Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

NOV 1 4 2003

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

In the Matter of) Docket No.50-390
Tennessee Valley Authority)

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1 - REACTOR COOLANT SYSTEM PRESSURE AND TEMPERATURE LIMITS REPORT (PTLR), REVISION 7

The purpose of this letter is to provide NRC the latest revision of the PTLR in accordance with WBN Technical Specification 5.9.6.c which states that the PTLR shall be provided to NRC upon issuance for each reactor vessel fluency period and for any revision or supplement thereto.

The enclosed PTLR Revision 7, incorporates the results of the analysis performed on Surveillance Capsule W which was removed during the Unit 1 Cycle 3 Refueling Outage. The revision also updates the reactor heat up and cooldown curves and the cold overpressure mitigation system (COMS) setpoints for the operating period from seven to sixteen effective full power years. The revision was incorporated into the plant design basis in October 2003.

If you have any questions about this report, please contact me at (423) 365-1824.

Sincerely,

P. L. Pace
Manager, Site Licensing
and Industry Affairs

Enclosure
cc: See page 2

D030

NOV 1 4 2003

cc (Enclosure):
NRC Resident Inspector
Watts Bar Nuclear Plant
1260 Nuclear Plant Road
Spring City, Tennessee 37381

Ms. Margaret H. Chernoff, Project Manager
U.S. Nuclear Regulatory Commission
MS 08G9
One White Flint North
11555 Rockville Pike
Rockville, Maryland 20852-2738

U.S. Nuclear Regulatory Commission
Region II
Sam Nunn Atlanta Federal Center
61 Forsyth St., SW, Suite 23T85
Atlanta, Georgia 30303

APPENDIX "A"

TO RCS SYSTEM DESCRIPTION N3-68-4001

WATTS BAR UNIT 1

RCS PRESSURE AND TEMPERATURE LIMITS REPORT (PTLR)

REVISION 7

Prepared by : 2/25/2003

Checked by: 3/21/2003

Approved by : 4/4/03

RCS PRESSURE AND TEMPERATURE LIMITS REPORT FOR WATTS BAR UNIT 1

1.0 RCS Pressure and Temperature Limits Report (PTLR)

This PTLR for Watts Bar Unit 1 has been prepared in accordance with the requirements of Technical Specification 5.9.6. Revisions to the PTLR shall be provided to the NRC after issuance.

The Technical Specifications affected by this report are listed below:

LCO 3.4.3. RCS Pressure and Temperature (P/T) Limits
LCO 3.4.12 Cold Overpressure Mitigation System (COMS)

2.0 RCS Pressure and Temperature Limits

The limits for LCO 3.4.3 are presented in the subsection which follows. These limits have been developed (Ref. 1, 8) using the NRC-approved methodologies specified in Technical Specification 5.9.6.

2.1 RCS Pressure and Temperature (P/T) Limits (LCO 3.4.3)

2.1.1 The RCS temperature rate-of-change limits are (Ref. 1):

a. A maximum heatup Rate 100 °F per hour.
b. A maximum cooldown Rate 100 °F per hour.
c. A maximum temperature change of 10 °F in any 1-hour period during inservice hydrostatic and leak testing operations above the heatup and cooldown limit curves.

2.1.2 The RCS P/T limits for heatup, cooldown, inservice hydrostatic and leak testing, and criticality are specified by Figures 2.1-1 and 2.1-2 (Ref. 1).

NOTE: The heat-up and cool-down curves are based on beltline conditions and do not compensate for pressure differences between the pressure transmitter and reactor midplane/beltline or for instrument inaccuracies. Refer to Table 2.1-3 for pressure differences (Ref. 2). Site Engineering Setpoint and Scaling documents SSD-1-P-68-63, -64, -66, and -70 provide the adjusted curves for temperature and pressure limits which are compensated for pressure differential and instrument inaccuracy to be used for heatup and cooldown.

NOTE: Steady-state conditions (0 °F per hour heatup or cooldown curves) are achieved after maintaining a constant temperature for a duration of 1 hour (Ref. 1). Steady state conditions are maintained if temperature fluctuations remain within ± 9.2°F (Ref. 1).

3.0 Cold Overpressure Mitigation System (LCO 3.4.12)

Unit 1 PTLR

The lift setpoints for the pressurizer Power Operated Relief Valves (PORVs) are presented in the subsection which follows. These lift setpoints have been developed using the NRC-approved methodologies specified in Technical Specification 5.9.6.

3.1 Pressurizer PORV Lift Setting Limits

The pressurizer PORV lift setpoints are depicted in Figures 3.1-1 through 3.1-4 and specified by Table 3.1-1 (Ref. 8). The limits for the COMS setpoints are contained in the 16 EFPY curves adjusted per ASME Code Case N-514 for Heatup (Figure 3.1-5 and Table 3.1-2) and Cooldown (Figure 3.1-6 and Table 3.1-3) (Ref. 1) which are based on beltline conditions and are not compensated for pressure differences between the pressure transmitter and the reactor midplane/beltline or for instrument inaccuracies. Refer to Table 2.1-3 for pressure differences (Ref. 2).

NOTE: These setpoints include allowance for pressure difference between the pressure transmitter and reactor midplane, and also includes 63 psig pressure channel uncertainty. Site Engineering Setpoint and Scaling documents for instrument loop numbers 1-T-68-1B and 1-T-68-43B contain the adjusted curves compensated for pressure differential and instrument inaccuracy which provides the PORV lift limits for the COMS.

4.0 Reactor Vessel Material Surveillance Program

The reactor vessel material irradiation surveillance specimens shall be removed and examined to determine changes in material properties. The removal schedule is provided in Table 4.0-1. The results of these examinations shall be used to update Figures 2.1-1, 2.1-2, and 3.1-1 through 3.1-4.

The pressure vessel steel surveillance program (Ref. 3) is in compliance with Appendix H to 10 CFR 50, entitled "Reactor Vessel Material Surveillance Program Requirements". The material test requirements and the acceptance standard utilize the reference nil-ductility temperature, RT_{NDT}, which is determined in accordance with ASTM E208. The empirical relationship between RT_{NDT} and the fracture toughness of the reactor vessel steel is developed in accordance with Appendix G, "Protection Against Non-Ductile Failure", to Section III of the ASME Boiler and Pressure Vessel Code. The surveillance capsule removal schedule meets the requirements of ASTM E185-82. The removal schedule is provided in Table 4.0-1.

5.0 Supplemental Data Tables

Table 5.1 contains a comparison of measured surveillance material 30 ft-lb transition temperature shifts and upper shelf energy decreases with Regulatory Guide 1.99, Revision 2, predictions.

Unit 1 PTLR

Table 5.2 shows calculations of the surveillance material chemistry factors using surveillance capsule data.

Table 5.3 provides the required Watts Bar Unit 1 reactor vessel toughness data. The bolt-up temperature is also included in this table.

Table 5.4 provides a summary of the fluence values used in the generation of the heatup and cooldown limit curves.

Table 5.5 provides a summary of the adjusted reference temperature (ART) values of the Watts Bar Unit 1 reactor vessel beltline materials at the 1/4-T and 3/4-T locations for 16 EFPY.

Table 5.6 shows example calculations of the adjusted reference temperature (ART) values at 16 EFPY for the limiting Watts Bar Unit 1 reactor vessel material (Intermediate Shell Forging 05).

Table 5.7 provides a summary of the fluence values used in the Pressurized Thermal Shock (PTS) evaluation (Ref. 4).

Table 5.8 provides RT_{PTS} values for Watts Bar Unit 1 for 32 EFPY (Ref 4).

Table 5.9 provides RT_{PTS} values for Watts Bar Unit 1 for 48 EFPY (Ref 4).

REFERENCES

1. Structural Integrity Associates Report, No. SIR-01-140, Revision 1, "Heatup and Cooldown Limit Curves for Normal Operation for Watts Bar Unit 1", July 2002.

