Beaver Valley Unit 1

FirstEnergy Nuclear Operating Company

Overpressure Protection System

Setpoints for Y-Capsule

Revision 1

May 2001

APPROVALS

Function	Name, Title and Signature	Date
Author	R. Calvo, Fellow Engineer Plant Operations and Equipment Diagnostics R. Calvo	5/30/01
Reviewed	S. Abedin, Adv. Tech. Engineer Shamsul Abedin Plant Operations and Equipment Diagnostics	5/31/01
Approved	S. Palusamy J. Seenu Srinivasan for S.S.P Plant Operations and Equipment Diagnostics	5/31/01

©2001 Westinghouse Electric Company LLC
All Rights Reserved

REVISION HISTORY

RECORD OF CHANGES

Revision	Revision Made By	Description	Date
1	R. Calvo	Revised to incorporate customer comments and account for the Appendix G limit with reactor vessel flange requirement.	5/01

TABLE OF CONTENTS

References vi

1 Discussion/Bases 1-1

1.1 Operating Limits 1-1
1.2 Mass Input Considerations 1-1
1.3 Heat Input Considerations 1-2
1.4 PORV Operation 1-2

2 Specification For Mass Input Transients 2-1

2.1 Transients Analyzed 2-1
2.2 System/Operating Parameters 2-1
2.2.1 Temperatures 2-1
2.2.2 Reactor Coolant System (RCS) Volume 2-1
2.2.3 Initial Reactor Coolant System Pressure 2-1
2.2.4 Steam Generator Tube Plugging (SGTP) Level 2-1
2.2.5 Reactor Coolant System Relief Capability 2-1
2.3 Power-Operated Relief Valve Characteristics 2-2
2.3.1 General 2-2
2.3.2 Opening/Closing 2-2
2.4 Mass Injection Flow Capability 2-2

3 Specification For Heat Input Transients 3-1

3.1 Transient Analyzed 3-1
3.2 System/Operating Parameters 3-1
3.2.1 Temperatures 3-1
3.2.2 Volume 3-1
3.2.3 Initial Reactor Coolant System Pressure 3-1
3.2.4 Steam Generator Tube Plugging (SGTP) Level 3-1
3.2.5 Reactor Coolant System Relief Capability 3-1
3.3 Power-Operated Relief Valve Characteristics 3-1
3.3.1 General 3-1
3.3.2 Opening/Closing 3-2
3.3.3 Steam Generator Design Characteristics 3-2
3.3.4 Reactor Coolant Pump Design Characteristics 3-2

4 Specification For Determination Of Setpoint Program 4-1

4.1 Setpoint Window 4-1
4.2 Transients Considered 4-1
4.2.1 Mass Input 4-1
4.2.2 Heat Input 4-1

TABLE OF CONTENTS (Continued)

4.3 10CFR50 Appendix G Pressure Limit 4-1
4.4 Reactor Coolant Pump No. 1 Seal Pressure Limit 4-5
4.4.1 Curve Utilized 4-5
4.4.2 Applicability 4-6
4.5 Other Constraints 4-6
4.5.1 PORV Setpoints Capacity 4-6
4.5.2 Plant Operability 4-6
4.5.3 Thermal Transport (HI only) 4-6
4.5.4 PORV Piping Limit 4-6
4.5.5 ΔP Between Reactor Vessel and Transmitter 4-7
4.5.6 Instrument Uncertainties 4-7

5 Results Of Parametric Reactor Coolant System (Constant) Mass Input Transient Analyses 5-1

6 Results Of Reactor Coolant System Heat Input Transient Analysis 6-1

7 Setpoint Determination 7-1

7.1 Setpoint Selection Guidelines 7-1
7.2 Data Utilized 7-2
7.2.1 Mass Injection Peak Pressure Analysis 7-2
7.2.2 Heat Injection Peak Pressure Analysis 7-3
7.3 Setpoint Window 7-4
7.4 PORV Setpoint Selection 7-7
7.4.1 Setpoint Selection 7-7
7.4.2 Setpoints with RCP Restrictions 7-10
7.4.3 Setpoint Selection with Appendix G Limits Including Vessel Flange Requirements 7-12
7.4.4 Final Selected Setpoint 7-16

8 OPPS Arming and Enable Temperature 8-1

TABLE OF CONTENTS (Continued)
List of Tables

Table 4.3-1 Steady State Pressure/Temperature Limits without Uncertainties 4-2

Table 4.5-1 ΔP Between Reactor Vessel and Transmitter 4-7

Table 5-1 Summary Of Mass Input Results 5-1

Table 6-1 Summary Of Heat Input Results 6-1

Table 7.2-1 Charging Pump Analysis 7-2

Table 7.2-2 HI Transient Results Summary 7-3

Table 7.4-1 Maximum Allowable Nominal Setpoints – 22EFPY (No pump restrictions) 7-8

Table 7.4-2 Steady State Pressure/Temperature Limits with and without Reactor Vessel Flange Restriction – 22EFPY 7-14

List of Figures

Figure 2.3-1 Relief Valve Flow Characteristic 2-3

Figure 2.4-1 Charging Capacity vs. RCS Pressure 2-4

Figure 4.4-1 Minimum RCS Pressure for Pressure Undershoot Evaluation 4-5

Figure 5-1 MI Overshoot Study 5-2

Figure 5-2 MI Undershoot Study 5-3

Figure 6-1 HI Overshoot Study 6-5

Figure 6-2 HI Undershoot Study 6-6

Figure 7.3-1 22EFPY Setpoint Window 7-5

Figure 7.3-2 Setpoint Window - Detail 7-6

Figure 7.4-1 Maximum Allowable Nominal Setpoints – 22EFPY 7-9

Figure 7.4-2 Setpoint Window w/ Varying Number of RCPs Running 7-11

Figure 7.4-3 Beaver Valley Unit 1 OPPS Setpoints – No Flange Limit 7-18

Figure 7.4-4 Beaver Valley Unit 1 OPPS Setpoints – With Flange Limit 7-19

REFERENCES

Following is a list of references used throughout this document. References are denoted by the associated reference numbers as follows (Reference #).

