Plant: **Prairie Island 2** Material: **SA508CL3** Heat: **22642**
Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**

Capsule N Heat Affected Zone
Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-25	20.0	16.1	3.93
25	25.0	32.6	-7.64
30	30.0	34.7	-4.71
60	60.0	48.1	11.87
90	70.0	61.8	8.17
120	55.0	73.9	-18.88
175	98.0	88.7	9.29
275	100.0	98.1	1.95

CVGraph 6.02 11/08/2022 Page 2/2

Unirradiated Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/24/2022 4:57 PM

A = 61.30 B = 59.10 C = 78.31 T0 = 93.15 D = 0.00

Correlation Coefficient = 0.988

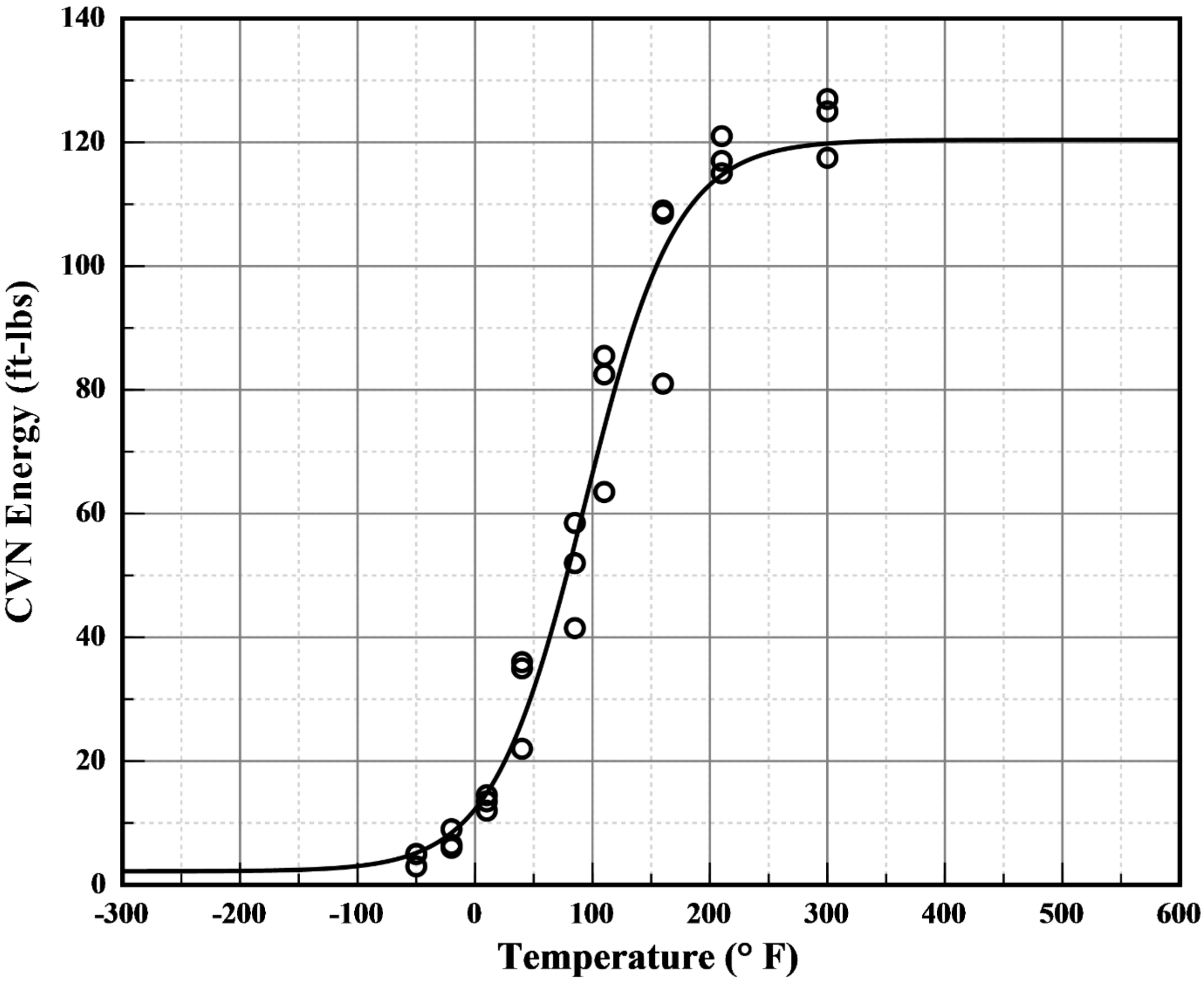
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 120.40 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs= 47.00° F Temp@35 ft-lbs= 55.70° F Temp@50 ft-lbs= 78.00° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **Unirrad** Fluence: **0.00E+000 n/cm²**



CVGraph 6.02 05/24/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **Unirrad** Fluence: **0.00E+000 n/cm²**

Unirradiated Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
-50	5.0	5.2	-0.18
-50	5.0	5.2	-0.18
-50	3.0	5.2	-2.18
-20	6.5	8.4	-1.93
-20	9.0	8.4	0.57
-20	6.0	8.4	-2.43
10	12.0	14.8	-2.83
10	14.5	14.8	-0.33
10	13.5	14.8	-1.33
40	22.0	26.4	-4.39
40	36.0	26.4	9.61
40	35.0	26.4	8.61
85	58.5	55.2	3.32
85	41.5	55.2	-13.68
85	52.0	55.2	-3.18
110	82.5	73.8	8.67
110	85.5	73.8	11.67
110	63.5	73.8	-10.33
160	108.5	102.3	6.24
160	81.0	102.3	-21.26
160	109.0	102.3	6.74
210	117.0	114.7	2.29
210	115.0	114.7	0.29
210	121.0	114.7	6.29
300	125.0	119.8	5.20
300	117.5	119.8	-2.30
300	127.0	119.8	7.20

CVGraph 6.02 05/24/2022 Page 2/2

Capsule V Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/25/2022 8:29 AM

A = 52.00 B = 49.80 C = 63.61 T0 = 200.63 D = 0.00

Correlation Coefficient = 0.990

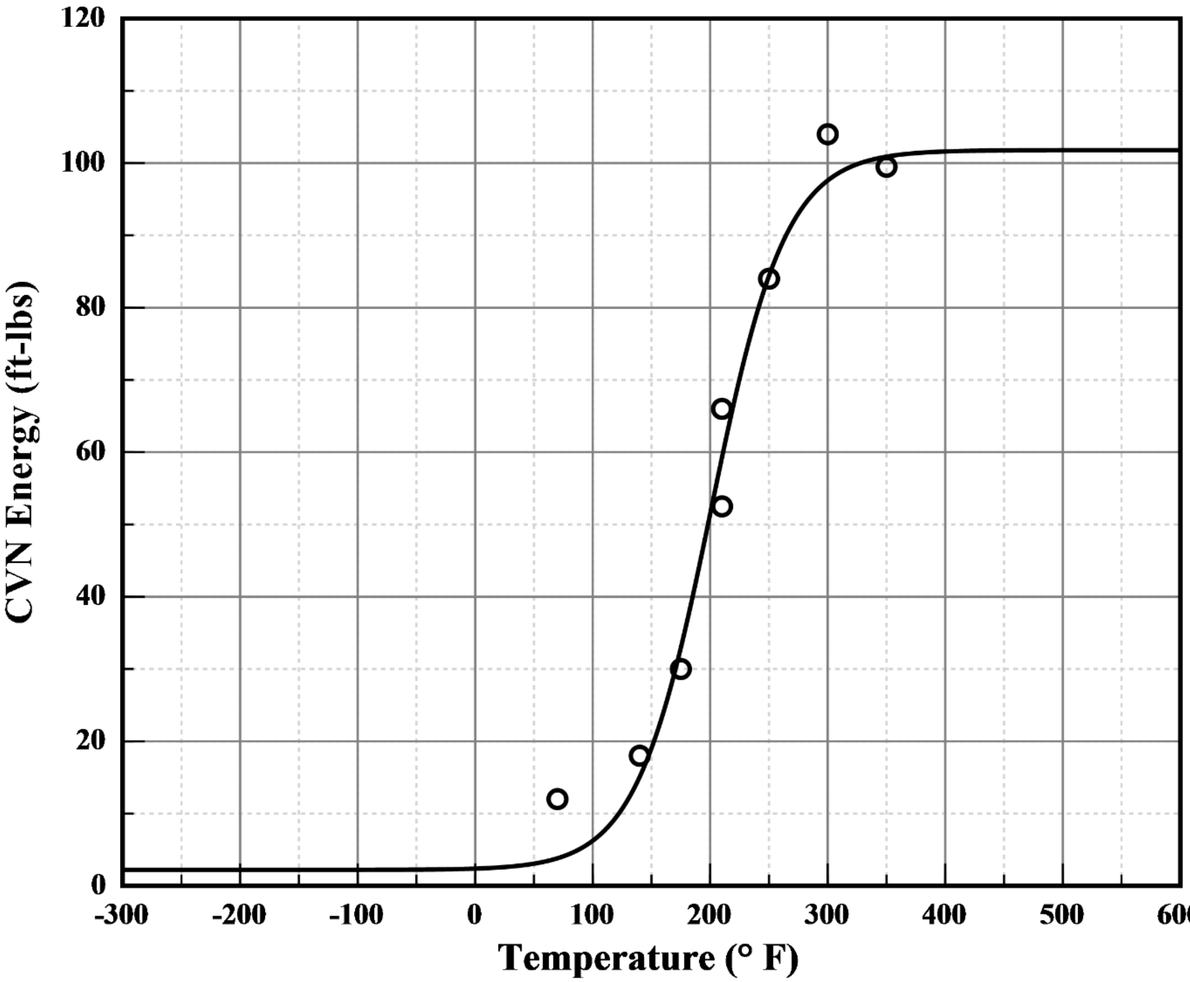
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 101.80 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=170.50° F Temp@35 ft-lbs=178.10° F Temp@50 ft-lbs=198.10° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **V** Fluence: **5.98E+018 n/cm²**



CVGraph 6.02 05/25/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **V** Fluence: **5.98E+018 n/cm²**

Capsule V Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
70	12.0	3.8	8.19
140	18.0	15.1	2.91
175	30.0	33.0	-2.95
210	66.0	59.3	6.72
210	52.5	59.3	-6.78
250	84.0	84.4	-0.40
300	104.0	97.6	6.39
350	99.5	100.9	-1.40

