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August 9, 1990

U.S. Nuclear Regulatory Commission
Mail Station P1-137
Washington, D.C. 20555

Attention: Document Control Desk

Gentlemen:

SUBJECT: Grand Gulf Nuclear Station
Unit 1
Docket No. 50-416
License No. NPF-29
Supplemental Information for PCOL-90/03
Revision 2
AECM-90/0142

Entergy Operations, Inc. - Grand Gulf Nuclear Station (GGNS) submitted by letter AECM-90/0135 dated August 6, 1990 a revision to the proposed amendment to the GGNS Operating License (OL) previously submitted April 27, 1990 (AECM-90/0056) and July 5, 1990 (AECM-90/0111). The proposed amendment requested changes to the GGNS Technical Specifications (TS) due to the addition of the Alternate Decay Heat Removal System (ADHRS). In addition, TS changes were proposed to address the Staff concern regarding manual realignment of low pressure coolant injection emergency core cooling subsystems during plant shutdown. The Staff concern was identified in the Safety Evaluations for OL Amendments 58 and 59 dated March 16, 1989 and March 27, 1989, respectively.

A telephone conference was held on July 16, 1990 in which the Staff provided feedback to Entergy Operations - GGNS on the July 5, 1990 resubmittal. Attachment 2 of AECM-90/0135 provided the Entergy Operations - GGNS responses to the Staff's feedback received July 16, 1990. In AECM-90/0135 Entergy Operations - GGNS committed in response to Staff Feedback Nos. 8 and 13 to provide responses in a submittal separate from AECM-90/0135.

The attached supplemental information to this letter (Attachments 2, 3 and 4) is Entergy Operations - GGNS response to Staff Feedback Nos. 8 and 13. Attachment 3 provides the evaluation of the effectiveness of RHR shutdown cooling and ADHRS flowpaths and flowrates for reactor coolant circulation and heat removal in Operational Conditions 4 and 5 requested by the Staff.

In accordance with the provisions of 10CFR50.4, the signed original of the supplemental information is enclosed. This supplemental information has been reviewed and accepted by the Plant Safety Review Committee and the Safety Review Committee.





A001 /11

Based on the guidelines presented in 10CFR50.92, Entergy Operations - GGNS has concluded, as documented in AECM-90/0135, that the proposed amendment involves no significant hazards considerations. The attached supplemental information does not affect this conclusion.

The use of the ADHRS is required in order to support the upcoming fourth refueling outage (RF04) at GGNS. As now scheduled, RF04 is to begin approximately October 1, 1990. In order to support the current outage schedule, Entergy Operations - GGNS requests that the NRC complete its review of the proposed TS amendment by no later than September 24, 1990 to allow sufficient time for implementation of the TS amendment prior to RF04.

Yours truly,

W T Cottle

WTC:mtc

Attachments:
1. Affirmation per 10CFR50.30
2. Responses to NRC Staff Feedback Nos. 8 and 13 on AECM-90/0111
3. Evaluation of the Effectiveness of RHR Shutdown Cooling and ADHRS Flowpaths and Flowrates for Reactor Coolant Circulation and Heat Removal in Operational Conditions 4 and 5
4. Proposed TS 3/4.9.11.2

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BEFORE THE

UNITED STATES NUCLEAR REGULATORY COMMISSION

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LICENSE NO. NPF-29

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DOCKET NO. 50-416

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IN THE MATTER OF

MISSISSIPPI POWER & LIGHT COMPANY
and
SYSTEM ENERGY RESOURCES, INC.
and
SOUTH MISSISSIPPI ELECTRIC POWER ASSOCIATION
and
ENTERGY OPERATIONS, INC.

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AFFIRMATION

I, W. T. Cottle, being duly sworn, state that I am Vice President, Operations GGNS of Entergy Operations, Inc.; that on behalf of Entergy Operations, Inc., System Energy Resources, Inc., and South Mississippi Electric Power Association I am authorized by Entergy Operations, Inc. to sign and file with the Nuclear Regulatory Commission, this application for amendment of the Operating License of the Grand Gulf Nuclear Station; that I signed this application as Vice President, Operations GGNS of Entergy Operations, Inc.; and that the statements made and the matters set forth therein are true and correct to the best of my knowledge, information and belief.

W. T. Cottle (signature)
W. T. Cottle

STATE OF MISSISSIPPI
COUNTY OF CLAIBORNE

SUBSCRIBED AND SWORN TO before me, a Notary Public, in and for the County and State above named, this 9th day of August, 1990.

