15.5 Increase in Reactor Coolant Inventory

Section 15.5 describes the following anticipated operational occurrences (AOO) that increase reactor coolant system (RCS) inventory during power operation:

- Section 15.5.1 - Inadvertent operation of emergency core cooling system (ECCS) or extra borating system (EBS).
- Section 15.5.2 - Malfunction of chemical and volume control system (CVCS).

15.5.1 Inadvertent Operation of ECCS or EBS

15.5.1.1 Identification of Causes and Event Description

The inadvertent operation of the ECCS event is an AOO that results from the spurious actuation of the safety injection system (SIS). The SIS (refer to Sections 5.4.7 and 6.3) consists of four trains, each with two pumps: the medium-head safety injection (MHSI) pump and the low-head safety injection (LHSI)/residual heat removal (RHR) pump. Each train also includes an accumulator pressurized with nitrogen gas. The pumps take suction from the in-containment refueling water storage tank (IRWST) and inject into the RCS cold leg via the ECCS header. Inadvertent operation of the ECCS is not an issue for the U.S. EPR because the SIS pumps are medium- and low-head pumps and lack sufficient head to deliver flow to the RCS at power conditions. The accumulators also do not inject at power conditions because the nitrogen gas pressure is below the normal RCS pressure. A spurious safety injection (SI) signal causes a reactor trip (RT), initiates partial cooldown, and isolates the RCS boundary. This scenario is bounded by the overcooling analyses presented in Section 15.1.

In addition to the SIS, the U.S. EPR has a manually actuated safety-related EBS that also increases the inventory of the RCS if it is inadvertently actuated. The EBS (described in Section 6.8) is a safety-related system designed to inject borated water into the RCS against RCS pressure following design-basis accidents. The system consists of two trains, each with a high-pressure, positive displacement pump, and an EBS tank. During normal operation the pumps are in standby mode and must be started manually. It is postulated that both EBS pumps are started with the corresponding isolation valves opening simultaneously to increase RCS inventory.

During normal operation, the pressurizer (PZR) level control maintains RCS inventory by regulating the CVCS letdown flow. Since the removal capacity of the letdown system is greater than the combined injection capacity of both EBS pumps, PZR level is maintained. However, for the purpose of this analysis, it is assumed the letdown flow path is closed and the charging flow is zero at the start of the event.

The PZR level increases until the protection system (PS) trips the reactor on high PZR level, which causes turbine trip. A loss of offsite power (LOOP) is assumed to occur with RT, which causes the reactor coolant pumps (RCP) to coast down and also causes the loss of main feedwater (MFW). Without MFW, the steam generator (SG) level drops. After a slight delay, the main steam relief trains (MSRT) open on the secondary side to control pressure. Emergency feedwater (EFW) is automatically actuated as SG level decreases to the actuation setpoint. During this time, the reduction in SG heat removal causes the RCS coolant to heat-up and expand, which contributes to the increase in PZR level. The resulting pressurization of the RCS causes the PZR safety relief valves (PSRV) to open to control primary system pressure. After 30 minutes, the operator terminates the event by de-energizing the EBS pumps or closing the EBS isolation valves. No other operator actions are credited. At this point, the plant is in a controlled state with continued secondary system heat removal, primary system pressure control, and PZR level control.

The EBS malfunction event is classified as an anticipated operational occurrence (AOO). The acceptance criteria for AOOs are in Section 15.0.0.2 and include:

- Pressure in the reactor coolant and main steam systems should be maintained below 110 percent of the design values.
- Fuel cladding integrity should be maintained by maintaining the minimum departure from nucleate boiling ratio (DNBR) above the 95/95 DNBR limit.
- An AOO should not generate a more serious plant condition without other faults occurring independently.

15.5.1.2 Method of Analysis and Assumptions

The S-RELAP5 computer code, described in Section 15.0.2.5, is used to calculate the transient thermal and hydraulic response of the primary and secondary systems in accordance with the NRC approved methodology described in AREVA Topical Report ANP-10263P-A (Reference 1). The computer code simulates the necessary components and contains the features required to model this event. This event is not limiting with respect to DNBR because pressure is increasing during the event until operator action is taken.

The following are assumed for analysis:

- Two EBSs actuate.
- The reactivity effects of EBS boron addition are neglected; the automatic rod position controller is in the manual mode.
- CVCS charging and letdown are assumed balanced and therefore are neglected.
- LOOP is assumed to occur with RT because, without LOOP, the RCPs remain in operation. This condition avoids the heatup and expansion of the RCS associated with establishing natural circulation.

- The single failure is the closure of one main steam relief control valve (MSRCV) when the main steam relief isolation valve (MSRIV) opens; equipment maintenance does not make the event more severe.

- The operation of non-safety-related equipment is assumed when it results in a more limiting transient. In this case, PZR heaters and sprays are assumed to operate as designed.

Table 15.5-1—Inadvertent Operation of the EBS - Key Input Parameters, presents the initial conditions and key inputs. Table 15.5-2 presents the status of mitigating equipment and components. The PS initiates RT on either high-PZR level or pressure.

To determine the limiting event for each acceptance criteria for the EBS malfunction event, a spectrum of scenarios are examined. The spectrum examines the range of initial conditions specified in Table 15.0-5, including time in cycle, with or without LOOP, with or without pressure control, zero percent or five percent tube plugging, manual rod control (MRC) or average coolant temperature (ACT) control, nominal or low initial RCS pressure, nominal, high, or low initial PZR levels, and high or low PSRV opening and closing tolerances. Because of the similarity between this event and the CVCS malfunction event described in Section 15.5.2, the limiting scenario and conditions determined for the CVCS malfunction event are used in this analysis.

The event is terminated by a high PZR level trip in conjunction with the operator de-energizing the EBS pumps or closing the EBS isolation valves after 30 minutes. The charging flow, if operational, is automatically isolated on RT with LOOP or at high PZR level for RT with no LOOP. SI and EFW are not actuated for this event. After RT, the MSRTs open to relieve SG pressure and this enhances primary-to-secondary heat transfer. Failure of one MSRT and closure of one MSRCV when the MSRIV opens, is the most limiting single failure because the reduced heat transfer from the primary system to the secondary system increases the heatup of the RCS.

The criterion pertaining to the DNBR is not challenged because the RCS pressure is increasing or constant and the power is constant during the event. RCS overpressurization is the primary concern and the RCS pressure is maintained within acceptance limits by the PSRVs. The secondary system pressure is maintained within acceptance limits by the MSRTs. The PZR does not overfill during the event, therefore the event does not lead to a more serious plant condition.

Various parameters are selected to maximize the RCS pressurization and overfill, based on the sensitivity studies performed for the CVCS malfunction event. The event analysis considers hot full power and low RCS loop flow rate. The limiting case conditions are: HFP, BOC, MRC, pressure control, LOOP, five percent SG tube plugging, nominal PZR pressure and level, and PSRVs biased low. The limiting case and the initial conditions for these cases are summarized in Table 15.0-62—Transient

Analysis Limiting Cases and Table 15.0-63—Transient Analysis Limiting Case Conditions, respectively. The results for the limiting case are presented below.

15.5.1.3 Results

Table 15.5-3 presents the sequence of events for this analysis. Figure 15.5-1 through Figure 15.5-5 show transient reactor power, core average heat flux, core inlet mass flux, RCS temperature, and PZR pressure.

PZR level increases because of the EBS injection until the reactor trips on high PZR level (see Figure 15.5-6). After RT, the level increase results mainly from primary coolant expansion due to the increase in SG pressure to the MSRT setpoint and established RCS conditions for natural circulation. The EBS injection continues to contribute to the level increase. EBS injection is terminated by the operator after 30 minutes. The peak PZR level is reached before the PZR fills (Figure 15.5-6). The PSRVs open just after RT to prevent overpressurization of the RCS (Figure 15.5-5). Flow through the PSRVs is provided in Figure 15.5-7.

Figure 15.5-8 shows the secondary pressure response and Figure 15.5-9 shows the EBS flow rate used in the analysis. Minimum DNBR is not challenged during the transient.

15.5.1.4 Radiological Consequences

No radiological consequences are associated with this event because no fuel or cladding failures occur, and no radiological releases to the environment occur. The discharge of primary fluid into containment due to PSRV opening is bounded by other events. Radiological evaluations are described in Section 15.0.3.

15.5.1.5 Conclusions

The following acceptance criteria derived from GDC 10, GDC 13, GDC 15, and GDC 26 (Section 3.0), as described in Section 15.0.0.2, are met for this event:

- Pressure in the reactor coolant and main steam systems are maintained below 110 percent of the design values presented in Section 5.1.4.
- Fuel-cladding integrity is maintained by keeping the minimum DNBR above the 95/95 DNBR limit.
- An AOO does not generate a more serious plant condition without other faults occurring independently.

RCS overpressurization is the primary concern for this event. The analysis shows the RCS is maintained within pressure acceptance limits by the PSRVs. The PZR does not overfill during the event. Secondary system pressure is maintained within acceptance limits by the MSRTs.

The criterion pertaining to minimum DNBR is not challenged because RCS pressure is increasing or constant during the transient. By terminating the EBS flow at 30 minutes, the operator brings the plant to a controlled state; therefore, this event does not lead to a more serious plant condition.

15.5.1.6 SRP Acceptance Criteria

A summary of the SRP acceptance criteria for Section 15.5.1 events included in NUREG-0800, Section 15.5.1–15.5.2, (Reference 2) and descriptions of how these criteria are met are listed below:

1. Pressure in the reactor coolant and main steam systems should be maintained below 110 percent of the design values.

   – Response: The inadvertent actuation of ECCS does not challenge RCS pressure limits because the MHSI and LHSI are respectively medium- and low-head systems with shutoff heads well below the PSRV opening setpoint. The EBS does not challenge RCS pressure limits because its flow capacity is much lower than that of the PSRVs.

2. Fuel-cladding integrity is maintained by keeping the minimum DNBR above the 95 percent probability/95 percent confidence DNBR limit.

   – Response: The criterion pertaining to minimum DNBR is not challenged because RCS pressure is increasing or constant during the transient.

3. An incident of moderate frequency should not generate a more serious plant condition without other faults occurring independently.

   – Response: Operator action to terminate the EBS flow at 30 minutes brings the plant to a controlled state. Therefore, this event does not lead to a more serious plant condition.

4. According to the SRP (Reference 2), the values of parameters used in the analytical model should be suitably conservative. The following values are considered acceptable for use in the model:

   A. The initial power level is taken as the licensed core thermal power for the number of loops initially assumed to be operating plus an allowance of two percent to account for power measurement uncertainties, unless a lower power level can be justified by the applicant. The number of loops operating at the initiation of the event should correspond to the operating condition which maximizes the consequences of the event.

      • Response: The initial power level is rated output plus measurement uncertainty. The four loops are operating at the initiation of the event, as required by technical specifications.

B. Conservative scram characteristics are assumed, i.e., for a PWR maximum time delay with the most reactive rod held out of the core and for a boiling water reactor (BWR) a design conservatism factor of 0.8 times the calculated negative reactivity insertion rate.

- Response: Conservative scram characteristics are assumed.

C. The core burnup is selected to yield the most limiting combination of moderator temperature coefficient, void coefficient, Doppler coefficient, axial power profile, and radial power distribution.

