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TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2
CONTAINMENT INTEGRITY ANALYSES FOR ICE WEIGHT OPTIMIZATION
ENGINEERING REPORT

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EXECUTIVE SUMMARY

Loss-of-Coolant Long Term Containment Mass and Energy Release and Containment Integrity Analyses have been performed to support ice weight optimization at the Sequoyah Nuclear Plant Units 1 and 2. The objective of this effort was to provide revised containment mass and energy release data using current Sequoyah specific information and more realistic models to support ice weight reduction. The analyses conducted are consistent with current licensed methodology.

The analyses include LOCA long term mass and energy releases to be used to support the analytical basis and subsequently used in the LOTIC-1 Computer Code in the containment integrity response analyses.

The objective of this effort was to obtain ice weight optimization, retain current time interval (approximately 156 seconds) relationship between ice bed meltout time and containment spray switchover time and provide for peak pressure margin to design pressure.

The results of the analysis support the following:

- An ice mass of 1.7924875×10^6 lbms
- A calculated containment peak pressure of 11.45 psig occurring at 6378 seconds
- Ice bed meltout occurred at 3262 seconds (Containment spray switchover is completed at 3113 seconds thus the containment spray switchover ice bed meltout relationship is 149 seconds.

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1.0 INTRODUCTION

Containment Integrity analysis were performed to support ice weight optimization. The analysis effort was similar to the Sequoyah design basis containment integrity analysis presently documented in WCAP-12455 (1.93 million pound ice mass case) which was amended by WCAP-12455 Supplement 1.

Containment Integrity Analysis are performed during nuclear plant design to ensure that the pressure inside containment will remain below the containment building design pressure if a Loss-of-Coolant Accident (LOCA) inside containment should occur during plant operation. The analysis ensures that the containment heat removal capability is sufficient to remove the maximum possible discharge of mass and energy to containment from the Nuclear Steam Supply System without exceeding the acceptance criteria [design pressure].

This analysis utilized revised input assumptions which eliminated analytical conservatisms from the present analysis. Several areas addressed were assumed core stored energy, decay heat release, steam flow to turbine, steam generator metal heat steam and generator depressurization and equilibration. The analysis was completed to provide the analytical basis for a reduction in the present Sequoyah design basis ice mass of 1.93 million pounds with minimal impact on current margins in peak calculated containment pressure and ice bed meltout time to containment spray switchover time.

In addition to the design basis (WCAP-14255, Supplement 1), this analysis accounted for the effects of other plant changes that Westinghouse is aware of. These include effects stemming from RHR recirculation switchover alignment, revised minimum safety injection flows, initial condition uncertainties on RCS temperature of 5.5°F, which includes allowance for cold leg streaming, RCS (pressurizer) pressure uncertainty of 50 psia, and 17x17 V5H fuel. It should be noted that these items were included for completeness even though any or all of the items may not currently be implemented at the Sequoyah Units 1 and 2.

1.1 PURPOSE OF ANALYSIS

The purpose of this program was to calculate the long term Loss of Coolant (LOCA) mass and energy releases and the subsequent containment integrity response in order to demonstrate support for ice weight optimization and increased operating margins. This effort will address current Sequoyah specific plant conditions and revised models as a means of using available analytical margins to support a reduction in the amount ice required in the ice condenser. The objective of this effort in conducting the ice weight reduction from the current design basis 1.93 million pounds will be to maintain the current time interval (156 seconds) relationship between containment spray switchover time and ice bed

meltout time, and to provide peak pressure margin to design pressure.

A key element in obtaining ice mass reduction will be reducing the energy available to containment in the event of a LOCA. Areas such as core stored energy, decay heat, available steam generator metal heat, steam release to turbine from steam generators at the start of the event and a better segmental representation of the mass and energy release transient from the computer models currently contain margins which can be used to reduce energy input into containment.

This program will provide the analytical basis and the results which show that the containment design pressure is not exceeded in the event of a LOCA. The conclusions presented will demonstrate, with respect to LOCA, that containment integrity has not been compromised, and that a reduction in initial ice mass is acceptable. This containment analysis bounds both Units 1 and 2.

Rupture of any of the piping carrying pressurized high temperature reactor coolant, termed a LOCA, will result in release of steam and water into the containment. This, in turn, will result in an increase in the containment pressure and temperature. The mass and energy release rates described in this document form the basis of further computations to evaluate the structural integrity of the containment following a postulated accident to satisfy the Nuclear Regulatory acceptance criteria, General Design Criterion 38. Section 2.0 presents the long term mass and energy release analysis for containment pressurization evaluations. Section 3.0 presents the Containment Pressure Calculations.

1.2 SYSTEM CHARACTERISTICS AND MODELING ASSUMPTIONS

The mass and energy release analysis is sensitive to the assumed characteristics of various plant systems, in addition to other key modeling assumptions. Some of the most critical items are the: RCS initial conditions, core decay heat, safety injection flow, and metal and steam generator heat release modeling. Specific assumptions concerning each of these items are discussed below. Tables 2-1 through 2-3 present key data assumed in the analysis.

For the long term mass and energy release calculations, operating temperatures to bound the highest average coolant temperature range were used as bounding analysis conditions. The modeled core rated power of 3411 MWt adjusted for calorimetric error (+2 percent of power) was the basis in the analysis. The use of higher temperatures is conservative because the initial fluid energy is based on coolant temperatures which are at the maximum levels attained in steady state operation. Additionally, an allowance of +5.5 °F is reflected in the vessel/core temperature in order to account for instrument error and deadband. The initial reactor coolant system (RCS) pressure in this analysis is based on a nominal value of 2250 psia. Also included is an allowance of +50 psi, which accounts for the measurement uncertainty on pressurizer

pressure. The selection of 2250 psia as the limiting pressure is considered to affect the blowdown phase results only, since this represents the initial pressure of the RCS. The RCS rapidly depressurizes from this value until the point at which it equilibrates with containment pressure.

The rate at which the RCS blows down is initially more severe at the higher RCS pressure. Additionally the RCS has a higher fluid density at the higher pressure (assuming a constant temperature) and subsequently has a higher RCS mass available for releases. Thus, 2300 psia initial pressure was selected as the limiting case for the long term mass and energy release calculations. These assumptions conservatively maximize the mass and energy in the RCS.

The selection of the fuel design features for the long term mass and energy calculation is based on the need to conservatively maximize the core stored energy. The margin in core stored energy was chosen to be +15 percent. Thus, the analysis very conservatively accounts for the stored energy in the core. The fuel conditions were adjusted to provide a bounding analysis for current Sequoyah Nuclear Plant Units 1 and 2 fuel features. The following items serve as the basis to ensure conservatism in the core stored energy calculation: a conservatively high reload core loading; time of maximum fuel densification, i.e., highest BOL temperatures;, and irradiated fuel assemblies are assumed to have an average burnup ≥15000 MWD/MTU.

Margin in RCS volume of 3% (which is composed of 1.6% allowance for thermal expansion and 1.4% for uncertainty) is modeled.

Regarding safety injection flow, the mass and energy calculation considered the historically limiting configuration of minimum safety injection flow.

The following assumptions were employed to ensure that the mass and energy releases are conservatively calculated, thereby maximizing energy release to containment:

1. Maximum expected operating temperature of the reactor coolant system (100% full power conditions)

2. An allowance in temperature for instrument error and dead band was assumed on the vessel/core inlet temperature (+5.5 degrees F)

3. Margin in volume of 3% (which is composed of 1.6% allowance for thermal expansion, and 1.4% for uncertainty)

4. Core rated power of 3411 MWt

5. Allowance for calorimetric error (+2 percent of power)

6. Conservative coefficient of heat transfer (i.e., steam

generator primary/secondary heat transfer and reactor coolant system metal heat transfer)

7. Allowance in core store energy for effect of fuel densification

8. A margin in core stored energy (+15 percent included to account for manufacturing tolerances)

9. An allowance for RCS initial pressure uncertainty (+50 psi)

10. A maximum containment backpressure equal to design pressure

11. The steam generator metal mass was modeled to include only the portion of the steam generators (SG) which is in contact with the fluid on the secondary side. Portions of the SGs such as the elliptical head, upper shell and misc. internals have poor heat transfer due to location. The heat stored in these areas available for release to containment will not be able to effectively transfer energy to the RCS, thus the energy will be removed at a much slower rate and time period (>10000 seconds).

12. A provision for modeling steam flow in the secondary side through the steam generator turbine stop valve was conservatively addressed only at the start of the event. Turbine stop valve isolation time equal to 1.19 seconds was considered.

13. As noted in Section 2.4 of Reference 1, the option to provide more specific modeling pertaining to decay heat has been exercised to specifically reflect the Sequoyah Units 1 and 2 core heat generation, while retaining the two sigma uncertainty to assure conservatism.

14. Steam generator tube plugging leveling (0% uniform)

    - Maximizes reactor coolant volume and fluid release
    - Maximizes heat transfer area across the SG tubes
    - Reduces coolant loop resistance, which Δp upstream of break and increases break flow

Thus, based on the previously noted conditions and assumptions, a bounding analysis of Sequoyah Units 1 and 2 is made for the release of mass and energy from the RCS in the event of a LOCA to support ice weight optimization.

2.0 LONG TERM LOCA MASS AND ENERGY RELEASE ANALYSIS

2.1 INTRODUCTION

The evaluation model used for the long term LOCA mass and energy release calculations was the March 1979 model described in Reference 1. This evaluation model has been reviewed and approved by the NRC, and has been used in the analysis of other ice condenser plants.

This report section presents the long term LOCA mass and energy releases that were generated in support of the Sequoyah Nuclear Plant Units 1 and 2 ice weight optimization program. These mass and energy releases are then subsequently used in the LOTIC-1 computer code for containment integrity analysis peak pressure calculations.

2.2 LOCA MASS AND ENERGY RELEASE PHASES

The containment system receives mass and energy releases following a postulated rupture in the RCS. These releases continue over a time period, which, for the LOCA mass and energy analysis, is typically divided into four phases:

1. Blowdown - the period of time from accident initiation (when the reactor is at steady state operation) to the time that the RCS and containment reach an equilibrium state at containment design pressure.

2. Refill - the period of time when the lower plenum is being filled by accumulator and ECCS water. At the end of blowdown, a large amount of water remains in the cold legs, downcomer, and lower plenum. To conservatively consider the refill period for the purpose of containment mass and energy releases, it is assumed that this water is instantaneously transferred to the lower plenum along with sufficient accumulator water to completely fill the lower plenum. This allows an uninterrupted release of mass and energy to containment. Thus, the refill period is conservatively neglected in the mass and energy release calculation.

3. Reflood - begins when the water from the lower plenum enters the core and ends when the core is completely quenched.

4. Post-reflood (Froth) - describes the period following the reflood transient. For the pump suction break, a two-phase mixture exits the core, passes through the hot legs, and is superheated in the steam generators. After the broken loop steam generator cools, the break flow becomes two phase.

2.2.1 Computer Codes

The Reference 1 mass and energy release evaluation model is

comprised of mass and energy release versions of the following codes: SATAN VI, WREFLOOD, and FROTH. These codes were used to calculate the long term LOCA mass and energy releases for the Sequoyah Nuclear Plant Units 1 and 2.

SATAN calculates blowdown, the first portion of the thermal-hydraulic transient following break initiation, including pressure, enthalpy, density, mass and energy flowrates, and energy transfer between primary and secondary systems as a function of time.

The WREFLOOD code addresses the portion of the LOCA transient where the core reflooding phase occurs after the primary coolant system has depressurized (blowdown) due to the loss of water through the break and when water supplied by the Emergency Core Cooling refills the reactor vessel and provides cooling to the core. The most important feature is the steam/water mixing model (See Section 2.5.2).

FROTH models the post-reflood portion of the transient. The FROTH code is used for the steam generator heat addition calculation from the broken and intact loop steam generators.

2.3 BREAK SIZE AND LOCATION

Generic studies have been performed with respect to the effect of postulated break size on the LOCA mass and energy releases. The double ended guillotine break has been found to be limiting due to larger mass flow rates during the blowdown phase of the transient. During the reflood and froth phases, the break size has little effect on the releases.

Three distinct locations in the reactor coolant system loop can be postulated for pipe rupture:

1. Hot leg (between vessel and steam generator)
2. Cold leg (between pump and vessel)
3. Pump suction (between steam generator and pump)

The break location analyzed for the Ice Optimization Program is the pump suction double ended rupture guillotine, DEPSG (10.46 ft^2). Break mass and energy releases have been calculated for the blowdown, reflood, and post-reflood phases of the LOCA for each case analyzed. The following information provides a discussion on each break location.

The hot leg double ended rupture has been shown in previous studies to result in the highest blowdown mass and energy release rates. Although the core flooding rate would be the highest for this break location, the amount of energy released from the steam generator secondary is minimal because the majority of the fluid which exits the core bypasses the steam generators venting directly to containment. As a result, the reflood mass and energy releases are reduced significantly as compared to either the pump suction or

cold leg break locations where the core exit mixture must pass through the steam generators before venting through the break. For the hot leg break, generic studies have confirmed that there is no reflood peak (i.e., from the end of the blowdown period the containment pressure would continually decrease). The mass and energy releases for the hot leg break have not been included in the scope of this containment integrity analysis because for the hot leg break only the blowdown phase of the transient is of any significance. Since there are no reflood and post-reflood phases to consider, the limiting peak pressure calculated would be the compression peak pressure and not the peak pressure following ice bed meltout.

