Consumers Power Company

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October 29, 1982

Harold R Denton, Director
Office of Nuclear Reactor Regulation
Division of Licensing
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND NUCLEAR COGENERATION PLANT
MIDLAND DOCKET NOS 50-329, 50-330
SINGLE LOOP NATURAL CIRCULATION COOLDOWN ANALYSIS
FILE: 0505.16, 0928.6 SERIAL: 19405

Reference: J W Cook to H R Denton, CP Co Serial 18434 Dated 08/26/82

Enclosure: (1) Babcock & Wilcox Report, Single Loop Natural Circulation Cooldown
(2) F J Levandoski (B&W) to T J Sullivan, CPCO: 4029 Dated 10/20/82

Natural circulation cooldown analyses were identified as Outstanding Open Item 7 in Section 1.7 of the Midland Plant SER (NUREG-0793). Enclosure (1) provides the requested information and should be sufficient to close the item. Natural circulation cooldown with both reactor coolant loops will be demonstrated during natural circulation testing.

Consumers Power Company has addressed the recommendations in the report as follows:

- Venting of the reactor vessel head - As outlined in the referenced letter, the vessel head will be vented continuously to the top of a hot leg. Enclosure (2) provides an analysis of the effect that the head vent will have on natural circulation cooldown.

- Measurement of the reactor vessel head fluid temperature - Data gathered during natural circulation testing will establish cooldown and depressurization rates. The need to measure the reactor vessel head fluid temperature is obviated.

B001

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- Measurement of reactor coolant system loop boron concentration - The existing sampling systems were reviewed and are considered adequate.

James W. Cook

JWC/JRW/fms

CC RJCook, Midland Resident Inspector
RHernan, US NRC
WLJensen, US NRC
DBMiller, Midland Construction
RWHuston, Washington

CONSUMERS POWER COMPANY
Midland Units 1 and 2
Docket No 50-329, 50-330

Letter Serial 19405 Dated October 29, 1982

At the request of the Commission and pursuant to the Atomic Energy Act of 1954, and the Energy Reorganization Act of 1974, as amended and the Commission's Rules and Regulations thereunder, Consumers Power Company submits the B&W Report "Single Loop Natural Circulation Cooldown" and the letter F J Levandoski (B&W) to T J Sullivan CPCO: 4029 dated October 20, 1982.

CONSUMERS POWER COMPANY

By J.W. Cook

J W Cook, Vice President
Projects, Engineering and Construction

Sworn and subscribed before me this 19th day of Nov. 1982.

Patricia A Puffer
Notary Public
Bay County, Michigan

My Commission Expires 3-4-86

Babcock & Wilcox
a McDermott company

Nuclear Power Generation Division
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October 20, 1982

CPCO: 4029
File: 12B/T1.2

Consumers Power Company
1945 Parnall Road
Jackson, MI 49201

Attention: Dr. T.J. Sullivan
Manager, Safety & Licensing

Subject: Consumers Power Company
Midland Plant, Units 1 and 2
NATURAL CIRCULATION COOLDOWN RATES WITH
HEAD VENT - PRELIMINARY

Dear Dr. Sullivan:

Attached please find the subject analysis. This is being sent to you in its present form on a preliminary basis at the request of J.R. Webb.

Prior to issuing the analysis results in their final form, B&W intends to make the following revisions and additions:

- The text will be reviewed for clarity and completeness,

- Figures 1 and 2 will be expanded to show the Driving Head and Flow-Rate, respectively, for a RV Head Temperature of 350°F,

- Figure 3 will be expanded to show at least two (2) additional vent flow rates in the 0.9 to 6.0 range, and to include flow rates for an initial head temperature of 350°F.

The calculated pressure drops and flow rates in the attachment are based on an assumed 100 feet of pipe length from the service structure to the hot leg containing eight 90° elbows. We have just received an unofficial piping layout drawing from Bechtel which shows our assumptions to be conservative. Thus, flow rates will increase. This will be factored into the final analysis.

If you or your people have any specific requests for additional information to be included in the final transmittal, please call me.