1. *CN-CSA-88-044, Beaver Valley Unit 1 Low Temperature Overpressure Prevention System (LTOPS; a.k.a. COMS) Setpoint Analysis

2. *CN-POE-83-36, LOFTRAN Input/Algorithm Development for DLW Cold Overpressure Mitigation System (COMS) Setpoint Determination

3. *CN-OPES(99)-041, Beaver Valley Unit 1 COMS Setpoint Evaluation at 16 EFPY

4. *Purchase Order.7032413 WEC-00B-01001,Beaver Valley LTOPS Setpoint Development

5. WCAP-14040-NP-A, Rev. 2, Methodology Used to Develop Cold Overpressure Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves

6. *I&CE/POED(00)-023C, Rev. 1, Beaver Valley Unit 1 COMS Analysis – Y Capsule

7. WCAP-15570, Beaver Valley Unit 1 Heatup and Cooldown Limit Curves for Normal Operation

8. WCAP-15570, Revision 1, Beaver Valley Unit 1 Heatup and Cooldown Limit Curves for Normal Operation

9. WCAP-15570, Revision 2, Beaver Valley Unit 1 Heatup and Cooldown Limit Curves for Normal Operation

10. FENOC letter ND1MLM:0054, Beaver Valley Unit 1, Resolution of Westinghouse Comments on LAR and Associated Documentation for Heatup and Cooldown Curves, OPPS, and PTLR Relocation

*Internal Westinghouse References

1 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 Y-capsule (References 7-9). Note that in this report the terms OPPS and Cold Over-Pressure Mitigation System (COMS) are used interchangeably. The setpoints will maintain Reactor Coolant System pressure within acceptable limits following all credible overpressurization incidents occurring in Beaver Valley Unit 1 during low temperature, water-solid operation. The results of LOFTRAN transient analyses, utilized in the determination of the setpoint program, are also included.

Revision 0 of this report developed the OPPS setpoints based on the Appendix G limits as described in Reference 7. Since the issuance of this report, Reference 8 revised the Reference 7 Appendix G limits to account for the reactor vessel flange requirements. This required a revision to the OPPS setpoints. The setpoint revision methodology is described in Section 7.4.3.

During the time when the analyses were being performed to address the Reference 8 Appendix G limits, Reference 9 was issued which revised the Appendix G limits during plant heatup maneuvers. These revisions did not affect the steady-state cooldown Appendix G limits included in References 7 and 8 and the OPPS setpoints developed herein are not affected by Reference 9.

1.1 OPERATING LIMITS

The PORV setpoints were developed utilizing the methodology described in Reference 5. 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 No. 1 Seal limit, the Appendix G limit takes precedence (Reference 5).

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 RCP. This ensures the utilization of a minimum pressure limit curve that 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 (MI) 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 MI based on consideration of single centrifugal charging pump operation is consistent with the Technical Specification requirements.

From the standpoint of determining maximum setpoint underpressure and proximity to the RCP No. 1 Seal minimum pressure limit, an envelope of MI rates was investigated to ensure that the worst case was considered for ultimate setpoint determination. MI rates ranging from 40 gpm to 600 gpm were considered.

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 (SGs) and the RCS 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 SPECIFICATION FOR MASS INPUT TRANSIENTS

2.1 TRANSIENTS ANALYZED

A parametric study was previously performed in Reference 1. As MI transients conditions are not changing, the MI analyses will not be re-analyzed for this current project. As such, the Reference 1 MI analysis results will be used in determining the new COMS setpoints. The analysis assumptions used in Reference 1 are repeated below for convenience.

2.2 SYSTEM/OPERATING PARAMETERS

A parametric study (Reference 1) was previously performed using constant MI rates between 40 gpm and 600 gpm. This range was sufficiently extensive to include all RCS MI rates enveloped by the charging capability curve of Figure 2.4-1 for Beaver Valley Unit 1. All data listed below was taken from Reference 1, unless noted otherwise.

2.2.1 Temperatures

RCS temperature is equal to 100°F.

2.2.2 Reactor Coolant System (RCS) Volume

The RCS volume is [ ]^{a,c} ft^3; this is for the limiting 30% steam generator tube plugging (SGTP) condition (Reference 6).

2.2.3 Initial Reactor Coolant System Pressure

The initial RCS pressure is set at [ ]^{a,c} psi below the PORV setpoint.

There is negligible effect on the relief valve performance and the pressure transient due to initial starting pressure. The MI transients were conservatively analyzed at [ ]^{a,c} psi below the PORV setpoint to assure that the MI mechanism was always at full performance before the mitigating relief valve was operated.

