VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

May 27, 2003

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

Serial No. 03-245
NLOS/ETS R0
Docket Nos. 50-338/339
License Nos. NPF-4/7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
SMALL BREAK LOSS OF COOLANT ACCIDENT (SBLOCA) ANALYSIS RESULTS FOR THE PROPOSED TECHNICAL SPECIFICATIONS CHANGES AND EXEMPTION REQUEST FOR USE OF FRAMATOME ANP ADVANCED MARK-BW FUEL

In a March 28, 2002 letter (Serial No. 02-167), Virginia Electric and Power Company (Dominion) requested an amendment to Facility Operating License Numbers NPF-4 and NPF-7 and associated exemptions from 10 CFR 50.44 and 10 CFR 50.46 for North Anna Power Station Units 1 and 2. The amendments and exemptions will permit North Anna Units 1 and 2 to use Framatome ANP Advanced Mark-BW fuel. This fuel design has been evaluated by Framatome and Dominion for compatibility with the resident Westinghouse fuel and for compliance with fuel design limits. Subsequent to the March 28, 2002 letter, Dominion submitted a supplemental evaluation of small break LOCA phenomena (August 2, 2002, Serial No. 02-167C). In a letter dated March 21, 2003, NRC found this evaluation approach unacceptable and requested that a reanalysis be performed. The March 21, 2003 letter also forwarded a request for additional information (RAI), based on review of the August 2, 2002 letter.

The attachment to this letter provides the SBLOCA results for Advanced Mark-BW fuel in North Anna Units 1 and 2. The SBLOCA information is presented in the form of a supplement to the evaluation report provided in our March 28, 2002 letter (i.e., for Section 7.3).

In conjunction with this submittal of an explicit SBLOCA re-analysis, Dominion no longer intends to pursue the SBLOCA approach described in the letter dated August 2, 2002, Serial No. 02-167C. Dominion thus withdraws the August 2, 2002, Serial No. 02-167C supplement from our March 28, 2002 letter and requests that the staff terminate review of that evaluation approach. Since an explicit SBLOCA re-analysis has been provided, Dominion no longer considers the Requests for Additional Information (NRC letter dated March 21, 2003) as germane. Accordingly, no response is planned.

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Two additional submittals are planned that will provide the remaining technical evaluations necessary to support the amendment request for both North Anna Units 1 and 2. The first evaluation will revise the Core Operating Limits Report (Technical Specification 5.6.5) to include the RLBLOCA and SBLOCA topical reports. This submittal is planned for June 15, 2003. The last evaluation will provide the RLBLOCA analysis results for North Anna Unit 1, and is planned for submittal by July 30, 2003. These dates were discussed with the NRC in a telephone conversation on March 31, 2003.

To support the use of Framatome Advanced Mark-BW fuel in North Anna Unit 2, Cycle 17, we respectfully request the NRC to complete their review and approval of the license amendment and exemptions by September 30, 2003. We appreciate your consideration of our technical and schedular requests. If you have any questions or require additional information, please contact us.

Very truly yours,

Leslie N. Hartz
Vice President - Nuclear Engineering

Commitments made in this letter: None

Attachment

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SN: 03-245
Docket Nos.: 50-338/339
Subject: TS Change – Framatome Fuel Transition - SBLOCA

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Leslie N. Hartz, who is Vice President - Nuclear Engineering, of Virginia Electric and Power Company. She has affirmed before me that she is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of her knowledge and belief.

Acknowledged before me this 27th day of May, 2003.

My Commission Expires: March 31, 2004.

Notary Public

(SEAL)

Attachment 1

Small Break LOCA Analysis Results
North Anna Power Station Units 1 and 2

Framatome Fuel Transition Program
Technical Specification Change

Virginia Electric and Power Company
(Dominion)
North Anna Power Station Units 1 and 2

7.3 Small Break LOCA Analysis

Small break LOCA (SBLOCA) analyses were also performed to support operation with FANP Advanced Mark-BW fuel in NAPS Units 1 and 2. Calculations follow the NRC-approved methodology outlined in Volume II of the Framatome ANP RSG LOCA EM, Reference 7-3. The results of the small break studies for Units 1 and 2 demonstrate compliance with the regulatory criteria of 10CFR50.46.

7.3.1 Small Break LOCA Transient Description

A small break LOCA transient is characterized as developing in distinct phases: (1) subcooled depressurization, (2) RCS loop saturation and flow coastdown, (3) loss of RCS loop circulation and reflux cooling, (4) loop seal clearing and core refill, and (5) long-term cooling provided by ECCS pumps and accumulators.

Following the break, the primary system rapidly depressurizes to the saturation pressure of the hot leg fluid. During the initial depressurization phase, a reactor trip is generated on low pressurizer pressure, and the turbine is tripped on the reactor trip. Loss-of-offsite power is assumed concurrent with the reactor trip, resulting in an RCP trip.

In the second phase, the reactor coolant pumps coast down. Natural circulation flow in the RCS loops provides continuous core heat removal via the steam generators. The continued RCS flow removes the power operation core stored energy.

The RCS loop draining phase that follows results in the interruption of natural circulation. During this period, heat transfer in the steam generator tubes is by reflux boiling. For smaller breaks, this cooling mode is required to remove decay heat from the reactor coolant system. The RCS pressure stabilizes at a quasi-equilibrium value somewhat above the steam generator secondary side pressure. The system reaches a quiescent state, characterized by a balance between core decay heat, break flow, and steam generator heat removal.

Loop seal clearing and core recovery occur in the next phase of an SBLOCA transient. RCS inventory continues to decrease. Steam venting from the core to the break is blocked by the presence of a liquid loop seal in the RCP suction piping. Steam buildup in the upper regions of the RCS suppresses liquid levels in the reactor core and in the steam generator side of the suction piping. During this buildup, the core mixture level descends into the active core region and a short temperature excursion ensues. Eventually, the level in the suction piping is suppressed below the spill under elevation and the loop seal clears. With the loop seals cleared, steam venting is established through the break, pressure at the core exit is reduced, and the hydrostatic heads in the various RCS components readjust, allowing the core mixture level to recover.

Following loop seal clearing, the emergency core cooling system (ECCS) flow may be insufficient to replenish the mass lost through core boiling. The duration and magnitude of this imbalance sets the core liquid inventory. During this period, the core may uncover and undergo a temperature excursion.

The final phase of a SBLOCA transient is characterized as the long-term cooling period. Steam continues to be relieved through the break and the RCS continues to depressurize, allowing ECCS flow to increase. Eventually, break flow energy removal plus ECCS-provided liquid inventory replacement will balance core decay heat. RCS inventory increases, the core is recovered, and any core temperature excursion is terminated.

7.3.2 Small Break LOCA Evaluation Model

RELAP5 is used to predict the reactor coolant system thermal-hydraulic responses to small break LOCA. The code is NRC approved for licensing applications and is documented and described in detail in Reference 7-4. The SBLOCA modeling configuration is discussed in the LOCA EM, Reference 7-3. The modeling used for the NAPS SBLOCA calculations is totally consistent with the approved EM as described in Reference 7-3. Noding diagrams are presented in Figures 7.3-1 and 7.3-2. Figure 7.3-1 shows the loop noding for both NAPS units. Figure 7.3-2a shows the Unit 1 upflow baffle-barrel configuration. The baffle-barrel region coupling for the Unit 2 downflow model is shown in Figure 7.3-2b.

The reactor core is divided into two regions: one region represents the hot fuel assembly (the hot fluid channel), and the second region represents the remainder of the core (the average fluid channel). The core is divided into twenty-nine axial segments. Crossflow junctions connect the hot fluid channel to the adjacent average fluid channel. This arrangement allows the computation of hot assembly cladding and vapor temperatures with proper coupling to the average, fluid channel coolant. Axial noding (above the mid-plane) resolves the mixture level to within 0.3 feet. The average channel-to-hot channel crossflow is reduced by using a resistance ten times greater than the hot-to-average channel resistance in the upper core region. Initial fuel pin parameters are set based on TACO3 predictions (Reference 7-5). The TACO3 hot pin, volume-averaged, fuel temperature uncertainty of 11.5 percent is conservatively applied to all fuel assemblies in the initialization of the core. The reactor vessel downcomer and upper plenum regions are represented in axial detail. This allows for a proper representation of the void distribution that affects the system hydrostatic balance.

The RCS is divided into two flow loops. One loop represents the broken loop and the other represents the two intact loops. The steam generator tubes are divided into two regions. One region represents the shortest half of the tubes and the other region represents the remainder of the tubes. This provides appropriate modeling accuracy to properly simulate tube-draining effects that can be sensitive to tube length. The reactor coolant pump suction nodalization is selected, per Reference 7-3, to produce an accurate hydrodynamic representation of loop seal clearing. Fine nodalization is used for the pump suction piping. This allows resolution of the void distributions and elevation heads that control the occurrence and timing of the loop seal clearing.

The SBLOCA EM is configured to promote the clearing of the loop seal in only one pipe, that representing the broken loop. The intent is to limit steam flow to the break, promote degradation of core conditions, and increase the potential for uncovering the core. The bias (to clear only the loop seal in a single loop) is enacted by artificially extending the bottom elevation of the intact loop pump suction piping at least one foot below that of the broken loop (Reference 7-3). This preferentially promotes the clearing of only the broken loop.

The intact loop reactor coolant pump discharge piping is modeled per the SBLOCA EM. Like the broken loop pump discharge piping, it is characterized by four nodes. This allows an accurate simulation of the hydrodynamic effects of ECCS injection.

The NAPS SBLOCA plant models are constructed within the guidelines of the EM, Reference 7-3, Volume II, based on Dominion-supplied plant-specific inputs. The small break models adhere to the requirements of 10CFR50, Appendix K. The models contain demonstrated conservatism regarding the ECCS mitigation of a postulated small break LOCA at the NAPS units.

7.3.3 Small Break LOCA Inputs and Assumptions

The major plant operating parameters used in the NAPS SBLOCA analyses are listed in Table 7.3-1. The limiting single failure is the failure of a diesel generator, which results in the loss of one full train of ECC pumped injection. The analysis assumes the flow from one high-head safety injection (HHSI) pump and one low-head safety injection (LHSI) pump, selected from Tables 7.3-2 through 7.3-7, for the appropriate unit and break configuration. Tables 7.3-2 and 7.3-3 provide NAPS Unit 1 pumped LHSI and HHSI flows for pump discharge pipe breaks, respectively. Tables 7.3-4 and 7.3-5 provide the same information for a safety injection (SI) line break. The broken loop SI injection is assumed to spill to the containment for the SI line break. The HHSI flows in Tables 7.3-3 and 7.3-5 are also applicable to NAPS Unit 2. Tables 7.3-6 and 7.3-7 provide NAPS Unit 2 LHSI flows for RCS pipe breaks and the SI line break, respectively. The steam generator secondary system is isolated on reactor trip and auxiliary feedwater is initiated on reactor trip with a 60-second delay. The steam generator level is maintained at 18 percent of the narrow range (39 feet above the top of the tubesheet). Loss of one AFW pump, consistent with the single failure assumption, is evaluated in addition to the no AFW failure scenario. For SBLOCA, pumped ECC injection is first delivered from the HHSI pumps. Initially, the HHSI system flow purges the water contained in the boron injection tank (BIT) - a tank containing approximately 900 gallons of high temperature, 146 °F, water. Following BIT purge, the water temperatures of the SI during the initial injection and re-circulation phases are 60 °F and 150 °F, respectively. The start of re-circulation is 70 minutes after SI initiation.

7.3.4 Small Break LOCA Analysis Break Spectrum

A range of break sizes, along with unit differences, was accommodated in establishing the SBLOCA analysis case set. Cases were performed that addressed break spectrum, AFW availability, and mixed core configuration for both NAPS Unit 1 and Unit 2. Unit 1 has an upflow barrel-baffle configuration, while Unit 2 has a downflow configuration. The analyses accommodate the slightly different LHSI flows between units.

A spectrum of six cases was analyzed to predict core and system responses over a range of break sizes. Prior studies, for example the EM study (Volume II, Appendix A of Reference 7-3), indicate that break areas ranging in diameter from 2- to 4-inches produce the greatest degree of core uncovering. For the NAPS units, break diameters of 2-, 2.5-, 3-, 4-, and 6-inches were analyzed. The breaks were located in the bottom of the RCP discharge piping. The spectrum also considered a 5.2-inch diameter break of a safety injection line (6" Schedule 160, ID = 5.187"). This break is in the top of the RCP discharge piping. Both high and low head safety injection lines tee into this safety injection pipe upstream of the break; hence, pumped injection into the RCS is significantly reduced for this break.

The limiting spectrum case was evaluated for AFW availability. The study accounts for the one-on-one lineup of AFW pumps to the three steam generators. The study evaluates the failure of one AFW pump. The limiting AFW configuration case was then used to investigate the mixed core configuration. The NAIF and Advanced Mark-BW fuel assemblies are thermal-hydraulically comparable, excepting a pressure drop difference of ~2.5 psi (based on rated flow) attributable to the mid-span mixing grids (MSMGs) on the FANP assembly. This fuel design difference was modeled by running a case with the MSMG resistance removed from the average core. This modeling approach causes the predicted flow diversion away from the one Advanced Mark-BW fuel assembly to be maximized.

All of the analyzed breaks, except for the SI line break, were simulated at the bottom of the RCS piping to minimize ECCS delivery to the reactor vessel. This break orientation selection is validated in Reference 7-9. The reference generically shows that breaks in the side or top of the pump discharge piping were non-limiting for T_{HOT} plants relative to bottom pipe breaks. In Reference 7-10, NRC concurred that top and side breaks were not limiting, noting "plant procedural guidance instructs operators to begin a timely depressurization of the primary system prior to the onset of the extended core uncovery." The staff further concluded "that this issue is adequately addressed through plant procedural guidance, and a plant-specific break orientation analysis is not required." A review of the North Anna Emergency Operating Procedures (EOP) confirmed the existence of procedural guidance to depressurize the RCS. Hence, no top or side break analyses were required for the NAPS unit SBLOCA calculations.

7.3.4.1 NAPS Unit 1 Small Break LOCA Analysis Results

Table 7.3-8 presents a time sequence of events for the spectrum cases. The spectrum thermal responses for the hot fuel assembly are given in Table 7.3-9. SBLOCA parameters of interest are shown in Figures 7.3-5 through 7.3-46. A plot of RCS pressure, break flow, hot channel mixture level (12 feet represents the top of the active core), hot spot cladding temperature, hot channel outlet vapor temperature, intact loop seal level, and broken loop seal level is provided for each spectrum case.

The results of the analyses demonstrate that the spectrum of breaks (including the SI line break) described in Section 7.3.4 is adequate to determine the limiting peak clad temperature (PCT). For the spectrum of breaks within the pump discharge piping, the worst case occurs for the 3.0-inch break. For this case, the PCT is 1,348 °F. This is a break in the middle of the analyzed spectrum. Break size-dependent cooling phenomena dictate that the PCT decreases for either larger or smaller break areas.

For relatively small breaks, cooling is supplied by HHSI only. The 2.0-inch break is characteristic of this break class. Core uncovering initiates at about 3,300 seconds with the minimum core level occurring between 4,700 and 5,000 seconds. This is followed by a gradual HHSI-induced recovery. The PCT for this case is 1,110 °F and occurs coincident with the minimum core mixture level. The accumulators do not discharge during this clad temperature excursion. For smaller breaks (i.e., less than 2.0 inches in diameter), break flow will be reduced, core uncovering will be delayed, and the HHSI will be more capable of controlling the RCS inventory. This results in lower PCTs.

Breaks of around 5 inches in diameter start to exhibit characteristics of large break LOCAs. Break-induced depressurization is sufficient to reduce the RCS pressure such that core cooling is provided by all three ECC systems: HHSI, Accumulators and LHSI. The 6.0-inch break is characteristic of this break class. RCS depressurization is rapid, progressing swiftly through the activation of the various ECC systems so that no core uncovering or clad temperature excursion occurs. Even the clad heatup at loop seal clearing is minimized.

The limiting pump discharge case occurs when the break allows the system to enter the core boil-down phase relatively early at high decay heat levels while not producing a quick depressurization to initiate accumulator discharge. For the 3.0-inch case, core uncovering initiates at 930 seconds. The minimum core mixture level, accumulator actuation and time of PCT are coincident at around 1,280 seconds. The initial accumulator discharge provides sufficient coolant to raise the core inventory from a mixture level of 7 feet to about 10 feet, arresting the cladding temperature excursion. After this, increasing HHSI flow in combination with continued accumulator injection provides a gradual increase in core level until recovery occurs at around 4,300 seconds.

Between the 3.0-inch break and progressing to those breaks at the spectrum boundaries (2.0-inch and 6.0-inch breaks), the transients demonstrate appropriate intermediate characteristics. The 2.5-inch break uncovers at around 1,500 seconds with accumulator injection, minimum core mixture level and PCT occurring simultaneous at around 2,150 seconds. Although this break displays the same cooling characteristics as the 3.0-inch break, the slower depressurization means that key events occur later at lower decay heat levels and are more easily controlled by the ECC systems. On the larger side, the 4.0-inch break uncovers the core early, around 600 seconds, initiating a cladding temperature excursion. System depressurization, however, is sufficiently rapid that a surge of accumulator injection recovers the core, arresting the temperature excursion at approximately 700 seconds. After the accumulator surge, the break is unable to support continued depressurization at a sufficient rate and the HHSI flow does not match decay heat-induced boiling. This leads to a second core uncovering at around 2,900 seconds. This cladding temperature excursion is terminated at around 3,300 seconds by the combined LHSI and accumulator flows. After this, the ECCS flows are sufficient to maintain the core covered. The case demonstrates the characteristics of the larger 6.0-inch break, but it not quite sufficient in blowdown potential to pass through the intermediate cooling modes to LHSI cooling without injection interruptions creating momentary clad temperature excursions.

The limiting North Anna Unit 1 break is the SI line break between the nozzle in the RCS piping and the first check valve. The inside pipe diameter for the SI line is 5.2 inches. The SI line break evolves much like the 4.0- or 6.0-inch breaks. Loop seal clearing for the 4.0-inch break occurs at 300 seconds and at 140 seconds for the 6.0-inch break. The SI line break clears loop seals at around 200 seconds. The depressurization is sufficiently rapid that the core level depression between 350 and 400 seconds does not lead to a cladding temperature excursion. The second uncovering, starting at about 1,800 seconds, is arrested with only a small temperature excursion. However, the assumed break in the SI line reduces ECCS flow to the intact loops and enhances the flow to the broken SI line. The downstream pressure for the broken SI line is the containment building pressure while the downstream pressure for the other SI lines is the reactor coolant system pressure. Because the SI systems incorporate a common header, flow is disproportionately directed away from the two intact loops to the broken line. This limits the pumped ECCS supplied to the intact loops such that there is a third core uncovering period starting at around 2,700 seconds. This uncovering period lasts longer than the first two periods leading to the peak cladding temperature of 1,380 °F at around 3,500 seconds. The temperature excursion is arrested when the system pressure drops below the pressure (~135 psia) at which LHSI flow to the intact loop starts. Two more cycles of core level depression and recovery, each with lesser cladding temperature excursions, occur before the pressure has decreased such that ECCS flow to the intact loops is able to sustain core coverage and cooling at about 7,300 seconds.

Because the SI line break is limiting, it serves as a base for the AFW availability study. Tables 7.3-10 and 7.3-11, and Figures 7.3-47 through 7.3-53 provide the results for this case. The relative large size of this break leads to a rapid decrease in RCS pressure below the steam generator secondary safety valve control pressure. Once the primary system pressure decreases below the secondary side pressure, the feed of coolant to the secondary side becomes relatively unimportant to the course of the transient. Therefore, the SI line break transient evolves along a nearly identical path to that of the full AFW case. The peak cladding temperature is 1,395 °F, which is essentially the same as the PCT of 1,380 °F for the full AFW case. The PCT difference of 15 °F is well within the expected range of model resolution.

The results from the mixed core study are presented in Tables 7.3-12 and 7.3-13, and Figures 7.3-54 through 7.3-60. The SI line break with a failed AFW pump served as the base case for this study. As discussed in Section 7.3.4 the mixed core was represented by removing the three MSMGs (located at 6.45 feet, 8.16 feet and 9.87 feet) from the fuel assemblies modeled in the average core. This was done to maximize flow diversion away from the Advanced Mark-BW fuel assembly modeled in the hot channel. Study results show that there is essentially no impact on PCT. The PCT is 1,404 °F, an increase of 9 °F relative to the base case. This PCT difference is well within the resolution capability of the SBLOCA modeling. Figure 7.3-56 (core mixture level) shows that the top two MSMGs (core elevations 8.16 and 9.87 feet) are above the mixture level. However, as with the other SI line break studies, the temperature excursions are arrested by surges of ECCS coolant while the hot spot is experiencing near adiabatic heating. Under such circumstances, any flow diversion is largely irrelevant, resulting in essentially no change in PCT. Thus, substantive differences in results should not be expected nor were they observed in case predictions.

In summary, the PCT for the NAPS Unit 1 SBLOCA is 1,404 °F. Both the local oxidation and the whole-core oxidation are substantially below the respective acceptance criteria of 17 percent and 1 percent.

7.3.4.2 NAPS Unit 2 Small Break LOCA Analysis Results

The break spectrum of six cases, which was discussed in Section 7.3.4.1 for North Anna Unit 1, was also analyzed for North Anna Unit 2. Table 7.3-14 presents a time sequence of events for these cases. The spectrum thermal responses for the hot fuel assembly are given in Table 7.3-15. SBLOCA parameters of interest are shown in Figures 7.3-63 through 7.3-118.

Figure 7.3-61 provides an overlay of the NAPS Units 1 and 2 PCTs versus break size and configuration. The pipe break spectrums develop in a nearly identical manner between the two plants. The change in baffle configuration, from upflow to downflow, has some impact on the smaller break results (1,110 °F PCT for the Unit 1 2.0-inch break versus 1,022 °F for Unit 2). For the larger breaks in the main RCS piping, differences in results between units are within the expected range of model resolution.

The PCT for a SI line break is 100 °F cooler (1,280 °F) for Unit 2 than for Unit 1. The difference is due to a small variation in core inventories during core uncovering between 3,000 and 4,000 seconds. The reactor vessel flow dynamics, which the different core barrel-baffle configurations can affect, lead to an earlier core uncovering and a lower core mixture level for Unit 1 than for Unit 2 (see Figures 7.3-35 and 7.3-93). Thus, the Unit 1 cladding temperature is slightly higher when the LHSI ends the temperature excursion at around 3,500 seconds. Following the occurrence of peak clad temperature, the mixture level for Unit 2 is consistently above the top of the core. Figure 7.3-62 shows that, for the RCS pressure near the time of PCT (~125 psia), the LHSI flow for Unit 1 is 10 to 20 percent lower than for Unit 2. This difference is sufficient for the combined LHSI and HHSI flows to maintain a core mixture level above the active core for Unit 2 after 4,000 seconds but not for Unit 1 until about 7,000 seconds.

Thus, the most severe SBLOCA for NAPS Unit 2 is a 3.0-inch diameter break in the RCS piping at the pump discharge. This break was used for the AFW and mixed core studies with much the same sensitivity results as occurred for Unit 1. For Unit 2, the PCT was less than the PCT for Unit 1 by 50 °F when one AFW pump was disabled, and by 25 °F for the mixed core. Both these differences are within the expected range of model resolution. Data for these studies are provided in Tables 7.3-16 through 7.3-19 and plots of important variables are shown in Figures 7.3-105 through 7.3-118.

The 3.0-inch break with no assumed AFW pump failure clears the broken loop. This leaves the intact loops stagnant and pressure increasing in the broken loop steam generator. With one AFW pump failed, a brief intact loop seal clearing occurs as shown in Figure 7.3-110. This provides additional steam venting, resulting in a somewhat lower peak cladding temperature. The mixed core case shows no significant difference from the base all Framatome ANP fuel core case. For Unit 2, the core mixture level, based here on a 3.0-inch break, falls slightly below the upper most MSMG, allowing the differing axial resistances to be of only slight importance. Again, however, the cladding temperature excursion is arrested by a surge in accumulator flow, during a near adiabatic heatup, making any flow diversion inconsequential.

In summary, the PCT for the NAPS Unit 2 SBLOCA is 1,370 °F. Both the local oxidation and the whole-core oxidation are substantially below the respective acceptance criteria of 17 percent and 1 percent.

7.3.5 Small Break LOCA Compliance to 10CFR50.46

The SBLOCA calculations demonstrate compliance with the PCT and local metal-water reaction criteria of 10CFR50.46. The mixed core was evaluated with no significant impact noted on either co-resident fuel assemblies. In all cases, PCT and local metal-water are substantially below criterion limits of 2,200 °F and 17 percent, respectively. The analysis also serves as the basis for demonstrating compliance with whole-core oxidation and coolable geometry criteria. The average hot channel oxidation is less than one percent. Thus, the whole-core oxidation criterion is met.

The fourth acceptance criterion of 10CFR50.46 requires coolable geometry compliance. The SBLOCA calculations discussed in this section assess core geometry alterations resulting from SBLOCA at the worst core location and demonstrate successful fuel pin cooling. As presented in Section 7.2.5 (provided in the May 6, 2003 submittal), the LOCA plus seismic load combination may produce deformation in the fuel pin lattice for peripheral assemblies. The deformation does not alter the basic pin-coolant-channel to pin-coolant-channel arrangement for these assemblies. There is no significant consequence of the damage for the pool boiling and steam cooling environment of SBLOCA because of the low power level of the peripheral assemblies. Thus, the maximum cladding temperatures and local oxidation predicted by the LOCA calculation for SBLOCA are unchanged, and the fuel assemblies retain a coolable geometry, meeting the criteria of 10CFR50.46.

The fifth acceptance criterion of 10CFR50.46 requires assurance of long-term cooling. Successful initial operation of the ECCS is shown by demonstrating that the core is quenched and the cladding temperature is returned to near saturation temperature. Compliance to the long-term cooling criterion is demonstrated in the NAPS UFSAR for the systems and components specific to the units. Compliance is unrelated to fuel design. The initial phase of core cooling results in low clad and fuel temperatures. A pumped injection system, which re-circulation capable, is available and operated by each unit to provide extended coolant injection. Therefore, compliance with the long-term cooling criterion of 10CFR50.46 is assured.

7.3.6 Small Break LOCA Conclusions

The analyses reported herein support operation at a power level of 2,893 MWt, with a steam generator tube plugging level of 7 percent in each generator, a total peaking factor (F_Q) of 2.32 and a nuclear enthalpy rise factor ($F_{\Delta H}$) of 1.65. The local power is axially restricted by the K_Z curve in Figure 7.3-3. The impact of NAIF co-resident fuel on FANP Advanced Mark-BW fuel is included within the analyses - the analyses consider a conservative representation of mixed-cores which contain both NAIF and Advanced Mark-BW fuel.

Compliance with the five criteria of 10CFR50.46 has been demonstrated. The SBLOCA analysis results are presented in Tables 7.3-8 through 7.3-19. In summary, the PCTs for the NAPS Units 1 and 2 SBLOCA are 1,404 °F and 1,370 °F, respectively. Both the local oxidation and the whole-core oxidation are substantially below the respective acceptance criteria of 17 percent and 1 percent. The mixed core was evaluated with no significant impact on either fuel assembly design. Discussions in Section 7.3.5 demonstrate compliance with the coolable geometry and long-term cooling criteria.

Table 7.3-1: NAPS Units 1 and 2 Small Break LOCA Plant Operating Parameters

Parameter	Value
Power Level, MWt	2,951 (1.02% of 2,893)
Total RCS Flow, gpm	289,100
Maximum Core Peaking, F_Q	2.32
Normalized Hot Channel Factor, K_Z	Figure 7.3-3
Axial Peaking Factor	1.4
Axial Power Shape	Figure 7.3-4
RCS Average Temperature, °F	586.8
Fuel Assembly Array	17 x 17 Advanced Mark-BW w/M5™
Accumulator Liquid Volume, ft^3/tank	1,025[1]
Steam Generator Tube Plugging, % per SG	7
ECCS Pumped Injection Delay Time, s	27 (after SIS)

[1] This value includes the unusable accumulator tank volume (the volume below the accumulator outlet nozzle) and the accumulator line volume between the accumulator tank and the first check valve.

Table 7.3-2: NAPS Unit 1 SBLOCA Pumped LHSI for RCS Pipe Breaks

RCS Pressure, psia	Flow to Intact Loop, lbm/s	Flow to Broken Loop, lbm/s
14.7	323.91	200.96
24.7	313.09	194.25
34.7	301.94	187.33
44.7	290.40	180.18
54.7	278.50	172.77
64.7	266.13	165.12
74.7	253.29	157.14
84.7	239.93	148.86
94.7	225.97	140.18
104.7	211.31	131.10
114.7	195.89	121.52
124.7	179.57	111.39
134.7	162.16	100.60
144.7	143.49	89.02
154.7	123.19	76.44
164.7	100.84	62.56
174.7	75.60	46.89
184.7	45.93	28.50
194.7	8.04	4.99
196.8	0.00	0.00

Table 7.3-3: NAPS Units 1 and 2 SBLOCA Pumped HHSI for RCS Pipe Breaks

RCS Pressure, psia	Flow to Intact loop, lbm/s	Flow to Broken Loop, lbm/s
14.7	44.89	24.46
64.7	44.42	24.21
114.7	43.94	23.94
264.7	44.17	24.07
514.7	41.73	22.75
764.7	39.16	21.36
1014.7	36.44	19.87
1264.7	31.46	17.16
1514.7	28	15.29
1764.7	24.74	13.51
2014.7	21.44	11.72
2114.7	20.82	11.39

Table 7.3-4: NAPS Unit 1 SBLOCA Pumped LHSI Injection for SI Line Break*

RCS Pressure, psia	Flow to Intact Loop, lbm/s	Flow to Broken Loop, lbm/s
14.7	340.88	187.91
24.7	319.48	198.21
34.7	297.48	208.47
44.7	274.76	218.72
54.7	251.11	228.98
64.7	226.74	239.27
74.7	200.12	249.35
84.7	172.92	259.87
94.7	144.05	270.60
104.7	113.06	281.64
114.7	79.25	293.12
124.7	41.46	305.21
134.7	0.00	316.33

* Note that the broken loop SI flow spills directly to the containment.

Table 7.3-5: NAPS Units 1 and 2 SBLOCA Pumped HHSI for SI Line Break*

RCS Pressure, psia	Flow to Intact Loop, lbm/s	Flow to Broken Loop, lbm/s
14.7	44.91	24.46
34.7	44.65	24.55
54.7	44.39	24.63
64.7	44.26	24.67
74.7	44.12	24.71
94.7	43.86	24.79
114.7	43.60	24.87
134.7	43.42	24.99
264.7	43.32	26.32
514.7	39.96	27.32
764.7	36.4	28.31
1014.7	32.6	29.33
1264.7	26.06	29.71
1514.7	21.22	30.82
1764.7	15.37	31.97

* Note that the broken loop SI flow spills directly to the containment.

Table 7.3-6: NAPS Unit 2 SBLOCA Pumped LHSI for RCS Pipe Breaks

RCS Pressure, psia	Flow to Intact Loop, lbm/s	Flow to Broken Loop, lbm/s
14.7	328.31	178.87
24.7	317.39	172.92
34.7	306.14	166.80
44.7	294.53	160.47
54.7	282.52	153.93
64.7	270.06	147.15
74.7	257.14	140.11
84.7	243.70	132.78
94.7	229.63	125.11
104.7	214.88	117.07
114.7	199.35	108.61
124.7	182.92	99.67
134.7	165.39	90.12
144.7	146.58	79.86
154.7	126.11	68.71
164.7	103.48	56.38
174.7	77.86	42.40
184.7	47.53	25.90
194.7	8.23	4.49
196.8	0.00	0.0

Table 7.3-7: NAPS Unit 2 SBLOCA Pumped LHSI for SI Line Break*

RCS Pressure, psia	Flow to Intact Loop, lbm/s	Flow to Broken Loop, lbm/s
14.7	341.67	164.57
24.7	320.60	174.67
34.7	298.99	184.67
44.7	276.76	194.58
54.7	253.00	204.15
64.7	229.03	213.99
74.7	204.05	223.88
84.7	177.86	233.82
94.7	150.20	243.90
104.7	120.70	254.16
114.7	88.80	264.71
124.7	53.62	275.68
134.7	9.48	287.23
136.8	0.00	287.23

* Note that the broken loop SI flow spills directly to the containment.

Table 7.3-8: NAPS Unit 1 SBLOCA Break Spectrum Time Sequence of Events (seconds)

Event	2.0-inch	2.5-inch	3.0-inch	4.0-inch	5.2-inch*	6.0-inch
Break Initiation	0.0	0.0	0.0	0.0	0.0	0.0
Reactor Trip	44.40	30.12	22.43	15.04	11.64	10.68
MFW Isolation	44.40	30.12	22.43	15.05	11.64	10.68
MSIV Closure	44.91	30.62	22.93	15.55	12.15	11.19
SI Injection	77.11	61.56	53.38	45.14	39.97	37.04
Broken Loop Seal Clearing	940.0	615.0	585.0	315.0	205.0	155.0
Intact Loop Seal Clearing	NA	NA	NA	300.0	205.0	140.0
Core Uncovered	3365.0	1510.0	930.0	620.0	1715.0	NA
Accumulator Injection	NA	2140.0	1245.0	690.0	390.0	270.0
PCT Time	4708.0	2151.0	1277.0	702.0	3451.0	NA
Core Recovered	6525.0	5910.0	4305.0	3230.0	7190.0	NA

* SI line break

Table 7.3-9 NAPS Unit 1 SBLOCA Break Spectrum Results

Parameter	2.0-inch	2.5-inch	3.0-inch	4.0-inch	5.2-inch*	6.0-inch
PCT, °F	1110.0	1223.0	1348.0	907.0	1380.0	702**
PCT Location, ft	11.671	11.671	11.671	11.014	11.671	NA
Local Zr-H_2O Reaction, %	0.06	0.08	0.13	NA	0.25	NA
Whole Core Zr-H_2O Reaction, %	< 0.01	< 0.01	< 0.02	NA	< 0.03	NA
Max Local Zr-H_2O Location, ft	11.671	11.671	11.671	NA	11.671	NA
Hot Rod Burst Location, ft	NA	NA	NA	NA	NA	NA
Hot Rod Burst Time, sec	NA	NA	NA	NA	NA	NA

* SI line break
** Initial cladding temperature

Table 7.3-10: NAPS Unit 1 SBLOCA AFW Study Time Sequence of Events (seconds)

Event	5.2-inch SI Line Break	5.2-inch SI Line Break
Intact Loop AFW	Yes	Yes
Broken Loop AFW	Yes	No
Break Initiation	0.0	0.0
Reactor Trip	11.64	11.64
MFW Isolation	11.64	11.64
MSIV Closure	12.15	12.15
SI Injection	39.97	39.97
Broken Loop Seal Clearing	205.0	205.0
Intact Loop Seal Clearing	205.0	180.0
Core Uncovered	1715.0	1800.0
Accumulator Injection	390.0	390.0
PCT Time	3451.0	3561.0
Core Recovered	7190.0	7510.0

Table 7.3-11: NAPS Unit 1 SBLOCA AFW Study Results

Parameter	5.2-inch SI Line Break	5.2-inch SI Line Break
Intact Loop AFW	Yes	Yes
Broken Loop AFW	Yes	No
PCT, °F	1380.0	1395.0
PCT Location, ft	11.671	11.671
Local Zr-H_2O Reaction, %	0.25	0.28
Whole Core Zr-H_2O Reaction, %	< 0.03	< 0.03
Max Local Zr-H_2O Location, ft	11.671	11.671
Hot Rod Burst Location, ft	NA	NA
Hot Rod Burst Time, sec	NA	NA

Table 7.3-12: NAPS Unit 1 SBLOCA Mixed Core Study Time Sequence of Events (seconds)

Event	FANP Core	Mixed Core
Break Initiation	0.0	0.0
Reactor Trip	11.64	11.58
MFW Isolation	11.64	11.58
MSIV Closure	12.15	12.09
SI Injection	39.97	39.91
Broken Loop Seal Clearing	205.0	205.0
Intact Loop Seal Clearing	180.0	180.0
Core Uncovered	1800.0	1825.0
Accumulator Injection	390.0	390.0
PCT Time	3561.0	3556.0
Core Recovered	7510.0	6985.0

Table 7.3-13: NAPS Unit 1 SBLOCA Mixed Core Study Results

Cases	FANP Core	Mixed Core
PCT, °F	1395.0	1404.0
PCT Location, ft	11.671	11.671
Local Zr-H_2O Reaction, %	0.28	0.31
Whole Core Zr-H_2O Reaction, %	< 0.03	< 0.03
Max Local Zr-H_2O Location, ft	11.671	11.671
Hot Rod Burst Location, ft	NA	NA
Hot Rod Burst Time, sec	NA	NA

Table 7.3-14: NAPS Unit 2 SBLOCA Break Spectrum Time Sequence of Events (seconds)

Event	2.0-inch	2.5-inch	3.0-inch	4.0-inch	5.2-inch*	6.0-inch
Break Initiation	0.0	0.0	0.0	0.0	0.0	0.0
Reactor Trip	44.31	30.06	22.38	14.99	11.63	10.67
MFW Isolation	44.31	30.06	22.38	14.99	11.63	10.67
MSIV Closure	44.82	30.56	22.88	15.5	12.14	11.18
SI Injection	77.05	61.50	53.32	45.08	39.90	37.0
Broken Loop Seal Clearing	935.0	615.0	600.0	300.0	205.0	155.0
Intact Loop Seal Clearing	NA	NA	NA	275.0	200.0	135.0
Core Uncovered	3515.0	1490.0	840.0	645.0	1805.0	NA
Accumulator Injection	NA	2015.0	1215.0	705.0	390.0	270.0
PCT Time	4649.0	2026.0	1248.0	3066.0	3548.0	NA
Core Recovered	7990.0	6235.0	4070.0	3320.0	3865.0	NA

* SI line break

Table 7.3-15 NAPS Unit 2 SBLOCA Break Spectrum Results

Parameter	2.0-inch	2.5-inch	3.0-inch	4.0-inch	5.2-inch*	6.0-inch
PCT, °F	1022.0	1230.0	1370.0	913.0	1280.0	702**
PCT Location, ft	11.671	11.671	11.671	11.014	11.671	NA
Local Zr-H_2O Reaction, %	0.01	0.08	0.16	NA	0.10	NA
Whole Core Zr-H_2O Reaction, %	NA	< 0.01	< 0.02	NA	< 0.01	NA
Max Local Zr-H_2O Location, ft	11.671	11.671	11.671	NA	11.671	NA
Hot Rod Burst Location, ft	NA	NA	NA	NA	NA	NA
Hot Rod Burst Time, sec	NA	NA	NA	NA	NA	NA

* SI line break
** Initial cladding temperature

Table 7.3-16: NAPS Unit 2 SBLOCA AFW Study Time Sequence of Events (seconds)

Event	3-inch	3-inch
Intact Loop AFW	Yes	Yes
Broken Loop AFW	Yes	No
Break Initiation	0.0	0.0
Reactor Trip	22.38	22.38
MFW Isolation	22.38	22.38
MSIV Closure	22.88	22.88
SI Injection	53.32	53.32
Broken Loop Seal Clearing	600.0	470.0
Intact Loop Seal Clearing	NA	440.0*
Core Uncovered	840.0	995.0
Accumulator Injection	1215.0	1325.0
PCT Time	1248.0	1334.0
Core Recovered	4070.0	6070.0

* The intact loop resealed later in the transient.