- Response: A conservative core burnup is selected for the analysis. The analysis is performed at beginning of cycle (BOC) with conservatively bounding feedback coefficients. This event does not challenge specified acceptable fuel design limits (SAFDL). Axial and radial power profiles are considered conservatively in the DNB analysis.

15.5.2 Chemical and Volume Control System Malfunction that Increases Reactor Coolant Inventory

15.5.2.1 Identification of Causes and Event Description

A malfunction in the PZR level control system is an AOO postulated to cause an increase in the RCS inventory. During normal operation, RCS inventory and PZR water level are controlled by the CVCS charging pumps and letdown control valve. The CVCS (refer to Section 9.3.4) maintains a constant charging flow and adjusts the letdown flow to account for volume changes due to RCS temperature variations. The PZR level control system continuously adjusts the CVCS letdown flow while a charging pump provides makeup. Normally, only one of the two CVCS charging pumps is in operation. If the PZR level falls low enough, the second CVCS pump starts. If level continues to fall, the letdown line is isolated. For maximizing the increase in RCS inventory, it is assumed that both charging pumps are operating and the letdown control valve is fully closed.

When pressure control is available, the PZR sprays actuate to maintain pressure as PZR level increases. If pressure control is terminated, RCS pressure increases. In either case, the increase in PZR level or pressure causes RT.

If LOOP is assumed to occur upon RT, the CVCS charging pumps are de-energized. The charging pumps are connected to the station blackout diesel generators (SBO), but do not start automatically. If LOOP does not occur, the charging pumps are isolated automatically when the PZR level reaches its safety-related high-level setpoint.

The turbine trips automatically following RT. If LOOP occurs, EFW is initiated automatically when the SG level reaches a low level. The turbine trip causes SG pressure to increase, resulting in a heatup of the primary system. If the turbine bypass system is not operating, the MSRTs operate to control secondary system pressure. The expansion of the RCS inventory contributes to an increase in PZR level. If pressure in the primary system increases to the PSRV setpoint, they open to terminate the pressure increase.

The event is terminated by an RT and safety-related isolation of the charging pump on high PZR level. No operator actions are required or credited during the event.

The CVCS malfunction event is classified as an anticipated operational occurrence (AOO). The acceptance criteria for AOOs are in Section 15.0.0.2 and include:

- Pressure in the reactor coolant and main steam systems should be maintained below 110 percent of the design values.
- Fuel cladding integrity should be maintained by maintaining the minimum departure from nucleate boiling ratio (DNBR) above the 95/95 DNBR limit.
- An AOO should not generate a more serious plant condition without other faults occurring independently.

15.5.2.2 Method of Analysis and Assumptions

The S-RELAP5 computer code, described in Section 15.0.2.5, is used to calculate the transient thermal and hydraulic response of the primary and secondary systems in accordance with the NRC approved methodology described in Reference 1. The computer code simulates the necessary components and contains the features required to model this event. The minimum DNBR is evaluated for this event using the methodology in AREVA Topical Report ANP-10269P-A (Reference 3).

The following are assumed for analysis:

- Two CVCS charging pumps actuate and letdown is isolated.
- LOOP is assumed to occur with RT because without LOOP RCPs remain in operation, which avoids the heatup and expansion of the RCS associated with establishing natural circulation.
- The single failure is the closure of one MSRCV when the MSRIV opens; equipment maintenance does not make the event more severe.
- The operation of non-safety-related equipment is assumed when it results in a more limiting transient. In this case, PZR heaters and sprays are assumed to operate as designed.
- No operator actions are credited to mitigate this event. However, it is assumed that the operator restarts one CVCS charging pump powered by the SBO diesel generator following LOOP because this action makes the event more severe.

Table 15.5-4 presents the initial conditions and key inputs. Table 15.5-5 presents the status of mitigating equipment and components. The PS initiates RT on either high PZR level or pressure.

To determine the limiting event for each acceptance criteria for the CVCS malfunction event, a spectrum of scenarios are analyzed. The spectrum examines the range of initial conditions specified in Table 15.5-5—Plant Parameters Used in Accident Analyses, including time in cycle, with or without LOOP, with or without pressure control, zero percent or five percent tube plugging, MRC or ACT control, nominal or low initial RCS pressure, nominal, high, or low initial PZR levels, and high or low PSRV opening and closing tolerances.

The event is terminated by a high PZR level or pressure. The charging flow, if operational, is automatically isolated on RT with LOOP or at high PZR level for RT with no LOOP. SI and EFW are not actuated for this event. After RT, the MSRTs open to relieve SG pressure and this enhances primary-to-secondary heat transfer. Failure of one MSRT and closure of one MSRCV when the MSRIV opens, is the most limiting single failure because the reduced heat transfer from the primary system to the secondary system increases the heatup of the RCS.

The criterion pertaining to the DNBR is not challenged because the RCS pressure is increasing or constant and the power is constant during the event. RCS overpressurization is the primary concern and the RCS pressure is maintained within acceptance limits by the PSRVs. The secondary system pressure is maintained within acceptance limits by the MSRTs. The PZR does not overfill during the event, therefore the event does not lead to a more serious plant condition.

Various parameters are selected to maximize the RCS pressurization and overfill. The event analysis considers hot full power and low RCS loop flow rate. Nominal initial values are used for some parameters such as Tavg, PZR pressure or liquid level, and SG level, since either the effect of these parameters are not significant or sensitivity studies show that these values are appropriate to use. Sensitivity studies also showed that the effect of ACT control is insignificant and that the BOC reactivity parameters are limiting.

A lower setpoint for the PSRVs opens the valves sooner and thereby increases the in-surge into the PZR and maximizes the final PZR level. The MSRTs are biased high to delay the opening and the secondary pressure relief, which maximizes the primary system expansion. The PZR high level and pressure trips are biased high to delay the RT. The charging isolation setpoint is biased high to maximize the inventory addition. The limiting case conditions are: HFP, BOC, MRC, pressure control, LOOP, five percent SG tube plugging, nominal PZR pressure and level, and PSRVs biased low. The limiting case and initial conditions for these cases are summarized in

Tables 15.0-62 and 15.0-63, respectively. The results for the limiting case are presented below.

15.5.2.3 Results

Table 15.5-6 presents the sequence of events for this scenario. Figure 15.5-10 through Figure 15.5-14 present, transient reactor power, core average heat flux, core inlet mass flux, RCS temperature, and PZR pressure.

The primary system temperature decreases slightly before RT (Figure 15.5-13) because of the low temperature of the charging fluid. PZR sprays maintain pressure relatively constant until RT at 783 seconds, when the sprays are lost on coastdown of the RCPs following LOOP (Figure 15.5-14). The operator is assumed to restart one CVCS charging pump powered by the SBO diesel generator. Subsequent pressure increase is a result of the continued increase in PZR level. The increase in pressure is terminated when PSRVs open to release steam. The PSRVs continue to cycle to control pressure (Figure 15.5-16). Figure 15.5-17 presents the secondary pressure response.

CVCS charging is terminated automatically when the PZR level reaches the PS high PZR CVCS isolation setpoint. Figure 15.5-18 shows the charging flow rates used in the analysis. The PZR level continues to increase as the RCS heats up to establish natural circulation, but peaks before the PZR completely fills (see Figure 15.5-15).

Minimum DNBR is not challenged during the transient since pressure is increasing or constant.

15.5.2.4 Radiological Consequences

No radiological consequences are associated with this event because no fuel or cladding failures occur, and no radiological releases to the environment occur. The discharge of primary fluid into containment due to PSRV opening is bounded by other events. Radiological evaluations are described in Section 15.0.3.

15.5.2.5 Conclusions

The following acceptance criteria derived from GDC 10, 13, 15, and 26 (Section 3.0), as described in Section 15.0.0.2, are met for this event:

- Pressure in the reactor coolant and main steam systems are maintained below 110 percent of the design value.
- Fuel-cladding integrity is maintained by keeping the minimum DNBR above the 95/95 DNBR limit.
- An AOO does not generate a more serious plant condition without other faults occurring independently.

RCS overpressurization is the primary concern for this event. The analysis shows the RCS is maintained within pressure acceptance limits by the PSRVs. The PZR does not overfill during the event. Secondary system pressure is maintained within acceptance limits by the MSRTs.

The criterion pertaining to minimum DNBR is not challenged because RCS pressure is increasing or constant during the transient. The PS automatically terminates the event by isolating CVCS charging flow on high PZR level, thereby enabling the plant to enter a controlled state. Therefore, this event does not lead to a more serious plant condition.

15.5.2.6 SRP Acceptance Criteria

A summary of the SRP acceptance criteria for Section 15.5.2 events included in NUREG-0800, Section 15.5.1–15.5.2, (Reference 2) and descriptions of how these criteria are met are listed below:

1. Pressure in the reactor coolant and main steam systems should be maintained below 110 percent of the design values.
   - Response: The PSRVs open to control RCS pressure. CVCS charging is terminated automatically when the PZR level reaches the PS high PZR CVCS isolation setpoint.
2. Fuel-cladding integrity is maintained by keeping the minimum DNBR above the 95 percent probability/95 percent confidence DNBR limit.
   - Response: The criterion pertaining to minimum DNBR is not challenged because RCS pressure is increasing or constant during the transient.
3. An incident of moderate frequency should not generate a more serious plant condition without other faults occurring independently.
   - Response: This event does not lead to a more serious plant condition.
4. According to the SRP (Reference 2), the values of parameters used in the analytical model should be suitably conservative. The following values are considered acceptable for use in the model:

   A. The initial power level is taken as the licensed core thermal power for the number of loops initially assumed to be operating plus an allowance of two percent to account for power measurement uncertainties, unless a lower power level can be justified by the applicant. The number of loops operating at the initiation of the event should correspond to the operating condition which maximizes the consequences of the event.
      - Response: The initial power level is rated output plus measurement uncertainty. The four loops are operating at the initiation of the event, as required by technical specifications.

B. Conservative scram characteristics are assumed, i.e., for a PWR maximum time delay with the most reactive rod held out of the core and for a BWR a design conservatism factor of 0.8 times the calculated negative reactivity insertion rate.

- Response: Conservative scram characteristics are assumed.

C. The core burnup is selected to yield the most limiting combination of moderator temperature coefficient, void coefficient, Doppler coefficient, axial power profile, and radial power distribution.

- Response: A conservative core burnup is selected for the analysis. The analysis is performed at BOC with conservatively bounding feedback coefficients. This event does not challenge SAFDLs. Axial and radial power profiles are considered conservatively in the DNB analysis.

