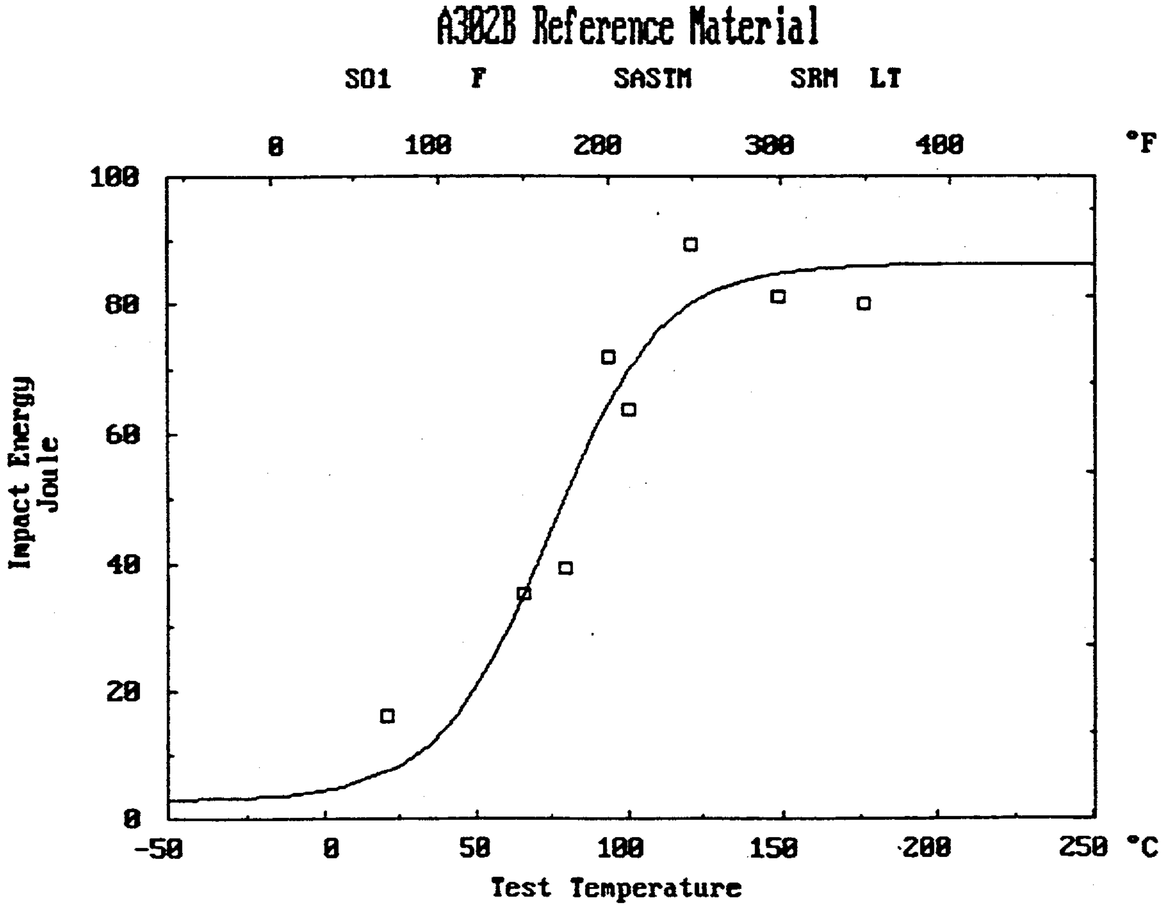
A302B REFERENCE MATERIAL

San Onofre Unit 1, Capsule F

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
SO1    F     SASTM     SRM  LT : Fluence = 5.140E+19 , Irr. Temp. =  304
```

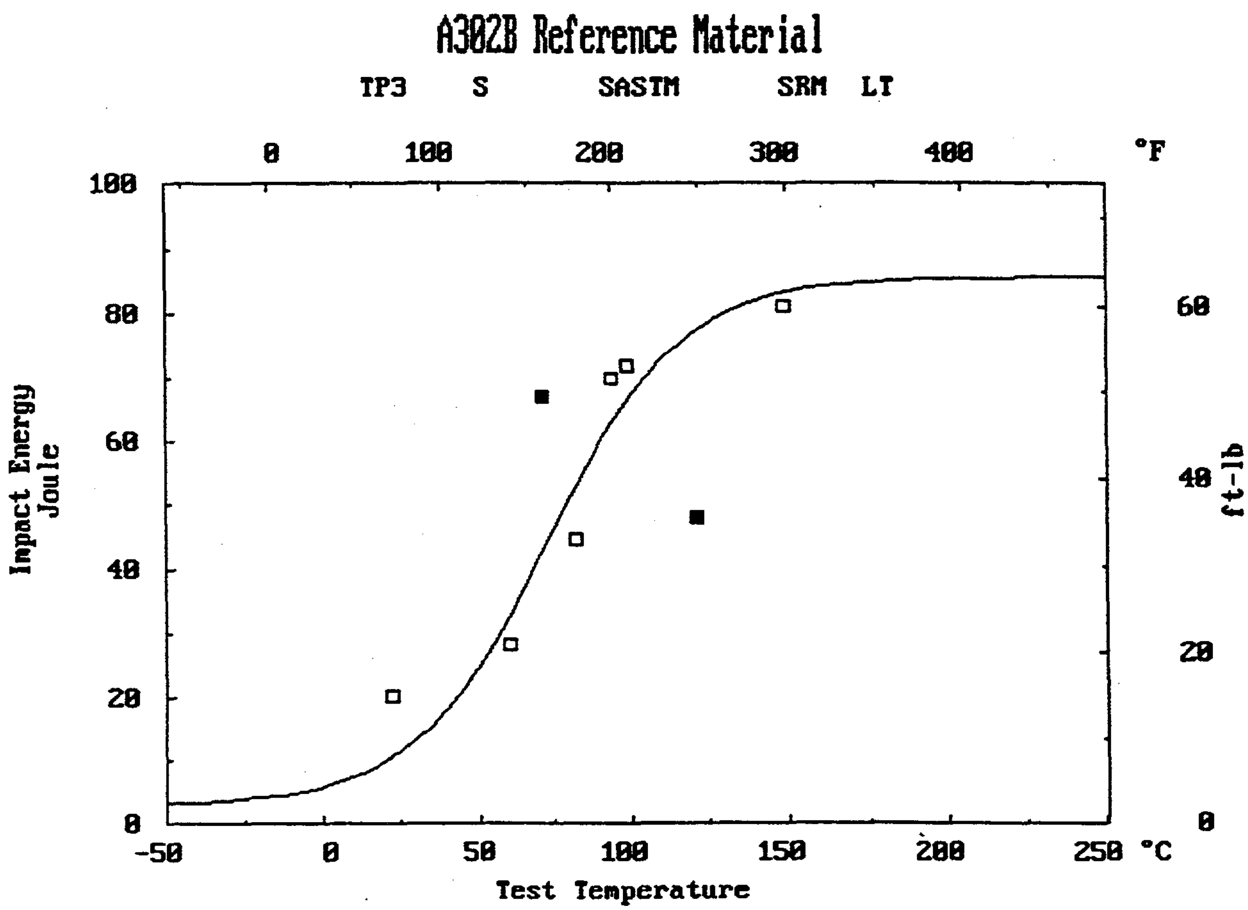
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	86.2	6.5	0.117				
CVT at Midpoint (C)	74.3	8.3	0.411	0.498			
1/slope (C)	36.4	12.2	-0.394	0.273	-0.377		
CVT at 41 Joule (C)	71.1	7.9	0.451	0.150	0.921	-0.631	
CVT at 68 Joule (C)	98.1	6.4	-0.064	-0.075	0.274	0.427	0.258



A302B REFERENCE MATERIAL
Turkey Point Unit 3, Capsule S

USE= 85.8 J, LSE= 3.0 J, CVT(1/2)= 73.C , Slope = 0.0230
CVT(41J) = 69. C , CVT(68J) = 101. C ,
Fluence = 1.410E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R1	22.	72.	20.	15.	0.33	13.	5.
R2	60.	140.	28.	21.	0.48	19.	15.
*R5	71.	160.	67.	49.	1.02	40.	40.
R6	82.	180.	45.	33.	0.79	31.	50.
R8	93.	200.	70.	51.	1.27	50.	95.
R3	99.	210.	72.	53.	1.19	47.	90.
*R7	121.	250.	48.	35.	0.86	34.	60.
R4	149.	300.	81.	60.	1.30	51.	100.



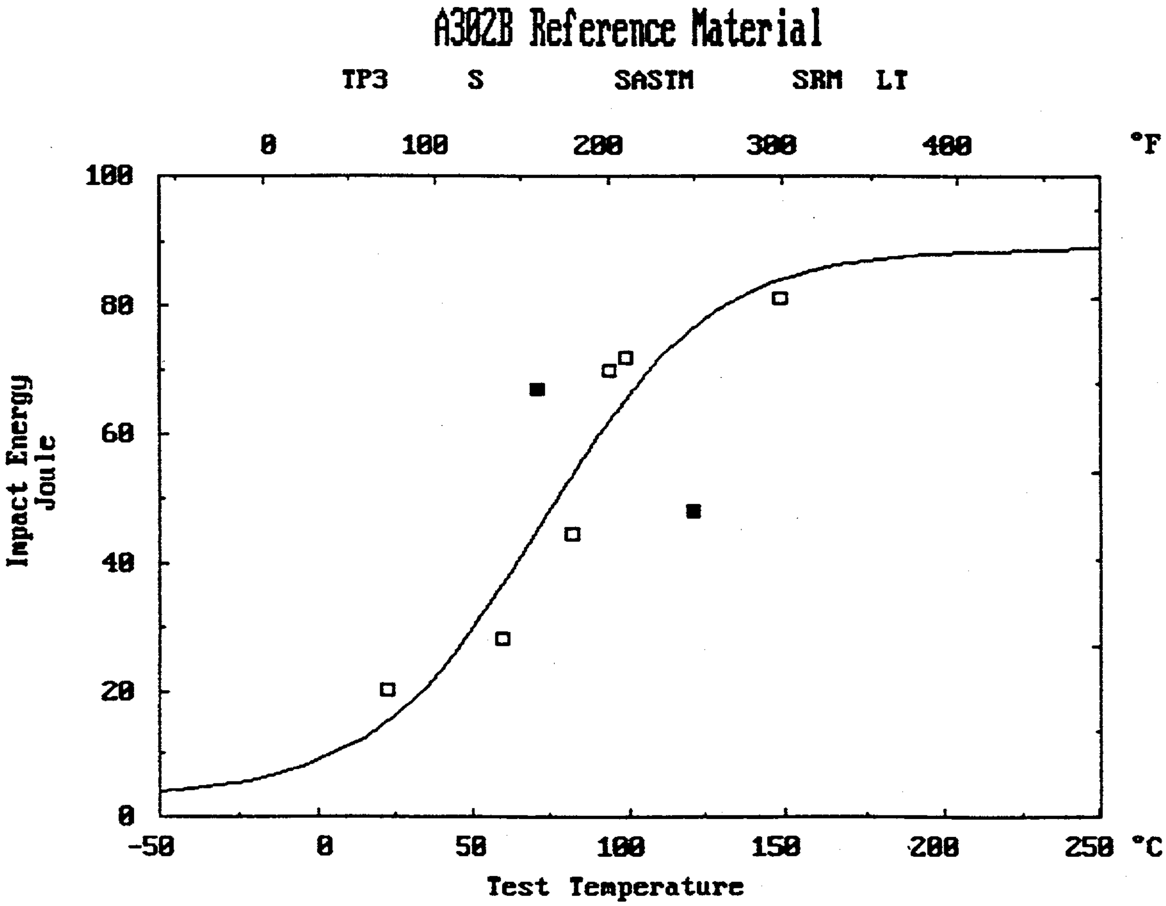
A302B REFERENCE MATERIAL

Turkey Point Unit 3, Capsule S

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

TP3 S SASTM SRM LT : Fluence = 1.410E+19 , Irr. Temp. = 304

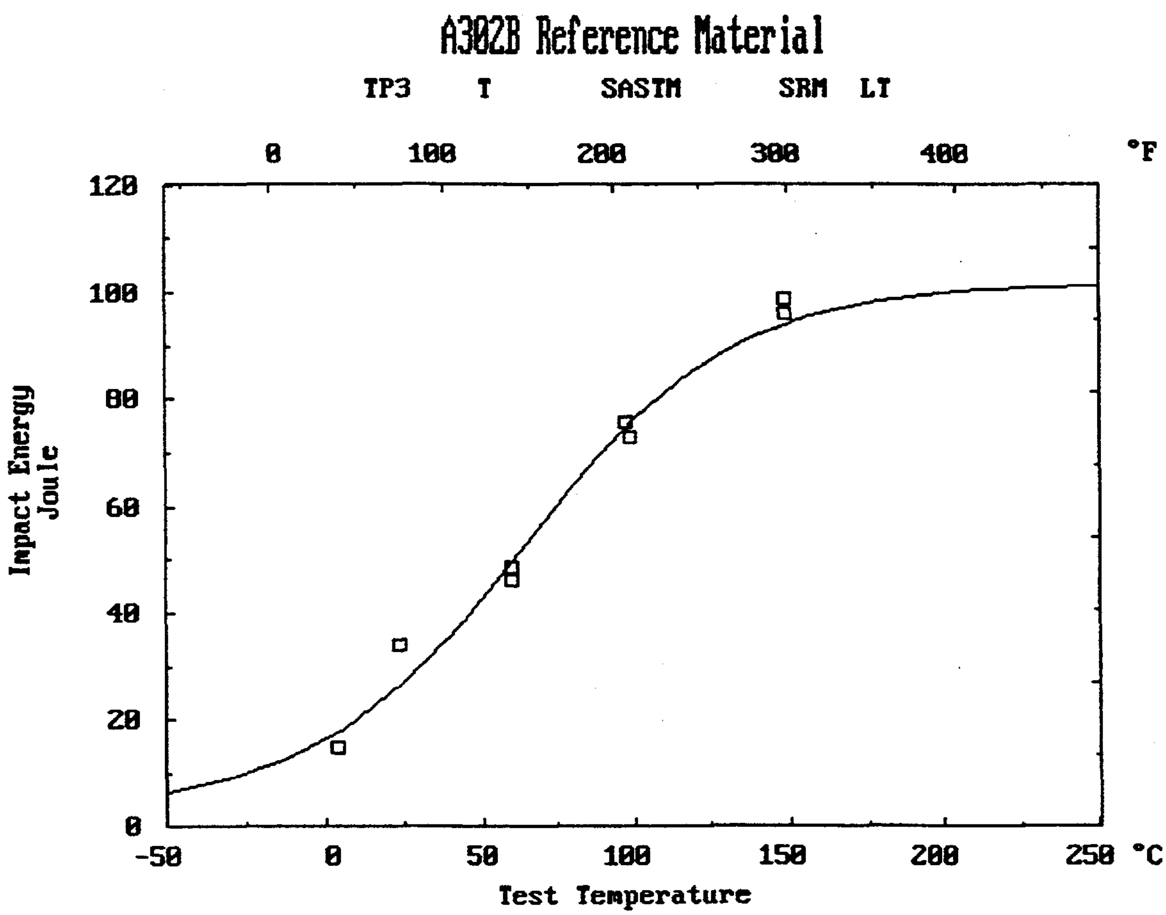
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	89.2	11.9	0.135				
CVT at Midpoint (C)	72.1	11.5	0.266	0.778			
1/slope (C)	54.9	18.3	-0.313	0.342	0.048		
CVT at 41 Joule (C)	65.7	7.9	0.346	0.143	0.694	-0.489	
CVT at 68 Joule (C)	106.7	14.2	-0.243	-0.402	-0.291	0.459	-0.091



A302B REFERENCE MATERIAL
Turkey Point Unit 3, Capsule T

USE= 101.8 J, LSE= 3.0 J, CVT(1/2)= 64.C , Slope = 0.0147
CVT(41J) = 48. C , CVT(68J) = 86. C ,
Fluence = 5.680E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R59	4.	40.	15.	11.	0.15	6.	3.
R63	24.	75.	34.	25.	0.43	17.	5.
R60	60.	140.	49.	36.	0.69	27.	30.
R61	60.	140.	46.	34.	0.61	24.	15.
R57	98.	208.	76.	56.	1.19	47.	75.
R64	99.	210.	73.	54.	0.89	35.	70.
R58	149.	300.	99.	73.	1.42	56.	100.
R62	149.	300.	96.	71.	1.24	49.	100.

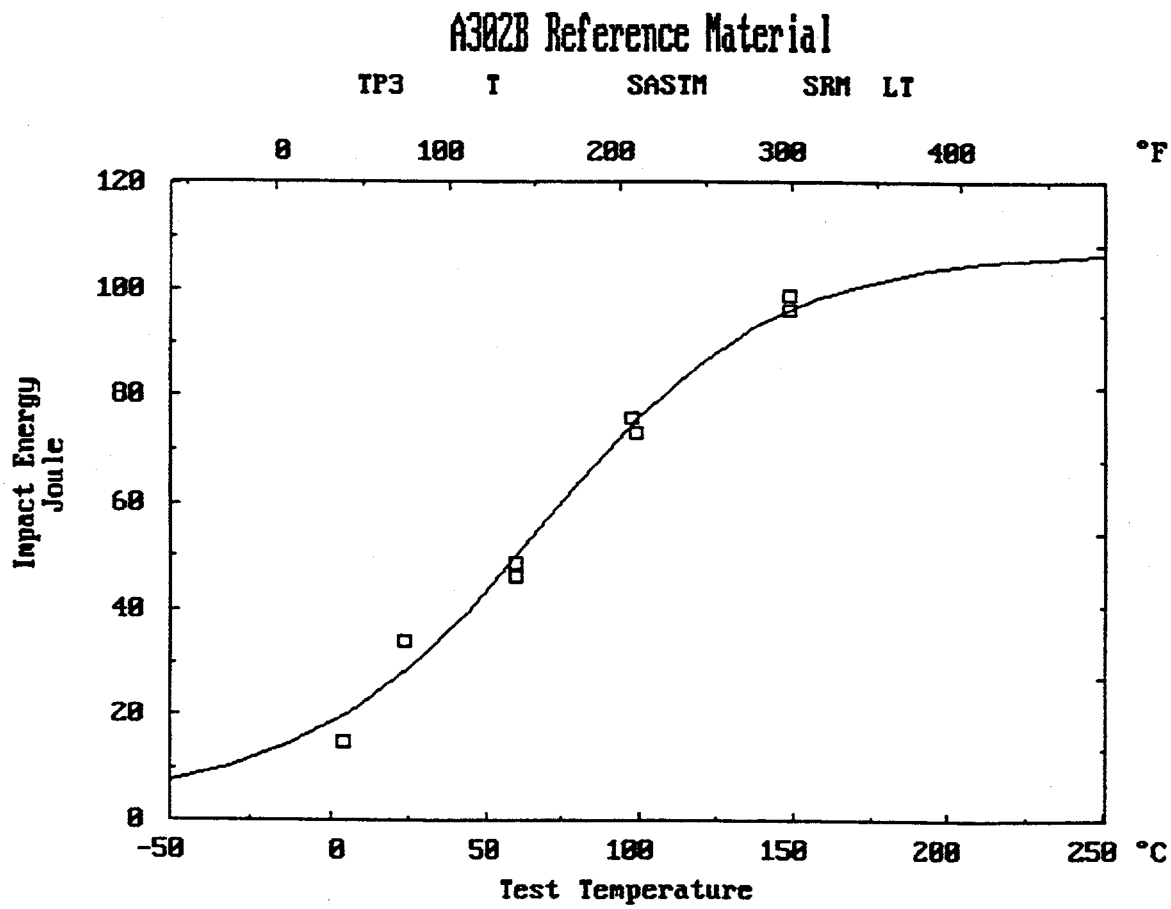


Turkey Point Unit 3, Capsule T

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

TP3 T SASTM SRM LT : Fluence = 5.680E+18 , Irr. Temp. = 304

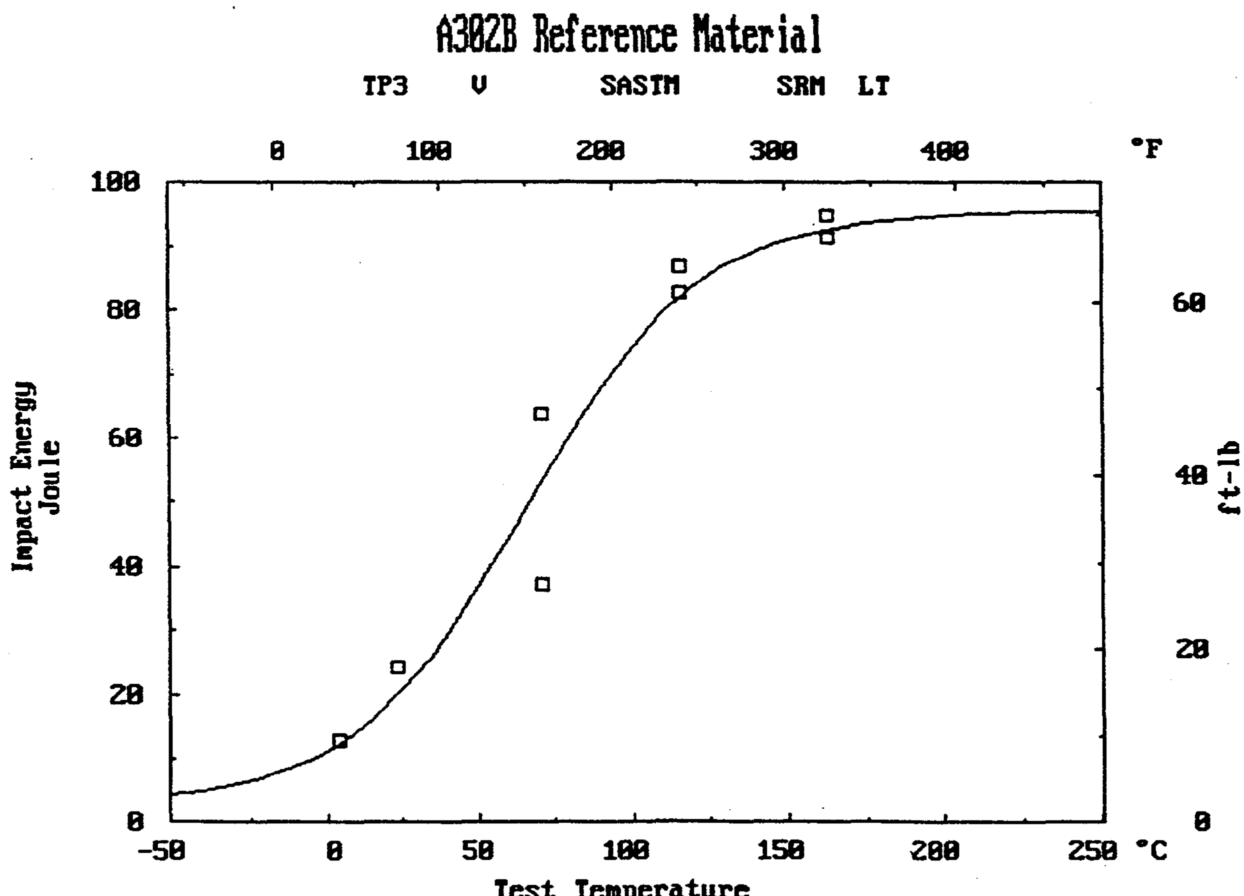
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	107.4	13.1	0.256				
CVT at Midpoint (C)	67.6	13.9	0.365	0.871			
1/slope (C)	76.1	17.9	0.089	0.616	0.455		
CVT at 41 Joule (C)	46.0	8.6	0.322	0.146	0.550	-0.407	
CVT at 68 Joule (C)	87.0	7.2	0.322	0.250	0.595	0.401	0.524



A302B REFERENCE MATERIAL
Turkey Point Unit 3, Capsule V

USE= 95.7 J, LSE= 3.0 J, CVT(1/2)= 66.C , Slope = 0.0176
CVT(41J) = 56. C , CVT(68J) = 90. C ,
Fluence = 1.229E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R47	4.	40.	13.	9.	0.20	8.	0.
R42	23.	74.	24.	18.	0.36	14.	5.
R45	71.	160.	64.	47.	1.07	42.	60.
R48	71.	160.	37.	27.	0.66	26.	30.
R44	116.	240.	83.	61.	1.37	54.	100.
R46	116.	240.	87.	64.	1.30	51.	100.
R41	163.	325.	92.	67.	1.50	59.	100.
R43	163.	325.	95.	70.	1.57	62.	100.



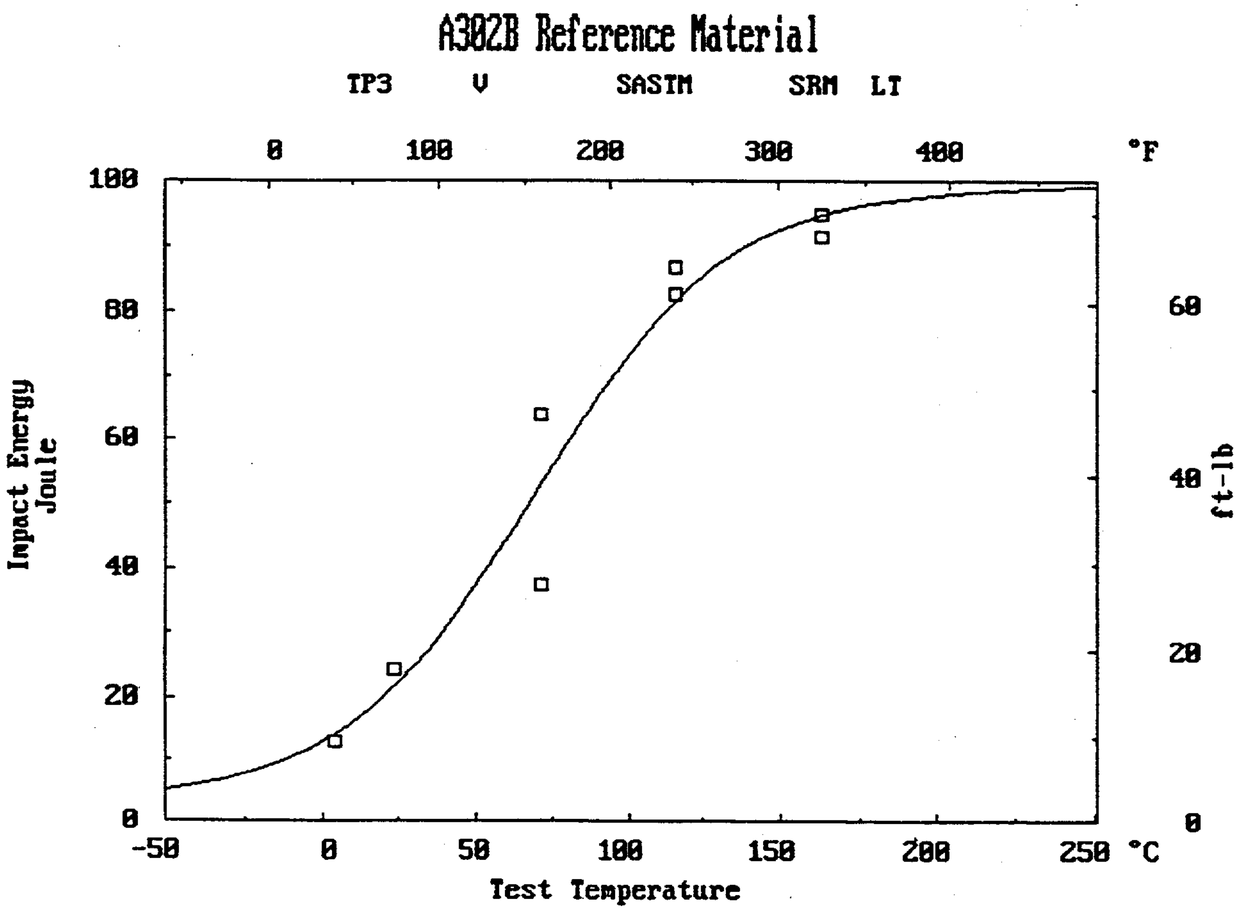
A302B REFERENCE MATERIAL

Turkey Point Unit 3, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

TP3 V SASTM SRM LT : Fluence = 1.229E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	99.5	8.9	0.032				
CVT at Midpoint (C)	68.9	11.1	0.171	0.776			
1/slope (C)	63.0	17.3	-0.140	0.553	0.339		
CVT at 41 Joule (C)	55.0	8.3	0.283	0.161	0.689	-0.364	
CVT at 68 Joule (C)	91.7	8.4	0.091	0.303	0.682	0.553	0.475



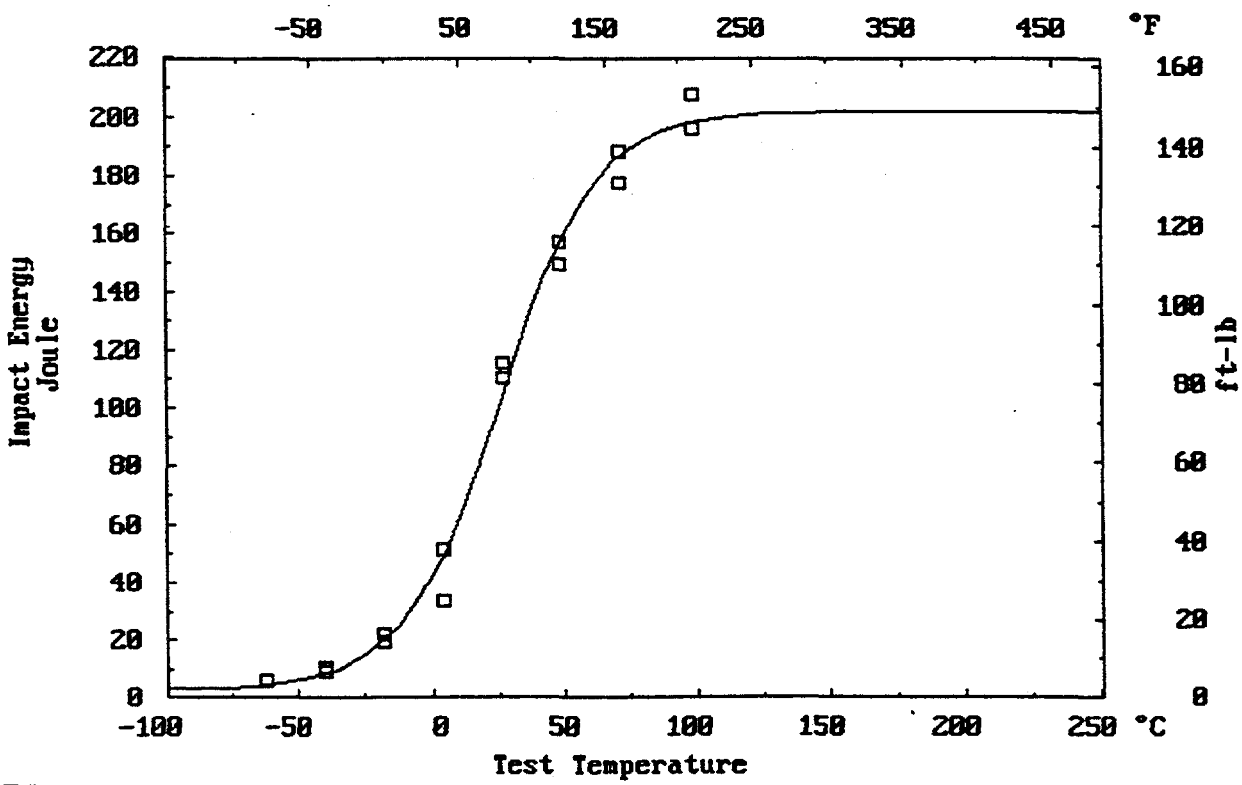
A533B HSST01 REFERENCE MATERIAL
Arkansas Unit 2, Baseline

USE= 201.7 J, LSE= 3.0 J, CVT(1/2)= 26.C , Slope = 0.0272
Unirradiated Charpy Specimen, CVT(41J) = -1. C , CVT(68J) = 13. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
7A3	-62.	-80.	6.	4.	0.05	2.	0.
7AA	-40.	-40.	11.	8.	0.18	7.	5.
7AL	-40.	-40.	9.	7.	0.15	6.	5.
7A1	-18.	0.	22.	16.	0.43	17.	15.
7AK	-18.	0.	20.	14.	0.36	14.	15.
7A2	4.	40.	34.	25.	0.66	26.	25.
7A7	4.	40.	52.	38.	0.84	33.	25.
7A5	27.	80.	110.	81.	1.60	63.	40.
7AC	27.	80.	115.	85.	1.73	68.	50.
7A4	49.	120.	149.	110.	1.98	78.	70.
7AJ	49.	120.	157.	116.	2.13	84.	70.
7A6	71.	160.	188.	139.	2.31	91.	95.
7AD	71.	160.	178.	131.	2.16	85.	90.
7AB	99.	210.	196.	144.	2.31	91.	100.
7AE	99.	210.	207.	153.	2.13	84.	100.

A533B Reference Material (HSST Plate #1)

ANZ SHSS01 SRM LT



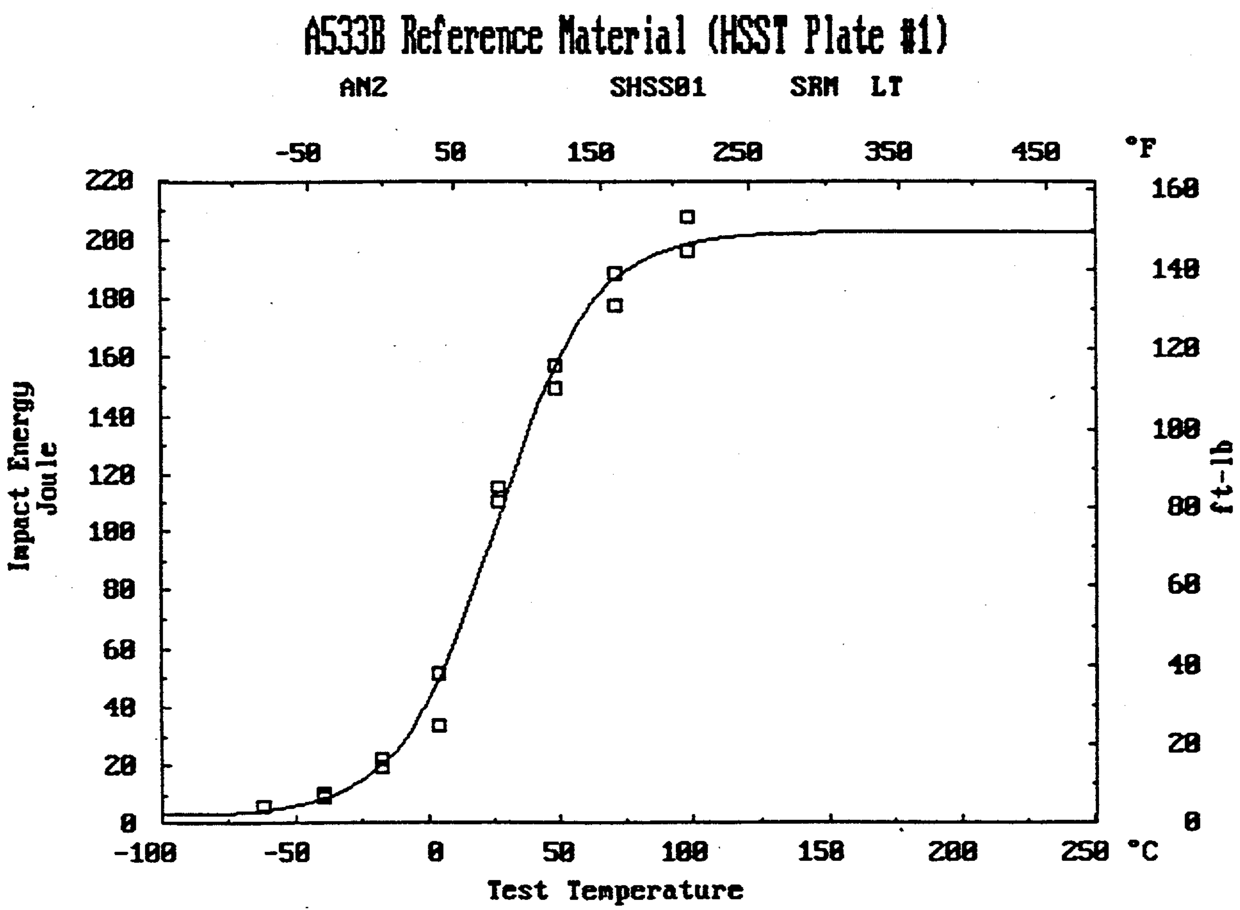
A533B HSST01 REFERENCE MATERIAL

Arkansas Unit 2, Baseline

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

AN2 SHSS01 SRM LT

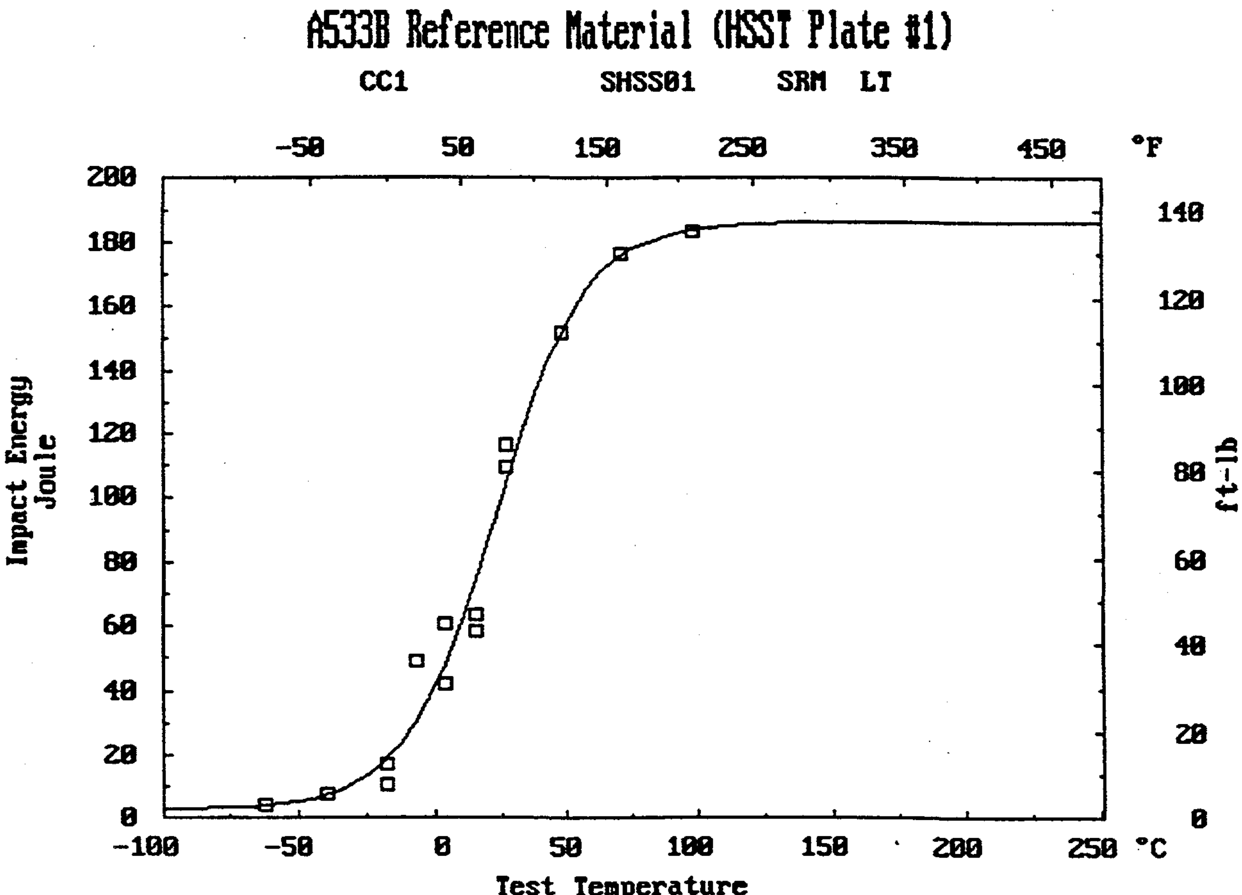
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	202.5	8.9	-0.093				
CVT at Midpoint (C)	26.2	3.5	0.034	0.768			
1/slope (C)	36.9	5.9	-0.250	0.721	0.591		
CVT at 41 Joule (C)	-0.6	3.8	0.324	-0.363	0.059	-0.760	
CVT at 68 Joule (C)	12.7	2.6	0.284	-0.024	0.510	-0.356	0.877



A533B HSST01 REFERENCE MATERIAL
Calvert Cliffs Unit 1, Baseline

USE= 186.5 J, LSE= 3.0 J, CVT(1/2)= 23.C , Slope = 0.0291
Unirradiated Charpy Specimen, CVT(41J) = 0. C , CVT(68J) = 13. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
64U	-62.	-80.	5.	3.	0.15	6.	0.
657	-40.	-40.	8.	6.	0.15	6.	10.
64L	-18.	0.	11.	8.	0.30	12.	15.
655	-18.	0.	17.	12.	0.51	20.	15.
653	-7.	20.	49.	36.	0.81	32.	20.
64K	4.	40.	42.	31.	0.79	31.	20.
64T	4.	40.	61.	45.	1.02	40.	25.
651	16.	60.	58.	43.	1.02	40.	30.
654	16.	60.	64.	47.	1.09	43.	30.
64M	27.	80.	117.	86.	1.68	66.	40.
652	27.	80.	110.	81.	1.63	64.	45.
64Y	49.	120.	152.	112.	2.18	86.	75.
656	49.	120.	152.	112.	2.03	80.	75.
64P	71.	160.	176.	130.	2.39	94.	90.
65A	99.	210.	184.	135.	2.34	92.	100.



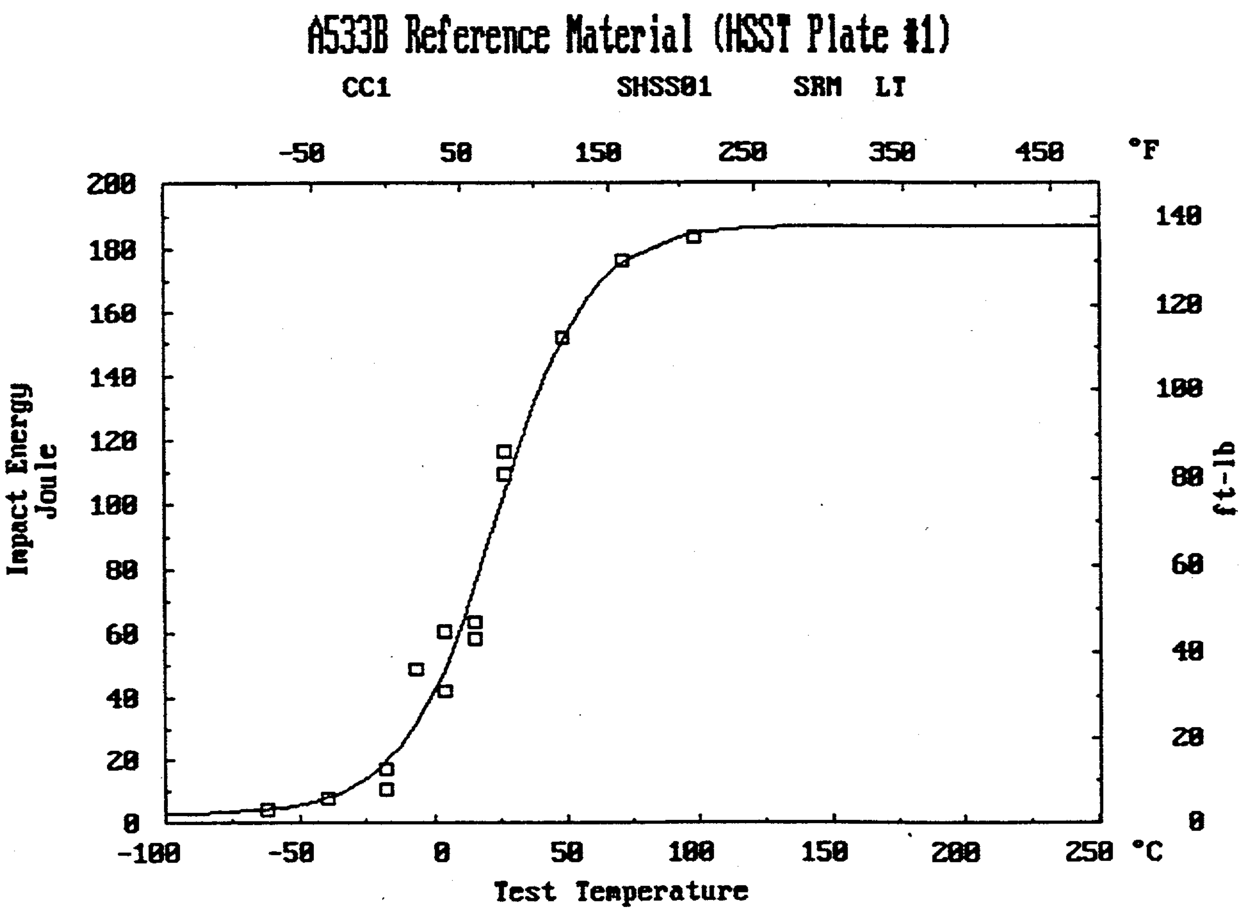
A533B HSST01 REFERENCE MATERIAL

Calvert Cliffs Unit 1, Baseline

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000


CC1          SHSS01    SRM  LT
```

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	187.1	9.2	-0.071				
CVT at Midpoint (C)	23.4	3.1	0.075	0.758			
1/slope (C)	35.2	4.7	-0.156	0.611	0.555		
CVT at 41 Joule (C)	-0.4	3.0	0.255	-0.246	0.151	-0.715	
CVT at 68 Joule (C)	12.6	2.1	0.246	0.039	0.585	-0.257	0.857



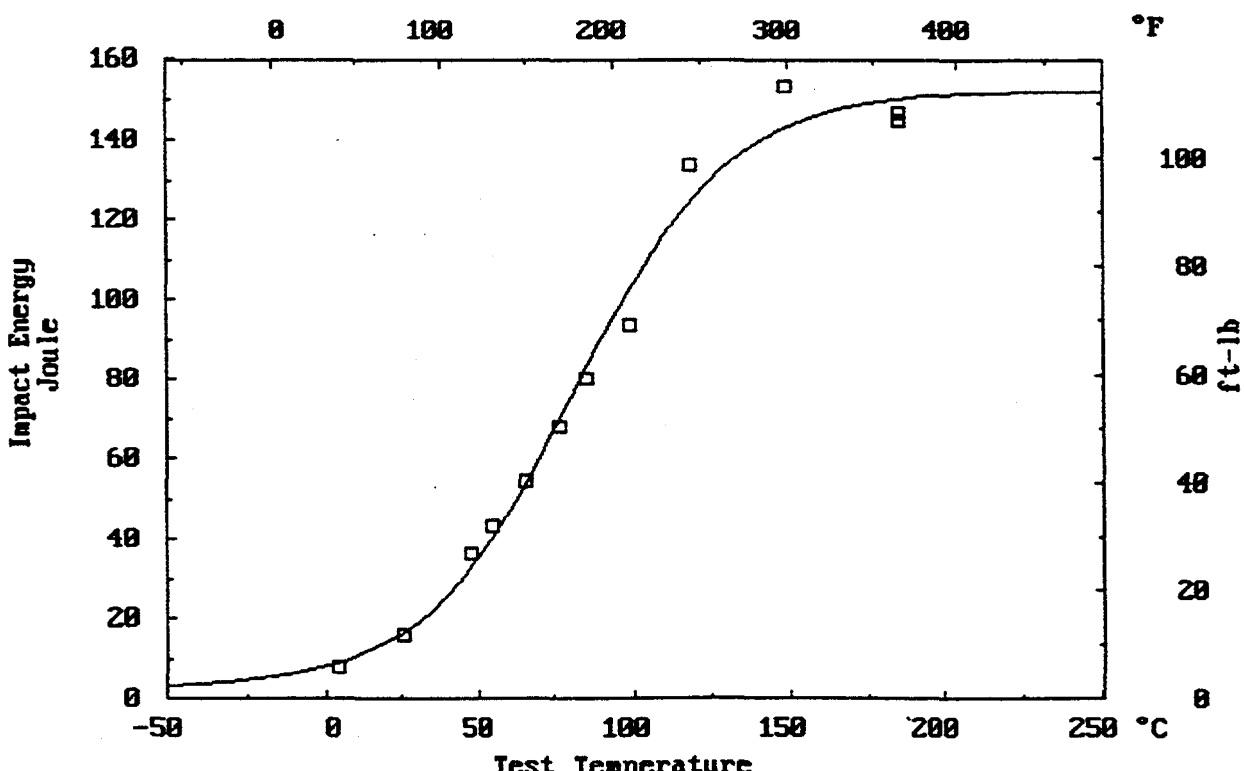
A533B HSST01 REFERENCE MATERIAL
Calvert Cliffs Unit 1, Capsule W263

USE= 152.2 J, LSE= 3.0 J, CVT(1/2)= 82.C , Slope = 0.0205
CVT(41J) = 56. C , CVT(68J) = 75. C ,
Fluence = 5.900E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
64B	4.	40.	8.	6.	0.15	6.	5.
644	26.	78.	16.	12.	0.33	13.	5.
64J	48.	118.	37.	27.	0.66	26.	25.
647	54.	130.	43.	32.	0.84	33.	20.
643	66.	150.	55.	40.	0.97	38.	35.
64C	77.	170.	68.	50.	1.17	46.	35.
645	85.	185.	80.	59.	1.30	51.	35.
64D	99.	210.	94.	69.	1.57	62.	50.
64E	118.	245.	134.	99.	1.93	76.	85.
642	149.	300.	153.	113.	2.31	91.	100.
646	186.	366.	147.	108.	2.18	86.	100.
64A	186.	366.	145.	107.	2.18	86.	100.

A533B Reference Material (HSST Plate #1)

CC1 W263 SHSS01 SRM LT



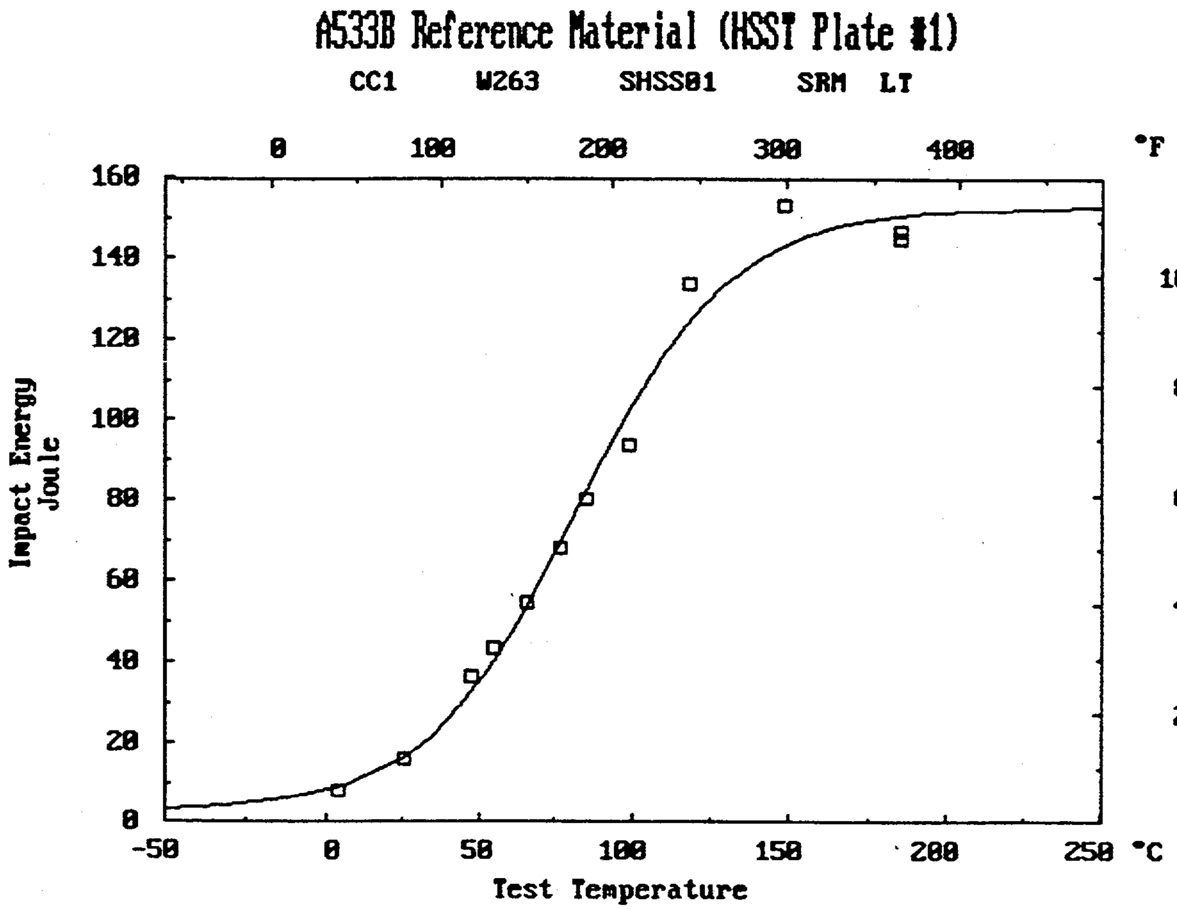
A533B HSST01 REFERENCE MATERIAL

Calvert Cliffs Unit 1, Capsule W263

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

CC1 W263 SHSS01 SRM LT : Fluence = 5.900E+18 , Irr. Temp. = 288

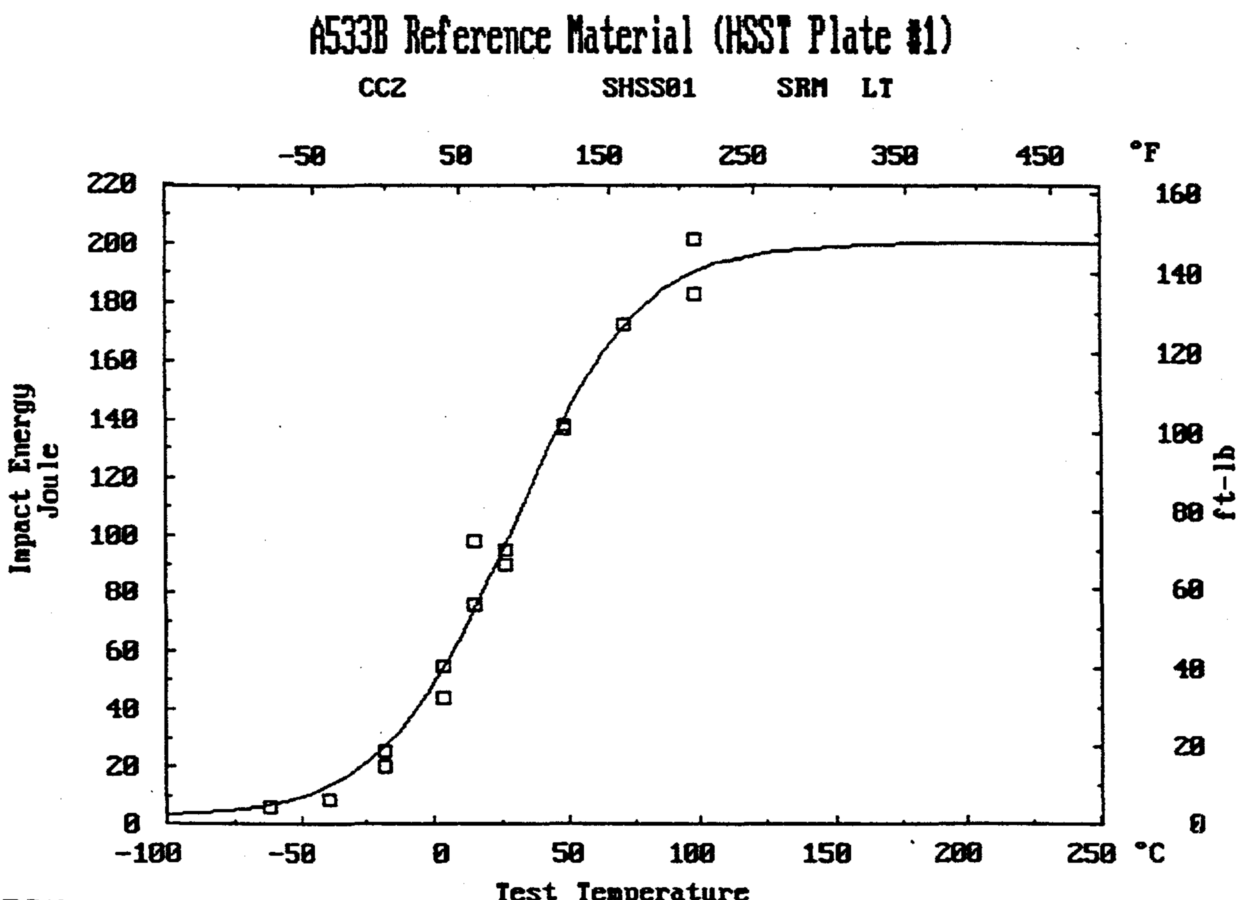
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	152.8	6.3	-0.050				
CVT at Midpoint (C)	82.2	4.2	0.040	0.626			
1/slope (C)	49.1	6.5	-0.172	0.345	0.282		
CVT at 41 Joule (C)	55.7	4.4	0.184	0.005	0.529	-0.630	
CVT at 68 Joule (C)	75.7	3.3	0.116	0.144	0.839	-0.084	0.820



A533B HSST01 REFERENCE MATERIAL
Calvert Cliffs Unit 2, Baseline

USE= 200.0 J, LSE= 3.0 J, CVT(1/2)= 29.C , Slope = 0.0212
Unirradiated Charpy Specimen, CVT(41J) = -5. C , CVT(68J) = '12. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
6A7	-62.	-80.	6.	4.	0.05	2.	0.
6A5	-40.	-40.	8.	6.	0.13	5.	10.
675	-18.	0.	25.	18.	0.43	17.	15.
6A6	-18.	0.	20.	15.	0.36	14.	15.
674	4.	40.	55.	40.	0.86	34.	20.
67U	4.	40.	44.	32.	0.76	30.	20.
671	16.	60.	76.	56.	1.22	48.	30.
6A4	16.	60.	98.	72.	1.40	55.	35.
66Y	27.	80.	90.	66.	1.35	53.	40.
6A2	27.	80.	95.	70.	1.42	56.	40.
67T	49.	120.	138.	101.	1.83	72.	65.
67Y	49.	120.	136.	100.	1.75	69.	60.
6A1	71.	160.	172.	127.	2.29	90.	90.
66U	99.	210.	201.	148.	2.34	92.	100.
6A3	99.	210.	182.	134.	2.18	86.	100.



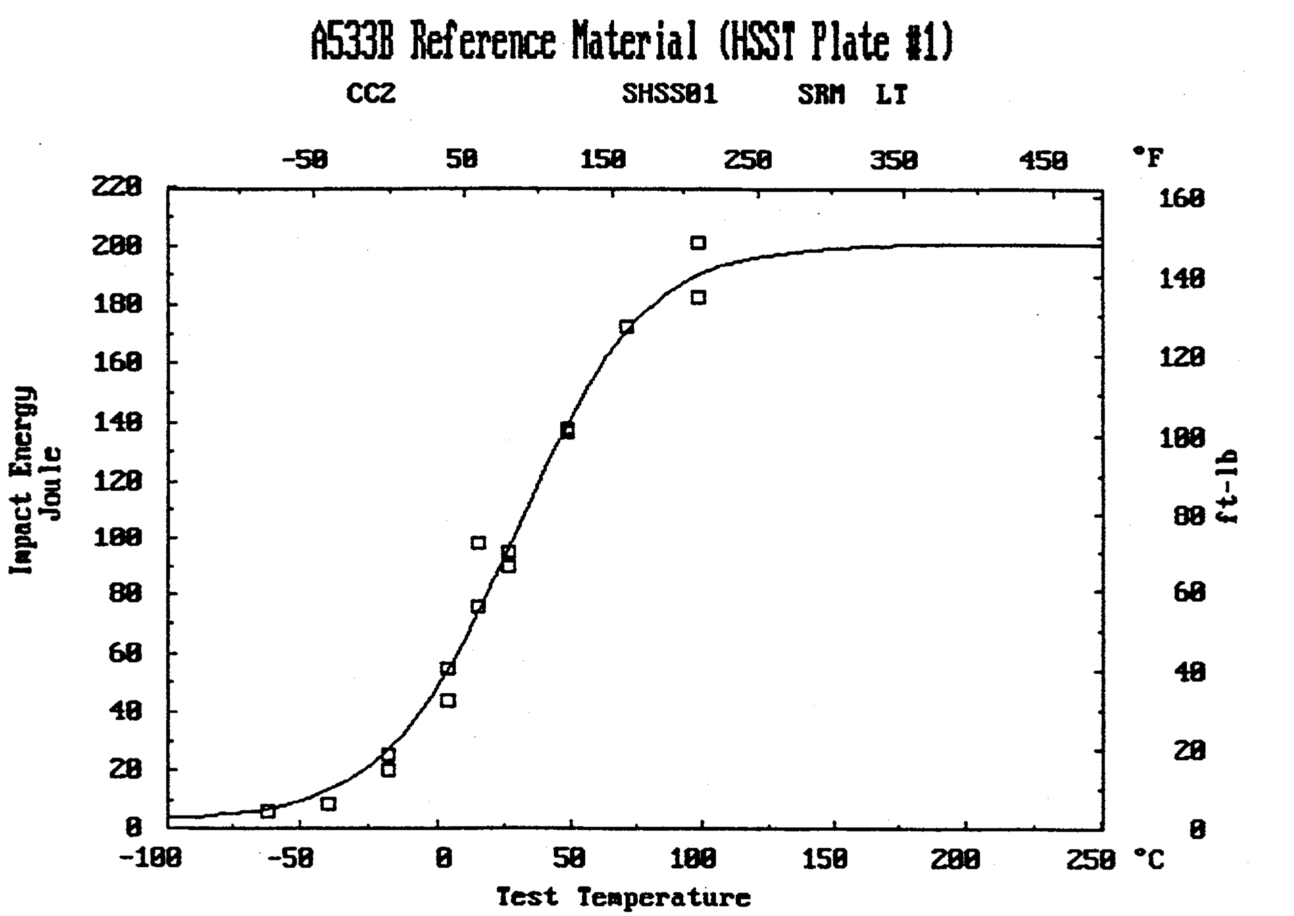
A533B HSST01 REFERENCE MATERIAL

Calvert Cliffs Unit 2, Baseline

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

CC2 SHSS01 SRM LT

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	200.5	11.3	0.028				
CVT at Midpoint (C)	29.6	4.5	0.025	0.854			
1/slope (C)	47.8	6.0	-0.056	0.622	0.626		
CVT at 41 Joule (C)	-4.8	3.7	0.074	-0.171	0.068	-0.712	
CVT at 68 Joule (C)	12.5	2.6	0.060	0.142	0.509	-0.268	0.864



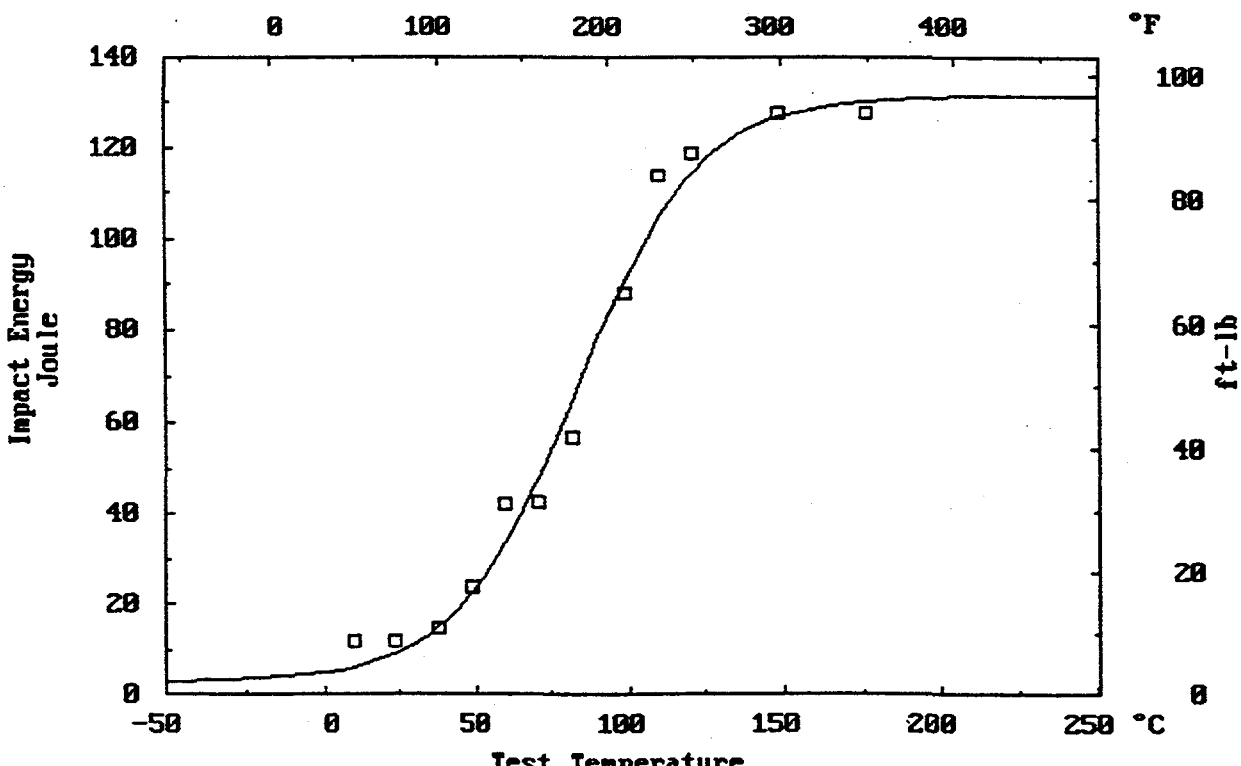
A533B HSST01 REFERENCE MATERIAL
Calvert Cliffs Unit 2, Capsule W263

USE= 131.3 J, LSE= 3.1 J, CVT(1/2)= 83.C , Slope = 0.0252
CVT(41J) = 66. C , CVT(68J) = 84. C ,
Fluence = 8.140E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
67A	10.	50.	12.	9.	0.28	11.	0.
66D	24.	75.	12.	9.	0.28	11.	5.
676	38.	100.	15.	11.	0.33	13.	5.
677	49.	120.	24.	17.	0.51	20.	10.
67P	60.	140.	42.	31.	0.76	30.	10.
66T	71.	160.	43.	32.	0.76	30.	20.
66A	82.	180.	57.	42.	1.70	67.	25.
66C	99.	210.	88.	65.	1.45	57.	25.
67K	110.	230.	114.	84.	1.88	74.	100.
667	121.	250.	119.	87.	1.90	75.	100.
66M	149.	300.	127.	94.	2.06	81.	100.
67L	177.	350.	127.	94.	1.93	76.	100.

A533B Reference Material (HSST Plate #1)

CCZ W263 SHSS01 SRM LT



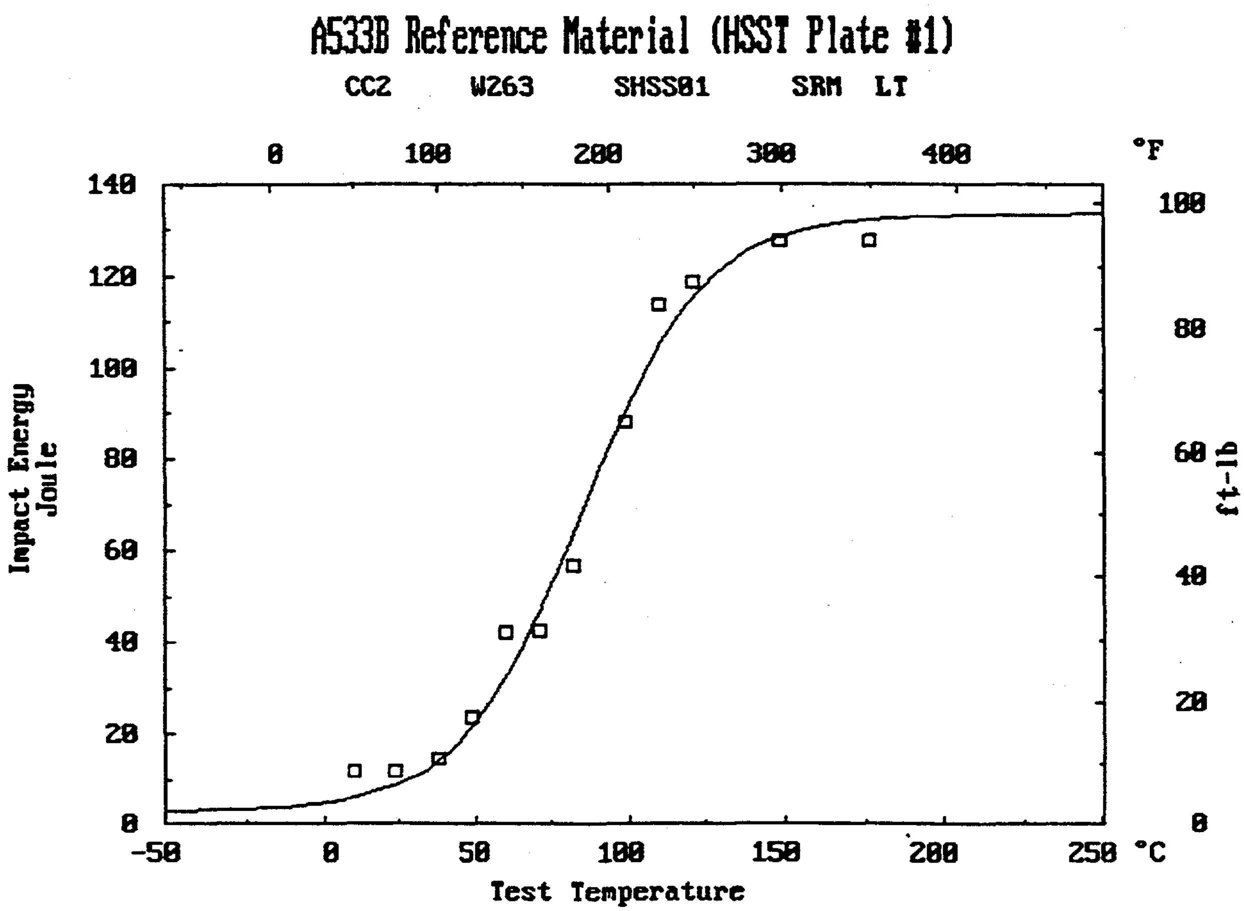
A533B HSST01 REFERENCE MATERIAL

Calvert Cliffs Unit 2, Capsule W263

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

CC2 W263 SHSS01 SRM LT : Fluence = 8.140E+18 , Irr. Temp. = 288

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	133.6	7.8	0.046				
CVT at Midpoint (C)	84.8	4.9	0.243	0.702			
1/slope (C)	39.7	7.8	-0.387	0.425	0.286		
CVT at 41 Joule (C)	67.0	4.7	0.518	0.043	0.556	-0.601	
CVT at 68 Joule (C)	84.6	3.6	0.309	0.264	0.867	0.076	0.740



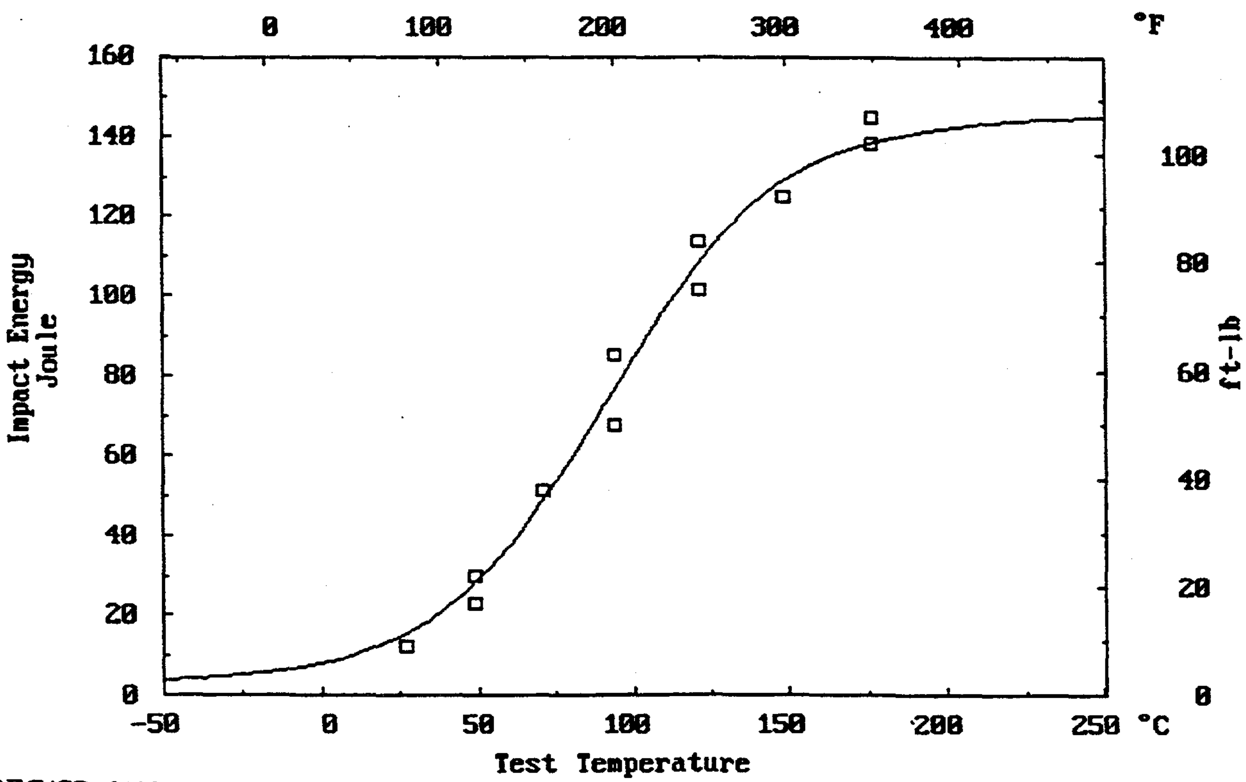
A533B HSST01 REFERENCE MATERIAL
Fort Calhoun Unit 1, Capsule W225

USE= 145.3 J, LSE= 3.0 J, CVT(1/2)= 92.C , Slope = 0.0180
CVT(41J) = 64. C , CVT(68J) = 87. C ,
Fluence = 4.800E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
55T	27.	80.	12.	9.	0.18	7.	0.
566	49.	120.	30.	22.	0.53	21.	0.
573	49.	120.	23.	17.	0.48	19.	0.
55M	71.	160.	52.	38.	0.61	24.	20.
55Y	71.	160.	52.	38.	0.84	33.	20.
563	93.	200.	85.	63.	1.19	47.	30.
56J	93.	200.	68.	50.	0.97	38.	30.
565	121.	250.	114.	84.	1.78	70.	80.
56A	121.	250.	102.	75.	1.27	50.	70.
56D	149.	300.	125.	92.	1.90	75.	90.
55P	177.	350.	145.	107.	2.11	83.	100.
575	177.	350.	138.	102.	2.03	80.	100.

A533B Reference Material (HSST Plate #1)

FC1 W225 SHSS01 SRM LT



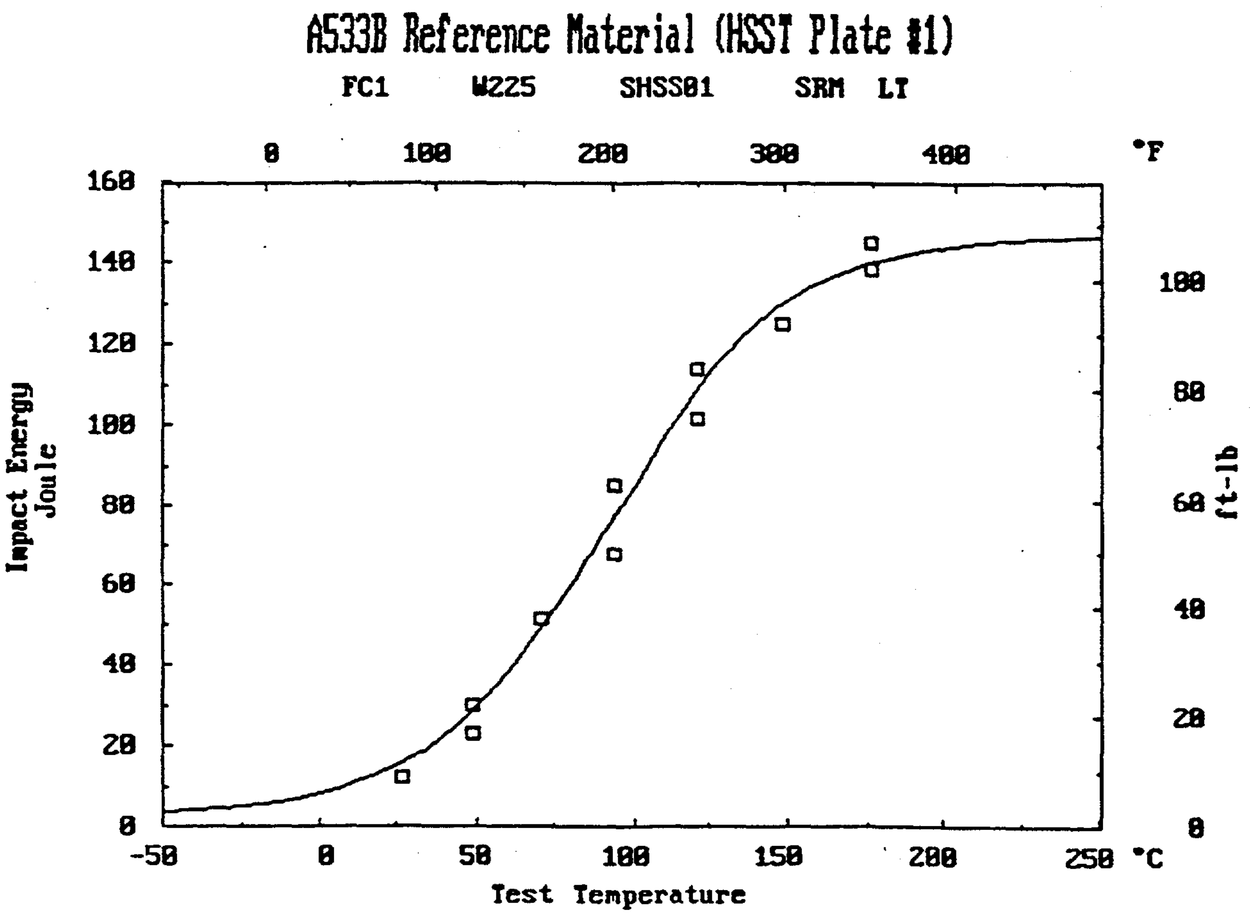
A533B HSST01 REFERENCE MATERIAL

Fort Calhoun Unit 1, Capsule W225

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

FC1 W225 SHSS01 SRM LT : Fluence = 4.800E+18 , Irr. Temp. = 288

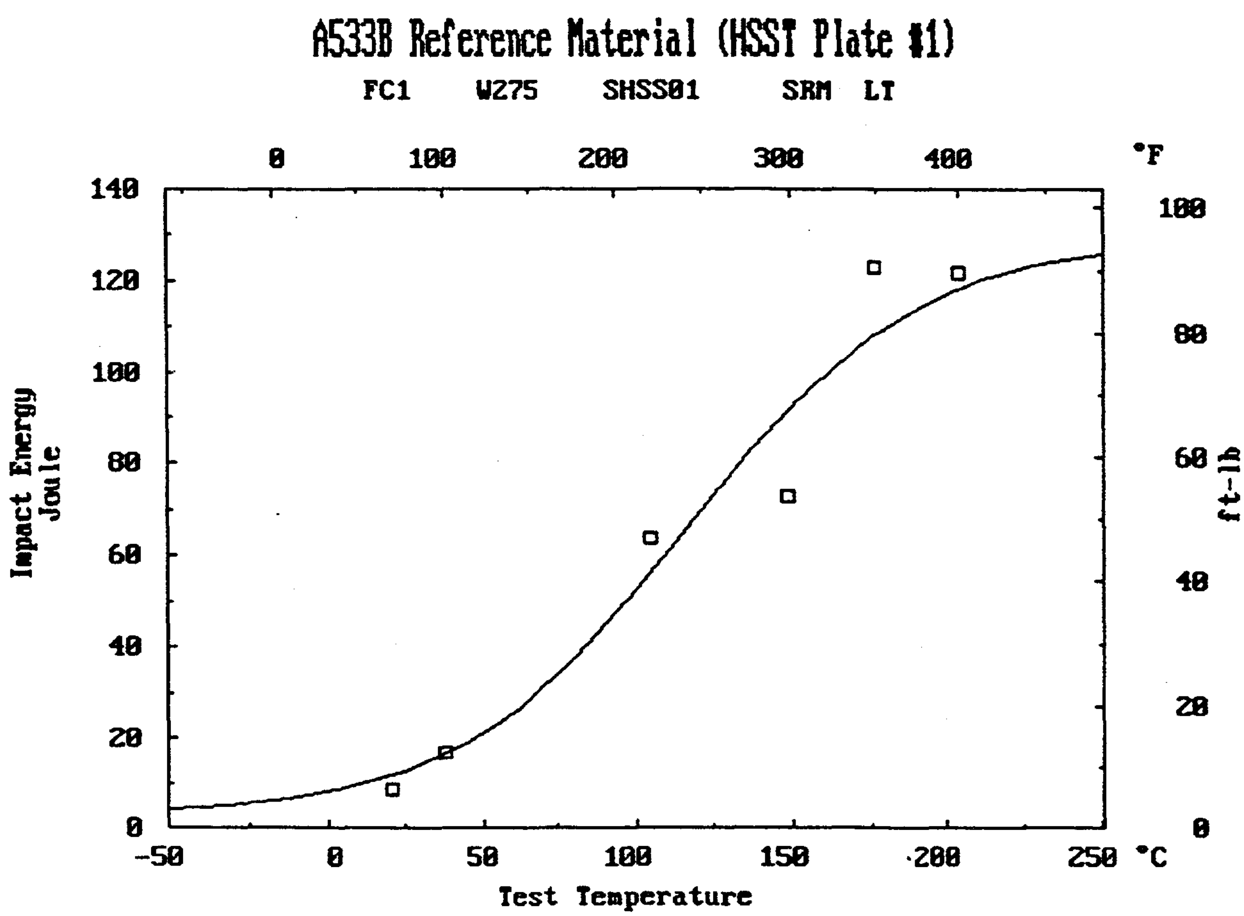
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	147.0	9.9	0.109				
CVT at Midpoint (C)	92.1	6.6	0.105	0.839			
1/slope (C)	56.3	9.6	0.132	0.723	0.644		
CVT at 41 Joule (C)	63.1	4.8	-0.050	-0.167	0.233	-0.556	
CVT at 68 Joule (C)	86.5	3.8	0.056	0.315	0.769	0.189	0.700



A533B HSST01 REFERENCE MATERIAL
Fort Calhoun Unit 1, Capsule W275

USE= 129.1 J, LSE= 3.0 J, CVT(1/2)= 117.C , Slope = 0.0135
CVT(41J) = 86. C , CVT(68J) = 119. C ,
Fluence = 1.280E+19 , Irr. Temp. = 280 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
56T	21.	70.	9.	6.	0.15	6.	0.
56E	38.	100.	17.	12.	0.33	13.	5.
564	104.	220.	64.	47.	1.17	46.	50.
572	149.	300.	73.	53.	1.32	52.	95.
56K	177.	350.	123.	90.	1.98	78.	100.
56B	204.	400.	121.	89.	2.11	83.	100.



