MAINE YANKEE ATOMIC POWER COMPANY

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Director of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Edward J. Butcher, Jr.
Acting Branch Chief
Operating Reactors Branch No. 3
Division of Licensing

References:
(a) License No. DPR-36 (Docket No. 50-309)
(b) 10 CFR 50, Appendix R - Fire Protection Program
(c) USNRC Letter to MYAPCo dated February 3, 1983

Subject: Maine Yankee Appendix R Cooldown Analysis

Gentlemen:

In accordance with your request, attached is a description of the Maine Yankee Appendix R Cooldown Analysis.

Section III.L of Appendix R requires that alternate shutdown capability for a specific fire area be able to achieve cold shutdown conditions within 72 hours. Maine Yankee requested, and was granted, Reference (c), exception to this requirement, and allowed 130 hours to reach cold shutdown using a solid water steam generator mode of operation.

The Appendix R Cooldown Analysis demonstrates Maine Yankee's ability to reach cold shutdown within 130 hours, and assures that adequate water inventory and boration capability are available. The attached cooldown analysis has been divided into three sections as follows:

A. General Cooldown Analysis
B. Boration Requirements
C. Water Inventory Requirements

Should you have any questions, please contact us.

Very truly yours,

MAINE YANKEE ATOMIC POWER COMPANY

G D Whittier

G. D. Whittier, Manager
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Enclosure: (7 Pages)
cc: Dr. Thomas E. Murley
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ATTACHMENT

A. GENERAL COOLDOWN ANALYSIS

Assumptions and Design Inputs

1. Initial Conditions

   a. Hot standby, T_{av} = 532°F in Reactor Coolant System (RCS).

   b. Natural circulation flow.

   c. Normal Steam Generator (SG) and pressurizer levels.

2. Final Conditions

   a. Cold shutdown, T_{av} = 200°F in RCS.

   b. Natural circulation flow.

3. Transient Conditions

   a. The Steam Driven Auxiliary Feedwater Pump (SDAFP) is available to supply feedwater flow until it loses its capability to maintain SG level due to decreasing steam pressure or it cannot supply sufficient feedwater to remove decay heat.

   b. Nominal decay heat is calculated via NUREG 75/087, BTP ASB 9-2, "Residual Decay Energy for Light Water Reactors for Long-Term Cooling," 1981.

   c. The SG follows the RCS cold leg temperature.

   d. Liquid-to-liquid SG heat transfer is used once the decay heat has been reduced to less than the heat removal capability of the SG in the liquid-to-liquid cooling mode.

   e. All three SGs are available and used for decay heat removal.

   f. Sufficient feedwater inventory is available for heat removal during the transient.

   g. The fire pump is available as early as 3 hours from the initiation of the cooldown, but is actually used once the SDAFP capability is lost and decay heat has sufficiently dropped off.

   h. No Reactor Coolant System leakage.

   i. A feedwater temperature of 70°F.

   j. Steam enthalpy = 1150 Btu/lbm for steam cooling which corresponds to atmospheric conditions to conservatively maximize the feedwater flow requirements.

Method

The capability of the alternate shutdown equipment to cool the plant to cold shutdown conditions is determined by the following steps:

1. Calculate the stored heat in the RCS and SGs. The metal and water masses and heat capacities of the RCS and SGs are determined at hot standby conditions to determine the stored energy to be removed during the cooldown.

2. Determine decay heat vs. time during the cooldown.

3. Determine the primary makeup and feedwater flow requirements to support the cooldown.

4. Considering equipment capabilities, determine ability of available pumps to supply the required flow and the optimal time to fill steam generators and commence liquid-to-liquid cooling mode.

5. Based on the above, demonstrate that cold shutdown can be reached within the 130 hours.

Results

1. The RCS and SG stored heat is 1,465,792 Btu/^{o}F with the SG at normal level and 2,196,489 Btu/^{o}F with the SG filled with water.

2. Decay heat and SG stored heat vs. time is shown in Figure 1.

3. The auxiliary charging pump, P-7, is capable, at 33 gpm, to support approximately a 45^{o}F/hr cooldown rate, which far exceeds the rates specified in the Post-Fire Shutdown Procedures. The feedwater flow requirements are given in Figure 2.

