I&CE/POED(01)-206

Beaver Valley Unit 1

FirstEnergy Nuclear Operating Company

Overpressure Protection System

Setpoints for Master Curve

Revision 1

August 2001

APPROVALS

Function	Name, Title and Signature	Date
Author	P. P. Prasatya, Engineer Plant Operations and Equipment Diagnostics	10/01/01
Reviewed	R. Calvo, Fellow Engineer Plant Operations and Equipment Diagnostics	10/1/01
Approved	S. Palusamy, Manager Plant Operations and Equipment Diagnostics for S.S.P.	10/1/01

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Reviewed	R. Calvo, Fellow Engineer Plant Operations and Equipment Diagnostics	10/11/01
Approved	S. Palusamy, Manager Plant Operations and Equipment Diagnostics for S.S.P.	10/11/01

REVISION HISTORY

RECORD OF CHANGES

Revision	Revision Made By	Description	Date
1	P. Prasatya	Revised to incorporate customer comments	8/01

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2. *CN-I&CE/POED(00)-023C, Revision 0, "Beaver Valley Unit 1 COMS Analysis – Y Capsule," T. A. Miller, dated December 13, 2000

3. *Purchase Order # 7055697, dated March 4, 2001

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5. *CN-I&CE/POED(00)-023C, Revision 1, "Beaver Valley Unit 1 COMS Analysis – Y Capsule," R. Calvo, dated May 2001

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7. *I&CE/POED(01)-084, "Beaver Valley Unit 1 COMS Analysis and Report (Y-Capsule) Revision," R. Calvo, dated May 9, 2001

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1.0 DISCUSSION/BASES

This report documents the development of the Power Operated Relief Valve (PORV) setpoints as determined for the Overpressure Protection System (OPPS), for the Beaver Valley Unit 1 master curve (Ref. 6). The setpoints will maintain reactor coolant system pressure within acceptable limits following design basis overpressurization incidents occurring at Beaver Valley Unit 1 during low temperature, water-solid operation. Reference 2 forms the basis of the version 0 (Ref. 8) of this document and has been revised accordingly in References 5 and 7 to incorporate customer comments. This document is likewise revised to implement the customer comments incorporated in Reference 7. This document supercedes Reference 8.

1.1. OPERATING LIMITS

The PORV setpoints were developed utilizing the methodology described in Reference 4. The selected setpoints are designed to prevent overpressures produced by valve opening from exceeding the 10CFR50 Appendix G reactor vessel NDT limit and will prevent underpressures produced by valve closure from violating the Reactor Coolant Pump (RCP) No. 1 Seal minimum pressure requirement. However, when a choice must be made between protecting the Appendix G limit and the RCP number one seal limit, the Appendix G limit takes precedence (Ref. 4).

The minimum RCS pressure curve utilized in the setpoint determination is based on system pressure as determined by a wide range pressure instrument in a loop not containing the active reactor coolant pump. This ensures the utilization of a minimum pressure limit curve which will cover this eventuality as well as that case in which the instrument is directly located in the loop with the active pump.

1.2. MASS INPUT CONSIDERATIONS

The most severe, credible mass input event for Beaver Valley Unit 1, utilized in the determination of the OPPS setpoint program, involves single centrifugal charging pump operation. Specifically, a loss of air incident is postulated, whereby the flow control valve in the charging line fails open, and simultaneously, the flow control valve in the letdown line fails closed. Limiting mass input based on consideration of single centrifugal charging pump operation is consistent with the Technical Specifications requirements.

From the standpoint of determining maximum setpoint underpressure and proximity to the RCP No. 1 Seal minimum pressure limit, an envelope of mass injection rates was investigated to ensure that the worst case was considered for ultimate setpoint determination.

1.3. HEAT INPUT CONSIDERATIONS

The heat input (HI) mechanism considered for analysis involved Reactor Coolant System (RCS) pump startup in one loop with temperature asymmetry in the RCS, whereby the steam generators were at a higher temperature than the remainder of the system. The magnitude of the temperature difference between the steam generators and the reactor coolant system depends on the previous plant operations, which allowed the asymmetry to develop. For this study, a maximum temperature of 50°F was analyzed.

1.4. PORV OPERATION

The selected setpoints include the effect of time delays associated with transmission of the wide range RCS pressure signal.

2.0 10CFR50 APPENDIX G PRESSURE LIMIT

Appendix G limits, developed using ASME Code Case N-641, for 22 EFPY, 27.44 EFPY and 44.18 EFPY are shown in Ref 6. These limits are developed based upon isothermal heatup and cooldown limits, and do not include instrumentation errors. Setpoints were developed using the 22 EFPY, 27.44 EFPY, and 44.18 EFPY pressure limits. Table 2-1 lists the pressure-temperature limits from the master curve without instrument uncertainties at all EFPY conditions.

Table 2-1 Steady State Pressure/Temperature Limits (Ref. 6)
(without instrument uncertainties)

22 EFPY		27.44 EFPY		44.18 EFPY	
Steady State		Steady State		Steady State	
Temp.	Press.	Temp.	Press.	Temp.	Press.
(°F)	(psig)	(°F)	(psig)	(°F)	(psig)

a,c

Table 2-1 Steady State Pressure/Temperature Limits (Continued)

22 EFPY		27.44 EFPY		44.18 EFPY	
Steady State		Steady State		Steady State	
Temp.	Press.	Temp.	Press.	Temp.	Press.
(°F)	(psig)	(°F)	(psig)	(°F)	(psig)

a,c

3.0 MASS INJECTION (MI) TRANSIENT

A parametric study was previously performed in Reference 1. As there were no significant plant physical changes (i.e. RCS volumes, PORVs characteristics, etc.) and also the mass injection transient conditions are not changing, the mass injection analyses will not be re-analyzed for this current project. As such, the Reference 1 mass injection analysis results remain applicable for this analysis and are used to determine the new OPPS setpoints. The transient was analyzed for the actuation of one PORV in operation. Table 3-1 lists the MI transient analysis results from Reference 1.

The MI transient analyses results presented in Table 3-1 assumed 0% steam generator tube plugging (SGTP) level. However, the setpoint study performed in this document is intended to bound 0 – 30% SGTP level. A previous study was performed in Reference 7, which showed that an increase in SGTP level to 30% was accounted for by adding [ ]^{a,c} psi to the MI overshoots. The setpoint determination method presented in Section 6 of this report includes this increase in MI overshoots.