(SEAL)

Elizabeth L. Lang (signature)
Notary Public

My commission expires:

December 29, 1991

A9007302/SNLICFLR - 4

Responses to NRC Staff Feedback on AECM-90/0111

On July 16, 1990 the NRC Staff provided feedback to Entergy Operations - GGNS concerning letter AECM-90/0111, "Alternate Decay Heat Removal System and LPCI Manual Realignment, PCOL-90/03 Revision 2", dated July 5, 1990. Entergy Operations - GGNS responded to the Staff's July 16, 1990 feedback in letter AECM-90/0135, dated August 6, 1990. Below are the Entergy Operations - GGNS responses to NRC Staff Feedback Nos. 8 and 13 which were not addressed in AECM-90/0135.

Staff Feedback No. 8

Because the effectiveness of coolant circulation when returning coolant via the Low Pressure Coolant Injection (LPCI) injection line is in question, the proposed reference to the Alternate Decay Heat Removal System (ADHRS) in Technical Specification (TS) 3.9.11.2 Action b may not be appropriate.

Entergy Operations - GGNS Response No. 8

The effectiveness of coolant circulation and temperature monitoring when a LPCI injection line is used as the return flowpath for decay heat removal is documented in Attachment 3 of this submittal. However, the proposed reference to the ADHRS in TS 3.9.11.2 Action b was removed in AECM-90/0135 and is included for reference as Attachment 4 of this submittal.

Staff Feedback No. 13

Using TS 3.4.9.2 as an example, the Staff stated the Limiting Condition for Operation (LCO) addresses two different functions, namely, decay heat removal and reactor coolant circulation. With shutdown cooling return flow through a LPCI injection line, the Staff asked if the mixing is effective enough, when compared to return flow through the feedwater system, to prevent exceeding the Operational Condition (OC) 4 TS coolant temperature limit and inadvertently pressurizing the reactor? Also, in relation to the concern of pressurization, the Staff asked if the coolant temperature monitoring provides representative temperature measurements so that the operator will realize that coolant temperature inside the reactor is increasing (i.e., inadvertent pressurization)? The Staff said their main concern was right after shutdown in OCs 4 and 5 while the reactor pressure vessel head was still in place.

Entergy Operations - GGNS Response No. 13

Attachment 3 of this submittal provides an evaluation of the effectiveness of Residual Heat Removal (RHR) system and ADHRS decay heat removal flowpaths and flowrates for reactor coolant circulation and heat removal in OCs 4 and 5. The evaluation demonstrates that the use of the LPCI injection flowpath by either RHR or by ADHRS during OCs 4 and 5 is as effective as returning flow via the feedwater system for maintaining coolant circulation, mixing, heat removal and temperature monitoring and control.

# EVALUATION OF THE EFFECTIVENESS OF RHR SHUTDOWN COOLING AND ADHRS FLOWPATHS AND FLOWRATES FOR REACTOR COOLANT CIRCULATION AND HEAT REMOVAL IN OPERATIONAL CONDITIONS 4 AND 5

# Evaluation of the Effectiveness of RHR Shutdown Cooling and ADHRS Flowpaths and Flowrates for Reactor Coolant Circulation and Heat Removal In Operational Conditions 4 and 5

## I. Evaluation Objectives

The normal Residual Heat Removal (RHR) reactor shutdown cooling mode flowpaths and flowrates were established by analyses and tests such that adequate coolant circulation and heat transfer within the reactor vessel were assured for all reactor conditions and decay heat loads. To provide additional operational flexibility, the traditionally used reactor cooling flowpaths and flowrates are being expanded to include additional flowpaths over a larger range of flowrates. Figure 4 illustrates the internal arrangement of the GGNS reactor vessel. The primary distinction of the new flowpaths is injection directly inside the core shroud versus outside the shroud via the feedwater spargers. These new flowpaths were previously evaluated and approved for use during the third refueling outage (RFO3) based on their similarity to the alternate shutdown cooling mode. These flowpaths were also previously reviewed and approved by General Electric. This evaluation is being prepared as a result of an NRC request for additional information concerning the permanent licensing of these new flowpaths. The objectives of this evaluation are to further evaluate the effectiveness of these additional reactor cooling flowpaths and flowrates for meeting reactor coolant circulation, heat removal, and temperature monitoring and control requirements and to determine if any additional restrictions or requirements need be imposed on their use.

## II. Requirements for Decay Heat Removal

The capabilities of the decay heat removal systems must ensure that the average reactor coolant temperature is limited to ≤ 200°F in Operational Condition (OC) 4 and ≤ 140°F in OC 5 in accordance with the GGNS Technical Specifications (TS Table 1.2). These requirements are established so as to maintain the reactor in a depressurized state in OC 4 and within the Standard Review Plan (SRP) guidelines for spent fuel pool operations (i.e., refueling) in OC 5 (see SRP 9.1.3). Since the greatest demands for reactor coolant circulation, temperature monitoring, and decay heat removal during OCs 4 and 5 are established at the highest average reactor coolant temperature (e.g., 200°F for OC 4), the highest decay heat load, the lowest forced circulation flowrates (i.e., with the recirculation pumps shutdown), and with the highest resistance to the core region flowpaths (e.g., shroud head installed), this evaluation is primarily based on the system flowpaths and reactor conditions prevalent soon after entry into OC 4 from OC 3. This evaluation will not take credit for any forced circulation from operation of the reactor recirculation pumps. The effectiveness of decay heat removal methods during OC 5 will be established by a comparison with the results for OC 4 and is discussed later in this evaluation.

