CAPSULE 83° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0; Hyperbolic Tangent Curve Printed on 12/1/2014 1:18 PM

A = 38.18 B = 37.18 C = 84.59 T0 = 82.80 D = 0.00

Correlation Coefficient = 0.937

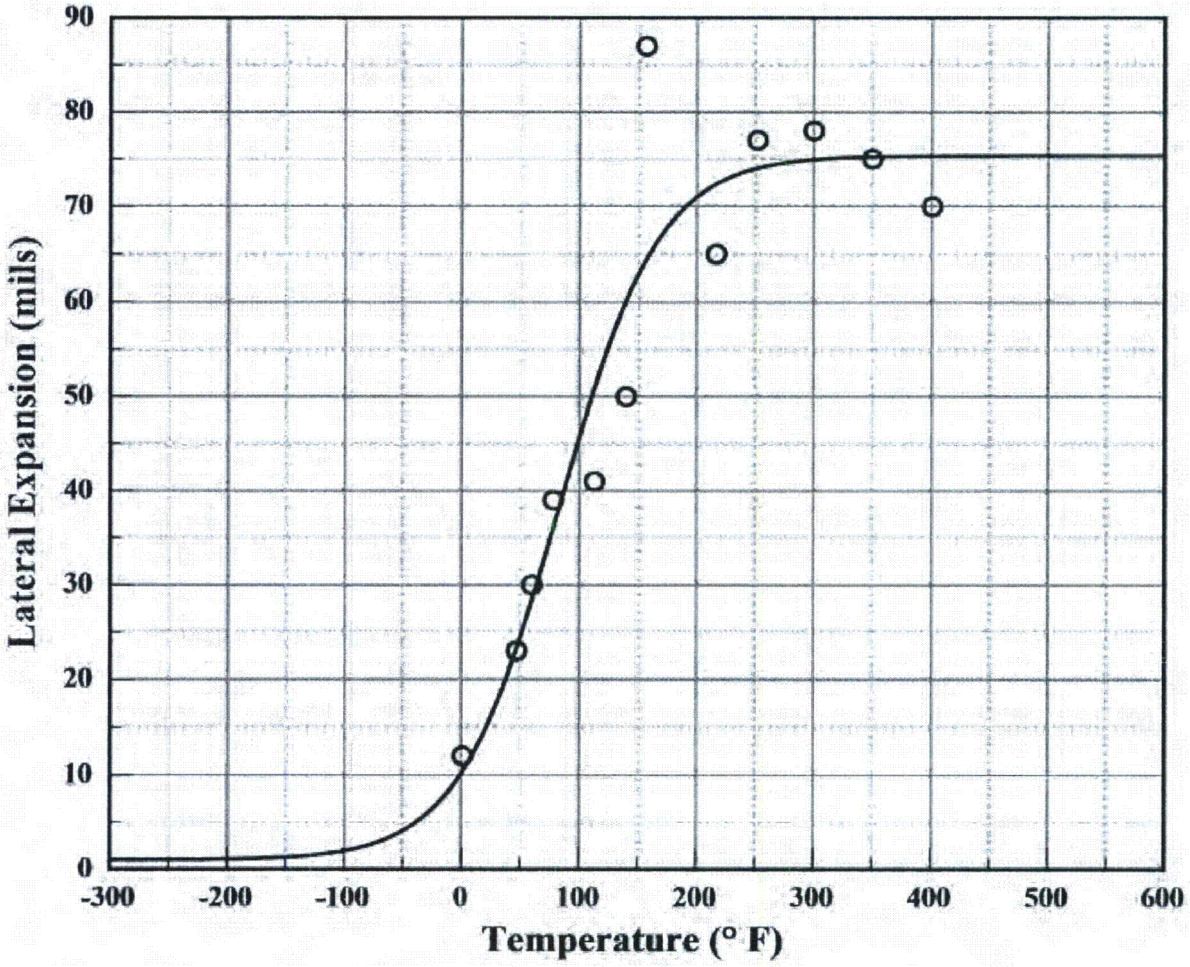
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 75.37 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= 75.60° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 83° Fluence:

CAPSULE 83° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
1	12.0	10.4	1.61
47	23.0	23.3	-0.32
60	30.0	28.4	1.60
78	39.0	36.1	2.92
113	41.0	50.9	-9.92
140	50.0	60.1	-10.09
157	87.0	64.4	22.60
217	65.0	72.4	-7.38
252	77.0	74.0	2.97
300	78.0	74.9	3.07
350	75.0	75.2	-0.23
401	70.0	75.3	-5.33

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 83° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:24 PM

A = 50.00 B = 50.00 C = 115.59 T0 = 169.55 D = 0.00

Correlation Coefficient = 0.937

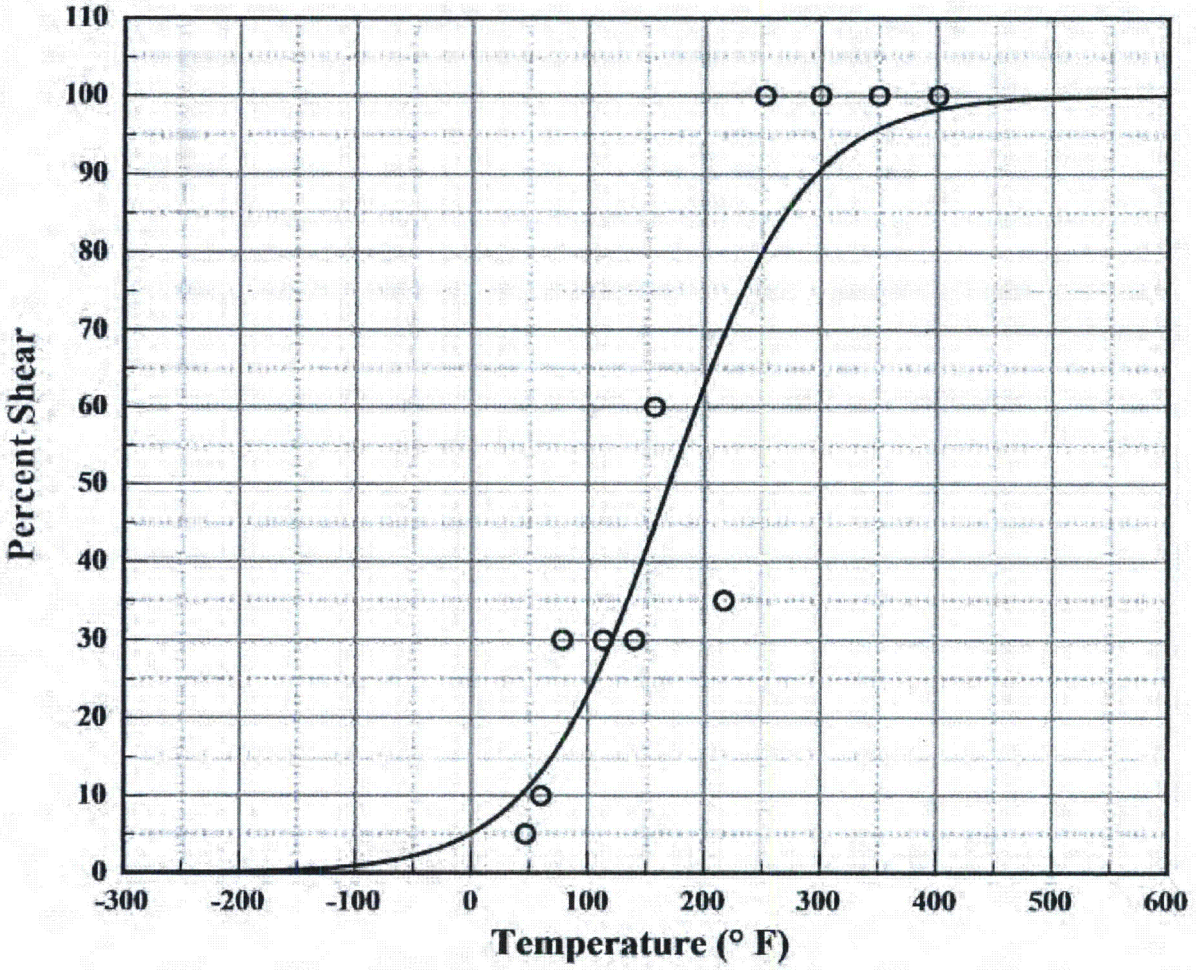
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 169.60

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 83° Fluence:

CAPSULE 83° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
1	0.0	5.1	-5.14
47	5.0	10.7	-5.71
60	10.0	13.1	-3.06
78	30.0	17.0	12.98
113	30.0	27.3	2.68
140	30.0	37.5	-7.49
157	60.0	44.6	15.41
217	35.0	69.4	-34.44
252	100.0	80.6	19.36
300	100.0	90.5	9.47
350	100.0	95.8	4.22
401	100.0	98.2	1.79

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 83° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:27 PM

A = 51.10 B = 48.90 C = 65.83 T0 = -4.33 D = 0.00

Correlation Coefficient = 0.959

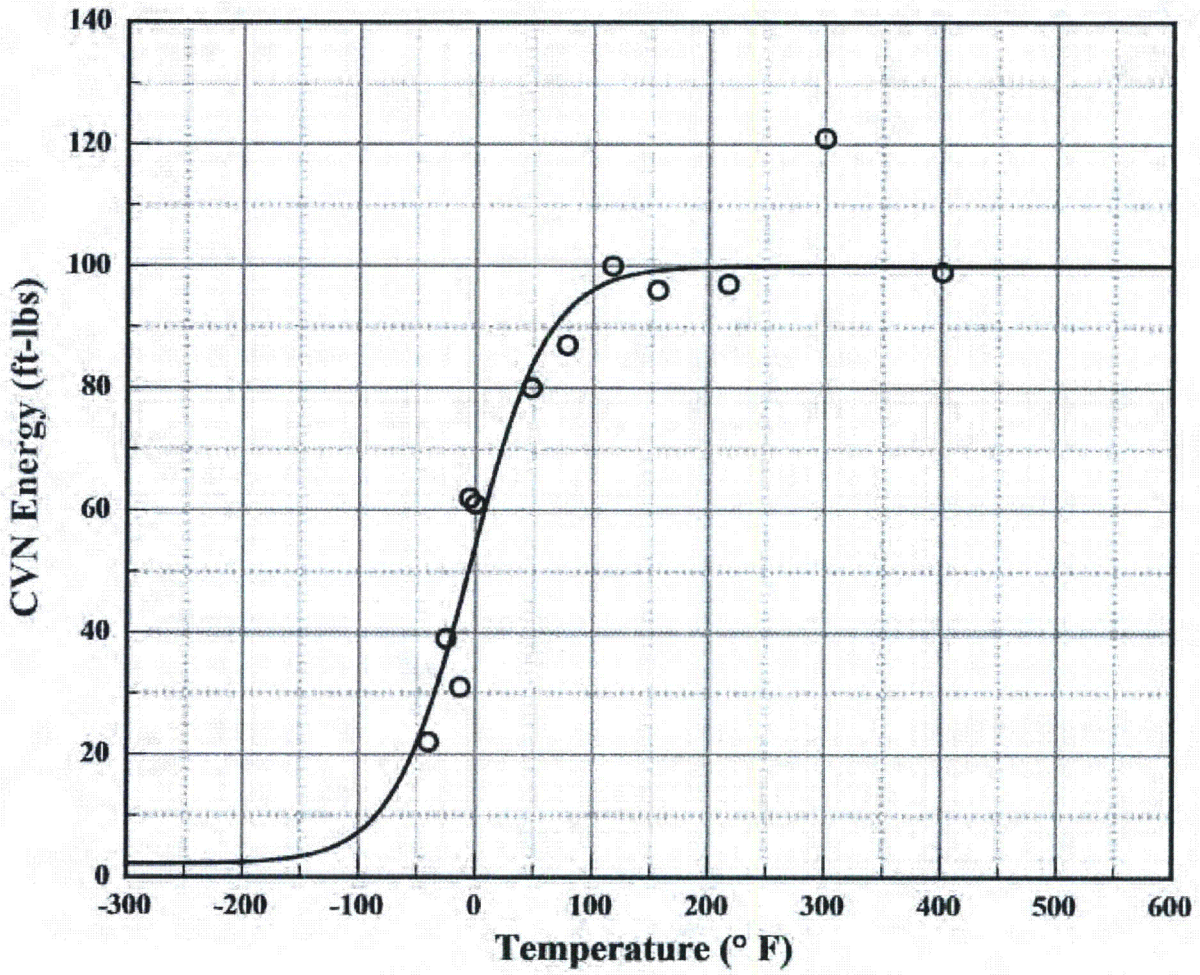
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 100.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=-34.70° F Temp@35 ft-lbs=-26.80° F Temp@50 ft-lbs= -5.80° F

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 83° Fluence:

CAPSULE 83° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-40	22.0	26.9	-4.93
-25	39.0	36.2	2.77
-13	31.0	44.7	-13.70
-5	62.0	50.6	11.39
0	61.0	54.3	6.68
48	80.0	83.4	-3.44
78	87.0	92.6	-5.59
117	100.0	97.6	2.39
156	96.0	99.3	-3.26
217	97.0	99.9	-2.88
300	121.0	100.0	21.01
401	99.0	100.0	-1.00

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 83° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:34 PM

A = 41.43 B = 40.43 C = 76.80 T0 = -3.71 D = 0.00

Correlation Coefficient = 0.973

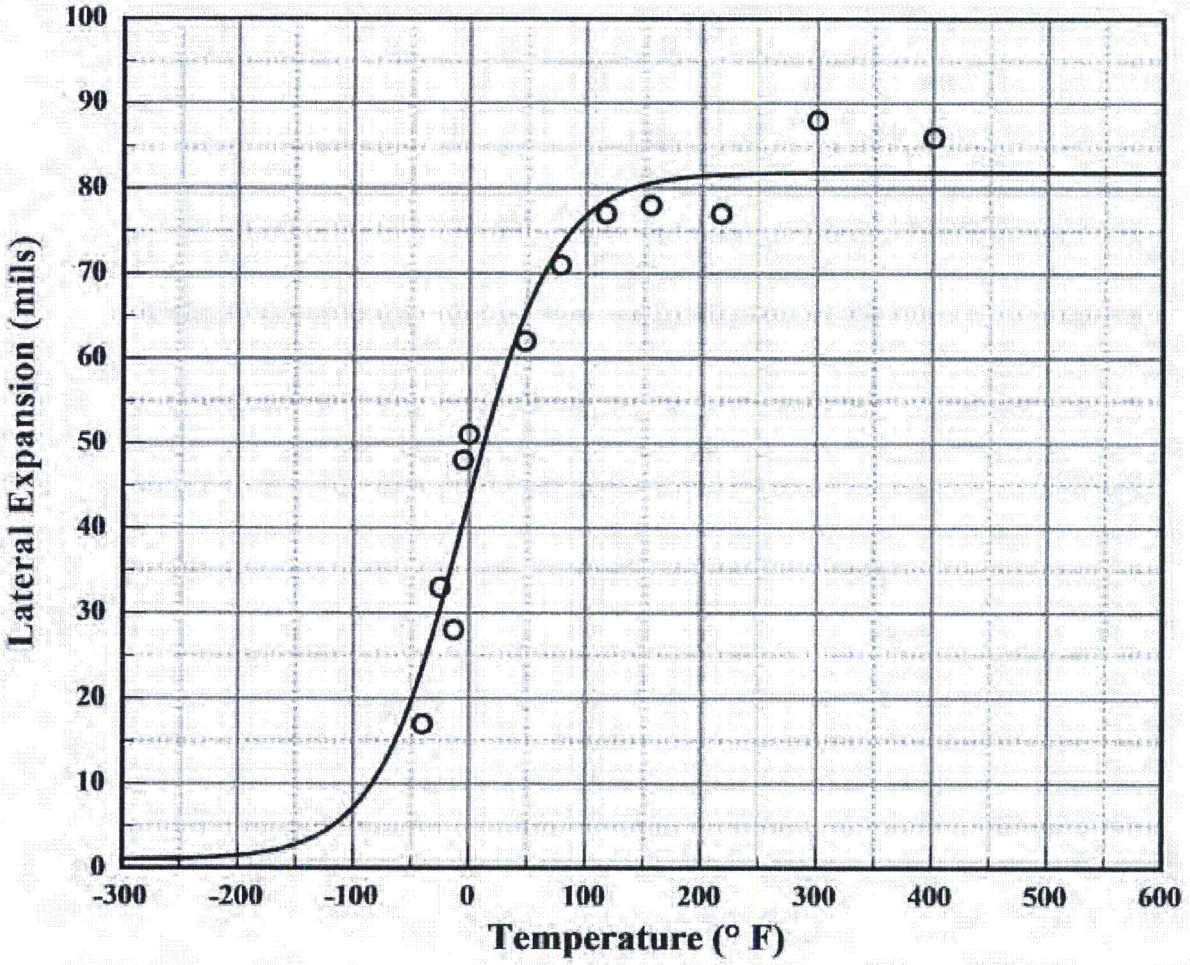
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 81.86 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=-16.00° F

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 83° Fluence:

CAPSULE 83° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-40	17.0	23.6	-6.63
-25	33.0	30.5	2.50
-13	28.0	36.6	-8.56
-5	48.0	40.8	7.25
0	51.0	43.4	7.62
48	62.0	65.2	-3.17
78	71.0	73.3	-2.26
117	77.0	78.5	-1.52
156	78.0	80.6	-2.62
217	77.0	81.6	-4.60
300	88.0	81.8	6.17
401	86.0	81.9	4.14

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 83° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:37 PM

A = 50.00 B = 50.00 C = 53.68 T0 = 10.76 D = 0.00

Correlation Coefficient = 0.974

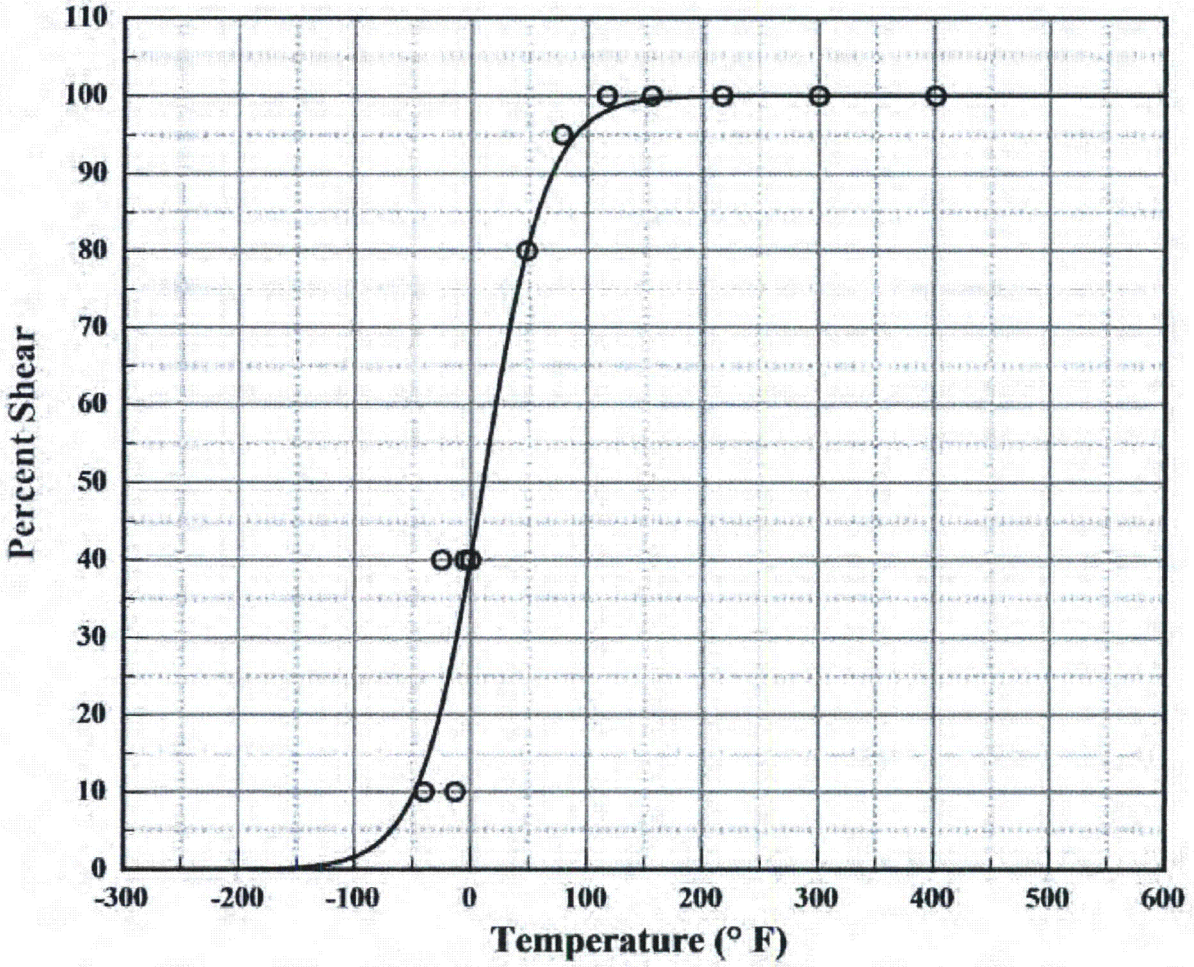
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 10.80