2. Westinghouse Letter to TVA, WAT-D-9448, "Revised COMS PORV Setpoints," August 27, 1993.

3. WCAP-9298, Revision 1, "Watts Bar Unit 1 Reactor Vessel Radiation Surveillance Program", April 1993.

4. Structural Integrity Associates Report, No. SIR-01-137, Revision 0, "RT_{PTS} Evaluation for Watts Bar", January 2002.

5. WCAP-14040, Revision 1, "Methodology Used To Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves", December 1994.

6. WCAP-15046, "Analysis of Capsule U From Tennessee Valley Authority Watts Bar Unit 1 Reactor Vessel Radiation Surveillance Program", June 1998.

7. BWXT SERVICES, Inc., "Analysis of Capsule W From The Tennessee Valley Authority Watts Bar Unit 1 Reactor Vessel Material Surveillance Program", September 2001.

8. Structural Integrity Associates Report, No. SIR-01-147, Revision 0, "Revised COMS PORV Setpoints", January 2002.

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL FORGING 05

INITIAL RT_{NDT} 47 °F

LIMITING ART AT 16 EFPY: 1/4-T, 191.7 °F

3/4-T, 156.7 °F

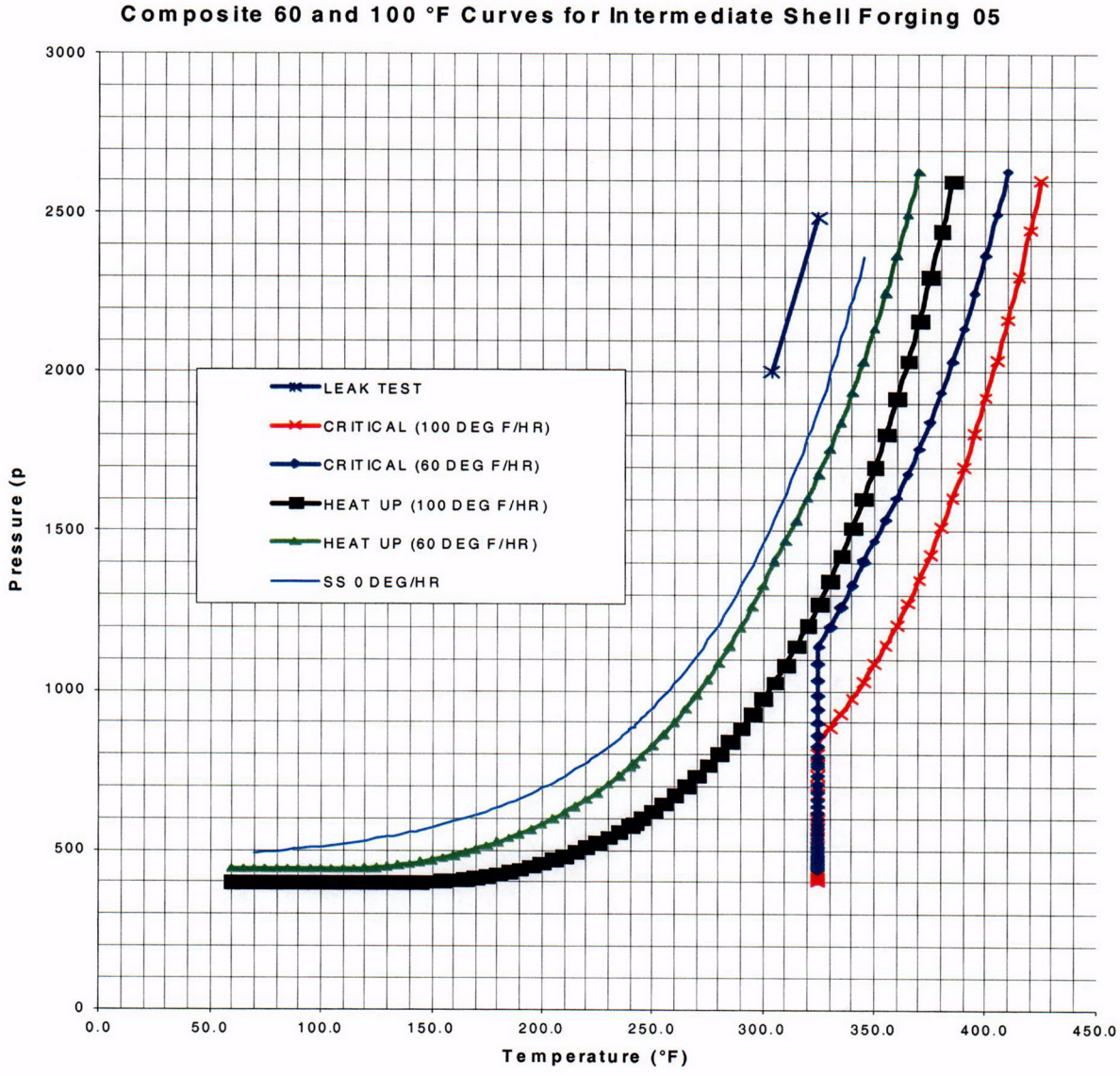

Figure 2.1-1

Watts Bar Unit 1 Reactor Coolant System Heatup Limitations (Heatup rates of 60 and 100 °F/hr) Applicable for the First 16 EFPY (Without Margins for Instrumentation Errors)

(Plotted Data (Ref. 1) provided on Table 2.1-1 with SS curve from Table 2.1-2)

Table 2.1-1
Watts bar Unit 1 Heatup Limits
(Data points plotted on Figure 2.1-1)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)				
	HEATUP RATE (60 °F/HR)	HEATUP RATE (100 °F/HR)	LEAK TEST LIMITS	CRITICALITY LIMITS (60 °F/HR)	CRITICALITY LIMITS (100 °F/HR)
60	439.84	399.21			
65	439.84	399.21			
70	439.84	399.21			
75	439.84	399.21			
80	439.84	399.21			
85	439.84	399.21			
90	439.84	399.21			
95	439.84	399.21			
100	439.84	399.21			
105	439.84	399.21			
110	439.84	399.21			
115	440.08	399.21			
120	441.55	399.21			
125	443.90	399.21			
130	446.98	399.21			
135	450.87	399.21			
140	455.75	398.97			
145	461.23	399.67			
150	467.65	400.78			
155	474.92	402.94			
160	482.62	406.05			
165	491.30	409.84			
170	501.13	414.52			
175	511.70	419.66			
180	523.16	425.95			
185	535.67	432.79			
190	548.99	440.89			
195	564.07	449.33			

Table 2.1-1
Watts bar Unit 1 Heatup Limits
(Data points plotted on Figure 2.1-1)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)				
	HEATUP RATE (60 °F/HR)	HEATUP RATE (100 °F/HR)	LEAK TEST LIMITS	CRITICALITY LIMITS (60 °F/HR)	CRITICALITY LIMITS (100 °F/HR)
200	579.65	459.50			
205	596.87	469.97			
210	615.60	481.74			
215	635.15	494.85			
220	656.93	508.79			
225	679.70	523.95			
230	704.81	540.61			
235	731.50	558.85			
240	760.51	578.29			
245	791.53	599.34			
250	824.34	622.09			
255	860.28	647.04			
260	898.89	673.28			
265	940.37	702.05			
270	984.93	733.27			
275	1032.79	766.47			
280	1084.18	802.12			
285	1139.36	840.72			
290	1198.59	881.97			
295	1262.17	927.35			
300	1330.39	974.93			
304			2000		
305	1403.57	1026.14			
310	1469.09	1082.37			
315	1533.77	1141.03			
320	1603.14	1205.73			
325	1677.51	1273.73	2485	0 to 1139.36	0 to 840.72
330	1757.23	1346.12		1198.59	881.97

