ARKANSAS POWER & LIGHT COMPANY
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February 28, 1985

1CANØ2851Ø

Director of Nuclear Reactor Regulation
ATTN: Mr. J. F. Stolz, Chief
Operating Reactors Branch #4
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Natural Circulation Cooldown
Analysis - Generic Letter 81-21

Gentlemen:

By NRC letter dated April 23, 1984 (1CNAØ284Ø2), AP&L was requested to provide additional information in response to Generic Letter 81-21 concerning natural circulation cooldown (NCC). More specifically, the letter requested that AP&L provide

> ". . . the demonstration, via analysis and/or test data, requested in Generic Letter 81-21, to show that a natural circulation cooldown can be performed without formation of a reactor vessel head void."

As you are aware, AP&L intends to demonstrate the ability to perform a natural circulation cooldown (NCC) without drawing voids in the reactor vessel head by use of the reactor vessel head vents during cooldown. In conjunction with Duke Power Company, the analysis has been performed specifically for ANO-1 conditions. The results demonstrate that by following a given cooldown sequence, the desired cooldown can be accomplished.

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Based on our review of the analysis, AP&L believes the issue is adequately resolved by the approach taken. We have attached a more detailed explanation of the analytical method with the technical bases for your review. In summary, AP&L intends to revise our natural circulation cooldown procedure to reflect the cooldown method as modeled in the analysis. It is based on a 40°F/hr cooldown to Decay Heat Removal System Conditions. The final procedure changes will be implemented following completion of AP&L's independent design review of the analysis which is expected shortly.

Very truly yours,

J. Ted Enos

J. Ted Enos
Manager, Licensing

JTE:CHT:ds

Attachments

ANO-1 NATURAL CIRCULATION COOLDOWN ANALYSIS

This analysis was performed with a RETRAN model of the reactor vessel head. Comparison of Oconee reactor vessel drawings with those of the ANO-1 vessel showed that the vessel dimensions are identical for both plants. Therefore the vessel head model is applicable to Arkansas. However, there is a difference between the reactor vessel high point vents. The locations of the vents are the same for Oconee and ANO-1, but the Arkansas vent has less capacity since it has a smaller hole (3/16" ID) at the top of its APSR. Junction 101 in the RETRAN model was adjusted to reflect the characteristics of the ANO-1 head vent.

A 40°F per hour natural circulation cooldown was analyzed with the ANO-1 reactor vessel head model The method of analysis is described in our December 12, 1984 submittal to the NRC (see Attachment). The case began with the hot leg and the upper head at 600°F. At the beginning of the cooldown, the head vent was opened to provide a continuous flow of reactor coolant through the reactor vessel upper head. The RCS pressure and temperature boundary conditions are given in the table below, as specified by Arkansas Power and Light in their February 6, 1985 letter (Enos to Canady). The natural circulation cooldown was considered complete when the hot leg temperature was reduced enough for decay heat cooling to begin (280°F at ANO-1).

Hot Leg Temperature (°F)	RCS Pressure (psig)
600	2155
450	2155
425	2100
400	1850
375	1500
350	1100
325	800
300	600
275	400

The reactor vessel upper head remained subcooled throughout the cooldown to 280°F. The upper head subcooled margin at the end of the cooldown was 62°F. The hottest temperature in the upper head at that time was 396°F. The upper head and RCS temperatures are shown on Figure 1. Figure 2 shows the temperature in the different upper head fluid volumes. The RCS pressure is traced Figure 3, and Figure 4 displays the RCS and upper head subcooled margin.

This analysis verifies that a 40°F per hour natural circulation cooldown with continuous head venting can be performed at ANO-1 without forming a steam void in the reactor vessel upper head.