Table 3-1 Summary of Mass Input Results

Mass Injection Rate (gpm)	LTOP Setpoint (psig)	Overpressure		Underpressure	
		Value (psig)	Delta P (psi)	Value (psig)	Delta P (psi)

a,c

Table 3-1 Summary of Mass Input Results (Continued)						
Mass Injection Rate (gpm)	LTOP Setpoint (psig)	Overpressure		Underpressure		a,c
		Value (psig)	Delta P (psi)	Value (psig)	Delta P (psi)	

4.0 HEAT INJECTION (HI) TRANSIENT

The transient analyzed is the inadvertent startup of an RCS Pump with temperature asymmetry between the RCS and SG and with the RCS in a water solid condition (Heat Input mechanism producing the worst case overpressurization). Analysis assumptions are based on the previous analysis (Refs. 5 and 7), which include:

- The RCS/SG temperature difference is 50°F,
- Valve opening/closing time of 3.0 seconds ([ ]^{a,c} seconds stroke time and [ ]^{a,c} seconds delay time), and
- 30 % Peak SGTP level.

Table 4-1 lists the HI transient analyses results based on References 2 and 5.

Table 4-1 Summary of Heat Input Results

RCS/SG Temperature (°F)	PS PORV Setpoint (psig)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psig)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psig)

a,c

Table 4-1 Summary of Heat Input Results (Continued)						
RCS/SG Temperature (°F)	PS PORV Setpoint (psig)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psig)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psig)	a,c

Table 4-1 Summary of Heat Input Results (Continued)					
RCS/SG Temperature (°F)	PS PORV Setpoint (psig)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psig)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psig)

a,c

Table 4-1 Summary of Heat Input Results (Continued)					
RCS/SG Temperature (°F)	PS PORV Setpoint (psig)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psig)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psig)

a,c

5.0 OTHER LIMITS UTILIZED

5.1 MASS INJECTION FLOW CAPABILITY

Mass Injection design basis is the maximum credible mass injection into the RCS from a single centrifugal pump as defined in Reference 1 (see Figure 5-1).

a,c

Figure 5-1 - Charging Capacity vs. RCS Pressure

5.2 REACTOR COOLANT PUMP NO. 1 SEAL PRESSURE LIMIT

The minimum RCS pressures to meet the reactor coolant pump No. 1 seal limit as a function of RCS temperatures are taken from Reference 2 and listed in Table 5-1. The seal limits in Table 5-1 are listed without instrument uncertainties.

Table 5-1 RCP No. 1 Seal ΔP Limit

[

RCS Temp (°F)	Pressure Limit (psig)

] a,c

Reference 4 does not explicitly require the inclusion of instrument uncertainty in the Reactor Coolant Pump No.1 Seal limit. Furthermore, References 5 and 7 did not use instrument uncertainty for RCP No. 1 Seal Limit in the Y-Capsule analysis. Therefore, to be consistent with References 5 and 7, the RCP No. 1 Seal Limit without the instrument uncertainties will also be used in this evaluation.

5.3 TRANSMITTER ΔP

The differential pressure between the reactor vessel and the RCS wide range pressure transmitter reading (NSAL 93-05) as a function of the number of RCPs running is identified in Table 5-2 (Reference 7).

Table 5-2 ΔP Between Reactor Vessel and Transmitter	
Number of RCPs	Delta-P (psi) (Ref. 7)
3	[ ]
2	
1	
0	

a,c

5.4 HEAT TRANSPORT EFFECT

To address the temperature measurement at the start of a HI transient, 50°F is added to the temperature measurement.

5.5 INSTRUMENT UNCERTAINTIES

Pressure uncertainties, defined below, were provided in References 5 and 7. Temperature uncertainties for automatic OPPS actuation are not applicable to Beaver Valley Unit 1, as the plant does not have a function generator and associated uncertainties. However, since restrictions are placed on operation of a certain number of Reactor Coolant Pumps based on measured wide range RCS temperatures, account of the wide range temperature uncertainty is included.

Channel statistical allowance for WR pressurizer press. uncertainty: ± [ ]^{a,c} psig*

WR cold leg temperature instrumentation uncertainty: [ ]^{a,c} °F

Temperature Error for automatic OPPS actuation: [ ]^{a,c} °F

* The pressure uncertainty includes the transmitter plus the process equipment. Conservatively, [ ]^{a,c} psig was used to determine the PORV setpoint in this document.

5.6 PORV PIPING LIMIT

Westinghouse practice, for all OPPS analyses, has been to select setpoints such that the peak overpressure will not exceed 800 psig or Appendix G limits. The PORV piping limit of 800 psig results from an analysis of water hammer effects on relief valve piping for certain classes of rapidly opening valves (e.g., Garrett solenoid valves) under water solid conditions. Given the right combination of rapid stroke time and a sharply rising valve open/close characteristic curve, the valve becomes fully open or fully closed within a few tenths of a second, thus setting the conditions for water hammer.

The flow through an air operated valve, such as the Masoneilan valve featured at Beaver Valley Unit 1, is relatively less sensitive to stem position than the solenoid valves. When combined with the relatively slow opening and closing times, the water hammer forces on the discharge piping of the air-operated valve has not been analyzed by Westinghouse. The practice has been to assume the conservative position of taking the worst case results and applying them to all OPPS setpoint evaluations, regardless of the relief valve employed. This is consistent with the previous OPPS analyses.

In other words, the relatively slower stroke times of an air operated valve, such as the Masoneilan valves employed at Beaver Valley Unit 1, would impart lower water hammer loads than the fast stroking Garrett style valves. Still, the generic 800 psig upper limit is employed for the cold over pressure analyses performed herein.

6.0 SETPOINT DETERMINATION

6.1 SETPOINT SELECTION GUIDELINES

The setpoints are selected such that the OPPS operational limits, defined below, are not violated:

1. The peak RCS pressure from the design basis MI and HI events will not exceed:
   - Maximum allowable pressure of the steady state 10CFR50 Appendix G heatup/cooldown reactor vessel limits including margins for instrument uncertainties,
   - 800 psig (PORV discharge piping limit), or
   - whichever of the above limits are lower.
2. The minimum RCS pressure from a design basis MI or HI event will not drop below RCP No. 1 seal ΔP limit. However, if there is a conflict between the upper pressure limit and the pump seal limit, the upper pressure limit takes precedence.
3. The final PORV setpoints should be selected, if possible, to prevent dual (simultaneous) actuation of the OPPS PORVs (i.e., the higher PORV setpoint must be above the peak RCS pressure expected to occur when the lower set PORV opens).