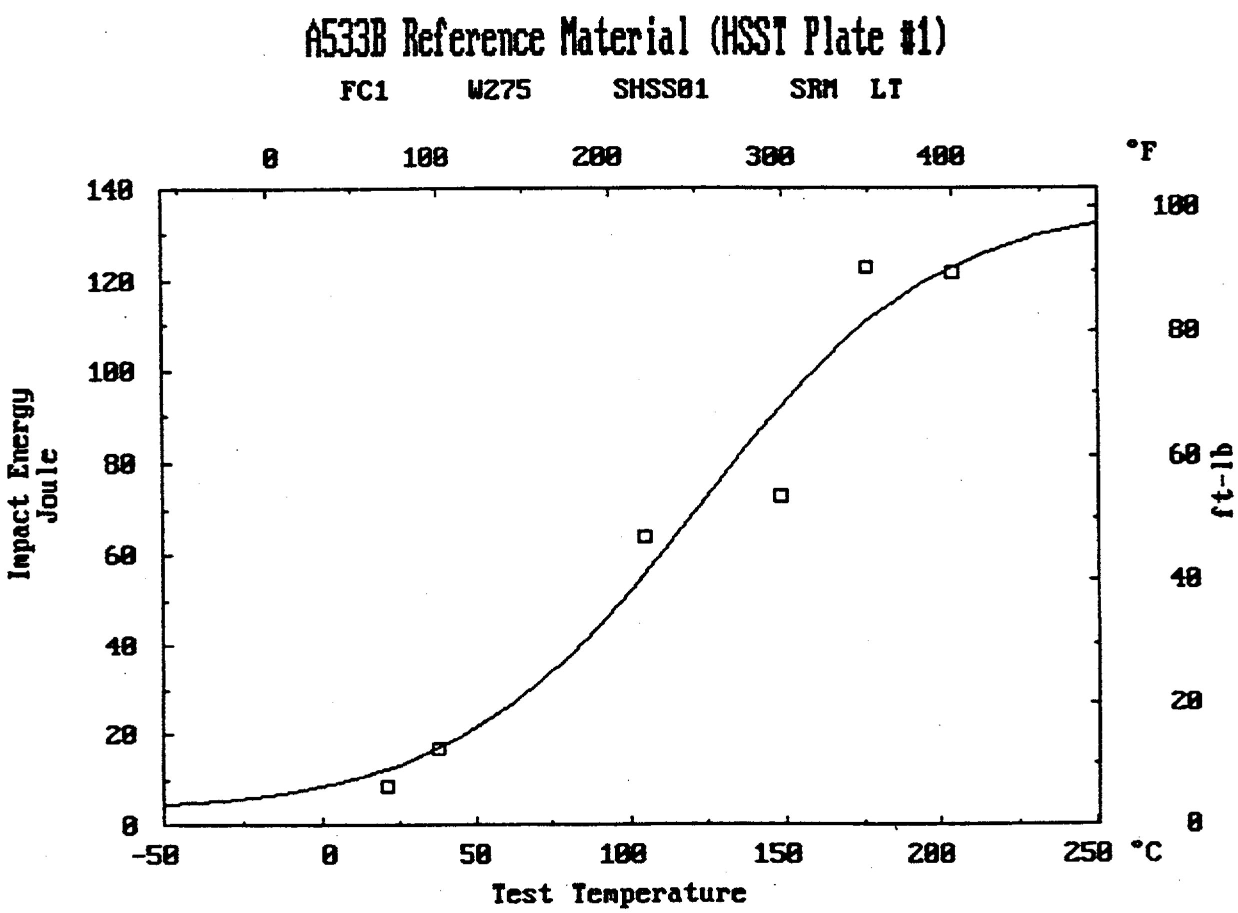
A533B HSST01 REFERENCE MATERIAL

Fort Calhoun Unit 1, Capsule W275

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

FC1 W275 SHSS01 SRM LT : Fluence = 1.280E+19 , Irr. Temp. = 280

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	137.0	17.8	0.218				
CVT at Midpoint (C)	121.7	15.6	0.236	0.870			
1/slope (C)	77.7	14.8	0.176	0.596	0.420		
CVT at 41 Joule (C)	85.6	10.8	0.085	0.196	0.586	-0.435	
CVT at 68 Joule (C)	119.5	8.6	0.171	0.390	0.786	0.023	0.872



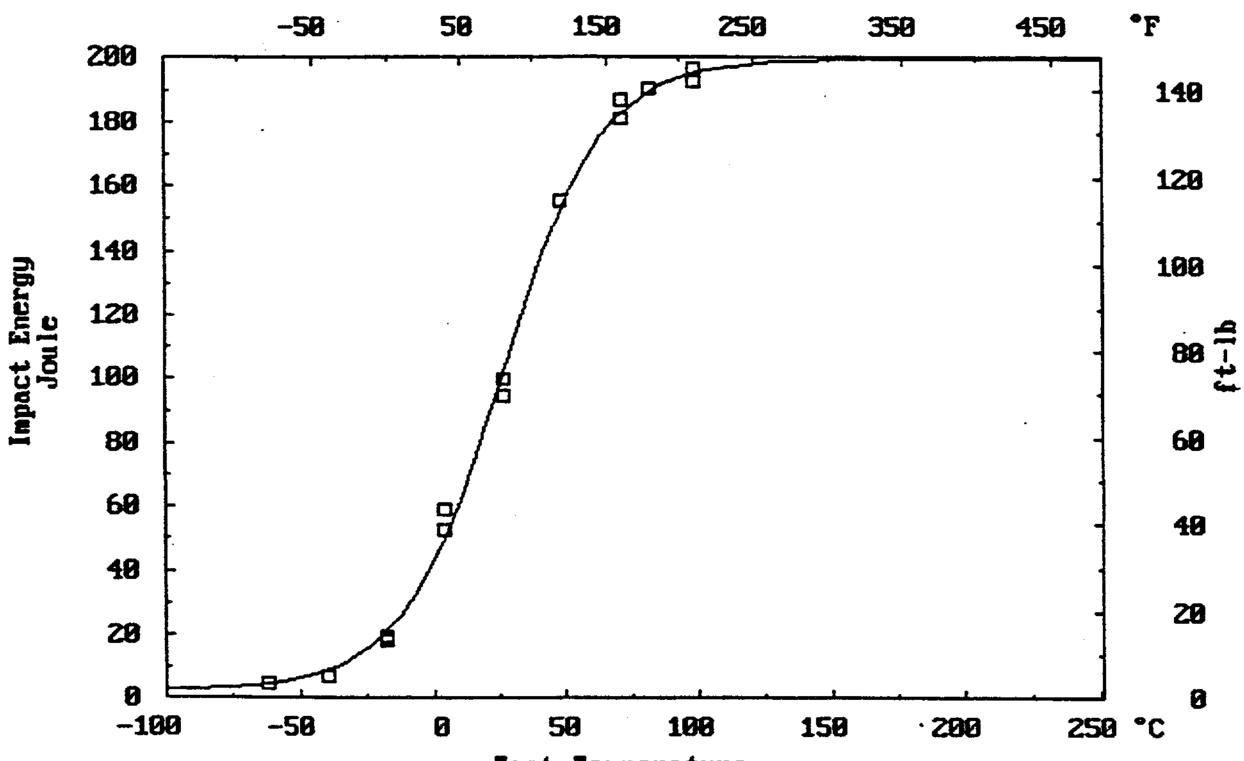
A533B HSST01 REFERENCE MATERIAL
Millstone Unit 2, Baseline

USE= 199.8 J, LSE= 3.0 J, CVT(1/2)= 26.C , Slope = 0.0261
Unirradiated Charpy Specimen, CVT(41J) = -1. C , CVT(68J) = 13. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
755	-62.	-80.	5.	3.	0.08	3.	0.
75U	-40.	-40.	7.	5.	0.18	7.	0.
757	-18.	0.	18.	13.	0.38	15.	15.
75J	-18.	0.	20.	14.	0.41	16.	15.
75B	4.	40.	59.	43.	0.91	36.	25.
75M	4.	40.	53.	39.	0.89	35.	20.
75C	27.	80.	100.	73.	1.52	60.	45.
75D	27.	80.	94.	69.	1.35	53.	45.
75A	49.	120.	155.	114.	2.01	79.	80.
75P	49.	120.	155.	114.	2.16	85.	80.
75K	71.	160.	187.	138.	2.26	89.	100.
75T	71.	160.	181.	133.	2.34	92.	90.
75L	82.	180.	190.	140.	2.26	89.	100.
756	99.	210.	193.	142.	2.26	89.	100.
75E	99.	210.	197.	145.	2.34	92.	100.

A533B Reference Material (HSST Plate #1)

ML2 SHSS01 SRM LT



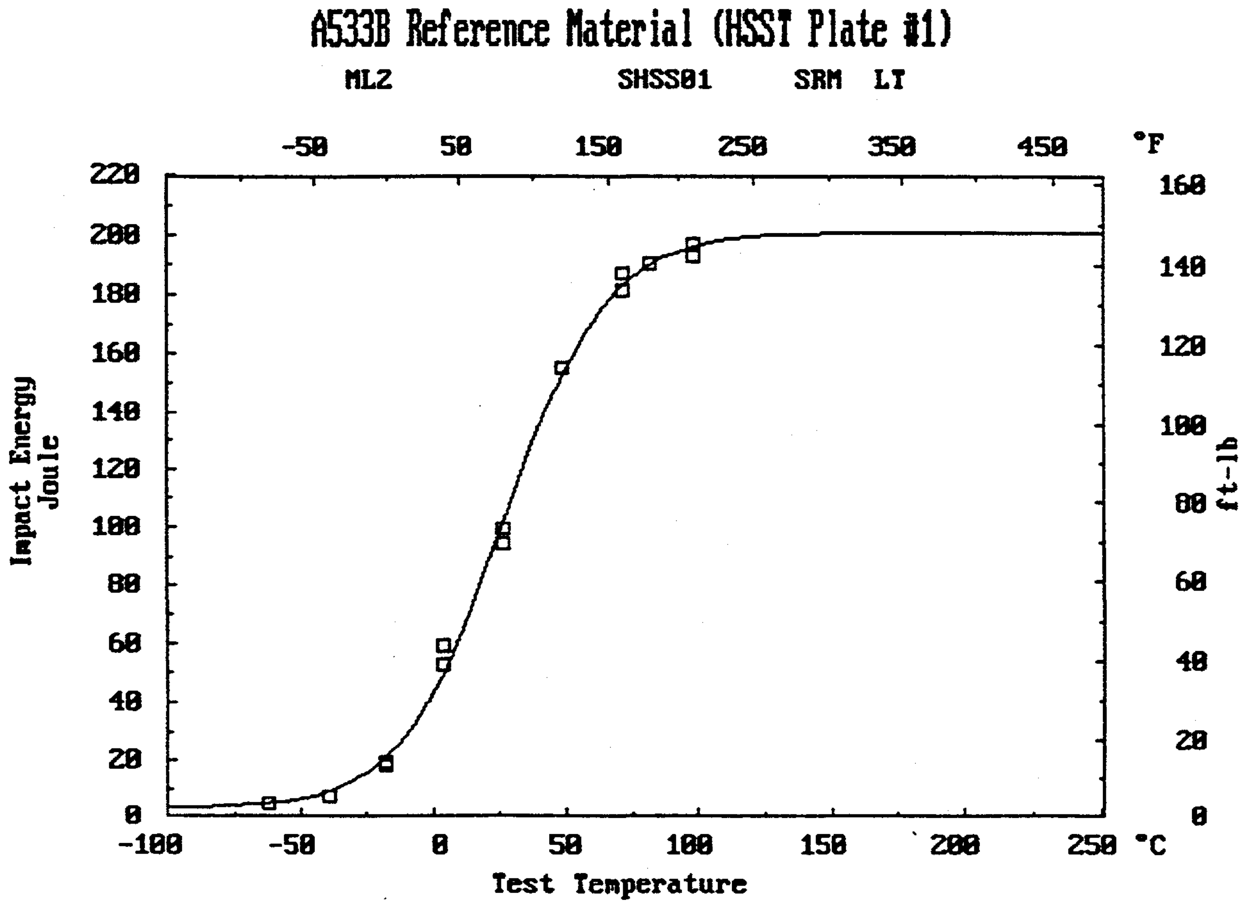
A533B HSST01 REFERENCE MATERIAL

Millstone Unit 2, Baseline

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

ML2 SHSS01 SRM LT

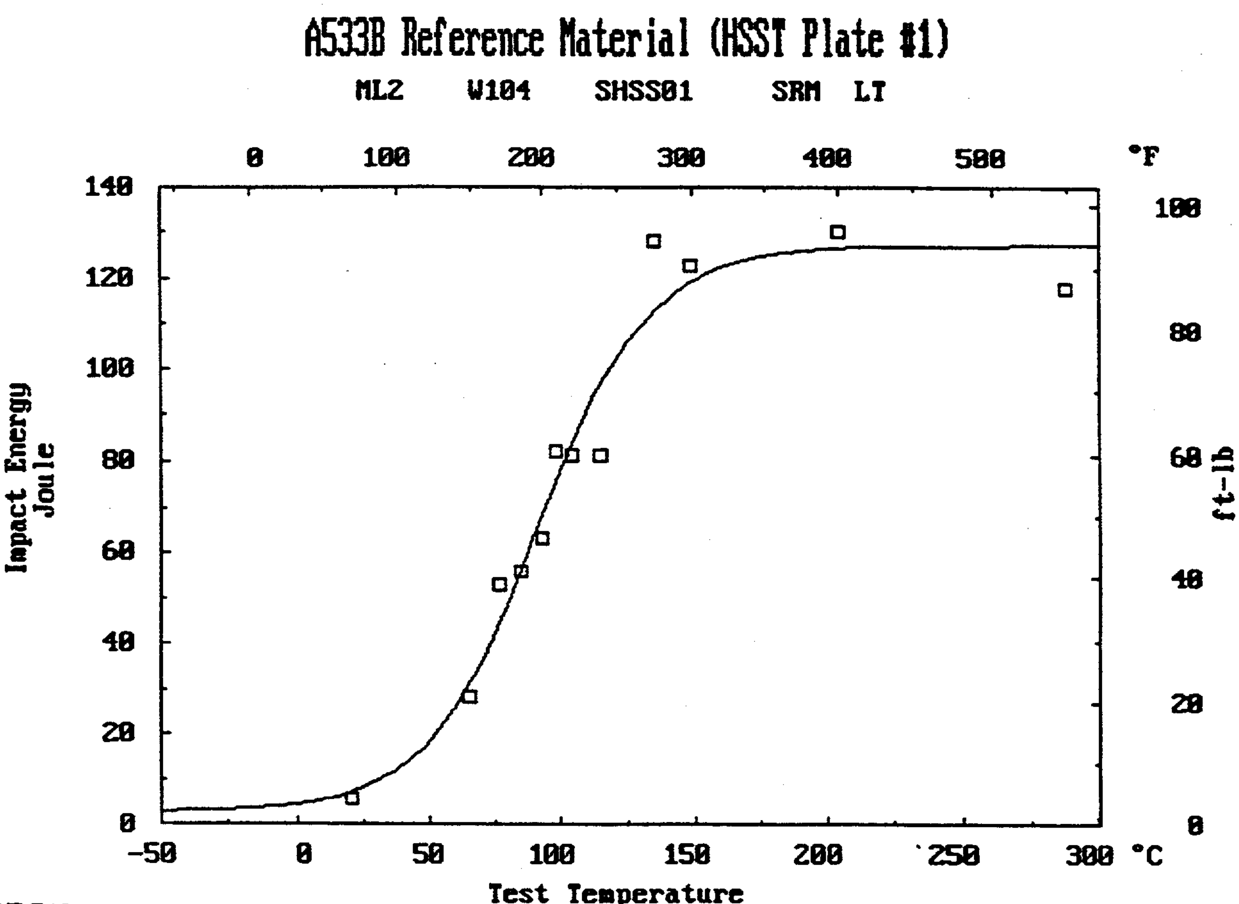
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	200.7	7.6	-0.190				
CVT at Midpoint (C)	26.8	3.4	0.068	0.669			
1/slope (C)	38.5	5.4	-0.381	0.676	0.356		
CVT at 41 Joule (C)	-0.9	4.3	0.429	-0.295	0.324	-0.760	
CVT at 68 Joule (C)	13.0	3.1	0.372	-0.047	0.632	-0.470	0.930



A533B HSST01 REFERENCE MATERIAL
Millstone Unit 2, Capsule W104

USE= 127.0 J, LSE= 3.0 J, CVT(1/2)= 91.C , Slope = 0.0236
CVT(41J) = 74. C , CVT(68J) = 93. C ,
Fluence = 8.840E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
74L	21.	70.	6.	4.	0.20	8.	0.
74J	66.	150.	28.	21.	0.56	22.	20.
747	77.	170.	53.	39.	0.91	36.	40.
74D	85.	185.	56.	41.	0.97	38.	40.
751	93.	200.	63.	46.	1.19	47.	50.
741	99.	210.	82.	60.	1.30	51.	60.
754	104.	220.	81.	60.	1.37	54.	60.
74P	116.	240.	81.	60.	1.45	57.	60.
74A	135.	275.	128.	94.	2.01	79.	100.
74K	149.	300.	123.	90.	1.96	77.	100.
74E	204.	400.	130.	96.	2.16	85.	100.
742	288.	550.	118.	87.	1.98	78.	100.



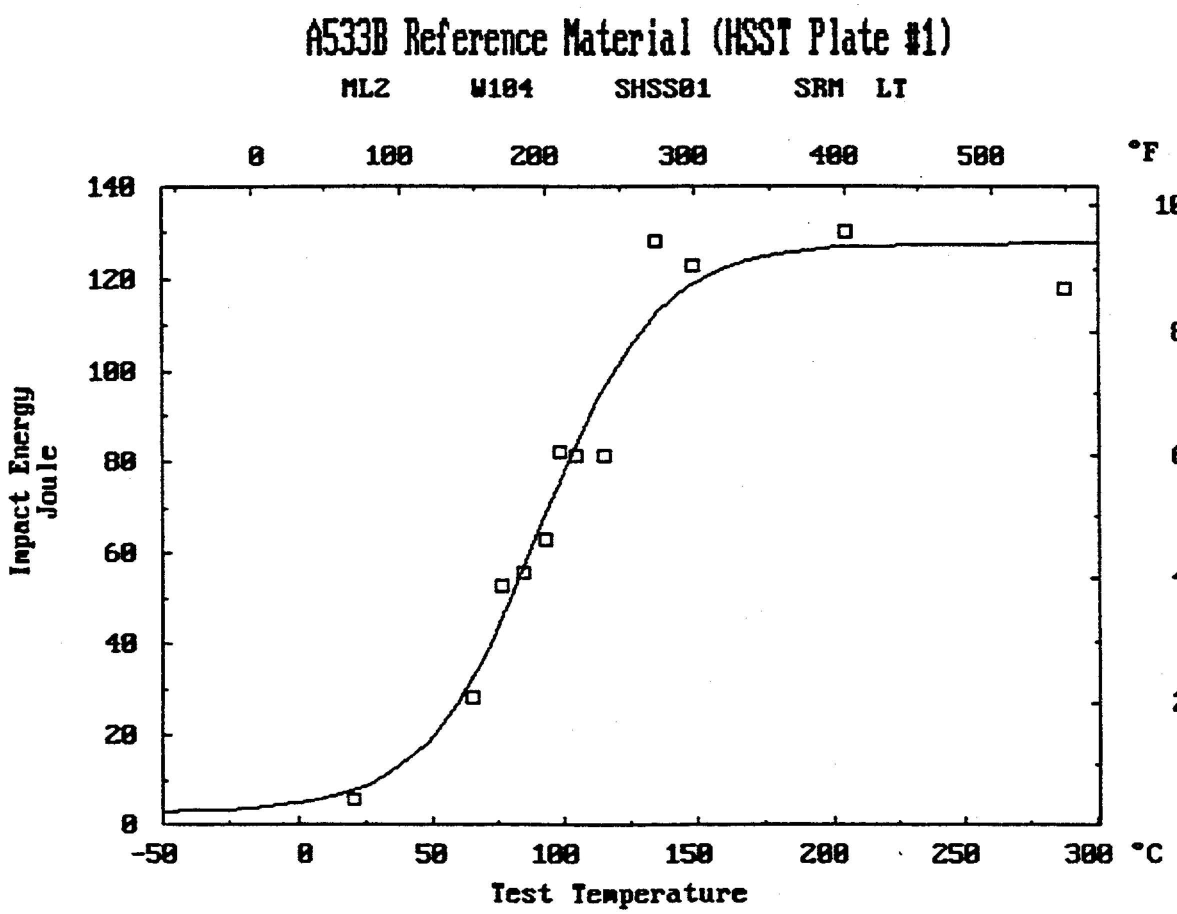
A533B HSST01 REFERENCE MATERIAL

Millstone Unit 2, Capsule W104

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

ML2 W104 SHSS01 SRM LT : Fluence = 8.840E+18 , Irr. Temp. = 288

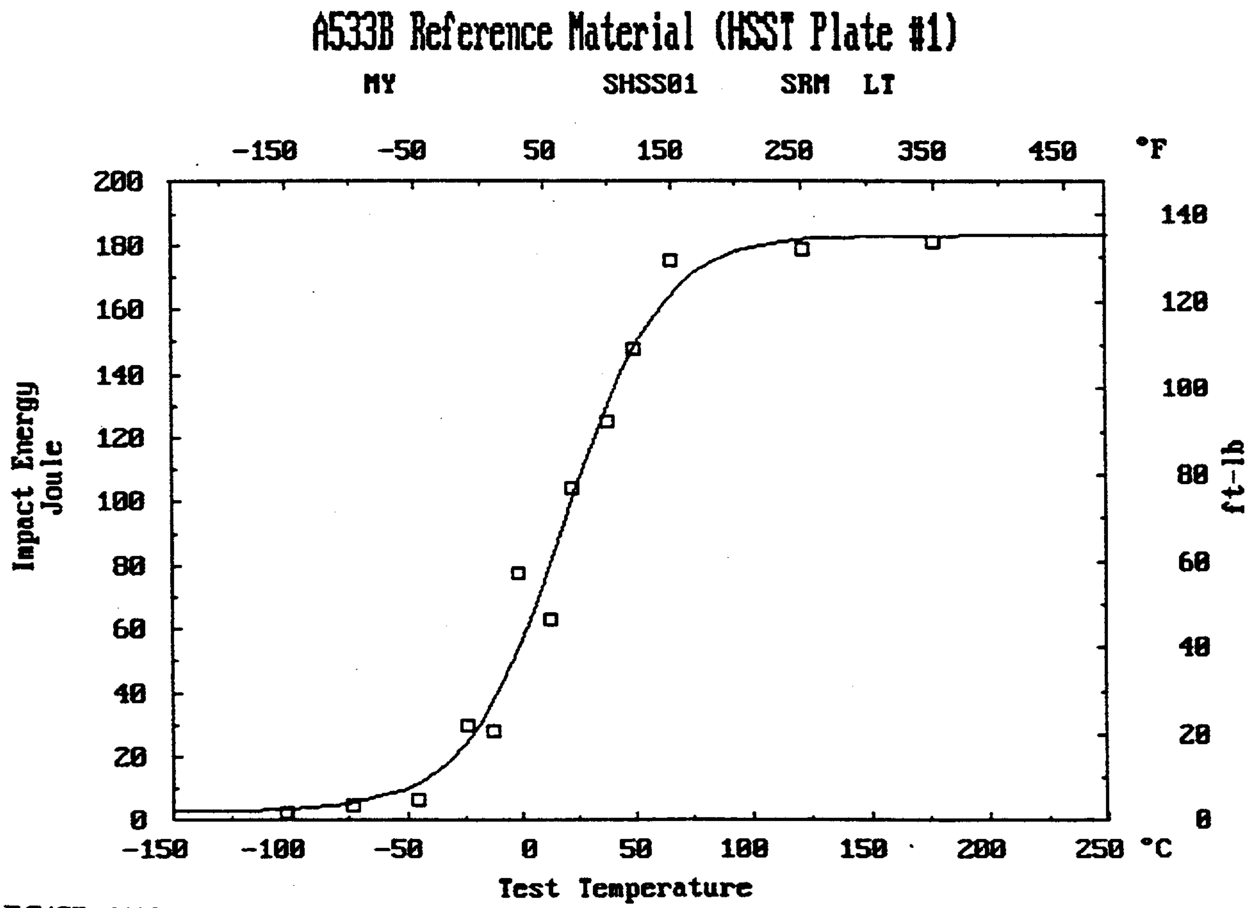
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	127.4	5.2	0.108				
CVT at Midpoint (C)	91.2	4.1	0.257	0.591			
1/slope (C)	44.1	7.4	-0.134	0.364	0.019		
CVT at 41 Joule (C)	73.0	4.9	0.262	-0.004	0.664	-0.708	
CVT at 68 Joule (C)	93.2	3.3	0.231	0.181	0.894	-0.101	0.765



A533B HSST01 REFERENCE MATERIAL
Maine Yankee, Baseline

USE= 183.2 J, LSE= 3.0 J, CVT(1/2)= 19.C , Slope = 0.0233
Unirradiated Charpy Specimen, CVT(41J) = -10. C , CVT(68J) = 6. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
5AY	-101.	-150.	2.	2.	0.03	1.	0.
5AP	-73.	-100.	5.	3.	0.10	4.	0.
62U	-46.	-50.	7.	5.	0.20	8.	1.
5AJ	-23.	-10.	30.	22.	0.63	25.	20.
62Y	-12.	10.	28.	21.	0.56	22.	20.
631	-1.	30.	78.	57.	1.24	49.	30.
62T	13.	55.	63.	47.	0.99	39.	40.
632	22.	71.	104.	77.	1.63	64.	50.
633	38.	100.	125.	92.	2.01	79.	70.
5AK	49.	120.	148.	109.	2.21	87.	80.
5AU	66.	150.	175.	129.	2.29	90.	90.
5AM	121.	250.	179.	132.	2.46	97.	99.
5AL	177.	350.	181.	134.	2.08	82.	99.



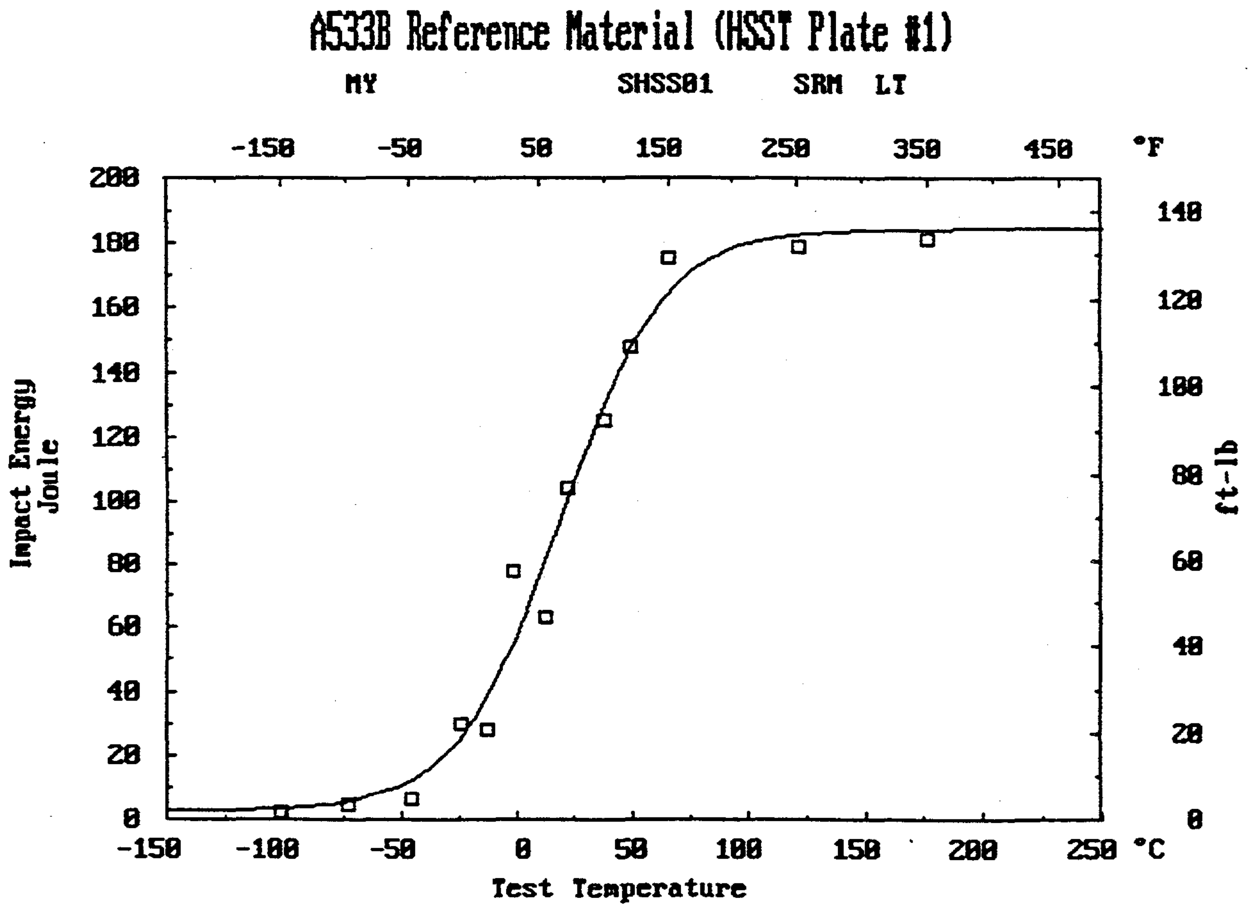
A533B HSST01 REFERENCE MATERIAL

Maine Yankee, Baseline

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

MY SHSS01 SRM LT

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	184.4	6.4	-0.119				
CVT at Midpoint (C)	18.8	3.4	0.022	0.610			
1/slope (C)	44.2	5.3	-0.323	0.403	0.277		
CVT at 41 Joule (C)	-10.6	4.1	0.315	-0.084	0.436	-0.726	
CVT at 68 Joule (C)	5.9	3.0	0.234	0.075	0.739	-0.372	0.906



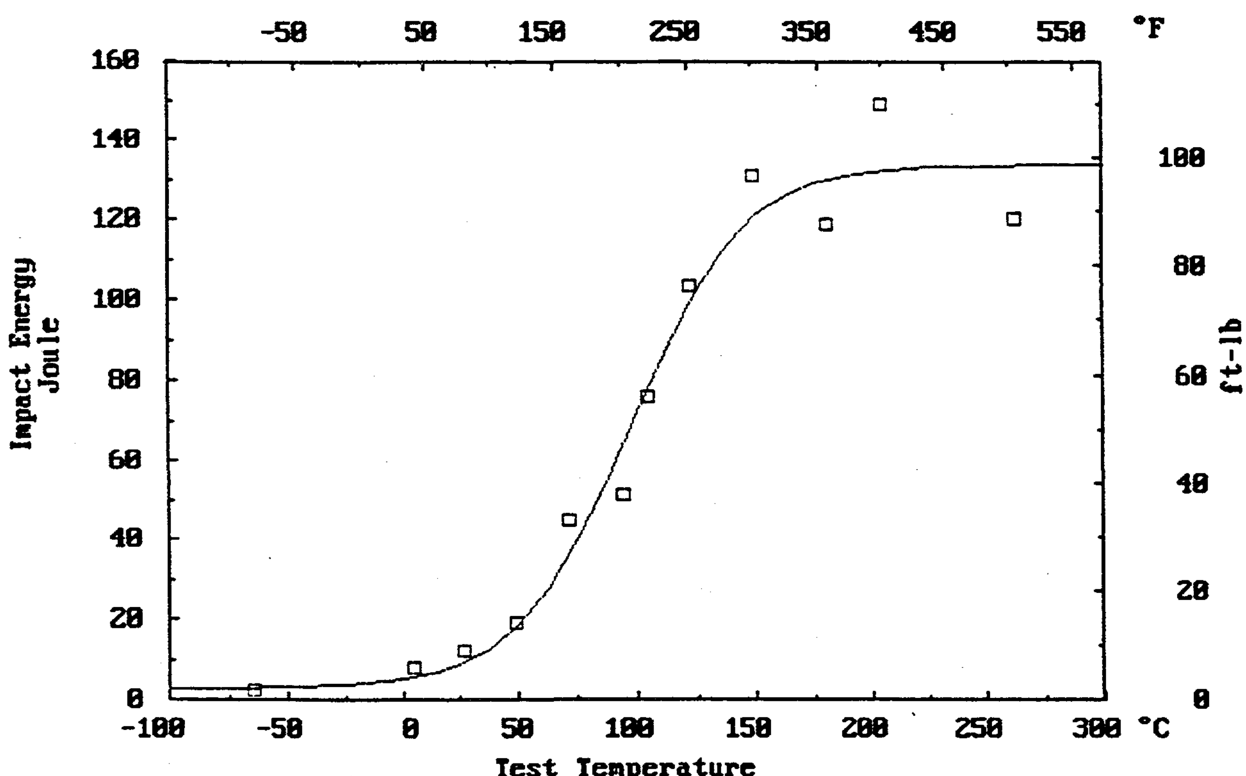
A533B HSST01 REFERENCE MATERIAL
Maine Yankee, Capsule A25

USE= 133.7 J, LSE= 3.0 J, CVT(1/2)= 97.C , Slope = 0.0212
CVT(41J) = 76. C , CVT(68J) = 97. C ,
Fluence = 1.300E+19 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
62E	-64.	-84.	3.	2.	0.10	4.	0.
61Y	4.	40.	8.	6.	0.10	4.	5.
61B	26.	79.	12.	9.	0.15	6.	10.
62B	49.	120.	19.	14.	0.30	12.	20.
62M	71.	160.	45.	33.	0.74	29.	30.
62C	93.	200.	52.	38.	0.84	33.	35.
611	104.	220.	76.	56.	1.07	42.	50.
62D	121.	250.	103.	76.	1.32	52.	70.
617	149.	300.	131.	96.	1.47	58.	100.
62L	180.	356.	119.	87.	1.47	58.	100.
62K	204.	400.	149.	110.	1.52	60.	100.
62J	262.	504.	120.	89.	1.45	57.	100.

A533B Reference Material (HSST Plate #1)

MY A25 SHSS01 SRM LT



A533B HSST01 REFERENCE MATERIAL

Maine Yankee, Capsule A25

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
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MY     A25    SHSS01     SRM  LT : Fluence = 1.300E+19 , Irr. Temp. =  288
```
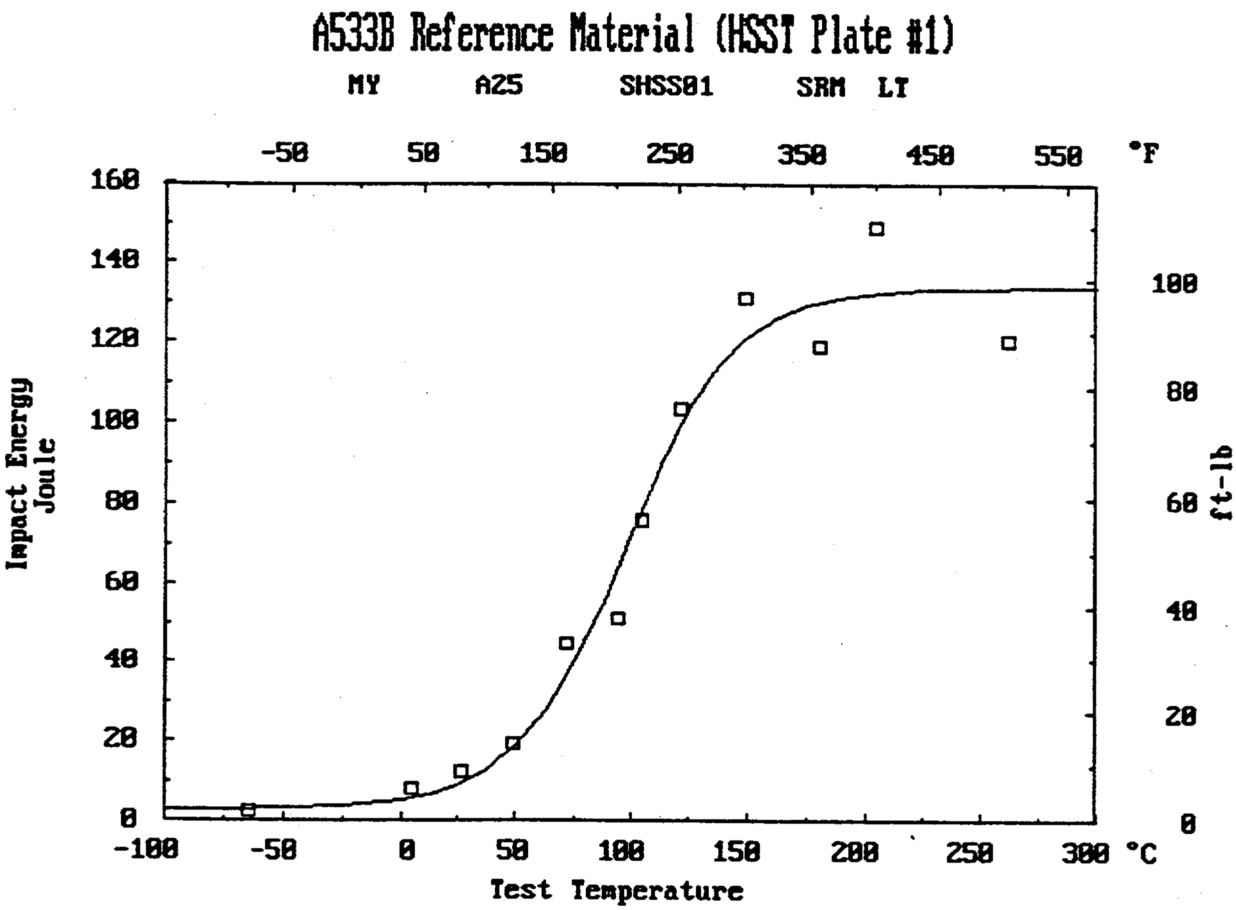
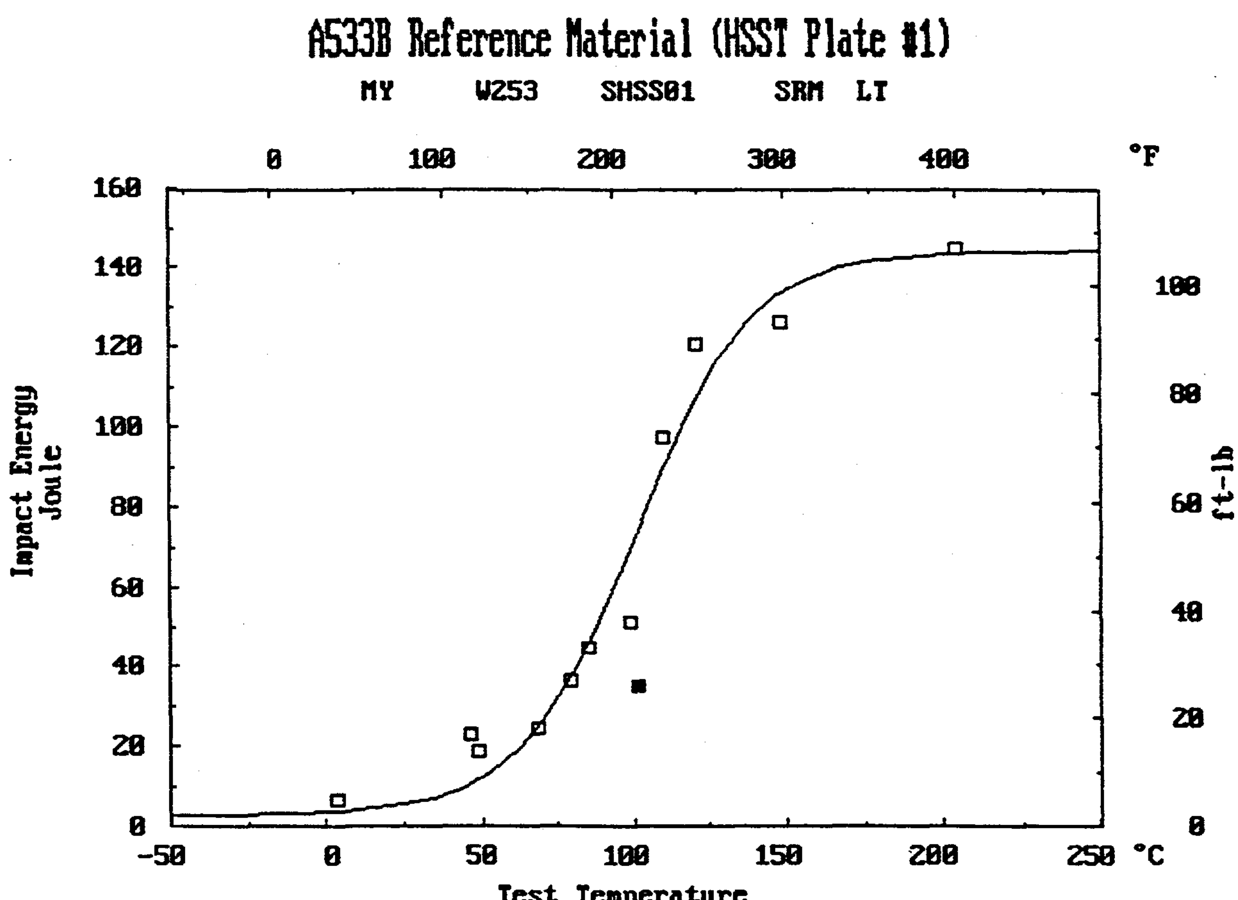

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	133.6	5.8	0.015				
CVT at Midpoint (C)	96.7	5.2	0.208	0.566			
1/slope (C)	47.1	9.0	-0.177	0.284	0.009		
CVT at 41 Joule (C)	75.7	6.3	0.273	0.048	0.683	-0.700	
CVT at 68 Joule (C)	96.5	4.3	0.234	0.188	0.914	-0.133	0.795



A533B HSST01 REFERENCE MATERIAL
Maine Yankee, Capsule W253

USE= 144.3 J, LSE= 3.1 J, CVT(1/2)= 101.C , Slope = 0.0263
CVT(41J) = 82. C , CVT(68J) = 98. C ,
Fluence = 1.250E+19 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
61E	4.	40.	7.	5.	0.25	10.	5.
614	46.	115.	23.	17.	0.41	16.	15.
61P	49.	120.	19.	14.	0.30	12.	15.
61C	68.	155.	24.	18.	0.41	16.	20.
61M	79.	175.	37.	27.	0.66	26.	35.
627	85.	185.	45.	33.	0.74	29.	35.
62A	99.	210.	52.	38.	0.89	35.	45.
*61A	102.	215.	35.	26.	0.69	27.	40.
61D	110.	230.	98.	72.	1.45	57.	95.
61T	121.	250.	121.	89.	1.75	69.	100.
61U	149.	300.	126.	93.	1.93	76.	100.
61J	204.	400.	145.	107.	2.29	90.	100.



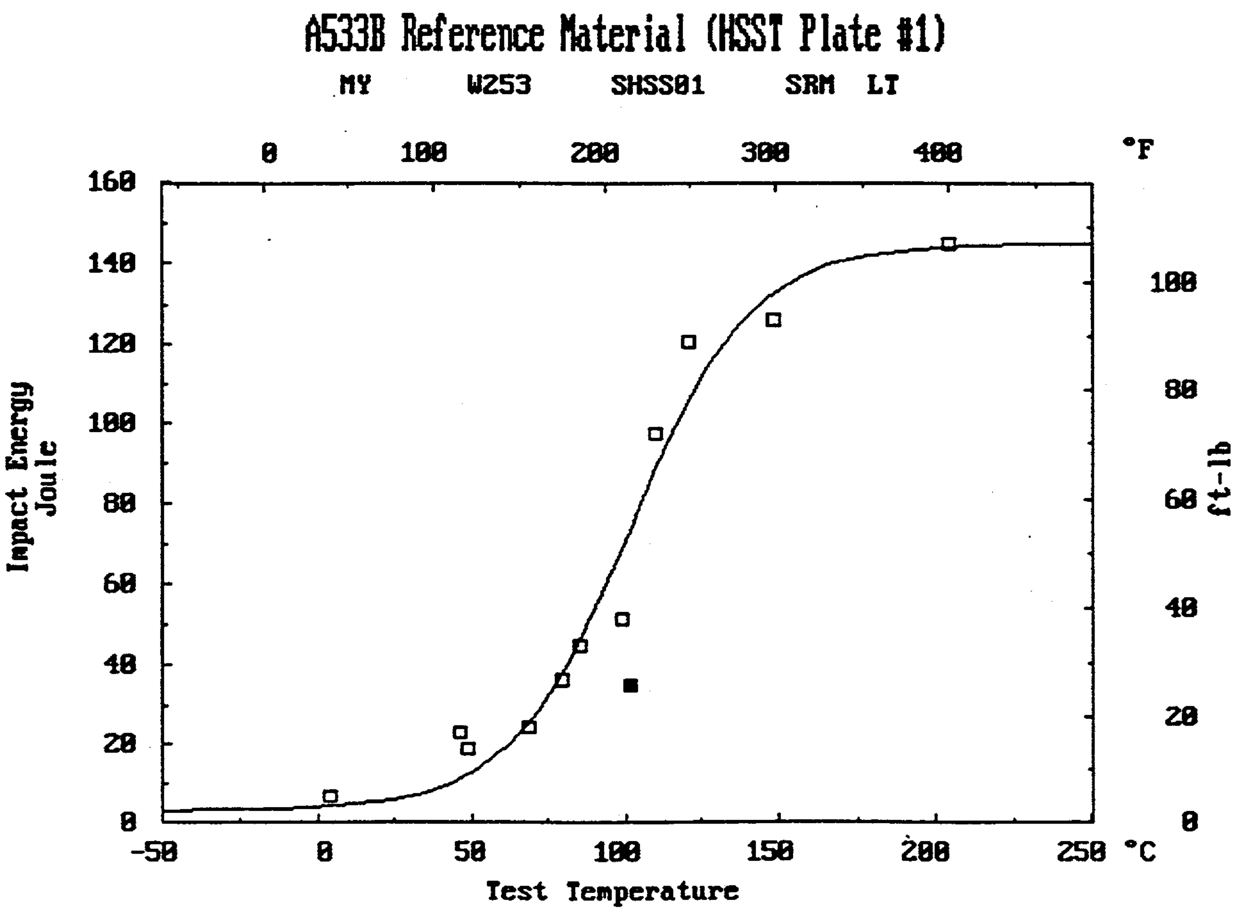
A533B HSST01 REFERENCE MATERIAL

Maine Yankee, Capsule W253

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

MY W253 SHSS01 SRM LT : Fluence = 1.250E+19 , Irr. Temp. = 288

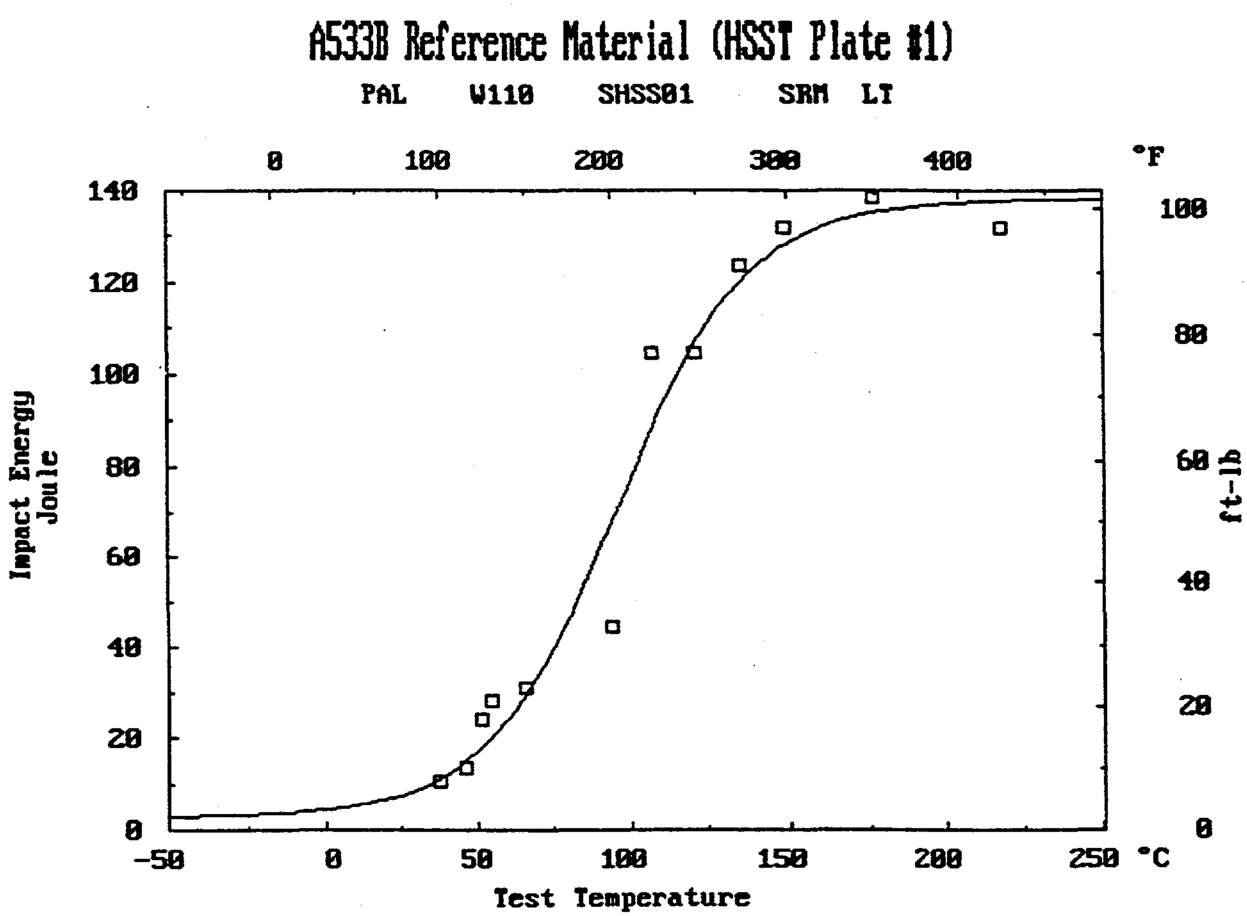
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	144.9	9.7	-0.178				
CVT at Midpoint (C)	101.7	4.9	-0.007	0.739			
1/slope (C)	39.3	9.4	-0.486	0.551	0.501		
CVT at 41 Joule (C)	81.7	4.8	0.536	-0.187	0.219	-0.706	
CVT at 68 Joule (C)	98.2	3.2	0.237	0.189	0.778	0.060	0.655



A533B HSST01 REFERENCE MATERIAL
Palisades, Capsule W110

USE= 137.9 J, LSE= 3.0 J, CVT(1/2)= 96.C , Slope = 0.0238
CVT(41J) = 76. C , CVT(68J) = 94. C ,
Fluence = 1.779E+19 , Irr. Temp. = 280 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
52Y	38.	100.	11.	8.	0.18	7.	5.
52M	46.	115.	14.	10.	0.28	11.	10.
52T	52.	125.	24.	18.	0.58	23.	10.
52K	54.	130.	28.	21.	0.46	18.	15.
52D	66.	150.	31.	23.	0.56	22.	15.
52J	93.	200.	45.	33.	0.69	27.	25.
52U	107.	225.	104.	77.	1.45	57.	60.
514	121.	250.	104.	77.	1.42	56.	80.
52P	135.	275.	123.	91.	1.37	54.	80.
512	149.	300.	132.	97.	1.90	75.	100.
513	177.	350.	138.	102.	1.98	78.	100.
52E	218.	425.	132.	97.	1.93	76.	100.



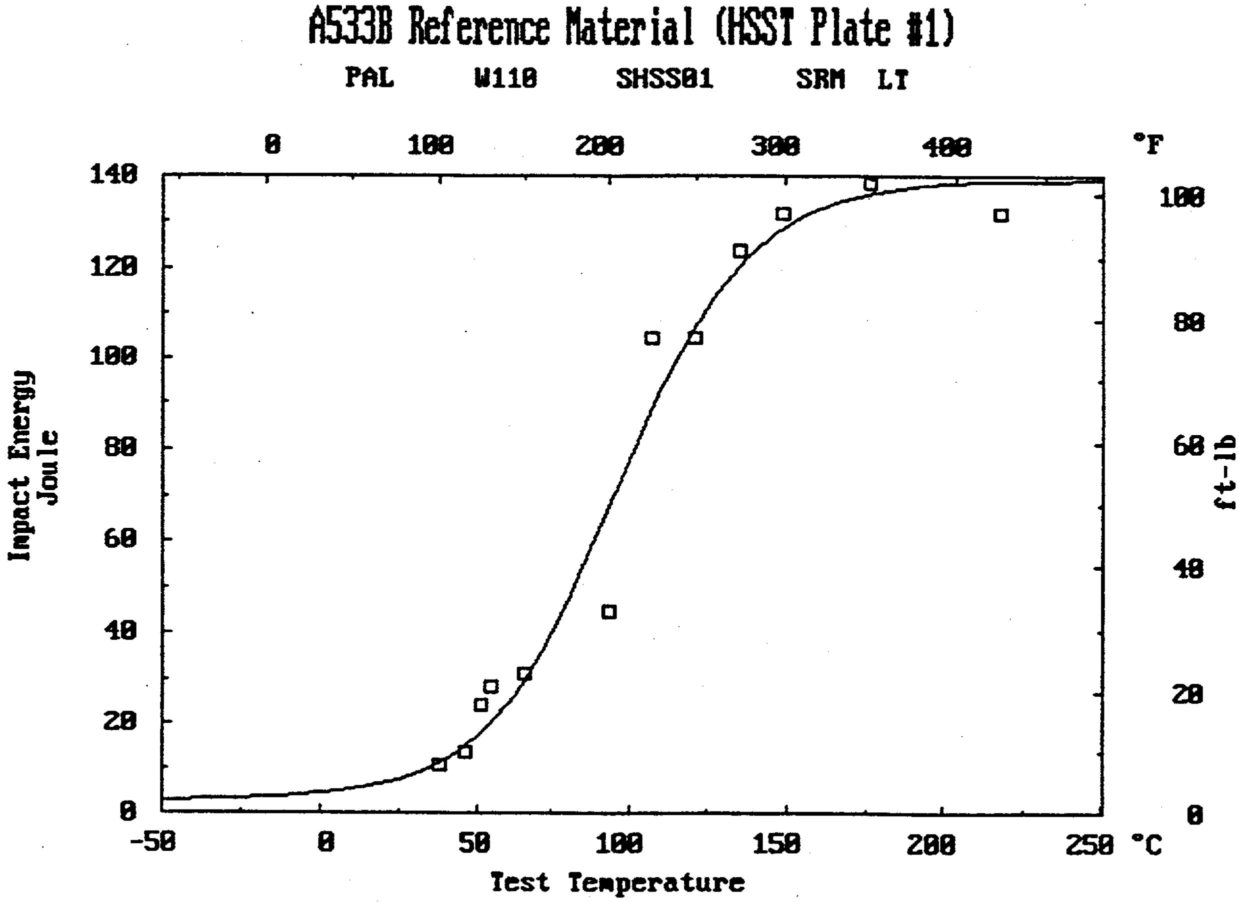
A533B HSST01 REFERENCE MATERIAL

Palisades, Capsule W110

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PAL W110 SHSS01 SRM LT : Fluence = 1.779E+19 , Irr. Temp. = 280

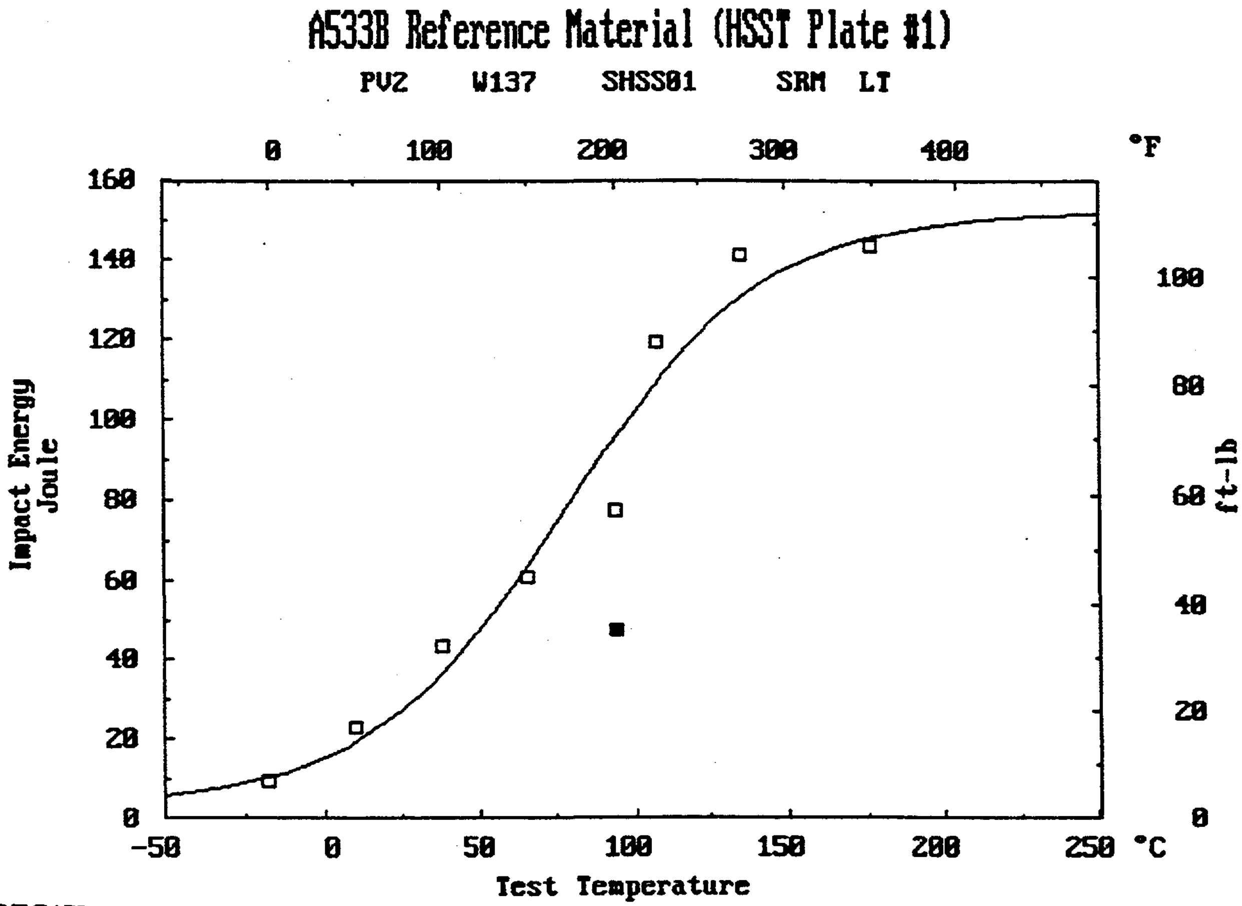
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	138.9	6.4	-0.040				
CVT at Midpoint (C)	96.0	4.5	0.298	0.573			
1/slope (C)	42.2	6.7	-0.497	0.334	0.056		
CVT at 41 Joule (C)	76.0	5.1	0.574	0.025	0.682	-0.662	
CVT at 68 Joule (C)	94.1	3.7	0.404	0.152	0.893	-0.175	0.848



A533B HSST01 REFERENCE MATERIAL
Palo Verde Unit 2, Capsule W137

USE= 152.1 J, LSE= 3.0 J, CVT(1/2)= 78.C , Slope = 0.0155
CVT(41J) = 43. C , CVT(68J) = 70. C ,
Fluence = 4.071E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
1BD3Y	-18.	0.	9.	7.	0.20	8.	5.
1BD43	10.	50.	23.	17.	0.51	20.	15.
1BD4P	38.	100.	43.	32.	0.76	30.	20.
1BD35	66.	150.	61.	45.	1.17	46.	40.
*1BD2D	93.	200.	47.	35.	0.81	32.	35.
1BD52	93.	200.	77.	57.	1.35	53.	60.
1BD3E	107.	225.	119.	88.	1.90	75.	85.
1BD2M	135.	275.	141.	104.	2.13	84.	100.
1BD2B	177.	350.	144.	106.	2.21	87.	100.



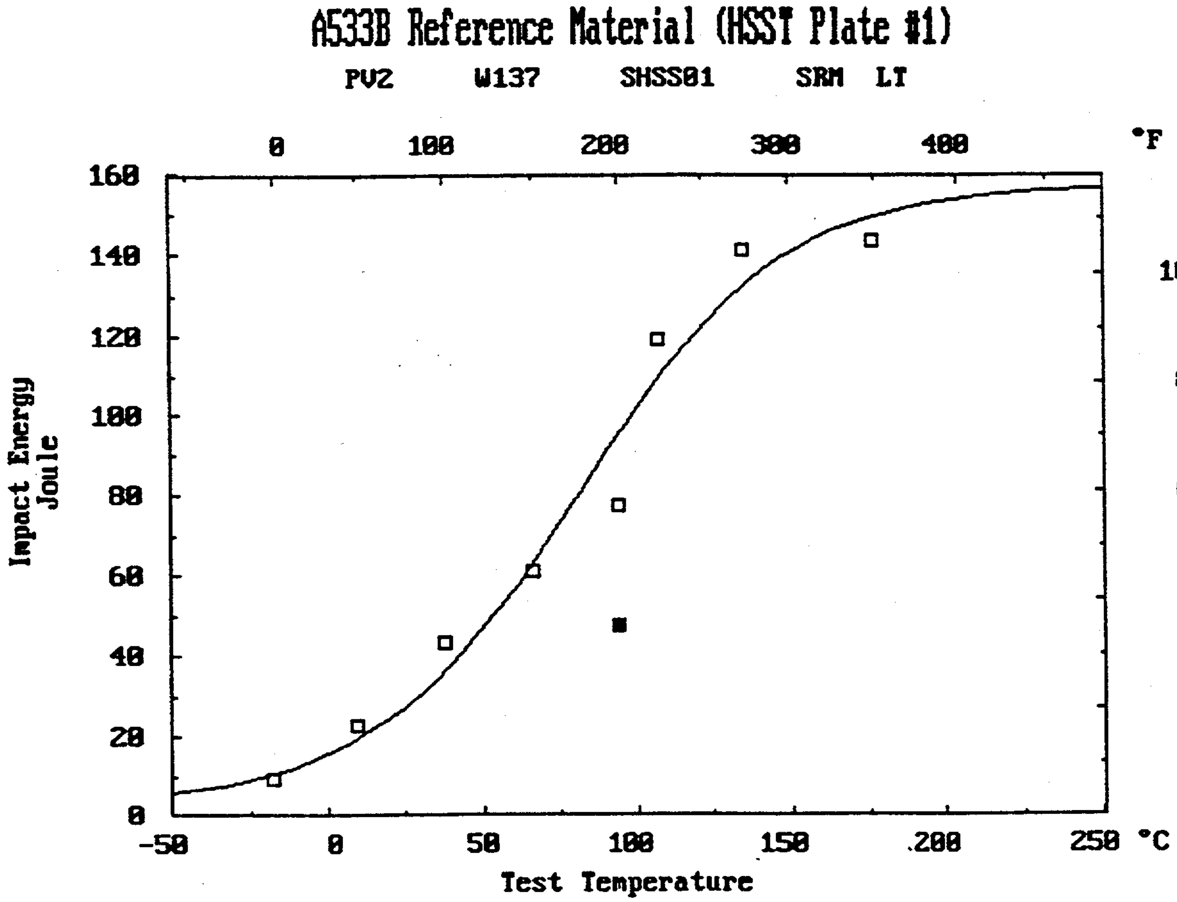
A533B HSST01 REFERENCE MATERIAL

Palo Verde Unit 2, Capsule W137

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PV2 W137 SHSS01 SRM LT : Fluence = 4.071E+18 , Irr. Temp. = 288

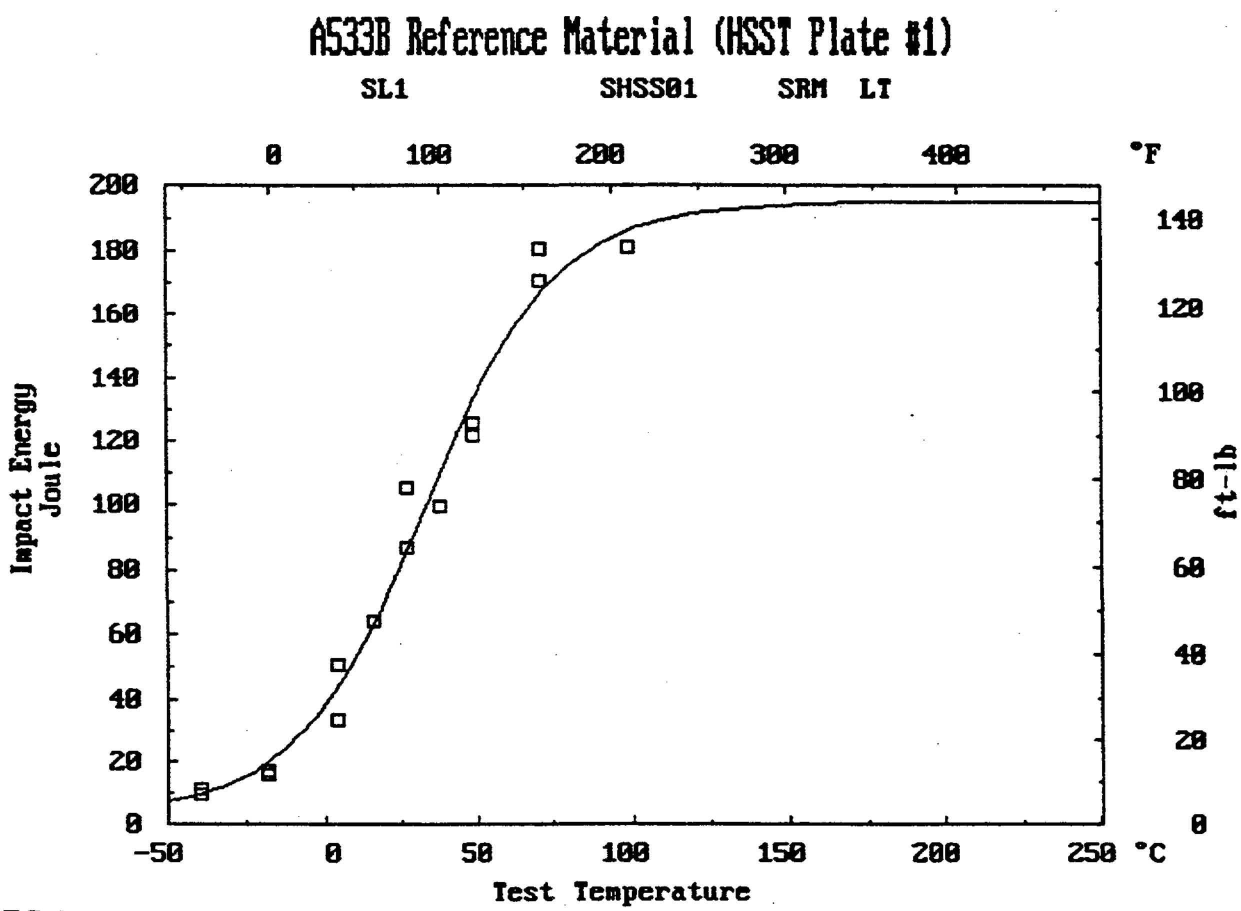
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	157.7	12.7	-0.163				
CVT at Midpoint (C)	80.8	8.7	0.061	0.820			
1/slope (C)	66.2	12.3	-0.395	0.615	0.419		
CVT at 41 Joule (C)	43.5	8.0	0.473	-0.120	0.317	-0.703	
CVT at 68 Joule (C)	70.0	5.4	0.372	0.174	0.676	-0.259	0.863



A533B HSST01 REFERENCE MATERIAL
St. Lucie Unit 1, Baseline

USE= 195.1 J, LSE= 3.0 J, CVT(1/2)= 33.C , Slope = 0.0229
Unirradiated Charpy Specimen, CVT(41J) = 2. C , CVT(68J) = 18. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
72J	-40.	-40.	9.	7.	0.03	1.	0.
72L	-40.	-40.	12.	8.	0.03	1.	0.
72U	-18.	0.	17.	12.	0.15	6.	10.
732	-18.	0.	16.	12.	0.15	6.	10.
72K	4.	40.	33.	25.	0.46	18.	10.
731	4.	40.	51.	37.	0.71	28.	20.
72P	16.	60.	64.	48.	0.89	35.	30.
72E	27.	80.	87.	64.	1.19	47.	40.
72T	27.	80.	106.	78.	1.50	59.	40.
72C	38.	100.	100.	73.	1.32	52.	40.
72B	49.	120.	126.	93.	1.68	66.	60.
72Y	49.	120.	122.	90.	1.68	66.	60.
72D	71.	160.	180.	133.	2.11	83.	95.
72M	71.	160.	171.	126.	2.11	83.	95.
72A	99.	210.	181.	133.	2.21	87.	100.



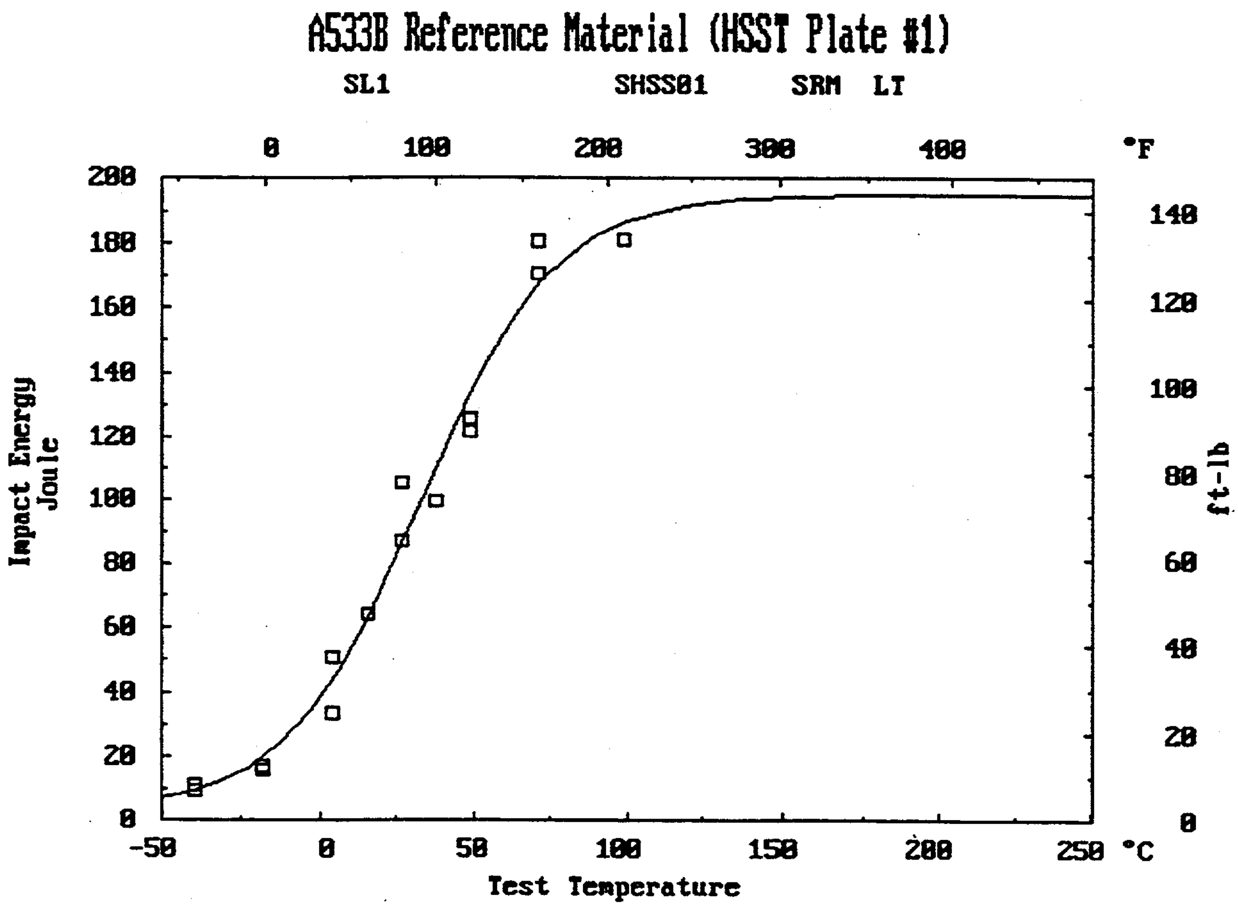
A533B HSST01 REFERENCE MATERIAL

St. Lucie Unit 1, Baseline

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SL1 SHSS01 SRM LT

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	195.2	12.3	-0.011				
CVT at Midpoint (C)	32.7	4.5	0.024	0.877			
1/slope (C)	43.4	5.7	-0.095	0.743	0.728		
CVT at 41 Joule (C)	2.2	3.1	0.151	-0.258	0.007	-0.657	
CVT at 68 Joule (C)	18.0	2.2	0.128	0.165	0.536	-0.105	0.815



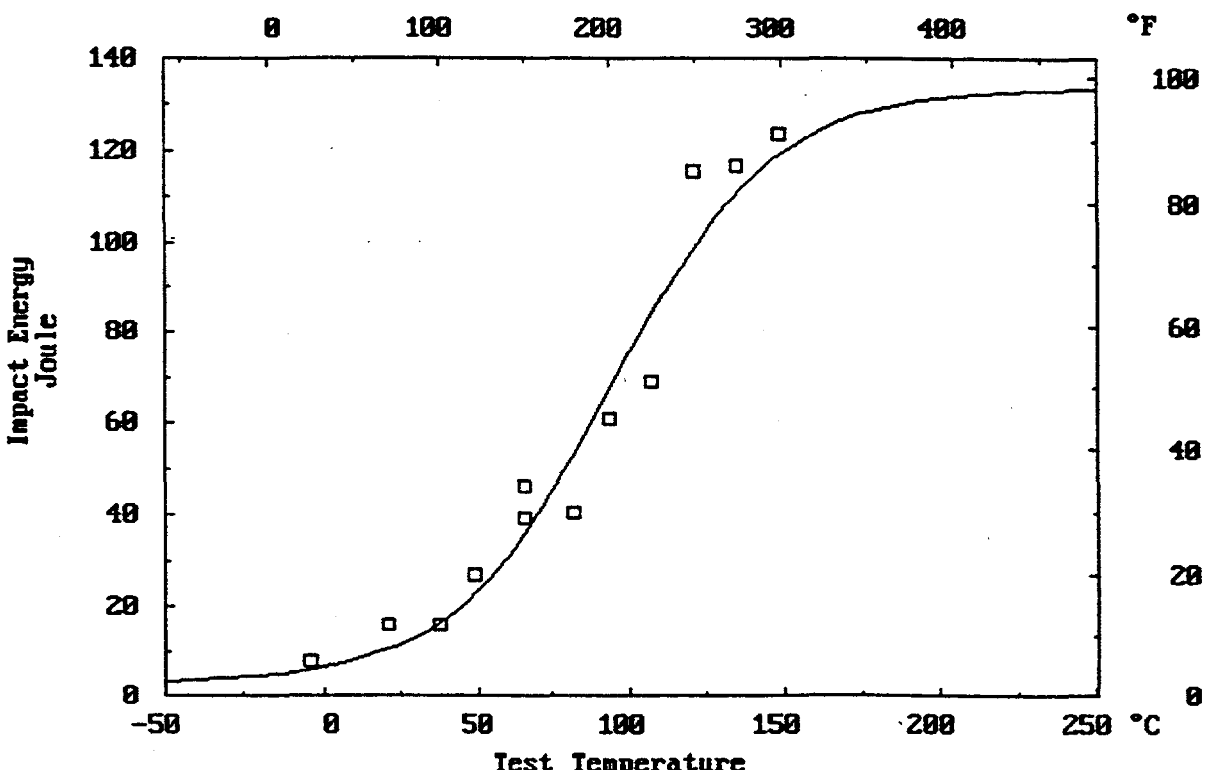
A533B HSST01 REFERENCE MATERIAL
St. Lucie Unit 1, Capsule W104

USE= 133.4 J, LSE= 3.1 J, CVT(1/2)= 94.C , Slope = 0.0192
CVT(41J) = 71. C , CVT(68J) = 94. C ,
Fluence = 7.160E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
721	-4.	25.	8.	6.	0.23	9.	5.
71L	21.	70.	16.	12.	0.18	7.	10.
71P	38.	100.	16.	12.	0.36	14.	10.
724	49.	120.	27.	20.	0.46	18.	15.
723	66.	150.	46.	34.	0.71	28.	30.
726	66.	150.	39.	29.	0.58	23.	20.
725	82.	180.	41.	30.	0.74	29.	40.
71U	93.	200.	61.	45.	0.91	36.	40.
71T	107.	225.	69.	51.	1.22	48.	90.
71Y	121.	250.	115.	85.	1.90	75.	100.
71M	135.	275.	117.	86.	1.80	71.	100.
71A	149.	300.	123.	91.	1.93	76.	100.

A533B Reference Material (HSST Plate #1)

SL1 W104 SHSS01 SRM LT



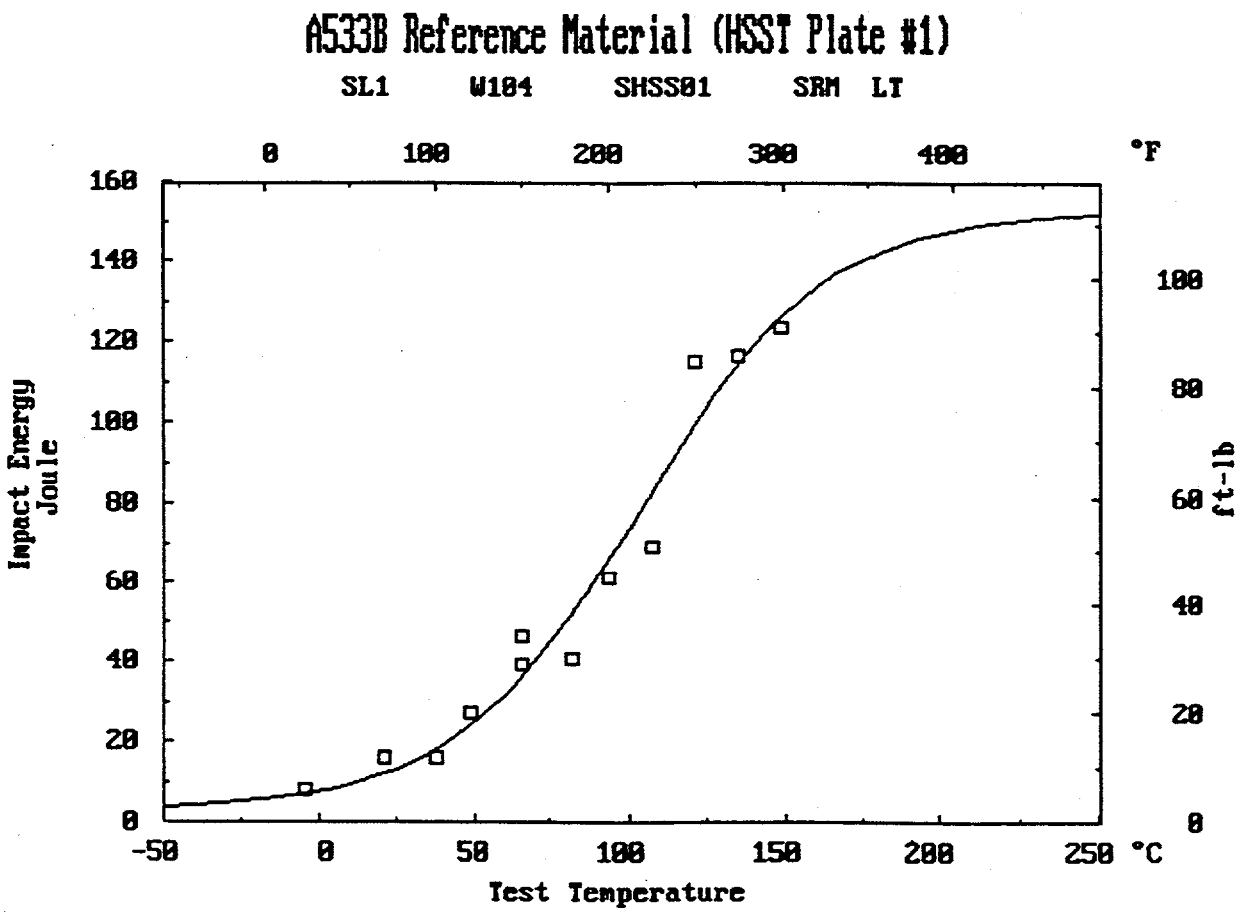
A533B HSST01 REFERENCE MATERIAL

St. Lucie Unit 1, Capsule W104

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

SL1 W104 SHSS01 SRM LT : Fluence = 7.160E+18 , Irr. Temp. = 288

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	152.8	23.5	-0.183				
CVT at Midpoint (C)	103.3	11.1	-0.112	0.939			
1/slope (C)	59.6	10.6	-0.378	0.645	0.637		
CVT at 41 Joule (C)	71.0	5.3	0.367	0.094	0.293	-0.480	
CVT at 68 Joule (C)	95.5	3.9	0.159	0.340	0.622	0.145	0.753



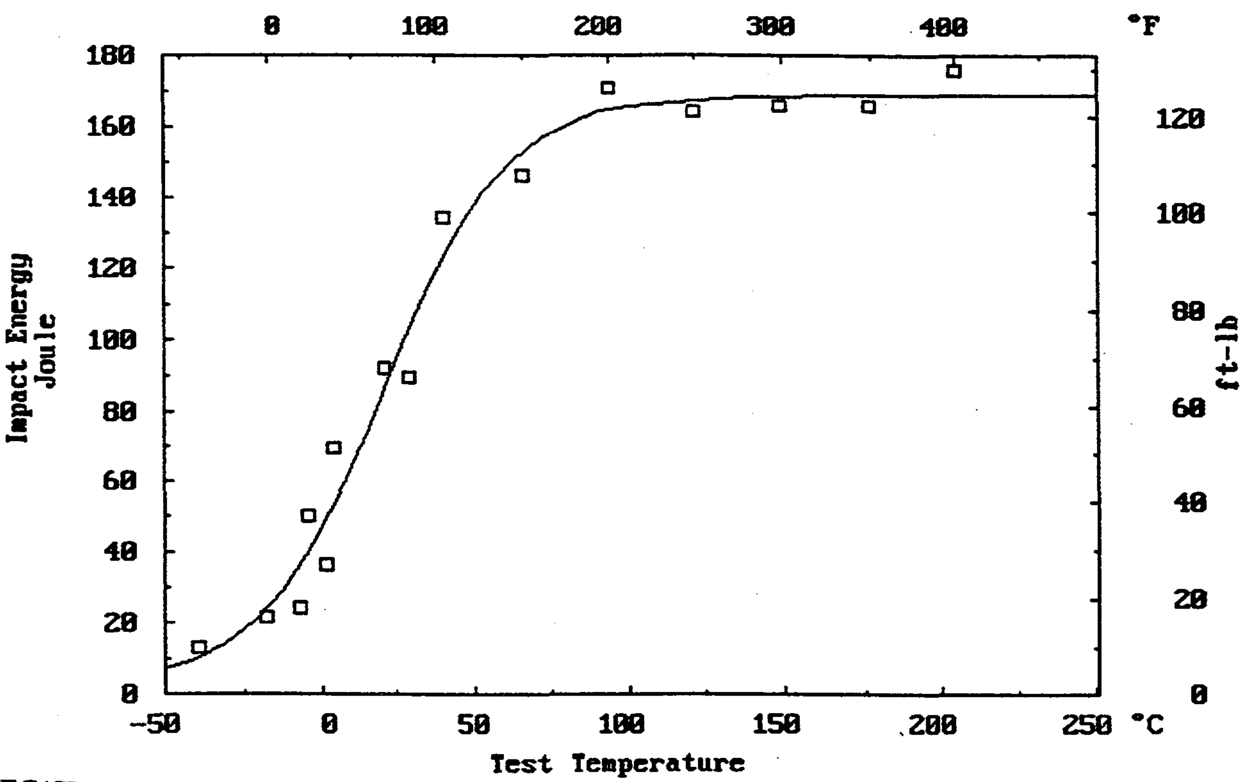
A533B HSST01 REFERENCE MATERIAL
St. Lucie Unit 2, Baseline

USE= 168.6 J, LSE= 3.0 J, CVT(1/2)= 21.C , Slope = 0.0252
Unirradiated Charpy Specimen, CVT(41J) = -3. C , CVT(68J) = 12. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
B17	-40.	-40.	14.	10.	0.28	11.	0.
AAL	-18.	0.	22.	16.	0.46	18.	10.
AAT	-7.	20.	24.	18.	0.43	17.	10.
B13	-4.	25.	50.	37.	0.79	31.	10.
B11	2.	35.	37.	27.	0.66	26.	10.
AAK	4.	40.	69.	51.	1.14	45.	20.
AAJ	21.	70.	92.	68.	1.40	55.	50.
AAM	29.	85.	89.	66.	1.35	53.	50.
B12	41.	105.	134.	99.	1.85	73.	70.
B14	66.	150.	146.	108.	2.08	82.	100.
B16	93.	200.	171.	126.	2.01	79.	100.
AAP	121.	250.	164.	121.	1.80	71.	100.
AAU	149.	300.	165.	122.	1.88	74.	100.
B15	177.	350.	165.	122.	1.98	78.	100.
AAY	204.	400.	176.	130.	1.93	76.	100.

A533B Reference Material (HSST Plate #1)

SL2 SHSS01 SRM LT



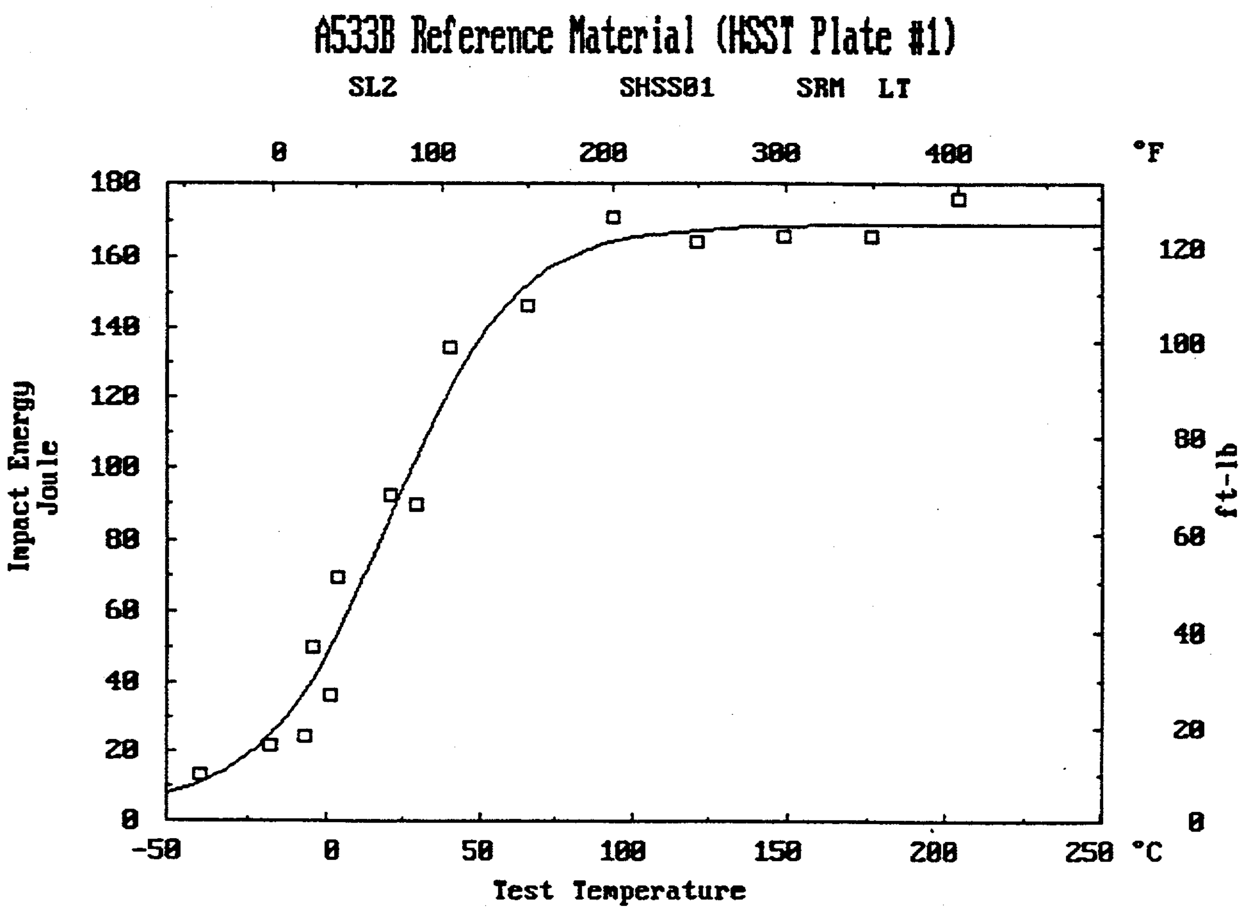
A533B HSST01 REFERENCE MATERIAL

St. Lucie Unit 2, Baseline

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SL2 SHSS01 SRM LT

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	168.7	4.6	-0.011				
CVT at Midpoint (C)	20.8	3.2	-0.051	0.430			
1/slope (C)	40.9	4.8	-0.094	0.337	0.368		
CVT at 41 Joule (C)	-4.0	3.5	0.030	-0.102	0.525	-0.577	
CVT at 68 Joule (C)	11.9	2.8	-0.020	0.026	0.858	-0.072	0.854



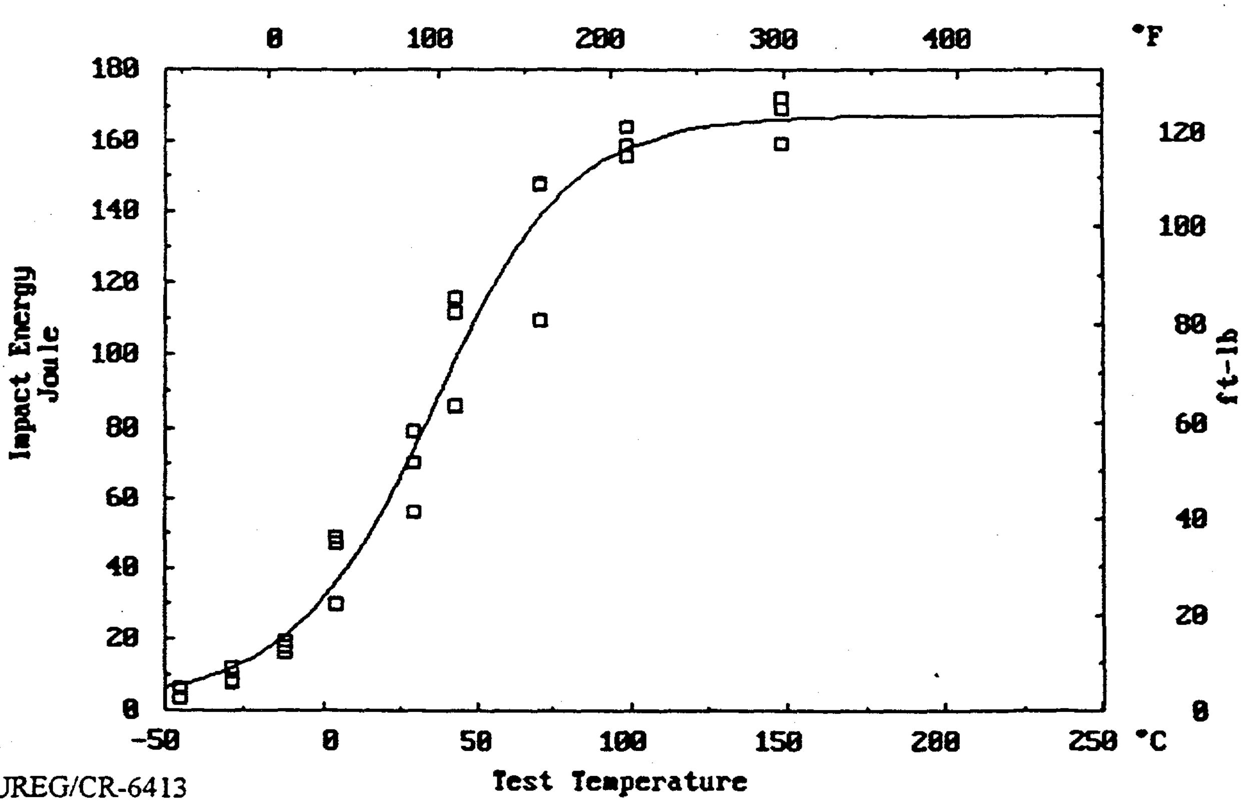
A533B HSST02 REFERENCE MATERIAL, Baseline

USE= 167.4 J, LSE= 2.9 J, CVT(1/2)= 36.C , Slope = 0.0220
Unirradiated Charpy SpecimenCVT(41J) = 8. C , CVT(68J) = 26. C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
	-46.	-50.	7.	5.	0.08	3.	9.
	-46.	-50.	7.	5.	0.13	5.	9.
	-46.	-50.	4.	3.	0.10	4.	9.
	-29.	-20.	9.	6.	0.15	6.	9.
	-29.	-20.	12.	9.	0.25	10.	13.
	-29.	-20.	8.	6.	0.23	9.	13.
	-12.	10.	16.	12.	0.38	15.	23.
	-12.	10.	20.	14.	0.36	14.	23.
	-12.	10.	18.	13.	0.36	14.	23.
	4.	40.	30.	22.	0.58	23.	33.
	4.	40.	49.	36.	0.81	32.	29.
	4.	40.	47.	35.	0.81	32.	29.
	29.	85.	79.	58.	1.30	51.	43.
	29.	85.	56.	41.	1.07	42.	41.
	29.	85.	70.	52.	1.14	45.	42.
	43.	110.	112.	82.	1.52	60.	58.
	43.	110.	116.	85.	1.80	71.	67.
	43.	110.	86.	63.	1.37	54.	55.
	71.	160.	147.	108.	1.83	72.	84.
	71.	160.	110.	81.	1.75	69.	85.
	71.	160.	148.	109.	2.01	79.	87.
	99.	210.	159.	117.	2.13	84.	98.
	99.	210.	156.	115.	2.24	88.	98.
	99.	210.	164.	121.	2.21	87.	100.
	149.	300.	169.	125.	2.21	87.	100.
	149.	300.	159.	117.	2.11	83.	100.
	149.	300.	172.	127.	2.13	84.	100.

A533B Reference Material

HSST02 Baseline LT



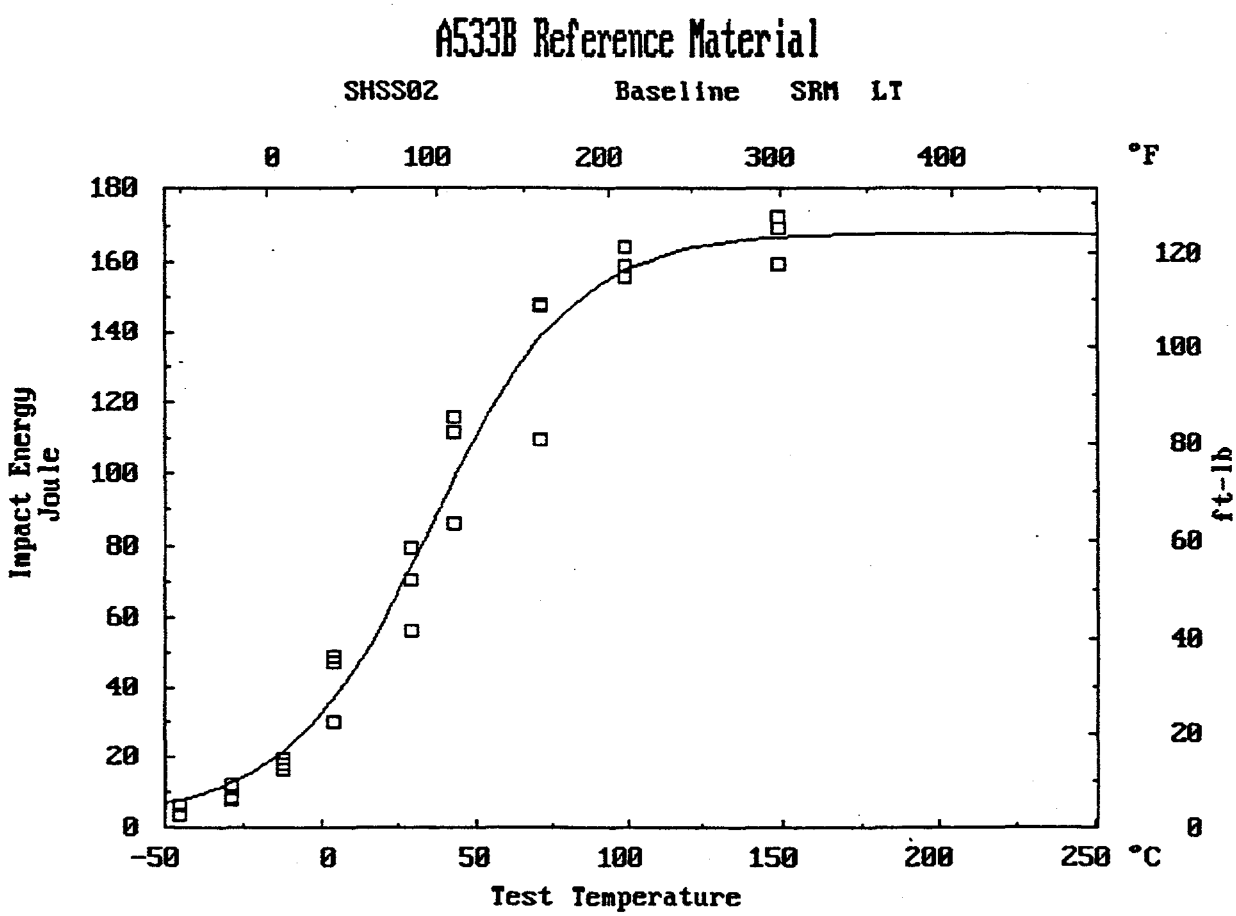
A533B HSST02 REFERENCE MATERIAL

Baseline

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

SHSS02 Baseline SRM LT

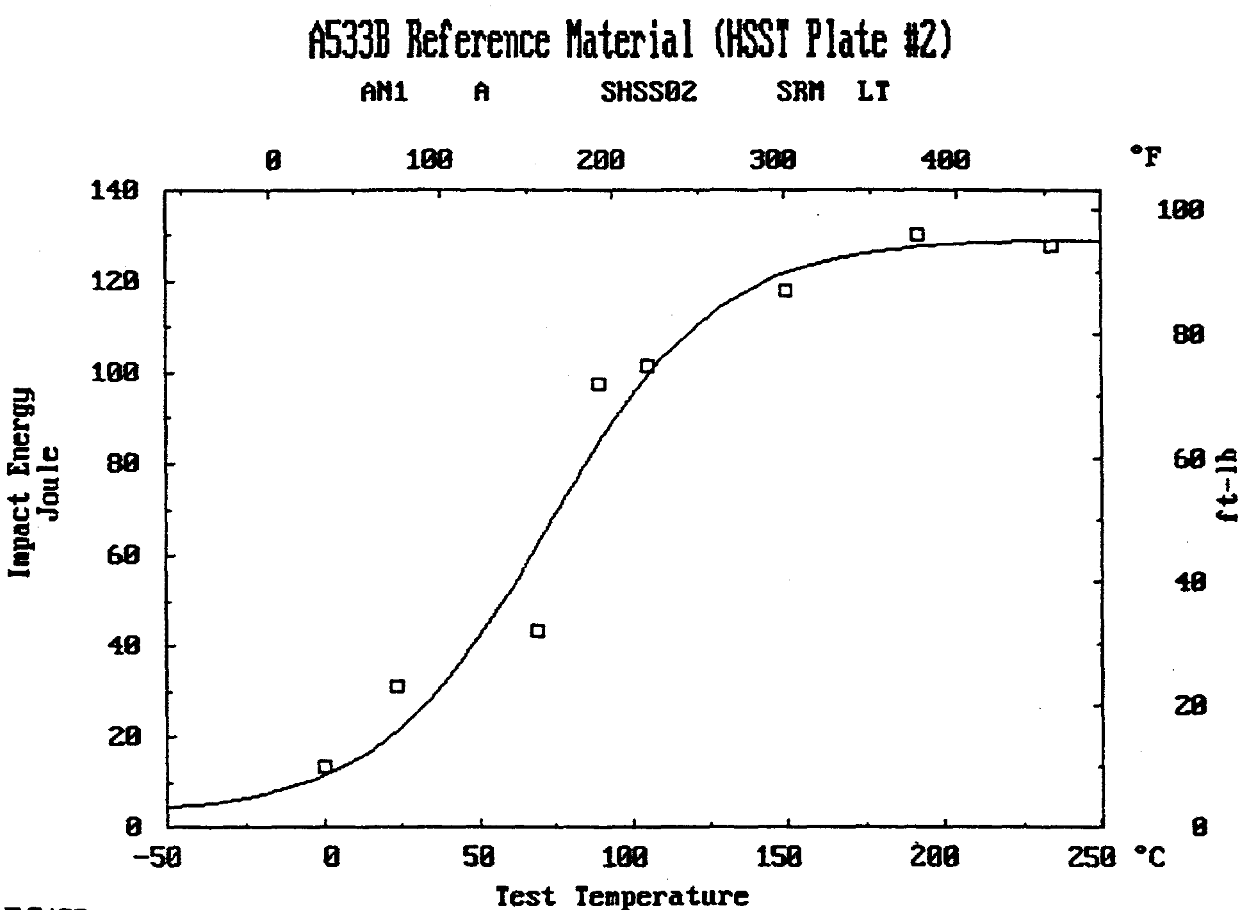
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	167.9	5.9	-0.042				
CVT at Midpoint (C)	35.7	3.4	0.024	0.741			
1/slope (C)	46.5	4.6	-0.251	0.582	0.607		
CVT at 41 Joule (C)	7.6	2.6	0.295	-0.077	0.331	-0.518	
CVT at 68 Joule (C)	25.7	2.2	0.162	0.250	0.792	0.118	0.784



A533B HSST02 REFERENCE MATERIAL,
Arkansas Unit 1, Capsule A

USE= 129.0 J, LSE= 3.0 J, CVT(1/2)= 73.C , Slope = 0.0180
CVT(41J) = 49. C , CVT(68J) = 74. C ,
Fluence = 1.030E+19 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
GG940	0.	32.	14.	10.	0.23	9.	0.
GG939	24.	75.	31.	23.	0.51	20.	5.
GG942	69.	156.	43.	32.	0.76	30.	15.
GG918	89.	192.	98.	72.	1.42	56.	80.
GG932	106.	222.	102.	75.	1.40	55.	95.
GG904	150.	302.	118.	87.	1.98	78.	100.
GG935	192.	378.	130.	96.	1.90	75.	100.
GG949	234.	454.	127.	94.	1.85	73.	100.



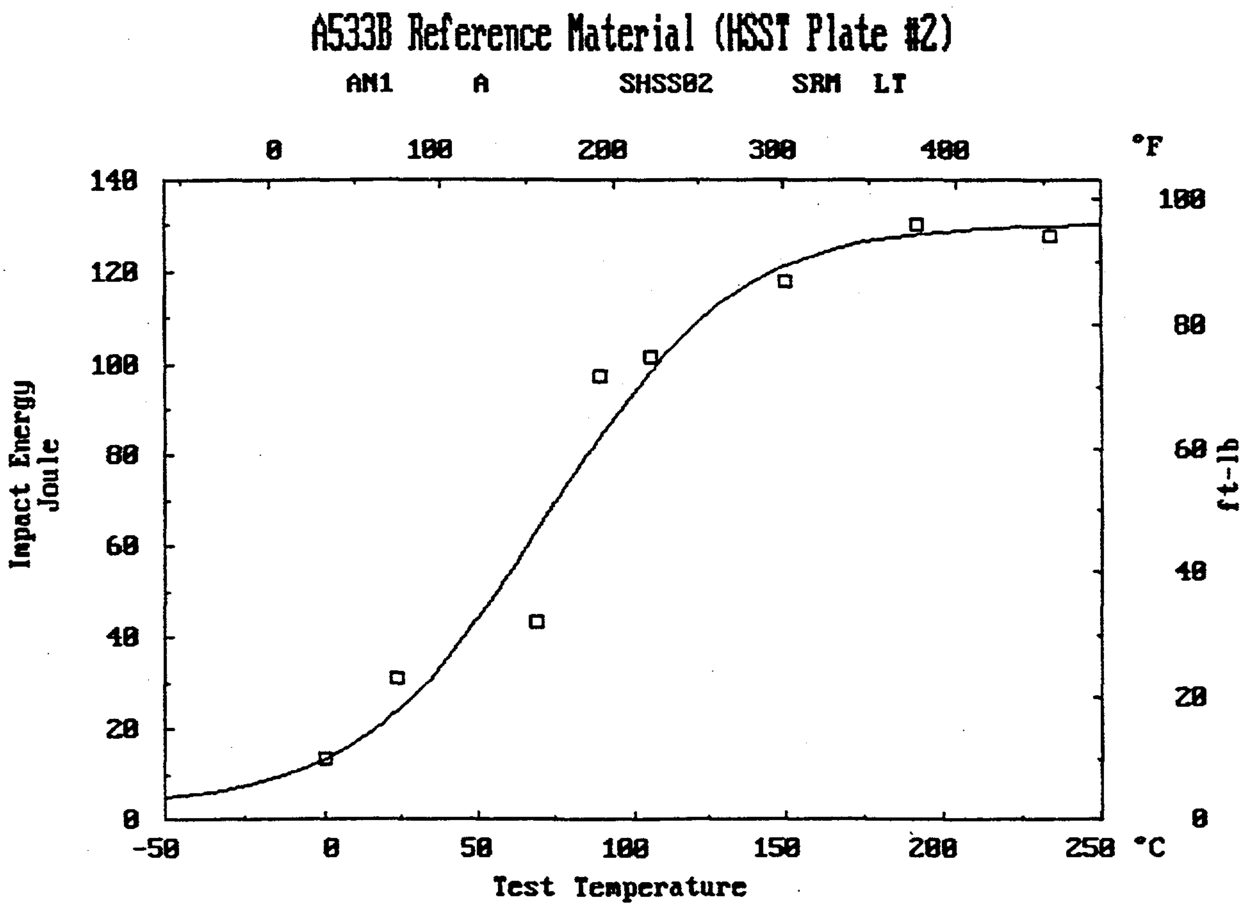
A533B HSST02 REFERENCE MATERIAL,

Arkansas Unit 1, Capsule A

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

AN1 A SHSS02 SRM LT : Fluence = 1.030E+19 , Irr. Temp. = 303

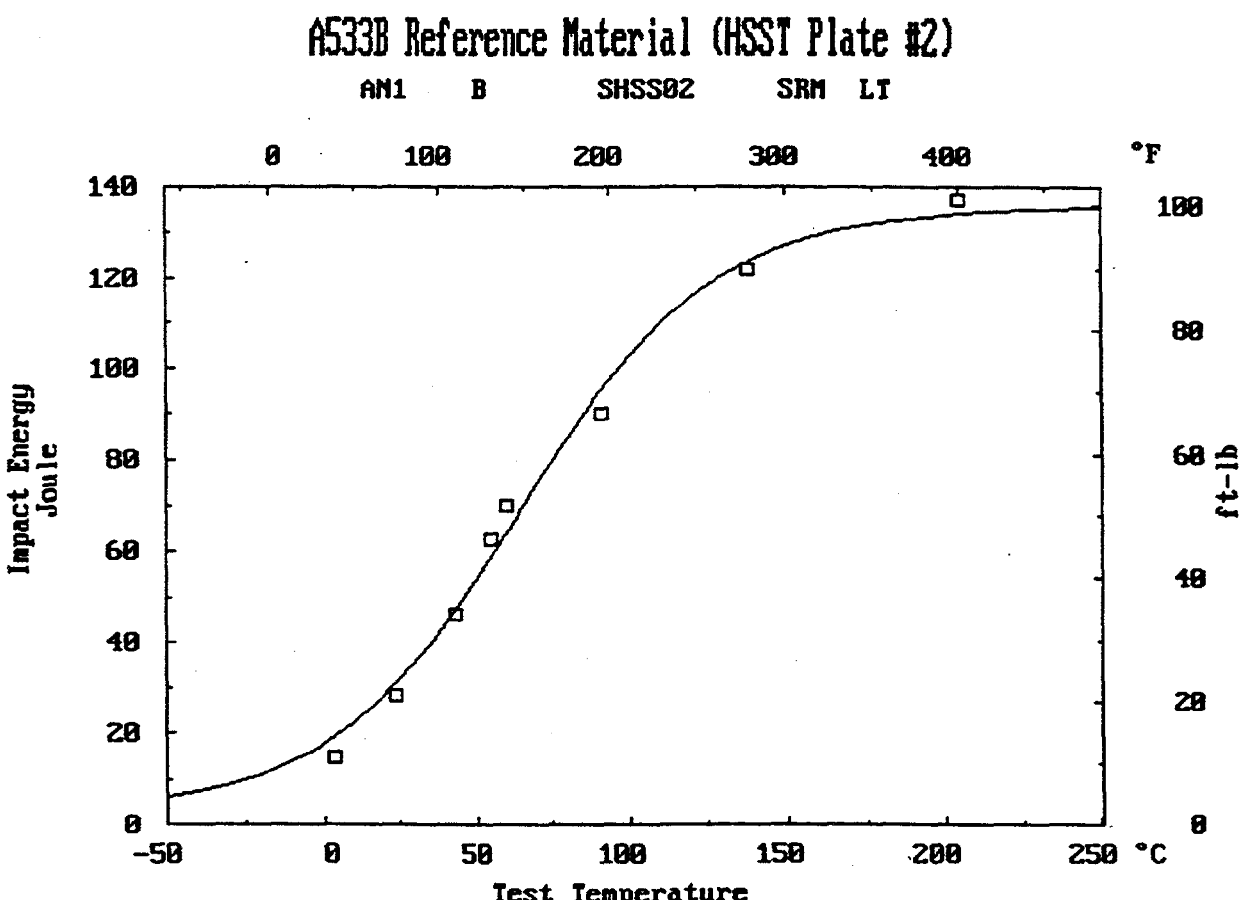
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	130.3	7.6	0.040				
CVT at Midpoint (C)	72.5	7.7	0.251	0.565			
1/slope (C)	60.0	13.6	-0.412	0.386	0.101		
CVT at 41 Joule (C)	46.7	9.0	0.472	-0.060	0.625	-0.679	
CVT at 68 Joule (C)	73.7	6.4	0.260	0.106	0.873	-0.062	0.765



A533B HSST02 REFERENCE MATERIAL
Arkansas Unit 1, Capsule B

USE= 135.6 J, LSE= 3.0 J, CVT(1/2)= 65.C , Slope = 0.0160
CVT(41J) = 36. C , CVT(68J) = 64. C ,
Fluence = 4.280E+18 , Irr. Temp. = 309 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
HH916	3.	38.	15.	11.	0.15	6.	0.
HH909	24.	75.	28.	21.	0.48	19.	10.
HH922	43.	110.	46.	34.	0.76	30.	10.
HH936	54.	130.	62.	46.	0.84	33.	30.
HH931	60.	140.	70.	51.	1.12	44.	30.
HH929	91.	196.	90.	66.	1.57	62.	100.
HH943	138.	280.	122.	90.	1.96	77.	100.
HH905	204.	400.	137.	101.	1.98	78.	100.



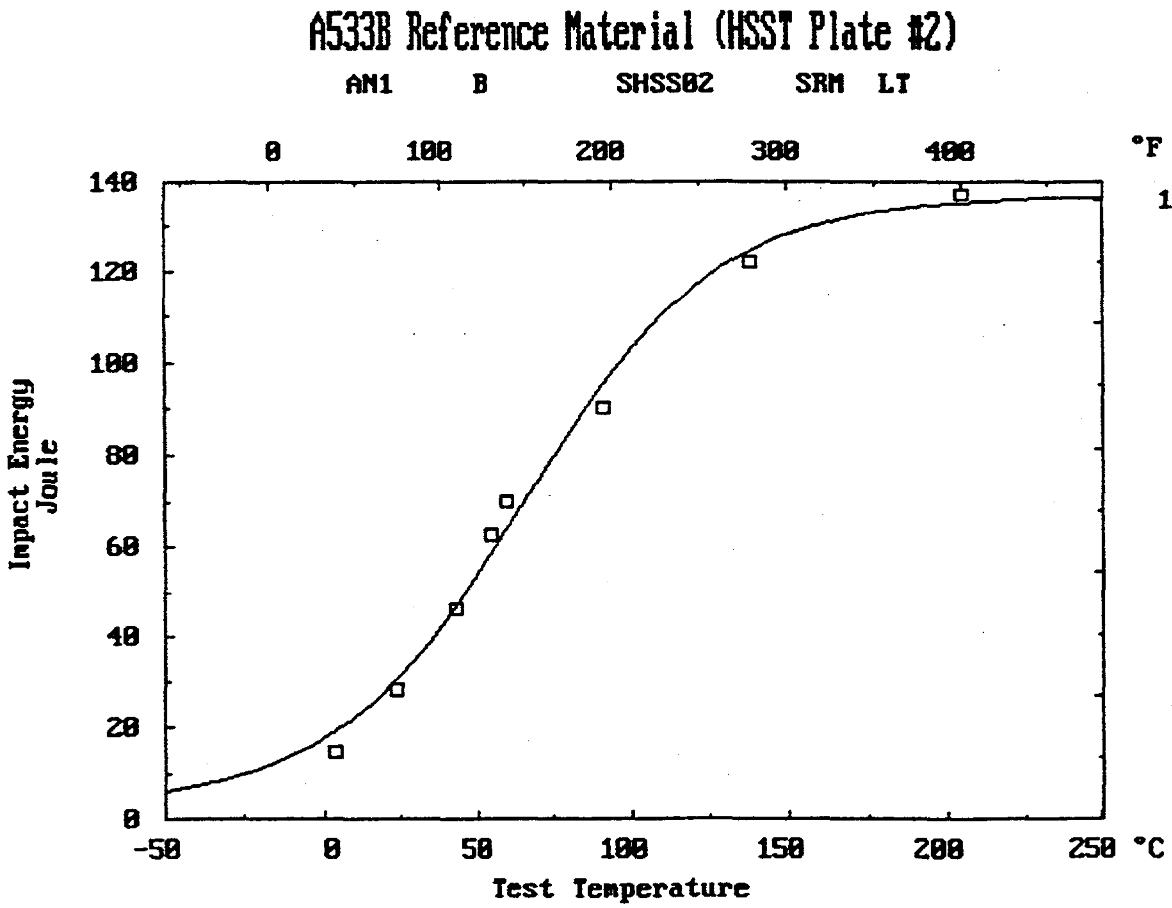
A533B HSST02 REFERENCE MATERIAL

Arkansas Unit 1, Capsule B

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

AN1 B SHSS02 SRM LT : Fluence = 4.280E+18 , Irr. Temp. = 309

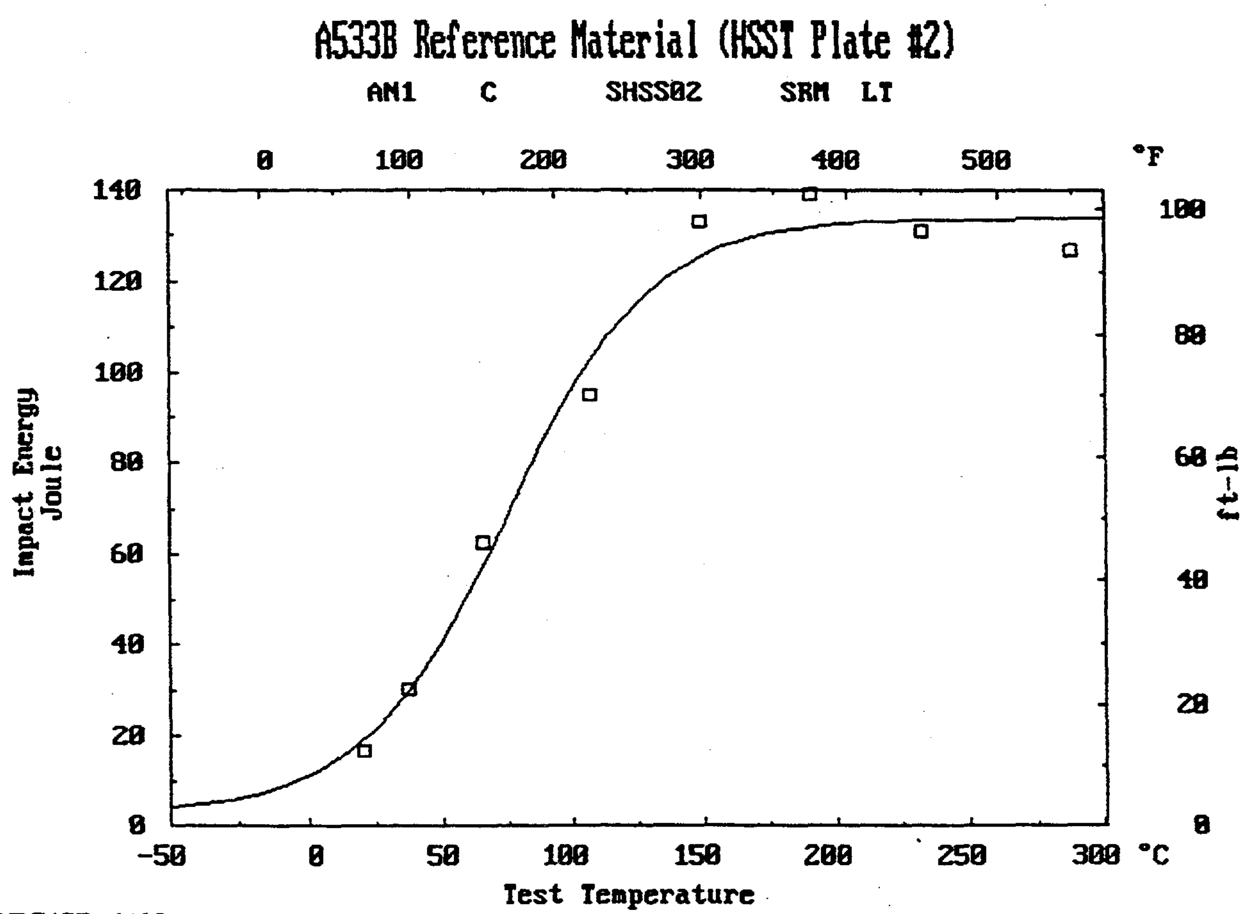
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	136.7	11.3	0.010				
CVT at Midpoint (C)	65.6	9.9	-0.044	0.839			
1/slope (C)	62.6	13.9	0.094	0.681	0.704		
CVT at 41 Joule (C)	36.4	5.8	-0.179	-0.008	0.333	-0.384	
CVT at 68 Joule (C)	63.6	5.8	-0.079	0.444	0.852	0.487	0.602



A533B HSST02 REFERENCE MATERIAL
Arkansas Unit 1, Capsule C

USE= 133.6 J, LSE= 3.0 J, CVT(1/2)= 75.C , Slope = 0.0181
CVT(41J) = 50. C , CVT(68J) = 74. C ,
Fluence = 1.460E+19 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
GG946	21.	70.	17.	12.	0.33	13.	10.
GG920	38.	100.	31.	22.	0.46	18.	20.
GG915	66.	150.	62.	46.	0.89	35.	40.
GG937	107.	225.	95.	70.	1.55	61.	90.
GG903	149.	300.	133.	98.	1.90	75.	100.
GG941	191.	375.	139.	102.	2.06	81.	100.
GG948	232.	450.	131.	96.	1.98	78.	100.
GG927	288.	550.	127.	93.	2.08	82.	100.

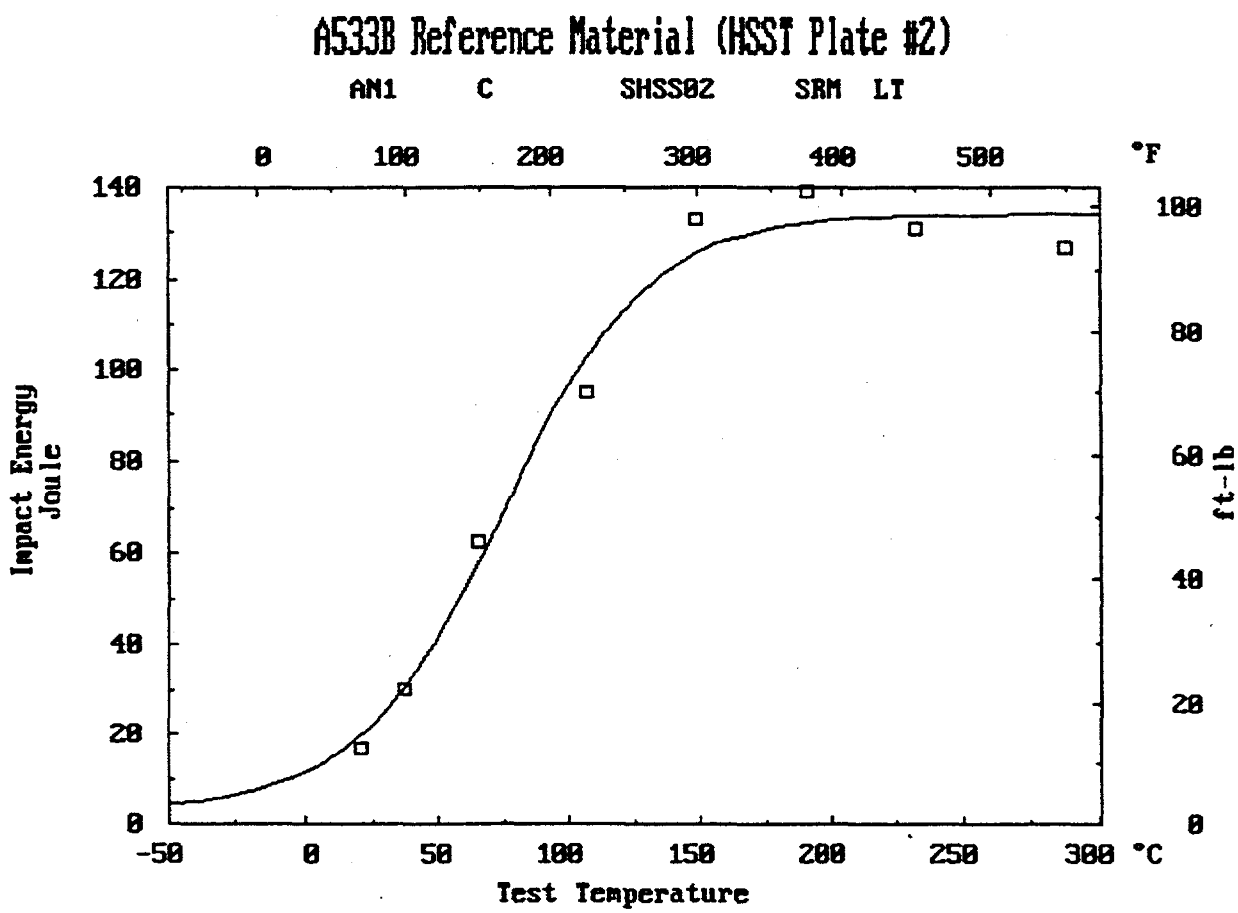


A533B HSST02 REFERENCE MATERIAL

Arkansas Unit 1, Capsule C

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000


AN1    C     SHSS02     SRM  LT : Fluence = 1.460E+19 , Irr. Temp. =  303
```

