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GINNA NUCLEAR STATION
ECCS SWITCHOVER TO RECIRCULATION

R. W. FLEMING

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WESTINGHOUSE ELECTRIC CORPORATION
P. O. BOX 355
PITTSBURGH, PA 15230

Introduction

The Ginna Nuclear Station Safety Injection System Design (see Figure 1) and Emergency Instruction E-1.2 have been reviewed specifically with respect to the post-LOCA switchover to recirculation. These documents reflect the original design intent which allowed both low head safety injection (LHSI/RHR) pumps, two high head safety injection (HHSI) pumps and one containment spray pump to continue to operate until the refueling water storage tank (RWST) level decreased to a level near the RWST outlet nozzles. All the operating safeguards pumps were then stopped and the systems realigned for the recirculation mode before restarting the pumps.

Since the design resulted in a termination of all injection flow while the system realignment to the recirculation mode was being completed, the reactor coolant would continue to boil away without makeup. The total boiloff time period would be determined by the sum of the time increments required for the operator to accomplish several discrete actions to realign the pumps and valves in both the LHSI and HHSI parts of the system.

An improvement in the use of the installed safety injection system, during a large LOCA, would result if all injection flow is not terminated during the switchover to recirculation. Since the reactor coolant makeup will be greater than the boiloff rate from the reactor coolant system, a net loss of system inventory will not occur during the switchover of the LHSI pumps.

Potential Alternative Switchover Procedures

Several alternative procedures have been suggested for other Westinghouse designed plants, each intended to maintain some safety injection flow during the switchover from the injection mode to the recirculation mode of operation. The following is a brief description of three of these alternatives.