FIGURE 1

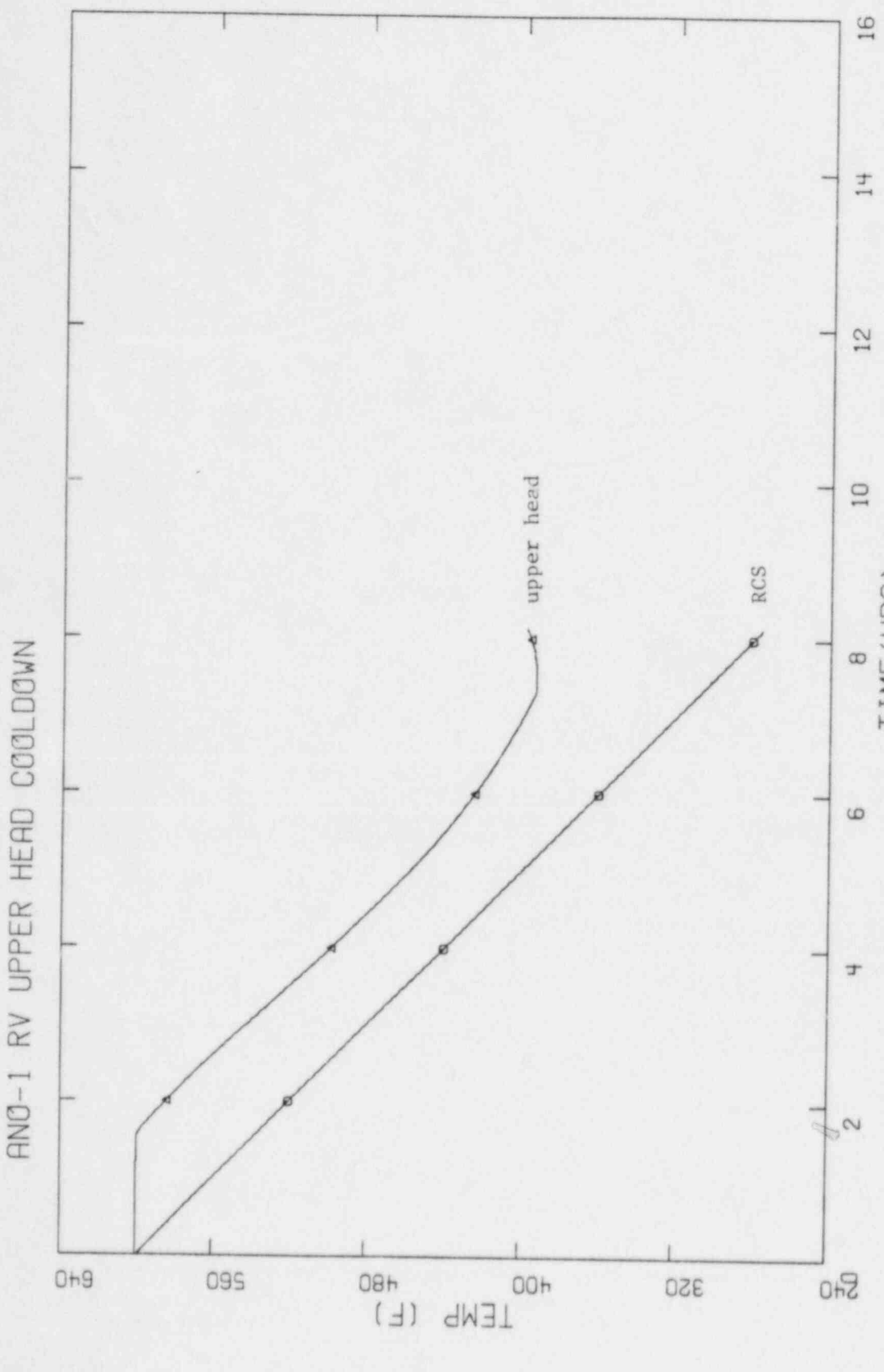