2.2.4 Steam Generator Tube Plugging (SGTP) Level

The original analysis (Reference 1) assumed a 0% SGTP. The setpoints developed in this analysis bound a 0 to 30% SGTP level.

2.2.5 Reactor Coolant System Relief Capability

The transient is analyzed for the actuation of one power-operated relief valve (PORV). Due to the single failure assumptions, the second PORV is assumed to be inoperable.

2.3 POWER-OPERATED RELIEF VALVE CHARACTERISTICS

2.3.1 General

- Valve Type – Masoneilan
- C_v = 46 gpm/$\sqrt{psi}$
- The following MI rates and pressure setpoints:
  MI rates – [ ]^{a,c} gpm
  RCS pressure setpoints – [ ]^{a,c} psig

2.3.2 Opening/Closing

- Ramp (linear) plug lift characteristic; non-linear variation of valve opening/closing (flow) with plug position (Figure 2.3-1)
- The PORV opening/closing times of 3 seconds were provided by FENOC (Reference 10). Included in the 3 seconds opening/closing time is the [ ]^{a,c} second delay time, where the delay time is defined as the time delay between when the setpoint pressure is reached and when the PORV begins to move. The PORV opening/closing time is described below:
  - Valve opening time = [ ]^{a,c} seconds (Reference 1)
  - Delay Time

		a,c
Pressure sensing line transport delay =	[ ]	sec
Pressure transmitter delay =		sec
Electronic delay =		sec
Solenoid actuation delay =		sec
Valve chamber (pneumatic delay) =		sec
Total delay =		sec

  - Total modeled opening time = [ ]^{a,c} = 3.0 sec

2.4 MASS INJECTION FLOW CAPABILITY

MI design basis is maximum credible MI into the RCS from a single centrifugal charging pump as defined in Reference 1 (see Figure 2.4-1).

a,c

Figure 2.3-1 Relief Valve Flow Characteristic

a,c

Figure 2.4-1 Charging Capacity vs. RCS Pressure

3 SPECIFICATION FOR HEAT INPUT TRANSIENTS

3.1 TRANSIENT ANALYZED

The transient analyzed is the inadvertent startup of an RCS pump while the plant primary system is in a water solid condition and the steam generators are at a temperature of 50°F higher than the remainder of the RCS (heat input mechanism producing the worst case overpressurization). Analysis assumptions developed to be consistent with the previous analysis (Reference 2) except for:

- The RCS/SG temperature difference increases from 25 to 50°F,
- Peak SGTP level increases from 0 to 30%.

3.2 SYSTEM/OPERATING PARAMETERS

3.2.1 Temperatures

SG - RCS temperature difference = 50°F

SG (heat source) temperatures are [ ]^{a,c} °F

3.2.2 Volume

Reactor Coolant volume is [ ]^{a,c} ft3 (30% SGTP) (Reference 6)

3.2.3 Initial Reactor Coolant System Pressure

The transient is analyzed for [ ]^{a,c} psig.

3.2.4 Steam Generator Tube Plugging (SGTP) Level

The analyses were performed to bound a 0 to 30% SGTP level.

3.2.5 Reactor Coolant System Relief Capability

The transient is analyzed for the actuation of one power-operated relief valve. Due to the single failure assumptions, the second PORV is assumed to be inoperable.

3.3 POWER-OPERATED RELIEF VALVE CHARACTERISTICS

3.3.1 General

- Valve Type – Masoneilan
- $C_v = 46\ gpm/\sqrt{psi}$

- The following RCS temperatures and pressure setpoints were considered as required for algorithm application:

- RCS temperatures are [ ]^{a,c} °F

- PORV setpoints are [ ]^{a,c} psig

3.3.2 Opening/Closing

- Ramp (linear) plug lift characteristic; non-linear variation of valve opening/closing (flow) with plug position (Figure 2.3-1)

- Valve opening time = [ ]^{a,c} seconds (Reference 1)

- Delay Time
  Pressure sensing line transport delay =
  Pressure transmitter delay =
  Electronic delay =
  Solenoid actuation delay =
  Valve chamber (pneumatic delay) =
  Total delay =

  [ ] a,c

- Total modeled opening time = [ ]^{a,c} = 3.0 sec

See Section 2.3.2 for details

3.3.3 Steam Generator Design Characteristics

- SG Type - Model 51

- SG Tube Heat Transfer Surface Area = [ ]^{a,c} ft^2

3.3.4 Reactor Coolant Pump Design Characteristics

- RCP Type = Model 93A

- RCP Motor HP = 6000

4 SPECIFICATION FOR DETERMINATION OF SETPOINT PROGRAM

4.1 SETPOINT WINDOW

The development of the setpoint window for setpoint determination is described in Section 7.3.

4.2 TRANSIENTS CONSIDERED

4.2.1 Mass Input

All cases described in the specification for MI transients (Section 2.1).

4.2.2 Heat Input

All cases described in the specification for HI transients (Section 3.1).

4.3 10CFR50 APPENDIX G PRESSURE LIMIT

19, 22, 28, and 45EFPY Appendix G limits are shown in Table 4.3-1. These limits are developed based upon isothermal heatup and cooldown limits, and do not include instrumentation errors. Setpoints were developed using the 22EFPY pressure limits.

The detailed analyses done in Sections 7.1 through 7.4.2 were based upon the 22EFPY Appendix G limits as included in Reference 7. Subsequent to the completion of these analyses, Reference 8 was issued which addressed the vessel flange requirements of 10CFR 50 Appendix G. Section 7.4.3 includes a comparison of the References 7 and 8 Appendix G limits and a development of the required setpoints to meet the Reference 8 Appendix G limits.