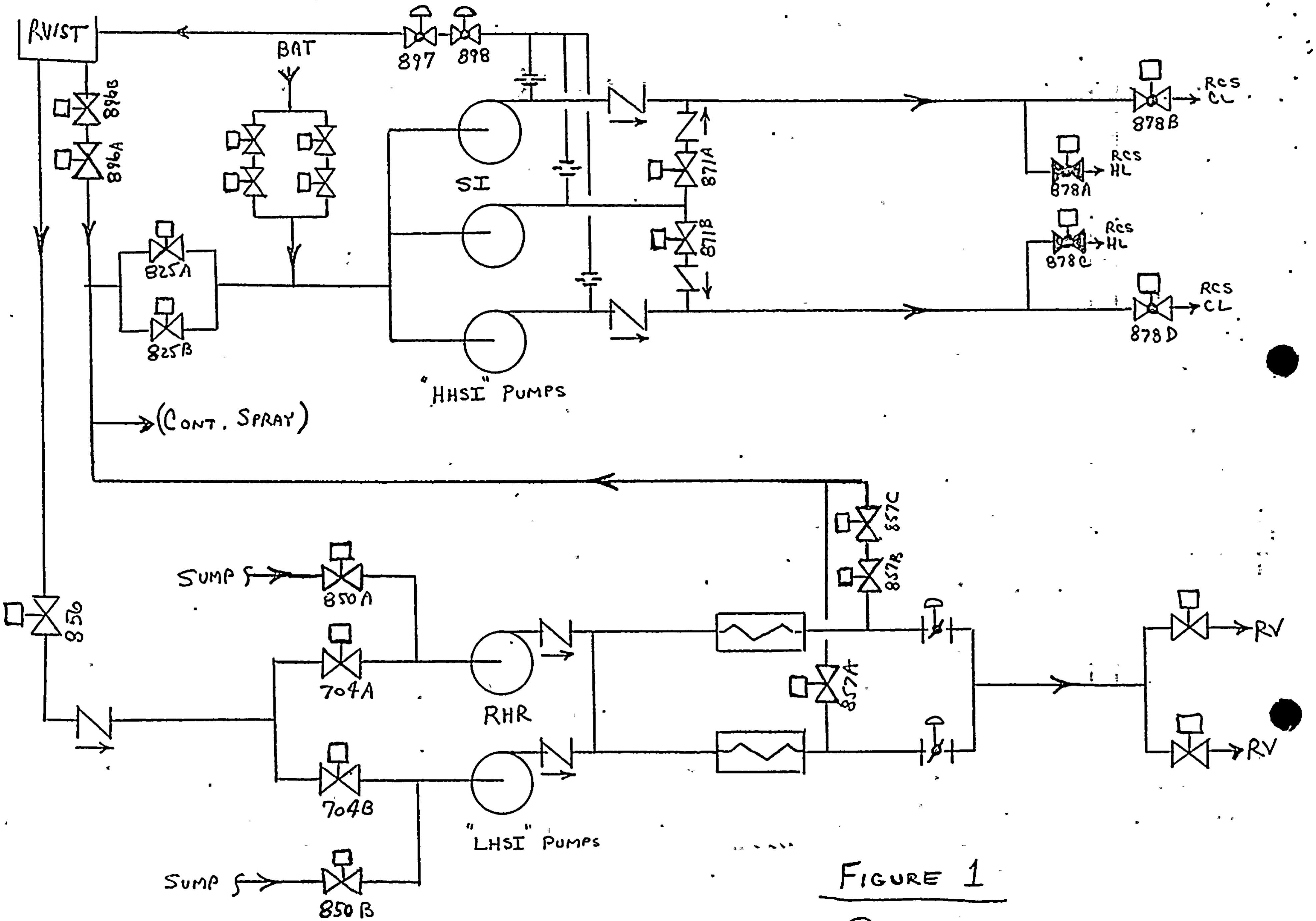

FIGURE 1

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1. In those system designs which include check valves at the pump suction connections from both the RWST and the sump, a "flying" transfer of the pump suction source can be made without stopping either the LHSI or HHSI pumps. For the LHSI, the sump valves are opened while the pumps continue to draw from the RWST. Then depending on the relative pressures on the lines caused by the elevation of the RWST or the pressure in the containment, the LHSI will draw from one suction source while the check valves prevent backflow in the line with the lower source of pressure. Subsequently the LHSI pump discharge isolation valves to the HHSI pump suction header would be opened while the HHSI pumps continue to draw from the RWST. Again, check valves prevent backflow to the RWST as the HHSI pump suction pressure is increased by the discharge pressure from the LHSI pumps.

   Note that this flying transfer alternative is not possible on Ginna due to the absence of check valves in the pump suction lines.

2. Another procedure which gives a partial "flying" transfer involves only the LHSI pumps. In this alternative, the sump valves would be opened while the LHSI pumps continue to draw from the RWST. However, if the elevation of the water in the RWST provides a pressure at the pump suction greater than the pressure in the containment sump, water would flow from the RWST into the sump until the LHSI pump suction isolation valves could be closed. Note that if one of these isolation valves could not be closed, the RWST would continue to drain into the sump until the RWST emptied. This single failure can be accepted if the RWST has sufficient margin, between the level at which the transfer to recirculation begins and the empty level, to allow the operators to complete all actions required

[illegible]

to realign the system for recirculation before the tank empties.

Since this alternative presents a potential concern regarding the extra volume margin required in the RWST, it was not considered for Ginna.

3. The third alternative procedure is a modification of the present procedure and involves simply transferring the LHSI and HHSI pumps suction from the injection mode to the recirculation mode separately so that both sets of pumps are not inoperative at the same time. The LHSI pumps are transferred first and during the realignment the HHSI pumps continue to inject into the RCS. After the LHSI pumps have been realigned, and are operating in their recirculation mode, the HHSI are realigned. This alternative maintains either the LHSI or HHSI pumps in operation at all times and prevents the complete termination of all injection flow during the switchover to recirculation following a large LOCA.

   This third alternative is the one selected for further evaluation for the Ginna Station.

<u>Summary Operating Guidelines</u>

Attachment I presents a summary of the operator actions required to effect a switchover to recirculation in a way which avoids terminating all safety injection flow to the RCS following a large LOCA. The objective of the procedure is to switchover the LHSI pumps to the recirculation mode while the HHSI pumps continue to operate taking their suction from the RWST.

It should be noted that in these guidelines, the component cooling isolation valves for the residual heat exchangers are opened before the switchover procedure is begun. This operation

can be performed at a time in the procedure after the operator has verified the proper operation of the service water and component cooling pumps.

The present RWST level setpoint function (31 percent), which alerts the operators to reduce the number of operating pumps, will be eliminated and a new low level setpoint function added at a lower RWST level. The new low level setpoint will be the signal to stop both LHSI (RHR) pumps and begin the realignment of the LHSI valve for the switchover to recirculation. The new low level alarm will also alert the operator to trip one containment spray pump, if two are in operation and to trip safety injection pump 1C if all three HHSI pumps are in operation. Note that while the LHSI valves are being repositioned, to transfer the LHSI pumps suction from the RWST to the containment sump, the HHSI pumps continue to draw from the RWST in their injection mode.

