

**Mano K. Nazar**  
**Site Vice President**  
Prairie Island Nuclear Generating Plant  
Nuclear Management Company, LLC  
1717 Wakonade Dr. East • Welch MN 55089

November 7, 2002

U S Nuclear Regulatory Commission  
Attn: Document Control Desk  
Washington, DC 20555

**PRAIRIE ISLAND NUCLEAR GENERATING PLANT**  
Docket No. 50-282 License No. DPR-42  
Docket No. 50-306 License No. DPR-60

**Pressure and Temperature Limits Report (PTLR) Revisions 2 and 3**

Attached are approved copies of Revisions 2 and 3 to the Pressure and Temperature Limits Report (PTLR) for the Prairie Island Nuclear Generating Plant (PINGP). These revisions are submitted in accordance with the provisions of Technical Specification 5.6.6.c.

Revision 2 was issued to make the PTLR consistent with Technical Specifications (TS) license amendments (LA) 158/149, conversion to Improved Technical Specifications. The Revision 2 changes included revision of references to TS to conform to LA 158/149 and addition of subsections for pressurizer and steam generator pressure and temperature limits.

Revision 3 was issued to add approval of the Site Director of Engineering, correct the maximum pressurizer cooldown rate and conform references to the Technical Requirements Manual (TRM) to the latest revision of the TRM.

A001

USNRC  
November 7, 2002  
Page 2 of 2

NUCLEAR MANAGEMENT COMPANY

The Nuclear Management Company has not made new or revised existing Nuclear Regulatory Commission commitments in this letter or the attachments. Please contact Dale Vincent (651-388-1121) if you have any questions related to these reports.



Mano K. Nazar  
Site Vice President  
Prairie Island Nuclear Generating Plant

c: Regional Administrator - Region III, NRC  
Senior Resident Inspector, NRC  
NRR Project Manager, NRC  
James Bernstein, State of Minnesota

Attachments: Pressure and Temperature Limits Report, Revision 2  
Pressure and Temperature Limits Report, Revision 3

# Prairie Island Nuclear Generating Plant Units One and Two

## Pressure and Temperature Limits Report Revision 2 (Effective until 35 EFPY)

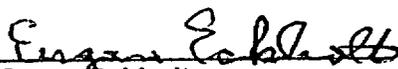
Prepared by:

  
\_\_\_\_\_  
Roy Waterman

9/27/2002  
Date

Sr. Engineer  
Nuclear Engineering

Reviewed by:

  
\_\_\_\_\_  
Gene Ackholt

10/1/02  
Date

Licensing Supervisor

Approved by:

  
\_\_\_\_\_  
Randy Womack

10/2/02  
Date

Programs Engineering Manager

## Table of Contents

Section		Page
1.0	Purpose	1
2.0	Applicability	1
3.0	Operating Limits	2
	Over Pressure Protection System (OPPS) Enable Temperature	2
	Safety Injection (SI) Pump Disable Temperature	2
	RCS Pressure/Temperature (P/T) Limits	3
	Instrumentation Uncertainty for P/T Curves	3
	RCS Heatup/Cooldown Rate Limits	3
	Over Pressure Protection System (OPPS) PORV Setpoint	3
	RCS Minimum Temperature When Not Vented	4
	Minimum Boltup Temperature	4
	Pressurizer Temperature Limits	4
	Steam Generator Temperature/Pressure Limit	4
4.0	Discussion	5
	Adjusted Reference Temperature (ART)	5
	End of Life Fluence Reference Temperature ( $RT_{pts}$ )	6
	Neutron Fluences ( $f$ )	6
	Chemistry Factor (CF)	7
	Reactor Vessel Material Surveillance Program	7
	Supplemental Data Tables	7
	Surveillance Data Credibility	7
	RCS Minimum Temperature When Not Vented	8
	Minimum Boltup Temperature	8
5.0	References	9
6.0	Tables and Figures	10
	Table 6.1 35 EFPY Heatup Data Points	11
	Table 6.2 35 EFPY Cooldown Data Points	12
	Table 6.3 Reactor Vessel Material Surveillance Capsule Removal Schedule	13
	Table 6.4 Prairie Island Unit 1 1/4T and 3/4T ART Calculations at 35 EFPY	14
	Table 6.5 Prairie Island Unit 2 1/4T and 3/4T ART Calculations at 35 EFPY	15
	Figure 6.1 Prairie Island Reactor Coolant System Heatup Limitations Applicable to 35 EFPY	16

Figure 6.2 Prairie Island Reactor Coolant System Cooldown  
Limitations Applicable to 35 EFPY

17

## 1.0 Purpose

The purpose of the Prairie Island Nuclear Generating Station Pressure and Temperature Limits Report (PTLR) is to present operating limits for Units 1 and 2 relating to; (1) RCS pressure and temperature during Heatup, Cooldown and low temperature operation; (2) RCS heatup and cooldown rates; (3) the Over Pressure Protection System (OPPS) arming temperature; (4) OPPS lift settings; (5) Safety Injection Pump disable temperature as well as (6) thermal stress related temperature limitations for the pressurizer and steam generators. This report has been prepared in accordance with the requirements with Technical Specification 5.6.6.

## 2.0 Applicability

This report is applicable to both Units 1 and 2 until 35 Effective Full Power Years (EFPY) is reached on that particular units' Reactor Pressure Vessel. The Technical Specifications that are affected by the information contained in this report are:

TS 3.4.3	RCS Pressure and Temperature (P/T) Limits
TS 3.4.6	RCS Loops – MODE 4
TS 3.4.7	RCS Loops – MODE 5, Loops Filled
TS 3.4.10	Pressurizer Safety Valves
TS 3.4.12	Low Temperature Overpressure Protection (LTOP) – Reactor Coolant System Cold Leg Temperature (RCSCLT) > Safety Injection (SI) Pump Disable Temperature
TS 3.4.13	Low Temperature Overpressure Protection (LTOP) – Reactor Coolant System Cold Leg Temperature (RCSCLT) ≤ Safety Injection (SI) Pump Disable Temperature
TS 3.5.3	ECCS – Shutdown
TRM 3.10.1	Miscellaneous Specifications – Technical Requirements Manual

### 3.0 Operating Limits

All limits are valid until 35 EFPY, which is projected to be beyond the expiration of the operating license for each of Prairie Island Units 1 and 2.

#### Over Pressure Protection System (OPPS) Enable Temperature

**310 °F\***

Referenced in:	TS 3.4.6, TS 3.4.7, TS 3.4.10, TS 3.4.12, TS 3.4.13, SR 3.4.12.4, SR 3.4.13.5
----------------	---

\*Analytical limit [225 °F] plus indicating instrument channel uncertainty [18 °F]  
(Reference 5.11) plus additional margin for operational simplicity.

#### Safety Injection (SI) Pump Disable Temperature

**218 °F \***

Referenced in:	TS 3.4.12, TS 3.4.13, TS 3.5.3
----------------	--------------------------------------

\* Analytical limit [200 °F] plus indicating instrument channel uncertainty [18 °F]  
(Reference 5.11).

RCS Pressure/Temperature (P/T) Limits

**Figure 6.1\*** RCS P/T limits for heatup

**Figure 6.2\*** RCS P/T limits for cooldown

Referenced in:	TS 3.4.3, TS 3.4.12, TS 3.4.13, SR 3.4.3.1
----------------	---

\* Figures are analytical limits and do not include instrumentation uncertainty.  
Note: Tables 6.1 and 6.2 contain a tabulated version of the curves.

Instrumentation Uncertainty for P/T Curves

**124 psig** Pressure Uncertainty

**18 °F** Temperature Uncertainty

Note: These values must be applied to the P/T limit curves in operating procedures (Reference 5.10 and 5.11).

RCS Heatup/Cooldown Rate Limits

**100 °F per hour** Maximum RCS Heatup Rate

**100 °F per hour** Maximum RCS Cooldown Rate

Referenced in:	TS 3.4.3, SR 3.4.3.1
----------------	-------------------------

Over Pressure Protection System (OPPS) PORV Setpoint

**500 psig\***

Referenced in:	TS 3.4.12, TS 3.4.13
----------------	-------------------------

\*This setpoint accounts for instrument channel uncertainty (Reference 5.8).

RCS Minimum Temperature When Not Vented

**86 °F\***

Referenced in:	TS 3.4.3, TS 5.6.6
----------------	-----------------------

\* Analytical limit [68°F] plus indicating instrument channel uncertainty [18°F]  
(Reference 5.11)

Minimum Boltup Temperature

**60 °F\*\***

Referenced in:	TS 5.6.6
----------------	----------

\*\*No instrument uncertainty included.

Pressurizer Temperature Limits

**100 °F per hour** Maximum Pressurizer Heatup Rate

**100 °F per hour** Maximum Pressurizer Cooldown Rate

**320 °F** Maximum Temperature Difference Between the Pressurizer and the Spray Fluid for which the Pressurizer Spray can be used.

