APPENDIX C

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

Contained in Table C-1 are the upper shelf energy values used as input for the generation of the Charpy V-notch plots using CVGRAPH, Version 4.1. The definition for Upper Shelf Energy (USE) is given in ASTM E185-82, Section 4.18, and reads as follows:

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

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

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

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

Material	Unirradiated	Capsule X	Capsule V	Capsule Y
Lower Shell Plate C4339-1 (Longitudinal Orientation)	128	122	121	111
Lower Shell Plate C4339-1 (Transverse Orientation)	104	94	94	94
Weld Metal (heat # 0227)	91	71	60	58
HAZ Material	116	101	94	94
Correlation Monitor Material	123	103	102	100

UNIRR LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:08:19 on 07-19-2002

Page 1

Coefficients of Curve 1

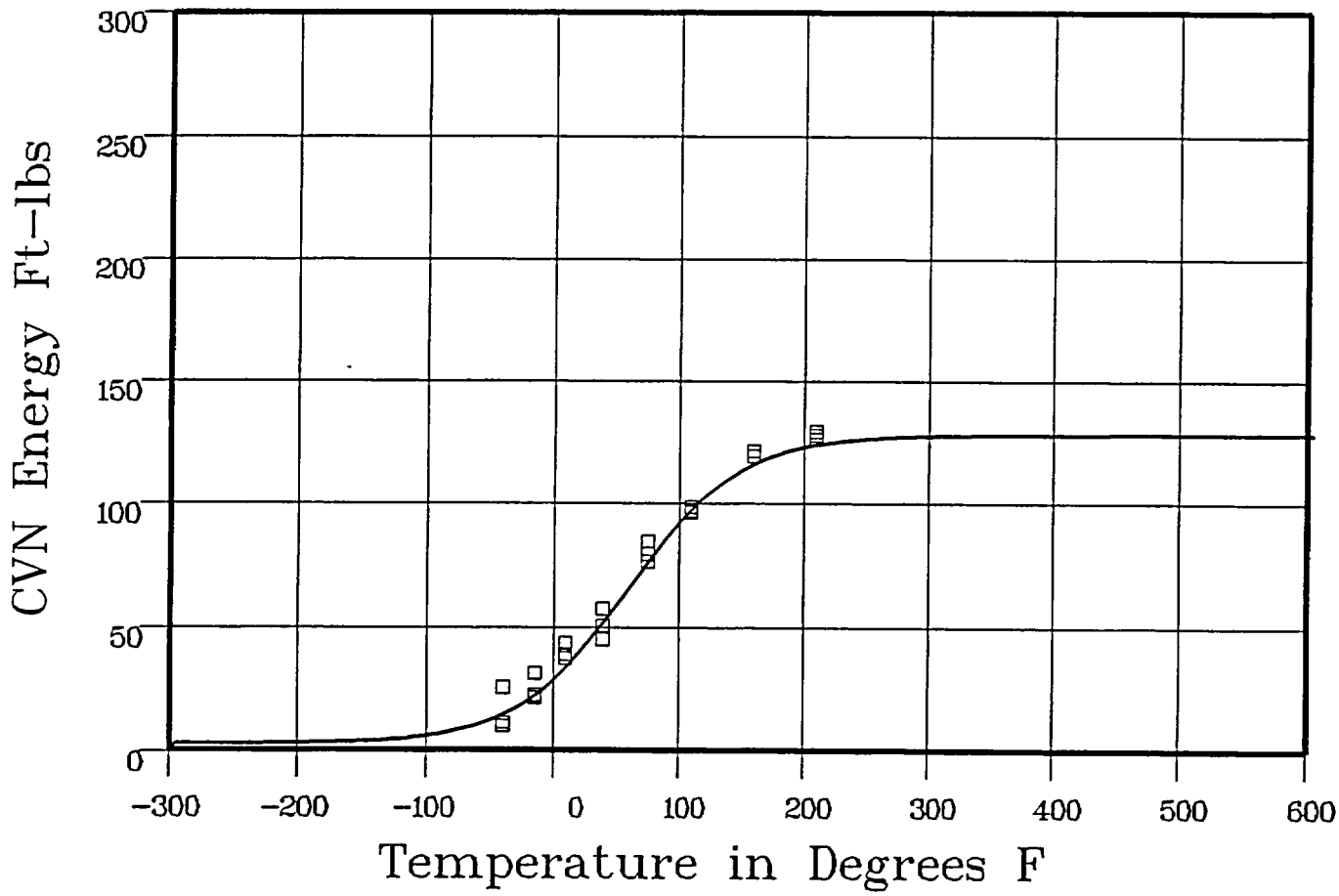
A = 65.09	B = 62.9	C = 89.57	T0 = 55.31

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

Upper Shelf Energy: 128 Fixed Temp. at 30 ft-lbs: -1.1 Temp. at 50 ft-lbs: 33.3 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: PLATE SA533B1 Ori.: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	11	15.58	-4.58
-40	9.5	15.58	-6.08
-40	25	15.58	9.41
-15	22	23.86	-1.86
-15	31	23.86	7.13
-15	21	23.86	-2.86
10	38.5	35.74	2.75
10	43	35.74	7.25
10	37	35.74	1.25

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

UNIRR LOWER SHELL PLATE C4339-1 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
40	57	54.45	2.54
40	50	54.45	-4.45
40	44.5	54.45	-9.95
75	84	78.7	5.29
75	79	78.7	.29
75	76	78.7	-2.7
110	96	99.34	-3.34
110	96.5	99.34	-2.84
110	98	99.34	-1.34
160	119	116.92	2.07
160	119	116.92	2.07
160	121	116.92	4.07
210	126	124.14	1.85
210	129	124.14	4.85
210	127.5	124.14	3.35

SUM of RESIDUALS = 14.2

CAPSULE X LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:08:19 on 07-19-2002

Page 1

Coefficients of Curve 2

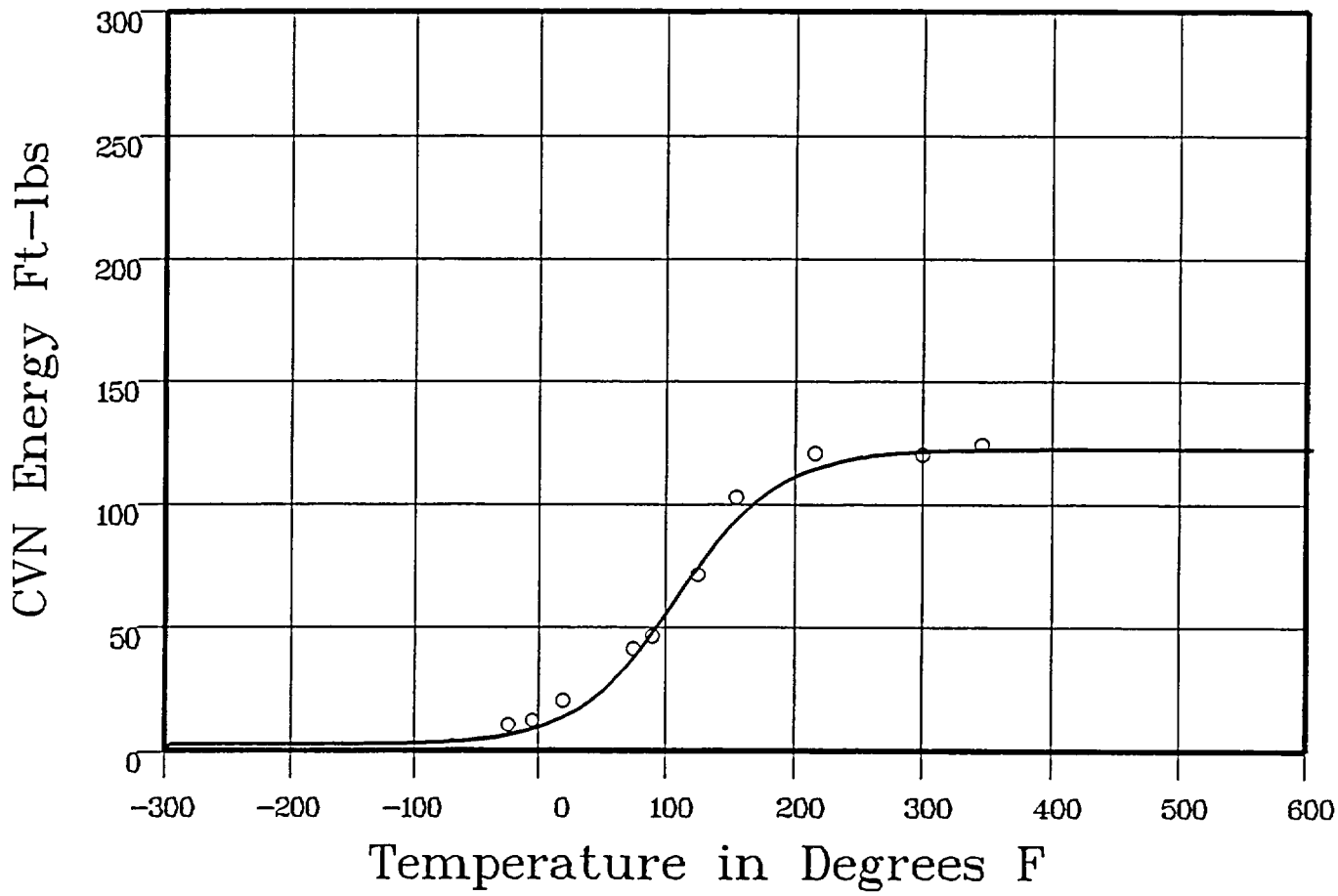
A = 62.09	B = 59.9	C = 78.88	T0 = 105.17

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

Upper Shelf Energy: 122 Fixed Temp. at 30 ft-lbs: 57.9 Temp. at 50 ft-lbs: 89 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-25	10	6.45	3.54
-5	12	9.11	2.88
20	20	14.59	5.4
75	41	40.24	.75
90	46	50.71	-4.71
125	71	76.84	-5.84
155	102.5	95.59	6.9
215	120.5	115.03	5.46

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

CAPSULE X LOWER SHELL PLATE C4339-1 (LONG)

Page 2

Material. PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
300	120	121.14	-1.14
345	124	121.72	2.27

SUM of RESIDUALS = 15.53

CAPSULE V LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:08:19 on 07-19-2002

Page 1

Coefficients of Curve 3

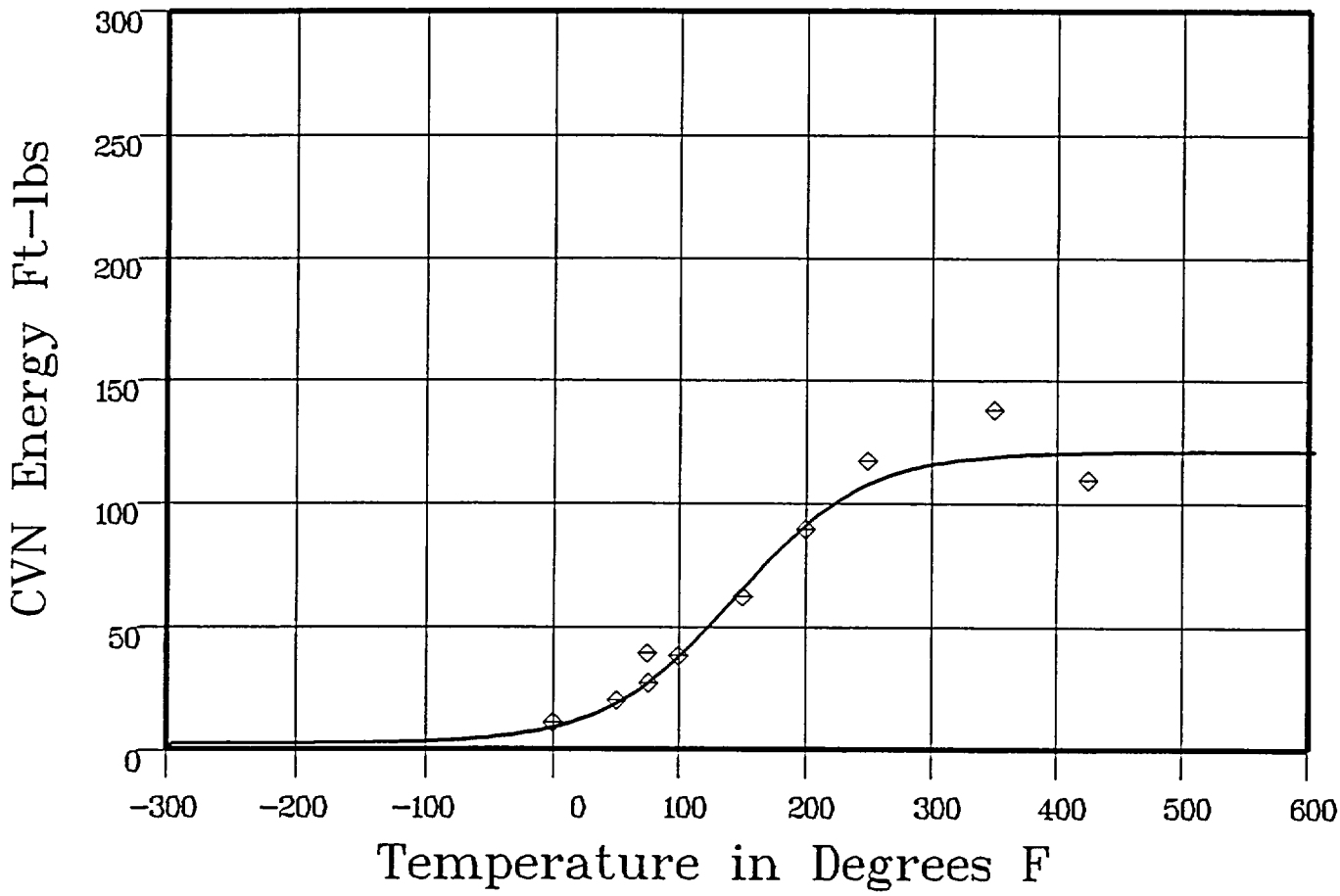
A = 61.59	B = 59.4	C = 103.62	T0 = 139.45

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

Upper Shelf Energy: 121 Fixed Temp. at 30 ft-lbs: 78 Temp. at 50 ft-lbs: 118.9 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
0	11	9.74	1.25
50	20	20.14	-.14
75	39	28.78	10.21
76	27	29.18	-2.18
100	38	40.01	-2.01
150	62	67.62	-5.62
200	89	92.83	-3.83
250	117	108.42	8.57

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

CAPSULE V LOWER SHELL PLATE C4339-1 (LONG)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
350	138	118.99	19
425	109	120.52	-11.52

SUM of RESIDUALS = 13.74

CAPSULE Y LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:08:19 on 07-19-2002

Page 1

Coefficients of Curve 4

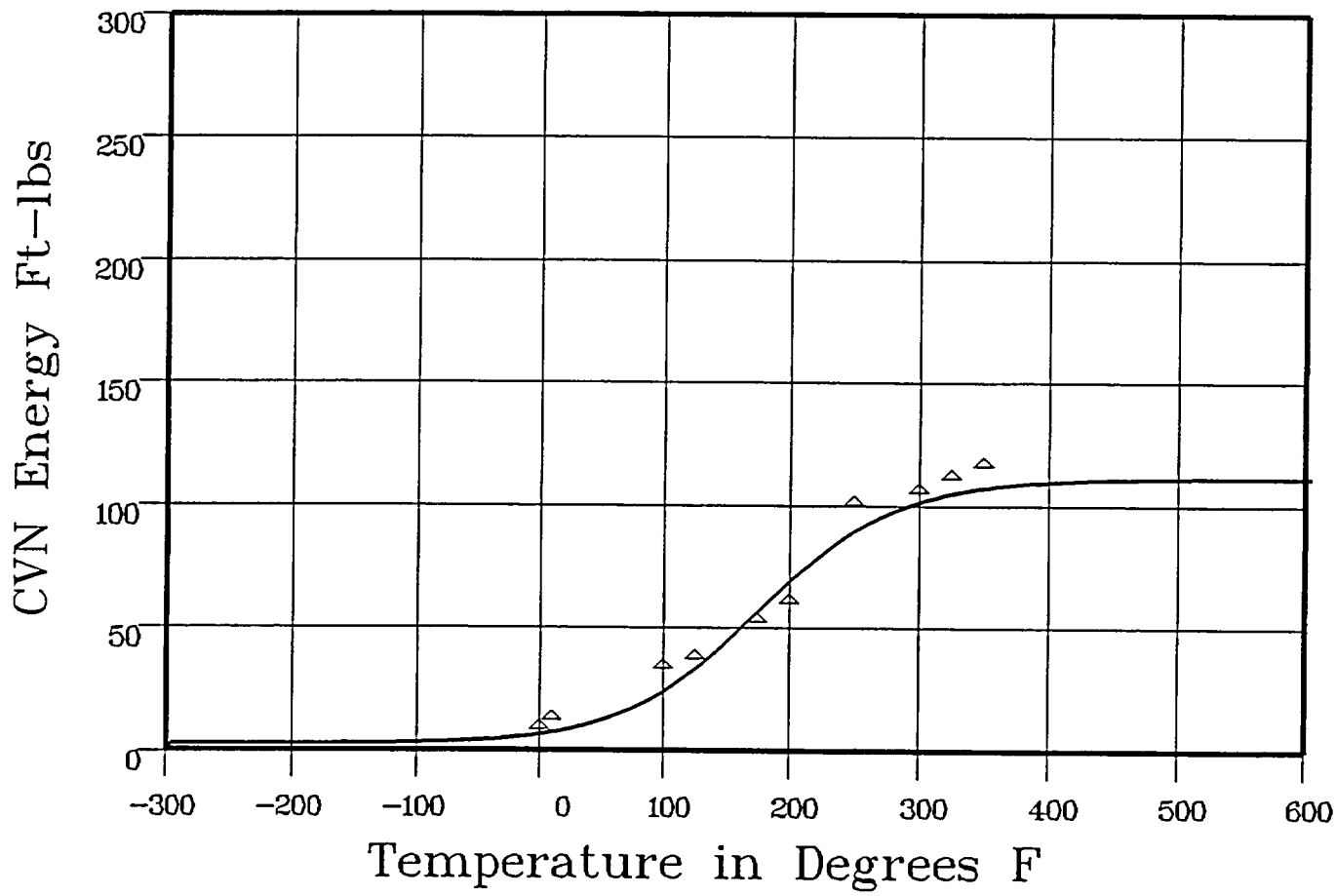
A = 56.59	B = 54.4	C = 107.88	T0 = 170.8

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

Upper Shelf Energy: 111 Fixed Temp. at 30 ft-lbs: 113.1 Temp. at 50 ft-lbs: 157.6 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: PLATE SA533B1 Ori.: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
0	8	6.6	1.39
10	12	7.45	4.54
100	33	25.27	7.72
125	37	34.79	2.2
175	52	58.71	-6.71
200	60	70.97	-10.97
250	100	90.63	9.36

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

CAPSULE Y LOWER SHELL PLATE C4339-1 (LONG)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
300	105	101.91	3.08
325	111	105.09	5.9
350	116	107.21	8.78

SUM of RESIDUALS = 25.33

UNIRR LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:02:49 on 07-11-2002

Page 1

Coefficients of Curve 1

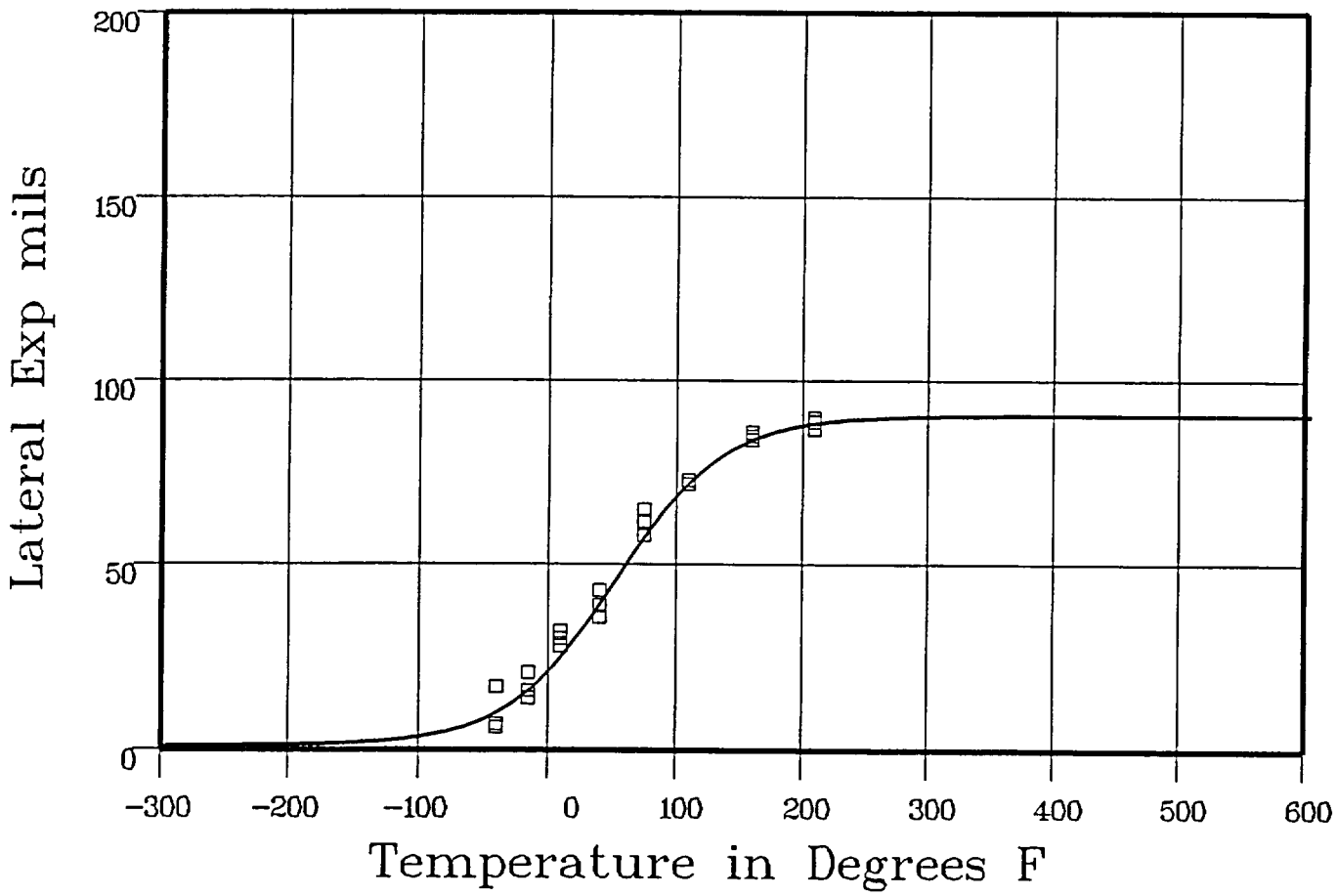
A = 45.8	B = 44.8	C = 84.91	T0 = 47.81

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

Upper Shelf L.E.: 90.61 Temperature at L.E. 35: 26.9 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: PLATE SA533B1 Ori.: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	7	11.05	-4.05
-40	6	11.05	-5.05
-40	17	11.05	5.94
-15	16	17.62	-1.62
-15	21	17.62	3.37
-15	14	17.62	-3.62
10	30	27.07	2.92
10	32	27.07	4.92
10	28	27.07	.92

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

UNIRR LOWER SHELL PLATE C4339-1 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
40	43	41.69	1.3
40	39	41.69	-2.69
40	36	41.69	-5.69
75	65	59.68	5.31
75	62	59.68	2.31
75	58	59.68	-1.68
110	73	73.78	-.78
110	72	73.78	-1.78
110	72	73.78	-1.78
160	85	84.65	.34
160	84	84.65	-.65
160	86	84.65	1.34
210	87	88.69	-1.69
210	89	88.69	.3
210	90	88.69	1.3

SUM of RESIDUALS = -.81

CAPSULE X LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:02:49 on 07-11-2002

Page 1

Coefficients of Curve 2

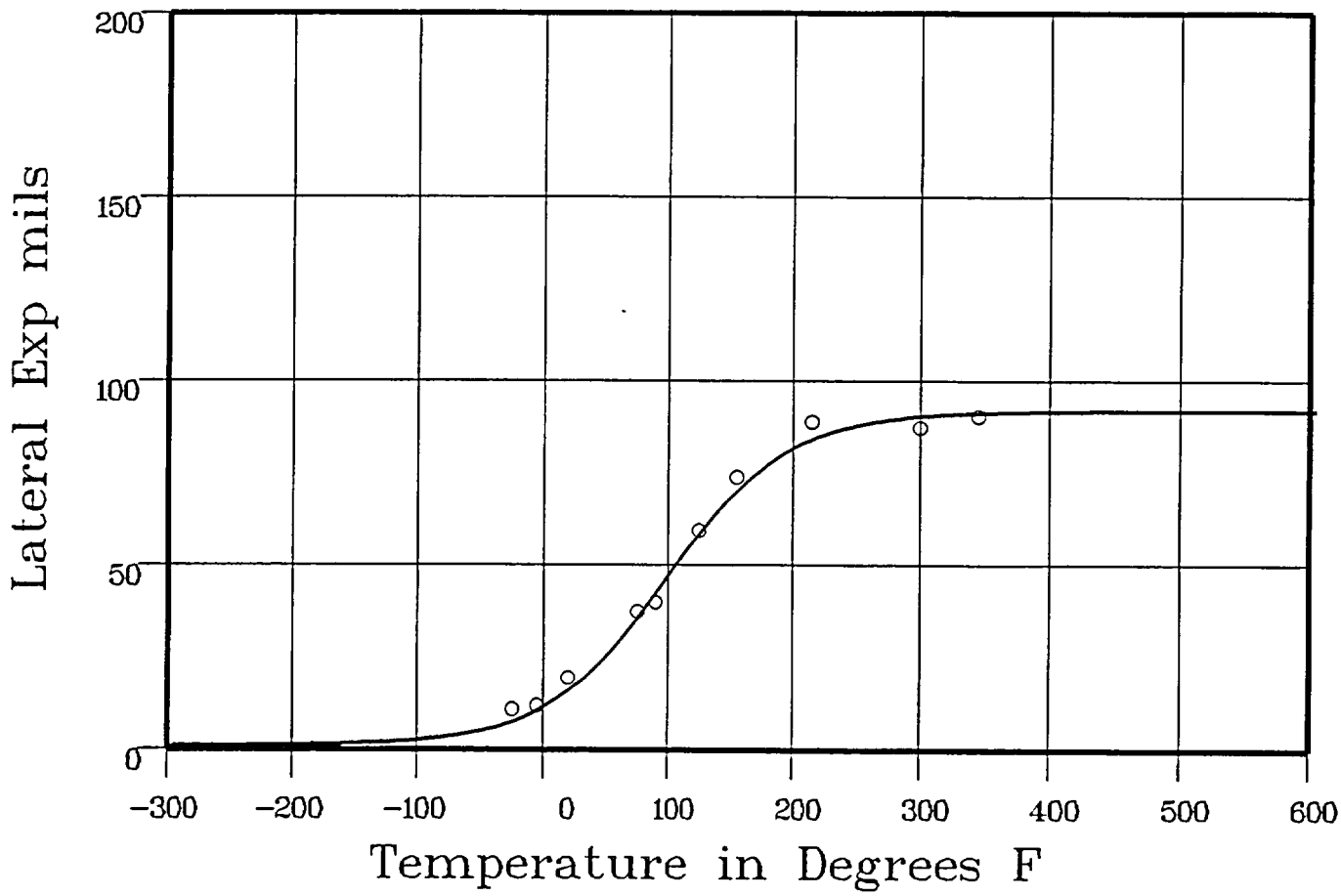
A = 46.41	B = 45.41	C = 97.66	T0 = 93.94

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

Upper Shelf L.E.: 91.83 Temperature at L.E. 35: 68.8 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: X Material: PLATE SA533B1 Ori.: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-25	11	8.31	2.68
-5	12	11.58	.41
20	19.5	17.37	2.12
75	37.5	37.71	-.21
90	40	44.58	-4.58
125	59.5	60.39	-.89
155	74	71.61	2.38
215	89	84.81	4.18

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

CAPSULE X LOWER SHELL PLATE C4339-1 (LONG)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
300	87.5	90.52	-3.02
345	90.5	91.3	-.8

SUM of RESIDUALS = 2.29

CAPSULE V LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:02:49 on 07-11-2002

Page 1

Coefficients of Curve 3

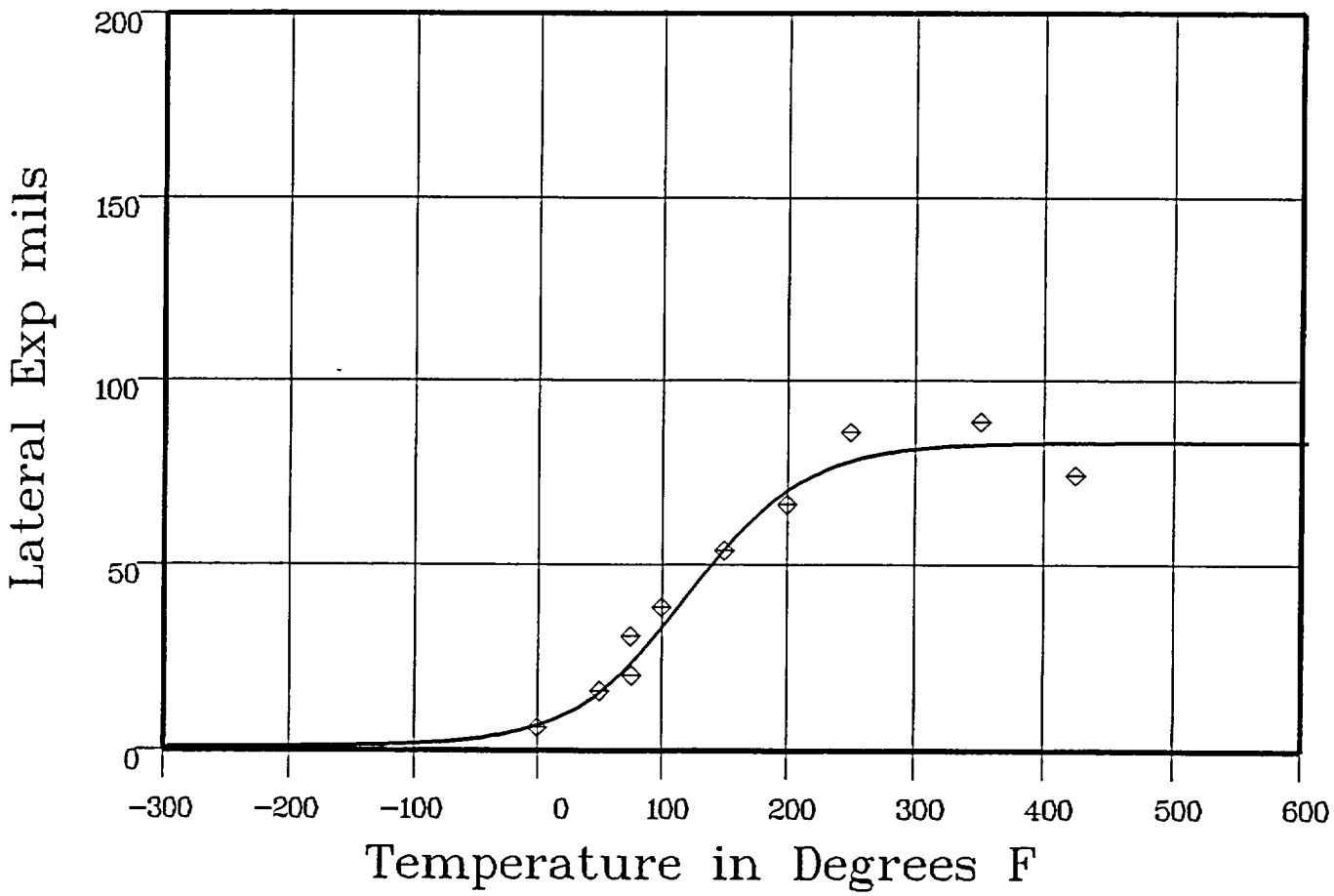
A = 42.09	B = 41.09	C = 93.82	T0 = 116.71

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

Upper Shelf L.E.: 83.19 Temperature at L.E. 35: 100.3 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
0	6	7.3	-1.3
50	16	16.97	-.97
75	30.5	24.93	5.56
76	20	25.3	-5.3
100	38.5	34.84	3.65
150	54	56.08	-2.08
200	66.5	71.28	-4.78
250	86	78.65	7.34

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

CAPSULE V LOWER SHELL PLATE C4339-1 (LONG)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
350	89	82.62	6.37
425	74.5	83.07	-8.57

SUM of RESIDUALS = -.09

CAPSULE Y LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:02:49 on 07-11-2002

Page 1

Coefficients of Curve 4

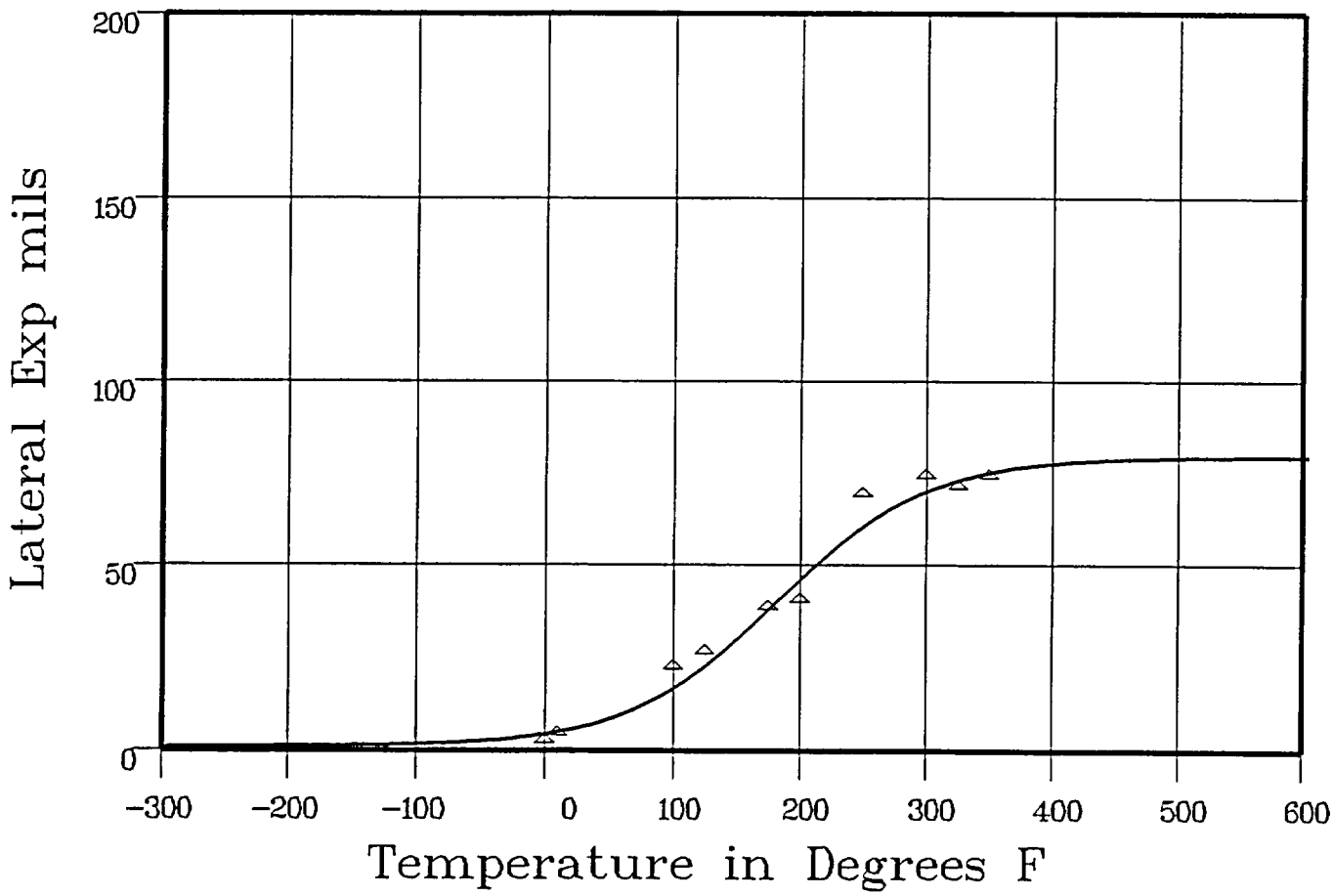
A = 40.37	B = 39.37	C = 118.31	T0 = 177.77

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

Upper Shelf L.E.: 79.75 Temperature at L.E. 35: 161.5 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: Y Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
0	2	4.71	-2.71
10	4	5.36	-1.36
100	22	17.67	4.32
125	26	23.89	2.1
175	38	39.45	-1.45
200	40	47.68	-7.68
250	69	61.81	7.18

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

CAPSULE Y LOWER SHELL PLATE C4339-1 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
300	74	70.89	3.1
325	71	73.71	-2.71
350	74	75.68	-1.68
		SUM of RESIDUALS =	-.89

UNIRR LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:30:09 on 07-11-2002

Page 1

Coefficients of Curve 1

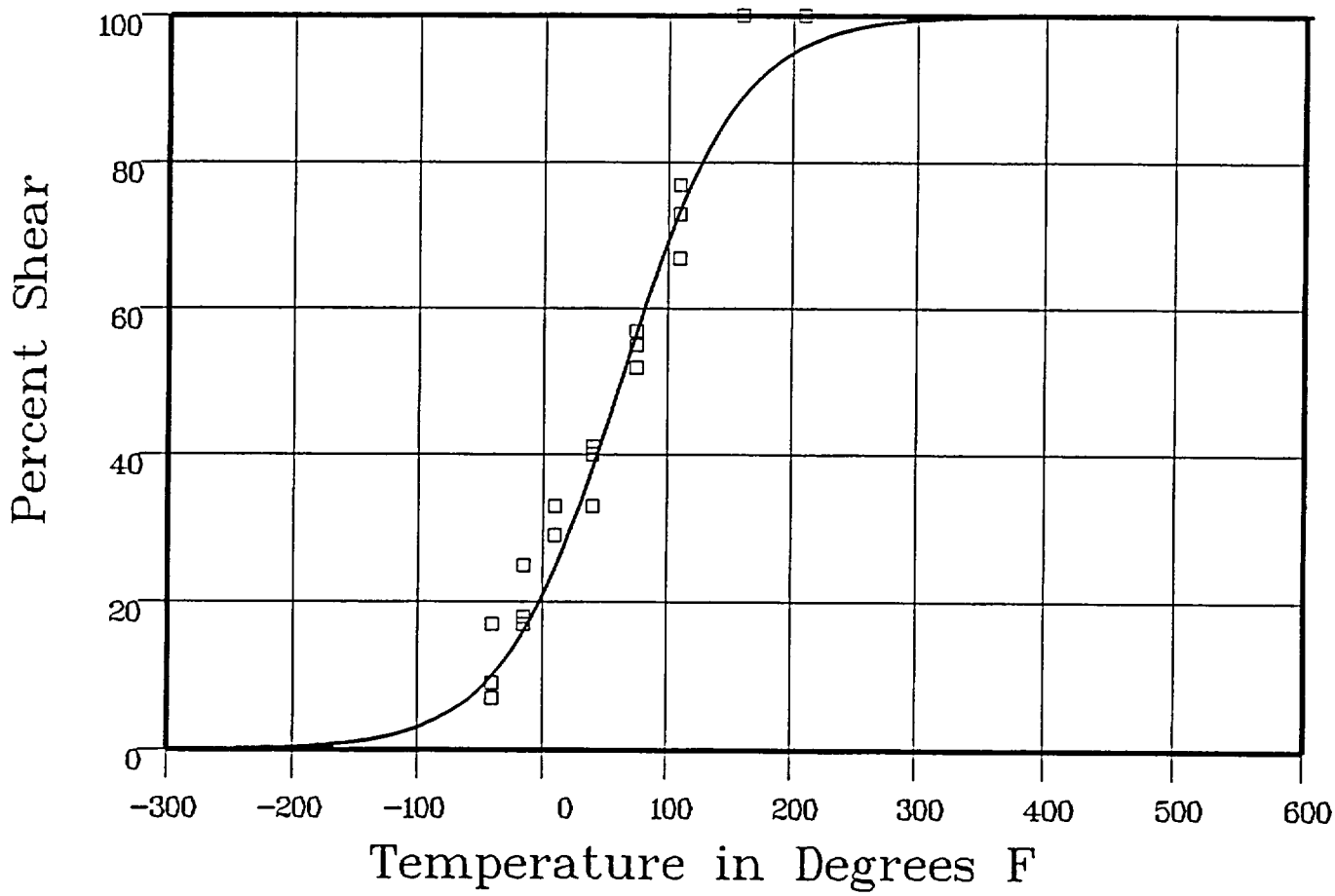
A = 50	B = 50	C = 93.52	T0 = 57.63

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

Temperature at 50% Shear: 57.6

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-40	9	11.02	-2.02
-40	7	11.02	-4.02
-40	17	11.02	5.97
-15	17	17.46	-.46
-15	25	17.46	7.53
-15	18	17.46	.53
10	33	26.52	6.47
10	33	26.52	6.47
10	29	26.52	2.47