The LHSI pumps cannot be restarted taking their suction from the sump until there is sufficient water on the containment floor to provide adequate NPSH for the pumps. Therefore, the new RWST low level setpoint has been selected such that the switchover does not occur until refueling water has been pumped into the containment to a depth of two feet of water above the containment floor. This depth provides about one foot margin on the $NPSH_a$ to the LHSI pumps.

After the LHSI pumps have been realigned and are operating in their recirculation mode, the operator may proceed to realign the HHSI pumps. The low-low level alarm from the RWST is retained to alert the operator to proceed to realign the HHSI pumps, and in particular to stop any pumps still taking suction from the RWST.

The present low-low level alarm at ten percent RWST level signalled the time to trip all operating pumps. However, since the containment spray pump has been shown to require slightly more NPSH than would be available at the ten percent level, the new low-low level alarm will be raised to fifteen percent to provide a suction pressure margin for the spray pump. This change was suggested in a previous report by Gilbert/Commonwealth.

Attachment III presents additional information regarding the estimated times available to complete the required operator actions and Attachment II presents a summary of the RWST volumes available for use.

RWST Volume Summary

Attachment II, Figure IIA, presents a summary of the water volumes available in the RWST considering that the two alarm setpoints remain at their present values. The effect of an instrument uncertainty of ±3 percent of span also has been shown on the figure around each setpoint.

The tank parameters used to establish the volume summary are as follows:

tank diameter	26.45	feet
total volume available	338,000	gal
normal water volume	300,000	gal
volume below nozzle	6,165	gal
span of instrument	1000	inches
volume/foot	4,110	gal
volume/% span	3,425	gal

Since the new switchover guidelines call for the trip of the LHSI pumps at the low alarm setpoint, if the present 31 percent value were retained there would be insufficient water on the containment floor to provide adequate NPSH for the LHSI pumps. Note from Figure IIA that there might be as little as 113,550 gal of refueling water in the containment, with 30,000 gallons held up in the refueling cavity, if the LHSI pumps were transferred to the sump at the 31 percent level. Since at least 154,600 gallons must be on the floor of the containment to provide sufficient NPSH for the LHSI pumps, a total of 184,600 gallons must be delivered before the LHSI switchover procedure is begun.

Figure IIB describes the RWST volume summary required to be compatible with the new recommended operating guidelines. Note also that the RWST low-low level setpoint is raised to fifteen percent to provide margin to the spray pump $NPSH_R$ and an operating margin between the level at which the HHSI and spray pumps are tripped off and the level where the tank outlet nozzle becomes uncovered.

The new value of the low alarm setpoint (28 percent) provides a minimum differential volume of 23,975 gallons to support the continued operation of one spray and two HHSI pumps while the LHSI realignment takes place. The differential volume of 184,950 gallons between the new low-low alarm and the new Technical Specification limit provides the volume of refueling water required to assure adequate NPSH for the LHSI pumps when they are restarted taking suction from the containment sump.

These new volumes shown on Figure IIB indicate a larger Technical Specification volume must be specified which requires a normal water level above the present specified level. The

result will be a slightly smaller operating band for the normal water level in the RWST.

Operator Time Allowances

Attachment III describes the operator time allowances to perform the various required actions to accomplish the switchover from injection to recirculation during a large LOCA when the RWST level is receding rapidly due to all safeguards pumps running at their maximum capacity. It is assumed in this summary that discrete operator actions are not taken earlier than at one minute intervals although realistically the operator can move through the procedure at a more rapid rate.

It is assumed that multiple pump trips can occur very quickly without pause between and that both trains are acted upon by the operator simultaneously. Also, if two similar pumps (such as two RHR pumps) are to be tripped out of service, both switches are moved together with no significant pause between. In the case of restarting of multiple pumps however, it is assumed that each pump is started individually and verified to be operating before moving to the next pump to be started. Even though it is expected that a pump will be in satisfactory operation within a few seconds, the one minute criteria between pump starts is maintained in this evaluation.

Specifically in the case of realigning the LHSI valves, (704A/B and 850A/B), the time allowance is lengthened to the actual measured time for the valves to fully stroke before moving to the next step. That is, the sump valves (850A/B) are not started on their opening stroke until the isolation valves from the RWST (704A/B) are completely closed. This

[illegible]

is to prevent a possible spill of some RWST into the containment sump while the valves are being repositioned. Similarly, the LHSI pumps are not restarted until the sump valves have completed their stroke.