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 83° Fluence:

CAPSULE 83° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-40	10.0	13.1	-3.11
-25	40.0	20.9	19.12
-13	10.0	29.2	-19.21
-5	40.0	35.7	4.27
0	40.0	40.1	-0.11
48	80.0	80.0	-0.02
78	95.0	92.4	2.55
117	100.0	98.1	1.87
156	100.0	99.6	0.44
217	100.0	100.0	0.05
300	100.0	100.0	0.00
401	100.0	100.0	0.00

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CAPSULE 83° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:39 PM

A = 60.60 B = 58.40 C = 180.77 T0 = 53.59 D = 0.00

Correlation Coefficient = 0.662

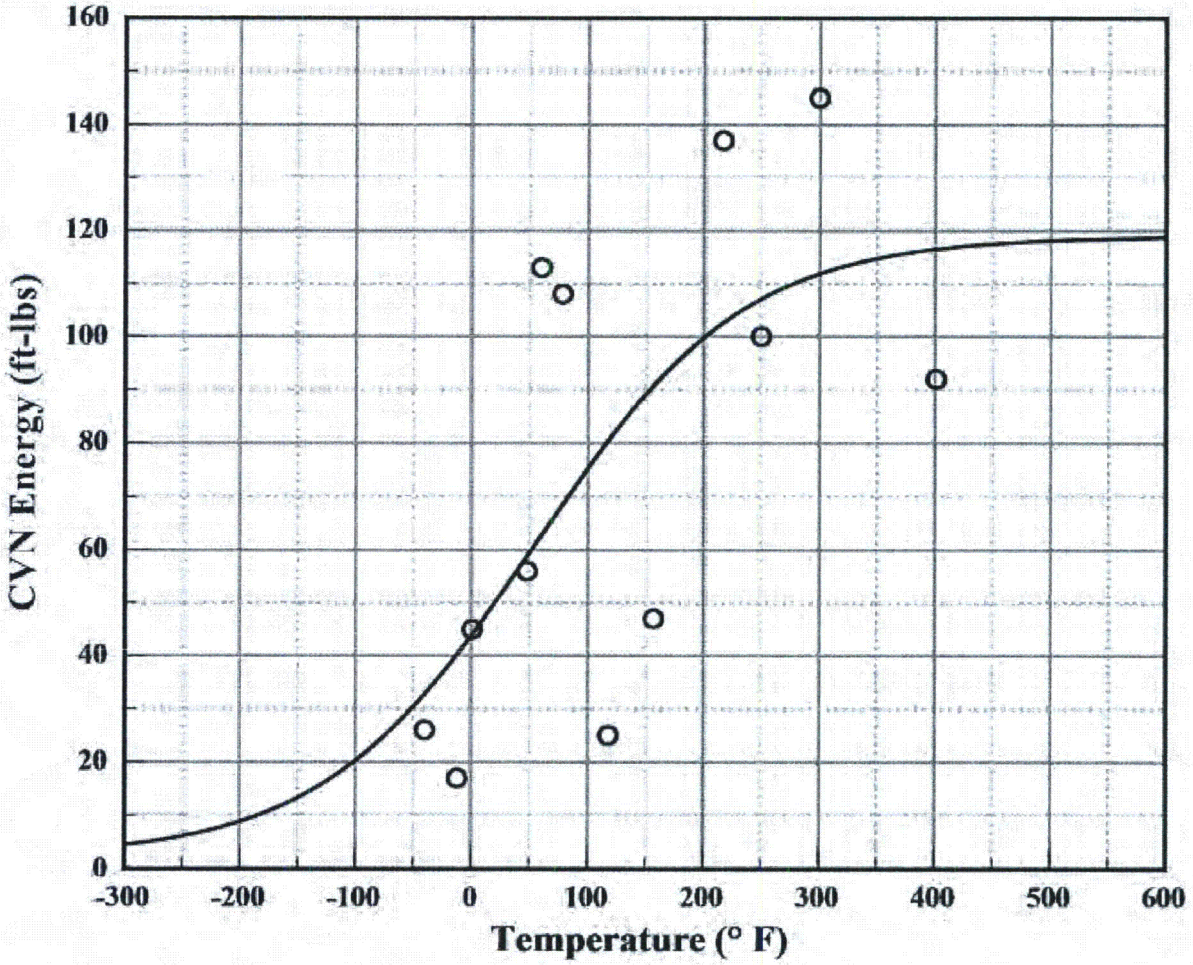
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 119.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=-51.50° F Temp@35 ft-lbs=-31.40° F Temp@50 ft-lbs= 20.50° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 83° Fluence:

CAPSULE 83° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-40	26.0	32.8	-6.80
-12	17.0	40.3	-23.29
1	45.0	44.1	0.93
48	56.0	58.8	-2.79
60	113.0	62.7	50.33
78	108.0	68.4	39.56
118	25.0	80.6	-55.57
157	47.0	90.8	-43.78
217	137.0	102.5	34.46
250	100.0	107.1	-7.06
300	145.0	111.8	33.18
401	92.0	116.6	-24.55

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CAPSULE 83° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:45 PM

A = 36.45 B = 35.45 C = 132.83 T0 = 16.72 D = 0.00

Correlation Coefficient = 0.735

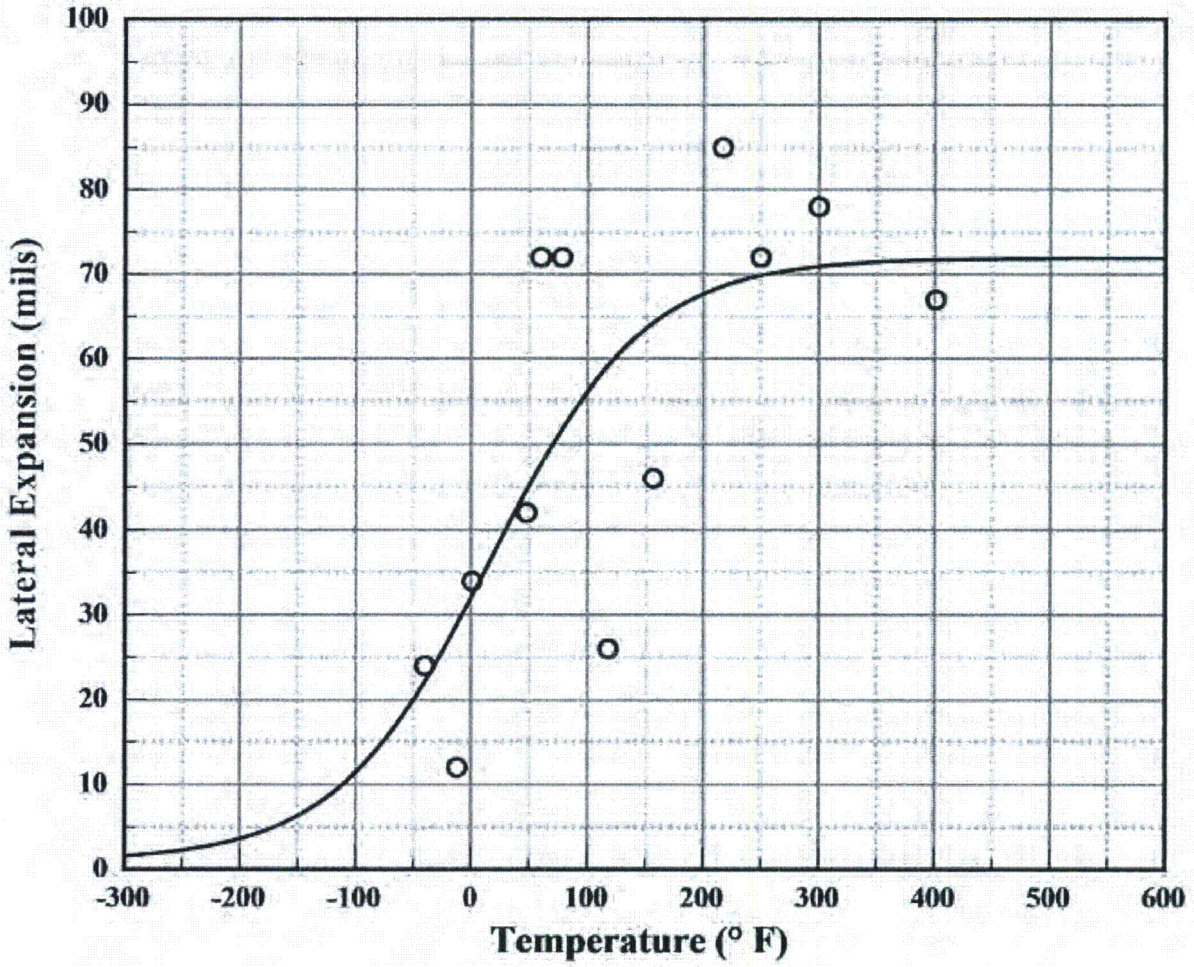
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 71.91 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= 11.30° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 83° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 83° Fluence:

CAPSULE 83° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-40	24.0	22.2	1.83
-12	12.0	28.9	-16.90
1	34.0	32.3	1.72
48	42.0	44.7	-2.65
60	72.0	47.6	24.39
78	72.0	51.7	20.26
118	26.0	59.2	-33.23
157	46.0	64.3	-18.25
217	85.0	68.6	16.41
250	72.0	69.9	2.15
300	78.0	70.9	7.08
401	67.0	71.7	-4.69

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CAPSULE 83° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 1:51 PM

A = 50.00 B = 50.00 C = 148.77 T0 = 61.46 D = 0.00

Correlation Coefficient = 0.828

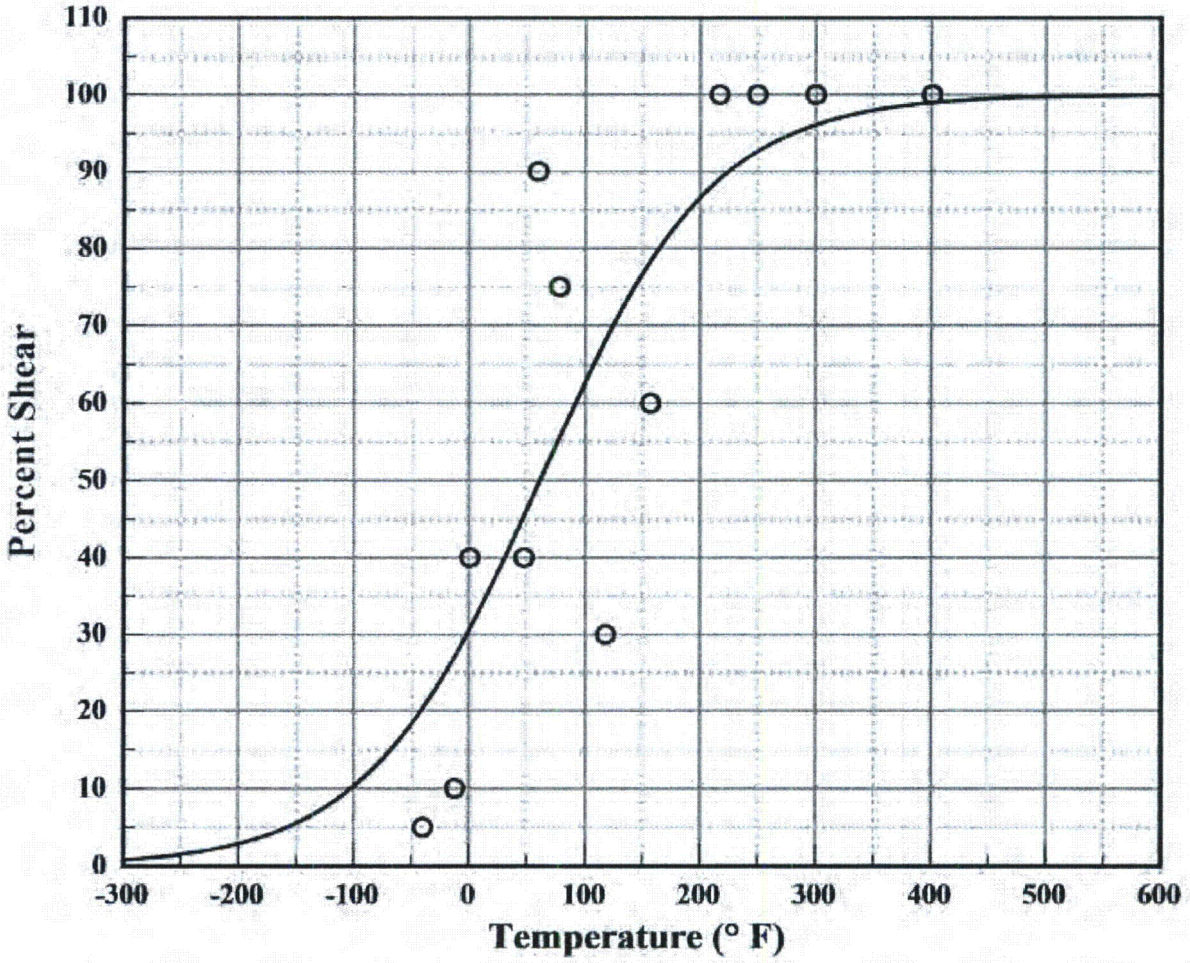
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 61.50

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 83° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 83° Fluence:

CAPSULE 83° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-40	5.0	20.4	-15.36
-12	10.0	27.1	-17.14
1	40.0	30.7	9.27
48	40.0	45.5	-5.49
60	90.0	49.5	40.49
78	75.0	55.5	19.46
118	30.0	68.1	-38.14
157	60.0	78.3	-18.32
217	100.0	89.0	11.00
250	100.0	92.7	7.35
300	100.0	96.1	3.89
401	100.0	99.0	1.03

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 263° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:36 PM

A = 40.60 B = 38.40 C = 91.96 T0 = 159.08 D = 0.00

Correlation Coefficient = 0.955

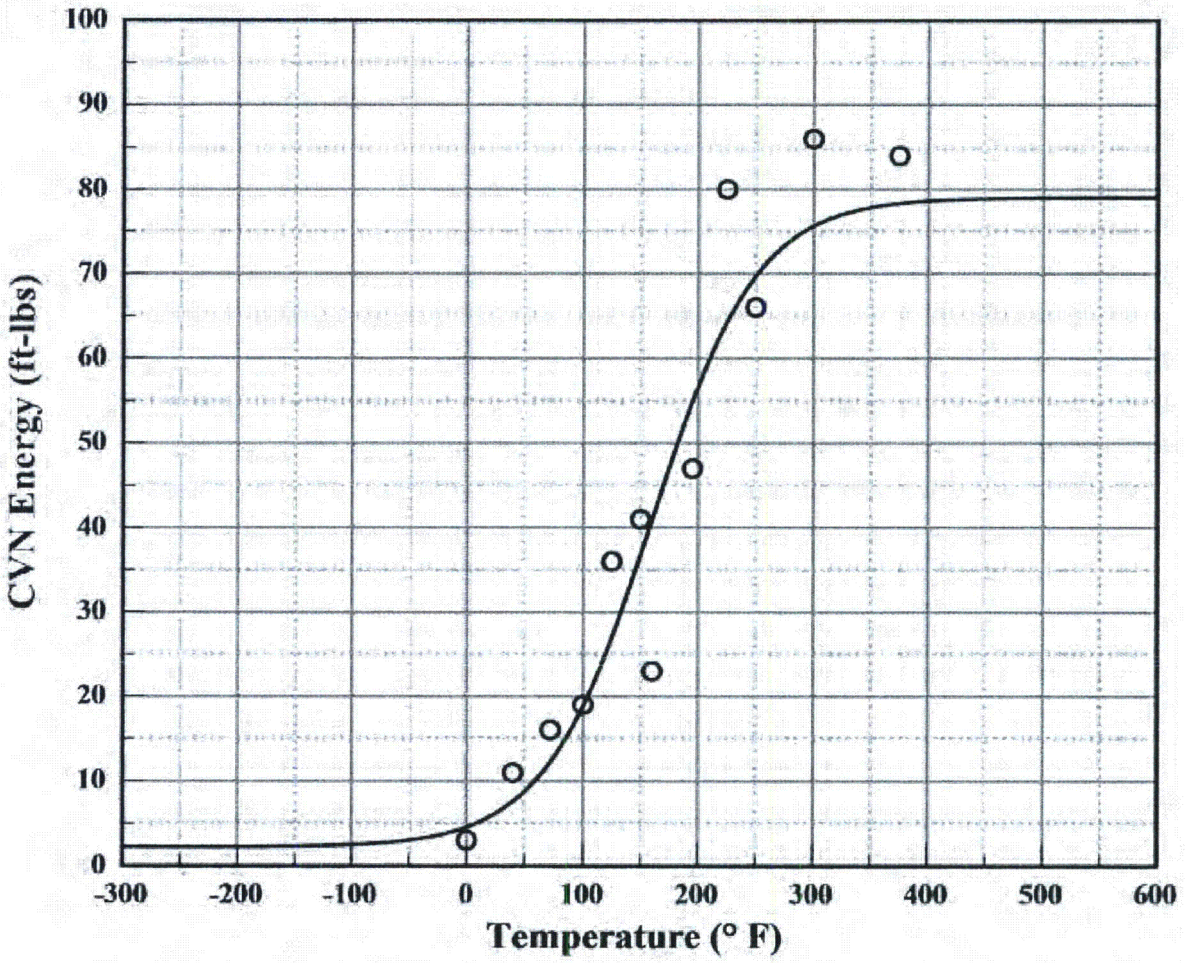
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 79.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=133.10° F Temp@35 ft-lbs=145.60° F Temp@50 ft-lbs=182.10° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 263° Fluence:

CAPSULE 263° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
0	3.0	4.5	-1.54
40	11.0	7.6	3.44
72	16.0	12.2	3.75
100	19.0	18.8	0.16
125	36.0	27.0	9.01
150	41.0	36.8	4.18
160	23.0	41.0	-17.98
195	47.0	54.9	-7.88
225	80.0	64.2	15.78
250	66.0	69.7	-3.66
300	86.0	75.6	10.42
375	84.0	78.3	5.69

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CAPSULE 263° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:41 PM

A = 43.37 B = 42.37 C = 115.12 T0 = 177.75 D = 0.00

Correlation Coefficient = 0.969

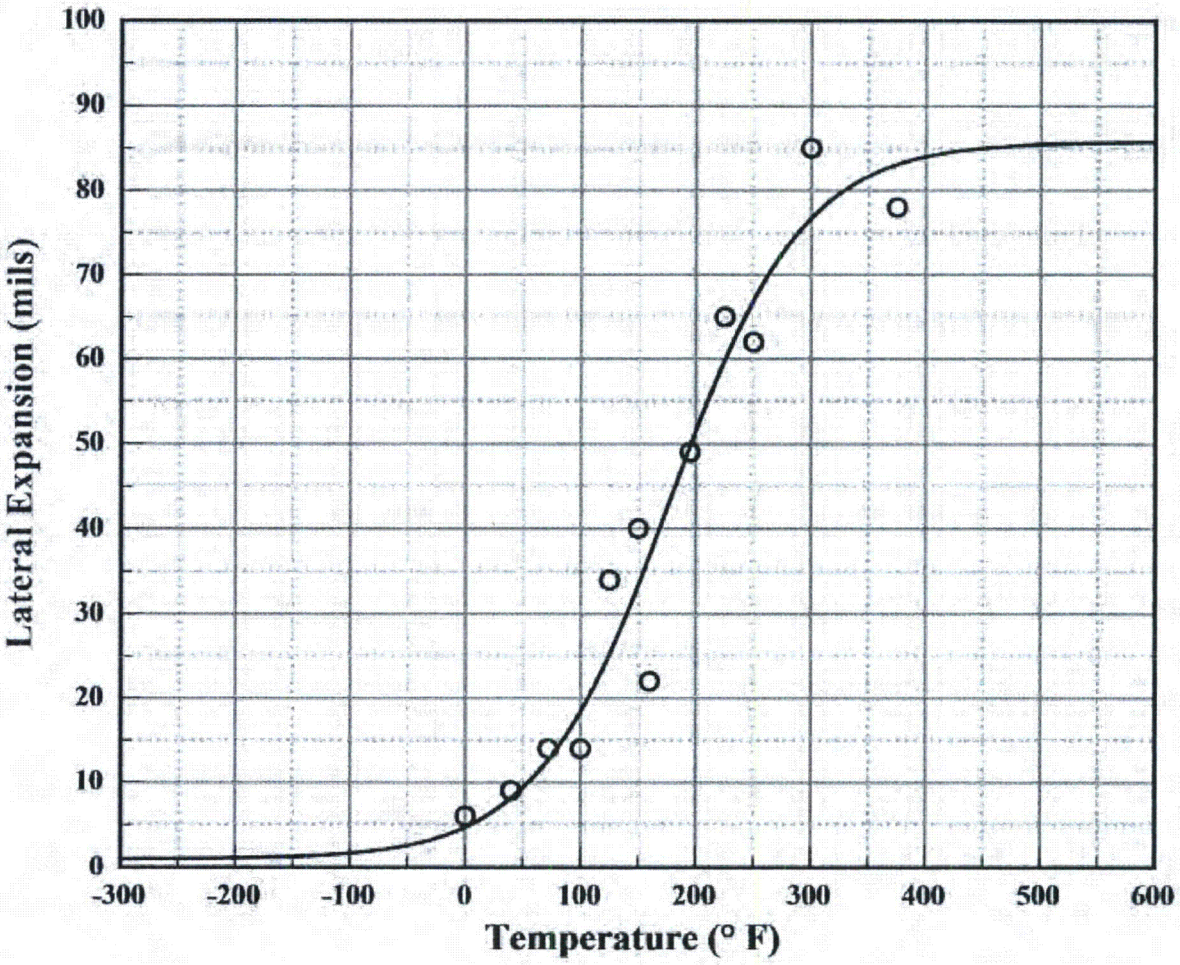
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 85.74 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=154.80° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 263° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 263° Fluence:

CAPSULE 263° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
0	6.0	4.7	1.30
40	9.0	8.1	0.91
72	14.0	12.6	1.36
100	14.0	18.4	-4.44
125	34.0	25.2	8.79
150	40.0	33.4	6.65
160	22.0	36.9	-14.89
195	49.0	49.7	-0.67
225	65.0	59.8	5.15
250	62.0	66.9	-4.95
300	85.0	76.7	8.31
375	78.0	83.1	-5.07

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CAPSULE 263° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:43 PM

A = 50.00 B = 50.00 C = 69.76 T0 = 175.16 D = 0.00

Correlation Coefficient = 0.962

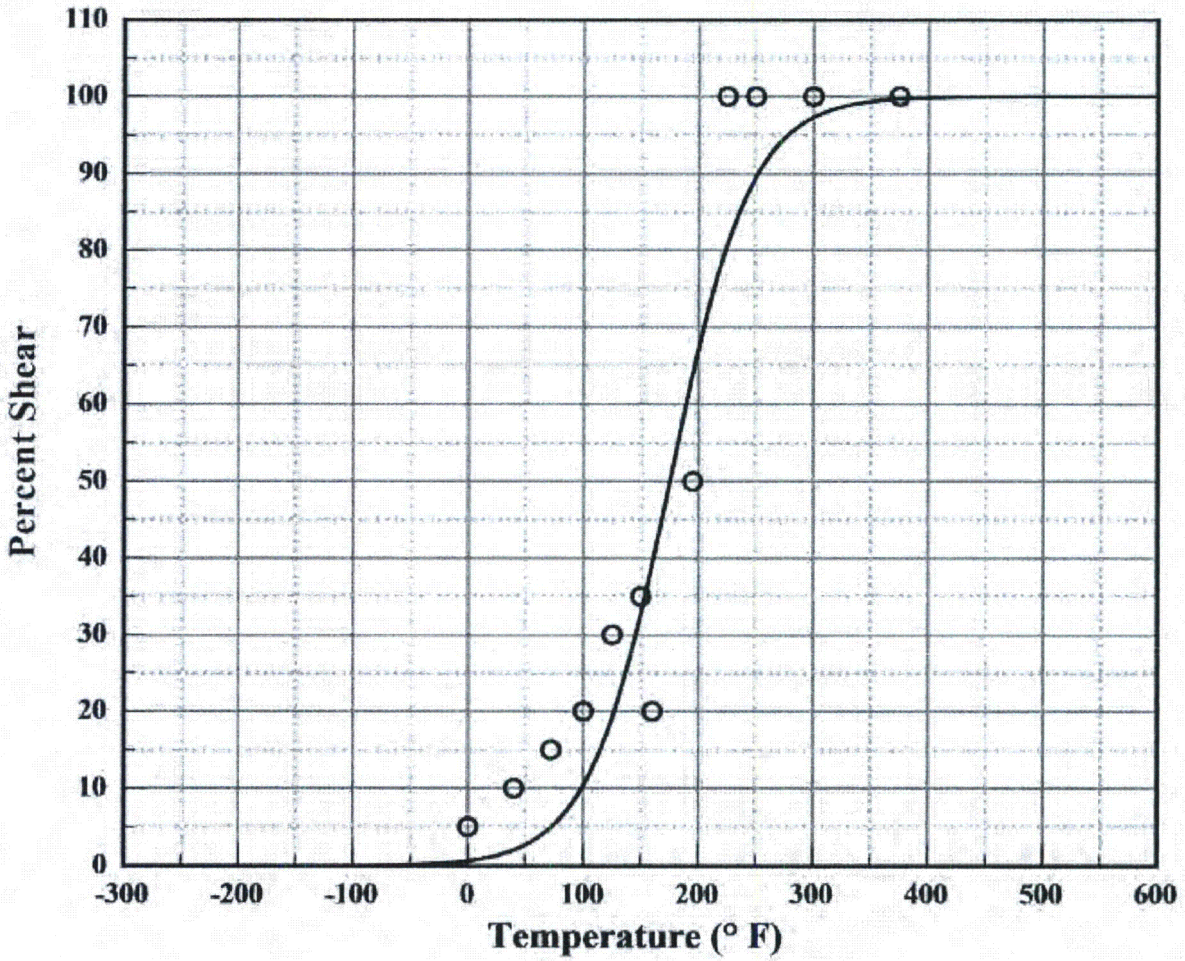
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 175.20

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 263° Fluence:

CAPSULE 263° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
0	5.0	0.7	4.35
40	10.0	2.0	7.97
72	15.0	4.9	10.06
100	20.0	10.4	9.61
125	30.0	19.2	10.82
150	35.0	32.7	2.29
160	20.0	39.3	-19.30
195	50.0	63.9	-13.85
225	100.0	80.7	19.32
250	100.0	89.5	10.47
300	100.0	97.3	2.71
375	100.0	99.7	0.32

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 263° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:45 PM

A = 53.60 B = 51.40 C = 101.75 T0 = 26.49 D = 0.00

Correlation Coefficient = 0.966

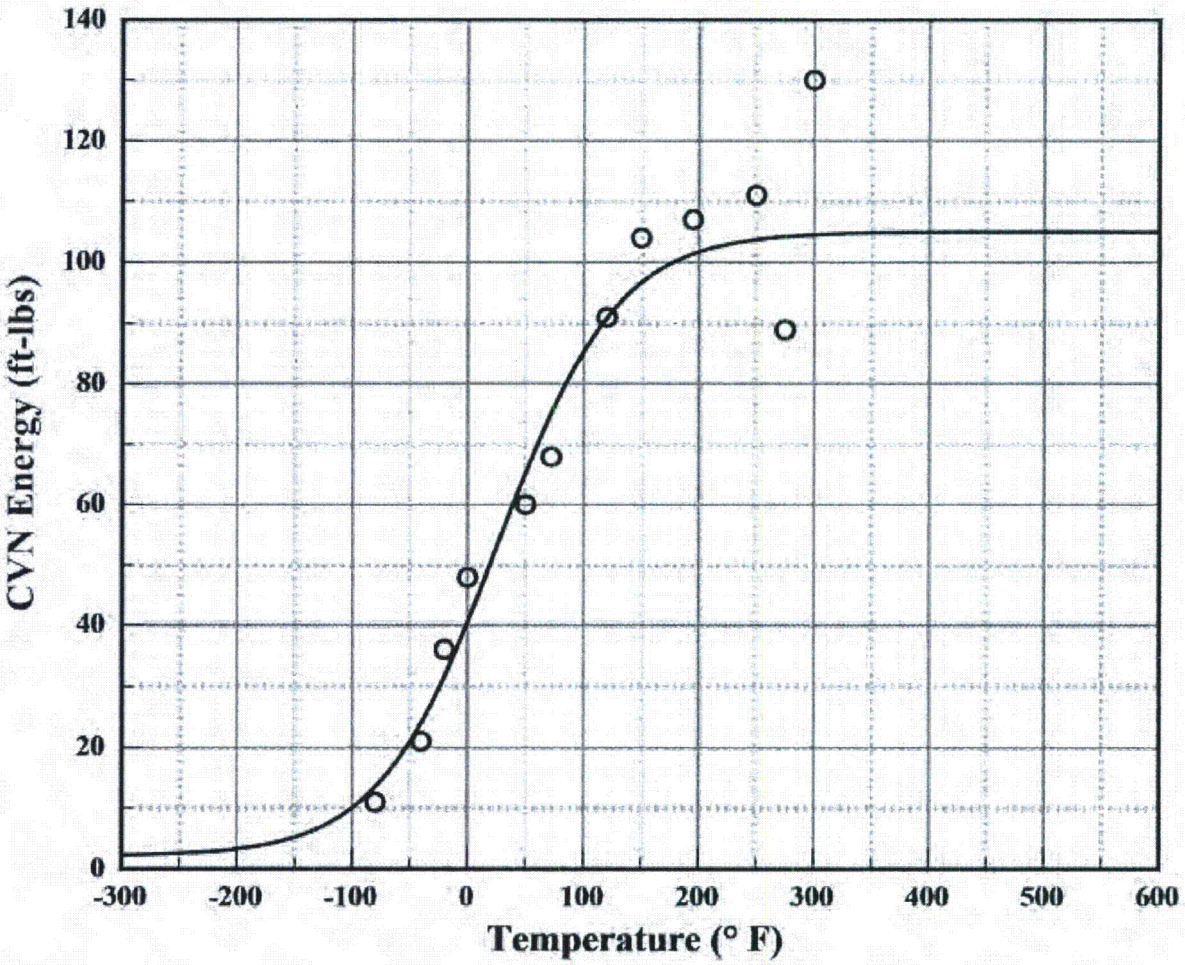
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 105.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=-24.00° F Temp@35 ft-lbs=-12.00° F Temp@50 ft-lbs= 19.40° F

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 263° Fluence:

CAPSULE 263° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-80	11.0	13.5	-2.48
-40	21.0	24.1	-3.10
-20	36.0	31.6	4.38
0	48.0	40.5	7.49
50	60.0	65.3	-5.27
72	68.0	75.2	-7.17
120	91.0	90.9	0.11
150	104.0	96.7	7.34
195	107.0	101.4	5.61
250	111.0	103.7	7.26
275	89.0	104.2	-15.23
300	130.0	104.5	25.47

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CAPSULE 263° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:48 PM

A = 57.58 B = 56.58 C = 116.98 T0 = 48.32 D = 0.00

Correlation Coefficient = 0.967

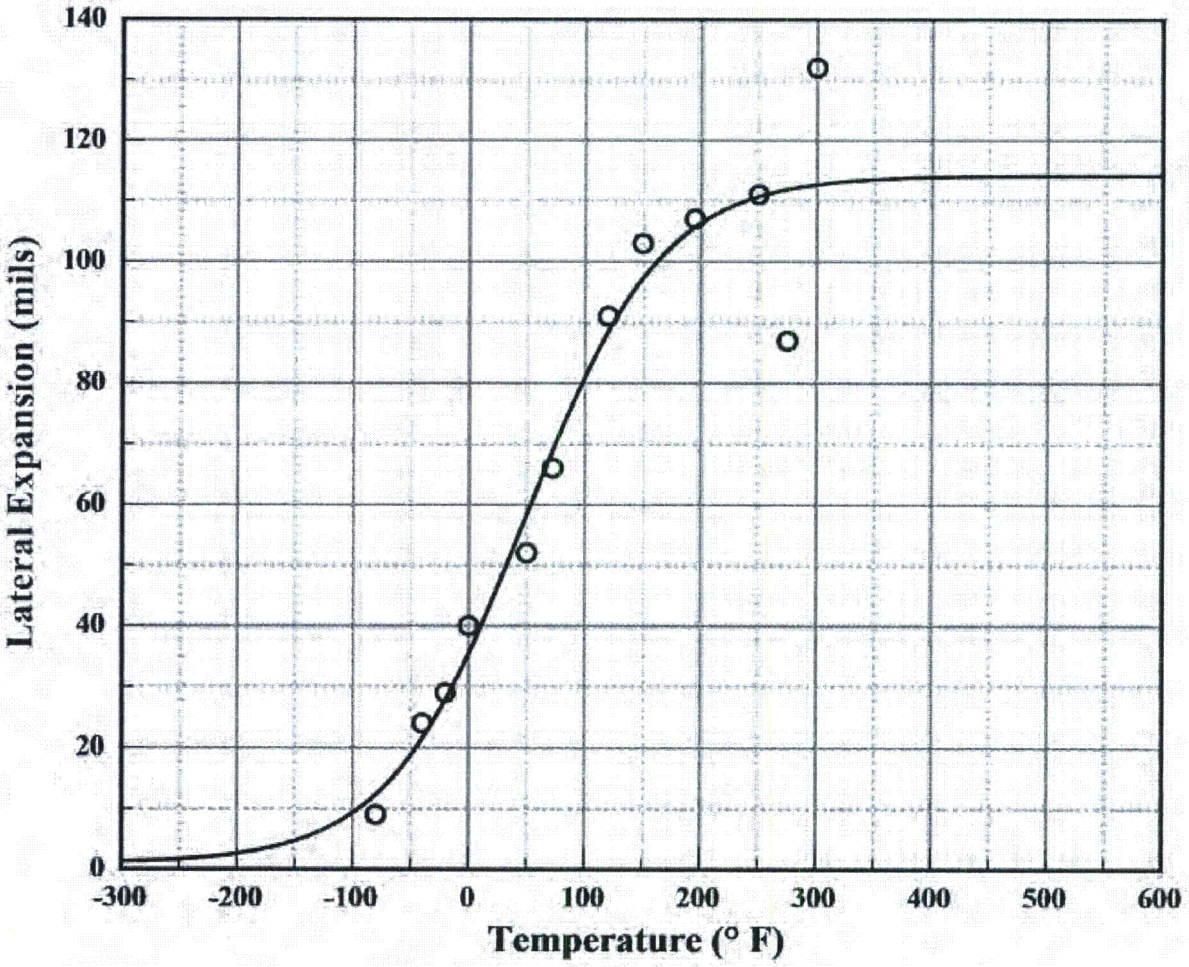
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 114.16 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= -1.10° F

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 263° Fluence:

CAPSULE 263° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-80	9.0	12.3	-3.35
-40	24.0	21.5	2.53
-20	29.0	27.8	1.16
0	40.0	35.5	4.55
50	52.0	58.4	-6.39
72	66.0	68.9	-2.88
120	91.0	88.5	2.53
150	103.0	97.2	5.76
195	107.0	105.6	1.37
250	111.0	110.7	0.33
275	87.0	111.9	-24.86
300	132.0	112.6	19.35

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CAPSULE 263° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:51 PM

A = 50.00 B = 50.00 C = 92.15 T0 = 16.30 D = 0.00

Correlation Coefficient = 0.997

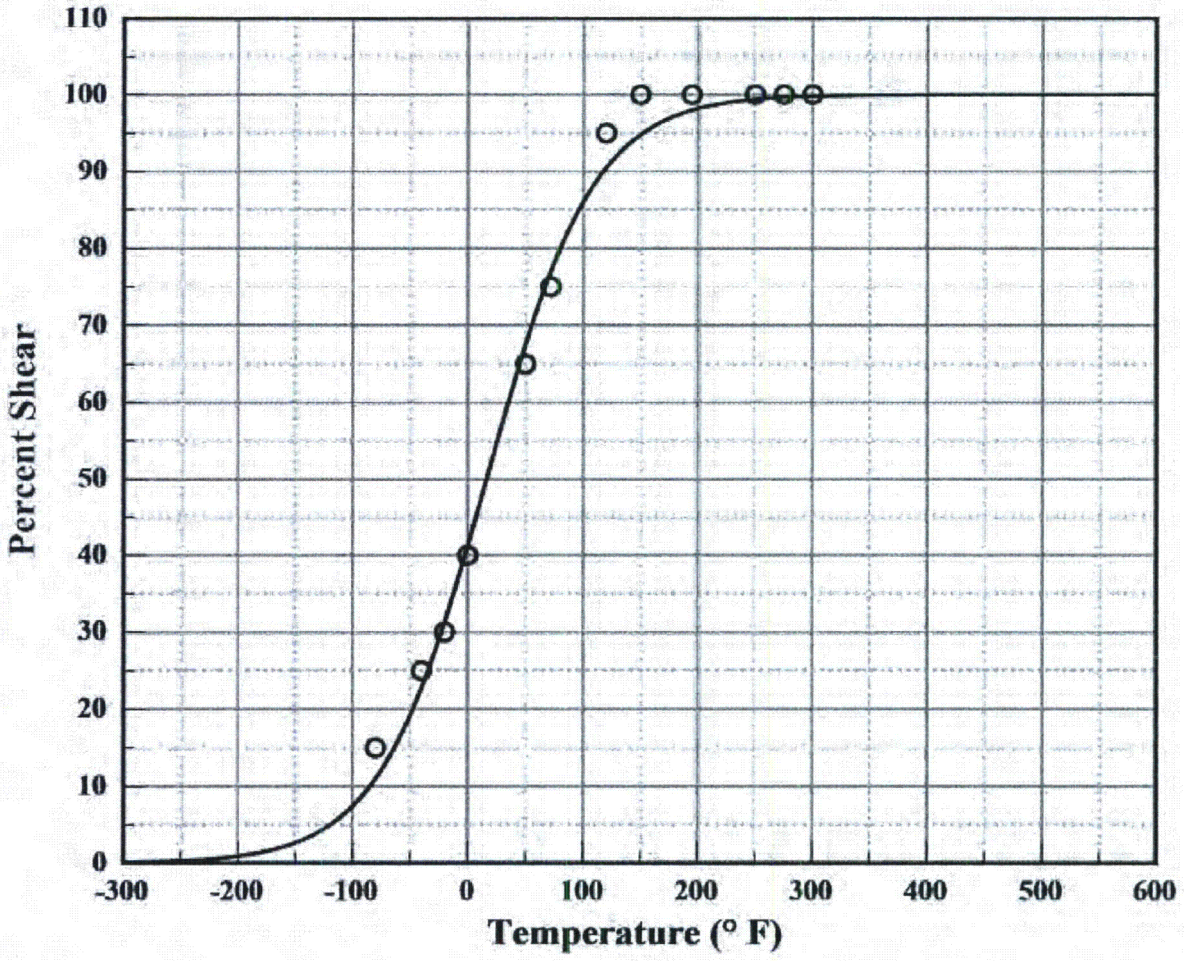
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 16.40

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 263° Fluence:

CAPSULE 263° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-80	15.0	11.0	3.99
-40	25.0	22.8	2.24
-20	30.0	31.3	-1.26
0	40.0	41.2	-1.25
50	65.0	67.5	-2.51
72	75.0	77.0	-2.01
120	95.0	90.5	4.53
150	100.0	94.8	5.21
195	100.0	98.0	2.03
250	100.0	99.4	0.62
275	100.0	99.6	0.36
300	100.0	99.8	0.21

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CAPSULE 263° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:53 PM