6.2 SETPOINT WINDOW

Beaver Valley Unit 1 uses a single setpoint for each PORV (i.e. no function generator is used). Since this plant has a single PORV setpoint, the analysis is aimed to determine the setpoints for the most limiting case for both mass and heat injection transients, which is at a temperature of 60°F, where the Appendix G limit is at the lowest. The heat injection output data (Table 4-1) are extrapolated to 60°F and the results are listed below.

Table 6-1 Heat Injection Data at 60°F

RCS TEMPERATURE (DEG F)	PS PORV SETPOINT (PSIG)	PMAX PEAK RCS PRESSURE (PSIG)	PMIN MINIMUM RCS PRESSURE (PSIG)
60	350	[	]
	400		
	450		
	500		
	550		
	600		
	800		
	1000	]	]

a,c

Using Fig. 5-1, the mass injection rates (MIR) corresponding to the chosen setpoints are developed (Table 6-2). These rates are then used to determine the overpressure at each setpoint using the mass injection data in Table 3-1. The results are presented in Table 6-3.

Table 6-2 Charging Flow Rate for Each Setpoint

[

Setpoint	Flow Rate (gpm) (*)

] a,c

Note: (*) Interpolated using Figure 5-1.

Table 6-3 Mass Injection Pressure Lines Data

Setpoint (psig)	Overpressure (*) (psig)	Underpressure (**) (psig)
400	[	] a,c
500		
600		
700		
800(***)	[	]

Note : (*) Interpolated from Table 3-1 using the flow rates in Table 6-2 at corresponding setpoint. To account for 30% SGTP, [ ]^{a,c} psi is added to the Table 3-1 overpressures (Ref. 7)

(**) Undershoot = [ ]^{a,c} (Ref. 7); Underpressure = Undershoot + Setpoint

(***) The over and underpressures are extrapolated to 800 psig.

Using the data for both the heat and mass injection cases from Tables 6-1 and 6-3, respectively, a plot of RCS pressures as a function of setpoints is generated at a temperature of 60°F (the limiting point).

The setpoint for each case of transient is determined from:

- the intersection between the Appendix G limit with 3 RCPs running and the maximum allowable mass injection pressure line for the mass injection case and

- the intersection between the Appendix G limit with 1 RCP running and the maximum allowable heat injection pressure line for the heat injection case.

The PORV maximum allowable setpoint is selected by comparing which of these two setpoints are limiting. The minimum pressures are determined from the intersection between the PORV setpoint and the minimum pressure lines of the heat/mass injection lines. In this analysis the heat injection underpressure line is more limiting. Therefore, it is used as a guide to define the minimum pressure. Figure 6-1 illustrates the setpoint determination for 22 EFPY at RCS temperature of 60°F.

Note that the piping limit of 800 psig is higher than the Appendix G limit at 60°F. Consequently, the lower limit (i.e. Appendix G limit) is used as a setpoint selection guideline (refer to Section 6.1). The RCP No. 1 seal ΔP limit for 60°F is extrapolated using the data from Table 5-1. The minimum pressure in this case is higher than the seal limit. Hence, it does not violate the setpoint selection guidelines. Similar steps are performed for the 27.44 EFPY and 44.18 EFPY conditions using the same mass and heat injection pressure lines. The setpoint results are shown in Table 8-1.

a,c

Figure 6-1 Setpoint Selection for 22 EFPY

The single setpoint for each EFPY condition (refer to Tables 7-1 to 7-4) is limited by the mass injection transient. Since the results of the mass injection transient are not dependent on RCS temperatures, the inclusion of temperature uncertainty for single setpoint selection is not needed. Consequently, temperature uncertainty is not required to be accounted for since the limiting setpoint is based on the Appendix G limit at 60°F. However the temperature uncertainty should be accounted for in the determination of the RCS temperatures for the number of RCPs allowed to be in operation (see Section 8.2).

7.0 SETPOINTS WITH RCP RESTRICTIONS

The methodology described in Section 6 is used to determine the setpoints with restrictions on RCP operation. For this section, the setpoints are evaluated over a range of RCS temperatures from 60°F to 300°F. This is required to determine the RCS temperature at which the restrictions will apply. Similar steps as described in the previous section are performed to determine the setpoint as a function of RCS temperature. In addition to Tables 6-1 and 6-3, the remaining heat injection transients results in Table 4-1 are utilized in the process of determining these setpoints. Table 7-1 lists the heat injection setpoints as a function of temperatures at 22 EFPY, 27.44 EFPY, and 44.18 EFPY. Tables 7-2 to 7-4 illustrate the mass injection setpoint development for 22 EFPY, 27.44 EFPY, and 44.18 EFPY.

Table 7-1 Heat Injection Setpoints for 22 EFPY, 27.44 EFPY, and 44.18 EFPY

	22 EFPY					27.44 EFPY					44.18 EFPY				
T	App. G	App. G w/unc	1 RCP	Adj. Limit	HI Setpoint	App. G	App. G w/unc	1 RCP	Adj. Limit	HI Setpoint	App. G	App. G W/unc	1 RCP	Adj. Limit	HI Setpoint
(°F)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)
(1)	(2)	(3)	(4)	(5)	(6)	(2)	(3)	(4)	(5)	(6)	(2)	(3)	(4)	(5)	(6)
60	[														] a,c
70															
100															
125															
150															
175															
200															
225															
250															
275															
300	[														]

Note: (*) The Appendix G of 22 EFPY is extrapolated to 300°F using the data in Table 2-1

(1) RCS Temperature

(2) Appendix G limit at corresponding RCS temperature (1) taken from Table 2-1

(3) Appendix G – pressure uncertainty = (2) – [ ]^{a,c} psi (Refer to Section 5.5 for uncertainty measurement)

(4) (3) – Transmitter ΔP for 1 RCP in operation = (3) – [ ]^{a,c} psi (Refer to Section 5.3 for ΔP)

(5) If (4) < 800 psig (piping limit), then (5) = (4). Otherwise, (5) = 800 psig (Refer to Section 6.1)

(6) The maximum allowable nominal setpoints are determined for each RCS temperature (1) based on (5) using the heat injection transient results from Table 6-1 for RCS temperature of 60°F and Table 4-1 for RCS temperatures greater than 60°F and method illustrated in Figure 6-1.