Figure IIIA describes the operator time allowances for the LHSI switchover procedure which begins with the actuation of the RWST low level alarm. It can be seen that using the criteria above, the realignment of the LHSI consisting of four actions will be completed in less than eight minutes.

The time allowances for the HHSI switchover is described by Figure IIIB. Note on this figure, six actions are identified and the one minute criteria is applied except where it is necessary to wait for isolation vavles to be fully open before restarting the pumps. The realignment of the HHSI is shown to occur in about seven and one-half minutes.

The evaluation above, and shown by Figures IIIA and IIIB, describes the expected time allowances for the operator to complete the required actions. To provide an indication of the time available to the operator for his diagnosis and actions during a large LOCA, when the shortest times are available, an estimate of the maximum flow rates out of the RWST was made. It was assumed that all safeguards pumps were in operation and that the containment pressure (backpressure on pumps) remained at zero during the draindown period. The flow rates from the LHSI and containment spray pumps were obtained from previous calculations but were increased by five percent for conservatism. The flow rates from the safety injection pumps, obtained from actual on-site test data, were increased three percent to account for flow instrument uncertainties.

The pump flow rates used in this evaluation are as follows:

TABLE III

Pump	Flow rate, GPM Nominal	plus margin
Safety injection,		
two pumps, two cold legs	934	962
three pumps, two cold legs	1080	1113
Residual heat removal		
two pumps	3250	3413
Containment spray		
one pump	1783	1872
two pumps	3566	3745

Using the flow rate from Table III and the RWST water volumes described by Figure IIB, it is shown that the minimum time to pump down the RWST from the new minimum Technical Specification limit of 291,125 gallons to the new low alarm (plus margin) would be 22.4 minutes. This then is the earliest time that the operator would be required to begin the LHSI pump switchover procedure for a large LOCA.

After the LHSI pumps are stopped and only one containment spray pump and two safety injection pumps remain in operation, the flow rate out of the RWST will decrease to about 2834 GPM, while the LHSI pumps are realigned for recirculation. The estimated eight minutes to complete the realignment at an outflow rate of 2834 GPM results in a RWST volume minimum requirement of 22,672 gallons between the low and the low-low

setpoints. After rounding off the setpoints to fifteen percent and twenty-eight percent this delta volume is 23,975 gallons.

The estimated earliest time in a large LOCA that the HHSI pumps and containment spray pump would be tripped off based on the above volumes and flow rates would be 30.9 minutes.

A summary of these estimated time margins are as follows:

Activity	Time, minutes
1. Injection phase, Tech Spec level to low alarm	22.4
2. LHSI switchover period	8.5
3. Injection phase, Tech Spec level to low-low alarm	30.9

Conclusion

The Ginna post-LOCA switchover procedure, from the injection mode to the recirculation mode, can be modified and improved to avoid the termination of all injection flow by transferring the LHSI and HHSI pumps separately.

The emergency procedure for LOCA mitigation can be modified to transfer the LHSI (RHR) pumps suction from the RWST to the containment sump while the HHSI pumps remain in service to provide emergency core coolant during the transfer. Similarly, the HHSI pumps suction can be transferred to the recirculation mode while the LHSI pumps remain in operation.

To provide the required NPSH for the LHSI pumps, after their suction is transferred to the containment sump, the RWST low level alarm which signals the proper time to begin the switchover procedure must be lowered to twenty-eight percent. This new setpoint allows the operator a minimum of 22.4 minutes in a large LOCA before the first required action must take place and allows at least eight minutes to transfer the LHSI pumps suction before the RWST low-low level alarm is actuated.

In addition to decreasing the low level alarm, the nominal Technical Specification RWST water level must be raised to 301,400 gallons or eighty-eight percent (indicated) to assure that sufficient water volume is delivered to the containment before the LHSI pumps are restarted taking their suction from the sump. This new higher Technical Specification limit results in a smaller operating margin on the RWST normal working level.

ATTACHMENT I

SUMMARY SWITCHOVER GUIDELINE

1. As the RWST water level decreases, perform the following actions:

   a. Open the two component cooling water isolation valves to provide cooling water to the residual heat exchangers.

2. When the RWST water level has decreased to the low level alarm setpoint, (28 percent) stop both residual heat removal pumps, one containment spray pump, if two are operating, and safety injection pump 1C if all three HHSI pumps are operating.

3. Realign the RHR pumps for low head recirculation as follows:

   a. Close the two RWST to RHR pump suction isolation valves (704A/B).

   b. Open the two sump isolation valves to the RHR pumps (850A/B).

   c. Start each RHR pump individually.

