Tennessee Valley Authority, Post Office Box 2000, Soddy-Daisy, Tennessee 37384-2000

September 12, 2001

TVA-SQN-TS-01-04 10 CFR 50.90

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

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - UNITS 1 AND 2 - TECHNICAL SPECIFICATION (TS) CHANGE NO. 01-04, REVISED ICE WEIGHT

In accordance with the provisions of 10 CFR 50.4 and 50.90, TVA is submitting a request for an amendment to SQN's Licenses DPR-77 and 79 to change the TSs for Units 1 and 2. The proposed change revises the SQN Ice Condenser Specification 3/4.6.5 to increase the total ice weight from 2,082,024 pounds to 2,225,880 pounds. The proposed change is required to address a computer modeling input error that was identified by Westinghouse Electric Company (reference Westinghouse Potential Issue Number PI-00-011) regarding the treatment of mass and energy inputs in SQN's long-term containment pressurization analysis. The input error affects the ice mass required by the analysis to maintain the present calculated peak containment pressure. The basis for TVA's proposed TS change is provided in an enclosed topical report entitled, "Tennessee Valley Authority Sequoyah Nuclear Plant Units 1 and 2 Containment Integrity Reanalyses Engineering Report (WCAP-12455, Revision 1, Supplement 1R)."

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The analysis input error is being addressed within TVA's Corrective Action Program and is being administratively controlled in accordance with NRC Administrative Letter 98-10. This administrative control is provided as a commitment in TS 01-07, "Ultimate Heat Sink," submitted to NRC on July 10, 2001.

TVA has determined that there are no significant hazards considerations associated with the proposed change and that the change is exempt from environmental review pursuant to the provisions of 10 CFR 51.22(c)(9).

The SQN Plant Operations Review Committee and the SQN Nuclear Safety Review Board have reviewed this proposed change and determined that operation of SQN Units 1 and 2, in accordance with the proposed change, will not endanger the health and safety of the public. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Tennessee State Department of Public Health.

Enclosure 1 to this letter provides the description and evaluation of the proposed change. This includes TVA's determination that the proposed change does not involve a significant hazards consideration, and is exempt from environmental review. Enclosure 2 contains copies of the appropriate TS pages from Units 1 and 2 marked up to show the proposed change. Enclosure 3 forwards the revised TS pages for Units 1 and 2 which incorporate the proposed change. Enclosure 4 provides a copy of the engineering topical report (WCAP-12455, Revision 1, Supplement 1R).

As previously discussed, administrative controls are in place for this TS change. Thus, TVA does not have a specific need date for NRC review and approval. No commitments are contained in this letter.

In accordance with NRC RIS 2001-05, only one paper copy of this document is being sent to the NRC Document Control Desk.

If you have any questions about this change, please telephone me at (423) 843-7170 or J. D. Smith at (423) 843-6672.

Sincerely,

Pedro Salas

Licensing and Industry Affairs Manager
Subscribed and sworn to before me
on this 12th day of September

Peggy M. Billingsley
Notary Public

My Commission Expires October 9, 2002

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ENCLOSURE 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT (SQN)
UNITS 1 AND 2
DOCKET NOS. 327 AND 328

PROPOSED TECHNICAL SPECIFICATION (TS) CHANGE NO. 01-04
DESCRIPTION AND EVALUATION OF THE PROPOSED CHANGE

I. DESCRIPTION OF THE PROPOSED CHANGE

TVA proposes to modify the Sequoyah Nuclear Plant (SQN) Units 1 and 2 technical specifications (TSs) to revise TS 3.6.5.1 and Surveillance Requirement (SR) 4.6.5.1.d.2 to raise SQN's minimum TS ice basket weight from 1,071 pounds (lbs) to 1,145 lbs, and to raise the overall ice condenser weight from 2,082,024 lbs to 2,225,880 lbs. The associated TS Bases section is also revised to include these changes in ice weight values.

II. REASON FOR THE PROPOSED CHANGE

TVA is proposing a revision to SQN TSs to ensure that TS ice mass values remain consistent with design basis values as contained in SQN's containment integrity analysis.

Westinghouse Electric Company has determined that the interface between two computer models (i.e., computer model for loss-of-coolant accident [LOCA] mass and energy release for containment design and the computer model for long-term ice condenser containment [LOTIC-1]) contained an incorrect input assumption regarding the separation of steam and water from the two-phase mixture released downstream of a primary reactor coolant pipe break following a postulated LOCA. This resulted in erroneous treatment of the two-phase mixture which causes the calculated peak pressure inside containment to be non-conservatively low. A containment integrity reanalysis (WCAP-12455, Revision 1, Supplement 1R) was performed to implement corrections to the LOTIC-1 computer code input assumptions that account for the mass and energy interface error. The reanalysis determined that an increase in the analytical ice mass value is necessary to retain the current calculated peak pressure. Consequently, TVA is proposing the enclosed change to the TSs to increase the licensing basis minimum ice mass.

III. SAFETY ANALYSIS

The current containment integrity analysis for SQN Units 1 and 2 is documented in WCAP-12455, Revision 1 (September 1995). The analysis utilizes a Westinghouse computer model (LOTIC-1) to calculate the peak containment pressure following a LOCA inside containment. The calculated peak pressure for SQN is 11.44 pounds per square inch gauge (psig) which is below the containment design pressure of 12.0 psig. The assumption contained in the LOTIC-1 computer model for this analysis includes an initial ice mass in the ice condenser of 1.792×10^6 lbs of ice. A discussion of SQN's design basis analysis (WCAP-12455) is contained in Section 6.2.1.3 of the SQN Final Safety Analysis Report.

A reanalysis of SQN's containment integrity analysis was performed to account for a correction to the LOTIC-1 code The reanalysis is provided in Enclosure 4 as WCAP-12455, Revision 1, Supplement 1R, "Tennessee Valley Authority Sequoyah Nuclear Plant Units 1 and 2 Containment Integrity Reanalyses Engineering Report." The reanalysis determined that the ice mass necessary to maintain the same containment peak pressure (11.44 psig) increases from 1.792×10^6 to 1.916×10^6 lbs. Additional changes to the SQN plant specific pressurization model include: (1) revision of SQN's ultimate heat sink temperature from 85 degrees Fahrenheit (°F) to 87 °F, and (2) enhancement of containment spray heat exchanger performance.

The SQN TSs currently contain minimum operational ice mass values that provide margins above the analytical minimum ice mass values. The TS minimum ice mass ensures that adequate ice is available over an entire 18-month fuel cycle. Currently, the SQN TS minimum ice basket weight is 1071 lbs of ice per basket which includes a 15 percent conservative allowance for ice loss through sublimation. The current TS minimum for total ice weight in the ice condenser is 2,082,024 lbs of ice which includes an additional 1 percent conservative allowance to account for systematic error in weighing instruments.

TVA adds ice to SQN's ice condensers each refueling outage to ensure that the TS minimum ice mass is achieved prior to startup (this ice mass is referred to as the as-left value). As a conservative measure, TVA adds additional ice to the ice condensers over and above the TS minimum. The addition of ice over the TS minimum is a TVA maintenance practice (servicing plan) that is based on historical ice weight data and visual inspection history

of the ice baskets. This maintenance practice ensures that distribution of ice is uniform throughout the ice condenser. During the last refueling outages (Cycle 10 refueling outage for each unit), TVA added additional ice to the ice condensers as part of TVA's servicing plan. The additional ice mass provided as-left ice weight for Cycle 11 operation. The as-left ice weight for Unit 1 at the start of Cycle 11 operation was 2,672,000 lbs of ice for an average as-left weight per basket of 1374 lbs (95 percent level of confidence). The as-left ice weight for Unit 2 at the start of Cycle 11 operation was 2,582,761 lbs of ice for an average as-left weight per basket of 1346 lbs.

TVA's proposed TS change increases the TS minimum ice weight from 2,082,024 lbs to 2,225,880 lbs. This 6.9 percent increase in weight reduces the margin between the TS required minimum and the as-left ice weight, however, TVA's servicing plan and the as-left ice weight values from Cycle 10 as provided above, ensure that sufficient ice is present to support safe operation during cycle 11.

SQN's containment integrity analysis remains unchanged with regard to SQN's containment design pressure and the analytical peak containment pressure following a postulated LOCA. The margin of safety provided by the containment design is not affected by TVA's proposed TS change. Accordingly, justification exists for increasing SQN's TS minimum ice weight values to account for the LOTIC-1 code error.

IV. NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

TVA has concluded that operation of Sequoyah (SQN) Units 1 and 2, in accordance with the proposed change to the technical specifications (TS), does not involve a significant hazards consideration. TVA's conclusion is based on its evaluation, in accordance with 10 CFR 50.91(a)(1), of the three standards set forth in 10 CFR 50.92(c).

TVA proposes to modify SQN TS 3.6.5.1 and Surveillance Requirement (SR) 4.6.5.1.d.2 to raise SQN's minimum TS ice basket weight from 1,071 pounds (lbs) to 1,145 lbs, and to raise the overall ice condenser weight from 2,082,024 lbs to 2,225,880 lbs. The associated TS Bases section is also revised to include these changes in ice weight values.

A. <u>The proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.</u>

The analyzed accidents of consideration in regards to changes affecting the ice condenser are a loss-of-coolant accident (LOCA) and a main steam line break (MSLB) inside containment. The ice condenser is a passive system and is not postulated as being the initiator of any LOCA or main steam line break (MSLB) and is designed to remain functional following a design basis earthquake. In addition, the ice condenser does not interconnect or interact with any systems that have an interface with the reactor coolant or main steam systems.

For SQN, the LOCA is the more severe accident in terms of containment pressure and ice bed meltout and is therefore the more limiting accident. SQN's LOCA Containment Integrity Analysis calculates the post-LOCA peak containment pressure to be 11.44 pounds per square inch gauge (psig), which is below SQN's containment design pressure of 12.0 psig. The analysis contains an assumed ice mass that is an input value to the calculation to ensure that sufficient heat removal capability is available from SQN's ice condenser to limit the accident peak pressure inside containment. The analyzed peak accident pressure must remain below the containment design pressure.

TVA's proposed TS revision reflects the ice mass assumed in the SQN's Containment Integrity Analysis. Accordingly, TVA's proposed change ensures that ice mass values retain the existing margin between the calculated peak containment accident pressure and SQN's containment design pressure.

Since the proposed changes to the TS and TS bases are solely to revise ice weight values to reflect current margins within SQN's analysis, and are not the result of or require any physical changes to the ice condenser, there is no change in the probability of an accident previously evaluated in the Safety Analysis Report.

Based on the above discussions, the proposed changes do not involve an increase in the probability or consequences of an accident previously evaluated.

B. **The proposed amendment does not create the possibility of a new or different kind of accident from any accident previously evaluated.**

Because the TS and TS bases changes do not involve any physical changes to the ice condenser, or chemical changes to the ice contained therein, or make any changes in the operational aspects of the ice condenser as required by the TS, there are no new or different kind of accidents created from those already identified and evaluated.

C. **The proposed amendment does not involve a significant reduction in a margin of safety.**

The ice condenser TSs ensure that during a LOCA or MSLB the ice condenser will initially pass sufficient air and steam mass to preclude over-pressurizing lower containment, that it will absorb sufficient heat energy initially and over a prescribed time period to assist in precluding containment vessel failure, and that it will not alter the bulk containment sump pH and boron concentration assumed in the accident analysis. TVA's proposed change does not physically alter the ice condenser, but rather accounts for changes to input assumptions for SQN's containment pressure analysis to correct a computer model input error. The correction to the model provides a more accurate accounting of the pressure response inside containment following a LOCA. The error correction requires an increase the ice mass assumed in the analysis to ensure that SQN's post-LOCA peak containment pressures remain unchanged. The margin that exists between the accident peak pressure and the containment design pressure is unaffected. Accordingly, TVA's proposed change does not reduce the margin of safety.

V. ENVIRONMENTAL IMPACT CONSIDERATION

The proposed change does not involve a significant hazards consideration, a significant change in the types of or significant increase in the amounts of any effluents that may be released offsite, or a significant increase in individual or cumulative occupational radiation exposure. Therefore, the proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), an environmental assessment of the proposed change is not required.

ENCLOSURE 2

TENNESSEE VALLEY AUTHORITY
SEQUOYAH PLANT (SQN)
UNITS 1 AND 2

PROPOSED TECHNICAL SPECIFICATION (TS) CHANGE 01-04
MARKED PAGES

I. AFFECTED PAGE LIST

Unit 1

3/4 6-26
3/4 6-27
B 3/4 6-4

Unit 2

3/4 6-27
3/4 6-28
B 3/4 6-4

II. MARKED PAGES

See attached.