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

UNIRR LOWER SHELL PLATE C4339-1 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
40	41	40.68	.31
40	40	40.68	-.68
40	33	40.68	-7.68
75	57	59.17	-2.17
75	55	59.17	-4.17
75	52	59.17	-7.17
110	77	75.39	1.6
110	73	75.39	-2.39
110	67	75.39	-8.39
160	100	89.92	10.07
160	100	89.92	10.07
160	100	89.92	10.07
210	100	96.29	3.7
210	100	96.29	3.7
210	100	96.29	3.7

SUM of RESIDUALS = 33.5

CAPSULE X LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:30:09 on 07-11-2002

Page 1

Coefficients of Curve 2

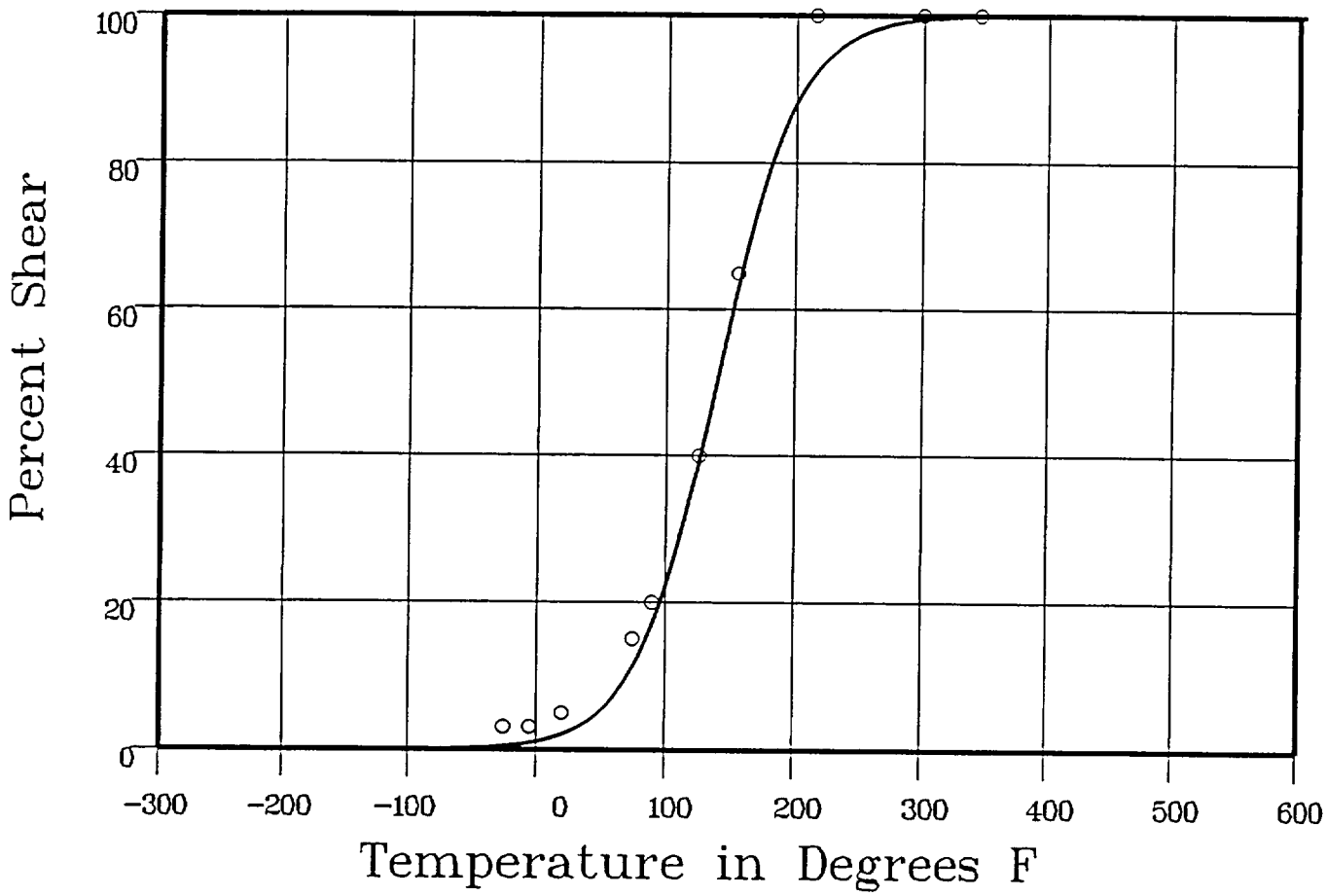
A = 50	B = 50	C = 61.52	T0 = 134.17

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

Temperature at 50% Shear: 134.1

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-25	3	.56	2.43
-5	3	1.07	1.92
20	5	2.38	2.61
75	15	12.74	2.25
90	20	19.21	.78
125	40	42.59	-2.59
155	65	66.3	-1.3
215	100	93.25	6.74

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

CAPSULE X LOWER SHELL PLATE C4339-1 (LONG)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
300	100	99.54	.45
345	100	99.89	.1

SUM of RESIDUALS = 13.42

CAPSULE V LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 10:30:09 on 07-11-2002

Page 1

Coefficients of Curve 3

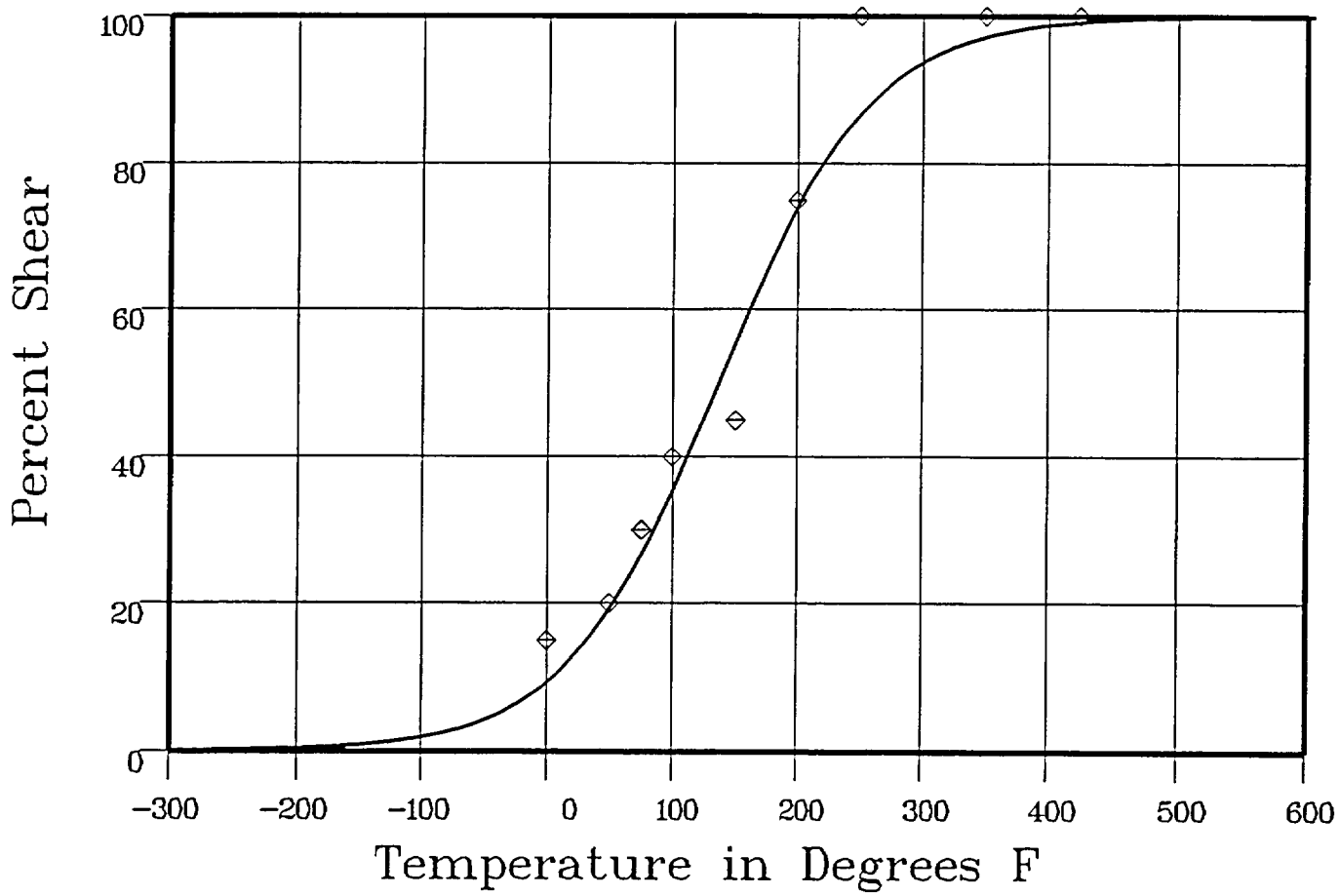
A = 50	B = 50	C = 120.87	T0 = 131.83

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

Temperature at 50% Shear: 131.8

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
0	15	10.14	4.85
50	20	20.52	-.52
75	30	28.08	1.91
76	30	28.41	1.58
100	40	37.12	2.87
150	45	57.45	-12.45
200	75	75.54	-.54
250	100	87.59	12.4

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

CAPSULE V LOWER SHELL PLATE C4339-1 (LONG)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
350	100	97.36	2.63
425	100	99.22	.77

SUM of RESIDUALS = 13.51

CAPSULE Y LOWER SHELL PLATE C4339-1 (LONG)

CVGRAPH 41 Hyperbolic Tangent Curve Printed at 10:30:09 on 07-11-2002

Page 1

Coefficients of Curve 4

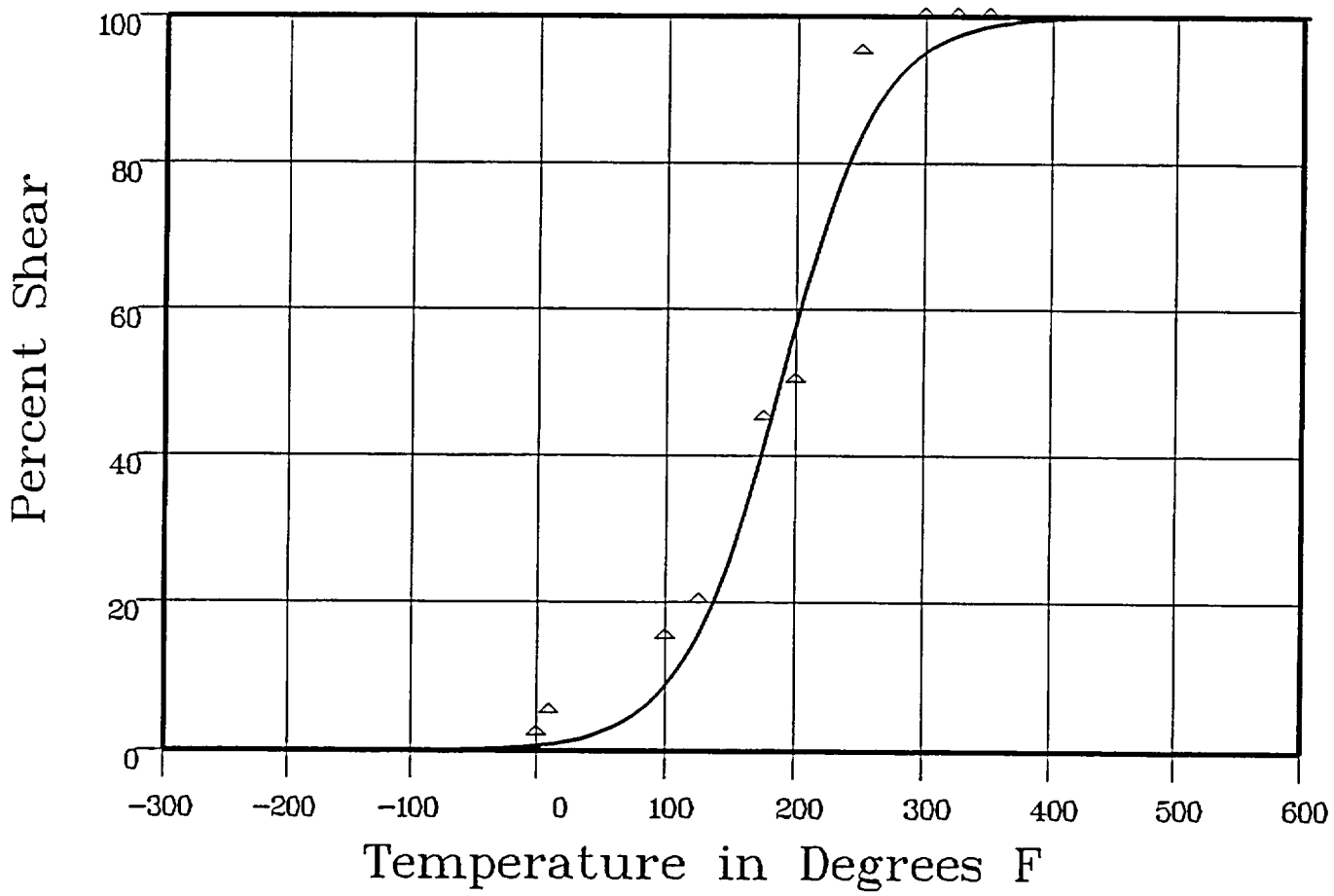
A = 50	B = 50	C = 75.01	T0 = 183.75

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

Temperature at 50% Shear: 183.7

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: Y Material: PLATE SA533B1 Ori: LT Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
0	2	.73	1.26
10	5	.96	4.03
100	15	9.68	5.31
125	20	17.27	2.72
175	45	44.19	.8
200	50	60.66	-10.66
250	95	85.4	9.59

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

CAPSULE Y LOWER SHELL PLATE C4339-1 (LONG)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
300	100	95.68	4.31
325	100	97.73	2.26
350	100	98.82	1.17

SUM of RESIDUALS = 20.83

UNIRR LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:24:33 on 07-19-2002

Page 1

Coefficients of Curve 1

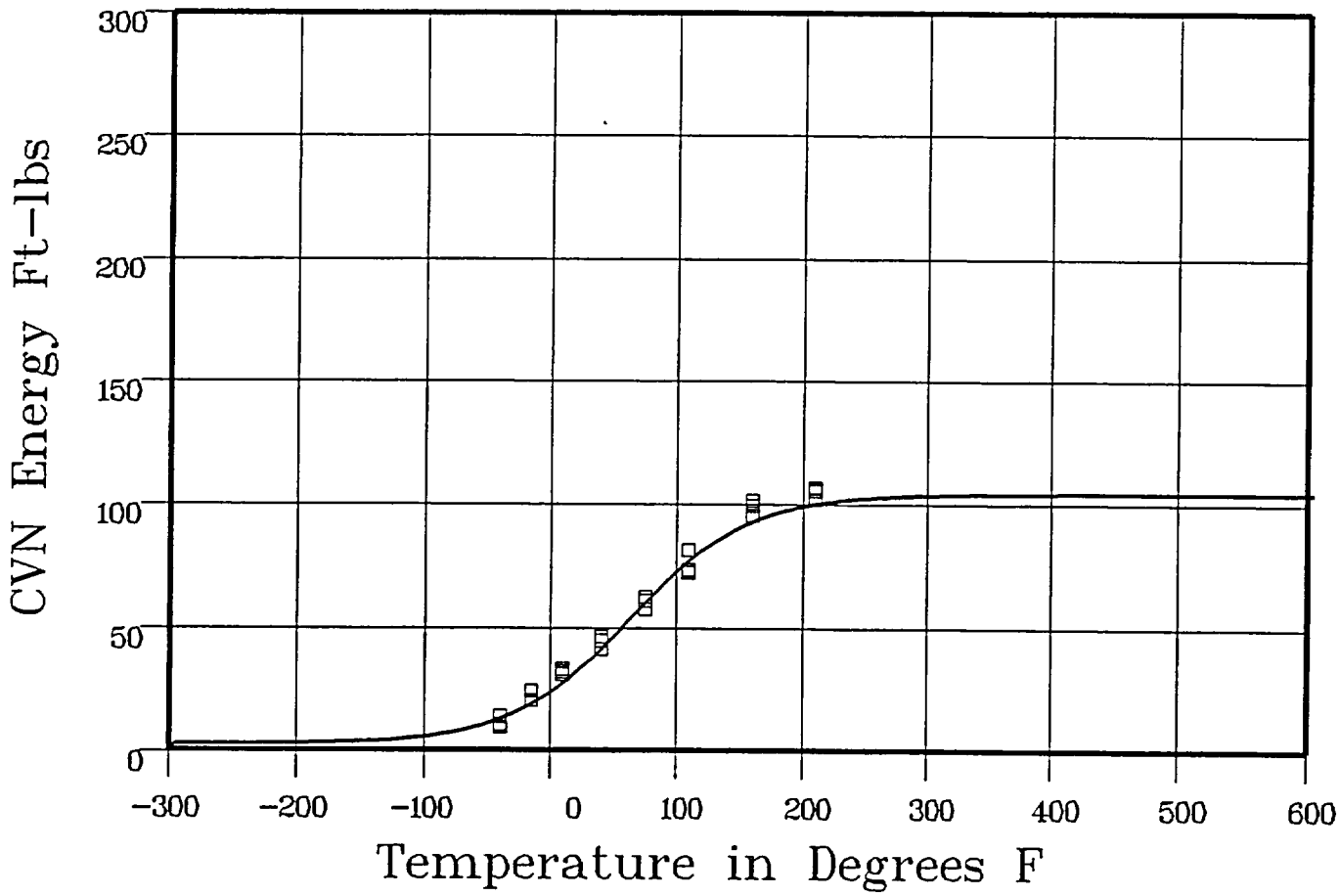
A = 53.09	B = 50.9	C = 94.36	T0 = 57.65

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

Upper Shelf Energy: 104 Fixed Temp. at 30 ft-lbs: 11.4 Temp. at 50 ft-lbs: 51.9 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: PLATE SA533B1 Ori.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-40	13.5	13.6	-.1
-40	10	13.6	-3.6
-40	9	13.6	-4.6
-15	20	20.17	-.17
-15	24	20.17	3.82
-15	24	20.17	3.82
10	33	29.37	3.62
10	32	29.37	2.62
10	31	29.37	1.62

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

UNIRR LOWER SHELL PLATE C4339-1 (TRANS)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
40	44.5	43.68	.81
40	46	43.68	2.31
40	41	43.68	-2.68
75	62	62.35	-.35
75	60.5	62.35	-1.85
75	57	62.35	-5.35
110	81	78.75	2.24
110	73	78.75	-5.75
110	72	78.75	-6.75
160	101	93.55	7.44
160	99	93.55	5.44
160	95	93.55	1.44
210	106	100.12	5.87
210	101.5	100.12	1.37
210	105	100.12	4.87

SUM of RESIDUALS = 16.09

CAPSULE X LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:24:33 on 07-19-2002

Page 1

Coefficients of Curve 2

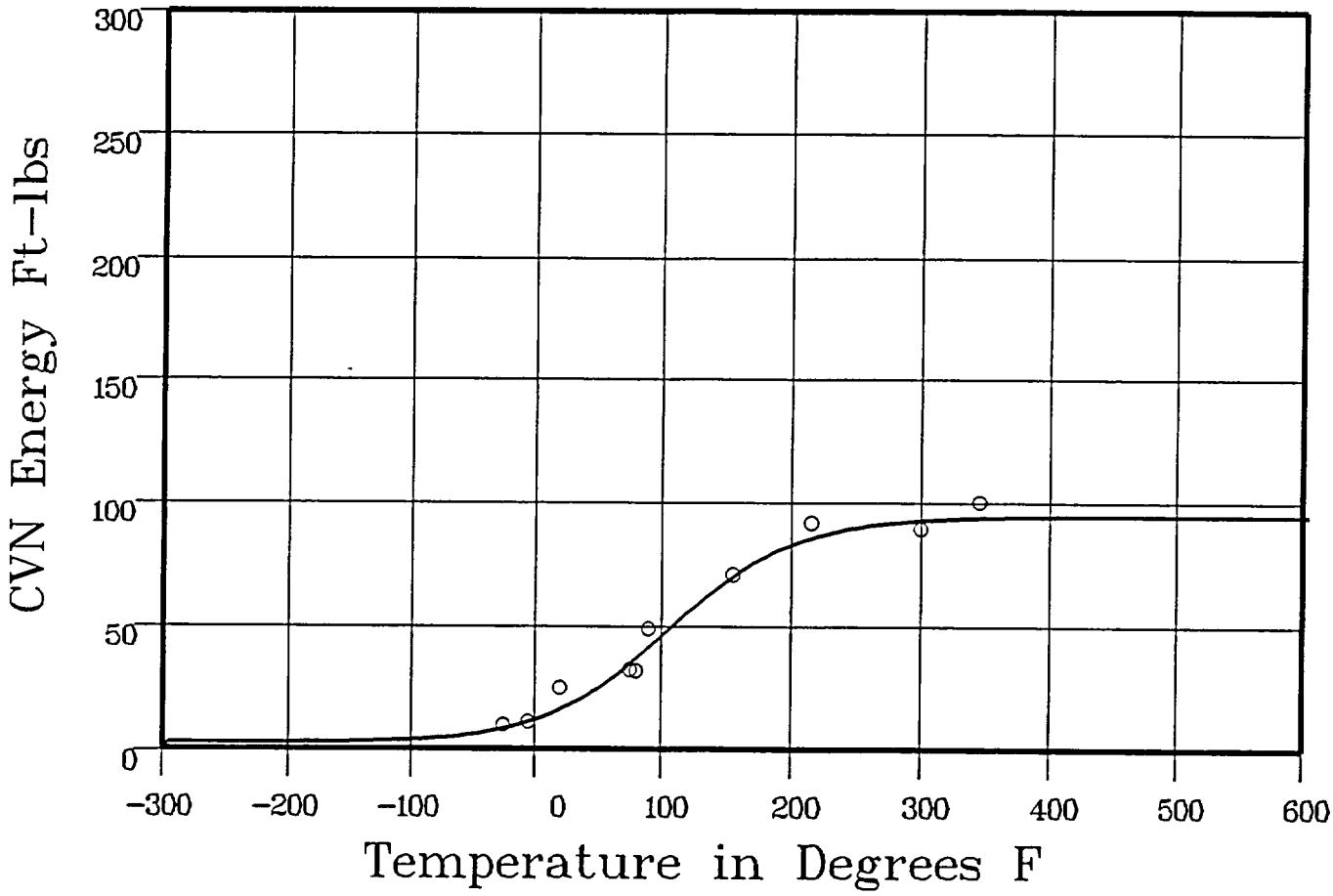
A = 48.09	B = 45.9	C = 97.48	T0 = 100.78

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

Upper Shelf Energy: 94 Fixed Temp. at 30 ft-lbs: 60.1 Temp. at 50 ft-lbs: 104.8 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: X Material: PLATE SA533B1 Ori.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-25	9.5	8.66	.83
-5	11	11.6	-.6
20	24.5	16.9	7.59
75	32	36.23	-4.23
80	31.5	38.46	-6.96
90	48.5	43.04	5.45
155	70.5	71.28	-.78
215	91.5	85.95	5.54

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

CAPSULE X LOWER SHELL PLATE C4339-1 (TRANS)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
300	89	92.48	-3.48
345	100	93.39	6.6
		SUM of RESIDUALS =	9.96

CAPSULE V LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 41 Hyperbolic Tangent Curve Printed at 09:24:33 on 07-19-2002

Page 1

Coefficients of Curve 3

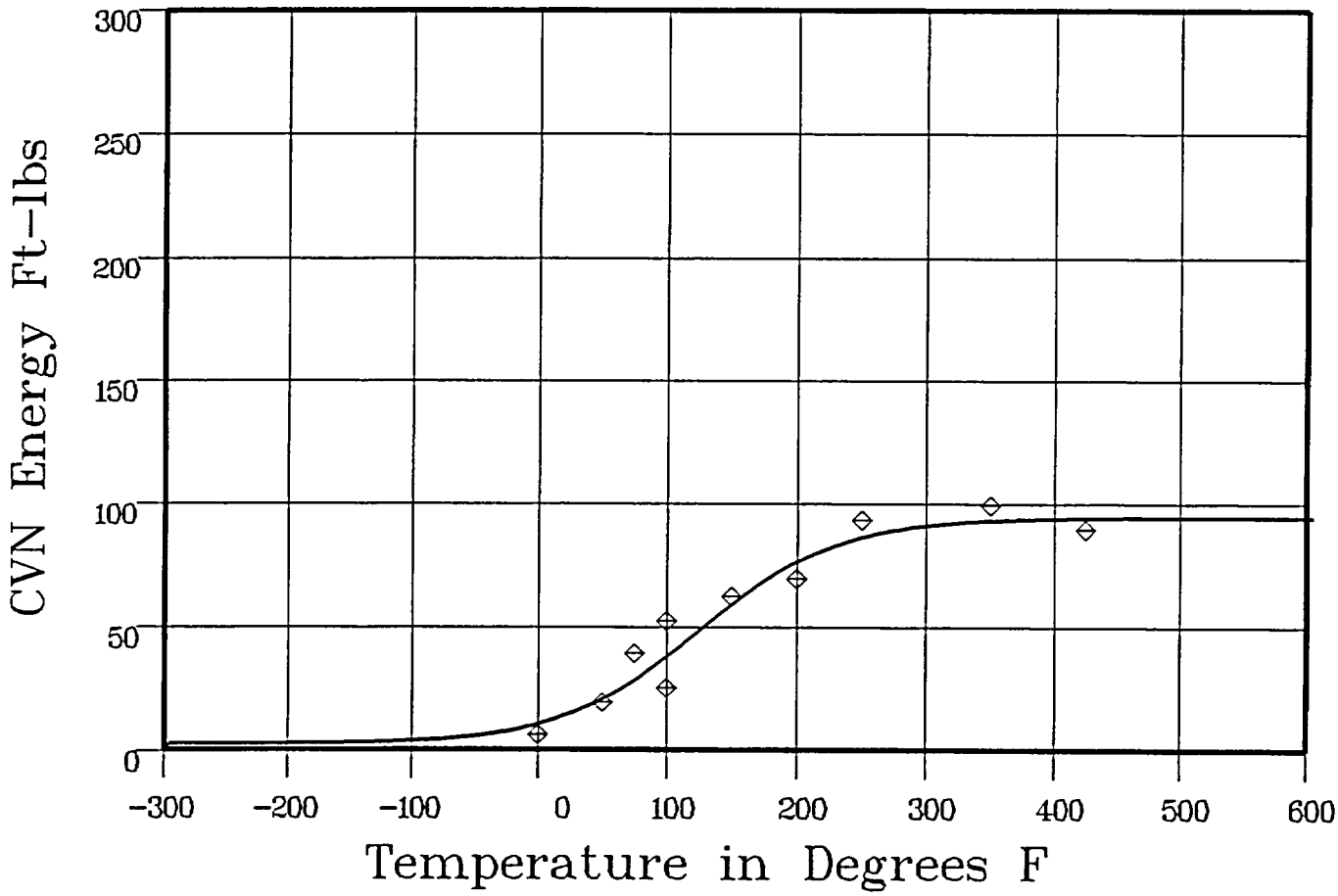
A = 48.09	B = 45.9	C = 106.92	T0 = 119.64

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

Upper Shelf Energy: 94 Fixed Temp. at 30 ft-lbs: 75 Temp. at 50 ft-lbs: 124 Lower Shelf Energy: 219 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: PLATE SA533B1 Ori: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
0	6	11.04	-5.04
50	19	21.81	-2.81
75	39	29.97	9.02
100	52	39.75	12.24
100	25	39.75	-14.75
150	62	60.79	1.2
200	69	77.29	-8.29
250	93	86.62	6.37

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

CAPSULE V LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
350	99	92.78	6.21
425	89	93.69	-4.69

SUM of RESIDUALS = -.55

CAPSULE Y LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:24:33 on 07-19-2002

Page 1

Coefficients of Curve 4

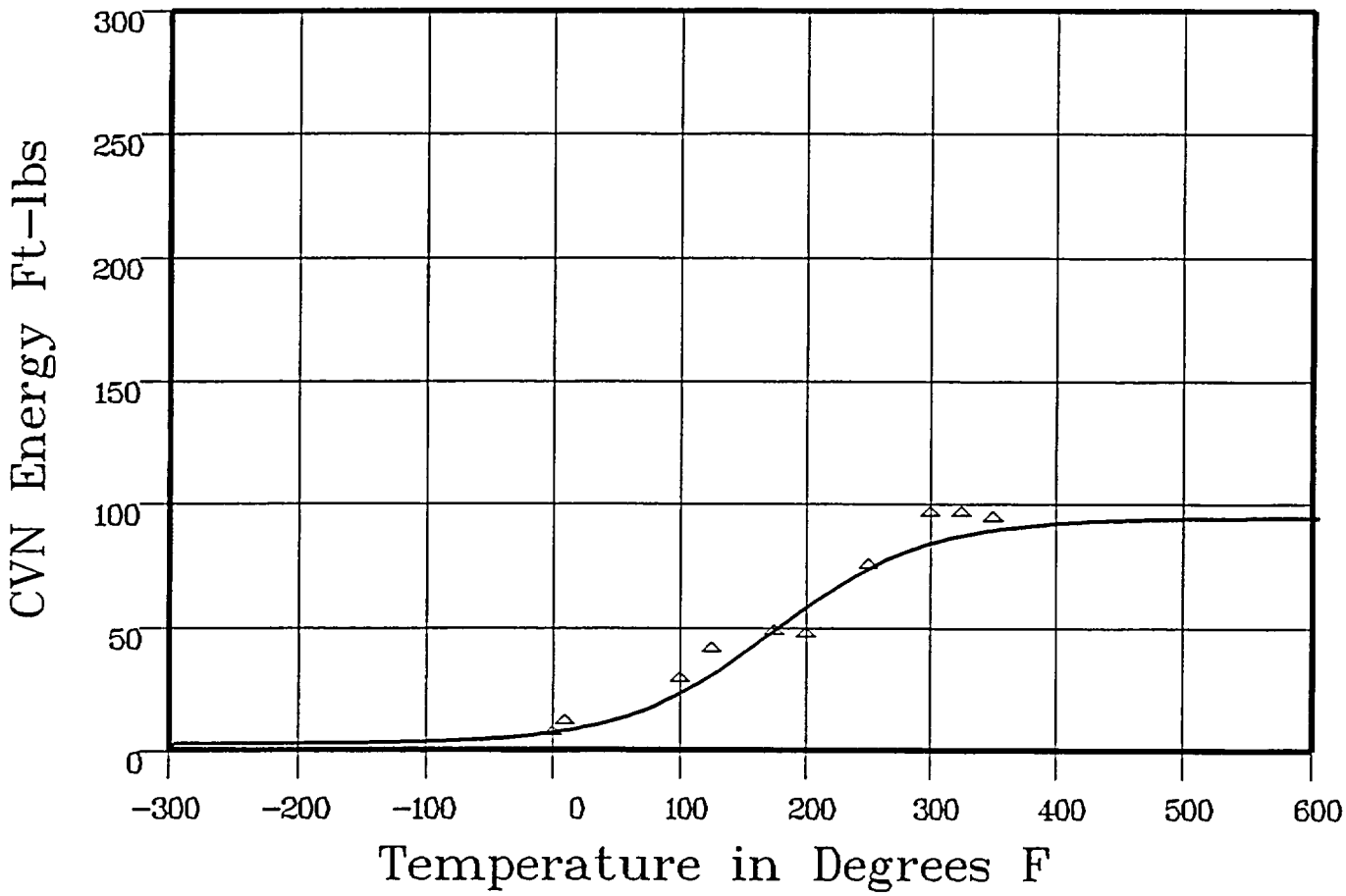
A = 48.09	B = 45.9	C = 121.77	T0 = 169.04

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

Upper Shelf Energy: 94 Fixed Temp. at 30 ft-lbs: 118.2 Temp. at 50 ft-lbs: 174 Lower Shelf Energy: 2.19 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: PLATE SA533B1 Ori.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
0	6	7.58	-1.58
10	11	8.47	2.52
100	28	24.54	3.45
125	40	32.18	7.81
175	47	50.34	-3.34
200	46	59.52	-13.52
250	74	74.79	-.79

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

CAPSULE Y LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
300	95	84.42	10.57
325	95	87.42	7.57
350	93	89.52	3.47

SUM of RESIDUALS = 16.16

UNIRR LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:08:53 on 07-11-2002
Page 1

Coefficients of Curve 1

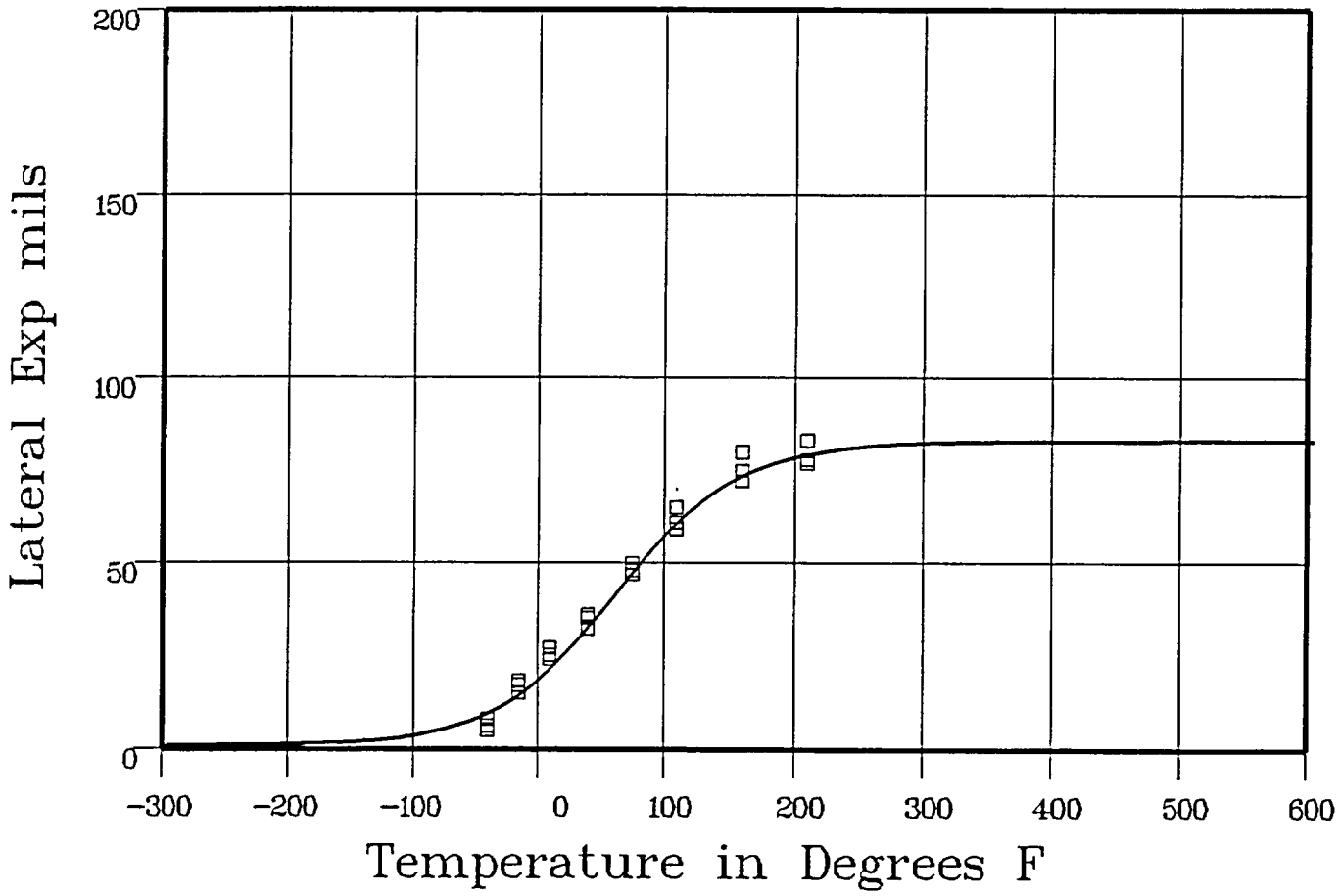
A = 41.98	B = 40.98	C = 95.24	T0 = 58.12

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

Upper Shelf L.E.: 82.96 Temperature at L.E. 35: 41.7 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: PLATE SA533B1 Ori.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-40	8	10.26	-2.26
-40	6	10.26	-4.26
-40	5	10.26	-5.26
-15	15	15.52	-.52
-15	18	15.52	2.47
-15	17	15.52	1.47
10	24	22.87	1.12
10	27	22.87	4.12
10	25	22.87	2.12

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

UNIRR LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
40	35	34.27	.72
40	36	34.27	1.72
40	32	34.27	-2.27
75	50	49.16	.83
75	48	49.16	-1.16
75	47	49.16	-2.16
110	65	62.32	2.67
110	59	62.32	-3.32
110	61	62.32	-1.32
160	80	74.32	5.67
160	75	74.32	.67
160	72	74.32	-2.32
210	83	79.72	3.27
210	77	79.72	-2.72
210	78	79.72	-1.72

SUM of RESIDUALS = -2.45

CAPSULE X LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:08:53 on 07-11-2002

Page 1

Coefficients of Curve 2

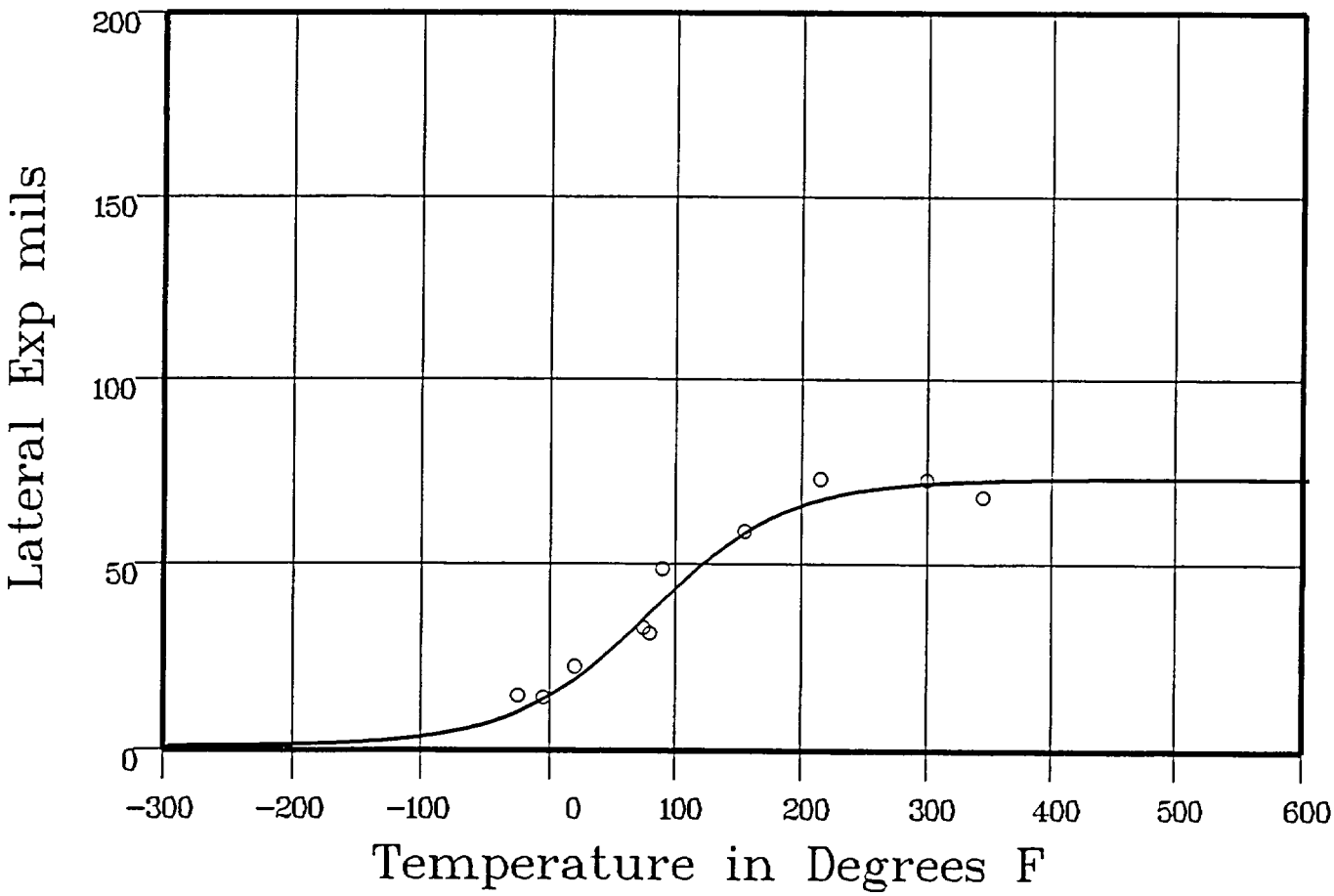
A = 37.23	B = 36.23	C = 109.95	T0 = 75.93

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

Upper Shelf L.E.: 73.46 Temperature at L.E. 35: 69.1 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: X Material: PLATE SA533B1 Orl.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-25	14.5	10.96	3.53
-5	14	14.52	-.52
20	22.5	20.24	2.25
75	33	36.92	-3.92
80	31.5	38.57	-7.07
90	49	41.84	7.15
155	59	59.56	-.56
215	73.5	68.11	5.38

