AEOD ENGINEERING EVALUATION REPORT*

UNIT: Vermont Yankee Nuclear Power Station
DOCKET NO.: 50-271
LICENSEE: Vermont Yankee Nuclear Power Corp.
NSSS/AE: General Electric/Ebasco

EE REPORT NO. AEOD/E425
DATE: October 11, 1984
EVALUATOR/CONTACT: M. Chiramal

SUBJECT: HPCI SYSTEM LOCKOUT

References: (1) Vermont Yankee Nuclear Power Station LER 84-004.

(2) Vermont Yankee Nuclear Power Station LER 84-005.

(3) Letter to Vermont Yankee Nuclear Power Corp. dated June 8, 1984 from Richard W. Starostecki, Director, Division of Projects and Resident Programs, USNRC, Region I (with Appendix A, Notice of Violation and Inspection Report 50-271/84-08).

(4) Letter from Vermont Yankee Nuclear Power Corporation dated July 7, 1984, to USNRC, Region I "Response to Inspection Report 84-08."

SUMMARY

On April 16, 1984, the Vermont Yankee unit experienced a transient that led to a plant trip. After necessary repairs, the unit was started up and returned to operation. Four days later, during normal operation, while the operators were performing the monthly HPCI system valve operability test, the HPCI system was found inoperable. The HPCI system high vessel water level shutdown relay in the HPCI system logic circuit had "sealed in" during the transient on April 16, and remained energized until it was reset on April 20, 1984. During these four days, the HPCI system was not capable of either manual initiation or automatic actuation on a high drywell pressure initiation; however, automatic initiation on a reactor vessel low water level condition was fully operational. Although the plant startup procedure does instruct the operators to reset all reset pushbuttons and switches, it does not specifically address each reset button. Since the HPCI system was not called upon to operate during the transient and since no direct indication of the high level lockout was available to the operators, the manual reset operation was apparently overlooked by the operators. To prevent recurrence of this event, the licensee has planned procedural changes, additional operator training and

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* This report documents results of studies completed to date by the Office for Analysis and Evaluation of Operational Data with regard to operational evaluations. The findings and conclusions obtained in this report are provided in support of other ongoing NRC activities concerning this subject. Since the studies are ongoing, this report is not final, and the findings and conclusions provided for consideration do not represent the positons or requirements of the responsibe program office of the NRC.

review of the system design. The NRC Resident Inspector and Region I have been following up on the event and licensee corrective actions. Based on this, we believe that the HPCI system problem resulting from the event is adequately addressed.

Since the HPCI system logic schemes at other operating BWRs are similar to the one at Vermont Yankee, this event was deemed to have generic implications. We reviewed the HPCI system logic drawings and elementary diagrams of the Hatch and Browns Ferry units. At these plants a direct indication of the high vessel water level trip signal seal-in condition is provided at the main control room panels. We also review the updated FSARs of Cooper and Pilgrim stations for information on HPCI systems. The logic diagrams show that an indication light is provided at these plants, too. We also conducted a search of the Sequence Coding and Search System (SCSS) LER data base for events from 1981 to the present, involving HPCI system and high vessel water level condition. No other event similar to the Vermont Yankee event was found.

Based on our review and evaluation we concluded that although the HPCI system lockout problem appears to be confined to Vermont Yankee, there is sufficient similarity in the HPCI system logic to warrant feedback of the event and its details to licensees of other operating BWR units. This could be accomplished by incuding the details of the event in a forthcoming issue of Power Reactor Events (PRE).

DISCUSSION

On April 16, 1984 the Vermont Yankee unit experienced a transient while testing the main steam isolation valves (MSIVs). The plant was operating at 100% power when the event occurred. While one of the MSIVs was undergoing the partial closure test, it continued to shut past the 10% position instead of returning to the open position. Although a power reduction was immediately attempted, a primary containment isolation occurred due to high steam flow in the other three steam lines. The consequent closure of the MSIVs resulted in a reactor scram and operation of primary relief valves. During the transient variations in reactor vessel level and pressure also occurred. The plant operators used the appropriate plant procedures to recover from the scram and to maintain the plant in the hot standby condition. The plant remained in hot standby for approximately 13 hours while the pneumatic pilot valve assembly, that caused the MSIV problem, was replaced. (The details of this event are included in Reference 1).