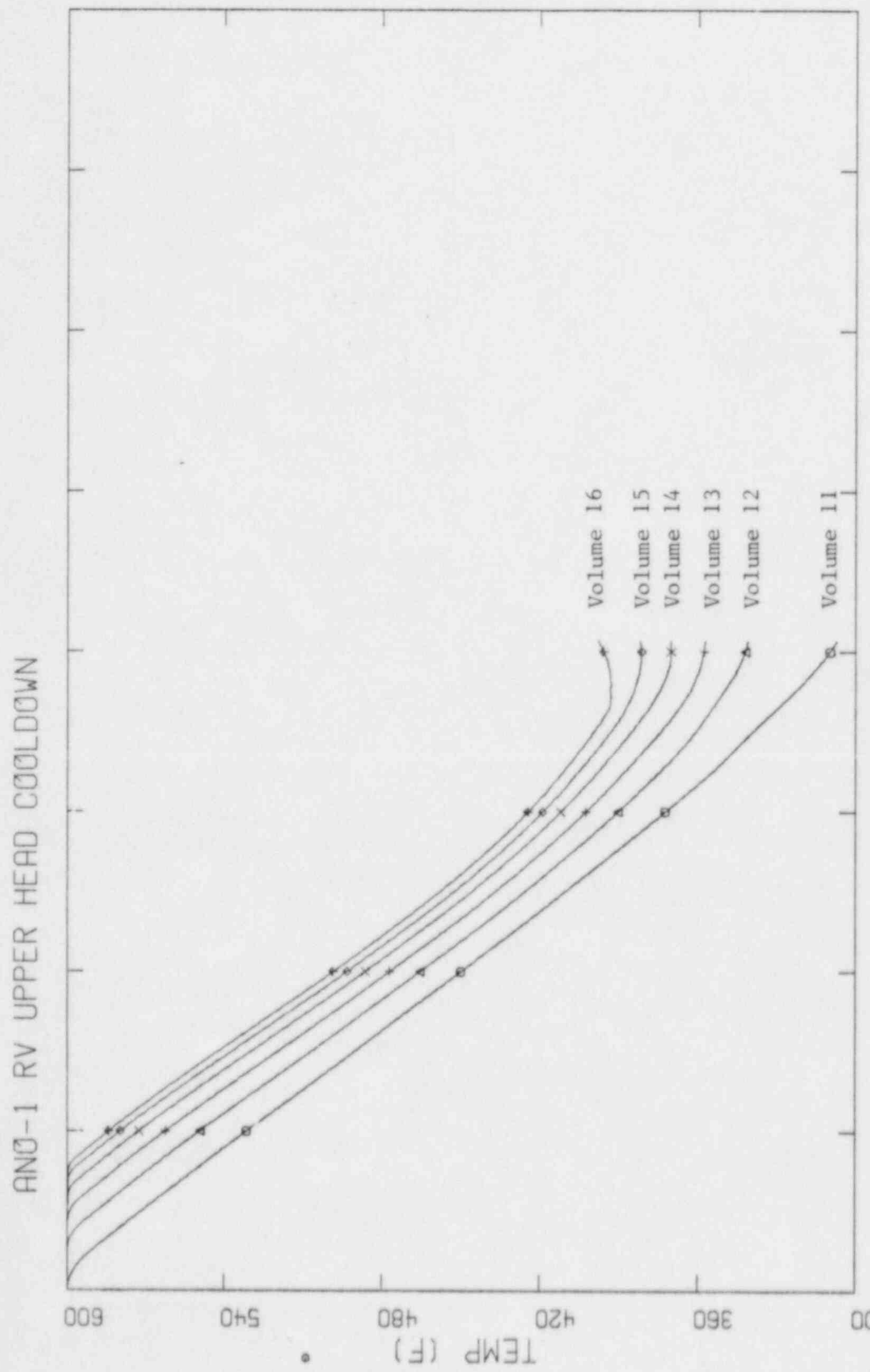
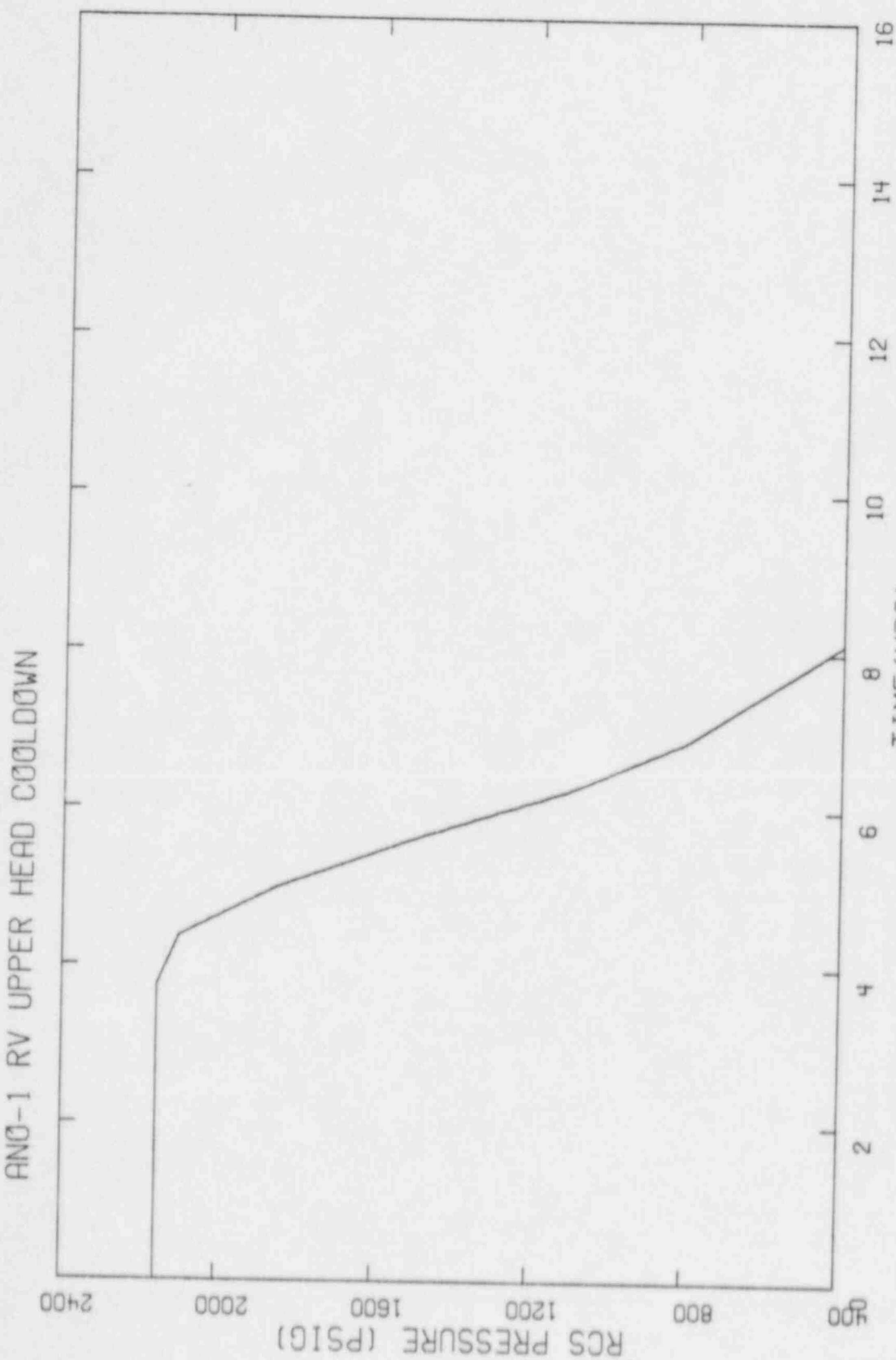