Table 7-2 Mass Injection Setpoints at 22 EFPY

			No pump		1 pump			2 pump			3 pump		
T	App G	App G w/ unc	Adj. Limit	MI Setpt	1 RCP	Adj. Limit	MI Setpt	2 RCP	Adj. Limit	MI Setpt	3 RCP	Adj Limit	MI Setpt
(°F)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(6)	(7)	(8)	(6)	(7)	(8)
60	[												] a,c
70													
100													
125													
150													
175													
200													
225													
250													
275													
300	]												

Table 7-3 Mass Injection Setpoints at 27.44 EFPY

			No pump		1 pump			2 pump			3 pump		
T	App G	App G w/ unc	Adj. Limit	MI Setpt	1 RCP	Adj. Limit	MI Setpt	2 RCP	Adj. Limit	MI Setpt	3 RCP	Adj Limit	MI Setpt
(°F)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(6)	(7)	(8)	(6)	(7)	(8)
60	[												] a,c
70													
100													
125													
150													
175													
200													
225													
250													
275													
300	]												

Table 7-4 Mass Injection Setpoints at 44.18 EFPY

			No pump		1 pump			2 pump			3 pump		
T	App G	App G w/ unc	Adj. Limit	MI Setpt	1 RCP	Adj. Limit	MI Setpt	2 RCP	Adj. Limit	MI Setpt	3 RCP	Adj Limit	MI Setpt
(°F)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)	(psig)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(6)	(7)	(8)	(6)	(7)	(8)
60	[												] a,c
70													
100													
125													
150													
175													
200													
225													
250													
275													
300	]												

Note for Tables 7-2 to 7-4: (*) The Appendix G of 22 EFPY is extrapolated to 300°F using the data in Table 2-1

(1) RCS Temperature

(2) Appendix G limit at corresponding RCS temperature (1) taken from Table 2-1

(3) Appendix G – pressure uncertainty = (2) – [ ]^{a,c} psi (Refer to Section 5.5 for uncertainty measurement)

(4) If (3) < 800 psig (piping limit), then (4) = (3). Otherwise, (4) = 800 psig (Refer to Section 6.1)

(5) The maximum allowable nominal setpoints are determined for each RCS temperature (1) based on (4) using the mass injection transient results from Table 6-3 and method illustrated in Figure 6-1

(6) (3) – Transmitter ΔP for 1 RCP in operation = (3) – [ ]^{a,c} psi (Refer to Section 5.3 for ΔP)

(3) – Transmitter ΔP for 2 RCP in operation = (3) – [ ]^{a,c} psi (Refer to Section 5.3 for ΔP)

(3) – Transmitter ΔP for 3 RCP in operation = (3) – [ ]^{a,c} psi (Refer to Section 5.3 for ΔP)

(7) If (6) < 800 psig (piping limit), then (7) = (6). Otherwise, (7) = 800 psig (Refer to Section 6.1)

(8) The maximum allowable nominal setpoints are determined for each RCS temperature (1) based on (7) using the mass injection transient results from Table 6-3 and method illustrated in Figure 6-1

The heat injection setpoints in Table 7-1 are shifted by [ ]^{a,c} °F to account for the heat transport effect. The next step is to select the final setpoint for each case (i.e. 0/1/2/3 RCPs) by analyzing the mass and heat injection setpoints. Figures 7-1 to 7-12 illustrate the final maximum allowable nominal setpoint selection method for 22 EFPY, 27.44 EFPY and 44.18 EFPY for 0/1/2/3-RCPs cases. The open and filled symbols in these figures denote the mass and heat injection maximum allowable nominal setpoints, respectively, while the line shows the setpoints selected. Note that the temperature on Figures 7-1 to 7-12 is the Measured Temperature.