As stated in Reference 2, four days later (on April 20, 1984) while the plant was operating at 100% power, the operators were performing monthly HPCI valve operability test. When the auxiliary oil pump was started, the operator observed that the turbine throttle valve had not opened as expected. A second attempt also proved unsuccessful. The Senior Control Room Operator (SCRO) then recalled the high vessel water level condition that occurred during the transient on April 16, and correctly assumed that the high vessel water level trip signal in the HPCI logic circuit was still sealed-in, locking out the HPCI system. He then pushed the high level reset button which cleared the trip signal and, the throttle valve opened and the HPCI system testing was successfully completed.

The high vessel water level trip signal in the HPCI system logic circuit is designed to seal in and trip the HPCI turbine in order to bypass the high drywell pressure initiation signal to prevent the system cycling around the high level set point during an accident. The trip signal will automatically reset on a low vessel water level initiation signal; but requires to be manually reset otherwise.

During the transient on April 16, 1984, the reactor water level reached the high level trip set point of the HPCI system and sealed in the trip, although the HPCI system itself was not called on to operate. During the vessel level increase the control room annunciator did alarm a high level condition (HPCI hi-level trip), but the alarm cleared when the level subsequently fell below the alarm set point. However, the high level trip signal remained sealed-in. At Vermont Yankee, no direct indication of this condition is provided. The plant start-up procedure does instruct the operators to reset all reset buttons, but does not provide individual sign-offs for each required reset button. Since the HPCI system was not called on to operate during the transient and since no relevant alarm was present during the period when the reactor was in the hot standby condition, the particular reset button was overlooked by the operators during the subsequent startup. Therefore, until April 20, 1984, when the HPCI valve operability test was performed, the high level trip signal remained sealed-in locking out automatic actuation of the

HPCI system on high drywell pressure initiation and manual initiation. (The automatic initiation on low reactor water level was fully operable during the entire period).

This event was reviewed by the Resident Inspector at Vermont Yankee and the review documented in Inspection Report No. 50-271/84-08 and the report and Notice of Violation was issued by Region I (Reference 3). The report and Notice of Violation cited two items related to this event that were contrary to the plant technical specification requirements. The requirements that were not met are 1) that the HPCI system be operable during reactor operations above 150 psig and, 2) that written procedures governing reactor startup operations be implemented and followed. By letter dated July 7, 1984, (Reference 4) the licensee responded discussing the corrective actions taken and future actions planned to avoid further similar violations. The licensee stated that the plant emergency scram procedure was modified to ensure that all logic resets are accomplished in accordance with reactor startup procedure. The "HPCI hi-level trip" annunciator response will contain instructions to depress the HPCI logic pushbutton. Further training on HPCI logic will be included as part of the plant operator requalification program. The plant Control Room Design Review Committee will be considering this event as part of their Human Factors Analysis of the control room design of Vermont Yankee (NUREG-0737 Supplement 1 committment).

Based on the review and actions taken by the Resident Inspector and Region I, and on the corrective actions taken and planned to be taken by the licensee, we believe that the HPCI lockout problem at Vermont Yankee has been adequately addressed.

