CHAPTER 34

SEVERE ACCIDENT PHENOMENA TREATMENT

34.1 Introduction

This chapter describes how the AP1000 containment addresses challenges from severe accident phenomena, and how the challenges are evaluated in the probabilistic risk assessment (PRA). In the PRA, the Modular Accident Analysis Program (MAAP) version 4.04 code (Reference 34-8) is used to evaluate severe accident scenarios. Severe accident phenomenological uncertainties are treated with Risk-Oriented Accident Analysis Methodology (ROAMM) (Reference 34-2) phenomenological evaluations, with AP1000-specific decomposition event tree phenomenological evaluations or with assumptions that certain low-frequency severe accident phenomena fail the containment. The objective of these studies is to show, with a high degree of confidence, that the AP1000 containment will accommodate the effects of severe accidents in a range of scenarios for at least the first 24 hours after the onset of core damage. Such evaluations demonstrate the robustness of the containment design.

34.2 Treatment of Physical Processes

The following eight issues are identified in Reference 34-1 as being representative of the phenomenological issues pertaining to severe accident conditions.

1. Loss-of-coolant accident (LOCA)
2. Fuel-coolant interaction (steam explosion)
3. Hydrogen combustion and detonation
4. Melt attack on concrete structure or containment pressure boundary
5. High-pressure melt ejection
6. Core-concrete interaction (CCI)
7. Containment pressurization from decay heat
8. Elevated temperature (equipment survivability)

The challenge to the containment integrity from a LOCA blowdown is covered in the containment design basis and is not specifically addressed here. Treatment of physical processes affecting the remaining challenges is discussed in this chapter. For the AP1000 design, issues 4 and 6 above arise primarily from the same physical processes: ex-vessel debris coolability. Therefore, they are discussed together within that subject in Section 34.2.5.

Phenomenological analyses and event trees are developed for key severe accident phenomena to provide a systematic and logical method to investigate the uncertainties in the phenomena.

34.2.1 In-Vessel Retention of Molten Core Debris

In-vessel retention (IVR) of core debris by external reactor vessel cooling is a severe accident mitigation attribute of the AP1000 design; it is discussed in detail in Chapter 39. With the reactor vessel intact and debris retained in the lower head, phenomena such as molten

core-concrete interaction and ex-vessel steam explosion, which occur as a result of core debris relocation to the reactor cavity, are prevented.

The AP1000 reactor vessel insulation and containment geometry promote in-vessel retention. Engineered design features of the AP1000 containment flood the containment reactor cavity region during accidents, and thereby, submerge the reactor vessel in water. Liquid effluent released through the break during a LOCA event is directed to the reactor cavity. The AP1000 functional restoration guidelines include a provision for draining the in-containment refueling water storage tank (IRWST) water into the reactor cavity through an operator action action if automatic draining fails. Therefore, in an accident the reactor pressure vessel is most likely submerged in water.

Chapter 39 presents an AP1000-specific evaluation to determine the likelihood that sufficient heat can be removed from the outside surface of the submerged reactor pressure vessel lower head to prevent reactor vessel failure and relocation of debris to containment. The methodology used to quantify the margin to vessel failure in Reference 34-2 for the AP600 was adapted to the AP1000. For the AP1000 the methodology assumes that:

- The RCS is depressurized.
- The reactor vessel is submerged above the 98-ft elevation in the containment.
- The reflective insulation promotes the two-phase natural circulation in the reactor vessel cooling annulus.
- The external surface treatment promotes wetability of the reactor vessel.

The containment event tree includes a node to ascertain that the reactor coolant system (RCS) is depressurized and a node to determine if adequate water is available in the cavity to achieve two-phase natural circulation. Success at both of these nodes is required to demonstrate that the conditions and assumptions of the IVR analysis presented in Chapter 39 are met. The AP1000 design specifies that the reactor vessel insulation is designed appropriately and that the outer surface of the reactor vessel promotes wetability.

Accounting for the uncertainties in thermal-hydraulic parameters, the heat fluxes to the vessel wall and reactor vessel internals from the debris pool are calculated. These heat fluxes are compared to the critical heat flux limit for the downward-facing curved surface. Vessel failure is assumed if the critical heat flux is exceeded. The results show large margin to failure for the reactor vessel if it is externally cooled by water. Therefore, reactor vessel integrity is assured at node VF in the containment event tree analysis if the reactor coolant system is depressurized and the cavity adequately flooded.

34.2.2 Fuel-Coolant Interaction (Steam Explosions)

A steam explosion may occur as a result of molten metal or oxide core debris mixing with water and interacting thermally. Steam is created at a very high rate, producing a sonic pressure front and dynamic loading on local structures. Steam explosions are postulated to occur inside the reactor vessel when debris relocates from the core region into the lower

plenum and in the reactor cavity if the vessel fails and debris is ejected from it into water in the reactor cavity.

34.2.2.1 In-Vessel Fuel-Coolant Interaction

In-vessel steam explosions were studied extensively in the AP600 analyses. A ROAAM analysis of the AP600 reactor vessel lower head integrity under in-vessel steam explosion loading is presented in Reference 34-3. The analysis focused on failure of the lower head since that steam explosion vessel failure mode would impair the in-vessel retention capability of the reactor vessel. The ROAAM analysis concludes that lower-head vessel failure from in-vessel steam explosion is physically unreasonable with very large margin to failure.

Based on the in-vessel core relocation scenario for the AP1000, the in-vessel steam explosion ROAAM analysis presented for the AP600 can be extended to the AP1000. Molten debris relocation from the upper core region to the lower plenum is expected to occur as a result of a sidewall failure of the core shroud and core barrel. Downward relocation is not considered to be a reasonable relocation mode due to the large heat sink below the active fuel region formed by the fuel rod lower plenum zircaloy plugs, the bottom nozzles of the fuel assemblies and the lower core support plate. The sideward failure allows a limited mass of molten debris to initially relocate to the lower plenum. The mass flow rate, superheat and composition of debris in the relocation from the upper core region to the lower head is expected to be essentially the same as the AP600. The geometry of the lower head of the AP1000 is the same as the AP600. Therefore, it is reasonable to extend the results of the AP600 in-vessel steam explosion ROAAM analysis to the AP1000.

The results of the in-vessel steam explosion ROAAM can also be extended to containment failure induced by in-vessel steam explosions (α-mode containment failure). The sideward failure mode does not initially relocate sufficient debris to the lower head. The in-vessel fuel-coolant interaction cannot generate sufficient energy, in a short time scale, to produce a missile that could fail the AP1000 containment. The likelihood for vessel failure and subsequent containment failure due to in-vessel steam explosion is so small as to be negligible. This conclusion is in agreement with the conclusions of the U.S. Nuclear Regulatory Commission (NRC)-sponsored Steam Explosion Review Group (Reference 34-4).

34.2.2.2 Ex-Vessel Fuel-Coolant Interaction

The first level of defense for ex-vessel steam explosion is the in-vessel retention of the molten core debris. If molten debris does not relocate from the vessel to the containment, there are no conditions for ex-vessel steam explosion. In the event that the reactor cavity is not flooded and the vessel fails, the PRA containment event tree assumes that the containment fails in the early time frame.

An analysis of the structural response of the reactor cavity was performed for the AP600 (Reference 34-5, Appendix B) As in the in-vessel steam explosion analysis, the results of this AP600 ex-vessel steam explosion analysis are extended to the AP1000. The vessel failure modes for AP600 and AP1000 are the same. The initial debris mass, superheat and composition are assumed to be the same as the AP600. The mass assumption is conservative since the AP1000 vessel lower head is closer to the cavity floor resulting in less debris mass

participating in the interaction. The reactor cavity geometry and water depth prior to vessel failure are the same as AP600. Therefore, the results of the AP600 ex-vessel steam explosion analysis are considered to be appropriate for the AP1000.

34.2.3 Hydrogen Combustion and Detonation

A decomposition event tree analysis discussed in Chapter 41 evaluates the potential for hydrogen combustion threatening the containment integrity during a severe accident sequence in the AP1000. The analysis examines diffusion flame burning and local detonation occurring during in-vessel hydrogen generation prior to hydrogen mixing in the containment and global deflagration and detonation, which may occur later when the hydrogen is mixed throughout the containment. Only in-vessel hydrogen generation is considered, since vessel failure and ex-vessel debris relocation is assumed to fail containment.

If the igniters are operational, the potential for diffusion-flame-induced containment failures is considered during the hydrogen generation and release from the reactor coolant system (RCS). Diffusion flames may be formed when high-concentration, nonflammable hydrogen plumes encounter oxygen and burn as a standing flame. Flames that have a large view factor or that impinge on the containment pressure boundary may fail the containment pressure boundary due to the locally high temperatures. The pathways that in-vessel hydrogen can take to containment are reviewed for potential impact on containment integrity. Locations where diffusion flames may be postulated are examined for potential failure of the containment due to creep of the containment shell at high temperature.

The AP1000 provides defense-in-depth to address hydrogen diffusion flames that may challenge containment integrity. The first level of defense is the stage four automatic depressurization system (ADS Stage 4) lines from the RCS, which prevent significant hydrogen releases to the in-containment refueling water storage tank (IRWST) and Passive Core Cooling System (PXS) compartments. The ADS Stage 4 lines provide a path of least resistance to release hydrogen generated in-vessel to the containment. ADS Stage 4 vents from the RCS hot legs to the loop compartments, which are shielded from the containment shell and have a constant source of oxygen from the natural circulation in the containment. Hydrogen can burn as a diffusion flame in the loop compartments without threatening the containment integrity. If ADS Stage 4 fails, the AP1000 has provided design considerations in the IRWST vents to mitigate diffusion flames near the containment walls. Vents from the passive injection system compartments and chemical volume and control system compartment are located away from the containment shell and penetrations in order to mitigate the threat from hydrogen diffusion flames.

Containment failure from a directly initiated detonation wave is not considered to be a credible event for the AP1000 containment. There are no ignition sources of sufficient energy to directly initiate a detonation in the AP1000 containment. Deflagration to detonation transition (DDT) is considered to the be the only likely mechanism to produce a detonation in the AP1000 containment.

The likelihood of DDT in the AP1000 containment is evaluated locally in confined compartments during in-vessel hydrogen generation and globally after in-vessel generation is concluded and hydrogen is mixed in the containment. For a DDT to occur, the combination of

the gas mixture sensitivity to detonation and the geometric configuration potential for flame acceleration must be conducive to DDT. Since the hydrogen concentration necessary to form a detonable mixture depends on the size of the enclosure, concentration requirements for DDT in different regions of the AP1000 containment are extrapolated from the FLAME facility data (Reference 34-6) using scaling arguments based on the detonation cell width. The geometric requirement is evaluated considering aspects such as the degree of confinement and the extent and type of obstacles present in the postulated flame propagation path. In all cases, DDT is assumed to result in containment failure in the containment event tree analysis.

Global hydrogen deflagration and the potential for containment failure are modeled on the containment event tree. Adiabatic, isochoric, complete combustion (AICC) is assumed, and peak pressure probability distributions are developed for the accident scenarios. The probability of containment failure due to hydrogen deflagration is evaluated from the containment failure probability distribution combined with the peak pressure probability distribution.

34.2.4 High-Pressure Melt Ejection

The AP1000 incorporates design features that prevent high-pressure core melt. These features include the passive residual heat removal (PRHR) system and the ADS. These design features provide primary system heat removal and depressurization to prevent high pressure core damage conditions. The consequences from postulated high pressure melt ejection (HPME) are mitigated by the containment layout which provides a torturous pathway to the upper compartment and no direct pathway for the impingement of debris on the containment shell.

In high-pressure core damage sequences (i.e., non-LOCA or very small LOCA events with the ADS and PRHR inoperable), the potential exists for creep-rupture-induced failures of the RCS piping at the hot-leg nozzles, the surge line, the steam generator tubes and, given debris relocation to the lower plenum, in the reactor vessel lower head. Failure of the hot-leg nozzle or surge line prior to failures of other components results in the rapid depressurization of the RCS. Failure of the steam generator tubes results in a containment bypass and a large release of fission products to the environment. Failure of the lower head of the reactor vessel results in the potential for HPME.

The AP1000 RCS loops have canned-motor pumps mounted to the steam generator outlet plenum. The coolant loops do not have water-trap loop seals as in conventional plant designs. A large natural-circulation flow heats the reactor coolant loop components in a relatively uniform manner. Hot-leg nozzle failure is expected prior to steam generator tube failure, but because of large uncertainties, hot-leg nozzle creep rupture failure is not credited with preventing steam generator tube failure. In the PRA, steam generator tube failure is assumed for high-pressure sequences in the containment event tree analysis unless operator action to depressurize the RCS with the ADS is successful.

34.2.5 Core Debris Coolability

In accident sequences where the reactor pressure vessel failure is not prevented, core debris may be discharged into the reactor cavity. The likely vessel failure modes produce a low

pressure melt ejection (LPME) to the containment. The AP1000 cavity design provides area for the core debris to spread. Condensate from the passive containment cooling system (PCS) returns to the reactor cavity, thereby providing a long-term supply of water to cool the core debris.

To accommodate the requirements for in-vessel retention of core debris, the AP1000 provides highly reliable RCS depressurization and cavity flooding capability. At vessel failure it is very likely that the cavity will be filled with water from the RCS, core makeup tanks (CMTs), and accumulators to at least the 83-ft elevation. There are significant uncertainties associated with debris spreading into a water-filled cavity. Debris-spreading is mainly a function of the highly uncertain vessel failure mode. A large-scale lower head failure releasing debris at a high rate would enhance spreading, while a localized failure mode would release debris at a slow rate, which would most likely cause the debris to pile up under the reactor vessel and minimize spreading.

Given the uncertainties in the debris-spreading and in non-condensable gas generation and combustion, the containment event tree analysis does not credit containment integrity in the event of failure of the lower head of the vessel and relocation of the core.

A limited set of deterministic analyses of debris spreading and core-concrete interaction in the AP1000 cavity is presented in Appendix B. The analyses show that basemat melt-through is not predicted to occur within 24 hours of the accident initiation. Basemat melt through is predicted to occur before pressurization of the containment by non-condensable gases challenges the containment integrity.

34.2.6 Containment Pressurization from Decay Heat

The AP1000 containment is cooled via the PCS (see Chapter 40). Evaporative water cooling of the containment shell provides long-term containment cooling and limits the containment pressure to less than the design pressure for all severe accident events except hydrogen combustion, which is addressed separately. Containment water is provided to the top of the containment via redundant, diverse system of valves and lines, including a line that can be connected to an outside water source such as a fire truck.

In the unlikely event that water cannot be supplied to the top of the containment shell for an extended period of time, air-only cooling by air flowing through the PCS annulus provides significant cooling to the containment. Under the right environmental conditions, the containment is expected to reach an equilibrium pressure that will not challenge containment integrity. However, under nominal-to-conservative environmental conditions, containment integrity by air-only cooling cannot be assured. In this case, containment failure is predicted to occur more than 24 hours after accident initiation.

A significant amount of time is available for operator action to vent the containment under the severe accident management guidance (SAMG). Containment venting mitigates uncontrolled releases of fission products from a failed containment. The AP1000 can be vented on an ad-hoc basis under the SAMG from a number of containment penetrations. Once venting is concluded, the increased steam concentration in the containment improves the air-only cooling from the PCS such that no further venting is anticipated. Containment

venting also reduces the partial pressure of non-condensable gases in the containment, and thus creates a new containment underpressure failure mode that may occur if containment is cooled after venting.

34.2.7 Elevated Temperature (Equipment Survivability)

Reference 34-7 states that equipment identified as being useful to mitigate the consequences of severe accidents must be designed to provide reasonable assurance that it will continue to operate in a severe accident environment for the length of time needed to accomplish its function. Also, 10 CFR 50.34(f) requires safety equipment to continue performing its function after being exposed to a containment environment created as a consequence of generating a quantity of hydrogen equivalent to that from 100-percent cladding oxidation. As the AP1000 design uses thermal igniters to burn hydrogen in a controlled manner, it is necessary to demonstrate that the safety equipment can continue to perform its function in the high-temperature environment created by the hydrogen burning.

The functions of the equipment in containment for which credit is taken in the AP1000 PRA were reviewed to determine if the equipment is required to operate in a severe accident environment and beyond design basis limits The equipment and the basis for operation are the same as the AP600. Therefore, the results of the AP600 are extended to the AP1000 for equipment survivability. In the calculation of the large release frequency (LERF), only the containment pressure boundary is credited to perform beyond its design basis. The performance of the AP1000 containment pressure boundary beyond its design basis is evaluated in Chapter 42. Other equipment is credited in the analysis, but either the containment environmental conditions do not exceed the equipment qualification conditions at the time the function is performed, or the design basis for the equipment is a severe accident environment. The radiation environment for equipment qualification for safety-related equipment in containment is based on the severe accident source term involving significant in-vessel fuel melting described in NUREG-1465. The equipment credited in the LERF calculation is assumed to survive the radiation dose associated with the accidents over the time required to perform its function.

Equipment considered to be useful for post-accident monitoring is presented in Table 34-1.

34.2.8 Summary

The potential for and the consequences of severe accident phenomena are evaluated. The preventive and mitigative features of the AP1000 addressing the severe accident phenomena are discussed. This information is applied to the containment event trees and used in the quantification of the LERF.

34.3 Analysis Method

The analyses of the fission-product source terms for the release categories discussed in Chapter 45 are completed with the MAAP4.04 computer code (Reference 34-8).

The following sections are presented for each of the accident classes for the fission-product source term MAAP4.04 analyses. First, the intact containment (IC) analyses are described,

including any sensitivity analyses completed to define the most conservative system assumptions, then the relevant containment failure analyses are presented.

Table 34-2 provides a summary of the accident classes for the AP1000 Level 1 quantification. Table 34-3 summarizes the Level 2 release categories.

34.4 Severe Accident Analyses

34.4.1 Accident Class 3BE – Intact Containment

34.4.1.1 3BE-1

The sequence description and assumptions are listed below.

- DVI line break in PXS compartment (PXS is flooded through broken DVI line)
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 1/2 CMTs
- 1/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- Hydrogen igniters operating

No containment failure is considered, and thus, the release category is IC. However, normal leakage from the containment is assumed.

The main events of the case are shown in Table 34-4, while relevant plots are presented in Figures 34-1 through 34-17.

34.4.1.2 3BE-2

The sequence description and assumptions are listed below.

- DVI line break in PXS compartment (PXS is not flooded through broken DVI line)
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 1/2 CMTs
- 1/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines

- 2/2 cavity flooding lines
- Hydrogen igniters operating

The main events of the case are shown in Table 34-5, while relevant plots are presented in Figures 34-18 through 34-34. Note that without flooding of the PXS compartment, RCS reflood does not occur

34.4.1.3 3BE-4

The sequence description and assumptions are listed below.

- One valve of ADS Stage 4 spuriously opens
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- Hydrogen igniters operating

The main events of the case are shown in Table 34-6, while relevant plots are presented in Figures 34-35 through 34-51.

34.4.1.4 3BE-5

The sequence description and assumptions are listed below.

- 2-inch hot-leg break to steam generator compartment
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- Hydrogen igniters operating

The main events of the case are shown in Table 34-7, while relevant plots are presented in Figures 34-52 through 34-68.

34.4.1.5 3BE-6

The sequence description and assumptions are listed below.

- 2-inch hot-leg break to steam generator compartment
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 1/2 cavity flooding lines
- Hydrogen igniters operating

The main events of the case are shown in Table 34-8, while relevant plots are presented in Figures 34-69 through 34-85.

34.4.2 Accident Class 3BE – Failed Containment

34.4.2.1 3BE-7

The sequence description and assumptions are listed below.

- 2-inch hot-leg break to steam generator compartment
- Containment failure at peak of debris quench (vessel failure)
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 0/2 cavity flooding lines
- Hydrogen igniters operating

The main events of the case are shown in Table 34-9, while relevant plots are presented in Figures 34-86 through 34-102.

34.4.2.2 3BE-3

The sequence description and assumptions are listed below.

- DVI line break in PXS compartment (PXS is flooded through broken DVI line)
- Hydrogen burn and containment failure after reflood
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 1/2 CMTs
- 1/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- No hydrogen igniters operating

The main events of the case are shown in Table 34-10, while relevant plots are presented in Figures 34-103 through 34-119.

34.4.3 Accident Class 3BL – Intact Containment

34.4.3.1 3BL-1

The sequence description and assumptions are listed below.

- 2-inch hot-leg break to steam generator compartment
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 2/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- Hydrogen igniters operating
- Cavity flooding unnecessary (IRWST gravity injection successful)

No containment failure is considered, and thus, the release category is IC. However, normal leakage from the containment is assumed. Reflooding the core via the hot leg break is not credited.

The main events of the case are shown in Table 34-11, while relevant plots are presented in Figures 34-120 through 34-136.

34.4.3.2 3BL-2

This case compares the results of changes to system assumptions to the dominant sequence discussed above. The results of this comparison are used to define the system assumptions for subsequent 3BL containment failure analyses.

The sequence description and assumptions are listed below.

- DVI line break in PXS compartment (PXS is not flooded through broken DVI line)
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 1/2 CMTs
- 1/2 accumulators
- 1/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- Hydrogen igniters operating
- Cavity flooding unnecessary (IRWST gravity injection successful)

The main events of the case are shown in Table 34-12, while relevant plots are presented in Figures 34-137 through 34-153.

34.4.4 Accident Class 3BR – Intact Containment

34.4.4.1 3BR-1

The sequence description and assumptions are listed below.

- Double-ended guillotine break (DEGB) in the cold leg to the steam generator compartment
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 0/2 accumulators
- 2/2 IRWST gravity injection lines
- 2/2 IRWST recirculation lines
- Hydrogen igniters operating
- Cavity flooding unnecessary (IRWST gravity injection successful)

No containment failure is considered, and thus, the release category is IC. However, normal leakage from the containment is assumed.

The main events of the case are shown in Table 34-13, while relevant plots are presented in Figures 34-154 through 34-170.

34.4.4.2 3BR-1a

The sequence description and assumptions are listed below.

- Double-ended guillotine break (DEGB) in the cold leg to the steam generator compartment
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 0/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- Hydrogen igniters operating
- Cavity flooding unnecessary (IRWST gravity injection successful)

No containment failure is considered, and thus, the release category is IC. However, normal leakage from the containment is assumed.

The main events of the case are shown in Table 34-14, while relevant plots are presented in Figures 34-171 through 34-187.

34.4.5 Accident Class 3C – Intact Containment

34.4.5.1 3C-1

The sequence description and assumptions are listed below.

- Large LOCA at belt of vessel into cavity
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 2/2 IRWST gravity injection lines
- 2/2 IRWST recirculation lines
- Hydrogen igniter operating
- Cavity flooding unnecessary (IRWST gravity injection successful)

No containment failure is considered, and thus, the release category is IC. However, normal leakage from the containment is assumed.

The main events of the case are shown in Table 34-15, while relevant plots are presented in Figures 34-188 through 34-204.

34.4.6 Accident Class 3C – Failed Containment

34.4.6.1 3C-2

The sequence description and assumptions are listed below.

- Large LOCA at belt of vessel into cavity
- Containment failure at start of event
- Failure of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 2/2 IRWST gravity injection lines
- 2/2 IRWST recirculation lines
- Hydrogen igniter operating
- Cavity flooding unnecessary (IRWST gravity injection successful)

The main events of the case are shown in Table 34-16, while relevant plots are presented in Figures 34-205 through 34-221.

34.4.7 Accident Class 3D – Intact Containment

34.4.7.1 3D-1

The sequence description and assumptions are listed below.

- One valve of ADS Stage 4 spuriously opens
- Failure of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 0/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding
- Hydrogen igniters operating

No containment failure is considered, and thus, the release category is IC. However, normal leakage from the containment is assumed.

The main events of the case are shown in Table 34-17, while relevant plots are presented in Figures 34-222 through 34-238.

34.4.7.2 3D-2

The sequence description and assumptions are listed below.

- Two valves of ADS Stage 4 spuriously open
- Failure of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 0/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding
- Hydrogen igniters operating

The main events of the case are shown in Table 34-18, while relevant plots are presented in Figures 34-239 through 34-255.

34.4.7.3 3D-3

The sequence description and assumptions are listed below.

- DVI line break in PXS compartment
- Failure of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 1/2 CMTs (no low-2 CMT signal)
- 1/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding
- Hydrogen igniters operating

The main events of the case are shown in Table 34-19, while relevant plots are presented in Figures 34-256 through 34-272.

34.4.8 Accident Class 3D – Failed Containment

34.4.8.1 3D-4

The sequence description and assumptions are listed below.

- Two valves of ADS Stage 4 spuriously open
- Failure of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 0/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- Hydrogen igniters operating
- Upper compartment failure due to hydrogen release from IRWST

The main events of the case are shown in Table 34-20, while relevant plots are presented in Figures 34-273 through 34-289.

34.4.9 Accident Class 6E – Bypass Containment

34.4.9.1 6E-1

The sequence description and assumptions are listed below.

- Coincident rupture of five hot side steam generator tubes
- Broken steam generator SV fails to reseat upon automatic opening
- Success of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 2/2 CMTs
- 2/2 accumulators
- 2/2 IRWST gravity injection lines
- 2/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- Hydrogen igniters operating

This is a containment bypass sequence; thus the release category is BP. Note that due to the lack of ADS Stage 4, no IRWST injection flow is available to provide core cooling.

The main events of the case are shown in Table 34-21, while relevant plots are presented in Figures 34-290 through 34-306.

34.4.10 Accident Class 6L – Bypass Containment

34.4.10.1 6L-1

The sequence description and assumptions are listed below.

- Coincident rupture of 5 hot side steam generator tubes
- Broken steam generator SV fails to reseat upon automatic opening
- Success of PRHR
- 2/2 ADS stage 1 - automatic
- 2/2 ADS stage 2 - automatic
- 2/2 ADS stage 3 - automatic
- 4/4 ADS stage 4 - automatic
- 2/2 CMTs
- 2/2 accumulators
- 2/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- Cavity flooding unnecessary (IRWST gravity injection successful)
- Hydrogen igniters operating

The main events of the case are shown in Table 34-22, while relevant plots are presented in Figures 34-307 through 34-323.

34.4.11 Accident Class 1AP

34.4.11.1 1AP-1

The sequence description and assumptions are listed below.

- 3/8-inch hot-leg break to steam generator compartment
- Creep rupture of five steam generator tubes
- Success of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 0/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 2/2 cavity flooding lines
- Hydrogen igniters operating

This is a containment bypass sequence; thus the release category is BP.

The main events of the case are shown in Table 34-23, while relevant plots are presented in Figures 34-324 through 34-340. The temperatures of the steam generator tubes were monitored for creep rupture potential based on the Larsen-Miller correlation (Reference 34-9).

34.4.11.2 1AP-2

The sequence description and assumptions are listed below.

- 3/8-inch hot-leg break to steam generator compartment
- Creep rupture of five steam generator tubes
- Success of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 2/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 0/2 IRWST recirculation lines
- 0/2 cavity flooding lines
- Hydrogen igniters operating

This is a containment bypass sequence; thus the release category is BP.

The main events of the case are shown in Table 34-24, while relevant plots are presented in Figures 34-341 through 34-357. The temperatures of the hot leg and steam generator tubes were monitored for creep rupture potential based on the Larsen-Miller correlation (Reference 34-9).

34.4.12 Accident Class 1A

34.4.12.1 1A-1

The sequence description and assumptions are listed below.

- Loss of feedwater transient
- Creep rupture of five steam generator tubes
- Failure of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 2/2 CMTs
- 2/2 accumulators
- 2/2 IRWST gravity injection lines
- 2/2 IRWST recirculation lines

- 2/2 cavity flooding lines
- Hydrogen igniters operating

This is a containment bypass sequence; thus the release category is BP.

The main events of the case are shown in Table 34-25, while relevant plots are presented in Figures 34-358 through 34-374. The temperatures of the hot leg and steam generator tubes were monitored for creep rupture potential based on the Larsen-Miller correlation (Reference 34-9)

34.4.12.2 1A-2

The sequence description and assumptions are listed below.

- Loss of feedwater transient
- Creep rupture of five steam generator tubes
- Creep rupture of hot leg
- Failure of PRHR
- 0/2 ADS stage 1
- 0/2 ADS stage 2
- 0/2 ADS stage 3
- 0/4 ADS stage 4
- 0/2 CMTs
- 2/2 accumulators
- 0/2 IRWST gravity injection lines
- 2/2 IRWST recirculation lines
- 0/2 cavity flooding lines
- Hydrogen igniters operating

This is a containment bypass sequence; thus the release category is BP

The main events of the case are shown in Table 34-26, while relevant plots are presented in Figures 34-375 through 34-391. The temperatures of the hot leg and steam generator tubes were monitored for creep rupture potential based on the Larsen-Miller correlation (Reference 34-9). The steam generator tubes failed first.

34.5 Insights and Conclusions

The analyses of the severe accident phenomena for the AP1000 PRA highlight the following insights and conclusions·

- The design of the AP1000 reactor vessel, vessel insulation and reactor cavity, and the ability to flood the cavity after a severe accident reduce the potential challenges to the containment integrity by maintaining the vessel integrity.

- Should a failure of the reactor vessel occur, the design of the reactor cavity enhances the ability to cool any core debris that exits the vessel.

- Lower head vessel failure due to in-vessel steam explosions is physically unreasonable.
- The ADS and PRHR system are design features that can be used to prevent high-pressure core melt in a severe accident.
- A directly-initiated hydrogen detonation in the AP1000 containment is not a credible event.
- The equipment needed to mitigate the consequences of a severe accident is designed to provide reasonable assurance that it will continue to operate during an accident.

34.6 References

34-1 Letter from D. A. Ward, Advisory Committee on Reactor Safeguards, to K. A. Carr, Chairman, Nuclear Regulatory Commission, "Proposed Criteria to Accommodate Severe Accidents in Containment Design," dated May 17, 1991.

34-2 Theofanous, T. G., et al, "In-Vessel Coolability and Retention of a Core Melt," DOE/ID-10460, July 1995.

34-3 Theofanous, T. G., et al., "Lower Head Integrity Under In-Vessel Steam Explosion Loads," DOE/ID-10541, July 1996.

34-4 NUREG-1116, *A Review of the Current Understanding of the Potential for Containment Failure From In-Vessel Steam Explosions*, 1985.

34-5 GW-GL-022, AP600 Probabilistic Risk Assessment, August 1998.

34-6 Sherman, M. P., Tieszen, S. R., and Benedick, W. B., *FLAME Facility - The Effects of Obstacles and Transverse Venting on Flame Acceleration and Transition to Detonation for Hydrogen-Air Mixtures at Large Scale*, NUREG/CR-5275, April 1989.

34-7 Attachment to letter from D. M. Crutchfield, Office of Nuclear Reactor Regulation, to E. E. Kintner, Advanced Light Water Reactor Steering Committee, "Major Technical and Policy Issues Concerning the Evolutionary and Passive Plant Designs," dated February 27, 1992.

34-8 "EPRI MAAP 4.0 Users Manual."

34-9 Larson, F. R., Miller, J., "A Time-Temperature Relationship for Rupture and Creep Stress," Transactions of the American Society of Mechanical Engineers, pp. 765-775, July 1952.

Table 34-1 (Sheet 1 of 2)

POST-ACCIDENT MONITORING EQUIPMENT

Parameter	Primary Purposes	Method of Measurement (or Estimate)
Steam Generator Water Level	• To determine if there is an RCS heat sink available • To determine if creep rupture of the steam generator tubes is a concern • To mitigate fission-product releases from faulty or leaking steam generator tubes	• Wide-range steam generator level • Narrow-range steam generator level
RCS Pressure	• To determine the ability to inject into the RCS • To determine if high-pressure melt ejection is a concern • To determine if there is an uncontrolled opening in the RCS	• Wide-range RCS pressure • Pressurizer pressure • Accumulator pressure • CMT flow • IRWST flow
Core Temperature (RCS Temperature or Reactor Vessel Level)	• To determine if the core is covered with water	• Core-exit thermocouples • Hot-leg/cold-leg RTDs • Subcooling margin monitor • Reactor vessel level • Source range monitor • Power range monitor
Containment Water Level	• To determine if equipment and instruments are flooded • To determine if core cooling in the recirculation mode is possible • To determine if the outside of the reactor vessel is covered with water • To determine if the core is coolable if reactor vessel failure occurs	• Containment recirculation sump level • IRWST water level
Site Release	• To determine if release mitigation is desired	• Site-specific list

Table 34-1 (Sheet 2 of 2)

POST-ACCIDENT MONITORING EQUIPMENT

Parameter	Primary Purposes	Method of Measurement (or Estimate)
Containment Pressure	• To determine if there is a challenge to the containment due to overpressurization or due to a sub-atmospheric condition • To determine if the containment atmosphere is steam inerted • To determine if there is a challenge to the containment due to hydrogen flammability	• Containment pressure • Wide-range containment pressure • Water levels that use containment as reference leg • Containment hydrogen monitor

Table 34-2

LEVEL 1 ACCIDENT CLASS

FUNCTIONAL DEFINITIONS OF LEVEL 1 ACCIDENT CLASS

Accident Class	Subclass	Definition
1	A	Core damage with RCS at high pressure following transient or RCS leak
1	AP	Core damage with no depressurization following small LOCA and RCS leak with PRHR operating or medium LOCA
1	D	Core damage with partial depressurization of RCS following transient
3	A	Core damage with RCS at high pressure following ATWS or main steam line break inside containment
3	BR	Core damage following large LOCA with full RCS depressurization, but accumulator failed
3	BE	Core damage following large LOCA or other event with full depressurization
3	BL	Core damage at long term following failure of water recirculation to reactor pressure vessel (RPV) after successful gravity injection
3	C	Core damage following vessel rupture
3	D	Core damage following small or medium LOCA with partial depressurization
6	E	Core damage following steam generator tube rupture or interfacing systems LOCA – early core damage (loss of injection)
6	L	Core damage following steam generator tube rupture – late core damage (loss of recirculation)

Table 34-3

SUMMARY OF RELEASE CATEGORIES

Release Category	Release Category Name	Release Category Description
IC	Intact Containment	Containment integrity is maintained throughout the accident, and the release of radiation to the environment is due to nominal leakage.
BP	Bypass Containment	Fission products are released directly from the RCS to the environment via the secondary system or other interfacing system bypass. Containment failure occurs prior to onset of core damage
CI	Containment Isolation Failure	Fission products are released through a failure of the system or valves that close the penetrations between the containment and the environment. Containment failure occurs prior to onset of core damage.
CFE	Early Containment Failure	Fission products are released through a containment failure caused by dynamic severe accident phenomena occurring after the onset of core damage, but prior to core relocation. Such phenomena include hydrogen detonation, hydrogen diffusion flame, steam explosions, and vessel failure.
CFI	Intermediate Containment Failure	Fission products are released through a containment failure caused by dynamic severe accident phenomena occurring after core relocation, but before 24 hours. Such phenomena include hydrogen detonation and hydrogen deflagration.
CFL	Late Containment Failure	Fission products are released through a containment failure caused by severe accident phenomena occurring after 24 hours. Such phenomena include the failure of containment heat removal (failure of passive containment cooling).

Table 34-4

3BE-1 EVENT SUMMARY

Time (Second)	Description
0.0	DVI Line Break to PXS Compartment
20.5	Reactor Scram
25.3	Main Coolant Pump Trip
25.3	CMT Actuation
56.0	PCS Actuation
615.0	ADS Stage 1 Actuation - Automatic
735.7	ADS Stage 2 Actuation - Automatic
855 7	ADS Stage 3 Actuation - Automatic
901.0	Accumulator Water Depleted
1594.0	ADS Stage 4 Actuation - Automatic
1670 0	Cavity Water Level @ 83'
3359.3	Cavity Flooding Actuation
3405.0	Onset of Core Melting
5050.0	Cavity Water Level @ 98'
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Begin Core Relocation to Lower Plenum
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-5

3BE-2 EVENT SUMMARY

Time (Second)	Description
0.0	DVI Line Break to PXS Compartment
20.5	Reactor Scram
25.3	Main Coolant Pump Trip
25 3	CMT Actuation
56 0	PCS Actuation
616.0	ADS Stage 1 Actuation - Automatic
736 4	ADS Stage 2 Actuation - Automatic
856 4	ADS Stage 3 Actuation - Automatic
901 0	Accumulator Water Depleted
1500.0	Cavity Water Level @ 83′
1594.4	ADS Stage 4 Actuation - Automatic
3359.0	Cavity Flooding Actuation
3406 4	Onset of Core Melting
5100.0	Cavity Water Level @ 98′
5880 0	Begin Core Relocation to Lower Plenum
7500 0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-6

3BE-4 EVENT SUMMARY

Time (Second)	Description
0.0	Spurious ADS Stage 4
5 0	Reactor Scram
5.3	Main Coolant Pump Trip
5 3	CMT Actuation
5 3	PCS Actuation
240 0	Cavity Water Level @ 83'
371.5	Accumulator Water Depleted
659.6	ADS Stage 1 Actuation - Automatic
779.6	ADS Stage 2 Actuation - Automatic
899.6	ADS Stage 3 Actuation - Automatic
1416 0	ADS Stage 4 Actuation - Automatic
3156 5	Cavity Flooding Actuation
3406 4	Onset of Core Melting
4650 0	Cavity Water Level @ 98'
5572.0	Begin Core Relocation to Lower Plenum
7400.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-7

3BE-5 EVENT SUMMARY

Time (Second)	Description
0 0	2-inch Hot-Leg Break to Steam Generator Compartment
149 0	Reactor Scram
165.2	Main Coolant Pump Trip
165.2	CMT Actuation
289.3	PCS Actuation
371.5	Accumulator Water Depleted
2047 4	ADS Stage 1 Actuation - Automatic
2167.4	ADS Stage 2 Actuation - Automatic
2287.4	ADS Stage 3 Actuation - Automatic
2300.0	Cavity Water Level @ 83′
2946.0	ADS Stage 4 Actuation - Automatic
4792.3	Cavity Flooding Actuation
4847.5	Onset of Core Melting
6300.0	Cavity Water Level @ 98′
7617.0	Begin Core Relocation to Lower Plenum
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-8

3BE-6 EVENT SUMMARY

Time (Second)	Description
0.0	2-inch Hot-Leg Break to Steam Generator Compartment
149.1	Reactor Scram
165.7	Main Coolant Pump Trip
165.7	CMT Actuation
287 8	PCS Actuation
2046.3	ADS Stage 1 Actuation - Automatic
2163.6	ADS Stage 2 Actuation - Automatic
2283 6	ADS Stage 3 Actuation - Automatic
2300.0	Cavity Water Level @ 83'
2511.5	Accumulator Water Depleted
2948.9	ADS Stage 4 Actuation - Automatic
4793.2	Cavity Flooding Actuation
4847.7	Onset of Core Melting
7525.0	Begin Core Relocation to Lower Plenum
7800.0	Cavity Water Level @ 98'
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-9

3BE-7 EVENT SUMMARY

Time (Second)	Description
0.0	2-inch Hot-Leg Break to Steam Generator Compartment
149.0	Reactor Scram
165.2	Main Coolant Pump Trip
165.2	CMT Actuation
289.3	PCS Actuation
1949.9	ADS Stage 4 Actuation - Automatic
2044.1	ADS Stage 1 Actuation - Automatic
2164.1	ADS Stage 2 Actuation - Automatic
2284.1	ADS Stage 3 Actuation - Automatic
2400.0	Cavity Water Level @ 83′
2512.6	Accumulator Water Depleted
4782.1	Cavity Flooding Actuation
4839.0	Onset of Core Melting
7520 0	Begin Core Relocation to Lower Plenum
9000 0	Lower Plenum Dryout
11302.0	Vessel Failure
11302.0	Containment Failure
N/A	Cavity Water Level @ 98′
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Creep Rupture of RCS

Table 34-10

3BE-3 EVENT SUMMARY

Time (Second)	Description
0 0	DVI Line Break to PXS Compartment
20 5	Reactor Scram
25.3	Main Coolant Pump Trip
25.3	CMT Actuation
58.1	PCS Actuation
613.0	ADS Stage 1 Actuation - Automatic
733.0	ADS Stage 2 Actuation - Automatic
853.0	ADS Stage 3 Actuation - Automatic
898.2	Accumulator Water Depleted
1588.5	ADS Stage 4 Actuation - Automatic
1700 0	Cavity Water Level @ 83'
3347 0	Cavity Flooding Actuation
3394 4	Onset of Core Melting
5000.0	Cavity Water Level @ 98'
10010 0	Containment Failure
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Begin Core Relocation to Lower Plenum
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Creep Rupture of RCS

Table 34-11

3BL-1 EVENT SUMMARY

Time (Second)	Description
0.0	2-inch Hot-Leg Break to Steam Generator Compartment
149.0	Reactor Scram
165.3	Main Coolant Pump Trip
165.3	CMT Actuation
289 5	PCS Actuation
2043 7	ADS Stage 1 Actuation - Automatic
2100.0	Cavity Water Level @ 83′
2163.7	ADS Stage 2 Actuation - Automatic
2283.7	ADS Stage 3 Actuation - Automatic
2511.0	Accumulator Water Depleted
2945.3	ADS Stage 4 Actuation - Automatic
2945.3	IRWST Injection Initiated
5750 0	Cavity Water Level @ 98′
27651.1	Onset of Core Melting
30456.0	Begin Core Relocation to Lower Plenum
40000.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-12

3BL-2 EVENT SUMMARY

Time (Second)	Description
0.0	DVI Line Break to PXS Compartment
20.5	Reactor Scram
25.3	Main Coolant Pump Trip
25.3	CMT Actuation
56.0	PCS Actuation
617.2	ADS Stage 1 Actuation - Automatic
737.2	ADS Stage 2 Actuation - Automatic
857.2	ADS Stage 3 Actuation - Automatic
902.0	Accumulator Water Depleted
1500.0	Cavity Water Level @ 83′
1594.4	ADS Stage 4 Actuation - Automatic
1594.4	IRWST Injection Initiated
8800.0	Cavity Water Level @ 98′
45358.2	Onset of Core Melting
53093.0	Begin Core Relocation to Lower Plenum
64000.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-13

3BR-1 EVENT SUMMARY

Time (Second)	Description
0.0	Large LOCA in Cold Leg to Steam Generator Compartment
0.6	Reactor Scram
1.3	Main Coolant Pump Trip
1.3	CMT Actuation
1.3	PCS Actuation
383.8	ADS Stage 1 Actuation - Automatic
503.8	ADS Stage 2 Actuation - Automatic
618.8	ADS Stage 3 Actuation - Automatic
700.0	Cavity Water Level @ 83′
1134.6	ADS Stage 4 Actuation - Automatic
3900.0	Cavity Water Level @ 98′
N/A	Hot Leg Submerged
N/A	Onset of Core Melting
N/A	Begin Core Relocation to Lower Plenum
N/A	Accumulator Water Depleted
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-14

3BR-1a EVENT SUMMARY

Time (Second)	Description
0 0	Large LOCA in Cold Leg to Steam Generator Compartment
0 2	Reactor Scram
0 7	Main Coolant Pump Trip
0.7	CMT Actuation
0 7	PCS Actuation
372.3	ADS Stage 1 Actuation - Automatic
492.3	ADS Stage 2 Actuation - Automatic
612.3	ADS Stage 3 Actuation - Automatic
1000 0	Cavity Water Level @ 83′
1131.5	ADS Stage 4 Actuation - Automatic
2848 2	Onset of Core Melting
5157 0	Begin Core Relocation to Lower Plenum
7000 0	Lower Plenum Dryout
N/A	Cavity Water Level @ 98′
N/A	Hot Leg Submerged
N/A	Accumulator Water Depleted
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-15

3C-1 EVENT SUMMARY

Time (Second)	Description
0.0	Large LOCA at Belt of Reactor Vessel
0.05	Reactor Scram
0.6	Main Coolant Pump Trip
0.6	CMT Actuation
0.6	PCS Actuation
50 0	Cavity Water Level @ 83′
302 8	Accumulator Water Depleted
555.5	ADS Stage 1 Actuation – Automatic
675.5	ADS Stage 2 Actuation – Automatic
795.5	ADS Stage 3 Actuation – Automatic
1312.5	ADS Stage 4 Actuation - Automatic
1312.5	IRWST Injection Initiated
1511.0	Begin Core Relocation to Lower Plenum
4300.0	Cavity Water Level @ 98′
7611.8	Onset of Core Melting
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-16

3C-2 EVENT SUMMARY

Time (Second)	Description
0.0	Large LOCA at Belt of Reactor Vessel
0.0	Containment Failure
0.1	Reactor Scram
0.6	Main Coolant Pump Trip
0.6	CMT Actuation
0.6	PCS Actuation
30.0	Cavity Water Level @ 83′
293.8	Accumulator Water Depleted
352.8	Onset of Core Melting
561.2	ADS Stage 1 Actuation - Automatic
681.2	ADS Stage 2 Actuation - Automatic
801.2	ADS Stage 3 Actuation - Automatic
1318.0	ADS Stage 4 Actuation - Automatic
1318.0	IRWST Injection Initiated
1533.0	Begin Core Relocation to Lower Plenum
4350.0	Cavity Water Level @ 98′
N/A	Hot Leg Submerged
N/A	PRHR Actuation
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Lower Plenum Dryout
N/A	Vessel Failure
N/A	Creep Rupture of RCS

Table 34-17

3D-1 EVENT SUMMARY

Time (Second)	Description
0.0	Spurious ADS Stage 4
5.0	Reactor Scram
5.3	Main Coolant Pump Trip
5.3	PCS Actuation
300.0	Cavity Water Level @ 83′
372.3	Accumulator Water Depleted
1490.0	Cavity Flooding Actuation
1532.5	Onset of Core Melting
3400.0	Cavity Water Level @ 98′
3468.0	Begin Core Relocation to Lower Plenum
4900.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	CMT Actuation
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-18

3D-2 EVENT SUMMARY

Time (Second)	Description
0.0	Spurious ADS Stage 2
2.9	Reactor Scram
4 0	Main Coolant Pump Trip
22.2	PCS Actuation
1927 5	Accumulator Water Depleted
2000 0	Cavity Water Level @ 83′
3427 4	Cavity Flooding Actuation
3491 3	Onset of Core Melting
5300 0	Cavity Water Level @ 98′
5825 0	Begin Core Relocation to Lower Plenum
7500 0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	CMT Actuation
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-19

3D-3 EVENT SUMMARY

Time (Second)	Description
0 0	DVI Line Break to PXS Compartment
20.5	Reactor Scram
25.3	Main Coolant Pump Trip
25.3	CMT Actuation
56.1	PCS Actuation
1800.0	Cavity Water Level @ 83′
4227.9	Accumulator Water Depleted
4767.8	Cavity Flooding Actuation
4881.3	Onset of Core Melting
6400.0	Cavity Water Level @ 98′
7714.0	Begin Core Relocation to Lower Plenum
9500.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-20

3D-4 EVENT SUMMARY

Time (Second)	Description
0.0	Spurious ADS Stage 2
2.9	Reactor Scram
4 0	Main Coolant Pump Trip
22.2	PCS Actuation
1927.5	Accumulator Water Depleted
2000.0	Cavity Water Level @ 83'
3491.3	Onset of Core Melting
4491.0	Containment Failure
5350.0	Cavity Water Level @ 98'
5831.0	Begin Core Relocation to Lower Plenum
7500 0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation – Automatic
N/A	ADS Stage 2 Actuation – Automatic
N/A	ADS Stage 3 Actuation – Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	CMT Actuation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Creep Rupture of RCS

TABLE 34-21

6E-1 EVENT SUMMARY

Time (Second)	Description
0 0	Steam Generator Tube Rupture (five tubes)
147.7	Reactor Scram
164.6	Main Coolant Pump Trip
164.6	CMT Actuation
166.8	PRHR Actuation
3673.3	Accumulator Water Depleted
19184 0	IRWST Injection Initiated
32612.0	Cavity Flooding Actuation
32706.0	Onset of Core Melting
33000.0	Cavity Water Level @ 83'
35050.0	Cavity Water Level @ 98'
36844.0	Begin Core Relocation to Lower Plenum
38500.0	Lower Plenum Dryout
39911 3	IRWST Low Level - Switchover to Recirculation
68637 0	PCS Actuation
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-22

6L-1 EVENT SUMMARY

Time (Second)	Description
0 0	Steam Generator Tube Rupture (five tubes)
148.7	Reactor Scram
165	Main Coolant Pump Trip
165	CMT Actuation
167.0	PRHR Actuation
3672 5	Accumulator Water Depleted
17028 0	ADS Stage 1 Actuation - Automatic
17148 0	ADS Stage 2 Actuation - Automatic
17268 0	ADS Stage 3 Actuation - Automatic
17863 0	ADS Stage 4 Actuation - Automatic
17863.0	IRWST Injection Initiated
18500.0	Cavity Water Level @ 83'
22000.0	Cavity Water Level @ 98'
23793.0	PCS Actuation
44464.0	Onset of Core Melting
48447.0	Begin Core Relocation to Lower Plenum
53000.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Containment Failure
N/A	Creep Rupture of RCS

Table 34-23

1AP-1 EVENT SUMMARY

Time (Second)	Description
0.0	3/8-inch Hot-Leg Break to Steam Generator Compartment
4689.8	Reactor Scram
4697.2	Main Coolant Pump Trip
4698.0	PRHR Actuation
14001.0	PCS Actuation
36000.0	Cavity Water Level @ 83′
86381.8	Accumulator Water Depleted
133253 0	Creep Rupture of RCS (Steam Generator Tube Creep)
137540 1	Cavity Flooding Actuation
137740.7	Onset of Core Melting
139000.0	Cavity Water Level @ 98′
144724.0	Begin Core Relocation to Lower Plenum
146000.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	CMT Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure

Table 34-24

1AP-2 EVENT SUMMARY

Time (Second)	Description
0 0	3/8-inch Hot-Leg Break to Steam Generator Compartment
4689 8	Reactor Scram
4697.2	Main Coolant Pump Trip
4697.2	CMT Actuation
4698.0	PRHR Actuation
15556.1	PCS Actuation
40000.0	Cavity Water Level @ 83′
92439.2	Accumulator Water Depleted
139113.0	Creep Rupture of RCS (Steam Generator Tube Creep)
150556.0	Onset of Core Melting
157909.0	Begin Core Relocation to Lower Plenum
160000.0	Lower Plenum Dryout
N/A	Cavity Water Level @ 98′
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Containment Failure

Table 34-25

1A-1 EVENT SUMMARY

Time (Second)	Description
0.0	Feedwater Failure
3.8	Reactor Scram
4015.5	Main Coolant Pump Trip
4015.5	CMT Actuation
4015.5	PCS Actuation
10500.0	Cavity Water Level @ 83′
14000.0	Creep Rupture of RCS (Steam Generator Tube Creep)
15413.0	IRWST Injection Initiated
15721.5	Cavity Flooding Actuation
15864 0	Onset of Core Melting
17700.0	Cavity Water Level @ 98′
19604.0	Begin Core Relocation to Lower Plenum
20500.0	Lower Plenum Dryout
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	Accumulator Water Depleted
N/A	PRHR Actuation
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Vessel Failure
N/A	Containment Failure

Table 34-26

1A-2 EVENT SUMMARY

Time (Second)	Description
0 0	Feedwater Failure
3 8	Reactor Scram
4015.5	Main Coolant Pump Trip
4015.5	PCS Actuation
7000.0	Creep Rupture of RCS (Steam Generator Tube Creep)
8550.1	Onset of Core Melting
11495 0	Begin Core Relocation to Lower Plenum
12250 0	Lower Plenum Dryout
22175 0	Creep Rupture of RCS (Hot-Leg Creep)
22333 8	Accumulator Water Depleted
22500 0	Cavity Water Level @ 83′
N/A	Cavity Water Level @ 98′
N/A	Hot Leg Submerged
N/A	ADS Stage 1 Actuation - Automatic
N/A	ADS Stage 2 Actuation - Automatic
N/A	ADS Stage 3 Actuation - Automatic
N/A	ADS Stage 4 Actuation - Automatic
N/A	CMT Actuation
N/A	PRHR Actuation
N/A	IRWST Injection Initiated
N/A	IRWST Low Level - Switchover to Recirculation
N/A	Cavity Flooding Actuation
N/A	Vessel Failure
N/A	Containment Failure

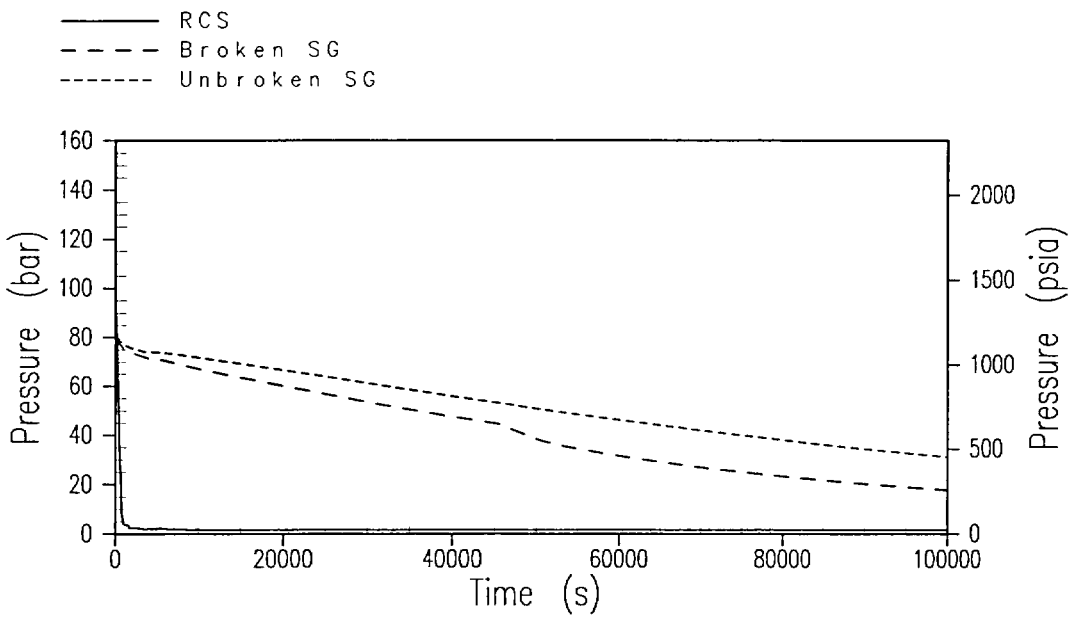

Figure 34-1

Case 3BE-1: Reactor Coolant System and Steam Generator Pressure DVI Line Break, Containment Water Level

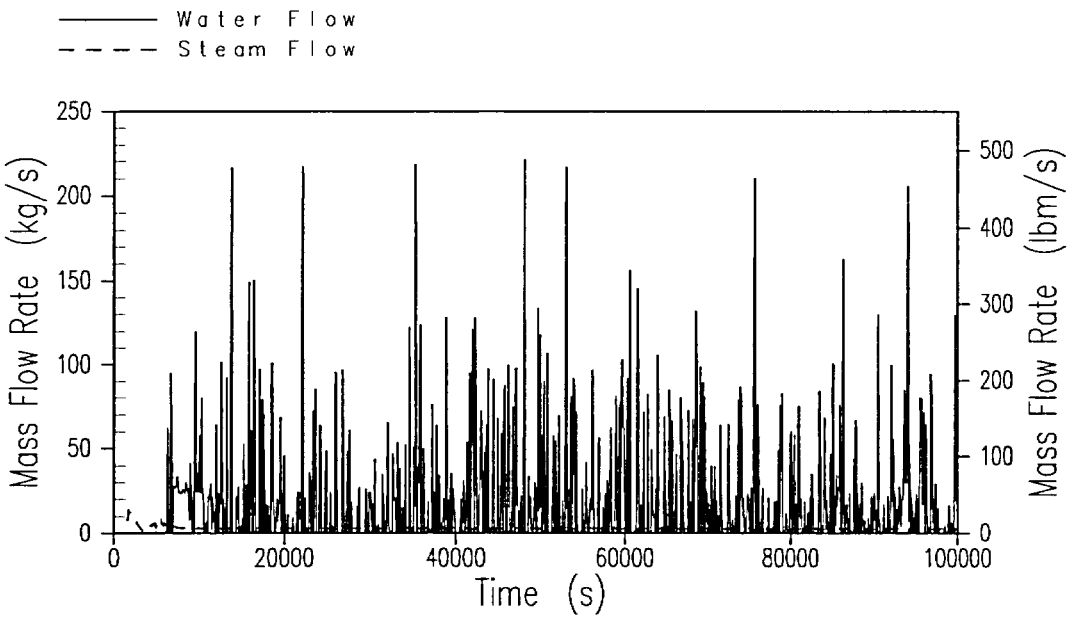

Figure 34-2

Case 3BE-1: ADS Stage 4 Flow Rates DVI Line Break, Containment Water Level

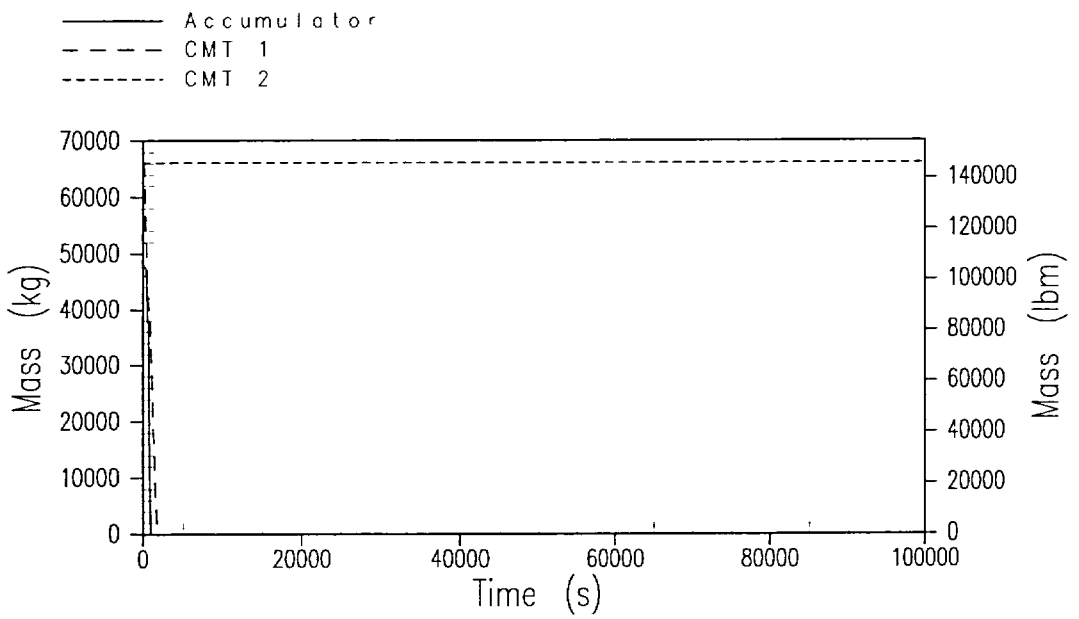

Figure 34-3

Case 3BE-1: Accumulator/CMT Water Mass DVI Line Break, Containment Water Level

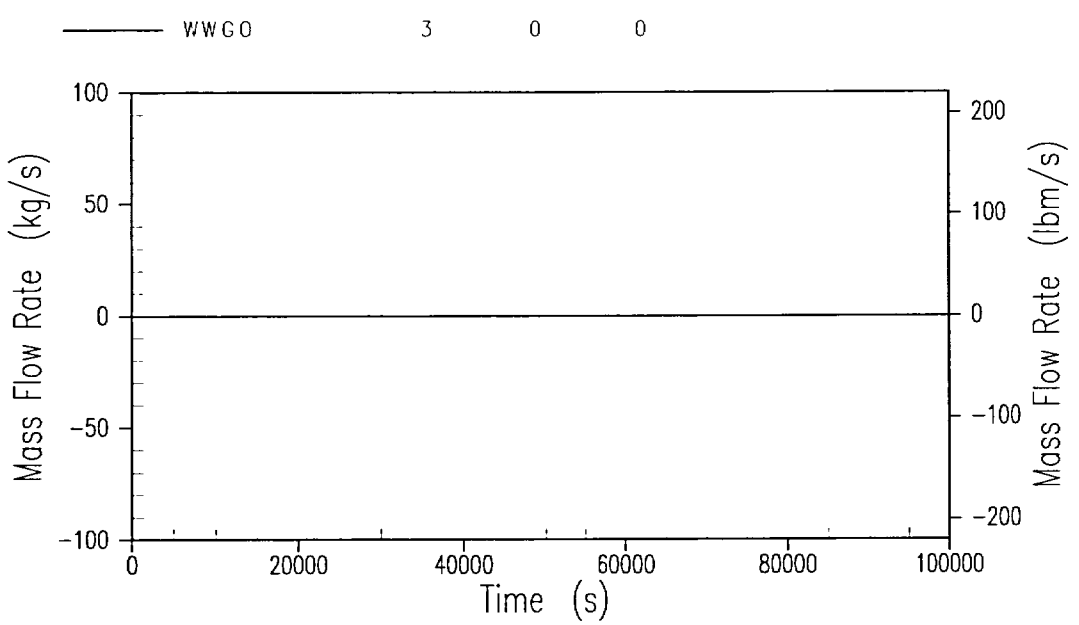

Figure 34-4

Case 3BE-1: IRWST Injection Flow Rate DVI Line Break, Containment Water Level

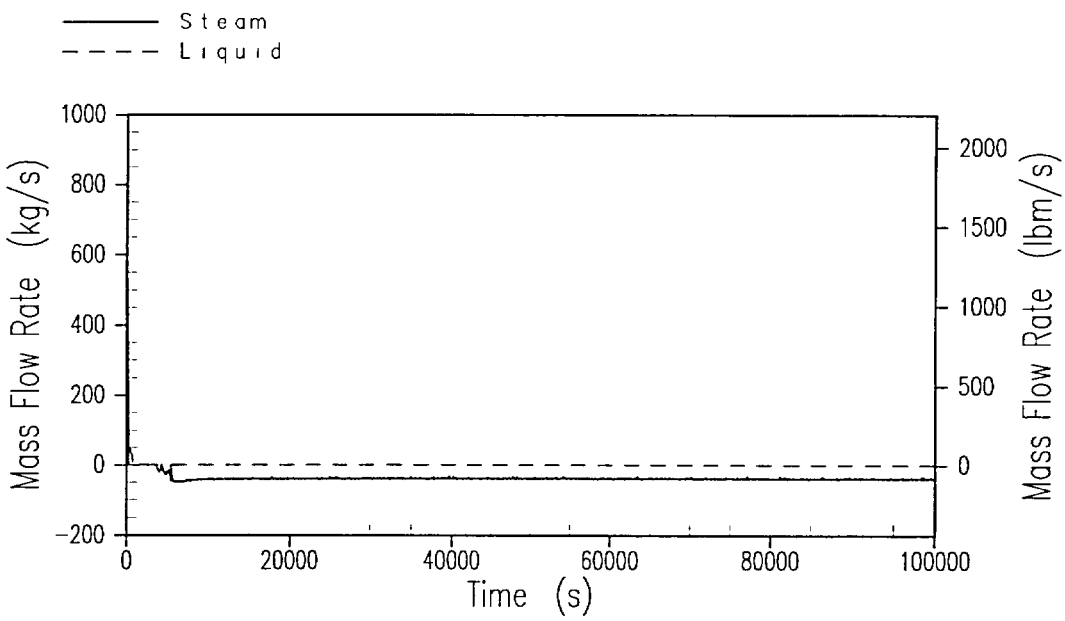

Figure 34-5

Case 3BE-1: Break Flow Rate
DVI Line Break, Containment Water Level

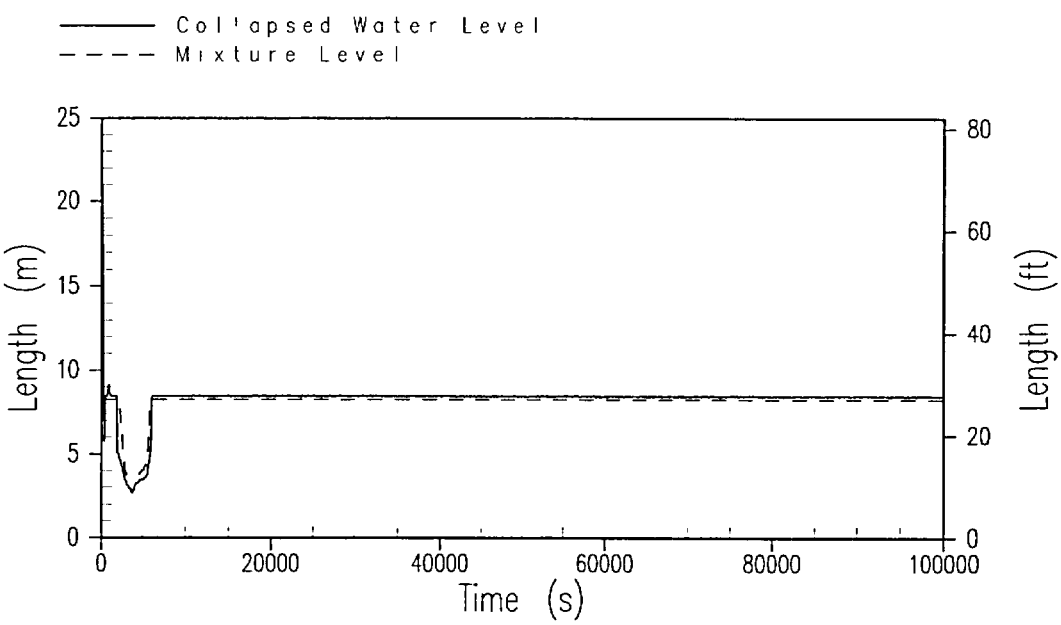

Figure 34-6

Case 3BE-1: Reactor Vessel Water Level
DVI Line Break, Containment Water Level

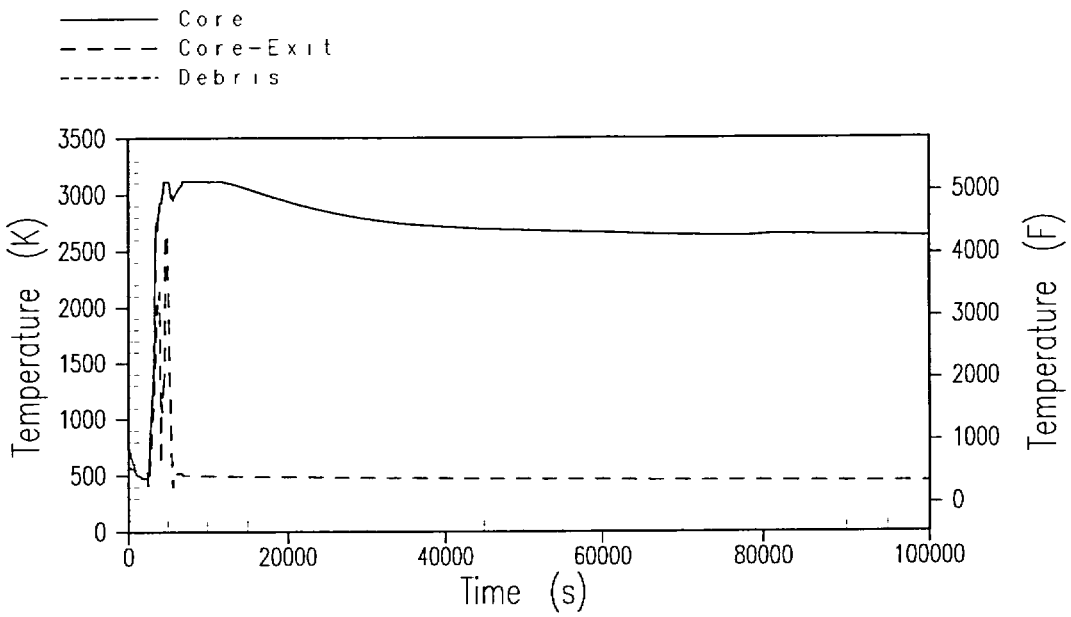

Figure 34-7

Case 3BE-1: Core Temperatures
DVI Line Break, Containment Water Level

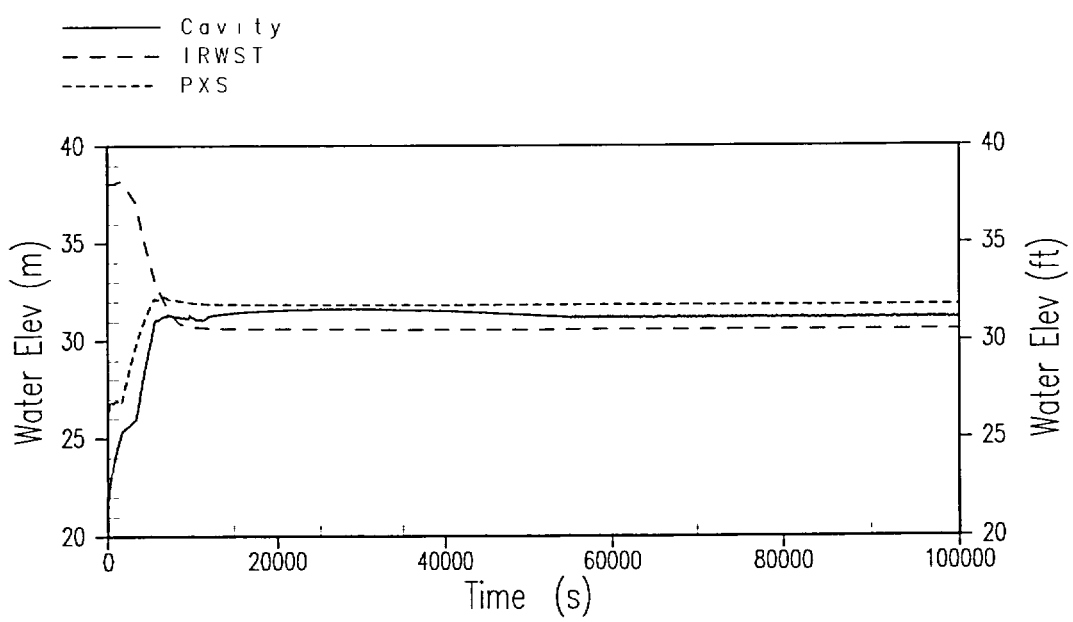

Figure 34-8

Case 3BE-1: Containment Water Pool Elevations
DVI Line Break, Containment Water Level

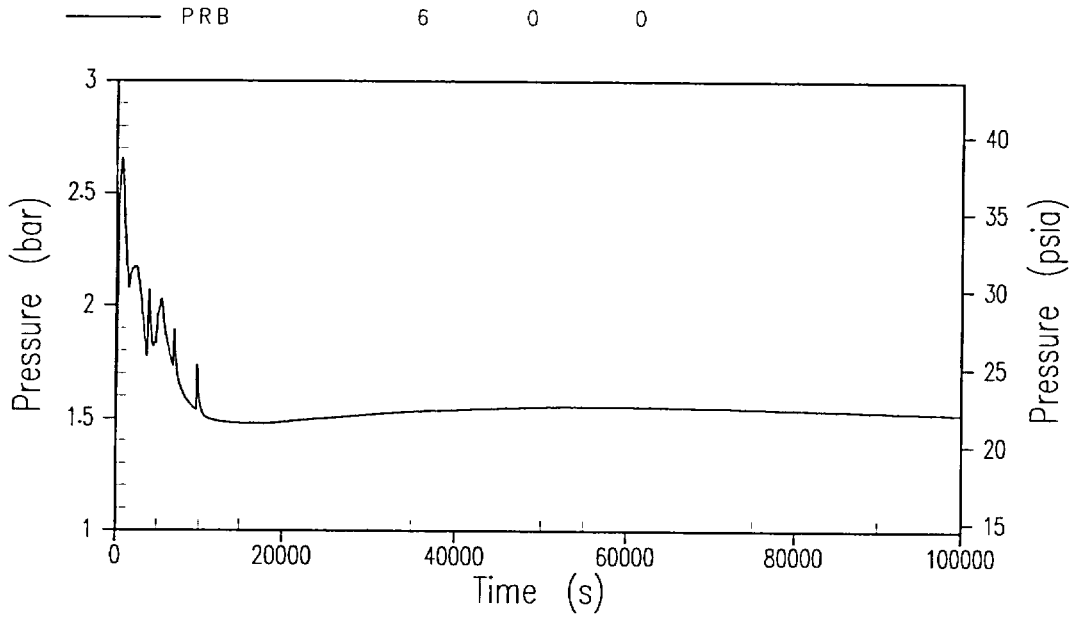

Figure 34-9

Case 3BE-1: Containment Pressure
DVI Line Break, Containment Water Level

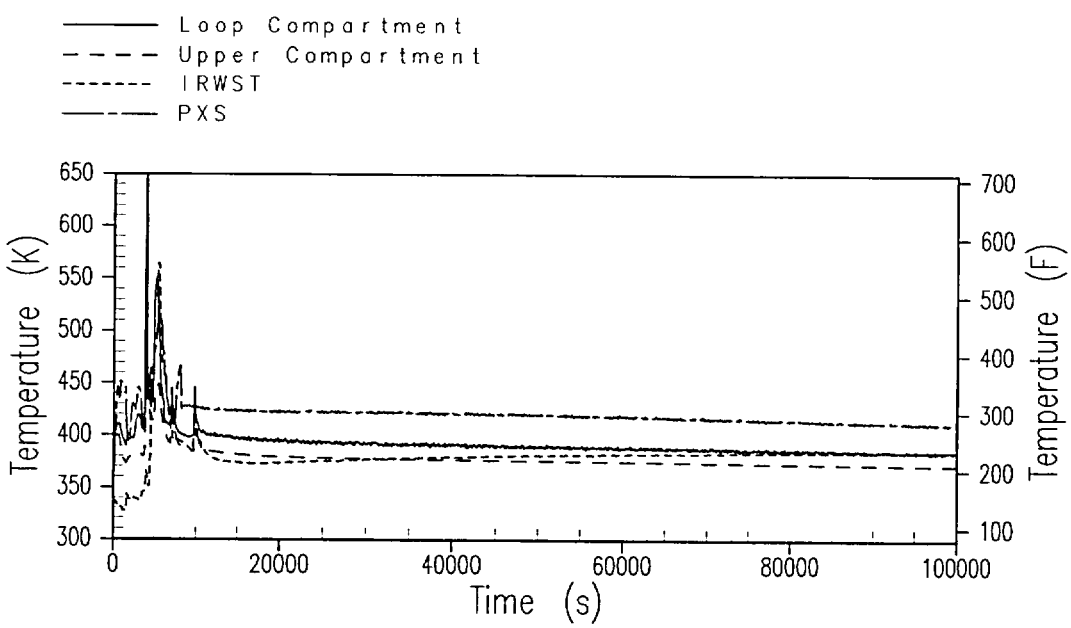

Figure 34-10

Case 3BE-1: Containment Gas Temperatures
DVI Line Break, Containment Water Level

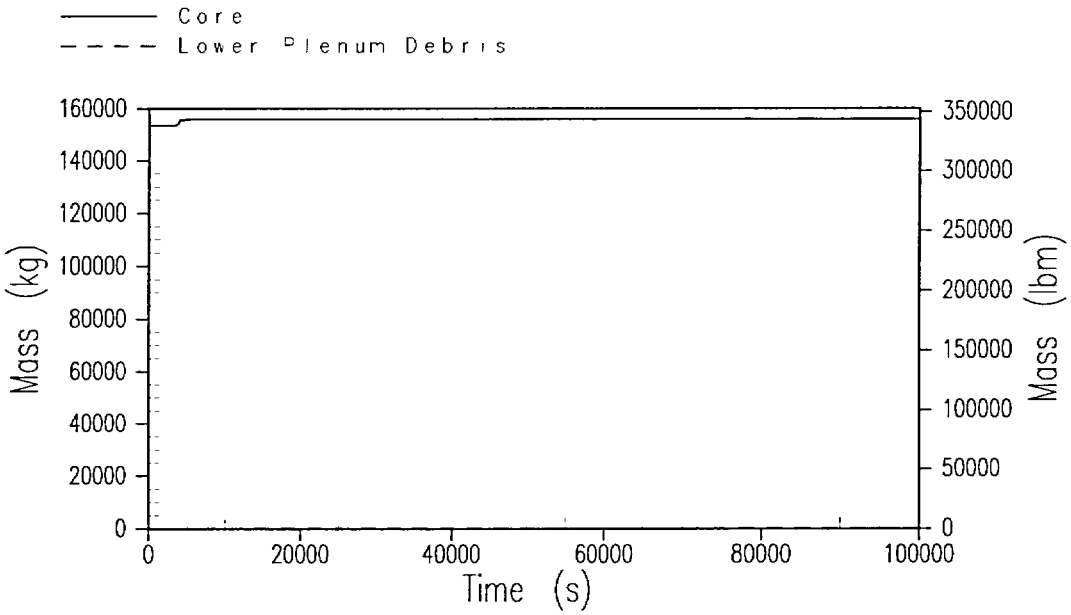

Figure 34-11

Case 3BE-1: Core Mass
DVI Line Break, Containment Water Level

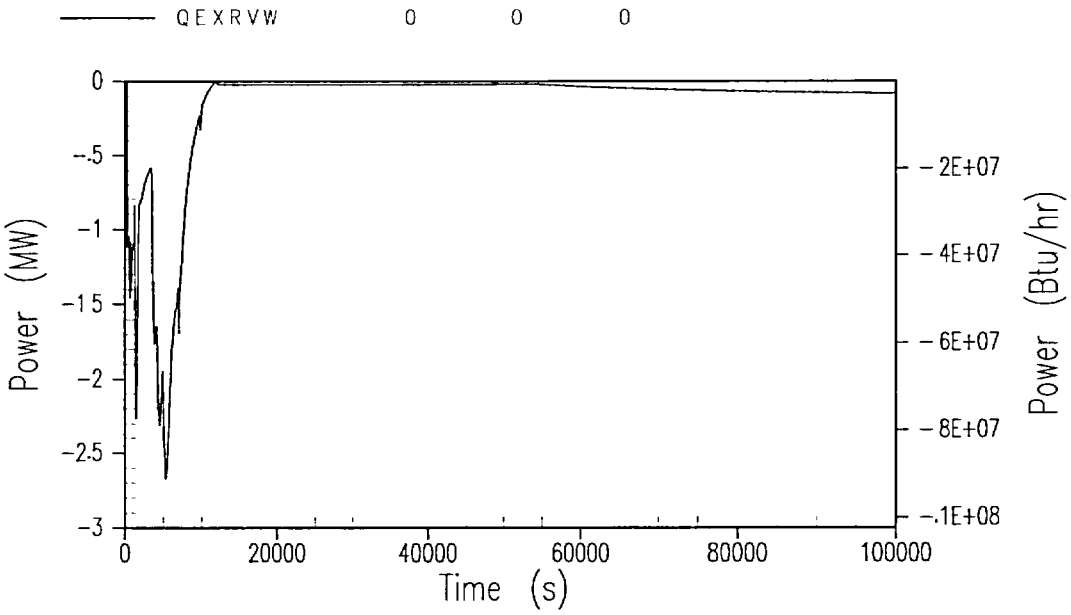

Figure 34-12

Case 3BE-1: Reactor Pressure Vessel to Cavity Water Heat Transfer
DVI Line Break, Containment Water Level

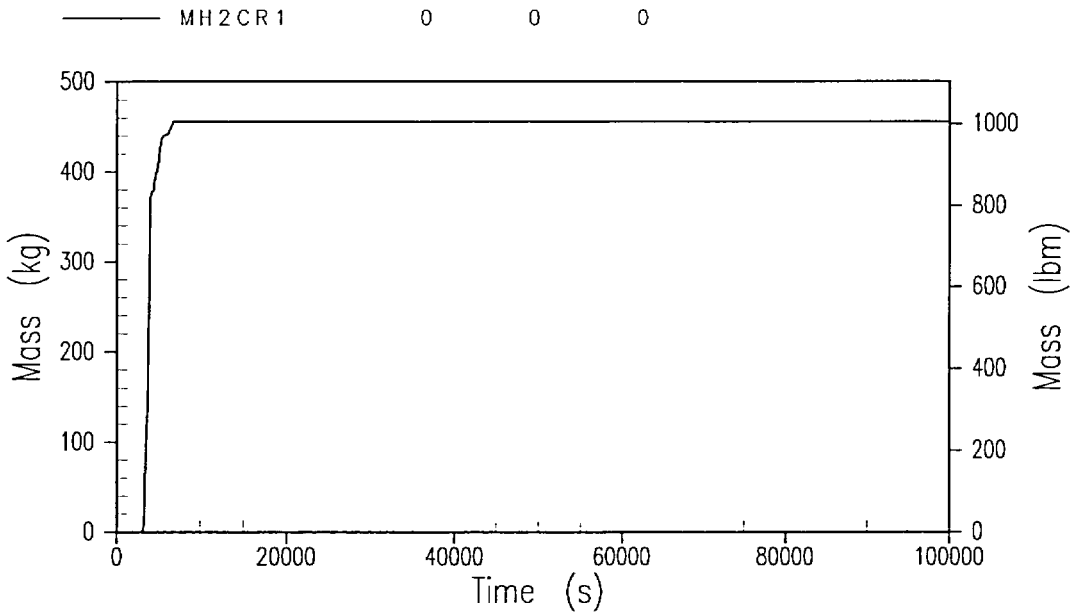

Figure 34-13

Case 3BE-1: In-Vessel Hydrogen Generation DVI Line Break, Containment Water Level

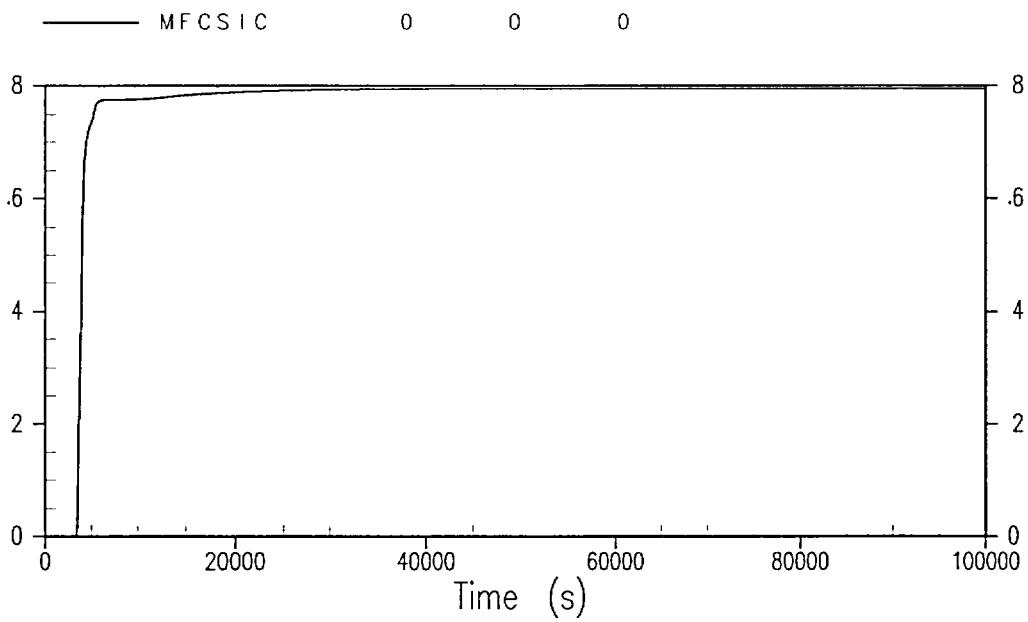

Figure 34-14

Case 3BE-1: Mass Fraction of CsI Released to Containment DVI Line Break, Containment Water Level

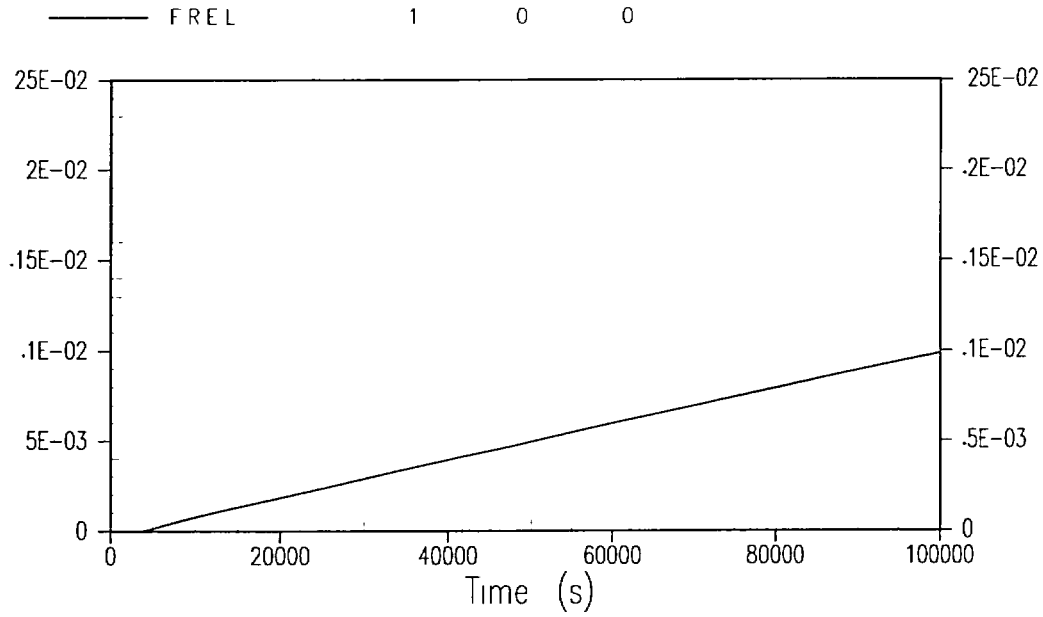

Figure 34-15

Case 3BE-1: Mass Fraction of Noble Gases Released to Environment DVI Line Break, Containment Water Level

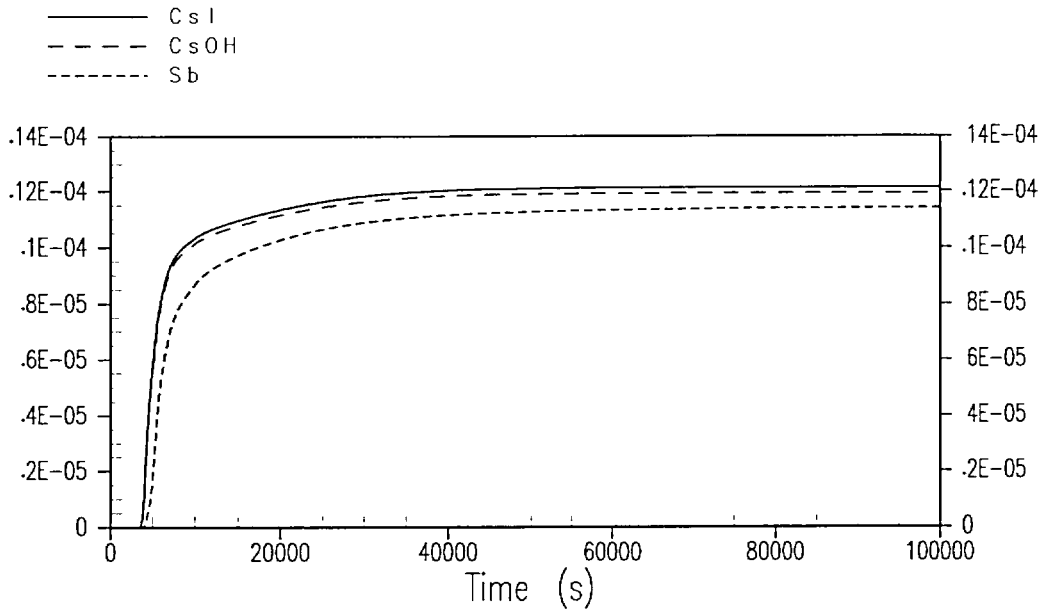

Figure 34-16

Case 3BE-1: Mass Fraction of Fission Products Released to Environment DVI Line Break, Containment Water Level

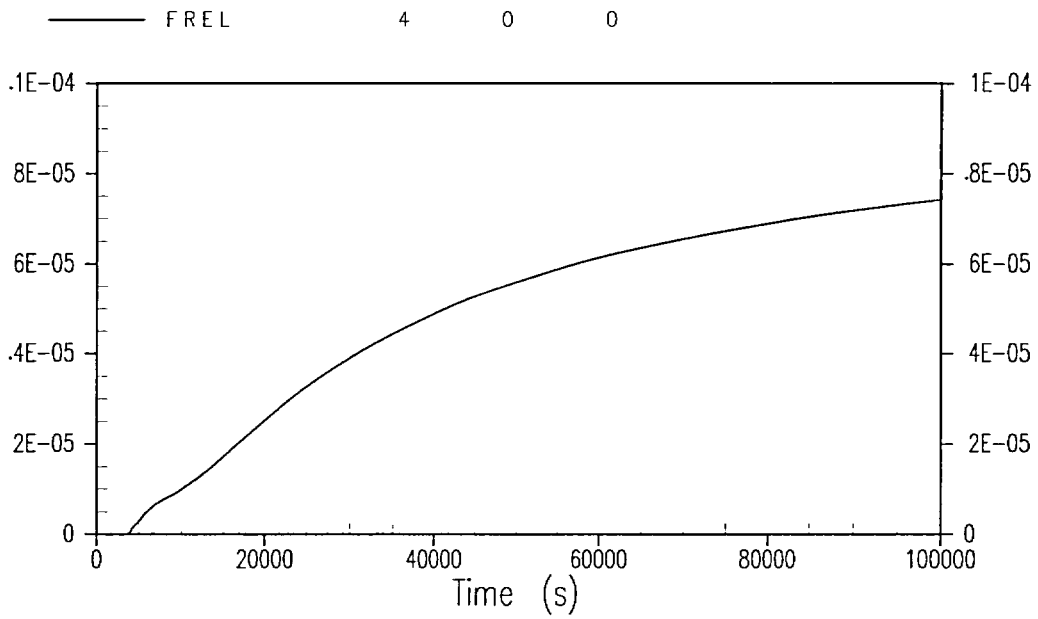

Figure 34-17

Case 3BE-1: Mass Fraction of SrO Released to Environment DVI Line Break, Containment Water Level

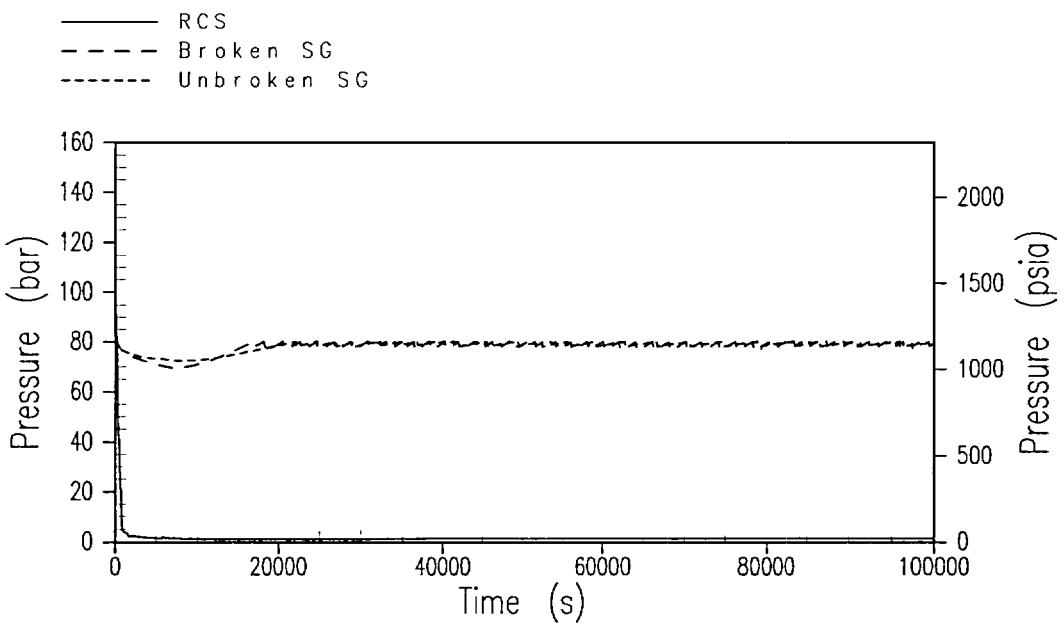

Figure 34-18

Case 3BE-2: Reactor Coolant System and Steam Generator Pressure DVI Line Break, Fail Gravity Injection, No DVI Flooding

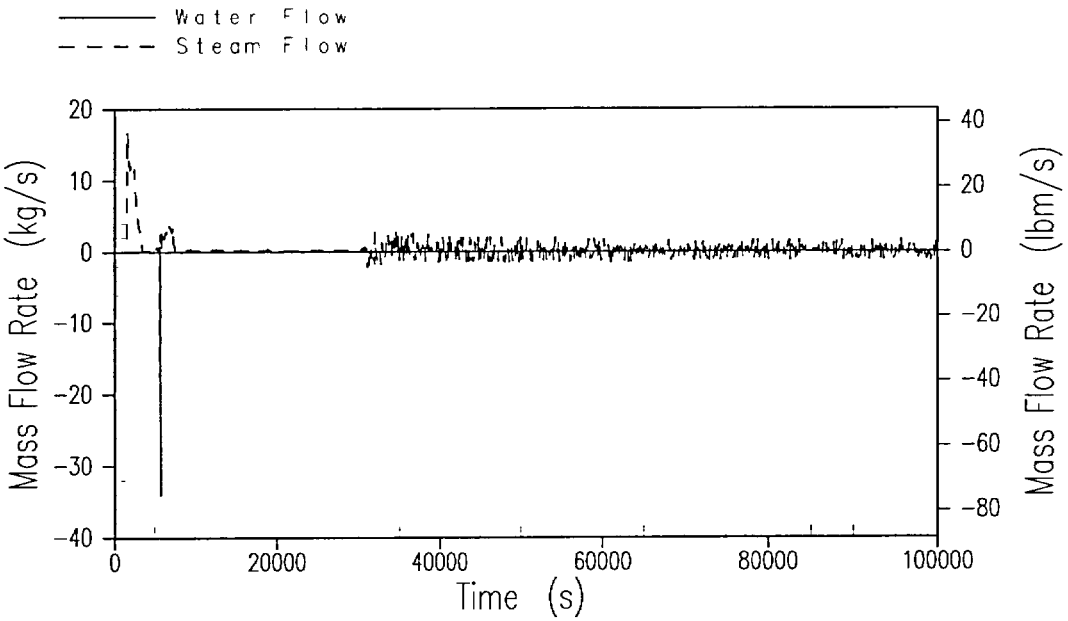

Figure 34-19

Case 3BE-2: ADS Stage 4 Flow Rates
DVI Line Break, Fail Gravity Injection, No DVI Flooding

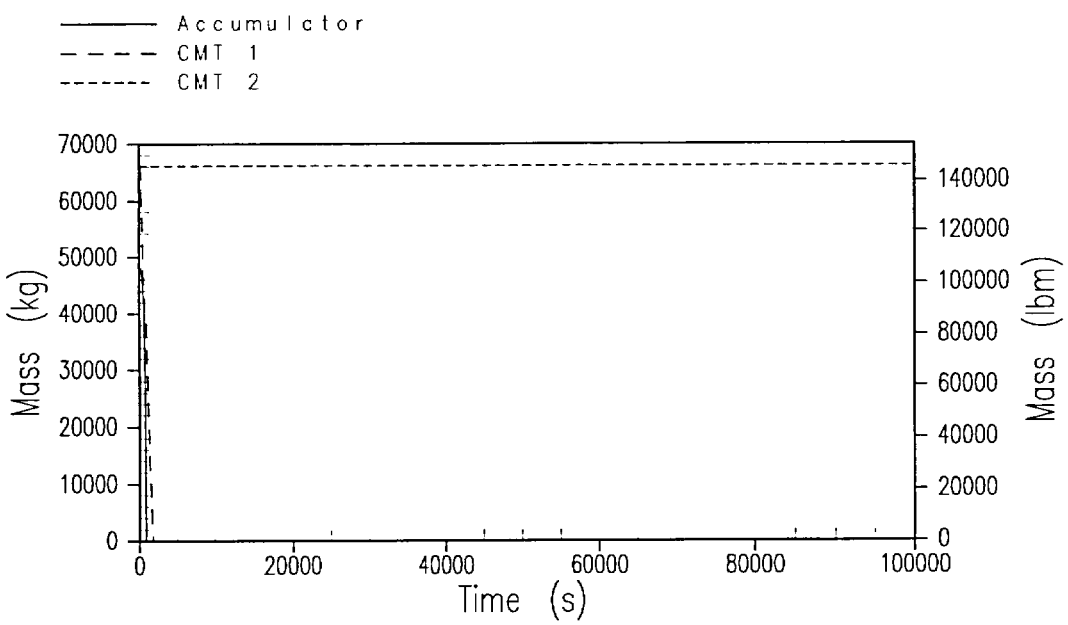

Figure 34-20

Case 3BE-2: Accumulator/CMT Water Mass
DVI Line Break, Fail Gravity Injection, No DVI Flooding

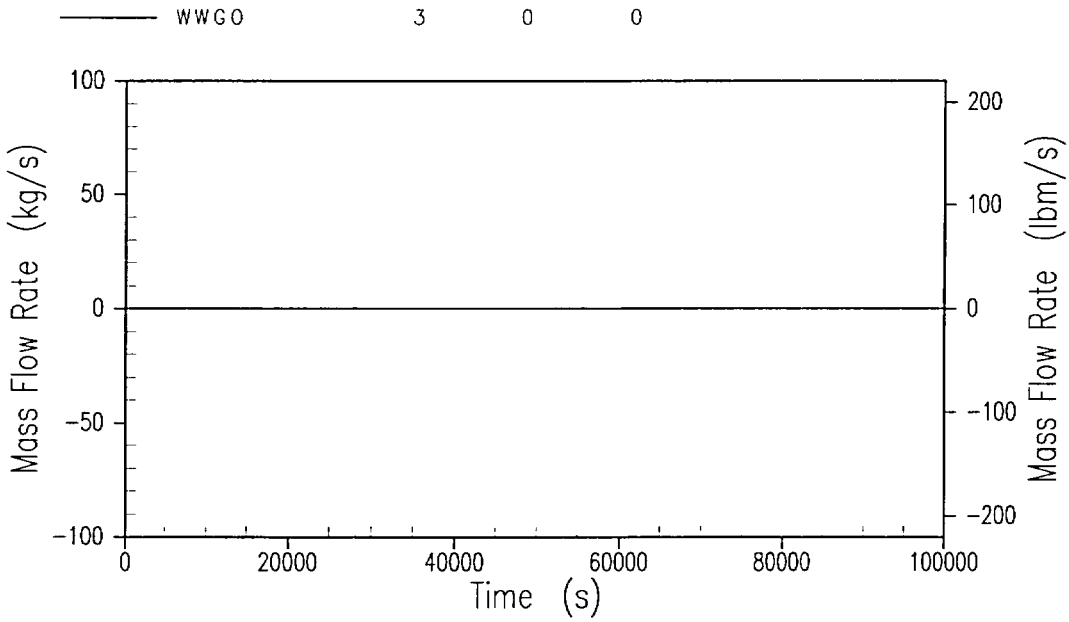

Figure 34-21

Case 3BE-2: IRWST Injection Flow Rate
DVI Line Break, Fail Gravity Injection, No DVI Flooding

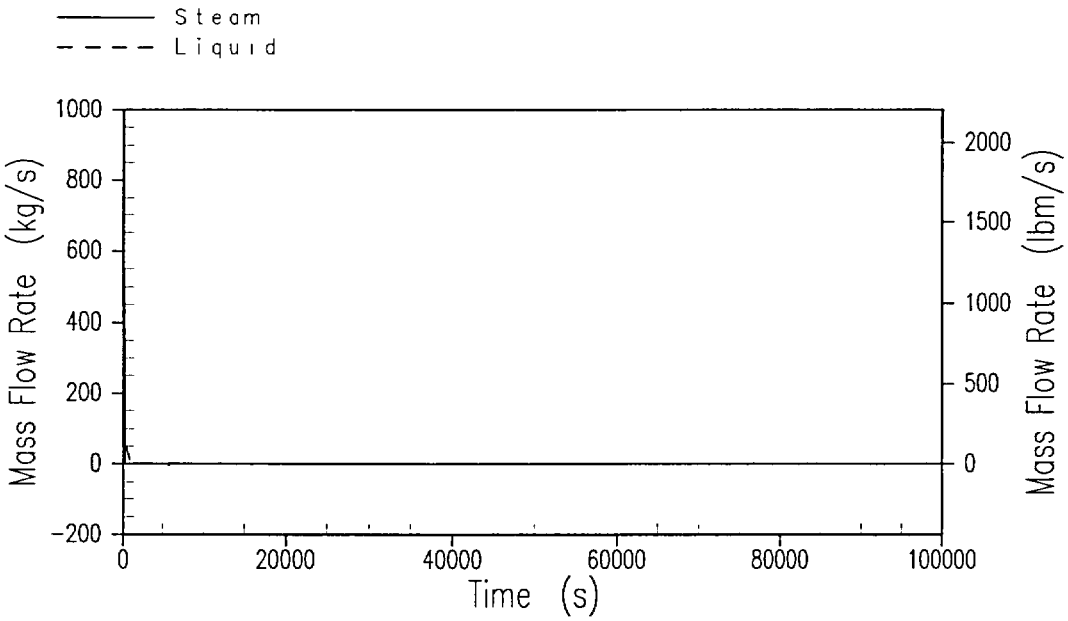

Figure 34-22

Case 3BE-2: Break Flow Rate
DVI Line Break, Fail Gravity Injection, No DVI Flooding

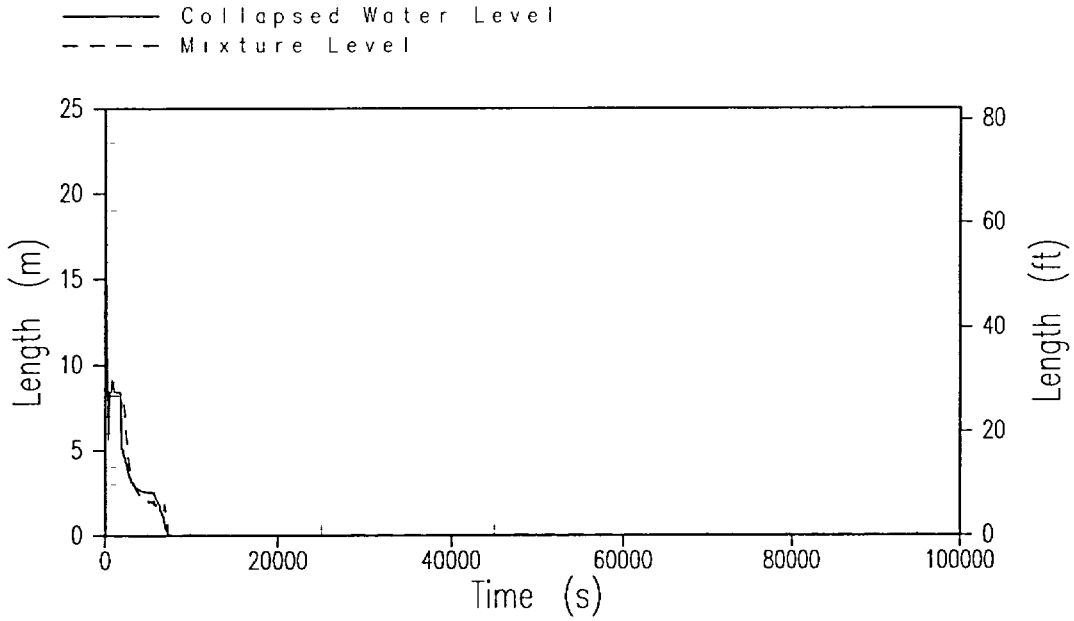

Figure 34-23

Case 3BE-2: Reactor Vessel Water Level
DVI Line Break, Fail Gravity Injection, No DVI Flooding

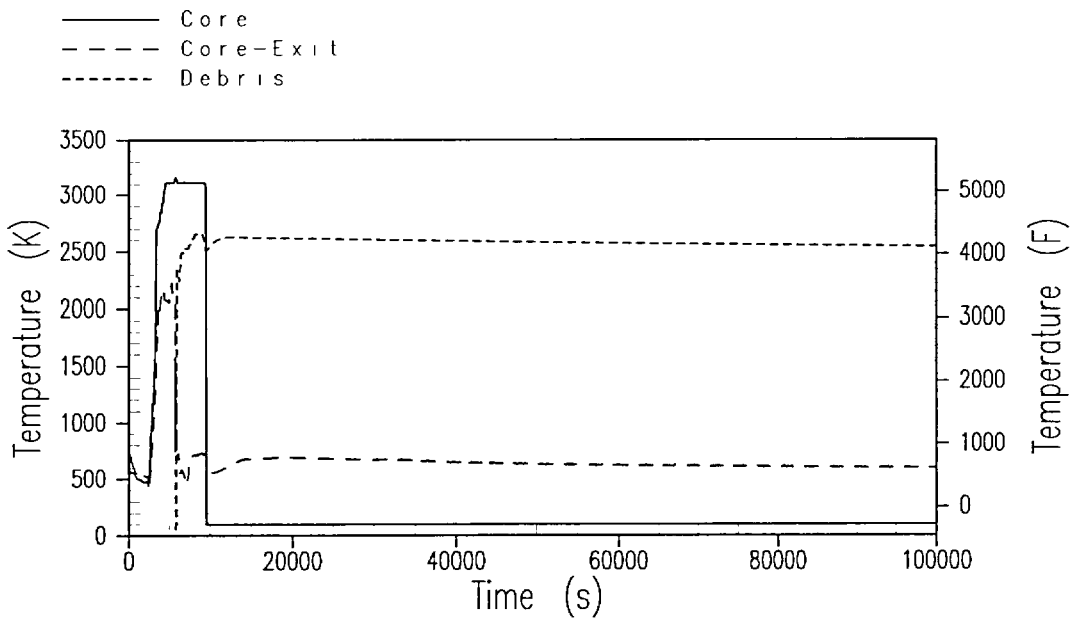

Figure 34-24

Case 3BE-2: Core Temperatures
DVI Line Break, Fail Gravity Injection, No DVI Flooding

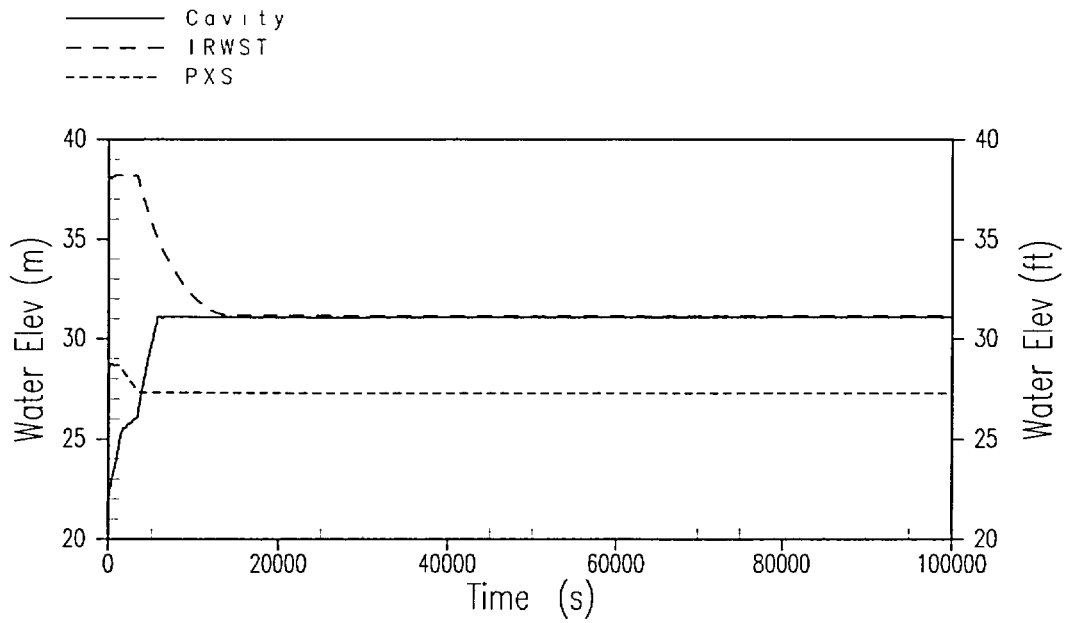

Figure 34-25

Case 3BE-2: Containment Water Pool Elevations
DVI Line Break, Fail Gravity Injection, No DVI Flooding

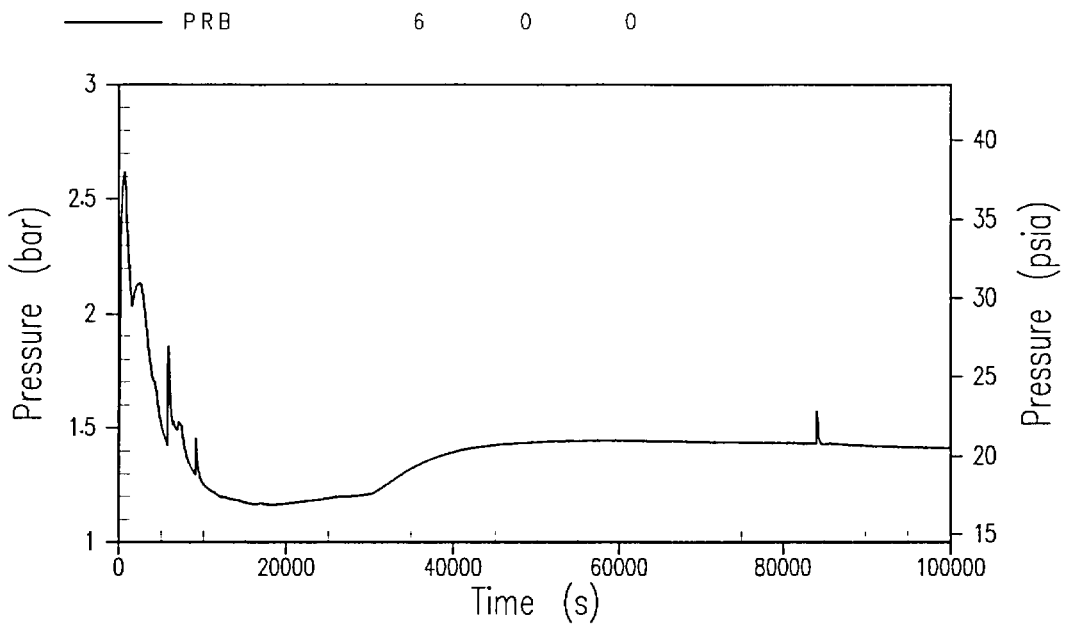

Figure 34-26

Case 3BE-2: Containment Pressure
DVI Line Break, Fail Gravity Injection, No DVI Flooding

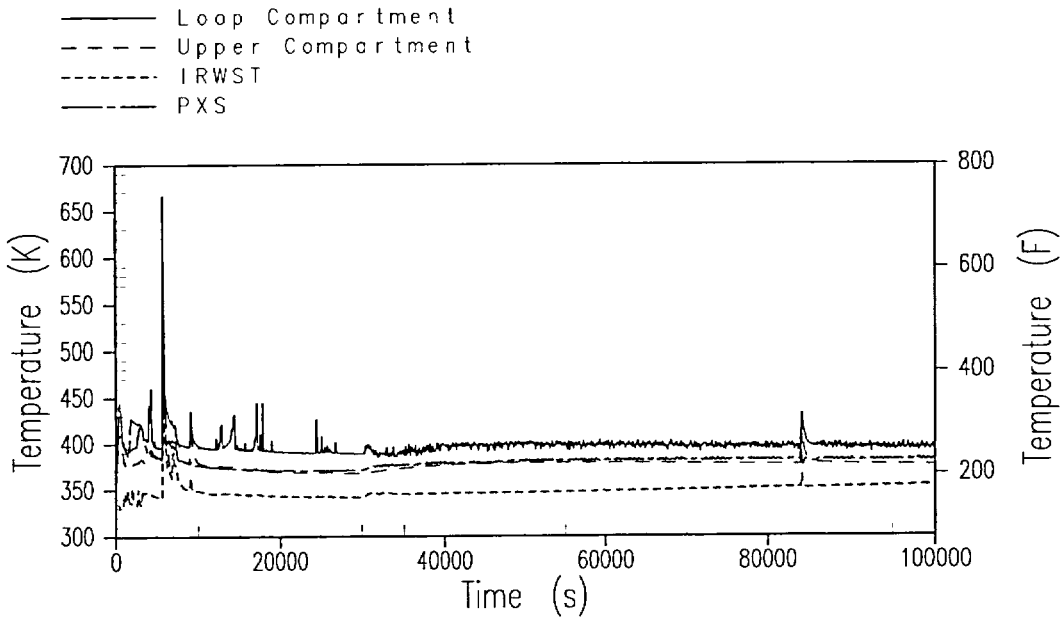

Figure 34-27

Case 3BE-2: Containment Gas Temperatures
DVI Line Break, Fail Gravity Injection, No DVI Flooding