## III. Methods Of Reactor Decay Heat Removal

This evaluation will address the following three methods of decay heat removal during OC 4 and 5:

1) the RHR system shutdown cooling mode with coolant injection via the feedwater spargers;

2) the RHR system shutdown cooling mode with coolant injection via one of the LPCI injection nozzles;

3) the Alternate Decay Heat Removal System (ADHRS) with coolant injection via the LPCI "C" injection nozzle.

The effectiveness of the decay heat removal methods will be examined in this evaluation by comparing the reactor coolant circulation paths, mixing regions, and temperature profiles for all three methods during steady state conditions.

## IV. RHR Shutdown Cooling Return Through Feedwater

One of the currently licensed decay heat removal methods is the shutdown cooling mode of RHR which takes suction from reactor recirculation loop "B" and returns the coolant to the vessel via the feedwater spargers located outside the steam separator shroud head. Although the total RHR system flow can be throttled as needed for various process control purposes, this method normally uses a constant RHR flowrate and varies the heat removal capacity of the RHR system (by varying the heat exchanger bypass flowrate) so as to control reactor coolant temperatures as the decay heat load changes.

Figure 1 illustrates the coolant flowpaths during OC 4 due to the induced (pumped) RHR flowrate and the natural circulation flowrate developed as a result of decay heating of the reactor core water and the density differences between the coolant inside the shroud and that in the downcomer annulus. As shown, the cooling water supplied by RHR establishes a flowpath from the spray nozzles on the feedwater spargers through the entire downcomer annulus and exits the vessel via the recirculation outlet nozzle. The reactor coolant heated in the core region establishes a natural circulation flowpath (UFSAR Section 4.4) which forces the water from the core inside the shroud up through the steam separator extension piping and out the bottom end of the steam separator standpipes where it is mixed with the cooling water exiting the feedwater spargers. This natural circulation flowpath is assured at all times by maintaining the Reactor Water Level at or above Reactor Water Level 3 trip function setpoint, which is well above the bottom openings of the steam separator (by at least 2 feet).

For this method of decay heat removal, the mixing region for the reactor coolant and the cooling water from RHR is outside the shroud and above the jet pumps (areas 1 and 2 on Figure 1). Mixing in this region is enhanced for two reasons. The first is the cooling water flow out of the feedwater spargers is directed radially inward toward the exit point of the warmer water rising through the steam separator. Secondly, the warmer water rising from inside the shroud is directed

through a relatively large number of paths (i.e., 300 separator standpipes). This mixture at a combined RHR and natural circulation flowrate continues through the downcomer annulus where the flow splits between the RHR flow which exits the vessel and the natural circulation flow which enters the jet pumps and returns to the core region via the core plate openings.

The expected coolant temperatures and flowrates for each of the vessel regions at a measured coolant outlet temperature of 200° F (maximum value during all cold shutdown and refueling activities) and a decay heat load of 79 MBtu/hr (corresponding to the approximate heat load at 24 hours following shutdown) are shown in Figure 1. These values demonstrate that for RHR injection via feedwater, significant flowrates are established to support adequate mixing for controlling bulk reactor conditions.

During OC 5 with the shroud head removed and lower bulk reactor coolant temperatures (maximum of 140° F), the overall natural circulation flowrates necessary for effective reactor cooling are reduced lower than those associated with OC 4 in the early stages of an outage.

## V. RHR Shutdown Cooling Return Through LPCI

Figure 2 describes the coolant flowpaths established for RHR during OC 4 with the vessel return via the LPCI injection line. Although the LPCI injection flowpath reenters the vessel at only one location, whereas feedwater enters at three and is radially distributed, the LPCI flow deflectors inside the shroud radially distributes the injected cooling water. As opposed to the feedwater injection flowpath where the thermal mixing region is in the volume outside the shroud and above the jet pumps, cooling water injection directly inside the shroud moves the primary mixing region into the immediate vicinity of the core (areas 3 and 4 on Figure 2). For steady state thermal conditions, all of the mixing and thus all of the heat exchange occurs inside the shroud. Based on an independent evaluation by General Electric, complete mixing is obtained inside the shroud for this injection point. This mixing is achieved by countercurrent flows throughout the core region. One flow path ($L_u$ on Figure 2) is upward through the core bypass region and into the plenum directly above the core where it interacts with and cools the heated water exiting the core. Another flowpath ($L_d$ on Figure 2) is downward through the core bypass region where it is mixed with the lower plenum fluid. With sufficient decay heat, the $L_d$ component of flow exiting the core into the lower plenum would be recirculated back up into fuel channels. At low decay heat levels, a reverse flowpath would be established through the lower plenum and up the jet pumps into the downcomer annulus for a portion of the overall coolant flow. In both situations, all of the coolant circulation passes through the shroud interior.