Reference 9 was issued to combine the Reference 7 and 8 Appendix G limits into one document, and to correct an error in the development of the Appendix G limit heatup curves shown in References 7 and 8. These changes have no effect on the steady-state cooldown curves which are used in the OPPS setpoint development described in this report. Therefore, Reference 9 does not impact the OPPS setpoint analysis described herein.

Table 4.3-1 Steady State Pressure/Temperature Limits without Uncertainties							
19EFPY Steady State		22EFPY Steady State		28EFPY Steady State		45EFPY Steady State	
Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)

a,c

Table 4.3-1 Steady State Pressure/Temperature Limits without Uncertainties (Continued)							
19EFPY Steady State		22EFPY Steady State		28EFPY Steady State		45EFPY Steady State	
Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)

a,c

Table 4.3-1 Steady State Pressure/Temperature Limits without Uncertainties (Continued)							
19EFPY Steady State		22EFPY Steady State		28EFPY Steady State		45EFPY Steady State	
Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)	Temp. (°F)	Press. (psig)

a,c

4.4 REACTOR COOLANT PUMP NO. 1 SEAL PRESSURE LIMIT

4.4.1 Curve Utilized

Minimum RCS pressure vs. RCS temperature correlation is described in Figure 4.4-1.

a,c

Figure 4.4-1 Minimum RCS Pressure for Pressure Undershoot Evaluation

4.4.2 Applicability

RCP No. 1 Seal DP = [ ]^{a,c} psid

4.5 OTHER CONSTRAINTS

4.5.1 PORV Setpoints Capacity

Either PORV provides the required relief capacity for both MI and HI transients (single failure of either valve is considered).

4.5.2 Plant Operability

The highest possible setpoints were determined, consistent with the limits and constraints described in this section, to provide the plant operator with maximum pressure margin for plant operation during shutdown.

4.5.3 Thermal Transport (HI only)

Setpoints will be determined such that the HI transient with the steam generators at a temperature 50°F higher than the reactor vessel temperature will not violate the Appendix G pressure limit at the lower reactor vessel temperature (isothermal overpressurizations occur for MI events).

4.5.4 PORV Piping Limit

Westinghouse practice, for all LTOPS 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 waterhammer 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 tenths of a second, thus setting the conditions for waterhammer.

The PORV piping limit of 800 psig is based on a conservative analysis that models the structural effects on the PORV piping due to waterhammer during the design basis OPPS MI and HI events below RCS temperatures of approximately 350°F. The cycling of the PORVs from an open to closed position causes pressure to increase and decrease in accordance with the open/close characteristics of the PORV. The COMS design transient conservatively assumes that pressure will cycle between a maximum of 800 psig and a minimum of 200 psig every second, over a 10 -minute period, for a total of 600 cycles. Ten events are postulated over the lifetime of the plant. The postulated cycles are significantly greater than the number of cycles anticipated during an actual low temperature overpressure event.

The flow though an air-operated valve, such as the Masoneilan valve featured at Beaver Valley Unit 1, is relatively less sensitive to stem position than a solenoid-actuated valve. When

combined with the relatively slow opening and closing times, it would be expected that the waterhammer forces on the piping associated with an air-operated valve would be less than those associated with operation of a solenoid-actuated valve. However, the piping analysis has not been performed by Westinghouse. The practice has been to assume the conservative position of taking the worst case results and applying them to all LTOPS setpoint evaluations, regardless of the relief valve employed. This is consistent with the previous COMS 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 waterhammer loads than the fast stroking Garrett-style valves. Still, the generic 800 psig upper limit is employed for the cold overpressure analyses performed herein.

4.5.5 ΔP Between Reactor Vessel and Transmitter

The differential pressure between the reactor vessel and the RCS wide range pressure transmitter reading (NSAL 93-05) is identified in Table 4.5-1.

Table 4.5-1 ΔP Between Reactor Vessel and Transmitter

Number of RCPs	Delta-P (psi) (Reference 3)
3	[ ]a,c
2	
1	
0	

4.5.6 Instrument Uncertainties

The setpoints were determined allowing for pressure and temperature uncertainties. Temperature uncertainties for automatic COMS actuation are not applicable to Beaver Valley Unit 1 as the plant does not have a function generator and associated uncertainties.

Channel statistical allowance for WR pressurizer press. uncertainty: ± [ ]a,c psi*

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

Temperature error for automatic COMS actuation: [ ]a,c °F

* Conservatively, [ ]a,c psi was used

5 RESULTS OF PARAMETRIC REACTOR COOLANT SYSTEM (CONSTANT) MASS INPUT TRANSIENT ANALYSES

Table 5-1 Summary of Mass Input Results

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

a,c

a,c

Figure 5-1 MI Overshoot Study

a,c

Figure 5-2 MI Undershoot Study

6 RESULTS OF REACTOR COOLANT SYSTEM HEAT INPUT TRANSIENT ANALYSIS

Table 6-1 Summary of Heat Input Results

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

a,c

Table 6-1 Summary of Heat Input Results (Continued)					
RCS/SG Temperature (°F)	PS PORV Setpoint (psi)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psi)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psi)

a,c

Table 6-1 Summary of Heat Input Results (Continued)					
RCS/SG Temperature (°F)	PS PORV Setpoint (psi)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psi)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psi)

a,c

Table 6-1 Summary of Heat Input Results (Continued)					
RCS/SG Temperature (°F)	PS PORV Setpoint (psi)	DP Over Setpoint Pressure Overshoot (psi)	PMAX Peak RCS Pressure (psi)	DP Under Setpoint Pressure Undershoot (psi)	PMIN Minimum RCS Pressure (psi)

a,c

a,c

Figure 6-1 HI Overshoot Study

a,c

Figure 6-2 HI Undershoot Study

7 SETPOINT DETERMINATION

7.1 SETPOINT SELECTION GUIDELINES

The setpoints will be selected such that the OPPS operational limits, defined below, are not violated. This is consistent with the methodology in Reference 5.