A = 66.10 B = 63.90 C = 163.76 T0 = 151.18 D = 0.00

Correlation Coefficient = 0.862

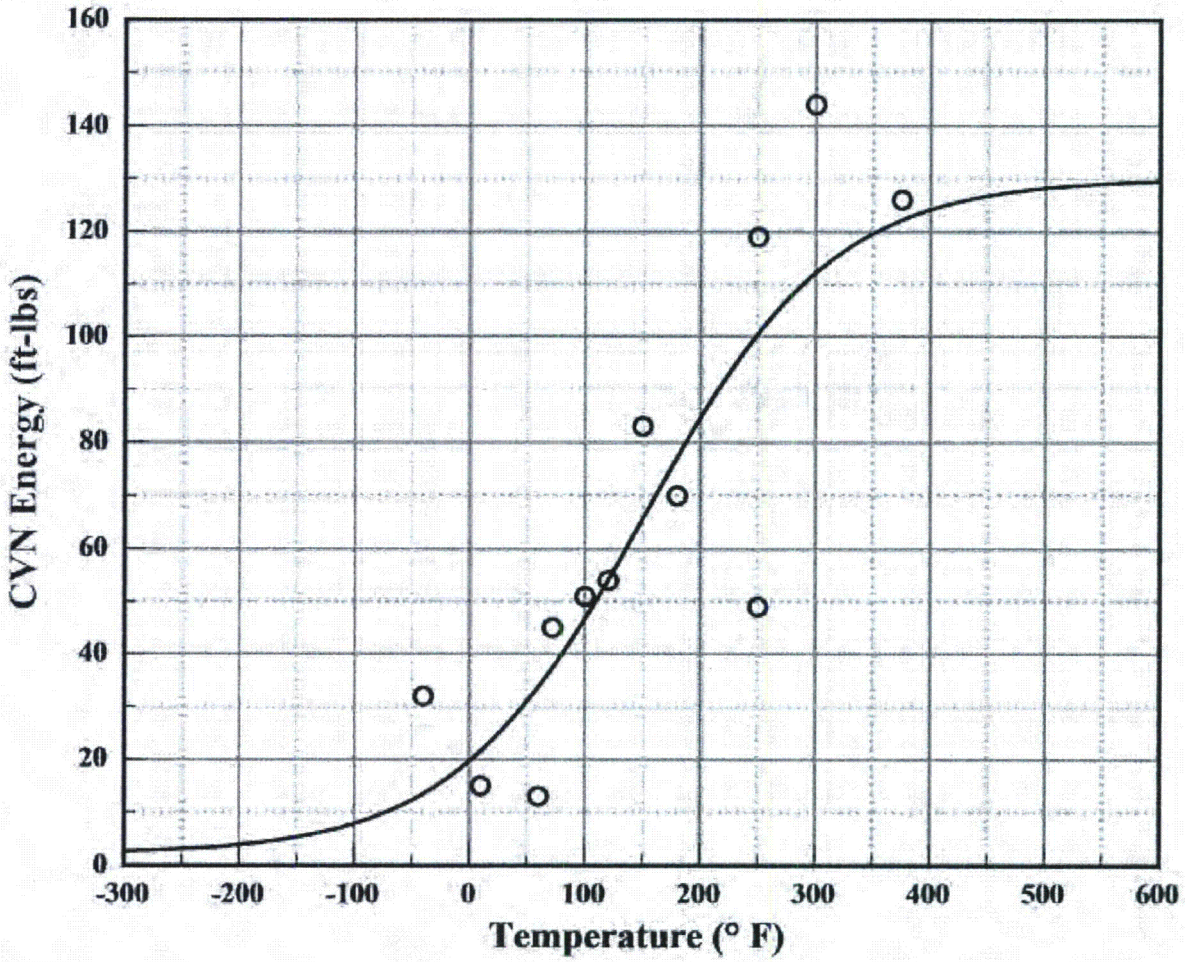
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 130.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs= 46.40° F Temp@35 ft-lbs= 64.20° F Temp@50 ft-lbs=109.10° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 263° Fluence:

CAPSULE 263° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-40	32.0	13.5	18.52
10	15.0	21.5	-6.54
60	13.0	33.8	-20.79
72	45.0	37.4	7.59
100	51.0	46.8	4.24
120	54.0	54.1	-0.08
150	83.0	65.6	17.36
180	70.0	77.2	-7.23
250	119.0	100.6	18.43
250	49.0	100.6	-51.57
300	144.0	112.1	31.86
375	126.0	122.2	3.80

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 263° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:56 PM

A = 42.05 B = 41.05 C = 172.87 T0 = 106.52 D = 0.00

Correlation Coefficient = 0.909

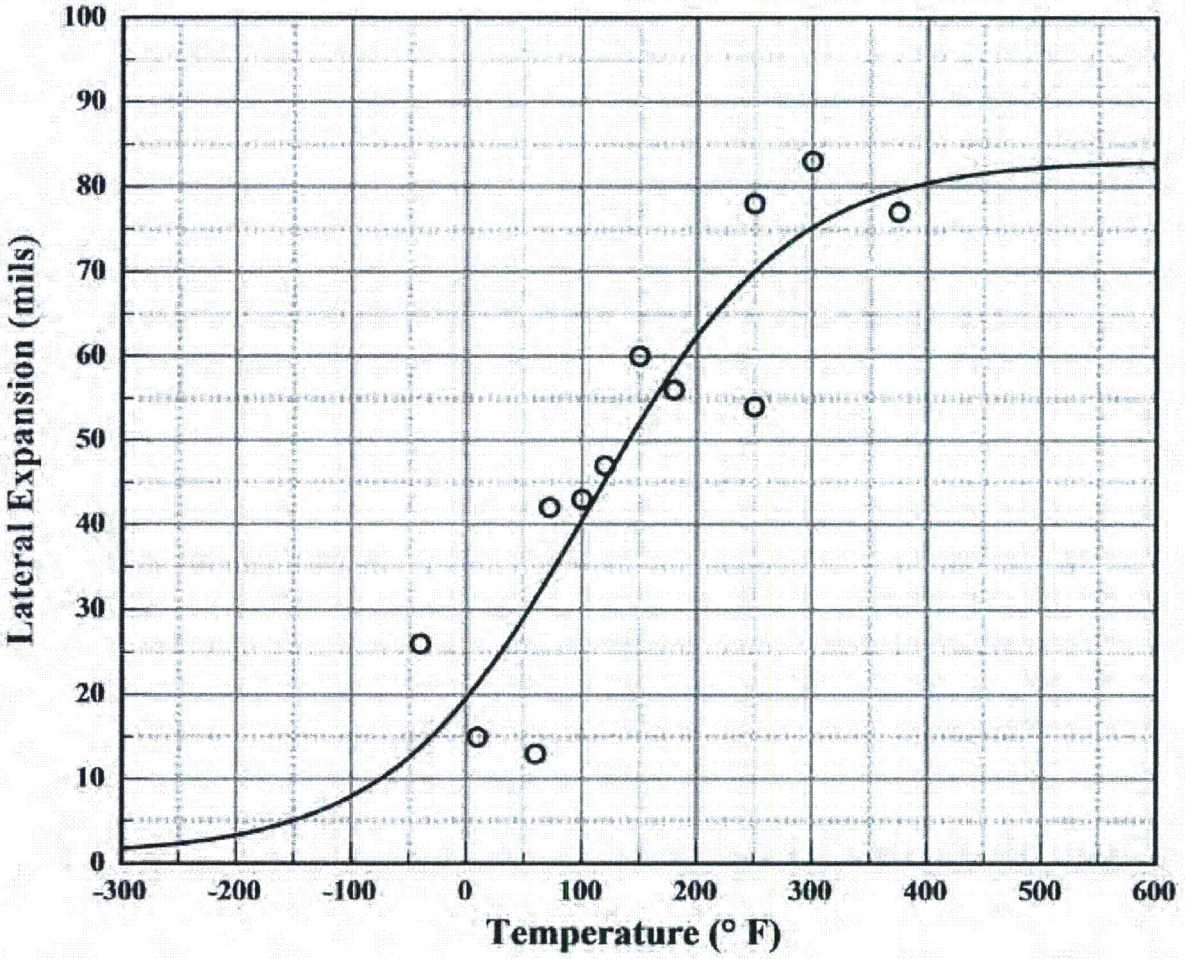
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 83.10 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= 76.60° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 263° Fluence:

CAPSULE 263° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-40	26.0	13.7	12.27
10	15.0	21.2	-6.25
60	13.0	31.3	-18.26
72	42.0	34.0	8.04
100	43.0	40.5	2.50
120	47.0	45.2	1.75
150	60.0	52.2	7.83
180	56.0	58.5	-2.52
250	54.0	70.0	-15.99
250	78.0	70.0	8.01
300	83.0	75.2	7.81
375	77.0	79.6	-2.58

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 263° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 2:58 PM

A = 50.00 B = 50.00 C = 139.62 T0 = 101.67 D = 0.00

Correlation Coefficient = 0.950

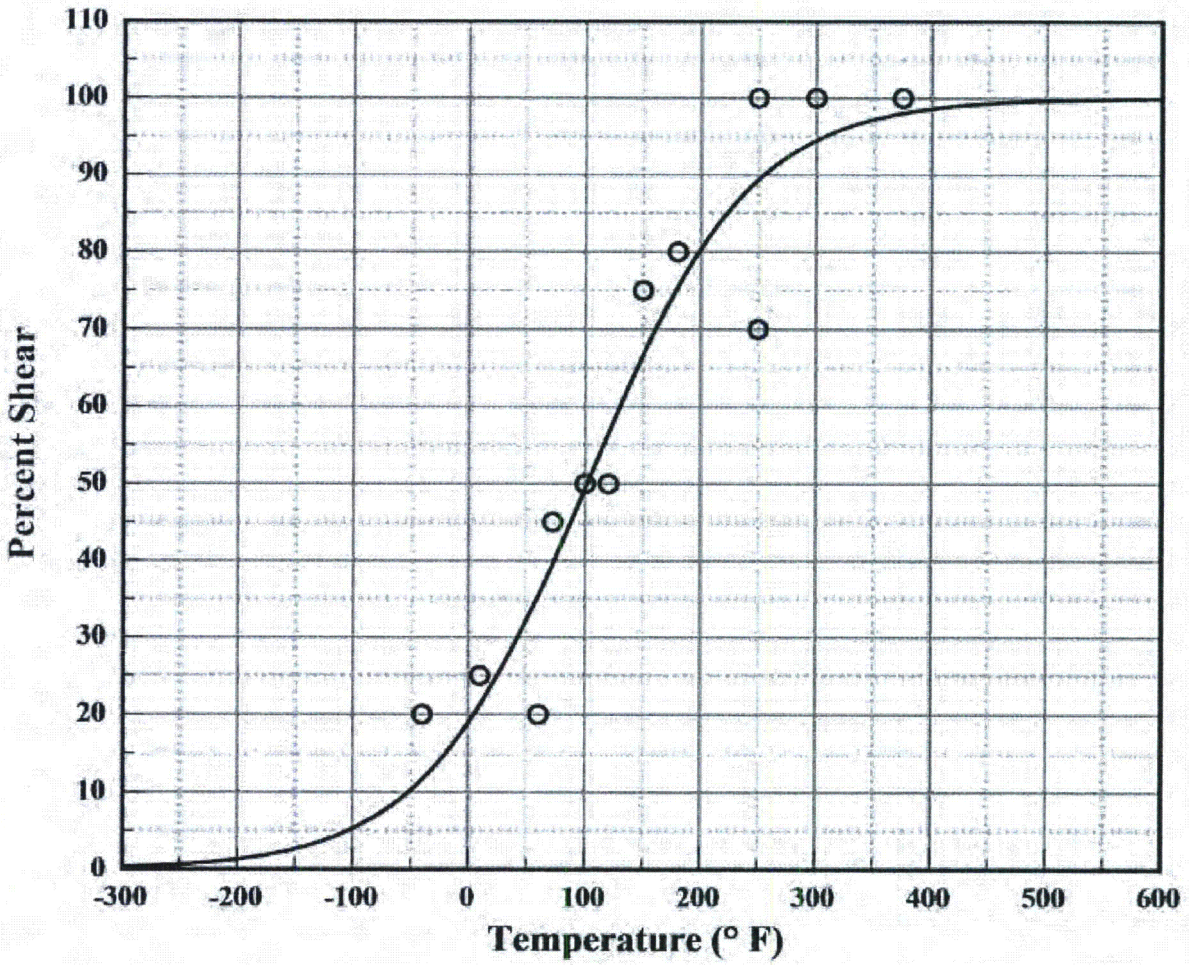
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 101.70

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 263° Fluence:

CAPSULE 263° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-40	20.0	11.6	8.39
10	25.0	21.2	3.80
60	20.0	35.5	-15.50
72	45.0	39.5	5.47
100	50.0	49.4	0.60
120	50.0	56.5	-6.53
150	75.0	66.6	8.35
180	80.0	75.4	4.56
250	100.0	89.3	10.67
250	70.0	89.3	-19.33
300	100.0	94.5	5.51
375	100.0	98.0	1.95

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 263° STANDARD REFERENCE MATERIAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 3:01 PM

A = 44.10 B = 41.90 C = 89.08 T0 = 188.20 D = 0.00

Correlation Coefficient = 0.974

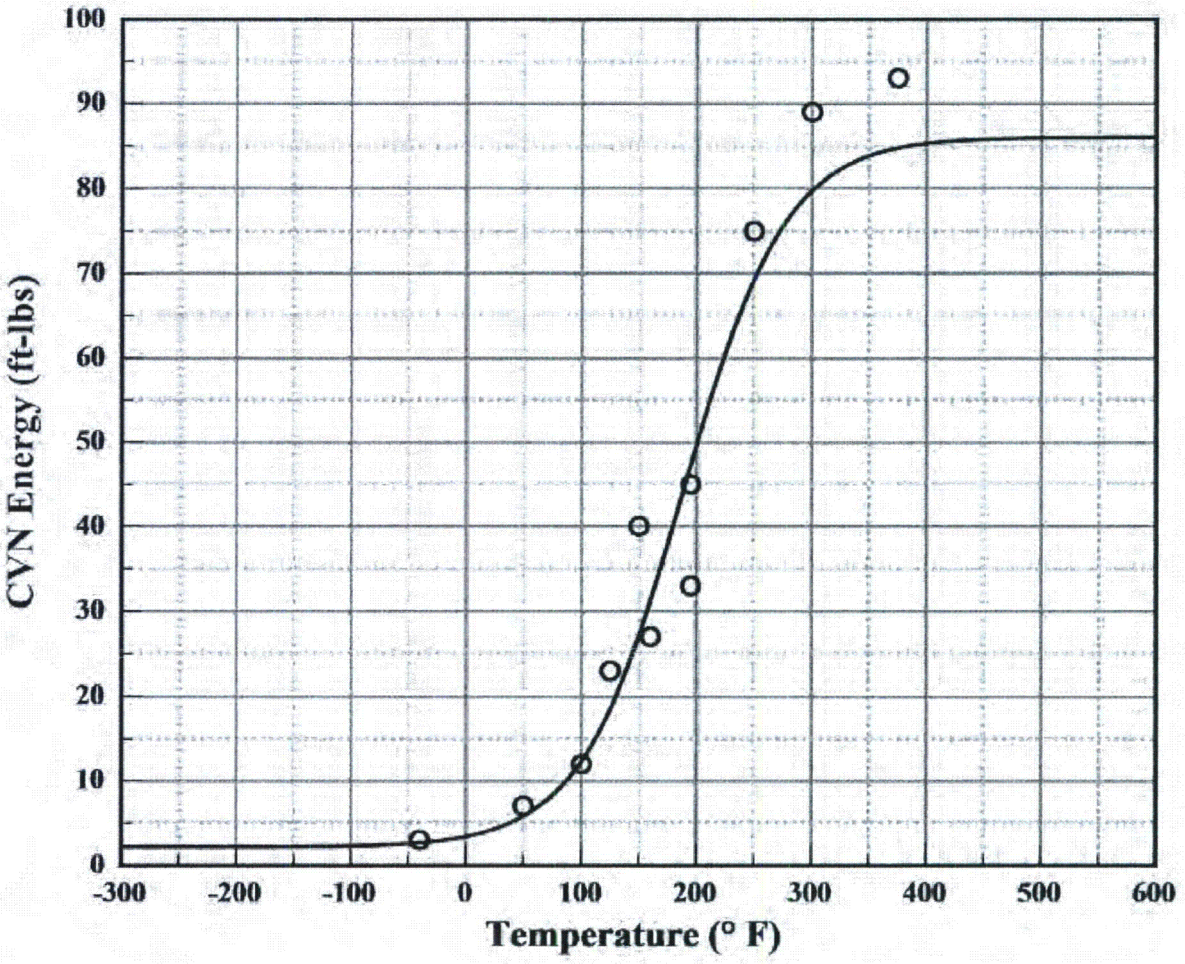
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 86.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=157.10° F Temp@35 ft-lbs=168.60° F Temp@50 ft-lbs=200.90° F

Plant: St. Lucie 2 Material: SA533B1 Heat: HSST-01MY

Orientation: LT Capsule: 263° Fluence:



CVGraph 6.0 12/01/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: HSST-01MY
Orientation: LT Capsule: 263° Fluence:

CAPSULE 263° STANDARD REFERENCE MATERIAL

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-40	3.0	2.7	0.30
50	7.0	5.8	1.20
100	12.0	12.4	-0.36
125	23.0	18.5	4.47
150	40.0	27.2	12.84
160	27.0	31.3	-4.26
195	33.0	47.3	-14.29
195	45.0	47.3	-2.29
250	75.0	69.3	5.75
300	89.0	79.7	9.30
375	93.0	84.8	8.25

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 263° STANDARD REFERENCE MATERIAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 3:03 PM

A = 44.19 B = 43.19 C = 110.55 T0 = 207.15 D = 0.00

Correlation Coefficient = 0.980

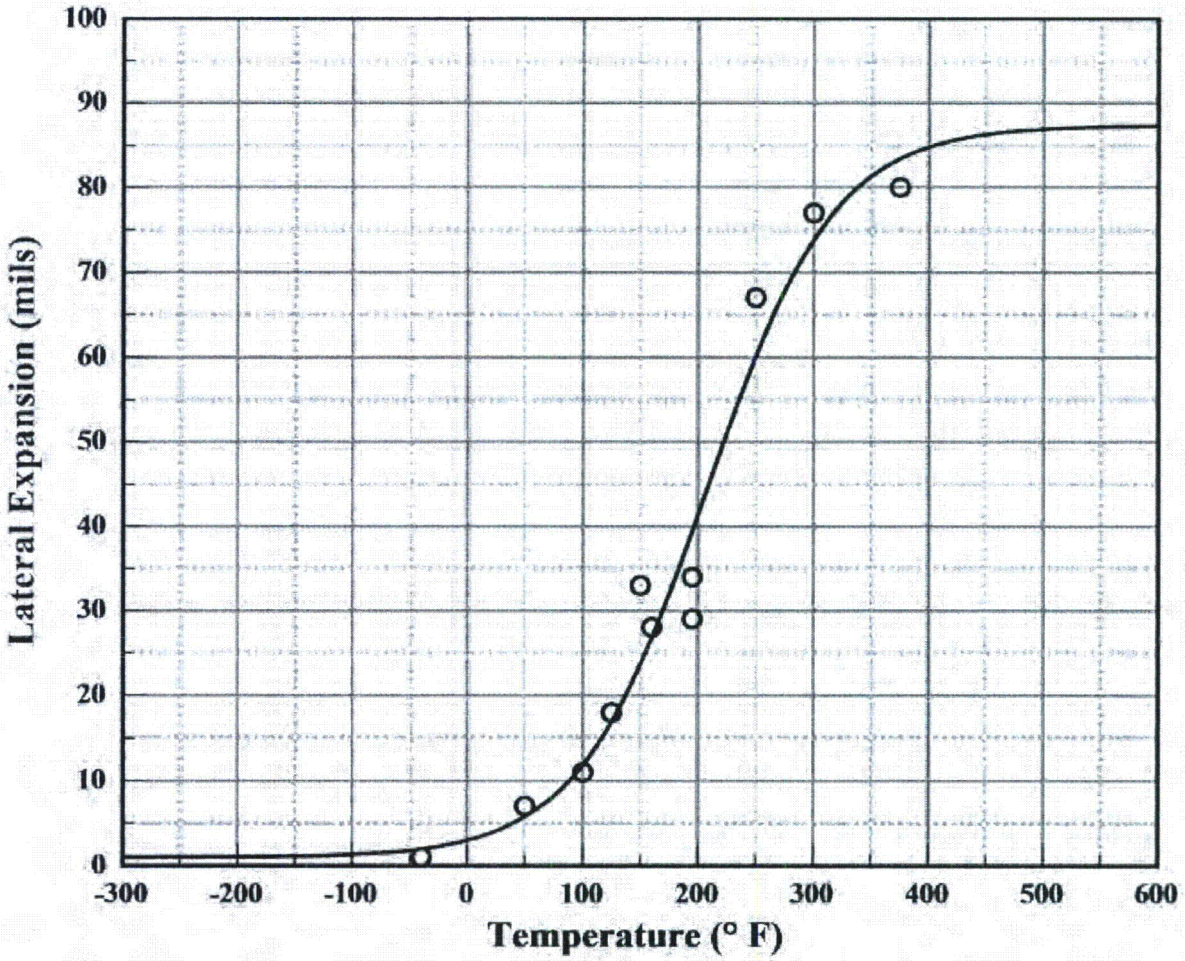
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 87.37 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=183.30° F

Plant: St. Lucie 2 Material: SA533B1 Heat: HSST-01MY

Orientation: LT Capsule: 263° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: HSST-01MY
Orientation: LT Capsule: 263° Fluence:

CAPSULE 263° STANDARD REFERENCE MATERIAL

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-40	1.0	2.0	-0.98
50	7.0	5.8	1.25
100	11.0	11.9	-0.87
125	18.0	16.9	1.06
150	33.0	23.7	9.34
160	28.0	26.8	1.19
195	34.0	39.5	-5.46
195	29.0	39.5	-10.46
250	67.0	60.1	6.86
300	77.0	73.8	3.20
375	80.0	83.4	-3.42

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CAPSULE 263° STANDARD REFERENCE MATERIAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/1/2014 3:05 PM