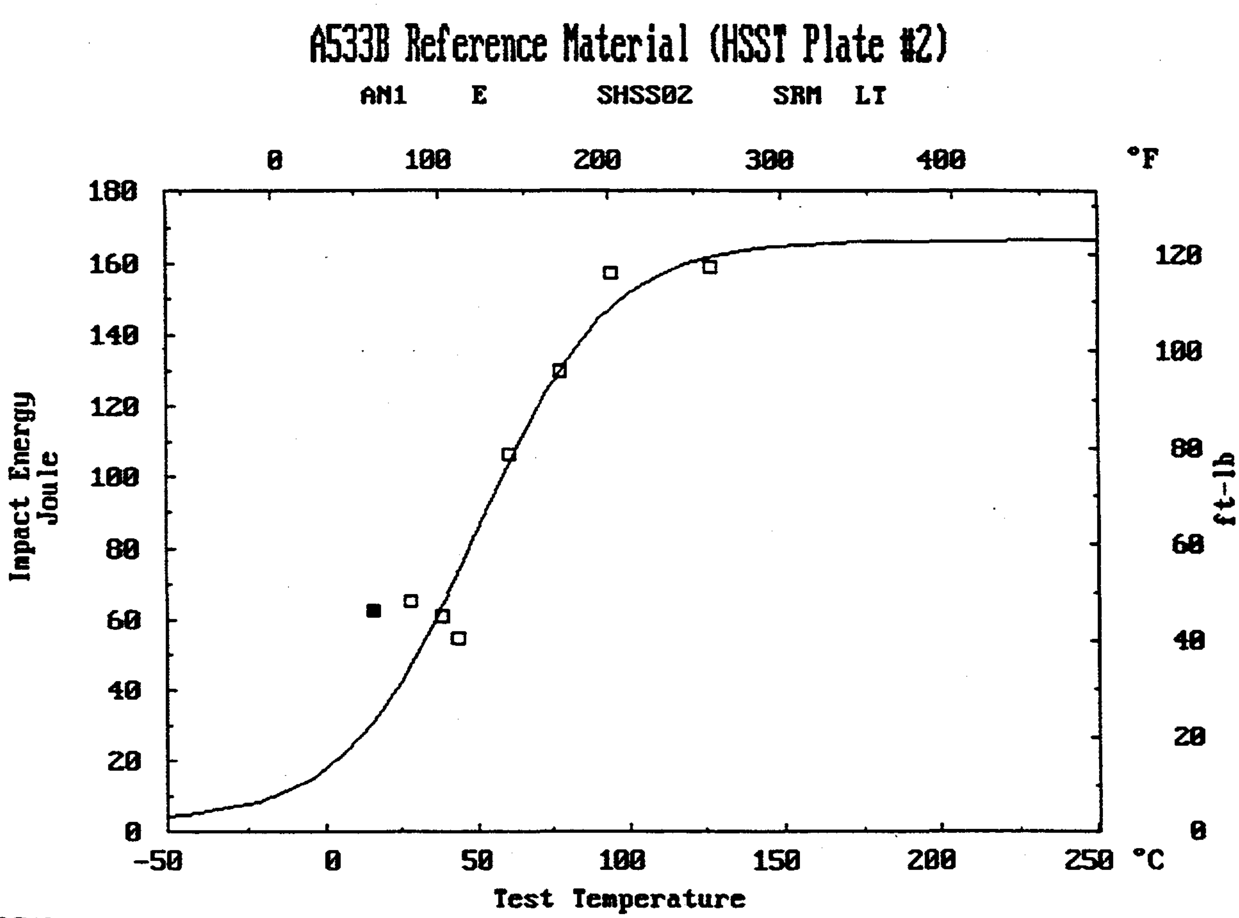
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	134.0	5.6	0.094				
CVT at Midpoint (C)	74.3	7.7	0.255	0.543			
1/slope (C)	55.8	9.8	0.197	0.332	0.333		
CVT at 41 Joule (C)	49.3	7.0	0.132	0.144	0.757	-0.333	
CVT at 68 Joule (C)	73.9	6.7	0.255	0.259	0.951	0.260	0.819



A533B HSST02 REFERENCE MATERIAL
Arkansas Unit 1, Capsule E

USE= 166.5 J, LSE= 3.0 J, CVT(1/2)= 50.C , Slope = 0.0230
CVT(41J) = 24. C , CVT(68J) = 41. C ,
Fluence = 7.270E+17 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
*GG928	16.	60.	62.	46.	0.74	29.	6.
GG917	28.	83.	65.	48.	0.94	37.	18.
GG924	38.	101.	61.	45.	0.81	32.	20.
GG930	44.	111.	55.	40.	0.69	27.	50.
GG912	61.	141.	106.	78.	1.30	51.	50.
GG938	77.	171.	130.	96.	1.52	60.	85.
GG913	94.	202.	157.	116.	1.70	67.	100.
GG914	127.	260.	159.	117.	1.52	60.	100.



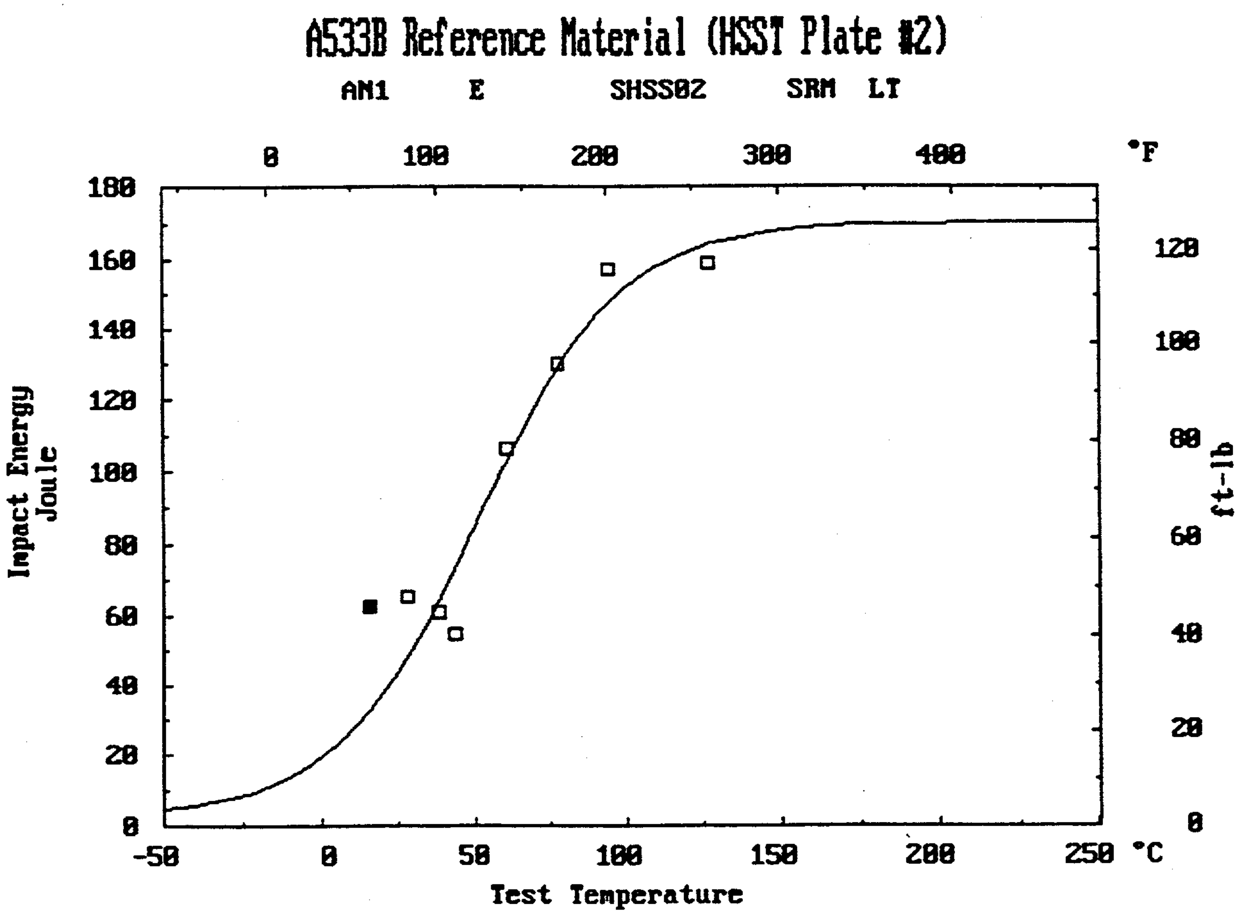
A533B HSST02 REFERENCE MATERIAL

Arkansas Unit 1, Capsule E

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
AN1    E      SHSS02     SRM  LT : Fluence = 7.270E+17 , Irr. Temp. =  304
```

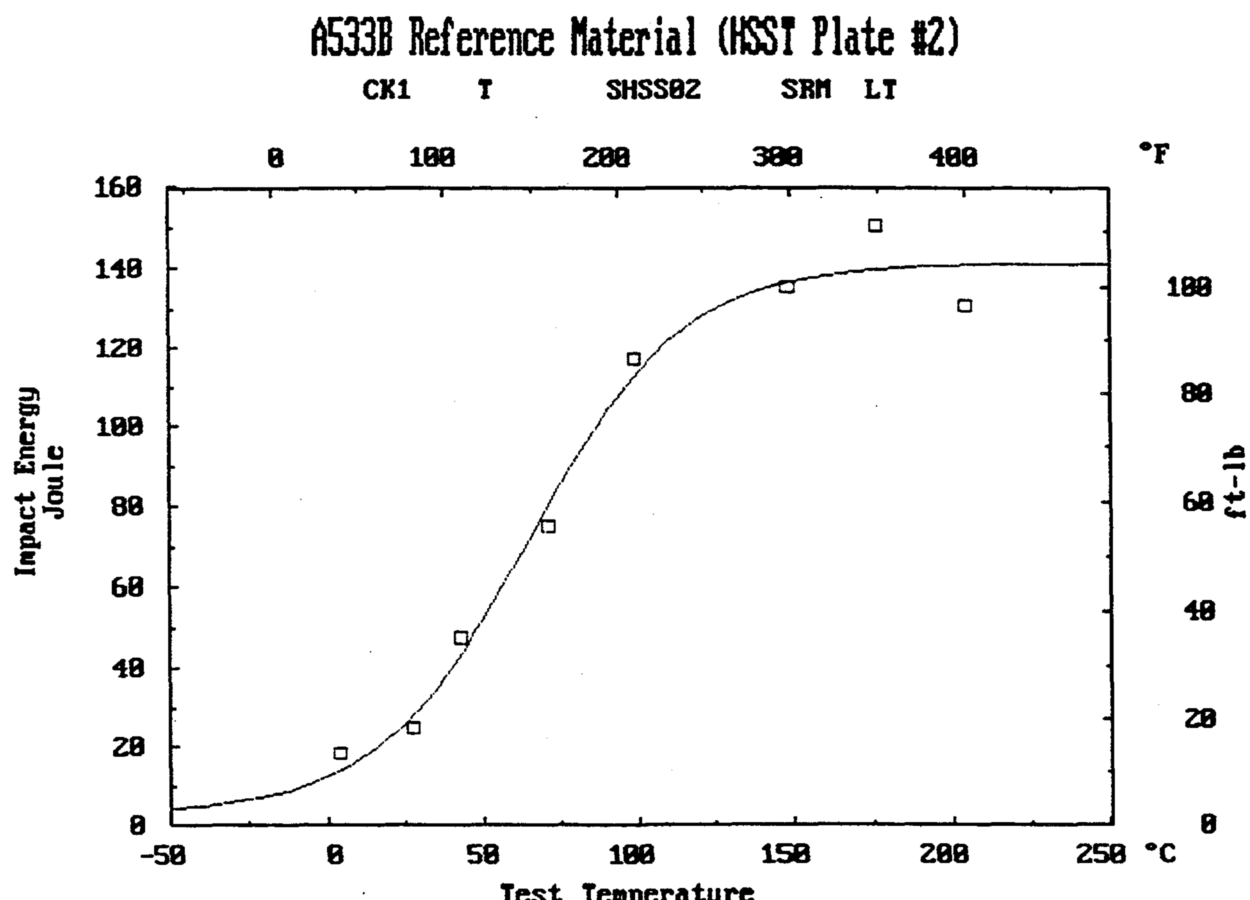
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	170.4	12.8	-0.029				
CVT at Midpoint (C)	51.4	6.0	0.126	0.803			
1/slope (C)	46.5	10.6	-0.206	0.665	0.443		
CVT at 41 Joule (C)	22.7	6.9	0.331	-0.300	0.146	-0.807	
CVT at 68 Joule (C)	40.6	4.3	0.346	0.004	0.538	-0.440	0.882



A533B HSST02 REFERENCE MATERIAL
Donald C. Cook Unit 1, Capsule T

USE= 141.4 J, LSE= 3.0 J, CVT(1/2)= 65.C , Slope = 0.0202
CVT(41J) = 41. C , CVT(68J) = 62. C ,
Fluence = 1.800E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R33	4.	40.	18.	13.	0.33	13.	5.
R37	28.	82.	25.	18.	0.46	18.	10.
R38	43.	110.	47.	35.	0.81	32.	20.
R39	71.	160.	75.	55.	1.14	45.	40.
R40	99.	210.	117.	86.	1.68	66.	95.
R34	149.	300.	136.	100.	1.45	57.	100.
R35	177.	350.	150.	111.	2.13	84.	100.
R36	204.	400.	131.	96.	2.13	84.	100.



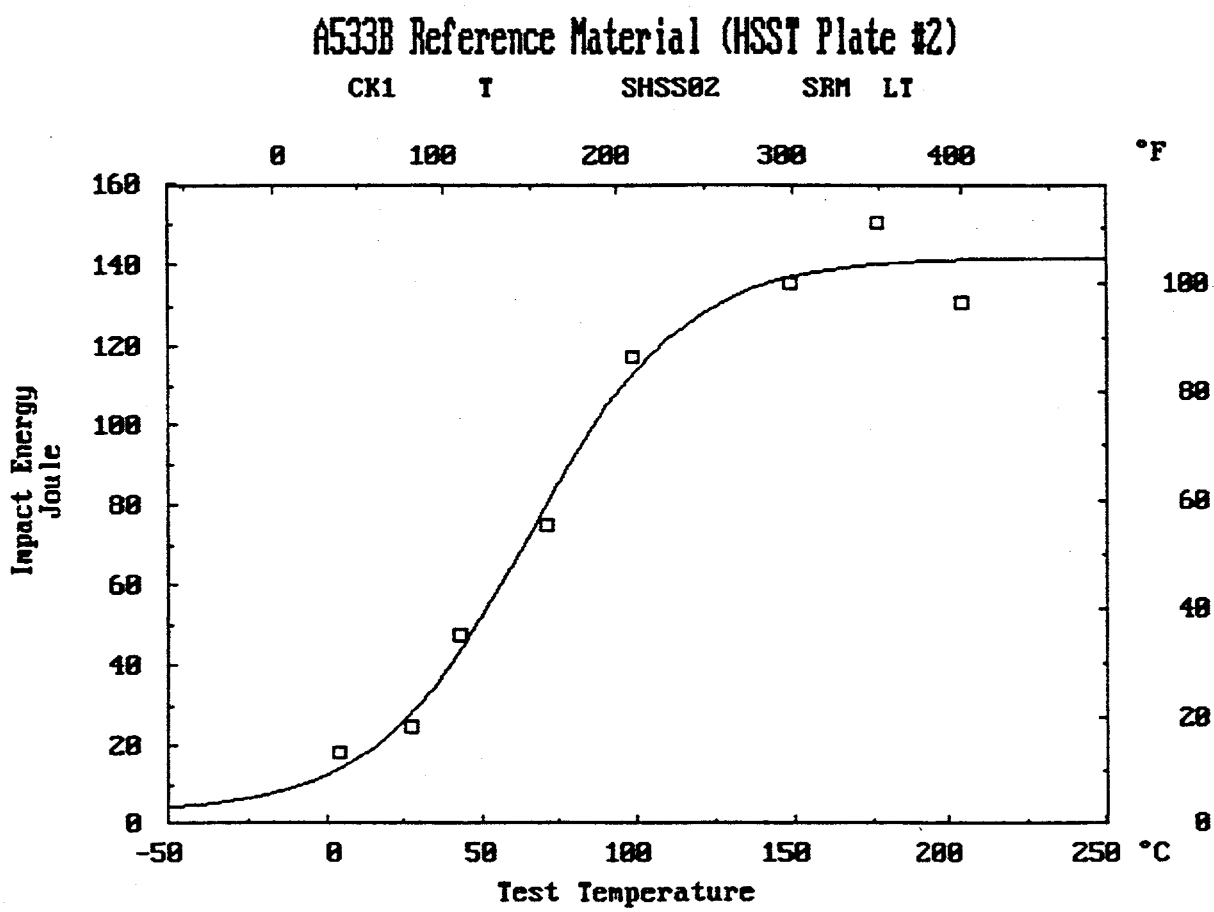
A533B HSST02 REFERENCE MATERIAL

Donald C. Cook Unit 1, Capsule T

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CK1 T SHSS02 SRM LT : Fluence = 1.800E+18 , Irr. Temp. = 304

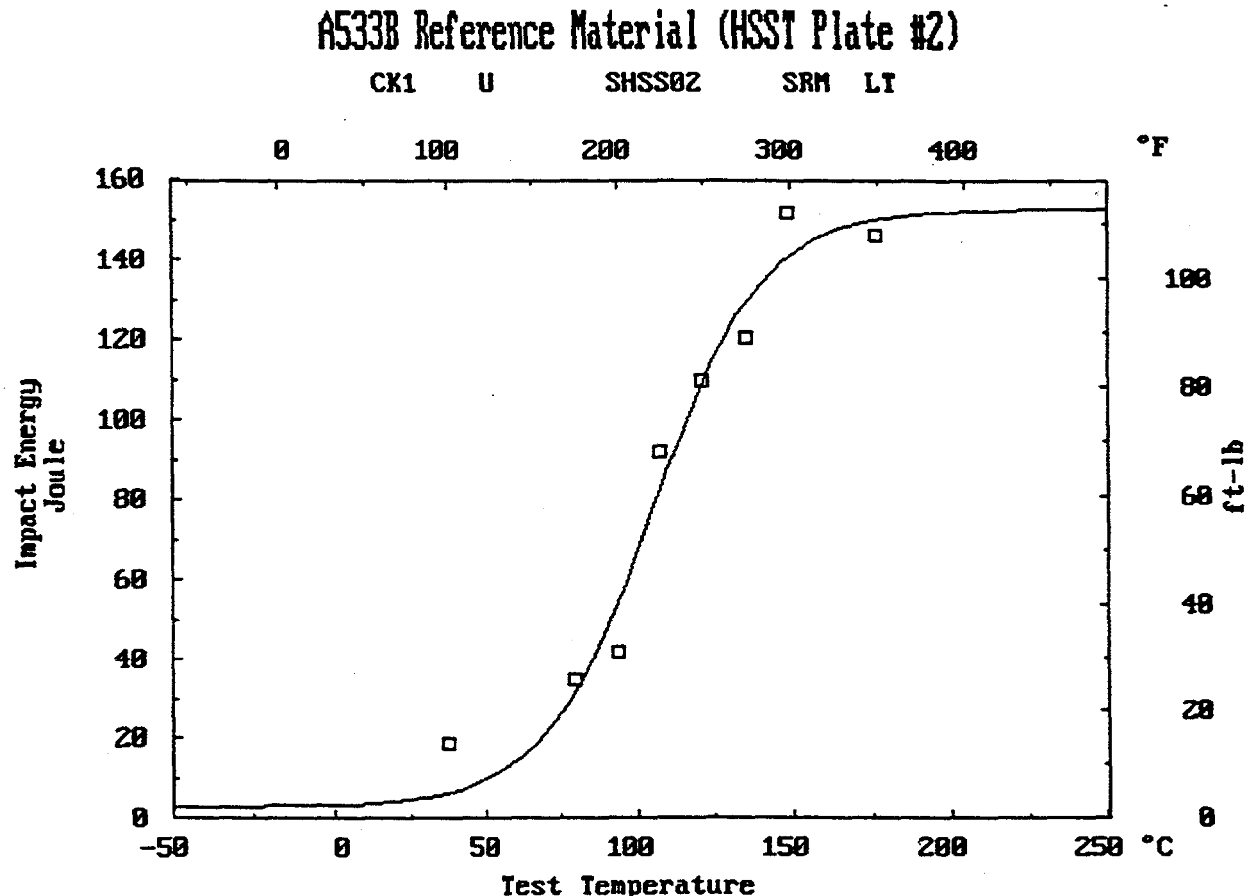
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	141.8	6.5	0.022				
CVT at Midpoint (C)	65.1	5.6	0.160	0.510			
1/slope (C)	49.8	10.8	-0.140	0.475	0.135		
CVT at 41 Joule (C)	40.7	7.3	0.214	-0.183	0.546	-0.739	
CVT at 68 Joule (C)	61.8	4.9	0.184	0.051	0.872	-0.220	0.816



A533B HSST02 REFERENCE MATERIAL
Donald C. Cook Unit 1, Capsule U

USE= 152.8 J, LSE= 3.1 J, CVT(1/2)= 105.C , Slope = 0.0281
CVT(41J) = 86. C , CVT(68J) = 100. C ,
Fluence = 1.880E+19 , Irr. Temp. = 288 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R44	38.	100.	19.	14.	0.30	12.	10.
R42	79.	175.	35.	26.	0.51	20.	25.
R43	93.	200.	42.	31.	0.63	25.	30.
R48	107.	225.	92.	68.	1.24	49.	90.
R45	121.	250.	110.	81.	1.50	59.	100.
R46	135.	275.	121.	89.	1.70	67.	100.
R47	149.	300.	152.	112.	1.78	70.	100.
R41	177.	350.	146.	108.	1.88	74.	100.



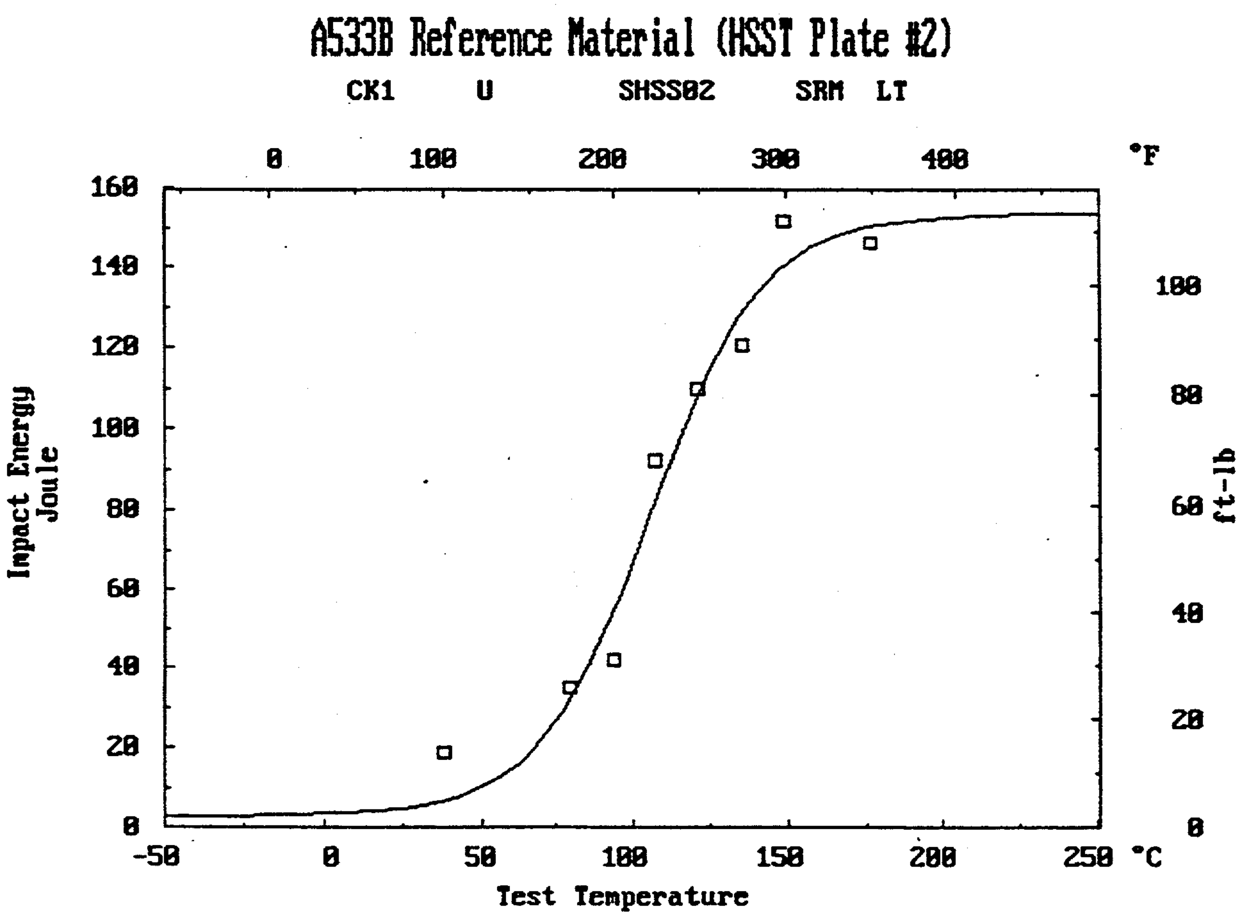
A533B HSST02 REFERENCE MATERIAL

Donald C. Cook Unit 1, Capsule U

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CK1 U SHSS02 SRM LT : Fluence = 1.880E+19 , Irr. Temp. = 288

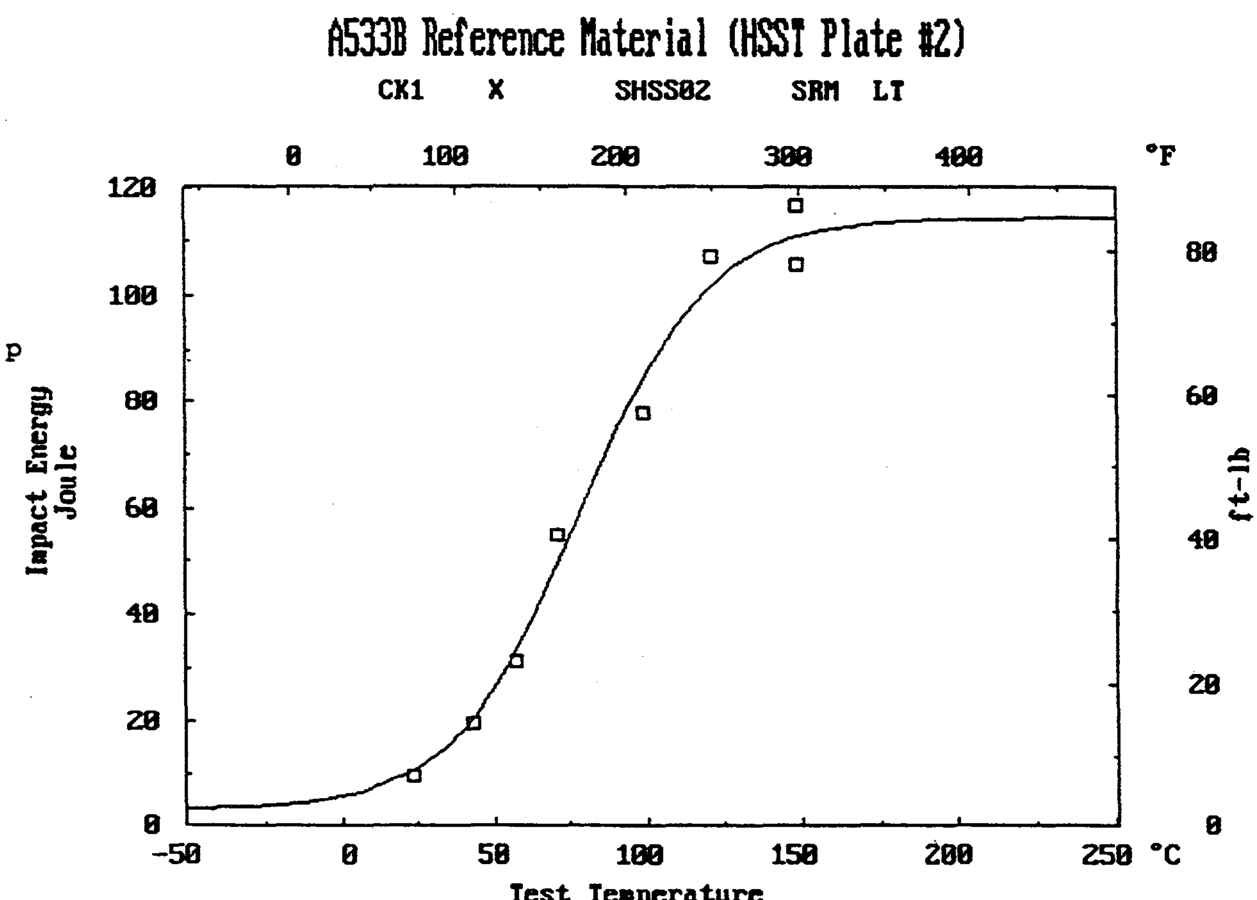
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	153.6	12.7	-0.249				
CVT at Midpoint (C)	105.5	5.1	-0.109	0.771			
1/slope (C)	36.5	9.5	-0.418	0.721	0.493		
CVT at 41 Joule (C)	85.3	5.5	0.381	-0.381	0.125	-0.780	
CVT at 68 Joule (C)	100.1	3.4	0.192	-0.001	0.600	-0.275	0.811



A533B HSST02 REFERENCE MATERIAL
Donald C. Cook Unit 1, Capsule X

USE= 114.5 J, LSE= 3.0 J, CVT(1/2)= 78.C , Slope = 0.0242
CVT(41J) = 64. C , CVT(68J) = 85. C ,
Fluence = 6.900E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R25	24.	75.	9.	7.	0.15	6.	
R26	43.	110.	20.	14.	0.38	15.	
R32	57.	135.	31.	23.	0.58	23.	
R27	71.	160.	55.	40.	0.89	35.	
R28	99.	210.	78.	57.	1.35	53.	
R29	121.	250.	107.	79.	1.78	70.	
R30	149.	300.	117.	86.	1.85	73.	
R31	149.	300.	106.	78.	1.78	70.	



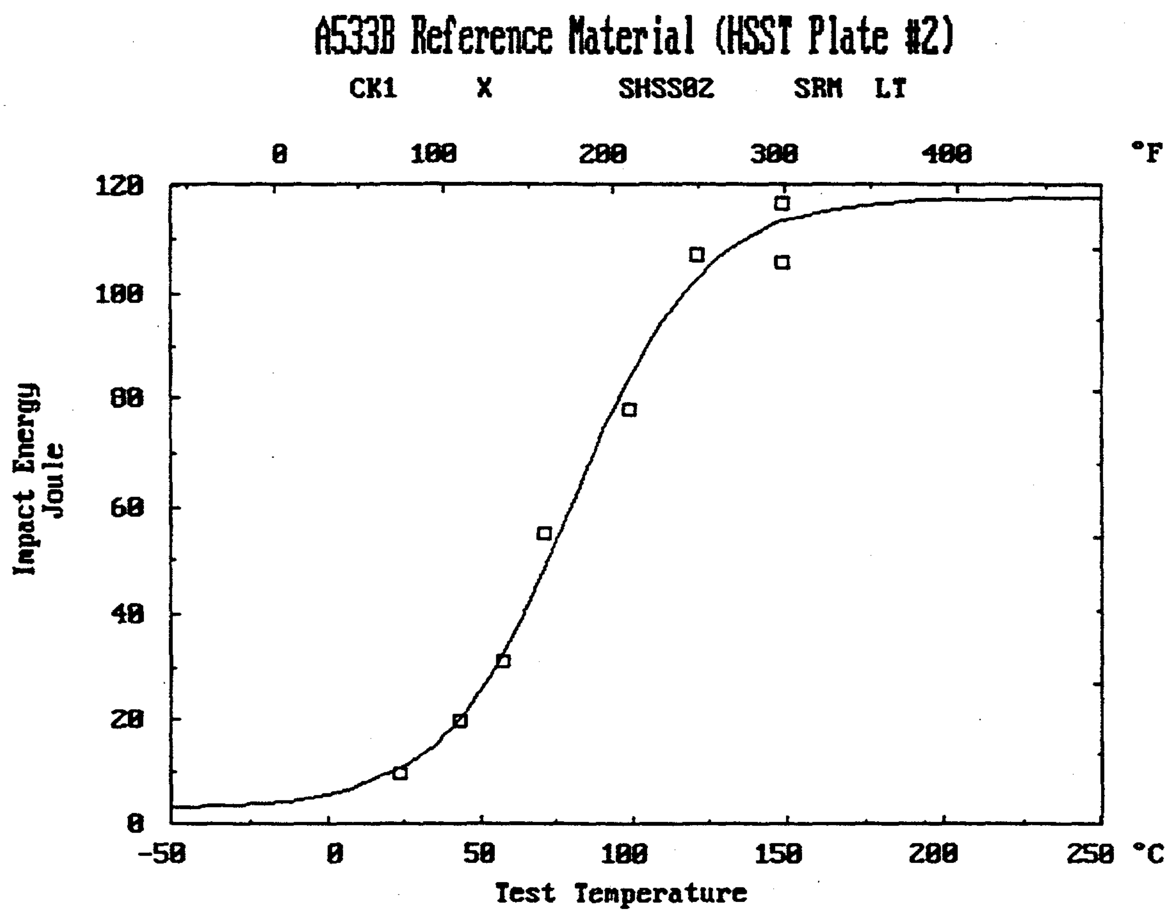
A533B HSST02 REFERENCE MATERIAL

Donald C. Cook Unit 1, Capsule X

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CK1 X SHSS02 SRM LT : Fluence = 6.900E+18 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	117.8	11.7	-0.054				
CVT at Midpoint (C)	80.2	9.2	0.001	0.851			
1/slope (C)	42.4	10.9	-0.028	0.727	0.669		
CVT at 41 Joule (C)	64.9	5.3	0.045	0.262	0.659	-0.055	
CVT at 68 Joule (C)	85.5	6.2	0.029	0.564	0.897	0.608	0.737



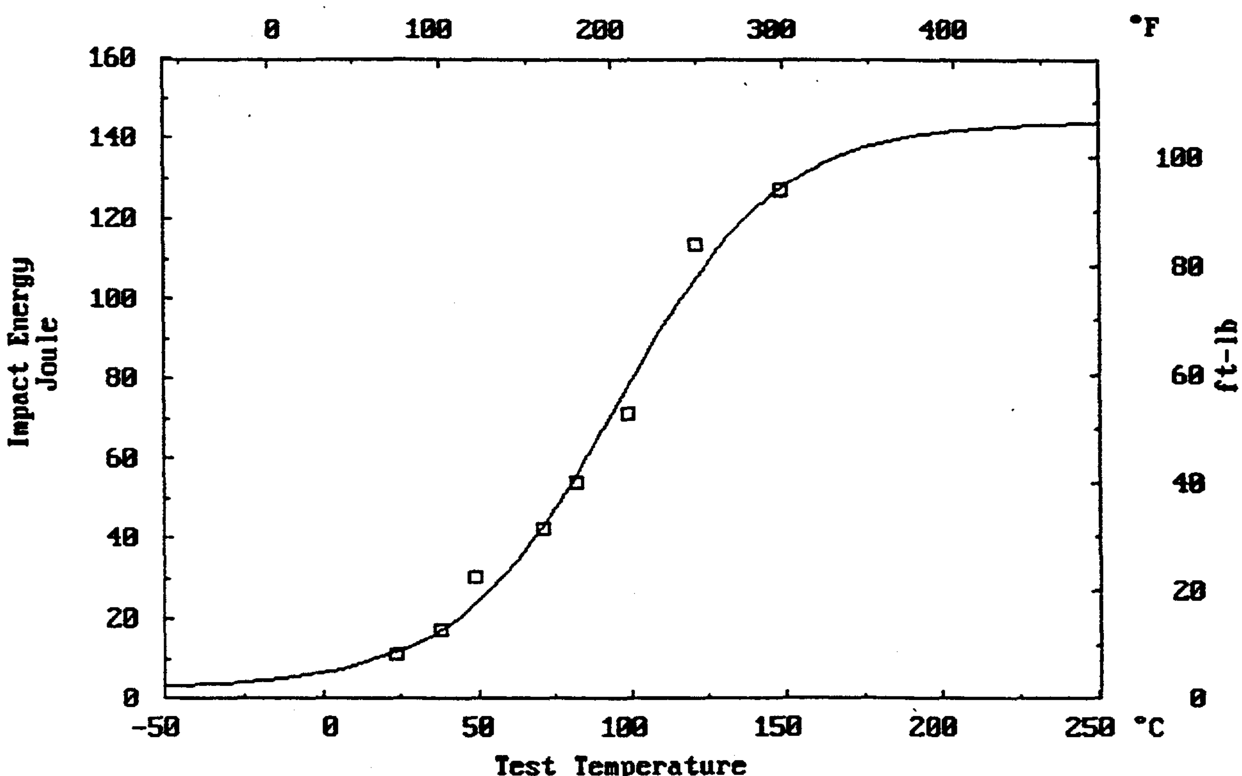
A533B HSST02 REFERENCE MATERIAL
Donald C. Cook Unit 1, Capsule Y

USE= 144.2 J, LSE= 3.0 J, CVT(1/2)= 95.C , Slope = 0.0190
CVT(41J) = 69. C , CVT(68J) = 91. C ,
Fluence = 1.060E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R50	24.	75.	12.	8.	0.18	7.	2.
R55	38.	100.	18.	13.	0.33	13.	5.
R52	49.	120.	31.	22.	0.53	21.	10.
R49	71.	160.	43.	32.	0.76	30.	15.
R51	82.	180.	54.	40.	0.97	38.	25.
R54	99.	210.	71.	52.	1.19	47.	60.
R53	121.	250.	114.	84.	1.80	71.	100.
R56	149.	300.	127.	94.	2.06	81.	100.

A533B Reference Material (HSST Plate #2)

CK1 Y SHSS02 SRM LT



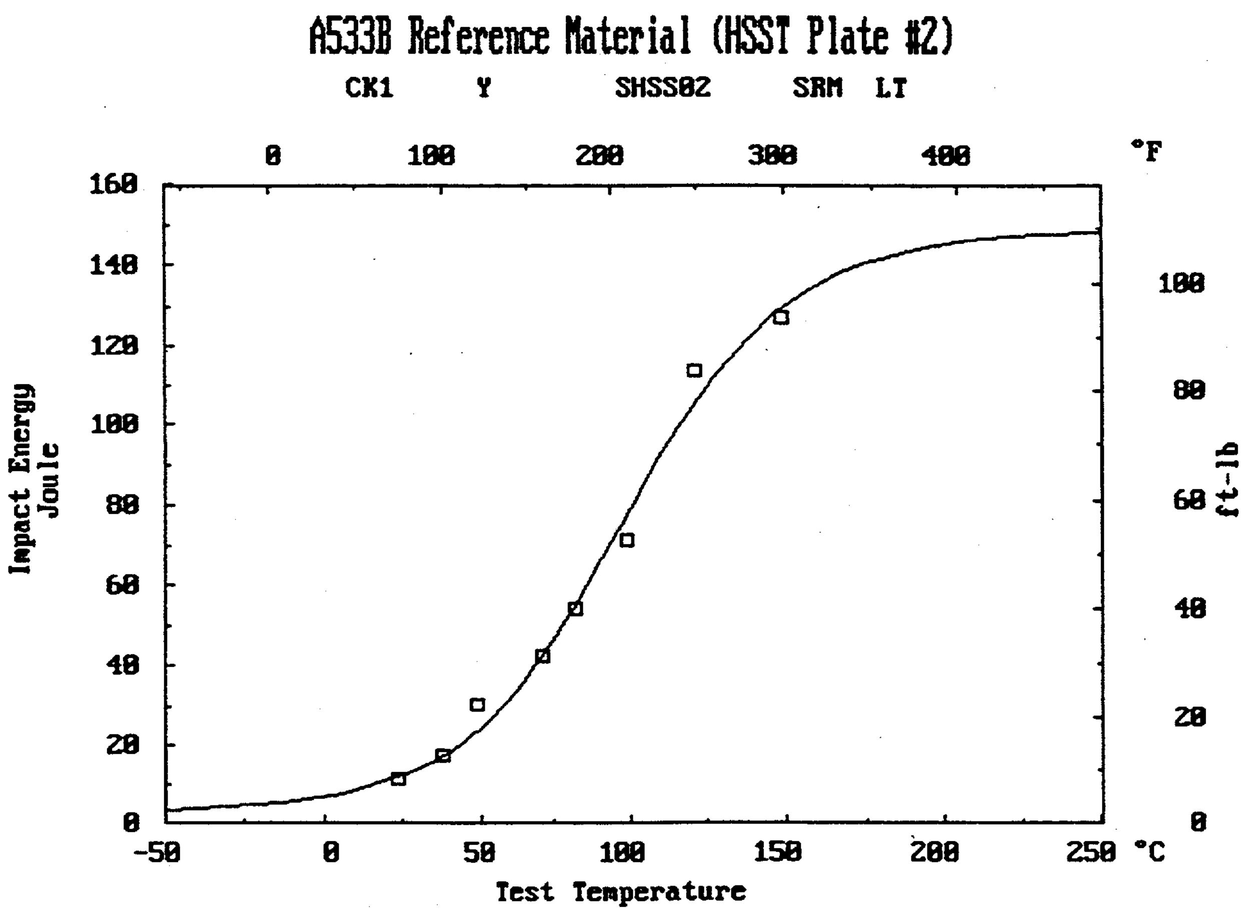
A533B HSST02 REFERENCE MATERIAL

Donald C. Cook Unit 1, Capsule Y

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

CK1 Y SHSS02 SRM LT : Fluence = 1.060E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	148.5	24.1	-0.134				
CVT at Midpoint (C)	97.5	11.8	-0.095	0.918			
1/slope (C)	53.6	13.3	-0.273	0.778	0.754		
CVT at 41 Joule (C)	69.1	5.9	0.261	-0.148	0.123	-0.501	
CVT at 68 Joule (C)	91.4	4.8	0.064	0.300	0.635	0.214	0.711

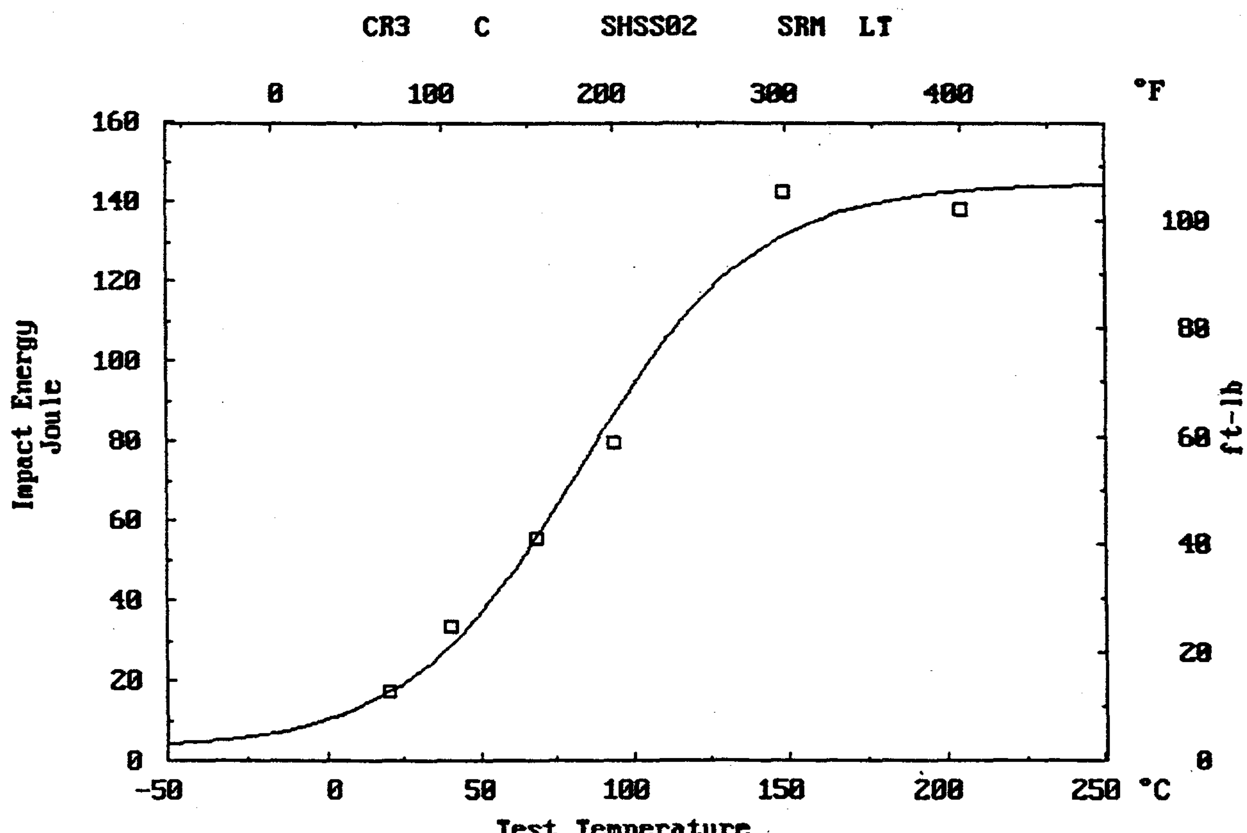


A533B HSST02 REFERENCE MATERIAL
Crystal River Unit 3, Capsule C

USE= 144.8 J, LSE= 3.0 J, CVT(1/2)= 83.C , Slope = 0.0175
CVT(41J) = 55. C , CVT(68J) = 78. C ,
Fluence = 6.560E+18 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
NN918	21.	69.	18.	13.	0.33	13.	5.
NN903	41.	105.	34.	25.	0.51	20.	20.
NN901	68.	155.	56.	41.	0.84	33.	35.
NN911	93.	200.	80.	59.	1.22	48.	60.
NN909	149.	300.	142.	105.	2.03	80.	100.
NN912	204.	400.	138.	102.	1.90	75.	100.

A533B Reference Material (HSST Plate #2)



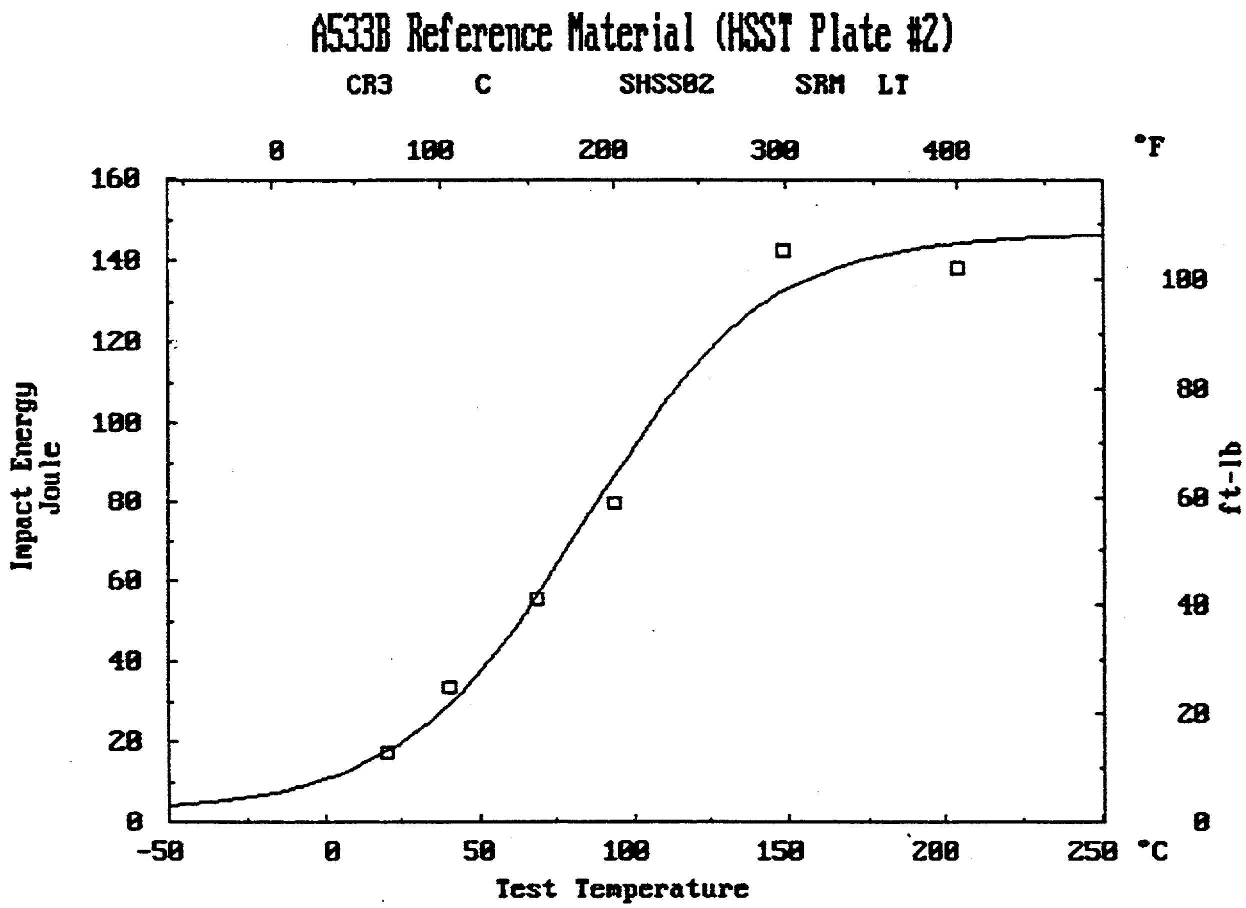
A533B HSST02 REFERENCE MATERIAL

Crystal River Unit 3, Capsule C

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
CR3   C     SHSS02    SRM  LT : Fluence = 6.560E+18 , Irr. Temp. =  303
```

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	146.7	9.6	0.174				
CVT at Midpoint (C)	83.8	8.3	0.235	0.713			
1/slope (C)	58.3	11.5	-0.129	0.409	0.340		
CVT at 41 Joule (C)	53.9	7.6	0.299	0.073	0.536	-0.574	
CVT at 68 Joule (C)	78.2	5.9	0.254	0.261	0.845	0.002	0.809



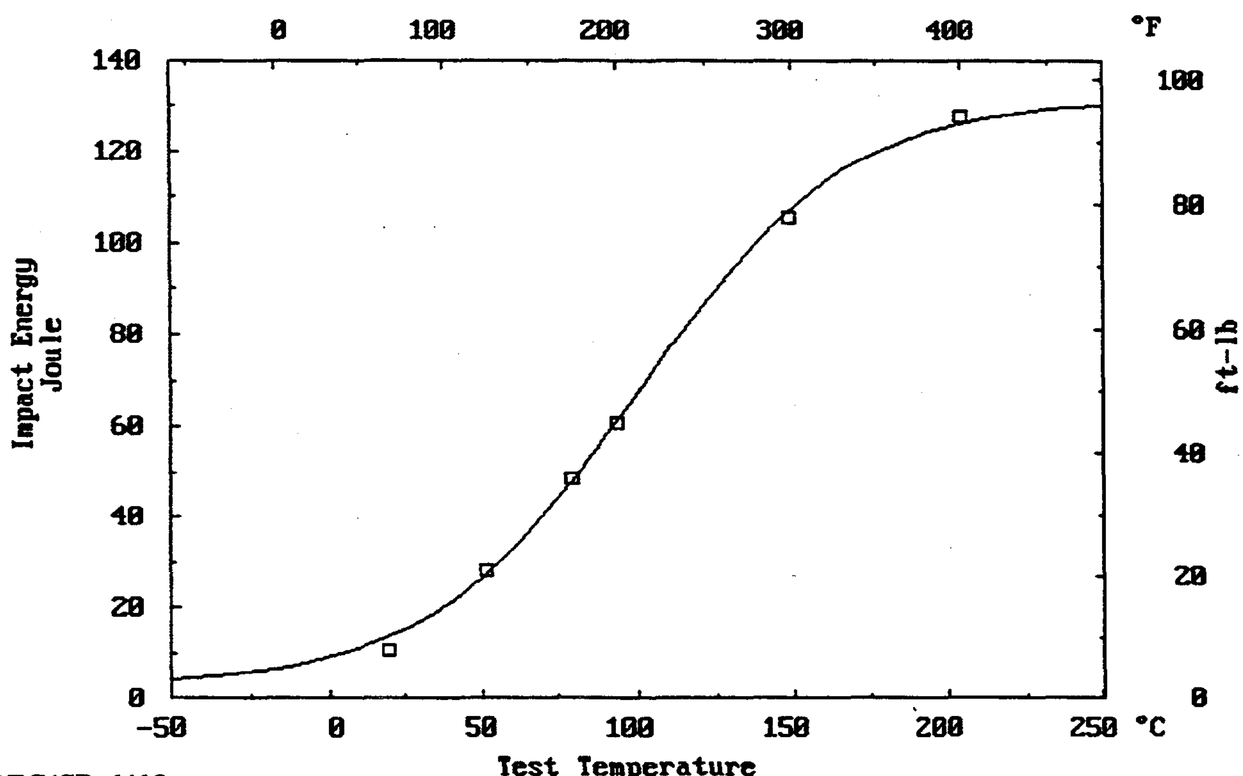
A533B HSST02 REFERENCE MATERIAL
Davis-Besse Unit 1, Capsule A

USE= 131.5 J, LSE= 3.0 J, CVT(1/2)= 100.C , Slope = 0.0150
CVT(41J) = 71. C , CVT(68J) = 101. C ,
Fluence = 1.290E+19 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
SS928	20.	68.	11.	8.	0.20	8.	0.
SS905	52.	125.	28.	21.	0.46	18.	20.
SS913	79.	175.	49.	36.	0.76	30.	40.
SS930	93.	200.	61.	45.	1.02	40.	50.
SS901	149.	300.	106.	78.	1.60	63.	70.
SS921	204.	400.	127.	94.	1.85	73.	100.