The cold leg break location has also been found in previous studies to be much less limiting in terms of the overall containment energy releases. The cold leg blowdown is faster than that of the pump suction break, and more mass is released into the containment. However, the core heat transfer is greatly reduced, and this results in a considerably lower energy release into containment. Studies have determined that the blowdown transient for the cold leg is, in general, less limiting than that for the pump suction break. During reflood, the flooding rate is greatly reduced and the energy release rate into the containment is reduced. Therefore, the cold leg break is not included in the scope of this program.

The pump suction break combines the effects of the relatively high core flooding rate, as in the hot leg break, and the addition of the stored energy in the steam generators. As a result, the pump suction break yields the highest energy flow rates during the post-blowdown period by including all of the available energy of the Reactor Coolant System in calculating the releases to containment. This break has been determined to be the limiting break for all ice condenser plants.

In summary, the analysis of the limiting break location for an ice condenser containment has been performed and is shown in this report. The double-ended pump suction guillotine break has historically been considered to be the limiting break location, by virtue of its consideration of all energy sources in the Reactor Coolant System (RCS). This break location provides mechanism for the release of the available energy in the RCS, including both the broken and intact loop steam generators.

2.4 APPLICATION OF SINGLE FAILURE CRITERIA

An analysis of the effects of the single failure criteria has been performed on the mass and energy release rates for the pump suction (DEPSG) break. An inherent assumption in the generation of the mass and energy release is that offsite power is lost. This results in the actuation of the emergency diesel generators, required to power the safety injection system. This is not an issue for the blowdown period which is limited by the compression

peak pressure.

The limiting minimum safety injection case has been analyzed for the effects of a single failure. In the case of minimum safeguards, the single failure postulated to occur is the loss of an emergency diesel generator. This results in the loss of one pumped safety injection train, i.e. ECCS pumps and heat exchangers.

2.5 MASS AND ENERGY RELEASE DATA

2.5.1 Blowdown Mass and Energy Release Data

A version of the SATAN-VI code is used for computing the blowdown transient, which is the code used for the Emergency Core Cooling System (ECCS) calculation in Reference 2.

The code utilizes the control volume (element) approach with the capability for modeling a large variety of thermal fluid system configurations. The fluid properties are considered uniform and thermodynamic equilibrium is assumed in each element. A point kinetics model is used with weighted feedback effects. The major feedback effects include moderator density, moderator temperature, and Doppler broadening. A critical flow calculation for subcooled (modified Zaloudek), two-phase (Moody), or superheated break flow is incorporated into the analysis. The methodology for the use of this model is described in Reference 1.

Table 2-4 presents the calculated mass and energy releases for the blowdown phase of the DEPSG break. For the pump suction breaks, break path 1 in the mass and energy release tables refers to the mass and energy exiting from the steam generator side of the break; break path 2 refers to the mass and energy exiting from the pump side of the break.

2.5.2 Reflood Mass and Energy Release Data

The WREFLOOD code used for computing the reflood transient, is a modified version of that used in the 1981 ECCS evaluation model, Reference 2.

The WREFLOOD code consists of two basic hydraulic models - one for the contents of the reactor vessel, and one for the coolant loops. The two models are coupled through the interchange of the boundary conditions applied at the vessel outlet nozzles and at the top of the downcomer. Additional transient phenomena such as pumped safety injection and accumulators, reactor coolant pump performance, and steam generator release are included as auxiliary equations which interact with the basic models as required. The WREFLOOD code permits the capability to calculate variations during the core reflooding transient of basic parameters such as core flooding rate, core and downcomer water levels, fluid thermodynamic conditions (pressure, enthalpy, density) throughout the primary

system, and mass flow rates through the primary system. The code permits hydraulic modeling of the two flow paths available for discharging steam and entrained water from the core to the break; i.e. the path through the broken loop and the path through the unbroken loops.

A complete thermal equilibrium mixing condition for the steam and emergency core cooling injection water during the reflood phase has been assumed for each loop receiving ECCS water. This is consistent with the usage and application of the Reference 1 mass and energy release evaluation model, in recent analyses, e.g. D.C. Cook Docket [Reference 3]. Even though the Reference 1 model credits steam/mixing only in the intact loop and not in the broken loop, justification, applicability, and NRC approval for using the mixing model in the broken loop has been documented [Reference 3]. This assumption is justified and supported by test data, and is summarized as follows:

The model assumes a complete mixing condition (i.e., thermal equilibrium) for the steam/water interaction. The complete mixing process, however, is made up of two distinct physical processes. The first is a two phase interaction with condensation of steam by cold ECCS water. The second is a single phase mixing of condensate and ECCS water. Since the steam release is the most important influence to the containment pressure transient, the steam condensation part of the mixing process is the only part that need be considered. (Any spillage directly heats only the sump.)

The most applicable steam/water mixing test data has been reviewed for validation of the containment integrity reflood steam/water mixing model. This data is that generated in 1/3 scale tests [Reference 4], which are the largest scale data available and thus most clearly simulates the flow regimes and gravitational effects that would occur in a PWR. These tests were designed specifically to study the steam/water interaction for PWR reflood conditions.

From the entire series of 1/3 scale tests, a group corresponds almost directly to containment integrity reflood conditions. The injection flowrates for this group cover all phases and mixing conditions calculated during the reflood transient. The data from these tests were reviewed and discussed in detail in Reference 1. For all of these tests, the data clearly indicate the occurrence of very effective mixing with rapid steam condensation. The mixing model used in the containment integrity reflood calculation is therefore wholly supported by the 1/3 scale steam/water mixing data.

Additionally, the following justification is also noted. The post-blowdown limiting break for the containment integrity peak pressure analysis is the pump suction double ended rupture break. For this break, there are two flowpaths available in the RCS by which mass and energy may be released to containment. One is through the outlet of the steam generator, the other via reverse flow through the reactor coolant pump. Steam which is not condensed by ECCS

injection in the intact RCS loops passes around the downcomer and through the broken loop cold leg and pump in venting to containment. This steam also encounters ECCS injection water as it passes through the broken loop cold leg, complete mixing occurs and a portion of it is condensed. It is this portion of steam which is condensed that is taken credit for in this analysis. This assumption is justified based upon the postulated break location, and the actual physical presence of the ECCS injection nozzle. A description of the test and test results is contained in References 1 and 4.

Table 2-5 present the calculated mass and energy release for the reflood phase of the pump suction double ended rupture with minimum safety injection.

The transients of the principal parameters during reflood are given in Table 2-6.

2.5.3 Post-Reflood Mass and Energy Release Data

The FROTH code [Reference 5] is used for computing the post-reflood transient.

The FROTH code calculates the heat release rates resulting from a two-phase mixture level present in the steam generator tubes. The mass and energy releases that occur during this phase are typically superheated due to the depressurization and equilibration of the broken loop and intact loop steam generators. During this phase of the transient, the RCS has equilibrated with the containment pressure, but the steam generators contain a secondary inventory at an enthalpy that is much higher than the primary side. Therefore, there is a significant amount of reverse heat transfer that occurs. Steam is produced in the core due to core decay heat. For a pump suction break, a two phase fluid exits the core, flows through the hot legs and becomes superheated as it passes through the steam generator. Once the broken loop cools, the break flow becomes two phase. The methodology for the use of this model is described in Reference 1.

After steam generator depressurization/equilibration, the mass and energy release available to containment is generated directly from core boiloff/decay heat.

Table 2-7 presents the two phase post-reflood (froth) mass and energy release data for the pump suction double ended case.

2.5.4 Decay Heat Model

On November 2, 1978 the Nuclear Power Plant Standards Committee (NUPPSCO) of the American Nuclear Society approved ANS standard 5.1 for the determination of decay heat. This standard was used in the mass and energy release model with the following input specific for

the Sequoyah Nuclear Plant Units 1 and 2. The primary assumptions which make this calculation specific for the Sequoyah Nuclear Plant Units 1 and 2 are the enrichment factor, minimum/maximum new fuel per cycle, and cycle length. A conservative lower bound for enrichment of 3% was used. Table 3-2 lists the decay heat curve used in the Sequoyah Ice Weight Optimization analysis.

Significant assumptions in the generation of the decay heat curve:

1. Decay heat sources considered are fission product decay and heavy element decay of U-239 and N_p-239.

2. Decay heat power from fissioning isotopes other than U-235 is assumed to be identical to that of U-235.

3. Fission rate is constant over the operating history of maximum power level.

4. The factor accounting for neutron capture in fission products has been taken from Equation 11, of Reference 6 up to 10,000 seconds, and Table 10, of Reference 6 beyond 10,000 seconds.

5. The fuel has been assumed to be at full power for 10^8 seconds.

6. The number of atoms of U-239 produced per second has been assumed to be equal to 70% of the fission rate.

7. The total recoverable energy associated with one fission has been assumed to be 200 MeV/fission.

8. Two sigma uncertainty (two times the standard deviation) has been applied to the fission product decay.

2.5.5 Steam Generator Equilibration and Depressurization

Steam generator equilibration and depressurization is the process by which secondary side energy is removed from the steam generators in stages. The FROTH computer code calculates the heat removal from the secondary mass until the secondary temperature is Tsat at the containment design pressure. After the FROTH calculations, steam generator secondary energy is removed until the steam generator reaches Tsat at the user specified intermediate equilibration pressure, when the secondary pressure is assumed to reach the actual containment pressure. The heat removal of the broken loop and intact loop steam generators are calculated separately.

During the FROTH calculations, steam generator heat removal rates are calculated using the secondary side temperature, primary side temperature and a secondary side heat transfer coefficient determined using a modified McAdam's correlation. Steam generator

energy is removed during the FROTH transient until the secondary side temperature reaches saturation temperature at the containment design pressure. The constant heat removal rate used is based on the final heat removal rate calculated by FROTH. The remaining SG energy available to be released is determined by calculating the difference in secondary energy available at the containment design pressure and that at the (lower) user specified equilibration pressure, assuming saturated conditions. This energy is then divided by the energy removal rate, resulting in an equilibration time.

2.6 SOURCES OF MASS AND ENERGY

The sources of mass considered in the LOCA mass and energy release analysis are given in Table 2-8. These sources are the reactor coolant system, accumulators, and pumped safety injection.

The energy inventories considered in the LOCA mass and energy release analysis are given in Table 2-9. The energy sources include:

1. Reactor Coolant System Water

2. Accumulator Water

3. Pumped Injection Water

4. Decay Heat

5. Core Stored Energy

6. Reactor Coolant System Metal
   - Primary Metal (includes SG tubes)

7. Steam Generator Metal
   (includes transition cone, shell, wrapper, and other internals)

8. Steam Generator Secondary Energy
   (includes fluid mass and steam mass)

9. Secondary Transfer of Energy (feedwater into and steam out of the steam generator secondary)

It should be noted that the inconsistency in the energy balance tables from the end of Reflood to the time of intact loop steam generator depressurization/equilibration, i.e., "Total Available" data versus "Total Accountable" resulted from the omission of the reactor upper head in the analysis following blowdown. It has been concluded that the results are more conservative when the upper head is neglected. This does not affect the instantaneous mass and energy releases, or the integrated values, but causes an increase in the total accountable energy within the energy balance table.

The mass and energy inventories are presented at the following times, as appropriate:

1. Time zero (initial conditions)
2. End of blowdown time
3. End of refill time
4. End of reflood time
5. Time of broken loop steam generator equilibration to pressure setpoint
6. Time of intact loop steam generator equilibration to pressure setpoint

In the mass and energy release data presented, no Zirc-water reaction heat was considered because the clad temperature did not rise high enough for the rate of the Zirc-water reaction heat to be of any significance.

The consideration of the various energy sources in the mass and energy release analysis provides assurance that all available sources of energy have been included in this analysis. Thus the review guidelines presented in Standard Review Plan Section 6.2.1.3 have been satisfied.