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

CAPSULE X LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
300	73	72.25	.74
345	68.5	72.92	-4.42

SUM of RESIDUALS = 2.56

CAPSULE V LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:08:53 on 07-11-2002

Page 1

Coefficients of Curve 3

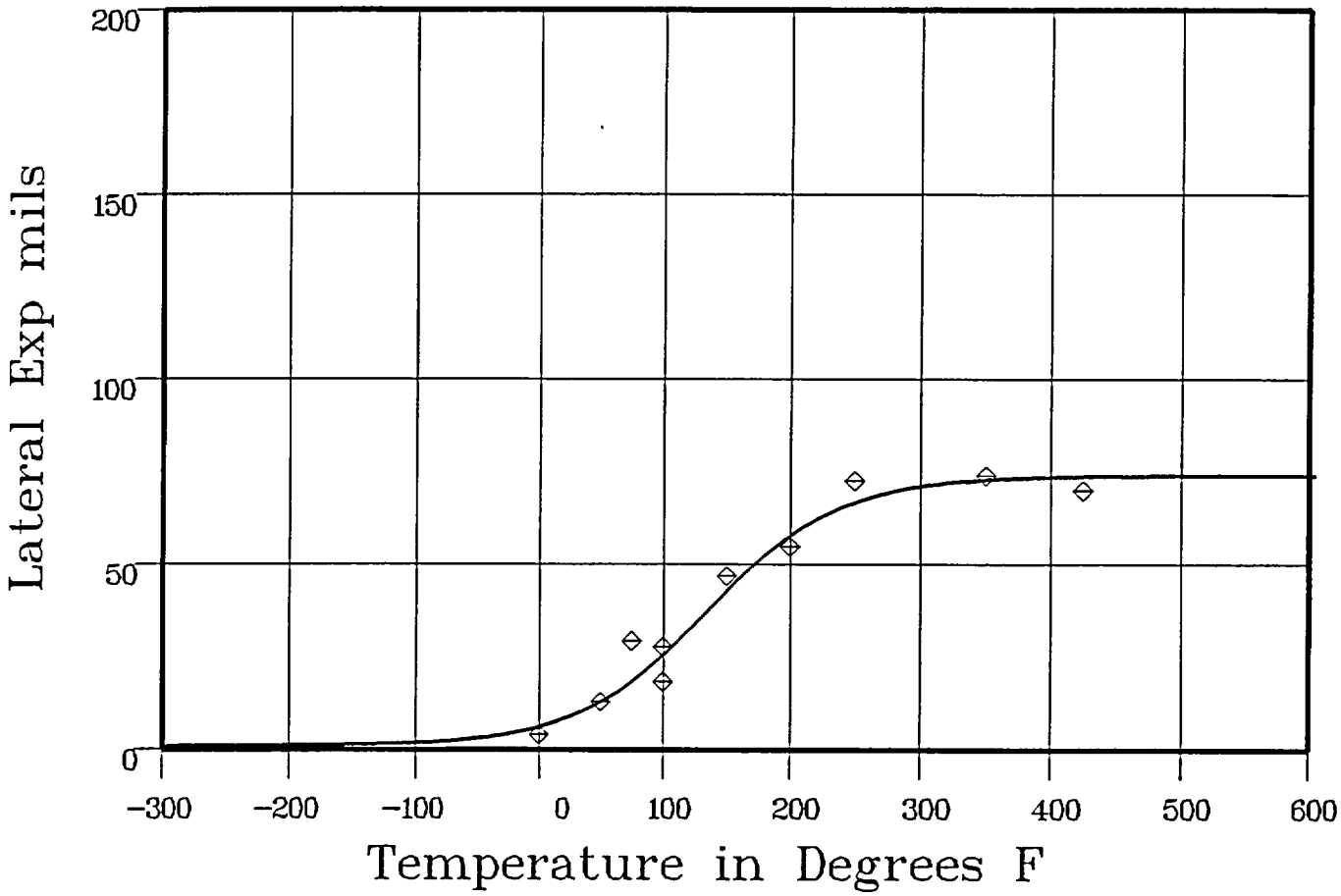
A = 37.47	B = 36.47	C = 103.4	T0 = 129.37

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

Upper Shelf L.E.: 73.94 Temperature at L.E. 35: 122.3 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: V Material: PLATE SA533B1 Ori.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
0	4	6.52	-2.52
50	13	13.92	-.92
75	29.5	19.88	9.61
100	28	27.38	.61
100	18.5	27.38	-8.88
150	47	44.65	2.34
200	55	59.11	-4.11
250	72.5	67.49	5

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

CAPSULE V LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
350	74	72.93	1.06
425	70	73.7	-3.7

SUM of RESIDUALS = -1.51

CAPSULE Y LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:08:53 on 07-11-2002
Page 1
Coefficients of Curve 4

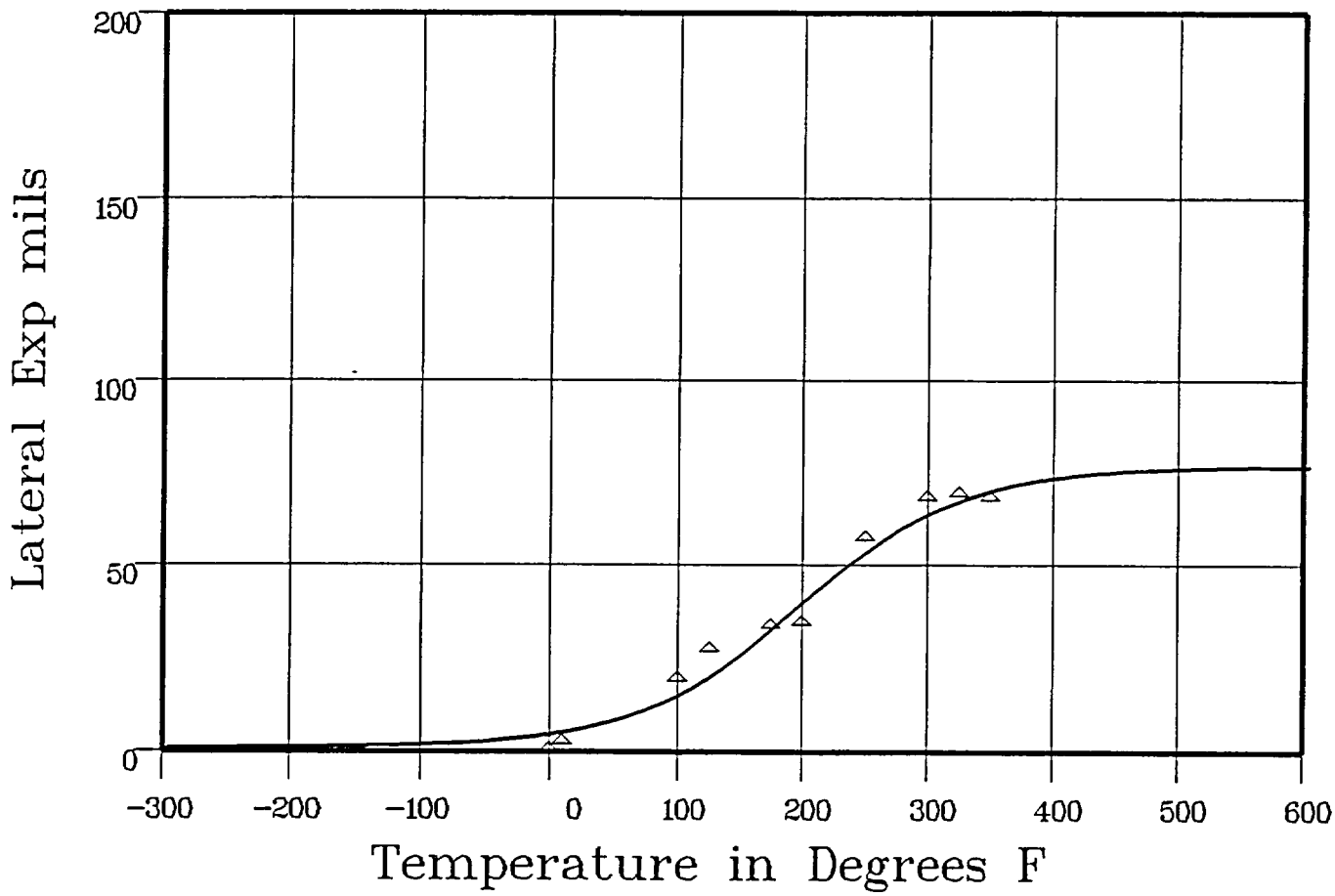
A = 39.01	B = 38.01	C = 131.42	T0 = 192.48

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

Upper Shelf L.E.: 77.03 Temperature at L.E. 35: 178.5 Lower Shelf L.E.: 1 Fixed

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: Y Total Fluence:



Data Set(s) Plotted
Plant: SU2 Cap.: Y Material: PLATE SA533B1 Ori.: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
0	0	4.85	-4.85
10	2	5.45	-3.45
100	19	15.95	3.04
125	27	21.05	5.94
175	33	33.99	-.99
200	34	41.19	-7.19
250	57	54.67	2.32

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

CAPSULE Y LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
300	68	64.64	3.35
325	69	68.1	.89
350	68	70.69	-2.69

SUM of RESIDUALS = -3.62

UNIRR INTER LOWER PLATE C4339-1 (TRANS)

CVGRAPH 41 Hyperbolic Tangent Curve Printed at 14:21:48 on 07-11-2002

Page 1

Coefficients of Curve 1

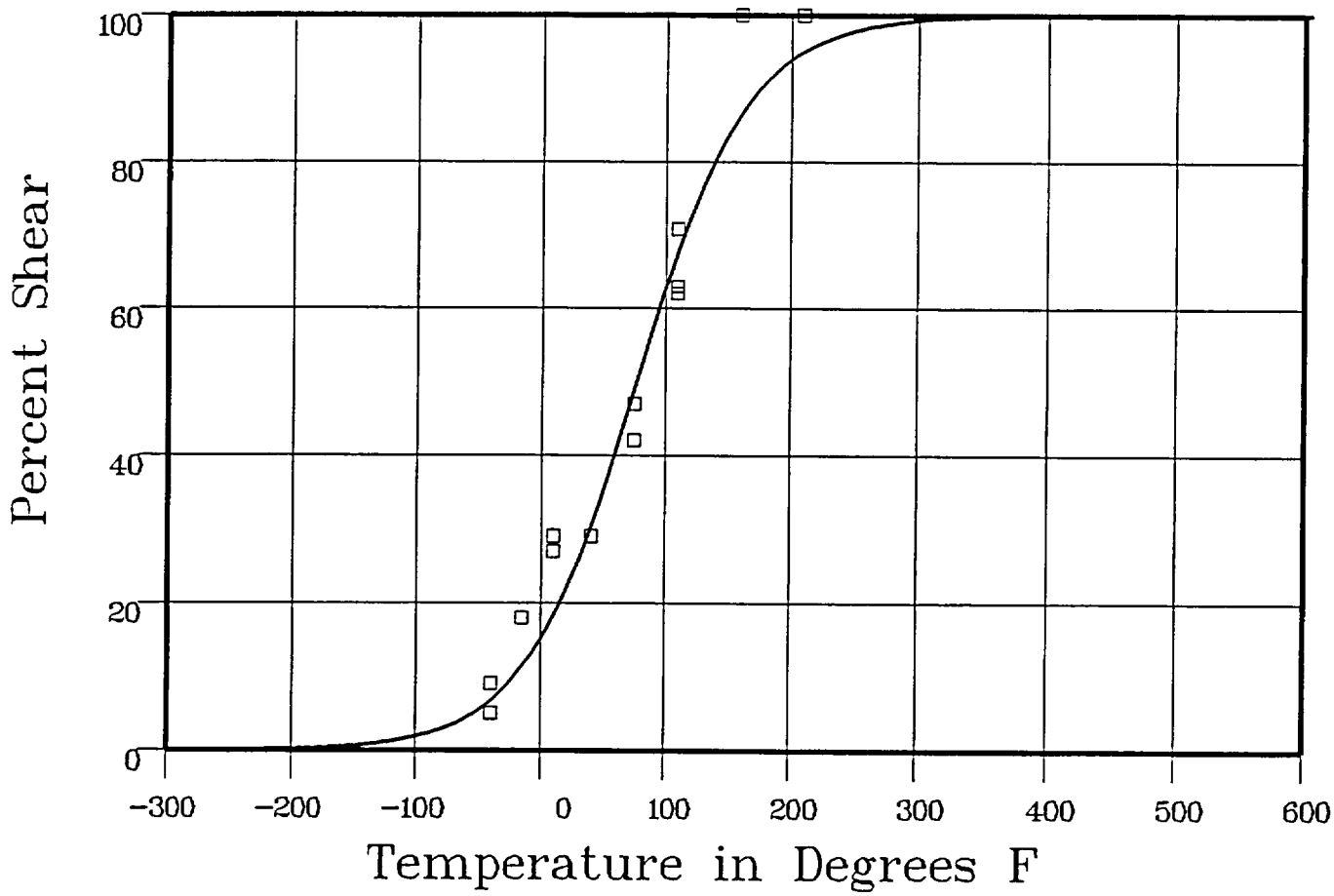
A = 50	B = 50	C = 89.35	T0 = 72.18

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

Temperature at 50% Shear: 72.1

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: PLATE SA533B1 Ori: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-40	9	7.5	1.49
-40	5	7.5	-2.5
-40	5	7.5	-2.5
-15	18	12.43	5.56
-15	18	12.43	5.56
-15	18	12.43	5.56
10	29	19.91	9.08
10	27	19.91	7.08
10	29	19.91	9.08

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

UNIRR LOWER SHELL PLATE C4339-1 (TRANS)

Page 2

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
40	29	32.72	-3.72
40	29	32.72	-3.72
40	29	32.72	-3.72
75	47	51.57	-4.57
75	47	51.57	-4.57
75	42	51.57	-9.57
110	71	69.97	1.02
110	62	69.97	-7.97
110	63	69.97	-6.97
160	100	87.71	12.28
160	100	87.71	12.28
160	100	87.71	12.28
210	100	95.62	4.37
210	100	95.62	4.37
210	100	95.62	4.37

SUM of RESIDUALS = 44.56

CAPSULE X LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:21:48 on 07-11-2002

Page 1

Coefficients of Curve 2

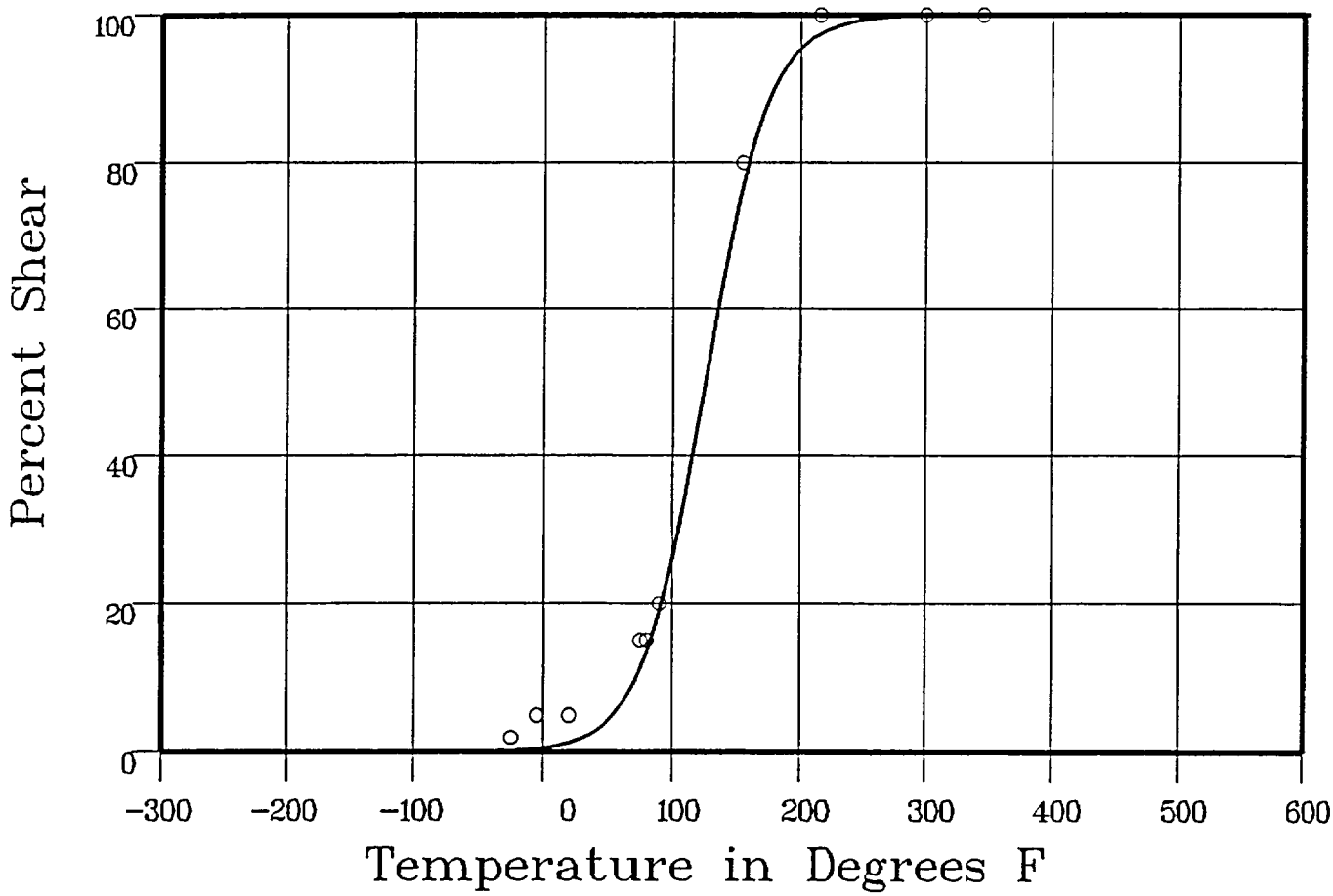
A = 50	B = 50	C = 49.04	T0 = 121.1

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

Temperature at 50% Shear: 121.1

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: PLATE SA533B1 Ori: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-25	2	.25	1.74
-5	5	.58	4.41
20	5	1.59	3.4
75	15	13.23	1.76
80	15	15.75	-.75
90	20	21.95	-1.95
155	80	.79.93	.06
215	100	97.87	2.12

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

CAPSULE X LOWER SHELL PLATE C4339-1 (TRANS)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: X Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
300	100	99.93	.06
345	100	99.98	.01

SUM of RESIDUALS = 10.89

CAPSULE V LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:21:48 on 07-11-2002

Page 1

Coefficients of Curve 3

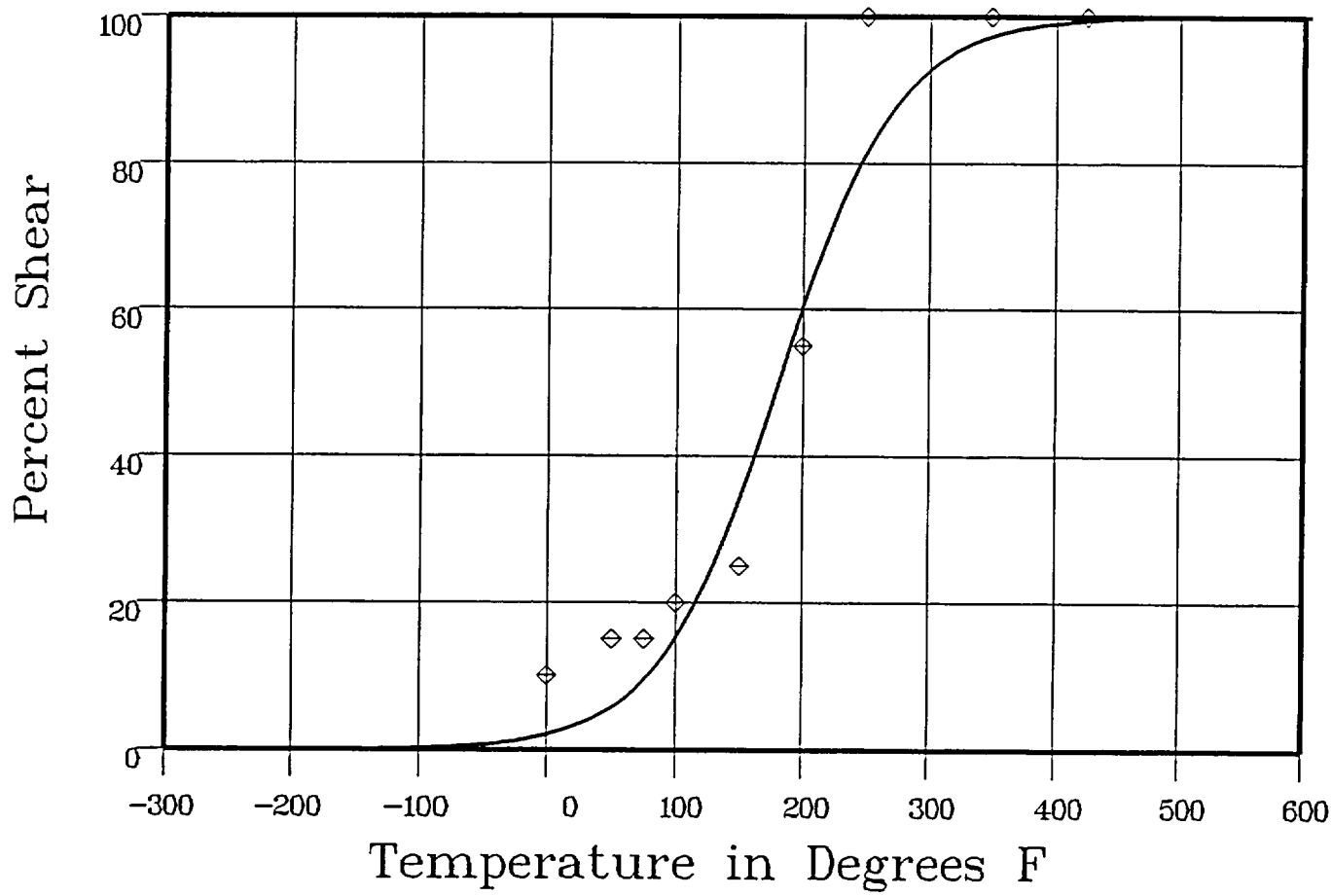
A = 50	B = 50	C = 93.53	T0 = 175.78

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

Temperature at 50% Shear: 175.7

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: PLATE SA533B1 Ori: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
0	10	2.27	7.72
50	15	6.35	8.64
75	15	10.38	4.61
100	20	16.51	3.48
100	20	16.51	3.48
150	25	36.55	-11.55
200	55	62.66	-7.66
250	100	83.01	16.98

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

CAPSULE V LOWER SHELL PLATE C4339-1 (TRANS)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: V Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
350	100	97.64	2.35
425	100	99.51	.48

SUM of RESIDUALS = 28.54

CAPSULE Y LOWER SHELL PLATE C4339-1 (TRANS)

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:21:48 on 07-11-2002
Page 1
Coefficients of Curve 4

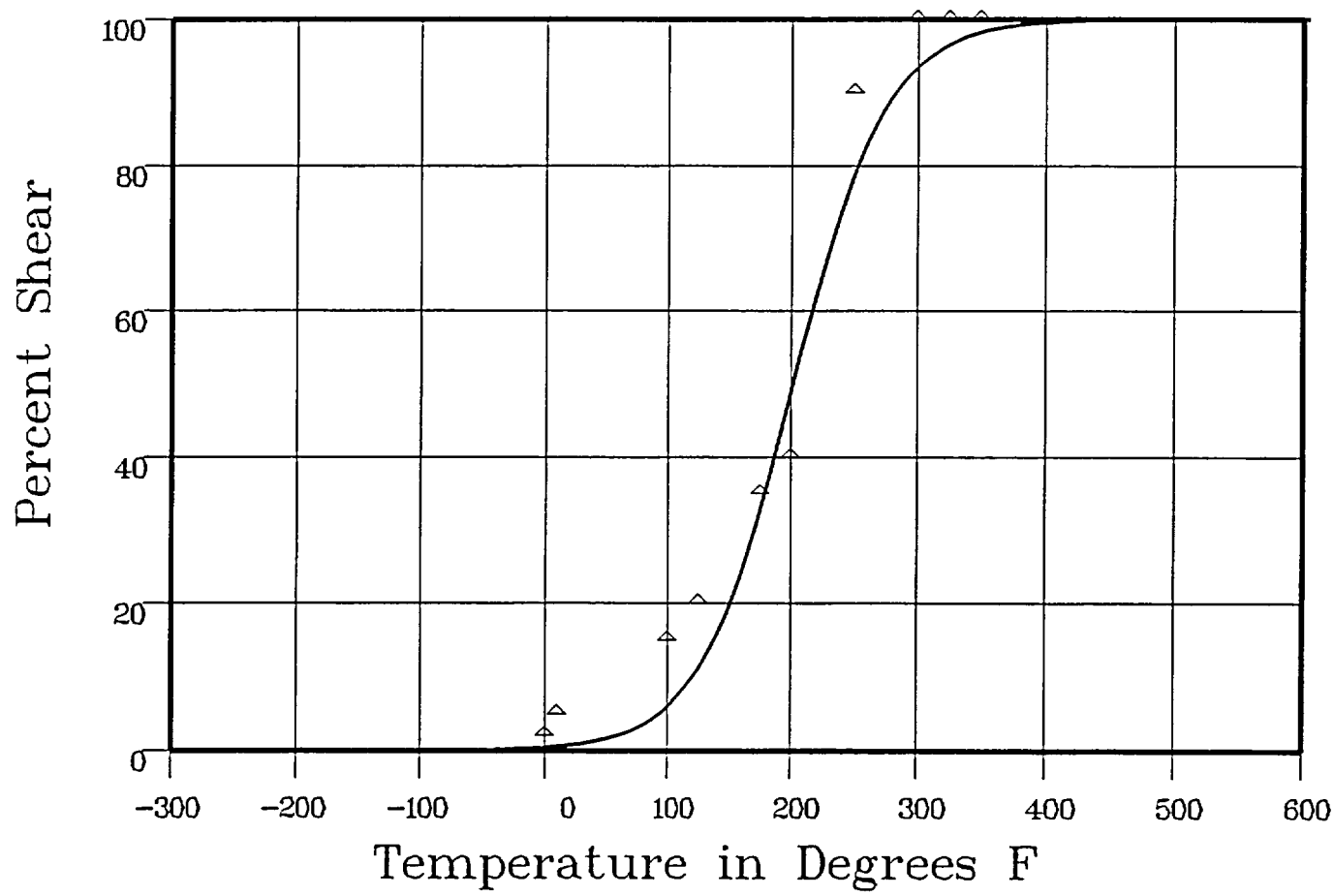
A = 50	B = 50	C = 73.84	T0 = 196.87

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

Temperature at 50% Shear: 196.8

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: Y Total Fluence:



Data Set(s) Plotted
Plant: SU2 Cap: Y Material: PLATE SA533B1 Ori: TL Heat #: C4339-1

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
0	2	.48	1.51
10	5	62	4.37
100	15	6.76	8.23
125	20	12.49	7.5
175	35	35.6	-.6
200	40	52.11	-12.11
250	90	80.82	9.17

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

CAPSULE Y LOWER SHELL PLATE C4339-1 (TRANS)

Material: PLATE SA533B1 Heat Number: C4339-1 Orientation: TL

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
300	100	94.23	5.76
325	100	96.98	3.01
350	100	98.44	1.55

SUM of RESIDUALS = 28.42

UNIRRADIATED WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:31:31 on 07-19-2002

Page 1

Coefficients of Curve 1

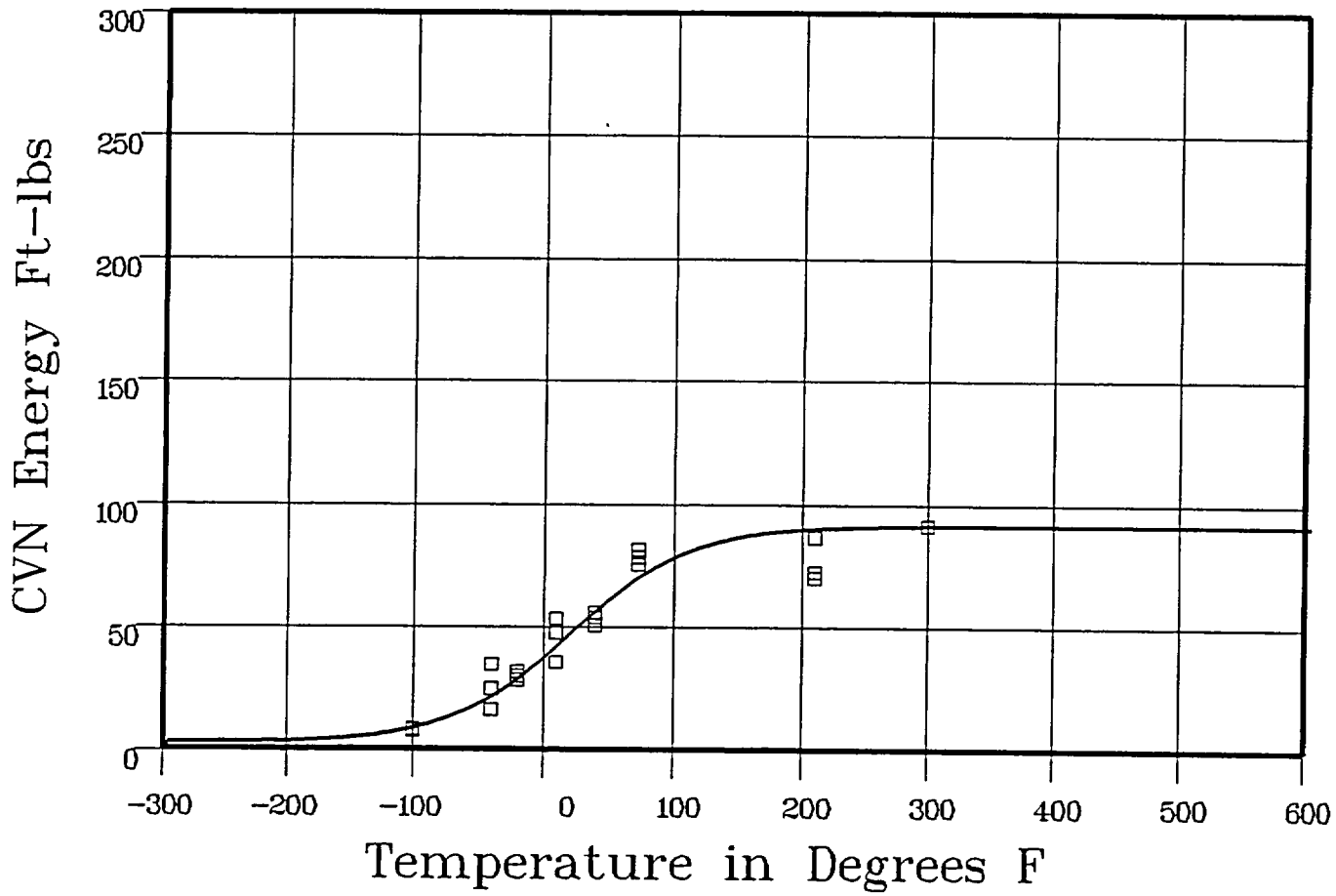
A = 46.59	B = 44.4	C = 91.49	T0 = 15.46

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

Upper Shelf Energy: 91 Fixed Temp. at 30 ft-lbs: -20.4 Temp. at 50 ft-lbs: 22.4 Lower Shelf Energy: 2.19 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: WELD Ori.: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-100	7	8.78	-1.78
-100	7	8.78	-1.78
-100	7.5	8.78	-1.28
-40	34	22.55	11.44
-40	15.5	22.55	-7.05
-40	24	22.55	1.44
-20	29	30.2	-1.2
-20	31	30.2	.79
-20	27.5	30.2	-2.7

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

UNIRRADIATED WELD

Page 2

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
10	35	43.94	-8.94
10	53	43.94	9.05
10	47	43.94	3.05
40	50	58.22	-8.22
40	55.5	58.22	-2.72
40	53.5	58.22	-4.72
73	75	71.34	3.65
73	81	71.34	9.65
73	78	71.34	6.65
210	86	89.75	-3.75
210	69.5	89.75	-20.25
210	72	89.75	-17.75
300	91	90.82	.17
300	91	90.82	.17
300	91	90.82	.17

SUM of RESIDUALS = -35.92

CAPSULE X WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:31:31 on 07-19-2002

Page 1

Coefficients of Curve 2

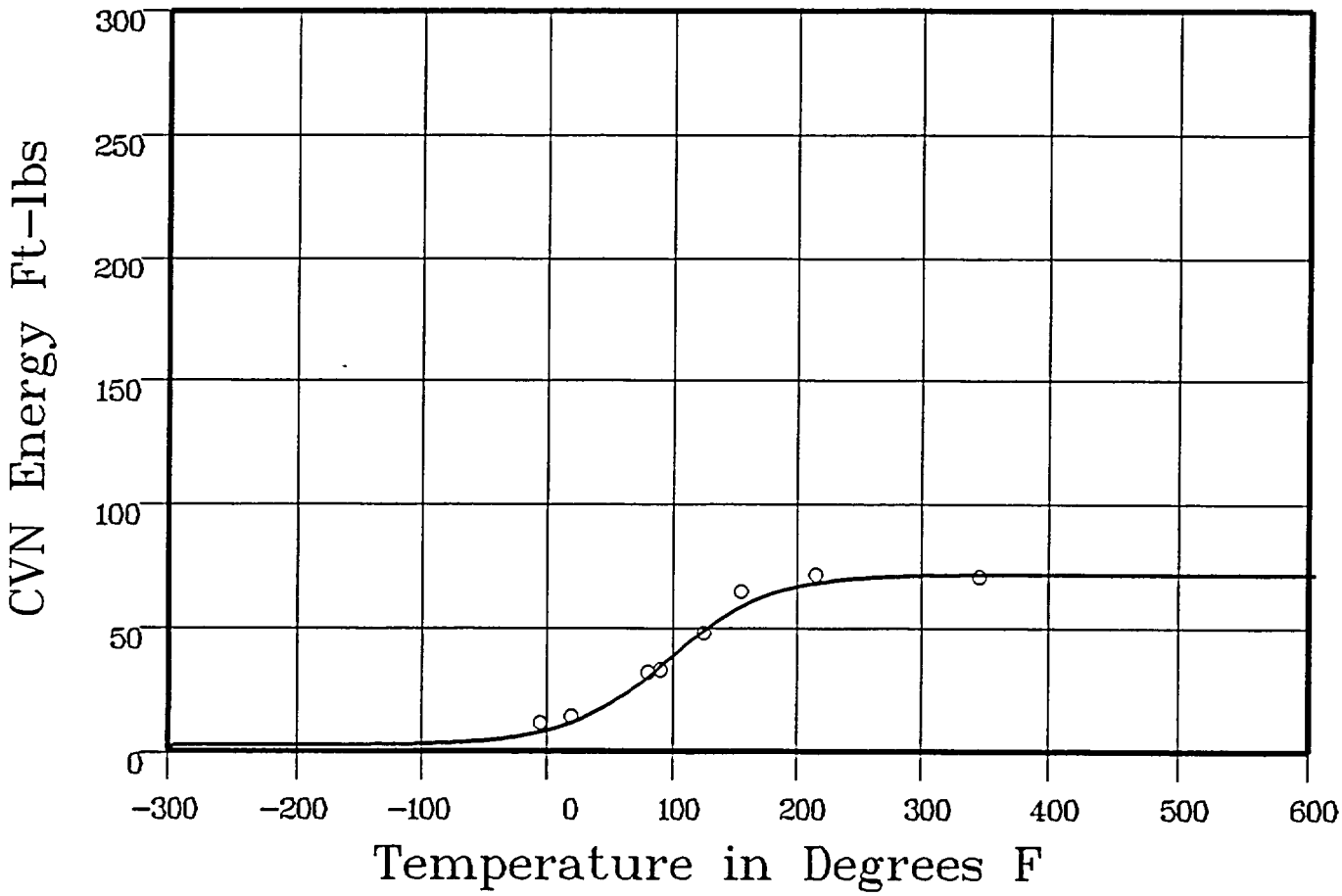
A = 36.59	B = 34.4	C = 81.74	T0 = 91.04

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

Upper Shelf Energy: 71 Fixed Temp. at 30 ft-lbs: 75.1 Temp. at 50 ft-lbs: 124.6 Lower Shelf Energy: 2.19 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-5	11.5	8.18	3.31
20	14	12.48	1.51
80	32	31.97	.02
90	33	36.15	-3.15
125	47.5	50.11	-2.61
155	64	59.09	4.9
215	71	67.83	3.16
345	70	70.86	-.86

SUM of RESIDUALS = 6.26

CAPSULE V WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:31:31 on 07-19-2002
Page 1
Coefficients of Curve 3

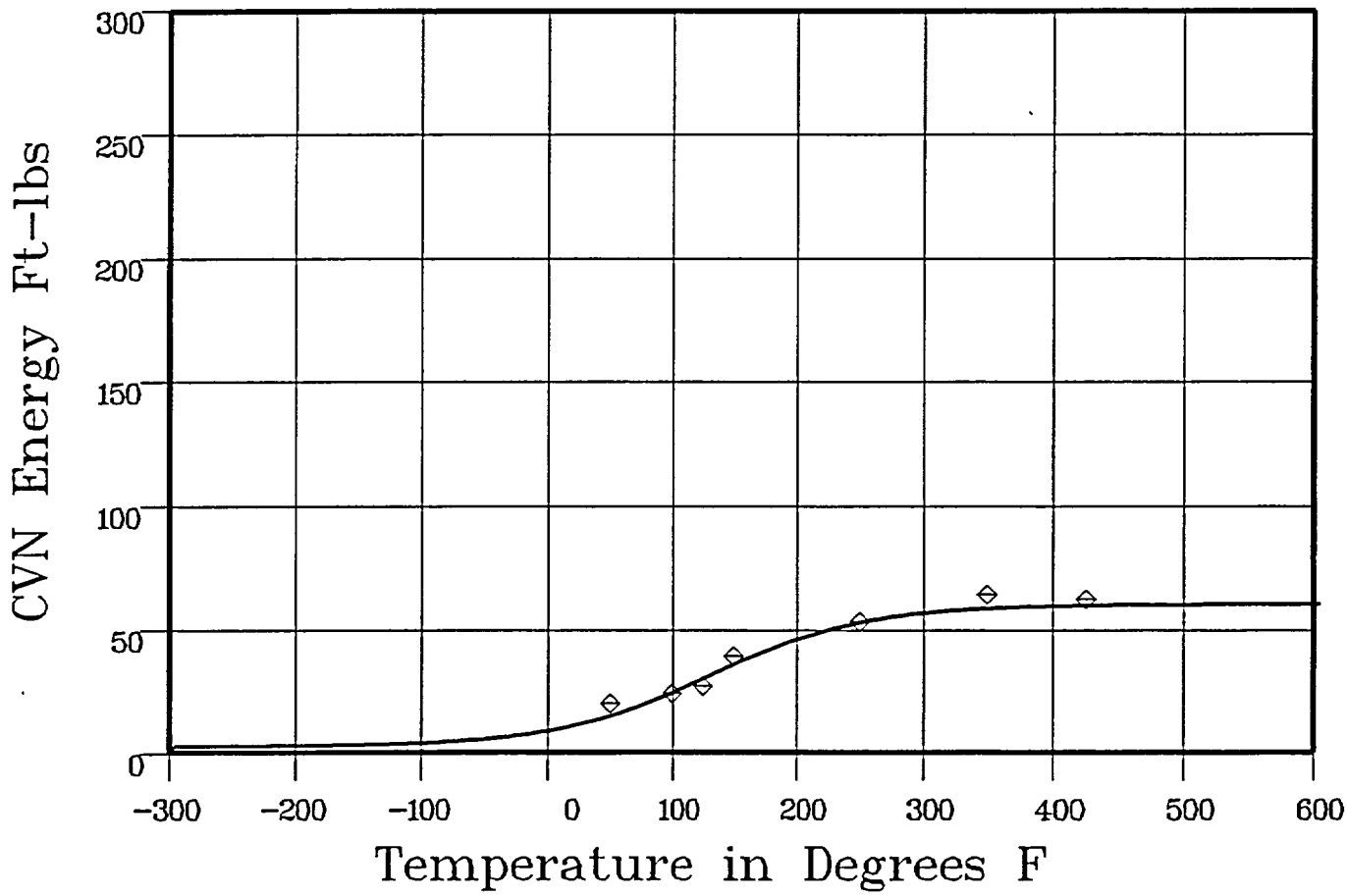
A = 31.1	B = 28.89	C = 125.54	T0 = 124.51

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

Upper Shelf Energy: 60 Fixed Temp. at 30 ft-lbs: 119.7 Temp. at 50 ft-lbs: 222.7 Lower Shelf Energy: 2.2 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted
Plant: SU2 Cap: V Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
50	20	15.71	4.28
100	24	25.52	-1.52
125	27	31.21	-4.21
150	39	36.88	2.11
250	53	53.1	-.1
350	64	58.45	5.54
425	62	59.52	2.47