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 ≥ 1800 ppm and ≤ 2500 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~~ 2,225,880 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 18 months by verifying, by visual inspection, accumulation of ice on structural members comprising flow channels through the ice bed is ≤ 15 percent blockage of the total flow area for each safety analysis section.

NRC approved change for TSC 00-02 that becomes effective during U1C11 refueling outage (Fall 2001).

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. Deleted.

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~~ 1145 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~~ 1145 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~~ 1145 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~~ 2,225,880 pounds.

e. At least once per 54 months by chemical analysis of the stored ice in at least one randomly selected ice basket from each ice condenser bay verify:

1. Ice bed boron concentration is ≥ 1800 ppm and ≤ 2500 ppm as sodium tetraborate and;

2. pH is ≥ 9.0 and ≤ 9.5

NOTE: The requirements of this SR are satisfied if the boron concentration and pH values obtained from averaging the individual sample results are within the limits specified above.

f. Each ice addition verify, by chemical analysis, that ice added to the ice condenser meets the boron concentration and pH requirements of SR 4.6.5.1.e.

NOTE: The chemical analysis may be performed on either the liquid solution or the resulting ice.

NRC approved change for TSC 00-02 that becomes effective during U1C11 refueling outage (Fall 2001).

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.

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.

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~~ 1145 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~~ 2,225,880 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 ≥ 1800 ppm and ≤ 2500 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~~ 2,225,880 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 18 months by verifying, by visual inspection, accumulation of ice on structural members comprising flow channels through the ice bed is ≤ 15 percent blockage of the total flow area for each safety analysis section.

NRC approved change for TSC 00-02 that becomes effective during U2C11 refueling outage (Spring 2002).

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. Deleted.

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~~ 1145 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~~ 1145 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~~ 1145 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~~ 2,225,880 pounds.

e. At least once per 54 months by chemical analysis of the stored ice in at least one randomly selected ice basket from each ice condenser bay verify:

1. Ice bed boron concentration is ≥ 1800 ppm and ≤ 2500 ppm as sodium tetraborate and;

2. pH is ≥ 9.0 and ≤ 9.5

NOTE: The requirements of this SR are satisfied if the boron concentration and pH values obtained from averaging the individual sample results are within the limits specified above.

f. Each ice addition verify, by chemical analysis, that ice added to the ice condenser meets the boron concentration and pH requirements of SR 4.6.5.1.e.

NOTE: The chemical analysis may be performed on either the liquid solution or the resulting ice

NRC approved change for TSC 00-02 that becomes effective during U2C11 refueling outage (spring 2002).

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.

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.

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.

1145 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~~ 2,225,880 pounds of ice also contains an additional 1% conservative allowance to account for systematic error in weighing instruments. In the

ENCLOSURE 3

TENNESSEE VALLEY AUTHORITY
SEQUOYAH PLANT (SQN)
UNITS 1 AND 2

PROPOSED TECHNICAL SPECIFICATION (TS) CHANGE 01-04
REVISED PAGES

I. AFFECTED PAGE LIST

Unit 1

3/4 6-26
3/4 6-27
B 3/4 6-4

Unit 2

3/4 6-27
3/4 6-28
B 3/4 6-4

II. REVISED PAGES

See attached.

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 ≥ 1800 ppm and ≤ 2500 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 2,225,880 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 18 months by verifying, by visual inspection, accumulation of ice on structural members comprising flow channels through the ice bed is ≤ 15 percent blockage of the total flow area for each safety analysis section.

NRC approved change for TSC 00-02 that becomes effective during U1C11 refueling outage (Fall 2001).

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. Deleted.

2. Weighing a representative sample of at least 144 ice baskets and verifying that each basket contains at least 1145 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 1145 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 1145 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 1145 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 2,225,880 pounds.

e. At least once per 54 months by chemical analysis of the stored ice in at least one randomly selected ice basket from each ice condenser bay verify:

1. Ice bed boron concentration is ≥ 1800 ppm and ≤ 2500 ppm as sodium tetraborate and;

2. pH is ≥ 9.0 and ≤ 9.5

NOTE: The requirements of this SR are satisfied if the boron concentration and pH values obtained from averaging the individual sample results are within the limits specified above.

f. Each ice addition verify, by chemical analysis, that ice added to the ice condenser meets the boron concentration and pH requirements of SR 4.6.5.1.e.

NOTE: The chemical analysis may be performed on either the liquid solution or the resulting ice.

NRC approved change for TSC 00-02 that becomes effective during U1C11 refueling outage (Fall 2001).

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.

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.

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 1145 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 2,225,880 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 ≥ 1800 ppm and ≤ 2500 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 2,225,880 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 18 months by verifying, by visual inspection, accumulation of ice on structural members comprising flow channels through the ice bed is ≤ 15 percent blockage of the total flow area for each safety analysis section.

NRC approved change for TSC 00-02 that becomes effective during U2C11 refueling outage (Spring 2002).

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. Deleted.

2. Weighing a representative sample of at least 144 ice baskets and verifying that each basket contains at least 1145 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 1145 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 1145 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 1145 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 2,225,880 pounds.

e. At least once per 54 months by chemical analysis of the stored ice in at least one randomly selected ice basket from each ice condenser bay verify:

   1. Ice bed boron concentration is ≥ 1800 ppm and ≤ 2500 ppm as sodium tetraborate and;

   2. pH is ≥ 9.0 and ≤ 9.5

NOTE: The requirements of this SR are satisfied if the boron concentration and pH values obtained from averaging the individual sample results are within the limits specified above.

f. Each ice addition verify, by chemical analysis, that ice added to the ice condenser meets the boron concentration and pH requirements of SR 4.6.5.1.e.

NOTE: The chemical analysis may be performed on either the liquid solution or the resulting ice

NRC approved change for TSC 00-02 that becomes effective during U2C11 refueling outage (Spring 2002).

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.

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.

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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 1145 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 2,225,880 pounds of ice also contains an additional 1% conservative allowance to account for systematic error in weighing instruments. In the

ENCLOSURE 4

TENNESSEE VALLEY AUTHORITY
SEQUOYAH PLANT (SQN)
UNITS 1 AND 2

WCAP-12455, REVISION 1, SUPPLEMENT 1

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2
CONTAINMENT INTEGRITY REANALYSES
ENGINEERING REPORT

Westinghouse Non-Proprietary Class 3

WCAP-12455
REVISION 1
Supplement 1R

TENNESSEE VALLEY AUTHORITY SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2 CONTAINMENT INTEGRITY REANALYSES ENGINEERING REPORT

Westinghouse Electric Company LLC

WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-12455
Revision 1
Supplement 1R

TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2
CONTAINMENT INTEGRITY REANALYSES
ENGINEERING REPORT

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September, 2001

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EXECUTIVE SUMMARY

Loss-of-Coolant (LOCA) Containment Integrity Analyses have been updated to support recent changes to the Westinghouse computer code, LOTIC-1 and to include effects due to post-LOCA hydrogen generation for the Sequoyah Nuclear Plant Units 1 and 2. The analyses conducted are consistent with current licensed methodology.

The objective of this effort was to address 1) the LOTIC-1 mass and energy interface issue, 2) the addition of post-LOCA evolved hydrogen to the containment, and 3) determine an ice weight that preserved the current LOCA containment integrity pressure margin. Additionally, the containment spray switchover interval (approximately 156 seconds) relationship between ice bed meltout time and containment spray switchover time was to be preserved.

The results of the analysis support the following:

- An ice mass of 1.916×10^6 lbms
- A calculated containment peak pressure of 11.459 psig occurring at 7068.86 seconds
- Ice bed meltout occurred at 3367 seconds (Containment spray switchover is completed at 3113 seconds thus the containment spray switchover ice bed meltout relationship is 250 seconds).

The ice bed mass of 1.916×10^6 Lbms equates to an average of 980 Lbm per basket. This average value recognizes that all baskets may not have the same initial weight nor have the same sublimation rate. To ensure that a sufficient quantity of ice exists in each basket to survive the blowdown phase of a LOCA, a minimum amount of ice per basket to survive the blowdown would be approximately 325 Lbm, based on Table 2-3. To ensure that an adequate distribution of ice exists in the Ice Condenser to prevent early burn-through of a localized area, 325 Lbm of ice should be the minimum weight of ice per basket at any time while also ensuring that the average weight per basket remains above 986 Lbm.

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1.0 INTRODUCTION

Containment Integrity reanalysis were performed to implement the recent corrections to the LOTIC-1 computer code due to the mass and energy interface issue, and to include the effects on containment peak pressure due to evolved hydrogen post-LOCA. The analysis used the mass and energy releases generated for the current Sequoyah design basis containment integrity analysis documented in WCAP-12455, Revision 1 (September 1995) (1.7924875 million pound ice mass case).

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 reanalysis utilized revised input assumptions that eliminated analytical conservatisms from the present analysis. Areas addressed were the decay heat release, and the ice condenser metal mass. The analysis was completed to provide the analytical basis for a change to the Sequoyah design basis ice mass of 1.7924875 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, Revision 1), this analysis accounted for the effects of a change to the containment spray heat exchanger performance and included margin in the Essential Raw Cooling Water (ERCW) temperature assumption of two (2) Degrees-F, (increase from 85 to 87 Deg-F). 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.

PURPOSE OF ANALYSIS

The purpose of this program was to reanalyze the containment integrity response in order to incorporate the corrected LOTIC-1 code and account for the post-LOCA hydrogen addition to the containment. The objective of this effort will be to determine the necessary analytical ice mass that results in the same peak pressure as was calculated in WCAP-12455, Revision 1, while maintaining the current time interval (156 seconds) relationship between containment spray switchover time and ice bed meltout time.

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. 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 WCAP-12455, Revision 1, Section 2.0 forms the basis for 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 Containment Pressure Calculations.

TABLE 1-1

SEQUOYAH UNITS 1 AND 2
SYSTEM PARAMETERS
INITIAL CONDITIONS

PARAMETERS	VALUE
Core Thermal Power (MWt)	3455
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 1-2

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
-End of Cycle Core Average Burnup of 52,687 Mwd/MTU
-Low bound for enrichment: 3.0%

2.0 LOCA CONTAINMENT INTEGRITY ANALYSIS

2.1 Description of LOTIC-1 Model and Interface Issue

The LOTIC code is described in reference 4.

The LOTIC 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 that 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.

The Reference 4 model was developed when the Reference 5 model was the predominate model for developing LOCA mass and energy releases. The Reference 1 analysis used LOCA mass and energy releases developed from the Reference 6 model. Recently, Westinghouse has determined that the interface between the Reference 6 mass and energy release model and the LOTIC code contained an incompatible assumption regarding the separation of steam and water from the two-phase mixture exiting the pump side of a pump suction break. Previously, when the Reference 5 model was used mass and energy release were separated outside of LOTIC. When the Reference 6 methodology was implemented, the mass and energy releases were directly input into LOTIC. However, the LOTIC-1 code did not separate the steam but put the two-phase mixture directly into the sump where LOTIC-1 then assumed the mixture to become hot water. This treatment of the two-phase mixture is not acceptable and a modification to the LOTIC-1 code to separate the steam into the containment atmosphere resulted in an increase in the calculated containment peak pressure for Sequoyah. This change to LOTIC required the reanalysis presented below and an increase in the licensing basis minimum ice mass.

2.2 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. $1.916 * 10^6$ lbs. of ice initially in the ice condenser.

3. The blowdown, reflood, and post reflood mass and energy releases described in Section 2.5 of Reference 1 were 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. Hydrogen gas was added to the containment in the amount of 21,366 Standard Cubic Feet (SCF) over 24 hours. Sources accounted for were radiolysis in the core and sump post-LOCA, corrosion of plant materials (Aluminum, Zinc, and painted surfaces found in containment), reaction of 1% of the Zirconium fuel rod cladding in the core, and hydrogen gas assumed to be dissolved in the Reactor Coolant System water. (This bounds tritium producing core designs)

7. Essential service water temperature of 87°F is used on the spray heat exchanger and the component cooling heat exchanger.

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

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

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

11. 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.

12. 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 Reference 1, Table 3-1 and APPENDIX A).

13. Containment structural heat sinks are assumed with conservatively low heat transfer rates. (See Tables 2-1,and 2-2) Note: The Dead-Ended compartment structural heat sinks were conservatively neglected.

14. 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.

15. The operation of one containment spray heat exchanger ($UA = 2.953 * 10^6$ 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.

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

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

18. 100.7% of 3455 MWt power is used in the calculations.