CVGraph 6.02 05/25/2022 Page 2/2

Capsule T Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/25/2022 10:30 AM

A = 44.95 B = 42.75 C = 53.13 T0 = 224.36 D = 0.00

Correlation Coefficient = 0.978

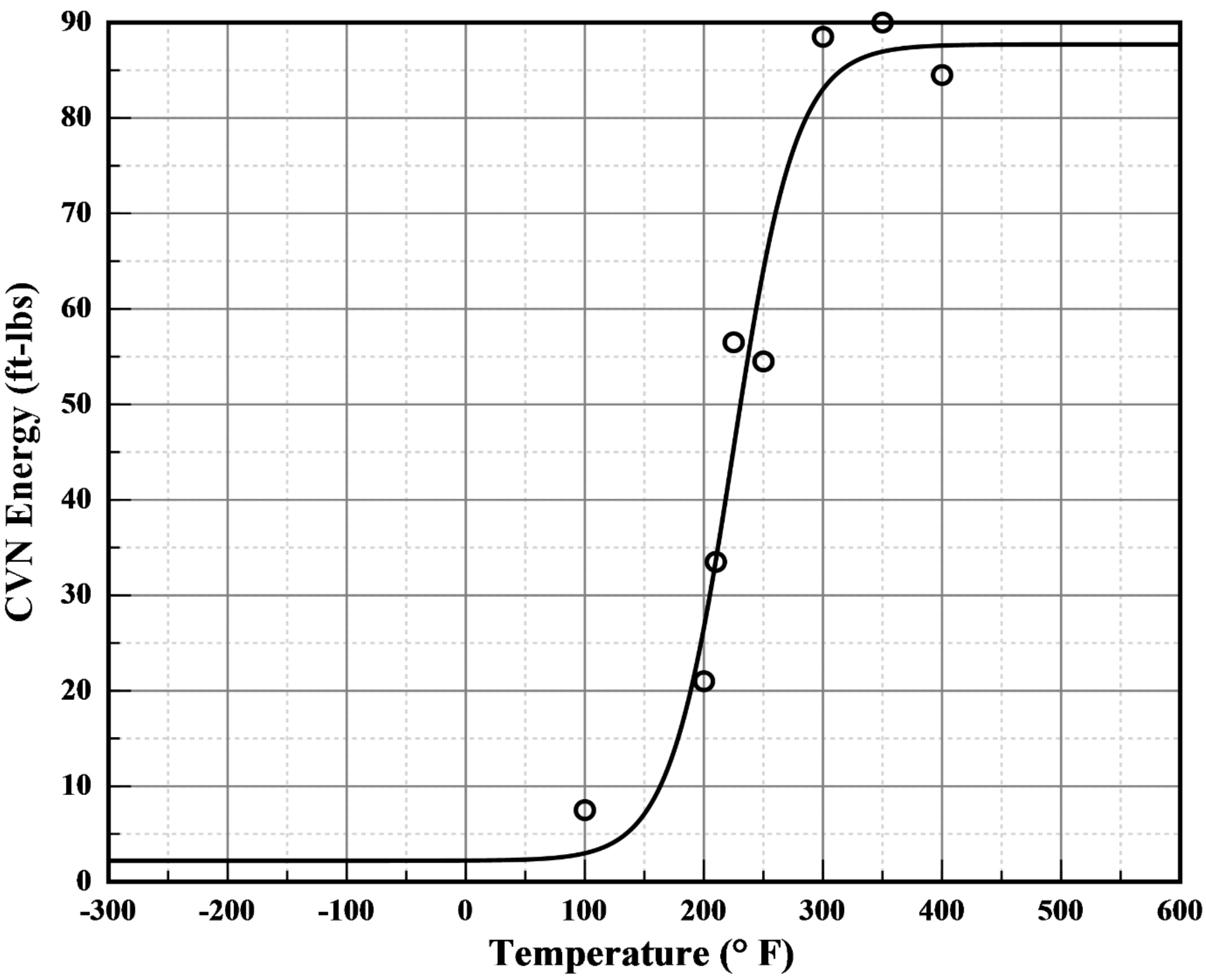
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 87.70 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=205.00° F Temp@35 ft-lbs=211.80° F Temp@50 ft-lbs=230.70° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **T** Fluence: **1.10E+019 n/cm²**



CVGraph 6.02 05/25/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **T** Fluence: **1.10E+019 n/cm²**

Capsule T Correlation Monitor Material
Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
100	7.5	3.0	4.52
200	21.0	26.6	-5.61
210	33.5	33.7	-0.17
225	56.5	45.5	11.04
250	54.5	64.1	-9.61
300	88.5	83.0	5.49
350	90.0	87.0	3.05
400	84.5	87.6	-3.09

CVGraph 6.02 05/25/2022 Page 2/2

Capsule R Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/31/2022 6:41 AM

A = 39.60 B = 37.40 C = 65.96 T0 = 247.48 D = 0.00

Correlation Coefficient = 0.973

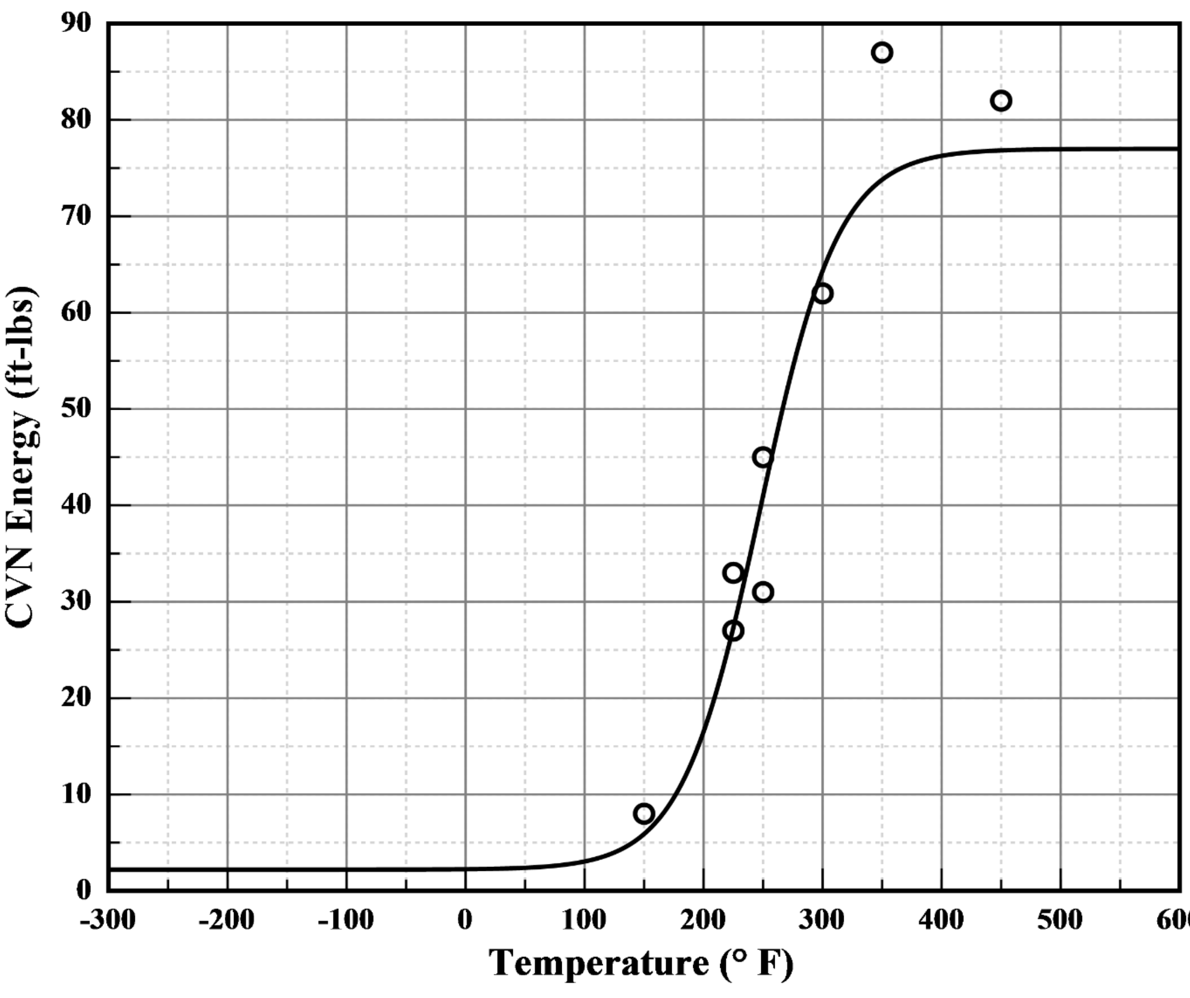
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 77.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=230.20° F Temp@35 ft-lbs=239.40° F Temp@50 ft-lbs=266.40° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **R** Fluence: **4.11E+019 n/cm²**



CVGraph 6.02 05/31/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **R** Fluence: **4.11E+019 n/cm²**

Capsule R Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
150	8.0	5.9	2.10
225	33.0	27.3	5.68
225	27.0	27.3	-0.32
250	45.0	41.0	3.97
250	31.0	41.0	-10.03
300	62.0	64.4	-2.36
350	87.0	73.8	13.20
450	82.0	76.8	5.16

CVGraph 6.02 05/31/2022 Page 2/2

Capsule P Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/31/2022 10:54 AM

A = 49.10 B = 46.90 C = 85.09 T0 = 280.50 D = 0.00

Correlation Coefficient = 0.999

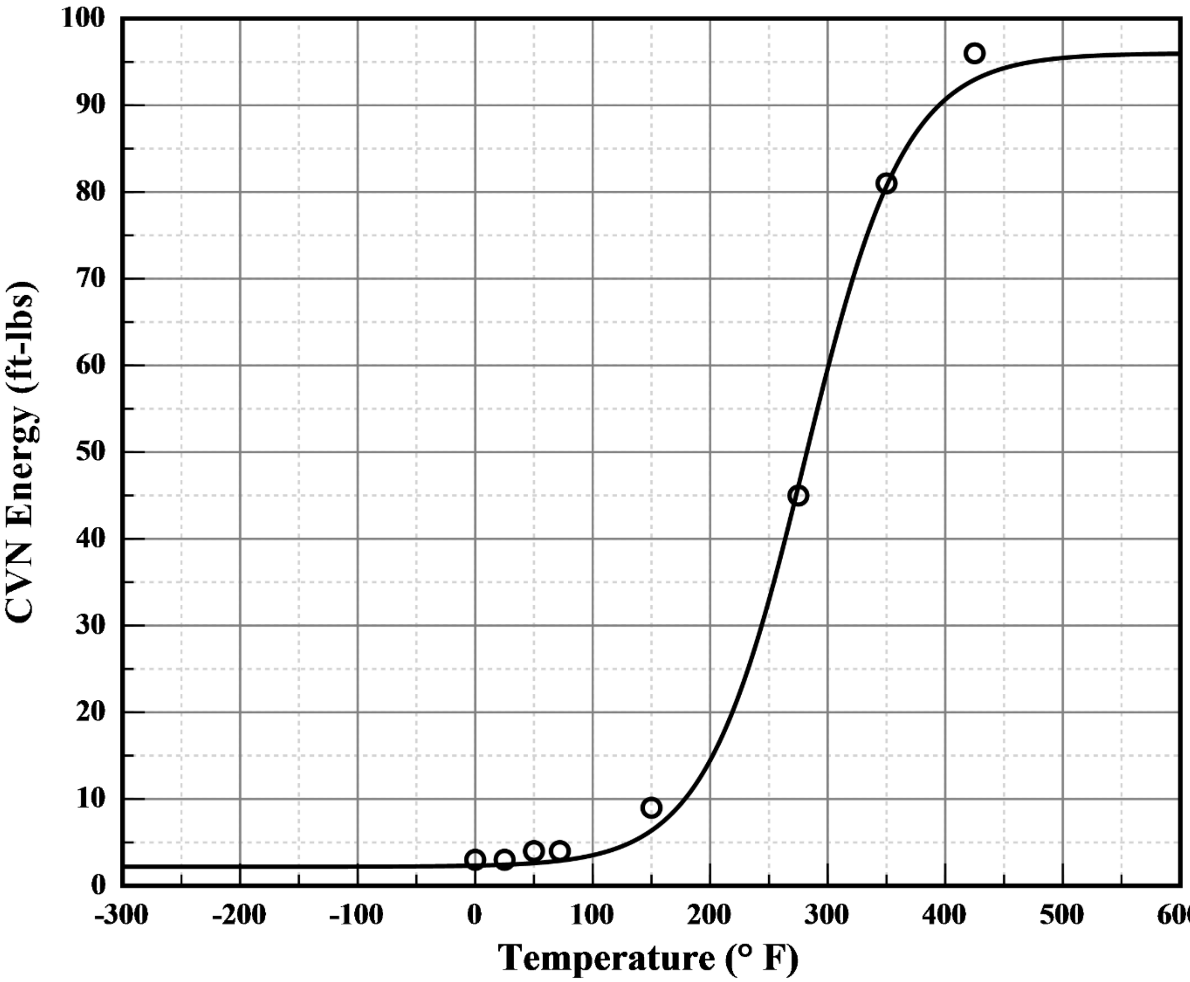
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf Energy = 96.00 (Fixed) Lower Shelf Energy = 2.20 (Fixed)

Temp@30 ft-lbs=243.80° F Temp@35 ft-lbs=254.20° F Temp@50 ft-lbs=282.20° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **P** Fluence: **4.27E+019 n/cm²**



CVGraph 6.02 05/31/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **P** Fluence: **4.27E+019 n/cm²**

Capsule P Correlation Monitor Material
Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
0	3.0	2.3	0.67
25	3.0	2.4	0.57
50	4.0	2.6	1.39
72	4.0	2.9	1.11
150	9.0	6.4	2.63
275	45.0	46.1	-1.07
350	81.0	80.7	0.32
425	96.0	93.0	3.04