Table 7.3-17: NAPS Unit 2 SBLOCA AFW Study Results

Parameter	3-inch	3-inch
Intact Loop AFW	Yes	Yes
Broken Loop AFW	Yes	No
PCT, °F	1370.0	1324.0
PCT Location, ft	11.671	11.671
Local Zr-H_2O Reaction, %	0.16	0.13
Whole Core Zr-H_2O Reaction, %	< 0.02	< 0.02
Max Local Zr-H_2O Location, ft	11.671	11.671
Hot Rod Burst Location, ft	NA	NA
Hot Rod Burst Time, sec	NA	NA

Table 7.3-18: NAPS Unit 2 SBLOCA Mixed Core Study Time Sequence of Events (seconds)

Event	FANP Core	Mixed Core
Break Initiation	0.0	0.0
Reactor Trip	22.38	22.38
MFW Isolation	22.38	22.38
MSIV Closure	22.88	22.88
SI Injection	53.28	52.28
Broken Loop Seal Clearing	600.0	595.0
Intact Loop Seal Clearing	NA	NA
Core Uncovered	840.0	865.0
Accumulator Injection	1215.0	1230.0
PCT Time	1248.0	1242.0
Core Recovered	4070.0	4275.0

Table 7.3-19: NAPS Unit 2 SBLOCA Mixed Core Study Results

Cases	FANP Core	Mixed Core
PCT, °F	1370.0	1345
PCT Location, ft	11.671	11.671
Local Zr-H_2O Reaction, %	0.16	0.14
Whole Core Zr-H_2O Reaction, %	< 0.02	< 0.02
Max Local Zr-H_2O Location, ft	11.671	11.671
Hot Rod Burst Location, ft	NA	NA
Hot Rod Burst Time, sec	NA	NA

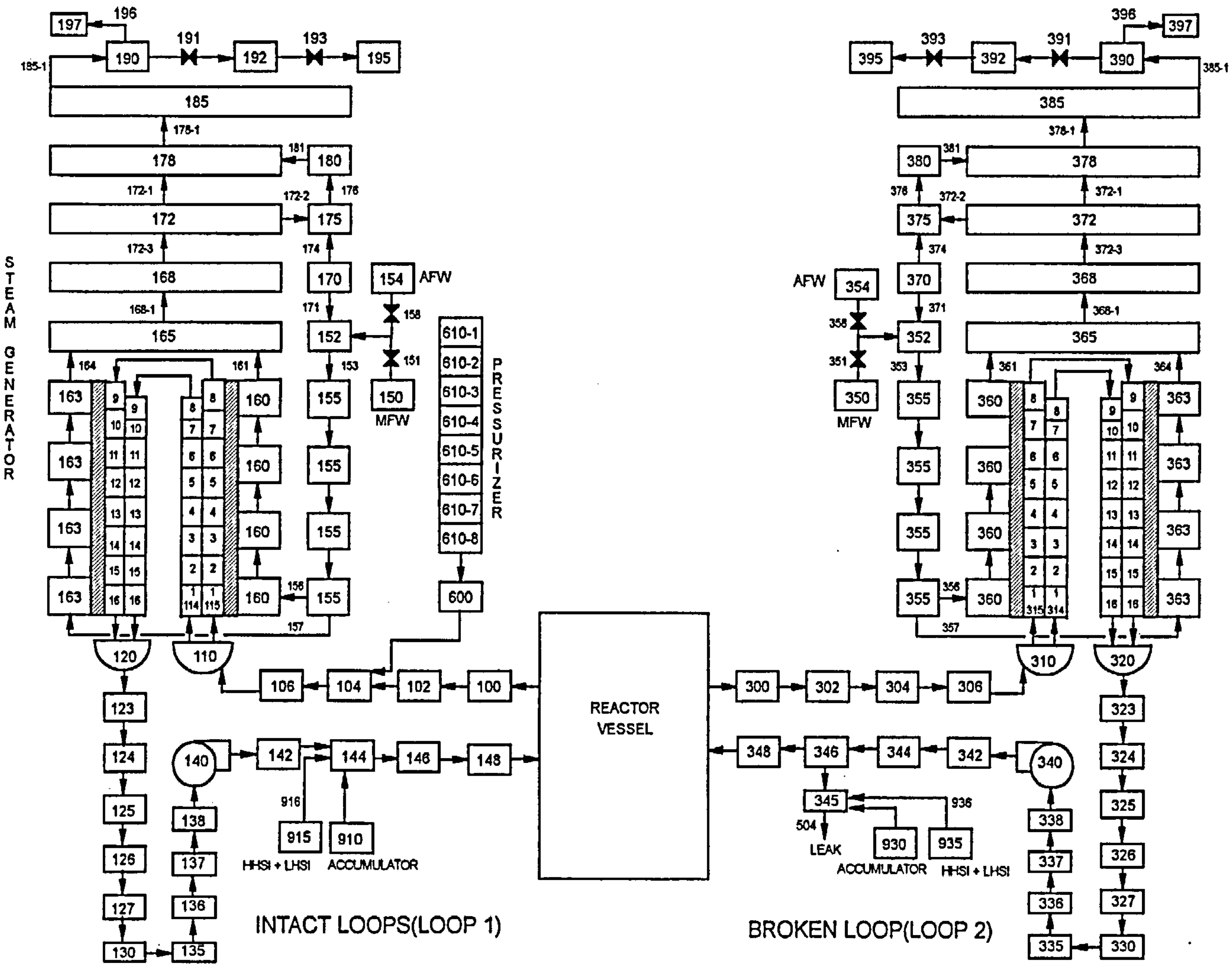

Figure 7.3-1: NAPS Units 1 and 2 RELAP5 SBLOCA Loop Noding Diagram

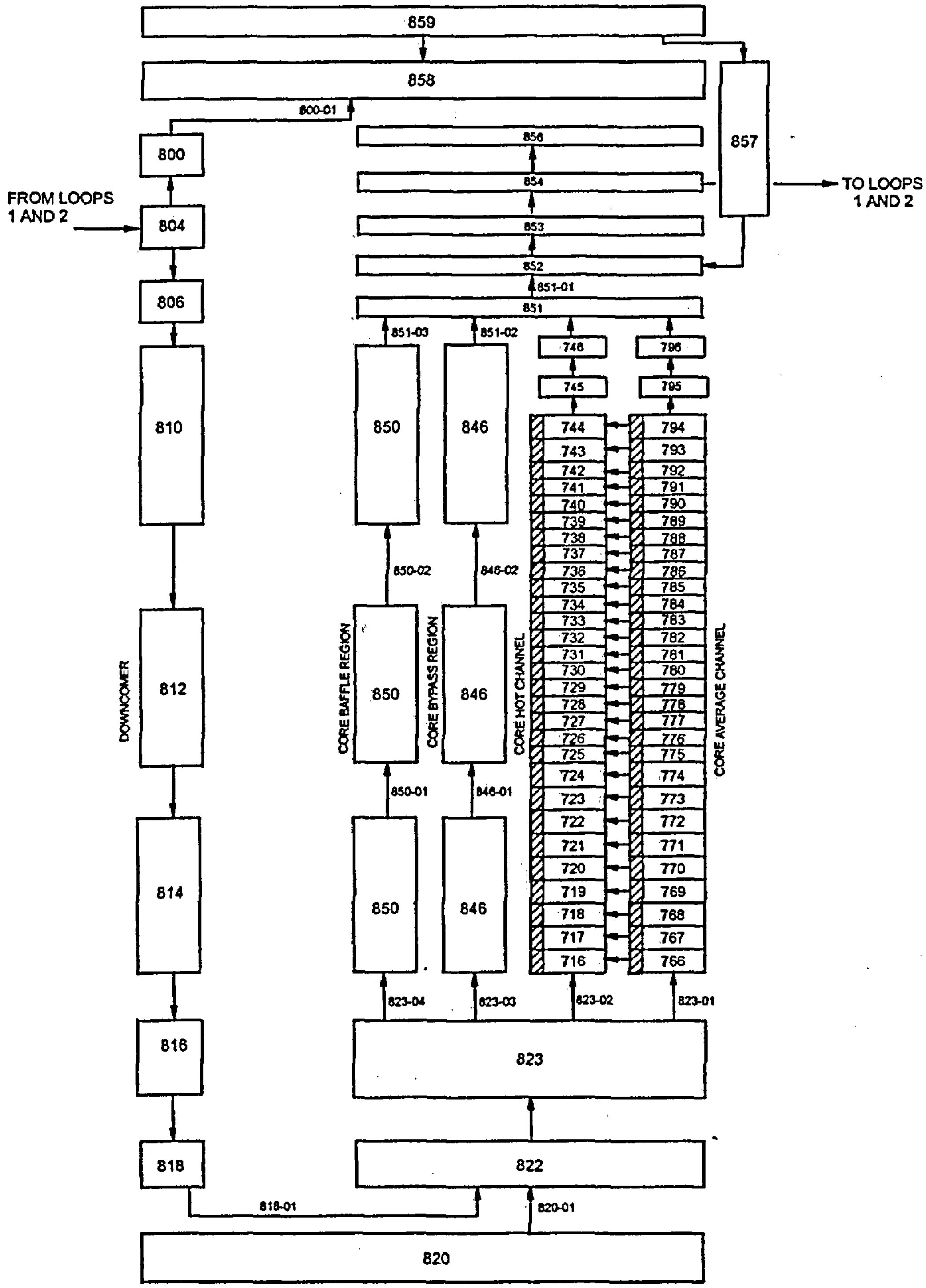

Figure 7.3-2a: NAPS Unit 1 RELAP5 SBLOCA Core Noding Diagram

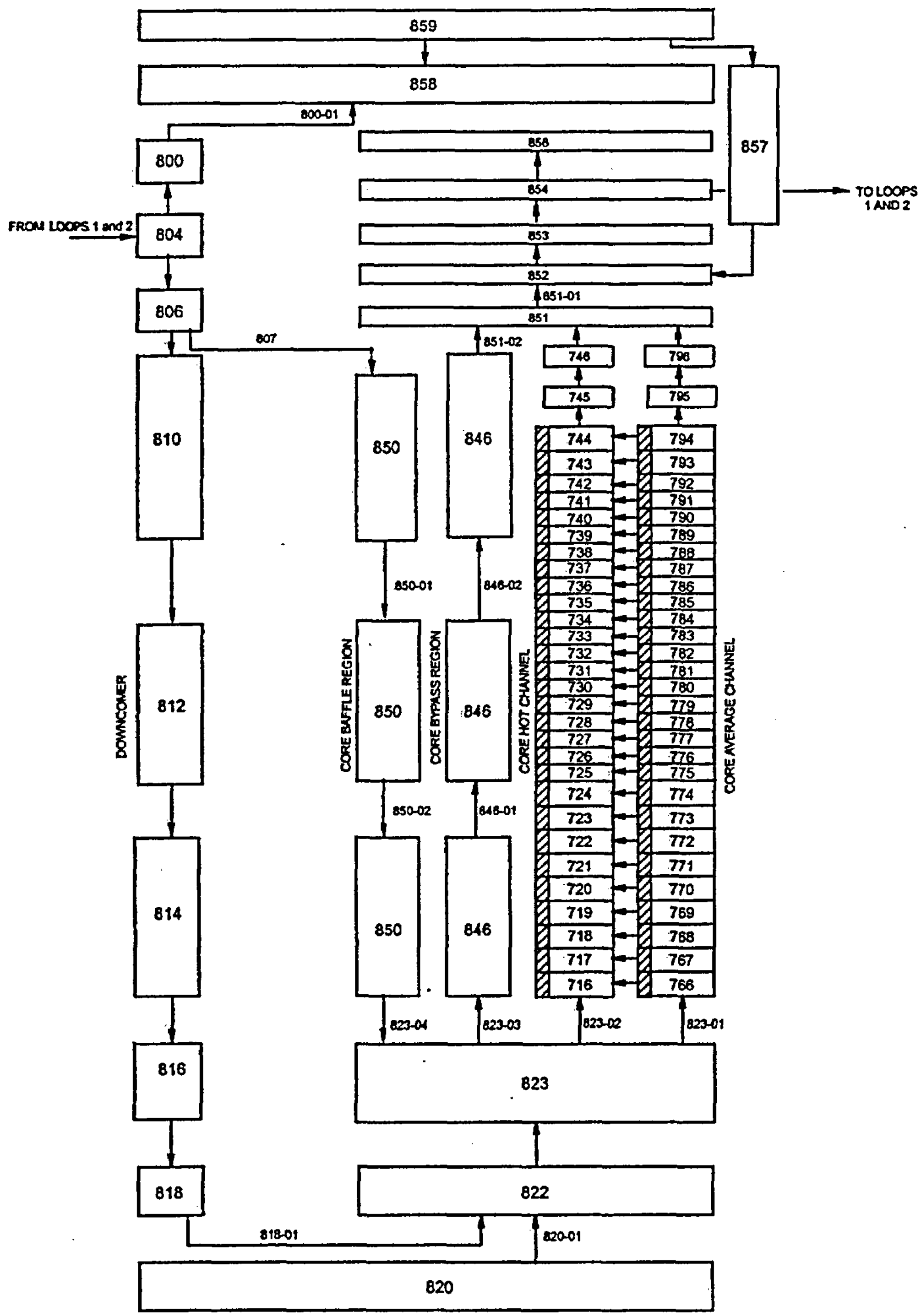

Figure 7.3-2b: NAPS Unit 2 RELAP5 SBLOCA Core Noding Diagram

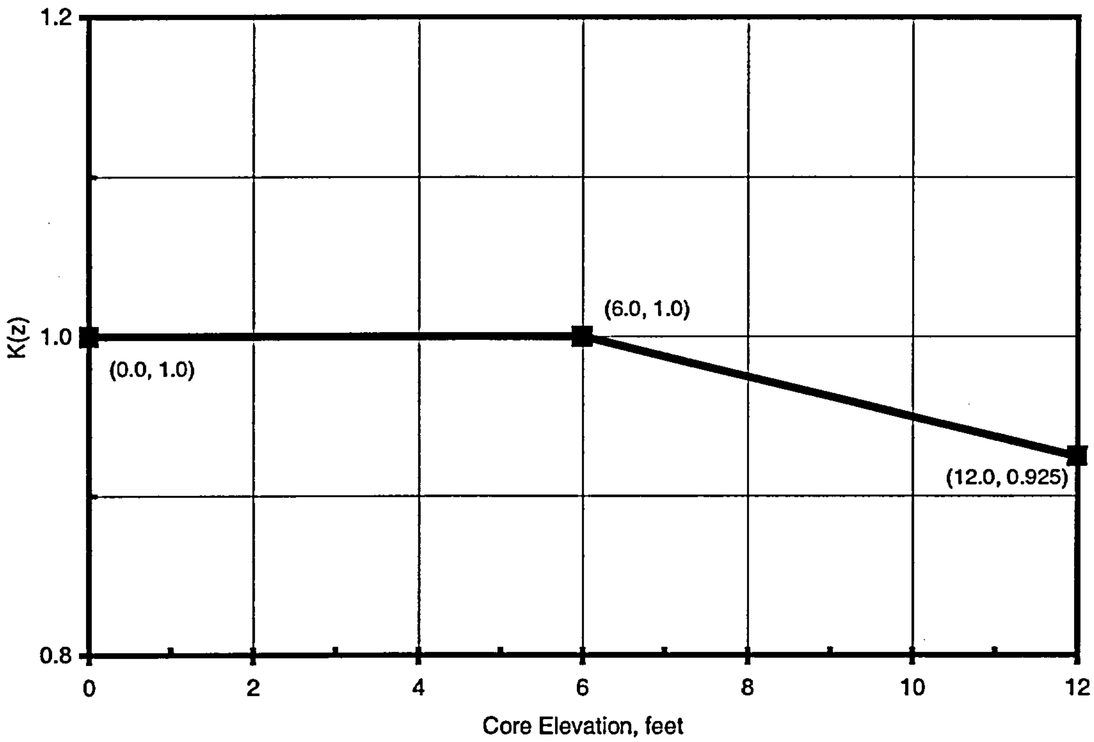

Figure 7.3-3: NAPS Units 1 and 2 Small Break LOCA K_Z Curve

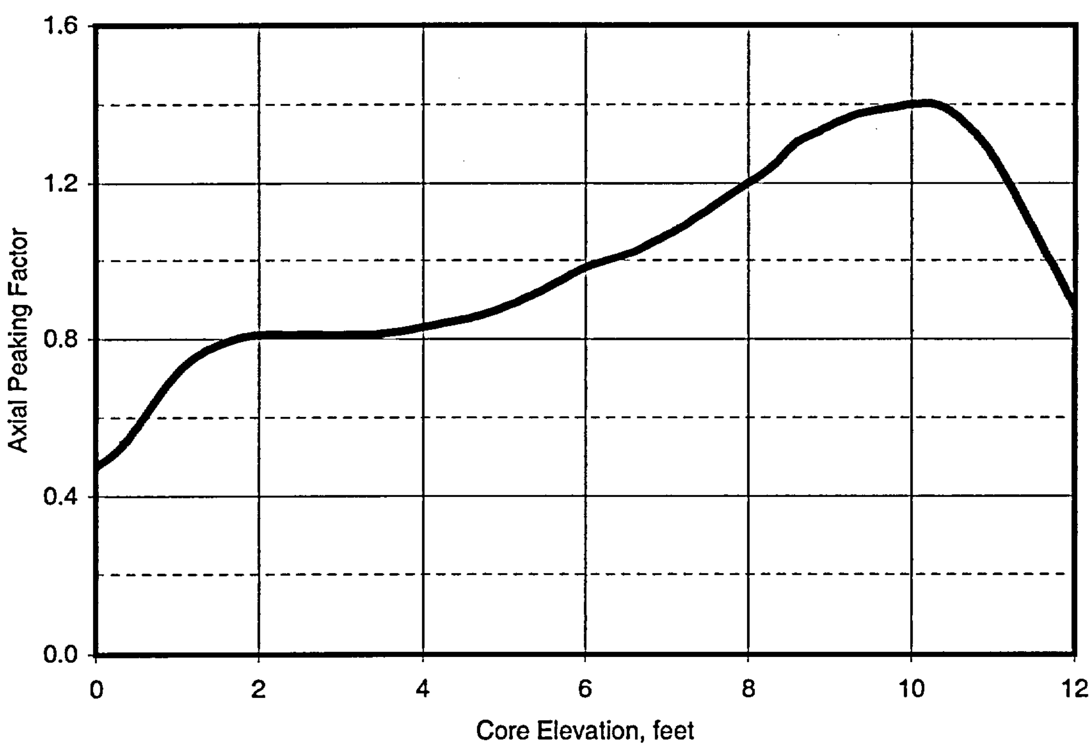

Figure 7.3-4: NAPS Units 1 and 2 Small Break LOCA Axial Power Profile

Figure 7.3-5: NAPS Unit 1 RCS Pressure - 2-inch Break

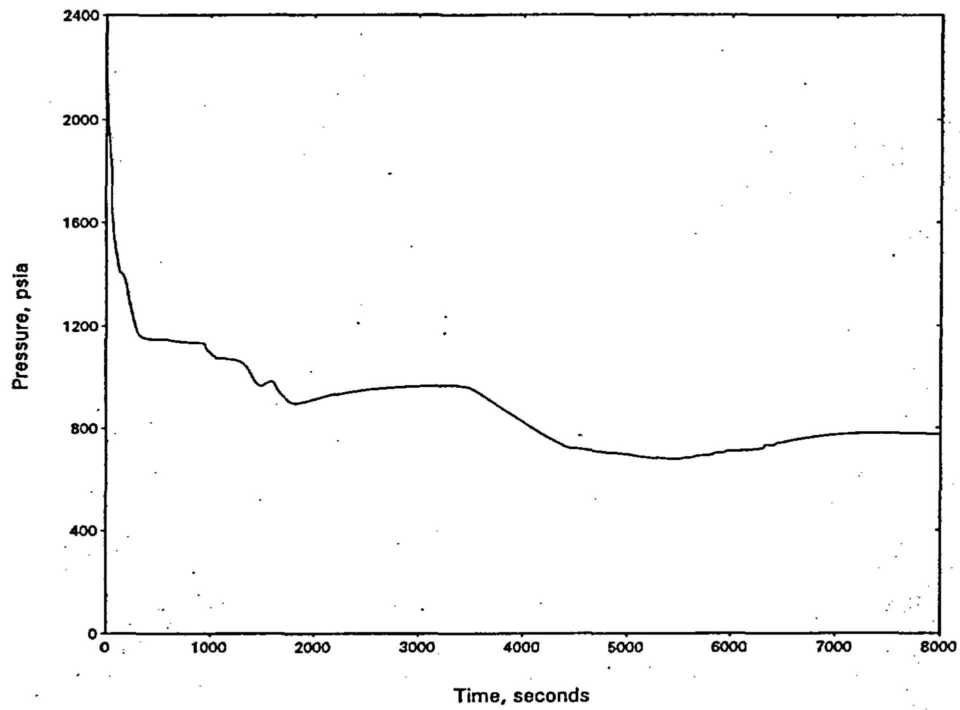

Figure 7.3-6: NAPS Unit 1 Break Flow - 2-inch Break

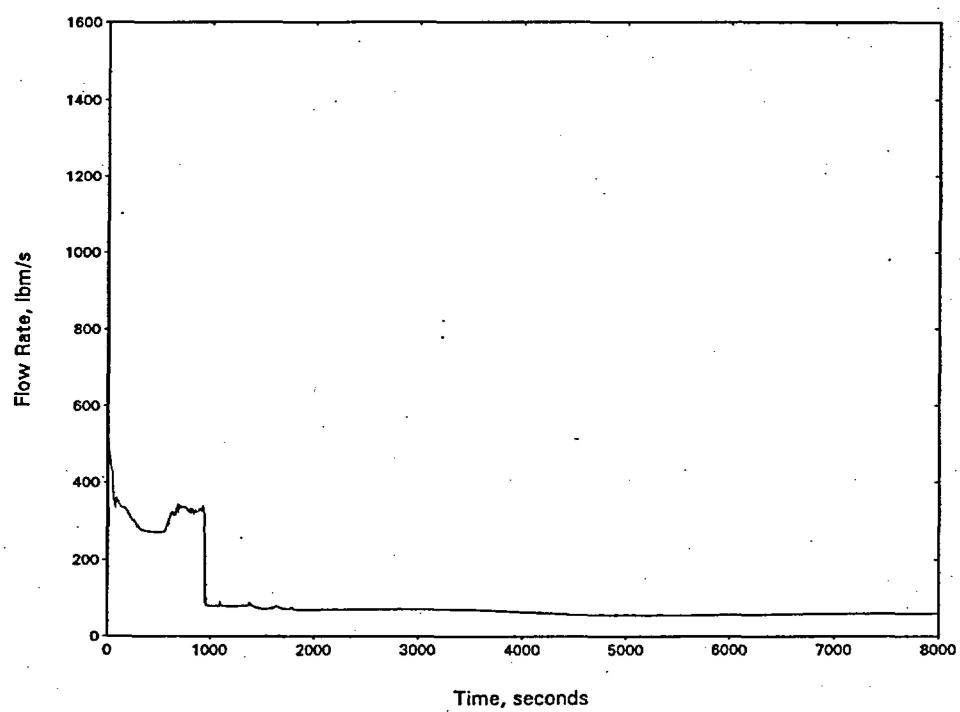

Figure 7.3-7: NAPS Unit 1 Hot Channel Mixture Level - 2-inch Break

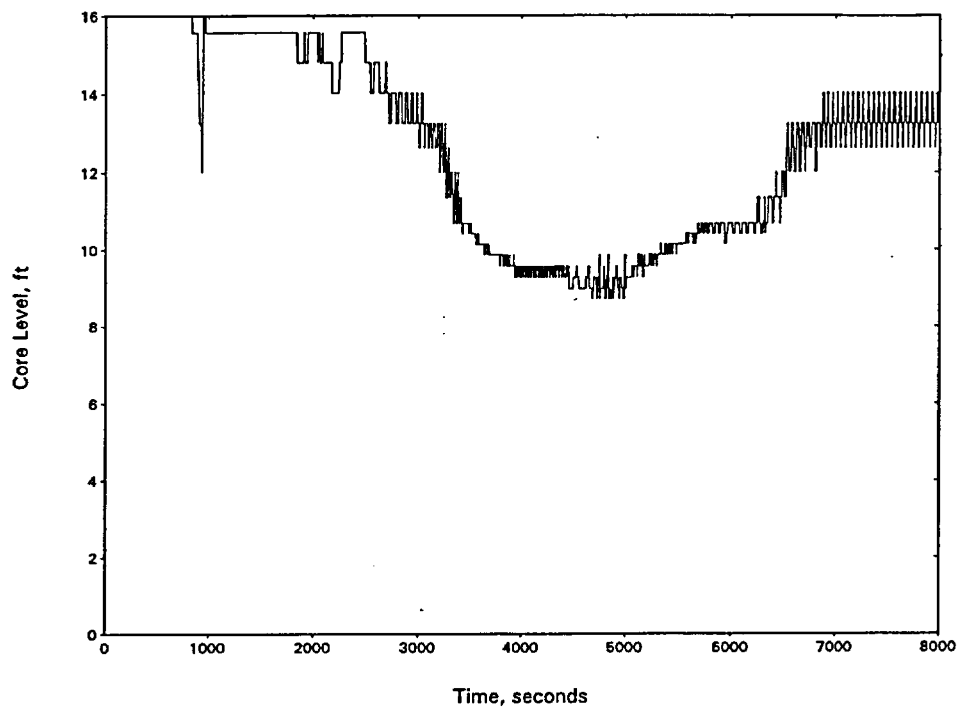

Figure 7.3-8: NAPS Unit 1 Hot Spot PCT - 2-inch Break

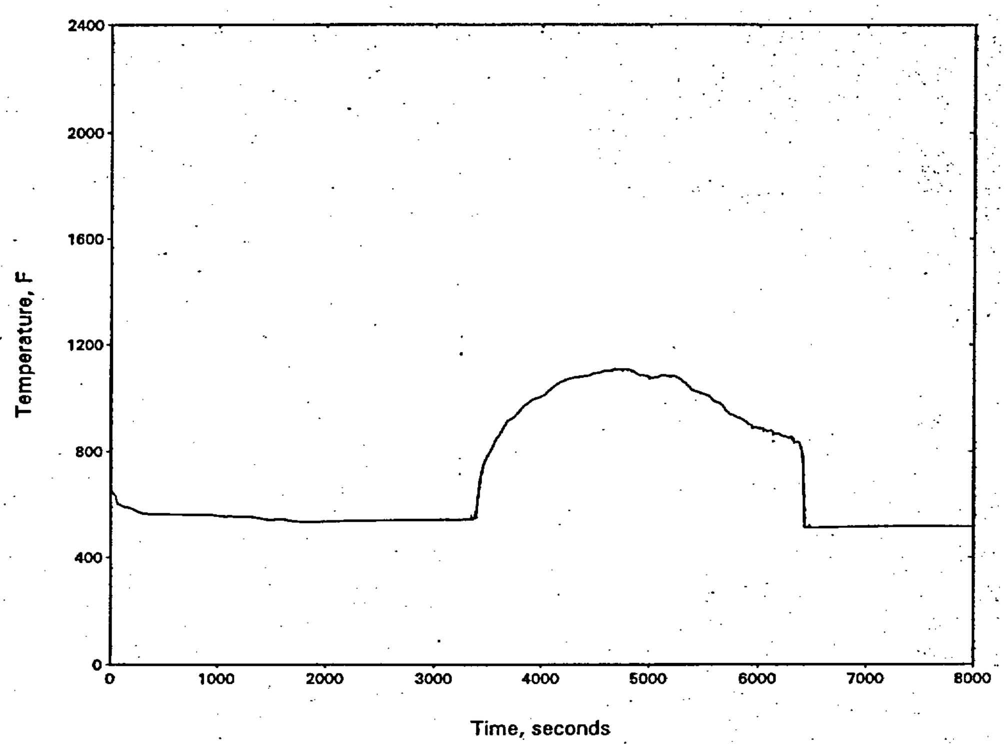

Figure 7.3-9: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 2-inch Break

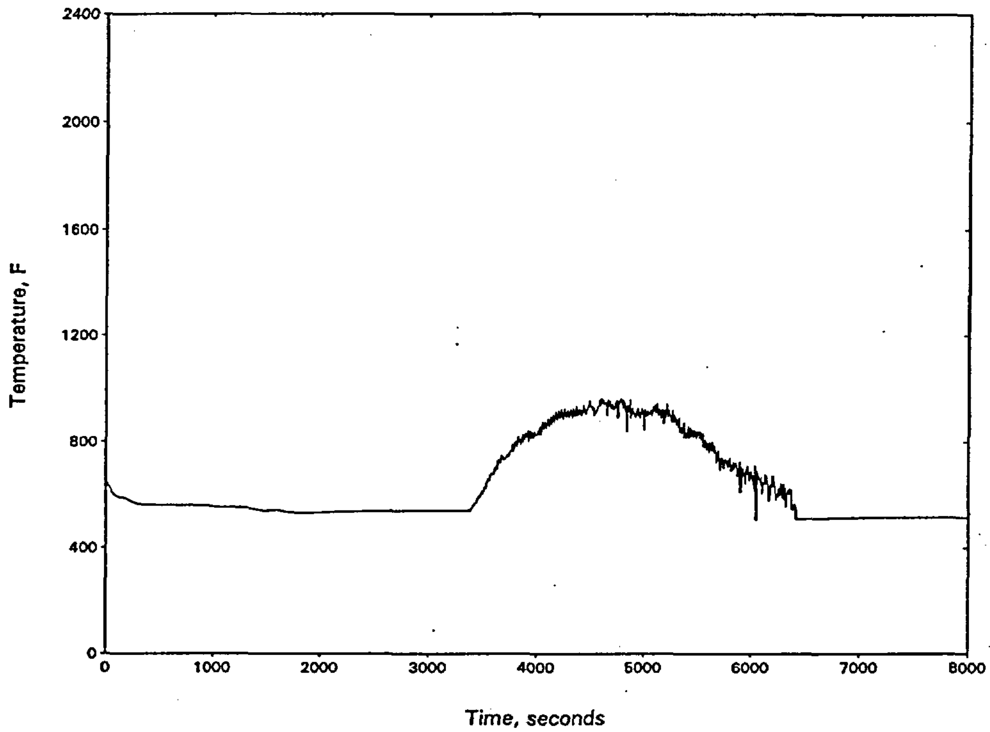

Figure 7.3-10: NAPS Unit 1 Intact Loop Seal Level - 2-inch Break

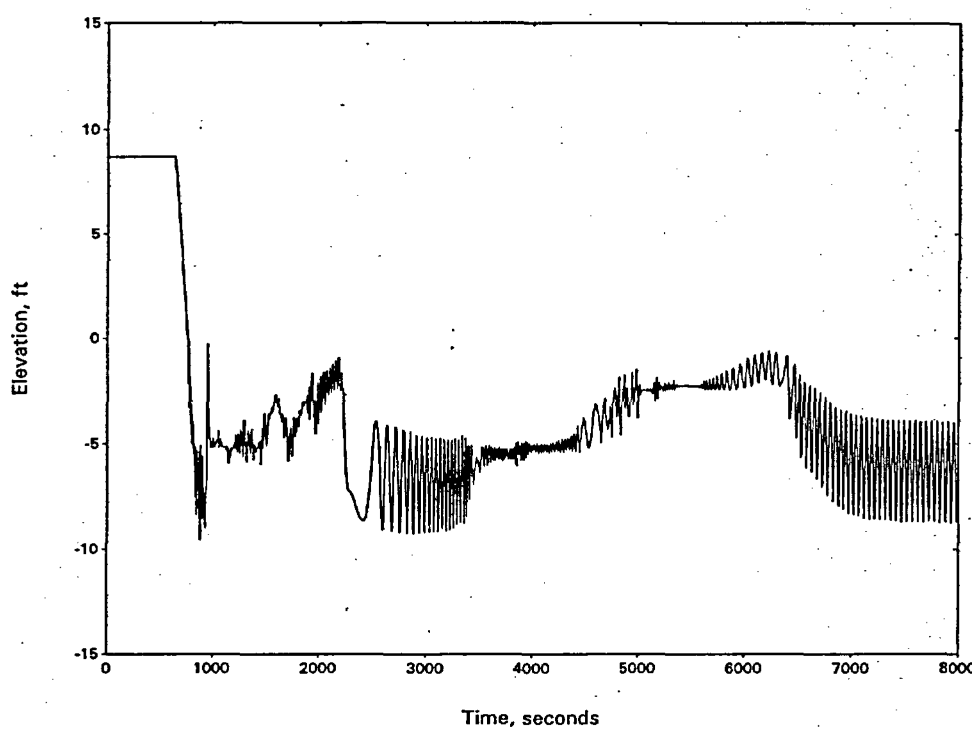

Figure 7.3-11: NAPS Unit 1 Broken Loop Seal Level - 2-inch Break

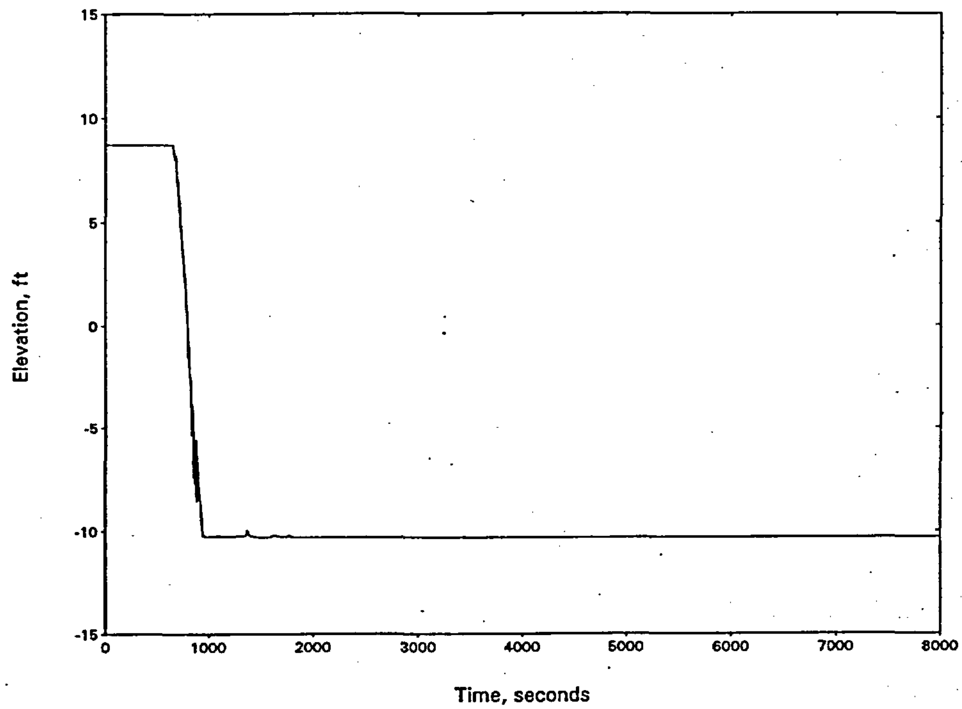

Figure 7.3-12: NAPS Unit 1 RCS Pressure - 2.5-inch Break

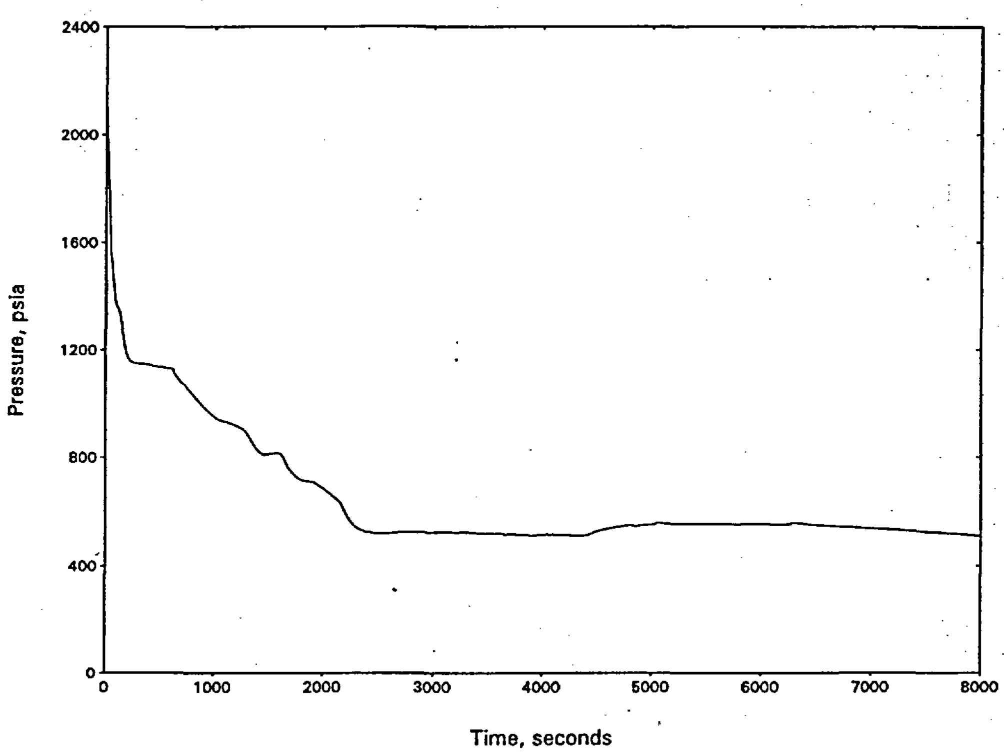

Figure 7.3-13: NAPS Unit 1 Break Flow - 2.5-inch Break

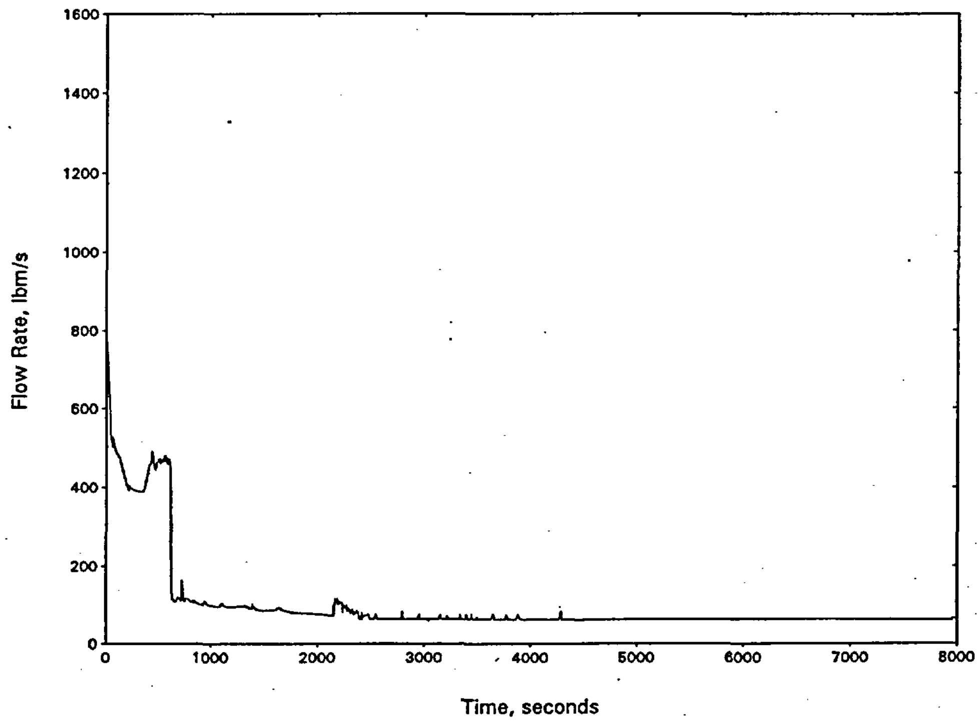

Figure 7.3-14: NAPS Unit 1 Hot Channel Mixture Level - 2.5-inch Break

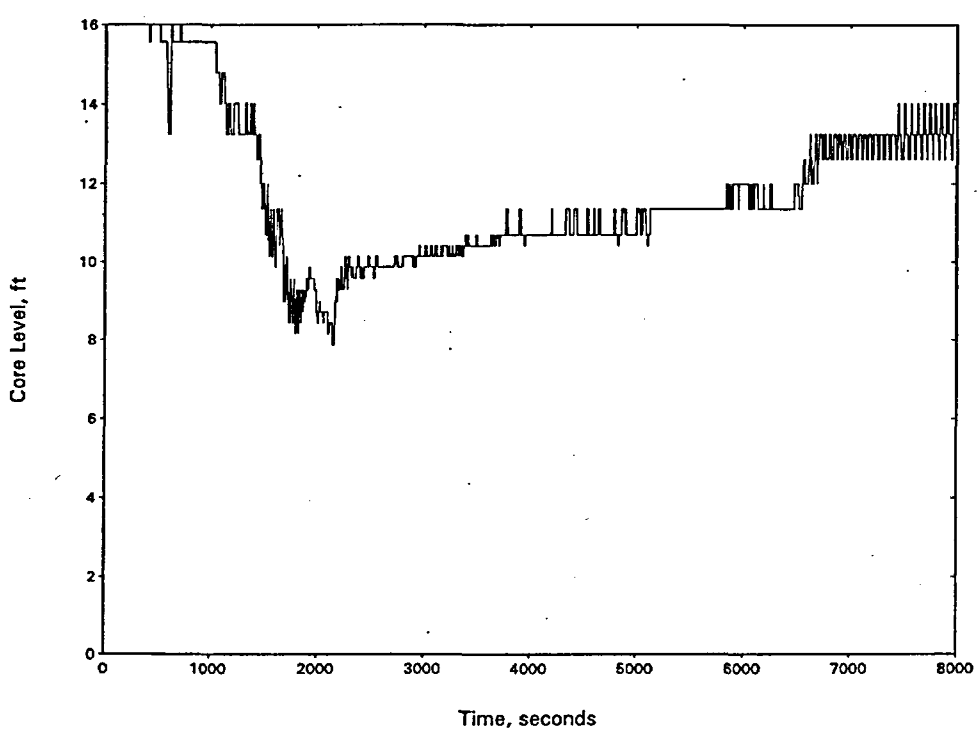

Figure 7.3-15: NAPS Unit 1 Hot Spot PCT - 2.5-inch Break

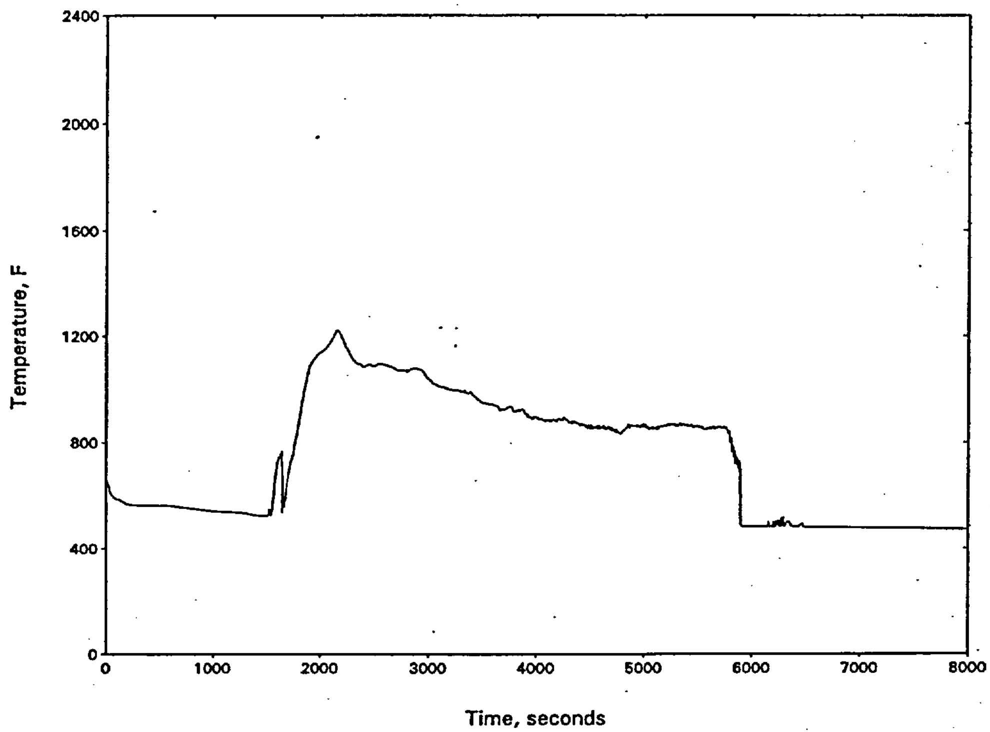

Figure 7.3-16: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 2.5-inch Break