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

20. Nuclear service water flow to the containment spray heat exchanger was modeled as 3400 gpm. Also the nuclear service water flow to the component cooling heat exchanger was modeled as 4000 gpm.

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

    Significant assumptions in the generation of the decay heat curve:

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

    B. Decay heat power from the following fissioning isotopes are included; U-238,

U-235, and Pu-239.

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

D. The factor accounting for neutron capture in fission products has been taken from Equation 11, of Reference 2 (up to 10,000 seconds) and Table 10 of Reference 2 (beyond 10,000 seconds).

E. The fuel has been assumed to be at full power for 1116 days.

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

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

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

22. Core stored energy based on the time in life for maximum fuel densification. The assumptions used to calculate the fuel temperatures for the core stored energy calculation account for appropriate uncertainties associated with the models in the PAD code (e.g., calibration of the thermal model, pellet densification model, cladding creep model, etc.). In addition, the fuel temperatures for the core stored energy calculation account for appropriate uncertainties associated with manufacturing tolerances (e.g., pellet as-built density). The total uncertainty for the fuel temperature calculation is a statistical combination of these effects and is dependent upon fuel type, power level, and burnup.

23. Reloads utilizing Mark-BW17 fuel with up to 96 fresh assemblies are bounded based on the evaluation provided in Reference 8.

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.

2.3 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 2-1 and 2-2.

The heat transfer coefficient to the containment structure is based primarily on the work of Tagami [Reference 7] 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.

2.4 Analysis Results

The results of the analysis shows that the maximum calculated containment pressure is 11.459 psig, for the double-ended pump suction minimum safeguards break case. This pressure peak occurs at approximately 7068.86 seconds, with ice bed meltout at approximately 3367 seconds.

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

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

Tables 2-3 and 2-4 give energy accountings at various points in the transient. Table 2-5 provides the sequence of events, which includes results previously calculated in Reference 1.

2.5 Relevant Acceptance Criteria

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.

2.6 Conclusions

Based upon the information presented in this report, it may be concluded that operation with an initial ice weight of 1.916 million pounds for the Sequoyah Nuclear Plant is acceptable. Operation with an initial ice mass of 1.916 million pounds results in a calculated peak containment pressure of 11.459 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.

3.0 REFERENCES

1. WCAP-12455,Revision 1, "TENNESSEE VALLEY AUTHORITY,SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2.CONTAINMENT INTEGRITY ANAI YSES FOR ICE WEIGHT OPTIMIZATION ENGINEERING REPORT," September 1995.

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

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

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

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. "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).

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

8. TVA-01-113, John W Irons (W) to Mr. D. L. Lundy (TVA), "Tennessee Valley Authority, Sequoyah Units 1 and 2, Transmittal - Wesdyne Letter NDP-01-0367,'Revision to LOCA M&E Confirmation for Sequoyah Tritium Production Core Designs,' ," August 21, 2001

TABLE 2-1

SEQUOYAH UNITS 1 AND 2
STRUCTURAL HEAT SINK TABLE

Heat Sink / Material		AREA (ft^2)	Thickness (ft)
Upper Compartment			
1.	Operating Deck	4,880	
	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 2-1 (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	
	Concrete		1.6
9.	Interior Concrete	3,590	
	Paint		0.0011
	Concrete		1.5
10.	Reactor Cavity	2,270	
	Stainless Steel		0.02082
	Concrete		2.0
11.	Containment Shell & Misc. Steel	19,500	
	Paint		0.000625
	Steel		0.0495
12.	Misc. Steel	9,000	
	Paint		0.000625
	Steel		0.1008

TABLE 2-1 (Continued)

SEQUOYAH UNITS 1 AND 2
STRUCTURAL HEAT SINK TABLE

Heat Sink / Material		AREA (ft^2)	Thickness (ft)
Ice Condenser			
13.	Ice Basket	149,600	
	Steel		0.00663
14.	Lattice Frames	75,865	
	Steel		0.0217
15.	Lower Support Structure	28,670	
	Steel		0.0587
16.	Ice Condenser Floor	3,336	
	Paint		0.000833
	Concrete		0.333
17.	Containment Wall Panels & Containment Shell	19,100	
	Steel & Insulation		1.0
	Steel		0.4625
18.	Crane Wall Panels & Crane Wall	13,055	
	Composite Panel (Steel & Insulation)		1.2
	Concrete		1.0

TABLE 2-2

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
$Paint_2$	0.0633	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 2-3

SEQUOYAH UNITS 1 AND 2

ENERGY ACCOUNTING

	Approx† End of Blowdown (t = 10.0 Seconds)	Approx†† End of Reflood (t = 216.0 Seconds)
	(In Millions of Btus)	
Ice Heat Removal	195.86	244.4
Structural Heat Sinks*	18.05	61.74
RHR Heat Exchanger Heat Removal*	0.00	0.00
Spray Heat Exchanger Heat Removal*	0.00	0.00
Energy Content of Sump	183.7	235.6
Ice Melted (Pounds)(10^6)	0.632	0.8266

* Integrated Energies

†- End of Blowdown is redefined in LOTIC-1 to occur at 10 seconds, per results from the Waltz Mill Ice condenser test.

††- The approximate time is the time closest to the event that is captured in the LOTIC-1 code major print out. Table 2-5 provides the actual sequence of events

TABLE 2-4

SEQUOYAH UNITS 1 AND 2

ENERGY ACCOUNTING

	Approximate† Time of Ice Melt Out (t=3363 Seconds)	Approximate† Time of Peak Pressure (t=6983 Seconds
	(In Millions of Btus)	
Ice Heat Removal	516.45	516.45
Structural Heat Sinks*	79.795	121.440
RHR Heat Exchanger Heat Removal	16.085	45.919
Spray Heat Exchanger Heat Removal*	4.165	69.33
Energy Content of Sump	623.99	651.71
Ice Melted (Pounds)(10^6)	1.916	1.916

* Integrated Energies

† - The approximate time is the time closest to the event that is captured in the LOTIC-1 code major print out. Table 2-5 provides the actual sequence of events.

TABLE 2-5

SEQUOYAH UNITS 1 AND 2

DOUBLE ENDED PUMP SUCTION LOCA

MINIMUM SAFEGUARDS

SEQUENCE OF EVENTS

Event	Time (Sec)
Rupture	0.0
Accumulator Flow Starts	15.0
End of Blowdown	32.5
Assumed Initiation of ECCS	32.5
Accumulators Empty	83.6
End of Reflood	216.
Assumed Initiation of Spray System	250.
Low Level Alarm from Refueling Water Storage Tank	1681.
Start of ECCS Cold Leg Recirculation	1691.
Low-Low Level Alarm from RWST - Sprays Stopped	2803.
Spray Pumps Restart in Recirculation Mode	3113.
Ice Bed Meltout	3367.
RHR Spray Realignment	3600.
Peak Containment Pressure	7068.

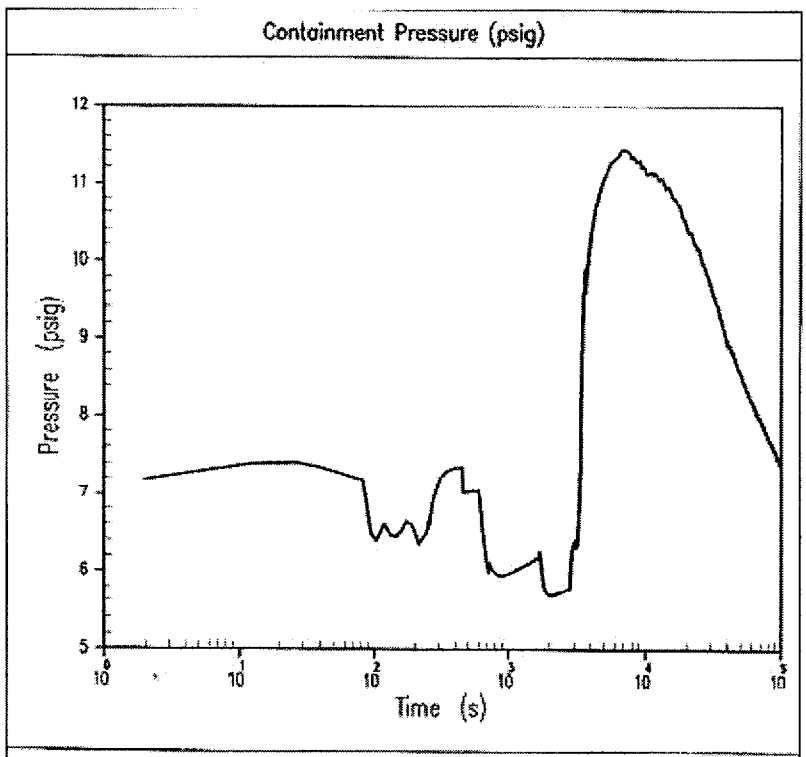
Containment Pressure (psig)
Pressure (psig)
12
11
10
9
8
7
6
5
Time (s)

Figure 2-1

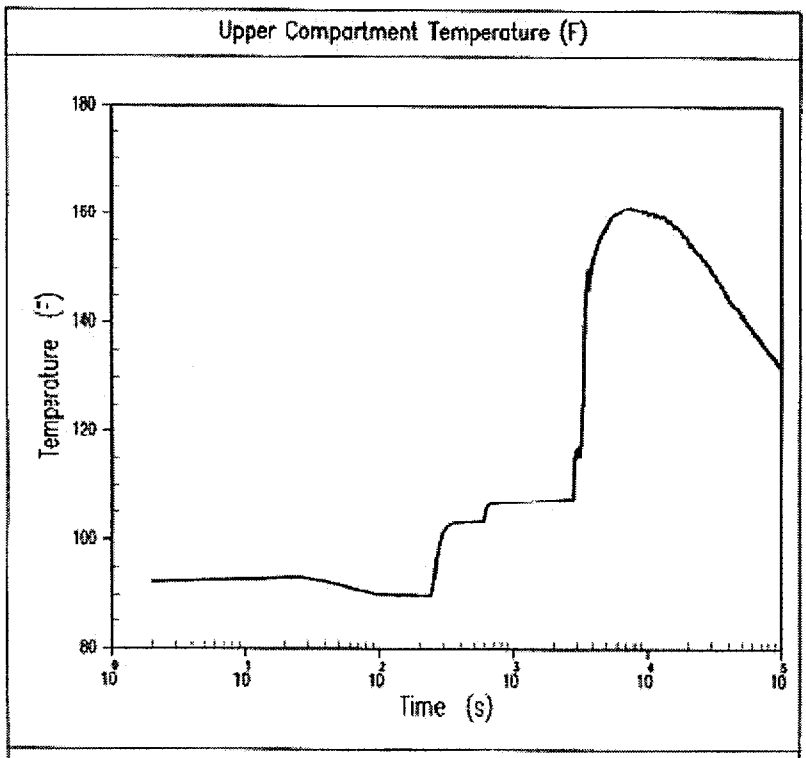
Upper Compartment Temperature (F)
180
160
140
120
100
80
Temperature (°)
10^0
10^1
10^2
10^3
10^4
10^5
Time (s)

Figure 2–2

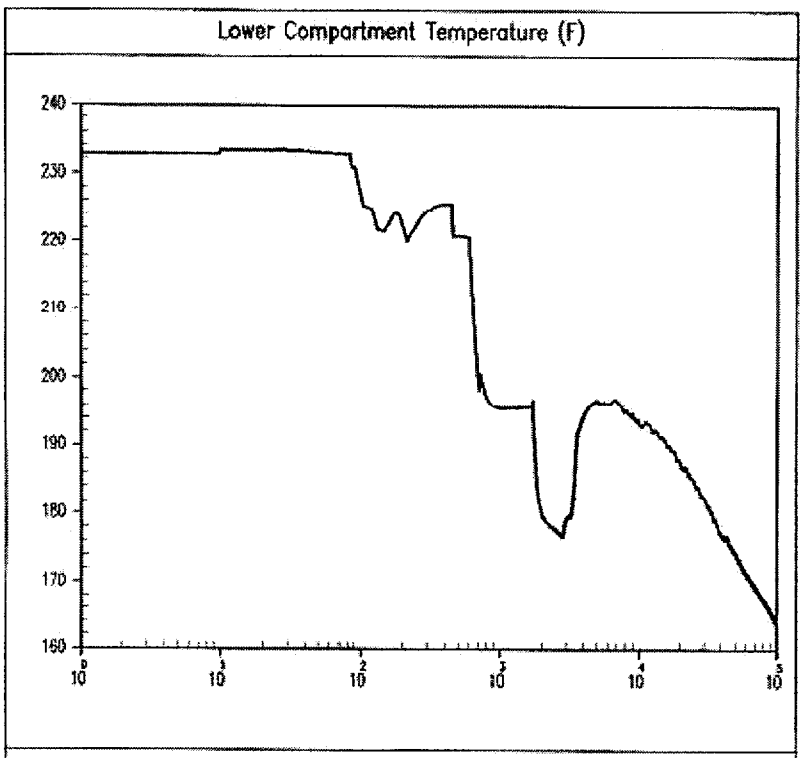
Lower Compartment Temperature (F)
240
230
220
210
200
190
180
170
160
10^0
10^1
10^2
10^3
10^4
10^5

