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U. S. Nuclear Regulatory Commission
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Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Supplemental Information Regarding ANO's June 29, 2000,
Containment Cooling System License Amendment Request

Gentlemen:

In a letter dated June 29, 2000, (2CAN060003), Entergy Operations, Inc. submitted a license amendment request for Arkansas Nuclear One, Unit 2 (ANO-2) regarding a change to the ANO-2 Technical Specifications that would require both units in each group of containment coolers to meet the design basis accident containment heat removal requirements. During a telephone call on September 18, 2000, the NRC Staff asked four questions in regard to the containment cooling system analysis. The purpose of this letter is to respond to the Staff's questions.

The details are contained in the attachment to this letter. Should you have any questions, please contact Dana Millar at 601-368-5445 or Steve Bennett at 501-858-4626.

I declare under penalty of perjury that the foregoing is true and correct. Executed on October 4, 2000.

Very truly yours,

Jimmy D. Vandergrift
Director, Nuclear Safety Assurance

JDV/sab
Attachment

A001

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RESPONSE TO FOUR NRC QUESTIONS REGARDING THE CONTAINMENT COOLING SYSTEM ANALYSIS

NRC Question 1

In your response to GL 96-06 you stated that two-phase flow in the SW coils would not occur. What has changed to now cause two-phase flow in the SW coils of the Containment Cooling System?

ANO Response

The only parameter that was changed that now makes this phenomenon an issue is the cooling coil fouling factor (resistance to heat transfer) assumed in the evaluation. The calculation performed for the GL 96-06 response with respect to two-phase flow (Calculation 94-R-0013-01) assumed that the containment coolers used design fouling values. The input used in the analysis for the fouling factor was 0.002. In terms of flashing, this is a non-conservative assumption. Clean coils exhibit higher service water discharge temperatures, which decrease the margin to saturation. The revised calculation conservatively assumes a fouling factor equal to zero since the actual degree of fouling is unknown and cannot be easily determined. This concern was identified during the 1999 SSEI and was discussed in NRC Inspection Report 50-313/99-09 dated November 16, 1999 as an unresolved item of that report. It is currently being addressed under ANO's Corrective Action Program. The conditions that create the potential for flashing are not related to Containment Uprate. Although more severe environmental conditions associated with the uprate tend to increase the potential for flashing, this effect is mitigated by the proposed reduction in airflow across the containment cooler coils.

NRC Question 2

On Page 2 of 5 you say that a cooler performance is acceptable if SW pressure is greater than 70 psia. Is there flashing at 70 psia? Over what time period does flashing occur? Can you supply Quality vs. Time curves?

ANO Response

There is some flashing at a 70 psia supply pressure with clean coils. The results of the analysis indicate that adequate heat removal capacity was maintained at a supply pressure of 70 psia or greater. At a fixed supply pressure of 70 psia, the degree of flashing is somewhat dependent upon the return pressure. For high return pressures, flashing ceases by the end of the first 900 seconds. For low return pressures, flashing ceases in three of the four coil banks in about 1000 seconds. Flashing continues beyond 1500 seconds in the upstream bank of the cooler, which is located at the highest elevation (2VCC-2B or D). Please see Quality vs. Time graphs following Question 4 response. Results from two

cases, one assuming the highest return pressure and one assuming the lowest return pressure, are provided in Graphs 4-7 and Graphs 11-14 respectively.

NRC Question 3

How was the Containment Cooling System (particularly two-phase flow in SW coils) modeled in GOTHIC?

ANO Response

The modeled piping system included the piping between the inlet and outlet connections to the service water mains (20" or 18" pipes for ANO-2). Each horizontal and vertical run was modeled with a separate volume. A total of 26 piping volumes were used, connected to one another by flow paths. The vertical piping runs on the outlet side of the containment air coolers were modeled to enable GOTHIC to predict the possible development of annular flow and steam entrapment when there is boiling in the containment air coolers. All other piping, except the cooler tubes, were modeled as lumped volumes.

The piping system model included loss factors for elbows, valves, tees, reducers, and wall friction. However, these loss factors were only approximate and did not include additional loss for system fouling. Further, the loss factors for the coolers themselves were not known. Therefore, the total loss through the piping system had to be adjusted to match known system performance from plant measurements. The additional loss factor to account for the coolers' fouling (resistance to flow) and other neglected losses was put at the entrance of the containment air coolers. This conservatively underestimates the pressure in the containment coolers and therefore results in an overestimate of the boiling.

The containment air cooler model consists of two subdivided volumes for the secondary waterside, one for the front tube bank and one for the rear tube bank. Each cell in the subdivided volumes represented one tube pass. The ANO-2 coolers have 6 tube passes in each bank. The tube volume represented the combined flow through all the parallel tubes. The elevation of the tube volume was set to the elevation of the upper most tube in the cooler (at the lowest pressure) to conservatively overestimate the boiling.

The tubes were modeled using GOTHIC tube conductors with the inside connected to tube volumes and the outside connected to a series of volumes representing the primary side of the containment air coolers. The performance of the model was benchmarked against American Air Filter's coil predictions for subcooled flow.

NRC Question 4

Show that containment cooling effectiveness in the COPATTA calculations (11/3 and 6/29 submittals) is consistent with heat removal capability in the GOTHIC calculations. (Reference November 3, 1999 application for uprate of containment to 59 psi.)

