ATTACHMENT 7

NON-PROPRIETARY VERSION OF SBLOCA SUMMARY REPORT

The following pages provide the non-proprietary version of the technical summary report provided by Framatome supporting this license amendment request.

ANP-3943NP, "Callaway Small Break LOCA Analysis with GAIA Fuel Design," Revision 1, dated October 2022

[NON-PROPRIETARY REPORT]

57 pages follow this cover sheet

Callaway Small Break LOCA Analysis with GAIA Fuel Design

ANP-3943NP
Revision 1

Licensing Report

October 2022

Nature of Changes

Item	Revision No	Section(s) or Page(s)	Description and Justification
1	1	All	Updated Proprietary notations throughout document.

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Nomenclature

Acronym	Definition
AFW	Auxiliary Feedwater
BOC	Beginning-of-Cycle
CFR	Code of Federal Regulations
CWO	Core Wide Oxidation
DC	Downcomer
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EM	Evaluation Model
EOC	End-of-Cycle
$F_{\Delta H}$	Nuclear Enthalpy Rise Factor/Radial Peaking Factor
F_Q	Total Peaking Factor
Framatome	Framatome Inc.
HEM	Homogeneous Equilibrium Model
HHSI	High Head Safety Injection
HMP	High Mechanical Performance
IGM	Intermediate GAIA Mixing Grid
IHSI	Intermediate Head Safety Injection
k(z)	Axial-Dependent Peaking Factor
LHSI	Low Head Safety Injection
LOCA	Loss-of-Coolant Accident
LOOP	Loss-of-Offsite Power
LS	Loop Seal
LSC	Loop Seal Clearing
MFW	Main Feedwater

Acronym	**Definition**
MLO	Maximum Local Oxidation
MSSV	Main Steam Safety Valve
NRC	Nuclear Regulatory Commission
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RPS	Reactor Protection System
RT	Reactor Trip
RV	Reactor Vessel
PCT	Peak Cladding Temperature
PWR	Pressurized Water Reactor
PZR	Pressurizer
SBLOCA	Small Break Loss-of-Coolant Accident
SG	Steam Generator
SI	Safety Injection
SIAS	Safety Injection Actuation Signal
SRM	Swelling and Rupture Model
T_{avg}	RCS Average Temperature
TT	Turbine Trip
VQP	Vender Qualification Program

1.0 INTRODUCTION

This report summarizes the small break loss-of-coolant accident (SBLOCA) analysis for Callaway Nuclear Plant Unit 1 (Callaway). The purpose of the SBLOCA analysis is to support the Vendor Qualification Program (VQP) for Callaway with the Framatome 17x17 GAIA fuel design. This analysis was performed in accordance with the U.S. Nuclear Regulatory Commission (NRC)-approved S-RELAP5-based methodology described in Reference 1 as modified by Reference 2 with the noted exceptions in Section 3.3. Reference 3 discusses the incorporation of $M5_{Framatome}$ properties into the SBLOCA methodology.

Callaway is a four-loop, Westinghouse-designed Pressurized Water Reactor (PWR). The Framatome GAIA fuel design with $M5_{Framatome}$ cladding for Callaway consists of a 17x17 array with GAIA and intermediate GAIA mixing (IGM) grids, a lower high mechanical performance (HMP) grid and an upper HMP grid. The fuel assembly includes a MONOBLOC guide tube design, $M5_{Framatome}$ fuel rod design and a GRIP lower nozzle.

The analysis supports plant operation at a core power level of 3636 MWt (including measurement uncertainty), a maximum-allowed total peaking factor (F_Q) of 2.5 (represents total peaking with uncertainties applied and an axial-dependent factor k(z) set to 1.0), a radial peaking factor of ($F_{\Delta H}$) of 1.65 (including measurement uncertainty), and up to 5% steam generator (SG) tube plugging per SG.

A complete spectrum of cold leg pump discharge break sizes was considered, ranging from 1.00 inch diameter to 8.70 inch diameter. In addition, other supporting analyses prescribed by the methodology were performed which consider a delayed reactor coolant pump (RCP) trip, attached piping break, and sensitivity to Emergency Core Cooling System (ECCS) fluid temperature.

2.0 SUMMARY OF RESULTS

The SBLOCA analysis results demonstrate the adequacy of the ECCS to satisfy the 10 CFR 50.46(b) (1-4) criteria (Reference 4) for Callaway operating with Framatome supplied GAIA fuel design with $M5_{Framatome}$ cladding. The limiting peak cladding temperature (PCT) is 1618°F for an 8.70-inch diameter cold leg pump discharge break. The same break produced the limiting maximum local oxidation (MLO) and core wide oxidation (CWO) values. The limiting total MLO and limiting CWO values for the spectrum are 3.38% and <0.01%, respectively. The total MLO value includes [ ].

In addition to the cold leg pump discharge break spectrum analysis, three sensitivity studies were performed to investigate: a delayed RCP trip, a break in an attached pipe, and a different ECCS temperature. The results of the delayed RCP trip study demonstrated that there is at least 10 minutes for operators to trip all four RCPs after the specified trip criteria being met. The attached piping study analyzed breaks in the accumulator line and high head safety injection line (HHSI) line. The ECCS temperature sensitivity study analyzed the sensitivity to ECCS fluid temperatures different from those used in the break spectrum analysis. The conclusions of these studies support the applicability of the cold leg pump discharge break spectrum as the licensing basis.

3.0 DESCRIPTION OF ANALYSIS

3.1 *Acceptance Criteria*

The purpose of the analysis is to verify the adequacy of the Callaway ECCS by demonstrating compliance with the following 10 CFR 50.46(b) criteria (Reference 4):

1. The calculated maximum fuel element cladding temperature shall not exceed 2200°F.

2. The calculated total oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation.

3. The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react.

4. Calculated changes in core geometry shall be such that the core remains amenable to cooling.

3.2 *Description of SBLOCA Event*

The postulated SBLOCA is defined as a break in the Reactor Coolant System (RCS) pressure boundary with an area less than or equal to 10% of the cold leg pipe area. The most limiting break location is in the cold leg pipe on the discharge side of the RCP. This break location results in the largest amount of RCS inventory loss, the largest fraction of ECCS fluid discharged out the break, and the largest pressure drop between the core exit and the top of the downcomer (DC). This produces the greatest degree of core uncovery, the longest fuel rod heatup time, and consequently, the greatest challenge to the 10 CFR 50.46(b)(1-4) criteria (Reference 4).

The SBLOCA event progression develops in the following distinct phases: (1) subcooled depressurization (also known as blowdown), (2) natural circulation, (3) loop seal clearing, (4) core boil-off, (5) core recovery and long-term cooling. The duration of each of these phases is break size and system dependent.

Following the break, the RCS 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. The assumption of a loss-of-offsite power (LOOP) concurrent with the reactor scram results in RCP trip.

In the second phase of the transient, the RCS transitions to a quasi-equilibrium condition in which the core decay heat, leak flow, SG heat removal, and system hydrostatic head balance combine to control the core inventory. During this period, the RCPs are coasting down and the system drains from the top of the RCS with the first voiding occurring at the top of the SG tubes, in the reactor vessel (RV) upper head, and at the top of the RV upper plenum region. Also, the loop seals remain plugged during this phase, trapping vapor generated by the core in the RCS, resulting in a low-quality flow at the break.

The third phase in the transient is characterized by loop seal clearing (LSC). During this phase the loop seal (i.e., liquid trapped in the RCP suction piping) can prevent steam from venting to the break. The maximum pressure difference between the RV upper head and DC is reached when the liquid level on the downside of the SG is depressed to the elevation of the horizontal loop seal piping. When this point is reached, the loop seal clears, and the trapped steam can be vented to the break. For some break sizes, the transient develops slowly, and the core can become temporarily uncovered before the loop seal clears. Following LSC, the break flow transitions to primarily steam and the core recovers to approximately the cold leg elevation as pressure imbalances throughout the RCS are relieved.