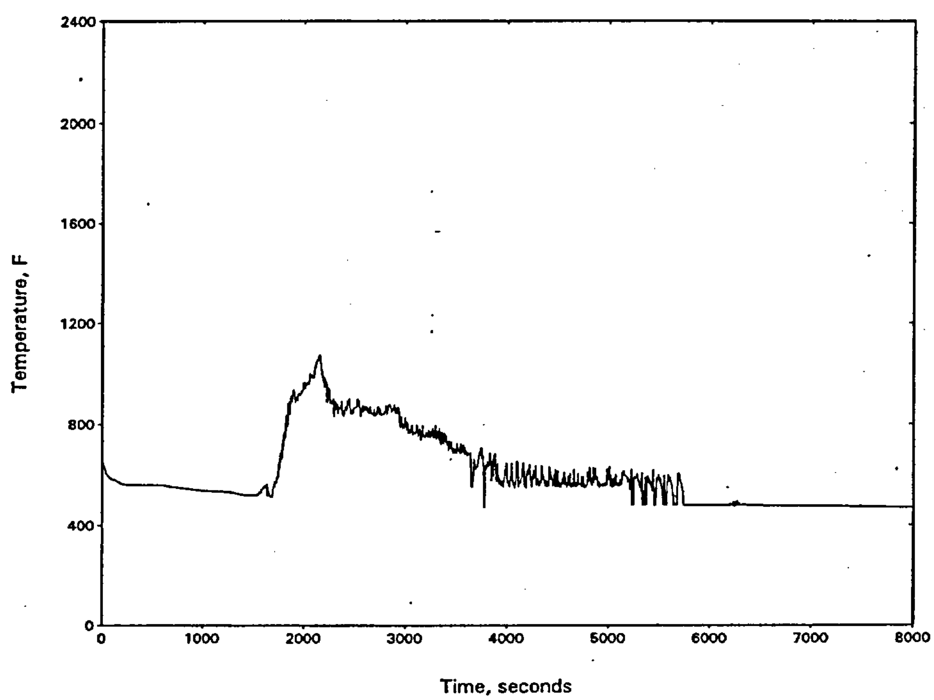

Figure 7.3-17: NAPS Unit 1 Intact Loop Seal Level - 2.5-inch Break

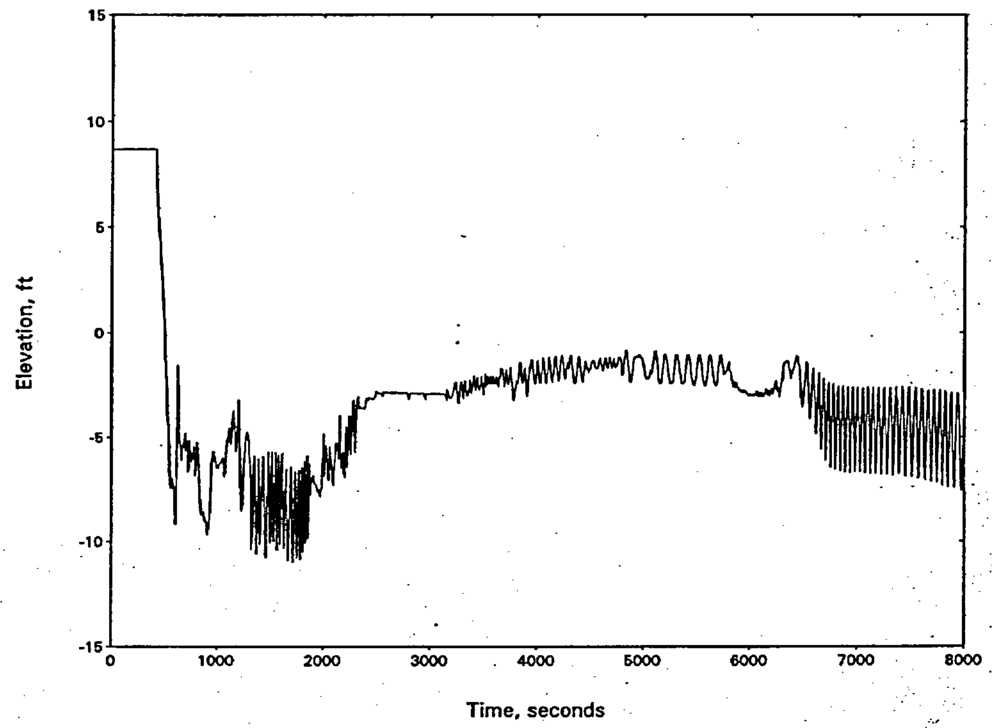

Figure 7.3-18: NAPS Unit 1 Broken Loop Seal Level - 2.5-inch Break

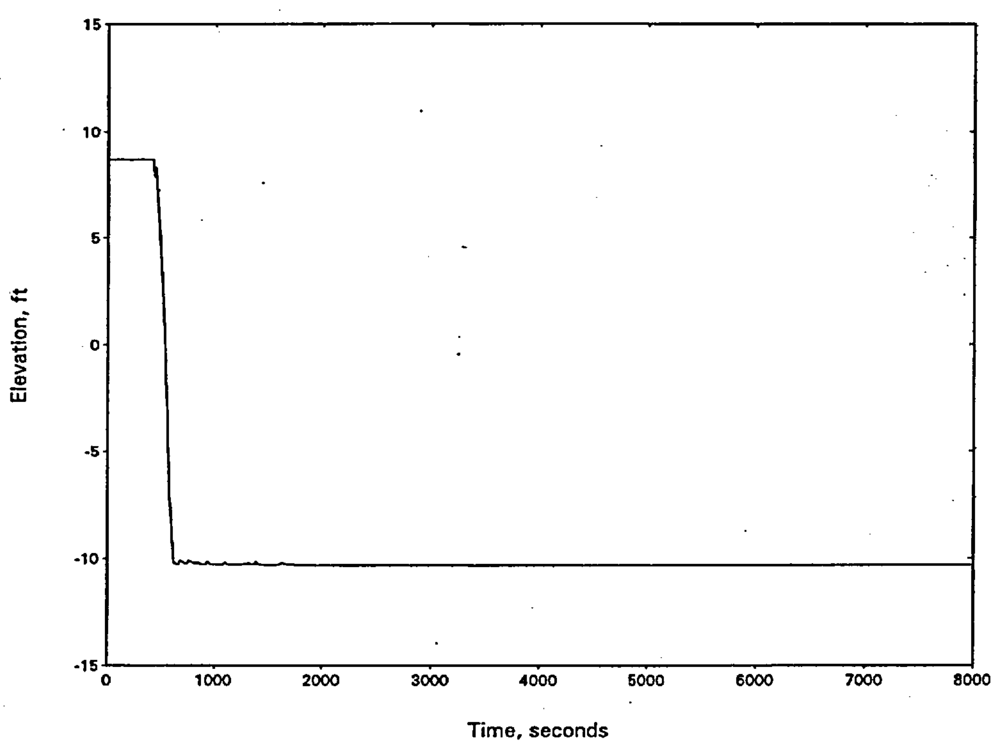

Figure 7.3-19: NAPS Unit 1 RCS Pressure - 3-inch Break

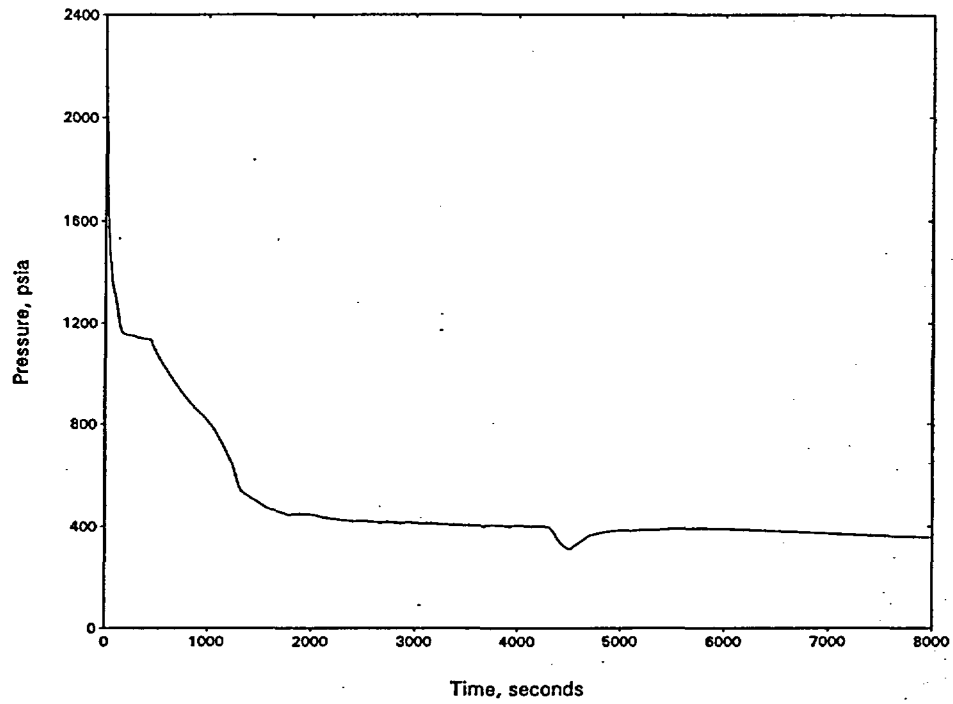

Figure 7.3-20: NAPS Unit 1 Break Flow - 3-inch Break

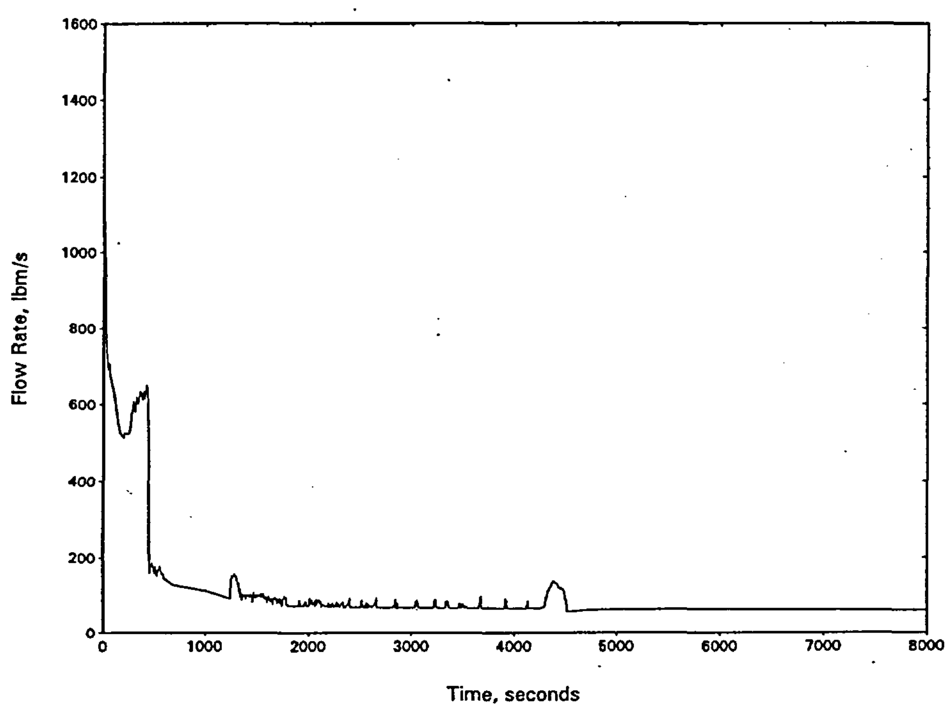

Figure 7.3-21: NAPS Unit 1 Hot Channel Mixture Level - 3-inch Break

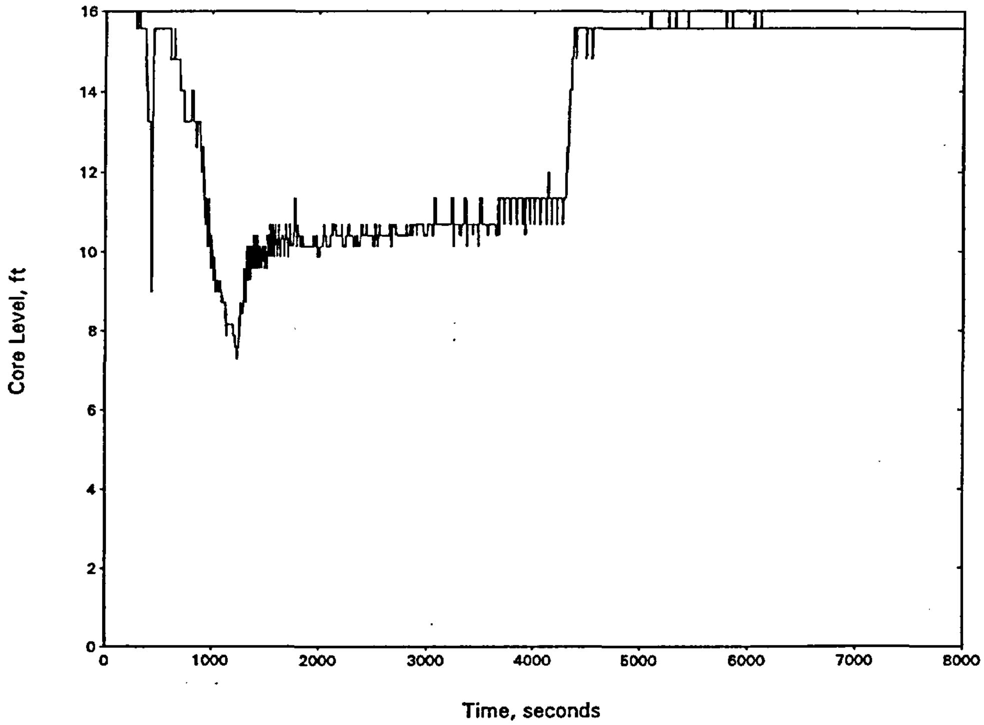

Figure 7.3-22: NAPS Unit 1 Hot Spot PCT - 3-inch Break

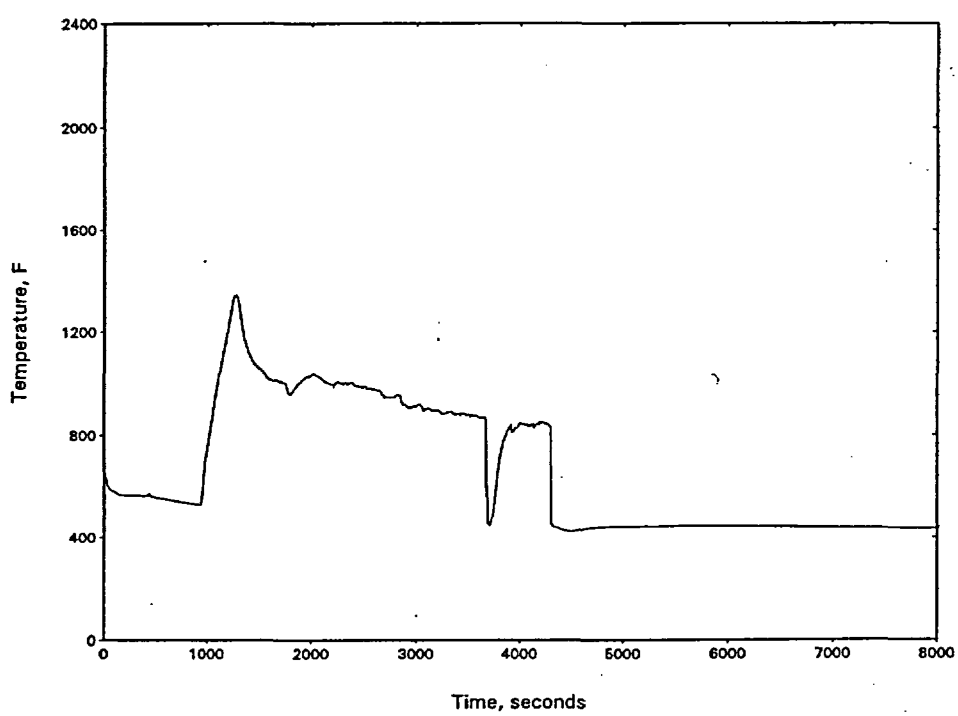

Figure 7.3-23: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 3-inch Break

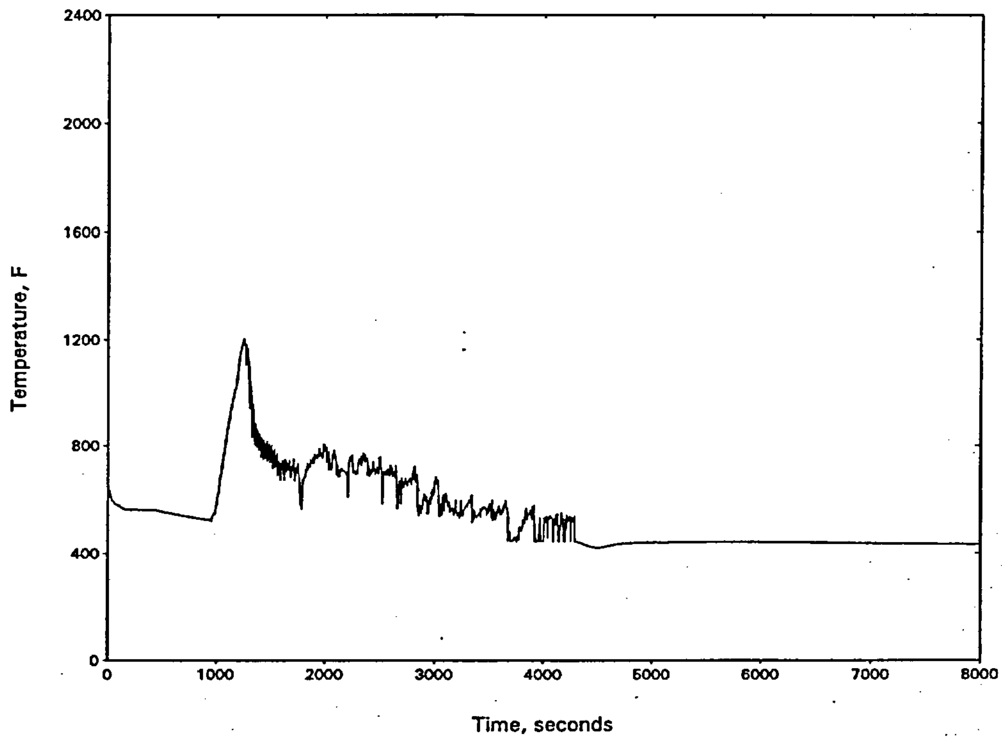

Figure 7.3-24: NAPS Unit 1 Intact Loop Seal Level - 3-inch Break

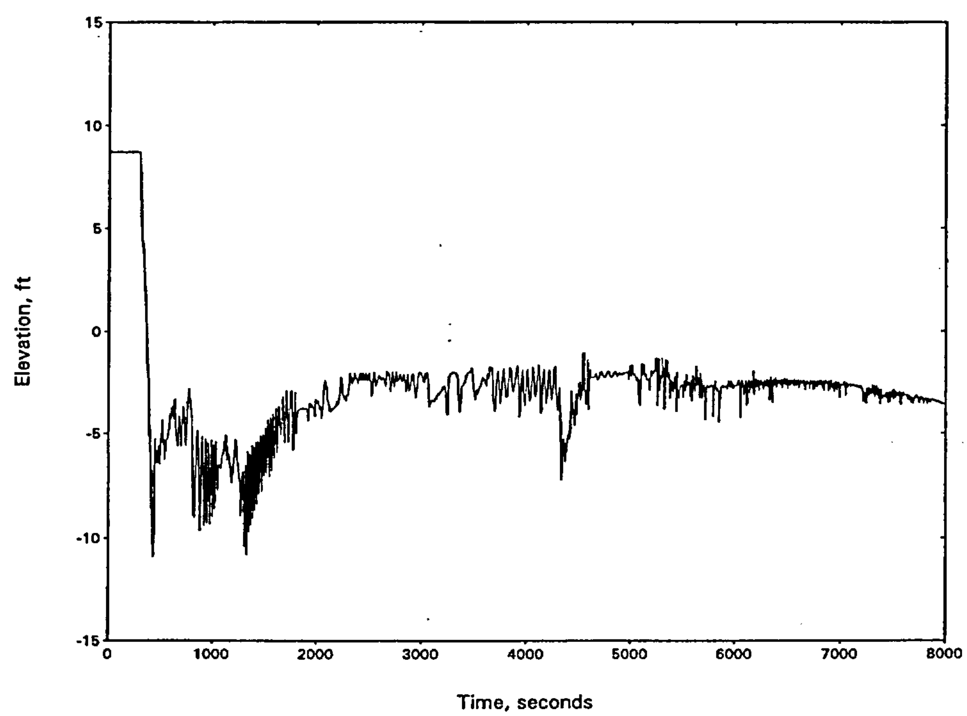

Figure 7.3-25: NAPS Unit 1 Broken Loop Seal Level - 3-inch Break

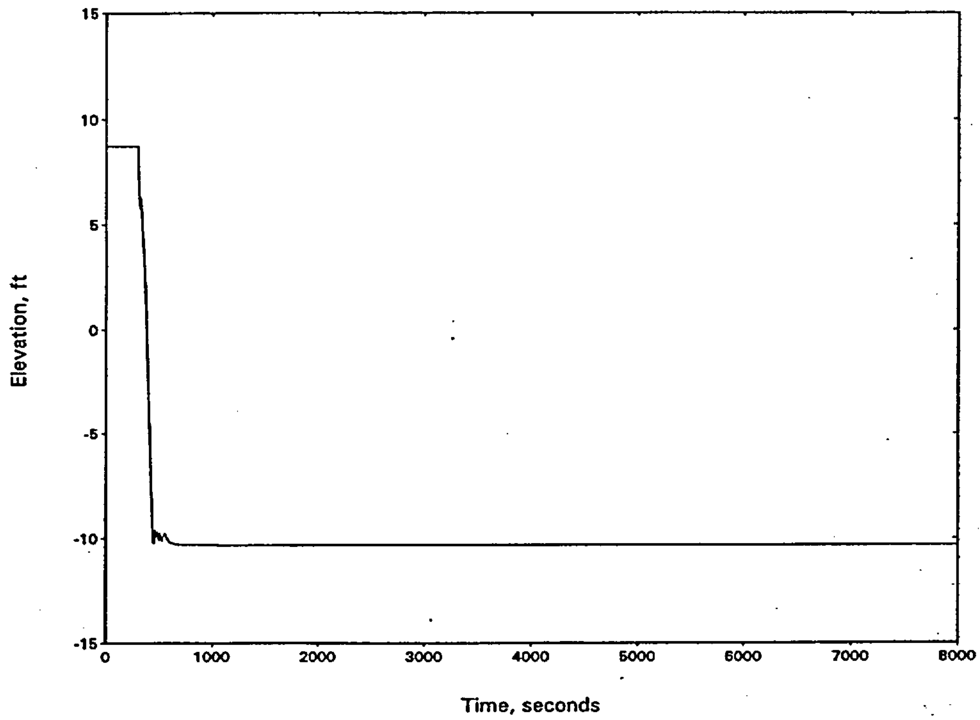

Figure 7.3-26: NAPS Unit 1 RCS Pressure - 4-inch Break

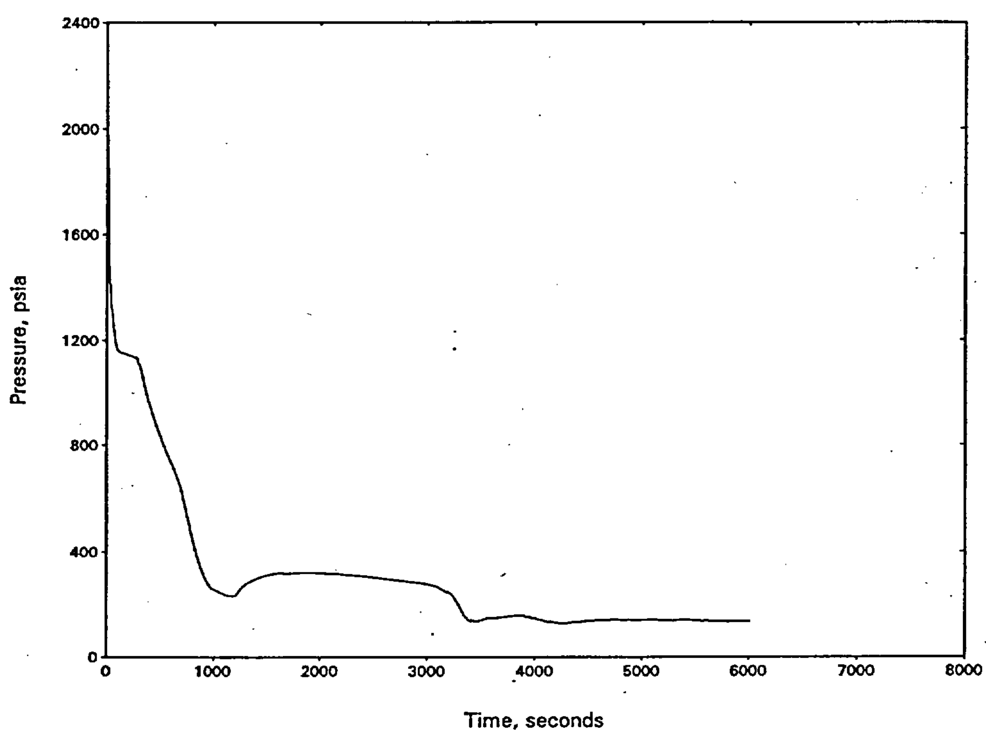

Figure 7.3-27: NAPS Unit 1 Break Flow - 4-inch Break

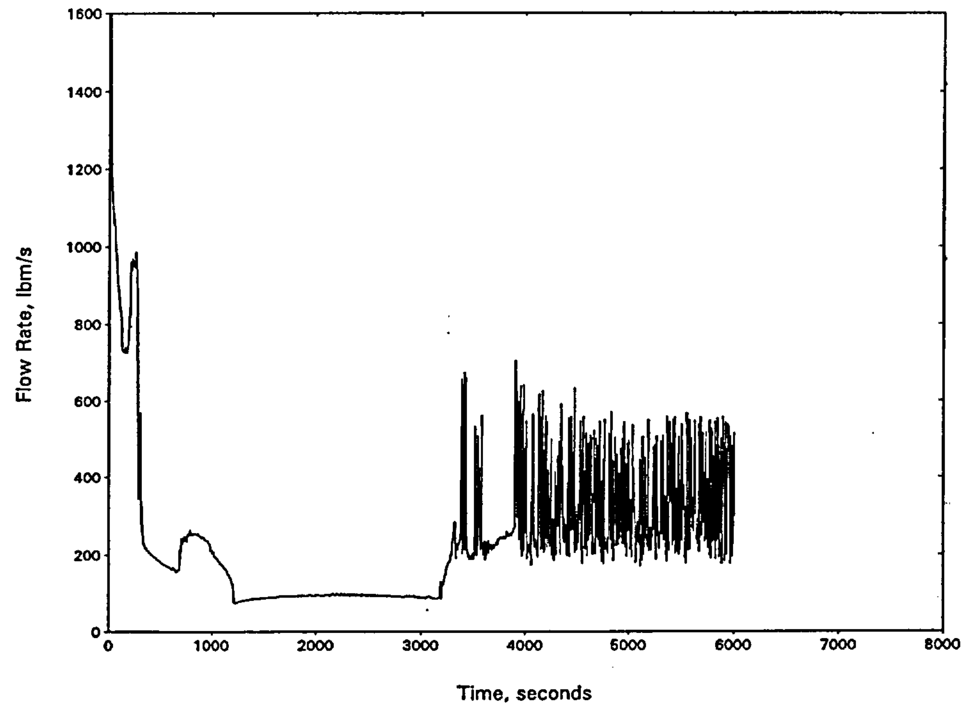

Figure 7.3-28: NAPS Unit 1 Hot Channel Mixture Level - 4-inch Break

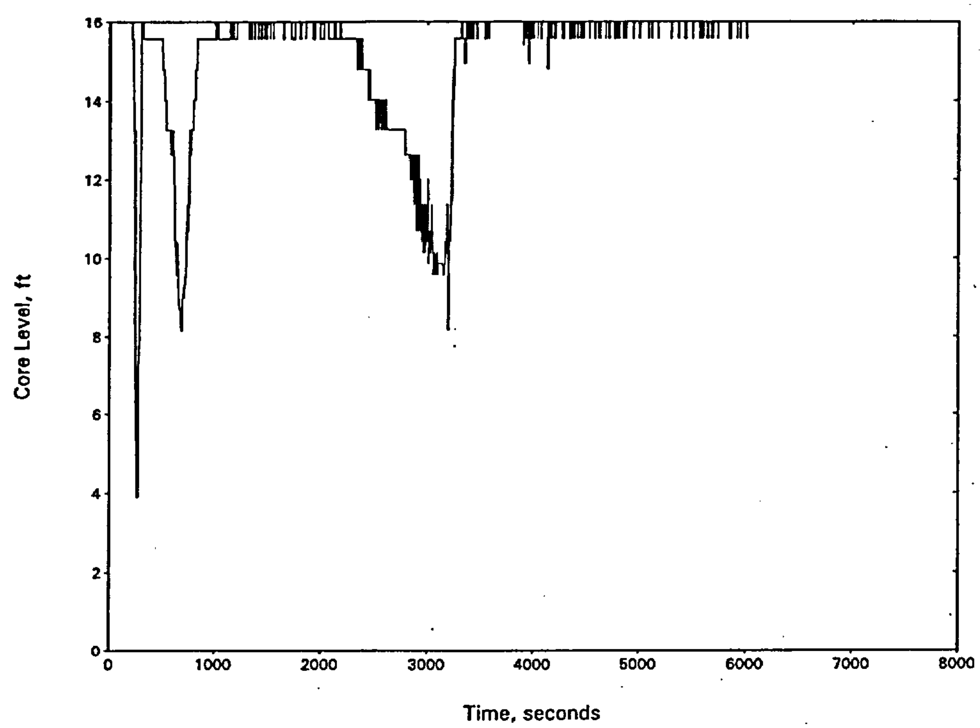

Figure 7.3-29: NAPS Unit 1 Hot Spot PCT - 4-inch Break

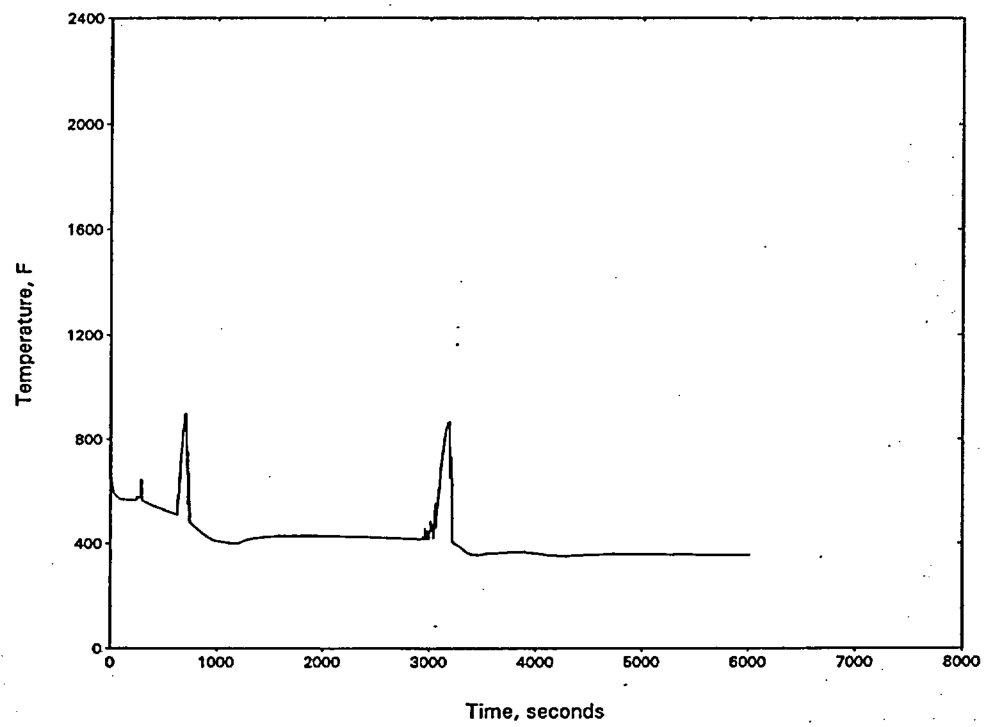

Figure 7.3-30: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 4-inch Break

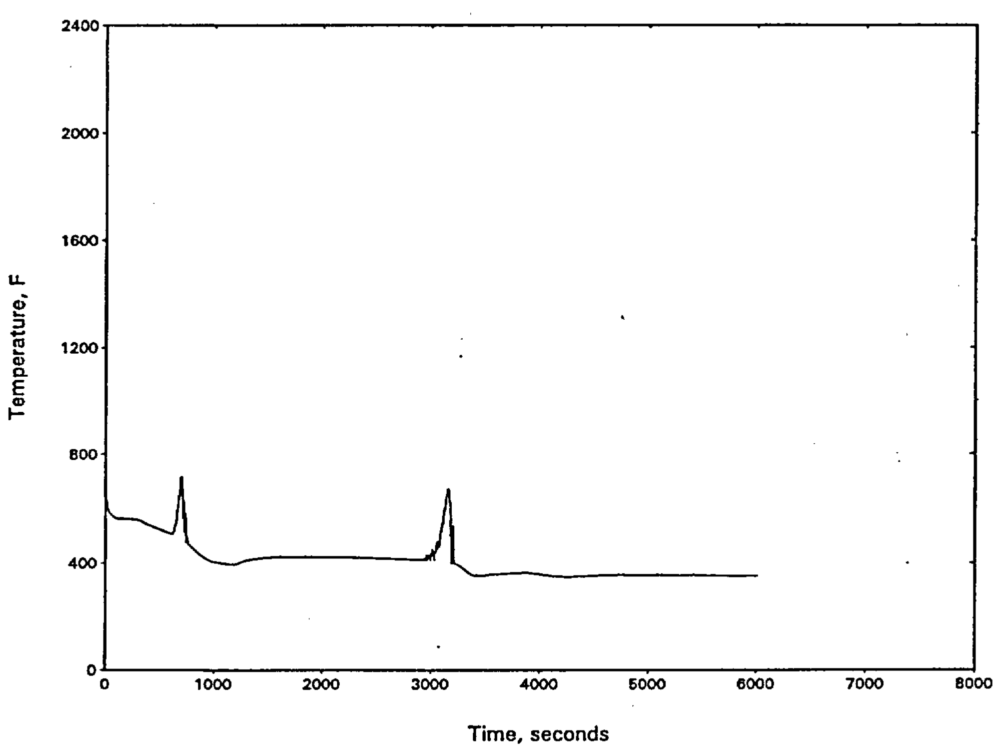

Figure 7.3-31: NAPS Unit 1 Intact Loop Seal Level - 4-inch Break

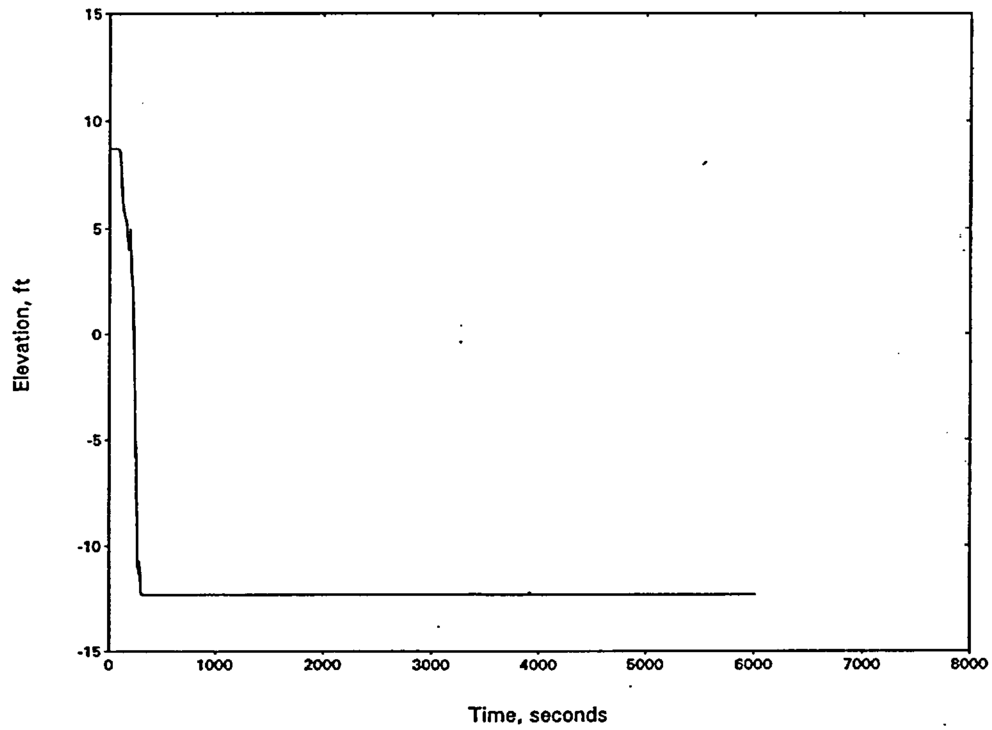

Figure 7.3-32: NAPS Unit 1 Broken Loop Seal Level - 4-inch Break

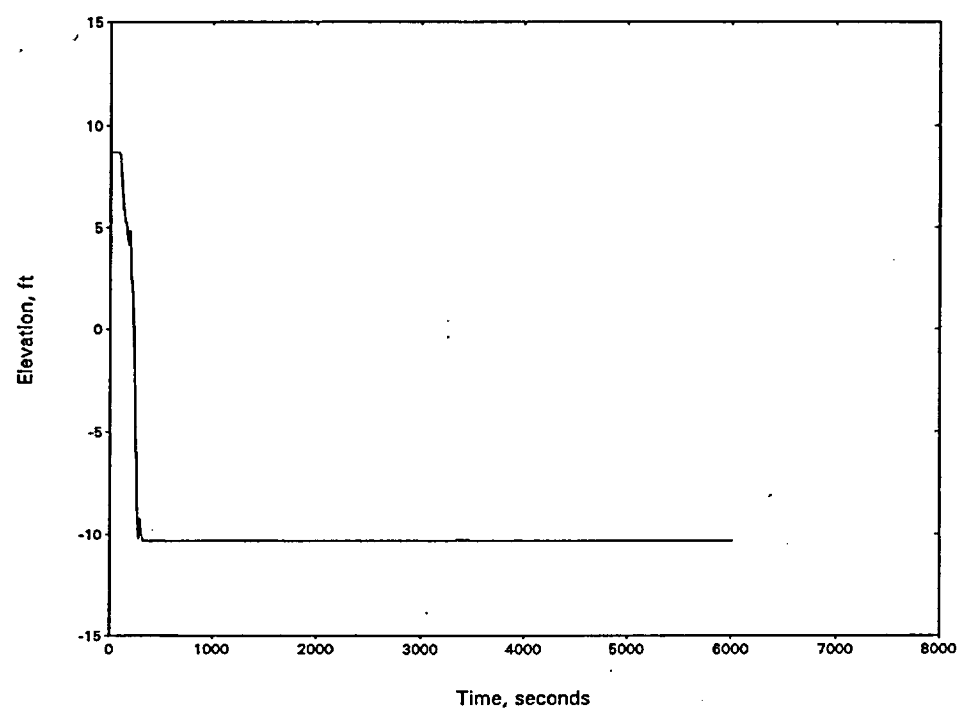

Figure 7.3-33: NAPS Unit 1 RCS Pressure - 5.2-inch SI Line Break

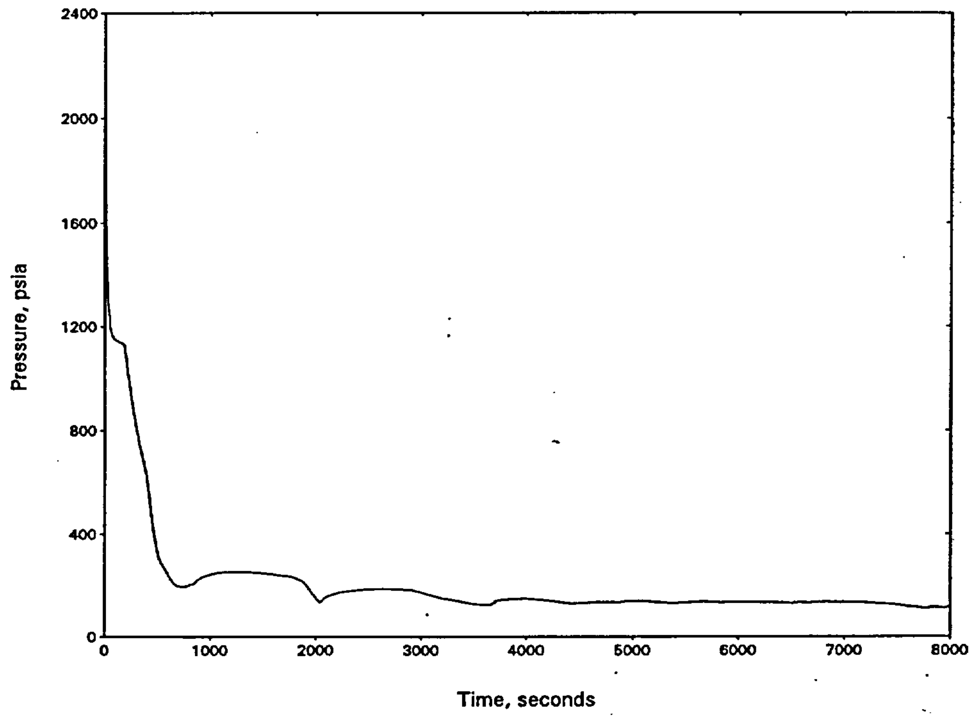

Figure 7.3-34: NAPS Unit 1 Break Flow - 5.2-inch SI Line Break