Using the same reactor and shutdown cooling conditions evaluated for the feedwater flowpath, the expected coolant temperatures and estimated maximum flowrates for each of the vessel regions are shown in Figure 2. These values demonstrate that a very effective decay heat removal process exists for RHR injection via LPCI. When compared with the feedwater injection flowpath, the shroud exit water temperatures are lower for the LPCI flowpath and the bulk average water temperatures for the entire reactor vessel are more evenly distributed.

As shown in Figure 2, the temperature of the fluid entering the recirculation suction and continuing to the RHR heat exchangers where the temperature is measured is the same as that of the fluid entering the jet pumps. The reactor coolant temperature is approximately constant (excluding negligible heat transfer through the vessel walls and piping systems) throughout the downcomer annulus, lower plenum under the core plate, and the steam separator region outside the shroud. Although the fluid temperatures inside the shroud can vary from a minimum value equal to that of the injected cooling water (e.g., 178°F) to a maximum value equal to the saturation temperature at the bottom of the fuel channels (e.g., 245°F at normal water levels corresponding to a static pressure head of 27.3 psia), the average reactor coolant temperature inside the shroud cannot be greater than that outside the shroud since all of the coolant circulates from the shroud interior to the exterior regions. Thus, effective heat removal from the core region and representative temperature monitoring are maintained by coolant injection directly inside the shroud.

In addition, for a postulated event in which the reactor water level decreases below the steam separator, shutdown cooling injection directly inside the shroud (the same as ECCS) instead of via feedwater would more effectively maintain reactor coolant circulation and decay heat removal by keeping the upper plenum and standpipes full of water. It should be noted though that at no time during OCs 4 or 5 is the reactor water level intentionally lowered to the elevation of the bottom openings of the steam separator. Also as mentioned earlier, the Reactor Water Level 3 trip function setpoint is above this point and would therefore isolate the shutdown cooling common suction line effectively preventing the steam separator bottom openings from being uncovered.

## VI. <u>ADHRS Reactor Cooling Return Through LPCI "C"</u>

The flowpath for ADHRS is essentially the same as that for an RHR shutdown cooling system with coolant injection via LPCI (see Figure 3). The only thermal-hydraulic difference between these two methods of decay heat removal is that ADHRS varies the heat removal capacity by varying the system flowrate. While the RHR flowrate is normally maintained constant at approximately 7500 gpm, the ADHRS flowrate is normally controlled within a range of 1000 to 3600 gpm. These flowrates were established based on the heat removal requirements for the system with the reactor in either OCs 4 or 5 and 24 hours after shutdown decay heat loads (approximately 79 MBtu/hr). As with RHR via LPCI, complete mixing of the ADHRS cooling water and heated reactor water exiting the core is obtained by injection directly inside the shroud. Figure 3 provides the expected coolant temperatures and estimated maximum flowrates for each of the vessel regions for ADHRS. These values demonstrate that effective core cooling is obtained even for the lower ADHRS flowrates.

VII. Reactor Coolant Temperature Monitoring Methods

Although a number of instruments exist for monitoring reactor coolant temperatures (e.g., reactor vessel bottom head piping when RWCU is operating and taking suction via this path), indications from the temperature instruments in the reactor recirculation piping and inlet and outlet to the RHR and ADHRS heat exchangers are normally used during cold shutdown and refueling in association with the system in operation. The temperature elements in the RHR and ADHR systems provide information to assess the performance of the decay heat removal process such that appropriate decisions can be made regarding the selection of equipment and adjustment of operating parameters. The temperature elements in the recirculation piping are used to monitor reactor coolant temperatures when at least one of the recirculation pumps is running. For cold shutdown operations when no reactor recirculation pumps are running, the reactor coolant temperature is monitored via temperature instrumentation in the RHR and ADHR systems.

The most representative reactor coolant temperature monitoring is provided by the recirculation system temperature elements. However, during steady state thermal-hydraulic conditions without a recirculation pump in operation, the temperature monitoring provided by the decay heat removal systems is very representative of the average reactor coolant temperature due to the circulation and mixing previously discussed.

