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Fred Dacimo
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April 19, 2004
NL-04-042

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Indian Point Nuclear Generating Unit No. 3
Docket 50-286
Reactor Vessel Material Surveillance Program:
Preliminary Analysis Results for Capsule X

Dear Sir:

Pursuant to Appendix H to 10CFR50, Attachment I to this letter provides a summary technical report, "Summary Report IPEC-RPT-04-0005, Rev. 0, Preliminary Analysis of Capsule X – Indian Point Unit 3 Reactor Vessel Surveillance Program."

The information in this report, which is pending final independent verification, validates the Indian Point 3 Technical Specifications pertaining to Reactor Coolant System heatup, cooldown and setpoints for the Low Temperature Overpressure Protection System. The report includes Charpy V-Notch testing analysis, Upper Shelf Energy (USE) analysis and credibility evaluation.

Tensile testing and dosimetry measurements are complete, and the results are being processed. It should be noted that neither tensile data nor dosimetry data affect the validation of the Technical Specifications. Tensile testing is part of the routine capsule test program, but the results are not applied to the embrittlement or USE calculations. Dosimetry measurements provide an independent check of the fluence models, but the official capsule fluence values, as provided in the report, are not affected by the measurement results. Tensile and dosimetry data will be included in the final report.

Entergy Nuclear Operations, Inc, will provide the final report to the NRC by July 30, 2004.

A008

There are no new commitments identified in this letter. If you have any questions, please contact Ms. Charlene Faison at 914-272-3378.

Sincerely,

For

Fred R. Dacimo
Site Vice President
Indian Point Energy Center

Attachment: Summary Report IPEC-RPT-04-00005 Rev 0, Preliminary Analysis of Capsule X, Indian Point 3 Reactor Vessel Surveillance Program

cc:

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ATTACHMENT I

SUMMARY REPORT IPEC-RPT-04-00005 REV. 0
PRELIMINARY ANALYSIS OF CAPSULE X
INDIAN POINT 3 REACTOR VESSEL SURVEILLANCE PROGRAM

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Engineering Report No. IPEC-RPT-04-00005 Rev. 0
Page 1 of 36

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ENTERGY NUCLEAR NORTHEAST
Engineering Report Cover Sheet

Summary Report IPEC-RPT-04-0005:
Preliminary Analysis of Capsule X
Indian Point Unit 3 Reactor Vessel Surveillance Program

Engineering Report Type:

New ☒ Revision ☐ Cancelled ☐ Superceded ☐

Applicable Site(s)

IP1 ☐ IP2 ☐ IP3 ☒ JAF ☐ PNPS ☐ VY ☐

Quality-Related: ☒ Yes ☐ No

Prepared by: Floyd Gumble / [signature] Date: 4/15/04
(Responsible Engineer (Print Name/Sign)

Verified/ Reviewed by: Gordon Canaday / [signature] Date: 4/15/04
Design Verifier/Reviewer (Print Name/Sign)

Approved by: Jerald Head / [signature] Date: 4/15/04
Supervisor (Print Name/Sign)

Multiple Site Review			
Site	Design Verifier/Reviewer (Print Name/Sign)	Supervisor (Print Name/Sign)	Date
	N/A	N/A	

TABLE OF CONTENTS

1.0 Revision Summary

This is Rev 0 of the engineering report.

2.0 Purpose

This report provides a summary of measurements associated with the testing program for Capsule X in the Indian Point Unit 3 (IP3) reactor vessel surveillance program. Capsule X was withdrawn from the IP3 reactor vessel at a service life of 15.5 Effective Full Power Years (EFPY) resulting in a predicted fluence of 0.874×10^{19} n/cm^2.

The intent of the reactor vessel surveillance program is to validate the IP3 Technical Specifications associated with Reactor Coolant System (RCS) heatup, cooldown and setpoints for the Low Temperature Overpressure Protection System (LTOPS). In addition, the surveillance testing determines Upper Shelf Energy (USE) for limiting vessel materials at predicted End-of-Life (EOL) conditions.

The test results in this report are presented in accordance with the requirements of 10CFR50 Appendix H. The results are in the form of raw data and are in the process of formal review. Upon completion of data review, Westinghouse will provide a formal report (WCAP-16251-NP) (Reference 6.1). Entergy will submit a copy of this report to the NRC no later than July 30, 2004.

The majority of the information provided in this report is taken directly from the preliminary version of Reference 6.1.

3.0 Summary of Results

As noted below and in the sections that follow, the preliminary results of the testing confirm the validity of the Technical Specifications and identify EOL USE values greater than the required minimum of 50 ft-lbs for all limiting vessel plates and welds.

1) The measured 30 ft-lb shift in transition temperature values of the lower shell plate B2803-3 contained in capsule X (longitudinal & transverse) is greater than the Regulatory Guide 1.99, Revision 2, predictions. However, the shift values are less than two sigma allowance by Regulatory Guide 1.99, Revision 2 (Reference 6.2).

2) The measured 30 ft-lb shift in transition temperature value of the weld metal contained in capsule X is greater than the Regulatory Guide 1.99, Revision 2, predictions. However, the shift value is less than two sigma allowance by Regulatory Guide 1.99, Revision 2.

3) The measured 30 ft-lb shift in transition temperature value of the intermediate shell plate B2802-2 contained in capsule X (longitudinal) is greater than the Regulatory Guide 1.99, Revision 2, predictions. However, the shift value is less than two sigma allowance by Regulatory Guide 1.99, Revision 2.

4) The measured percent decrease in upper shelf energy for all the surveillance materials of Capsules X contained in the Indian Point Unit 3 surveillance program are in good agreement with the Regulatory Guide 1.99, Revision 2 predictions.

5) All beltline materials exhibit a more than adequate upper shelf energy level for continued safe plant operation and are predicted to maintain an upper shelf energy greater than 50 ft-lb throughout the life of the vessel (27.1 EFPY) as required by 10CFR50, Appendix G.

6) The Indian Point Unit 3 surveillance data from the lower shell plate B2803-3 was found to be credible. This evaluation can be found in Section 4.2.

7) The calculated Chemistry Factor (CF), as defined in Reg Guide 1.99, Rev 2, is 167.9 degF, which is lower than the calculated CF of 170.9 degF currently in use at IP3 (References 6.3, 6.4). Therefore, the Technical Specifications controlling heatup, cooldown and LTOPS operation are slightly conservative for the present applicable service life of ≤20 Effective Full-Power Years.

8) A fluence evaluation utilizing the recently released neutron transport and dosimetry cross-section libraries was derived from the ENDF/B-VI database. Capsule X received a fluence of 0.874×10^{19} n/cm^2 after irradiation to 15.5 EFPY. The peak clad/base metal interface vessel fluence after 15.5 EFPY of plant operation was 5.86×10^{18} n/cm^2.

4.0 Evaluation

4.1 Charpy V-Notch Test Results

The results of the Charpy V-notch impact tests performed on the various materials contained in Capsule X, which received a fluence of 0.874×10^{19} n/cm^2 (E> 1.0 MeV) in 15.5 EFPY of operation, are presented in Tables 1 through 10 and are compared with unirradiated results as shown in Figures 1 through 12.

The transition temperature increases and upper shelf energy decreases for the Capsule X materials are summarized in Table 9 and led to the following results:

Irradiation of the reactor vessel lower shell plate B2803-3 Charpy specimens, oriented with the longitudinal axis of the specimen parallel to the major working direction (longitudinal orientation), resulted in an irradiated 30 ft-lb transition temperature of 191.6°F and an irradiated 50 ft-lb transition temperature of 223.8°F. This results in a 30 ft-lb transition temperature increase of 159.6°F and a 50 ft-lb transition temperature increase of 161.7°F for the longitudinal oriented specimens. See Table 9.

Irradiation of the reactor vessel lower shell plate B2803-3 Charpy specimens, oriented with the longitudinal axis of the specimen perpendicular to the major working direction (transverse orientation), resulted in an irradiated 30 ft-lb transition temperature of

216.5°F and an irradiated 50 ft-lb transition temperature of 327.4°F. This results in a 30 ft-lb transition temperature increase of 158.2°F and a 50 ft-lb transition temperature increase of 217.9°F for the longitudinal oriented specimens. See Table 9.