A533B Reference Material (HSST Plate #2)

DB1 A SHSS02 SRM LT

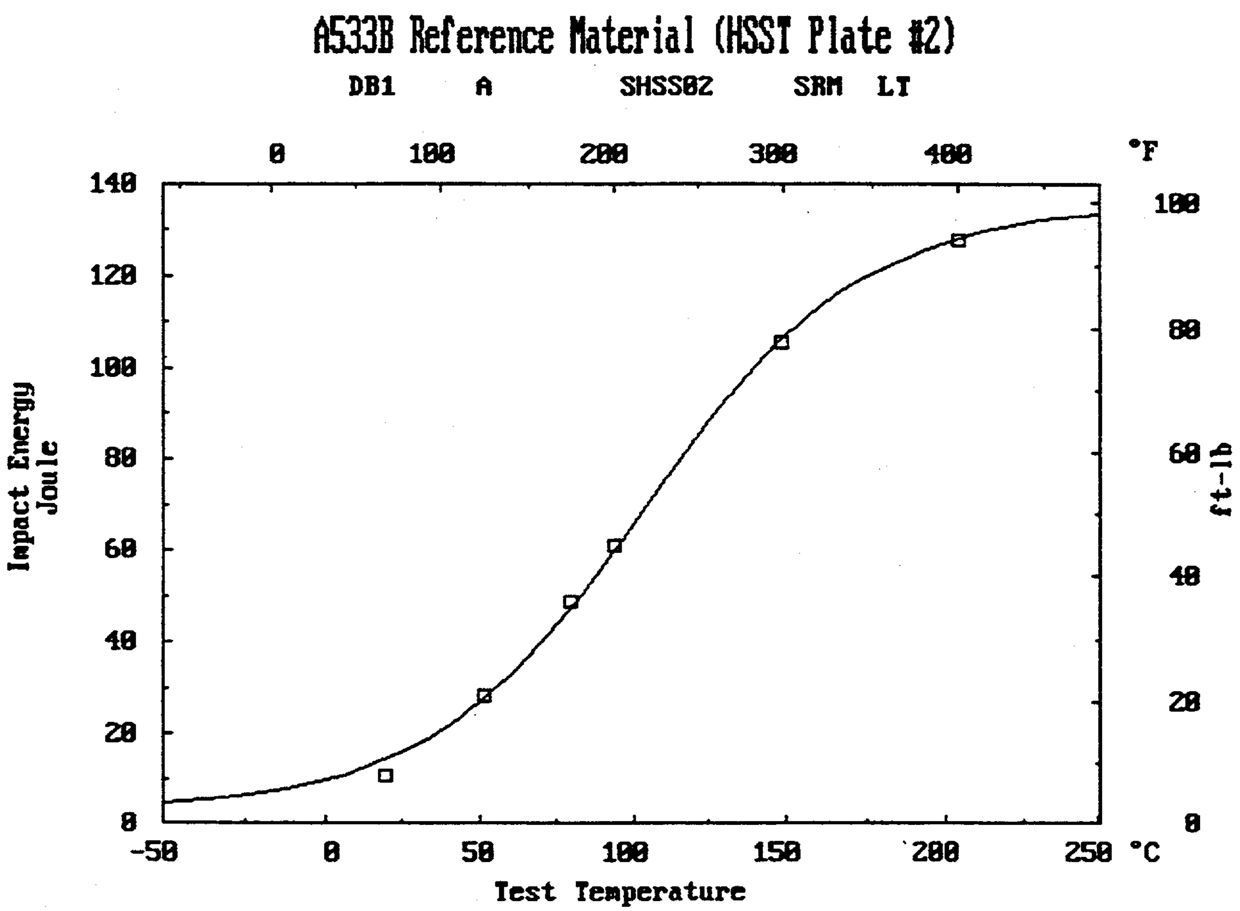


A533B HSST02 REFERENCE MATERIAL

Davis-Besse Unit 1, Capsule A

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000


DB1    A     SHSS02    SRM  LT : Fluence = 1.290E+19 , Irr. Temp. =  303
```

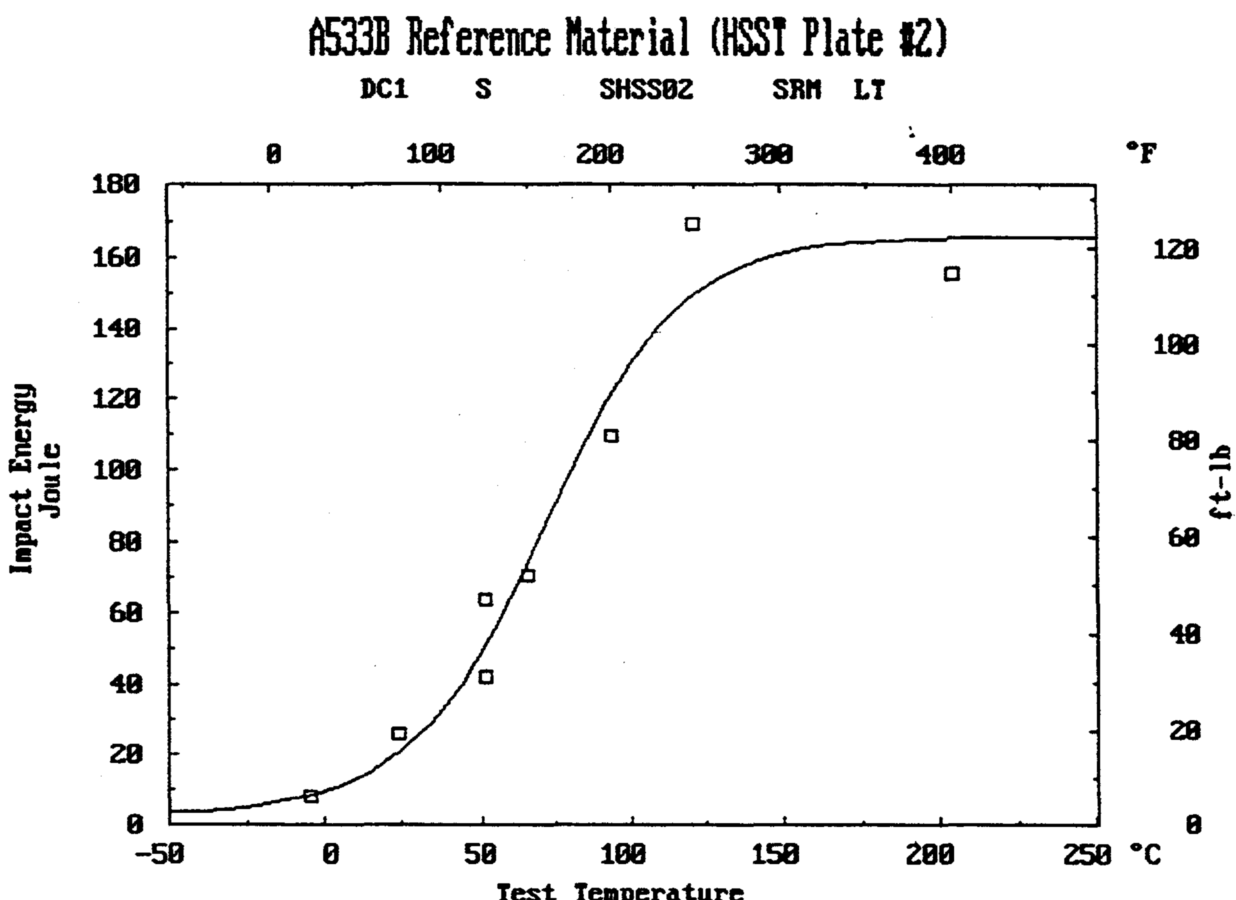
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	135.4	14.3	-0.036				
CVT at Midpoint (C)	103.9	13.4	-0.013	0.837			
1/slope (C)	70.8	17.4	-0.055	0.589	0.662		
CVT at 41 Joule (C)	71.3	7.7	0.035	0.107	0.440	-0.297	
CVT at 68 Joule (C)	102.3	8.1	-0.014	0.386	0.817	0.508	0.644



A533B HSST02 REFERENCE MATERIAL
Diablo Canyon Unit 1, Capsule S

USE= 165.9 J, LSE= 3.0 J, CVT(1/2)= 71.C , Slope = 0.0222
CVT(41J) = 45. C , CVT(68J) = 62. C ,
Fluence = 2.980E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R43	-4.	25.	8.	6.	0.18	7.	1.
R42	24.	76.	26.	19.	0.51	20.	10.
R45	52.	125.	42.	31.	0.76	30.	30.
R46	52.	125.	64.	47.	1.09	43.	45.
R44	66.	150.	70.	52.	1.14	45.	45.
R48	93.	200.	110.	81.	1.52	60.	60.
R47	121.	250.	169.	125.	2.13	84.	100.
R41	204.	400.	156.	115.	2.11	83.	100.



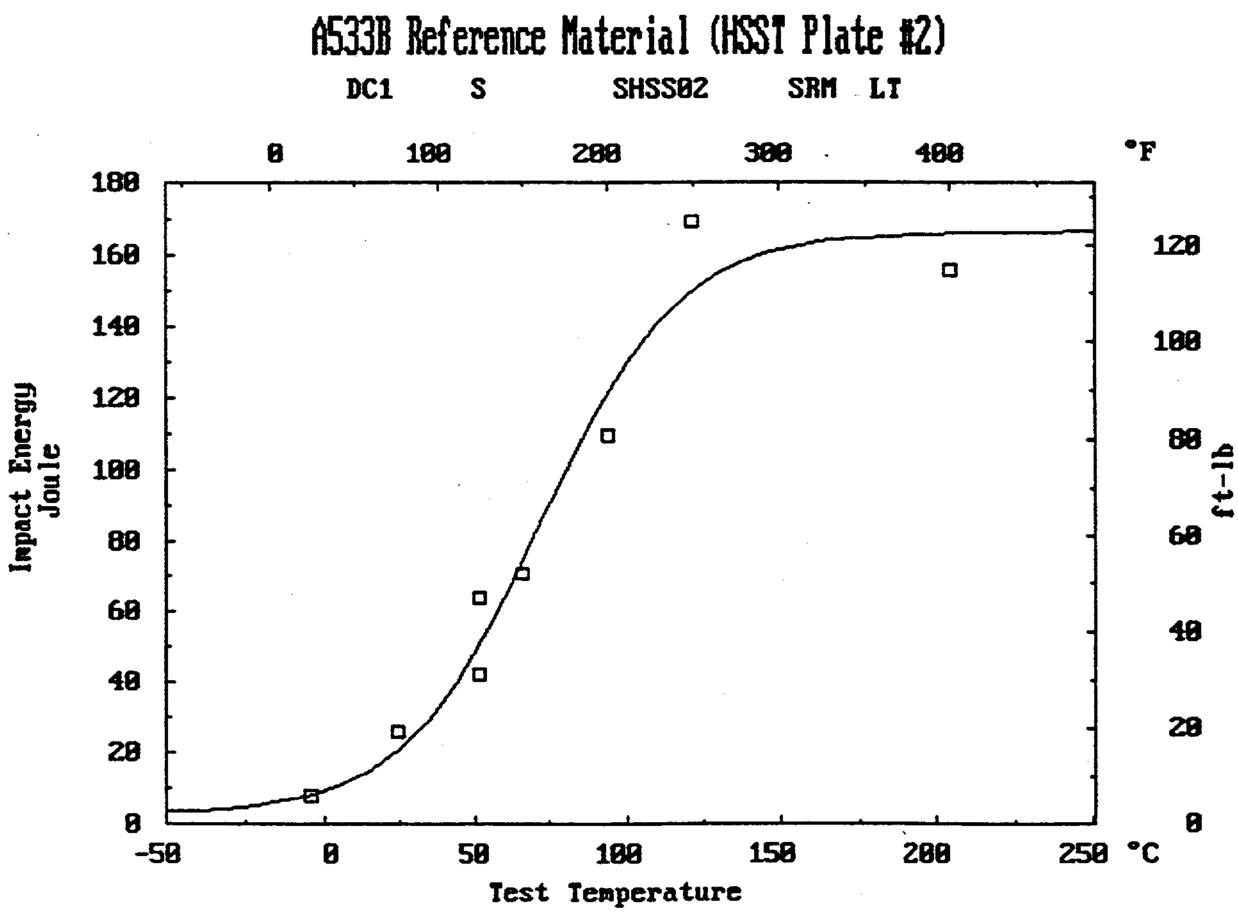
A533B HSST02 REFERENCE MATERIAL

Diablo Canyon Unit 1, Capsule S

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
DC1    S     SHSS02    SRM  LT : Fluence = 2.980E+18 , Irr. Temp. =  304
```

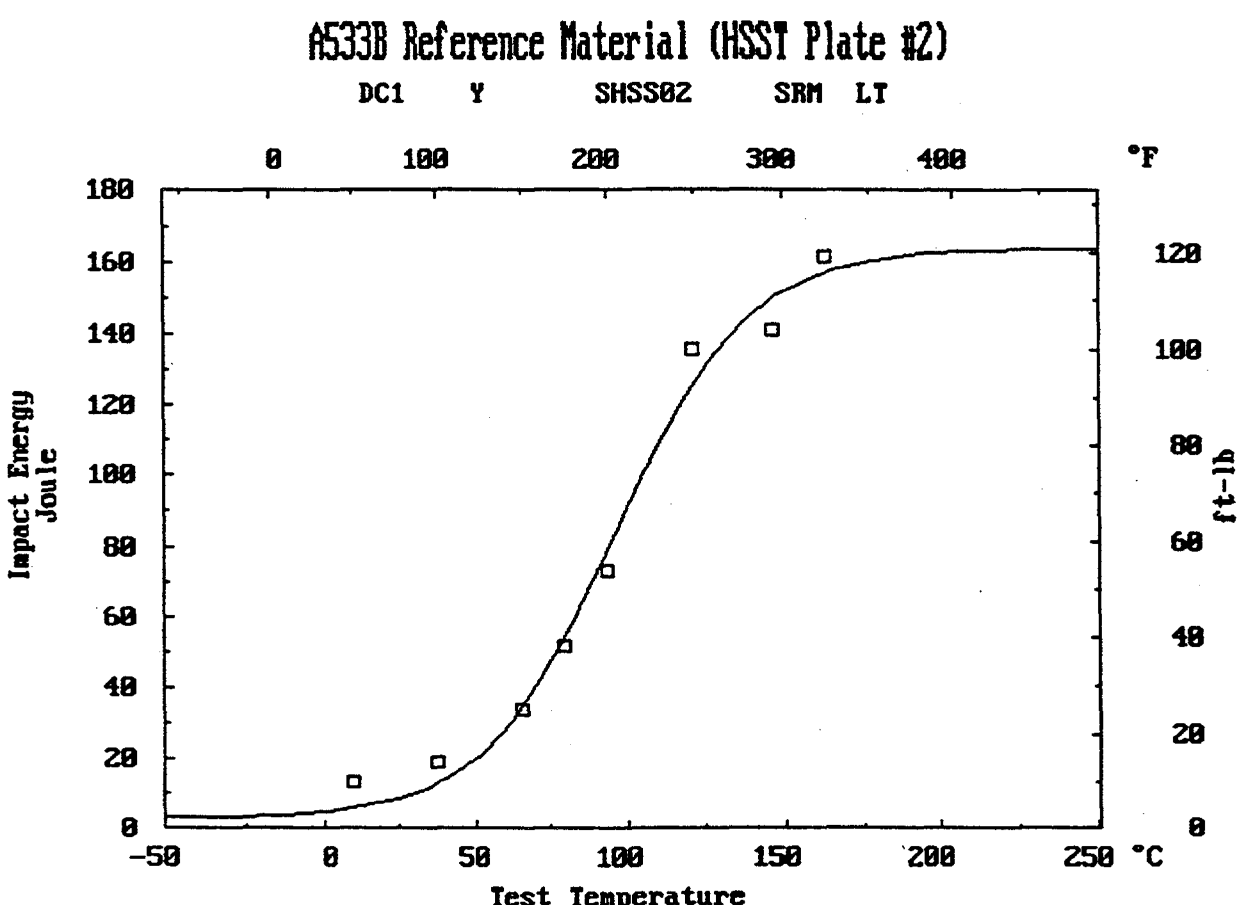
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.1					
Upper Shelf Energy (J)	166.5	8.4	0.126				
CVT at Midpoint (C)	71.8	4.6	0.308	0.666			
1/slope (C)	45.0	6.8	-0.198	0.252	0.212		
CVT at 41 Joule (C)	44.9	5.1	0.396	0.102	0.536	-0.682	
CVT at 68 Joule (C)	62.5	3.7	0.390	0.208	0.814	-0.247	0.873



A533B HSST02 REFERENCE MATERIAL
Diablo Canyon Unit 1, Capsule Y

USE= 163.9 J, LSE= 3.1 J, CVT(1/2)= 96.C , Slope = 0.0234
CVT(41J) = 71. C , CVT(68J) = 88. C ,
Fluence = 1.020E+19 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R60	10.	50.	14.	10.	0.25	10.	10.
R62	38.	100.	19.	14.	0.36	14.	15.
R61	66.	150.	34.	25.	0.58	23.	25.
R57	79.	175.	52.	38.	0.81	32.	40.
R59	93.	200.	73.	54.	1.07	42.	50.
R64	121.	250.	136.	100.	1.85	73.	96.
R58	146.	295.	141.	104.	2.11	83.	100.
R63	163.	325.	161.	119.	2.29	90.	100.



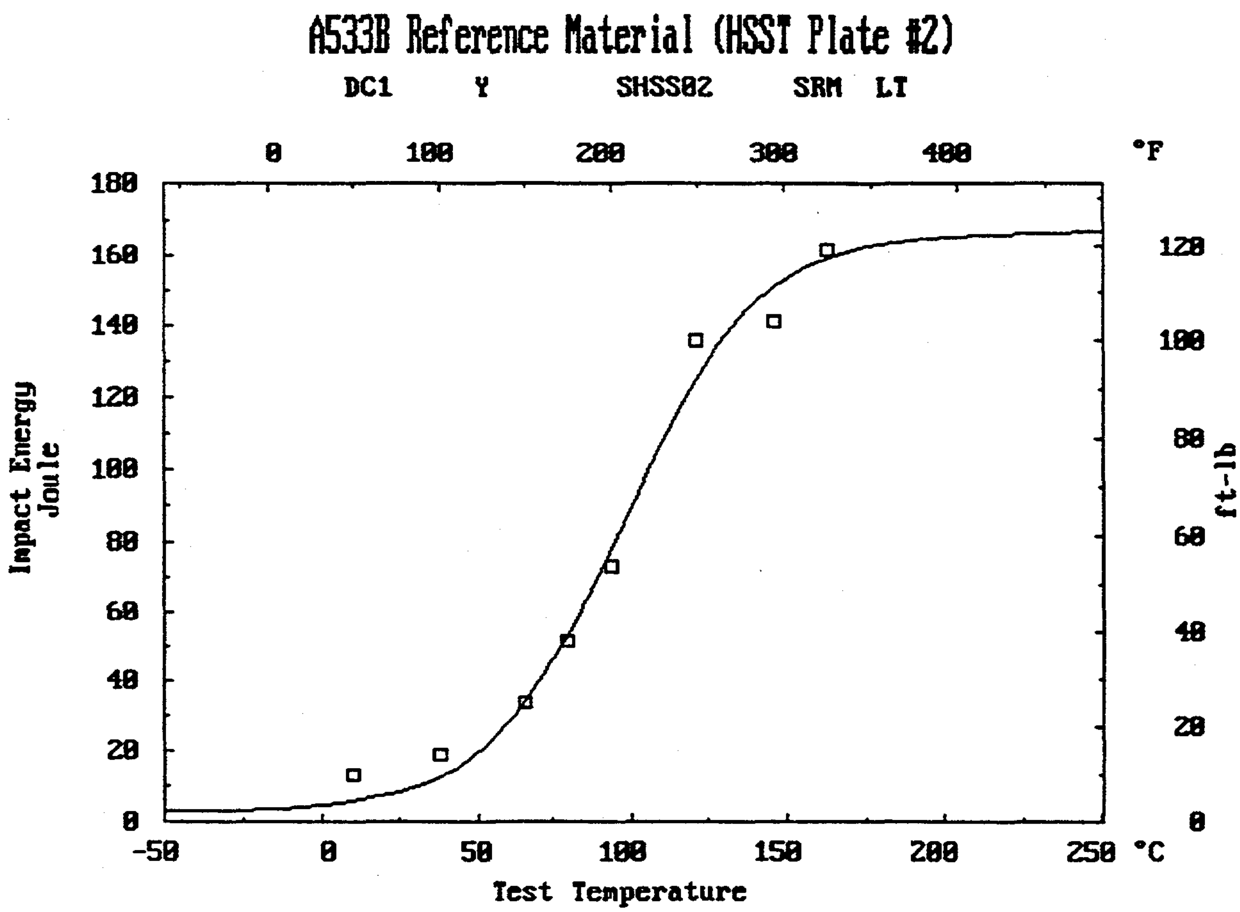
A533B HSST02 REFERENCE MATERIAL

Diablo Canyon Unit 1, Capsule Y

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

DC1 Y SHSS02 SRM LT : Fluence = 1.020E+19 , Irr. Temp. = 288

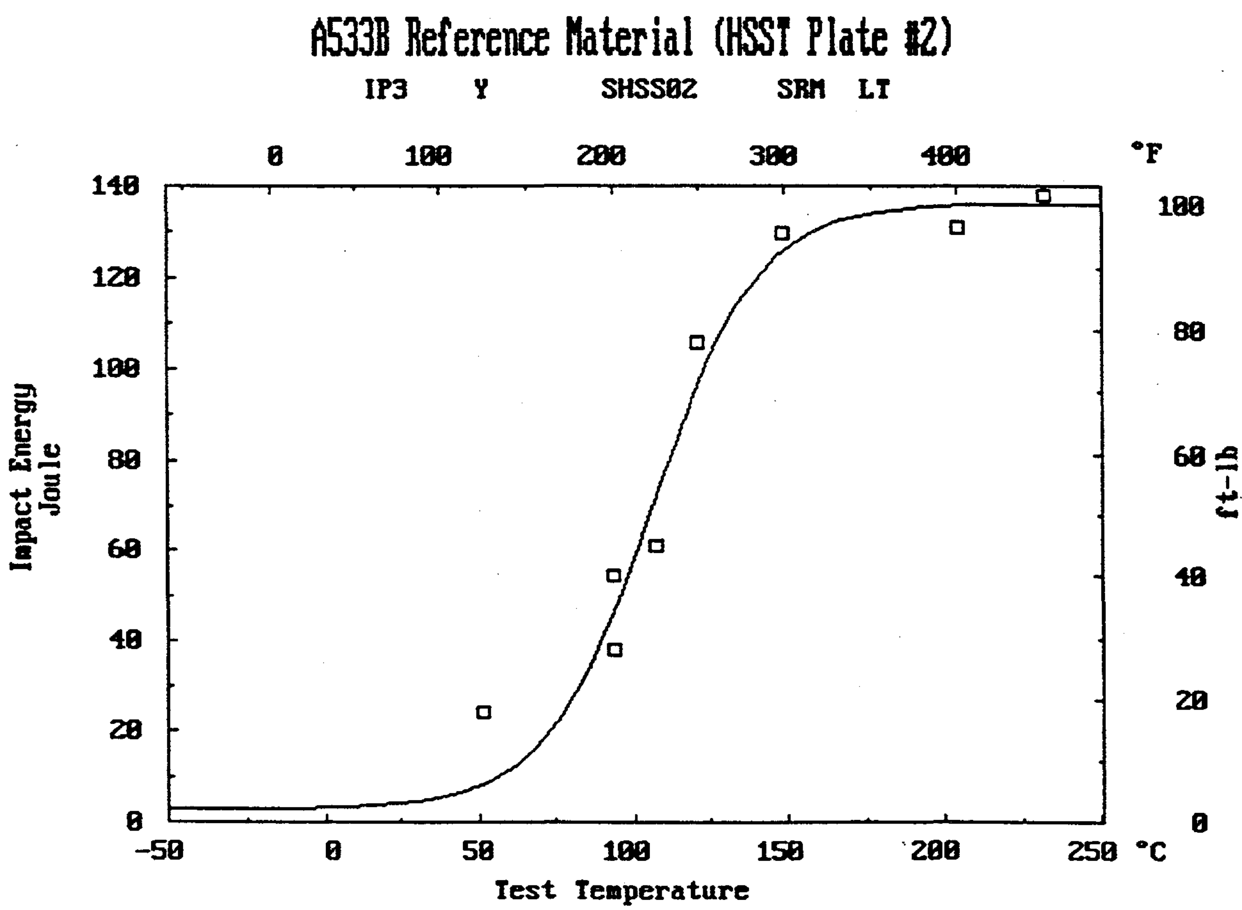
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	166.7	14.6	-0.285				
CVT at Midpoint (C)	97.4	6.6	-0.136	0.836			
1/slope (C)	43.2	11.1	-0.439	0.736	0.630		
CVT at 41 Joule (C)	71.2	6.0	0.452	-0.353	0.012	-0.748	
CVT at 68 Joule (C)	88.0	3.9	0.264	0.090	0.568	-0.181	0.783



A533B HSST02 REFERENCE MATERIAL
Indian Point Unit 3, Capsule Y

USE= 135.9 J, LSE= 3.1 J, CVT(1/2)= 106.C , Slope = 0.0291
CVT(41J) = 90. C , CVT(68J) = 105. C ,
Fluence = 8.050E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R15	52.	125.	24.	18.	0.25	10.	26.
R11	93.	200.	38.	28.	0.58	23.	36.
R14	93.	200.	54.	40.	0.76	30.	44.
R16	107.	225.	61.	45.	0.94	37.	52.
R9	121.	250.	106.	78.	1.50	59.	67.
R10	149.	300.	129.	95.	1.96	77.	100.
R12	204.	400.	131.	96.	1.85	73.	100.
R13	232.	450.	138.	101.	1.90	75.	100.



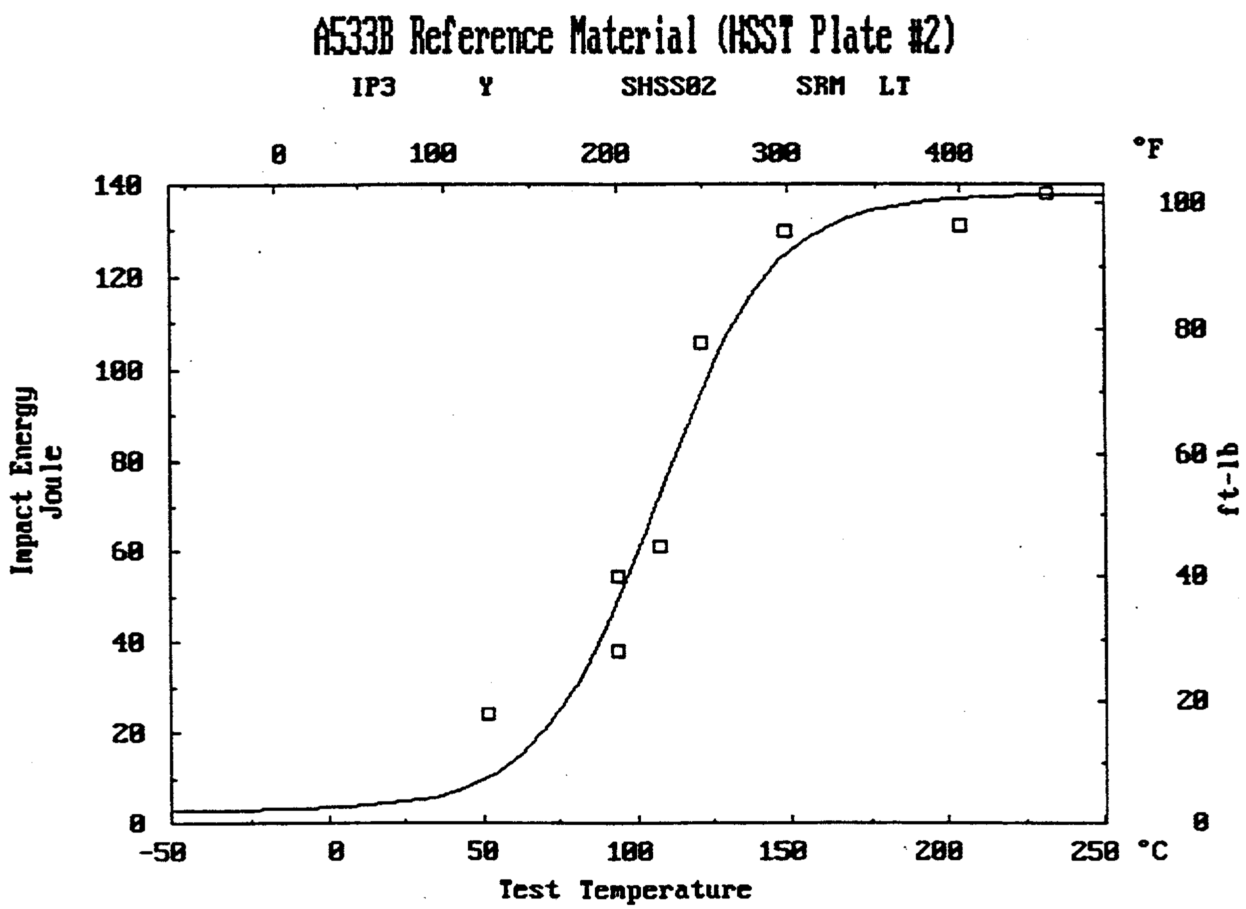
A533B HSST02 REFERENCE MATERIAL

Indian Point Unit 3, Capsule Y

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
IP3    Y     SHSS02    SRM  LT : Fluence = 8.050E+18 , Irr. Temp. =  304
```

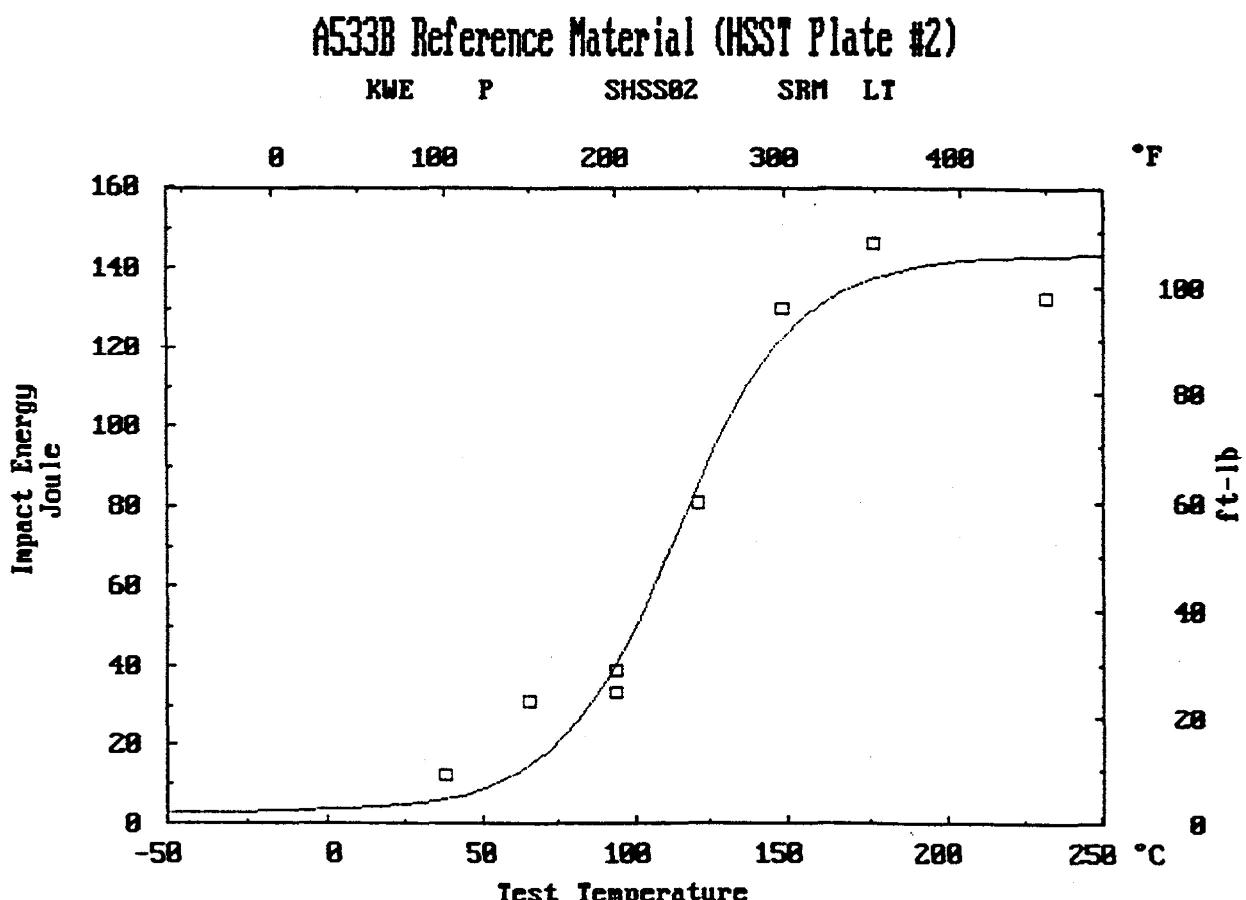
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.0					
Upper Shelf Energy (J)	137.4	6.2	-0.141				
CVT at Midpoint (C)	106.1	3.9	0.074	0.424			
1/slope (C)	37.8	11.2	-0.495	0.463	0.174		
CVT at 41 Joule (C)	88.3	6.3	0.485	-0.332	0.373	-0.833	
CVT at 68 Joule (C)	104.7	3.5	0.207	-0.101	0.841	-0.187	0.694



A533B HSST02 REFERENCE MATERIAL
Kewaunee, Capsule P

USE= 143.4 J, LSE= 3.1 J, CVT(1/2)= 114.C , Slope = 0.0251
CVT(41J) = 94. C , CVT(68J) = 111. C ,
Fluence = 2.890E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R41	38.	100.	12.	9.	0.23	9.	10.
R45	66.	150.	31.	23.	0.53	21.	20.
R42	93.	200.	34.	25.	0.61	24.	25.
R46	93.	200.	39.	29.	0.61	24.	30.
R47	121.	250.	81.	60.	1.22	48.	65.
R44	149.	300.	130.	96.	2.01	79.	100.
R48	177.	350.	146.	108.	2.08	82.	100.
R43	232.	450.	133.	98.	2.26	89.	100.



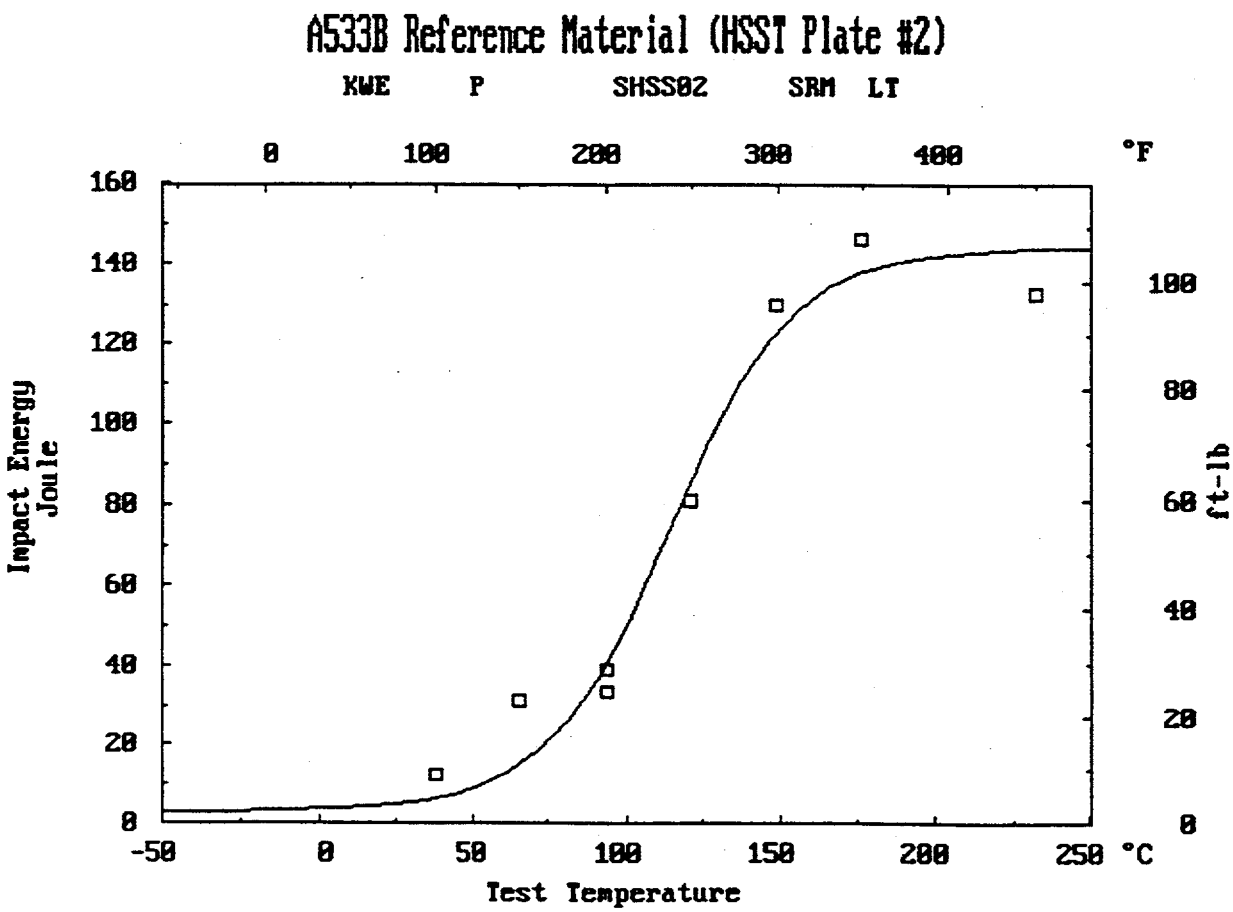
A533B HSST02 REFERENCE MATERIAL

Kewaunee, Capsule P

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

KWE P SHSS02 SRM LT : Fluence = 2.890E+19 , Irr. Temp. = 304

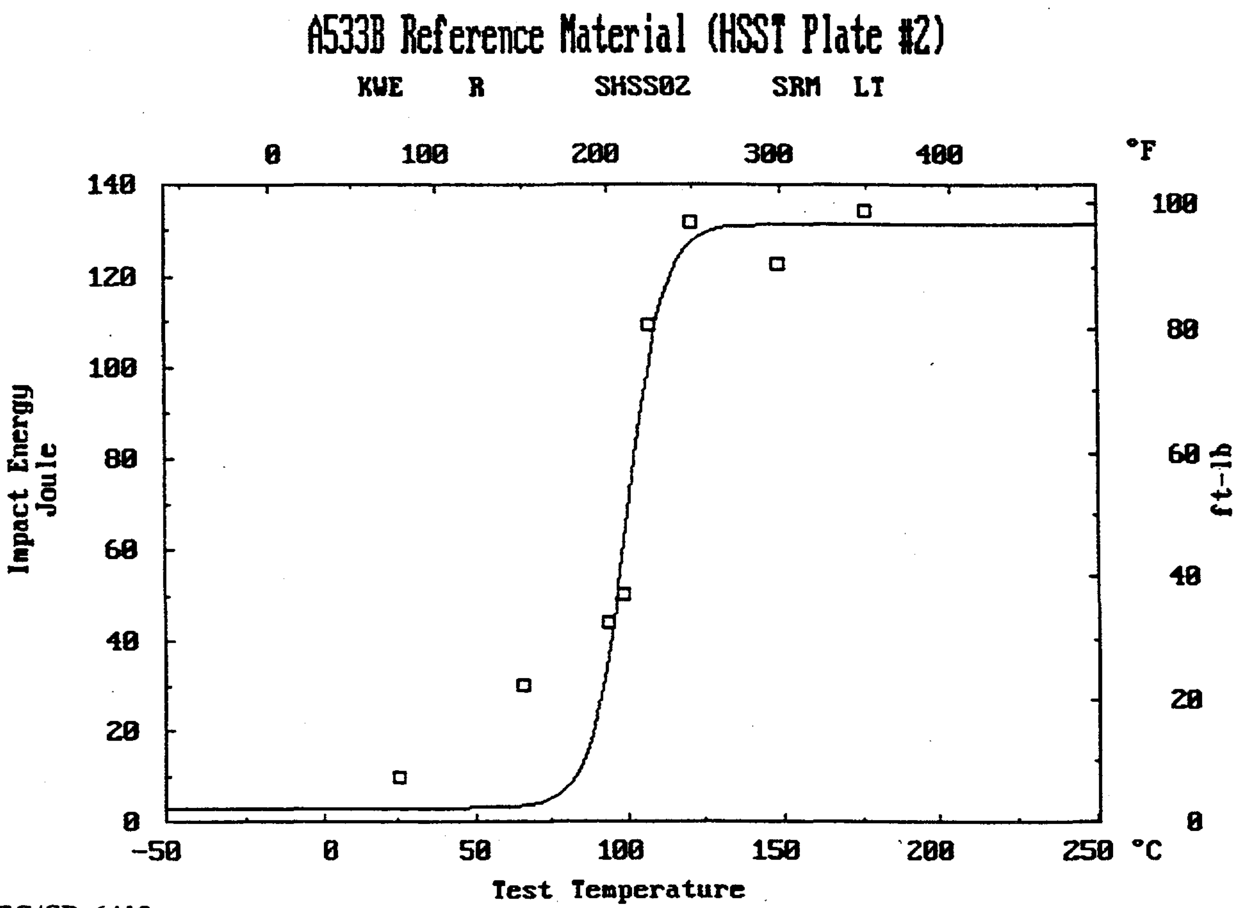
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	144.2	7.6	-0.003				
CVT at Midpoint (C)	113.9	5.3	0.142	0.501			
1/slope (C)	40.1	8.8	-0.475	0.372	0.220		
CVT at 41 Joule (C)	93.8	6.0	0.470	-0.075	0.593	-0.630	
CVT at 68 Joule (C)	110.6	4.6	0.232	0.088	0.895	-0.056	0.807



A533B HSST02 REFERENCE MATERIAL
Kewaunee, Capsule R

USE= 131.2 J, LSE= 3.2 J, CVT(1/2)= 100.C , Slope = 0.0837
CVT(41J) = 95. C , CVT(68J) = 100. C ,
Fluence = 2.070E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R13	26.	78.	10.	8.	0.13	5.	14.
R12	66.	150.	31.	22.	0.48	19.	25.
R9	93.	200.	44.	32.	0.76	30.	27.
R10	99.	210.	50.	37.	0.76	30.	35.
R16	107.	225.	109.	80.	1.40	55.	70.
R15	121.	250.	132.	97.	1.75	69.	69.
R11	149.	300.	123.	90.	1.90	75.	100.
R14	177.	350.	134.	99.	2.36	93.	100.



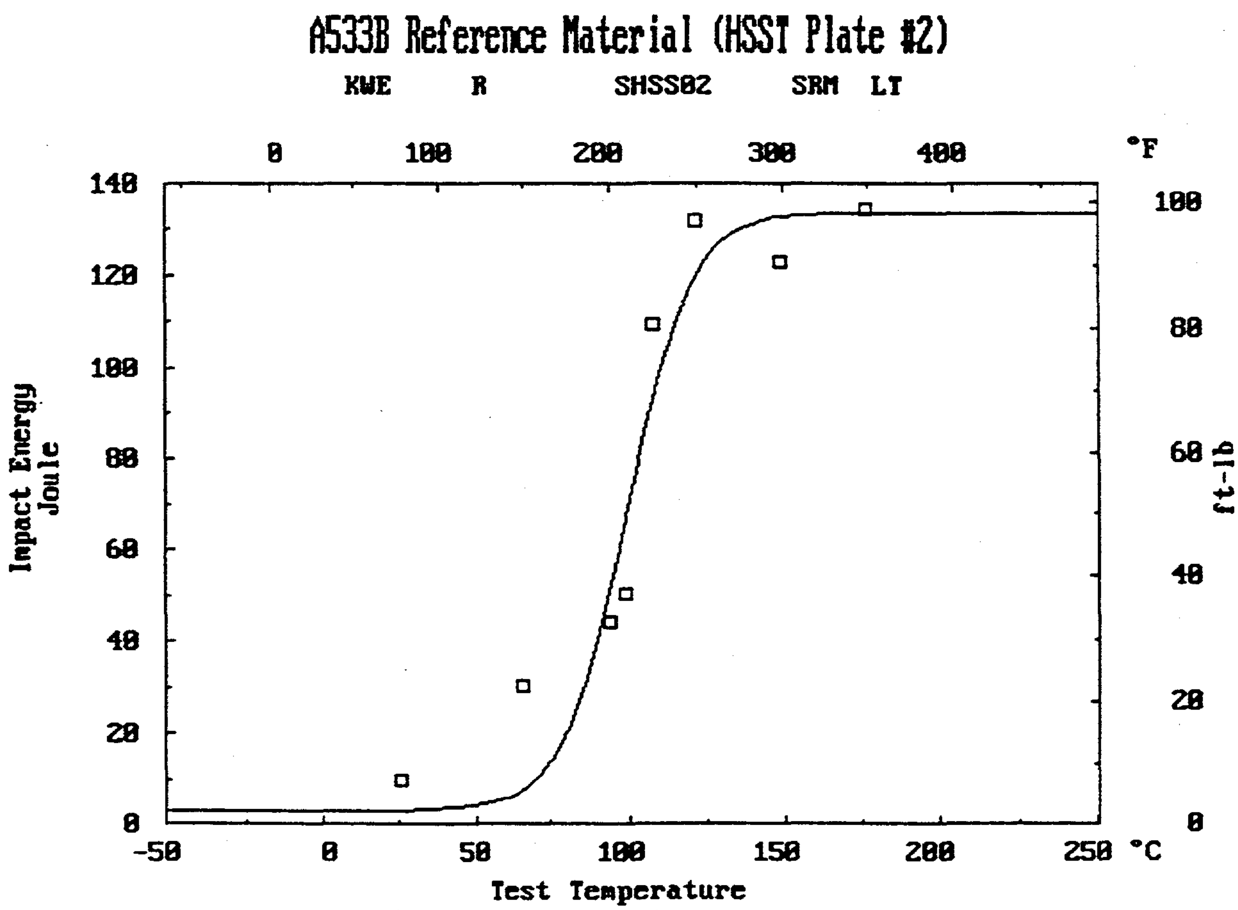
A533B HSST02 REFERENCE MATERIAL

Kewaunee, Capsule R

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
KWE   R     SHSS02     SRM  LT : Fluence = 2.070E+19 , Irr. Temp. =  304
```

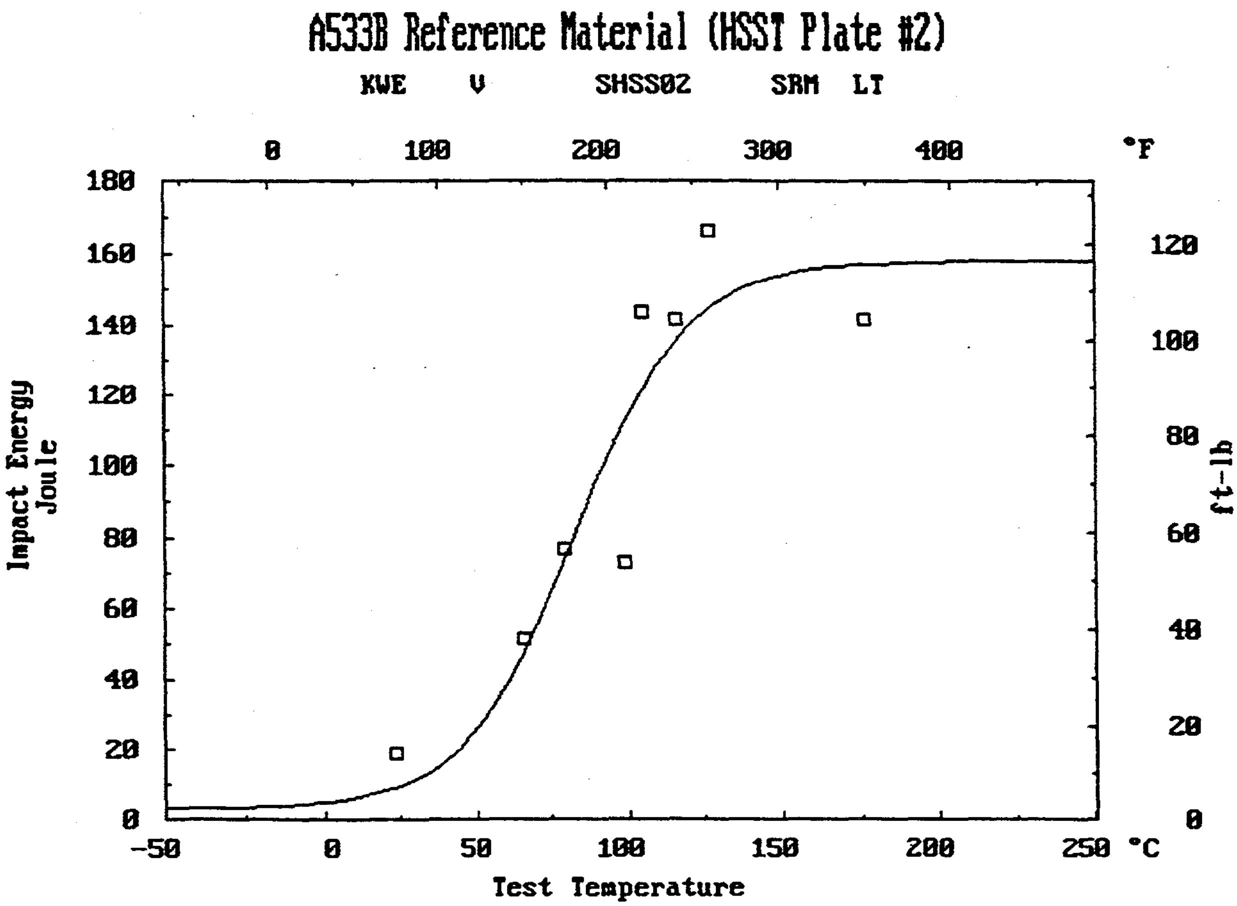
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.2	0.1					
Upper Shelf Energy (J)	133.5	7.0	-0.043				
CVT at Midpoint (C)	99.2	3.5	0.245	0.321			
1/slope (C)	20.1	7.8	-0.534	0.326	-0.319		
CVT at 41 Joule (C)	90.1	5.7	0.480	-0.142	0.752	-0.854	
CVT at 68 Joule (C)	99.0	3.3	0.285	-0.003	0.938	-0.475	0.861



A533B HSST02 REFERENCE MATERIAL
Kewaunee, Capsule V

USE= 157.8 J, LSE= 3.1 J, CVT(1/2)= 83.C , Slope = 0.0272
CVT(41J) = 62. C , CVT(68J) = 77. C ,
Fluence = 5.590E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R2	24.	75.	19.	14.	0.30	12.	10.
R7	66.	150.	52.	38.	0.66	26.	30.
R8	79.	175.	77.	56.	1.12	44.	40.
R1	99.	210.	73.	54.	1.07	42.	50.
R3	104.	220.	144.	106.	1.80	71.	100.
R6	116.	240.	142.	105.	1.83	72.	100.
R4	127.	260.	166.	122.	1.98	78.	100.
R5	177.	350.	142.	105.	1.96	77.	100.



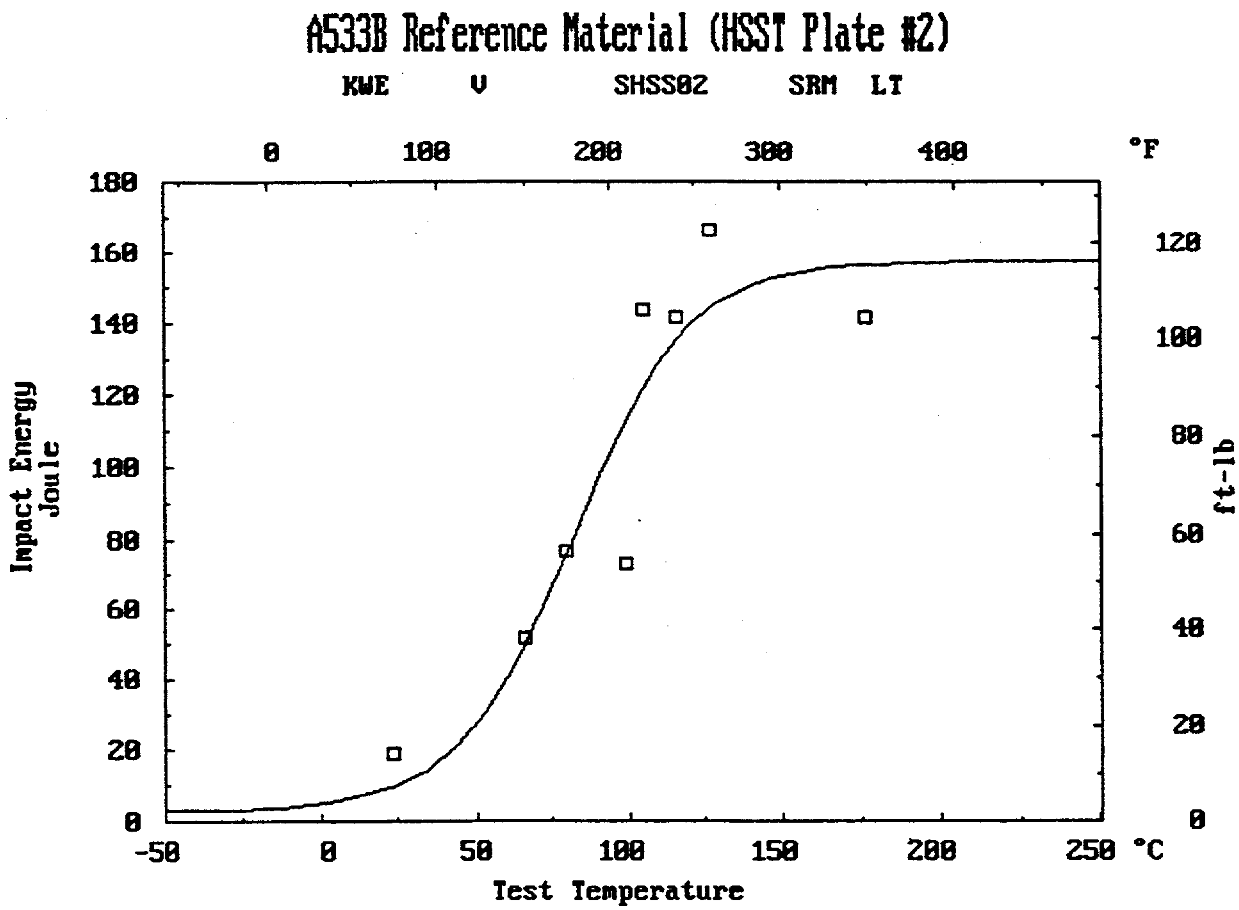
A533B HSST02 REFERENCE MATERIAL

Kewaunee, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
KWE   V     SHSS02     SRM  LT : Fluence = 5.590E+18 , Irr. Temp. =  304
```

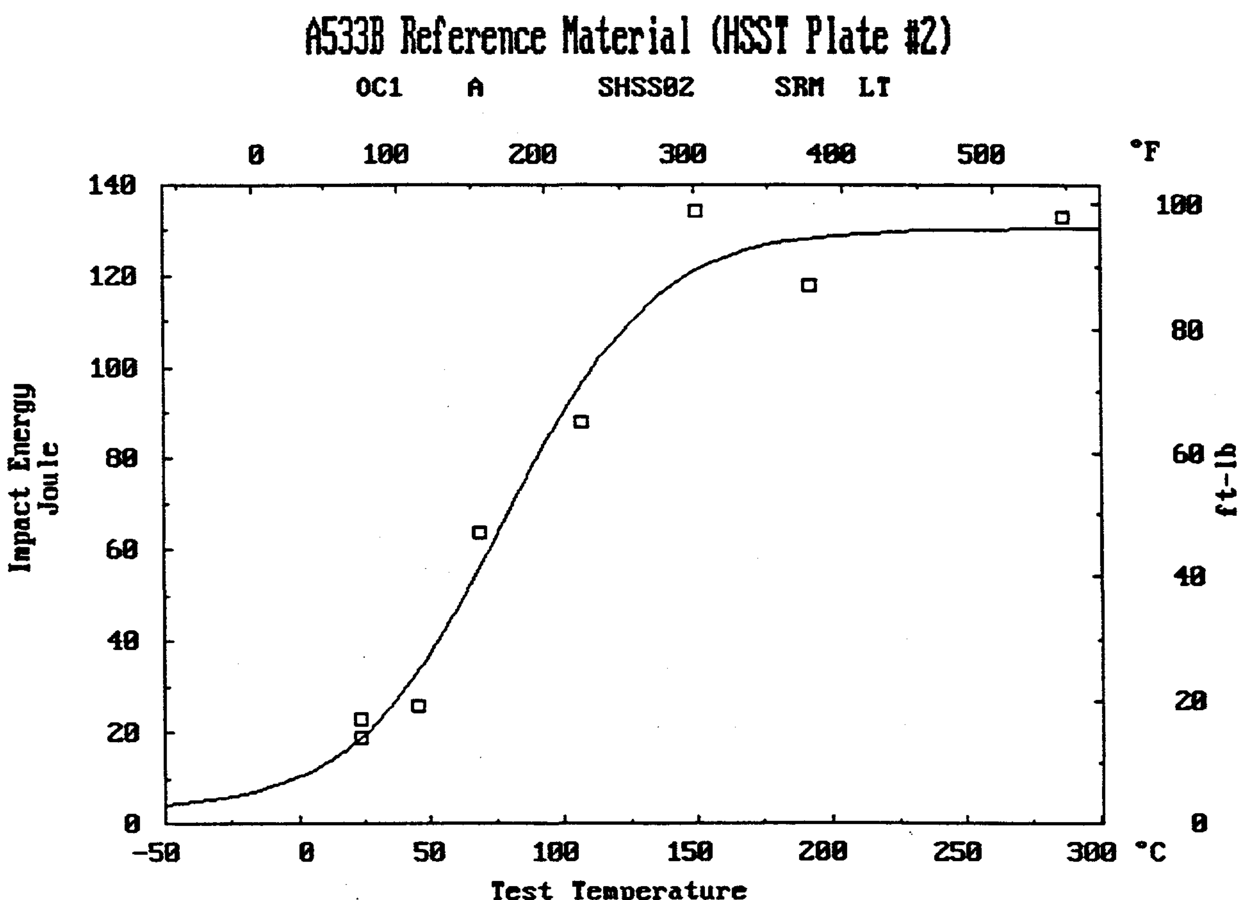
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.0					
Upper Shelf Energy (J)	157.2	7.6	0.027				
CVT at Midpoint (C)	81.6	4.6	0.365	0.530			
1/slope (C)	37.6	7.2	-0.314	0.410	-0.135		
CVT at 41 Joule (C)	60.5	6.5	0.445	-0.072	0.688	-0.799	
CVT at 68 Joule (C)	75.6	4.5	0.440	0.073	0.862	-0.551	0.940



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 1, Capsule A

USE= 130.4 J, LSE= 3.0 J, CVT(1/2)= 79.C , Slope = 0.0178
CVT(41J) = 54. C , CVT(68J) = 80. C ,
Fluence = 8.950E+18 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
AA922	24.	75.	23.	17.	0.46	18.	0.
AA974	24.	75.	19.	14.	0.36	14.	0.
AA950	46.	115.	26.	19.	0.46	18.	5.
AA903	69.	156.	64.	47.	0.89	35.	15.
AA920	107.	225.	88.	65.	1.24	49.	100.
AA946	150.	302.	134.	99.	1.90	75.	100.
AA961	192.	378.	118.	87.	1.75	69.	100.
AA948	287.	548.	133.	98.	1.96	77.	100.



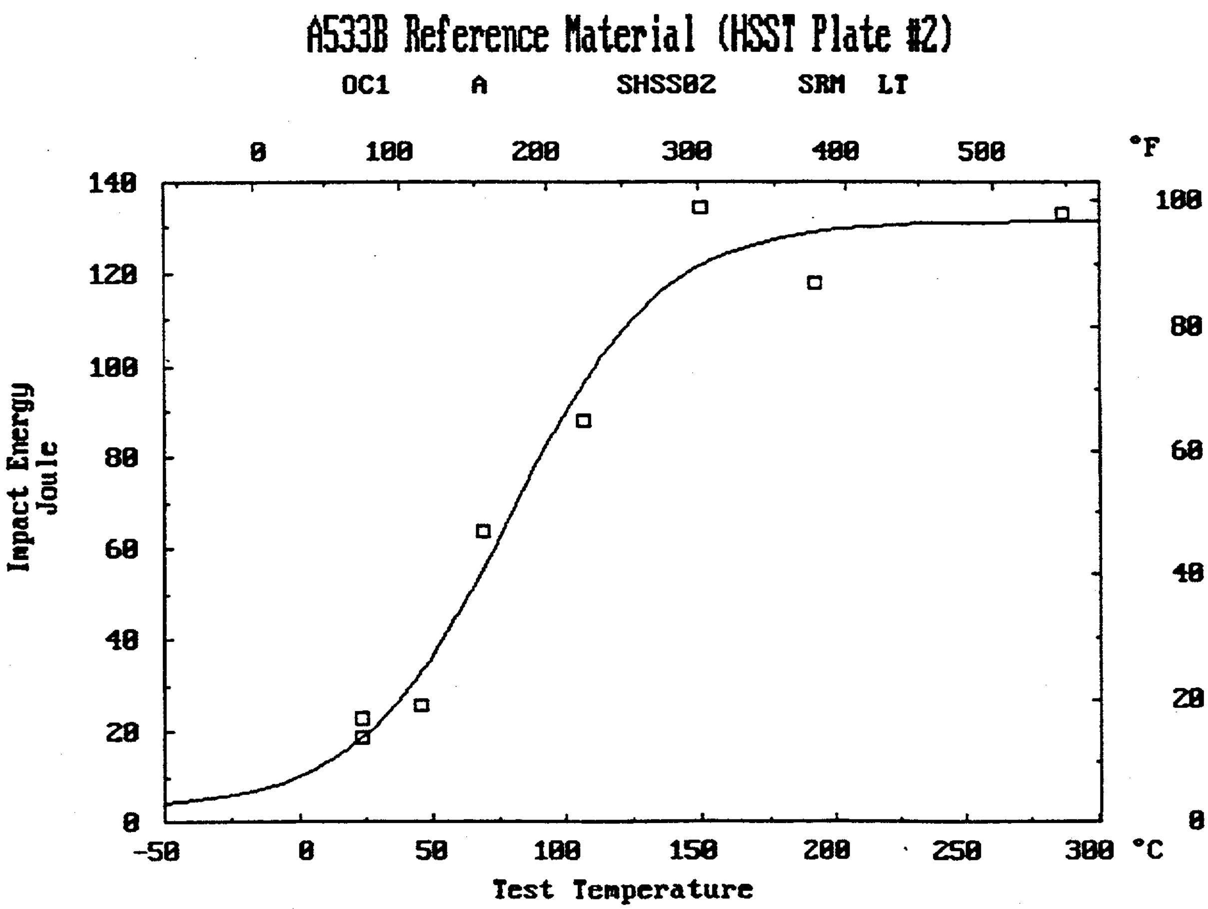
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 1, Capsule A

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
OC1    A     SHSS02    SRM  LT : Fluence = 8.950E+18 , Irr. Temp. =  303
```

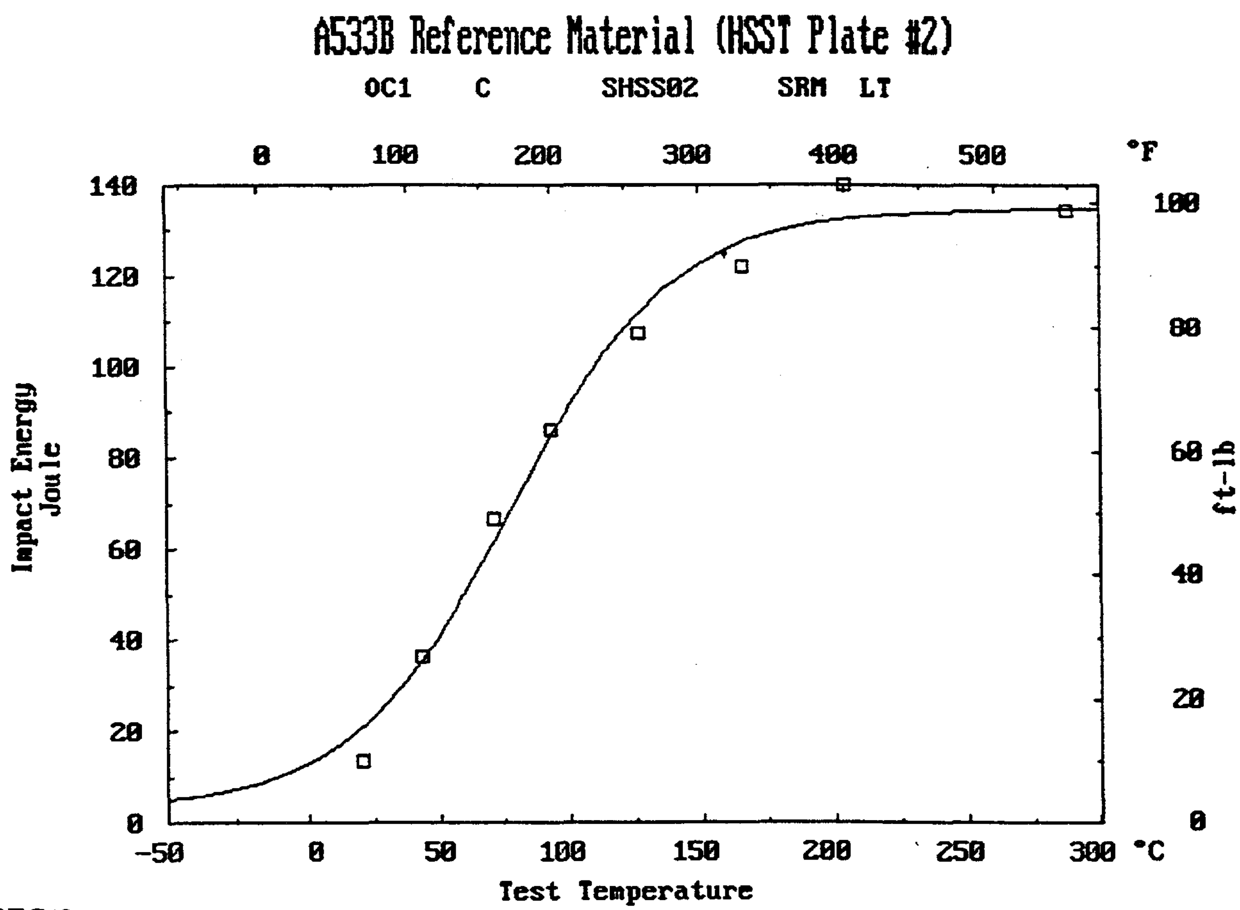
Parameter	Mean	Std.Dev.	Correlation Coefficients			
Lower Shelf Energy (J)	3.0	0.0				
Upper Shelf Energy (J)	131.2	6.9	0.018			
CVT at Midpoint (C)	79.3	7.7	0.063	0.590		
1/slope (C)	56.3	10.8	-0.087	0.399	0.472	
CVT at 41 Joule (C)	54.9	6.4	0.136	0.070	0.649	-0.319
CVT at 68 Joule (C)	80.0	6.4	0.070	0.227	0.918	0.380	0.747



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 1, Capsule C

USE= 134.6 J, LSE= 3.0 J, CVT(1/2)= 78.C , Slope = 0.0161
CVT(41J) = 50. C , CVT(68J) = 77. C ,
Fluence = 9.860E+18 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
AAC949	21.	70.	14.	10.	0.18	7.	10.
AAC931	43.	110.	37.	27.	0.61	24.	30.
AAC942	71.	160.	66.	49.	0.91	36.	50.
AAC939	93.	200.	86.	63.	1.42	56.	60.
AAC959	127.	260.	107.	79.	1.57	62.	95.
AAC956	166.	330.	122.	90.	1.93	76.	100.
AAC905	204.	400.	140.	103.	1.96	77.	100.
AAC954	288.	550.	134.	99.	1.90	75.	100.



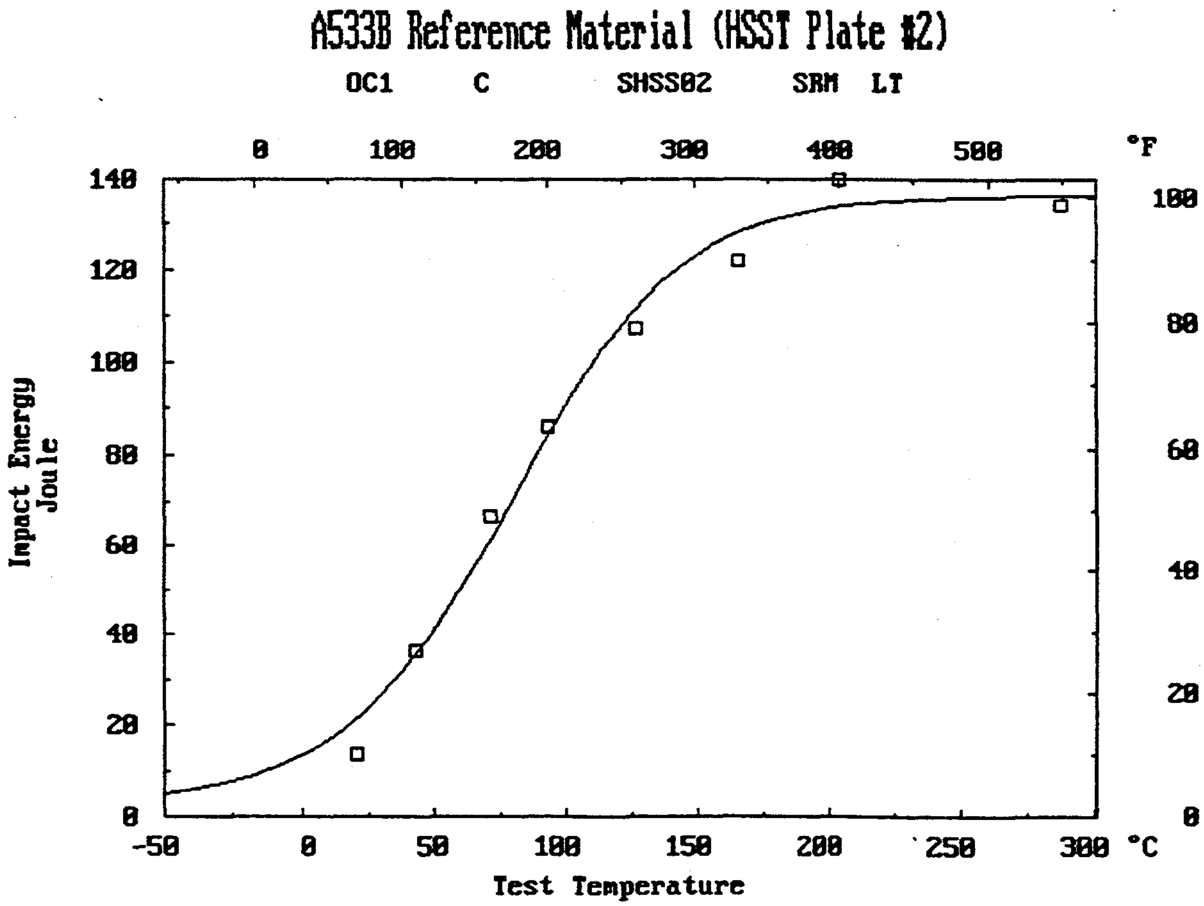
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 1, Capsule C

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

OC1 C SHSS02 SRM LT : Fluence = 9.860E+18 , Irr. Temp. = 303

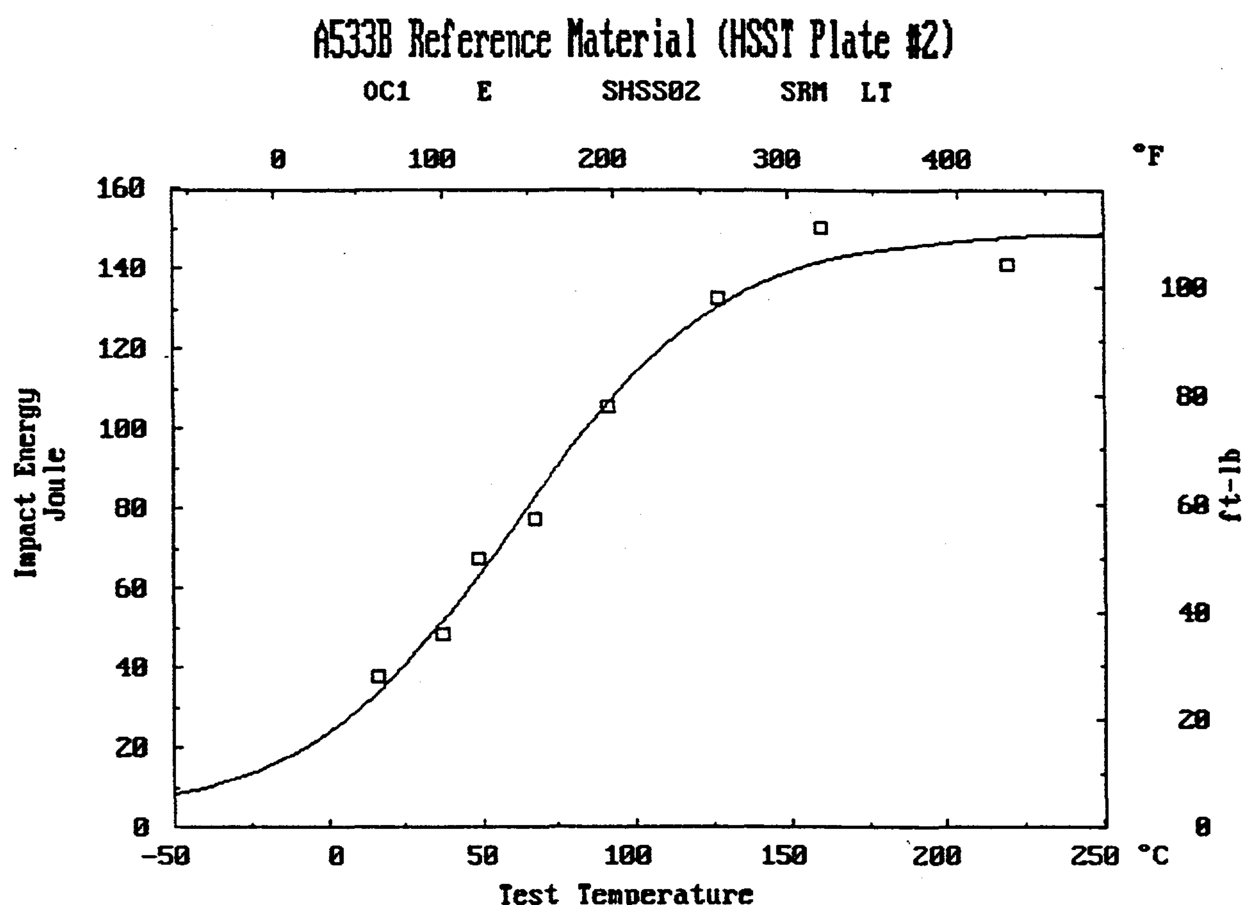
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	136.4	8.1	0.112				
CVT at Midpoint (C)	79.3	8.4	0.068	0.754			
1/slope (C)	63.9	14.7	0.149	0.600	0.567		
CVT at 41 Joule (C)	49.7	7.0	-0.114	-0.094	0.336	-0.552	
CVT at 68 Joule (C)	77.4	5.9	0.006	0.351	0.870	0.314	0.609



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 1, Capsule E

USE= 149.4 J, LSE= 3.0 J, CVT(1/2)= 61.C , Slope = 0.0147
CVT(41J) = 25. C , CVT(68J) = 53. C ,
Fluence = 1.500E+18 , Irr. Temp. = 309 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
AAE967	17.	62.	38.	28.	0.58	23.	2.
AAE971	37.	99.	49.	36.	0.76	30.	6.
AAE927	49.	120.	68.	50.	0.99	39.	30.
AAE908	68.	154.	77.	57.	1.09	43.	30.
AAE964	92.	197.	106.	78.	1.32	52.	65.
AAE966	127.	260.	133.	98.	1.75	69.	95.
AAE935	161.	321.	150.	111.	1.80	71.	100.
AAE929	220.	428.	141.	104.	1.88	74.	100.