For the most common non-steady state conditions, (e.g., an inadvertent over-throttling of the decay heat removal flowrates), the bulk average reactor coolant temperature changes only a few degrees per hour. The RHR or ADHR system temperature measurements are fully representative of the average reactor coolant conditions for these types of transients in which the decay heat removal system remains operating. For more extreme transients (e.g., for a postulated casualty such as a complete loss of shutdown cooling and thus also a loss of temperature monitoring by the associated decay heat removal system) the bulk reactor conditions are monitored by other parameters such as reactor vessel pressure and water level. This design approach is consistent with the requirements of Regulatory Guide 1.97 for those variables to be monitored that provide the primary information required to permit the operator to take specific manual actions for which no automatic control is provided (UFSAR Section 7.5).

VIII. Effects Of Reactor Recirculation Pump Operation

The evaluation presented above did not take credit for any induced flow from the reactor recirculation pumps. During OCs 4 and 5 with both recirculation pumps secured, some minor thermal stratification may occur in the lower portions of the bottom head only for relatively low reactor coolant circulation flowrates. Based on a General Electric evaluation, even the lower flowrates associated with ADHRS operation are adequate for inhibiting any detrimental thermal stratification as long as the existing minimum vessel water levels are maintained (water level equal to or greater than Reactor Water Level 3). Although the relatively high coolant circulation flowrates resulting from the operation of a recirculation pump would essentially eliminate any stratification, this operation is not deemed necessary since ADHRS flowrates are maintained high enough to control decay heat removal, and very effective mixing is obtained within the core region itself.

IX. Decay Heat Removal During OC 5

During OC 5 with the shroud head installed, the flowpaths are essentially the same as those during OC 4 with lower relative coolant temperatures corresponding to the lower TS temperature limits and the reduced decay heat loads. Although the temperature differences between the downcomer annulus and the shroud interior are not substantially changed, the natural circulation flowrate is lower due to the reduced two-phase volume in the core region. Removal of the shroud head results in a slight increase in the natural circulation flowrates due to the resulting decreased flow resistance in the upper plenum. In addition, with the shroud head removed the mixing is very similar for both coolant injection methods; the feedwater spargers direct flow radially inward and inside the shroud the LPCI injection also radially distributes the return flow. The only difference between the two flowpaths is the shroud injection occurs at a lower elevation. The overall effectiveness of the evaluated decay heat removal methods during OC 5 with and without the shroud head is thus fundamentally identical to that during OC 4 with lower thermal conditions. It should also be noted that the thermal performance data obtained by the ADHRS test performed during RFO3 in OC 5 demonstrated that the system can adequately control reactor decay heat in this mode.

X. Conclusions

The evaluation presented herein demonstrates that the use of the LPCI injection flowpath by either RHR or by ADHRS during OCs 4 and 5 is highly effective for maintaining coolant circulation, mixing, heat removal, and temperature monitoring and control. In fact, it is concluded that cooling water injection directly inside the shroud for decay heat removal results in a more even temperature distribution throughout the reactor vessel than by injection outside the shroud at equivalent flowrates. It is also concluded that the LPCI injection flowpath provides an improved method of reactor coolant temperature control during unanticipated operational transients which result in lower reactor water levels.

