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AUTH. NAME AUTHOR AFFILIATION
ALEXICH, M. P. Indiana Michigan Power Co. (formerly Indiana & Michigan Ele
RECIP. NAME RECIPIENT AFFILIATION
MURLEY, T. E. Document Control Branch (Document Control Desk)

SUBJECT: Responds to 870709 generic ltr re loss of RHR while RCS partially filled. RCS level lowered prior to removing reactor vessel head & prior to opening RCS for maint activities.

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Indiana Michigan
Power Company
One Summit Square
P.O. Box 60
Fort Wayne, IN 46801
219 425 2111

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Donald C. Cook Nuclear Plant Units 1 and 2
Docket Nos. 50-315 and 50-316
License Nos. DPR-58 and DPR-74
RESPONSE TO GENERIC LETTER 87-12: LOSS OF
RESIDUAL HEAT REMOVAL (RHR) WHILE THE REACTOR
COOLANT SYSTEM (RCS) IS PARTIALLY FILLED

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Attn: T. E. Murley

November 20, 1987

Dear Dr. Murley:

This letter responds to the subject Generic Letter dated July 9, 1987, which we received on July 21, 1987. By letter AEP:NRC:1033A dated October 21, 1987, we notified you of an extension to November 21, 1987 (agreed upon between your staff and ours) of the due date for this response.

The attachment to this letter provides our specific responses to the nine items requested by the Generic Letter. As suggested by the Generic Letter, we have not specifically responded to the topics in Enclosure 1. Although we have made every effort to encompass the information contained in the enclosure, differences in approach, phraseology, etc., may result in our addressing an item in a manner different from what you anticipated. If this is the case, please notify us and we will supply the additional information as required.

Summarized below is our position on the major items in Enclosure 1. This is presented to you principally to serve as an introduction to our position with regard to the major topics addressed by the Generic Letter.

Item (1)

We are relying on the work done by the Westinghouse Owners Group to provide analysis and guidance as to procedural adjustments and safety analysis that may be required if

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boiling occurs following loss of RHR. The work being done by the Westinghouse Owners Group is described in our response to Item 5 of the Generic Letter.

Item (2)

We have had several adverse experiences concerning operation at half loop. Two are described as part of our response to Item 2 of the Generic Letter. One of these experiences directly involved inaccurate information from our level instrumentation. Based upon those experiences, we have strengthened our operating procedures in this area to the extent we believe they are adequate to address many, although not all, of the concerns addressed under this item. Further detail in this area is provided in our response to Item 2 and Item 5 of the Generic Letter.

Item (3)

The second event at the Cook Plant concerned RHR air entrainment, and the corrective measures we have taken to preclude its occurrence. We have described in our response to Question 5 our positions with respect to that issue. We believe the intent of this issue has been addressed. Under item (d) we share the concern cited, and in fact have submitted Technical Specification change requests to allow RHR operation at lower flows than those currently required by the license.

Item (4)

This is responded to throughout our response to the Generic Letter. Direct indication of RCS level is available in the control room. Temperature indication is also available through the incore thermocouples as long as they are available. Should they be unavailable, a very good indirect indication is through RHR heat exchanger temperatures. We have limited indication for system pressure, although some inferential information is available through existing instrumentation.

Item (5)

Should a loss of RHR occur while operating at half loop, we do not consider core uncovery a credible event. This evaluation is based on the timely restoration of core cooling using available methods versus the time required to boil off the reactor coolant system. Since core uncovery will not

occur, radiation doses to the public will be minimal. Therefore, we have no restrictions on containment operations when in Mode 5 with the RCS partially filled.

Item (6)

Our position on this item is summarized in response to Item 1 of the Generic Letter.

It is of note that the Generic Letter addresses operation while the reactor coolant system is partially filled. As we indicate in our attached responses, there are two evolutions of concern. They are (1) when we would drain the system down for maintenance activities and (2) when we drain down to initiate refueling activities. We have focused our response on the former for the sake of clarity in order to limit the volume of information contained herein, and because it is our belief that this was the primary focus of the Generic Letter. If you should require similar information with regard to the latter, please notify us and we will respond accordingly. It is also to be noted that many of our responses refer to operation at "half loop." This term is used for convenience only and is intended to refer to operation in a configuration with the reactor loops partially filled, albeit exactly at half loop or slightly deviating from that condition.

The Westinghouse Owners Group has recently requested Westinghouse to investigate portions of Question 5. Although we feel we have adequately addressed this question, we will notify you upon the Westinghouse Owners Group project's completion if we feel any discrepancies require resolution. The Westinghouse Owners Group project is presently targeted for completion in February, 1988.

Sincerely,

M. P. Alexich
Vice President

cm
Attachments
cc: John E. Dolan
W. G. Smith, Jr. - Bridgman
R. C. Callen
G. Bruchmann
G. Charnoff
NRC Resident Inspector - Bridgman
A. B. Davis - Region III

[illegible]

STATE OF OHIO

COUNTY OF FRANKLIN

Milton P. Alexich, being duly sworn, deposes and says that he is the Vice President of licensee Indiana Michigan Power Company, that he has read the foregoing Response to Generic Letter 87-12 and knows the contents thereof; and that said contents are true to the best of his knowledge and belief.

Subscribed and sworn to before me this 20th day of November, 1987.

NOTARY PUBLIC

Commission expires 3-9-91

Item 1

A detailed description of the circumstances and conditions under which your plant would be entered into and brought through a draindown process and operated with the RCS partially filled, including any interlocks that could cause a disturbance to the system. Examples of the type of information required are the time between full-power operation and reaching a partially filled condition (used to determine decay heat loads); requirements for minimum steam generator (SG) levels; changes in the status of equipment for maintenance and testing and coordination of such operations while the RCS is partially filled; restrictions regarding testing, operations, and maintenance that could perturb the nuclear steam supply system (NSSS); ability of the RCS to withstand pressurization if the reactor vessel head and steam generator manway are in place; requirements pertaining to isolation of containment; the time required to replace the equipment hatch should replacement be necessary; and requirements pertinent to reestablishing the integrity of the RCS pressure boundary.