4. The following restrictions were determined to apply to the cooldown based on equipment limitations:

   - The steam driven auxiliary feedwater pump is dependent on SG pressure and, as a result, cannot supply adequate flow to continue the cooldown of the RCS below approximately 347^{o}F.

   - The fire pump does not have sufficient capacity to remove decay heat and continue the cooldown until 27 hours.

   - SG fill can commence at 66 hours and liquid-to-liquid cooling can begin at 87 hours.

   Figure 3 provides the proposed cooldown curve included with the Post-Fire Shutdown Procedures.

B. BORATION REQUIREMENTS

Design Inputs

1. The source of borated water is the RWST, from which the water is injected into the RCS by the auxiliary charging pump, P-7, at a maximum flow of 33 gpm via the safety injection piping.

2. The total RCS free volume, excluding the pressurizer = 9526 ft^3.

3. Injection piping volumes - determined from pipe stress isometrics.

4. Pressurizer volume vs. level curve.

Assumptions

1. No stuck or inoperable CEAs.

2. The boron concentrations corresponding to 5 percent subcritical were determined based on nominal critical boron concentrations for ARI, no xenon, 68^oF, without any additional uncertainty allowances.

3. Boration requirements are cycle dependent and are required by procedure to be reviewed each cycle.

4. The initial RCS boron concentration is assumed to be the normalized ARO, HFP, Eq Xe, critical concentration.

5. No RCS leakage or letdown.

Method

The final mixed RCS boron concentration is determined by the following equation:

$$C_B^{RCS}(\text{final}) = \frac{M^{RCS}(\text{initial}) \times C_B^{RCS}(t=0) + M_B^{SI} \times C_B^{SI}}{M^{RCS}(\text{final})}$$

where: $M^{RCS}(\text{initial})$ = The initial RCS inventory excluding the pressurizer.

$C_B^{RCS}(t=0)$ = The initial RCS boron concentration (ppm) at the start of the cooldown.

M_B^{SI} = The integrated mass flow of borated injected flow over the cooldown.

C_B^{SI} = Boron concentration (ppm) of SI flow.

$M^{RCS}(\text{final})$ = The total RCS liquid inventory at the end of the cooldown.

The required injection flow concentration is found by determining the nominal value for final RCS C_B equivalent to 5 percent subcritical (Technical Specification cold shutdown requirement) and solving for C_B^{SI}.

Results

The RWST and SI piping are sufficiently borated (1720 ppm) to result in th reactor being a nominal 5 percent subcritical at the end of the cooldown. It will be necessary to increase pressurizer level from 60 to 80 percent during the cooldown to allow injection of adequate borated water. This requirement has been included in the Post-Fire Shutdown Procedures.

C. WATER INVENTORY REQUIREMENTS

Assumptions

1. Only the DWST and raw water storage pond (fire water source) are assumed to be available for supplying feedwater for the cooldown.
2. The RWST is considered the only source for Reactor Coolant System make-up.

Method

The cooldown water requirements were compared with the available water supplies:

1. Reactor Coolant System Makeup

   Total injected water volume = 2027.7 ft^3
   = 15,167 gal

   The RWST with a Technical Specification required volume of 300,000 gallons is more than adequate.

2. Feedwater Requirements

   Total feedwater flow requirements for the cooldown, defined by Figure 3, is 1,322,500 gallons.

   The capacity of the raw water storage pond and DWST is approximately 3,100,000 gallons minus 600,000 gallons fire water requirements = 2,600,000 gallons available for cooldown, which is more than adequate to supply the required feedwater.

RESULTS

Assuming minimum water availability, it has been demonstrated that the cooldown water requirements can be met.