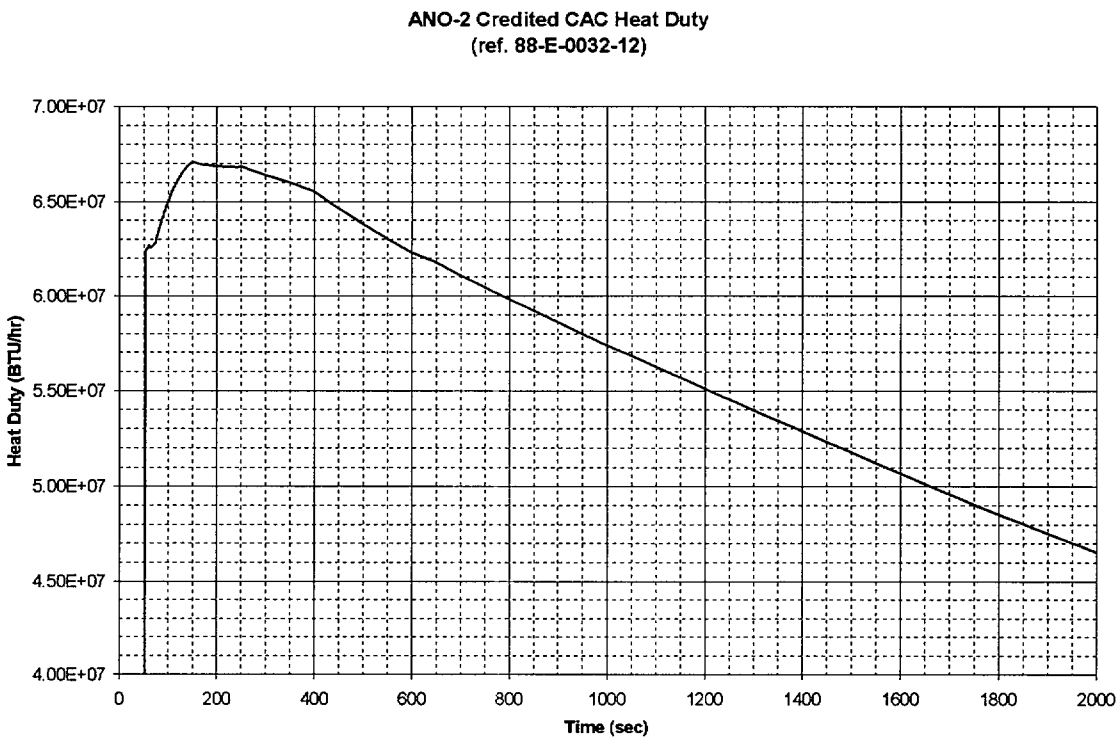
ANO Response

ANO Calculation 00-E-0012-03, Evaluation of Flashing within the Service Water Coils of the Containment Air Coolers, contains a curve of cooler heat duty versus time that was extracted from the limiting COPATTA analysis for containment uprate. The performance of clean coils with flashing was shown to exceed the duty credited in the COPATTA analysis under various scenarios as long as service water can be supplied at a pressure greater than or equal to 70 psia. As an example the heat removal capacities calculated by GOTHIC for the two cases mentioned in the response to question 2 above are depicted on Graphs 3 and 10 on the following pages. Note that the total heat capacity of the train is determined by taking the sum of both curves shown on these graphs. The total heat capacity of the train in both examples exceeds the heat duty credited by COPATTA that is illustrated on Figure 1 below.

RAI Supporting Curves and Graphs

Figure 1 below depicts the Containment Air Cooler heat duty that is credited in the revised Containment DBA analysis. The heat removal capacity predicted by GOTHIC was checked against this curve for each case considered. The pages that follow summarize GOTHIC results for two extreme cases. Both cases assume a service water supply pressure of 70 psia. The first case entitled Case 5 assumes a high return header pressure such that minimum acceptable service water flow (1250 gpm) is developed through the train of coolers. The second case entitled Case 9 demonstrates the effect of dropping return header pressure to near atmospheric pressure.

Figure 1



In Case 5 (Graphs #1 - #7) downstream pressure is set relatively high such that approximately 1250 gpm is developed through the train at a minimum service water supply pressure of 70 psia.

Graph # 1 (Case 5)

ANO2 System model - Case 5
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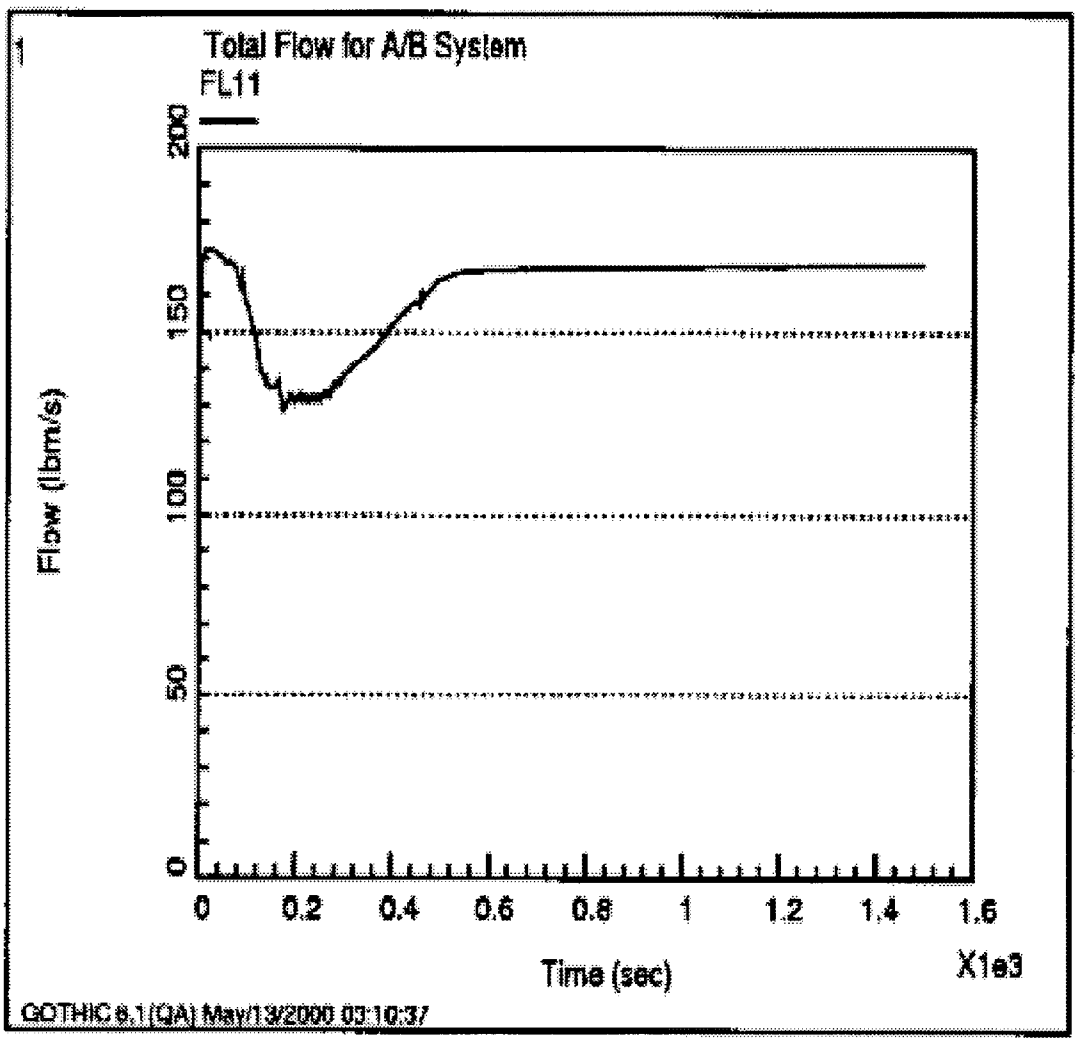
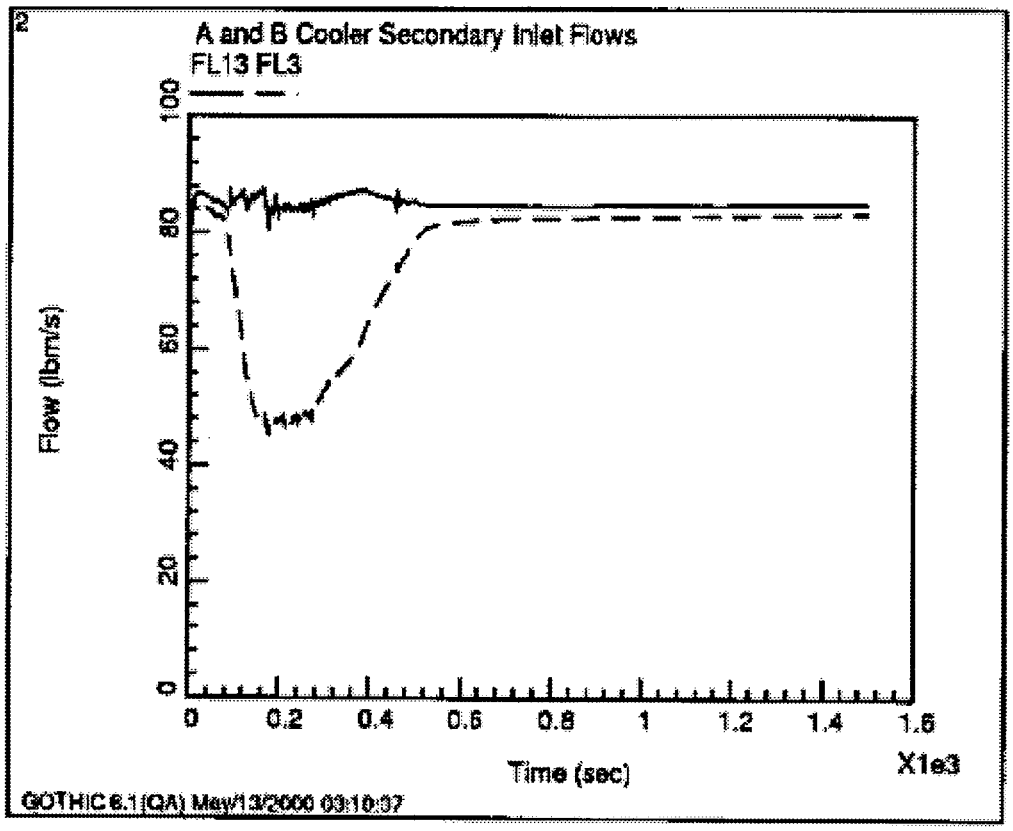
GOTHIC Version 6.1(QA) - July 1999