15.5.3 References

1. ANP-10263P-A, Revision 0, "Codes and Methods Applicability Report for the U.S. EPR," AREVA NP Inc., November 2007.

2. NUREG-0800, "U.S. NRC Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, March 2007.

3. ANP-10269P-A, Revision 0, "The ACH-2 CHF Correlation for the U.S. EPR Topical Report," AREVA NP Inc., March 2008.

Table 15.5-1—Inadvertent Operation of the EBS - Key Input Parameters

Parameter	Analysis Value
Initial reactor power	4612 MW_t
Initial RCS loop flow rate	119,692 gpm/loop
Initial reactor vessel average temperature	594°F
Initial PZR pressure	2250 psia
Initial PZR liquid level	54.3%
Initial main steam pressure	1090 psia
Feedwater flow rate	1442 lb_m/s
Feedwater temperature	446°F
Initial SG level	49% NR
SG tube plugging	5%
MSRIV/MSRT opening pressure	1414.7 psia
PSRV open setpoints	2499.0 psia
Moderator temperature coefficient (BOC) [1]	0 pcm/°F
Doppler reactivity feedback (BOC) [1]	-1.17 pcm/°F
High PZR pressure trip setpoint (RT, TT)	2439.9 psia
High PZR level trip	80.5%

Note:

1. Beginning of Cycle.

Table 15.5-2—Inadvertent Operation of the EBS - Key Equipment Status

Plant Equipment or System	Status
RPS	Operable
Rod position controller	Manual
RCCAs	Most reactive RCCA failed in full withdrawn position
PZR heaters/sprays	Available (more limiting)
MSRT/MSSV/PSRV	All except one MSRT operable (unavailable due to SF)
MFW	Isolated at RT for cases with LOOP
EFW	Two out of four available (not actuated)
RCPs	Operating until LOOP
Turbine bypass/partial trip	Not credited
Charging pumps	Operable (not operating, consistent with letdown assumption)
EBS pumps	Two available
CVCS letdown	Not operating (conservative assumption)
MHSI/LHSI	Not applicable

Table 15.5-3—Inadvertent Operation of the EBS - Sequence of Events

Event	Time (s)
Transient start, both EBS pumps start, charging and letdown flow equal to zero	0
PZR level, 75.5%	1180
RT on high PZR level, turbine trip, LOOP, RCPs trip, charging pumps trip	1446
PZR spray lost due to LOOP	1446
First opening of PSRV	1557
PZR level reaches 85.5%	1665
First opening of MSRTs	1820
EBS flow terminated by operator	1860
Maximum PZR level reached (98.7%)	3422
End of calculation	3600

Table 15.5-4—CVCS Malfunction that Increases RCS Inventory - Key Input Parameters

Parameter	Analysis Value
Initial reactor power	4612 MW_t
Initial RCS loop flow rate	119,692 gpm/loop
Initial reactor vessel average temperature	594°F
Initial PZR pressure	2250 psia
Initial PZR liquid level	54.3%
Initial main steam pressure	1090 psia
Feedwater flow rate	1442 lb_m/s
Feedwater temperature	446°F
Initial SG level	49% NR
SG tube plugging	5%
MSRIV/MSRT opening pressure	1414.7 psia
PSRV open setpoints	2499.0 psia
Moderator temperature coefficient (BOC) [1]	0 pcm/°F
Doppler reactivity feedback (BOC) [1]	-1.17 pcm/°F
High PZR pressure trip setpoint (RT, TT)	2439.9 psia
High PZR level trip	80.5%
High PZR level for charging isolation	85.5%

Note:

1. Beginning of Cycle.

Table 15.5-5—CVCS Malfunction that Increases RCS Inventory - Key Equipment Status

Plant Equipment or System	Status
PS	Operable
Rod position controller	Manual
RCCAs [1]	Most reactive RCCA failed in full withdrawn position
PZR heaters/sprays	Available (conservative assumption)
MSRT/MSSV/PSRV	All except one MSRT operable (one MSRT unavailable due to SF)
MFW	Isolated at RT for cases with LOOP
EFW	Two out of four available (not actuated)
RCPs	Four available, operating until LOOP
Turbine bypass/partial trip	Not credited
Charging pumps	Available, both pumps operating until LOOP, one pump restarted after LOOP (assumed operator error)
CVCS letdown	Not operating (consistent with event initiation)
MHSI/LHSI	Not applicable

Note:

1. Rod Cluster Control Assembly.

Table 15.5-6—CVCS Malfunction that Increases RCS Inventory - Sequence of Events

Event	Time (s)
Transient start, letdown isolated, both charging pumps operating	0
PZR level, 75.5%	641
RT on high PZR level, turbine trip, LOOP, RCPs trip	783
PZR spray lost due to LOOP	783
Charging pumps isolated on LOOP with 40 second delay (one charging pump restarted as a worst case assumption)	823
First opening of PSRV	890
PZR level reaches 85.5%	979
Charging pumps isolated with 40 second delay	1019
First opening of MSRT	1177
Maximum PZR level reached (98.6%)	2142
End of calculation	2500