Irradiation of the weld metal (*heat number W5214*) Charpy specimens resulted in an irradiated 30 ft-lb transition temperature of 128.5°F and an irradiated 50 ft-lb transition temperature of 196.8°F. This results in a 30 ft-lb transition temperature increase of 193.2°F and a 50 ft-lb transition temperature increase of 242.8°F. See Table 9.

Irradiation of the reactor vessel intermediate shell plate B2802-2 Charpy specimens, oriented with the longitudinal axis of the specimen parallel to the major working direction (longitudinal orientation), resulted in an irradiated 30 ft-lb transition temperature of 98.1°F and an irradiated 50 ft-lb transition temperature of 145.0°F. This results in a 30 ft-lb transition temperature increase of 152.6°F and a 50 ft-lb transition temperature increase of 166.5°F for the longitudinal oriented specimens. See Table 9.

The average upper shelf energy of the lower shell plate B2803-3 (longitudinal orientation) resulted in an average energy decrease of 24 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 81 ft-lb for the longitudinal oriented specimens. See Table 9.

The average upper shelf energy of the lower shell plate B2803-3 (transverse orientation) resulted in an average energy decrease of 24 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 52 ft-lb for the longitudinal oriented specimens. See Table 9.

The average upper shelf energy of the weld metal Charpy specimens resulted in an average energy decrease of 46 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 74 ft-lb for the weld metal specimens. See Table 9.

The average upper shelf energy of the intermediate shell plate B2802-2 (longitudinal orientation) resulted in an average energy decrease of 20 ft-lb after irradiation. This results in an irradiated average upper shelf energy of 105 ft-lb for the longitudinal oriented specimens. See Table 9.

A comparison, as presented in Table 10, of the Indian Point Unit 3 reactor vessel surveillance material test results with the Regulatory Guide 1.99, Revision 2 predictions led to the following conclusions:

- The measured 30 ft-lb shift in transition temperature values of the lower shell plate B2803-3 contained in capsule X (longitudinal & transverse) is greater than the Regulatory Guide 1.99, Revision 2, predictions. However, the shift value is less than two sigma allowance by Regulatory Guide 1.99, Revision 2.

- The measured 30 ft-lb shift in transition temperature value of the weld metal contained in capsule X is greater than the Regulatory Guide 1.99, Revision 2, predictions. However, the shift value is less than two sigma allowance by Regulatory Guide 1.99, Revision 2.

- The measured 30 ft-lb shift in transition temperature values of the intermediate shell plate B2802-2 contained in capsule X (longitudinal) is greater than the Regulatory Guide 1.99, Revision 2, predictions. However, the shift value is less than two sigma allowance by Regulatory Guide 1.99, Revision 2.

- The measured percent decrease in upper shelf energy for all the surveillance materials of Capsules X contained in the Indian Point Unit 3 surveillance program are in good agreement with the Regulatory Guide 1.99, Revision 2 predictions.

All beltline materials exhibit a more than adequate upper shelf energy level for continued safe plant operation and are predicted to maintain an upper shelf energy greater than 50 ft-lb throughout the extended life of the vessel (27.1 EFPY) as required by 10CFR50, Appendix G.

The fracture appearance of each irradiated Charpy specimen from the various surveillance Capsule X materials shows an increasingly ductile or tougher appearance with increasing test temperature.

The Charpy V-notch data presented in WCAP-8475, WCAP-9491, WCAP-10300, and WCAP-11815 (i.e., the surveillance program and the three other surveillance capsule reports) were based on hand-fit Charpy curves using engineering judgment. However, the results presented in this report are based on a re-plot of all applicable capsule data using CVGRAPH, Version 5.0.2, which is a hyperbolic tangent curve-fitting program.

Table 1 Charpy V-notch Data for the Indian Point Unit 3 Lower Shell Plate B2803-3 Irradiated to a Fluence of 0.874 x 10^{19} n/cm^2 (E> 1.0 MeV) (Longitudinal Orientation)

Sample	Temperature		Impact Energy		Lateral Expansion		Shear
Number	°F	°C	ft-lbs	Joules	mils	mm	%
A37	100	38	7	9	2	0.05	10
A34	150	66	21	28	14	0.36	15
A36	175	79	22	30	15	0.38	20
A33	200	93	27	37	18	0.46	40
A40	225	107	51	69	36	0.91	70
A39	280	138	82	111	59	1.50	100
A35	350	177	78	106	57	1.45	100
A38	375	191	83	113	68	1.73	100

Table 2 Charpy V-notch Data for the Indian Point Unit 3 Lower Shell Plate B2803-3 Irradiated to a Fluence of 0.874 x 10^{19} n/cm^2 (E> 1.0 MeV) (Transverse Orientation)

Sample	Temperature		Impact Energy		Lateral Expansion		Shear
Number	°F	°C	ft-lbs	Joules	mils	mm	%
AT64	100	38	6	8	0	0.00	15
AT69	175	79	20	27	14	0.36	25
AT68	210	99	22	30	14	0.36	30
AT67	225	107	33	45	25	0.64	60
AT66	250	121	44	60	34	0.86	95
AT65	325	163	47	64	38	0.97	100
AT62	375	191	54	73	45	1.14	100
AT63	390	199	55	75	45	1.14	100

Table 3 Charpy V-notch Data for the Indian Point Unit 3 Surveillance Weld Metal Irradiated to a Fluence of 0.874 x 10^{19} n/cm^2 (E> 1.0 MeV)

Sample	Temperature		Impact Energy		Lateral Expansion		Shear
Number	°F	°C	ft-lbs	Joules	mils	mm	%
W42	75	24	9	12	5	0.13	20
W41	125	52	49	66	36	0.91	50
W43	125	52	24	33	19	0.48	40
W48	150	66	35	47	26	0.66	45
W47	200	93	37	50	30	0.76	70
W44	250	121	67	91	52	1.32	95
W45	300	149	72	98	56	1.42	98
W46	350	177	75	102	57	1.45	100

Table 4 Charpy V-notch Data for the Indian Point Unit 3 Intermediate Shell Plate B2802-2 Irradiated to a Fluence of 0.874 x 10^{19} n/cm^2 (E> 1.0 MeV)

Sample	Temperature		Impact Energy		Lateral Expansion		Shear
Number	°F	°C	Ft-lbs	Joules	mils	mm	%
N2	25	-4	8	11	3	0.08	5
N6	75	24	24	33	14	0.36	15
N5	125	52	59	80	40	1.02	30
N7	150	66	40	54	30	0.76	55
N4	200	93	58	79	44	1.12	65
N1	250	121	104	141	69	1.75	100
N8	300	149	105	142	71	1.80	100
N3	325	163	105	142	68	1.73	100

Table 5	Instrumented Charpy Impact Test Results for the Indian Point Unit 3 Lower Shell Plate B2803-3 Irradiated to a Fluence of 0.874×10^{19} n/cm^2 (E>1.0 MeV) (Longitudinal Orientation)												
Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2)			Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress σ_Y (ksi)	Flow Stress (ksi)
			Charpy E_D/A	Max. E_M/A	Prop. E_p/A								
A37	100	7	56	19	37	2108	0.11	2304	0.13	2304	363	70	73
A34	150	21	169	68	101	3363	0.14	4187	0.22	4047	372	112	126
A36	175	22	177	68	110	3336	0.14	4173	0.22	4090	609	111	125
A33	200	27	218	65	152	3311	0.14	4061	0.22	3913	1082	110	123
A40	225	51	411	226	185	3331	0.14	4567	0.50	4529	2496	111	132
A39	280	82	661	236	425	3336	0.14	4671	0.51	n/a	n/a	111	133
A35	350	78	628	225	403	3176	0.14	4480	0.51	n/a	n/a	106	127
A38	375	83	669	222	447	3165	0.14	4344	0.51	n/a	n/a	105	125

Table 6 Instrumented Charpy Impact Test Results for the Indian Point Unit 3 Lower Shell Plate B2803-3 Irradiated to a Fluence of 0.874×10^{19} n/cm^2 (E>1.0 MeV) (Transverse Orientation)

Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2) Charpy E_D/A	Max. E_M/A	Prop. E_p/A	Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress σ_Y (ksi)	Flow Stress (ksi)
AT64	100	6	48	14	34	1416	0.09	1672	0.12	1659	455	47	51
AT69	175	20	161	68	93	3310	0.14	4149	0.22	4090	683	110	124
AT68	210	22	177	67	110	3407	0.15	4091	0.22	3927	987	113	125
AT67	225	33	266	66	200	3380	0.14	4113	0.21	4017	2273	113	125
AT66	250	44	355	162	193	3091	0.14	4136	0.41	3999	2397	103	120
AT65	325	47	379	143	236	3089	0.13	4027	0.37	3853	1829	103	118
AT62	375	54	435	162	274	2969	0.13	4063	0.41	n/a	n/a	99	117
AT63	390	55	443	148	295	3028	0.13	4080	0.38	n/a	n/a	101	118

Table 7 Instrumented Charpy Impact Test Results for the Indian Point Unit 3 Surveillance Weld Metal Irradiated to a Fluence of 0.874 x 10^{19} n/cm^2 (E>1.0 MeV)

Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2)			Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress σ_Y (ksi)	Flow Stress (ksi)
			Charpy E_D/A	Max. E_M/A	Prop. E_p/A								
W42	75	9	73	36	36	3426	0.14	3696	0.16	3687	0	114	119
W41	125	49	395	226	169	3411	0.15	4363	0.52	4288	617	114	129
W43	125	24	193	68	126	3341	0.14	4109	0.22	4058	1313	111	124
W48	150	35	282	184	98	3416	0.14	4449	0.42	4417	1141	114	131
W47	200	37	298	150	148	3371	0.14	4260	0.37	4222	1713	112	127
W44	250	67	540	227	313	3486	0.14	4432	0.50	4251	2819	116	132
W45	300	72	580	218	362	3329	0.14	4303	0.50	3029	2501	111	127
W46	350	75	604	221	383	3285	0.14	4309	0.51	n/a	n/a	109	126

Table 8	Instrumented Charpy Impact Test Results for the Indian Point Unit 3 Intermediate Shell Plate B2802-2 Irradiated to a Fluence of 0.874 x 10^{19} n/cm^2 (E>1.0 MeV) (Longitudinal Orientation)												
Sample No.	Test Temp. (°F)	Charpy Energy E_D (ft-lb)	Normalized Energies (ft-lb/in^2)			Yield Load P_{GY} (lb)	Time to Yield t_{GY} (msec)	Max. Load P_M (lb)	Time to Max. t_M (msec)	Fast Fract. Load P_F (lb)	Arrest Load P_A (lb)	Yield Stress σ_Y (ksi)	Flow Stress (ksi)
			Charpy E_D/A	Max. E_M/A	Prop. E_p/A								
N2	25	8	64	35	29	3649	0.15	3761	0.16	3761	0	121	123
N6	75	24	193	146	47	3388	0.14	4306	0.36	4303	0	113	128
N5	125	59	475	327	148	3470	0.15	4594	0.68	4444	687	116	134
N7	150	40	322	185	138	3292	0.14	4338	0.44	4332	1570	110	127
N4	200	58	467	231	237	3239	0.14	4423	0.53	4369	2112	108	128
N1	250	104	838	311	527	3193	0.15	4446	0.68	n/a	n/a	106	127
N8	300	105	846	312	534	3272	0.14	4494	0.67	n/a	n/a	109	129
N3	325	105	846	302	544	3068	0.14	4374	0.67	n/a	n/a	102	124

Table 9 Effect of Irradiation to 0.874 x 10^{19} n/cm^2 (E>1.0 MeV) on the Capsule "X" Notch Toughness Properties of the Indian Point Unit 3 Reactor Vessel Surveillance Materials[c]												
Material	**Average 30 (ft-lb)[a] Transition Temperature (°F)**			**Average 35 mil Lateral[b] Expansion Temperature (°F)**			**Average 50 ft-lb[a] Transition Temperature (°F)**			**Average Energy Absorption[a] at Full Shear (ft-lb)**		
	Unirradiated	Irradiated	ΔT	Unirradiated	Irradiated	ΔT	Unirradiated	Irradiated	ΔT	Unirradiated	Irradiated	ΔE
Lower Shell Plate B2803-3 (Long.)	32.0	191.6	159.6	48.6	225.0	176.4	62.1	223.8	161.7	105	81	-24
Lower Shell Plate B2803-3 (Trans.)	58.3	216.5	158.2	75.3	269.3	194.0	109.5	327.4	217.9	68	52	-16
Weld Metal (Heat # W5214)	-64.7	128.5	193.2	-59.3	184.6	243.9	-46.0	196.8	242.8	120	74	-46
Inter. Shell Plate B2802-2 (Long.)	-54.5	98.1	152.6	-38.6	147.3	185.9	-21.5	145.0	166.5	125	105	-20

a. "Average" is defined as the value read from the curve fit through the data points of the Charpy tests (see Figures 1, 4, 7 and 10).

b. "Average" is defined as the value read from the curve fit through the data points of the Charpy tests (see Figures 2, 5, 8 and 11).

Table 10	**Comparison of the Indian Point Unit 3 Surveillance Material 30 ft-lb Transition Temperature Shifts and Upper Shelf Energy Decreases with Regulatory Guide 1.99, Revision 2, Predictions**					
Material	**Capsule**	**Fluence[(d)] (x 10^{19} n/cm², E > 1.0 MeV)**	**30 ft-lb Transition Temperature Shift**		**Upper Shelf Energy Decrease**	
			Predicted (°F) [(a)]	**Measured (°F) [(b)]**	**Predicted (%) [(a)]**	**Measured (%)[(c)]**
Lower Shell Plate	T	0.263	101.9	139.4	24	12
B2803-3	Z	1.04	161.6	167.8	33.5	22
(*Longitudinal*)	X	0.874	153.9	159.6	32	23
Lower Shell Plate	T	0.263	101.9	105.9	24	16
B2803-3	Y	0.692	143.5	148.9	30	25
	Z	1.04	161.6	157.9	33.5	18
(*Transverse*)	X	0.874	153.9	158.2	32	24
Surveillance	T	0.263	102.6	151.6	22	30
Program	Y	0.692	144.4	172.0	26	43
Weld Metal	Z	1.04	162.6	229.2	32	37
	X	0.874	154.9	196.8	29	38
Intermediate Shell Plate B2802-2 (*Longitudinal*)	X	0.874	146.2	152.6	30	16

Notes:

(a) Based on Regulatory Guide 1.99, Revision 2, methodology using the mean weight percent values of copper and nickel of the surveillance material.

(b) Calculated using measured Charpy data plotted using CVGRAPH, Version 4.1

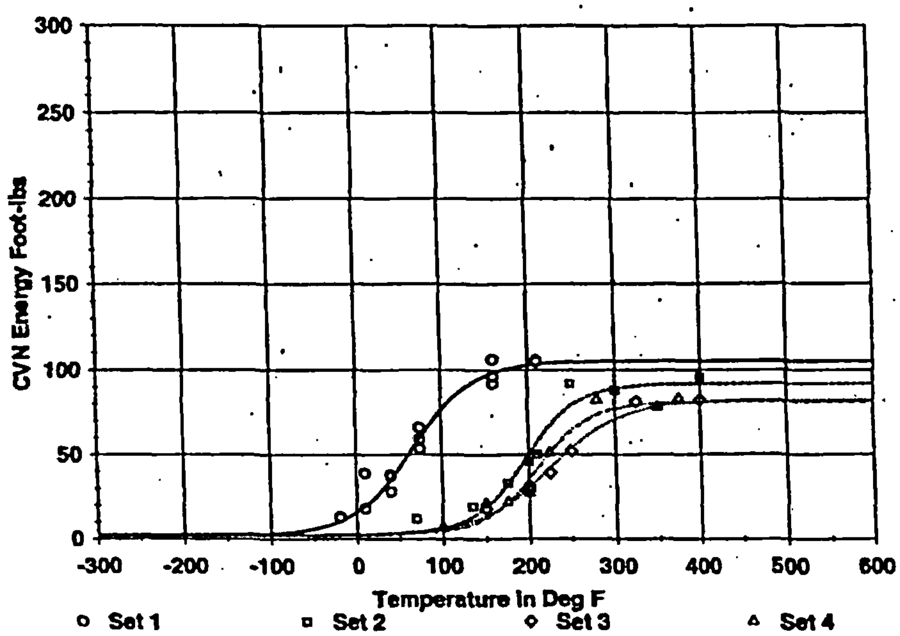
(c) Values are based on the definition of upper shelf energy given in ASTM E185-82.