Referenced in:	TRM Miscellaneous Specification 3.10.1
----------------	---

Steam Generator Temperature/Pressure Limit

**200 psig** Maximum secondary side Pressure if the temperature of the steam generator is below **70 °F**.

Referenced in:	TRM Miscellaneous Specification 3.10.1
----------------	---

#### 4.0 Discussion

This PTLR for Prairie Island Units 1 and 2 has been prepared in accordance with the requirements contained in Technical Specification 5.6.6. Periodic adjustments to the curves, limits and setpoints based on new irradiation fluences of the reactor vessel or changes in instrument uncertainty can be made under the conditions of 10CFR50.59, with the updated PTLR submitted to the NRC upon issuance.

Changes to the curves, limits, setpoints or parameters in the PTLR resulting from new or additional analysis of either beltline or weld material properties (e.g. additional capsule data) must be submitted to the NRC prior to issuance of an updated PTLR.

The results of the analysis of the Units 1 and 2 reactor vessel material surveillance capsule tests show that the limitations for Unit 1 are the most restrictive and conservative. For simplicity these results have been applied to both units.

The following parameters were used in the development of the curves, limits, and setpoints given in section 3.0 of this report. These values were obtained from Prairie Island Units 1 and 2 Reactor Vessel Radiation Surveillance Program Data. The surveillance program capsules were removed as indicated in Table 6.3.

#### Adjusted Reference Temperature (ART)

The adjusted reference temperature is the reference temperature (as defined in the ASME Boiler and Pressure Vessel Code, Section XI, Appendix G for Nil-ductility transition) that has been adjusted for radiation effects. This temperature was determined for all beltline materials for both Prairie Island Units 1 and 2 at the 1/4T and 3/4T thicknesses from the reactor vessel clad/base metal interface radius, where T is the reactor vessel thickness. Comparison of ARTs for all materials shows that the limiting material is the Unit 1 nozzle to intermediate shell forging circumferential weld material (Table 6.4 and 6.5). The limiting ARTs are as follows:

$$1/4T = 154 \text{ }^{\circ}\text{F}$$

$$3/4T = 136 \text{ }^{\circ}\text{F}$$

References:	5.3
	5.6

### End of Life Fluence Reference Temperature (RT<sub>pts</sub>)

The RT<sub>pts</sub> reference temperature is the end of life reference temperature determined at the clad/base metal interface radius of the reactor vessel and adjusted for radiation effect to the projected end of plant life. The reference temperature has been obtained for all bellline materials in both Prairie Island Units 1 and 2. The projected end of life for both units is 35 Effective Full Power Years (35 EFPY). Comparison of RT<sub>pts</sub> for all materials indicates that the limiting material is the Unit 1 nozzle to intermediate shell forging circumferential weld material. The limiting RT<sub>pts</sub> is as follows:

$$RT_{pts} = 162 \text{ }^\circ\text{F}$$

References:	5.4
	5.7

### Neutron Fluences (f)

The ARTs are determined, in part, based on neutron fluence that is determined by using analytical techniques and passive neutron flux monitoring devices included within the Reactor Vessel Material Surveillance Program. Neutron fluence is determined for the present and future condition of the reactor vessel. The neutron fluences used in determining the 35 EFPY limiting ART for the reactor vessels are as follows:

Units are  $10^{19}$  n/cm<sup>2</sup>, for energies > 1.0 MeV at 35 EFPY

$$\begin{aligned} \text{Clad/Base Metal Interface} &= 2.2 \\ 1/4T &= 1.47 \\ 3/4T &= 0.66 \end{aligned}$$

References:	5.2
	5.5

Note: These values are not the highest fluences that were obtained in the reactor vessels, but are the values determined for the most limiting material - the Unit 1 nozzle to intermediate shell forging circumferential weld. The highest fluences were obtained at the unit 2 intermediate to lower shell forging circumferential weld. (Reference 5. 5).

### Chemistry Factor (CF)

Chemistry Factors are parameters used in the development of the ARTs for the beltline materials and account for the Copper and Nickel content in the reactor vessel beltline materials. The chemistry factors determined for the limiting ARTs are as follows.

$$1/4T = 79.5 \text{ }^{\circ}\text{F}$$

$$3/4T = 79.5 \text{ }^{\circ}\text{F}$$

References:	5.3
	5.6

### Reactor Vessel Material Surveillance Program

The Reactor Vessel Material Surveillance Program is described in the USAR (Reference 5.9). The schedule for removal of the Units 1 and 2 capsules is contained in Table 6.3 of this report.

References:	5.2
	5.5
	5.9

### Supplemental Data Tables

Tables 6.4 and 6.5 contain the development of all of the ARTs for the beltline materials for Unit 1 and Unit 2 respectively, including all the parameters.

References:	5.3
	5.6

### Surveillance Data Credibility

The credibility of surveillance capsule data is determined as specified in Regulatory Guide 1.99, Revision 2, Section B. Four radiation surveillance capsules have been removed from each of the Prairie Island Reactor Vessels, as shown in Table 6.3, and the credibility of these capsule data is analyzed in references 5.2 and 5.5. The credibility of the surveillance data effects how it is applied in the development of the materials' ARTs.

When two or more credible surveillance data sets become available, the data sets may be used to determine the ART values as described in Regulatory Guide 1.99, Revision 2, Position 2.1. If the ART values based on surveillance capsule data are larger than those calculated per Regulatory Guide 1.99, Revision 2, Position 1.1, the surveillance data must be used. If the surveillance

capsule data gives lower values, either may be used. In the case of the Prairie Island limiting material, the Unit 1 nozzle to intermediate shell forging circumferential weld, surveillance data was not available and Position 1.1 of Regulatory Guide 1.99, Revision 2, was applied. For comparison Tables 6.4 and 6.5 contains the ARTs for all those materials in the surveillance programs using both Regulatory Guide 1.99, Revision 2, development methods: Position 1.1 and Position 2.1.

#### RCS Minimum Temperature When Not Vented

This is the RCS lower temperature limit until the system is vented with at least a 3 square inch vent.

#### Minimum Boltup Temperature

The Minimum Boltup Temperature is the minimum temperature of the reactor vessel flange metal required any time reactor vessel flange is under tensioning stress.

## 5.0 References

- 5.1 WCAP-14040-NP-A, Methodology Used to Develop Cold Overpressure Mitigation, Revision 2, January 1996.
- 5.2 WCAP-14779, Analysis of Capsule S from the Northern States Power Company Prairie Island Unit 1 Reactor Vessel Radiation Surveillance Program, Revision 2, February 1998.
- 5.3 WCAP-14780, Prairie Island Unit 1 Heatup and Cooldown Limit Curves Normal Operation, Revision 3, February 1998.
- 5.4 WCAP-14781, Evaluation of Pressurized Thermal Shock for Prairie Island Unit 1, Revision 3, February 1998.
- 5.5 WCAP-14613, Analysis of Capsule P from the Northern States Power Company Prairie Island Unit 2 Reactor Vessel Radiation Surveillance Program, Revision 2, February 1998.
- 5.6 WCAP-14637, Prairie Island Unit 2 Heatup and Cooldown Limit Curves Normal Operation, Revision 3, December 1999.
- 5.7 WCAP-14638, Evaluation of Pressurized Thermal Shock for Prairie Island Unit 2, Revision 3, December 1999.
- 5.8 Westinghouse Letter NSP-98-0120, "Prairie Island Units 1 and 2 COMS Setpoint Analysis," Revision 2, February 1998.
- 5.9 USAR Section 4.7.2, "Reactor Vessel Material Surveillance Program"
- 5.10 NSP Calculation No. SPCRC002, "Unit 1 Reactor Coolant Hot Leg Pressure Control Room Indication at 1PR-420 (0-750 psig scale) with 2 RC Pumps Running," Revision 0.
- 5.11 NSP Calculation No. SPCRC003, "Unit 1 Wide Range RCS Cold Leg Temperature Control Room Indication Loop 1T-450B Uncertainty with Streaming Effects," Revision 0.

## 6.0 Tables and Figures

Table 6.1	35 EFPY Heatup Data Points
Table 6.2	35 EFPY Cooldown Data Points
Table 6.3	Reactor Vessel Material Surveillance Capsule Removal Schedule.
Table 6.4	Prairie Island Unit 1 1/4T and 3/4T ART Calculations at 35 EFPY
Table 6.5	Prairie Island Unit 2 1/4T and 3/4T ART Calculations at 35 EFPY
Figure 6.1	Prairie Island Reactor Coolant System Heatup Limitations Applicable to 35 EFPY.
Figure 6.2	Prairie Island Reactor Coolant System Cooldown Limitations Applicable to 35 EFPY.