CVGraph 6.02 05/31/2022 Page 2/2

Capsule N Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 7/12/2022 7:16 AM

A = 40.60 B = 38.40 C = 94.51 T0 = 286.65 D = 0.00

Correlation Coefficient = 0.971

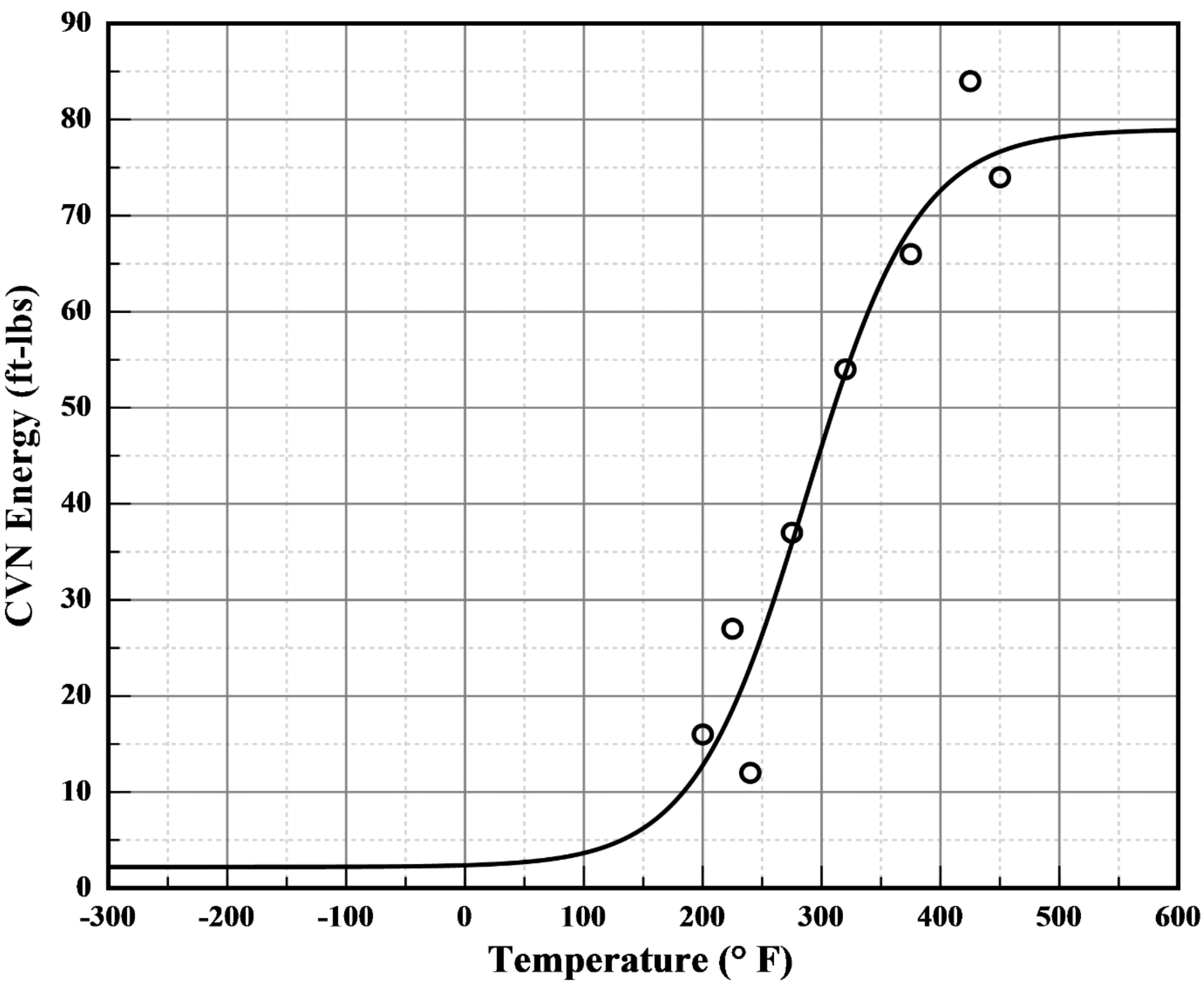
Equation is A + B * [Tanh((T-T0)/(C+DT))]

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

Temp@30 ft-lbs=259.90° F Temp@35 ft-lbs=272.80° F Temp@50 ft-lbs=310.30° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**



CVGraph 6.02 07/12/2022 Page 1/2

Plant: **Prairie Island 2** Material: **SA533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**

Capsule N Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input CVN	Computed CVN	Differential
200	16.0	12.8	3.22
225	27.0	18.6	8.41
240	12.0	23.0	-11.05
275	37.0	35.9	1.11
320	54.0	53.6	0.38
375	66.0	68.7	-2.74
425	84.0	75.1	8.90
450	74.0	76.7	-2.65

CVGraph 6.02 07/12/2022 Page 2/2

Unirradiated Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/24/2022 4:59 PM

A = 43.71 B = 42.71 C = 84.07 T0 = 76.44 D = 0.00

Correlation Coefficient = 0.992

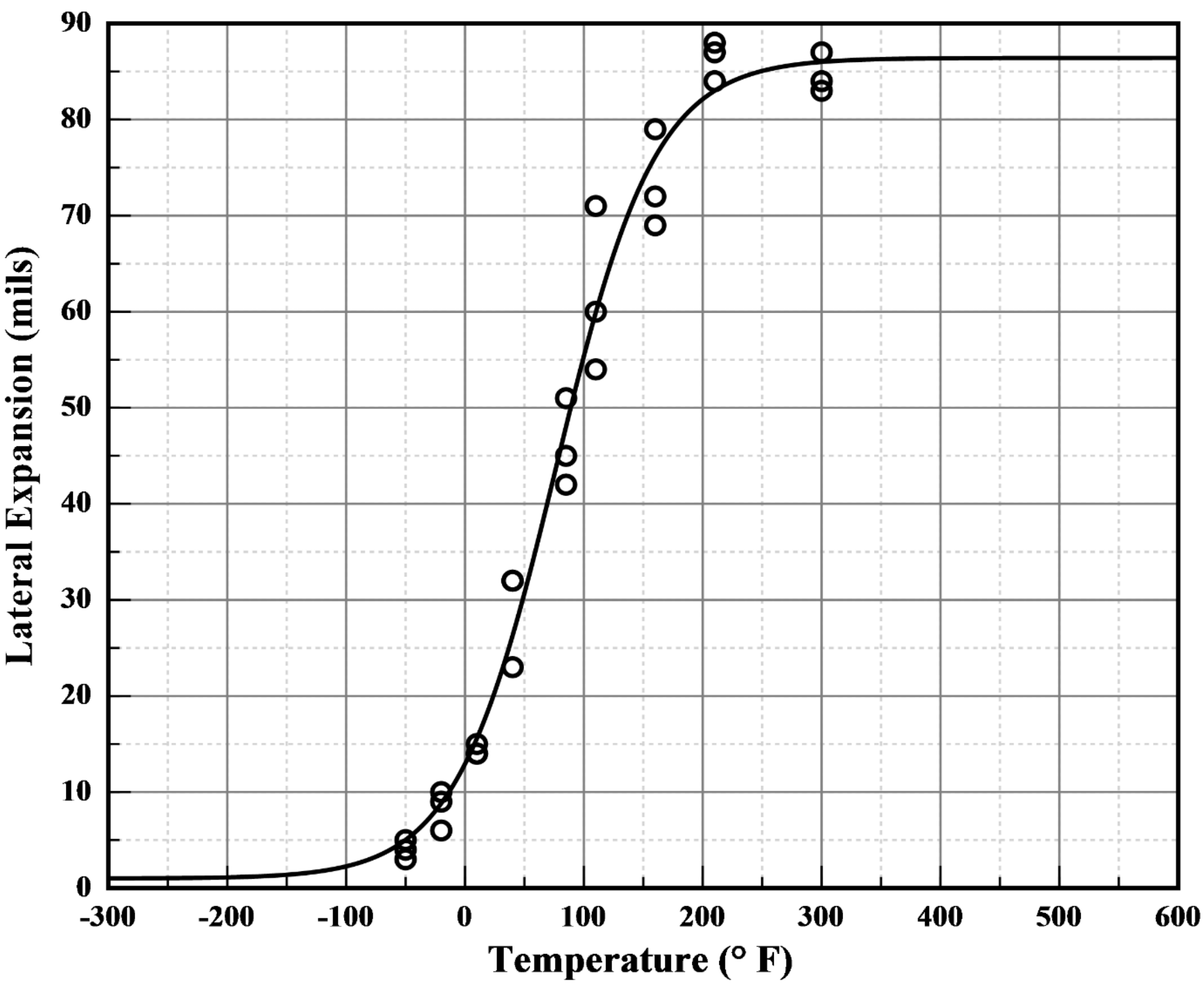
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 86.42 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils= 59.10° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **Unirrad** Fluence: **0.00E+000 n/cm²**



CVGraph 6.02 05/24/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **Unirrad** Fluence: **0.00E+000 n/cm²**

Unirradiated Correlation Monitor Material
Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
-50	3.0	5.0	-2.02
-50	5.0	5.0	-0.02
-50	4.0	5.0	-1.02
-20	6.0	8.8	-2.82
-20	10.0	8.8	1.18
-20	9.0	8.8	0.18
10	15.0	15.6	-0.58
10	14.0	15.6	-1.58
10	14.0	15.6	-1.58
40	23.0	26.3	-3.28
40	32.0	26.3	5.72
40	32.0	26.3	5.72
85	51.0	48.0	2.96
85	42.0	48.0	-6.04
85	45.0	48.0	-3.04
110	60.0	59.9	0.09
110	71.0	59.9	11.09
110	54.0	59.9	-5.91
160	72.0	76.1	-4.13
160	69.0	76.1	-7.13
160	79.0	76.1	2.87
210	84.0	83.0	1.00
210	88.0	83.0	5.00
210	87.0	83.0	4.00
300	87.0	86.0	1.00
300	83.0	86.0	-3.00
300	84.0	86.0	-2.00

CVGraph 6.02 05/24/2022 Page 2/2

Capsule V Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/25/2022 8:32 AM

A = 36.11 B = 35.11 C = 112.42 T0 = 210.29 D = 0.00

Correlation Coefficient = 0.994

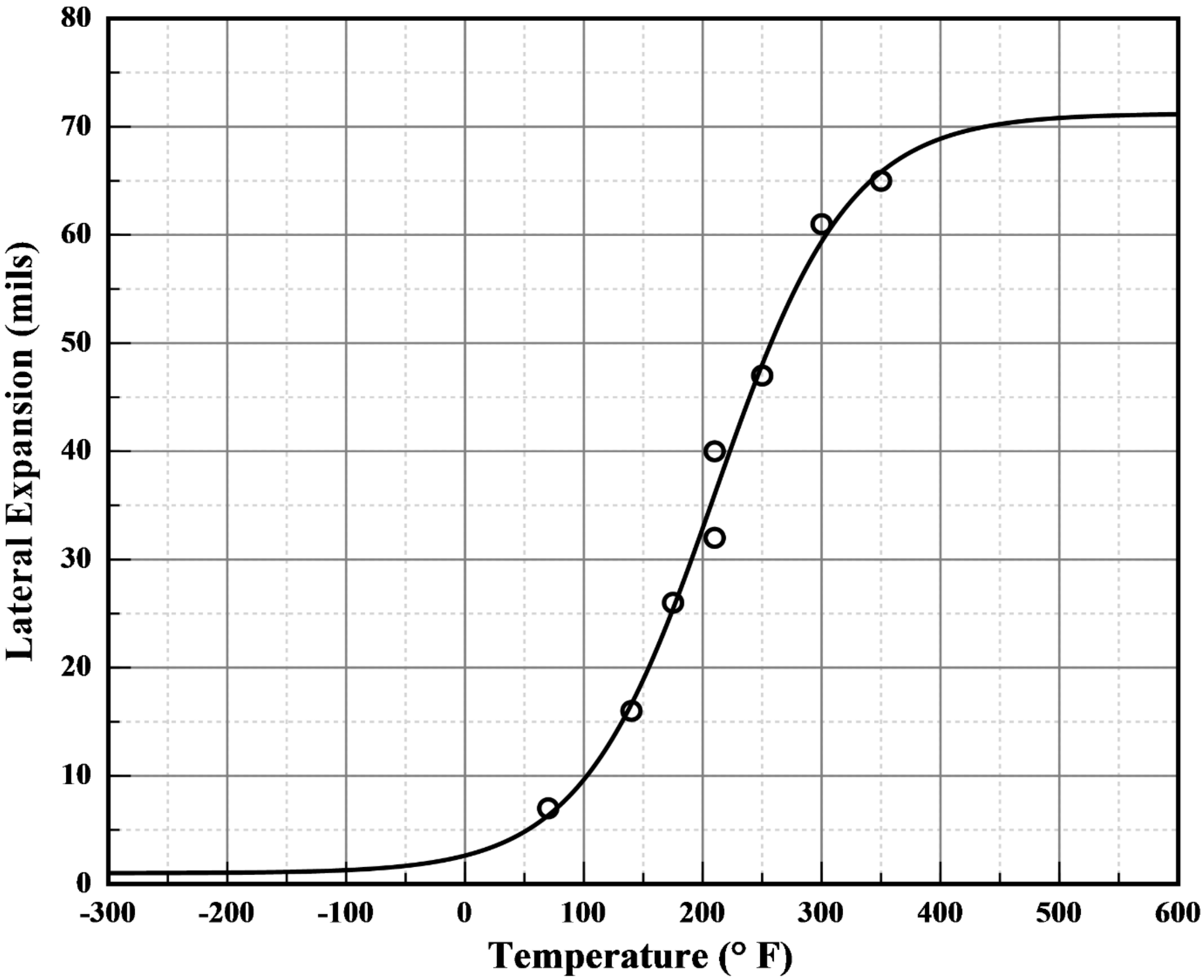
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 71.21 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=206.80° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **V** Fluence: **5.98E+018 n/cm²**