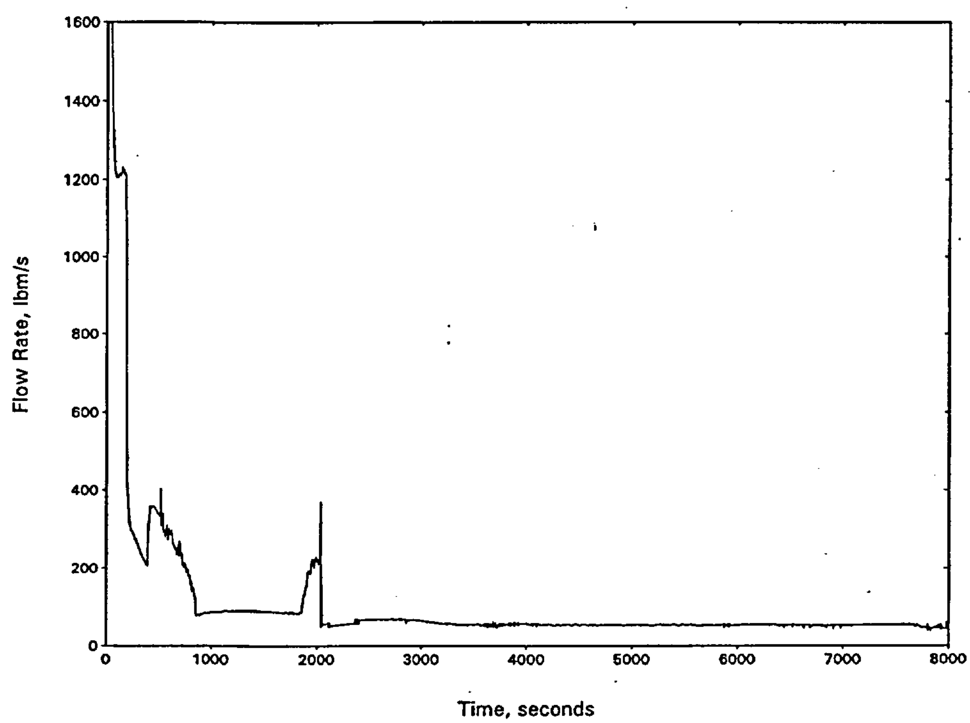

Figure 7.3-35: NAPS Unit 1 Hot Channel Mixture Level - 5.2-inch SI Line Break

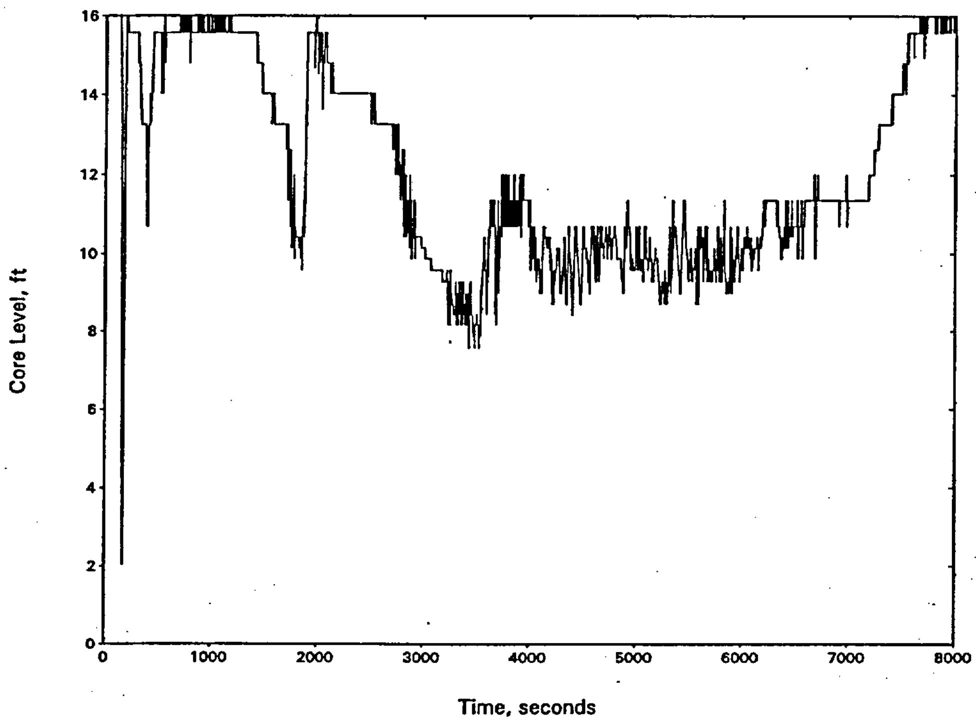

Figure 7.3-36: NAPS Unit 1 Hot Spot PCT - 5.2-inch SI Line Break

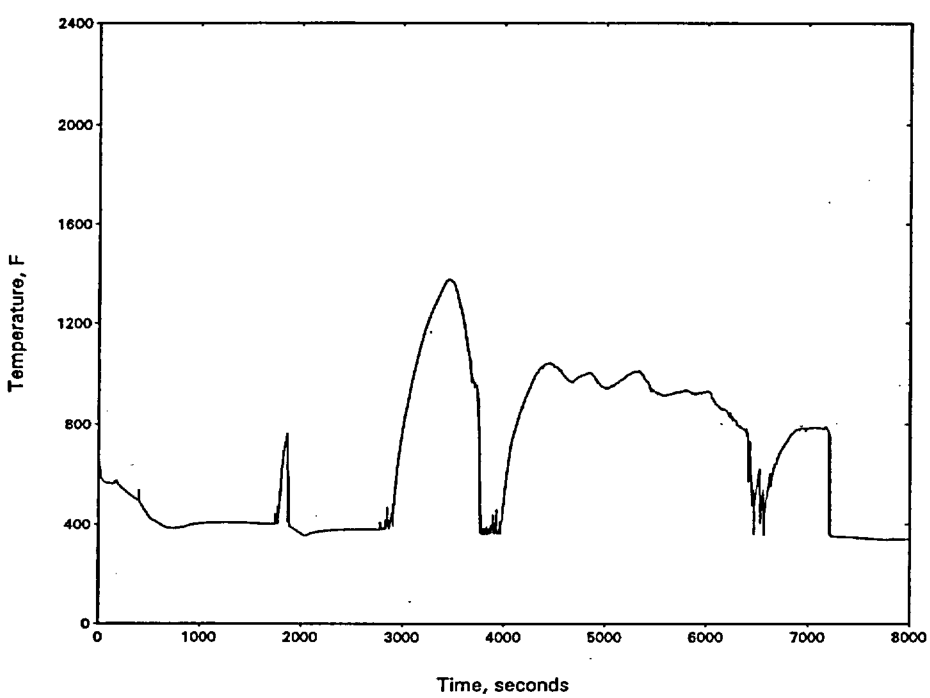

Figure 7.3-37: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 5.2-inch SI Line Break

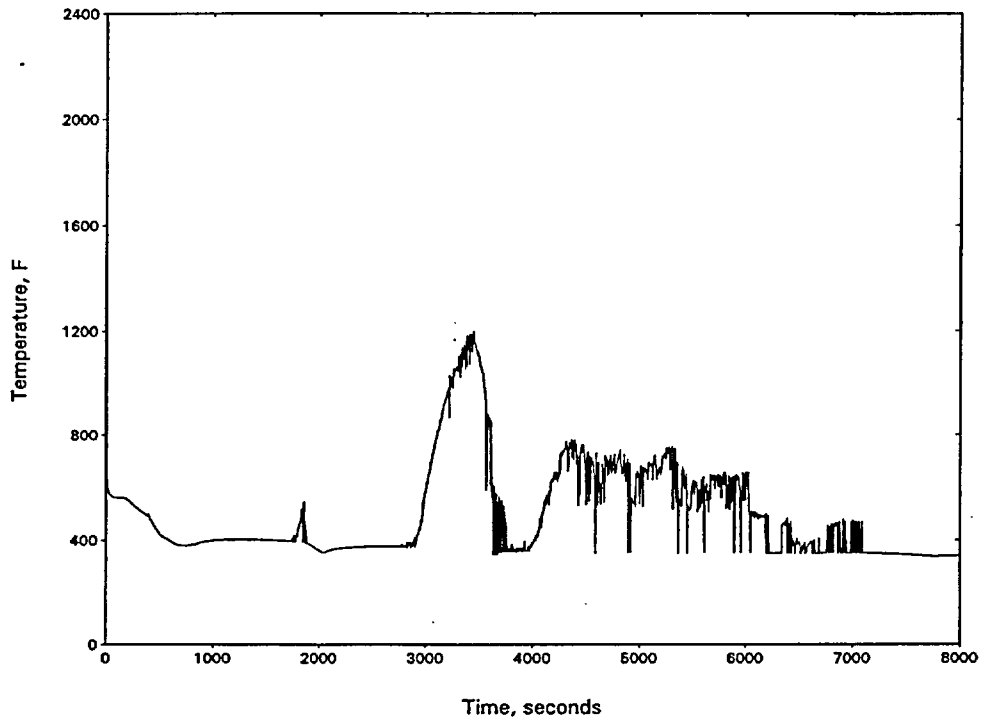

Figure 7.3-38: NAPS Unit 1 Intact Loop Seal Level - 5.2-inch SI Line Break

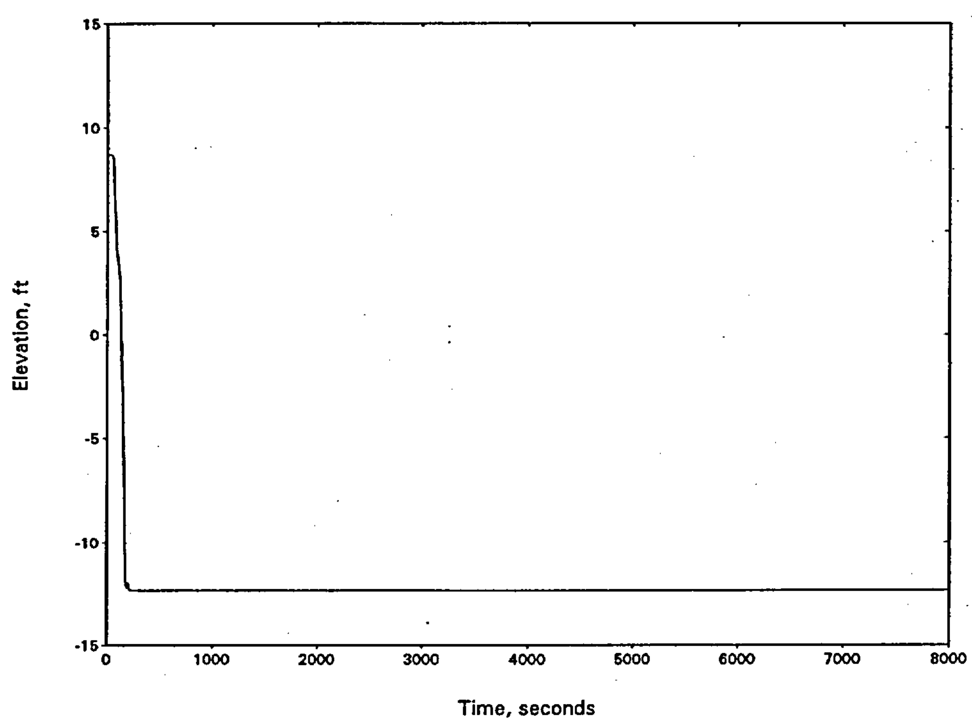

Figure 7.3-39: NAPS Unit 1 Broken Loop Seal Level - 5.2-inch SI Line Break

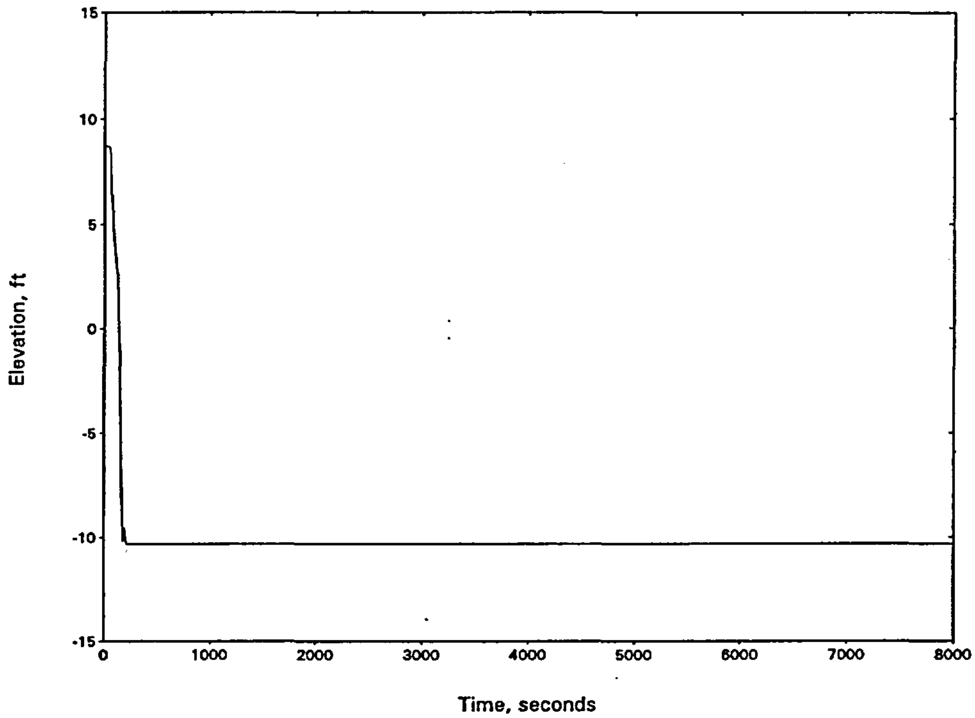

Figure 7.3-40: NAPS Unit 1 RCS Pressure - 6-inch Break

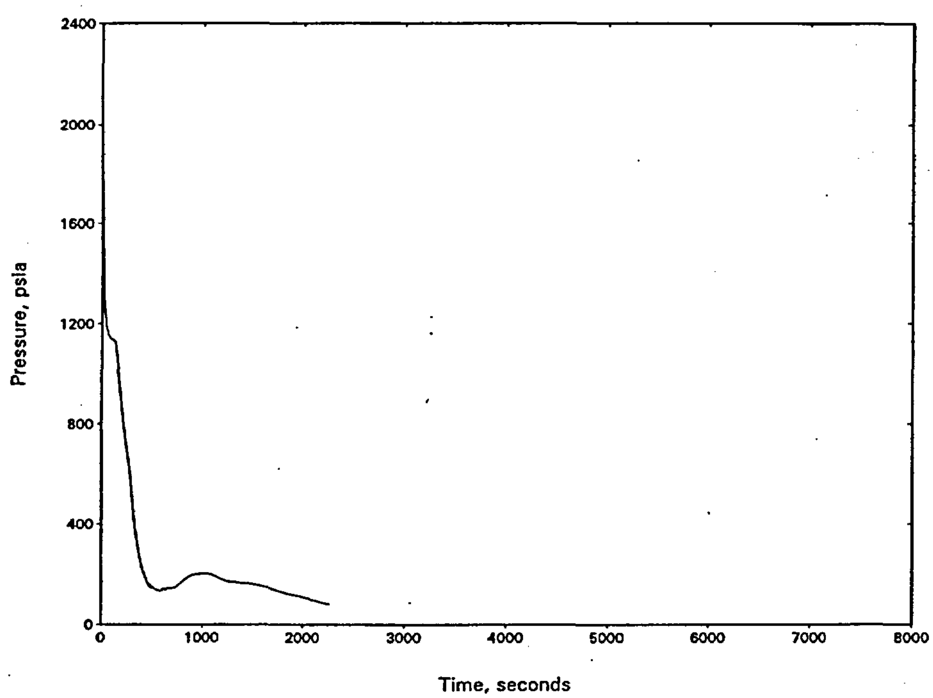

Figure 7.3-41: NAPS Unit 1 Break Flow - 6-inch Break

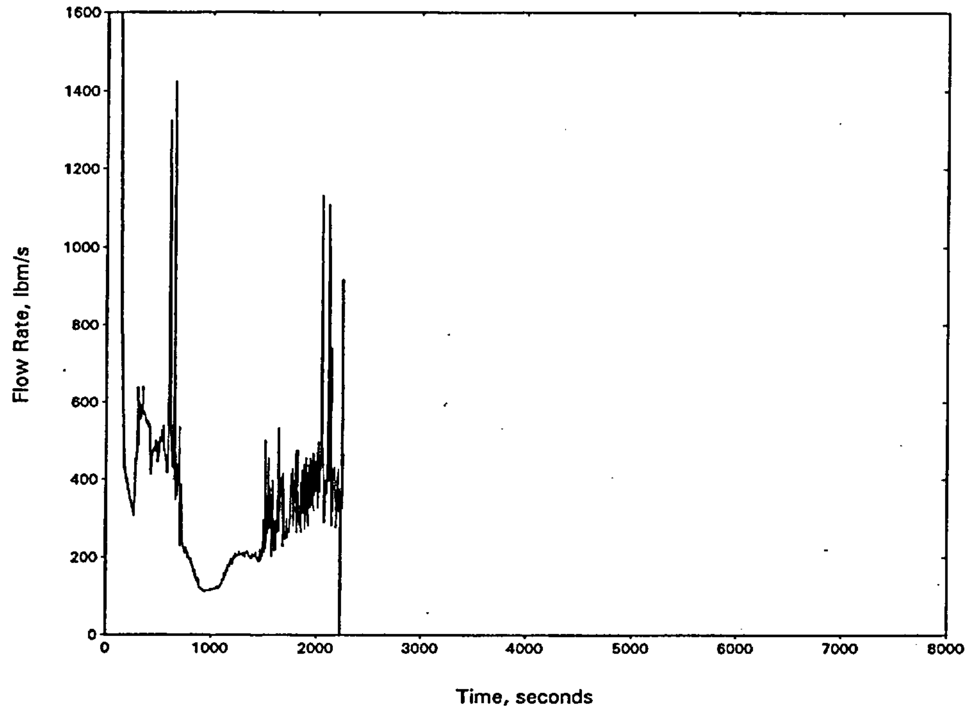

Figure 7.3-42: NAPS Unit 1 Hot Channel Mixture Level - 6-inch Break

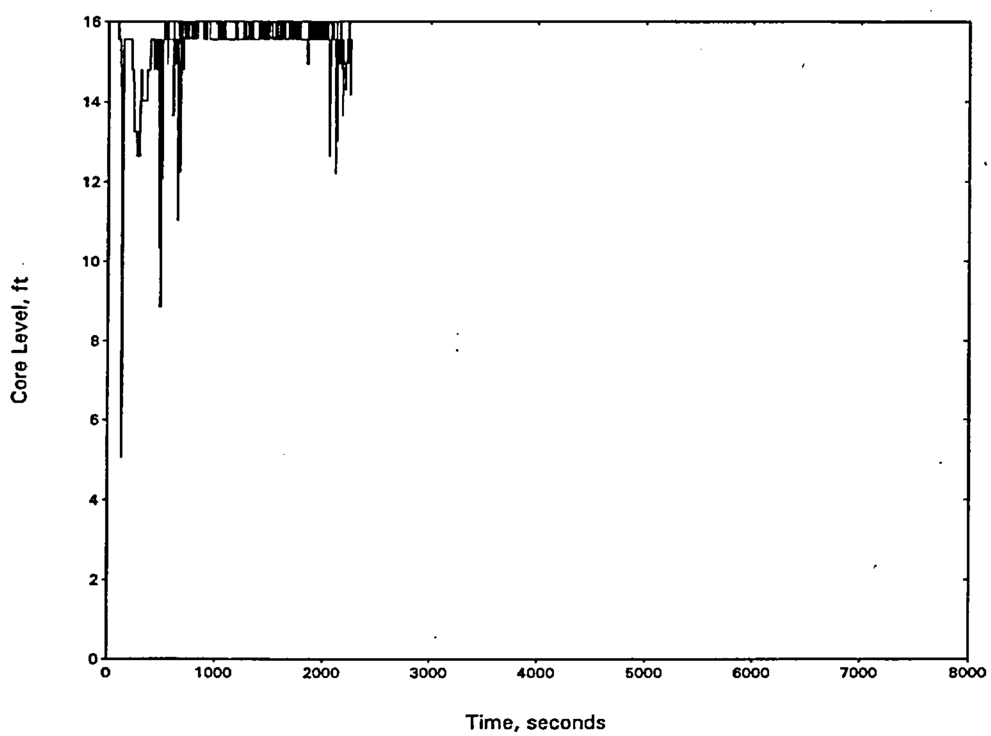

Figure 7.3-43: NAPS Unit 1 Hot Spot PCT - 6-inch Break

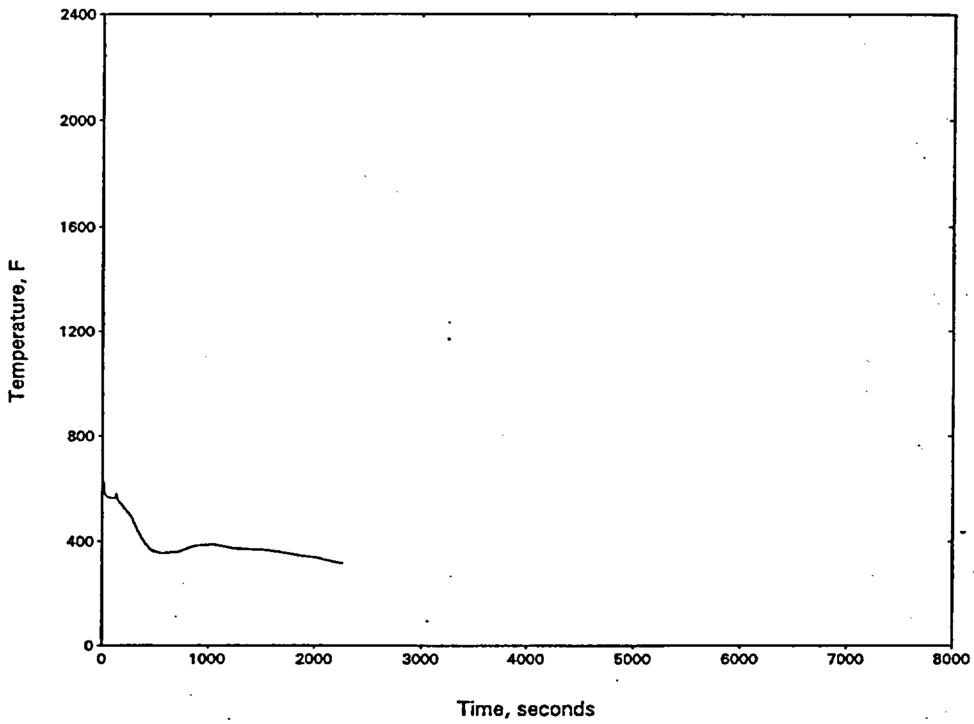

Figure 7.3-44: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 6-inch Break

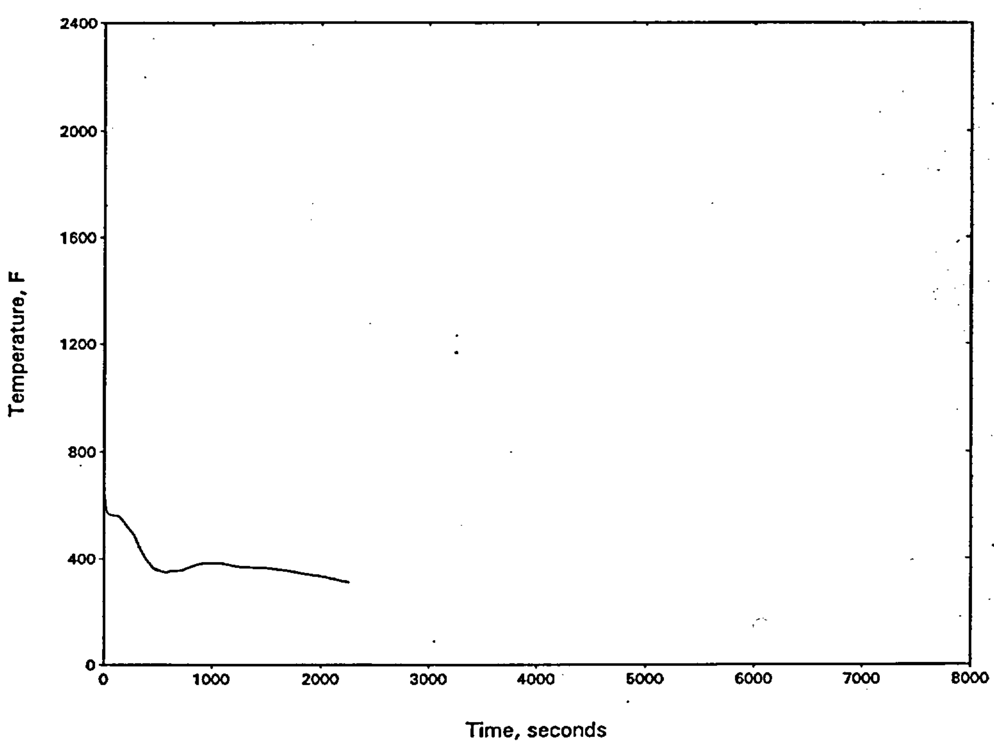

Figure 7.3-45: NAPS Unit 1 Intact Loop Seal Level - 6-inch Break

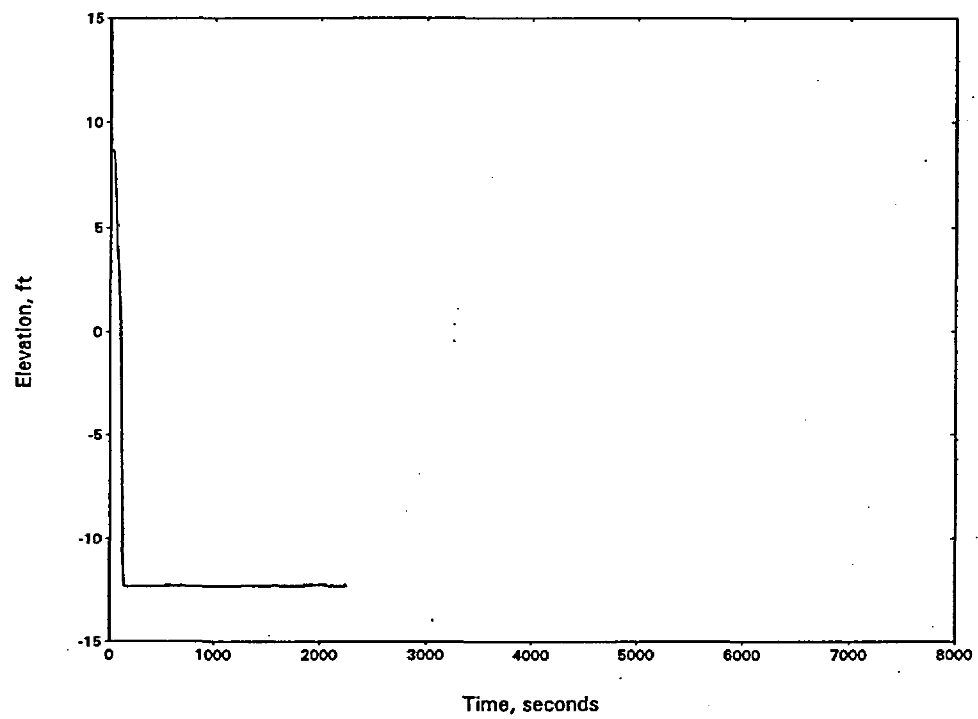

Figure 7.3-46: NAPS Unit 1 Broken Loop Seal Level - 6-inch Break

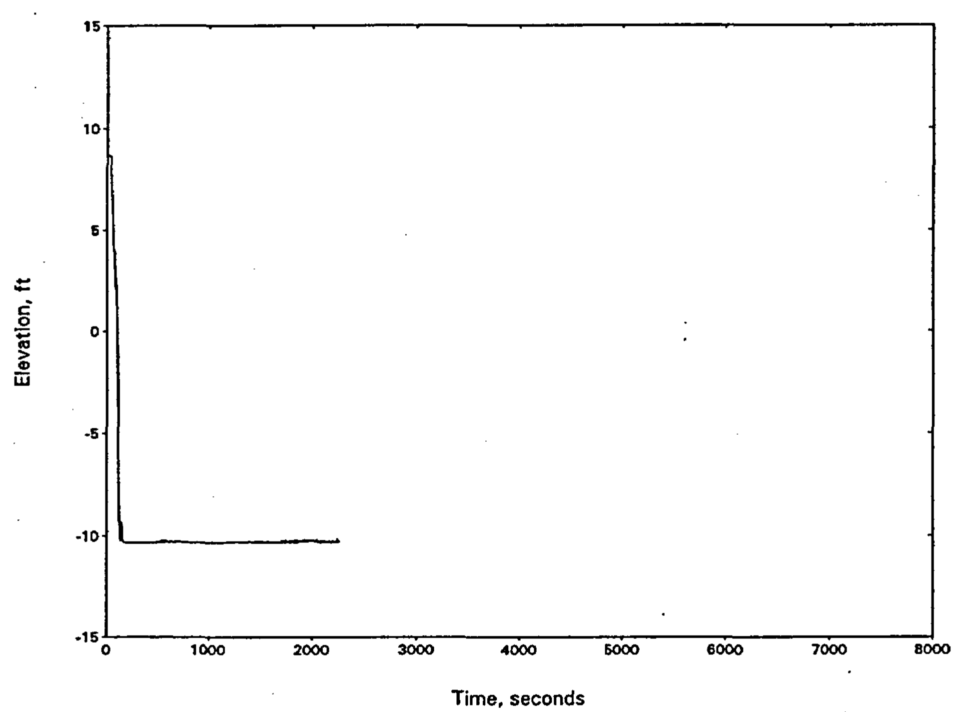

Figure 7.3-47: NAPS Unit 1 RCS Pressure - 3.0-inch Break AFW Failure

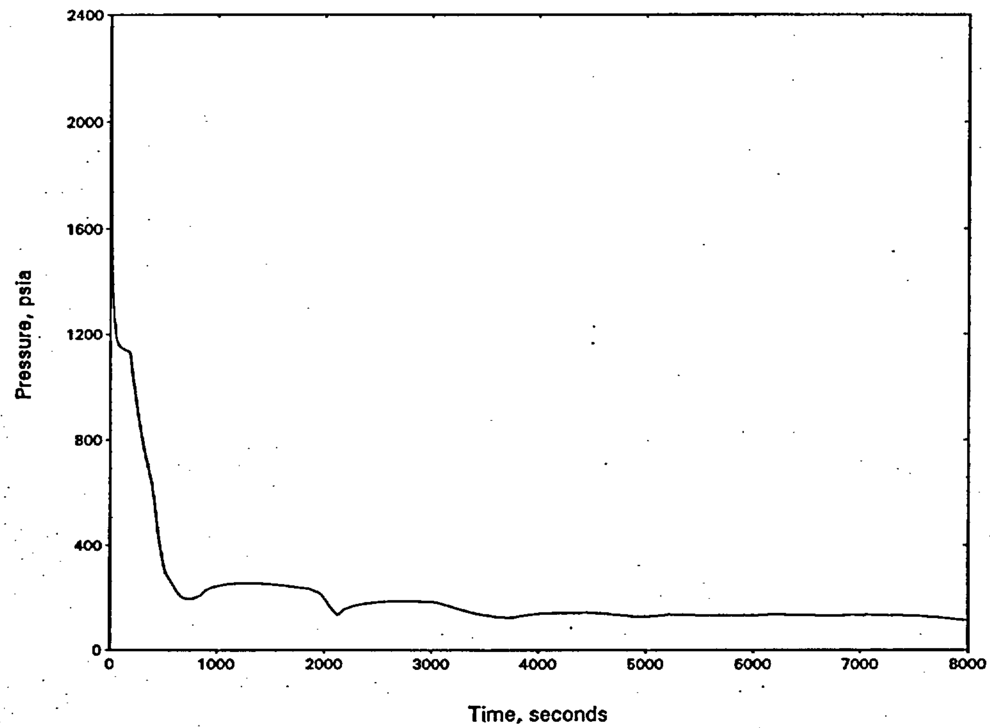

Figure 7.3-48: NAPS Unit 1 Break Flow - 3.0-inch Break AFW Failure

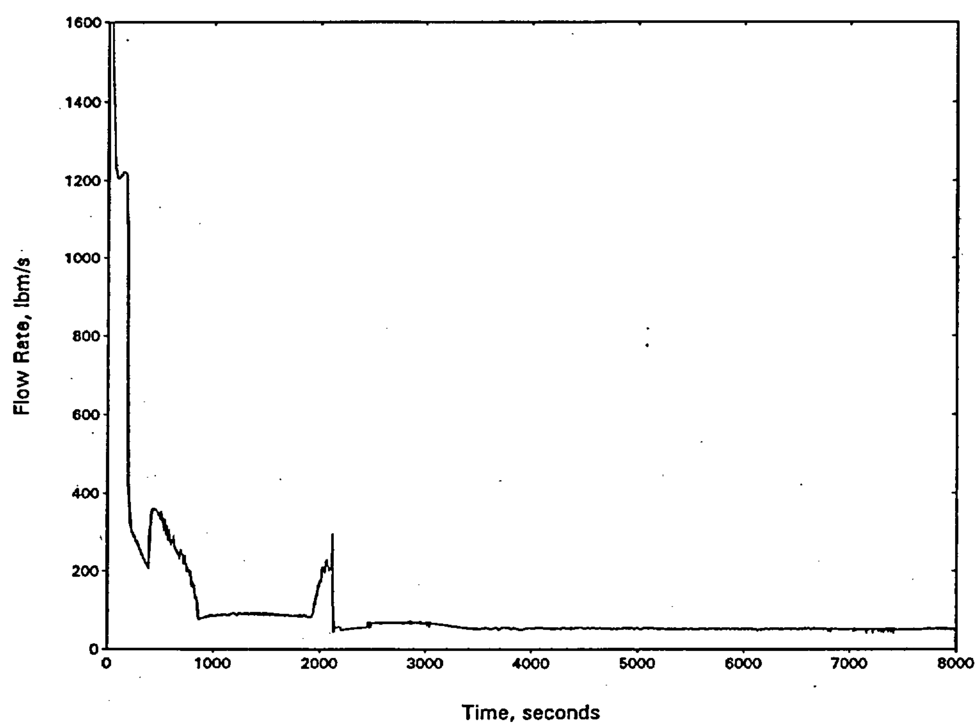

Figure 7.3-49: NAPS Unit 1 Hot Channel Mixture Level - 3.0-inch Break AFW Failure

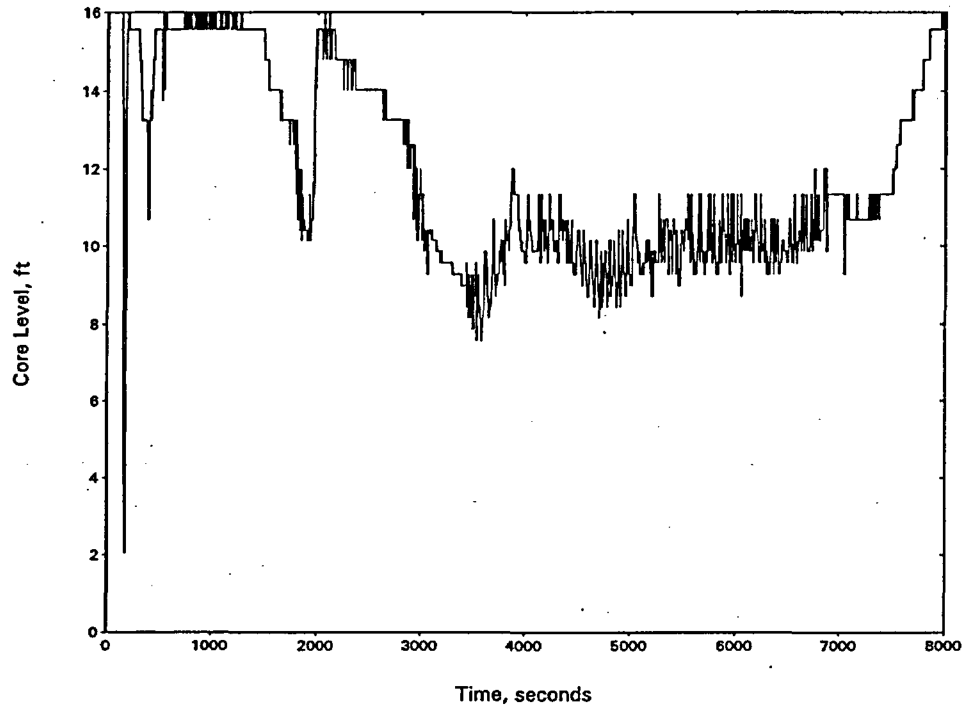

Figure 7.3-50: NAPS Unit 1 Hot Spot PCT - 3.0-inch Break AFW Failure

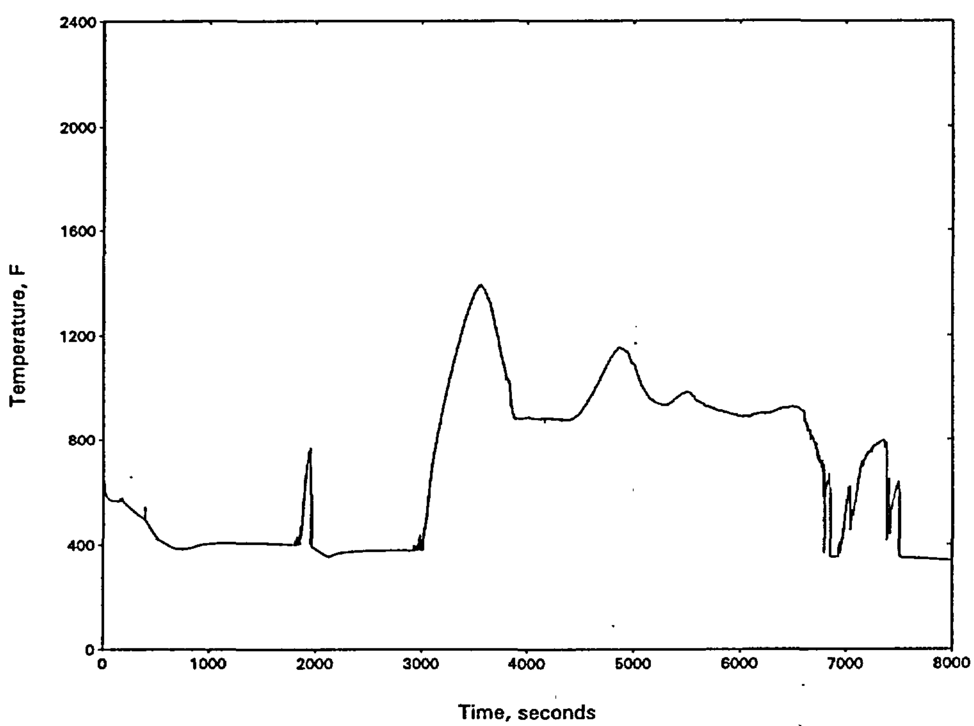

Figure 7.3-51: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 3.0-inch Break AFW Failure