SUM of RESIDUALS = 8.58

CAPSULE Y WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:31:31 on 07-19-2002

Page 1

Coefficients of Curve 4

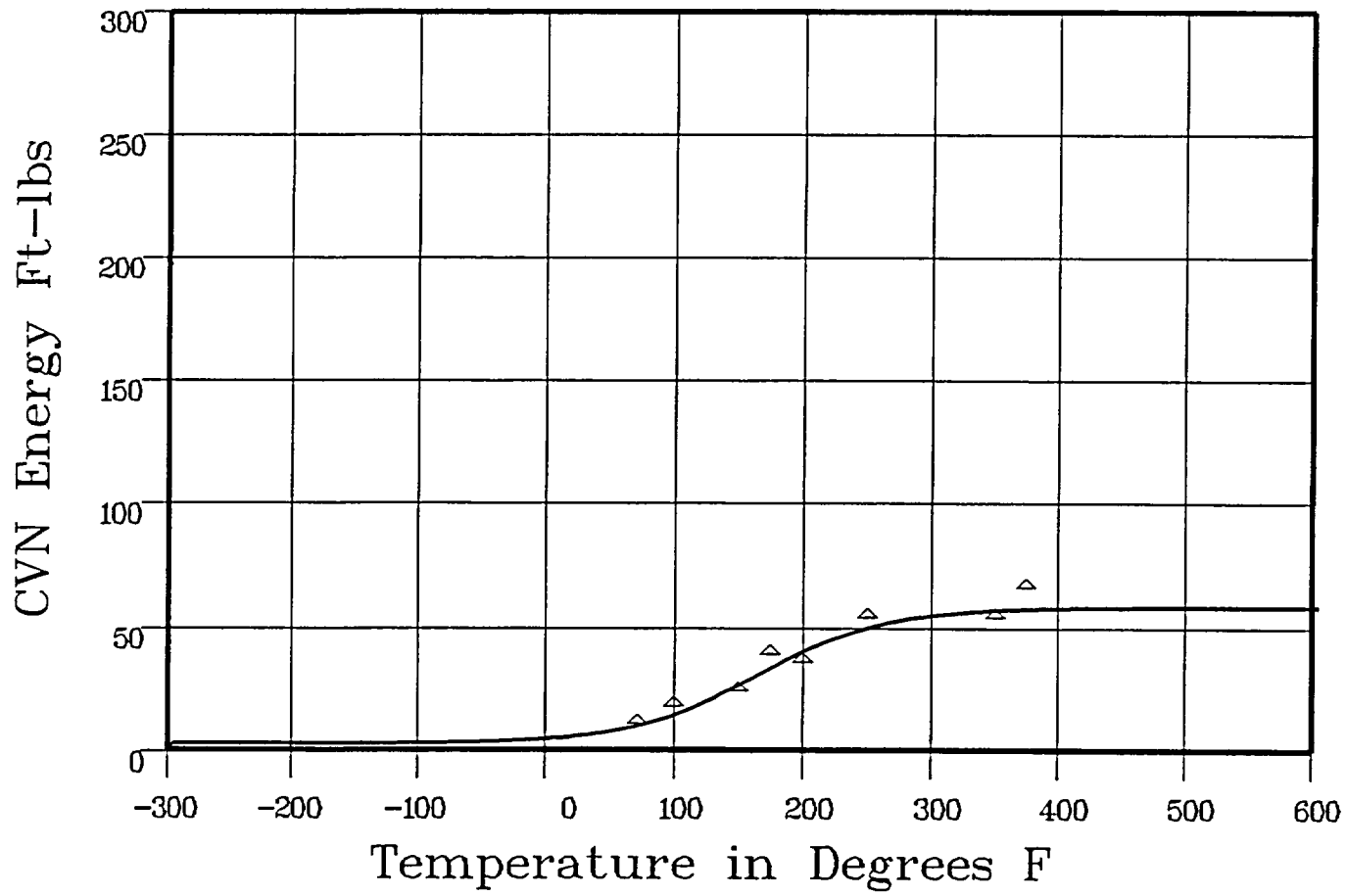
A = 30.1	B = 27.89	C = 99.63	T0 = 158.2

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

Upper Shelf Energy: 58 Fixed Temp. at 30 ft-lbs: 157.8 Temp. at 50 ft-lbs: 247.2 Lower Shelf Energy: 22 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: WELD Ori.: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
72	11	10.6	.39
100	18	15.43	2.56
150	24	27.8	-3.8
175	39	34.75	4.24
200	36	41.16	-5.16
250	54	50.36	3.63
350	54	56.83	-2.83

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

CAPSULE Y WELD

Page 2

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
375	66	57.29	8.7

SUM of RESIDUALS = 7.73

UNIRRADIATED WELD

CVGRAPH 41 Hyperbolic Tangent Curve Printed at 14:56:32 on 07-11-2002
Page 1
Coefficients of Curve 1

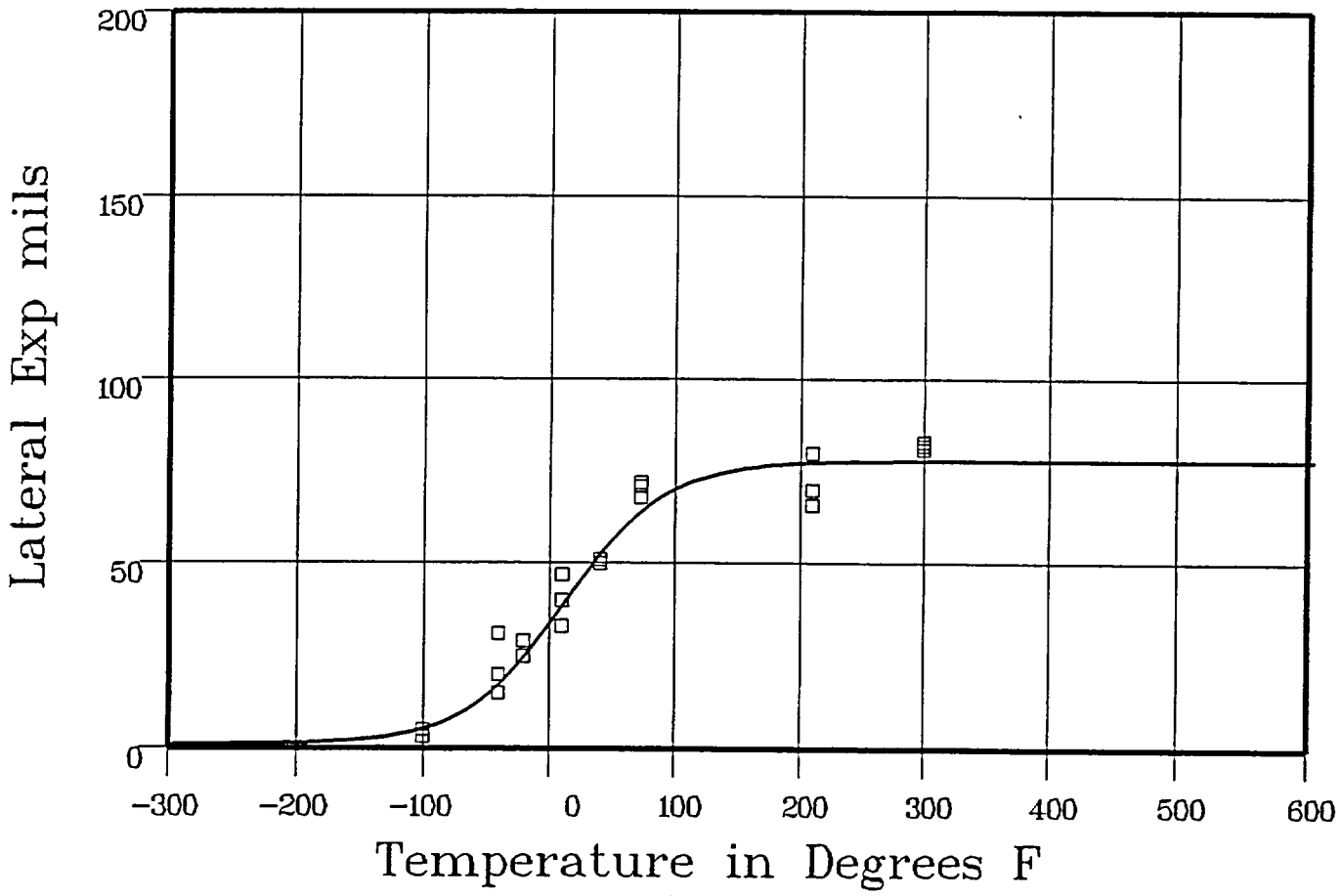
A = 39.5	B = 38.5	C = 79.87	T0 = 7.5

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

Upper Shelf L.E.: 78 Temperature at L.E. 35: -1.8 Lower Shelf L.E.: 1 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: WELD Ori.: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-100	3	5.88	-2.88
-100	5	5.88	-.88
-100	5	5.88	-.88
-40	31	18.97	12.02
-40	15	18.97	-3.97
-40	20	18.97	1.02
-20	25	26.74	-1.74
-20	29	26.74	2.25
-20	25	26.74	-1.74

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

UNIRRADIATED WELD

Page 2

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
10	33	40.7	-7.7
10	47	40.7	6.29
10	40	40.7	-.7
40	50	54.36	-4.36
40	51	54.36	-3.36
40	51	54.36	-3.36
73	68	65.49	2.5
73	72	65.49	6.5
73	71	65.49	5.5
210	80	77.52	2.47
210	66	77.52	-11.52
210	70	77.52	-7.52
300	83	77.95	5.04
300	81	77.95	3.04
300	82	77.95	4.04

SUM of RESIDUALS = 0

CAPSULE X WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:56:32 on 07-11-2002

Page 1

Coefficients of Curve 2

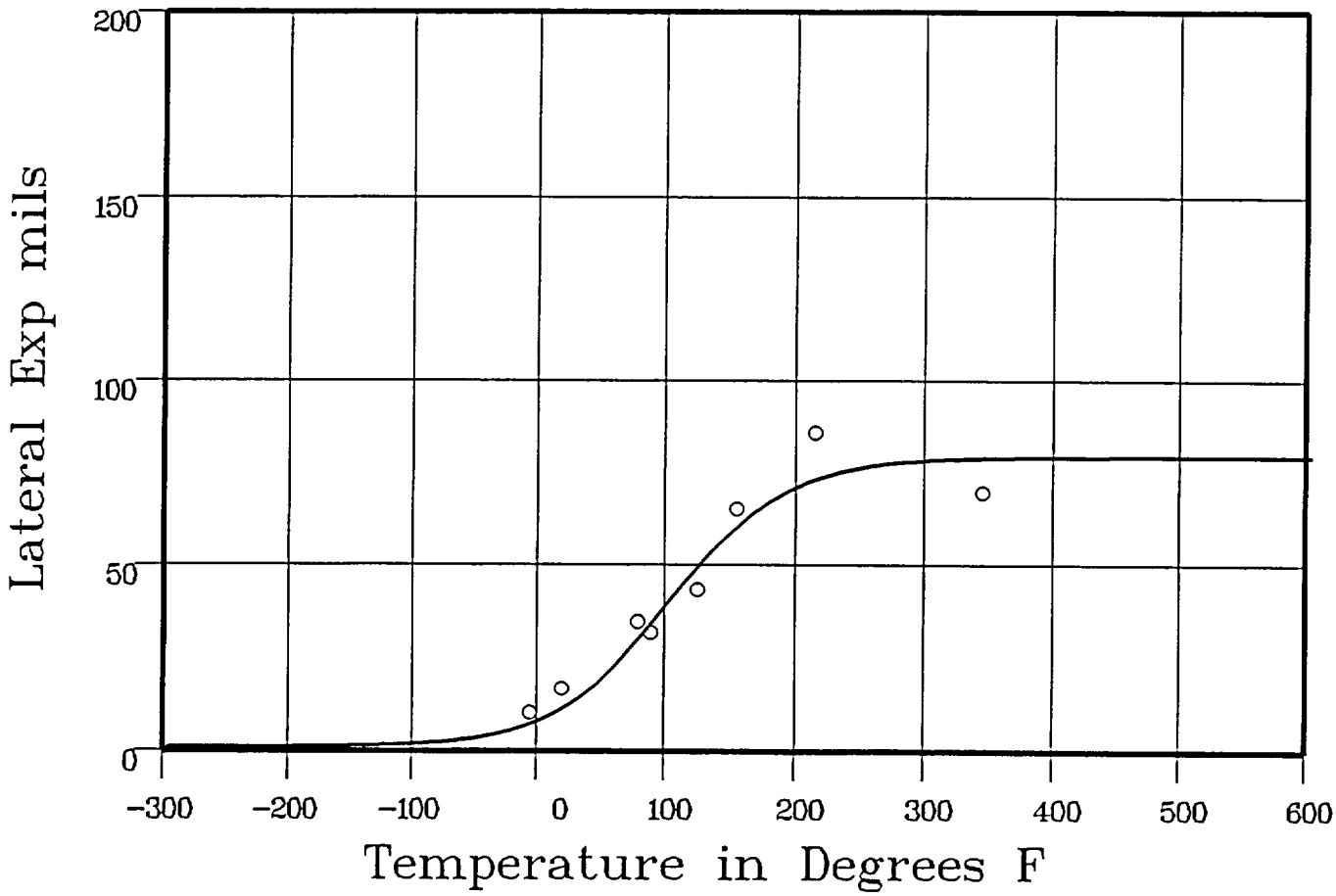
A = 40.22	B = 39.22	C = 89.74	T0 = 99.02

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

Upper Shelf L.E.: 79.44 Temperature at L.E. 35: 86.9 Lower Shelf L.E.: 1 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-5	10.5	8.03	2.46
20	17	12.5	4.49
80	35	32.03	2.96
90	32	36.29	-4.29
125	43.5	51.27	-7.77
155	65.5	61.94	3.55
215	86	73.94	12.05
345	70	79.12	-9.12

SUM of RESIDUALS = 4.35

CAPSULE V WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:56:32 on 07-11-2002

Page 1

Coefficients of Curve 3

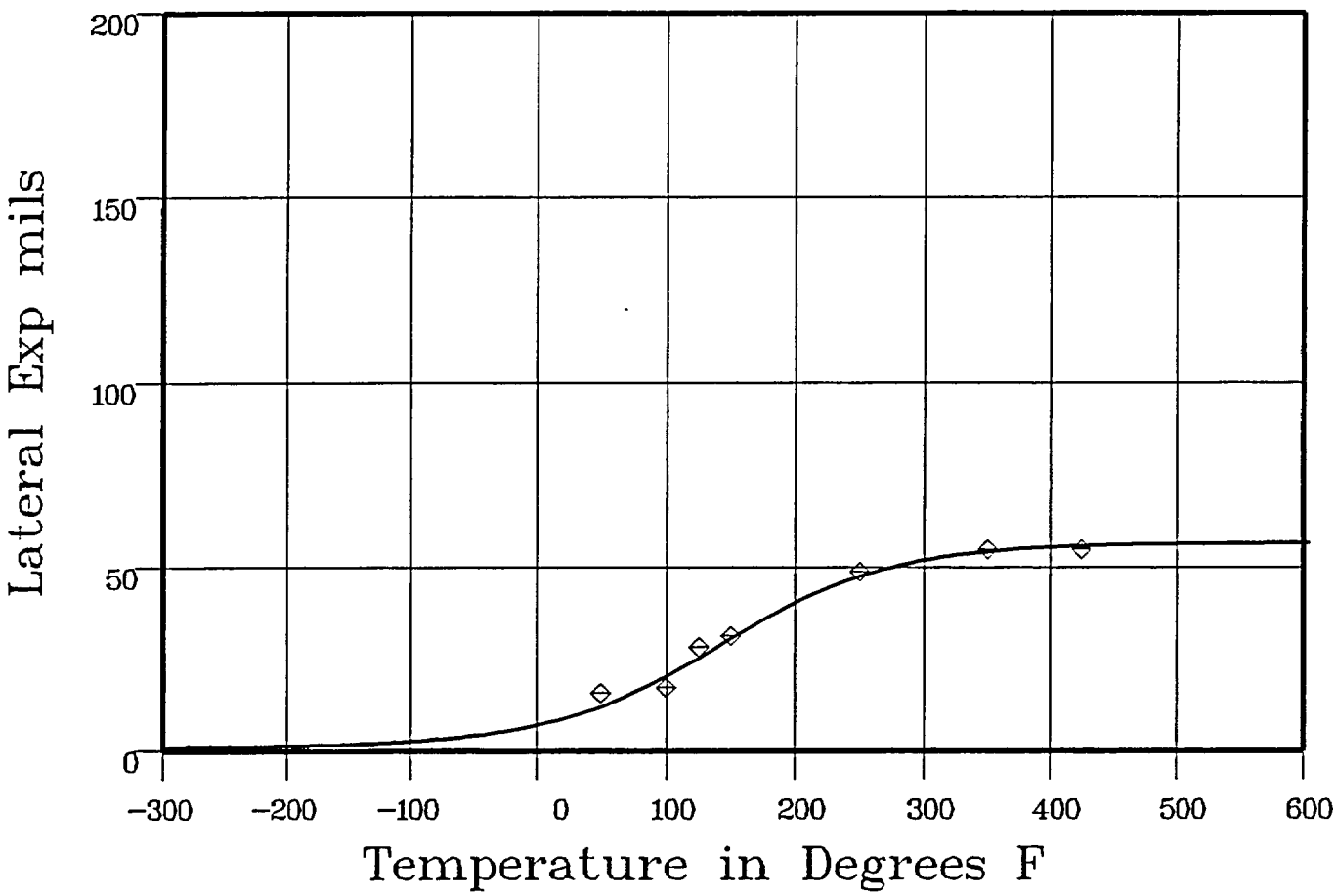
A = 28.85	B = 27.85	C = 133.08	T0 = 135.46

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

Upper Shelf L.E.: 56.71 Temperature at L.E. 35: 165.3 Lower Shelf L.E.: 1 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: WELD Ori.: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
50	16	13.07	2.92
100	17.5	21.6	-4.1
125	28.5	26.66	1.83
150	31.5	31.88	-.38
250	49	48.25	.74
350	55	54.57	.42
425	55	56	-1

SUM of RESIDUALS = .42

CAPSULE Y WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:56:32 on 07-11-2002
Page 1

Coefficients of Curve 4

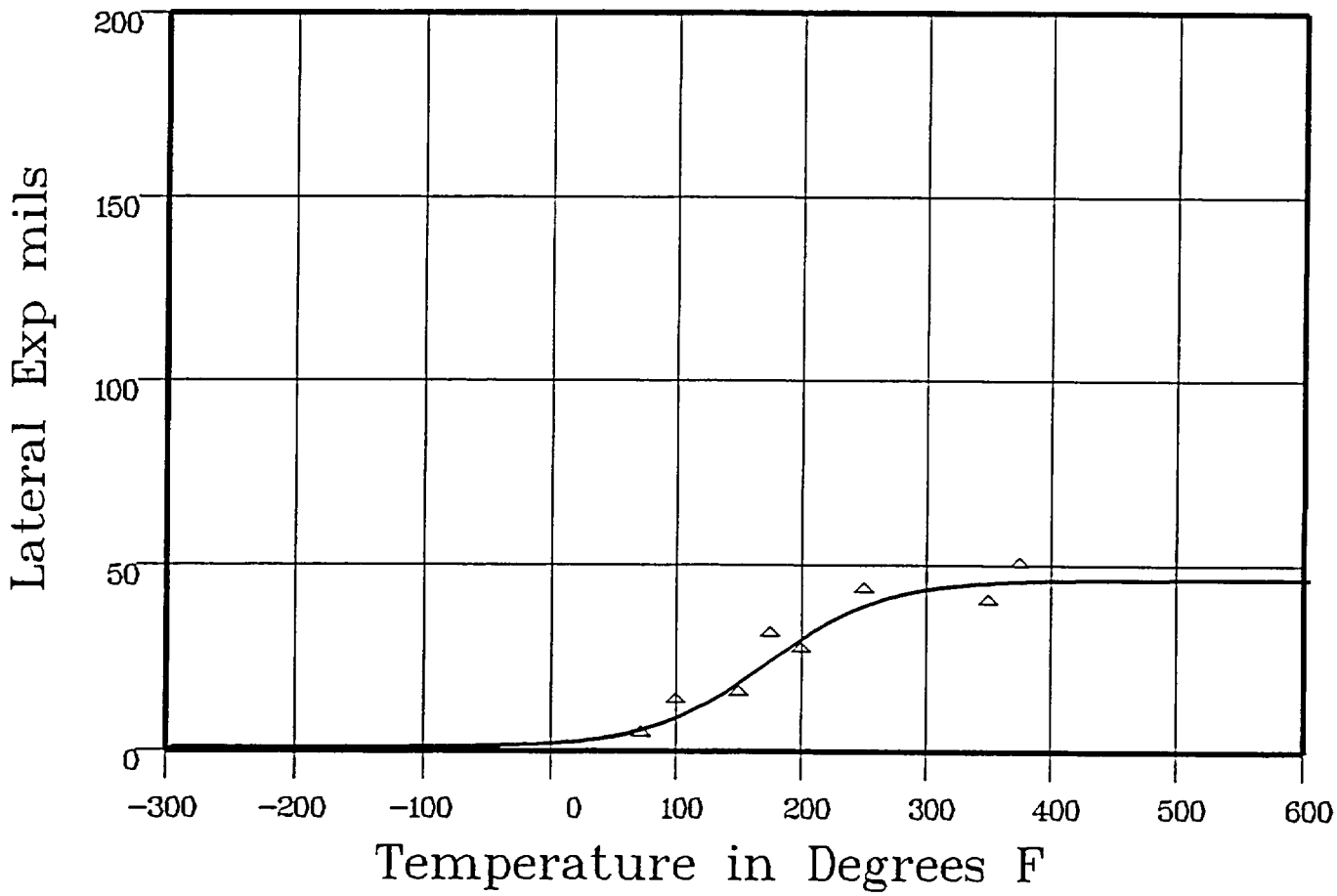
A = 23.68	B = 22.68	C = 92.31	T0 = 167.81

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

Upper Shelf L.E.: 46.37 Temperature at L.E. 35: 218.3 Lower Shelf L.E.: 1 Fixed

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: WELD Ori.: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
72	4	6.05	-2.05
100	13	9.48	3.51
150	15	19.36	-4.36
175	31	25.45	5.54
200	27	31.29	-4.29
250	43	39.83	3.16
350	40	45.51	-5.51

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

CAPSULE Y WELD

Page 2

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
375	50	45.87	4.12

SUM of RESIDUALS = .13

UNIRRADIATED WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:13 on 07-11-2002

Page 1

Coefficients of Curve 1

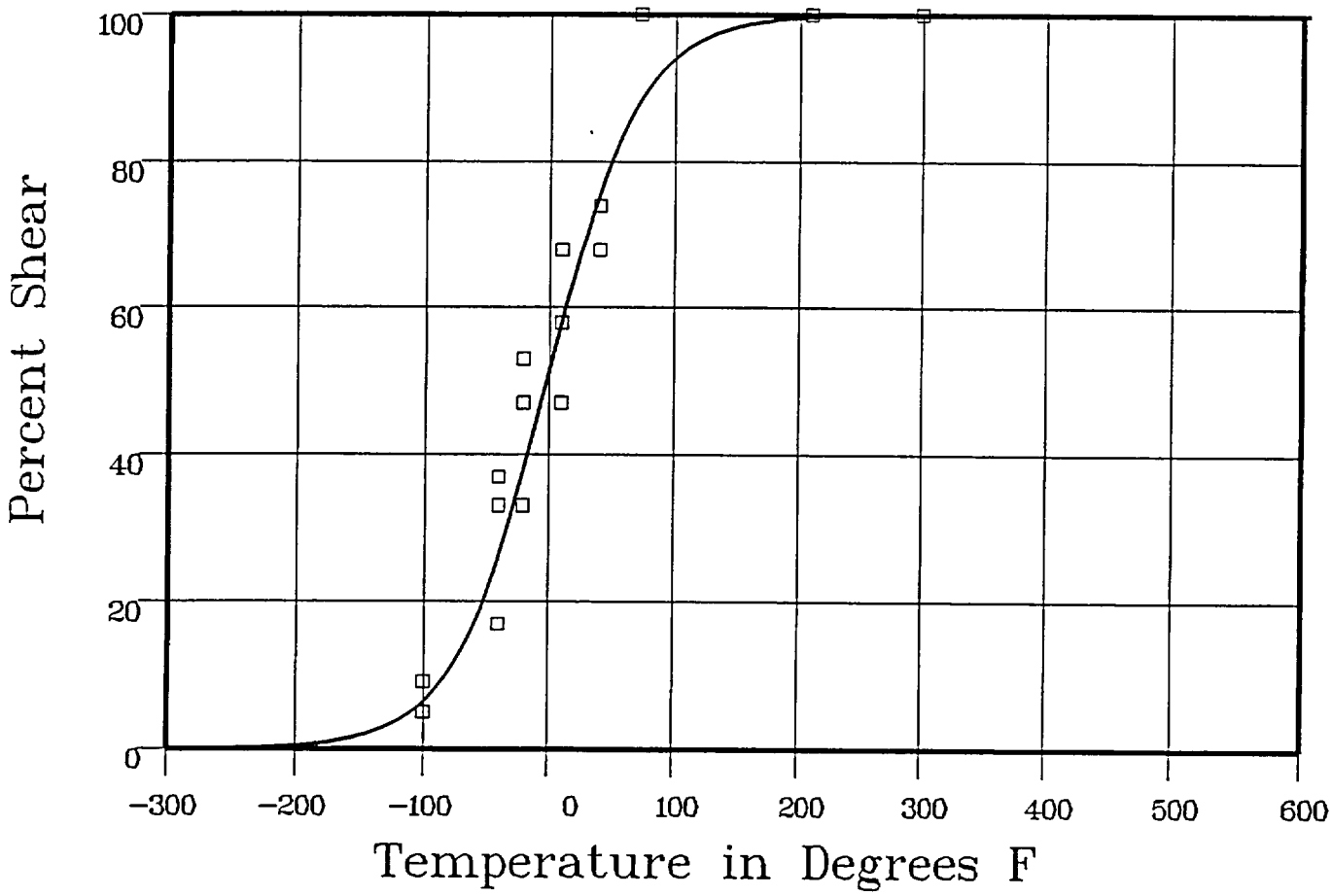
A = 50	B = 50	C = 73.51	T0 = -6.56

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

Temperature at 50% Shear: -6.5

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-100	5	7.29	-2.29
-100	9	7.29	1.7
-100	9	7.29	1.7
-40	33	28.7	4.29
-40	17	28.7	-11.7
-40	37	28.7	8.29
-20	33	40.96	-7.96
-20	53	40.96	12.03
-20	47	40.96	6.03

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

UNIRRADIATED WELD

Page 2

Material. WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: UNIRR Total Fluence·

Charpy V–Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
10	47	61.07	-14.07
10	68	61.07	6.92
10	58	61.07	-3.07
40	74	78.01	-4.01
40	74	78.01	-4.01
40	68	78.01	-10.01
73	100	89.7	10.29
73	100	89.7	10.29
73	100	89.7	10.29
210	100	99.72	.27
210	100	99.72	.27
210	100	99.72	.27
300	100	99.97	.02
300	100	99.97	.02
300	100	99.97	.02

SUM of RESIDUALS = 15.61

CAPSULE X WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:13 on 07-11-2002

Page 1

Coefficients of Curve 2

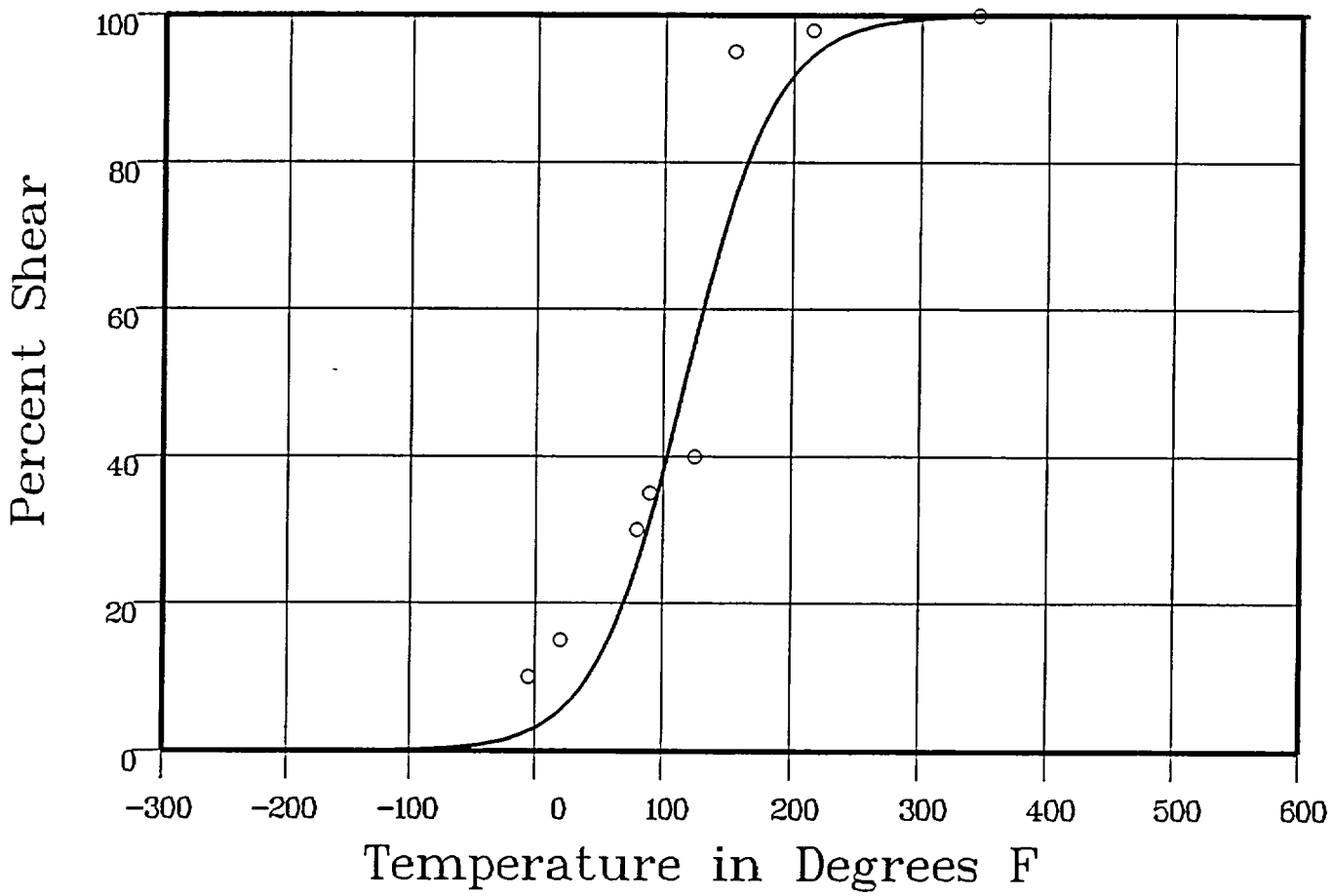
A = 50	B = 50	C = 68.85	T0 = 112.79

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

Temperature at 50% Shear: 112.7

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-5	10	3.16	6.83
20	15	6.32	8.67
80	30	27.83	2.16
90	35	34.02	.97
125	40	58.77	-18.77
155	95	77.31	17.68
215	98	95.11	2.88
345	100	99.88	.11

SUM of RESIDUALS = 20.56

CAPSULE V WELD

CVGRAPH 41 Hyperbolic Tangent Curve Printed at 15:07:13 on 07-11-2002

Page 1

Coefficients of Curve 3

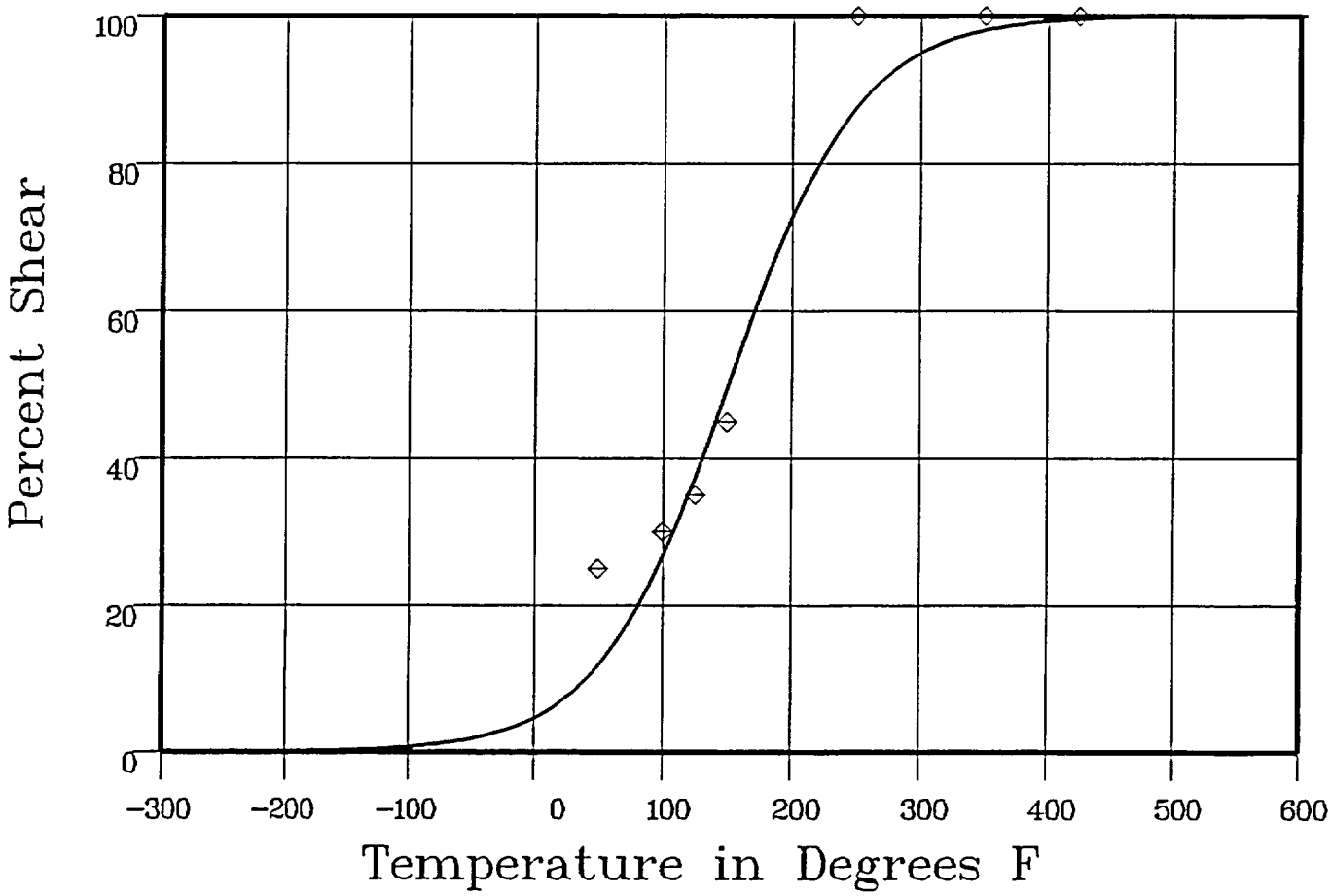
A = 50	B = 50	C = 100.78	T0 = 146.19

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

Temperature at 50% Shear: 146.1

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
50	25	12.91	12.08
100	30	28.56	1.43
125	35	39.63	-4.63
150	45	51.88	-6.88
250	100	88.69	11.3
350	100	98.27	1.72
425	100	99.6	.39

SUM of RESIDUALS = 15.41

CAPSULE Y WELD

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 15:07:13 on 07-11-2002

Page 1

Coefficients of Curve 4

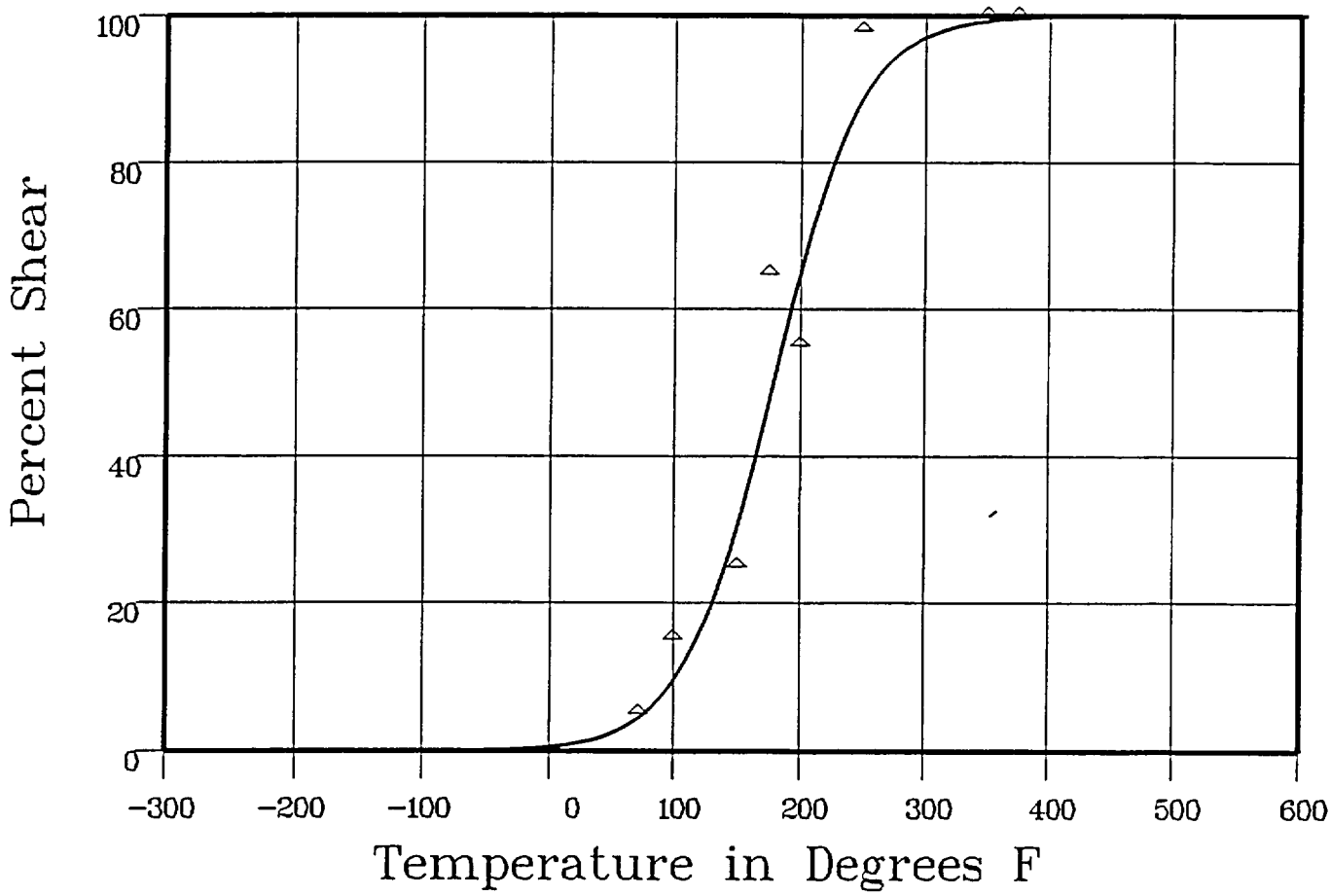
A = 50	B = 50	C = 69.41	T0 = 174.02

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

Temperature at 50% Shear: 174

Material: WELD Heat Number: WIRE HEAT 0227 Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: Y Material: WELD Ori: Heat #: WIRE HEAT 0227

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72	5	5.02	-.02
100	15	10.59	4.4
150	25	33.35	-8.35
175	65	50.7	14.29
200	55	67.88	-12.88
250	98	89.92	8.07
350	100	99.37	.62

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

CAPSULE Y WELD

Page 2

Material: WELD Heat Number: WIRE HEAT 0227 Orientation·

Capsule: Y Total Fluence:

Charpy V–Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
375	100	99.69	.3

SUM of RESIDUALS = 6.44

UNIRRADIATED HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:39:11 on 07-19-2002