ANO-1 RV UPPER HEAD COOLDOWN
TEMP (F)
TIME (HRS)
upper head
RCS
640
560
480
400
320
240
0
2
4
6
8
10
12
14
16

FIGURE 2



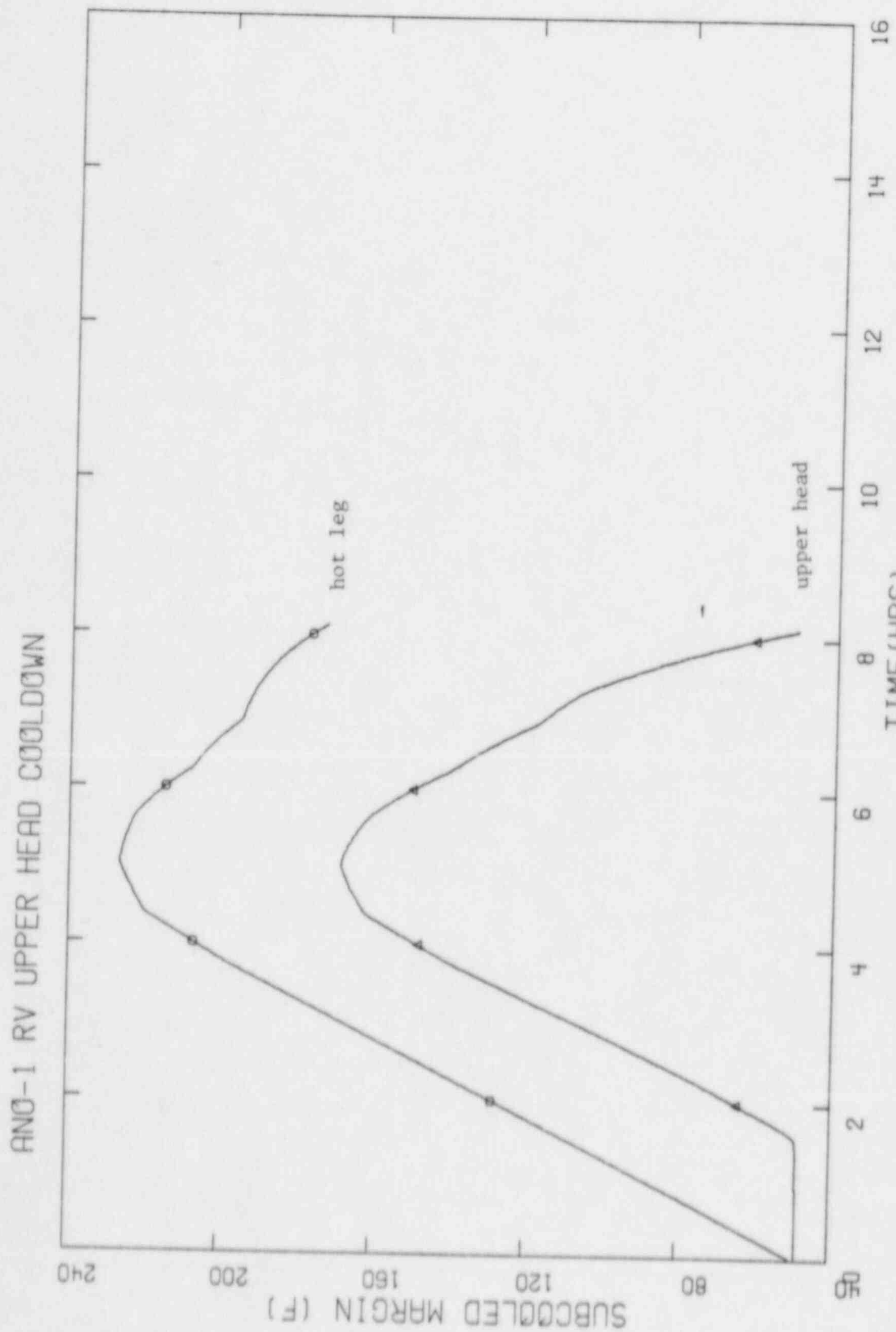
ANO-1 RV UPPER HEAD COOLDOWN
TEMP (F)
600
540
480
420
360
300
TIME(HRS)
0
2
4
6
8
10
12
14
16
Volume 16
Volume 15
Volume 14
Volume 13
Volume 12
Volume 11

FIGURE 3



ANO-1 RV UPPER HEAD COOLDOWN
RCS PRESSURE (PSIG)
TIME (HRS)
400
800
1200
1600
2000
2400
2
4
6
8
10
12
14
16

FIGURE 4



ANO-1 RV UPPER HEAD COOLDOWN
SUBCOOLED MARGIN (F)
TIME(HRS)
hot leg
upper head
40
80
120
160
200
240
0
2
4
6
8
10
12
14
16

ATTACHMENT

SPW

DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

December 12, 1984

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. John F. Stolz, Chief
Operating Reactors Branch No. 4

Subject: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

By a letter dated April 23, 1984, the NRC Staff requested a schedule for providing a demonstration, via analysis or test data, that a natural circulation cooldown can be performed at Oconee without formation of a head void. This issue was first raised by Generic Letter 81-21 dated May 5, 1981. The Staff was advised of Duke's intention to participate with the B&W Owners Group in developing a generic response to the issue. Subsequently, Duke has developed and analyzed a natural circulation cooldown approach for Oconee which ensures that void formation in the reactor vessel head will not occur. That strategy and the associated technical basis are discussed herein.

Duke intends to continuously vent the reactor vessel upper head to the containment during a natural circulation cooldown. The flow of primary coolant through the upper head and out the reactor vessel high point vent will keep the upper head water cool enough to prevent flashing as the RCS is depressurized. This will enable the operators to perform a 50°F per hour cooldown to Decay Heat Removal System (DHRS) conditions.

Duke recognizes that the staff has expressed an interest in a generic approach to natural circulation cooldown. However, reactor vessel high point vent characteristics are plant specific so a generic response utilizing this cooldown method is not feasible. Duke feels that the continuous venting approach is optimal for the Oconee units because it allows a rapid, relatively uncomplicated cooldown to DHRS conditions. Arkansas Power and Light's ANO-1 unit also has a vessel head vent with sufficient capacity for continuous venting, and they are also planning to take this approach to natural circulation cooldown.

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The appropriate steps necessary to implement this cooldown strategy have been included in the Oconee Emergency Procedure Guidelines. The pertinent section of the guidelines is included as Attachment 1 to this letter. The analysis which provides the technical basis for this approach is described in Attachment 2.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

SPN/PFG/glb

Attachments

cc: Mr. James P. O'Reilly, Regional Administrator
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101 Marietta Street, NW, Suite 2900
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NRC Resident Inspector
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J. M. Boone
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M. S. Tuckman
J. N. Pope
R. T. Bond
S. A. Holland
Charles Turk (Arkansas Power and Light)
Group File: OS-801.01

5.4 Restart one RCP in each loop per OP/1103/06. Restart RCP A1 (Unit 1) [RCP B1 (Units 2 & 3)] for pressurizer spray.

5.5 GO TO STEP 3.0.

6.0

UNIT STATUS

The subcooled margin and SG heat transfer exists. A pressurizer bubble most likely exists and the RCS is in natural circulation. No RCPs are operable. Further actions are at the discretion of station management. IF a natural circulation cooldown is to be undertaken, THEN continue with Step 6.1.