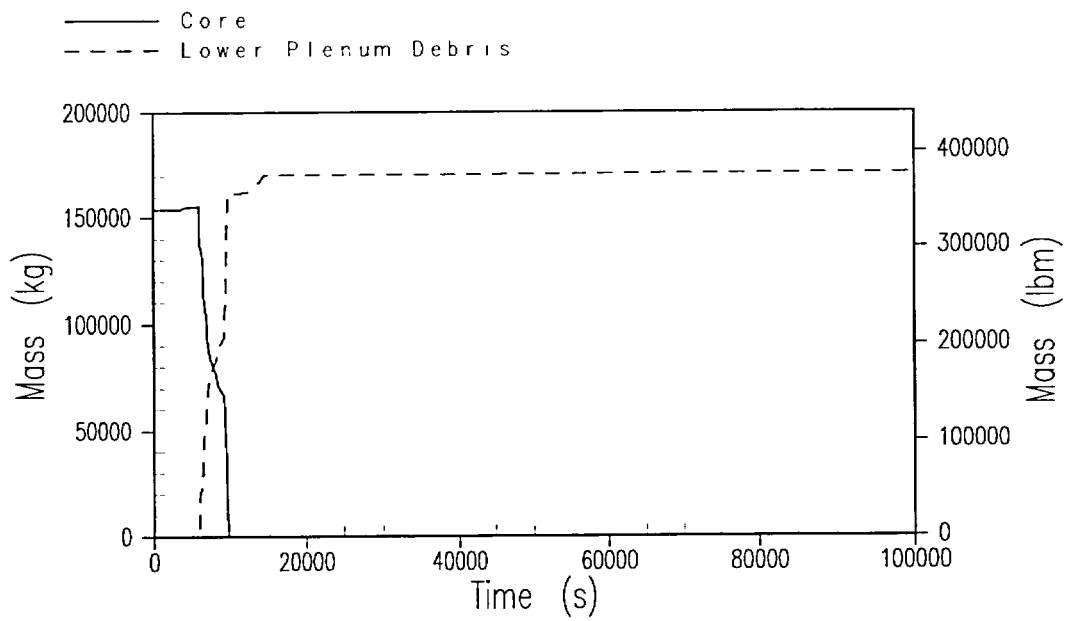

Figure 34-28

Case 3BE-2: Core Mass
DVI Line Break, Fail Gravity Injection, No DVI Flooding

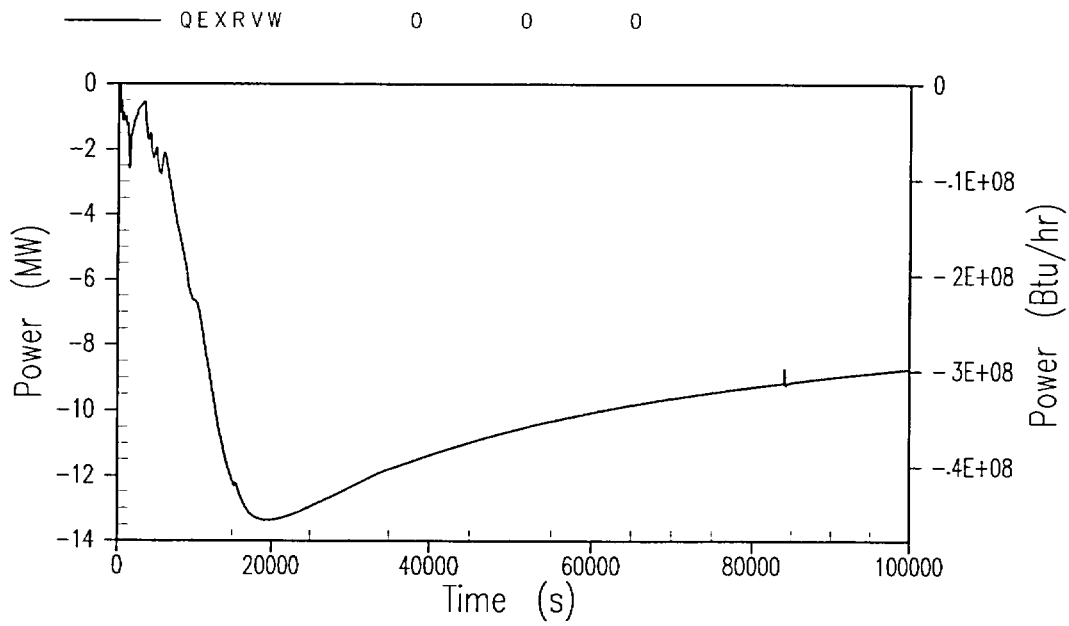

Figure 34-29

Case 3BE-2: Reactor Pressure Vessel to Cavity Water Heat Transfer DVI Line Break, Fail Gravity Injection, No DVI Flooding

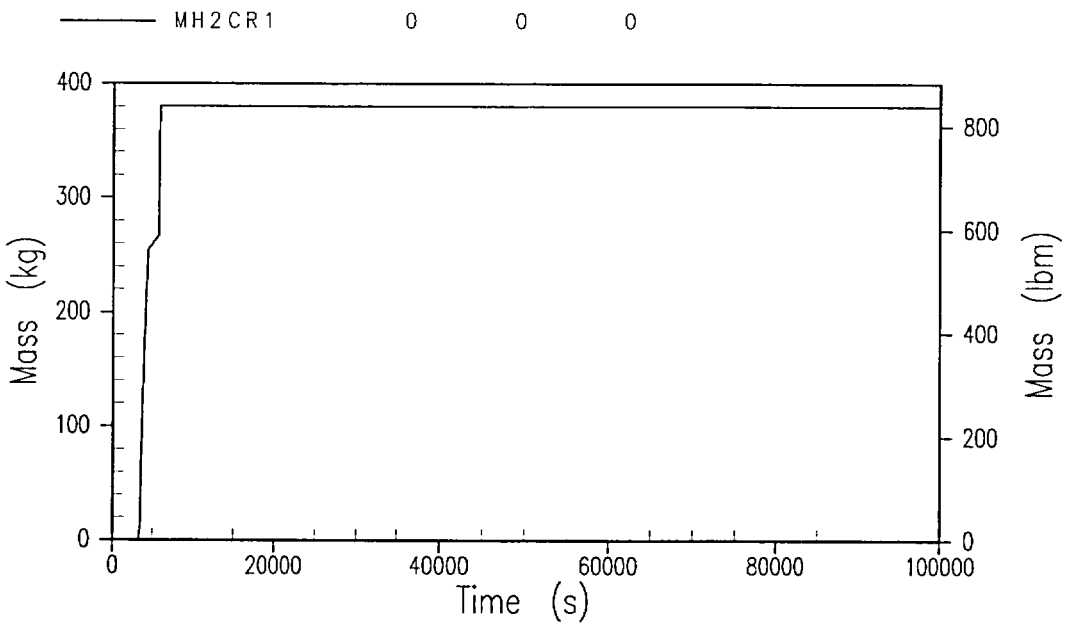

Figure 34-30

Case 3BE-2: In-Vessel Hydrogen Generation DVI Line Break, Fail Gravity Injection, No DVI Flooding

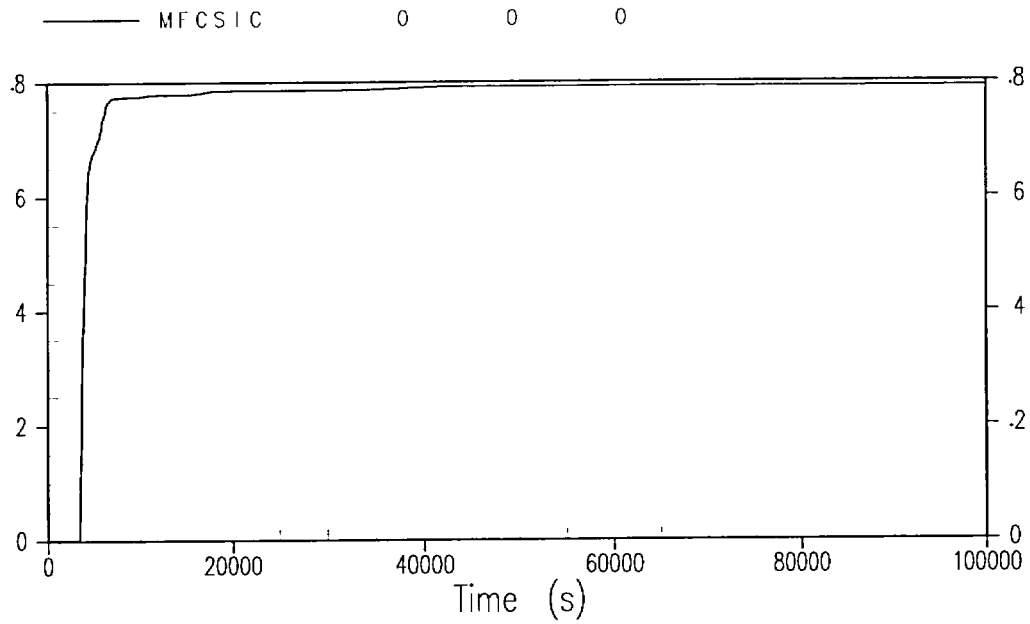

Figure 34-31

Case 3BE-2: Mass Fraction of CsI Released to Containment DVI Line Break, Fail Gravity Injection, No DVI Flooding

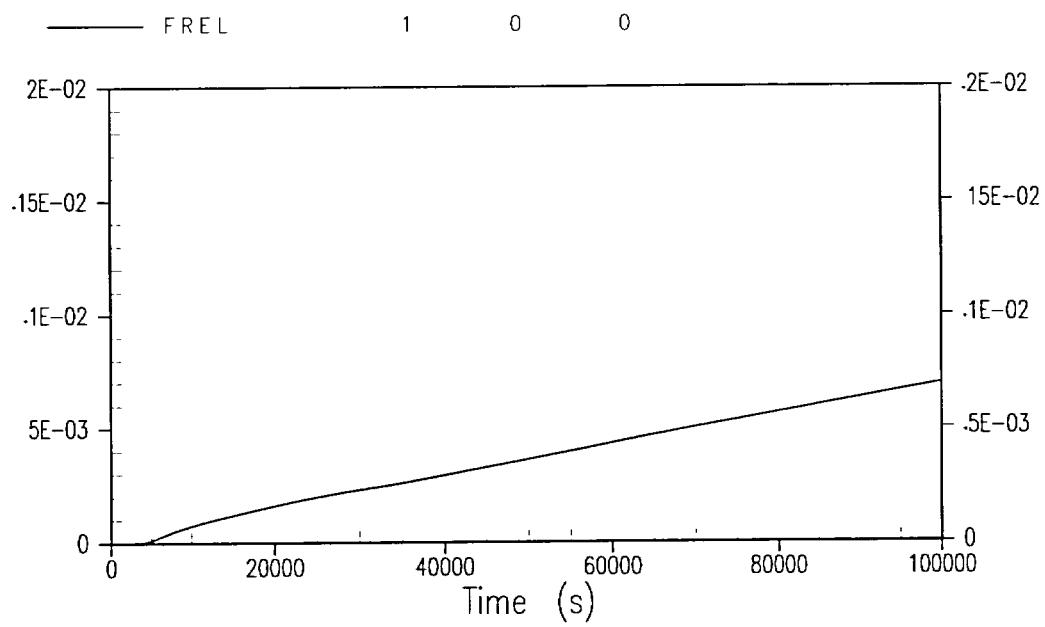

Figure 34-32

Case 3BE-2: Mass Fraction of Noble Gases Released to Environment DVI Line Break, Fail Gravity Injection, No DVI Flooding

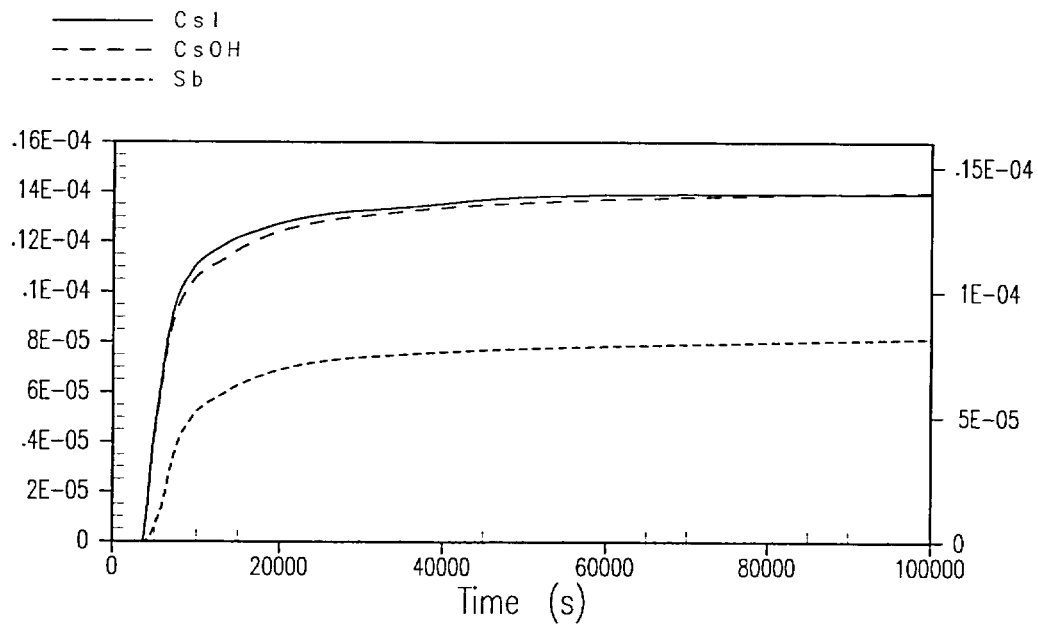

Figure 34-33

Case 3BE-2: Mass Fraction of Fission Products Released to Environment DVI Line Break, Fail Gravity Injection, No DVI Flooding

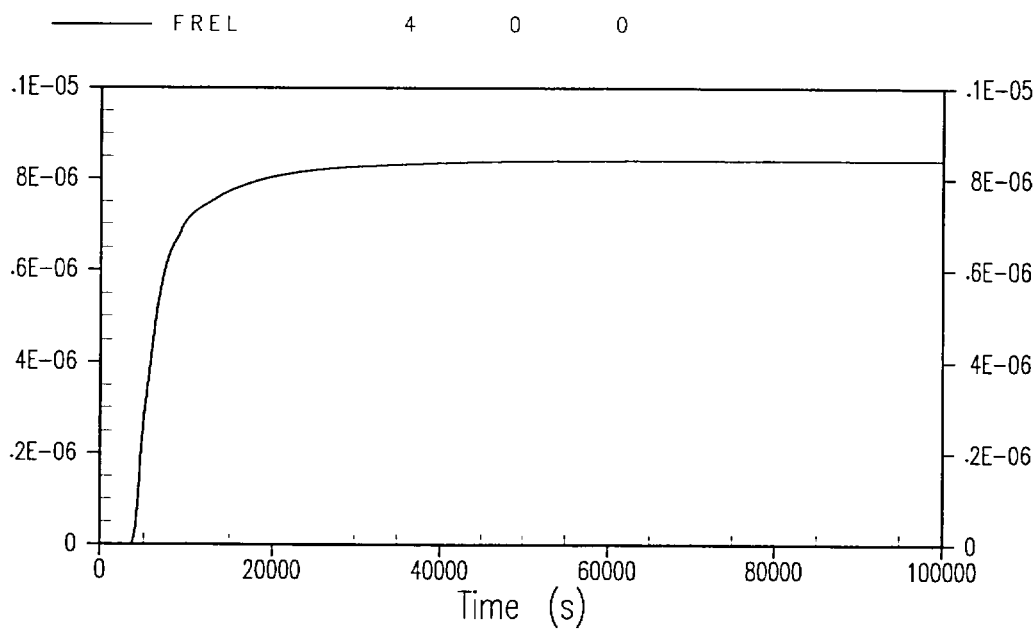

Figure 34-34

Case 3BE-2: Mass Fraction of SrO Released to Environment DVI Line Break, Fail Gravity Injection, No DVI Flooding

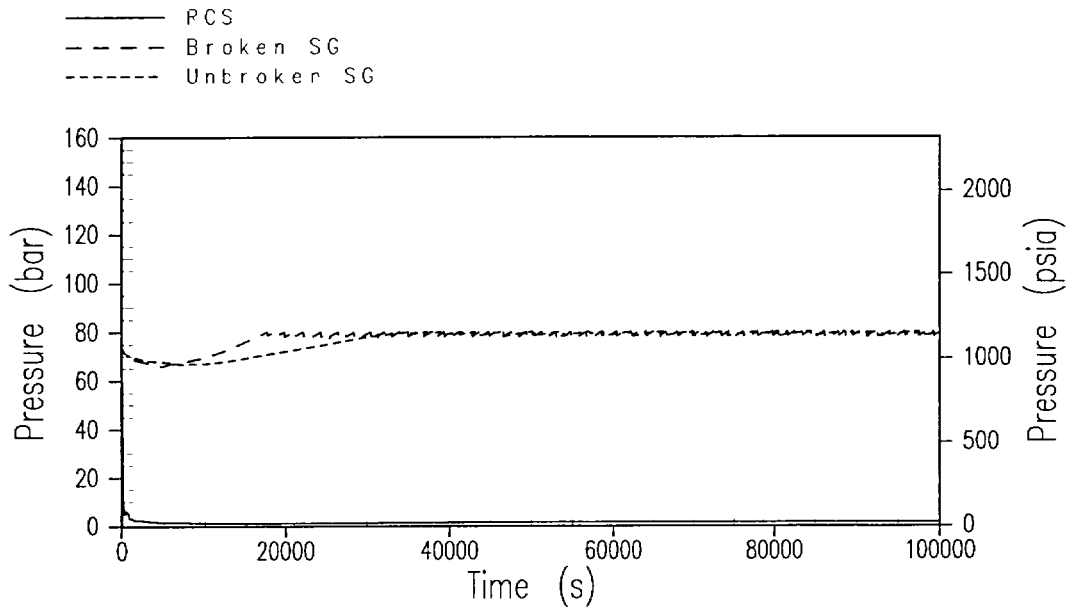

Figure 34-35

Case 3BE-4: Reactor Coolant System and Steam Generator Pressure Spurious ADS, Failed Gravity Injection

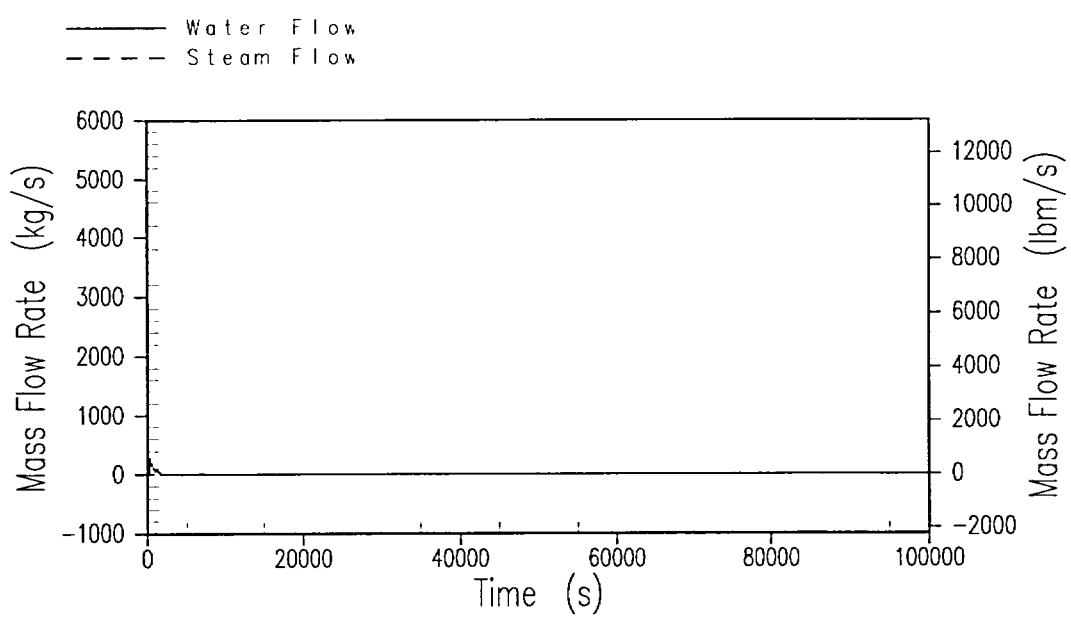

Figure 34-36

Case 3BE-4: ADS Stage 4 Flow Rates Spurious ADS, Failed Gravity Injection

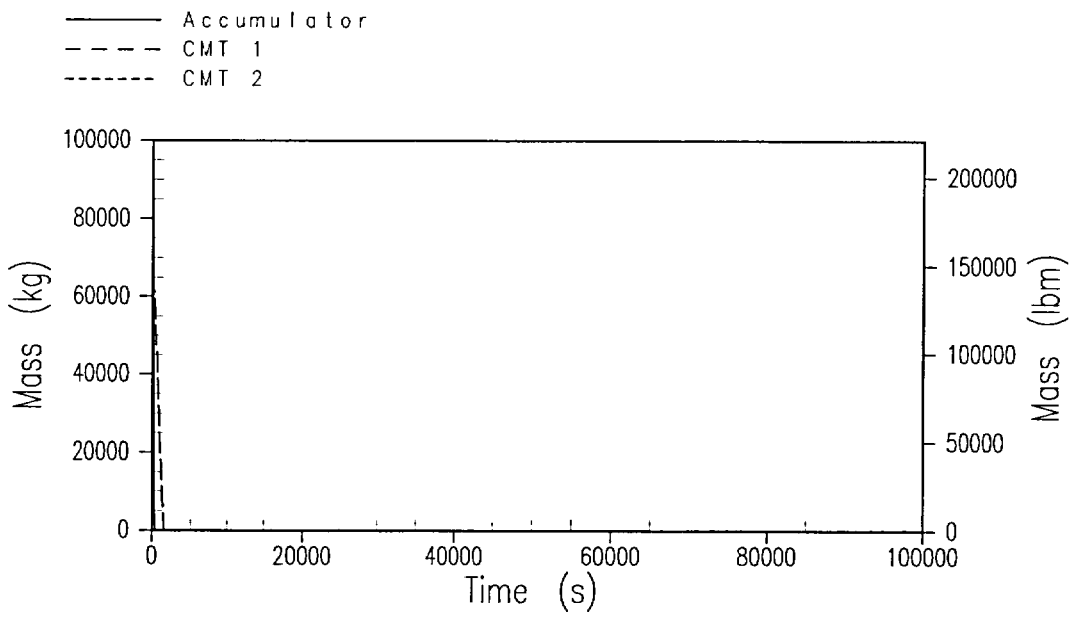

Figure 34-37

Case 3BE-4: Accumulator/CMT Water Mass Spurious ADS, Failed Gravity Injection

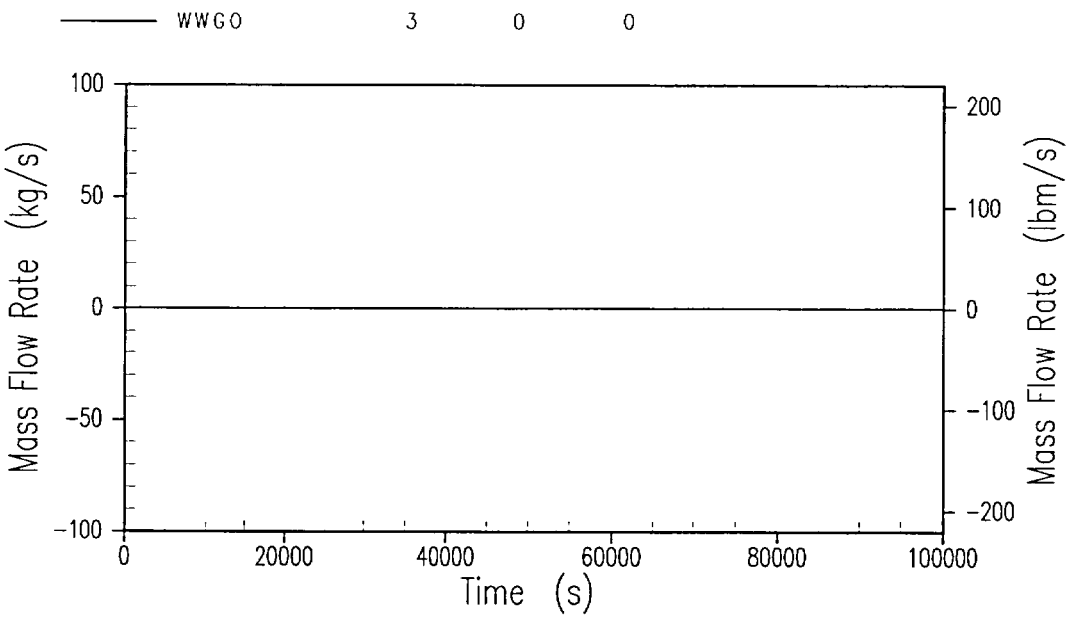

Figure 34-38

Case 3BE-4: IRWST Injection Flow Rate Spurious ADS, Failed Gravity Injection

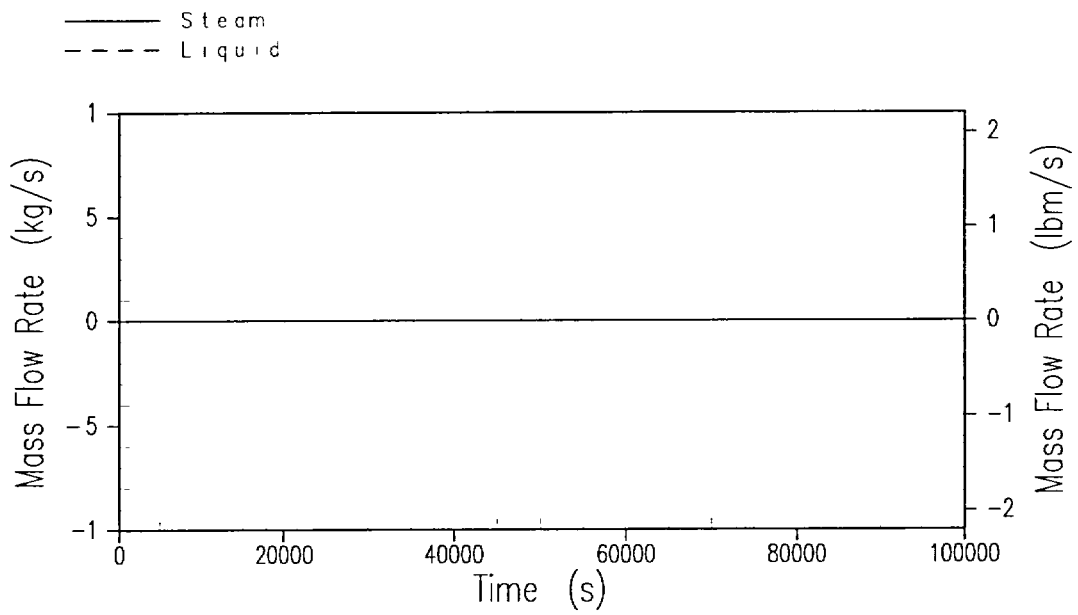

Figure 34-39

Case 3BE-4: Break Flow Rate
Spurious ADS, Failed Gravity Injection

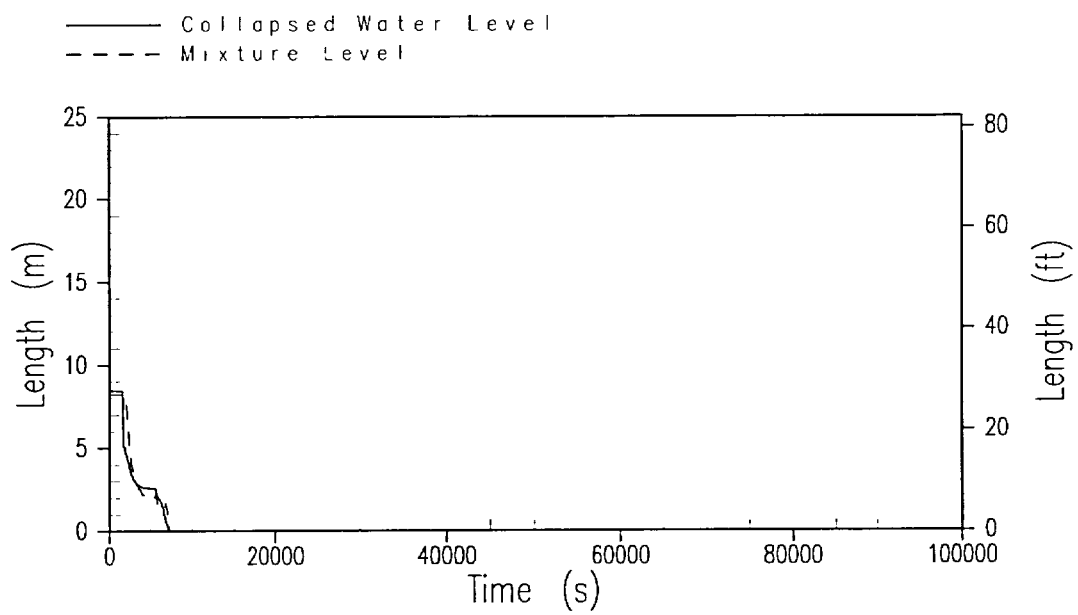

Figure 34-40

Case 3BE-4: Reactor Vessel Water Level
Spurious ADS, Failed Gravity Injection

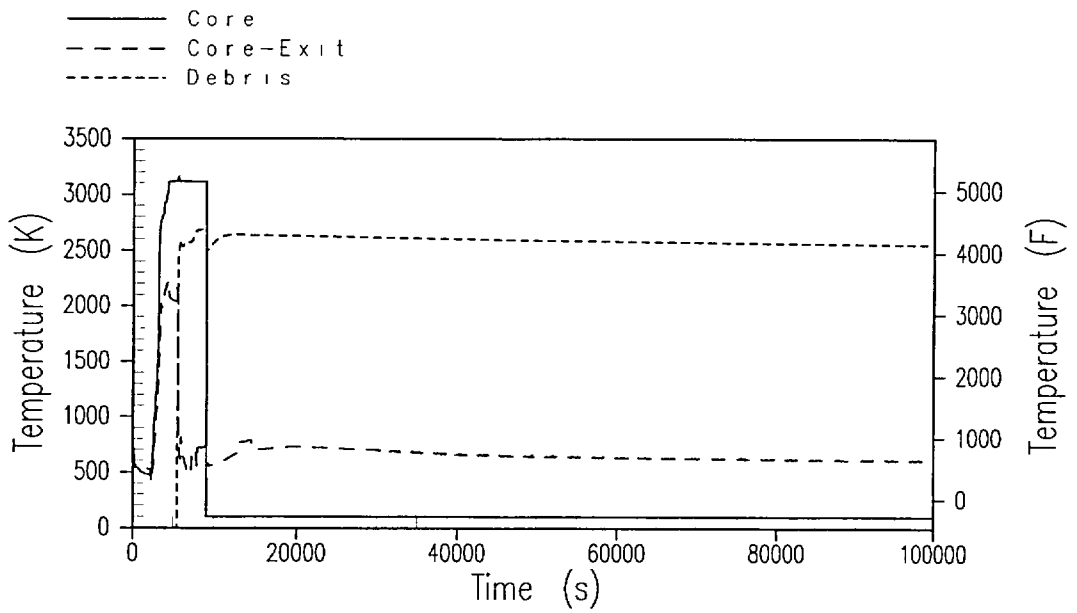

Figure 34-41

Case 3BE-4: Core Temperatures
Spurious ADS, Failed Gravity Injection

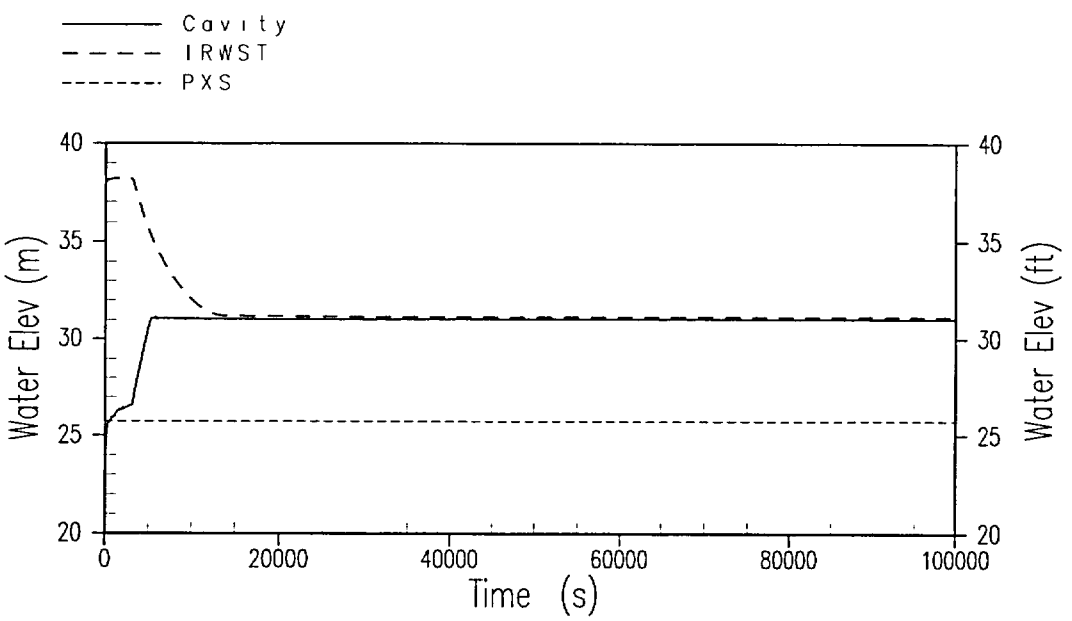

Figure 34-42

Case 3BE-4: Containment Water Pool Elevations
Spurious ADS, Failed Gravity Injection

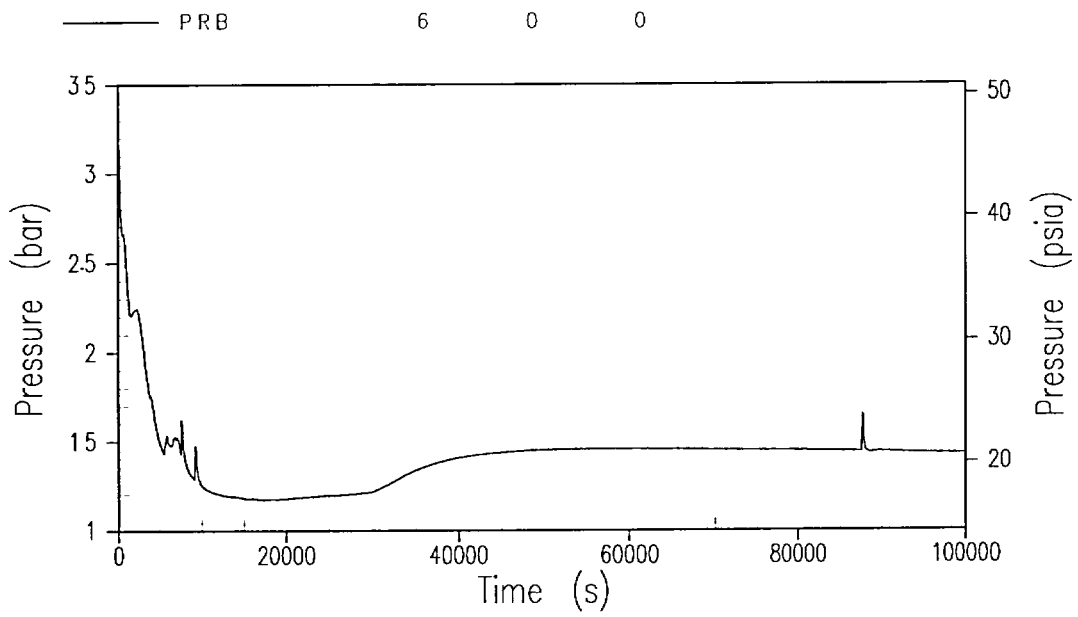

Figure 34-43

Case 3BE-4: Containment Pressure Spurious ADS, Failed Gravity Injection

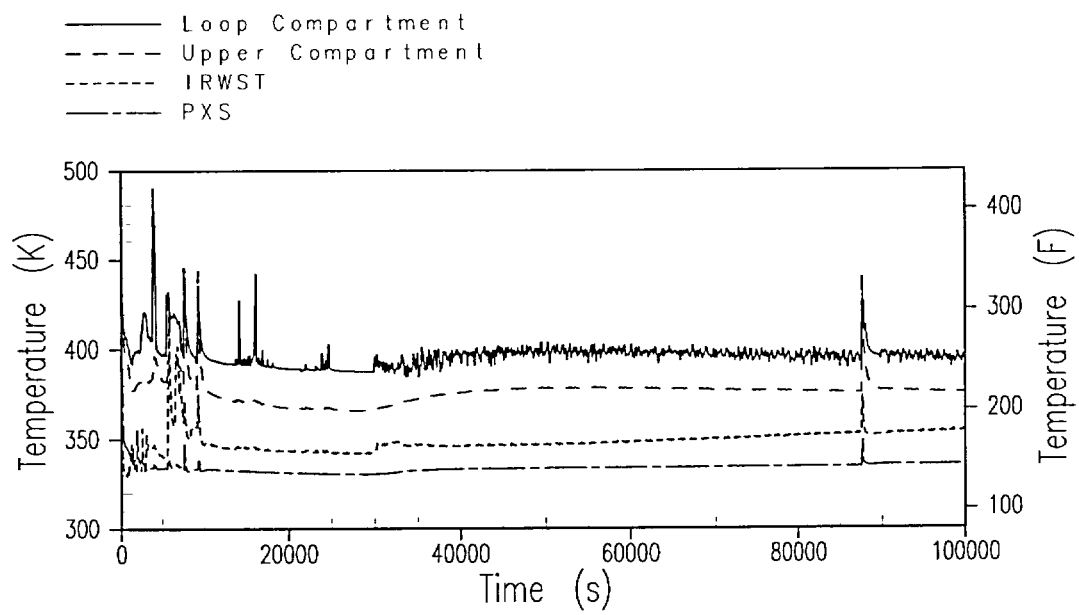

Figure 34-44

Case 3BE-4: Containment Gas Temperatures Spurious ADS, Failed Gravity Injection

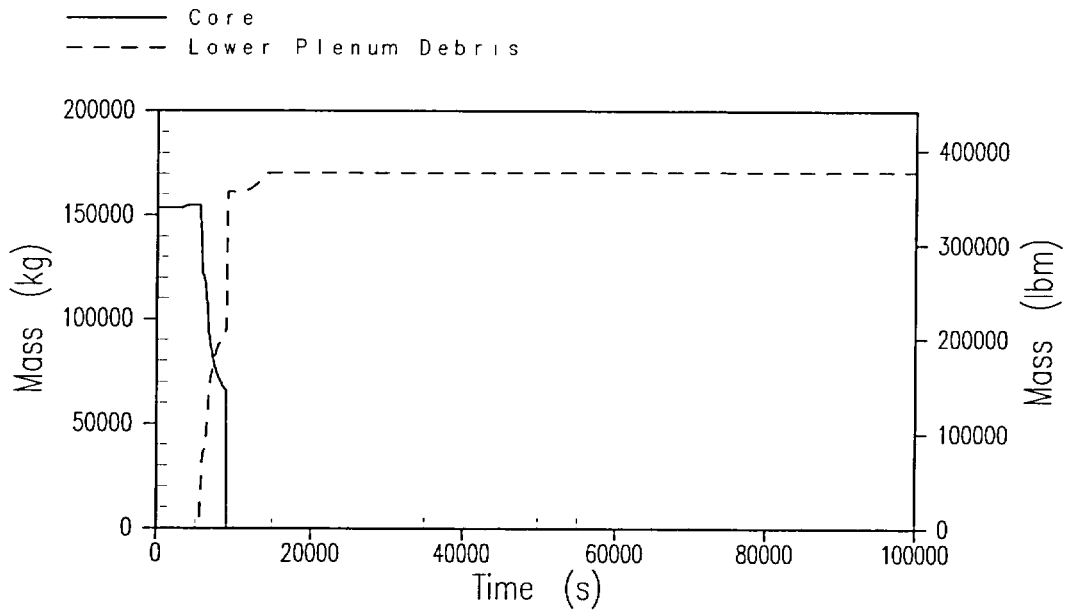

Figure 34-45

Case 3BE-4: Core Mass
Spurious ADS, Failed Gravity Injection

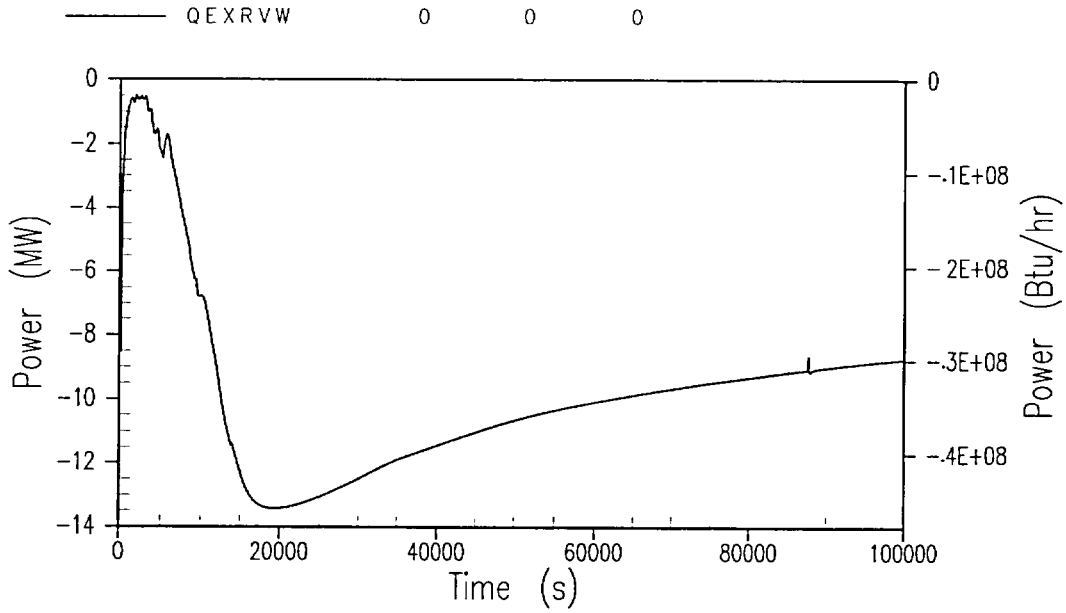

Figure 34-46

Case 3BE-4: Reactor Pressure Vessel to Cavity Water Heat Transfer
Spurious ADS, Failed Gravity Injection

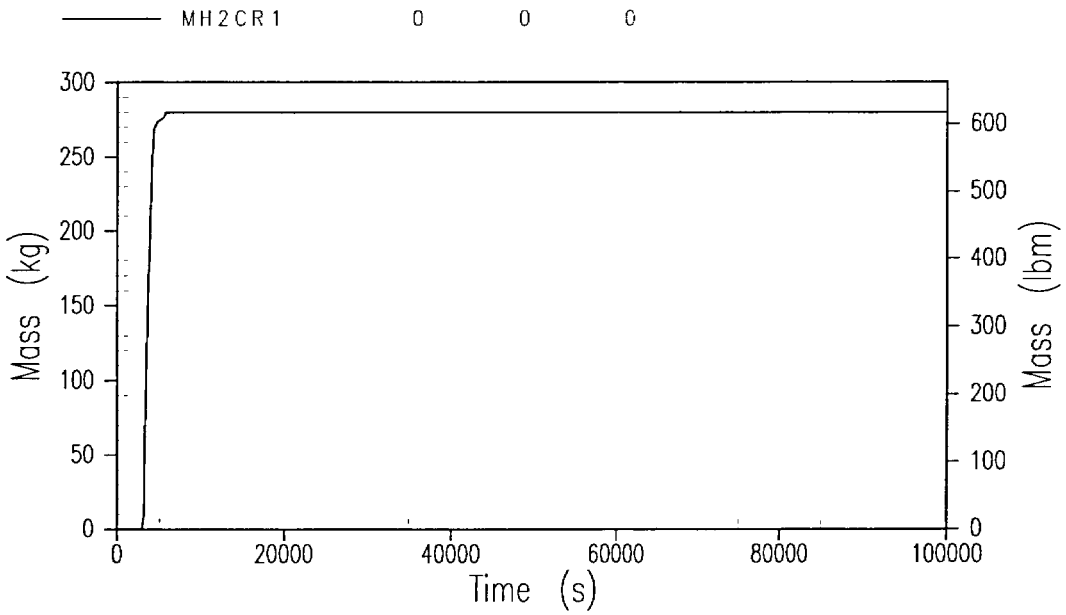

Figure 34-47

Case 3BE-4: In-Vessel Hydrogen Generation Spurious ADS, Failed Gravity Injection

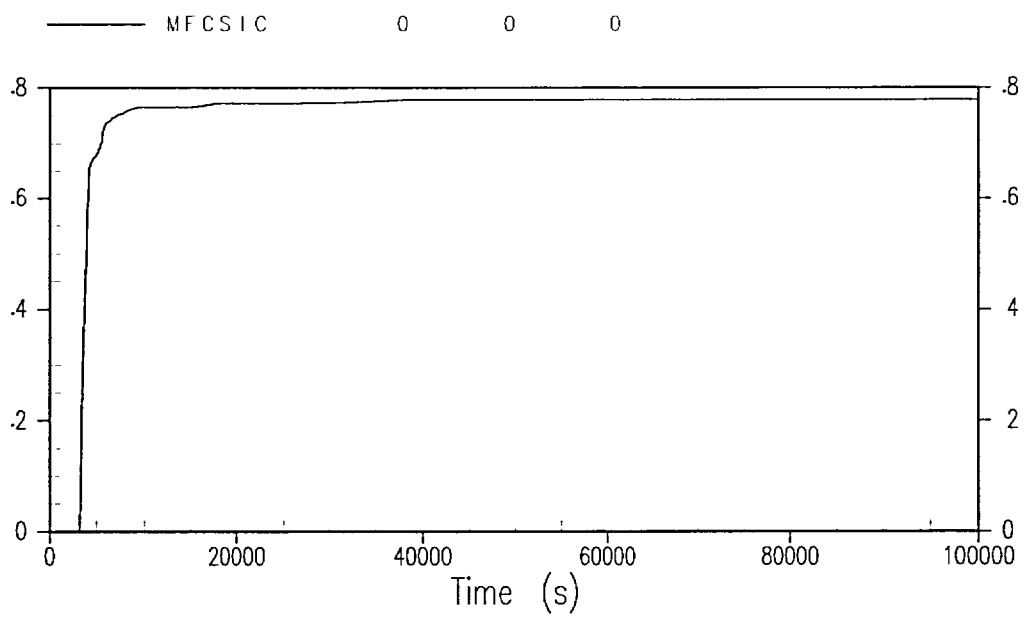

Figure 34-48

Case 3BE-4: Mass Fraction of CsI Released to Containment Spurious ADS, Failed Gravity Injection

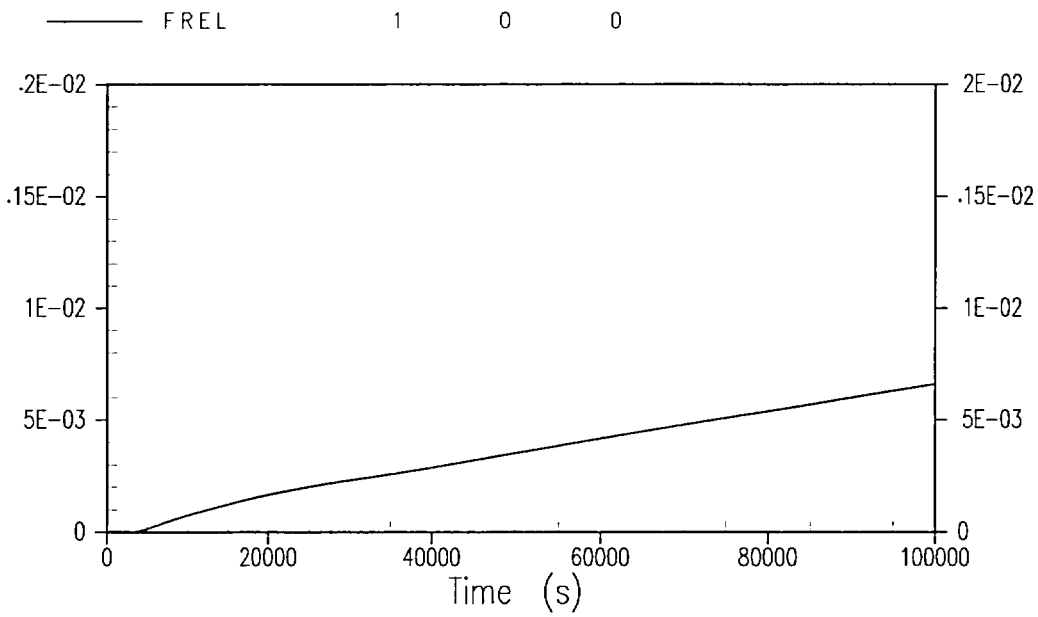

Figure 34-49

Case 3BE-4: Mass Fraction of Noble Gases Released to Environment Spurious ADS, Failed Gravity Injection

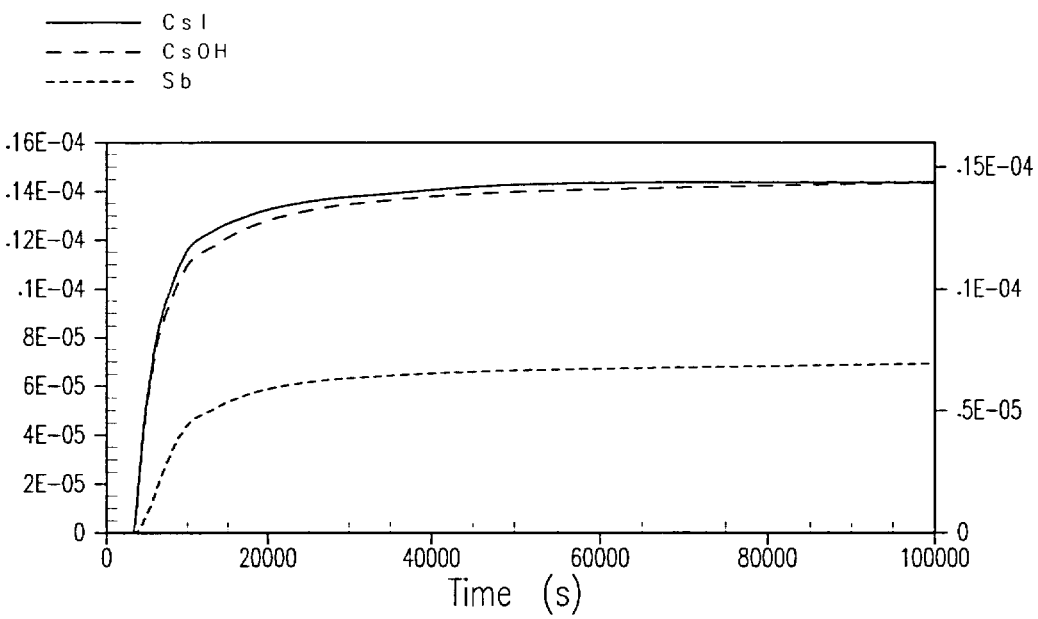

Figure 34-50

Case 3BE-4: Mass Fraction of Fission Products Released to Environment Spurious ADS, Failed Gravity Injection

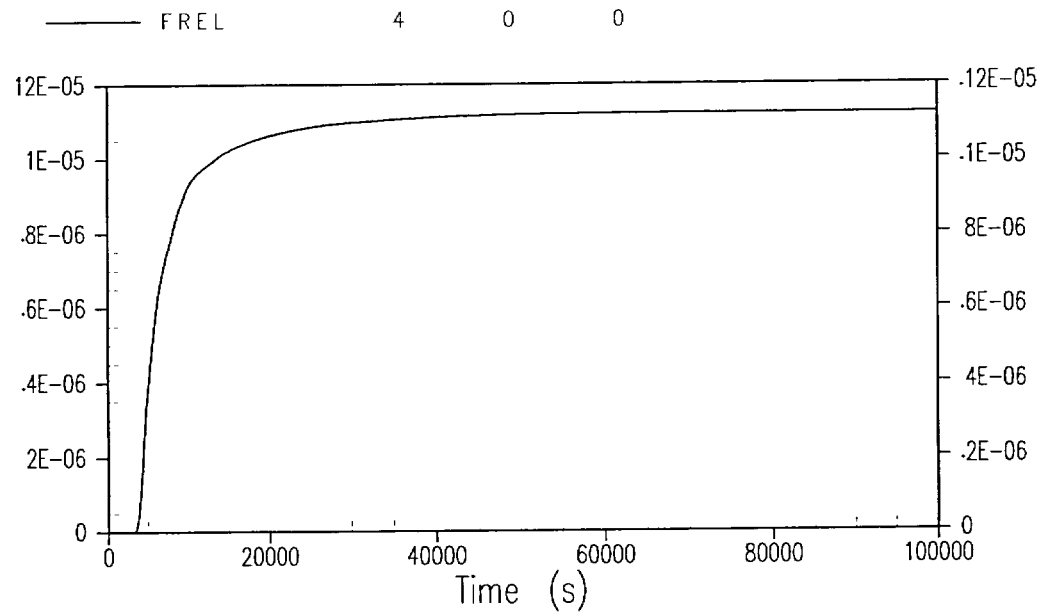

Figure 34-51

Case 3BE-4: Mass Fraction of SrO Released to Environment Spurious ADS, Failed Gravity Injection

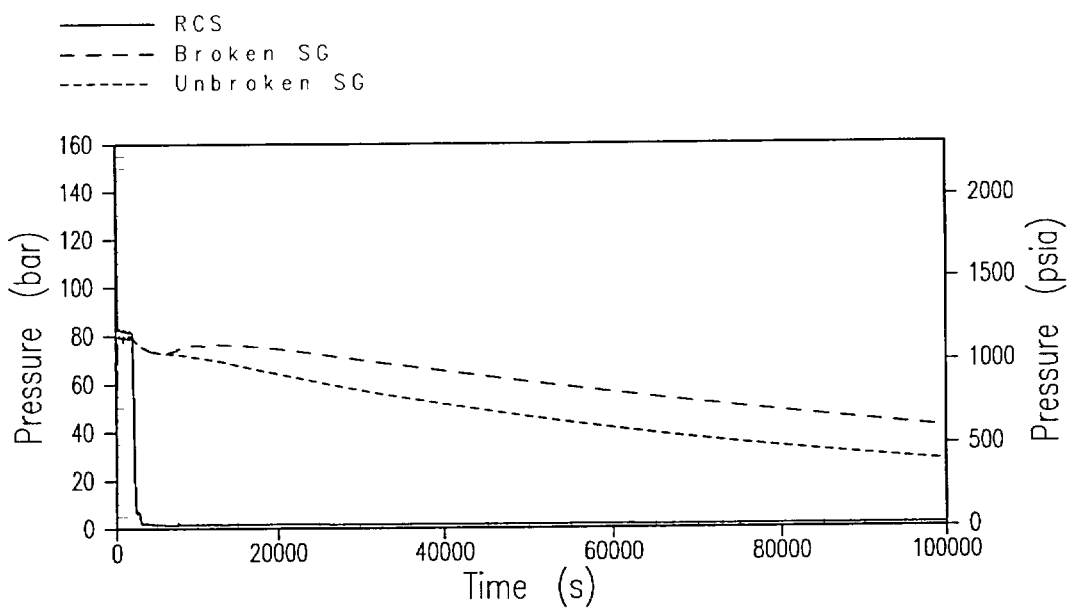

Figure 34-52

Case 3BE-5: Reactor Coolant System and Steam Generator Pressure SBLOCA with Failed Gravity Injection

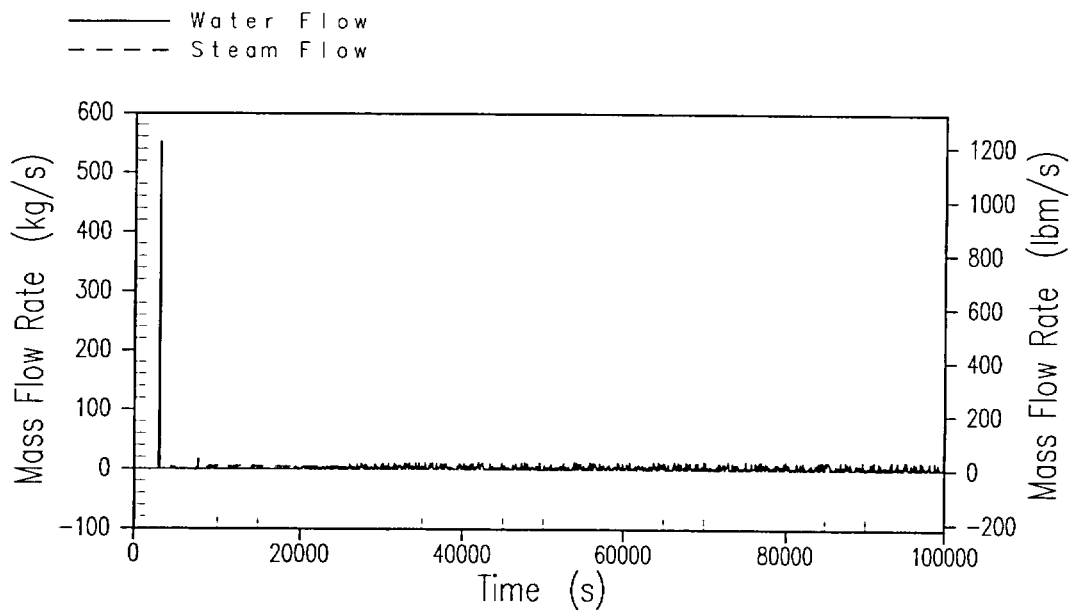

Figure 34-53

Case 3BE-5: ADS Stage 4 Flow Rates
SBLOCA with Failed Gravity Injection

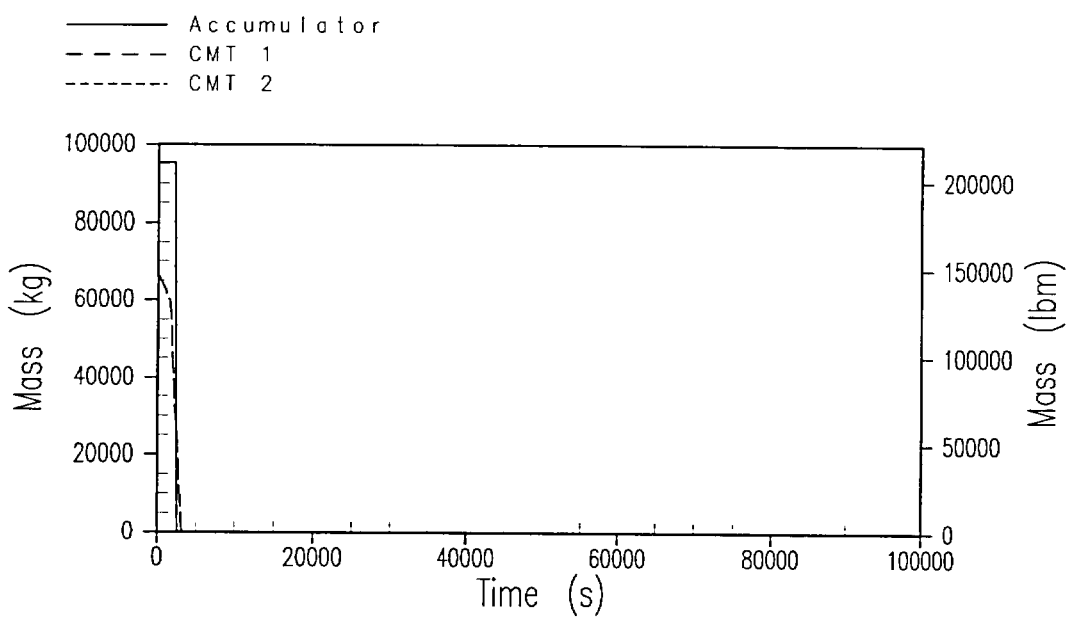

Figure 34-54

Case 3BE-5: Accumulator/CMT Water Mass
SBLOCA with Failed Gravity Injection

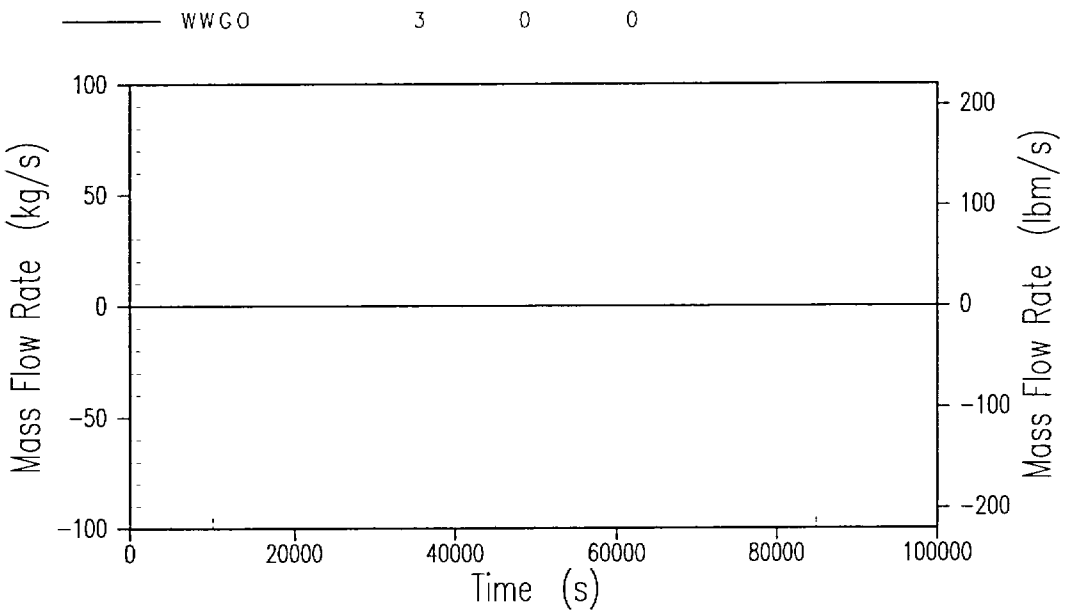

Figure 34-55

Case 3BE-5: IRWST Injection Flow Rate
SBLOCA with Failed Gravity Injection

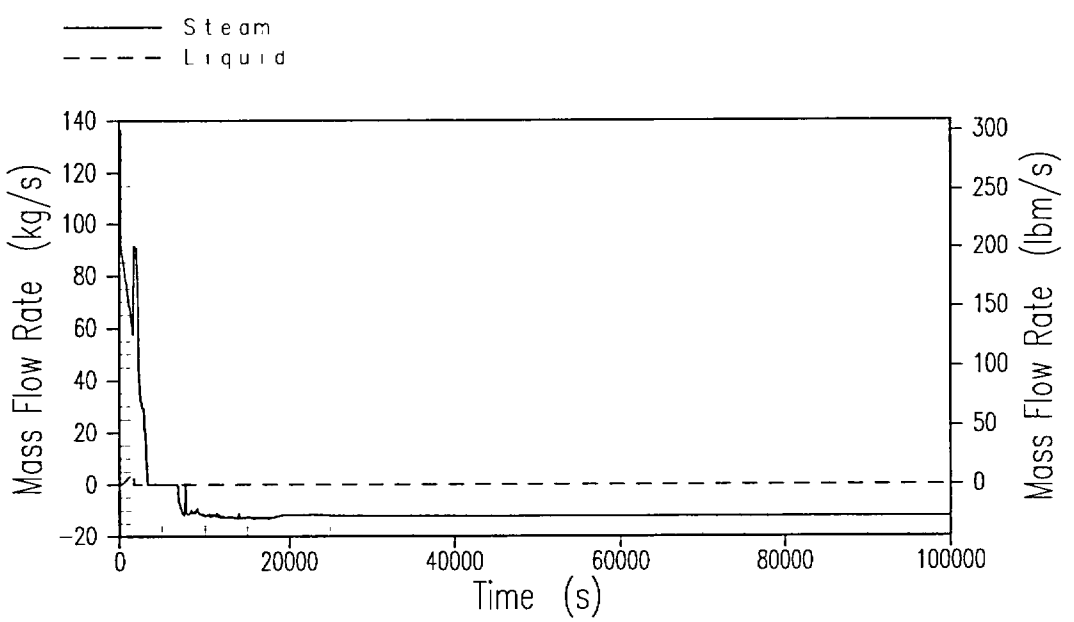

Figure 34-56

Case 3BE-5: Break Flow Rate
SBLOCA with Failed Gravity Injection

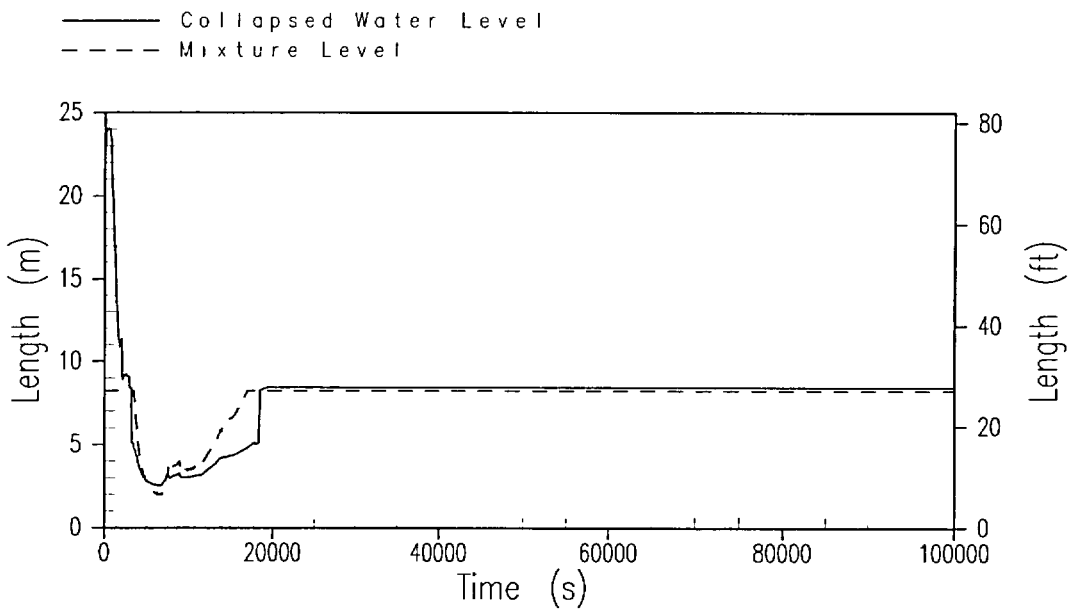

Figure 34-57

Case 3BE-5: Reactor Vessel Water Level SBLOCA with Failed Gravity Injection

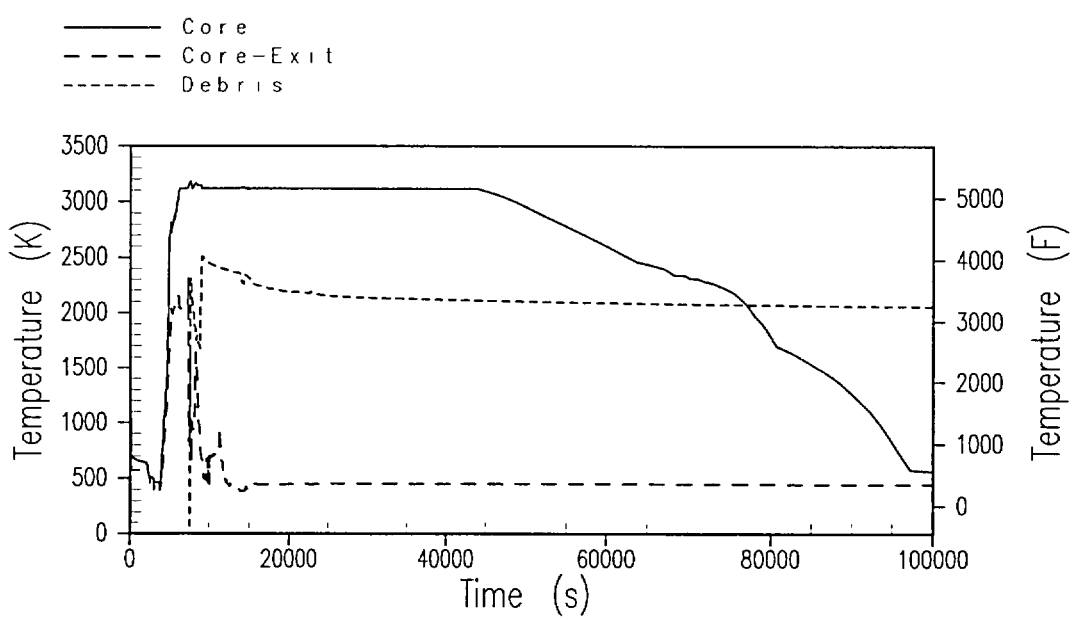

Figure 34-58

Case 3BE-5: Core Temperatures SBLOCA with Failed Gravity Injection

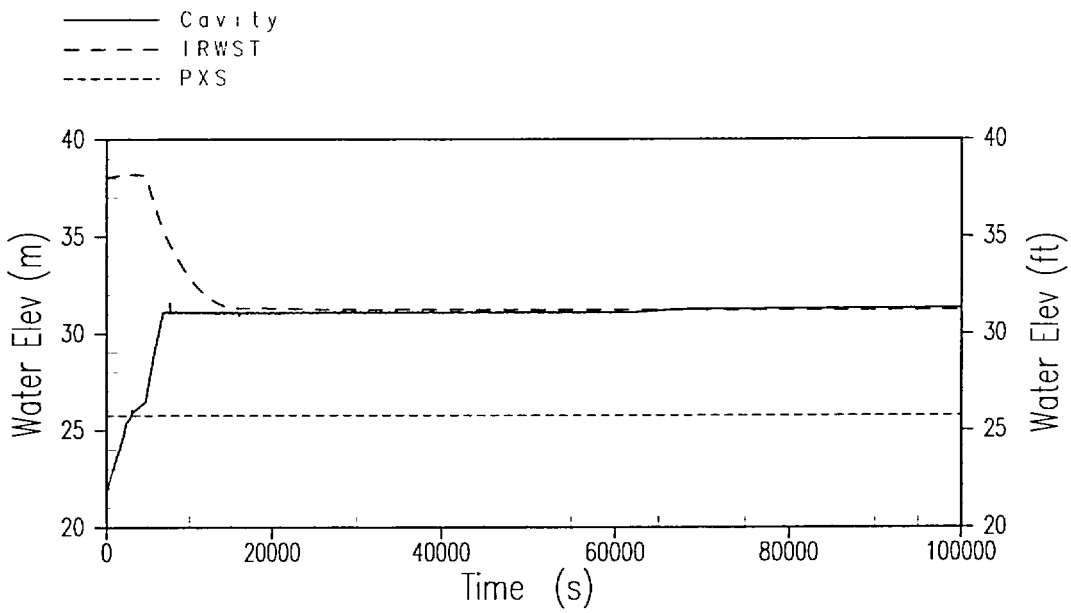

Figure 34-59

Case 3BE-5: Containment Water Pool Elevations SBLOCA with Failed Gravity Injection

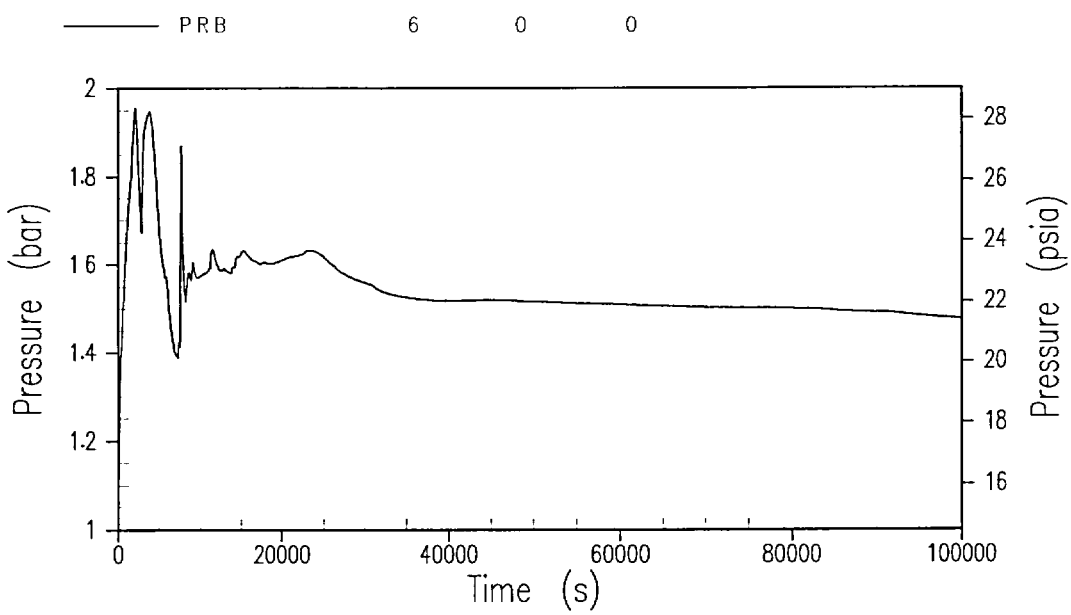

Figure 34-60

Case 3BE-5: Containment Pressure SBLOCA with Failed Gravity Injection

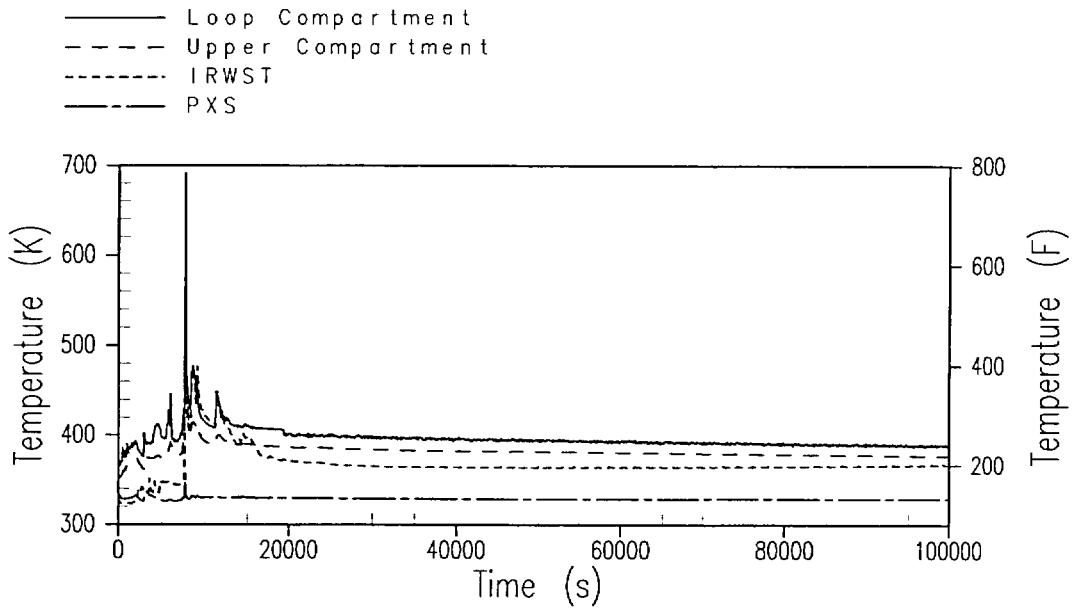

Figure 34-61

Case 3BE-5: Containment Gas Temperature SBLOCA with Failed Gravity Injection

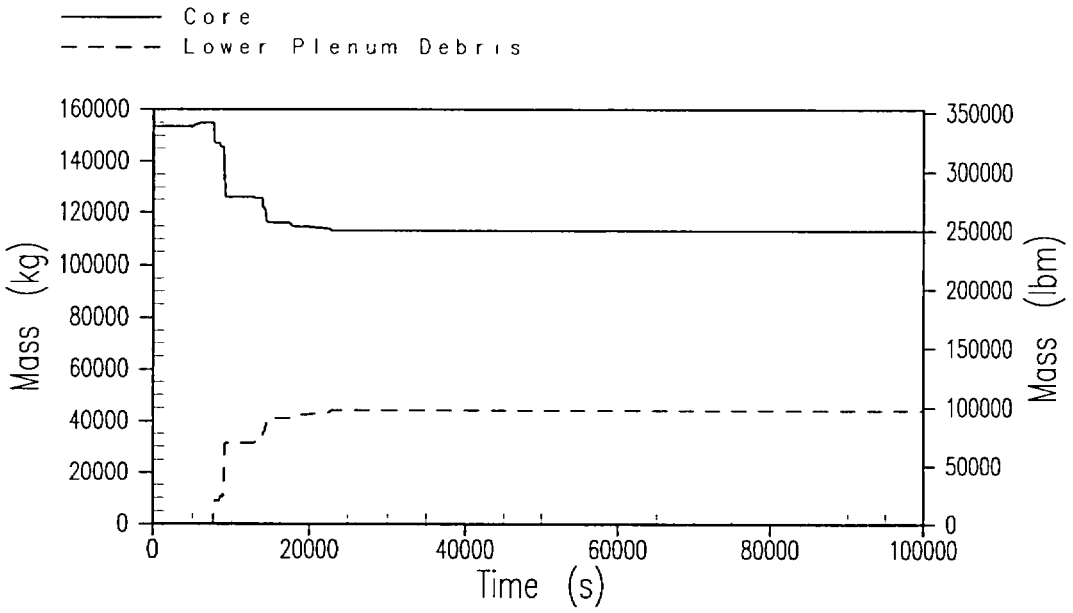

Figure 34-62

Case 3BE-5: Core Mass SBLOCA with Failed Gravity Injection

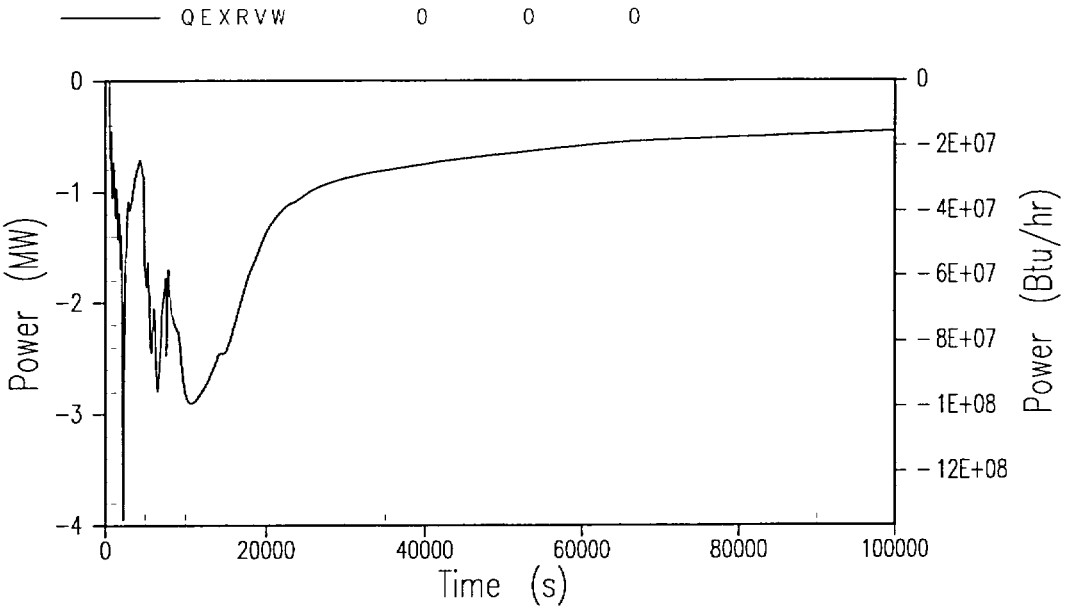

Figure 34-63

Case 3BE-5: Reactor Pressure Vessel to Cavity Water Heat Transfer SBLOCA with Failed Gravity Injection

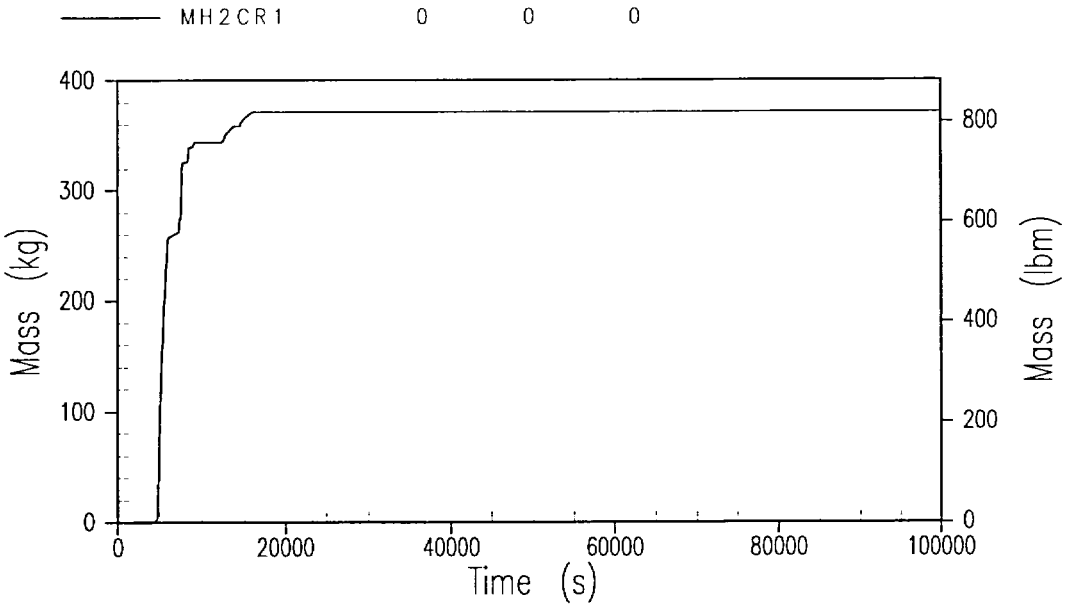

Figure 34-64

Case 3BE-5: In-Vessel Hydrogen Generation SBLOCA with Failed Gravity Injection

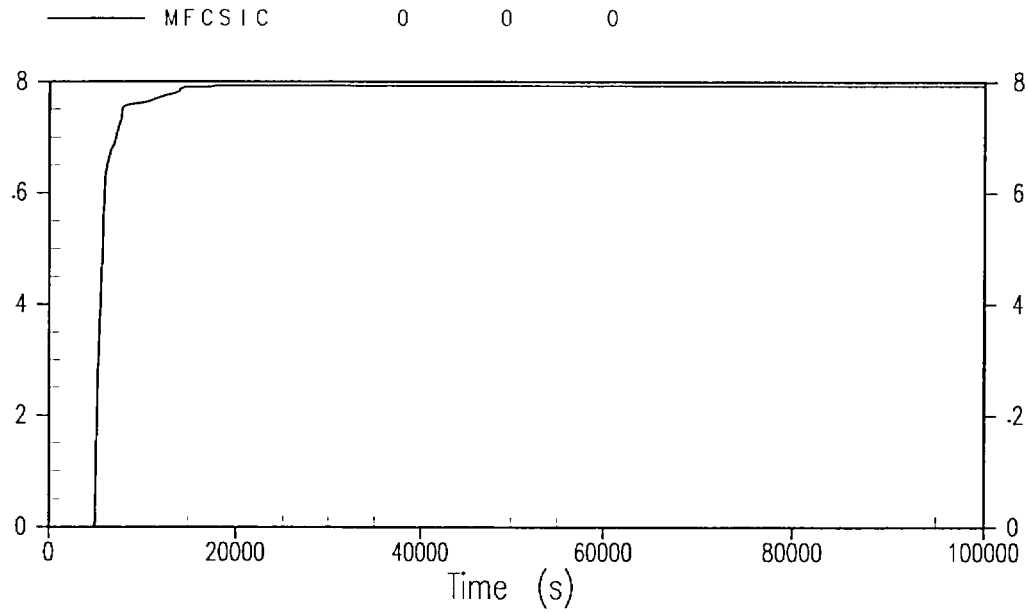

Figure 34-65

Case 3BE-5: Mass Fraction of CsI Released to Containment SBLOCA with Failed Gravity Injection

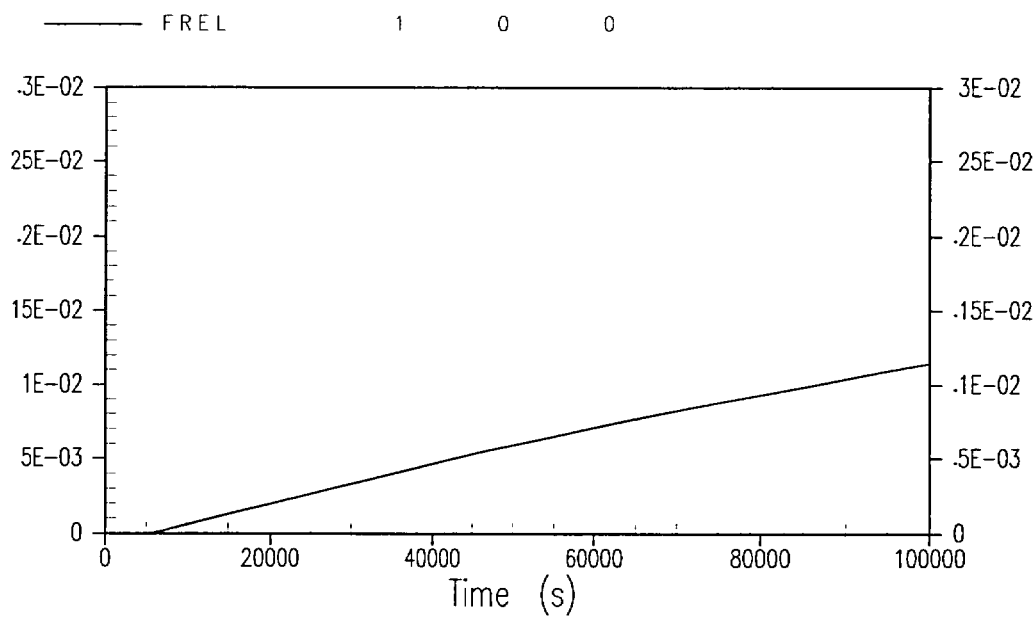

Figure 34-66

Case 3BE-5: Mass Fraction of Noble Gases Released to Environment SBLOCA with Failed Gravity Injection

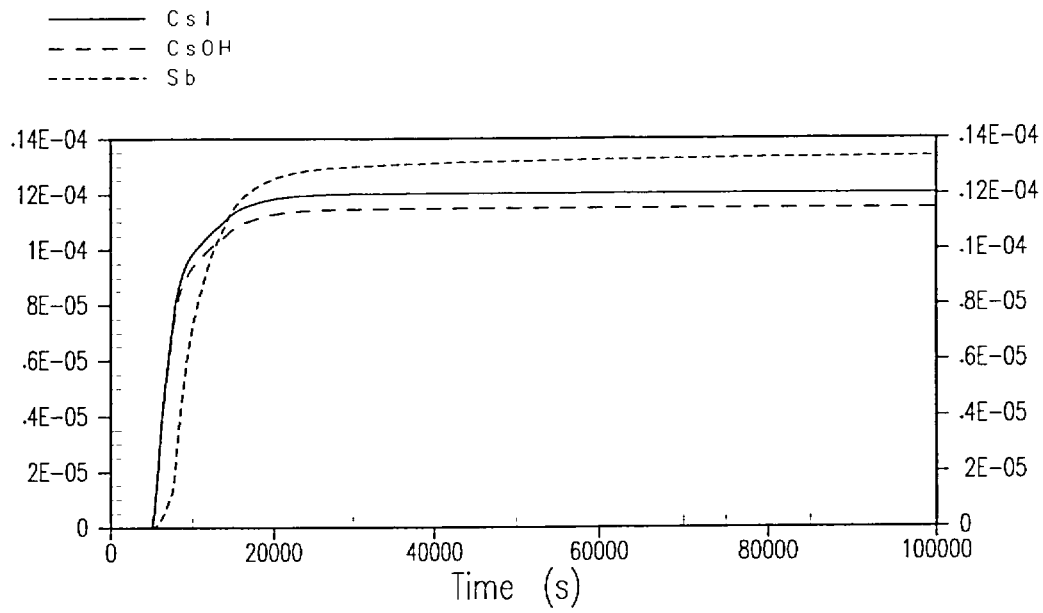

Figure 34-67

Case 3BE-5: Mass Fraction of Fission Products Released to Environment SBLOCA with Failed Gravity Injection

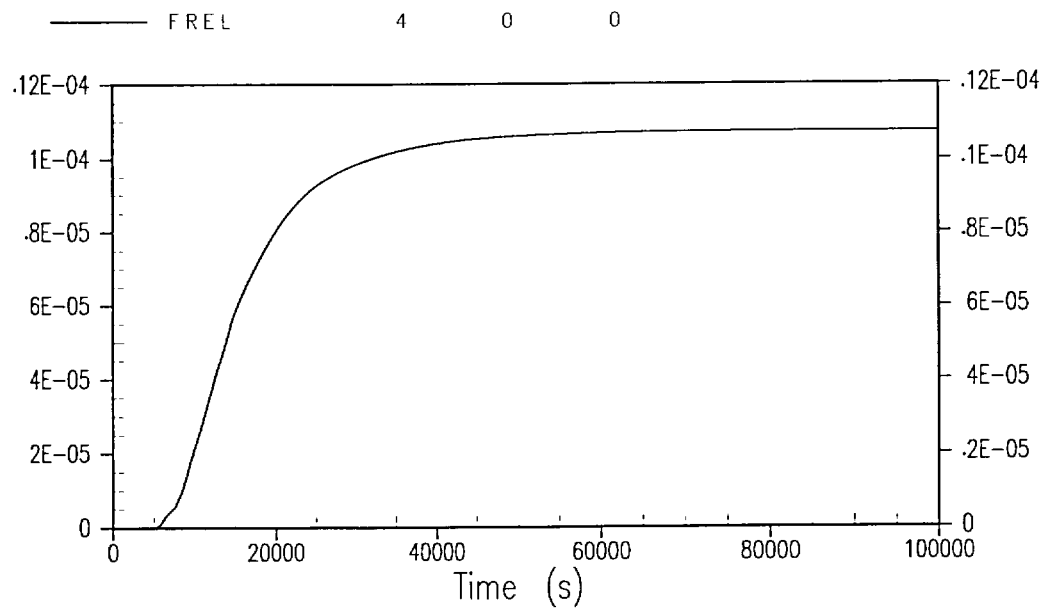

Figure 34-68

Case 3BE-5: Mass Fraction of SrO Released to Environment SBLOCA with Failed Gravity Injection

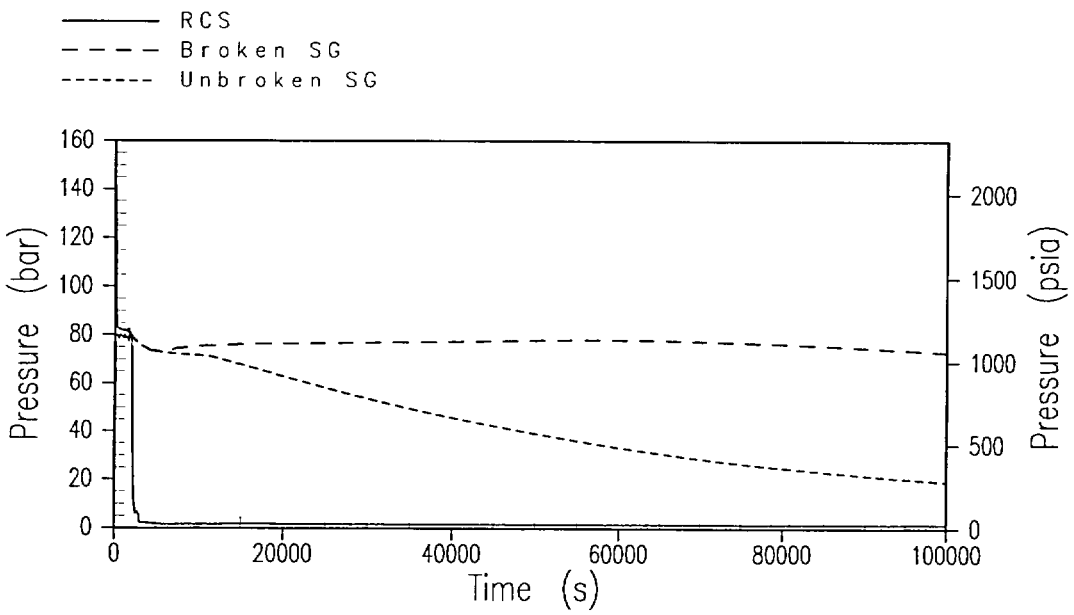

Figure 34-69

Case 3BE-6: Reactor Coolant System and Steam Generator Pressure SBLOCA with Failed Gravity Injection

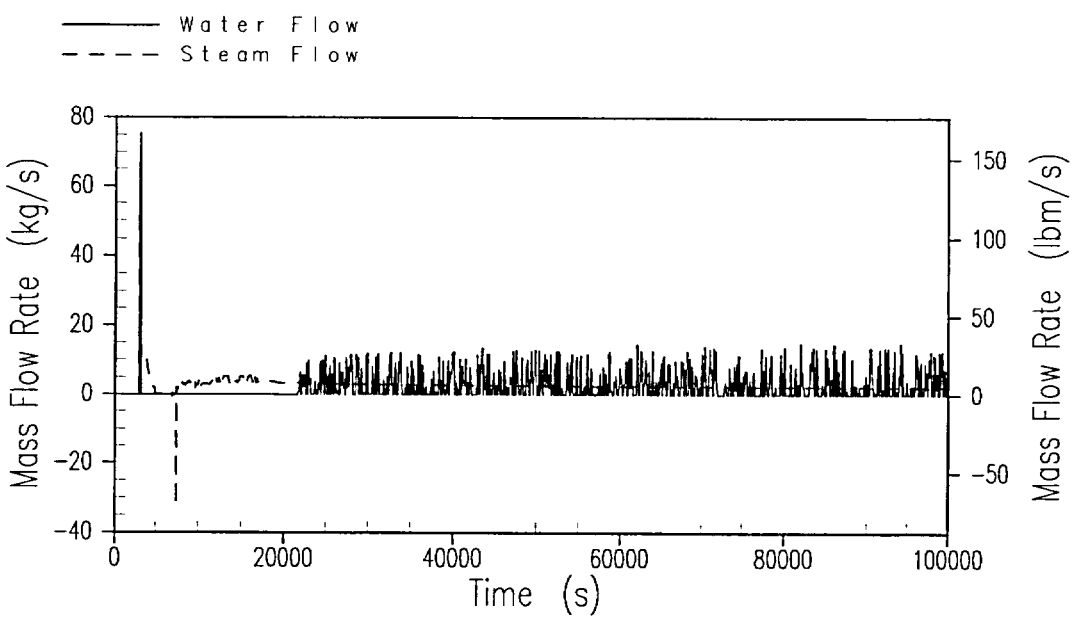

Figure 34-70

Case 3BE-6: ADS Stage 4 Flow Rates SBLOCA with Failed Gravity Injection

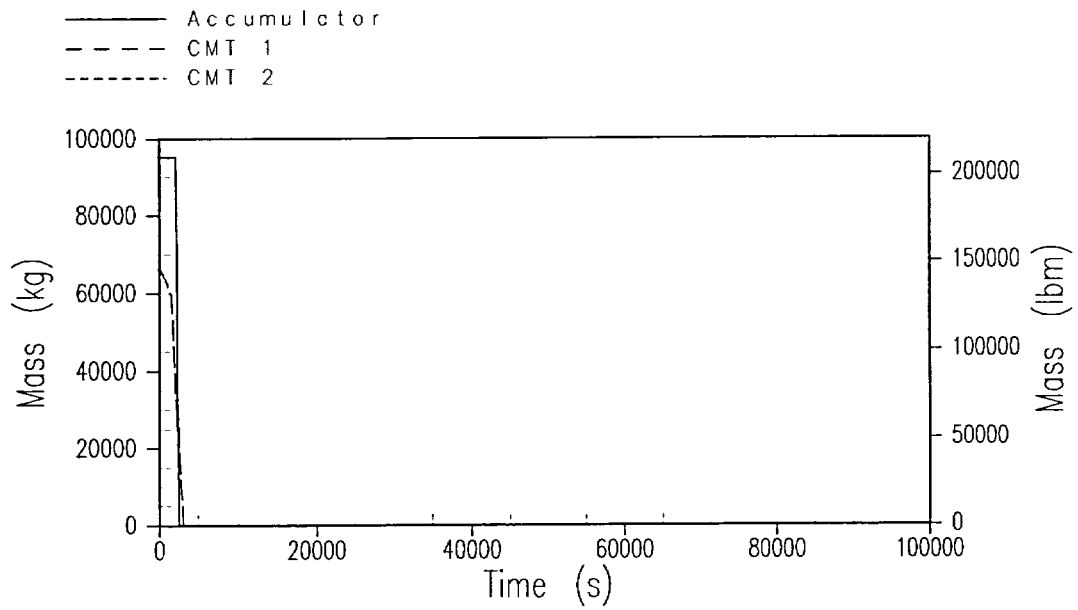

Figure 34-71

Case 3BE-6: Accumulator/CMT Water Mass SBLOCA with Failed Gravity Injection

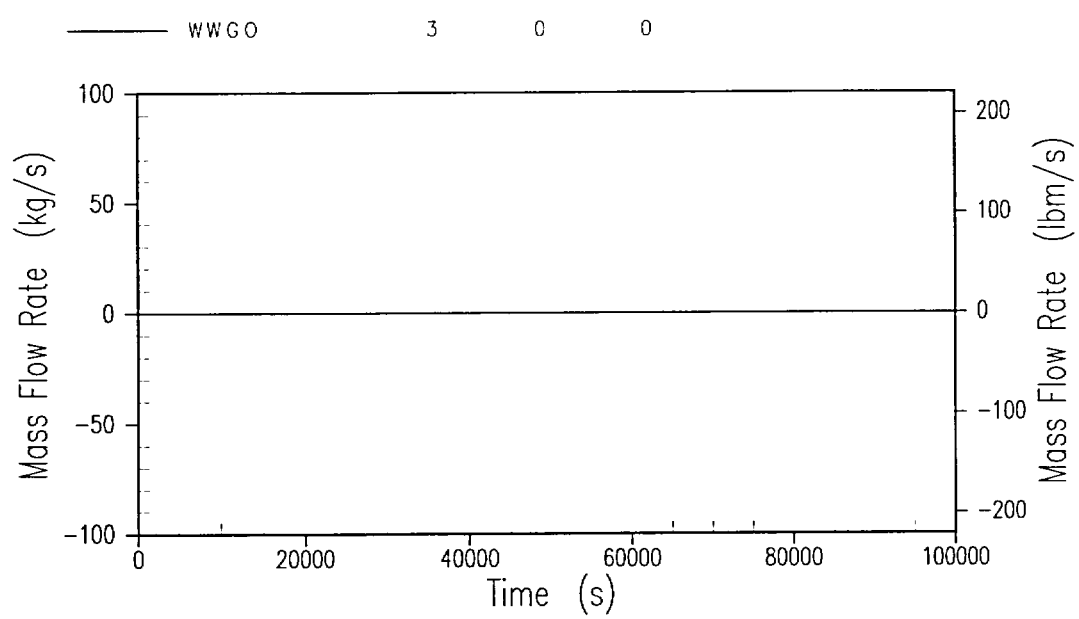

Figure 34-72

Case 3BE-6: IRWST Injection Flow Rate SBLOCA with Failed Gravity Injection

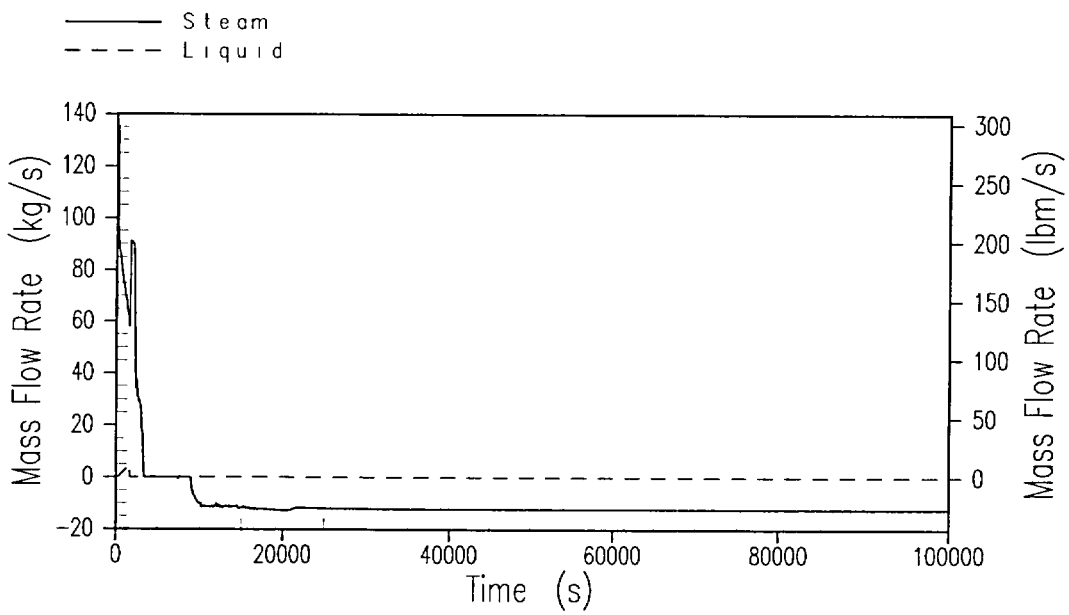

Figure 34-73

Case 3BE-6: Break Flow Rate SBLOCA with Failed Gravity Injection

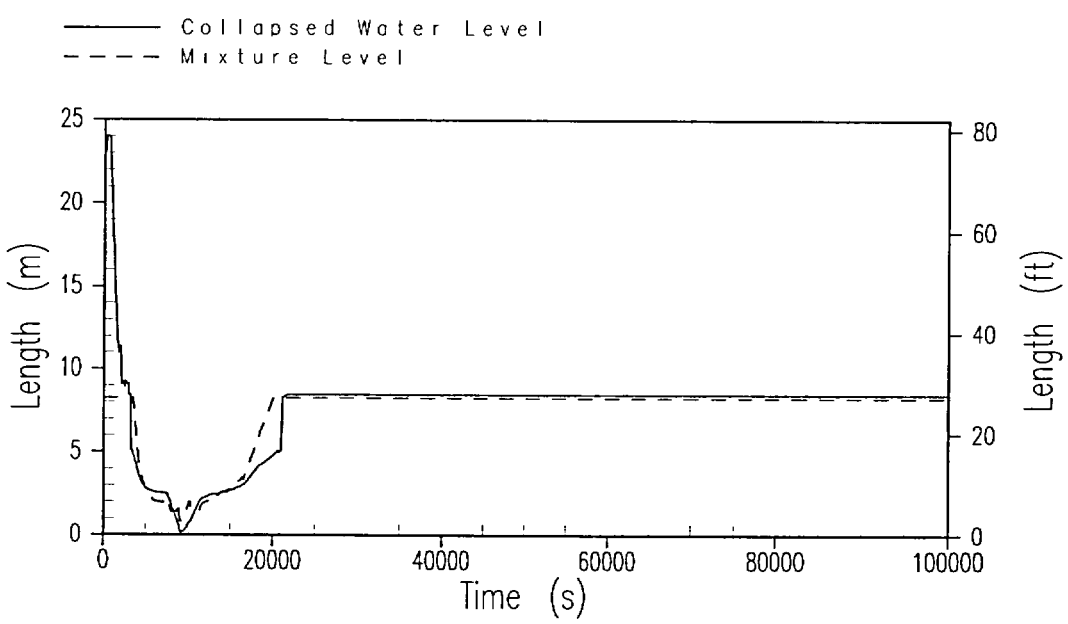

Figure 34-74

Case 3BE-6: Reactor Vessel Water Level SBLOCA with Failed Gravity Injection

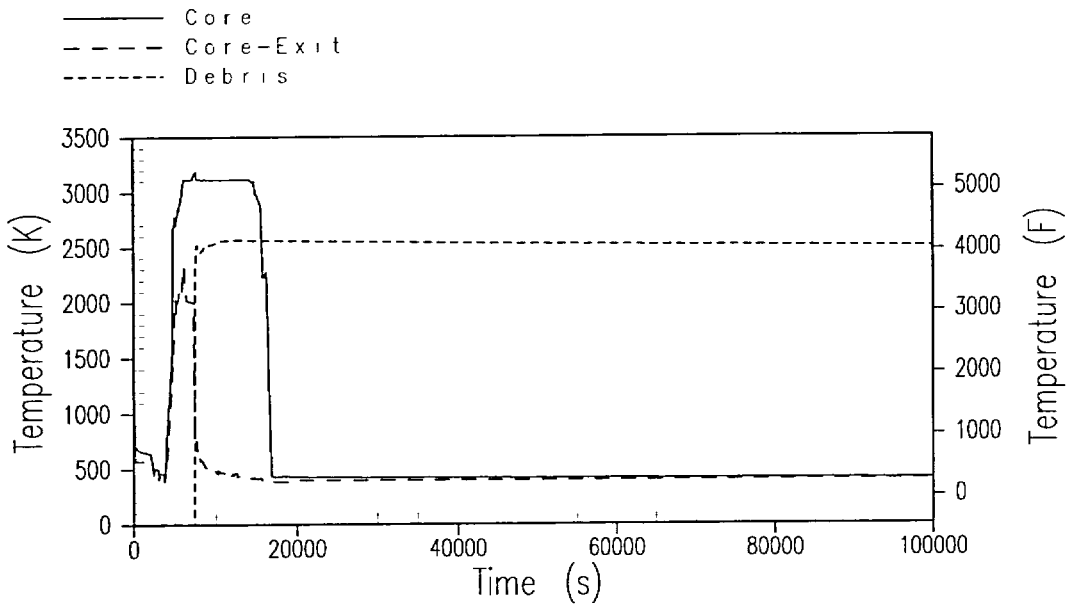

Figure 34-75

Case 3BE-6: Core Temperatures
SBLOCA with Failed Gravity Injection

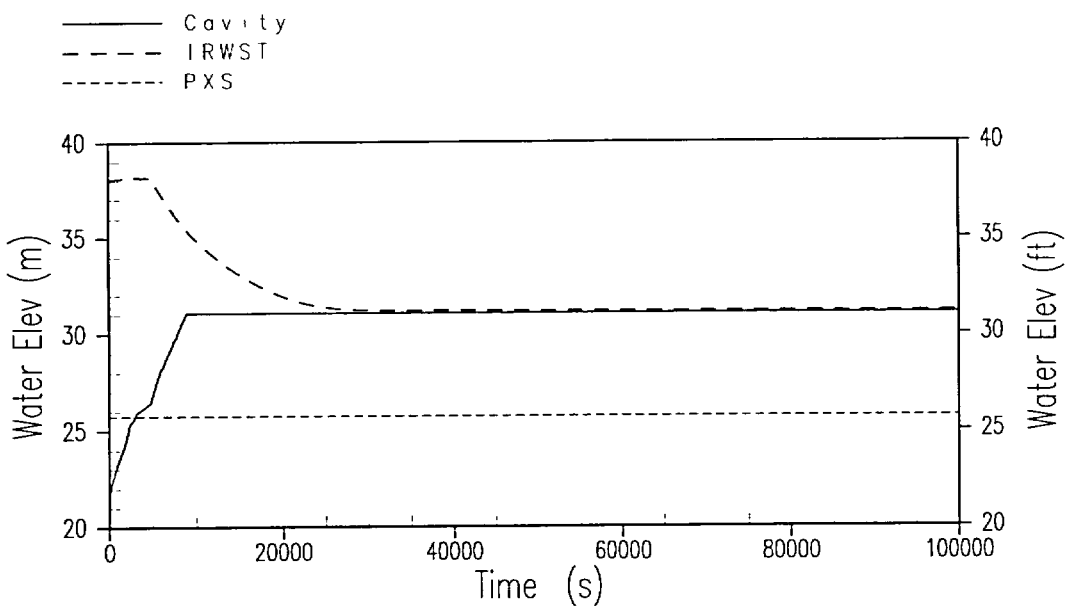

Figure 34-76

Case 3BE-6: Containment Water Pool Elevations
SBLOCA with Failed Gravity Injection

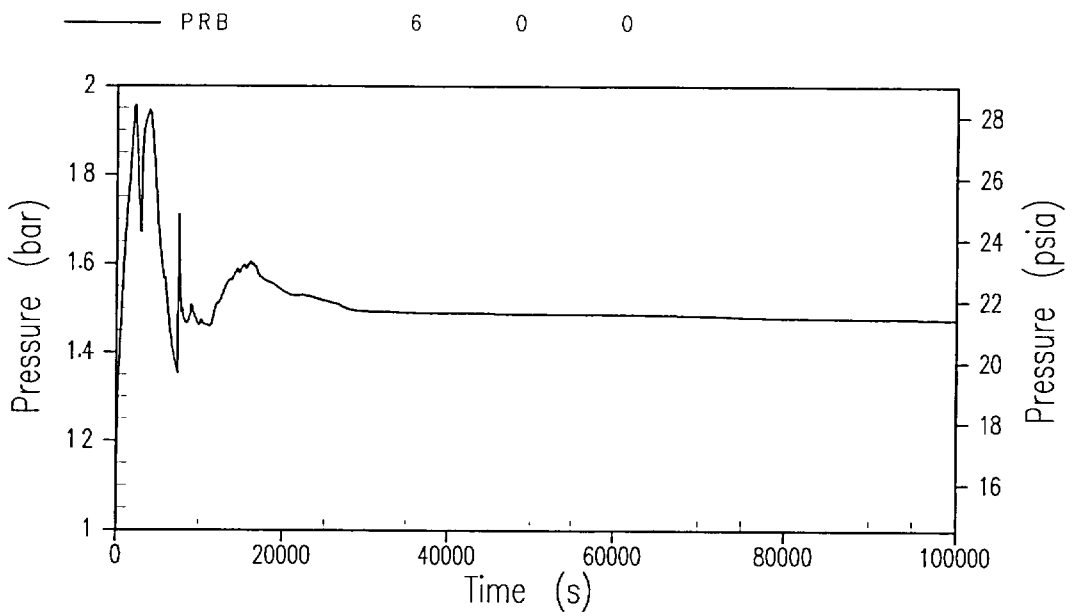

Figure 34-77

Case 3BE-6: Containment Pressure SBLOCA with Failed Gravity Injection

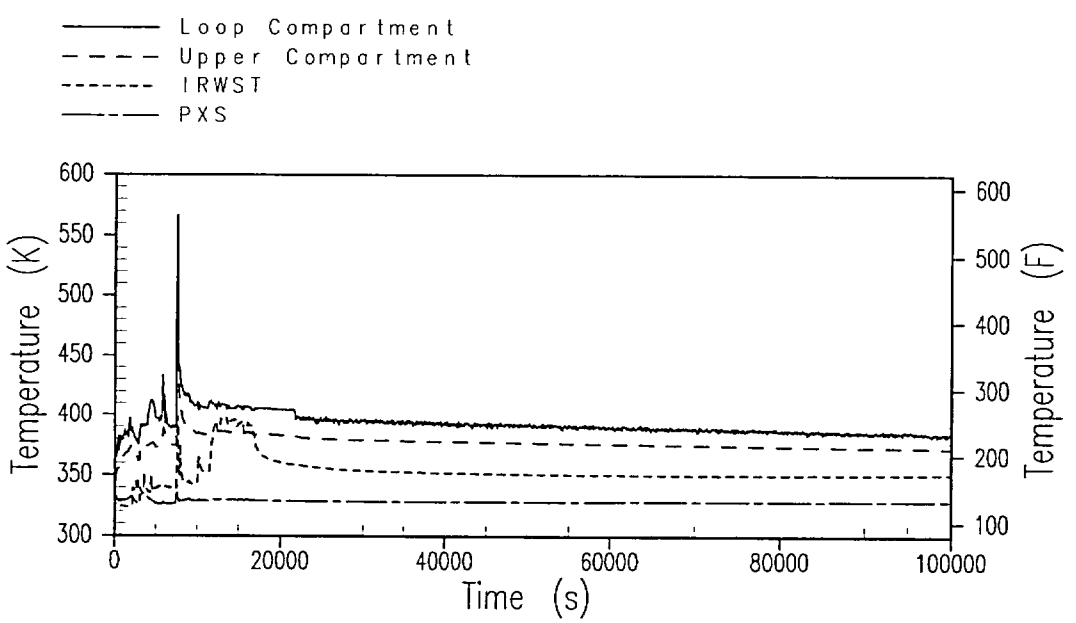

Figure 34-78

Case 3BE-6: Containment Gas Temperature SBLOCA with Failed Gravity Injection

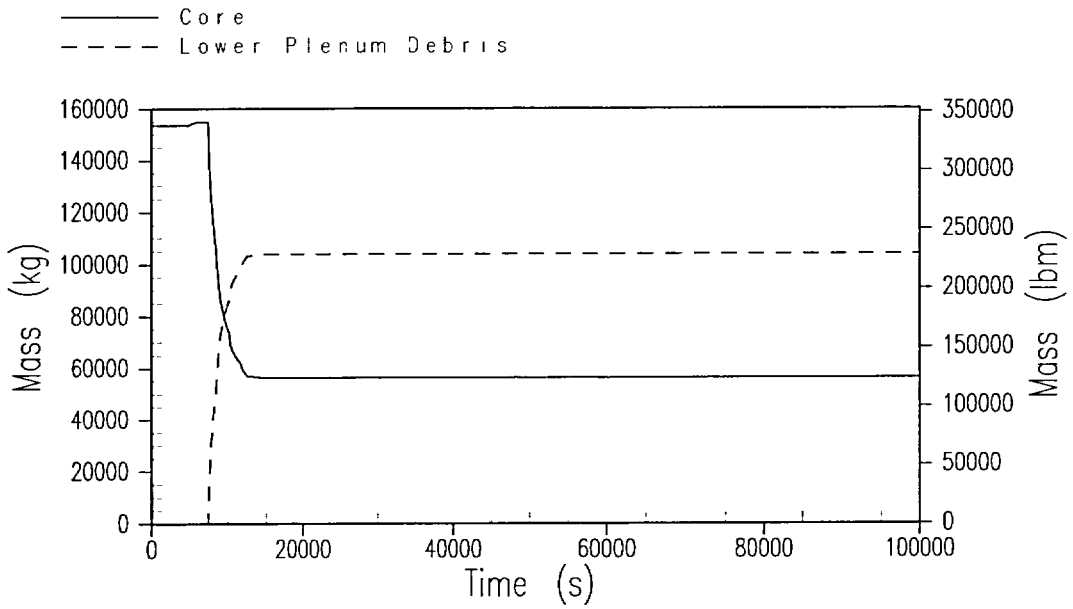

Figure 34-79

Case 3BE-6: Core Mass
SBLOCA with Failed Gravity Injection

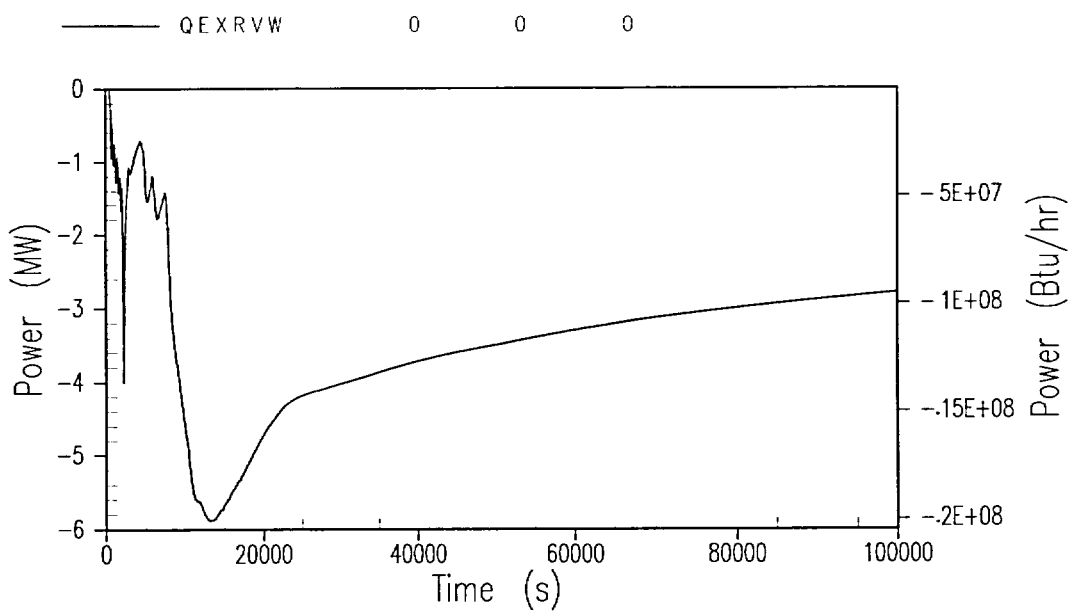

Figure 34-80

Case 3BE-6: Reactor Pressure Vessel to Cavity Water Heat Transfer
SBLOCA with Failed Gravity Injection