Figure 15.5-1—Inadvertent Operation of the EBS - Transient Reactor Power

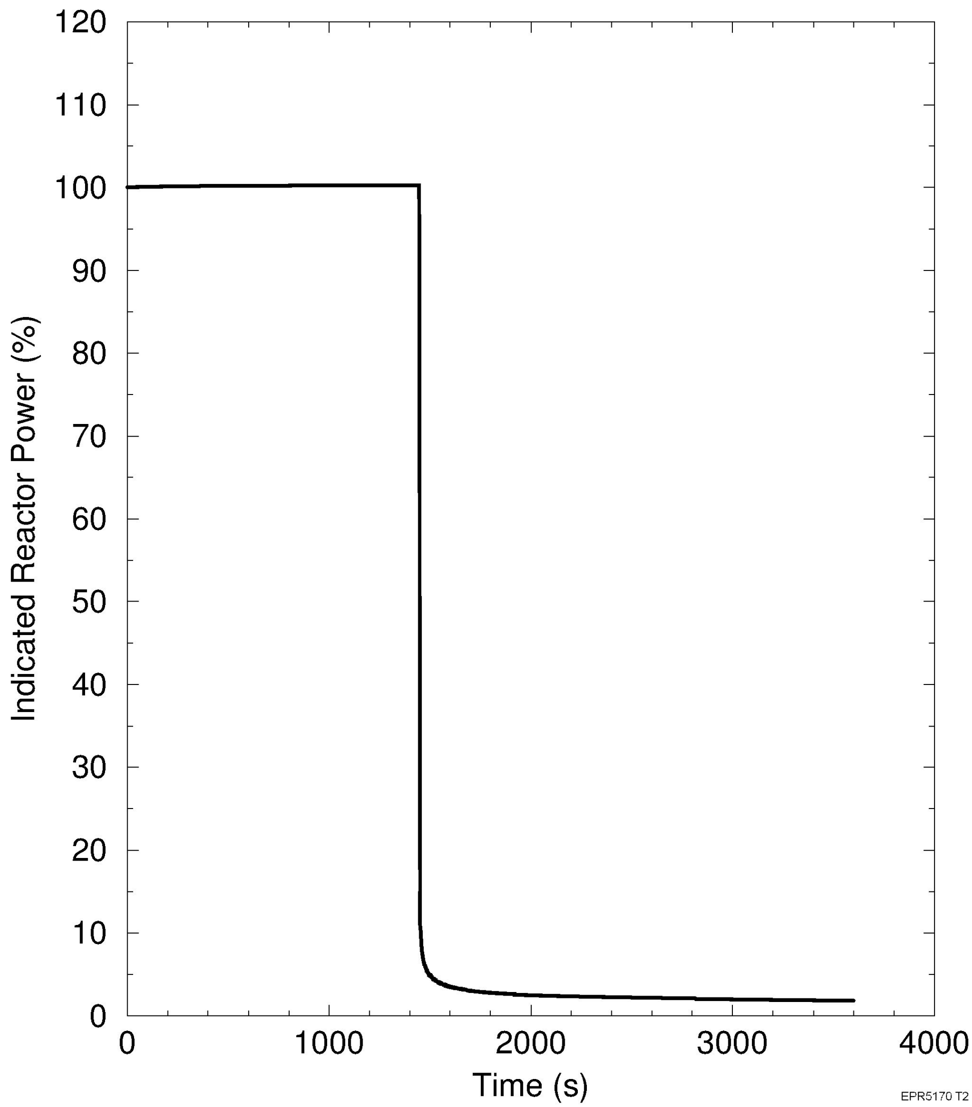


Figure 15.5-2—Inadvertent Operation of the EBS - Core Average Heat Flux

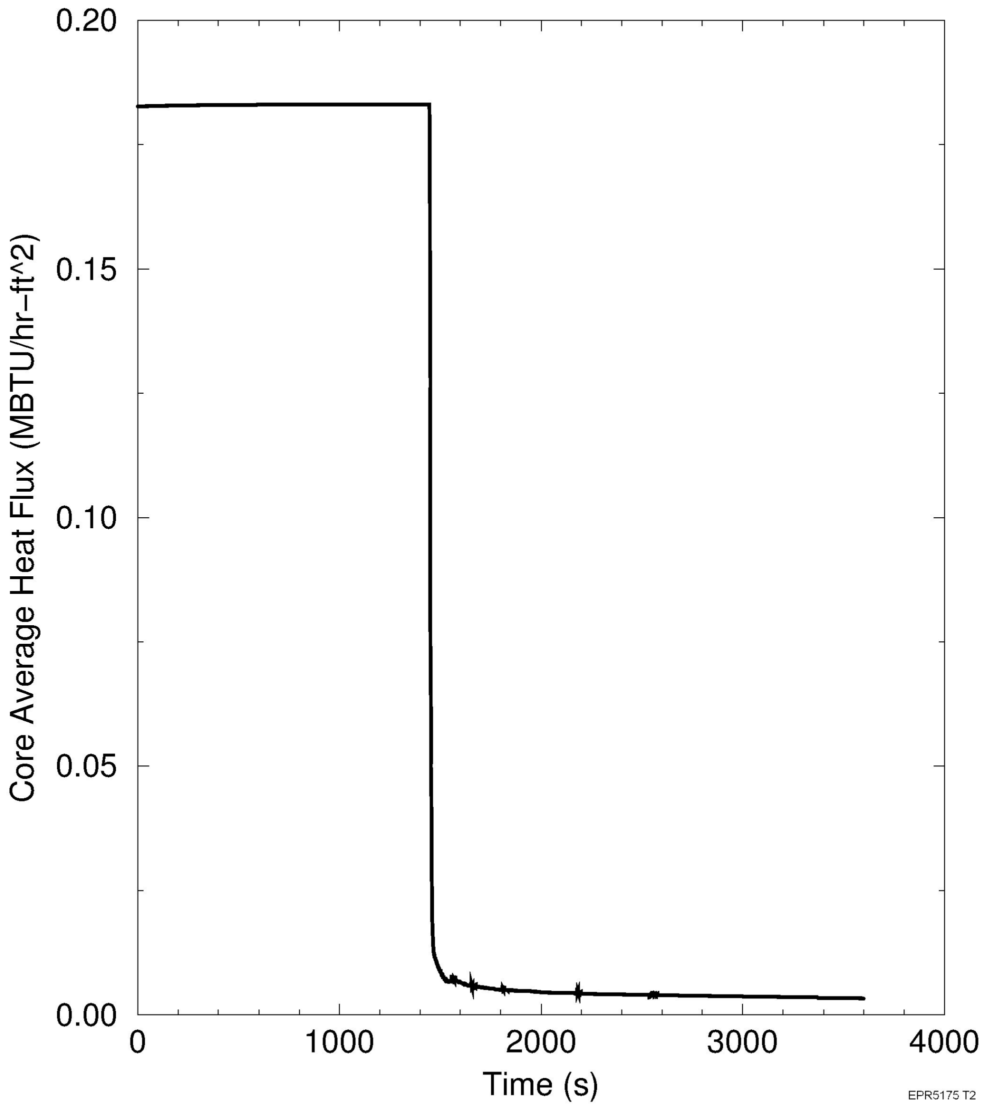


Figure 15.5-3—Inadvertent Operation of the EBS - Core Inlet Mass Flux

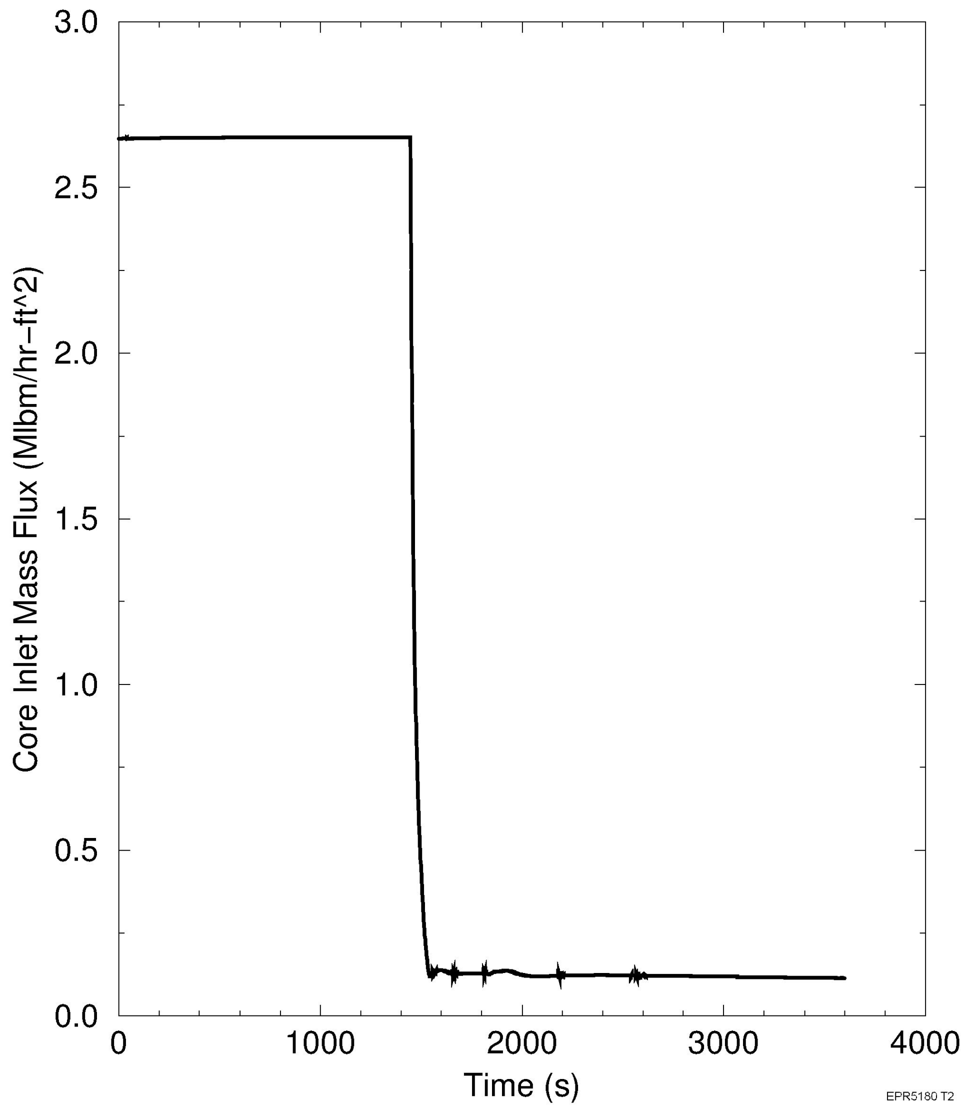


Figure 15.5-4—Inadvertent Operation of the EBS - RCS Temperature

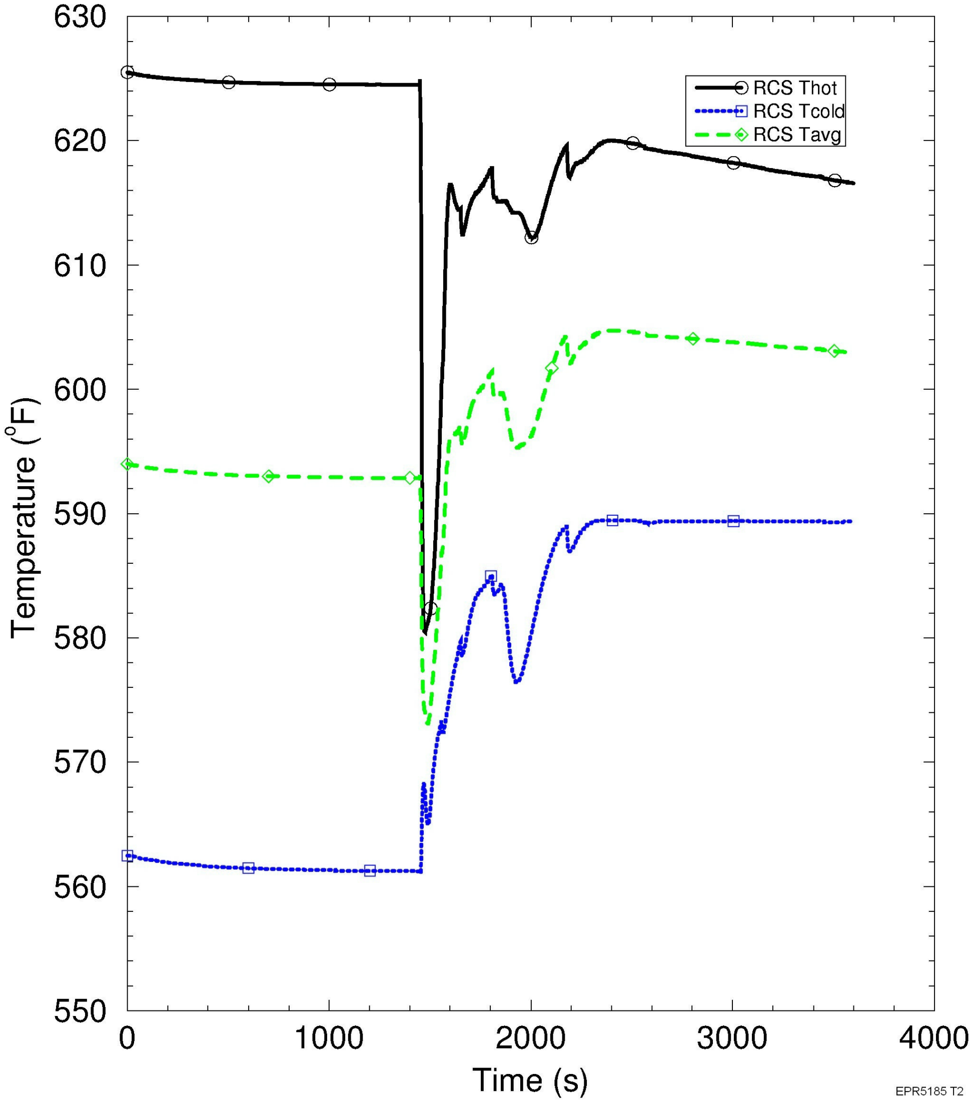