**TABLE 6.1**  
**35 EFY Heatup Data Points**  
**(Without Instrumentation Uncertainty Margins)**

Heatup Curves									
60 Heatup		Critical. Limit		100 Heatup		Critical. Limit		Leak Test Limit	
T	P	T	P	T	P	T	P	T	P
60	0	273	0	60	0	273	0	251	2000
60	584	273	594	60	560	273	560	273	2485
65	584	273	587	65	560	273	560		
85	584	273	584	85	560	273	560		
90	584	273	584	90	560	273	560		
95	584	273	586	95	560	273	560		
100	586	273	591	100	560	273	560		
105	591	273	597	105	560	273	560		
110	597	273	604	110	560	273	562		
115	604	273	613	115	562	273	566		
120	613	273	622	120	566	273	571		
125	622	273	633	125	571	273	577		
130	633	273	645	130	577	273	585		
135	645	273	658	135	585	273	594		
140	658	273	672	140	594	273	604		
145	672	273	687	145	604	273	615		
150	687	273	704	150	615	273	627		
155	704	273	722	155	627	273	641		
160	722	273	741	160	641	273	656		
165	741	273	761	165	656	273	672		
170	761	273	784	170	672	273	690		
175	784	273	808	175	690	273	709		
180	808	273	833	180	709	273	730		
185	833	273	861	185	730	273	752		
190	861	273	891	190	752	273	777		
195	891	273	923	195	777	273	802		
200	923	273	957	200	802	273	831		
205	957	273	994	205	831	273	861		
210	994	273	1033	210	861	273	893		
215	1033	273	1076	215	893	273	928		
220	1076	273	1121	220	928	273	966		
225	1121	273	1170	225	966	273	1006		
230	1170	275	1223	230	1006	275	1049		
235	1223	280	1279	235	1049	280	1096		
240	1279	285	1339	240	1096	285	1149		
245	1339	290	1404	245	1146	290	1199		
250	1404	295	1473	250	1199	295	1257		
255	1473	300	1548	255	1257	300	1318		
260	1548	305	1628	260	1318	305	1384		
265	1628	310	1713	265	1384	310	1455		
270	1713	315	1805	270	1455	315	1531		
275	1805	320	1903	275	1531	320	1612		
280	1903	325	2007	280	1612	325	1699		
285	2007	330	2119	285	1699	330	1792		
290	2119	335	2231	290	1792	335	1892		
295	2231	340	2347	295	1892	340	1998		
300	2347	345	2471	300	1998	345	2112		
305	2471			305	2112	350	2233		
				310	2233	355	2363		
				315	2363				

**TABLE 6.2**  
**35 EFPY Cooldown Data Points**  
**(Without Margins for Instrumentation Uncertainty)**

Cooldown Curves									
Steady State		20 deg F		40 deg F		60 deg F		100 deg F	
T	P	T	P	T	P	T	P	T	P
60	0	60	0	60	0	60	0	60	0
60	590	60	563	60	537	60	510	60	455
65	594	65	568	65	542	65	515	65	460
70	599	70	573	70	547	70	520	70	465
75	605	75	579	75	552	75	526	75	471
80	611	80	585	80	558	80	532	80	478
85	617	85	591	85	565	85	539	85	485
90	621	90	598	90	572	90	546	90	493
95	621	95	605	95	580	95	554	95	502
100	621	100	613	100	588	100	563	100	511
105	621	105	621	105	597	105	572	105	520
110	621	110	621	110	607	110	582	110	531
115	621	115	621	115	617	115	592	115	543
116	621	116	621	120	628	120	604	120	555
116	668	116	644	125	640	125	616	125	568
120	676	120	652	130	653	130	630	130	583
125	687	125	664	135	667	135	644	135	599
130	699	130	676	140	682	140	660	140	615
135	712	135	690	145	698	145	676	145	634
140	726	140	704	150	715	150	695	150	653
145	741	145	720	155	734	155	714	155	674
150	757	150	736	160	754	160	735	160	697
155	774	155	754	165	776	165	757	165	722
160	793	160	773	170	799	170	782	170	748
165	813	165	794	175	824	175	808	175	777
170	834	170	816	180	851	180	836	180	808
175	857	175	841	185	880	185	866	185	841
180	882	180	866	190	911	190	899	190	876
185	909	185	894	195	945	195	934	195	915
190	937	190	924	200	981	200	972	200	956
195	968	195	956	205	1019	205	1012	205	1001
200	1001	200	990	210	1061	210	1056	210	1048
205	1036	205	1027	215	1106	215	1102	215	1100
210	1075	210	1067	220	1154	220	1153	220	1155
215	1115	215	1110	225	1205				
220	1159	220	1156						
225	1206	225	1205						
230	1257								
235	1311								
240	1370								
245	1432								
250	1500								
255	1572								
260	1649								
265	1732								
270	1820								
275	1915								
280	2017								
285	2126								
290	2243								
295	2367								

**Table 6.3**  
**Reactor Vessel Material Surveillance Capsule Removal Schedule**

Recommended Surveillance Capsule Removal Schedule for Unit 1				
Capsule	Capsule Location (degree)	Lead Factor <sup>(a)</sup>	Withdrawal EFPY <sup>(b)</sup>	Fluence <sup>(a)</sup> (n/cm <sup>2</sup> , E> 1.0 MeV)
V	77	2.94	1.34	5.630 x 10 <sup>18(c)</sup>
P	247	1.72	4.60	1.318 x 10 <sup>19(c)</sup>
R	257	2.99	8.56	4.478 x 10 <sup>19(c)</sup>
S	57	1.77	18.12	4.017 x 10 <sup>19(c)</sup>
T	67	1.89	Standby	---
N	237	1.77	Standby	---

Recommended Surveillance Capsule Removal Schedule for Unit 2				
Capsule	Capsule Location (degree)	Lead Factor <sup>(d)</sup>	Withdrawal EFPY <sup>(b)</sup>	Fluence <sup>(d)</sup> (n/cm <sup>2</sup> , E> 1.0 MeV)
V	77	2.95	1.39	6.206 x 10 <sup>18(c)</sup>
T	67	1.75	4.00	1.199 x 10 <sup>19(c)</sup>
R	257	2.99	8.81	4.376 x 10 <sup>19(c)</sup>
P	247	1.84	17.24	4.165 x 10 <sup>19(c)</sup>
N	237	1.72	Standby	---
S	57	1.72	Standby	---

Notes:

- (a) Updated in Capsule S dosimetry analysis.
- (b) Effective Full Power Years (EFPY) from plant startup.
- (c) Plant specific evaluation.
- (d) Updated in Capsule P dosimetry analysis.

Table 6.4

Prairie Island Unit 1 1/4T and 3/4T ART Calculations at 35 EFPY

Material	CF	f @35 EFPY <sup>(a)</sup>	1/4T f 3/4T f	1/4T FF <sup>(d)</sup> 3/4T FF	I <sup>(e)</sup> (°F)	M <sup>(g)</sup> (°F)	$\Delta T_{ND}$ T (°F)	ART (°F)
----------	----	---------------------------	------------------	-----------------------------------	--------------------------	--------------------------	---------------------------	-------------

1/4T Calculations

Nozzle (upper)Shell Forging B	51	2.20	1.47	1.11	-4	34	56.6	87
Nozzle to Inter. Shell Circ Weld (Heat 2269)	79.5	2.20	1.47	1.11	0 <sup>(c)</sup>	66	88.2	154
Intermediate Shell Forging C	44.0	3.95	2.64	1.26	14	34	55.4	103
Using S/C Data	54.7	3.95	2.64	1.26	14	34 <sup>(b)</sup>	68.9	117
Circumferential Weld	69.7	3.95	2.64	1.26	-13	56	87.8	131
Using S/C Data	80.8	3.95	2.64	1.26	-13	56 <sup>(b)</sup>	101.8	145
Lower Shell Forging D	44.0	3.95	2.64	1.26	-4	34	55.4	85

3/4T Calculations

Nozzle (upper) Shell Forging B	51	2.20	0.660	0.884	-4	34	45.1	75
Nozzle to Inter. Shell Circ Weld (Heat 2269)	79.5	2.20	0.660	0.884	0 <sup>(c)</sup>	66	70.3	136
Intermediate Shell Forging C	44.0	3.95	1.18	1.05	14	34	46.2	94
Using S/C Data	54.7	3.95	1.18	1.05	14	34 <sup>(b)</sup>	57.4	105
Circumferential Weld	69.7	3.95	1.18	1.05	-13	56	73.2	116
Using S/C Data	80.8	3.95	1.18	1.05	-13	56 <sup>(b)</sup>	84.8	128
Lower Shell Forging D	44.0	3.95	1.18	1.05	-4	34	46.2	76

NOTE:

- (a) Fluence values (f) are  $\times 10^{19}$  n/cm<sup>2</sup> (E > 1.0 MeV). In addition, the values used are the calculated values since they are higher than the best-estimate values (Ref. 5.3).
- (b) The full  $\sigma_d$  margin of 17°F for the forging and 28°F for the weld was used since the surv. data was deemed not credible (Ref. 5.3).
- (c) Estimated per Standard Review Plan Section 5.3.2 (Ref. 5.3).
- (d) FF, Fluence Factor =  $f(0.28-0.1 \cdot \log f)$  (Ref. 5.3)
- (e) I is the unirradiated material reference temperature. (Ref. 5.3)
- (g) M is a margin term required for conservative results. (Ref. 5.3)

Table 6.5

Prairie Island Unit-2 1/4T and 3/4T ART Calculations at 35 EFPY

Material	CF	f @35 EFPY	1/4T f 3/4T f <sup>(a)</sup>	1/4T FF <sup>(c)</sup> 3/4T FF	I <sup>(d)</sup> (°F)	M <sup>(e)</sup> (°F)	$\Delta RT_{ND}$ T (°F)	ART (°F)
----------	----	------------	---------------------------------	-----------------------------------	--------------------------	--------------------------	----------------------------	-------------

1/4T Calculations

Upper Shell Forging B	44.0	2.379	1.59	1.13	-13	34	49.7	71
Upper to Inter. Shell Weld W2	70.0	2.379	1.59	1.13	-13	56	79.1	122
Using Unit 1 S/C Data <sup>(b)</sup>	80.8	2.379	1.59	1.13	-13	56	91.3	134
Intermediate Shell Forging C	44.0	4.183	2.80	1.27	14	34	55.9	104
Inter. to Lower Shell Weld W3	52.0	4.183	2.80	1.27	-31	56	66.0	91
Using S/C Data	80.0	4.183	2.80	1.27	-31	28	101.6	99
Lower Shell Forging D	51.0	4.183	2.80	1.27	-4	34	64.8	95
Using S/C Data	60.0	4.183	2.80	1.27	-4	34	76.2	106

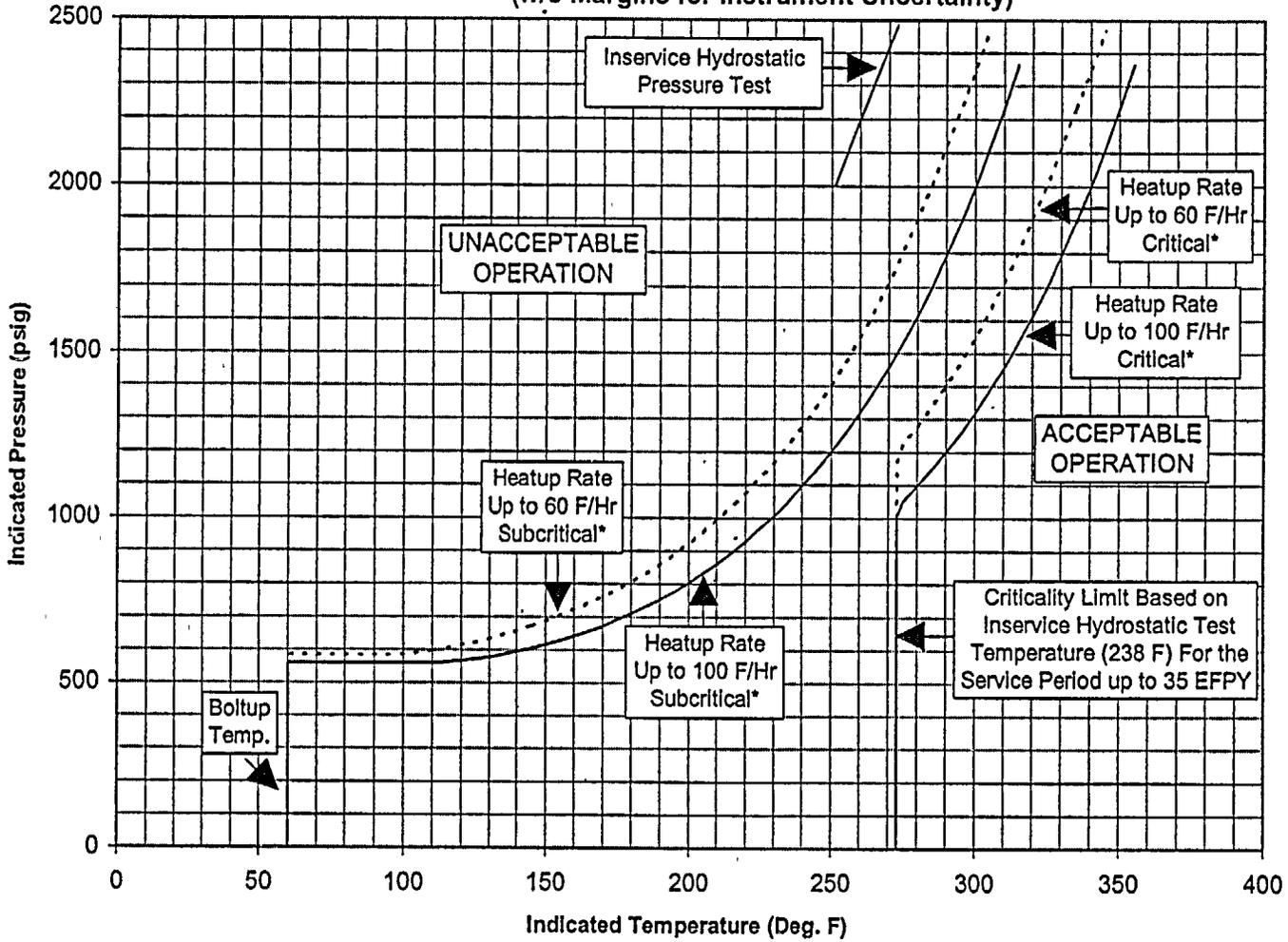
3/4T Calculations

Upper Shell Forging B	44.0	2.379	0.71	0.90	-13	34	39.7	61
Upper to Inter. Shell Weld W2	70.0	2.379	0.71	0.90	-13	56	63.0	106
Using Unit 1 S/C Data <sup>(b)</sup>	80.8	2.379	0.71	0.90	-13	56	72.7	116
Intermediate Shell Forging C	44.0	4.183	1.25	1.06	14	34	46.6	95
Inter. to Lower Shell Weld W3	52.0	4.183	1.25	1.06	-31	55.1	55.1	79
Using S/C Data	80.0	4.183	1.25	1.06	-31	28	84.8	82
Lower Shell Forging D	51.0	4.183	1.25	1.06	-4	34	54.1	84
Using S/C Data	60.0	4.183	1.25	1.06	-4	34	63.6	94

NOTE:

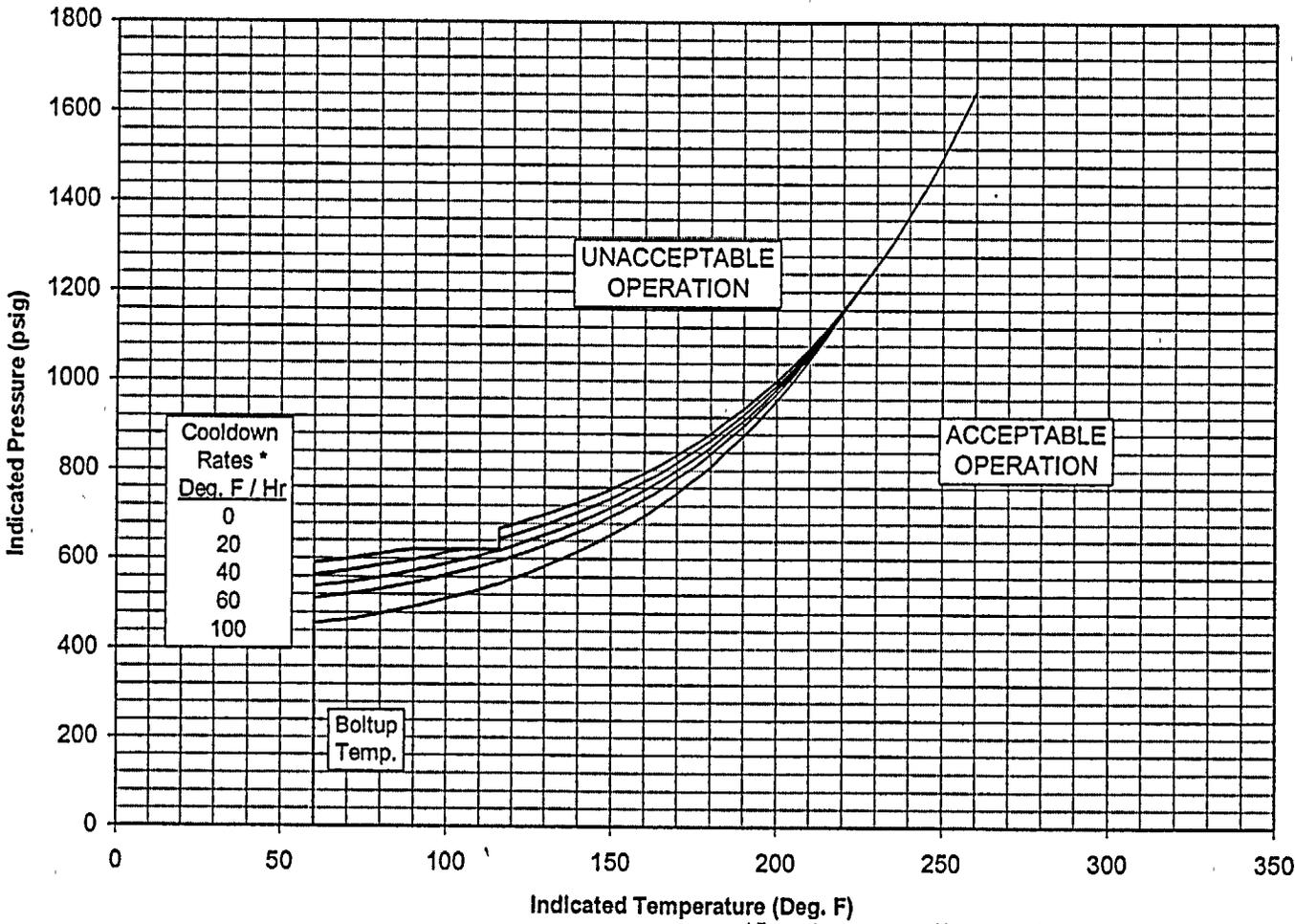
- (a) Fluence values (f) are  $\times 10^{19}$  n/cm<sup>2</sup> (E > 1.0 MeV). In addition, the values used are the Best-Estimate values since they are higher than the calculated values.
- (b) This calculation is using the chemistry factor based on the surveillance capsule data for the Prairie Island Unit 1 surveillance program. Per WCAP-14779 Rev. 1, the surveillance weld data is not credible, therefore, a full  $\sigma_A$  of 28°F was used in the margin term.
- (c) FF, Fluence Factor =  $f(0.28-0.1 \cdot \log f)$ . (Ref. 5.3)
- (d) I is the unirradiated material reference temperature. (Ref. 5.3)
- (e) M is a margin term required for conservative results. (Ref. 5.3)

Figure 6.1  
Prairie Island Reactor Coolant System Heatup Limitations Applicable to 35 EFPY  
(w/o Margins for Instrument Uncertainty)



\* For each curve, acceptable operation is to the right and below the curve.

Figure 6.2  
Prairie Island Reactor Coolant System Cooldown Limitations to 35 EFPY  
(w/o Margins for Instrument Uncertainty)



\* For each curve, acceptable operation is to the right and below the curve.

# Prairie Island Nuclear Generating Plant Units One and Two

## Pressure and Temperature Limits Report

Revision 3 (Effective until 35 EFPY)

Prepared by:

  
\_\_\_\_\_  
Roy Waterman

10/17/2002  
Date

Sr. Engineer  
Nuclear Engineering

Reviewed by:

  
\_\_\_\_\_  
Gene Eckholt

10/17/02  
Date

Licensing Supervisor

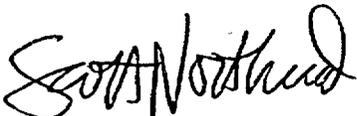
Reviewed by:

  
\_\_\_\_\_  
Randy Wornack

10/18/2002  
Date

Programs Engineering Manager

Approved by:

  
\_\_\_\_\_  
Scott Northard

10-21-02  
Date

Site Director of Engineering

## Table of Contents

Section		Page
1.0	Purpose	1
2.0	Applicability	1
3.0	Operating Limits	2
	Over Pressure Protection System (OPPS) Enable Temperature	2
	Safety Injection (SI) Pump Disable Temperature	2
	RCS Pressure/Temperature (P/T) Limits	3
	Instrumentation Uncertainty for P/T Curves	3
	RCS Heatup/Cooldown Rate Limits	3
	Over Pressure Protection System (OPPS) PORV Setpoint	3
	RCS Minimum Temperature When Not Vented	4
	Minimum Boltup Temperature	4
	Pressurizer Temperature Limits	4
	Steam Generator Temperature/Pressure Limit	4
4.0	Discussion	5
	Adjusted Reference Temperature (ART)	5
	End of Life Fluence Reference Temperature ( $RT_{pts}$ )	6
	Neutron Fluences (f)	6
	Chemistry Factor (CF)	7
	Reactor Vessel Material Surveillance Program	7
	Supplemental Data Tables	7
	Surveillance Data Credibility	7
	RCS Minimum Temperature When Not Vented	8
	Minimum Boltup Temperature	8
5.0	References	9
6.0	Tables and Figures	10
	Table 6.1 35 EFPY Heatup Data Points	11
	Table 6.2 35 EFPY Cooldown Data Points	12
	Table 6.3 Reactor Vessel Material Surveillance Capsule Removal Schedule	13
	Table 6.4 Prairie Island Unit 1 1/4T and 3/4T ART Calculations at 35 EFPY	14
	Table 6.5 Prairie Island Unit 2 1/4T and 3/4T ART Calculations at 35 EFPY	15
	Figure 6.1 Prairie Island Reactor Coolant System Heatup Limitations Applicable to 35 EFPY	16

**Figure 6.2 Prairie Island Reactor Coolant System Cooldown  
Limitations Applicable to 35 EFPY**

17

## 1.0 Purpose

The purpose of the Prairie Island Nuclear Generating Station Pressure and Temperature Limits Report (PTLR) is to present operating limits for Units 1 and 2 relating to; (1) RCS pressure and temperature during Heatup, Cooldown and low temperature operation; (2) RCS heatup and cooldown rates; (3) the Over Pressure Protection System (OPPS) arming temperature; (4) OPPS lift settings; (5) Safety Injection Pump disable temperature as well as (6) thermal stress related temperature limitations for the pressurizer and steam generators. This report has been prepared in accordance with the requirements with Technical Specification 5.6.6.

## 2.0 Applicability

This report is applicable to both Units 1 and 2 until 35 Effective Full Power Years (EFPY) is reached on that particular units' Reactor Pressure Vessel. The Technical Specifications that are affected by the information contained in this report are:

TS 3.4.3	RCS Pressure and Temperature (P/T) Limits
TS 3.4.6	RCS Loops – MODE 4
TS 3.4.7	RCS Loops – MODE 5, Loops Filled
TS 3.4.10	Pressurizer Safety Valves
TS 3.4.12	Low Temperature Overpressure Protection (LTOP) – Reactor Coolant System Cold Leg Temperature (RCSCLT) > Safety Injection (SI) Pump Disable Temperature
TS 3.4.13	Low Temperature Overpressure Protection (LTOP) – Reactor Coolant System Cold Leg Temperature (RCSCLT) ≤ Safety Injection (SI) Pump Disable Temperature
TS 3.5.3	ECCS – Shutdown
	Miscellaneous Specifications – Technical Requirements Manual
TRM 3.4.4	PTLR Compliance – Pressurizer
TRM 3.4.5	PTLR Compliance – Steam Generator(s)

### 3.0 Operating Limits

All limits are valid until 35 EFPY, which is projected to be beyond the expiration of the operating license for each of Prairie Island Units 1 and 2.

#### Over Pressure Protection System (OPPS) Enable Temperature

**310 °F\***

Referenced in:	TS 3.4.6, TS 3.4.7, TS 3.4.10, TS 3.4.12, TS 3.4.13, SR 3.4.12.4, SR 3.4.13.5
----------------	---

\*Analytical limit [225 °F] plus indicating instrument channel uncertainty [18 °F]  
(Reference 5.11) plus additional margin for operational simplicity.

#### Safety Injection (SI) Pump Disable Temperature

**218 °F \***

Referenced in:	TS 3.4.12, TS 3.4.13, TS 3.5.3
----------------	--------------------------------------

\* Analytical limit [200 °F] plus indicating instrument channel uncertainty [18 °F]  
(Reference 5.11).

RCS Pressure/Temperature (P/T) Limits

**Figure 6.1\*** RCS P/T limits for heatup

**Figure 6.2\*** RCS P/T limits for cooldown

Referenced in:	TS 3.4.3, TS 3.4.12, TS 3.4.13, SR 3.4.3.1
----------------	---

\* Figures are analytical limits and do not include instrumentation uncertainty.  
Note: Tables 6.1 and 6.2 contain a tabulated version of the curves.

Instrumentation Uncertainty for P/T Curves

**124 psig** Pressure Uncertainty

**18 °F** Temperature Uncertainty

Note: These values must be applied to the P/T limit curves in operating procedures  
(Reference 5.10 and 5.11).