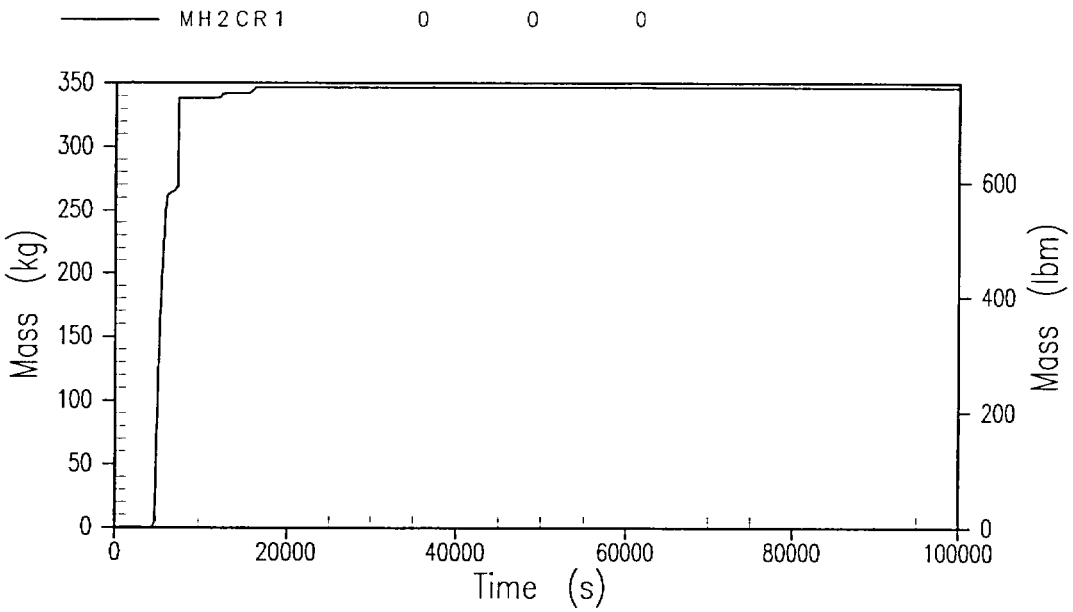

Figure 34-81

Case 3BE-6: In-Vessel Hydrogen Generation SBLOCA with Failed Gravity Injection

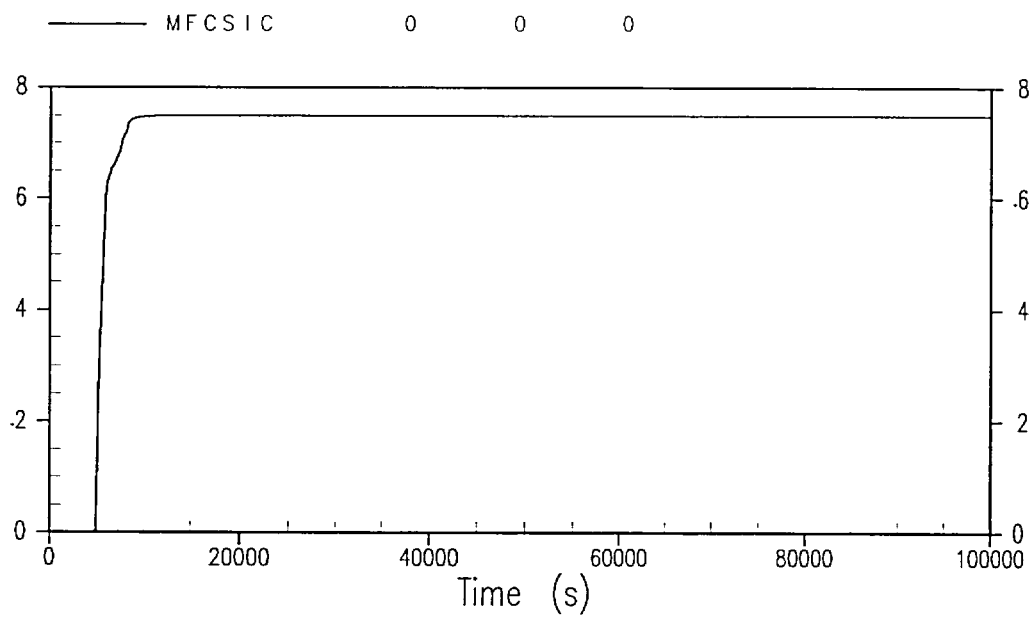

Figure 34-82

Case 3BE-6: Mass Fraction of CsI Released to Containment SBLOCA with Failed Gravity Injection

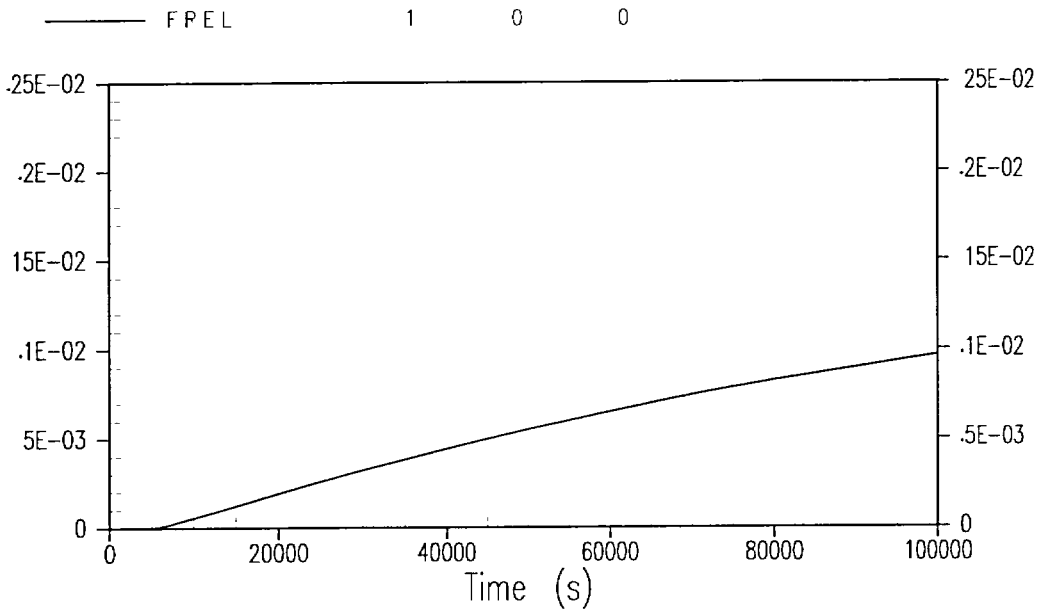

Figure 34-83

Case 3BE-6: Mass Fraction of Noble Gases Released to Environment SBLOCA with Failed Gravity Injection

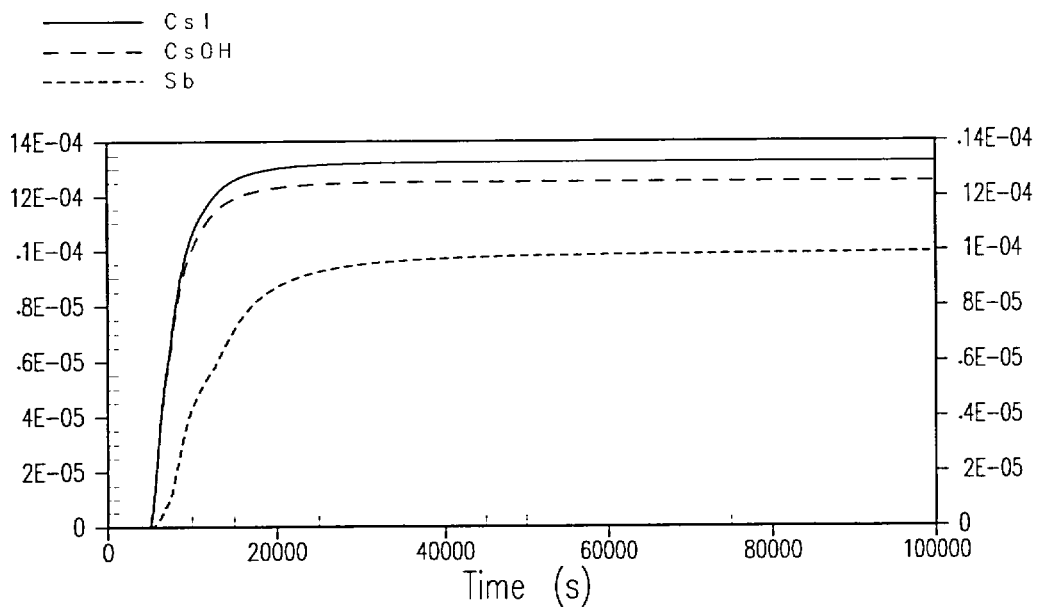

Figure 34-84

Case 3BE-6: Mass Fraction of Fission Products Released to Environment SBLOCA with Failed Gravity Injection

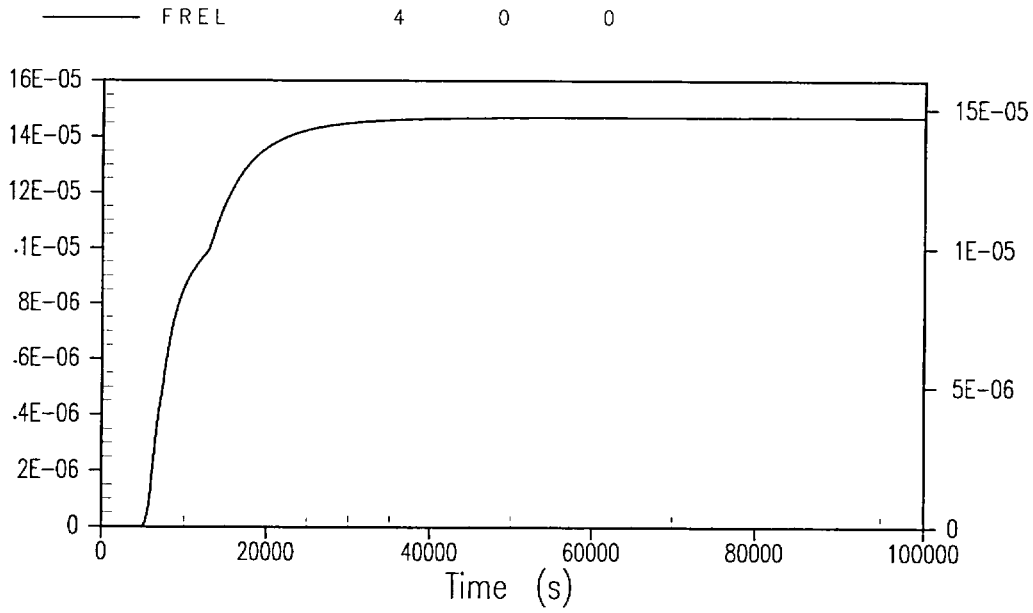

Figure 34-85

Case 3BE-6: Mass Fraction of SrO Released to Environment SBLOCA with Failed Gravity Injection

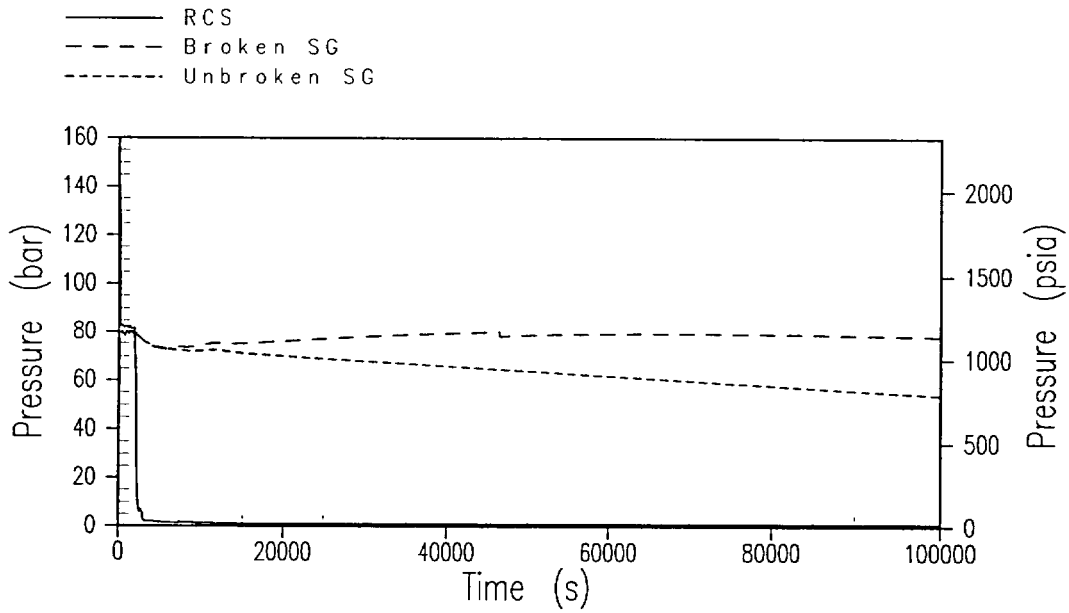

Figure 34-86

Case 3BE-7: Reactor Coolant System and Steam Generator Pressure SBLOCA with Failed Gravity Injection

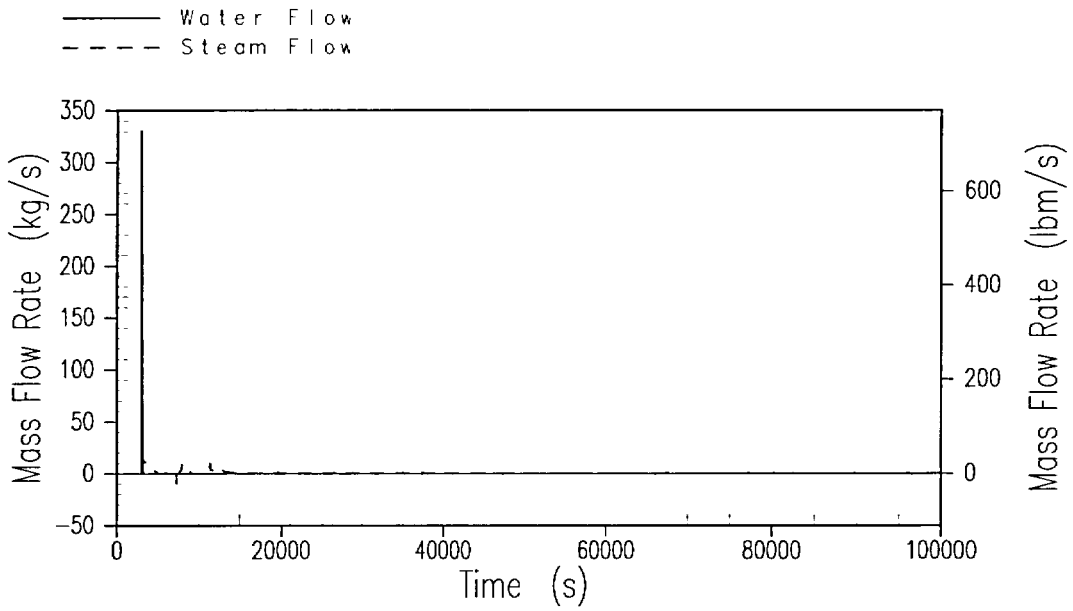

Figure 34-87

Case 3BE-7: ADS Stage 4 Flow Rates
SBLOCA with Failed Gravity Injection

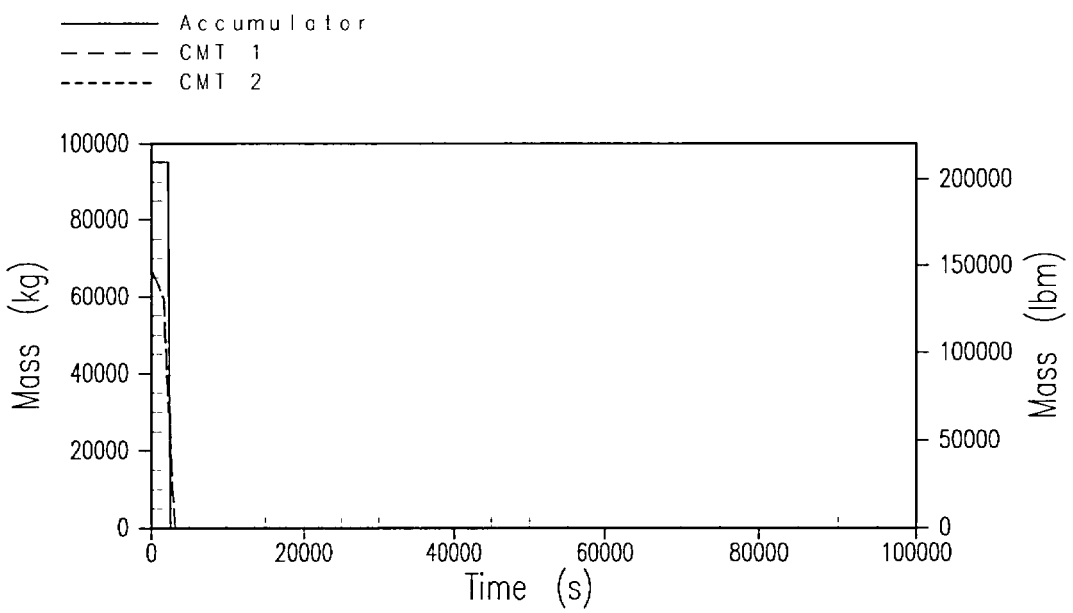

Figure 34-88

Case 3BE-7: Accumulator/CMT Water Mass
SBLOCA with Failed Gravity Injection

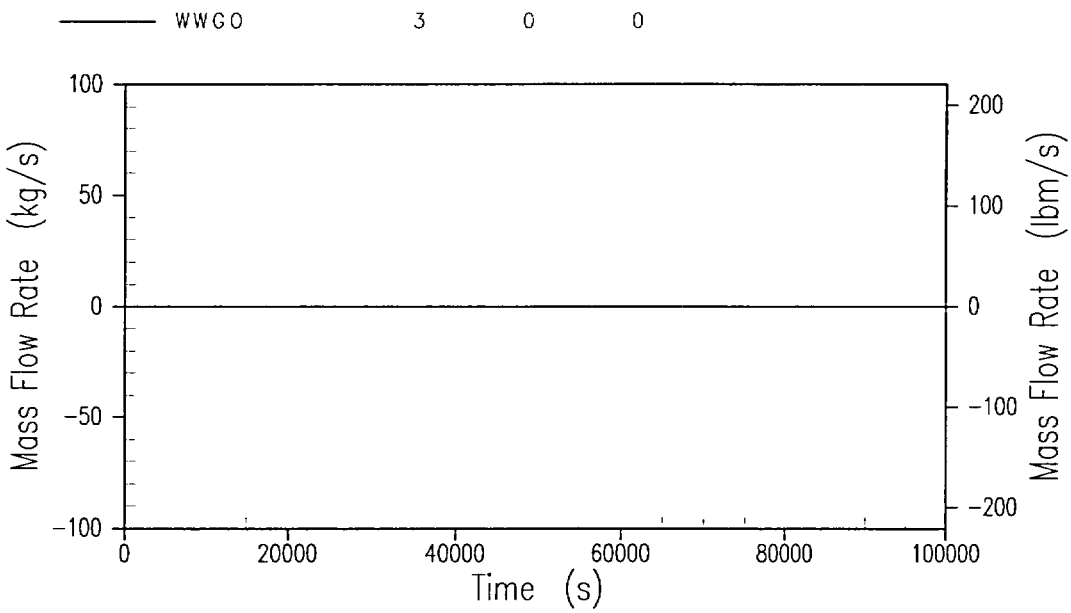

Figure 34-89

Case 3BE-7: IRWST Injection Flow Rate SBLOCA with Failed Gravity Injection

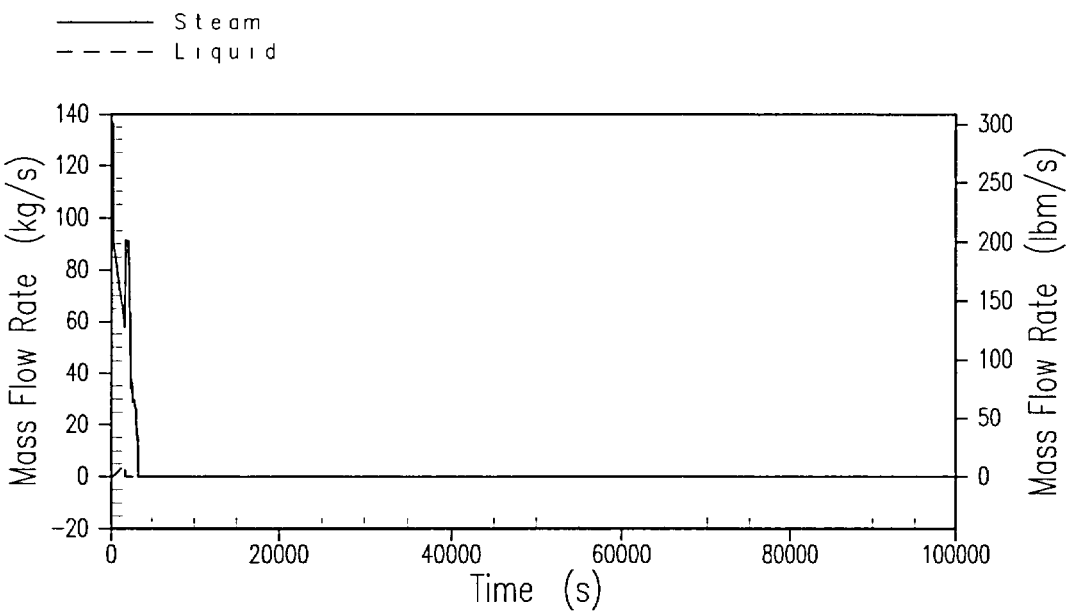

Figure 34-90

Case 3BE-7: Break Flow Rate SBLOCA with Failed Gravity Injection

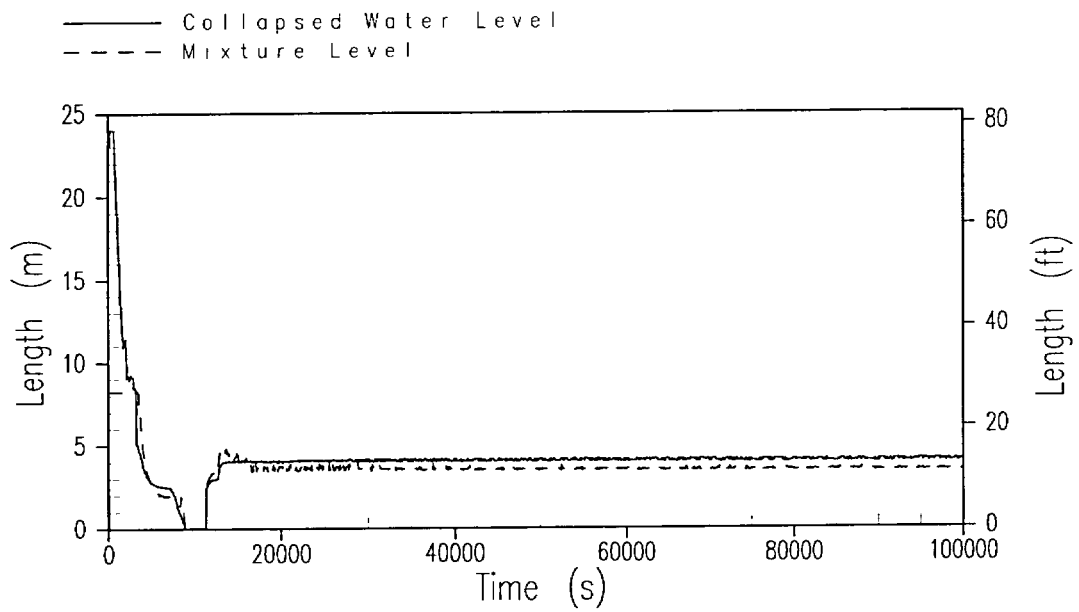

Figure 34-91

Case 3BE-7: Reactor Vessel Water Level SBLOCA with Failed Gravity Injection

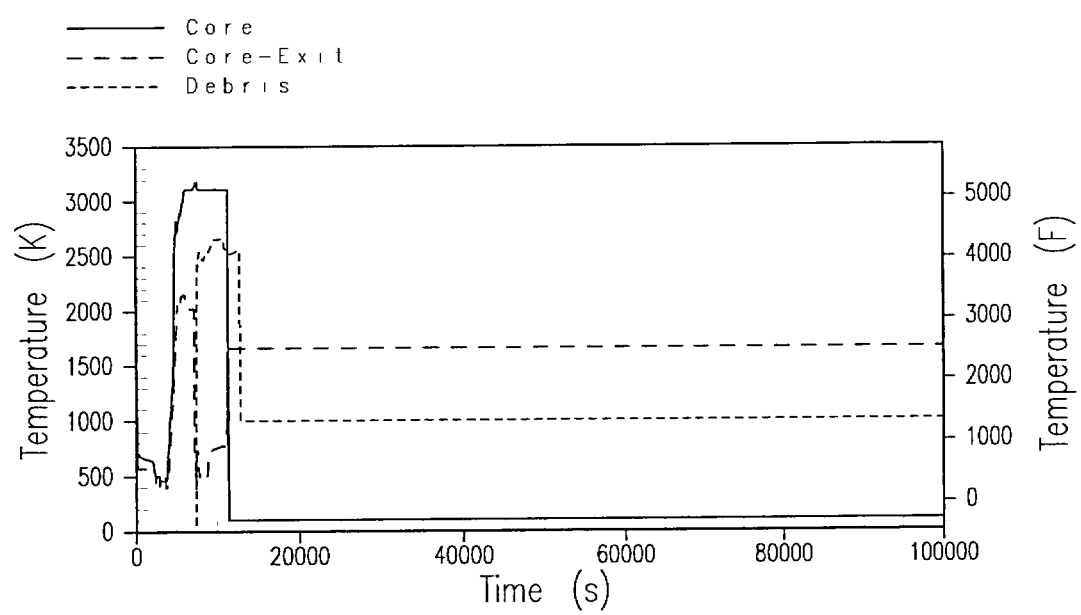

Figure 34-92

Case 3BE-7: Core Temperatures SBLOCA with Failed Gravity Injection

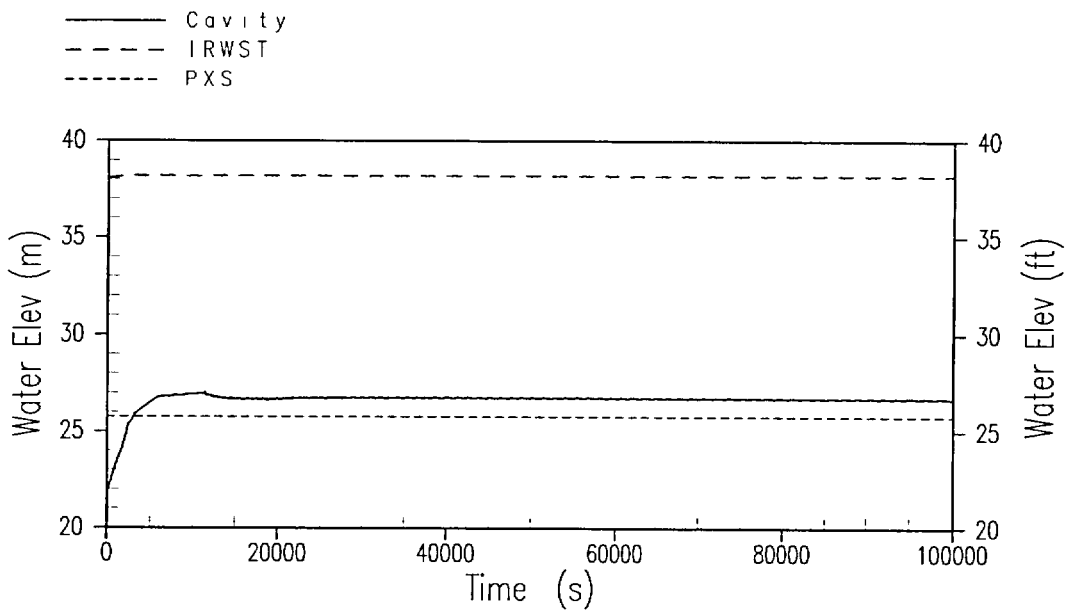

Figure 34-93

Case 3BE-7: Containment Water Pool Elevations SBLOCA with Failed Gravity Injection

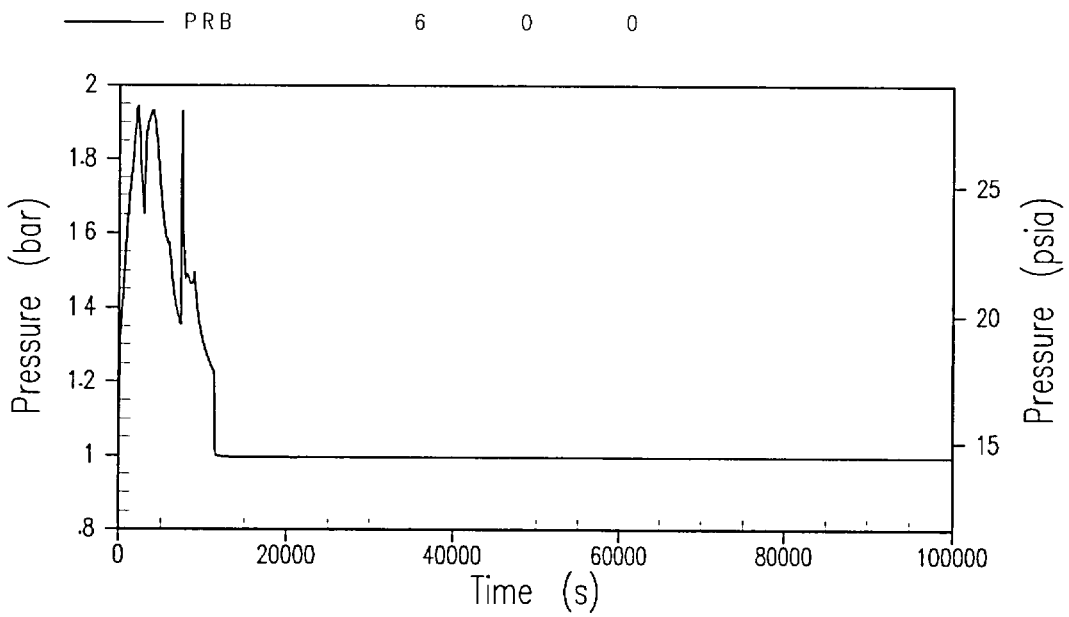

Figure 34-94

Case 3BE-7: Containment Pressure SBLOCA with Failed Gravity Injection

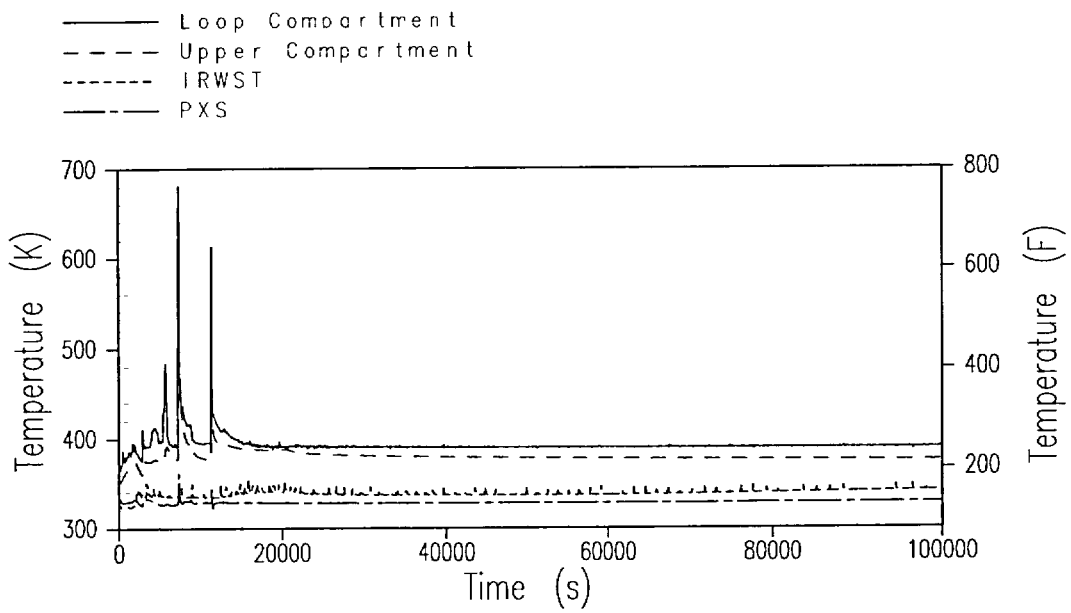

Figure 34-95

Case 3BE-7: Containment Gas Temperature SBLOCA with Failed Gravity Injection

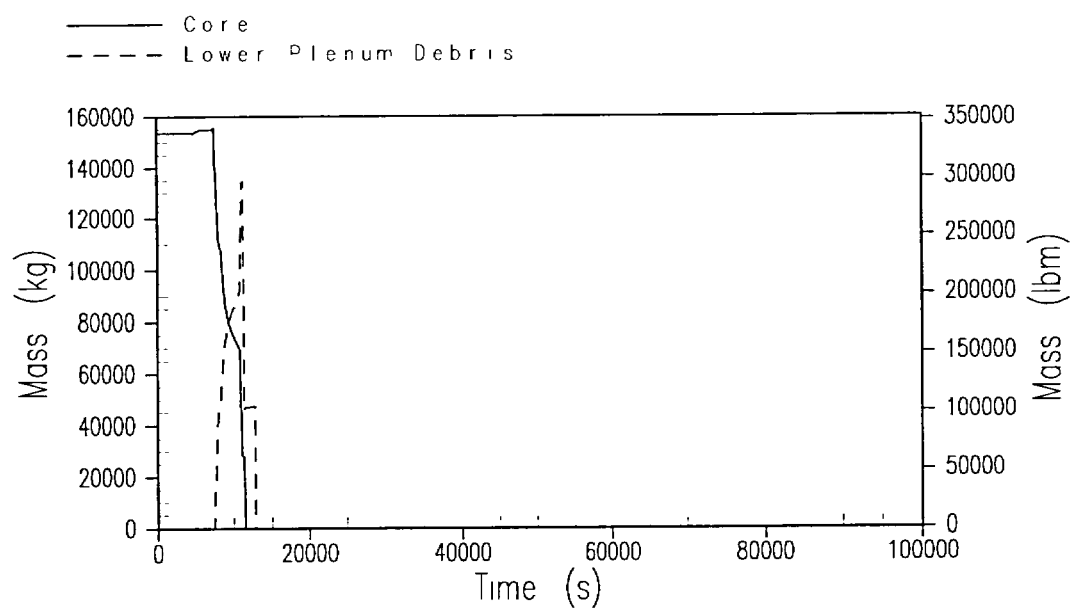

Figure 34-96

Case 3BE-7: Core Mass SBLOCA with Failed Gravity Injection

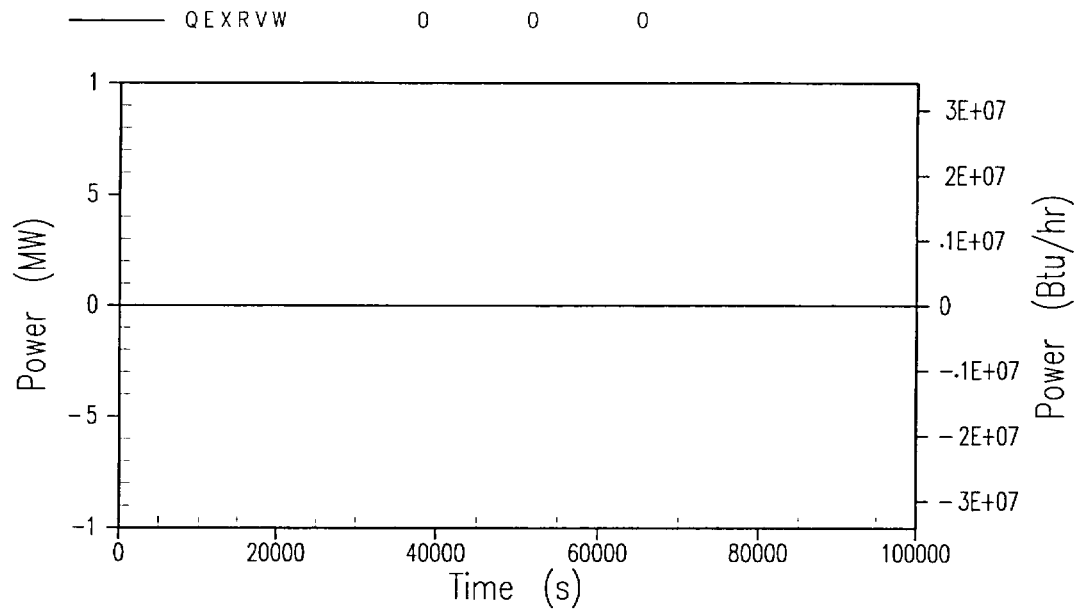

Figure 34-97

Case 3BE-7: Reactor Pressure Vessel to Cavity Water Heat Transfer SBLOCA with Failed Gravity Injection

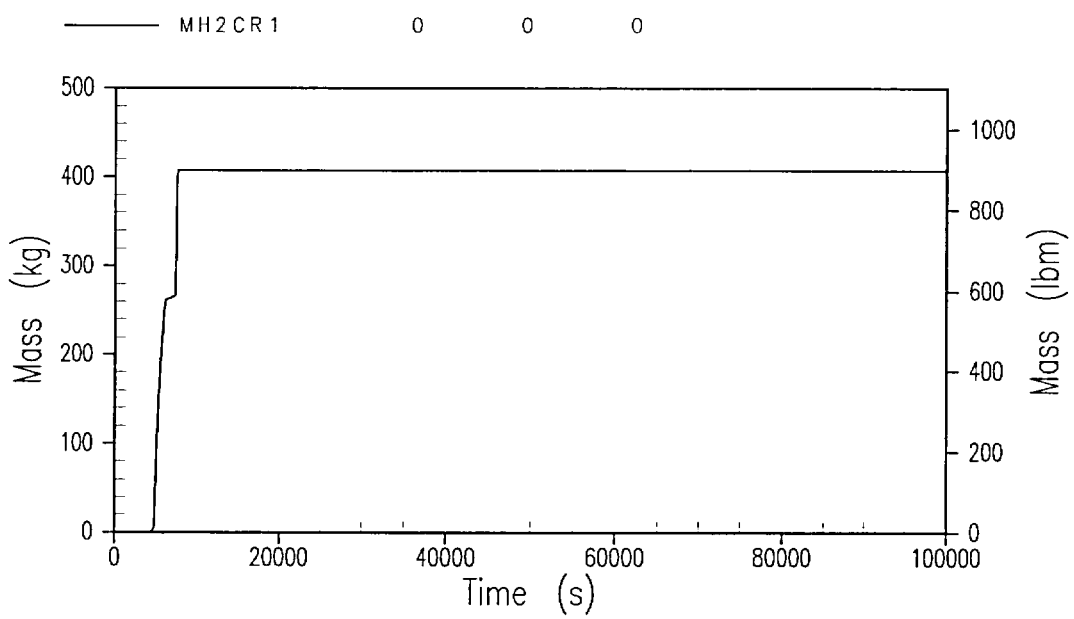

Figure 34-98

Case 3BE-7: In-Vessel Hydrogen Generation SBLOCA with Failed Gravity Injection

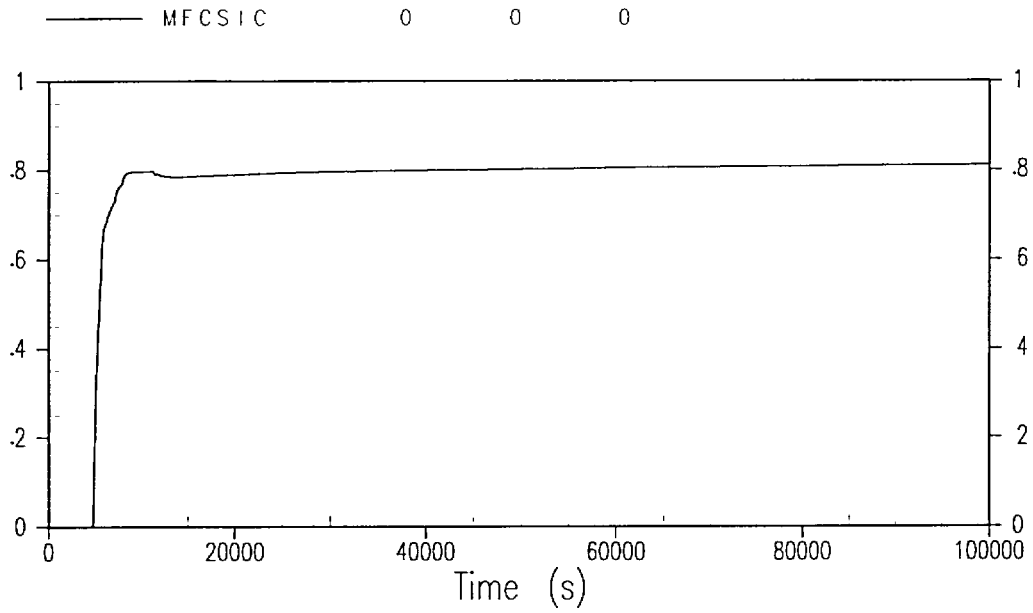

Figure 34-99

Case 3BE-7: Mass Fraction of CsI Released to Containment SBLOCA with Failed Gravity Injection

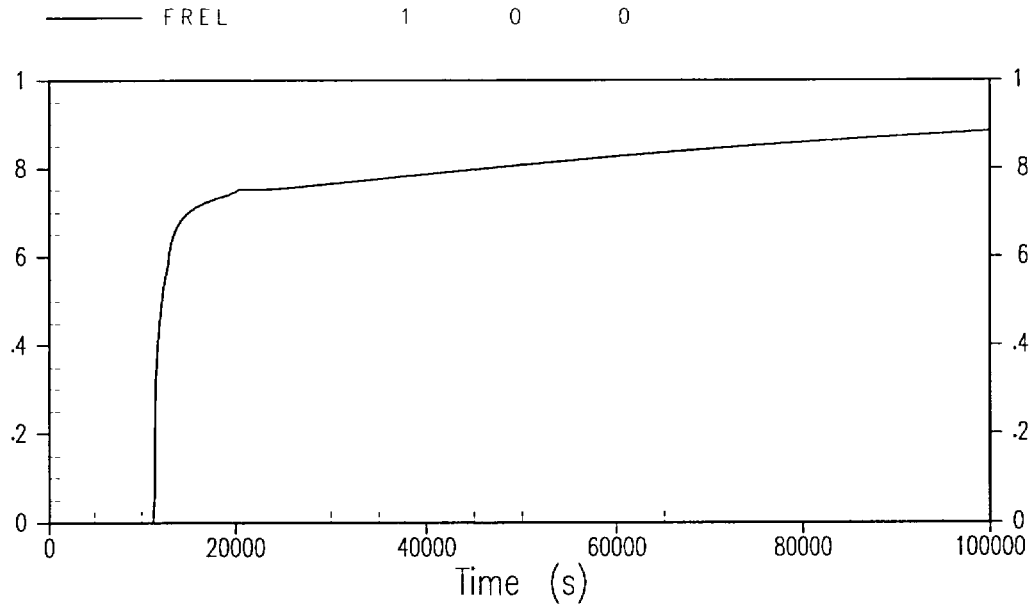

Figure 34-100

Case 3BE-7: Mass Fraction of Noble Gases Released to Environment SBLOCA with Failed Gravity Injection

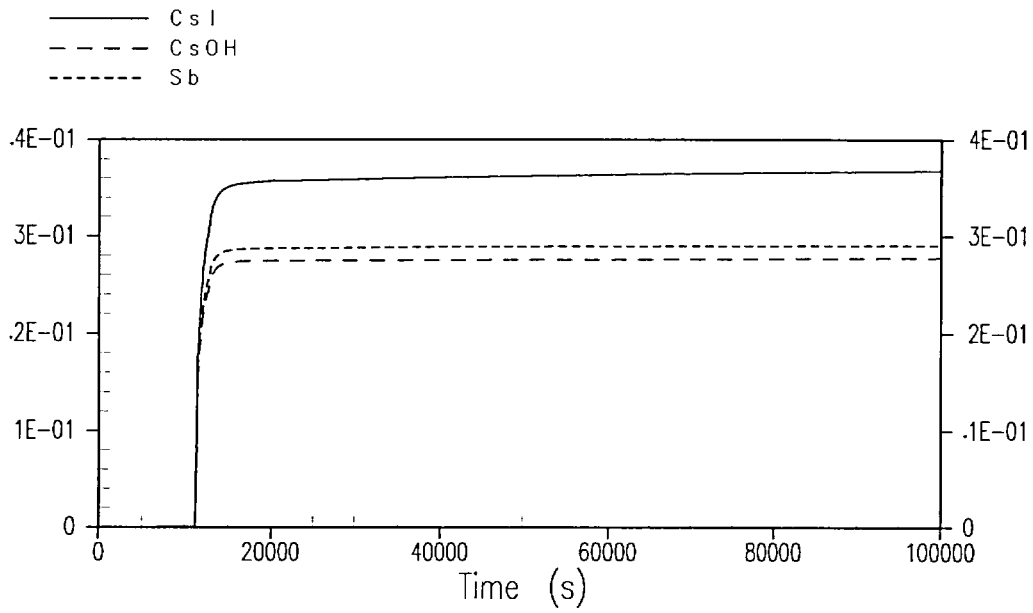

Figure 34-101

Case 3BE-7: Mass Fraction of Fission Products Released to Environment SBLOCA with Failed Gravity Injection

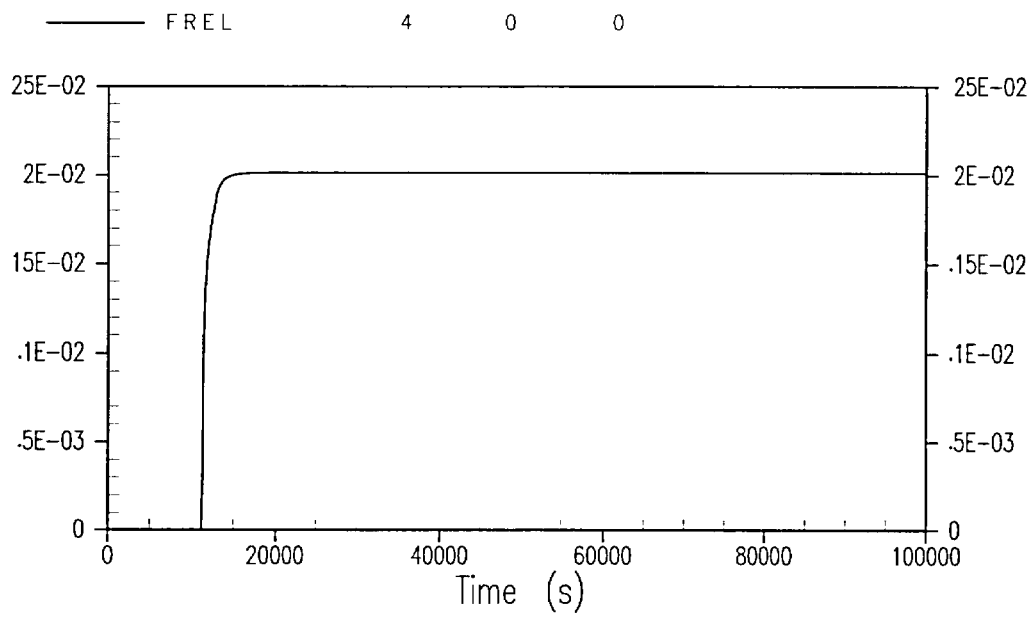

Figure 34-102

Case 3BE-7: Mass Fraction of SrO Released to Environment SBLOCA with Failed Gravity Injection

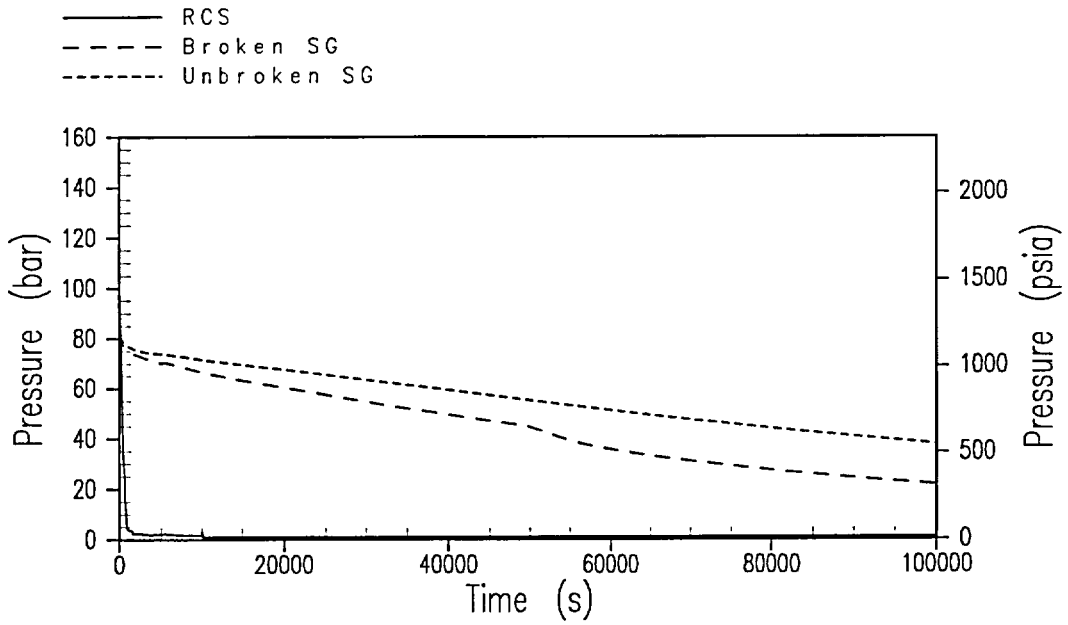

Figure 34-103

Case 3BE-3: Reactor Coolant System and Steam Generator Pressure DVI Line Break, Failed Gravity Injection, No PXS Flooding

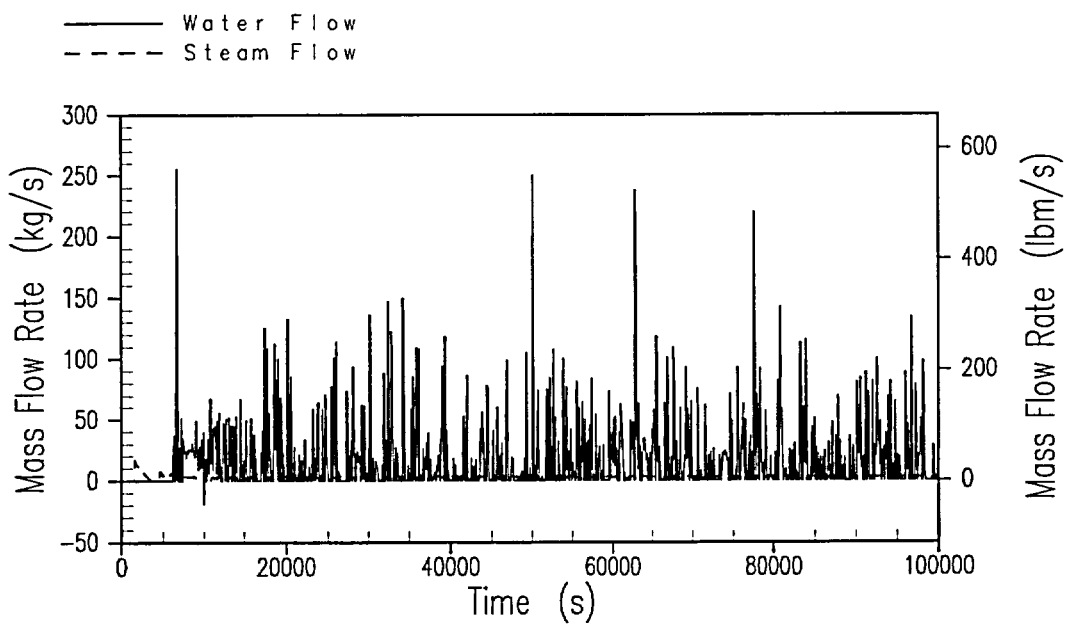

Figure 34-104

Case 3BE-3: ADS Stage 4 Flow Rate DVI Line Break, Failed Gravity Injection, No PXS Flooding

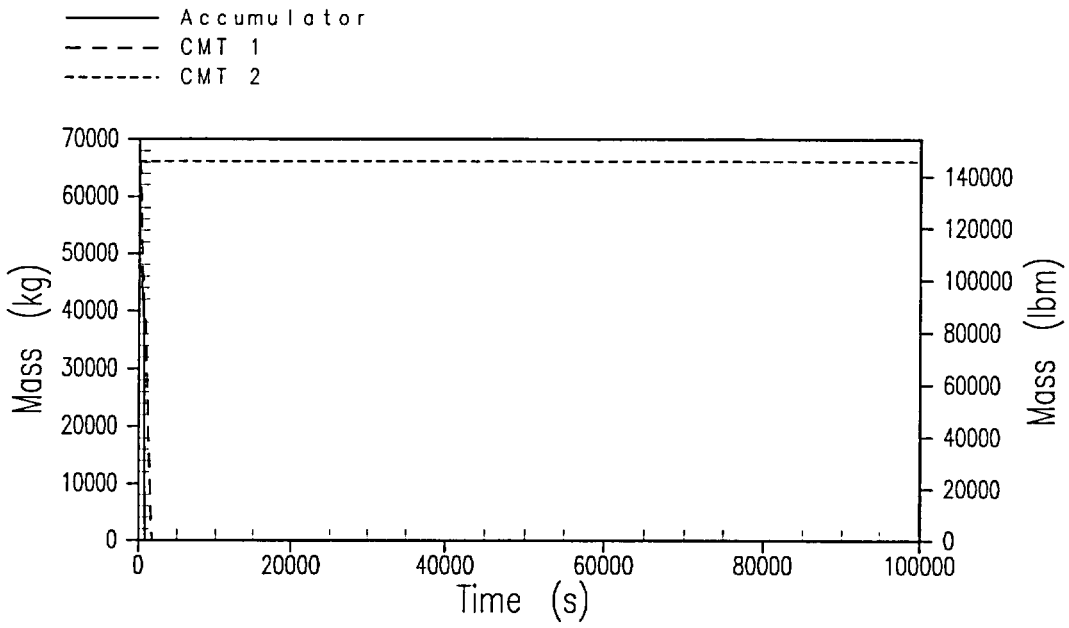

Figure 34-105

Case 3BE-3: Accumulator/CMT Water Mass
DVI Line Break, Failed Gravity Injection, No PXS Flooding

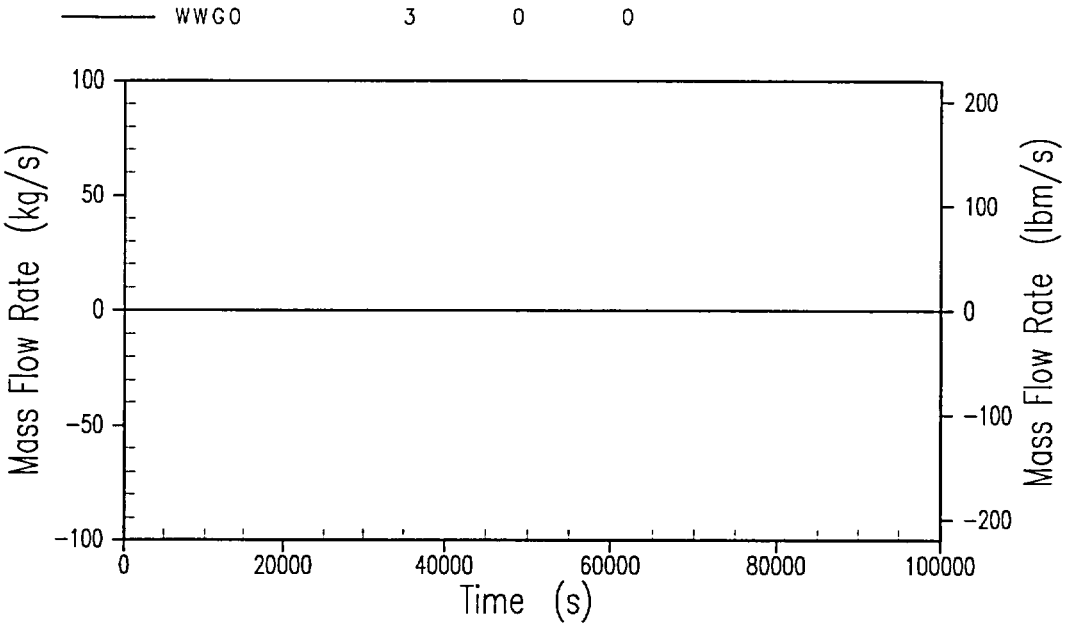

Figure 34-106

Case 3BE-3: IRWST Injection Flow Rate
DVI Line Break, Failed Gravity Injection, No PXS Flooding

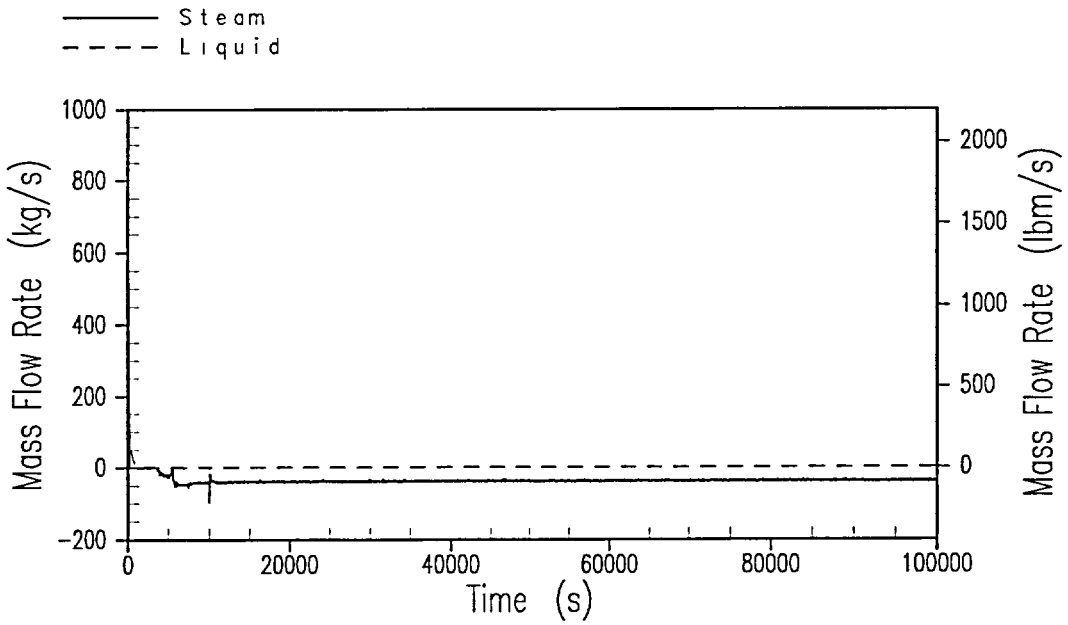

Figure 34-107

Case 3BE-3: Break Flow Rate
DVI Line Break, Failed Gravity Injection, No PXS Flooding

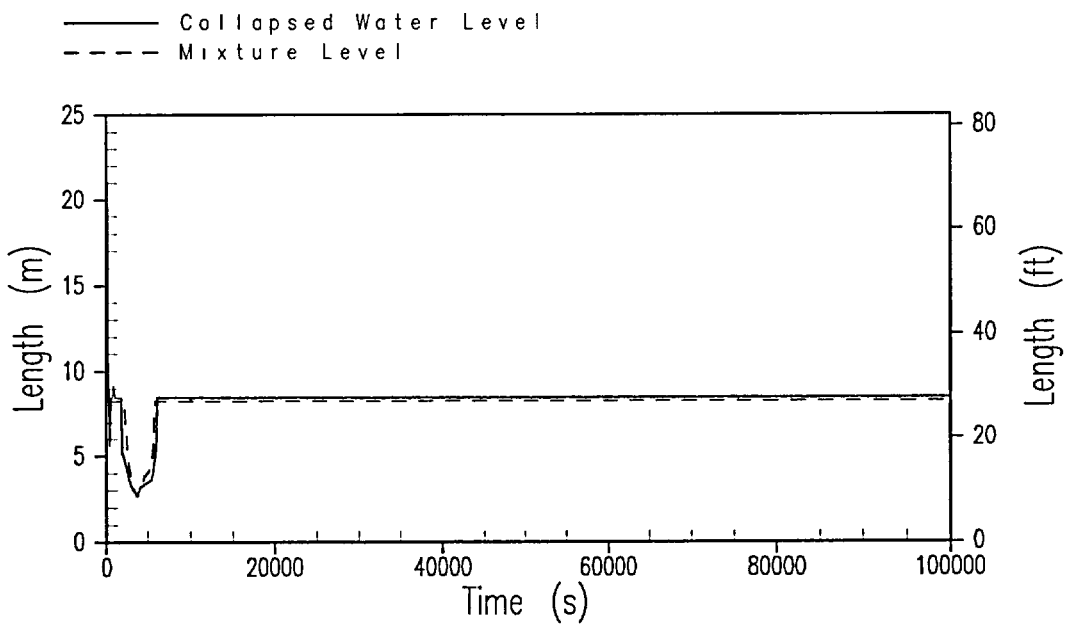

Figure 34-108

Case 3BE-3: Reactor Vessel Water Level
DVI Line Break, Failed Gravity Injection, No PXS Flooding

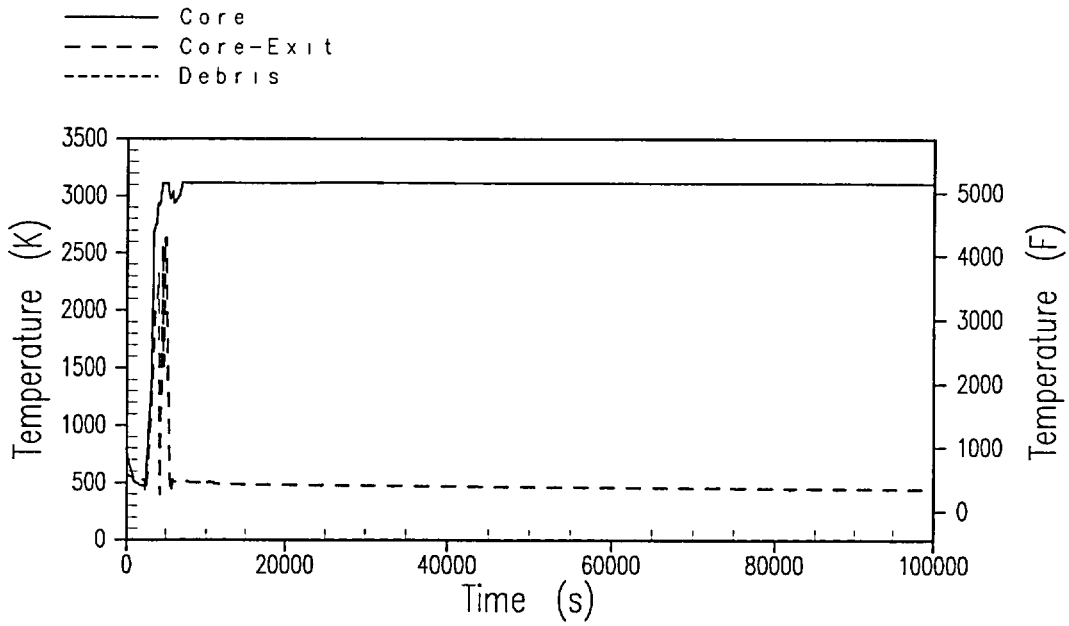

Figure 34-109

Case 3BE-3: Core Temperatures
DVI Line Break, Failed Gravity Injection, No PXS Flooding

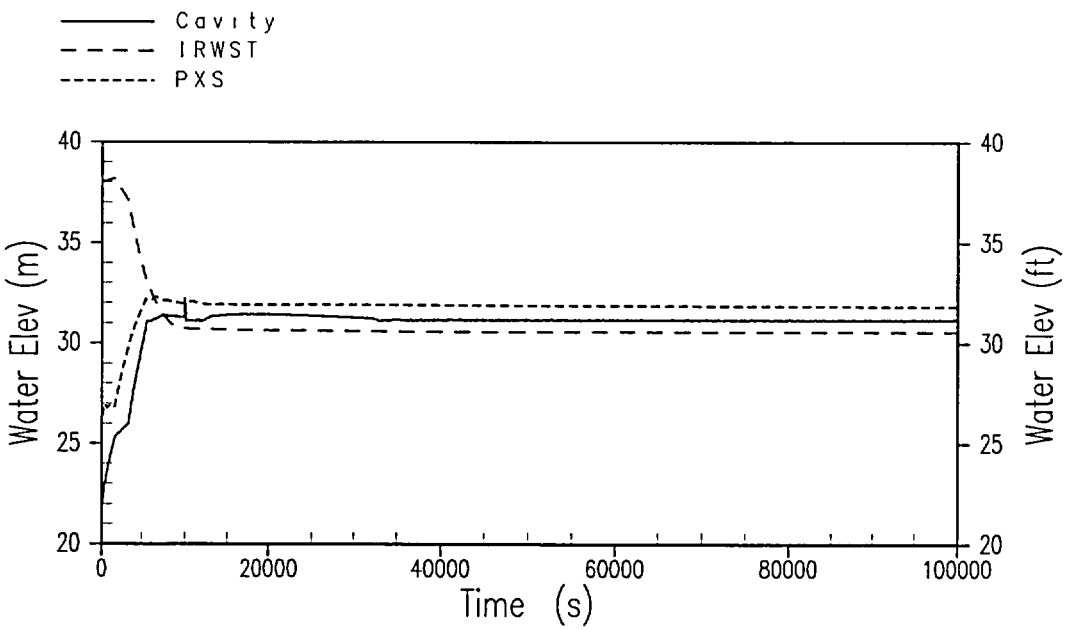

Figure 34-110

Case 3BE-3: Containment Water Pool Elevations
DVI Line Break, Failed Gravity Injection, No PXS Flooding

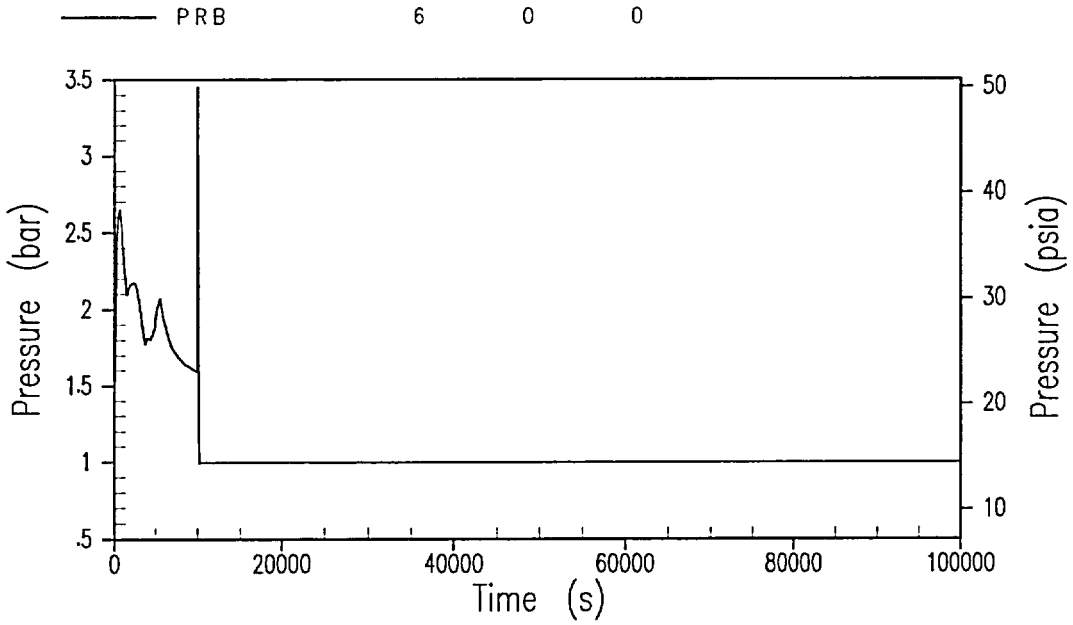

Figure 34-111

Case 3BE-3: Containment Pressure
DVI Line Break, Failed Gravity Injection, No PXS Flooding

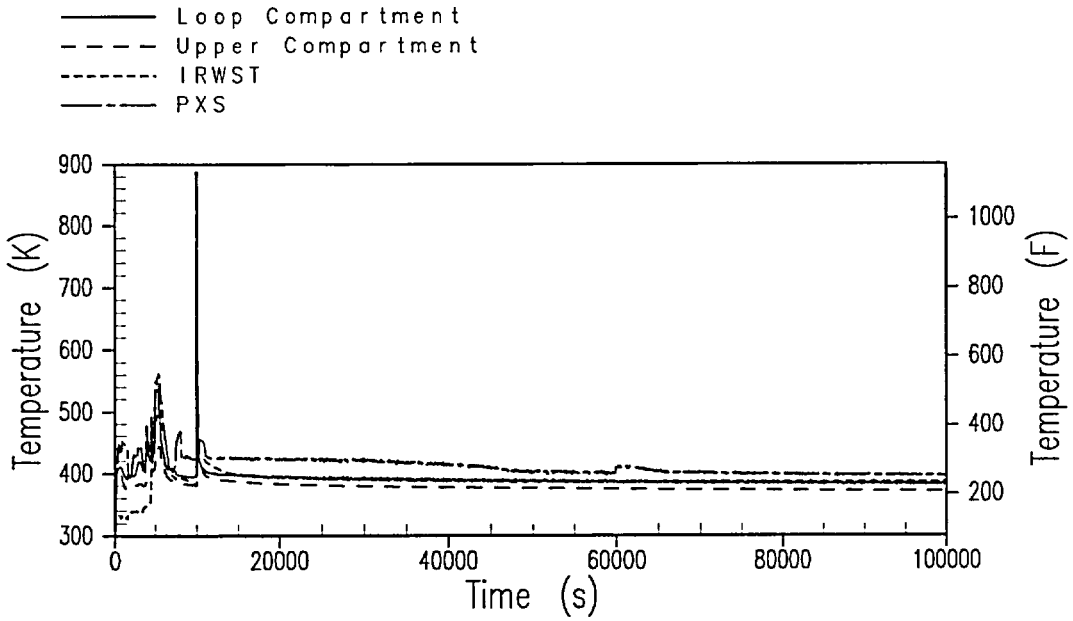

Figure 34-112

Case 3BE-3: Containment Gas Temperature
DVI Line Break, Failed Gravity Injection, No PXS Flooding

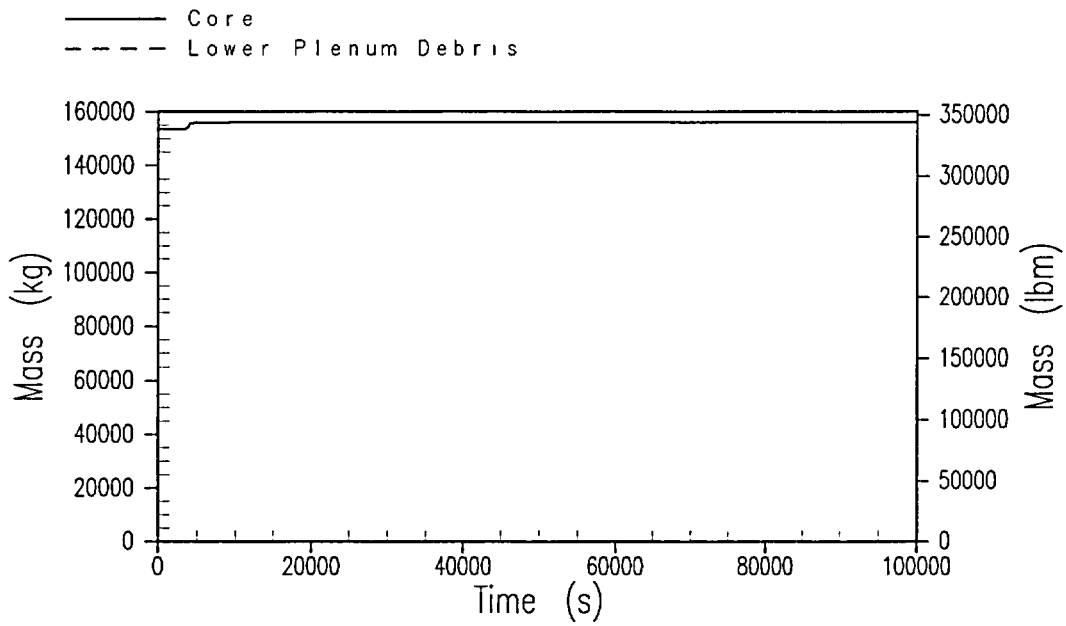

Figure 34-113

Case 3BE-3: Core Mass
DVI Line Break, Failed Gravity Injection, No PXS Flooding

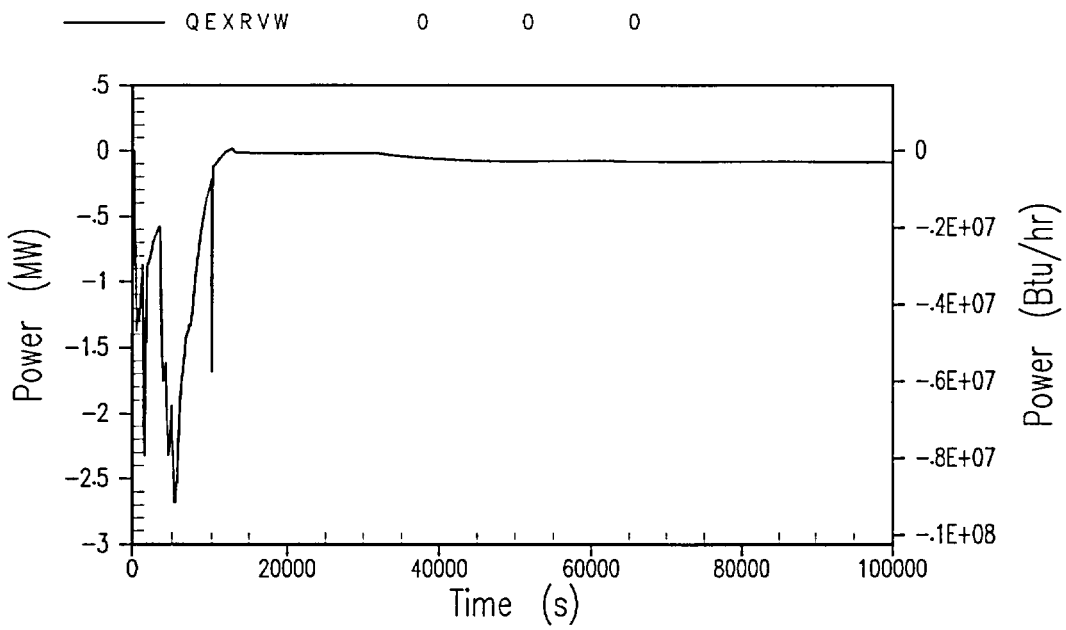

Figure 34-114

Case 3BE-3: Reactor Pressure Vessel to Cavity Water Heat Transfer
DVI Line Break, Failed Gravity Injection, No PXS Flooding

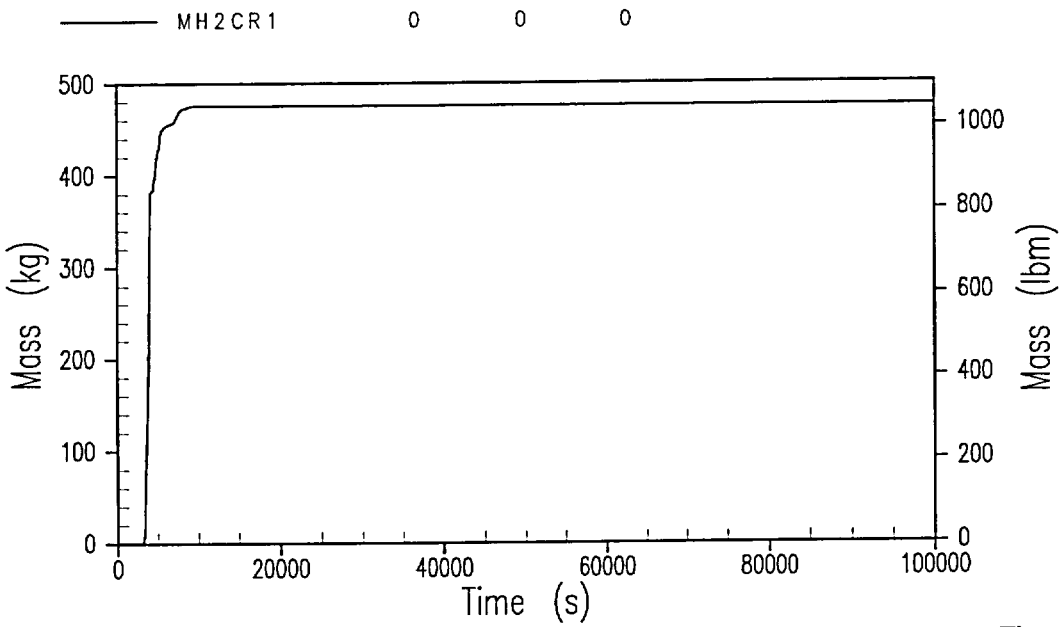

Figure 34-115

Case 3BE-3: In-Vessel Hydrogen Generation
DVI Line Break, Failed Gravity Injection, No PXS Flooding

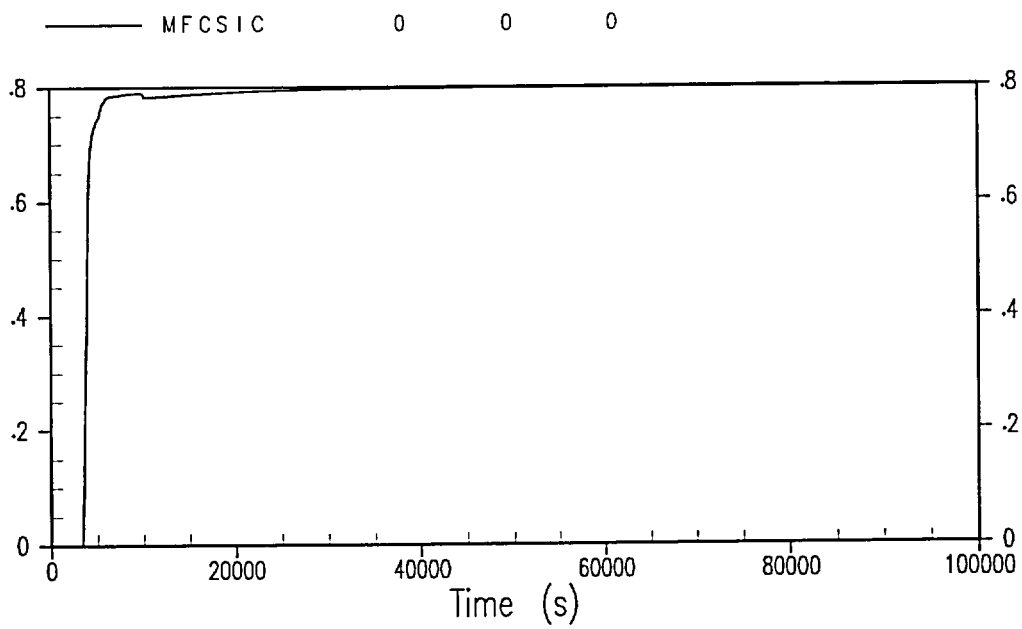

Figure 34-116

Case 3BE-3: Mass Fraction of CsI Released to Containment
DVI Line Break, Failed Gravity Injection, No PXS Flooding

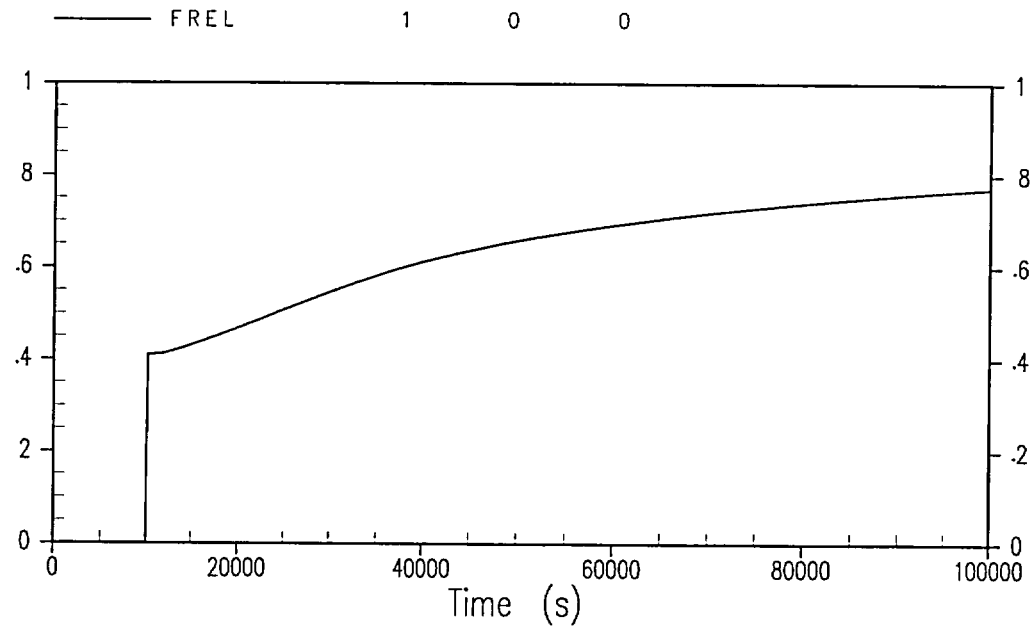

Figure 34-117

Case 3BE-3: Mass Fraction of Noble Gases Released to Environment DVI Line Break, Failed Gravity Injection, No PXS Flooding

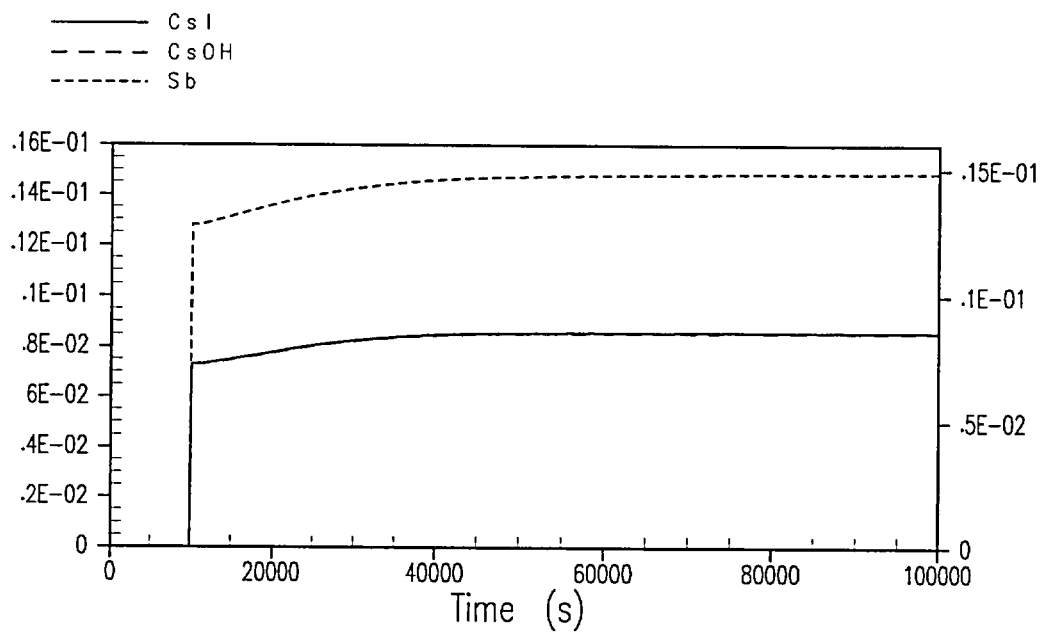

Figure 34-118

Case 3BE-3: Mass Fraction of Fission Products Released to Environment DVI Line Break, Failed Gravity Injection, No PXS Flooding

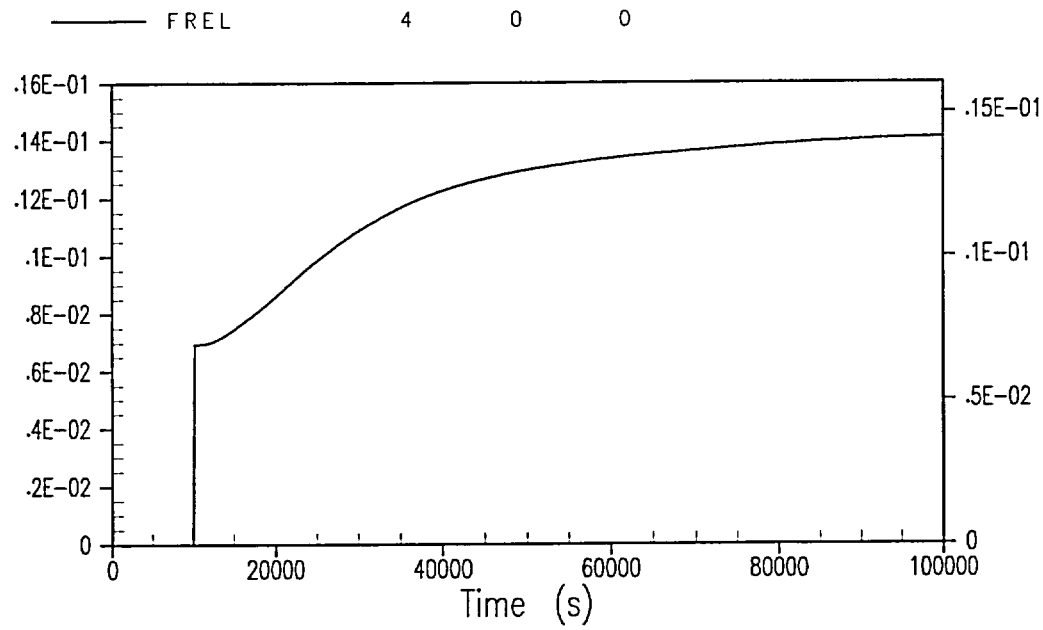

Figure 34-119

Case 3BE-3: Mass Fraction of SrO Released to Environment DVI Line Break, Failed Gravity Injection, No PXS Flooding

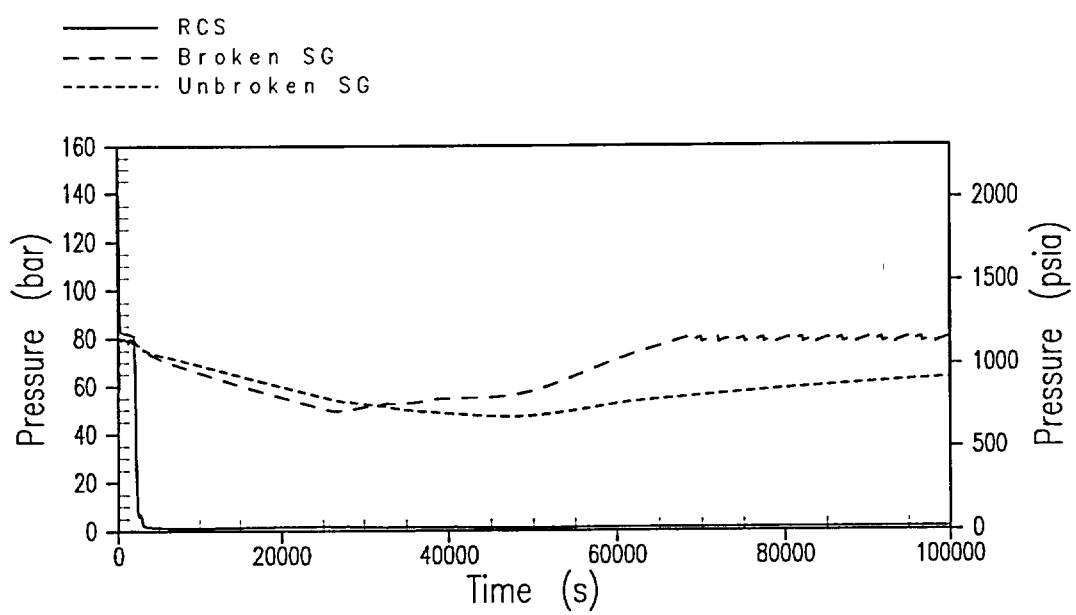

Figure 34-120

Case 3BL-1: Reactor Coolant System and Steam Generator Pressure SBLOCA with Failed Gravity Injection

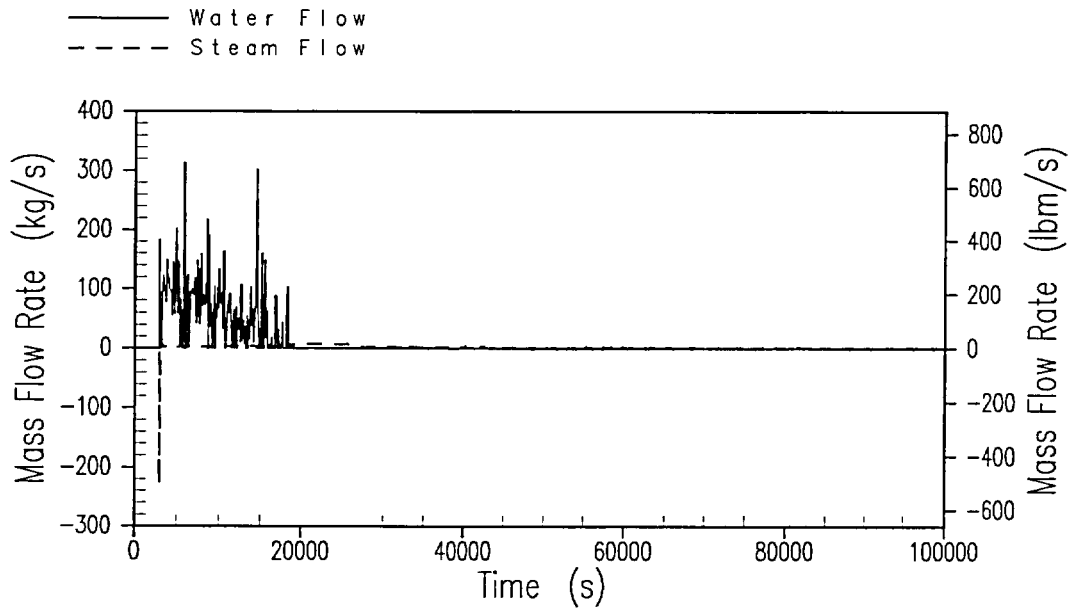

Figure 34-121

Case 3BL-1: ADS Stage 4 Flow Rates
SBLOCA with Failed Gravity Injection

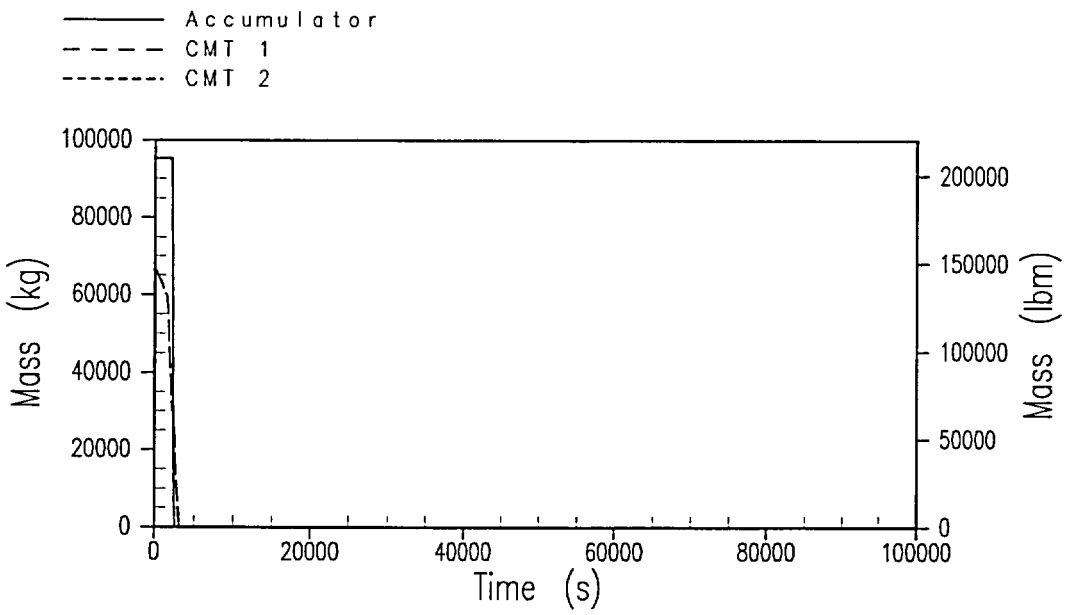

Figure 34-122

Case 3BL-1: Accumulator/CMT Water Mass
SBLOCA with Failed Gravity Injection

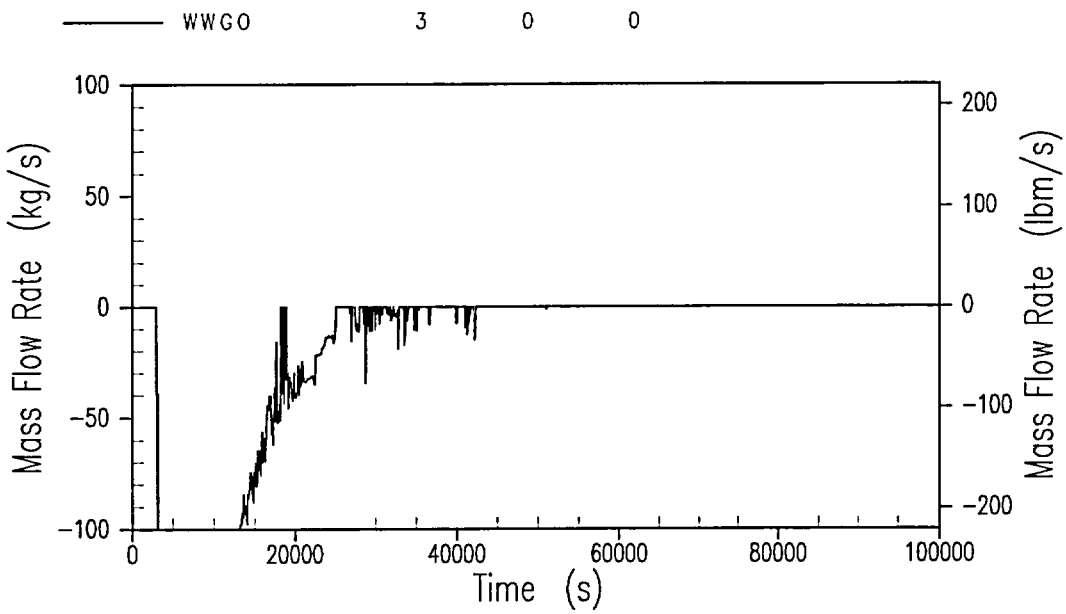

Figure 34-123

Case 3BL-1: IRWST Injection Flow Rate SBLOCA with Failed Gravity Injection

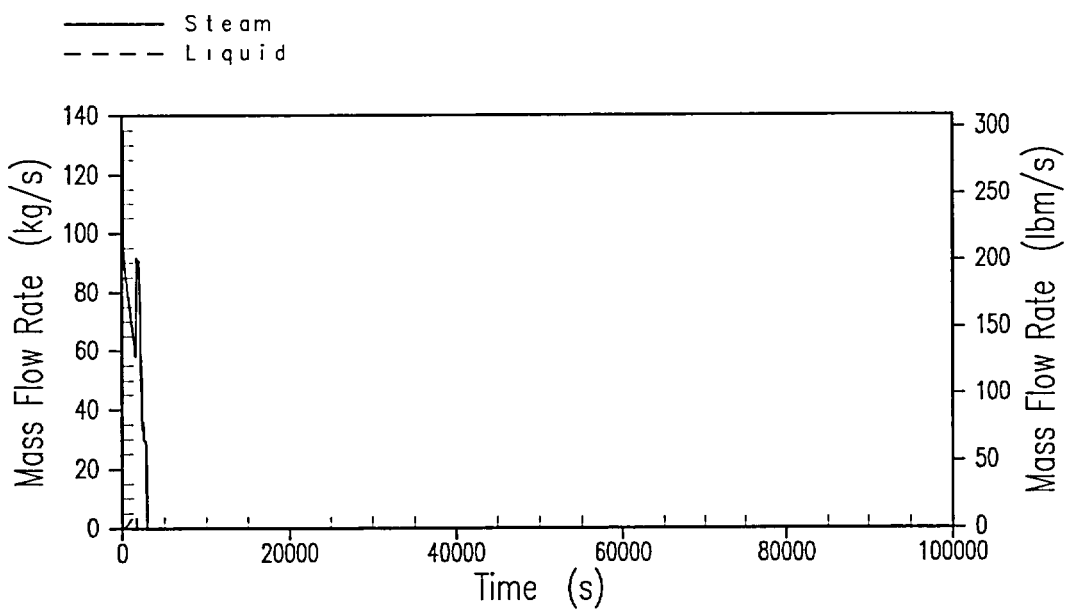

Figure 34-124

Case 3BL-1: Break Flow Rate SBLOCA with Failed Gravity Injection

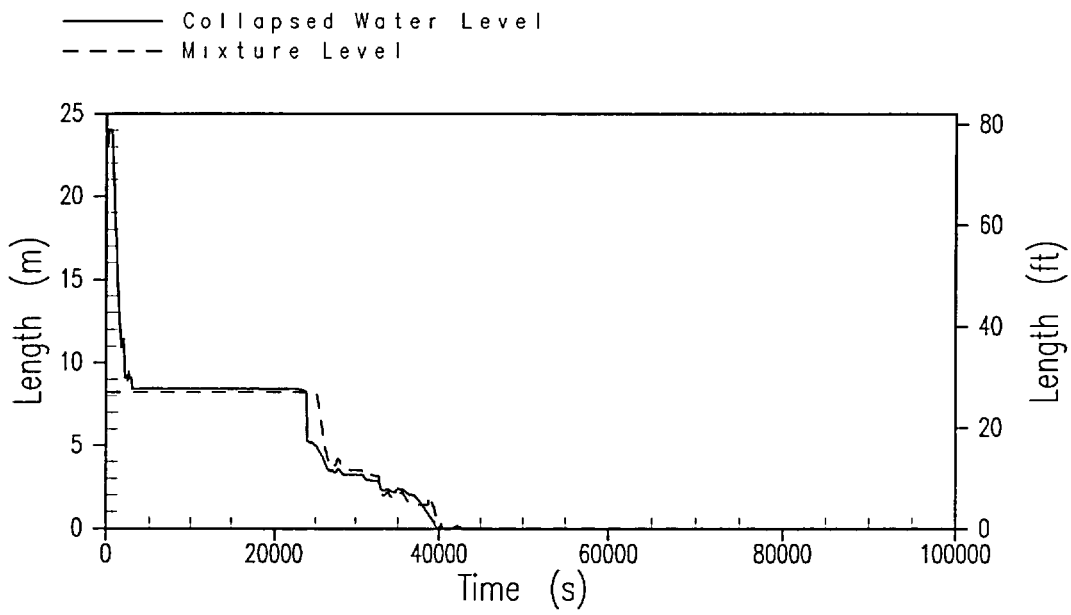

Figure 34-125

Case 3BL-1: Reactor Vessel Water Level SBLOCA with Failed Gravity Injection

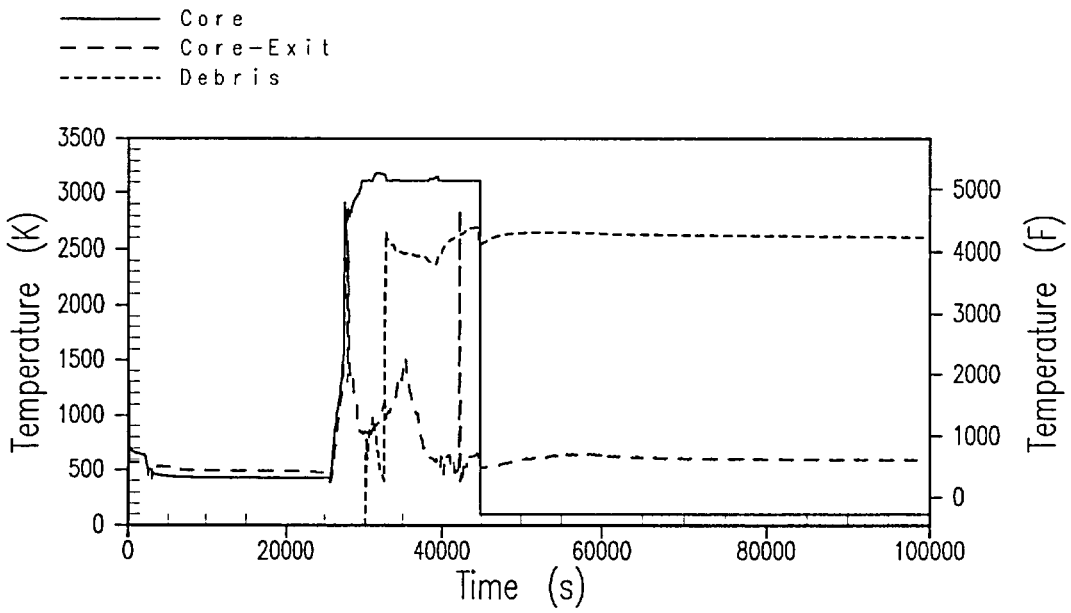

Figure 34-126

Case 3BL-1: Core Temperatures SBLOCA with Failed Gravity Injection

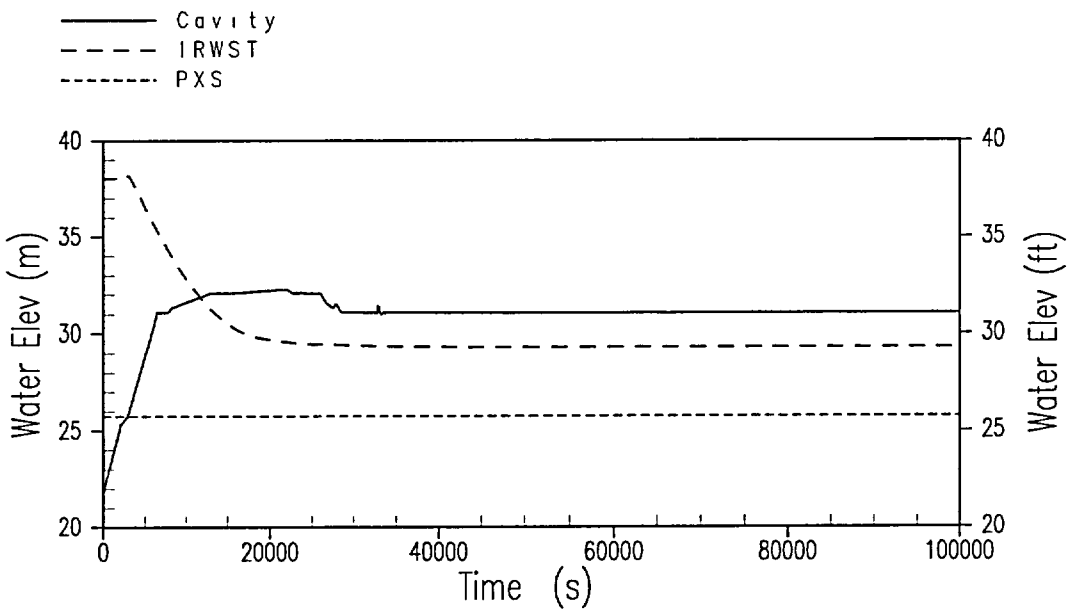

Figure 34-127

Case 3BL-1: Containment Water Pool Elevations SBLOCA with Failed Gravity Injection

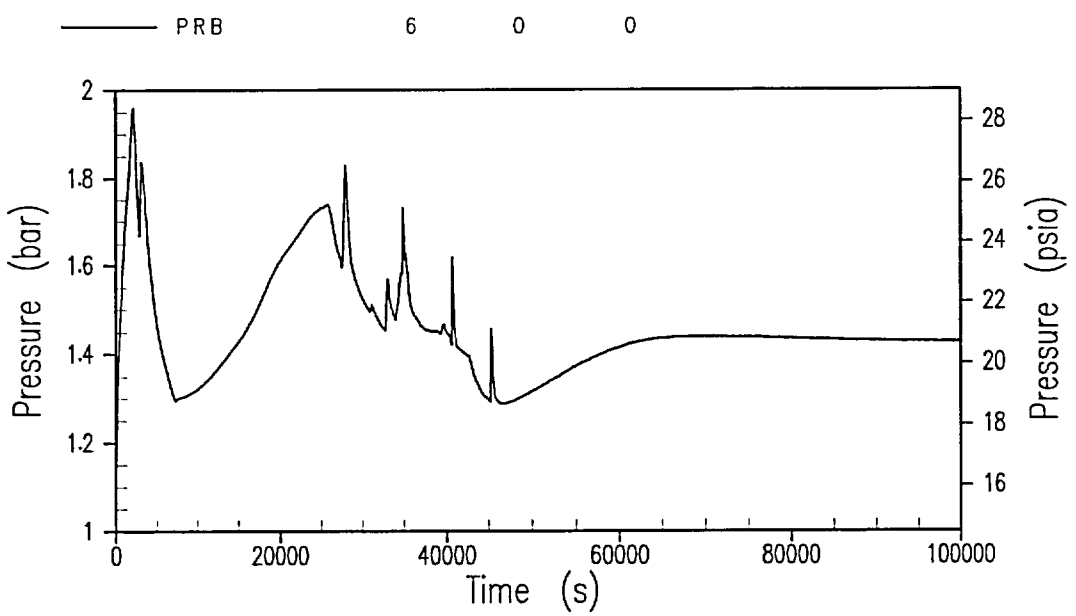

Figure 34-128

Case 3BL-1: Containment Pressure SBLOCA with Failed Gravity Injection

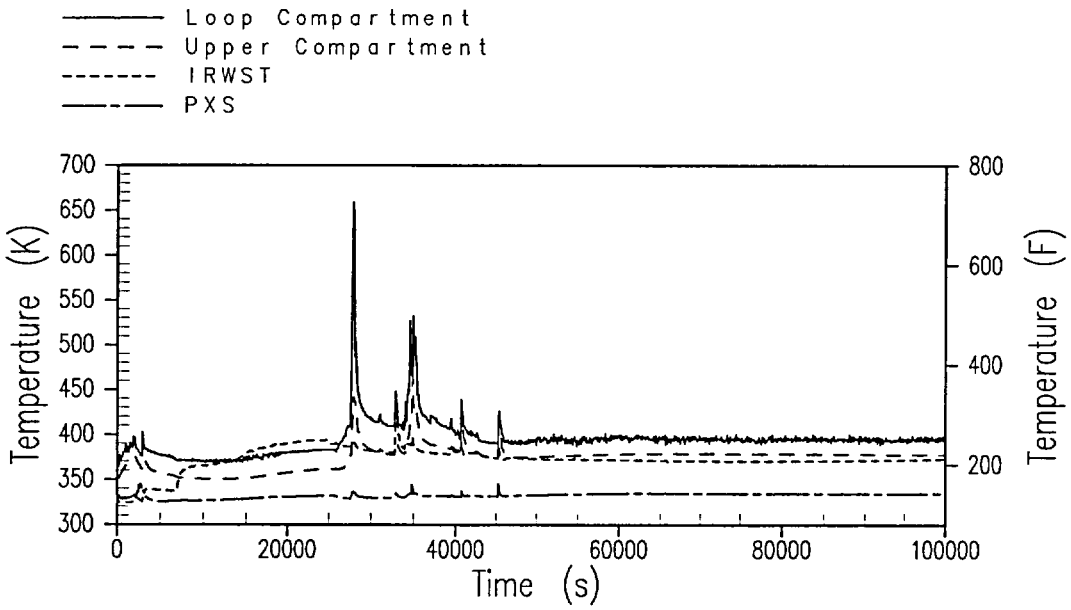

Figure 34-129

Case 3BL-1: Containment Gas Temperature SBLOCA with Failed Gravity Injection

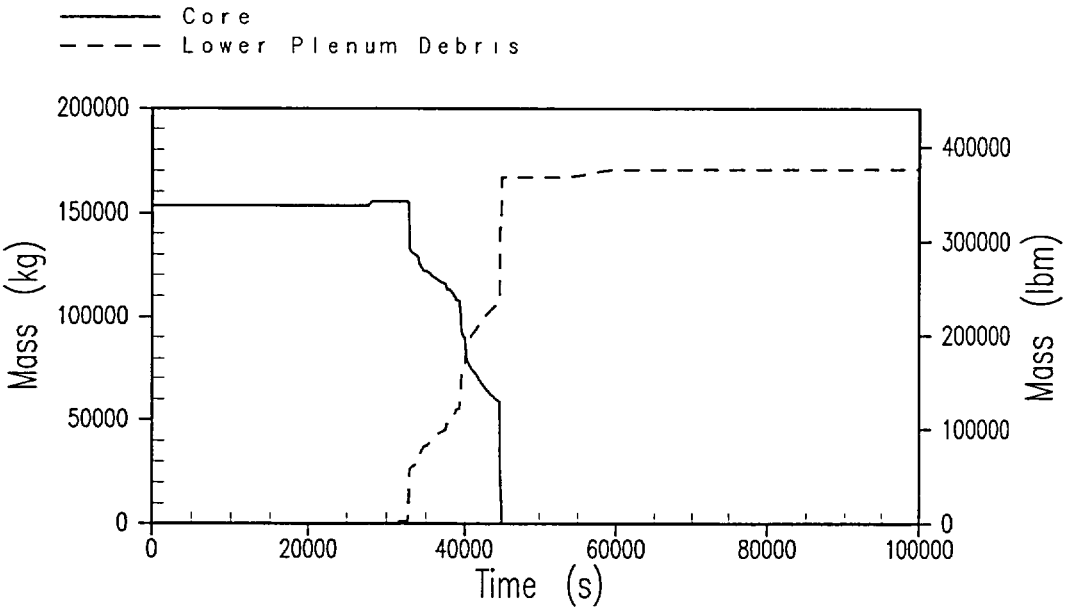

Figure 34-130

Case 3BL-1: Core Mass SBLOCA with Failed Gravity Injection

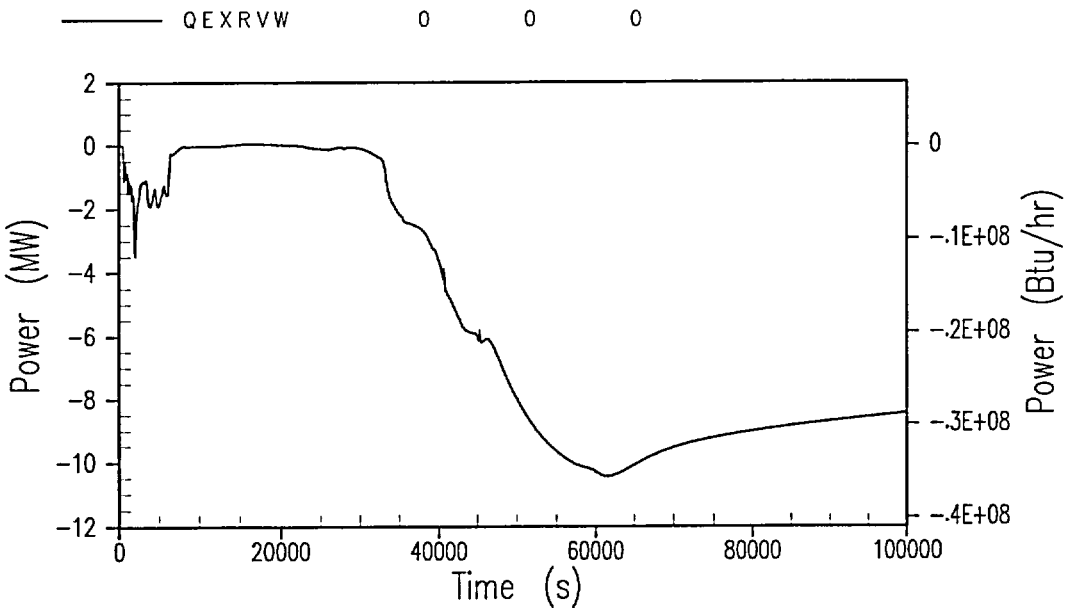

Figure 34-131

Case 3BL-1: Reactor Pressure Vessel to Cavity Water Heat Transfer SBLOCA with Failed Gravity Injection