Very truly yours,

F.J. Levandoski
Associate Project Manager

For: D.F. JUDD
SENIOR PROJECT MANAGER

Attachment
FJL/leh
cc: JR WEBB
LS GIBSON
EM HUGHES
RC BAUMAN

Review of Past Work

Previous analyses determined the reactor vessel cooldown rate during natural circulation with stagnant conditions in the RV upper head. The cooldown was governed by ambient losses from the coolant through the shell and insulation and conductive losses from the head metal downward to the RV flange region where cooler water was available to remove heat. These mechanisms combined for a maximum head cooldown rate of approximately 1.7°F/hr.

Effect of Vent Line

The RV vent line provides an additional means of heat removal from the head. Thus, the cooldown rate increases as a function of vent flow rate. The vent flow rate is dependent on the driving head induced by the RV head-hot leg temperature differential and the unrecoverable pressure losses between the RV head and hot leg. Since the unrecoverable losses are fixed, it is important to maximize the driving head. Driving head calculations assume an adiabatic vent line. Departure from this condition will reduce the driving head and consequently, the head cooldown rate (see Analysis Limitations).

RV Head Cooldown Code Modifications

The finite difference computer code used previously to analyze the stagnant condition cooldown was modified to reflect the presence of the vent line. The program was run for various flowrates and the results are shown in Figure 3. The same initial conditions (see Figure 3) and program were used as in the stagnant case with the following modifications:

- addition of the RV head vent and flow distribution model in the upper head region
- addition of a mixing subroutine to prevent cold fluid above hot fluid layering
- change of flow distribution below the cover to more accurately model this flow.

Figure 4 shows the flow model used in these analyses. Since the vent is located off the center line of the head, a stagnant region forms at the top of the head. This area limits the cooldown rate. A vent in the center of the head would prevent stagnant regions from forming and the head would cool down twice as fast as in the asymmetric case.

The cooldown rates achievable with the head vent flow can be estimated using the following figures.

- Figure 1 - Vent flow driving head as a function of fluid conditions in the RV head and hot leg
- Figure 2 - Vent flow rate as a function of pressure drop, i.e. driving head
- Figure 3 - RV head cooldown rate as a function of vent flow

Therefore, given the hot leg temperature the driving head can be found from Figure 1, a flow rate can be found from this driving head and Figure 2, and a cooldown rate can be found from the flowrate and Figure 3. For example, if

$T_{RV\ head} = 600°F$, $T_{hot\ leg} = 500°F$, $P \sim 2000$ psia

then from Figure 1,

$\Delta P_{driving\ head} = 1.94$ psid

and from Figure 2,

$Q_{vent\ flow} = 4.5$ gpm

and from Figure 3,

the cooldown rate $\approx 10°F/hr$.

Recall that the stagnant condition cooldown rate was $\approx 1.7°F/hr$. Smaller temperature differences between the RV head and hot leg will result in smaller driving heads, vent flow rates, and cooldown rates, while larger temperature differences will result in the opposite effects. For example, a 43 gpm vent flow (highly unrealistic) results in a 40°F/hr. cooldown rate, while a .9 gpm vent flow rate causes a cooldown rate only marginally better than the stagnant case. The relationship between the driving head for vent flow and head cooldown

rates is therefore nonlinear. Vent flow rates are expected to be between 0 and 5 gpm depending on the RV head-hot leg temperature difference and the ambient heat loss rate. This will result in cooldown rates between 1.7 and 10°F/hr.

Analysis Limitations

The analysis for determining the driving head assumes that the vent line is adiabatic. Because of the low vent flow rates and high transit times (for 3.3 gpm flow the transit time is about one minute), heat losses to the containment atmosphere will decrease the vent line temperature and consequently the driving head. An uninsulated vent line can reduce the driving head by as much as 20% and the vent flow by 10%. Therefore, to maximize the head cooldown rate, the heat losses must be minimized through the use of insulation.