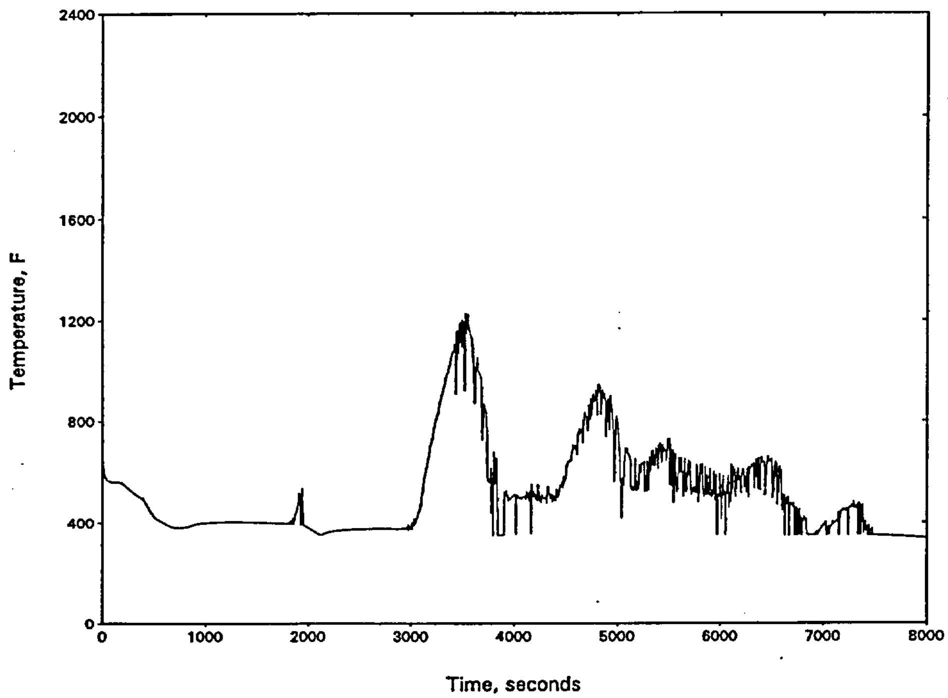

Figure 7.3-52: NAPS Unit 1 Intact Loop Seal Level - 3.0-inch Break AFW Failure

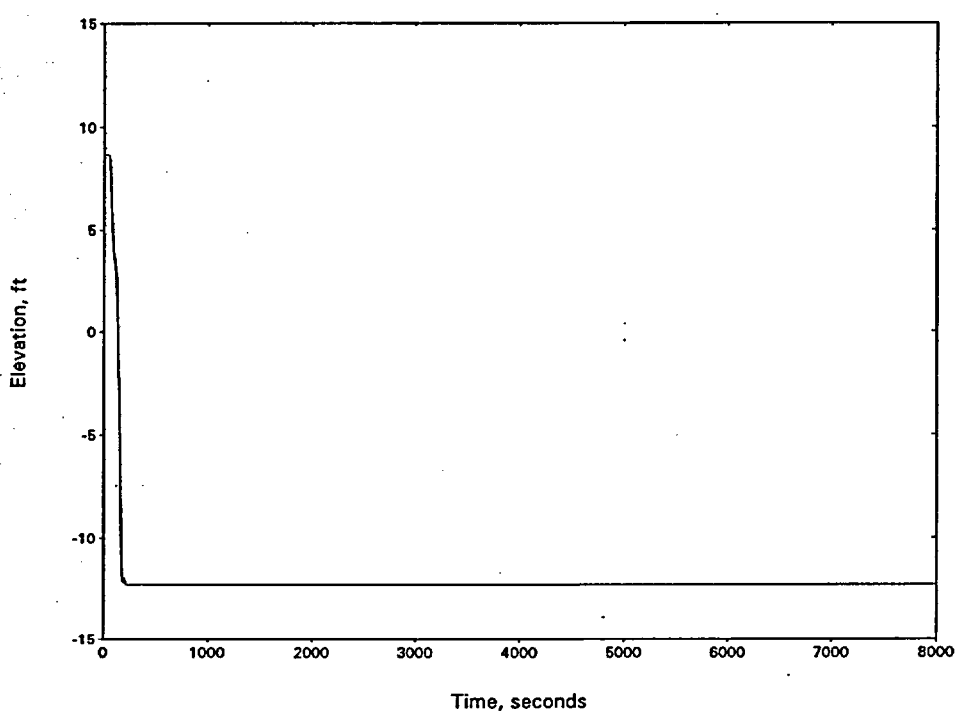

Figure 7.3-53: NAPS Unit 1 Broken Loop Seal Level - 3.0-inch Break AFW Failure

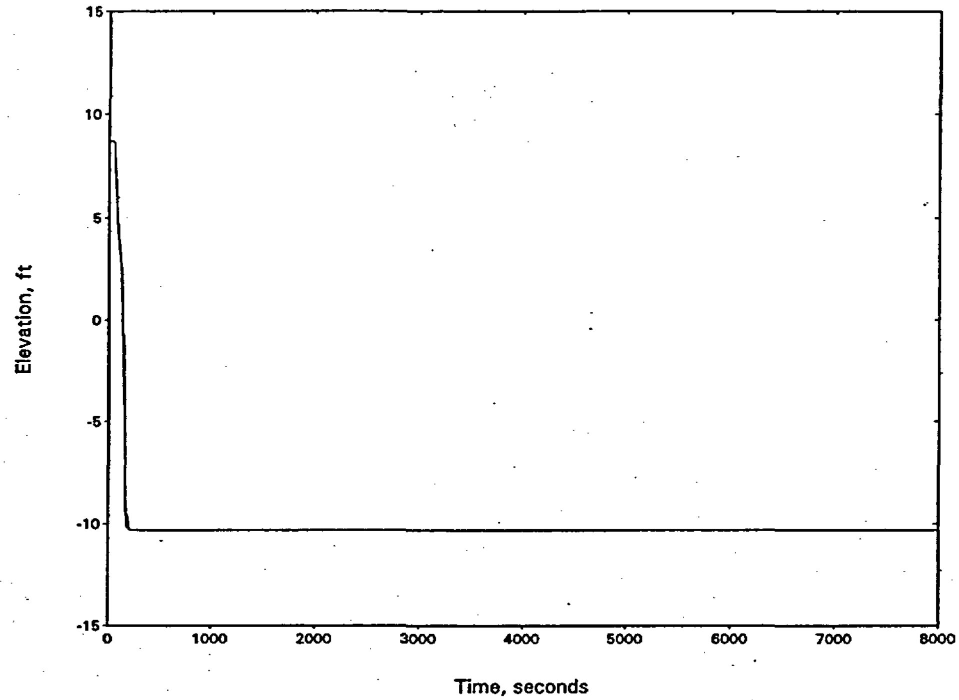

Figure 7.3-54: NAPS Unit 1 RCS Pressure - 3.0-inch Break Mixed Core

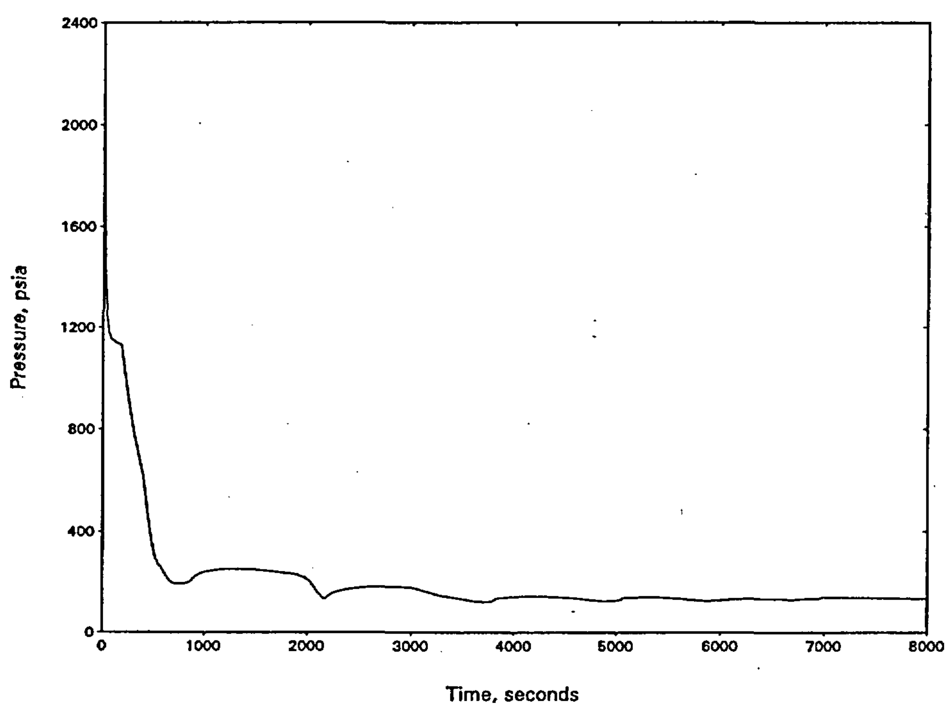

Figure 7.3-55: NAPS Unit 1 Break Flow - 3.0-inch Break Mixed Core

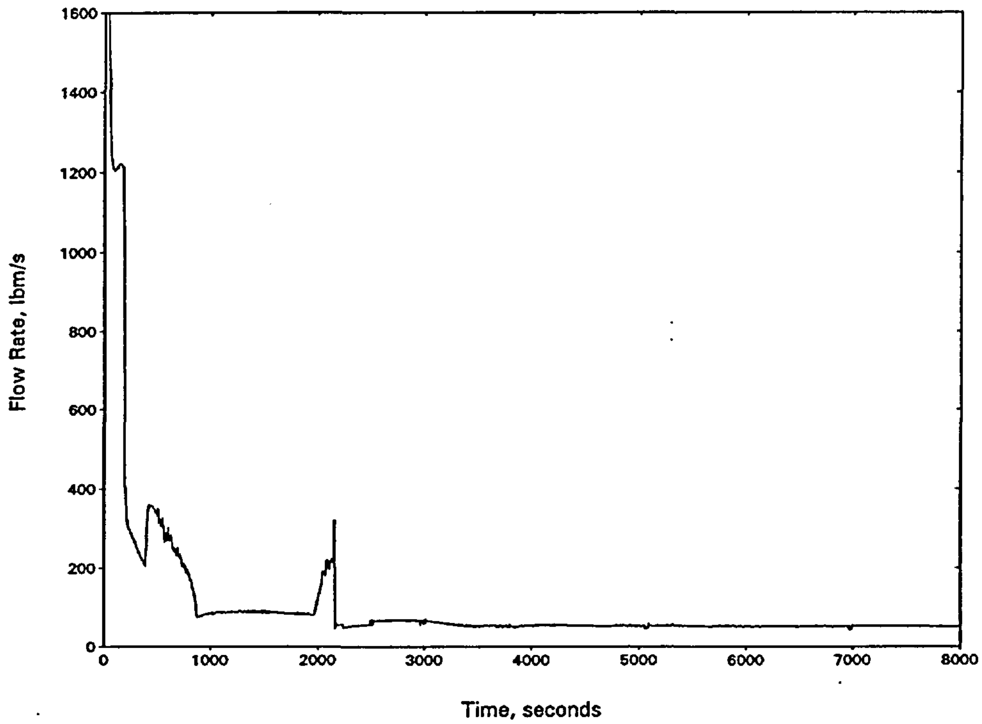

Figure 7.3-56: NAPS Unit 1 Hot Channel Mixture Level - 3.0-inch Break Mixed Core

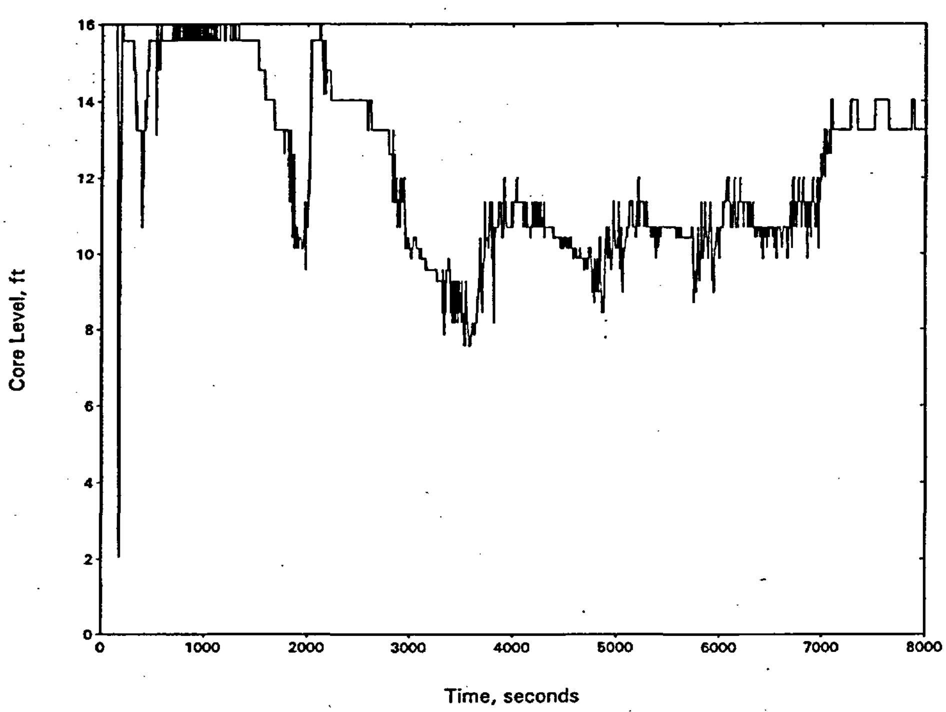

Figure 7.3-57: NAPS Unit 1 Hot Spot PCT - 3.0-inch Break Mixed Core

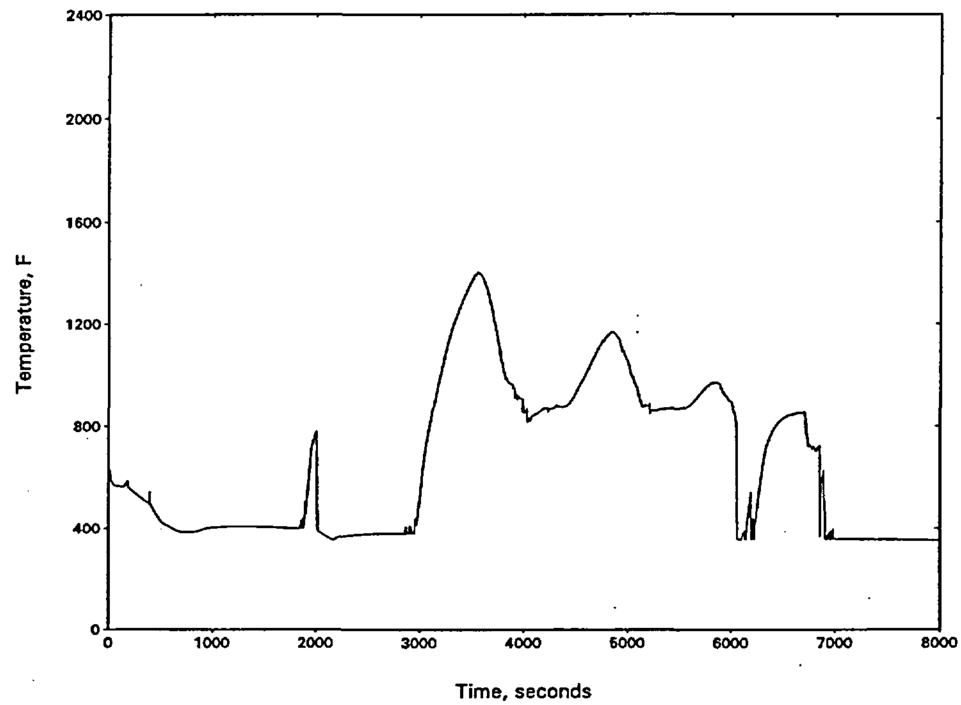

Figure 7.3-58: NAPS Unit 1 Hot Channel Outlet Vapor Temperature - 3.0-inch Break Mixed Core

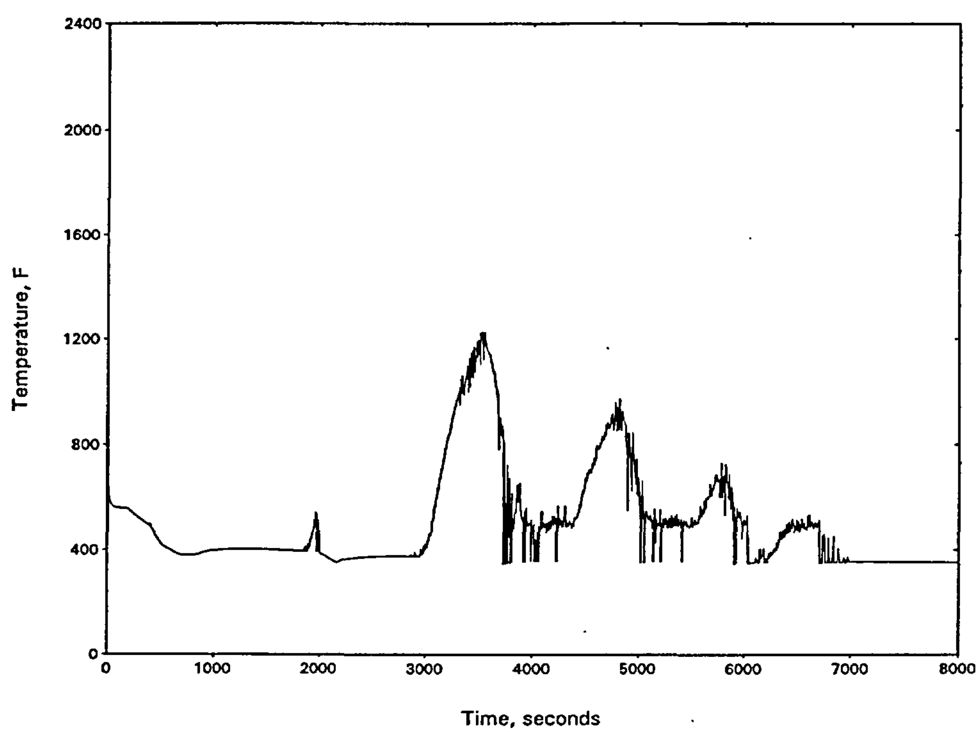

Figure 7.3-59: NAPS Unit 1 Intact Loop Seal Level - 3.0-inch Break Mixed Core

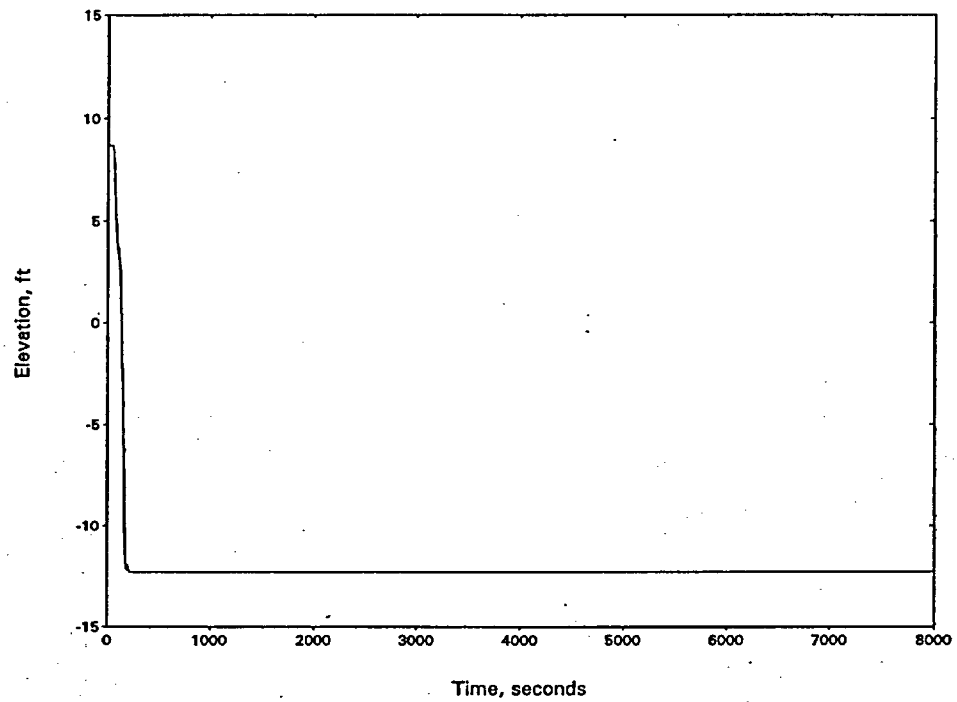

Figure 7.3-60: NAPS Unit 1 Broken Loop Seal Level - 3.0-inch Break Mixed Core

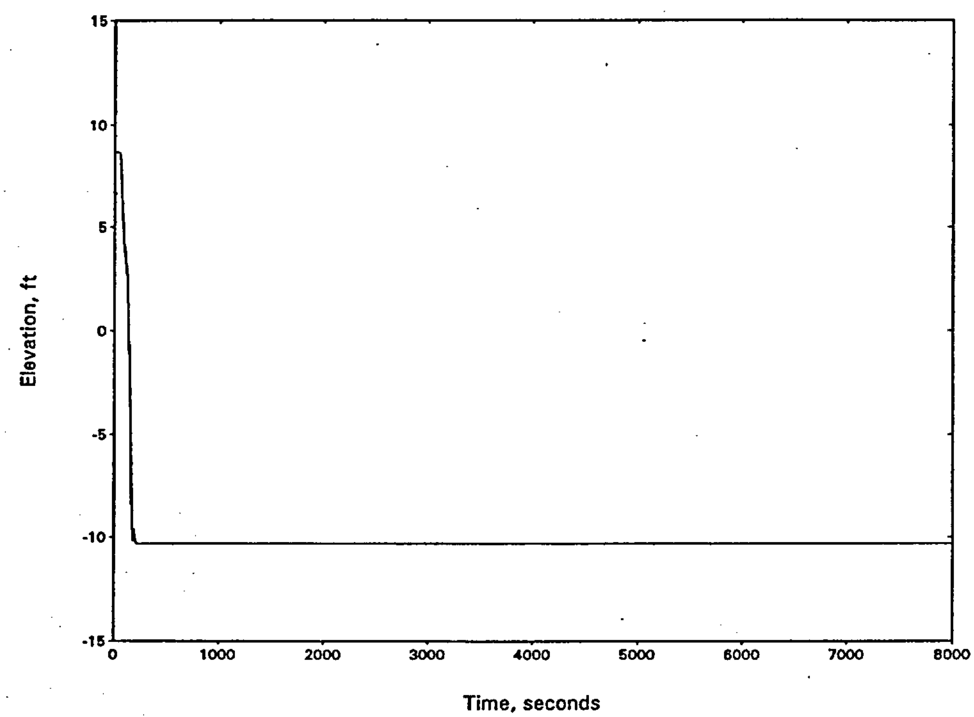

Figure 7.3-61: NAPS Units 1 and 2 PCT versus Break Size

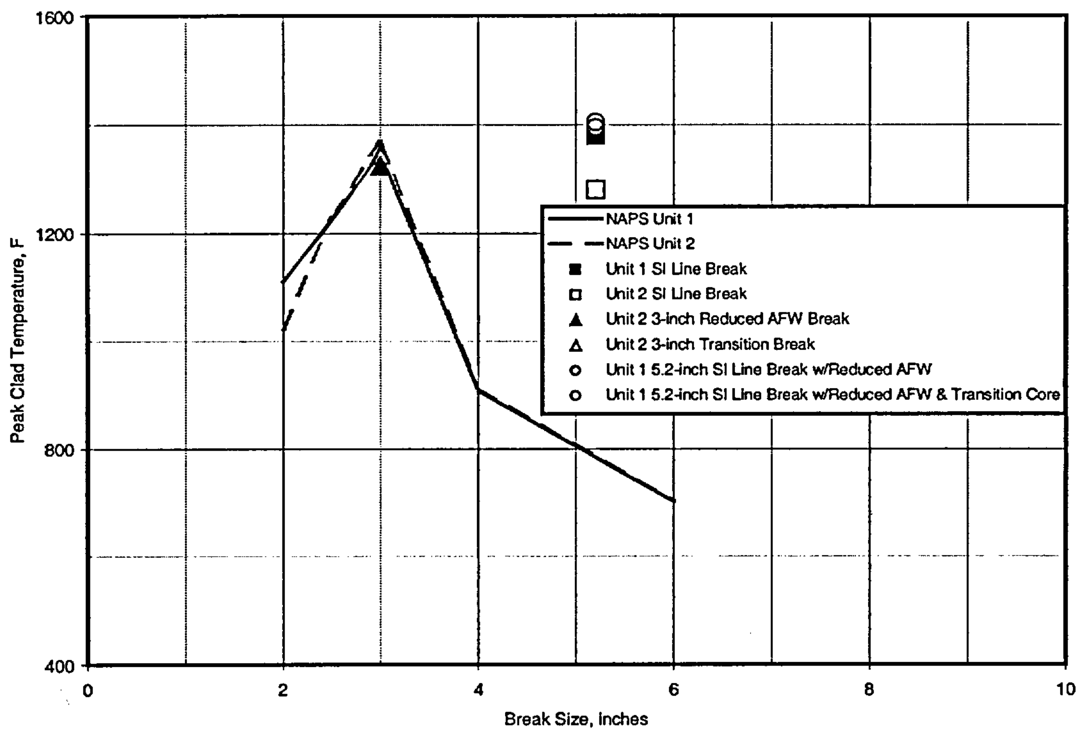

Figure 7.3-62: NAPS Units 1 and 2 LHSI Flow to Intact Loop Comparison for SI Line Break