[ ] a,c

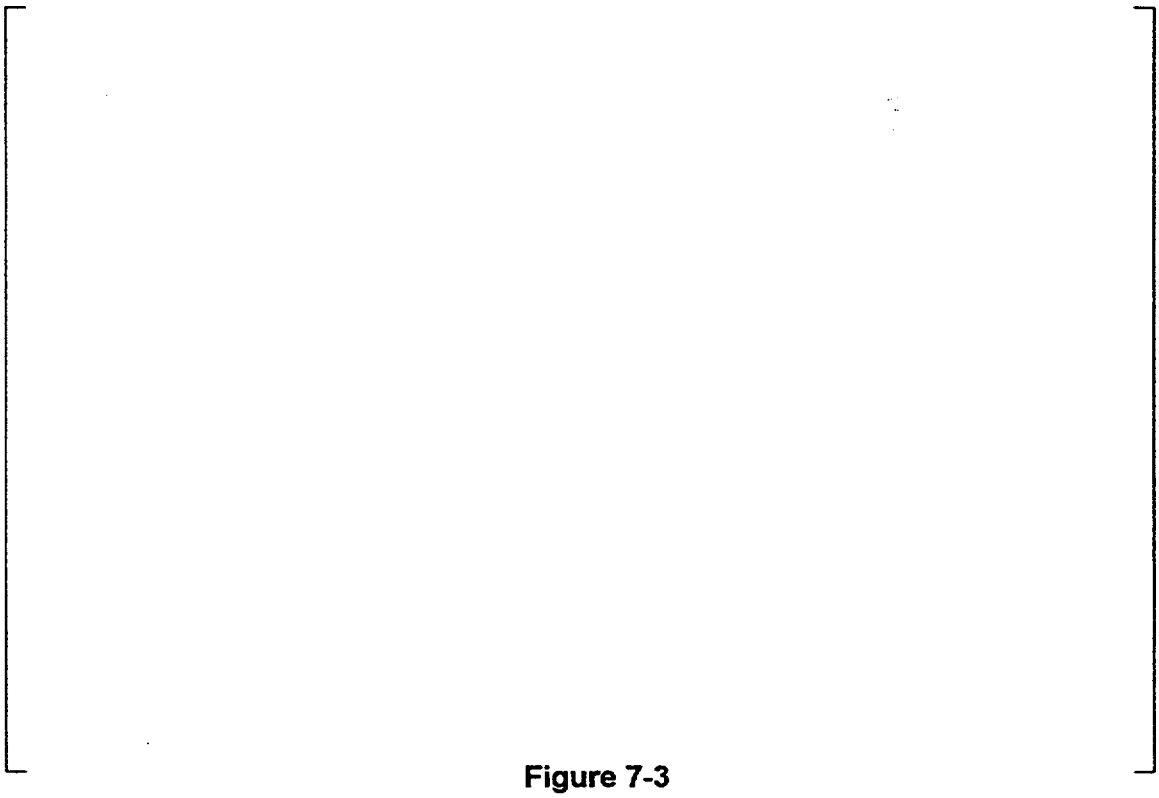
Figure 7-1

[ ] a,c

Figure 7-2

Symbols for Figs 7-1 and 7-2: ▫ MI Setpoints ▪ HI Setpoints —— Selected Setpoints

[a,c



] a,c

Figure 7-3

[a,c

] a,c

Figure 7-4

Symbols for Figs 7-3 and 7-4: ▫ MI Setpoints ▪ HI Setpoints —— Selected Setpoints

[ ] a,c

Figure 7-5

[ ] a,c

Figure 7-6

Symbols for Figs 7-5 and 7-6: ▫ MI Setpoints ▪ HI Setpoints ——— Selected Setpoints

[ ] a,c

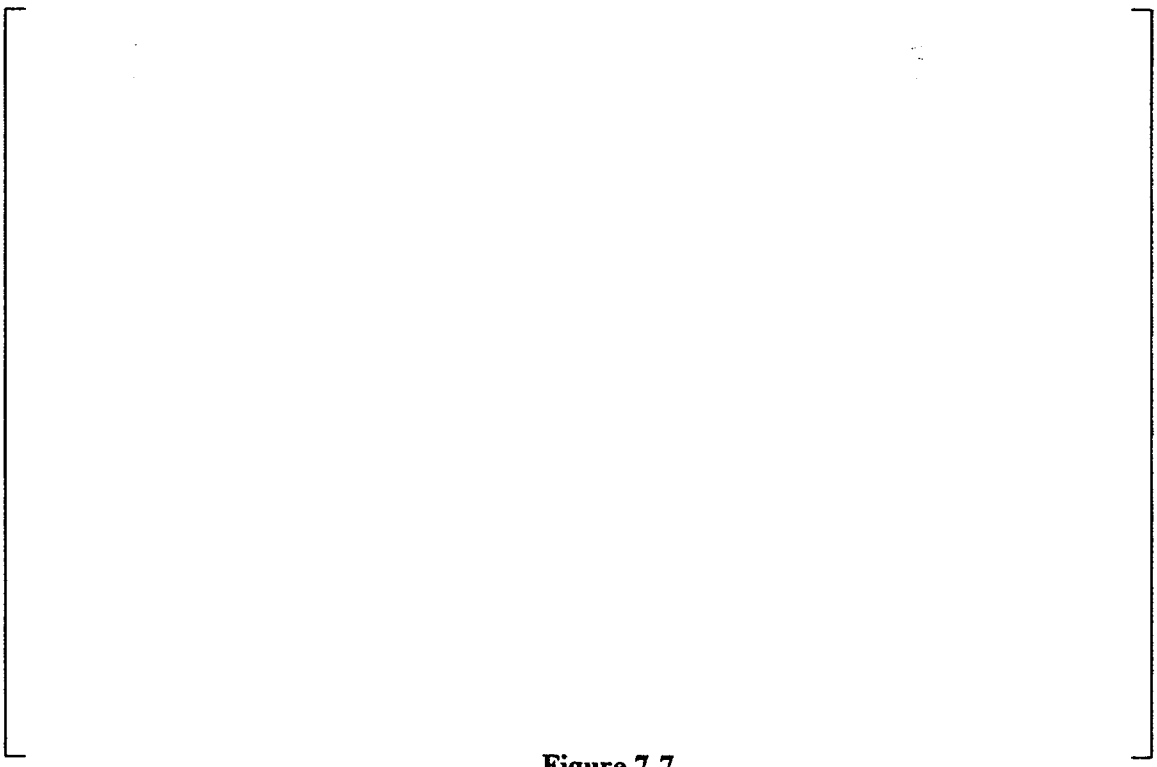


Figure 7-7

[ ] a,c

Figure 7-8

Symbols for Figs 7-7 and 7-8: MI Setpoints HI Setpoints Selected Setpoints

[ ] a,c

Figure 7-9

[ ] a,c

Figure 7-10

Symbols for Figs 7- 9 and 7-10: ▫ MI Setpoints ▪ HI Setpoints —— Selected Setpoints

[ ] a,c

Figure 7-11

[ ] a,c

Figure 7-12

Symbols for Figs 7-11 and 7-12: ▫ MI Setpoints ▪ HI Setpoints ——— Selected Setpoints

After determining the final setpoints for the 0/1/2/3-RCPs running case, the next step is to evaluate the temperature ranges where the number of pumps running are restricted. Figures 7-13 to 7-15 illustrate the method on determining the temperature ranges on different number of RCPs running. "Selected Setpt" on Figures 7-13 to 7-15 is defined as the limiting setpoint where only one RCP is running. Whereas, the "Current Limit" is defined as the setpoint corresponding to no restrictions on the number of RCPs running (i.e. all 3 RCPs are running). By following the "Selected Setpt" line to the right (i.e. for increasing temperatures), the point can be found where 2 and then 3 RCPs are running. The "Current Limit" or the maximum allowable setpoints with no RCPs restrictions (i.e. all 3 RCPs are running) as a function of EFPYs are listed in Table 8-1. The results with restriction on the number of RCPs running are summarized in Tables 8-2 and 8-3.