The fourth phase is characterized as core boil-off. With the loop seal cleared, the venting of steam through the break causes a rapid RCS depressurization below the secondary pressure. As boiling increases in the core, the core mixture level decreases. The core mixture level will reach a minimum, in some cases resulting in deep core uncovering. The transient boil-off period ends when the core liquid level reaches this minimum. At this time, the RCS has depressurized to the point where ECCS flow into the RV matches the rate of boil-off from the core.

The last phase of the transient is characterized as core recovery. The core recovery period extends from the time at which the core mixture level reaches a minimum in the core boil-off phase until all parts of the core are quenched and covered by a low-quality mixture. Core recovery is provided by pumped injection and passive accumulator injection when the RCS pressure decreases below the accumulator pressure. Generally, PCT occurs at the beginning of the core recovery phase before the mixture level has increased high enough to provide enhanced cooling to the PCT location on the hot rod.

The SBLOCA transient progression is dependent on the size of the break and is typically broken into three different break size ranges. For break sizes towards the larger end of the break spectrum, significant RCS inventory loss results in more rapid RCS depressurization to the accumulator actuation pressure. Accumulator flow provides sufficient inventory early in the transient to limit the core uncovery and hot rod heatup. For break sizes in the middle of the spectrum, the rate of inventory loss from the RCS is such that the HHSI pumps typically cannot preclude significant core uncovery. The RCS depressurization rate is slow, extending the time required to reach the accumulator injection pressure, if reached at all. This tends to maximize the heatup time of the hot rod which produces the maximum PCT and local cladding oxidation. Break sizes in this range, will either exhibit core recovery with the HHSI pumped injection alone while the RCS pressure remains barely above the accumulator injection setpoint, or exhibit core recovery from accumulator injection. For break sizes at the low end of the spectrum, the RCS pressure does not reach the accumulator injection pressure. However, RCS inventory loss is not significant and typically within the means of HHSI makeup capacity such that core uncovery is minimal if not precluded.

3.3 *Description of Analytical Methods*

The NRC-approved SBLOCA methodology is documented in EMF-2328(P)(A) and Supplement 1 to EMF-2328 (References 1 and 2) and is used in this analysis. This evaluation model for event response of the primary and secondary systems and the hot fuel rod is based on the use of two computer codes. The appropriate conservatisms, as prescribed by Appendix K of 10 CFR 50 (Reference 5), are incorporated.

The two Framatome computer codes used in this analysis are:

1. The RODEX2-2A code was used to determine the burnup dependent initial fuel rod conditions for the system calculations.

2. The S-RELAP5 code was used to predict the primary and secondary system thermal-hydraulic and hot rod transient response.

The SBLOCA methodology (Reference 1, Reference 2) has been reviewed and approved by the NRC to perform SBLOCA analyses. However, two modeling deviations from the approved SBLOCA methodology were included in this analysis, as described below. These differences have been presented in recent NRC-approved SBLOCA analyses (References 6 and 7).

[ ]

Representative system nodalization figures for a Westinghouse four-loop plant are shown in Figure 3-1 through Figure 3-3. As such, minor variations for Callaway specific details are not shown. For example, the charging system is not simulated as a separate component in the SBLOCA analysis; therefore, the charging system noding diagram shown in Figure 3-1 is not used. See Section 3.4 for additional details.

Figure 3-1
S-RELAP5 SBLOCA Reactor Coolant System Nodalization

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Criteria (c) and (d) defined in associated affidavit for this document apply to bracketed material on this page.

Figure 3-2
S-RELAP5 SBLOCA Secondary System Nodalization

Figure 3-3
S-RELAP5 SBLOCA Reactor Vessel Nodalization

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3.4 *Plant Description and Summary of Analysis Parameters*

The plant analyzed is the Callaway Nuclear Plant Unit 1, Westinghouse-designed PWR, which has four loops, each with a hot leg, a U-tube steam generator, and a cold leg with an RCP. A pressurizer is connected to the hot leg of one of the loops. Main feedwater (MFW) is injected into the downcomer of each SG. The auxiliary feedwater (AFW) system provides flow to the four SGs when normal feedwater is not available. The ECCS provides injection to each of the four loops via the centrifugal charging/HHSI system, SI/intermediate head safety injection (IHSI) system, residual heat removal (RHR)/low head safety injection (LHSI) system, and accumulators. For the purpose of this report, the centrifugal charging/HHSI, SI/IHSI, and LHSI/RHR systems are referred to as the HHSI, IHSI, and LHSI systems, respectively.

The RCS, SG, reactor vessel, pressurizer, and ECCS are explicitly modeled in the S-RELAP5 model to provide an accurate representation of the plant. The model includes four accumulators, a pressurizer, and four SGs with both primary and secondary sides modeled. For the secondary side, the model includes the main steam lines between their respective SGs and the turbine control valve, including the connected main steam safety valve (MSSV) inlet piping.

For the SBLOCA break spectrum analysis, IHSI and HHSI are modeled as the same system and identified as HHSI. For each RCS loop, the ECCS model includes an injection connection to the cold leg for the accumulator, another connection for HHSI, and another connection for LHSI. The ECCS injection connections to the cold leg pipe are downstream of the RCP discharge. The ECCS pumped injection is modeled as a table of flow versus RCS backpressure.

Important system parameters and initial conditions used in the analysis are given in Table 3-1. The heat generation rate in the S-RELAP5 reactor core model is determined from reactor kinetics equations with actinide and decay heating as prescribed by 10 CFR 50 Appendix K (Reference 5).

The break spectrum analysis assumes a LOOP concurrent with reactor scram, which is based on the reactor protection system (RPS) low pressurizer pressure reactor trip plus trip delay. The assumption of LOOP concurrent with reactor scram results in an RCP trip.

The RCPs are tripped at the time of reactor scram, instead of the opening of the break (time zero). This is considered to be conservative, since continued RCP operation will delay LSC. This delay in LSC will result in additional RCS inventory loss since the break flow is mostly liquid until the time of LSC. After LSC, a path for steam venting is established and the break flow transitions from liquid to steam, lowering the break mass flow rate.

The single failure criterion required by 10 CFR 50 Appendix K (Reference 5) is satisfied by assuming the loss of one emergency diesel generator (EDG). As a result, one motor-driven AFW pump, one HHSI pump, and one LHSI pump are assumed available to mitigate the transient.

Following the safety injection actuation system (SIAS) activation on low pressurizer pressure, actuation of the HHSI and LHSI systems are delayed by 29 seconds and 44 seconds, respectively. Table 3-2 and Table 3-3 show the minimum ECCS flow rates with one EDG failure for HHSI and LHSI, respectively, for a break in the cold leg pump discharge. The HHSI and LHSI flow to the intact loops is modeled to be distributed equally among the three intact loops.

With one of the two motor-driven AFW pumps assumed unavailable for the single failure criterion, the remaining motor-driven AFW pump delivers flow to the four SGs. A SG tube plugging level of 5% is modeled in each SG. The MSSVs are set to open at their nominal setpoints plus 3% accumulation.

The axial power shapes for this analysis are shown in Figure 3-4. The figure shows the input axial power shape and the axial power shape after being adjusted so that it is consistent with the Technical Specification total and radial peaking factors.

3.5 *Safety Evaluation Compliance*

The NRC-approved supplemented EMF-2328 method (Reference 1 and Reference 2) contains no restrictions. The analysis was performed in accordance with the approved methodology except as indicated in Section 3.3.