Response to Item 1

The reactor coolant system (RCS) level is lowered prior to removing the reactor vessel head and prior to opening the RCS for maintenance activities. These maintenance activities include, but are not limited to: steam generator primary side inspection and tube plugging, reactor coolant pump seal work, and any activity involving opening of the RCS for valve maintenance (e.g., spray valves, injection lines, RTD manifold isolations).

Prior to RCS draindown, RHR will be used to maintain RCS temperature. Mode 5 Technical Specifications (T/Ss) require 2 loops operable, with one in service. The pressurizer variable and backup heater breakers must be tagged open. The pressurizer is open to the pressurizer relief tank (PRT) through a power-operated relief valve. A temporary tygon tube level device is in place and is monitored by closed circuit TV from the control room. Primary water from the primary water storage tank to the Chemical Volume and Control System (CVCS) blender is isolated to prevent inadvertent RCS dilution. The reactor head vent is connected to the PRT by an installed spool piece. If the reactor vessel head is to be unbolted, K_{eff} must be less than or equal to .95 and the average RCS temperature less than or equal to 140°F. At least cold shutdown must exist prior to RCS draindown (i.e., K_{eff} less than or equal to .99 and T_{AVG} less than or equal to 200°F).

During any operational mode that the RCS is open to the atmosphere, power is locked out to both RHR suction isolation valves to eliminate any possibility of isolation valve closure due to an increasing RCS pressure interlock signal. There is also an interlock to allow opening of the RHR/RCS suction isolation valves. This interlock allows valve operation

when RCS pressure is below the RHR suction safety valve relief setpoint. The valve closure interlock previously discussed will also signal for valve closure once the increasing RCS pressure setpoint is exceeded. However, this interlock is also defeated during RCS low pressure operation by removing power from the affected valves. Due to removing power from the RHR isolation valves, the RHR safety valves may lift unless actions are taken to reduce RCS pressure.

Two interlocks are provided for the RHR system when it is operating in its Engineered Safety Features (ESF) Mode. Both of these interlocks are provided with test switches which are under administrative control to defeat the interlocks when RHR is operating in a cooldown mode. The ESF Mode interlocks are pump related. These interlocks are diesel load shed and Refueling Water Storage Tank (RWST) Lo-Lo Level coincident with the RHR/RWST pump suction valves open.

The RHR pump motor itself is provided with motor protection trips of motor overload and motor instantaneous trip, both of which alarm on actuation. These protective circuits are not defeated during system operation at a half-loop level.

If half loop is required to perform maintenance on the reactor coolant system with the reactor head installed, then the minimum time is dictated by cooldown and degassing. To achieve a normal cooldown, depressurization and degassification from 100% rated thermal power, a minimum time of approximately 66 hours would be expected. This time is based on the following:

1) Reactor shutdown is normally accomplished in 2 hours.

2) Cooldown and depressurization from 547°F (hot zero power) to 350°F in approximately 4 hours.

3) RHR cooldown and depressurization from 350°F to 140°F in approximately 20 hours.

4) RCS degassification in approximately 20 hours.

5) Drain down from full RCS to half loop in approximately 20 hours.

As part of our submittal AEP:NRC:0916W, "Proposed Technical Specification for Unit 1 Cycle 10 Reload and Related Unit 2 Proposals", we presented an analysis to demonstrate that 2000 gpm RHR flow is sufficient for the purposes of T/Ss 3/4.1.1.3 and 3/4.9.8.1. The results of the analysis demonstrated that at 2.5 days (60 hours) after shutdown, an RHR flowrate of 2000 gpm would be sufficient to cool the reactor and remain below the technical specification temperature limit of 200°F in Mode 5. To be conservative, the analysis assumed a lake temperature of 95°F and added a 20% decay heat margin. As a result of the above, we believe that sufficient cooling is available to assure decay heat removal 66 hours after normal reactor shutdown.

No minimum level requirements exist for steam generator secondary-side water levels while the RCS is partially filled. In the analytic basis described in subsequent sections, no credit is taken for cooling by secondary-side water in the steam generator.

With the exception of prohibiting removal of an operable RHR flowpath and associated equipment from service for elective purposes, there are no specific controls preventing maintenance at half-loop operation. An RHR flowpath and related equipment are not removed from service (made inoperable) for elective reasons (i.e., other than Emergency Job Orders to restore RHR equipment to operable status) with the RCS drained below the steam generator tubes or all steam generators otherwise inoperable (for Modes 4 and 5), or with less than 23 feet of water over the fuel (Mode 6). Residual heat removal system testing required by Technical Specifications is conducted while at half loop. There are no restrictions in the surveillance procedure with respect to half-loop operation, however the status of the RCS is required to be noted (i.e., test is being performed during half-loop operation).

Maintenance and testing during any unit outage is scheduled and coordinated by Outage Coordinators. These coordinators represent each department and interface with all major maintenance and testing evolutions affecting the unit.

Draining of the reactor coolant system below loop centerline (614') is prohibited when nuclear fuel is in the vessel or while on RHR. RCS level must remain stable for a minimum of four hours prior to declaring half loop.

Simultaneous operation of both RHR pumps when the RCS is at half-loop configuration is administratively prohibited in order to protect against the loss of pump suction. RHR flow is maintained less than 3500 gpm while lowering the RCS to eight inches above cold leg centerline to prevent vortexing and air entrainment at the RHR suction lines. Further information regarding RHR flow versus RCS level is given in response to Item 5.