(d) The fluence values presented here are the calculated values, not the best estimate values.

LOWER SHELL PLATE B2803-3 (LONGITUDINAL ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 04:43 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	LT	A-0512-2
2	Indian Point 3	T	SA302B	LT	A-0512-2
3	Indian Point 3	Z	SA302B	LT	A-0512-2
4	Indian Point 3	X	SA302B	LT	A-0512-2



Results

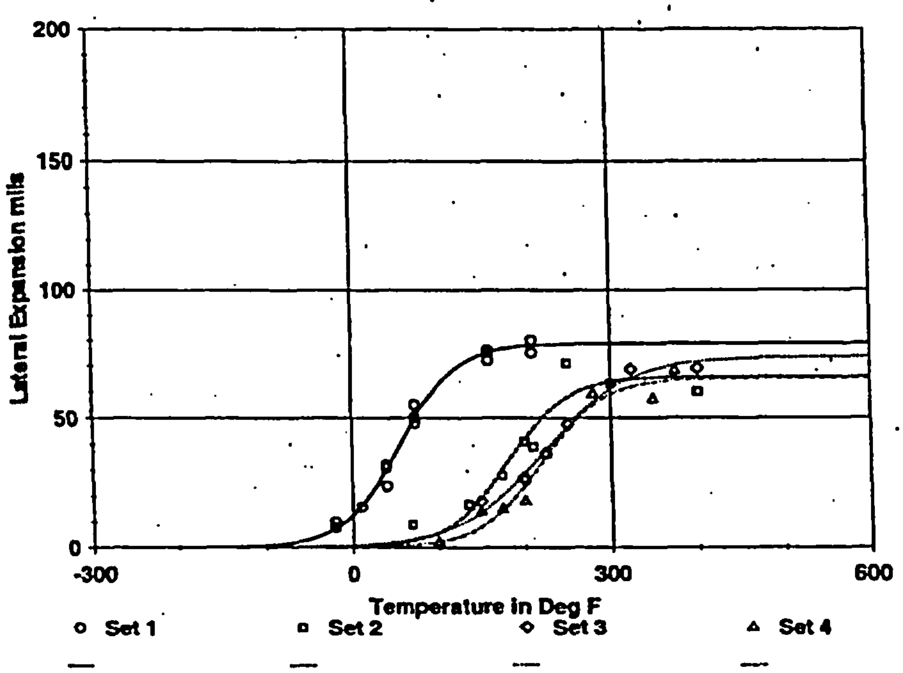
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	105.0	.0	32.0	.0	62.1	.0
2		2.2	92.0	-13.0	171.4	139.4	200.2	138.1
3		2.2	82.0	-23.0	199.8	167.8	242.7	180.6
4		2.2	81.0	-24.0	191.6	159.6	223.8	161.7

Figure 1 Charpy V-Notch Impact Energy vs. Temperature for Indian Point Unit 3 Reactor Vessel Lower Shell Plate B2803-3 (Longitudinal Orientation)

LOWER SHELL PLATE B2803-3 (LONGITUDINAL ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 04:57 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	LT	A-0512-2
2	Indian Point 3	T	SA302B	LT	A-0512-2
3	Indian Point 3	Z	SA302B	LT	A-0512-2
4	Indian Point 3	X	SA302B	LT	A-0512-2



Results

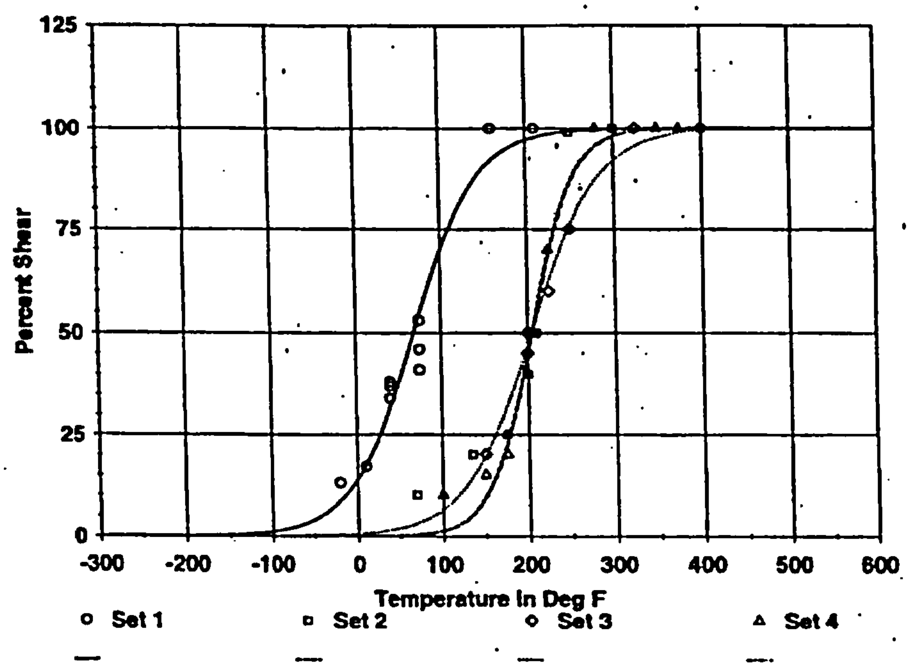
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	78.7	.0	48.6	.0
2		.0	65.8	-12.9	185.4	136.8
3		.0	73.4	-5.2	218.3	169.7
4		.0	65.1	-13.5	225.0	176.4

Figure 2 Charpy V-Notch Lateral Expansion vs. Temperature for Indian Point Unit 3 Reactor Vessel Lower Shell Plate B2803-3 (Longitudinal Orientation)

LOWER SHELL PLATE B2803-3 (LONGITUDINAL ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 04:53 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	LT	A-0512-2
2	Indian Point 3	T	SA302B	LT	A-0512-2
3	Indian Point 3	Z	SA302B	LT	A-0512-2
4	Indian Point 3	X	SA302B	LT	A-0512-2



Results

Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	68.8	.0
2		.0	100.0	.0	204.7	135.9
3		.0	100.0	.0	205.3	136.5
4		.0	100.0	.0	206.3	137.5

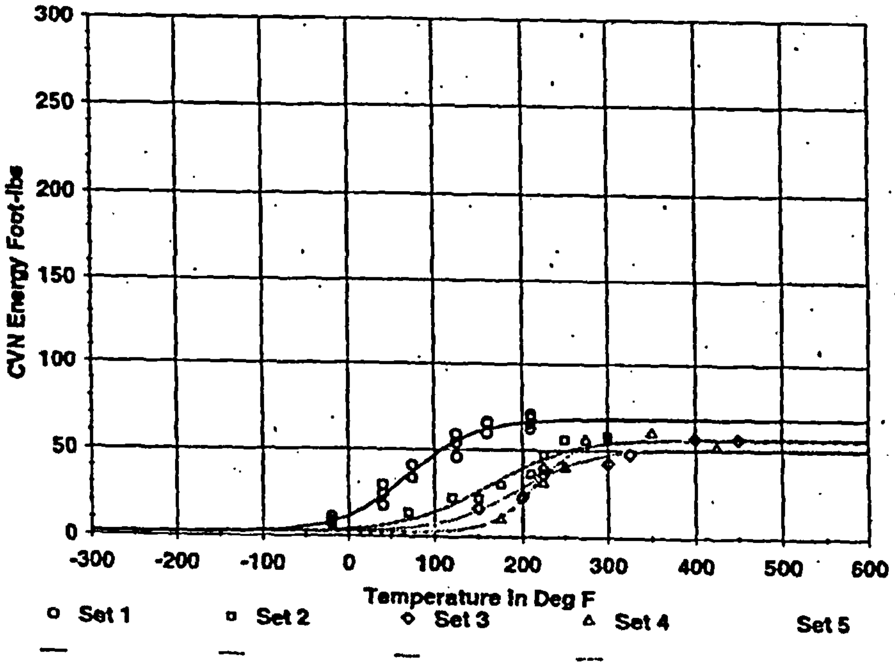
Figure 3 **Charpy V-Notch Percent Shear vs. Temperature for Indian Point Unit 3 Reactor Vessel Lower Shell Plate B2803-3 (Longitudinal Orientation)**