Table 2.1-1
Watts bar Unit 1 Heatup Limits
(Data points plotted on Figure 2.1-1)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)				
	HEATUP RATE (60 °F/HR)	HEATUP RATE (100 °F/HR)	LEAK TEST LIMITS	CRITICALITY LIMITS (60 °F/HR)	CRITICALITY LIMITS (100 °F/HR)
335	1842.64	1425.79		1262.17	927.35
340	1934.10	1511.21		1330.39	974.93
345	2032.01	1602.75		1403.57	1026.14
350	2136.89	1700.67		1469.09	1082.37
355	2248.85	1805.37		1533.77	1141.03
360	2368.47	1917.72		1603.14	1205.73
365	2496.14	2035.38		1677.51	1273.73
370	2632.29	2163.59		1757.23	1346.12
375		2300.46		1842.64	1425.79
380		2446.44		1934.10	1511.21
385		2601.96		2032.01	1602.75
390				2136.89	1700.67
395				2248.85	1805.37
400				2368.47	1917.72
405				2496.14	2035.38
410				2632.29	2163.59
415					2300.46
420					2446.44
425					2601.96

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL FORGING 05

INITIAL RT_{NDT} 47 °F

LIMITING ART AT 16 EFPY: 1/4-T, 191.7 °F

3/4-T, 156.7 °F

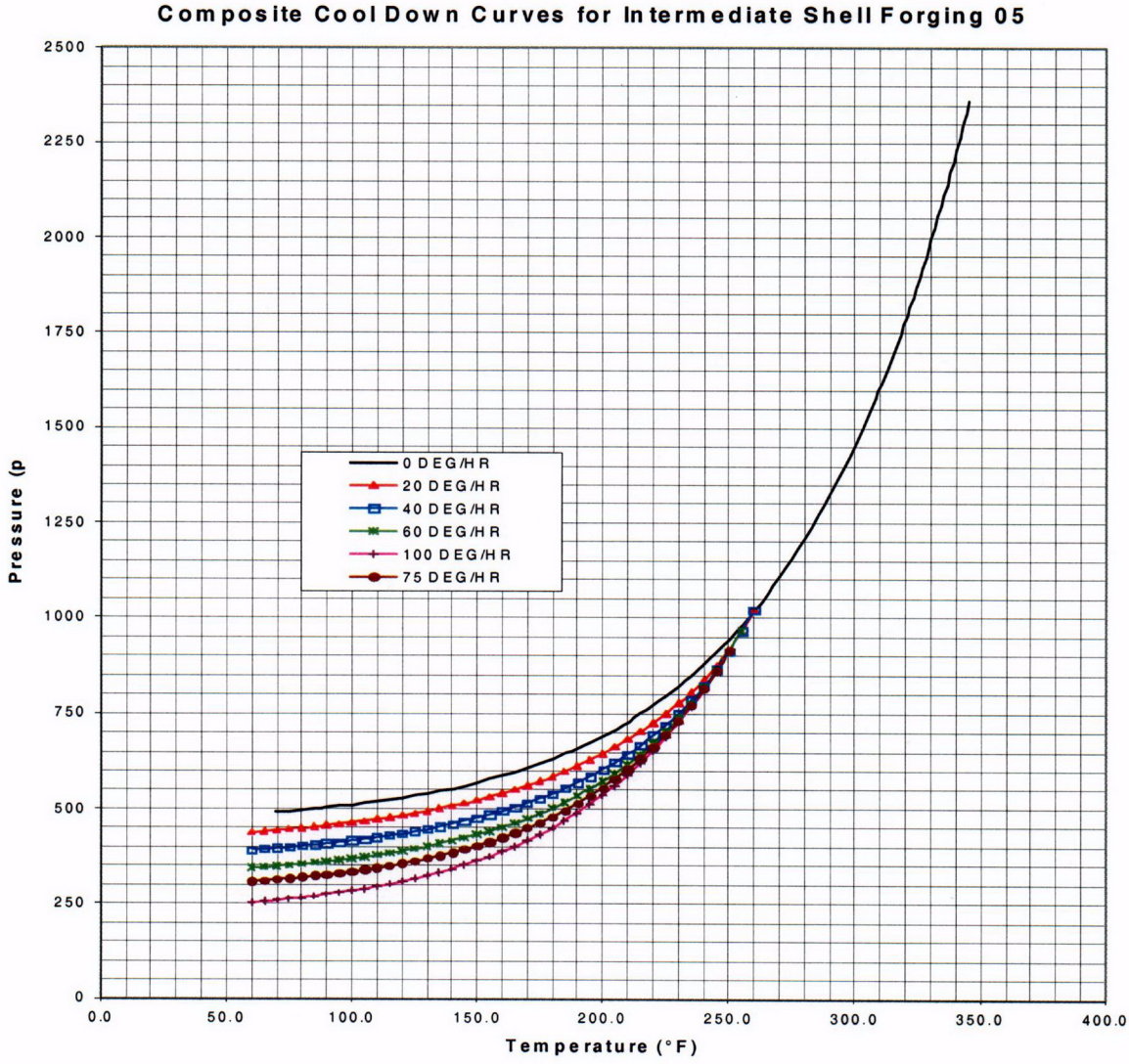

Figure 2.1-2

Watts Bar Unit 1 Reactor Coolant System Cooldown Limitations (Cooldown rates up to 100°F/hr) Applicable for the First 16 EFPY (Without Margins for Instrumentation Errors)

(Plotted Data (Ref. 1) provided on Table 2.1-2)

Table 2.1-2
Watts Bar Unit 1 Cooldown Limits
(Data points plotted on figure 2.1-2)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)					
	100 °F/HR	75 °F/HR	60 °F/HR	40 °F/HR	20 °F/HR	0 °F/HR
60	251.75	307.29	342.16	389.88	437.67	
65	254.72	309.64	344.51	392.23	440.02	
70	257.87	312.64	347.50	394.76	442.54	490.13
75	261.36	315.51	350.22	397.47	445.25	492.77
80	264.91	318.58	353.14	400.39	448.17	495.72
85	268.82	322.19	356.43	403.53	451.31	498.88
90	273.13	325.72	359.80	406.90	454.68	502.28
95	277.69	329.81	363.43	410.53	458.31	505.94
100	282.84	333.87	367.49	414.43	462.20	509.87
105	288.28	338.68	372.00	418.62	466.40	514.09
110	294.19	343.50	376.66	423.29	470.90	518.64
115	300.59	348.97	381.66	428.13	475.75	523.52
120	307.35	354.96	387.34	433.34	480.96	528.77
125	314.51	361.19	393.10	438.95	486.56	534.42
130	322.56	367.99	399.43	444.97	492.58	540.39
135	331.21	375.71	406.38	451.45	499.05	546.91
140	340.50	383.60	413.96	458.41	506.01	553.93
145	350.79	392.48	422.07	466.36	513.49	561.47
150	361.63	401.92	430.89	474.41	521.54	569.58
155	373.38	412.13	440.32	483.22	530.19	578.31
160	386.26	423.46	450.39	492.52	539.48	587.56
165	400.29	435.46	461.63	502.98	549.48	597.63
170	415.07	448.53	473.46	513.89	560.22	608.47
175	431.43	462.41	486.57	526.06	571.78	620.12
180	448.81	478.23	500.85	538.79	584.19	632.50
185	467.89	494.68	516.37	552.76	597.54	645.97
190	488.28	513.21	533.04	567.89	611.89	660.44
195	510.67	532.97	551.40	584.09	627.47	675.98
200	534.52	554.50	571.39	602.07	644.05	692.57