- 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).
  - Whichever of the above limits is lower.
- 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 will take precedence.
- The final PORV setpoints should be selected 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).

7.2 DATA UTILIZED

7.2.1 Mass Injection Peak Pressure Analysis

The charging pump curve (Figure 2.4-1) was used to determine the correlation between the MI over and undershoots (Table 7.2-1).

Table 7.2-1 Charging Pump Analysis

SP psig	MIR(1) gpm	OS@MIR(2) psi	Pmax(3) psig	US@MIR(4) psi	Pmin(5) psig

a,c

1. Mass Injection Rate (MIR) taken from Figure 2.4-1.
2. The Overshoot (OS) was determined by taking the equation of the line that represents the MI results [ ]a,c shown in Figure 5-1.
3. The peak pressure (Pmax) = Setpressure + OS
4. The Undershoot (US) was determined by taking the equation of the line that represents the MI results [ ]a,c shown in Figure 5-2.
5. The minimum pressure (Pmin) = Setpressure + US

7.2.2 Heat Injection Peak Pressure Analysis

The HI overshoots and undershoots from Table 6-1 are summarized below.

Table 7.2-2 HI Transient Results Summary

Trcs (°F)→	70	100	125	150	175	200	225	250	275	300
SP (psig)↓	Overshoot									
350										
400										
450										
500										
550										
600										
800										
1000										

a,c

Trcs (°F)→	70	100	125	150	175	200	225	250	275	300
SP (psig)↓	Undershoot									
350										
400										
450										
500										
550										
600										
800										
1000										

a,c

7.3 SETPOINT WINDOW

With the Appendix G limit (Table 4.3-1), PORV discharge piping limit (800 psig), reactor vessel to pressure transmitter ΔP (Table 4.5-1), RCS pressure overshoots and undershoots (Section 7.2), and RCP minimum pump seal limits (Figure 4.4-1), the window for selecting the setpoints are established. The setpoint window is developed in the following manner.

1. At any chosen RCS temperature, the maximum allowable pressure limit was determined based on the minimum of the following:

   - Appendix G limit (minus the ΔP between the wide range pressure transmitter and the vessel mid-plane elevations [with three RCPs running for MI cases and one RCP running for HI case]), or

   - PORV discharge piping pressure limit of 800 psig.

2. Determine the minimum allowable pressure limit. This is the minimum pressure to avoid the transient pressure undershoot from exceeding the minimum pressure related to the reactor coolant pump #1 seal limit (Figure 4.4-1).

3. From the pressure overshoot/undershoot data (Sections 7.2), the maximum and minimum pressure reached for any chosen PORV setpoint was determined.

4. The results of items one though three are plotted in Figure 7.3-1 and these curves form the setpoint window.

a,c

Figure 7.3-1 22EFPY Setpoint Window

a,c

Figure 7.3-2 Setpoint Window - Detail

7.4 PORV SETPOINT SELECTION

7.4.1 Setpoint Selection

The minimum of the MI and HI maximum allowable set pressures at any given RCS temperature becomes the maximum setpoint limit. Selected setpoints cannot exceed this maximum limit. The setpoint selection process is demonstrated in Table 7.4-1 and illustrated in Figure 7.4-1.

The limiting setpoint at T=60°F of 434 psig was selected as Beaver Valley Unit 1 uses a single setpoint for each PORV (i.e., no function generator is used). This setpoint has no RCP operating restrictions and is valid for 0, 1, 2, or 3 RCPs running.

Table 7.4-1 Maximum Allowable Nominal Setpoints – 22EFPY (No pump restrictions)							
RCS Temp (°F)	Max_MI_SP (psig)[1]	RCS Temp (°F)[4]	Max_HI_SP (psig)[1]	RCS Temp (°F)	Max Limit (psig)[2]	RCS Temp (°F)	Selected Setpoints (psig)[3]

a,c

1. Development described in Section 7.1
2. Minimum of Max_MI_SP or Max_HI_SP at any given temperature
3. Max Limit adjusted to create a smooth curve
4. Temperature includes 50°F heat transport effect for temperatures above 60°F

a,c

Figure 7.4-1 Selected Maximum Allowable Nominal Setpoints – 22EFPY

7.4.2 Setpoints with RCP Restrictions

The methodology described in Section 7.1 was used to determine setpoints with RCP restrictions. The results are shown in Figure 7.4-2.

Setpoints that take advantage of increased margin due to restricting the number of RCPs in operation, taken from Figure 7.4-2 are summarized below. Note, these setpoints do not include temperature measurement instrumentation uncertainty. These temperatures can be rounded up for operator convenience.