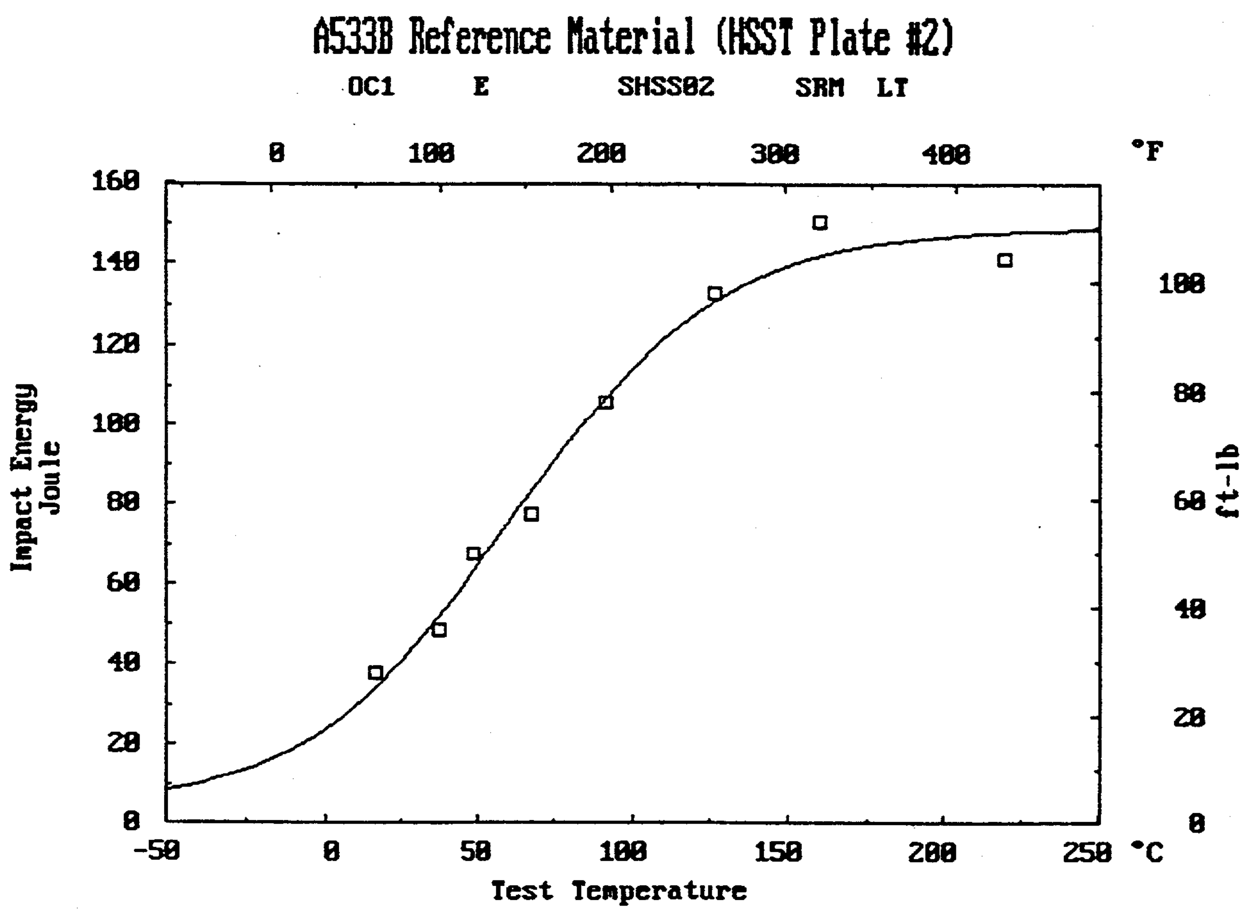
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 1, Capsule E

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
OC1    E      SHSS02     SRM  LT : Fluence = 1.500E+18 , Irr. Temp. =  309
```

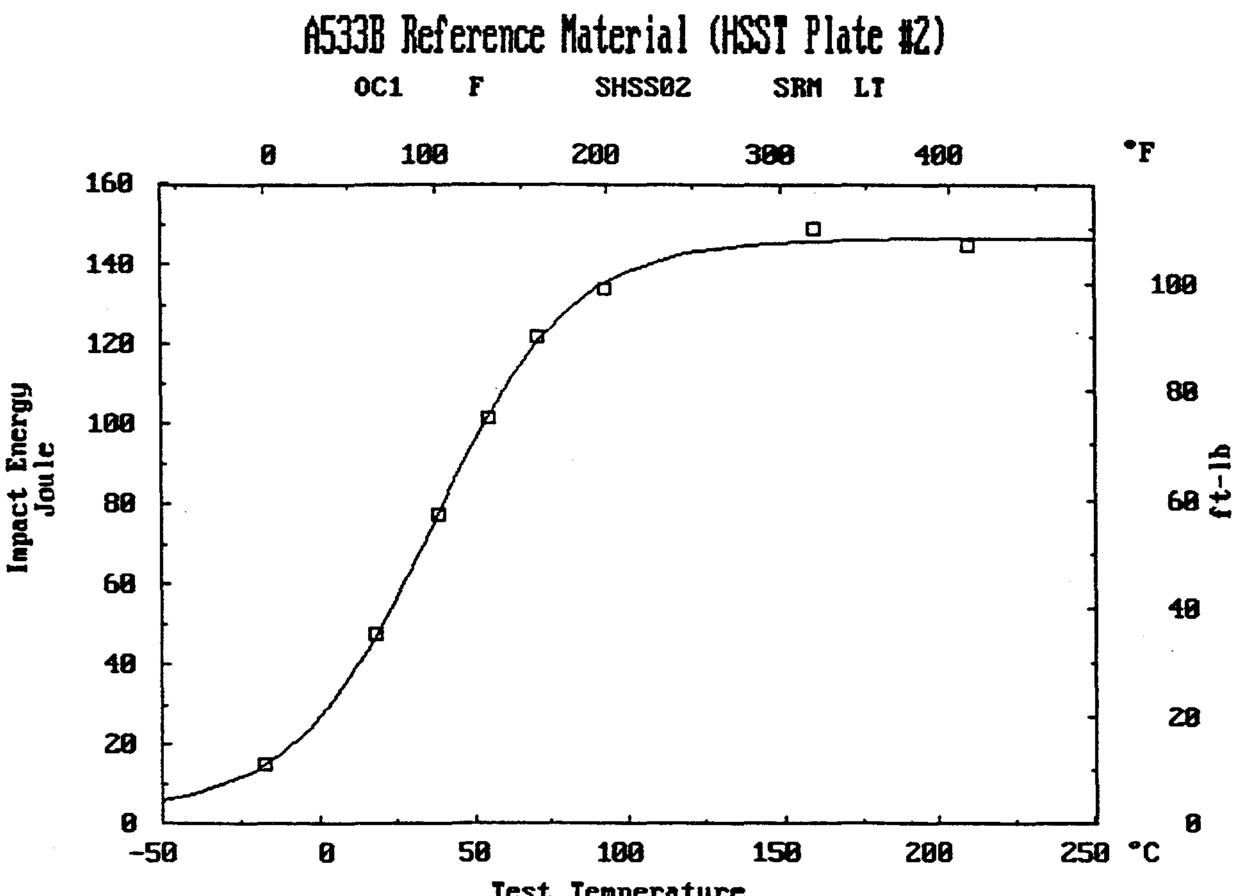
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	149.3	8.5	0.147				
CVT at Midpoint (C)	60.9	6.9	0.178	0.710			
1/slope (C)	67.9	13.1	-0.040	0.593	0.397		
CVT at 41 Joule (C)	25.1	7.9	0.156	-0.238	0.289	-0.739	
CVT at 68 Joule (C)	53.1	5.2	0.177	0.079	0.725	-0.190	0.796



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 1, Capsule F

USE= 146.7 J, LSE= 3.0 J, CVT(1/2)= 37.C , Slope = 0.0221
CVT(41J) = 14. C , CVT(68J) = 32. C ,
Fluence = 8.300E+17 , Irr. Temp. = 309 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
BBF936	-17.	1.	15.	11.	0.25	10.	2.
BBF921	18.	65.	47.	35.	0.74	29.	12.
BBF969	38.	101.	77.	57.	1.07	42.	30.
BBF968	54.	130.	102.	75.	1.32	52.	35.
BBF958	71.	160.	122.	90.	1.42	56.	55.
BBF901	93.	199.	134.	99.	1.60	63.	100.
BBF940	160.	320.	149.	110.	1.57	62.	100.
BBF910	211.	411.	145.	107.	1.57	62.	100.



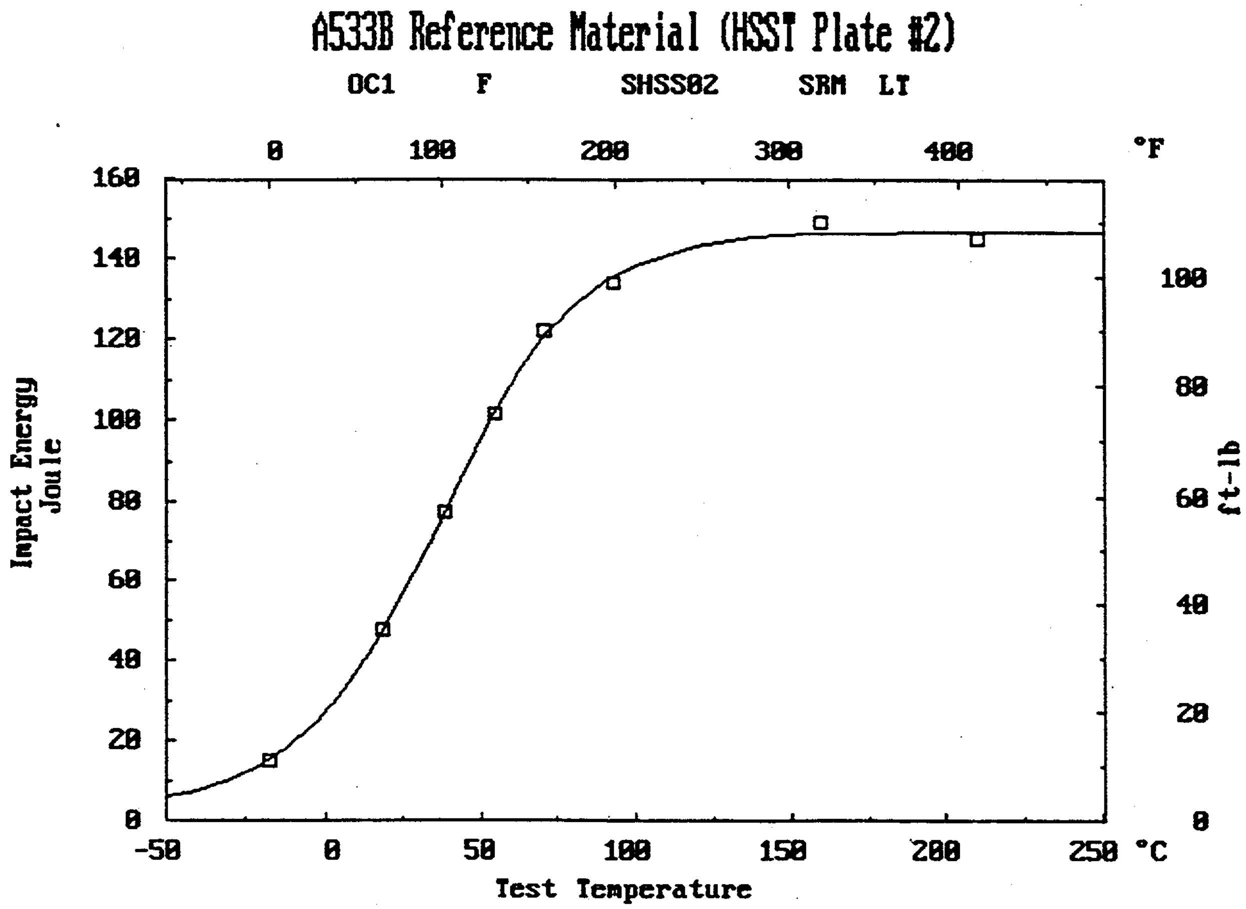
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 1, Capsule F

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
OC1    F     SHSS02     SRM  LT : Fluence = 8.300E+17 , Irr. Temp. =  309
```

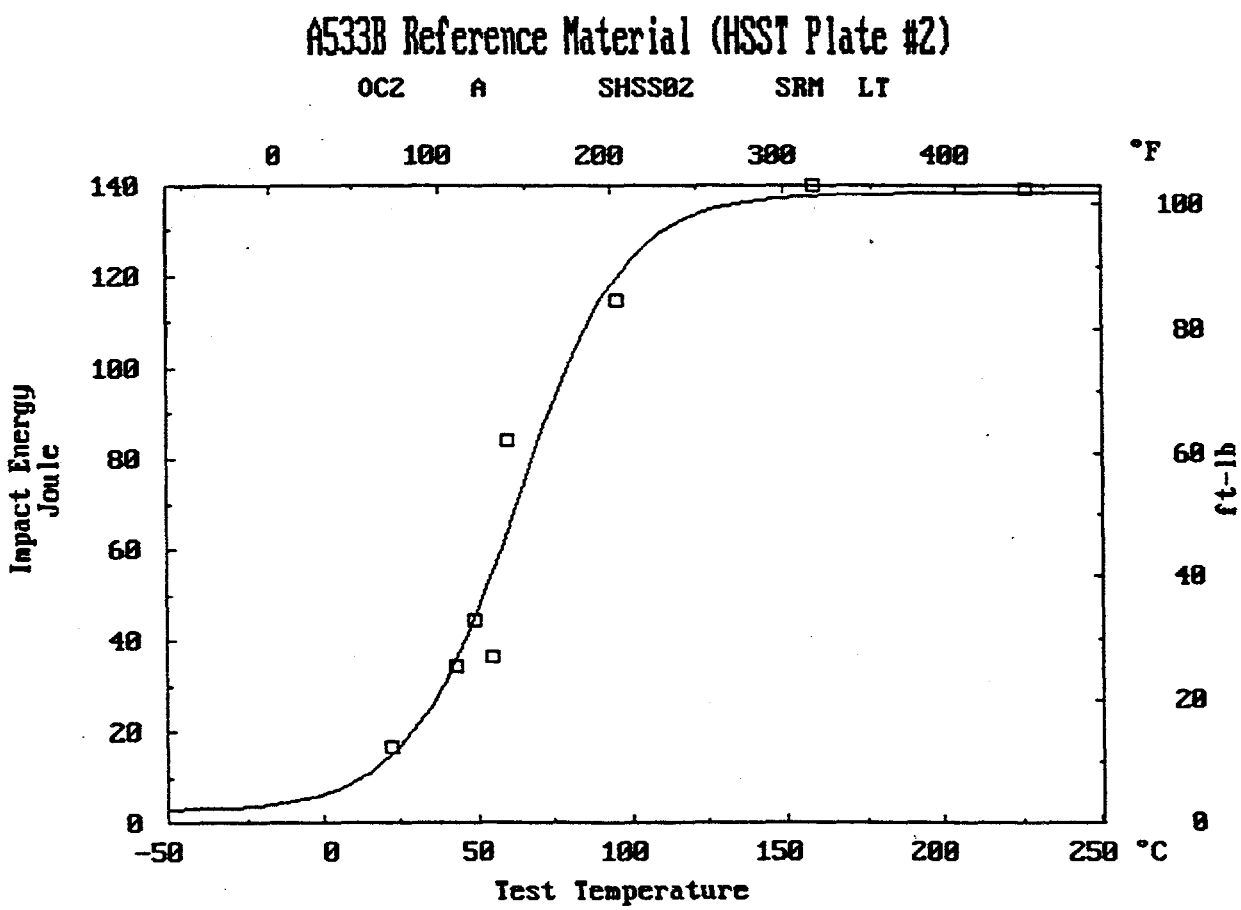
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	146.8	6.5	-0.047				
CVT at Midpoint (C)	36.8	5.3	0.016	0.575			
1/slope (C)	45.7	9.7	-0.181	0.493	0.121		
CVT at 41 Joule (C)	13.3	6.9	0.152	-0.120	0.568	-0.734	
CVT at 68 Joule (C)	32.2	4.7	0.075	0.141	0.876	-0.271	0.850



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 2, Capsule A

USE= 138.2 J, LSE= 3.0 J, CVT(1/2)= 63.C , Slope = 0.0285
CVT(41J) = 47. C , CVT(68J) = 62. C ,
Fluence = 3.370E+18 , Irr. Temp. = 321 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
EE950	22.	72.	17.	12.	0.25	10.	2.
EE942	43.	110.	35.	25.	0.53	21.	30.
EE903	49.	120.	45.	33.	0.76	30.	15.
EE904	54.	130.	37.	27.	0.81	32.	30.
EE934	60.	140.	84.	62.	1.35	53.	35.
EE919	96.	204.	115.	84.	1.63	64.	100.
EE914	159.	318.	140.	103.	2.13	84.	100.
EE935	227.	440.	139.	102.	1.98	78.	100.



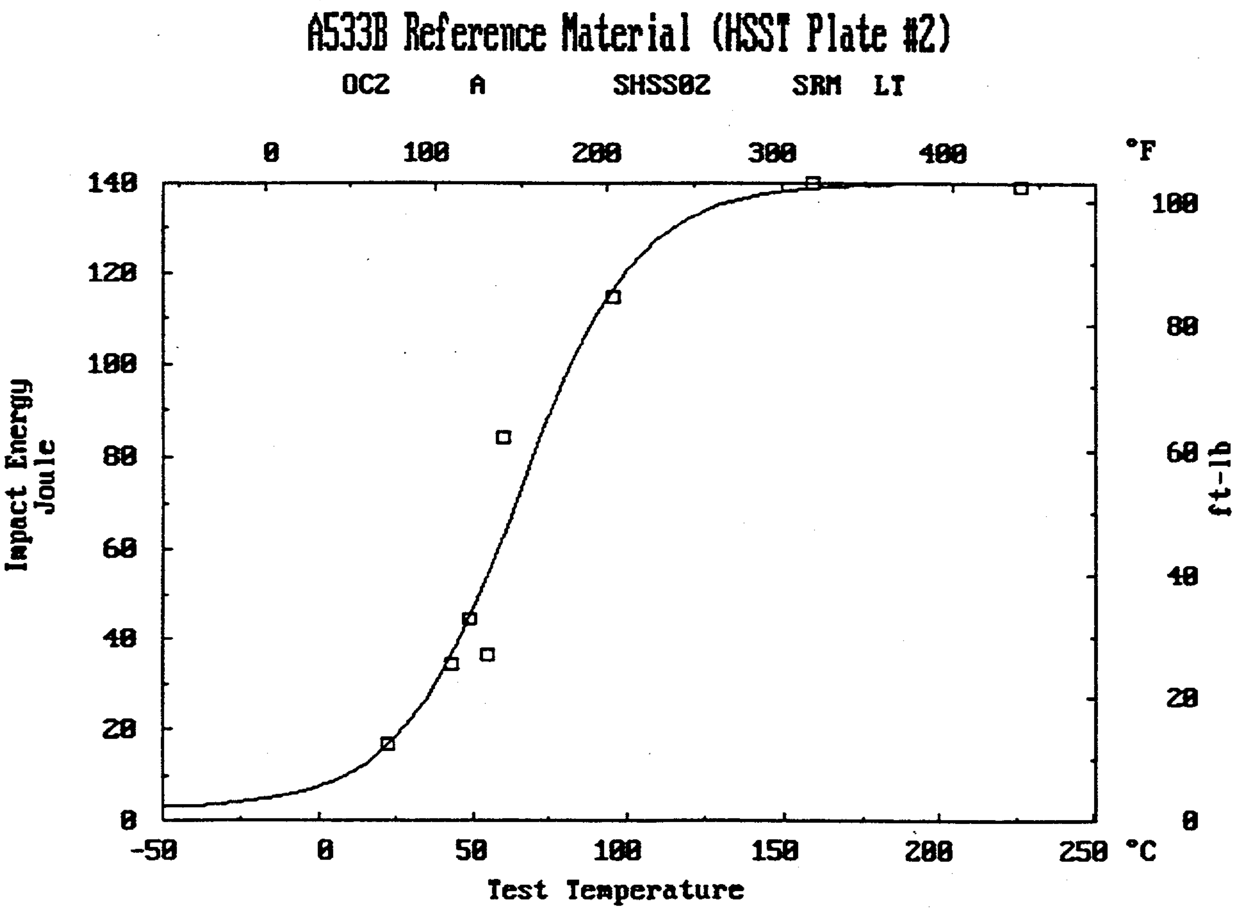
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 2, Capsule A

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

OC2 A SHSS02 SRM LT : Fluence = 3.370E+18 , Irr. Temp. = 321

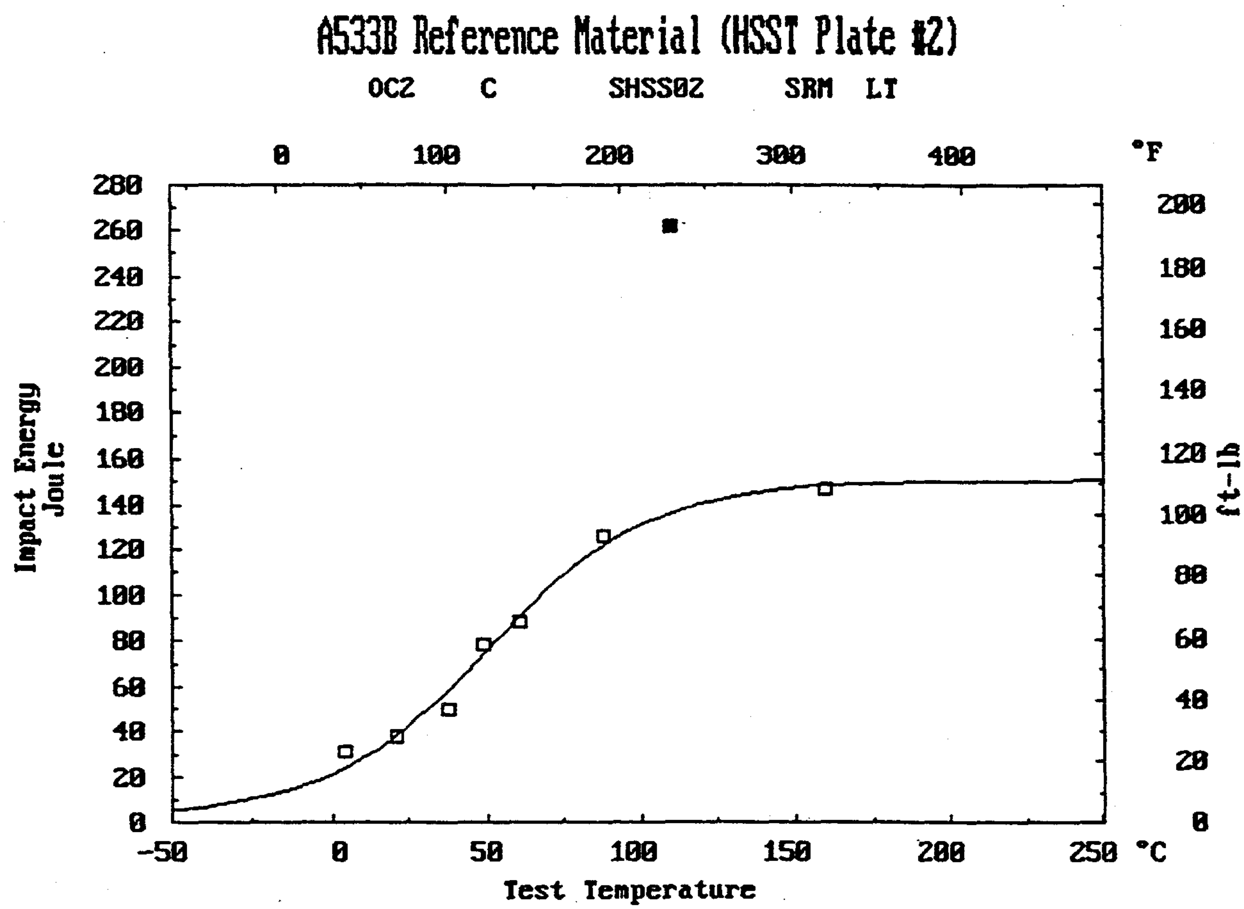
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	139.9	8.0	-0.023				
CVT at Midpoint (C)	65.0	5.6	-0.071	0.650			
1/slope (C)	38.7	9.4	-0.228	0.484	0.625		
CVT at 41 Joule (C)	46.4	4.2	0.150	-0.045	0.395	-0.431	
CVT at 68 Joule (C)	62.9	4.2	-0.065	0.274	0.900	0.456	0.598



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 2, Capsule C

USE= 150.7 J, LSE= 3.0 J, CVT(1/2)= 51.C , Slope = 0.0193
CVT(41J) = 23. C , CVT(68J) = 45. C ,
Fluence = 9.430E+17 , Irr. Temp. = 309 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
EE911	4.	40.	31.	23.	0.51	20.	4.
EE928	21.	70.	38.	28.	0.58	23.	12.
EE930	38.	100.	50.	37.	0.66	26.	18.
EE939	49.	120.	79.	58.	0.99	39.	28.
EE912	60.	140.	88.	65.	1.22	48.	40.
EE941	88.	190.	125.	92.	1.37	54.	88.
*EE958	110.	230.	262.	193.	1.50	59.	95.
EE921	159.	319.	147.	108.	1.47	58.	100.



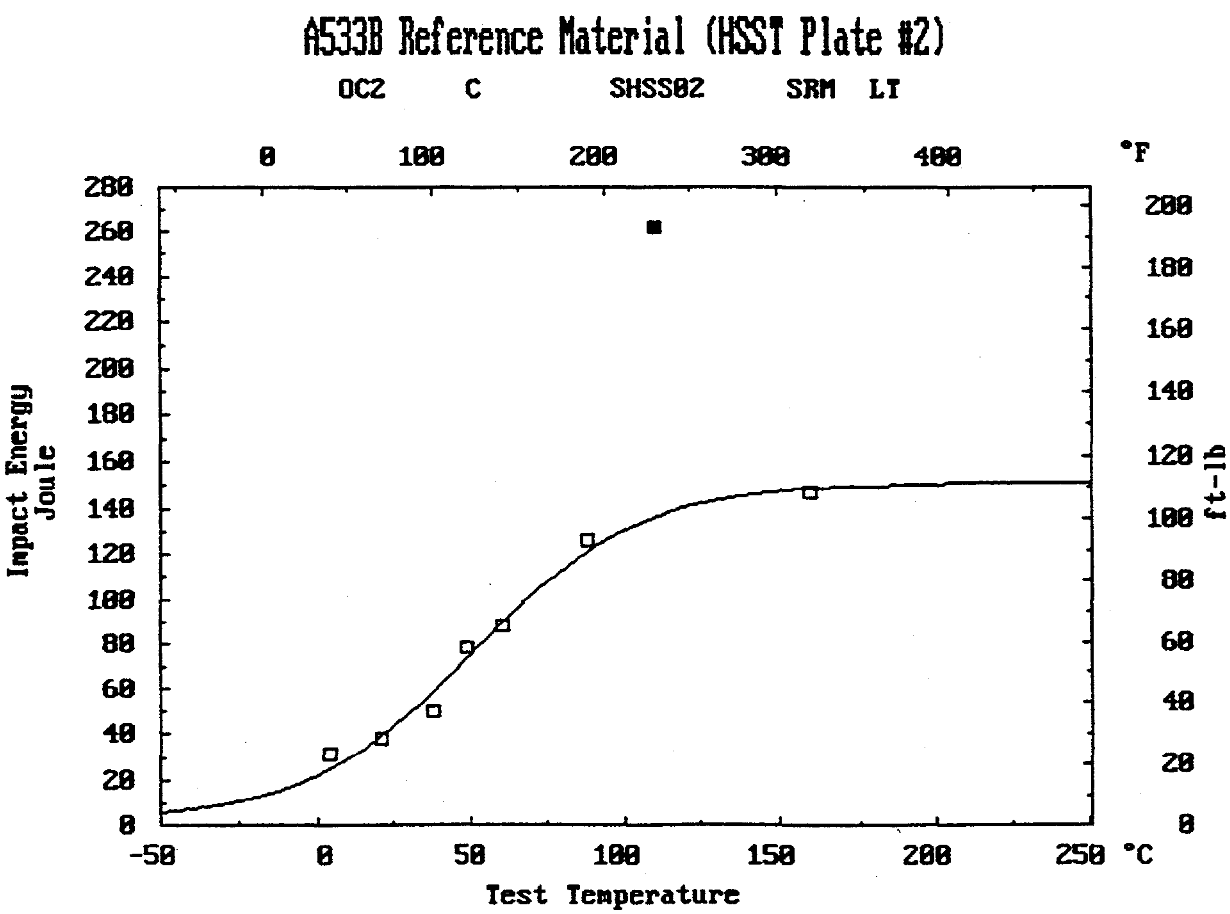
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 2, Capsule C

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

OC2 C SHSS02 SRM LT : Fluence = 9.430E+17 , Irr. Temp. = 309

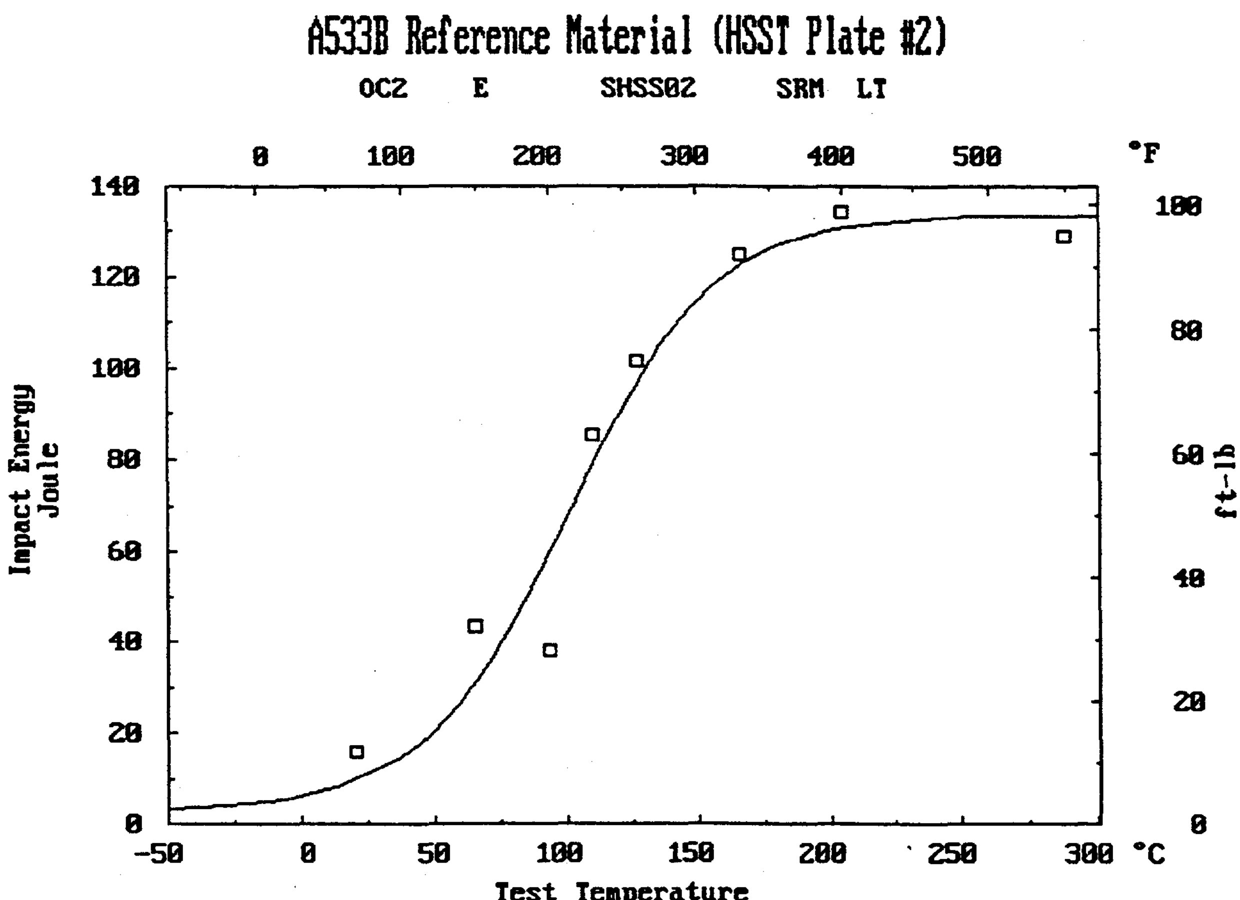
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	151.2	10.1	-0.059				
CVT at Midpoint (C)	51.3	6.1	0.041	0.748			
1/slope (C)	53.4	12.5	-0.297	0.464	0.495		
CVT at 41 Joule (C)	22.8	6.3	0.365	-0.177	0.117	-0.776	
CVT at 68 Joule (C)	44.6	3.8	0.216	0.109	0.687	-0.050	0.658



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 2, Capsule E

USE= 133.6 J, LSE= 3.0 J, CVT(1/2)= 101.C , Slope = 0.0183
CVT(41J) = 77. C , CVT(68J) = 101. C ,
Fluence = 1.210E+19 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
EE944	21.	70.	16.	12.	0.30	12.	20.
EE937	66.	150.	43.	32.	0.66	26.	40.
EE947	93.	200.	38.	28.	0.61	24.	70.
EE916	110.	230.	85.	63.	1.24	49.	80.
EE959	127.	260.	102.	75.	1.57	62.	95.
EE955	166.	330.	125.	92.	1.85	73.	100.
EE929	204.	400.	134.	99.	2.03	80.	100.
EE925	288.	550.	129.	95.	2.41	95.	100.



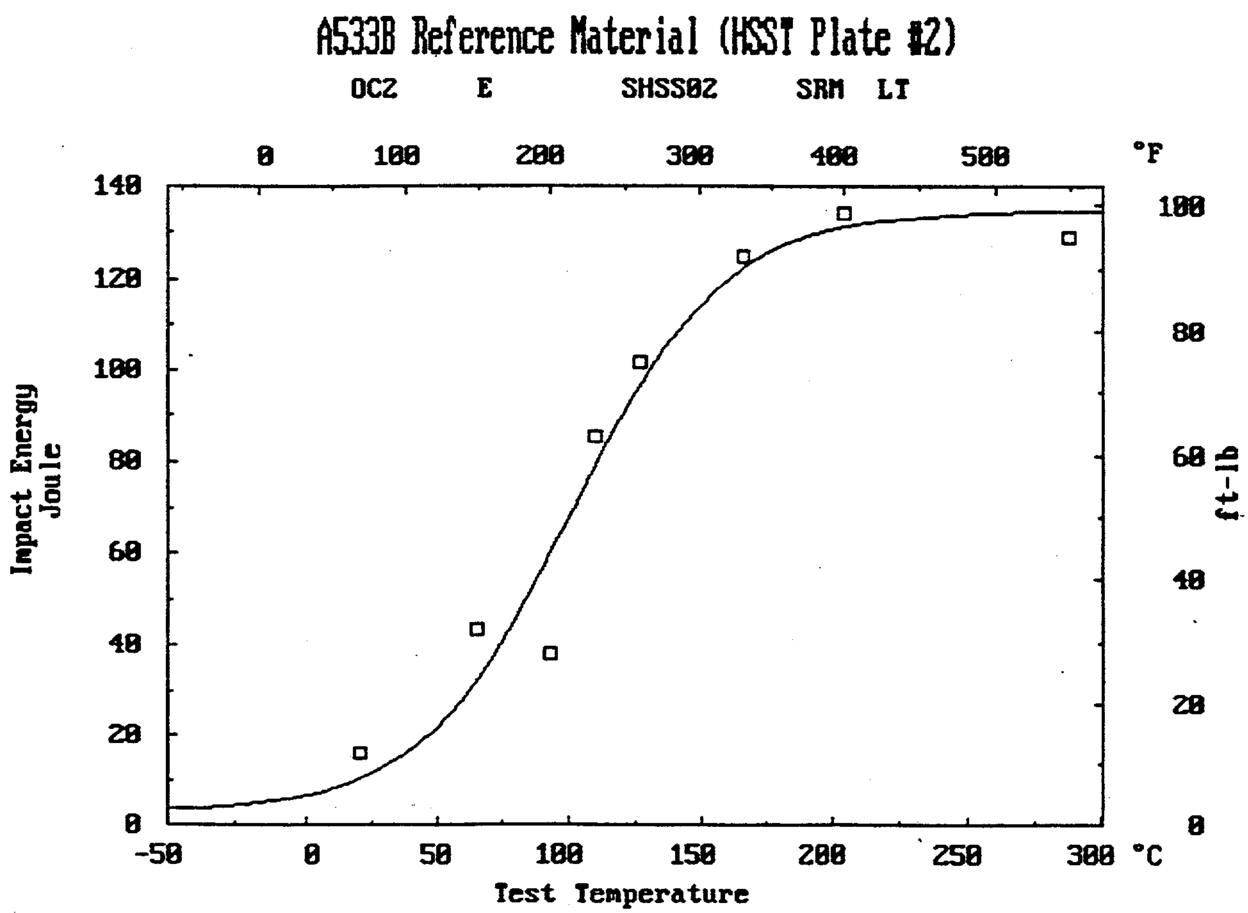
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 2, Capsule E

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

OC2 E SHSS02 SRM LT : Fluence = 1.210E+19 , Irr. Temp. = 303

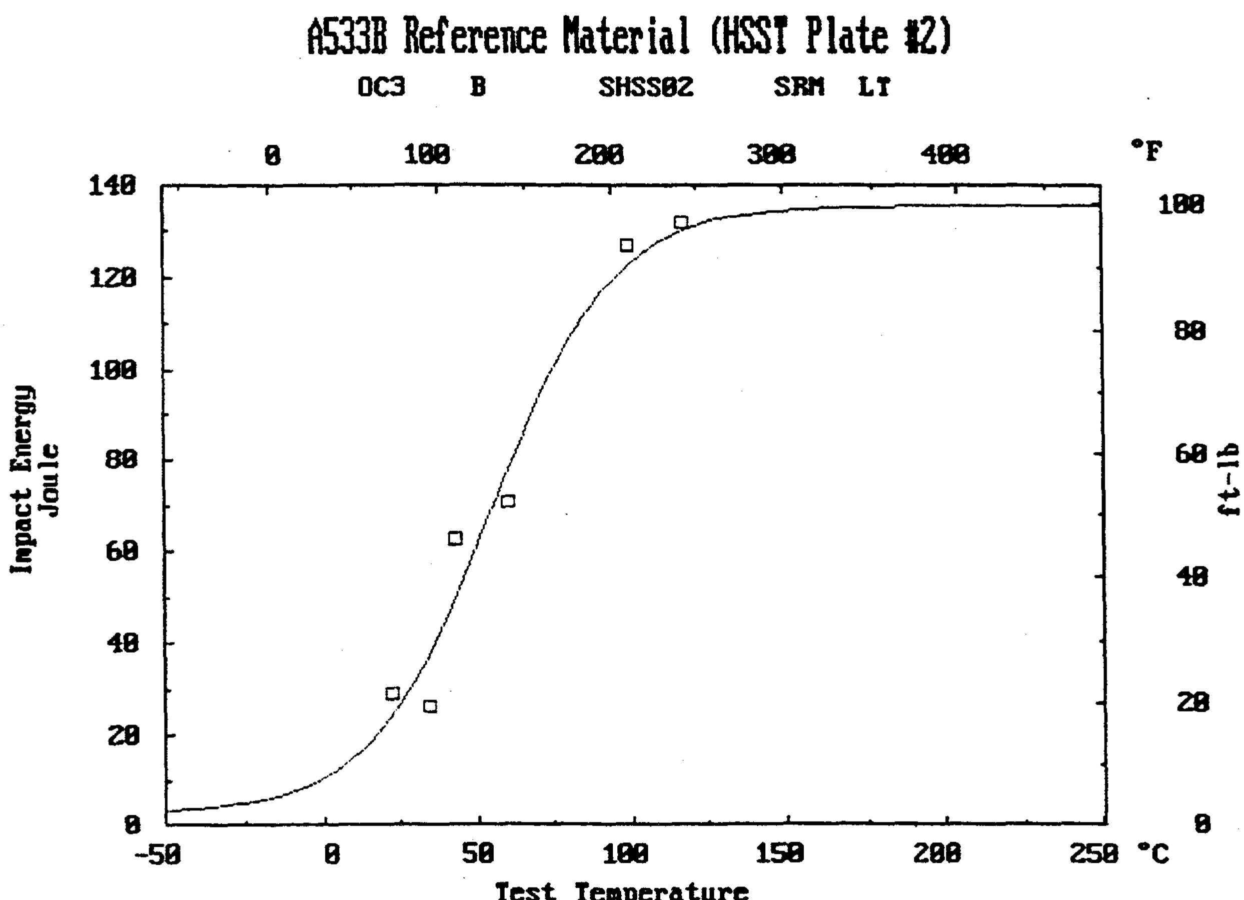
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	134.6	7.0	-0.061				
CVT at Midpoint (C)	101.1	6.4	0.242	0.467			
1/slope (C)	56.8	13.2	-0.409	0.491	-0.092		
CVT at 41 Joule (C)	75.3	9.4	0.433	-0.234	0.620	-0.820	
CVT at 68 Joule (C)	100.2	5.7	0.306	-0.043	0.855	-0.412	0.854



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 3, Capsule B

USE= 135.4 J, LSE= 3.0 J, CVT(1/2)= 55.C , Slope = 0.0254
CVT(41J) = 37. C , CVT(68J) = 54. C ,
Fluence = 3.120E+18 , Irr. Temp. = 309 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
JJ918	22.	72.	29.	21.	0.43	17.	5.
JJ916	34.	94.	26.	19.	0.41	16.	10.
JJ908	43.	110.	62.	46.	0.89	35.	20.
JJ902	60.	140.	70.	52.	1.07	42.	40.
JJ914	99.	210.	127.	93.	1.85	73.	100.
JJ911	117.	242.	132.	97.	1.90	75.	100.



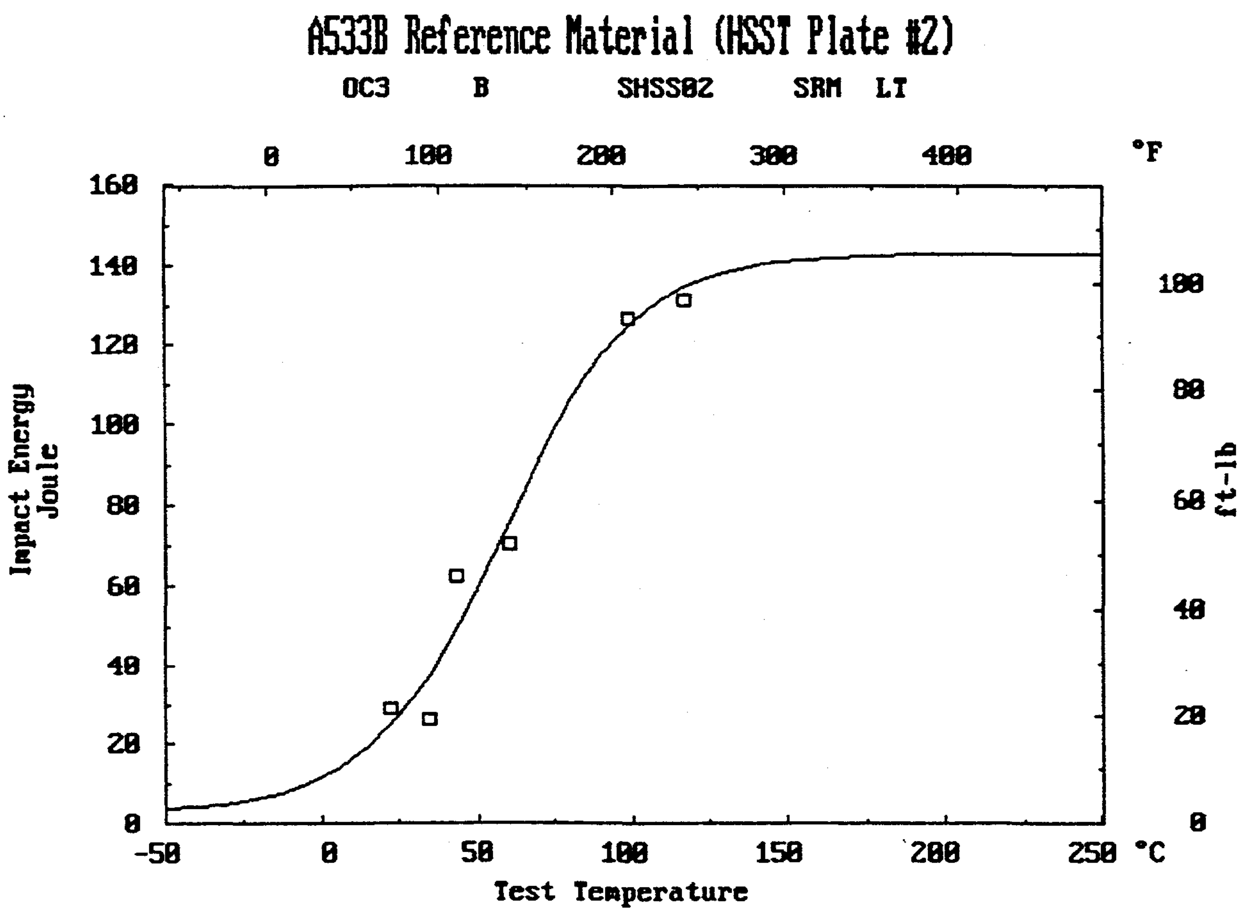
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 3, Capsule B

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

OC3 B SHSS02 SRM LT : Fluence = 3.120E+18 , Irr. Temp. = 309

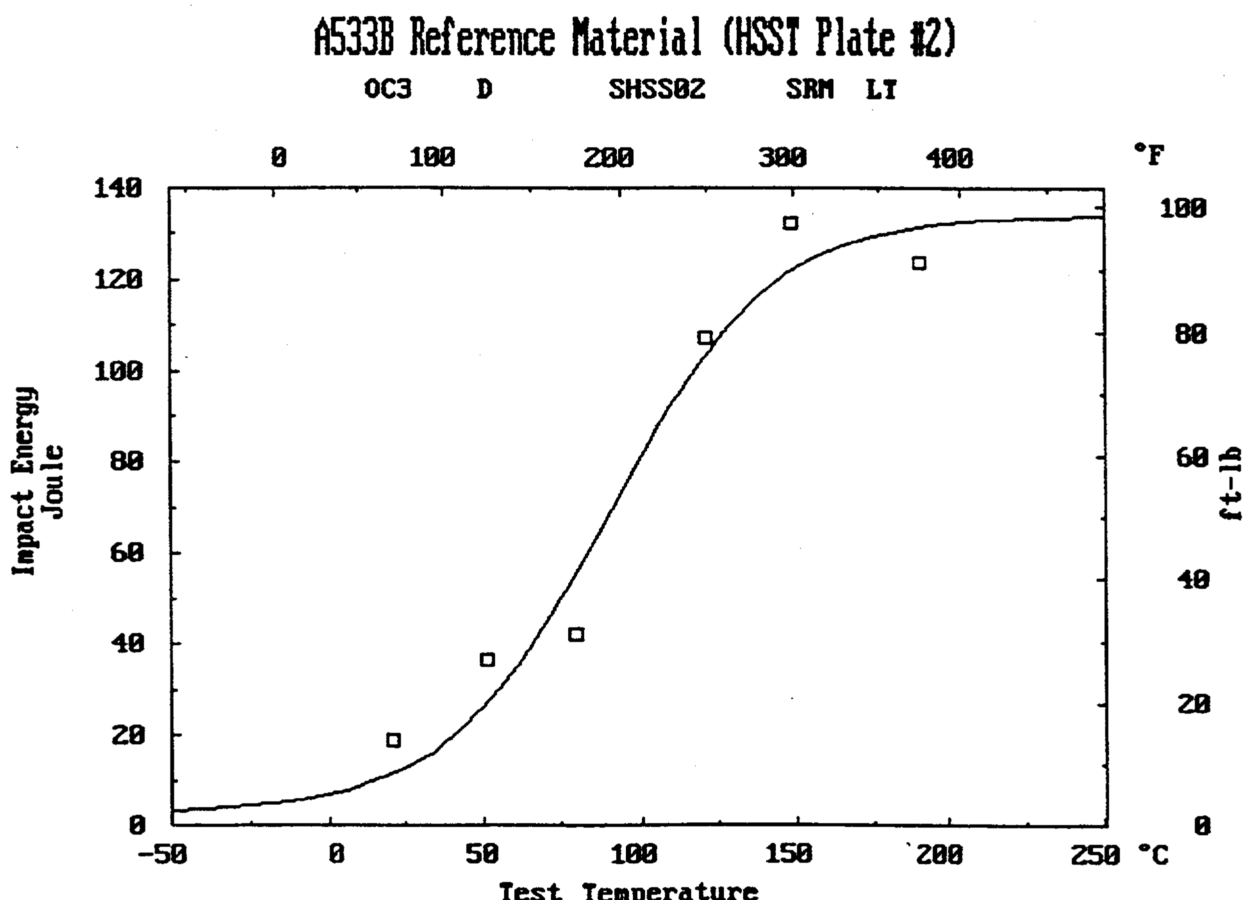
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	143.2	16.5	-0.013				
CVT at Midpoint (C)	58.4	9.0	0.079	0.870			
1/slope (C)	42.5	11.2	-0.003	0.753	0.749		
CVT at 41 Joule (C)	37.0	4.8	0.172	-0.042	0.294	-0.360	
CVT at 68 Joule (C)	54.9	4.7	0.178	0.450	0.820	0.441	0.664



A533B HSST02 REFERENCE MATERIAL
Oconee Unit 3, Capsule D

USE= 133.9 J, LSE= 3.0 J, CVT(1/2)= 90.C , Slope = 0.0195
CVT(41J) = 67. C , CVT(68J) = 90. C ,
Fluence = 1.450E+19 , Irr. Temp. = 292 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
JJ907	21.	70.	19.	14.	0.28	11.	10.
JJ904	52.	125.	37.	27.	0.56	22.	20.
JJ906	79.	175.	42.	31.	0.74	29.	30.
JJ912	121.	250.	107.	79.	1.68	66.	70.
JJ913	149.	300.	132.	97.	1.96	77.	90.
JJ909	191.	375.	123.	91.	2.08	82.	100.



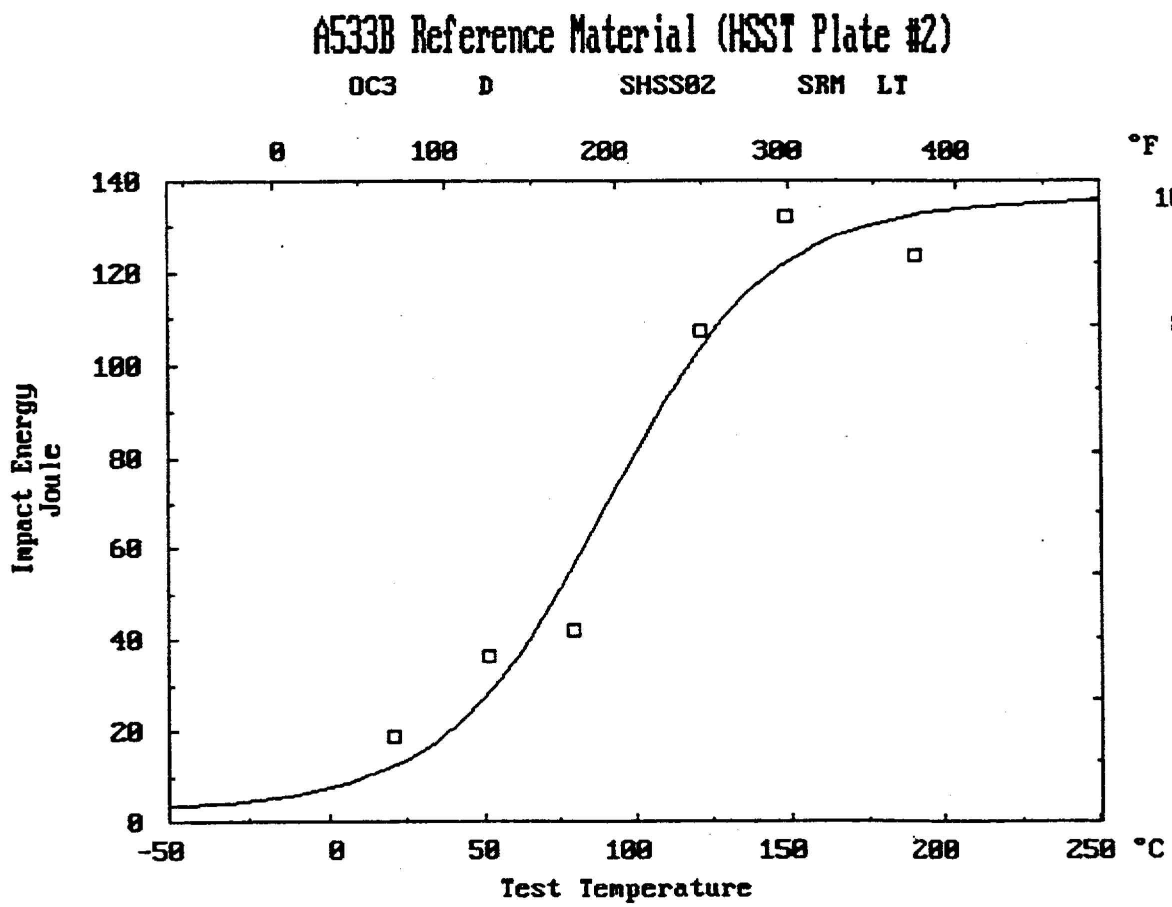
A533B HSST02 REFERENCE MATERIAL

Oconee Unit 3, Capsule D

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

OC3 D SHSS02 SRM LT : Fluence = 1.450E+19 , Irr. Temp. = 292

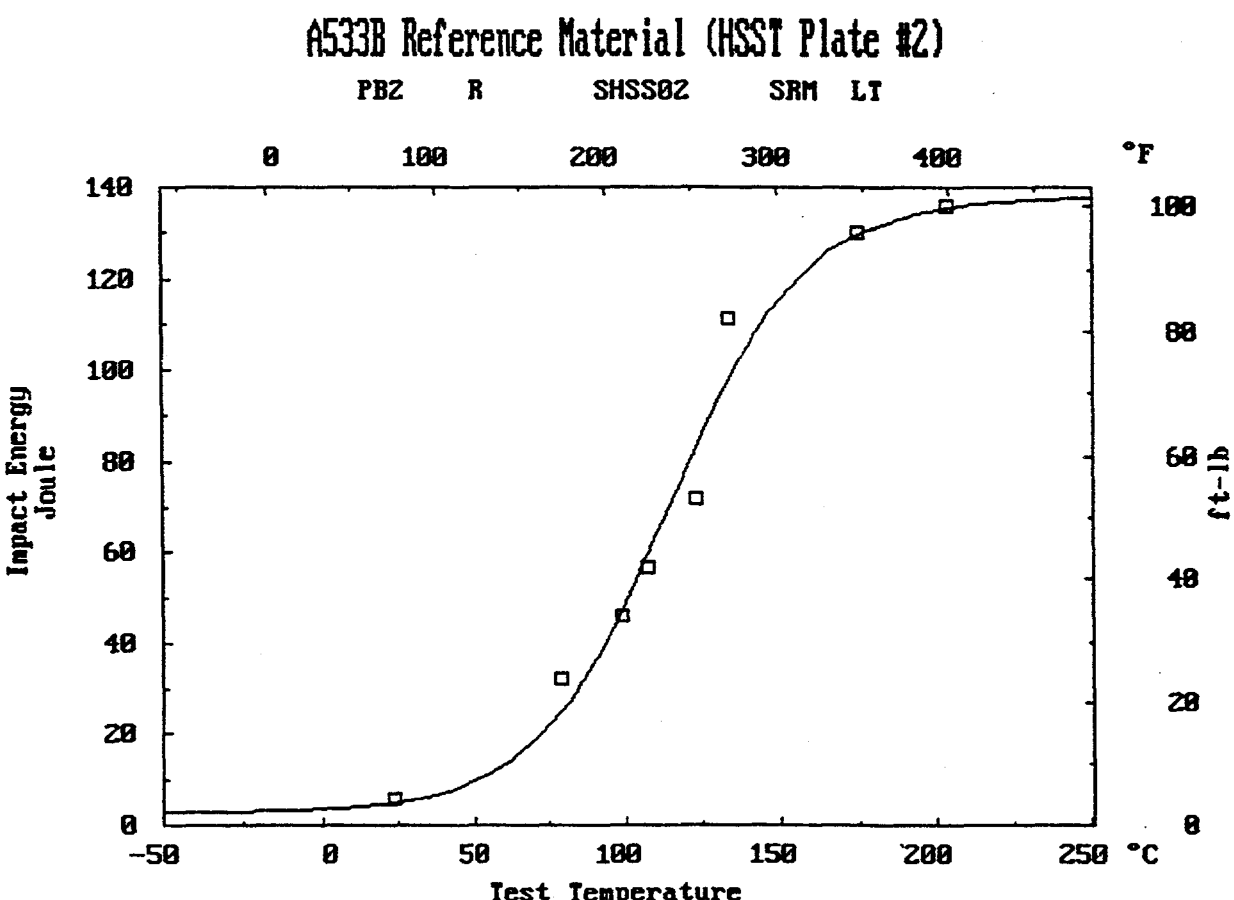
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	135.5	10.0	0.060				
CVT at Midpoint (C)	90.2	8.2	0.289	0.645			
1/slope (C)	53.5	13.0	-0.419	0.511	0.149		
CVT at 41 Joule (C)	65.6	9.2	0.517	-0.071	0.589	-0.686	
CVT at 68 Joule (C)	89.0	6.4	0.361	0.171	0.856	-0.190	0.837



A533B HSST02 REFERENCE MATERIAL
Point Beach Unit 2, Capsule R

USE= 137.6 J, LSE= 3.0 J, CVT(1/2)= 114.C , Slope = 0.0230
CVT(41J) = 94. C , CVT(68J) = 113. C ,
Fluence = 2.010E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R14	24.	75.	6.	4.	0.05	2.	5.
R12	79.	174.	33.	24.	0.66	26.	23.
R13	99.	210.	46.	34.	0.71	28.	34.
R11	107.	225.	57.	42.	0.99	39.	38.
R10	123.	253.	72.	53.	0.76	30.	62.
R9	134.	273.	111.	82.	1.52	60.	52.
R15	175.	347.	130.	96.	1.68	66.	100.
R16	204.	399.	136.	100.	2.01	79.	100.