Figure 15.5-5—Inadvertent Operation of the EBS - PZR Pressure

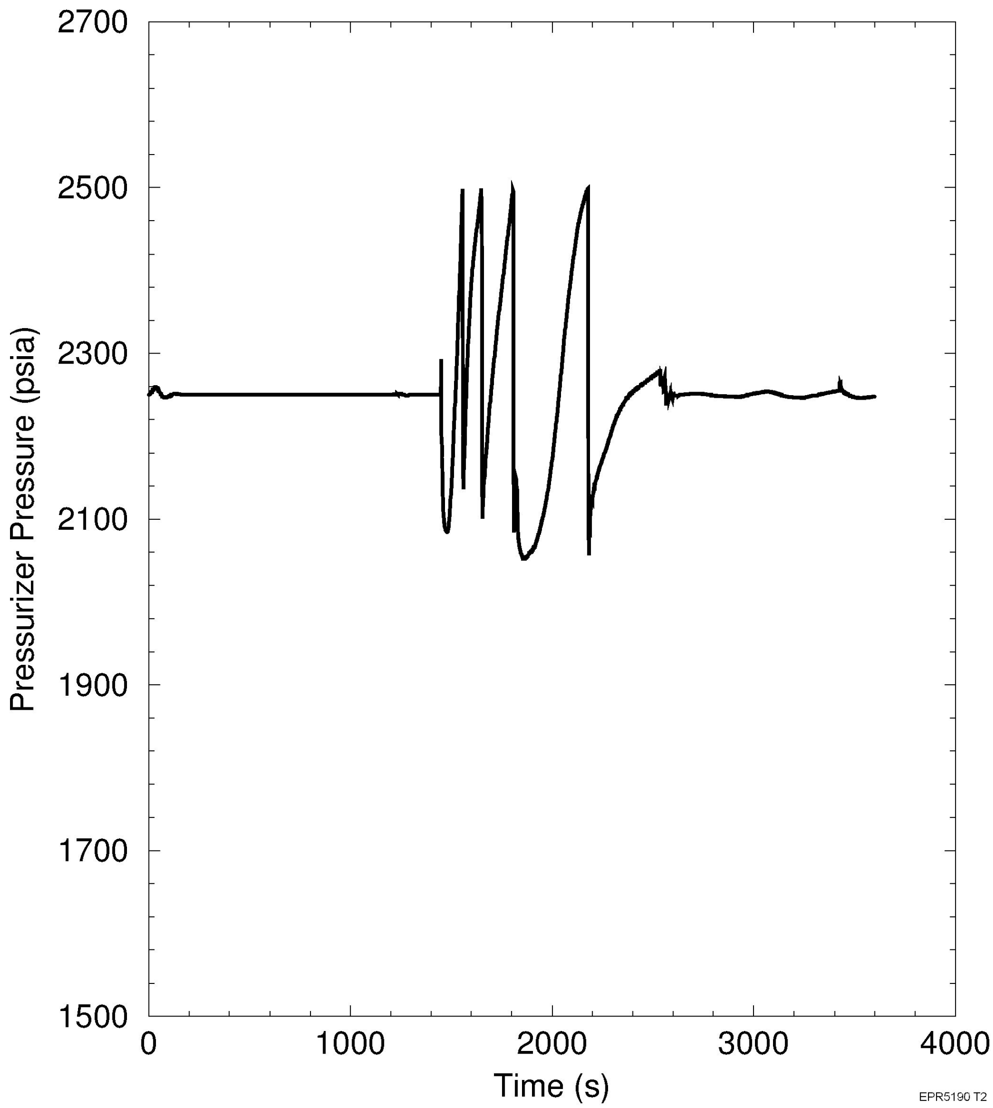


Figure 15.5-6—Inadvertent Operation of the EBS - PZR Level

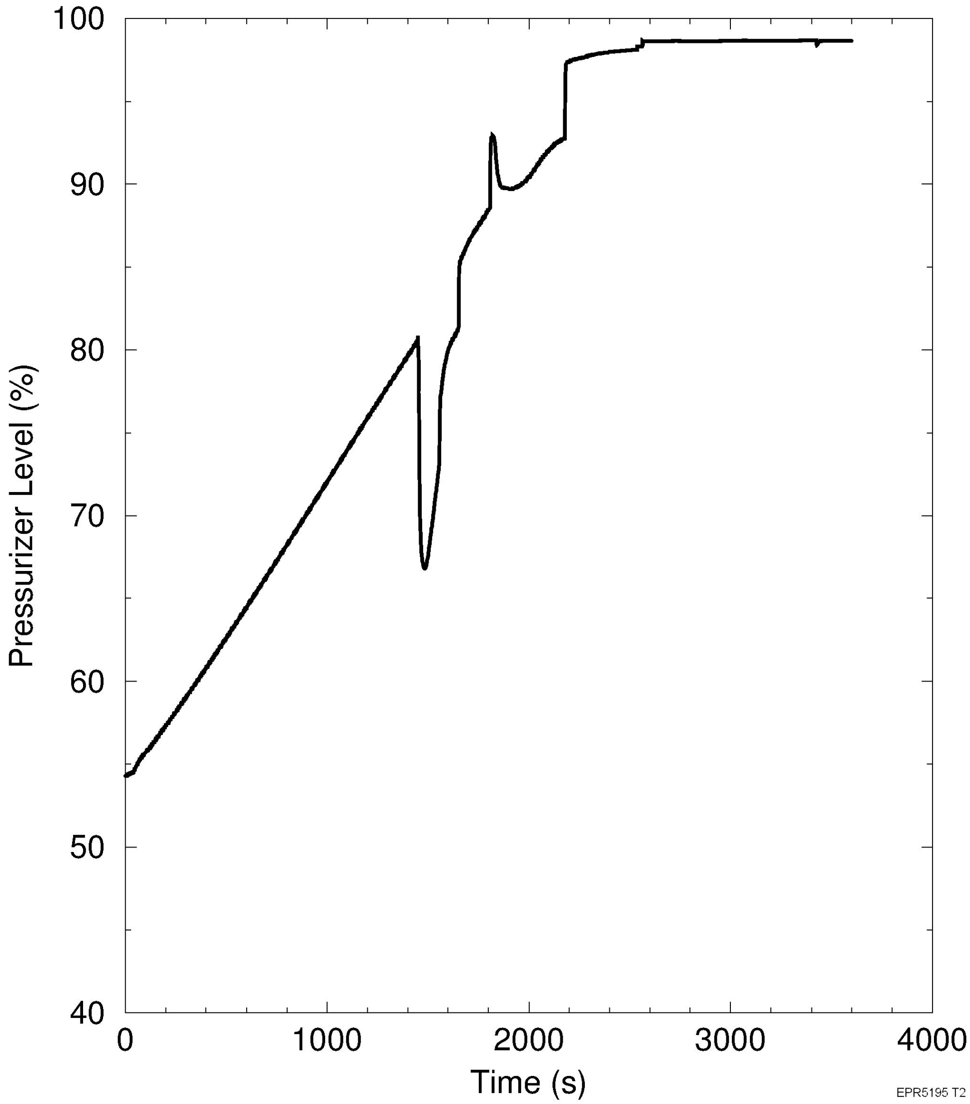


Figure 15.5-7—Inadvertent Operation of the EBS - PSRV Flow

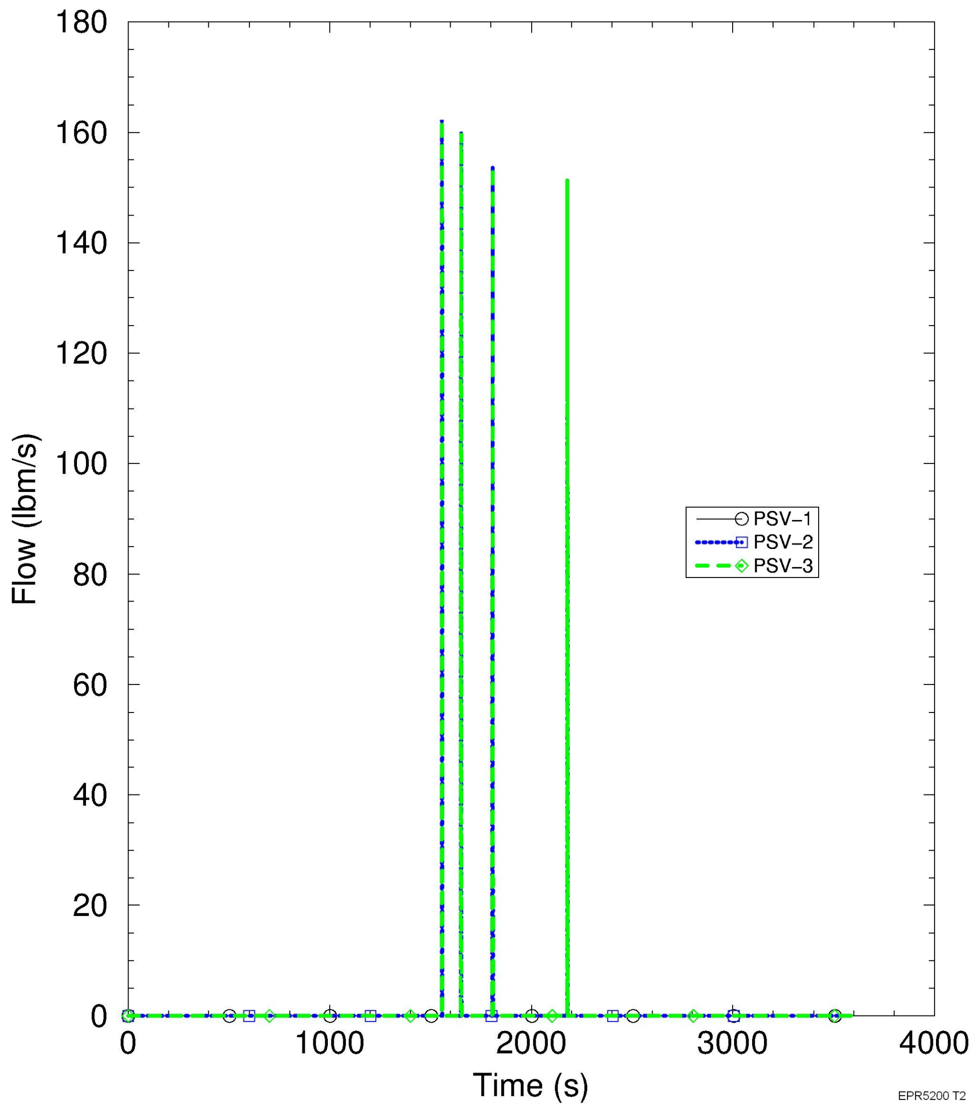


Figure 15.5-8—Inadvertent Operation of the EBS - SG Pressure

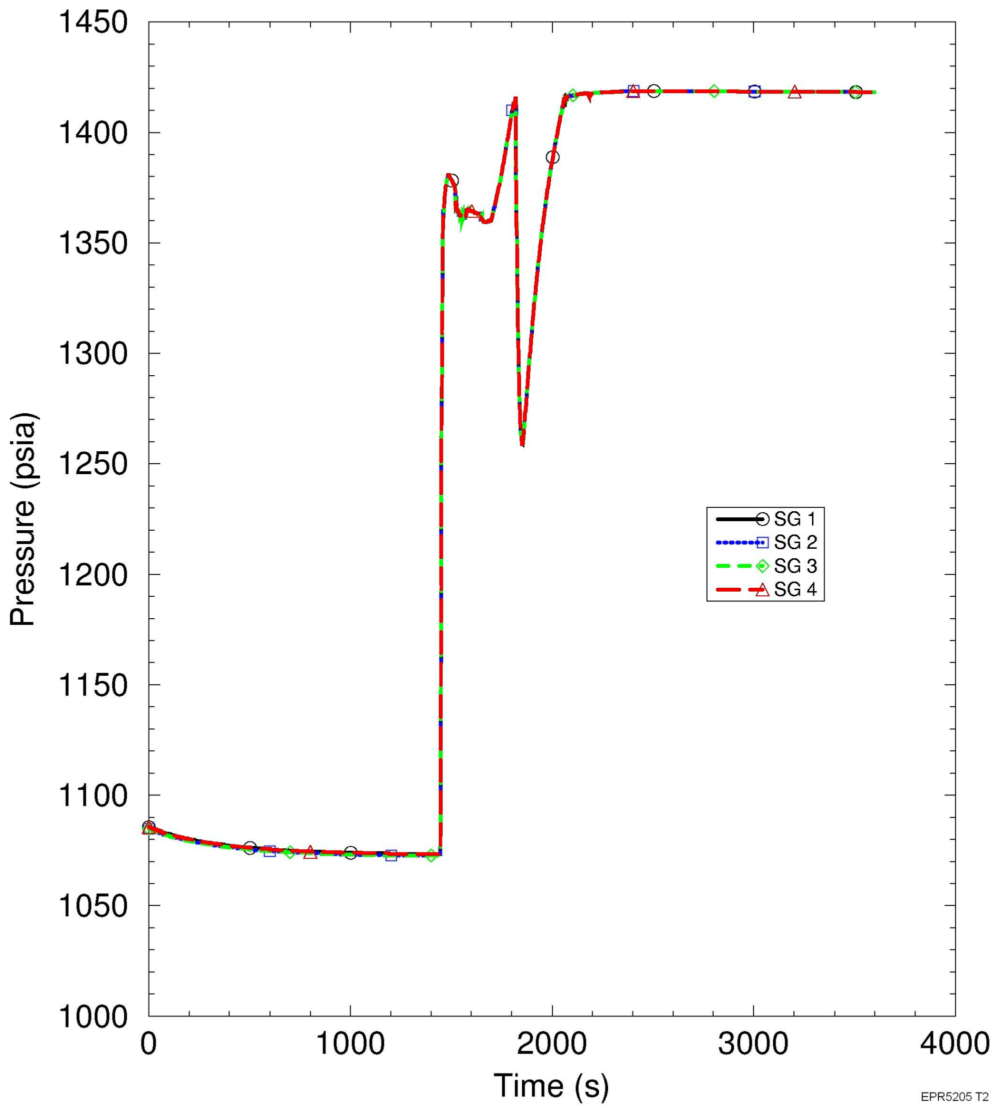