Figure 2-3

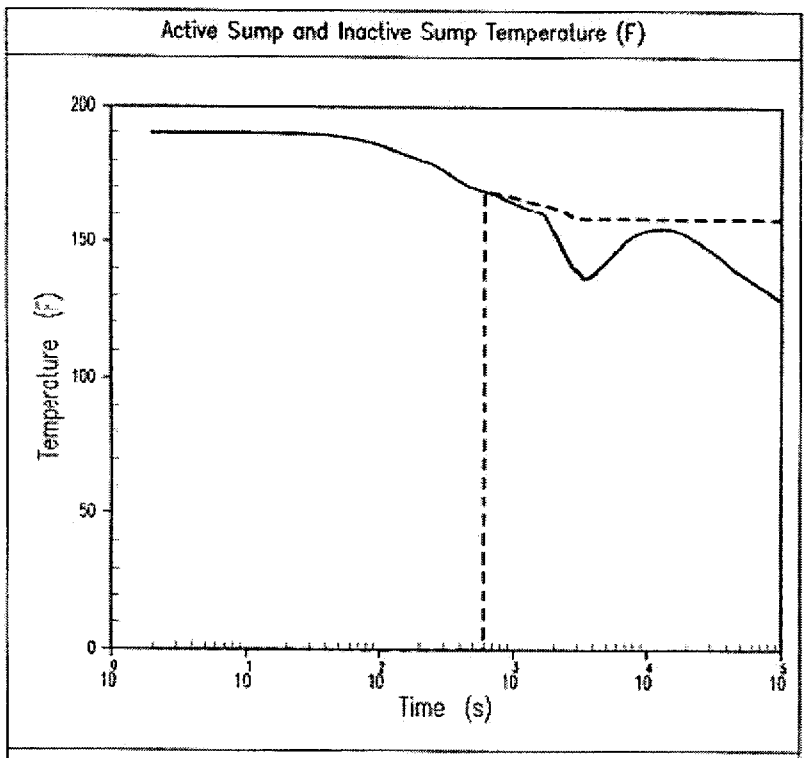
Active Sump and Inactive Sump Temperature (F)
200
150
100
50
0
Temperature (F)
10^0
10^1
10^2
10^3
10^4
10^5
Time (s)

Figure 2–4

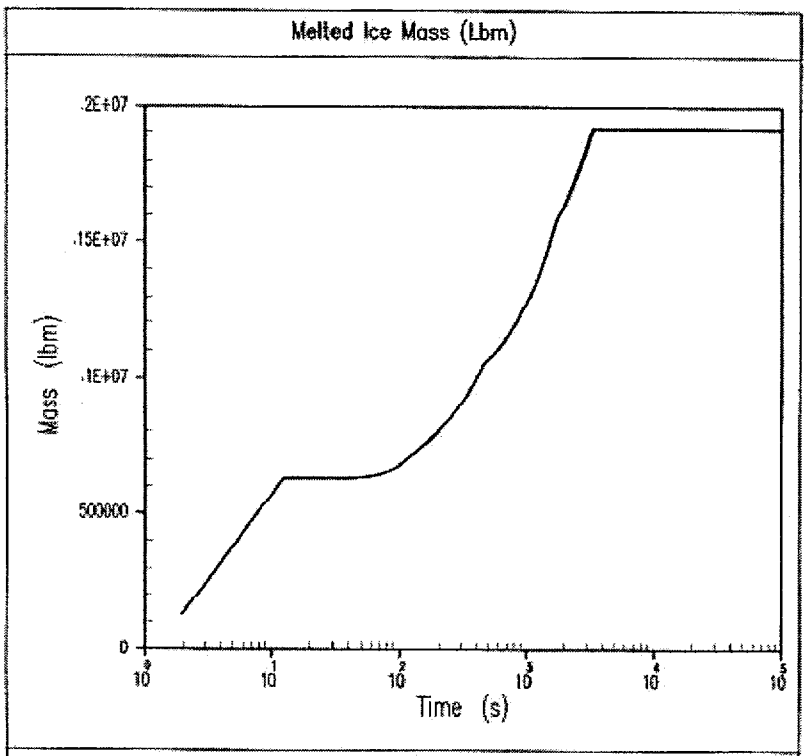
Melted Ice Mass (Lbm)
.2E+07
.15E+07
.1E+07
500000
0
Mass (lbm)
10^0
10^1
10^2
10^3
10^4
10^5
Time (s)

Figure 2-5

APPENDIX A

FSAR MARKUP

For a further discussion, see Section 5 of Reference 21.

Containment Pressure Calculation

The following are the major input assumptions used to calculate the containment transients for the pump suction pipe rupture cases with the steam generators considered as an active heat source for the Sequoyah Nuclear Station Containment:

1. Minimum containment 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 recirculation fans. 14

2. Initial ice weight in the ice condenser as specified in Table 6.2.1-1.

3. The Blowdown, Reflood, and Post-Reflood mass and energy releases described in Section 6.2.1.3.6 are used. 14

4. Blowdown and post-blowdown ice condenser drain temperature of 190°F and 130°F were used. (These numbers are based on the long-term Waltz Mill ice condenser test data described in Reference 21).

5. Nitrogen from the accumulators in the amount of 3676 lbs. is included in the calculations. 14

6. The air recirculation fan is assumed to be effective, approximately 10 minutes after the transient is initiated.

7. Essential service water temperature of ~~85~~ 87°F is used on the spray heat exchanger and the component cooling heat exchanger. 14

8. Even distribution of steam flow into the ice bed is assumed.

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, a temperature of 15°F in the ice condenser, and a temperature of 85°F in the upper volume. All volumes are at a pressure of 0.3 psig and a 10% relative humidity, except for the ice condenser which is at a 100% relative humidity.

11. The pump flows vs. time given in Table 6.2.1-7 were used.

12. A residual spray of 1277 gpm is assumed at 1 hour into the accident. Residual heat removal pump and spray pump take suction from the sump, after 1691 seconds, and 3113 seconds respectively. 14

13. Containment structural heat sinks are assumed with conservatively low heat transfer rates.

14. The Containment compartment volumes were based on the following: Upper Compartment 651,000 ft³; Lower Compartment 248,500 ft³; and Dead-Ended Compartment 129,900 ft³. 14

Hydrogen from post-LOCA sources - approximately 94 LBM by two hours was included in the calculations

15. The operation of one containment spray heat exchanger (UA = ~~2.811~~ 2.753 * 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.

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

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

18. 102% of 3411 MWt power is used in the calculations.

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

20. Nuclear service water flow to the containment spray heat exchanger was modeled as 3400 ~~3500~~ gpm. Also the nuclear service water flow to the component cooling heat exchanger was modeled as 4000 gpm.

21. The decay heat curve used to calculate mass and energy releases after steam generator equilibration is presented in Table 6.2.1-8.

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

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 Table 6.2.1-32.

The heat transfer coefficient to the containment structure is based primarily on the work of Tagami (Reference 77). 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.

Analysis Results

The results of the analysis shows that the maximum calculated containment pressure is 11.4~~5~~6 psig, for the double-ended pump suction minimum safeguards break case. This pressure peak occurs at approximately ~~6378~~ 7068 seconds, with ice bed meltout at approximately ~~3207~~ 3363 seconds.

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

Figure 6.2.1-15	Containment Pressure Transient
Figure 6.2.1-16	Temperature Transient for Upper Compartment
Figure 6.2.1-17	Temperature Transient for Lower Compartment
Figure 6.2.1-18	Temperature Transient of the Active Sump and Inactive Sump
Figure 6.2.1-19	Ice Melt versus Time

The following tables have also been provided:

Table 6.2.1-9	Energy accounting until end of reflood
Table 6.2.1-10	Energy accounting at time of ice melt and peak pressure

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.

Conclusions

Based upon the information presented in this report, it may be concluded that operation with an initial ice weight of ~~1.79~~ 1.916 million pounds for the Sequoyah Nuclear Plant is acceptable. Operation with an initial ice mass of ~~1.79~~ 1.916 million pounds results in a calculated peak containment pressure of ~~11.45~~ 11.44 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.

Mark-BW17 Fuel Evaluation

The effect of transitioning to and loading Mark-BW17 fuel on the previously discussed analysis results, which utilized Westinghouse fuel, was evaluated. The important aspects of the fuel change that have the possibility of impacting the analysis include the changes in the flow characteristics past the fuel, the RCS operating T_{avg}, the core-stored energy and fuel-heat capacity, and the decay heat.

There are very small deviations in flow characteristics past the fuel. However, for an ice condenser design, since the peak pressure occurs late in the transient, well after the ice bed has melted out, the single effect of small deviations in flow is insignificant relative to analysis results. Total energy content, or total energy available for release to containment, is significant, which remains unchanged. The RCS T_{avg} remains at 578.2°F.

~~For the reload core, there is no difference in the mechanical heat capacity of the fuel; however, the core stored energy has increased slightly. The increase was evaluated, and it was determined to have an increased energy effect of 1.32x10^6 BTUs. However, there are margins in the current calculations that offset this small increase. For example, the current basis utilizes the specific TVA Sequoyah Decay Heat Curve as defined in Table 6.2.1-8a until the time of steam generator equilibration (i.e., 1697.2 seconds). The LOTIC code then conservatively determines the decay heat based upon Table 6.2.1-8 after equilibration. If the Sequoyah specific data is also used after steam generator equilibration, it is found that 2.11E+06 BTUs can be removed from the calculation up to the time of ice bed meltout, and 6.00E+06 BTUs can be removed up to the time of peak pressure. This conservatism more than offsets the increased core-stored energy effect.~~

The metric tons of Uranium, the enrichment, and the fuel reload cycle utilized in the current analysis remain bounding for the B&W fuel. Therefore, the Sequoyah-specific decay heat curve remains bounding.

In summary, the effect of including Mark-BW17 Fuel on the current LOCA M&E and the containment integrity analysis has been evaluated. It has been concluded that the current analysis results remain bounding.

6.2.1.3.5 Effect of Steam Bypass

The sensitivity of the compression peak pressure to deck bypass is shown in Figure 6.2.1-22, which shows that an increase in deck bypass area of 50 percent would cause an increase of about 0.2 psi in final peak compression pressure. Also, it is important to note that the plant final peak compression pressure of 7.18 psig already includes a contribution of 0.4 psi from the plant deck bypass area of 5 ft^2.

This effect of deck leakage on upper containment pressure has been verified by a series of four special, full-scale section tests. These tests were all identical except different size deck leakage areas were used.

The results of these tests are given in Figure 6.2.1-23 which includes two curves of test results. Each curve shows the difference in upper compartment pressure between one test and another resulting from a difference in deck leakage area. One curve shows the increase in upper compartment pressure at the end of the boiler blowdown (after the compression peak pressure, at about 50 seconds in these tests), and the second curve shows the increase in upper compartment peak pressure (at about 10 seconds in these tests). It should be noted that the pressure at the end of the blowdown is less than the peak compression ratio pressure occurring at about 10 seconds for reference blowdown test.

The containment pressure increase due to deck leakage is directly proportional to the total amount of steam leakage into the upper compartment, and the amount of this steam leakage is, in turn, proportional to the amount of steam released from the boiler, less the inventory of steam remaining in the lower compartment. Notably, the increase in upper compartment compression peak pressure is substantially less than the upper compartment pressure increase at the end of blowdown, because the peak compression pressure occurs before the boiler has released all of its energy, and measured increase in peak compression pressure due to increased deck leakage,

INSERT

Mark-BW17 Fuel Evaluation

For the reload core, there is no difference in the mechanical heat capacity of the fuel; however, the core stored energy has increased slightly. The increase was evaluated, and it was determined to have an increased energy effect of 132,000 BTUs. However, the Tech-Spec ice mass based on the Reference 72 analysis contains an additional 384 Lbms of ice due to roundoff. The increase in core stored energy is offset by the roundoff in the Tech-Spec operational limit. Therefore, the Reference 72 analysis bounds operation with reloads having up to 96 fresh Mark-BW17 fuel assemblies.