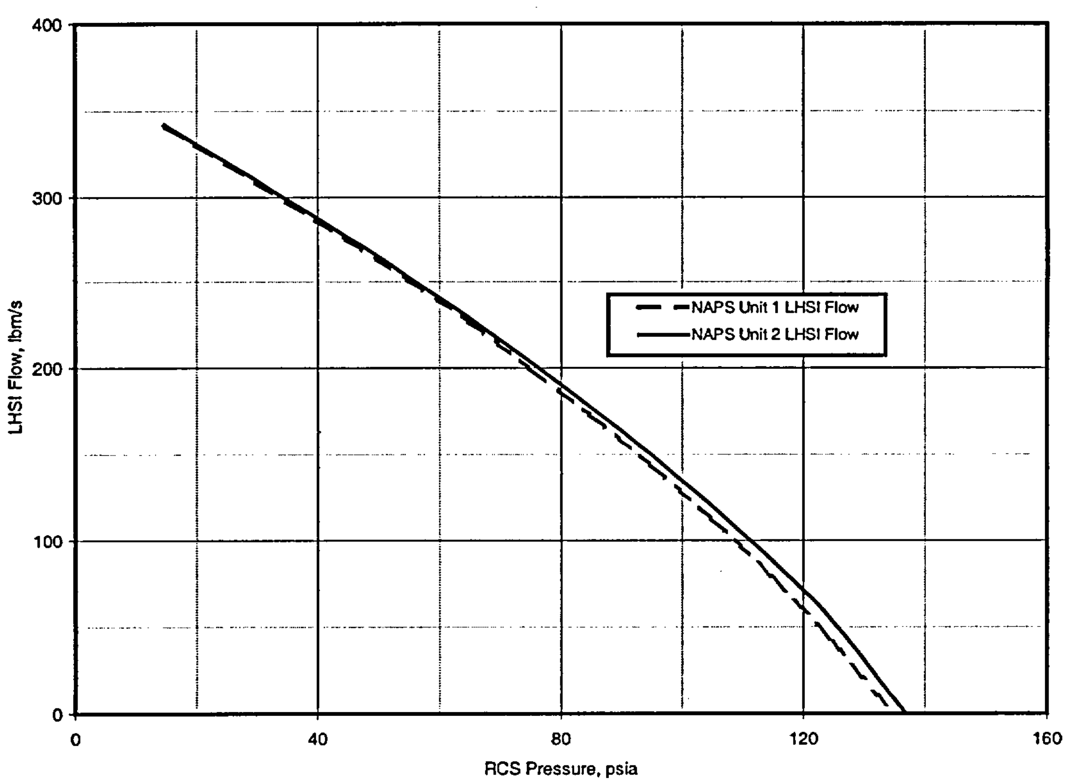

Figure 7.3-63: NAPS Unit 2 RCS Pressure - 2-inch Break

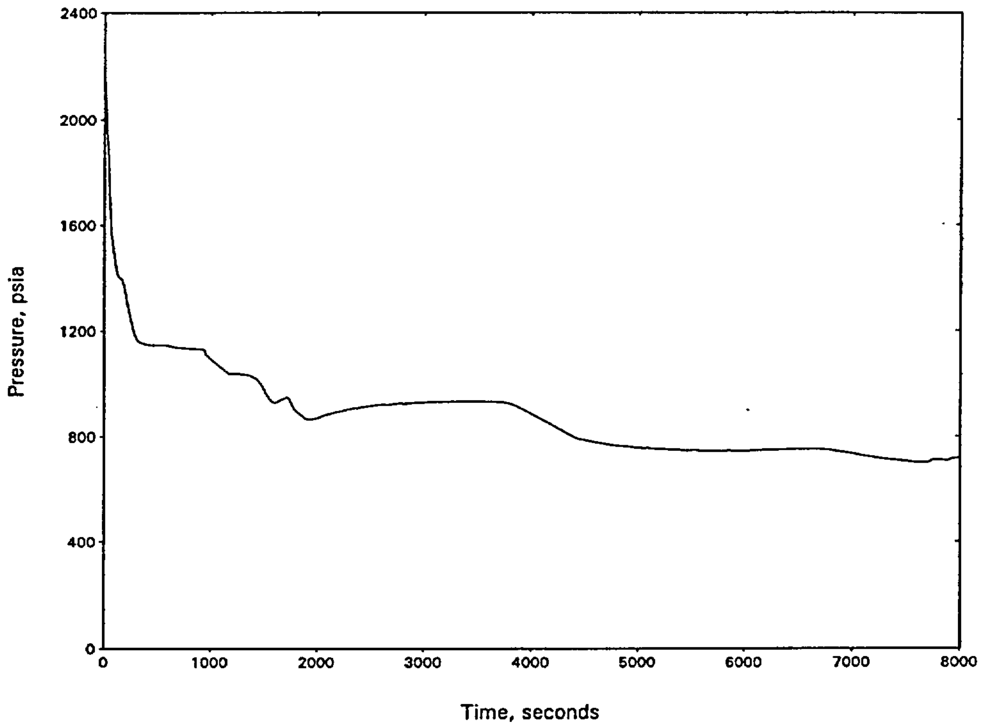

Figure 7.3-64: NAPS Unit 2 Break Flow - 2-inch Break

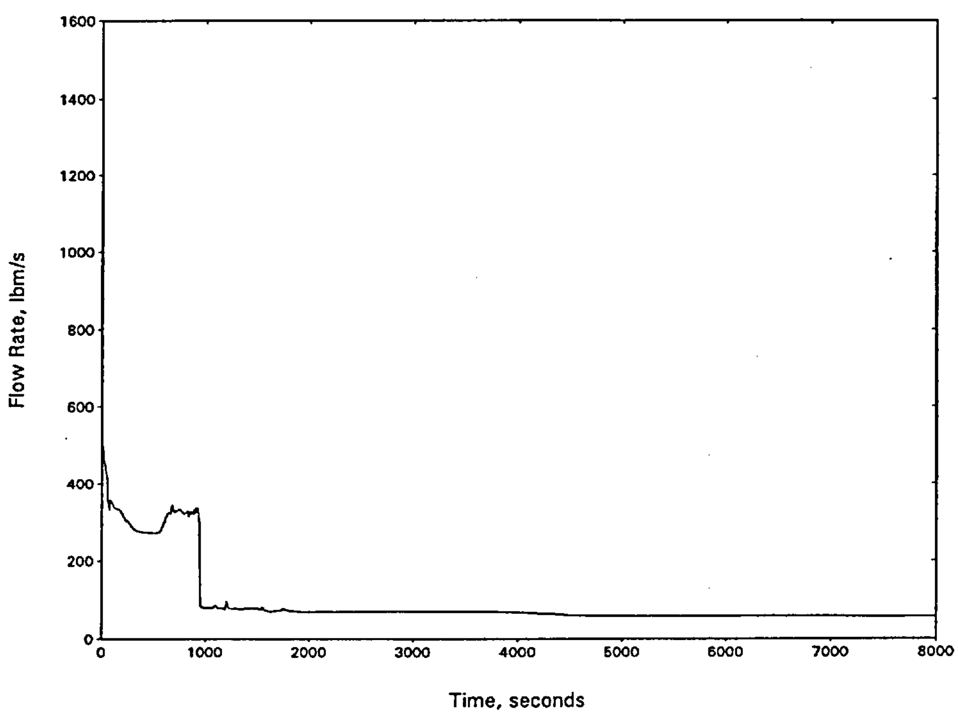

Figure 7.3-65: NAPS Unit 2 Hot Channel Mixture Level - 2-inch Break

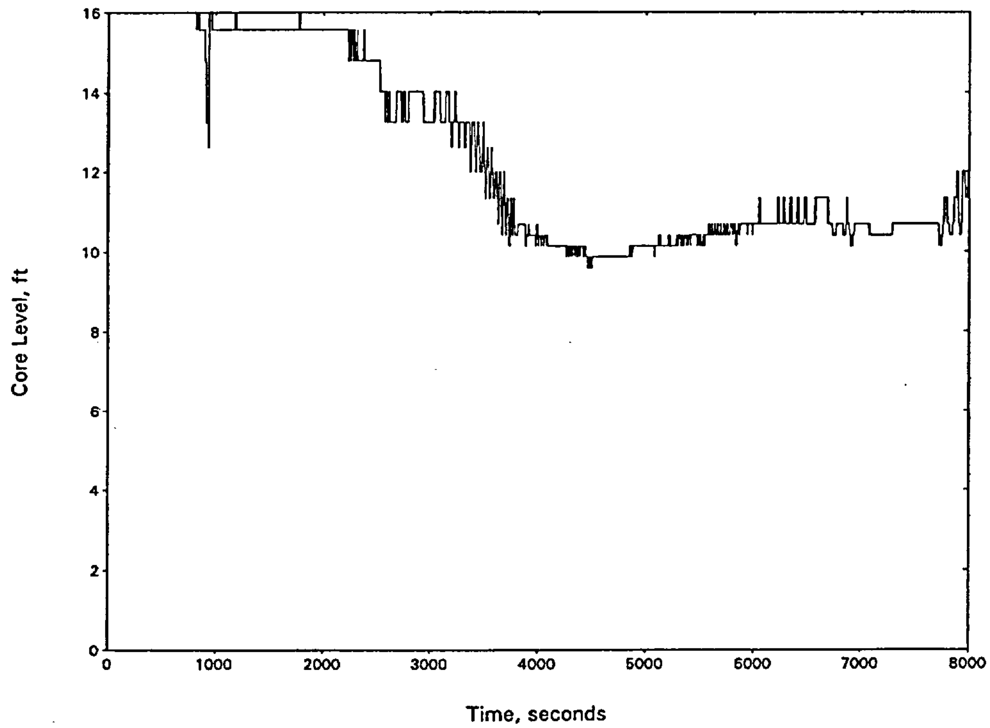

Figure 7.3-66: NAPS Unit 2 Hot Spot PCT - 2-inch Break

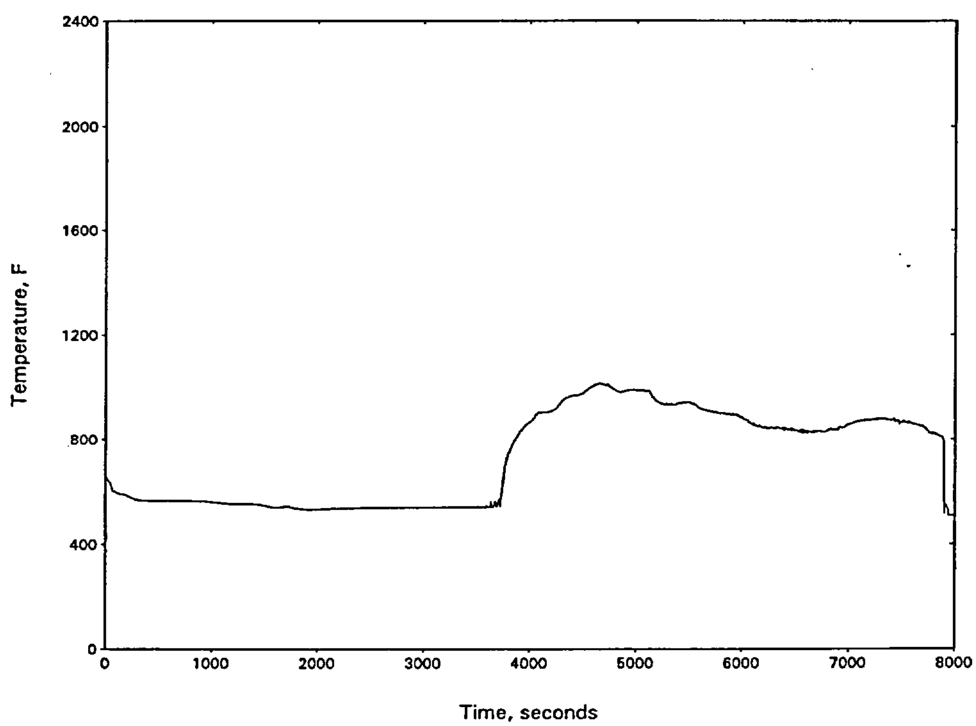

Figure 7.3-67: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 2-inch Break

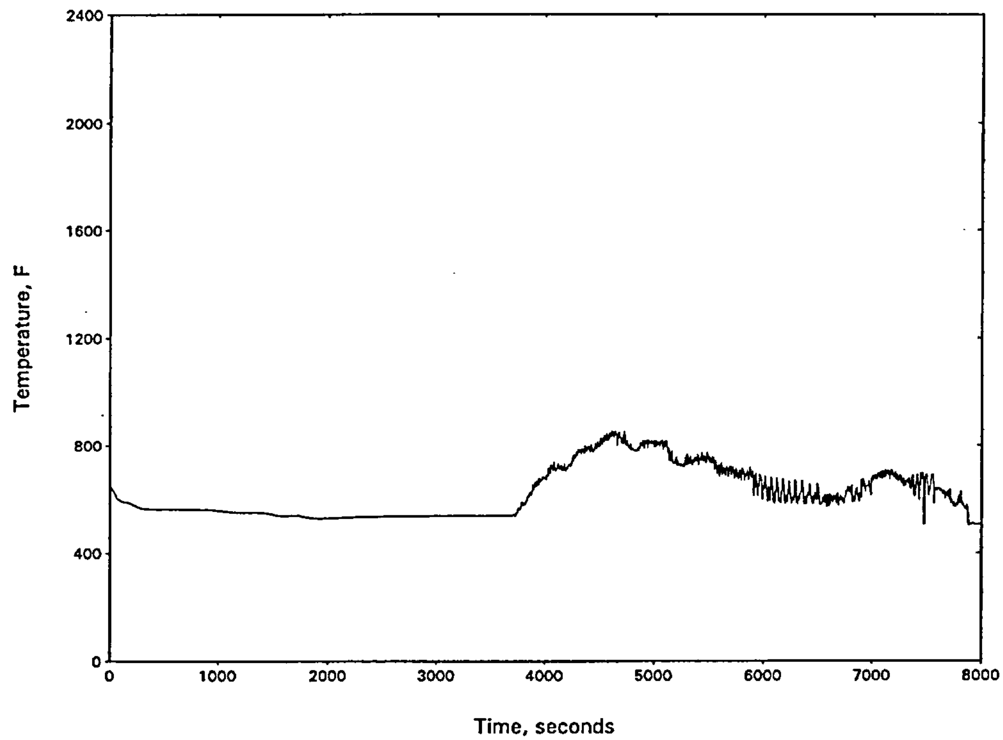

Figure 7.3-68: NAPS Unit 2 Intact Loop Seal Level - 2-inch Break

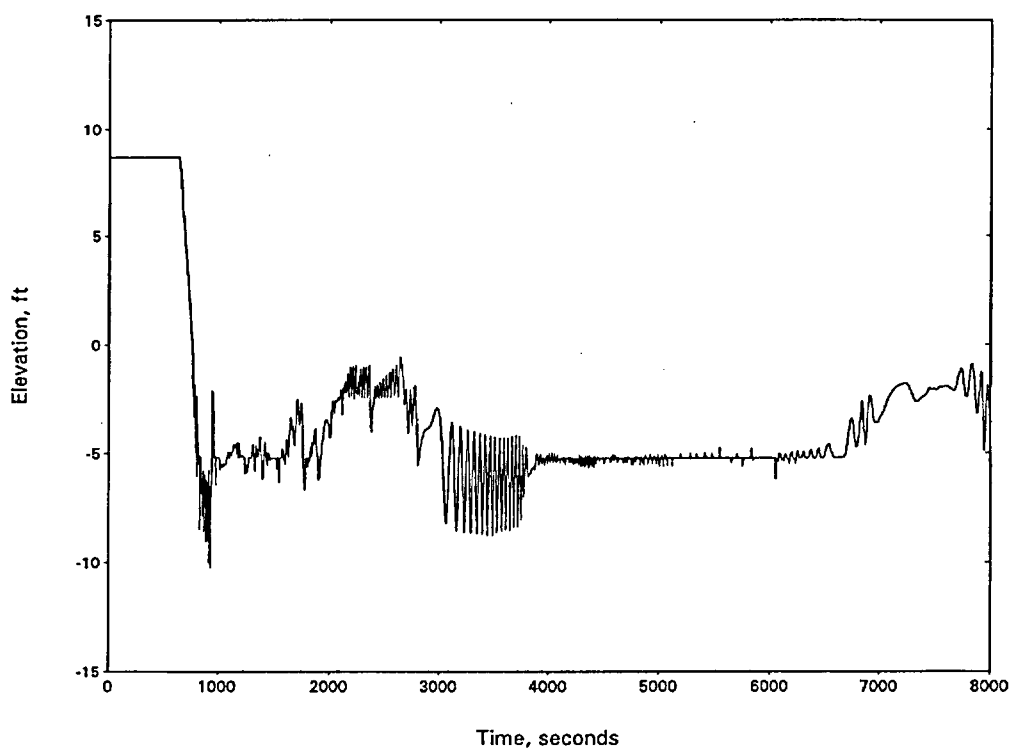

Figure 7.3-69: NAPS Unit 2 Broken Loop Seal Level - 2-inch Break

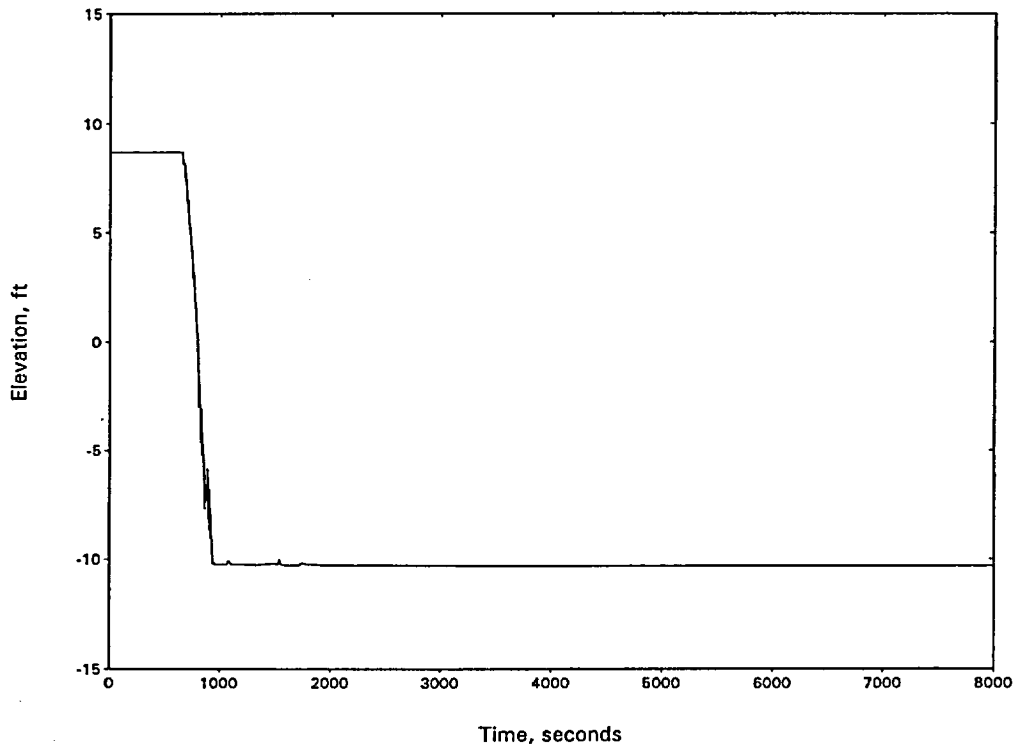

Figure 7.3-70: NAPS Unit 2 RCS Pressure - 2.5-inch Break

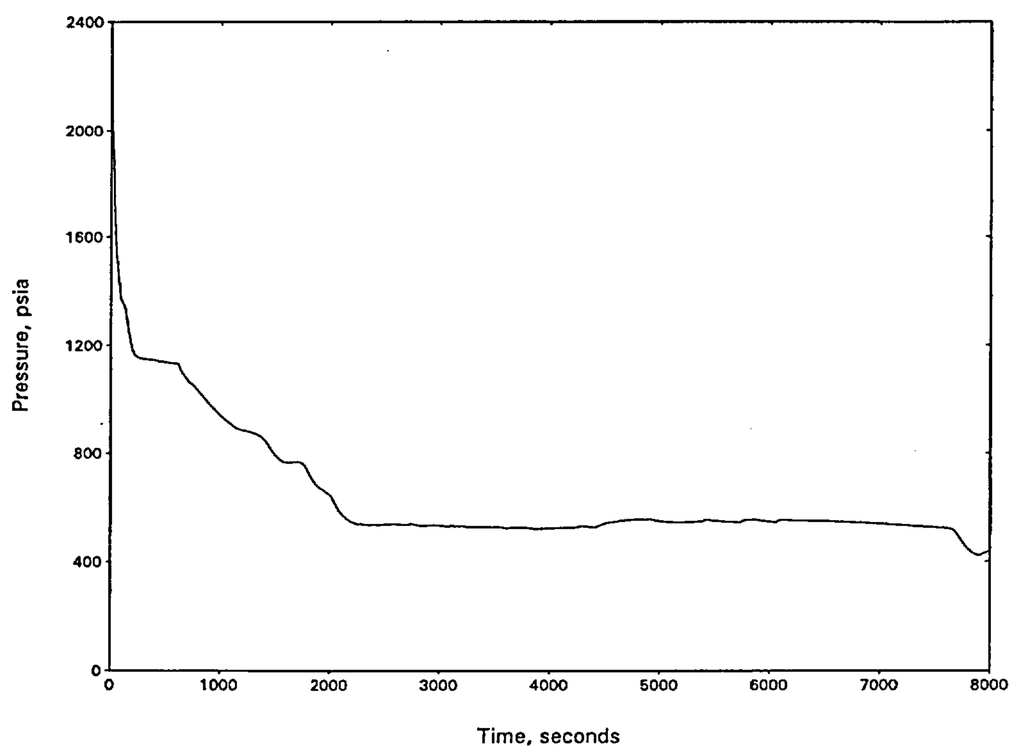

Figure 7.3-71: NAPS Unit 2 Break Flow - 2.5-inch Break

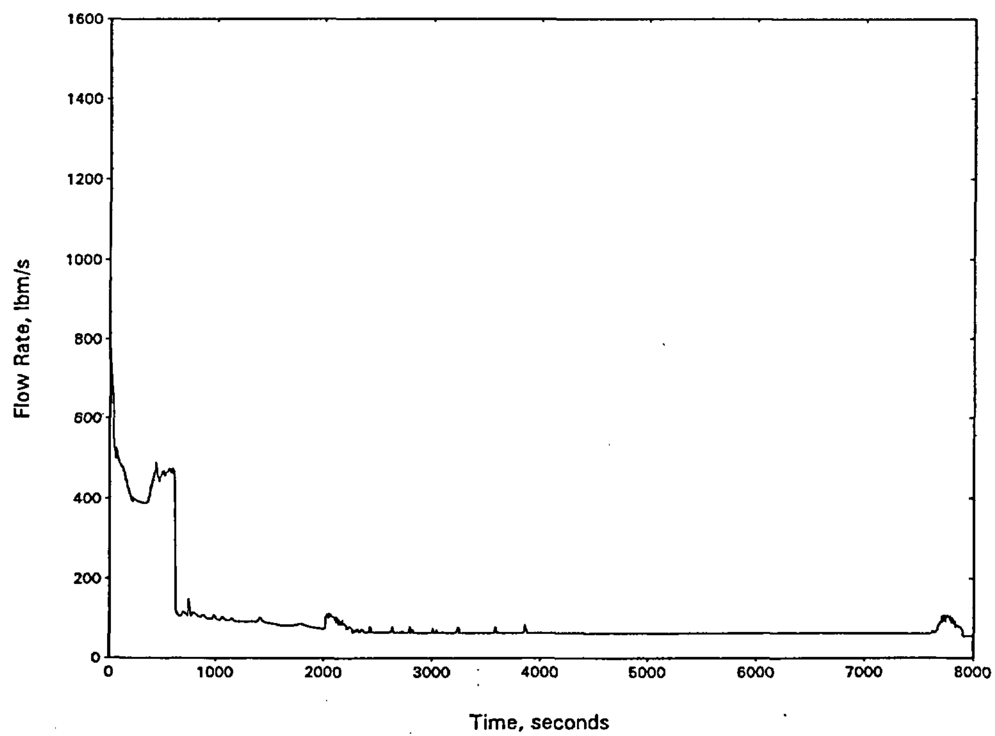

Figure 7.3-72: NAPS Units 2 Hot Channel Mixture Level - 2.5-inch Break

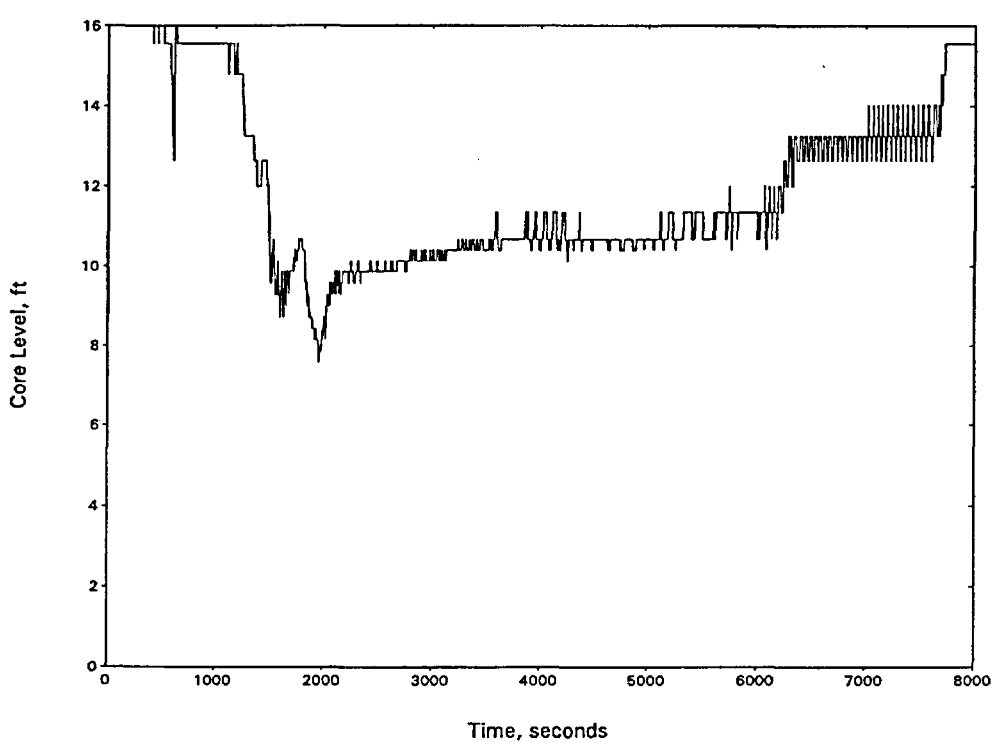

Figure 7.3-73: NAPS Unit 2 Hot Spot PCT - 2.5-inch Break

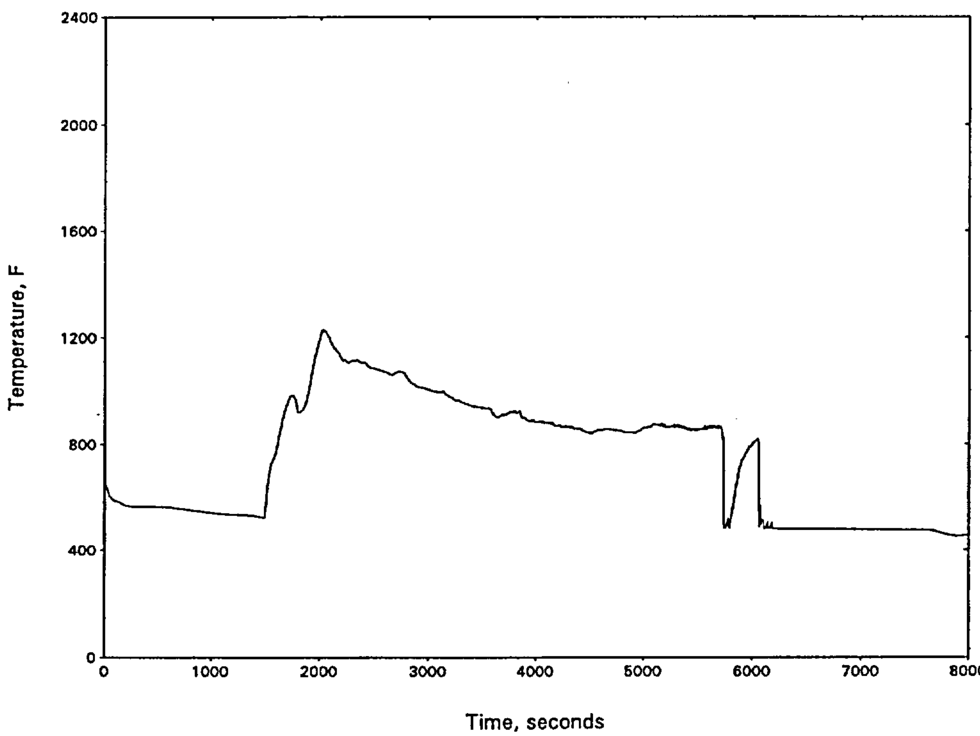

Figure 7.3-74: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 2.5-inch Break

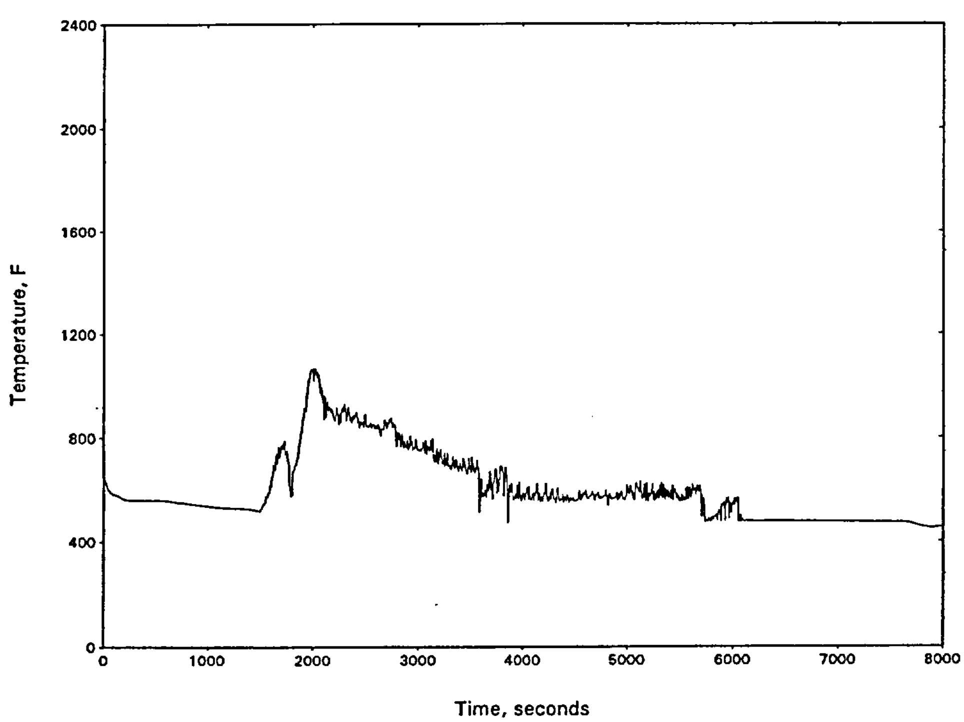

Figure 7.3-75: NAPS Unit 2 Intact Loop Seal Level - 2.5-inch Break

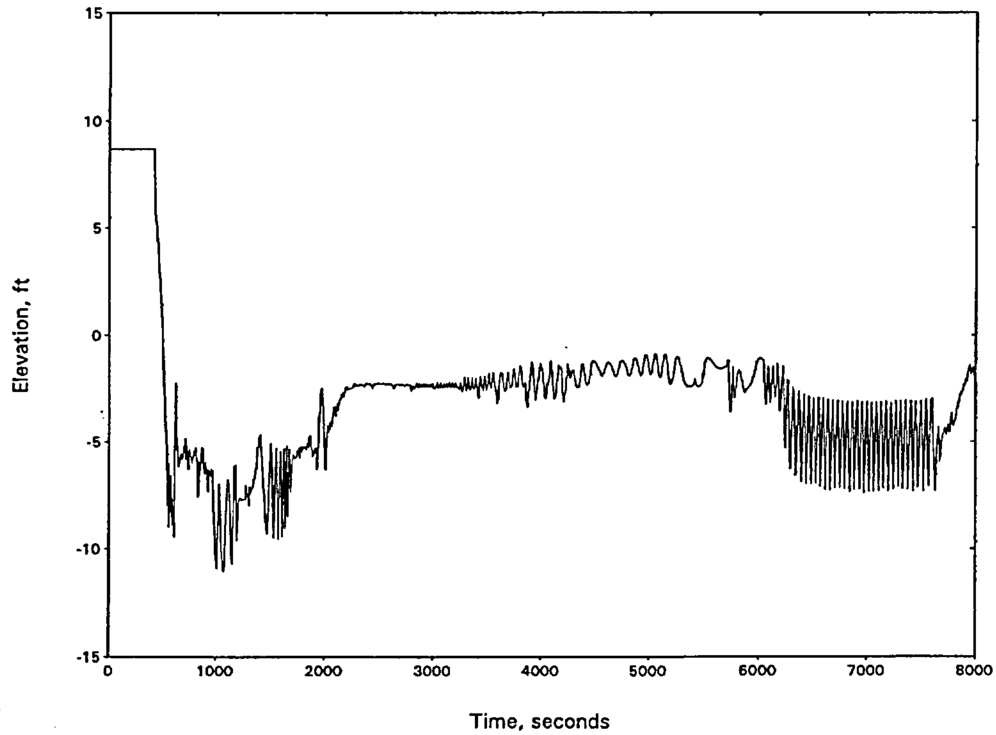

Figure 7.3-76: NAPS Unit 2 Broken Loop Seal Level - 2.5-inch Break

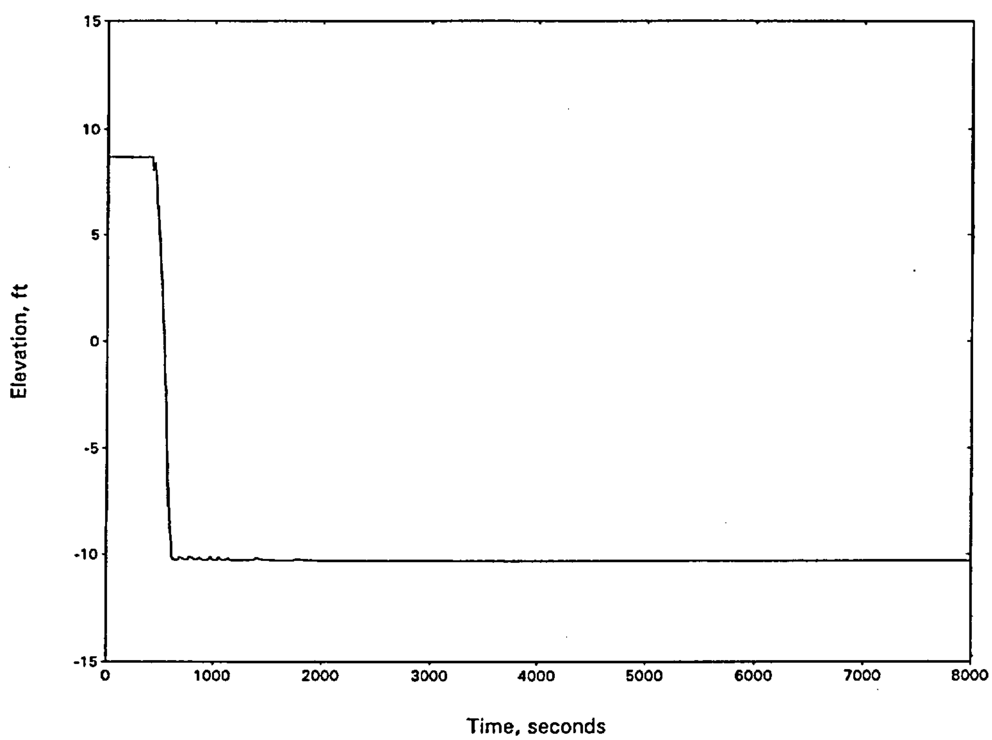

Figure 7.3-77: NAPS Unit 2 RCS Pressure - 3.0-inch Break

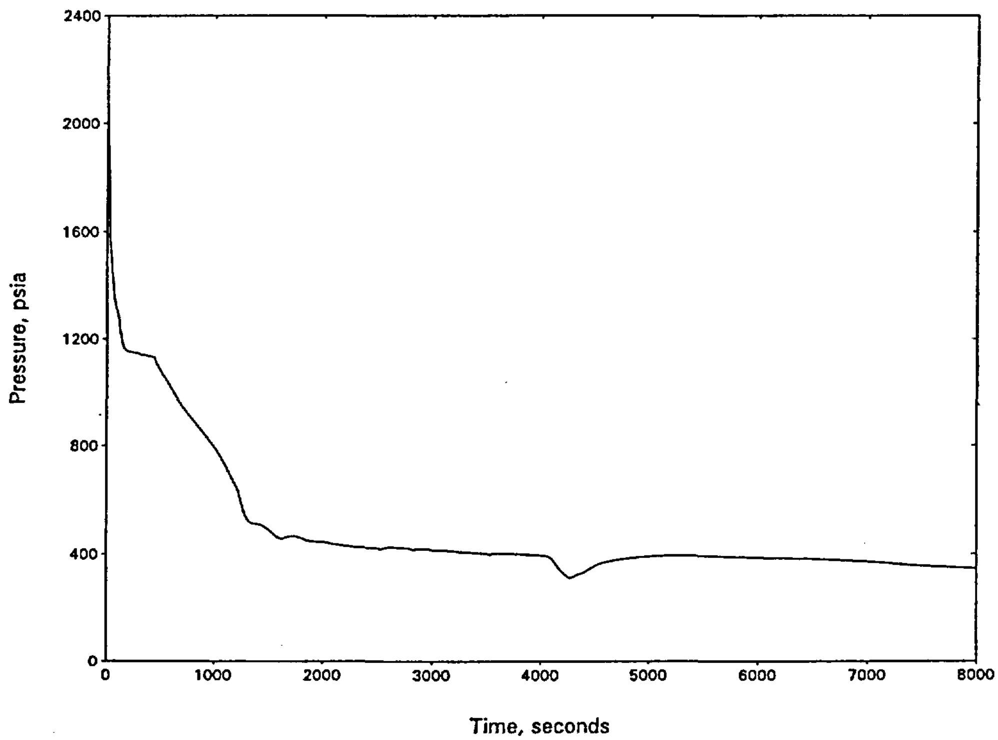

Figure 7.3-78: NAPS Unit 2 Break Flow - 3.0-inch Break

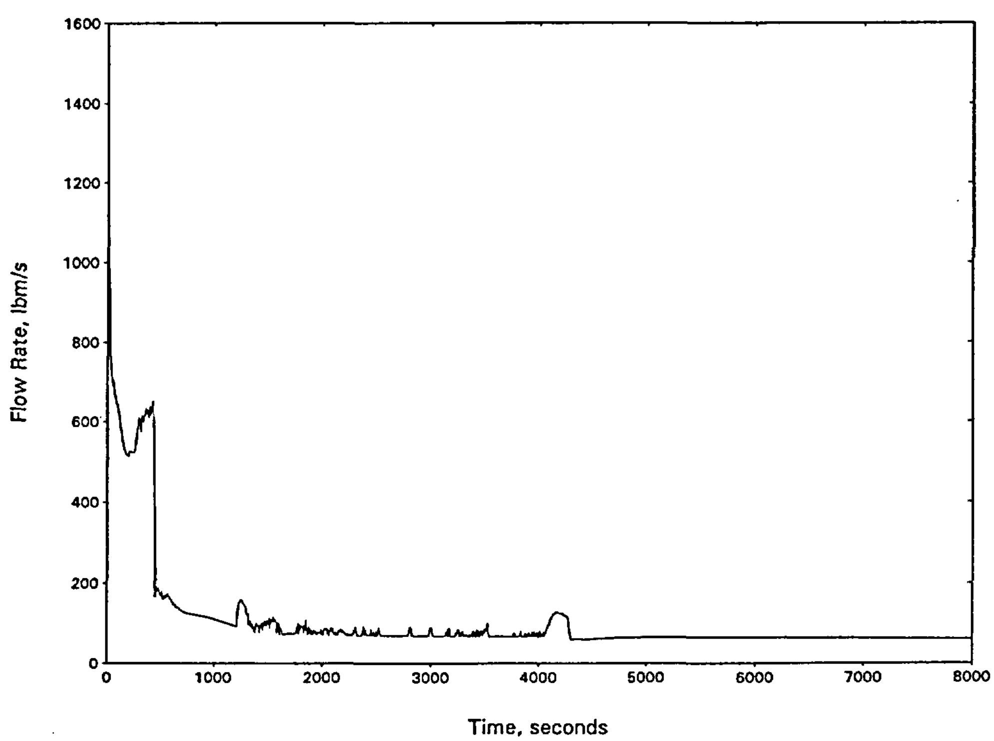

Figure 7.3-79: NAPS Unit 2 Hot Channel Mixture Level - 3.0-inch Break

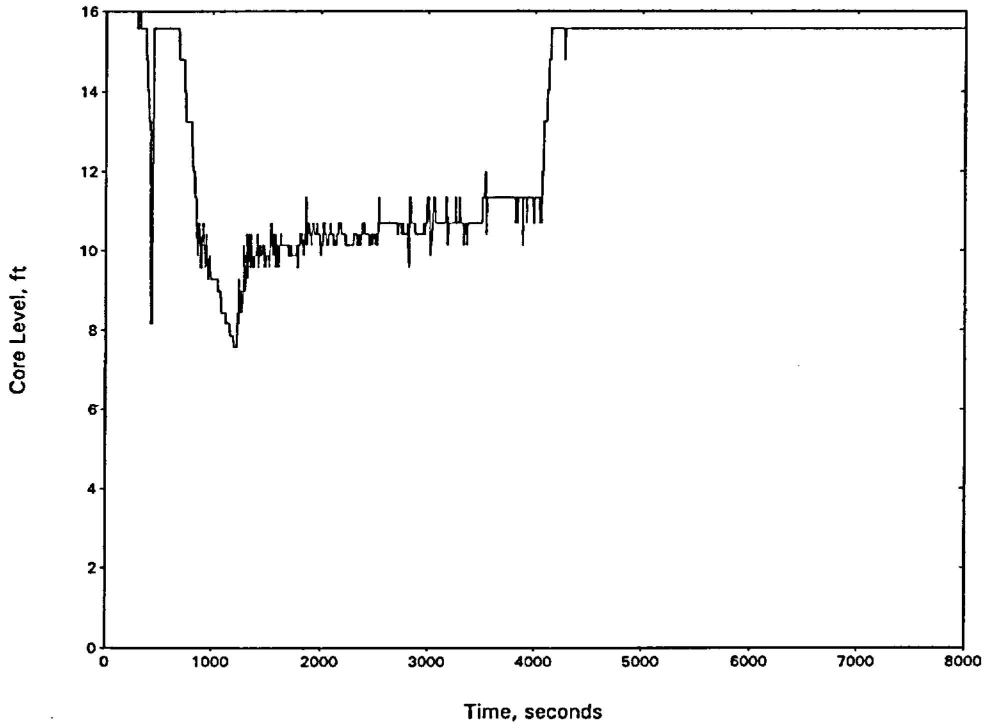

Figure 7.3-80: NAPS Unit 2 Hot Spot PCT - 3.0-inch Break

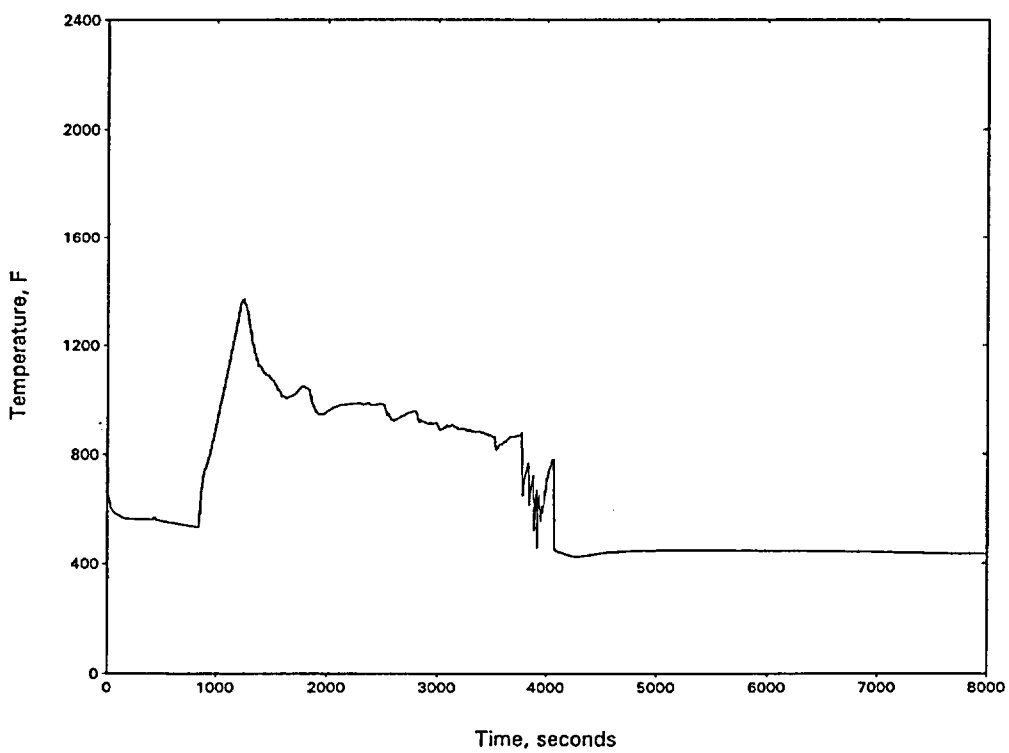

Figure 7.3-81: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 3.0-inch Break