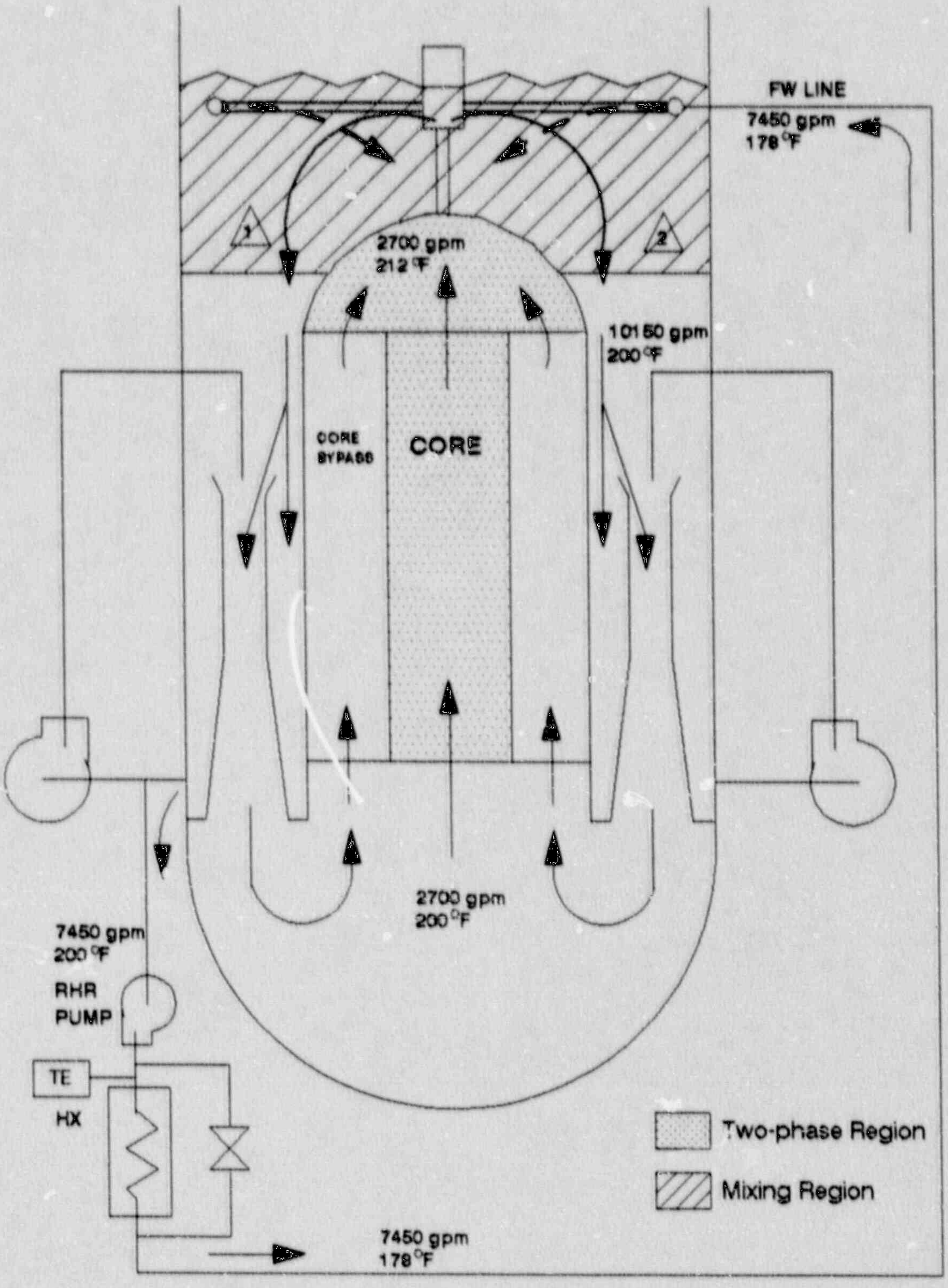



**Figure 1. RHR SDC Flow Paths with Return via Feedwater Line**

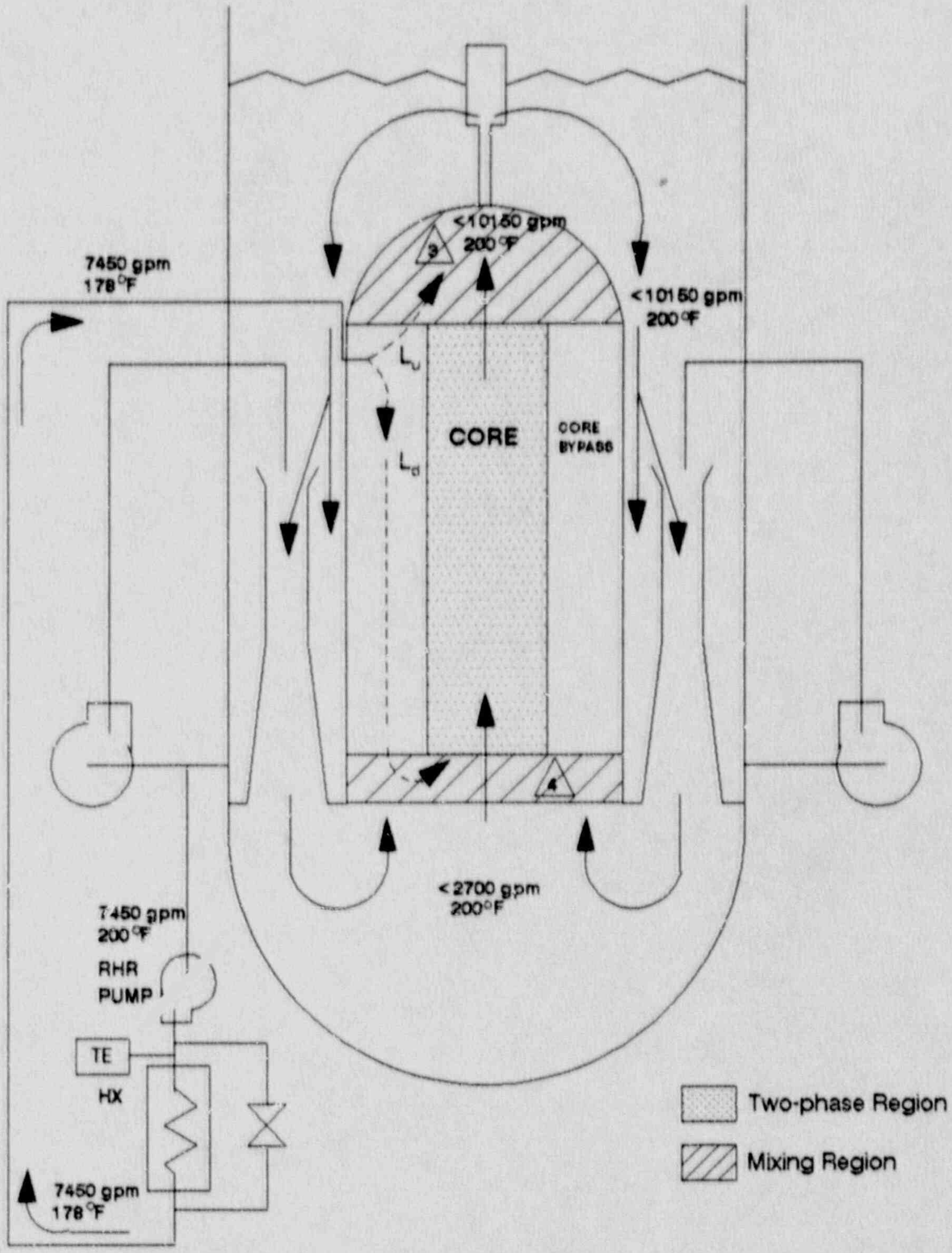



**Figure 2. RHR SDC Flow Paths with Return via LPCI Line**