A = 50.00 B = 50.00 C = 76.59 T0 = 190.04 D = 0.00

Correlation Coefficient = 0.973

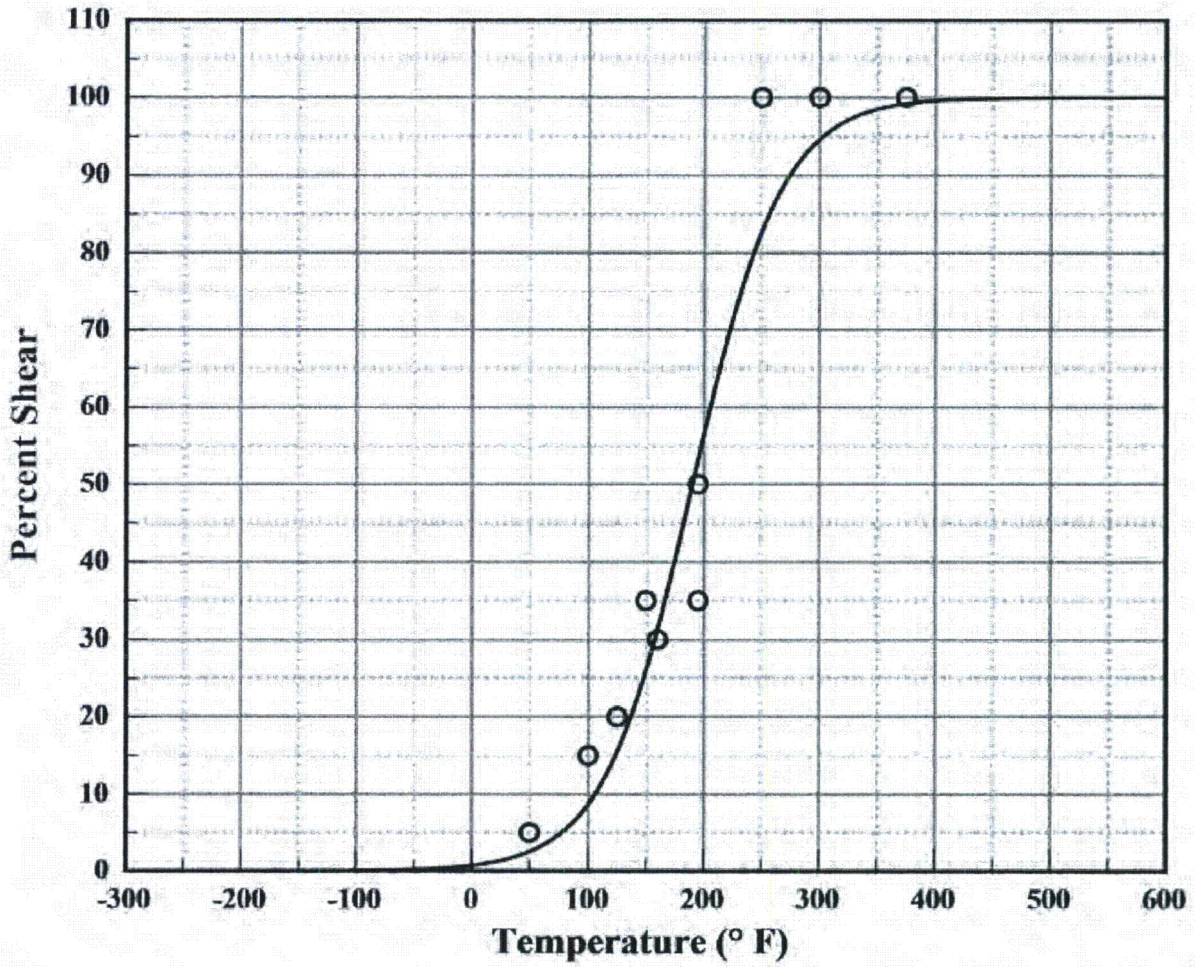
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 190.10

Plant: St. Lucie 2 Material: SA533B1 Heat: HSST-01MY

Orientation: LT Capsule: 263° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: HSST-01MY
Orientation: LT Capsule: 263° Fluence:

CAPSULE 263° STANDARD REFERENCE MATERIAL

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-40	0.0	0.2	-0.25
50	5.0	2.5	2.48
100	15.0	8.7	6.30
125	20.0	15.5	4.53
150	35.0	26.0	8.99
160	30.0	31.3	-1.34
195	50.0	53.2	-3.23
195	35.0	53.2	-18.23
250	100.0	82.7	17.28
300	100.0	94.6	5.36
375	100.0	99.2	0.79

CVGraph 6.0 12/01/2014 Page 2/2

CAPSULE 97° IS PLATE M-605-1 (LONGITUDINAL)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:09 AM

A = 55.10 B = 52.90 C = 116.96 T0 = 184.60 D = 0.00

Correlation Coefficient = 0.898

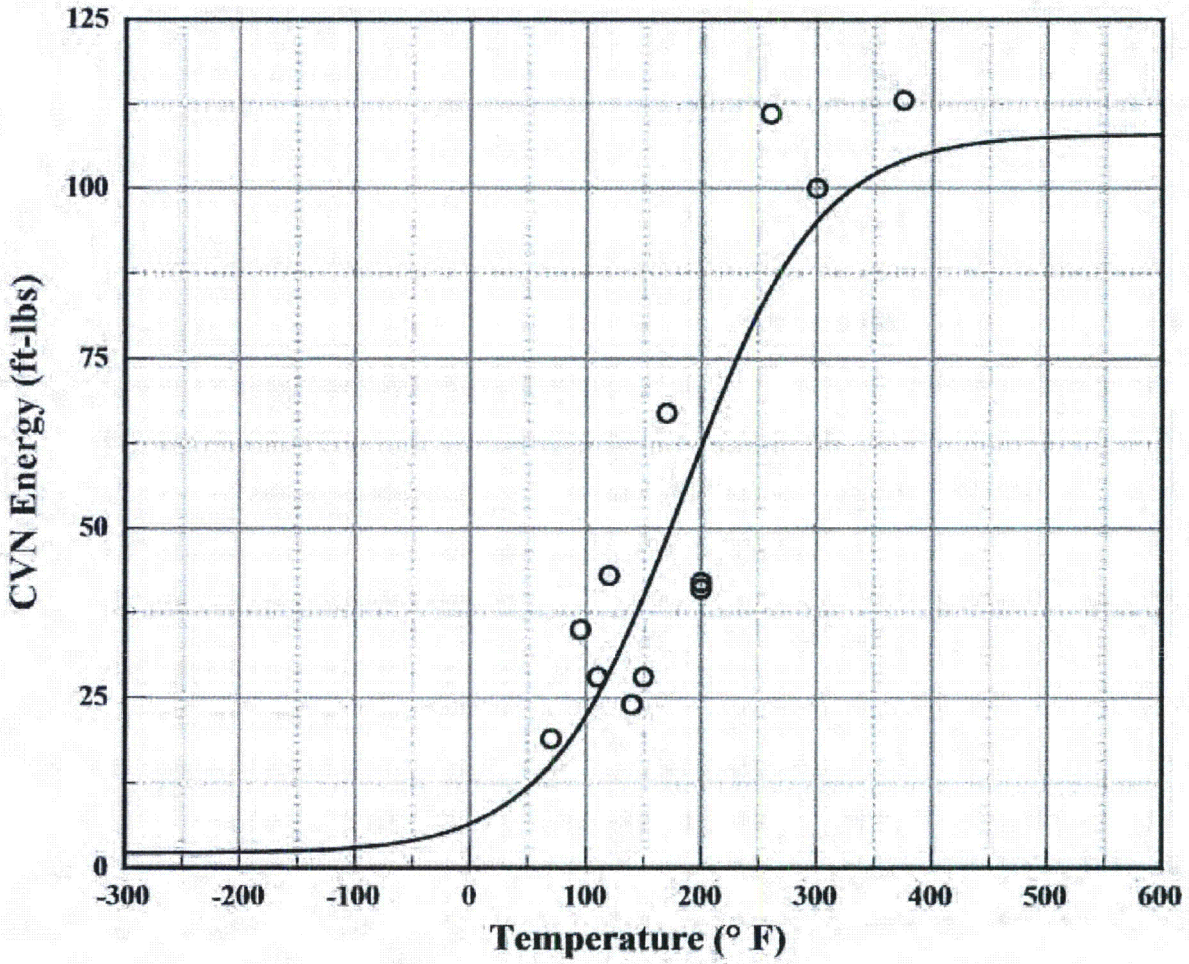
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 108.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=124.30° F Temp@35 ft-lbs=137.90° F Temp@50 ft-lbs=173.30° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: LT Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: LT Capsule: 97° Fluence:

CAPSULE 97° IS PLATE M-605-1 (LONGITUDINAL)

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
70	19.0	15.3	3.73
95	35.0	21.0	14.00
110	28.0	25.3	2.71
120	43.0	28.5	14.47
140	24.0	35.9	-11.85
150	28.0	39.9	-11.89
170	67.0	48.5	18.47
200	41.0	62.0	-21.02
200	42.0	62.0	-20.02
260	111.0	85.1	25.85
300	100.0	95.1	4.91
375	113.0	104.1	8.93

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CAPSULE 97° IS PLATE M-605-1 (LONGITUDINAL)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:15 AM

A = 53.40 B = 52.40 C = 162.40 T0 = 207.35 D = 0.00

Correlation Coefficient = 0.901

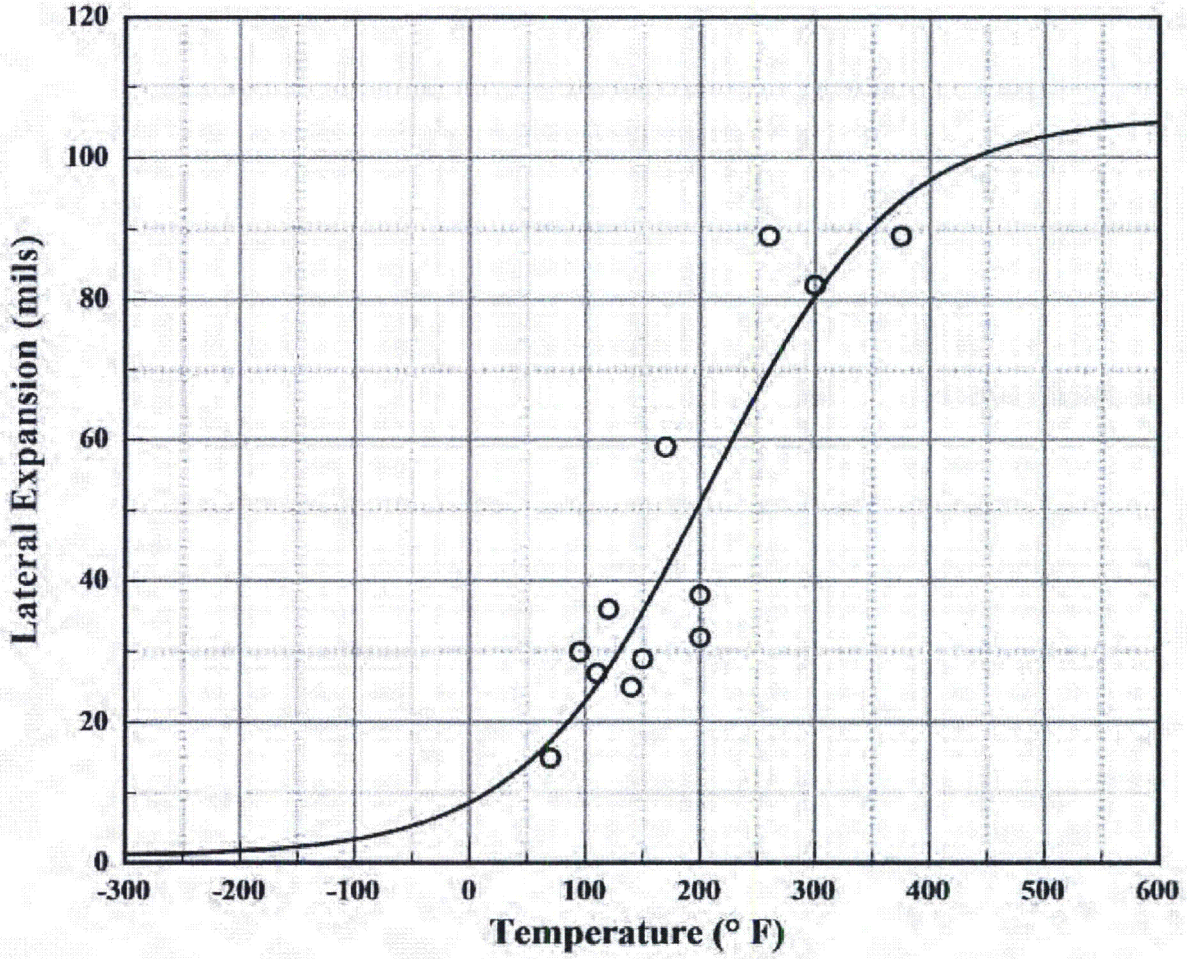
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 105.80 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=147.80° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: LT Capsule: 97° Fluence:



CVGraph 6.0 12/08/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: LT Capsule: 97° Fluence:

CAPSULE 97° IS PLATE M-605-1 (LONGITUDINAL)

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
70	15.0	17.3	-2.30
95	30.0	22.0	8.00
110	27.0	25.3	1.72
120	36.0	27.7	8.35
140	25.0	32.8	-7.83
150	29.0	35.6	-6.63
170	59.0	41.6	17.44
200	32.0	51.0	-19.03
200	38.0	51.0	-13.03
260	89.0	69.8	19.18
300	82.0	80.4	1.58
375	89.0	94.0	-5.00

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CAPSULE 97° IS PLATE M-605-1 (LONGITUDINAL)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:48 AM

A = 50.00 B = 50.00 C = 110.16 T0 = 180.44 D = 0.00

Correlation Coefficient = 0.934

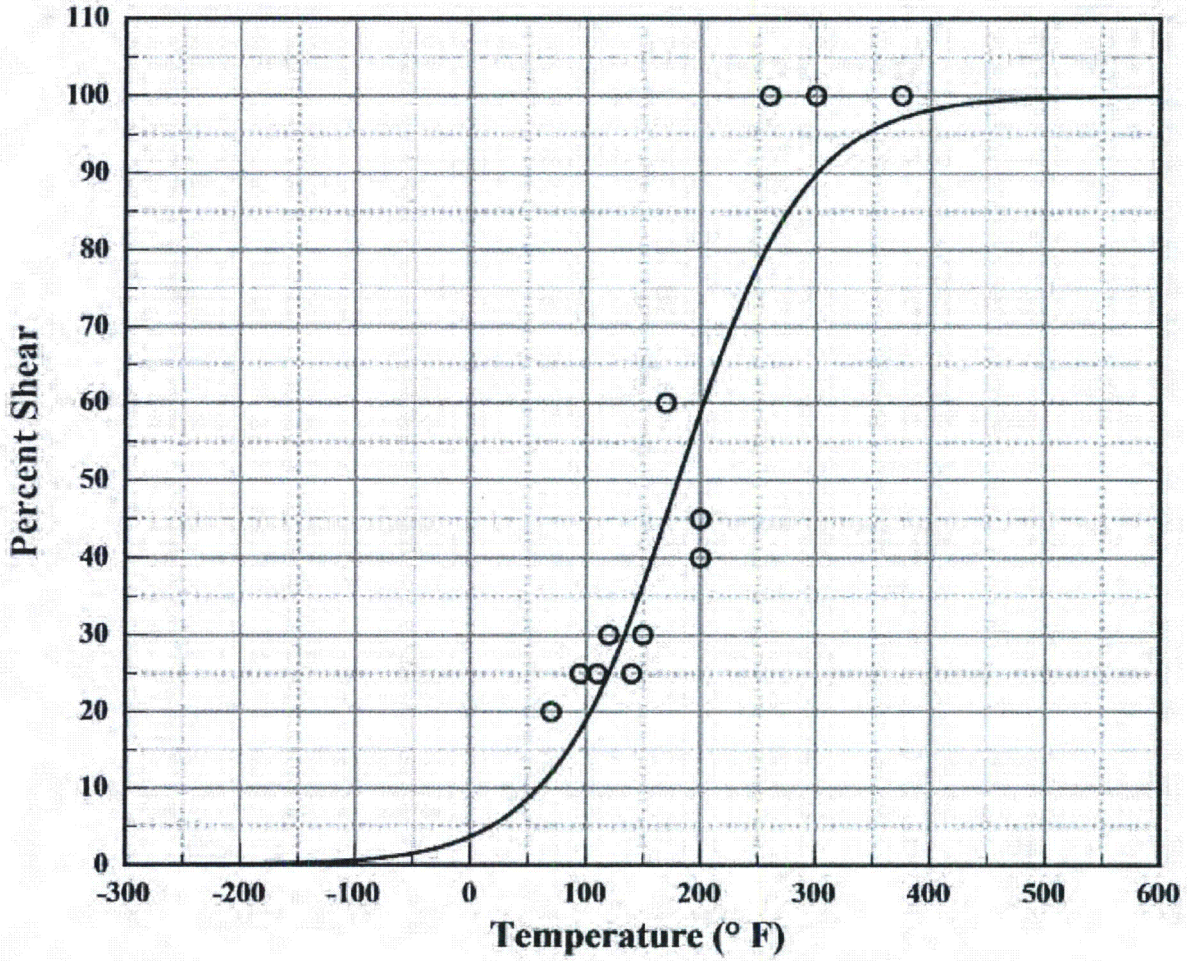
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 180.50

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: LT Capsule: 97° Fluence:



CVGraph 6.0 12/08/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: LT Capsule: 97° Fluence:

CAPSULE 97° IS PLATE M-605-1 (LONGITUDINAL)

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
70	20.0	11.9	8.13
95	25.0	17.5	7.51
110	25.0	21.8	3.23
120	30.0	25.0	4.98
140	25.0	32.4	-7.43
150	30.0	36.5	-6.53
170	60.0	45.3	14.72
200	45.0	58.8	-13.79
200	40.0	58.8	-18.79
260	100.0	80.9	19.09
300	100.0	89.8	10.24
375	100.0	97.2	2.84

CVGraph 6.0 12/08/2014 Page 2/2

CAPSULE 97° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:22 AM

A = 40.10 B = 37.90 C = 114.35 T0 = 189.17 D = 0.00

Correlation Coefficient = 0.910

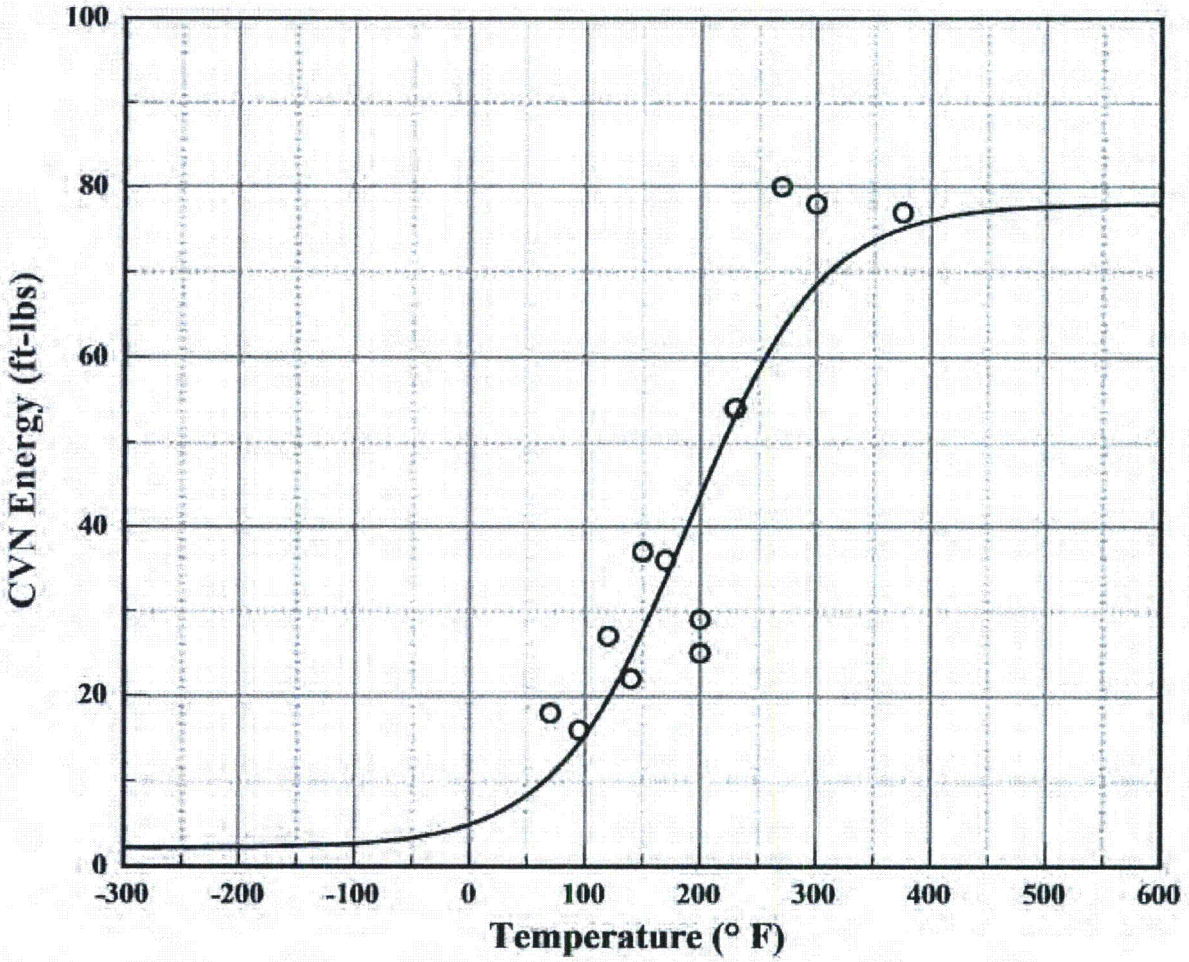
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 78.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=158.00° F Temp@35 ft-lbs=173.70° F Temp@50 ft-lbs=219.80° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 97° Fluence:

CAPSULE 97° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
70	18.0	10.6	7.41
95	16.0	14.4	1.56
120	27.0	19.6	7.38
140	22.0	24.7	-2.74
150	37.0	27.6	9.40
170	36.0	33.8	2.19
200	25.0	43.7	-18.68
200	29.0	43.7	-14.68
230	54.0	53.1	0.91
270	80.0	63.2	16.83
300	78.0	68.5	9.54
375	77.0	75.2	1.83

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CAPSULE 97° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:43 AM

A = 40.30 B = 39.30 C = 146.82 T0 = 215.90 D = 0.00

Correlation Coefficient = 0.916

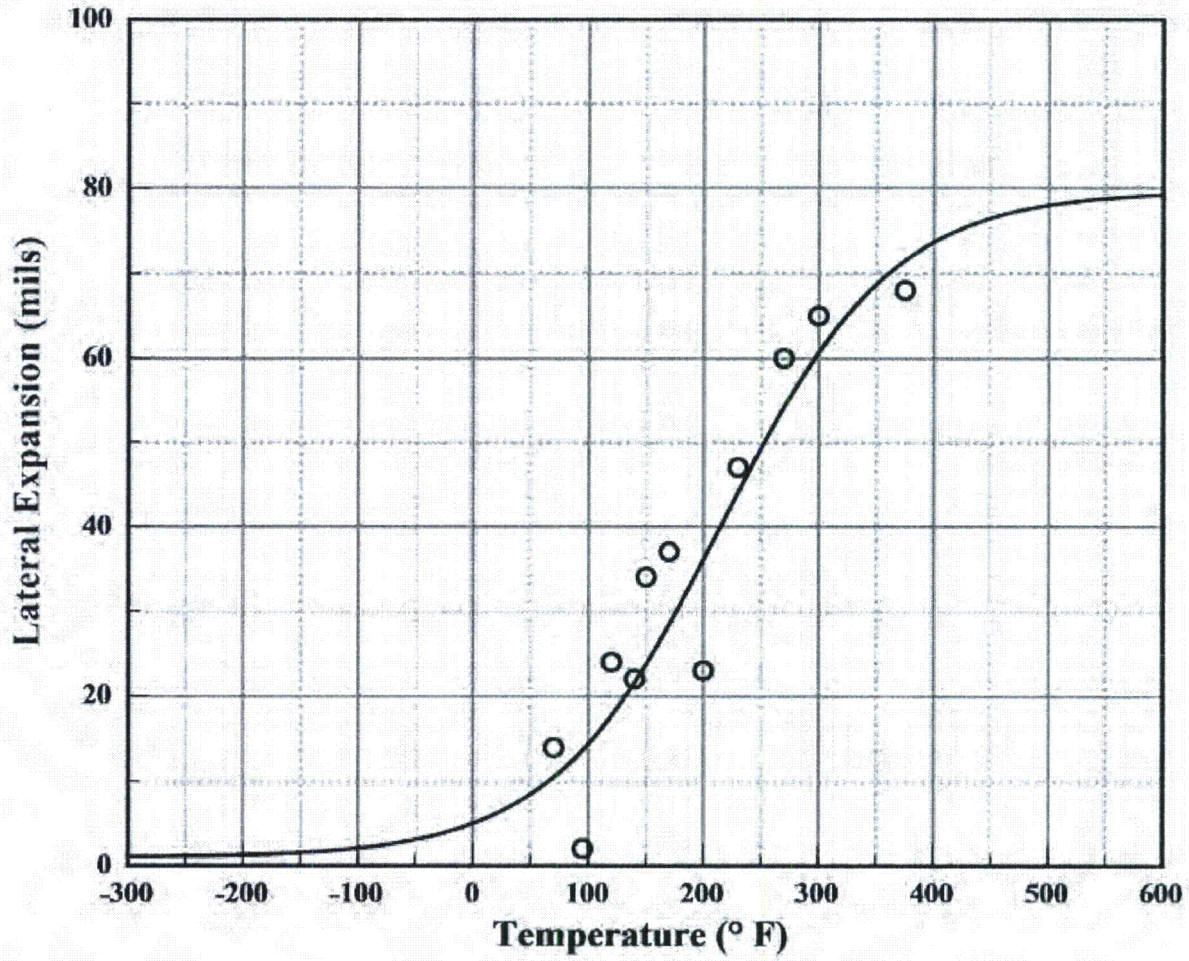
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 79.59 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=196.00° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 97° Fluence:



CVGraph 6.0 12/08/2014 Page 1/2

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 97° Fluence:

CAPSULE 97° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (°F)	Input L. E.	Computed L. E.	Differential
70	14.0	10.5	3.53
95	2.0	13.7	-11.70
120	24.0	17.7	6.25
140	22.0	21.6	0.38
150	34.0	23.8	10.24
170	37.0	28.4	8.60
200	23.0	36.1	-13.06
200	23.0	36.1	-13.06
230	47.0	44.1	2.94
270	60.0	54.2	5.84
300	65.0	60.6	4.37
375	68.0	71.5	-3.52

CVGraph 6.0 12/08/2014 Page 2/2

CAPSULE 97° IS PLATE M-605-1 (TRANSVERSE)

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:45 AM

A = 50.00 B = 50.00 C = 104.82 T0 = 187.21 D = 0.00

Correlation Coefficient = 0.948

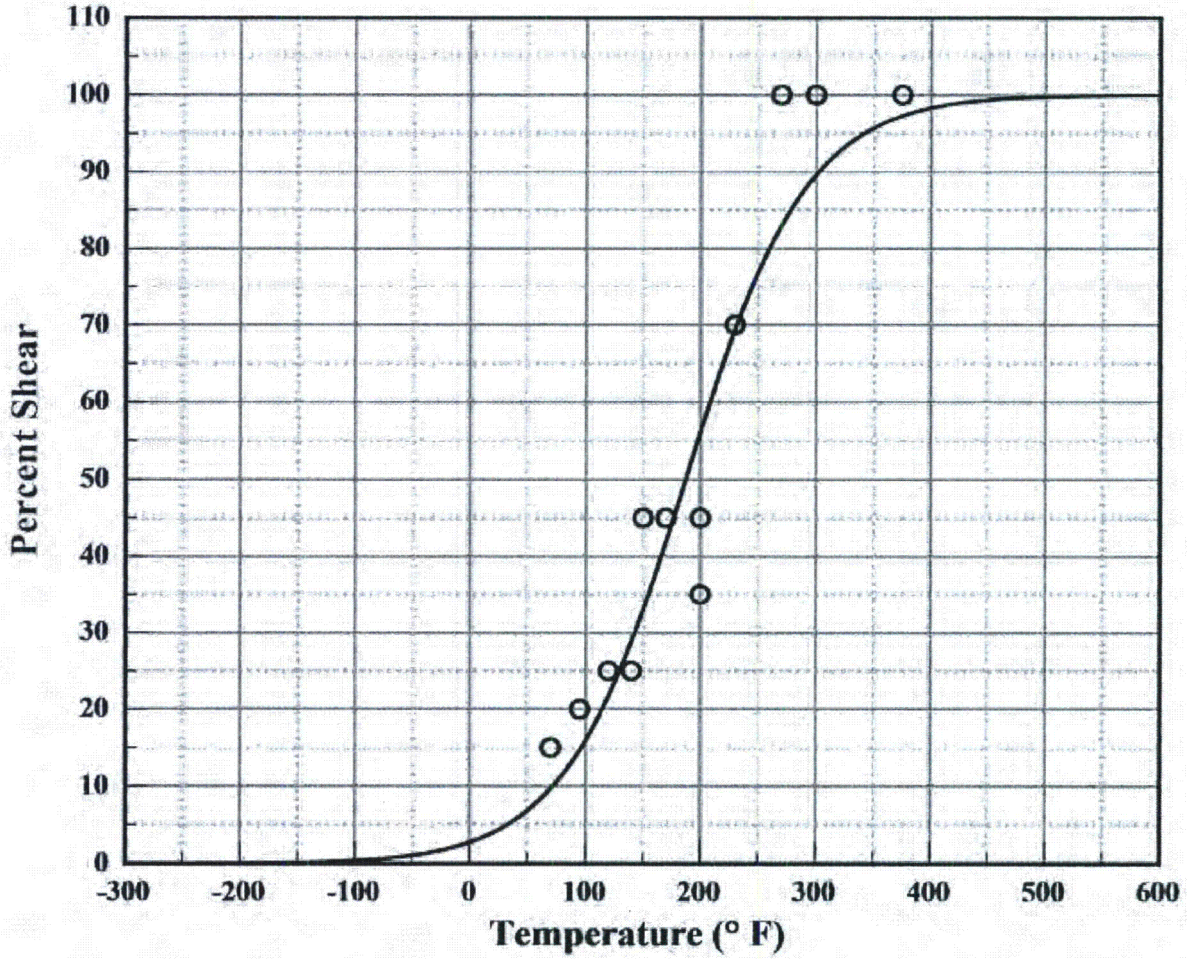
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 187.30

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: TL Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: TL Capsule: 97° Fluence:

CAPSULE 97° IS PLATE M-605-1 (TRANSVERSE)

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
70	15.0	9.7	5.35
95	20.0	14.7	5.31
120	25.0	21.7	3.29
140	25.0	28.9	-3.89
150	45.0	33.0	12.04
170	45.0	41.9	3.14
200	35.0	56.1	-21.07
200	45.0	56.1	-11.07
230	70.0	69.3	0.65
270	100.0	82.9	17.09
300	100.0	89.6	10.41
375	100.0	97.3	2.70

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CAPSULE 97° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 9:51 AM

A = 48.60 B = 46.40 C = 92.15 T0 = 13.41 D = 0.00

Correlation Coefficient = 0.951

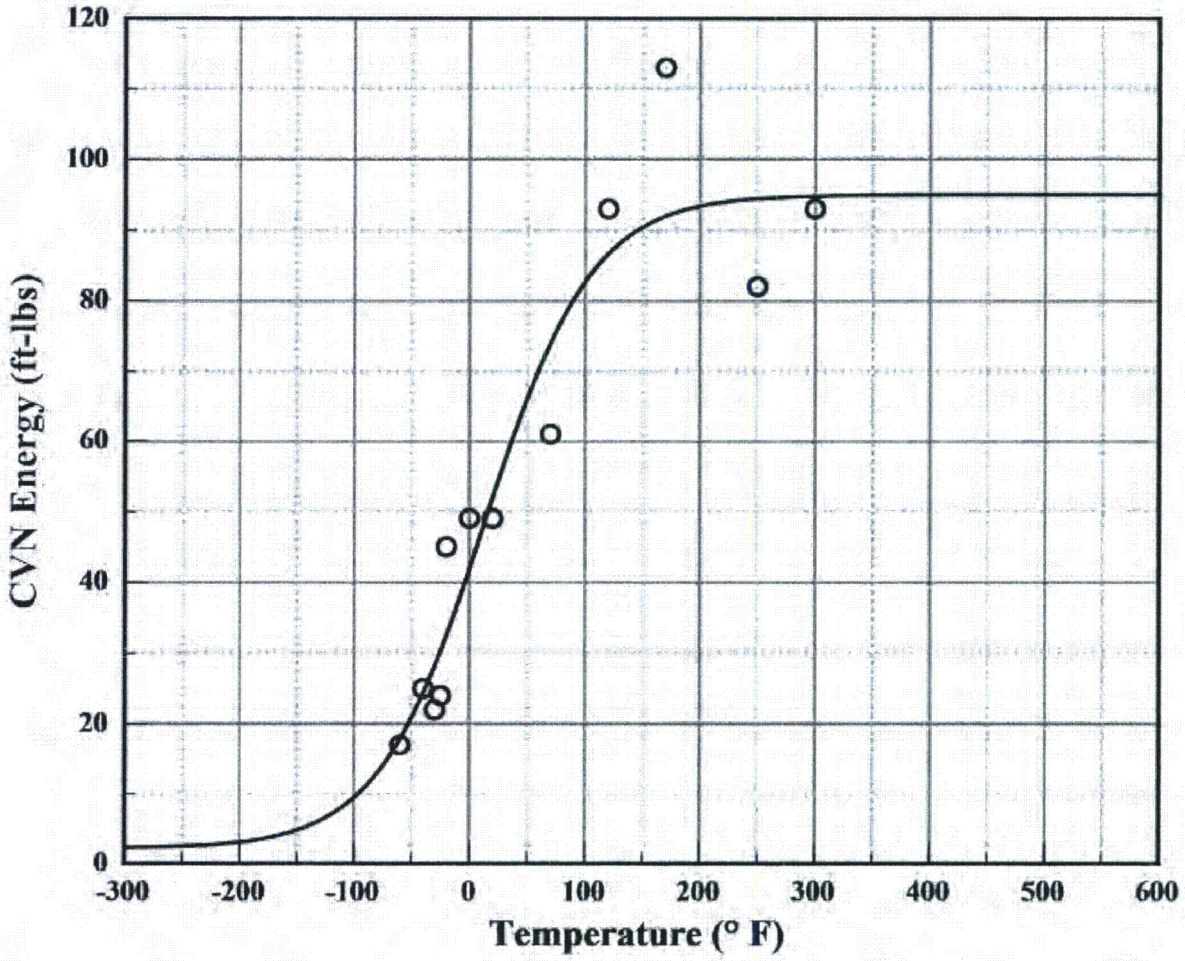
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 95.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=-25.70° F Temp@35 ft-lbs=-14.40° F Temp@50 ft-lbs= 16.20° F

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 97° Fluence:



CVGraph 6.0 12/08/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 97° Fluence:

CAPSULE 97° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-60	17.0	17.9	-0.88
-40	25.0	24.4	0.64
-30	22.0	28.2	-6.23
-25	24.0	30.3	-6.31
-20	45.0	32.5	12.52
0	49.0	41.9	7.10
20	49.0	51.9	-2.91
70	61.0	74.0	-12.98
120	93.0	86.6	6.35
170	113.0	92.0	21.00
250	82.0	94.5	-12.46
300	93.0	94.8	-1.82

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CAPSULE 97° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 10:04 AM

A = 41.22 B = 40.22 C = 88.46 T0 = 11.76 D = 0.00

Correlation Coefficient = 0.967

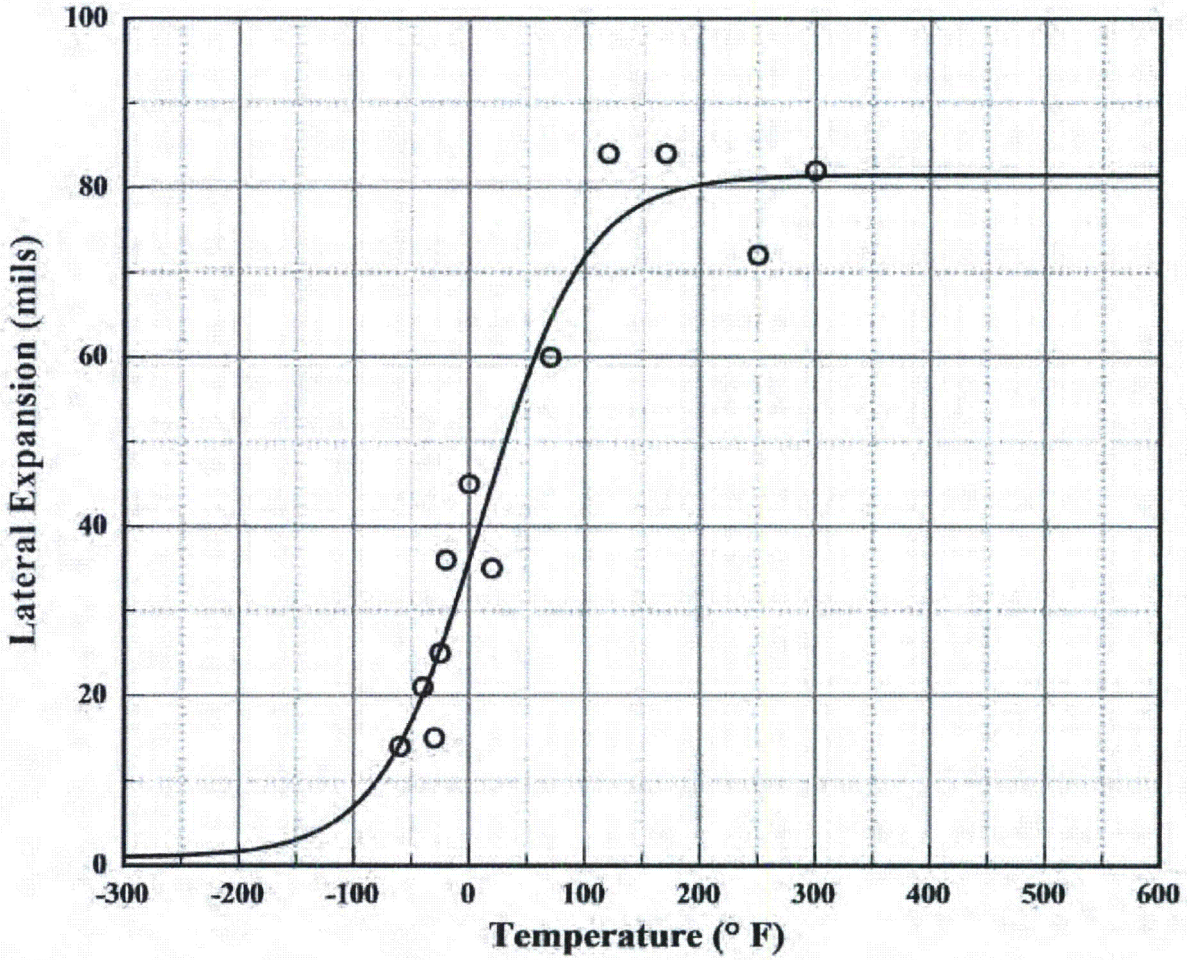
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 81.45 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= -2.00° F

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 97° Fluence:



CVGraph 6.0 12/08/2014 Page 1/2

Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 97° Fluence:

CAPSULE 97° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-60	14.0	14.3	-0.26
-40	21.0	20.0	0.95
-30	15.0	23.5	-8.53
-25	25.0	25.4	-0.41
-20	36.0	27.4	8.63
0	45.0	35.9	9.09
20	35.0	45.0	-9.96
70	60.0	64.4	-4.44
120	84.0	75.0	8.96
170	84.0	79.3	4.74
250	72.0	81.1	-9.08
300	82.0	81.3	0.67

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CAPSULE 97° SURVEILLANCE PROGRAM WELD METAL