a,c

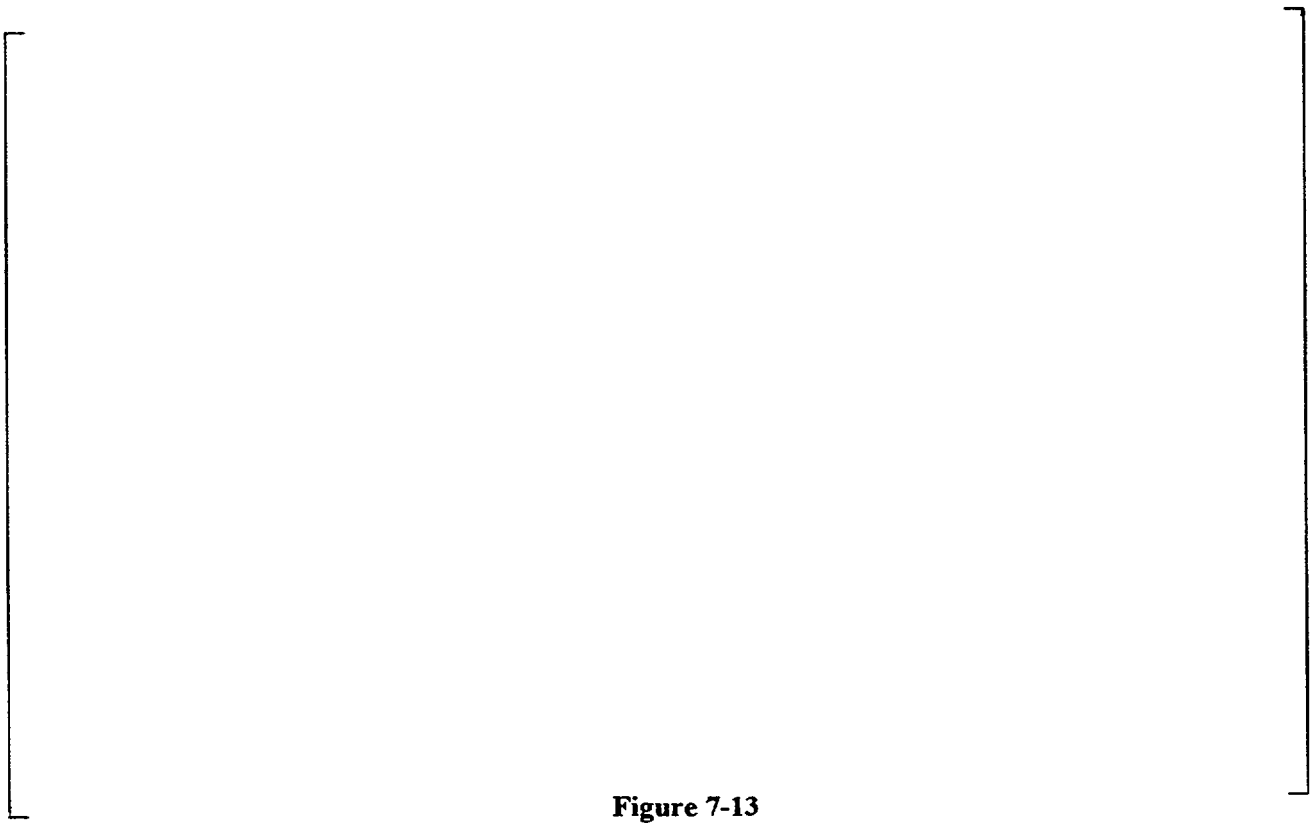


Figure 7-13

[ ]a,c

Figure 7-14

[ ]a,c

Figure 7-15

8.0 RESULTS

8.1 ALL RCP IN OPERATION

The maximum allowable nominal setpoints for the case where all 3 pumps are operated (i.e. no restrictions on number of RCPs running) are summarized in Table 8-1.

Table 8-1 Setpoints for 22 EFPY, 27.44 EFPY, and 44.18 EFPY

	22 EFPY	27.44 EFPY	44.18 EFPY
Setpoint (psig)	452	451	446
Minimum Pressure (psig)	309	307	303

The maximum/minimum pressures shown on Table 8-1 will not violate the Appendix G limits up to the respective EFPY, the PORV discharge piping limit (800 psig) or the RCP No. 1 Seal ΔP Limit ([ ]^{a,c} psig at 60°F). However, if [ ]^{a,c} psig uncertainty measurement (see Section 5.5) is added to the seal limit, the minimum pressures listed in Table 8-1 violate the RCP No. 1 seal limit [ ]^{a,c} at 60°F. In addition, dual PORV actuation would result in violation of the reactor coolant pump seal limit, either with or without the inclusion of instrument uncertainties in the seal limit.

8.2. LIMITED RCPs RUNNING

Table 8-2 presents the temperature ranges where the number of RCPs running are restricted. Note that T in Table 8-2 is the indicated RCS Temperature. The selected setpoint on Tables 8-2 and 8-3 at various EFPY is the maximum allowable nominal single PORV setpoint which meets respective Appendix G and RCP No. 1 Seal Limits.

Table 8-2 Summary of Temperature Ranges for Pump Restrictions (No Uncertainty Applied) a,c

[

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The results presented in Table 8-2 do not include the temperature uncertainty. With the uncertainty measurement of [ ]^{a,c} °F (from Section 5.5), the temperature ranges with RCP restriction are tabulated in Table 8-3. For conservatism, a value of [ ]^{a,c} °F is used for the uncertainty measurement.

Table 8-3 Summary of Temperature Ranges for Pump Restrictions (With Uncertainty of [ ]^{a,c} °F)

22 EFPY		27.44 EFPY		44.18 EFPY	
Selected Setpoint = 484 psig		Selected Setpoint = 482 psig		Selected Setpoint = 478 psig	
T≤120°F	0 or 1 RCP	T≤122°F	0 or 1 RCP	T≤131°F	0 or 1 RCP
120°F<T≤140°F	0, 1, or 2 RCPs	122°F<T≤143°F	0, 1, or 2 RCPs	131°F<T≤158°F	0, 1, or 2 RCPs
T>140°F	All RCPs may be in operation	T>143°F	All RCPs may be in operation	T>158°F	All RCPs may be in operation

9.0 OPPS ARMING AND ENABLE TEMPERATURE

Arming temperature (when OPPS should be switched on to be operable) is established where the App. G limit is 2500 psia. (Turning OPPS on sooner, i.e., at higher temperatures, is conservative). This temperature is usually around 350°F. At this temperature, a steam bubble would be present in the pressurizer, thus reducing the potential for a water hammer discharge slug that could challenge the piping limits. Based on this method, the temperature for each condition at an Appendix G limit of 2500 psia is listed in Table 9-1.