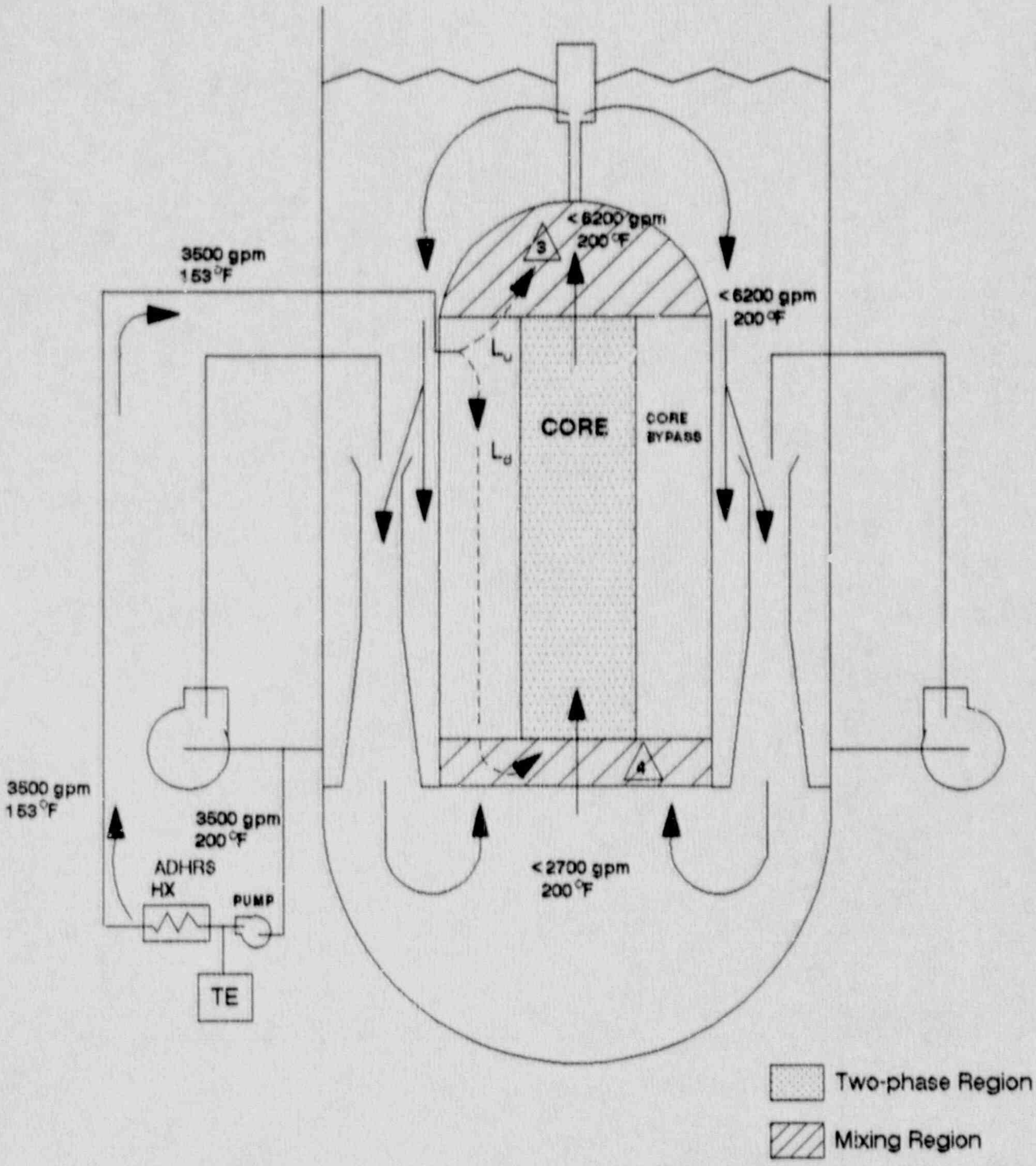
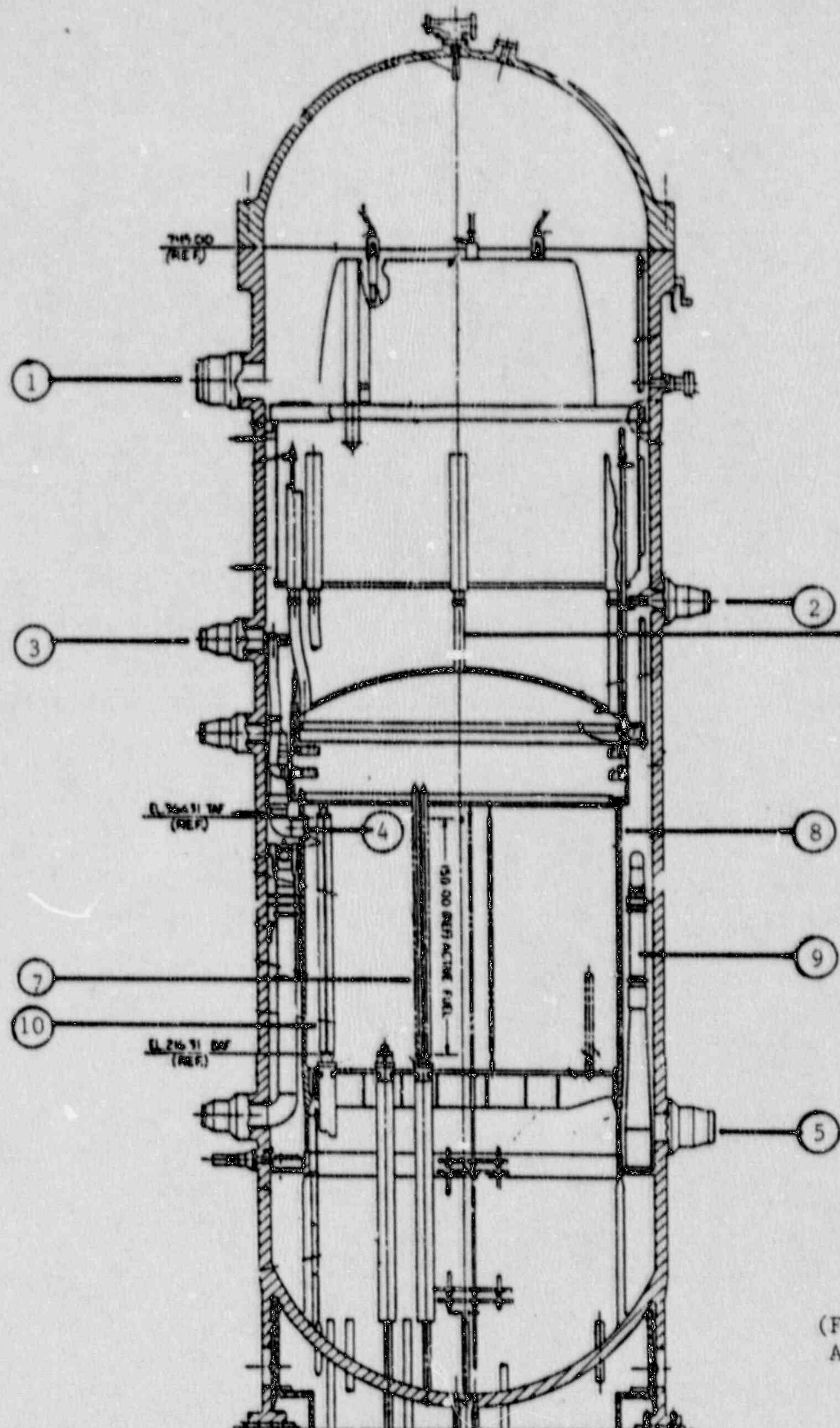



**Figure 3. ADHRS Flow Paths with Return via LPCI Line**




(For Notes See Attached Sheet)

Figure 4. GGNS Reactor Vessel

## Figure 4 Notes

1. Steam Outlet
2. Feedwater Inlet
3. LPCI Inlet to Reactor Vessel
4. LPCI Inlet to Shroud
5. Recirculation Water Outlet
6. Steam Separator Assembly
7. Fuel Assemblies
8. Core Shroud
9. Jet Pump Assembly
10. Control Rod