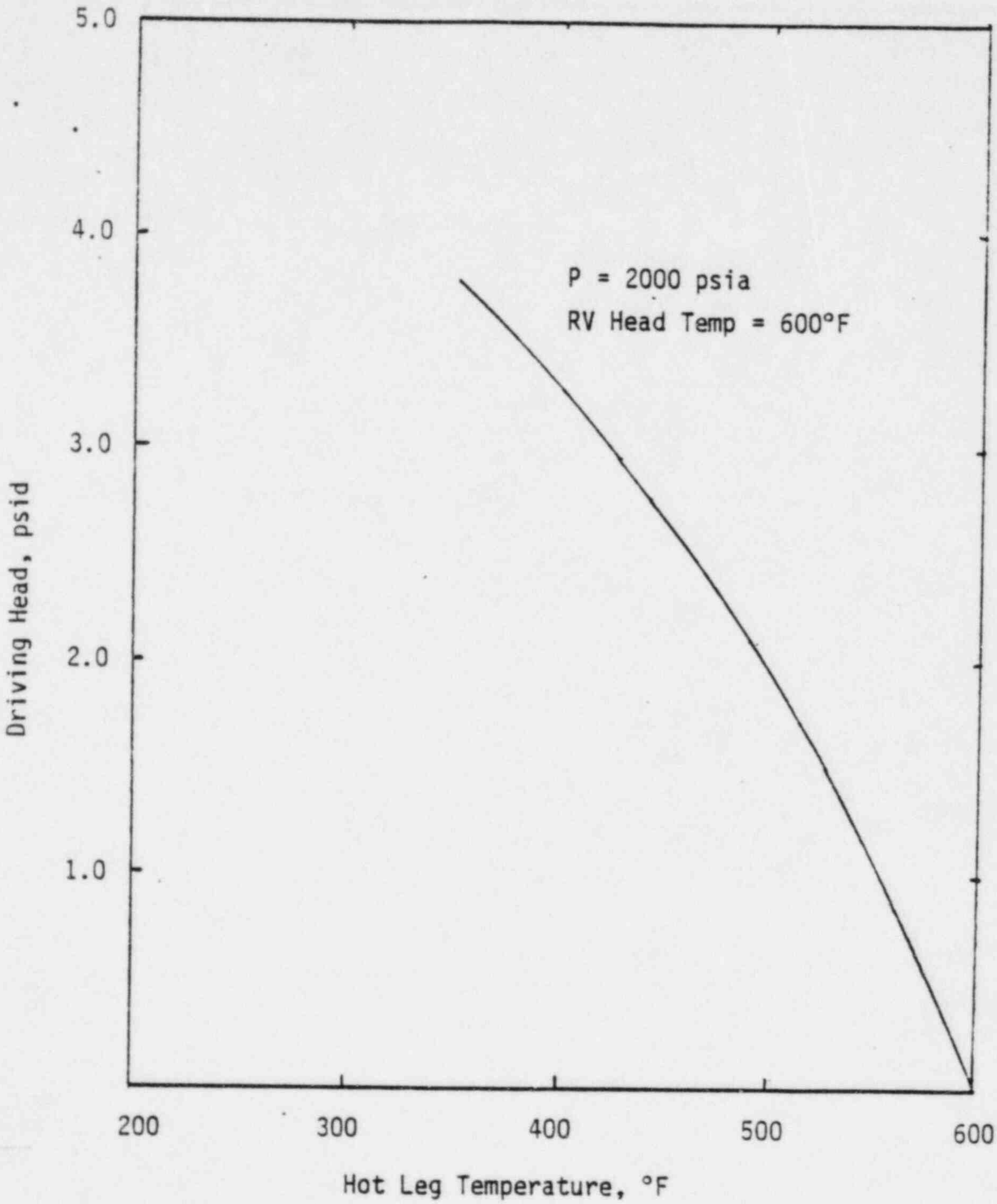


FIGURE I - Driving Head vs. Hot Leg Temperature

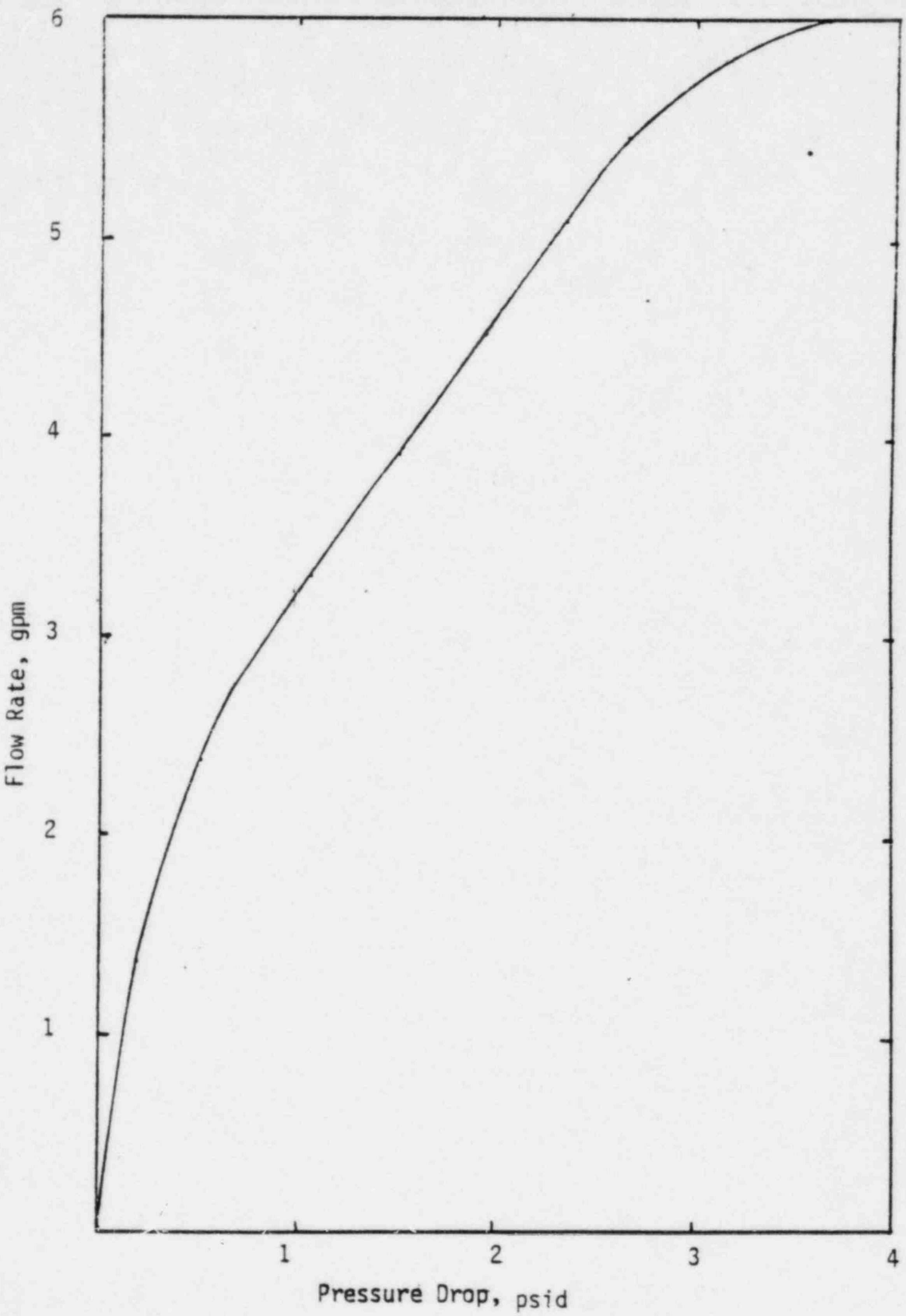


FIGURE 2 - Vent Flow Vs. Pressure Drop