CAUTION: DO NOT IMPLEMENT A NATURAL CIRCULATION COOLDOWN UNLESS NECESSARY. A SIGNIFICANT REACTOR BUILDING CLEANUP EFFORT WILL BE NECESSARY DUE TO VESSEL HEAD VENTING.

6.1 Borate to the cold shutdown boron concentration.

6.2 Dispatch an operator to align auxiliary pressurizer spray, start all operable CRDM cooling fans, and perform any other local RB actions required to achieve and maintain cold shutdown.

6.3 Evacuate the Reactor Building.

6.4 Isolate the RB sump and non-essential penetrations.

6.5 Maximize RB cooling.

6.6 IF all RCS T-hot indications (RTDs and CETCs) >450 F, THEN establish and maintain RCS pressure at 2155 psig. IF ≤ 450 F, THEN establish and maintain a subcooled margin > 150 F based on T-hot.

6.7 Initiate and maintain a cooldown rate < 50 F/hr.

6.8 Open the reactor vessel head vent (RC-159, 160).

6.9 Maintain pressurizer level.

6.10 WHEN all RCS T-hot indications (RTDs and CETCs) ≤ 450 F, THEN reduce RCS pressure below 2155 psig while maintaining the subcooled margin (based on T-hot) > 150°F AND RCS pressure less than the NDT limit (based on T-cold).

6.11 Continue to cold shutdown per OP/1102/10.

NOTE: Vessel head venting must be maintained to prevent void formation until the vessel head cools to below the saturation temperature for the final RCS pressure.

END

Attachment 2

Technical Basis for the Oconee Nuclear Station Natural Circulation Cooldown Approach

Duke Power Company has developed a natural circulation cooldown approach for the Oconee Nuclear Station which ensures that void formation in the reactor vessel head will not occur. This attachment describes the cooldown strategy and the technical basis for the approach.

With the reactor coolant pumps off and the Reactor Coolant System (RCS) in natural circulation, the primary coolant flow rate is greatly reduced. It is possible that a nearly stagnant fluid region can develop in the reactor vessel upper head during such conditions. If a natural circulation cooldown is performed, the temperature in the upper head will lag the reactor outlet temperature due to the low upper head coolant flow. The upper head can become the hottest fluid region in the RCS. As a result, when the RCS is being depressurized a steam bubble may form in the top of the reactor vessel head. Such voiding was experienced by Florida Power and Light's St. Lucie Unit 1 during a June 11, 1980, natural circulation cooldown.

Upper head voiding is not a safety concern since it does not degrade the ability to remove decay heat from the reactor core. However, with an upper head steam bubble, RCS pressure control can be more difficult since two fluid regions are at saturation instead of the normal one (the pressurizer).

Duke Power Company has developed and analyzed a natural circulation cooldown approach which will prevent head void formation while allowing the cooldown to proceed at a nearly normal rate. This approach consists of opening the reactor vessel high point vent at the beginning of the natural circulation cooldown. The constant flow of reactor coolant out the vent will displace the hot stagnant water in the upper head. This natural circulation cooldown strategy has been analyzed and shown to be effective in preventing bubble formation in the upper head.

The RETRAN02 MOD003 computer code (Reference 1) was used to analyze the thermal response of the Oconee reactor vessel upper head during a natural circulation cooldown. The RETRAN thermal-hydraulic analysis code has seen widespread use in the utility industry and has been reviewed by the Nuclear Regulatory Commission (Reference 2). RETRAN is an appropriate tool for this analysis because the situation of interest is a relatively simple one-dimensional fluid flow and heat transfer problem which is well within the limits of applicability of the code.

The Oconee reactor vessel is shown on Figure 1. An eight volume RETRAN model was developed to analyze the upper head response to a natural circulation cooldown. The model nodalization is shown on Figure 2. Volumes 11 through 16 represent the upper head fluid region above the top of the control rod guide tubes. Volume 1 is a time dependent volume (TDV) which was used to simulate the RCS pressure and the temperature in the region between the upper plenum cover and the top of the control rod guide tubes. Volume 101 is another TDV which was used to represent the containment pressure and temperature boundary conditions. Conductors 11 through 16 were used to simulate the vessel upper head metal.