As part of the system alignment for normal half-loop operation, a flow path exists from the reactor vessel head vent and pressurizer PORVs to the PRT and then via a tygon tube to atmosphere. Therefore, during half-loop operation, the RCS is vented to the atmosphere. Nonetheless, with the reactor vessel head and steam generator manways in place, the RCS could potentially pressurize. This problem will be investigated by the Westinghouse Owners Group. However, if rapid pressurization does occur, the RCS is provided with a low temperature overpressurization (LTOP) mitigating system to prevent inadvertent repressurization of the RCS that exceeds pressure-temperature operating constraints. This system consists of various arrangements of Pressurizer Power-Operated Relief Valves (PORVs) and the RHR System Suction safety valve. The basic system is a combination of any one of the following: 2 of the 3 Pressurizer PORVs or 1 Pressurizer PORV and a RHR Suction Safety Valve or a 2 square inch vent opening. If the plant is operating in a mode in which operation of the LTOP mitigating system has not been required by technical specifications, simple manual operation of the associated enable switch will provide pressure relief. The PORVs associated with LTOP can also be opened independently of LTOP by manual operation of their control switches.

When RHR is open to the RCS, RCS pressure relief is also provided by the RHR system suction and return line safety valves. Since the RHR/RCS increasing pressure interlocks are defeated during half-loop operation, these safety valves are available for protection.

Following initial draindown and prior to opening the RCS for work activities, an eductor is installed on the reactor head vent. This eductor is utilized to draw a slight vacuum on the RCS to aid in the removal of radioactive off gases. Once the RCS is opened for maintenance, the eductor is used to prevent elevated airborne activity.

Containment closure requirements are given in the answer to Item 4.

Reactor coolant system boundaries are re-established utilizing operations and maintenance procedures. Maintenance procedures verify installation of manways throughout the primary system (if they have been opened). Verification of proper installation is performed at full system pressure and temperature to ensure primary leakage does not exist. Cleanliness inspections are performed prior to manway installation. Operations procedures ensure the integrity of the RCS by verifying correct valve alignment. These requirements are performed as part of the plant's fill and vent procedures and are documented therein. Following refueling operations, setting of the reactor head and subsequent inspection is verified by the refueling procedure.

Item 2

A detailed description of the instrumentation and alarms provided to the operators for controlling thermal and hydraulic aspects of the NSSS during operation with the RCS partially filled. You should describe temporary connections, piping, and instrumentation used for this RCS condition and the quality control process to ensure proper functioning of such connections, piping instrumentation, including assurance that they do not contribute to loss of RCS inventory or otherwise lead to perturbation of the NSSS while the RCS is partially filled. You should also provide a description of your ability to monitor RCS pressure, temperature, and level after the RHR function may be lost.

Response to Item 2

The operators have the following instrumentation and alarms: RHR pump amperage indication; RHR flow rates and "Loss of Flow" alarms, RHR pump discharge pressure, temperature indications on both inlet and outlet of the RHR heat exchangers, incore thermocouples (if not already removed for subsequent vessel head removal), RCS wide range pressure instrumentation, and reactor water level monitored by closed-circuit television (temporary reactor vessel level indication system (TRVLIS)).

The RHR system is provided with flow indication on the normal cooldown return path and on both the ECCS flow paths. The system is also provided with cooldown "loss of flow" alarms. The RHR Heat Exchangers are provided with inlet and outlet temperature indications. Each RHR system pump is provided with indication of motor amps.

The RCS is provided with the Reactor Vessel Level Indication System (RVLIS). RVLIS provides three types of indication: RCS loop to top of Reactor Vessel head; bottom of Reactor Vessel to top of Reactor Vessel head; and Reactor Coolant Pumps running bottom of Reactor Vessel to top of Reactor Vessel. The RVLIS indications, although designed to assist in mitigating small-break LOCA incidents, is expected to provide a trending capability with the RCS partially filled. The RCS is also provided with redundant wide range pressure indication. Wide range pressure is also expected to provide trending capability when operating with the RCS partially filled if inadvertent RCS repressurization occurs. What is meant by trending capability is that although the absolute value displayed by the indication will be in error, a recorder indication will provide trending of increasing or decreasing level or pressure.

A temporary tygon hose, used as a level instrument, is connected at one end to a drain line from the loop 3 cross-under piping at valve RC-116-L3 as shown on the sketch on page 8. The other end of the hose is initially connected to the temporary vent header, located downstream of the open pressurizer relief tank (PRT) vent valve WD-238. This provides the same

pressure on both legs of the tygon level indicator, since the PRT gas pressure is the same as that in the RCS (pressurizer). When the RCS level approaches 8 inches above centerline, the nitrogen gas supply to the PRT is removed, RCS drainage is stopped and the reactor head, pressurizer and PRT are vented through the temporary vent header to the instrument room purge exhaust. After pressure equalization is complete, the tygon hose is removed from the vent header and relocated to the containment purge exhaust at the refueling cavity window. A closed circuit television camera and monitor are used to observe the level in the tube. The reactor head vent is also temporarily connected to the pressurizer relief tank via the installed vent spool piece.

Following installation of the TRVLIS by the D. C. Cook Plant Maintenance Department, the installation is verified by the Operations Department. This verification ensures that no loop seals or kinks exist in the tygon hose to be used for level indication. It also verifies that the system is properly aligned and free of obstruction. The closed circuit TV is installed by Instrumentation & Control personnel and is verified operational by Operations personnel.

Proper function is verified by operation, that is decreasing or increasing RCS level accomplished through various RCS lineups should be indicated accordingly by TRVLIS. If, however, this is not properly indicated, then installation will be reverified. In addition, corrections to TRVLIS readings to account for phenomena that create discrepancies in the TRVLIS readings enhance the usefulness and functionality of TRVLIS. Control Room operators will be made aware of the impact of these discrepancies so that the appropriate corrections can be made. The various discrepancies are described in detail in the response to item 5.

Cook Plant has experienced two incidents related to temporary instrument connections while the RCS was partially filled, which have resulted in perturbations to the NSSS.