LOWER SHELL PLATE B2803-3 (TRANSVERSE ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 05:10 PM

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	TL	A-0512-2
2	Indian Point 3	T	SA302B	TL	A-0512-2
3	Indian Point 3	Y	SA302B	TL	A-0512-2
4	Indian Point 3	Z	SA302B	TL	A-0512-2
5	Indian Point 3	X	SA302B	TL	A-0512-2



Results

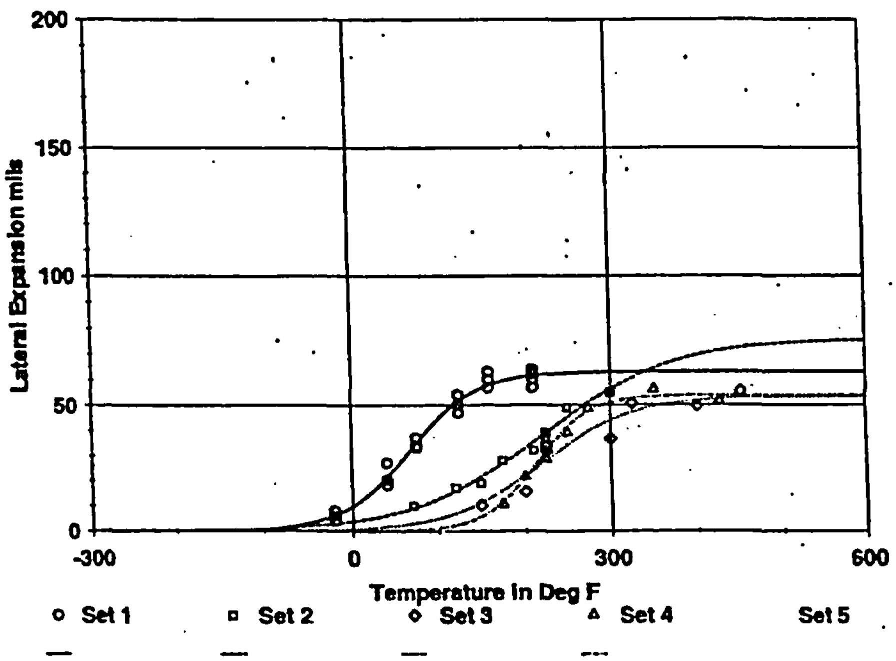
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	68.0	.0	58.3	.0	109.5	.0
2		2.2	57.0	-11.0	164.2	105.9	256.4	146.9
3		2.2	51.0	-17.0	207.2	148.9	362.1	252.6
4		2.2	56.0	-12.0	216.2	157.9	266.7	157.2
5		2.2	52.0	-16.0	216.5	158.2	327.4	217.9

Figure 4 Charpy V-Notch Impact Energy vs. Temperature for Indian Point Unit 3 Reactor Vessel Lower Shell Plate B2803-3 (Transverse Orientation)

LOWER SHELL PLATE 2803-3 (TRANSVERSE ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 05:36 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	TL	A-0512-2
2	Indian Point 3	T	SA302B	TL	A-0512-2
3	Indian Point 3	Y	SA302B	TL	A-0512-2
4	Indian Point 3	Z	SA302B	TL	A-0512-2
5	Indian Point 3	X	SA302B	TL	A-0512-2



Results

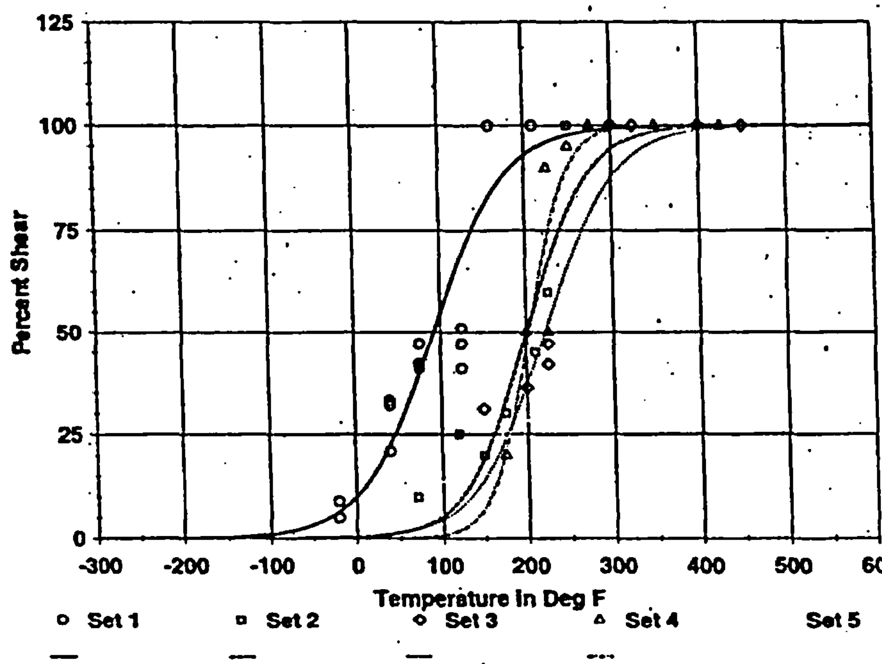
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	63.1	.0	75.3	.0
2		.0	76.0	12.9	209.2	133.9
3		.0	53.3	-9.8	254.3	179.0
4		.0	53.9	-9.2	232.8	157.5
5		.0	44.4	-18.7	269.3	194.0

Figure 5 Charpy V-Notch Lateral Expansion vs. Temperature for Indian Point Unit 3 Reactor Vessel Lower Shell Plate B2803-3 (Transverse Orientation)

LOWER SHELL PLATE B2803-3 (TRANSVERSE ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 05:16 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	TL	A-0512-2
2	Indian Point 3	T	SA302B	TL	A-0512-2
3	Indian Point 3	Y	SA302B	TL	A-0512-2
4	Indian Point 3	Z	SA302B	TL	A-0512-2
5	Indian Point 3	X	SA302B	TL	A-0512-2



Results

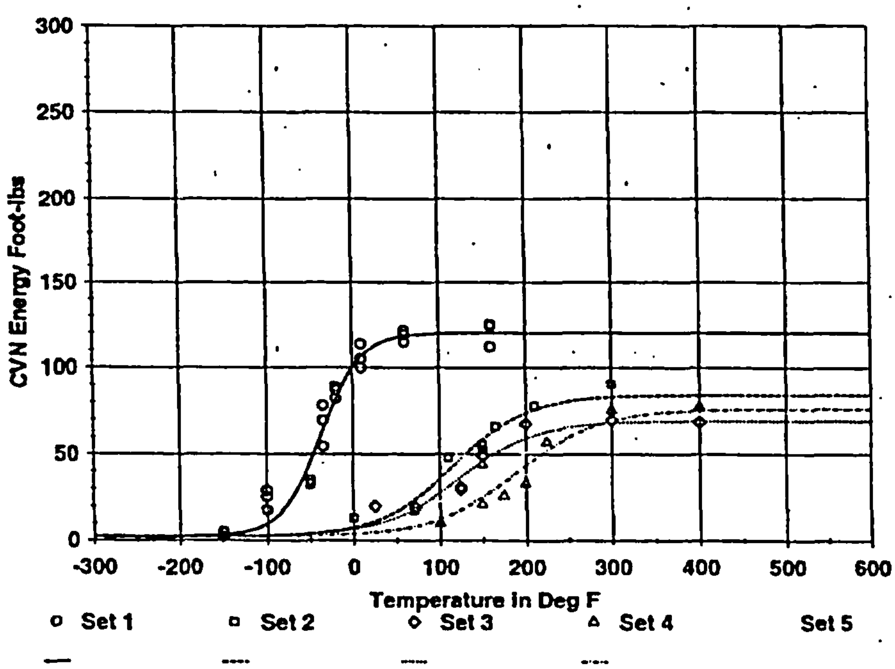
Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	92.2	.0
2		.0	100.0	.0	200.4	108.2
3		.0	100.0	.0	221.9	129.7
4		.0	100.0	.0	203.3	111.1
5		.0	100.0	.0	217.1	124.9