Table 3-1
System Parameters and Initial Conditions

Parameter	Value
Reactor Power (MWt)	3636[1]
Axial Power Shape	Figure 3-4
Radial Peaking Factor ($F_{\Delta H}$)	1.65[1]
Maximum-Allowed Total Power Peaking Factor (F_Q)	2.5[2]
Total RCS Flow Rate (gpm)	374,400
Pressurizer Pressure (psia)	2249.3
RCS Operating Temperature, T_{avg} (°F)	590.1
SG Tube Plugging per SG (%)	5
SG Secondary Pressure (psia)	998.9
MFW Temperature (°F)	446
RPS Low Pressurizer Pressure for Reactor Trip (psia)	1859.3
RPS Low Pressurizer Pressure Trip Delay (sec)	2
RPS Scram Delay (sec)	0
SIAS Low Pressurizer Pressure Activation Setpoint (psia)	1714.3
Accumulator Pressure (psia)	616.3
Accumulator Fluid Temperature (°F)	120
Accumulator Water Volume per Accumulator (ft^3)	850
AFW Temperature (°F)	120
Total AFW Flow Rate (gpm)	400
AFW Initiation on Low-Low SG Narrow Range Level Setpoint (% Narrow Range Span)	0
AFW Injection Delay (sec)	60[3]
ECCS Pumped Injection Temperature (°F)	100
HHSI Injection Delay Time on SIAS (sec)	29[3]
LHSI Injection Delay Time on SIAS (sec)	44[3]
MSSV Lift Pressure and Accumulation	Nominal + 3% Accumulation

[1] Includes measurement uncertainty.
[2] Includes uncertainties and k(z) set to 1.0.
[3] Delay applied to all analyses regardless of offsite power availability.

Table 3-2
High Head Safety Injection Flow Rates for Cold Leg Pump Discharge Break Location

RCS Pressure (psia)	Broken Loop Flow (gpm)	Total Intact Loops Flow (gpm)
14.3	253.6	738.2
114.3	246.2	716.3
214.3	238.5	694.2
314.3	230.2	670.2
414.3	221.9	645.8
514.3	213.2	620.1
614.3	204.1	594.0
714.3	194.9	567.0
814.3	185.3	539.2
914.3	175.0	509.1
1014.3	164.1	477.3
1114.3	152.6	443.6
1214.3	133.8	389.1
1314.3	118.2	343.5
1414.3	96.0	278.7
1514.3	55.7	160.8
1614.3	52.3	151.1
1714.3	48.9	141.3
1814.3	45.5	131.4
1914.3	42.0	121.2
2014.3	37.8	109.1
2114.3	33.4	96.4
2214.3	28.4	82.2
2314.3	22.8	65.7
2414.3	11.0	31.5
2514.3	0.0	0.0

Table 3-3
Low Head Safety Injection Flow Rates for Cold Leg Pump Discharge Break Location

RCS Pressure (psia)	Broken Loop Flow (gpm)	Total Intact Loops Flow (gpm)
14.3	932.1	2848.4
34.3	865.1	2306.1
54.3	792.0	1744.9
74.3	711.0	1196.1
94.3	618.5	826.9
114.3	509.1	375.8
134.3	0.0	0.0

Figure 3-4
Axial Power Distribution Comparison

Criteria (c) and (d) defined in associated affidavit for this document apply to bracketed material on this page.

4.0 SBLOCA ANALYSIS

The analysis results demonstrate the adequacy of the ECCS to satisfy the criteria given in 10 CFR 50.46(b)(1-4) for Callaway operating with Framatome supplied GAIA fuel design with $M5_{Framatome}$ cladding.

4.1 *Break Spectrum Results*

The Callaway break spectrum analysis for SBLOCA includes breaks of varying diameter up to 10% of the flow area for the cold leg pump discharge. The spectrum includes a break size range from 1.00 to 8.70 inches in diameter, where the break size interval is sufficient to establish a PCT trend. Additional break sizes are analyzed with a smaller break interval once the potential limiting break size is determined to confirm the limiting break size. Figure 4-1 shows the calculated PCTs for these breaks. For the break spectrum analysis, RCP trip is assumed to occur on reactor scram.

The results of the cold leg pump discharge SBLOCA break spectrum analysis are presented in Table 4-1. The predicted event times for the break spectrum are provided in Table 4-2. The limiting PCT break size is determined to be 8.70 inches in diameter (0.41282 ft^2), resulting in a PCT of 1618°F. The 8.70-inch break size yielded the highest transient MLO and CWO from the spectrum. The limiting total MLO and limiting CWO values for the spectrum are 3.38% and <0.01%, respectively.

4.2 *Discussion of Transient for Limiting PCT Break*

The limiting PCT break spectrum case is an 8.70-inch diameter cold leg pump discharge break. The PCT of this case is 1618°F. The break opens at t=0 seconds and initiates a subcooled depressurization of the RCS. The RPS low pressurizer pressure trip setpoint is reached at 6.62 seconds and at 8.62 seconds the reactor is scrammed, coincident with the RCP and turbine trips (Figure 4-2, Figure 4-9, and Table 4-2). MFW is also isolated on reactor scram following a 2 second delay (Figure 4-10). The pressure in the secondary side begins to rise but does not reach the MSSV setpoints, which remain closed for the duration of the transient (Figure 4-11).

The SIAS is issued at 9.03 seconds. Following the EDG loading delay, HHSI begins to inject at 38 seconds (Figure 4-15 and Table 4-2). However, HHSI does not provide sufficient inventory to offset the large amounts lost out the break at this time (Figure 4-18). Therefore, the core begins to uncover at 52 seconds, with effective cooling lost to most of the hot assembly in a short period of time (Figure 4-19).

All four loop seals clear before time of PCT, with the broken loop clearing first after 87 seconds, followed closely by the other three loops clearing between 90 and 92 seconds (Figure 4-6 and Table 4-2). The clearing of the loop seals produces a temporary increase in core level at approximately 90 seconds (Figure 4-19). However, the mixture level remains near the bottom of the active core during the increase, resulting in continued poor cooling in the upper regions of the core and allowing the clad temperature excursion to proceed (Figure 4-20).

The accumulators begin injecting at 173 seconds (Figure 4-17 and Table 4-2). The minimum RV mass occurs around 190 seconds (Figure 4-8). There is a time delay from the time when accumulator injection begins to the mixture level reaching sufficient levels to cool the upper locations in the core. The delay results in a rupture of the hot rod at 200 seconds (Table 4-1). The rupture allows for interior metal-water reaction, thereby increasing the local oxidation at the rupture node.

The cladding temperature excursion is terminated at 201 seconds with a PCT of 1618°F (Figure 4-20 and Table 4-1). The core is quenched at approximately 230 seconds with the first major accumulator injection ending around the same time (Figure 4-17). At this point, enough decay heat is being removed and adequate mixture level is sustained primarily by HHSI with intermittent accumulator injection (Figure 4-15 and Figure 4-17). As the RCS continues to depressurize, LHSI begins at 416 second in the broken loop and 428 seconds in the intact loops, where injection is sustained for the duration of the transient (Figure 4-16 and Table 4-2). Since sustained LHSI injection begins well after the time of PCT, the effects of LHSI on transient mitigation are considered minimal.

4.3 *Delayed RCP Trip Study*

The delayed RCP trip study is performed in accordance with the NRC-approved supplement to the EMF-2328 methodology (Reference 2). For plants such as Callaway that do not have an automatic RCP trip, a delayed RCP trip can potentially result in a more limiting condition than tripping the RCPs at reactor scram. Continued operation of the RCPs can result in more overall inventory loss out the break. It has been postulated that tripping the pumps when the minimum RCS inventory occurs could cause a collapse of voids in the core, thus depressing the core level and provoking a deeper core uncovering, and a potentially higher PCT. Therefore, the methodology prescribes an RCP trip study for both the cold and hot leg breaks consistent with the plant licensing basis and Emergency Operating Procedures.

For Callaway, the condition for which all four RCPs are tripped is based on the availability of centrifugal charging or SI pumps and RCS pressure with consideration of required operator action times specified in the plant Emergency Operating Procedure. A delayed RCP trip time of 10 minutes following event initiation (break opening) is analyzed to evaluate the adequacy of the specified trip criteria and demonstrate compliance to 10 CFR 50.46(b)(1-4) criteria (Reference 4).

The spectrum of cold and hot leg breaks in this study includes break sizes from 1.00 to 8.70 inches. The results of the delayed RCP trip cases indicate that there is at least 10 minutes for operators to trip all four RCPs after the specified trip criteria being met with considerable margin to the 10 CFR 50.46(b)(1-4) criteria.

4.4 *Attached Piping Break Study*

The ECCS must cope with ruptures of the main RCS piping and breaks in attached piping. To demonstrate this, as prescribed by the NRC-approved supplement to EMF-2328 (Reference 2), an analysis of the ruptures in attached piping that compromise the ability to inject emergency coolant into the RCS is performed. The size of the rupture and the portion of ECCS lost directly to containment are dependent on the plant design.