On June 1, 1986, while draining the Unit 1 RCS to half-loop, the motor amps on east RHR pump began to oscillate although the temporary level indicator showed RCS level at greater than half-loop. After reducing pump flow to steady motor amps, RCS makeup was started and the west RHR pump was vented and then placed in service after removal of the east pump. During the recovery process it was discovered that a valve on the vent leg of the temporary level instrument was not opened as it should have been. This caused an erroneous high level reading when the level was actually below half-loop. The valve was opened and full RHR flow was established when level returned to half-loop. The operating procedure was modified to preclude reoccurrence of this event.

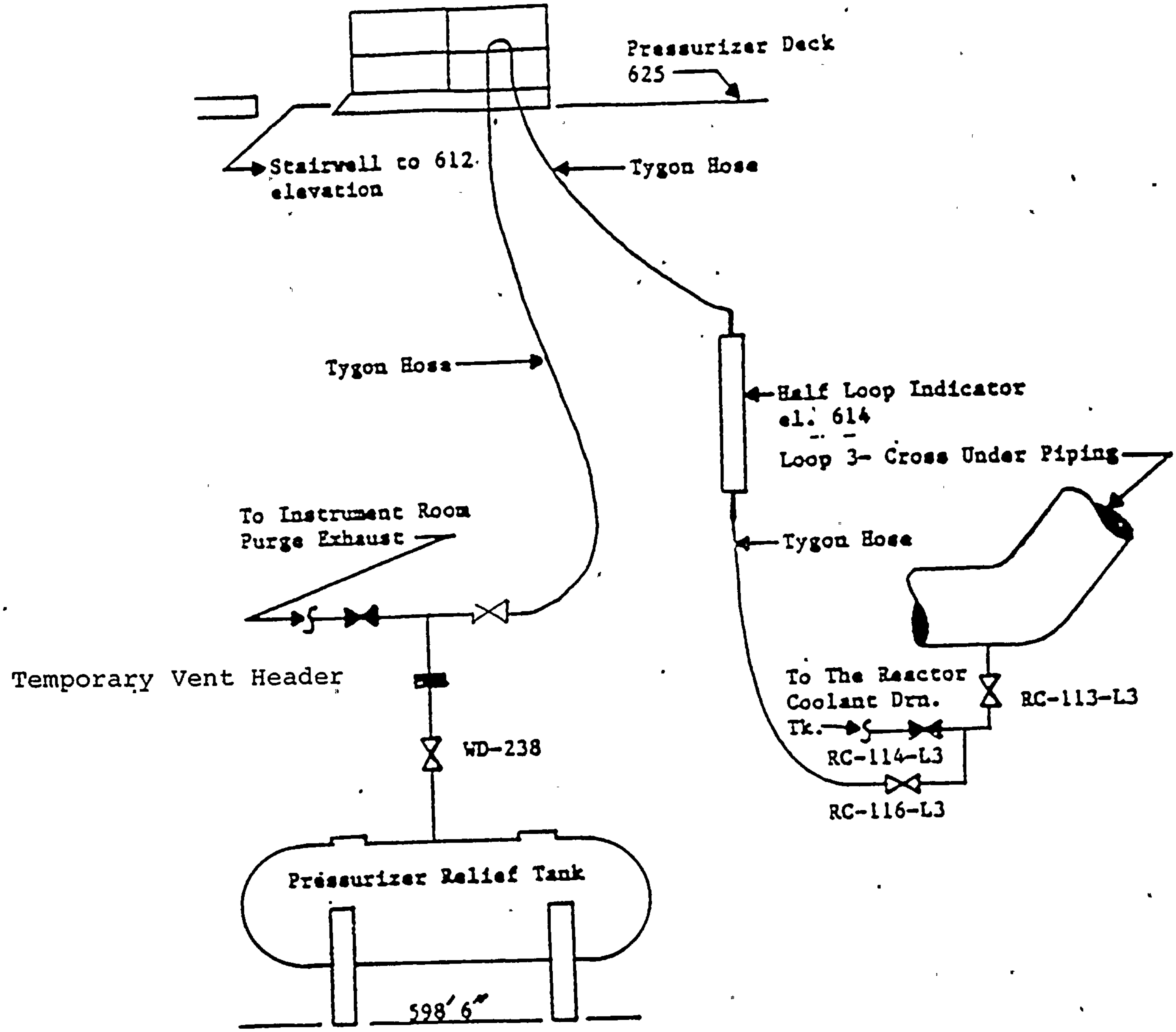
On August 26, 1985, Unit 2 RCS level had been reduced to 5 to 8 inches above loop centerline for 36 hours, as measured on the temporary level indicator. However, the actual level was found to be much higher when approximately 5000 gallons of water flowed out of the No. 21 steam generator when the diaphragm was removed. This false indication was caused by a vacuum condition on the RCS side of the temporary level instrument. To prevent reoccurrence of this event, a check valve was removed from the vent piping to prevent vacuum build-up in the RCS and allow proper venting of the two legs of the level instrument.

In the event of loss of RHR flow, the TRVLIS is monitored by an operator on closed-circuit TV. If the level is shown to be inadequate, make up is supplied from the refueling water storage tank (RWST) until normal level is achieved. If half-loop level is not in view from TRVLIS in the control room, then an operator is dispatched to locally determine the actual level and verify proper line-up for the temporary level hose.

RCS temperature can be monitored using the incore thermocouples. However, the thermocouples are disconnected prior to vessel head removal. The incore thermocouples have a range of 200°F to 2300°F. RCS wide range pressure, as described previously, can be used for trending purposes following loss of RHR flow.

HALF LOOP LEVEL INDICATION SYSTEM

TEMPORARY REACTOR VESSEL LEVEL INCATION SYSTEM (TRVLIS)



Note: Valve configuration shown prior to pressure equalizatic

Item 3

Identification of all pumps that can be used to control NSSS inventory. Include: (a) pumps you require be operable or capable of operation (include information about such pumps that may be temporarily removed from service for testing or maintenance); (b) other pumps not included in item a (above); and (c) an evaluation of items a and b (above) with respect to applicable T/S requirements.