TABLE 2-1

SEQUOYAH UNITS 1 AND 2
SYSTEM PARAMETERS
INITIAL CONDITIONS

PARAMETERS	VALUE
Core Thermal Power (MWt)	3411
Reactor Coolant System Flowrate, per Loop (gpm)	91400.
Vessel Outlet Temperature* (°F)	609.7
Core Inlet Temperature* (°F)	546.7
Vessel Average Temperature (°F)	578.2
Initial Steam Generator Steam Pressure (psia)	857
Steam Generator Design	Model 51
Steam Generator Tube Plugging (%)	0
Initial Steam Generator Secondary Side Mass (lbm)	114075
Accumulator	
Water Volume (ft^3)	1103
N_2 Cover Gas Pressure (psig)	600
Temperature (°F)	120
Safety Injection Delay (sec) (includes time to reach pressure setpoint)	29.0

* (analysis value includes an additional +5.5°F allowance for instrument error and deadband)

TABLE 2-2

SEQUOYAH UNITS 1 AND 2
SYSTEM PARAMETERS
DECAY HEAT CURVE

Time (sec)	Decay Heat (BTU/BTU)
10	0.052293
15	0.049034
20	0.047562
40	0.041504
60	0.038493
80	0.036410
100	0.034842
150	0.032180
200	0.030432
400	0.026664
600	0.024486
800	0.022943
1000	0.021722
1500	0.019483
2000	0.017903
4000	0.014386
6000	0.012684
8000	0.011645
10000	0.010916
15000	0.010130
20000	0.009368
40000	0.007784
60000	0.006976
80000	0.006439
100000	0.006034
150000	0.005336
200000	0.004859
400000	0.003781
600000	0.003212
800000	0.002844
1000000	0.002589
1500000	0.002175
2000000	0.001915
4000000	0.001356
6000000	0.001090
8000000	0.000924
10000000	0.000804

Key Assumptions

-18 month fuel cycle
-Standard and V5H fuel
-Low bound for enrichment: 3.0%

TABLE 2-3

SEQUOYAH UNITS 1 AND 2
SAFETY INJECTION FLOW
MINIMUM SAFETY INJECTION

INJECTION MODE

RCS Pressure (psig)	Total Flow (GPM)
0	4957.1
12	4810.0
20	4711.9
40	4445.9
60	4132.9
80	3771.2
100	3364.8
120	2933.3
140	2413.7
160	1697.9
180	966.3
200	959.6

INJECTION MODE (POST-REFLOOD PHASE)

RCS Pressure (psig)	Total Flow (GPM)
12	4810.0

RECIRCULATION MODE
(W/O RHR SPRAY)

RCS Pressure (psig)	Total Flow (GPM)
0	3299

RECIRCULATION MODE
(W/ RHR SPRAY)

RCS Pressure (psig)	Total Flow (GPM)
0	1060

TABLE 2-4

SEQUOYAH UNITS 1 AND 2
DOUBLE-ENDED PUMP SUCTION GUILLOTINE
BLOWDOWN MASS AND ENERGY RELEASES

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
SECONDS	LBM/SEC	THOUSAND BTU/SEC	LBM/SEC	THOUSAND BTU/SEC
.000	.0	.0	.0	.0
.100	40652.3	22155.5	21305.4	11589.8
.300	44913.9	24637.7	23255.3	12671.0
.500	45662.7	25421.3	21735.4	11862.1
.901	43941.2	25431.4	18780.1	10260.7
1.30	39865.3	24065.2	17981.7	9830.1
1.70	33580.8	21305.0	17844.4	9753.1
2.30	26469.4	17686.8	17455.7	9529.1
2.50	21202.7	14364.1	17153.4	9358.2
3.10	17483.2	12106.9	15751.3	8575.3
4.00	14400.1	9943.1	14154.3	7688.0
4.80	14561.0	9784.1	12829.8	6960.9
5.20	10803.2	8250.7	12320.6	6682.7
5.40	10576.5	8027.4	12099.6	6562.5
5.80	12028.9	8539.9	12883.7	6989.3
6.40	16798.1	10844.8	12678.5	6882.4
6.80	24411.2	15173.7	12339.0	6700.6
7.40	27252.6	16402.6	11535.6	6266.4
8.40	27794.5	16485.8	10378.6	5638.3
9.20	27093.2	16102.4	9506.0	5161.8
10.0	25303.0	15075.4	8720.1	4734.0
10.2	12469.4	7437.0	9168.7	4985.9
10.4	9375.5	5800.2	8805.7	4781.8
11.0	7501.7	4906.4	9210.6	5013.3
12.6	7580.7	4823.4	8914.2	4879.6
13.2	8691.7	5616.6	8849.2	4879.3
13.6	5747.2	4750.1	8657.3	4780.1
14.8	7576.4	4781.3	7932.9	4409.3
15.6	6502.2	4198.1	6906.1	3958.1
16.0	6175.3	4171.9	7957.7	4576.8
16.4	5667.4	3945.4	6571.9	3753.3
17.2	5209.0	3694.0	6436.9	3775.6
18.4	4391.4	3527.5	5210.7	3312.9
19.4	2870.0	3156.9	4642.9	2704.3
19.8	2406.2	2870.9	3845.9	2176.1
20.4	1914.0	2362.0	4624.5	2051.6
21.6	1176.5	1470.0	4758.3	1805.5
22.4	850.2	1067.6	1557.8	568.1
23.0	623.9	785.9	3228.9	882.2
25.4	206.2	262.0	1130.4	273.0
25.8	172.7	219.7	1666.9	387.5
26.0	155.6	198.0	.0	.0
27.6	83.1	106.3	.0	.0
27.8	72.2	92.4	1564.6	364.9
28.0	74.6	95.5	.0	.0
28.6	94.6	120.9	940.1	227.7
28.8	88.1	112.7	.0	.0
29.6	52.0	66.8	.0	.0
30.0	27.8	35.8	.0	.0
32.5	.0	.0	.0	.0

TABLE 2-5

SEQUOYAH UNITS 1 AND 2
DOUBLE-ENDED PUMP SUCTION GUILLOTINE
REFLOOD MAS AND ENERGY RELEASE - MINIMUM SI

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
SECONDS	LBM/SEC	THOUSAND BTU/SEC	LBM/SEC	THOUSAND BTU/SEC
32.5	.0	.0	.0	.0
33.0	.0	.0	161.5	11.8
33.4	.0	.0	161.5	11.8
33.5	34.0	39.8	161.5	11.8
33.7	16.6	19.4	161.5	11.8
34.6	58.4	68.2	161.5	11.8
36.6	108.1	126.5	161.5	11.8
37.6	126.7	148.3	161.5	11.8
38.6	348.2	410.1	4042.8	567.7
39.5	357.9	421.8	4128.5	595.1
40.6	352.8	415.7	4076.0	589.7
41.6	347.5	409.5	4021.0	583.4
43.6	337.0	396.9	3907.9	569.9
45.6	326.9	384.9	3797.7	556.4
47.6	317.4	373.6	3692.9	543.5
49.6	308.6	363.2	3594.0	531.3
51.6	300.4	353.4	3500.8	519.8
53.6	292.8	344.4	3412.9	508.9
55.6	285.7	335.9	3330.0	498.6
57.6	279.0	328.0	3251.7	488.9
59.6	272.8	320.6	3177.5	479.7
61.6	266.9	313.7	3107.2	471.0
63.6	261.4	307.1	3040.3	462.7
67.6	251.2	295.0	2915.8	447.2
71.6	242.1	284.2	2802.1	433.0
75.6	233.7	274.3	2697.7	419.9
79.6	226.1	265.4	2601.2	407.8
83.6	219.1	257.1	2511.7	396.5
84.6	368.5	434.3	293.4	180.3
85.6	380.3	448.4	297.9	187.0
86.6	373.8	440.7	295.2	183.3
90.7	345.0	406.3	283.5	167.1
105.6	280.8	330.1	258.1	132.6
109.6	270.5	317.8	254.1	127.2
113.6	262.0	307.7	250.8	122.9
117.6	255.1	299.6	248.2	119.3
129.6	241.9	283.9	243.1	112.5
143.6	234.6	275.3	240.3	108.8
151.6	233.2	273.6	239.8	107.9
157.6	235.4	276.1	243.1	109.0
165.6	238.9	280.3	251.7	110.7
173.6	240.8	282.5	261.3	111.8
181.6	240.8	282.5	271.5	112.3
183.6	240.5	282.2	274.2	112.3
191.6	238.5	279.8	285.3	112.1
197.6	236.0	276.8	294.3	111.7
205.6	231.1	271.0	306.6	110.9
207.6	229.6	269.2	309.7	110.6
215.6	222.8	261.2	322.7	109.5
216.0	222.4	260.8	323.4	109.4

TABLE 2-6

SEQUOYAH UNITS 1 AND 2

DOUBLE-ENDED PUMP SUCTION GUILLOTINE
MINIMUM SAFETY INJECTION
PRINCIPAL PARAMETRES DURING REFLOOD

TIME	FLOODING TEMP	FLOODING RATE	CARRYOVER FRACTION	CORE HEIGHT	DOWNCOMER HEIGHT	FLOW FRACTION	INJECTION TOTAL	INJECTION ACCUMULATOR	INJECTION SPILL	ENTHALPY
SECONDS	DEGREE F	IN/SEC		FT	FT		(POUNDS MASS PER SECOND)			BTU/LBM
32.5	188.9	.000	.000	.00	.00	.250	.0	.0	.0	.00
33.2	187.0	23.831	.000	.61	1.35	.000	6543.9	5897.9	.0	87.90
33.4	185.9	26.676	.000	1.04	1.31	.000	6507.5	5861.4	.0	87.89
33.7	185.4	2.723	.089	1.29	1.90	.257	6434.3	5788.2	.0	87.87
33.9	185.4	2.826	.127	1.33	2.56	.302	6403.9	5757.8	.0	87.87
34.9	185.6	2.356	.310	1.50	5.93	.361	6230.4	5584.3	.0	87.82
35.6	185.8	2.283	.400	1.59	8.22	.372	6118.2	5472.1	.0	87.79
38.6	186.7	3.974	.602	1.90	16.06	.574	5019.1	4414.9	.0	87.54
39.5	186.9	3.816	.639	2.01	16.07	.572	4852.9	4252.2	.0	87.49
40.6	187.2	3.613	.667	2.13	16.07	.571	4746.2	4144.2	.0	87.44
45.0	189.1	3.190	.715	2.50	16.07	.565	4399.5	3791.4	.0	87.25
52.4	193.2	2.840	.740	3.00	16.07	.553	3956.7	3340.5	.0	86.96
61.2	198.9	2.583	.751	3.50	16.07	.541	3557.9	2935.4	.0	86.64
71.0	205.4	2.379	.757	4.00	16.07	.528	3212.8	2585.2	.0	86.31
82.6	212.1	2.197	.762	4.53	16.07	.516	2890.2	2258.1	.0	85.92
83.6	212.6	2.183	.762	4.57	16.07	.515	2865.6	2233.2	.0	85.89
84.6	213.2	3.150	.761	4.63	16.00	.608	597.1	.0	.0	73.03
85.6	213.8	3.208	.761	4.69	15.84	.609	592.2	.0	.0	73.03
90.7	216.7	2.925	.763	5.00	15.18	.605	602.3	.0	.0	73.03
101.6	221.8	2.519	.766	5.58	14.41	.595	615.9	.0	.0	73.03
110.6	225.3	2.321	.768	6.00	14.19	.589	621.4	.0	.0	73.03
123.6	229.5	2.156	.771	6.56	14.26	.583	625.9	.0	.0	73.03
134.6	232.6	2.082	.773	7.00	14.52	.580	628.0	.0	.0	73.03
147.6	235.7	2.036	.776	7.50	14.95	.579	629.4	.0	.0	73.03
151.6	236.5	2.031	.777	7.66	15.10	.579	629.7	.0	.0	73.03
160.8	238.4	2.046	.779	8.00	15.42	.582	629.3	.0	.0	73.03
169.6	240.0	2.054	.780	8.33	15.65	.587	628.9	.0	.0	73.03
175.6	241.0	2.050	.781	8.56	15.77	.589	628.9	.0	.0	73.03
187.5	242.8	2.020	.783	9.00	15.93	.594	629.4	.0	.0	73.03
201.6	244.3	1.952	.784	9.51	16.03	.598	630.9	.0	.0	73.03
216.0	244.0	1.853	.784	10.00	16.06	.599	633.3	.0	.0	73.03

TABLE 2-7
SEQUOYAH UNITS 1 AND 2

DOUBLE-ENDED PUMP SUCTION GUILLOTINE
MINIMUM SAFETY INJECTION
POST REFLOOD MASS AND ENERGY RELEASES

TIME	BREAK PATH NO.1 FLOW		BREAK PATH NO.2 FLOW	
		THOUSAND		THOUSAND
SECONDS	LBM/SEC	BTU/SEC	LBM/SEC	BTU/SEC
216.1	214.1	263.6	449.8	117.7
221.1	213.8	263.2	450.1	117.6
226.1	213.5	262.9	450.4	117.6
231.1	212.4	261.5	451.5	117.7
236.1	212.0	261.0	451.8	117.6
256.1	210.4	259.1	453.4	117.4
261.1	210.0	258.5	453.9	117.4
271.1	208.9	257.2	454.9	117.3
281.1	207.8	255.8	456.1	117.3
286.1	207.9	255.9	456.0	117.1
296.1	206.5	254.3	457.3	117.1
301.1	206.5	254.2	457.4	117.0
306.1	205.7	253.2	458.2	117.0
311.1	205.6	253.1	458.3	116.9
316.1	204.7	252.0	459.2	117.0
321.1	204.4	251.7	459.4	116.9
326.1	203.4	250.5	460.4	116.9
336.1	202.6	249.5	461.2	116.8
346.1	201.5	248.1	462.3	116.8
351.1	201.5	248.1	462.4	116.6
356.1	200.7	247.1	463.2	116.7
361.1	200.4	246.8	463.4	116.6
366.1	199.4	245.6	464.4	116.7
371.1	198.9	244.9	464.9	116.6
376.1	198.9	244.9	465.0	116.5
381.1	198.1	243.9	465.8	116.5
386.1	197.6	243.3	466.2	116.5
391.1	197.0	242.6	466.8	116.5
396.1	196.7	242.2	467.2	116.4
401.1	196.1	241.4	467.7	116.4
406.1	195.3	240.5	468.5	116.4
411.1	194.7	239.7	469.2	116.4
416.1	194.5	239.5	469.3	116.3
421.1	193.8	238.6	470.0	116.3
431.1	192.7	237.2	471.2	116.3
436.1	192.4	236.9	471.4	116.2
446.1	191.2	235.4	472.6	116.2
451.1	190.7	234.8	473.1	116.1
456.1	86.1	105.9	577.8	138.2
711.3	86.1	105.9	577.8	138.2
711.4	79.8	93.0	584.0	121.9
716.1	79.7	98.0	584.2	136.8
1690.9	79.7	98.0	584.2	136.8
1691.0	65.1	80.1	387.0	125.6
1697.2	65.2	80.2	387.0	125.6