CVGraph 6.02 05/25/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **V** Fluence: **5.98E+018 n/cm²**

Capsule V Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
70	7.0	6.3	0.65
140	16.0	16.6	-0.63
175	26.0	25.4	0.56
210	40.0	36.0	3.98
210	32.0	36.0	-4.02
250	47.0	48.0	-1.02
300	61.0	59.4	1.62
350	65.0	65.8	-0.82

CVGraph 6.02 05/25/2022 Page 2/2

Capsule T Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/25/2022 10:37 AM

A = 39.24 B = 38.24 C = 63.30 T0 = 229.26 D = 0.00

Correlation Coefficient = 0.965

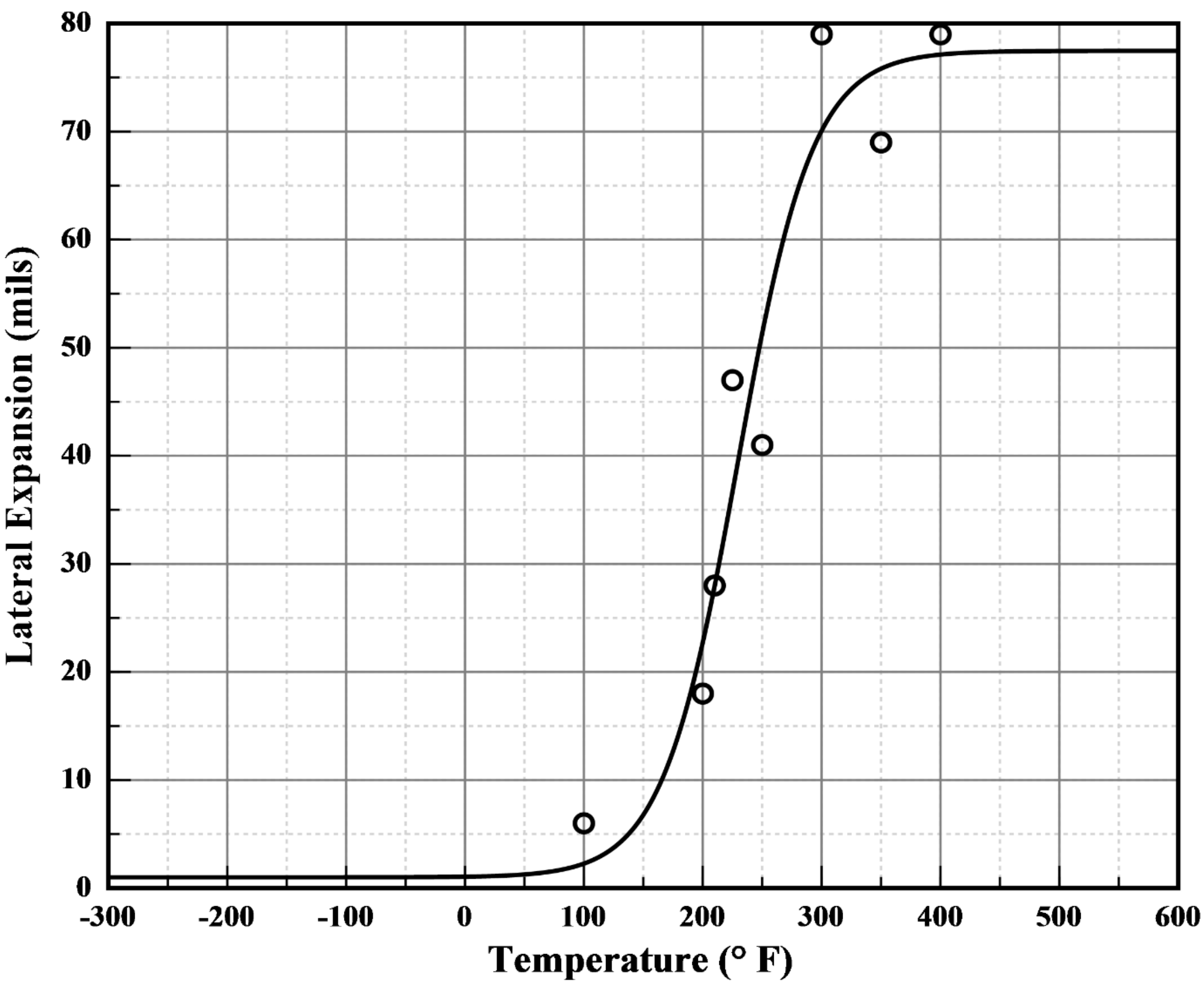
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 77.47 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=222.30° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **T** Fluence: **1.10E+019 n/cm²**



CVGraph 6.02 05/25/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **T** Fluence: **1.10E+019 n/cm²**

Capsule T Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
100	6.0	2.3	3.73
200	18.0	22.7	-4.72
210	28.0	28.0	0.05
225	47.0	36.7	10.33
250	41.0	51.3	-10.33
300	79.0	70.1	8.92
350	69.0	75.8	-6.82
400	79.0	77.1	1.87

CVGraph 6.02 05/25/2022 Page 2/2

Capsule R Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/31/2022 7:19 AM

A = 32.11 B = 31.11 C = 71.34 T0 = 244.03 D = 0.00

Correlation Coefficient = 0.940

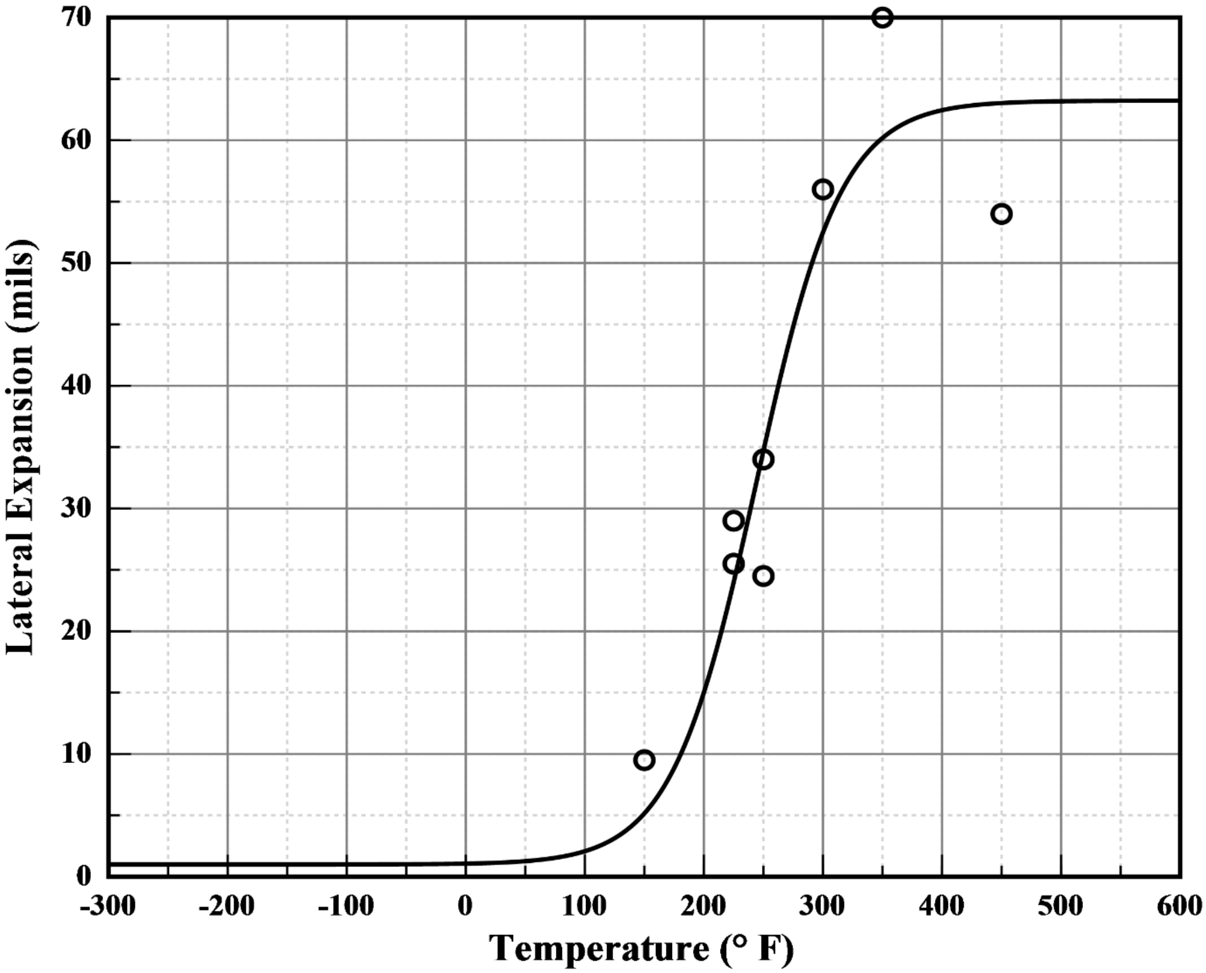
Equation is A + B * [Tanh((T-T0)/(C+DT))]

Upper Shelf L.E. = 63.23 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=250.70° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **R** Fluence: **4.11E+019 n/cm²**



CVGraph 6.02 05/31/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **R** Fluence: **4.11E+019 n/cm²**

Capsule R Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
150	9.5	5.2	4.34
225	25.5	24.0	1.50
225	29.0	24.0	5.00
250	34.0	34.7	-0.71
250	24.5	34.7	-10.21
300	56.0	52.5	3.50
350	70.0	60.2	9.81
450	54.0	63.0	-9.03

CVGraph 6.02 05/31/2022 Page 2/2

Capsule P Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/31/2022 10:56 AM

A = 38.51 B = 37.51 C = 109.90 T0 = 270.73 D = 0.00

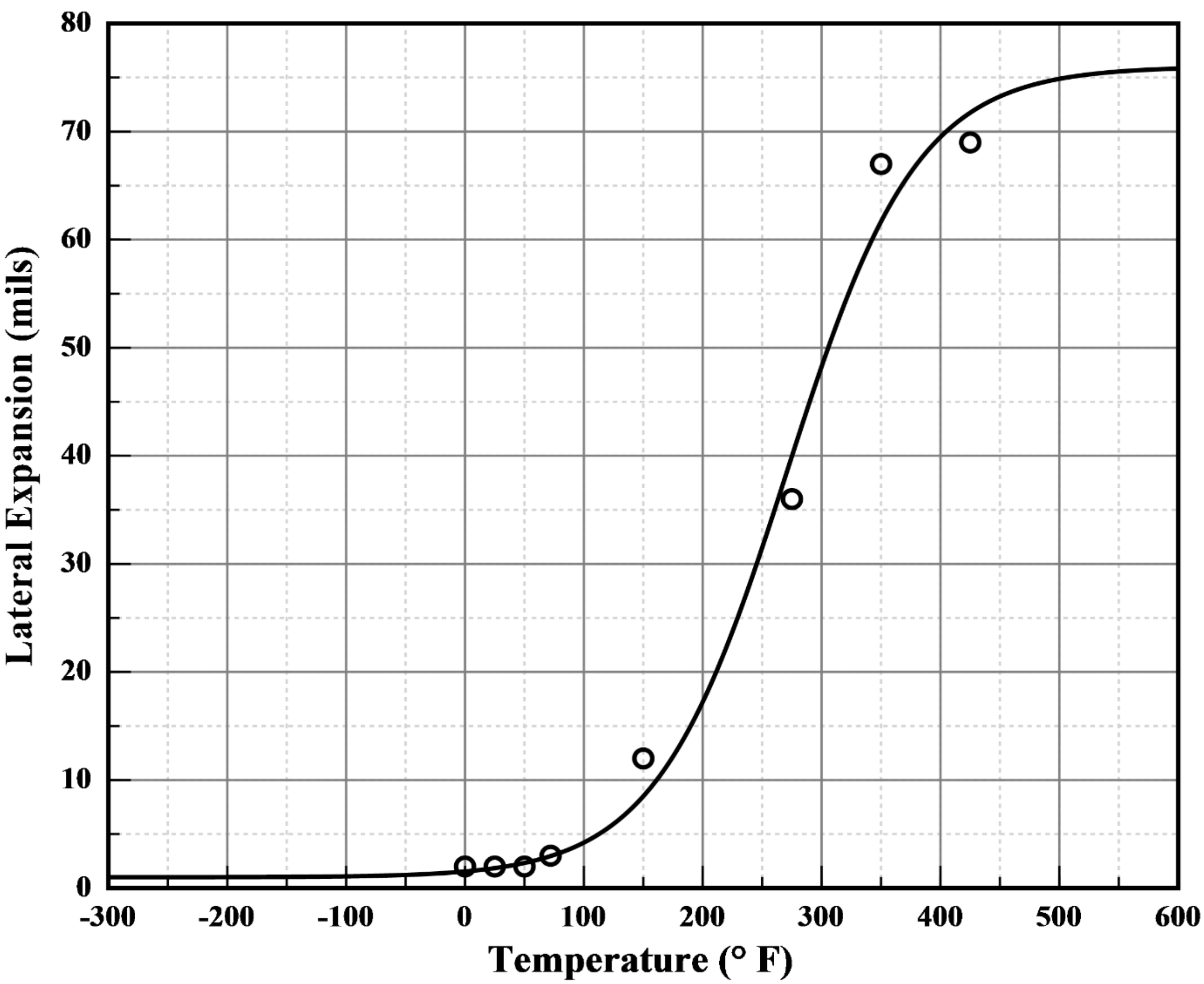
Correlation Coefficient = 0.995

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

Upper Shelf L.E. = 76.02 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=260.50° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **P** Fluence: **4.27E+019 n/cm²**