RCS Heatup/Cooldown Rate Limits

**100 °F per hour** Maximum RCS Heatup Rate

**100 °F per hour** Maximum RCS Cooldown Rate

Referenced in:	TS 3.4.3, SR 3.4.3.1
----------------	-------------------------

Over Pressure Protection System (OPPS) PORV Setpoint

**500 psig\***

Referenced in:	TS 3.4.12, TS 3.4.13
----------------	-------------------------

\*This setpoint accounts for instrument channel uncertainty (Reference 5.8).

RCS Minimum Temperature When Not Vented

**86 °F\***

Referenced in:	TS 3.4.3, TS 5.6.6
----------------	-----------------------

\* Analytical limit [68°F] plus indicating instrument channel uncertainty [18°F]  
(Reference 5.11)

Minimum Boltup Temperature

**60 °F\*\***

Referenced in:	TS 5.6.6
----------------	----------

\*\*No instrument uncertainty included.

Pressurizer Temperature Limits

**100 °F per hour** Maximum Pressurizer Heatup Rate

**200 °F per hour** Maximum Pressurizer Cooldown Rate

**320 °F** Maximum Temperature Difference Between the Pressurizer and the Spray Fluid for which the Pressurizer Spray can be used.

Referenced in:	TRM Specification 3.4.4
----------------	----------------------------

Steam Generator Temperature/Pressure Limit

**200 psig** Maximum secondary side Pressure if the temperature of the steam generator is below **70 °F**.

Referenced in:	TRM Specification 3.4.5
----------------	----------------------------

#### 4.0 Discussion

This PTLR for Prairie Island Units 1 and 2 has been prepared in accordance with the requirements contained in Technical Specification 5.6.6. Periodic adjustments to the curves, limits and setpoints based on new irradiation fluences of the reactor vessel or changes in instrument uncertainty can be made under the conditions of 10CFR50.59, with the updated PTLR submitted to the NRC upon issuance.

Changes to the curves, limits, setpoints or parameters in the PTLR resulting from new or additional analysis of either beltline or weld material properties (e.g. additional capsule data) must be submitted to the NRC prior to issuance of an updated PTLR.

The results of the analysis of the Units 1 and 2 reactor vessel material surveillance capsule tests show that the limitations for Unit 1 are the most restrictive and conservative. For simplicity these results have been applied to both units.

The following parameters were used in the development of the curves, limits, and setpoints given in section 3.0 of this report. These values were obtained from Prairie Island Units 1 and 2 Reactor Vessel Radiation Surveillance Program Data. The surveillance program capsules were removed as indicated in Table 6.3.

#### Adjusted Reference Temperature (ART)

The adjusted reference temperature is the reference temperature (as defined in the ASME Boiler and Pressure Vessel Code, Section XI, Appendix G for Nil-ductility transition) that has been adjusted for radiation effects. This temperature was determined for all beltline materials for both Prairie Island Units 1 and 2 at the 1/4T and 3/4T thicknesses from the reactor vessel clad/base metal interface radius, where T is the reactor vessel thickness. Comparison of ARTs for all materials shows that the limiting material is the Unit 1 nozzle to intermediate shell forging circumferential weld material (Table 6.4 and 6.5). The limiting ARTs are as follows:

$$1/4T = 154 \text{ }^{\circ}\text{F}$$

$$3/4T = 136 \text{ }^{\circ}\text{F}$$

References:	5.3
	5.6

### End of Life Fluence Reference Temperature (RT<sub>pts</sub>)

The RT<sub>pts</sub> reference temperature is the end of life reference temperature determined at the clad/base metal interface radius of the reactor vessel and adjusted for radiation effect to the projected end of plant life. The reference temperature has been obtained for all beltline materials in both Prairie Island Units 1 and 2. The projected end of life for both units is 35 Effective Full Power Years (35 EFPY). Comparison of RT<sub>pts</sub> for all materials indicates that the limiting material is the Unit 1 nozzle to intermediate shell forging circumferential weld material. The limiting RT<sub>pts</sub> is as follows:

$$RT_{pts} = 162 \text{ }^\circ\text{F}$$

References:	5.4
	5.7

### Neutron Fluences (f)

The ARTs are determined, in part, based on neutron fluence that is determined by using analytical techniques and passive neutron flux monitoring devices included within the Reactor Vessel Material Surveillance Program. Neutron fluence is determined for the present and future condition of the reactor vessel. The neutron fluences used in determining the 35 EFPY limiting ART for the reactor vessels are as follows:

Units are  $10^{19}$  n/cm<sup>2</sup>, for energies > 1.0 MeV at 35 EFPY

$$\begin{aligned} \text{Clad/Base Metal Interface} &= 2.2 \\ 1/4T &= 1.47 \\ 3/4T &= 0.66 \end{aligned}$$

References:	5.2
	5.5

Note: These values are not the highest fluences that were obtained in the reactor vessels, but are the values determined for the most limiting material - the Unit 1 nozzle to intermediate shell forging circumferential weld. The highest fluences were obtained at the unit 2 intermediate to lower shell forging circumferential weld. (Reference 5. 5).

### Chemistry Factor (CF)

Chemistry Factors are parameters used in the development of the ARTs for the beltline materials and account for the Copper and Nickel content in the reactor vessel beltline materials. The chemistry factors determined for the limiting ARTs are as follows.

$$1/4T = 79.5 \text{ }^{\circ}\text{F}$$

$$3/4T = 79.5 \text{ }^{\circ}\text{F}$$

References:	5.3
	5.6

### Reactor Vessel Material Surveillance Program

The Reactor Vessel Material Surveillance Program is described in the USAR (Reference 5.9). The schedule for removal of the Units 1 and 2 capsules is contained in Table 6.3 of this report.

References:	5.2
	5.5
	5.9

### Supplemental Data Tables

Tables 6.4 and 6.5 contain the development of all of the ARTs for the beltline materials for Unit 1 and Unit 2 respectively, including all the parameters.

References:	5.3
	5.6

### Surveillance Data Credibility

The credibility of surveillance capsule data is determined as specified in Regulatory Guide 1.99, Revision 2, Section B. Four radiation surveillance capsules have been removed from each of the Prairie Island Reactor Vessels, as shown in Table 6.3, and the credibility of these capsule data is analyzed in references 5.2 and 5.5. The credibility of the surveillance data effects how it is applied in the development of the materials' ARTs.

When two or more credible surveillance data sets become available, the data sets may be used to determine the ART values as described in Regulatory Guide 1.99, Revision 2, Position 2.1. If the ART values based on surveillance capsule data are larger than those calculated per Regulatory Guide 1.99, Revision 2, Position 1.1, the surveillance data must be used. If the surveillance

capsule data gives lower values, either may be used. In the case of the Prairie Island limiting material, the Unit 1 nozzle to intermediate shell forging circumferential weld, surveillance data was not available and Position 1.1 of Regulatory Guide 1.99, Revision 2, was applied. For comparison Tables 6.4 and 6.5 contains the ARTs for all those materials in the surveillance programs using both Regulatory Guide 1.99, Revision 2, development methods: Position 1.1 and Position 2.1.

#### RCS Minimum Temperature When Not Vented

This is the RCS lower temperature limit until the system is vented with at least a 3 square inch vent.

#### Minimum Boltup Temperature

The Minimum Boltup Temperature is the minimum temperature of the reactor vessel flange metal required any time reactor vessel flange is under tensioning stress.

## 5.0 References

- 5.1 WCAP-14040-NP-A, Methodology Used to Develop Cold Overpressure Mitigation, Revision 2, January 1996.
- 5.2 WCAP-14779, Analysis of Capsule S from the Northern States Power Company Prairie Island Unit 1 Reactor Vessel Radiation Surveillance Program, Revision 2, February 1998.
- 5.3 WCAP-14780, Prairie Island Unit 1 Heatup and Cooldown Limit Curves Normal Operation, Revision 3, February 1998.
- 5.4 WCAP-14781, Evaluation of Pressurized Thermal Shock for Prairie Island Unit 1, Revision 3, February 1998.
- 5.5 WCAP-14613, Analysis of Capsule P from the Northern States Power Company Prairie Island Unit 2 Reactor Vessel Radiation Surveillance Program, Revision 2, February 1998.
- 5.6 WCAP-14637, Prairie Island Unit 2 Heatup and Cooldown Limit Curves Normal Operation, Revision 3, December 1999.
- 5.7 WCAP-14638, Evaluation of Pressurized Thermal Shock for Prairie Island Unit 2, Revision 3, December 1999.
- 5.8 Westinghouse Letter NSP-98-0120, "Prairie Island Units 1 and 2 COMS Setpoint Analysis," Revision 2, February 1998.
- 5.9 USAR Section 4.7.2, "Reactor Vessel Material Surveillance Program"
- 5.10 NSP Calculation No. SPCRC002, "Unit 1 Reactor Coolant Hot Leg Pressure Control Room Indication at 1PR-420 (0-750 psig scale) with 2 RC Pumps Running," Revision 0.
- 5.11 NSP Calculation No. SPCRC003, "Unit 1 Wide Range RCS Cold Leg Temperature Control Room Indication Loop 1T-450B Uncertainty with Streaming Effects," Revision 0.