TABLE 2-8

SEQUOYAH UNITS 1 AND 2
DOUBLE-ENDED PUMP SUCTION GUILLOTINE
MINIMUM SAFETY INJECTION

MASS BALANCE

	TIME (SECONDS)	.00	32.52	32.52	216.02	711.35	1697.19
		MASS (THOUSAND LBM)					
INITIAL	IN RCS AND ACC	809.59	809.59	809.59	809.59	809.59	809.59
ADDED MASS	PUMPED INJECTION	.00	.00	.00	114.53	443.31	1096.45
	TOTAL ADDED	.00	.00	.00	114.53	443.31	1096.45
*** TOTAL AVAILABLE ***		809.59	809.59	809.59	924.12	1252.90	1906.04
DISTRIBUTION	REACTOR COOLANT	536.70	92.70	92.78	148.21	148.21	148.21
	ACCUMULATOR	272.89	169.85	169.76	.00	.00	.00
	TOTAL CONTENTS	809.59	262.54	262.54	148.21	148.21	148.21
EFFLUENT	BREAK FLOW	.00	547.02	547.02	775.89	1104.67	1757.80
	ECCS SPILL	.00	.00	.00	.00	.00	.00
	TOTAL EFFLUENT	.00	547.02	547.02	775.89	1104.67	1757.80
*** TOTAL ACCOUNTABLE ***		809.59	809.57	809.57	924.10	1252.87	1906.00

TABLE 2-9

SEQUOYAH UNITS 1 AND 2
DOUBLE-ENDED PUMP SUCTION GUILLOTINE
MINIMUM SAFETY INJECTION

ENERGY BALANCE

	TIME (SECONDS)	.00	32.52	32.52	216.02	711.35	1697.19
		ENERGY (MILLION BTU)					
INITIAL ENERGY,	IN RCS,ACC,S GEN	819.53	819.53	819.53	819.53	819.53	819.53
ADDED ENERGY	PUMPED INJECTION	.00	.00	.00	8.36	32.37	80.15
	DECAY HEAT	.00	9.75	9.75	30.59	73.62	141.70
	HEAT FROM SECONDAR	.00	-4.86	-4.86	-4.86	1.35	12.41
	TOTAL ADDED	.00	4.90	4.90	34.10	107.34	234.26
*** TOTAL	AVAILABLE ***	819.53	824.43	824.43	853.63	926.87	1053.79
DISTRIBUTION	REACTOR COOLANT	309.28	15.04	15.05	31.65	31.65	31.65
	ACCUMULATOR	24.43	15.21	15.20	.00	.00	.00
	CORE STORED	23.53	12.59	12.59	3.92	3.62	3.52
	PRIMARY METAL	155.21	145.35	145.35	118.31	76.14	56.14
	SECONDARY METAL	46.53	45.95	45.95	40.75	31.30	20.49
	STEAM GENERATOR	260.55	261.61	261.61	228.75	178.03	125.02
	TOTAL CONTENTS	819.53	495.75	495.75	423.39	320.74	236.83
EFFLUENT	BREAK FLOW	.00	328.10	328.10	420.84	596.74	801.94
	ECCS SPILL	.00	.00	.00	.00	.00	.00
	TOTAL EFFLUENT	.00	328.10	328.10	420.84	596.74	801.94
*** TOTAL	ACCOUNTABLE ***	819.53	823.84	823.84	844.23	917.47	1038.77

3.0 LOCA CONTAINMENT INTEGRITY ANALYSIS

3.1 Description of LOTIC-1 Model

Early in the ice condenser development program it was recognized that there was a need for modeling of long term ice condenser performance. It was realized that the model would have to have capabilities comparable to those of the dry containment (COCO) model. These capabilities would permit the model to be used to solve problems of containment design and optimize the containment and safeguards systems. This has been accomplished in the development of the LOTIC code, described in reference 8.

The model of the containment consists of five distinct control volumes, the upper compartment, the lower compartment, the portion of the ice bed from which the ice has melted, the portion of the ice bed containing unmelted ice, and the dead ended compartment. The ice condenser control volume with unmelted and melted ice is further subdivided into six subcompartments to allow for maldistribution of break flow to the ice bed.

The conditions in these compartments are obtained as a function of time by the use of fundamental equations solved through numerical techniques. These equations are solved for three phases in time. Each phase corresponds to a distinct physical characteristic of the problem. Each of these phases has a unique set of simplifying assumptions based on test results from the ice condenser test facility. These phases are the blowdown period, the depressurization period, and the long term.

The most significant simplification of the problem is the assumption that the total pressure in the containment is uniform. This assumption is justified by the fact that after the initial blowdown of the Reactor Coolant System, the remaining mass and energy released from this system into the containment are small and very slowly changing. The resulting flow rates between the control volumes will also be relatively small. These flow rates then are unable to maintain significant pressure differences between the compartments.

In the control volumes, which are always assumed to be saturated, steam and air are assumed to be uniformly mixed and at the control volume temperature. The air is considered a perfect gas, and the thermodynamic properties of steam are taken from the ASME steam table.

The condensation of steam is assumed to take place in a condensing node located, for the purpose of calculation, between the two control volumes in the ice storage compartment. The exit temperature of the air leaving this node is set equal to a specific value which is equal to the temperature of the ice filled control volume of the ice storage compartment. Lower compartment exit temperature is used if the ice bed section is melted.

3.2 Containment Pressure Calculation

The following are the major input assumptions used in the LOTIC analysis for the pump suction pipe rupture case with the steam generators considered as an active heat source for the Sequoyah Nuclear Plant Containment:

1. Minimum safeguards are employed in all calculations, e.g., one of two spray pumps and one of two spray heat exchangers; one of two RHR pumps and one of two RHR heat exchangers providing flow to the core; one of two safety injection pumps and one of two centrifugal charging pumps; and one of two air return fans.

2. $1.7924875 * 10^6$ lbs. of ice initially in the ice condenser.

3. The blowdown, reflood, and post reflood mass and energy releases described in Section 2.5 are used.

4. Blowdown and post-blowdown ice condenser drain temperature of 190°F and 130°F are used. (These values are based on the Long-Term Waltz-Mill ice condenser test data described in WCAP-8110-Sup.6.)

5. Nitrogen from the accumulators in the amount of 3676 lbs. is included in the calculations.

6. Essential service water temperature of 85°F is used on the spray heat exchanger and the component cooling heat exchanger.

7. The air return fan is effective, 10 minutes after the transient is initiated.

8. No maldistribution of steam flow to the ice bed is assumed. (This assumption is conservative, contributes to early ice bed melt out time.)

9. No ice condenser bypass is assumed. (This assumption depletes the ice in the shortest time and is thus conservative.)

10. The initial conditions in the containment are a temperature of 100°F in the lower and dead-ended volumes, 85°F in the upper volume and a temperature 15°F in the ice condenser. All volumes are at a pressure of 0.3 psig and a 10% relative humidity, except the ice condenser which is at 100% relative humidity.

11. The minimum ECCS and Containment Spray flow rates versus time assumed in the peak containment pressure calculations were calculated based upon the assumption of loss of offsite power (See Table 3-1 and APPENDIX A).

12. Containment structural heat sinks are assumed with conservatively low heat transfer rates. (See Tables 3-2, and 3-3) Note: The Dead-Ended compartment structural heat sinks were conservatively neglected.

13. The Containment compartment volumes were based on the following: Upper Compartment 651,000 ft^3; Lower Compartment 248,500 ft^3; and Dead-Ended Compartment 129,900 ft^3.

14. The operation of one containment spray heat exchanger ($UA = 2.811 * 10^6$ Btu/hr-°F), for containment cooling and the operation of one RHR heat exchanger ($UA = 1.402 * 10^6$ Btu/hr-°F) for core cooling. The component cooling heat exchanger was modeled at $2.793 * 10^6$ Btu/hr-°F. All heat exchangers were modeled as strictly counterflow heat exchangers.

15. The air return fan returns air at a rate of 40,000 cfm from the upper to the lower compartment.

16. An active sump volume of 38,400 ft^3 is used.

17. 102% of 3411 MWt power is used in the calculations.

18. Subcooling of ECC water from the RHR heat exchanger is assumed.

19. Nuclear service water flow to the containment spray heat exchanger was modeled as 3600 gpm. Also the nuclear service water flow to the component cooling heat exchanger was modeled as 4000 gpm.

20. The decay heat curve conservatively used to calculate mass and energy releases after steam generator equilibration is presented in Figure 16 of Reference 1. [Westinghouse Model Decay Heat Curve (1979 ANS Plus 2 sigma uncertainty]

The minimum time at which the RHR pumps can be diverted to the RHR sprays are specified in the plant operating procedures as 60 minutes after the accident.

3.3 Structural Heat Removal

Provision is made in the containment pressure analysis for heat storage in interior and exterior walls. Each wall is divided

into a number of nodes. For each node, a conservation of energy equation expressed in finite difference forms accounts for transient conduction into and out of the node and temperature rise of the node for the containment structural heat sinks used in the analysis. The heat sink and material property data used are found in Tables 3-2 and 3-3.

The heat transfer coefficient to the containment structure is based primarily on the work of Tagami [Reference 9]. When applying the Tagami correlations, a conservative limit was placed on the lower compartment stagnant heat transfer coefficients. They were limited to a steam-air ratio of 1.4 according to the Tagami correlation. The imposition of this limitation is to restrict the use of the Tagami correlation within the test range of steam-air ratios where the correlation was derived.

With these assumptions, the heat removal capability of the containment is sufficient to absorb the energy releases and still keep the maximum calculated pressure below the design pressure.

3.4 Analysis Results

The results of the analysis shows that the maximum calculated containment pressure is 11.45 psig, for the double-ended pump suction minimum safeguards break case. This pressure peak occurs at approximately 6378 seconds, with ice bed meltout at approximately 3262 seconds.

The following plots show the containment integrity transient, as calculated by the LOTIC-1 code.

Figure 3-1, Containment Pressure Transient
Figure 3-2, Upper Compartment Temperature Transient
Figure 3-3, Lower Compartment Temperature Transient
Figure 3-4, Active and Inactive Sump Temperature Transient
Figure 3-5, Ice Melt Transient

Tables 3-4 and 3-5 give energy accountings at various points in the transient.

3.5 Relevant Acceptance Criteria

The LOCA mass and energy analysis has been performed in accordance with the criteria shown in the Standard Review Plan (SRP) section 6.2.1.3. In this analysis, the relevant requirements of General Design Criteria (GDC) 50 and 10 CFR Part 50 Appendix K have been included by confirmation that the calculated pressure is less than the design pressure, and because all available sources of energy have been included. These sources include: reactor power, decay heat, core stored energy, energy stored in the reactor vessel and internals, metal-water reaction energy, and stored energy in the secondary system.

The containment integrity peak pressure analysis has been performed in accordance with the criteria shown in the SRP section 6.2.1.1.b, for ice condenser containments. Conformance to GDC's 16, 38, and 50 is demonstrated by showing that the containment design pressure is not exceeded at any time in the transient. This analysis also demonstrates that the containment heat removal systems function to rapidly reduce the containment pressure and temperature in the event of a LOCA.

3.6 Conclusions

Based upon the information presented in this report, it may be concluded that operation with an initial ice weight of 1.7924875 million pounds for the Sequoyah Nuclear Plant is acceptable. Operation with an initial ice mass of 1.7924875 million pounds results in a calculated peak containment pressure of 11.45 psig, as compared to the design pressure of 12.0 psig. Thus, the most limiting case has been considered, and has been demonstrated to yield acceptable results.

4.0 REFERENCES

1. "Westinghouse LOCA Mass and Energy Release Model for Containment Design - March 1979 Version", WCAP-10325-P-A, May 1983 (Proprietary), WCAP-10326-A (Non-Proprietary).

2. "Westinghouse ECCS Evaluation Model - 1981 Version", WCAP-9220-P-A, Rev. 1, February 1982 (Proprietary), WCAP-9221-A, Rev.1 (Non-Proprietary)

3. Docket No. 50-315, "Amendment No. 126, Facility Operating License No. DPR-58 (TAC No. 7106), for D.C. Cook Nuclear Plant Unit 1", June 9, 1989.