Since the HPCI system logic scheme at Vermont Yankee is similar to those at other operating BWRs, we reviewed this HPCI system lockout problem for its generic applicability. The consequence of such a lockout is that the HPCI system will not perform its safety function upon high drywell pressure initiation or manual initiation. Further, since no direct indication of the lockout condition is provided to the operator, he is unaware that the system is inoperable. We reviewed the detailed elementary diagrams of the HPCI system at Hatch 1 and 2 and Browns Ferry 1, 2, and 3. Our review showed that at these plants the HPCI system lockout would occur under the circumstances of the Vermont Yankee event. However, at these plants there is direct indication of the high water level trip signal seal-in condition. An indicating light located in the main control room utilizing a contact of the reactor vessel high water level signal seal-in relay is provided in the HPCI system design. Other alarms (e.g. HPCI turbine trip solenoid energized or HPCI turbine tripped) are also provided to alert operators of the HPCI system status. We also reviewed the applicable sections of the updated FSARs of Cooper Nuclear Power Plant and Pilgrim Station. The logic diagrams in these FSARs show that an indication light, similar to the ones at the Hatch and Browns Ferry units, is provided at these plants too.

From this review of the HPCI system at these seven BWR units, we concluded that since a direct indication of the high vessel water level trip signal seal-in condition is provided to control room operators, the possibility of the HPCI system remaining locked out without the operators being aware of it is low at these units. We did not review the operating procedures of these plants and hence cannot comment on their adequacy regarding the required reset button operation. Because of the limited review of the design of the HPCI system logic for other operating BWRs, we could not conclude that the problem seen at Vermont Yankee is confined to that plant. Since the high vessel water level signal seal-in feature is utilized at all operating BWRs, it is possible that there are other BWR units where a direct indication of the seal-in condition is not provided and/or detailed procedures requiring resetting the condition may not be available.

We also conducted a search of the Sequence Coding and Search System (SCSS) data base, which included LERs from 1981 to the present, for events in which HPCI system and the high vessel level trip was involved. No other event similar to the Vermont Yankee event was found.

Based on the above considerations, we believe that the details of the Vermont Yankee event should be included in a future issue of the Power Reactor Events (PRE), to alert licensees of operating BWRs of the potential design and procedural deficiencies regarding the HPCI system lockout.

FINDINGS AND CONCLUSIONS

Based on the review of the event at Vermont Yankee and the follow-up actions taken by the Resident Inspector, Region I and the licensee, and the review of the drawings, and FSAR data of HPCI systems at certain other operating BWR units, the following findings and conclusions were obtained.

1. At Vermont Yankee during the transient on April 16, 1984, the reactor vessel water level reached to high level shutdown of the HPCI system, and although the HPCI system was not called on to operate, it was locked out due to the high vessel water level trip signal seal-in feature of the HPCI system logic.

2. Although the high level shutdown was annunciated, it cleared when the reactor vessel decreased below the alarm set point.

3. Direct indication was not provided in the main control room to alert operators of the high level trip seal-in condition of the HPCI system. Although the existing scram recovery and startup procedures do instruct the operators to reset all reset buttons, they do not specifically address each individual reset pushbutton.

4. Since the HPCI system was not called on to operate during the transient, the operators apparently overlooked the high level trip reset pushbutton when the plant was started up.

5. The high vessel water level trip remaining sealed-in caused the HPCI system to be inoperable for automatic initation on high drywell pressure and manual actuation. The low vessel level automatic initiation was still operable under this condition.

6. The HPCI system remained inoperable in this condition for a period of four days and the condition was discovered only following repeated attempts at performance of the monthly HPCI valve operability testing.

7. The Resident Inspector, Region I and the licensee have been following up on the event and the corrective actions taken and planned to be taken by them are adequate in addressing this problem at Vermont Yankee.

8. The HPCI (and HPCS) system logic at other operating BWRs have the same high vessel water level trip signal seal-in feature. Our limited review of the HPCI system at several operating BWR units showed that direct indication and/or alarms are provided at those units to alert operators of such a lockout condition.

9. A review of the LERs obtained from a search of the SCSS did not identify any other events similar to the event at Vermont Yankee.

10. Since our generic review of the HPCI systems was limted to a few operating BWRs and since our review did not include applicable operating procedures, we could not conclude that the problem is unique to Vermont Yankee.

RECOMMENDATION

Based on the above findings and conclusions, we recommend that the details of the event at Vermont Yankee should be included in a forthcoming issue of Power Reactor Events to alert licensees of operating BWRs of the potential problem of HPCI system lockout.