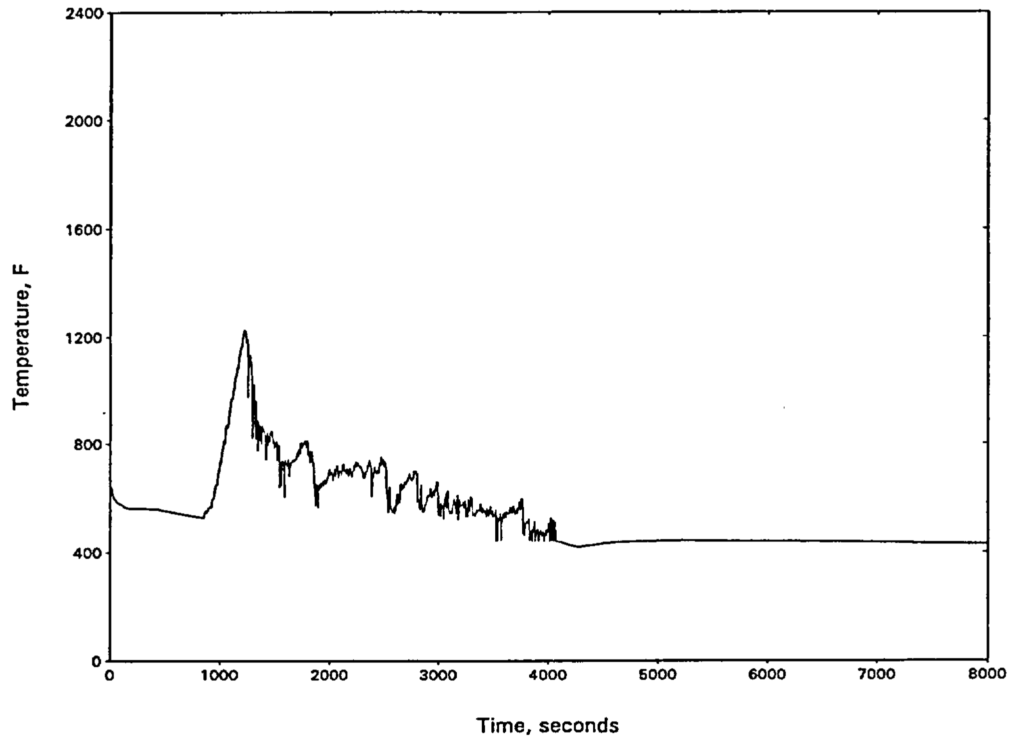

Figure 7.3-82: NAPS Unit 2 Intact Loop Seal Level - 3.0-inch Break

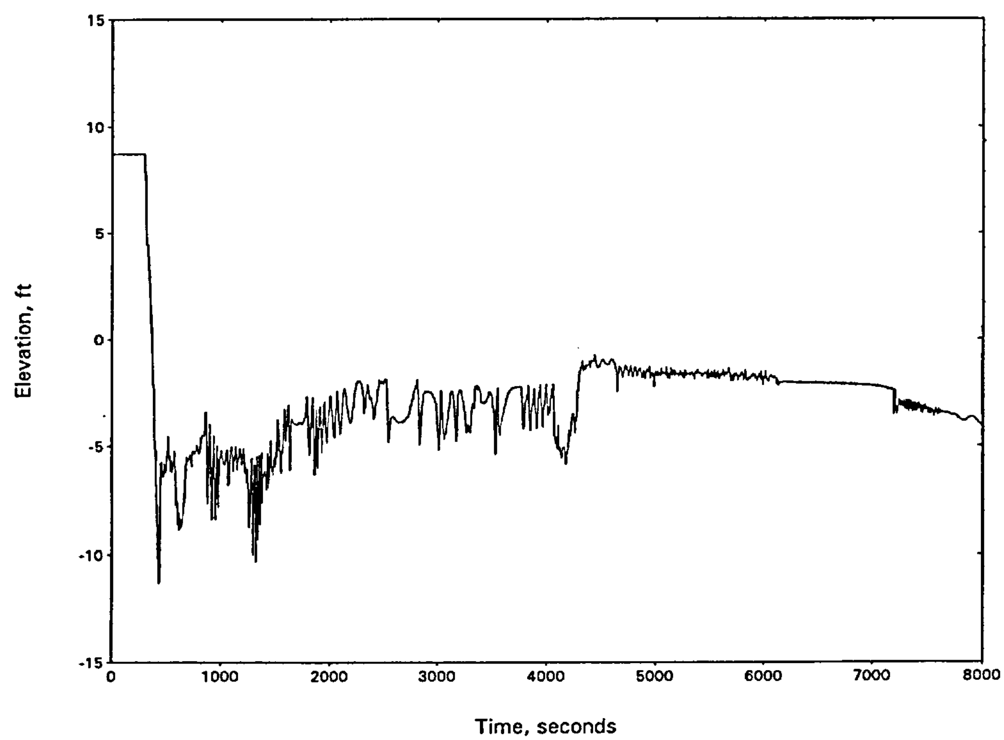

Figure 7.3-83: NAPS Unit 2 Broken Loop Seal Level - 3.0-inch Break

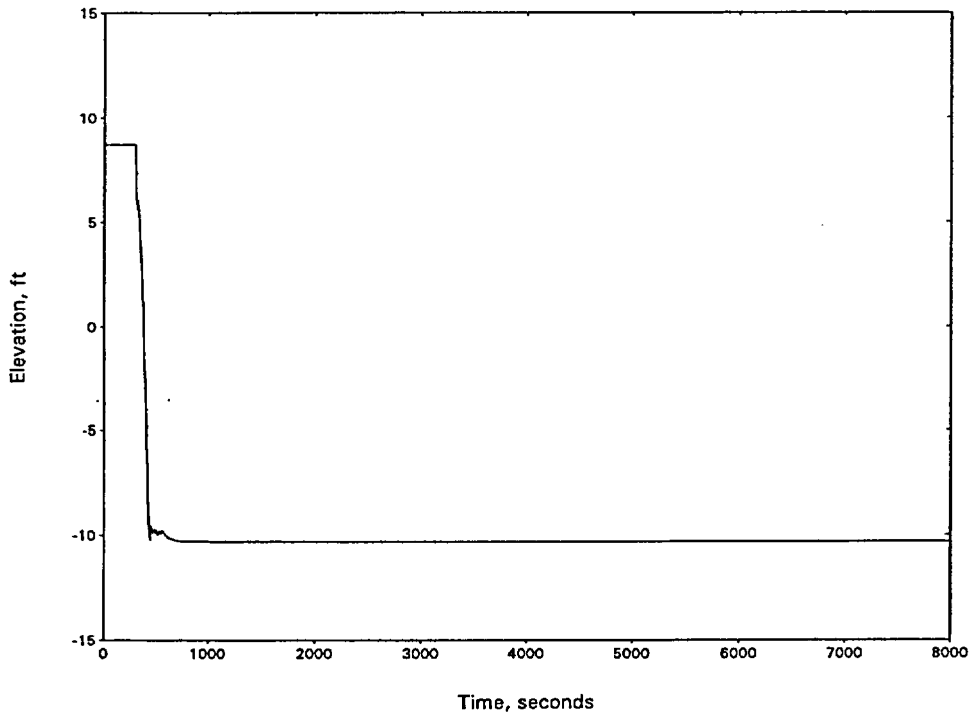

Figure 7.3-84: NAPS Unit 2 RCS Pressure - 4.0-inch Break

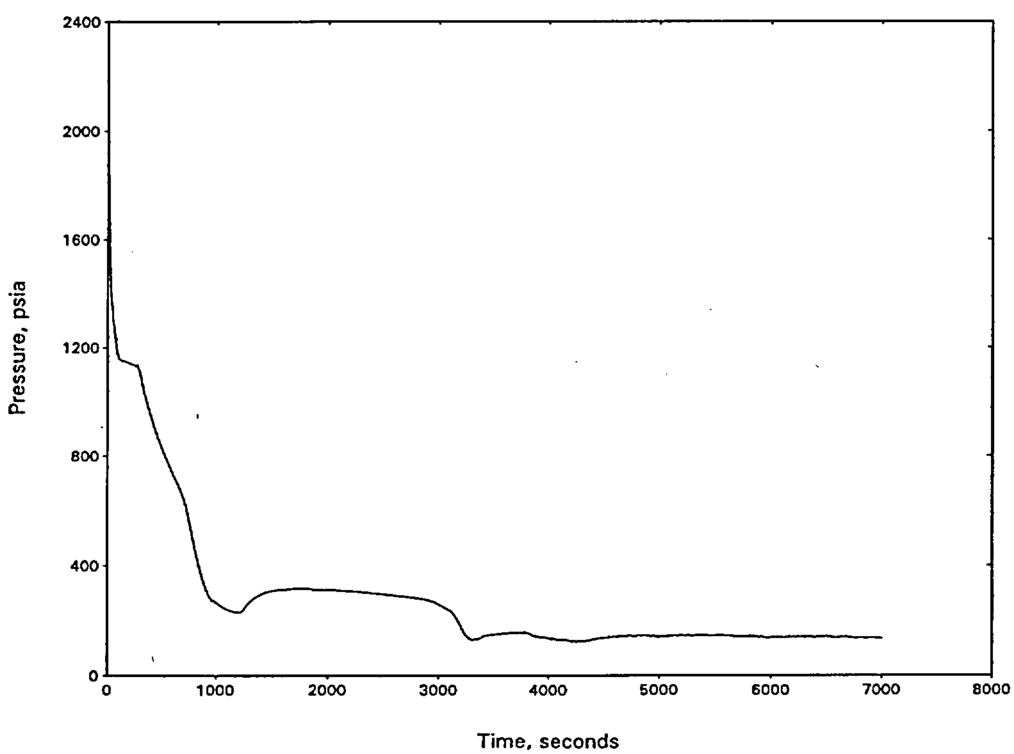

Figure 7.3-85: NAPS Unit 2 Break Flow - 4.0-inch Break

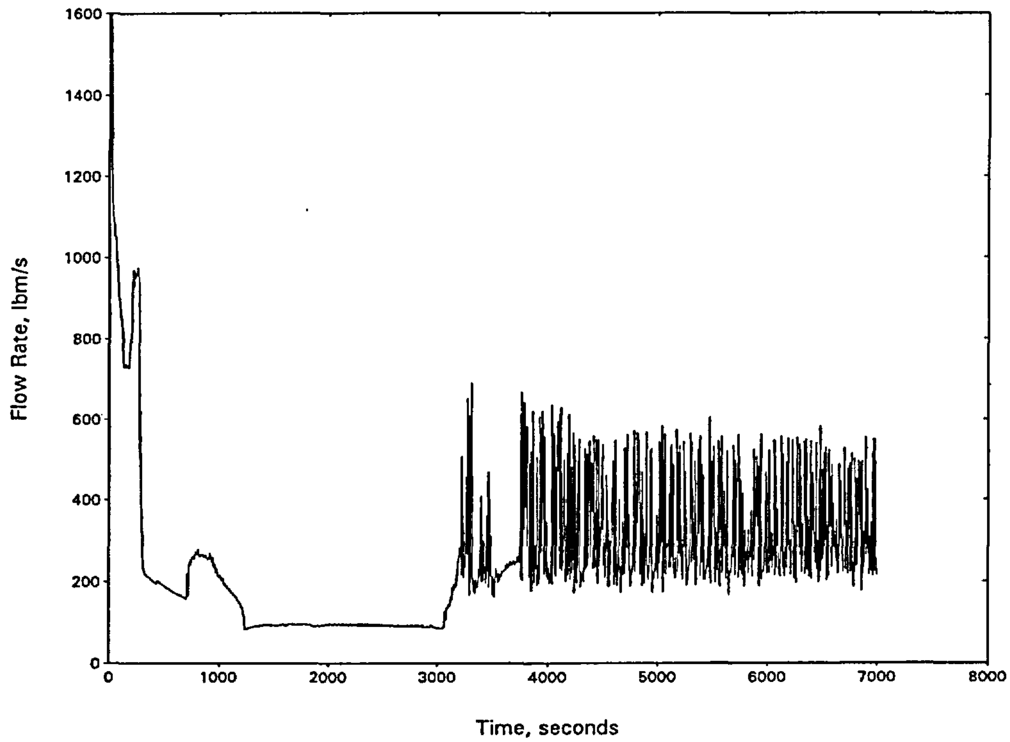

Figure 7.3-86: NAPS Unit 2 Hot Channel Mixture Level - 4.0-inch Break

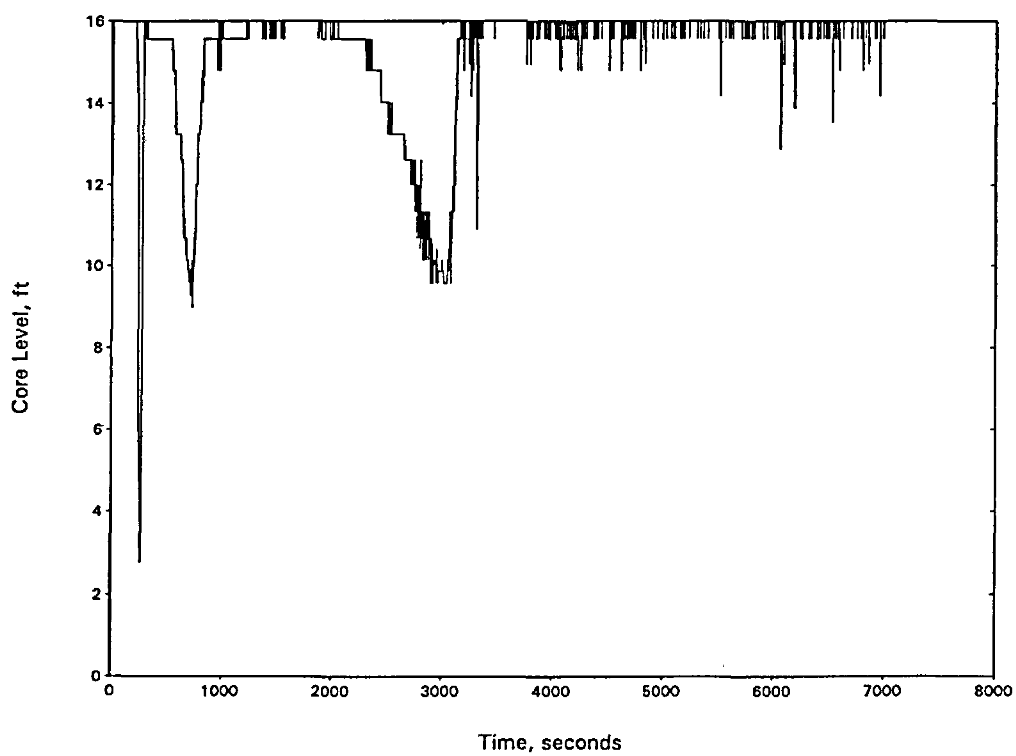

Figure 7.3-87: NAPS Unit 2 Hot Spot PCT - 4.0-inch Break

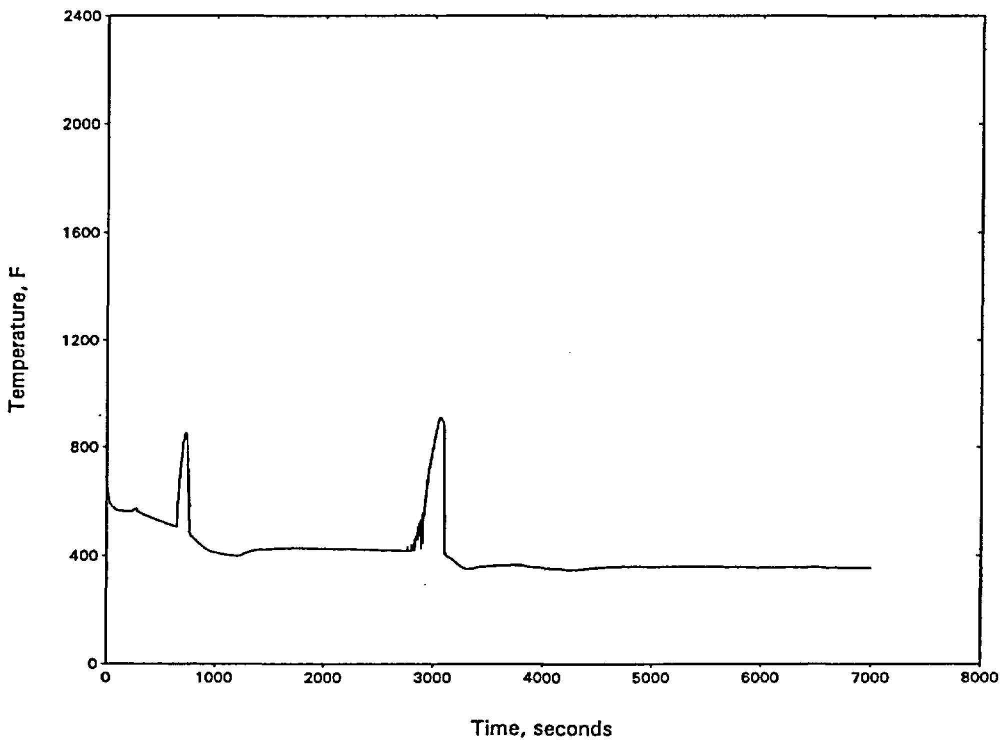

Figure 7.3-88: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 4.0-inch Break

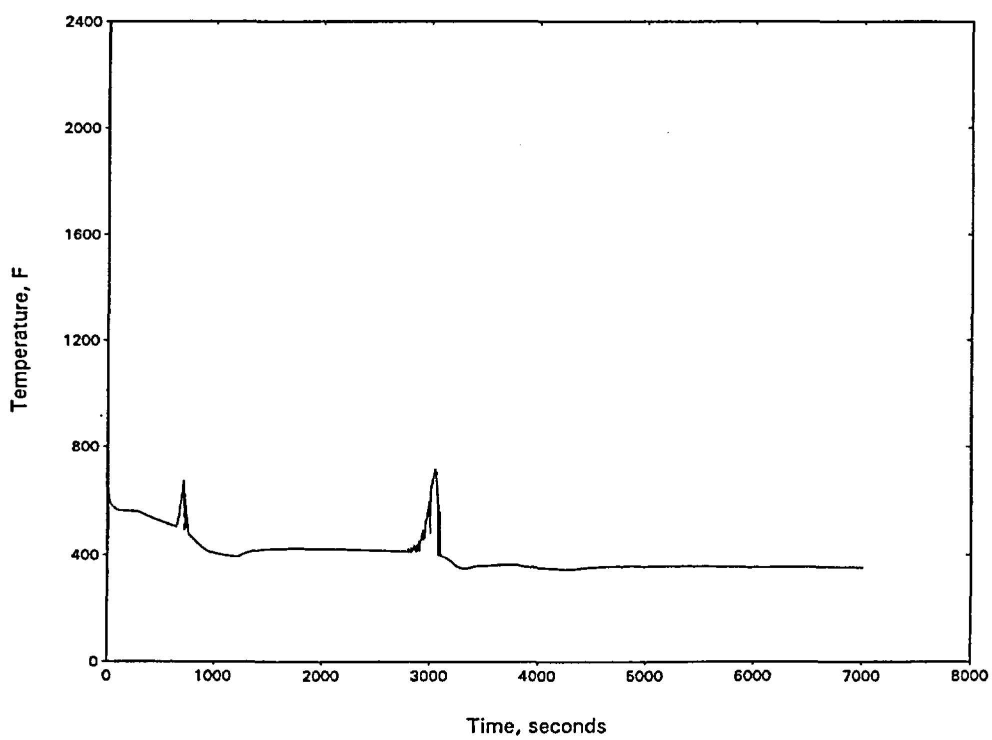

Figure 7.3-89: NAPS Unit 2 Intact Loop Seal Level - 4.0-inch Break

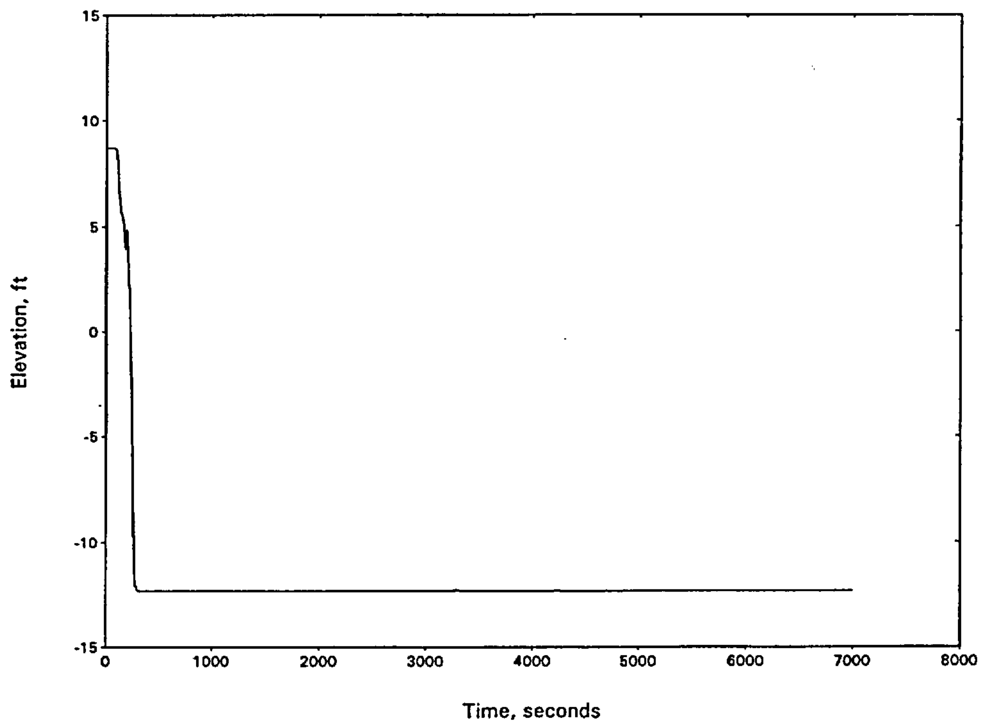

Figure 7.3-90: NAPS Unit 2 Broken Loop Seal Level - 4.0-inch Break

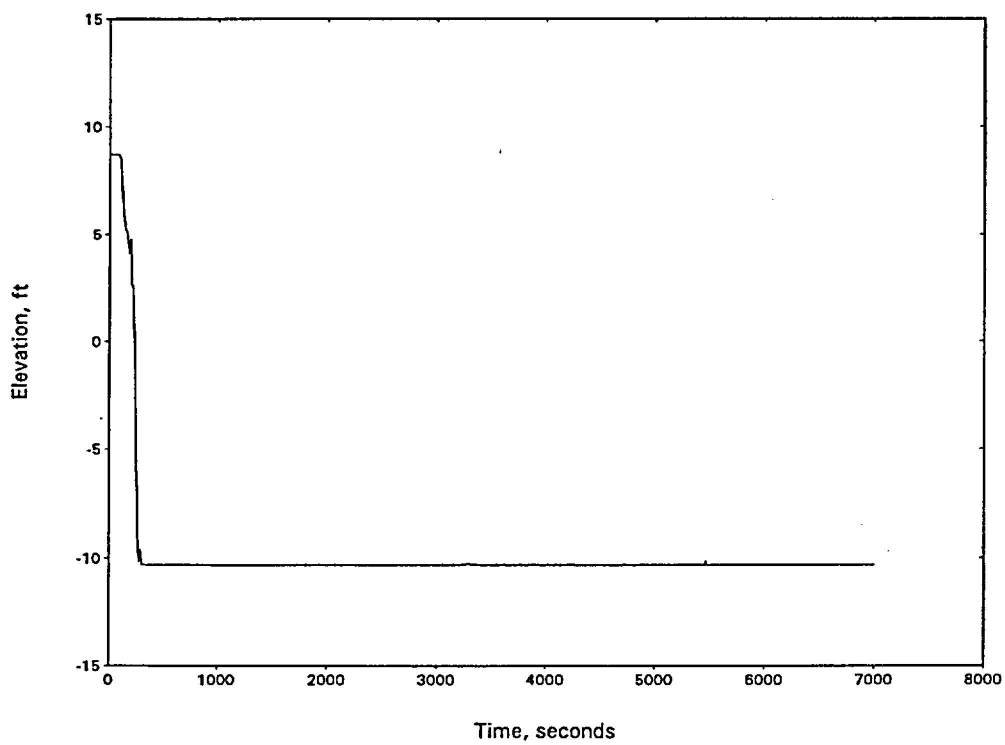

Figure 7.3-91: NAPS Unit 2 RCS Pressure - 5.2-inch SI Line Break

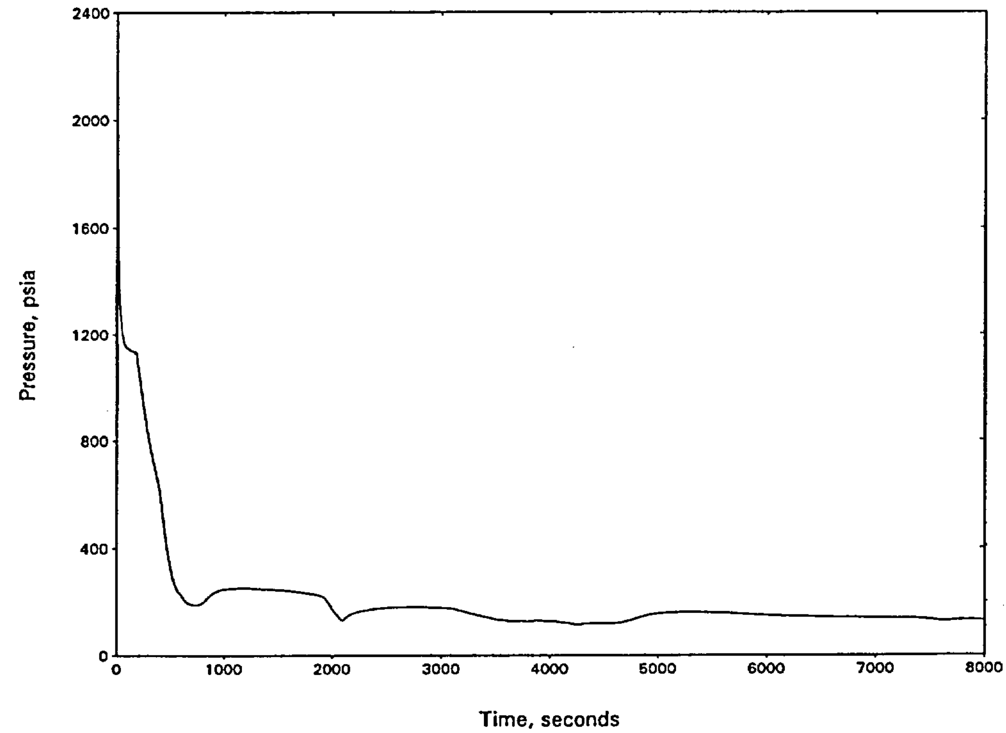

Figure 7.3-92: NAPS Unit 2 Break Flow - 5.2-inch SI Line Break

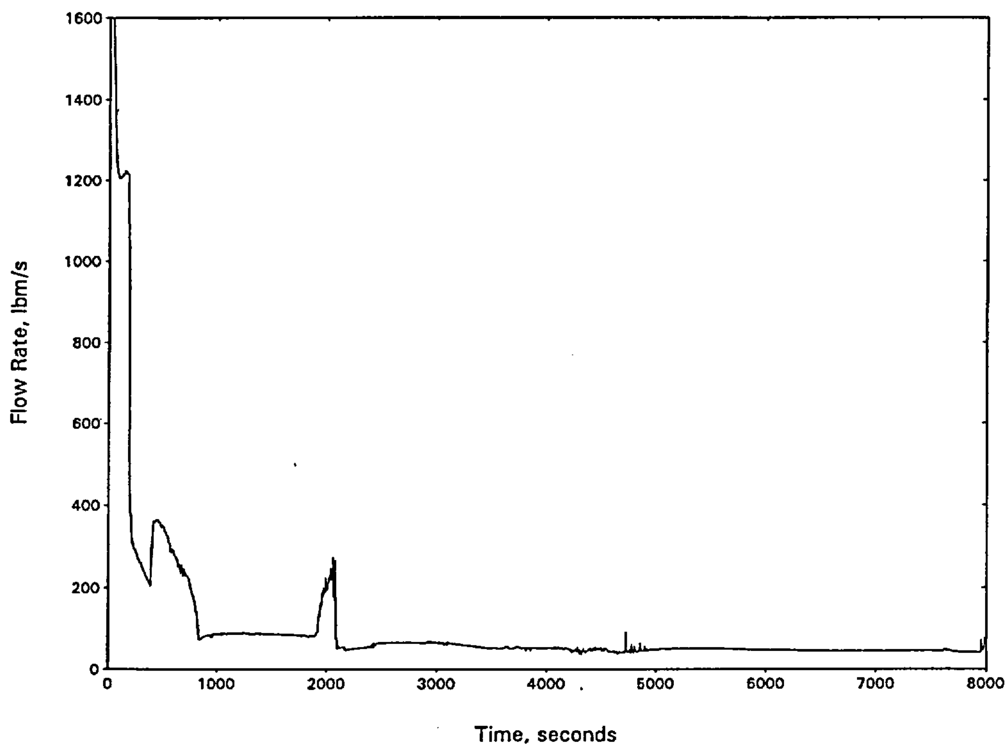

Figure 7.3-93: NAPS Unit 2 Hot Channel Mixture Level - 5.2-inch SI Line Break

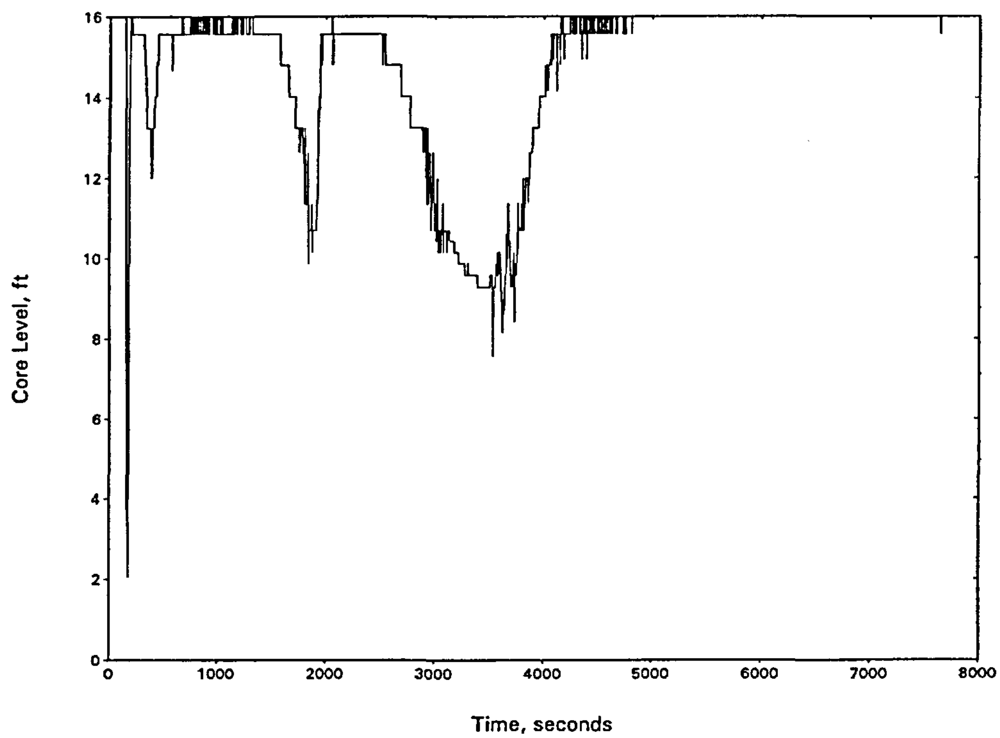

Figure 7.3-94: NAPS Unit 2 Hot Spot PCT - 5.2-inch SI Line Break

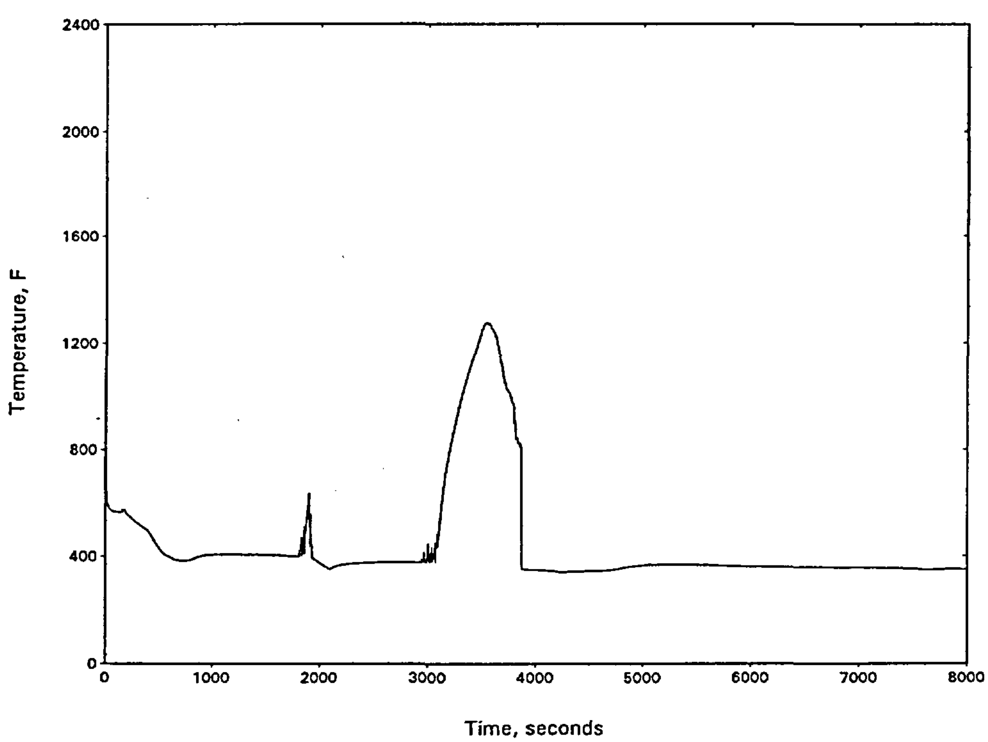

Figure 7.3-95: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 5.2-inch SI Line Break

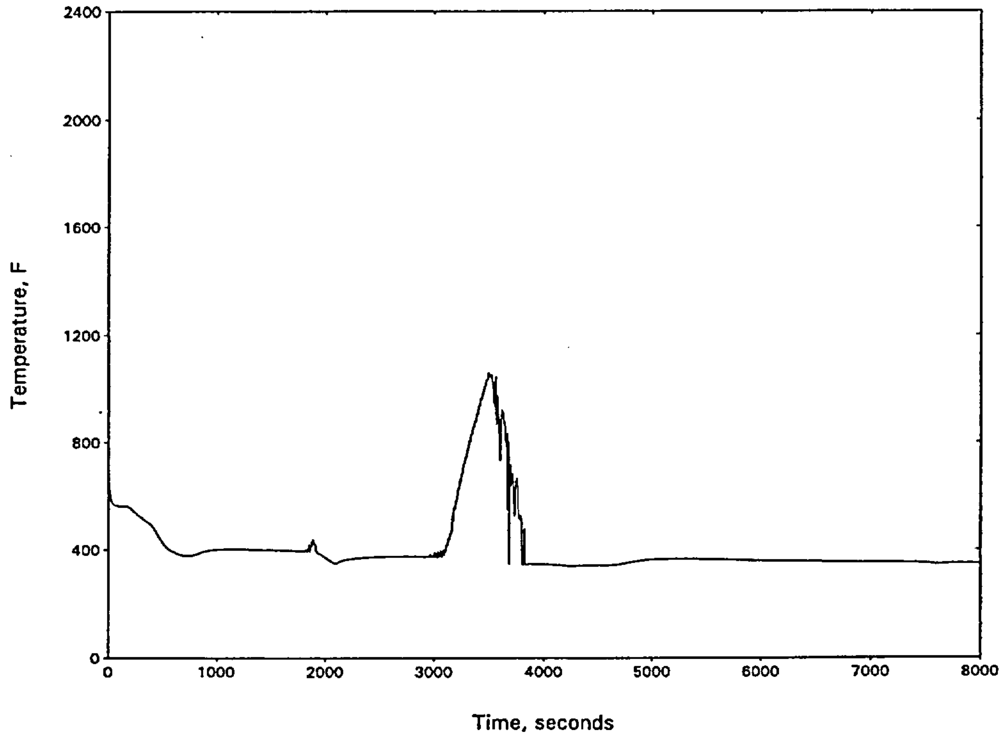

Figure 7.3-96: NAPS Unit 2 Intact Loop Seal Level - 5.2-inch SI Line Break

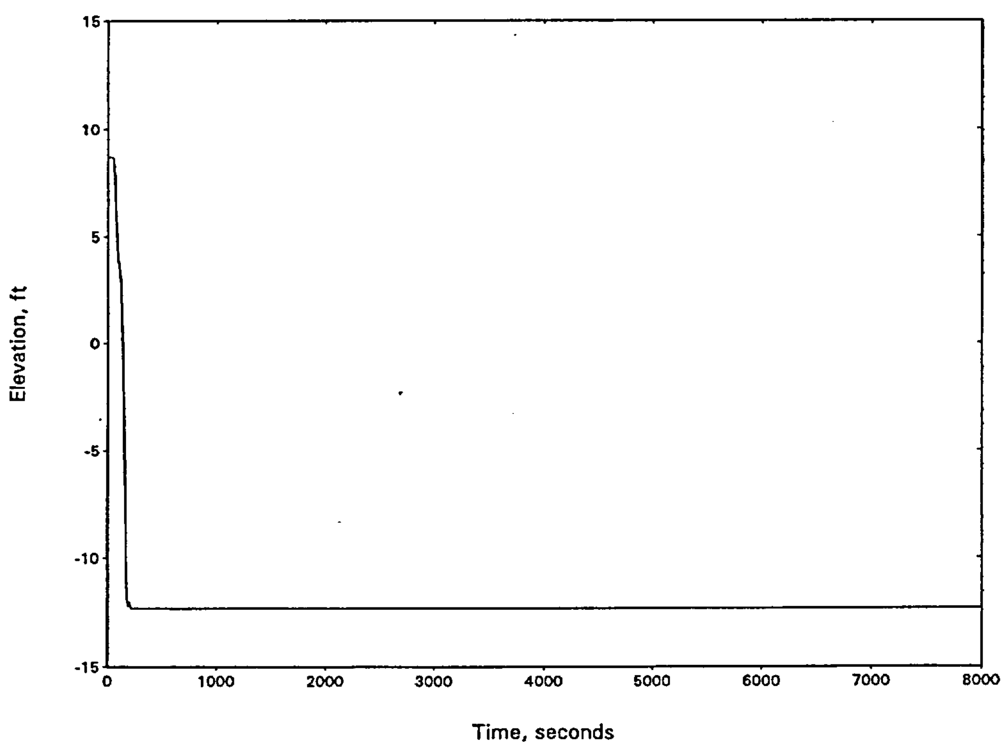

Figure 7.3-97: NAPS Unit 2 Broken Loop Seal Level - 5.2-inch SI Line Break

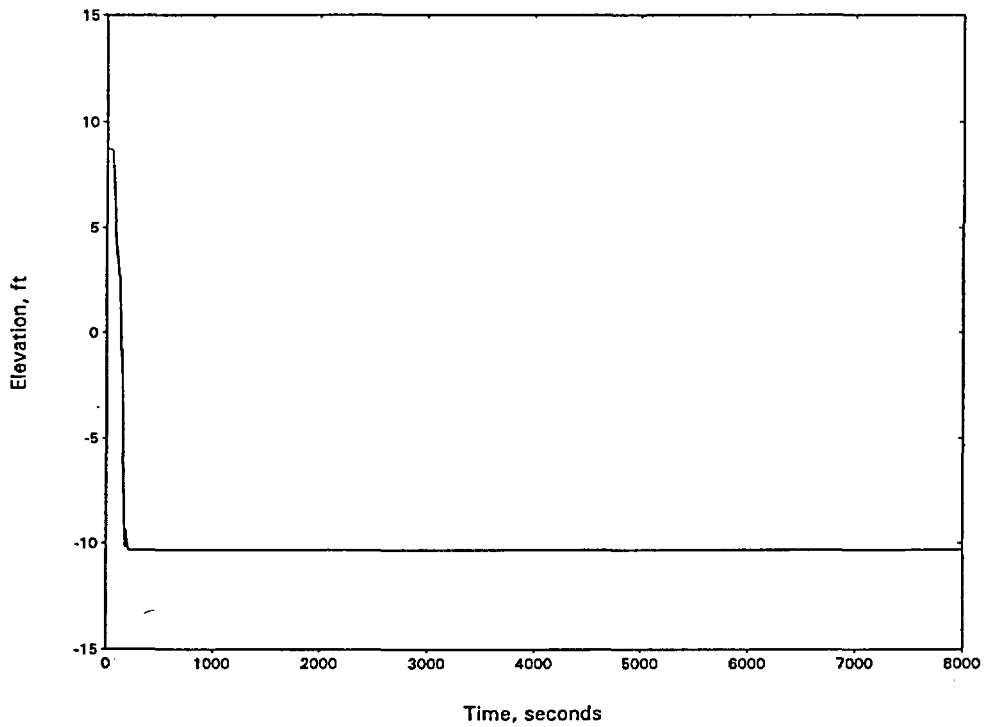

Figure 7.3-98: NAPS Unit 2 RCS Pressure - 6.0-inch Break

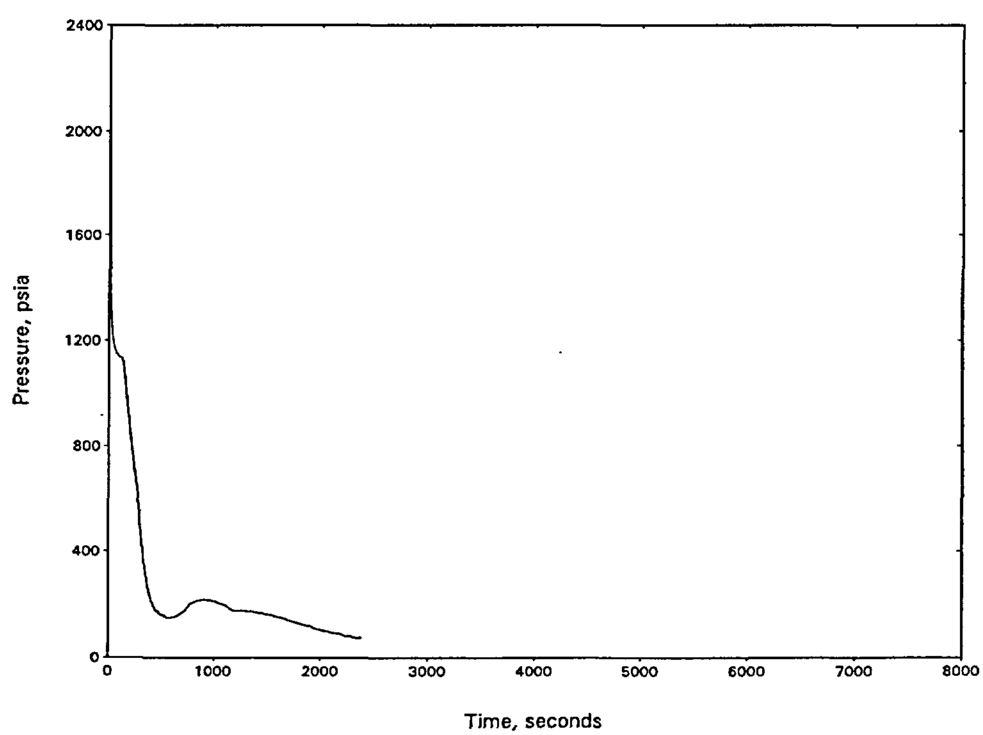

Figure 7.3-99: NAPS Unit 2 Break Flow - 6.0-inch Break

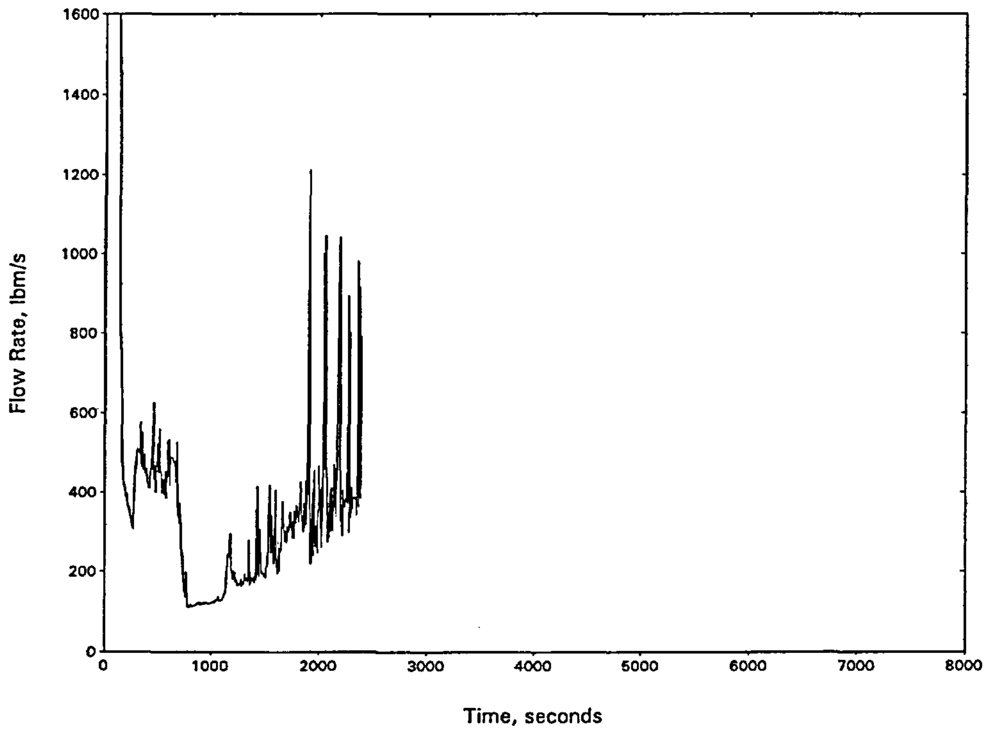

Figure 7.3-100: NAPS Unit 2 Hot Channel Mixture Level - 6.0-inch Break

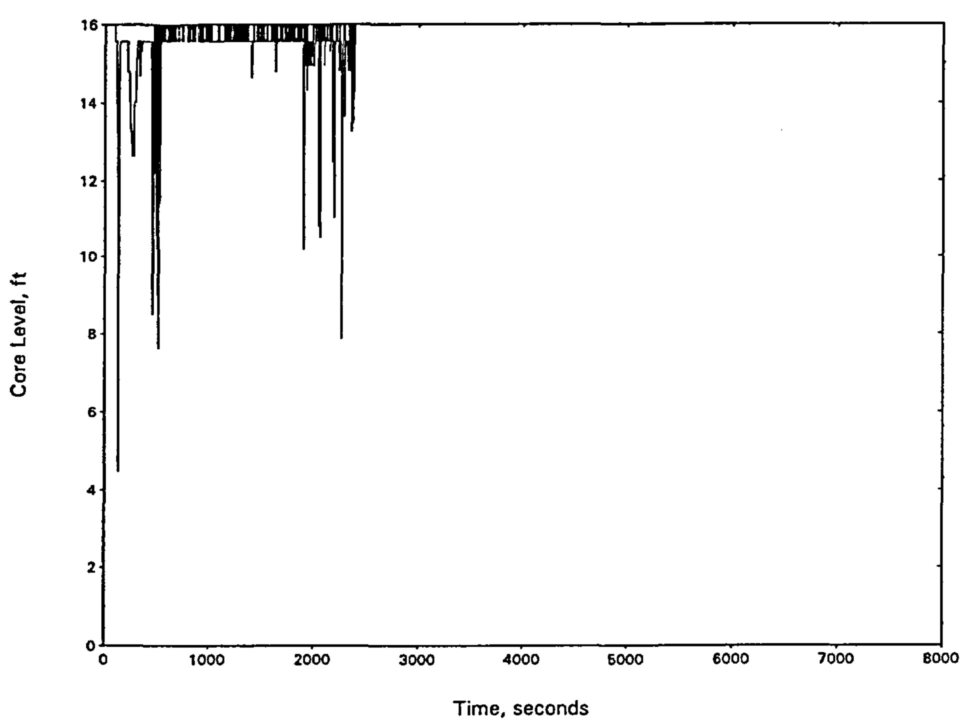

Figure 7.3-101: NAPS Unit 2 Hot Spot PCT - 6.0-inch Break

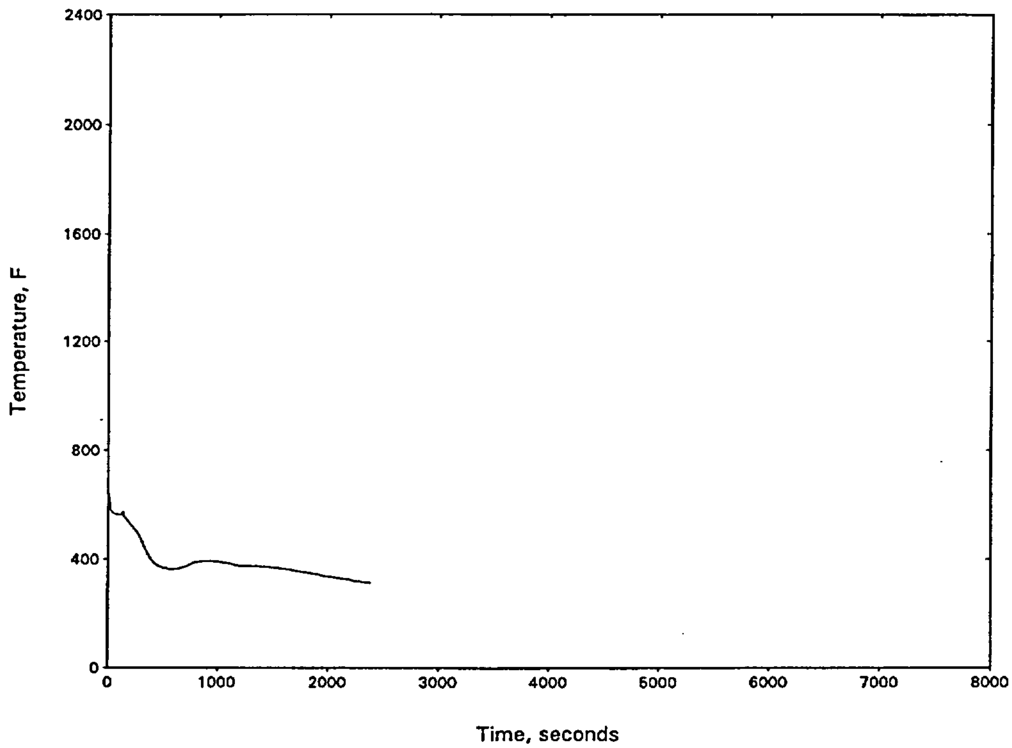

Figure 7.3-102: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 6.0-inch Break