## 6.0 Tables and Figures

- Table 6.1 35 EFPY Heatup Data Points
- Table 6.2 35 EFPY Cooldown Data Points
- Table 6.3 Reactor Vessel Material Surveillance Capsule Removal Schedule.
- Table 6.4 Prairie Island Unit 1 1/4T and 3/4T ART Calculations at 35 EFPY
- Table 6.5 Prairie Island Unit 2 1/4T and 3/4T ART Calculations at 35 EFPY
- Figure 6.1 Prairie Island Reactor Coolant System Heatup Limitations  
Applicable to 35 EFPY.
- Figure 6.2 Prairie Island Reactor Coolant System Cooldown Limitations  
Applicable to 35 EFPY.

**TABLE 6.1**  
**35 EFPY Heatup Data Points**  
**(Without Instrumentation Uncertainty Margins)**

Heatup Curves									
60 Heatup		Critical. Limit		100 Heatup		Critical. Limit		Leak Test Limit	
T	P	T	P	T	P	T	P	T	P
60	0	273	0	60	0	273	0	251	2000
60	584	273	594	60	560	273	560	273	2485
65	584	273	587	65	560	273	560		
85	584	273	584	85	560	273	560		
90	584	273	584	90	560	273	560		
95	584	273	586	95	560	273	560		
100	586	273	591	100	560	273	560		
105	591	273	597	105	560	273	560		
110	597	273	604	110	560	273	562		
115	604	273	613	115	562	273	566		
120	613	273	622	120	566	273	571		
125	622	273	633	125	571	273	577		
130	633	273	645	130	577	273	585		
135	645	273	658	135	585	273	594		
140	658	273	672	140	594	273	604		
145	672	273	687	145	604	273	615		
150	687	273	704	150	615	273	627		
155	704	273	722	155	627	273	641		
160	722	273	741	160	641	273	656		
165	741	273	761	165	656	273	672		
170	761	273	784	170	672	273	690		
175	784	273	808	175	690	273	709		
180	808	273	833	180	709	273	730		
185	833	273	861	185	730	273	752		
190	861	273	891	190	752	273	777		
195	891	273	923	195	777	273	802		
200	923	273	957	200	802	273	831		
205	957	273	994	205	831	273	861		
210	994	273	1033	210	861	273	893		
215	1033	273	1076	215	893	273	928		
220	1076	273	1121	220	928	273	966		
225	1121	273	1170	225	966	273	1006		
230	1170	275	1223	230	1006	275	1049		
235	1223	280	1279	235	1049	280	1096		
240	1279	285	1339	240	1096	285	1149		
245	1339	290	1404	245	1146	290	1199		
250	1404	295	1473	250	1199	295	1257		
255	1473	300	1548	255	1257	300	1318		
260	1548	305	1628	260	1318	305	1384		
265	1628	310	1713	265	1384	310	1455		
270	1713	315	1805	270	1455	315	1531		
275	1805	320	1903	275	1531	320	1612		
280	1903	325	2007	280	1612	325	1699		
285	2007	330	2119	285	1699	330	1792		
290	2119	335	2231	290	1792	335	1892		
295	2231	340	2347	295	1892	340	1998		
300	2347	345	2471	300	1998	345	2112		
305	2471			305	2112	350	2233		
				310	2233	355	2363		
				315	2363				

**TABLE 6.2**  
**35 EFPY Cooldown Data Points**  
**(Without Margins for Instrumentation Uncertainty)**

Cooldown Curves									
Steady State		20 deg F		40 deg F		60 deg F		100 deg F	
T	P	T	P	T	P	T	P	T	P
60	0	60	0	60	0	60	0	60	0
60	590	60	563	60	537	60	510	60	455
65	594	65	568	65	542	65	515	65	460
70	599	70	573	70	547	70	520	70	465
75	605	75	579	75	552	75	526	75	471
80	611	80	585	80	558	80	532	80	478
85	617	85	591	85	565	85	539	85	485
90	621	90	598	90	572	90	546	90	493
95	621	95	605	95	580	95	554	95	502
100	621	100	613	100	588	100	563	100	511
105	621	105	621	105	597	105	572	105	520
110	621	110	621	110	607	110	582	110	531
115	621	115	621	115	617	115	592	115	543
116	621	116	621	120	628	120	604	120	555
116	668	116	644	125	640	125	616	125	568
120	676	120	652	130	653	130	630	130	583
125	687	125	664	135	667	135	644	135	599
130	699	130	676	140	682	140	660	140	615
135	712	135	690	145	698	145	676	145	634
140	726	140	704	150	715	150	695	150	653
145	741	145	720	155	734	155	714	155	674
150	757	150	736	160	754	160	735	160	697
155	774	155	754	165	776	165	757	165	722
160	793	160	773	170	799	170	782	170	748
165	813	165	794	175	824	175	808	175	777
170	834	170	816	180	851	180	836	180	808
175	857	175	841	185	880	185	866	185	841
180	882	180	866	190	911	190	899	190	876
185	909	185	894	195	945	195	934	195	915
190	937	190	924	200	981	200	972	200	956
195	968	195	956	205	1019	205	1012	205	1001
200	1001	200	990	210	1061	210	1056	210	1048
205	1036	205	1027	215	1106	215	1102	215	1100
210	1075	210	1067	220	1154	220	1153	220	1155
215	1115	215	1110	225	1205				
220	1159	220	1156						
225	1206	225	1205						
230	1257								
235	1311								
240	1370								
245	1432								
250	1500								
255	1572								
260	1649								
265	1732								
270	1820								
275	1915								
280	2017								
285	2126								
290	2243								
295	2367								

**Table 6.3**  
**Reactor Vessel Material Surveillance Capsule Removal Schedule**

Recommended Surveillance Capsule Removal Schedule for Unit 1				
Capsule	Capsule Location (degree)	Lead Factor <sup>(a)</sup>	Withdrawal EFPY <sup>(b)</sup>	Fluence <sup>(a)</sup> (n/cm <sup>2</sup> , E> 1.0 MeV)
V	77	2.94	1.34	5.630 x 10 <sup>18(c)</sup>
P	247	1.72	4.60	1.318 x 10 <sup>19(c)</sup>
R	257	2.99	8.56	4.478 x 10 <sup>19(c)</sup>
S	57	1.77	18.12	4.017 x 10 <sup>19(c)</sup>
T	67	1.89	Standby	---
N	237	1.77	Standby	---

Recommended Surveillance Capsule Removal Schedule for Unit 2				
Capsule	Capsule Location (degree)	Lead Factor <sup>(d)</sup>	Withdrawal EFPY <sup>(b)</sup>	Fluence <sup>(d)</sup> (n/cm <sup>2</sup> , E> 1.0 MeV)
V	77	2.95	1.39	6.206 x 10 <sup>18(c)</sup>
T	67	1.75	4.00	1.199 x 10 <sup>19(c)</sup>
R	257	2.99	8.81	4.376 x 10 <sup>19(c)</sup>
P	247	1.84	17.24	4.165 x 10 <sup>19(c)</sup>
N	237	1.72	Standby	---
S	57	1.72	Standby	---

Notes:

- (a) Updated in Capsule S dosimetry analysis.
- (b) Effective Full Power Years (EFPY) from plant startup.
- (c) Plant specific evaluation.
- (d) Updated in Capsule P dosimetry analysis.