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 10:16 AM

A = 50.00 B = 50.00 C = 74.44 T0 = 8.73 D = 0.00

Correlation Coefficient = 0.995

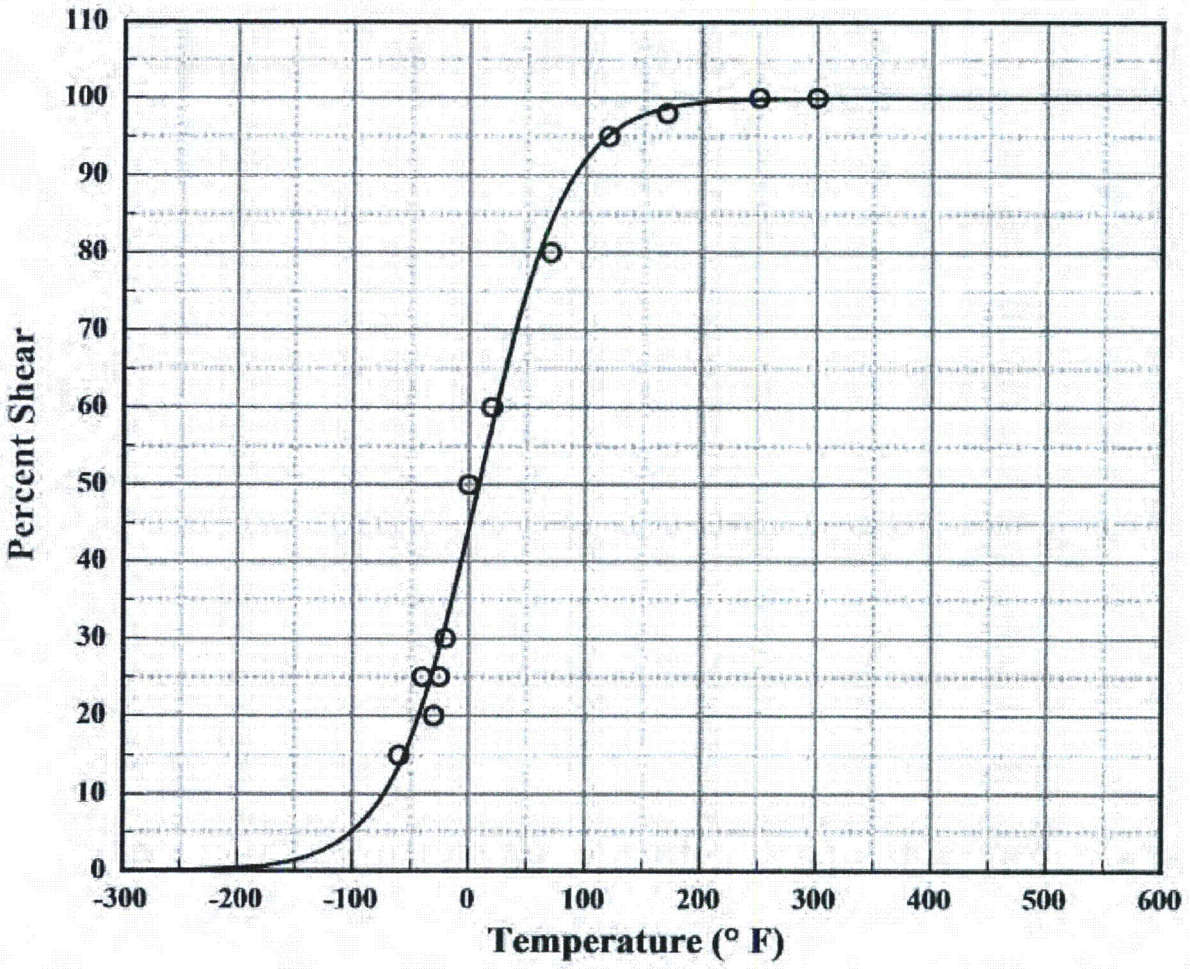
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 8.80

Plant: St. Lucie 2 Material: SAW Heat: 83637

Orientation: NA Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SAW Heat: 83637
Orientation: NA Capsule: 97° Fluence:

CAPSULE 97° SURVEILLANCE PROGRAM WELD METAL

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-60	15.0	13.6	1.37
-40	25.0	21.3	3.74
-30	20.0	26.1	-6.10
-25	25.0	28.8	-3.78
-20	30.0	31.6	-1.61
0	50.0	44.2	5.84
20	60.0	57.5	2.49
70	80.0	83.8	-3.84
120	95.0	95.2	-0.21
170	98.0	98.7	-0.70
250	100.0	99.8	0.15
300	100.0	100.0	0.04

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CAPSULE 97° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 10:27 AM

A = 47.60 B = 45.40 C = 435.22 T0 = 40.99 D = 0.00

Correlation Coefficient = 0.207

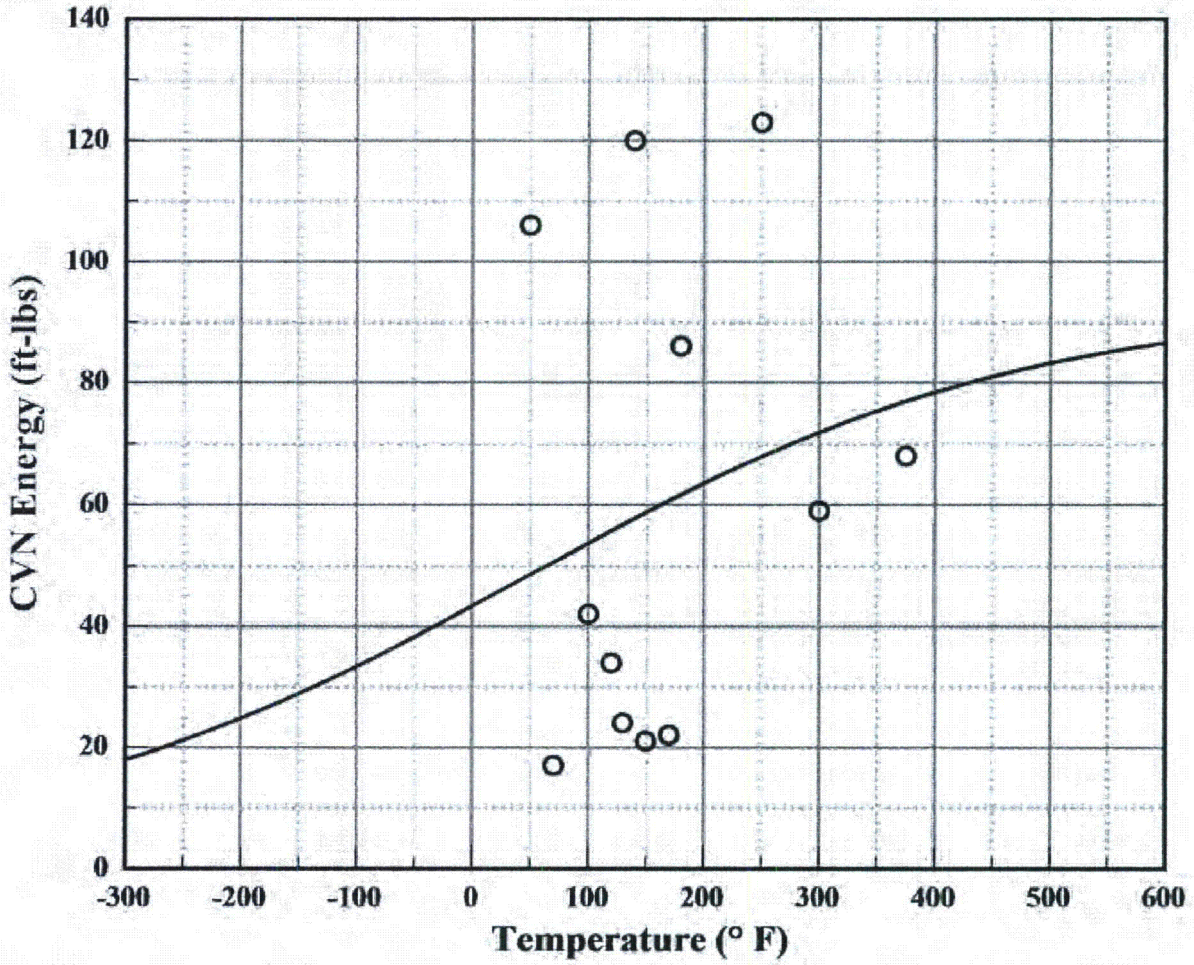
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 93.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=-137.00° F Temp@35 ft-lbs=-83.00° F Temp@50 ft-lbs= 64.10° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 97° Fluence:

CAPSULE 97° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
50	106.0	48.5	57.46
70	17.0	50.6	-33.62
100	42.0	53.7	-11.72
120	34.0	55.8	-21.75
130	24.0	56.8	-32.76
140	120.0	57.8	62.25
150	21.0	58.7	-37.74
170	22.0	60.7	-38.68
180	86.0	61.6	24.37
250	123.0	67.9	55.13
300	59.0	71.8	-12.82
375	68.0	76.9	-8.90

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CAPSULE 97° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 10:38 AM

A = 39.49 B = 38.49 C = 300.99 T0 = 116.80 D = 0.00

Correlation Coefficient = 0.444

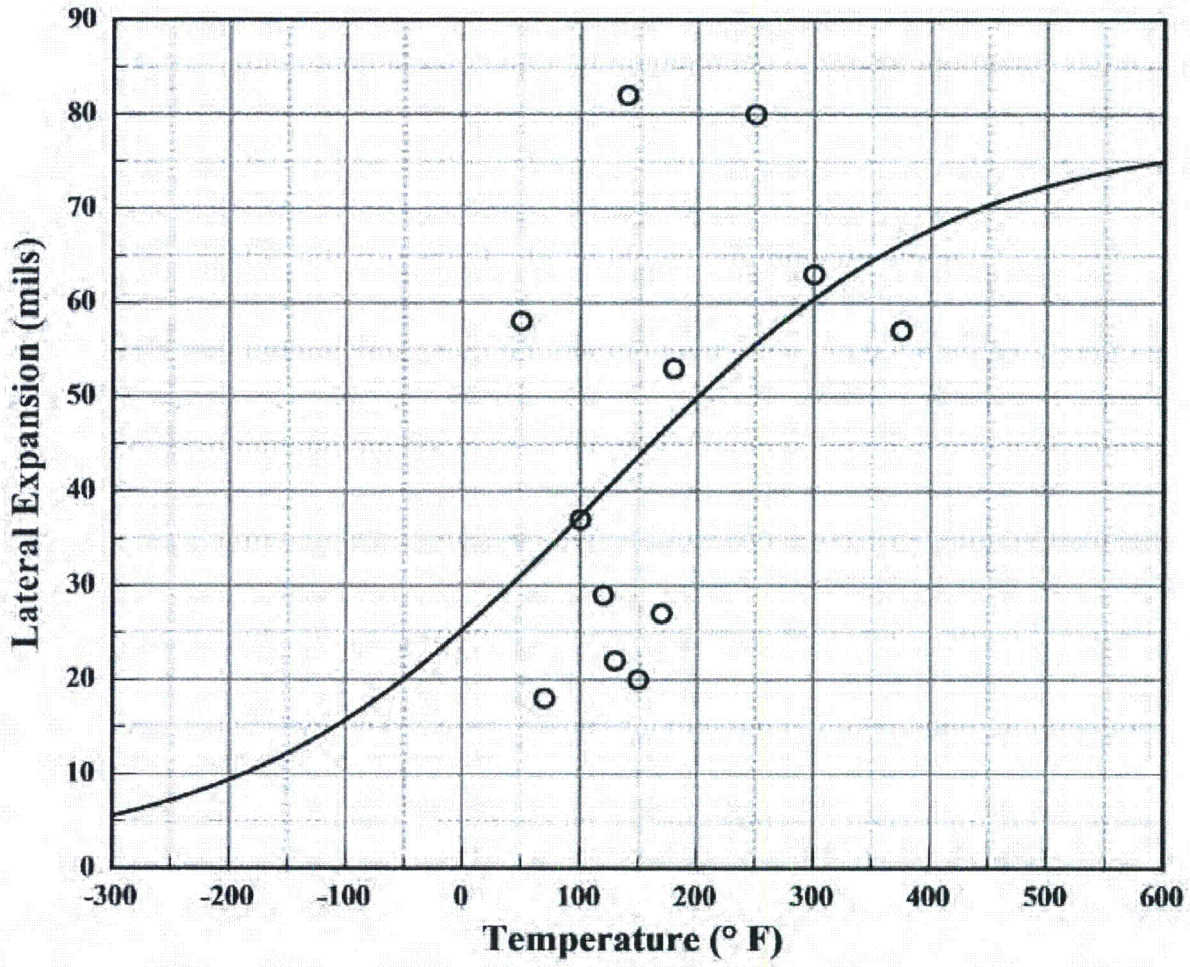
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 77.97 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= 81.60° F

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 97° Fluence:

CAPSULE 97° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
50	58.0	31.1	26.92
70	18.0	33.6	-15.55
100	37.0	37.3	-0.34
120	29.0	39.9	-10.90
130	22.0	41.2	-19.17
140	82.0	42.4	39.55
150	20.0	43.7	-23.71
170	27.0	46.2	-19.22
180	53.0	47.5	5.55
250	80.0	55.5	24.51
300	63.0	60.4	2.61
375	57.0	66.2	-9.24

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CAPSULE 97° HEAT AFFECTED ZONE

CVGraph 6.0: Hyperbolic Tangent Curve Printed on 12/8/2014 10:40 AM

A = 50.00 B = 50.00 C = 172.85 T0 = 92.39 D = 0.00

Correlation Coefficient = 0.743

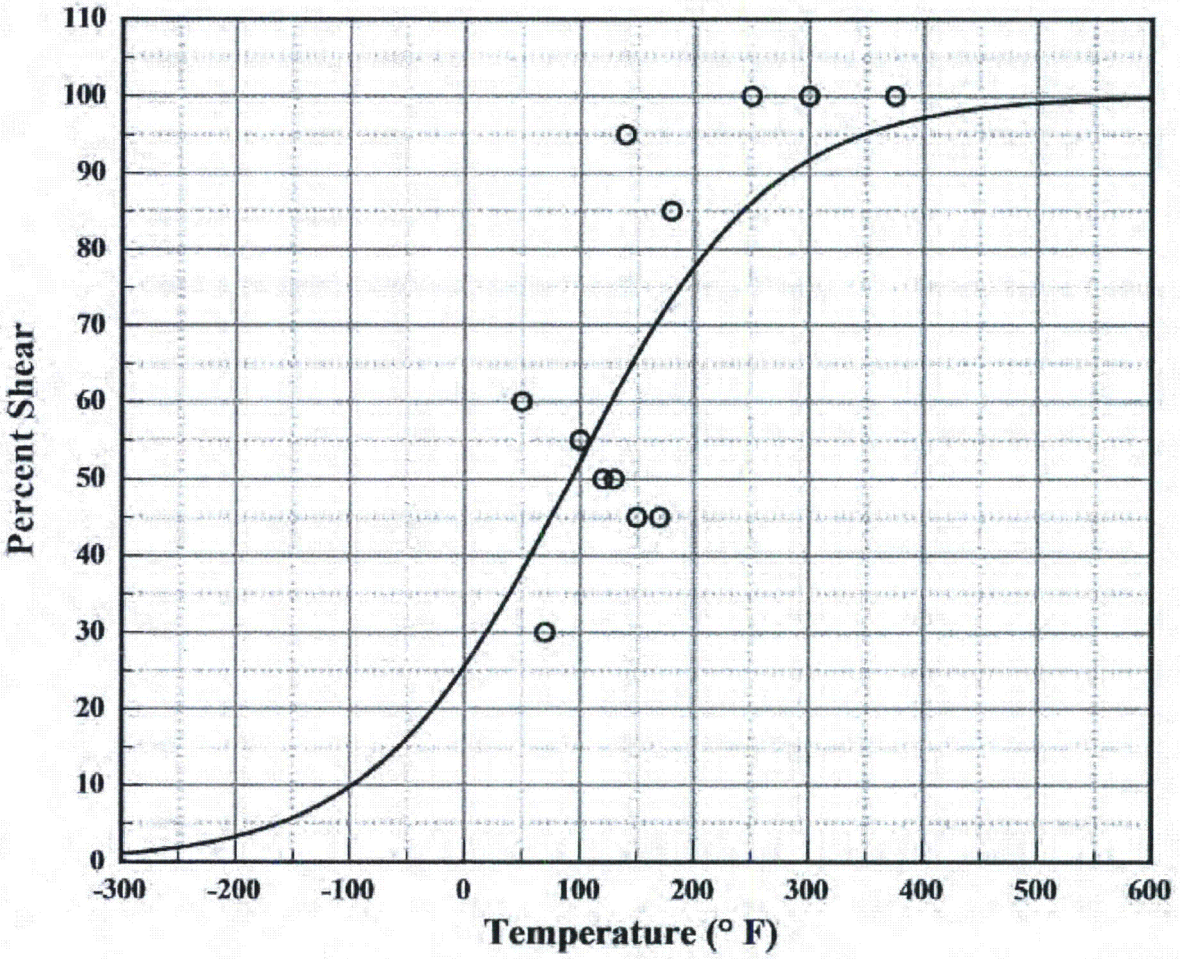
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf %Shear = 100.00 (Fixed) Lower Shelf %Shear = 0.00 (Fixed)

Temperature at 50% Shear = 92.40

Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2

Orientation: NA Capsule: 97° Fluence:



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Plant: St. Lucie 2 Material: SA533B1 Heat: A-8490-2
Orientation: NA Capsule: 97° Fluence:

CAPSULE 97° HEAT AFFECTED ZONE

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
50	60.0	38.0	22.02
70	30.0	43.6	-13.56
100	55.0	52.2	2.80
120	50.0	57.9	-7.92
130	50.0	60.7	-10.71
140	95.0	63.4	31.57
150	45.0	66.1	-21.07
170	45.0	71.1	-26.05
180	85.0	73.4	11.62
250	100.0	86.1	13.90
300	100.0	91.7	8.30
375	100.0	96.3	3.66

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APPENDIX D ST. LUCIE UNIT 2 SURVEILLANCE PROGRAM CREDIBILITY EVALUATION

D.1 INTRODUCTION

Regulatory Guide 1.99, Revision 2 [Ref. D-1] describes general procedures acceptable to the NRC staff for calculating the effects of neutron radiation embrittlement of the low-alloy steels currently used for light-water-cooled reactor vessels. Positions 2.1 and 2.2 of Regulatory Guide 1.99, Revision 2, describe the method for calculating the adjusted reference temperature and Charpy upper-shelf energy of reactor vessel beltline materials using surveillance capsule data. The methods of Positions 2.1 and 2.2 can only be applied when two or more credible surveillance data sets become available from the reactor in question.

To date there have been three surveillance capsules removed and tested from the St. Lucie Unit 2 reactor vessel. To use these surveillance data sets, they must be shown to be credible. In accordance with Regulatory Guide 1.99, Revision 2, the credibility of the surveillance data will be judged based on five criteria.

The purpose of this evaluation is to apply the credibility requirements of Regulatory Guide 1.99, Revision 2, to the St. Lucie Unit 2 reactor vessel surveillance data and determine if that surveillance data is credible.

D.2 EVALUATION

Criterion 1: Materials in the capsules should be those judged most likely to be controlling with regard to radiation embrittlement.

The beltline region of the reactor vessel is defined in Appendix G to 10 CFR Part 50, "Fracture Toughness Requirements" [Ref. D-2], as follows:

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

The St. Lucie Unit 2 reactor vessel beltline region consists of the following materials:

1. Intermediate Shell Plates M-605-1, M-605-2, and M-605-3
2. Lower Shell Plates M-4116-1, M-4116-2, and M-4116-3
3. Intermediate Shell Axial Welds (Heat # 83642, Flux Type Linde 0091)
4. Intermediate Shell Axial Weld Repair (Heat # 83637, Flux Type Linde 0091)
5. Intermediate to Lower Shell Girth Weld (Heat # 83637 and 3P7317, Flux Type Linde 124)
6. Lower Shell Axial Welds (Heat # 83637, Flux Type Linde 0091)

Per WCAP-15040, Revision 1 [Ref. D-3], the St. Lucie Unit 2 surveillance program was developed to the requirements of ASTM E185-73. Intermediate shell plate M-605-1 had the highest initial RT_{NDT} value and the second highest Cu wt. % value. This plate is also the same heat of material as the intermediate shell plate M-605-3; therefore, it is also representative of a second beltline plate. Intermediate shell plate M-605-2 has a higher wt. % Cu value; however, it has superior fracture toughness properties (Initial USE and RT_{NDT}) as compared to plate M-605-1. Lastly, all three lower shell plates, while having less than or equivalent initial USE values, have lower initial RT_{NDT} values and significantly better wt. % Cu values when compared to plate M-605-1. Hence, the intermediate shell plate M-605-1 was chosen as the most limiting plate material.

The surveillance weld metal was selected as Heat # 83637, Flux Type Linde 124, Lot # 0951. The selection of this weld material was the general practice for Combustion Engineering surveillance programs because it was considered representative material, even though this material is not directly applicable to any of the reactor vessel beltline welds. The vessel welds fabricated using the same weld wire heat, 83637, are the intermediate shell axial weld repair, and the lower shell axial welds. However, these welds all used a different Flux Type: Linde 0091 for the reactor vessel and Linde 124 for the surveillance weld. The intermediate to lower shell girth weld seam used the same heat and flux type; however, this weld was made with a second weld wire, heat # 3P7317, making the surveillance weld only partially applicable to the vessel. Hence, weld wire Heat # 83637, Flux Type Linde 124 (flux lot # 0951) was utilized in the surveillance program.

Based on the above discussion and the methodology in use at the time the program was developed, the St. Lucie Unit 2 surveillance material meets the intent of Criterion 1.