71. Westinghouse to M. J. Burzynski, TVA 93-243, "Coatings in Containment Assessment -Additional Information," October 21, 1993.

72. Kolano, J. A. and Smith, L. C., "Tennessee Valley Authority Sequoyah Nuclear Plant Units 1 and 2 - Containment Integrity Analysis for Ice Weight Optimization Engineering Report," WCAP-12455, Revision 1, September 1995 (RIMS B88 960104 801). | 14

73. Sequoyah Containment Isolation System Description Document, N2-88-400

74. Malinowski, D.D., "Iodine Removal in The Ice Condenser System", WCAP-7426, March, 1970 (RIMS S18 900327 035)

75. Letter from T.A. Lordi of Westinghouse to J.B. Hosmer of TVA dated September 25, 1987, TVA-87-805 (RIMS B25 871003 013)

76. Letter from L. M. Mills to E. Adensam dated August 31, 1983.

77. Tayami, Takasi, "Interim Report on Safety Assessments and Facilities Establishment Project in Japan for Period Ending June, 1966 (No. 1)."

78. "Westinghouse ECCS Evaluation Model - 1981 Version," WCAP-9220-P-A; Revision 1, February 1982 (Proprietary), WCAP-4221-A, Revision 1 (Non-Proprietary).

79. 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. | 14

80. EPRI 294-2, "Mixing of Emergency Core Cooling Water With Steam; Y3 Scale Test and Summary," (WCAP-8423), Final Report, June 1975.

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

THOMPSON, C.M., and SMITH, L.C., "Tennessee Valley Authority Nuclear Plants Units 1 and 2 Containment Integrity Reanalysis Update Engineering Report," WCAP-12455, Revision 1, Supplement 1, February 2001.
~~AUGUST~~
SEPTEMBER

TABLE 6.2.1-1 (Sheet 1)

GENERAL INFORMATION RELATED TO CONTAINMENT

I. General Information

A.	Design pressure, psig	12
B.	Design temperature, °F	327
C.	Free volume, ft^3	1,186,920
D.	Design and maximum allowable leak rates, %/day	0.25

II. Initial Conditions

A. Reactor Coolant System (at design overpower of 102% and at normal liquid levels)

1. Reactor power level, mwt	3,479.2	
2. Average coolant temperature, °F	578.2	14
3. Mass of Reactor Coolant System liquid, lbm	538,640	
4. Mass of Reactor Coolant System liquid, lbm	4660	
5. Liquid plus steam energy, BTU (relative to 32°F)	334.6×10^6	

B. Containment

1. Normal pressure, psig	0	
2. Normal inside temperature, °F		
- upper compartment	85	
- lower compartment	100	
- ice condenser	15	
3. Outside temperature, °F	Not applicable	
4. Average relative humidity, %	30	
5. Maximum essential raw water temperature, °F	85 — 87	
6. Maximum refueling water temperature (if applicable), °F	105	
7. Initial ice mass (min.), lb	1.79×10^6 1.916	14

C. Stored Water (as applicable)

1. Refueling water storage tank, gal	375,000	
2. Quench spray tank, ft^3	Not applicable	
3. Four safety injection accumulators, ft^3)	4,372 maximum 4,253 minimum per unit	
4. Condensate storage tanks, ft^3	106,337 total of two tanks for both units	

III. The Design Basis Accident

See Figures 6.2.1-15, 6.2.1-16, 6.2.1-17, 6.2.1-18, and 6.2.1-19 | 14

IV. Mass and Energy Addition Tables

See Tables 6.2.1-13, 6.2.1-15, and 6.2.1-18 | 14

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TABLE 6.2.1-1 (Sheet 7)

GENERAL INFORMATION RELATED TO CONTAINMENT

VI. Engineered Safety Systems Information	Full Capacity	Value Used for Containment Analysis	
g. Flow rates:	Shell & U-Tube (Single - pass)	Shell & U-Tube (Single - pass)	
1. Tube Side, gpm each at 3600 sec	4,500	2.337	
a. RHR spray, gpm each	2,000	1,277	
b. RHR to RCS in spray mode gpm each	2,500	1,060	
2. Shell side, gpm each	5,000	5,000	
h. Source of cooling water	CCS	CCS	
i. Flow begins, seconds	Automatic level control	1,691	
2. Containment Spray System			
a. Type	Shell & Tube Counterflow	Shell & U-Tube Counterflow	15
b. Number (per unit)	2	1	
c. Heat exchanger surface area, ft² each	14,130 11,680 (1B)	12,246*	15
d. Tube plugging, % each	0	13.3*	
e. Heat transfer capacity, 10^5 BTU/hr each	95	75.3 2.953	
f. Heat transfer coefficient 10^5 BTU/hr-°F each	3.55 3.88 (1B)	2.811 (Modeled as counterflow type heat exchanger)	15
g. Flow rates			
1. Tubeside (spray flow) gpm each	4,750	4,750	
2. Shell side, gpm each	6,028	~~3,600~~ 3400	

*Values utilized in the current containment analysis were developed prior to Hx 1B replacement. These values remain conservative after Hx 1B replacement since the UA value for the new 1B Heat Exchanger (with its allowable tube plugging margin) at 3400 GPM ERCW flow is greater than 2.811.

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TABLE 6.2.1-8

*NORMALIZED DECAY HEAT
POST-STEAM GENERATOR EQUILIBRATION

Time (sec)	Decay Heat Generation Rate (BTU/BTUh)
1.00E+01	0.05387
1.50E+01	0.050[illegible]1
2.00E+01	0.046[illegible]18
4.00E+01	0.0[illegible]2401
[illegible]00E+01	0.[illegible]9244
8.[illegible]E+01	0.037065
1.00[illegible]+02	0.035466
1.50E[illegible]02	0.032724
2.00E+[illegible]	0.030936
4.00E+0[illegible]	0.027078
6.00E+02	0.024931
8.00E+02	0.023389
1.00E+03	0.022156
1.50E+03	0.019921
2.00E+03	0.018315
4.00E+03	0.014781
6.00E+03	0.013040
8.00E+03	0.012000
1.00E+04	0.011262
1.50E+04	0.010097
4.00E+04	0.007778
1.00E+05	0.006021
4.00E+0[illegible]	0.003770
6.00E+[illegible]5	0.[illegible]201
8.00E[illegible]05	0.00[illegible]34
1.00[illegible]+06	0.0025[illegible]0
1.5[illegible]E+06	0.00216[illegible]
2.[illegible]0E+06	0.001909
[illegible].00E+06	0.001355
[illegible]6.00E+06	0.001091
8.00E+06	0.000927
1.00E+07	0.000808

* Total deca[illegible]heat found by multiplying fraction by reactor power.

| 14

| 14

Replace with new 6.2.1-8

SQN

TABLE 6.2.1-8
NORMALIZED DECAY HEAT*

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
-End of Cycle Core Average Burnup of 52,687 Mwd/MTU
-Low bound for enrichment: 3.0%

* Total decay heat found by multiplying the fractions from above by the reactor power.

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TABLE 6.2.1-8a

SYSTEM PARAMETERS
DECAY HEAT CURVE
PRE-STEAM GENERATOR EQUILIBRATION

Time (sec)	Decay Heat BTU/BTU
0	0.052293
15	0.049034
20	0.047562
40	0.041504
60	0.038473
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	0.007764
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	0.002584
1500000	0.002175
2000000	0.001915
4000000	0.001356
6000000	0.001090
8000000	0.000924
10000000	0.000804

(Total decay heat found by multiplying fraction by reactor power.)

14

14

Delete this table

SQN

TABLE 6.2.1-9

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	[illegible]

*Intergrated Energies

14

Replace with new 6.2.1-9

SQN

TABLE 6.2.1-9

ENERGY ACCOUNTING

	Approx† End of Blowdown (t = 10.0 Seconds)	Approx†† End of Reflood (t = 216.0 Seconds)
	(In Millions of Btus)	
Ice Heat Removal	195.86	244.4
Structural Heat Sinks*	18.05	61.74
RHR Heat Exchanger Heat Removal*	0.00	0.00
Spray Heat Exchanger Heat Removal*	0.00	0.00
Energy Content of Sump	183.7	235.6
Ice Melted (Pounds)(10^6)	0.632	0.8266

* Integrated Energies

†- End of Blowdown is redefined in LOTIC-1 to occur at 10 seconds, per results from the Waltz Mill Ice condenser test.

††- The approximate time is the time closest to the event that is captured in the LOTIC-1 code major print out. Table 6.2.1-21 provides the actual sequence of events

SQN

TABLE 6.2.1-10

ENERGY ACCOUNTING

| 14

	Approx. Time of Ice Melt Out (t = 3262 sec.)	Approx. Time Peak Pressure (t = 5376 sec.)
	(In Millions of BTUs)	
Ice Heat Removal	485.[illegible]	485.4
Structural Heat Sinks*	72.57	113.21
RHR Heat Exchanger Heat Removal	17.[illegible]	45.49
Spray Heat Exchanger Heat Removal	2.79	64.13
Energy Content of Sump	643.88	662.62
Ice Melted (Pounds) (10^6)	1.79	1.[illegible]

*Intergrated Energies

14

Replace with new 6.2.1-10

SQN

TABLE 6.2.1-10

ENERGY ACCOUNTING

	Approximate† Time of Ice Melt Out (t=3363 Seconds)	Approximate† Time of Peak Pressure (t=6983 Seconds
	(In Millions of Btus)	
Ice Heat Removal	516.45	516.45
Structural Heat Sinks*	79.795	121.440
RHR Heat Exchanger Heat Removal*	16.085	45.919
Spray Heat Exchanger Heat Removal*	4.165	69.33
Energy Content of Sump	623.99	651.71
Ice Melted (Pounds)(10^6)	1.916	1.916

* Integrated Energies

† - The approximate time is the time closest to the event that is captured in the LOTIC-1 code major print out. Table 6.2.1-21 provides the actual sequence of events.

SQN

TABLE 6.2.1-21

DOUBLE ENDED PUMP SUCTION LOCA
MINIMUM SAFEGUARDS

Event	Time (sec)	
Rupture	0	
Accumulator flow starts	1[illegible]	| 14
End of blowdown	32.5	| 14
Assumed initiation of ECCS	32.5	| 14
Accumulators empty	83.6	| 14
Assumed initiation of spray system	250	
End of reflood	216	| 14
Low level alarm of refueling water storage tank	[illegible]	
Recirculation phase of safeguards operation	1691	
Ice Bed Meltout	3262	| 14
RHR spray realignment	3600	
Peak containment pressure	6378	| 14

Replace with new 6.2.1-21

SQN

TABLE 6.2.1-21

DOUBLE ENDED PUMP SUCTION LOCA

MINIMUM SAFEGUARDS

Event	Time (Sec)
Rupture	0.0
Accumulator Flow Starts	15.0
End of Blowdown	32.5
Assumed Initiation of ECCS	32.5
Accumulators Empty	83.6
End of Reflood	216.
Assumed Initiation of Spray System	250.
Low Level Alarm from Refueling Water Storage Tank	1681.
Start of ECCS Cold Leg Recirculation	1691.
Low-Low Level Alarm from RWST - Sprays Stopped	2803.
Spray Pumps Restart in Recirculation Mode	3113.
Ice Bed Meltout	3363.
RHR Spray Realignment	3600.
Peak Containment Pressure	7068.

