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DENTON, H.R. Office of Nuclear Reactor Regulation, Director

SUBJECT: Forwards supplemental responses to 810808 request for addl info re Westinghouse summary rept of reactor vessel level instrumentation sys for monitoring inadequate core cooling, per NUREG-0737, Item II.F.2.3.

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November 20, 1981
AEP:NRC:0398G

Donald C. Cook Nuclear Plant Unit Nos. 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
TMI ACTION PLAN, NUREG-0737, ITEM II.F.2.3
REACTOR VESSEL LEVEL INSTRUMENTATION

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

References: (1) Letter from Mr. S. A. Varga, NRC dated August 8, 1981
(2) Letter No. AEP:NRC:0398F, dated September 17, 1981

Dear Mr. Denton:

This letter and its attachment provide the remaining responses to Mr. S. A. Varga's letter of August 8, 1981 which requested additional information on the Westinghouse Summary Report of the Reactor Vessel Level Instrumentation System (RVLIS) for monitoring inadequate core cooling. We submitted a partial response via Reference (2).

The Attachment contains the responses to questions 9, 10, 12 and 20 of Reference (1). Item 12.3 is not directly applicable to the Donald C. Cook Nuclear Plant since the Cook Plant is not equipped with Upper Plenum Injection. However, the response is included for completeness.

The proprietary clause noted in Attachment 1 to AEP:NRC:0398F applies equally to the Attachment of this submittal. This completes our responses for additional information requested in Reference (1).

This document has been prepared following Corporate Procedures which incorporate a reasonable set of controls to insure its accuracy and completeness prior to signature by the undersigned.

Very truly yours,

G. P. Maloney
Vice President

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cc:(attached)

cc: John E. Dolan - Columbus
R. C. Callen
G. Charnoff
R. W. Jurgensen
D. V. Shaller - Bridgman
Joe Williams, Jr.
Region III Resident Inspector - Bridgman

ATTACHMENT

TO

AEP:NRC:0398G.

Item 9

There are indications that the TMI-2 core may be up to 95% blocked. Estimate the effect of partial blockage in the core on the differential pressure measurements for a range of values from 0 to 95% blockage.

Response

9. Blockage in the core will increase the frictional pressure drop and increase the total differential pressure across the vessel. This will be reflected as a higher RVLIS indication. The increase in the RVLIS will be most significant under forced flow conditions when the reactor coolant pumps are operating.

   In order for blockage to be present, the core would have to have been uncovered for a prolonged period of time. A low RVLIS indication along with a high core exit thermocouple indication would have been indicated during this time. If the RCP's had been operating throughout the transient, there would have been sufficient cooling to prevent significant core damage. Therefore, for significant blockage to exist during pump operation, the operator would have restarted the pumps after an ICC condition had existed for a period of time. Based on the history of the transient, the operator would know that the RVLIS would read higher than expected. Although the RVLIS would read high, it would still follow the trend in vessel inventory. The operator would be able to monitor the recovery with the RVLIS.

   Under natural circulation conditions, the impact of core blockage is not expected to be large. Although the RVLIS indication will read slightly higher than normal, the RVLIS will still trend with the vessel inventory and provide useful information for monitoring the recovery from ICC. ICC will have been indicated at an earlier time; before a significant amount of core blockage has occurred. The operator will know that the RVLIS could read slightly high, based on the history of the transient.

Item 10

Describe the effects of reverse flows within the reactor vessel on the indicated level.

Response

10. Reverse flows in the vessel will tend to decrease the DP across the vessel which would cause the RVLIS to indicate a lower collapsed level than actually exists. The low indication would not cause the operator to take unnecessary actions, since the RVLIS would be used along with the core exit thermocouples to indicate the approach to ICC. It is important to note that large reverse flows are not expected to occur for breaks smaller than 6" in diameter during the time that the core is uncovered. Large reverse flow rates may occur early in the blowdown transient for large diameter breaks but, as is discussed in the response to Item 7, it is not necessary to use the RVLIS as a basis for operator action for breaks in this range.

Item 12

Five conditions were identified which could cause the DP level system to give ambiguous indications. Discuss the nature of the ambiguities for 1. accumulator injection into a highly voided downcomer, 2. when the upper head behaves like a pressurizer, 3. upper plenum injection, and 4. periods of void redistribution.

Response

12. 1. When the downcomer is highly voided and the accumulators inject, the cold accumulator water condenses some of the steam in the downcomer which causes a local depressurization. The local depressurization will lower the pressure at the bottom of the vessel which will lower the DP across the vessel, causing an apparent decrease in level indication. The lower pressure in the downcomer also causes the mixture in the core to flow to the lower plenum, causing an actual decrease in level. The period of time when the RVLIS indication is lower than the actual collapsed liquid level will be brief.