4. EPRI 294-2, Mixing of Emergency Core Cooling Water with Steam; 1/3 Scale Test and Summary, (WCAP-8423), Final Report June 1975.

5. "Westinghouse Mass and Energy Release Data For Containment Design", WCAP-8264-P-A, Rev. 1, August 1975 (Proprietary), WCAP-8312-A (Non-Proprietary).

6. ANSI/ANS-5.11979, "American National Standard for Decay Heat Power in Light Water Reactors", August 1979.

7. W. H. McAdam, Heat Transmission, McGraw-Hill 3rd edition, 1954, p.172.

8. "Long Term Ice Condenser Containment Code - LOTIC Code", WCAP-8354-P-A, April 1976 (Proprietary), WCAP-8355-A (Non-Proprietary).

9. Tagami, Takasi, Interim Report on Safety Assessments and Facilities Establishment Project in Japan for Period Ending June, 1965 (No. 1).

TABLE 3-1

SEQUOYAH UNIT 1 AND 2

ECCS SWITCHOVER PUMP FLOW VS. TIME
(LOSS OF OFF-SITE POWER AT EVENT INITIATION)

Time After Safeguards Initiation (Sec)	ECCS Flow To Core (RWST) (Gpm)	Spray (Flow) (Gpm)	RHR Spray (Flow) (Gpm)	ECCS Flow To Core (Sump) (Gpm)	Comments
0	0	0	0	0	"S" - Signal
21.9	0	0	0	0	
22.0	1022	0	0	0	CCP/SIP Start
26.9	1022	0	0	0	
27.0	*4810	0	0	0	RHR/CP/SIP ECCs Flow
249.9	4810	0	0	0	
250.0	4810	4750	0	0	Containment Spray Start
1690.0	4810	4750	0	0	
1691.0	1022	4750	0	3299	RHR Switchover
1710.9	1022	4750	0	3299	
1711.0	0	4750	0	3299	CCP/SIP Switchover
2802.9	0	4750	0	3299	
2803.0	0	0	0	3299	CS Pump Stopped
3112.9	0	0	0	3299	
3113.0	0	4750 (Sump)	0	3299	CS Pump Switchover
3600.0	0	4750 (Sump)	0	3299	
3600.1	0	4750 (Sump)	1277	1060	RHR Alignment for Auxiliary CS
End of Transient	0	4750 (Sump)	1277	1060	

*4810 gpm Total Flow (RWST)
421.5 gpm - 1 Centrifugal Charging Pump
600.7 gpm - 1 Safety Injection Pump
3787.8 gpm - 1 RHR Pump

TABLE 3-2

SEQUOYAH UNITS 1 AND 2
STRUCTURAL HEAT SINK TABLE

Heat Sink / Material		AREA (ft^2)	Thickness (ft)
Upper Compartment			
1.	Operating Deck	4,800	
	Concrete		1.07
2.	Crane Wall	18,280	
	Paint		0.0005
	Concrete		1.292
3.	Refueling Canal (Steel-lined)	3,840	
	Stainless Steel		0.0208
	Concrete		1.5
4.	Operating Deck	760	
	Paint		0.00125
	Concrete		1.5
5.	Containment Shell & Misc. Steel	49,960	
	Paint		0.000625
	Steel		0.0403
6.	Misc. Steel	2,260	
	Paint		0.000625
	Steel		0.12
Lower Compartment			
7.	Operating Deck, Crane Wall & Interior Concrete	32,200	
	Concrete		1.416

TABLE 3-2 (Continued)

SEQUOYAH UNITS 1 AND 2
STRUCTURAL HEAT SINK TABLE

Heat Sink / Material		AREA (ft^2)	Thickness (ft)
Lower Compartment (Continued)			
8.	Area in Contact with Sump Water	15,540	
	Paint		0.0005
	Concrete		1.6
9.	Interior Concrete	2,830	
	Paint		0.00125
	Concrete		1.0
10.	Interior Concrete	760	
	Paint		0.0005
	Concrete		1.75
11.	Reactor Cavity	2,270	
	Stainless Steel		0.02082
	Concrete		2.0
12.	Containment Shell & Misc. Steel	19,500	
	Paint		0.000625
	Steel		0.0495
13.	Misc. Steel	9,000	
	Paint		0.000625
	Steel		0.1008
Ice Condenser			
14.	Ice Basket	180,600	
	Steel		0.00663

TABLE 3-2(Continued)

SEQUOYAH UNITS 1 AND 2
STRUCTURAL HEAT SINK TABLE

Heat Sink / Material		AREA (ft^2)	Thickness (ft)
Ice Condenser (Continued)			
15.	Lattice Frames	76,650	
	Steel		0.0217
16.	Lower Support Structure	28,670	
	Steel		0.0267
17.	Ice Condenser Floor	3,336	
	Paint		0.000833
	Concrete		0.333
18.	Containment Wall Panels & Containment Shell	19,100	
	Steel & Insulation		1.0
	Steel		0.0625
19.	Crane Wall Panels & Crane Wall	13,055	
	Composite Panel (Steel & Insulation)		1.0
	Concrete		1.0

TABLE 3-3

SEQUOYAH UNITS 1 AND 2
MATERIAL PROPERTIES TABLE

Material	Thermal Conductivity Btu/hr-ft-°F	Volumetric Heat Btu/ft^3-°F
$Paint_1$	0.2	14.0
$Paint_2$	0.0833	28.4
Concrete	0.8	28.8
Stainless Steel	9.4	56.35
Carbon Steel	26.0	56.35

Note: $Paint_1$ = on steel

$Paint_2$ = on concrete

TABLE 3-4

SEQUOYAH UNITS 1 AND 2

ENERGY ACCOUNTING

	Approx. End of Blowdown (t=10.0 sec.)	Approx. End of Reflood (t=216.0 sec.)
	(In Millions of Btus)	
Ice Heat Removal	194.7	235.1
Structural Heat Sinks*	19.69	57.49
RHR Heat Exchanger Heat Removal*	0	0
Spray Heat Exchanger Heat Removal*	0	0
Energy Content of Sump	183.1	241.3
Ice Melted (Pounds) (10^6)	0.63	0.79

* Integrated Energies

TABLE 3-5

SEQUOYAH UNITS 1 AND 2

ENERGY ACCOUNTING

	Approx. Time of Ice Melt Out (t=3262 sec.)	Approx. Time Peak Pressure (t=6378 sec.)
	(In Millions of Btus)	
Ice Heat Removal	485.4	485.4
Structural Heat Sinks*	72.57	113.21
RHR Heat Exchanger Heat Removal*	17.37	45.49
Spray Heat Exchanger Heat Removal*	2.79	64.13
Energy Content of Sump	643.88	662.62
Ice Melted (Pounds) (10^6)	1.7924875	1.7924875

* Integrated Energies

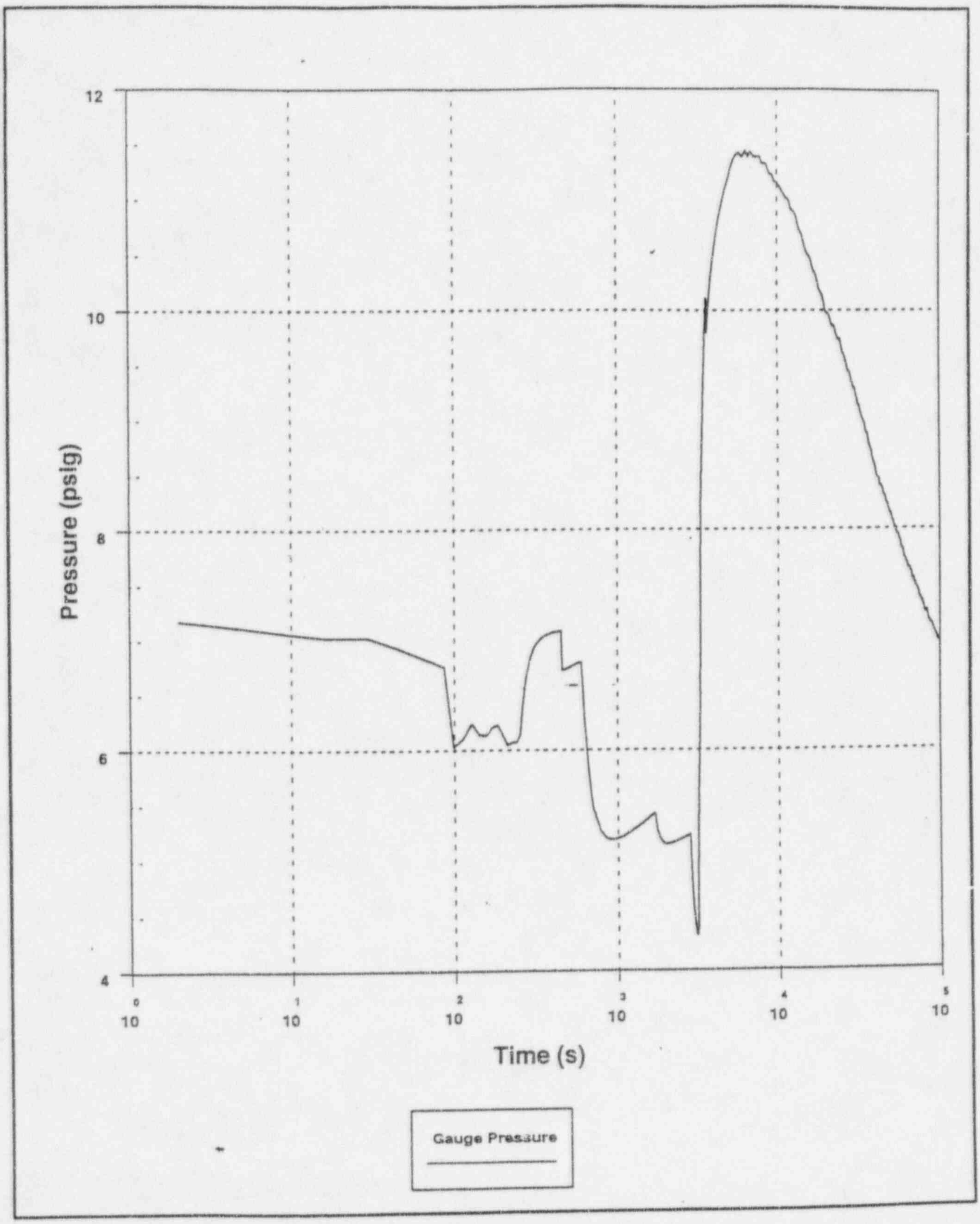

Figure 3- 1

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Containment Pressure

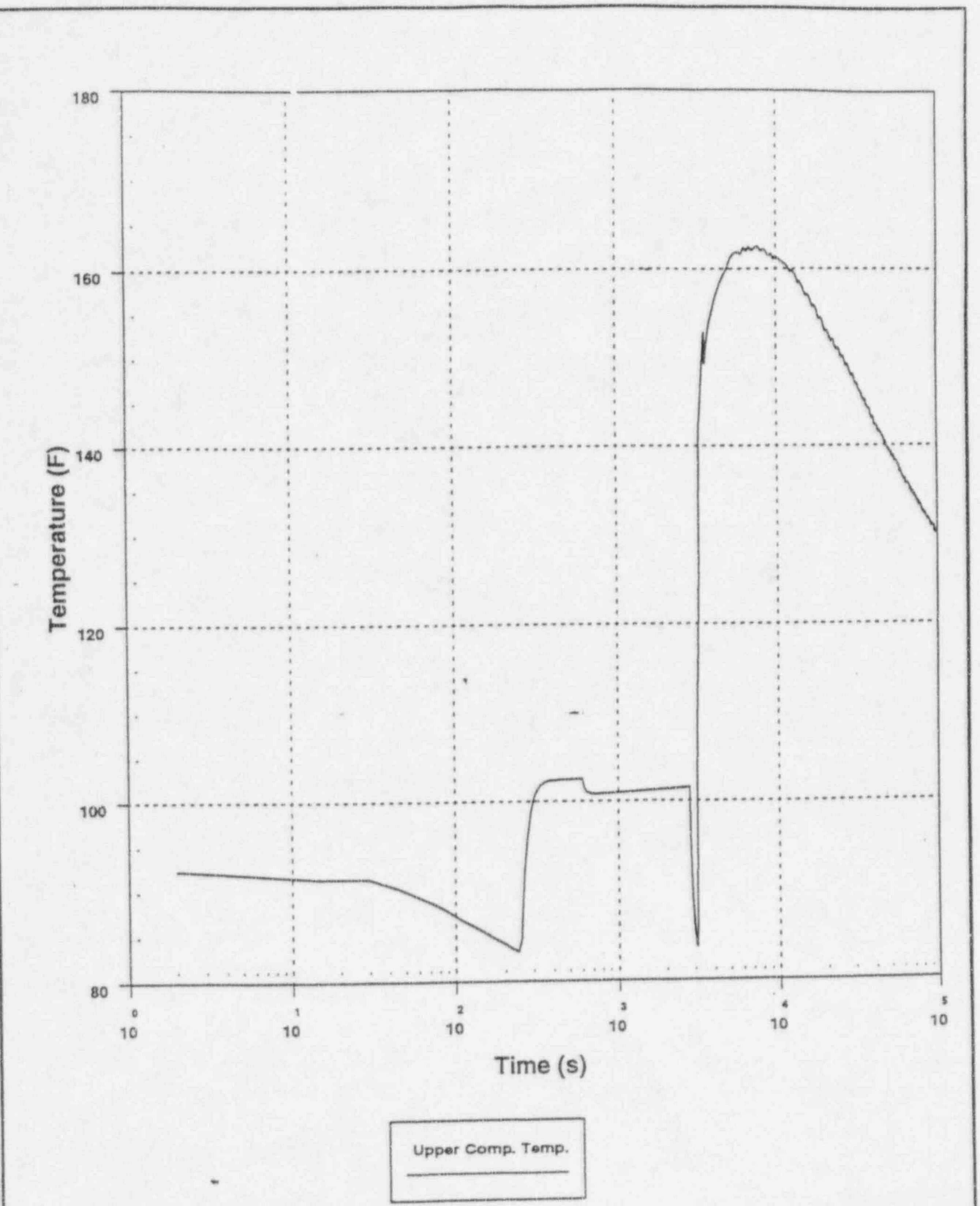

Figure 3- 2

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Upper Compartment Temperature