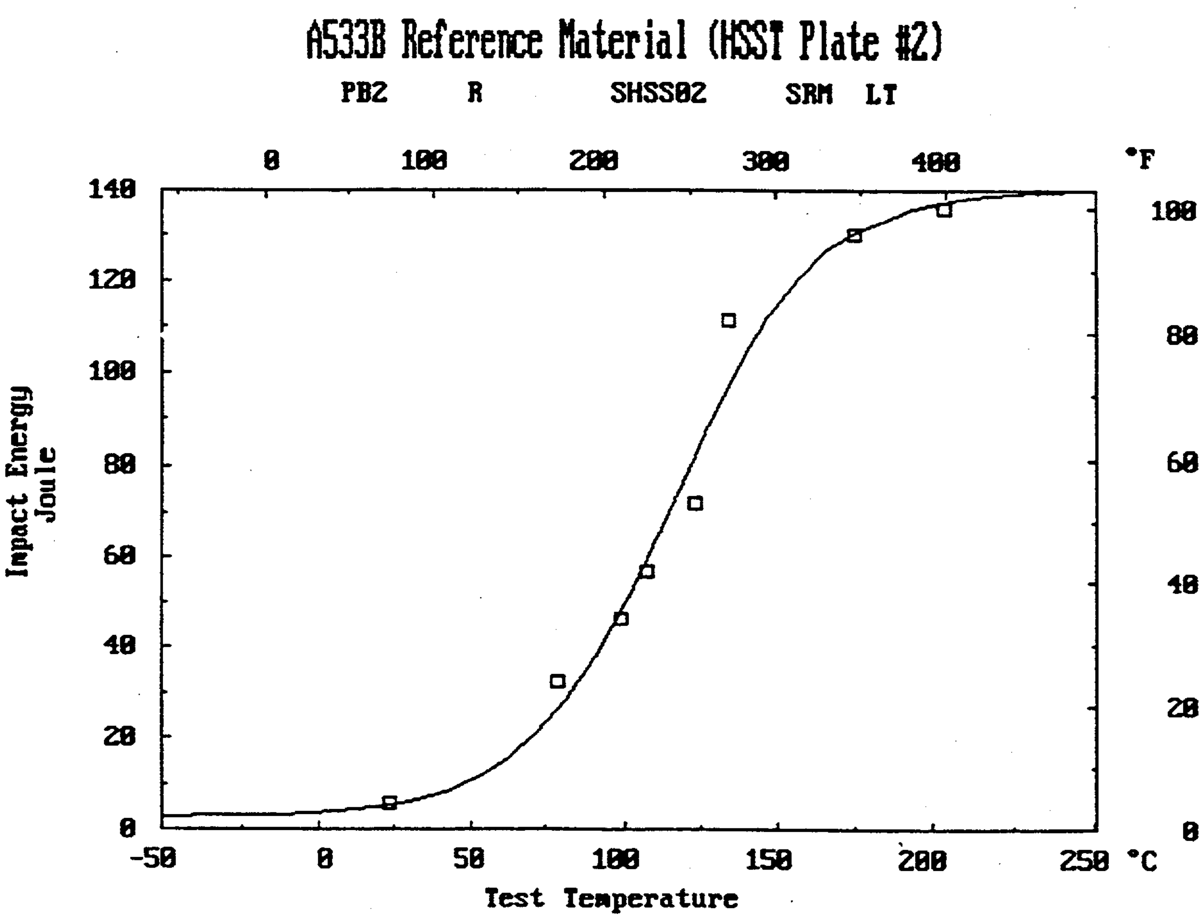
A533B HSST02 REFERENCE MATERIAL

Point Beach Unit 2, Capsule R

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
PB2    R      SHSS02     SRM  LT : Fluence = 2.010E+19 , Irr. Temp. =  304
```

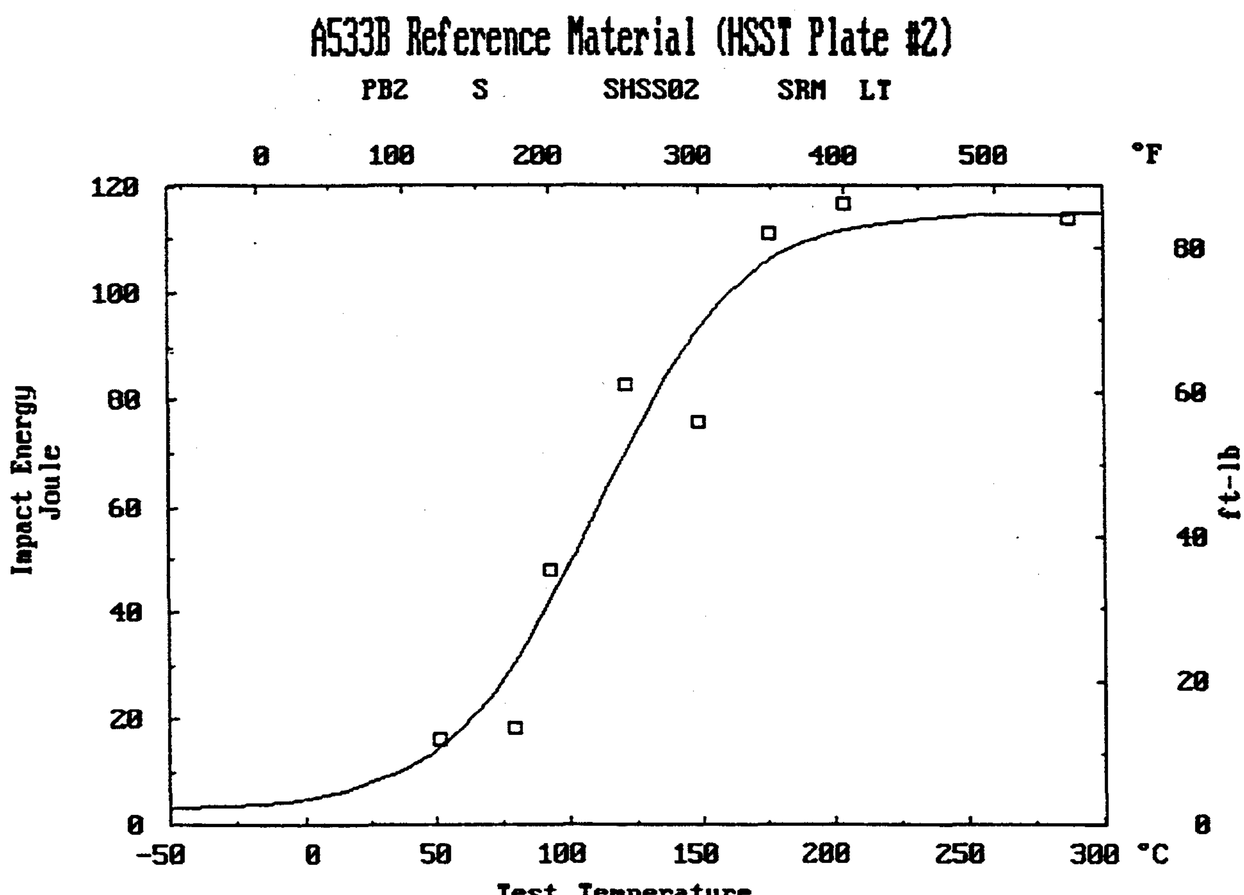
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	140.3	8.9	-0.085				
CVT at Midpoint (C)	115.6	5.8	0.115	0.708			
1/slope (C)	46.1	12.0	-0.356	0.400	0.306		
CVT at 41 Joule (C)	93.3	6.7	0.438	-0.057	0.364	-0.750	
CVT at 68 Joule (C)	113.0	4.2	0.279	0.214	0.819	-0.048	0.688



A533B HSST02 REFERENCE MATERIAL
Point Beach Unit 2, Capsule S

USE= 115.0 J, LSE= 3.0 J, CVT(1/2)= 110.C , Slope = 0.0185
CVT(41J) = 92. C , CVT(68J) = 119. C ,
Fluence = 3.470E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R18	52.	125.	16.	12.	0.25	10.	10.
R22	79.	175.	18.	13.	0.28	11.	45.
R20	93.	200.	48.	35.	0.76	30.	40.
R17	121.	250.	83.	61.	1.19	47.	60.
R21	149.	300.	76.	56.	1.24	49.	90.
R24	177.	350.	111.	82.	1.75	69.	100.
R23	204.	400.	117.	86.	1.80	71.	100.
R19	288.	550.	114.	84.	1.78	70.	100.



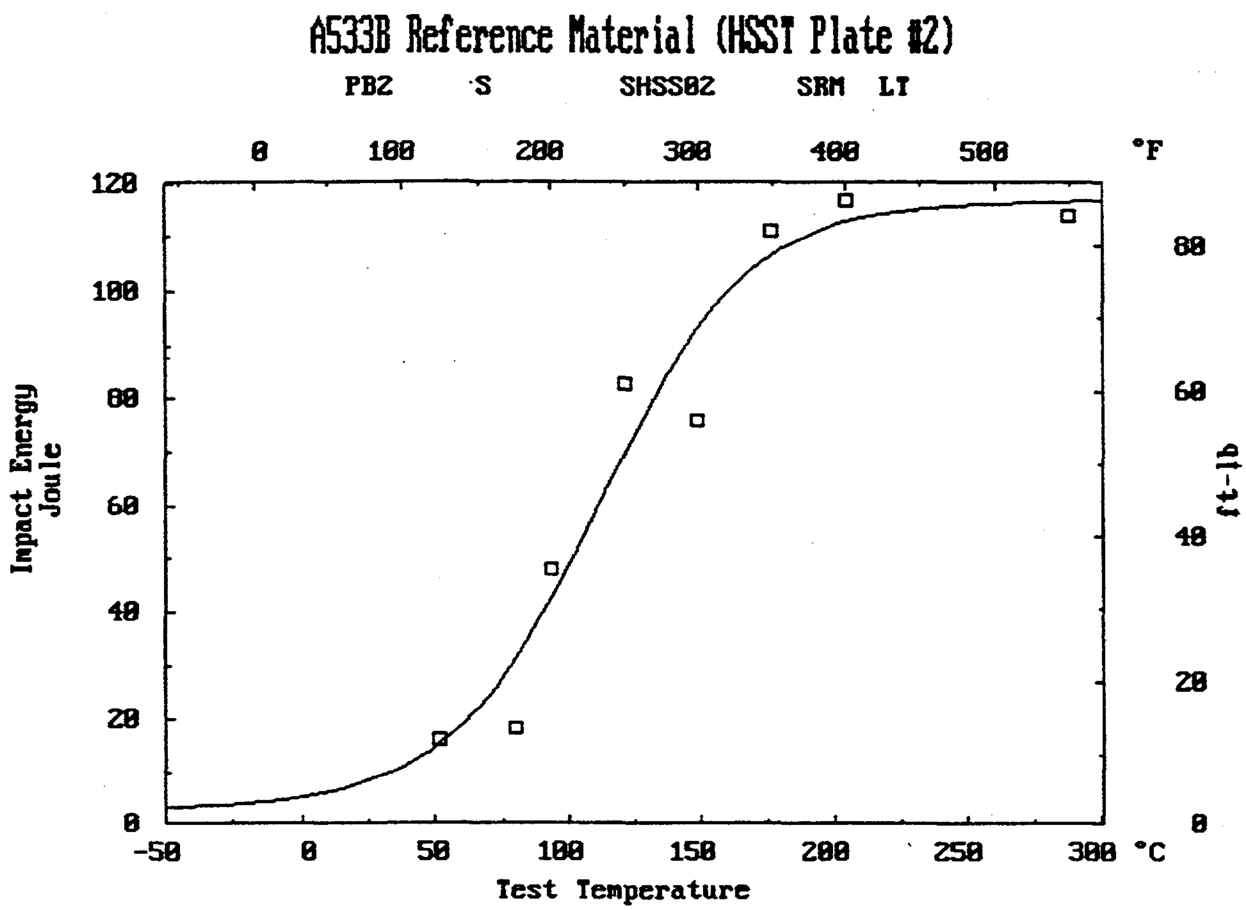
A533B HSST02 REFERENCE MATERIAL

Point Beach Unit 2, Capsule S

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

PB2 S SHSS02 SRM LT : Fluence = 3.470E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	116.8	8.0	-0.073				
CVT at Midpoint (C)	111.2	8.6	-0.001	0.683			
1/slope (C)	56.3	12.2	-0.012	0.603	0.456		
CVT at 41 Joule (C)	91.6	6.9	0.034	0.020	0.643	-0.333	
CVT at 68 Joule (C)	119.1	6.8	0.041	0.299	0.881	0.387	0.721

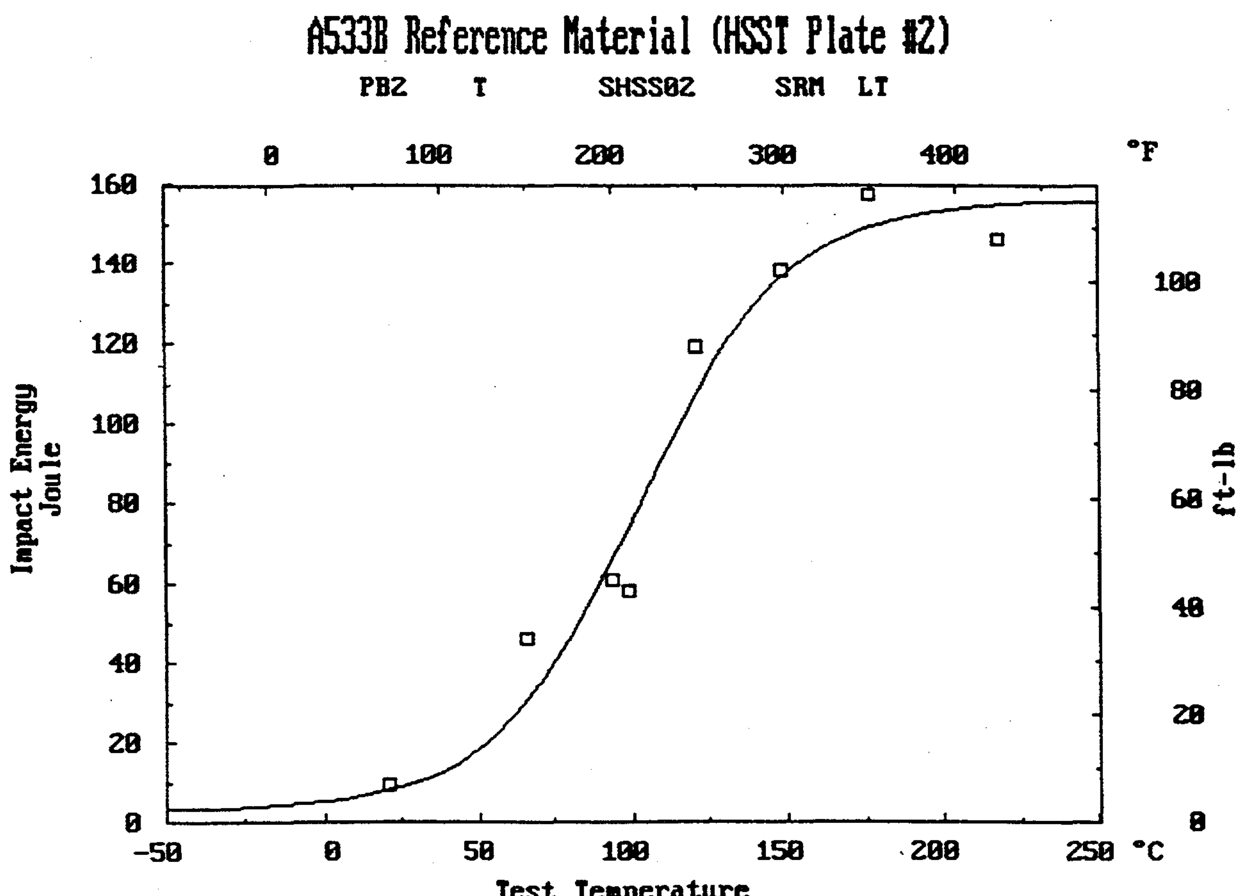


A533B HSST02 REFERENCE MATERIAL

Point Beach Unit 2, Capsule T

USE= 156.1 J, LSE= 3.0 J, CVT(1/2)= 102.C , Slope = 0.0209
CVT(41J) = 76. C , CVT(68J) = 95. C ,
Fluence = 9.450E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R30	21.	70.	9.	7.	0.08	3.	5.
R32	66.	150.	46.	34.	0.66	26.	20.
R26	93.	200.	61.	45.	0.86	34.	30.
R27	99.	210.	58.	43.	0.86	34.	40.
R31	121.	250.	119.	88.	1.57	62.	70.
R28	149.	300.	138.	102.	1.98	78.	100.
R25	177.	350.	157.	116.	2.13	84.	100.
R29	218.	425.	146.	108.	1.73	68.	100.



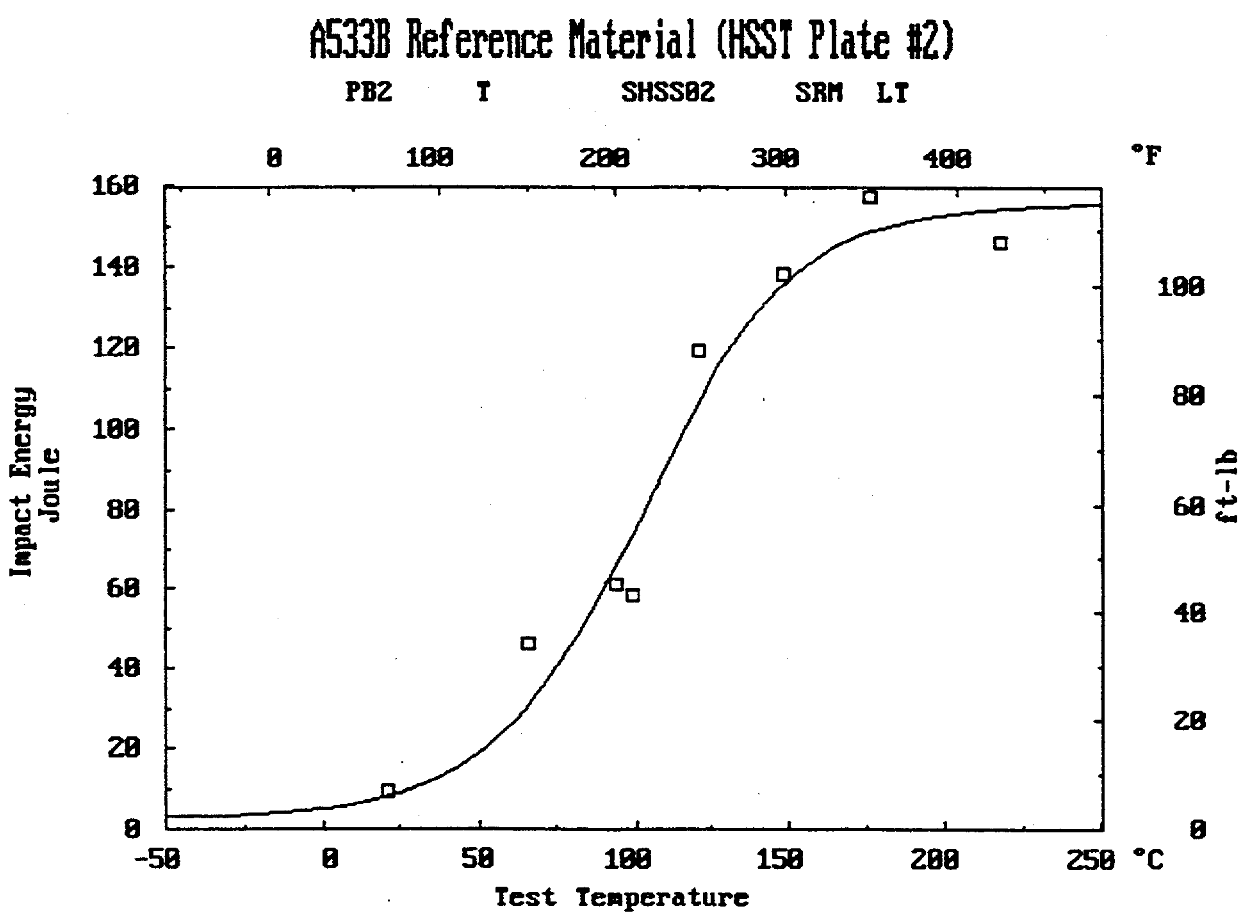
A533B HSST02 REFERENCE MATERIAL

Point Beach Unit 2, Capsule T

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

PB2 T SHSS02 SRM LT : Fluence = 9.450E+18 , Irr. Temp. = 304

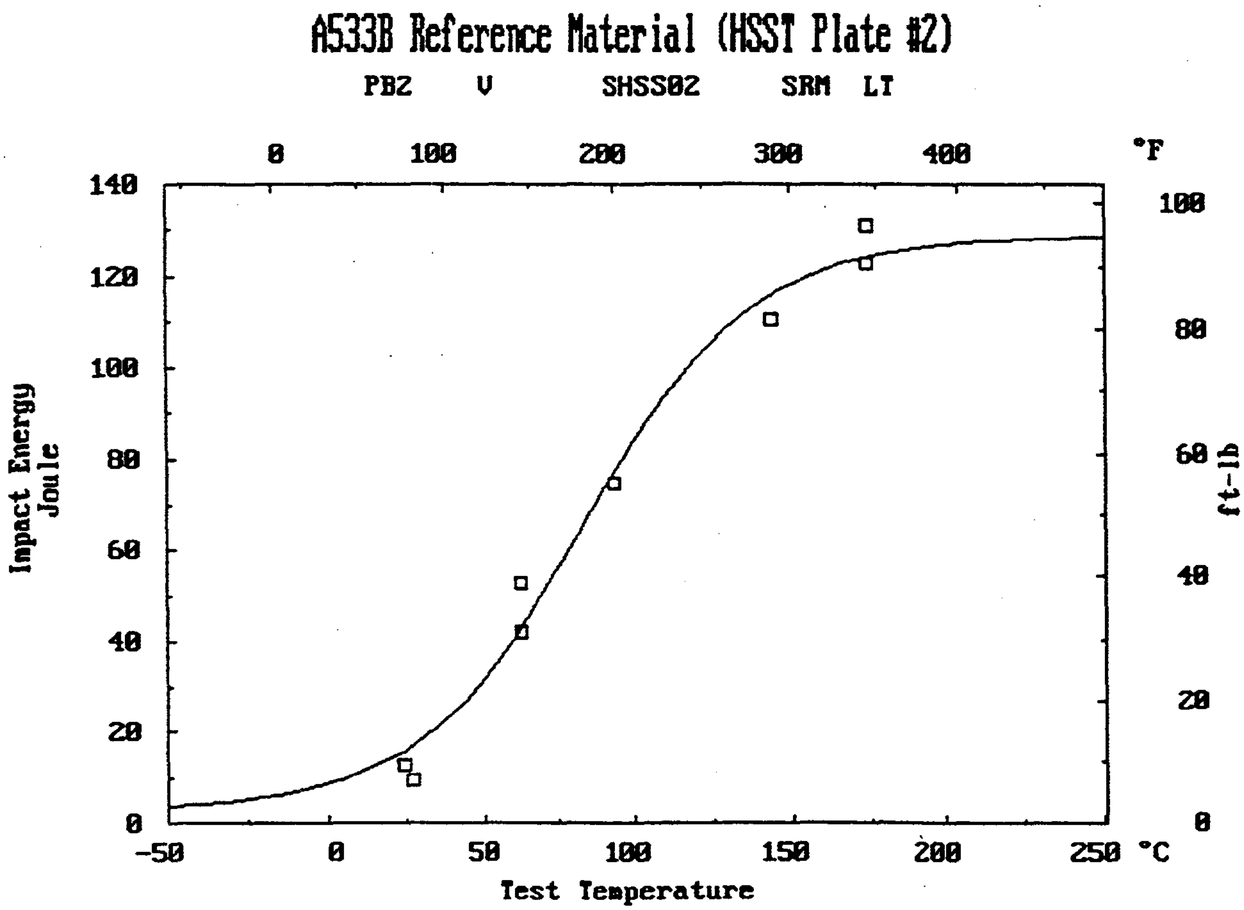
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	156.1	7.5	-0.060				
CVT at Midpoint (C)	102.5	5.1	0.265	0.503			
1/slope (C)	48.7	10.1	-0.357	0.553	0.121		
CVT at 41 Joule (C)	75.4	7.4	0.460	-0.292	0.486	-0.793	
CVT at 68 Joule (C)	95.0	4.9	0.407	-0.089	0.786	-0.430	0.888



A533B HSST02 REFERENCE MATERIAL
Point Beach Unit 2, Capsule V

USE= 128.6 J, LSE= 3.0 J, CVT(1/2)= 83.C , Slope = 0.0182
CVT(41J) = 61. C , CVT(68J) = 85. C ,
Fluence = 4.740E+18 , Irr. Temp. = 310 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R7	24.	76.	13.	9.	0.36	14.	10.
R2	27.	80.	9.	7.	0.28	11.	10.
R4	63.	145.	53.	39.	1.12	44.	25.
R5	63.	145.	42.	31.	0.91	36.	30.
R6	93.	200.	75.	55.	1.40	55.	50.
R8	143.	290.	110.	81.	1.93	76.	90.
R1	174.	345.	131.	96.	2.13	84.	100.
R3	174.	345.	123.	90.	2.24	88.	100.



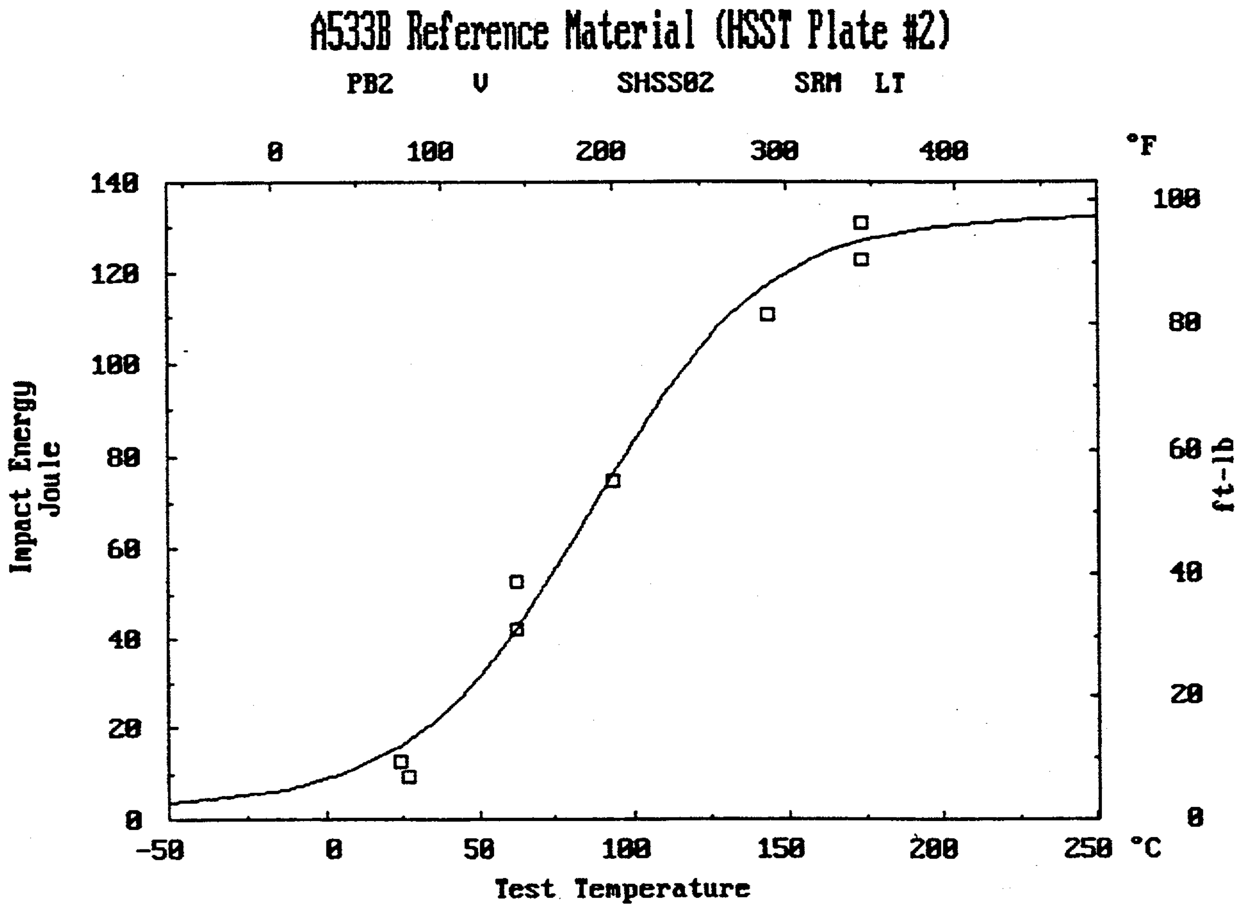
A533B HSST02 REFERENCE MATERIAL

Point Beach Unit 2, Capsule V

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PB2 V SHSS02 SRM LT : Fluence = 4.740E+18 , Irr. Temp. = 310

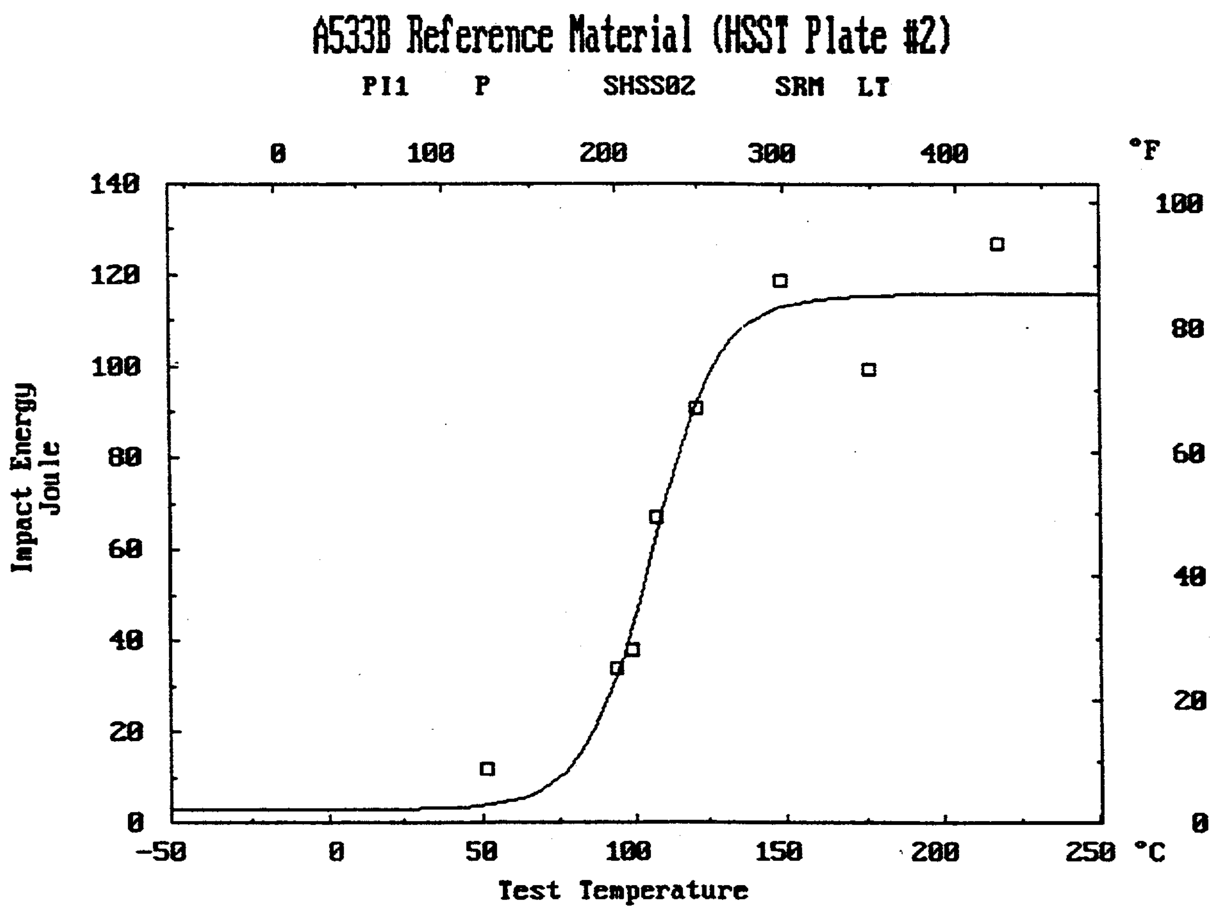
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	132.4	12.6	0.105				
CVT at Midpoint (C)	86.2	11.4	0.196	0.855			
1/slope (C)	56.7	14.9	0.222	0.769	0.774		
CVT at 41 Joule (C)	60.8	5.9	0.038	0.074	0.446	-0.171	
CVT at 68 Joule (C)	85.9	7.1	0.212	0.544	0.895	0.609	0.664



A533B HSST02 REFERENCE MATERIAL
Prairie Island Unit 1, Capsule P

USE= 115.7 J, LSE= 3.0 J, CVT(1/2)= 106.C , Slope = 0.0435
CVT(41J) = 98. C , CVT(68J) = 109. C ,
Fluence = 1.250E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R47	52.	125.	12.	9.	0.13	5.	9.
R44	93.	200.	34.	25.	0.53	21.	38.
R48	99.	210.	38.	28.	0.84	33.	34.
R43	107.	225.	67.	49.	0.91	36.	58.
R45	121.	250.	91.	67.	1.47	58.	65.
R41	149.	300.	119.	87.	1.19	47.	100.
R42	177.	350.	100.	73.	1.75	69.	100.
R46	218.	425.	127.	93.	1.55	61.	100.



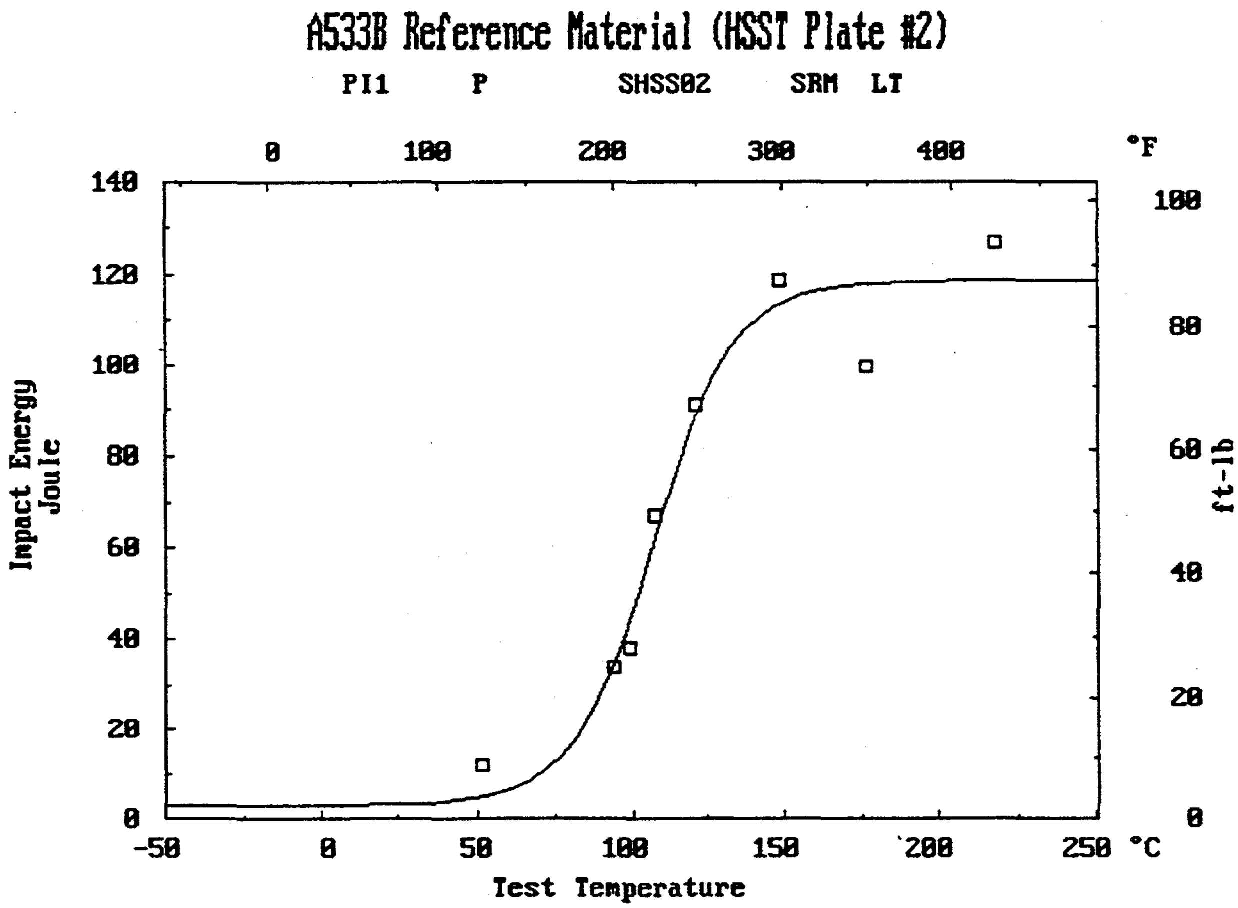
A533B HSST02 REFERENCE MATERIAL

Prairie Island Unit 1, Capsule P

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

PI1 P SHSS02 SRM LT : Fluence = 1.250E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	118.6	6.5	-0.058				
CVT at Midpoint (C)	106.8	4.1	0.084	0.540			
1/slope (C)	27.0	9.4	-0.244	0.492	0.303		
CVT at 41 Joule (C)	97.0	4.5	0.271	-0.159	0.513	-0.637	
CVT at 68 Joule (C)	110.0	3.6	0.045	0.237	0.914	0.354	0.486

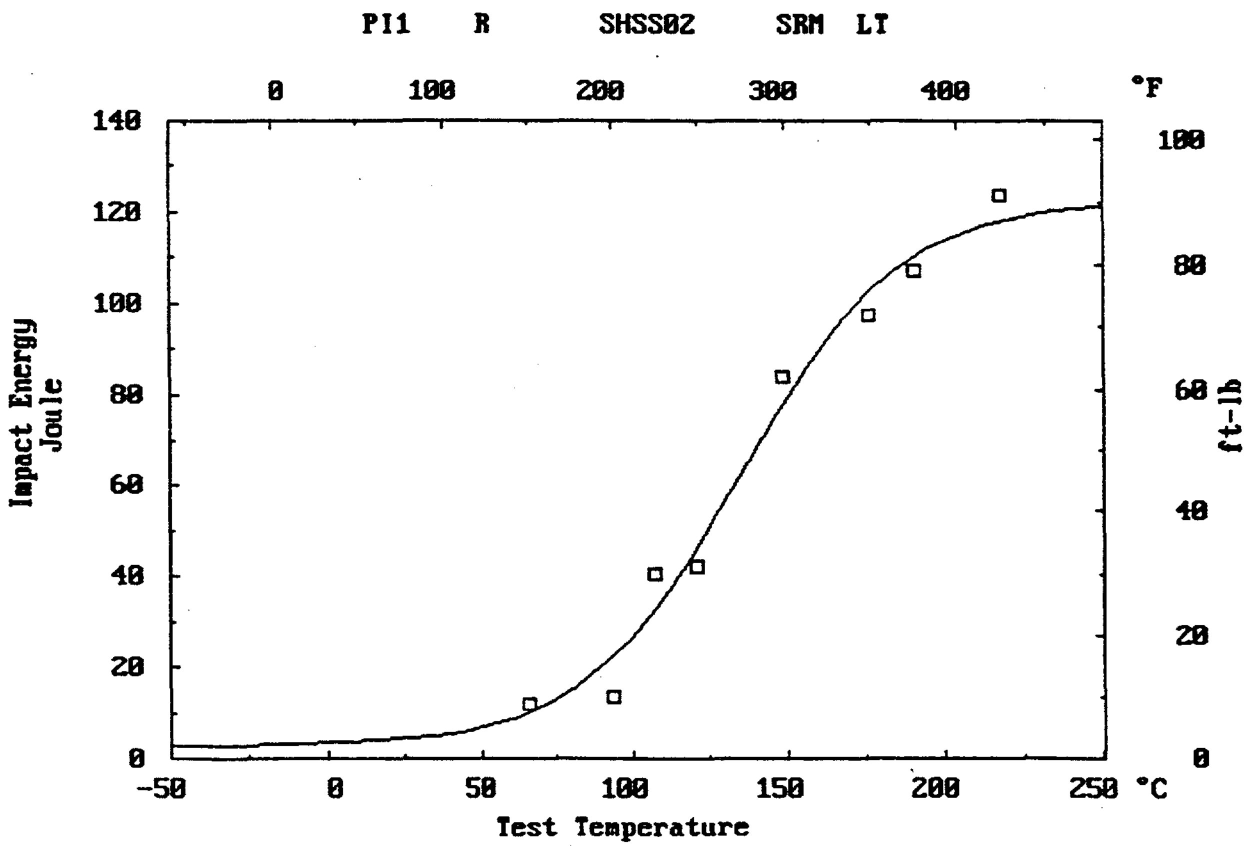


A533B HSST02 REFERENCE MATERIAL
Prairie Island Unit 1, Capsule R

USE= 122.3 J, LSE= 3.0 J, CVT(1/2)= 135.C , Slope = 0.0198
CVT(41J) = 116. C , CVT(68J) = 140. C ,
Fluence = 4.030E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R9	66.	150.	12.	9.	0.15	6.	13.
R14	93.	200.	14.	10.	0.25	10.	23.
R15	107.	225.	41.	30.	0.58	23.	32.
R12	121.	250.	42.	31.	0.46	18.	32.
R16	149.	300.	84.	62.	1.04	41.	59.
R13	177.	350.	98.	72.	1.42	56.	100.
R11	191.	375.	107.	79.	0.99	39.	100.
R10	218.	425.	123.	91.	1.78	70.	100.

A533B Reference Material (HSST Plate #2)



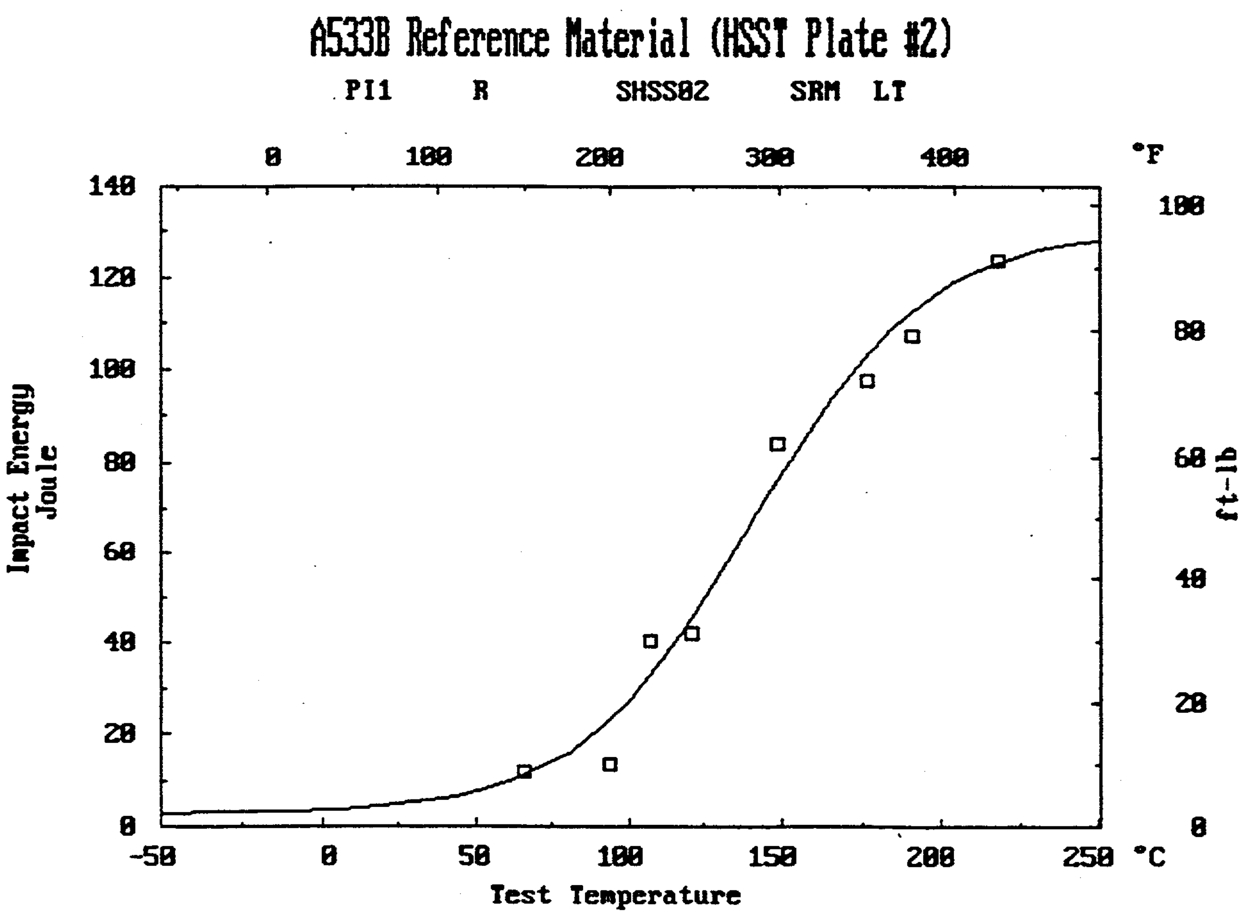
A533B HSST02 REFERENCE MATERIAL

Prairie Island Unit 1, Capsule R

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PI1 R SHSS02 SRM LT : Fluence = 4.030E+19 , Irr. Temp. = 304

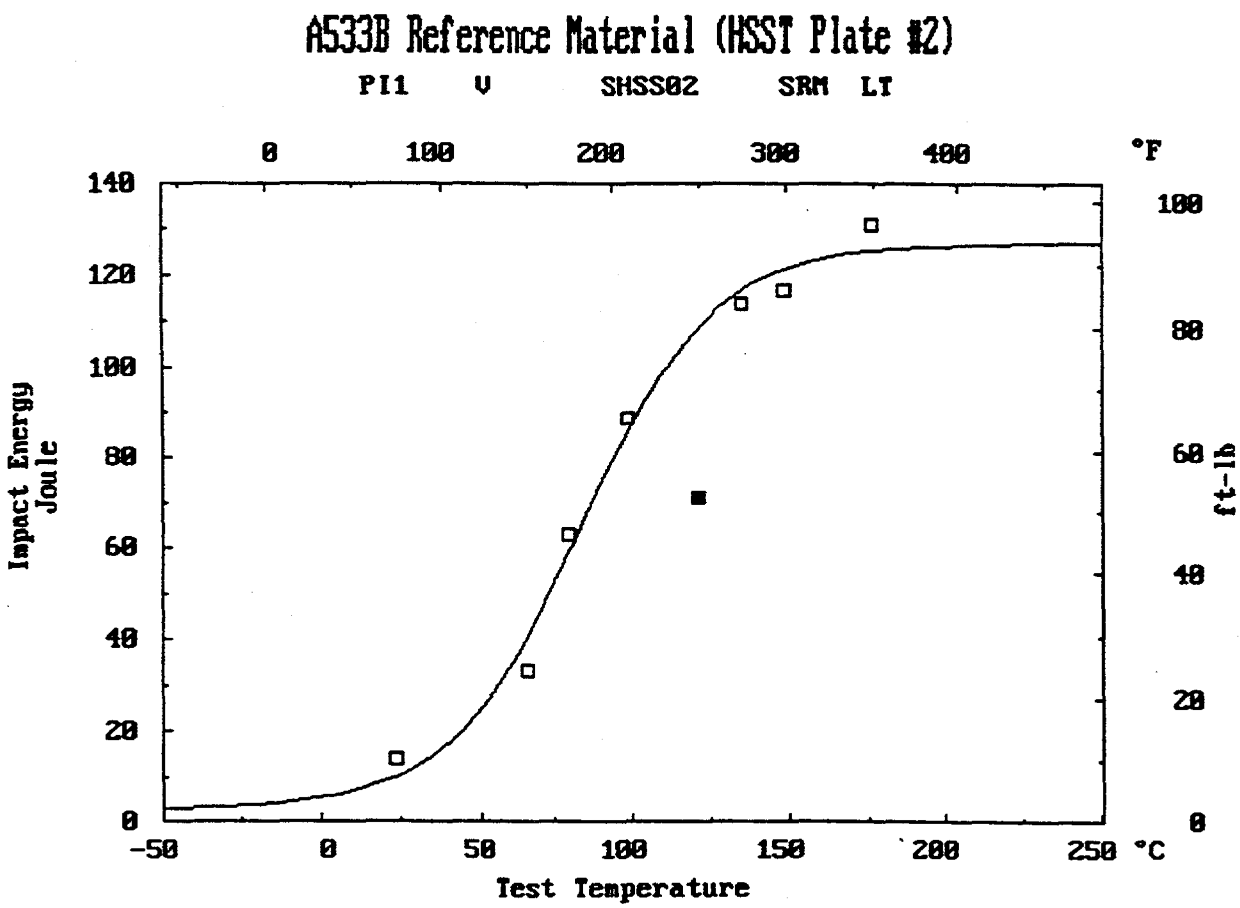
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	130.6	18.2	-0.175				
CVT at Midpoint (C)	140.4	12.6	-0.136	0.916			
1/slope (C)	55.8	15.3	-0.129	0.833	0.822		
CVT at 41 Joule (C)	115.8	5.5	-0.008	-0.013	0.292	-0.232	
CVT at 68 Joule (C)	140.8	6.3	-0.086	0.522	0.810	0.578	0.633



A533B HSST02 REFERENCE MATERIAL
Prairie Island Unit 1, Capsule V

USE= 126.8 J, LSE= 3.0 J, CVT(1/2)= 84.C , Slope = 0.0234
CVT(41J) = 66. C , CVT(68J) = 86. C ,
Fluence = 5.210E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R3	24.	75.	14.	10.	0.05	2.	10.
R7	66.	150.	33.	25.	0.46	18.	20.
R1	79.	175.	63.	46.	0.91	36.	35.
R2	99.	210.	89.	65.	1.19	47.	50.
*R8	121.	250.	71.	52.	1.17	46.	50.
R5	135.	275.	114.	84.	1.50	59.	70.
R6	149.	300.	117.	86.	1.73	68.	100.
R4	177.	350.	131.	96.	1.93	76.	100.



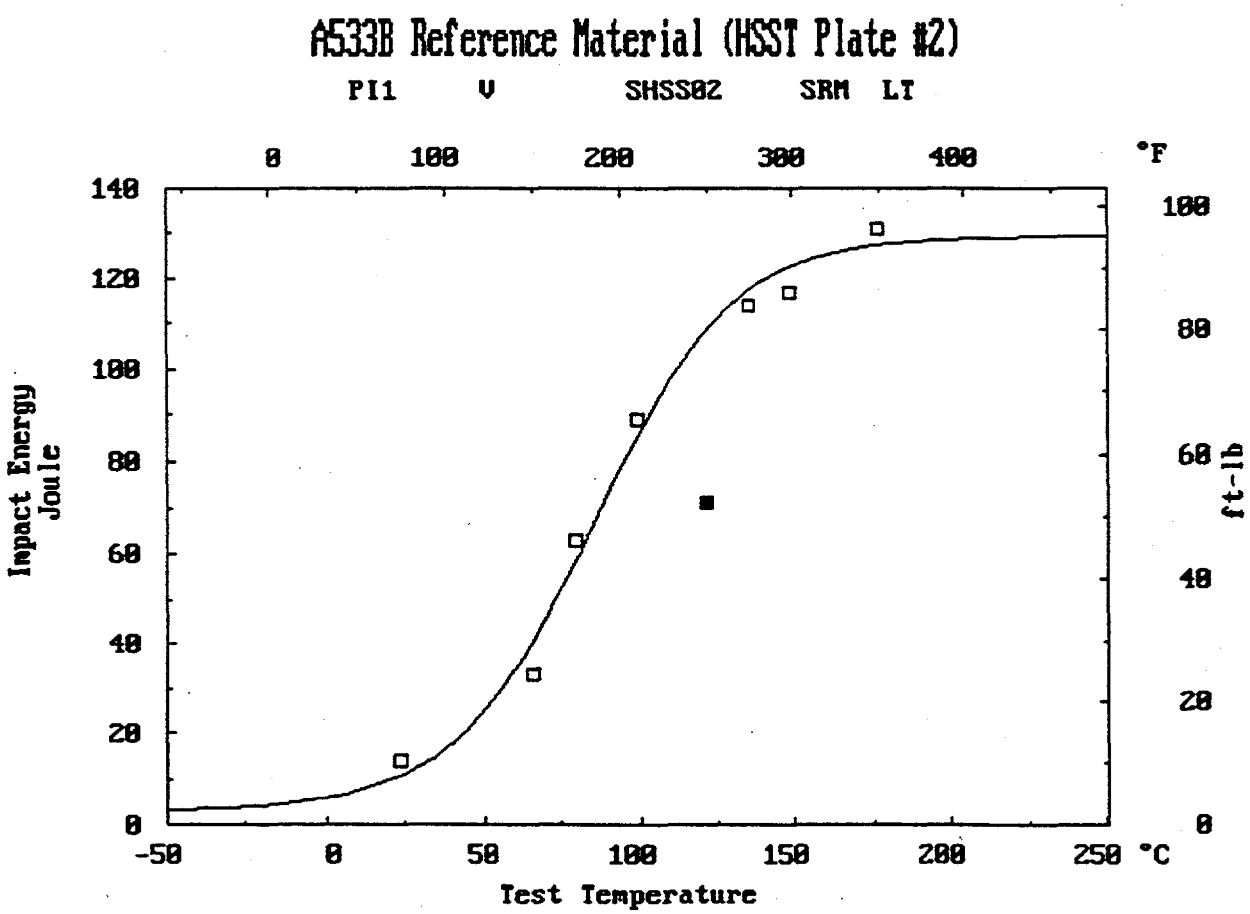
A533B HSST02 REFERENCE MATERIAL

Prairie Island Unit 1, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

PI1 V SHSS02 SRM LT : Fluence = 5.210E+18 , Irr. Temp. = 304

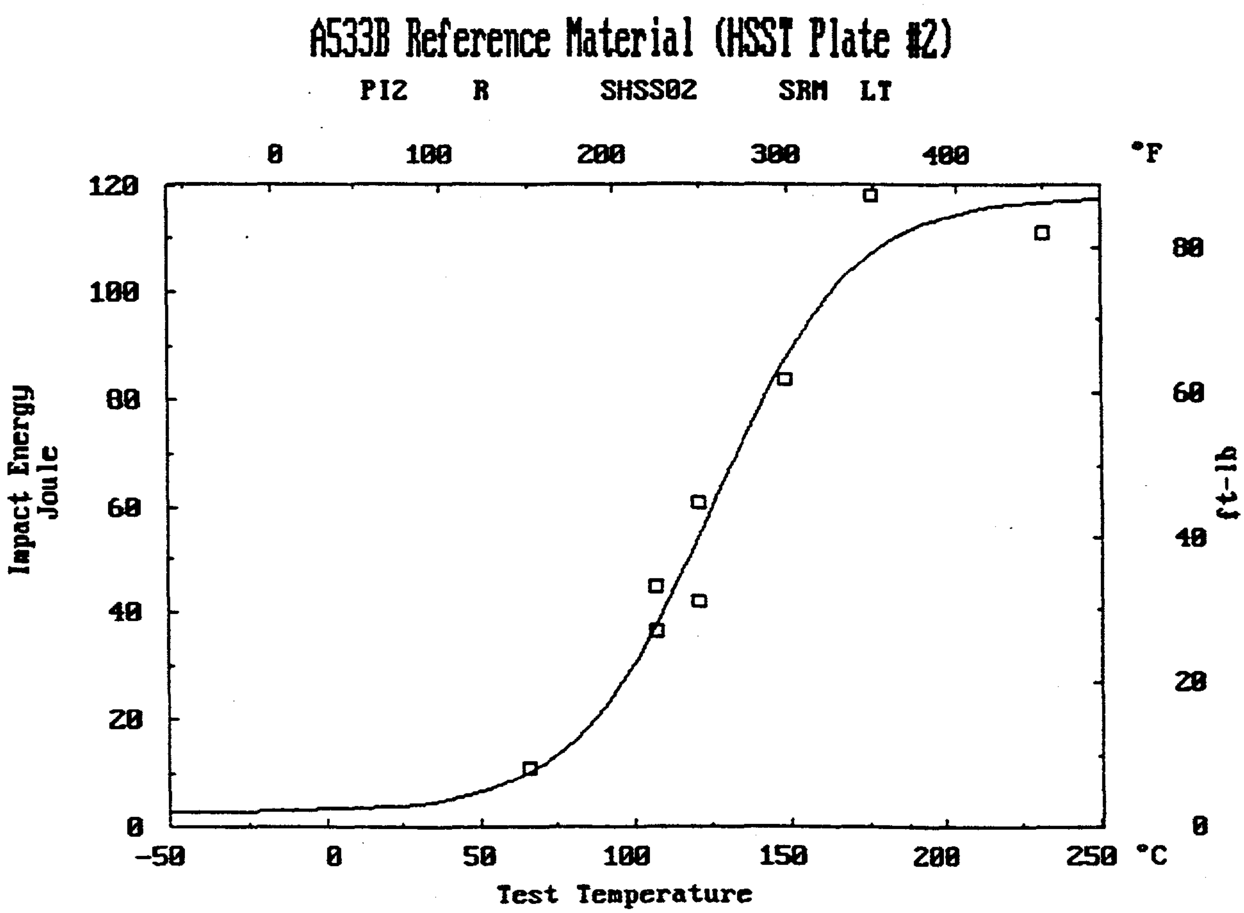
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	129.3	12.0	-0.127				
CVT at Midpoint (C)	84.9	8.0	-0.074	0.809			
1/slope (C)	44.5	14.1	-0.179	0.768	0.627		
CVT at 41 Joule (C)	65.6	6.1	0.150	-0.252	0.220	-0.591	
CVT at 68 Joule (C)	85.6	4.9	-0.007	0.395	0.846	0.338	0.547



A533B HSST02 REFERENCE MATERIAL
Prairie Island Unit 2, Capsule R

USE= 117.7 J, LSE= 3.0 J, CVT(1/2)= 126.C , Slope = 0.0228
CVT(41J) = 110. C , CVT(68J) = 132. C ,
Fluence = 4.420E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R15	66.	150.	11.	8.	0.25	10.	13.
R10	107.	225.	37.	27.	0.74	29.	33.
R16	107.	225.	45.	33.	0.66	26.	41.
R11	121.	250.	61.	45.	0.86	34.	56.
R9	121.	250.	42.	31.	0.63	25.	46.
R14	149.	300.	84.	62.	1.42	56.	100.
R12	177.	350.	118.	87.	1.78	70.	100.
R13	232.	450.	111.	82.	1.37	54.	100.



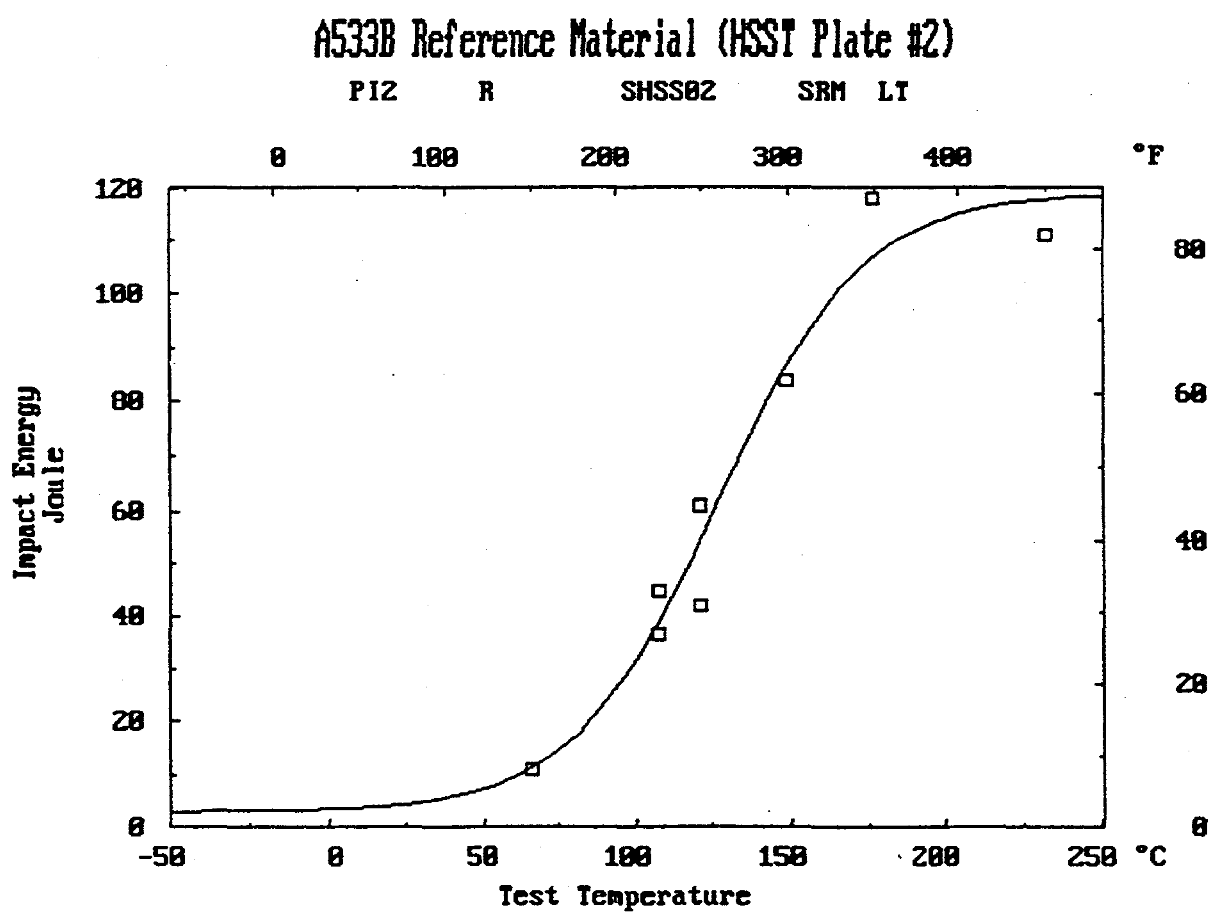
A533B HSST02 REFERENCE MATERIAL

Prairie Island Unit 2, Capsule R

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PI2 R SHSS02 SRM LT : Fluence = 4.420E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	119.2	10.4	-0.029				
CVT at Midpoint (C)	126.4	6.8	0.066	0.760			
1/slope (C)	46.8	11.8	-0.158	0.497	0.395		
CVT at 41 Joule (C)	109.3	5.7	0.233	-0.046	0.439	-0.585	
CVT at 68 Joule (C)	131.9	4.6	0.116	0.190	0.748	0.321	0.540



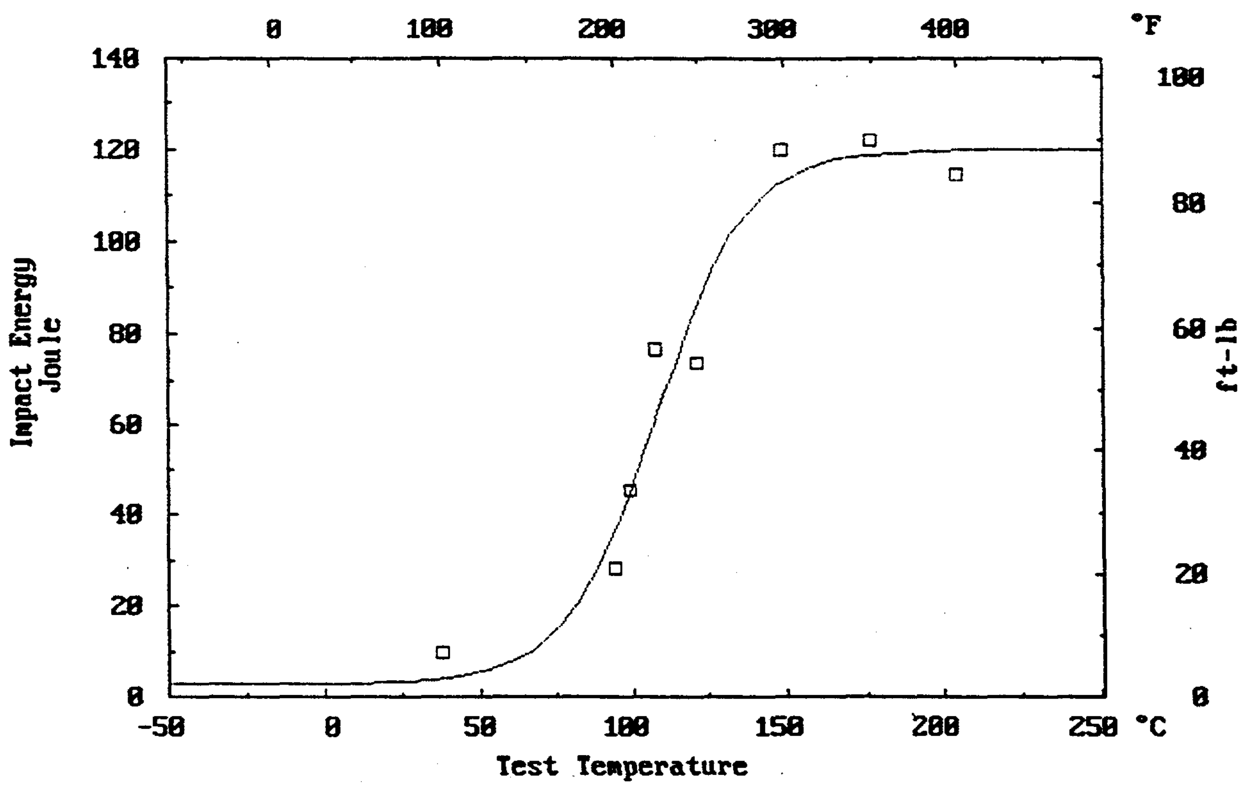
A533B HSST02 REFERENCE MATERIAL
Prairie Island Unit 2, Capsule T

USE= 120.0 J, LSE= 3.0 J, CVT(1/2)= 107.C , Slope = 0.0333
CVT(41J) = 96. C , CVT(68J) = 111. C ,
Fluence = 1.050E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R31	38.	100.	10.	8.	0.15	6.	14.
R32	93.	200.	28.	21.	0.46	18.	25.
R25	99.	210.	45.	33.	0.71	28.	30.
R27	107.	225.	77.	56.	1.19	47.	53.
R28	121.	250.	74.	54.	1.04	41.	62.
R30	149.	300.	120.	88.	2.01	79.	100.
R29	177.	350.	122.	90.	1.75	69.	100.
R26	204.	400.	115.	84.	2.01	79.	100.

A533B Reference Material (HSST Plate #2)

PI2 T SHSS02 SRM LT



A533B HSST02 REFERENCE MATERIAL

Prairie Island Unit 2, Capsule T

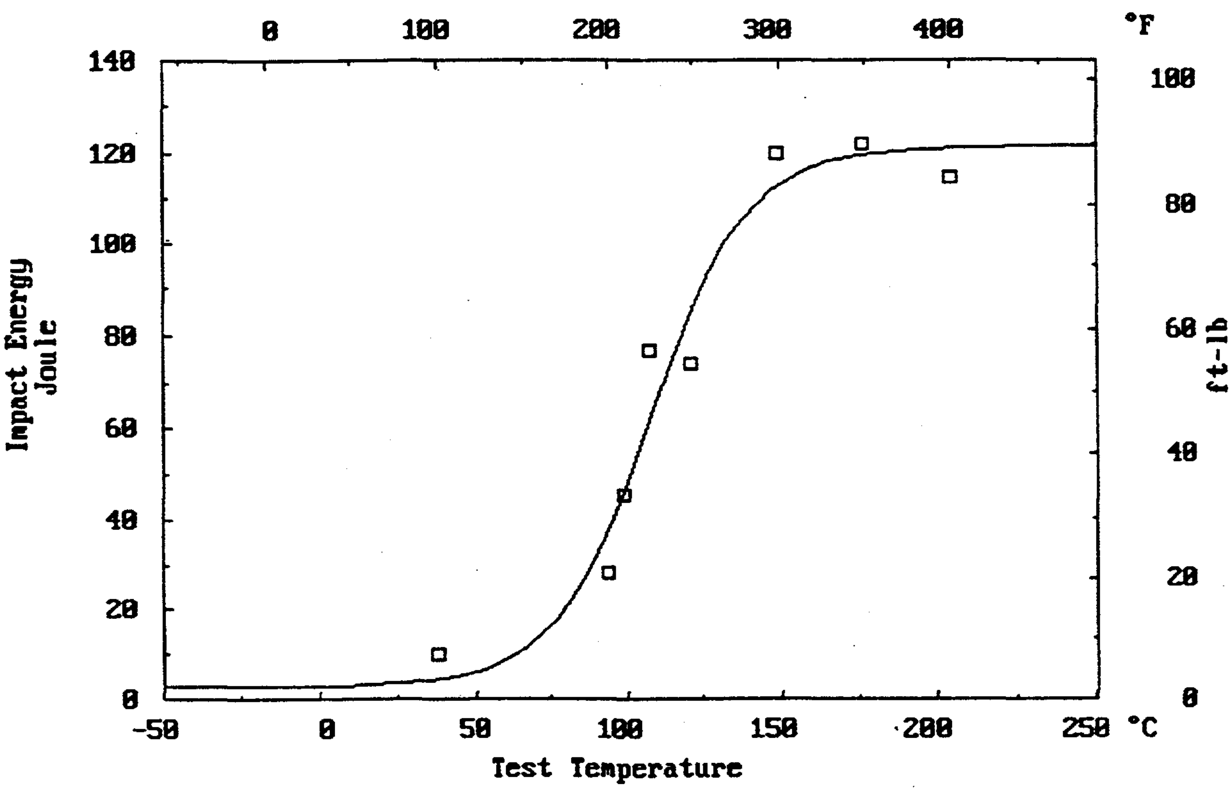
Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PI2 T SHSS02 SRM LT : Fluence = 1.050E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	121.4	6.1	-0.060				
CVT at Midpoint (C)	107.7	4.2	0.025	0.455			
1/slope (C)	32.0	8.0	-0.184	0.402	0.131		
CVT at 41 Joule (C)	95.6	4.9	0.148	-0.122	0.667	-0.617	
CVT at 68 Joule (C)	110.8	3.8	0.015	0.073	0.900	0.144	0.680

A533B Reference Material (HSST Plate #2)

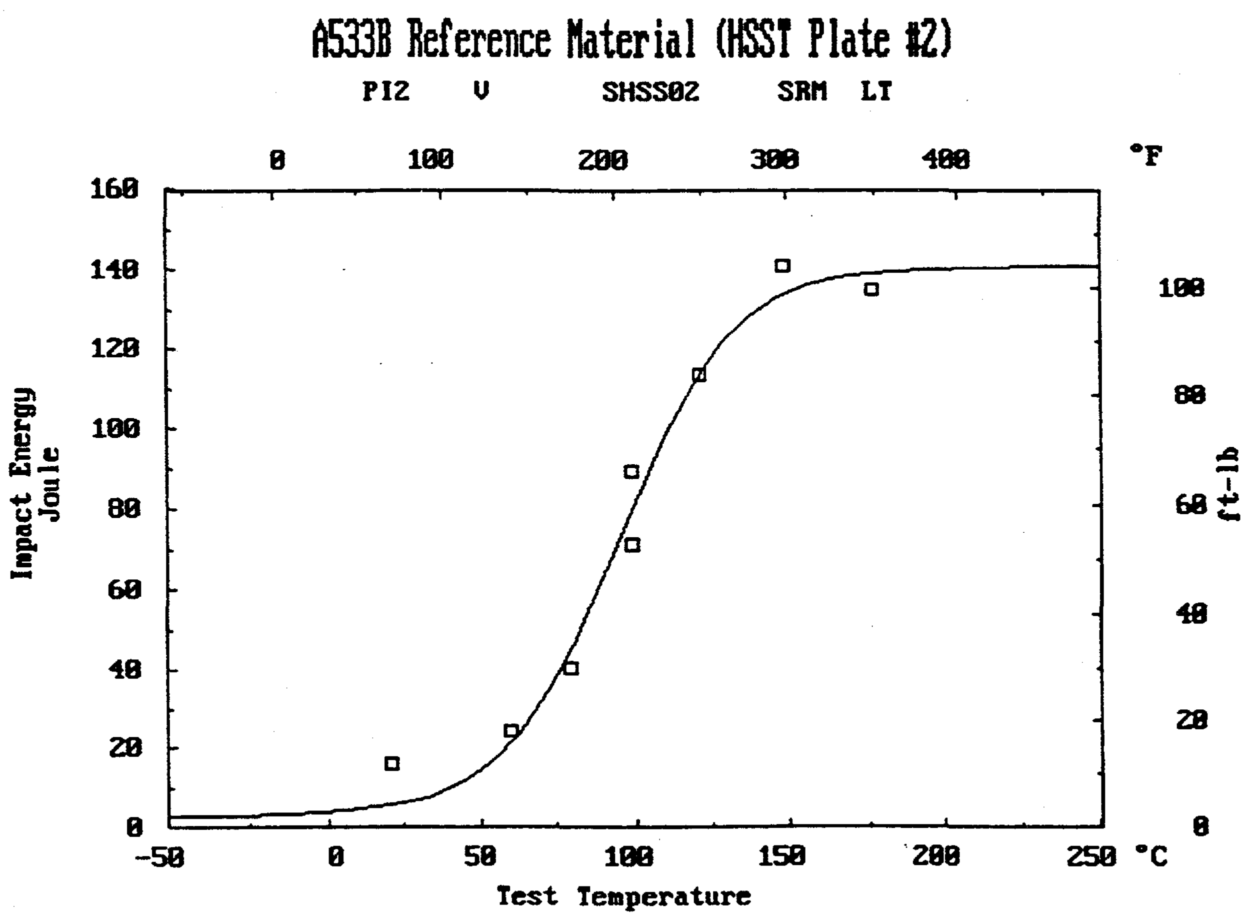
PI2 T SHSS02 SRM LT



A533B HSST02 REFERENCE MATERIAL
Prairie Island Unit 2, Capsule V

USE= 141.1 J, LSE= 3.1 J, CVT(1/2)= 95.C , Slope = 0.0271
CVT(41J) = 77. C , CVT(68J) = 93. C ,
Fluence = 5.490E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R5	21.	70.	16.	12.	0.18	7.	5.
R8	60.	140.	24.	18.	0.41	16.	30.
R3	79.	175.	41.	30.	0.66	26.	40.
R2	99.	210.	89.	66.	1.02	40.	50.
R7	99.	210.	71.	52.	0.81	32.	50.
R6	121.	250.	114.	84.	1.19	47.	80.
R1	149.	300.	141.	104.	1.55	61.	100.
R4	177.	350.	135.	99.	1.65	65.	100.



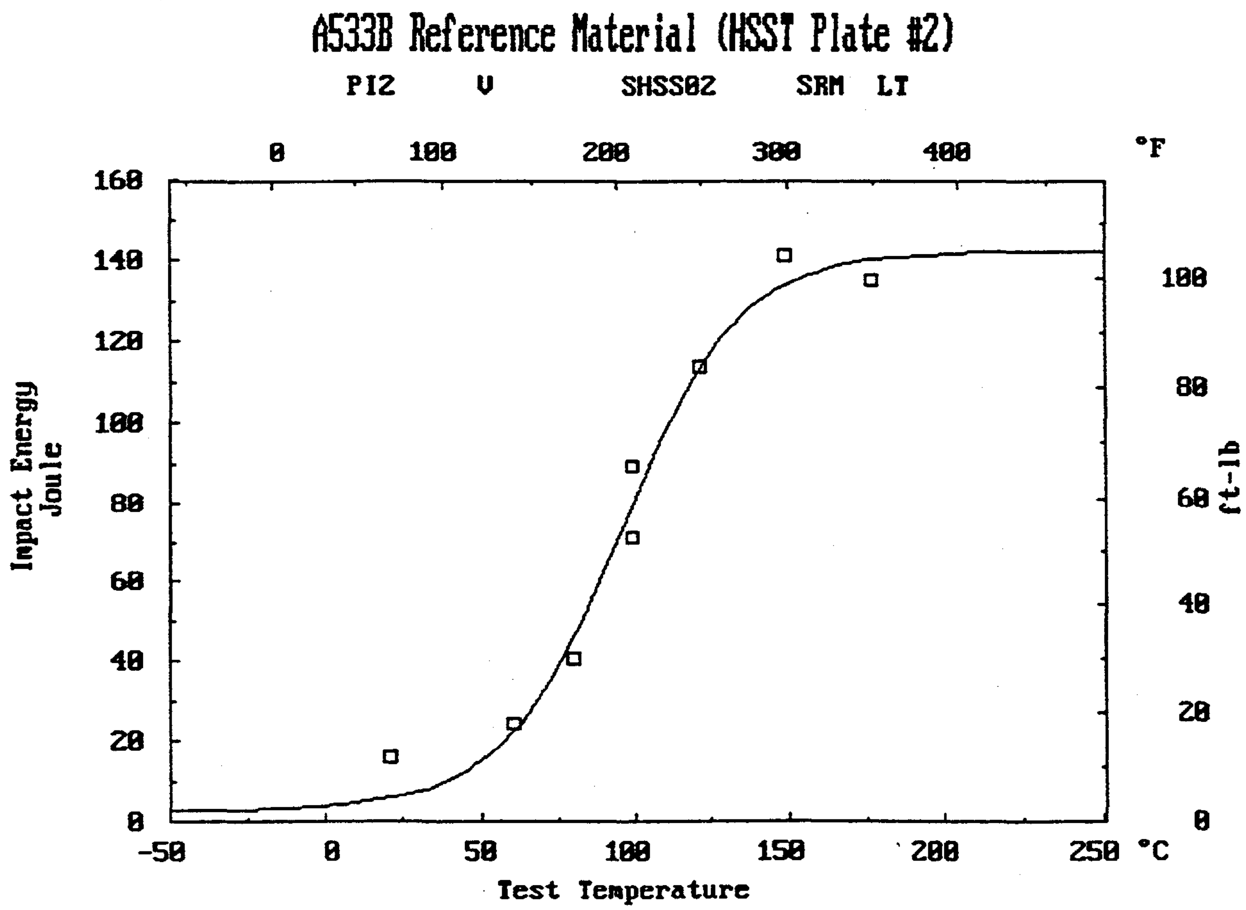
A533B HSST02 REFERENCE MATERIAL

Prairie Island Unit 2, Capsule V

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

PI2 V SHSS02 SRM LT : Fluence = 5.490E+18 , Irr. Temp. = 304

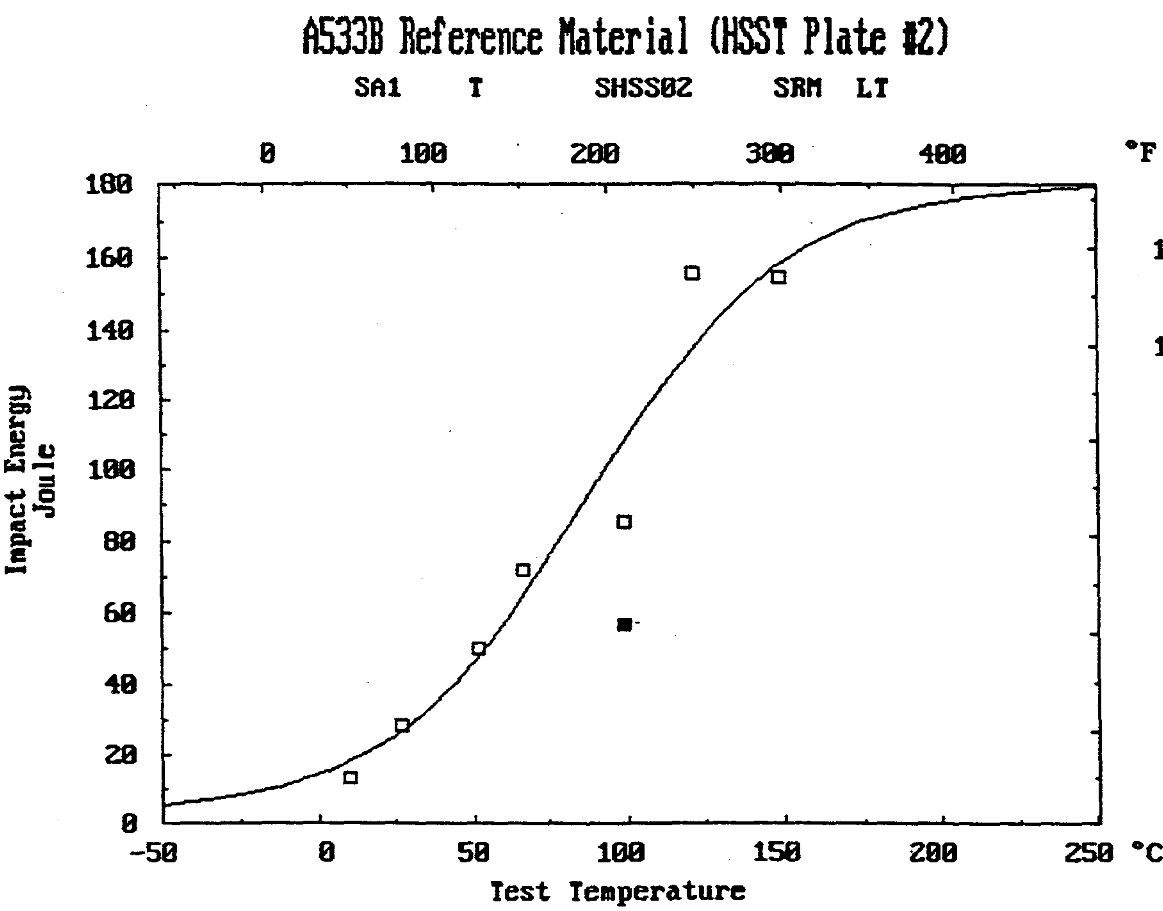
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	142.2	8.5	0.000				
CVT at Midpoint (C)	95.0	4.6	0.142	0.598			
1/slope (C)	38.3	9.7	-0.284	0.494	0.173		
CVT at 41 Joule (C)	76.1	6.2	0.313	-0.211	0.444	-0.784	
CVT at 68 Joule (C)	92.3	3.8	0.194	0.036	0.805	-0.260	0.798



A533B HSST02 REFERENCE MATERIAL
Salem Unit 1, Capsule T

USE= 180.8 J, LSE= 3.0 J, CVT(1/2)= 87.C , Slope = 0.0156
CVT(41J) = 45. C , CVT(68J) = 69. C ,
Fluence = 2.560E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R2	10.	50.	14.	10.	0.23	9.	1.
R1	27.	80.	28.	21.	0.36	14.	10.
R8	52.	125.	50.	37.	0.81	32.	25.
R6	66.	151.	72.	53.	1.04	41.	35.
R3	99.	210.	85.	63.	1.37	54.	65.
*R7	99.	210.	57.	42.	1.09	43.	45.
R5	121.	250.	156.	115.	2.18	86.	95.
R4	149.	300.	155.	114.	2.06	81.	100.



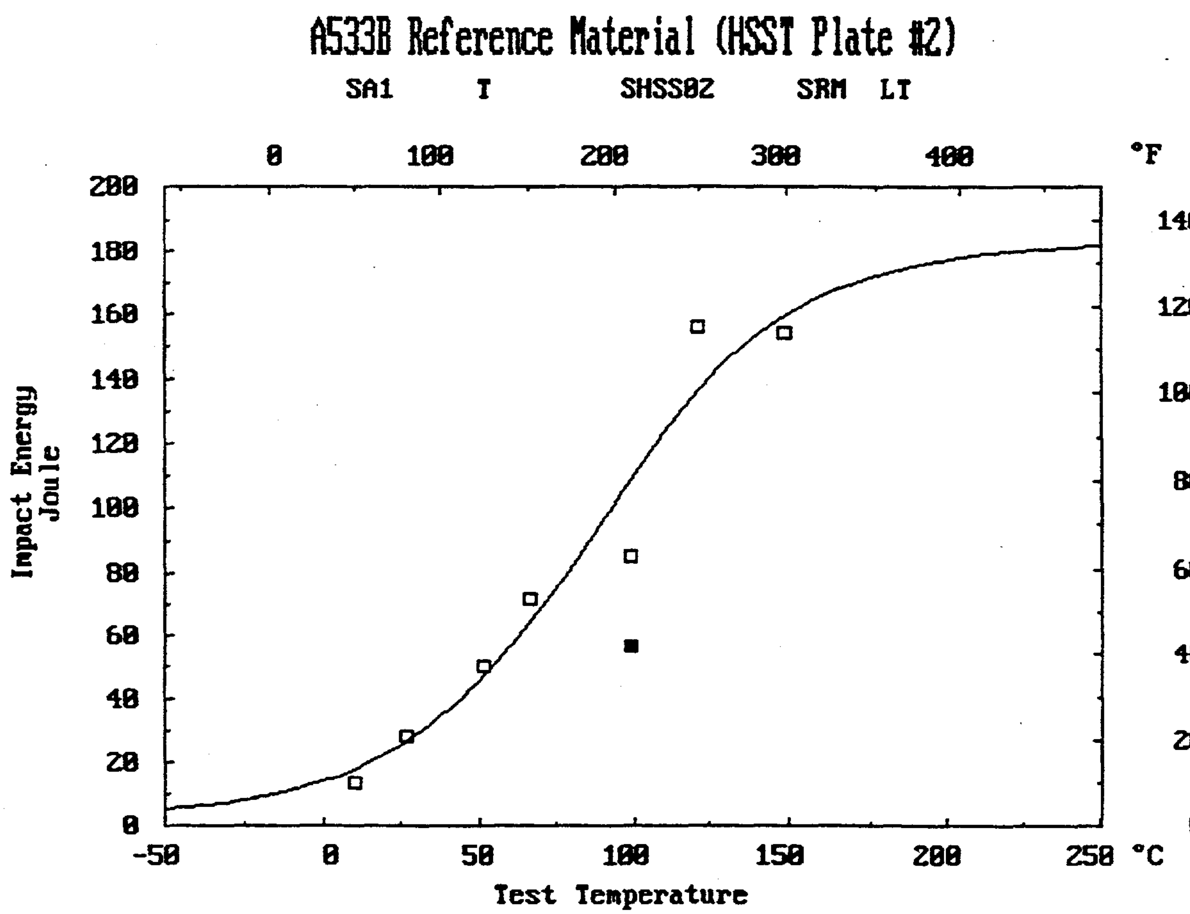
A533B HSST02 REFERENCE MATERIAL

Salem Unit 1, Capsule T

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SA1 T SHSS02 SRM LT : Fluence = 2.560E+18 , Irr. Temp. = 304

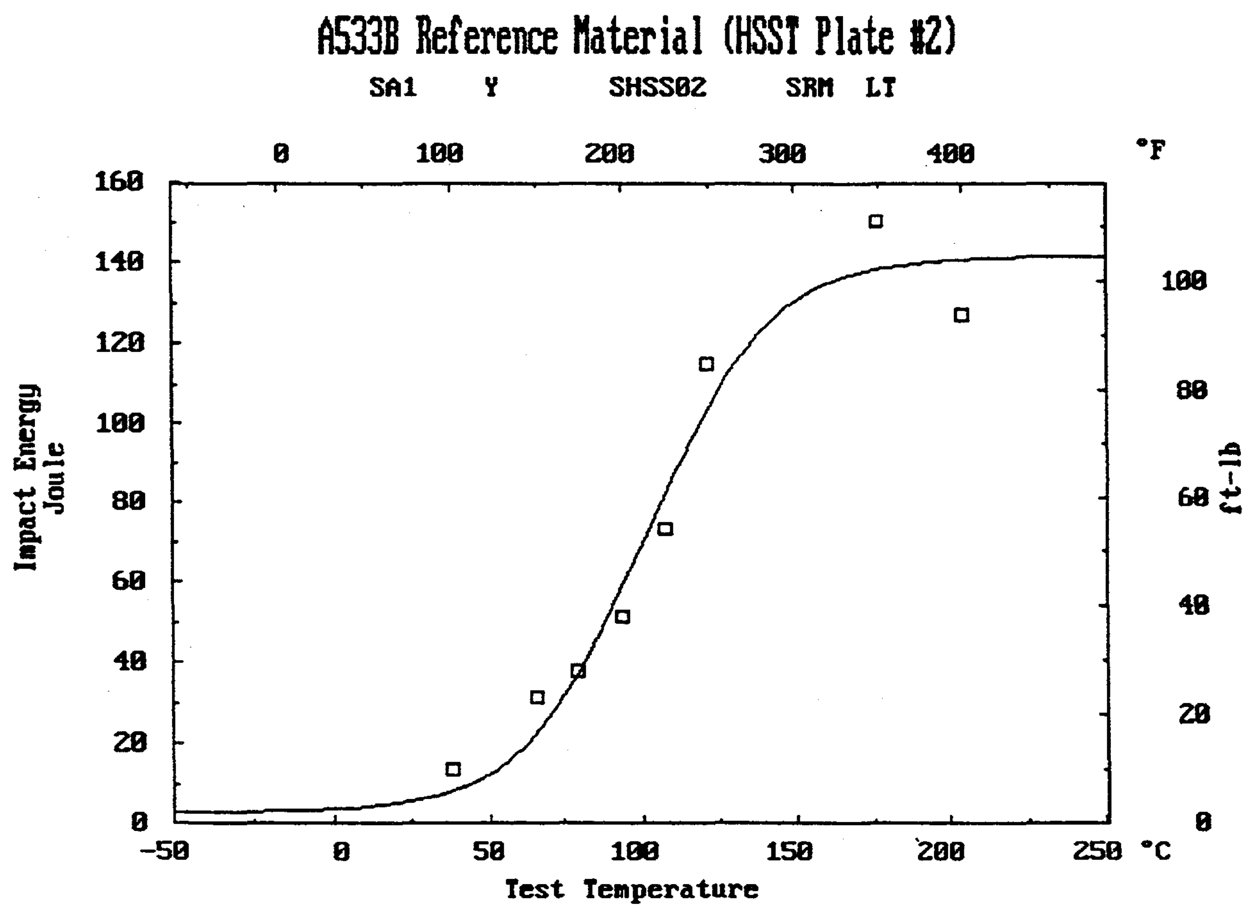
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	182.6	18.9	0.237				
CVT at Midpoint (C)	87.3	9.6	0.340	0.867			
1/slope (C)	63.6	9.7	0.138	0.609	0.567		
CVT at 41 Joule (C)	45.4	6.6	0.198	0.026	0.343	-0.537	
CVT at 68 Joule (C)	69.2	5.2	0.303	0.273	0.666	-0.094	0.884



A533B HSST02 REFERENCE MATERIAL
Salem Unit 1, Capsule Y

USE= 141.7 J, LSE= 3.1 J, CVT(1/2)= 102.C , Slope = 0.0254
CVT(41J) = 82. C , CVT(68J) = 99. C ,
Fluence = 8.910E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R62	38.	100.	14.	10.	0.23	9.	16.
R59	66.	150.	31.	23.	0.56	22.	24.
R57	79.	175.	38.	28.	0.79	31.	27.
R64	93.	200.	52.	38.	0.76	30.	33.
R58	107.	225.	73.	54.	0.94	37.	48.
R60	121.	250.	115.	85.	1.55	61.	64.
R63	177.	350.	150.	111.	2.08	82.	100.
R61	204.	400.	127.	94.	1.83	72.	100.



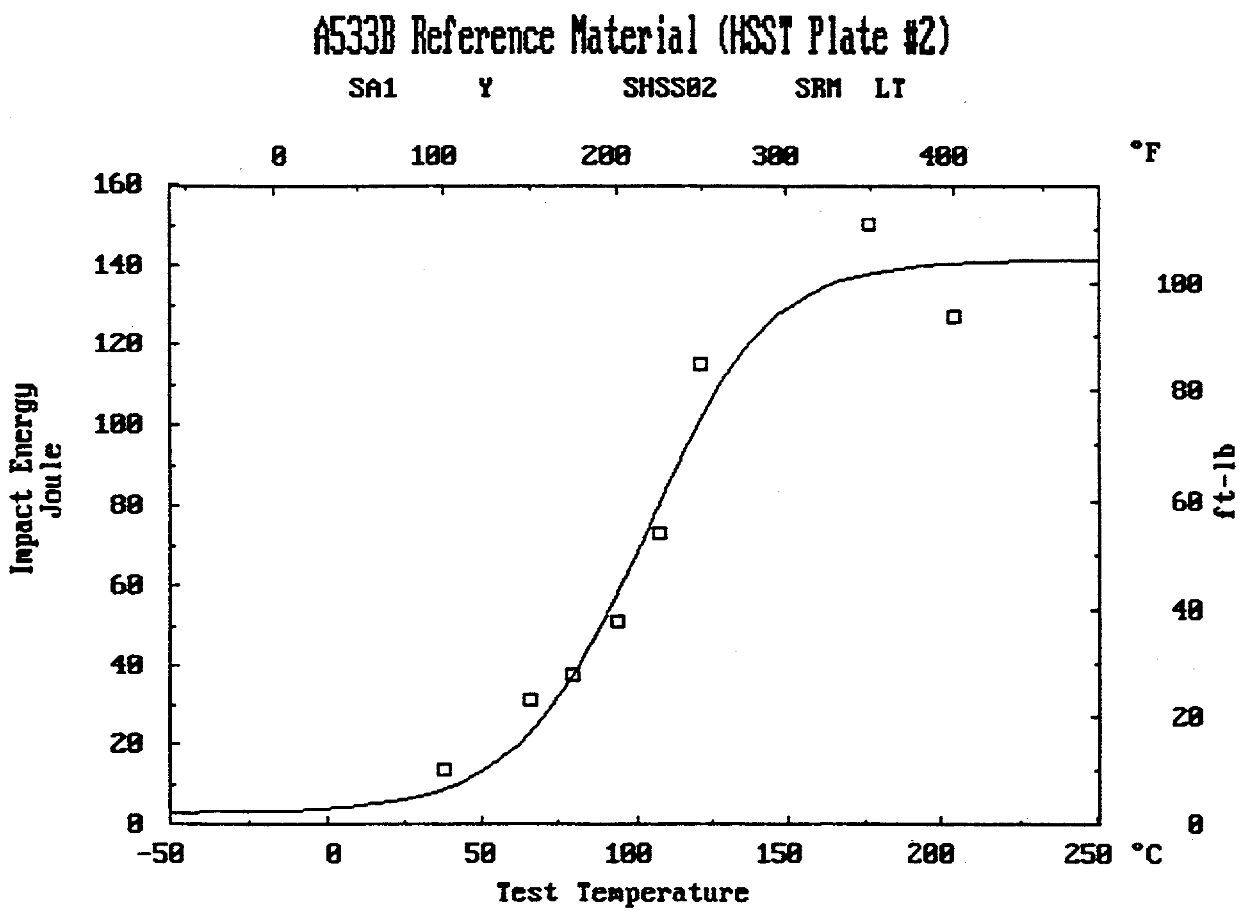
A533B HSST02 REFERENCE MATERIAL

Salem Unit 1, Capsule Y

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
SA1    Y     SHSS02    SRM  LT : Fluence = 8.910E+18 , Irr. Temp. =  304
```

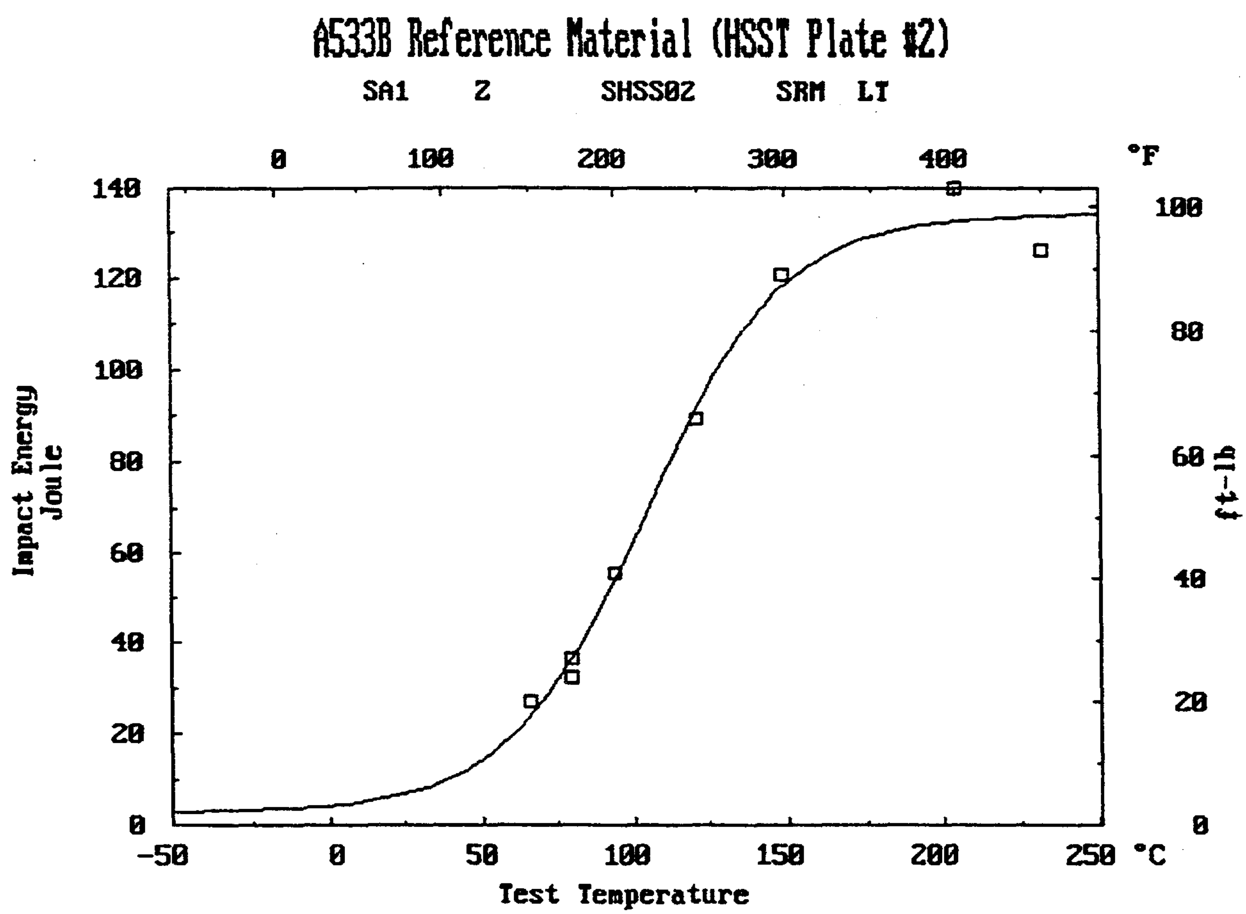
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.0					
Upper Shelf Energy (J)	142.0	7.8	-0.049				
CVT at Midpoint (C)	102.4	4.2	0.085	0.563			
1/slope (C)	41.1	8.5	-0.294	0.283	0.271		
CVT at 41 Joule (C)	82.3	4.9	0.337	-0.080	0.437	-0.709	
CVT at 68 Joule (C)	99.7	3.4	0.189	0.009	0.815	-0.022	0.712



A533B HSST02 REFERENCE MATERIAL
Salem Unit 1, Capsule Z

USE= 134.2 J, LSE= 3.0 J, CVT(1/2)= 104.C , Slope = 0.0220
CVT(41J) = 84. C , CVT(68J) = 104. C ,
Fluence = 1.330E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R35	66.	150.	27.	20.	0.56	22.	15.
R33	79.	175.	37.	27.	0.76	30.	25.
R40	79.	175.	33.	24.	0.63	25.	20.
R38	93.	200.	56.	41.	0.99	39.	35.
R39	121.	250.	89.	66.	1.78	70.	65.
R36	149.	300.	121.	89.	1.98	78.	95.
R37	204.	400.	140.	103.	2.26	89.	100.
R34	232.	450.	126.	93.	2.03	80.	100.



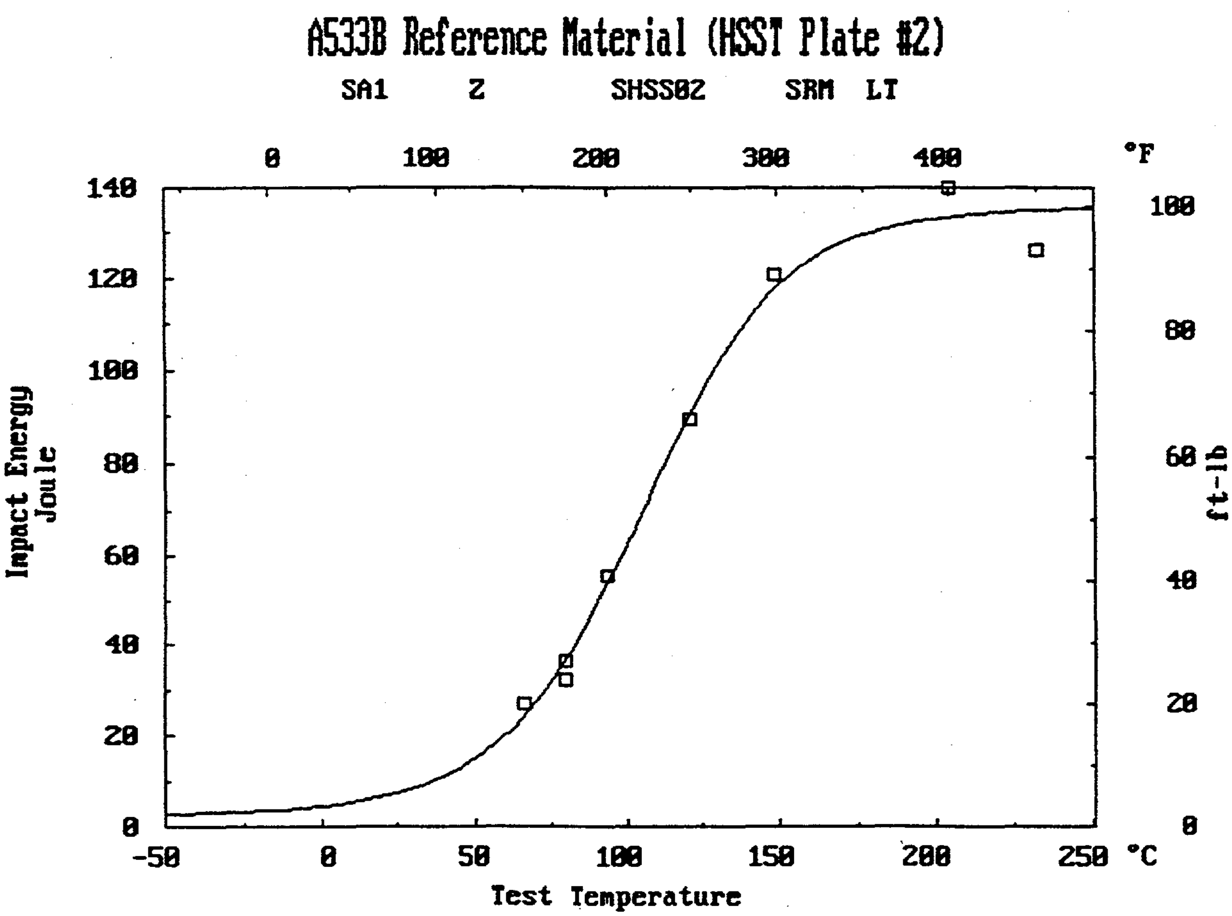
A533B HSST02 REFERENCE MATERIAL

Salem Unit 1, Capsule Z

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SA1 Z SHSS02 SRM LT : Fluence = 1.330E+19 , Irr. Temp. = 304

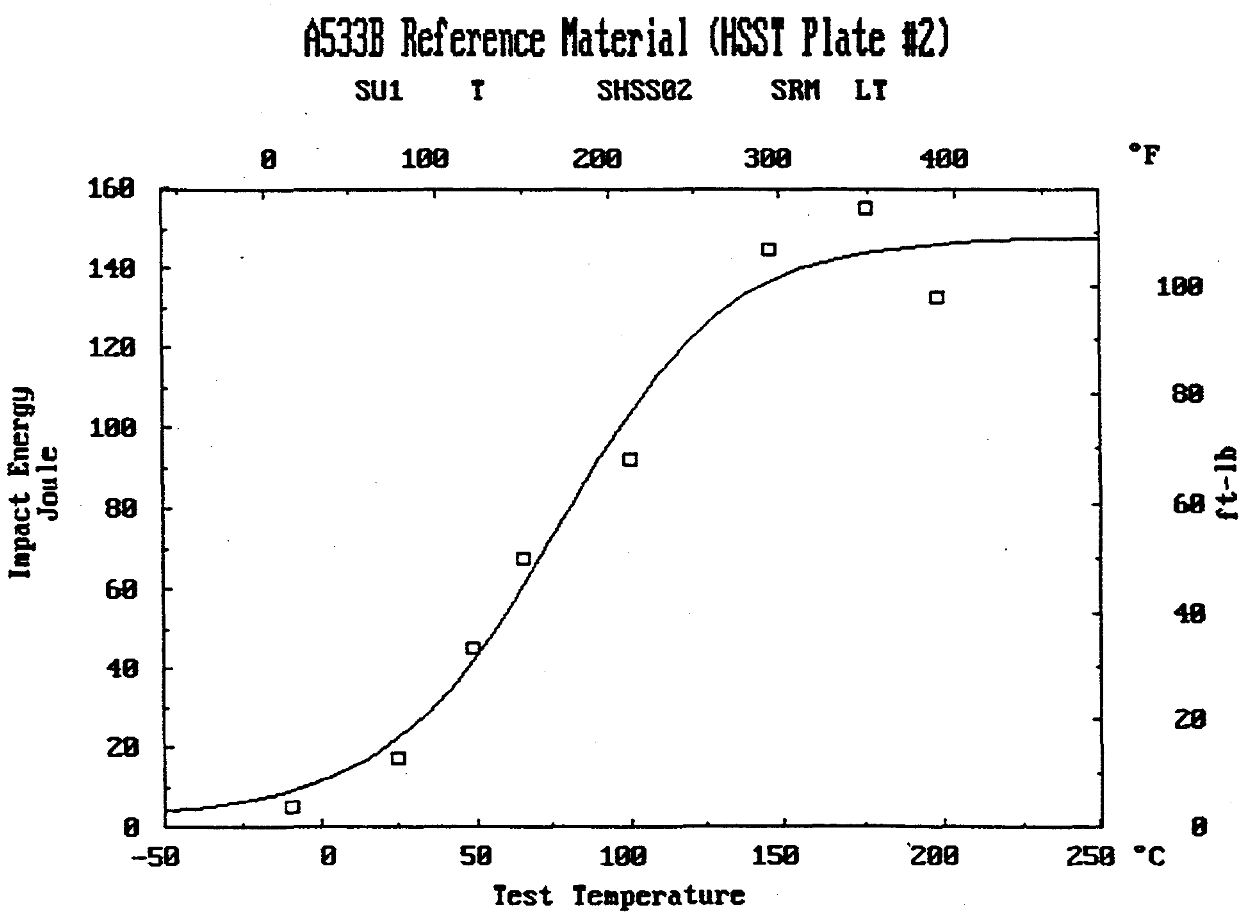
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	135.7	8.0	-0.003				
CVT at Midpoint (C)	104.9	5.6	0.122	0.682			
1/slope (C)	47.2	10.4	-0.077	0.549	0.598		
CVT at 41 Joule (C)	83.2	4.7	0.227	-0.178	0.295	-0.543	
CVT at 68 Joule (C)	103.8	4.2	0.173	0.197	0.843	0.368	0.568



A533B HSST02 REFERENCE MATERIAL
Surry Unit 1, Capsule T

USE= 148.2 J, LSE= 3.0 J, CVT(1/2)= 77.C , Slope = 0.0179
CVT(41J) = 48. C , CVT(68J) = 71. C ,
Fluence = 2.500E+18 , Irr. Temp. = 310 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R33	-9.	15.	5.	4.	0.18	7.	0.
R40	25.	77.	18.	13.	0.43	17.	20.
R38	49.	120.	45.	33.	0.94	37.	25.
R36	66.	150.	68.	50.	1.24	49.	45.
R39	100.	212.	92.	68.	1.57	62.	70.
R37	146.	295.	145.	107.	2.26	89.	100.
R34	177.	350.	155.	114.	1.80	71.	100.
R35	199.	390.	133.	98.	1.88	74.	100.