Legend: FL11 (solid) = Total service water flow (lbm/sec) to the train of coolers

Graph #2 (Case 5) – This curve indicates that flow degradation is most severe in the cooler having the highest elevation (curve FL3 – dashed line).

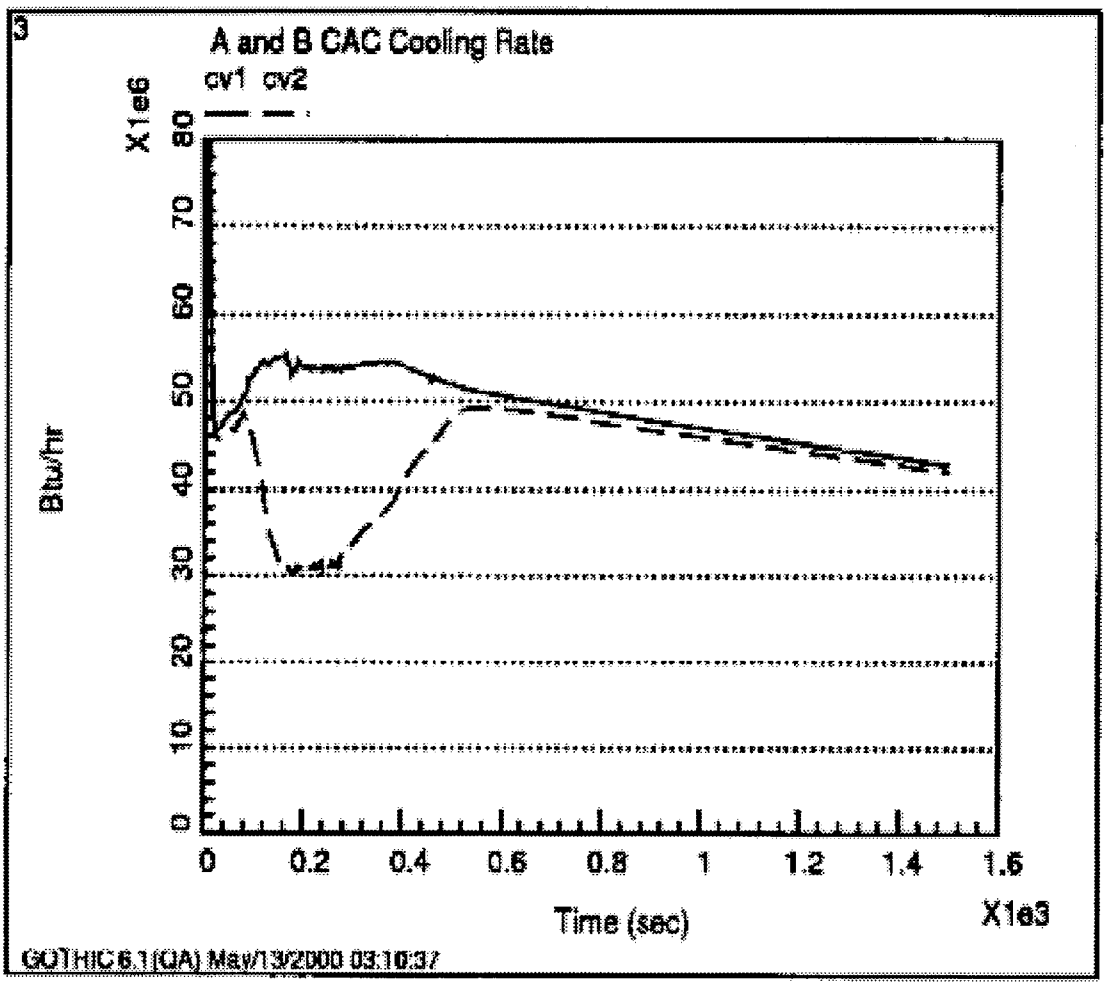
Graph #2 (Case 5)



Legend: FL13 (solid) = Service water flow (lbm/sec) to the cooler with lowest elev.
FL3 (dashed) = Service water flow (lbm/sec) to cooler with highest elev.

Graph #3 (Case 5) - Total heat capacity of the train is the sum of both of the curves.