Table 9-1 Arming Temperatures

	Arming Temperature (°F) (*)
22 EFPY	[ ] a,c
27.44 EFPY	
44.18 EFPY	

Note: (*) determined by linear extrapolation to 2500 psia from the steady state P-T limits with [ ]^{a,c} psig pressure uncertainties.

Consistent with Reference 7, the overpressure setpoints must protect against Appendix G limit violation, including the consideration of instrument uncertainties. Therefore the temperature where the Appendix G limit reaches 2500 psia (listed in Table 9-1) must be increased by the [ ]^{a,c} °F temperature uncertainty. Based on this method, the calculated arming temperature for 44.18 EFPY is [ ]^{a,c} °F. However, the current arming temperature at Beaver Valley Unit 1 is at a temperature of less than or equal to 350°F. Hence, for 44.18 EFPY, arming temperatures of less than or equal to 350°F is selected. The arming temperature should be set as follows:

OPPS must be armed for RCS temperature $\leq$ 330°F for 22 EFPY, 337°F for 27.44 EFPY, and 350°F for 44.18 EFPY.

Enable temperature is calculated based on where RCS temperature is less than 200°F or material concerns (design basis of reactor vessel metal temperature less than RT_{NTD} + 50°F), whichever is greater. The enable temperature does not address the piping limit issue.

The calculated enable temperatures, based on Reference 6, are reported below for each case:

- Enable Temperature = 300°F for 22 EFPY
- Enable Temperature = 305°F for 27.44 EFPY
- Enable Temperature = 325°F for 44.18 EFPY

Should a low temperature overpressure event occur below 350°F when the OPPS is not armed, pressure will continue to rise to the nominal PORV setpoint of 2335 psig. If a mass injection event occurs under water solid conditions, water discharge through the PORV piping and pressure cycling around 2335 psig (well above the 800 psig limit) could occur. There is no cycling associated with the heat injection event, though water discharge could occur for conditions in which the pressurizer is water solid. If a steam bubble is established, these events are considered to be unlikely and the conditions seen in the pressurizer and PORV piping would be more similar to those assumed in the design basis.

As the arming temperature is higher and therefore, more conservative than the enable temperature, it is recommended that the arming temperature be used for the RCS temperatures below which OPPS must be operable.

OPPS must be armed for RCS temperatures $\leq$ 330°F	for 22 EFPY
OPPS must be armed for RCS temperatures $\leq$ 337°F	for 27.44 EFPY
OPPS must be armed for RCS temperatures $\leq$ 350°F	for 44.18 EFPY

10.0 CONCLUSION

Figures 10-1 to 10-3 illustrate the setpoint window at a pressure range between 200 to 900 psig for 22 EFPY, 27.44 EFPY, and 44.18 EFPY with all 3 RCPs running. These figures are provided only for illustration purposes. A complete summary on the maximum allowable nominal single PORV setpoints for the revised Appendix G limits (Master Curve) for various EFPY is provided in Table 10-1. Arming temperatures are listed in Table 10-2.