The Callaway plant design injects IHSI and LHSI to the accumulator injection line which is connected to each cold leg while HHSI is injected through a separate line that is connected to each cold leg. Therefore, two break locations are analyzed, accumulator line and HHSI line. The break areas analyzed represents a double-ended guillotine of the accumulator line and HHSI line. The accumulator line and HHSI line break analyses results are less limiting than those of the break spectrum analysis.

4.5 *ECCS Temperature Sensitivity Study*

[ ]

[ ]

Table 4-1
Summary of SBLOCA Break Spectrum Results

[ ]

[4] No clad heat-up experienced, therefore, reported value is the initial clad temperature.

[5] [ ]

[6] [ ]

Table 4-2
Sequence of Events for Break Spectrum

[ ]

[7] No clad heat-up experienced, therefore, reported value is the initial clad temperature.

[8] [ ]

[9] [ ]

Table 4-2
Sequence of Events for Break Spectrum (cont'd)

[ ]

Table 4-2
Sequence of Events for Break Spectrum (cont'd)

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Table 4-2
Sequence of Events for Break Spectrum (cont'd)

Figure 4-1
SBLOCA Break Spectrum Peak Cladding Temperature versus Break Size

[ ]

Figure 4-2
Reactor Power – 8.70 inch Break

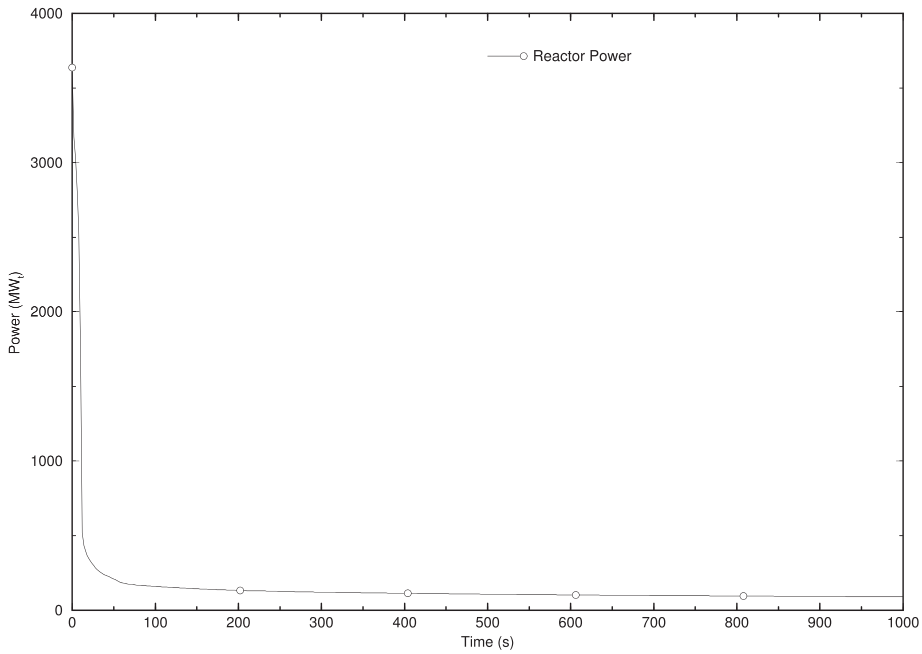


Figure 4-3