FIGURE 1

DECAY + STORED HEAT VS TIME

NOTE: STORED HEAT IS A CONSTANT 1.3 MW

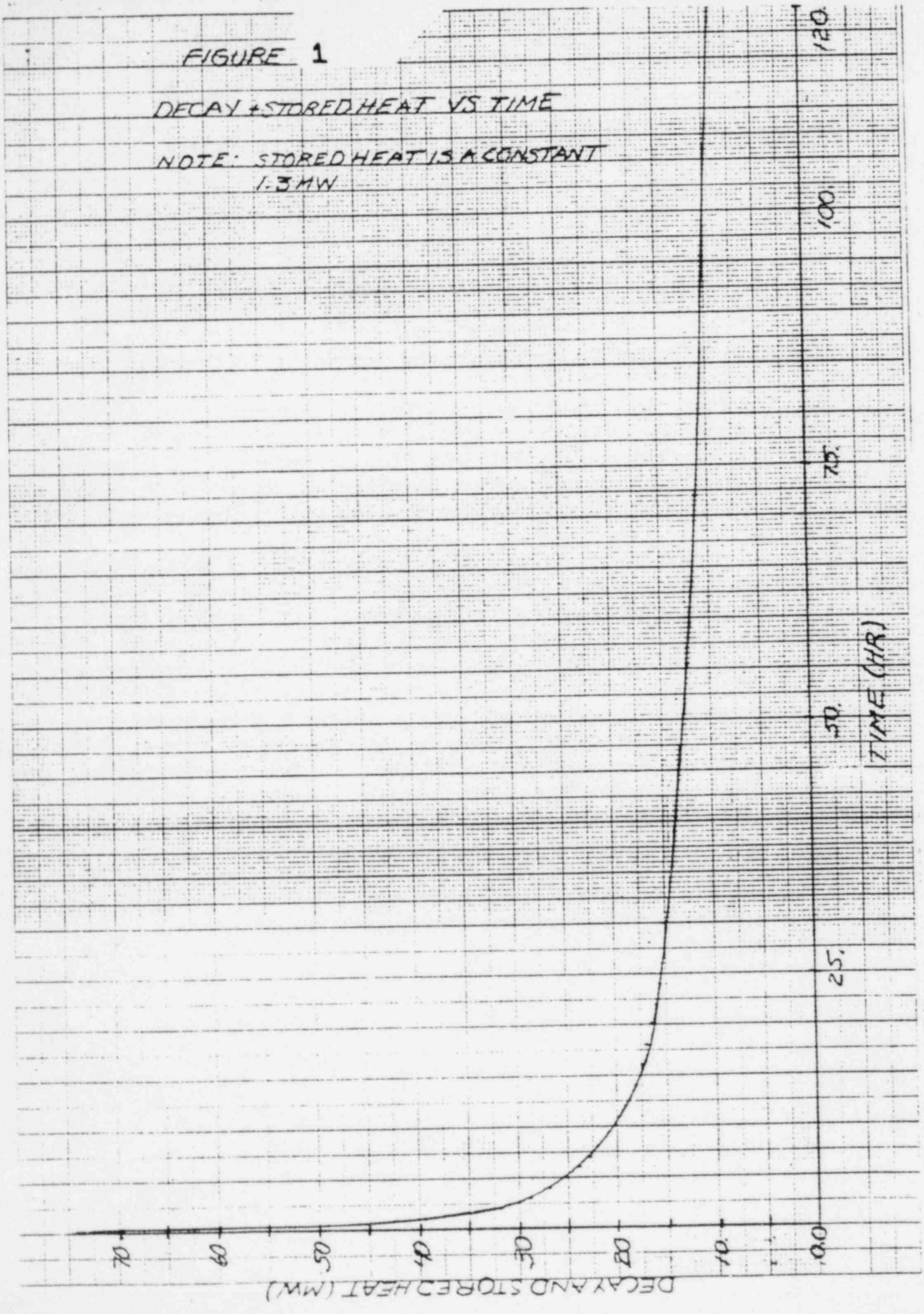

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FIGURE 2

APPENDIX R COOLDOWN FEEDWATER