Figure 6 Charpy V-Notch Percent Shear vs. Temperature for Indian Point Unit 3 Reactor Vessel Lower Shell Plate B2803-3 (Transverse Orientation)

SURVEILLANCE WELD MATERIAL

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 02:31 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SAW	NA	W5214
2	Indian Point 3	T	SAW	NA	W5214
3	Indian Point 3	Y	SAW	NA	W5214
4	Indian Point 3	Z	SAW	NA	W5214
5	Indian Point 3	X	SAW	NA	W5214



Results

Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	120.0	.0	-64.7	.0	-46.0	.0
2		2.2	84.0	-36.0	86.9	151.6	130.6	176.6
3		2.2	69.0	-51.0	107.3	172.0	164.2	210.2
4		2.2	76.0	-44.0	164.5	229.2	218.7	264.7
5		2.2	74.0	-46.0	128.5	193.2	196.8	242.8

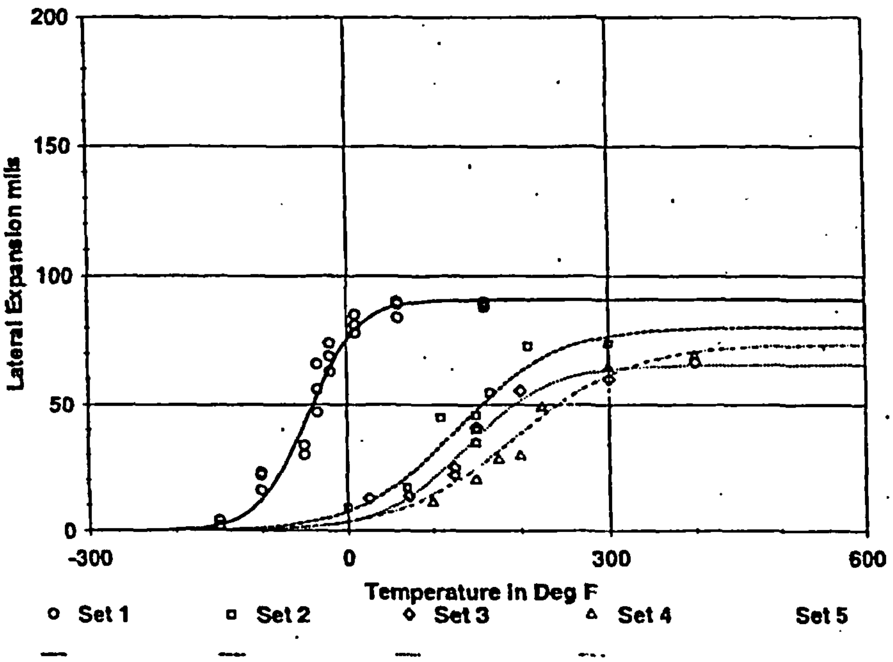
Figure 7 Charpy V-Notch Impact Energy vs. Temperature for Indian Point Unit 3 Reactor Vessel Weld Metal

SURVEILLANCE WELD MATERIAL

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 04:11 PM

Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SAW	NA	W5214
2	Indian Point 3	T	SAW	NA	W5214
3	Indian Point 3	Y	SAW	NA	W5214
4	Indian Point 3	Z	SAW	NA	W5214
5	Indian Point 3	X	SAW	NA	W5214



Results

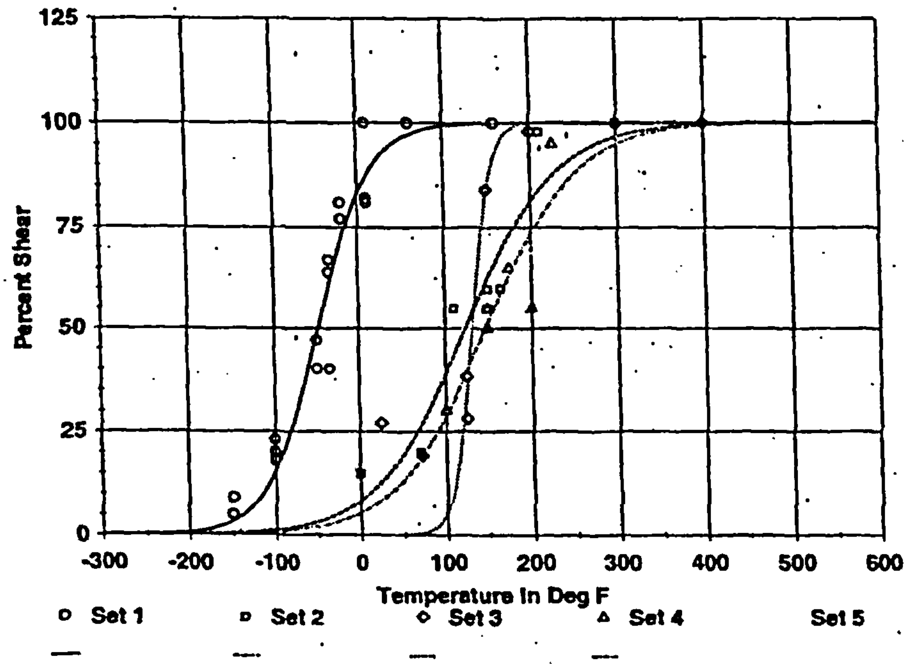
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	90.8	.0	-59.3	.0
2		.0	80.3	-10.5	113.3	172.6
3		.0	65.6	-25.2	145.0	204.3
4		.0	73.5	-17.3	187.8	247.1
5		.0	62.1	-28.7	184.6	243.9

Figure 8 Charpy V-Notch Lateral Expansion vs. Temperature for Indian Point Unit 3 Reactor Vessel Weld Metal

SURVEILLANCE WELD MATERIAL

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 03:57 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SAW	NA	W5214
2	Indian Point 3	T	SAW	NA	W5214
3	Indian Point 3	Y	SAW	NA	W5214
4	Indian Point 3	Z	SAW	NA	W5214
5	Indian Point 3	X	SAW	NA	W5214



Results

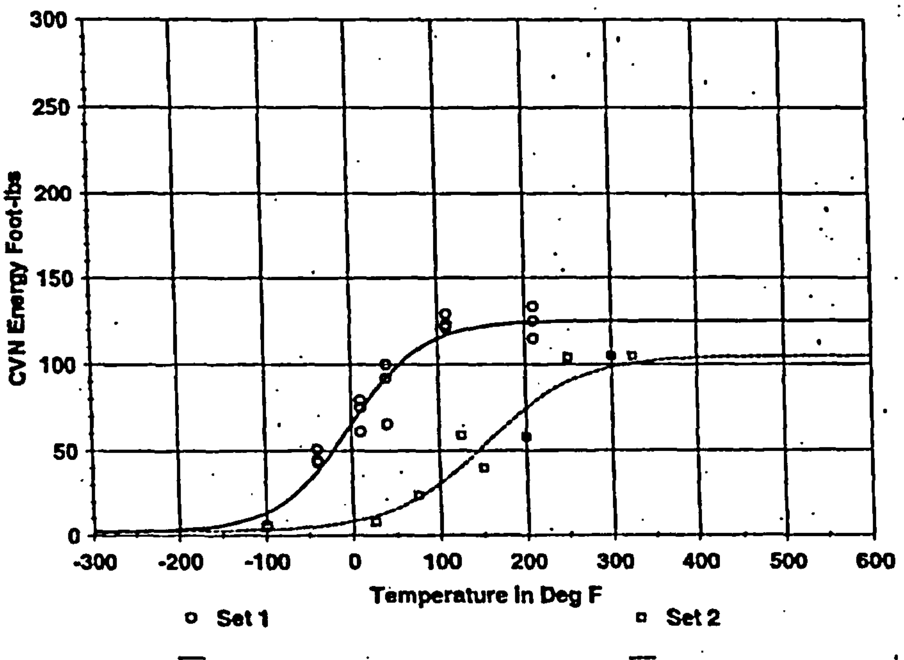
Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	-47.8	.0
2		.0	100.0	.0	124.0	171.8
3		.0	100.0	.0	132.6	180.4
4		.0	100.0	.0	147.5	195.3
5		.0	100.0	.0	144.5	192.3