CVGraph 6.02 05/31/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **P** Fluence: **4.27E+019 n/cm²**

Capsule P Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
0	2.0	1.5	0.46
25	2.0	1.8	0.15
50	2.0	2.3	-0.33
72	3.0	3.0	0.04
150	12.0	8.5	3.50
275	36.0	40.0	-3.97
350	67.0	61.7	5.32
425	69.0	71.7	-2.75

CVGraph 6.02 05/31/2022 Page 2/2

Capsule N Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 7/12/2022 7:18 AM

A = 36.79 B = 35.79 C = 158.23 T0 = 338.45 D = 0.00

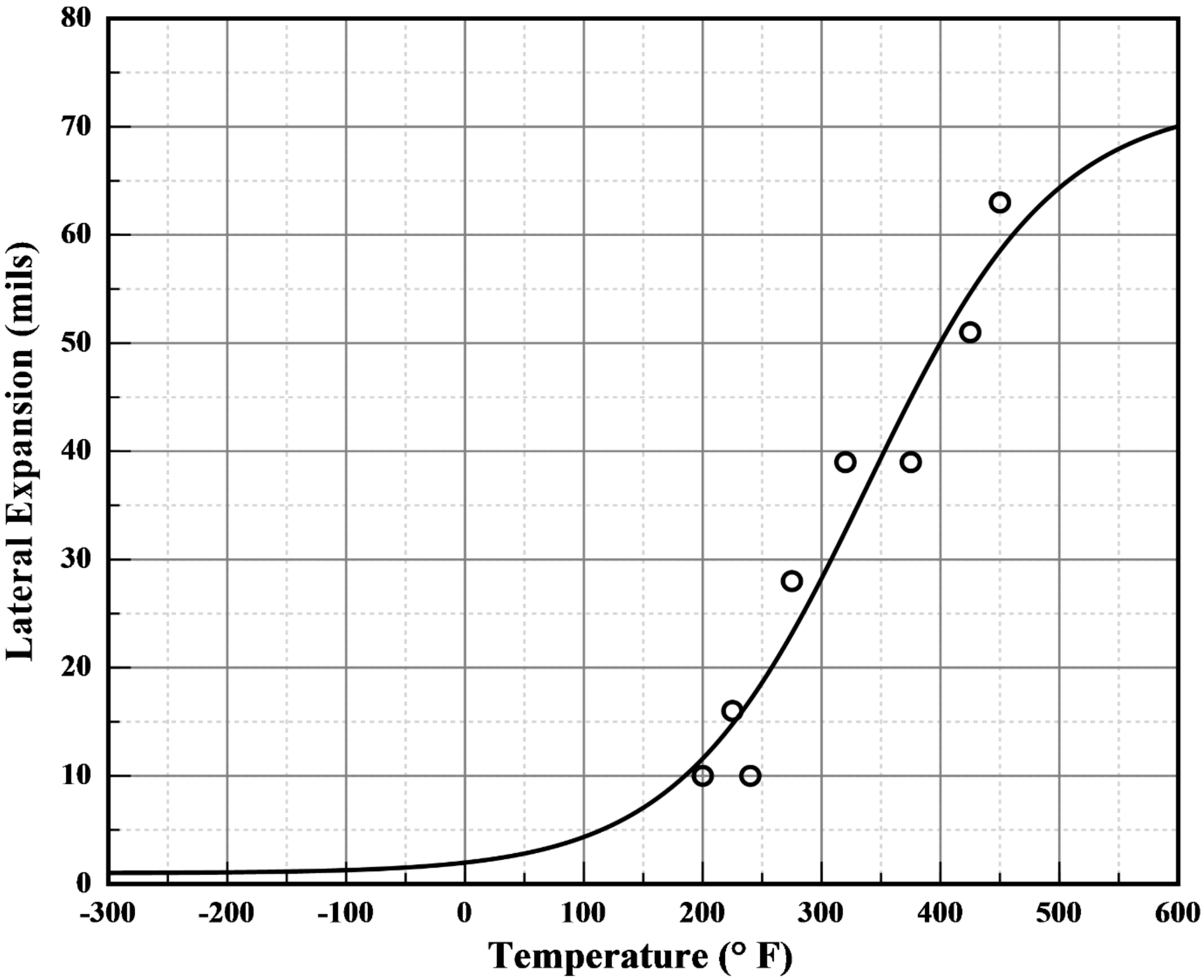
Correlation Coefficient = 0.965

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

Upper Shelf L.E. = 72.57 Lower Shelf L.E. = 1.00 (Fixed)

Temp@35 mils=330.60° F

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**



CVGraph 6.02 07/12/2022 Page 1/2

Plant: **Prairie Island 2** Material: **SA533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**

Capsule N Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input L. E.	Computed L. E.	Differential
200	10.0	11.6	-1.60
225	16.0	14.8	1.22
240	10.0	17.0	-7.01
275	28.0	23.2	4.84
320	39.0	32.6	6.37
375	39.0	44.9	-5.91
425	51.0	54.6	-3.62
450	63.0	58.5	4.47

CVGraph 6.02 07/12/2022 Page 2/2

Unirradiated Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/24/2022 4:58 PM

A = 50.00 B = 50.00 C = 100.78 T0 = 85.68 D = 0.00

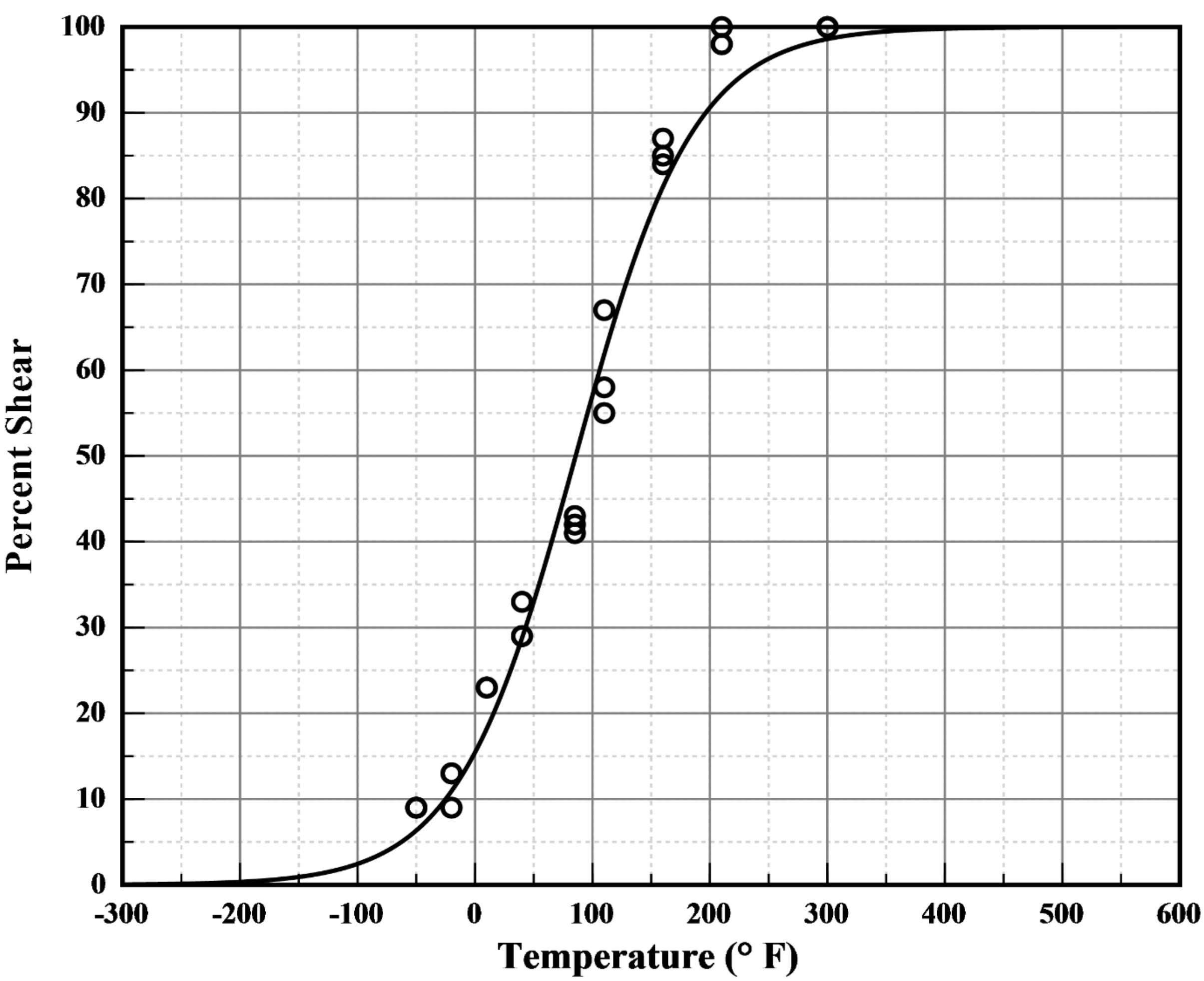
Correlation Coefficient = 0.992

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 = 85.70

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **Unirrad** Fluence: **0.00E+000 n/cm²**



CVGraph 6.02 05/24/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **Unirrad** Fluence: **0.00E+000 n/cm²**

Unirradiated Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-50	9.0	6.3	2.66
-50	9.0	6.3	2.66
-50	9.0	6.3	2.66
-20	9.0	10.9	-1.94
-20	13.0	10.9	2.06
-20	13.0	10.9	2.06
10	23.0	18.2	4.79
10	23.0	18.2	4.79
10	23.0	18.2	4.79
40	33.0	28.8	4.23
40	29.0	28.8	0.23
40	29.0	28.8	0.23
85	43.0	49.7	-6.66
85	41.0	49.7	-8.66
85	42.0	49.7	-7.66
110	58.0	61.8	-3.84
110	67.0	61.8	5.16
110	55.0	61.8	-6.84
160	84.0	81.4	2.62
160	85.0	81.4	3.62
160	87.0	81.4	5.62
210	98.0	92.2	5.82
210	98.0	92.2	5.82
210	100.0	92.2	7.82
300	100.0	98.6	1.40
300	100.0	98.6	1.40
300	100.0	98.6	1.40

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Capsule V Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/25/2022 8:31 AM