Table 2.1-2
Watts Bar Unit 1 Cooldown Limits
(Data points plotted on figure 2.1-2)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)					
	100 °F/HR	75 °F/HR	60 °F/HR	40 °F/HR	20 °F/HR	0 °F/HR
205	560.38	578.03	593.07	621.44	661.88	710.56
210	588.65	603.67	617.01	642.60	681.50	729.70
215	618.95	631.51	642.84	665.97	702.24	750.49
220	651.86	661.80	671.29	691.18	724.84	772.78
225	687.65	695.12	702.76	719.12	749.39	796.64
230	726.27	731.13	736.92	749.75	775.87	822.23
235	768.01	770.72	774.52	783.81	805.33	849.99
240	812.84	813.86	815.67	821.75	837.60	879.55
245	861.52	860.72	861.31	864.02	873.90	911.51
250	912.97	911.88	911.09	911.21	915.45	945.77
255		973.61	965.36	964.42	963.78	982.53
260				1019.03	1019.03	1022.00
265						1064.40
270						1109.98
275						1158.95
280						1211.57
285						1268.05
290						1328.61
295						1393.44
300						1463.21
305						1537.95
310						1618.11
315						1703.92
320						1795.88
325						1894.39
330						1999.72
335						2112.46
340						2232.88
345						2361.41

Table 2.1-3

Pressure Differentials

Number of Pumps	Delta P (psi)
0	5.2
1	31.0
2	38.0
3	52.0
4	74.0

Table 3.1-1
Watts Bar Unit 1 PORV Setpoints vs Temperature
(Data (Ref. 8) plotted on Figures 3.1-1 through 3.1-4)

TEMP (F)	SETPOINTS (PSIG)							
	1 RCS PUMP OPERATING		2 RCS PUMPS OPERATING		3 RCS PUMPS OPERATING		4 RCS PUMPS OPERATING	
	PORV-334	PORV-340A	PORV-334	PORV-340A	PORV-334	PORV-340A	PORV-334	PORV-340A
70	480	453 *	479	452 *	461	434 *	439 *	412 *
100	477	450 *	476	449 *	458 *	431 *	436 *	409 *
150	486	458 *	476	448 *	463	436 *	443 *	416 *
200	499	467	499	467	479	447 *	459	427 *
250	549	504	549	509	539	494	514	474
275	581	531	591	541	571	521	556	506
300	575	525	575	525	570	520	560	510
350	745	690	745	690	745	690	745	690
450	2350	2350	2350	2350	2350	2350	2350	2350

* Setpoint violates pump seal limit. The pump seal limit includes a 63 psig adjustment for pressure channel uncertainty.

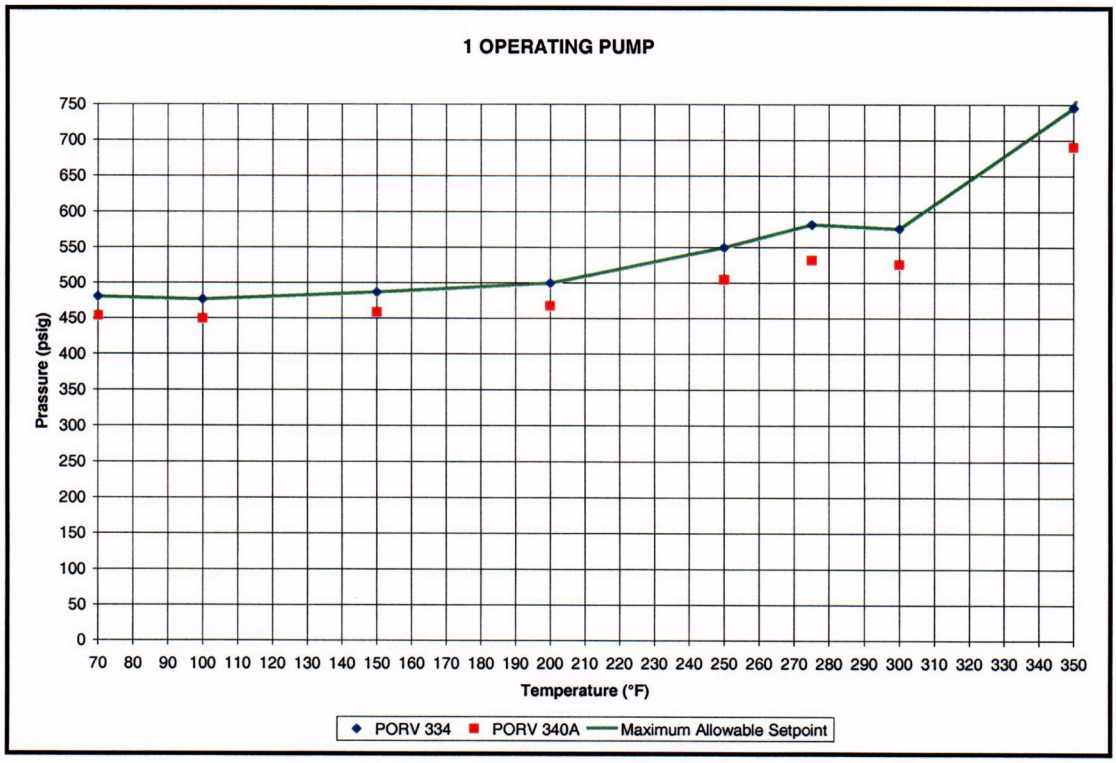

Figure 3.1-1

PORV Setpoint vs RCS Temperature
(Plotted data (Ref. 8) provided on Table 3.1-1)

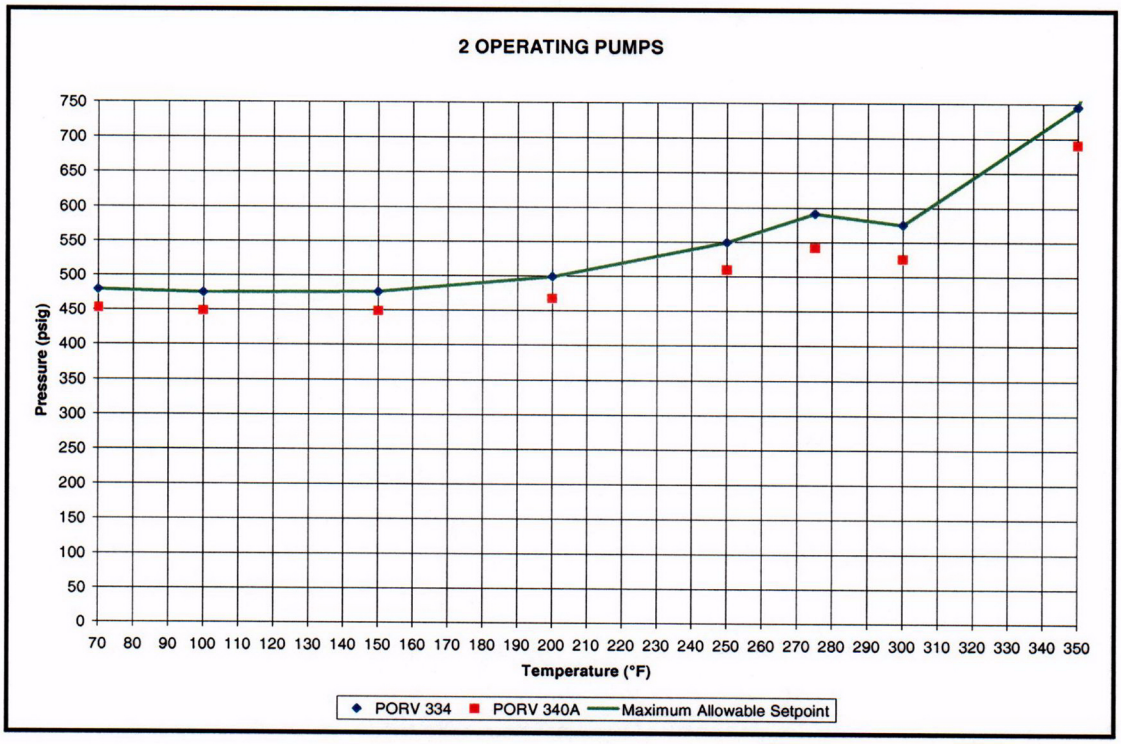

Figure 3.1-2

PORV Setpoint vs RCS Temperature
(Plotted data (Ref. 8) provided on Table 3.1-1)