Figure 9 **Charpy V-Notch Percent Shear vs. Temperature for Indian Point Unit 3 Reactor Vessel Weld Metal**

INTERMEDIATE SHELL PLATE B2802-2 (LONGITUDINAL ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 05:42 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	LT	A-0516-2
2	Indian Point 3	X	SA302B	LT	A-0516-2



Results

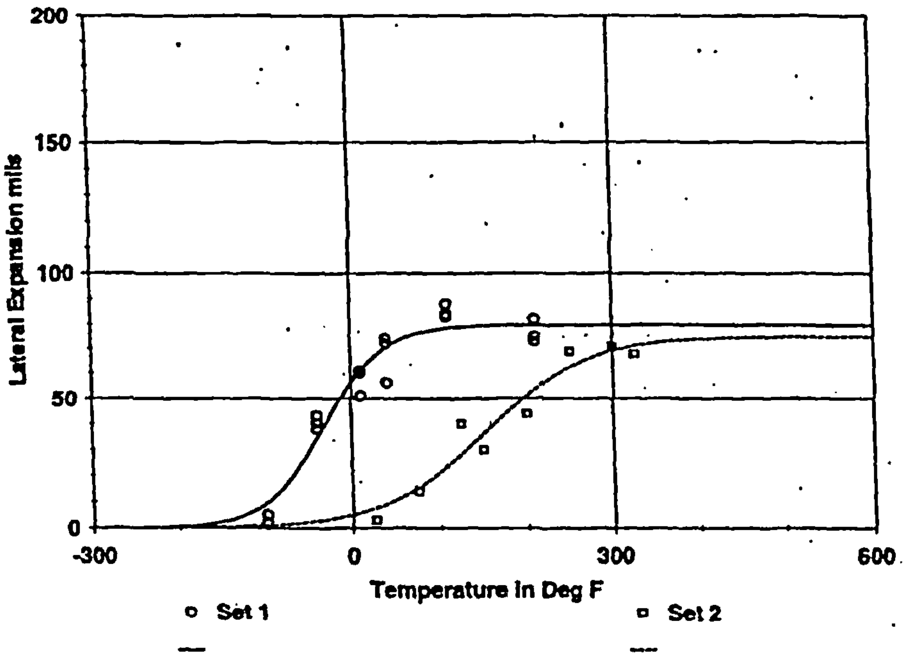
Curve	Fluence	LSE	USE	d-USE	T @30	d-T @30	T @50	d-T @50
1		2.2	125.0	.0	-54.5	.0	-21.5	.0
2		2.2	105.0	-20.0	98.1	152.6	145.0	166.5

Figure 10 Charpy V-Notch Impact Energy vs. Temperature for Indian Point Unit 3 Reactor Vessel Intermediate Shell Plate B2802-2 (Longitudinal)

INTERMEDIATE SHELL PLATE B2802-2 (LONGITUDINAL ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 05:48 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	LT	A-0516-2
2	Indian Point 3	X	SA302B	LT	A-0516-2



Results

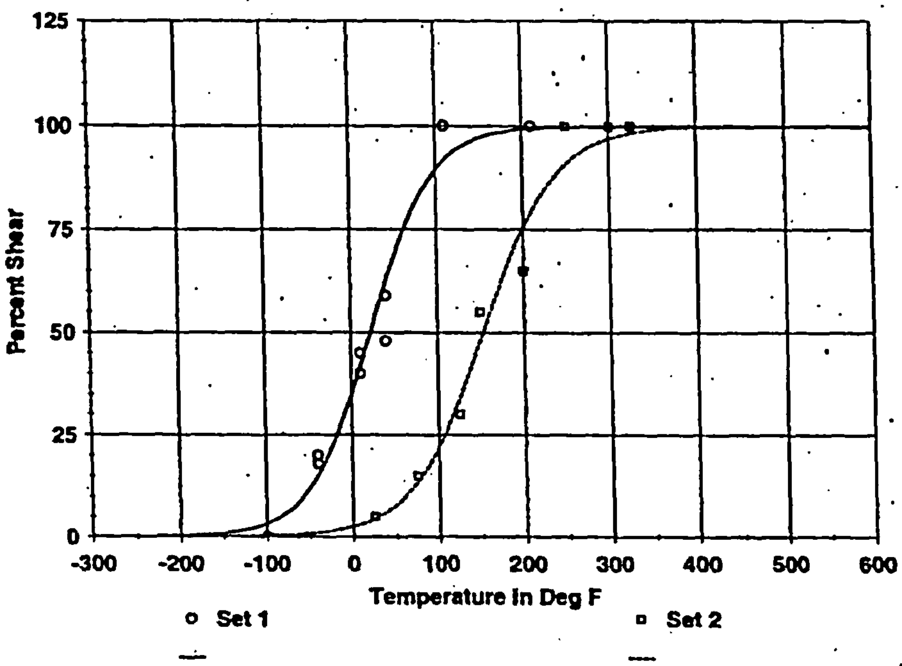
Curve	Fluence	LSE	USE	d-USE	T @35	d-T @35
1		.0	79.8	.0	-38.6	.0
2		.0	75.2	-4.6	147.3	185.9

Figure 11 **Charpy V-Notch Lateral Expansion vs. Temperature for Indian Point Unit 3 Reactor Vessel Intermediate Shell Plate B2802-2 (Longitudinal)**

INTERMEDIATE SHELL PLATE B2802-2 (LONGITUDINAL ORIENTATION)

CVGRAPH 5.0.2 Hyperbolic Tangent Curve Printed on 04/02/2004 05:45 PM
Data Set(s) Plotted

Curve	Plant	Capsule	Material	Ori.	Heat #
1	Indian Point 3	UNIRR	SA302B	LT	A-0516-2
2	Indian Point 3	X	SA302B	LT	A-0516-2



Results

Curve	Fluence	LSE	USE	d-USE	T @50	d-T @50
1		.0	100.0	.0	22.6	.0
2		.0	100.0	.0	153.2	130.6

Figure 12 Charpy V-Notch Percent Shear vs. Temperature for Indian Point Unit 3 Reactor Vessel Intermediate Shell Plate B2802-2 (Longitudinal)

4.2 Credibility Evaluation

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

To date there has been four surveillance capsules removed from the Indian Point Unit 3 reactor vessel. To use these surveillance data sets, they must be shown to be credible. In accordance with the discussion of Regulatory Guide 1.99, Revision 2, there are five requirements that must be met for the surveillance data to be judged credible.

The purpose of this evaluation is to apply the credibility requirements of Regulatory Guide 1.99, Revision 2, to the Indian Point Unit 3 reactor vessel surveillance data and determine if the Indian Point Unit 3 surveillance data is credible.

It should be noted that only surveillance plate B2803-3 will be evaluated for credibility for the following reasons: 1) The surveillance plates B2802-1, 2, and 3 do not contain sufficient irradiated data sets to be used in vessel material predictions, 2) The limiting surveillance plate B2803-3 has a significantly larger initial RT_{NDT}, where the remaining surveillance materials could not become limiting even with non-credible surveillance data (*i.e. using a full margin term*). 3) The surveillance weld heat is not the same heat as the beltline welds (*intermediate/lower shell longitudinal weld & intermediate to lower shell girth weld*), thus should not be used for vessel material predictions (*see discussion under Criterion 1*).