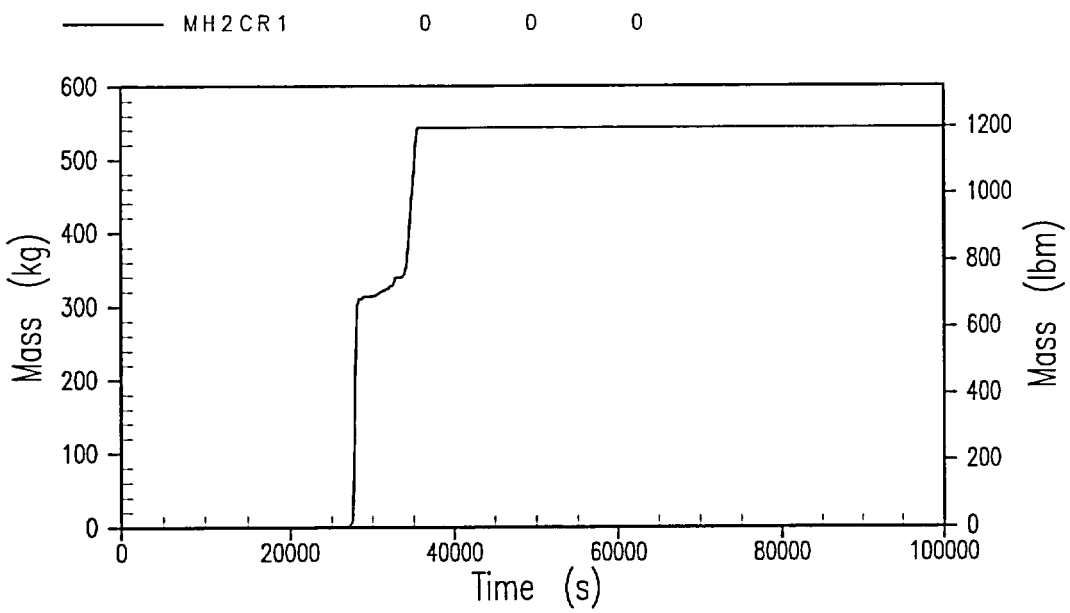

Figure 34-132

Case 3BL-1: In-Vessel Hydrogen Generation SBLOCA with Failed Gravity Injection

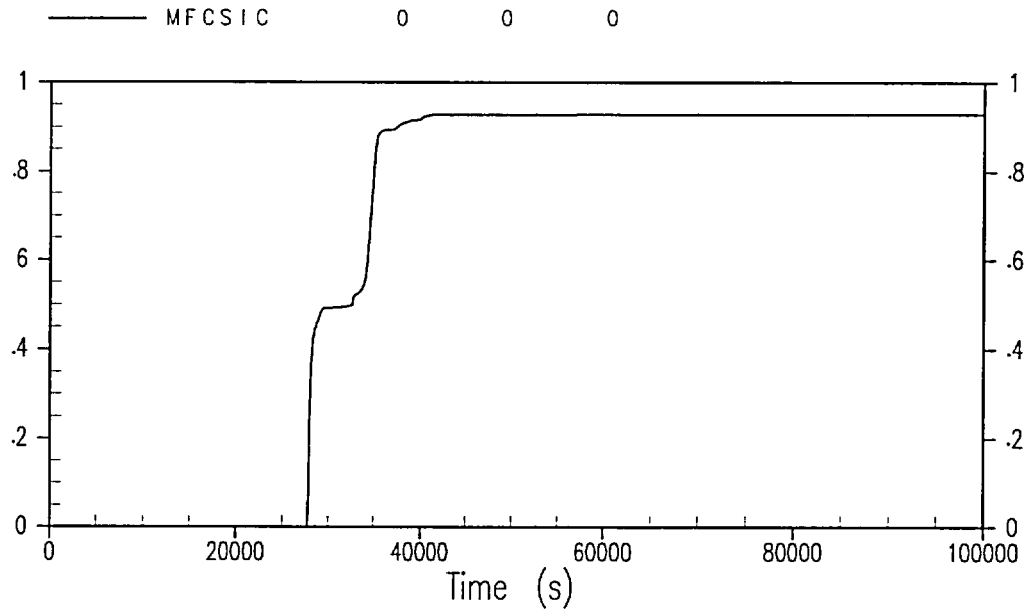

Figure 34-133

Case 3BL-1: Mass Fraction of CsI Released to Containment SBLOCA with Failed Gravity Injection

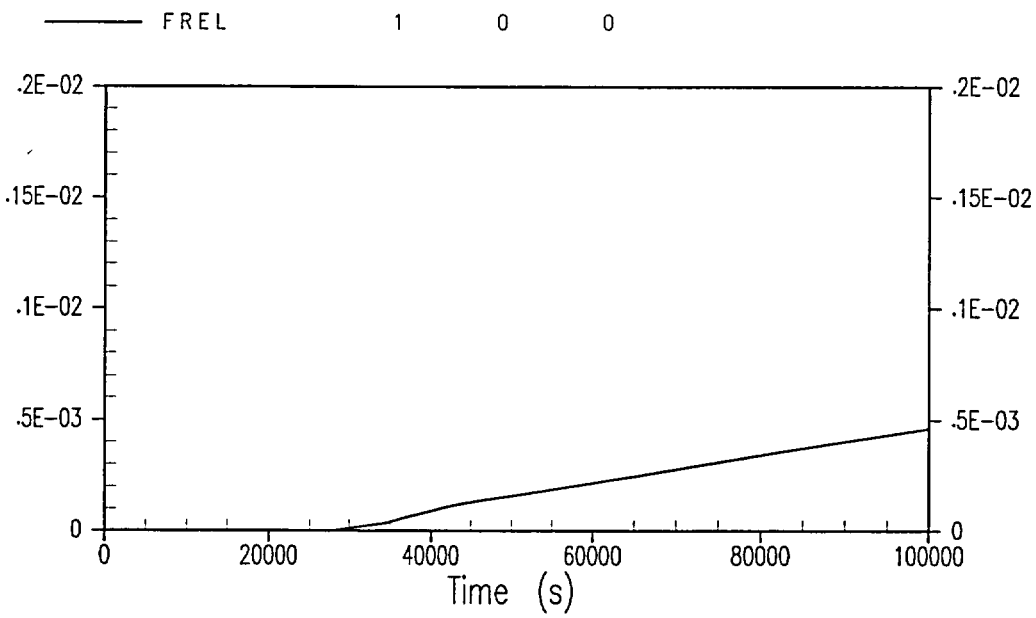

Figure 34-134

Case 3BL-1: Mass Fraction of Noble Gases Released to Environment SBLOCA with Failed Gravity Injection

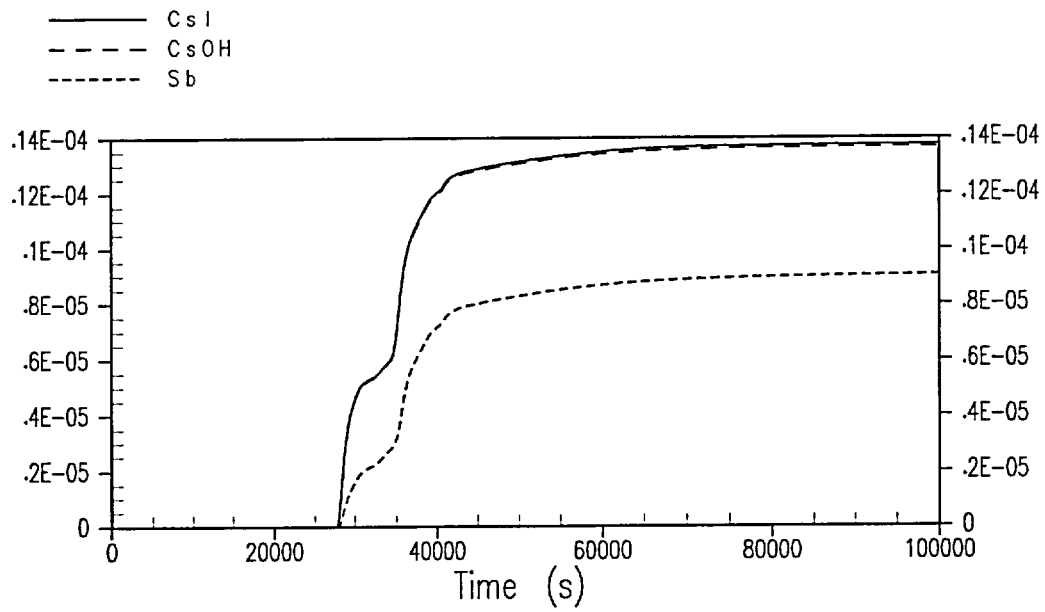

Figure 34-135

Case 3BL-1: Mass Fraction of Fission Products Released to Environment SBLOCA with Failed Gravity Injection

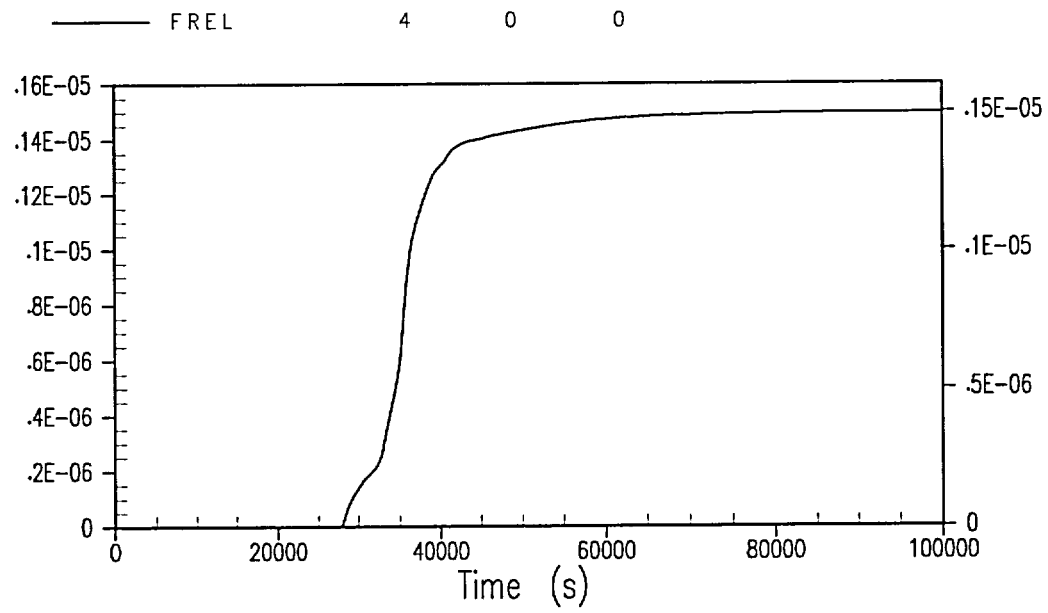

Figure 34-136

Case 3BL-1: Mass Fraction of SrO Released to Environment SBLOCA with Failed Gravity Injection

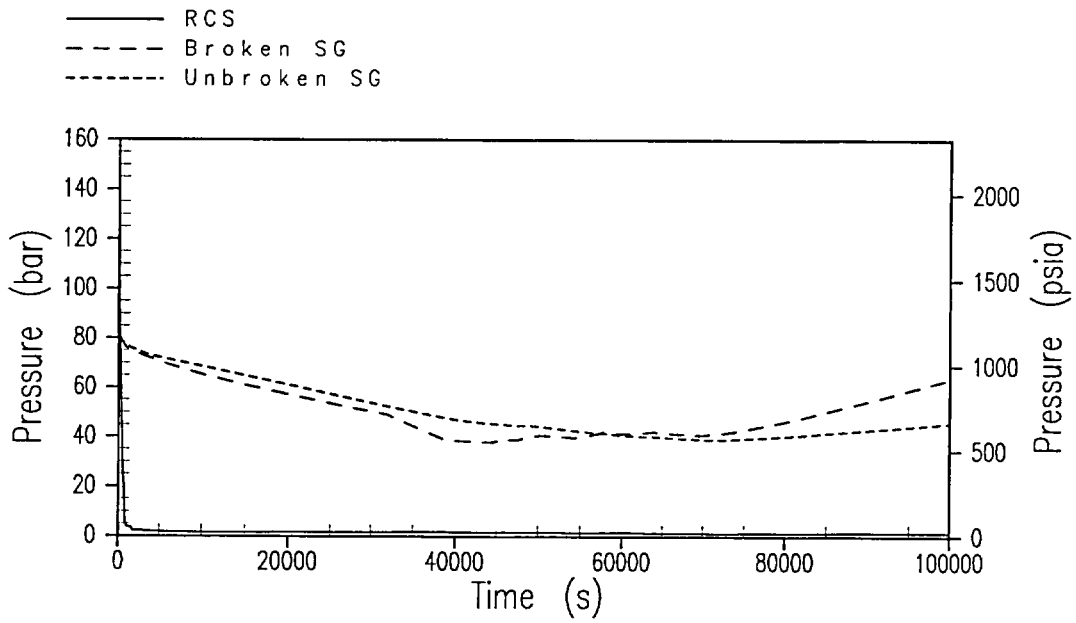

Figure 34-137

Case 3BL-2: Reactor Coolant System and Steam Generator Pressure
DVI Line Break with Failed Gravity Injection

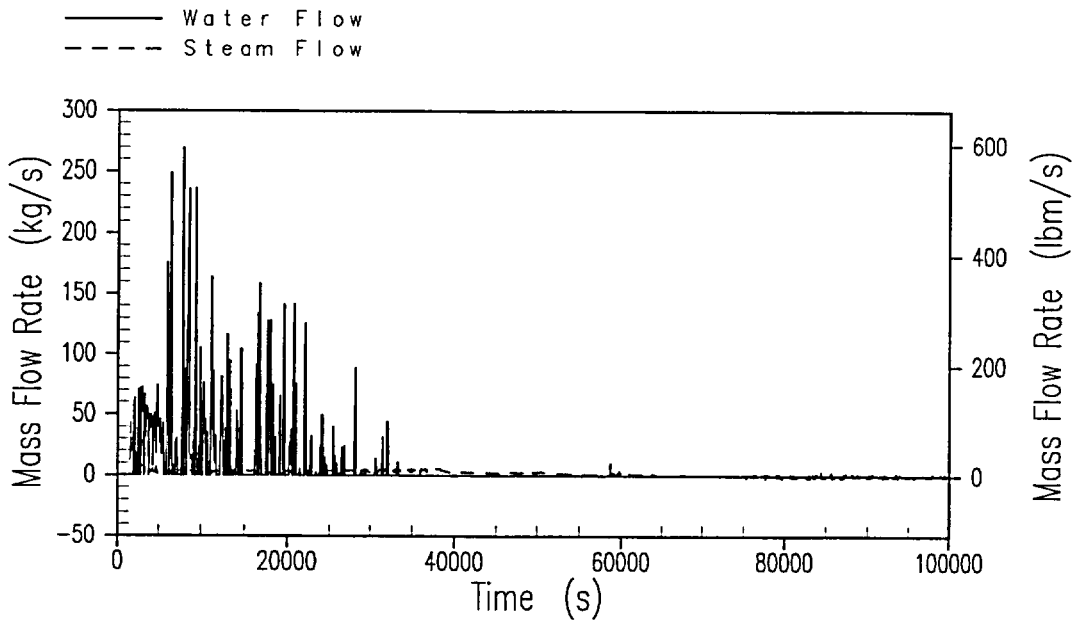

Figure 34-138

Case 3BL-2: ADS Stage 4 Flow Rates
DVI Line Break with Failed Gravity Injection

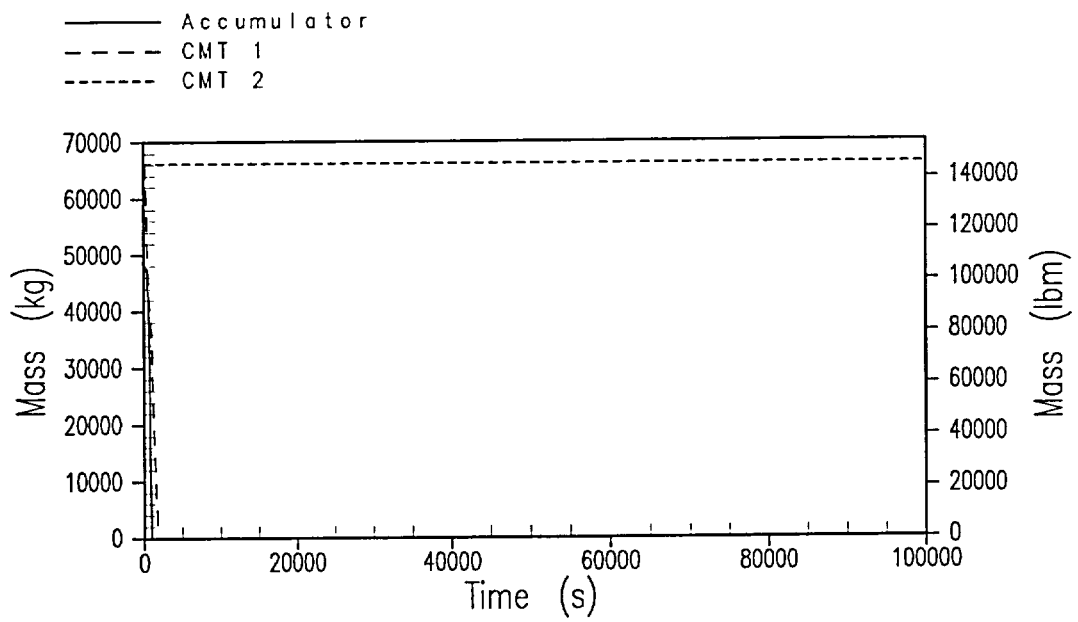

Figure 34-139

Case 3BL-2: Accumulator/CMT Water Mass DVI Line Break with Failed Gravity Injection

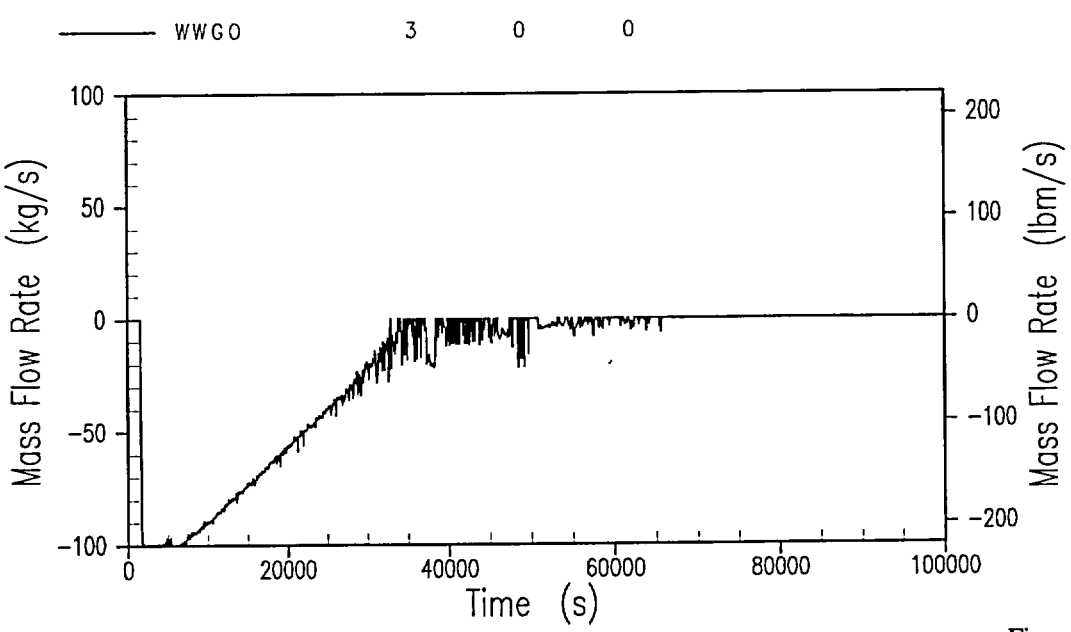

Figure 34-140

Case 3BL-2: IRWST Injection Flow Rate DVI Line Break with Failed Gravity Injection

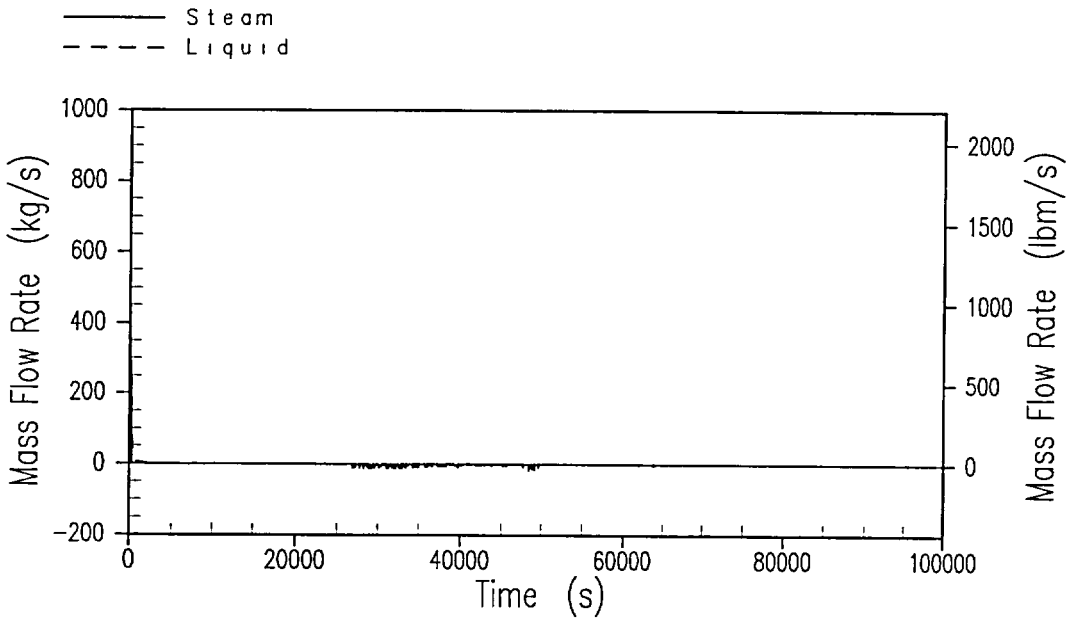

Figure 34-141

Case 3BL-2: Break Flow Rate
DVI Line Break with Failed Gravity Injection

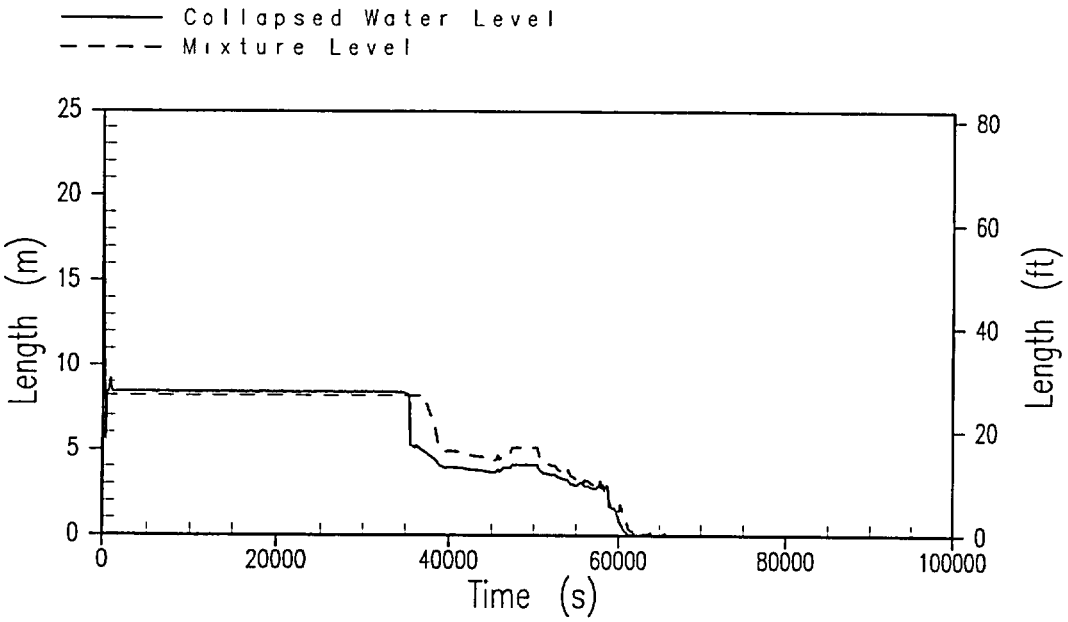

Figure 34-142

Case 3BL-2: Reactor Vessel Water Level
DVI Line Break with Failed Gravity Injection

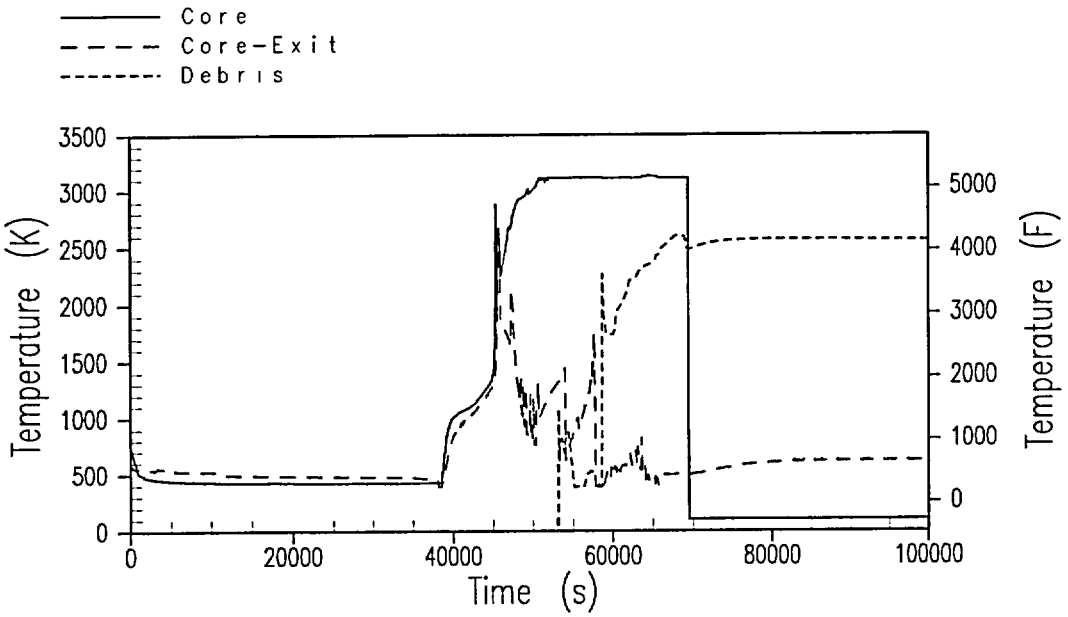

Figure 34-143

Case 3BL-2: Core Temperatures
DVI Line Break with Failed Gravity Injection

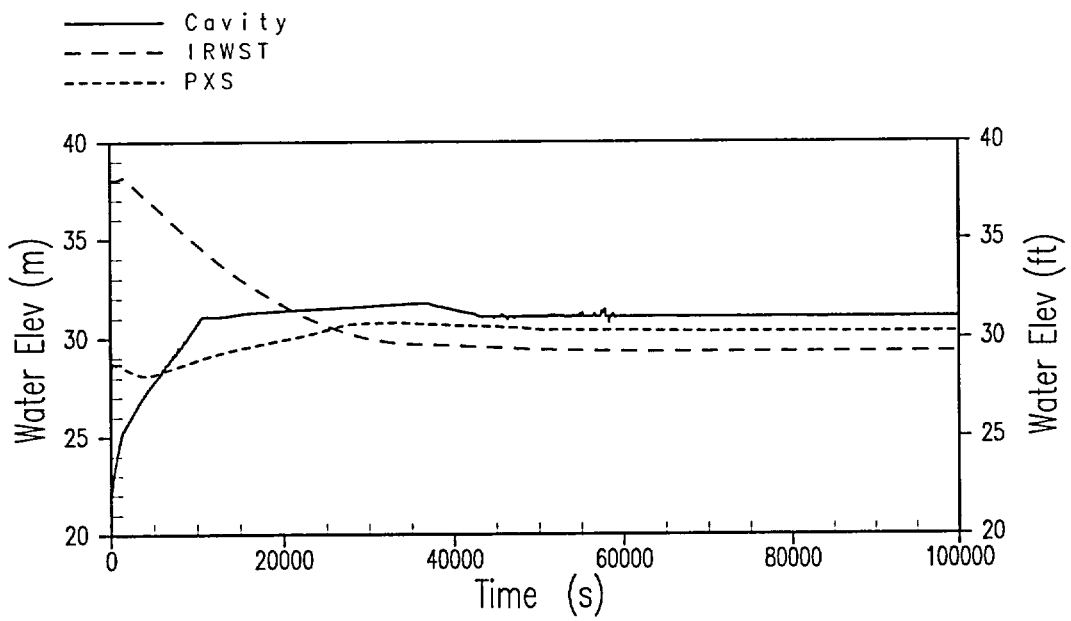

Figure 34-144

Case 3BL-2: Containment Water Pool Elevations
DVI Line Break with Failed Gravity Injection

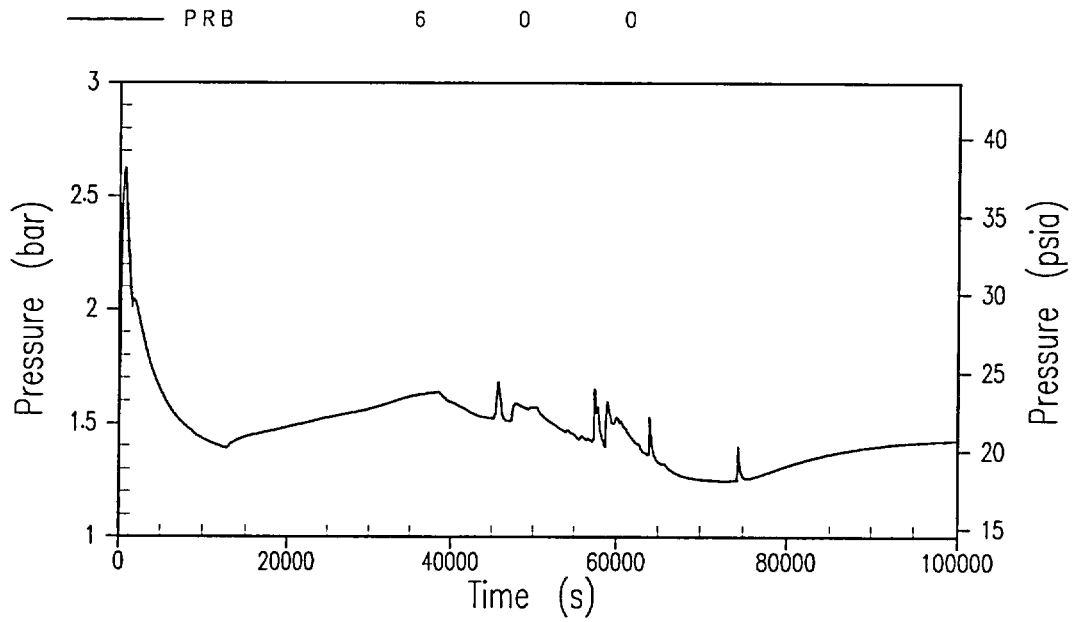

Figure 34-145

Case 3BL-2: Containment Pressure
DVI Line Break with Failed Gravity Injection

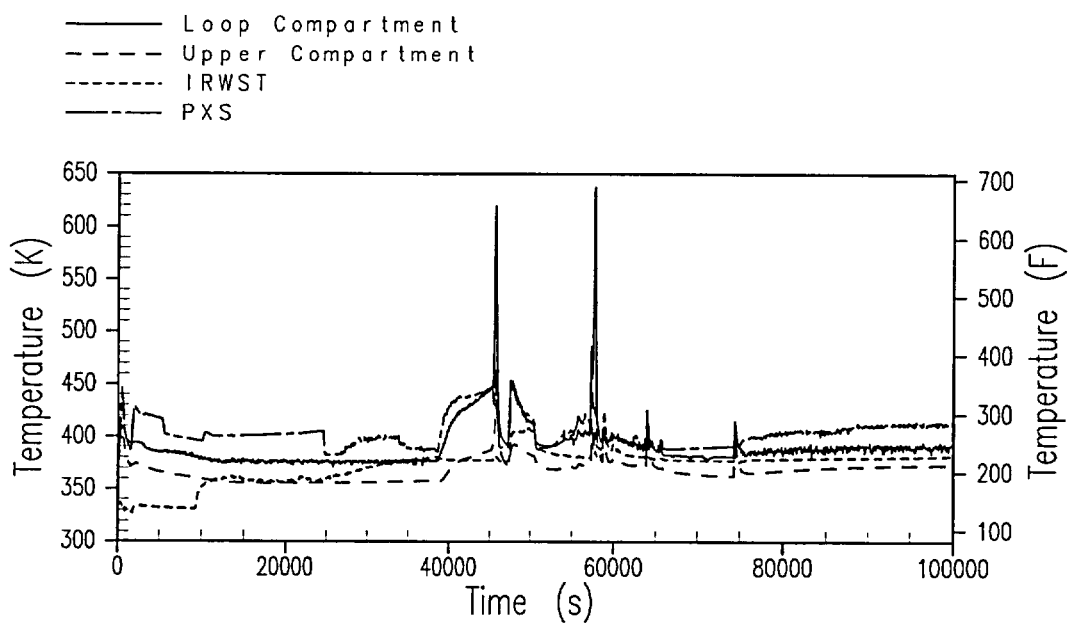

Figure 34-146

Case 3BL-2: Containment Gas Temperature
DVI Line Break with Failed Gravity Injection

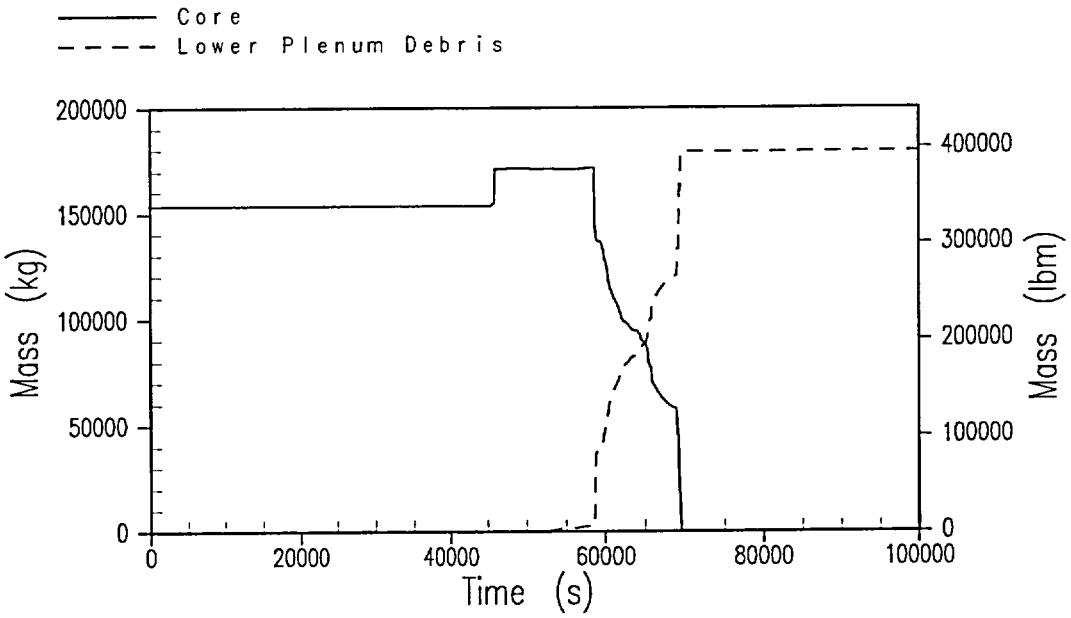

Figure 34-147

Case 3BL-2: Core Mass
DVI Line Break with Failed Gravity Injection

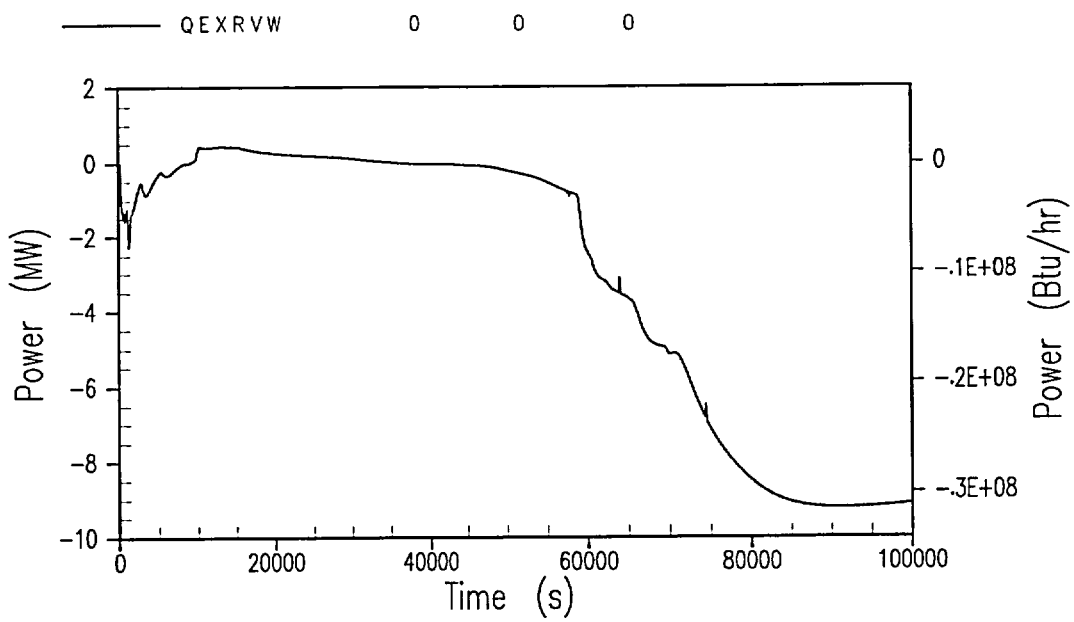

Figure 34-148

Case 3BL-2: Reactor Pressure Vessel to Cavity Water Heat Transfer
DVI Line Break with Failed Gravity Injection

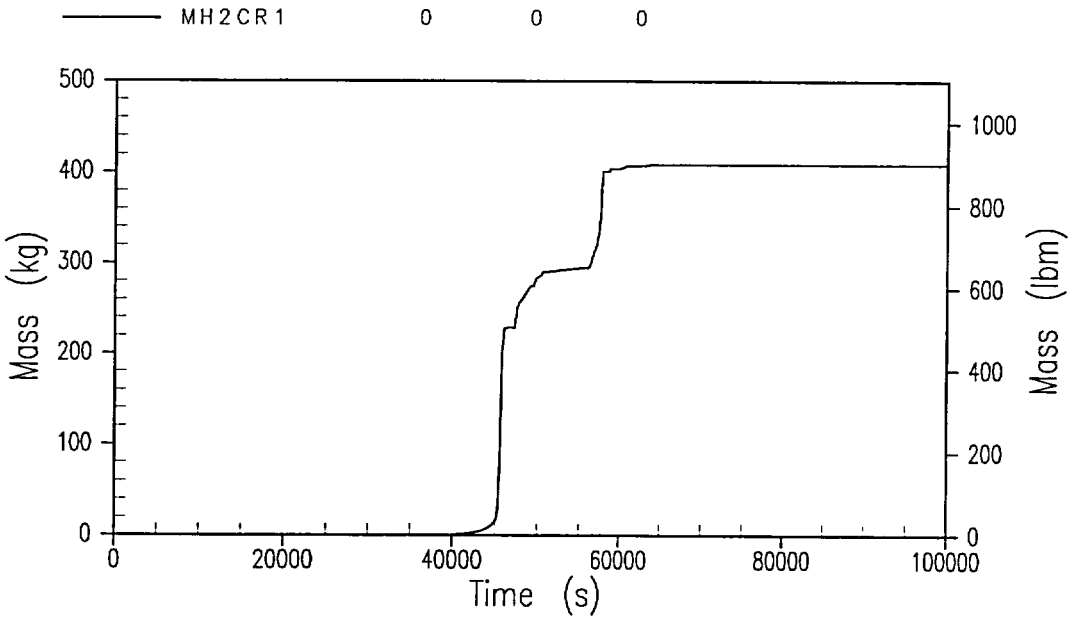

Figure 34-149

Case 3BL-2: In-Vessel Hydrogen Generation DVI Line Break with Failed Gravity Injection

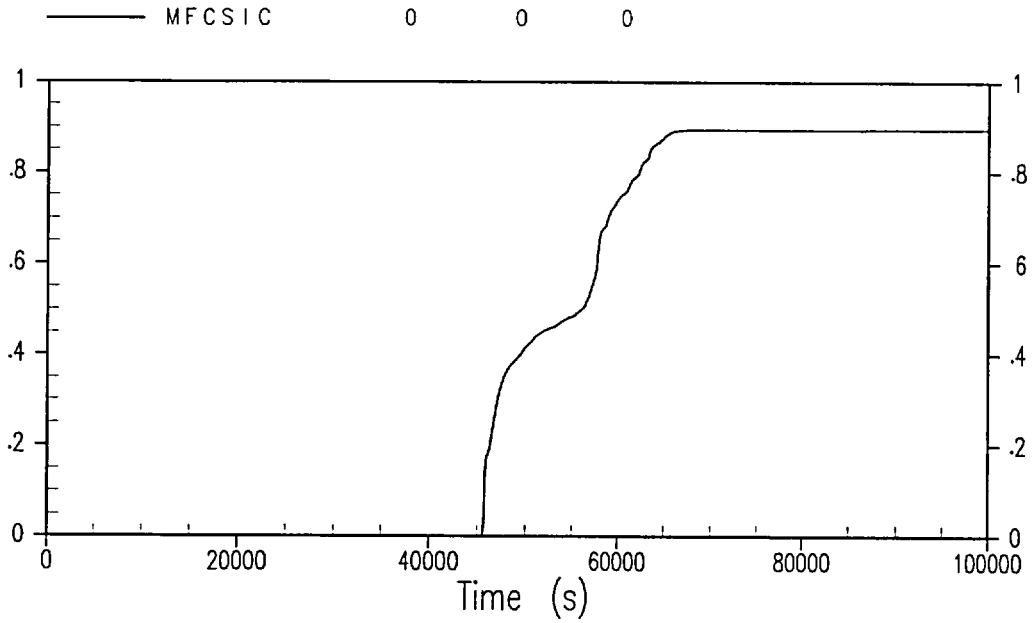

Figure 34-150

Case 3BL-2: Mass Fraction of CsI Released to Containment DVI Line Break with Failed Gravity Injection

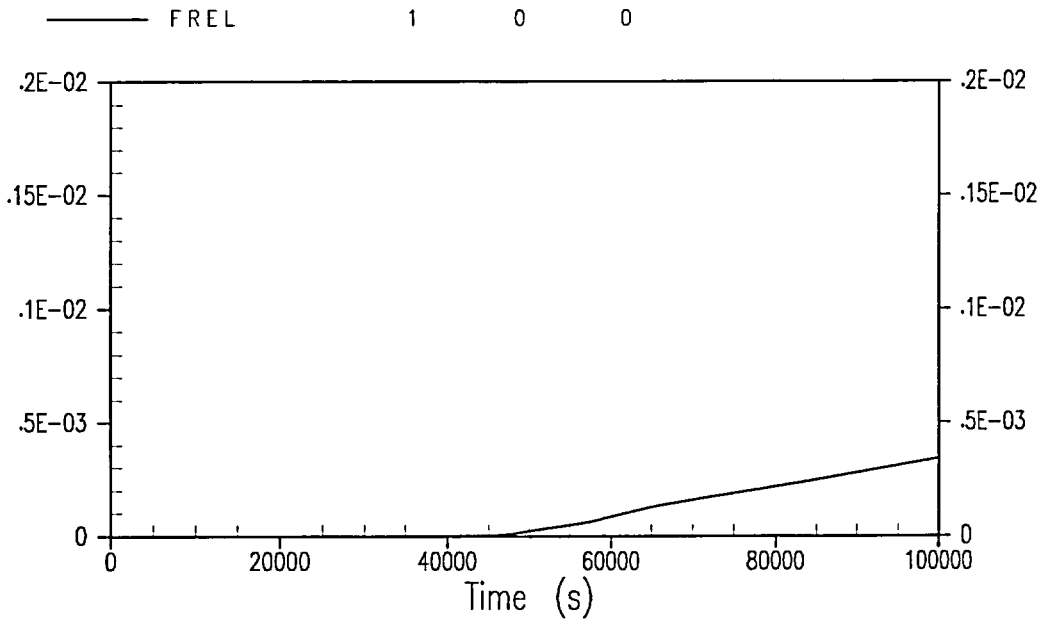

Figure 34-151

Case 3BL-2: Mass Fraction of Noble Gases Released to Environment DVI Line Break with Failed Gravity Injection

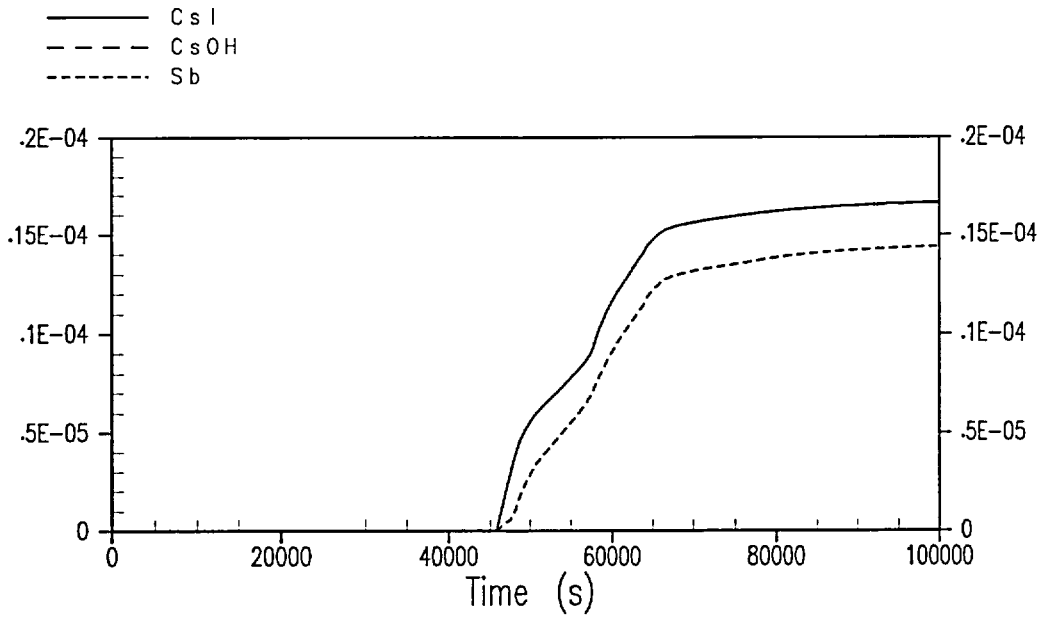

Figure 34-152

Case 3BL-2: Mass Fraction of Fission Products Released to Environment DVI Line Break with Failed Gravity Injection

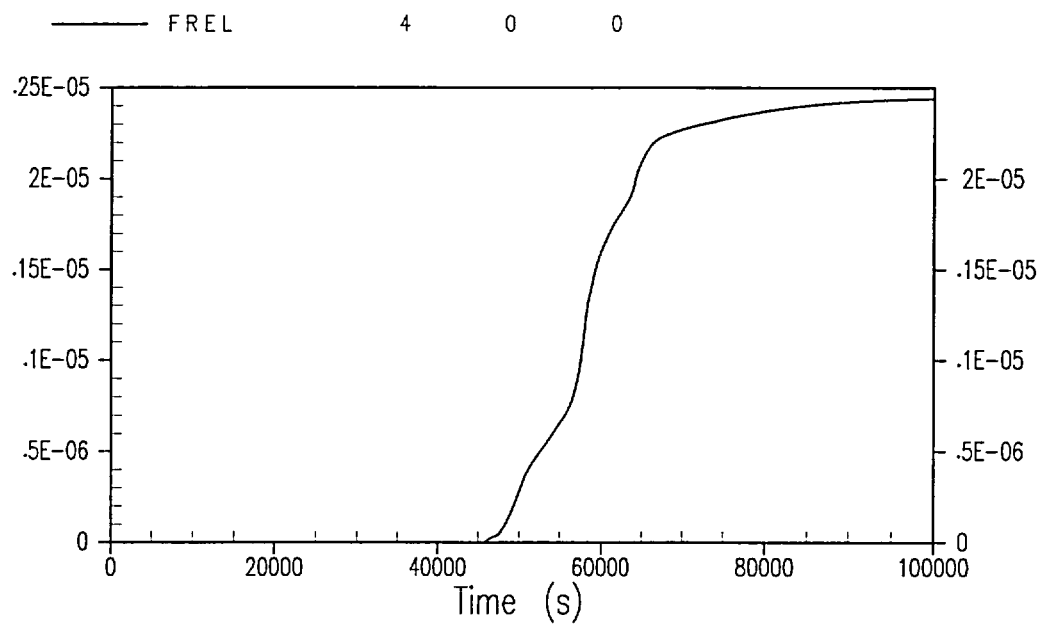

Figure 34-153

Case 3BL-2: Mass Fraction of SrO Released to Environment DVI Line Break with Failed Gravity Injection

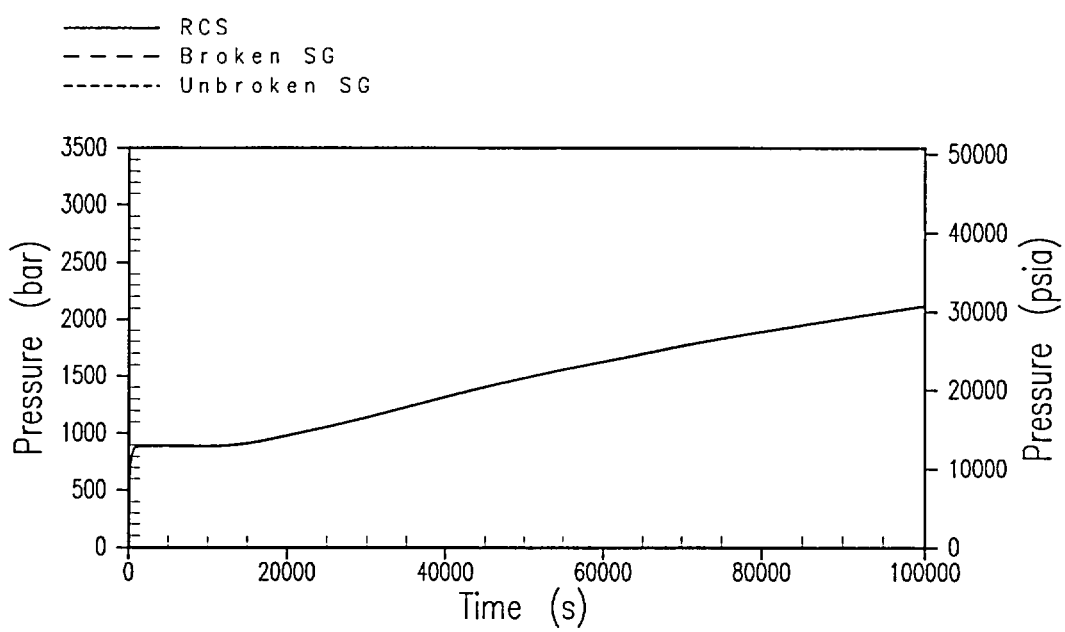

Figure 34-154

Case 3BR-1: Reactor Coolant System and Steam Generator Pressure CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

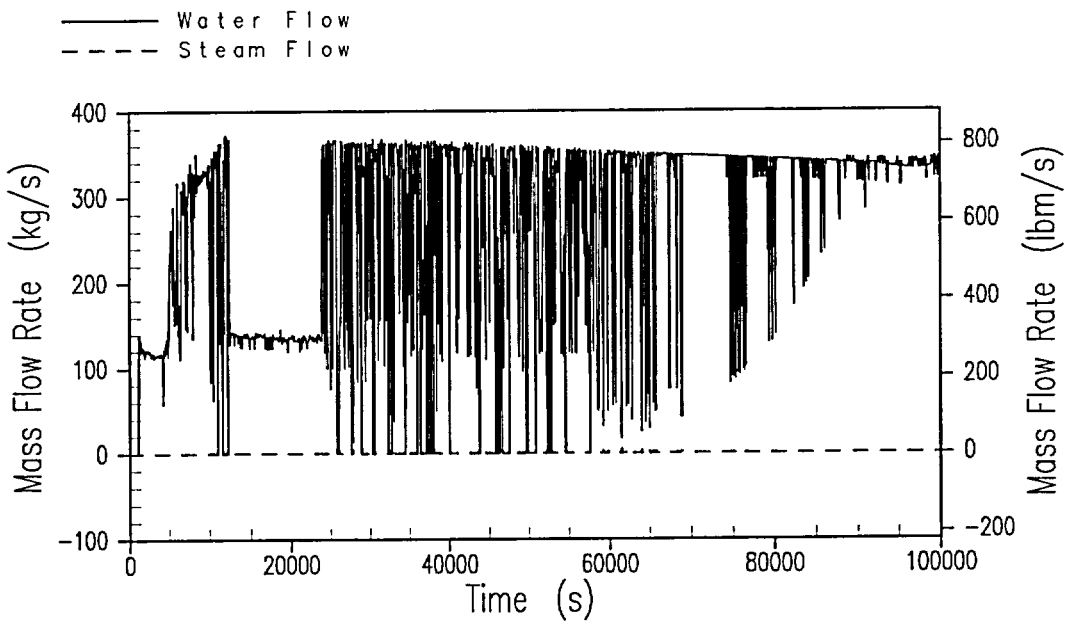

Figure 34-155

Case 3BR-1: ADS Stage 4 Flow Rates
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

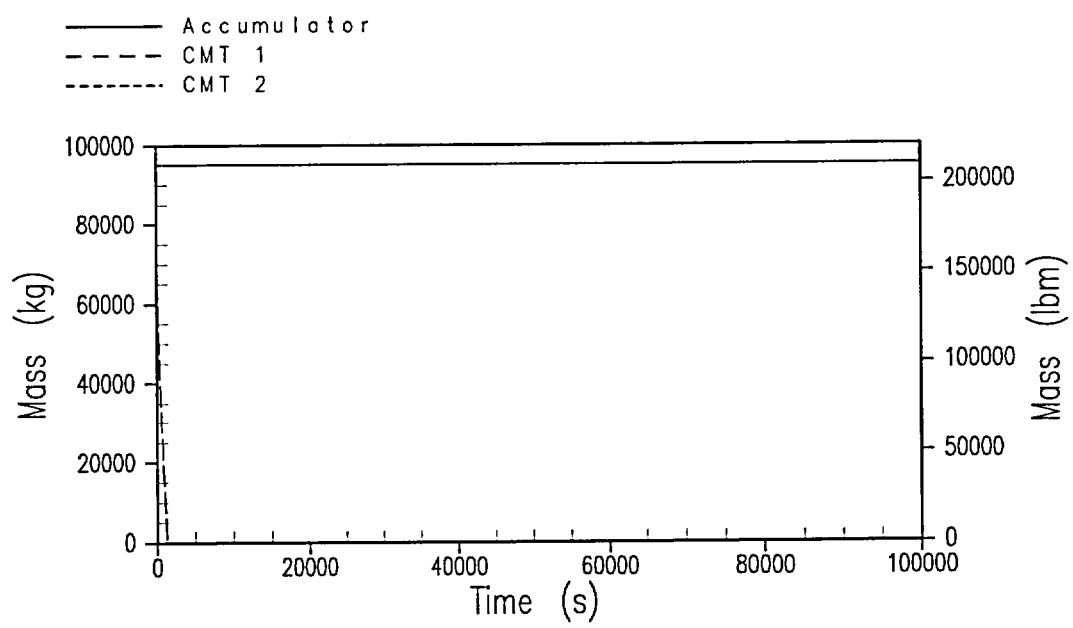

Figure 34-156

Case 3BR-1: Accumulator/CMT Water Mass
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

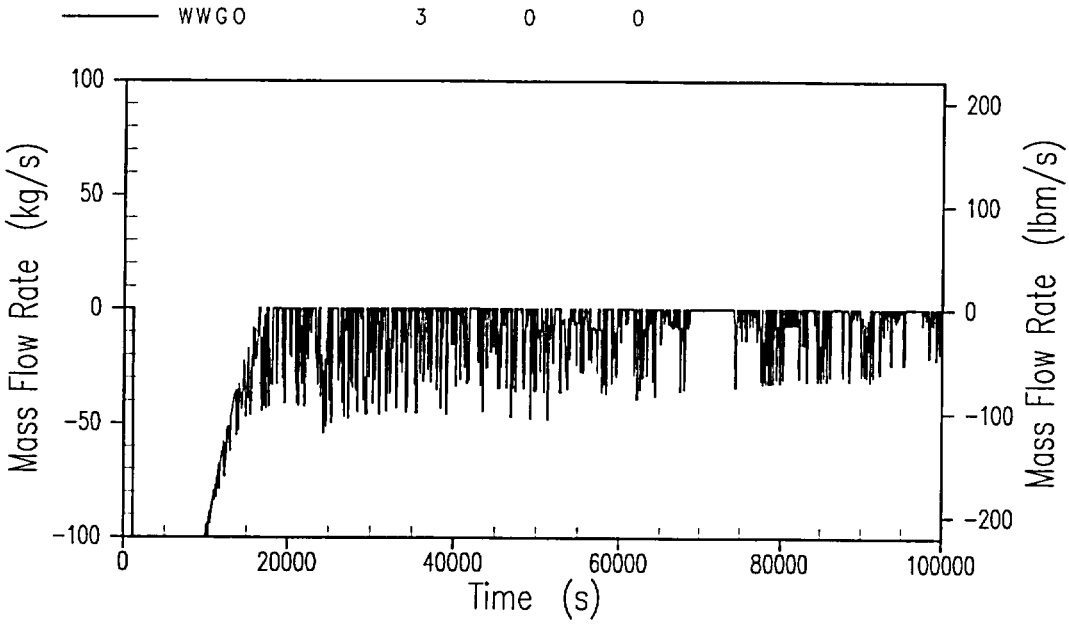

Figure 34-157

Case 3BR-1: IRWST Injection Flow Rate
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

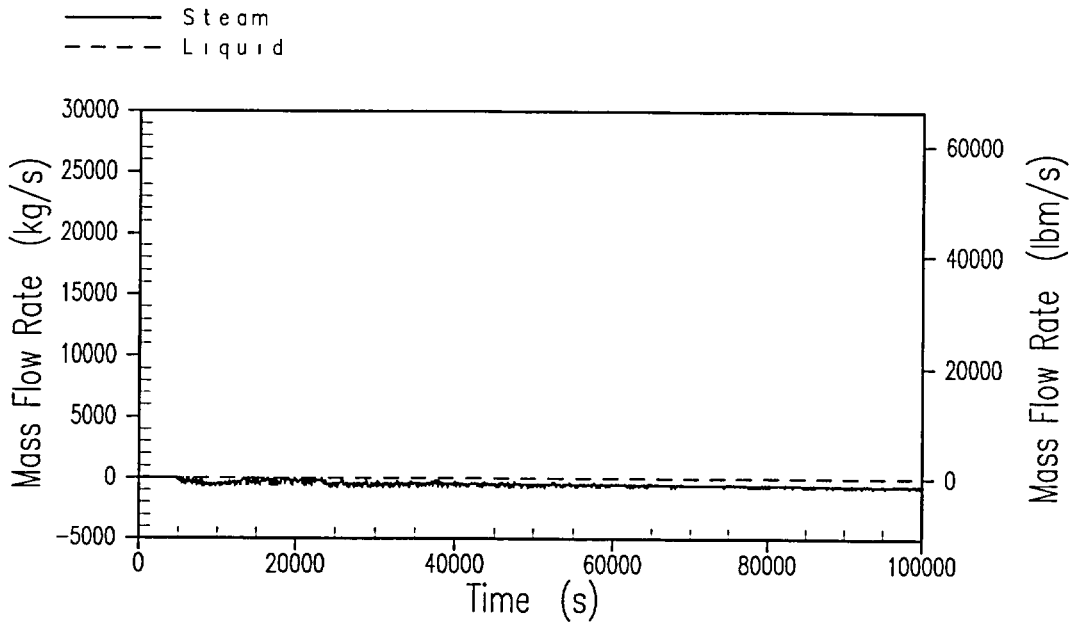

Figure 34-158

Case 3BR-1: Break Flow Rate
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

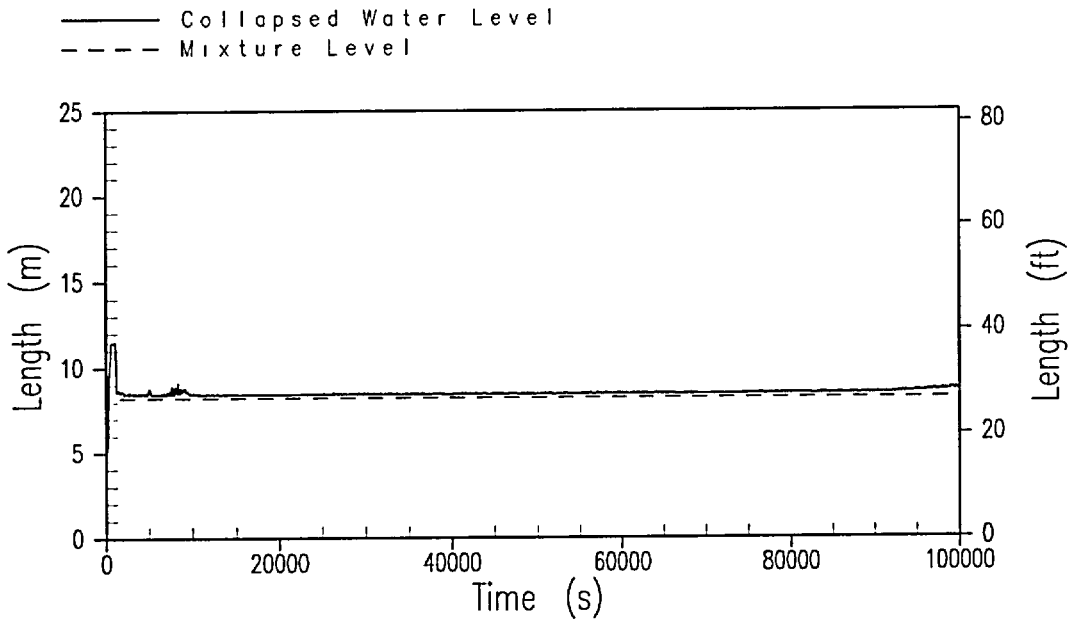

Figure 34-159

Case 3BR-1: Reactor Vessel Water Level
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

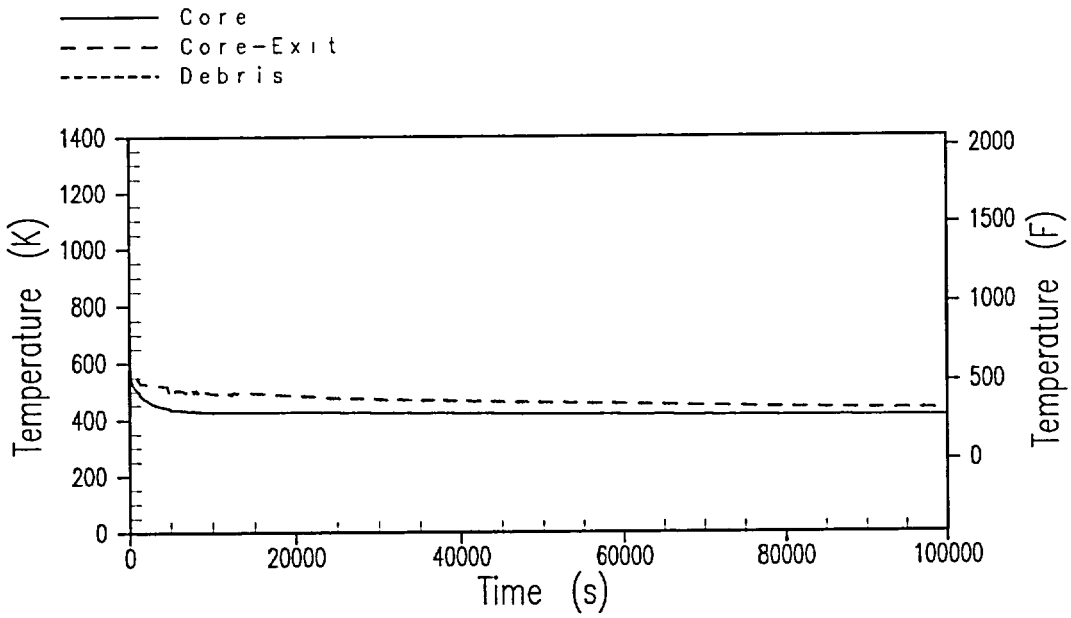

Figure 34-160

Case 3BR-1: Core Temperatures
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

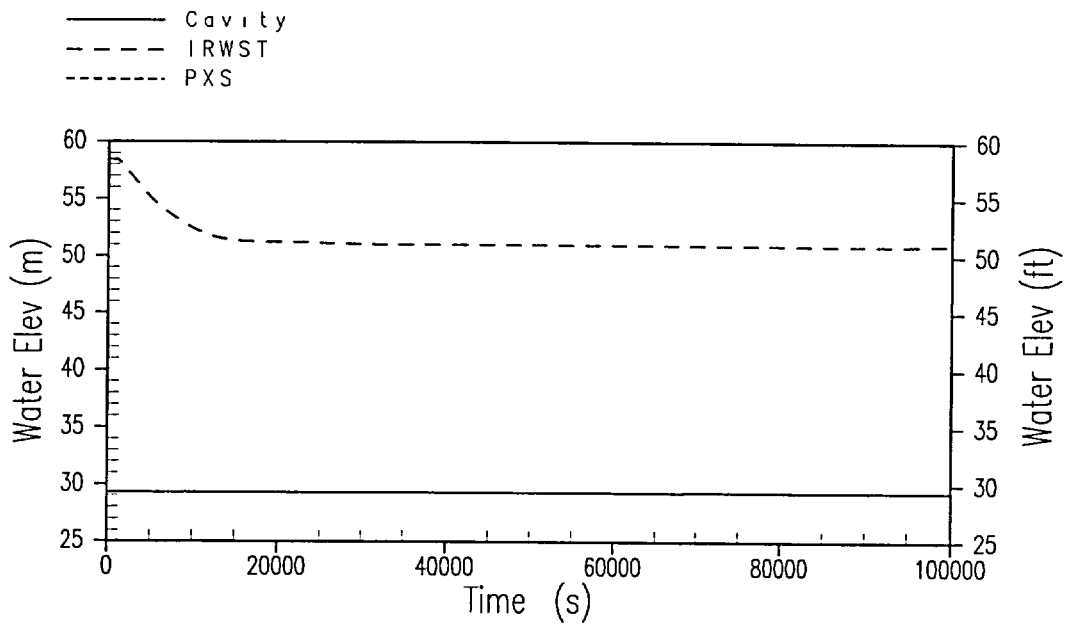

Figure 34-161

Case 3BR-1: Containment Water Pool Elevations
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

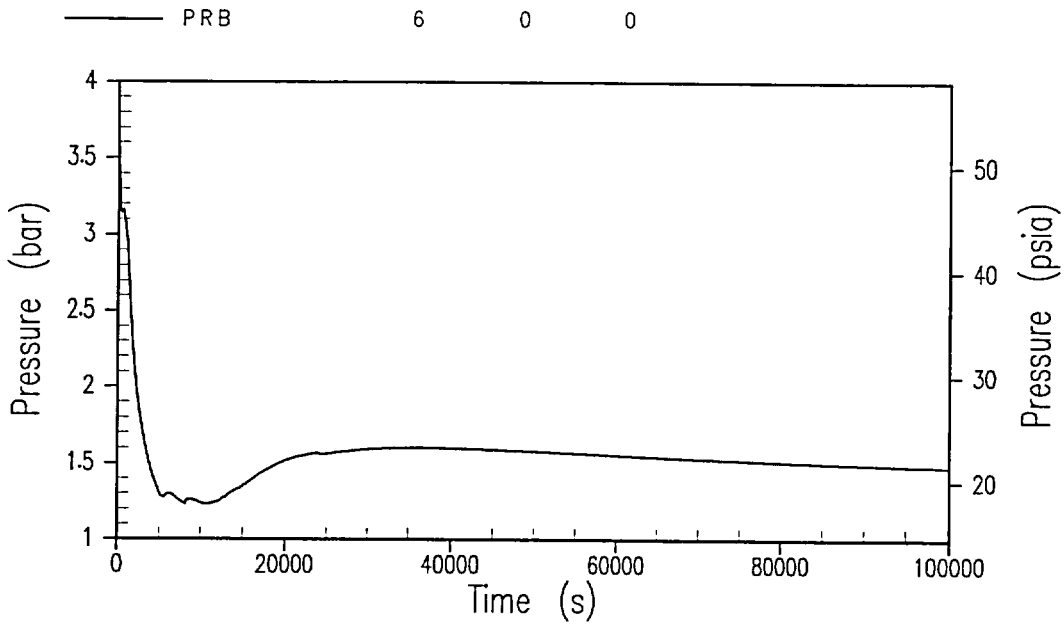

Figure 34-162

Case 3BR-1: Containment Pressure
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

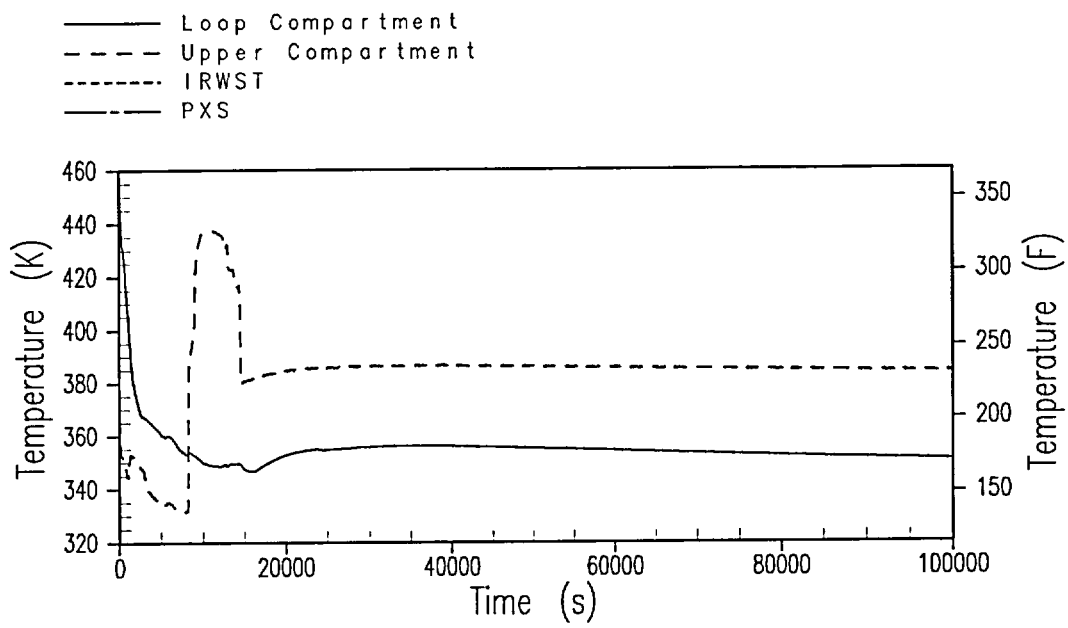

Figure 34-163

Case 3BR-1: Containment Gas Temperature
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

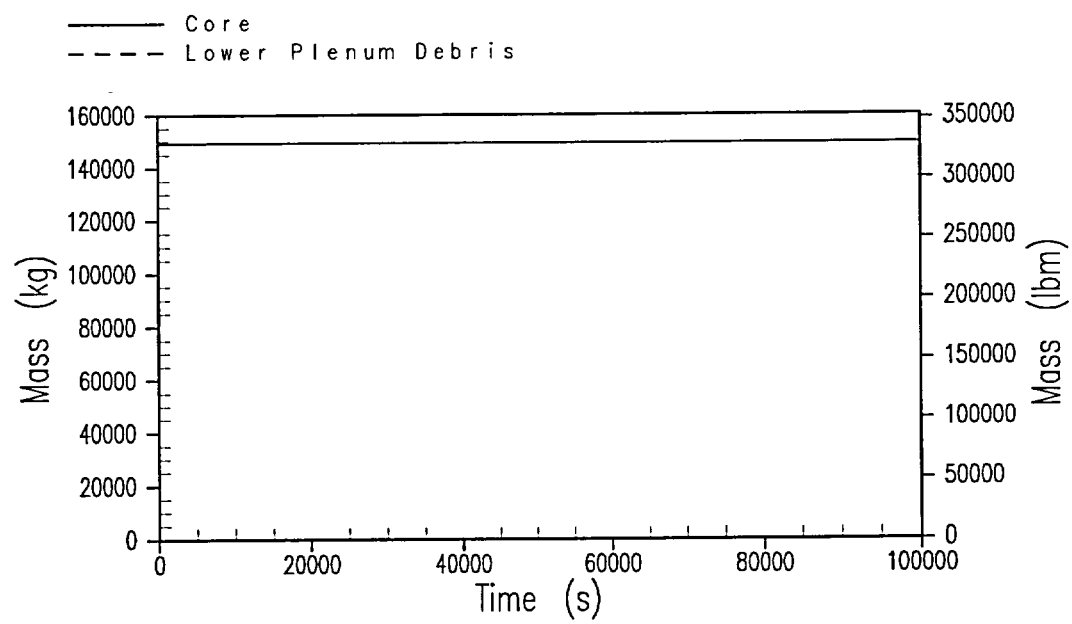

Figure 34-164

Case 3BR-1: Core Mass
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

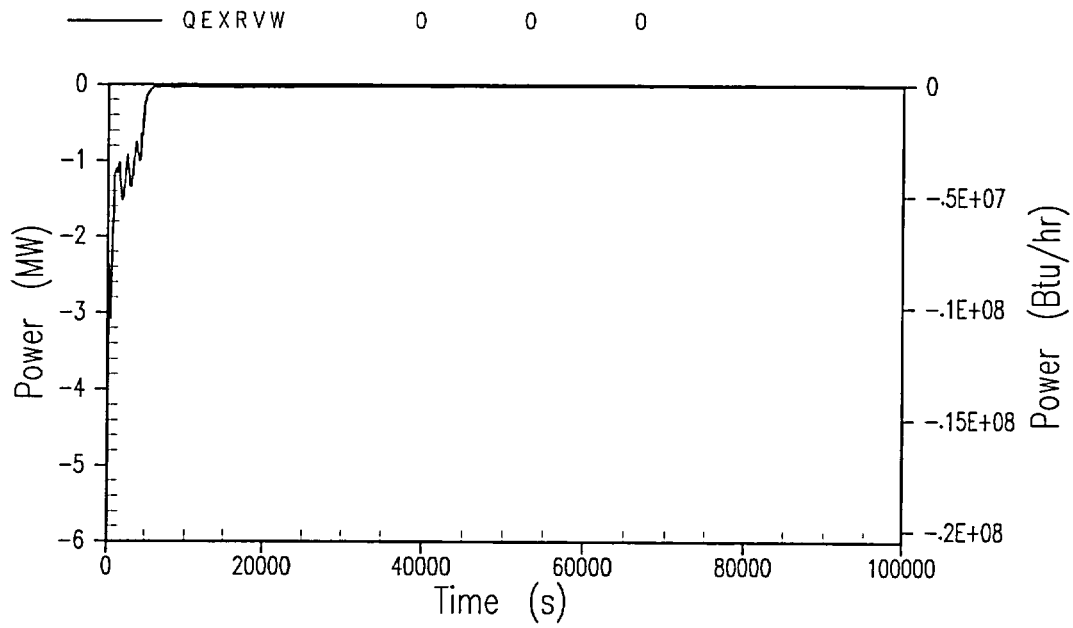

Figure 34-165

Case 3BR-1: Reactor Pressure Vessel to Cavity Water Heat Transfer
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

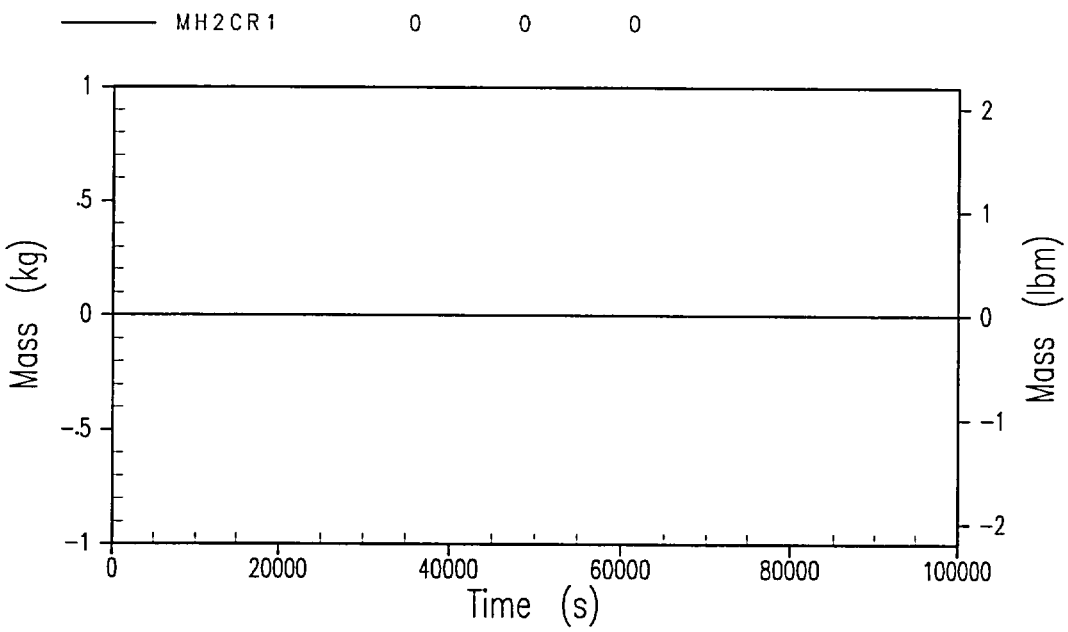

Figure 34-166

Case 3BR-1: In-Vessel Hydrogen Generation
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

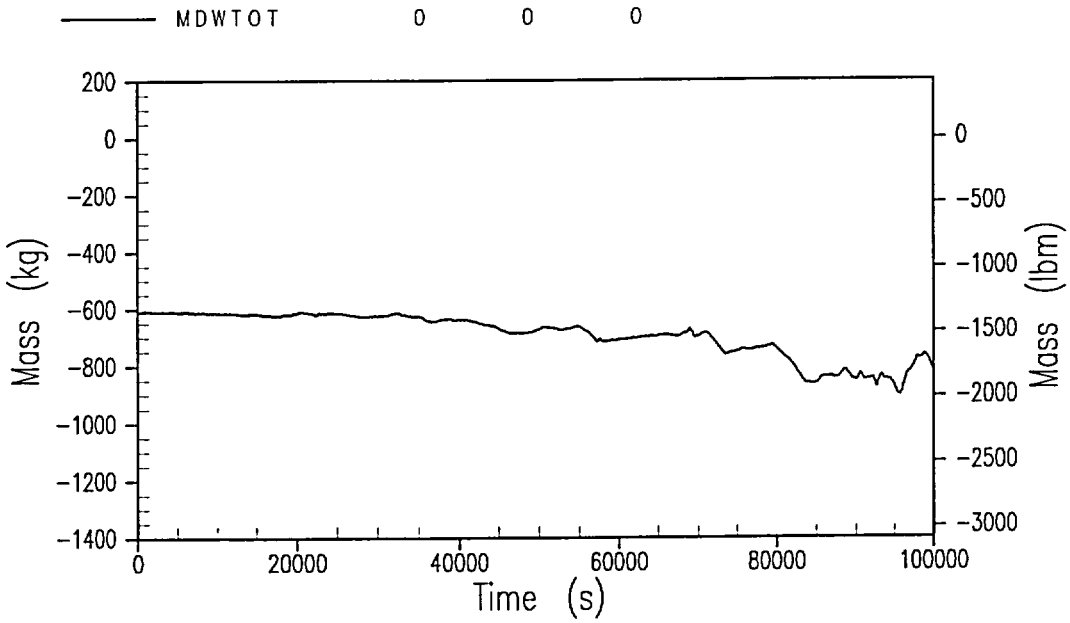

Figure 34-167

Case 3BR-1: Mass Fraction of CsI Released to Containment
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

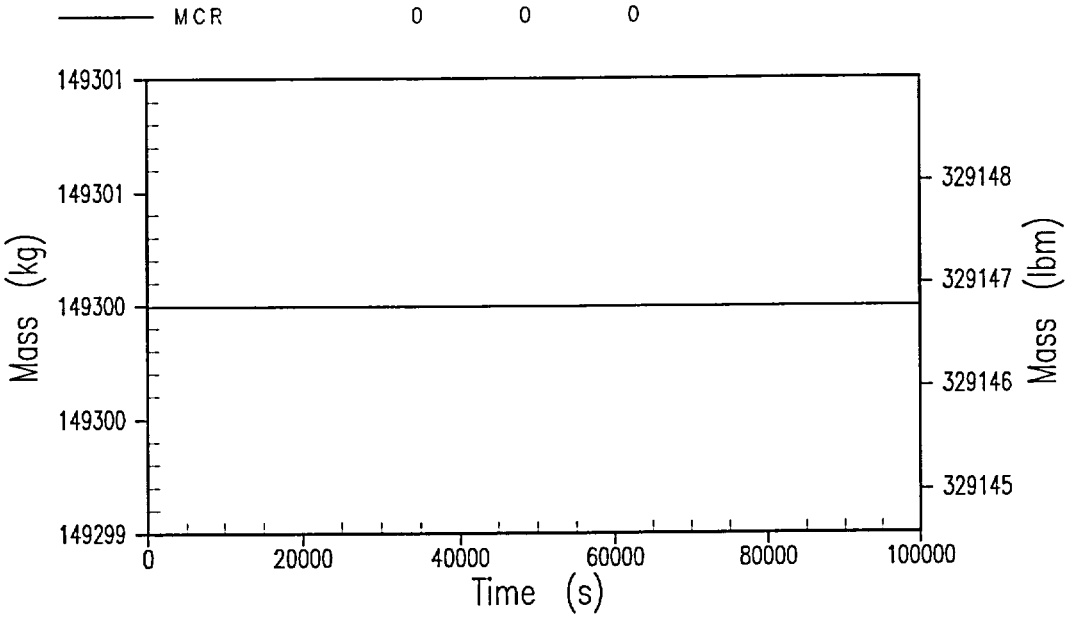

Figure 34-168

Case 3BR-1: Mass Fraction of Noble Gases Released to Environment
CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

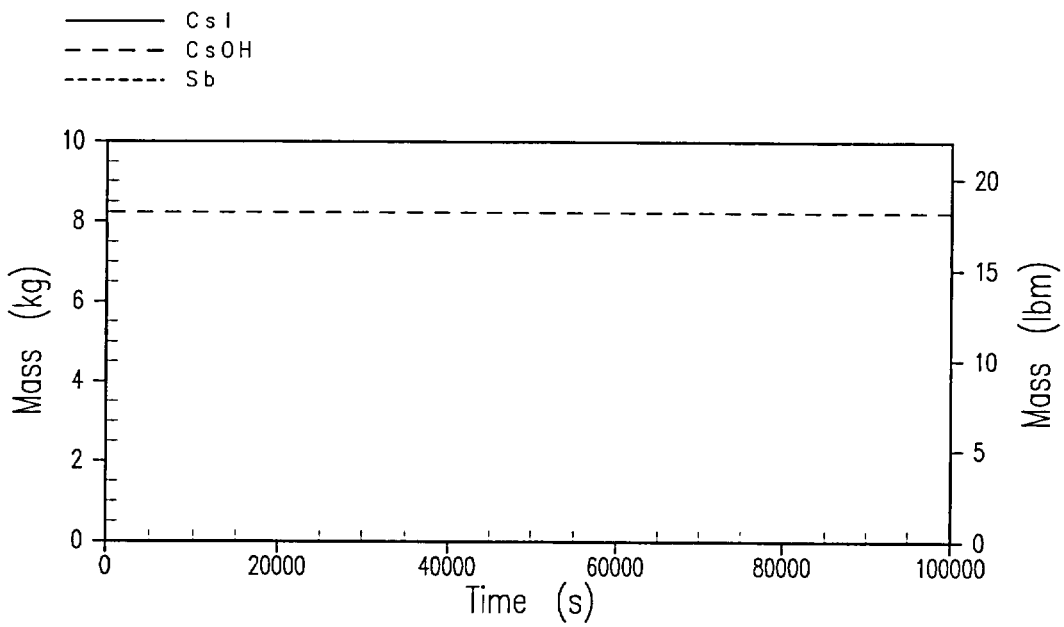

Figure 34-169

Case 3BR-1: Mass Fraction of Fission Products Released to Environment CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

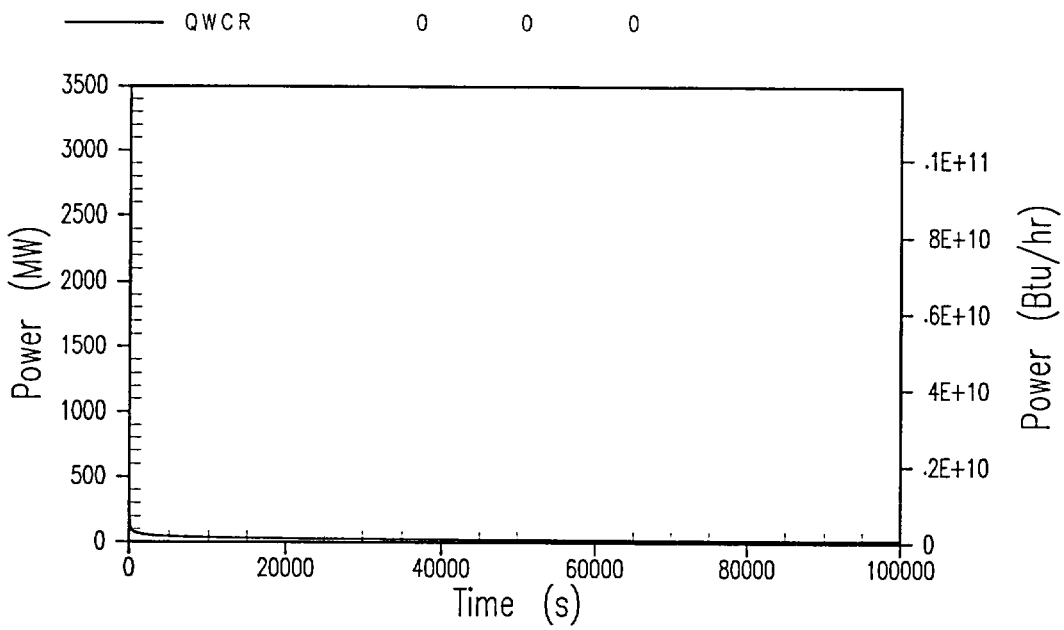

Figure 34-170

Case 3BR-1: Mass Fraction of SrO Released to Environment CL LBLOCA to Loop Compartment 2/2 Gravity Injection/Recirculation Lines

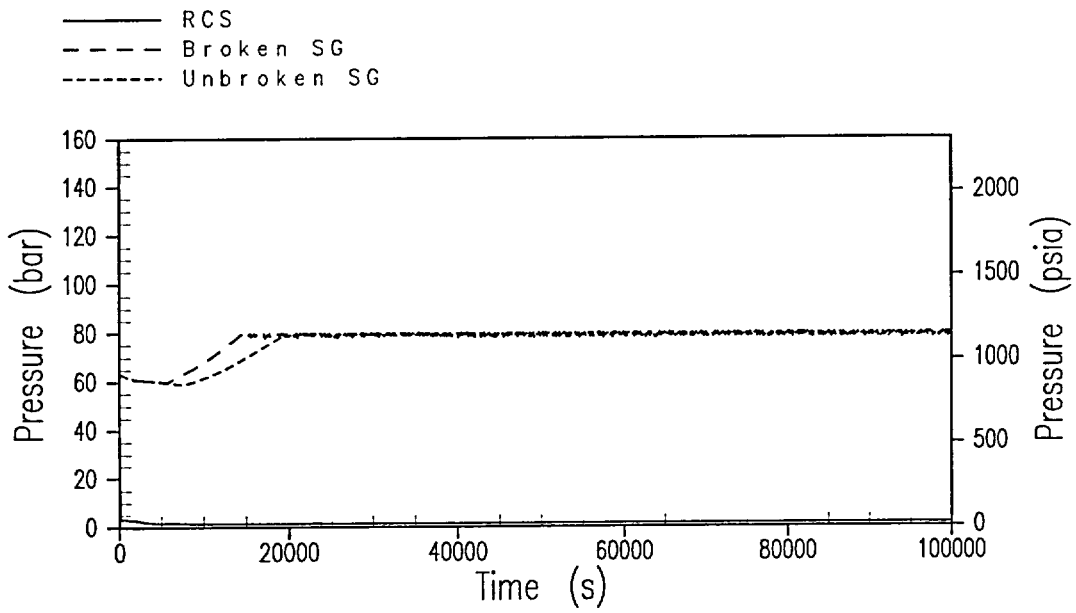

Figure 34-171

Case 3BR-1a: Reactor Coolant System and Steam Generator Pressure CL LBLOCA with Failed Accumulators

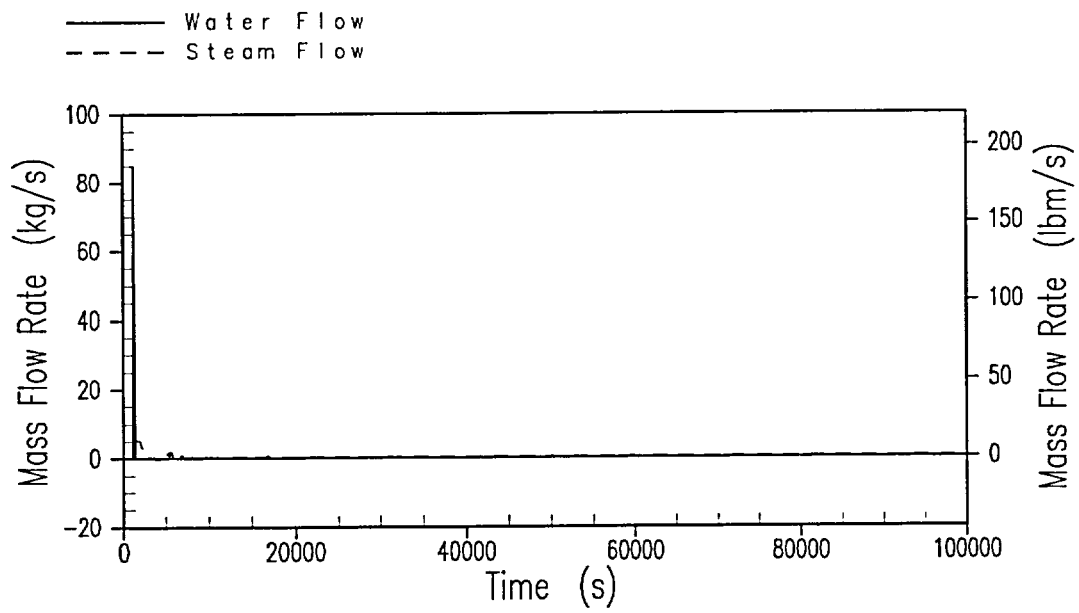

Figure 34-172

Case 3BR-1a: ADS Stage 4 Flow Rates CL LBLOCA with Failed Accumulators

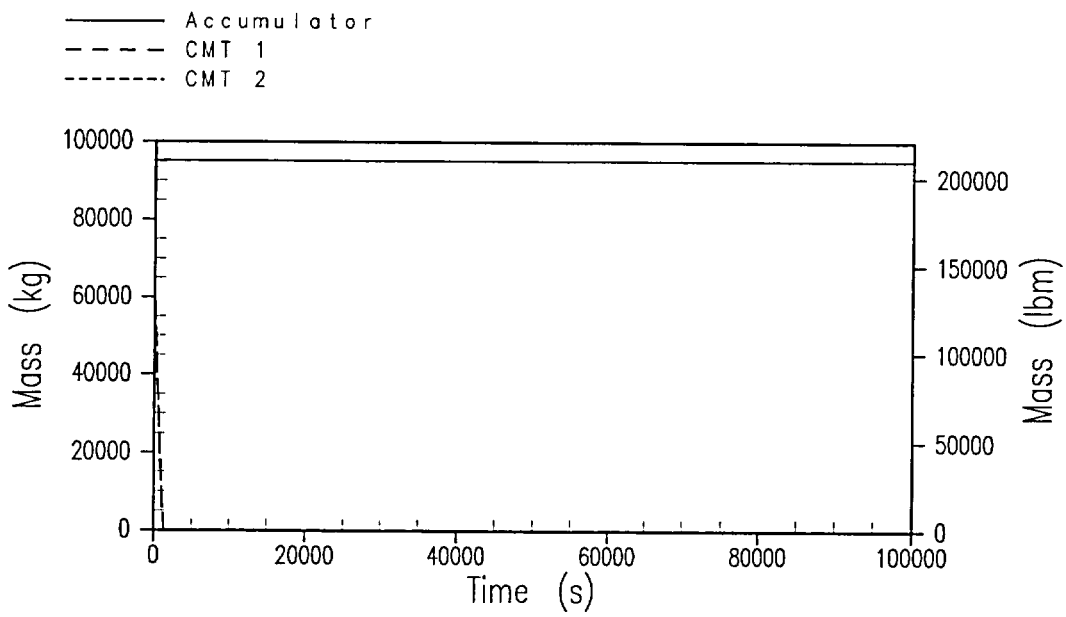

Figure 34-173

Case 3BR-1a: Accumulator/CMT Water Mass CL LBLOCA with Failed Accumulators

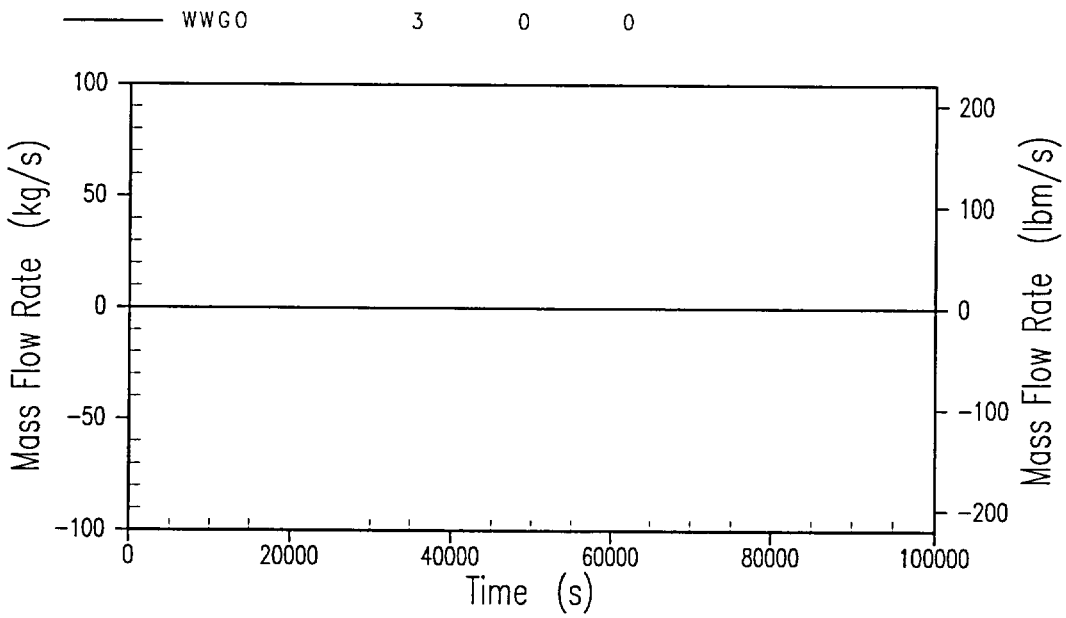

Figure 34-174

Case 3BR-1a: IRWST Injection Flow Rate CL LBLOCA with Failed Accumulators

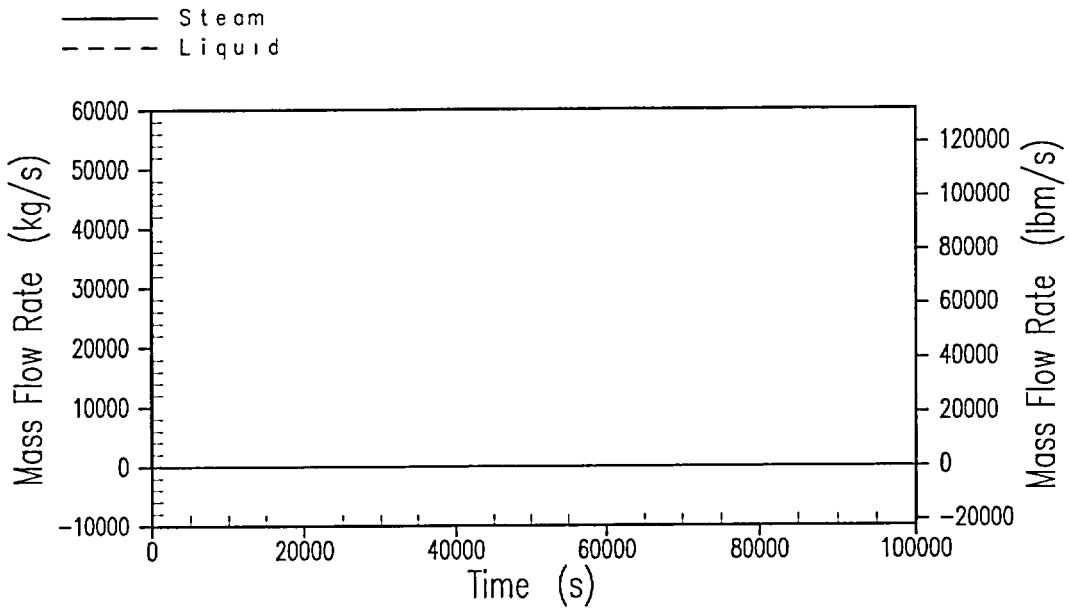

Figure 34-175

Case 3BR-1a: Break Flow Rate
CL LBLOCA with Failed Accumulators

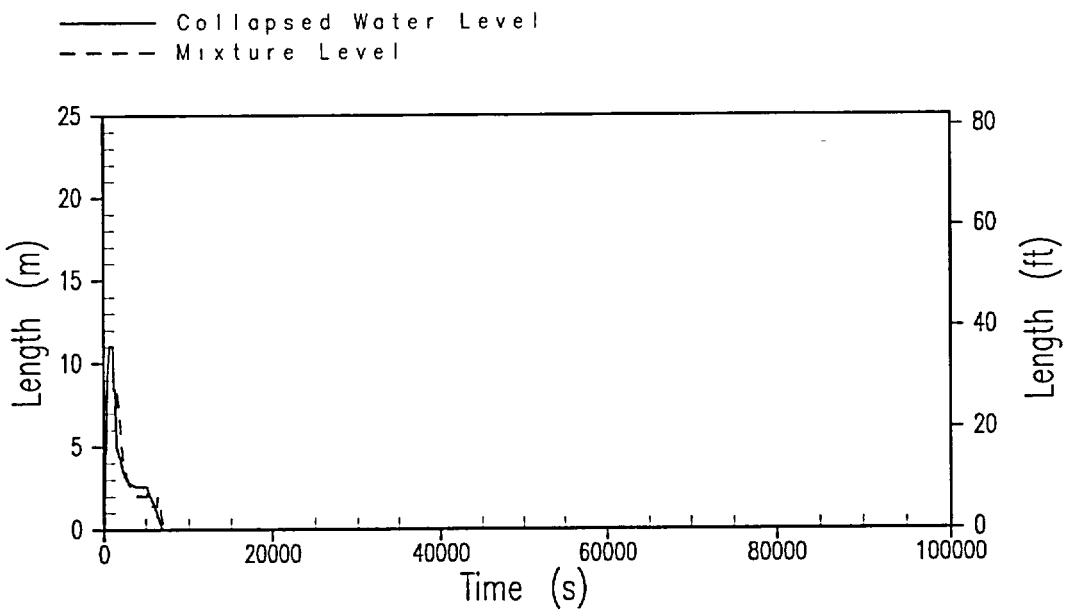

Figure 34-176

Case 3BR-1a: Reactor Vessel Water Level
CL LBLOCA with Failed Accumulators

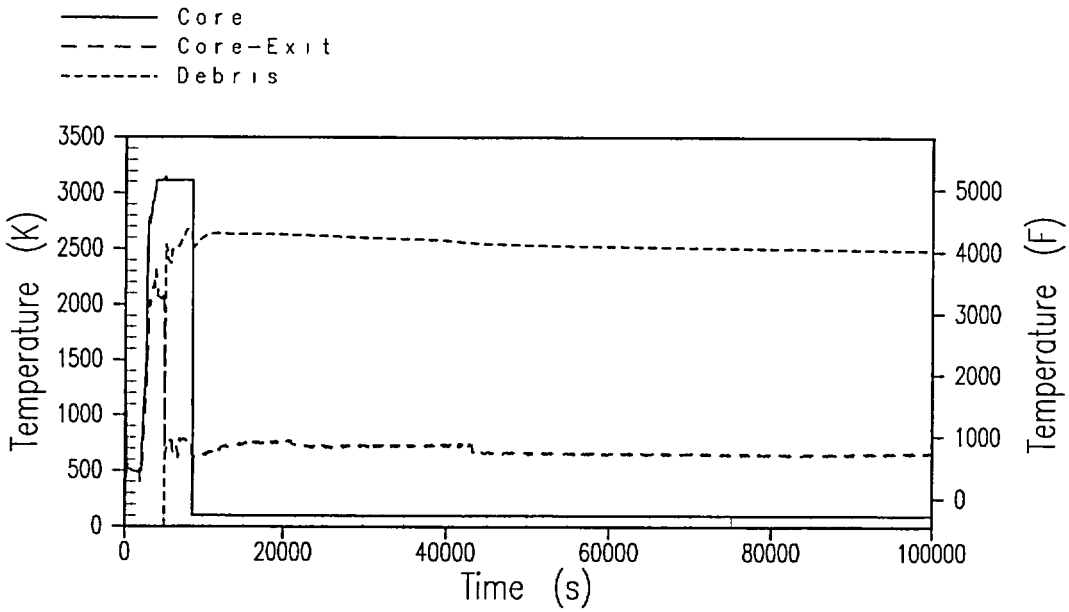

Figure 34-177

Case 3BR-1a: Core Temperatures
CL LBLOCA with Failed Accumulators

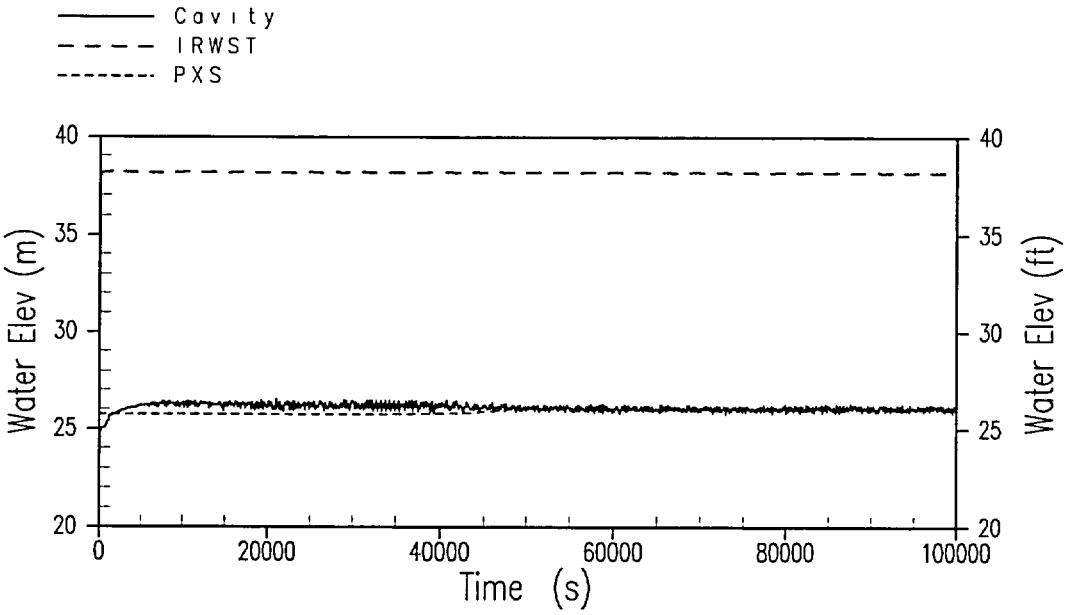

Figure 34-178

Case 3BR-1a: Containment Water Pool Elevations
CL LBLOCA with Failed Accumulators

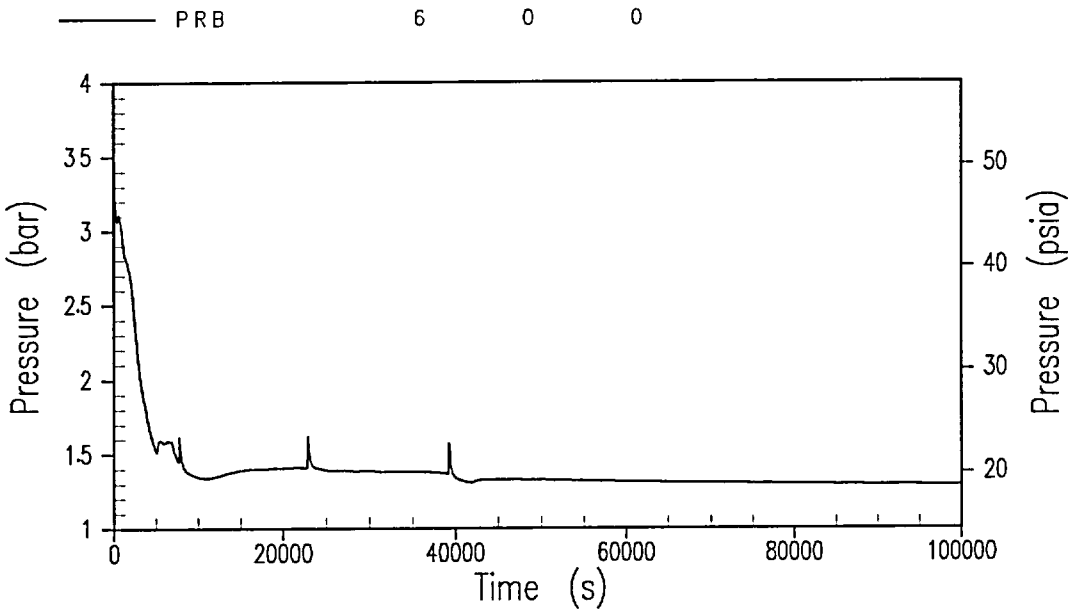

Figure 34-179

Case 3BR-1a: Containment Pressure
CL LBLOCA with Failed Accumulators

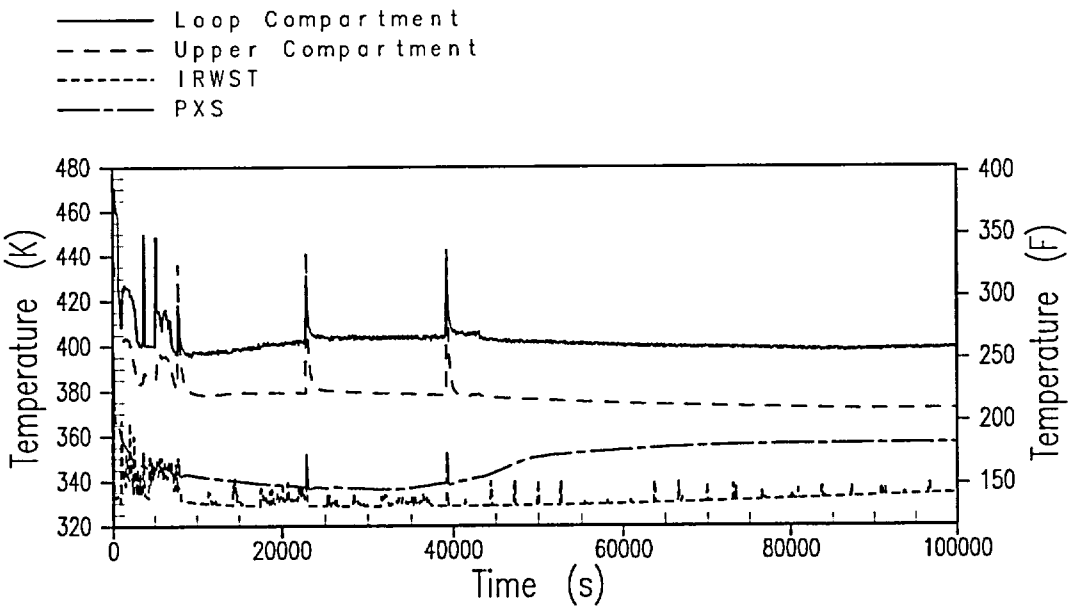

Figure 34-180

Case 3BR-1a: Containment Gas Temperature
CL LBLOCA with Failed Accumulators

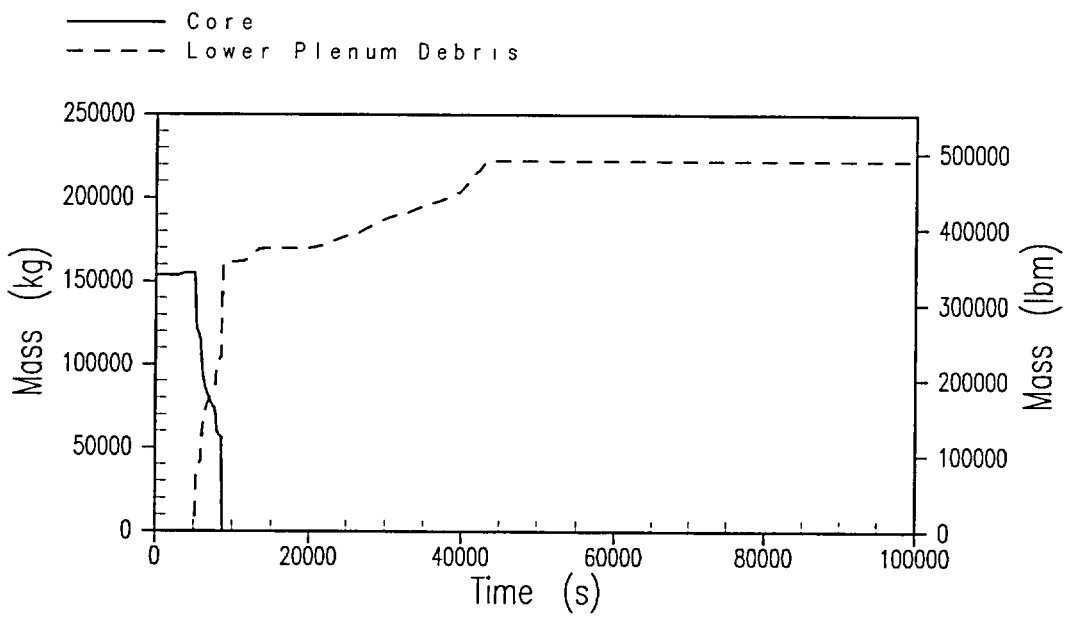

Figure 34-181

Case 3BR-1a: Core Mass
CL LBLOCA with Failed Accumulators

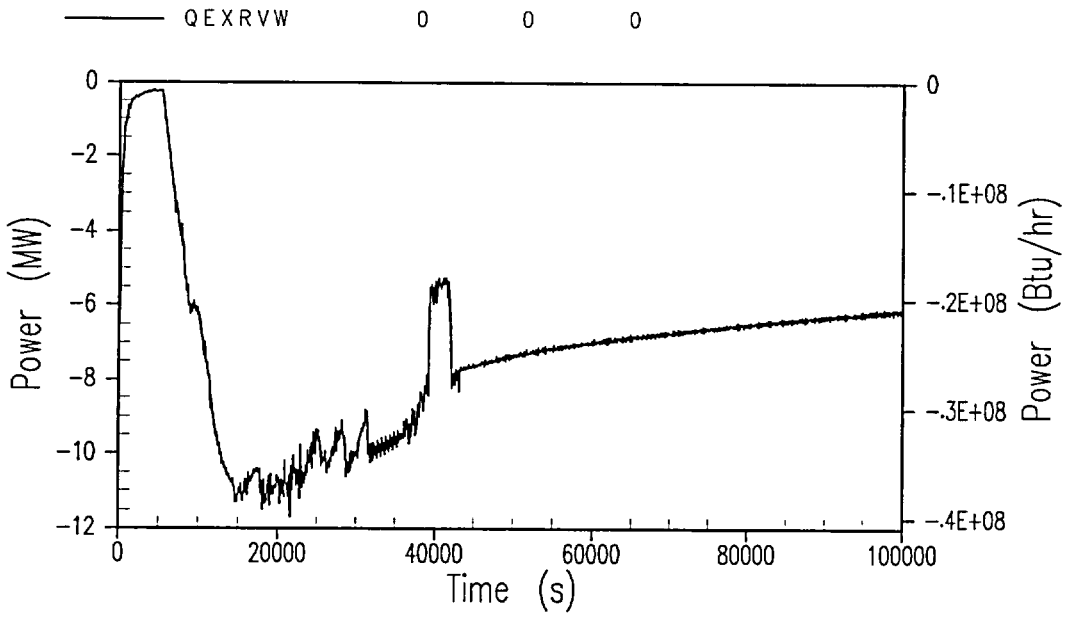

Figure 34-182

Case 3BR-1a: Reactor Pressure Vessel to Cavity Water Heat Transfer
CL LBLOCA with Failed Accumulators