Primary and Secondary System Pressures – 8.70 inch Break

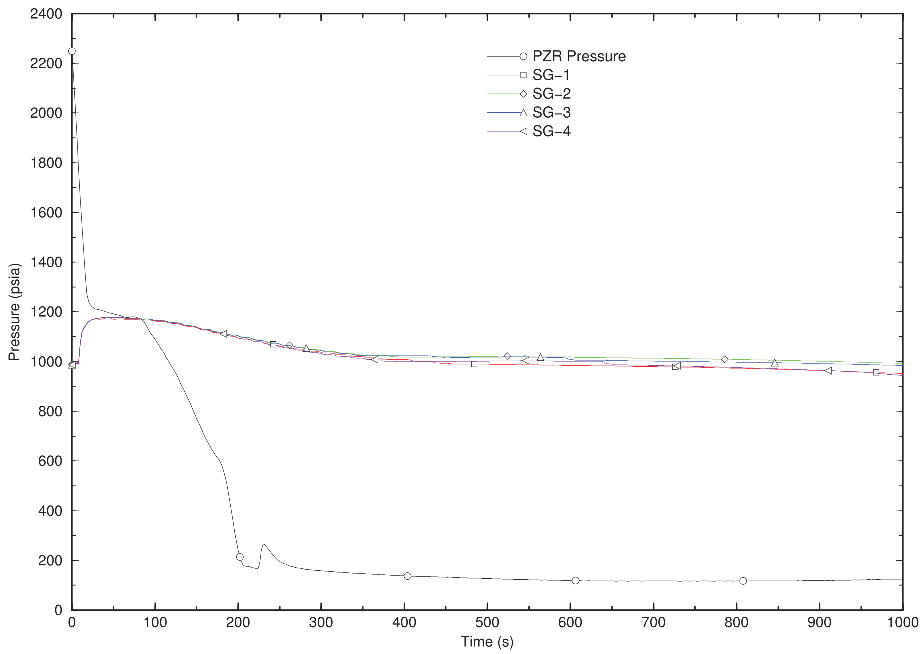


Figure 4-4
Break Mass Flow Rate – 8.70 inch Break

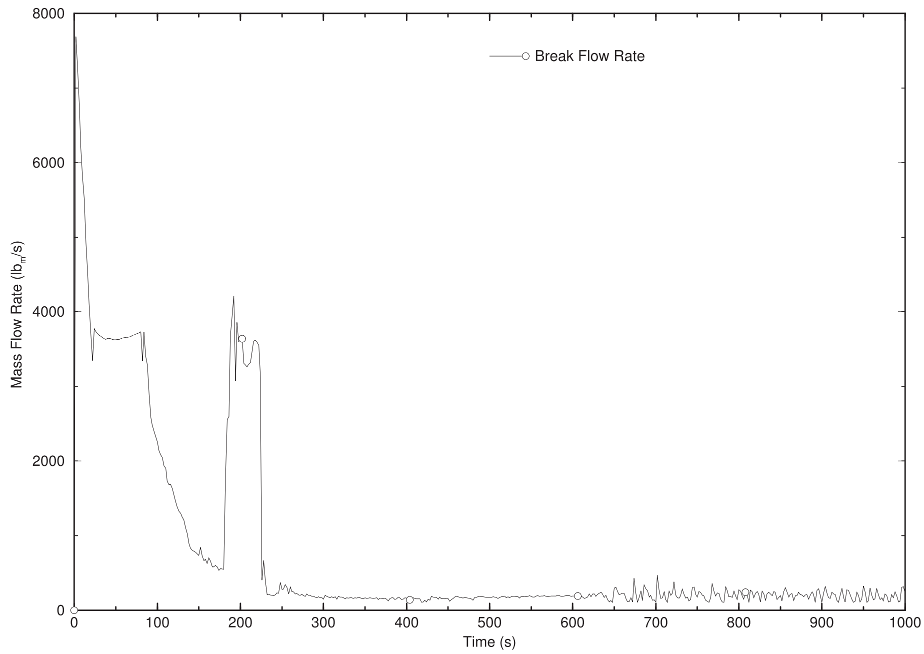


Figure 4-5
Break Vapor Void Fraction– 8.70 inch Break

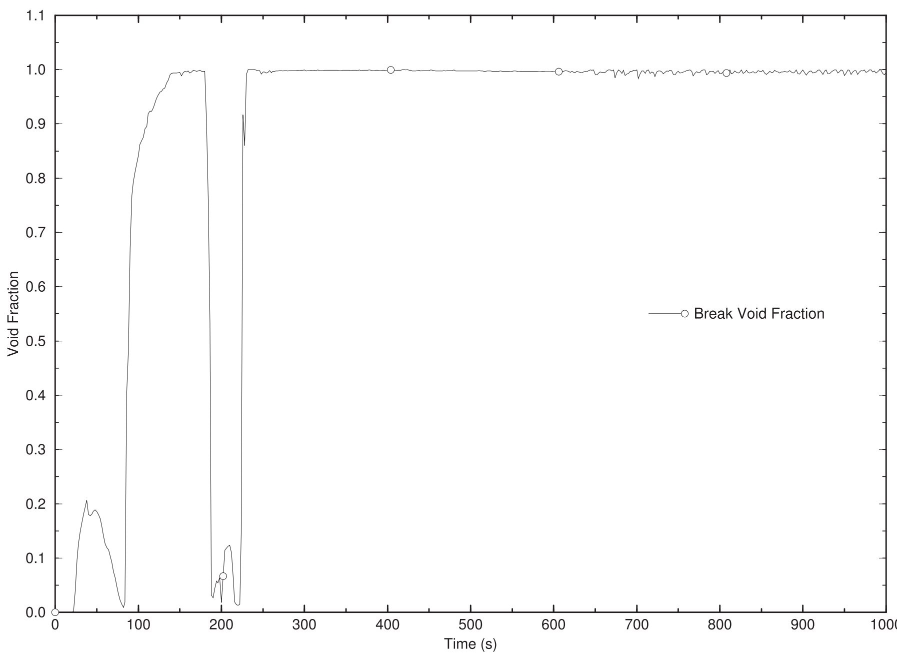


Figure 4-6
Loop Seal Upside Collapsed Levels – 8.70 inch Break

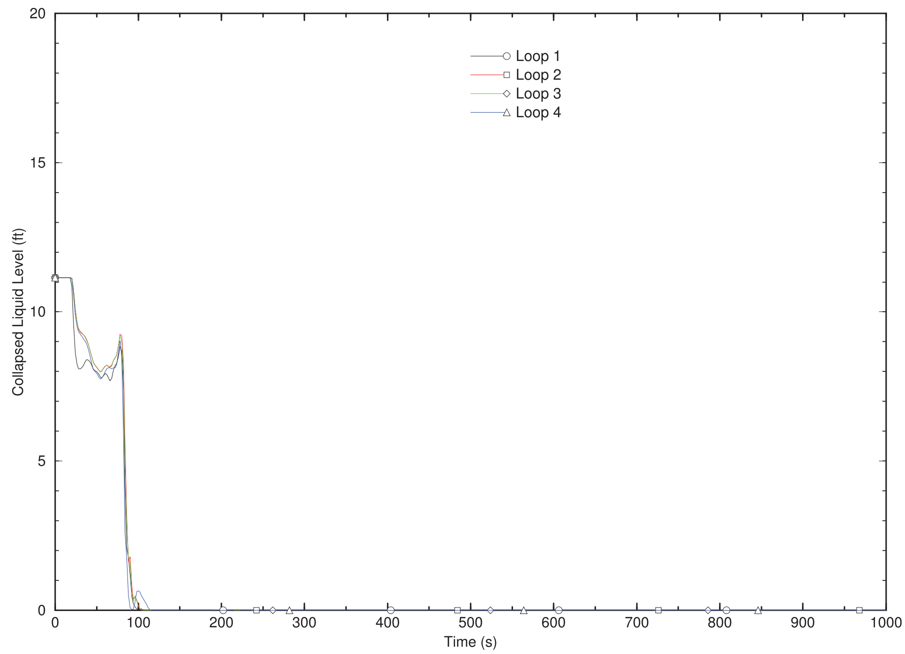


Figure 4-7
Downcomer Collapsed Liquid Level –8.70 inch Break

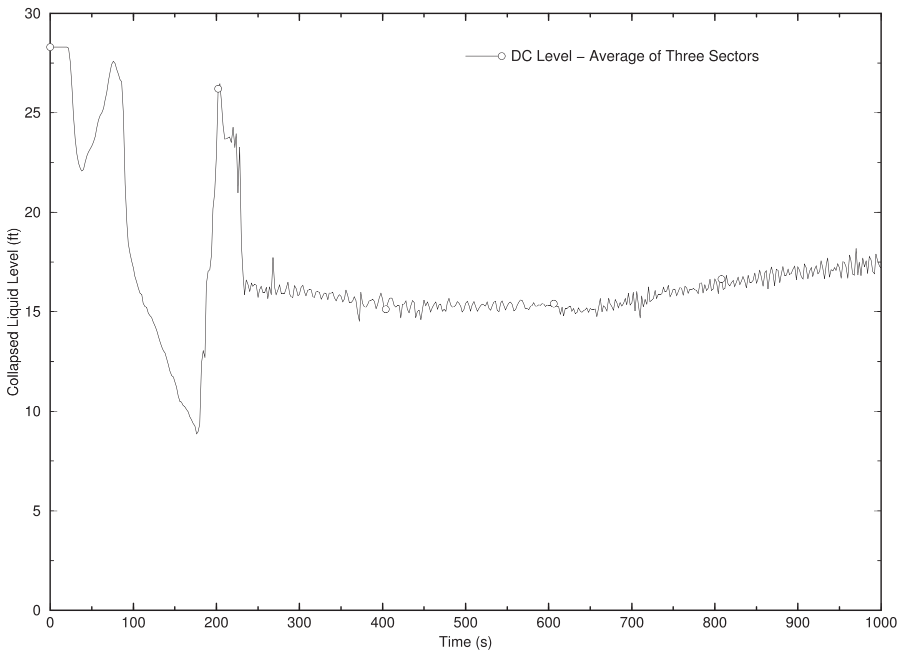


Figure 4-8
Primary System Masses – 8.70 inch Break

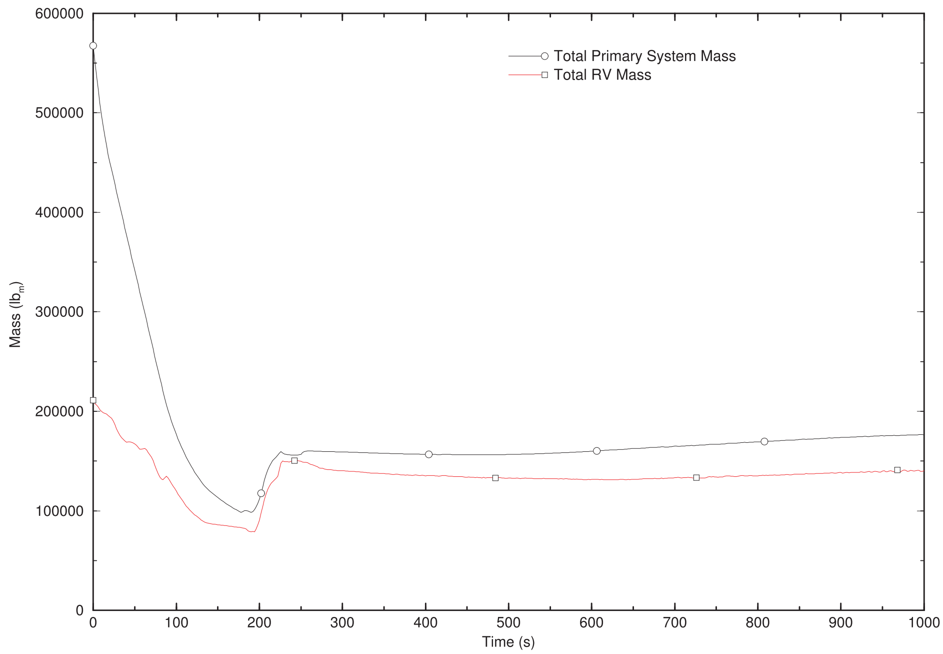


Figure 4-9
RCS Loop Mass Flow Rates – 8.70 inch Break