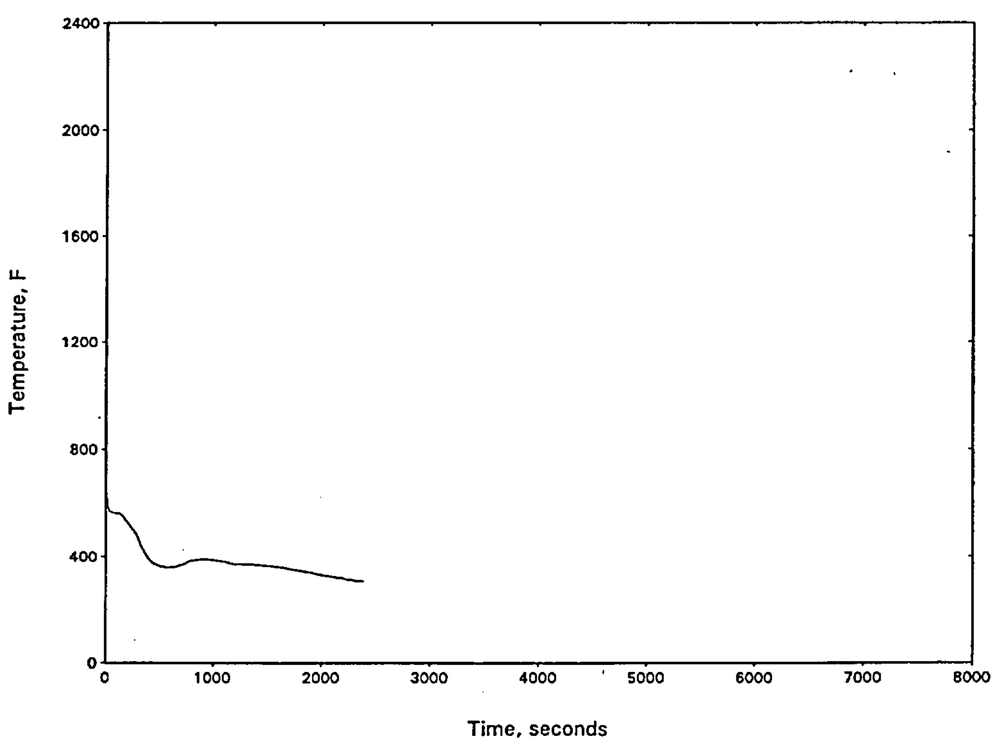

Figure 7.3-103: NAPS Unit 2 Intact Loop Seal Level - 6.0-inch Break

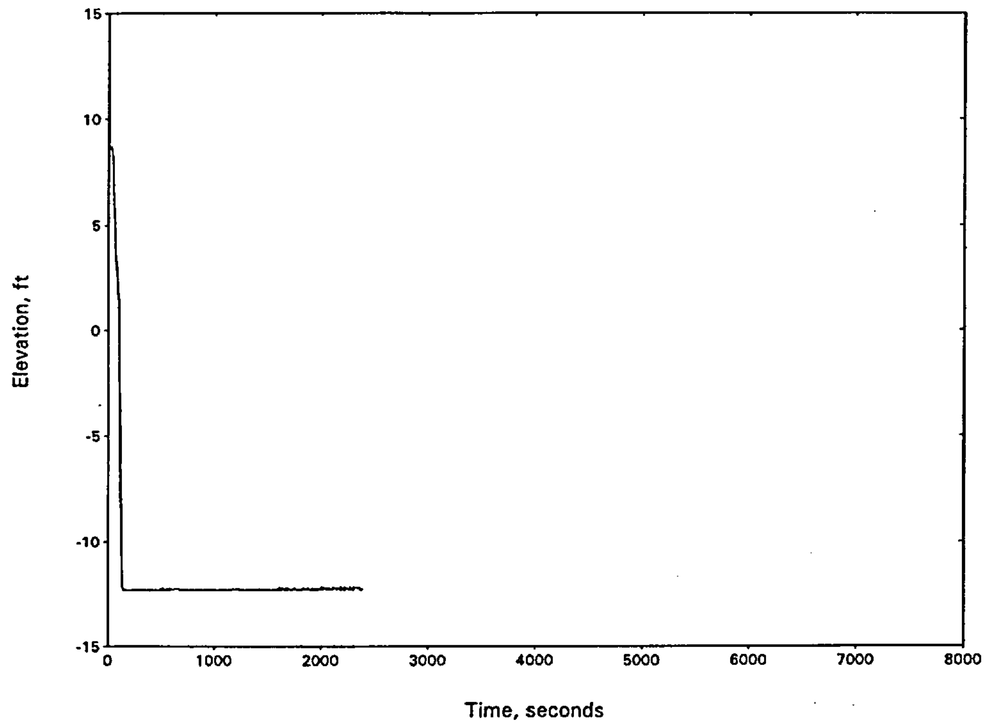

Figure 7.3-104: NAPS Unit 2 Broken Loop Seal Level - 6.0Break

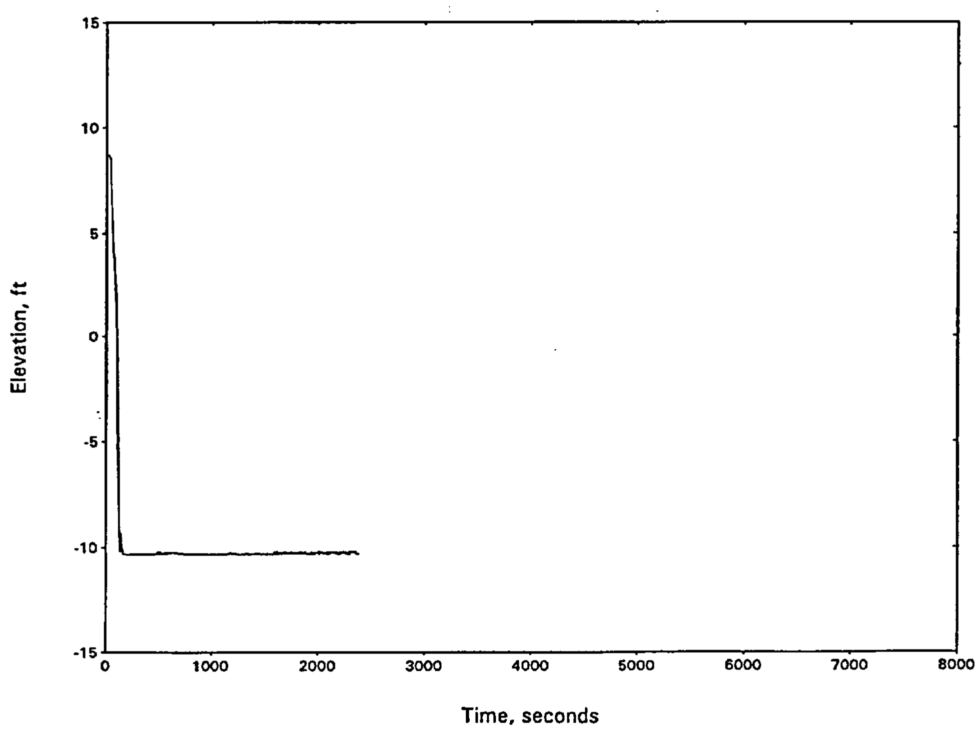

Figure 7.3-105: NAPS Unit 2 RCS Pressure - 3.0-inch Break AFW Failure

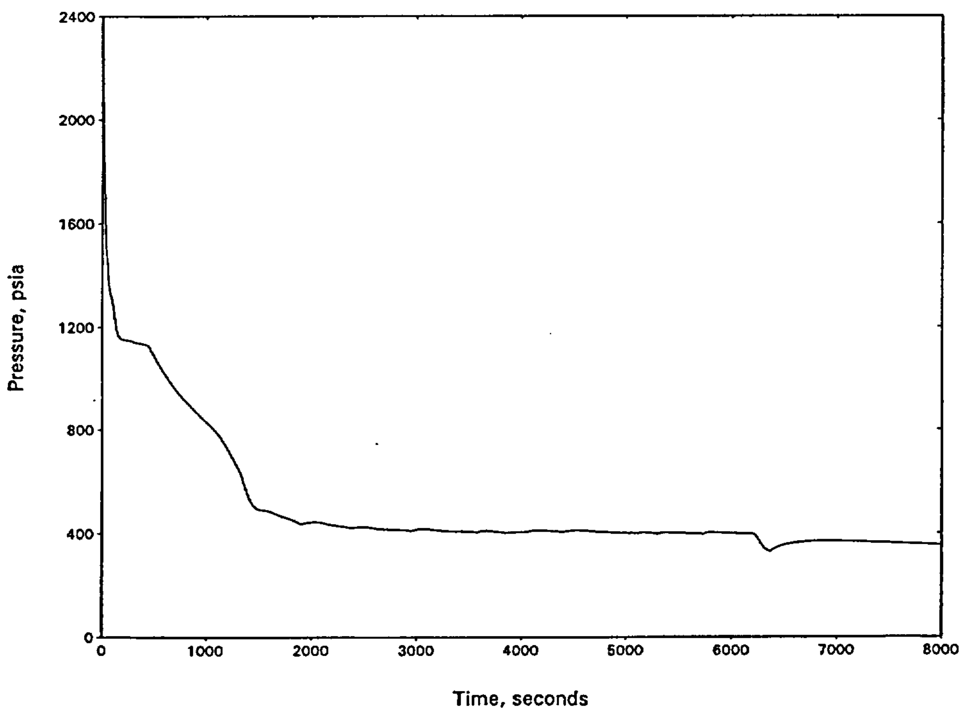

Figure 7.3-106: NAPS Unit 2 Break Flow - 3.0-inch Break AFW Failure

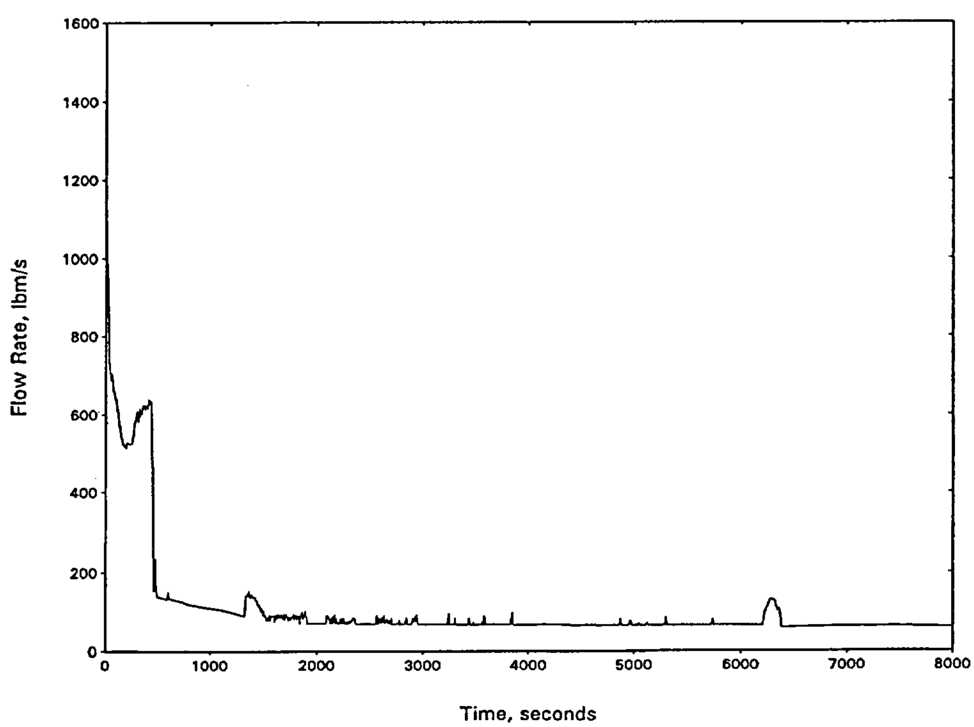

Figure 7.3-107: NAPS Unit 2 Hot Channel Mixture Level - 3.0-inch Break AFW Failure

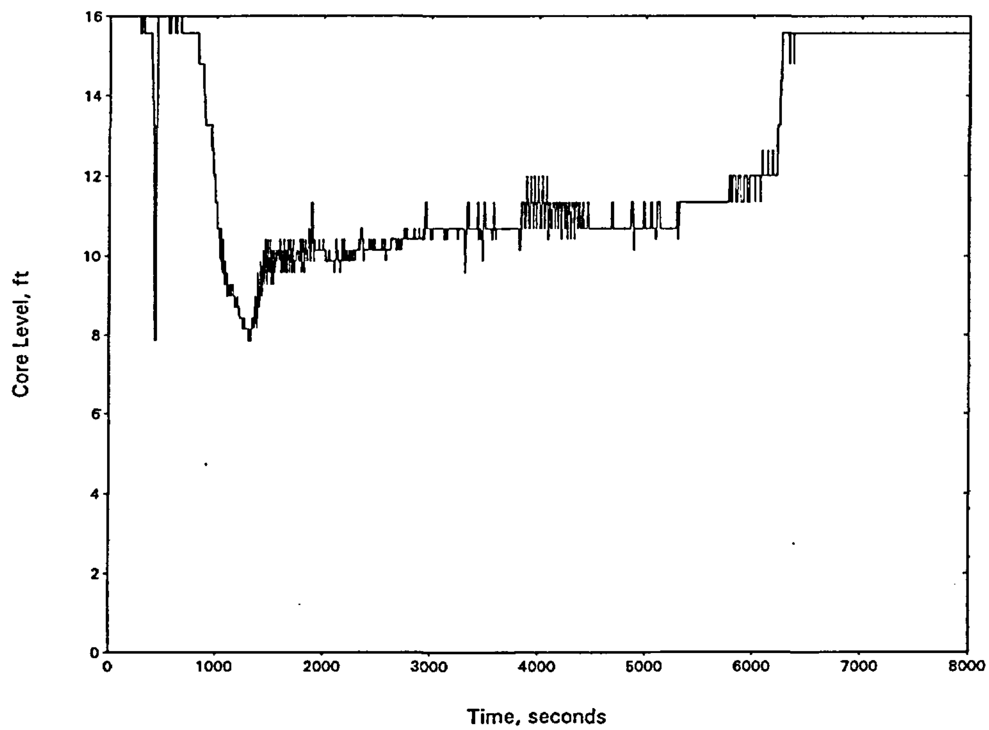

Figure 7.3-108: NAPS Unit 2 Hot Spot PCT - 3.0-inch Break AFW Failure

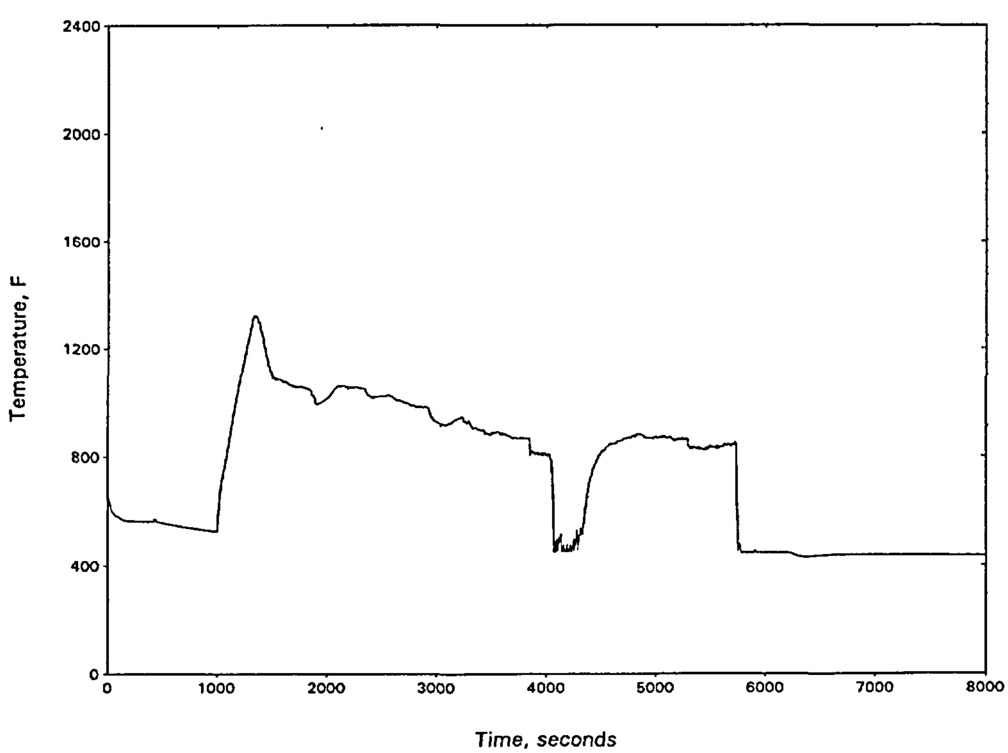

Figure 7.3-109: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 3.0-inch Break AFW Failure

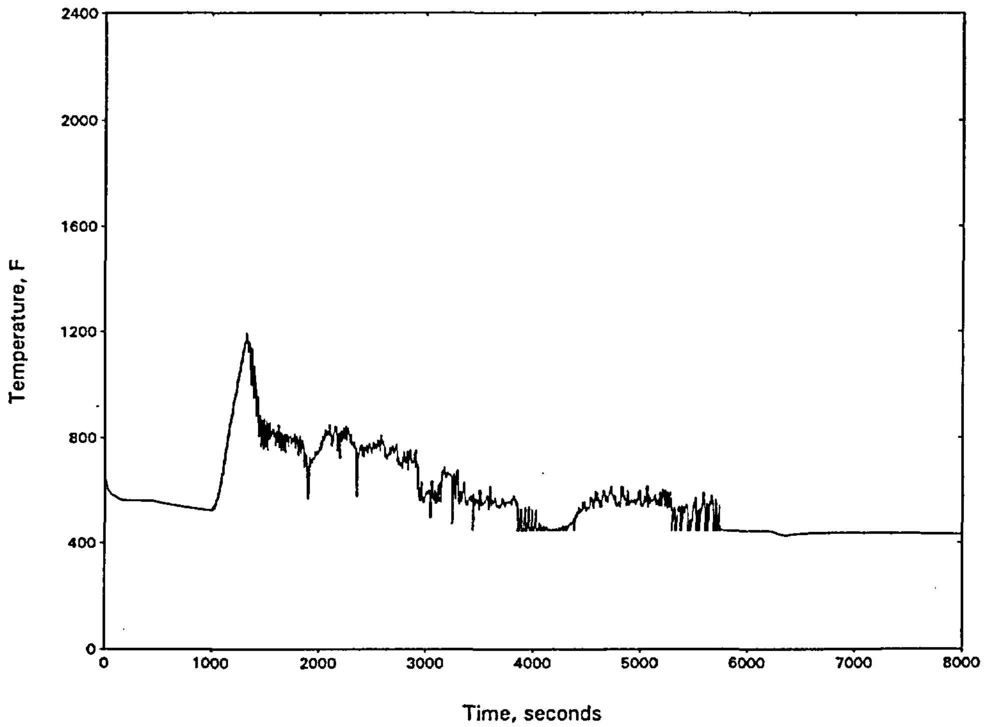

Figure 7.3-110: NAPS Unit 2 Intact Loop Seal Level - 3.0-inch Break AFW Failure

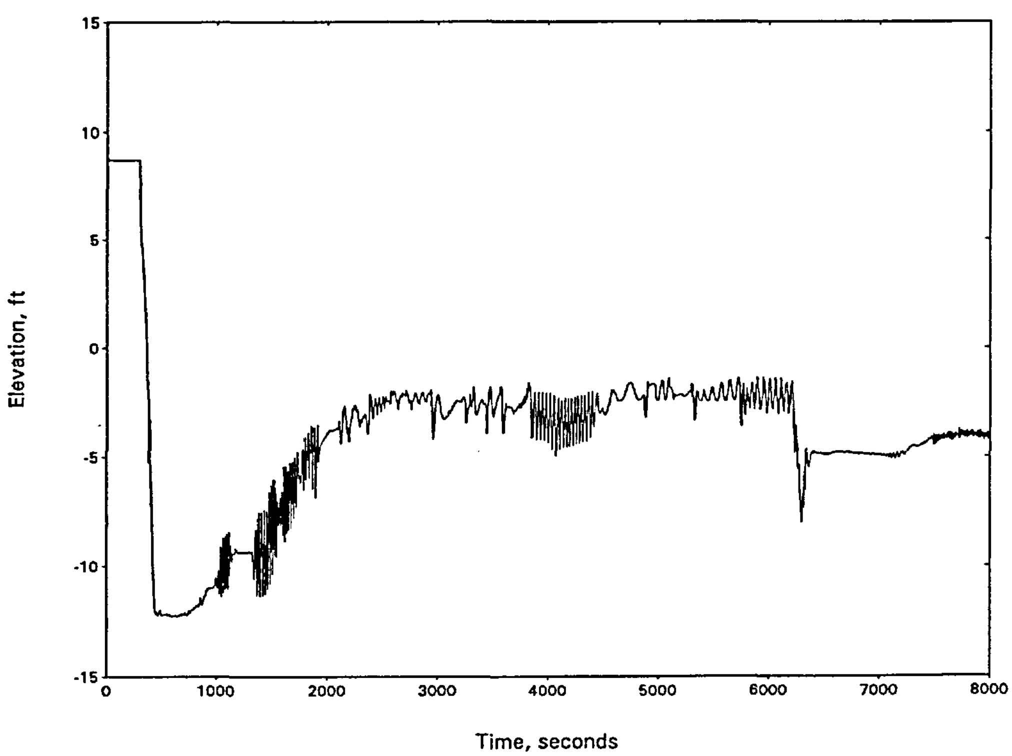

Figure 7.3-111: NAPS Unit 2 Broken Loop Seal Level - 3.0-inch Break AFW Failure

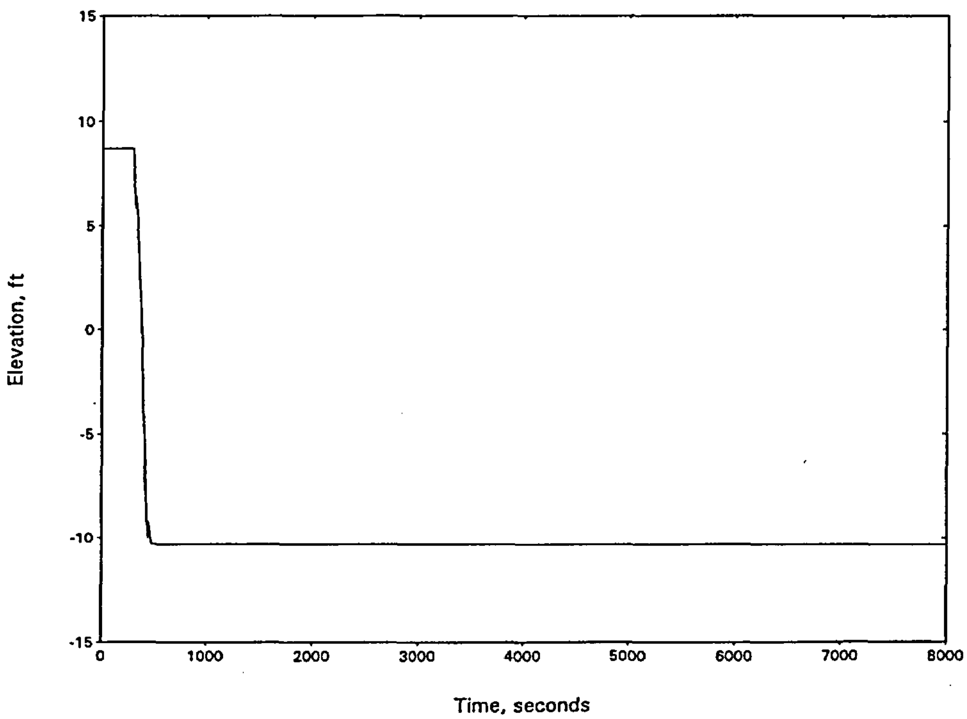

Figure 7.3-112: NAPS Unit 2 RCS Pressure - 3.0-inch Break Mixed Core

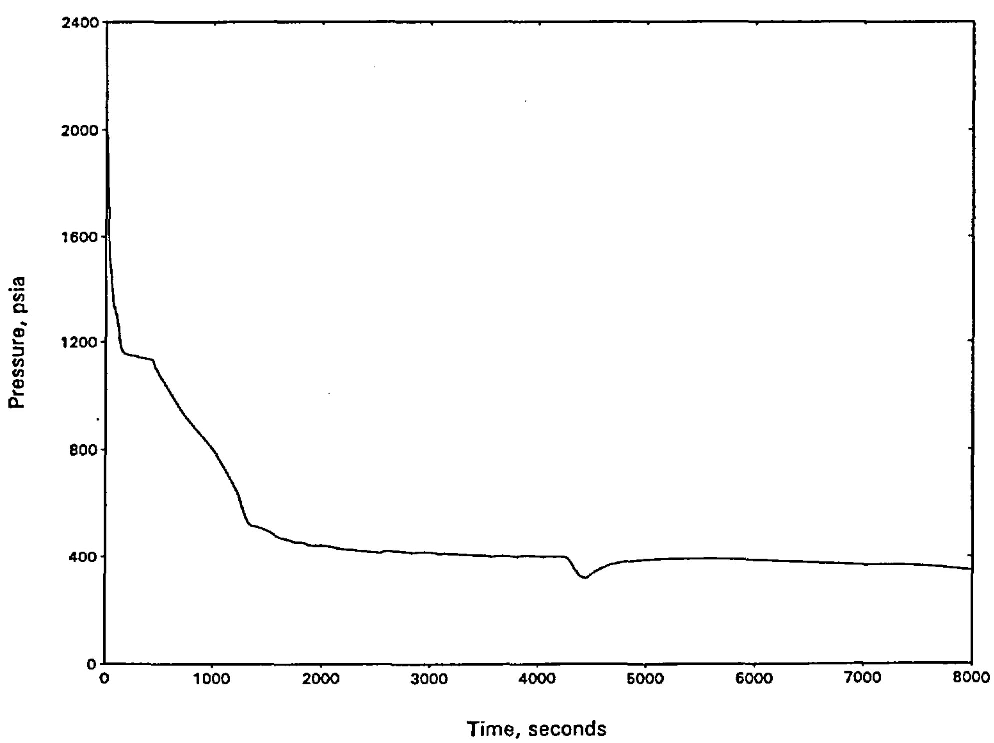

Figure 7.3-113: NAPS Unit 2 Break Flow - 3.0-inch Break Mixed Core

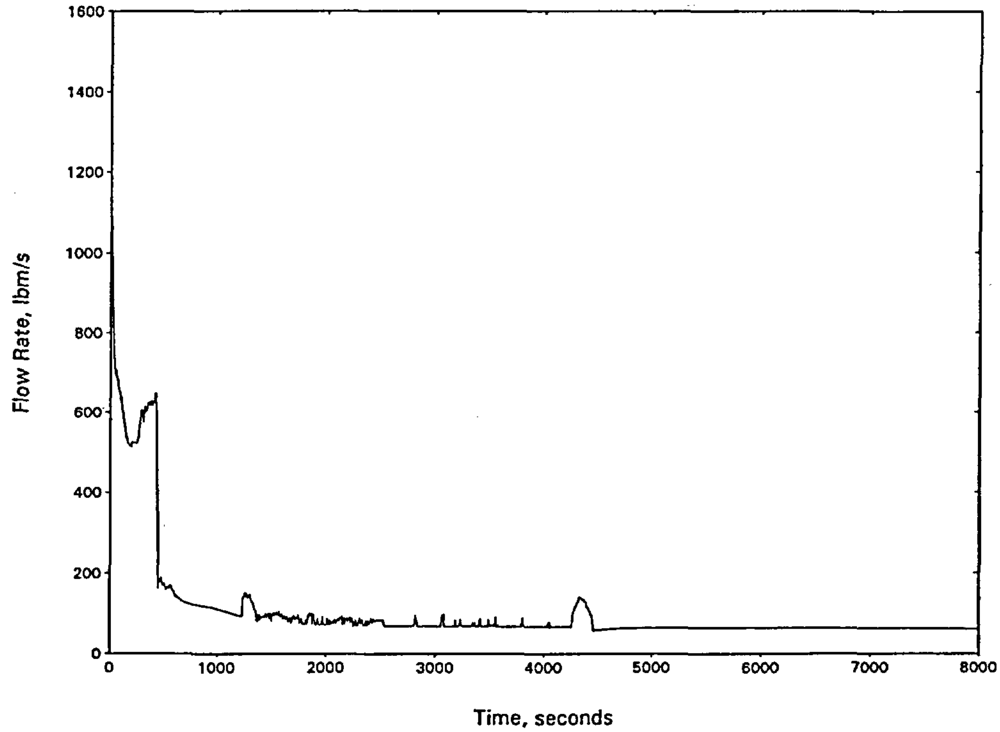

Figure 7.3-114: NAPS Unit 2 Hot Channel Mixture Level - 3.0-inch Break Mixed Core

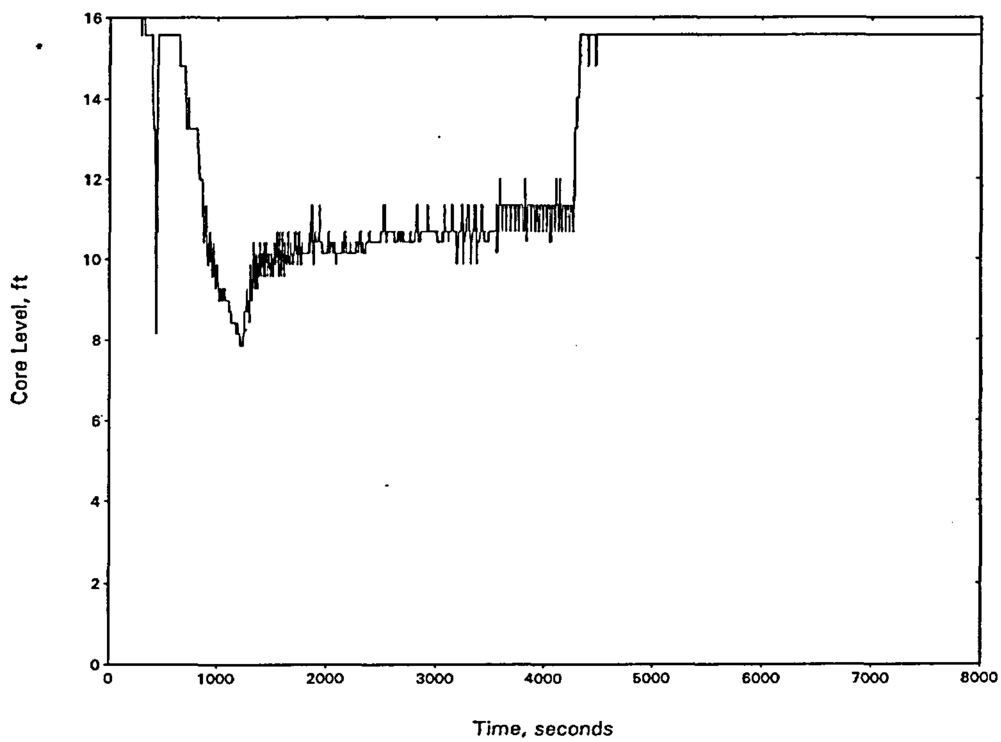

Figure 7.3-115: NAPS Unit 2 Hot Spot PCT - 3.0-inch Break Mixed Core

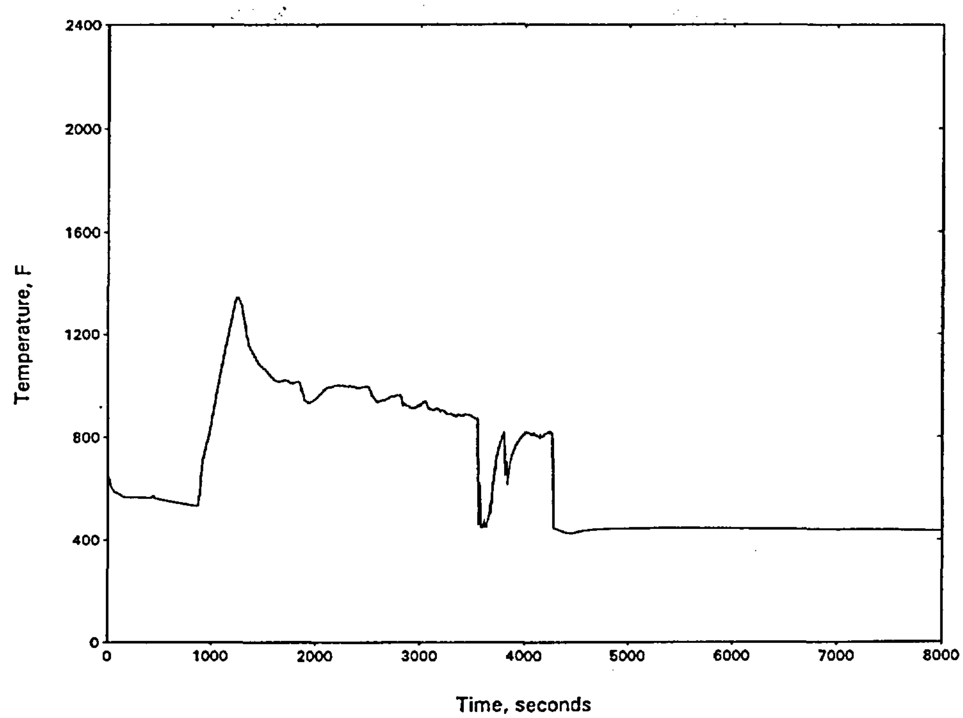

Figure 7.3-116: NAPS Unit 2 Hot Channel Outlet Vapor Temperature - 3.0-inch Break Mixed Core

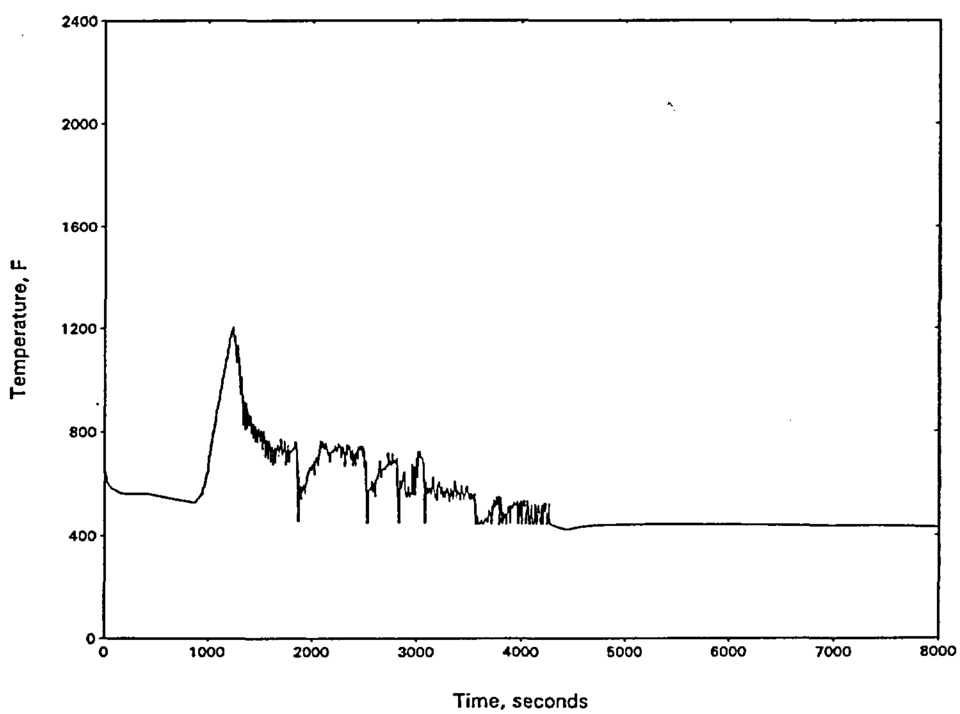

Figure 7.3-117: NAPS Unit 2 Intact Loop Seal Level - 3.0-inch Break Mixed Core

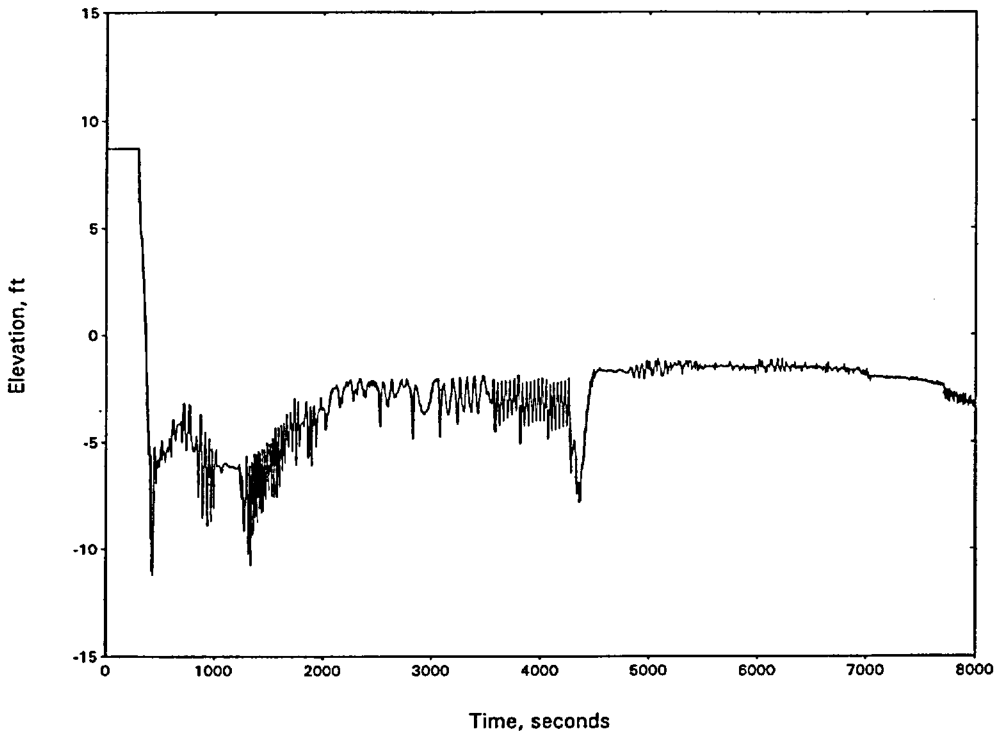

Figure 7.3-118: NAPS Unit 2 Broken Loop Seal Level - 3.0-inch Break Mixed Core