Table 6.4

Prairie Island Unit 1 1/4T and 3/4T ART Calculations at 35 EFPY

Material	CF	f @35 EFPY <sup>(a)</sup>	1/4T f 3/4T f	1/4T FF <sup>(d)</sup> 3/4T FF	I <sup>(e)</sup> (°F)	M <sup>(g)</sup> (°F)	$\Delta ART_{ND}$ T (°F)	ART (°F)
----------	----	---------------------------	------------------	-----------------------------------	--------------------------	--------------------------	-----------------------------	-------------

1/4T Calculations

Nozzle (upper)Shell Forging B	51	2.20	1.47	1.11	-4	34	56.6	87
Nozzle to Inter. Shell Circ Weld (Heat 2269)	79.5	2.20	1.47	1.11	0 <sup>(c)</sup>	66	88.2	154
Intermediate Shell Forging C	44.0	3.95	2.64	1.26	14	34	55.4	103
Using S/C Data	54.7	3.95	2.64	1.26	14	34 <sup>(b)</sup>	68.9	117
Circumferential Weld	69.7	3.95	2.64	1.26	-13	56	87.8	131
Using S/C Data	80.8	3.95	2.64	1.26	-13	56 <sup>(b)</sup>	101.8	145
Lower Shell Forging D	44.0	3.95	2.64	1.26	-4	34	55.4	85

3/4T Calculations

Nozzle (upper) Shell Forging B	51	2.20	0.660	0.884	-4	34	45.1	75
Nozzle to Inter. Shell Circ Weld (Heat 2269)	79.5	2.20	0.660	0.884	0 <sup>(c)</sup>	66	70.3	136
Intermediate Shell Forging C	44.0	3.95	1.18	1.05	14	34	46.2	94
Using S/C Data	54.7	3.95	1.18	1.05	14	34 <sup>(b)</sup>	57.4	105
Circumferential Weld	69.7	3.95	1.18	1.05	-13	56	73.2	116
Using S/C Data	80.8	3.95	1.18	1.05	-13	56 <sup>(b)</sup>	84.8	128
Lower Shell Forging D	44.0	3.95	1.18	1.05	-4	34	46.2	76

NOTE:

- (a) Fluence values (f) are  $\times 10^{19}$  n/cm<sup>2</sup> (E > 1.0 MeV). In addition, the values used are the calculated values since they are higher than the best-estimate values (Ref. 5.3).
- (b) The full  $\sigma_a$  margin of 17°F for the forging and 28°F for the weld was used since the surv. data was deemed not credible (Ref. 5.3).
- (c) Estimated per Standard Review Plan Section 5.3.2 (Ref. 5.3).
- (d) FF, Fluence Factor =  $f(0.28-0.1 \cdot \log f)$  (Ref. 5.3)
- (e) I is the unirradiated material reference temperature. (Ref. 5.3)
- (g) M is a margin term required for conservative results. (Ref. 5.3)

Table 6.5

Prairie Island Unit 2 1/4T and 3/4T ART Calculations at 35 EFPY

Material	CF	f @35 EFPY	1/4T f 3/4T f <sup>(a)</sup>	1/4T FF <sup>(c)</sup> 3/4T FF	I <sup>(d)</sup> (°F)	M <sup>(e)</sup> (°F)	$\Delta RT_{ND}$ T (°F)	ART (°F)
----------	----	------------	---------------------------------	-----------------------------------	--------------------------	--------------------------	----------------------------	-------------

1/4T Calculations

Upper Shell Forging B	44.0	2.379	1.59	1.13	-13	34	49.7	71
Upper to Inter. Shell Weld W2	70.0	2.379	1.59	1.13	-13	56	79.1	122
Using Unit 1 S/C Data <sup>(b)</sup>	80.8	2.379	1.59	1.13	-13	56	91.3	134
Intermediate Shell Forging C	44.0	4.183	2.80	1.27	14	34	55.9	104
Inter. to Lower Shell Weld W3	52.0	4.183	2.80	1.27	-31	56	66.0	91
Using S/C Data	80.0	4.183	2.80	1.27	-31	28	101.6	99
Lower Shell Forging D	51.0	4.183	2.80	1.27	-4	34	64.8	95
Using S/C Data	60.0	4.183	2.80	1.27	-4	34	76.2	106

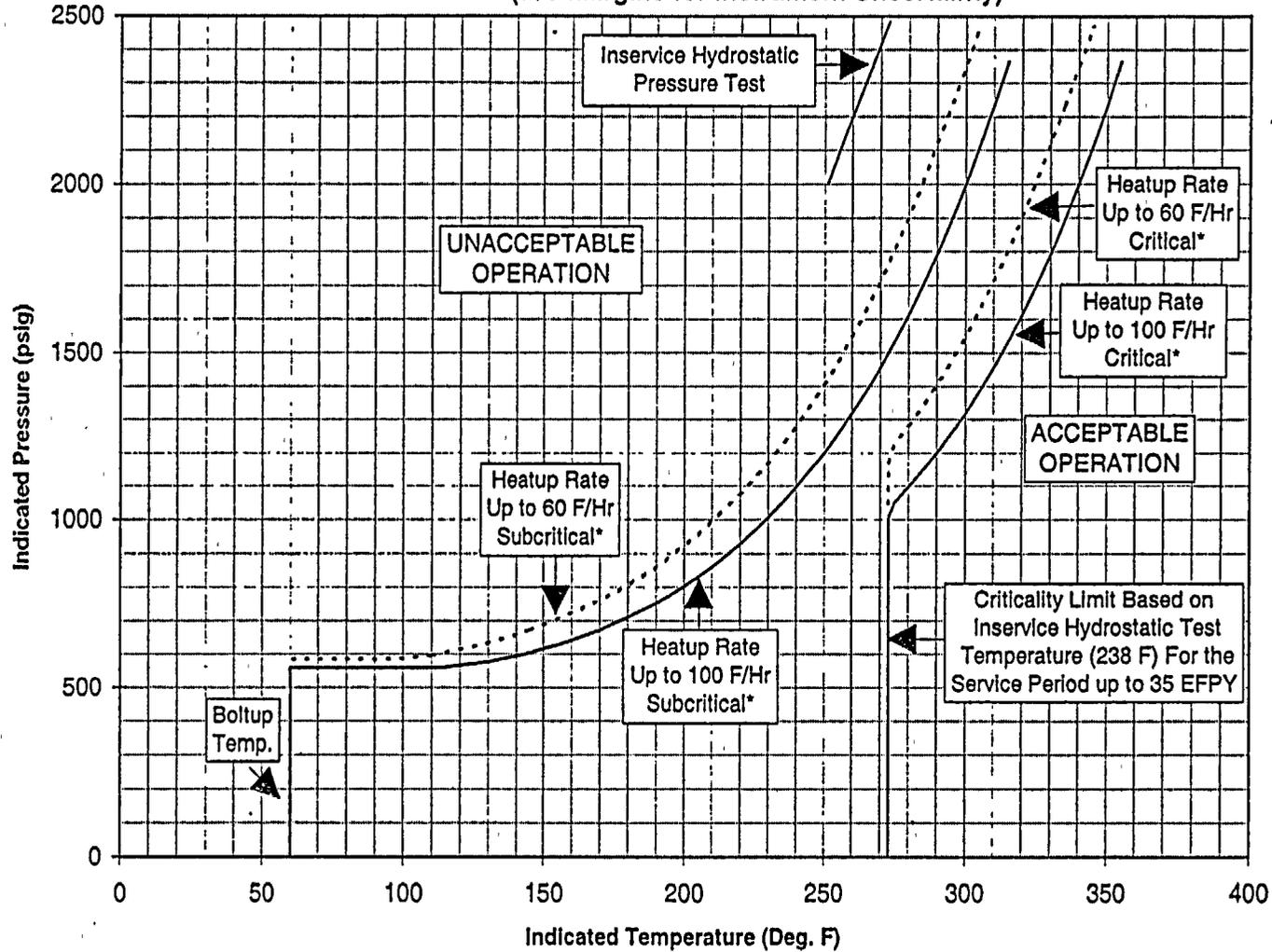
3/4T Calculations

Upper Shell Forging B	44.0	2.379	0.71	0.90	-13	34	39.7	61
Upper to Inter. Shell Weld W2	70.0	2.379	0.71	0.90	-13	56	63.0	106
Using Unit 1 S/C Data <sup>(b)</sup>	80.8	2.379	0.71	0.90	-13	56	72.7	116
Intermediate Shell Forging C	44.0	4.183	1.25	1.06	14	34	46.6	95
Inter. to Lower Shell Weld W3	52.0	4.183	1.25	1.06	-31	55.1	55.1	79
Using S/C Data	80.0	4.183	1.25	1.06	-31	28	84.8	82
Lower Shell Forging D	51.0	4.183	1.25	1.06	-4	34	54.1	84
Using S/C Data	60.0	4.183	1.25	1.06	-4	34	63.6	94

NOTE:

- (a) Fluence values (f) are  $\times 10^{19}$  n/cm<sup>2</sup> (E > 1.0 MeV). In addition, the values used are the Best-Estimate values since they are higher than the calculated values.
- (b) This calculation is using the chemistry factor based on the surveillance capsule data for the Prairie Island Unit 1 surveillance program. Per WCAP-14779 Rev. 1, the surveillance weld data is not credible, therefore, a full  $\sigma_{\Delta}$  of 28°F was used in the margin term.
- (c) FF, Fluence Factor =  $f(0.28-0.1 \cdot \log f)$ . (Ref. 5.3)
- (d) I is the unirradiated material reference temperature. (Ref. 5.3)
- (e) M is a margin term required for conservative results. (Ref. 5.3)

Figure 6.1  
Prairie Island Reactor Coolant System Heatup Limitations Applicable to 35 EFPY  
(w/o Margins for Instrument Uncertainty)



\* For each curve, acceptable operation is to the right and below the curve.

Figure 6.2  
Prairie Island Reactor Coolant System Cooldown Limitations to 35 EFY  
(w/o Margins for Instrument Uncertainty)