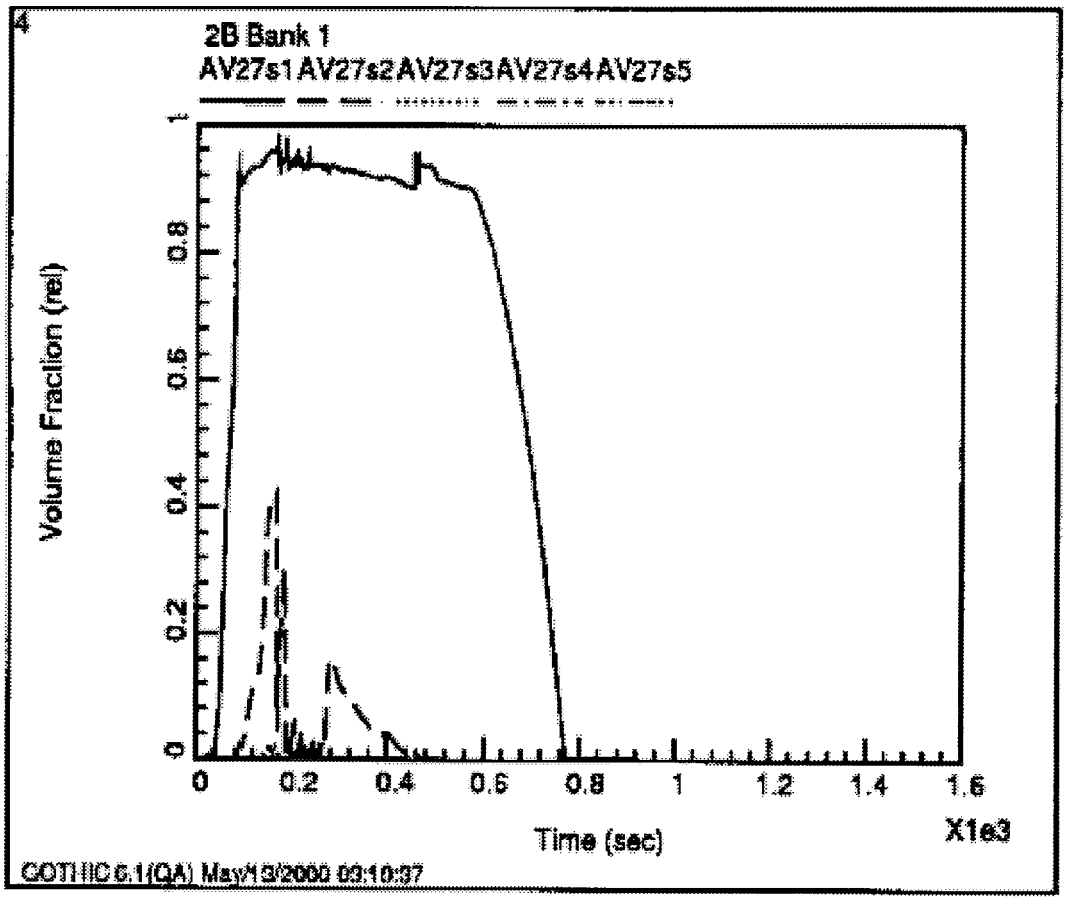
Graph #3 (Case 5)



Legend: cv1 (solid) = Cooling capacity (BTU/hr) of the cooler at the lowest elev.
cv2 (dashed) = Cooling capacity (BTU/hr) of the cooler at the highest elev.

Graphs #4 & #5 (Case 5) depict the vapor volume fraction as a function of time in the sub-volumes that make up a coil bank. The solid line represents the conditions in the final tube pass (hottest fluid). Graph #4 is for the upstream coil bank of the cooler with the highest elevation (worst location). Graph #5 is for the downstream coil bank of the cooler with the highest elevation.

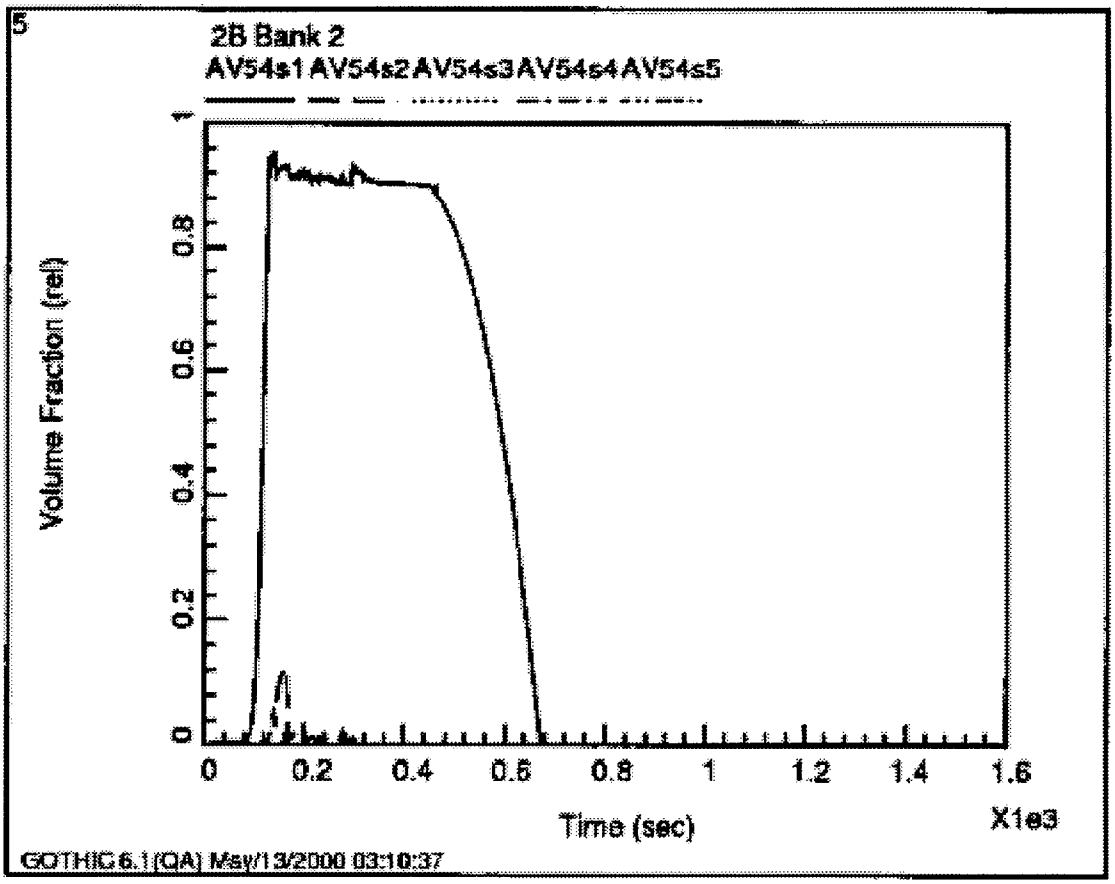
Graph #4 (Case 5)



Legend: AV27s1 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV27s2 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV27s3 thru AV27s5 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in the 1st through 4th tube passes of 2VCC2B Coil Bank 1 in this case.)

Graph #5 (Case 5)