Response to Item 3

a) The following pumps are required to be operable per T/Ss:

- o Residual Heat Removal (RHRP) - 2 pumps
- o Centrifugal Charging (CCP) - 1 pump
- o Boric Acid Transfer (BATP) - 1 pump

b) The following pumps are not listed in item a, but may be available:

- o Primary Water (PWP)
- o Safety Injection (SIP)
- o Reciprocating Charging (Recip Chg)

c) We believe the conditions addressed in this generic letter occur in Mode 5, therefore, T/S limits for Mode 5 are addressed.

Both RHR loops are required to be operable by T/S 3.4.1.3, with one loop required to be in operation and verified in operation every 12 hours, although both loops may be de-energized for up to 1 hour under certain conditions. This, however, would only occur at half loop when we are switching RHR pumps.

The first make-up source used in the operating procedure "Recovery from Loss of RCS Level when Partially Drained or at Half Loop" is gravity feed from the RWST either through the RHR or charging system. This method is used to restore adequate loop level before starting either RHR pump.

Should the system pressure prevent RWST gravity flow, the CCP can be used to restore level by taking suction from either the boric acid tank via the BATP or the RWST. Technical Specification 3.1.2.3 requires one of these flow paths as defined in 3.1.2.1 to be operable in Modes 5 and 6. The operable charging pump is tested in Mode 5 with the pump aligned in its recirculation mode. Should the pump be required to restore RCS level, it can be quickly realigned to the RCS. Maintenance on the charging pump is ordinarily limited to corrective actions required to maintain the system in an operable status.

One BATP is required to be operable if its flow path is used to satisfy T/S 3.1.2.3. If the RWST flow path is the operable path of record, no BATP is required. However, although not a T/S requirement, one of the two installed BATPs in each unit could be valved into the required flow path. (Except in the unlikely event that maintenance is being performed on both pumps simultaneously).

The BATP alone or combined with the PWP could supply liquid to the RCS through the blender or emergency boration path via the charging system.

Although neither the Reciprocating Charging pump nor the PWP are T/S related, both the PWP, combined with the BATP to prevent dilution, and the Reciprocating Charging pump could be used to add liquid to the RCS.

One CCP is required to be operable by T/S 3.1.2.3 with the other CCP (and the 2 SIPs) motor circuit breakers removed from the power source. Both SIPs have power removed per T/S to prevent overpressurization when RCS temperature is less than or equal to 170°F (152°F for Unit 2). However, in an emergency case, one SI pump could be energized and used to restore level, although we would be entering a limiting condition for operation. Availability of these pumps would be dependent on whether maintenance was being performed on one or both of the pumping systems. The same applies to the remaining charging pump that has its circuit breakers removed from the power source.

Item 4

A description of the containment closure condition you require for the conduct of operations while the RCS is partially filled. Examples of areas of consideration are the equipment hatch, personnel hatches, containment purge valves, SG secondary-side condition upstream of the isolation valves (including the valves), piping penetrations, and electrical penetrations.

Response to Item 4

There are no specific requirements with regard to containment closure during Mode 5 (i.e., half-loop) operation. This means there are no specific restrictions associated with the following items:

- o Equipment hatch position.
- o Personnel hatch positions.
- o Containment purge valves.
- o SG secondary-side condition upstream of the isolation valves (including the valves).
- o Piping penetrations.
- o Electrical penetrations.

There are no requirements imposed for maintaining configuration control for the purpose of establishing containment integrity within a specified time limit while in Mode 5.

In response to your question in item (1) regarding equipment hatch replacement time, equipment hatch replacement would require about 5 hours if the equipment hatch is removed with the airlock in place. However, if the airlock is separated from the hatch, which is usually the case, the replacement process is estimated to take 8 to 10 hours.

Item 5

Reference to and a summary description of procedures in the control room of your plant which describe operation while the RCS is partially filled. Your response should include the analytic basis you used for procedures development. We are particularly interested in your treatment of draindown to the condition where the RCS is partially filled, treatment of minor variations from expected behavior such as caused by air entrainment and de-entrainment, treatment of boiling in the core with and without RCS pressure boundary integrity, calculations of approximate time from loss of RHR to core damage, level differences in the RCS and the effect upon instrumentation indications, treatment of air in the RCS/RHR system, including the impact of air upon NSSS and instrumentation response, and treatment of vortexing at the connection of the RHR suction line(s) to the RCS.

Explain how your analytic basis supports the following as pertaining to your facility: (a) procedural guidance pertinent to timing of operations, required instrumentation, cautions, and critical parameters; (b) operations control and communications requirements regarding operations that may perturb the NSSS, including restrictions upon testing, maintenance, and coordination of operations that could upset the condition of the NSSS; and (c) response to loss of RHR, including regaining control of RCS heat removal, operations involving the NSSS if RHR cannot be restored, control of effluent from the containment if containment was not in an isolated condition at the time of loss of RHR, and operations to provide containment isolation if containment was not isolated at the time of loss of RHR (guidance pertinent to timing of operations, cautions and warnings, critical parameters, and notifications is to be clearly described).

Response to Item 5

The following are the procedures in the Unit 1 control room which describe operation while the RCS is partially filled. A summary of each Unit 1 procedure is provided. Similar procedures exist for Unit 2.

o 1-OHP 4021.002.001 "Reactor Coolant System Fill and Vent"

This procedure contains guidance for refilling and venting the reactor coolant system following operation at reduced inventories. Actions identified in this procedure include 1) establishing proper system alignments, 2) guidance for reactor coolant pump operation with respect to system venting and 3) restoration of the reactor head vent and pressurizer relief tank to operational configuration.

o 1-OHP 4021.002.005 "Draining the Reactor Coolant System"

This procedure provides guidance for lowering reactor coolant system level prior to removing the reactor vessel head or performing maintenance work requiring a reduced water level. Guidance offered in this procedure includes 1) Conditions necessary prior to draining the RCS, 2) Precautions to be observed when draining the RCS, and 3) Step-by-step instructions on the draining evolutions, including valve manipulations and diagrams.

o 1-OHP 4021.017.001 "Operation of the Residual Heat Removal System"

This procedure describes necessary actions for removing a RHR pump from service and transferring RHR pumps with the reactor coolant system at half-loop. These actions include: 1) Flow rate requirements, 2) Precautions with respect to operating multiple RHR pumps, and 3) Instructions on how pump transfers are to be made.

o 1-OHP 4022.002.006 "Loss of Refueling Water Level During Refueling Operations"

This procedure specifies the actions to be taken if the refueling cavity water level is lost while in refueling mode. Valving in half loop level indication (TRVLIS) is required upon loss of level if lower containment entry is feasible.

o 1-OHP 4022.002.013 "Recovery From Loss of RCS Level When Partially Drained or at Half Loop"

This procedure specifies actions to be taken in the event RCS loop level undergoes an uncontrollable decrease while the RCS is partially drained or at half-loop.