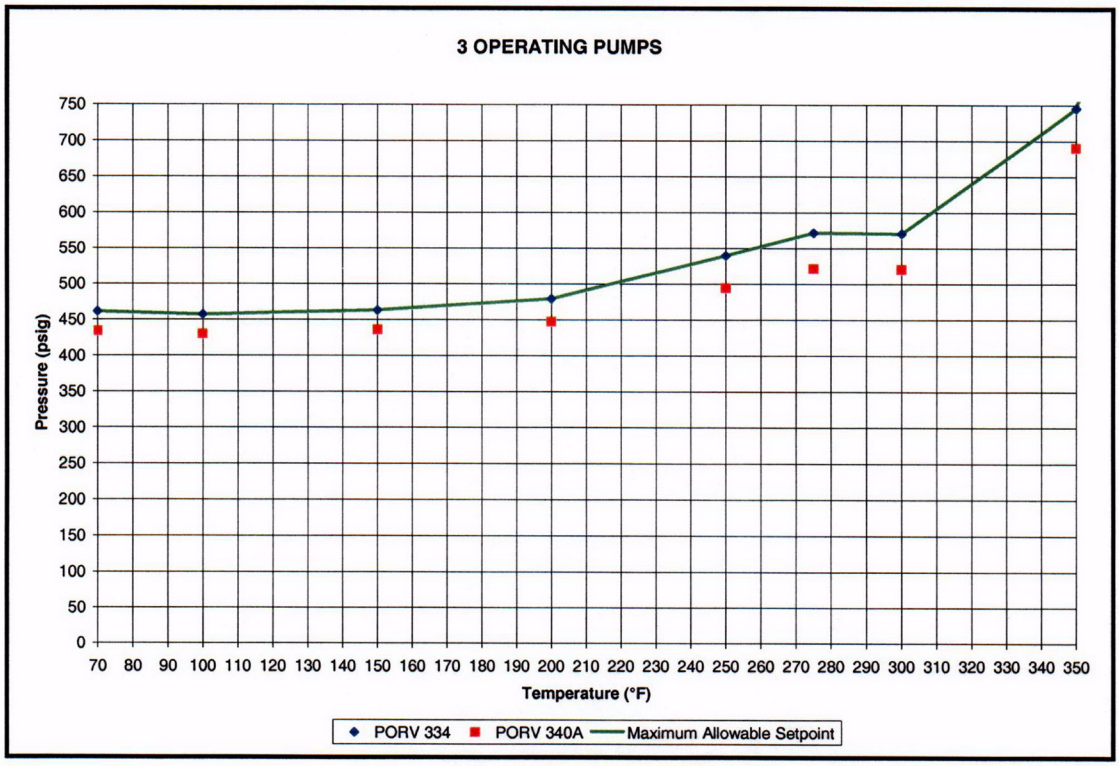

Figure 3.1-3

PORV Setpoint vs RCS Temperature
(Plotted data (Ref. 8) provided on Table 3.1-1)

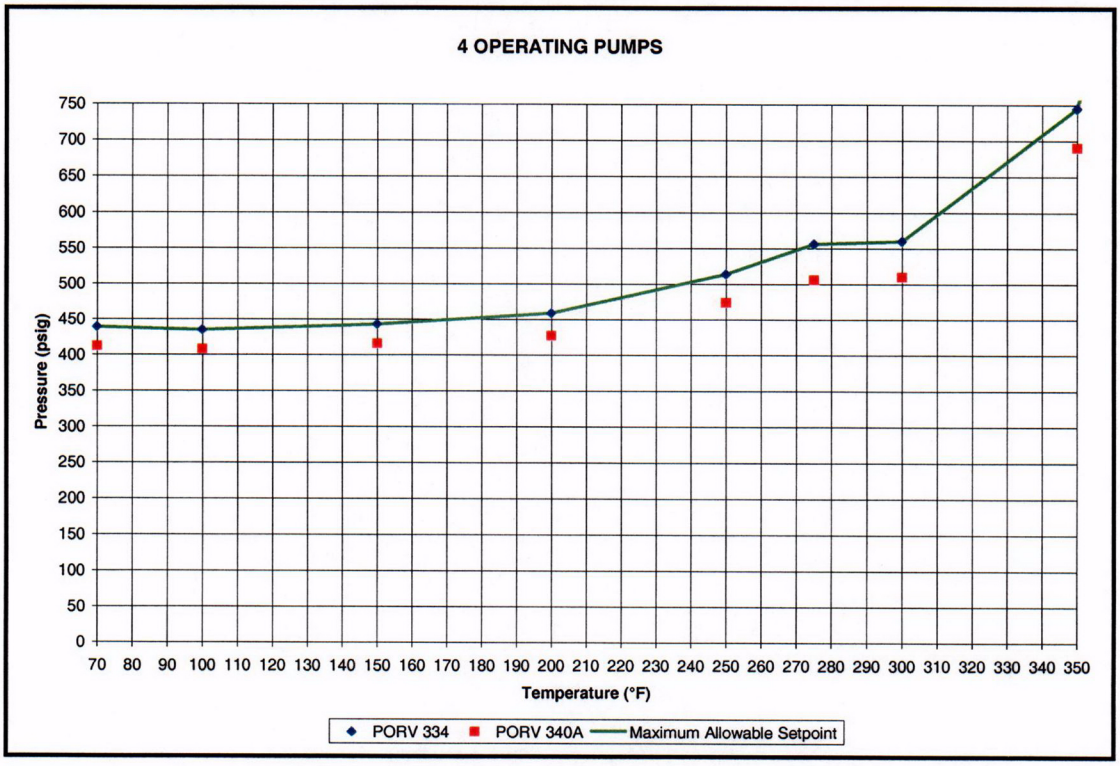

Figure 3.1-4

PORV Setpoint vs RCS Temperature
(Plotted data (Ref. 8) provided on Table 3.1-1)

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL FORGING 05
INITIAL RT_{NDT} 47 °F
LIMITING ART AT 16 EFPY: 1/4-T, 191.7 °F
3/4-T, 156.6 °F