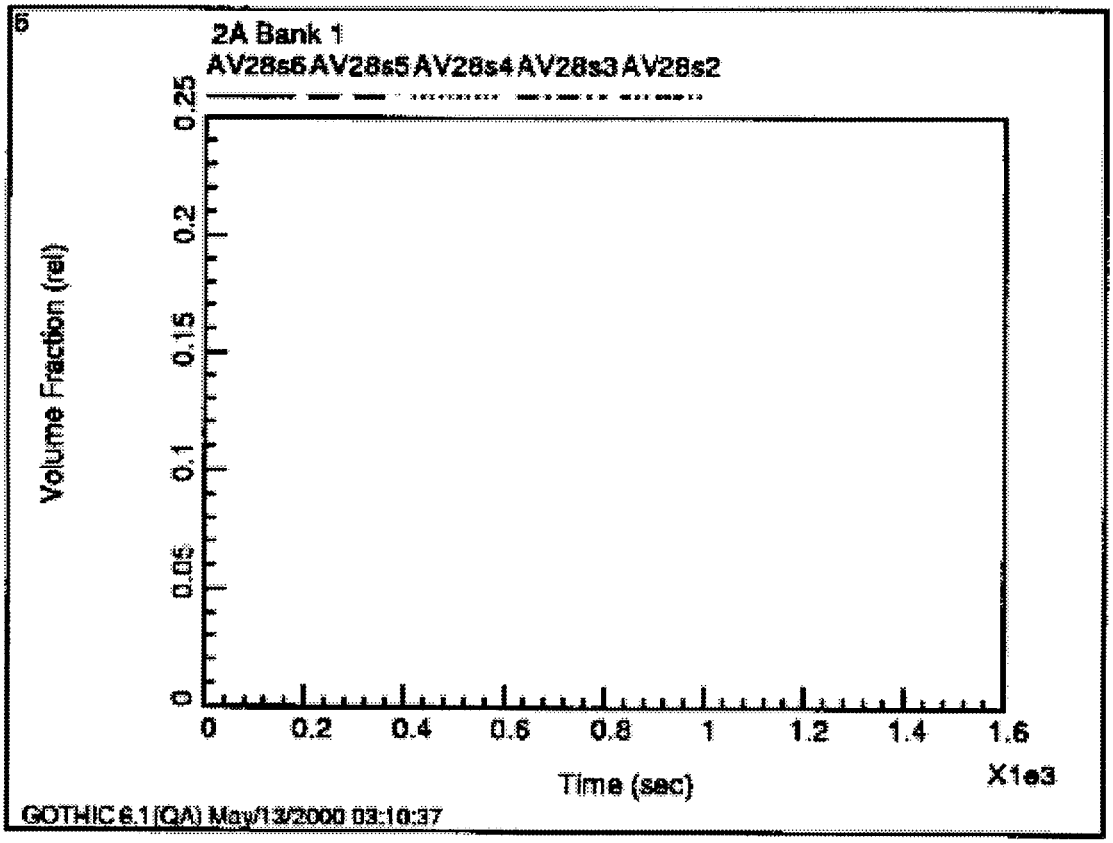


Legend: AV54s1 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV54s2 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV54s3 thru AV54s5 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in the 1st thru 4th tube passes of 2VCC2B Coil Bank 2 in this case.)

Graphs #6 & #7 (Case 5) show that flashing in the lower elevation cooler is insignificant.

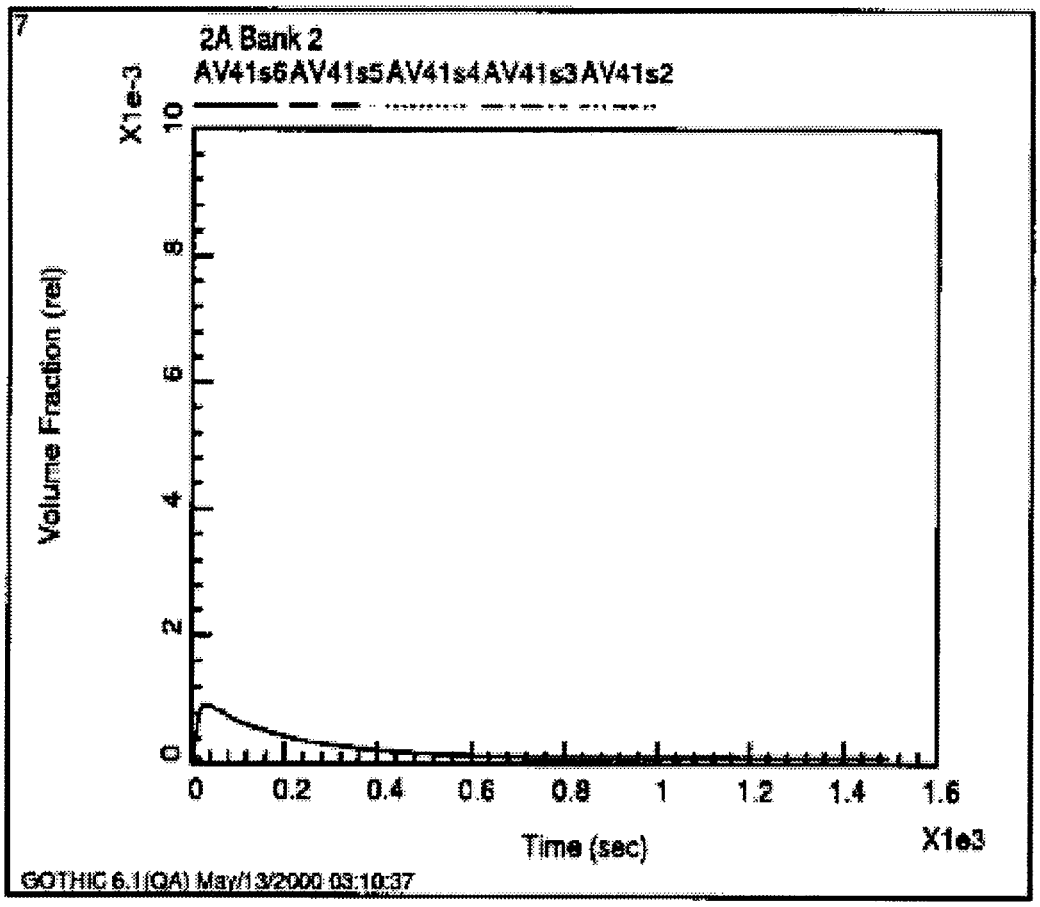
Graph #6 (Case 5)



Legend: AV28s6 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV28s5 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV28s4 thru AV28s2 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in 2VCC2A Bank 1 in this case.)

Graph #7 (Case 5)



Legend: AV41s6 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV41s5 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV41s4 thru AV41s2 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in 2VCC2A Bank 2 in this case. Note scale.)

In Case 9 (Graphs #8 - #14), return header pressure is dropped to near atmospheric, while supply pressure is maintained at 70 psia. This results in significantly more service water flow through the cooling train.

Graph #8 (Case 9) – Total Flow verses Time

Graph #8 (Case 9)