In addition to corrective actions taken to recover from a loss of RCS level (i.e., reduction in RHR flow, commencing makeup from the RWST, venting of the RHR pumps and utilizing the charging header for makeup), this procedure also outlines probable symptoms which would indicate a reduction in RCS level.

o 1-OHP 4023.017.001 "Loss of Residual Heat Removal (RHR)"

This procedure describes the actions required to be taken upon loss of RHR cooling capability during plant cooldown or shutdown periods.

Procedure guidance includes 1) Symptoms indicative of a loss of shutdown cooling, 2) Guidance for attempting to restart the RHR system, 3) Emergency Plan entry conditions, and 4) Alternate core coolant methods with the reactor head installed or removed.

Normally, a dedicated operator is assigned to monitor half-loop level during the draindown. Independent verification of the installed tygon hose configuration is made to ensure true level indication. Loop level is closely observed when draining to ensure that the level is maintained greater than or equal to 8 inches above centerline. RHR pump amperage will provide the earliest indication of possible air entrainment. Pump amperage is observed periodically.

The simplified sketch of the RCS found on page 15 is provided to assist in understanding the following description of the RCS draindown process.

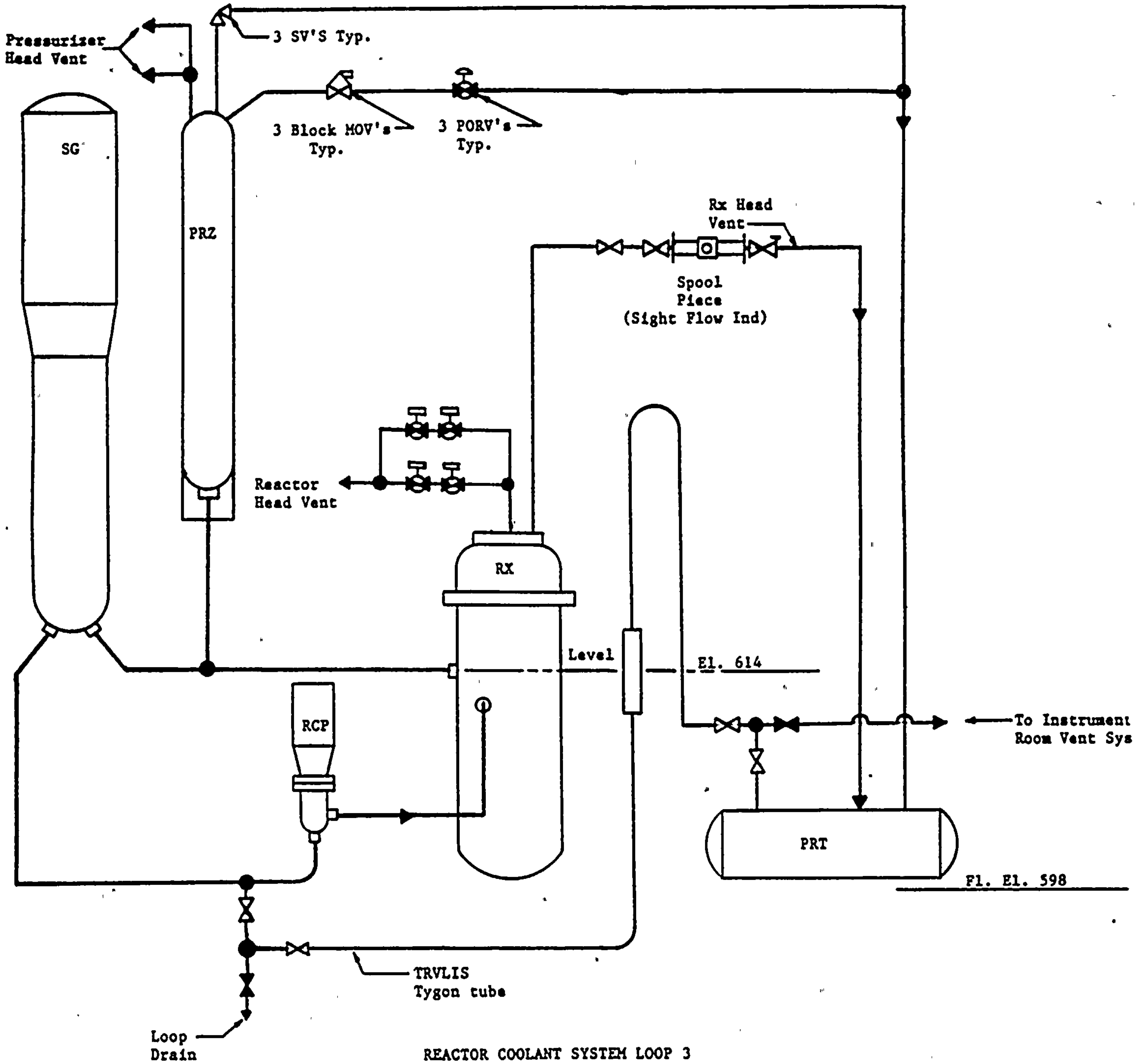
The RCS is drained initially through loop drains in the cross-under piping or by low pressure letdown. Nitrogen gas (N_2) is admitted to the system from the PRT through an open PORV to the pressurizer. The water level in the PRT is maintained below a level of 5% in order to allow N_2 to flow through the sparger pipe into the pressurizer. The RCS is drained by this method until the pressurizer level is reduced to 5% indicated.