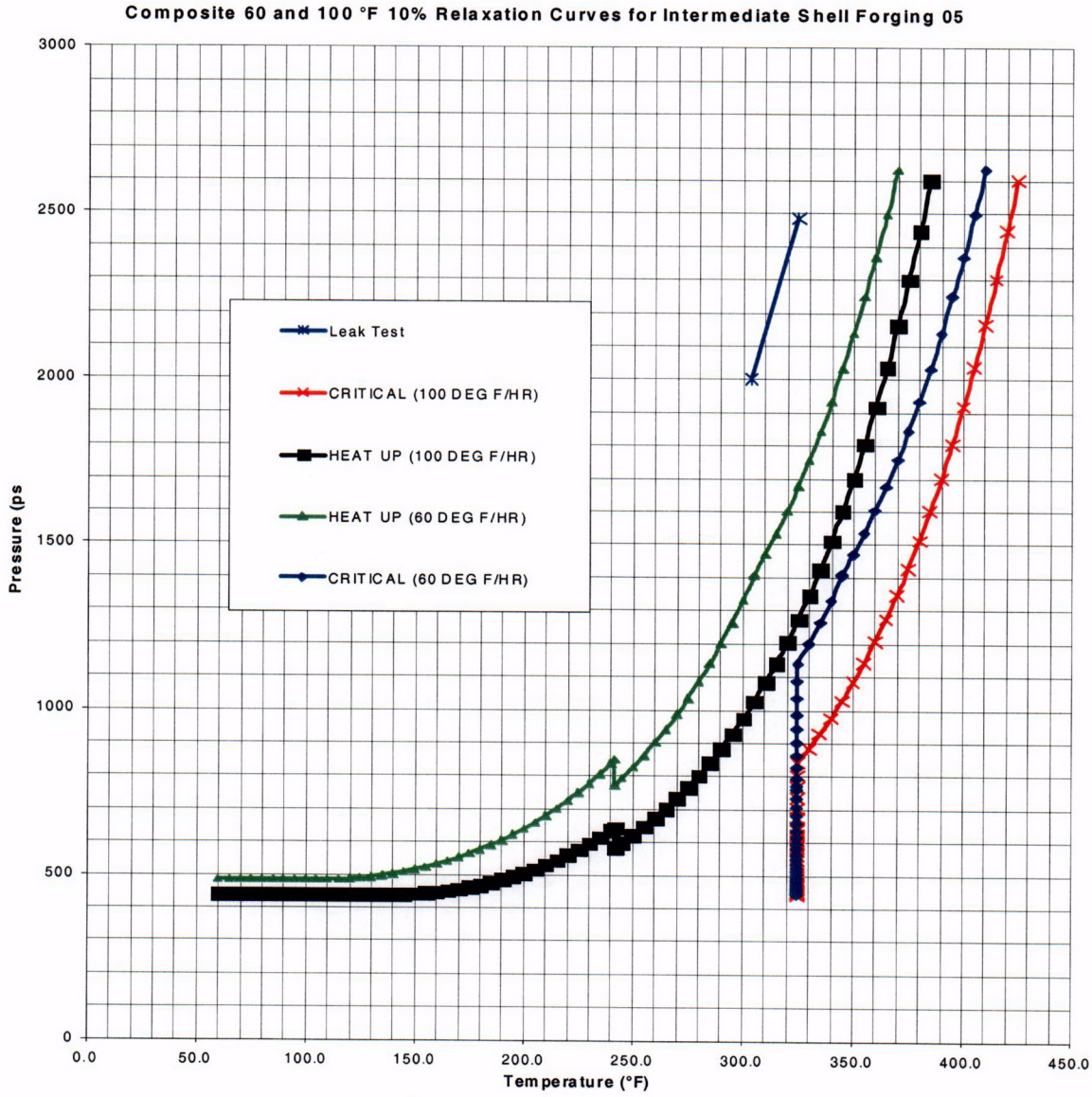

Figure 3.1-5

Watts Bar Unit 1 Reactor Coolant System Heatup Limitations (Heatup rates of 60 and 100°F/hr) Applicable for the First 16 EFPY (Without Margins for Instrumentation Errors) Including 10% Relaxation in Pressure for Temperature < 241.7°F per ASME Code Case N-514

(Plotted Data (Ref. 1) provided on Table 3.1-2)

Table 3.1-2
Watts Bar Unit 1 Heatup Limits
(Data (Ref. 1) plotted on Figure 3.1-5)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)				
	HEATUP RATE (60 °F/HR)	HEATUP RATE (100 °F/HR)	LEAK TEST LIMITS	CRITICALITY LIMITS (60 °F/HR)	CRITICALITY LIMITS (100 °F/HR)
85	483.83	439.13			
90	483.83	439.13			
95	483.83	439.13			
100	483.83	439.13			
105	483.83	439.13			
110	483.83	439.13			
115	484.09	439.13			
120	485.71	439.13			
125	488.29	439.13			
130	491.68	439.13			
135	495.96	439.13			
140	501.33	438.87			
145	507.35	439.64			
150	514.42	440.85			
155	522.42	443.23			
160	530.88	446.65			
165	540.43	450.83			
170	551.24	455.98			
175	562.87	461.63			
180	575.48	468.55			
185	589.24	476.07			
190	603.89	484.98			
195	620.48	494.27			
200	637.62	505.45			
205	656.56	516.97			
210	677.16	529.91			
215	698.67	544.33			
220	722.62	559.67			

Table 3.1-2
Watts Bar Unit 1 Heatup Limits
(Data (Ref. 1) plotted on Figure 3.1-5)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)				
	HEATUP RATE (60 °F/HR)	HEATUP RATE (100 °F/HR)	LEAK TEST LIMITS	CRITICALITY LIMITS (60 °F/HR)	CRITICALITY LIMITS (100 °F/HR)
225	747.67	576.34			
230	775.30	594.67			
235	804.65	614.74			
240	836.56	636.12			
241.7	847.78	642.71			
241.7	770.71	584.28			
245	791.53	599.34			
250	824.34	622.09			
255	860.28	647.04			
260	898.89	673.28			
265	940.37	702.05			
270	984.93	733.27			
275	1032.79	766.47			
280	1084.18	802.12			
285	1139.36	840.72			
290	1198.59	881.97			
295	1262.17	927.35			
300	1330.39	974.93			
304			2000		
305	1403.57	1026.14			
310	1469.09	1082.37			
315	1533.77	1141.03			
320	1603.14	1205.73			
325	1677.51	1273.73	2485	0 to 1139.36	0 to 840.72
330	1757.23	1346.12		1198.59	881.97
335	1842.64	1425.79		1262.17	927.35
340	1934.10	1511.21		1330.39	974.93
345	2032.01	1602.75		1403.57	1026.14

Table 3.1-2
Watts Bar Unit 1 Heatup Limits
(Data (Ref. 1) plotted on Figure 3.1-5)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)				
	HEATUP RATE (60 °F/HR)	HEATUP RATE (100 °F/HR)	LEAK TEST LIMITS	CRITICALITY LIMITS (60 °F/HR)	CRITICALITY LIMITS (100 °F/HR)
350	2136.89	1700.67		1469.09	1082.37
355	2248.85	1805.37		1533.77	1141.03
360	2368.47	1917.72		1603.14	1205.73
365	2496.14	2035.38		1677.51	1273.73
370	2632.29	2163.59		1757.23	1346.12
375		2300.46		1842.64	1425.79
380		2446.44		1934.10	1511.21
385		2601.96		2032.01	1602.75
390				2136.89	1700.67
395				2248.85	1805.37
400				2368.47	1917.72
405				2496.14	2035.38
410				2632.29	2163.59
415					2300.46
420					2446.44
425					2601.96

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL FORGING 05
INITIAL RT_{NDT} 47 °F
LIMITING ART AT 16 EFPY: 1/4-T, 191.7 °F
3/4-T, 156.7 °F