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", as follows:

> "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 Indian Point Unit 3 reactor vessel consists of the following beltline region materials:

- Intermediate Shell Plates B2802-1, 2, 3
- Lower Shell Plates R2803-1, 2, 3
- Intermediate & Lower Shell Longitudinal Weld Seams (Heat # 34B009, Flux Type Linde 1092),
- Intermediate to Lower Shell Circumferential Weld Seam (Heat # 13253, Flux Type Linde1092).

Per WCAP-8475, the Indian Point Unit 3 surveillance program was based on ASTM E185-62. When the surveillance program material was selected it was believed that copper and phosphorus were elements most important to embrittlement of the reactor vessel steels. Lower shell plate B2803-3 had the highest copper weight percents, the highest initial RT_{NDT} and the lowest USE of all plate materials in the beltline region. Thus, it was selected as one of the beltline plate materials included in the surveillance capsules. Since Indian Point Unit 3 had eight surveillance capsules, there was sufficient room for additional plate materials, thus, specimens from each of the intermediate shell plates were also included, but not to the extent as lower shell plate B2803-3.

The weld material in the Indian Point Unit 3 surveillance program was made of the weld wire heat W5214, flux type linde 1092. This is the same heat as that from the nozzle shell longitudinal welds, but the same flux type as those welds within the beltline region. In addition, predictions made at the time the capsule program was developed indicated that weld heat W5214, linde 1092 would produce similar predictions as those weld heats within the beltline region and thus deemed the surveillance weld heat W5214 representative of the beltline region. Therefore it was chosen as the surveillance weld material.

Hence, Criterion 1 is met for the Indian Point Unit 3 reactor vessel.

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 upper shelf energy of the Indian Point Unit 3 surveillance materials unambiguously. Hence, the Indian Point Unit 3 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 normally should be less than 28°F for welds and 17°F for base metal. Even if the fluence range is large (two or more orders of magnitude), the scatter should not exceed twice those values. Even if the data fail this criterion for use in shift calculations, they may be credible for determining decrease in upper shelf energy if the upper shelf can be clearly determined, following the definition given in ASTM E185-82.

The functional form of the least squares method as described in Regulatory Position 2.1 will be utilized to determine a best-fit line for this data and to determine if the scatter of these 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.

TABLE 11

Calculation of Chemistry Factors using Indian Point Unit 3 Surveillance Capsule Data

Material	Capsule	Capsule $f^{(a)}$	$FF^{(b)}$	$\Delta RT_{NDT}{}^{(c)}$	$FF*\Delta RT_{NDT}$	FF^2
Lower Shell Plate B2803-3 (*Longitudinal*)	T	0.263	0.637	139.4	88.798	0.406
	Z	1.04	1.01	167.8	169.478	1.02
	X	0.874	0.962	159.6	153.535	0.925
Lower Shell Plate B2803-3 (*Transverse*)	T	0.263	0.637	105.9	67.458	0.406
	Y	0.692	0.897	148.9	133.563	0.805
	Z	1.04	1.01	157.9	159.479	1.02
	X	0.874	0.962	158.2	152.188	0.925
				SUM:	924.499	5.507
	$CF_{B2803\text{-}3} = \Sigma(FF * \Delta RT_{NDT}) \div \Sigma(FF^2) = (924.499) \div (5.507) = 167.9°F$					

Notes:

(a) f = fluence. Calculated fluence = [x 10^{19} n/cm^2, E > 1.0 MeV].

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

(c) ΔRT_{NDT} values are the measured 30 ft-lb shift values taken from Figures 1 and 4, herein [°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 12.

TABLE 12
Indian Point Unit 3 Surveillance Capsule Data Scatter about the Best-Fit Line for Surveillance Forging Materials.

Material	Capsule	CF (°F)	FF	Measured ΔRT_{NDT}	Predicted ΔRT_{NDT} [a]	Scatter ΔRT_{NDT} (°F)	< 17°F (Base Metals)
Lower Shell Plate B2803-3 (*Longitudinal*)	T	167.9	0.637	139.4	107.0	32.4	No
	Z	167.9	1.01	167.8	169.6	-1.8	Yes
	X	167.9	0.962	159.6	161.5	-1.9	Yes
Lower Shell Plate B2803-3 (Transverse)	T	167.9	0.637	105.9	107.0	-1.1	Yes
	Y	167.9	0.897	148.9	150.6	-1.7	Yes
	Z	167.9	1.01	157.9	169.6	-11.7	Yes
	X	167.9	0.962	158.2	161.5	-3.3	Yes

NOTES:
(a) Predicted ΔRT_{NDT} = (CF * FF) Per Equation 2 of Reg. Guide 1.99 Rev. 2 Position 1.1.

Table 12 indicates that only 1 of 7 data points falls outside the +/- 1σ of 17°F scatter band for the lower shell plate B2803-3 surveillance data. One out of 7 data points is still considered credible. Therefore the lower shell plate B2803-3 surveillance data 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 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 such that the temperatures will not differ by more than 25°F. Hence, this criterion is met.

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 Indian Point Unit 3 surveillance program does contain correlation monitor material, but not in Capsule X. Past capsule results for the correlation monitor material is contained in NUREG/CR-6413, ORNL/TM-13133, which shows a plot of residual vs. fast fluence. The data shown in this report indicates that the CMM tested to date falls within acceptable limits. Hence, this criterion is met.

Therefore, based on the preceding responses to all five criteria of Regulatory Guide 1.99, Revision 2, the Indian Point Unit 3 surveillance plate (B2803-3) is credible.

4.3 Tensile Testing

All tensile testing of the applicable Capsule X materials has been performed, but the testing results have not been compiled or reviewed at this time. However, tensile results do not affect the validation of the Technical Specifications nor the EOL USE calculations. Therefore, it is acceptable to conclude that the tensile test results, when completed, will not result in any required change to plant design basis documents.

A complete analysis of tensile testing data will be included with the final report.

4.4 Dosimetry

Dosimetry data has been gathered and is being reduced at this time. The dosimetry results do not directly affect the Technical Specifications validation, since the associated evaluations (such as those involving the determination of Chemistry Factors or Fluence Factors) are based on calculated fluence.

A fluence evaluation utilizing the recently released neutron transport and dosimetry cross-section libraries was derived from the ENDF/B-VI data-base. Capsule X received a fluence of 0.874×10^{19} n/cm^2 after irradiation to 15.5 EFPY. The peak clad/base metal interface vessel fluence after 15.5 EFPY of plant operation was 5.86×10^{18} n/cm^2.

Fluence is determined to ensure consistency between measured and predicted values. Per Reference 6.6, this is required to be within 20%. Based on experience gained from the results of the three previous surveillance capsules, actual agreement is expected to be well within this criterion. Dosimetry measurements are not a required parameter for reporting under 10CFR50 Appendix H.

The predictions of fluence factors through license expiration are consistent with those that have previously been transmitted to the NRC (Reference 6.5) as part of the Appendix K 1.4% power uprate project. The calculated fluences were evaluated at that time to include the most up-to-date methodology, and the same considerations are unchanged for this application.

A detailed evaluation of measured versus predicted fluence will be included in the final report.

5.0 Conclusions

The preliminary results of the Capsule X data indicate that the IP3 Technical Specifications and EOL USE parameters for the reactor vessel remain valid and do not require revision. These conclusions are pending final review and verification of the data by Westinghouse and will be confirmed upon issuance of the final WCAP report.

6.0 References

6.1 WCAP-16251-NP Rev 0 (Preliminary), "Analysis of Capsule X from Entergy's Indian Point 3 Reactor Vessel Surveillance Program," Westinghouse Electric Co, April 2004 (preliminary)

6.2 Regulatory Guide 1.99 Rev 2, "Radiation Damage to Reactor Vessel Materials," USNRC, February 1986

6.3 WCAP-16037 Rev 1, "Final Report on Pressure-Temperature Limits for Indian Point Unit 3 NPP," Westinghouse Electric Co, May 2003

6.4 Indian Point Unit 3 Technical Specifications Amendment 220, December 2003

6.5 Entergy Report IP3-RPT-MULT-03614, Rev 0, "Indian Point Nuclear Generating Unit Number 3; 1.4% Measurement Uncertainty Recapture Power Uprate Application Report," May 2002

6.6 Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," USNRC, Office of Nuclear Regulatory Research, March 2001