ANO2 System model - Case 9
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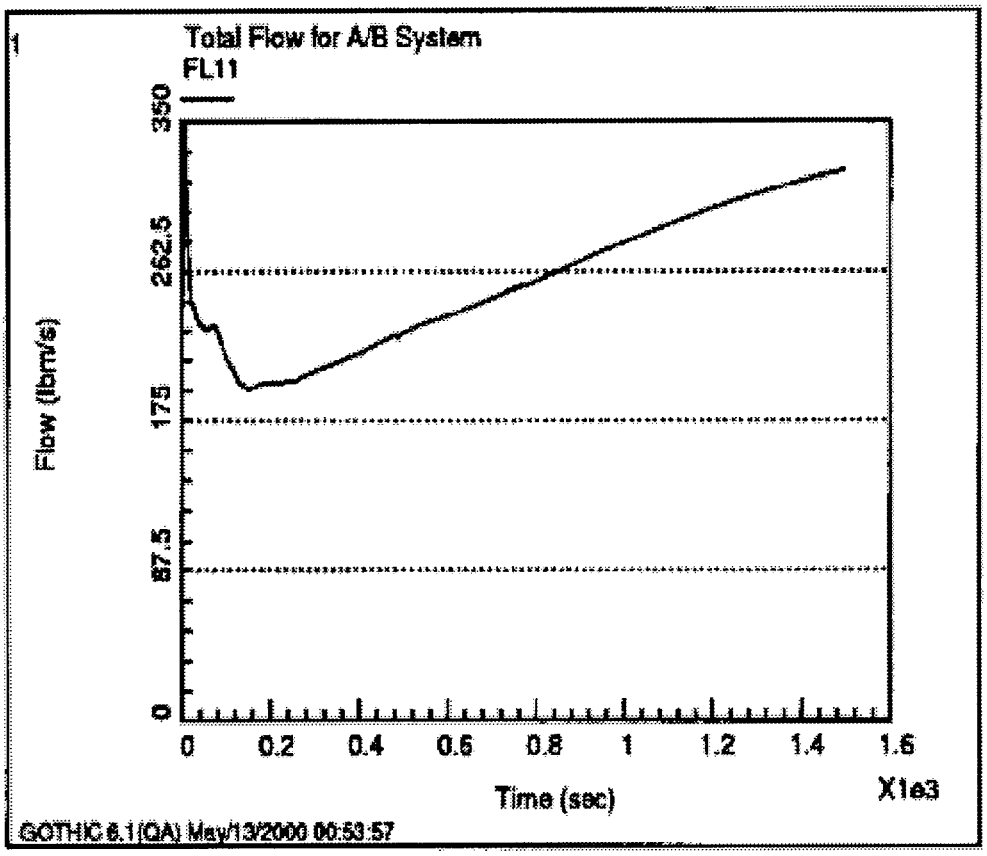
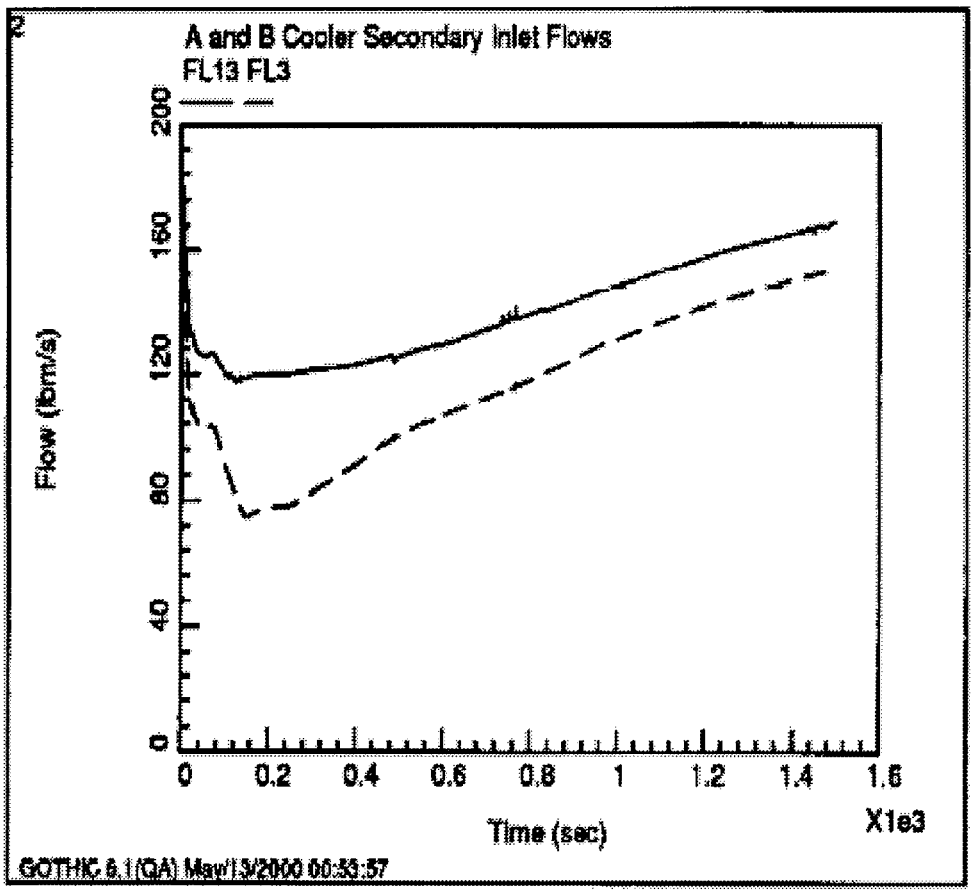
GOTHIC Version 6.1(QA) - July 1999



Legend: FL11 (solid) = Total service water flow (lbm/sec) to the train of coolers

Graph #9 (Case 9) – Flow (individual coolers) verses Time

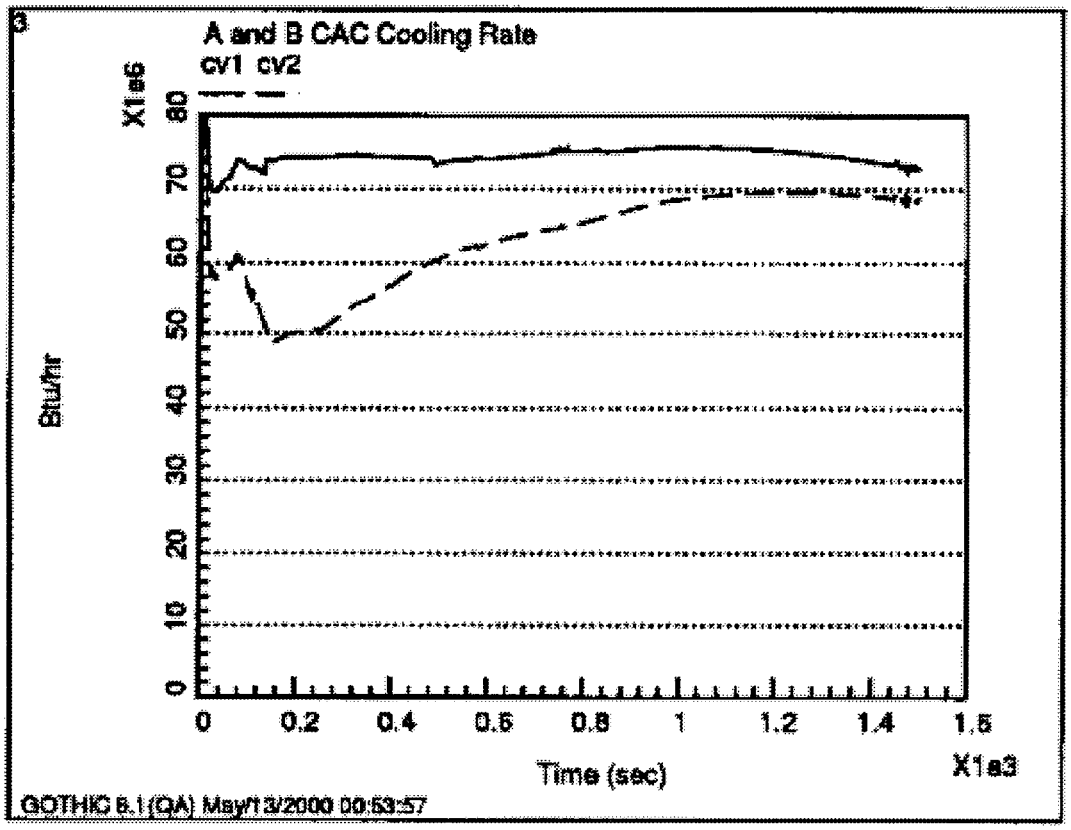
Graph #9 (Case 9)



Legend: FL13 (solid) = Service water flow (lbm/sec) to the cooler with lowest elev.
FL3 (dashed) = Service water flow (lbm/sec) to cooler with highest elev.