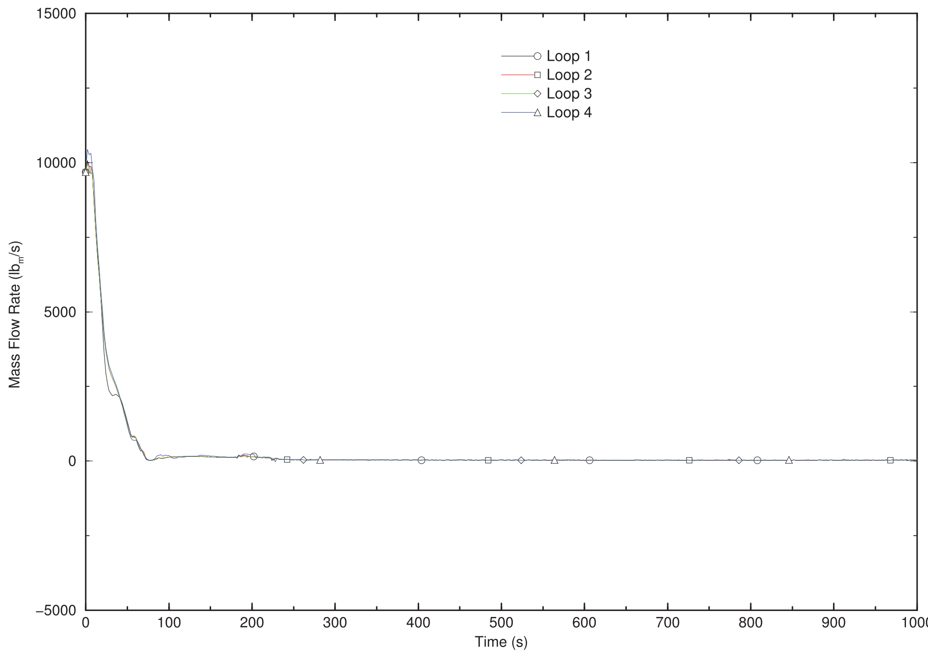


Figure 4-10
Steam Generator Main Feedwater Flow Mass Rates – 8.70 inch Break

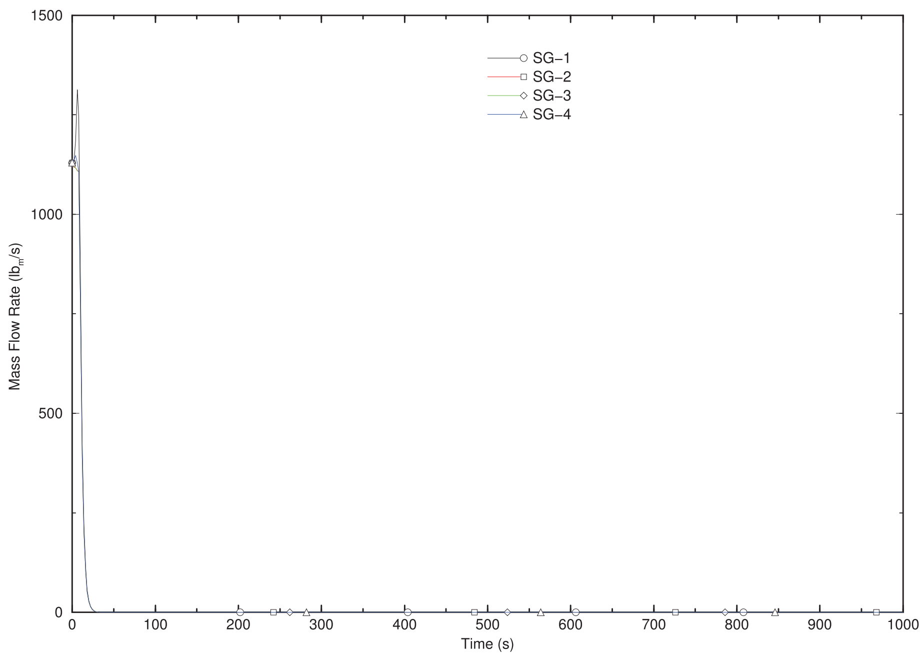


Figure 4-11
Steam Generator MSSV Mass Flow Rates – 8.70 inch Break

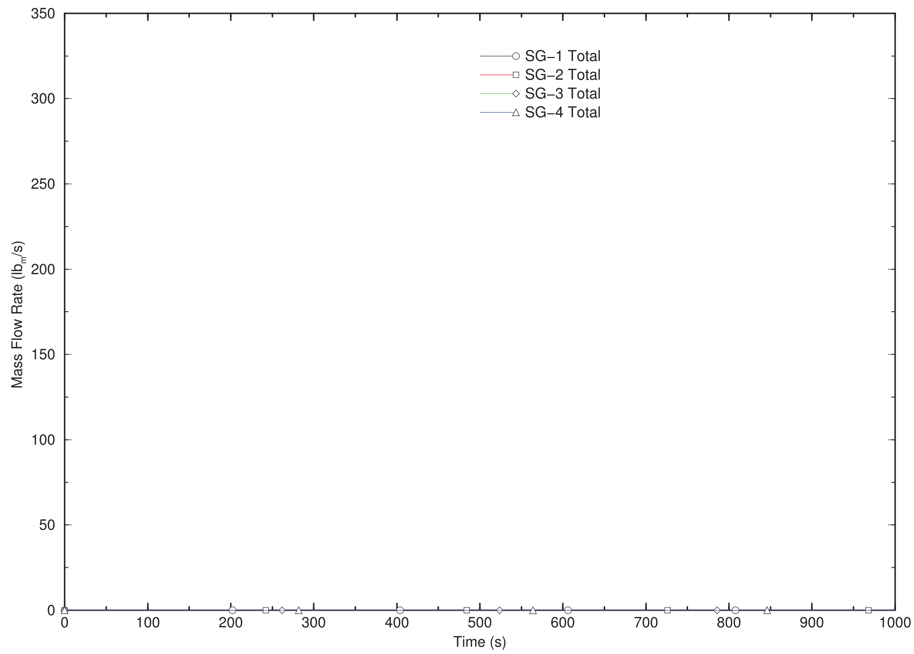


Figure 4-12
Steam Generator Auxiliary Feedwater Flow Rate – 8.70 inch Break

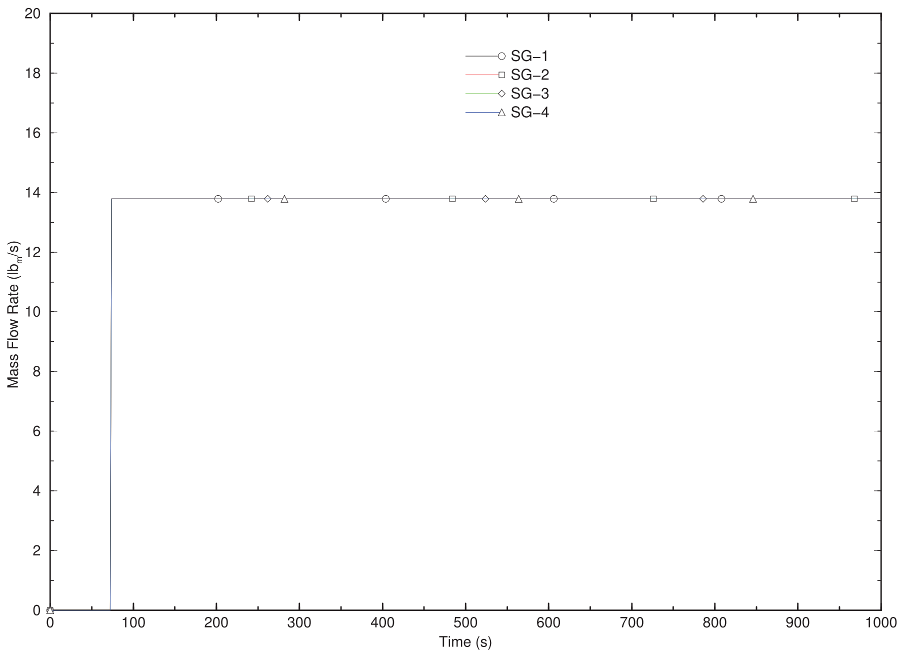


Figure 4-13
Steam Generator Total Mass – 8.70 inch Break

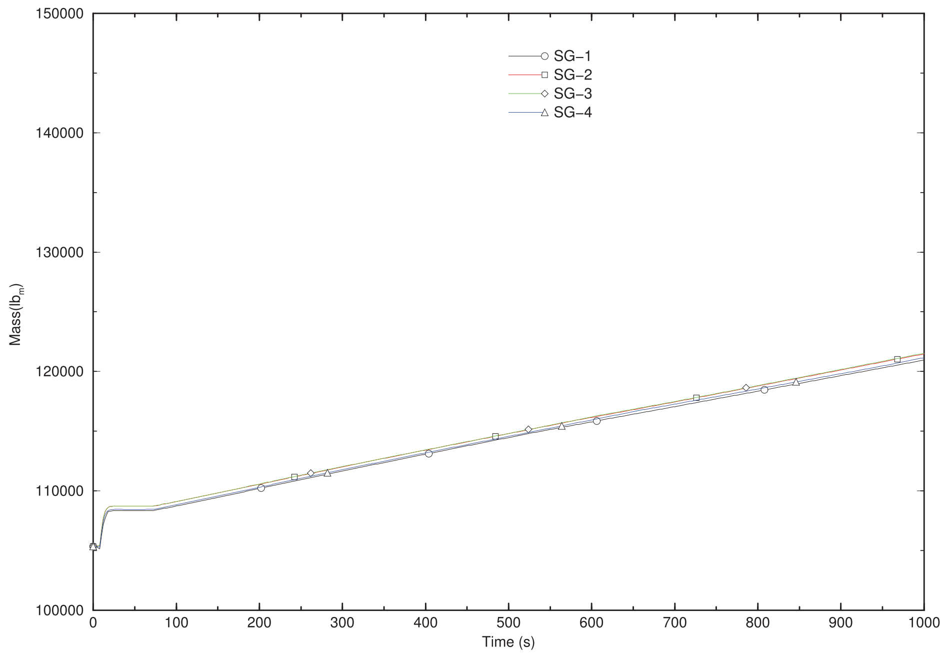


Figure 4-14
Steam Generator Narrow Range Level – 8.70 inch Break

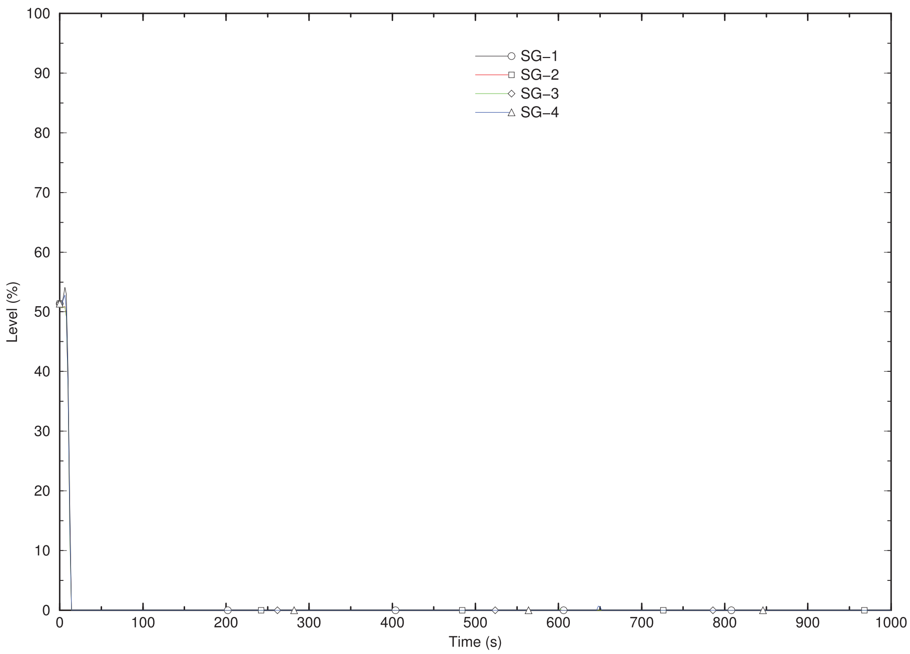


Figure 4-15
High Head Safety Injection Mass Flow Rates – 8.70 inch Break