Figure 15.5-9—Inadvertent Operation of the EBS - EBS Flow

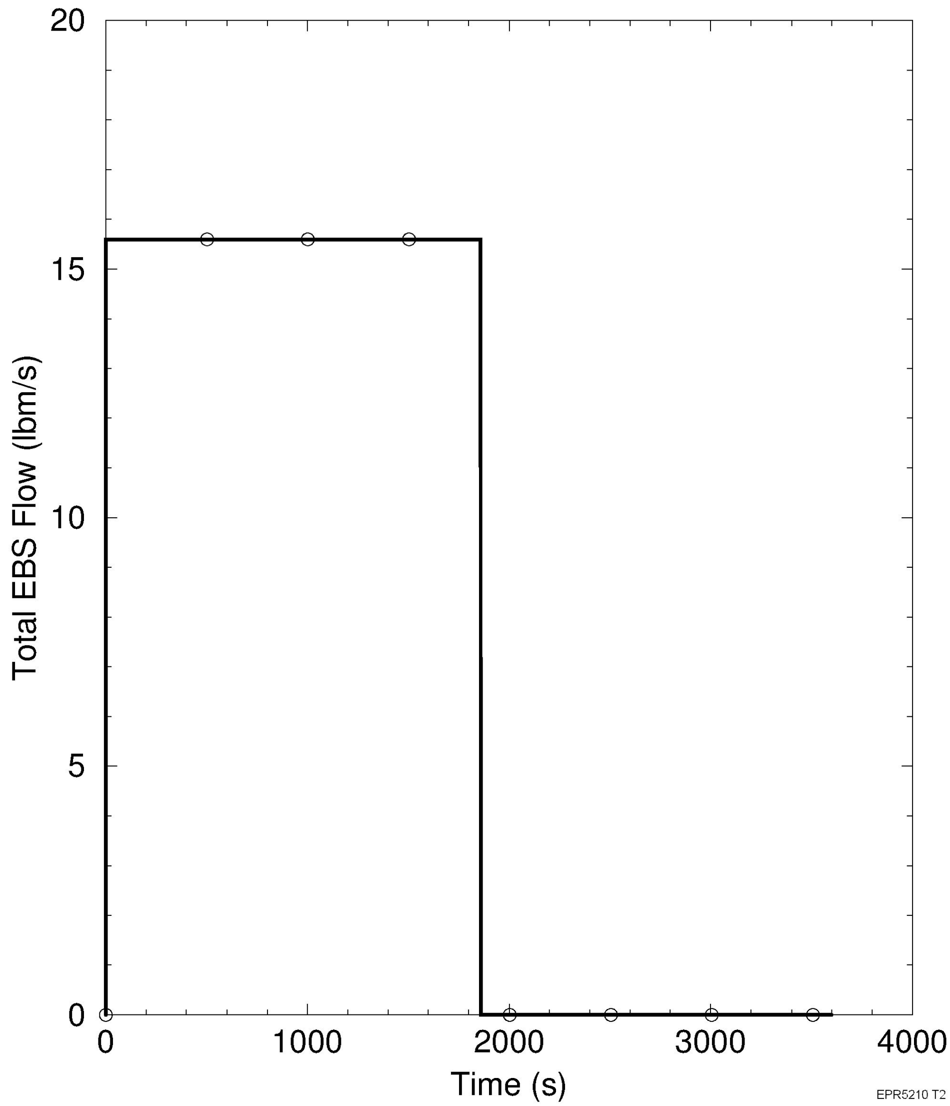


Figure 15.5-10—CVCS Malfunction that Increases RCS Inventory - Transient Reactor Power

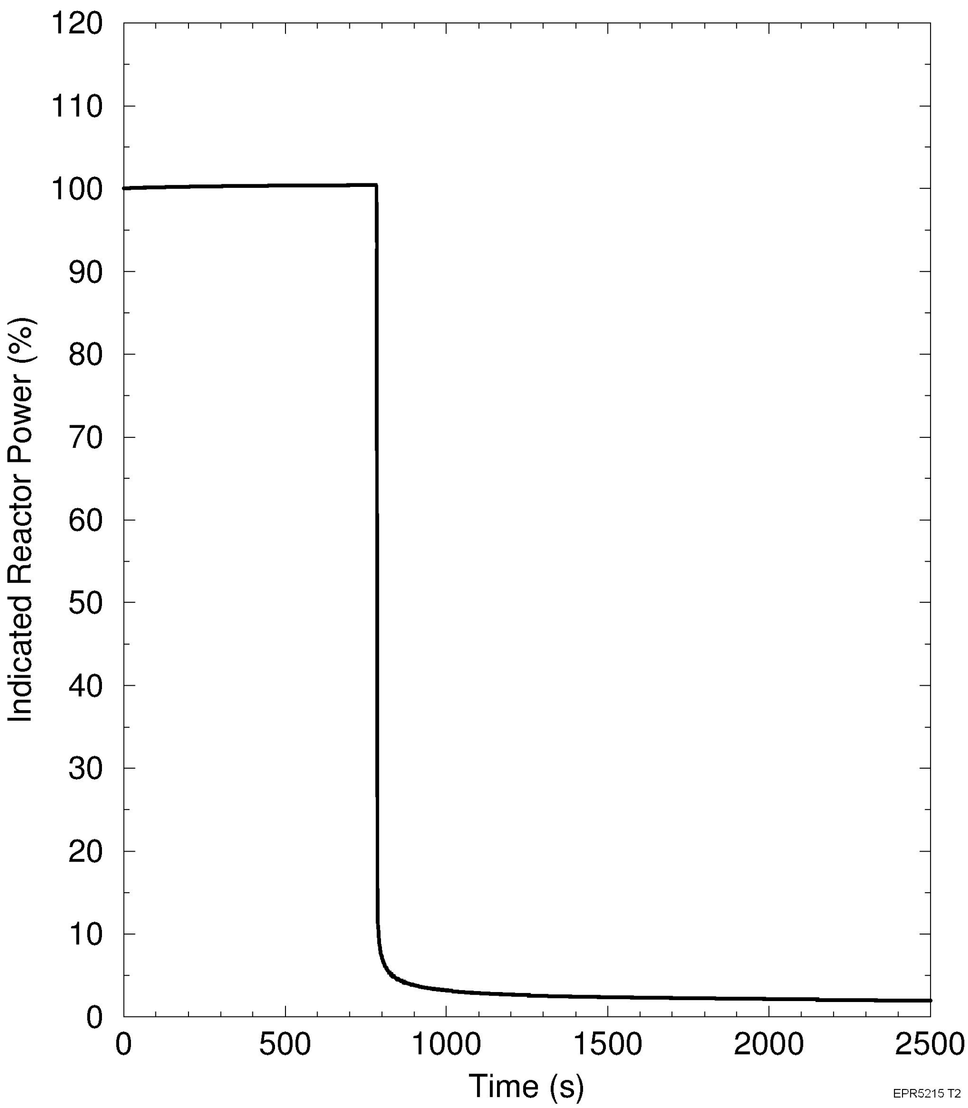


Figure 15.5-11—CVCS Malfunction that Increases RCS Inventory - Core Average Heat Flux

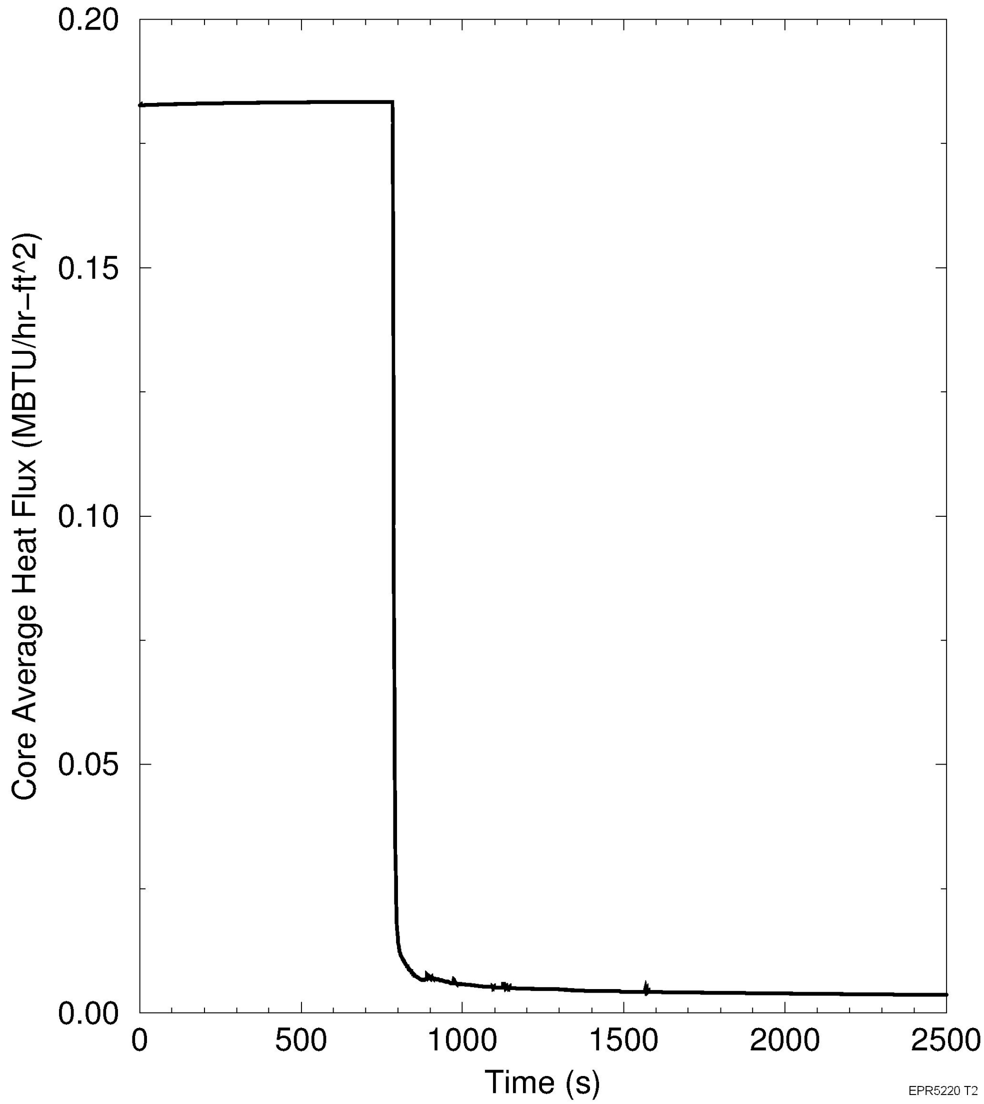


Figure 15.5-12—CVCS Malfunction that Increases RCS Inventory - Core Inlet Mass Flux