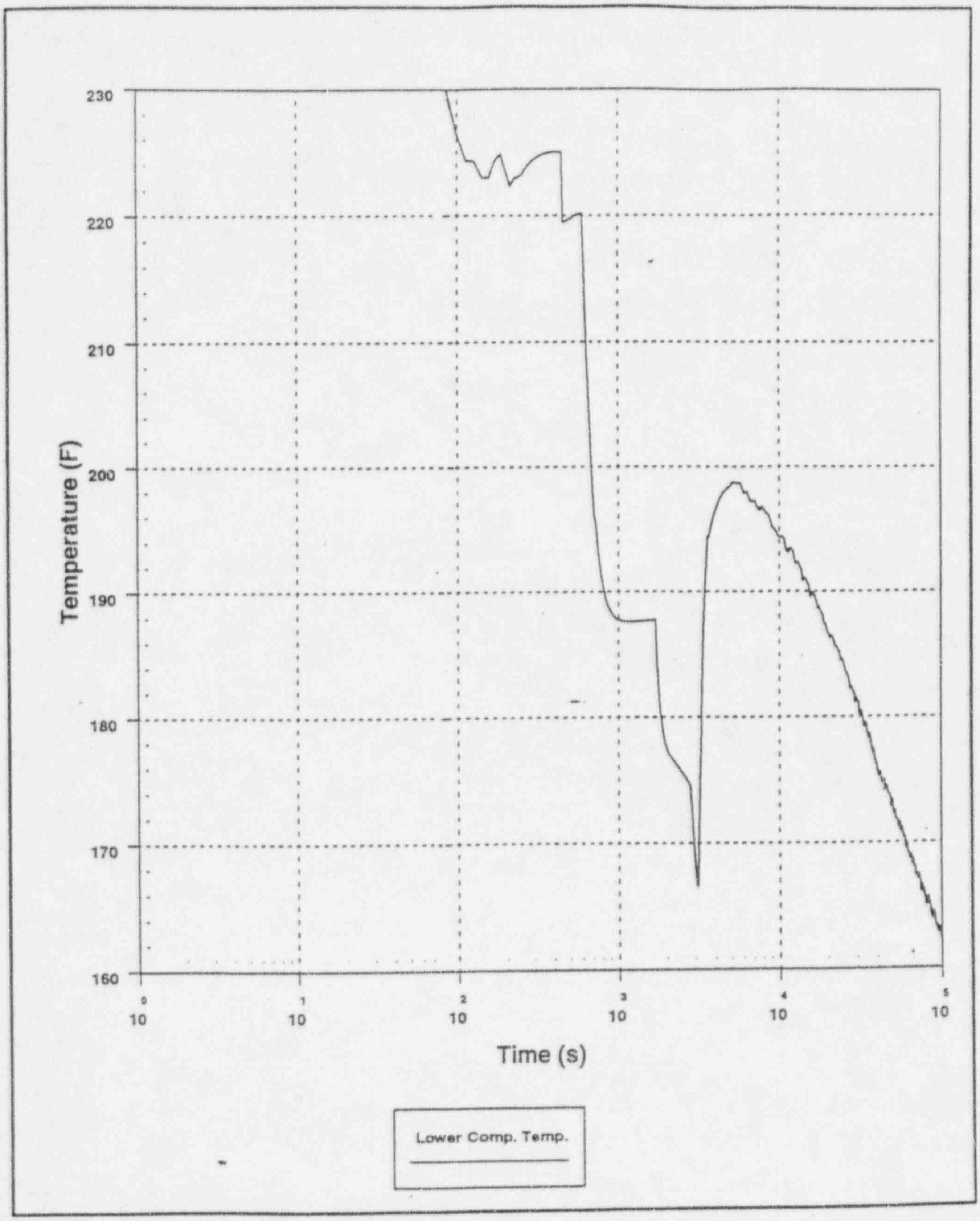

Figure 3- 3

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Lower Compartment Temperature

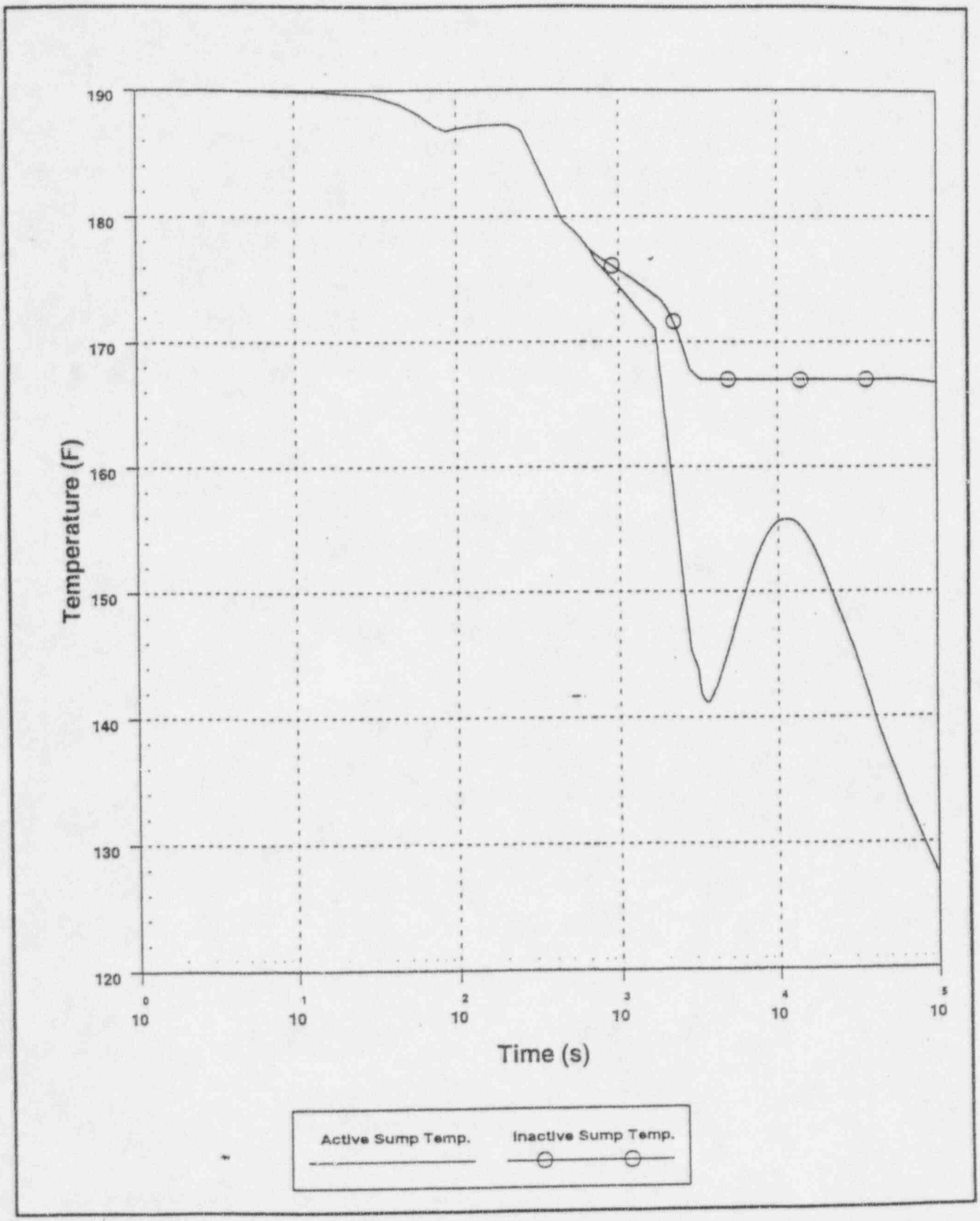

Figure 3- 4

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Active Sump and Inactive Sump Temperature Transient

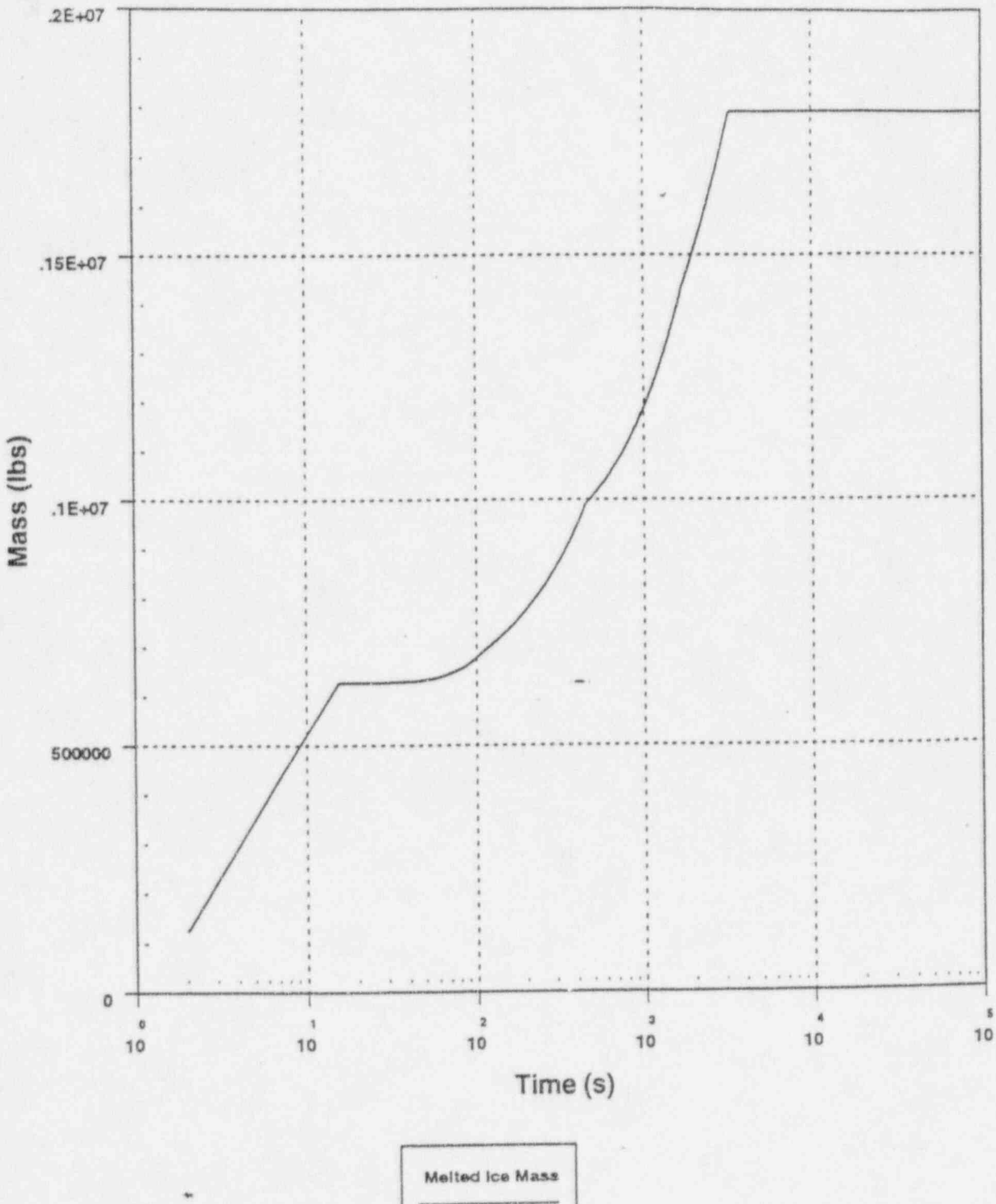

Figure 3- 5

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Ice Melt Transient

APPENDIX A

EMERGENCY CORE COOLING FLOW BASIS

The flows used in the Safeguards Data Package for the Sequoyah Site and in the Containment Analysis are as follows:

Containment Analysis Data:

Centrifugal Charging Pump Flows....................421.5 gpm
Safety Injection Pump Flows......................600.7 gpm
Residual Heat Removal Pump Flows...............3787.8 gpm

The following information are the assumptions used in the Fluid Systems Model to generate the Containment Analysis Data.