During the next phase of draindown, water is drained to the PRT through the reactor head vent. To accomplish this, a temporary connection with a sightglass for flow indication is installed, prior to draindown, between the head vent and the PRT. This provides a monitored method of draining while there is no direct level indication. PRT level is maintained at less than 5% while draining.

The TRVLIS is placed in service after reactor coolant water stops flowing through the sight glass flow indicator. The Loop 3 drain is used for the level indication, and is not used for further draining, as this method would give a false level reading. (This fact is emphasized in a caution statement in the procedure.) Draining of the RCS is resumed using either or both of the methods cited above (i.e., loop drains or letdown). Draining continues until a level of eight inches above centerline is reached.

In order to allow the water in the SG tubes to drain, a vent bottle is temporarily connected to the Loop 1 hot leg RTD manifold vent to provide an additional path for air to enter the system. The coolant level is maintained for a minimum of four hours to allow time for the SG tubes to drain.

The basis for the above draindown process is simply to recognize the pertinent elevations and geometry of the system and to admit gas at locations which will facilitate draindown and not compromise level indications. Due to the inverted U-tube geometry of the SG tubes, draining is not a smooth process, as gas can only enter the tubes through the bottom, and water can only drip out of the tubes. Thus, a waiting period is included in the procedure to allow time for this process to be completed.



REACTOR COOLANT SYSTEM LOOP 3

We have analyzed water heat-up and boil off in the reactor vessel after a loss of RHR flow. Our calculations assume initial heating of the reactor water in and above the core to saturation conditions, at which time bulk boiling begins. The mass of air in the system is sufficiently low so that the energy required to heat and pressurize the air is ignored. We also take no credit for heat removal through the steam generators because we require no level to be maintained in the steam generators. The energy to heat the water to saturation and to boil it off increases with the self-imposed pressure, therefore we believe the calculation for boiloff time for the open system (at atmospheric pressure) is conservative for the sealed system. Sensible heating to raise the fuel, cladding, and core structural materials to the boiling temperature have been included in the analysis.

The calculations are based on the following assumptions and initial conditions. We assume that core damage will occur when the top of the active fuel is exposed. The decay heat rate was calculated for a 3411 Mwt reactor initially operating at 100% power, and assuming the fuel is at a burnup level of 720 effective full power days at 60 hours after shutdown. A 20% additional margin for decay heat was included. The decay heat rate computed by this method was 47.1 million Btu/hr.

An initial reactor coolant temperature of 172°F was used to calculate the heat-up time to saturation. This value is representative of a steady-state RCS temperature at the RHR suction point if the following conditions are assumed: a decay heat rate of 47.1 million Btu/hr, an RHR flowrate of 2000 gpm, and a lake temperature of 85°F.

To the best of our knowledge, the highest lake temperature recorded at Cook Plant was 79.3°F. Thus, the use of a lake temperature of 85°F in this analysis is conservative. The analysis discussed in item (1) assumed a lake temperature of 95°F in order to be additionally conservative.

The approximate time to core uncovery is the sum of the heat-up time to boiling and the boiloff time until the top of the core is exposed. For a water level at the nozzle centerline, the calculated mass of water above the core to be boiled off is 59,970 lb. For the worst case condition, as stated previously and assuming we have an open system at atmospheric pressure, bulk boiling would occur within five minutes after loss of RHR flow. An additional 74 minutes would elapse before the top of the fuel is exposed. Thus, the total minimum time to core uncovery is 79 minutes.

A radiation dose analysis was performed to estimate the whole body and child thyroid doses at the site boundary for a loss of RHR accident with an open RCS. This analysis was based on the following assumptions:

- o The reactor coolant is in a degassed condition with 1% failed fuel activity.

- o The RCS is at half-loop level and the sequence is initiated 60 hours after shutdown.

- o An open path is assumed to exist from the RCS directly to outside containment through the equipment hatch (i.e., no containment dilution of fission product concentration).

- o All of the water above the active core is boiled off in 79 minutes, at which point the scenario is terminated by operator action.

- o All of the boiled off water escapes the containment through the equipment hatch, with no credit taken for any removal mechanisms. Under these conditions, the offsite whole body dose was estimated to be 0.6 millirem and the offsite child thyroid dose was found to be 7 rem. These doses are well below the 10 CFR Part 100 limits of 25 rem whole body dose and 300 rem thyroid dose.

- o The thyroid dose is based on the child thyroid dose. This is the dose used in emergency planning recommendations and is more limiting than the use of an adult thyroid dose. The regulation, 10 CFR 100, does not delineate between a child or adult in the setting of the 300 rem limit to the thyroid.

Calculations have been performed to estimate the differences between hot leg and cold leg level during normal half loop operation. The results of these calculations have shown the level differences between the cold and hot legs to be less than one inch when measured away from the area of RHR suction induced vortices in the hot leg. (It is of note that the cold legs will always be at a higher level than the hot leg since suction is taken from one hot leg and is then injected into two cold legs). Therefore, we believe that of measuring RCS level in the cold leg using TRVLIS is an acceptable indication of level in the hot leg when operating with the cold legs filled to a half loop level or greater.

RVLIS was designed to assist in mitigation of a small-break LOCA. It is also expected to provide a trending capability under the RCS partially filled operating condition. Although the absolute percent value displayed by the device will be in error, the system can provide indication of a increasing or decreasing level.

The same statement can be made for the RCS wide range pressure. That is, although the absolute value displayed by the indication is expected to be in error, the indication is expected to provide trending of increasing or decreasing pressure if inadvertent RCS repressurization occurs. Additionally, RCS wide range temperature will provide accurate temperatures once RCS water level has filled the coolant pipe.