a,c

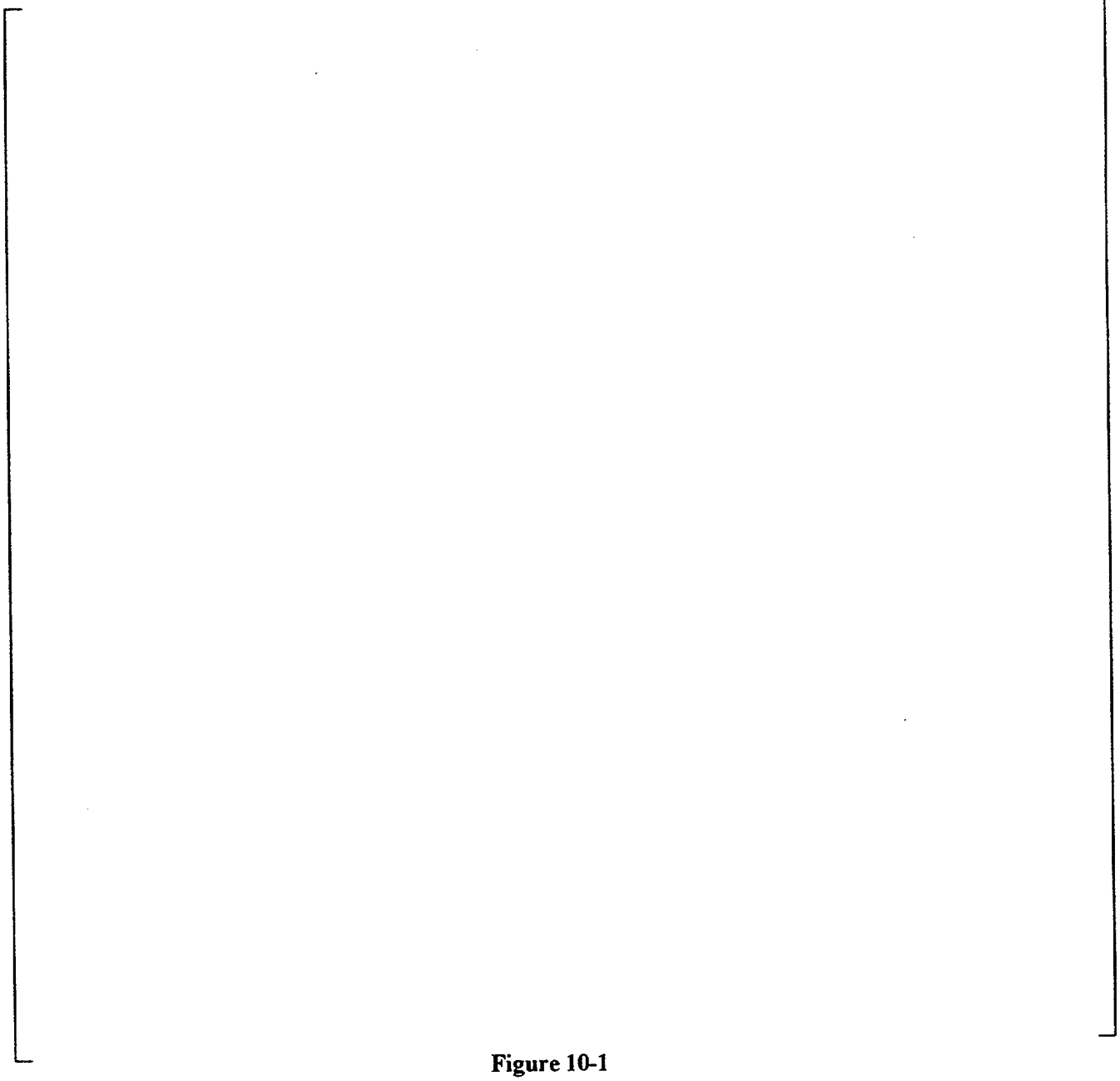

Figure 10-1

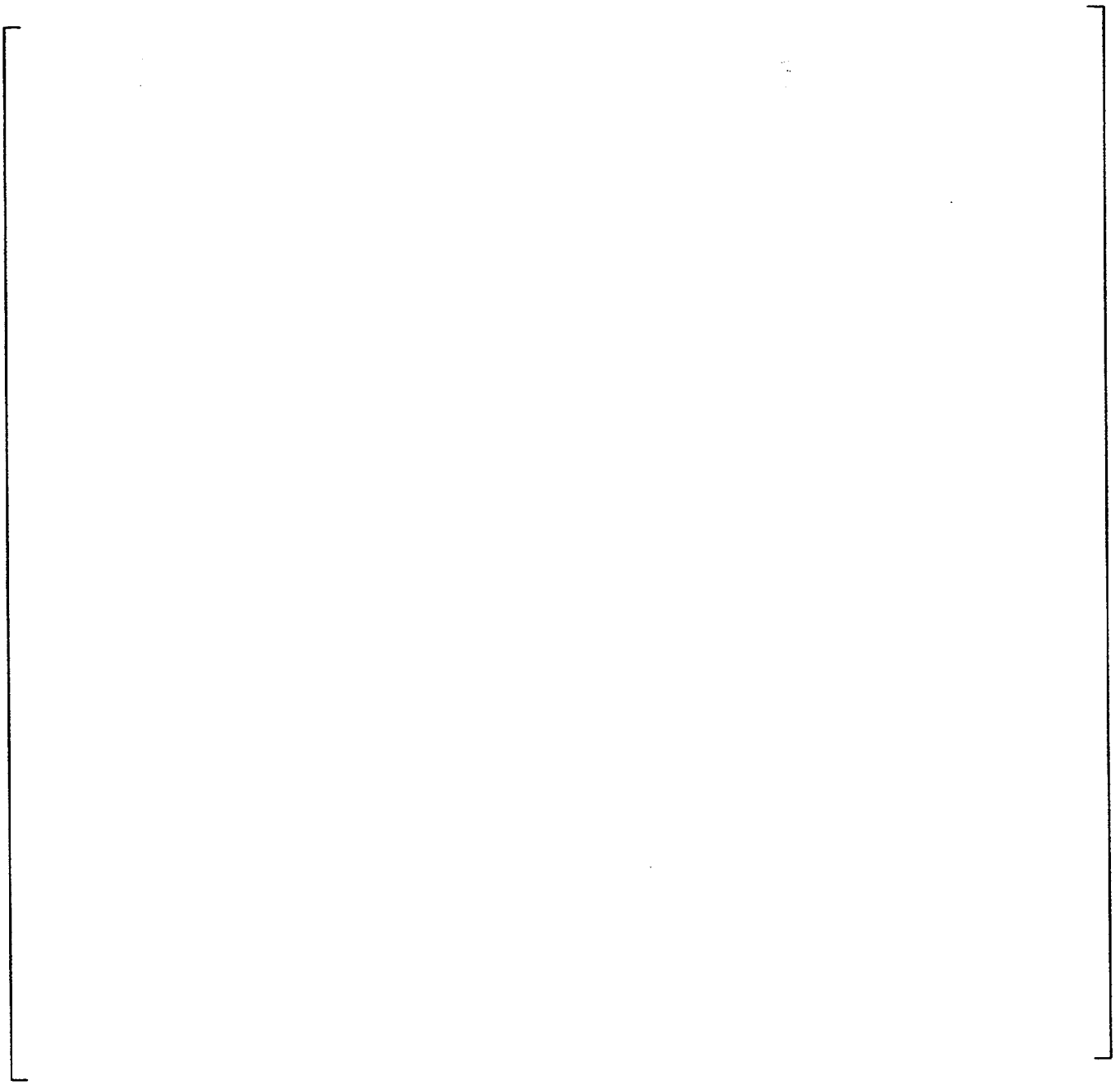

Figure 10-2

[ ] a,c

Figure 10-3

Table 10-1 Maximum Allowable Nominal PORV Setpoints with and without RCPs Restriction

	22 EFPY		27.44 EFPY		44.18 EFPY	
No RCP Restriction						
Setpoint for 3 RCPs running	452 psig		451 psig		446 psig	
Minimum Pressure *	309 psig		307 psig		303 psig	
With RCP Restriction						
Setpoint for 1 RCP running	484 psig		482 psig		478 psig	
RCS temperature ranges where the number of pumps running are restricted (RCS temperature listed includes [ ]^{a,c} °F uncertainty)	T≤120°F 120°F<T≤140°F T>140°F	0 or 1 RCP 0, 1, or 2 RCPs All RCPs may be in operation	T≤122°F 122°F<T≤143°F T>143°F	0 or 1 RCP 0, 1, or 2 RCPs All RCPs may be in operation	T≤131°F 131°F<T≤158°F T>158°F	0 or 1 RCP 0, 1, or 2 RCPs All RCPs may be in operation

* The minimum pressures calculated will violate the seal limit if [ ]^{a,c} psig pressure uncertainty is included in the seal limit.

Table 10-2 Summary of Arming Temperatures

22 EFPY	OPPS must be armed for RCS temperatures ≤ 330°F
27.44 EFPY	OPPS must be armed for RCS temperatures ≤ 337°F
44.18 EFPY	OPPS must be armed for RCS temperatures ≤ 350°F