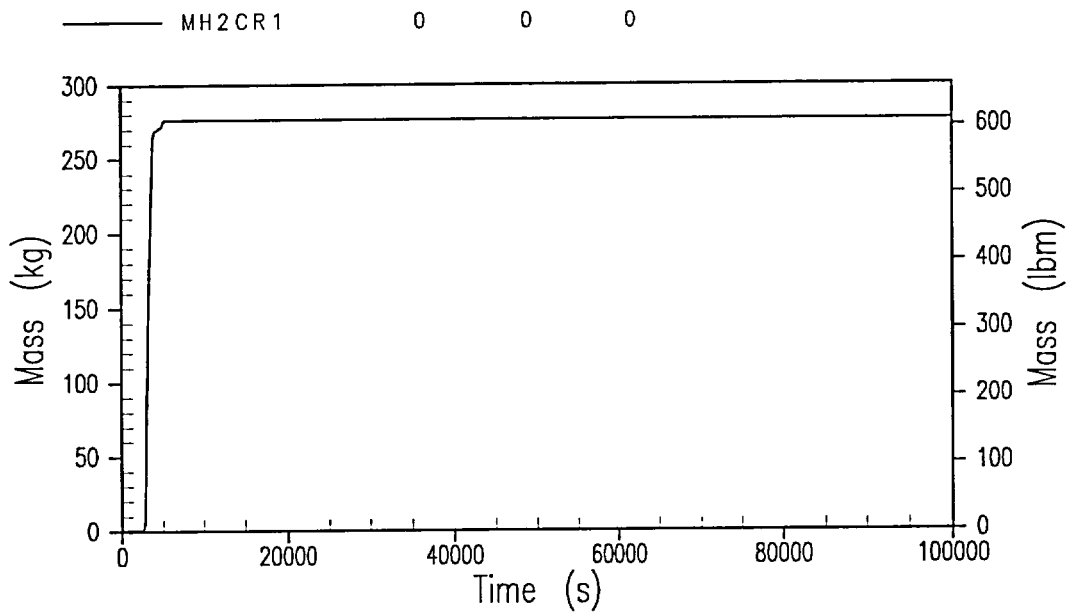

Figure 34-183

Case 3BR-1a: In-Vessel Hydrogen Generation CL LBLOCA with Failed Accumulators

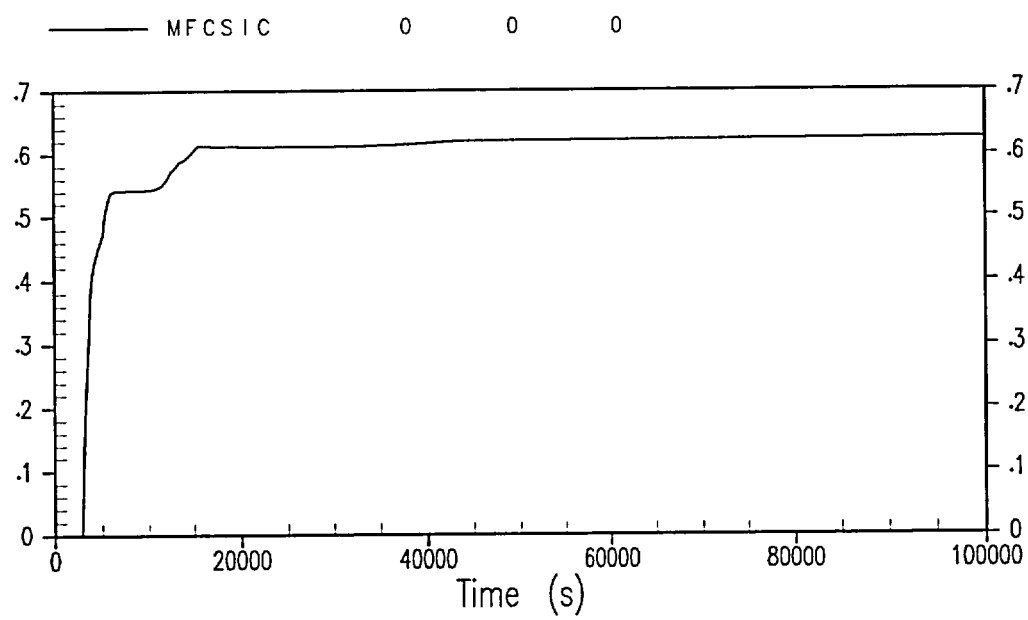

Figure 34-184

Case 3BR-1a: Mass Fraction of CsI Released to Containment CL LBLOCA with Failed Accumulators

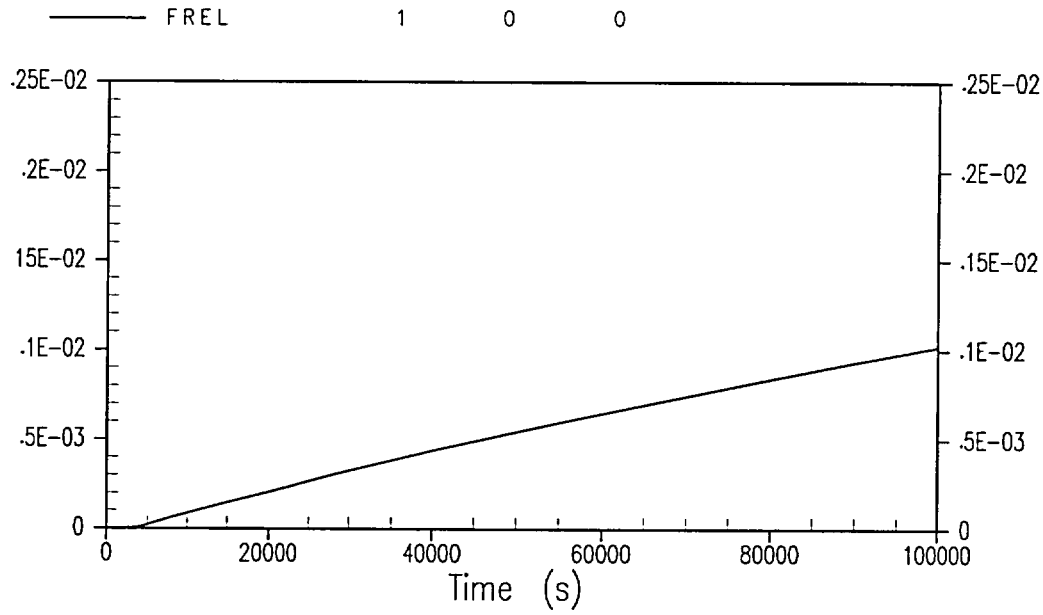

Figure 34-185

Case 3BR-1a: Mass Fraction of Noble Gases Released to Environment CL LBLOCA with Failed Accumulators

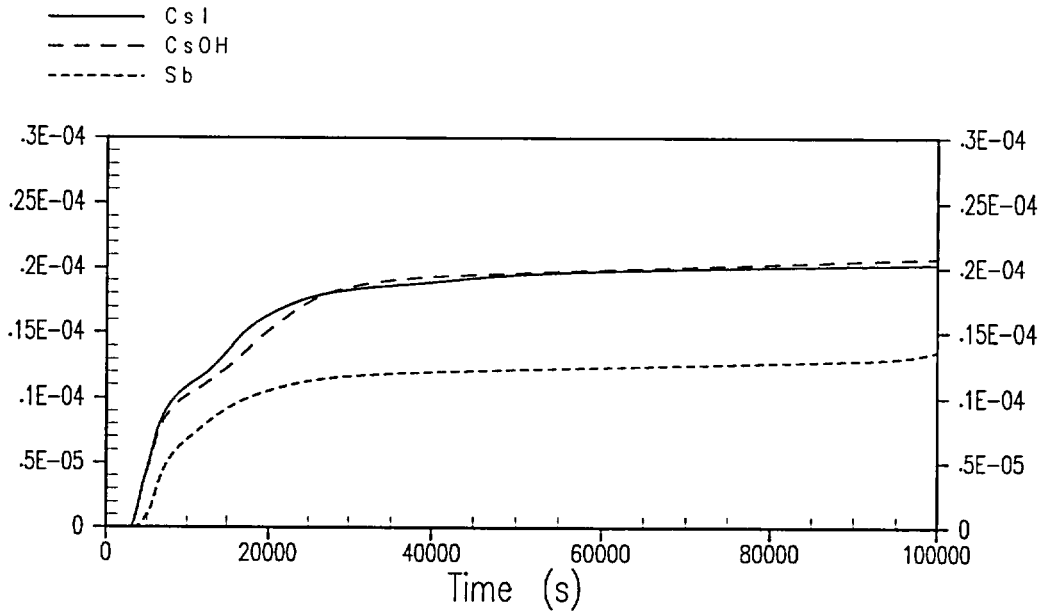

Figure 34-186

Case 3BR-1a: Mass Fraction of Fission Products Released to Environment CL LBLOCA with Failed Accumulators

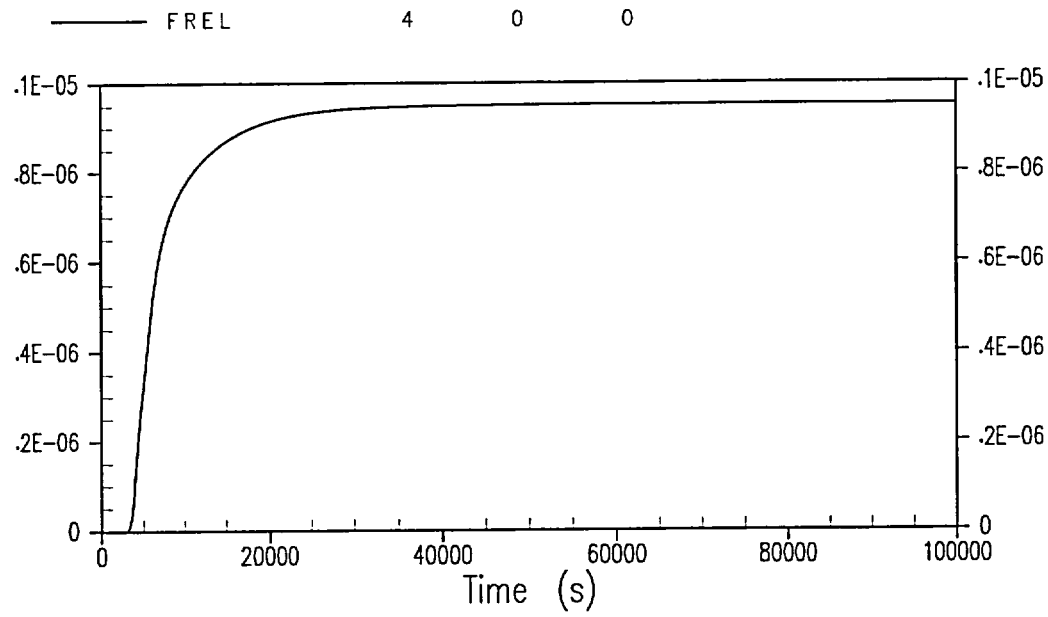

Figure 34-187

Case 3BR-1a: Mass Fraction of SrO Released to Environment CL LBLOCA with Failed Accumulators

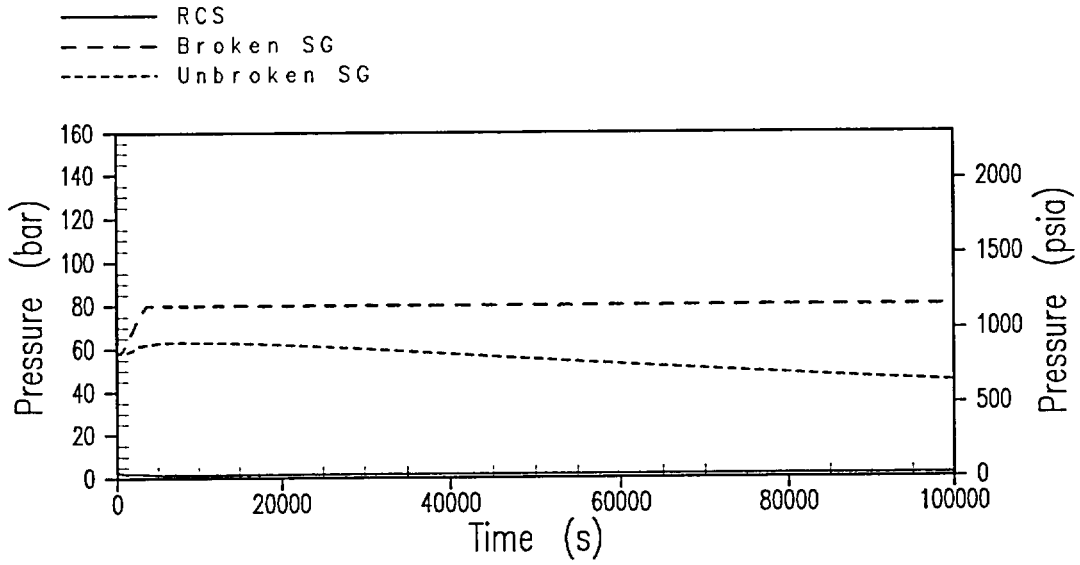

Figure 34-188

Case 3C-1: Reactor Coolant System and Steam Generator Pressure Vessel Rupture

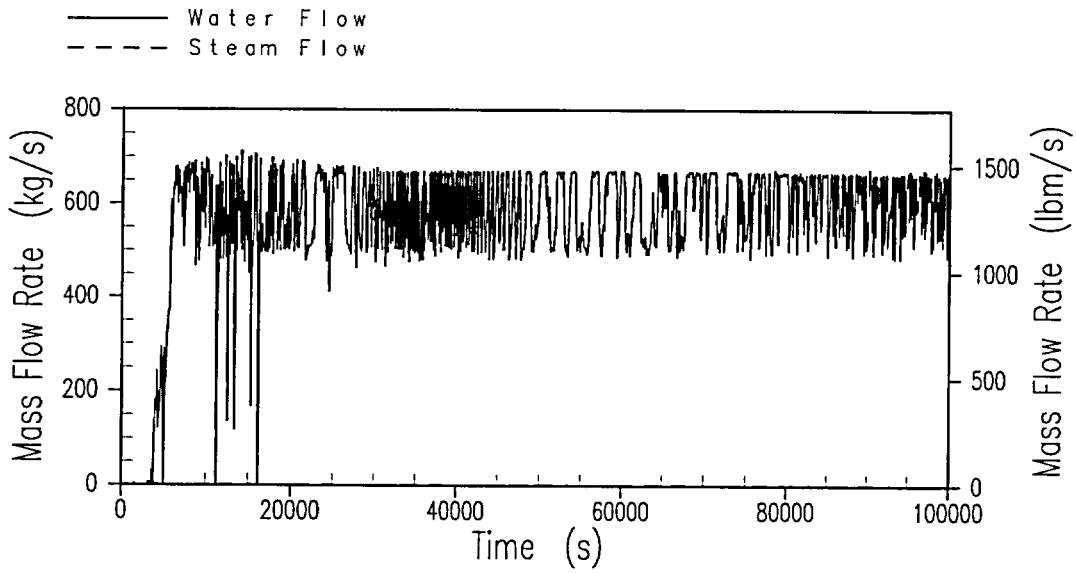

Figure 34-189

Case 3C-1: ADS Stage 4 Flow Rates Vessel Rupture

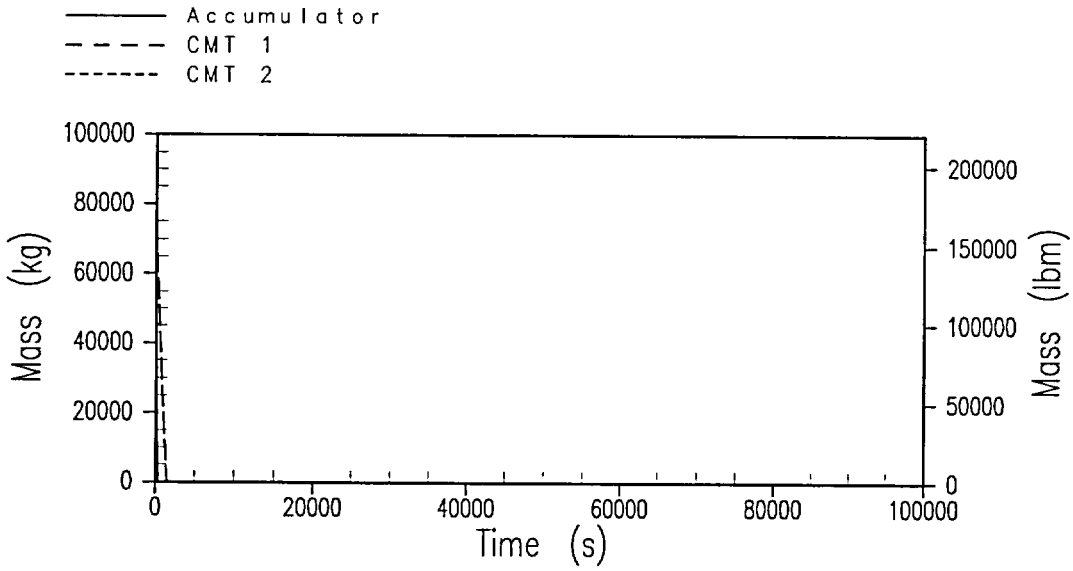

Figure 34-190

Case 3C-1: Accumulator/CMT Water Mass Vessel Rupture

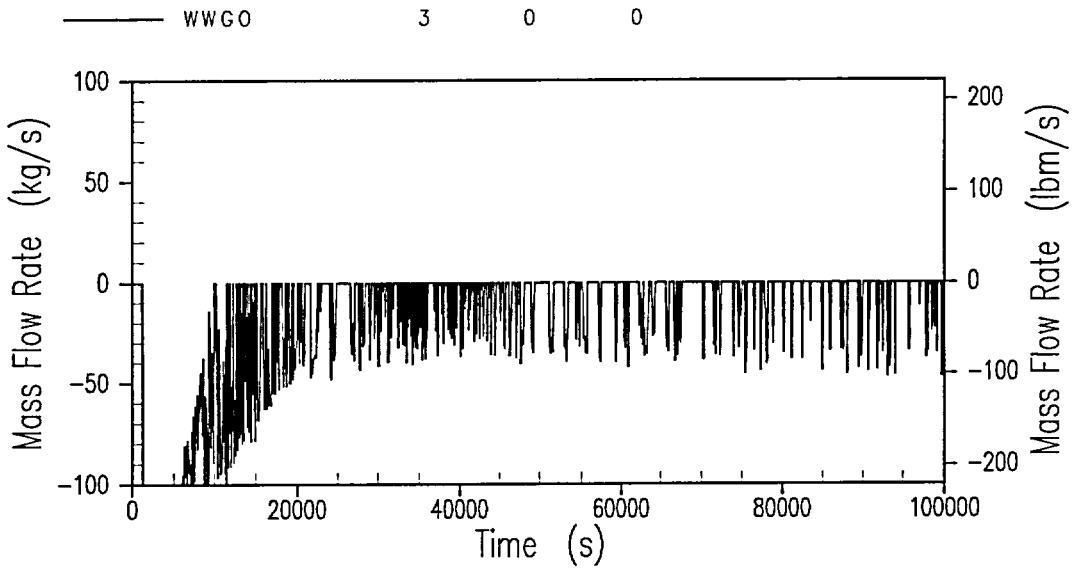

Figure 34-191

Case 3C-1: IRWST Injection Flow Rate Vessel Rupture

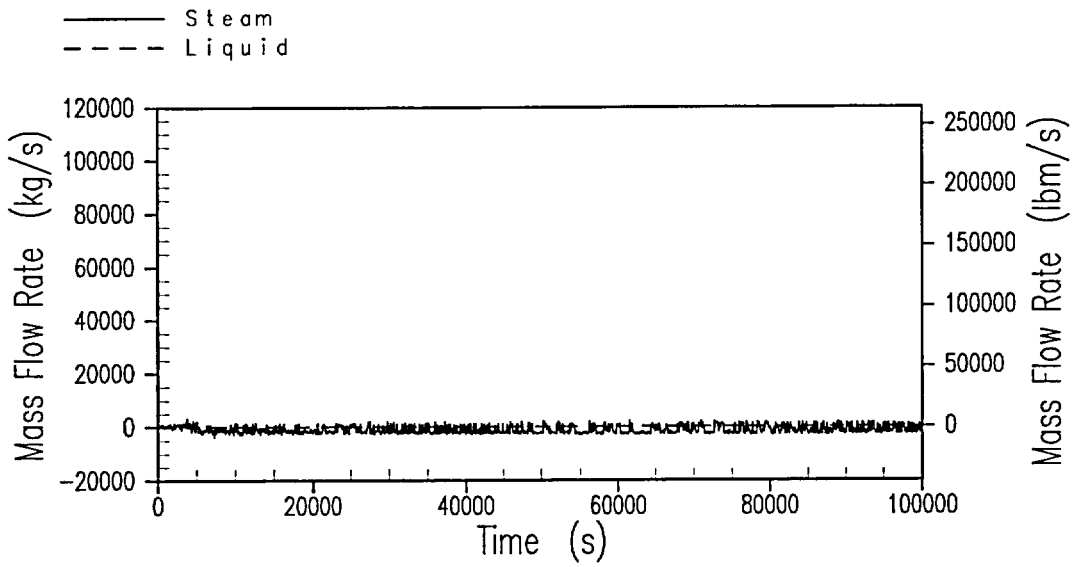

Figure 34-192

Case 3C-1: Break Flow Rate Vessel Rupture

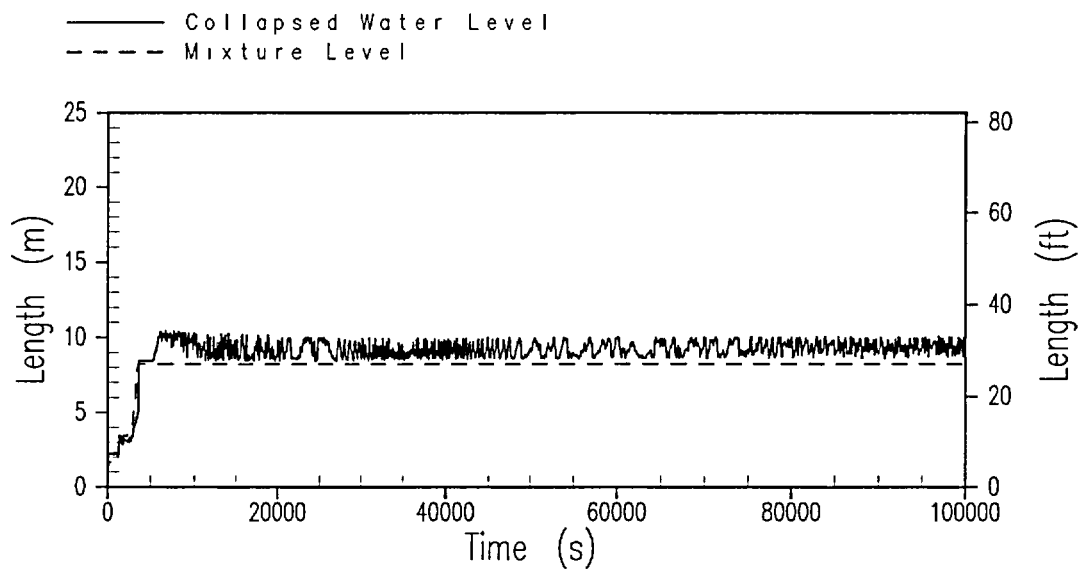

Figure 34-193

Case 3C-1: Reactor Vessel Water Level Vessel Rupture

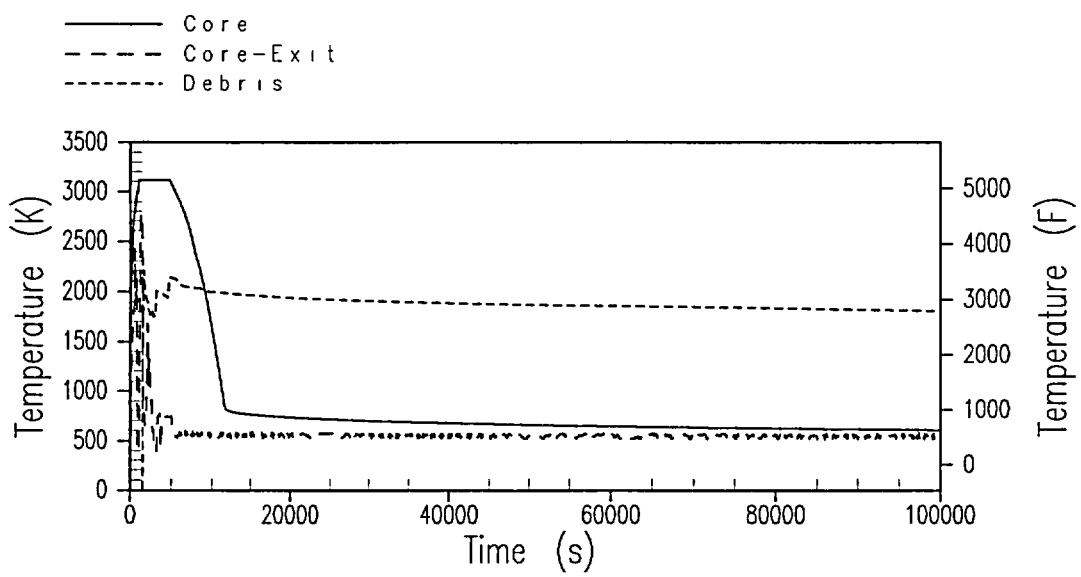

Figure 34-194

Case 3C-1: Core Temperatures Vessel Rupture

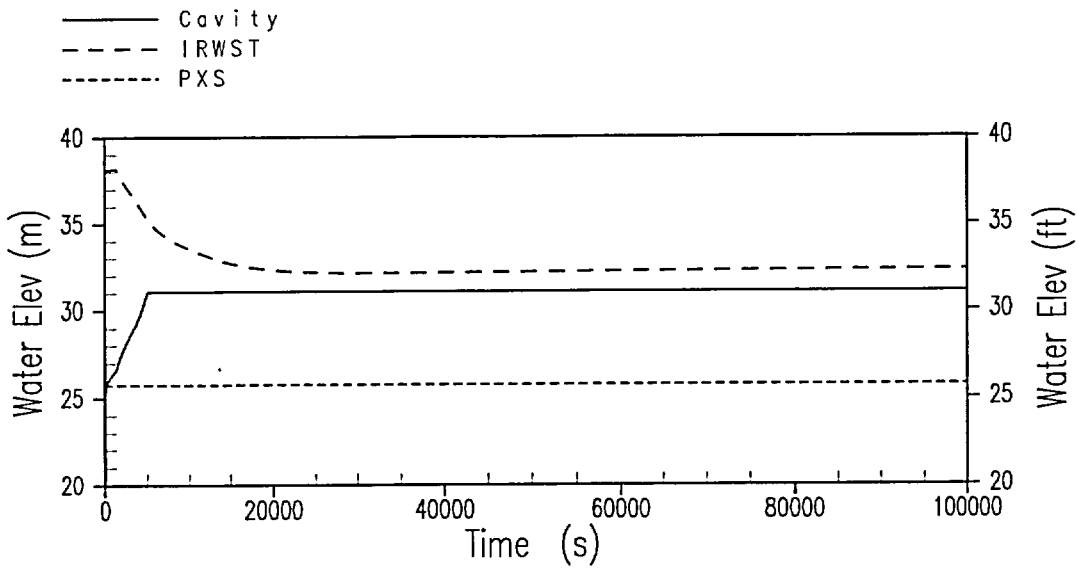

Figure 34-195

Case 3C-1: Containment Water Pool Elevations Vessel Rupture

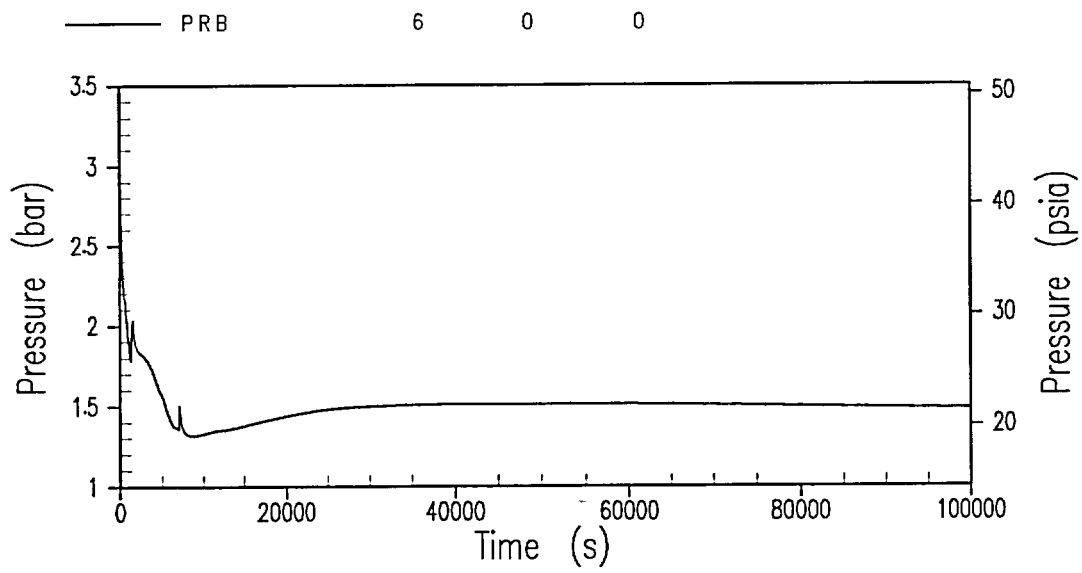

Figure 34-196

Case 3C-1: Containment Pressure Vessel Rupture

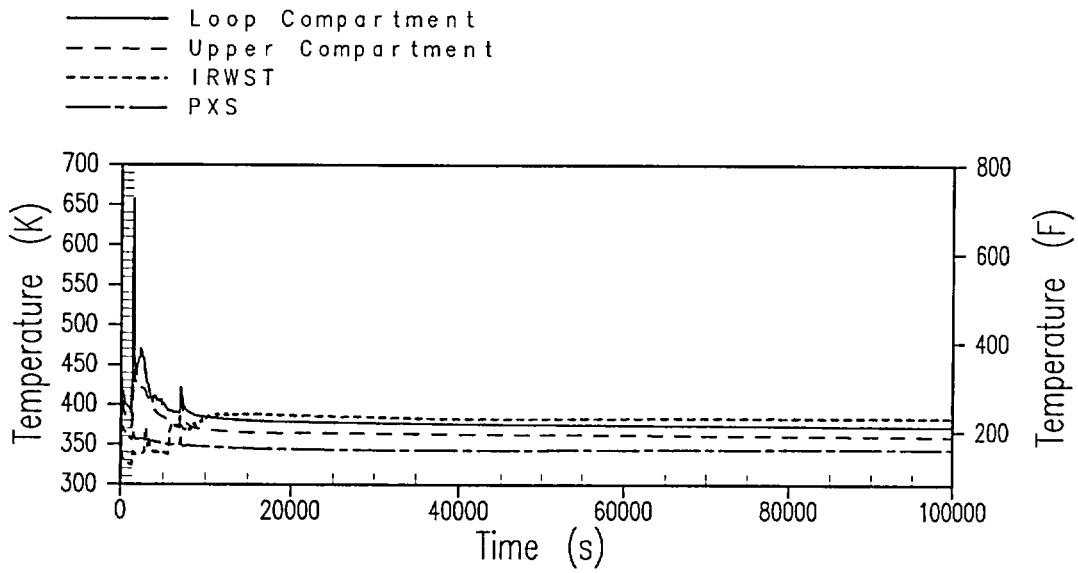

Figure 34-197

Case 3C-1: Containment Gas Temperature Vessel Rupture

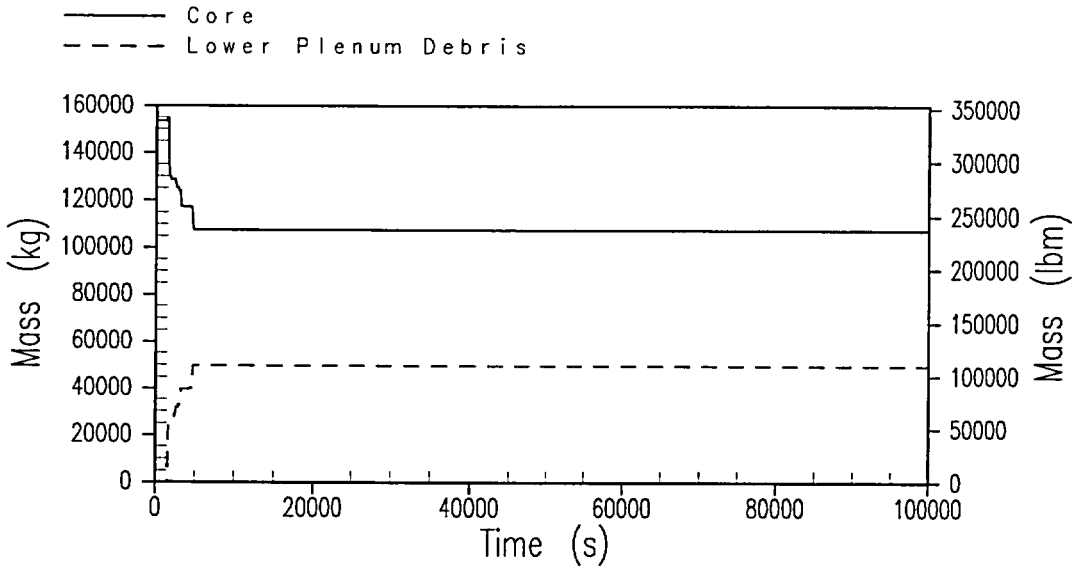

Figure 34-198

Case 3C-1: Core Mass Vessel Rupture

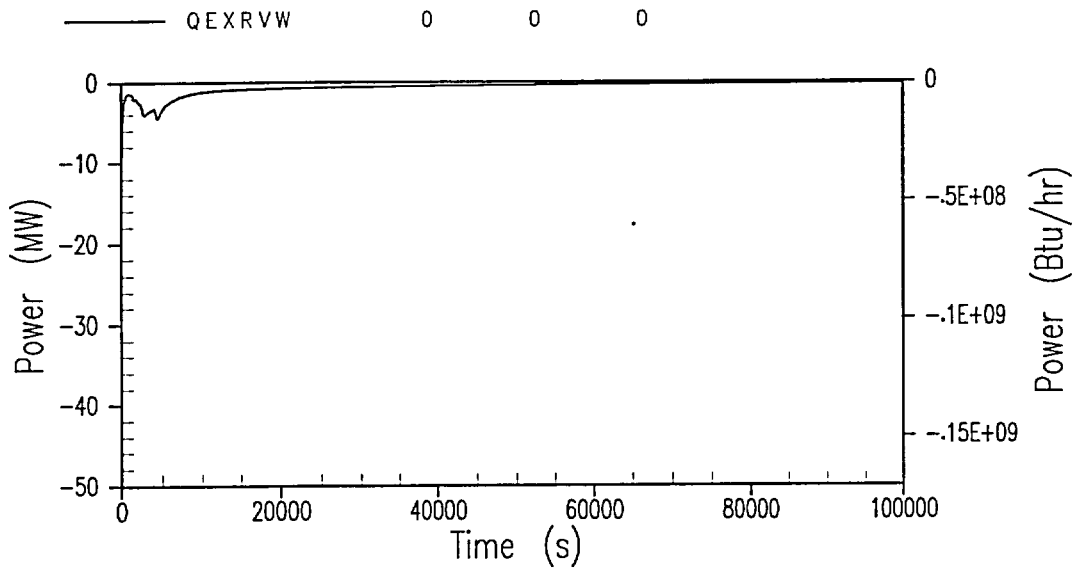

Figure 34-199

Case 3C-1: Reactor Pressure Vessel to Cavity Water Heat Transfer Vessel Rupture

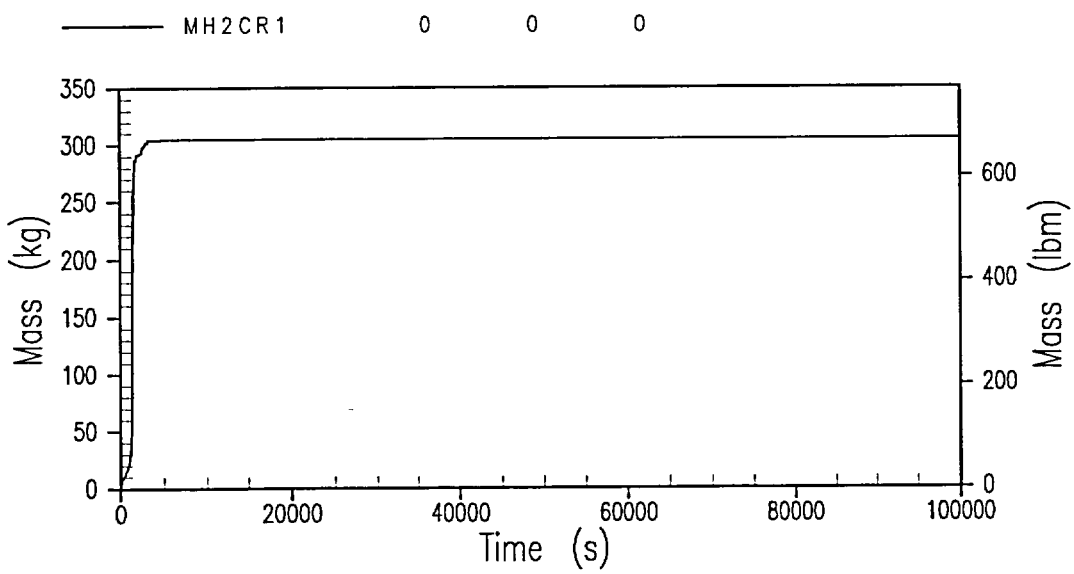

Figure 34-200

Case 3C-1: In-Vessel Hydrogen Generation Vessel Rupture

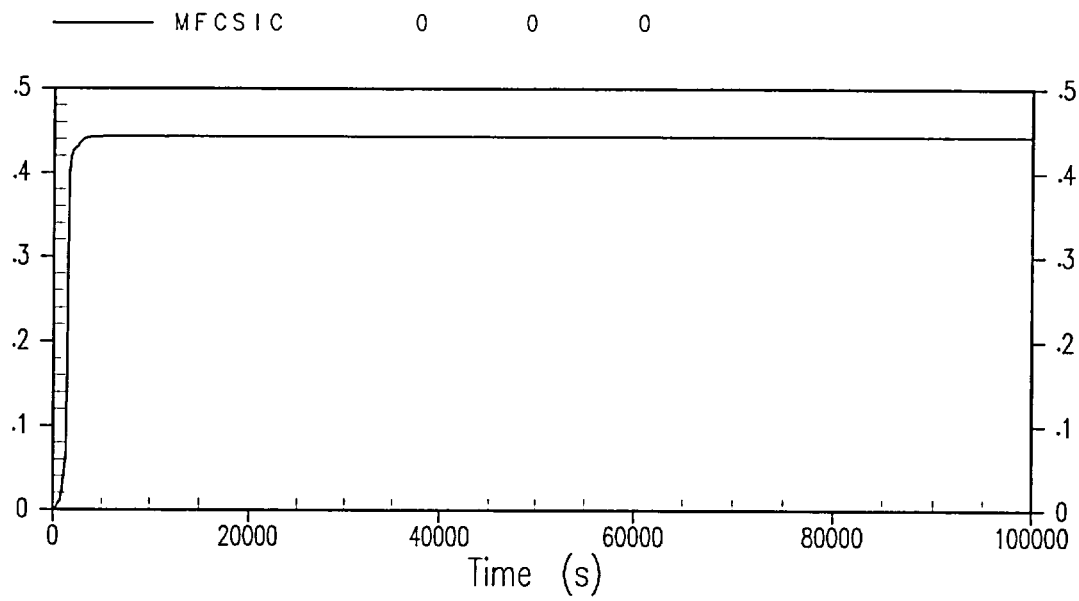

Figure 34-201

Case 3C-1: Mass Fraction of CsI Released to Containment Vessel Rupture

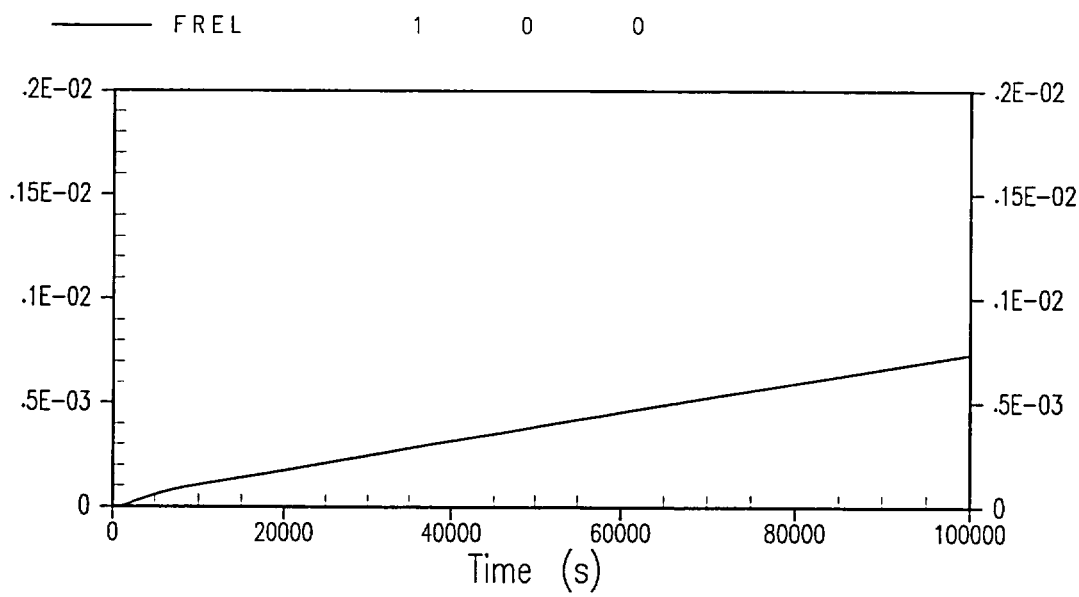

Figure 34-202

Case 3C-1: Mass Fraction of Noble Gas Released to Environment Vessel Rupture

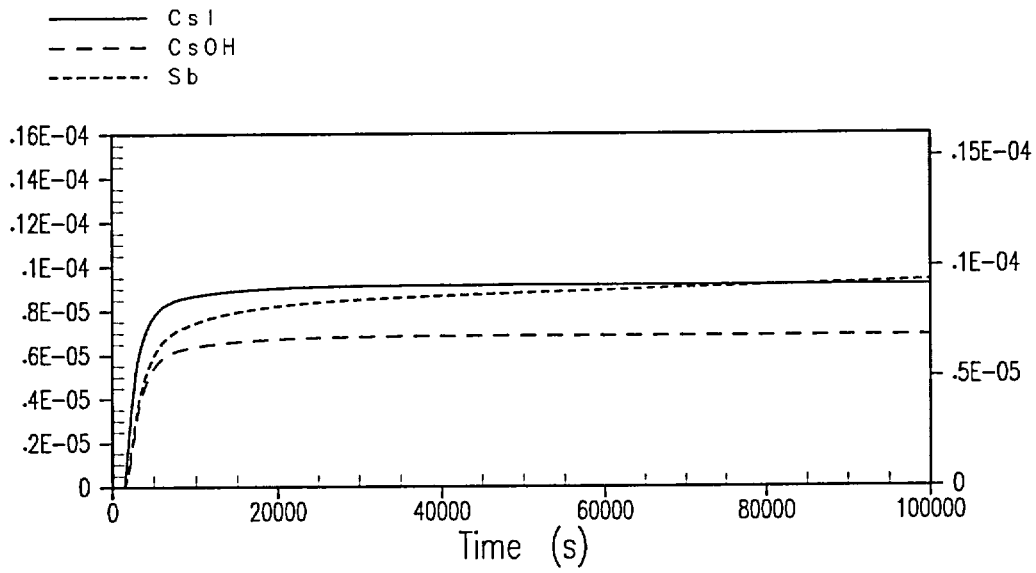

Figure 34-203

Case 3C-1: Mass Fraction of Fission Products Released to Environment Vessel Rupture

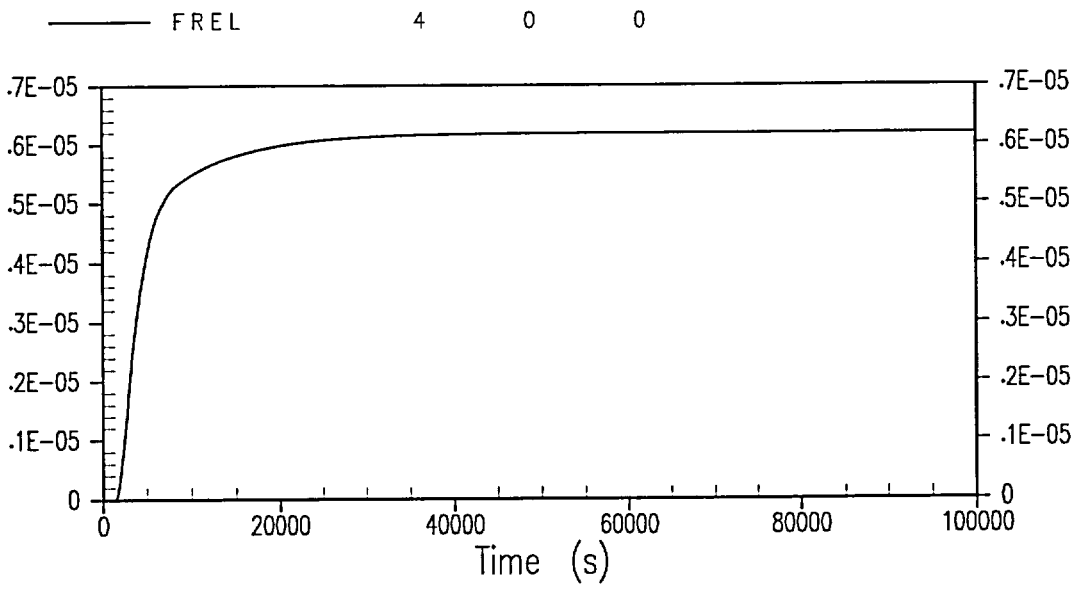

Figure 34-204

Case 3C-1: Mass Fraction of SrO Released to Environment Vessel Rupture

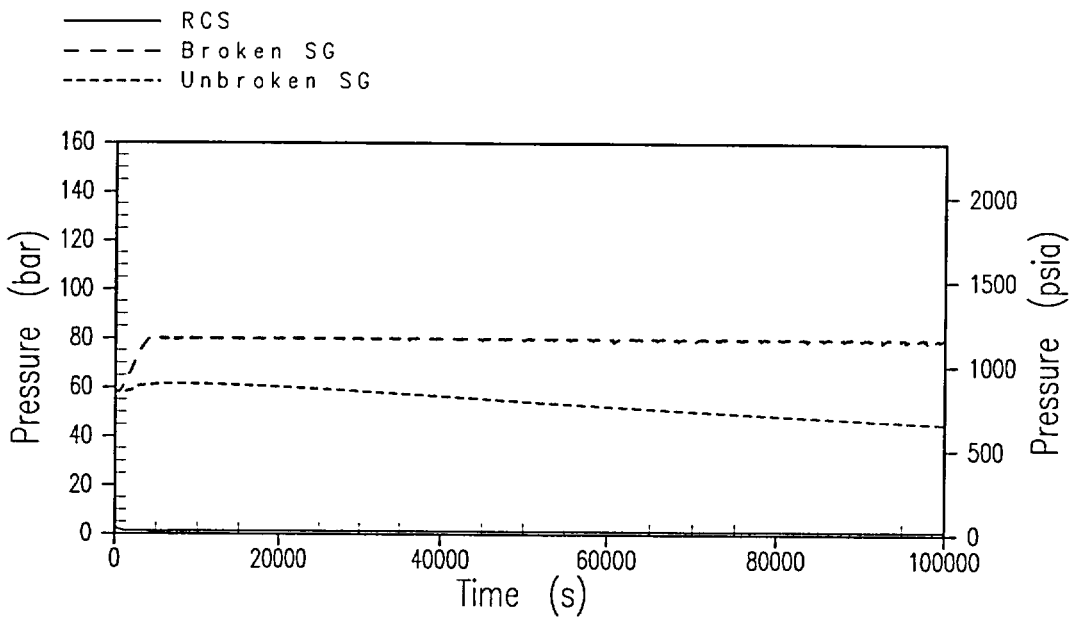

Figure 34-205

Case 3C-2: Reactor Coolant System and Steam Generator Pressure Vessel Rupture with Containment Failure

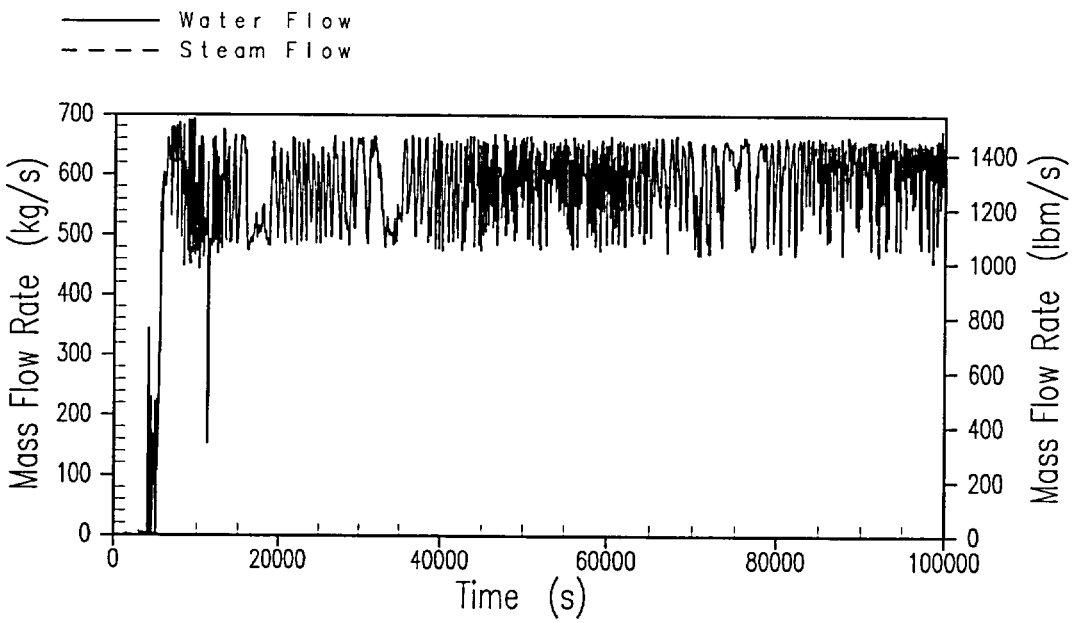

Figure 34-206

Case 3C-2: ADS Stage 4 Flow Rates Vessel Rupture with Containment Failure

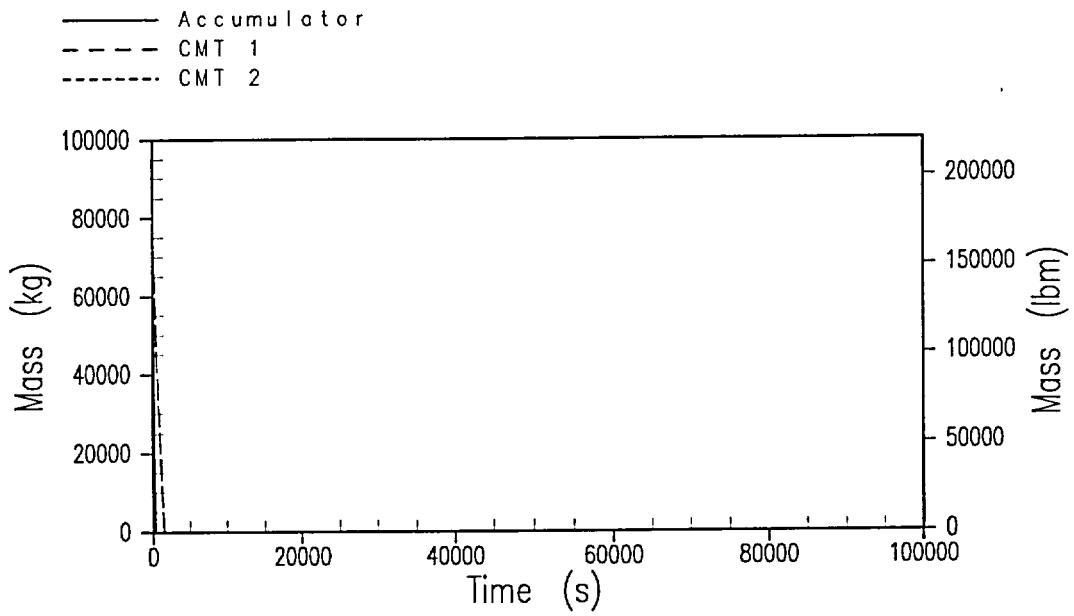

Figure 34-207

Case 3C-2: Accumulator/CMT Water Mass Vessel Rupture with Containment Failure

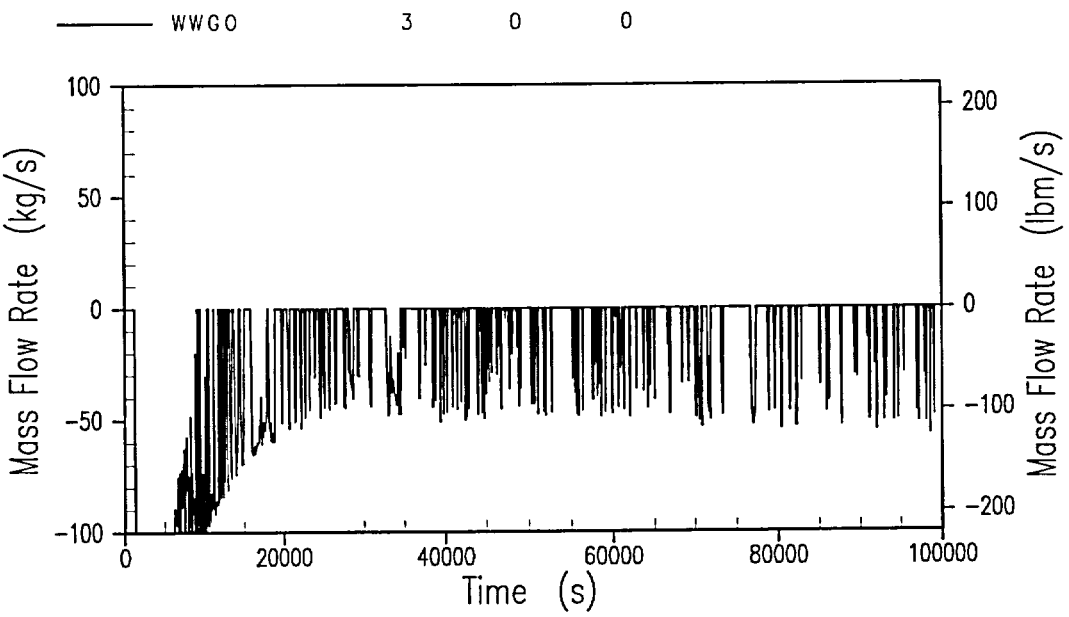

Figure 34-208

Case 3C-2: IRWST Injection Flow Rate Vessel Rupture with Containment Failure

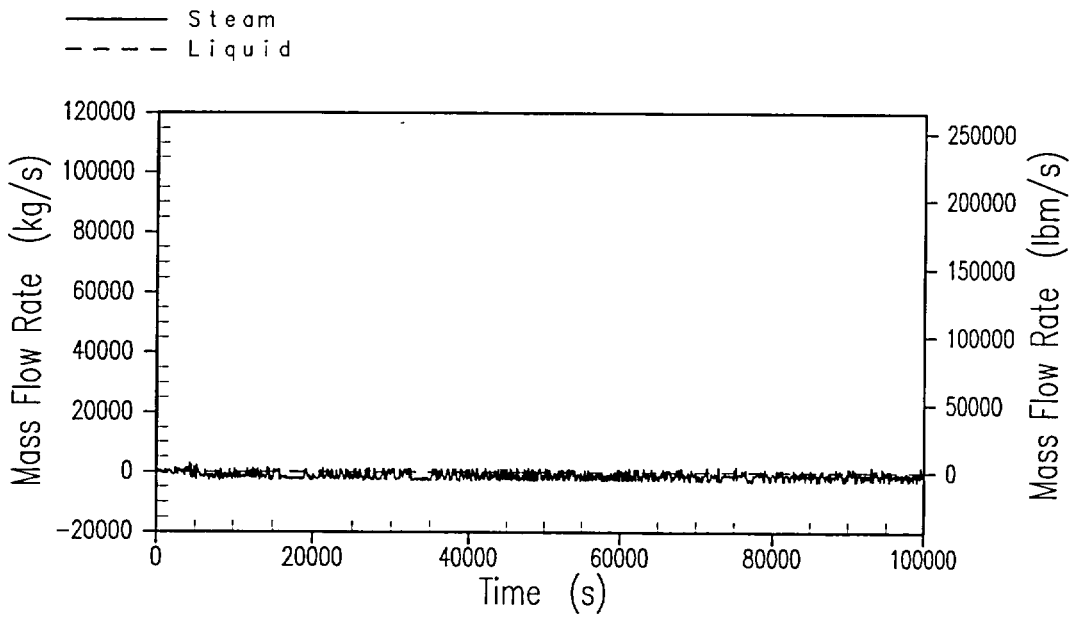

Figure 34-209

Case 3C-2: Break Flow Rate
Vessel Rupture with Containment Failure

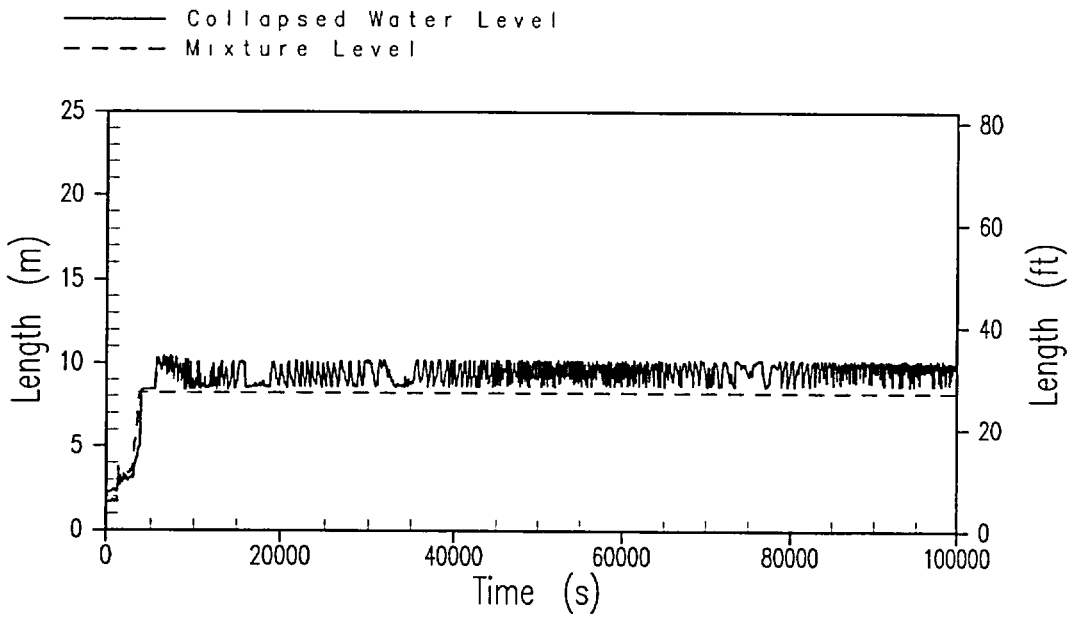

Figure 34-210

Case 3C-2: Reactor Vessel Water Level
Vessel Rupture with Containment Failure

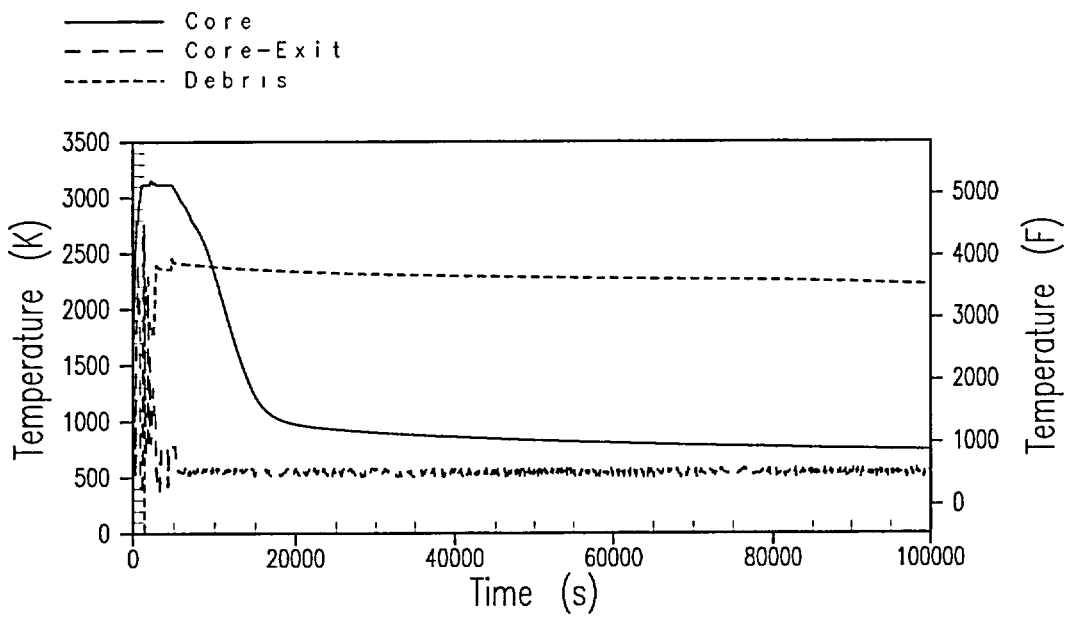

Figure 34-211

Case 3C-2: Core Temperatures
Vessel Rupture with Containment Failure

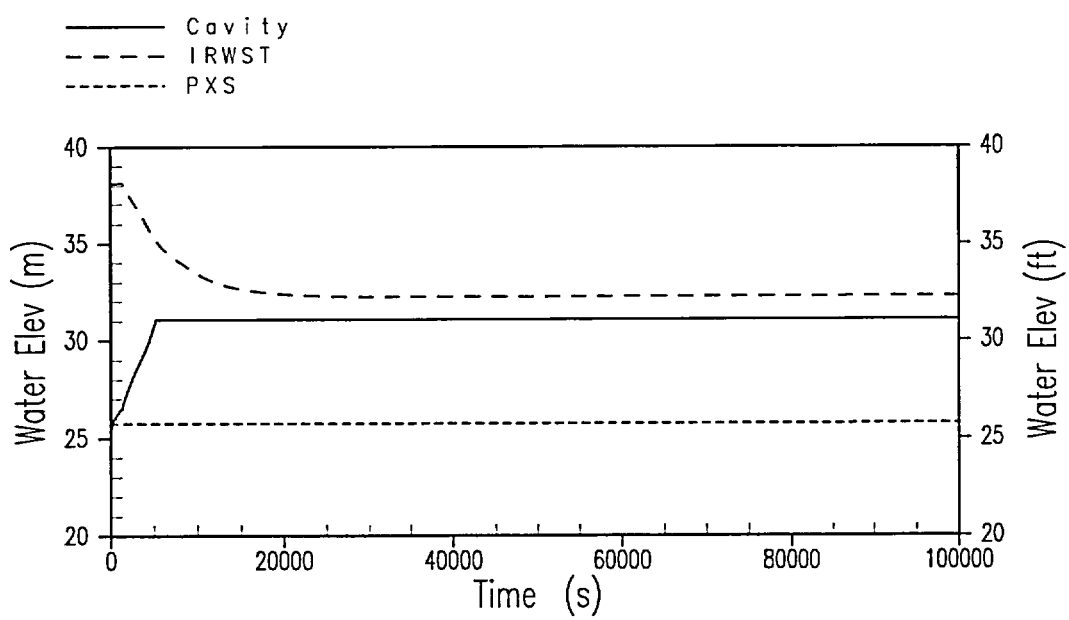

Figure 34-212

Case 3C-2: Containment Water Pool Elevations
Vessel Rupture with Containment Failure

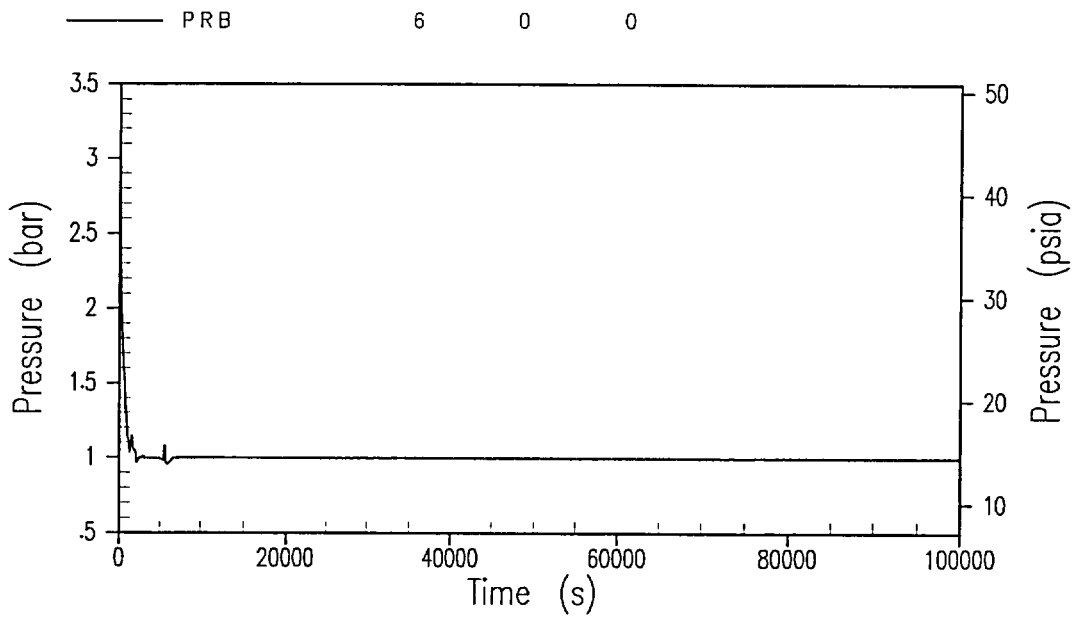

Figure 34-213

Case 3C-2: Containment Pressure Vessel Rupture with Containment Failure

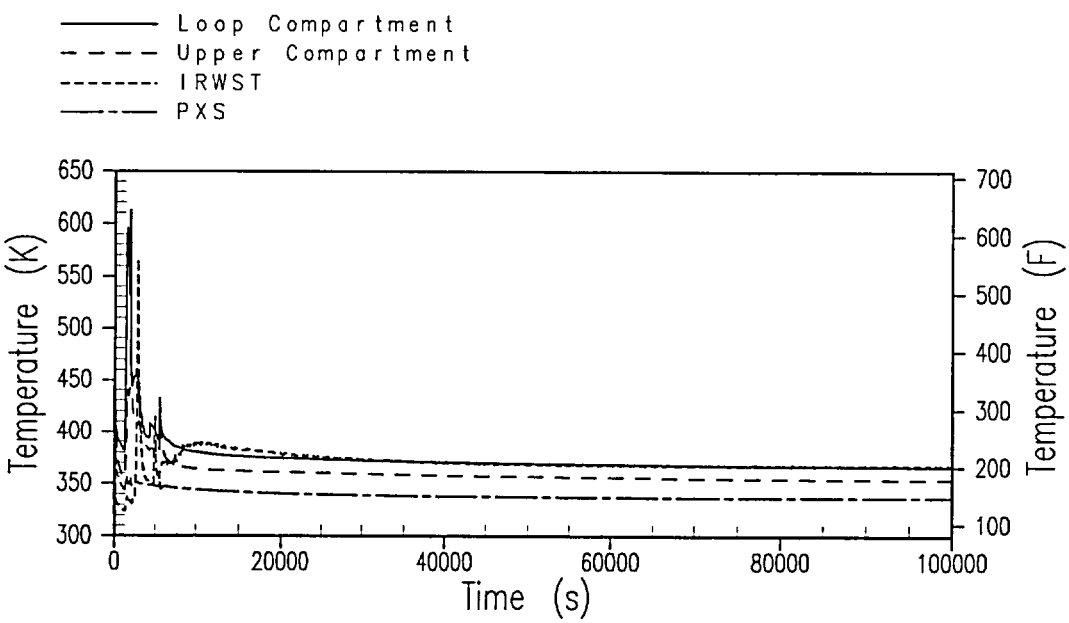

Figure 34-214

Case 3C-2: Containment Gas Temperature Vessel Rupture with Containment Failure

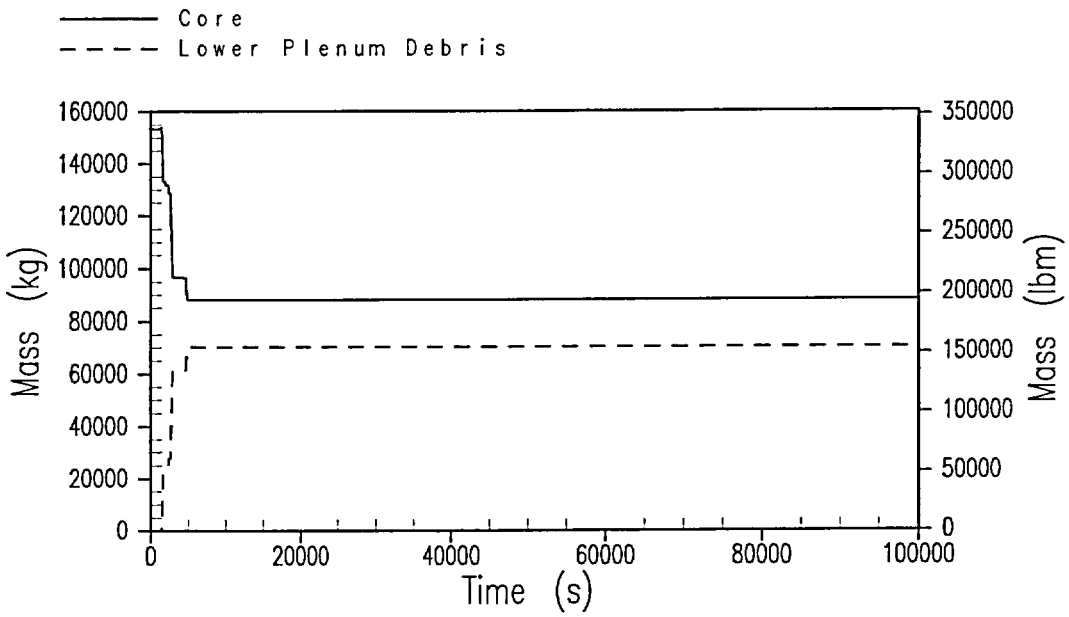

Figure 34-215

Case 3C-2: Core Mass
Vessel Rupture with Containment Failure

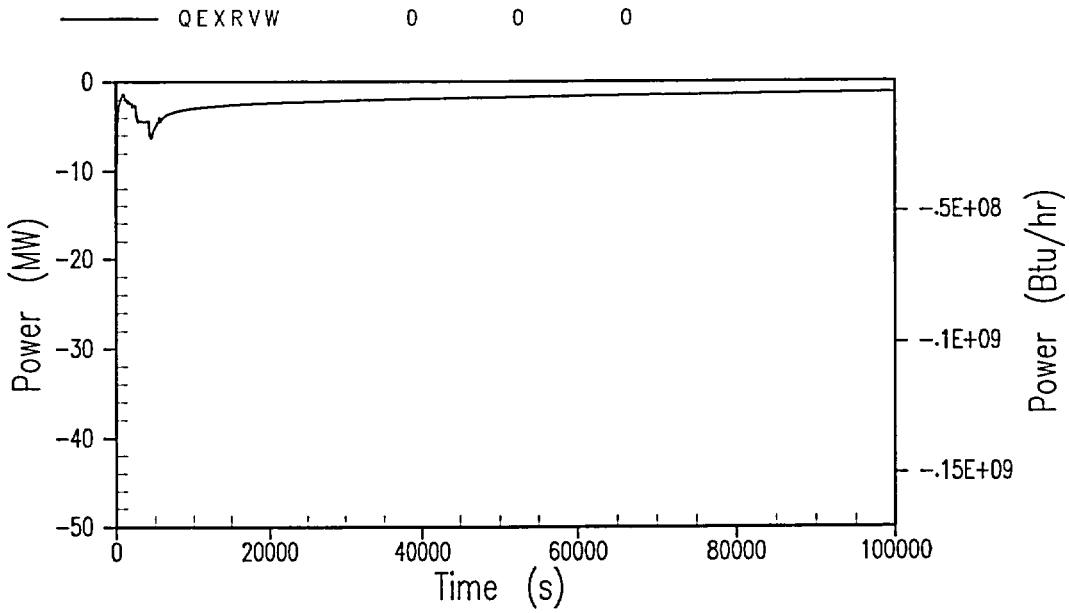

Figure 34-216

Case 3C-2: Reactor Pressure Vessel to Cavity Water Heat Transfer
Vessel Rupture with Containment Failure

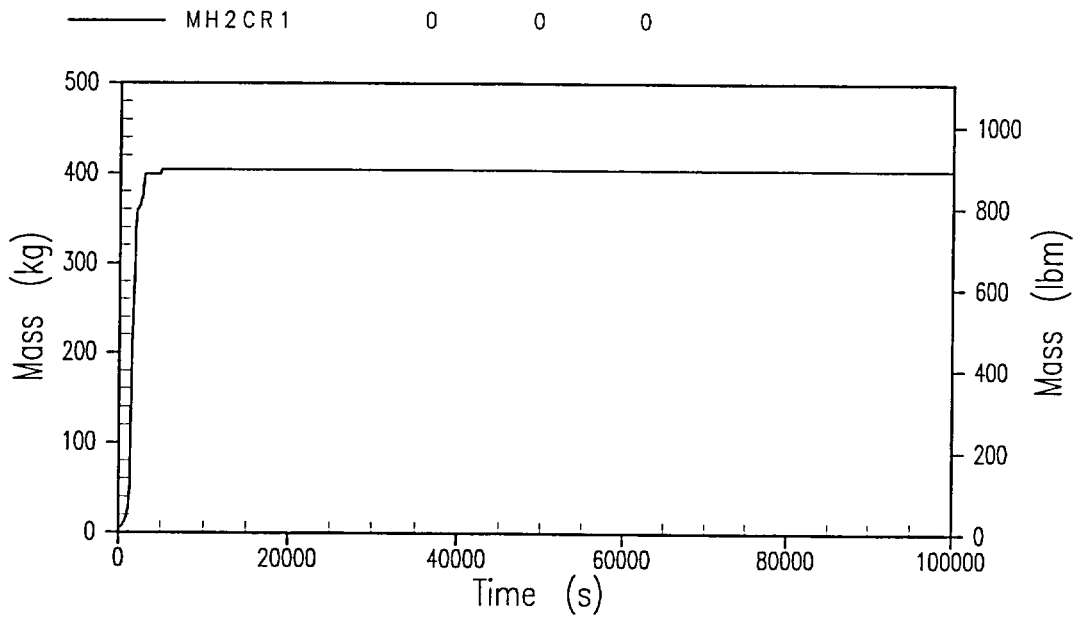

Figure 34-217

Case 3C-2: In-Vessel Hydrogen Generation Vessel Rupture with Containment Failure

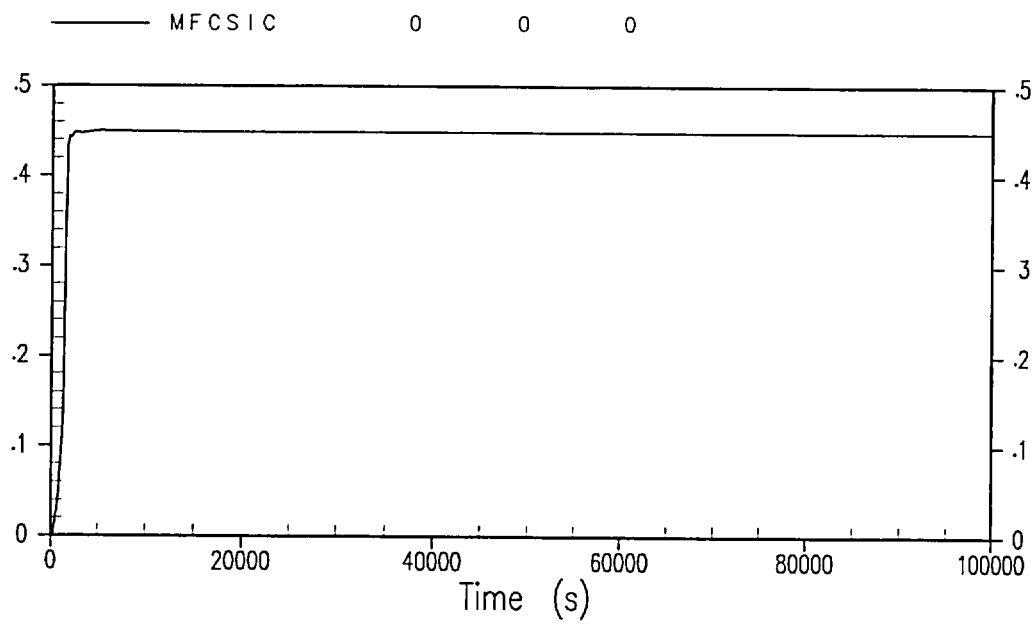

Figure 34-218

Case 3C-2: Mass Fraction of CsI Released to Containment Vessel Rupture with Containment Failure

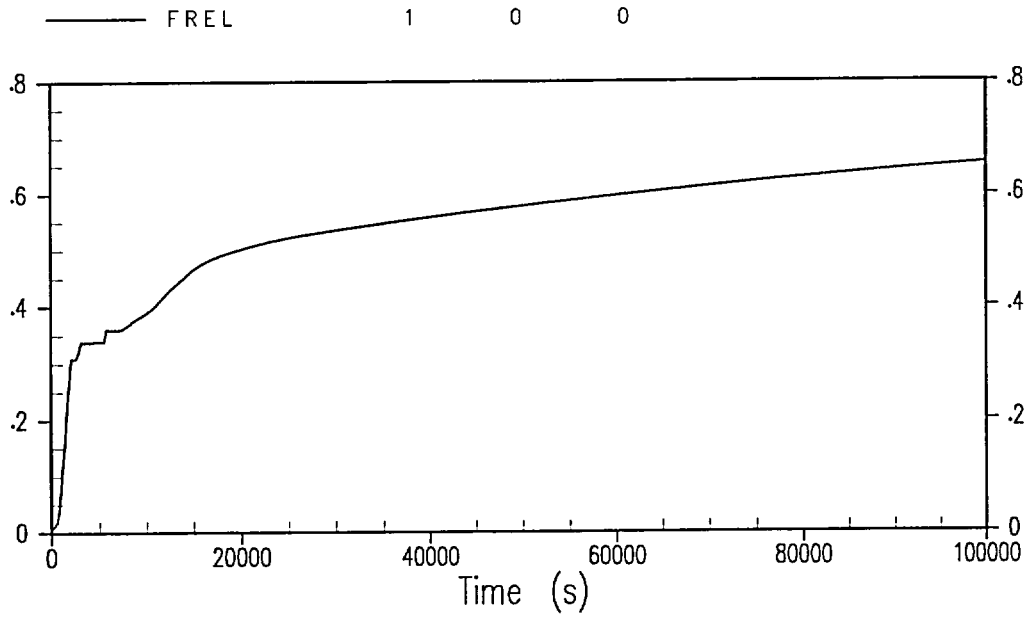

Figure 34-219

Case 3C-2: Mass Fraction of Noble Gases Released to Environment Vessel Rupture with Containment Failure

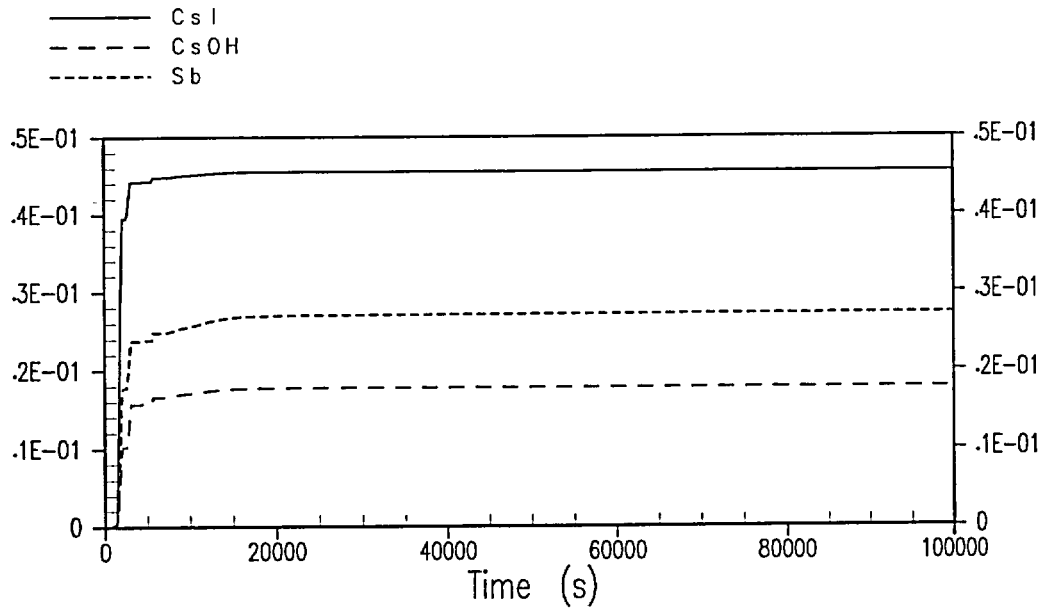

Figure 34-220

Case 3C-2: Mass Fraction of Fission Products Released to Environment Vessel Rupture with Containment Failure

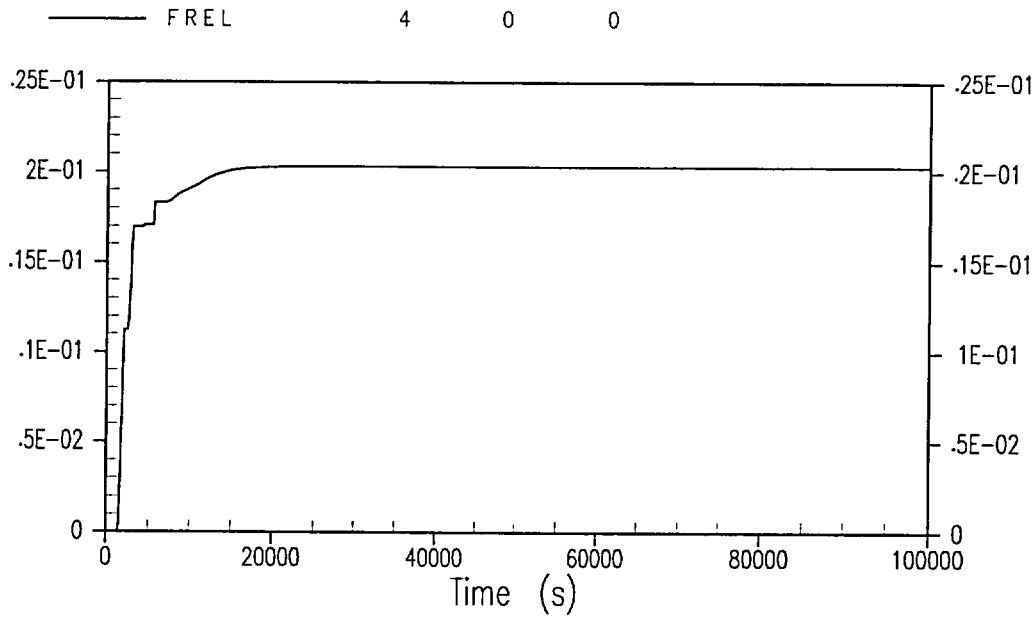

Figure 34-221

Case 3C-2: Mass Fraction of SrO Released to Environment Vessel Rupture with Containment Failure

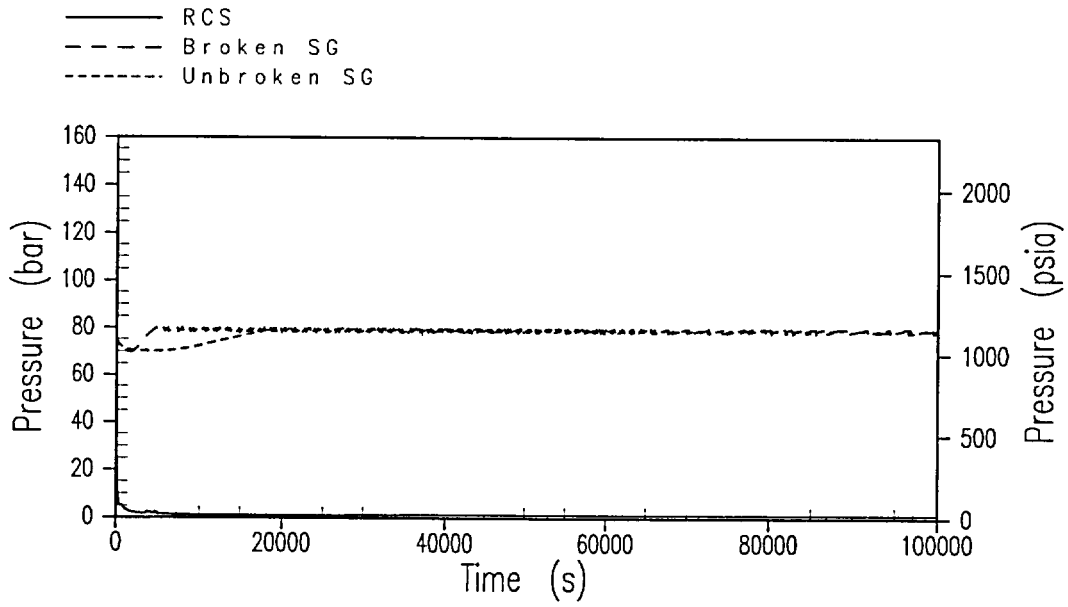

Figure 34-222

Case 3D-1: Reactor Coolant System and Steam Generator Pressure Spurious ADS-4 with Failed CMTs

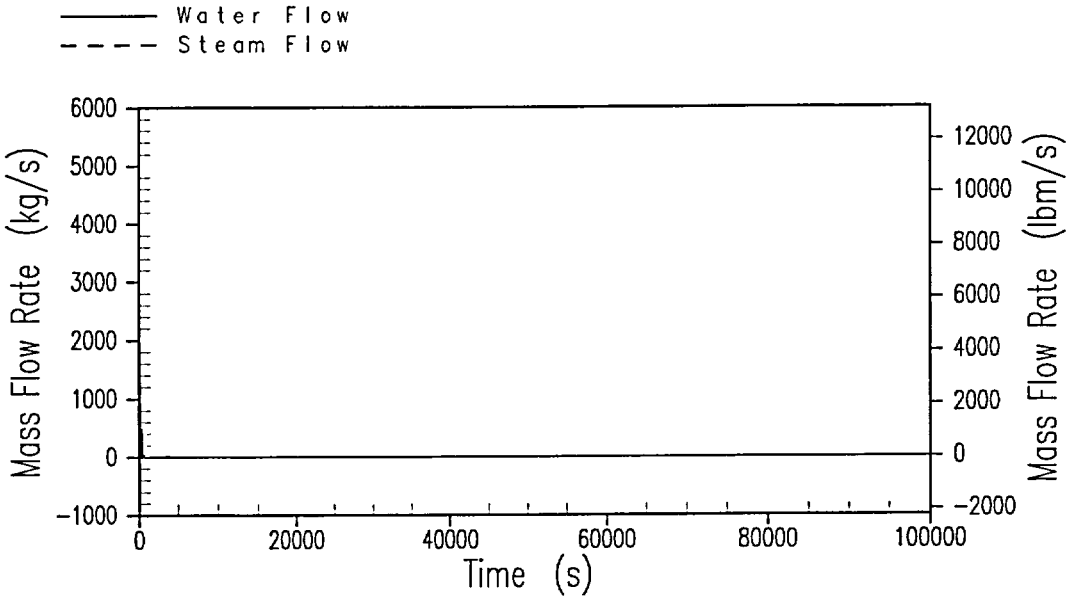

Figure 34-223

Case 3D-1: ADS Stage 4 Flow Rates Spurious ADS-4 with Failed CMTs

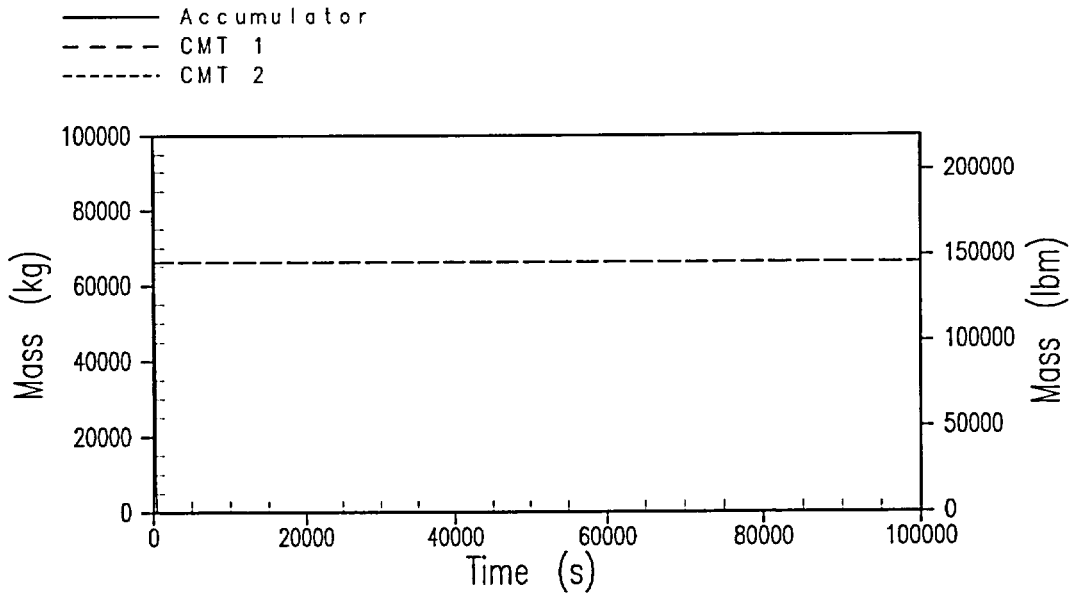

Figure 34-224

Case 3D-1: Accumulator/CMT Water Mass Spurious ADS-4 with Failed CMTs

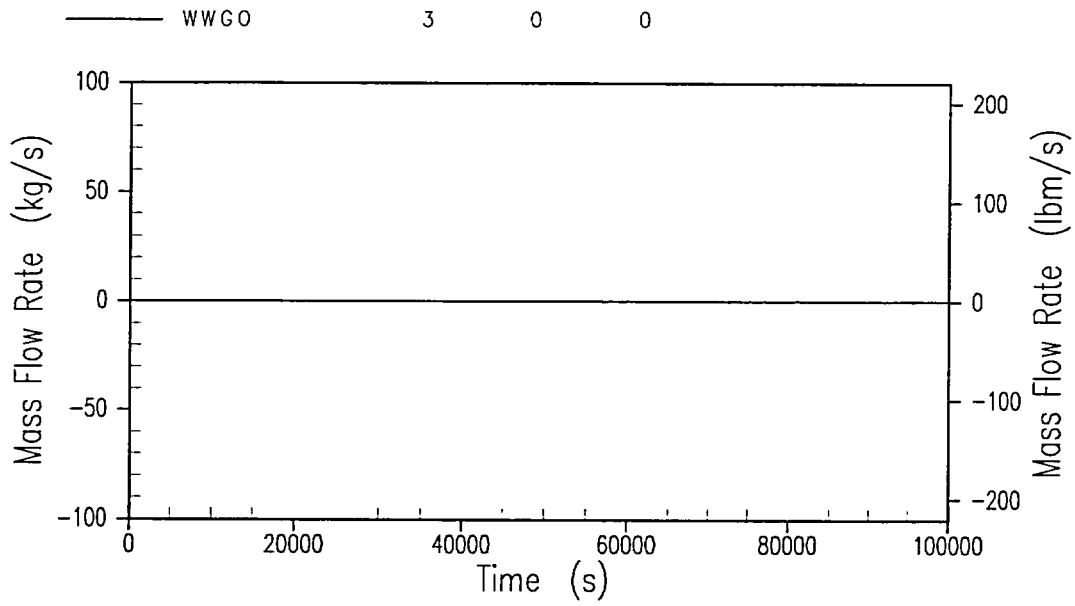

Figure 34-225

Case 3D-1: IRWST Injection Flow Rate Spurious ADS-4 with Failed CMTs

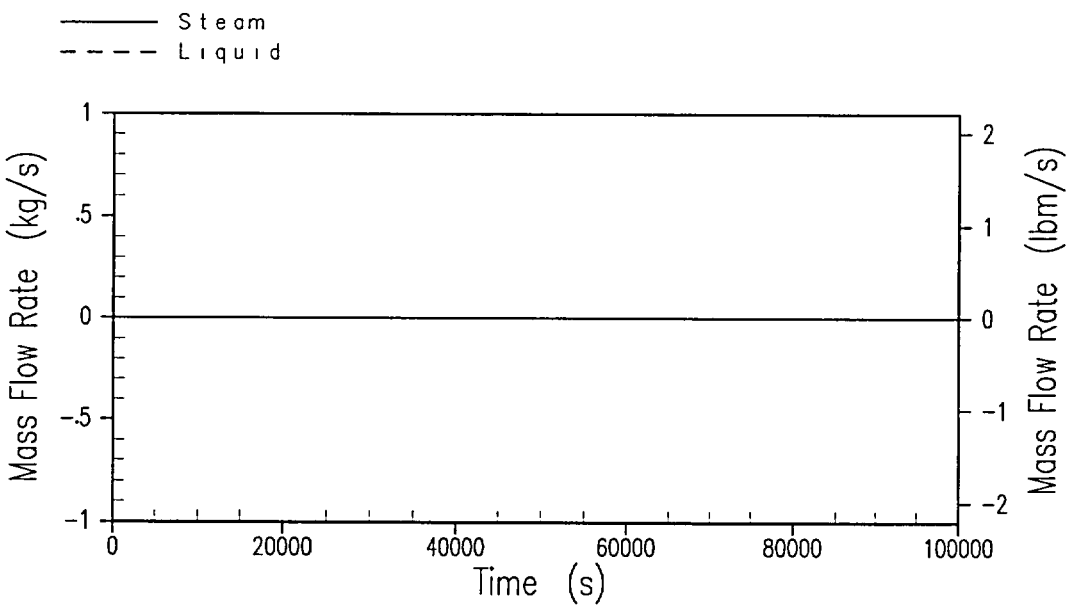

Figure 34-226

Case 3D-1: Break Flow Rate Spurious ADS-4 with Failed CMTs

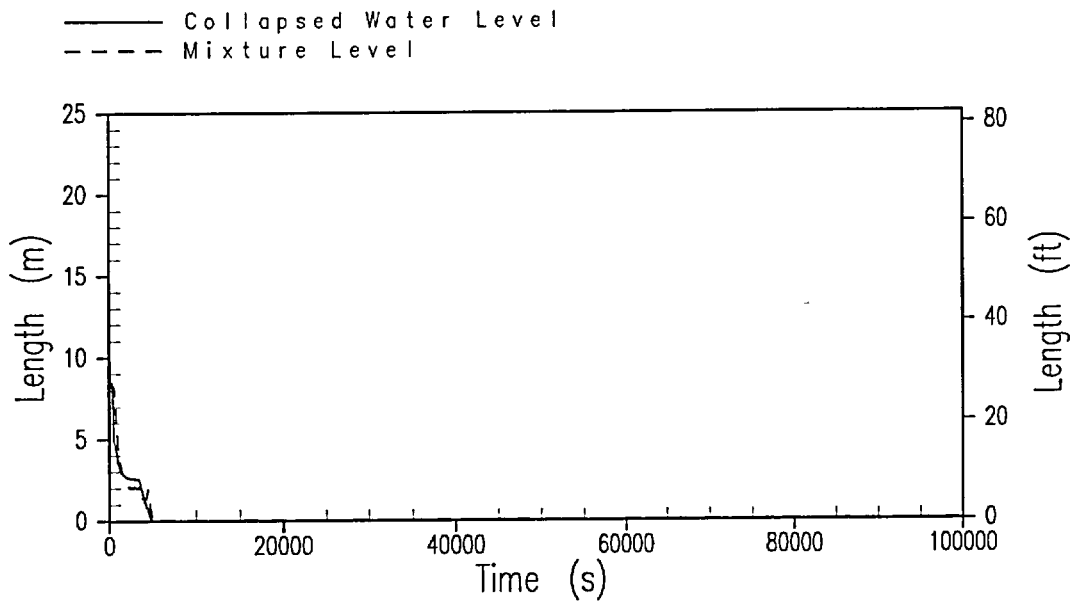

Figure 34-227

Case 3D-1: Reactor Vessel Water Level Spurious ADS-4 with Failed CMTs

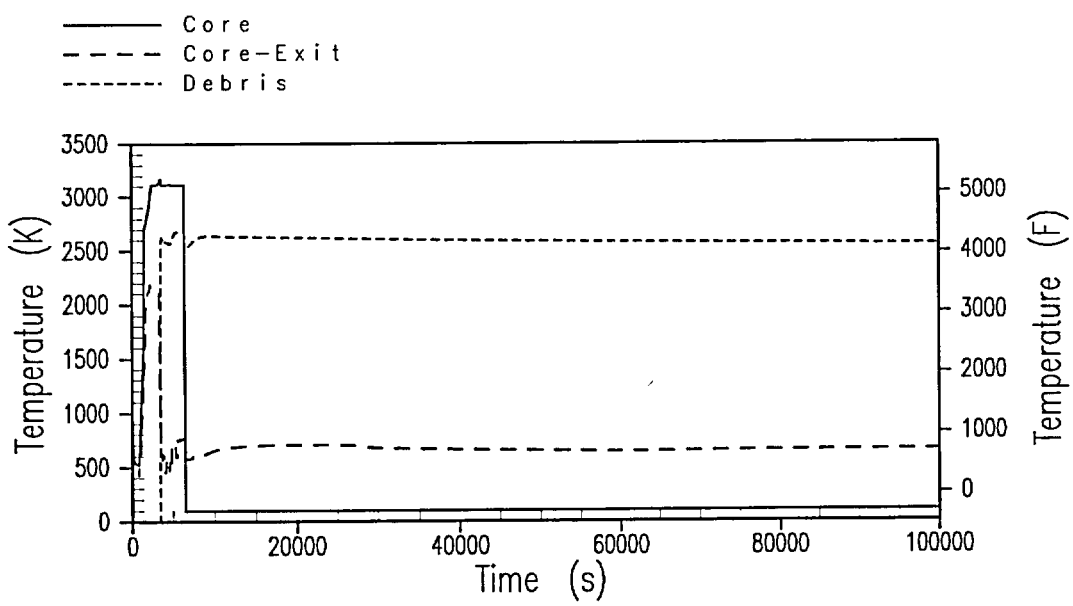

Figure 34-228

Case 3D-1: Core Temperatures Spurious ADS-4 with Failed CMTs

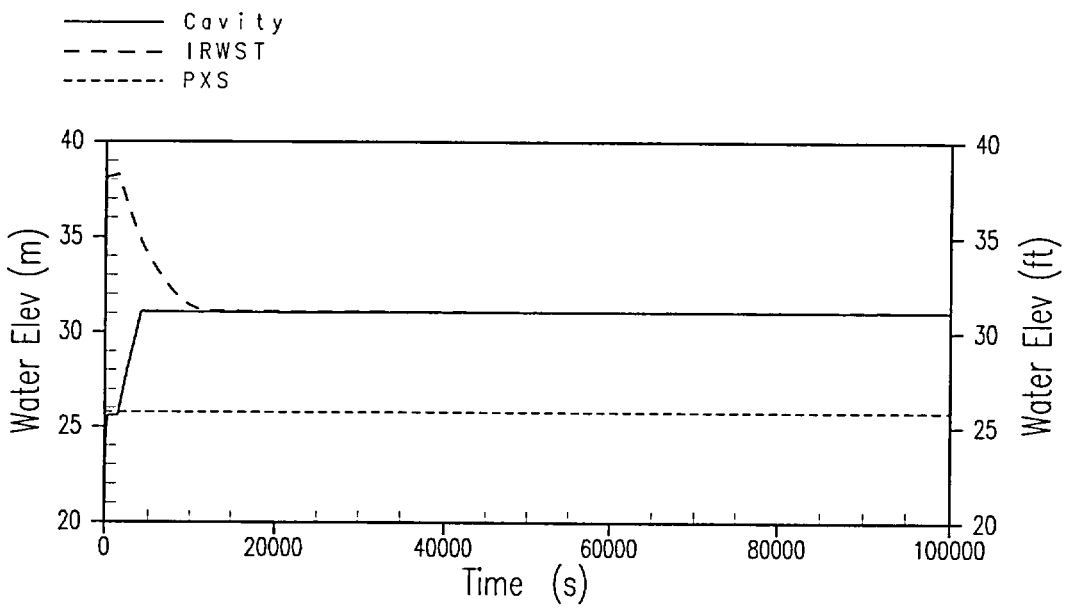

Figure 34-229

Case 3D-1: Containment Water Pool Elevations Spurious ADS-4 with Failed CMTs

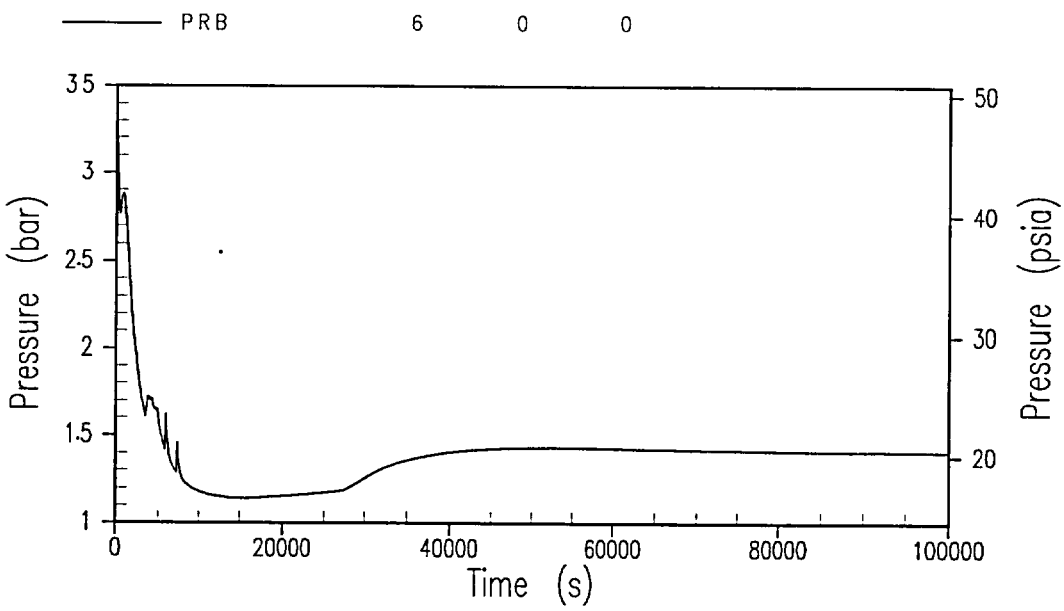

Figure 34-230

Case 3D-1: Containment Pressure Spurious ADS-4 with Failed CMTs

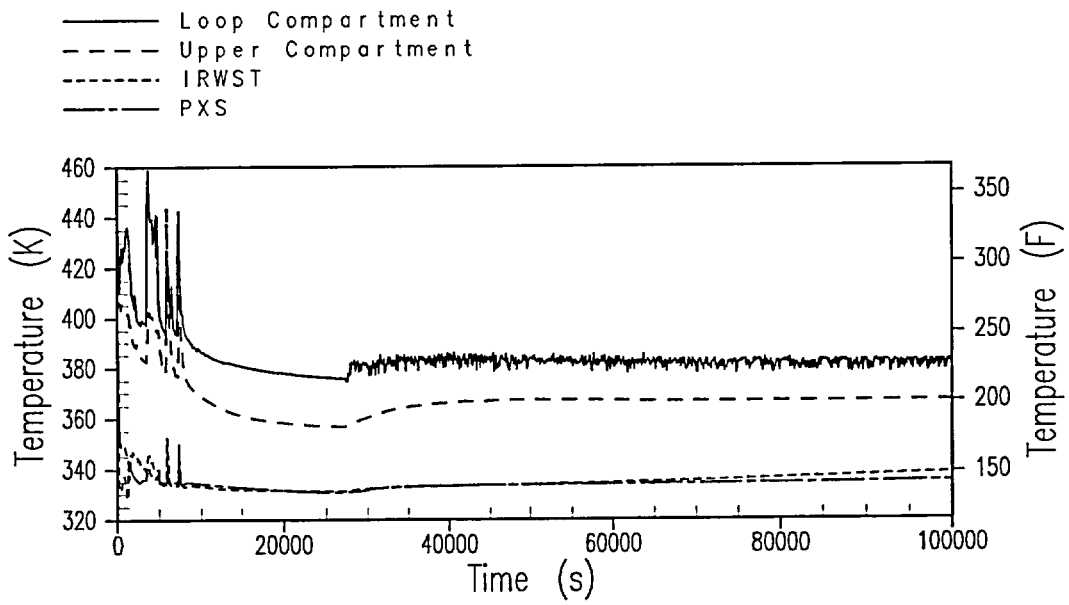

Figure 34-231

Case 3D-1: Containment Gas Temperature Spurious ADS-4 with Failed CMTs

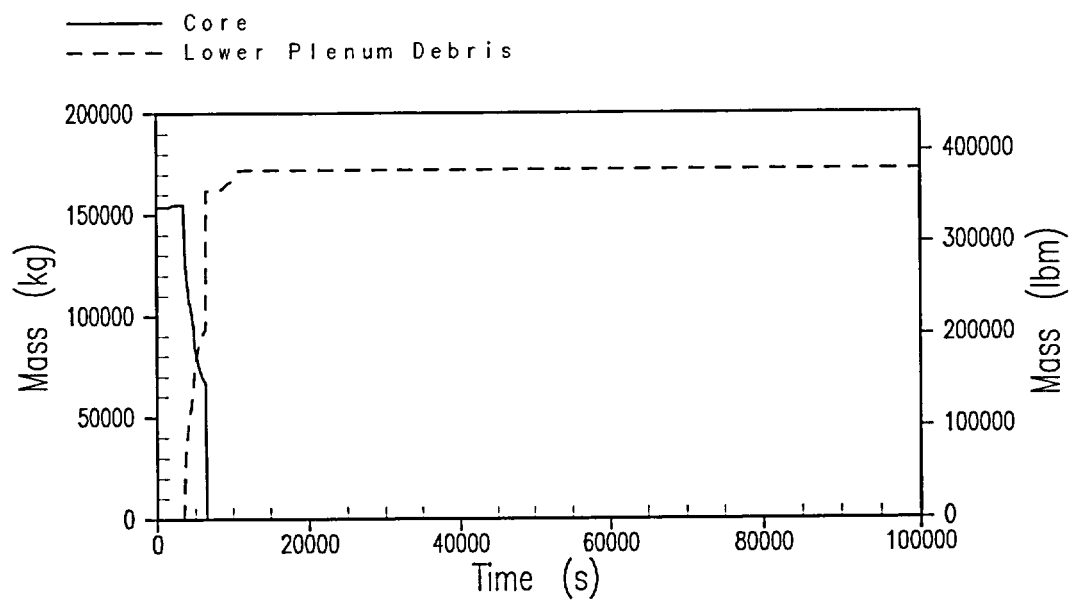

Figure 34-232

Case 3D-1: Core Mass Spurious ADS-4 with Failed CMTs

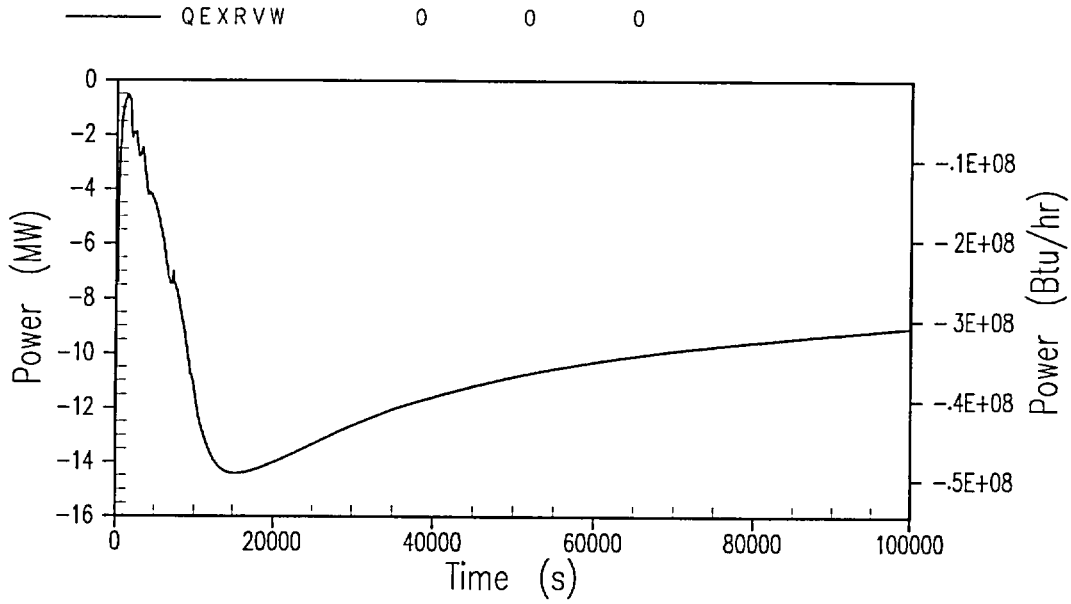

Figure 34-233

Case 3D-1: Reactor Pressure Vessel to Cavity Water Heat Transfer Spurious ADS-4 with Failed CMTs