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

Based on engineering judgment, the scatter in the data presented in these plots is small enough to permit the determination of the 30 ft-lb temperature and the USE of the St. Lucie Unit 2 surveillance materials unambiguously. Hence, the St. Lucie Unit 2 surveillance program meets this criterion.

Criterion 3: When there are two or more sets of surveillance data from one reactor, the scatter of ΔRT_{NDT} values about a best-fit line drawn as described in Regulatory Position 2.1 should normally be less than 28°F for welds and 17°F for base metal. Even if the fluence range is large (two or more orders of magnitude), the scatter should not exceed twice those values. Even if the data fail this criterion for use in shift calculations, they may be credible for determining decrease in USE if the upper shelf can be clearly determined, following the definition given in ASTM E185-82 [Ref. D-4].

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

Following is the calculation of the best-fit line as described in Regulatory Position 2.1 of Regulatory Guide 1.99, Revision 2. In addition, the recommended NRC methods for determining credibility will be followed. The NRC methods were presented to industry at a meeting held by the NRC on February 12 and 13, 1998 [Ref. D-5]. At this meeting the NRC presented five cases. Of the five cases, Case 1 ("Surveillance data available from plant but no other source") most closely represents the situation for the St. Lucie Unit 2 surveillance plate and weld material.

Furthermore, per ASTM E185-82, only transverse orientation base metal is required to be included in surveillance capsules. In addition, ASME Code requires that initial RT_{NDT} and USE be determined via testing of Charpy V-notch specimens oriented in the transverse direction. Therefore, even though 10 CFR 50.61 states that "Surveillance program results means any data that demonstrates the embrittlement trends for the limiting beltline material, including but not limited to data from test reactors or from surveillance programs at other plants with or without surveillance program integrated per 10 CFR Part 50, Appendix H," ASTM E185-82 suggests inclusion of a greater quantity of Charpy V-notch test specimens, whenever possible (which was done for St. Lucie Unit 2). The longitudinal orientation Charpy V-Notch test results do demonstrate embrittlement trends for the limiting beltline plate material. Consistent with 10 CFR 50.61, the longitudinal and transverse orientation plate data are all considered in Tables D-1 and D-2. As an alternative presentation of the plate data, an interim chemistry factor and credibility conclusion is presented in Tables D-3 and D-4 using only the transverse orientation base metal Charpy V-notch test results.

Case 1: Intermediate Shell Plate M-605-1 and Weld Heat # 83637

Following the NRC Case 1 guidelines, the St. Lucie Unit 2 surveillance plate and weld metal (Heat # 83637) will be evaluated using the St. Lucie Unit 2 data. This evaluation is contained in Table D-1. Note that when evaluating the credibility of the surveillance weld data, the measured ΔRT_{NDT} values for the surveillance weld metal do not include the adjustment ratio procedure of Regulatory Guide 1.99, Revision 2, Position 2.1, since this calculation is based on the actual surveillance weld metal measured shift values. In addition, only St. Lucie Unit 2 data is being considered; therefore, no temperature adjustment is required.

Table D-1 Calculation of Interim Chemistry Factors for the Credibility Evaluation for St. Lucie Unit 2 Using All Available Surveillance Data

Material	Capsule	Capsule Fluence ($\times 10^{19}$ n/cm^2, E > 1.0 MeV)	FF	ΔRT_{NDT} (°F)	FF*ΔRT_{NDT} (°F)	FF^2
Intermediate Shell Plate M-605-1 (Longitudinal)	83°	0.140	0.488	45.1	21.99	0.238
	97°	2.250	1.220	132.7	161.84	1.487
Intermediate Shell Plate M-605-1 (Transverse)	83°	0.140	0.488	29.4	14.33	0.238
	263°	1.000	1.000	102.7	102.70	1.000
	97°	2.250	1.220	127.6	155.62	1.487
	SUM:				456.48	4.450
	$CF_{M-605-1} = \Sigma(FF * \Delta RT_{NDT}) \div \Sigma(FF^2) = (456.48) \div (4.450) =$ **102.6°F**					
Surveillance Weld Metal (Heat #83637)	83°	0.140	0.488	15.8	7.70	0.238
	263°	1.000	1.000	26.5	26.50	1.000
	97°	2.250	1.220	24.8	30.25	1.487
	SUM:				64.45	2.725
	$CF_{Surv. Weld} = \Sigma(FF * \Delta RT_{NDT}) \div \Sigma(FF^2) = (64.45) \div (2.725) =$ **23.7°F**					

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

Table D-2 St. Lucie Unit 2 Surveillance Capsule Data Scatter about the Best-Fit Line Using All Available Surveillance Data

Material	Capsule	CF ($Slope_{best-fit}$) (°F)	Capsule Fluence ($x\ 10^{19}$ n/cm^2)	FF	Measured ΔRT_{NDT} (°F)	Predicted ΔRT_{NDT} (°F)	Scatter ΔRT_{NDT} (°F)	<17°F (Base Metal) <28°F (Weld)
Intermediate Shell Plate M-605-1 (Longitudinal)	83°	102.6	0.140	0.488	45.1	50.0	4.9	Yes
	97°	102.6	2.250	1.220	132.7	125.1	7.6	Yes
Intermediate Shell Plate M-605-1 (Transverse)	83°	102.6	0.140	0.488	29.4	50.0	20.6	No
	263°	102.6	1.000	1.000	102.7	102.6	0.1	Yes
	97°	102.6	2.250	1.220	127.6	125.1	2.5	Yes
Surveillance Weld Metal (Heat #83637)	83°	23.7	0.140	0.488	15.8	11.6	4.2	Yes
	263°	23.7	1.000	1.000	26.5	23.7	2.8	Yes
	97°	23.7	2.250	1.220	24.8	28.9	4.1	Yes

From a statistical point of view, +/- 1σ would be expected to encompass 68% of the data. Table D-2 indicates that four of the five surveillance data points fall inside the +/- 1σ of 17°F scatter band for surveillance base metals; therefore, the plate data is deemed "credible" per the third criterion.

Table D-2 indicates that three of the three surveillance data points fall inside the +/- 1σ of 28°F scatter band for surveillance weld materials; therefore, the surveillance weld data is deemed "credible" per the third criterion.

Table D-3 Calculation of Interim Chemistry Factor for the Credibility Evaluation for St. Lucie Unit 2 Using Only Transverse Orientation Base Metal Surveillance Data

Material	Capsule	Capsule Fluence ($\times 10^{19}$ n/cm^2, E > 1.0 MeV)	FF	ΔRT_{NDT} (°F)	FF*ΔRT_{NDT} (°F)	FF^2
Intermediate Shell Plate M-605-1 (Transverse)	83°	0.140	0.488	29.4	14.33	0.238
	263°	1.000	1.000	102.7	102.70	1.000
	97°	2.250	1.220	127.6	155.62	1.487
				SUM:	272.65	2.725
	$CF_{M\text{-}605\text{-}1\ TL\ Only} = \Sigma(FF * \Delta RT_{NDT}) \div \Sigma(FF^2) = (272.65) \div (2.725) =$ **100.1°F**					

The scatter of ΔRT_{NDT} values about the functional form of a best-fit line drawn as described in Regulatory Position 2.1 is presented in Table D-4 for only the transverse base metal data.

Table D-4 St. Lucie Unit 2 Surveillance Capsule Data Scatter about the Best-Fit Line Using Only Transverse Orientation Base Metal Surveillance Data

Material	Capsule	CF ($Slope_{best\text{-}fit}$) (°F)	Capsule Fluence ($\times 10^{19}$ n/cm^2)	FF	Measured ΔRT_{NDT} (°F)	Predicted ΔRT_{NDT} (°F)	Scatter ΔRT_{NDT} (°F)	<17°F (Base Metal)
Intermediate Shell Plate M-605-1 (Transverse)	83°	100.1	0.140	0.488	29.4	48.8	19.4	No
	263°	100.1	1.000	1.000	102.7	100.1	2.6	Yes
	97°	100.1	2.250	1.220	127.6	122.1	5.5	Yes

From a statistical point of view, +/- 1σ would be expected to encompass 68% of the data. Table D-4 indicates that only one of the three surveillance data points falls outside the +/- 1σ of 17°F scatter band for surveillance base metals. With consideration of the three points, 67% of the data is within the 17°F scatter band.

The one data point that falls outside of the scatter band is by 2.4°F, which is a small amount considering that the scatter band is 34°F (+/- 17°F). Furthermore, the two data points that are at fluence levels closer to the actual current vessel fluence and projected end of 40-year life fluence have very minimal scatter (2.6°F and 5.5°F). Since comparisons of the measured and predicted shifts for the two most recent data points have minimal scatter, it is reasonable to state that the transverse plate data only is deemed "credible" per the third criterion.

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

The surveillance materials are contained in capsules positioned near the reactor vessel inside wall so that the irradiation conditions (fluence, flux spectrum, temperature) of the test specimens resemble, as closely as possible, the irradiation conditions of the reactor vessel. The capsules are bisected by the midplane of the core and are placed in capsule holders positioned circumferentially about the core at locations near the regions of maximum flux. The location of the specimens with respect to the reactor vessel beltline provides assurance that the reactor vessel wall and the specimens experience equivalent operating conditions such that the temperatures will not differ by more than 25°F.

Hence, Criterion 4 is met for the St. Lucie Unit 2 surveillance program.

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

The St. Lucie Unit 2 surveillance program does contain Standard Reference Material (SRM). The material was obtained from an A533 Grade B, Class 1 plate (HSST Plate 01). NUREG/CR-6413, ORNL/TM-13133 [Ref. D-6] contains a plot of Residual vs. Fast Fluence for the SRM (Figure 11 in the report). This Figure shows a 2σ uncertainty of 50°F. The data used for this plot is contained in Table 14 in the report. However, the NUREG Report does not consider the recalculated fluence and ΔRT_{NDT} values for Capsule 263°. Thus, Table D-5 contains an updated calculation of Residual vs. Fast fluence, considering the recalculated capsule fluence and ΔRT_{NDT} values for Capsule 263°.

Table D-5 Calculation of Residual vs. Fast Fluence for St. Lucie Unit 2

Capsule	Capsule f ($x10^{19}$ n/cm^2, E > 1.0 MeV)	FF	Measured Shift (°F)[(a)]	RG 1.99, Rev. 2 Shift (°F)[(b)]	Residual (°F)[(c)]
263°	1.000	1.000	131.2	136.10	4.9

Notes for Table D-5:

(a) Measured ΔT_{30} values for the SRM were taken from Section 5 of this report.

(b) Per NUREG/CR-6413, ORNL/TM-13133, the Cu and Ni values for the SRM (HSST Plate 01) are 0.18 and 0.66, respectively. This equates to a chemistry factor value of 136.1°F based on Regulatory Guide 1.99, Revision 2, Position 1.1. The calculated shift is thus equal to CF * FF.

(c) Residual = Absolute Value [Measured Shift – RG 1.99 Shift].

Table D-5 shows a 2σ uncertainty of less than 50°F, which is the allowable scatter in NUREG/CR-6413, ORNL/TM-13133.

Hence, Criterion 5 is met for the St. Lucie Unit 2 surveillance program.

D.3 CONCLUSION

Based on the preceding responses to all five criteria of Regulatory Guide 1.99, Revision 2, Section B, the St. Lucie Unit 2 surveillance plate, with consideration of all surveillance data or considering only the transverse orientation Charpy data points, and weld data are both deemed credible.

D.4 REFERENCES

D-1 Regulatory Guide 1.99, Revision 2, *Radiation Embrittlement of Reactor Vessel Materials*, U.S. Nuclear Regulatory Commission, May 1998.

D-2 10 CFR 50, Appendix G, *Fracture Toughness Requirements*, Federal Register, Volume 60, No. 243, December 19, 1995.

D-3 WCAP-15040, Revision 1, *Analysis of Capsule 263° from the Florida Power & Light Company St. Lucie Unit 2 Reactor Vessel Radiation Surveillance Program*, February 2010.

D-4 ASTM E185-82, *Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels*, ASTM, 1982.

D-5 K. Wichman, M. Mitchell, and A. Hiser, USNRC, Generic Letter 92-01 and RPV Integrity Assessment Workshop Handouts, *NRC/Industry Workshop on RPV Integrity Issues*, February 12, 1998.

D-6 NUREG/CR-6413; ORNL/TM-13133, *Analysis of the Irradiation Data for A302B and A533B Correlation Monitor Materials*, J. A. Wang, Oak Ridge National Laboratory, Oak Ridge, TN, April 1996.

APPENDIX E ST. LUCIE UNIT 2 UPPER-SHELF ENERGY EVALUATION

E.1 EVALUATION

Per Regulatory Guide 1.99, Revision 2 [Ref. E-1], the Charpy upper-shelf energy (USE) is assumed to decrease as a function of fluence and copper content as indicated in Figure 2 of the Guide (Figure E-1 of this appendix) when surveillance data is not used. Linear interpolation is permitted. In addition, if surveillance data is to be used, the decrease in upper-shelf energy may be obtained by plotting the reduced plant surveillance data on Figure 2 of the Guide (Figure E-1 of this appendix) and fitting the data with a line drawn parallel to the existing lines as the upper bound of all the data. This line should be used in preference to the existing graph.

The 55 EFPY (end-of-license) upper-shelf energy of the vessel materials can be predicted using the corresponding 1/4T fluence projection, the copper content of the beltline materials and/or the results of the capsules tested to date using Figure 2 in Regulatory Guide 1.99, Revision 2. The maximum vessel clad/base metal interface fluence value was used to determine the corresponding 1/4T fluence value at 55 EFPY.

The St. Lucie Unit 2 reactor vessel beltline region minimum thickness is 8.625 inches. Calculation of the 1/4T vessel fluence values at 55 EFPY for the beltline materials is shown as follows:

$$\text{Maximum Vessel Fluence @ 55 EFPY} = 4.53 \times 10^{19}\ \text{n/cm}^2\ (E > 1.0\ \text{MeV})$$

$$\text{1/4T Fluence @ 55 EFPY} = (4.53 \times 10^{19}\ \text{n/cm}^2) * e^{(-0.24 * (8.625 / 4))}$$

$$= 2.700 \times 10^{19}\ \text{n/cm}^2\ (E > 1.0\ \text{MeV})$$

The following pages present the St. Lucie Unit 2 upper-shelf energy evaluation. Figure E-1, as indicated above, is used in making predictions in accordance with Regulatory Guide 1.99, Revision 2. Table E-1 provides the predicted upper-shelf energy values for 55 EFPY (EOL).

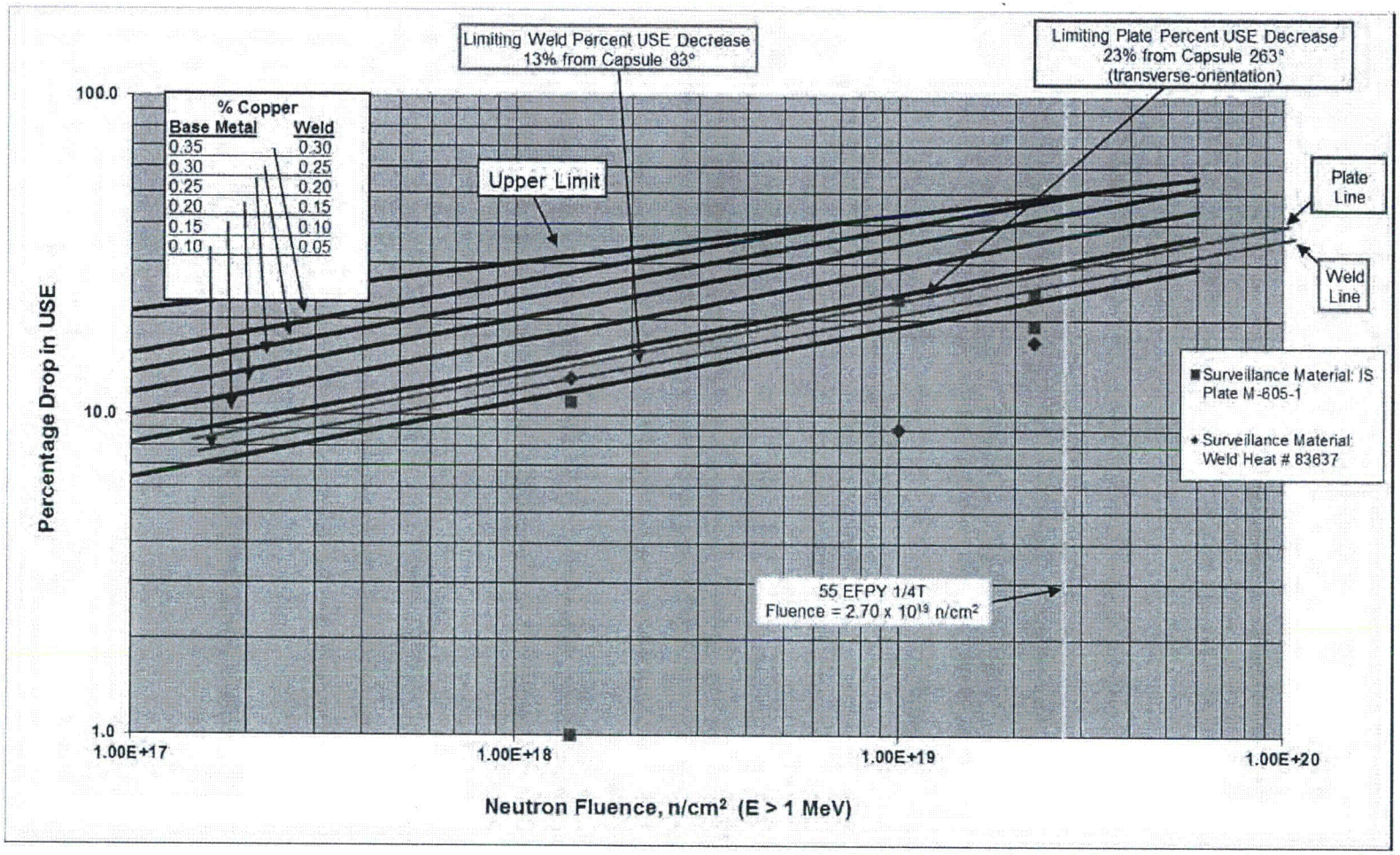

Figure E-1 Regulatory Guide 1.99, Revision 2 Predicted Decrease in Upper-Shelf Energy as a Function of Copper and Fluence

Table E-1 Predicted Positions 1.2 and 2.2 Upper-Shelf Energy Values at 55 EFPY

Material	Wt % Cu	1/4T EOL Fluence ($x10^{19}$ n/cm^2, E > 1.0 MeV)	Unirradiated USE (ft-lb)	Projected USE Decrease (%)	Projected EOL USE (ft-lb)
Position 1.2[(a)]					
Intermediate Shell Plate M-605-1	0.11	2.70	105	30	73.5
Intermediate Shell Plate M-605-2	0.13	2.70	113	30	79.1
Intermediate Shell Plate M-605-3	0.11	2.70	113	30	79.1
Lower Shell Plate M-4116-1	0.06	2.70	91	24	69.2
Lower Shell Plate M-4116-2	0.07	2.70	105	24	79.8
Lower Shell Plate M-4116-3	0.07	2.70	100	24	76.0
Intermediate to Lower Shell Girth Weld Seam 101-171	0.07	2.70	96	30	67.2
Intermediate Shell Axial Weld Seams 101-124 A, B, C	0.05	2.70	116	24	88.2
Intermediate Shell Axial Weld Seam 101-124 C REPAIR	0.05	2.70	136	24	103.4
Lower Shell Axial Weld Seams 101-142 A, B, C	0.05	2.70	136	24	103.4
Position 2.2[(b)]					
Intermediate Shell Plate M-605-1	0.11	2.70	105	29	74.6
Intermediate Shell Plate M-605-3	0.11	2.70	113	29	80.2

Notes:

(a) Calculated using the Cu wt. % value and 1/4T fluence value for each material and Regulatory Guide 1.99, Revision 2, Position 1.2. In calculating the Position 1.2 percent USE decreases, the copper weight percent values were conservatively rounded up to the next highest line for each plate and weld material.

(b) Calculated using surveillance capsule measured percent decrease in USE from Table 5-10 and Regulatory Guide 1.99, Revision 2, Position 2.2; see Figure E-1. Consistent with Criterion 1 of Appendix D, the surveillance weld percent USE decrease was not applied to the reactor vessel weld materials because none of the actual reactor vessel welds directly match both the heat and flux type used for the surveillance weld material.

USE Conclusion

As shown in Table E-1, all of the St. Lucie Unit 2 reactor vessel beltline materials are projected to remain above the USE screening criterion of 50 ft-lbs (per 10 CFR 50, Appendix G) at 55 EFPY.

E.2 REFERENCES

E-1 Regulatory Guide 1.99, Revision 2, *Radiation Embrittlement of Reactor Vessel Materials*, U.S. Nuclear Regulatory Commission, May 1998.