Graph #10 (Case 9) – The total heat capacity of the train is the sum of both curves.

Graph #10 (Case 9)

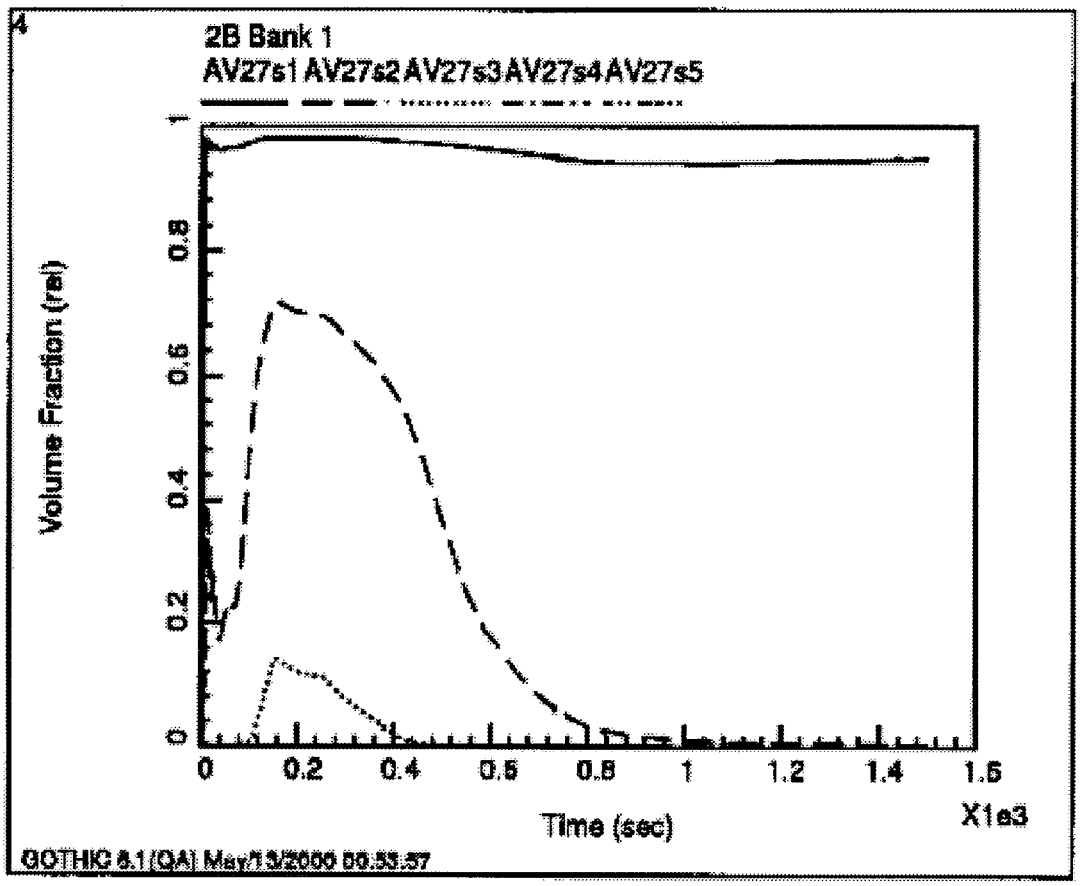


Legend: cv1 (solid) = Cooling capacity (BTU/hr) of the cooler at the lowest elev.
cv2 (dashed) = Cooling capacity (BTU/hr) of the cooler at the highest elev.

Graph #11 (Case 9) – Vapor volume as a function of time similar to graph #4. As shown in Graph #11 flashing persists for a longer period of time under the Case 9 scenario; however, heat removal capacity is greater since the lower return pressure results in a higher service water flow through the train.

Graphs #11 & #12 show flashing in the upper elevation cooler.

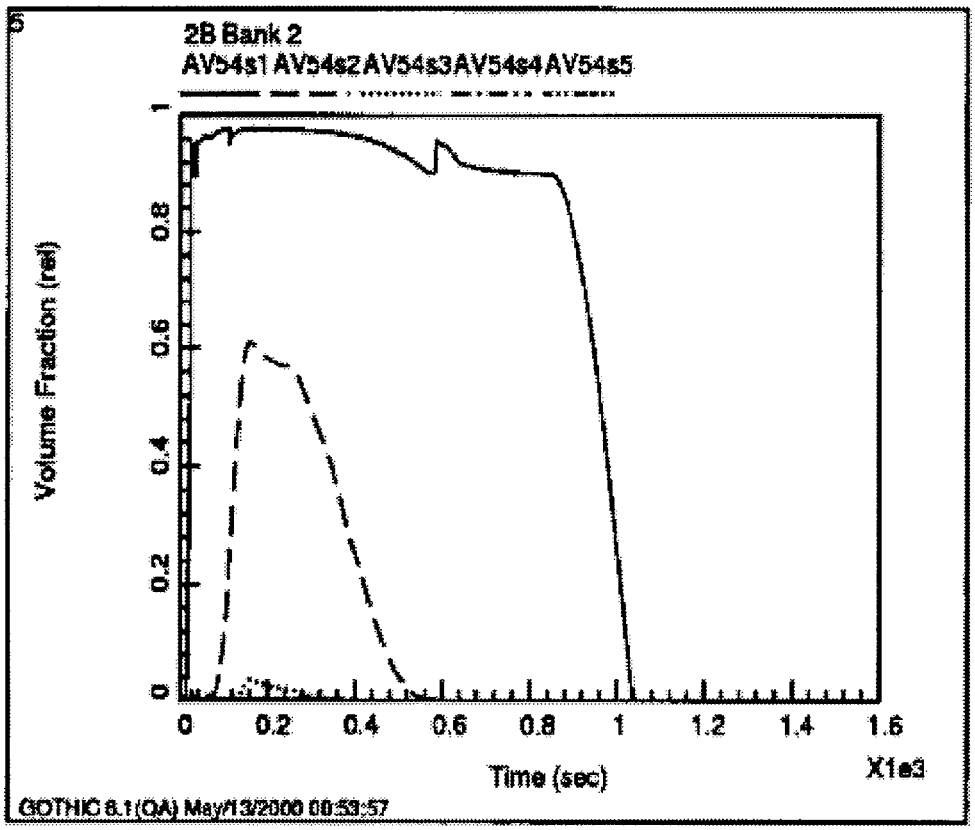
Graph #11 (Case 9)



Legend: AV27s1 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV27s2 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV27s3 thru AV27s5 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in the 1st through 3rd tube passes of 2VCC2B Coil Bank 1 in this case.)