<u>RCP Pump Restrictions</u>

Selected Setpoint = 464 psig

Pump Restrictions:

$T \leq 95°F$	0 or 1 RCP
$95°F < T \leq 116°F$	0, 1, or 2 RCPs
$T > 116°F$	All RCPs may be in operation

where T is the indicated RCS temperature

a,c

Figure 7.4-2 Setpoint Window w/ Varying Number of RCPs Running

7.4.3 Setpoint Selection with Appendix G Limits Including Vessel Flange Requirements

Subsequent to the setpoint development described in Sections 7.4.1 and 7.4.2, the Appendix G limits were revised to account for the reactor vessel flange requirements. Reference 8 includes these revised Appendix G limits; a comparison between these values and the ones shown in Table 4.3-1 for 22EFPY are included in Table 7.4-2.

The effect of the flange limit is to reduce the pressure-temperature limits for temperatures below 180°F in comparison with the one used in the bulk of this analysis. Lowering the limit requires a lowering of the PORV setpoints by an amount equal to the difference between the two Appendix G limits at 60°F. This is because the following are not impacted by a reduction in the PORV setpoints due to the lower Appendix G limit.

- Pressure uncertainty - this is a constant value and is independent of RCS pressure.
- Pressure difference from the reactor vessel to the wide-range pressure transmitter. This is only affected by RCS flow and is independent of RCS pressure.
- Pressure overshoot values above the PORV setpoint – values used in Section 7.3 would be representative for this Appendix G limit revision

The impact of the flange limit on the PORV setpoint can be accounted for by reducing the PORV setpoint by the difference between the two Appendix G limits at the limiting 60°F point. From Table 7.4-2, this is the difference between [ ]^{a,c} psig and [ ]^{a,c} psig, or [ ]^{a,c} psig. Therefore, the PORV setpoints are the 434 psig value identified in Section 7.4-1 minus [ ]^{a,c} psi, or 403 psig.

If the number of RCPs that are operating is restricted during certain phases of plant operation, then a higher setpoint can be developed. From Table 4.5-1, the pressure differential between the wide range pressure transmitter and the reactor vessel is [ ]^{a,c} psi for one RCP operating vs. [ ]^{a,c} psi for all three RCPs operating. Therefore, the selected setpoint can be increased by the difference between these two pressure differences [ ]^{a,c} if only one RCP is operating. This would raise the setpoint to [ ]^{a,c} psig. However, this assumes that the MI analysis will remain limiting over the temperature range of interest (in this case, up to 180°F after which the flange limit disappears). From reviewing Table 7.2-2 and interpolating for a temperature of 180°F, the HI overshoot would be [ ]^{a,c} psi for an RCS temperature of 180°F. Therefore, the pressure setpoint has to be reduced by the difference between the MI and HI overshoot, or [ ]^{a,c} psi. Therefore, the selected setpoint would be [ ]^{a,c} 432 psig.

Now, this setpoint would have to remain valid until the Appendix G limit rises enough to accommodate at least the pressure differential between the wide range pressure transmitter and the reactor vessel for one RCP operating ([ ]^{a,c} psi, from Table 4.5-1) and the similar pressure differential for two RCPs operating [ ]^{a,c}. The Appendix G limit is constant at [ ]^{a,c} psig until a temperature of 180°F is achieved, at which time the Appendix G limit steps to [ ]^{a,c} psig. This is an increase of [ ]^{a,c} psig, which far exceeds the [ ]^{a,c} psi pressure

differential with one vs. all three RCPs operating ([ ]^{a,c} vs. [ ]^{a,c} psi from Table 4.5-1). Therefore, above 180°F, all pumps can be in operation. Note that these setpoints do not include temperature measurement instrumentation uncertainty.

Selected Setpoint = 432 psig
Pump Restrictions:

T ≤ 180°F	0 or 1 RCP
T > 180°F	All RCPs may be in operation

Via the same methodology, if it was desired to allow a minimum of two RCPs operating at any time during the OPPS operating period, the following setpoints would result:

Selected Setpoint = 419 psig
Pump Restrictions:

T ≤ 180°F	0, 1, or 2 RCPs
T > 180°F	All RCPs may be in operation

Table 7.4-2 Steady State Pressure/Temperature Limits with and without Reactor Vessel Flange Restriction – 22EFPY		
	No Flange Limit (Reference 6)	With Flange Limit (Reference 7)
Temp. (°F)	Press. (psig)	Press. (psig)

a,c

Table 7.4-2 Steady State Pressure/Temperature Limits with and without Reactor Vessel Flange Restriction – 22EFPY (Continued)		
	No Flange Limit (Reference 6)	With Flange Limit (Reference 7)
Temp. (°F)	Press. (psig)	Press. (psig)

a,c

7.4.4 Final Selected Setpoint

The setpoints developed in Section 7.4.2 for the Appendix G limit without the reactor vessel flange limitation and in Section 7.4.3 for the Appendix G limit with the flange limitation for cases where there is restricted pump operation below certain RCS temperatures are shown without temperature uncertainties. Per the requirements of Reference 5, the setpoints must provide Appendix G limit protection even with the consideration of instrument uncertainties. Therefore, the temperature values associated with the pump restriction regimes have to account for the temperature measurement uncertainty of [ ]^{a,c} °F (rounded up from [ ]^{a,c} °F) identified in Section 4.5.6. This is done by adding this temperature uncertainty to the temperature values shown in Sections 7.4.2 and 7.4.3.