Page 1

Coefficients of Curve 1

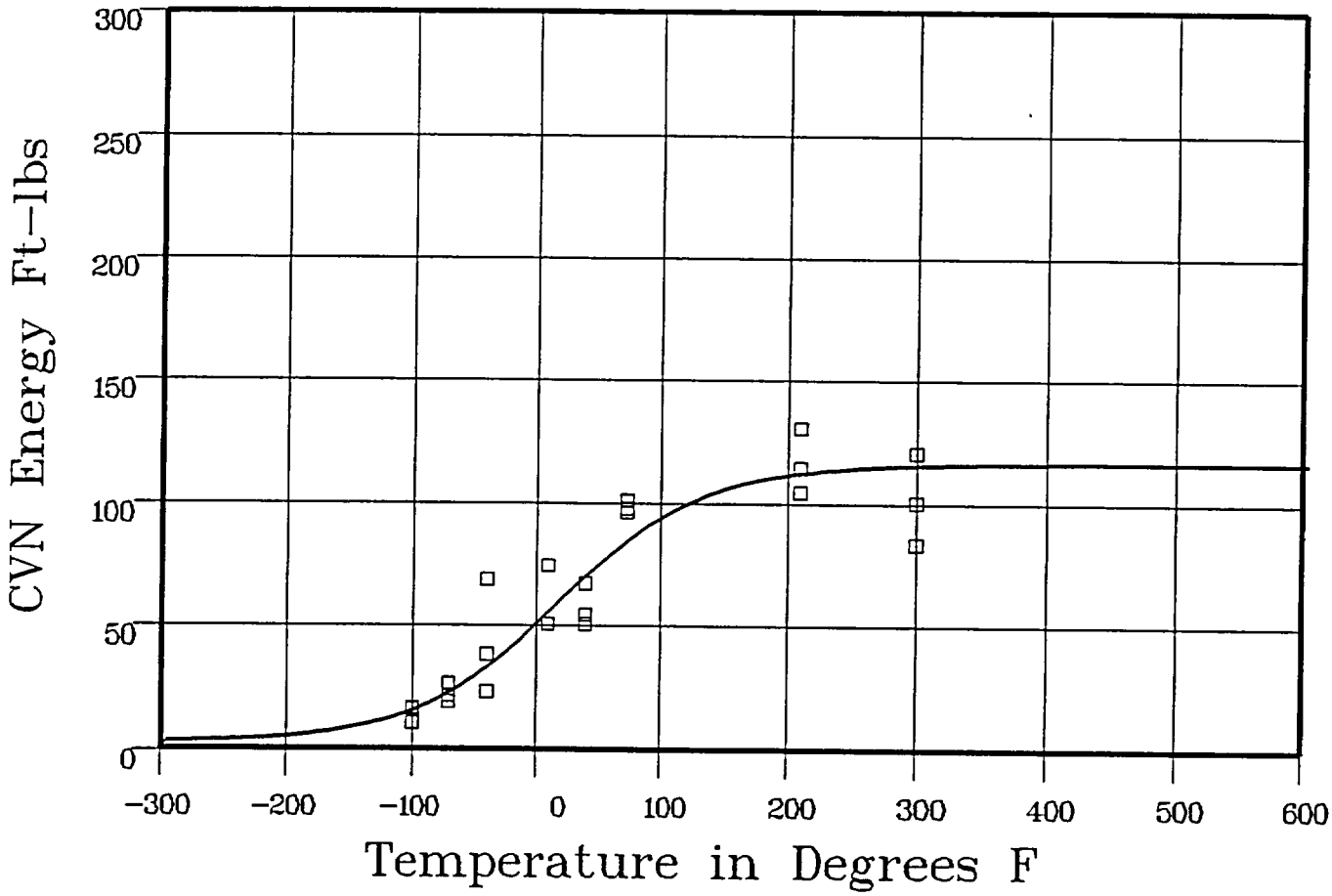
A = 59.09	B = 56.9	C = 116.82	T0 = 13.12

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

Upper Shelf Energy: 116 Fixed Temp. at 30 ft-lbs: -52.8 Temp. at 50 ft-lbs: -5.7 Lower Shelf Energy: 219 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: HEAT AFF'D ZONE Ori: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-100	16.5	16.53	-.03
-100	16	16.53	-.53
-100	10	16.53	-6.53
-70	21.5	24.29	-2.79
-70	19	24.29	-5.29
-70	26	24.29	1.7
-40	23	34.87	-11.87
-40	38	34.87	3.12
-40	68	34.87	33.12

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

UNIRRADIATED HEAT AFFECTED ZONE

Page 2

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
10	50	57.57	-7.57
10	50	57.57	-7.57
10	74	57.57	16.42
40	66.5	71.96	-5.46
40	54	71.96	-17.96
40	50	71.96	-21.96
73	100.5	85.95	14.54
73	97.5	85.95	11.54
73	96	85.95	10.04
210	114	112.21	1.78
210	104	112.21	-8.21
210	130	112.21	17.78
300	120	115.16	4.83
300	100	115.16	-15.16
300	83	115.16	-32.16

SUM of RESIDUALS = -28.26

CAPSULE X HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:39:11 on 07-19-2002

Page 1

Coefficients of Curve 2

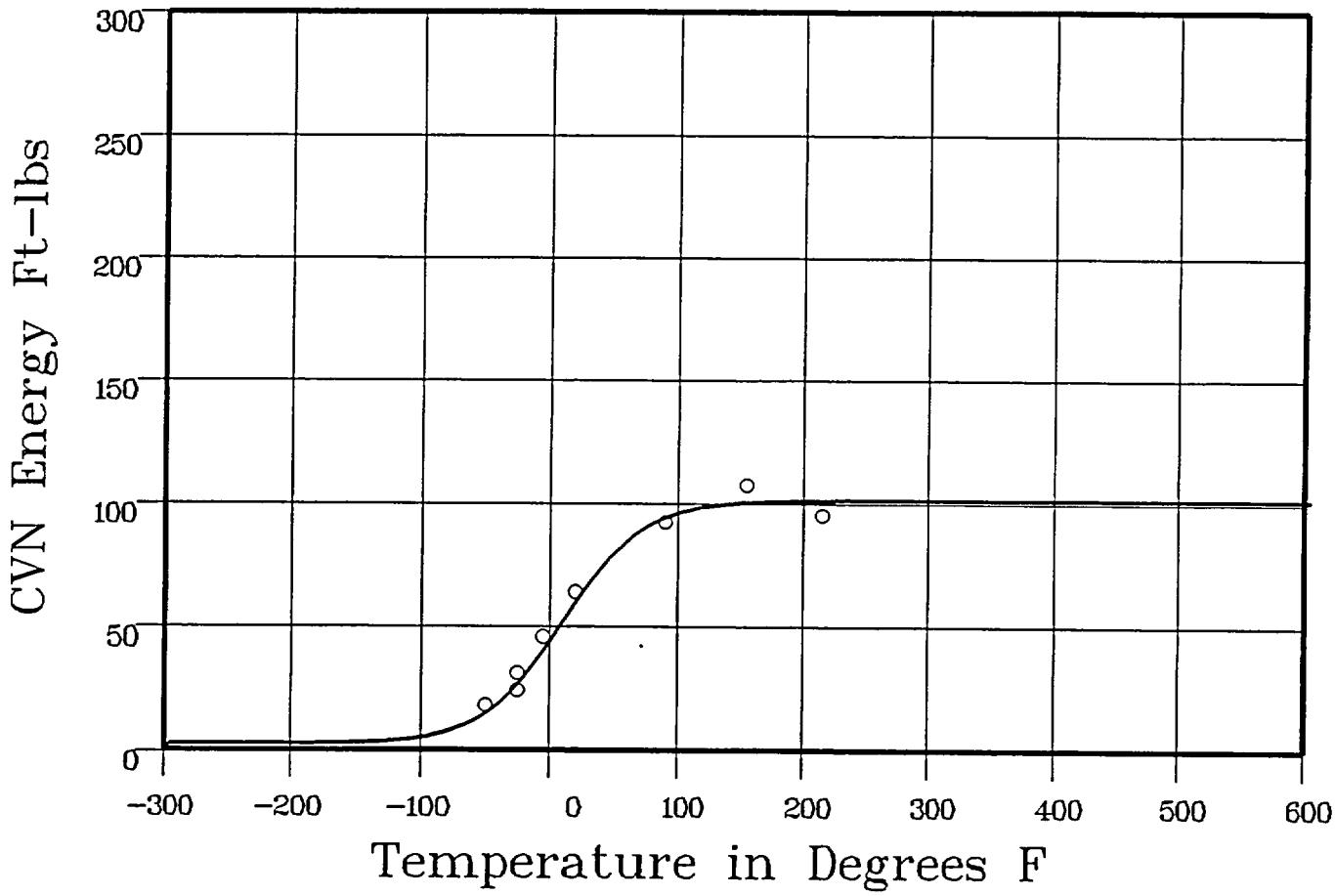
A = 51.59	B = 49.4	C = 62.37	T0 = 5.62

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

Upper Shelf Energy: 101 Fixed Temp. at 30 ft-lbs: -23.6 Temp. at 50 ft-lbs: 3.6 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: X Material: HEAT AFF'D ZONE Ori.: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	18	16.41	1.58
-25	24	29.12	-5.12
-25	31	29.12	1.87
-5	45.5	43.26	2.23
20	63.5	62.78	.71
90	92	94.8	-2.8
155	107	100.18	6.81
215	95	100.88	-5.88

SUM of RESIDUALS = -.58

CAPSULE V HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:39:11 on 07-19-2002

Page 1

Coefficients of Curve 3

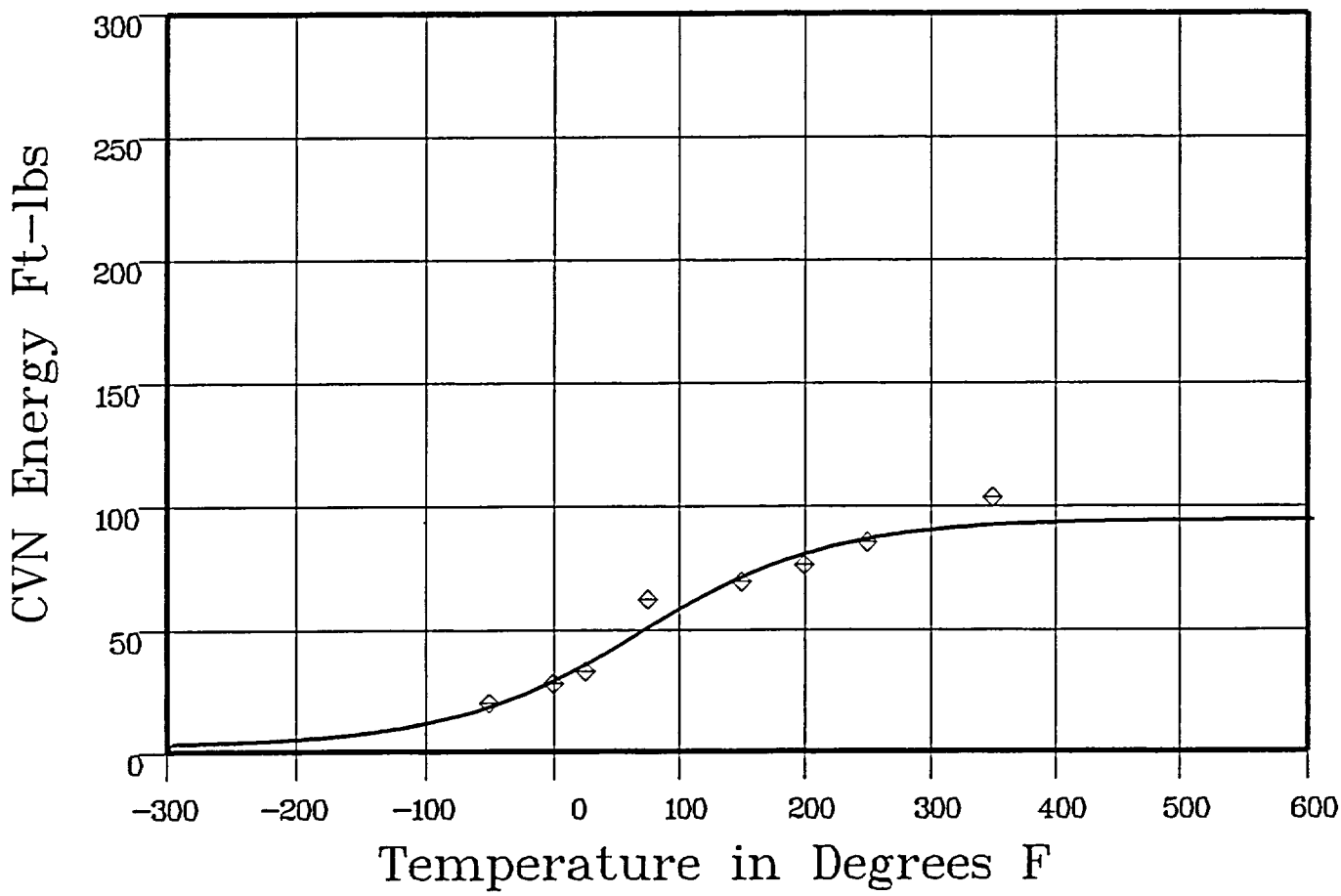
A = 48.09	B = 45.9	C = 152.25	T0 = 61.87

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

Upper Shelf Energy: 94 Fixed Temp. at 30 ft-lbs: -1.6 Temp. at 50 ft-lbs: 68.1 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: V Material: HEAT AFF'D ZONE Ori.: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	20	19.36	.63
0	28	30.4	-2.4
25	33	37.19	-4.19
75	62	52.04	9.95
150	69	72.05	-3.05
200	76	81.13	-5.13
250	85	86.84	-1.84
350	103	91.96	11.03

SUM of RESIDUALS = 4.98

CAPSULE Y HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:39:11 on 07-19-2002

Page 1

Coefficients of Curve 4

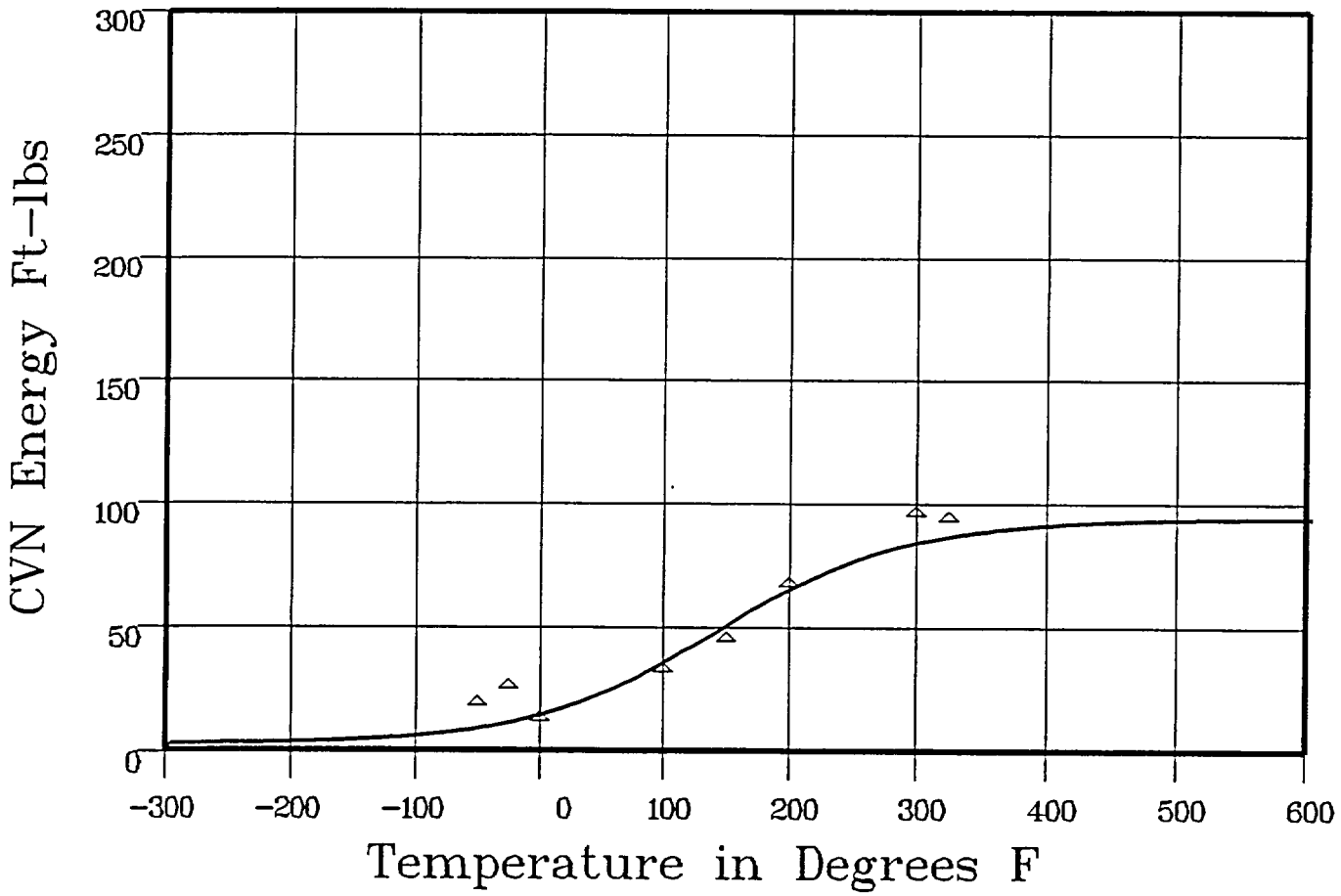
A = 48.09	B = 45.9	C = 151.59	T0 = 138.28

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

Upper Shelf Energy: 94 Fixed Temp. at 30 ft-lbs: 75 Temp. at 50 ft-lbs: 144.5 Lower Shelf Energy: 2.19 Fixed

Material: HEAT AFFD ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: Y Material: HEAT AFFD ZONE Ori: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	18	9.26	8.73
-25	25	11.74	13.25
0	12	14.95	-2.95
100	32	36.74	-4.74
150	44	51.64	-7.64
200	66	65.81	.18
300	95	84.28	10.71

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

CAPSULE Y HEAT AFFECTED ZONE

Material: HEAT AFFD ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
325	93	86.79	6.2

SUM of RESIDUALS = 23.75

UNIRRADIATED HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:12:16 on 07-12-2002

Page 1

Coefficients of Curve 1

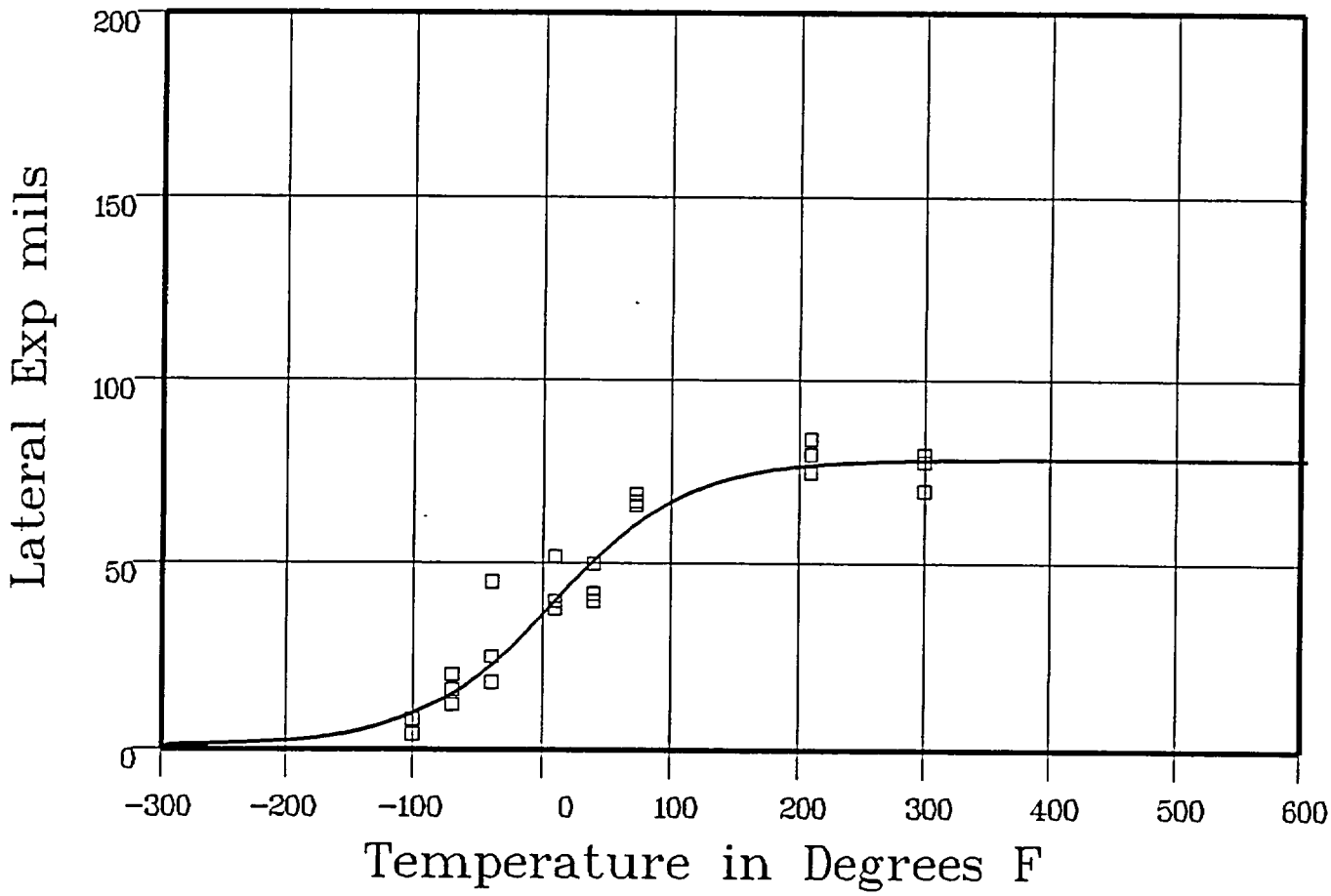
A = 39.92	B = 38.92	C = 105.58	T0 = 4.68

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

Upper Shelf L.E.: 78.84 Temperature at L.E. 35: -8.7 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: HEAT AFF'D ZONE Ori.: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-100	8	10.41	-2.41
-100	8	10.41	-2.41
-100	4	10.41	-6.41
-70	16	16.21	-.21
-70	12	16.21	-4.21
-70	20	16.21	3.78
-40	18	24.36	-6.36
-40	25	24.36	.63
-40	45	24.36	20.63

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

UNIRRADIATED HEAT AFFECTED ZONE

Page 2

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
10	38	41.87	-3.87
10	40	41.87	-1.87
10	52	41.87	10.12
40	50	52.47	-2.47
40	42	52.47	-10.47
40	40	52.47	-12.47
73	69	62.09	6.9
73	67	62.09	4.9
73	66	62.09	3.9
210	80	77.27	2.72
210	75	77.27	-2.27
210	84	77.27	6.72
300	80	78.55	1.44
300	78	78.55	-.55
300	70	78.55	-8.55

SUM of RESIDUALS = -2.81

CAPSULE X HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:12:16 on 07-12-2002

Page 1

Coefficients of Curve 2

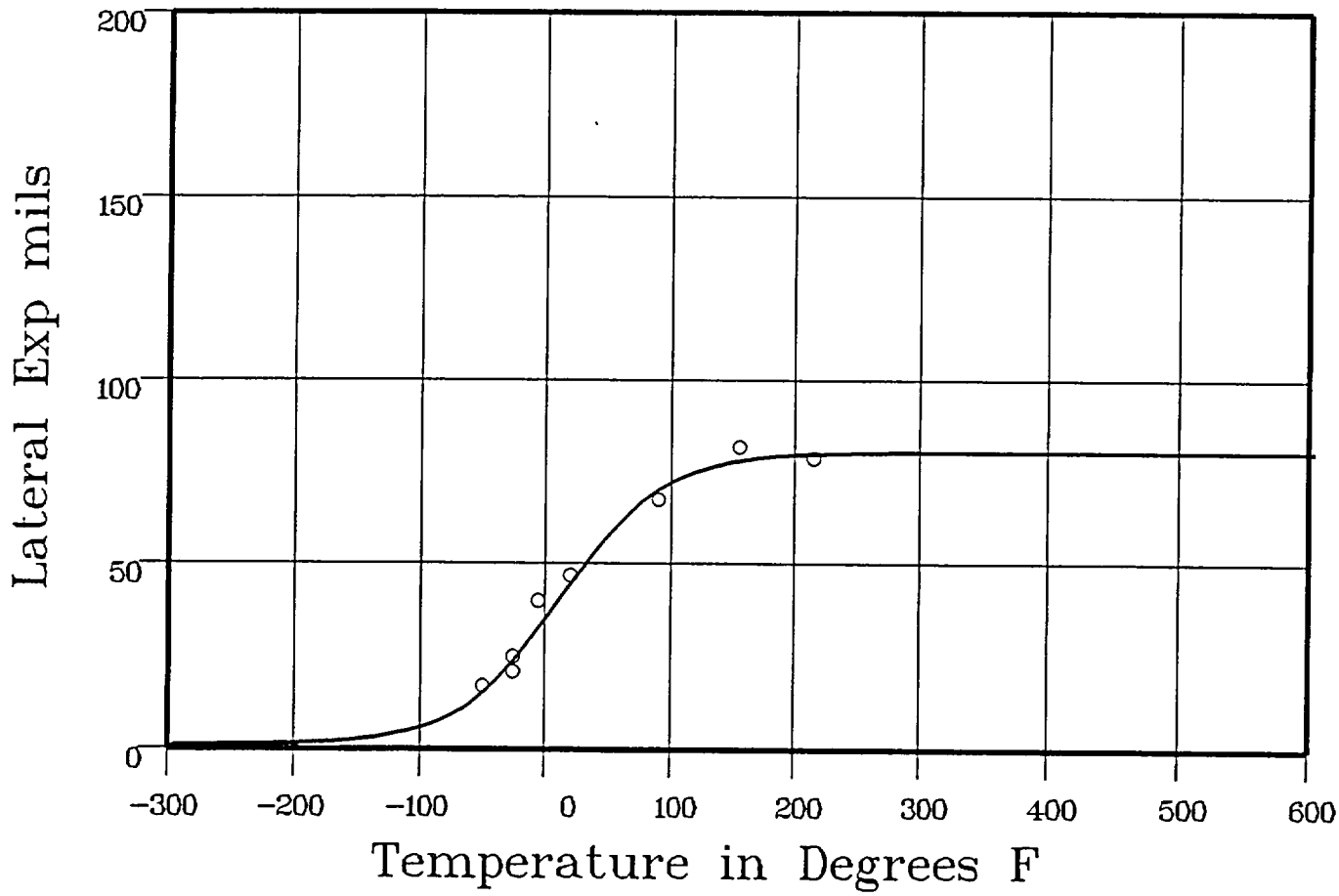
A = 40.77	B = 39.77	C = 81.58	T0 = 7.5

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

Upper Shelf L.E: 80.55 Temperature at L.E. 35: -4.4 Lower Shelf L.E: 1 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: HEAT AFF'D ZONE Ori: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	17	16.61	.38
-25	21	25.71	-4.71
-25	25	25.71	-.71
-5	40	34.72	5.27
20	47	46.82	.17
90	67.5	71.25	-3.75
155	82	78.46	3.53
215	79	80.06	-1.06

SUM of RESIDUALS = -.89

CAPSULE V HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:12:16 on 07-12-2002

Page 1

Coefficients of Curve 3

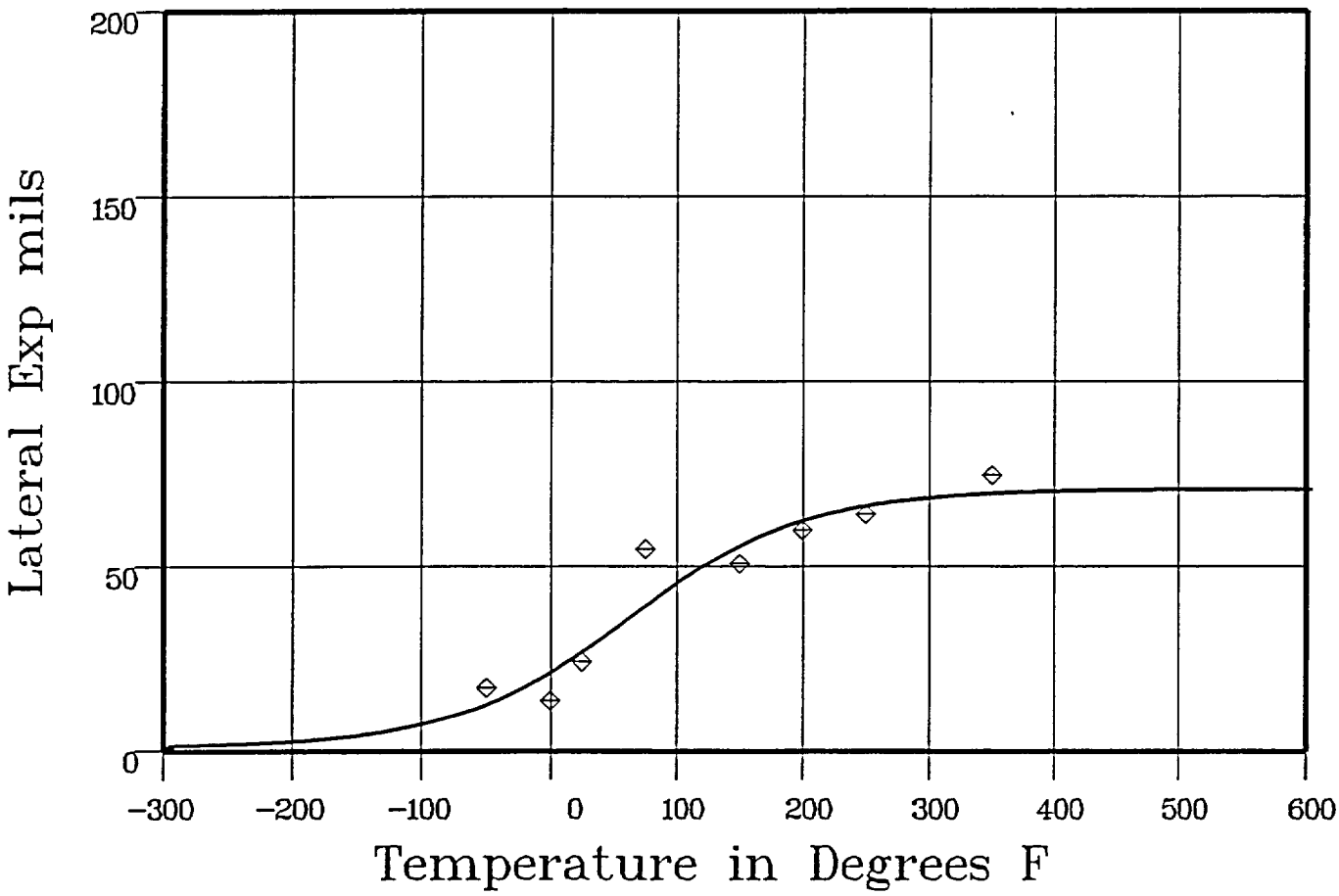
A = 36.07	B = 35.07	C = 139.98	T0 = 56.25

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

Upper Shelf L.E.: 71.15 Temperature at L.E. 35: 51.9 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: V Material: HEAT AFF'D ZONE Ori.: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	17.5	13.6	3.89
0	14	22.69	-8.69
25	24.5	28.37	-3.87
75	55	40.74	14.25
150	51	56.58	-5.58
200	60	63.17	-3.17
250	64.5	67	-2.5
350	75	70.11	4.88

SUM of RESIDUALS = -.8

CAPSULE Y HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:12:16 on 07-12-2002

Page 1

Coefficients of Curve 4

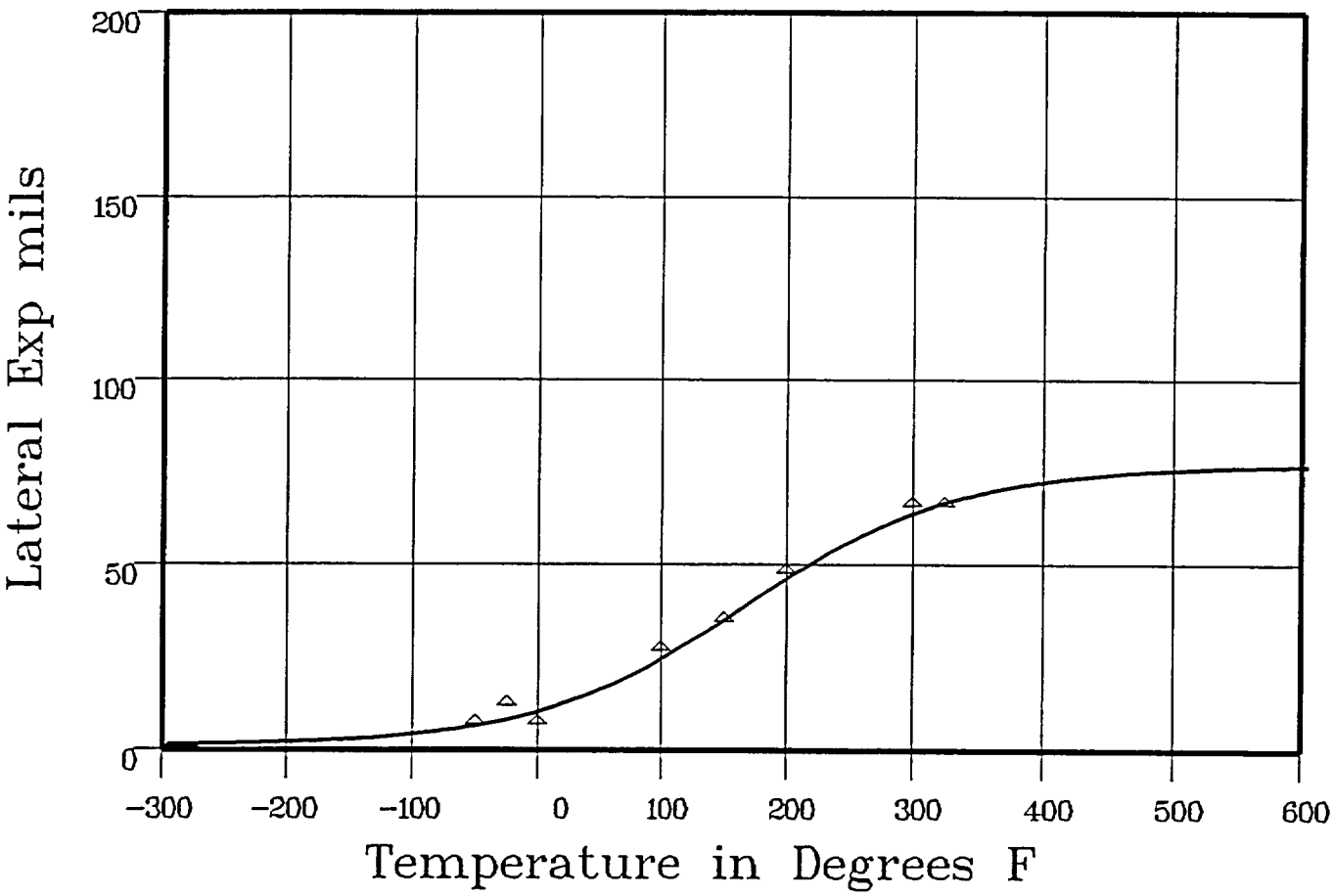
A = 39.04	B = 38.04	C = 169.94	T0 = 162.17

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

Upper Shelf L.E.: 77.08 Temperature at L.E. 35: 144 Lower Shelf L.E.: 1 Fixed

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: HEAT AFF'D ZONE Ori.: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	7	6.78	.21
-25	12	8.57	3.42
0	7	10.82	-3.82
100	27	25.71	1.28
150	35	36.32	-1.32
200	48	47.37	.62
300	66	64.54	1.45

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

CAPSULE Y HEAT AFFECTED ZONE

Page 2

Material: HEAT AFFD ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
325	66	67.32	-1.32

SUM of RESIDUALS = .53

UNIRRADIATED HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:20:32 on 07-12-2002

Page 1

Coefficients of Curve 1

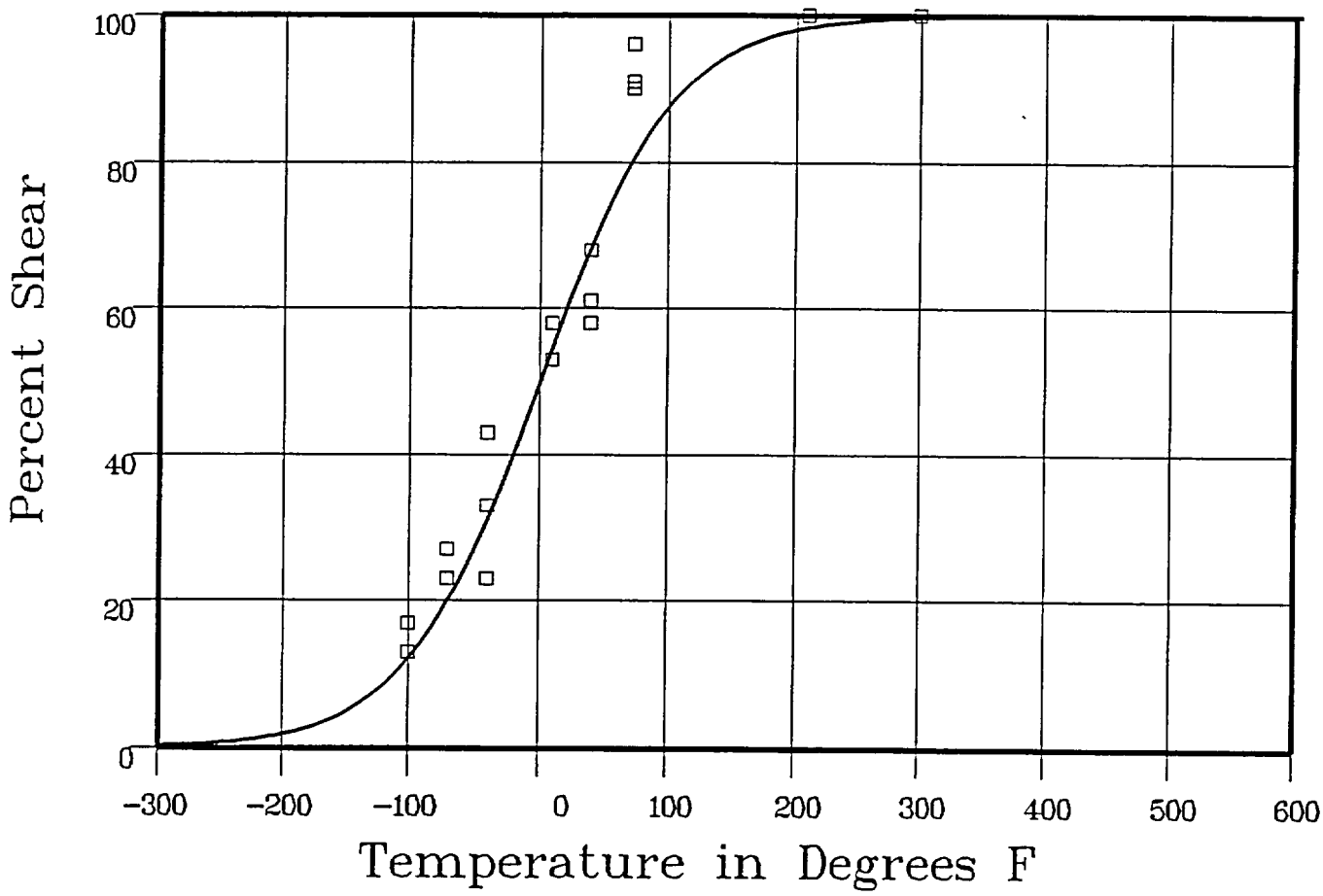
A = 50	B = 50	C = 101.97	T0 = -3.95

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

Temperature at 50% Shear: -3.9

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: HEAT AFF'D ZONE Ori: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-100	17	13.19	3.8
-100	13	13.19	-.19
-100	13	13.19	-.19
-70	23	21.49	1.5
-70	23	21.49	1.5
-70	27	21.49	5.5
-40	23	33.02	-10.02
-40	33	33.02	-.02
-40	43	33.02	9.97

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

UNIRRADIATED HEAT AFFECTED ZONE

Page 2

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
10	53	56.79	-3.79
10	53	56.79	-3.79
10	58	56.79	1.2
40	68	70.3	-2.3
40	58	70.3	-12.3
40	61	70.3	-9.3
73	96	81.89	14.1
73	91	81.89	9.1
73	90	81.89	8.1
210	100	98.51	1.48
210	100	98.51	1.48
210	100	98.51	1.48
300	100	99.74	.25
300	100	99.74	.25
300	100	99.74	.25

SUM of RESIDUALS = 18.04

CAPSULE X HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:20:32 on 07-12-2002