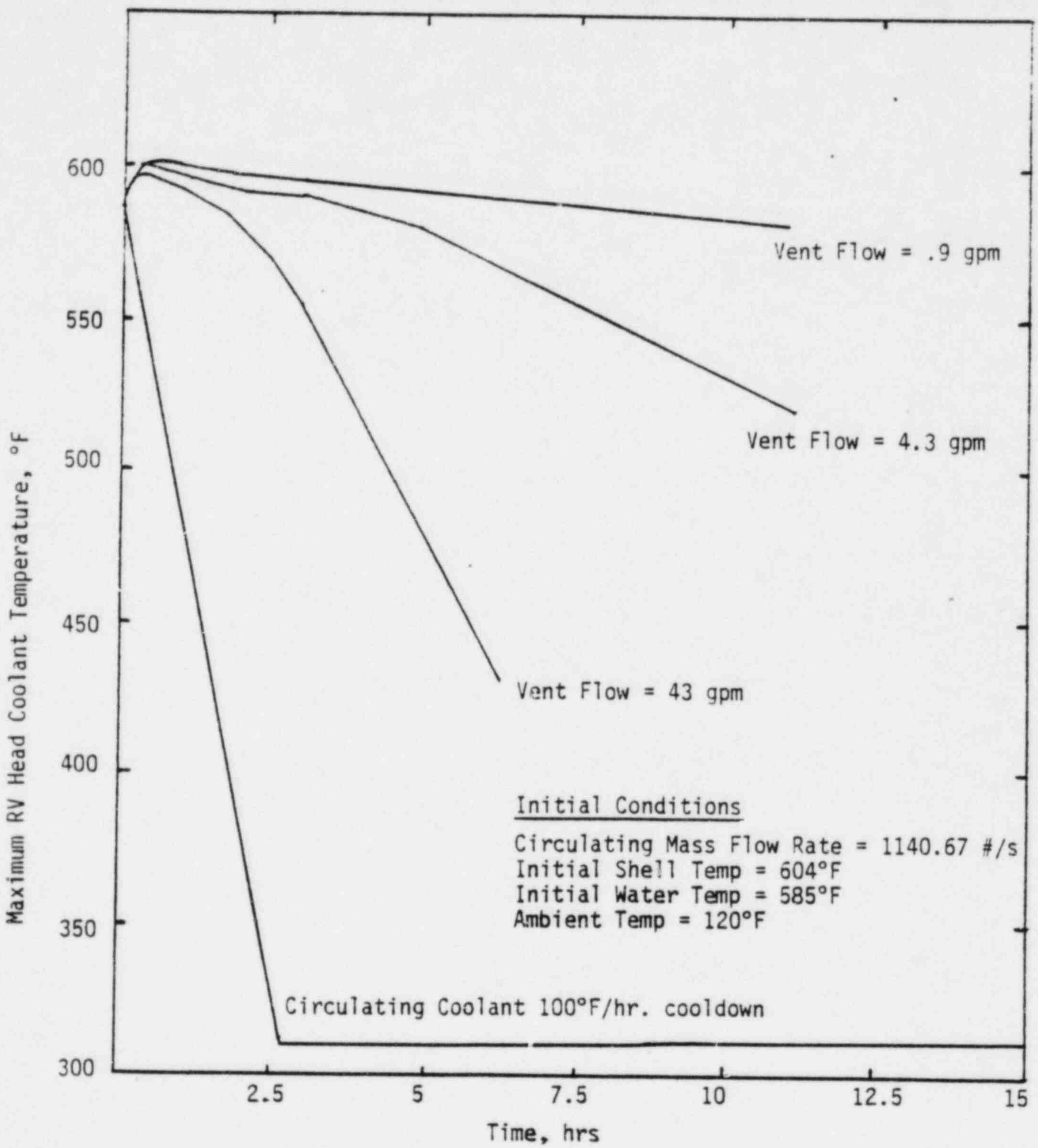
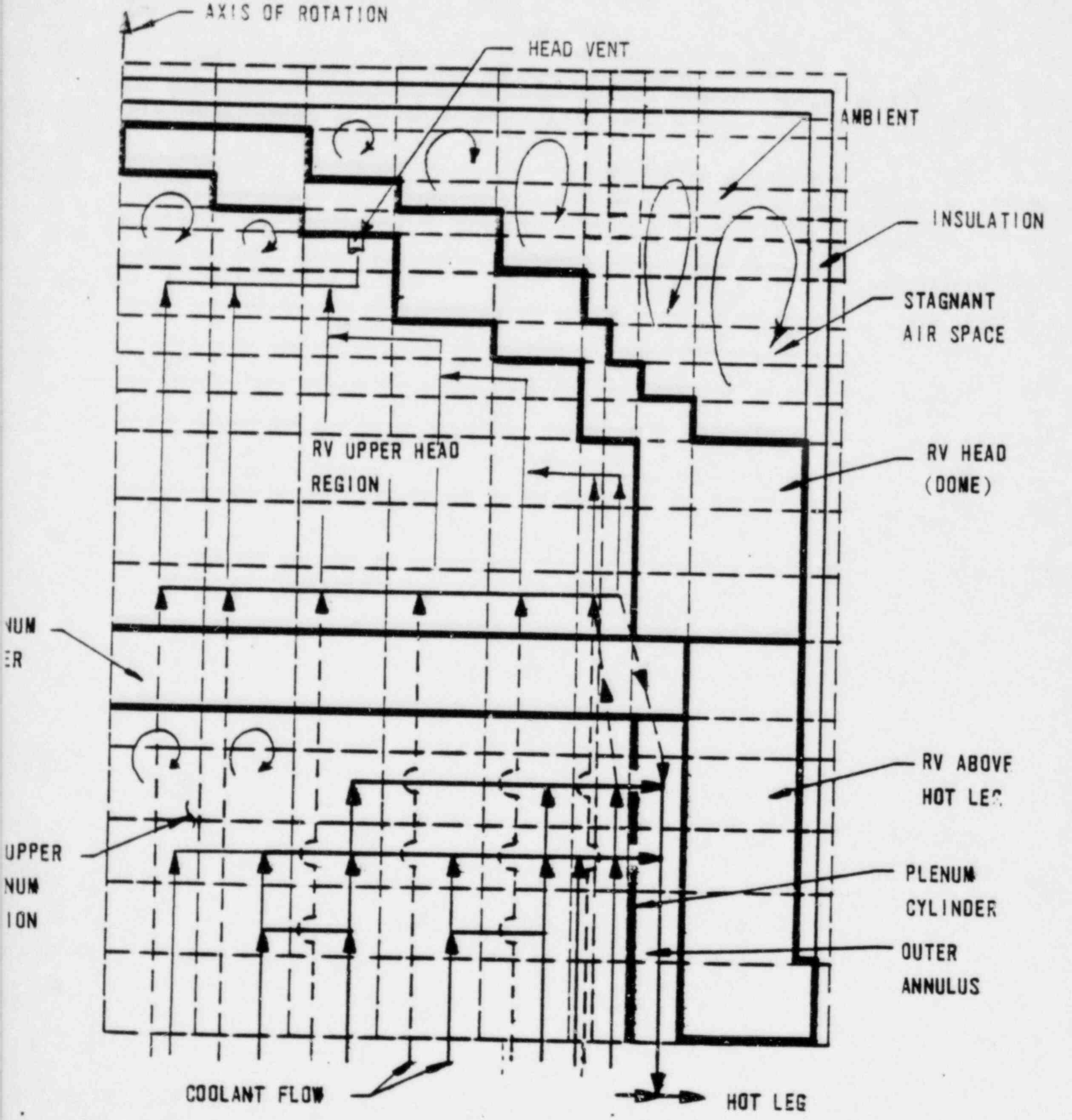


FIGURE 3 - Cooldown Rates vs. Vent Flow Rates

FIGURE 4

Flow Model with RV Head Vent



NOTE: THIS NODING DIAGRAM IS ONLY A ONE-HALF CROSS SECTION OF THE UPPER REACTOR VESSEL AND INTERNALS. IN THE ANALYSIS, THIS NODING DIAGRAM IS ROTATED ABOUT THE LEFT SIDE VERTICAL AXIS SO THAT THE RV AND INTERNALS ARE MODELED IN THREE DIMENSIONS. EACH NODE THUS BECOMES A RING.