A) No Reactor Vessel Flange Limitation

The limiting setpoints at T=60°F of 434 psig were selected as Beaver Valley Unit 1 uses a single setpoint for each PORV (i.e., no function generator is used). The selected setpoints are summarized below and shown in Figure 7.4-3. The applicable temperature for the cases with pump restrictions can be rounded up for operator convenience.

No Pump Restrictions
Selected Setpoint = 434 psig

RCP Pump Restrictions
Selected Setpoint = 464 psig
Pump Restrictions:

T ≤ 124°F	0 or 1 RCP
124°F < T ≤ 145°F	0, 1, or 2 RCPs
T > 145°F	All RCPs may be in operation

B) With Reactor Vessel Flange Limitation

The limiting setpoints at T=60°F of 403 psig were selected as Beaver Valley Unit 1 uses a single setpoint for each PORV (i.e., no function generator is used). The selected setpoints are summarized below and shown in Figure 7.4-4. The applicable temperature for the cases with pump restrictions can be rounded up for operator convenience.

No Pump Restrictions
Selected Setpoint = 403 psig

RCP Pump Restrictions – Maximum of 1 RCP Operation at Minimum Temperatures
Selected Setpoint = 432 psig
Pump Restrictions:

T ≤ 209°F	0 or 1 RCP
T > 209°F	All RCPs may be in operation

RCP Pump Restrictions – Maximum of 2 RCPs Operation at Minimum Temperatures
Selected Setpoint = 419 psig
Pump Restrictions:

$T \leq 209°F$	0, 1, or 2 RCPs
$T > 209°F$	All RCPs may be in operation

The above setpoints are common for both PORVs (PORV No. 1 and PORV No. 2). With the same setpoint for both PORVs, there is a potential for both valves to open simultaneously, then on closing, cause an undershoot that could violate the RCP No. 1 Seal limit.