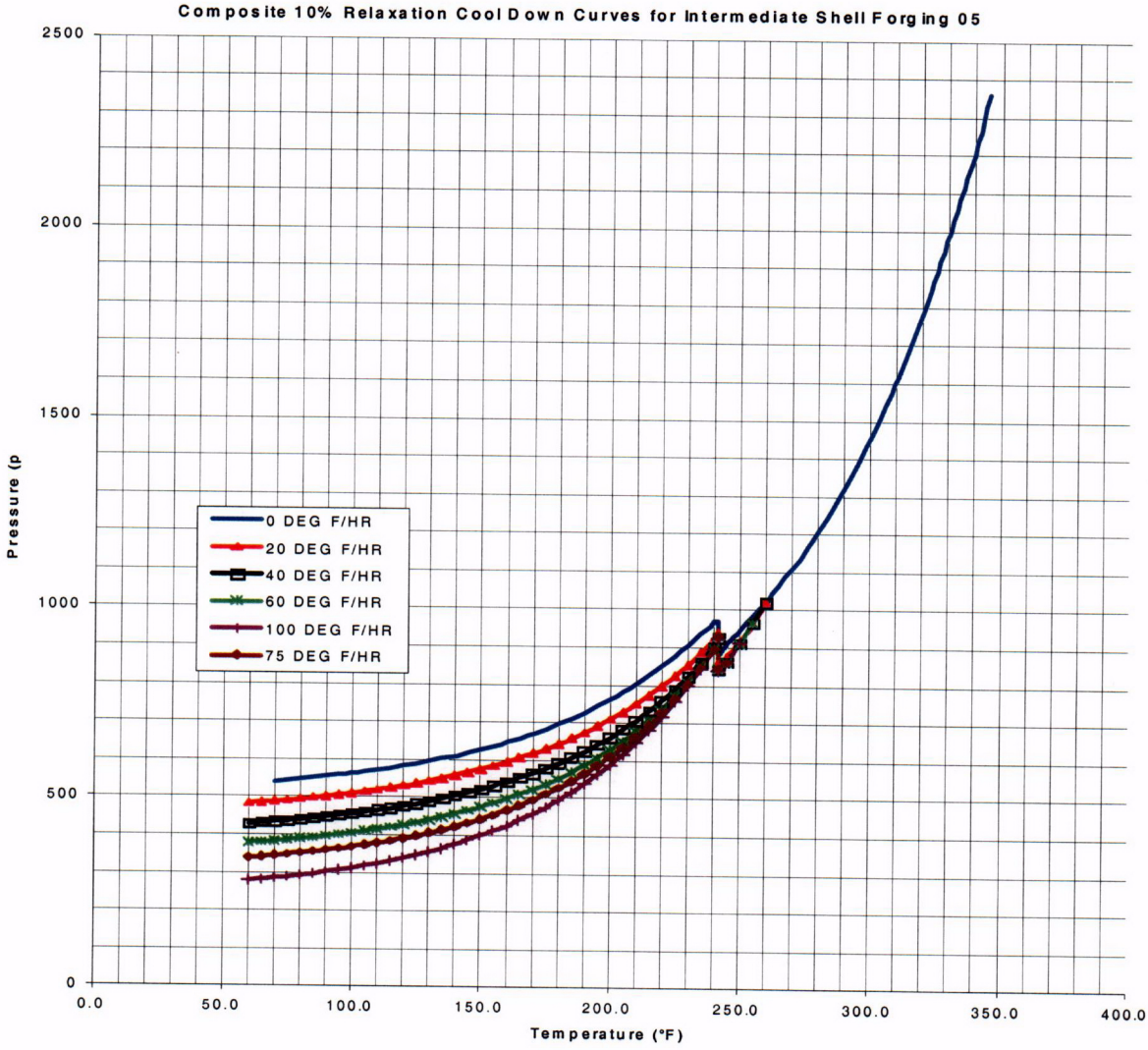

Figure 3.1-6

Watts Bar Unit 1 Reactor Coolant System Cooldown Limitations (Cooldown rates up to 100°F/hr) Applicable for the First 16 EFPY (Without Margins for Instrumentation Errors) Including 10% Relaxation in Pressure for Temperatures < 241.7°F per ASME Code Case N-514

(Plotted Data (Ref. 1) provided on Table 3.1-3)

Table 3.1-3
Watts Bar Unit 1 Cooldown Limits
(Data (Ref. 1) plotted on Fig 3.1-6)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)					
	100 °F/HR	75 °F/HR	60 °F/HR	40 °F/HR	20 °F/HR	0 °F/HR
60	276.92	338.02	376.37	428.87	481.43	
65	280.19	340.61	378.96	431.45	484.02	
70	283.66	343.90	382.25	434.23	486.79	539.14
75	287.50	347.06	385.24	437.22	489.78	542.05
80	291.40	350.44	388.45	440.43	492.99	545.29
85	295.71	354.41	392.07	443.88	496.44	548.77
90	300.44	358.29	395.78	447.59	500.15	552.51
95	305.46	362.79	399.78	451.58	504.14	556.53
100	311.12	367.26	404.24	455.87	508.43	560.86
105	317.11	372.55	409.20	460.49	513.04	565.50
110	323.61	377.85	414.33	465.61	517.99	570.50
115	330.65	383.87	419.83	470.95	523.32	575.87
120	338.09	390.46	426.07	476.68	529.05	581.65
125	345.96	397.30	432.41	482.84	535.21	587.86
130	354.81	404.79	439.37	489.47	541.84	594.43
135	364.33	413.28	447.01	496.59	548.96	601.60
140	374.55	421.96	455.36	504.25	556.61	609.32
145	385.86	431.73	464.27	513.00	564.84	617.62
150	397.79	442.12	473.98	521.85	573.69	626.54
155	410.72	453.34	484.35	531.54	583.20	636.14
160	424.88	465.62	495.43	541.77	593.43	646.32
165	440.32	479.00	507.80	553.28	604.43	657.39
170	456.58	493.38	520.81	565.28	616.25	669.32
175	474.57	508.65	535.22	578.67	628.95	682.13
180	493.69	526.06	550.93	592.67	642.61	695.75
185	514.68	544.15	568.00	608.04	657.30	710.57
190	537.11	564.53	586.34	624.68	673.08	726.48
195	561.74	586.26	606.54	642.50	690.22	743.58

Table 3.1-3
Watts Bar Unit 1 Cooldown Limits
(Data (Ref. 1) plotted on Fig 3.1-6)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)					
	100 °F/HR	75 °F/HR	60 °F/HR	40 °F/HR	20 °F/HR	0 °F/HR
200	587.98	609.95	628.52	662.28	708.46	761.83
205	616.42	635.84	652.38	683.58	728.07	781.62
210	647.51	664.04	678.71	706.86	749.65	802.67
215	680.85	694.66	707.12	732.57	772.47	825.54
220	717.05	727.98	738.41	760.30	797.32	850.06
225	756.41	764.64	773.04	791.03	824.33	876.30
230	798.90	804.24	810.62	824.72	853.46	904.45
235	844.81	847.79	851.97	862.19	885.86	934.99
240	894.12	895.25	897.24	903.92	921.36	967.51
241.7	924.36	931.07	929.70	927.11	937.98	968.61
241.7	840.32	846.43	845.18	842.82	860.19	886.34
245	861.52	860.72	861.31	864.02	873.90	911.51
250	912.97	911.88	911.09	911.21	915.45	945.77
255		973.61	965.36	964.42	963.78	982.53
260				1019.03	1019.03	1022.00
265						1064.40
270						1109.98
275						1158.95
280						1211.57
285						1268.05
290						1328.61
295						1393.44
300						1463.21
305						1537.95
310						1618.11
315						1703.92
320						1795.88
325						1894.39

Table 3.1-3
Watts Bar Unit 1 Cooldown Limits
(Data (Ref. 1) plotted on Fig 3.1-6)

RCS TEMPERATURE (°F)	INDICATED PRESSURE (PSIG)					
	100 °F/HR	75 °F/HR	60 °F/HR	40 °F/HR	20 °F/HR	0 °F/HR
330						1999.72
335						2112.46
340						2232.88
345						2361.41

Table 4.0-1
Surveillance Capsule Removal Schedule

Capsule	Vessel Location (deg.)	Capsule Lead Factor (c)	Removal Time (a)(b)	Capsule Fluence (n/cm^2, E>1.0 MeV) (c)
U	56.0	5.39	1.20	5.05×10^{18} (d)
W	124.0	5.21	3.80	1.23×10^{19} (e)
X	236.0	5.37	5.98	1.84×10^{19} (f)
Z	304.0	5.21	9.25	2.76×10^{19} (g)
V (h)	58.5	4.64	Stand-By	----
Y (h)	238.5	4.64	Stand-By	----

(a) Effective Full Power Years (EFPY) from plant startup.
(b) Removal times are based on nearest vessel refueling date of ASTM E185-82, Section 7.6.3.4. Capsules should be removed during the nearest refueling outage to the indicated time.
(c) Updated from Capsule W dosimetry analysis from BWXT Services, Inc. Report, Section 7 (Ref.7).
(d) The fluence is from plant specific evaluation.
(e) The fluence is from plant specific evaluation, and approximates the fluence at ¼ T at end-of-life (32 EFPY).
(f) This fluence is equal to the calculated peak reactor vessel surface fluence at EOL (32 EFPY).
(g) This fluence is not less than once or greater than twice the peak EOL fluence, and is approximately equal to the peak vessel fluence at 48 EFPY.
(h) These capsules will reach a fluence of 2.8×10^{19} (48 EFPY Peak Fluence) at approximately 10.7 EFPY.