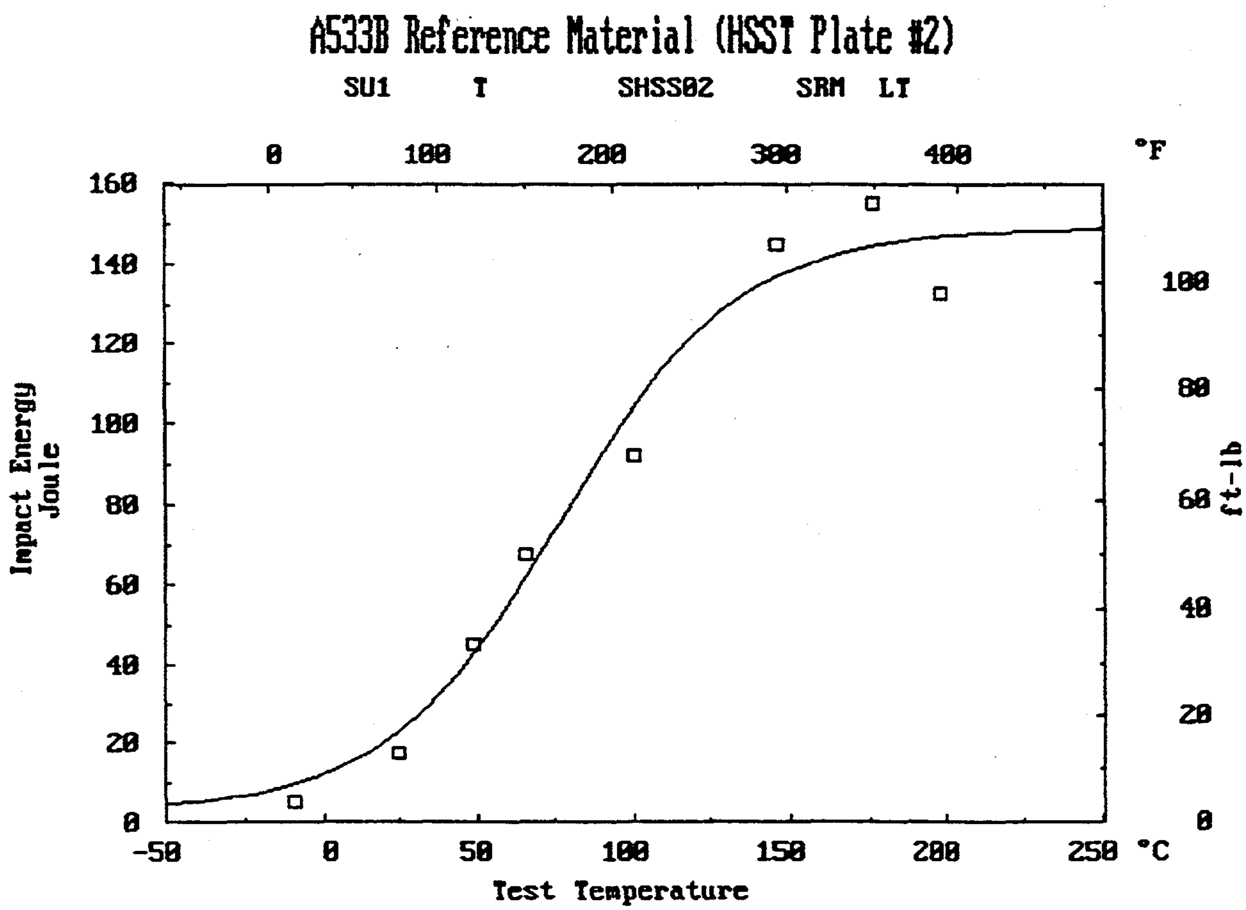
A533B HSST02 REFERENCE MATERIAL

Surry Unit 1, Capsule T

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SU1 T SHSS02 SRM LT : Fluence = 2.500E+18 , Irr. Temp. = 310

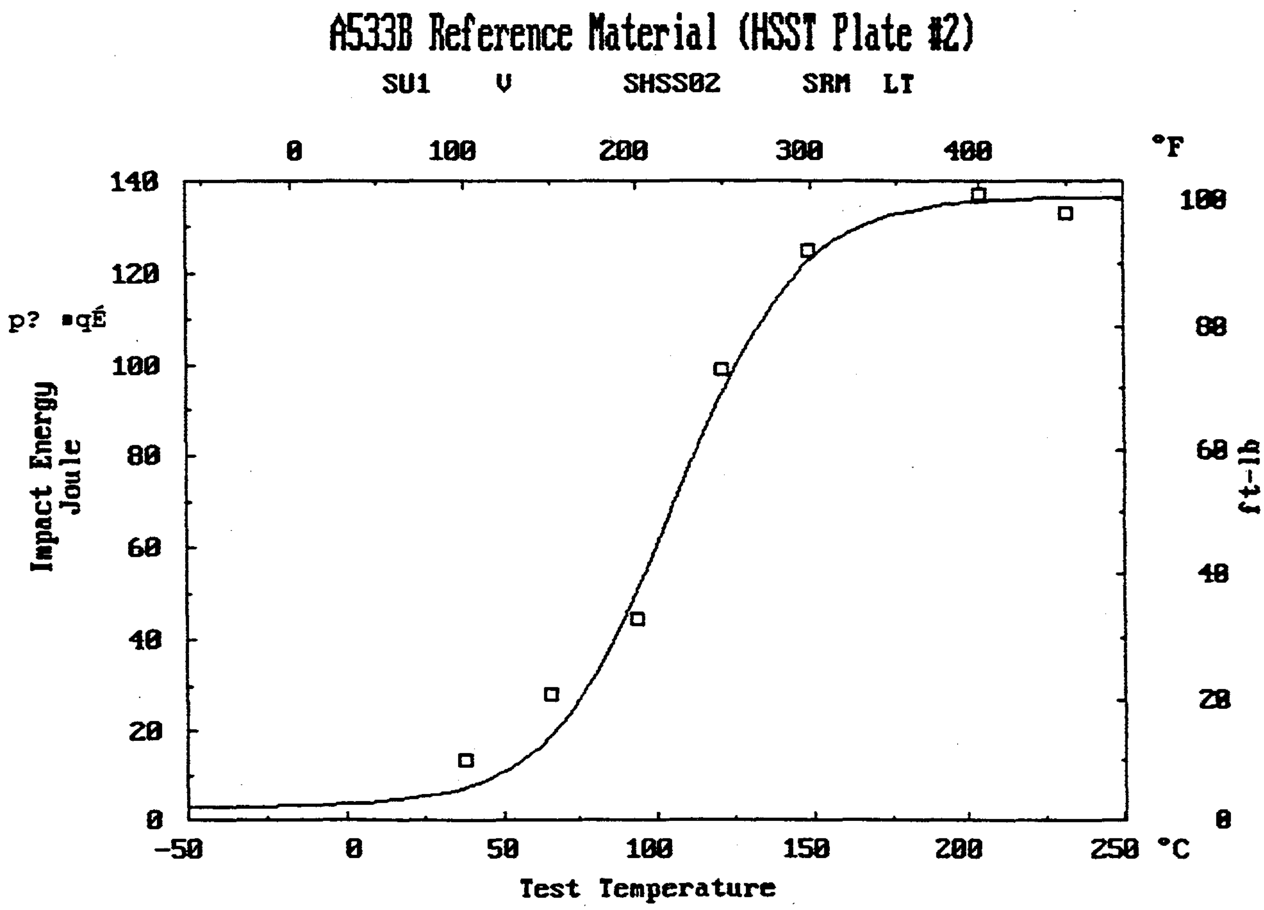
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	148.9	6.9	0.067				
CVT at Midpoint (C)	77.0	6.4	0.143	0.571			
1/slope (C)	56.9	8.9	0.007	0.510	0.408		
CVT at 41 Joule (C)	47.2	6.1	0.119	-0.093	0.564	-0.494	
CVT at 68 Joule (C)	70.7	5.2	0.137	0.137	0.879	0.072	0.827



A533B HSST02 REFERENCE MATERIAL
Surry Unit 1, Capsule V

USE= 136.4 J, LSE= 3.1 J, CVT(1/2)= 106.C , Slope = 0.0250
CVT(41J) = 87. C , CVT(68J) = 105. C ,
Fluence = 1.940E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R41	38.	100.	14.	10.	0.25	10.	4.
R43	66.	150.	28.	21.	0.48	19.	10.
R47	93.	200.	45.	33.	0.71	28.	33.
R48	93.	200.	45.	33.	0.58	23.	26.
R46	121.	250.	99.	73.	1.14	45.	43.
R44	149.	300.	125.	92.	1.75	69.	92.
R45	204.	400.	137.	101.	1.78	70.	100.
R42	232.	450.	133.	98.	1.85	73.	100.



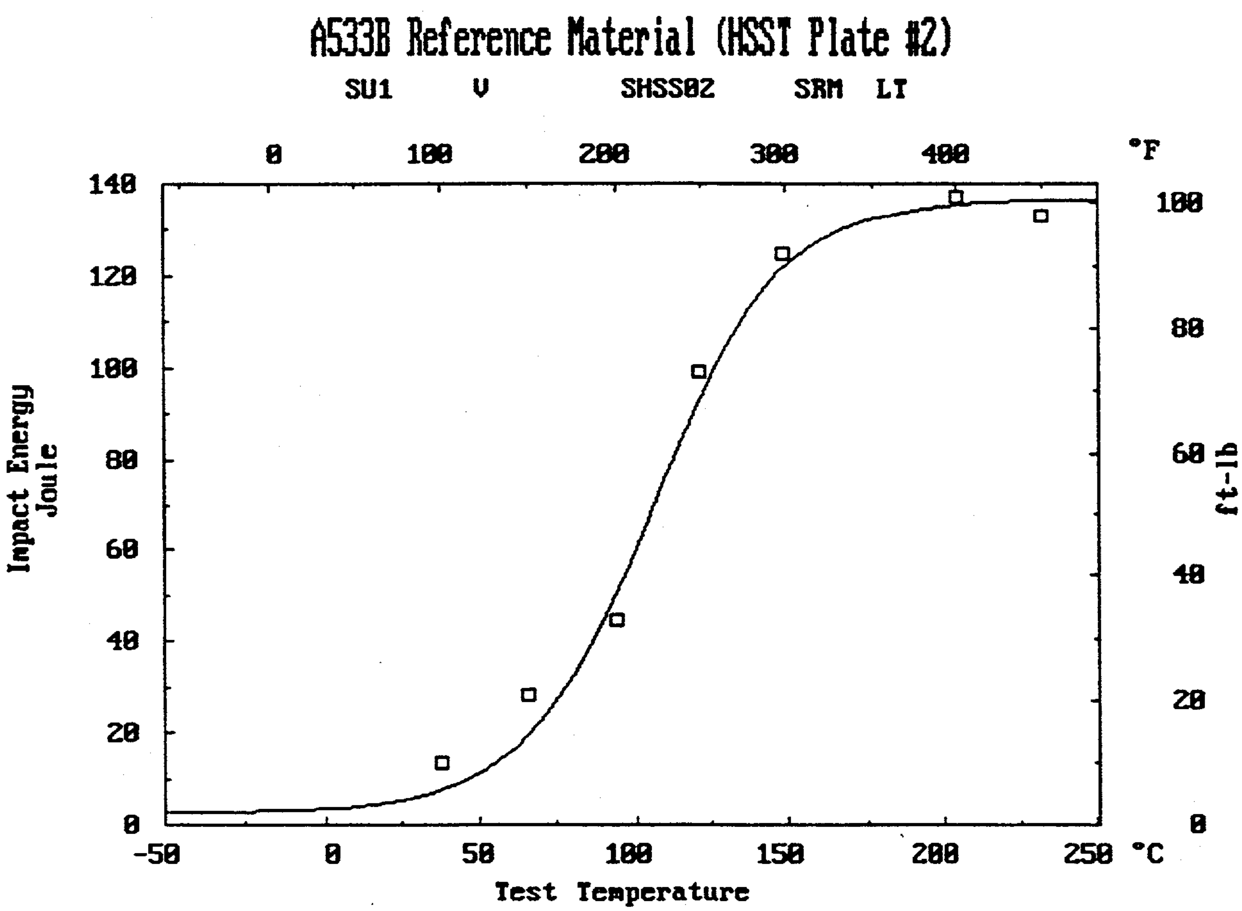
A533B HSST02 REFERENCE MATERIAL

Surry Unit 1, Capsule V

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
SU1   V     SHSS02    SRM  LT : Fluence = 1.940E+19 , Irr. Temp. =  304
```

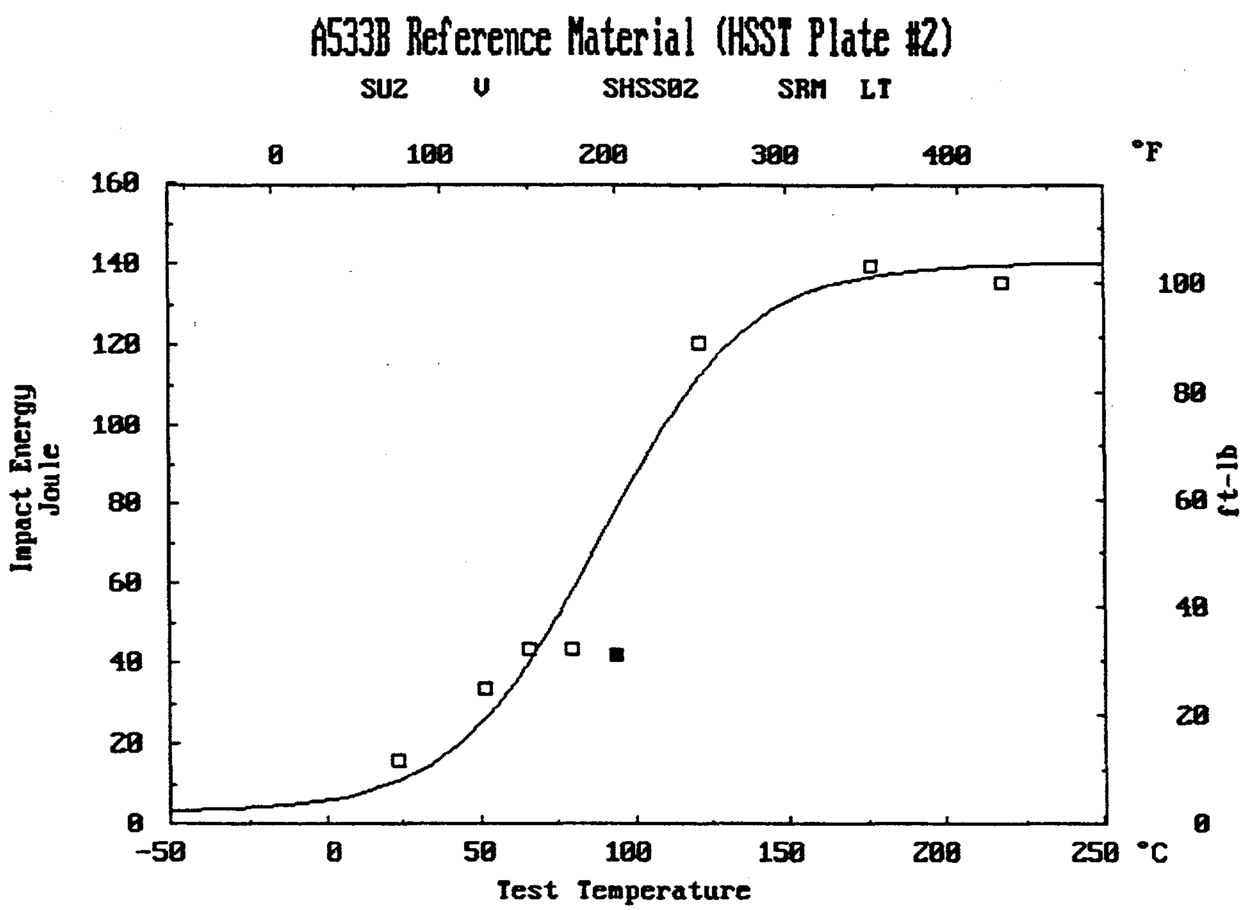
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	136.3	6.8	-0.109				
CVT at Midpoint (C)	105.8	5.4	0.105	0.626			
1/slope (C)	40.7	9.9	-0.459	0.392	0.283		
CVT at 41 Joule (C)	87.0	5.7	0.488	0.018	0.541	-0.632	
CVT at 68 Joule (C)	104.7	4.2	0.206	0.282	0.919	0.112	0.693



A533B HSST02 REFERENCE MATERIAL
Surry Unit 2, Capsule V

```
USE= 140.3 J, LSE=   3.0 J, CVT(1/2)=    89.C , Slope = 0.0215
CVT(41J) =    67. C , CVT(68J) =    87. C ,
Fluence = 1.880E+19 , Irr. Temp. = 304 C
```

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R15	24.	75.	16.	12.	0.43	17.	15.
R12	52.	125.	34.	25.	0.51	20.	25.
R16	66.	150.	43.	32.	0.56	22.	25.
R11	79.	175.	43.	32.	0.71	28.	35.
*R13	93.	200.	42.	31.	0.84	33.	45.
R10	121.	250.	121.	89.	1.57	62.	50.
R14	177.	350.	140.	103.	2.06	81.	100.
R9	218.	425.	136.	100.	2.06	81.	100.



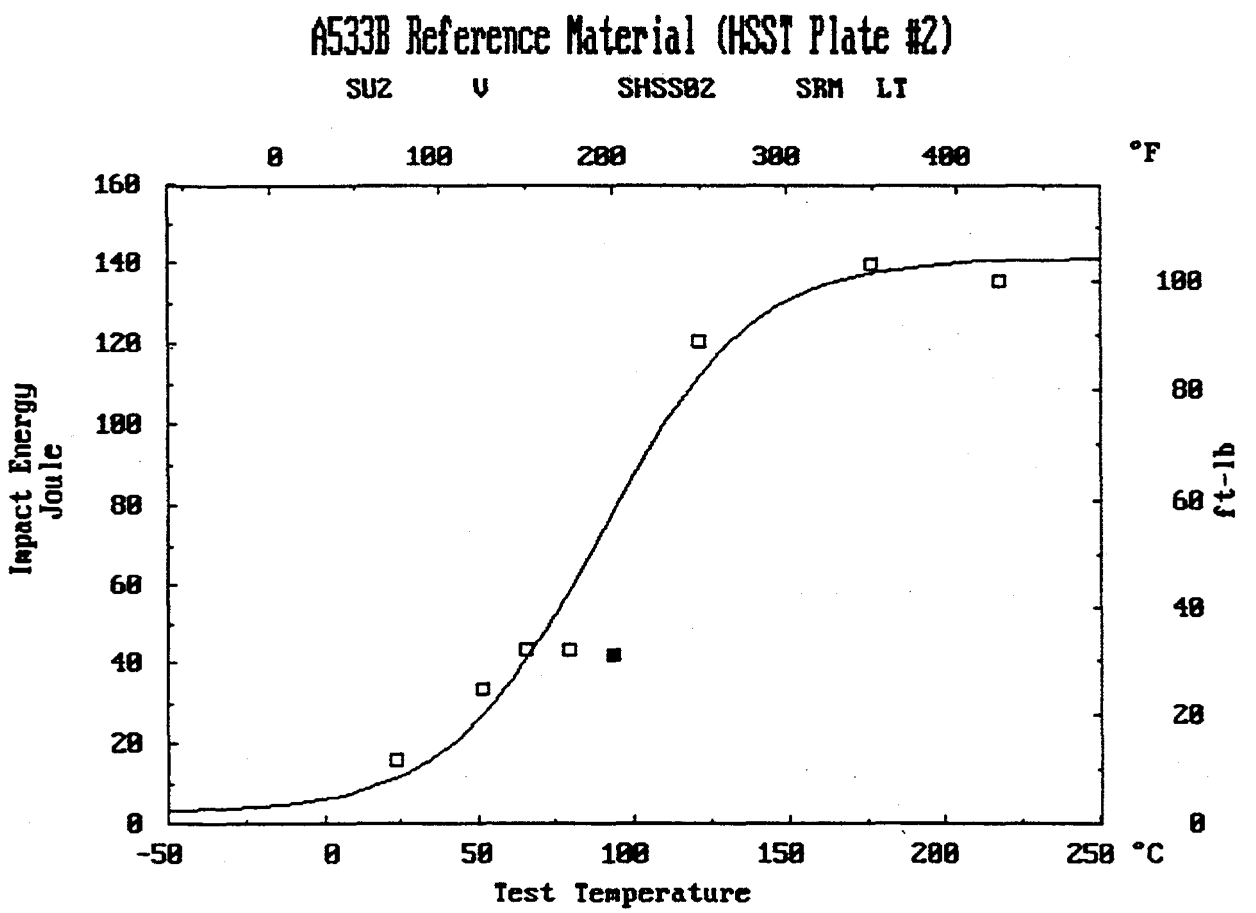
A533B HSST02 REFERENCE MATERIAL

Surry Unit 2, Capsule V

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

SU2 V SHSS02 SRM LT : Fluence = 1.880E+19 , Irr. Temp. = 304

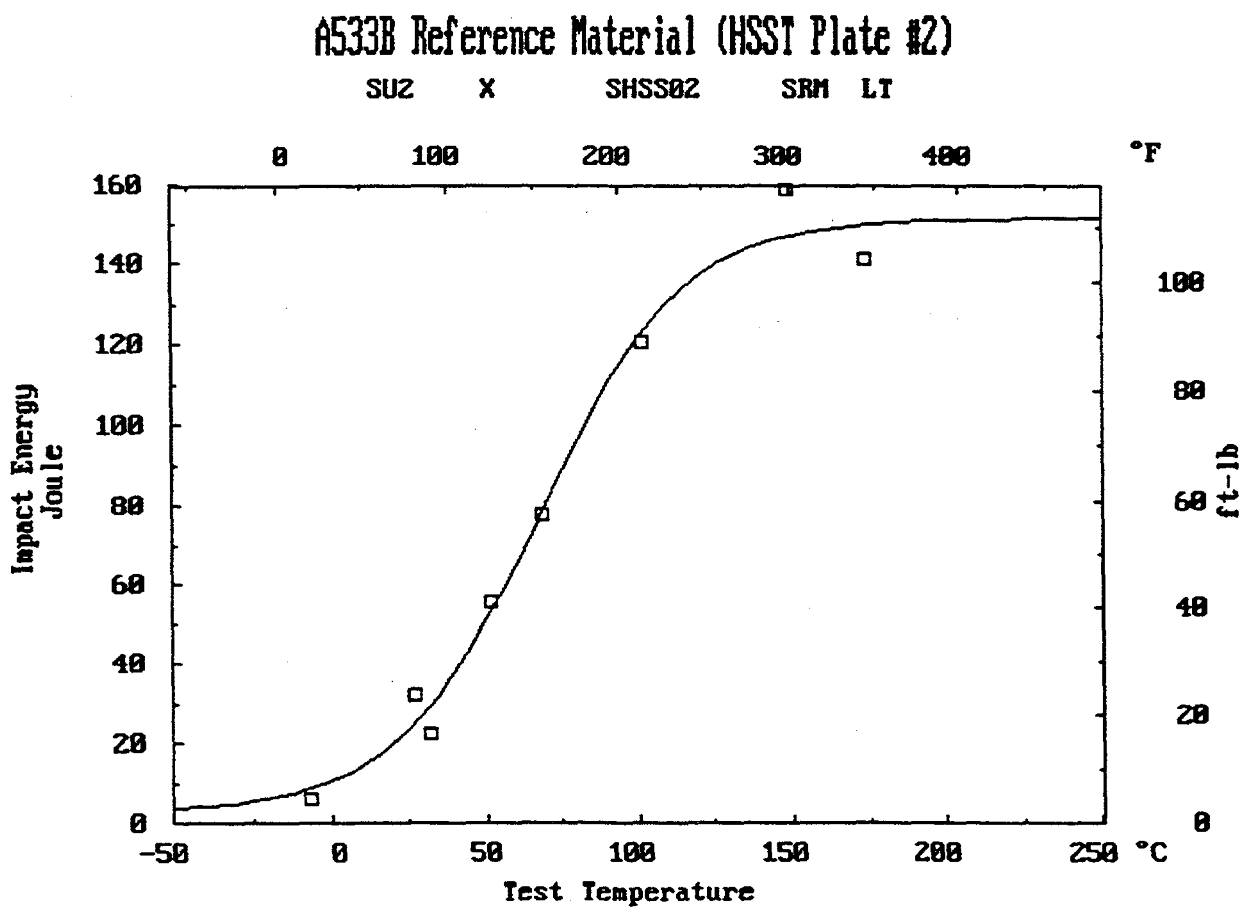
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	141.3	7.7	0.026				
CVT at Midpoint (C)	89.2	6.6	0.197	0.540			
1/slope (C)	48.2	10.3	-0.258	0.351	0.292		
CVT at 41 Joule (C)	65.7	6.8	0.368	-0.018	0.601	-0.554	
CVT at 68 Joule (C)	86.2	5.5	0.241	0.125	0.895	0.069	0.786



A533B HSST02 REFERENCE MATERIAL
Surry Unit 2, Capsule X

USE= 151.4 J, LSE= 3.0 J, CVT(1/2)= 67.C , Slope = 0.0214
CVT(41J) = 43. C , CVT(68J) = 62. C ,
Fluence = 3.020E+18 , Irr. Temp. = 310 C

Spec. ID	Test Temp.		Impact Energy		Lat. Exp.		% Shear
	C	F	J	ft-lb	mm	mil	
R32	-7.	20.	6.	4.	0.13	5.	3.
R28	27.	80.	33.	24.	0.63	25.	15.
R29	32.	90.	22.	16.	0.58	23.	15.
R30	52.	125.	56.	41.	0.97	38.	25.
R27	68.	155.	78.	57.	1.45	57.	35.
R31	102.	215.	121.	89.	2.01	79.	100.
R25	149.	300.	159.	117.	2.26	89.	100.
R26	174.	345.	141.	104.	2.11	83.	100.



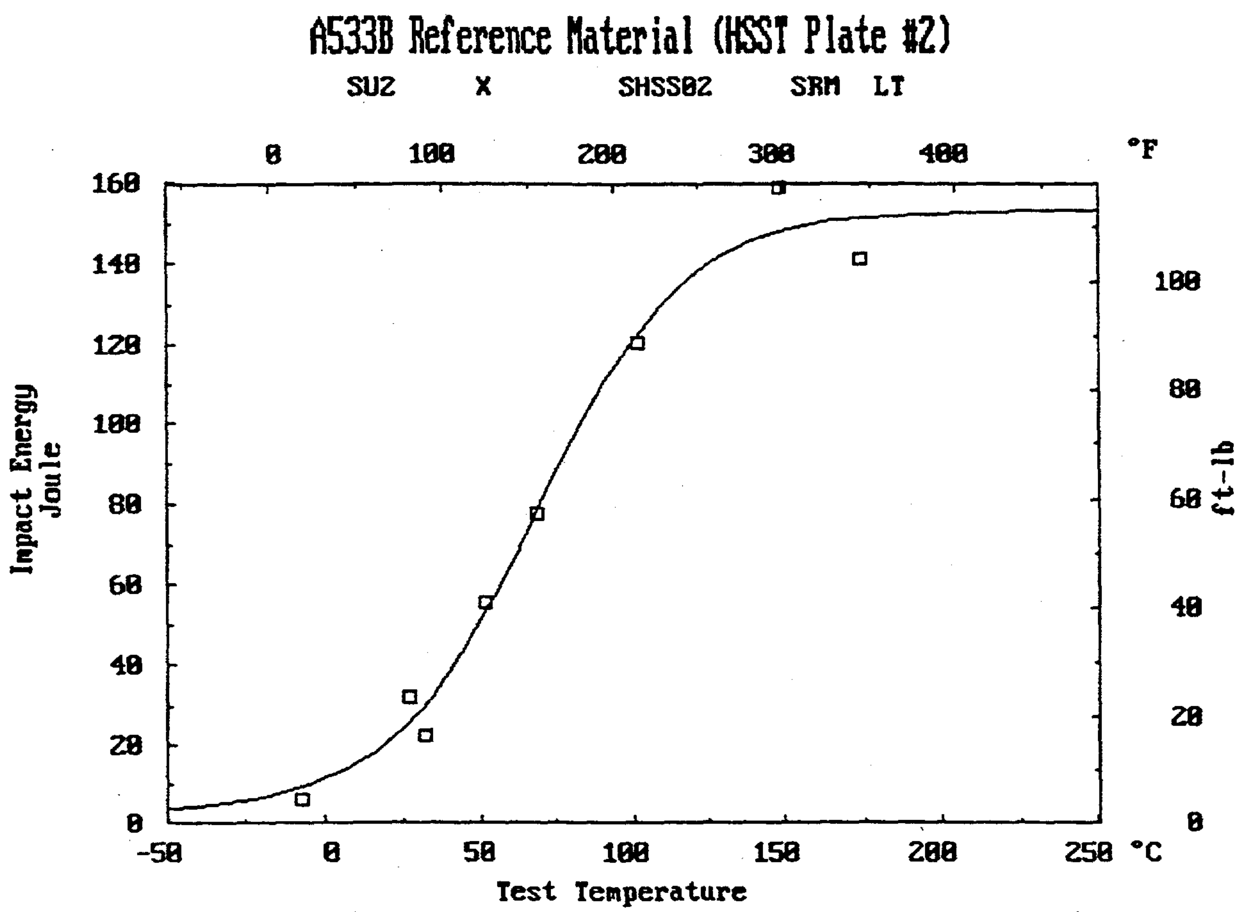
A533B HSST02 REFERENCE MATERIAL

Surry Unit 2, Capsule X

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

SU2 X SHSS02 SRM LT : Fluence = 3.020E+18 , Irr. Temp. = 310

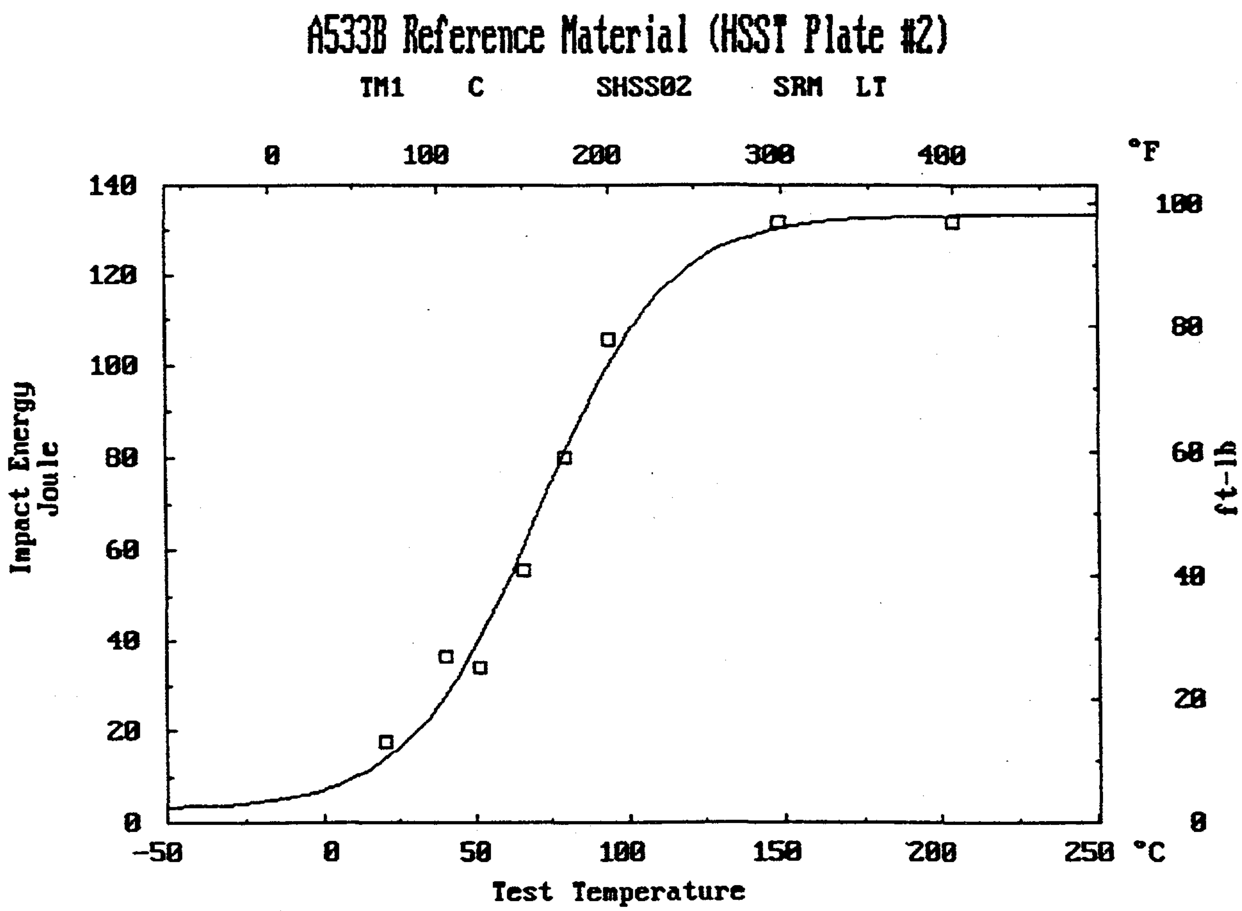
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	153.3	9.5	0.000				
CVT at Midpoint (C)	68.3	7.1	0.077	0.744			
1/slope (C)	48.1	9.7	-0.133	0.619	0.606		
CVT at 41 Joule (C)	42.0	5.4	0.231	-0.029	0.417	-0.441	
CVT at 68 Joule (C)	61.6	4.9	0.154	0.333	0.855	0.234	0.764



A533B HSST02 REFERENCE MATERIAL
Three Mile Island Unit 1, Capsule C

USE= 133.4 J, LSE= 3.0 J, CVT(1/2)= 71.C , Slope = 0.0237
CVT(41J) = 52. C , CVT(68J) = 71. C ,
Fluence = 8.660E+18 , Irr. Temp. = 303 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
CC945	21.	69.	18.	13.	0.36	14.	5.
CC921	41.	105.	37.	27.	0.58	23.	20.
CC915	52.	125.	34.	25.	0.58	23.	25.
CC961	66.	150.	56.	41.	0.86	34.	30.
CC928	79.	175.	80.	59.	1.22	48.	50.
CC937	93.	200.	106.	78.	1.52	60.	60.
CC916	149.	300.	132.	97.	1.88	74.	100.
CC955	204.	400.	132.	97.	2.06	81.	100.

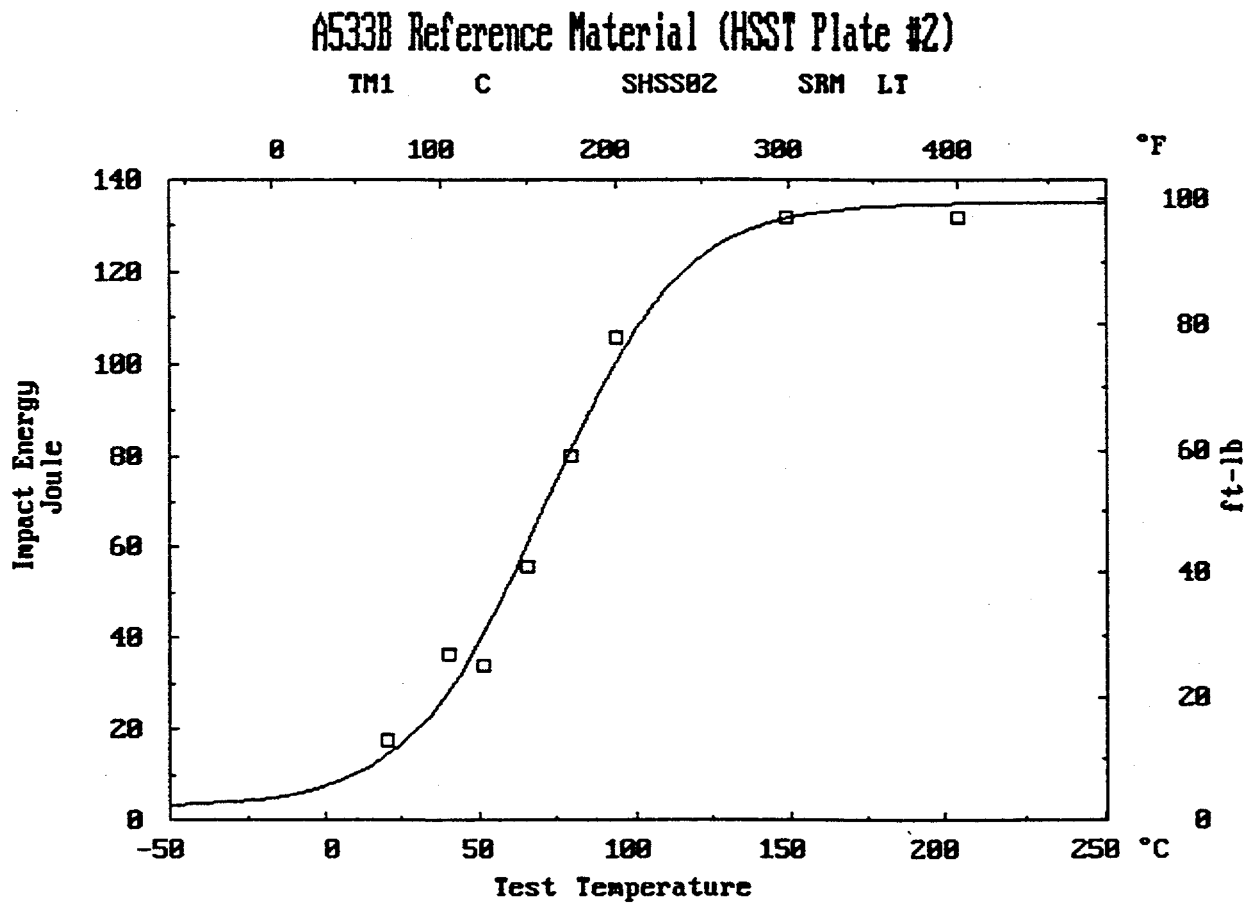


A533B HSST02 REFERENCE MATERIAL

Three Mile Island Unit 1, Capsule C

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000


TM1   C     SHSS02    SRM  LT : Fluence = 8.660E+18 , Irr. Temp. =  303
```

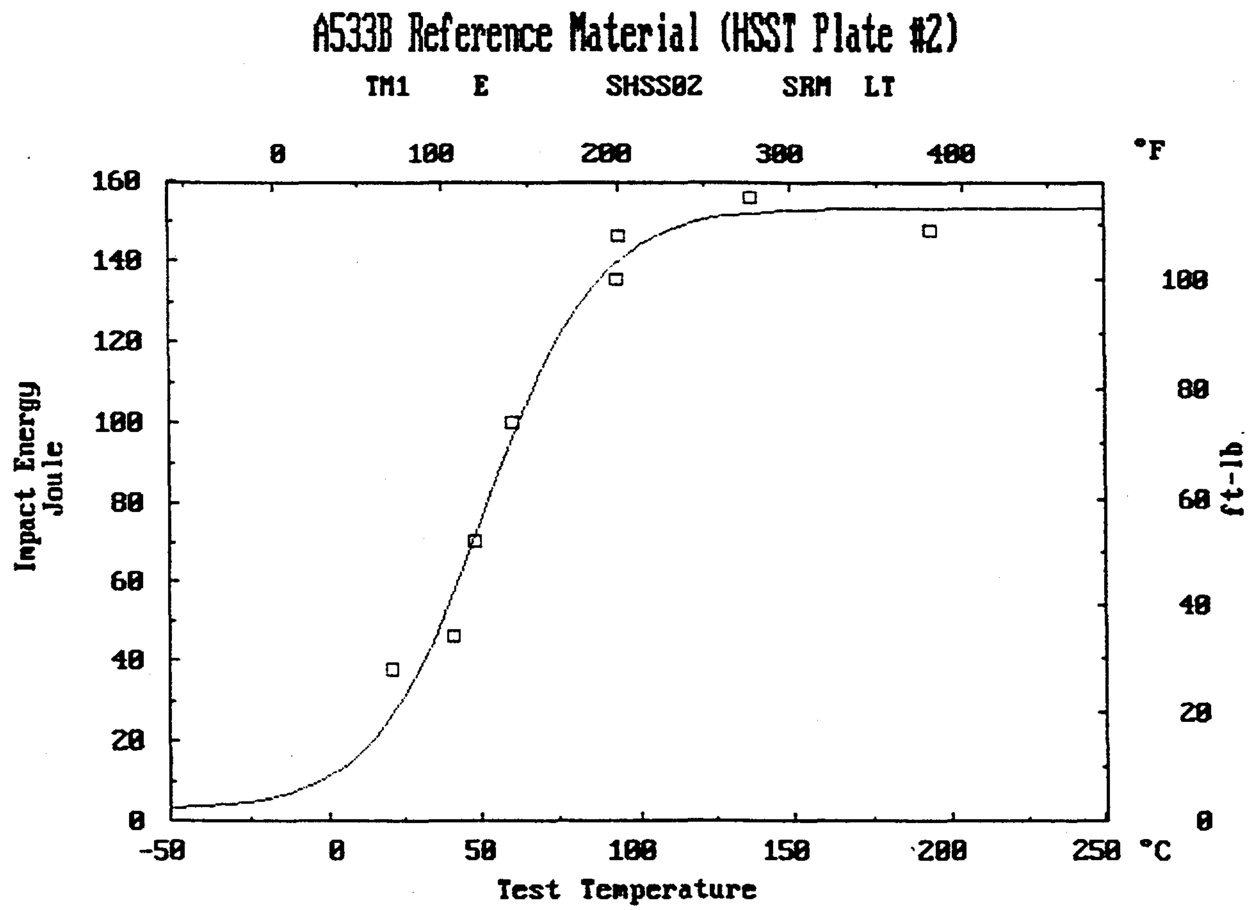
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	135.0	8.0	-0.050				
CVT at Midpoint (C)	71.4	5.0	0.085	0.593			
1/slope (C)	43.0	9.4	-0.365	0.382	0.257		
CVT at 41 Joule (C)	51.8	5.5	0.369	-0.094	0.500	-0.669	
CVT at 68 Joule (C)	70.6	4.0	0.142	0.076	0.840	0.034	0.709



A533B HSST02 REFERENCE MATERIAL
Three Mile Island Unit 1, Capsule E

USE= 153.3 J, LSE= 3.0 J, CVT(1/2)= 52.C , Slope = 0.0278
CVT(41J) = 32. C , CVT(68J) = 47. C ,
Fluence = 1.070E+18 , Irr. Temp. = 309 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
CCE922	21.	70.	38.	28.	0.53	21.	12.
CCE948	41.	106.	46.	34.	0.61	24.	20.
CCE964	49.	119.	70.	52.	0.94	37.	20.
CCE919	60.	140.	100.	74.	1.37	54.	35.
CCE925	93.	199.	136.	100.	1.35	53.	100.
CCE962	94.	201.	146.	108.	1.40	55.	92.
CCE913	136.	277.	156.	115.	1.65	65.	100.
CCE969	194.	381.	148.	109.	1.75	69.	100.



A533B HSST02 REFERENCE MATERIAL

Three Mile Island Unit 1, Capsule E

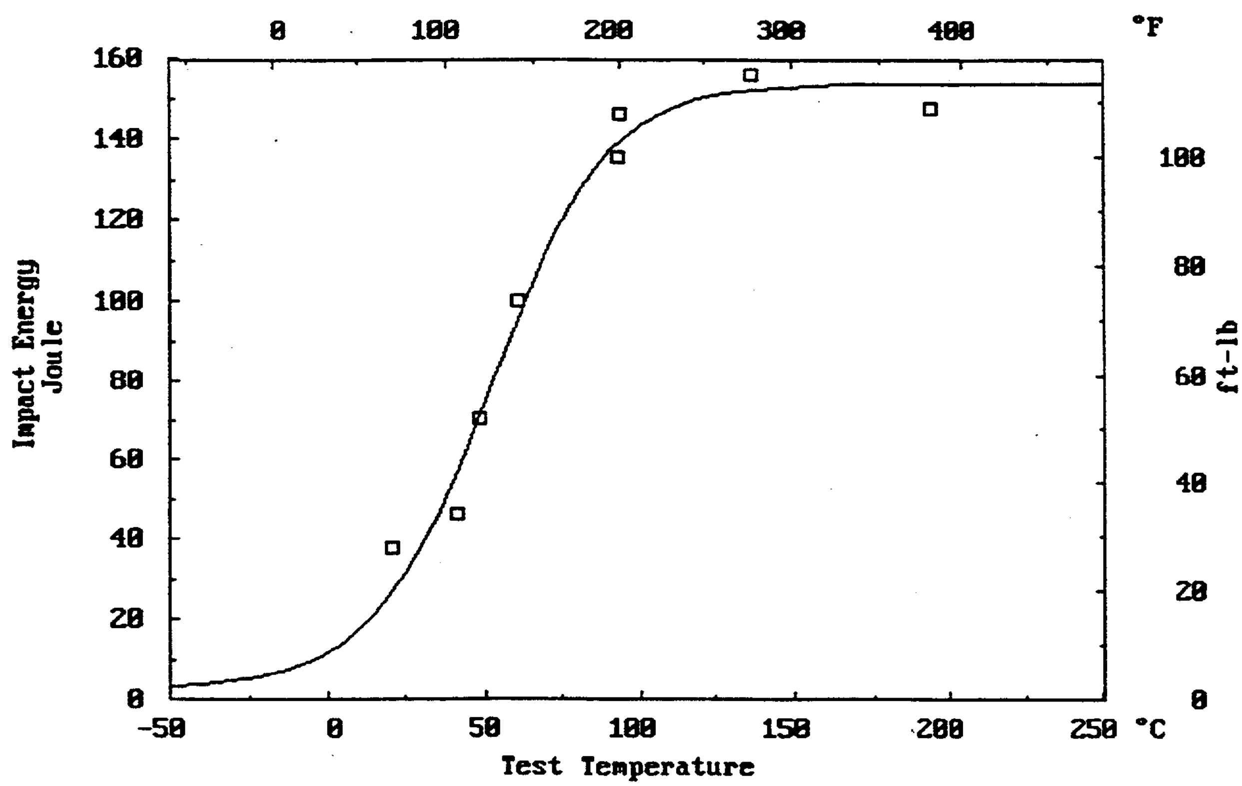
Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

TM1 E SHSS02 SRM LT : Fluence = 1.070E+18 , Irr. Temp. = 309

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	153.8	6.8	0.112				
CVT at Midpoint (C)	52.0	4.2	0.248	0.538			
1/slope (C)	36.9	7.5	-0.116	0.548	0.274		
CVT at 41 Joule (C)	31.9	5.1	0.272	-0.231	0.467	-0.707	
CVT at 68 Joule (C)	46.8	3.6	0.278	0.037	0.834	-0.208	0.837

A533B Reference Material (HSST Plate #2)

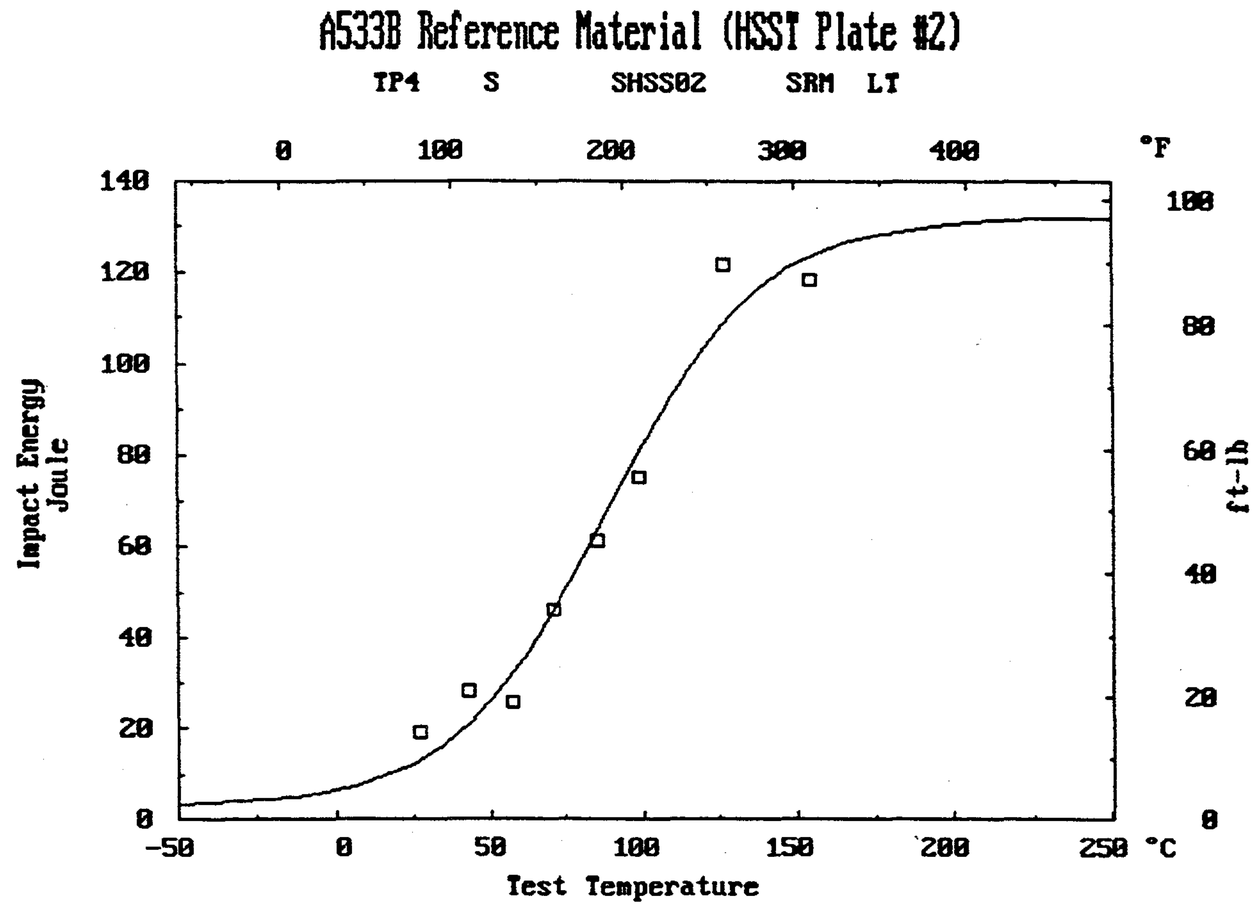
TM1 E SHSS02 SRM LT



A533B HSST02 REFERENCE MATERIAL
Turkey Point Unit 4, Capsule S

USE= 132.0 J, LSE= 3.0 J, CVT(1/2)= 88.C , Slope = 0.0200
CVT(41J) = 67. C , CVT(68J) = 89. C ,
Fluence = 1.250E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R1	27.	80.	20.	14.	0.33	13.	0.
R2	43.	110.	28.	21.	0.43	17.	10.
R8	57.	135.	26.	19.	0.41	16.	15.
R3	71.	160.	46.	34.	0.74	29.	20.
R7	85.	185.	61.	45.	1.02	40.	25.
R4	99.	210.	75.	55.	1.22	48.	60.
R5	127.	260.	122.	90.	1.90	75.	95.
R6	154.	310.	118.	87.	1.73	68.	100.



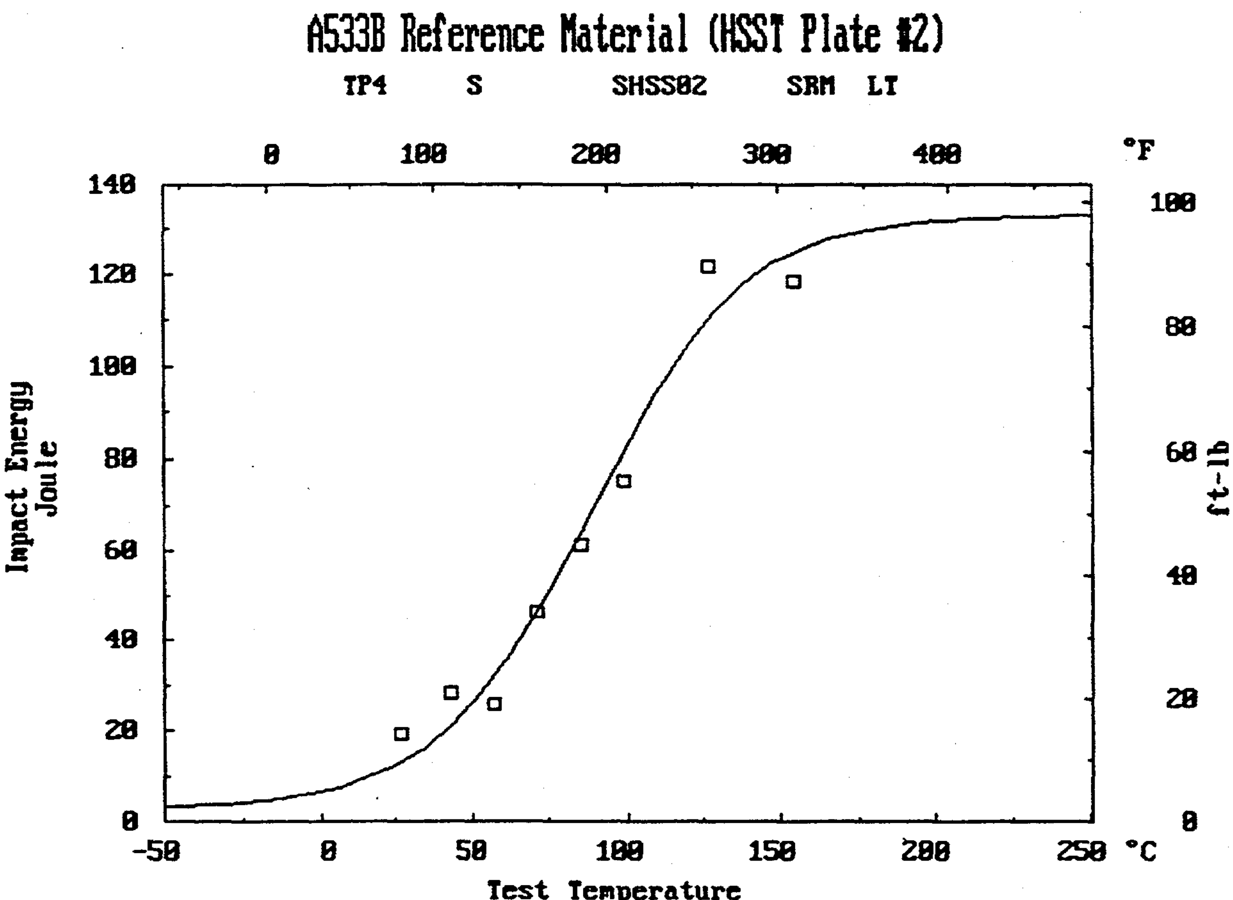
A533B HSST02 REFERENCE MATERIAL

Turkey Point Unit 4, Capsule S

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
TP4    S      SHSS02     SRM  LT : Fluence = 1.250E+19 , Irr. Temp. =  304
```

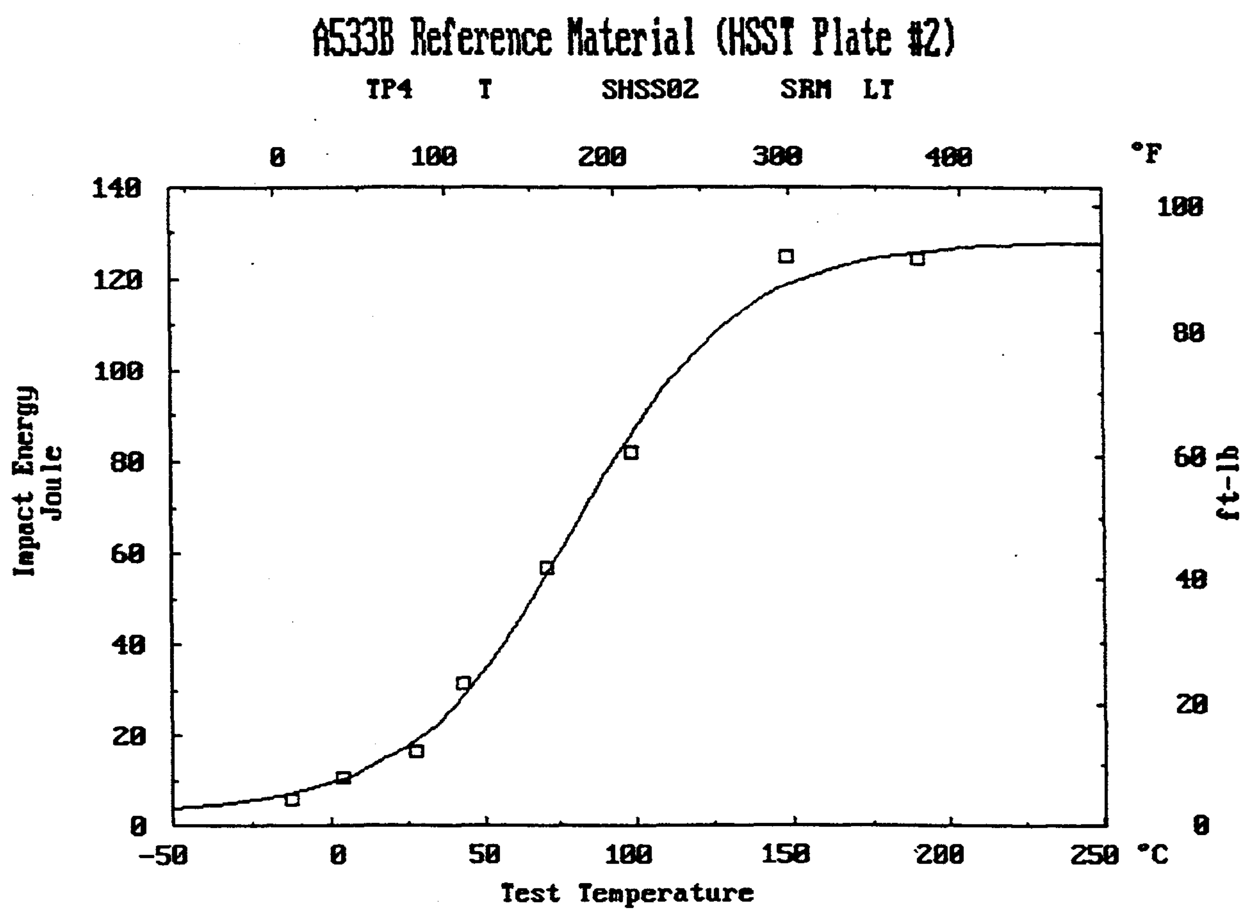
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	132.9	13.1	0.068				
CVT at Midpoint (C)	88.3	7.8	0.138	0.875			
1/slope (C)	49.3	12.2	-0.177	0.634	0.619		
CVT at 41 Joule (C)	66.2	5.1	0.333	-0.060	0.220	-0.582	
CVT at 68 Joule (C)	88.1	4.0	0.155	0.403	0.781	0.370	0.



A533B HSST02 REFERENCE MATERIAL
Turkey Point Unit 4, Capsule T

USE= 128.0 J, LSE= 3.0 J, CVT(1/2)= 80.C , Slope = 0.0184
CVT(41J) = 58. C , CVT(68J) = 82. C ,
Fluence = 6.050E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R62	-12.	10.	6.	4.	0.05	2.	0.
R63	4.	40.	11.	8.	0.13	5.	5.
R64	27.	81.	17.	12.	0.25	10.	10.
R61	43.	110.	32.	23.	0.43	17.	15.
R60	71.	160.	57.	42.	0.84	33.	20.
R59	99.	210.	82.	60.	1.24	49.	50.
R58	149.	300.	125.	92.	2.11	83.	100.
R57	191.	375.	124.	92.	2.03	80.	100.



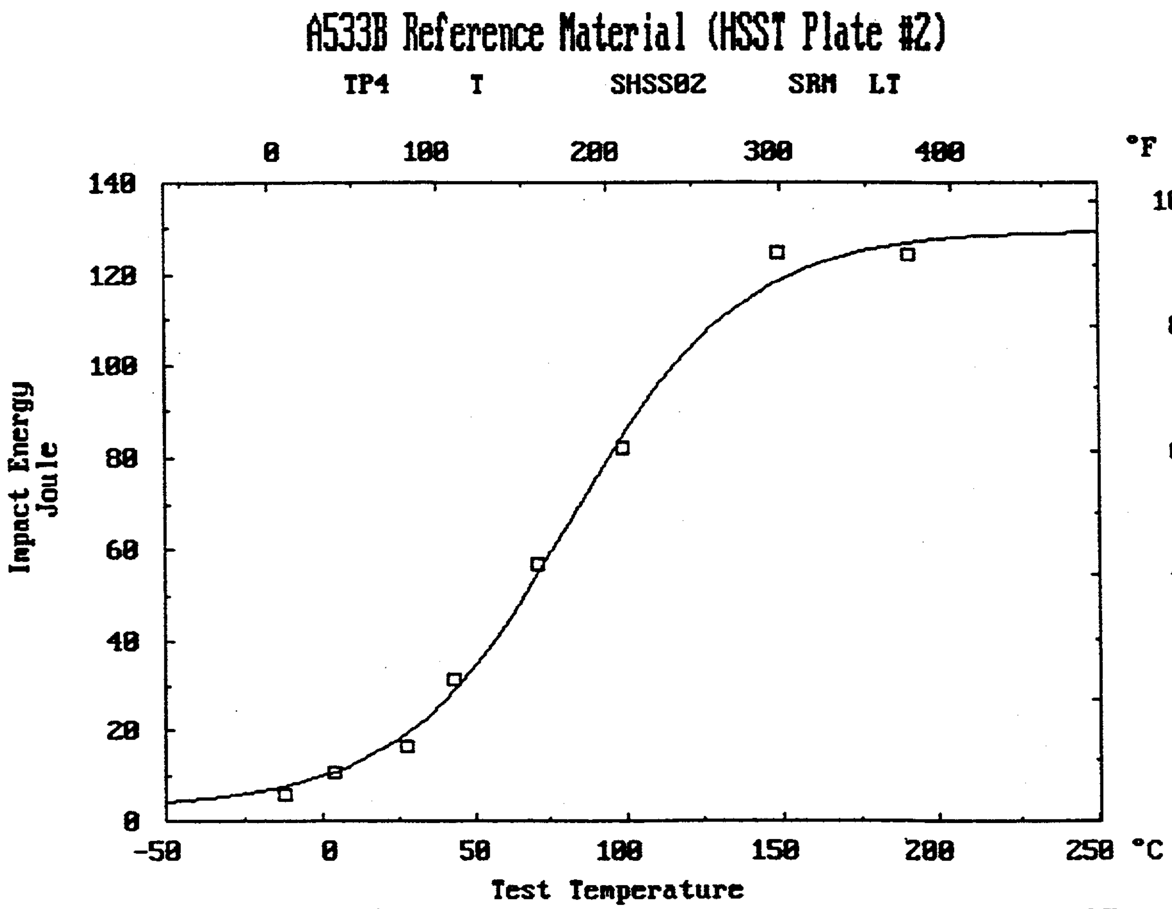
A533B HSST02 REFERENCE MATERIAL

Turkey Point Unit 4, Capsule T

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

TP4 T SHSS02 SRM LT : Fluence = 6.050E+18 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	129.6	9.4	-0.012				
CVT at Midpoint (C)	81.8	8.7	0.077	0.720			
1/slope (C)	57.0	11.9	-0.090	0.501	0.486		
CVT at 41 Joule (C)	57.5	6.7	0.170	0.088	0.591	-0.359	
CVT at 68 Joule (C)	83.2	6.5	0.106	0.305	0.875	0.355	0.731



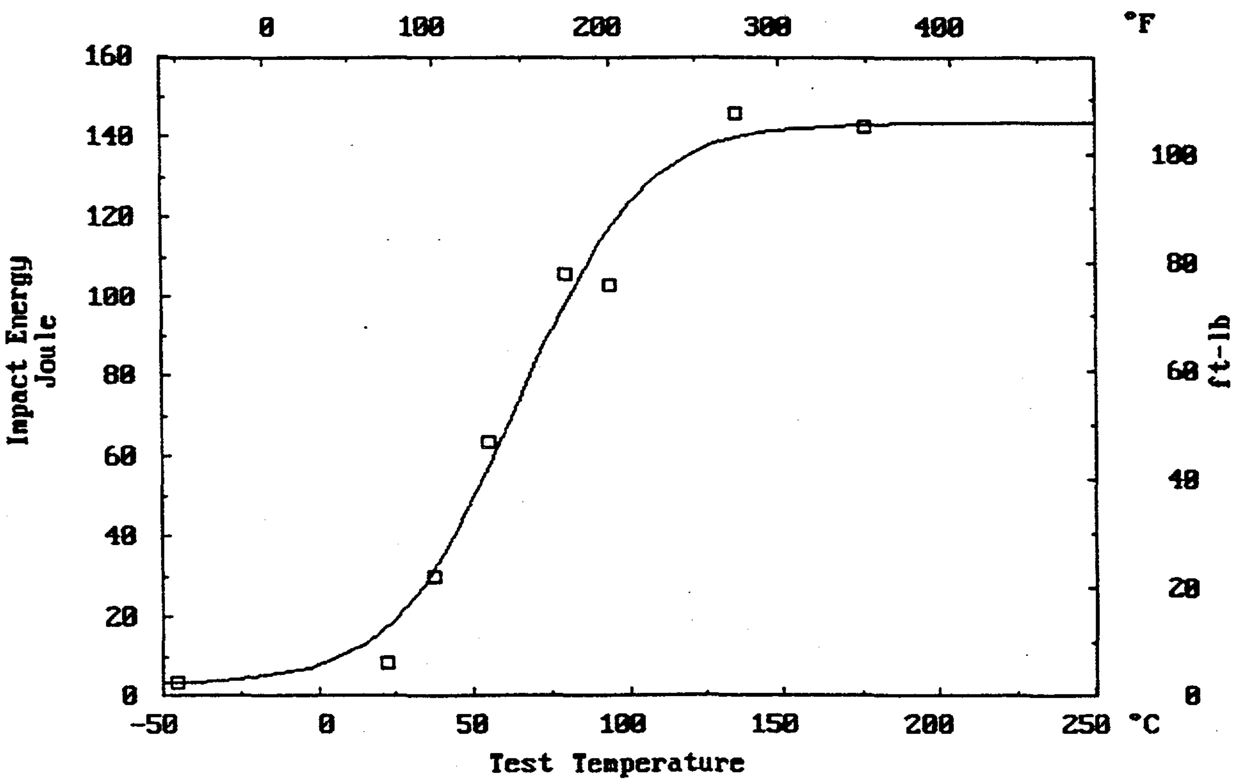
A533B HSST02 REFERENCE MATERIAL
Zion Unit 1, Capsule T

USE= 143.6 J, LSE= 3.0 J, CVT(1/2)= 65.C , Slope = 0.0255
CVT(41J) = 45. C , CVT(68J) = 62. C ,
Fluence = 1.800E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R34	-46.	-50.	3.	2.	0.03	1.	0.
R38	22.	72.	9.	6.	0.20	8.	10.
R37	38.	100.	30.	22.	0.61	24.	25.
R39	56.	132.	64.	47.	1.02	40.	35.
R40	79.	175.	106.	78.	1.57	62.	50.
R36	93.	200.	103.	76.	1.47	58.	55.
R33	135.	275.	146.	108.	1.78	70.	100.
R35	177.	350.	142.	105.	2.08	82.	100.

A533B Reference Material (HSST Plate #2)

ZN1 T SHSS02 SRM LT



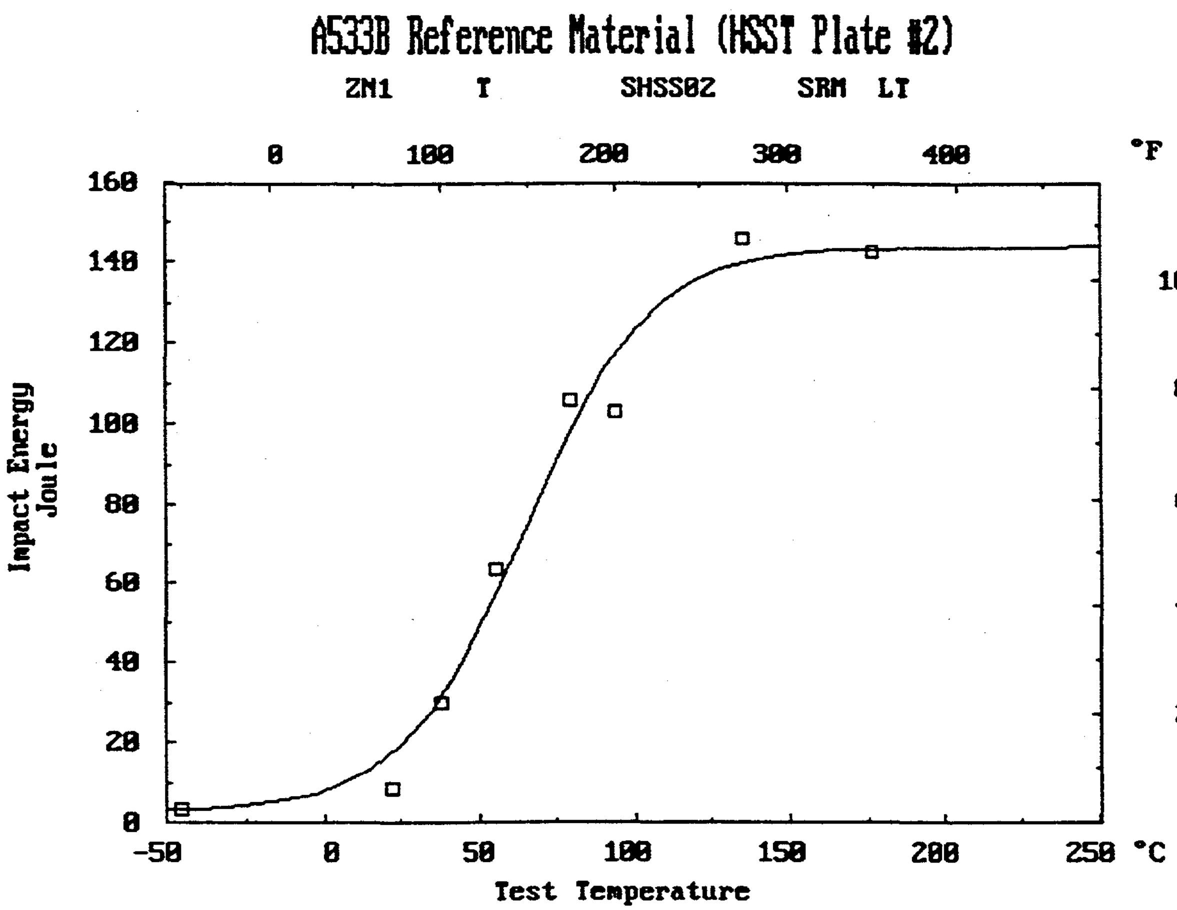
A533B HSST02 REFERENCE MATERIAL

Zion Unit 1, Capsule T

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

ZN1 T SHSS02 SRM LT : Fluence = 1.800E+18 , Irr. Temp. = 288

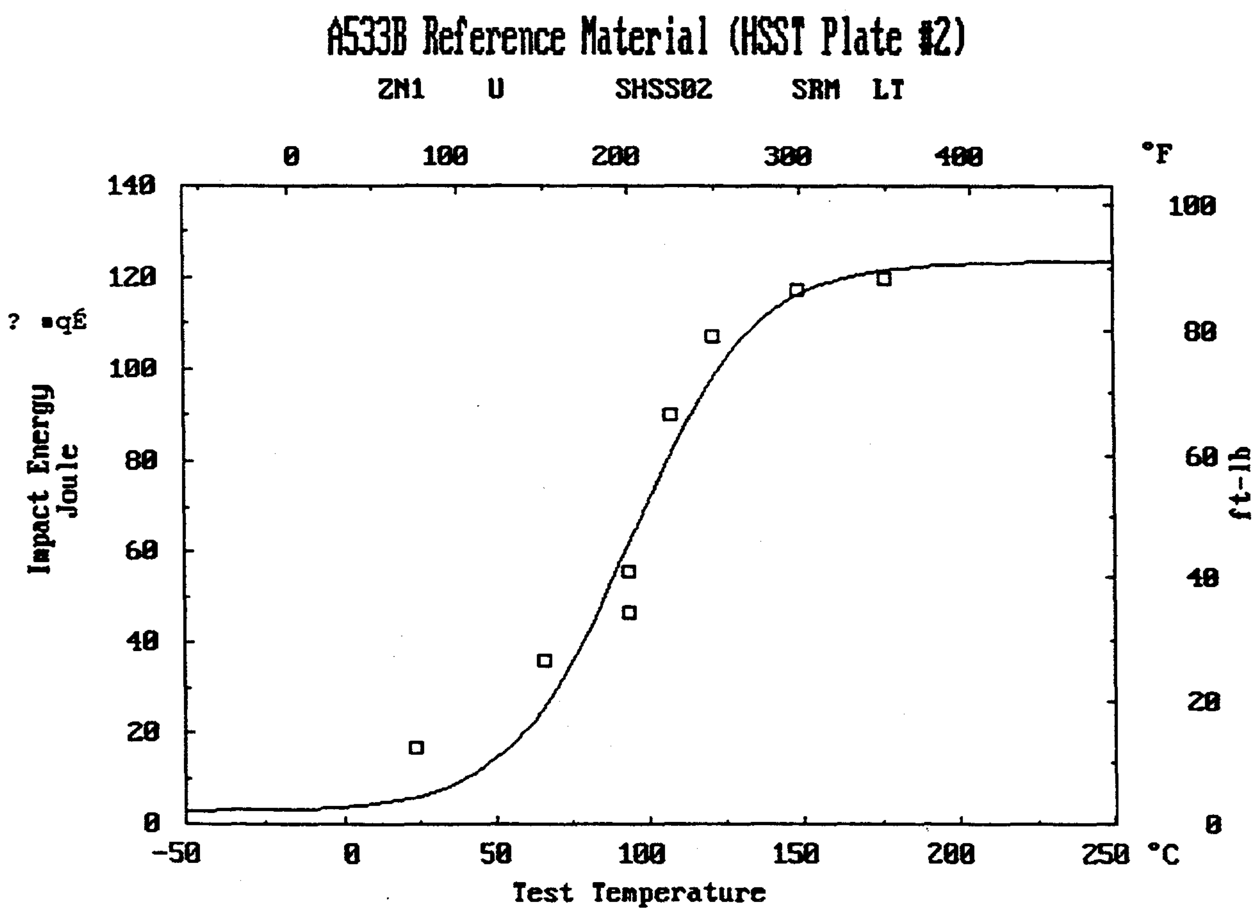
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	143.7	8.0	0.113				
CVT at Midpoint (C)	64.7	5.6	0.097	0.651			
1/slope (C)	39.3	7.9	0.101	0.555	0.480		
CVT at 41 Joule (C)	45.1	4.9	-0.022	-0.011	0.561	-0.429	
CVT at 68 Joule (C)	61.6	4.4	0.037	0.285	0.905	0.213	0.787



A533B HSST02 REFERENCE MATERIAL
Zion Unit 1, Capsule U

USE= 123.6 J, LSE= 3.1 J, CVT(1/2)= 95.C , Slope = 0.0255
CVT(41J) = 79. C , CVT(68J) = 98. C ,
Fluence = 8.920E+18 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	F	Impact Energy J	ft-lb	Lat. Exp. mm	mil	% Shear
R47	24.	75.	17.	12.	0.20	8.	17.
R43	66.	150.	36.	26.	0.56	22.	32.
R41	93.	200.	47.	34.	0.63	25.	39.
R42	93.	200.	56.	41.	0.97	38.	52.
R48	107.	225.	90.	66.	1.40	55.	58.
R46	121.	250.	107.	79.	1.78	70.	81.
R44	149.	300.	117.	86.	1.96	77.	99.
R45	177.	350.	120.	88.	1.96	77.	100.



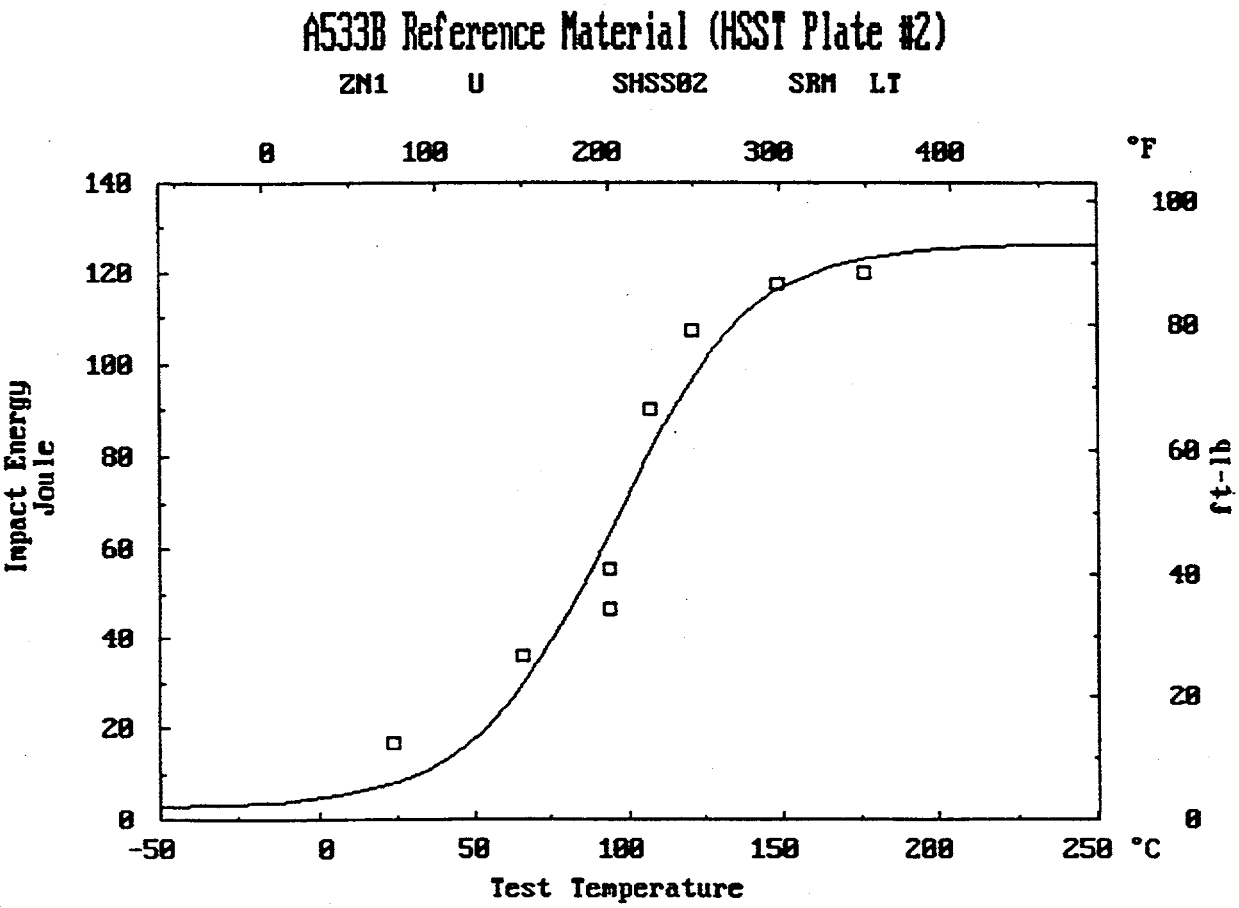
A533B HSST02 REFERENCE MATERIAL

Zion Unit 1, Capsule U

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
ZN1    U     SHSS02    SRM  LT : Fluence = 8.920E+18 , Irr. Temp. =  304
```

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.0					
Upper Shelf Energy (J)	126.1	9.6	-0.088				
CVT at Midpoint (C)	94.8	6.1	0.156	0.674			
1/slope (C)	44.6	12.2	-0.387	0.476	0.148		
CVT at 41 Joule (C)	76.6	7.0	0.425	-0.138	0.483	-0.760	
CVT at 68 Joule (C)	97.1	4.3	0.209	0.121	0.793	-0.064	0.679

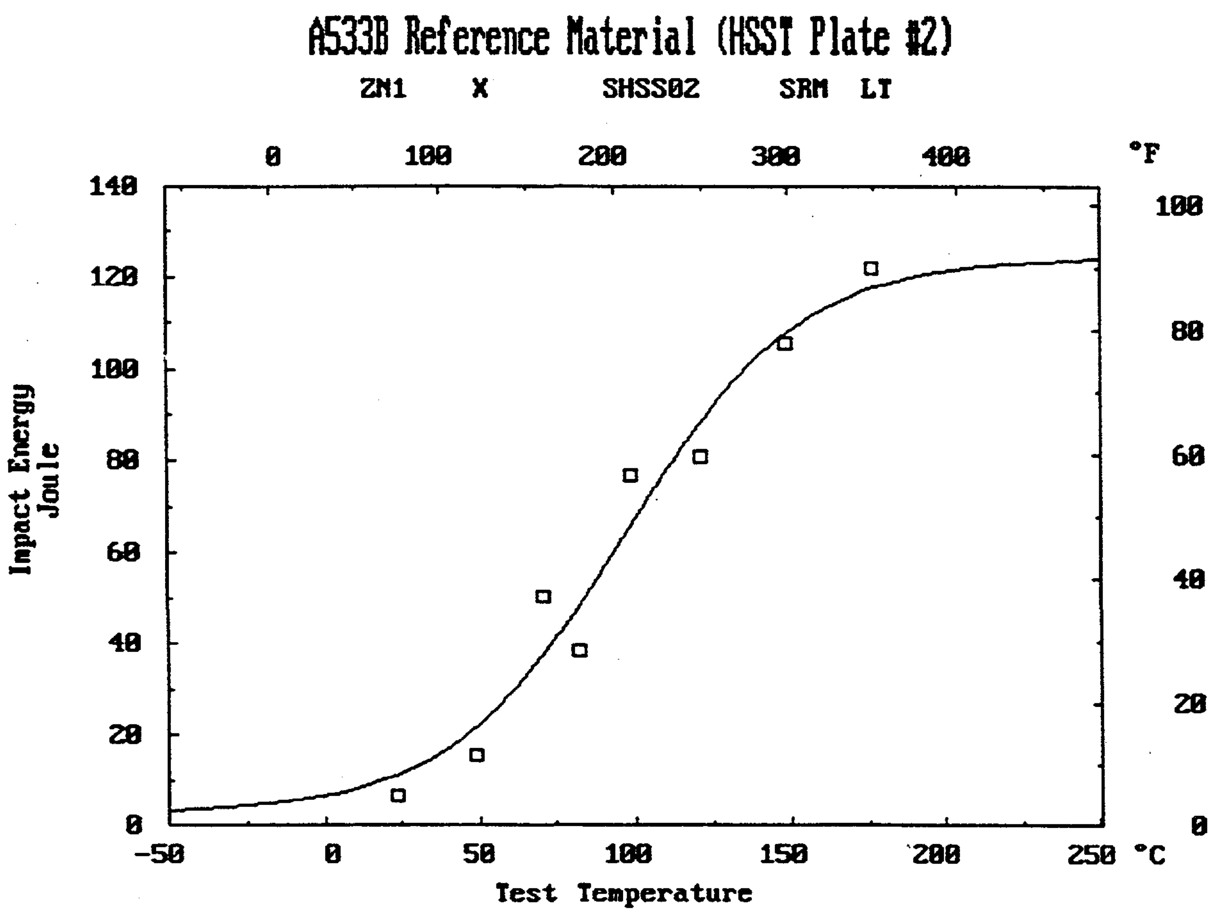


A533B HSST02 REFERENCE MATERIAL

Zion Unit 1, Capsule X

USE= 124.2 J, LSE= 3.0 J, CVT(1/2)= 97.C , Slope = 0.0178
CVT(41J) = 75. C , CVT(68J) = 101. C ,
Fluence = 1.400E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R25	24.	75.	7.	5.	0.10	4.	5.
R28	49.	120.	16.	11.	0.25	10.	10.
R26	71.	160.	50.	37.	0.81	32.	15.
R32	82.	180.	39.	28.	0.69	27.	30.
R27	99.	210.	77.	56.	1.19	47.	25.
R31	121.	250.	81.	59.	1.37	54.	50.
R29	149.	300.	106.	78.	1.47	58.	100.
R30	177.	350.	122.	90.	1.63	64.	100.