SQN

TABLE 6.2.1-32 (Sheet 1)

SEQUOYAH STRUCTURAL HEAT SINKS

Passive Heat Sinks

A. Material Properties

Material	Thermal Conductivity BTU/hr-F-ft	Volumetric Heat Capacity BTU/ft³-F
$Paint_1$	0.2000	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

B. Surfaces

Heat Sink	Material	Area (ft²)	Layer and Thickness (ft)	
Upper Compartment				
1) Operating Deck	Concrete	4,980 ~~4,800~~	1.07	Concrete
2) Crane Wall	Concrete	18,280	0.0005 1.29	Paint Concrete
3) Refueling Canal	Steel-lined Concrete	3,840	0.0208 1.5	Stainless Steel Concrete
4) Operating Deck	Concrete	760	0.00125 1.5	Paint Concrete

13

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SQN

TABLE 6.2.1-32 (Sheet 2)

SEQUOYAH STRUCTURAL HEAT SINKS

Heat Sink	Material	Area (ft^2)	Layer and Thickness (ft)	
Upper Compartment (continued)				
5) Containment Shell & Misc. Steel	Steel	49,960	0.000625 0.0403	Paint Steel
6) Misc. Steel	Steel	2,260	0.000625 0.12	Paint Steel
Lower Compartment				
7) Operating Deck, Crane Wall & Interior Concrete	Concrete	32,200	1.416	Concrete
8) Area in Contact With Sump Water	Concrete	15,540	~~0.0005~~ 1.6	~~Paint~~ Concrete
9) Interior Concrete	Concrete	~~2830~~ 2590	~~0.00125~~ .0011 ~~1.0~~ 1.5	Paint Concrete
~~10) Interior Concrete~~	~~Concrete~~	~~760~~	~~0.0005~~ ~~1.75~~	~~Paint~~ ~~Concrete~~
10 11) Reactor Cavity	Steel-Lined Concrete	2,270	0.02082 20 2.1	Stainless Steel Concrete

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TABLE 6.2.1-32 (Sheet 3)

SEQUOYAH STRUCTURAL HEAT SINKS

Heat Sink	Material	Area (ft^2)	Layer and Thickness (ft)	
Lower Compartment (Continued)				
11 ~~12~~) Containment Shell & Misc. Steel	Steel	19,500	0.000625 0.0495	Paint Steel
12 ~~13~~) Misc. Steel	Steel	9,000	0.000625 0.1008	Paint Steel
Ice Condenser				
13 ~~14~~) Ice Baskets	Steel	149,600 ~~180,000~~	.00663	Steel
14 ~~15~~) Lattice Frames	Steel	75,465 ~~76,650~~	0.217	Steel
15 ~~16~~) Lower Support Structure	Steel	28,670	0.0587 ~~0.216~~	Steel
16 ~~17~~) Ice Condenser Floor	Concrete	3,336	.000833 0.333	Paint Concrete
17 ~~18~~) Containment Wall Panels & Containment Shell	Composite Panel steel and insulation	19,100	1.0 ~~0.625~~ 0.4625	Steel & Insulation Steel sheet
18 ~~19~~) Crane Wall Panels and Crane Wall	Composite panel steel and insulation	13,055	~~1.0~~ 1.2 1.0	Steel & Insulation Concrete

13

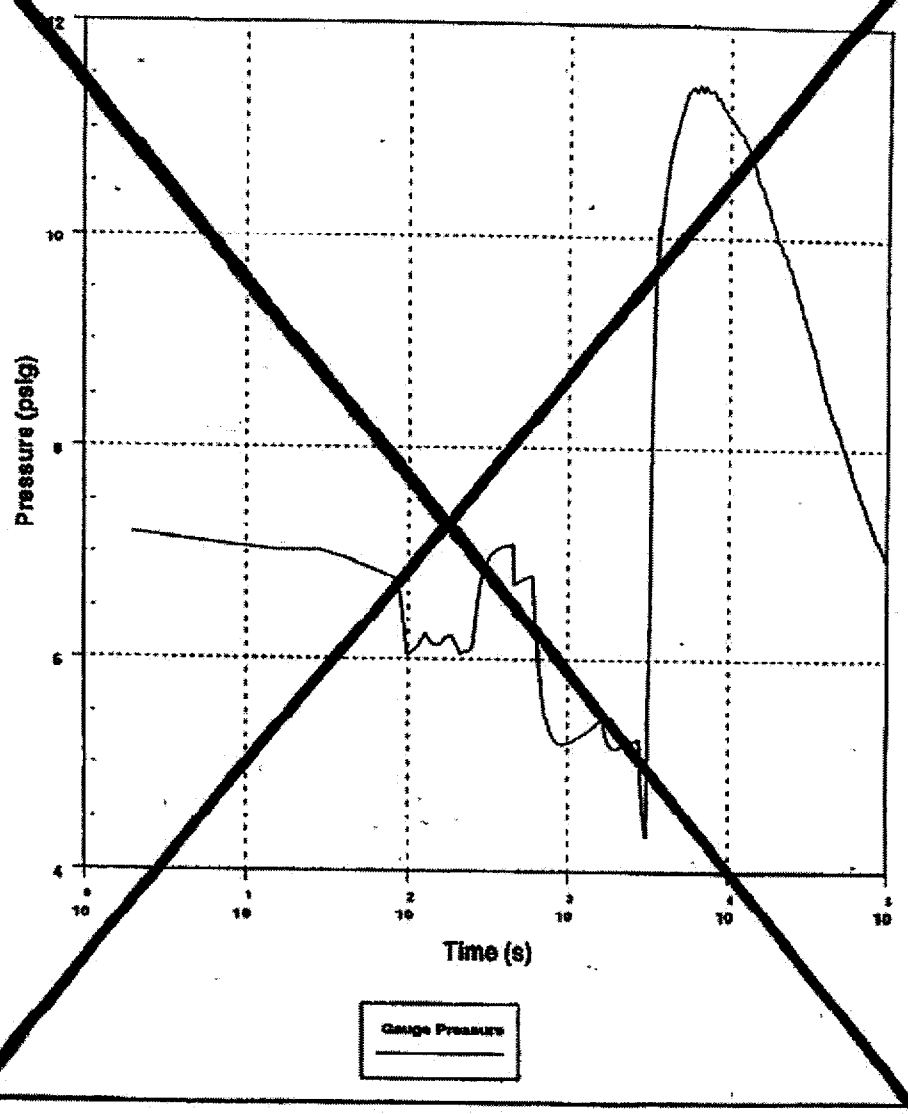

Figure 6.2.1-20

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Containment Pressure

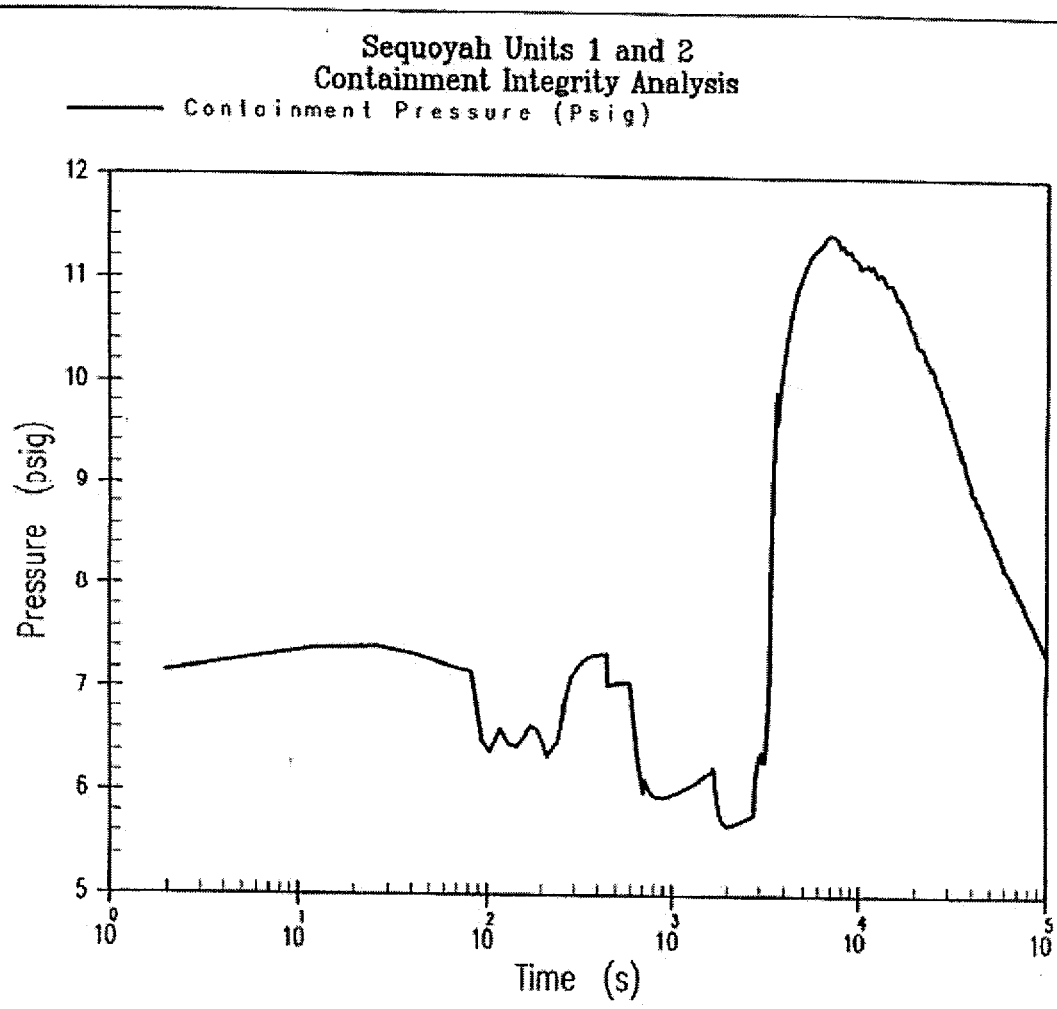

Figure 6.2.1–15

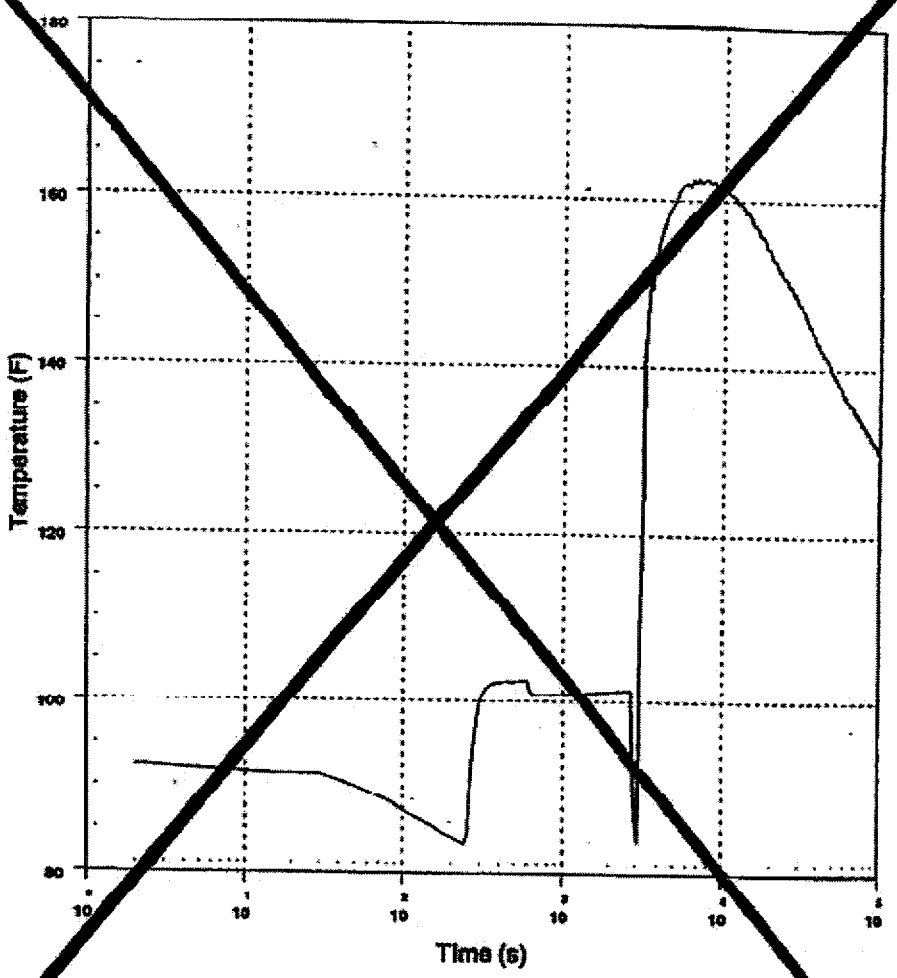

Figure 6.2.1-21a
LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY
Upper Compartment Temperature