A = 50.00 B = 50.00 C = 89.99 T0 = 197.36 D = 0.00

Correlation Coefficient = 0.984

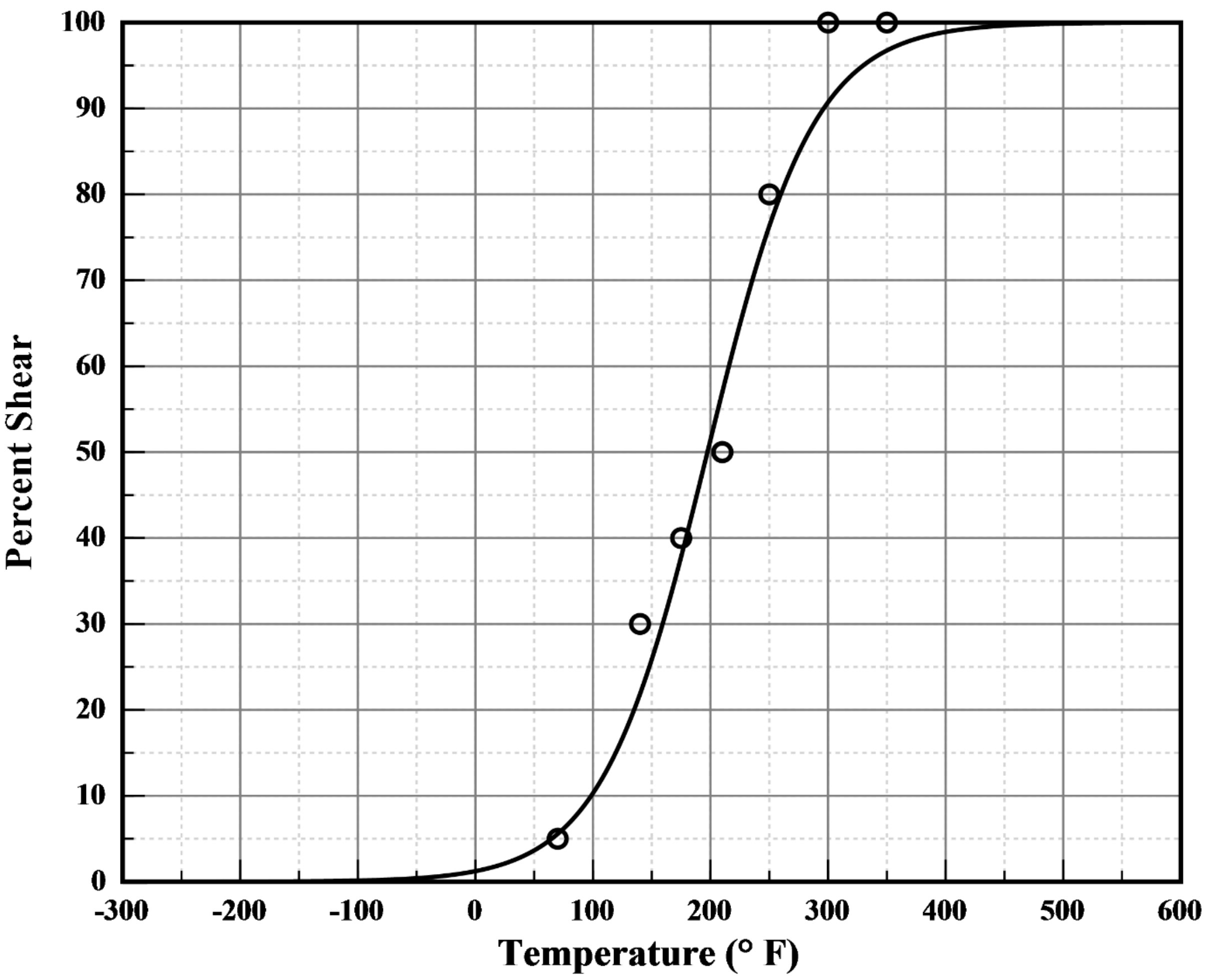
Equation is A + B * [Tanh((T-T0)/(C+DT))]

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

Temperature at 50% Shear = 197.40

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **V** Fluence: **5.98E+018 n/cm²**



CVGraph 6.02 05/25/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **V** Fluence: **5.98E+018 n/cm²**

Capsule V Correlation Monitor Material
Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
70	5.0	5.6	-0.57
140	30.0	21.8	8.15
175	40.0	37.8	2.17
210	50.0	57.0	-6.98
210	50.0	57.0	-6.98
250	80.0	76.3	3.69
300	100.0	90.7	9.27
350	100.0	96.7	3.25

CVGraph 6.02 05/25/2022 Page 2/2

Capsule T Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/25/2022 10:35 AM

A = 50.00 B = 50.00 C = 54.48 T0 = 229.00 D = 0.00

Correlation Coefficient = 0.986

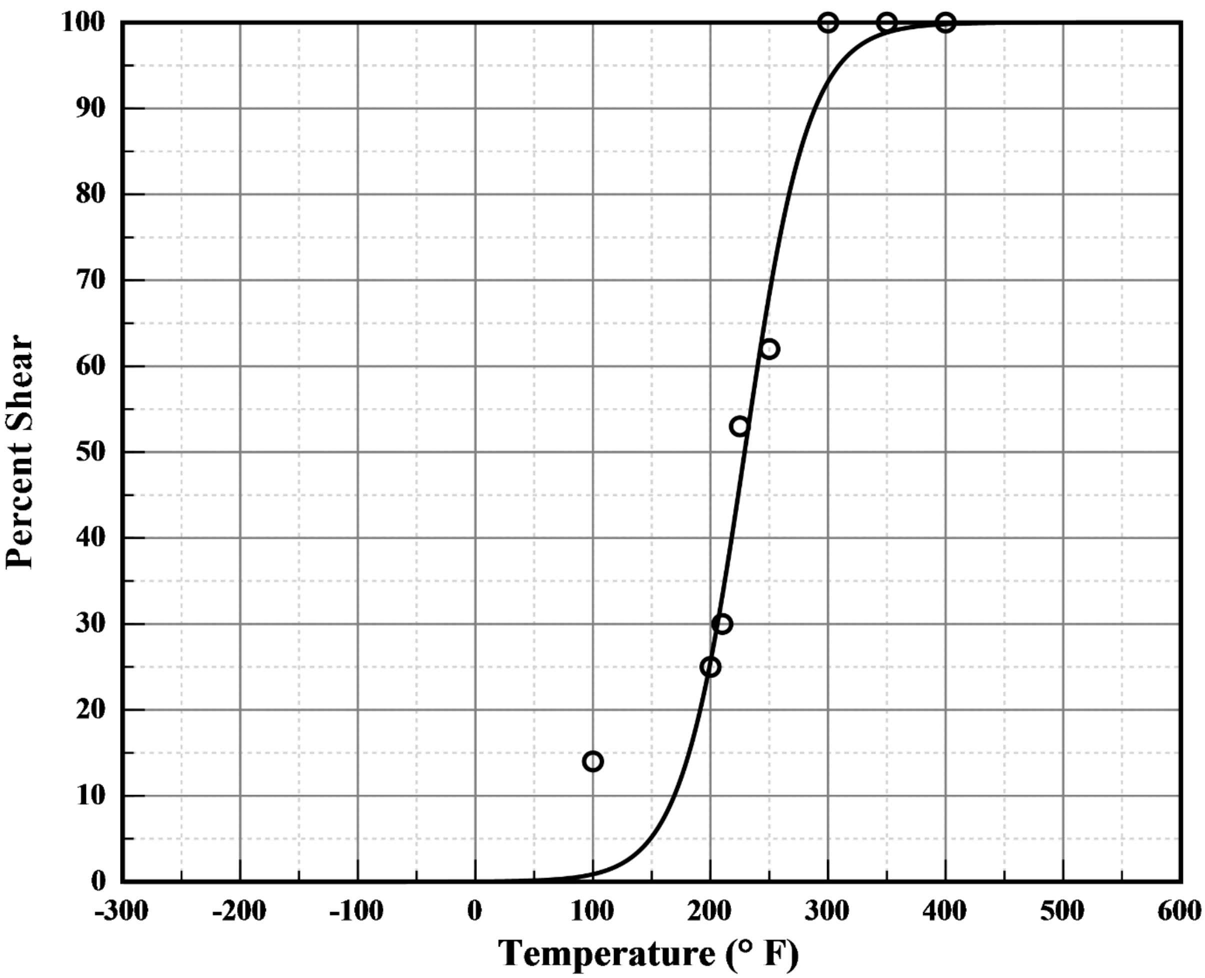
Equation is A + B * [Tanh((T-T0)/(C+DT))]

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

Temperature at 50% Shear = 229.10

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **T** Fluence: **1.10E+019 n/cm²**



CVGraph 6.02 05/25/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **T** Fluence: **1.10E+019 n/cm²**

Capsule T Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
100	14.0	0.9	13.13
200	25.0	25.6	-0.64
210	30.0	33.2	-3.24
225	53.0	46.3	6.66
250	62.0	68.4	-6.37
300	100.0	93.1	6.87
350	100.0	98.8	1.16
400	100.0	99.8	0.19

CVGraph 6.02 05/25/2022 Page 2/2

Capsule R Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/31/2022 7:18 AM

A = 50.00 B = 50.00 C = 55.42 T0 = 242.87 D = 0.00

Correlation Coefficient = 0.980

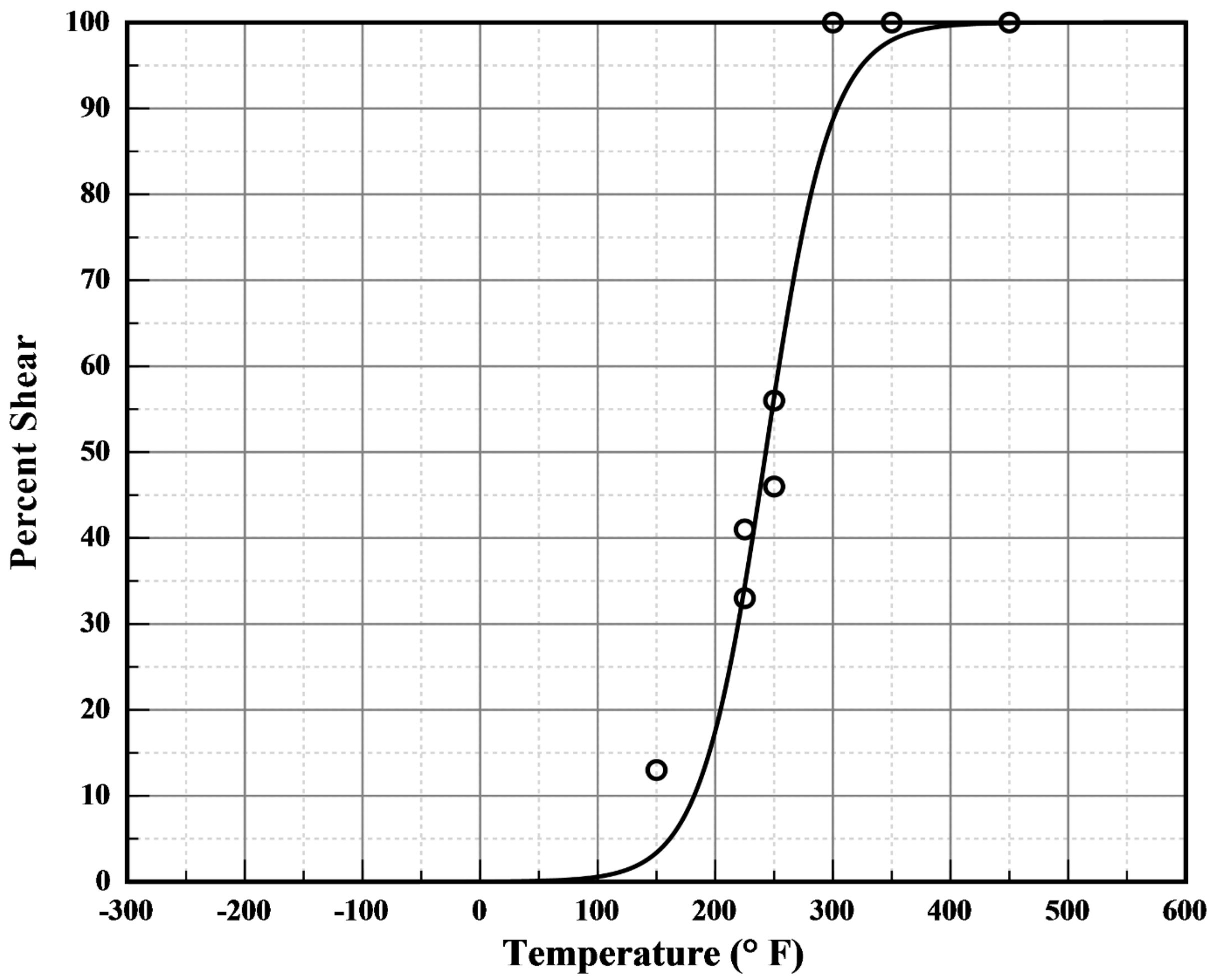
Equation is A + B * [Tanh((T-T0)/(C+DT))]