Page 1

Coefficients of Curve 2

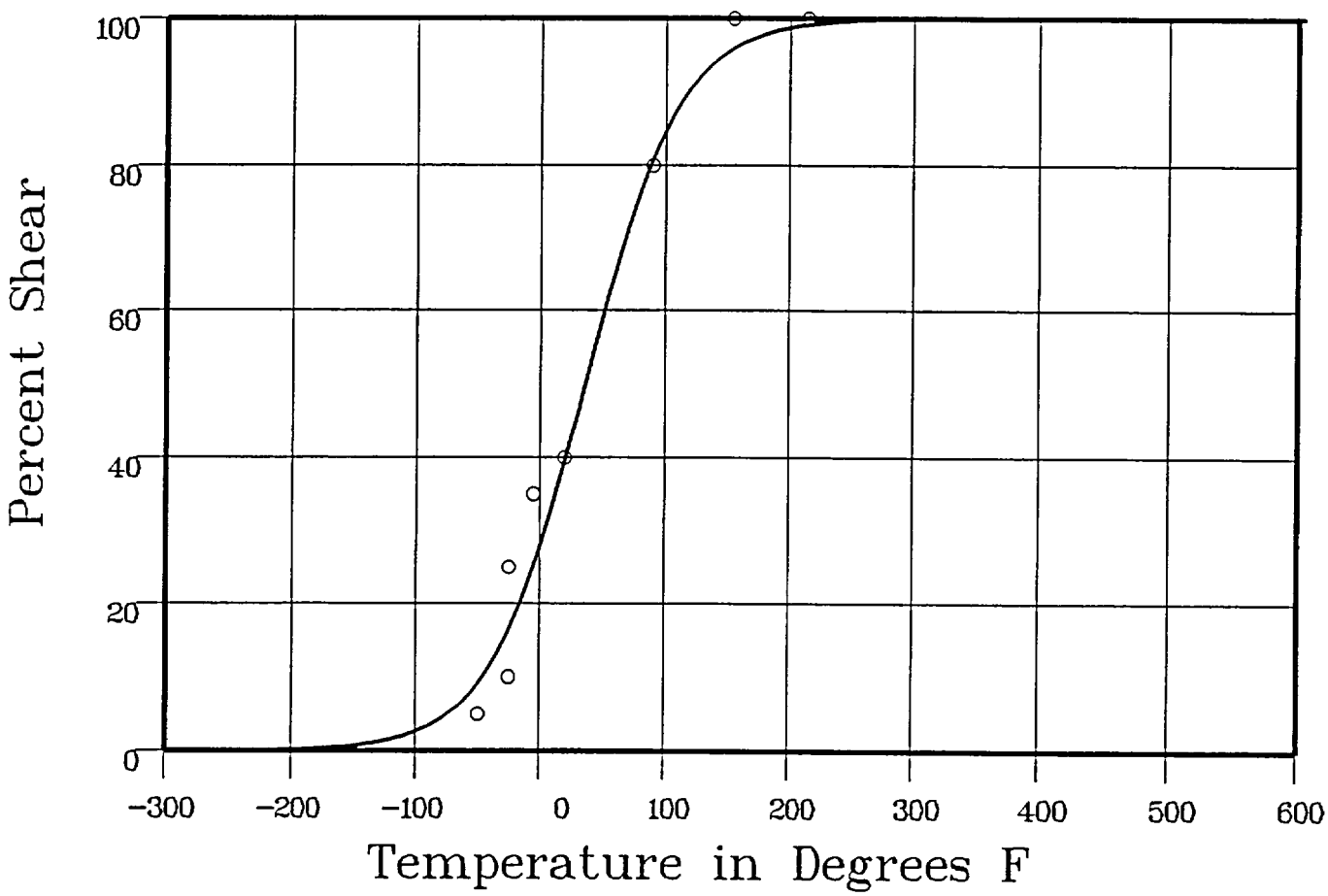
A = 50	B = 50	C = 75.03	T0 = 31.37

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

Temperature at 50% Shear: 31.3

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: X Material: HEAT AFF'D ZONE Ori.: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	5	10.25	-5.25
-25	10	18.2	-8.2
-25	25	18.2	6.79
-5	35	27.49	7.5
20	40	42.47	-2.47
90	80	82.67	-2.67
155	100	96.42	3.57
215	100	99.25	.74

SUM of RESIDUALS = .01

CAPSULE V HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:20:32 on 07-12-2002

Page 1

Coefficients of Curve 3

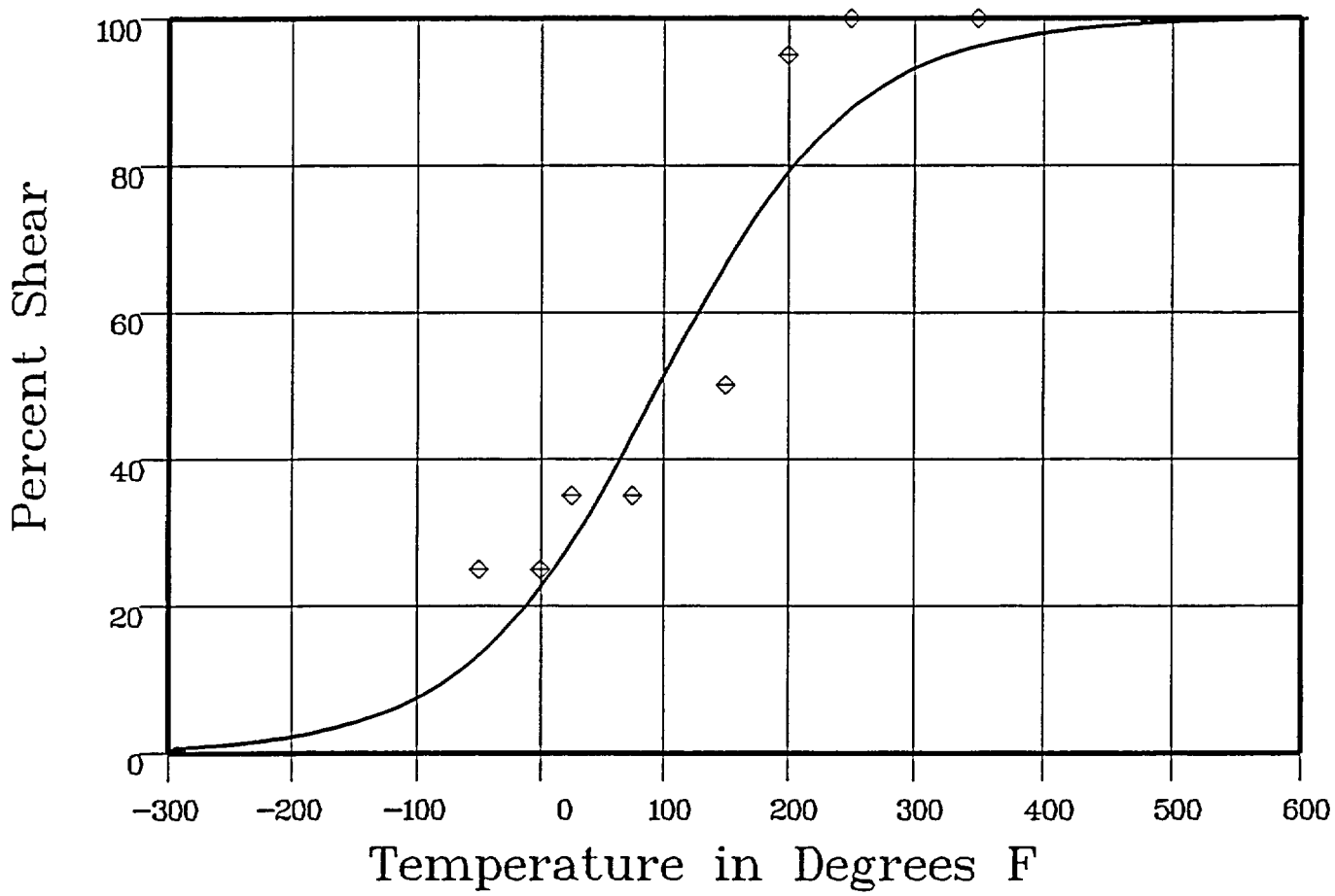
A = 50	B = 50	C = 156.16	T0 = 91.4

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

Temperature at 50% Shear: 91.4

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: HEAT AFF'D ZONE Ori: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	25	14.05	10.94
0	25	23.67	1.32
25	35	29.93	5.06
75	35	44.76	-9.76
150	50	67.92	-17.92
200	95	80.07	14.92
250	100	88.4	11.59
350	100	96.48	3.51

SUM of RESIDUALS = 19.69

CAPSULE Y HEAT AFFECTED ZONE

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 14:20:32 on 07-12-2002

Page 1

Coefficients of Curve 4

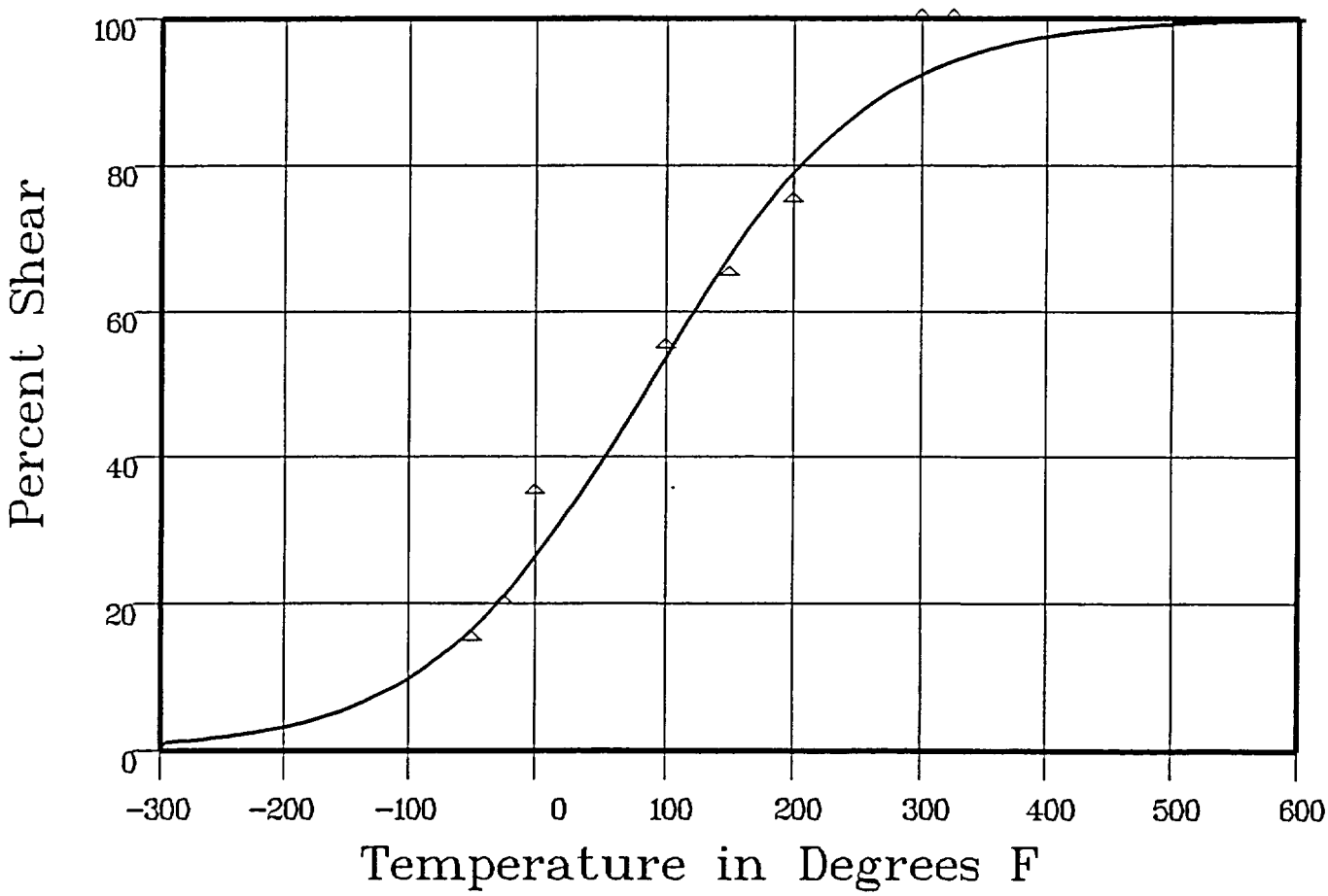
A = 50	B = 50	C = 170.18	T0 = 82.96

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

Temperature at 50% Shear: 82.9

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: Y Material: HEAT AFF'D ZONE Ori: Heat #: C4339-1 SIDE OF WELD

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	15	17.32	-2.32
-25	20	21.94	-1.94
0	35	27.38	7.61
100	55	54.98	.01
150	65	68.73	-3.73
200	75	79.82	-4.82
300	100	92.76	7.23

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

CAPSULE Y HEAT AFFECTED ZONE

Page 2

Material: HEAT AFF'D ZONE Heat Number: C4339-1 SIDE OF WELD Orientation:

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
325	100	94.5	5.49

SUM of RESIDUALS = 7.53

UNIRRADIATED CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:48:20 on 07-19-2002

Page 1

Coefficients of Curve 1

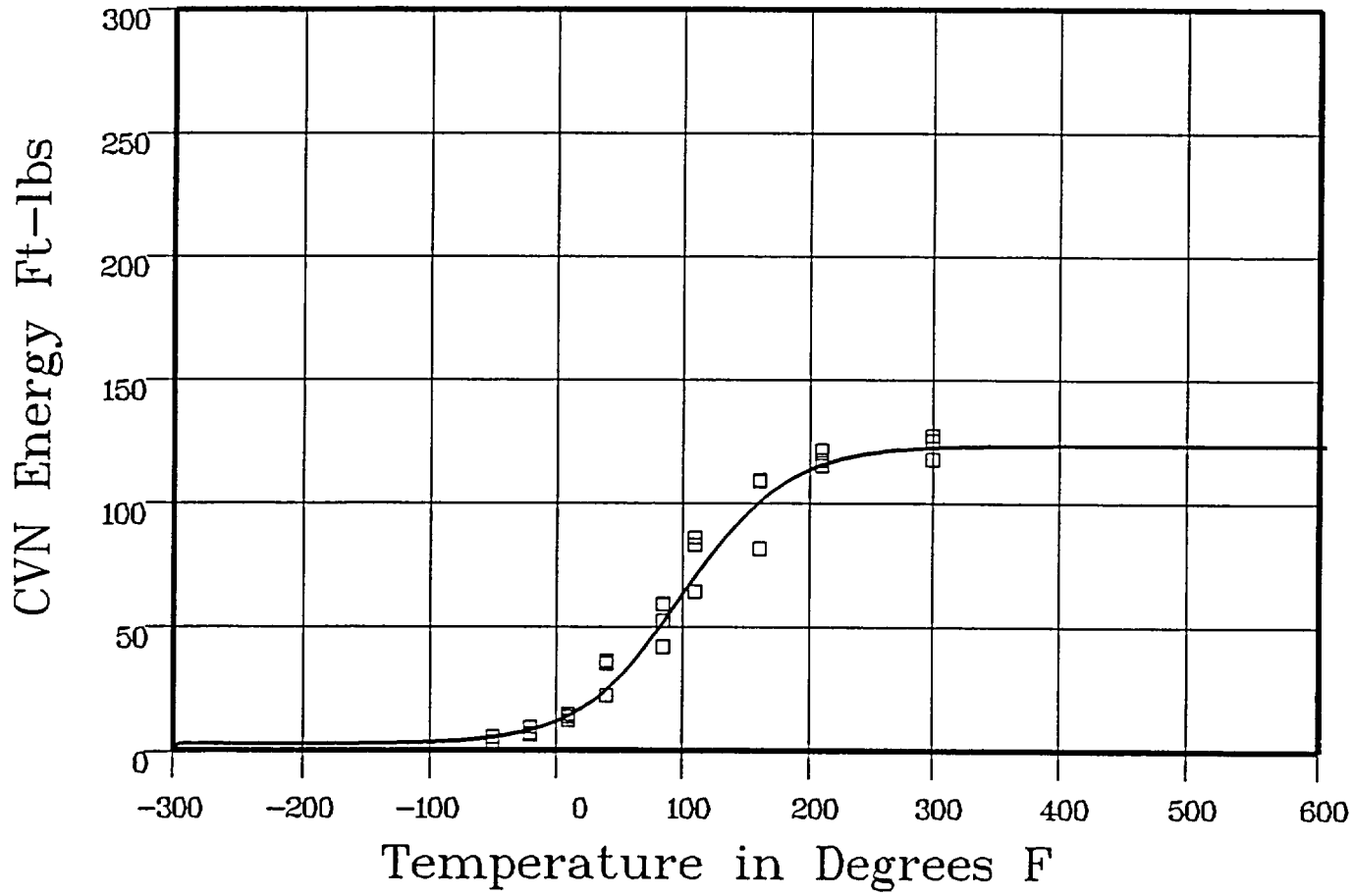
A = 62.59	B = 60.4	C = 81.25	T0 = 95.5

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

Upper Shelf Energy: 123 Fixed Temp. at 30 ft-lbs: 46.4 Temp. at 50 ft-lbs: 78.3 Lower Shelf Energy: 2.19 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
-50	3	5.47	-2.47
-50	5	5.47	-.47
-50	5	5.47	-.47
-20	6	8.84	-2.84
-20	6.5	8.84	-2.34
-20	9	8.84	.15
10	13.5	15.32	-1.82
10	12	15.32	-3.32
10	14.5	15.32	-.82

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

UNIRRADIATED CORRELATION MONITOR MATERIAL

Page 2

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V–Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
40	35	26.74	8.25
40	22	26.74	-4.74
40	36	26.74	9.25
85	41.5	54.83	-13.33
85	52	54.83	-2.83
85	58.5	54.83	3.66
110	63.5	73.25	-9.75
110	82.5	73.25	9.24
110	85.5	73.25	12.24
160	109	102.49	6.5
160	108.5	102.49	6
160	81	102.49	-21.49
210	117	116.19	.8
210	115	116.19	-1.19
210	121	116.19	4.8
300	127	122.21	4.78
300	117.5	122.21	-4.71
300	125	122.21	2.78

SUM of RESIDUALS = -4.17

CAPSULE X CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:48:20 on 07-19-2002

Page 1

Coefficients of Curve 2

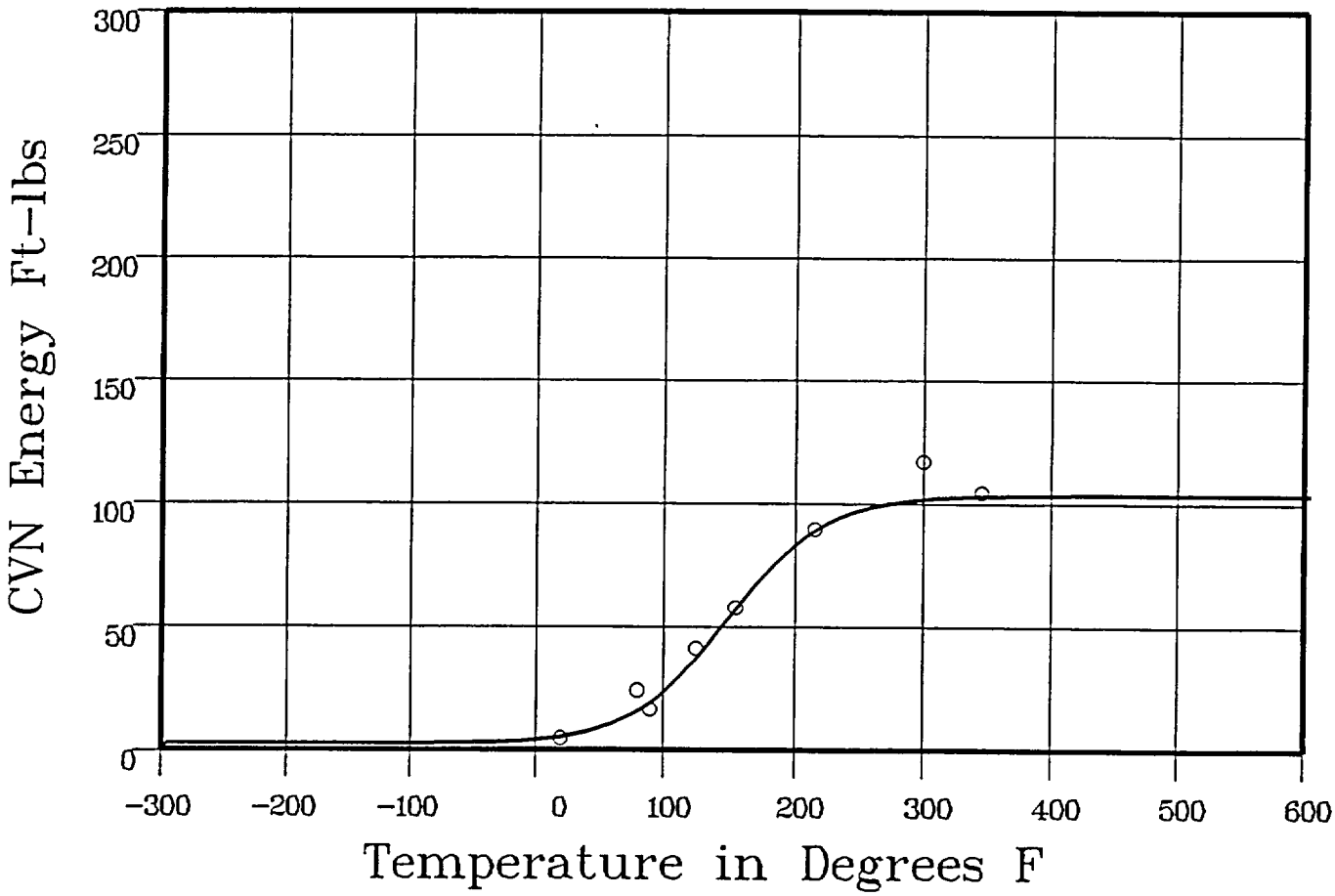
A = 52.59	B = 50.4	C = 74.14	T0 = 144.43

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

Upper Shelf Energy: 103 Fixed Temp. at 30 ft-lbs: 108.6 Temp. at 50 ft-lbs: 140.6 Lower Shelf Energy: 2.19 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
20	4.5	5.59	-1.09
80	24	17.27	6.72
90	16.5	21.07	-4.57
125	41	39.68	1.31
155	57.5	59.73	-2.23
215	89	89.92	-.92
300	117	101.5	15.49
345	104	102.55	1.44

SUM of RESIDUALS = 16.15

CAPSULE V CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:48:20 on 07-19-2002

Page 1

Coefficients of Curve 3

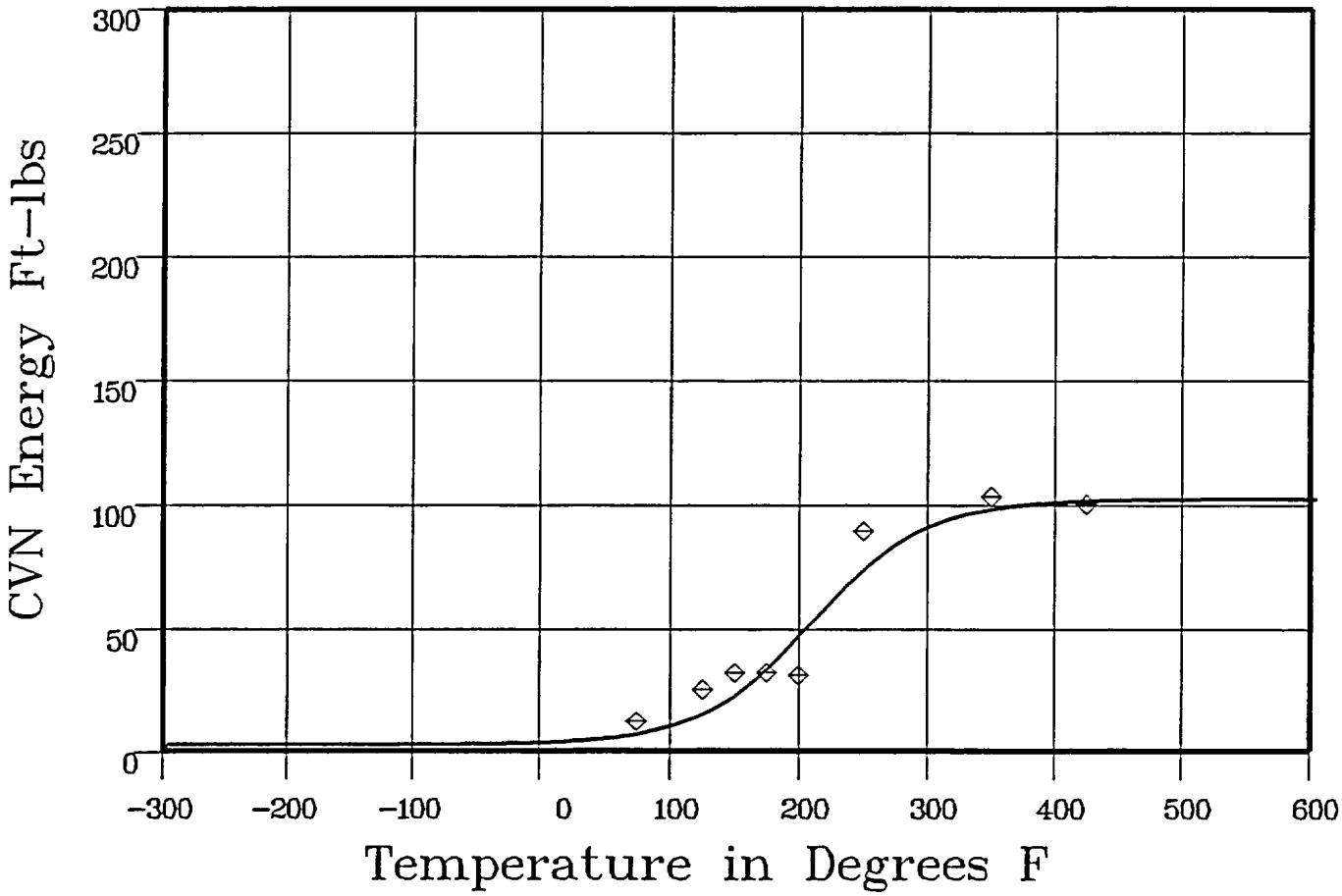
A = 52.09	B = 49.9	C = 88.08	T0 = 204.91

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

Upper Shelf Energy: 102 Fixed Temp. at 30 ft-lbs: 162.9 Temp. at 50 ft-lbs: 201.2 Lower Shelf Energy: 2.19 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
75	12	7.16	4.83
125	25	16.18	8.81
150	32	24.48	7.51
175	32	35.77	-3.77
200	31	49.32	-18.32
250	89	75.62	13.37
350	103	98.43	4.56
425	100	101.33	-1.33

SUM of RESIDUALS = 15.68

CAPSULE Y CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 09:48:20 on 07-19-2002

Page 1

Coefficients of Curve 4

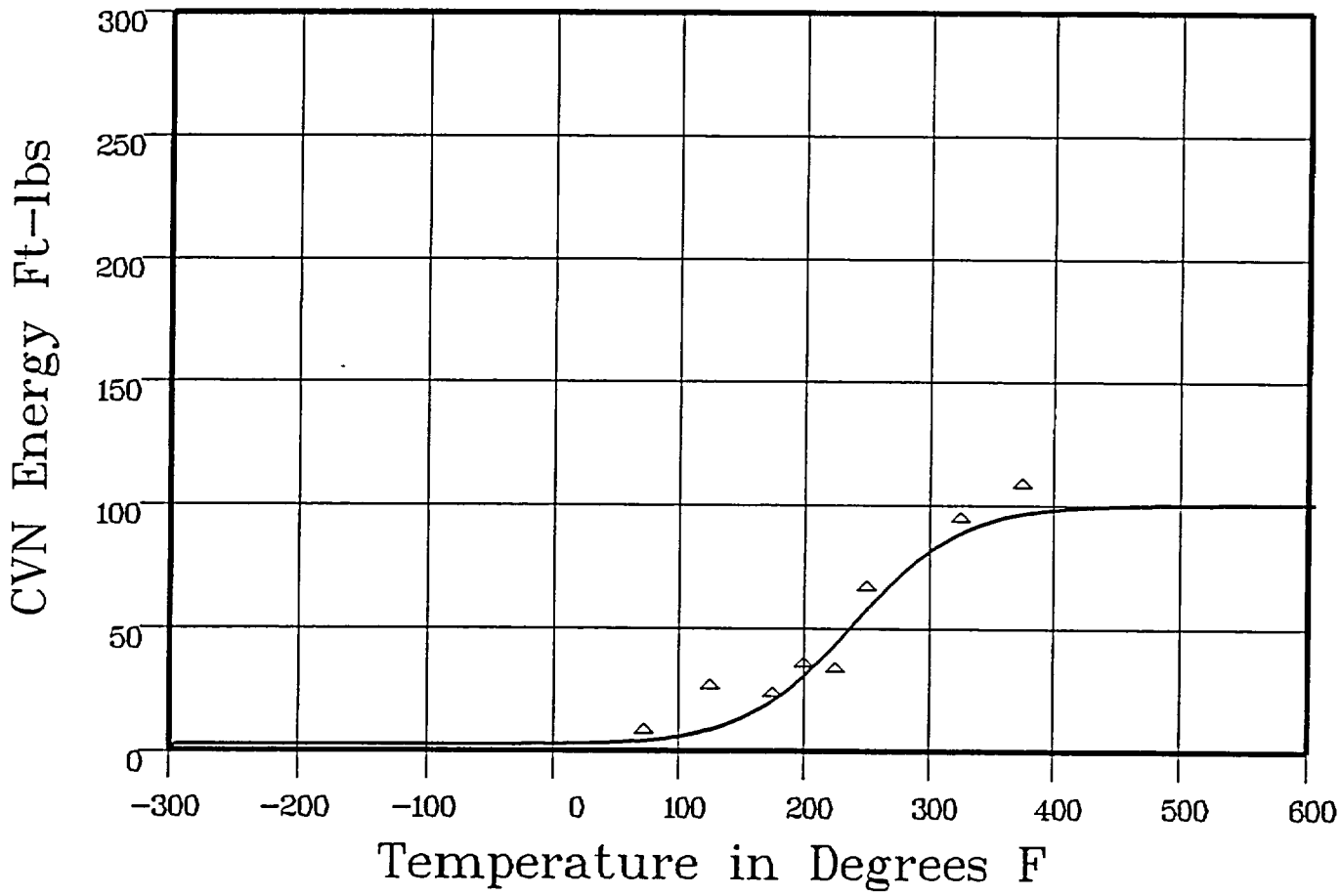
A = 51.09	B = 48.9	C = 86.41	T0 = 234.37

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

Upper Shelf Energy: 100 Fixed Temp. at 30 ft-lbs: 194.4 Temp. at 50 ft-lbs: 232.4 Lower Shelf Energy: 2.19 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: SRM SA533B1 Ori.: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input CVN Energy	Computed CVN Energy	Differential
72	7	4.42	2.57
125	25	9.4	15.59
175	22	21.95	.04
200	34	32.61	1.38
225	32	45.81	-13.81
250	65	59.84	5.15
325	93	89.3	3.69

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

CAPSULE Y CORRELATION MONITOR MATERIAL

Page 2

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input CVN Energy	Computed CVN Energy	Differential
375	107	96.36	10.63

SUM of RESIDUALS = 25.26

UNIRRADIATED CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:03:00 on 07-15-2002

Page 1

Coefficients of Curve 1

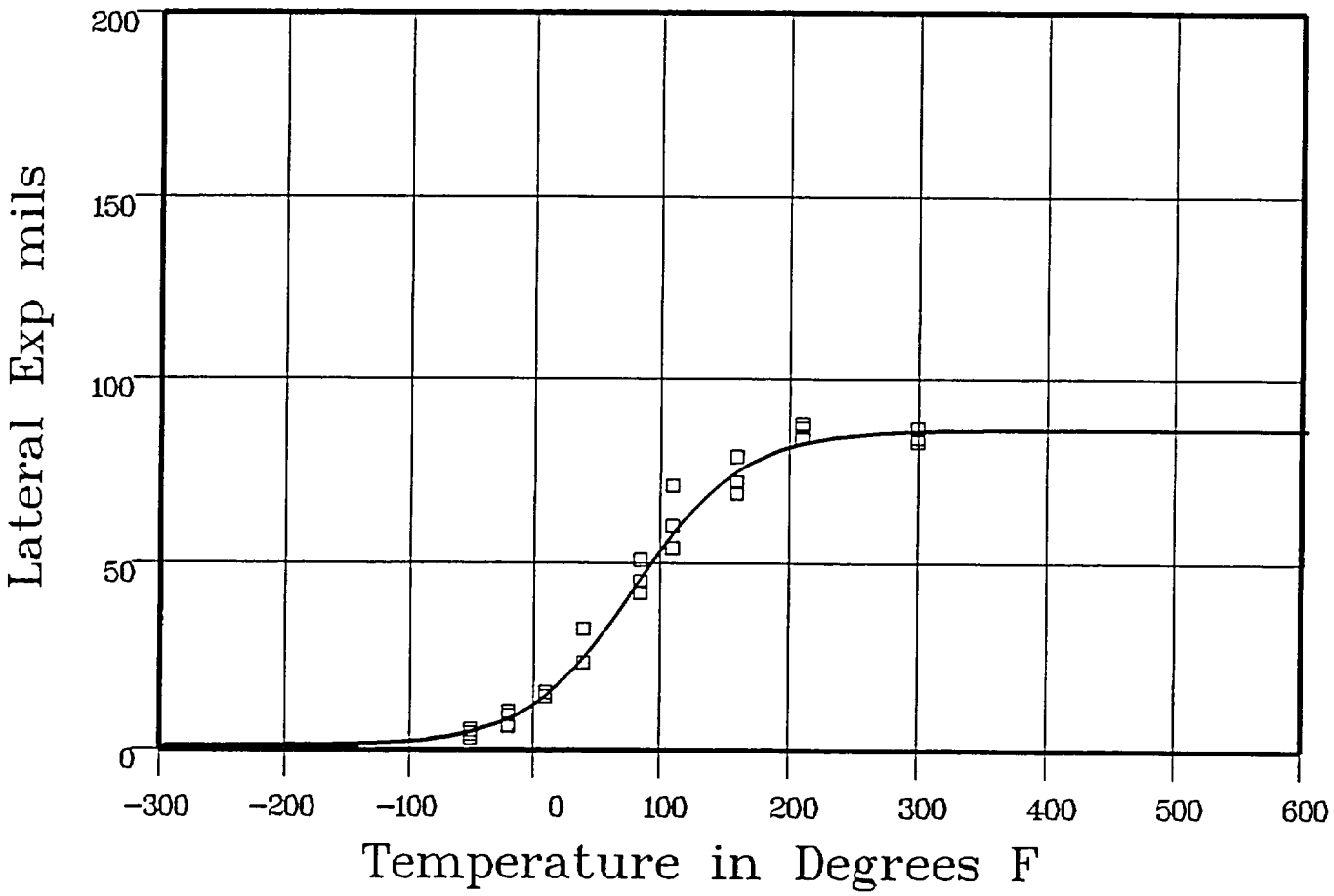
A = 43.65	B = 42.65	C = 84.08	T0 = 76.27

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

Upper Shelf L.E.: 86.31 Temperature at L.E. 35: 58.9 Lower Shelf L.E.: 1 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: UNIRR Material: SRM SA533B1 Ori.: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
-50	4	5.03	-1.03
-50	3	5.03	-2.03
-50	5	5.03	-.03
-20	9	8.84	.15
-20	6	8.84	-2.84
-20	10	8.84	1.15
10	14	15.61	-1.61
10	15	15.61	-.61
10	14	15.61	-1.61

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

UNIRRADIATED CORRELATION MONITOR MATERIAL

Page 2

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V–Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
40	32	26.31	5.68
40	23	26.31	-3.31
40	32	26.31	5.68
85	42	48.06	-6.06
85	45	48.06	-3.06
85	51	48.06	2.93
110	54	59.9	-5.9
110	60	59.9	.09
110	71	59.9	11.09
160	79	76.07	2.92
160	72	76.07	-4.07
160	69	76.07	-7.07
210	84	82.91	1.08
210	88	82.91	5.08
210	87	82.91	4.08
300	84	85.9	-1.9
300	83	85.9	-2.9
300	87	85.9	1.09

SUM of RESIDUALS = -3.03

CAPSULE X CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:03:00 on 07-15-2002

Page 1

Coefficients of Curve 2

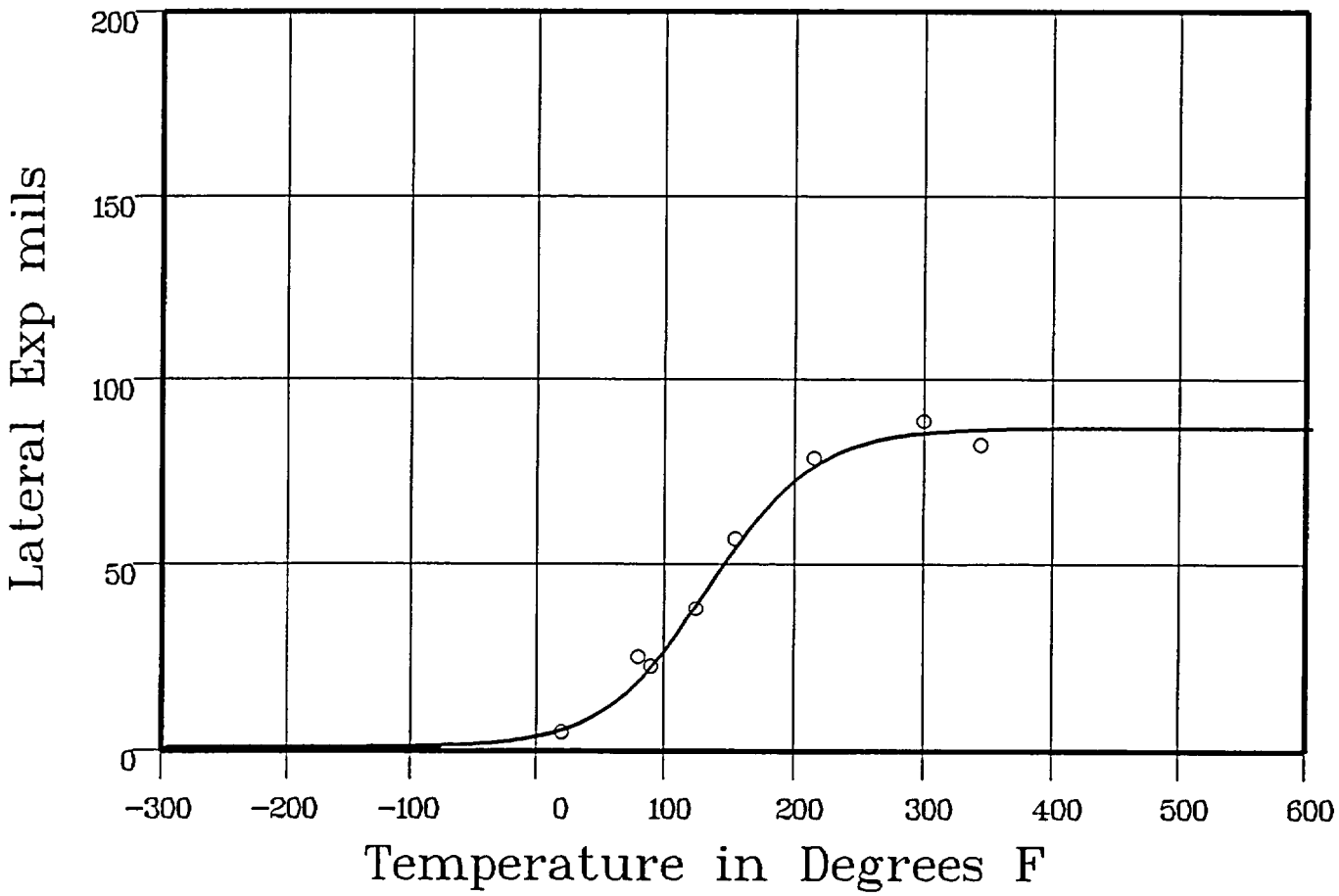
A = 43.97	B = 42.97	C = 80.38	T0 = 130.66

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

Upper Shelf L.E.: 86.95 Temperature at L.E. 35: 113.6 Lower Shelf L.E.: 1 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
20	5	6.14	-1.14
80	25	19.98	5.01
90	22.5	23.91	-1.41
125	38	40.95	-2.95
155	57	56.6	.39
215	79	77.56	1.43
300	89	85.7	3.29
345	82.5	86.54	-4.04

SUM of RESIDUALS = .56

CAPSULE V CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:03:00 on 07-15-2002