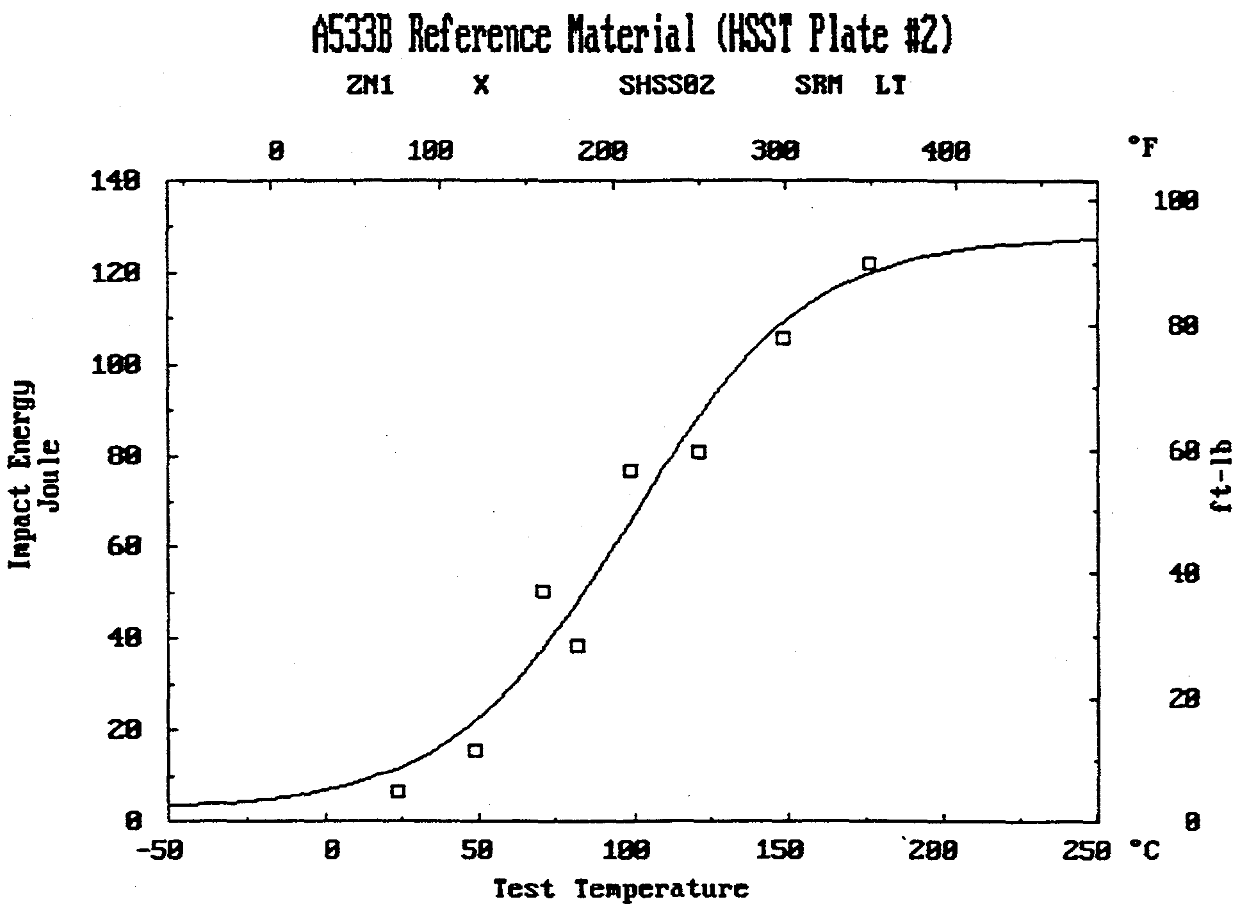
A533B HSST02 REFERENCE MATERIAL

Zion Unit 1, Capsule X

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

ZN1 X SHSS02 SRM LT : Fluence = 1.400E+19 , Irr. Temp. = 304

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	127.8	16.7	0.066				
CVT at Midpoint (C)	98.4	13.0	0.083	0.926			
1/slope (C)	57.6	15.1	0.053	0.816	0.791		
CVT at 41 Joule (C)	74.0	5.6	0.055	0.165	0.439	-0.142	
CVT at 68 Joule (C)	100.3	6.5	0.074	0.630	0.868	0.637	0.645



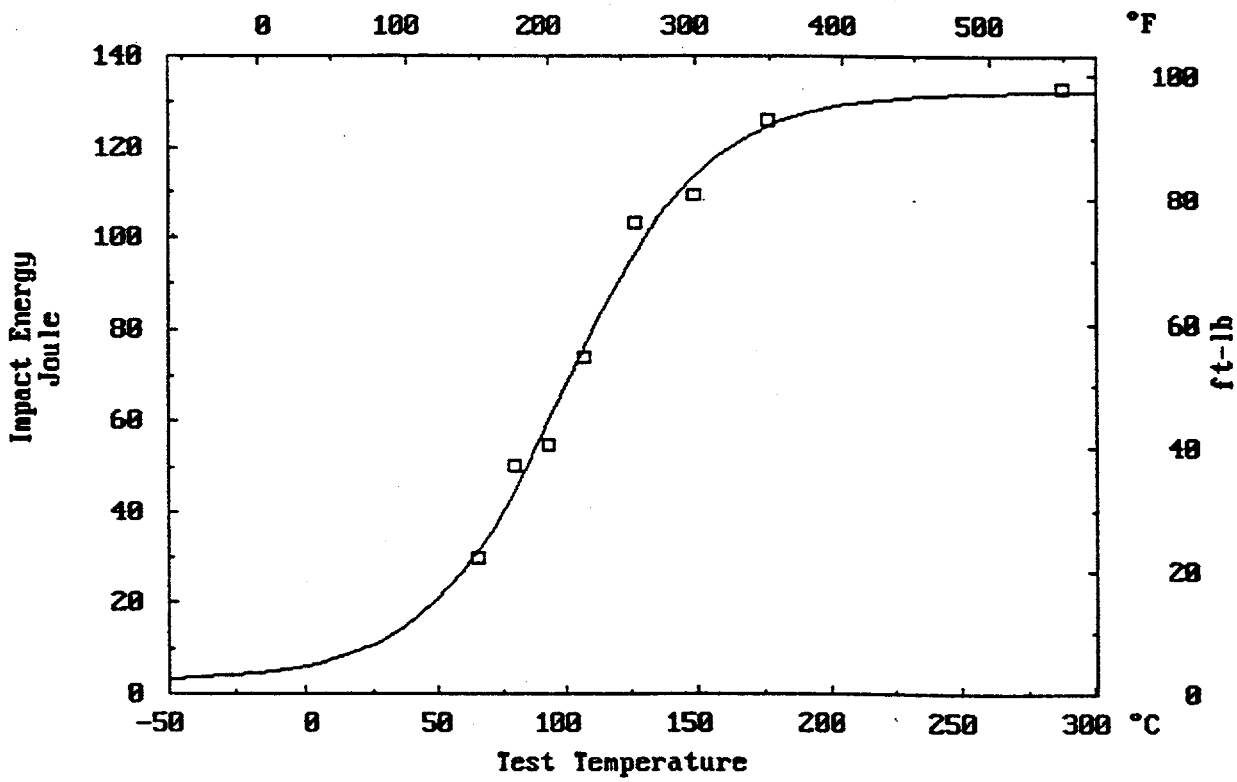
A533B HSST02 REFERENCE MATERIAL
Zion Unit 1, Capsule Y

USE= 132.1 J, LSE= 3.0 J, CVT(1/2)= 100.C , Slope = 0.0183
CVT(41J) = 76. C , CVT(68J) = 100. C ,
Fluence = 1.560E+19 , Irr. Temp. = 304 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R53	66.	150.	30.	22.	0.46	18.	20.
R55	79.	175.	50.	37.	0.81	32.	40.
R50	93.	200.	55.	40.	0.86	34.	40.
R52	107.	225.	74.	54.	1.12	44.	60.
R56	127.	260.	103.	76.	1.55	61.	100.
R51	149.	300.	109.	80.	1.68	66.	100.
R49	177.	350.	126.	93.	1.96	77.	100.
R54	288.	550.	133.	98.	2.13	84.	100.

A533B Reference Material (HSST Plate #2)

ZN1 Y SHSS02 SRM LT



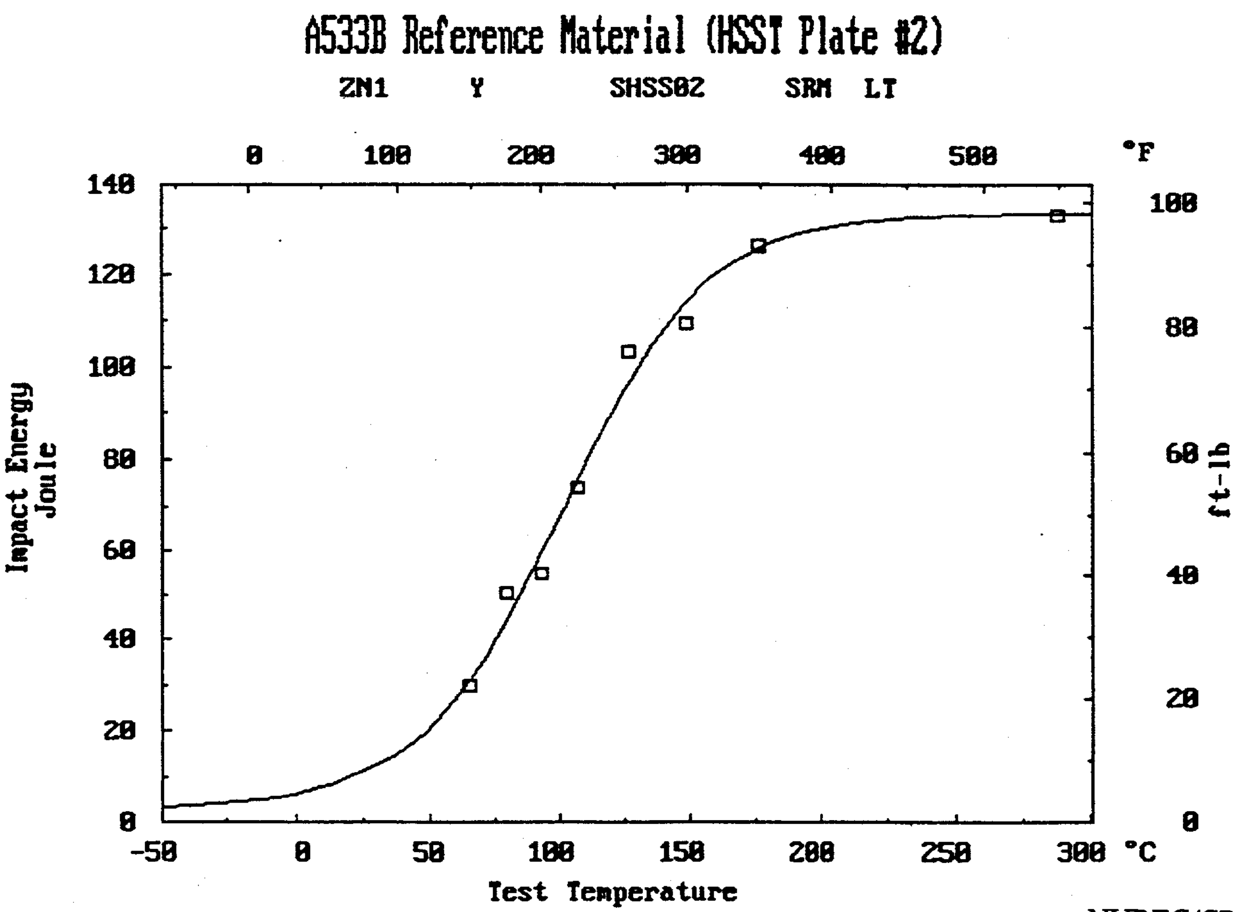
A533B HSST02 REFERENCE MATERIAL

Zion Unit 1, Capsule Y

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

```
ZN1    Y      SHSS02     SRM   LT : Fluence = 1.560E+19 , Irr. Temp. =  304
```

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	133.4	8.9	-0.076				
CVT at Midpoint (C)	100.8	6.9	-0.073	0.721			
1/slope (C)	55.0	13.1	-0.035	0.610	0.475		
CVT at 41 Joule (C)	76.1	6.6	0.001	-0.220	0.293	-0.671	
CVT at 68 Joule (C)	100.4	4.7	-0.015	0.200	0.812	0.136	0.631

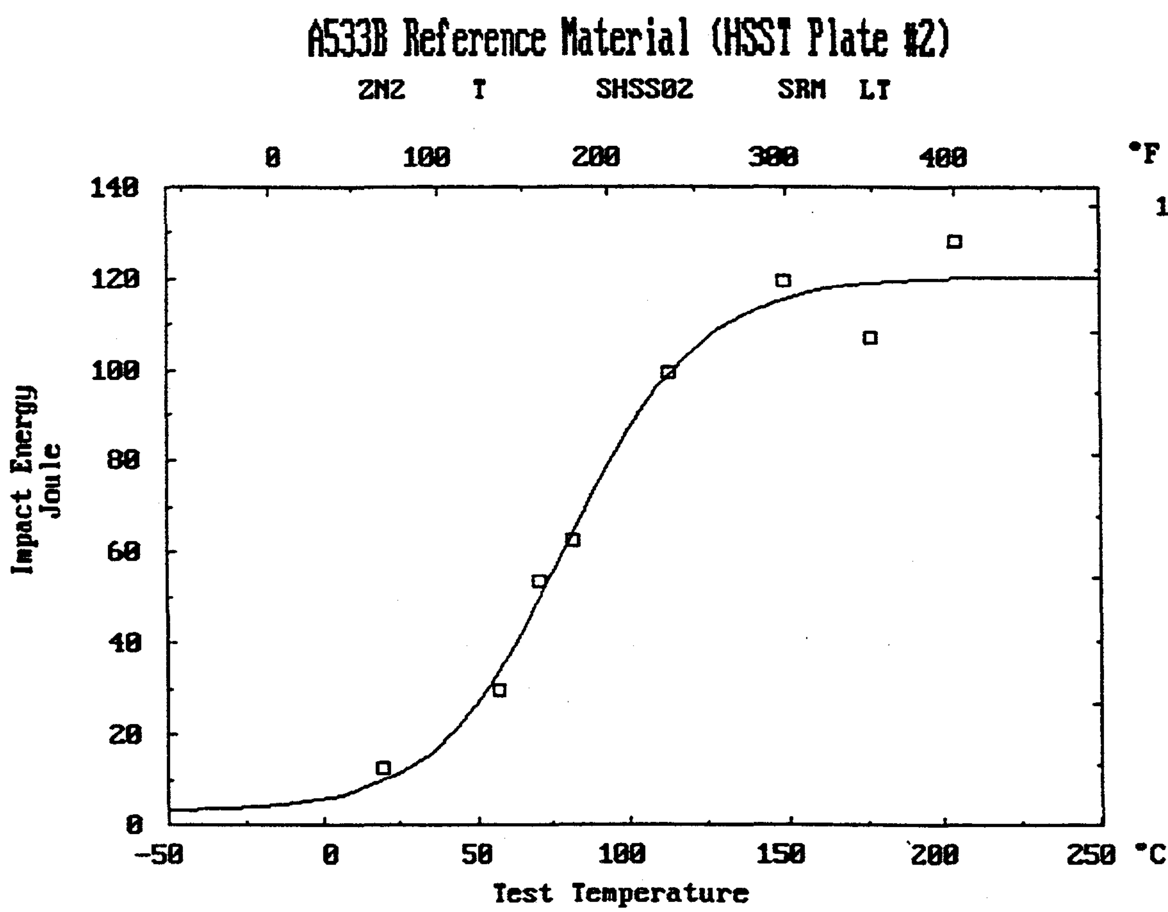


A533B HSST02 REFERENCE MATERIAL

Zion Unit 2, Capsule T

```
USE= 120.3 J, LSE=   3.0 J, CVT(1/2)=    80.C , Slope = 0.0230
CVT(41J) =    64. C , CVT(68J) =    85. C ,
Fluence = 1.000E+19 , Irr. Temp. = 304 C
```

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R40	20.	68.	13.	9.	0.20	8.	10.
R39	57.	135.	30.	22.	0.53	21.	20.
R33	71.	160.	54.	39.	0.86	34.	30.
R38	82.	180.	62.	46.	1.14	45.	30.
R37	113.	235.	100.	73.	1.63	64.	80.
R36	149.	300.	119.	88.	1.93	76.	100.
R35	177.	350.	107.	79.	1.80	71.	100.
R34	204.	400.	128.	94.	2.08	82.	100.



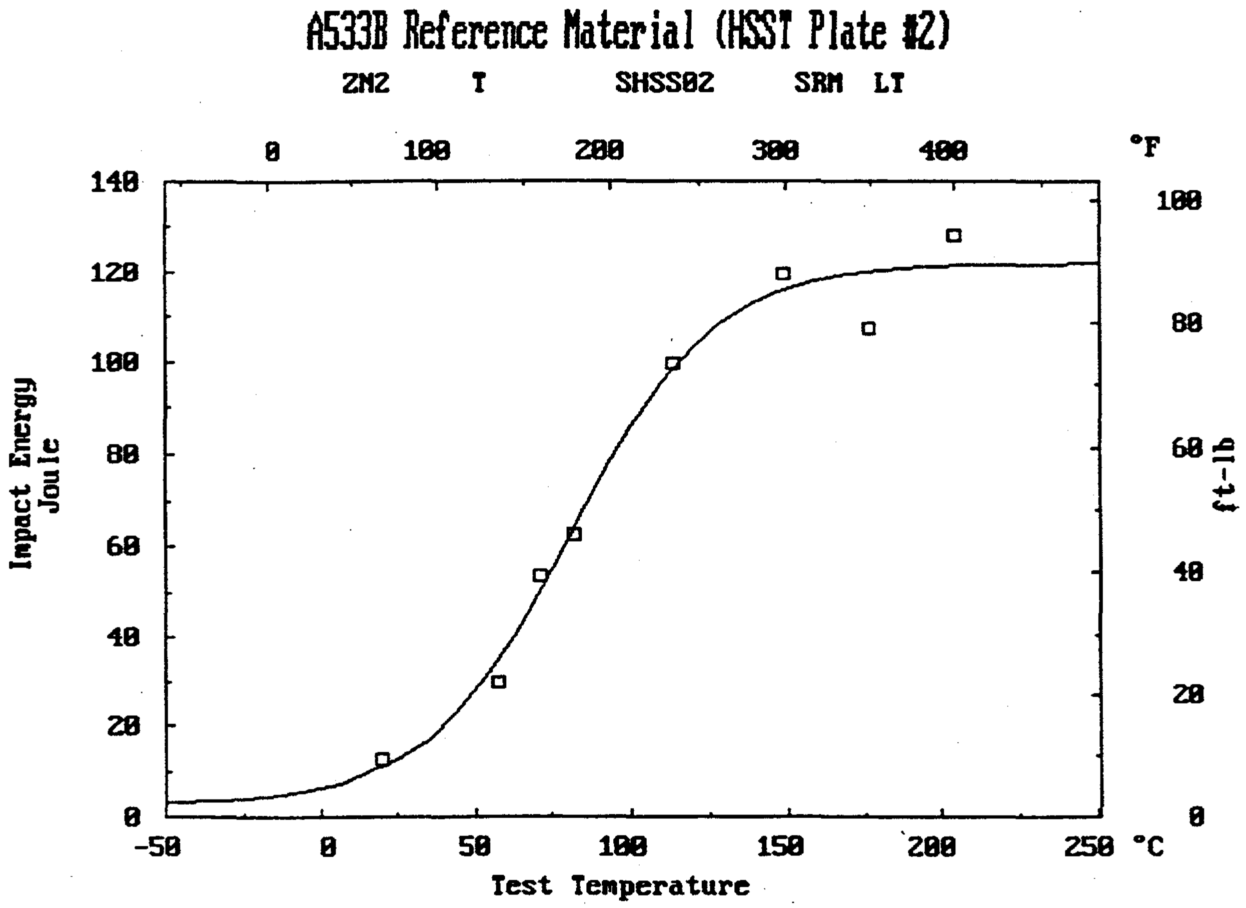
A533B HSST02 REFERENCE MATERIAL

Zion Unit 2, Capsule T

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

ZN2 T SHSS02 SRM LT : Fluence = 1.000E+19 , Irr. Temp. = 304

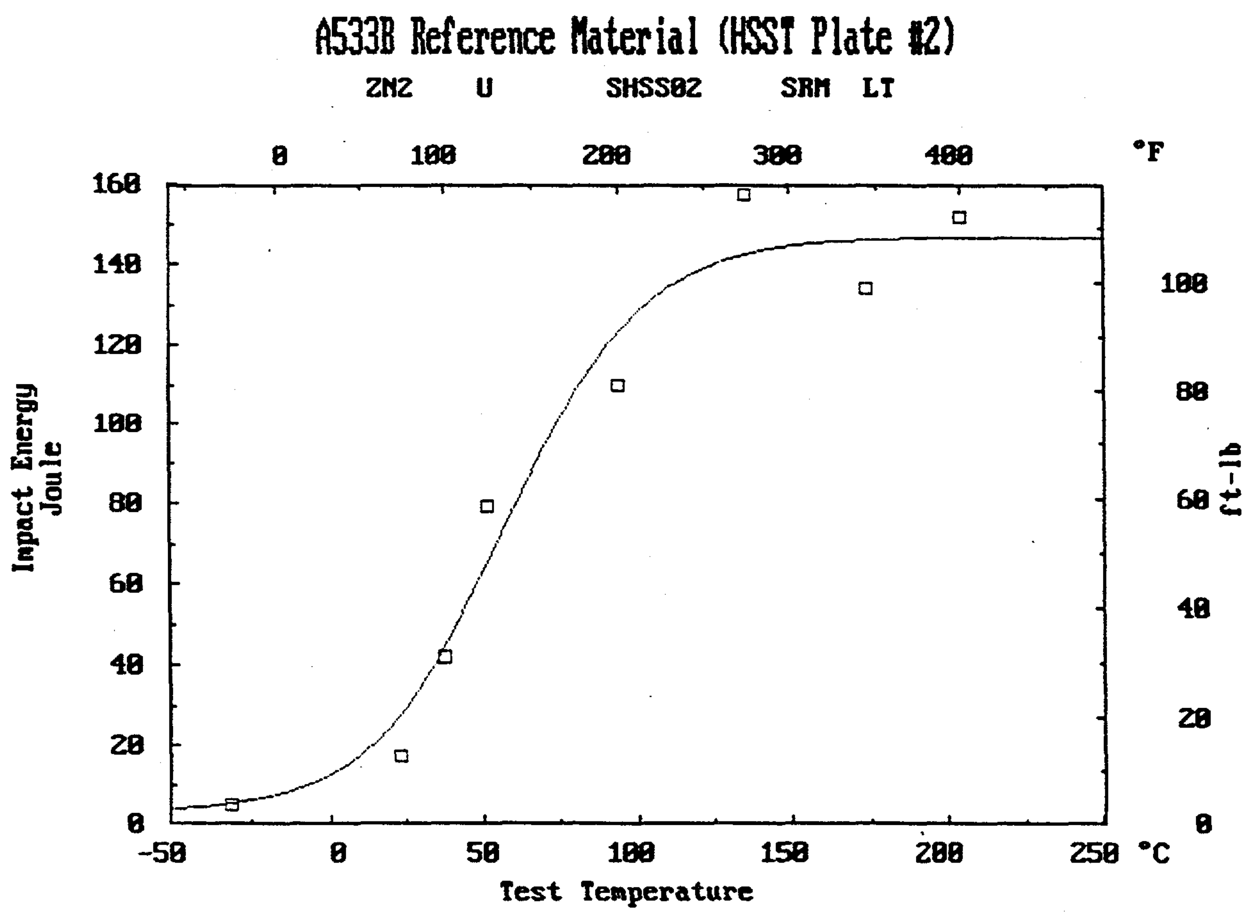
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	121.8	7.3	-0.120				
CVT at Midpoint (C)	80.7	6.7	-0.007	0.620			
1/slope (C)	46.1	12.7	-0.314	0.614	0.502		
CVT at 41 Joule (C)	63.1	5.9	0.290	-0.165	0.481	-0.483	
CVT at 68 Joule (C)	84.8	5.6	-0.008	0.292	0.916	0.441	0.562



A533B HSST02 REFERENCE MATERIAL
Zion Unit 2, Capsule U

USE= 146.8 J, LSE= 3.0 J, CVT(1/2)= 58.C , Slope = 0.0227
CVT(41J) = 35. C , CVT(68J) = 53. C ,
Fluence = 2.000E+18 , Irr. Temp. = 288 C

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R46	-32.	-25.	5.	3.	0.18	7.	0.
R42	23.	73.	18.	13.	0.43	17.	15.
R48	38.	100.	42.	31.	0.66	26.	25.
R41	52.	125.	79.	58.	1.22	48.	45.
R47	93.	200.	110.	81.	1.65	65.	70.
R43	135.	275.	157.	116.	2.24	88.	100.
R44	174.	345.	134.	99.	2.03	80.	100.
R45	204.	400.	152.	112.	2.03	80.	100.



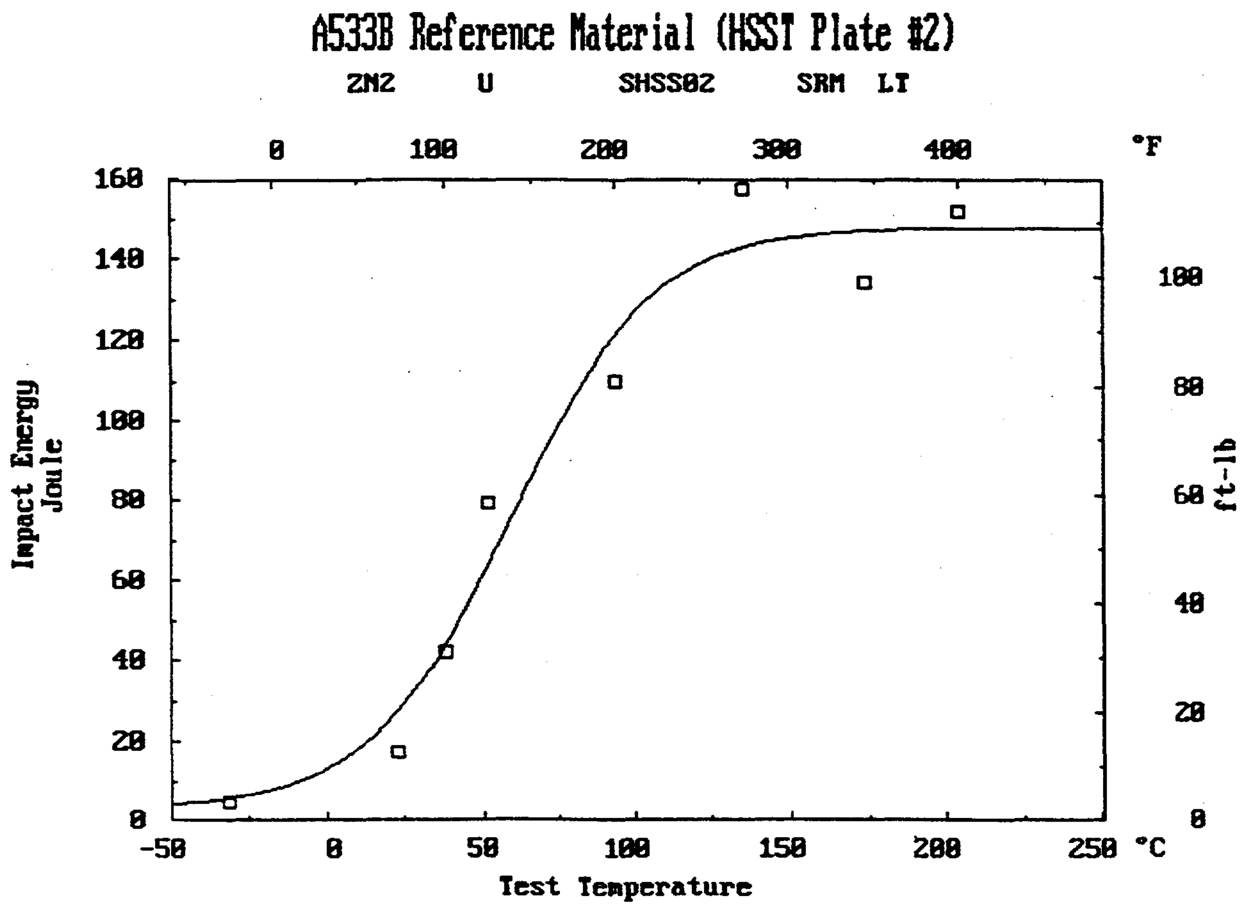
A533B HSST02 REFERENCE MATERIAL

Zion Unit 2, Capsule U

Impact Energy Uncertainty = 10.0 J
Test Temperature Uncertainty = 4.0 Degree C
Number of Successful Iterations = 200, Maximum = 1000

ZN2 U SHSS02 SRM LT : Fluence = 2.000E+18 , Irr. Temp. = 288

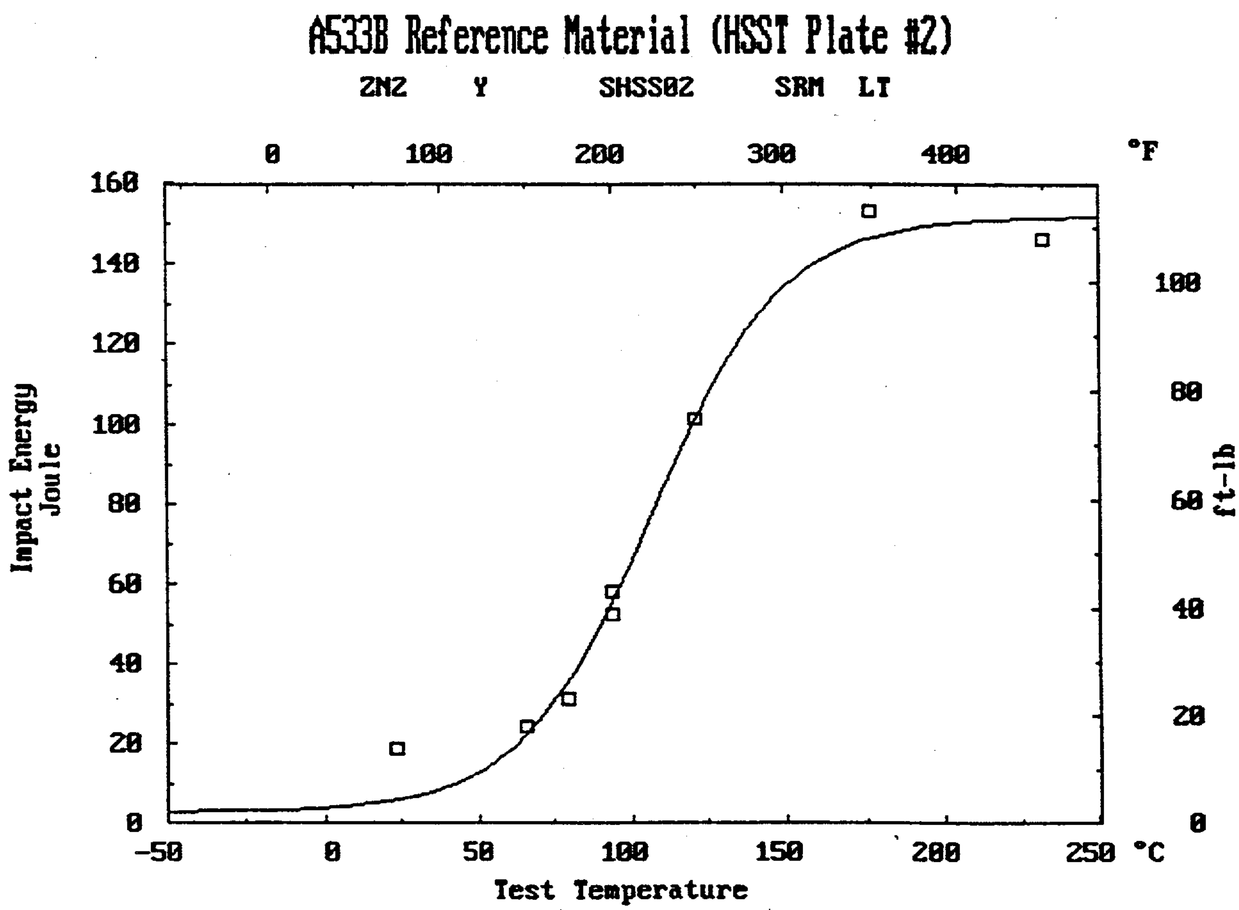
Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.0	0.0					
Upper Shelf Energy (J)	147.9	6.8	0.065				
CVT at Midpoint (C)	59.3	6.7	0.010	0.635			
1/slope (C)	45.7	10.0	-0.050	0.525	0.612		
CVT at 41 Joule (C)	35.5	5.2	0.047	0.001	0.488	-0.369	
CVT at 68 Joule (C)	54.5	5.1	0.004	0.329	0.925	0.385	0.713



A533B HSST02 REFERENCE MATERIAL
Zion Unit 2, Capsule Y

```
USE= 151.9 J, LSE=   3.1 J, CVT(1/2)=  106.C , Slope = 0.0235
CVT(41J) =   84. C , CVT(68J) =  101. C ,
Fluence = 1.480E+19 , Irr. Temp. = 288 C
```

Spec. ID	Test Temp. C	Test Temp. F	Impact Energy J	Impact Energy ft-lb	Lat. Exp. mm	Lat. Exp. mil	% Shear
R55	23.	74.	19.	14.	0.28	11.	10.
R51	66.	150.	24.	18.	0.38	15.	15.
R54	79.	175.	31.	23.	0.53	21.	20.
R49	93.	200.	58.	43.	0.79	31.	35.
R50	93.	200.	53.	39.	0.74	29.	35.
R56	121.	250.	102.	75.	1.35	53.	65.
R53	177.	350.	153.	113.	1.88	74.	100.
R52	232.	450.	146.	108.	1.78	70.	100.



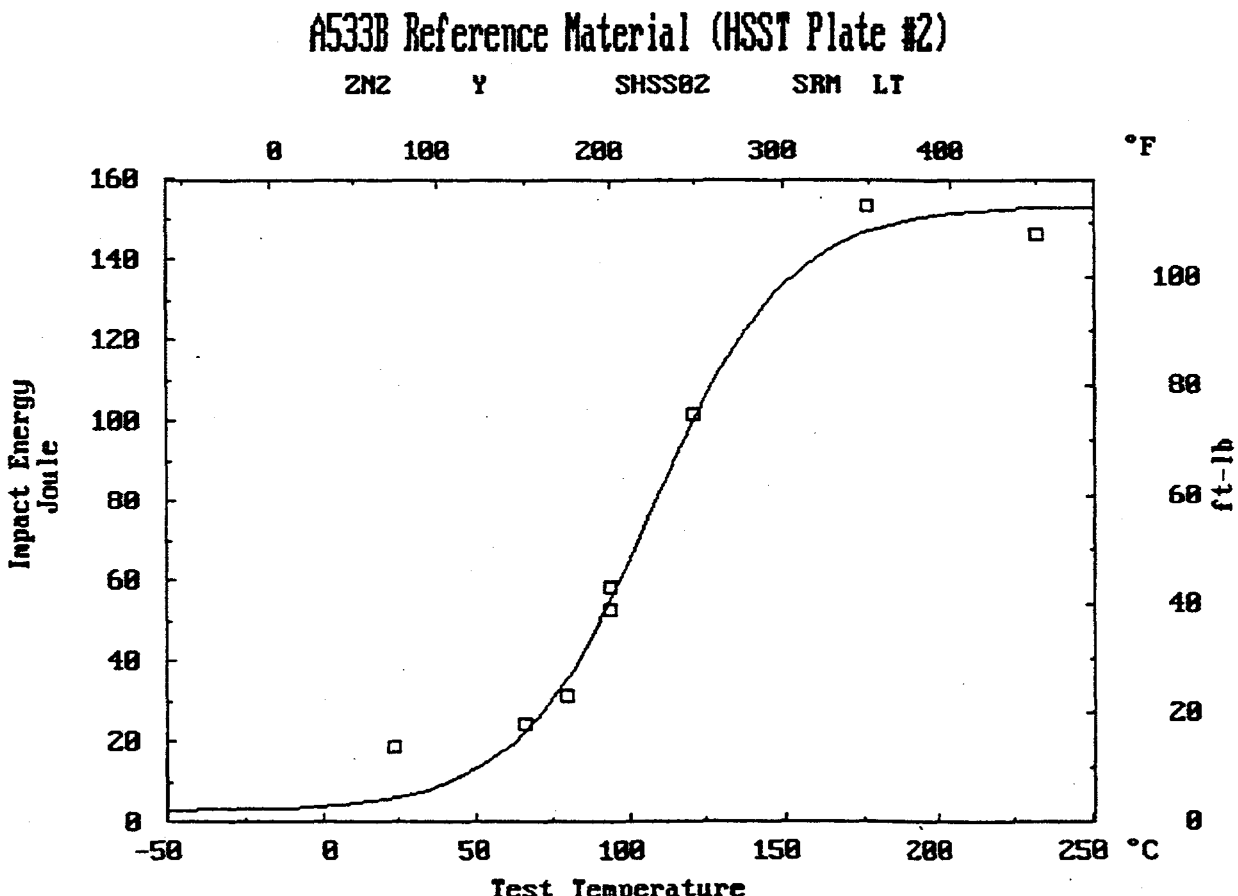
A533B HSST02 REFERENCE MATERIAL

Zion Unit 2, Capsule Y

```
Impact Energy Uncertainty =  10.0 J
Test Temperature Uncertainty =   4.0 Degree C
Number of Successful Iterations =  200, Maximum = 1000
```

ZN2 Y SHSS02 SRM LT : Fluence = 1.480E+19 , Irr. Temp. = 288

Parameter	Mean	Std.Dev.	Correlation Coefficients				
Lower Shelf Energy (J)	3.1	0.1					
Upper Shelf Energy (J)	153.2	7.4	0.025				
CVT at Midpoint (C)	107.6	5.3	0.039	0.584			
1/slope (C)	43.7	9.8	-0.239	0.363	0.566		
CVT at 41 Joule (C)	83.9	4.8	0.293	-0.069	0.272	-0.613	
CVT at 68 Joule (C)	101.6	3.8	0.118	0.171	0.857	0.226	0.627



APPENDIX B

BIBLIOGRAPHIC LISTING OF SURVEILLANCE REPORTS

The surveillance reports that provided the data for PR-EDB and for this report are listed below. Fluence values of Westinghouse data used in this report are chosen from "Westinghouse Surveillance Capsule Neutron Reevaluation," WCAP-14044.

Arkansas Nuclear One

A. L. Lowe, Jr. et al., "Analysis of Capsule ANI-E from Arkansas Power & Light Company Arkansas Nuclear One - Unit 1, Reactor Vessel Materials Surveillance Program," BAW-1440, Babcock & Wilcox, Lynchburg, Virginia, April 1977.

A. L. Lowe, Jr. et al., "Analysis of Capsule ANI-B from Arkansas Power & Light Company's Arkansas Nuclear One, Unit 1, Reactor Vessel Materials Surveillance Program," BAW-1698, Babcock & Wilcox, Lynchburg, Virginia, November 1981.

A. L. Lowe, Jr. et al., "Analyses of Capsule AN1-A Arkansas Power & Light Company, Arkansas Nuclear One, Unit 1, Reactor Vessel Material Surveillance Program," BAW-1836, Babcock & Wilcox, Lynchburg, Virginia, July 1984.

A. L. Lowe, Jr. et al., "Analysis of Capsule AN1-C Arkansas Power & Light Company Arkansas Nuclear One, Unit 1, Reactor Vessel Material Surveillance Program," BAW-2075, Rev. 1, Babcock & Wilcox, Lynchburg, Virginia, October 1989.

L. M. Lowry et al., "Summary Report on Examination, Testing, and Evaluation of Irradiated Pressure Vessel Surveillance Specimens from the Arkansas Nuclear One Unit 2 Generating Plant," Battelle Memorial Institute, Columbus, Ohio, May 1984.

A. Ragl, "Arkansas Power & Light Arkansas Nuclear One - Unit 2 Evaluation of Baseline Specimens Reactor Vessel Materials Irradiation Surveillance Program," TR-MCD-002, Combustion Engineering, Inc., Windsor, Connecticut, February 1976.

Big Rock Point

P. McConnell et al., "Irradiated Nuclear Pressure Vessel Steel Data Base," EPRI NP-2428, Electric Power Research Institute, Palo Alto, California, June 1982.

F. A. Brandt, "Reactor Pressure Vessel Material Surveillance Program at the Consumers Power Company Big Rock Point Nuclear Plant," GECR-4442, General Electric, San Jose, California, December 1963.

C. Z. Serpan, Jr. and H. E. Watson, "Mechanical Property and Neutron Spectral Analyses of the Big Rock Point Reactor Pressure Vessel, Naval Research Laboratory," Washington, D.C., Nucl. Eng. & Design 11(3), pp. 393-415, April 1970.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of Capsule 125 from the Consumers Power Company Big Rock Point Nuclear Plant Reactor Vessel Radiation Surveillance Program," WCAP-9794, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

Beznau

G. Ullrich and B. Burgisser, "Nachbestrahlungsuntersuchungen an NOK-Reaktordruckgefass-material der Kernkraftwerke Beznau I/2 - Kapsel R," PB-ME-75/03, Eidg. Institut für Reaktorforschung, November 1975.

G. Ullrich, B. Burgisser, E. Hegedues, and T. Aerne/jem, "Nachbestrahlungsuntersuchungen an NOK-Reaktordruckgefassmaterial des KKB I/Kapsel S," PB-ME 78/06, Eidg. Institut für Reaktorforschung, August 1978.

S. E. Yanichko, "NOK Reactor Vessel, Radiation Surveillance Program," WCAP-7214, Westinghouse Electric Corp., Pittsburgh, Pennsylvania, June 1968.

Jose Cabrera-Zorita

S. E. Yanichko, K. C. Tran, R. P. Shogan, and R. G. Lott, "Analysis of Capsule N from the Union Electrica, S.A., Jose Cabrera Reactor Vessel Radiation Surveillance Program," WCAP-10185, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, October 1982.

S. E. Yanichko, "Union Electrica Madrilena Zorita Reactor Vessel Radiation Surveillance Program," WCAP-7691-1, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1971.

T. R. Mager, R. Shogan, and S. Anderson, "Analysis of Capsules P and K from Union Electrica, S.A., Jose Cabrera Reactor Vessel Radiation Surveillance Program," WENX/76/64, Westinghouse Nuclear Europe, Brussels, August 1976.

Calvert Cliffs

J. S. Perrin et al., "Final Report on Calvert Cliffs Unit No. 1 Nuclear Plant Reactor Pressure Vessel Surveillance Program: Capsule 263," Battelle Columbus Laboratories, Columbus, Ohio, December 15, 1980.

A. E. Jundvall, Jr., "Response to NRC inquiries regarding Calvert Cliffs Nuclear Power Plant Unit No. 1 and 2, Docket No. 50-317 and 50-318 Reactor Vessel Material Surveillance Program," Baltimore Gas and Electric Company, Baltimore, Maryland, December 29, 1977.

S. T. Byrne, E. C. Biemiller, and A. Ragl, "Testing and Evaluation of Calvert Cliffs, Units 1 and 2 Reactor Vessel Materials Irradiation Surveillance Program Baseline Samples," TR-ESS-001, Combustion Engineering, Inc., Windsor, Connecticut, January 31, 1975.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Calvert Cliffs Unit 2 Analysis of 263-Deg. Capsule," SwRI-7524, Southwest Research Institute, San Antonio, Texas, September 1985.

Donald C. Cook

E. B. Norris, "Reactor Vessel Material Surveillance Program for Donald C. Cook Unit No. 1, Analysis of Capsule T," SwRI Project 02-4770, Southwest Research Institute, San Antonio, Texas, December 1977.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Donald C. Cook Unit No. 1 Analysis of Capsule X," SwRI Project No. 02-6159, Southwest Research Institute, San Antonio, Texas, June 22, 1981.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Donald C. Cook, Unit No. 1, Analysis of Capsule Y," SwRI-7244-001/1, Southwest Research Institute, San Antonio, Texas, January 1984.

E. Terek et al., "Analysis of Capsule U from the American Electric Power Company D. C. Cook Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-12483, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, January 1990.

S. E. Yanichko and D. J. Lege, "American Electric Power Service Corporation Donald C. Cook Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8047, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1973.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Donald C. Cook Unit 2 Analysis of Capsule T," SwRI Project No. 02-5928, Southwest Research Institute, San Antonio, Texas, September 16, 1981.

P. K. Nair and M. L. Williams, "Reactor Vessel Material Surveillance Program for Donald C. Cook Unit No. 2: Analysis of Capsule X," SwRI Project 06-8888, Southwest Research Institute, San Antonio, Texas, May 1987.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Donald C. Cook, Unit No. 2, Analysis of Capsule Y," SwRI-7244-002/1, Southwest Research Institute, San Antonio, Texas, February 1984.

J. A. Davidson, S. E. Yanichko, and J. H. Phillips, "American Electric Power Company Donald C. Cook Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8512, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, November 1975.

Crystal River

A. L. Lowe, Jr. et al., "Analyses of Capsule CR3-B, Florida Power Corporation, Crystal River Unit 3, Reactor Vessel Materials Surveillance Program," BAW-1679, Rev. 1, Babcock & Wilcox, Lynchburg, Virginia, June 1982.

A. L. Lowe, Jr., J. D. Aadland, W. A. Pavinich, and C. L. Whitmarsh, "Fracture Toughness Test Results from Capsule CR3-B Florida Power Corporation Crystal River Unit 3, Reactor Vessel Material Surveillance Program," BAW-1718, Babcock & Wilcox, Lynchburg, Virginia.

A. L. Lowe, Jr. et al., "Analysis of Capsule CR3-D Florida Power Corporation Crystal River Unit 3 Reactor Vessel Material Surveillance Program," BAW-1899, Babcock & Wilcox, Lynchburg, Virginia, March 1986.

A. L. Lowe, Jr. et al., "Analysis of Capsule CR3-F Florida Power Corporation Cristal River Unit-3, Reactor Vessel Material Surveillance Program," BAW-2049, Babcock & Wilcox, Lynchburg, Virginia, September 1988.

Haddam Neck

D. R. Ireland and V. G. Scotti, "Final Report on Examination and Evaluation of Capsule A for the Connecticut Yankee Reactor Pressure Vessel Surveillance Program," Battelle Memorial Institute, Columbus, Ohio, October 1970.

J. S. Perrin, J. W. Sheckherd, and V. G. Scotti, "Final Report on Examination and Evaluation of Capsule F for the Connecticut Yankee Reactor Pressure Vessel Surveillance Program, Part A. Primary Investigations and Part B. Supplementary Activities," Battelle Memorial Institute, Columbus, Ohio.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of Capsule D from the Connecticut Yankee Reactor Vessel Radiation Surveillance Program," WCAP-10236, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, January 1983.

S. E. Yanichko, "Connecticut Yankee Reactor Vessel Radiation Surveillance Program," WCAP-7036, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, April 1967.

P. J. Fields and S. L. Anderson, "Analysis of Capsule H from the Connecticut Yankee Reactor Vessel Radiation Surveillance Program," WCAP-9339, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, September 1978.

Davis-Besse

A. L. Lowe, Jr. et al., "Analyses of Capsule TE1-F, The Toledo Edison Company, Davis-Besse Nuclear Power Station Unit 1, Reactor Vessel Material Surveillance Program," BAW-1701, Babcock & Wilcox, Lynchburg, Virginia, January 1982 (Rev. 1, Toledo Edison, August 1).

A. L. Lowe, Jr., J. D. Aadland, J. E. Ewing, and W. A. Pavinich, "Fracture Toughness Test Results from Capsule TE1-F, the Toledo Edison Company, Davis-Besse Nuclear Power Station Unit 1, Reactor Vessel Material Surveillance Program," BAW-1719, Babcock & Wilcox.

A. L. Lowe, Jr. et al., "Analyses of Capsule TE1-B, The Toledo Edison Company, Davis-Besse Nuclear Power Station Unit 1, Reactor Vessel Material Surveillance Program," BAW-1834, Babcock & Wilcox, Lynchburg, Virginia, May 1984.

A. L. Lowe, Jr. et al., "Analyses of Capsule TE1-A, The Toledo Edison Company, Davis-Besse Nuclear Power Station Unit 1, Reactor Vessel Material Surveillance Program," BAW-1882, Babcock & Wilcox, Lynchburg, Virginia, September 1985.

A. L. Lowe, Jr. et al., "Analysis of Capsule TE1-D the Toledo Edison Company Davis Besse Nuclear Power Station Unit 1 Reactor Vessel Material Surveillance Program," BAW-2125, B&W Nuclear Service Company, Lynchburg, Virginia, December 1990.

Diablo Canyon

G. M. Rueger, Letter Subject: "Docket No. 50-275, OL-DPR-80, Diablo Canyon Unit 1 Supplemental Reactor Vessel Radiation Surveillance Program," Pacific Gas and Electric Company, San Francisco, California, March 31, 1992.

S. E. Yanichko, S. L. Anderson, J. C. Schmertz, and L. Albertin, "Analysis of Capsule S from Pacific Gas and Electric Company Diablo Canyon Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-11567, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

J. A. Davidson, J. H. Phillips, and S. E. Yanichko, "Pacific Gas and Electric Co. Diablo Canyon Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8465, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, January 1975.

S. E. Yanichko et al., "Analysis of Capsule U from the Pacific Gas and Electric Company Diablo Canyon Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-11851, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1988.

J. A. Davidson and S. E. Yanichko, "Pacific Gas and Electric Company Diablo Canyon Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8783, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, December 1976.

Dresden Nuclear Plant Station

F. A. Brandt and A. J. Alexander, "Dresden Nuclear Power Station Reactor Vessel Steel Surveillance Program," APED-3988, General Electric, San Jose, California, July 1962.

M. S. Turbak, "Dresden Station Unit 1 Reactor Vessel Material Surveillance Program NRC Docket No. 50-10," Commonwealth Edison, December 23, 1977.

M. S. Hersh, F. A. Brandt, and B. C. Beaudreau, "Dresden Nuclear Power Station Reactor Vessel Steel Surveillance Program," GECR-5165, General Electric, San Jose, California, May 1966.

G. F. Rieger and G. H. Henderson, "Dresden Nuclear Power Station Unit One and Unit Two Mechanical Properties of Irradiated Reactor Vessel Material Surveillance Specimens," NEDC-12585, General Electric, Pleasanton, California, May 1975.

E. O. Fromm et al., "Final Report on Dresden Nuclear Plant Reactor Pressure Vessel Surveillance Program: Unit No. 2 Capsule Basket Assembly No. 5," BCL-585-10, Battelle Columbus Laboratories, Columbus, Ohio, May 8, 1979.

J. S. Perrin et al., "Final Report on Dresden Nuclear Plant Reactor Pressure Vessel Surveillance Program: Unit No. 2 Neutron Dosimeter Monitor, Unit No. 2 Capsule Basket Assembly No. 2, and Unit No. 3 Capsule Basket Assembly No. 12," BCL-585-3, Battelle Columbus Laboratories, Columbus, Ohio.

G. F. Rieger and G. H. Henderson, "Dresden Nuclear Power Station, Mechanical Properties of Unirradiated Reactor Vessel Material," NEDC 12575, General Electric Company, April 1975.

G. F. Rieger and G. H. Henderson, "Dresden Nuclear Power Station Unit One and Unit Two Mechanical Properties of Irradiated Reactor Vessel Material Surveillance Specimens," NEDC-12585, General Electric, Pleasanton, California, May 1975.

E. B. Norris, "Dresden Nuclear Power Station Unit 2 Reactor Vessel Irradiation Surveillance Program, Analysis of Capsule No. 8," SwRI Project No. 06-6901-002, Southwest Research Institute, San Antonio, Texas, March 1983.

J. S. Perrin et al., "Final Report on Dresden Nuclear Plant Reactor Pressure Vessel Surveillance Program: Unit No. 3 Capsule Basket Assembly No. 6," BCL-585-14, Battelle Columbus Laboratories, Columbus, Ohio, June 15, 1979.

J. S. Perrin et al., "Final Report on Dresden Nuclear Plant Reactor Pressure Vessel Surveillance Program: Unit No. 2 Neutron Dosimeter Monitor, Unit No. 2 Capsule Basket Assembly No. 2, and Unit No. 3 Capsule Basket Assembly No. 12," BCL-585-3,Battelle Columbus Laboratories, Columbus, Ohio.

J. S. Perrin and L. M. Lowry, "Final Report on Dresden Nuclear Plant Unit No. 3 Vessel Surveillance Programs: Unirradiated Mechanical Properties," Battelle Columbus Laboratories, Columbus, Ohio, February 15, 1975.

J. S. Perrin et al., "Final Report on Dresden Nuclear Plant Unit No. 3 Reactor Pressure Vessel Surveillance Program: Capsule Basket No. 13, Capsule Basket No. 14, and Neutron Dosimeter Monitor," Battelle Columbus Laboratories, Columbus, Ohio, March 1, 1975.

E. B. Norris, "Dresden Nuclear Power Station Unit 3 Reactor Vessel Irradiation Surveillance Program, Analysis of Capsule No. 18," SwRI Project No. 06-7684-003, Southwest Research Institute, San Antonio, Texas, February 1984.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of the Fourth Capsule from the Commonwealth Edison Company Dresden Unit 3 Nuclear Plant Reactor Vessel Radiation Surveillance Program," WCAP-10030, Westinghouse Electric Corporation.

Fort Calhoun Station

A. Ragl, "Omaha Public Power District Fort Calhoun Station Unit No. 1 Evaluation of Baseline Specimens Reactor Vessel Materials Irradiation Surveillance Program," TR-O-MCD-001, Combustion Engineering, Inc., Windsor, Connecticut, March 1977.

S. T. Byrne, "Omaha Public Power District Fort Calhoun Station Unit No. 1, Post-Irradiation Evaluation of Reactor Vessel Surveillance Capsule W-225, Reactor Vessel Materials Irradiation Surveillance Program," TR-O-MCM-001, Combustion Engineering, Inc., Windsor, Connecticut.

S. T. Byrne, "Omaha Public Power District Fort Calhoun Station Unit No. 1, Post-irradiation Evaluation of Reactor Vessel Surveillance Capsule W-225," TR-0-MCM-001, Rev. 1, Combustion Engineering, Inc., Windsor, Connecticut, August 1980.

S. T. Byrne, "Omaha Public Power District Fort Calhoun Station Unit No. 1 Evaluation of Irradiated Capsule W-265 Reactor Vessel Materials Irradiation Surveillance Program," TR-O-MCM-002, Combustion Engineering Inc., Windsor, Connecticut, March 1984.

Garigliano

M. Galliani et al., "Garigliano Nuclear Power Plant Pressure Vessel Surveillance Program Updating to 7th Operation Cycle," DPT/SN/041/R/79, Ente Nazionale per l'Energia Elettrica, Roma, Italy, June 1979.

M. Galliani and C. Z. Serpan, "Neutron Embrittlement Surveillance of the Garigliano Reactor Vessel Steel," *Nucl. Eng. and Design* 26, pp. 313-325, 1974.

Robert E. Ginna

T. R. Mager et al., "Analysis of Capsule V from the Rochester Gas and Electric R. E. Ginna Unit No. 1 Reactor Vessel Radiation Surveillance Program," FP-RA-1, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1973.

S. E. Yanichko et al., "Analysis of Capsule T from the Rochester Gas and Electric Corporation R. E. Ginna Nuclear Plant Reactor Vessel Radiation Surveillance Program," WCAP-10086, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, April 1982.

S. E. Yanichko, "Rochester Gas and Electric Robert E. Ginna Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-7254, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1969.

S. E. Yanichko, T. R. Mager, and S. Kang, "Analysis of Capsule R from the Rochester Gas & Electric Corporation R. E. Ginna Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8421, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

H. B. Robinson

B. J. Furr, "Response to NRC inquiries regarding H. B. Robinson Steam Electric Plant, Unit No. 2 Docket No. 50-261 License No. DPR-23 Reactor Vessel Material Surveillance Program Data," Carolina Power & Light Company, Raleigh, North Carolina, October 19, 1977.

W. N. McElroy, Ed., "LWR Pressure Vessel Surveillance Dosimetry Improvement Program: LWR Power Reactor Surveillance Physics-Dosimetry Data Base Compendium," NUREG/CR-3319, HEDL-TME 85-3, U.S. Nuclear Regulatory Commission, Washington, D.C., August 1985.

E. B. Norris, "Analysis of the First Material Surveillance Capsule from H. B. Robinson Unit No. 2," SwRI Project 02-3574, Southwest Research Institute, San Antonio, Texas, July 1973.

E. B. Norris, "Reactor Vessel Material Surveillance Program for H. B. Robinson Unit No. 2, Analysis of Capsule V," SwRI Project No. 02-4397, Southwest Research Institute, San Antonio, Texas, October 1976.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of Capsule T from the H. B. Robinson Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-10304, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1983.

S. E. Yanichko, "Carolina Power and Light Co., H. B. Robinson, Unit No. 2, Reactor Vessel Radiation Surveillance Program," WCAP-7373, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, January 1970.

S. E. Yanichko, D. J. Lege, S. L. Anderson, and T. R. Mager, "Analysis of Capsule S from Carolina Power and Light Company H. B. Robinson Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8249, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

Humboldt Bay

"Mechanical Properties of Irradiated Reactor Material Surveillance Specimens Humboldt Bay Power Plant, Unit No. 3, Docket No. 50-133," Pacific Gas and Electric Company, San Francisco, California, April 1972.

F. A. Brandt, "Reactor Pressure Vessel Material Surveillance Program at the Consumers Power Company Big Rock Point Nuclear Plant," GECR-4442, General Electric, San Jose, California, December 1963.

F. A. Brandt, "Reactor Pressure Vessel Material Surveillance Program at the Pacific Gas and Electric Company Humboldt Bay Power Plant Unit No. 3," GECR-4443, General Electric, San Jose, California, December 1963.

F. A. Brandt, "Humboldt Bay Power Plant Unit No. 3, Reactor Vessel Steel Surveillance Program," GECR-5492, General Electric, San Jose, California, May 1967.

Indian Point

W. J. Cahill, Jr., "Response to NRC inquiries regarding Indian Point Unit 2 Reactor Vessel Material Surveillance Program, Docket No. 50-247," Consolidated Edison Company of New York, Inc., New York, New York, March 29, 1978.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Indian Point Unit No. 2 Analysis of Capsule T," SwRI Project 02-4531, Southwest Research Institute, San Antonio, Texas, June 1977.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Indian Point Unit No. 2 Analysis of Capsule T, Supplement to Final Report," SwRI Project No. 02-4531, Southwest Research Institute, San Antonio, Texas, December 1980.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Indian Point Unit No. 2 Analysis of Capsule Y," SwRI Project No. 02-5212, Southwest Research Institute, San Antonio, Texas, November 1980.

F. A. Iddings, D. G. Cadena, and M. L. Williams, "Reactor Vessel Material Surveillance Program for Indian Point Unit No. 2 Analysis of Capsule V, Final Report," SwRI Project No. 17-2108, Revised, Southwest Research Institute, San Antonio, Texas, March 1990.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Indian Point Unit No. 2 Analysis of Capsule Z," SWRI-7279-001/3, Southwest Research Institute, San Antonio, Texas, April 1984.

S. E. Yanichko et al., "Analysis of Capsule Z from the New York Power Authority Indian Point Unit 3 Reactor Vessel Radiation Surveillance Program," WCAP-11815, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1988.

S. E. Yanichko, "Consolidated Edison Co., Indian Point Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-7323, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1969.

S. E. Yanichko and S. L. Anderson, "Analysis of Capsule Y from the Power Authority of the State of New York Indian Point Unit 3 Reactor Vessel Radiation Surveillance Program," WCAP-10300, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1983.

S. E. Yanichko and J. A. Davidson, "Consolidated Edison Co. of New York Indian Point Unit No. 3, Reactor Vessel Radiation Surveillance Program," WCAP-8475, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, January 1975.

J. A. Davidson, S. L. Anderson, and W. T. Kaiser, "Analysis of Capsule T from the Indian Point Unit No. 3 Reactor Vessel Radiation Surveillance Program," WCAP-9491 Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, April 1979.

Kewaunee Nuclear Power Plant

E. W. James, "Response to NRC inquiries regarding Kewaunee Nuclear Power Plant Docket 50-305 Operating License DPR-43 Reactor Vessel Material Surveillance Program," Wisconsin Public Service Corp., Green Bay, Wisconsin, February 1, 1978.

S. E. Yanichko et al., "Analysis of Capsule P from the Wisconsin Public Service Corporation Kewaunee Nuclear Plant Reactor Vessel Radiation Surveillance Program," WCAP-12020, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, November 1988.

S. E. Yanichko, D. J. Lege, and G. C. Zula, "Wisconsin Public Service Corporation Kewaunee Nuclear Power Plant Reactor Vessel Radiation Surveillance Program," WCAP-8107, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, April 1973.

S. E. Yanichko, S. L. Anderson, and K. V. Scott, "Analysis of Capsule V from the Wisconsin Public Service Corporation Kewaunee Nuclear Plant Reactor Vessel Radiation Surveillance Program," WCAP-8908, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of Capsule R from the Wisconsin Public Service Corporation Kewaunee Nuclear Plant Reactor Vessel Radiation Surveillance Program," WCAP-9878, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

Lacrosse Boiling Water Reactor (Genoa-2)

"LaCrosse Boiling Water Reactor, Reactor Vessel Material Surveillance Program for Evaluation of Radiation Effects," ACNP-66513, Allis-Chalmers, Bethesda, Maryland, February 1966.

C. Z. Serpan, Jr., "Neutron Radiation Embrittlement of LaCrosse Reactor Vessel Steel and Weldment: Properties and Directionality Considerations," *Nucl. Eng. and Design* 8, pp. 95-107, 1968.

E. B. Norris, "Analysis of the First Vessel Material Surveillance Capsule Withdrawal from Lacrosse Boiling Water Reactor," SwRI Project 02-3467, Southwest Research Institute, San Antonio, Texas, March 1973.

E. B. Norris, "Analysis of the Vessel Material Surveillance Capsules Withdrawn from Lacrosse Boiling Water Reactor During the 1975 Refuelling," SwRI Project 02-4074-001, Southwest Research Institute, San Antonio, Texas, April 1977.

E. B. Norris, "Analysis of the Vessel Material Surveillance Capsules Withdrawn from LaCrosse Boiling Water Reactor During the 1980 Refuelling," SwRI Project No. 02-6208-001, Southwest Research Institute, San Antonio, Texas, October 9, 1981.

Millstone Nuclear Power Station

T. A. Caine, "Millstone Nuclear Power Station, Unit 1, Reactor Pressure Vessel Surveillance Materials Testing and Fracture Toughness Analysis," NEDC-30833, DRF B13-01285, General Electric Company, San Jose, California, December 1984.

A. Ragl, "Northeast Utilities Service Company Millstone Nuclear Unit No. 2 Evaluation of Baseline Specimens Reactor Vessel Materials Irradiation Surveil lance Program," 18767-TR-MCD-009, Combustion Engineering, Inc., Windsor, Connecticut, October 18, 1976.

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

D. C. Switzer, "Response to NRC inquiries regarding Millstone Nuclear Power Station, Unit No. 2 Reactor Pressure Vessel (RPV) Material Surveillance Program," Docket 50-336, Northeast Nuclear Energy Company, Hartford, Connecticut, December 9, 1977.

J. J. Koziol, "Program for Irradiation Surveillance of Millstone Point Unit 2 Reactor Vessel Materials," N-NLM-011, Combustion Engineering, Inc., Windsor, Connecticut, October 15, 1970.

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

S. E. Yanichko et al., "Analysis of Capsule U from the Northeast Utilities Service Company Millstone Unit 3 Reactor Vessel Radiation Surveillance Program," WCAP-11878, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1988.

Maine Yankee Nuclear Plant

J. S. Perrin et al., "Final Report on Maine Yankee Nuclear Plant Reactor Pressure Vessel Surveillance Program: Capsule 263," BCL-585-21, Battelle Columbus Laboratories, Columbus, Ohio, December 1980.

J. W. Sheckherd and R. A. Wullaert, "Unirradiated Mechanical Properties of Maine Yankee Nuclear Pressure Vessel Materials," CR 75-269, Effects Technology, Inc., Santa Barbara, California, February 1975.

R. A. Wullaert and J. W. Sheckherd, "Evaluation of the First Maine Yankee Accelerated Surveillance Capsule," CR 75-317, Effects Technology, Inc., Santa Barbara, California, August 1975.

E. Terek, S. L. Anderson, and L. Albertin, "Analysis of the Maine Yankee Reactor Vessel Second Wall Capsule Located at 253," WCAP-12819, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1991.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of the Maine Yankee Reactor Vessel Second Accelerated Surveillance Capsule," WCAP-9875, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1981.

Oconee Nuclear Station

A. L. Lowe, Jr., L. A. Hassler, H. S. Palme, and C. F. Zurlippe, "Analysis of Capsule OCI-F from Duke Power Company Oconee Unit 1 Reactor Vessel Materials Surveillance Program," BAW-1421, Rev. 1, Babcock & Wilcox, Lynchburg, Virginia, September 1975.

A. L. Lowe, Jr. et al., "Analysis of Capsule OCI-E Duke Power Company Oconee Nuclear Station Unit 1 Reactor Vessel Materials Surveillance Program," BAW-1436, Babcock & Wilcox, Lynchburg, Virginia, September 1977.

J. D. Aadland et al., "Analysis of Capsule OCI-A, Duke Power Company Oconee Nuclear Station, Unit 1," BAW-1837, Babcock & Wilcox, Lynchburg, Virginia, August 1984.

A. L. Lowe, Jr. et al., "Analysis of Capsule OC1-C Duke Power Company Oconee Nuclear Station Unit 1, Reactor Vessel Material Surveillance Program," BAW-2050, Babcock & Wilcox, Lynchburg, Virginia, October 1988.

"Analysis of Capsule OCII-C from Duke Power Company Oconee Nuclear Station, Unit 2, Reactor Vessel Materials Surveillance Program," BAW-1437, Babcock & Wilcox, Lynchburg, Virginia, May 1977.

"Analysis of Capsule OCII-A from Duke Power Company Oconee Nuclear Station, Unit 2, Reactor Vessel Materials Surveillance Program," BAW-1699, Babcock & Wilcox, Lynchburg, Virginia, December 1981.

A. S. Heller and A. L. Lowe, Jr., "Correlations for Predicting the Effects of Neutron Radiation on Linde 80 Submerged-Arc Welds," BAW-1803, Babcock & Wilcox, Lynchburg, Virginia, January 1984.

J. D. Aadland, "Babcock & Wilcox Owner's Group 177-Fuel Assembly Reactor Vessel and Surveillance Program Materials Information," BAW-1820, Babcock & Wilcox, Lynchburg, Virginia, December 1984.

A. L. Lowe, Jr. et al., "Analysis of Capsule OCII-E Duke Power Company Oconee Nuclear Station Unit 2, Reactor Vessel Material Surveillance Program," BAW-2051, Babcock & Wilcox, Lynchburg, Virginia, October 1988.

A. L. Lowe, Jr. et al., "Analysis of Capsule OCIII-A from Duke Power Company Oconee Nuclear Station Unit 3," BAW-1438, Babcock & Wilcox, Lynchburg, Virginia, July 1977.

A. L. Lowe, K. E. Moore, and J. D. Aadland, "Integrated Reactor Vessel Material Surveillance Program," BAW-1543, Rev. 2, Babcock & Wilcox, Lynchburg, Virginia, February 1984.

A. L. Lowe, Jr. et al., "Analysis of Capsule OCIII-B from Duke Power Company Oconee Nuclear Station Unit 3 Reactor Vessel Materials Surveillance Program," BAW-1697, Babcock & Wilcox, Lynchburg, Virginia, October 1981.

A. L. Lowe, Jr. et al., "Analysis of Capsule OCIII-D Duke Power Company Oconee Nuclear Station Unit-3 Reactor Vessel Material Surveillance Program," BAW-2128, B&W Nuclear Service Company, Lynchburg, Virginia, May 1991.

Palisades Nuclear Plant

J. S. Perrin and E. O. Fromm, "Final Report on Palisades Pressure Vessel Irradiation Capsule Program: Unirradiated Mechanical Properties," Battelle Columbus Laboratories, Columbus, Ohio, August 25, 1977.

J. S. Perrin et al., "Final Report on Palisades Nuclear Plant Reactor Pressure Vessel Surveillance Program: Capsule A-240," BCL-585-12, Battelle Columbus Laboratories, Columbus, Ohio, March 1979.

N. J. Porter, "Palisades Vessel Weld Documentation, Communication to Consumers Power Company in reference to Letter P-CE-7747 dated September 25, 1984," Letter P-CE-7752, Combustion Engineering, Inc., Windsor, Connecticut, October 9, 1984.

M. K. Kunka and C. A. Cheney, "Analysis of Capsules T-330 and W-290, Consumers Power Company, Palisades Reactor Vessel Radiation Surveillance Program," WCAP-10637, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, September 1984.

Point Beach Nuclear Plant

J. S. Perrin, J. W. Sheckherd, D. R. Farmelo, and L. M. Lowry, "Final Report on Point Beach Nuclear Plant Unit No. 1 Pressure Vessel Surveillance Program: Evaluation of Capsule V," Battelle Columbus Laboratories, Columbus, Ohio, June 1973.

S. E. Yanichko, V. A. Perone, and W. T. Kaiser, "Analysis of Capsule T from the Wisconsin Electric Power Company Point Beach Nuclear Plant Unit No. 1," WCAP-10736, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, December 1984.

S. E. Yanichko, "Wisconsin Michigan Power Co. Point Beach Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-7513, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1970.

S. E. Yanichko and S. L. Anderson, "Analysis of Capsule S from the Wisconsin Electric Power Company and Wisconsin Michigan Power Company Point Beach Nuclear Plant Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8739, Westinghouse Electric Corporation.

S. E. Yanichko and S. L. Anderson, "Analysis of Capsule R from the Wisconsin Electric Power Company Point Beach Nuclear Plant Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-9357, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

A. S. Heller and A. L. Lowe, Jr., "Correlations for Predicting the Effects of Neutron Radiation on Linde 80 Submerged-Arc Welds," BAW-1803, Babcock & Wilcox, Lynchburg, Virginia, January 1984.

A. L. Lowe, Jr. et al., "Analysis of Capsule S Wisconsin Electric Power Company Point Beach Nuclear Plant Unit No. 2 Reactor Vessel Material Surveillance Program," BAW-2140, Babcock & Wilcox Company, Lynchburg, Virginia, August 1991.

J. S. Perrin et al., "Final Report on Point Beach Nuclear Plant Unit No. 2 Pressure Vessel Surveillance Program: Evaluation of Capsule V," Battelle Columbus Laboratories, Columbus, Ohio, June 1975.

S. E. Yanichko and G. C. Zula, "Wisconsin Michigan Power Co. and the Wisconsin Electric Power Co. Point Beach Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-7712, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1971.

J. A. Davidson, S. L. Anderson, and R. P. Shogan, "Analysis of Capsule T from the Wisconsin Electric Power Company Point Beach Nuclear Plant Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-9331, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of Capsule R from the Wisconsin Electric Power Company Point Beach Nuclear Plant Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-9635, Westinghouse Electric Corporation , Pittsburgh, Pennsylvania.

Prairie Island

S. E. Yanichko, K. C. Tran, and W. T. Kaiser, "Analysis of Capsule P from Northern States Power Company Prairie Island Unit 1, Reactor Vessel Radiation Surveillance Program," WCAP-10102, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1982.

R. S. Boggs, T. V. Congedo, and H. Gong, "Analysis of Capsule R from the Northern States Power Company Prairie Island Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-11006, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, February 1986.

S. E. Yanichko and D. J. Lege, "Northern States Power Co. Prairie Island Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8086, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1973.

J. A. Davidson, S. L. Anderson, and K. V. Scott, "Analysis of Capsule V from Northern States Power Company Prairie Island Unit No. 1, Reactor Vessel Radiation Surveillance Program," WCAP-8916, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, August 1977.

S. E. Yanichko and J. C. Schmertz, "Analysis of Capsule R from the Northern States Power Company Prairie Island Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-11343, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, December 1986.

S. E. Yanichko and D. J. Lege, "Northern States Power Co. Prairie Island Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8193, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, September 1973.

J. A. Davidson, S. E. Yanichko, and S. L. Anderson, "Analysis of Capsule V from Northern States Power Company Prairie Island Unit No. 2, Reactor Vessel Radiation Surveillance Program," WCAP-9212, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

S. E. Yanichko, S. L. Anderson, and W. T. Kaiser, "Analysis of Capsule T from Northern States Power Company Prairie Island Unit No. 2, Reactor Vessel Radiation Surveillance Program," WCAP-9877, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1981.

<u>Salem</u>

R. S. Boggs, C. A. Cheney, and W. T. Kaiser, "Analysis of Capsule Y from the Public Service Electric and Gas Company Salem Unit 1, Reactor Vessel Radiation Surveillance Program," WCAP-10694, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, December 1984.

S. E. Yanichko et al., "Analysis of Capsule Z from the Public Service Electric and Gas Company Salem Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-11955, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, September 1988.

J. A. Davidson, J. H. Phillips, and S. E. Yanichko, "Public Service Electric and Gas Co. Salem Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8511, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, November 1975.

S. E. Yanichko, S. L. Anderson, and W. T. Kaiser, "Analysis of Capsule T from the Public Service Electric and Gas Company Salem Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-9678, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

R. S. Boggs, S. E. Yanichko, C. A. Cheney, and W. T. Kaiser, "Analysis of Capsule T from the Public Service Electric and Gas Company Salem Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-10492, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

S. E. Yanichko et al., "Analysis of Capsule U from the Public Service Electric and Gas Company Salem Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-11554, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, September 1987.

J. M. Chicots et al., "Analysis of Capsule X from the Public Service Electric and Gas Company Salem Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-13366, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1992.

J. H. Phillips et al., "Public Service Electric and Gas Company Salem Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8824, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, January 1977.

<u>St. Lucie</u>

S. T. Byrne, "Florida Power & Light Company, St. Lucie Unit No. 1, Post-Irradiation Evaluation of Reactor Vessel Surveillance Capsule W-97," TR-F-MCM-004, Combustion Engineering, Inc., Windsor, Connecticut, December 1983.

"Florida Power and Light Company St. Lucie Unit No. 1 Evaluation of Baseline Specimens Reactor Vessel Materials Irradiation Surveillance Program," TR-F-MCM-005, Combustion Engineering, Inc., Windsor, Connecticut.

J. M. Chicots et al., "Analysis of the Capsule at 104 from the Florida Power and Light Company St. Lucie Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-12751, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, November 1990.

A. L. Lowe, Jr. et al., "Analysis of Capsule W-83 Florida Power and Light Company St. Lucie Plant Unit No. 2 Reactor Vessel Material Surveillance Program," BAW-1880, Babcock & Wilcox, Lynchburg, Virginia, September 1985.

"Summary Report on Manufacture of Test Specimens and Assembly of Capsules for Irradiation Surveillance of St. Lucie No. 2 Reactor Vessel Materials," TR-L-MCM-001, Combustion Engineering, Inc., Windsor, Connecticut, November 30, 1979.

<u>San Onofre</u>

E. B. Norris, "Analysis of First Surveillance Material Capsule from San Onofre Unit 1," SwRI Project 07-2892, Southwest Research Institute, San Antonio, Texas, May 1971.

E. B. Norris, "Analysis of Second Surveillance Material Capsule from San Onofre Unit 1," SwRI Project No. 07-2892, Southwest Research Institute, San Antonio, Texas, June 5, 1972.

S. E. Yanichko, "San Onofre Reactor Vessel Radiation Surveillance Program," WCAP-2834-R1, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, November 1966.

S. E. Yanichko, S. L. Anderson, and W. T. Kaiser, "Analysis of Capsule F from the Southern California Edison Company San Onofre Reactor Vessel Radiation Surveillance Program," WCAP-9520, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1979.

M. P. Manahan, L. M. Lowry, and E. O. Fromm, "Final Report on Examination, Testing, and Evaluation of Irradiated Pressure Vessel Surveillance Specimens from the San Onofre Nuclear Generating Station Unit 2 (SONGS-2)," Battelle, Columbus, Ohio, December 1988.

E. Terek et al., "Analysis of the Southern California Edison Company San Onofre Unit 3 Reactor Vessel Surveillance Capsule Removed from the 97 Location," WCAP-12920, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1991.

Surry

J. S. Perrin et al., "Final Report on Surry Unit No. 1, Pressure Vessel Irradiation Capsule Program: Examination and Analysis of Capsule T," Docket 50280-462, Battelle Columbus Laboratories, Columbus, Ohio, June 1975.

S. E. Yanichko and V. A. Perone, "Analysis of Capsule V from the Virginia Electric Power Company Surry Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-11415, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, February 1987.

S. E. Yanichko, "Virginia Electric & Power Co. Surry Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-7723, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, July 1971.

J. S. Perrin et al., "Final Report on Surry Unit No. 2, Pressure Vessel Irradiation Capsule Program: Examination and Analysis of Capsule X," Battelle Columbus Laboratories, Columbus, Ohio, September 1975.

S. E. Yanichko and V. A. Perone, "Analysis of Capsule V from the Virginia Electric and Power Company Surry Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-11499, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1987.

S. E. Yanichko and D. J. Lege, "Virginia Electric & Power Co. Surry Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8085, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, June 1973.

Three Mile Island Nuclear Station

A. L. Lowe, Jr. et al., "Analysis of Capsule TMI-1E from Metropolitan Edison Company Three Mile Island Nuclear Station - Unit 1, Reactor Vessel Materials Surveillance Program," BAW-1439, Babcock & Wilcox, Lynchburg, Virginia, January 1977.

J. D. Aadland, "Babcock & Wilcox Owner's Group 177-Fuel Assembly Reactor Vessel and Surveillance Program Materials Information," BAW-1820, Babcock & Wilcox, Lynchburg, Virginia, December 1984.

A. L. Lowe, Jr. et al., "Analysis of Capsule TMI1-C GPU Nuclear Three Mile Island Nuclear Station Unit 1 Reactor Vessel Material Surveillance Program," BAW-1901, Babcock & Wilcox, Lynchburg, Virginia, March 1986.

Turkey Point Nuclear Power Station

P. McConnell et al., "Irradiated Nuclear Pressure Vessel Steel Data Base," EPRI NP-2428, Electric Power Research Institute, Palo Alto, California, June 1982.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Capsule S - Turkey Point Unit No. 3, Capsule S - Turkey Point Unit No. 4," SwRI Projects 02-5131 and 02-5380, Southwest Research Institute, San Antonio, Texas, May 1979.

P. K. Nair and E. B. Norris, "Reactor Vessel Material Surveillance Program for Turkey Point Unit No. 3: Analysis of Capsule V," SwRI Project No. 06-8575, Southwest Research Institute, San Antonio, Texas, August 1986.

S. E. Yanichko, "Florida Power and Light Co., Turkey Point Unit No. 3 Reactor Vessel Radiation Surveillance Program," WCAP-7656, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1971.

S. E. Yanichko, J. H. Phillips, and S. L. Anderson, "Analysis of Capsule T from the Florida Power and Light Company Turkey Point Unit No. 3 Reactor Vessel Radiation Surveillance Program," WCAP-8631, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Turkey Point Unit No. 4 Analysis of Capsule T," SwRI Project 02-4221, Southwest Research Institute, San Antonio, Texas, June 1976.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Capsule S - Turkey Point Unit No. 3, Capsule S - Turkey Point Unit No. 4," SwRI Projects 02-5131 and 02-5380, Southwest Research Institute, San Antonio, Texas, May 1979.

S. Yanichko, "Florida Power and Light Co. Turkey Point Unit No. 4 Reactor Vessel Radiation Surveillance Program," WCAP-7660, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1971.

Yankee-Rowe

C. Z. Serpan, Jr. and J. R. Hawthorne, "Yankee Reactor Pressure Vessel Surveillance: Notch Ductility Performance of Vessel Steel and Maximum Service Fluence Determined from Exposure During Cores II, III, and IV," *J. Basic Eng*., pp. 897-910, December 1967.

R. W. Smith, "Evaluation of the Fracture Toughness Properties of the Yankee Rowe Reactor Vessel," YAEC-1089, Yankee Atomic Electric Company, Westborough, Massachusetts, September 1975.

Zion Nuclear Plant Reactor

A. L. Lowe, Jr. et al., "Analysis of Capsule Y Commonwealth Edison Company Zion Nuclear Plant Unit 1 Reactor Vessel Material Surveillance Program," BAW-2082, Babcock & Wilcox, Lynchburg, Virginia, March 1990.

J. S. Perrin, D. R. Farmelo, R. G. Jung, and E. O. Fromm, "Final Report on Zion Nuclear Plant Reactor Pressure Vessel Surveillance Program: Unit No. 1 Capsule T and Unit No. 2 Capsule U," BCL-585-4, Battelle Columbus Laboratories, Columbus, Ohio, March 1978.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Zion Unit No. 1 Analysis of Capsule X," SwRI Project 06-7484-001, Southwest Research Institute, San Antonio, Texas, March 1984.

S. E. Yanichko and D. J. Lege, "Commonwealth Edison Co., Zion Unit No. 1 Reactor Vessel Radiation Surveillance Program," WCAP-8064, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, March 1973.

S. E. Yanichko, S. L. Anderson, R. P. Shogan, and R. G. Lott, "Analysis of Capsule U from the Commonwealth Edison Company Zion Nuclear Plant Unit 1 Reactor Vessel Radiation Surveillance Program," WCAP-9890, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

J. S. Perrin, D. R. Farmelo, R. G. Jung, and E. O. Fromm, "Final Report on Zion Nuclear Plant Reactor Pressure Vessel Surveillance Program: Unit No. 1 Capsule T and Unit No. 2 Capsule U," BCL-585-4, Battelle Columbus Laboratories, Columbus, Ohio, March 1978.

E. B. Norris, "Reactor Vessel Material Surveillance Program for Zion Unit No. 2 Analysis of Capsule T," SwRI Project 06-6901-001, Southwest Research Institute, San Antonio, Texas, July 1983.

E. Terek et al., "Analysis of Capsule Y from the Commonwealth Edison Company Zion Unit 2 Reactor Vessel Radiation Surveillance Program," WCAP-12396, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, September 1989.

S. E. Yanichko and D. J. Lege, "Commonwealth Edison Co., Zion Unit No. 2 Reactor Vessel Radiation Surveillance Program," WCAP-8132, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, May 1973.

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10. SUPPLEMENTARY NOTES

A. Taboada, NRC Project Manager

11. ABSTRACT *(200 words or less)*

The results of Charpy V-notch impact tests for A302B and A533B-1 Correlation Monitor Materials (CMM) listed in the surveillance power reactor data base (PR-EDB) and material test reactor data base (TR-EDB) are analyzed. The shift of the transition temperature at 30 ft-lb (T_{30}) is considered as the primary measure of radiation embrittlement in this report. The hyperbolic tangent fitting model and uncertainty of the fitting parameters for Charpy impact tests are presented in this report. For the surveillance CMM data, the transition temperature shifts at 30 ft-lb (ΔT_{30}) generally follow the predictions provided by Revision 2 of Regulatory Guide 1.99 (R.G. 1.99). Difference in capsule temperatures is a likely explanation for large deviations from R.G. 1.99 predictions. Deviations from the R.G. 1.99 predictions are correlated to similar deviations for the accompanying materials in the same capsules, but large random fluctuations prevent precise quantitative determination. Significant scatter is noted in the surveillance data, some of which may be attributed to variations from one specimen set to another, or inherent in Charpy V-notch testing. In general, the embrittlement behavior of both the A302B and A533B-1 plate materials is similar. There is evidence for a fluence-rate effect in the CMM data irradiated in test reactors; thus its implication on power reactor surveillance programs deserves special attention.

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