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

Temperature at 50% Shear = 242.90

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **R** Fluence: **4.11E+019 n/cm²**



CVGraph 6.02 05/31/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **R** Fluence: **4.11E+019 n/cm²**

Capsule R Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
150	13.0	3.4	9.62
225	41.0	34.4	6.59
225	33.0	34.4	-1.41
250	56.0	56.4	-0.40
250	46.0	56.4	-10.40
300	100.0	88.7	11.29
350	100.0	97.9	2.05
450	100.0	99.9	0.06

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Capsule P Correlation Monitor Material

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 5/31/2022 10:55 AM

A = 50.00 B = 50.00 C = 103.66 T0 = 262.59 D = 0.00

Correlation Coefficient = 0.996

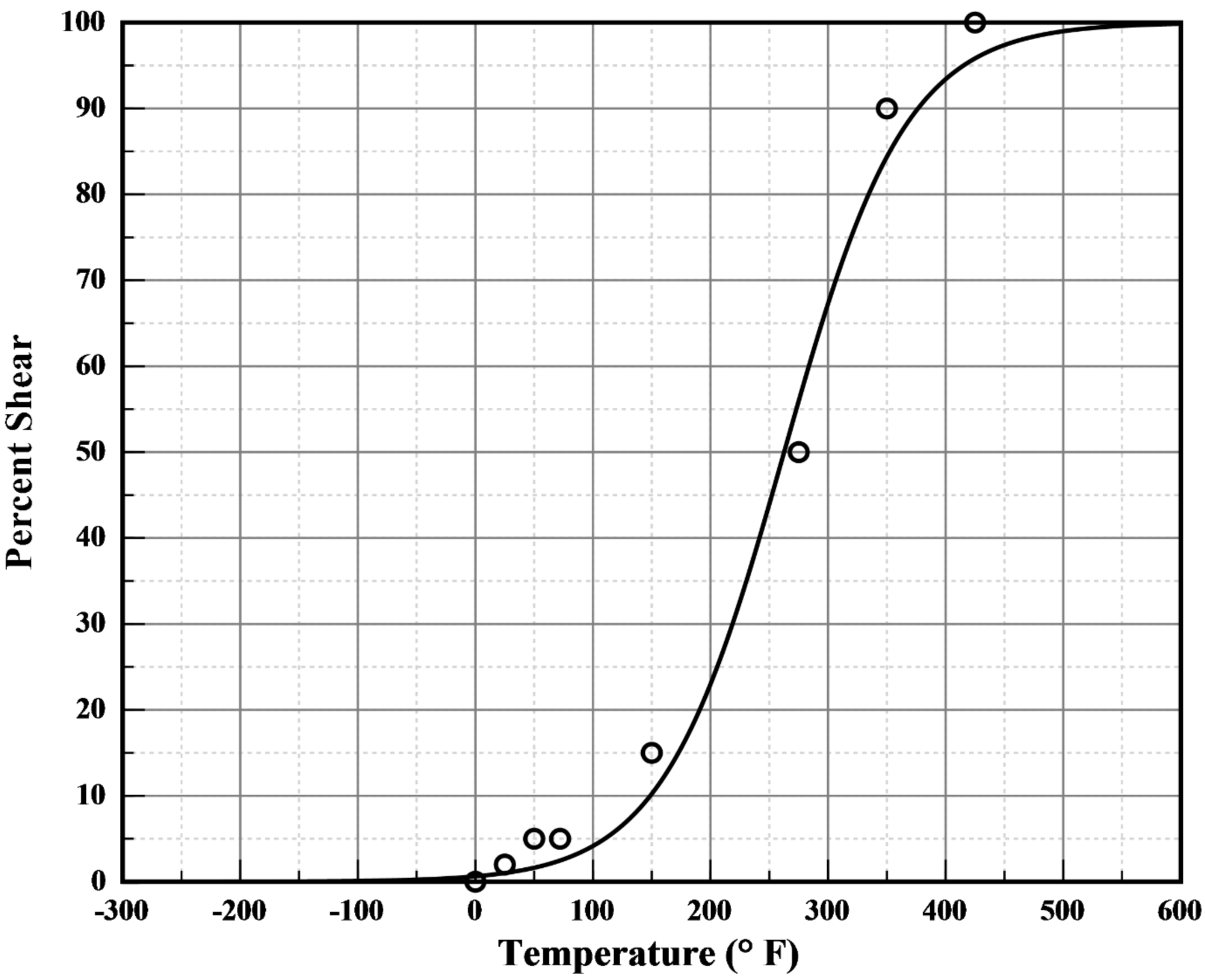
Equation is A + B * [Tanh((T-T0)/(C+DT))]

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

Temperature at 50% Shear = 262.60

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**

Orientation: **NA** Capsule: **P** Fluence: **4.27E+019 n/cm²**



CVGraph 6.02 05/31/2022 Page 1/2

Plant: **Prairie Island 2** Material: **A533B1** Heat: **HSST 02**
Orientation: **NA** Capsule: **P** Fluence: **4.27E+019 n/cm²**

Capsule P Correlation Monitor Material

Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
0	0.0	0.6	-0.63
25	2.0	1.0	0.99
50	5.0	1.6	3.37
72	5.0	2.5	2.53
150	15.0	10.2	4.77
275	50.0	56.0	-5.96
350	90.0	84.4	5.62
425	100.0	95.8	4.17

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Capsule N Heat Affected Zone

CVGraph 6.02: Hyperbolic Tangent Curve Printed on 11/8/2022 9:19 AM

A = 50.00 B = 50.00 C = 107.69 T0 = 64.02 D = 0.00

Correlation Coefficient = 0.944

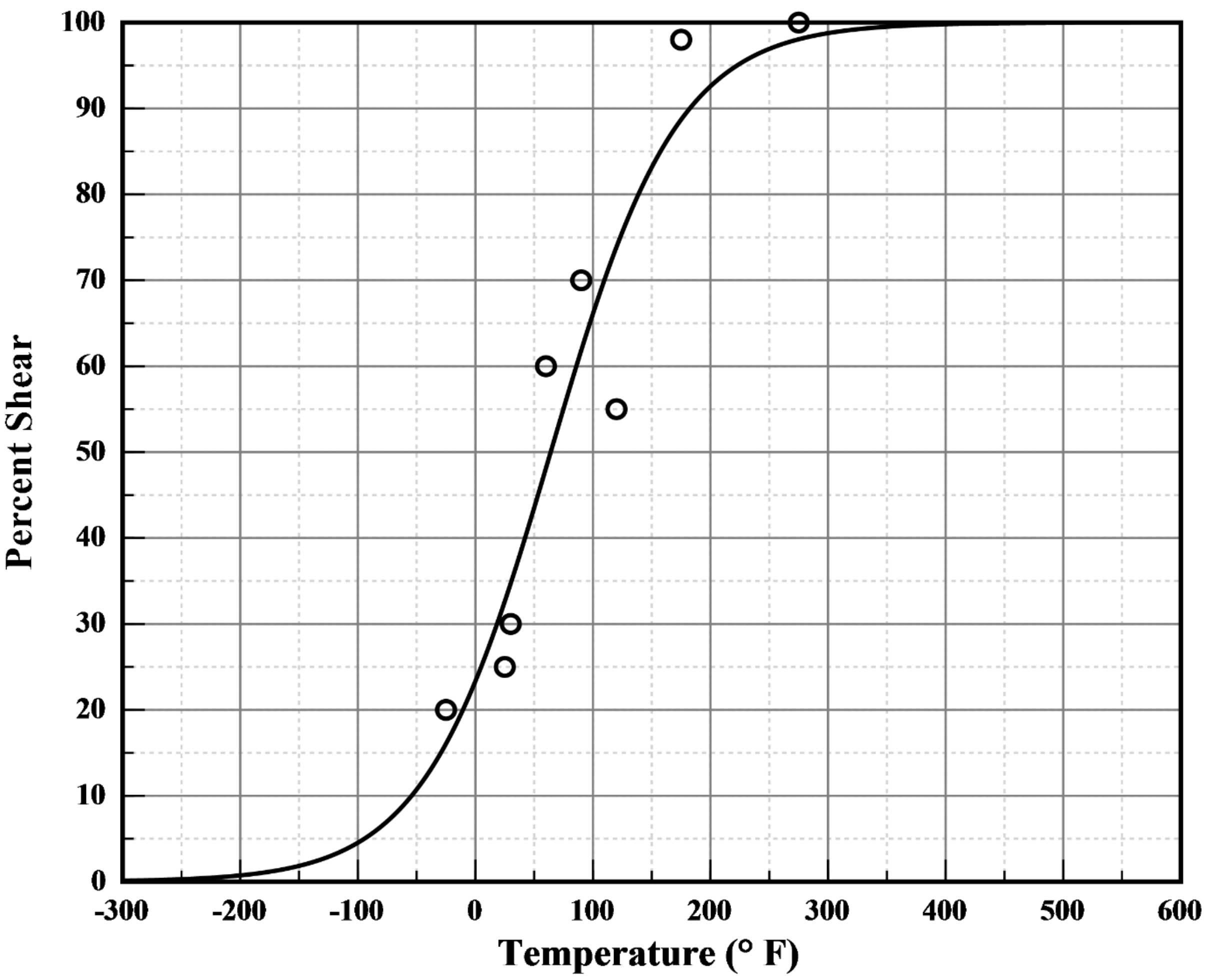
Equation is A + B * [Tanh((T-T0)/(C+DT))]

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

Temperature at 50% Shear = 64.10

Plant: **Prairie Island 2** Material: **SA508CL3** Heat: **22642**

Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**



CVGraph 6.02 11/08/2022 Page 1/2

Plant: **Prairie Island 2** Material: **SA508CL3** Heat: **22642**
Orientation: **NA** Capsule: **N** Fluence: **8.41E+019 n/cm²**

Capsule N Heat Affected Zone
Charpy V-Notch Data

Temperature (° F)	Input %Shear	Computed %Shear	Differential
-25	20.0	16.1	3.93
25	25.0	32.6	-7.64
30	30.0	34.7	-4.71
60	60.0	48.1	11.87
90	70.0	61.8	8.17
120	55.0	73.9	-18.88
175	98.0	88.7	9.29
275	100.0	98.1	1.95

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APPENDIX D PRAIRIE ISLAND UNIT 2 SURVEILLANCE PROGRAM CREDIBILITY EVALUATION

D.1 INTRODUCTION

Regulatory Guide 1.99, Revision 2 [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 surveillance data sets become available from the reactor in question.

To date, there have been five surveillance capsules removed from the Prairie Island Unit 2 reactor vessel. To use these surveillance data sets, the credibility must be determined. In accordance with Regulatory Guide 1.99, Revision 2, the credibility of the surveillance data will be judged based on five criteria.

The following subsections evaluate each of these five criteria for Prairie Island Unit 2 to determine the credibility of the surveillance data for use in neutron radiation embrittlement calculations.

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" [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."*

In addition, the Upper Shell Forging B and the Intermediate Shell Forging to Upper Shell Forging Weld Seam W2 will be considered to be part of the beltline region. Hence, the Prairie Island Unit 2 reactor vessel beltline region consists of the following materials:

1. Upper Shell Forging B (Heat # 22231/39088)
2. Intermediate Shell Forging C (Heat # 22829)
3. Lower Shell Forging D (Heat # 22642)
4. Upper Shell Forging B to Intermediate Shell Forging C Circumferential Weld Seam W2 (Weld Wire Type UM40/Heat # 1752, Flux Type UM 89/Lot # 1263)
5. Intermediate Shell Forging C to Lower Shell Forging D Circumferential Weld Seam W3 (Weld Wire Type UM40/Heat # 2721, Flux Type UM 89/Lot # 1263)

Per WCAP-8193 [D-3], the Prairie Island Unit 2 surveillance program was based on ASTM E185-70, "Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels." Per Section 3.1.2 of ASTM E185-70, "*A minimum test program shall consist of specimens taken from the following locations: (1) base metal of one heat, incorporated in the highest flux location of the reactor vessel, that has the highest initial ductile-brittle transition temperature, (2) weld metal fully representative of fabrication practice used for the welds in the highest flux location of the reactor vessel (weld wire or rod, and flux must come from one of the heats used in the highest flux region of the reactor vessel), and (3) the heat-affected zone of the weldments noted above.*"

It should be noted here that the Upper Shell Forging B and Weld Seam W2 were not considered when the surveillance program was developed. Therefore, at the time the Prairie Island Unit 2 surveillance capsule program was developed, Lower Shell Forging D (Heat # 22642) was judged to be most limiting. This was based on the fact that both the Intermediate Shell Forging C and Lower Shell Forging D initial RT_{NDT} values were within 2°F of each other and Lower Shell Forging D had a lower USE value. As for the weld, the Prairie Island Unit 2 vessel has only one weld in the highest flux region (Weld Seam W3, Weld Control # PS-011, Type UM40, Heat # 2721, Flux Type UM89, Flux Lot # 1263). The same weld was used in the surveillance program.