An example of when this phenomenon may occur is when the reactor coolant pumps are running for a long period of time in a small break transient. After the RCS loops have drained and the pumps are circulating mostly steam, the level in the downcomer will be depressed. A large volume of steam will be present in the downcomer, above the low mixture level, which allows a large amount of condensation to occur. For most small break transients, the reactor coolant pumps will be tripped early in the transient and the downcomer mixture level will remain high, even in cases where ICC occurs. When the downcomer level is high the effect of accumulator injection on the RVLIS indication will be minor.

2. When the upper head begins to drain, the pressure in the upper head decreases at a slower rate than the pressure in the rest of the RCS. This is due to the upper head region behaving much like the pressurizer. The higher resistance across the upper support plate relative to the rest of the RCS prevents the upper head from draining quickly. This situation only exists until the mixture level in the upper head falls below the top of the guide tubes. At this time, steam is allowed to flow from the upper plenum to the upper head and the pressure equilibrates. While the upper head is behaving like a pressurizer, the vessel differential pressure is reduced and the RVLIS indicates a lower than actual collapsed liquid level.

This phenomenon is discussed in the summary report on the RVLIS* relative to the three inch cold leg break. Since that time, the upper head modeling has been investigated in more detail. It was found that the modeling used at that time assumed a flow resistance that was too high for the guide tubes. Subsequent analyses have shown that the pressurizer effect has less impact on the vessel dp than was originally shown. There is very little impact on the results after the level drains below the top of the guide tubes. The pressurizer effect is still believed to exist and it becomes more significant as break size increases. The interval of time when the upper head behaves like a pressurizer is brief and the RVLIS will resume trending with the vessel level after the top of the guide tubes uncover. The reduced RVLIS indication will not cause the operator to take any unnecessary action, even if a level below the top of the core is indicated since the core exit thermocouples are used as a corroborative indication of the approach to ICC.

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* Westinghouse Electric Corporation, "Westinghouse Reactor Vessel Level Instrumentation System for Monitoring Inadequate Core Cooling," December 1980.

3. The normal condition for continuous upper plenum injection (UPI) occurs only with the operation of the low head safety injection pumps, which does not occur until a pressure of under 200 psi is realized. The RVLIS may not accurately trend with vessel level during the initial start of UPI. During this short period of time, the cold water being injected will mix with the steam in the upper plenum causing condensation. This condensation will occur faster than the system response. The system will equilibrate after a short period of time. Upon equilibrating, the system will continue to accurately trend with the vessel level.

   In the range of break sizes where RVLIS is most useful in detecting the approach to ICC, the system pressure will equilibrate at a level above the pressure where UPI will normally occur. It is important to note that the flow from the low head pumps is sufficient to recover the core and no operator action based on the RVLIS indication will be necessary.

   For the vast majority of small breaks, the condition of upper plenum injection does not cause a significant impact. For the remainder, the impact is very small and within tolerable limits.

4. During the time when the distribution of voids in the vessel is changing rapidly, there can be a large change in the two-phase mixture level with very little change in collapsed mixture level. The use of the RVLIS, in conjunction with the core exit thermocouples, is still valid for this situation, however. The only event that has been identified which could cause a large void redistribution is when the reactor coolant pumps are tripped when the vessel mixture is highly voided. After the pump performance has degraded enough that the flow pressure drop

contribution to the vessel differential pressure is small, the change in RVLIS indication will be small when the pumps are tripped. As discussed in the summary report, the approach to ICC would be indicated when the wide range indication read 33 percent. If the pumps were tripped at this time, the core would still be covered. The operator would know that the core may uncover if the pumps were tripped with a wide range indication lower than 33 percent. Prior to pump trip, the core will remain adequately cooled due to forced circulation of the mixture. When the pumps trip the two phase level may equillibrate at a level below the top of the core. The narrow range indication will provide an indication of core coolability at this time.

Item 20

Describe the behavior of the level measurement system when the upper head is full, but the lower vessel is not.

Response

20. During the course of a LOCA transient, the upper plenum will experience voiding before the upper head. The voids in the upper plenum will be indicated by a lower RVLIS reading. The RVLIS will not indicate where the voiding is occurring, but at this point in the transient, it is not necessary to know where the region of voiding is. In the early part of the transient when the mixture level is above the top of the guide tube in the upper head, it is sufficient for the operator to know that the vessel inventory is decreasing, irrespective of the region where voiding is occurring. As discussed in the response to Item 21, the fluid in the upper head does not affect the RVLIS indication after the upper head has drained to below the top of the guide tubes. As discussed in the response to Item 19, the upper head will drain before the onset of ICC and there will not be an ambiguous indication during the period of time when RVLIS will be used.