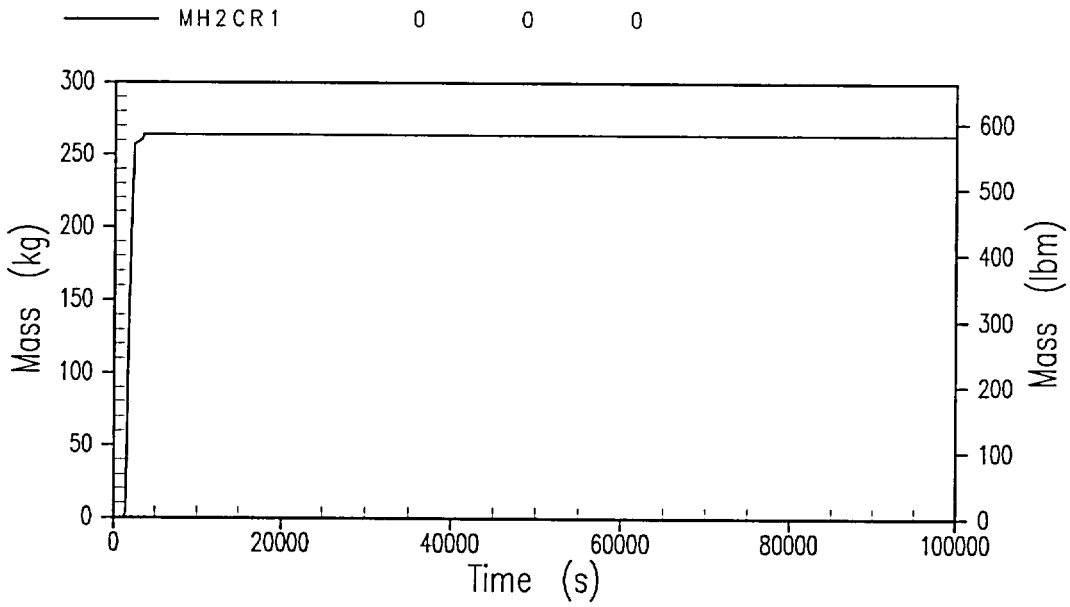

Figure 34-234

Case 3D-1: In-Vessel Hydrogen Generation Spurious ADS-4 with Failed CMTs

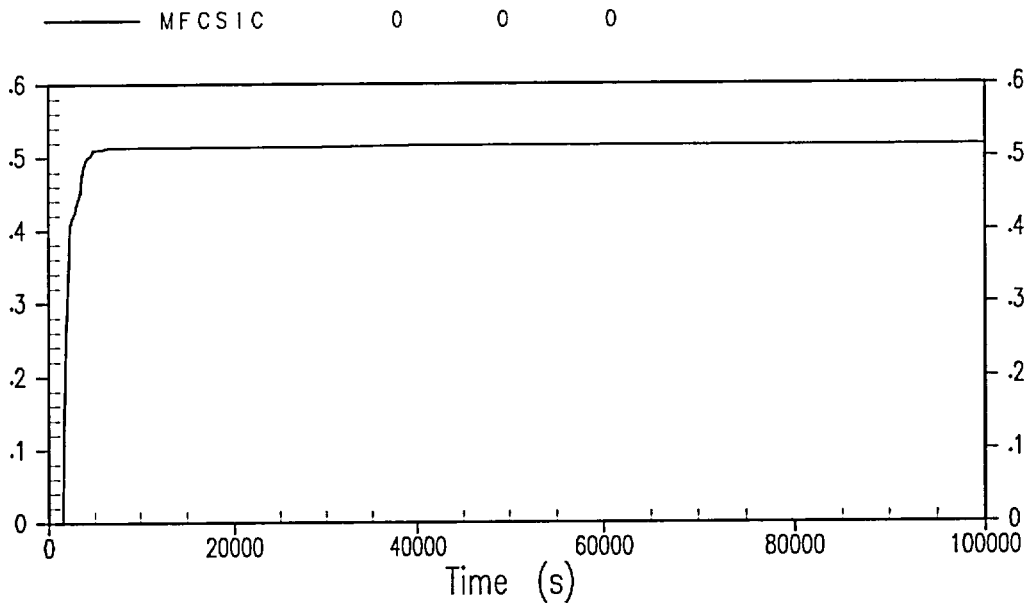

Figure 34-235

Case 3D-1: Mass Fraction of CsI Released to Containment Spurious ADS-4 with Failed CMTs

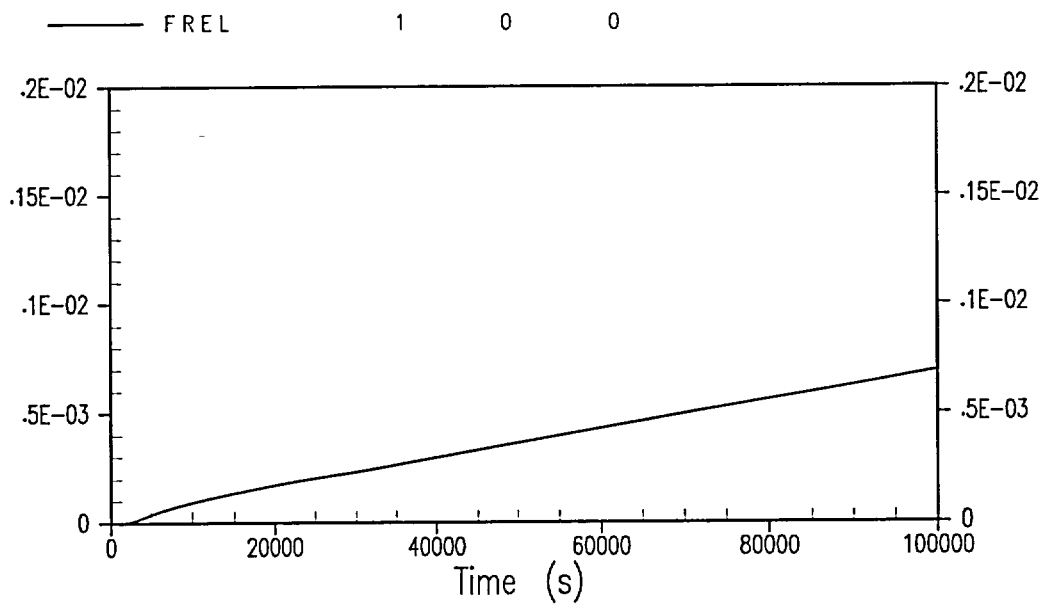

Figure 34-236

Case 3D-1: Mass Fraction of Noble Gases Released to Environment Spurious ADS-4 with Failed CMTs

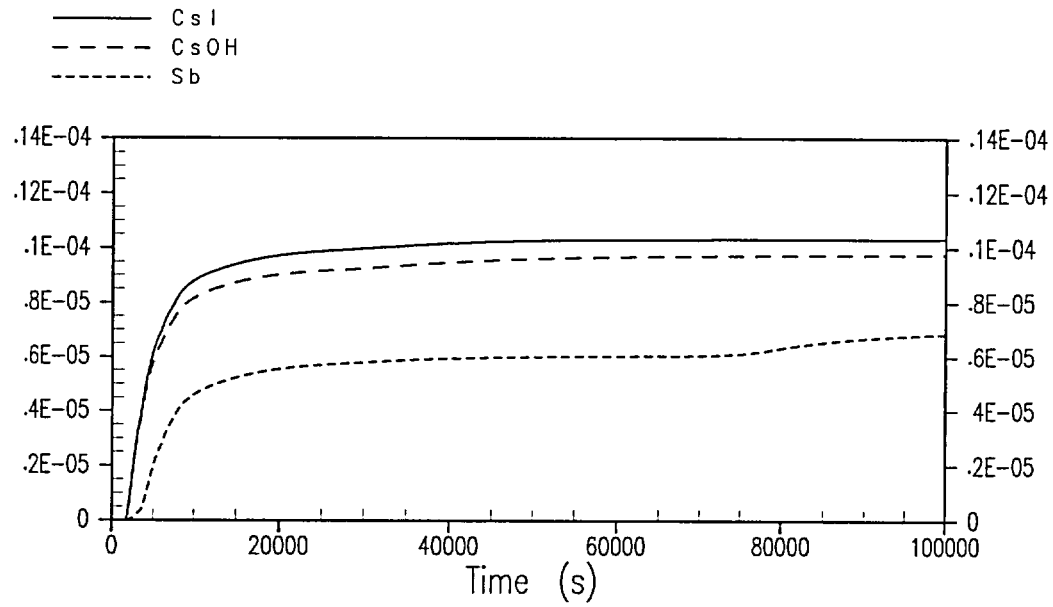

Figure 34-237

Case 3D-1: Mass Fraction of Fission Products Released to Environment Spurious ADS-4 with Failed CMTs

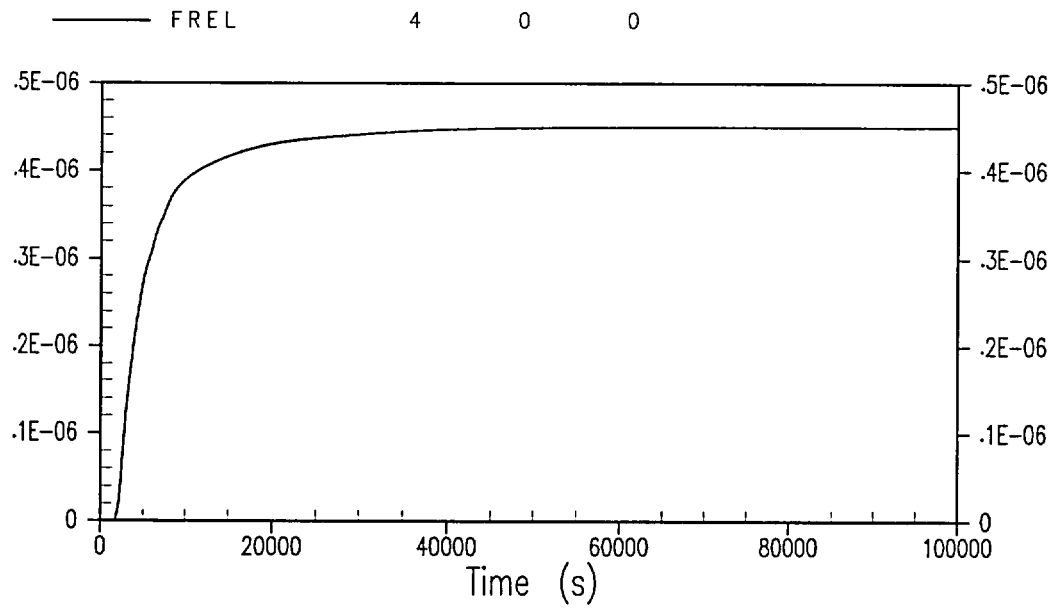

Figure 34-238

Case 3D-1: Mass Fraction of SrO Released to Environment Spurious ADS-4 with Failed CMTs

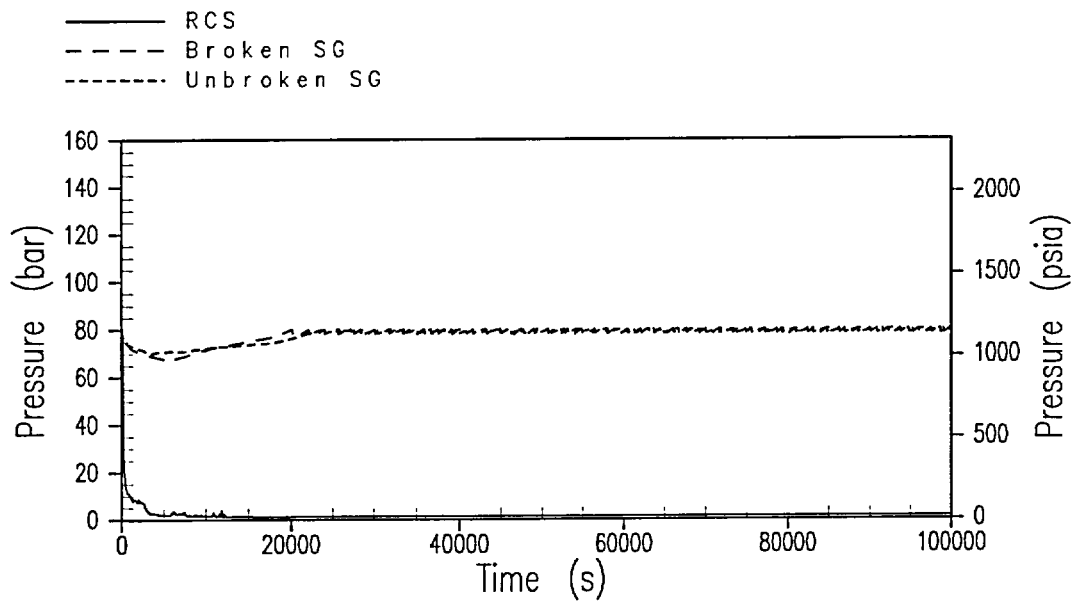

Figure 34-239

Case 3D-2: Reactor Coolant System and Steam Generator Pressure Spurious ADS-2 with Failed CMTs

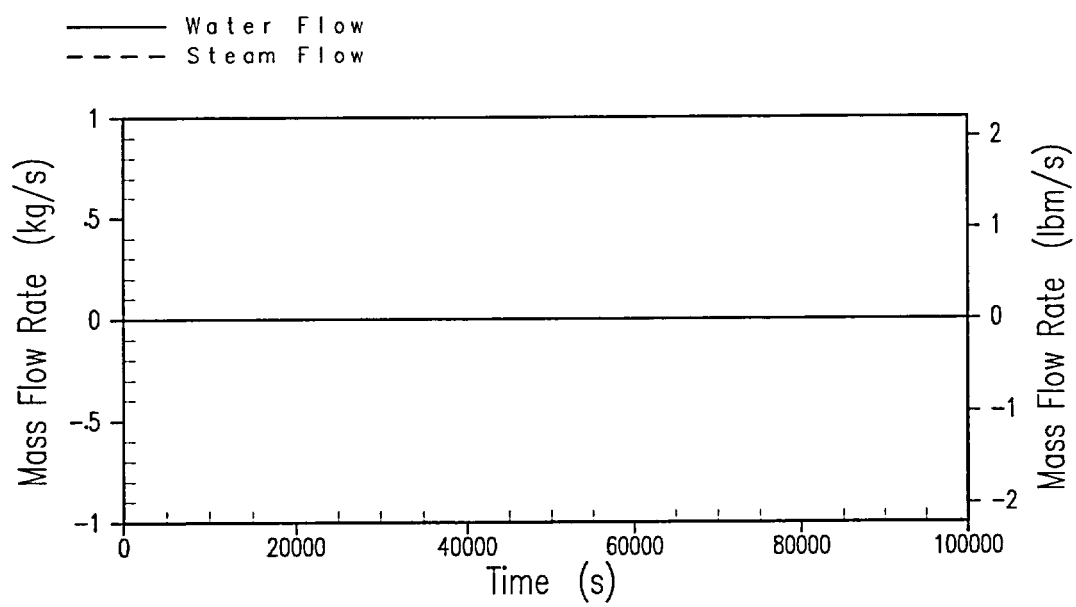

Figure 34-240

Case 3D-2: ADS Stage 4 Flow Rates Spurious ADS-2 with Failed CMTs

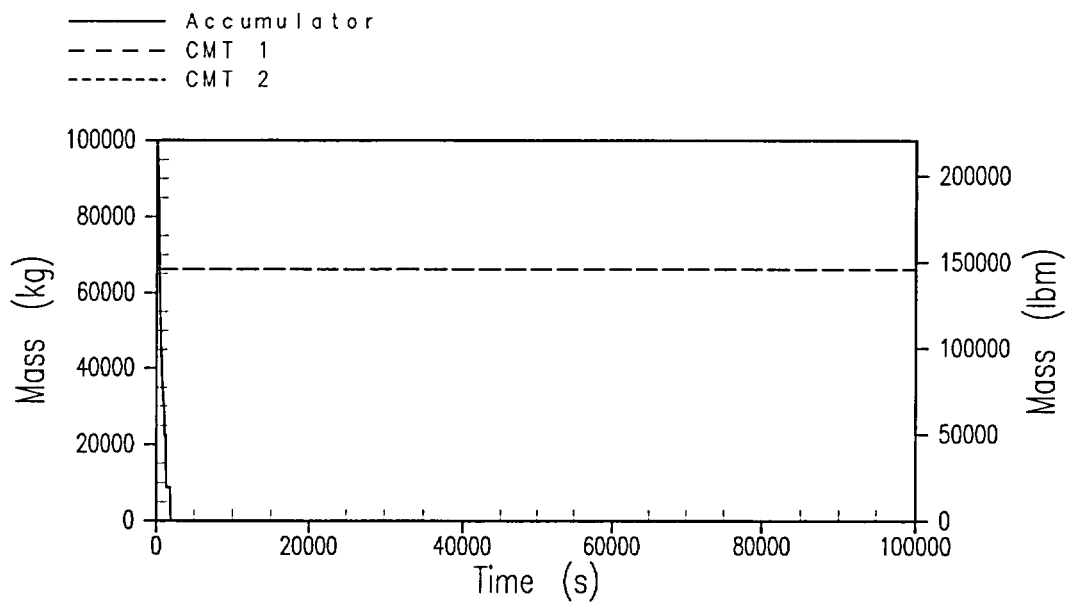

Figure 34-241

Case 3D-2: Accumulator/CMT Water Mass Spurious ADS-2 with Failed CMTs

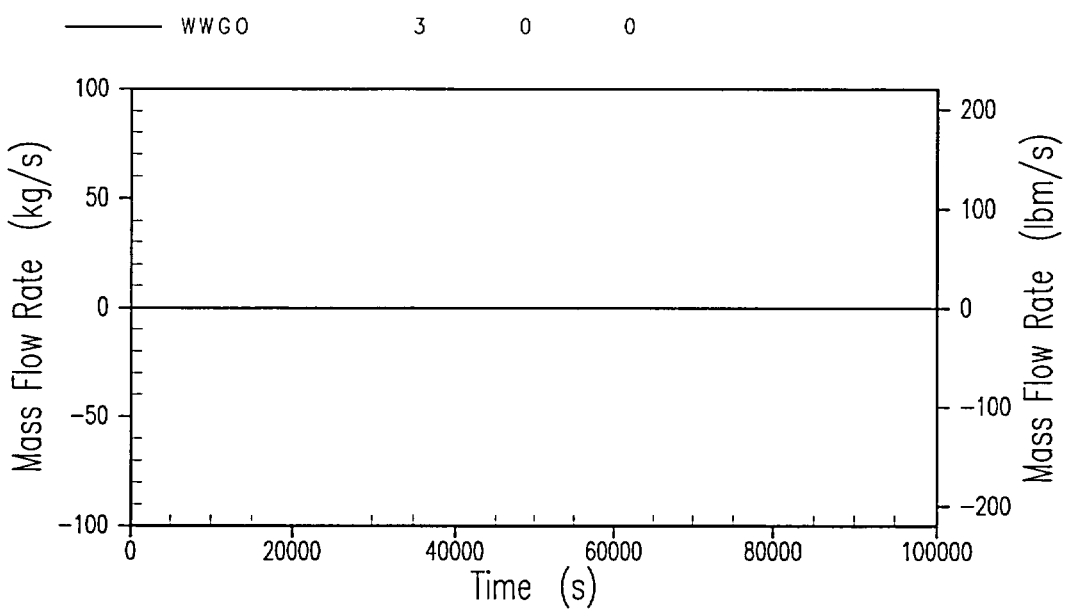

Figure 34-242

Case 3D-2: IRWST Injection Flow Rate Spurious ADS-2 with Failed CMTs

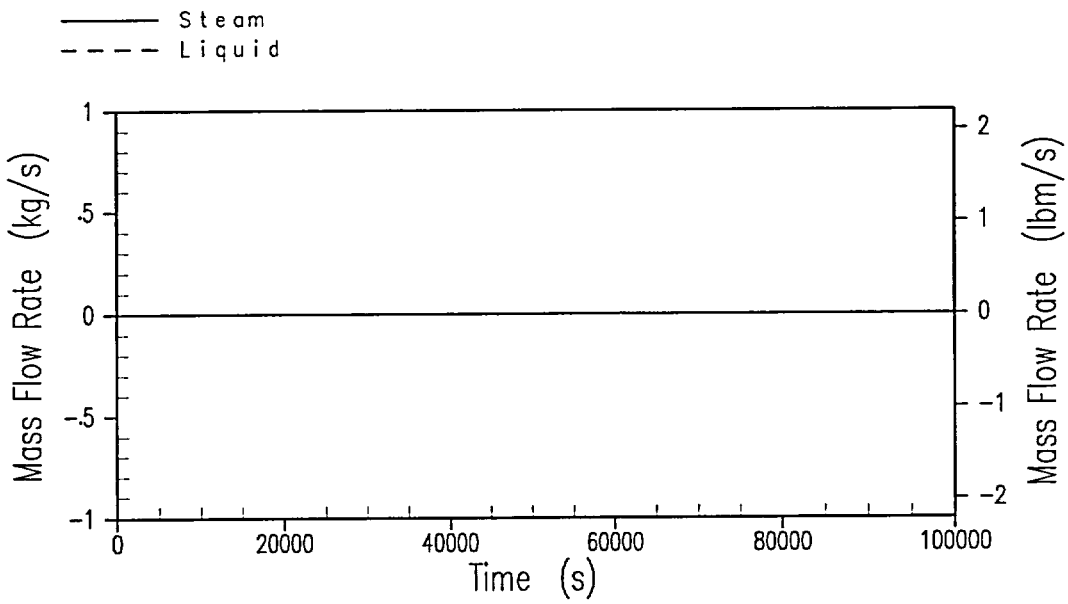

Figure 34-243

Case 3D-2: Break Flow Rate Spurious ADS-2 with Failed CMTs

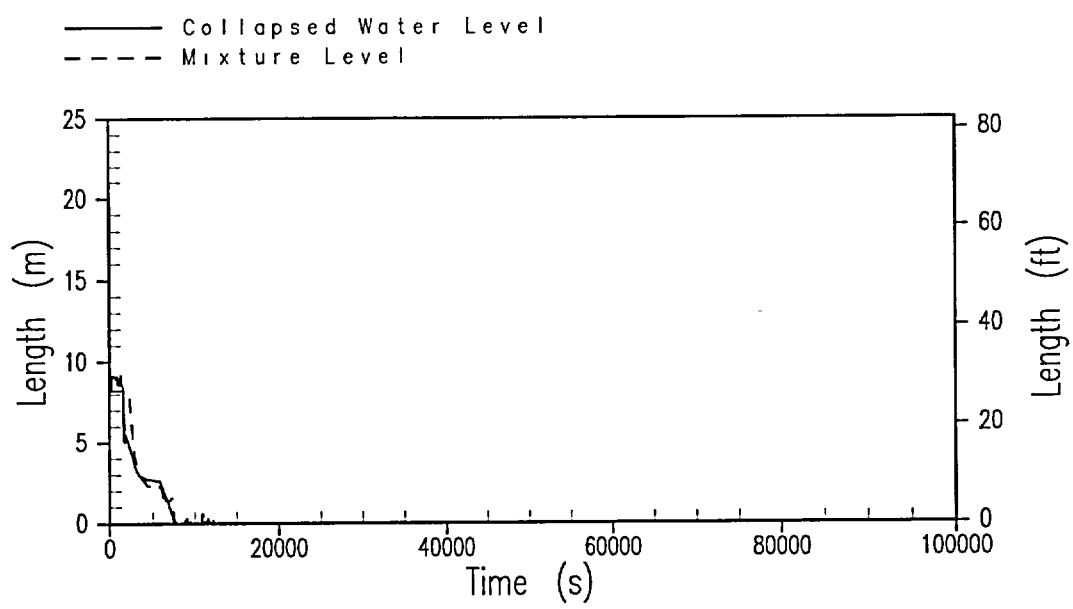

Figure 34-244

Case 3D-2: Reactor Vessel Water Level Spurious ADS-2 with Failed CMTs

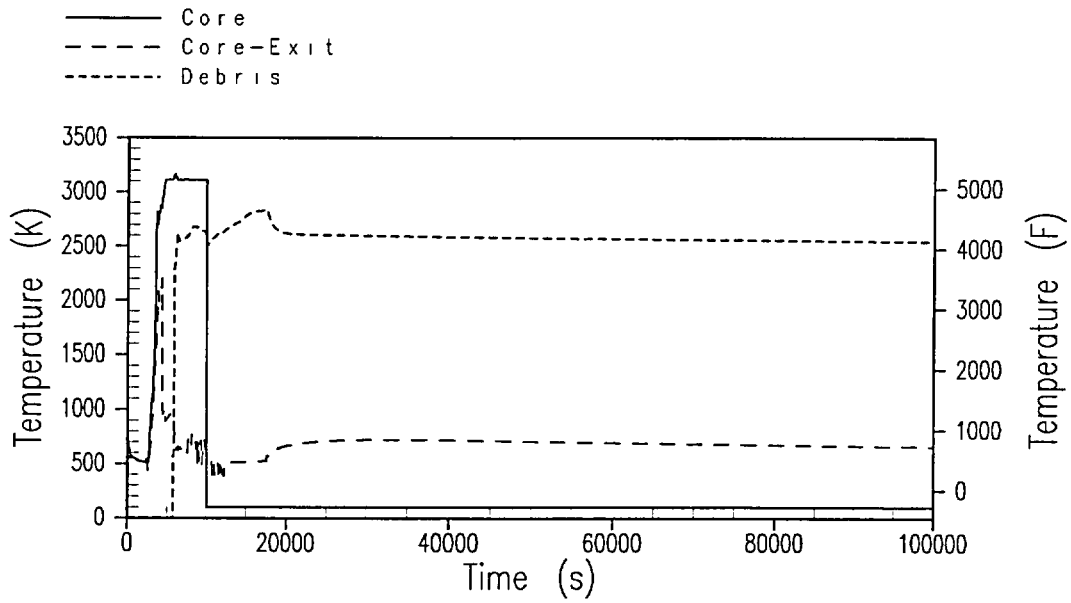

Figure 34-245

Case 3D-2: Core Temperatures Spurious ADS-2 with Failed CMTs

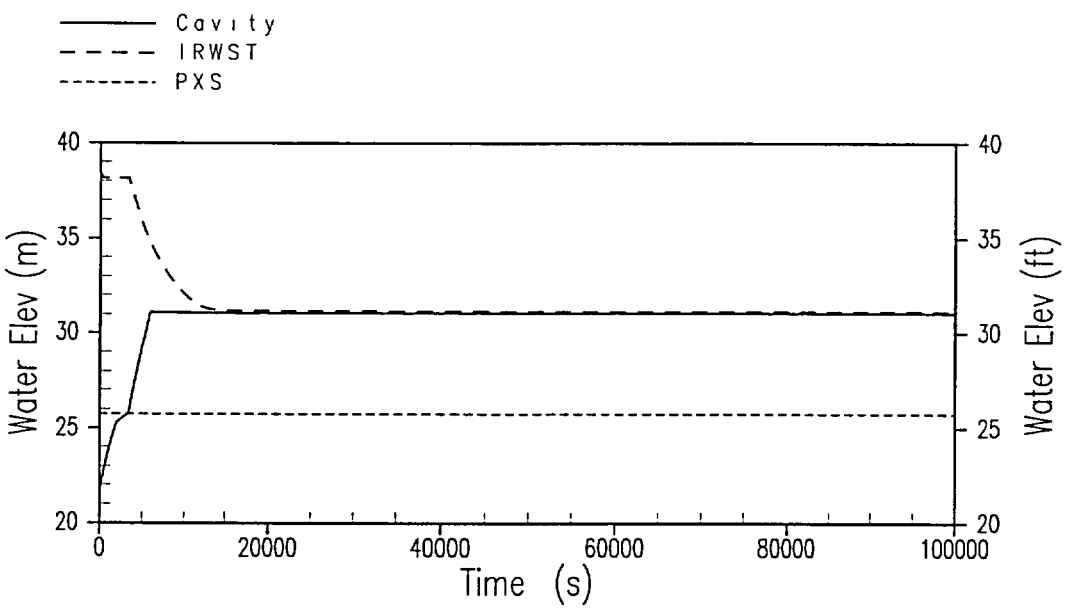

Figure 34-246

Case 3D-2: Containment Pool Water Elevations Spurious ADS-2 with Failed CMTs

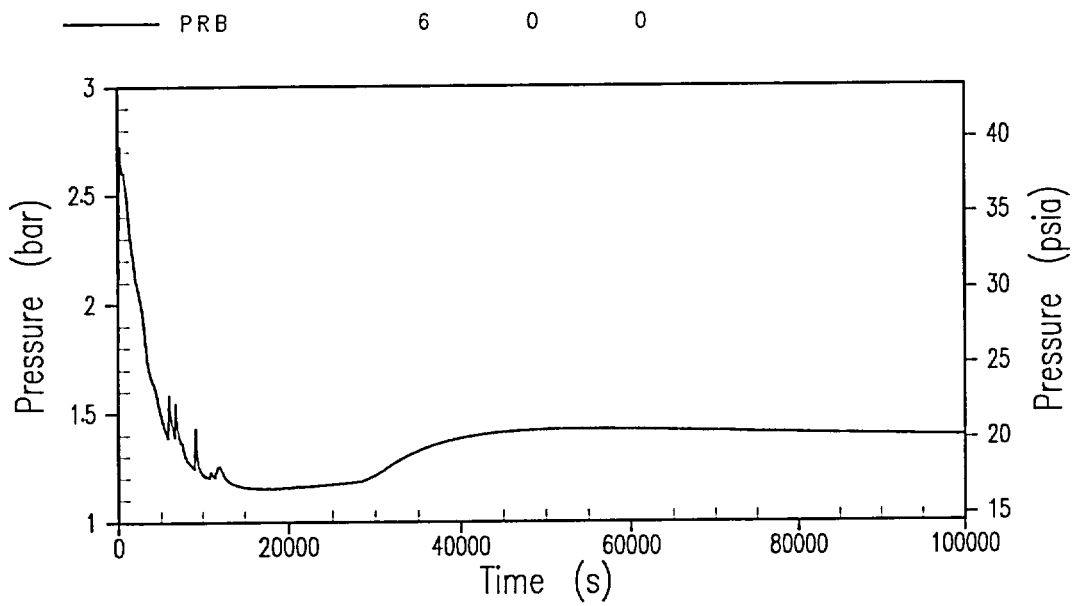

Figure 34-247

Case 3D-2: Containment Pressure Spurious ADS-2 with Failed CMTs

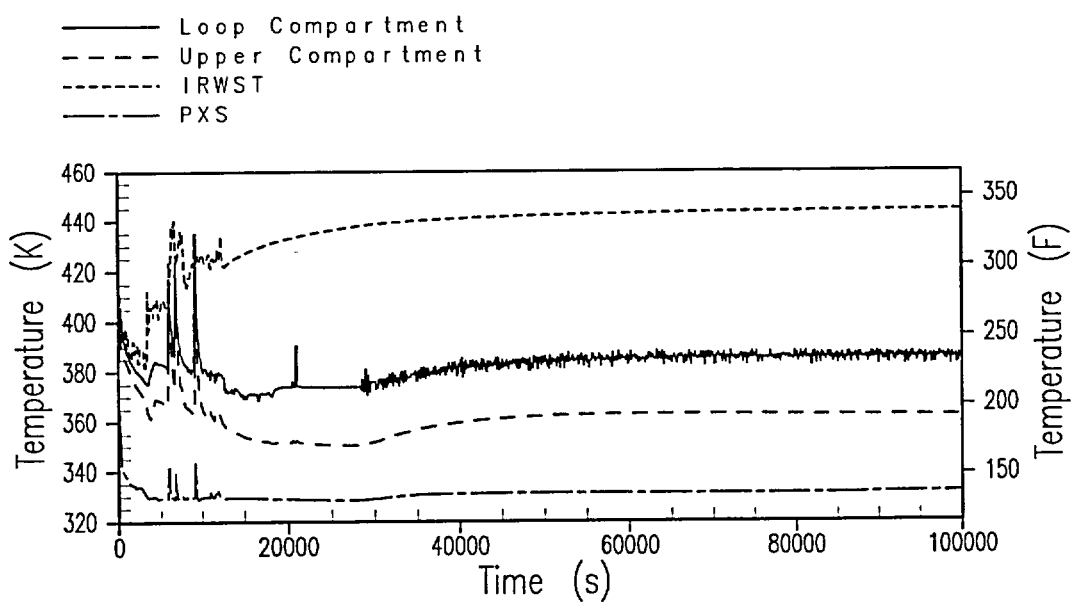

Figure 34-248

Case 3D-2: Containment Gas Temperature Spurious ADS-2 with Failed CMTs

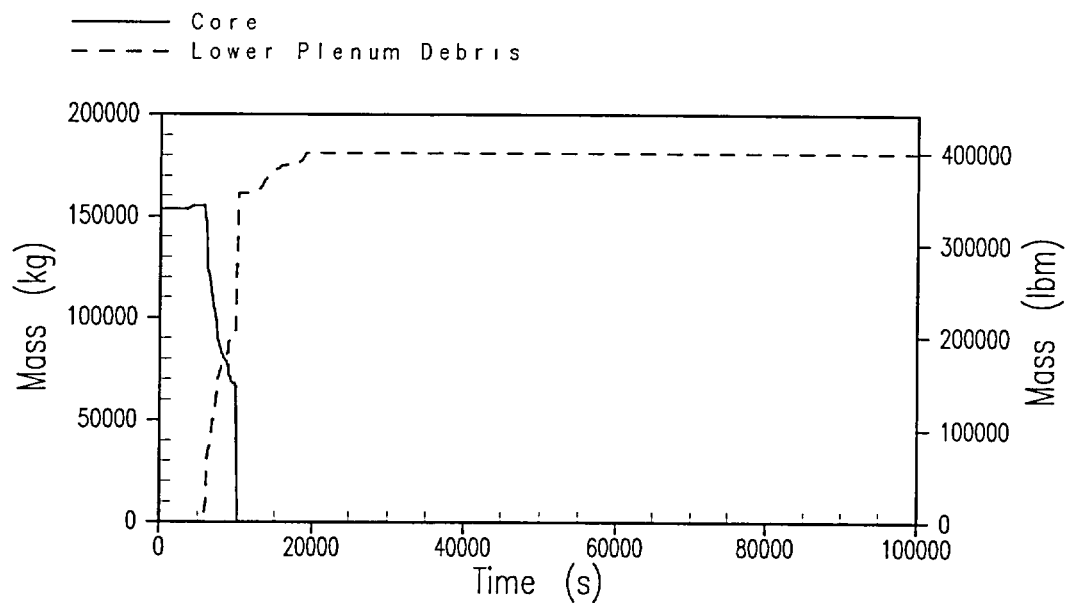

Figure 34-249

Case 3D-2: Core Mass
Spurious ADS-2 with Failed CMTs

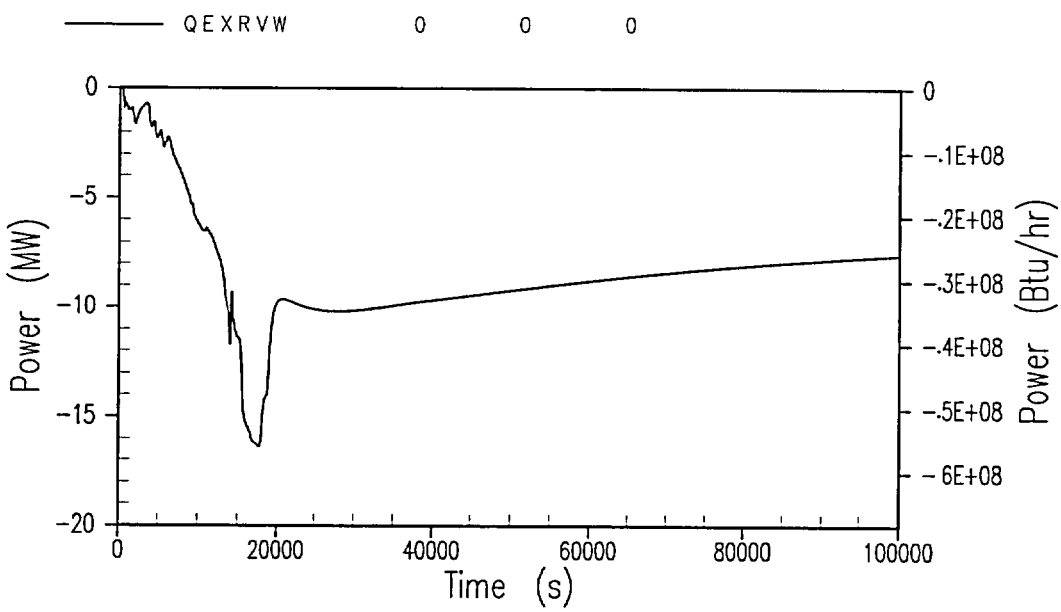

Figure 34-250

Case 3D-2: Reactor Pressure Vessel to Cavity Water Heat Transfer
Spurious ADS-2 with Failed CMTs

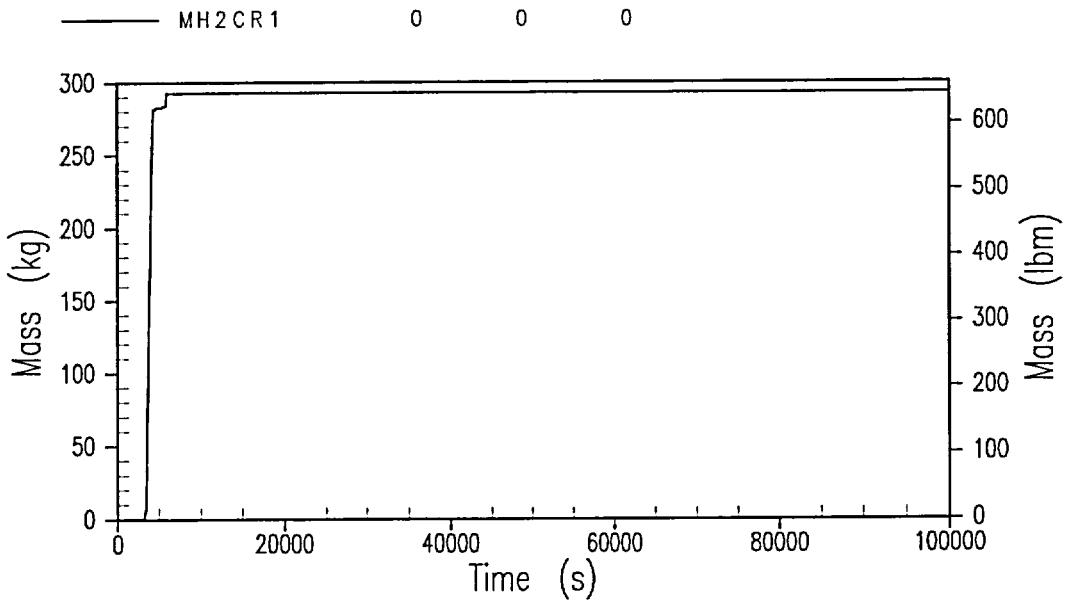

Figure 34-251

Case 3D-2: In-Vessel Hydrogen Generation Spurious ADS-2 with Failed CMTs

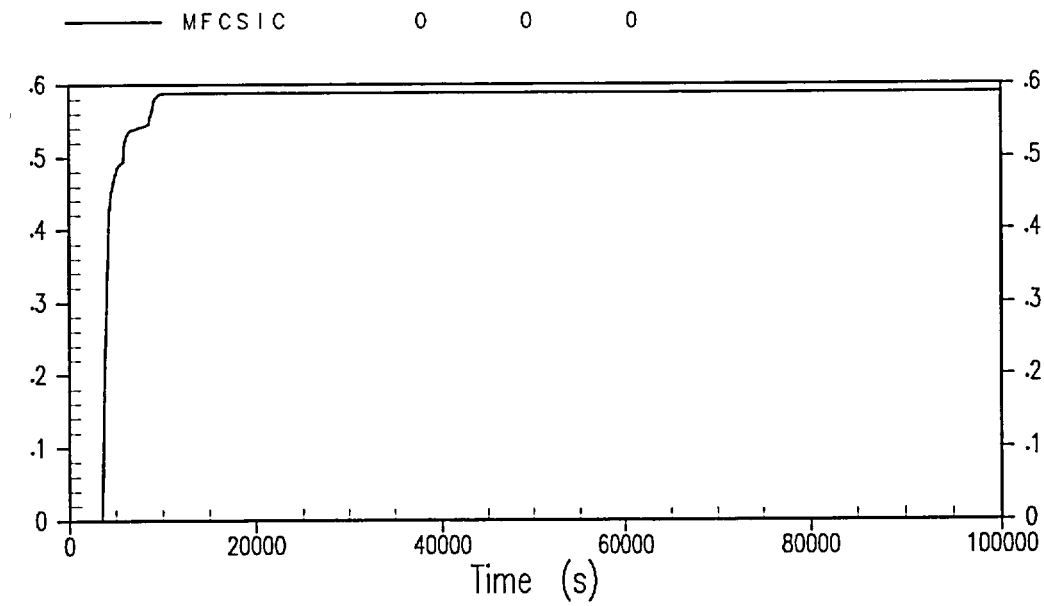

Figure 34-252

Case 3D-2: Mass Fraction of CsI Released to Containment Spurious ADS-2 with Failed CMTs

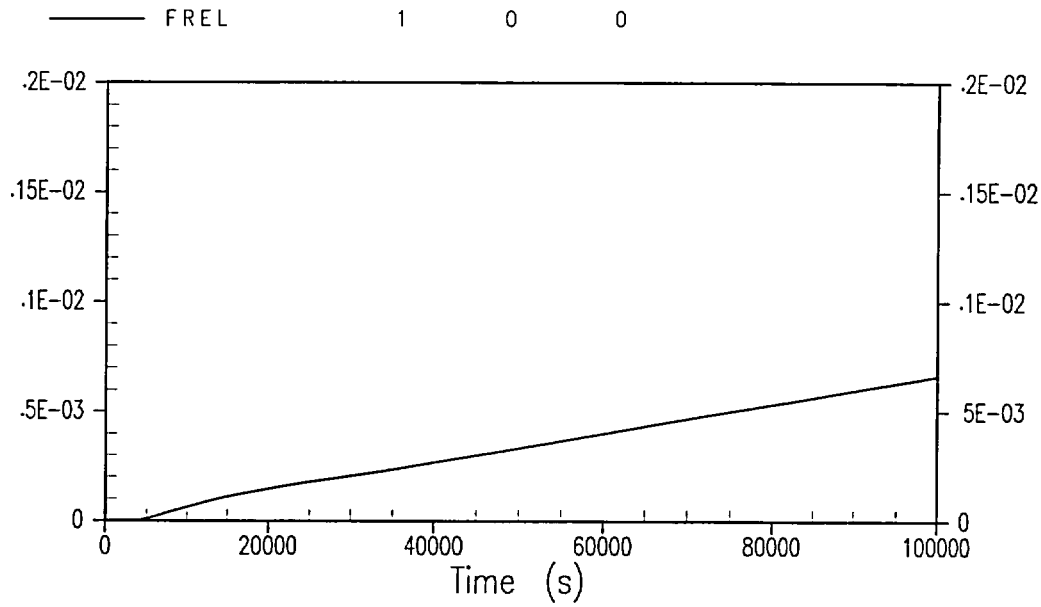

Figure 34-253

Case 3D-2: Mass Fraction of Noble Gas Released to Environment Spurious ADS-2 with Failed CMTs

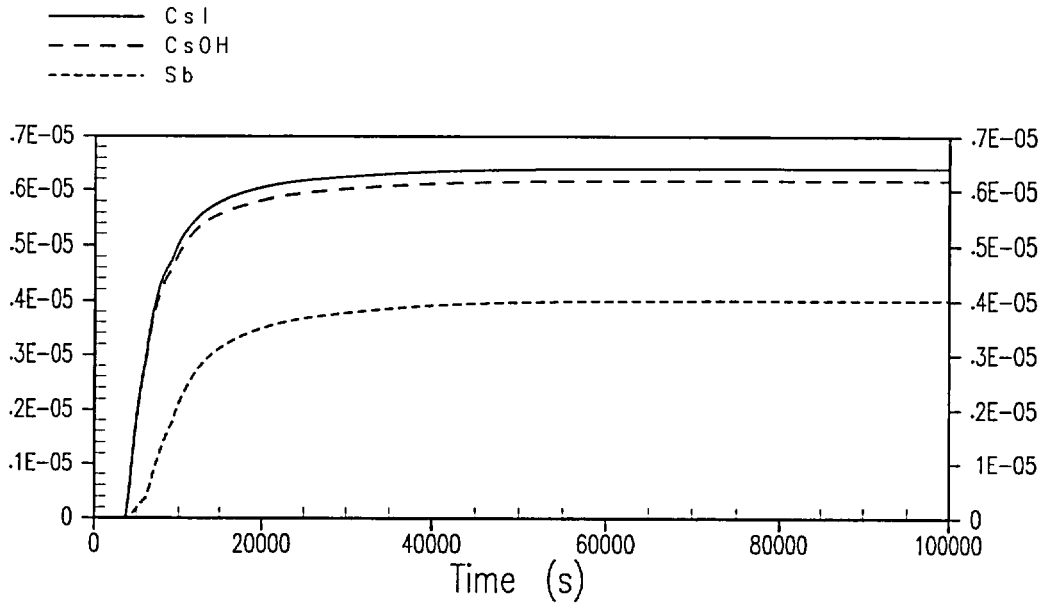

Figure 34-254

Case 3D-2: Mass Fraction of Fission Products Released to Environment Spurious ADS-2 with Failed CMTs

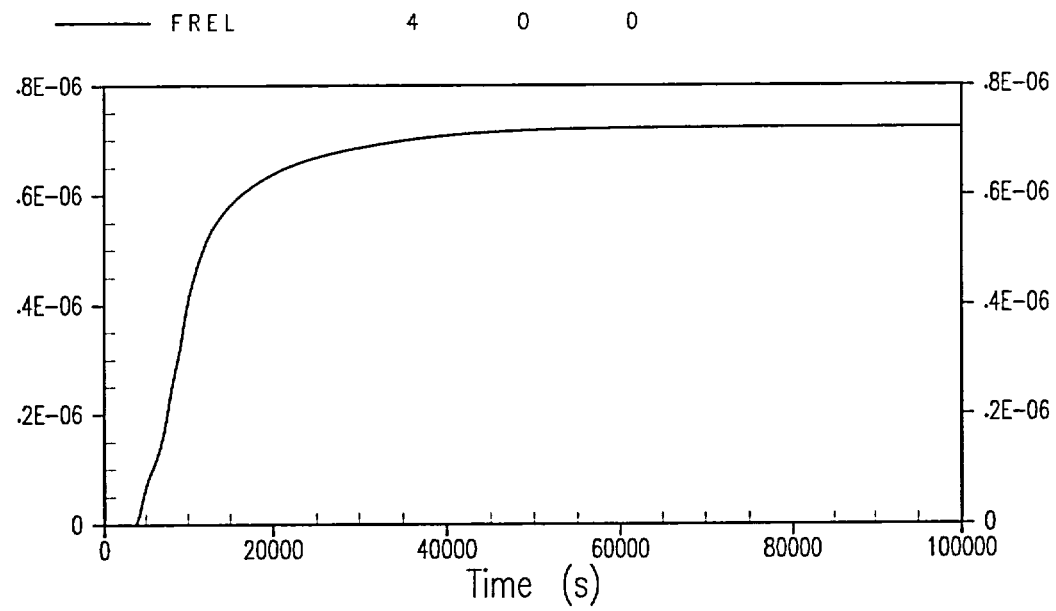

Figure 34-255

Case 3D-2: Mass Fraction of SrO Released to Environment Spurious ADS-2 with Failed CMTs

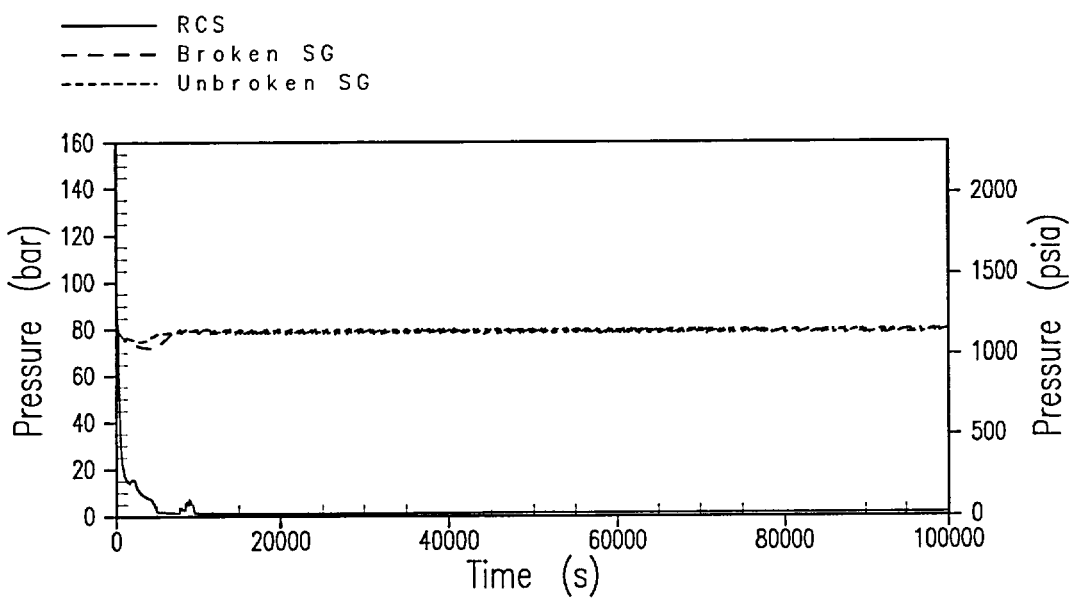

Figure 34-256

Case 3D-3: Reactor Coolant System and Steam Generator Pressure DVI Line Break with Failed ADS

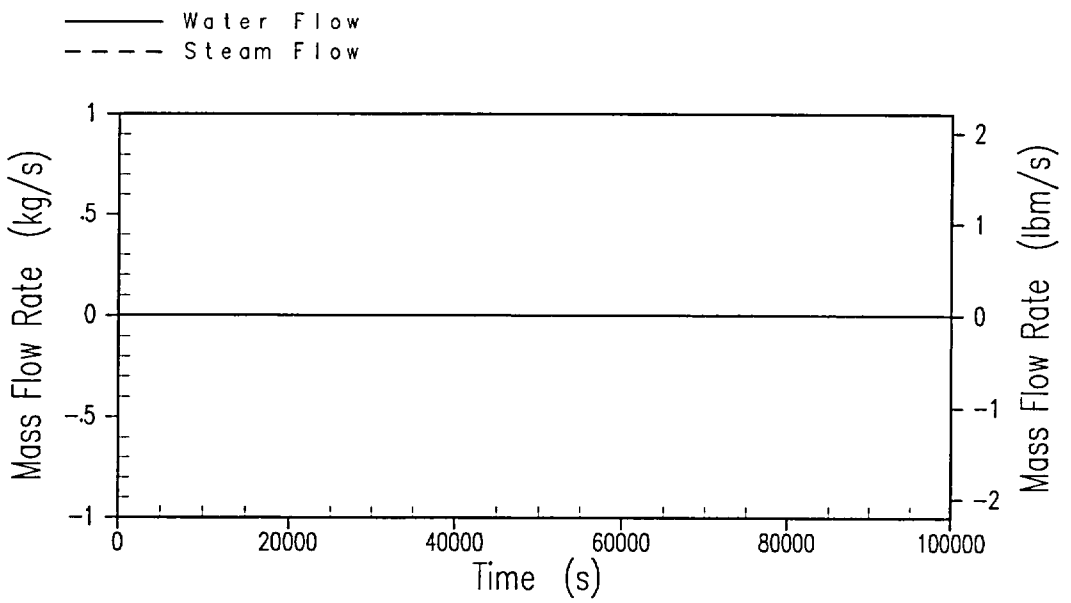

Figure 34-257

Case 3D-3: ADS Stage 4 Flow Rates
DVI Line Break with Failed ADS

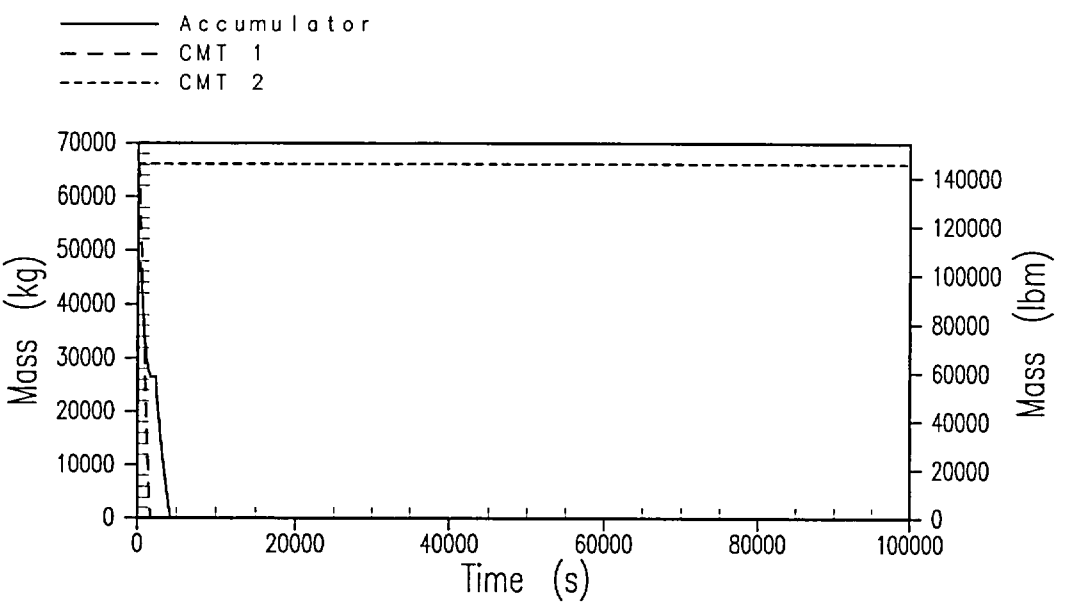

Figure 34-258

Case 3D-3: Accumulator/CMT Water Mass
DVI Line Break with Failed ADS

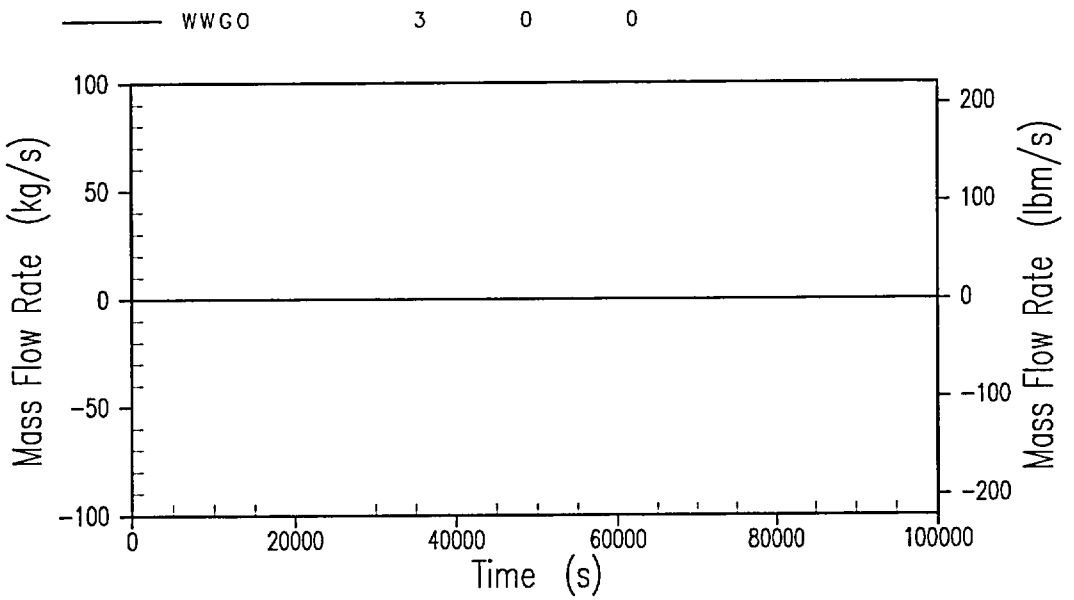

Figure 34-259

Case 3D-3: IRWST Injection Flow Rate
DVI Line Break with Failed ADS

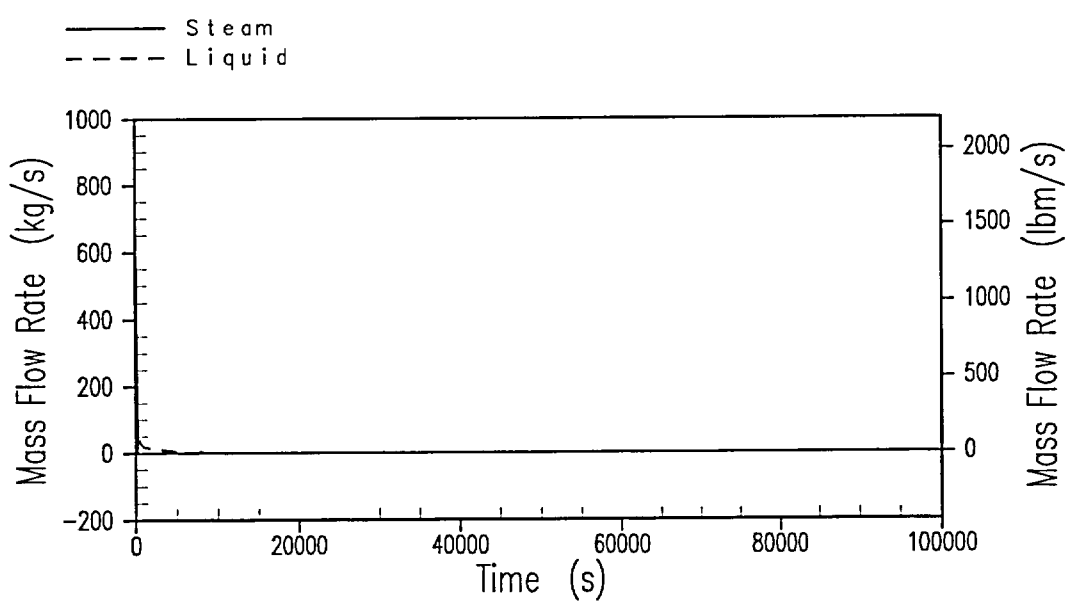

Figure 34-260

Case 3D-3: Break Flow Rate
DVI Line Break with Failed ADS

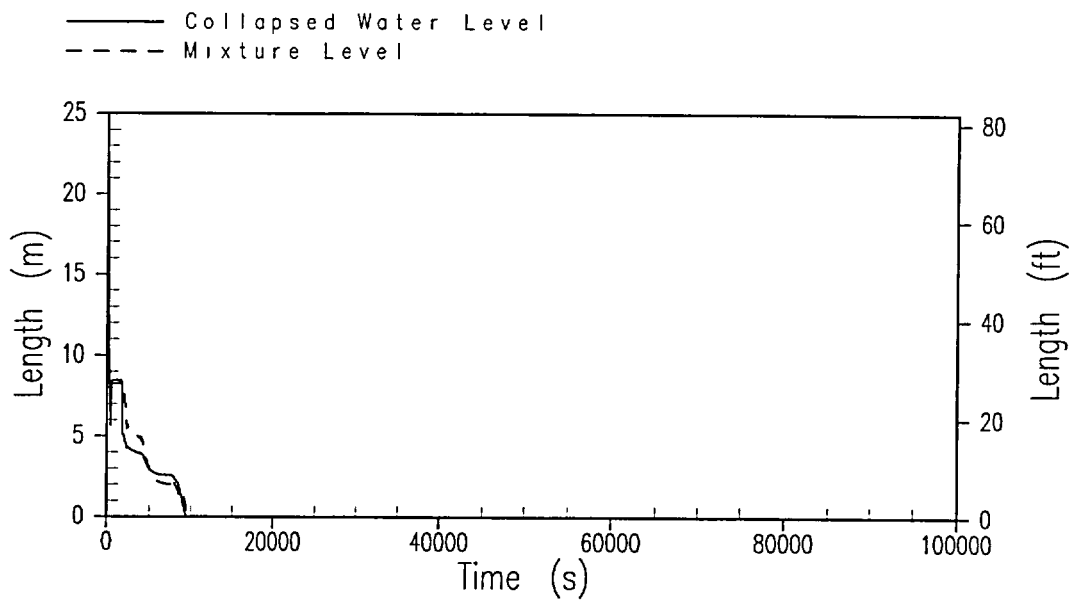

Figure 34-261

Case 3D-3: Reactor Vessel Water Level DVI Line Break with Failed ADS

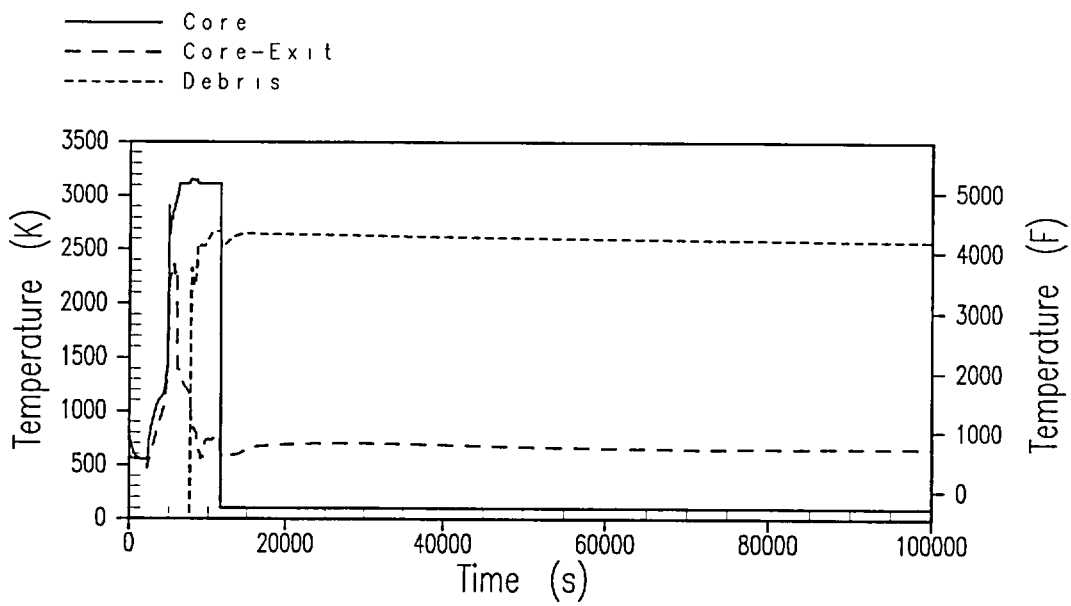

Figure 34-262

Case 3D-3: Core Temperatures DVI Line Break with Failed ADS

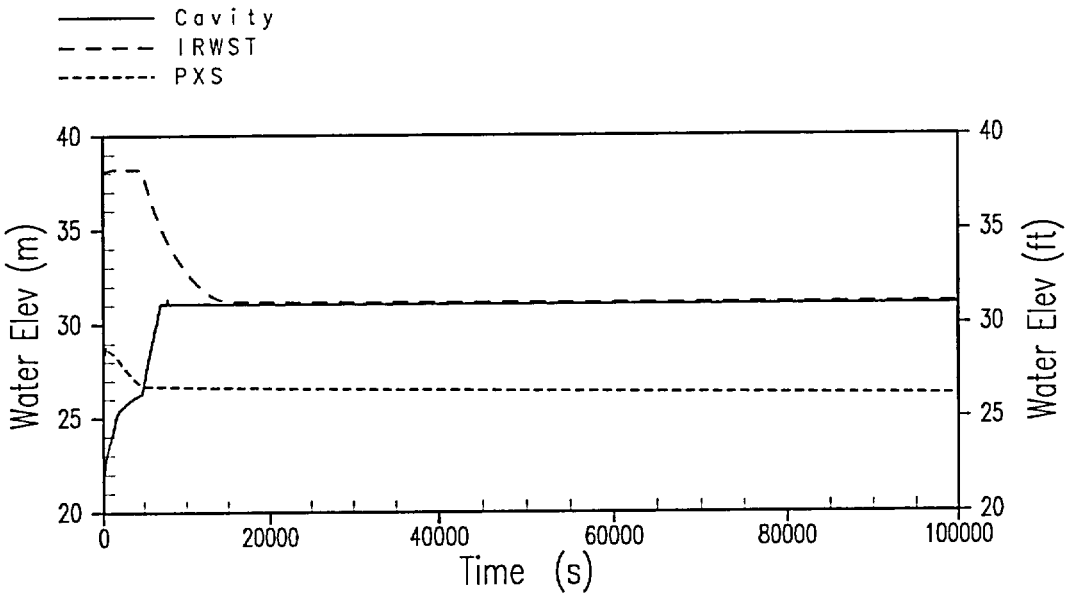

Figure 34-263

Case 3D-3: Containment Water Pool Elevations DVI Line Break with Failed ADS

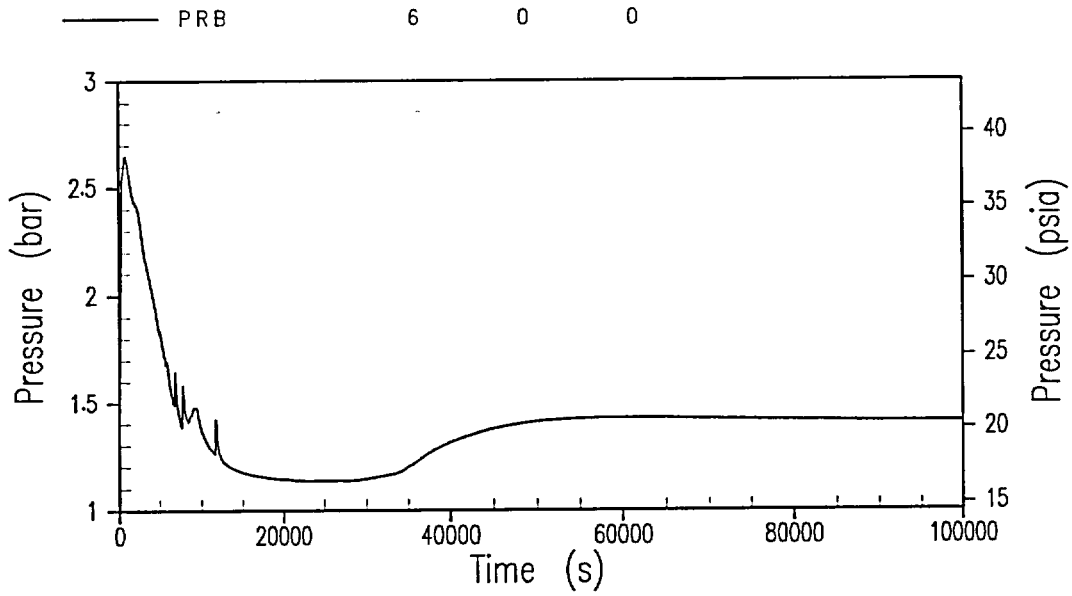

Figure 34-264

Case 3D-3: Containment Pressure DVI Line Break with Failed ADS

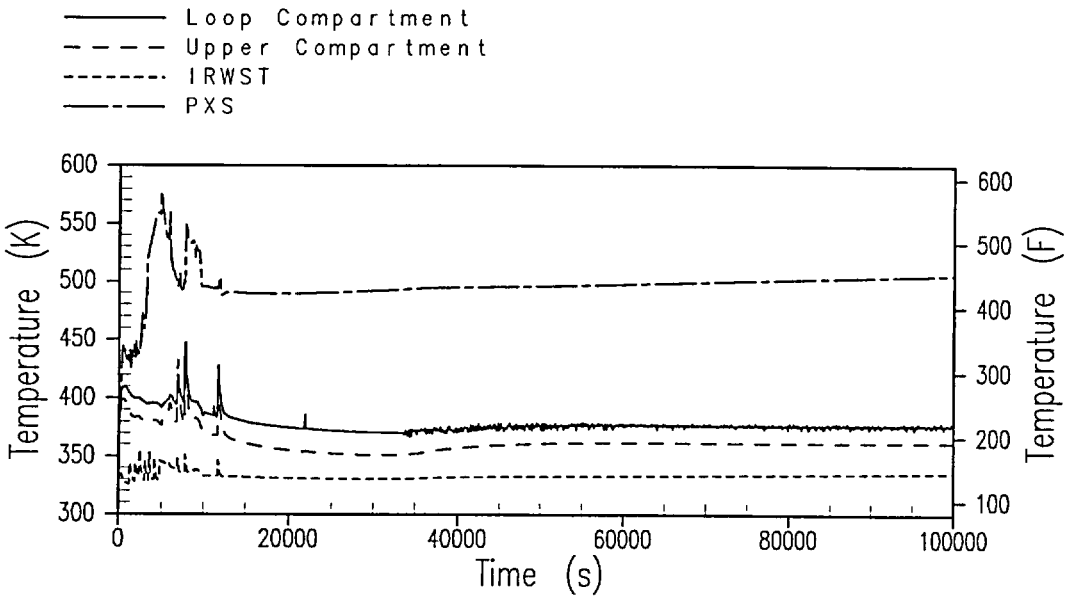

Figure 34-265

Case 3D-3: Containment Gas Temperature DVI Line Break with Failed ADS

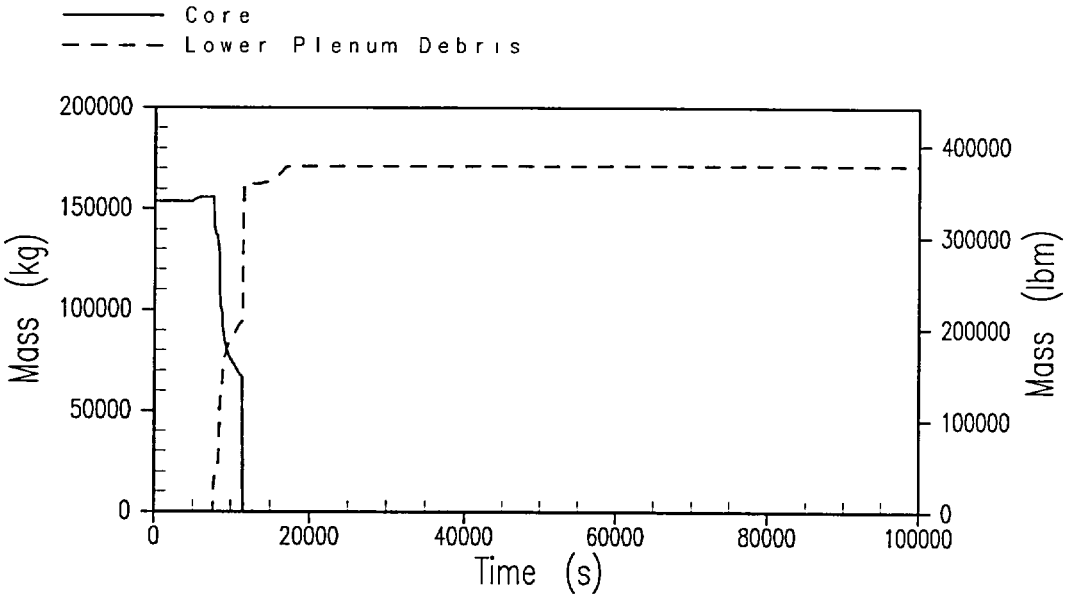

Figure 34-266

Case 3D-3: Core Mass DVI Line Break with Failed ADS

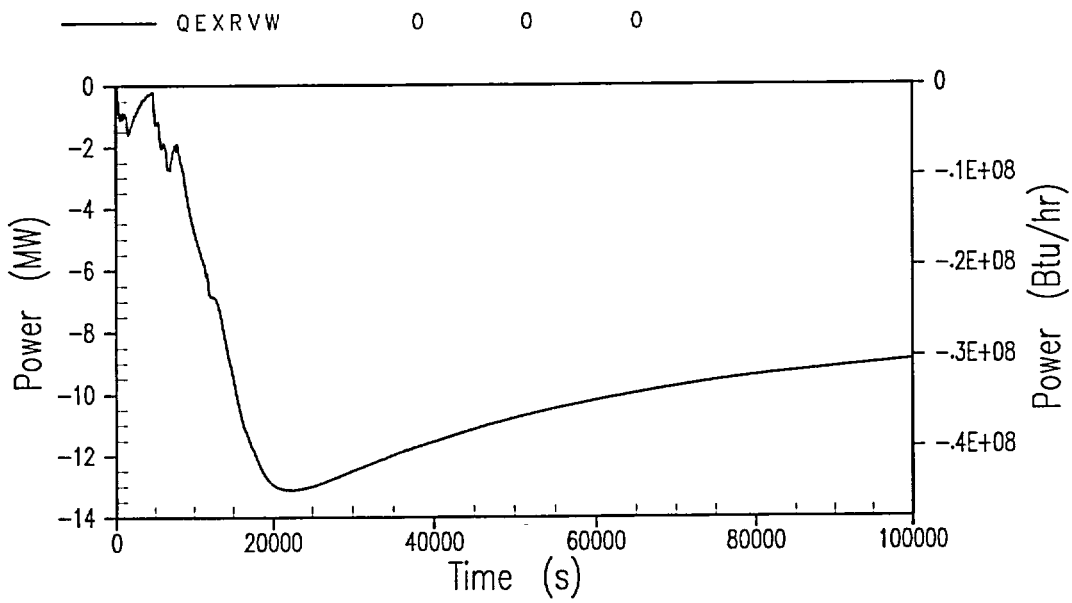

Figure 34-267

Case 3D-3: Reactor Pressure Vessel to Cavity Water Heat Transfer DVI Line Break with Failed ADS

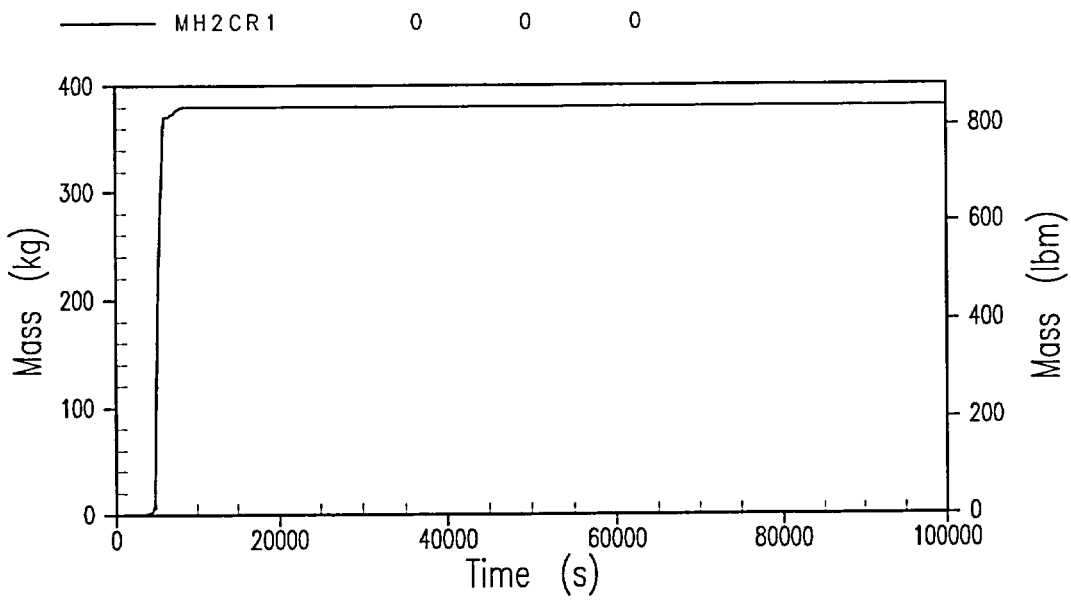

Figure 34-268

Case 3D-3: In-Vessel Hydrogen Generation DVI Line Break with Failed ADS

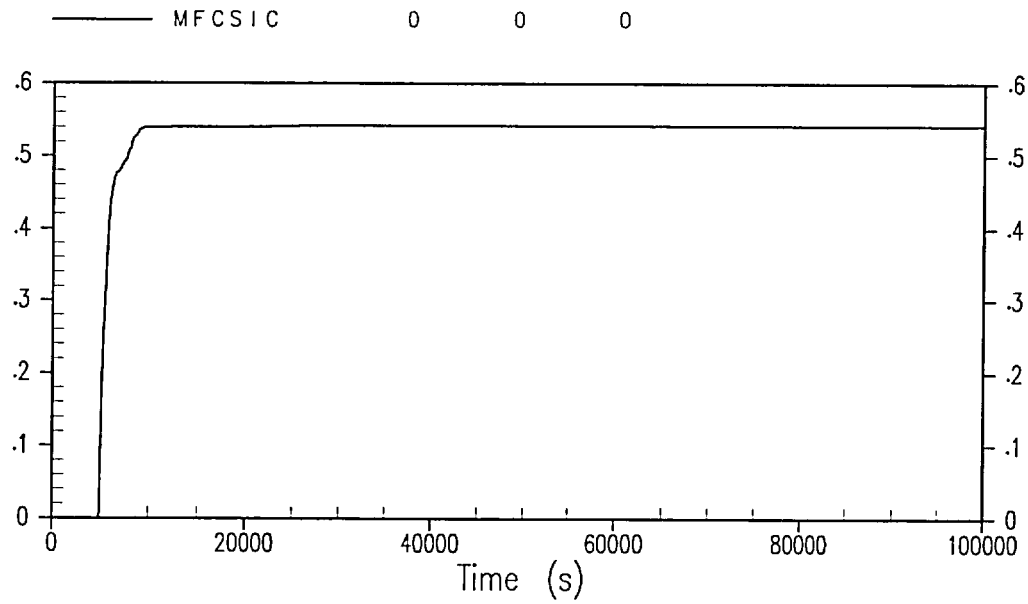

Figure 34-269

Case 3D-3: Mass Fraction of CsI Released to Containment DVI Line Break with Failed ADS

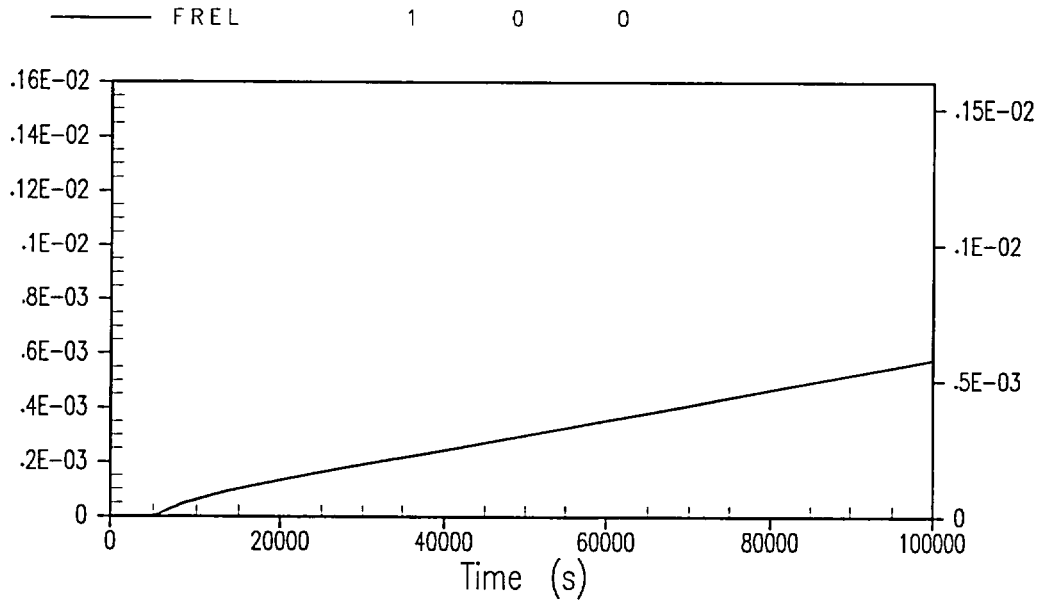

Figure 34-270

Case 3D-3: Mass Fraction of Noble Gases Released to Environment DVI Line Break with Failed ADS

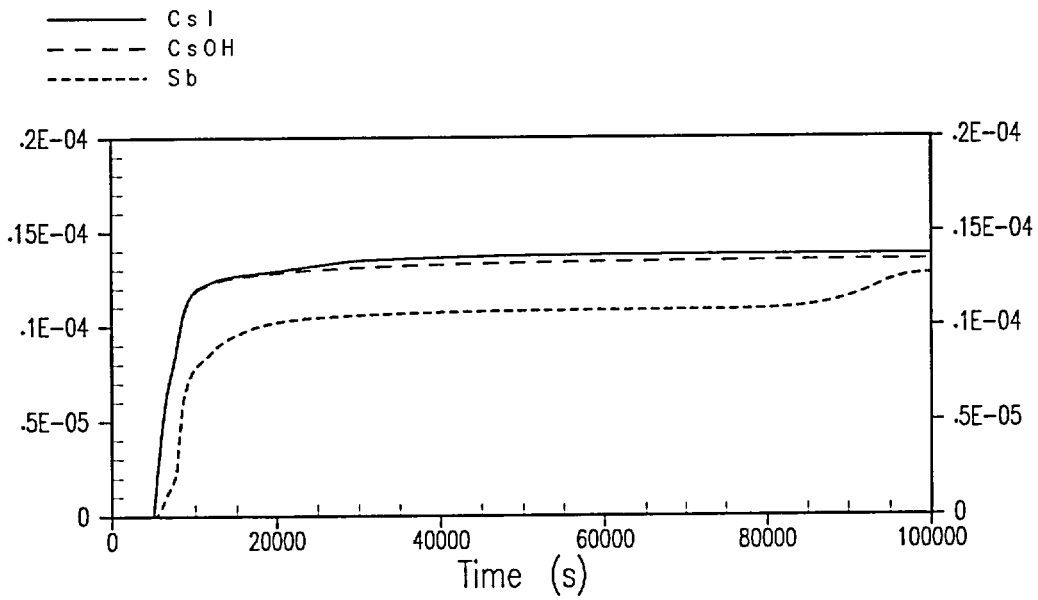

Figure 34-271

Case 3D-3: Mass Fraction of Fission Products Released to Environment DVI Line Break with Failed ADS

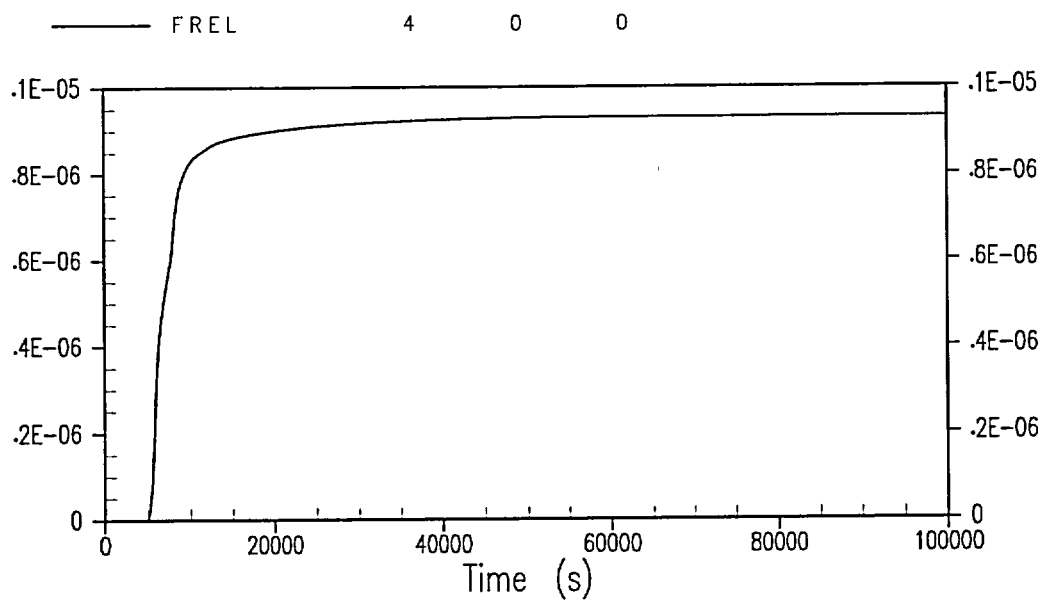

Figure 34-272

Case 3D-3: Mass Fraction of SrO Released to Environment DVI Line Break with Failed ADS

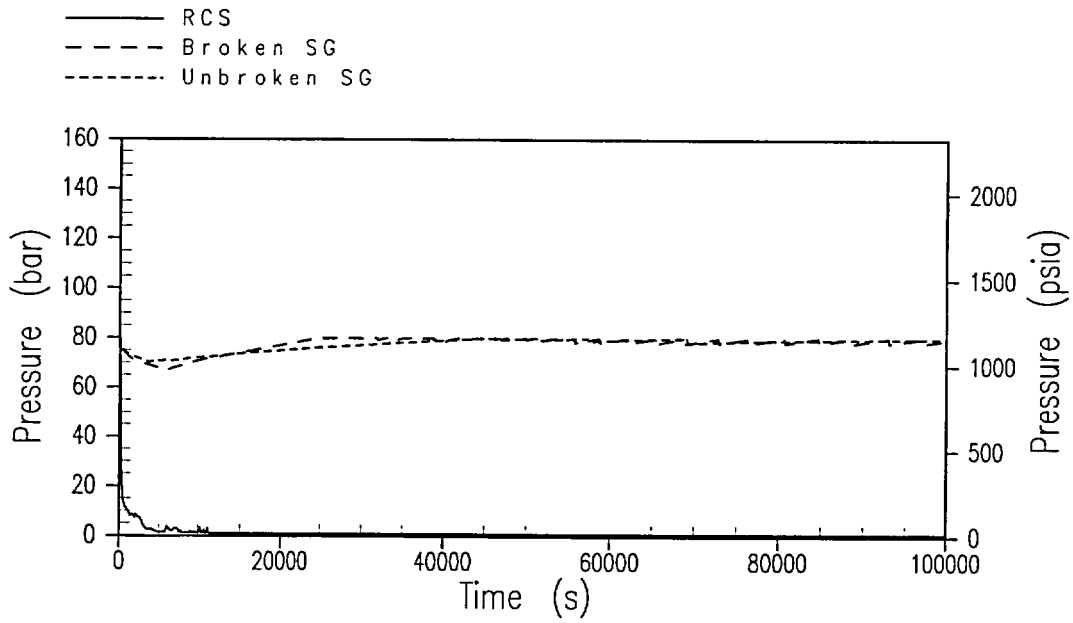

Figure 34-273

Case 3D-4: Reactor Coolant System and Steam Generator Pressure
Spurious ADS-2, Failed CMTs, Diffusion Flame

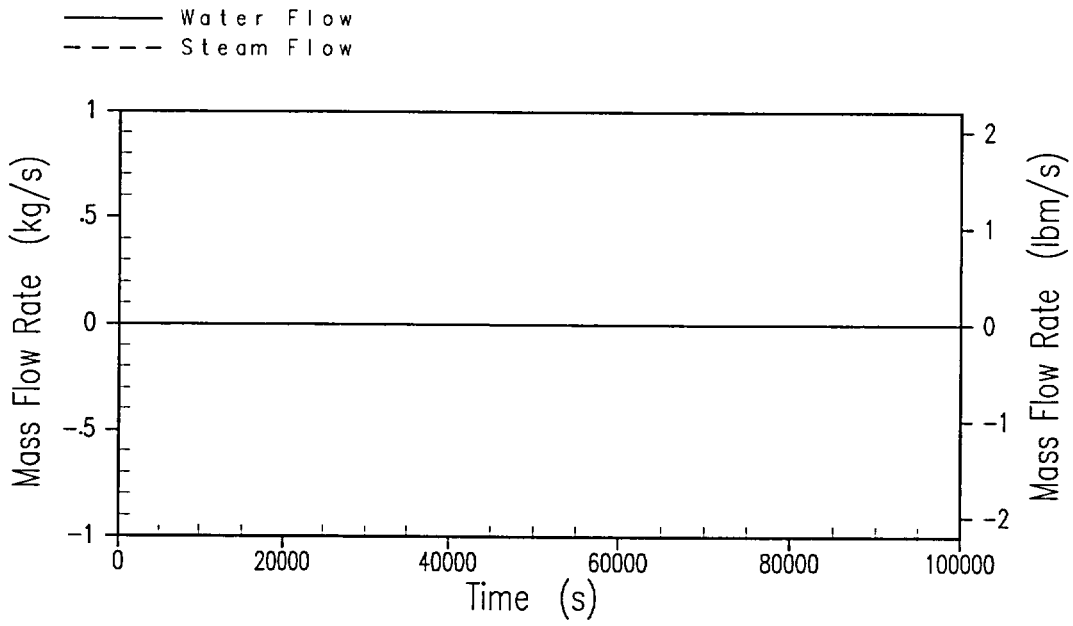

Figure 34-274

Case 3D-4: ADS Stage 4 Flow Rates
Spurious ADS-2, Failed CMTs, Diffusion Flame

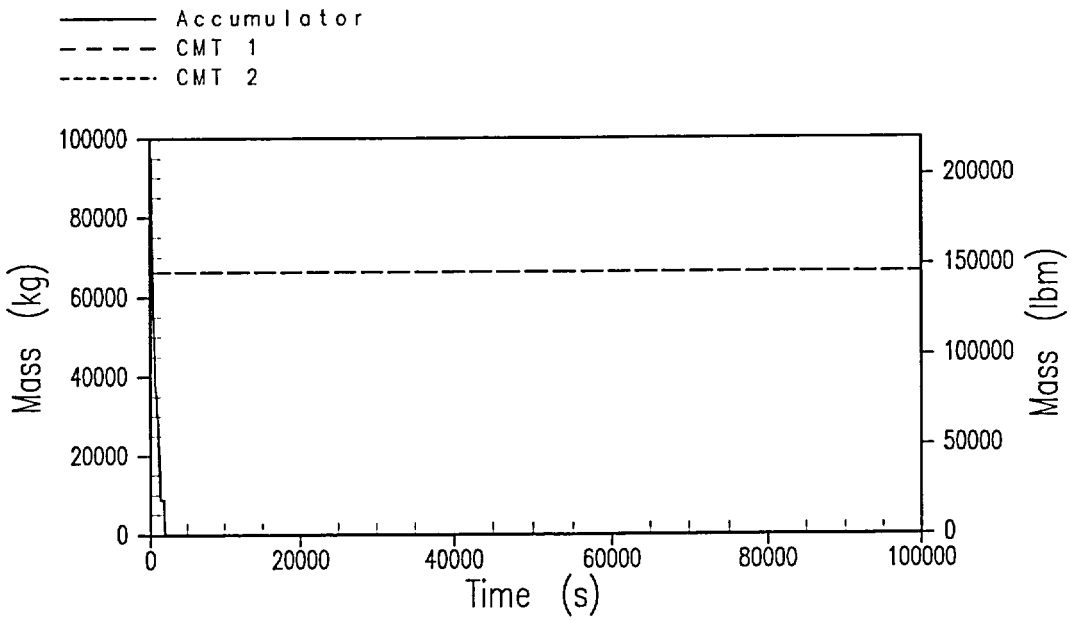

Figure 34-275

Case 3D-4: Accumulator/CMT Water Mass
Spurious ADS-2, Failed CMTs, Diffusion Flame

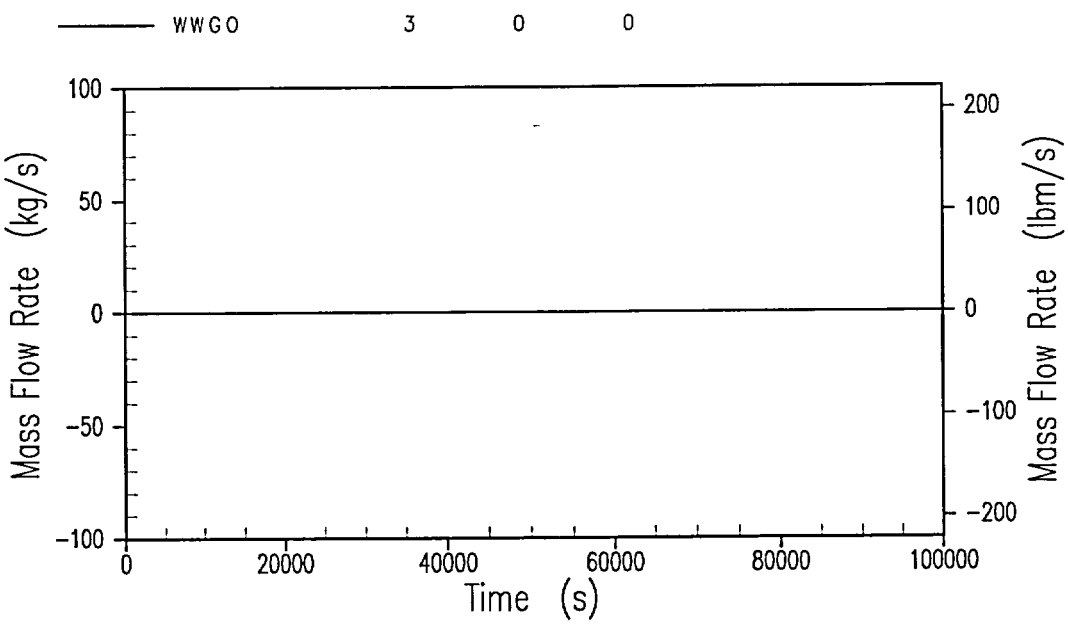

Figure 34-276

Case 3D-4: IRWST Injection Flow Rate
Spurious ADS-2, Failed CMTs, Diffusion Flame

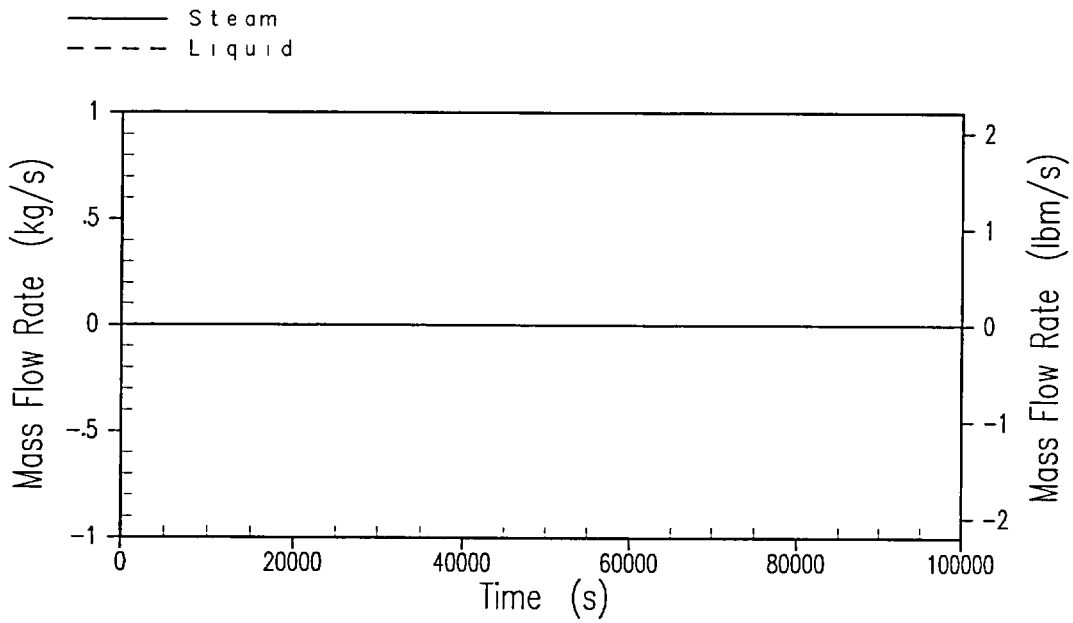

Figure 34-277

Case 3D-4: Break Flow Rate
Spurious ADS-2, Failed CMTs, Diffusion Flame

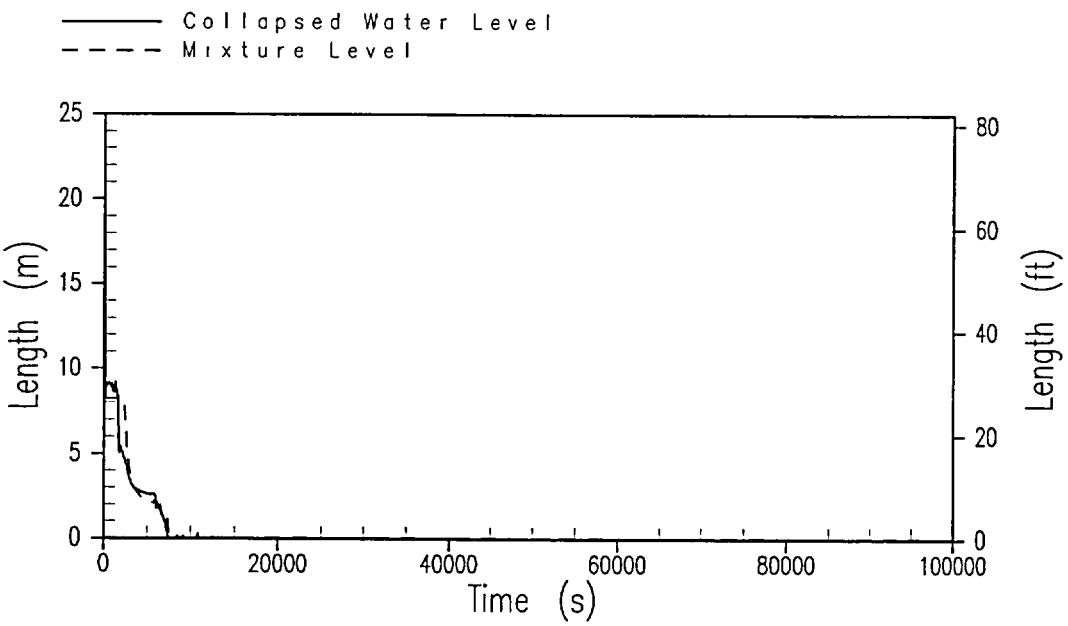

Figure 34-278

Case 3D-4: Reactor Vessel Water Level
Spurious ADS-2, Failed CMTs, Diffusion Flame

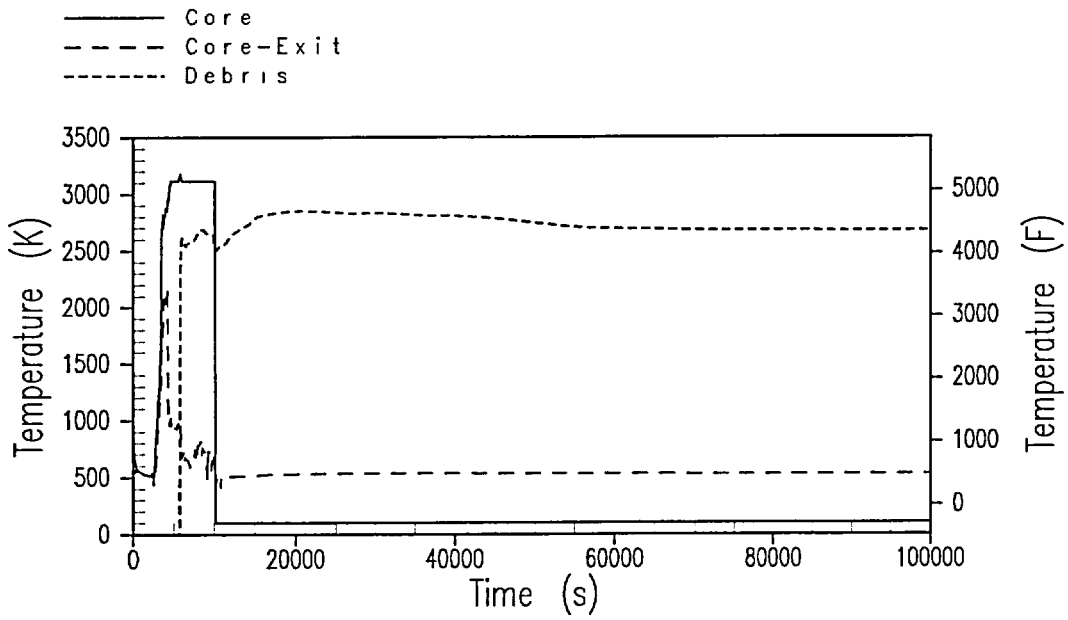

Figure 34-279

Case 3D-4: Core Temperatures
Spurious ADS-2, Failed CMTs, Diffusion Flame

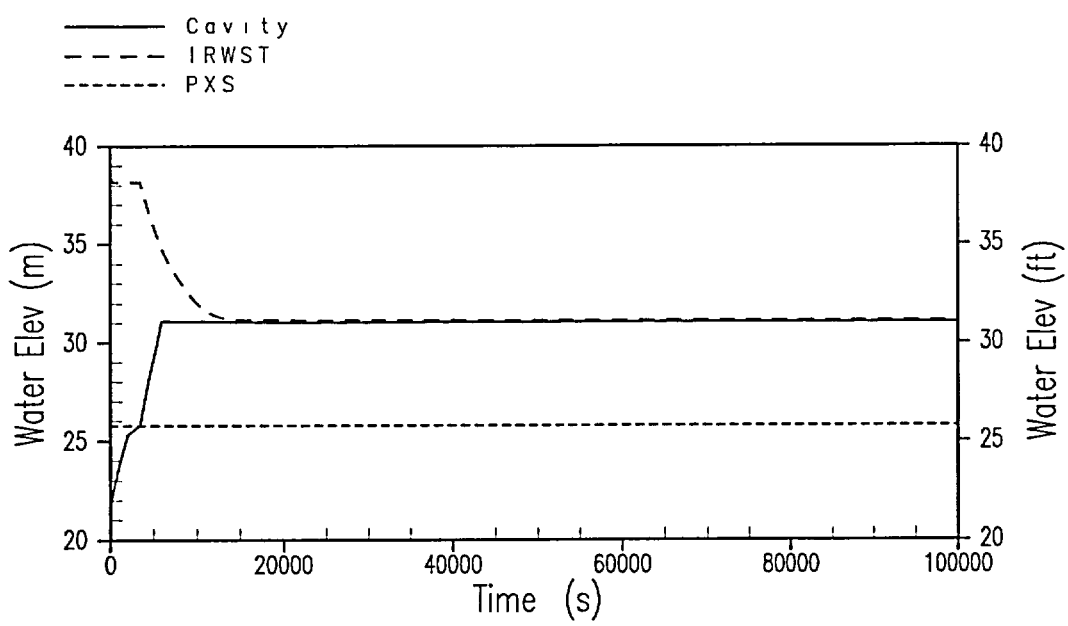

Figure 34-280

Case 3D-4: Containment Water Pool Elevations
Spurious ADS-2, Failed CMTs, Diffusion Flame

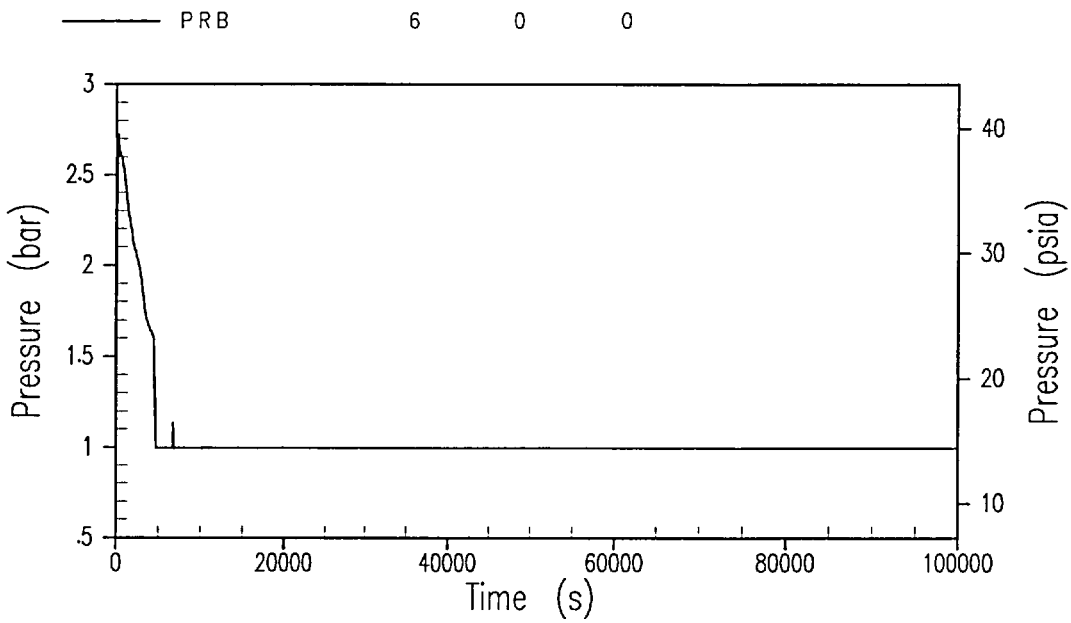

Figure 34-281

Case 3D-4: Containment Pressure
Spurious ADS-2, Failed CMTs, Diffusion Flame

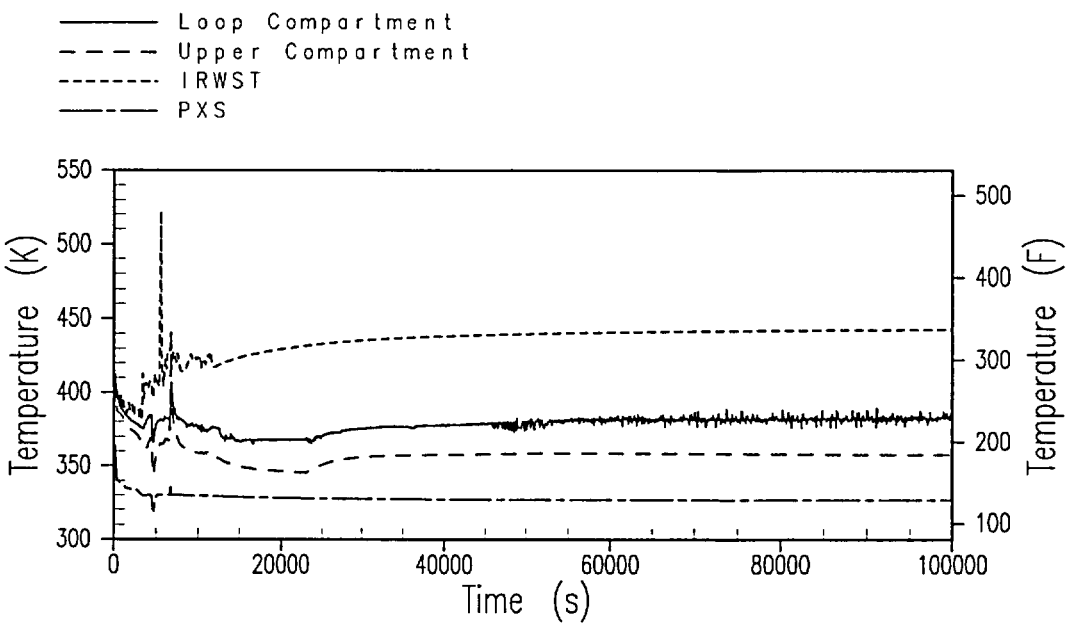

Figure 34-282

Case 3D-4: Containment Gas Temperature
Spurious ADS-2, Failed CMTs, Diffusion Flame

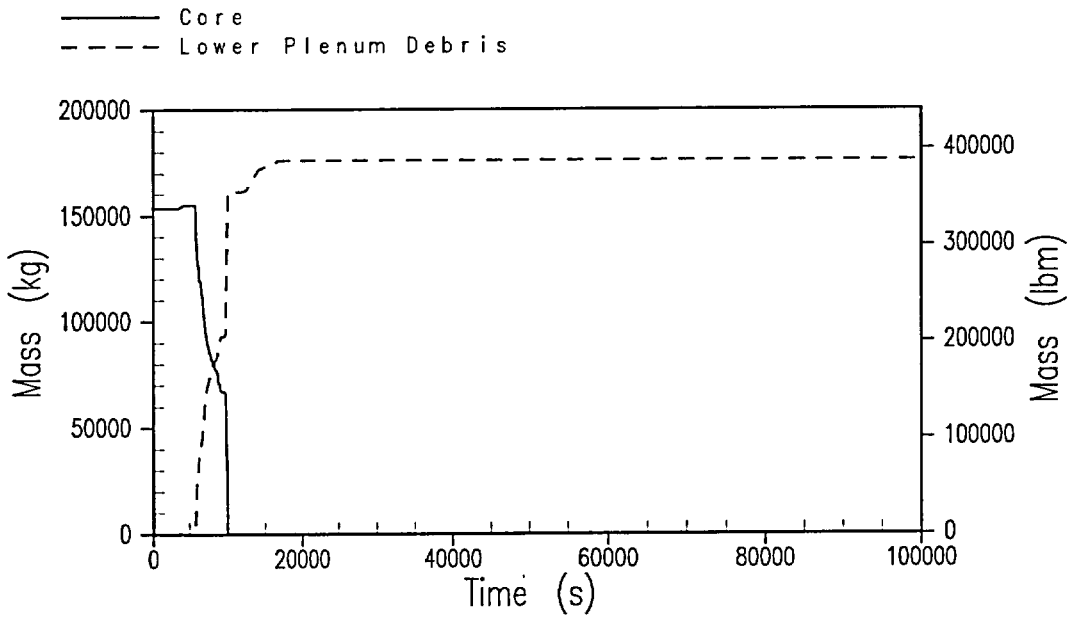

Figure 34-283

Case 3D-4: Core Mass
Spurious ADS-2, Failed CMTs, Diffusion Flame

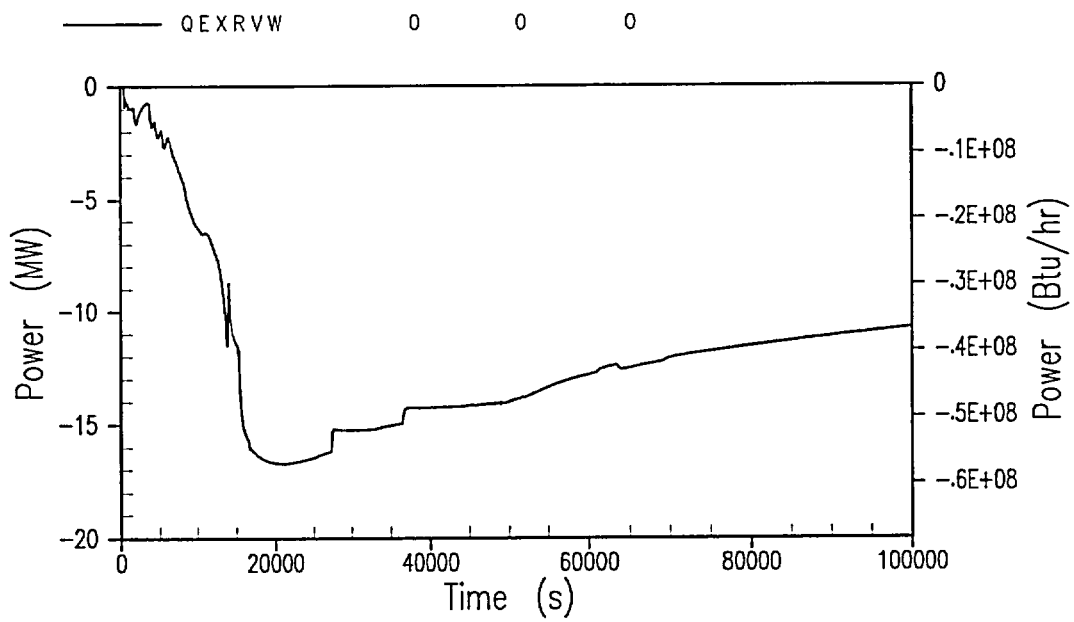

Figure 34-284

Case 3D-4: Reactor Pressure Vessel to Cavity Water Heat Transfer
Spurious ADS-2, Failed CMTs, Diffusion Flame

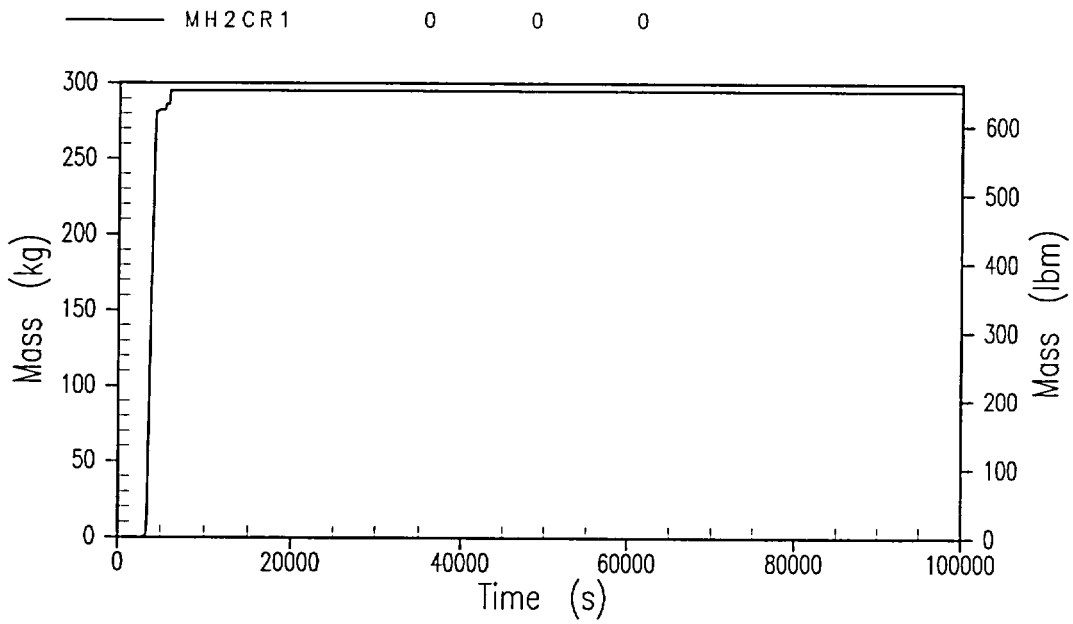

Figure 34-285

Case 3D-4: In-Vessel Hydrogen Generation Spurious ADS-2, Failed CMTs, Diffusion Flame

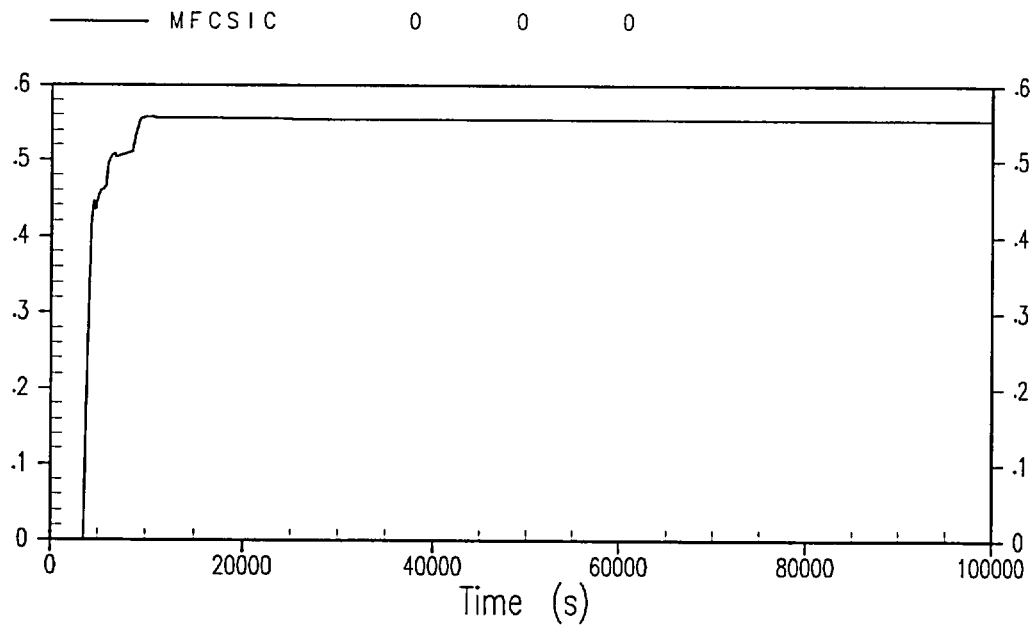

Figure 34-286

Case 3D-4: Mass Fraction of CsI Released to Containment Spurious ADS-2, Failed CMTs, Diffusion Flame