Therefore, the materials selected for use in the Prairie Island Unit 2 surveillance program were those judged to be most likely limiting with regard to radiation embrittlement according to the accepted methodology at the time the surveillance program was developed.

Based on the discussion, Criterion 1 is met for the Prairie Island Unit 2 surveillance program.

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, as documented in Section 5 and Appendix C, is small enough to permit the determination of the 30 ft-lb temperature and the upper-shelf energy of the Prairie Island Unit 2 surveillance materials unambiguously.

Hence, Criterion 2 is met for the Prairie Island Unit 2 surveillance program.

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 normally should be less than 28°F for welds and 17°F for base metal. Even if the fluence range is large (two or more orders of magnitude), the scatter should not exceed twice those values. Even if the data fail this criterion for use in shift calculations, they may be credible for determining decrease in upper-shelf energy if the upper shelf can be clearly determined, following the definition given in ASTM E185-82 [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. The NRC methods were presented to the industry at a meeting held by the NRC on February 12 and 13, 1998 [D-5]. At this meeting the NRC presented five cases. Of the five cases, Case 1 ("Surveillance Data Available from Plant but No Other Sources") most closely represents the situation for the Prairie Island Unit 2 Lower Shell Forging D (Heat # 22642) and the surveillance weld metal (Heat # 2721). It is noted that the Unit 2 Upper Shell Forging B to Intermediate Shell Forging C Circumferential Weld Seam W2 utilizes surveillance data for Heat # 1752 from the Prairie Island Unit 1 surveillance program, consistent with Case 5 ("Surveillance data from other sources only"); however, credibility of this data was evaluated in WCAP-18660-NP [D-87].

<u>Evaluation of Data from Prairie Island Unit 2 Only (Case 1)</u>

In accordance with the NRC Case 1 guidelines, the data from Prairie Island Unit 2 only will be evaluated. Note that when evaluating the credibility of the surveillance weld data, the measured ΔRT_{NDT} values for the surveillance weld do not include the adjustment ratio procedure of Regulatory Guide 1.99, Rev. 2, Position 2.1, since this calculation is based on the actual surveillance weld measured shift values. In addition, only Prairie Island Unit 2 is being considered; therefore, no temperature adjustment is required.

Table D-1 contains the calculation of chemistry factors for the Prairie Island Unit 2 reactor vessel beltline materials contained in the surveillance program.

Table D-1 Calculation of Interim Chemistry Factors for the Credibility Evaluation Using Prairie Island Unit 2 Surveillance Data

Material	Capsule	Capsule Fluence(1) (x 10^{19} n/cm^2, E > 1.0 MeV)	FF(2)	ΔRT_{NDT}(3) (°F)	FF*ΔRT_{NDT} (°F)	FF^2
Lower Shell Forging D (Heat # 22642) (Tangential Orientation)	V	0.598	0.856	33.8	28.9	0.733
	T	1.10	1.027	54.4	55.8	1.054
	R	4.11	1.362	89.6	122.0	1.855
	P	4.27	1.370	99.6	136.5	1.877
	N	8.41	1.491	176.5	263.1	2.222
Lower Shell Forging D (Heat # 22642) (Axial Orientation)	V	0.598	0.856	35.0	30.0	0.733
	T	1.10	1.027	27.9	28.6	1.054
	R	4.11	1.362	84.3	114.8	1.855
	P	4.27	1.370	103.5	141.8	1.877
	N	8.41	1.491	154.1	229.7	2.222
				SUM:	1151.4	15.484
	$CF_{LS\ Forg.\ D} = \Sigma(FF * \Delta RT_{NDT}) \div \Sigma(FF^2) = (1151.4) \div (15.484) =$ **74.4°F**					
Intermediate Shell to Lower Shell Circumferential Weld - Seam W3 (Heat # 2721)	V	0.598	0.856	69.3	59.3	0.733
	T	1.10	1.027	57.7	59.2	1.054
	R	4.11	1.362	100.3	136.6	1.855
	P	4.27	1.370	96.2	131.8	1.877
	N	8.41	1.491	135.6	202.2	2.222
				SUM:	589.1	7.742
	$CF_{Surv.\ Weld} = \Sigma(FF * \Delta RT_{NDT}) \div \Sigma(FF^2) = (589.1) \div (7.742) =$ **76.1°F**					

Notes:

1. Fluence taken from Table 6-1.
2. FF = fluence factor = $f^{(0.28 - 0.10*\log(f))}$.
3. ΔRT_{NDT} taken from Table 5-12.

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 Best-Fit Evaluation For Prairie Island Unit 2 Surveillance Materials Only

Material	Capsule	CF(1) (Slope$_{best-fit}$) (°F)	Capsule Fluence(2) (x 10^{19} n/cm², E > 1.0 MeV)	FF(3)	Measured ΔRT_{NDT}(4) (°F)	Predicted ΔRT_{NDT}(5) (°F)	Scatter ΔRT_{NDT}(6) (°F)	<17°F (Base Metal) <28°F (Weld)
Lower Shell Forging D (Heat # 22642) (Tangential Orientation)	V	74.4	0.598	0.856	33.8	63.7	29.9	NO
	T		1.10	1.027	54.4	76.4	22.0	NO
	R		4.11	1.362	89.6	101.3	11.7	YES
	P		4.27	1.370	99.6	101.9	2.3	YES
	N		8.41	1.491	176.5	110.9	65.6	NO
Lower Shell Forging D (Heat # 22642) (Axial Orientation)	V		0.598	0.856	35.0	63.7	28.7	NO
	T		1.10	1.027	27.9	76.4	48.5	NO
	R		4.11	1.362	84.3	101.3	17.0	NO
	P		4.27	1.370	103.5	101.9	1.6	YES
	N		8.41	1.491	154.1	110.9	43.2	NO
Intermediate Shell to Lower Shell Circumferential Weld - Seam W3 (Heat # 2721)	V	76.1	0.598	0.856	69.3	65.1	4.2	YES
	T		1.10	1.027	57.7	78.1	20.4	YES
	R		4.11	1.362	100.3	103.6	3.3	YES
	P		4.27	1.370	96.2	104.3	8.1	YES
	N		8.41	1.491	135.6	113.4	22.2	YES

Notes:

1. CF calculated in Table D-1.
2. Fluence taken from Table 6-1.
3. FF = fluence factor = $f^{(0.28 - 0.10*\log(f))}$.
4. Measured ΔRT_{NDT} taken from Table 5-12.
5. Predicted ΔRT_{NDT} = CF x FF.
6. Scatter ΔRT_{NDT} = Absolute Value [Predicted ΔRT_{NDT} – Adjusted ΔRT_{NDT}].

The scatter of ΔRT_{NDT} values about the best-fit line, drawn as described in Regulatory Guide 1.99, Rev. 2, Position 2.1 should be less than 17°F for base metal and less than 28°F for weld metal. From a statistical point of view, +/-1σ would be expected to encompass 68% of the data. Table D-2 indicates that three of the ten (30%) of surveillance data points fall inside the +/- 1σ of 17°F scatter band for surveillance base metal materials. All five (100%) of the surveillance data points fall inside the +/- 1σ of 28°F scatter band for the surveillance weld materials.

Therefore, the Lower Shell Forging D is deemed "not-credible", while the Surveillance weld is deemed "credible". Although Lower Shell Forging D did not meet Criterion 3, both materials may still be used in determining the upper-shelf energy decrease in accordance with Regulatory Guide 1.99, Revision 2, Position 2.2.

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 Prairie Island Unit 2 capsule specimens are located in the reactor between the thermal shield and the vessel wall and are positioned opposite the center of the core. The test capsules are in baskets attached to the thermal shield. 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 and will not differ by more than 25˚F.

The weld metal used in Weld Seam W2 is contained in the Unit 1 surveillance program. Both Prairie Island Unit 1 and Unit 2 operate at a similar temperature. Hence, the Unit 1 surveillance program weld metal was irradiated at a temperature within +/- 25°F of the Weld Seam W2 in Unit 2. Therefore, the Unit 1 surveillance weld will be used to project the fracture toughness properties of the Unit 2 Weld Seam W2.

Hence, Criterion 4 is met for the Prairie Island 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 Prairie Island Unit 2 surveillance program does contain correlation monitor material, which was supplied by Oak Ridge National Laboratory from plate material used in the AEC-Sponsored Heavy Section Steel Technology (HSST) Program. This material was obtained from a 12-inch-thick A533, Grade B, Class 1 plate (HSST Plate 02), which was provided to Subcommittee II of ASTM Committee E10 on Radioisotopes and Radiation Effects to serve as correlation monitor material in reactor vessel surveillance programs. The plate was produced by the Lukens Steel Company and heat treated by Combustion Engineering, Inc.

NUREG/CR-6413, ORNL/TM-13133 [D-6] contains a plot of Residual vs. Fast Fluence for the HSST02 correlation monitor material (Figure 11 of the report). The Figure shows a 2σ uncertainty of 50°F. The data used for this plot is contained in Tables 13, 14, and 15 (in the NUREG report). However, the data in the NUREG report does not consider the recalculated fluence values documented herein and also does not consider data pertaining to Capsule N. The table below presents an updated calculation of Residual vs. Fast Fluence for Prairie Island Unit 2.

Table D-3 Calculation of Residual vs. Fast Fluence for Prairie Island Unit 2 Correlation Monitor Material

Capsule	Capsule Fluence (x 10^{19} n/cm^2, E > 1.0 MeV)	FF	Measured Shift (˚F)(1)	RG 1.99 Shift (˚F)(2)	Residual (˚F)(3)	2σ Uncertainty Less Than 50˚F
V	0.598	0.856	123.5	109.6	13.9	YES
T	1.10	1.027	158.0	131.4	26.6	YES
R	4.11	1.362	183.2	174.3	8.9	YES
P	4.27	1.370	196.8	175.4	21.4	YES
N	8.41	1.491	212.9	190.8	22.1	YES

Notes:

1. Measured ΔT_{30} values for the correlation monitor material were taken from Table 5-12.
2. Per NUREG/CR-6413, ORNL/TM-13133 [D-6], the Cu and Ni values for the correlation monitor material (HSST Plate 02) are 0.17 and 0.64, respectively. This equates to a chemistry factor value of 128˚F based on Regulatory Guide 1.99, Revision 2, Position 1.1 [D-1]. The calculated shift is thus equal to CF * FF.
3. Residual = Measured Shift – RG 1.99 Shift.

Table D-3 shows a 2σ uncertainty of less than 50˚F, which is the allowable scatter in NUREG/CR-6413, ORNL/TM-13133 [D-6].

Hence, Criterion 5 is met for the Prairie Island Unit 2 surveillance program.

D.3 CONCLUSION

Based on the preceding responses to the five criteria of Regulatory Guide 1.99, Rev. 2, Section B, the Prairie Island Unit 2 surveillance forging is deemed "non-credible" while the surveillance weld data are deemed "credible".

D.4 REFERENCES

D-1 U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Regulatory Guide 1.99, Rev. 2, "Radiation Embrittlement of Reactor Vessel Materials'" May 1988. *[ADAMS Accession Number ML003740284]*

D-2 Code of Federal Regulations 10 CFR 50, Appendix G, "Fracture Toughness Requirements," U.S. Nuclear Regulatory Commission, Federal Register, November 29, 2019.

D-3 Westinghouse Report, WCAP-8193, Rev. 0, "Northern States Power Co. Prairie Island Unit No. 2 Reactor Vessel Radiation Surveillance Program," September 1973.

D-4 ASTM E185-82, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels," American Society for Testing and Materials, 1982.

D-5 K. Wichman, M. Mitchell, and A. Hiser, USNRC, "Generic Letter 92-01 and RPV Integrity Assessment, Status, Schedule, and Issues," NRC/Industry Workshop on RPV Integrity Issues, February 12, 1998. *[ADAMS Accession Number ML110070570]*.

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. *[ADAMS Accession Number ML20112B397]*

D-7 Westinghouse Report, WCAP-18660-NP, Rev. 0, "Analysis of Capsule N from the Xcel Energy Prairie Island Unit 1 Reactor Vessel Radiation Surveillance Program," November 2021.