   Note for small breaks, the RHR pumps will recirculate through the RHR heat exchangers with no new flow from the RWST to the RCS.

4. Continue to spray the containment with one spray pump and to inject refueling water into the RCS cold legs using two safety injection pumps.

5. When the RWST water level decreases to the low-low level setpoint (15 percent) stop the operating spray and safety injection pumps.

6. Realign the SI for high head recirculation as follows:

   a. Close both isolation valves in the RWST to SI/spray pumps's header (986A/B).

   b. Close both SI pumps to RWST recirculation isolation valves (897, 898).

   c. Open the RHR to SI pumps crossover valves (857A/B/C).

   d. Start each SI pump, 1A and 1B individually.

ATTACHMENT II

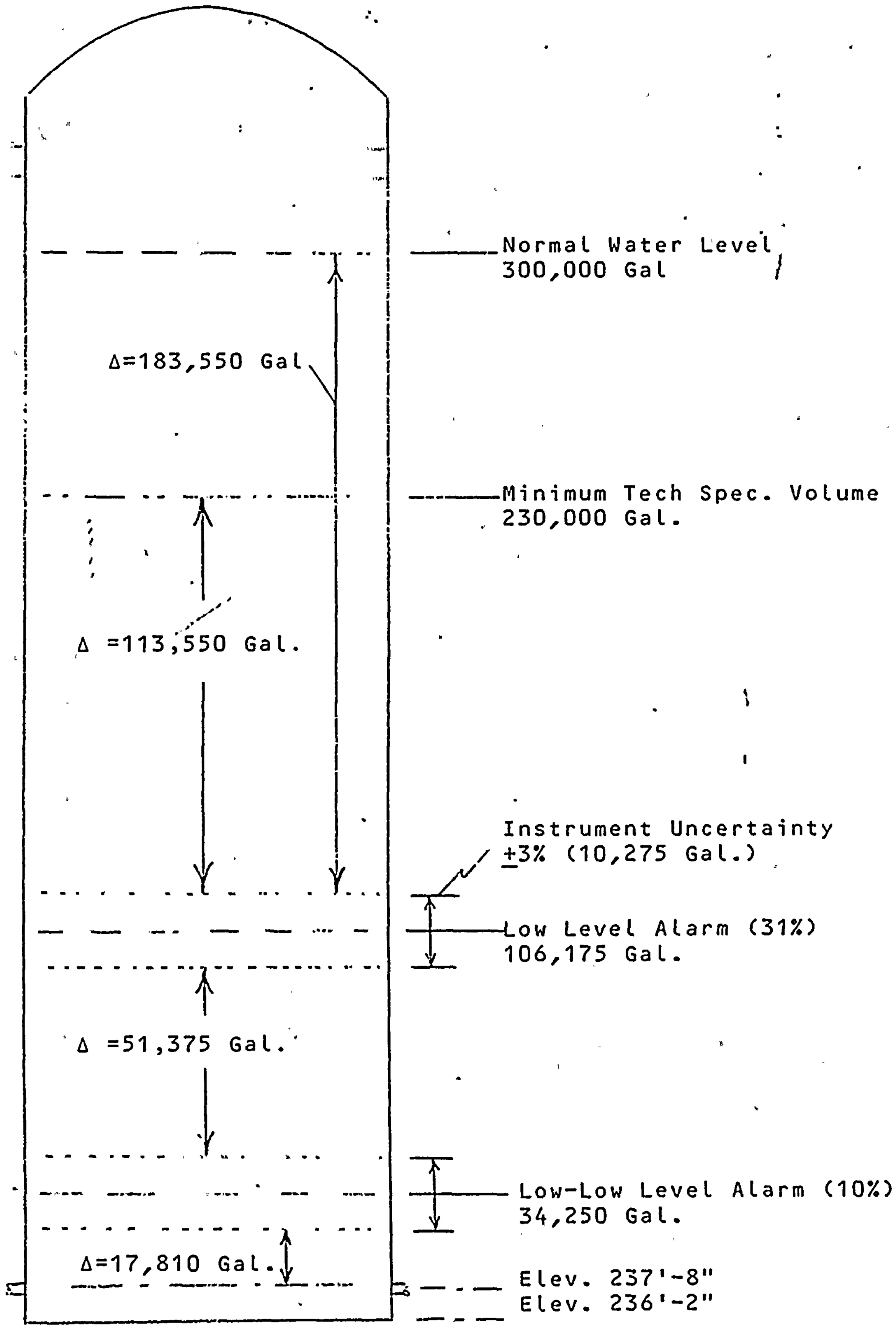


FIGURE IIA

GINNA-RWST

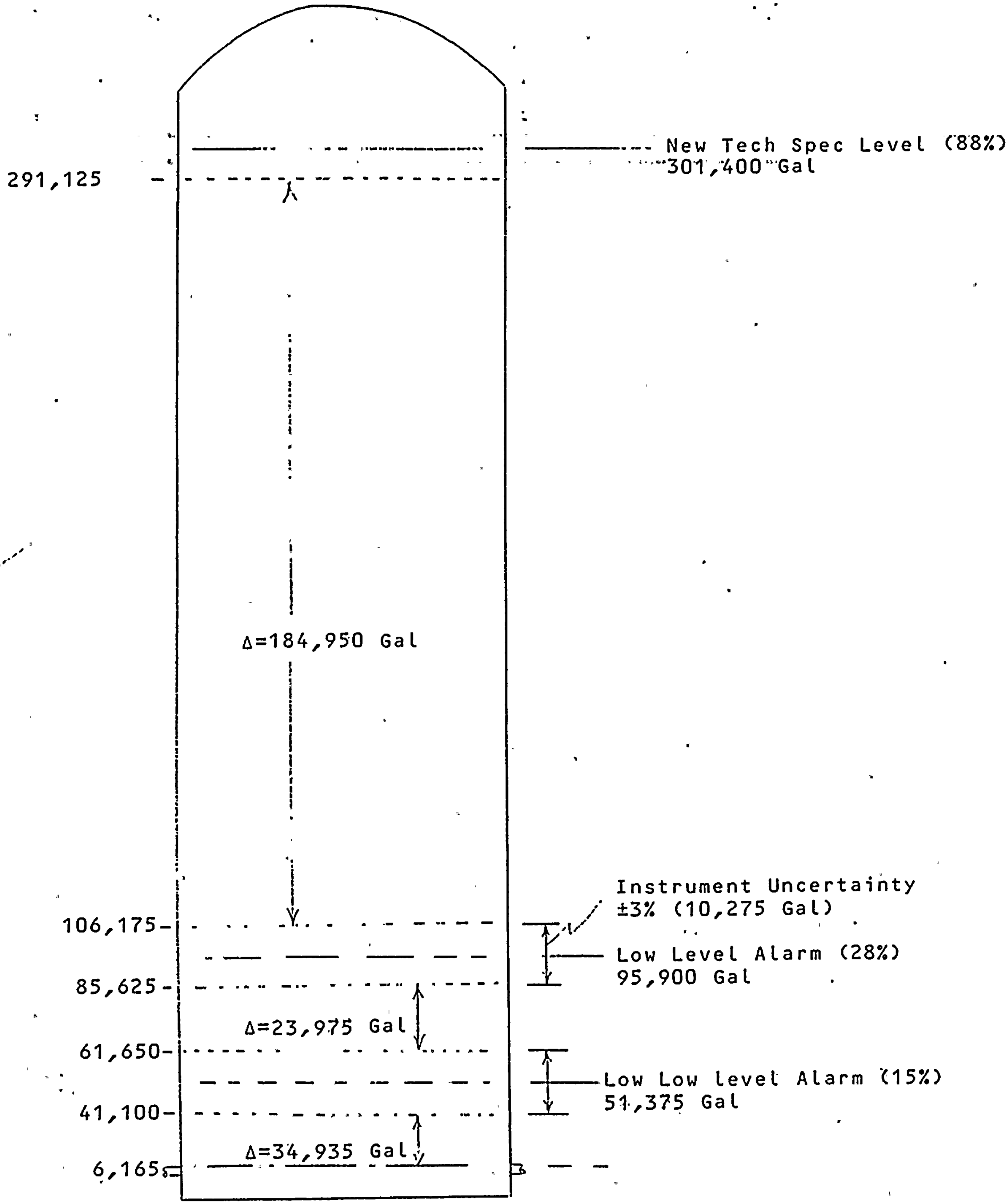


FIGURE IIB

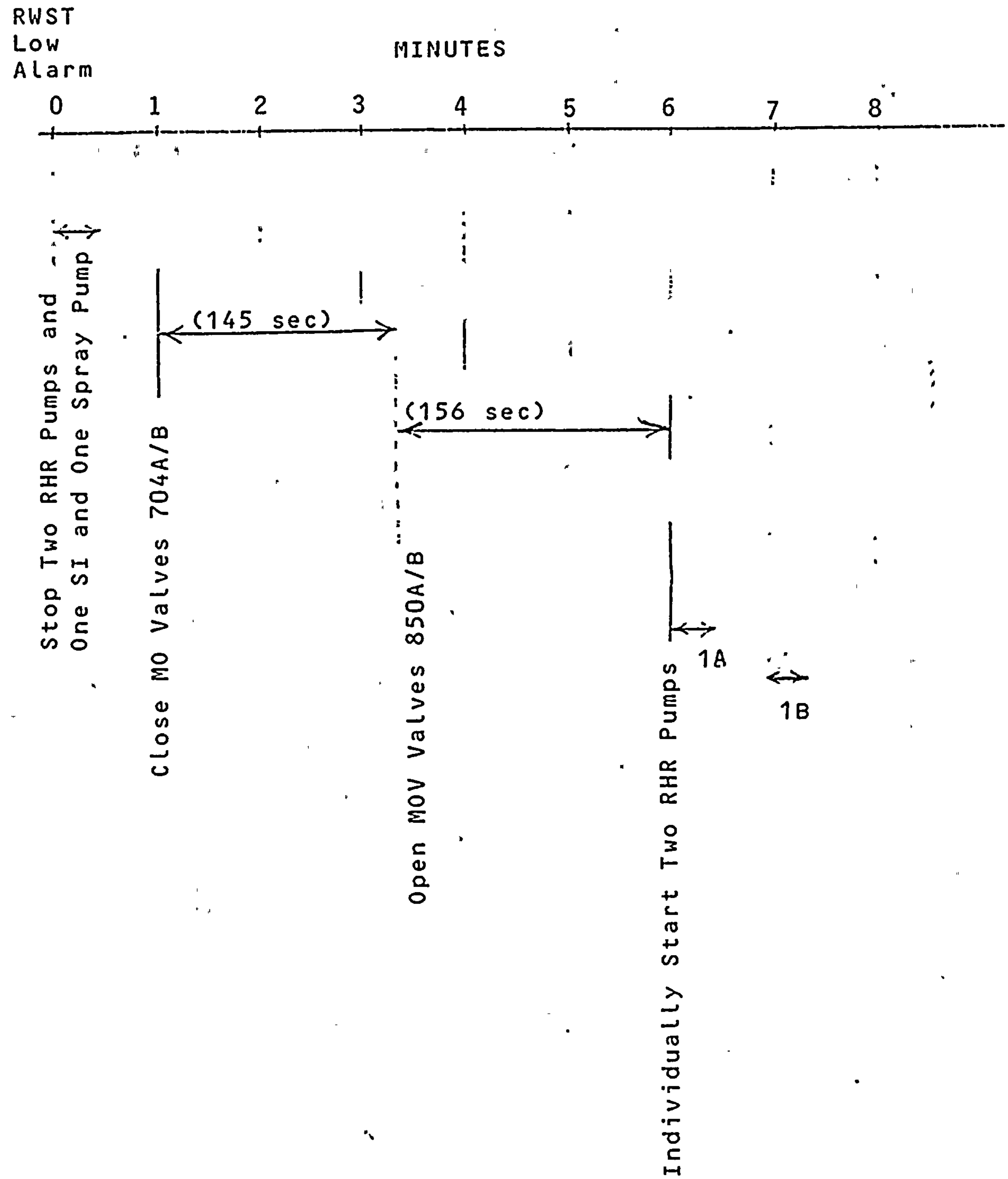
GINNA-RWST

ATTACHMENT III

OPERATOR TIME ALLOWANCES

LHSI (RHR) SWITCHOVER-LARGE BREAK

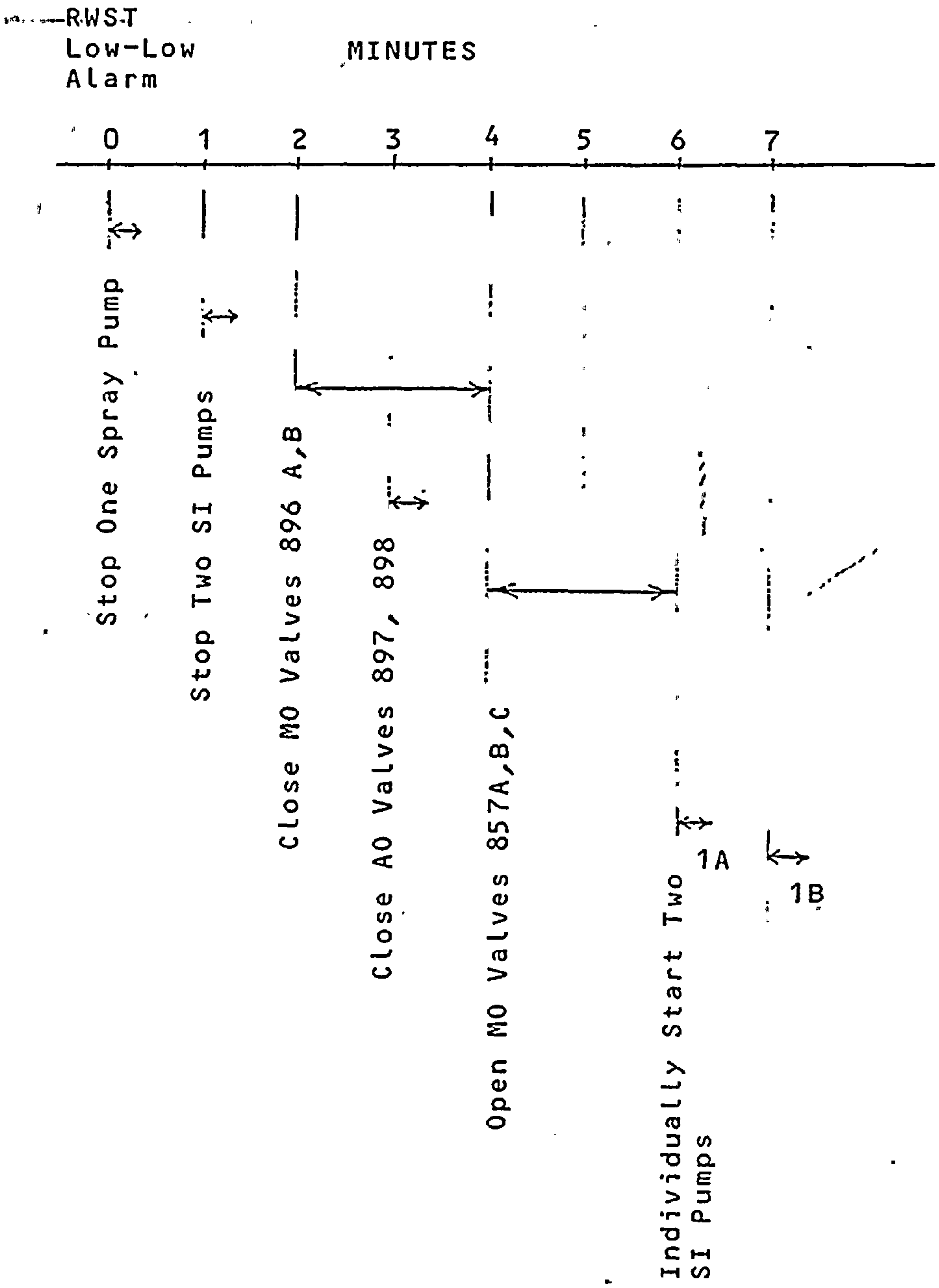
FIGURE IIIA



OPERATOR TIME ALLOWANCES

HHSI SWITCHOVER

FIGURE IIIB



BOIL-OFF ANALYSIS

In conjunction with the development of the revised guideline for ECCS switchover to recirculation (FSD/SS-M-2083), a calculation was performed to assess the ability of HHSI to compensate for the worst case of vessel coolant boil-off. It was established that the earliest switchover time would be 22.4 minutes. Injection water was drawn from the RWST at a conservative maximum temperature of $120^{\circ}F$ and heated to saturated vapor conditions at atmospheric pressure. The viable heat sources were assumed to be the fuel and vessel thick metal. The decay heat model which is assumed for the fuel is described in ANSI/ANS-5.1-1979. The fuel parameters were 100% core power at time zero, 3-year burnup, and the fission factions were 92% of U_{235} and 8% of U_{238} with a 2-sigma margin. The vessel metal heat contribution is minor accounting for approximately 2% of the total heat rate.

Considering the above, it would require approximately 28.6 LBM/SEC of HHSI flow to compensate for the coolant inventory lost due to boil-off. At the LHSI shutoff head of 150 psi, the HHSI can deliver 54.5 LBM/SEC of flow. This HHSI flow value assumes degraded performance (i.e., one train spilling to containment). The conclusion is that the HHSI flow adequately compensates for boil-off; vessel coolant inventory would not be depleted during switchover.