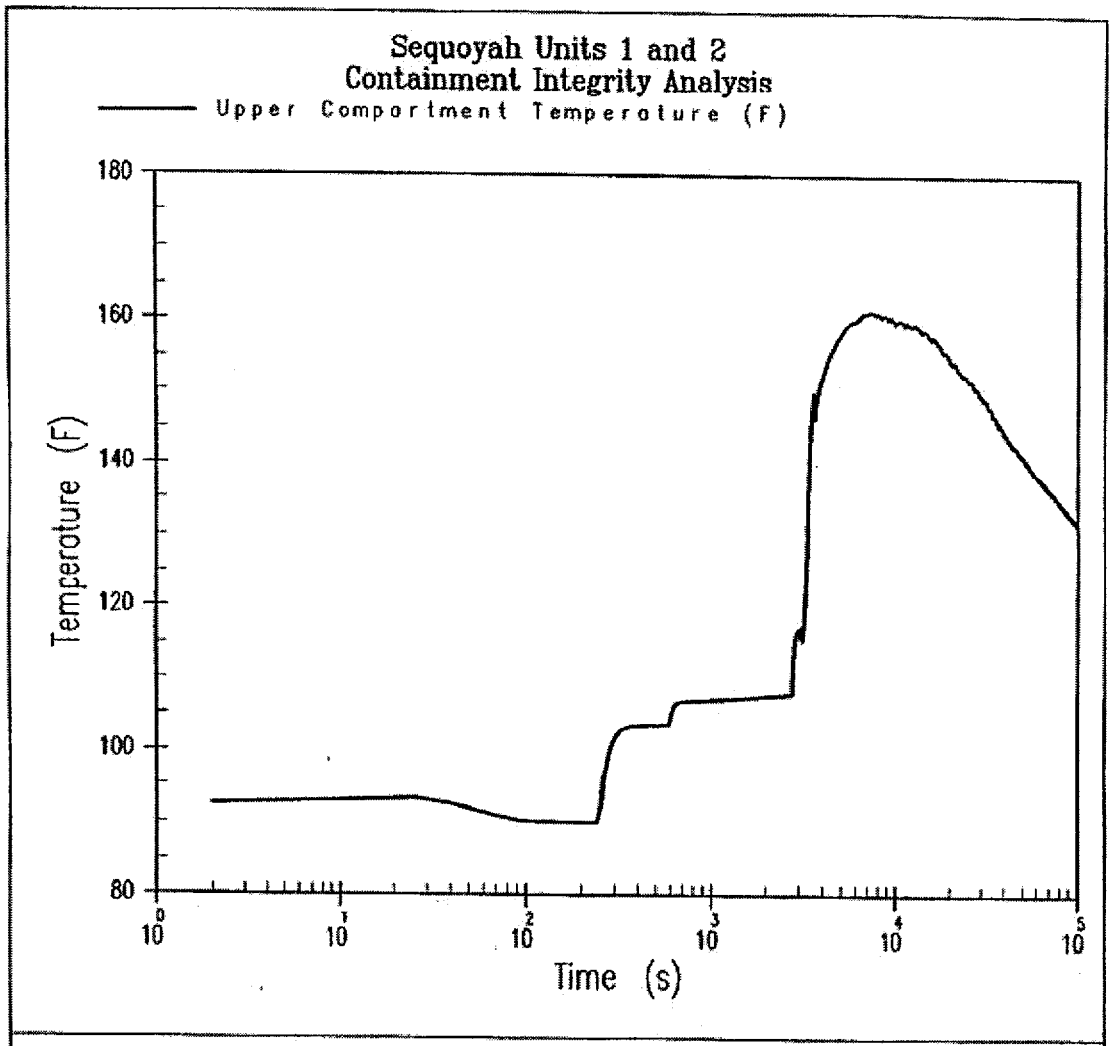

Figure 6.2.1–16

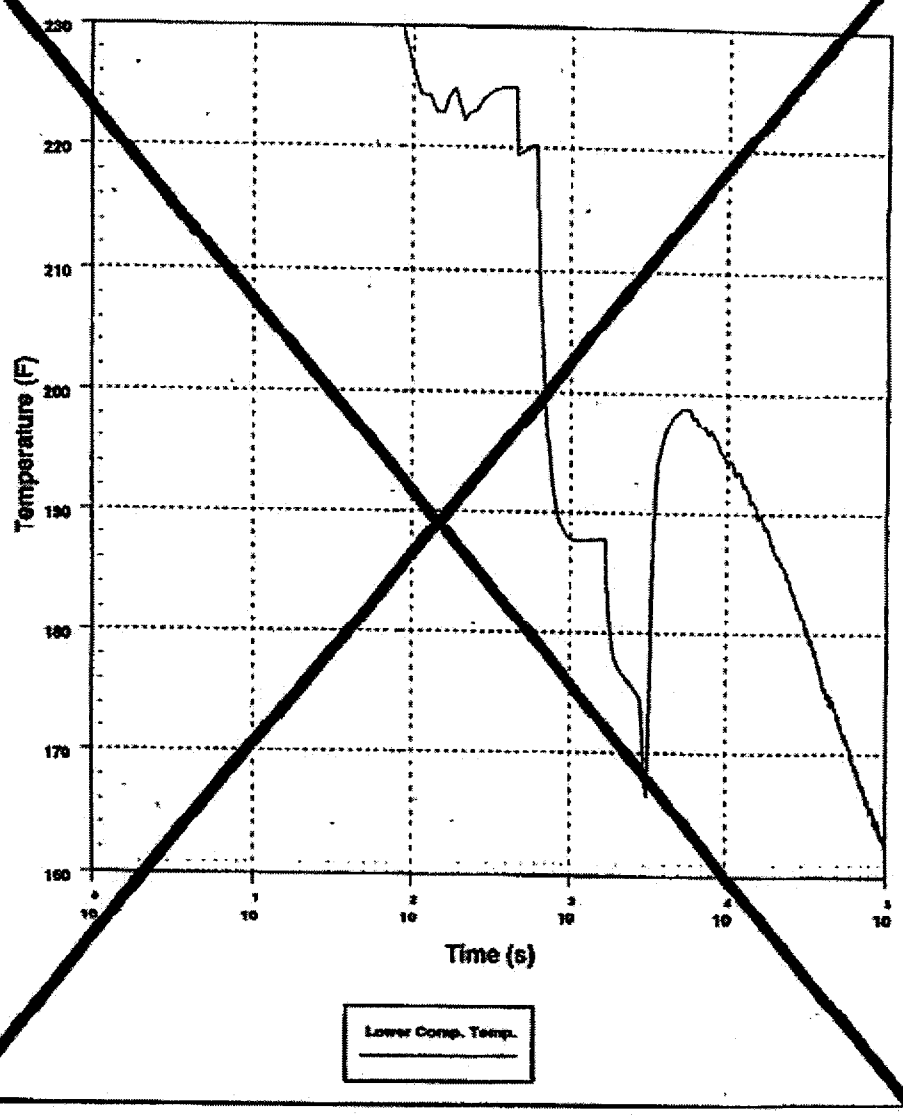

Figure 6.2.1-21b

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Lower Compartment Temperature