TABLE 5.1

Comparison of the Watts Bar Unit 1 Surveillance Material 30 ft-lb Transition Temperature Shifts and Upper Shelf Energy Decrease with Regulatory Guide 1.99, Revision 2, Predictions

Material	Capsule	Capsule Fluence ($\times 10^{19}$ n/cm^2, E > 1.0 MeV)	30 ft-lb Transition Temperature Shift (ΔRT_{NDT})		Upper Shelf Energy Decrease	
			Predicted[a] (°F)	Measured (°F) [b]	Predicted[a] (%)	Measured (%) [c]
Intermediate Shell Forging 05 (tangential)	U	5.05×10^{18}	100	98	22	19
Intermediate Shell Forging 05 (axial)	U	5.05×10^{18}	100	29	22	0
Weld Metal	U	5.05×10^{18}	33	0	16	0
HAZ Metal	U	5.05×10^{18}	--	51	--	11
Intermediate Shell Forging 05 (tangential)	W	1.23×10^{19}	91.3	111	28	26
Intermediate Shell Forging 05 (axial)	W	1.23×10^{19}	91.3	81	28	3
Weld Metal	W	1.23×10^{19}	19.6	31	20	14
HAZ Metal	W	1.23×10^{19}	--	50	--	8

(a) Based on Regulatory Guide 1.99, Revision 2, methodology using mean weight percent values of Cu and Ni of the surveillance material.
(b) Calculated using measured Charpy data plotted using CVGRAPH, Version 4.1 (Ref. 6) for Capsule U. Calculated using measured Charpy data plotted using CVGRAPH, Version 5.0 (Ref. 7) for Capsule W.
(c) Values are based on the definition of upper shelf energy given in ASTM E185-82.

TABLE 5.2

Watts Bar Unit 1 Calculation of Chemistry Factors Using Surveillance Capsule Data (32 EFPY)

Material	Capsule	Fluence (n/cm^2, E > 1.0 MeV)	FF	Measured ΔRT_{NDT} (°F)	$FF*\Delta RT_{NDT}$ (°F)	FF^2
Intermediate Shell Forging 05 (Tangential)	U	5.05×10^{18}	0.81	98.0	79.4	0.66
	W	1.23×10^{19}	1.06	111.0	117.7	1.12
Intermediate Shell Forging 05 (Axial)	U	5.05×10^{18}	0.81	29.0	23.5	0.66
	W	1.23×10^{19}	1.06	81.0	85.9	1.12
				Sum:	306.5	3.56
	Chemistry Factor = 86.1					
Weld Metal	U	5.05×10^{18}	0.81	0.0	0.0	0.66
	W	1.23×10^{19}	1.06	31.0	32.9	1.12
				Sum:	32.9	1.78
	Chemistry Factor = 18.5					

TABLE 5.3			
Watts Bar Unit 1 Reactor Vessel Toughness Table (Unirradiated)			
Material Description	Cu (%)[a]	Ni (%)[a]	Initial RT_{NDT} (°F)[b]
Closure Head Flange	0.13	0.75	-42
Vessel Flange	--	0.92	-40 [c]
Intermediate Shell Forging 05	0.17	0.80	47
Lower Shell Forging 04	0.08	0.83	5
Circumferential Weld	0.05	0.70	-43

NOTES:
a) Average values of copper and nickel weight percent.
b) Initial RT_{NDT} values are measured values.
c) Used in the consideration of flange requirements for heatup/cooldown curves. Per methodology given in WCAP-14040, the minimum boltup temperature is 60°F.

TABLE 5.4				
Watts Bar Unit 1 Reactor Vessel Surface Fluence Values at 16 EFPY (n/cm^2, E > 1.0 MeV)				
Azimuth	0°	15°	30°	45°
Surface	4.96×10^{18}	7.30×10^{18}	7.83×10^{18}	9.34×10^{18}

TABLE 5.5

Summary of ARTs for the Watts Bar Unit 1 Reactor Vessel Beltline Materials at the 1/4-T and 3/4-T Locations for 16 EFPY

Component	16 EFPY [a]	
	1/4-T (°F)	3/4-T (°F)
Intermediate Shell Forging 05	191.7 [b]	156.7 [b]
Lower Shell Forging 04	81.8	68.2
Circumferential Weld	70.0	52.0

NOTES:
(a) Calculated using the peak vessel fluence of $9.34 \times 10^{18}/cm^2$ (E > 1.0 MeV).
(b) Used to generate the heatup/cooldown curves.

TABLE 5.6

Calculation of Adjusted Reference Temperatures at 16 EFPY for the Limiting Watts Bar Unit 1 Reactor Vessel Material (Intermediate Shell Forging 05)

Parameter	Values	
Operating Time	16 EFPY	
Material	Inter. Shell Forging 05	Inter. Shell Forging 05
Location	1/4-T	3/4-T
Chemistry Factor (CF), °F	132	132
Fluence (f), $*10^{19}$ n/cm^2 (E > 1.0 MeV) (a)	0.561	0.2033
Fluence Factor (FF) (b)	0.839	0.573
ΔRT_{NDT} = CF x FF, °F	110.7	75.7
Initial RT_{NDT} (I), °F	47	47
Margin (M), °F (c)	34	34
ART = I + (CFxFF) + M, °F per Regulatory Guide 1.99, Revision 2	191.7	156.7

NOTES:

(a) Fluence, f, is based upon f_{surf}= 9.34 x 10^{18}/cm^2. The Watts Bar Unit 1 reactor vessel wall thickness is 8.465 inches at the beltline region.

(b) FF = $f^{(0.28 - 0.10 \log f)}$

(c) Margin is calculated as M = $2(\sigma_I^2 + \sigma_\Delta^2)^{0.5}$. The standard deviation for the initial RT_{NDT} margin term, σ_I, is 0 °F since the initial RT_{NDT} value is a measured value. The standard deviation for the ΔRT_{NDT} margin term, σ_Δ, is 17 °F for the forging, except that σ_Δ need not exceed 0.5 times the mean value of ΔRT_{NDT}.

Table 5.7				
Watts Bar Unit 1 Reactor Vessel Surface Fluence Values at 32 and 48 EFPY (n/cm^2, E > 1.0 MeV)				
EFPY	0°	15°	30°	45°
32	9.83×10^{18}	1.44×10^{19}	1.55×10^{19}	1.84×10^{19}
48	1.47×10^{19}	2.16×10^{19}	2.32×10^{19}	2.76×10^{19}

TABLE 5.8							
RT_{PTS} Values for Watts Bar Unit 1 for 32 EFPY							
Material	CF (°F)	Surface Fluence (n/cm^2, E > 1.0 MeV)	FF	RT_{NDT} (CF x FF) (°F)	I (°F)	M (°F)	RT_{PTS} (°F)
Inter. Shell Forging 05	132	1.84×10^{19}	1.17	154.1	47	34	235
Lower Shell Forging 04	51	1.84×10^{19}	1.17	59.5	5	34	99
Circ. Weld	68	1.84×10^{19}	1.17	79.4	-43	56	92

TABLE 5.9							
RT_{PTS} Values for Watts Bar Unit 1 for 48 EFPY							
Material	CF (°F)	Surface Fluence (n/cm^2, E > 1.0 MeV)	FF	RT_{NDT} (CF x FF) (°F)	I (°F)	M (°F)	RT_{PTS} (°F)
Inter. Shell Forging 05	132	2.76×10^{19}	1.27	167.7	47	34	249
Lower Shell Forging 04	51	2.76×10^{19}	1.27	64.8	5	34	104
Circ. Weld	68	2.76×10^{19}	1.27	86.4	-43	56	99

SOURCE NOTES

1. NCO820285003
2. NCO820285004