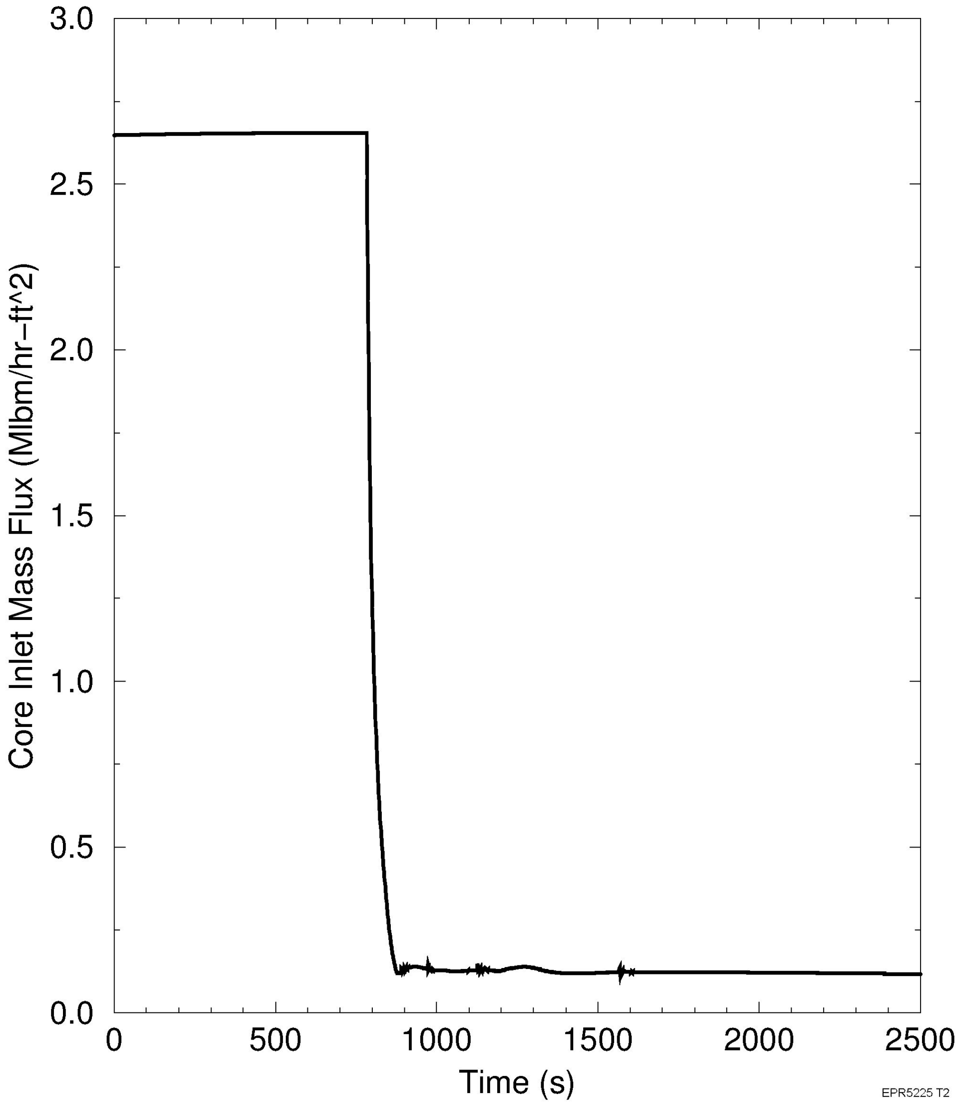


Figure 15.5-13—CVCS Malfunction that Increases RCS Inventory - RCS Temperature

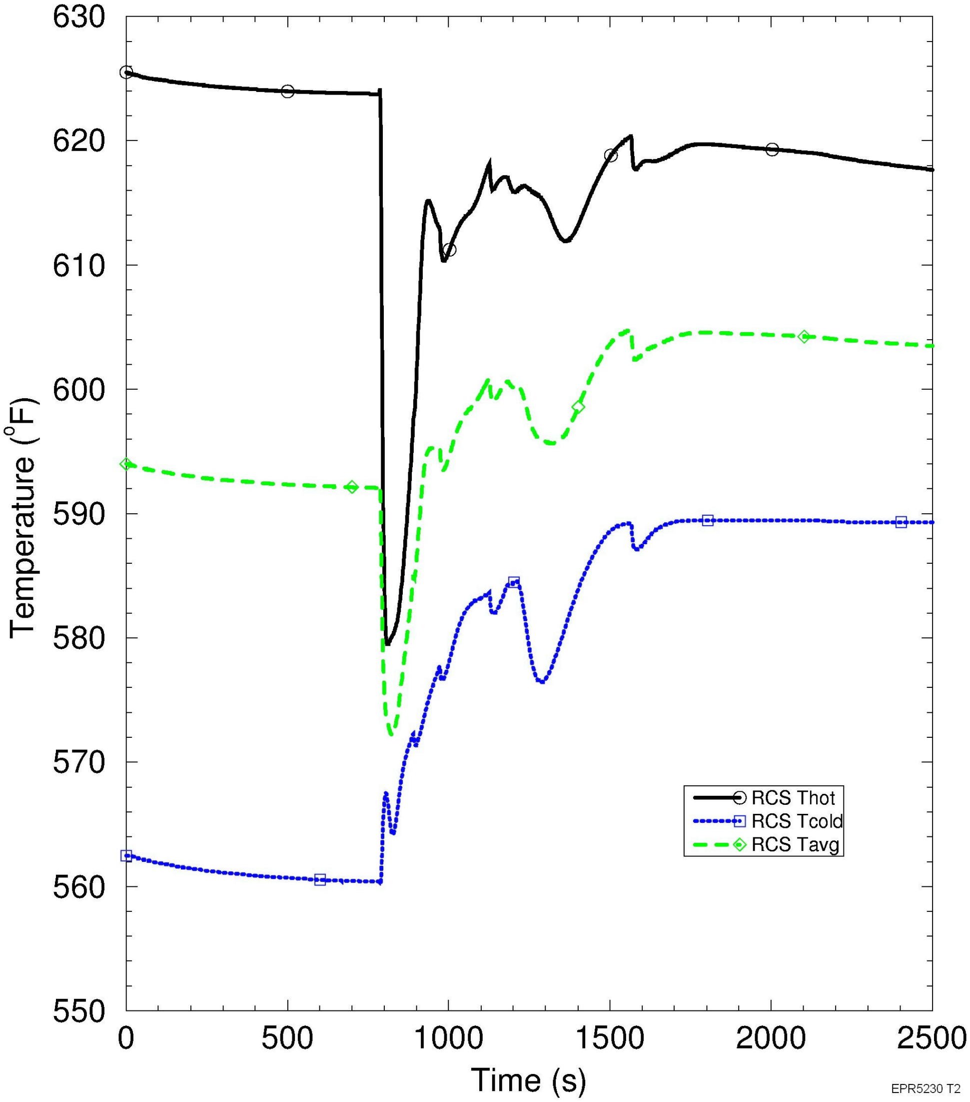


Figure 15.5-14—CVCS Malfunction that Increases RCS Inventory - PZR Pressure

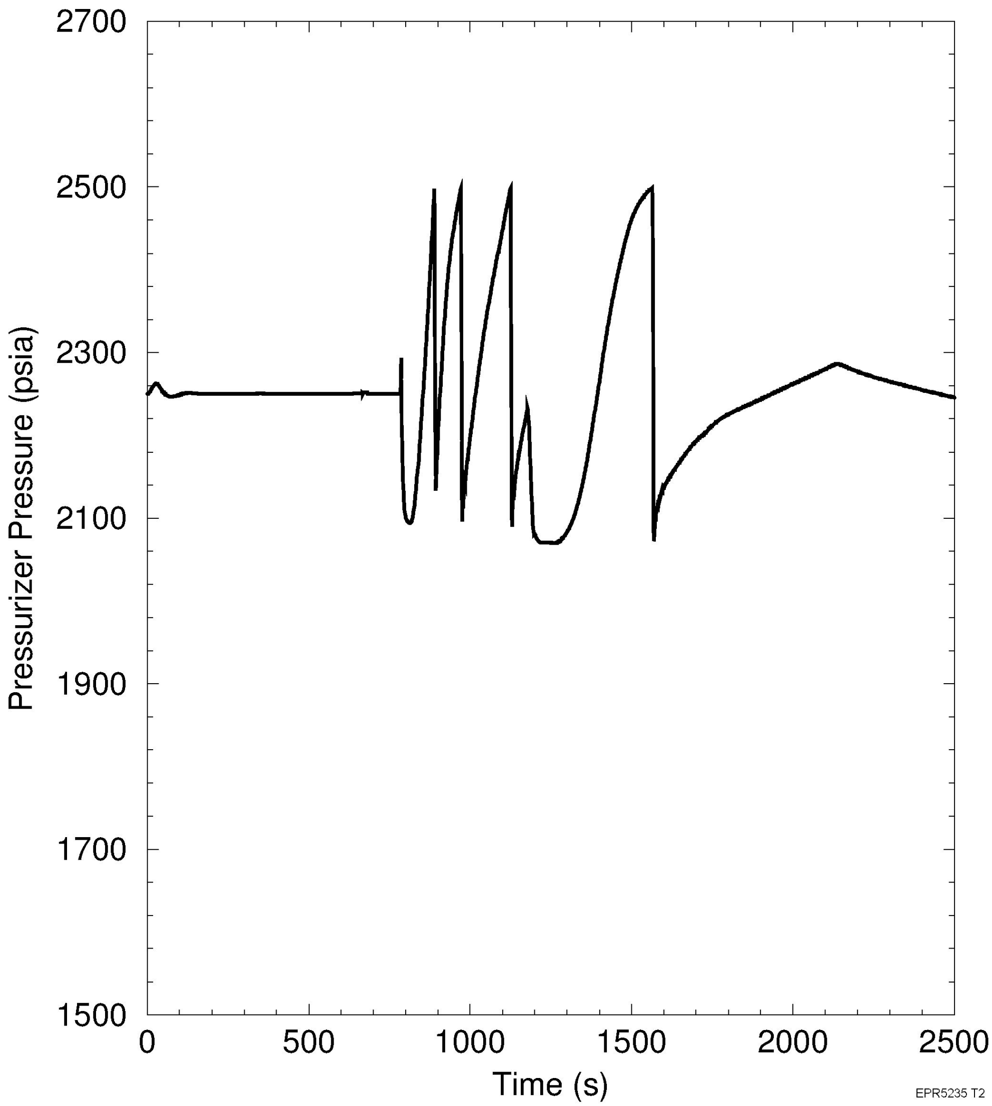


Figure 15.5-15—CVCS Malfunction that Increases RCS Inventory - PZR Level

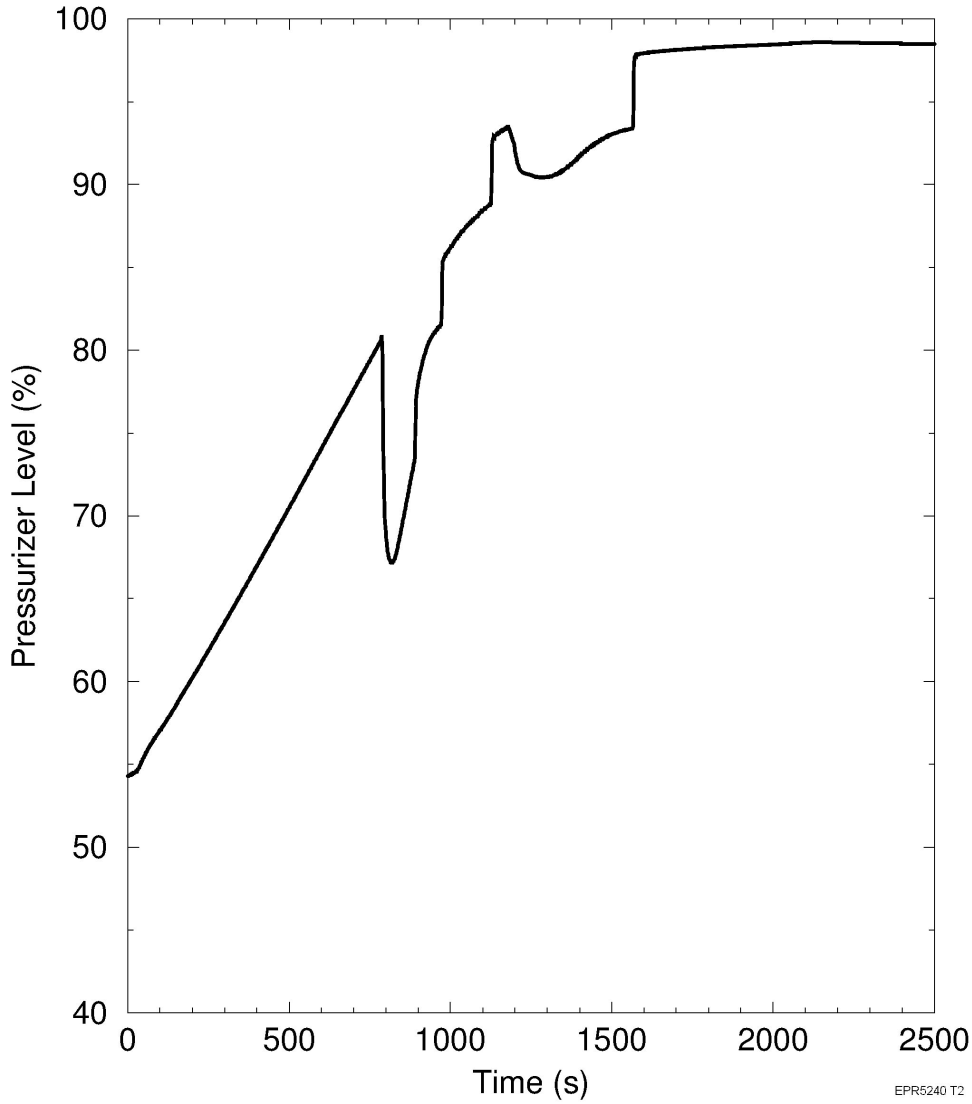