Graph #12 (Case 9)

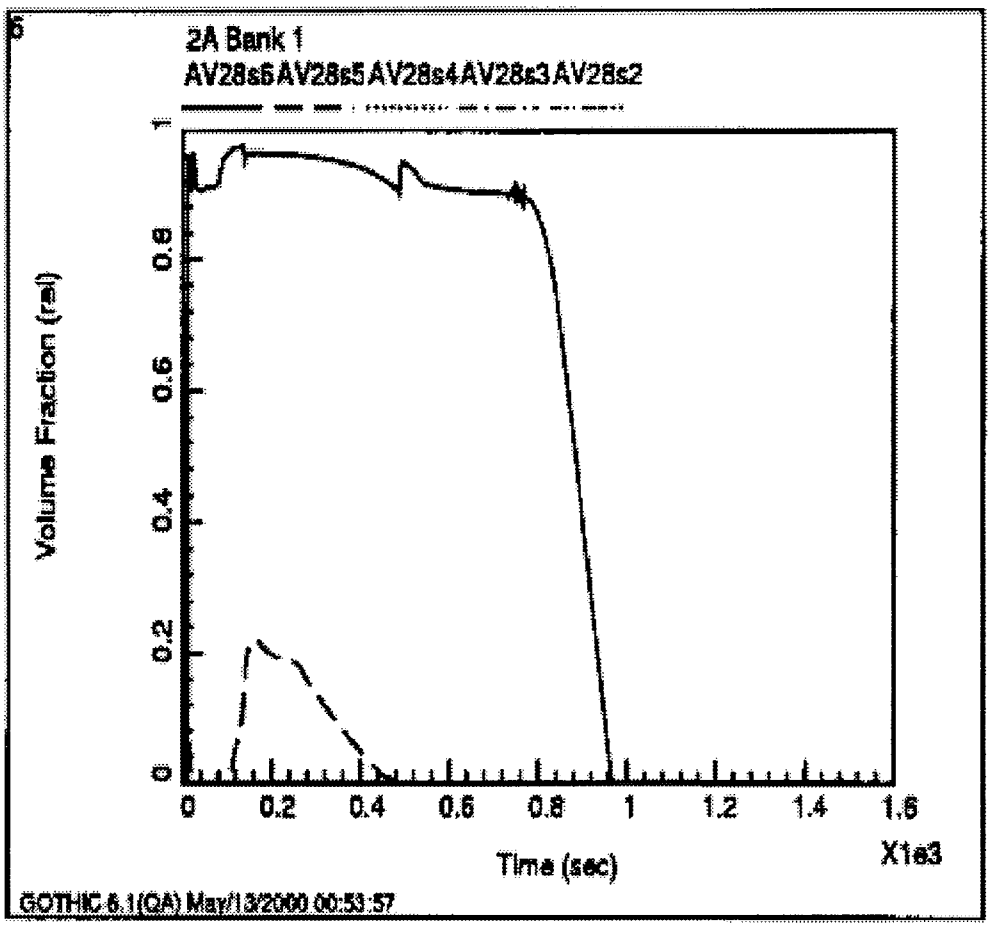


Legend: AV54s1 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV54s2 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV54s3 thru AV54s5 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in the 1st thru 3rd tube passes of 2VCC2B Coil Bank 2 in this case.)

Graphs #13 & #14 show flashing in the lower elevation cooler.

Graph #13 (Case 9)

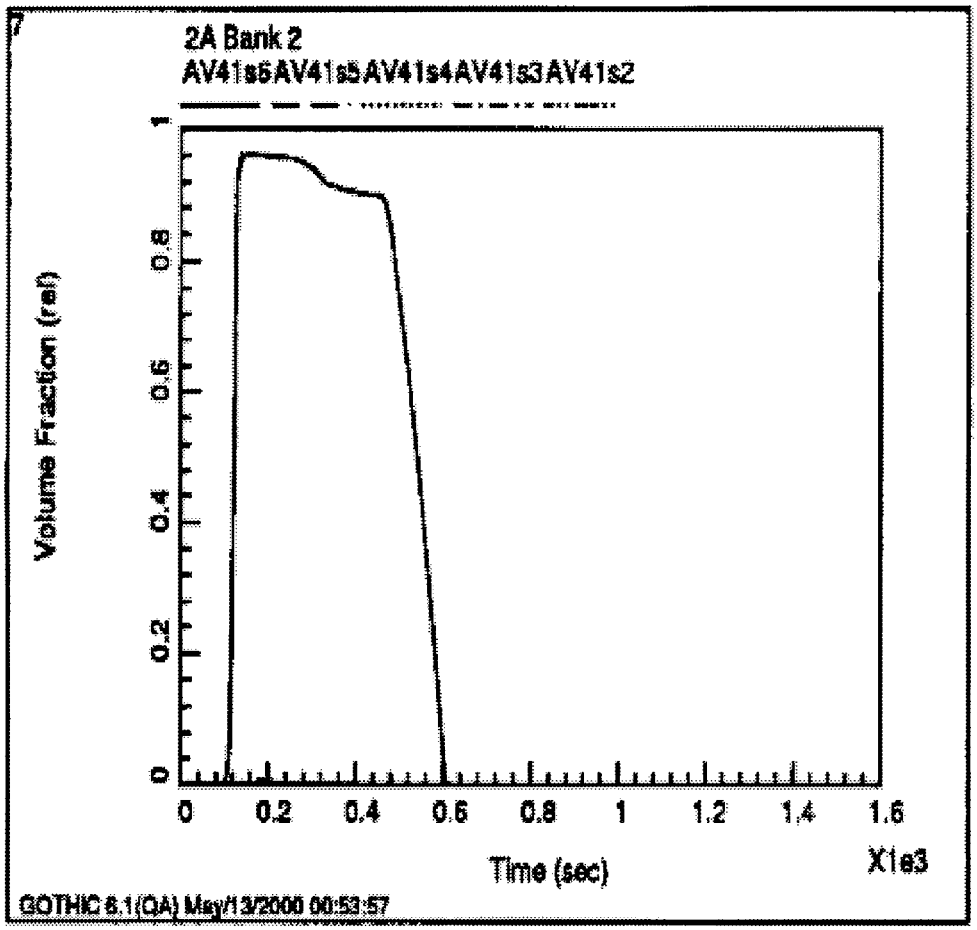


Legend: AV28s6 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV28s5 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV28s4 thru AV28s2 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in the 1st thru 4th tube passes of 2VCC2A Bank 1 in this case.)

Graph #14 (Case 9) - In this case a significant degree of flashing occurs in the lower elevation cooler.

Graph #14 (Case 9)



Legend: AV41s6 (solid) = Fraction of the volume in 6th tube pass that is vapor
AV41s5 (dashed) = Fraction of the volume in the 5th tube pass that is vapor
AV41s4 thru AV41s2 = 4th, 3rd, and 2nd tube passes respectively

(Note: Gothic does not predict any significant vapor formation in the 1st thru 5th tube passes of 2VCC2A Bank 2 in this case.)