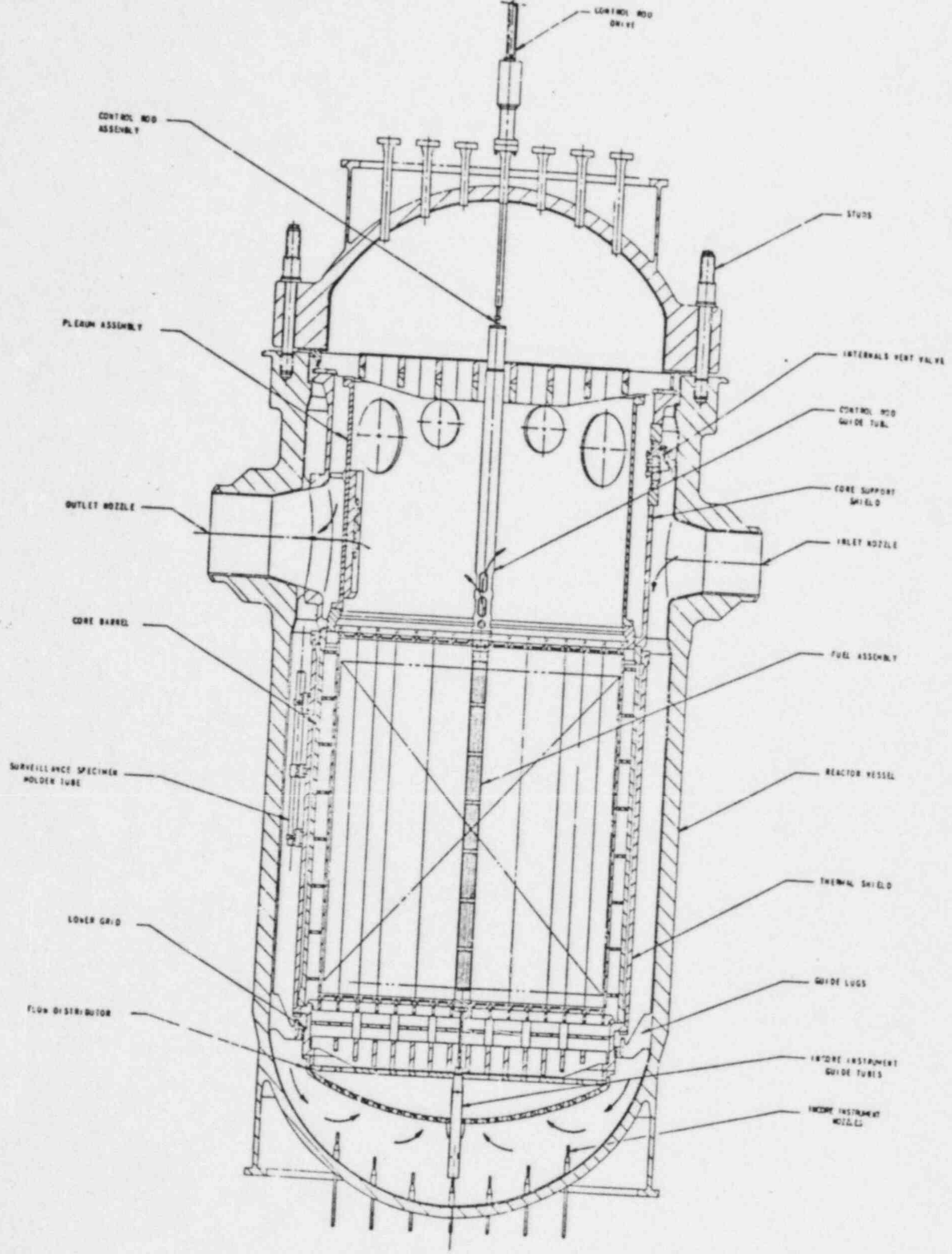
The Volume 11 boundary condition was based on the assumption of some flow through the control rod guide tubes during the natural circulation cooldown. Three percent of normal upper head flow was assumed to flow through the part of the upper head below the top of the control rod guide tubes. A mixing calculation was performed to determine the Volume 11 temperature as a function of RCS hot leg temperature. No credit was taken for flow of reactor coolant through the top portion of the upper head, with the exception of the flow through the high point vent.

The model was initialized with the upper head water and metal at 600°F. At the beginning of the cooldown the reactor vessel high point vent (Junction 101) was opened. A 50°F per hour decrease in RCS hot leg temperature was considered. The RCS pressure was maintained at 2155 psig until the hot leg temperature had been reduced to 450°F. From that point through the end of the cooldown the RCS pressure was adjusted to maintain a 150°F hot leg subcooled margin. The 50°F per hour cooldown was continued for more than seven hours to Decay Heat Removal System conditions (RCS hot leg temperature less than 246°F).

Throughout the 50°F per hour cooldown the fluid in the reactor vessel upper head remained subcooled. Figure 3 shows the hot leg and upper head temperatures throughout the cooldown. Figure 4 shows the upper head subcooled margin. The upper head temperature lagged the hot leg temperature more and more in the latter stages of the cooldown. This was because the high point vent flow decreased as the RCS pressure was reduced, slowing the exchange of primary coolant for hot upper head fluid. However, the vent flow was effective in preventing steam bubble formation during the entire cooldown to Decay Heat Removal System conditions.

A natural circulation cooldown at Oconee is an extremely unlikely event due to the diverse and reliable sources of offsite and onsite AC power. However, if a natural circulation cooldown is necessary the guidance used in this analysis will prevent upper head void formation.