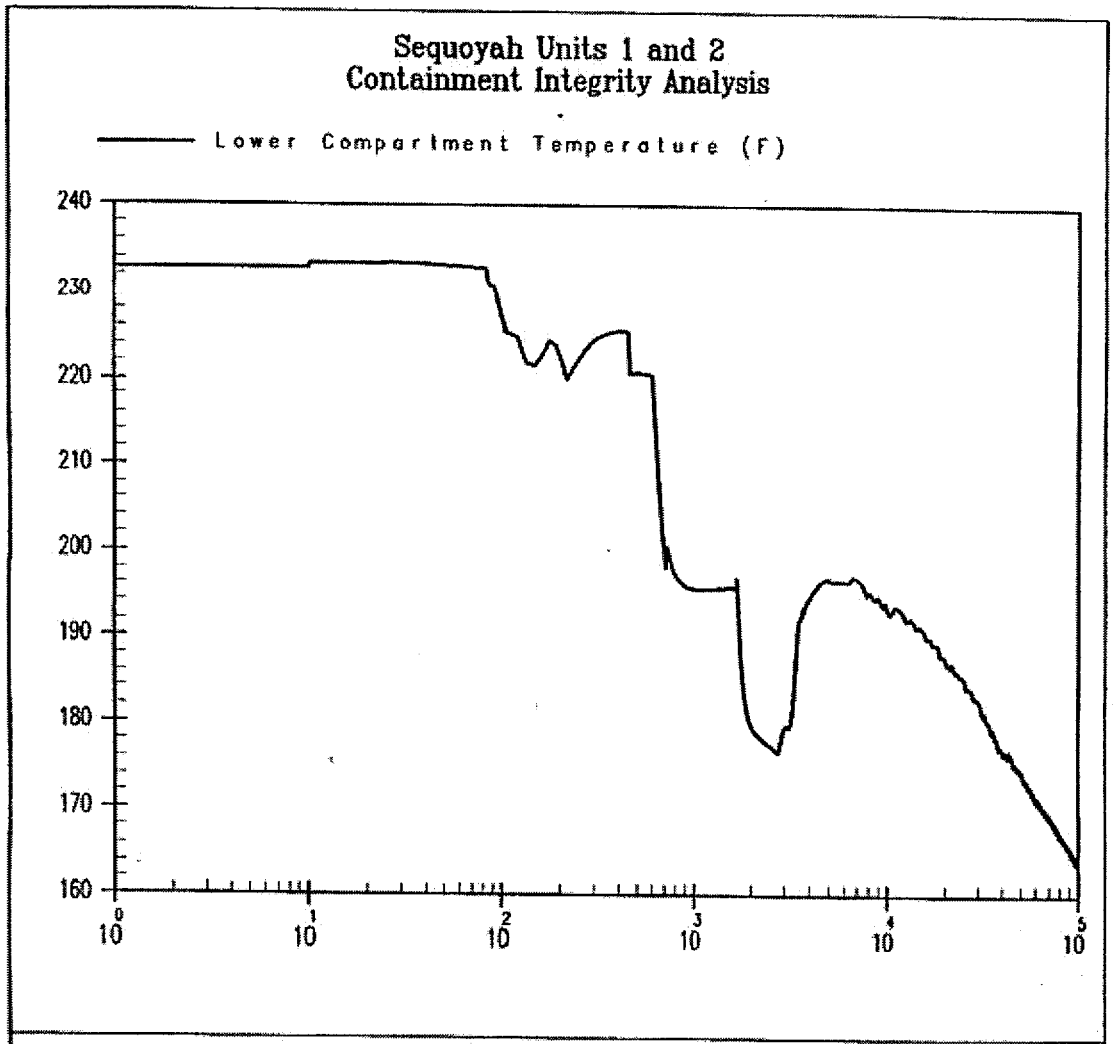

Figure 6.2.1–17

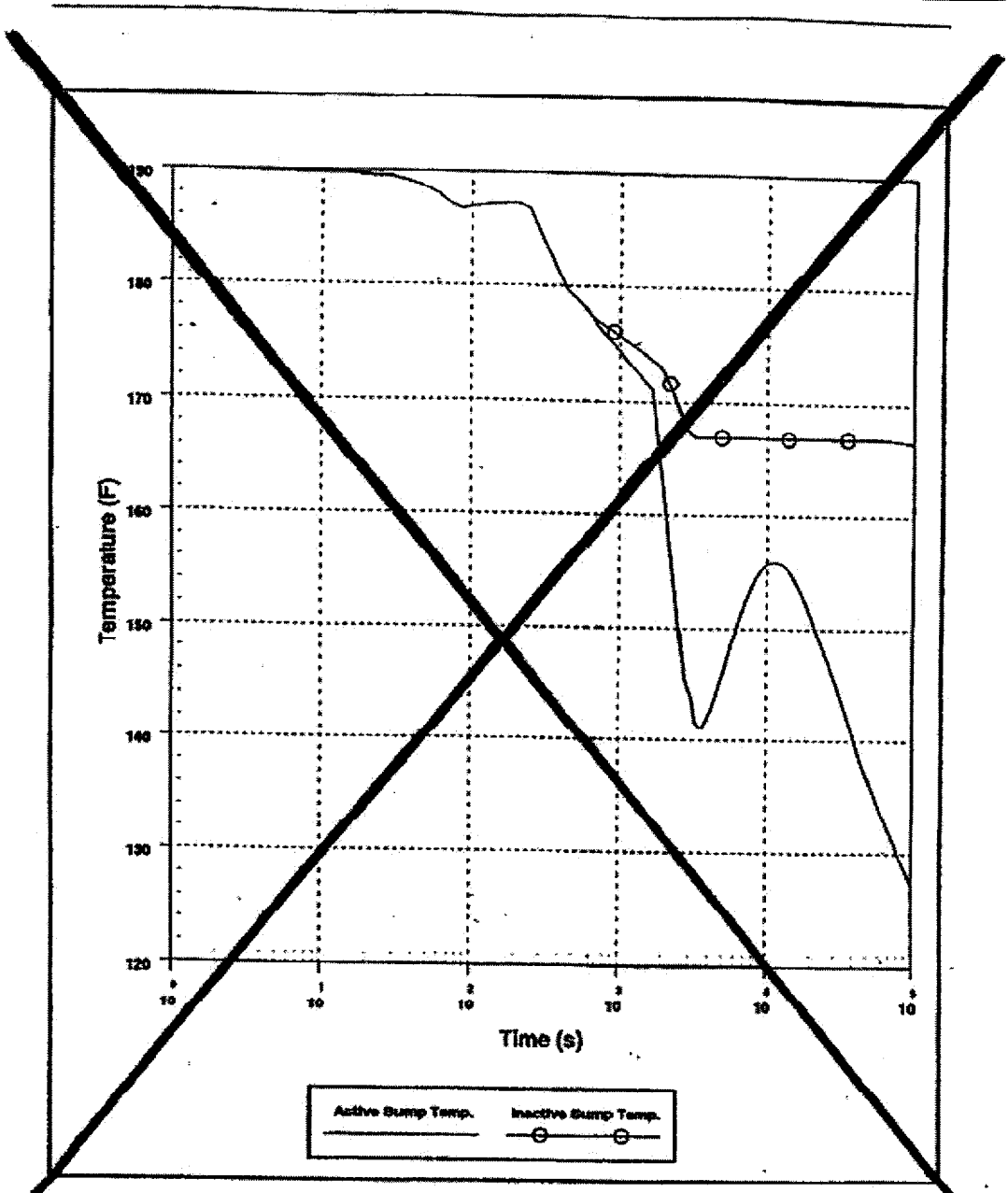

Figure 6.2.1-22

LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY

Active Sump and Inactive Sump Temperature Transient

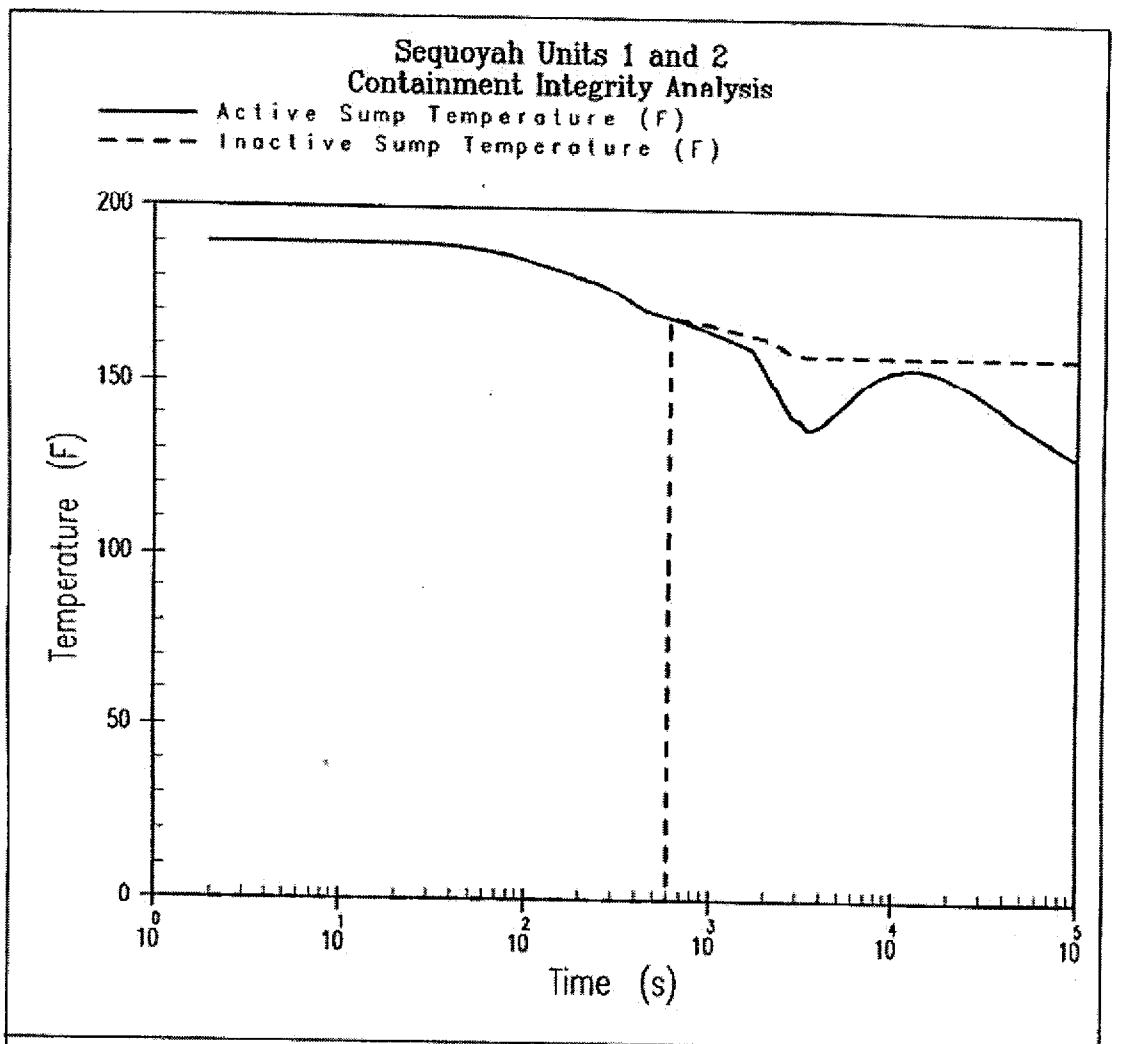

Figure 6.2.1–18

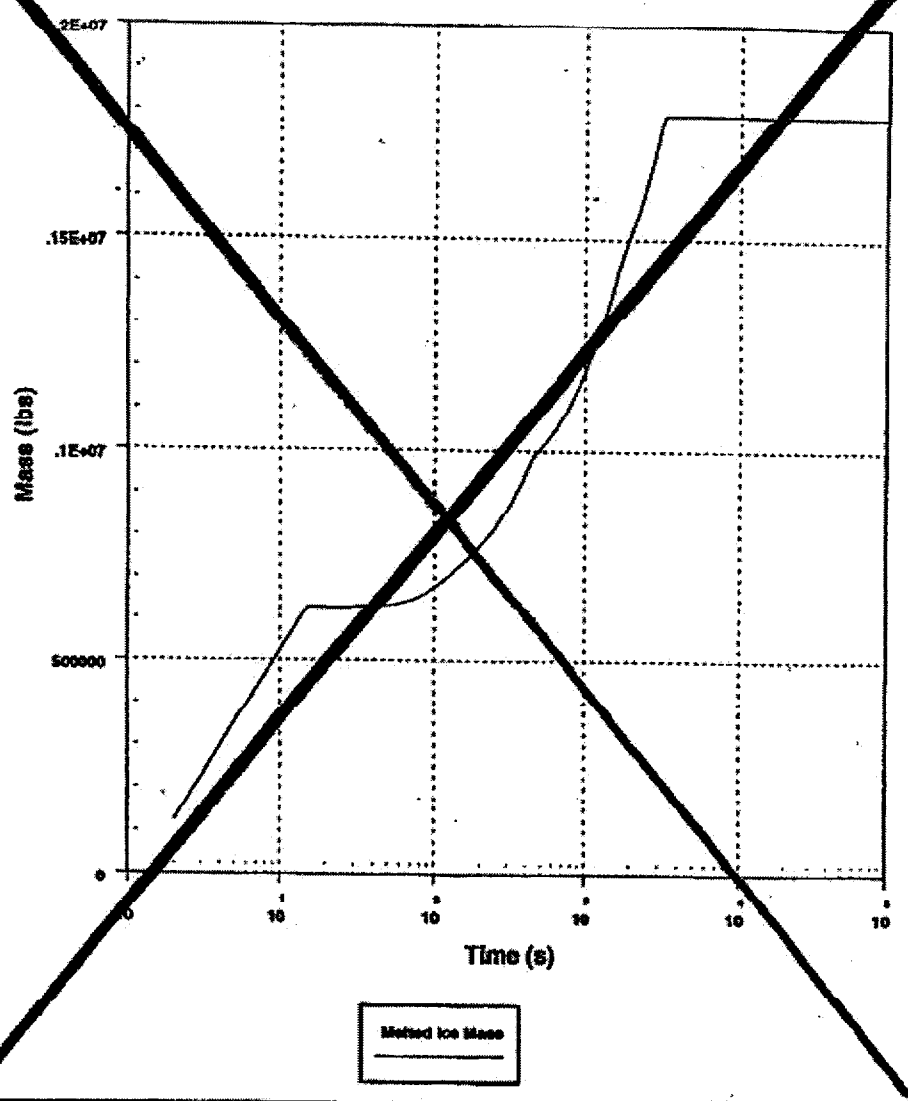

Figure 6.2.1-23
LOCA MASS AND ENERGY RELEASE CONTAINMENT INTEGRITY
Ice Melt Transient

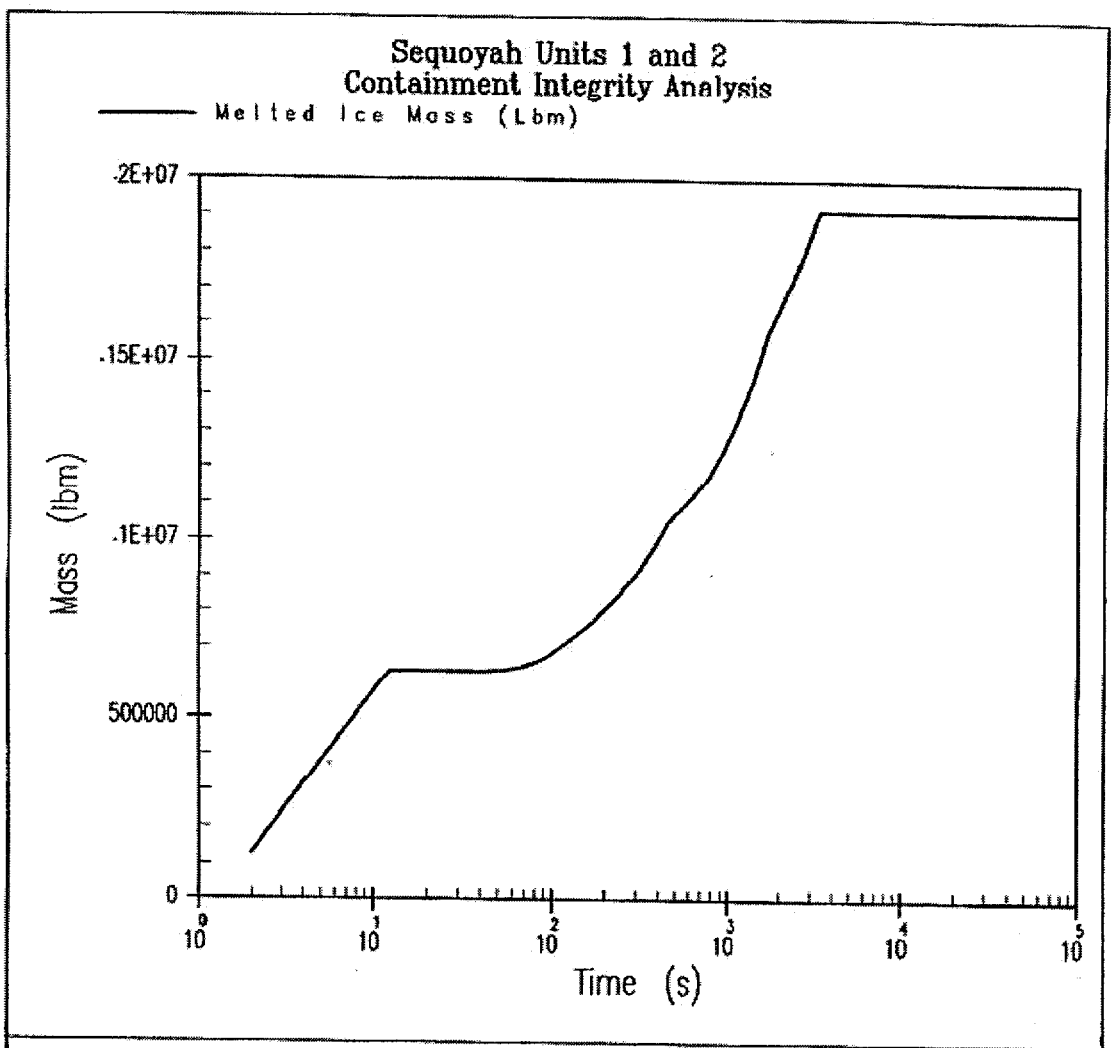

Figure 6.2.1–19

APPENDIX B

TECHNICAL SPECIFICATION MARKUP

CONTAINMENT SYSTEMS

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 ~~2,082,924~~ pounds at a 95% level of confidence, and

e. 1944 ice baskets. 2,225,880.

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:

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 2,062,024 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.

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.

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.

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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

2,225,880