Centrifugal Charging Pump Safety Injection System Minimum Safeguards Data

1. The flowrates consider single failure, therefore only one pump is operating and delivering flow to the four RCS cold legs.

2. One RCS cold leg is established as the least resistive path and is modeled to deliver 10 gpm more than the other RCS cold legs.

3. The plant pre-operational test data and the as built piping layout were used to establish the system header resistances. The branch line resistances were based on pump runout limits.

4. The pump performance characteristics are based upon the TVA vendor curves minus 15% of the minimum composite pump curve or the FSAR pump curve, whichever is less.

5. The pump mini-flow and RCP seal flows are in the system model and their flows are not included in the total RCS injected flows.

6. The system model delivers flow to all four RCS cold legs against a system backpressure of 12.0 psig.

Safety Injection Pump Minimum Safeguards Data

1. The flowrates consider single failure, therefore only one pump is operating delivering to four RCS cold legs.

2. One RCS cold leg is established as the least resistive path and delivers 10 gpm greater than the other RCS cold legs.

3. The plant pre-operational test data and the as built piping layout were used to determine the system header resistances. The branch line resistances were based on pipe runout limits.

4. The pump performance characteristics are based upon the TVA vendor curves minimum 10% of the minimum composite pump curve.

5. The pump min-flow is modeled and the flow is not included in the total RCS injected flows.

6. The system model delivers flow through all four RCS cold legs against a system backpressure of 12.0 psig.

Residual Heat Removal Pump Minimum Safeguards Data

1. The flowrates consider single failure, therefore only one pump is operating delivering to four RCS cold legs.

2. The pump performance characteristics are based upon the TVA vendor pump curve minus 15% of the minimum composite pump curve.

3. The system model delivers flow through all four RCS cold legs against a system backpressure of 12.0 psig.

The ECCS system alignments that were assumed for the calculation of the Cold Leg recirculation flows and RHR spray flows shown in figures A-1 through A-3 are discussed below.

The Cold Leg recirculation flows were calculated based on the following system alignment; the sump is providing suction to one RHRP which in turn provides flow to two cold legs, one SIP and one CCP. The SIP and CCP are assumed to provide flow to all four cold legs with the CCP flow through the BIT injection lines.

The injected flows during RHR spray were calculated based on the following system alignment; the sump is providing suction to one RHRP header, one CCP and one SIP. The SIP and CCP are assumed to provide flow to all four cold legs with the CCP flow through the BIT injection lines.

The RHR spray flow was calculated based on the following system alignment; the sump is providing suction to one RHRP which in turn provides flow to the RHR spray header, one CCP, one SIP and two cold legs, via wrap around flow. An assumption was made that the opposites train's cold leg injection lines could not be isolated due to train failure and therefore flow would be diverted from the RHR spray to the cold leg injection lines. The SIP and CCP are assumed to provide flow to all four cold legs with the CCP flow through the BIT injection lines.

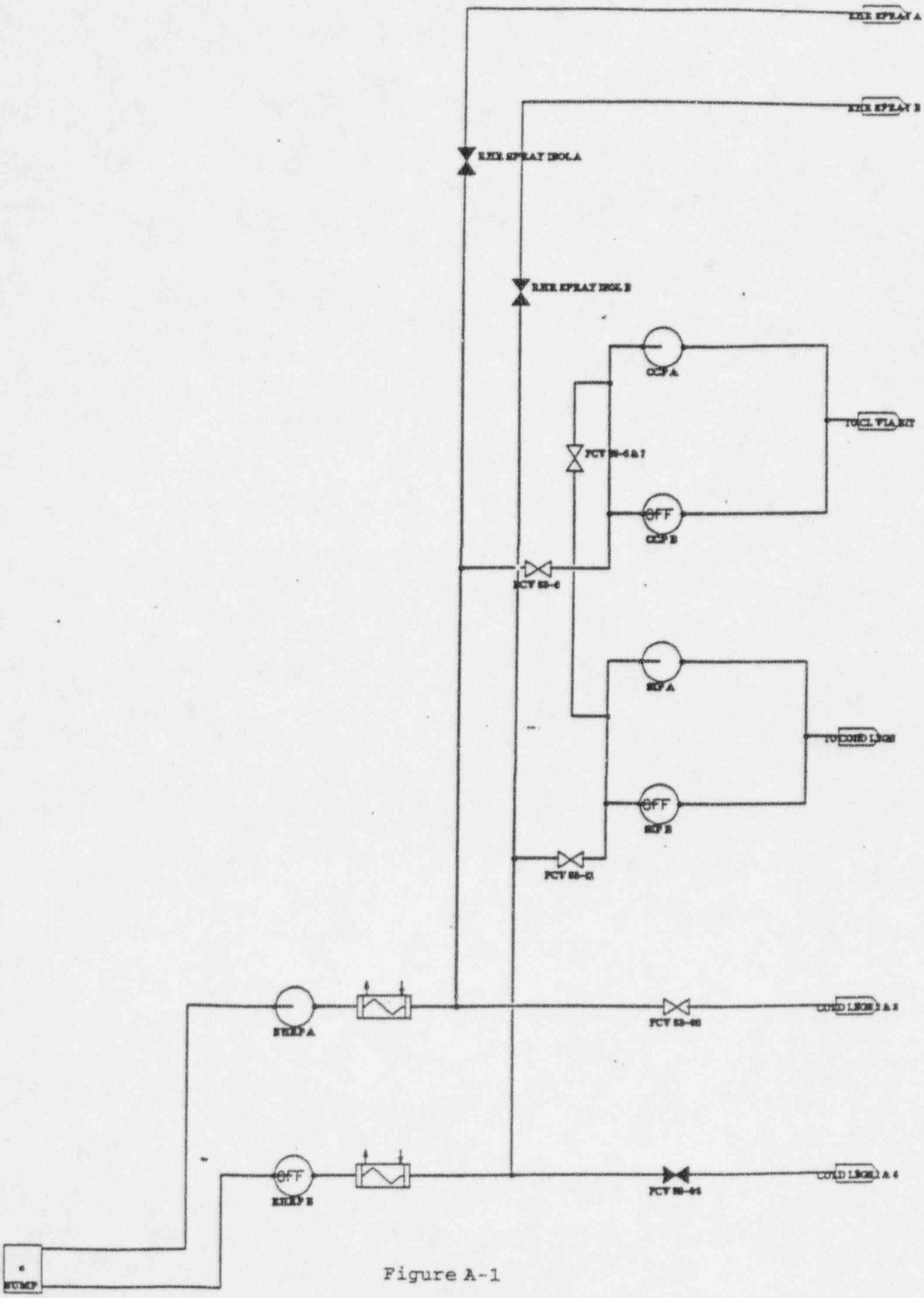

Figure A-1

Cold Leg Recirculation Alignment

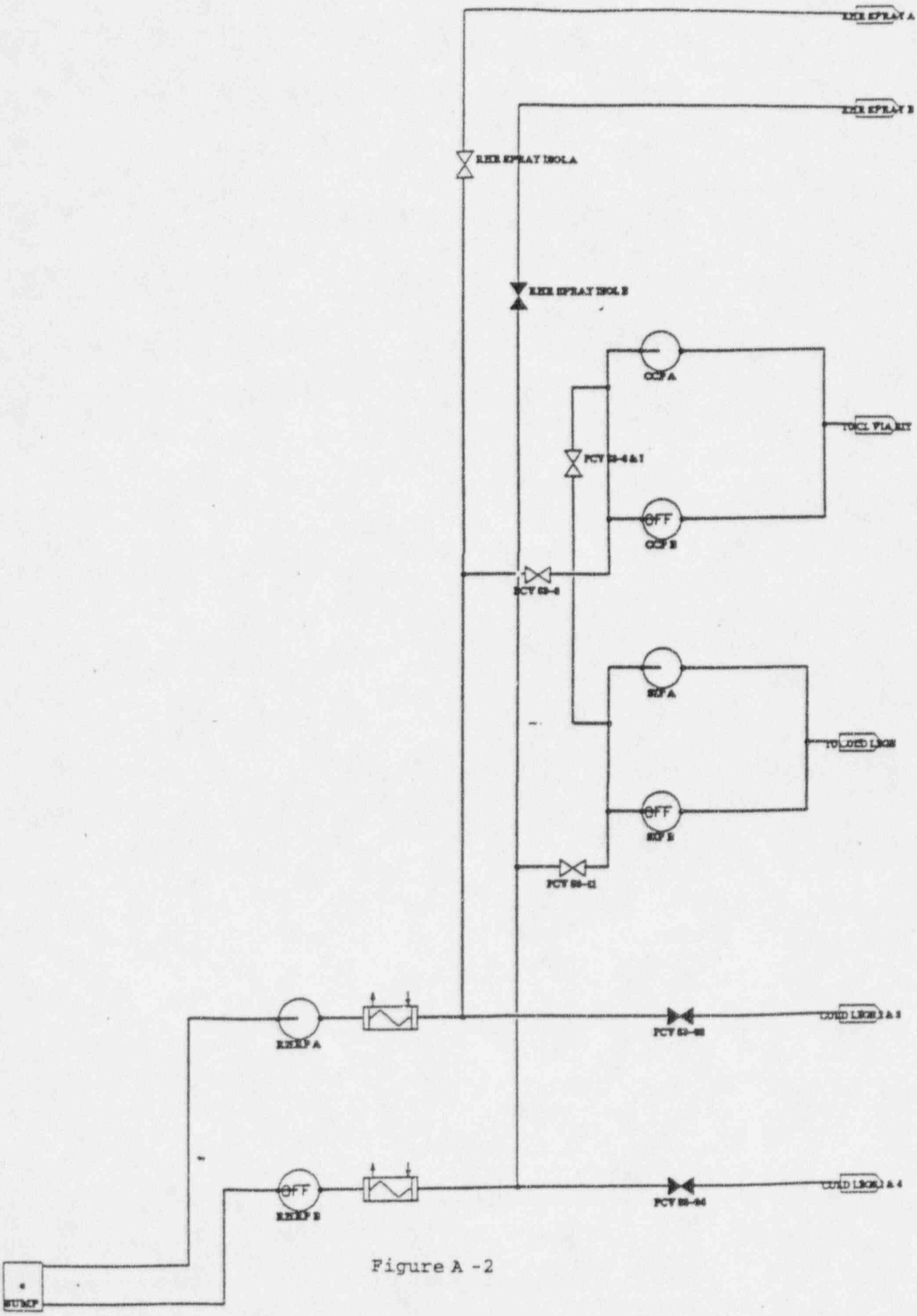

Figure A -2

RHR Spray Alignment - to calculate minimum RCS injected flow

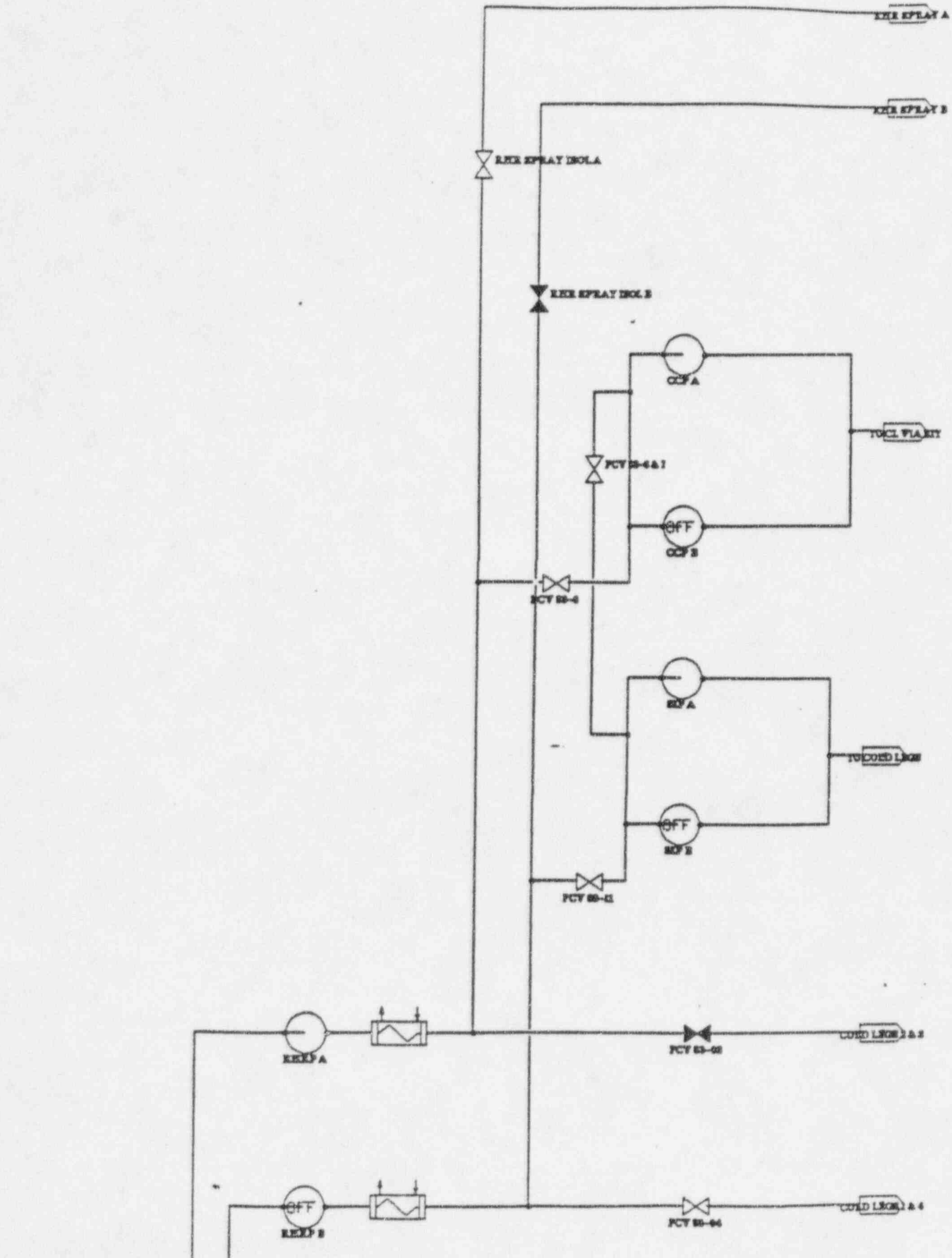

Figure A-3

RHR Spray Alignment - to calculated minimum RHR spray flow

ENCLOSURE 5

PROPOSED TECHNICAL SPECIFICATION CHANGE

SEQUOYAH NUCLEAR PLANT (SQN) UNITS 1 AND 2

DOCKET NOS. 50-327 AND 50-328

(TVA-SQN-TS-96-02)