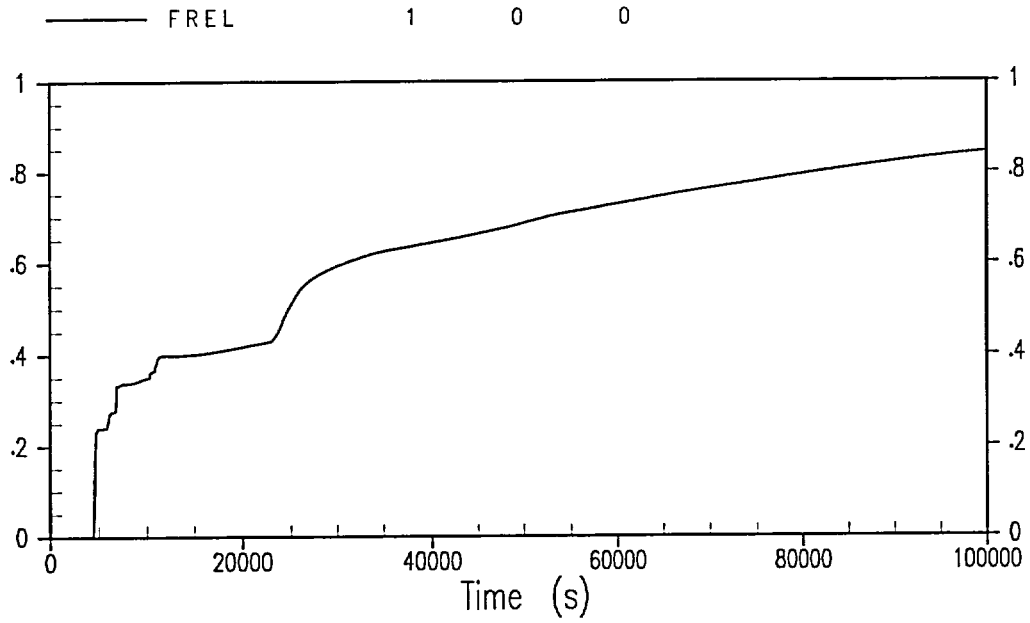

Figure 34-287

Case 3D-4: Mass Fraction of Noble Gases Released to Environment Spurious ADS-2, Failed CMTs, Diffusion Flame

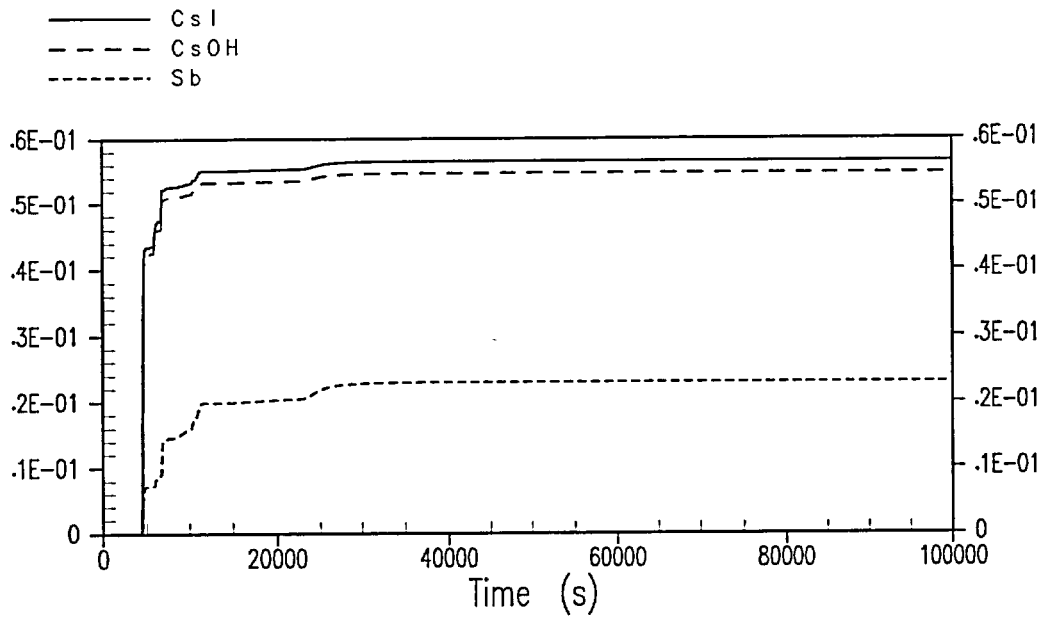

Figure 34-288

Case 3D-4: Mass Fraction of Fission Products Released to Environment Spurious ADS-2, Failed CMTs, Diffusion Flame

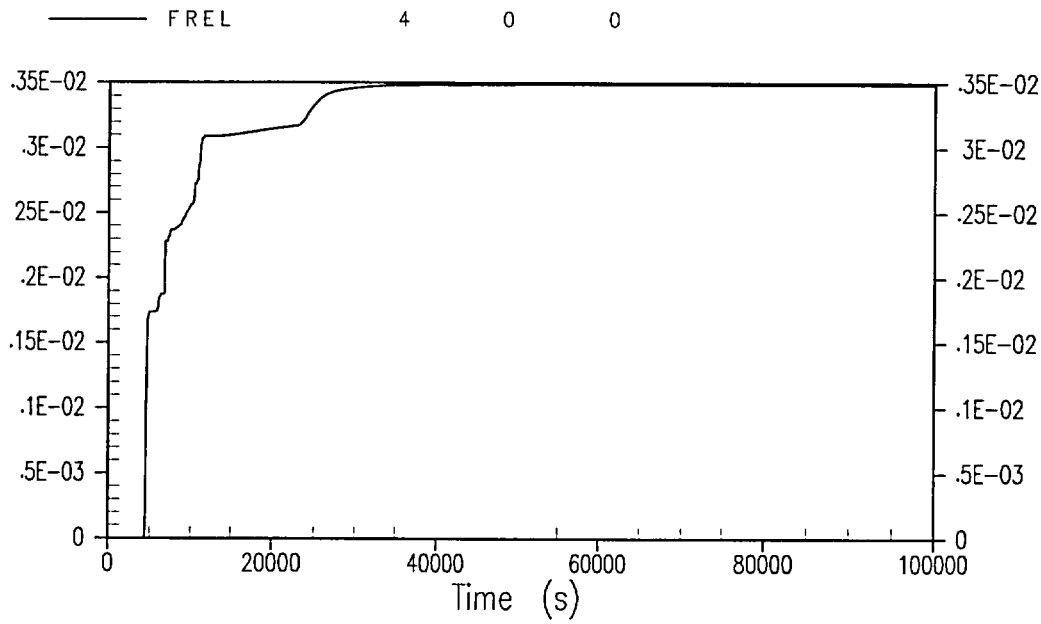

Figure 34-289

Case 3D-4: Mass Fraction of SrO Release to Environment Spurious ADS-2, Failed CMTs, Diffusion Flame

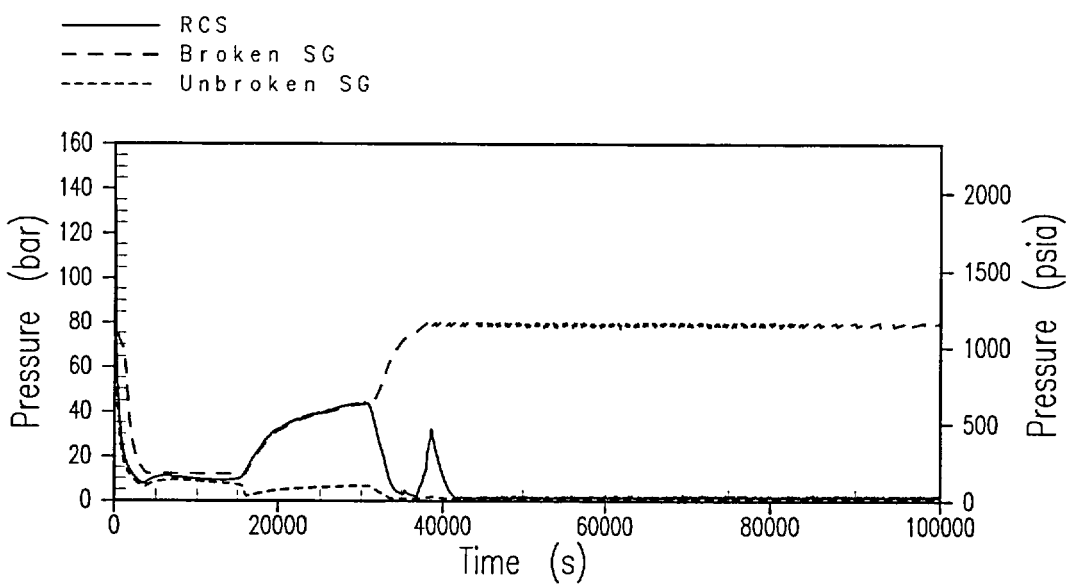

Figure 34-290

Case 6E-1: Reactor Coolant System and Steam Generator Pressure SGTR Early Core Melt

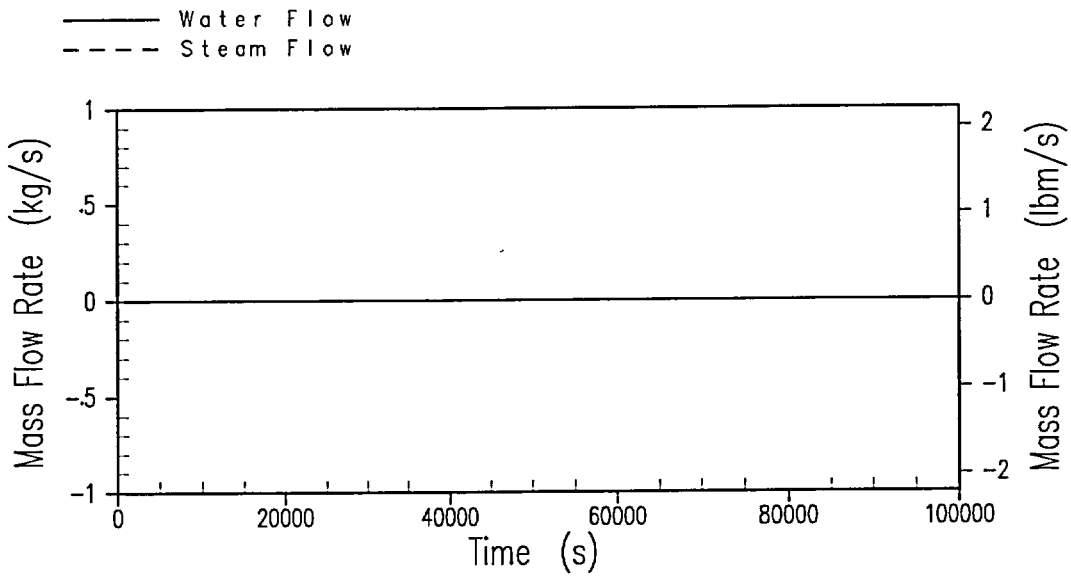

Figure 34-291

Case 6E-1: ADS Stage 4 Flow Rates SGTR Early Core Melt

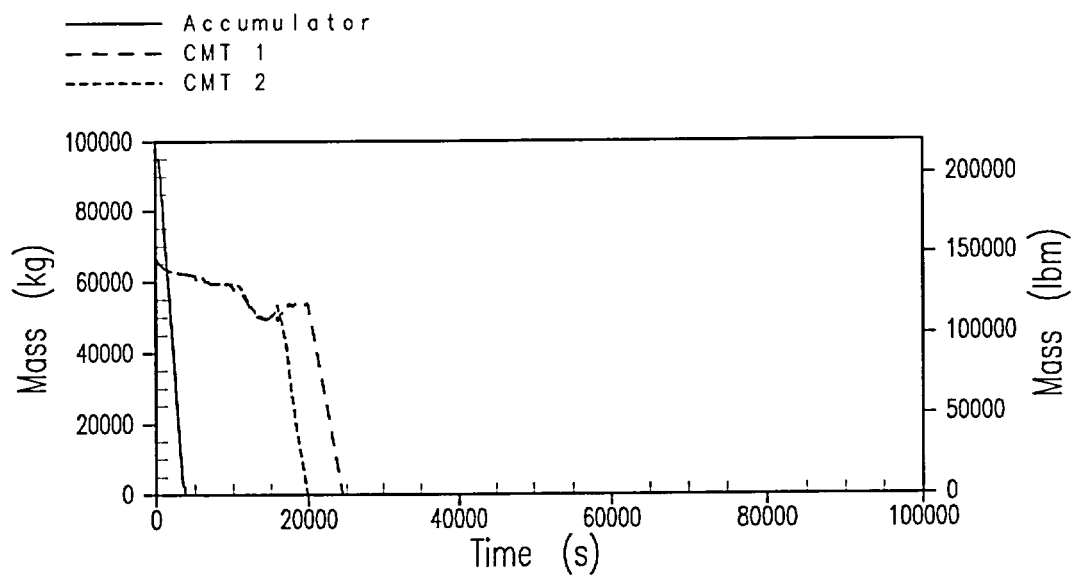

Figure 34-292

Case 6E-1: Accumulator/CMT Water Mass SGTR Early Core Melt

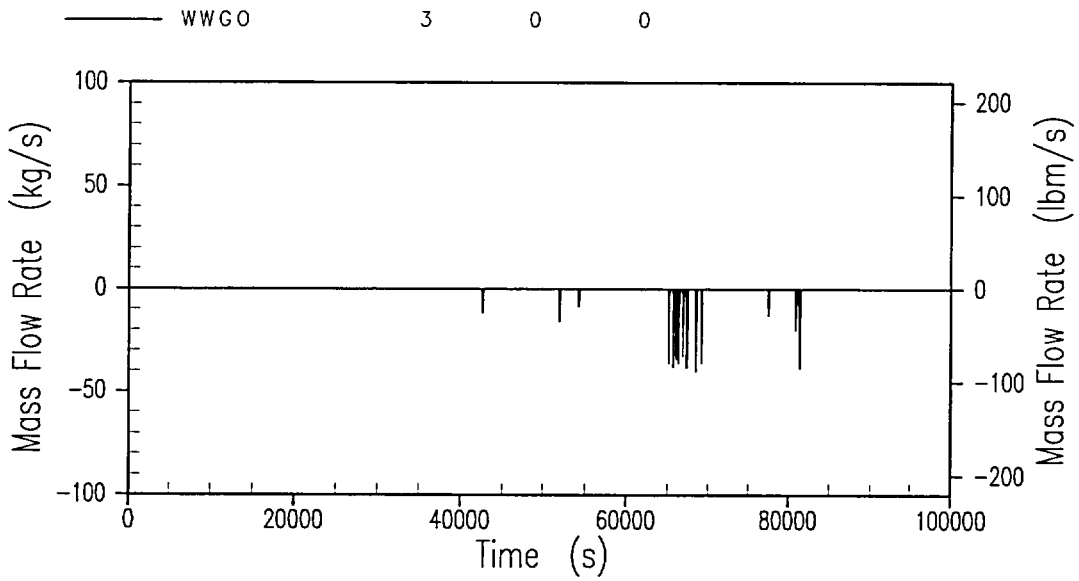

Figure 34-293

Case 6E-1: IRWST Injection Flow Rate
SGTR Early Core Melt

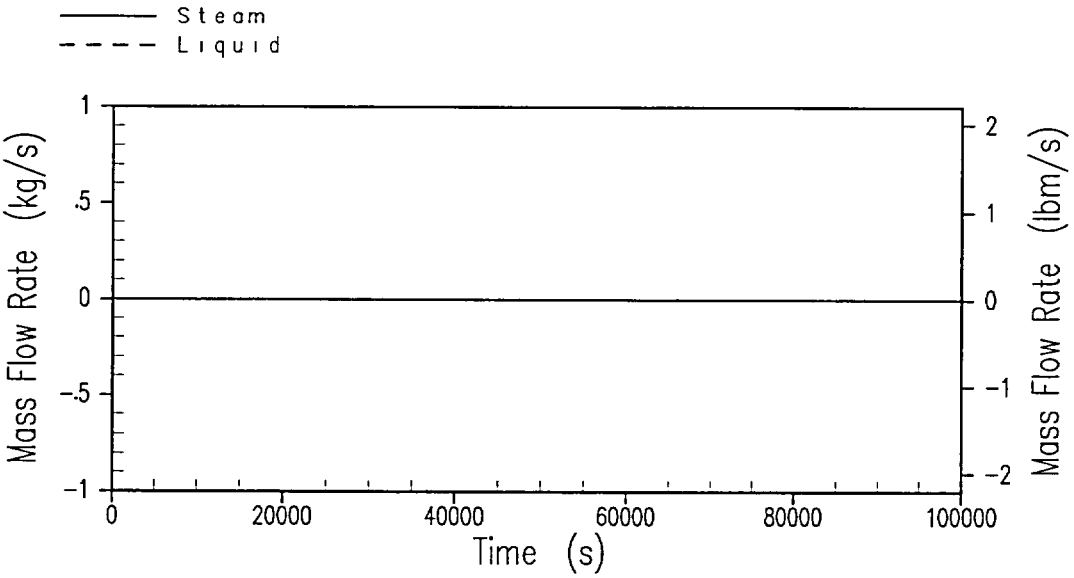

Figure 34-294

Case 6E-1: Break Flow Rate
SGTR Early Core Melt

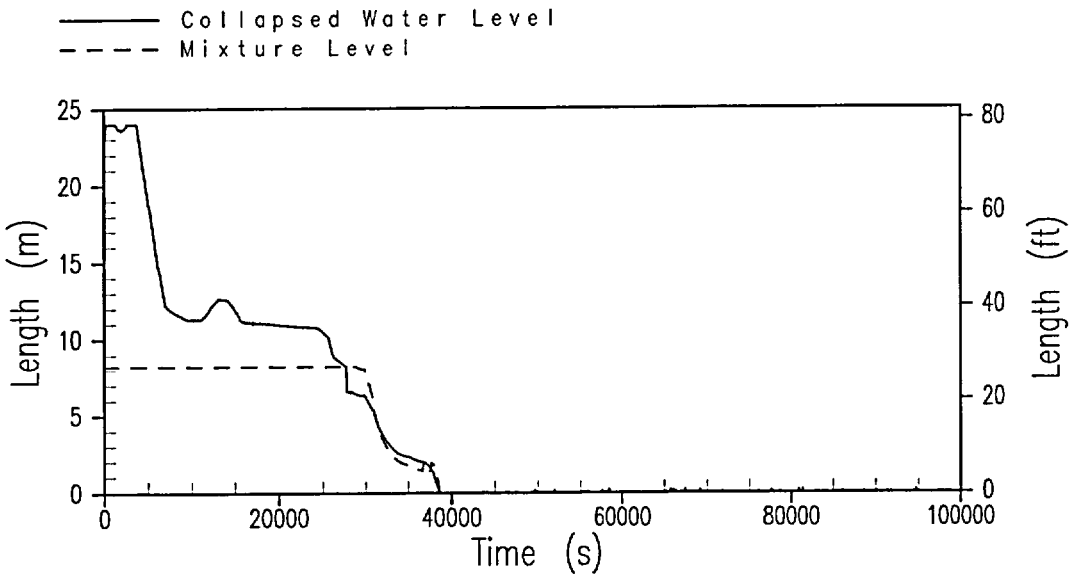

Figure 34-295

Case 6E-1: Reactor Vessel Water Level SGTR Early Core Melt

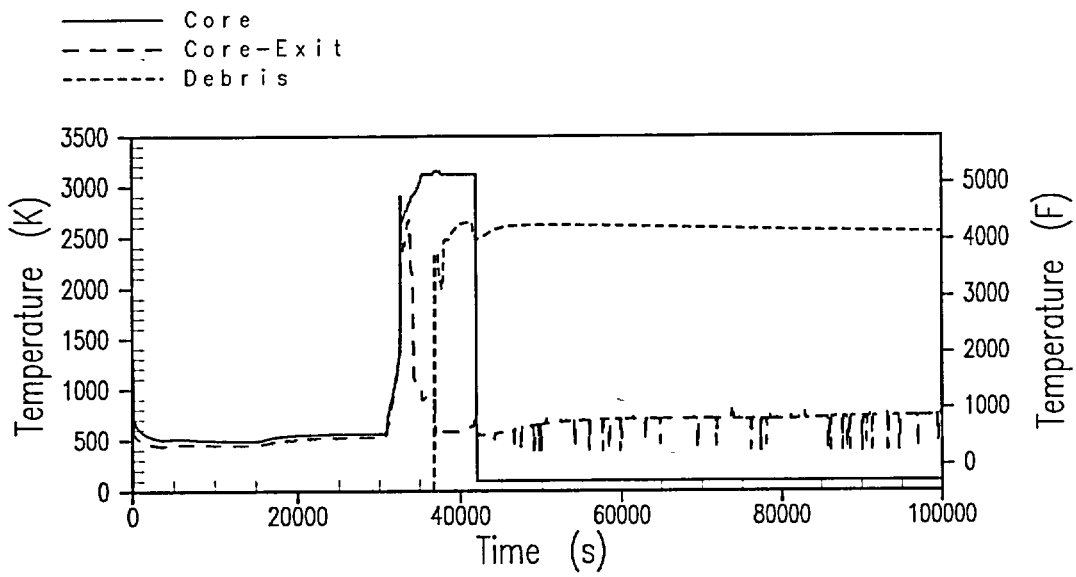

Figure 34-296

Case 6E-1: Core Temperatures SGTR Early Core Melt

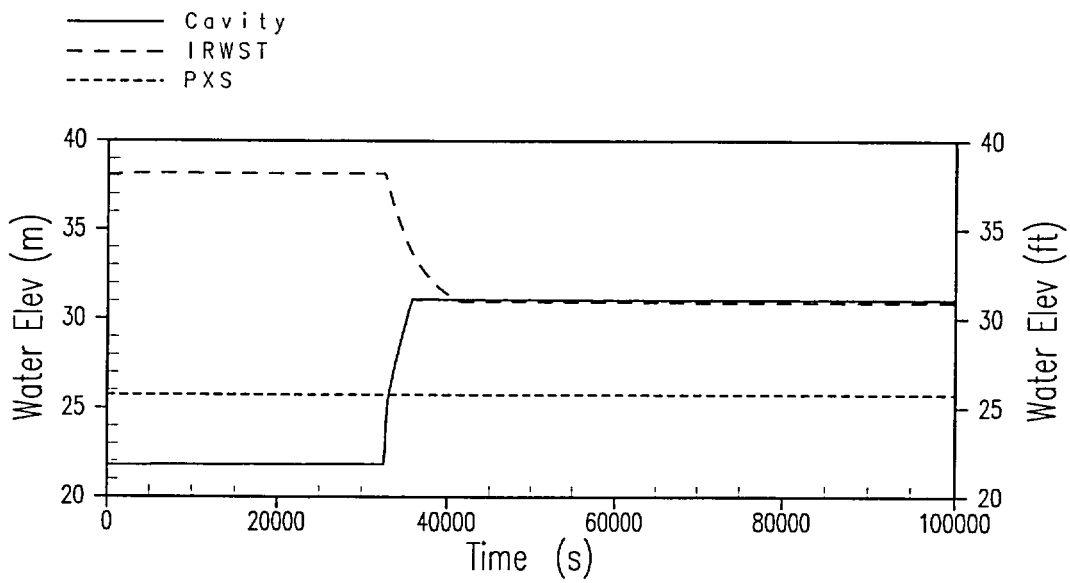

Figure 34-297

Case 6E-1: Containment Water Pool Elevations SGTR Early Core Melt

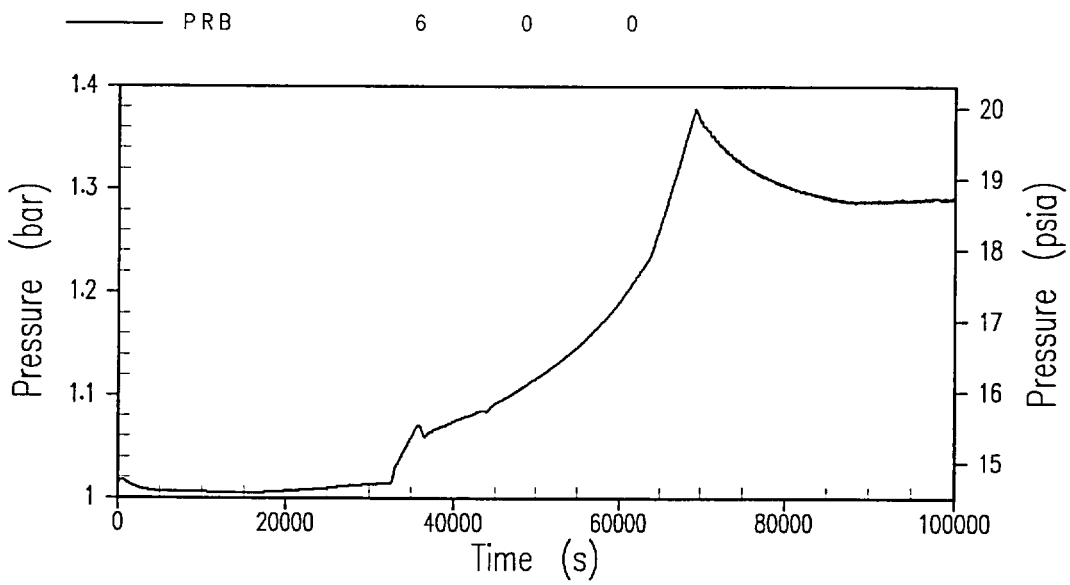

Figure 34-298

Case 6E-1: Containment Pressure SGTR Early Core Melt

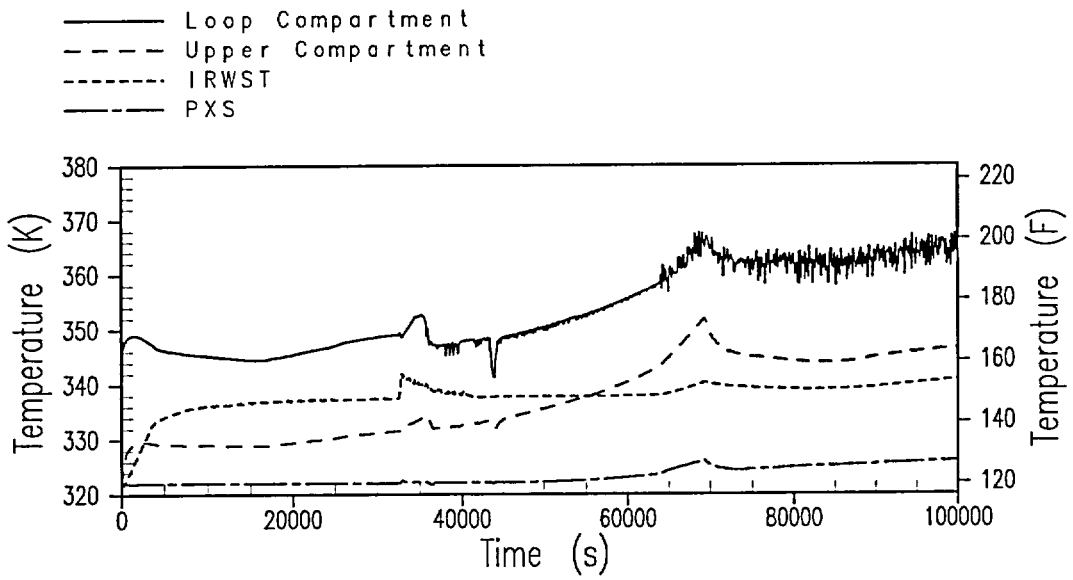

Figure 34-299

Case 6E-1: Containment Gas Temperature SGTR Early Core Melt

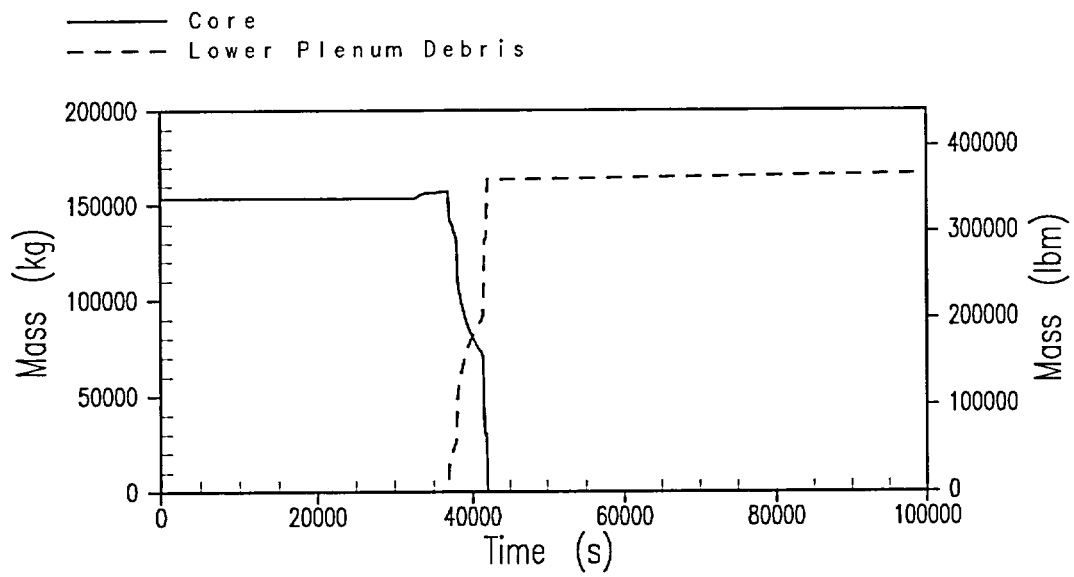

Figure 34-300

Case 6E-1: Core Mass SGTR Early Core Melt

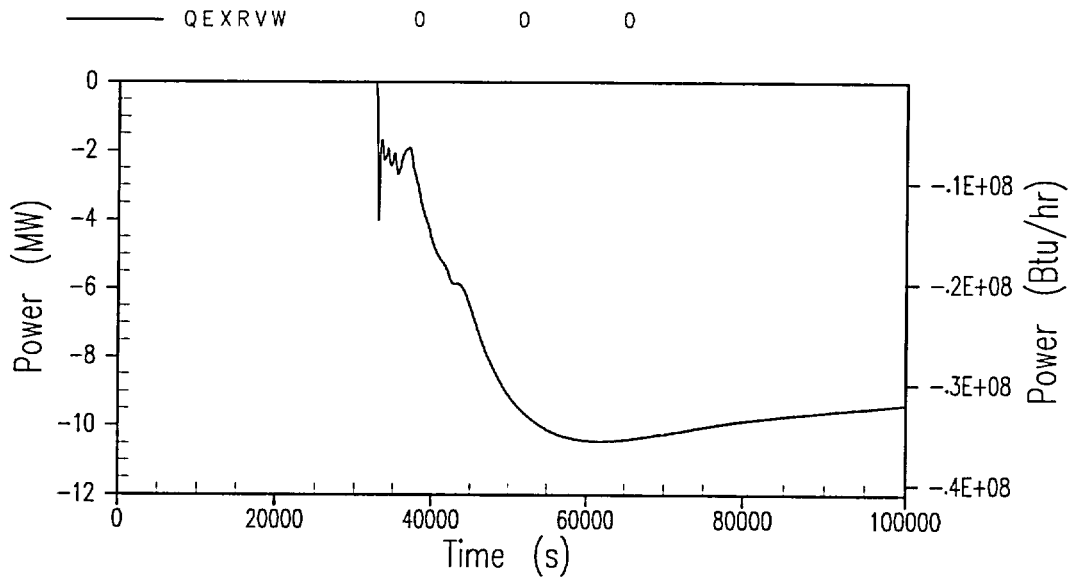

Figure 34-301

Case 6E-1: Reactor Pressure Vessel to Cavity Water Heat Transfer SGTR Early Core Melt

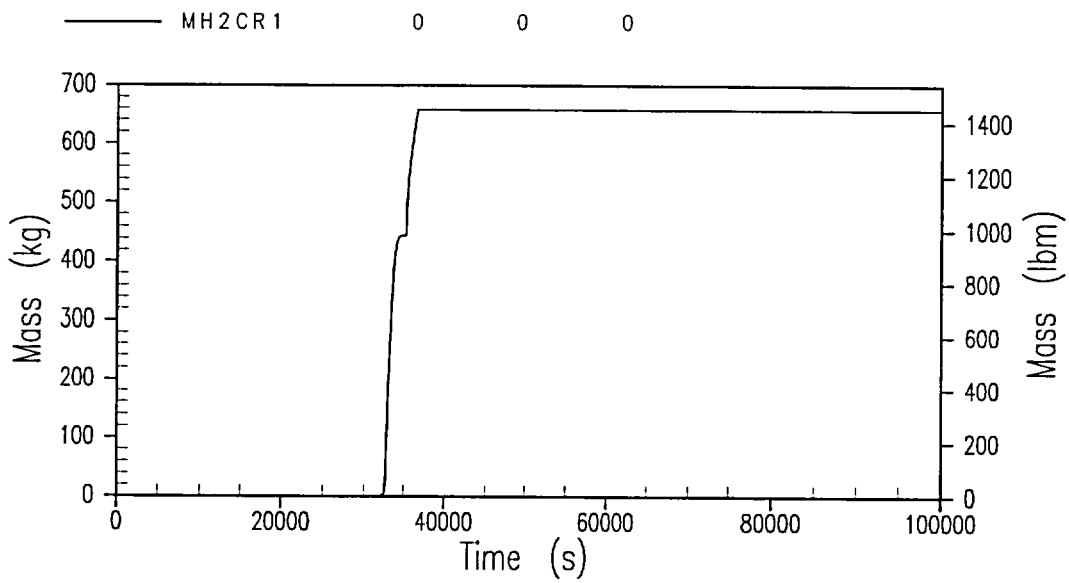

Figure 34-302

Case 6E-1: In-Vessel Hydrogen Generation SGTR Early Core Melt

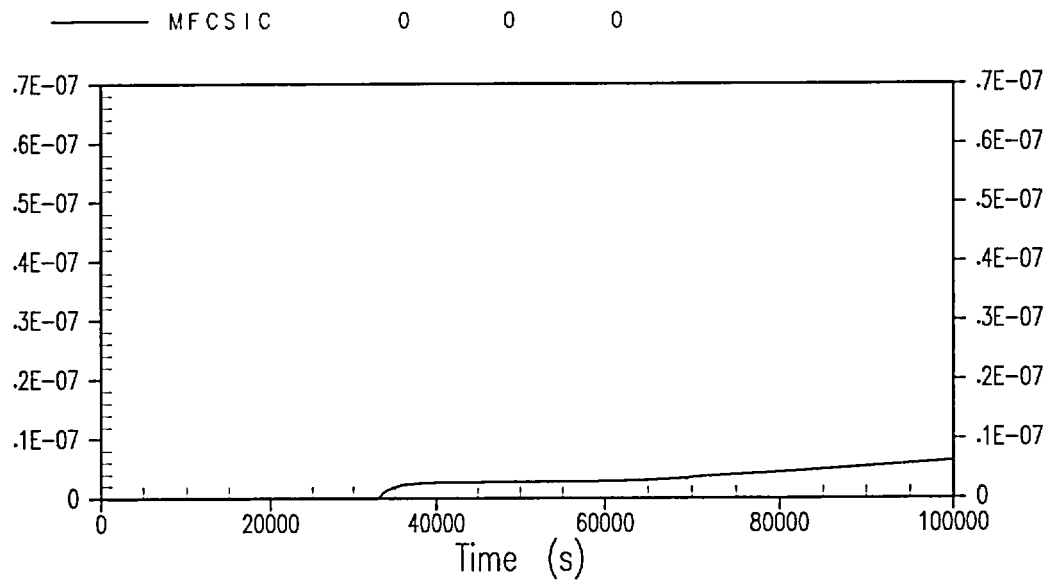

Figure 34-303

Case 6E-1: Mass Fraction of CsI Released to Containment SGTR Early Core Melt

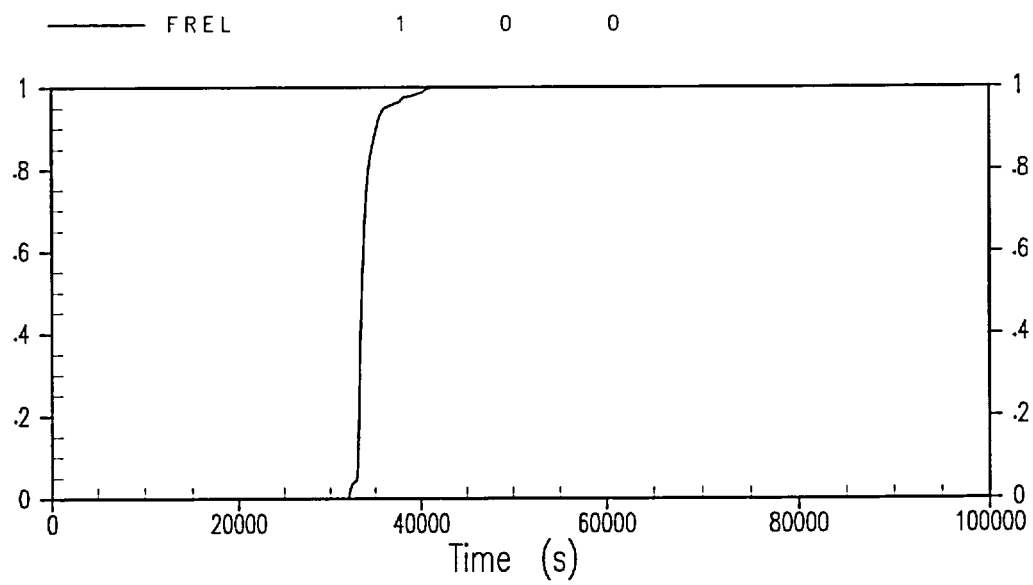

Figure 34-304

Case 6E-1: Mass Fraction of Noble Gases Released to Environment SGTR Early Core Melt

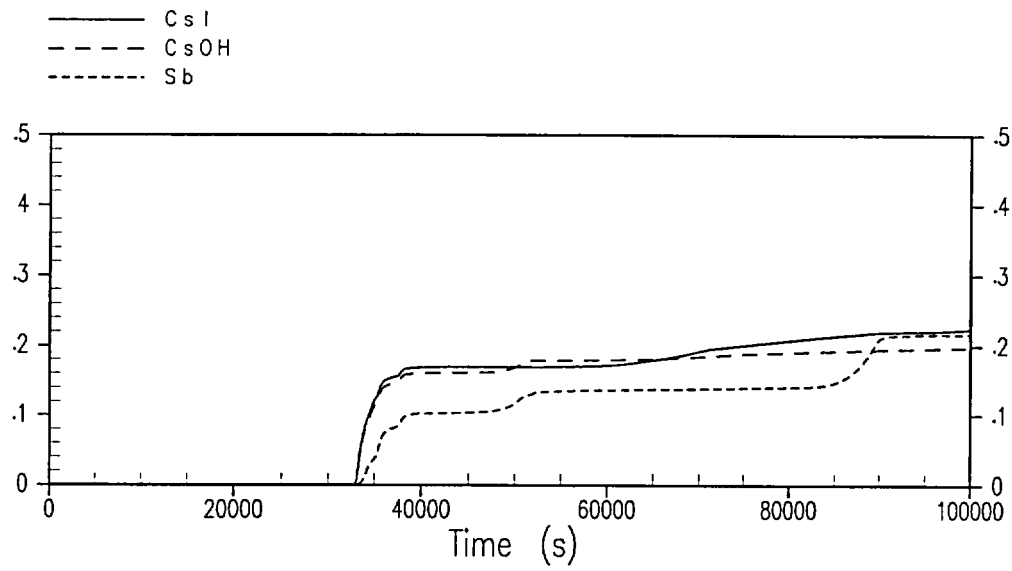

Figure 34-305

Case 6E-1: Mass Fraction of Fission Products Released to Environment SGTR Early Core Melt

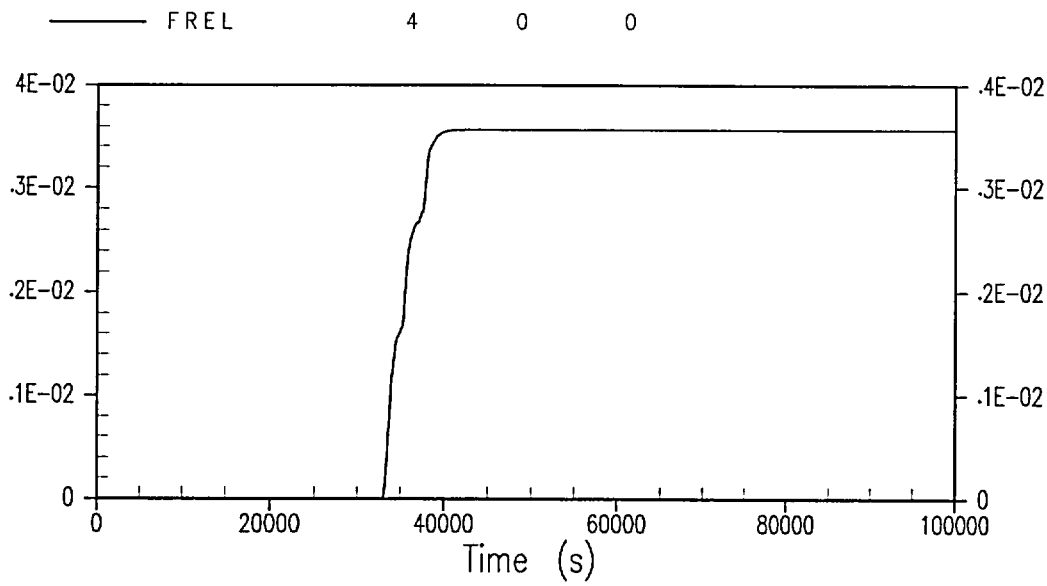

Figure 34-306

Case 6E-1: Mass Fraction of SrO Released to Environment SGTR Early Core Melt

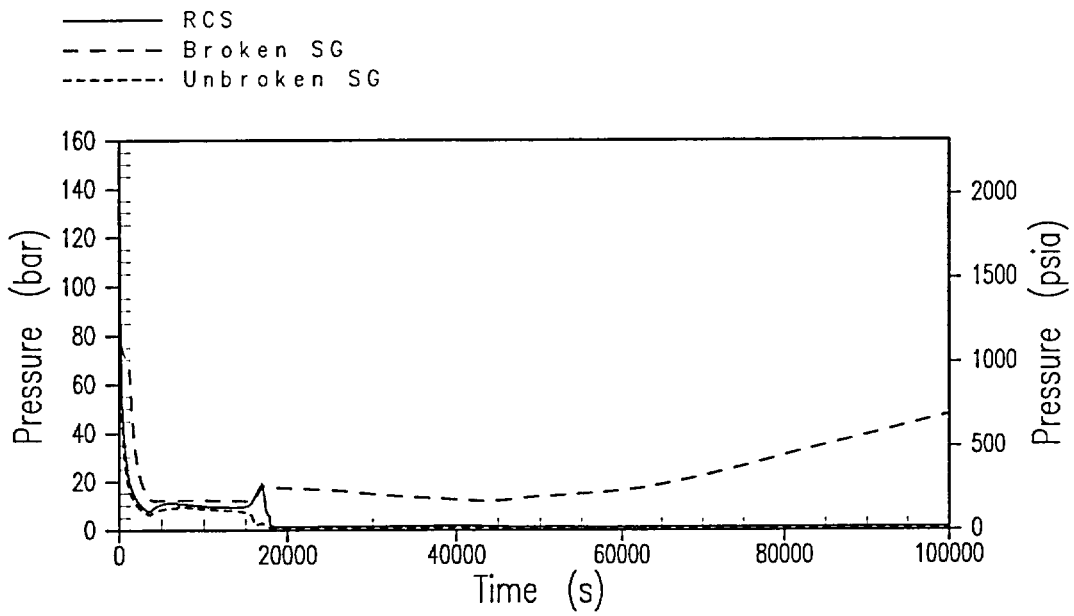

Figure 34-307

Case 6L-1: Reactor Coolant System and Steam Generator Pressure SGTR Core Melt Failure at Recirculation

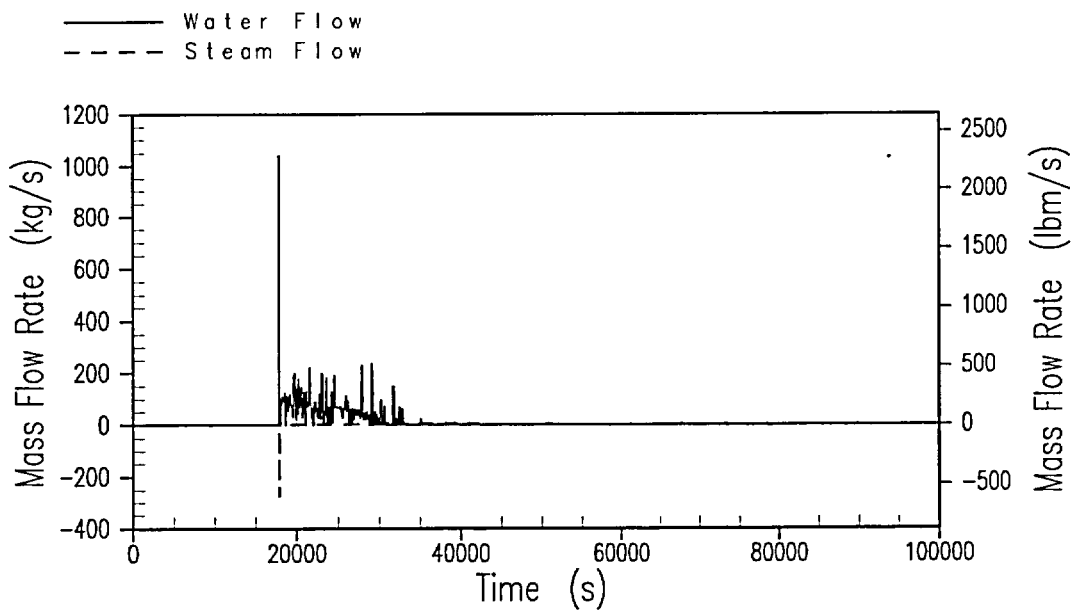

Figure 34-308

Case 6L-1: ADS Stage 4 Flow Rates SGTR Core Melt Failure at Recirculation

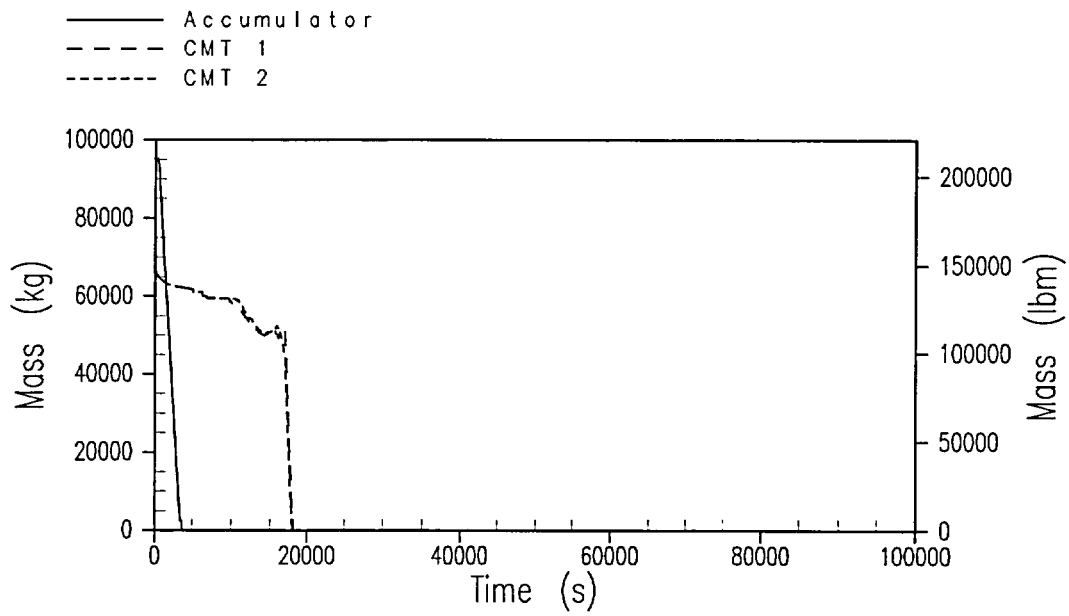

Figure 34-309

Case 6L-1: Accumulator/CMT Water Mass
SGTR Core Melt Failure at Recirculation

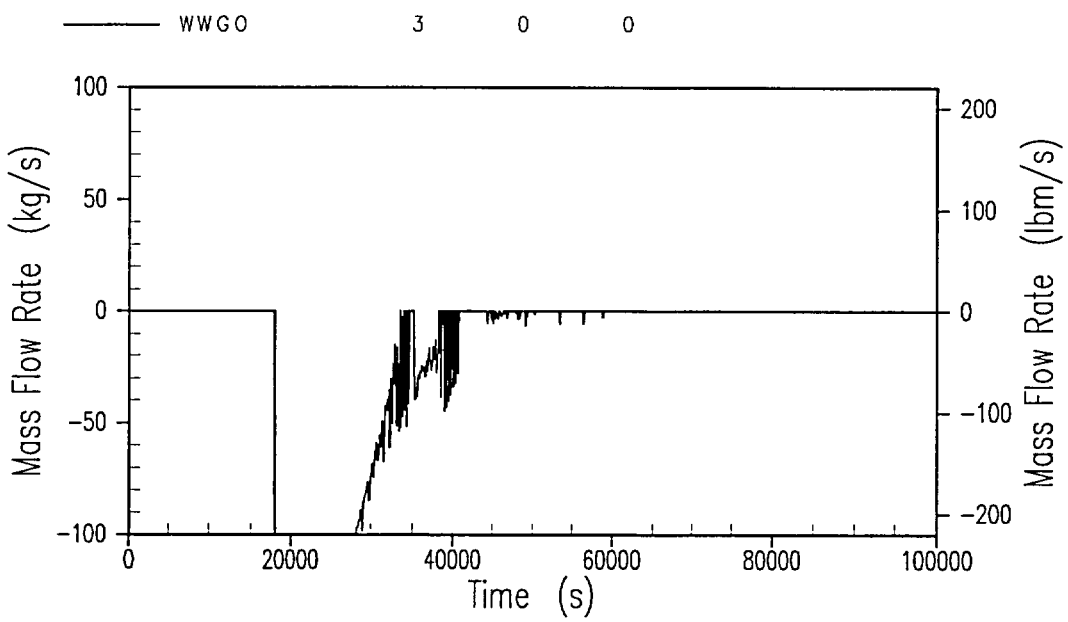

Figure 34-310

Case 6L-1: IRWST Injection Flow Rate
SGTR Core Melt Failure at Recirculation

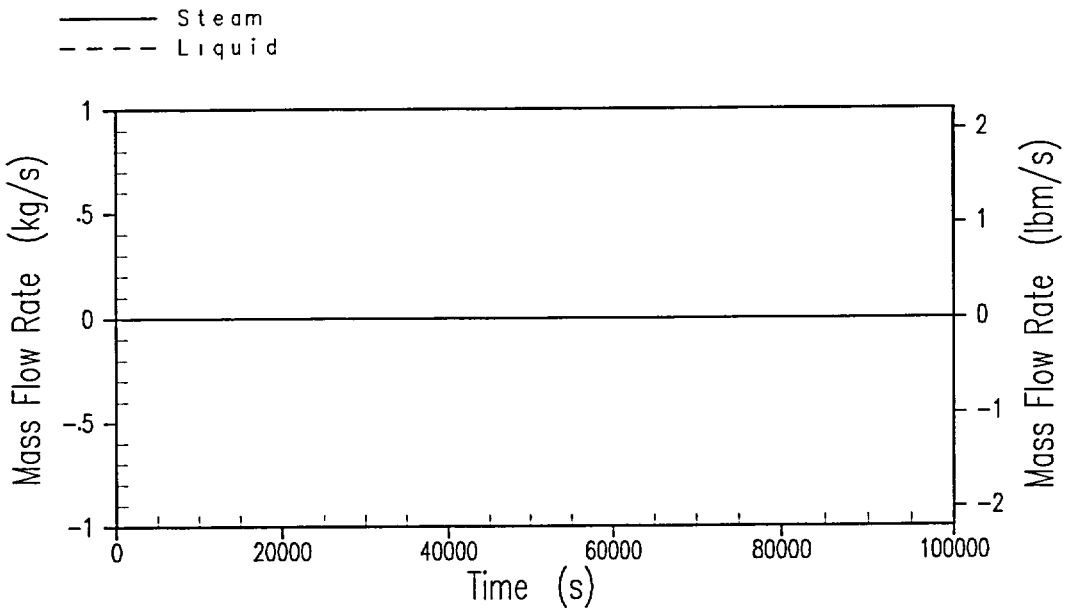

Figure 34-311

Case 6L-1: Break Flow Rate
SGTR Core Melt Failure at Recirculation

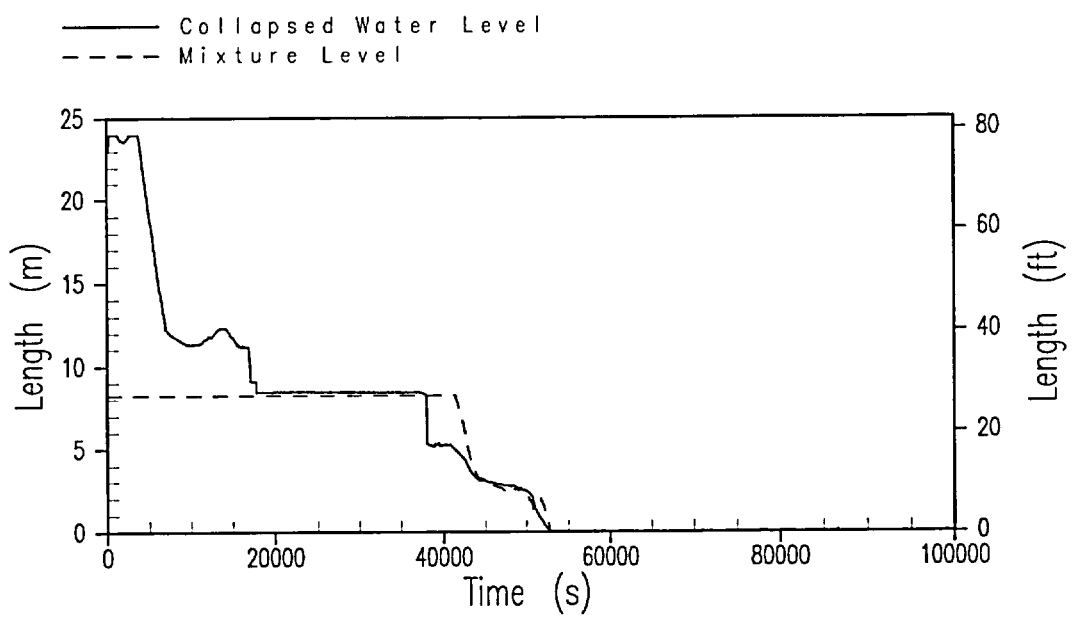

Figure 34-312

Case 6L-1: Reactor Vessel Water Level
SGTR Core Melt Failure at Recirculation

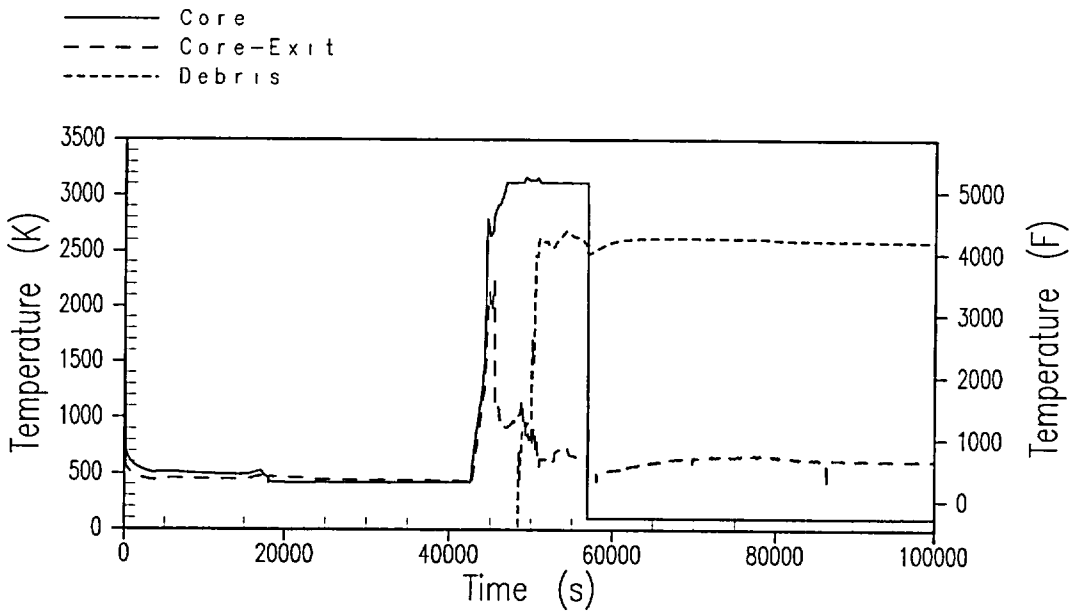

Figure 34-313

Case 6L-1: Core Temperatures
SGTR Core Melt Failure at Recirculation

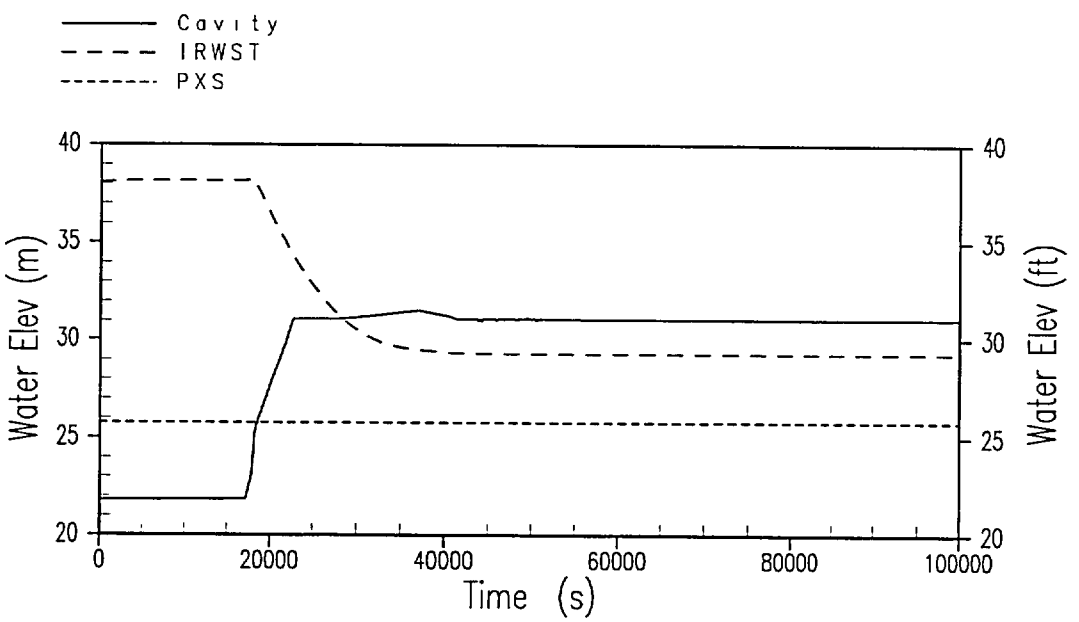

Figure 34-314

Case 6L-1: Containment Water Pool Elevations
SGTR Core Melt Failure at Recirculation

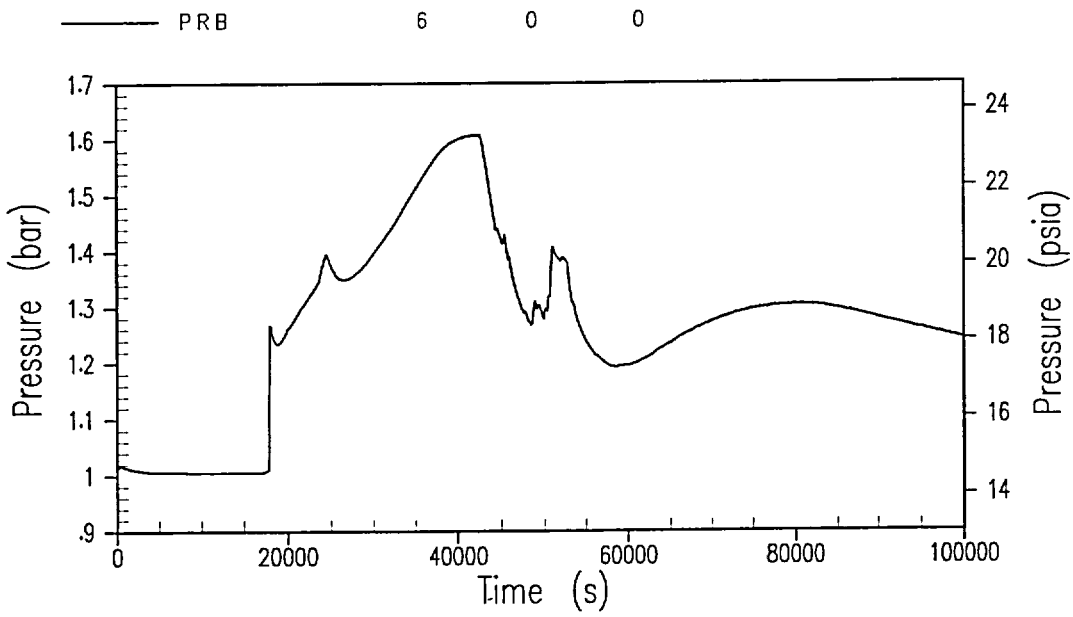

Figure 34-315

Case 6L-1: Containment Pressure
SGTR Core Melt Failure at Recirculation

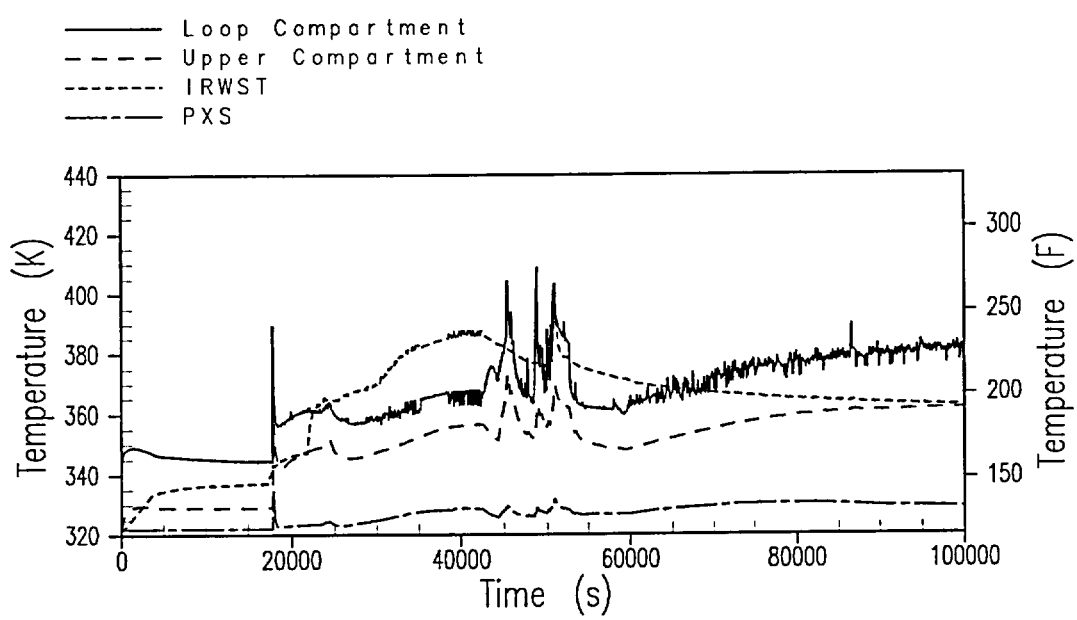

Figure 34-316

Case 6L-1: Containment Gas Temperature
SGTR Core Melt Failure at Recirculation

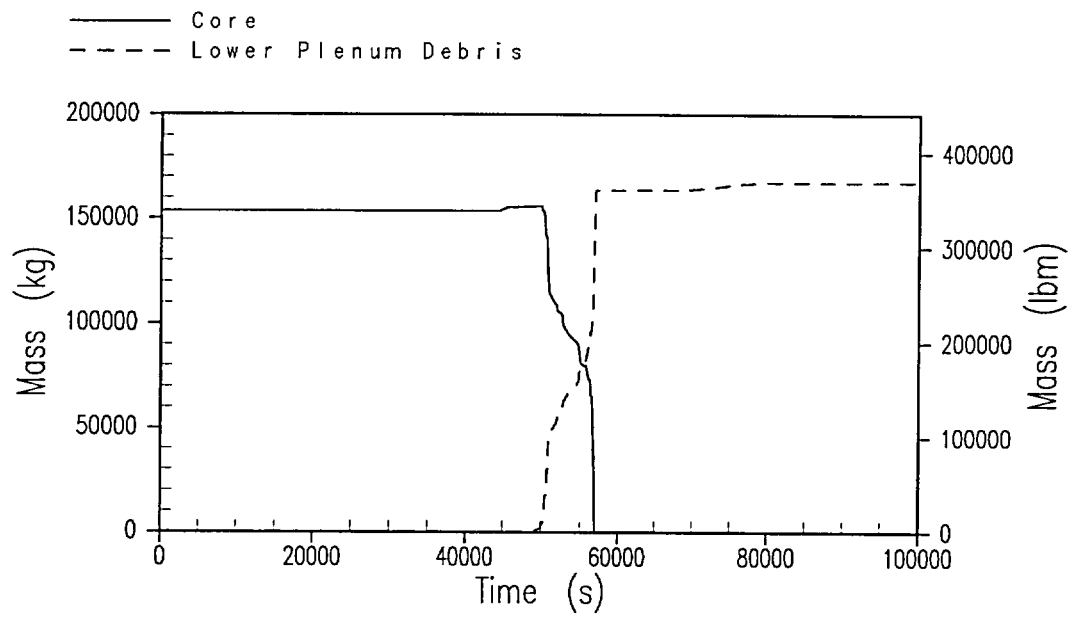

Figure 34-317

Case 6L-1: Core Mass
SGTR Core Melt Failure at Recirculation

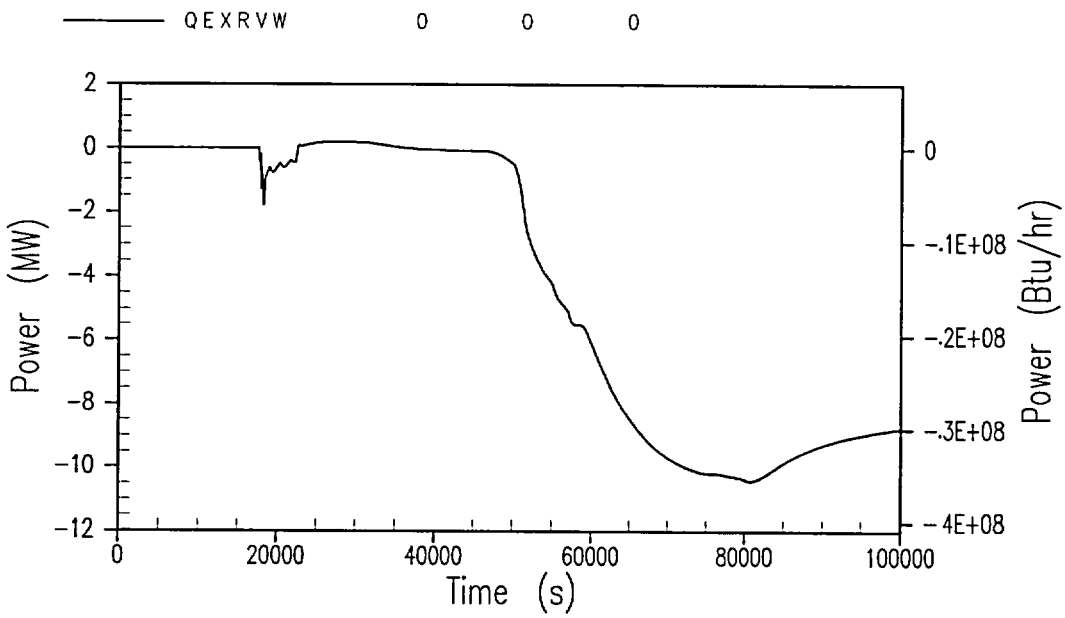

Figure 34-318

Case 6L-1: Reactor Pressure Vessel to Cavity Water Heat Transfer
SGTR Core Melt Failure at Recirculation

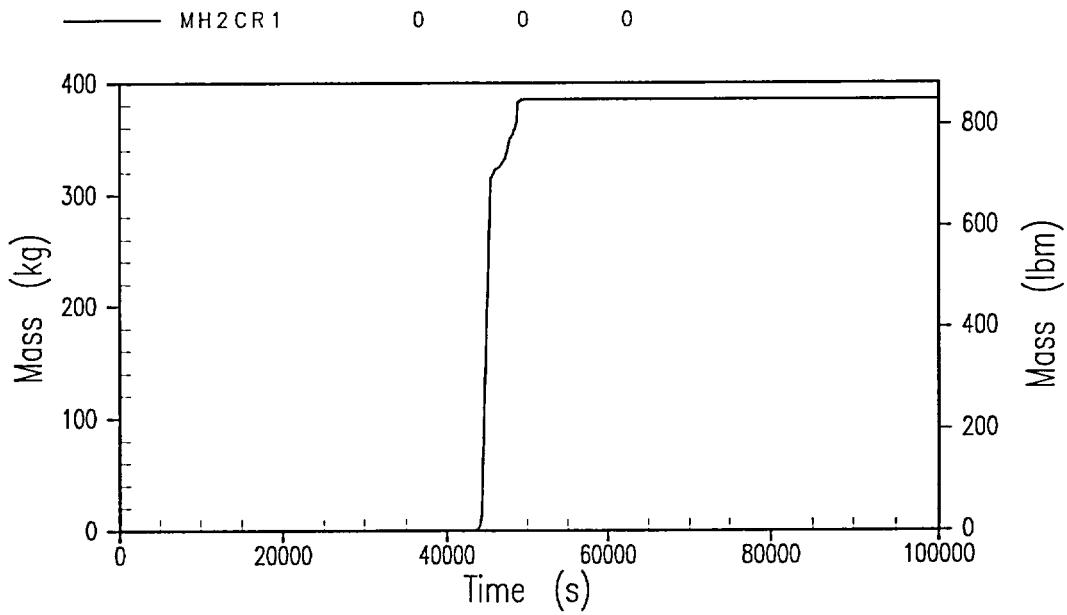

Figure 34-319

Case 6L-1: In-Vessel Hydrogen Generation SGTR Core Melt Failure at Recirculation

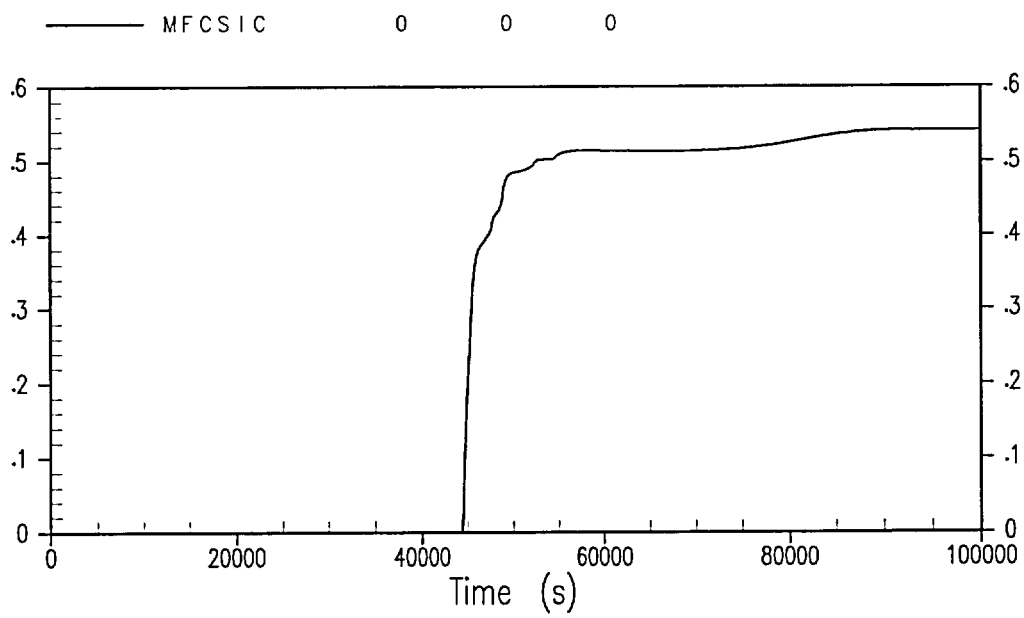

Figure 34-320

Case 6L-1: Mass Fraction of CsI Released to Containment SGTR Core Melt Failure at Recirculation

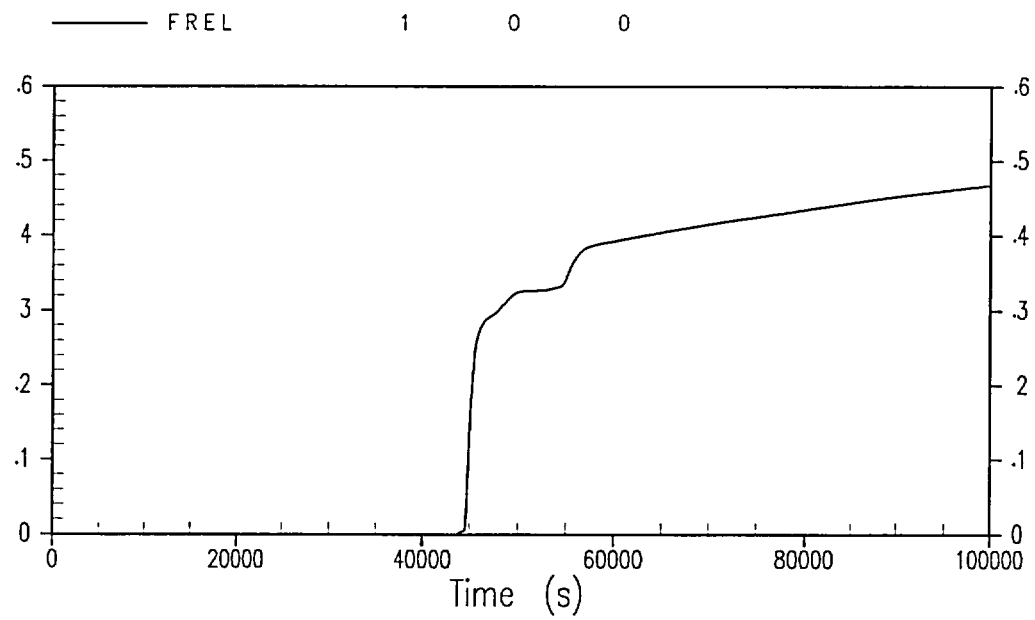

Figure 34-321

Case 6L-1: Mass Fraction of Noble Gases Released to Environment SGTR Core Melt Failure at Recirculation

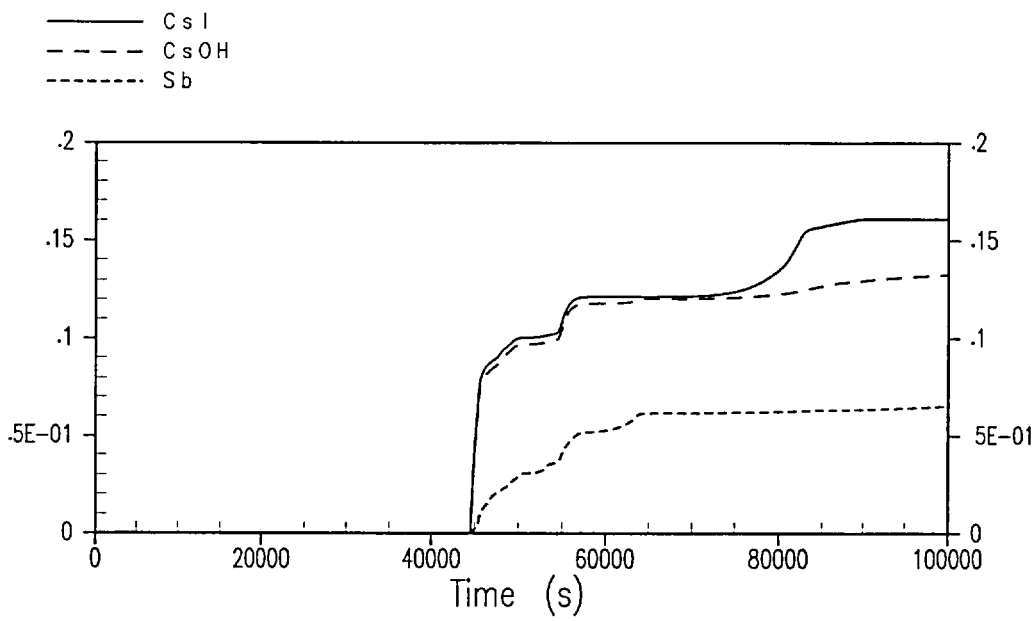

Figure 34-322

Case 6L-1: Mass Fraction of Fission Products Released to Environment SGTR Core Melt Failure at Recirculation

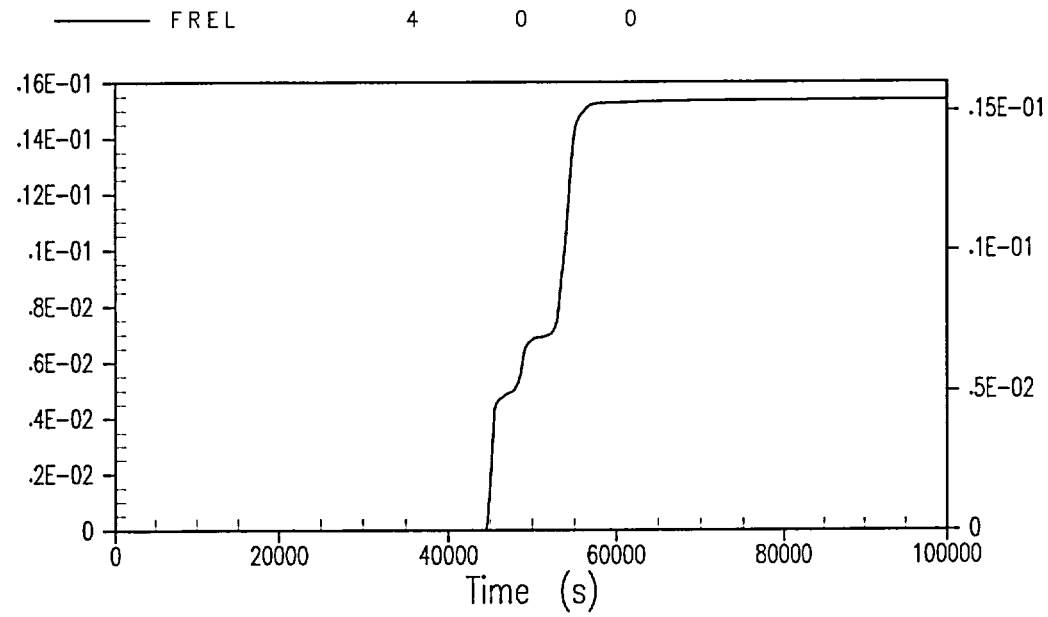

Figure 34-323

Case 6L-1: Mass Fraction of SrO Released to Environment SGTR Core Melt Failure at Recirculation

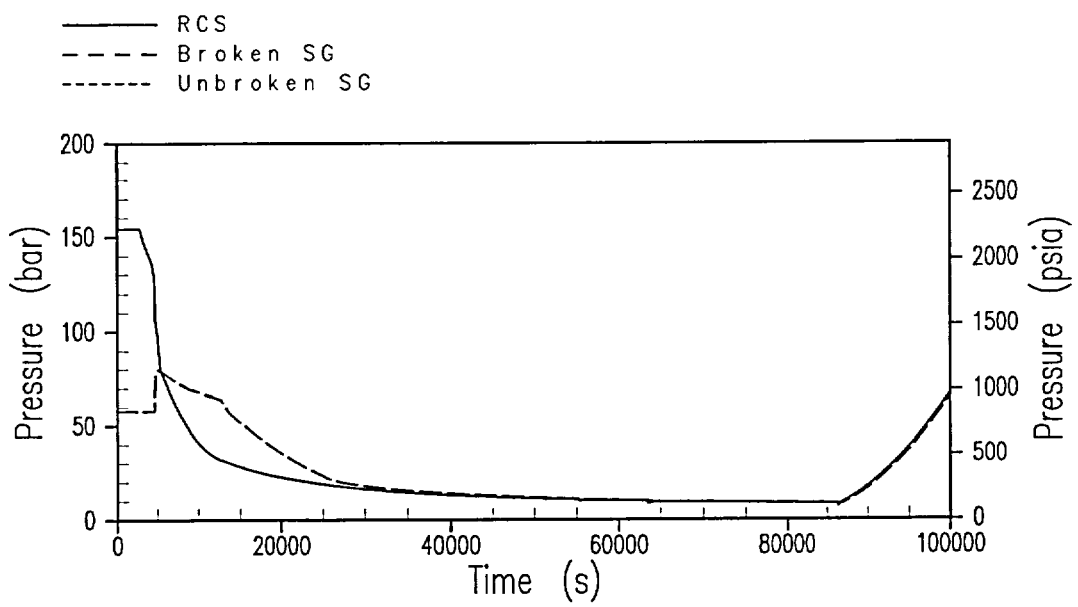

Figure 34-324

Case 1AP-1: Reactor Coolant System and Steam Generator Pressure SBLOCA with PRHR, CMTs Failed

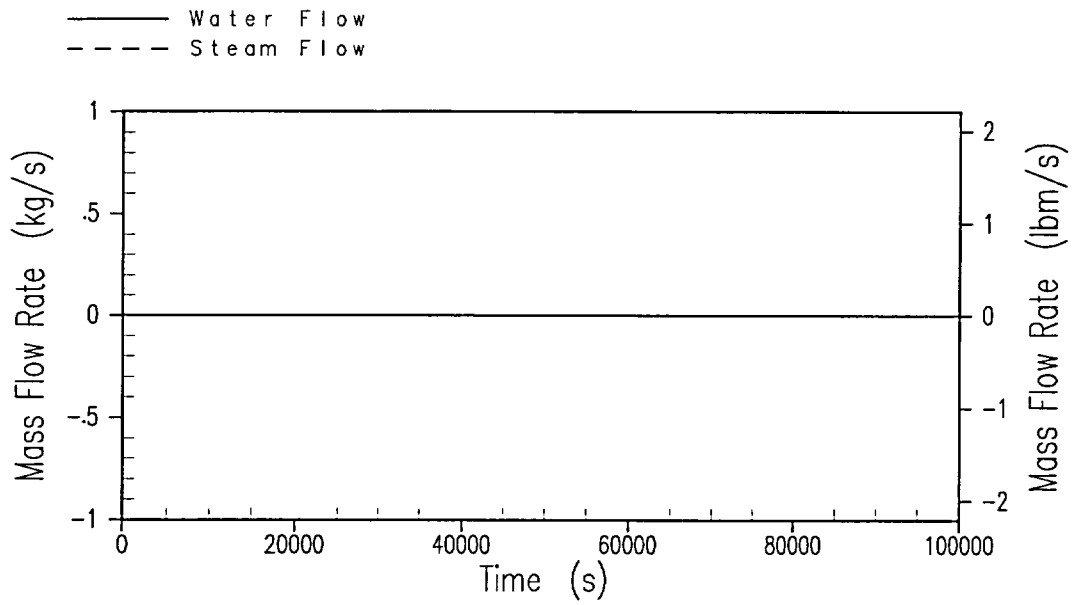

Figure 34-325

Case 1AP-1: ADS Stage 4 Flow Rates
SBLOCA with PRHR, CMTs Failed

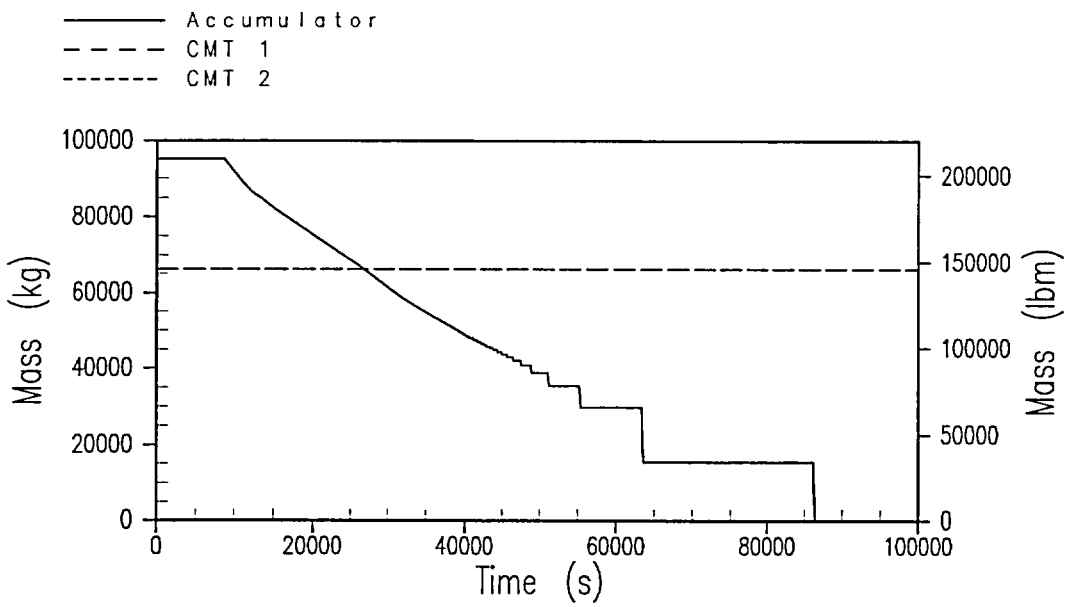

Figure 34-326

Case 1AP-1: Accumulator/CMT Water Mass
SBLOCA with PRHR, CMTs Failed

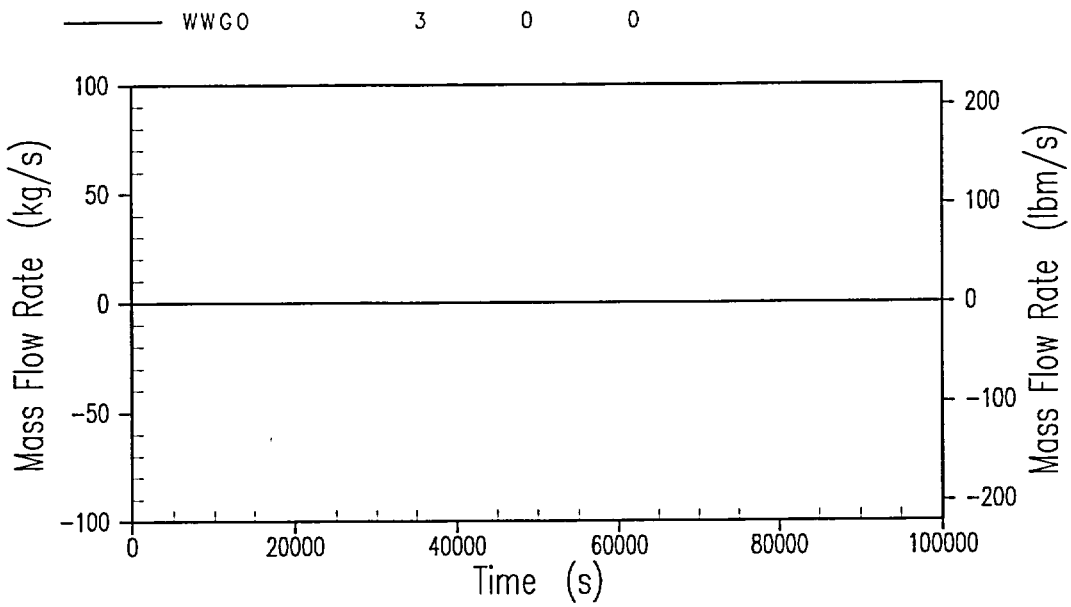

Figure 34-327

Case 1AP-1: IRWST Injection Flow Rate SBLOCA with PRHR, CMTs Failed

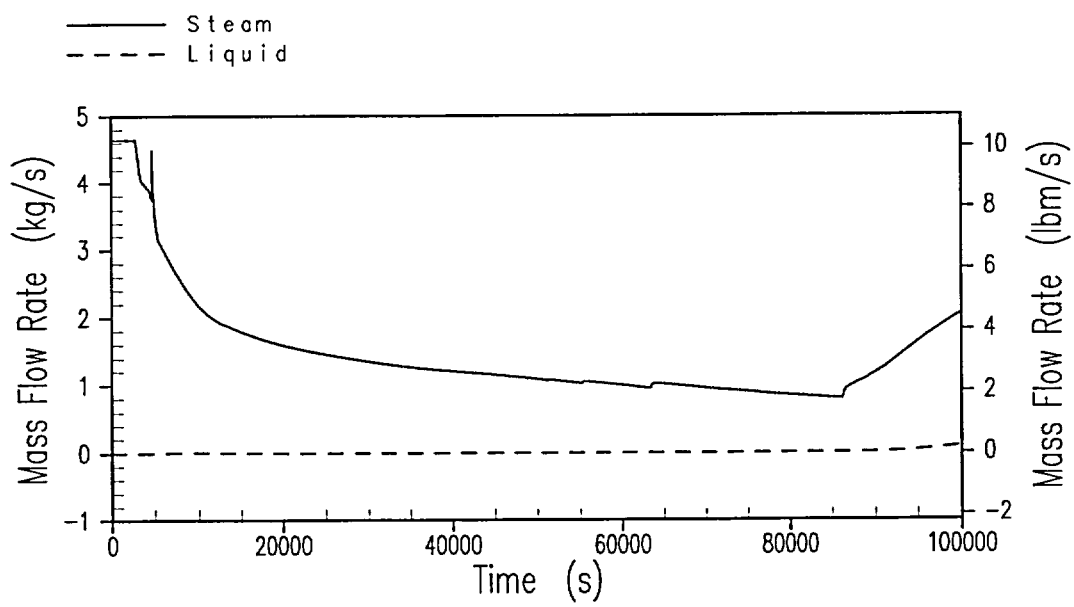

Figure 34-328

Case 1AP-1: Break Flow Rate SBLOCA with PRHR, CMTs Failed

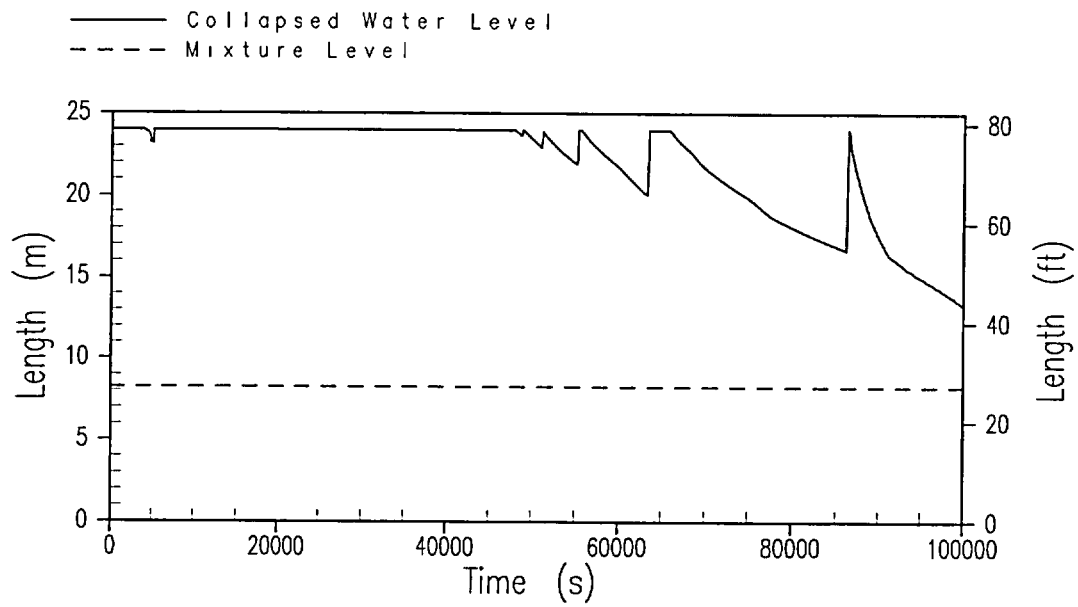

Figure 34-329

Case 1AP-1: Reactor Vessel Water Level SBLOCA with PRHR, CMTs Failed

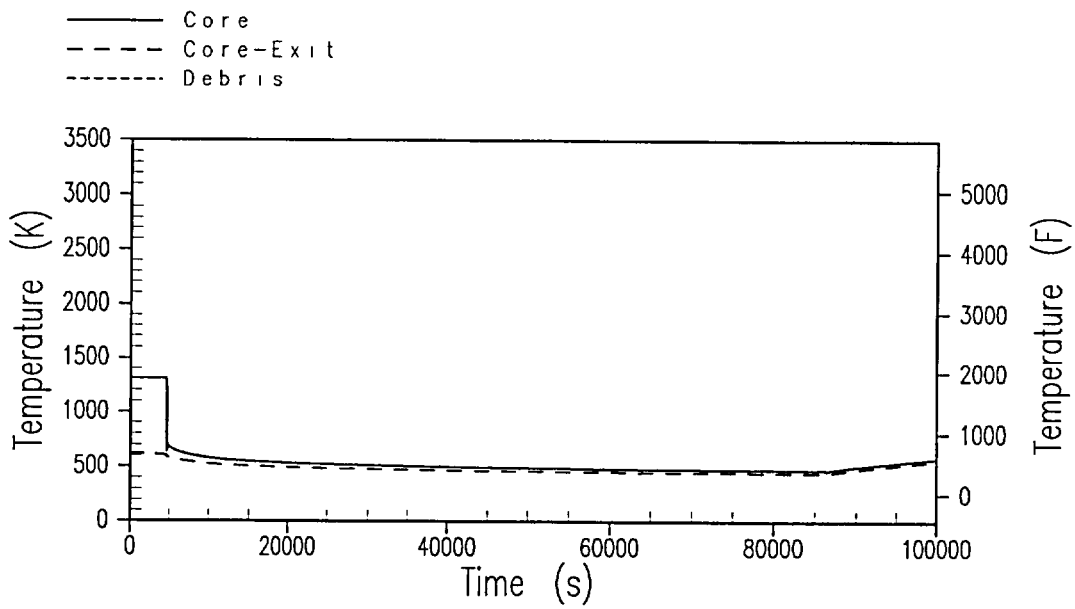

Figure 34-330

Case 1AP-1: Core Temperatures SBLOCA with PRHR, CMTs Failed

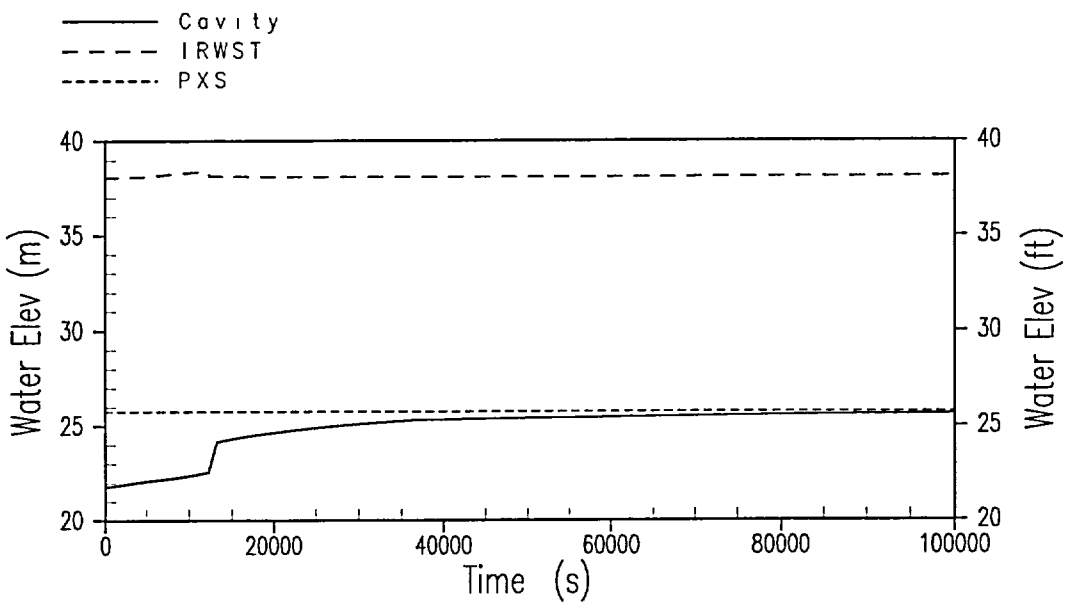

Figure 34-331

Case 1AP-1: Containment Pool Water Elevations SBLOCA with PRHR, CMTs Failed

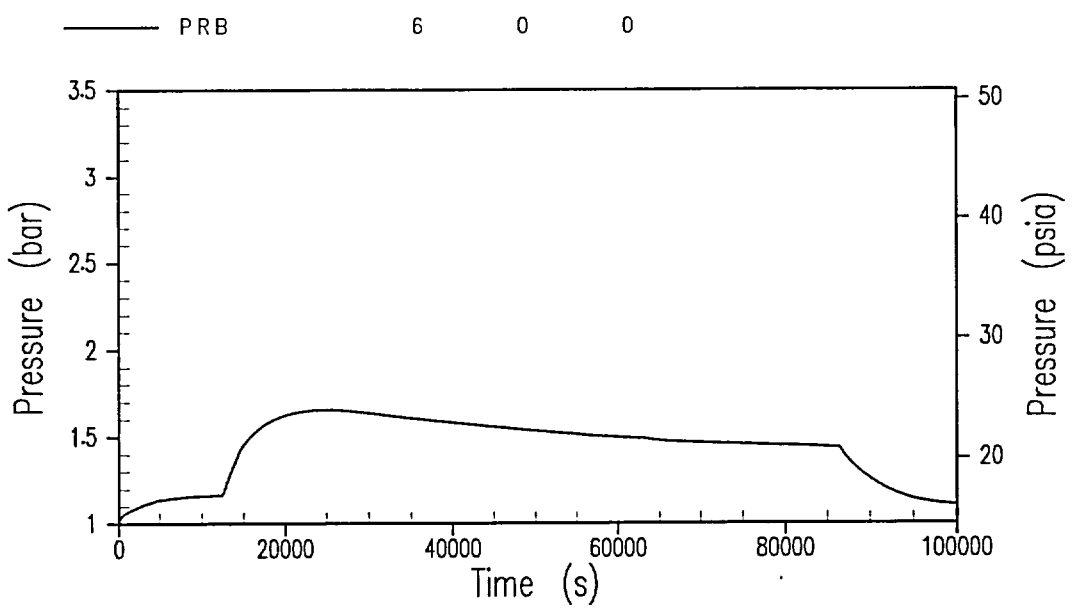

Figure 34-332

Case 1AP-1: Containment Pressure SBLOCA with PRHR, CMTs Failed

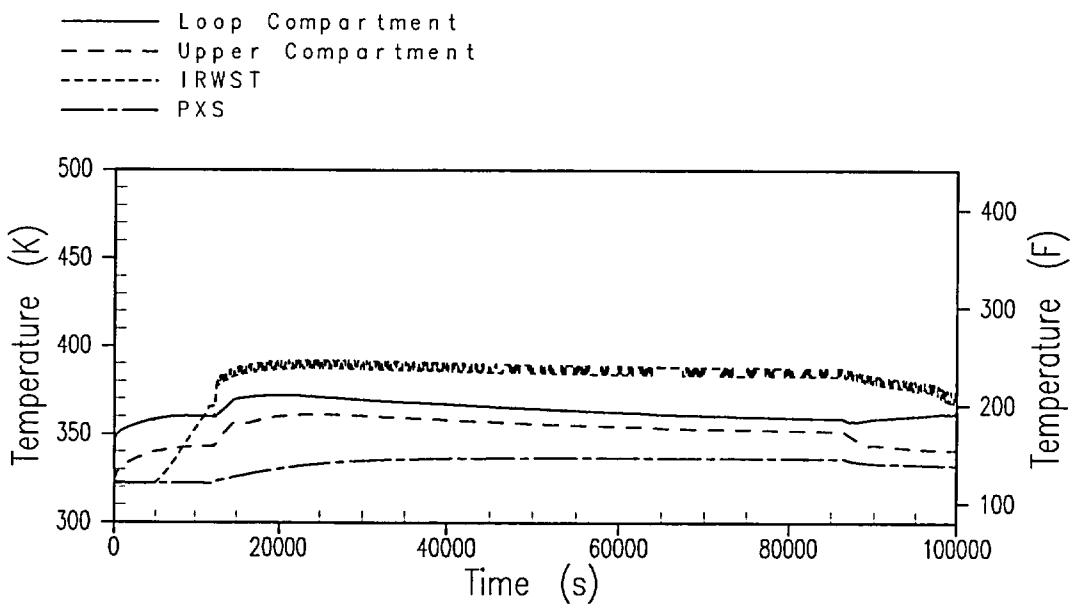

Figure 34-333

Case 1AP-1: Containment Gas Temperature SBLOCA with PRHR, CMTs Failed

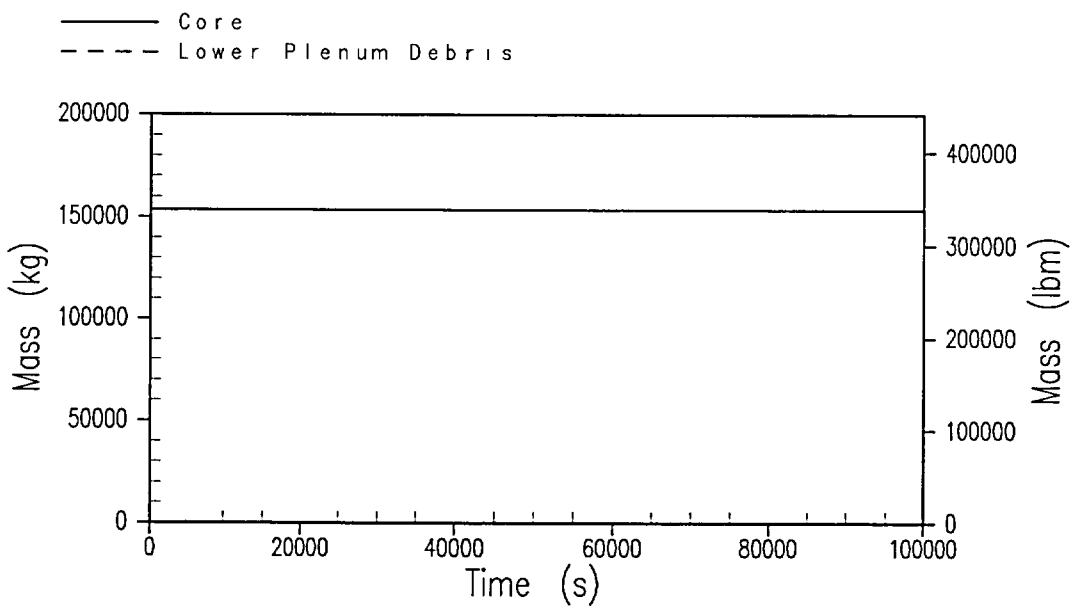

Figure 34-334

Case 1AP-1: Core Mass SBLOCA with PRHR, CMTs Failed

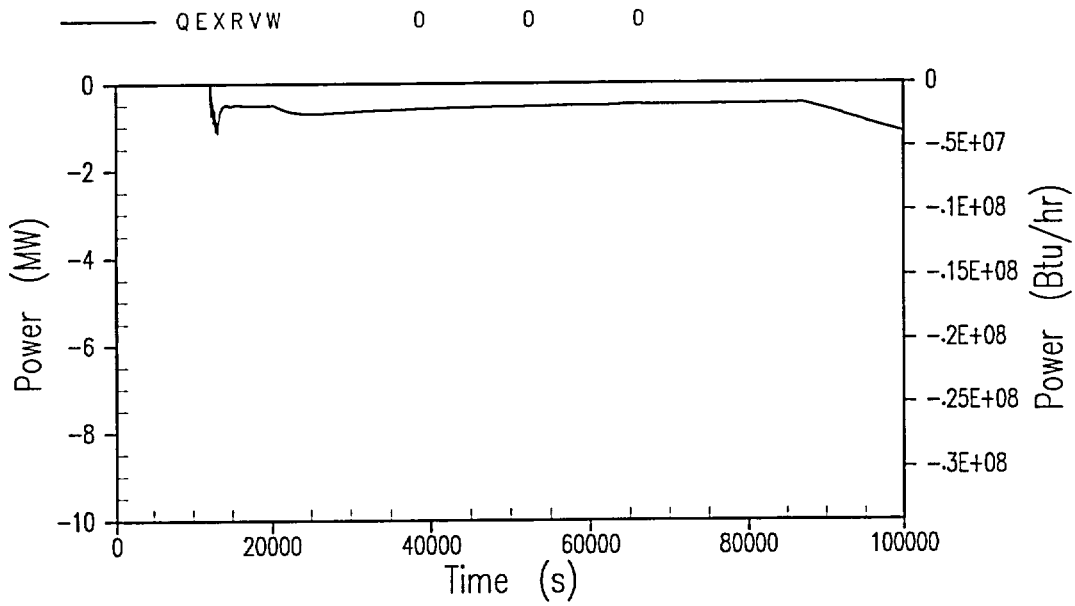

Figure 34-335

Case 1AP-1: Reactor Pressure Vessel to Cavity Water Heat Transfer SBLOCA with PRHR, CMTs Failed

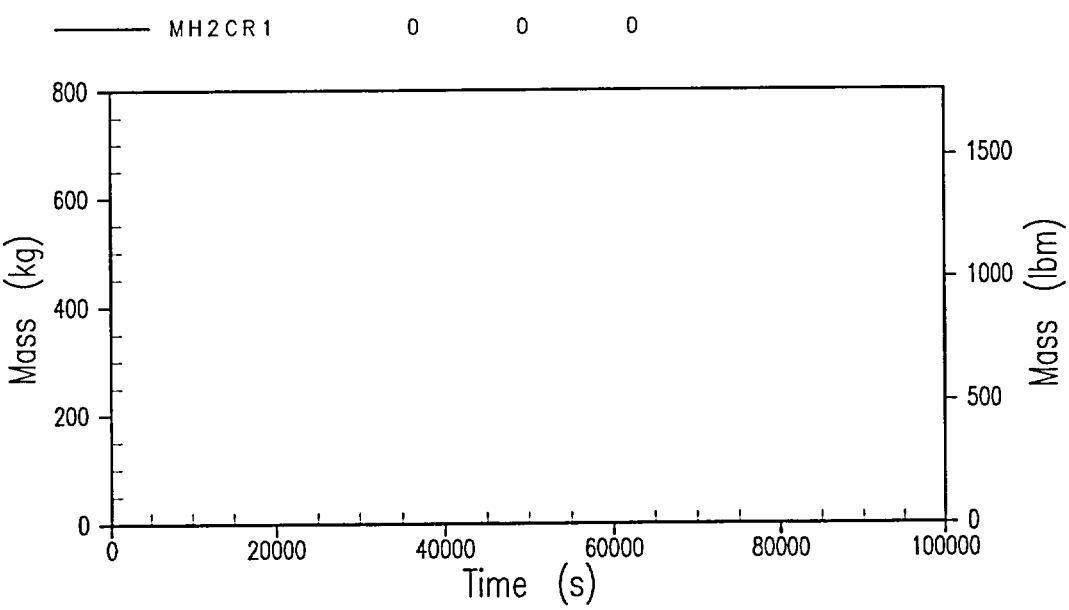

Figure 34-336

Case 1AP-1: In-Vessel Hydrogen Generation SBLOCA with PRHR, CMTs Failed

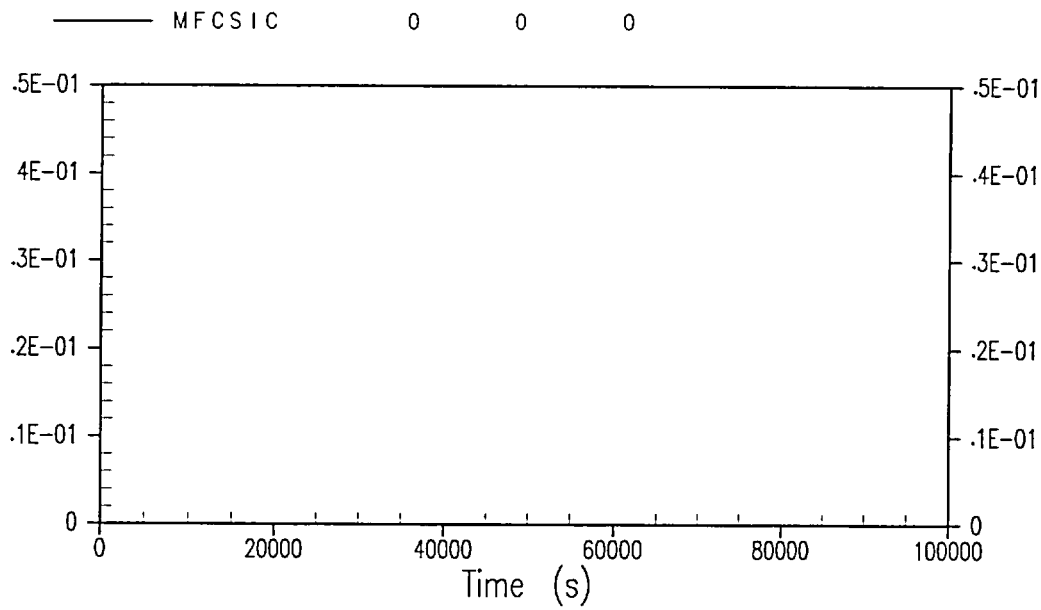

Figure 34-337

Case 1AP-1: Mass Fraction of CsI Released to Containment SBLOCA with PRHR, CMTs Failed

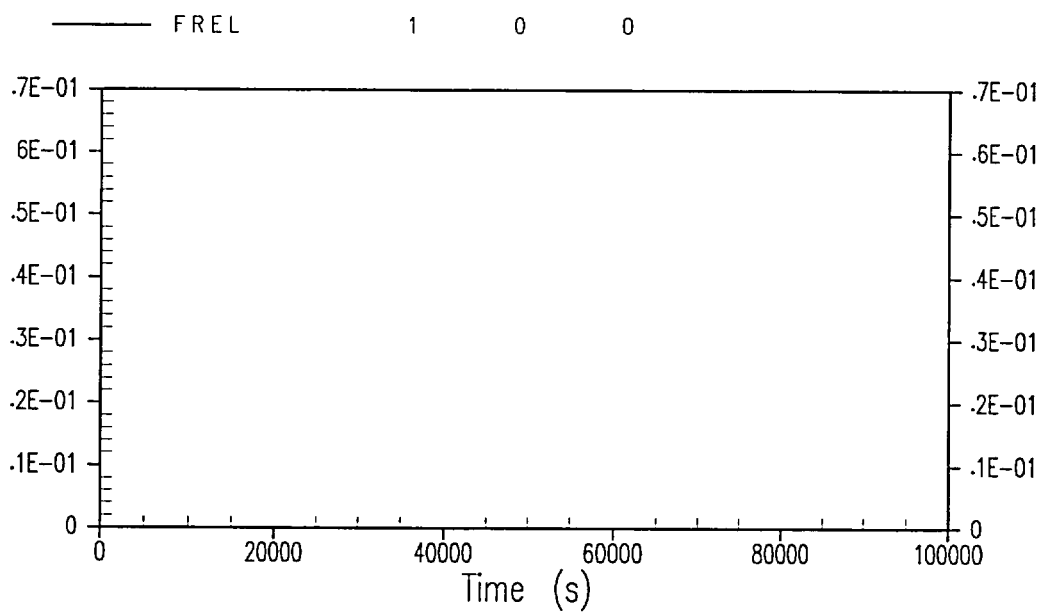

Figure 34-338

Case 1AP-1: Mass Fraction of Noble Gases Released to Environment SBLOCA with PRHR, CMTs Failed