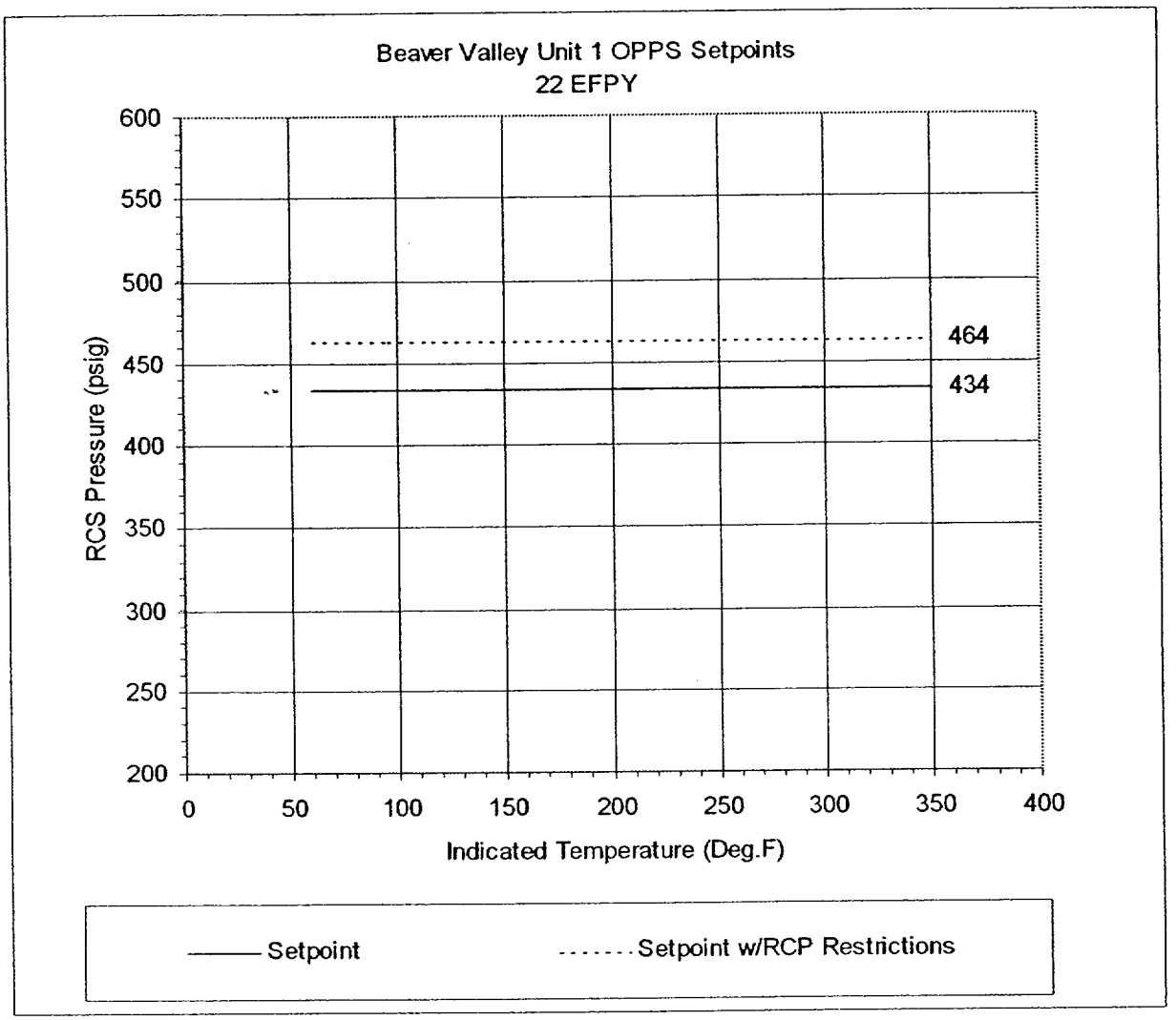

Figure 7.4-3 Beaver Valley Unit 1 OPPS Setpoints – No Flange Limit

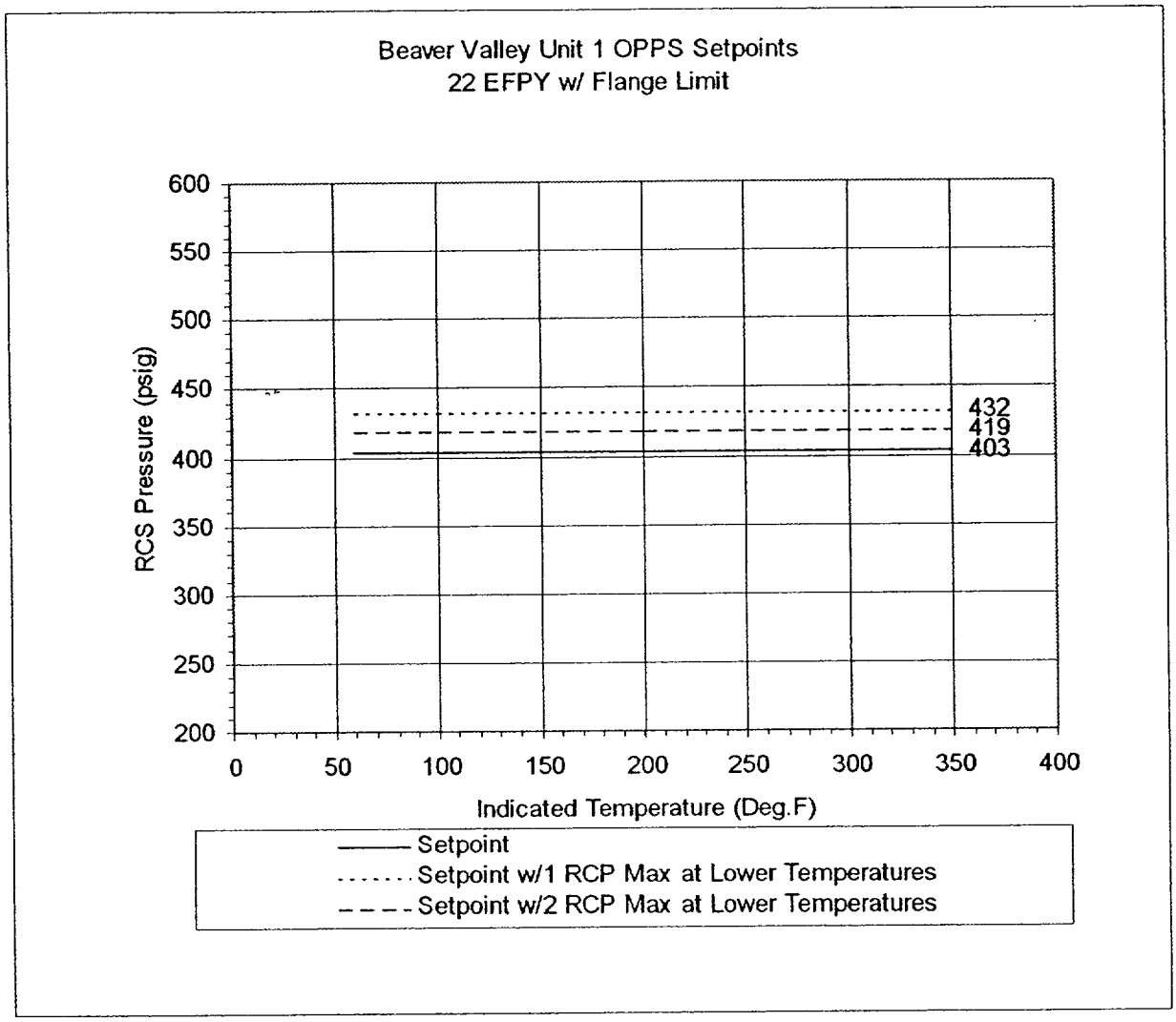

Figure 7.4-4 Beaver Valley Unit 1 OPPS Setpoints – With Flange Limit

8 OPPS ARMING AND ENABLE TEMPERATURE

Arming temperature (when OPPS should be switched on to be operable) is established where the Appendix G limit is 2500 psig. (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 waterhammer discharge slug that could challenge the piping limits. Based on this method, the arming temperature should be set as follows:

OPPS must be armed for RCS temperatures ≤ 343°F for 22EFPY

Per the requirements of Reference 5, the overpressure setpoints must protect against Appendix G limit violation, including the consideration of instrument uncertainties. Therefore, the temperature when the Appendix G limit reaches 2500 psig (i.e., [ ]^{a,c} °F) must be increased by the [ ]^{a,c} °F temperature uncertainty.

Enable temperature is calculated based on where RCS temperature is less than 200°F or materials 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 temperature is:

Enable Temperature = 308°F for 22EFPY

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 MI 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 HI 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 ≤ 343°F for 22EFPY