FIGURE 1



REACTOR VESSEL AND
INTERNALS GENERAL ARRANGEMENT
OCONEE NUCLEAR STATION
Figure 4.5-1

FIGURE 2

OCONEE REACTOR VESSEL UPPER HEAD
RETRAN NODALZATION

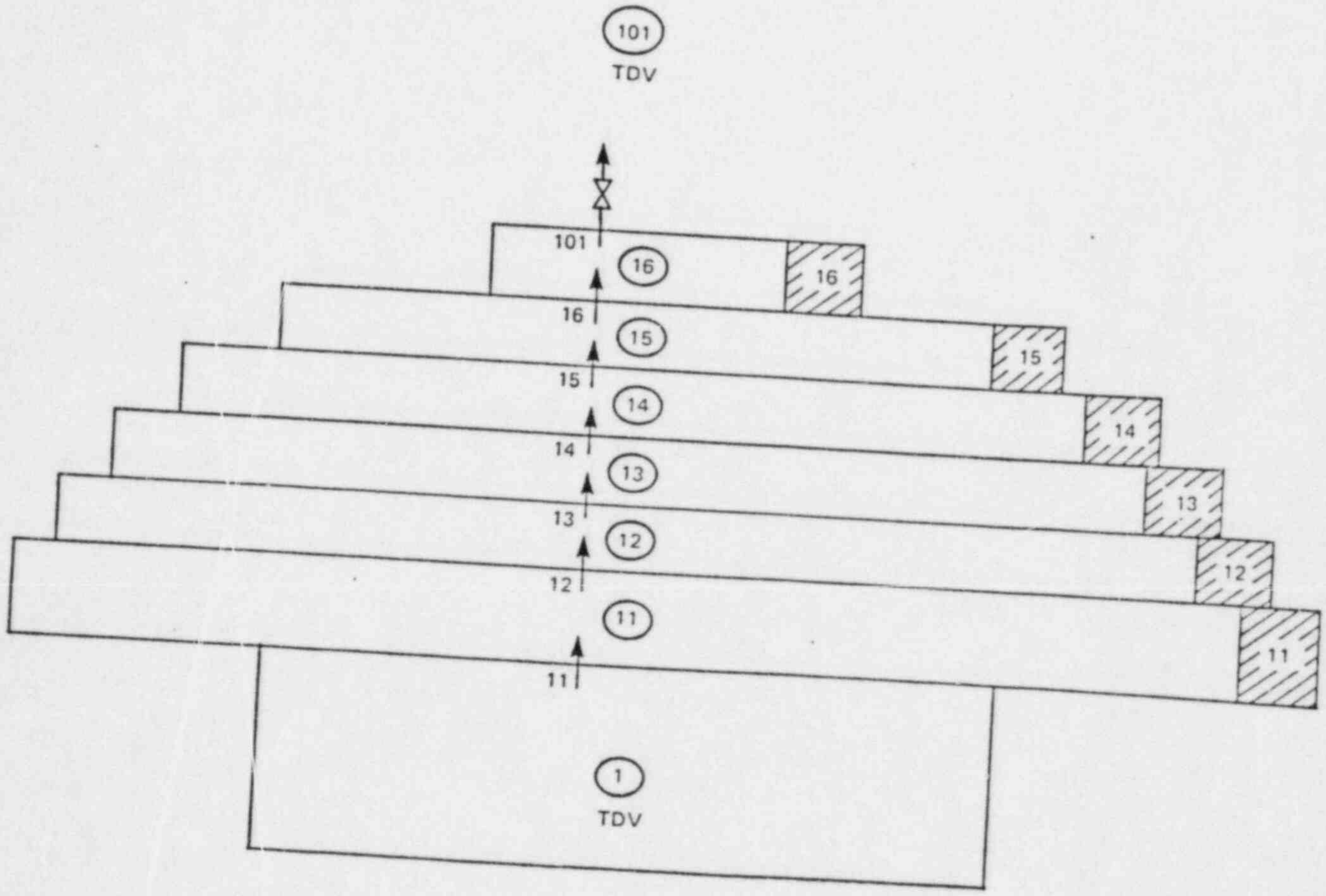


FIGURE 3

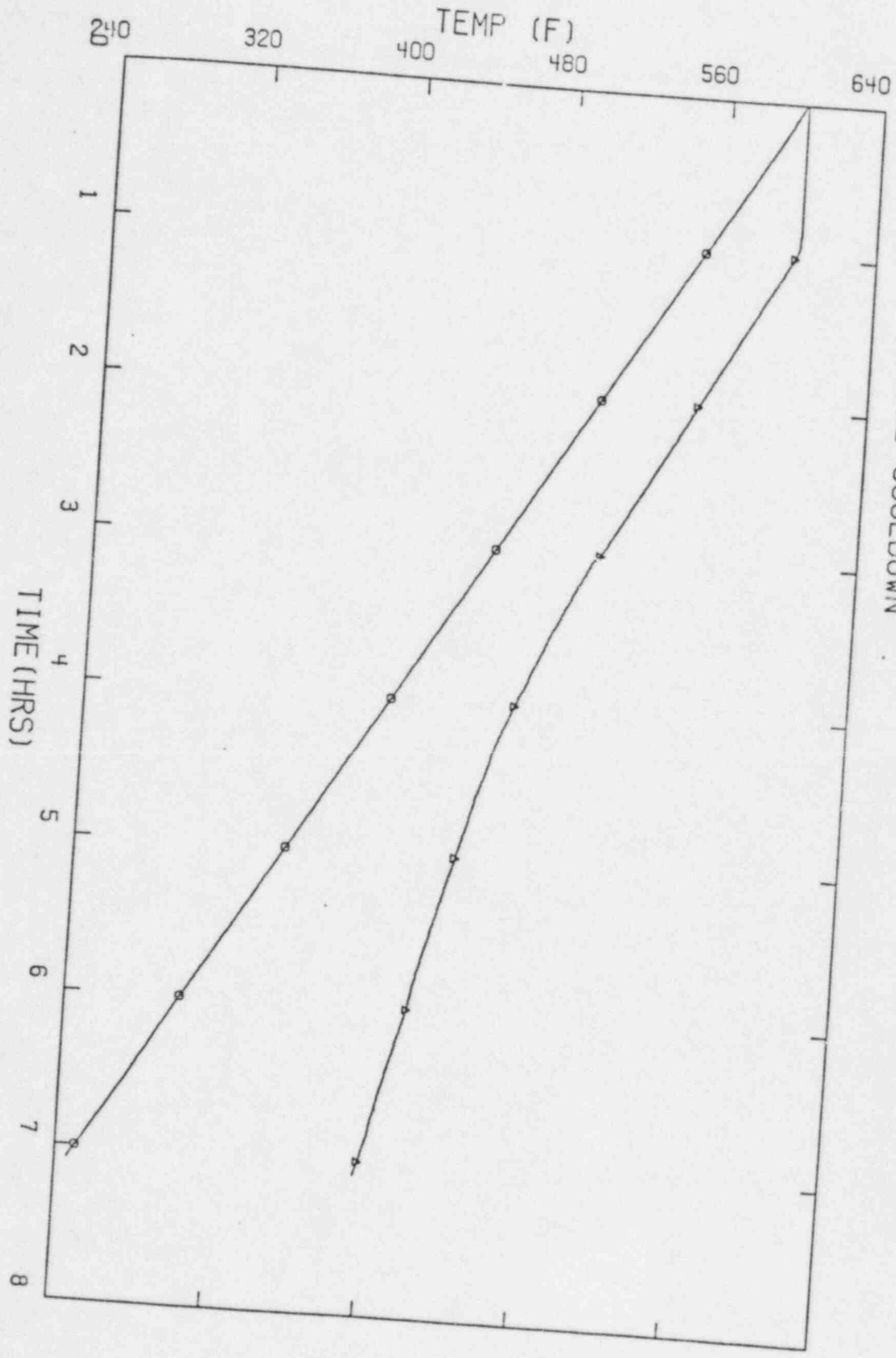
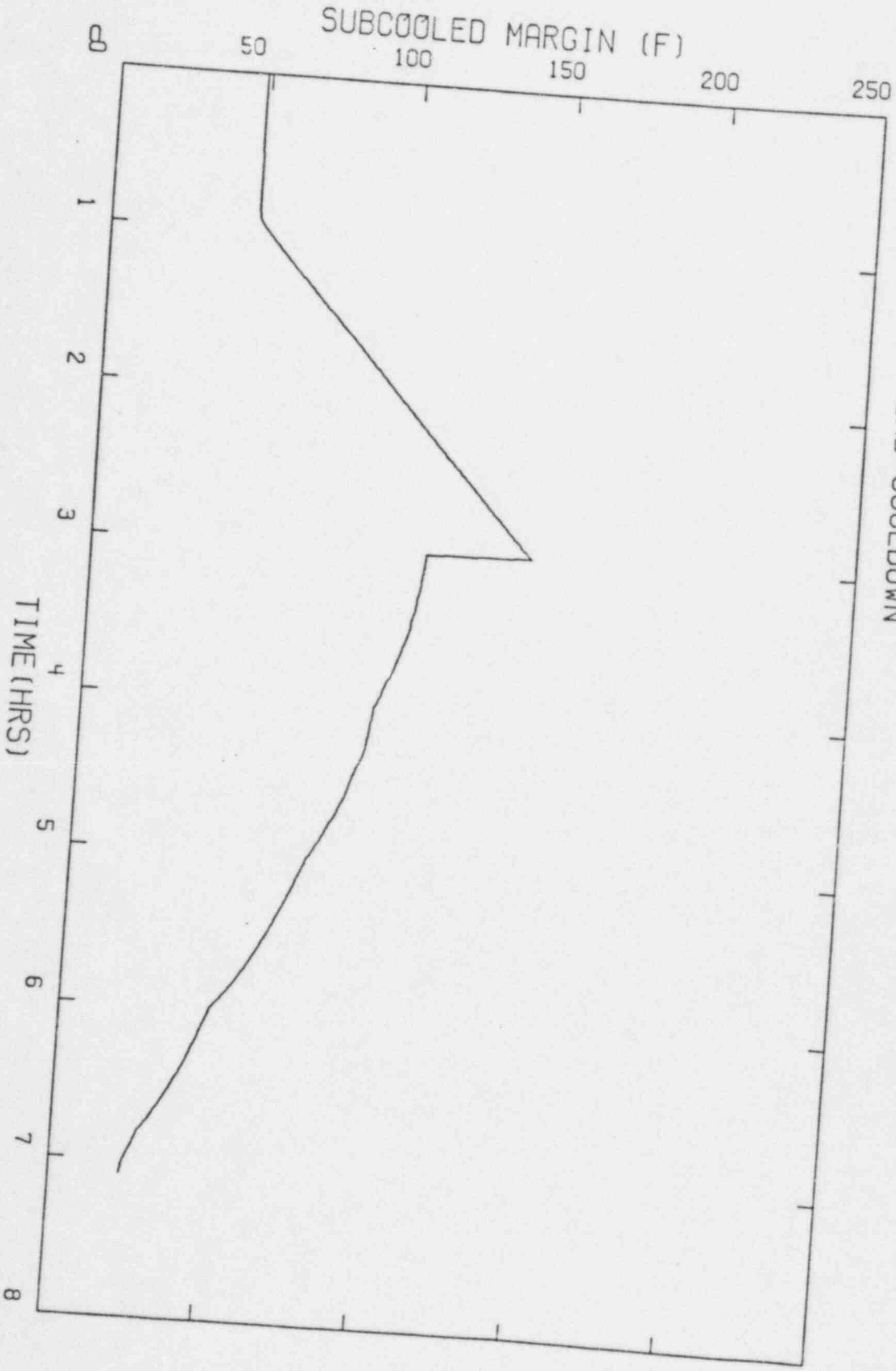

RV UPPER HEAD COOLDOWN
TEMP (F)
240
320
400
480
560
640
TIME (HRS)
0
1
2
3
4
5
6
7
8

FIGURE 4


RV UPPER HEAD COOLDOWN
SUBCOOLED MARGIN (F)
0
50
100
150
200
250
TIME (HRS)
1
2
3
4
5
6
7
8

REFERENCES

1. EPRI NP-1850-CCM, RETRAN-02 Computer Code Manual, May 1981.

2. Cecil O. Thomas (NRC--Division of Licensing) to Dr. Thomas W. Schnatz (Utility Group for Regulatory Application); Acceptance for Referencing of Licensing Topical Reports EPRI CCM-5, "RETRAN -- A Program for One Dimensional Transient Thermal Hydraulic Analysis of Complex Fluid Flow Systems", and EPRI NP-1850-CCM, "RETRAN-02 -- A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems", September 4, 1984.