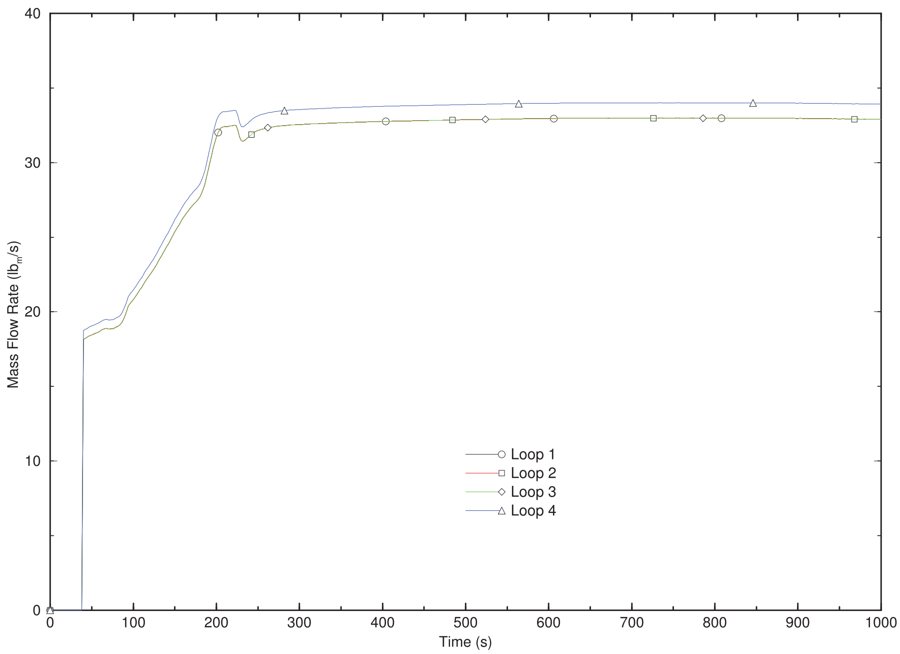


Figure 4-16
Low Head Safety Injection Mass Flow Rates– 8.70 inch Break

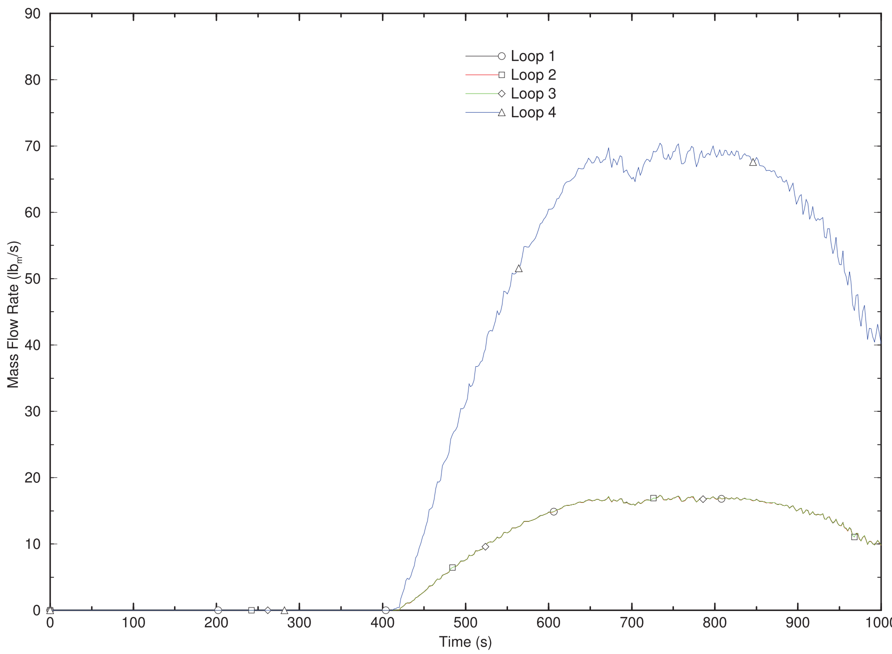


Figure 4-17
Accumulator Mass Flow Rates – 8.70 inch Break

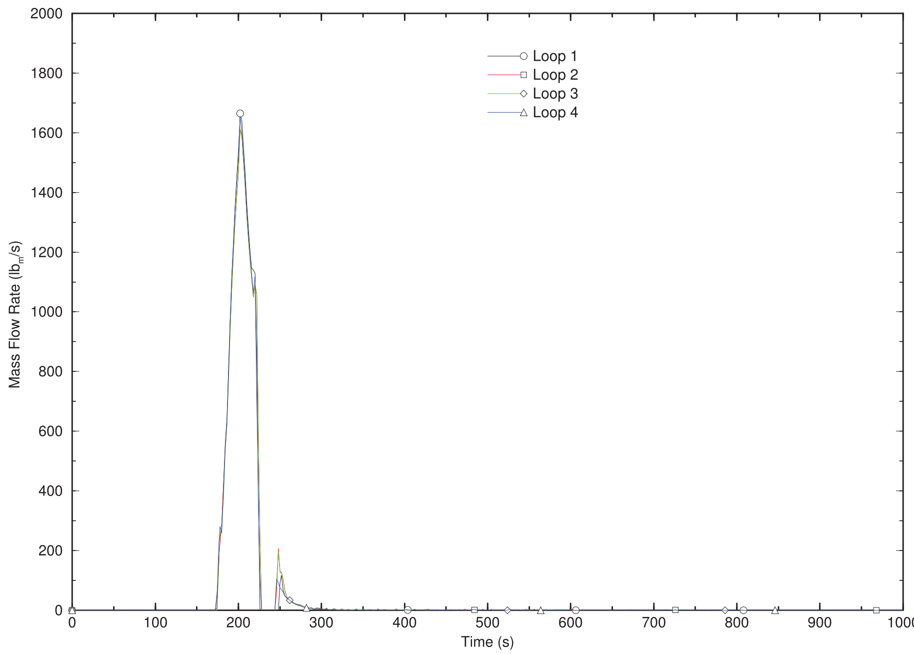


Figure 4-18
Total ECCS and Break Mass Flow Rates – 8.70 inch Break

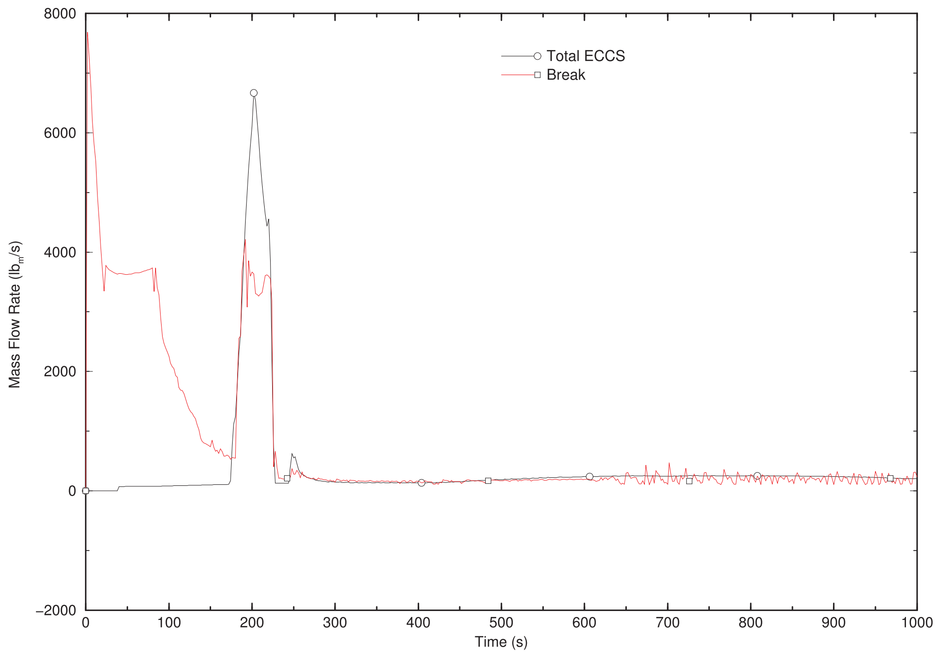


Figure 4-19
Hot Assembly Collapsed Liquid Level – 8.70 inch Break

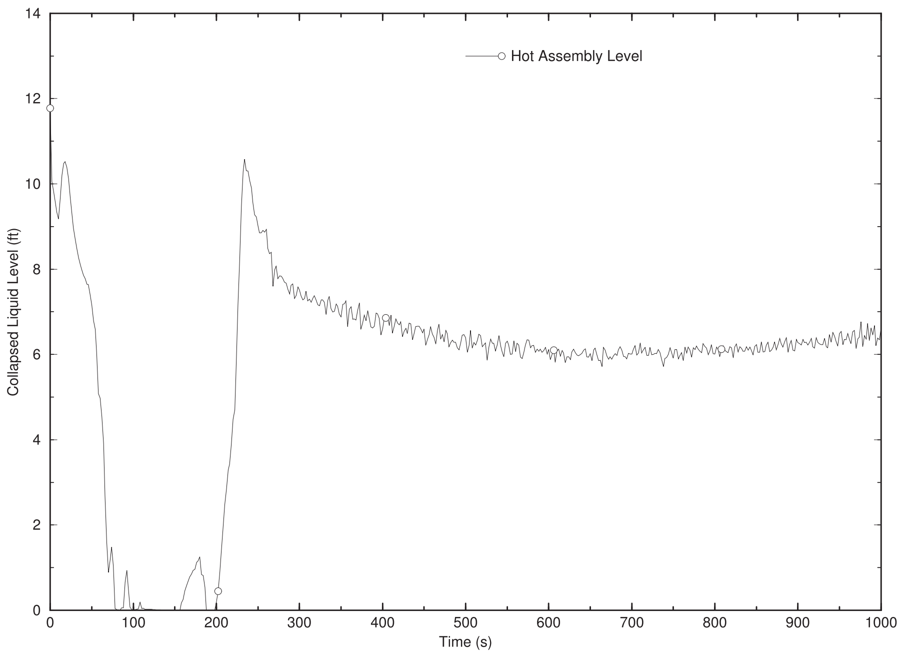
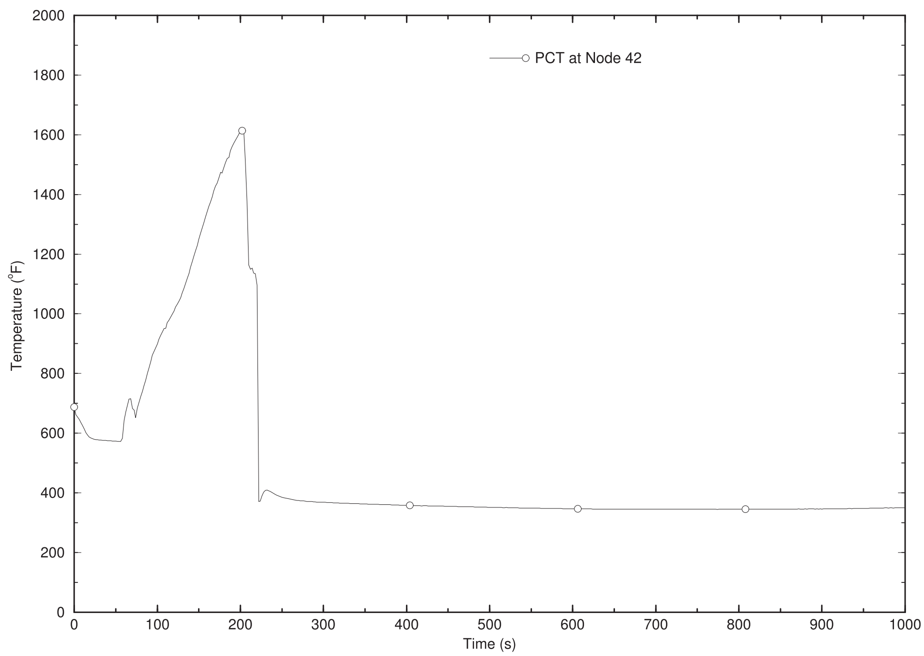


Figure 4-20
Cladding Temperature at PCT Node – 8.70 inch Break



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