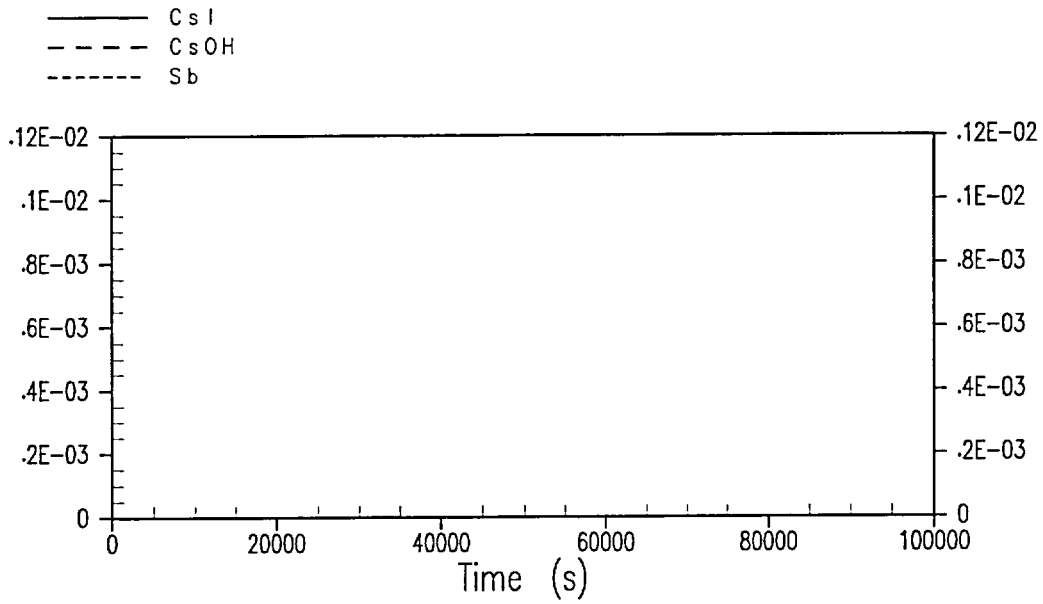

Figure 34-339

Case 1AP-1: Mass Fraction of Fission Products Released to Environment SBLOCA with PRHR, CMTs Failed

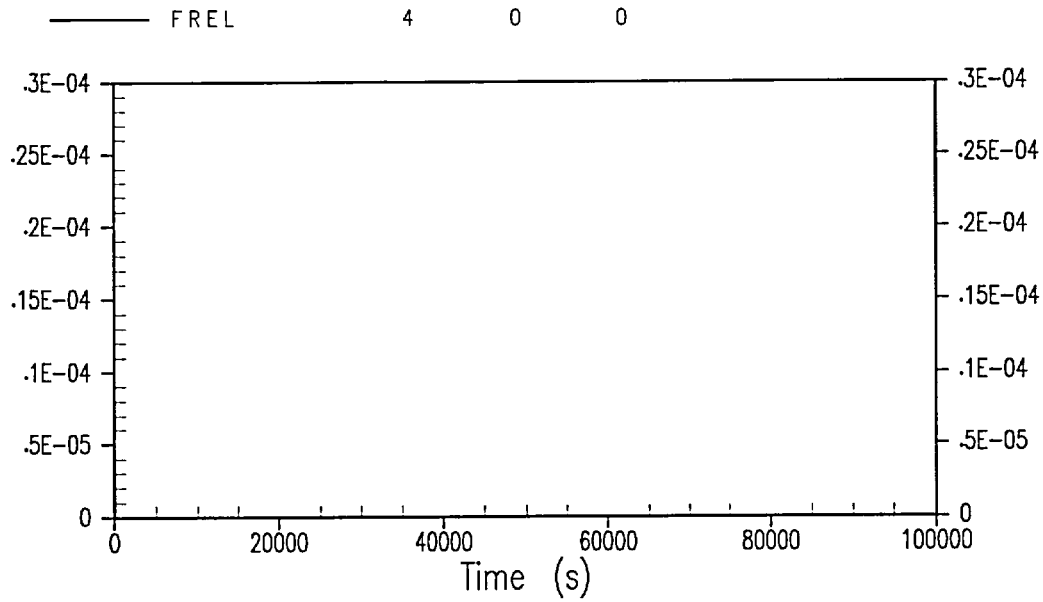

Figure 34-340

Case 1AP-1: Mass Fraction of SrO Released to Environment SBLOCA with PRHR, CMTs Failed

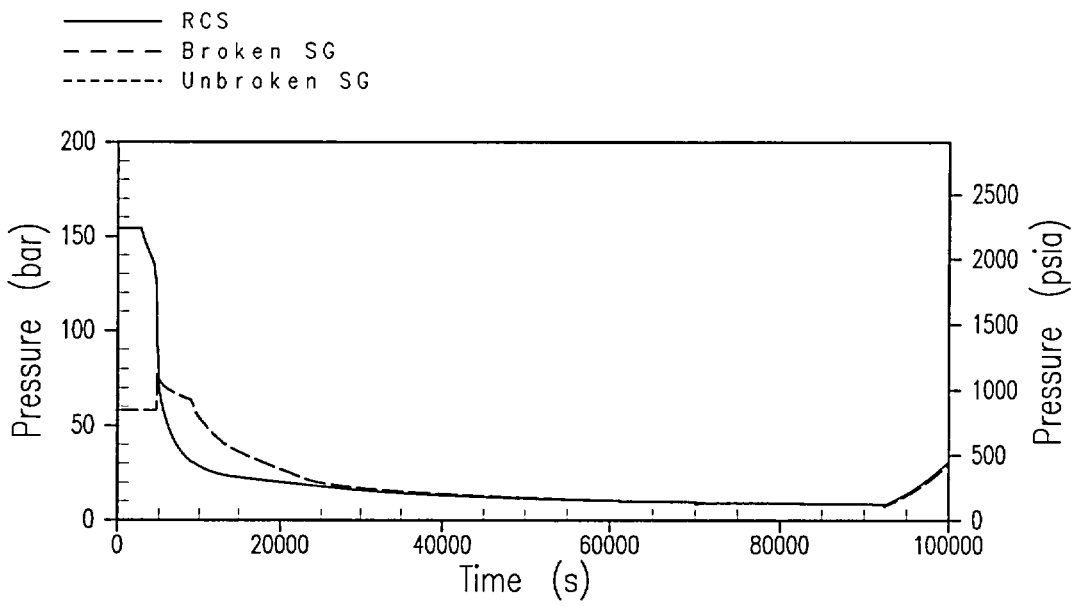

Figure 34-341

Case 1AP-2: Reactor Coolant System and Steam Generator Pressure SBLOCA with PRHR, CMTs Failed

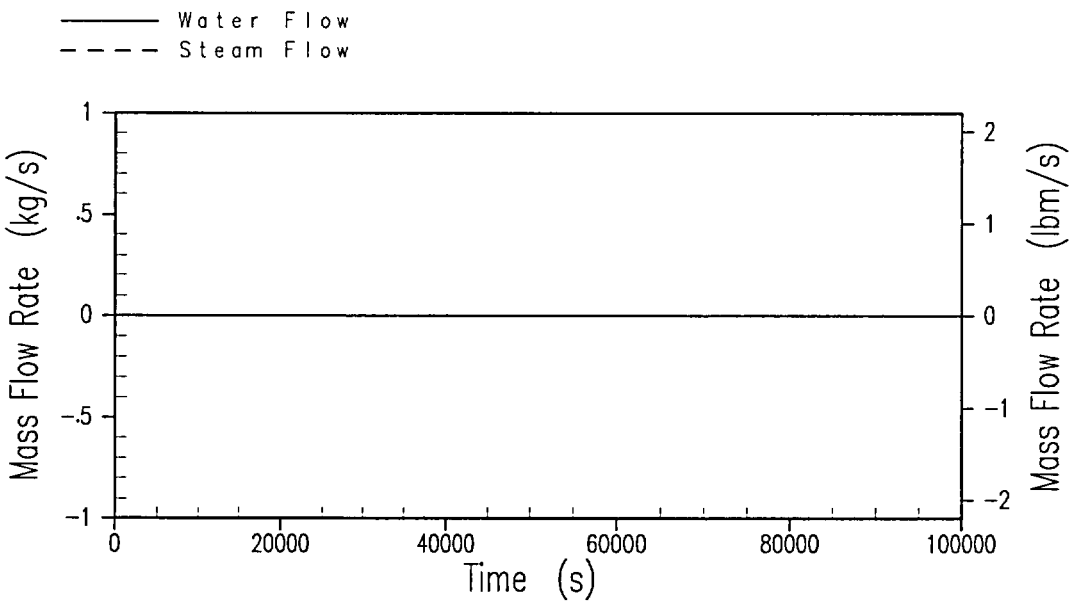

Figure 34-342

Case 1AP-2: ADS Stage 4 Flow Rates SBLOCA with PRHR, CMTs Failed

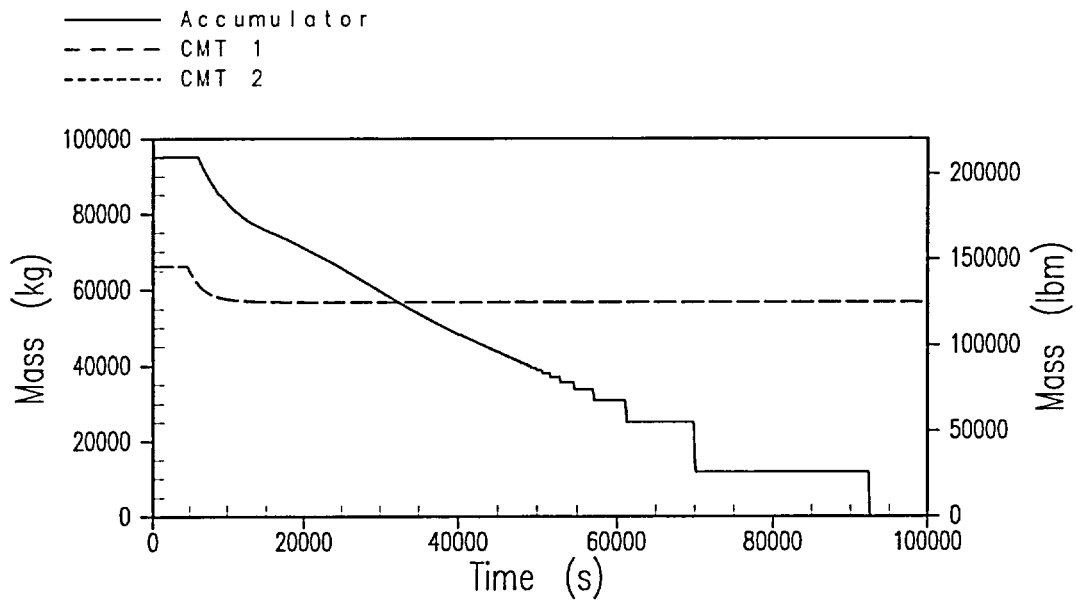

Figure 34-343

Case 1AP-2: Accumulator/CMT Water Mass SBLOCA with PRHR, CMTs Failed

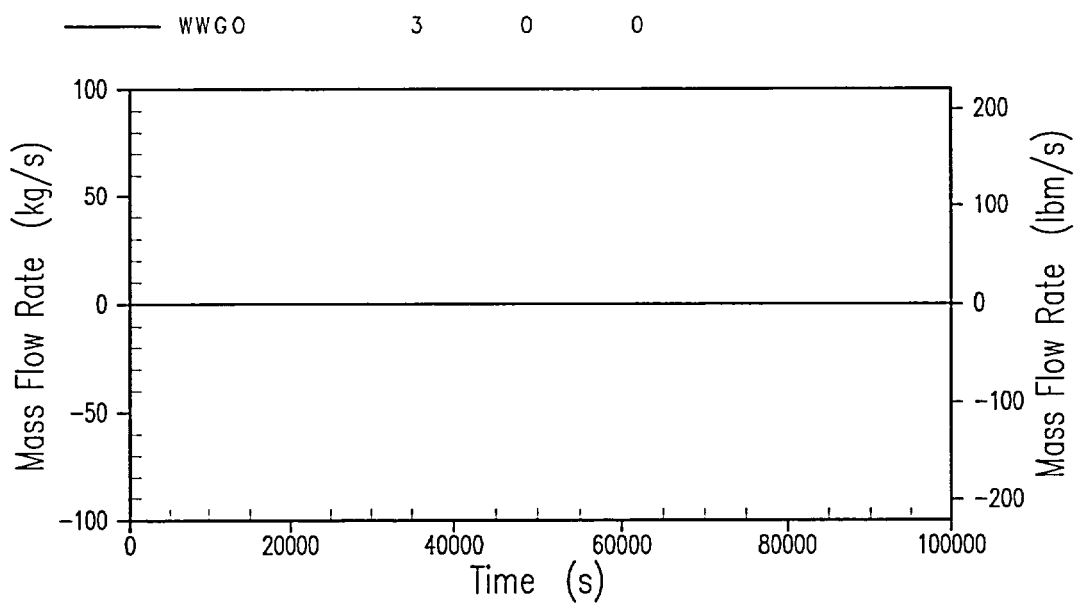

Figure 34-344

Case 1AP-2: IRWST Injection Flow Rate SBLOCA with PRHR, CMTs Failed

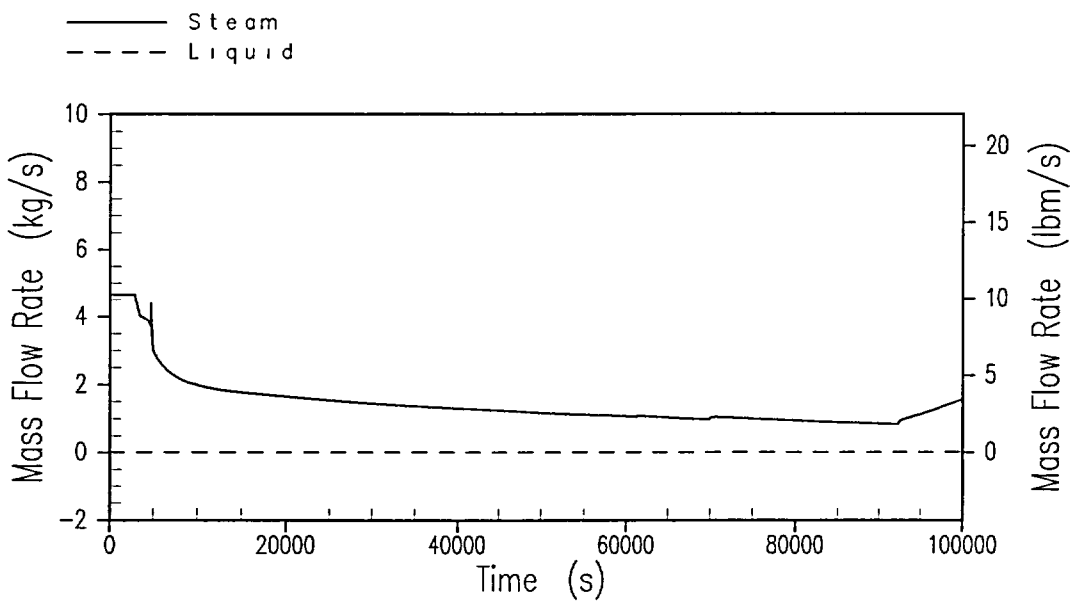

Figure 34-345

Case 1AP-2: Break Flow Rate
SBLOCA with PRHR, CMTs Failed

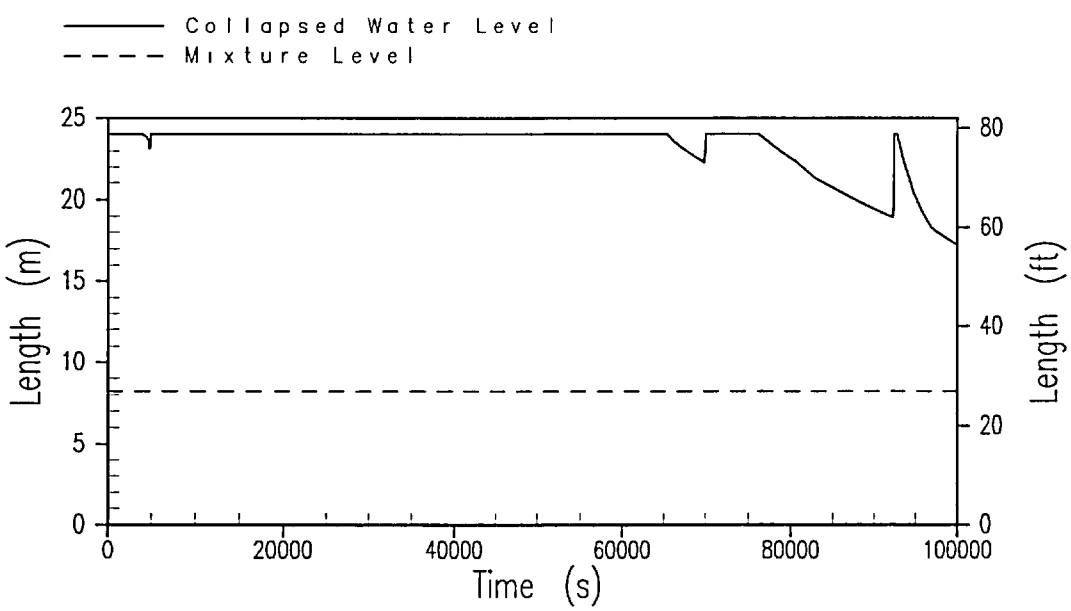

Figure 34-346

Case 1AP-2: Reactor Vessel Water Level
SBLOCA with PRHR, CMTs Failed

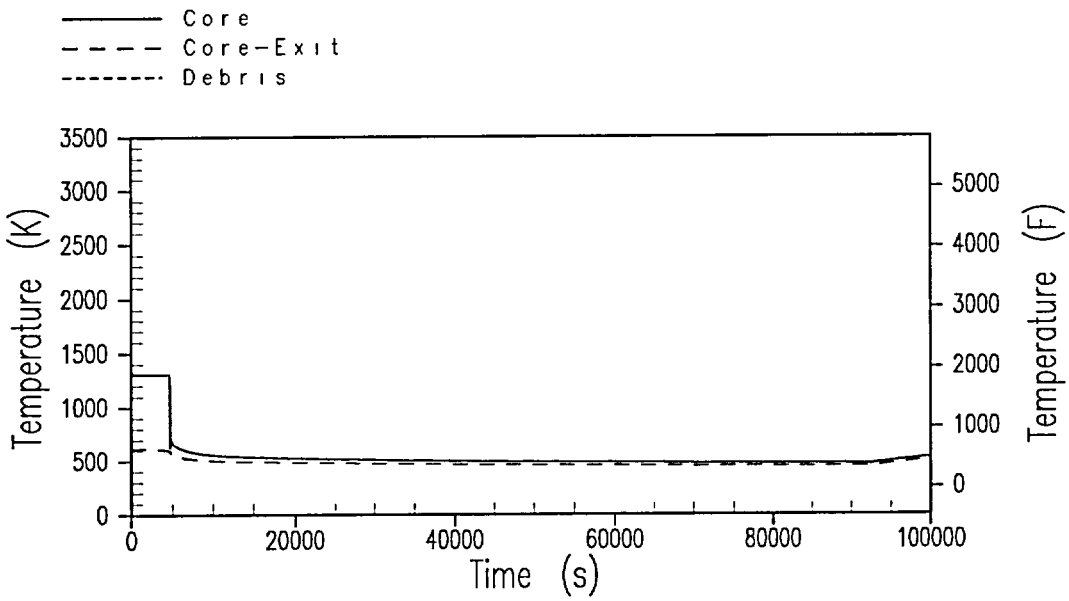

Figure 34-347

Case 1AP-2: Core Temperatures SBLOCA with PRHR, CMTs Failed

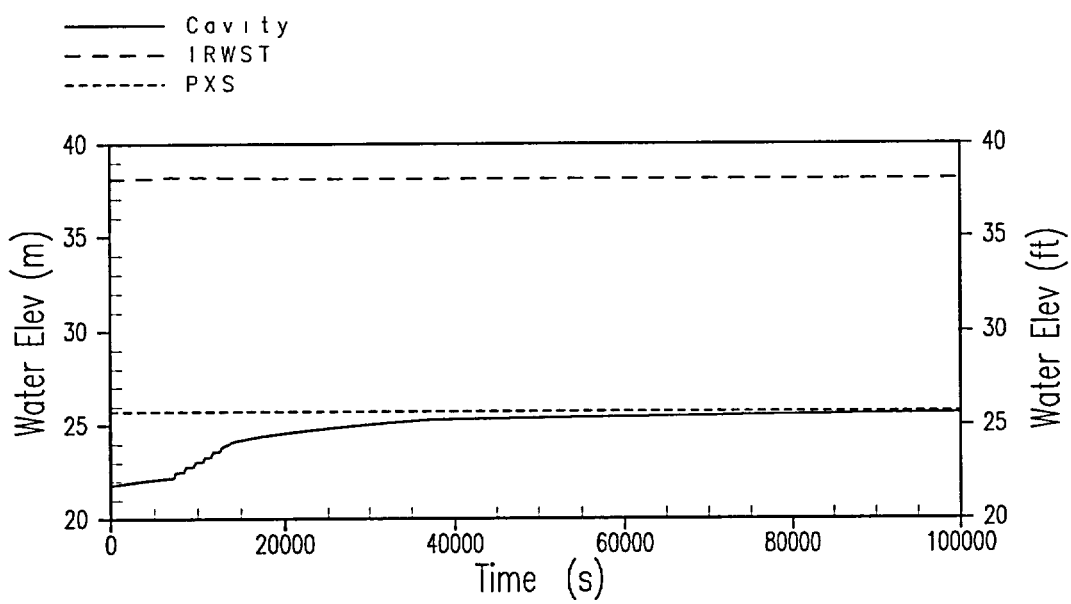

Figure 34-348

Case 1AP-2: Containment Water Pool Elevations SBLOCA with PRHR, CMTs Failed

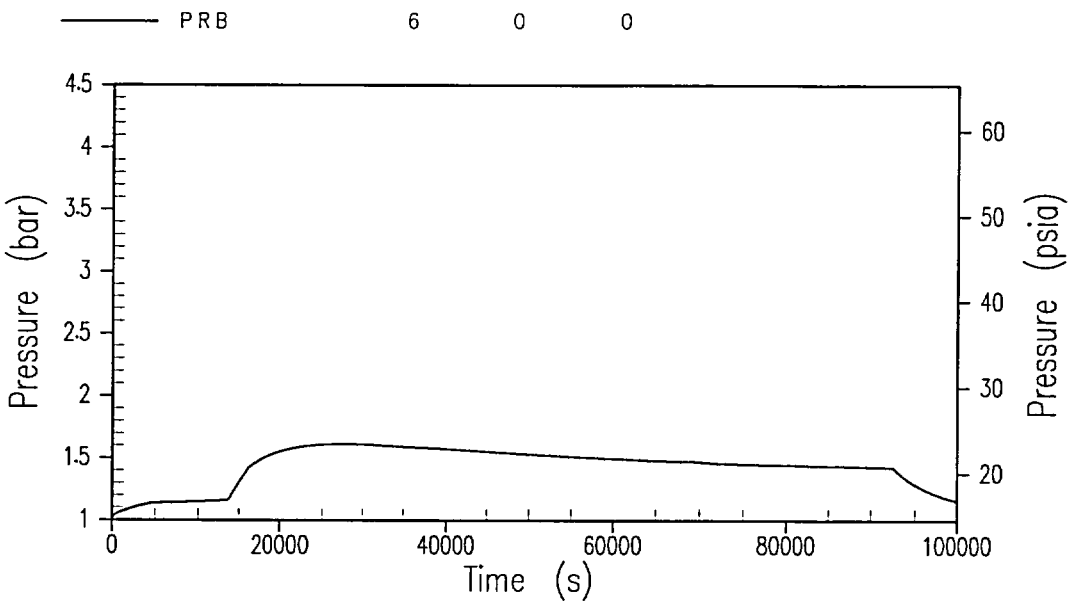

Figure 34-349

Case 1AP-2: Containment Pressure SBLOCA with PRHR, CMTs Failed

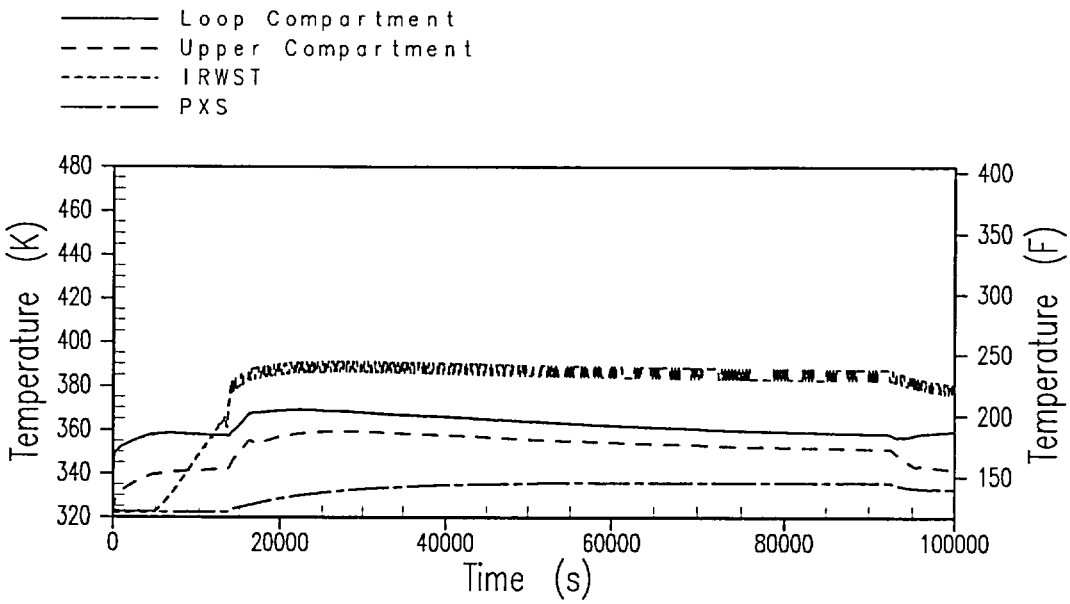

Figure 34-350

Case 1AP-2: Containment Gas Temperature SBLOCA with PRHR, CMTs Failed

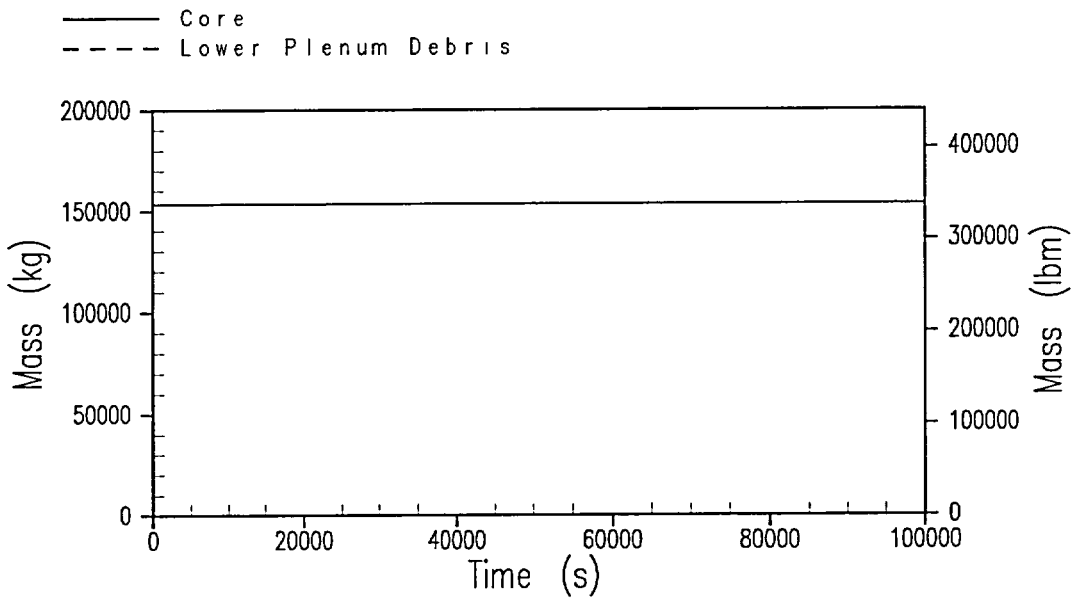

Figure 34-351

Case 1AP-2: Core Mass
SBLOCA with PRHR, CMTs Failed

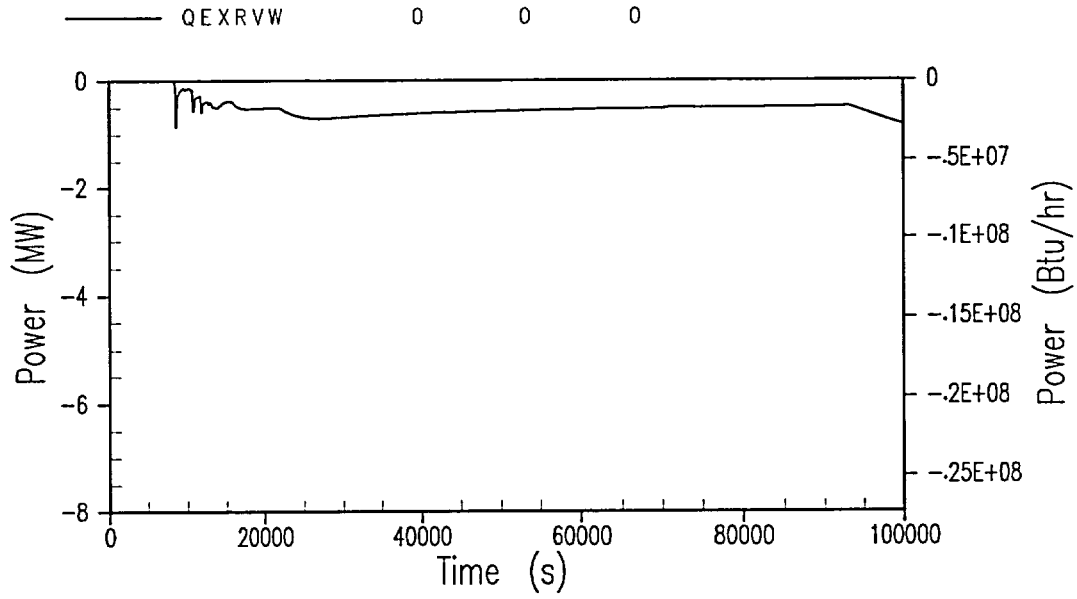

Figure 34-352

Case 1AP-2: Reactor Pressure Vessel to Cavity Water Heat Transfer
SBLOCA with PRHR, CMTs Failed

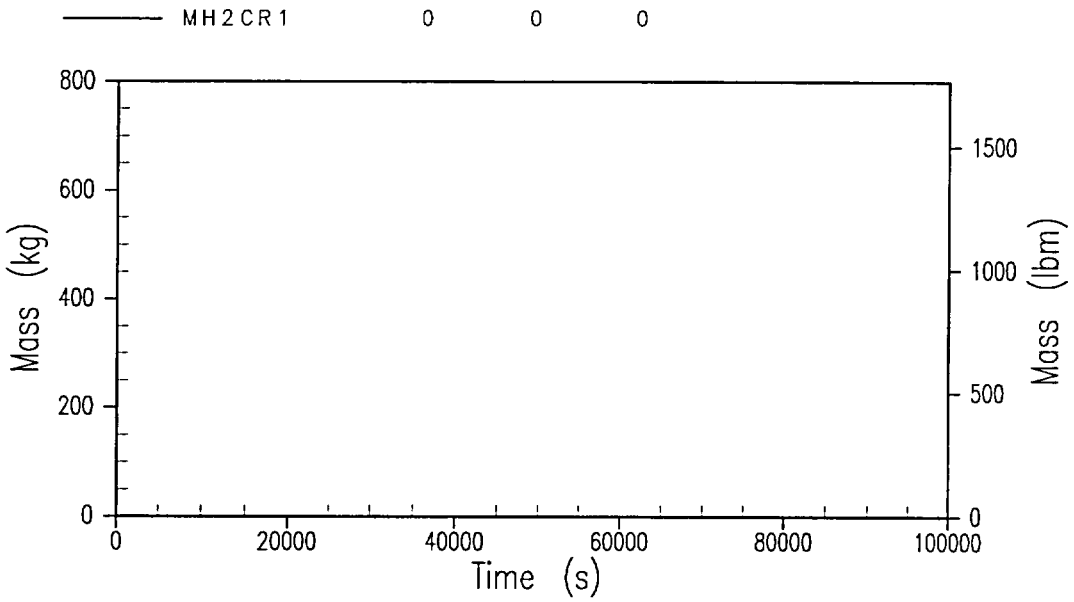

Figure 34-353

Case 1AP-2: In-Vessel Hydrogen Generation SBLOCA with PRHR, CMTs Failed

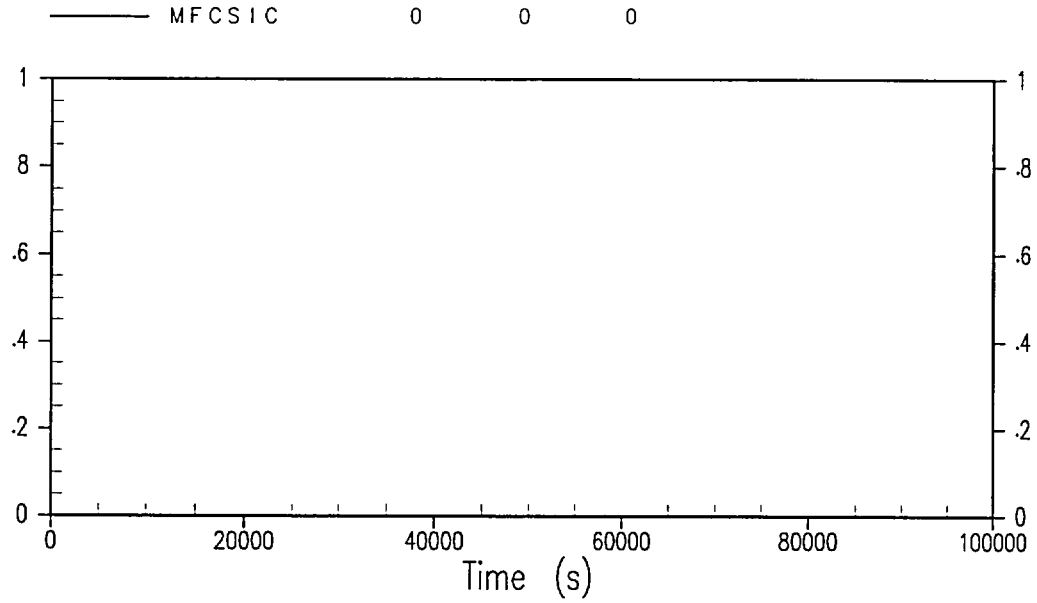

Figure 34-354

Case 1AP-2: Mass Fraction of CsI Released to Containment SBLOCA with PRHR, CMTs Failed

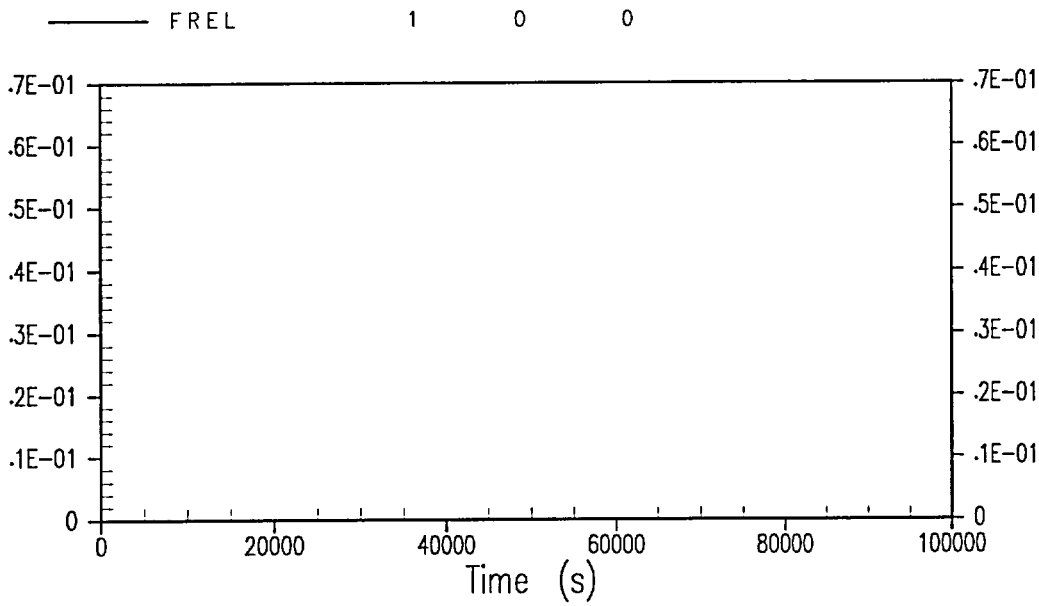

Figure 34-355

Case 1AP-2: Mass Fraction of Noble Gases Released to Environment SBLOCA with PRHR, CMTs Failed

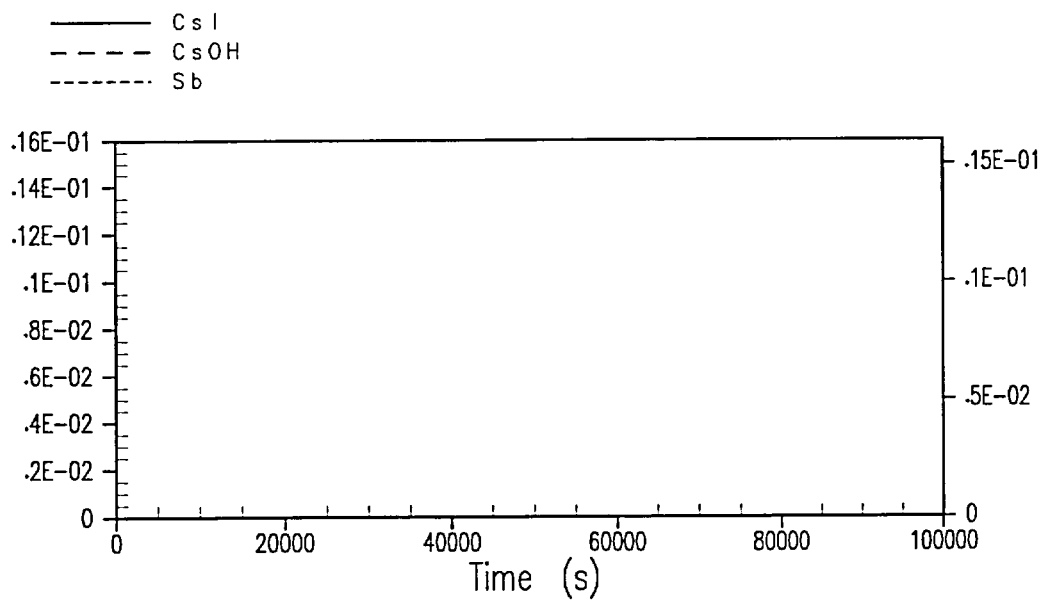

Figure 34-356

Case 1AP-2: Mass Fraction of Fission Products Released to Environment SBLOCA with PRHR, CMTs Failed

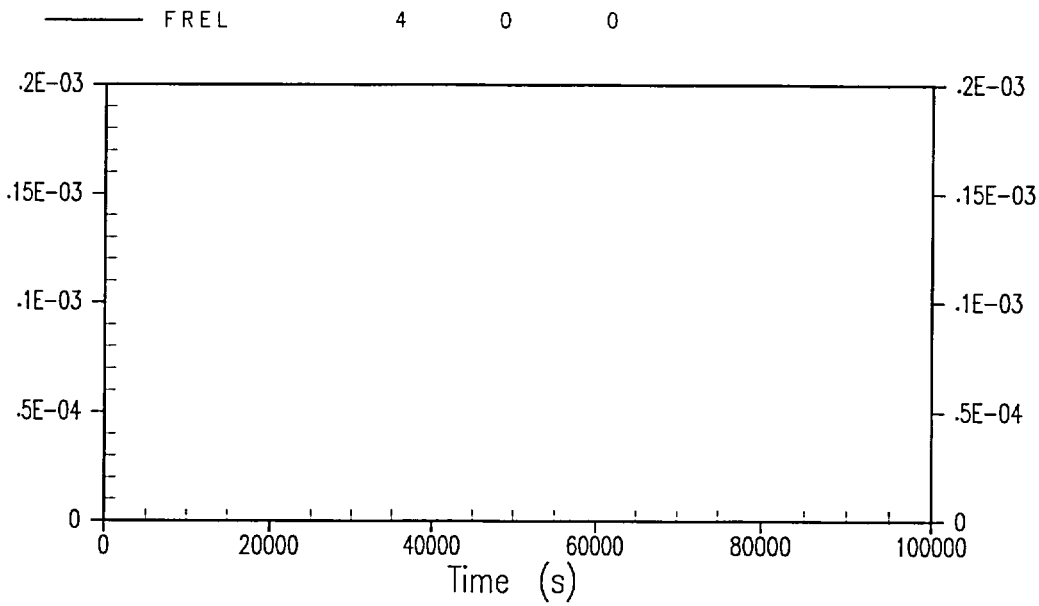

Figure 34-357

Case 1AP-2: Mass Fraction of SrO Released to Environment SBLOCA with PRHR, CMTs Failed

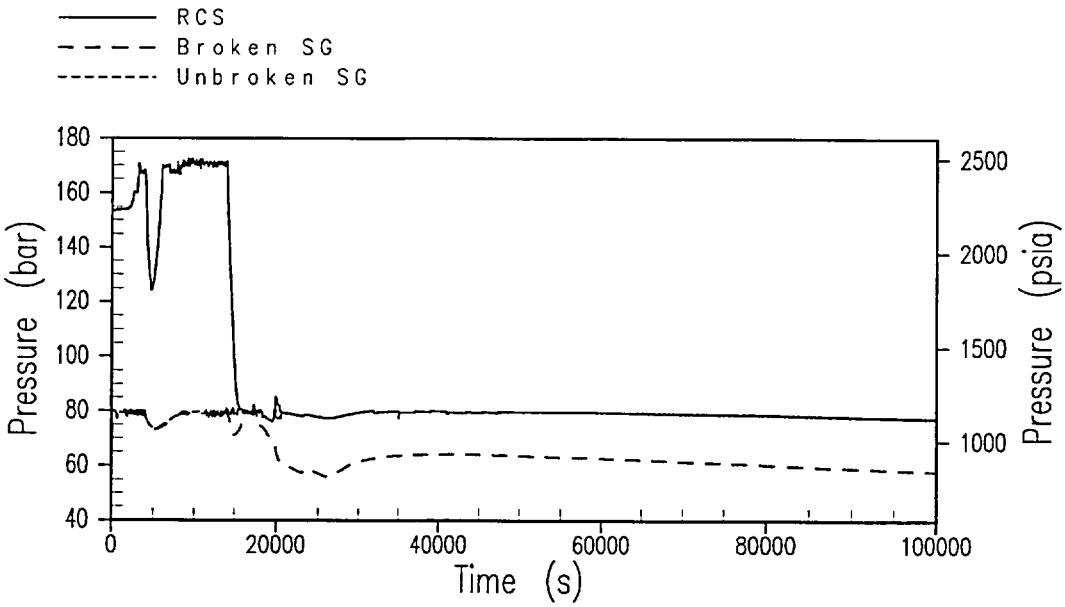

Figure 34-358

Case 1A-1: Reactor Coolant System and Steam Generator Pressure Transient with Creep of SG Tubes

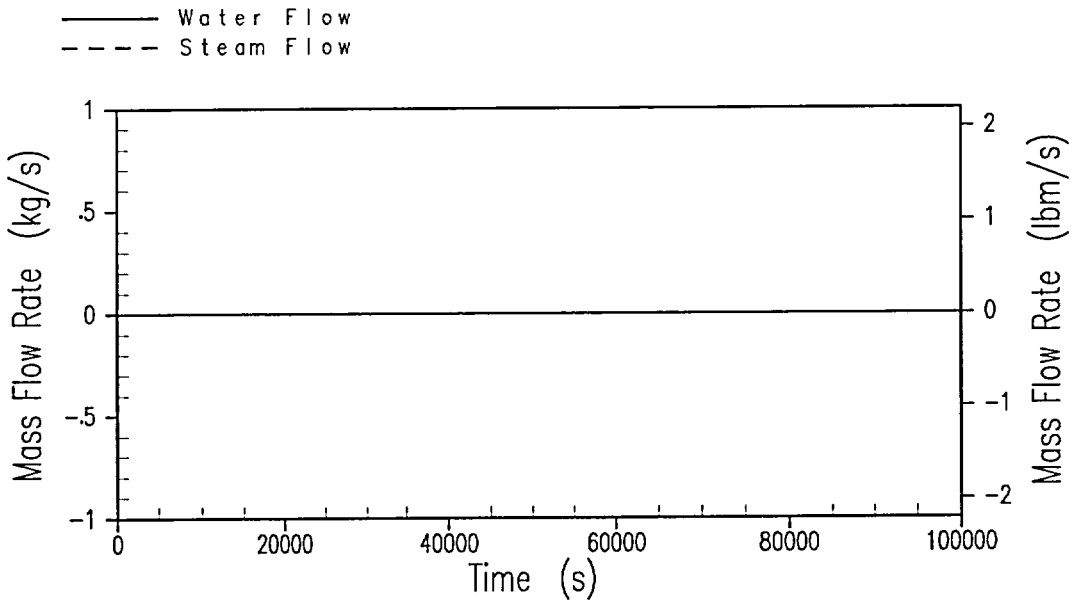

Figure 34-359

Case 1A-1: ADS Stage 4 Flow Rates Transient with Creep of SG Tubes

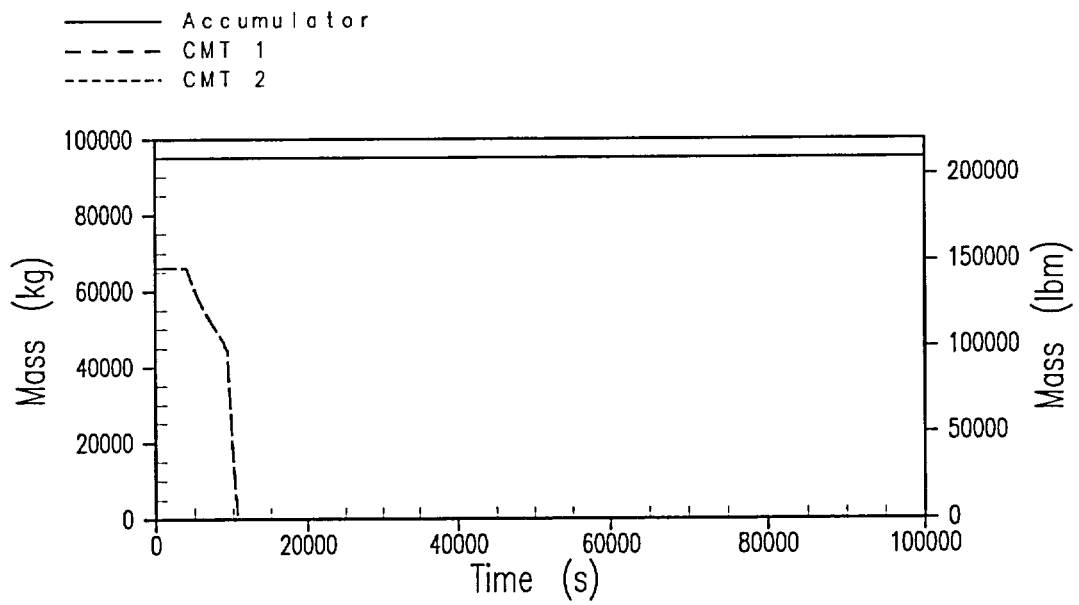

Figure 34-360

Case 1A-1: Accumulator/CMT Water Mass Transient with Creep of SG Tubes

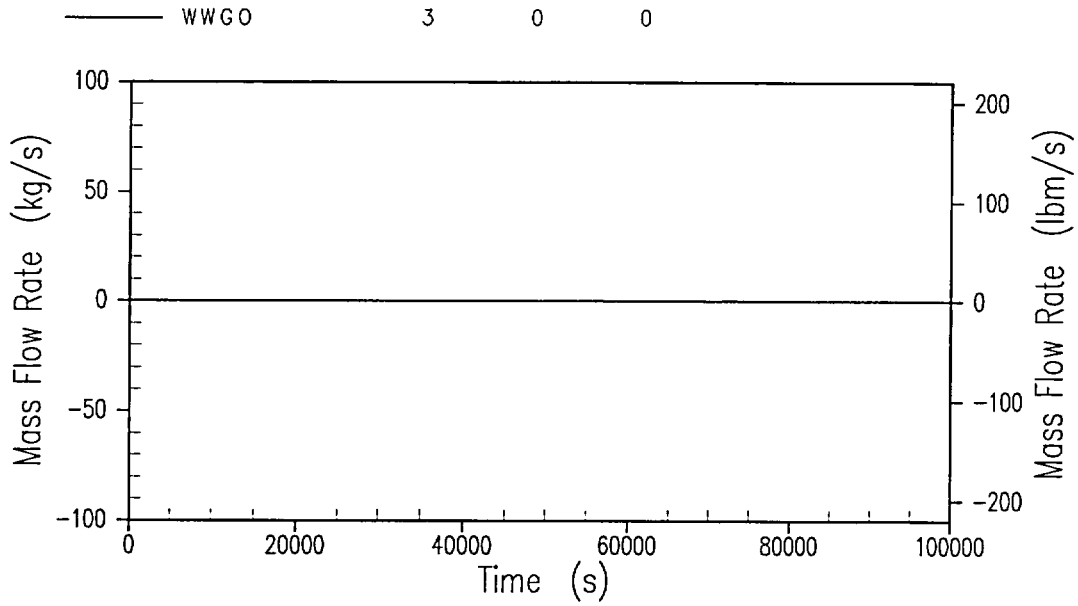

Figure 34-361

Case 1A-1: IRWST Injection Flow Rate Transient with Creep of SG Tubes

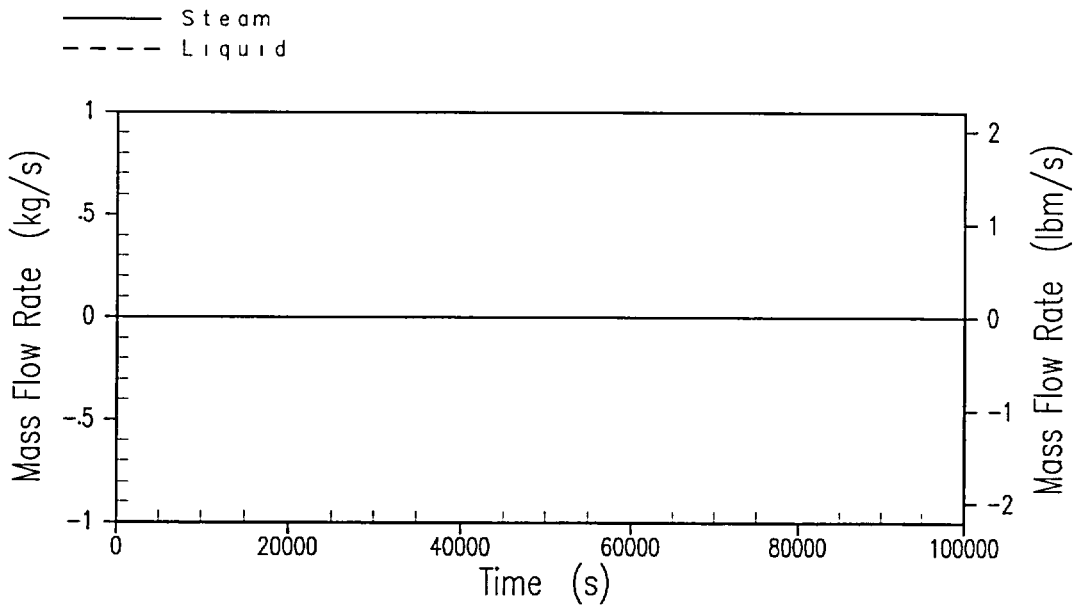

Figure 34-362

Case 1A-1: Break Flow Rate Transient with Creep of SG Tubes

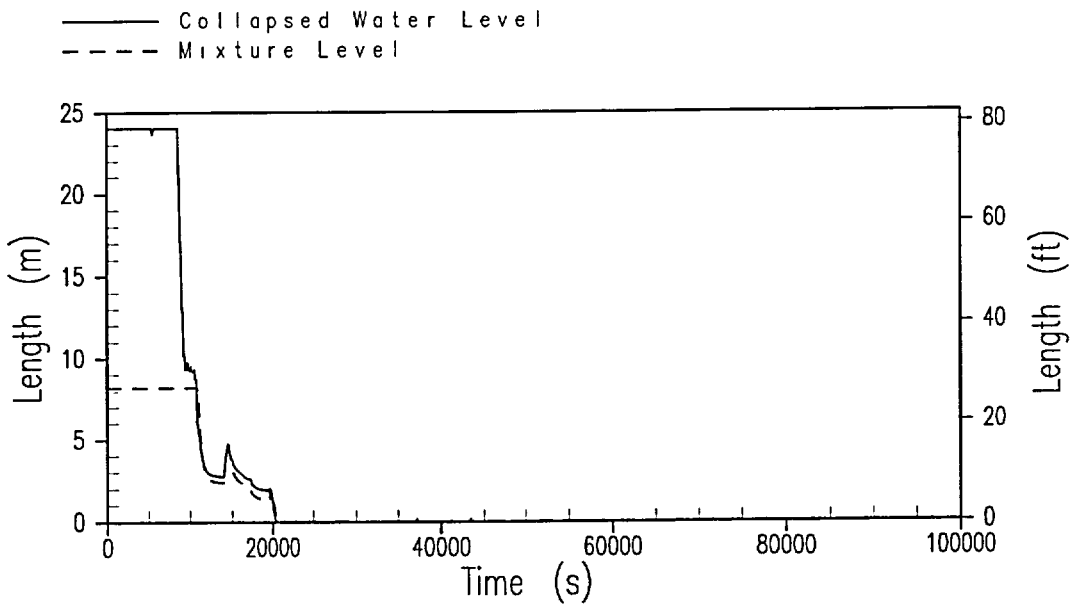

Figure 34-363

Case 1A-1: Reactor Vessel Water Level Transient with Creep of SG Tubes

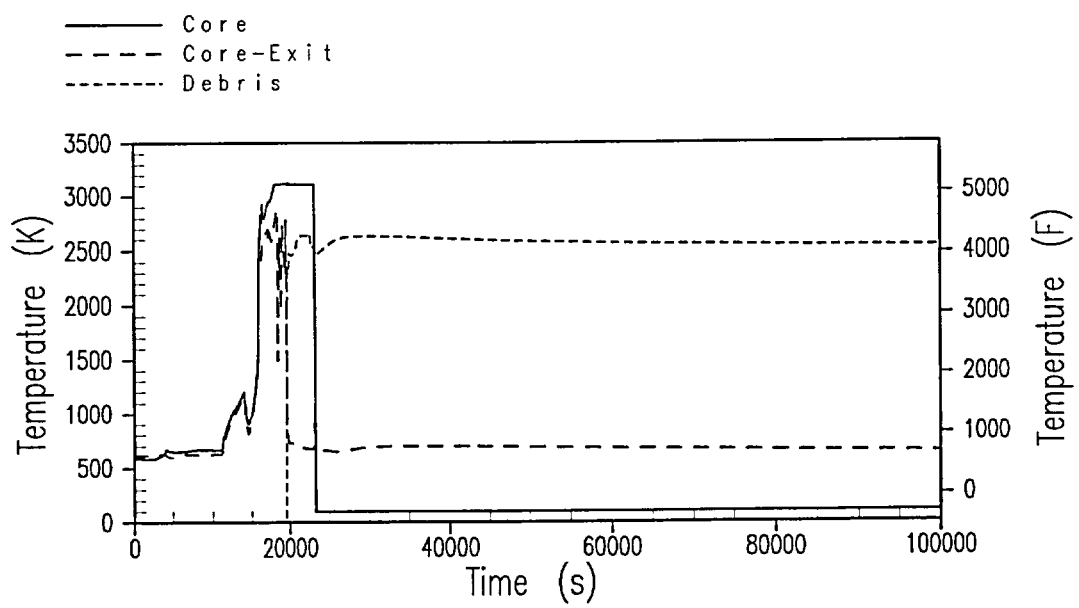

Figure 34-364

Case 1A-1: Core Temperatures Transient with Creep of SG Tubes

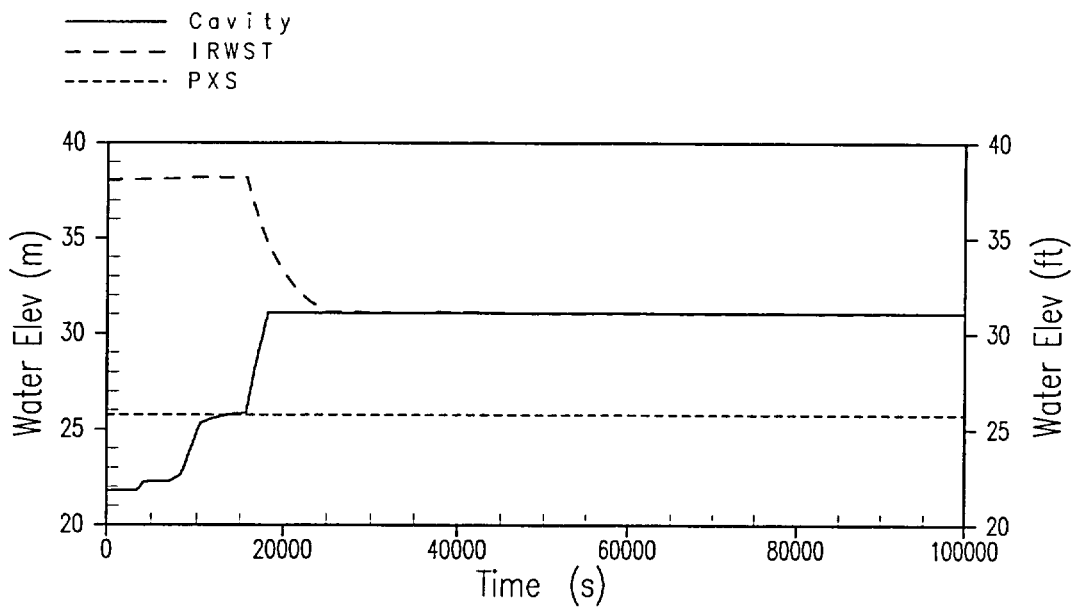

Figure 34-365

Case 1A-1: Containment Pool Water Elevations Transient with Creep of SG Tubes

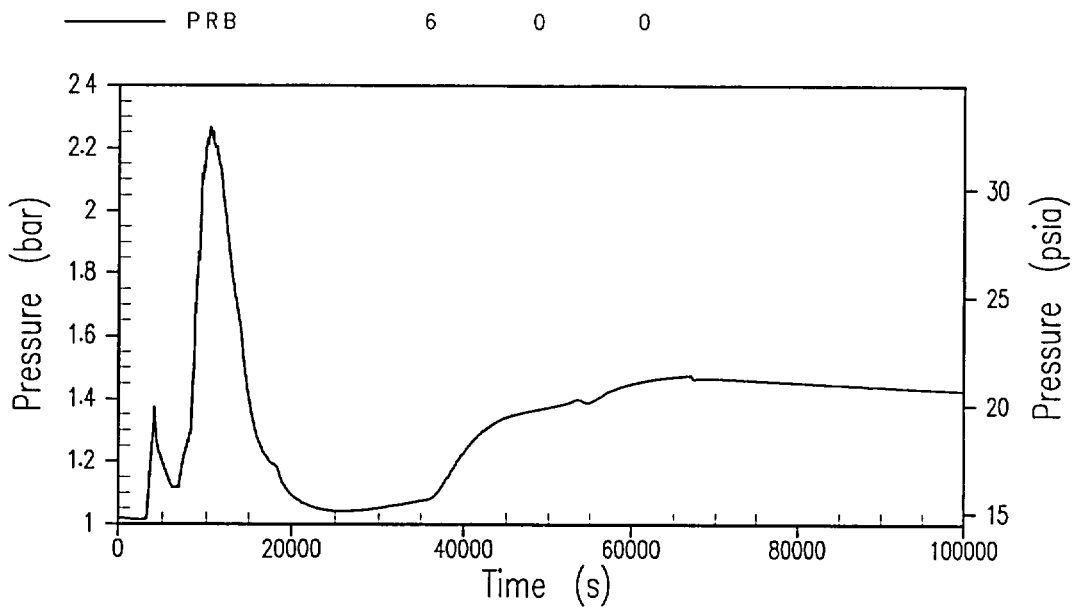

Figure 34-366

Case 1A-1: Containment Pressure Transient with Creep of SG Tubes

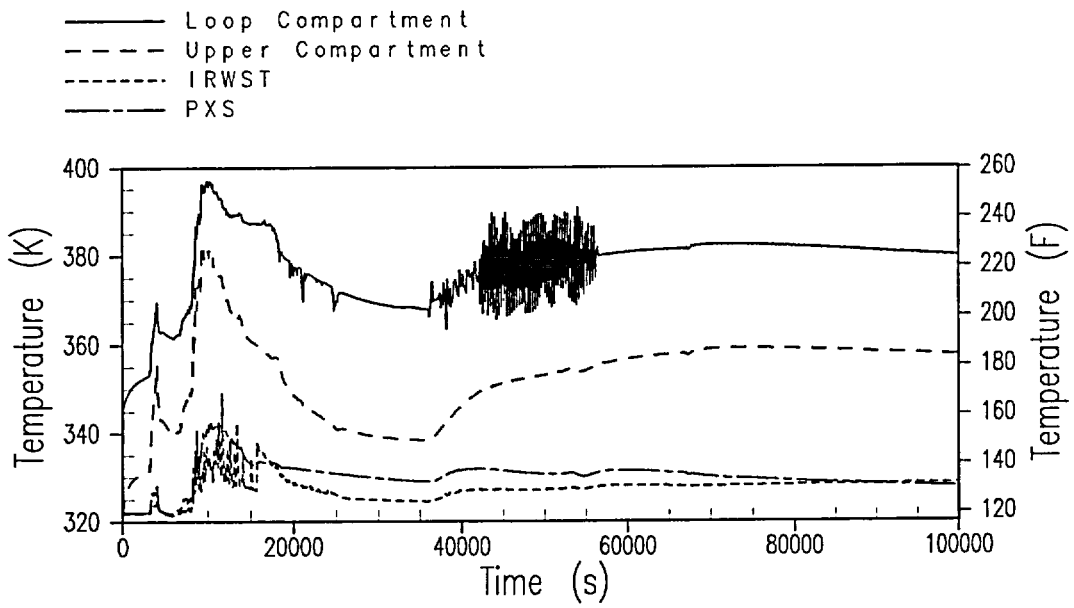

Figure 34-367

Case 1A-1: Containment Gas Temperature Transient with Creep of SG Tubes

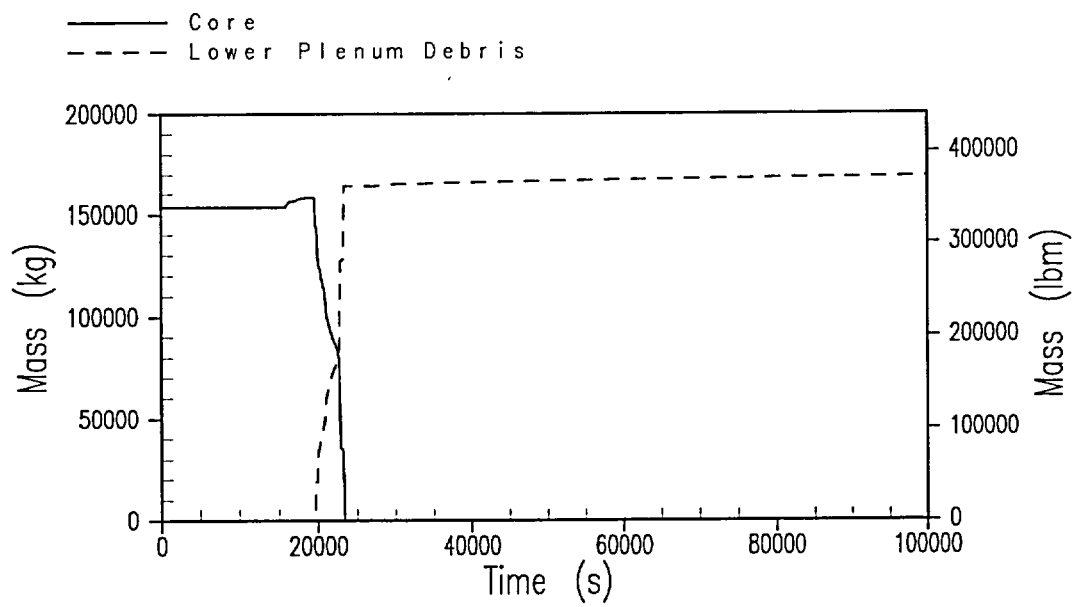

Figure 34-368

Case 1A-1: Core Mass Transient with Creep of SG Tubes

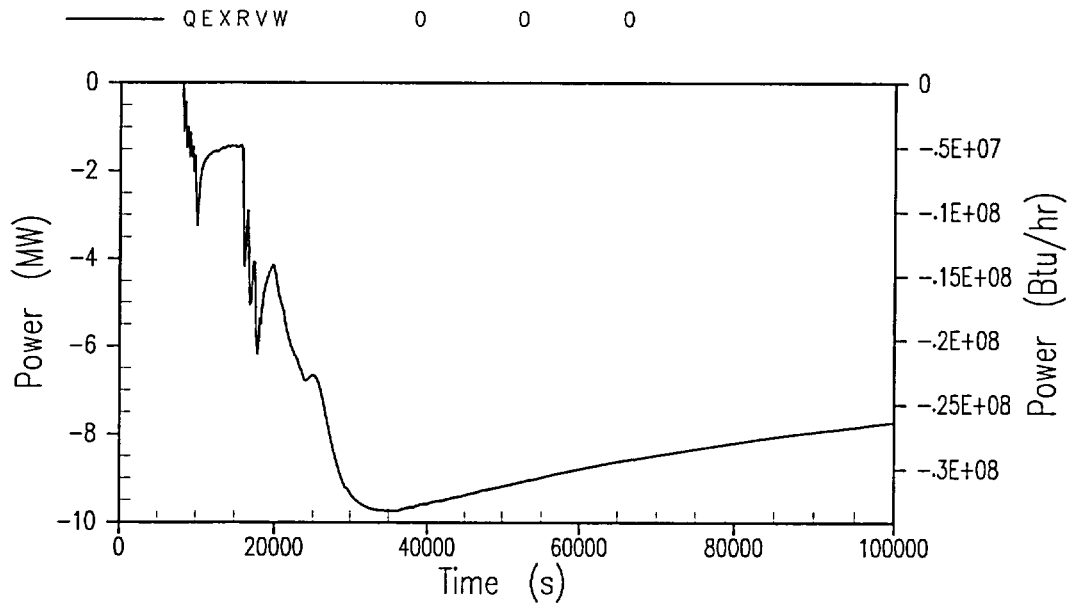

Figure 34-369

Case 1A-1: Reactor Pressure Vessel to Cavity Water Heat Transfer Transient with Creep of SG Tubes

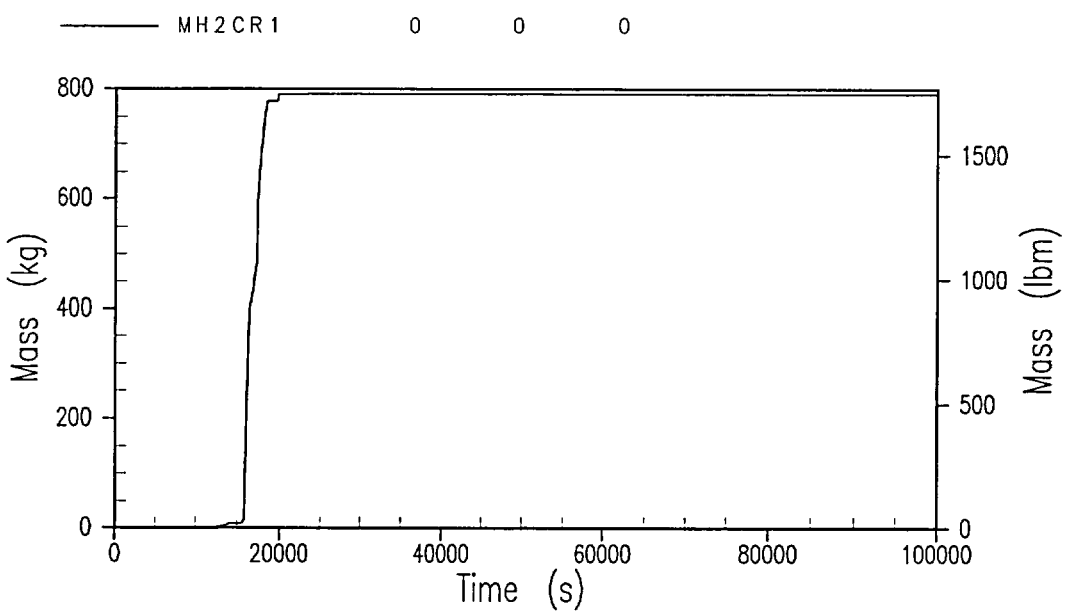

Figure 34-370

Case 1A-1: In-Vessel Hydrogen Generation Transient with Creep of SG Tubes

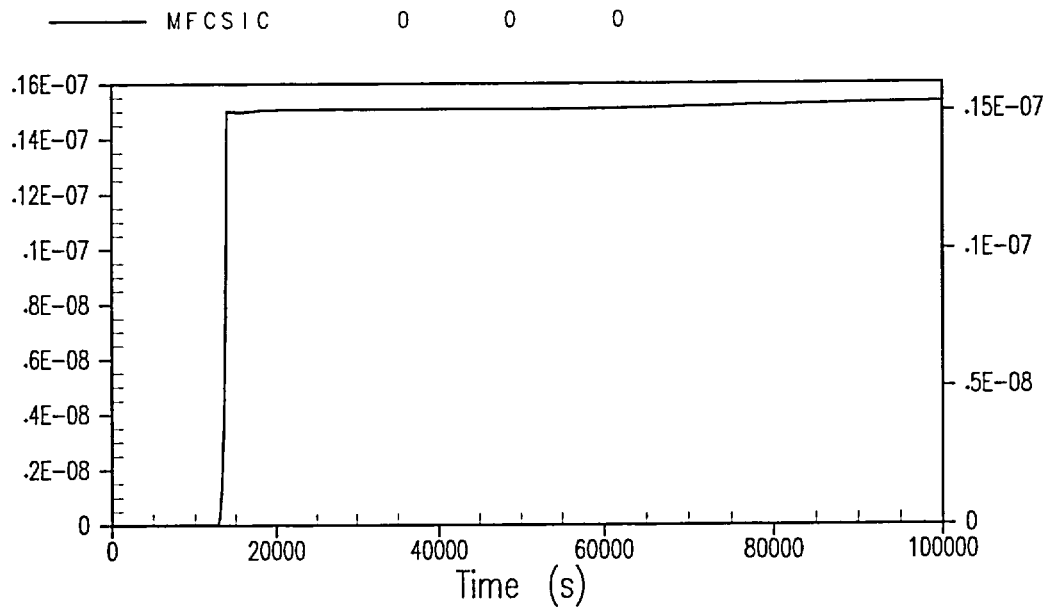

Figure 34-371

Case 1A-1: Mass Fraction of CsI Released to Containment Transient with Creep of SG Tubes

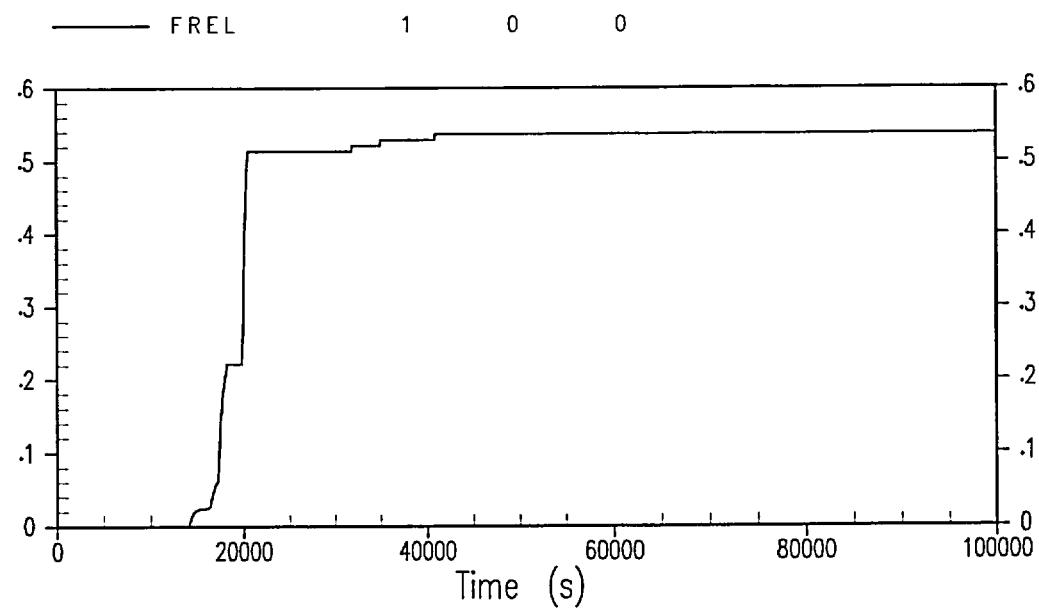

Figure 34-372

Case 1A-1: Mass Fraction of Noble Gases Released to Environment Transient with Creep of SG Tubes

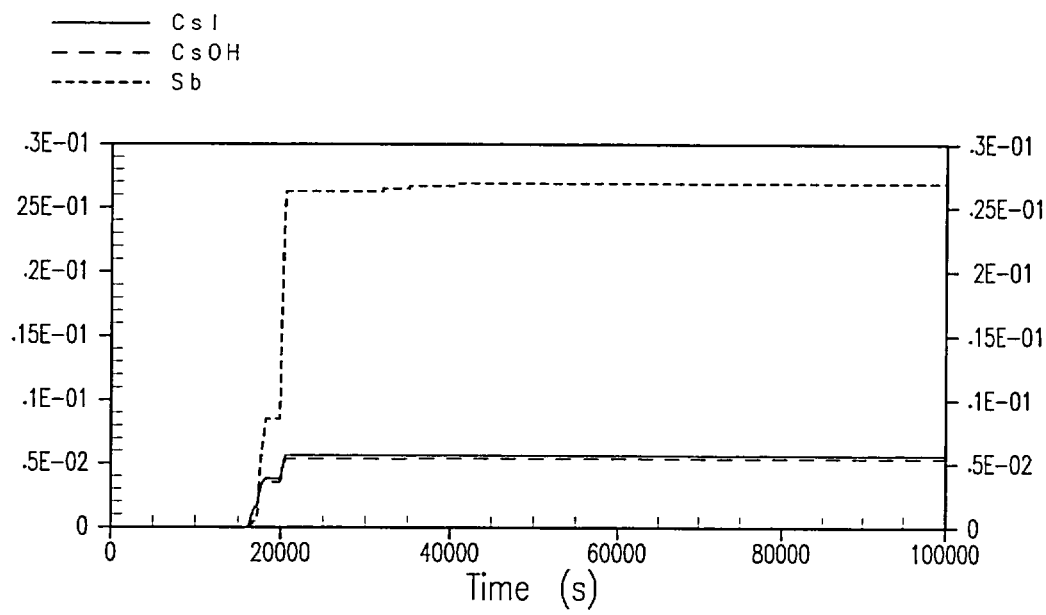

Figure 34-373

Case 1A-1: Mass Fraction of Fission Products Released to Environment Transient with Creep of SG Tubes

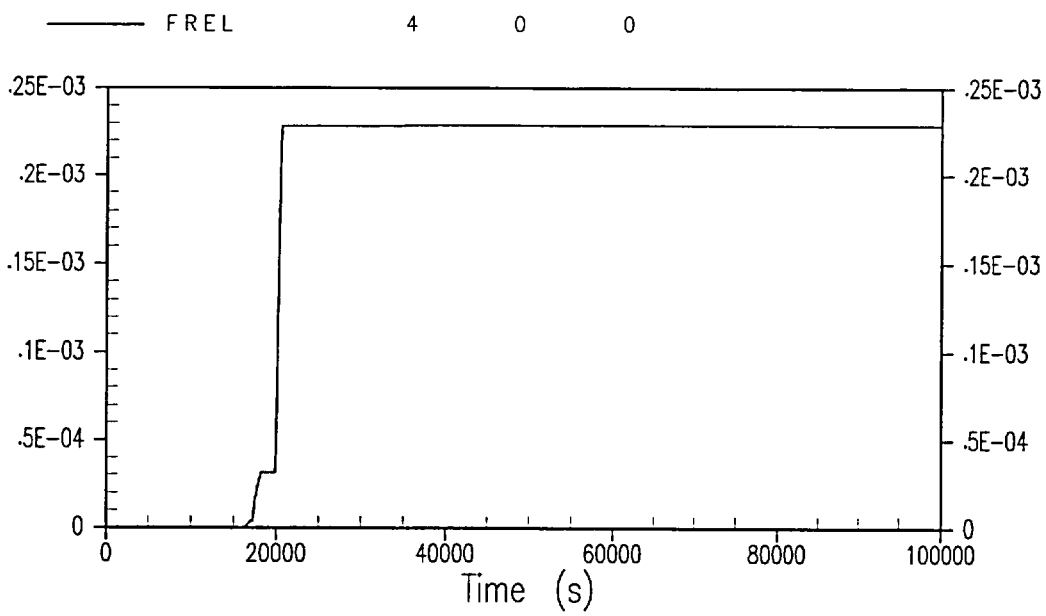

Figure 34-374

Case 1A-1: Mass Fraction of SrO Released to Environment Transient with Creep of SG Tubes

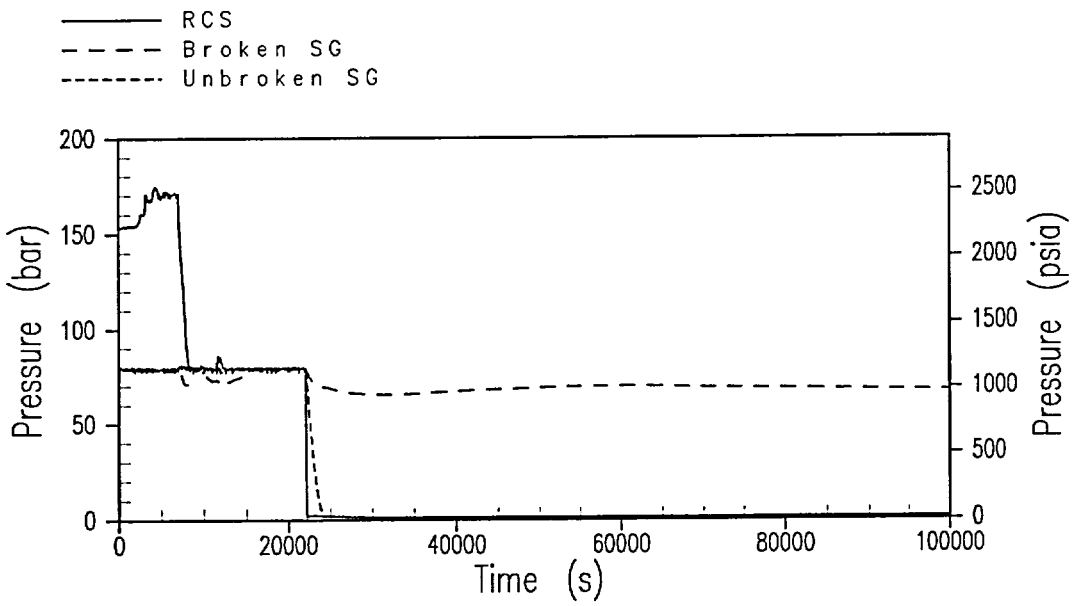

Figure 34-375

Case 1A-2: Reactor Coolant System and Steam Generator Pressure Transient with Creep of SG Tubes

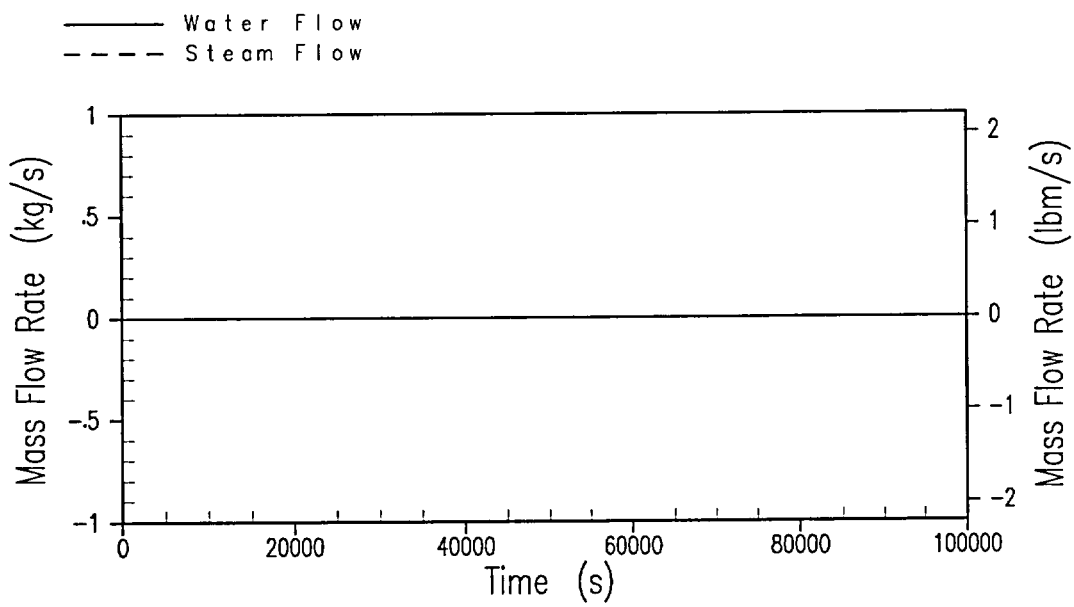

Figure 34-376

Case 1A-2: ADS Stage 4 Flow Rates Transient with Creep of SG Tubes

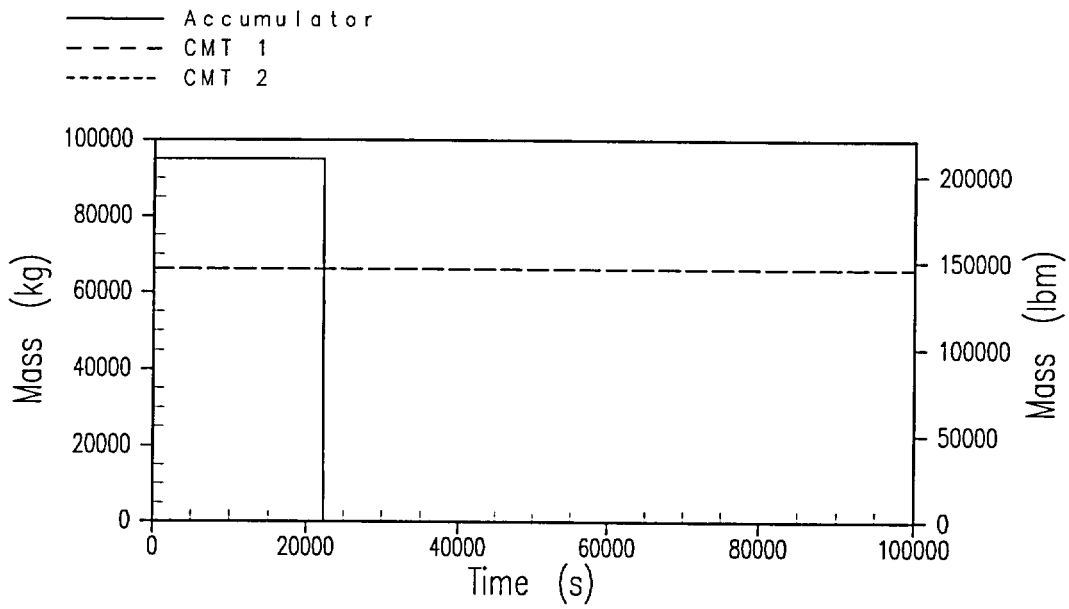

Figure 34-377

Case 1A-2: Accumulator/CMT Water Mass Transient with Creep of SG Tubes

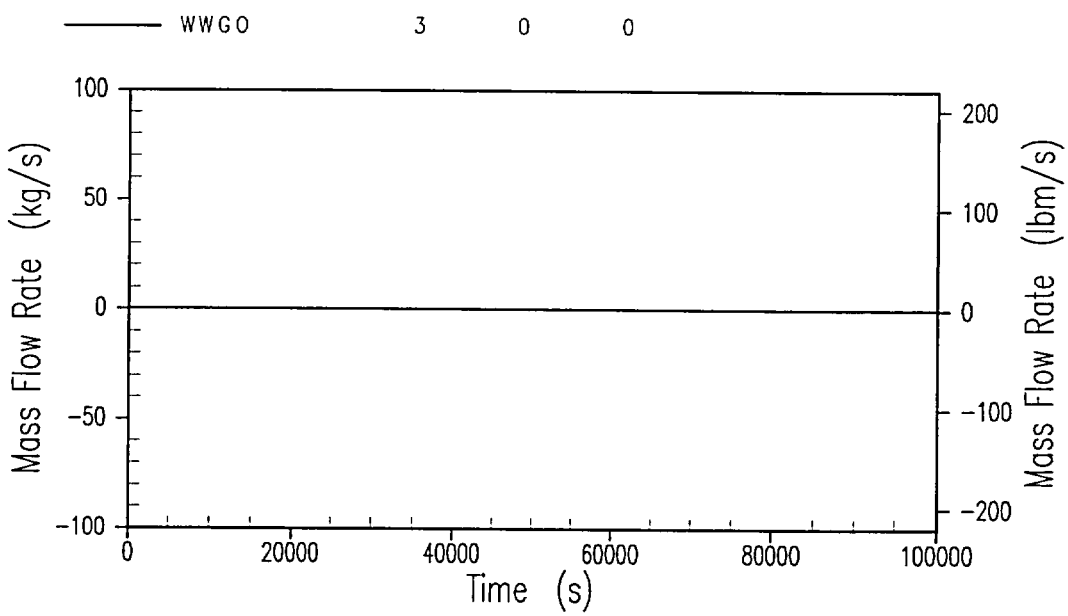

Figure 34-378

Case 1A-2: IRWST Injection Flow Rate Transient with Creep of SG Tubes

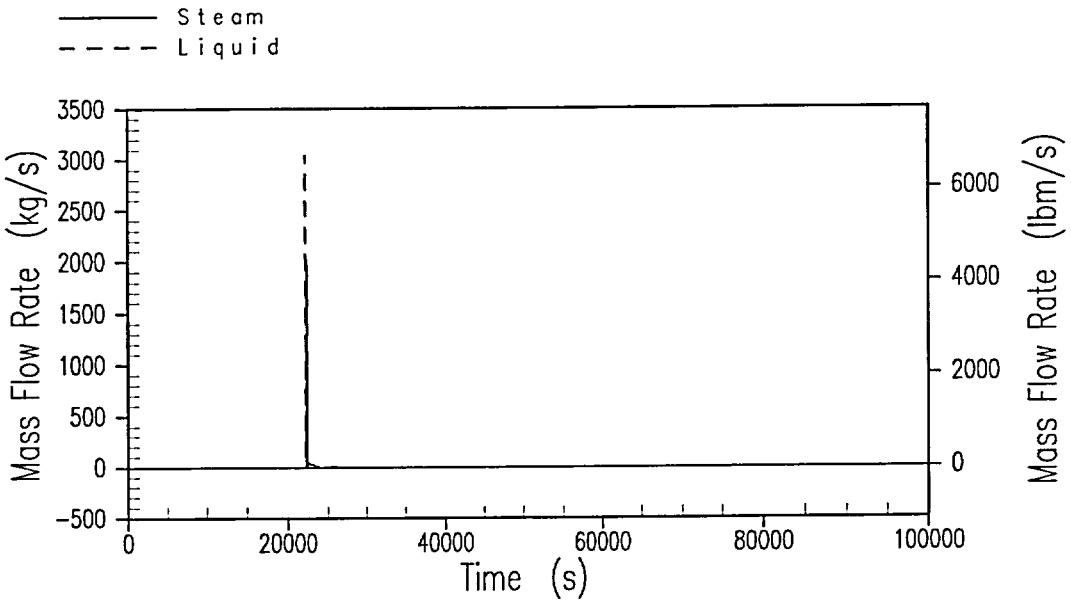

Figure 34-379

Case 1A-2: Break Flow Rate Transient with Creep of SG Tubes

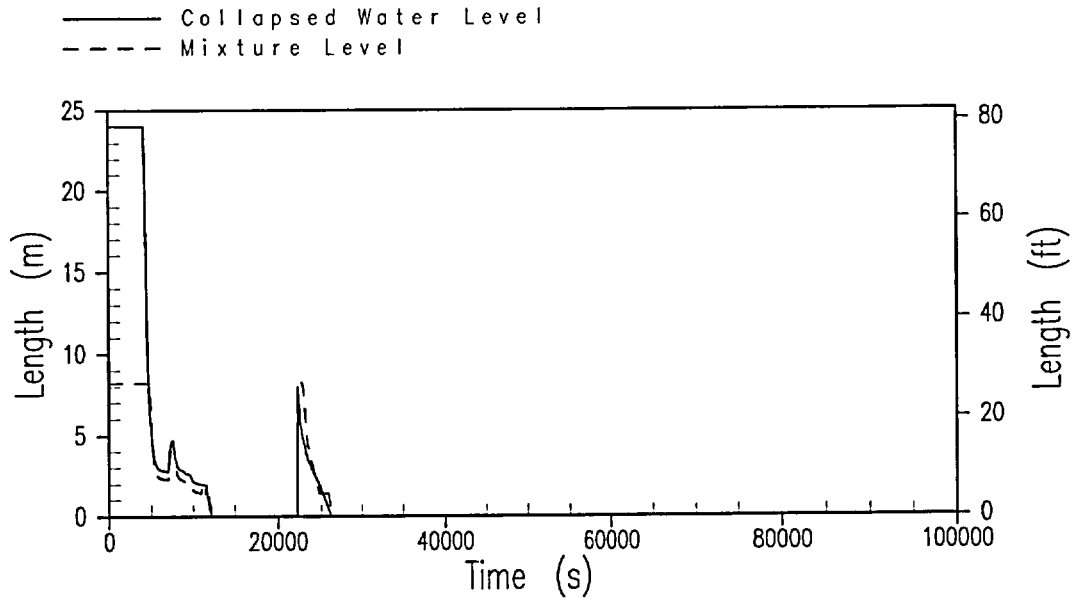

Figure 34-380

Case 1A-2: Reactor Vessel Water Level Transient with Creep of SG Tubes

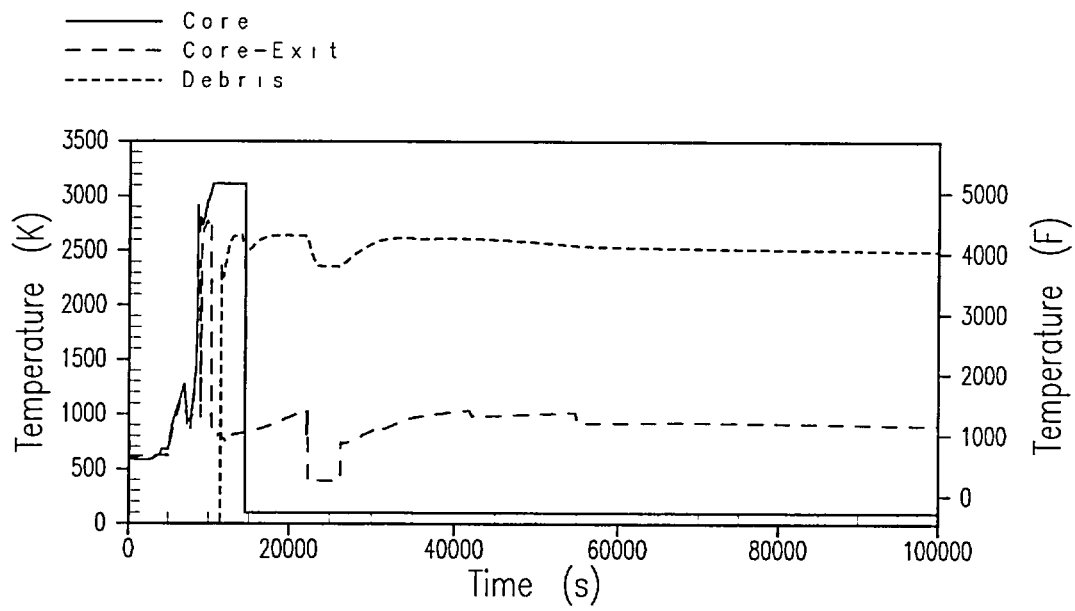

Figure 34-381

Case 1A-2: Core Temperatures Transient with Creep of SG Tubes

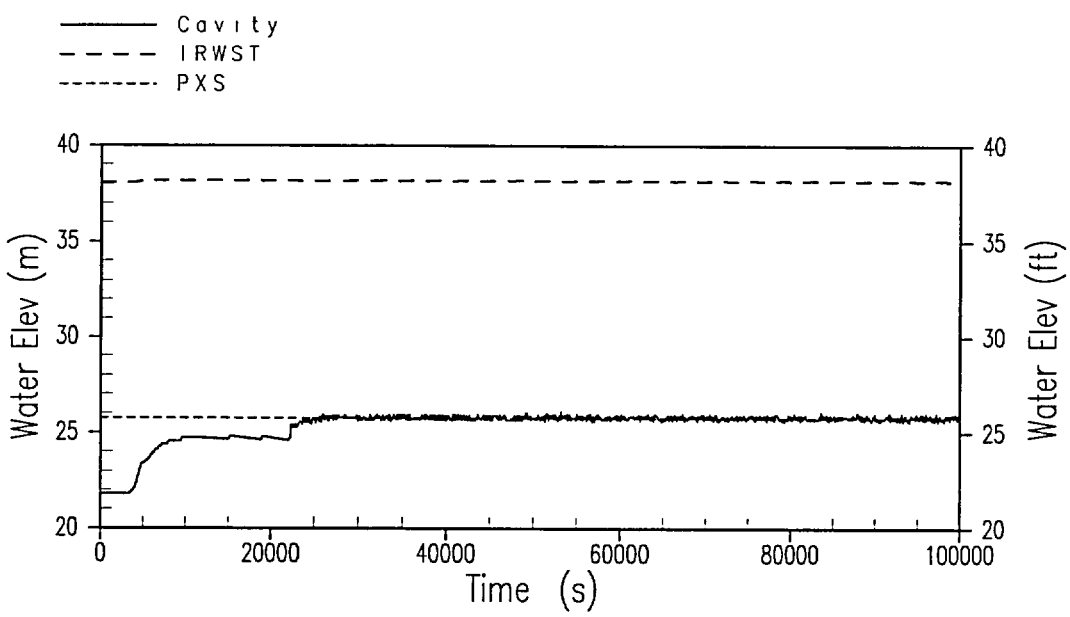

Figure 34-382

Case 1A-2: Containment Water Pool Elevations Transient with Creep of SG Tubes

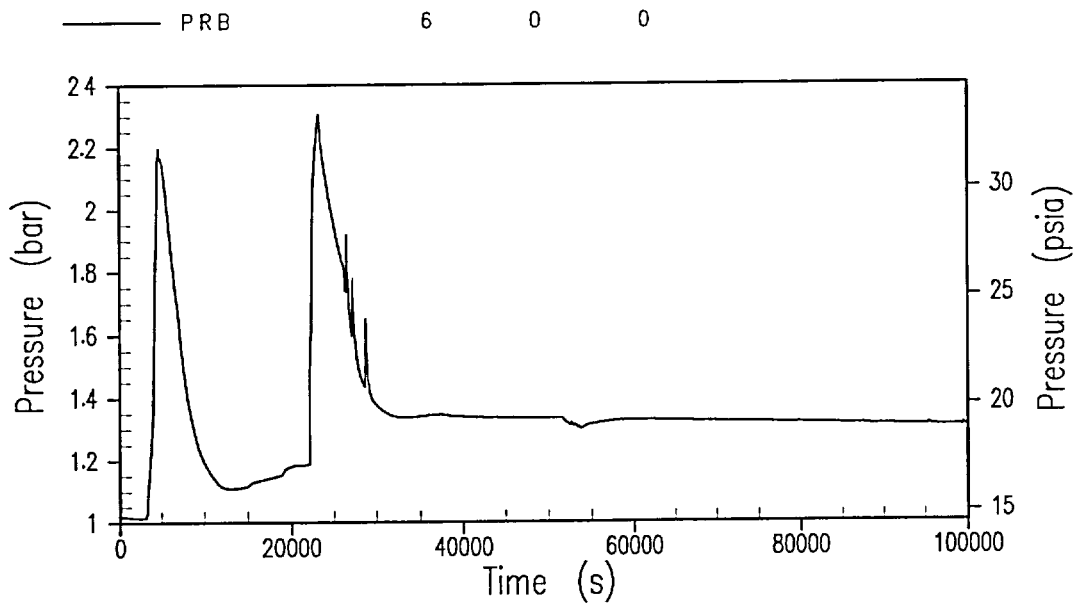

Figure 34-383

Case 1A-2: Containment Pressure Transient with Creep of SG Tubes

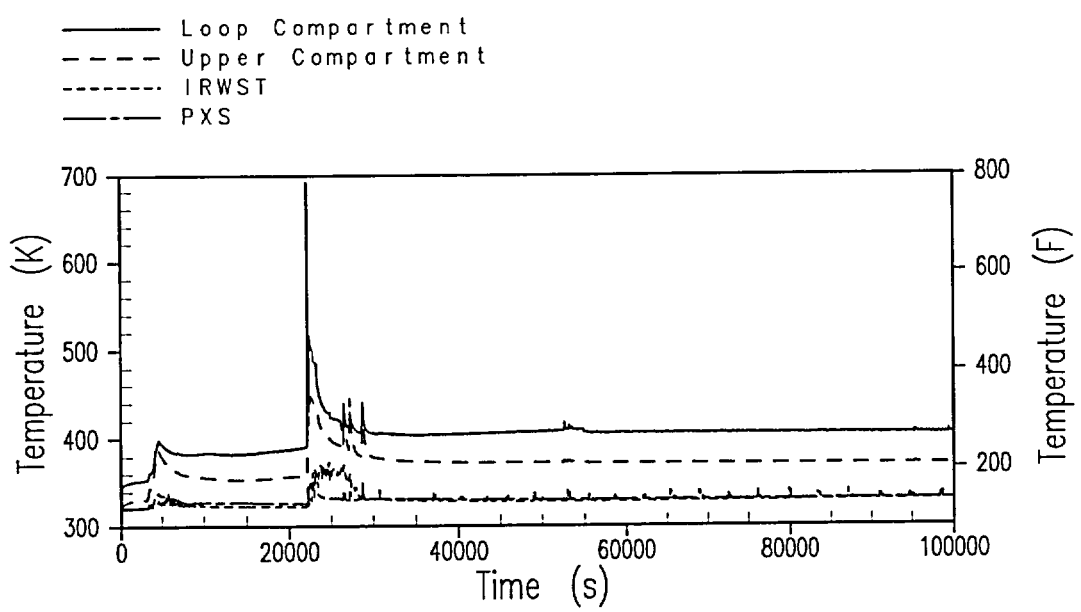

Figure 34-384

Case 1A-2: Containment Gas Temperature Transient with Creep of SG Tubes

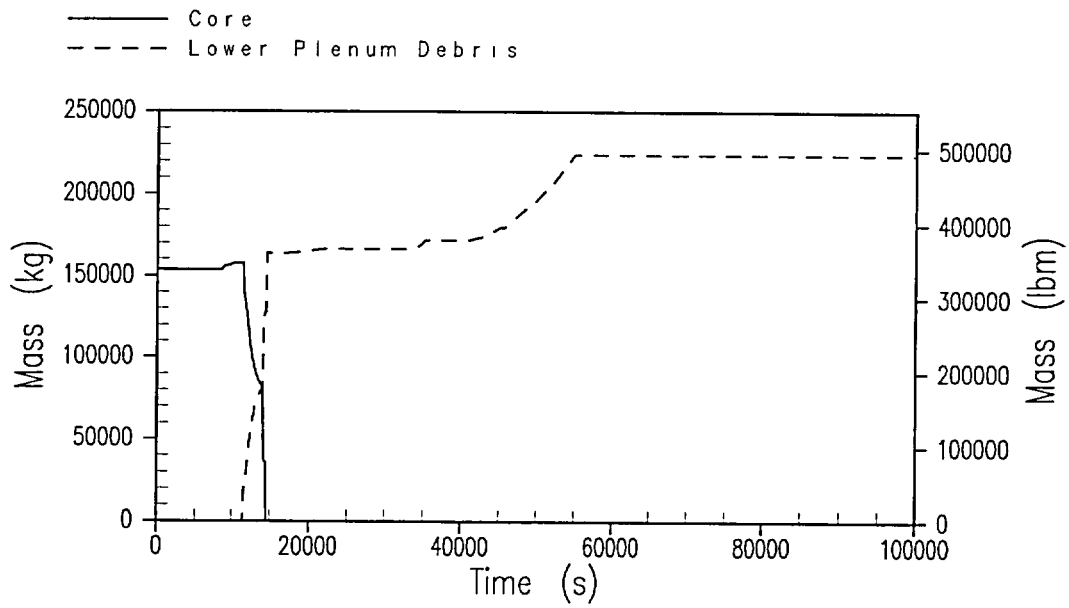

Figure 34-385

Case 1A-2: Core Mass Transient with Creep of SG Tubes

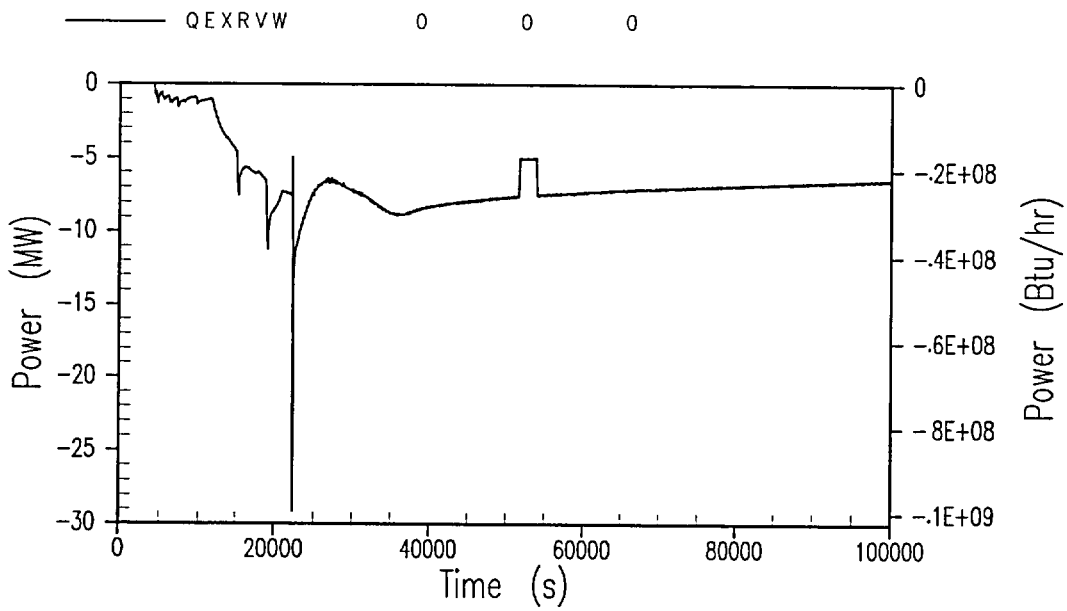

Figure 34-386

Case 1A-2: Reactor Pressure Vessel to Cavity Water Heat Transfer Transient with Creep of SG Tubes

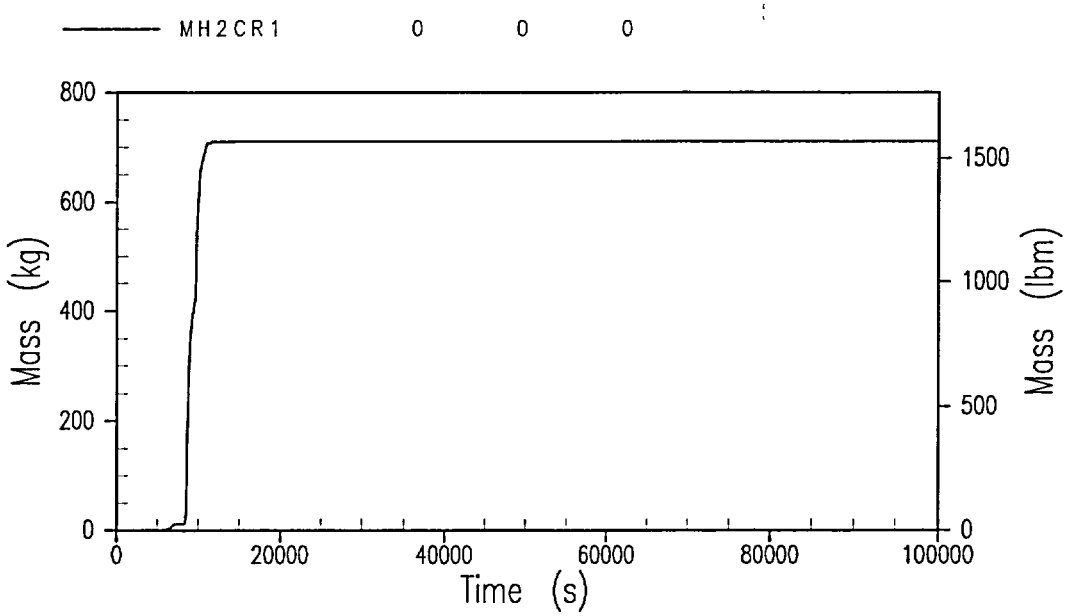

Figure 34-387

Case 1A-2: In-Vessel Hydrogen Generation Transient with Creep of SG Tubes

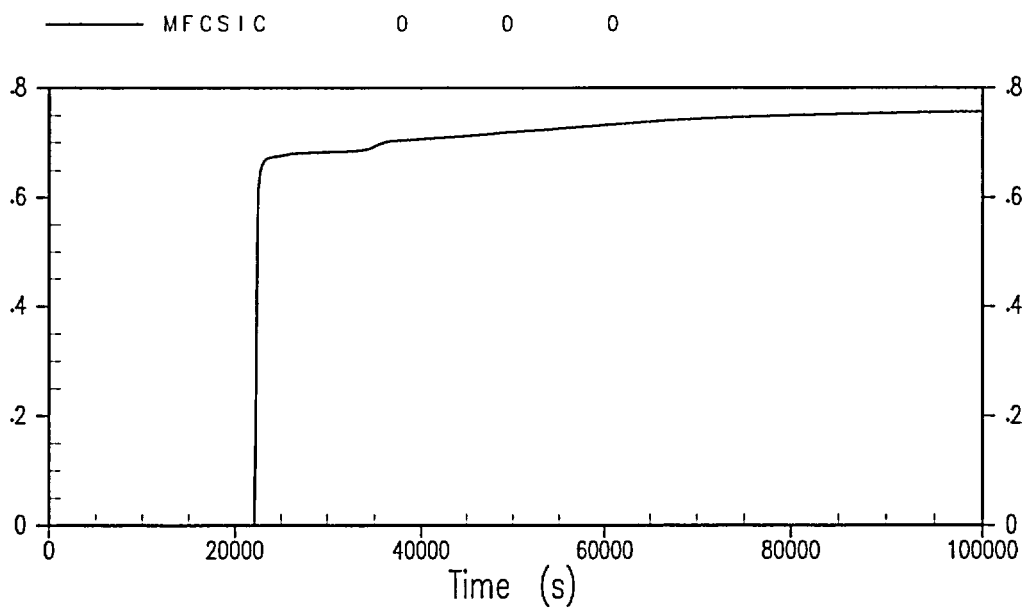

Figure 34-388

Case 1A-2: Mass Fraction of CsI Released to Containment Transient with Creep of SG Tubes

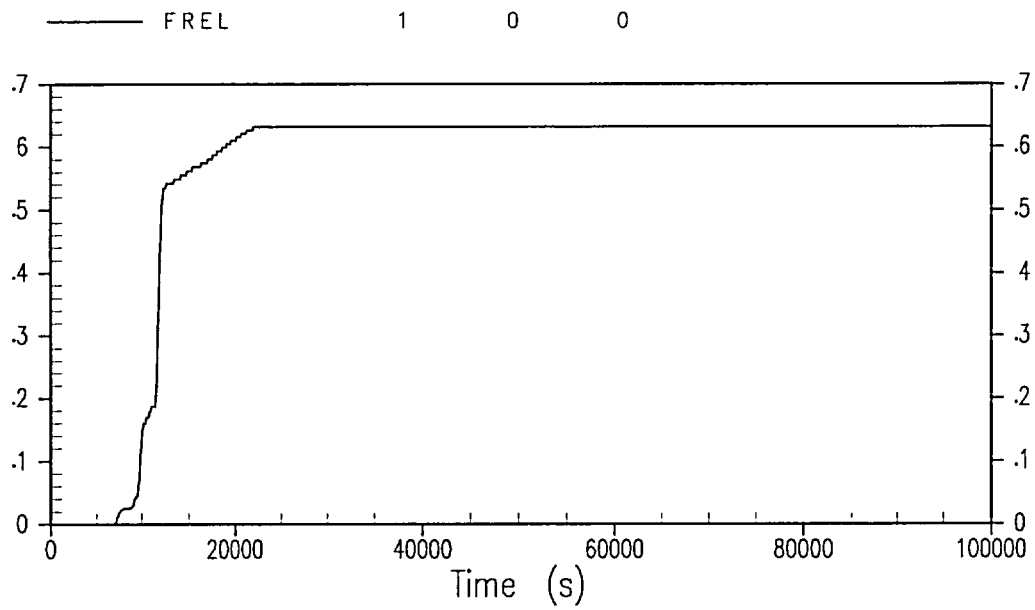

Figure 34-389

Case 1A-2: Mass Fraction of Noble Gases Released to Environment Transient with Creep of SG Tubes

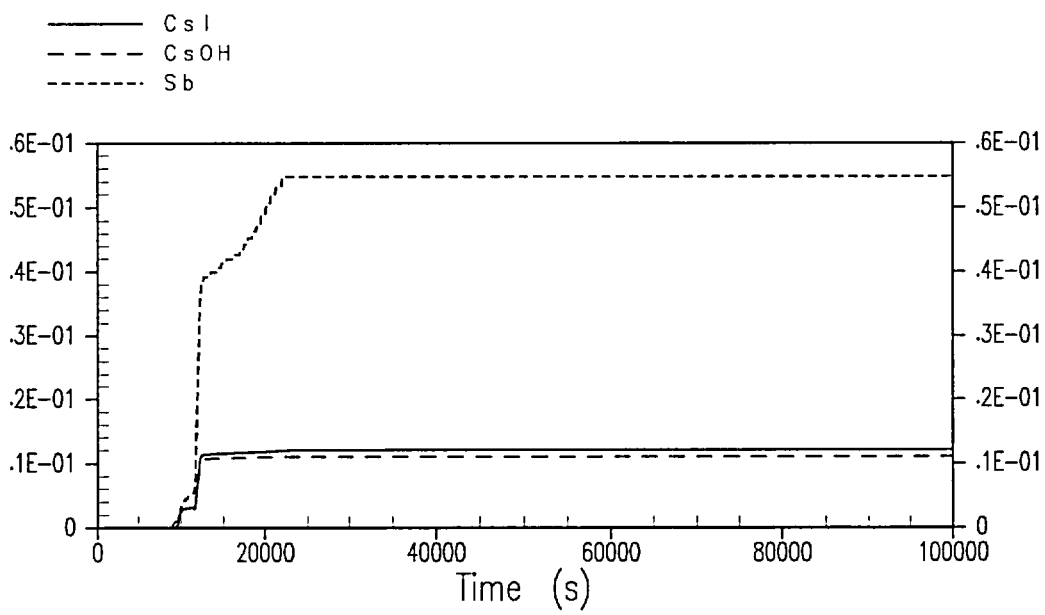

Figure 34-390

Case 1A-2: Mass Fraction of Fission Products Released to Environment Transient with Creep of SG Tubes

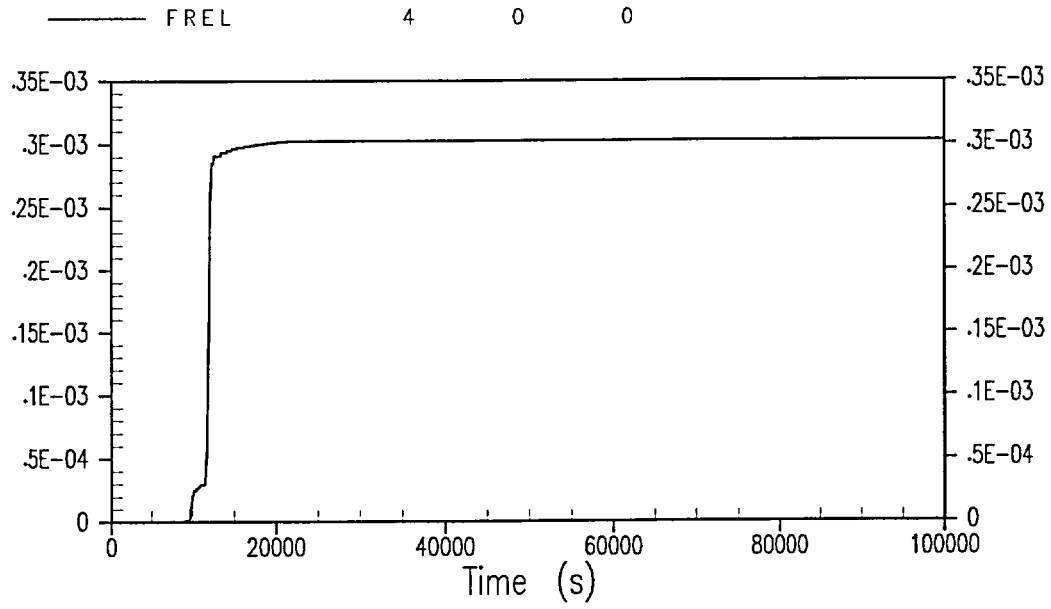

Figure 34-391

Case 1A-2: Mass Fraction of SrO Released to Environment Transient with Creep of SG Tubes