Figure 15.5-16—CVCS Malfunction that Increases RCS Inventory - PSRV Flow

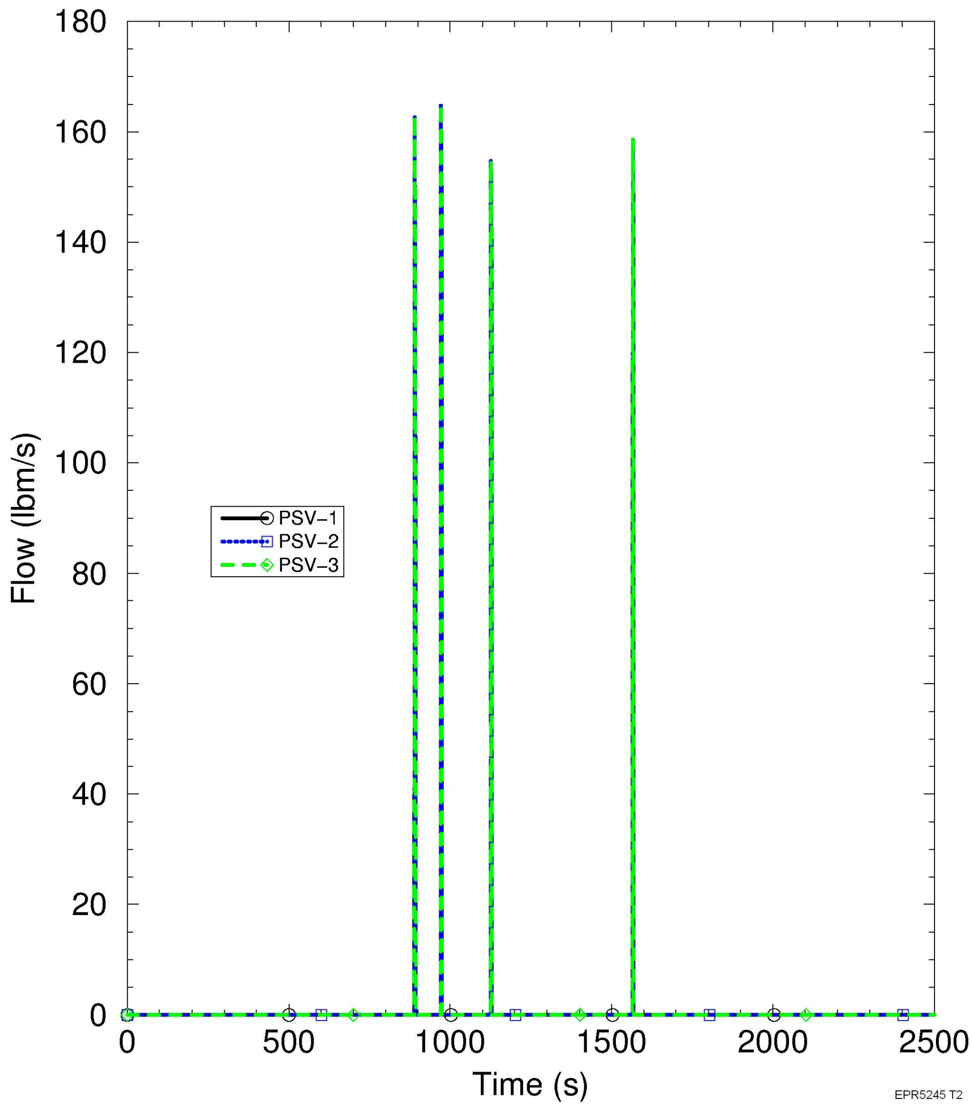


Figure 15.5-17—CVCS Malfunction that Increases RCS Inventory - SG Pressure

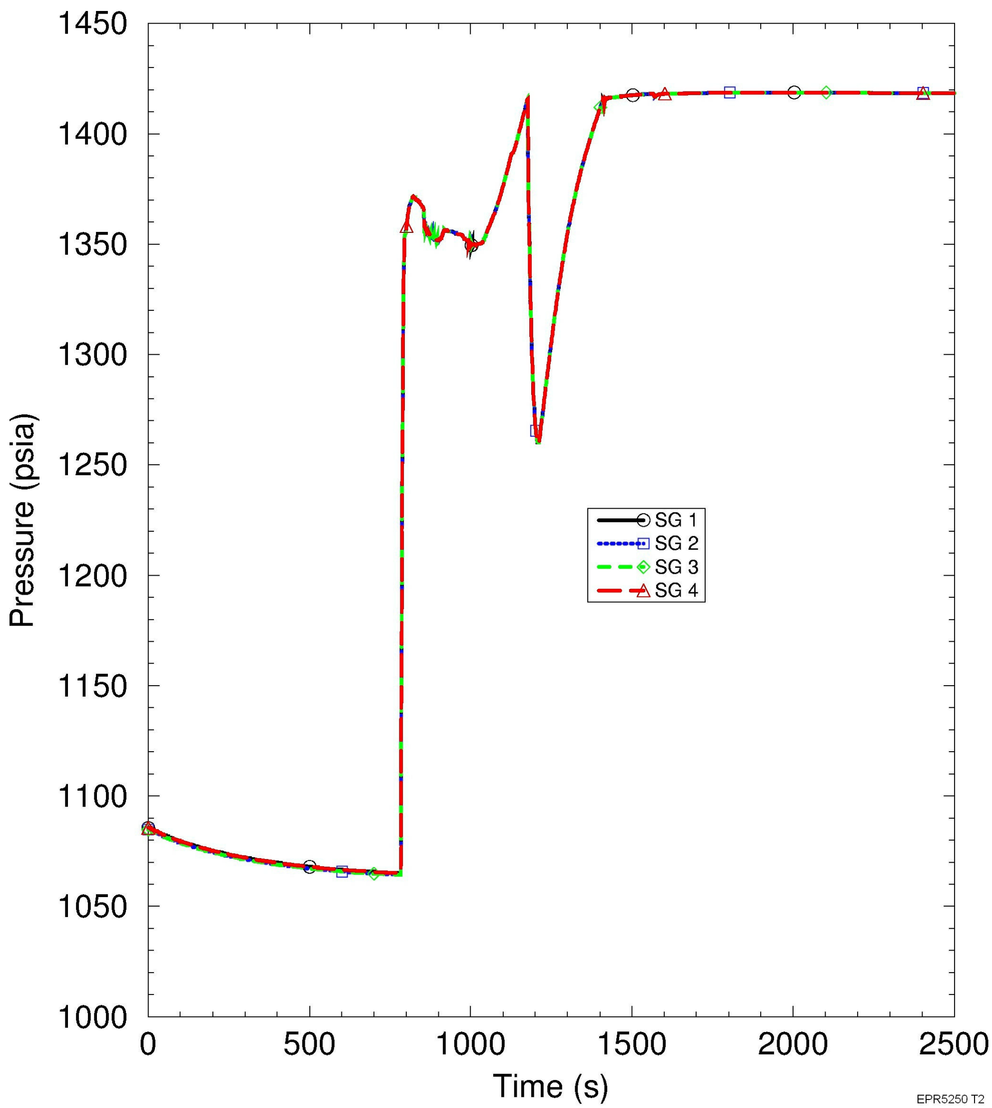
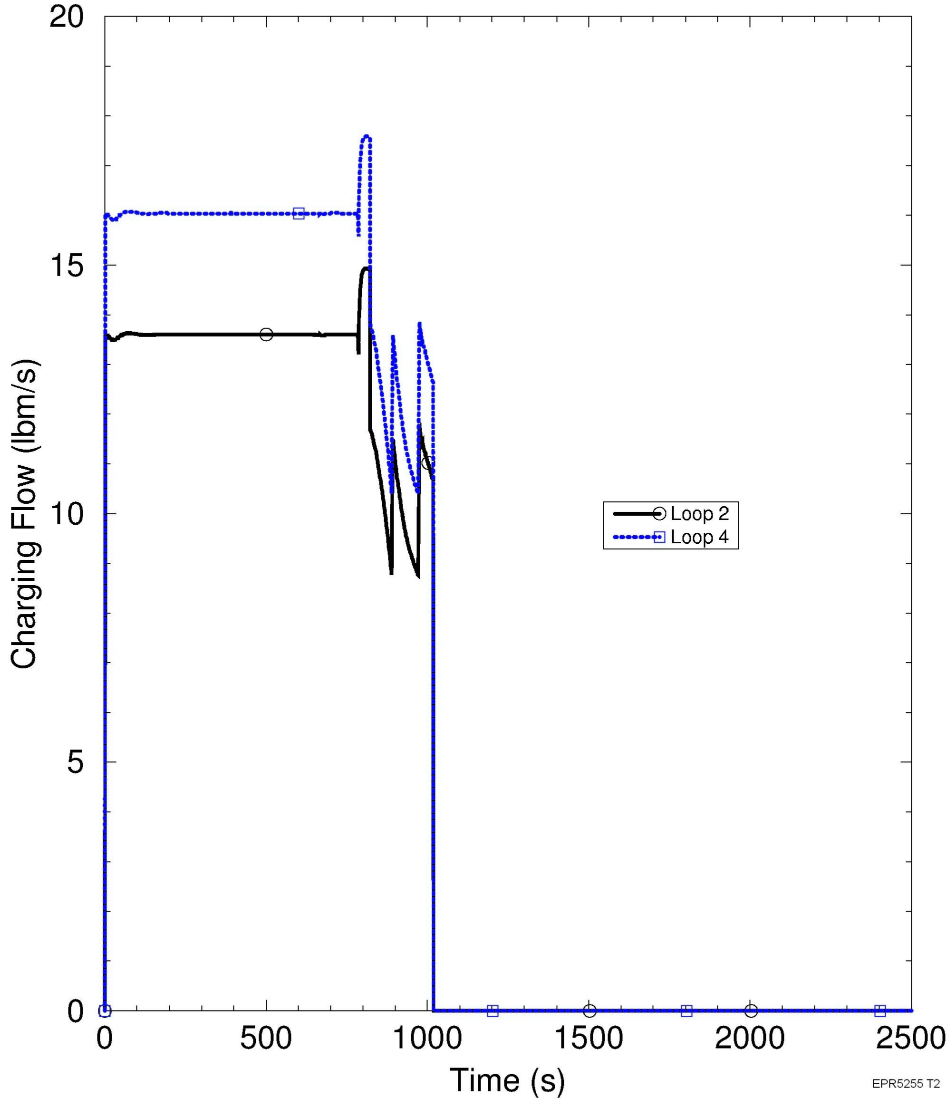


Figure 15.5-18—CVCS Malfunction that Increases RCS Inventory - Charging Flow



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