Page 1

Coefficients of Curve 3

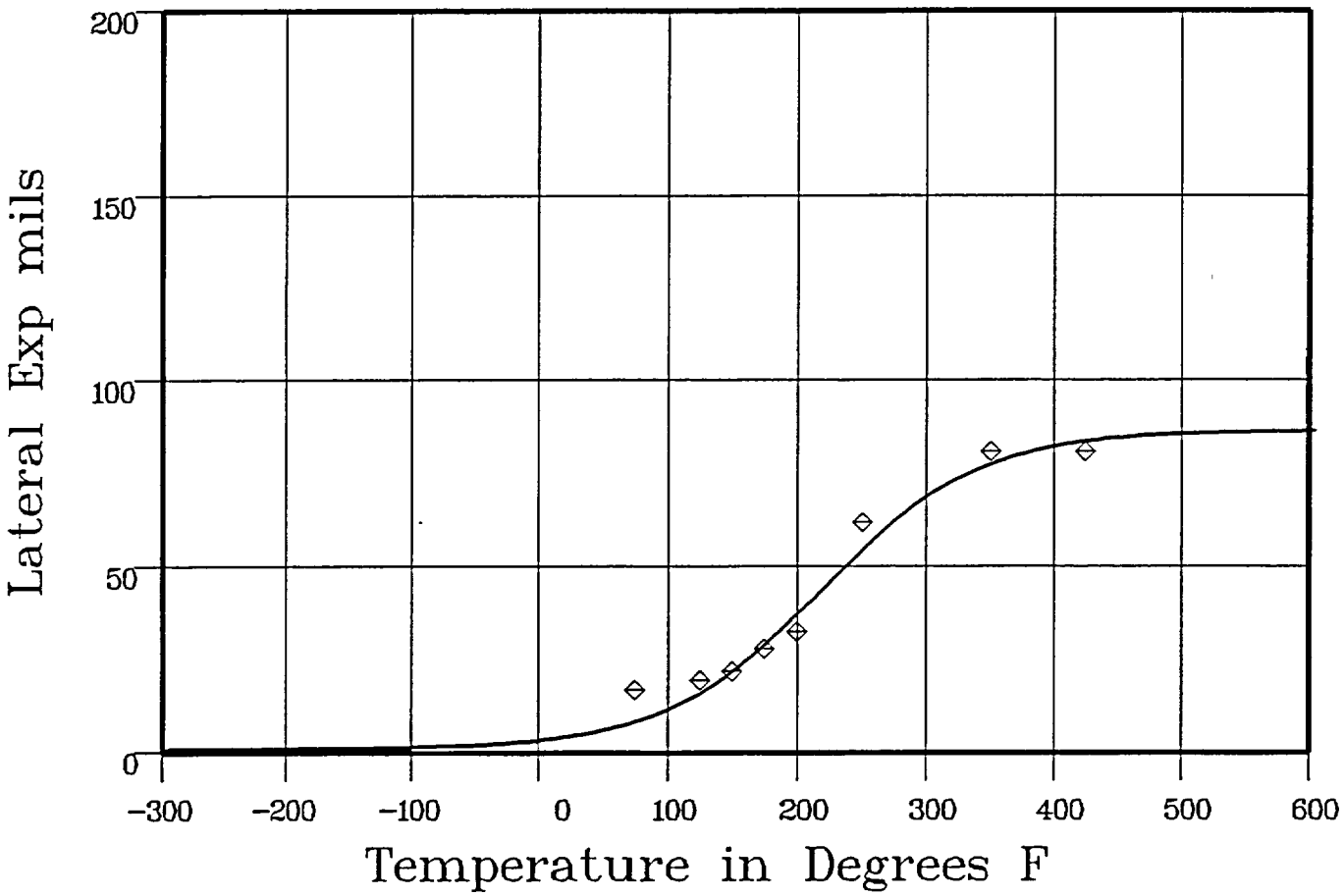
A = 43.75	B = 42.75	C = 121.68	T0 = 213.75

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

Upper Shelf L.E.: 86.5 Temperature at L.E. 35: 188.4 Lower Shelf L.E.: 1 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: SRM SA533B1 Ori.: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
75	17	8.93	8.06
125	19.5	17.13	2.36
150	22	23.2	-1.2
175	28	30.58	-2.58
200	32.5	38.94	-6.44
250	62	56.12	5.87
350	81	78.27	2.72
425	81	83.93	-2.93

SUM of RESIDUALS = 5.87

CAPSULE Y CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 11:03:00 on 07-15-2002

Page 1

Coefficients of Curve 4

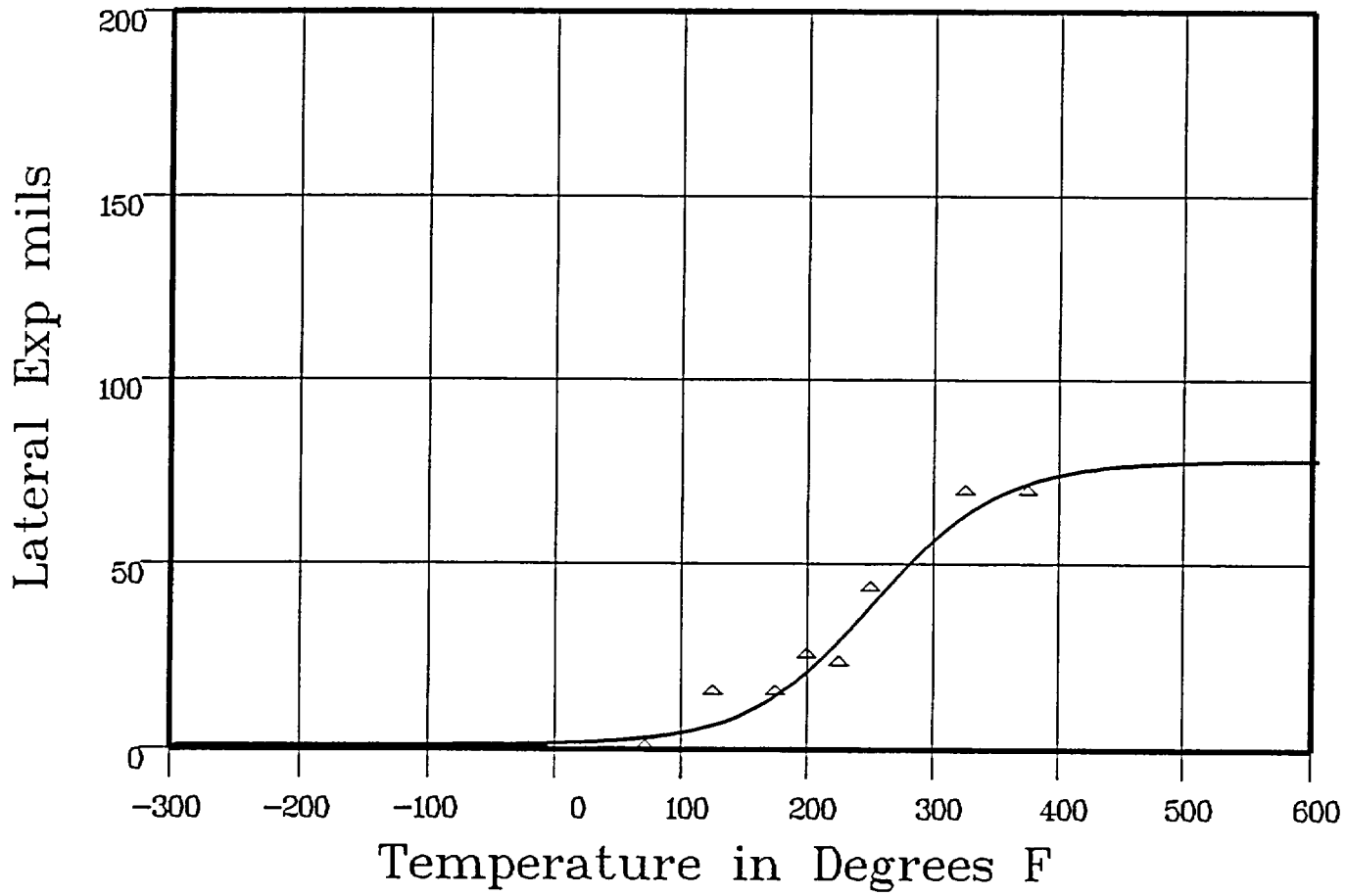
A = 39.52	B = 38.52	C = 100.86	T0 = 247.5

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

Upper Shelf L.E.: 78.05 Temperature at L.E. 35: 235.5 Lower Shelf L.E.: 1 Fixed

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap.: Y Material: SRM SA533B1 Ori.: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Lateral Expansion	Computed L.E.	Differential
72	0	3.3	-3.3
125	15	7.24	7.75
175	15	15.78	-.78
200	25	22.61	2.38
225	23	31.07	-8.07
250	43	40.47	2.52
325	69	64.41	4.58

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

CAPSULE Y CORRELATION MONITOR MATERIAL

Page 2

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Lateral Expansion	Computed L.E.	Differential
375	69	72.35	-3.35

SUM of RESIDUALS = 1.73

UNIRRADIATED CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:47:42 on 07-15-2002

Page 1

Coefficients of Curve 1

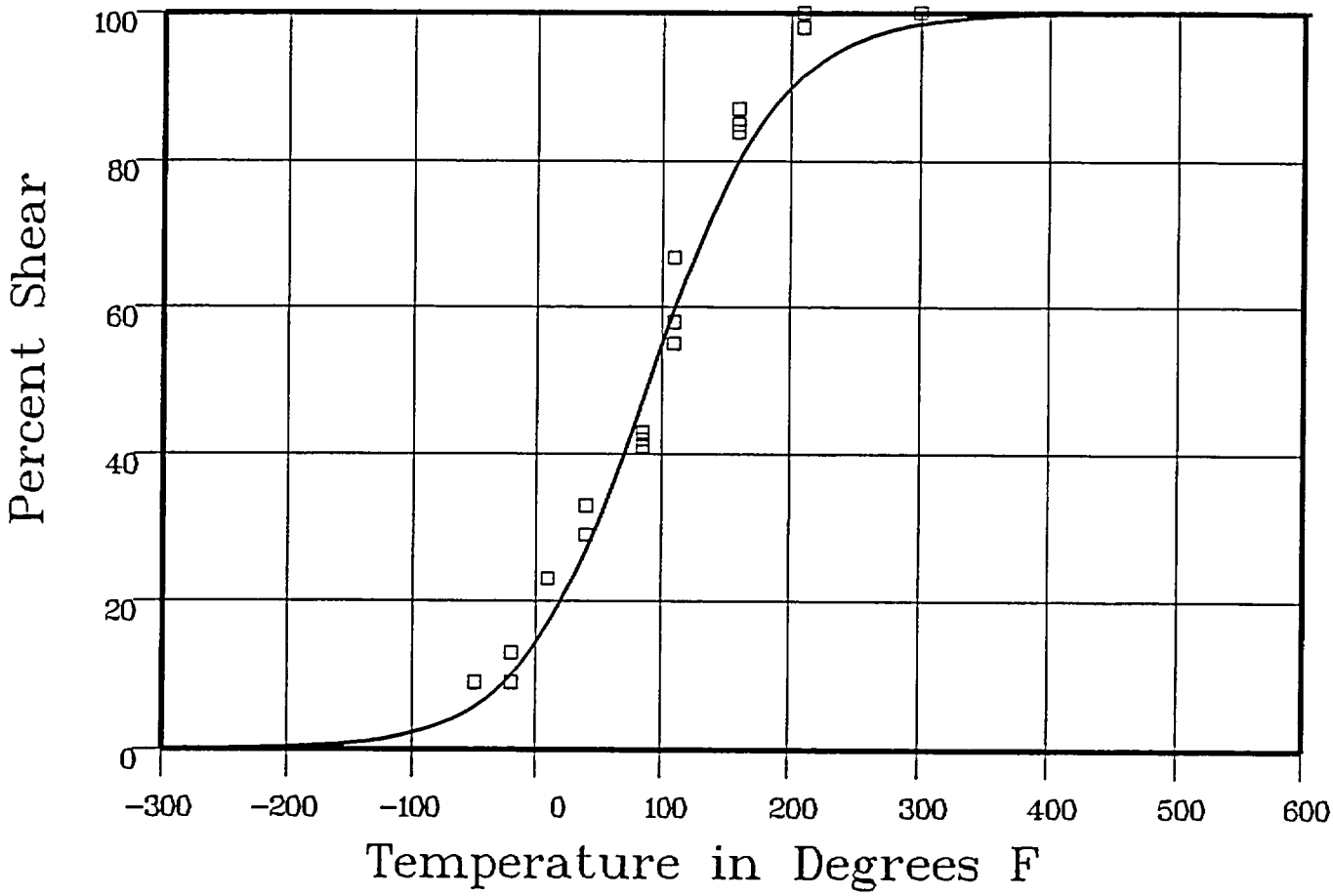
A = 50	B = 50	C = 100.89	T0 = 85.54

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

Temperature at 50% Shear: 85.5

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: UNIRR Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: UNIRR Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
-50	9	6.37	2.62
-50	9	6.37	2.62
-50	9	6.37	2.62
-20	13	10.98	2.01
-20	9	10.98	-1.98
-20	13	10.98	2.01
10	23	18.27	4.72
10	23	18.27	4.72
10	23	18.27	4.72

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

UNIRRADIATED CORRELATION MONITOR MATERIAL

Page 2

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: UNIRR Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
40	29	28.84	.15
40	33	28.84	4.15
40	29	28.84	.15
85	41	49.72	-8.72
85	42	49.72	-7.72
85	43	49.72	-6.72
110	55	61.88	-6.88
110	58	61.88	-3.88
110	67	61.88	5.11
160	87	81.39	5.6
160	84	81.39	2.6
160	85	81.39	3.6
210	98	92.17	5.82
210	98	92.17	5.82
210	100	92.17	7.82
300	100	98.59	1.4
300	100	98.59	1.4
300	100	98.59	1.4

SUM of RESIDUALS = 35.18

CAPSULE X CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:47:42 on 07-15-2002

Page 1

Coefficients of Curve 2

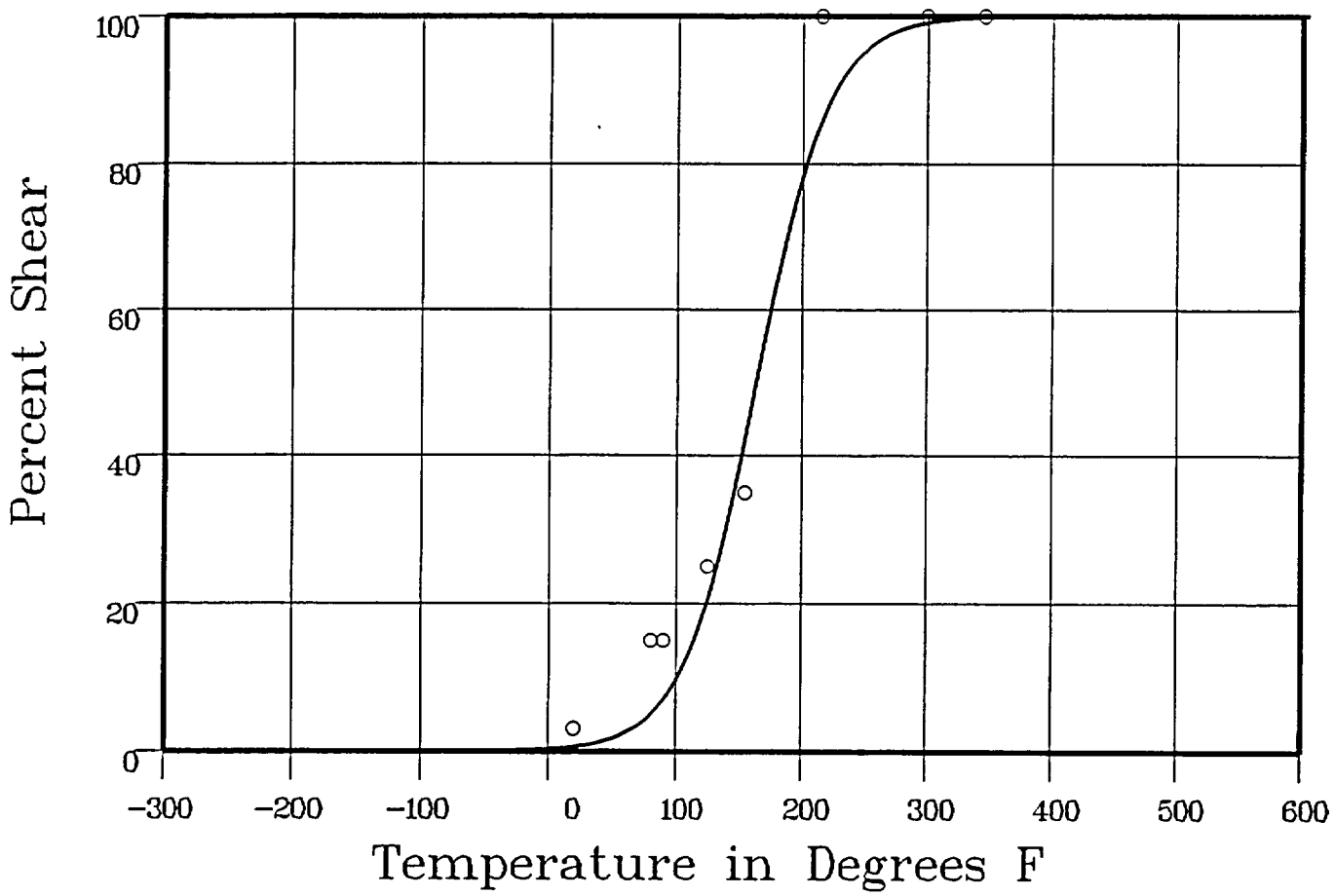
A = 50	B = 50	C = 56.91	T0 = 159.37

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

Temperature at 50% Shear: 159.3

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: X Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: X Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
20	3	.74	2.25
80	15	5.79	9.2
90	15	8.03	6.96
125	25	23	1.99
155	35	46.16	-11.16
215	100	87.59	12.4
300	100	99.29	.7
345	100	99.85	.14

SUM of RESIDUALS = 22.52

CAPSULE V CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:47:42 on 07-15-2002

Page 1

Coefficients of Curve 3

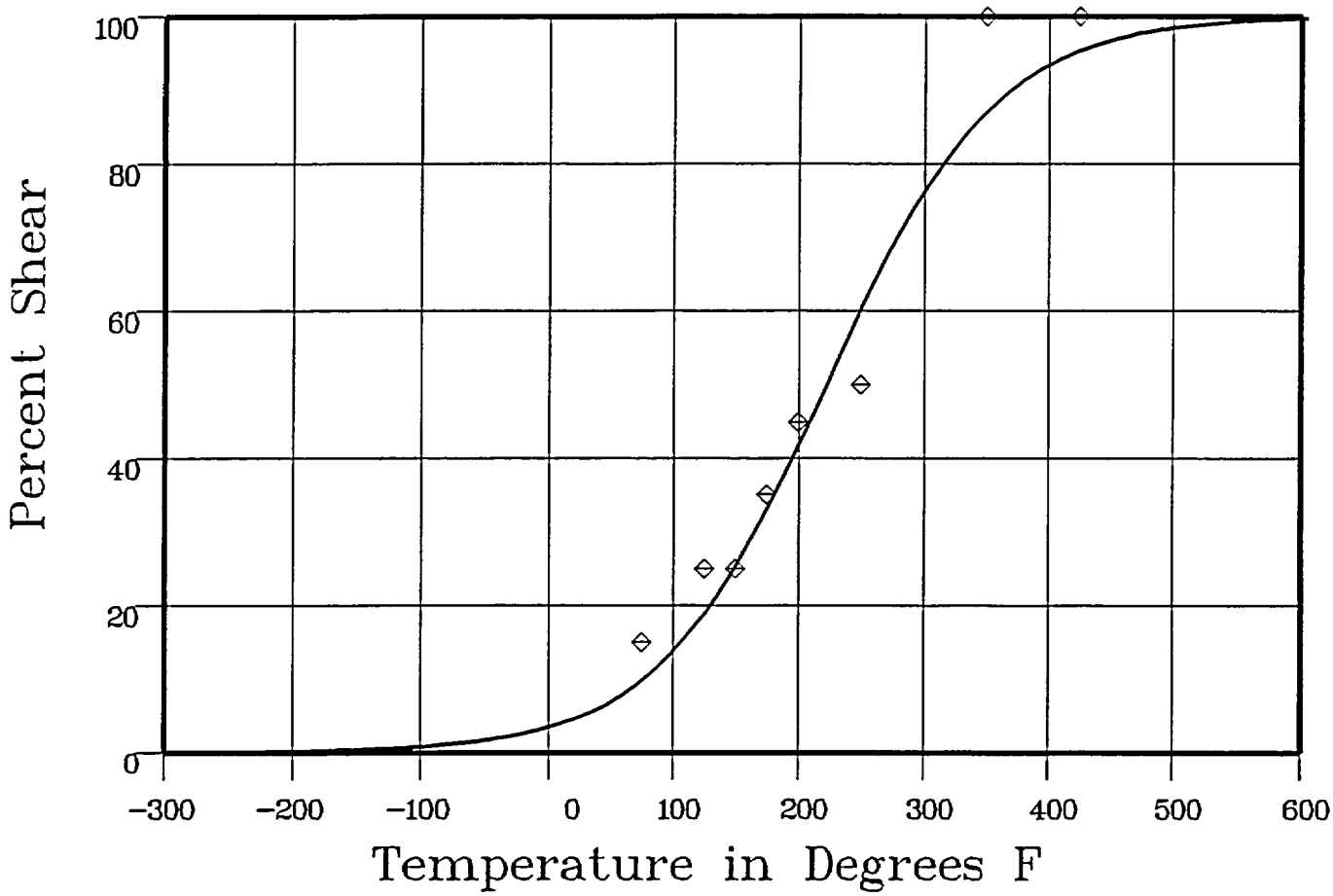
A = 50	B = 50	C = 133.48	T0 = 217.54

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

Temperature at 50% Shear: 217.5

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: V Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: V Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
75	15	10.56	4.43
125	25	19.99	5
150	25	26.65	-1.65
175	35	34.58	.41
200	45	43.46	1.53
250	50	61.92	-11.92
350	100	87.91	12.08
425	100	95.72	4.27

SUM of RESIDUALS = 14.16

CAPSULE Y CORRELATION MONITOR MATERIAL

CVGRAPH 4.1 Hyperbolic Tangent Curve Printed at 12:47:42 on 07-15-2002

Page 1

Coefficients of Curve 4

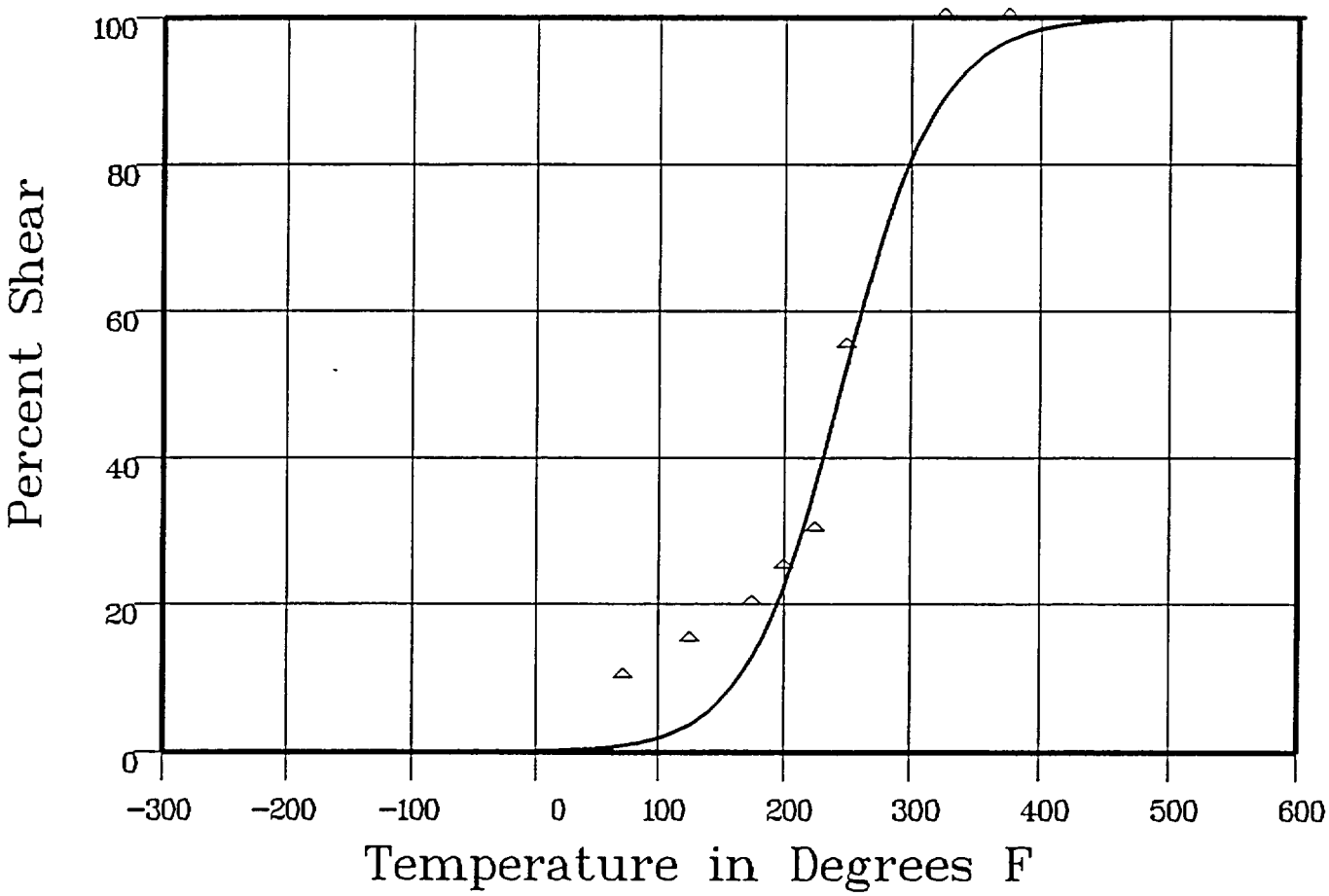
A = 50	B = 50	C = 74.78	T0 = 241.87

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

Temperature at 50% Shear: 241.8

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: Y Total Fluence:



Data Set(s) Plotted

Plant: SU2 Cap: Y Material: SRM SA533B1 Ori: LT Heat #: HSST PLATE 02

Charpy V-Notch Data

Temperature	Input Percent Shear	Computed Percent Shear	Differential
72	10	1.05	8.94
125	15	4.2	10.79
175	20	14.32	5.67
200	25	24.6	.39
225	30	38.9	-8.9
250	55	55.41	-.41
325	100	90.22	9.77

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

CAPSULE Y CORRELATION MONITOR MATERIAL

Page 2

Material: SRM SA533B1 Heat Number: HSST PLATE 02 Orientation: LT

Capsule: Y Total Fluence:

Charpy V-Notch Data (Continued)

Temperature	Input Percent Shear	Computed Percent Shear	Differential
375	100	97.23	2.76

SUM of RESIDUALS = 29.02

APPENDIX D

VALIDATION OF THE RADIATION TRANSPORT MODELS BASED ON NEUTRON DOSIMETRY MEASUREMENTS

D 1 Neutron Dosimetry

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

D.1.1 Sensor Reaction Rate Determinations

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

Capsule ID	Equivalent Azimuthal Location	Withdrawal Time	Irradiation Time [EFPY]
X	15°	End of Cycle 1	1.2
W	25°	End of Cycle 4	3.8
V	15°	End of Cycle 8	8.4
S	45°	End of Cycle 13	15.0
Y	25°/15°	End of Cycle 17	20.3

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

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

Sensor Material	Reaction Of Interest
Copper	$^{63}Cu(n,\alpha)^{60}Co$
Iron	$^{54}Fe(n,p)^{54}Mn$
Nickel	$^{58}Ni(n,p)^{58}Co$
Titanium	$^{46}Ti(n,p)^{46}Sc$
Uranium-238	$^{238}U(n,f)^{137}Cs$
Neptunium-237	$^{237}Np(n,f)^{137}Cs$
Cobalt-Aluminum	$^{59}Co(n,\gamma)^{60}Co$

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

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

The radiometric counting of the neutron sensors from Capsules X and W was carried out by the Battelle Memorial Institute. The radiometric counting of the sensors from Capsules V, S, and Y was completed at the Pace Analytical Services Laboratory located at the Westinghouse Waltz Mill Site. In all cases, the radiometric counting followed established ASTM procedures. Following sample preparation and weighing, the specific activity of each sensor was determined by means of a high-resolution gamma spectrometer. For

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

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

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

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

where.

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

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

For capsules remaining in a single location for the entire irradiation period, the spectrum averaged reaction cross-section is essentially constant and, therefore, the cycle dependent neutron flux (E > 1.0 MeV) can be substituted for individual reaction rates in the computation of the C_j term. However, for cases such as

Capsule Y where relocation of the capsule resulted in significant changes in the relative neutron energy spectrum, the explicit sensor reaction rates must be used to compute the time history corrections.

In the equation describing the reaction rate calculation, the ratio $[P_j]/[P_{ref}]$ accounts for month-by-month variation of reactor core power level within any given fuel cycle as well as over multiple fuel cycles. The ratio C_j, which was calculated for each fuel cycle using the transport methodology discussed in Section 6 2, accounts for the change in sensor reaction rates caused by variations in flux level induced by changes in core spatial power distributions from fuel cycle to fuel cycle. For a single-cycle irradiation, C_j is normally taken to be 1.0. However, for multiple-cycle irradiations, particularly those employing low leakage fuel management, the additional C_j term should be employed. The impact of changing flux levels for constant power operation can be quite significant for sensor sets that have been irradiated for many cycles in a reactor that has transitioned from non-low leakage to low leakage fuel management or for sensor sets contained in surveillance capsules that have been moved from one capsule location to another. The fuel cycle specific neutron flux values used in the time history corrections for Capsules X, W, V, and S as well as the individual sensor reaction rates used in the time history corrections for Capsule Y are listed in Table D-2. These values represent the cycle dependent results at the radial and azimuthal center of the respective capsules at the axial elevation of the active fuel midplane.

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

Correction	Capsule X	Capsule W	Capsule V	Capsule S	Capsule Y
^{235}U Impurity/Pu Build-in	0.873	0.860	0.843	0 813	0.785
$^{238}U(\gamma,f)$	0.957	0.961	0.959	0.957	0.961
Net ^{238}U Correction	0.835	0.826	0.808	0.778	0.754
$^{237}Np(\gamma,f)$	0.983	0.984	0.982	0.983	0 984

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

Results of the sensor reaction rate determinations for Capsules X, W, V, S, and Y are given in Table D-3. In Table D-3, the computed reaction rates for each sensor indexed to the radial center of the capsule are listed The fission sensor reaction rates as listed include the applied corrections for ^{238}U impurities, plutonium build-in, and gamma ray induced fission effects.

D 1.2 Least Squares Evaluation of Sensor Sets

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

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

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

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

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

1 - The calculated neutron energy spectrum and associated uncertainties at the measurement location
2 - The measured reaction rates and associated uncertainty for each sensor contained in the multiple foil set.
3 - The energy dependent dosimetry reaction cross-sections and associated uncertainties for each sensor contained in the multiple foil sensor set.

For the Surry Unit 2 application, the calculated neutron spectrum was obtained from the results of plant specific neutron transport calculations described in Section 6.2 of this report. The sensor reaction rates were derived from the measured specific activities using the procedures described in Section D.1.1. The dosimetry reaction cross-sections and uncertainties were obtained from the Sandia National Laboratory Radiation Metrology Laboratory (SNLRML) dosimeter cross-section library[D-3]. The SNLRML library is

an evaluated dosimetry reaction cross-section compilation recommended for use in LWR evaluations by ASTM Standard E1018, "Application of ASTM Evaluated Cross-Section Data File, Matrix E 706 (IIB)".

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

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

Reaction Rate Uncertainties

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

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

Reaction	Uncertainty
$^{63}Cu(n,\alpha)^{60}Co$	5%
$^{54}Fe(n,p)^{54}Mn$	5%
$^{58}Ni(n,p)^{58}Co$	5%
$^{46}Ti(n,p)^{46}Sc$	5%
$^{238}U(n,f)^{137}Cs$	10%
$^{237}Np(n,f)^{137}Cs$	10%
$^{59}Co(n,\gamma)^{60}Co$	5%

These uncertainties are given at the 1σ level.

Dosimetry Cross-Section Uncertainties

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

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

Reaction	Uncertainty
$^{63}Cu(n,\alpha)^{60}Co$	4.08-4.16%
$^{54}Fe(n,p)^{54}Mn$	3.05-3.11%
$^{58}Ni(n,p)^{58}Co$	4.49-4.56%
$^{46}Ti(n,p)^{46}Sc$	4.51-4.87%
$^{238}U(n,f)^{137}Cs$	0.54-0.64%
$^{237}Np(n,f)^{137}Cs$	10.32-10.97%
$^{59}Co(n,\gamma)^{60}Co$	0.79-3.59%

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

Calculated Neutron Spectrum

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

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

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

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

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

where

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

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

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

Flux Normalization Uncertainty (R_n)	15%
Flux Group Uncertainties (R_g, $R_{g'}$)	
(E > 0.0055 MeV)	15%
(0.68 eV < E < 0.0055 MeV)	29%
(E < 0.68 eV)	52%
Short Range Correlation (θ)	
(E > 0 0055 MeV)	0.9
(0.68 eV < E < 0.0055 MeV)	0.5
(E < 0.68 eV)	0.5
Flux Group Correlation Range (γ)	
(E > 0.0055 MeV)	6
(0.68 eV < E < 0.0055 MeV)	3
(E < 0.68 eV)	2

D.1.3 Comparisons of Measurements and Calculations

Results of the least squares evaluations of the dosimetry from the Surry Unit 2 surveillance capsules withdrawn to date are provided in Tables D-4 and D-5. In Table D-4, measured, calculated, and best-estimate values for sensor reaction rates are given for each capsule. Also provided in this tabulation are ratios of the measured reaction rates to both the calculated and least squares adjusted reaction rates. These ratios of M/C and M/BE illustrate the consistency of the fit of the calculated neutron energy spectra to the measured reaction rates both before and after adjustment. Also included in the tabulation are the results of the X^2/Degree of freedom statistical test associated with each of the least squares evaluations. In Table D-5, comparison of the calculated and best estimate values of neutron flux (E > 1.0 MeV) and iron atom displacement rate are tabulated along with the BE/C ratios observed for each of the capsules.

The data comparisons provided in Tables D-4 and D-5 show that the adjustments to the calculated spectra are relatively small and well within the assigned uncertainties for the calculated spectra, measured sensor reaction rates, and dosimetry reaction cross-sections. Further, these results indicate that the use of the least squares evaluation results in a reduction in the uncertainties associated with the exposure of the surveillance capsules. From Section 6.4 of this report, it may be noted that the uncertainty associated with the unadjusted calculation of neutron fluence (E > 1.0 MeV) and iron atom displacements at the surveillance capsule locations is specified as 12% at the 1σ level. From Table D-5, it is noted that the corresponding uncertainties associated with the least squares adjusted exposure parameters have been reduced to 6-7% for neutron flux (E > 1.0 MeV) and 6-8% for iron atom displacement rate. Again, the uncertainties from the least squares evaluation are at the 1σ level.

Further comparisons of the measurement results with calculations are given in Tables D-6 and D-7. These comparisons are given on two levels. In Table D-6, calculations of individual threshold sensor reaction rates are compared directly with the corresponding measurements. These threshold reaction rate comparisons provide a good evaluation of the accuracy of the fast neutron portion of the calculated energy spectra. In Table D-7, calculations of fast neutron exposure rates in terms of ϕ(E > 1.0 MeV) and dpa/s are compared with the best estimate results obtained from the least squares evaluation of the capsule dosimetry results. These two levels of comparison yield consistent and similar results with all measurement-to-calculation comparisons falling well within the 20% limits specified as the acceptance criteria in Regulatory Guide 1.190.

In the case of the direct comparison of measured and calculated sensor reaction rates, the M/C comparisons for fast neutron reactions range from 0.80–1.16 for the 23 samples included in the data set. The overall average M/C ratio for the entire set of Surry Unit 2 data is 0.97 with an associated sample standard deviation of 10.5%.

In the comparisons of best estimate and calculated fast neutron exposure parameters, the corresponding BE/C comparisons for the capsule data sets range from 0.84–1.01 for neutron flux (E > 1.0 MeV) and from 0.85-0.98 for iron atom displacement rate. The overall average BE/C ratios for neutron flux (E > 1.0 MeV) and iron atom displacement rate are 0.95 with a sample standard deviation of 6.9% and 0.94 with a samole standard deviation of 6.0%, respectively.

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

Table D-1

Nuclear Parameters Used In The Evaluation Of Neutron Sensors

Monitor Material	Reaction of Interest	Target Atom Fraction	90% Response Range (MeV)	Product Half-life	Fission Yield (%)
Copper	^{63}Cu (n,α)	0.6917	5.0 – 12.0	5.271 y	
Iron	^{54}Fe (n,p)	0.0585	2.4 – 8.8	312.3 d	
Nickel	^{58}Ni (n,p)	0.6808	1.7 – 8.4	70.82 d	
Uranium-238	^{238}U (n,f)	1 0000	1.5 – 7.9	30.07 y	
Neptunium-237	^{237}Np (n,f)	1.0000	0.45 – 5.0	30.07 y	6.02
Cobalt-Aluminum	^{59}Co (n,γ)	0 0017	non-threshold	5.271 y	6 17

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

Table D-2

$\phi(E > 1.0\ MeV)$ [n/cm^2-s] at the Surveillance Capsule Center
Core Midplane Elevation

Cycle	Capsule V	Capsule S
1	8.01e+10	2.79e+10
2	8.24e+10	3.03e+10
3	8.06e+10	3.01e+10
4	8.09e+10	2.81e+10
5	6.58e+10	2.44e+10
6	6.46e+10	2.34e+10
7	6.63e+10	2.29e+10
8	5.49e+10	2.20e+10
9		1.96e+10
10		1.99e+10
11		1.89e+10
12		1.83e+10
13		1.65e+10
14		
15		
16		
17		
Average	7.10e+10	2.27e+10

Table D-2 (Continued)

Sensor Reaction Rates [rps/a] at the Surveillance Capsule Center
Core Midplane Elevation

Cycle	Bare Cu-63(n,a)	Bare Fe-54(n,p)	Bare Ni-58(n,p)	Cd Cov. U-238(n,f)	Cd Cov. Np-237(n,f)	Bare Co-59(n,g)	Cd Cov. Co-59(n,g)
1	3.978E-17	4.133E-15	5.621E-15	1.901E-14	1.356E-13	2.048E-12	1.023E-12
2	4.114E-17	4.278E-15	5.819E-15	1.969E-14	1.406E-13	2.125E-12	1.062E-12
3	4.188E-17	4.362E-15	5.935E-15	2.010E-14	1.436E-13	2.171E-12	1.085E-12
4	4.018E-17	4.179E-15	5.684E-15	1.924E-14	1.374E-13	2.076E-12	1.037E-12
5	3.416E-17	3.457E-15	4.691E-15	1.566E-14	1.107E-13	1.654E-12	8.256E-13
6	3.428E-17	3.488E-15	4.736E-15	1.586E-14	1.123E-13	1.680E-12	8.390E-13
7	3.200E-17	3.222E-15	4.371E-15	1.457E-14	1.029E-13	1.539E-12	7.675E-13
8	3.037E-17	3.051E-15	4.139E-15	1.378E-14	9.724E-14	1.449E-12	7.234E-13
9	2.886E-17	2.887E-15	3.915E-15	1.301E-14	9.170E-14	1.365E-12	6.811E-13
10	3.047E-17	3.060E-15	4.151E-15	1.383E-14	9.759E-14	1.455E-12	7.266E-13
11	2.544E-17	2.519E-15	3.413E-15	1.130E-14	7.935E-14	1.177E-12	5.876E-13
12	2.611E-17	2.589E-15	3.509E-15	1.162E-14	8.165E-14	1 211E-12	6.045E-13
13	3.565E-17	3.756E-15	5.130E-15	1.771E-14	1.315E-13	2.155E-12	1.070E-12
14	3.305E-17	3.455E-15	4.716E-15	1.622E-14	1.201E-13	1.961E-12	9.728E-13
15	3.196E-17	3.346E-15	4.568E-15	1.573E-14	1.165E-13	1.906E-12	9.458E-13
16	3.211E-17	3.336E-15	4.551E-15	1.561E-14	1.153E-13	1.877E-12	9.312E-13
17	3.133E-17	3.247E-15	4.428E-15	1.517E-14	1.118E-13	1.813E-12	9.001E-13
Avg. 1-17	3.274E-17	3.356E-15	4.565E-15	1.541E-14	1.108E-13	1.708E-12	8.512E-13

Table D-3

Measured Sensor Activities And Reaction Rates

Sensor Reaction	Measured Reaction Rate [rps/nucleus]				
	Capsule X	Capsule W	Capsule V	Capsule S	Capsule Y
Cu-63(n,α)Co-60	5.87E-17	4.70E-17	4.86E-17	2.20E-17	3.21E-17
Fe-54(n,p)Mn-54	6.56E-15	4.39E-15	4.99E-15	1.69E-15	3 04E-15
Ni-58(n,p)Co-58	8.26E-15	5.92E-15	6.36E-15	2 29E-15	
U-238(n,f)Cs-137 (Cd)	2.75E-14	1.79E-14	2.36E-14	6.81E-15	1.36E-14
Np-237(n,f)Cs-137 (Cd)	1.89E-13		1.75E-13	5.04E-14	1.28E-13
Co-59(n,γ) Co-60	3.94E-12		3.12E-12	7.08E-13	1.53E-12
Co-59(n,γ) Co-60 (Cd)					1.06E-12

Table D-4

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

Capsule X (χ^2/DOF = 0 25)

Reaction	Reaction Rate [rps/atom]			M/C	M/BE
	Measured	Calculated	Best Estimate		
$^{63}Cu(n,\alpha)^{60}Co$	5.87E-17	5.23E-17	5.84E-17	1.12	1.01
$^{54}Fe(n,p)^{54}Mn$	6.56E-15	5.79E-15	6.29E-15	1.13	1.04
$^{58}Ni(n,p)^{58}Co$	8.26E-15	7.96E-15	8.42E-15	1.04	0.98
$^{238}U(n,f)^{137}Cs$ (Cd)	2.75E-14	2.82E-14	2.90E-14	0.98	0.95
$^{237}Np(n,f)^{137}Cs$ (Cd)	1.89E-13	2.14E-13	2.01E-13	0.88	0.94
$^{59}Co(n,\gamma)^{60}Co$	3.94E-12	3.53E-12	3.93E-12	1.12	1.00

Capsule W (χ^2/DOF = 0.27)

Reaction	Reaction Rate [rps/atom]			M/C	M/BE
	Measured	Calculated	Best Estimate		
$^{63}Cu(n,\alpha)^{60}Co$	4.70E-17	4.05E-17	4.56E-17	1.16	1.03
$^{54}Fe(n,p)^{54}Mn$	4.39E-15	4.21E-15	4.40E-15	1.04	1.00
$^{58}Ni(n,p)^{58}Co$	5.92E-15	5.74E-15	5.95E-15	1.03	0.99
$^{238}U(n,f)^{137}Cs$ (Cd)	1.79E-14	1.95E-14	1.95E-14	0.92	0.92

Capsule V (χ^2/DOF = 0.16)

Reaction	Reaction Rate [rps/atom]			M/C	M/BE
	Measured	Calculated	Best Estimate		
$^{63}Cu(n,\alpha)^{60}Co$	4.86E-17	4.76E-17	4.75E-17	1.02	1.02
$^{54}Fe(n,p)^{54}Mn$	4.99E-15	5.19E-15	4.94E-15	0.96	1.01
$^{58}Ni(n,p)^{58}Co$	6.36E-15	7.12E-15	6.63E-15	0.89	0.96
$^{238}U(n,f)^{137}Cs$ (Cd)	2.36E-14	2.51E-14	2.33E-14	0.94	1 01
$^{237}Np(n,f)^{137}Cs$ (Cd)	1.75E-13	1.90E-13	1.75E-13	0.92	1.00
$^{59}Co(n,\gamma)^{60}Co$	3.12E-12	3.10E-12	3.12E-12	1.01	1.00

Table D-4 cont'd

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

Capsule S (χ^2/DOF = 0.31)

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	2.20E-17	2.14E-17	2.09E-17	1.03	1.05
$^{54}Fe(n,p)^{54}Mn$	1 69E-15	1.98E-15	1.74E-15	0.85	0.97
$^{58}Ni(n,p)^{58}Co$	2.29E-15	2.66E-15	2.33E-15	0.86	0.98
$^{238}U(n,f)^{137}Cs$ (Cd)	6.81E-15	8.47E-15	7.22E-15	0.80	0.94
$^{237}Np(n,f)^{137}Cs$ (Cd)	5.04E-14	5.73E-14	4.93E-14	0.88	1.02
$^{59}Co(n,\gamma)^{60}Co$	7.08E-13	7.88E-13	7.09E-13	0.90	1.00

Capsule Y (χ^2/DOF = 0.36)

	Reaction Rate [rps/atom]				
Reaction	Measured	Calculated	Best Estimate	M/C	M/BE
$^{63}Cu(n,\alpha)^{60}Co$	3.21E-17	3.27E-17	3.15E-17	0.98	1.02
$^{54}Fe(n,p)^{54}Mn$	3.04E-15	3.35E-15	3.12E-15	0 91	0.97
$^{238}U(n,f)^{137}Cs$ (Cd)	1.36E-14	1.54E-14	1.46E-14	0.88	0.93
$^{237}Np(n,f)^{137}Cs$ (Cd)	1.28E-13	1.11E-13	1.17E-13	1.15	1.09
$^{59}Co(n,\gamma)^{60}Co$	1.53E-12	1.68E-12	1.57E-12	0 91	0.97
$^{59}Co(n,\gamma)^{60}Co$ (Cd)	1.06E-12	8.19E-13	1.03E-12	1.29	1.03

Table D-5

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

Capsule ID	$\phi(E > 1.0\ MeV)$ [n/cm²-s] Calculated	Best Estimate	Uncertainty (1σ)	BE/C
X	8.01E+10	8.11E+10	6%	1.01
W	5.37E+10	5.31E+10	7%	0.99
V	7.10E+10	6.59E+10	6%	0.93
S	2.27E+10	1.91E+10	6%	0.84
Y	4 27E+10	4.10E+10	6%	0.96

Capsule ID	Iron Atom Displacement Rate [dpa/s] Calculated	Best Estimate	Uncertainty (1σ)	BE/C
X	1.34E-10	1.32E-10	7%	0.98
W	8.75E-11	8.52E-11	8%	0.97
V	1.19E-10	1.09E-10	7%	0 92
S	3.64E-11	3.08E-11	6%	0 85
Y	6.99E-11	6.72E-11	7%	0.96

Table D-6

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

Reaction	M/C Ratio				
	Capsule X	Capsule W	Capsule V	Capsule S	Capsule Y
$^{63}Cu(n,\alpha)^{60}Co$ (Cd)	1.12	1.16	1.02	1.03	0.98
$^{54}Fe(n,p)^{54}Mn$	1.13	1.04	0.96	0.85	0.91
$^{58}Ni(n,p)^{58}Co$ (Cd)	1.04	1.03	0.89	0.86	
$^{238}U(n,f)^{137}Cs$ (Cd)	0.98	0.92	0.94	0.80	0.88
$^{237}Np(n,f)^{137}Cs$ (Cd)	0.88		0.92	0.88	1.15
Average	1.03	1.04	0.95	0.89	0.98
Sample % Standard Deviation	10.2	9.5	5.1	9.6	12.4

Notes:

1. The overall average M/C ratio for the set of 23 sensor measurements is 0.97 with an associated sample standard deviation of 10.5%.