REQUIREMENTS FOR STEAM AND LIQUID COOLING

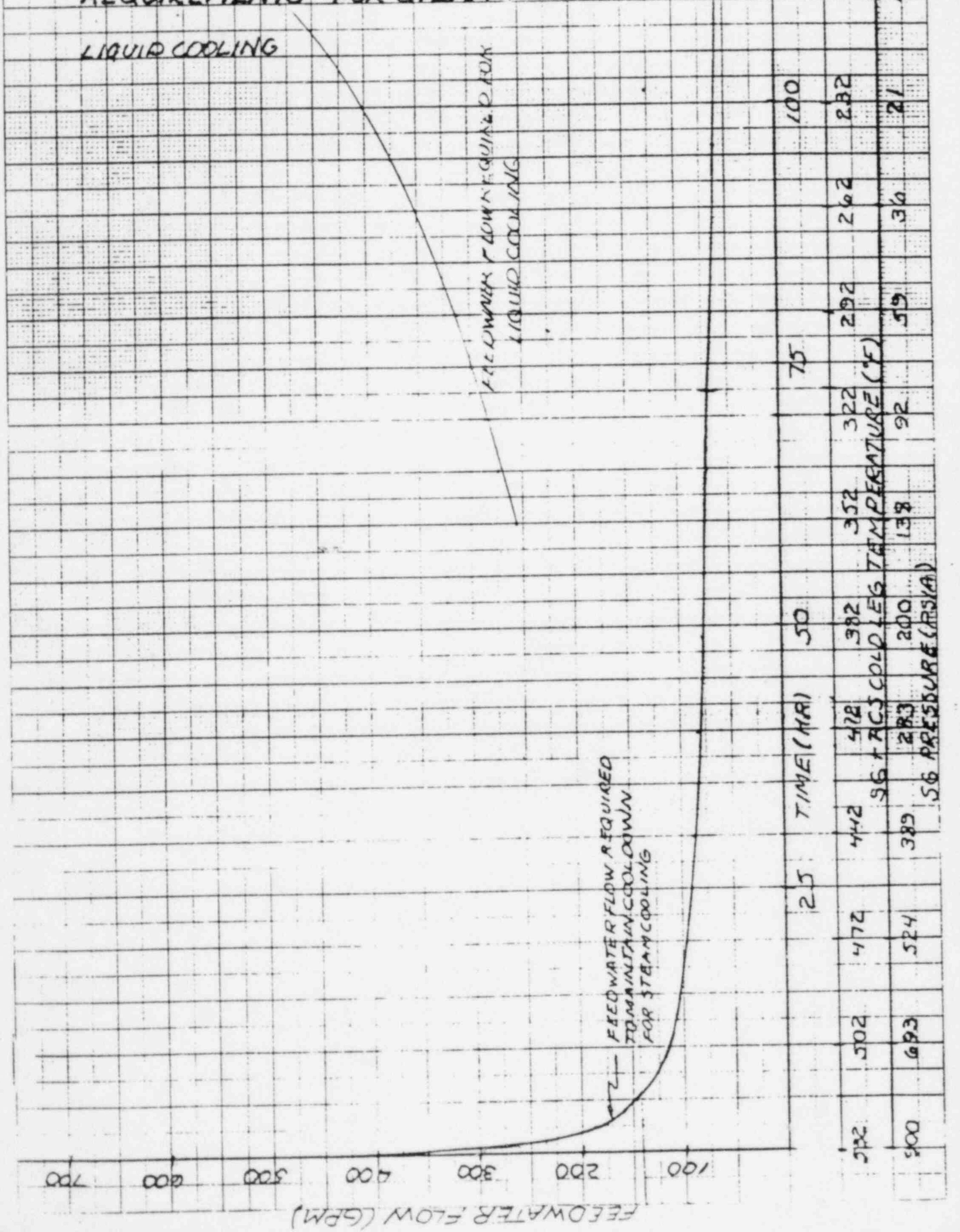
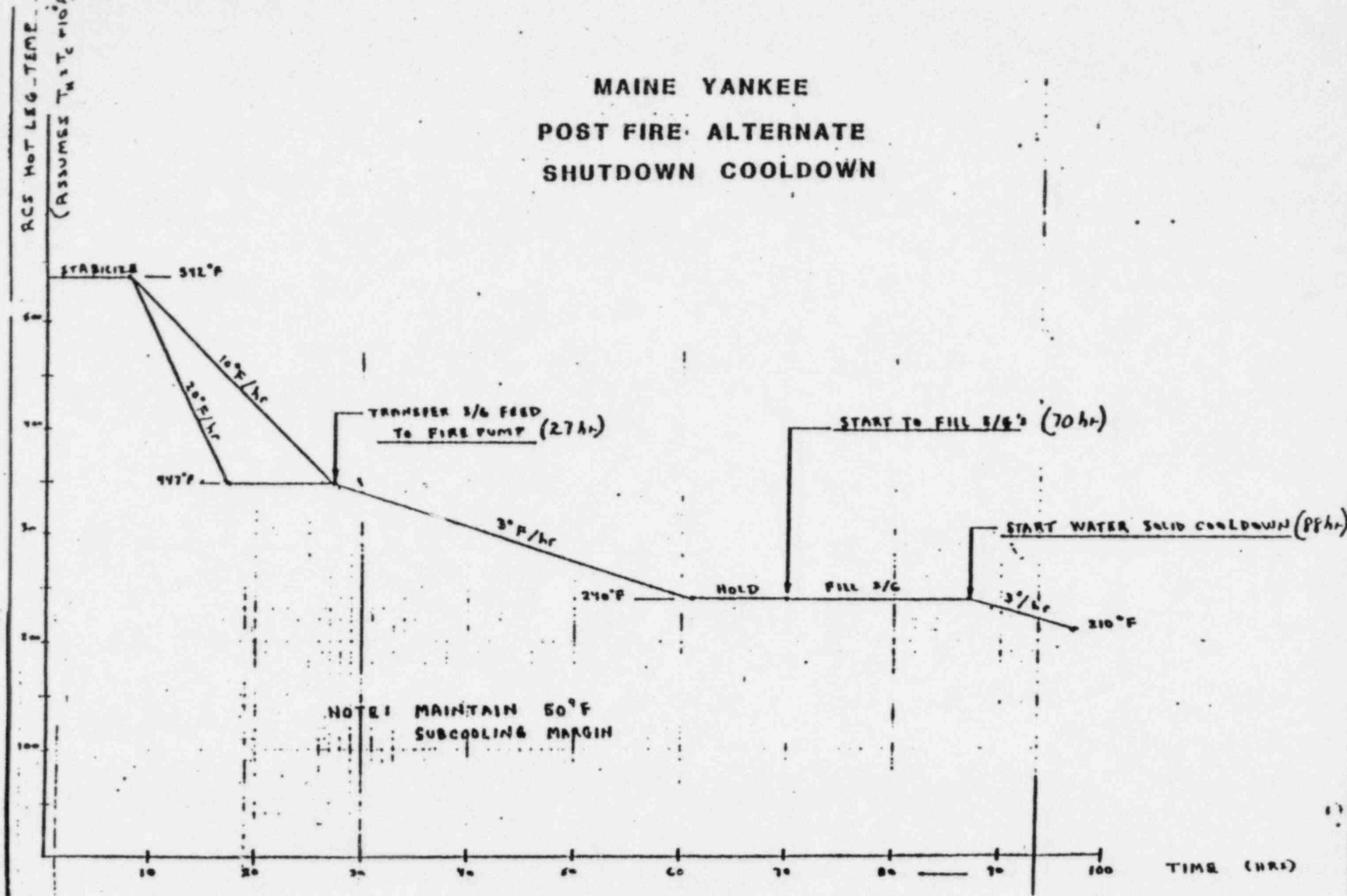


Figure 3



MAINE YANKEE
POST FIRE ALTERNATE
SHUTDOWN COOLDOWN
RCS HOT LEG TEMP
STABILIZE
10°F/hr
20°F/hr
TRANSFER S/G FEED
TO FIRE PUMP (27 hr)
3°F/hr
START TO FILL S/G's (70 hr)
START WATER SOLID COOLDOWN (88 hr)
240°F
HOLD
FILL S/G
210°F
NOTE: MAINTAIN 50°F
SUBCOOLING MARGIN
10
20
30
40
50
60
70
80
90
100
TIME (HRS)