REVISED TECHNICAL SPECIFICATION AS PROPOSED

3/4.6.5 ICE CONDENSER

ICE BED

LIMITING CONDITION FOR OPERATION

3.6.5.1. The ice bed shall be OPERABLE with:

a. The stored ice having a boron concentration of at least 1800 ppm boron as sodium tetraborate and a pH of 9.0 to 9.5,

b. Flow channels through the ice condenser,

c. A maximum ice bed temperature of less than or equal 27°F,

d. A total ice weight of at least 2,082,024 pounds at a 95% level of confidence, and

e. 1944 ice baskets. R7

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With the ice bed inoperable, restore the ice bed to OPERABLE status within 48 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.5.1 The ice condenser shall be determined OPERABLE:

a. At least once per 12 hours by using the ice bed temperature monitoring system to verify that the maximum ice bed temperature is less than or equal to 27°F.

b. At least once per 12 months by: R135

Verifying, by visual inspection of a representative random sample of at least 54 flow passages (33 percent) per ice condenser bay, that the accumulation of frost or ice on flow passages between ice baskets, past lattice frames, through the intermediate and top deck floor grating, or past the lower inlet plenum support structures and turning vanes is less than or equal to 15-percent blockage of the total flow area in each bay, with a 95-percent level of confidence.

If the summation of blockage from the sample fails to meet the acceptance criteria, then 100 percent of the passages of that bay shall be inspected. If the 100-percent inspection fails to meet the acceptance criteria, then the flow passages shall be cleaned to meet the acceptance criteria. Each flow passage that is cleaned will be reinspected. Any inaccessible flow passage that is not inspected will be considered blocked.

SURVEILLANCE REQUIREMENTS (Continued)

c. At least once per 40 months by lifting and visually inspecting the accessible portions of at least two ice baskets from each 1/3 of the ice condenser and verifying that the ice baskets are free of detrimental structural wear, cracks, corrosion or other damage. The ice baskets shall be raised at least 10 feet for this inspection.

d. At least once per 18 months by:

1. Chemical analyses which verify that at least 9 representative samples of stored ice have a boron concentration of at least 1800 ppm as sodium tetraborate and a pH of 9.0 to 9.5.

2. Weighing a representative sample of at least 144 ice baskets and verifying that each basket contains at least 1071 lbs of ice. The representative sample shall include 6 baskets from each of the 24 ice condenser bays and shall be constituted of one basket each from Radial Rows 1, 2, 4, 6, 8 and 9 (or from the same row of an adjacent bay if a basket from a designated row cannot be obtained for weighing) within each bay. If any basket is found to contain less than 1071 pounds of ice, a representative sample of 20 additional baskets from the same bay shall be weighed. The minimum average weight of ice from the 20 additional baskets and the discrepant basket shall not be less than 1071 pounds/basket at a 95% level of confidence.

   The ice condenser shall also be subdivided into 3 groups of baskets, as follows: Group 1 - bays 1 through 8, Group 2 - bays 9 through 16, and Group 3 - bays 17 through 24. The minimum average ice weight of the sample baskets from Radial Rows 1, 2, 4, 6, 8 and 9 in each group shall not be less than 1071 pounds/basket at a 95% level of confidence.

   The minimum total ice condenser ice weight at a 95% level of confidence shall be calculated using all ice basket weights determined during this weighing program and shall not be less than 2,082,024 pounds.

3/4.6.4 COMBUSTIBLE GAS CONTROL

The OPERABILITY of the equipment and systems required for the detection and control of hydrogen gas ensures that this equipment will be available to maintain the hydrogen concentration within containment below its flammable limit during post-LOCA conditions. Either recombiner unit or the hydrogen mitigation system, consisting of 68 hydrogen ignitions per unit, is capable of controlling the expected hydrogen generation associated with 1) zirconium-water reactions, 2) radiolytic decomposition of water and 3) corrosion of metals within containment. These hydrogen control systems are designed to mitigate the effects of an accident as described in Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a LOCA", Revision 2 dated November 1978. The hydrogen monitors of Specification 3.6.4.1 are part of the accident monitoring instrumentation in Specification 3.3.3.7 and are designated as Type A, Category 1 in accordance with Regulatory Guide 1.97, Revision 2, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident," December 1980. BR R153

The hydrogen mixing systems are provided to ensure adequate mixing of the containment atmosphere following a LOCA. This mixing action will prevent localized accumulations of hydrogen from exceeding the flammable limit.

The operability of at least 66 of 68 ignitors in the hydrogen mitigation system will maintain an effective coverage throughout the containment. This system of ignitors will initiate combustion of any significant amount of hydrogen released after a degraded core accident. This system is to ensure burning in a controlled manner as the hydrogen is released instead of allowing it to be ignited at high concentrations by a random ignition source. BR

3/4.6.5 ICE CONDENSER

The requirements associated with each of the components of the ice condenser ensure that the overall system will be available to provide sufficient pressure suppression capability to limit the containment peak pressure transient to less than 12 psig during LOCA conditions.

3/4.6.5.1 ICE BED

The OPERABILITY of the ice bed ensures that the required ice inventory will 1) be distributed evenly through the containment bays, 2) contain sufficient boron to preclude dilution of the containment sump following the LOCA and 3) contain sufficient heat removal capability to condense the reactor system volume released during a LOCA. These conditions are consistent with the assumptions used in the accident analyses.

The minimum weight figure of 1071 pounds of ice per basket contains a 15% conservative allowance for ice loss through sublimation which is a factor of 15 higher than assumed for the ice condenser design. The minimum weight figure of 2,082,024 pounds of ice also contains an additional 1% conservative allowance to account for systematic error in weighing instruments. In the

3/4.6.5 ICE CONDENSER

ICE BED

LIMITING CONDITION FOR OPERATION

3.6.5.1 The ice bed shall be OPERABLE with:

a. The stored ice having a boron concentration of at least 1800 ppm boron as sodium tetraborate and a pH of 9.0 to 9.5,

b. Flow channels through the ice condenser,

c. A maximum ice bed temperature of less than or equal to 27°F,

d. A total ice weight of at least 2,082,024 pounds at a 95% level of confidence, and

e. 1944 ice baskets.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With the ice bed inoperable, restore the ice bed to OPERABLE status within 48 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.6.5.1 The ice condenser shall be determined OPERABLE:

a. At least once per 12 hours by using the ice bed temperature monitoring system to verify that the maximum ice bed temperature is less than or equal to 27°F.

b. At least once per 12 months by: R118

Verifying, by visual inspection of a representative random sample of at least 54 flow passages (33 percent) per ice condenser bay, that the accumulation of frost or ice on flow passages between ice baskets, past lattice frames, through the intermediate and top deck floor grating, or past the lower inlet plenum support structures and turning vanes is less than or equal to 15-percent blockage of the total flow area in each bay, with a 95-percent level of confidence.

If the summation of blockage from the sample fails to meet the acceptance criteria, then 100 percent of the passages of that bay shall be inspected. If the 100-percent inspection fails to meet the acceptance criteria, then the flow passages shall be cleaned to meet the acceptance criteria. Each flow passage that is cleaned will be reinspected. Any inaccessible flow passage that is not inspected will be considered blocked.

SURVEILLANCE REQUIREMENTS (Continued)

c. At least once per 40 months by lifting and visually inspecting the accessible portions of at least two ice baskets from each 1/3 of the ice condenser and verifying that the ice baskets are free of detrimental structural wear, cracks, corrosion or other damage. The ice baskets shall be raised at least 10 feet for this inspection.

d. At least once per 18 months by: R118

1. Chemical analyses which verify that at least 9 representative samples of stored ice have a boron concentration of at least 1800 ppm as sodium tetraborate and a pH of 9.0 to 9.5.

2. Weighing a representative sample of at least 144 ice baskets and verifying that each basket contains at least 1071 lbs of ice. The representative sample shall include 6 baskets from each of the 24 ice condenser bays and shall be constituted of one basket each from Radial Rows 1, 2, 4, 6, 8 and 9 (or from the same row of an adjacent bay if a basket from a designated row cannot be obtained for weighing) within each bay. If any basket is found to contain less than 1071 pounds of ice, a representative sample of 20 additional baskets from the same bay shall be weighed. The minimum average weight of ice from the 20 additional baskets and the discrepant basket shall not be less than 1071 pounds/basket at a 95% level of confidence.

   The ice condenser shall also be subdivided into 3 groups of baskets, as follows: Group 1 - bays 1 through 8, Group 2 -bays 9 through 16, and Group 3 - bays 17 through 24. The minimum average ice weight of the sample baskets from Radial Rows 1, 2, 4, 6, 8 and 9 in each group shall not be less than 1071 pounds/basket at a 95% level of confidence.

   The minimum total ice condenser ice weight at a 95% level of confidence shall be calculated using all ice basket weights determined during this weighing program and shall not be less than 2,082,024 pounds.

3/4.6.4 COMBUSTIBLE GAS CONTROL

The OPERABILITY of the equipment and systems required for the detection and control of hydrogen gas ensures that this equipment will be available to maintain the hydrogen concentration within containment below its flammable limit during post-LOCA conditions. Either recombiner unit or the hydrogen mitigation system, consisting of 68 hydrogen igniters per unit, is capable of controlling the expected hydrogen generation associated with 1) zirconium-water reactions, 2) radiolytic decomposition of water and 3) corrosion of metals within containment. These hydrogen control systems are designed to mitigate the effects of an accident as described in Regulatory Guide 1.7, "Control of Combustible Gas Concentrations in Containment Following a LOCA," Revision 2, dated November 1978. The hydrogen monitors of Specification 3.6.4.1 are part of the accident monitoring instrumentation in Specification 3.3.3.7 and are designated as Type A, Category 1 in accordance with Regulatory Guide 1.97, Revision 2, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident," December 1980. BR R135

The hydrogen mixing systems are provided to ensure adequate mixing of the containment atmosphere following a LOCA. This mixing action will prevent localized accumulations of hydrogen from exceeding the flammable limit.

The operability of at least 66 of 68 igniters in the hydrogen control distributed ignition system will maintain an effective coverage throughout the containment. This system of ignitors will initiate combustion of any significant amount of hydrogen released after a degraded core accident. This system is to ensure burning in a controlled manner as the hydrogen is released instead of allowing it to be ignited at high concentrations by a random ignition source. BR

3/4.6.5 ICE CONDENSER

The requirements associated with each of the components of the ice condenser ensure that the overall system will be available to provide sufficient pressure suppression capability to limit the containment peak pressure transient to less than 12 psig during LOCA conditions.

3/4.6.5.1 ICE BED

The OPERABILITY of the ice bed ensures that the required ice inventory will 1) be distributed evenly through the containment bays, 2) contain sufficient boron to preclude dilution of the containment sump following the LOCA and 3) contain sufficient heat removal capability to condense the reactor system volume released during a LOCA. These conditions are consistent with the assumptions used in the accident analyses.

The minimum weight figure of 1071 pounds of ice per basket contains a 15% conservative allowance for ice loss through sublimation which is a factor of 15 higher than assumed for the ice condenser design. The minimum weight figure of 2,082,024 pounds of ice also contains an additional 1% conservative allowance to account for systematic error in weighing instruments. In the