Table D-7

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

Capsule ID	BE/C Ratio	
	$\phi(E > 1.0$ MeV)	dpa/s
X	1.01	0.98
W	0.99	0.97
V	0.93	0.92
S	0.84	0.85
Y	0.96	0.96
Average	0.95	0.94
% Standard Deviation	6.9	6.0

Appendix D References

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

D-2. A Schmittroth, *FERRET Data Analysis Core*, HEDL-TME 79-40, Hanford Engineering Development Laboratory, Richland, WA, September 1979.

D-3. RSIC Data Library Collection DLC-178, "SNLRML Recommended Dosimetry Cross-Section Compendium", July 1994.

ATTACHMENT 2

EVALUATION OF APPLICATION OF SURRY UNIT 2 CAPSULE Y SURVEILLANCE DATA TO SURRY UNIT 2 LOWER SHELL PLATE MATERIAL C4339-1 AND INTERMEDIATE TO LOWER SHELL CIRCUMFERENTIAL WELD MATERIAL R3008

ATTACHMENT 2

EVALUATION OF APPLICATION OF SURRY UNIT 2 CAPSULE Y SURVEILLANCE DATA TO SURRY UNIT 2 LOWER SHELL PLATE MATERIAL C4339-1 AND INTERMEDIATE-TO-LOWER SHELL CIRCUMFERENTIAL WELD MATERIAL R3008

BACKGROUND

Surry Unit 2 surveillance Capsule Y was withdrawn from the Surry Unit 2 reactor vessel on March 31, 2002. Capsule Y contains Surry Unit 2 lower shell plate material C4339-1 and intermediate-to-lower shell circumferential weld material R3008 (weld wire heat 0227).

This evaluation provides revised Surry Unit 2 data tables for the NRC's Reactor Vessel Integrity Database (RVID) and an evaluation of changes relative to the previous RVID update for Surry Unit 2 (1). The evaluation considers the impact of Surry Unit 2 Capsule Y surveillance data on (a) licensing basis reactor coolant system (RCS) pressure/temperature (P/T) limit curves, (b) the associated Low Temperature Overpressure Protection System (LTOPS) setpoints and enabling temperature, (c) 10 CFR 50.61 Pressurized Thermal Shock (PTS) screening calculations, and (d) Charpy Upper Shelf Energy (CvUSE) values. The evaluation was performed in a manner consistent with applicable regulatory guidance. Specifically, the calculation of the Reference Temperature for the Nil Ductility Transition (RTNDT) is performed in accordance with Regulatory Guide 1.99 Revision 2 (3), and the regulatory guidance provided in the meeting minutes from the November 12, 1997 NRC/Industry meeting on reactor vessel integrity (5). PTS screening calculations were performed in accordance with 10 CFR 50.61 (2). CvUSE values were developed in accordance with Regulatory Guide 1.99 Revision 2 (3). Evaluation results are presented in a format consistent with the data requirements of the NRC's Reactor Vessel Integrity Database (RVID).

DISCUSSION OF CHANGES TO PREVIOUSLY REPORTED INFORMATION

Surry Unit 2 revised RVID data tables are presented in Appendix A. Shaded cells in Appendix A indicate a changed value relative to those currently presented in RVID (Version 2.0.1, dated 7/6/00). The following changes have been incorporated into the revised tables:

Surry Unit 2 Lower Shell Plate material C4339-1 and Intermediate-to-Lower Shell Circumferential Weld Material R3008

- The RG 1.99 Revision 2 Position 2.1 chemistry factor (CF) calculation includes consideration of the capsule Y analysis results. The Capsule Y data are documented in Table 5-12 of Reference (4).

- Because the surveillance capsules were irradiated in a single reactor and the surveillance material was derived from a single source, irradiation temperature and chemistry corrections are not applied in the credibility determination.
- The surveillance data applicable to C4339-1were determined to be non-credible. However, the data were within 2σ of the RG 1.99 Rev. 2 Position 1.1 curve based on a CF for the average surveillance material chemical composition. Therefore, the Position 1.1 CF value was applied to the C4339-1 beltline material with a full margin term. The surveillance data for the R3008 material were determined to be credible, so the RG 1.99 Rev. 2 Position 2.1 CF values were applied for this material.

EVALUATION OF EXISTING P/T LIMITS AND LTOPS SETPOINTS

The existing Surry Units 1 and 2 P/T limits and LTOPS setpoints (7)(8) are based on a limiting ¼-thickness (¼-T) RTNDT of 228.4°F. When the P/T limits and LTOPS setpoints were developed, this value of RTNDT was determined to bound all Surry Units 1 and 2 reactor vessel beltline materials at fluences corresponding to 28.8 EFPY and 29.4 EFPY for Surry Units 1 and 2, respectively (7)(8). RTNDT calculations have been performed for all Surry Unit 2 reactor vessel beltline materials at a neutron fluence value corresponding to 30.1 EFPY (1). The results are presented in Appendix A. After consideration of the aforementioned changes to previously reported information, the most limiting ¼-T RTNDT value for Surry Unit 2 is 208.8°F at the fluence value corresponding to a cumulative core burnup of 30.1 EFPY (1). However, the P/T Limits and LTOPS Setpoints are based on a limiting ¼-T RTNDT value of 228.4°F. Therefore, the existing P/T Limits and LTOPS Setpoints remain valid and conservative.

EVALUATION OF PTS SCREENING CALCULATIONS

PTS screening calculations have been performed for all Surry Unit 2 reactor vessel beltline materials at a neutron fluence value corresponding to 30.1 EFPY (1). The results of these calculations are presented in Appendix A. After consideration of the aforementioned changes to previously reported information, it is concluded that all Surry Unit 2 beltline materials continue to meet the 10 CFR 50.61 screening criteria.

REPORT OF CvUSE VALUES

CvUSE data and calculations are presented in Appendix A. Although surveillance Capsule Y only contained Surry Unit 2 lower shell plate material C4339-1 and intermediate-to-lower shell circumferential weld material R3008 (weld wire heat 0227), the CvUSE table reflects the following changes:

- The current listing in the RVID for weld material L737/4275 (nozzle-to-intermediate shell circumferential weld) identifies the material as Linde 80 material when in fact it consists of SAF 89 material.

- The current listing in the RVID for weld material R3008/0227 (intermediate-to-lower shell circumferential weld) identifies the material as Linde 80 material when in fact it consists of Grau Lo material.
- ¼-T USE fluence values are calculated using the RG 1.99 Rev. 2 Position 1.1 attenuation equation. The RG 1.99 Rev. 2 Position 1.1 methodology includes the vessel clad material thickness in the fluence calculation (i.e., "...depth into the vessel wall measured from the inner (wetted) surface."):

  $f/f_{surf} = \exp(-0.24x)$, x = [0.25*vessel thickness] + [clad thickness]

  For Surry Unit 2, the maximum allowable f/f_{surf} would be:

  x = [0.25*8.079 in] + [0.157 in] = 2.177 in, $f/f_{surf} = 0.593$

  However, Surry Unit 2 attenuation was calculated by the more conservative approach of calculating wall depth by taking 25% of the total including the clad thickness:

  x = [0.25*(8.079 in + 0.157 in)] = 2.059 in, $f/f_{surf} = 0.610$

  The higher f/f_{surf} produces a higher ΔRTNDT, so the ¼-T fluences calculated for Surry Unit 2 are conservative with respect to the RG 1.99 Rev. 2 Position 1.1 methodology.

- The values for unirradiated USE for materials C4331-2 and C4339-1 appeared to have been mistyped in the RVID. Corrected values have been provided.
- The percentage drops in CvUSE values were calculated using the RG 1.99 Rev. 2 Position 1.2 methodology. CvUSE data obtained from surveillance capsules compares favorably with predictions. For those Rotterdam and Linde 80 materials that are below 50 ft-lbs, equivalent margin analyses (EMAs) have been previously approved in References (9) and (10).

CONCLUSIONS

After consideration of the aforementioned changes to previously reported information, the most limiting ¼-T RTNDT value for Surry Unit 2 is 208.8°F at a fluence value corresponding to a cumulative core burnup of 30.1 EFPY. The existing Surry Unit 2 Technical Specification RCS P/T limits, LTOPS setpoints, and LTOPS enabling temperature are based upon a ¼-T RTNDT value of 228.4°F (7) (8). Therefore, the analyses supporting the Surry Unit 2 RCS P/T limits, LTOPS setpoints, and LTOPS enabling temperature remain valid and conservative (7) (8). In addition, after consideration of the aforementioned changes to previously reported information, all Surry Unit 2 reactor vessel beltline materials continue to meet the 10 CFR 50.61 PTS screening criteria for cumulative core burnups up to 30.1 EFPY. Finally, calculated Surry Unit 2 CvUSE values continue to be greater than the 50 ft-lb 10CFR50 Appendix G criterion.

NRC REACTOR VESSEL INTEGRITY DATABASE

Virginia Power requests that information presented in Appendix A be used to update the NRC Reactor Vessel Integrity Database (RVID).

FUTURE CAPSULE EXTRACTION PLANS

The currently docketed reactor vessel materials surveillance program includes withdrawal of the final Surry Unit 2 surveillance capsule at a fluence value corresponding to a cumulative core burnup of 30.1 EFPY. As a result of Dominion's license renewal efforts for Surry Unit 2, a submittal is planned to change the capsule withdrawal schedule to reflect the recommendations of the Generic Aging Lessons Learned (GALL) report (6).

REFERENCES

(1) Letter from L. N. Hartz to USNRC, "Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Surry Power Station Units 1 and 2, Evaluation of Reactor Vessel Materials Surveillance Data," Serial Number 99-452A dated November 19, 1999.

(2) Title 10, Code of Federal Regulations, Part 50.61, "Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events."

(3) Regulatory Guide 1.99 Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," dated May, 1988.

(4) WCAP-16001, "Analysis of Capsule Y from Dominion Surry Unit 2 Reactor Vessel Radiation Surveillance Program," dated February 2003.

(5) Memorandum from K. R. Wichman to E. J. Sullivan, "Meeting Summary for November 12, 1997 Meeting with Owners Group Representatives and NEI Regarding Review of Responses to Generic Letter 92-01, Revision 1, Supplement 1 Responses," dated November 19, 1997.

(6) NUREG-1801, "Generic Aging Lessons Learned (GALL) Report," dated July 2001.

(7) Letter from R. F. Saunders to USNRC, "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Request for Exemption - ASME Code Case N-514, Proposed Technical Specifications Change, Revised Pressure/Temperature Limits and LTOPS Setpoint," Serial No. 95-197, June 8, 1995.

(8) Letter from B. C. Buckley to J. P. O'Hanlon, "Surry Units 1 and 2 - Issuance of Amendments Re: Surry Units 1 and 2 Reactor Vessel Heatup and Cooldown

Curves (TAC Nos. M92537 and M92538)," Serial No. 96-020, dated December 28, 1995.

(9) BAW-2178PA, "Low Upper Shelf Toughness Fracture Mechanics Analysis of Reactor Vessels of B&W Owners Reactor Vessel Working Group for Level C & D Service Loads," dated April 1994.

(10) BAW-2192PA, "Low Upper Shelf Toughness Fracture Analysis of Reactor Vessels of B&W Owners Group Reactor Vessel Working Group for Level A & B Conditions," dated April 1994.

APPENDIX A

REACTOR VESSEL MATERIALS DATA TABLES FOR SURRY UNIT 2

(11 pages)

Facility: Surry Unit 1
Vessel Manufacturer: B&W and Rotterdam Dockyard

RPV Weld Wire Heat or Material ID	Location	Best-Estimate Copper (wt%)	Best-Estimate Nickel (wt%)	ID Fluence (x1E19)	Assigned Material Chemistry Factor	Method of Determining CF	Initial RT(NDT)	Sigma(I)	Sigma(delta)	Margin	Inner Surf. ART or RT(PTS)	1/4-T ART*
122V109VA1	Nozzle Shell Forging	0 110	0 740	0 307	76 1	Tables	40	0 0	17 0	34 0	125 5	116 1
C4326-1	Intermediate Shell	0 110	0 550	3 530	73 5	Tables	10	0 0	17 0	34 0	141 6	132 8
C4326-2	Intermediate Shell	0 110	0 550	3 530	73 5	Tables	0	0 0	17 0	34 0	131 6	122 8
4415-1	Lower Shell	0 102	0 493	3 530	85 0	Surv Data	20	0 0	8 5	17 0	149 9	139 7
4415-2	Lower Shell	0 110	0 500	3 530	73 0	Tables	0	0 0	17 0	34 0	131 0	122 2
J726/25017	Nozzle to Int Shell Circ Weld	0 330	0 100	0 307	152 0	Tables	0	20 0	28 0	68 8	171 6	153 0
SA-1585/72445	Int to Low Sh Circ (ID 40%)	0 220	0 540	3 200	131 4	Surv Data	-5	19 7	28 0	68 5	235 1	218 9
SA-1650/72445	Int to Low Sh Circ (OD 60%)	0 220	0 540	3 200	131 4	Surv Data	-5	19 7	28 0	68 5	235 1	218 9
SA-1494/8T1554	Int Shell Long Welds L3 & L4	0 160	0 570	0 600	143 9	Tables	-5	19 7	28 0	68 5	186 8	167 4
SA-1494/8T1554	Lower Shell Long Weld L1	0 160	0 570	0 540	143 9	Tables	-5	19 7	28 0	68 5	182 6	163 4
SA-1526/299L44	Lower Shell Long Weld L2	0 340	0 680	0 540	220 6	Tables	-7	20 6	28 0	69 5	245 1	215 7

* 1/4-T ART value of 228 4 F was used in the determination of P/T limits

Note Shaded cells indicate a changed value relative to the NRC's Reactor Vessel Integrity Database (RVID) Version 2 0 1 (Data Update on 7/6/00)

Facility: Surry Unit 2
Vessel Manufacturer: B&W and Rotterdam Dockyard

RPV Weld Wire Heat or Material ID	Location	Best-Estimate Copper (wt%)	Best-Estimate Nickel (wt%)	ID Fluence (x1E19)	Assigned Material Chemistry Factor	Method of Determining CF	Initial RT(NDT)	Sigma(I)	Sigma(delta)	Margin	Inner Surf ART or RT(PTS)	1/4-T ART*
123V303VA1	Nozzle Shell Forging	0 110	0 720	0 298	75 8	Tables	30	0 0	17 0	34 0	114 7	105 5
C4331-2	Intermediate Shell	0 120	0 600	3 520	83 0	Tables	-10	0 0	17 0	34 0	134 2	124 2
C4339-2	Intermediate Shell	0 110	0 540	3 520	73 4	Tables	-20	0 0	17 0	34 0	111.5	102 6
C4208-2	Lower Shell	0 150	0 550	3 520	107 3	Tables	-30	0 0	17 0	34 0	146 4	133 5
C4339-1	Lower Shell	0 107	0 530	3 520	70 8	Tables	-10	0 0	17 0	34 0	118 0	109 5
L737/4275	Nozzle to Int Shell Circ Weld	0 350	0 100	0 298	160 5	Tables	0	20 0	28 0	68 8	176 1	156 6
R3008/0227	Int to Lower Shell Circ Weld	0 187	0 545	3 520	132 4	Surv Data	0	20 0	14 0	48 8	224 7	208 8
WF-4/8T1762	Int Shell Long L4 (ID 50%)	0 190	0 570	0 697	152 4	Tables	-5	19 7	28 0	68 5	200 4	179 6
SA-1585/72445	Int Sh L3 (100%), L4 (OD 50)	0 220	0 540	0 697	131 4	Surv Data	-5	19 7	28 0	68 5	181 6	163 7
WF-4/8T1762	LS L2 (ID 63%), L1 (100)	0 190	0 570	0 697	152 4	Tables	-5	19 7	28 0	68 5	200 4	179 6
WF-8/8T1762	LS Long Weld L2 (OD 37%)	0 190	0 570	0 697	152 4	Tables	-5	19.7	28 0	68 5	200 4	179 6

* 1/4-T ART value of 228 4 F was used in the determination of P/T limits

Note Shaded cells indicate a changed value relative to the NRC's Reactor Vessel Integrity Database (RVID) Version 2 0 1 (Data Update on 7/6/00)

CvUSE Values
Facility: Surry Unit 2
Vessel Manufacturer: B&W and Rotterdam Dockyard

RPV Weld Wire Heat or Material ID	Location	Forging or Flux Type	USE @ 1/4 T	1/4-T Fluence (x1E19)	Unirradiated USE	Unirradiated USE Method	%Drop in USE @ 1/4 T	%Drop in USE Method	Cu %
123V303VA1	Nozzle Shell Forging	SA508, Cl 2	89 5	0 182	104 0	Measured/MTEB 5-2	14 0%	Pos 1 2	0 11
C4331-2	Intermediate Shell	SA533, Gr B1	63 0	2 147	84 0	Measured/MTEB 5-2	25 0%	Pos 1 2	0 12
C4339-2	Intermediate Shell	SA533, Gr. B1	63 2	2.147	83 0	Measured/MTEB 5-2	23 9%	Pos 1 2	0 11
C4208-2	Lower Shell	SA533, Gr B1	67 3	2 147	94 0	Measured/MTEB 5-2	28 4%	Pos 1 2	0 15
C4339-1	Lower Shell	SA533, Gr B1	80 2	2 147	105 0	Measured	23 6%	Pos 1 2	0 11
L737/4275	Nozzle to Int Shell Circ Weld	SAF 89	EMA	0 182	EMA	Estimate	EMA	EMA	0 35
R3008/0227	Int to Lower Shell Circ Weld	Grau Lo	55 0	2 147	90 0	Measured	38 9%	Pos 1.2	0 19
WF-4/8T1762	Int. Shell Long L4 (ID 50%)	Linde 80	EMA	0 425	EMA	Estimate	EMA	EMA	0 19
SA-1585/72445	Int Sh L3 (100%), L4 (OD 50)	Linde 80	54 0	0 425	77 0	Measured	29 9%	Pos 1 2	0 22
WF-4/8T1762	LS L2 (ID 63%), L1 (100)	Linde 80	EMA	0 425	EMA	Estimate	EMA	EMA	0 19
WF-8/8T1762	LS Long Weld L2 (OD 37%)	Linde 80	EMA	0 425	EMA	Estimate	EMA	EMA	0 19

Note Shaded cells indicate a changed value relative to the NRC's Reactor Vessel Integrity Database (RVID) Version 2 0 1 (Data Update on 7/6/00)

Table 2: **Surry Unit 2 Plate Material C4339-1 (Combined Longitudinal and Transverse Data)**

Capsule ID (Including Source)	Copper (wt%)	Nickel (wt%)	Irradiation Temperature (F)	Fluence (x1E19)	Measured Delta-RT(NDT) (F)	Data Used In Assessing Vessel? (Yes or No)
Surry Unit 2 Capsule X (Long)	0 104	0 520	534 9	0 297	59	Yes
Surry Unit 2 Capsule V (Long)	0 104	0 520	540 1	1 890	79	Yes
Surry Unit 2 Capsule X (Trans)	0 104	0 520	534 9	0 297	49	Yes
Surry Unit 2 Capsule V (Trans)	0.104	0 520	540 1	1 890	64	Yes
Surry Unit 2 Capsule Y (Long)	0 104	0 520	543 7	2 730	114	Yes
Surry Unit 2 Capsule Y (Trans)	0 104	0 520	543 7	2 730	107	Yes
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Table 3: **Surry Unit 2 Plate Material C4339-1 (Combined Longitudinal and Transverse Data)**

Capsule ID (Including Source)	Copper (wt%)	Nickel (wt%)	Irradiation Temperature (F)	Fluence Factor	Measured Delta-RT(NDT) (F)	Adjusted Delta-RT(NDT) (F) *	Adjusted - Predicted Delta-RT(NDT) (F) *
Surry Unit 2 Capsule X (Long)	0 104	0 520	534 9	0 6677	59	59	9
Surry Unit 2 Capsule V (Long)	0 104	0 520	540 1	1.1743	79	79	-10
Surry Unit 2 Capsule X (Trans)	0 104	0 520	534 9	0 6677	49	49	-2
Surry Unit 2 Capsule V (Trans)	0 104	0 520	540 1	1 1743	64	64	-25
Surry Unit 2 Capsule Y (Long)	0 104	0 520	543 7	1 2679	114	114	18
Surry Unit 2 Capsule Y (Trans)	0 104	0 520	543 7	1 2679	107	107	11
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

** For credibility check, measured shift values are adjusted to average surveillance material chemistry and irradiation temperature as required See Table 4*

Table 4: Surry Unit 2 Plate Material C4339-1 (Combined Longitudinal and Transverse Data)

CF Determination

Beltline Material ID	Beltline Material Copper (wt%)	Beltline Material Nickel (wt%)	Irradiation Temperature (F)	Position 1 1 Chemistry Factor	Position 2 1 Chemistry Factor	Surveillance Data Credible or Non-Credible?	If Surv Data Non-Credible, Verify Conservatism of Position 1.1 CF *	Chemistry Factor Applied to Beltline Material **
Plate C4339-1	0 107	0 530	543.7	70 8	75 7	Non-Credible	0 0	70 8

** Measured shift values are adjusted to the average surveillance material chemistry and irradiation temperature, and are verified to be within 2 sigma of the trend curve based on RG 1 99 Rev 2 Position 1 1*

*** If surveillance data are non-credible but the Pos. 1 1 CF is shown to be conservative, the lower of the Pos 1.1 and Pos 2.1 chemistry factors is applied to the beltline material with a full margin term.*
If surveillance data are non-credible and the Pos 1 1 CF is shown to be non-conservative, the greater of the Pos 1.1 and Pos 2 1 chemistry factors is applied to the beltline material with a full margin term

Credibility Assessment

Capsule ID (Including Source)	(1) Temperature Correction Applied for Credibility?	(2) Chemistry Correction Applied for Credibility?	Surveillance Data Credible or Non-Credible?	(3) Temperature Correction Applied to Surv Data for Application to Beltline Material?	(4) Chemistry Correction Applied to Surv Data for Application to Beltline Material?	Conservatism Check for Pos 1.1 CF when Surv. Data Non-Credible: Adjusted Delta-RT(NDT) (F) *	Adjusted - Predicted Delta-RT(NDT) (F) *	Are adjusted surveillance data within 2 sigma of the applied CF trend curve? *
Surry Unit 2 Capsule X (Long)	No	No	Credible	No	No	59	13	Conservative
Surry Unit 2 Capsule V (Long)	No	No	Credible	No	No	79	-1	Conservative
Surry Unit 2 Capsule X (Trans)	No	No	Credible	No	No	49	3	Conservative
Surry Unit 2 Capsule V (Trans)	No	No	Non-Credible	No	No	64	-17	Conservative
Surry Unit 2 Capsule Y (Long)	No	No	Non-Credible	No	No	114	28	Conservative
Surry Unit 2 Capsule Y (Trans)	No	No	Credible	No	No	107	20	Conservative
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

(1) For the credibility determination, a temperature correction is not applied to measured values of transition temperature shift if applicable surveillance data were irradiated in a single reactor (i e , were irradiated at a similar temperature)
(2) For the credibility determination, a chemistry correction is not applied to measured values of transition temperature shift if applicable surveillance data were obtained from a single source (i e , were machined from the same block of material)
(3) For determination of the beltline material chemistry factor, a temperature correction is not applied to measured values of transition temperature shift if applicable surveillance data were irradiated in the reactor vessel which is being evaluated (i e , were irradiated at a similar temperature) A temperature correction is applied only in the conservative direction
(4) For determination of the beltline material chemistry factor, a chemistry correction (i e , ratio procedure) is not applied to measured values of transition temperature shift if the chemical composition of applicable surveillance data is essentially identical to the best-estimate chemical composition of the beltline material being evaluated

Table 5: CvUSE Data **Surry Unit 2 Plate Material C4339-1 (Combined Longitudinal and Transverse Data)**

Capsule ID (Including Source)	Fluence (x1E19)	Copper (wt%)	CvUSE (ft-lb)	CvUSE - Drop Measured %	CvUSE - Drop Predicted %	Delta-CvUSE %
Unirradiated Surv Material (Long)	0 00	0 10	128 00	-	-	-
Unirradiated Surv Material (Trans)	0 00	0 10	104 00	-	-	-
Surry Unit 2 Capsule X (Long)	0 30	0 10	122 00	4.7%	14 8%	-10 1%
Surry Unit 2 Capsule V (Long)	1 89	0 10	121 00	5 5%	22 6%	-17 1%
Surry Unit 2 Capsule X (Trans)	0 30	0 10	94 00	9 6%	14 8%	-5 1%
Surry Unit 2 Capsule V (Trans)	1 89	0 10	94 00	9 6%	22 6%	-12 9%
Surry Unit 2 Capsule Y (Long)	2 73	0 10	111 00	13 3%	24 4%	-11.1%
Surry Unit 2 Capsule Y (Trans)	2 73	0.10	94 00	9 6%	24 4%	-14 8%
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Table 2: **Surry Unit 2 Weld Material R3008**

Capsule ID (Including Source)	Copper (wt%)	Nickel (wt%)	Irradiation Temperature (F)	Fluence (x1E19)	Measured Delta-RT(NDT) (F)	Data Used In Assessing Vessel? (Yes or No)
Surry Unit 2 Capsule X	0 187	0 545	534 9	0 297	96	Yes
Surry Unit 2 Capsule V	0 187	0 545	540 1	1 890	140	Yes
Surry Unit 2 Capsule Y	0 187	0 545	543 7	2.730	178	Yes
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Table 3: **Surry Unit 2 Weld Material R3008**

Capsule ID (Including Source)	Copper (wt%)	Nickel (wt%)	Irradiation Temperature (F)	Fluence Factor	Measured Delta-RT(NDT) (F)	Adjusted Delta-RT(NDT) (F) *	Adjusted - Predicted Delta-RT(NDT) (F) *
Surry Unit 2 Capsule X	0 187	0 545	534 9	0 6677	96	96	7
Surry Unit 2 Capsule V	0 187	0 545	540 1	1.1743	140	140	-15
Surry Unit 2 Capsule Y	0 187	0 545	543 7	1 2679	178	178	10
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

** For credibility check, measured shift values are adjusted to average surveillance material chemistry and irradiation temperature as required See Table 4*

Table 4: **Surry Unit 2 Weld Material R3008**

CF Determination

Beltline Material ID	Beltline Material Copper (wt%)	Beltline Material Nickel (wt%)	Irradiation Temperature (F)	Position 1 1 Chemistry Factor	Position 2 1 Chemistry Factor	Surveillance Data Credible or Non-Credible?	If Surv Data Non-Credible, Verify Conservatism of Position 1 1 CF *	Chemistry Factor Applied to Beltline Material **
R3008	0 187	0 545	543 7	147 5	132.4	Credible	-	132 4

** Measured shift values are adjusted to the average surveillance material chemistry and irradiation temperature, and are verified to be within 2 sigma of the trend curve based on RG 1 99 Rev 2 Position 1 1*

*** If surveillance data are non-credible but the Pos 1.1 CF is shown to be conservative, the lower of the Pos 1.1 and Pos 2 1 chemistry factors is applied to the beltline material with a full margin term.*
If surveillance data are non-credible and the Pos 1 1 CF is shown to be non-conservative, the greater of the Pos 1 1 and Pos 2 1 chemistry factors is applied to the beltline material with a full margin term

Credibility Assessment

						Conservatism Check for Pos 1 1 CF when Surv Data Non-Credible		
Capsule ID (Including Source)	(1) Temperature Correction Applied for Credibility?	(2) Chemistry Correction Applied for Credibility?	Surveillance Data Credible or Non-Credible?	(3) Temperature Correction Applied to Surv. Data for Application to Beltline Material?	(4) Chemistry Correction Applied to Surv. Data for Application to Beltline Material?	Adjusted Delta-RT(NDT) (F) *	Adjusted - Predicted Delta-RT(NDT) (F) *	Are adjusted surveillance data within 2 sigma of the applied CF trend curve? *
Surry Unit 2 Capsule X	No	No	Credible	No	No	-	-	-
Surry Unit 2 Capsule V	No	No	Credible	No	No	-	-	-
Surry Unit 2 Capsule Y	No	No	Credible	No	No	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

(1) For the credibility determination, a temperature correction is not applied to measured values of transition temperature shift if applicable surveillance data were irradiated in a single reactor (i e , were irradiated at a similar temperature)
(2) For the credibility determination, a chemistry correction is not applied to measured values of transition temperature shift if applicable surveillance data were obtained from a single source (i e , were machined from the same block of material).
(3) For determination of the beltline material chemistry factor, a temperature correction is not applied to measured values of transition temperature shift if applicable surveillance data were irradiated in the reactor vessel which is being evaluated (i e , were irradiated at a similar temperature) A temperature correction is applied only in the conservative direction
(4) For determination of the beltline material chemistry factor, a chemistry correction (i e , ratio procedure) is not applied to measured values of transition temperature shift if the chemical composition of applicable surveillance data is essentially identical to the best-estimate chemical composition of the beltline material being evaluated

Table 5: CvUSE Data **Surry Unit 2 Weld Material R3008**

Capsule ID (Including Source)	Fluence (x1E19)	Copper (wt%)	CvUSE (ft-lb)	CvUSE - Drop Measured %	CvUSE - Drop Predicted %	Delta-CvUSE %
Unirradiated Surv Material	0 00	0 19	91 00	-	-	-
Surry Unit 2 Capsule X	0 30	0 19	71.00	22 0%	24 6%	-2 7%
Surry Unit 2 Capsule V	1 89	0 19	60 00	34 1%	37 8%	-3 7%
Surry Unit 2 Capsule Y	2 73	0 19	58 00	36 3%	40 9%	-4 6%
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
			-	-	-	-

Table 2: **Surry Unit 1 and 2 Weld Material SA-1585 (Point Beach 1 Data Only)**

Capsule ID (Including Source)	Copper (wt%)	Nickel (wt%)	Irradiation Temperature (F)	Fluence (x1E19)	Measured Delta-RT(NDT) (F)	Data Used In Assessing Vessel? (Yes or No)
Point Beach Unit 1 Capsule T	0 230	0 615	533 4	2 230	181	Yes
Point Beach Unit 1 Capsule R	0 230	0 615	541 6	2 190	155	Yes
Point Beach Unit 1 Capsule S	0 230	0 615	542 0	0 829	165	Yes
Point Beach Unit 1 Capsule V	0 230	0 615	542 0	0 634	107	Yes
Capsule CR3-LG2 (BWOG CR-3 Irrad)	0 220	0 590	556 0	1 670	164	No
Capsule CR3-LG1 (BWOG CR-3 Irrad)	0 220	0 590	556 0	0 510	139	No
Capsule W-1 (ANO-1 NBD)	0 220	0 590	546 3	0 660	138	No
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-

Table 3: **Surry Unit 1 and 2 Weld Material SA-1585 (Point Beach 1 Data Only)**

Capsule ID (Including Source)	Copper (wt%)	Nickel (wt%)	Irradiation Temperature (F)	Fluence Factor	Measured Delta-RT(NDT) (F)	Adjusted Delta-RT(NDT) (F) *	Adjusted - Predicted Delta-RT(NDT) (F) *
Point Beach Unit 1 Capsule T	0 230	0 615	533 4	1 2173	181	181	7
Point Beach Unit 1 Capsule R	0 230	0 615	541 6	1 2126	155	155	-18
Point Beach Unit 1 Capsule S	0 230	0 615	542 0	0 9474	165	165	30
Point Beach Unit 1 Capsule V	0 230	0 615	542 0	0 8723	107	107	-17
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-

** For credibility check, measured shift values are adjusted to average surveillance material chemistry and irradiation temperature as required See Table 4.*

Table 4: Surry Unit 1 and 2 Weld Material SA-1585 (Point Beach 1 Data Only)

CF Determination

Beltline Material ID	Beltline Material Copper (wt%)	Beltline Material Nickel (wt%)	Irradiation Temperature (F)	Position 1 1 Chemistry Factor	Position 2.1 Chemistry Factor	Surveillance Data Credible or Non-Credible?	If Surv Data Non-Credible, Verify Conservatism of Position 1.1 CF *	Chemistry Factor Applied to Beltline Material **
SA-1585/72445	0 220	0 540	542 0	158 0	131 4	Non-Credible	0 0	131 4

** Measured shift values are adjusted to the average surveillance material chemistry and irradiation temperature, and are verified to be within 2 sigma of the trend curve based on RG 1 99 Rev. 2 Position 1.1.*

*** If surveillance data are non-credible but the Pos 1 1 CF is shown to be conservative, the lower of the Pos 1.1 and Pos 2.1 chemistry factors is applied to the beltline material with a full margin term.*
If surveillance data are non-credible and the Pos 1 1 CF is shown to be non-conservative, the greater of the Pos 1.1 and Pos 2.1 chemistry factors is applied to the beltline material with a full margin term

Credibility Assessment

Capsule ID (Including Source)	(1) Temperature Correction Applied for Credibility?	(2) Chemistry Correction Applied for Credibility?	Surveillance Data Credible or Non-Credible?	(3) Temperature Correction Applied to Surv Data for Application to Beltline Material?	(4) Chemistry Correction Applied to Surv Data for Application to Beltline Material?	Conservatism Check for Pos 1 1 CF when Surv Data Non-Credible: Adjusted Delta-RT(NDT) (F) *	Adjusted - Predicted Delta-RT(NDT) (F) *	Are adjusted surveillance data within 2 sigma of the applied CF trend curve? *
Point Beach Unit 1 Capsule T	No	No	Credible	Yes	Yes	181	-28	Conservative
Point Beach Unit 1 Capsule R	No	No	Credible	Yes	Yes	155	-53	Conservative
Point Beach Unit 1 Capsule S	No	No	Non-Credible	Yes	Yes	165	2	Conservative
Point Beach Unit 1 Capsule V	No	No	Credible	Yes	Yes	107	-43	Conservative
Capsule CR3-LG2 (BWOG CR-3 Irrad)	-	-	-	-	-	-	-	-
Capsule CR3-LG1 (BWOG CR-3 Irrad)	-	-	-	-	-	-	-	-
Capsule W-1 (ANO-1 NBD)	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-

(1) For the credibility determination, a temperature correction is not applied to measured values of transition temperature shift if applicable surveillance data were irradiated in a single reactor (i e , were irradiated at a similar temperature)
(2) For the credibility determination, a chemistry correction is not applied to measured values of transition temperature shift if applicable surveillance data were obtained from a single source (i e , were machined from the same block of material)
(3) For determination of the beltline material chemistry factor, a temperature correction is not applied to measured values of transition temperature shift if applicable surveillance data were irradiated in the reactor vessel which is being evaluated (i e , were irradiated at a similar temperature) A temperature correction is applied only in the conservative direction
(4) For determination of the beltline material chemistry factor, a chemistry correction (i e , ratio procedure) is not applied to measured values of transition temperature shift if the chemical composition of applicable surveillance data is essentially identical to the best-estimate chemical composition of the beltline material being evaluated.

Table 5: CvUSE Data **Surry Unit 1 and 2 Weld Material SA-1585 (Point Beach 1 Data Only)**

Capsule ID (Including Source)	Fluence (x1E19)	Copper (wt%)	CvUSE (ft-lb)	CvUSE - Drop Measured %	CvUSE - Drop Predicted %	Delta-CvUSE %
Unirradiated Surv Material (Long) SA-1263	0 00	0 23	66 00	-	-	-
Unirradiated Surv Material (Long) SA-1585	0 00	0 23	79 00	-	-	-
Point Beach Unit 1 Capsule T	2 23	0 23	55 00	16 7%	44 3%	-27.7%
Point Beach Unit 1 Capsule R	2.19	0 23	52 00	21 2%	44 2%	-23 0%
Point Beach Unit 1 Capsule S	0 83	0 23	52 00	21 2%	35 3%	-14 1%
Point Beach Unit 1 Capsule V	0 63	0 23	53 00	19 7%	33 3%	-13 6%
Capsule CR3-LG2 (BWOG CR-3 Irrad)	1 67	0 22	53 00	32 9%	41 4%	-8 5%
Capsule CR3-LG1 (BWOG CR-3 Irrad)	0 51	0 22	56 00	29 1%	31 8%	-2 7%
Capsule W-1 (ANO-1 NBD)	0 66	0 22	51 00	35 4%	33 6%	1 8%
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-