Operation at too low of a water level can result in air entrainment into the RHR pump suction line by vortexing. The presence of air in the RCS and RHR system would cause unstable RHR pump operation and an eventual loss of RHR flow. This condition would cause erratic RHR pump motor current readings, oscillations of RHR flow and/or low flow alarms, oscillating RHR pump discharge pressure and oscillations of RCS half-loop levels.

As part of all operations involving RHR at half-loop, operators are cautioned as to the possibility of air entrainment. Tygon hoses are installed on the RHR pump casing vents prior to commencement of draindown. The indication used for determining air entrainment is RHR pump amperage. When pump amps are noted to be behaving erratically, RHR flow is reduced and, if necessary, an operator is dispatched to vent the RHR pump to remove air. If venting does not steady out the pump, an increase in RCS level is made by transferring water from the RWST.

Our RHR pump manufacturer has informed us that our pumps may operate successfully with up to 5% entrained air by volume. We can assume that for air entrainment of greater than 5%, pump performance will be degraded and this will be indicated by erratic pump amperage, as stated above. Small amounts of air that are ingested from the hot-leg air space into the RHR suction line may not be indicated by erratic pump operation. This air can be transported through the RHR system to the cold legs. As a result, the pressure in the air space in the cold leg will increase relative to that in the hot leg. This pressure difference will result in an increase in the RCS level indication, and will push cold-leg water into the hot legs. However, this increase in the water level in the hot legs will reduce or terminate the air entrainment. As part of a program initiated by the Westinghouse Owners Group, Westinghouse will evaluate the sensitivity of the RCS loop water elevation to the critical submergence depth for air entrainment as a function of RHR flowrate. This program is now tentatively planned for completion in February 1988. The results provided by this program will allow us to evaluate the impact of air entrainment carry over on the level indicated by TRVLIS.

Although in practice RHR flow is decreased in a more continuous manner, the following guidelines are provided by plant procedures to minimize the possibility of air entrainment:

- o Only one RHR pump is allowed to operate while the RCS is partially filled.

- o With loop level at 8 inches above centerline, the RHR flow is specified to be less than 3500 gpm.

- o With the loop level at 4 inches above centerline, the RHR flow is specified to be less than 3000 gpm.

- o When loop level is lowered to true half-loop, RHR flow is directed to be maintained at a nominal 2000 gpm.

The RHR suction line is a 14 inch pipe connected at a 45° angle below horizontal to the Loop 2 hot leg. Because the suction line is not connected to the bottom of the hot leg, the height of water above the suction line at half-loop is less than the radius of the hot leg. The actual vertical distance between the suction pipe centerline and the water surface at the nozzle centerline level was calculated to be nine inches. Increments of water level above nozzle centerline (true half-loop) would result in equivalent increments of the actual water level above the suction line centerline (four inches above true half-loop equals 13 inches above the suction line centerline).

To the best of our knowledge, the particular geometry of this connection relative to vortexing has not been studied experimentally or analytically in technical literature. Therefore, to determine air entrainment conditions, we rely on experience with the actual geometry and flow conditions. Based on operational experience, we have defined acceptable reactor vessel levels and flow rates during half-loop operation, as described above.

The Westinghouse Owners Group (WOG) has initiated a program with Westinghouse for evaluating scale model test data from experiments performed for this 45° RHR suction line geometry. An empirical correlation of vortex formation based on flow rate and level will be developed. Two other correlations will also be developed: one to determine RCS level and flow rate to ensure no vortex formation, and one to determine level and flow rate to limit vortex formation and air entrainment to acceptable limits. This program is now tentatively planned for completion in February 1988. Based on this information, as applied to Cook Plant-specific conditions, we will notify you of any resulting procedures or program changes.

The procedure governing recovery from loss of RCS level when partially filled alerts the operator that under adverse conditions the core may be exposed within 15 to 30 minutes due to the coolant boiling off. (These numbers are more cautious than the 79 minutes worst-case situation calculated in our analysis.) The operator is thus cautioned to minimize the time RHR flow is stopped. It is recognized in the procedure that high water make-up rates could result in RCS coolant spilling out of RCP seals or SG manways. The operator is instructed in the procedure that efforts should be made to evacuate individuals from affected areas prior to spillage.

Procedural guidance pertinent to RHR operations when the reactor vessel is partially filled is as follows: During normal half-loop operation, levels and flow rates are specified in the procedures as described above. This information is also provided in the procedure for draining the RCS to half-loop. The level instrumentation is required to be set up properly and independently verified. Procedures caution operators to not use the drain associated with the TRVLIS connection because it will result in a false level reading. If reactor level is suspected to be incorrect, procedures direct the operator to verify the valve lineup as correct.

Evolutions involving the NSSS System are communicated to the operations control room staff via the following flowpath:

- Activities are initially reviewed and scheduled by the Unit Coordinators, who plan unit evolutions.
- Once reviewed, activities are scheduled and transmitted to the Shift Supervisors.
- Shift Supervisors in turn review the feasibility of the evolution and then brief the Unit Supervisor and other licensed personnel concerning the planned evolution.

Restoration of the residual heat removal system during half-loop operation is done under the guidance of 1-OHP 4022.002.013, "Recovery From Loss of RCS Level When Partially Drained or at Half Loop," and also 1-OHP 4023.017.001, "Loss of RHR." These two procedures dictate necessary actions to be taken to restart an RHR pump, restore RCS level and reestablish RHR cooling.

In the event that the RHR system cannot be restored and we have secondary side level in the steam generators, we believe RCS cooling could be provided by reflux condensation cooling in the steam generator tubes. RCS temperature could then be maintained at the lowest practical level by using either the condenser or atmospheric steam dump (condenser dump availability is dependent on ability to establish condenser vacuum) until the RHR system can be placed back into service. The Westinghouse Owners Group is currently investigating the feasibility and magnitude of cooling provided by reflux condensation. Refer to the response to Item 3 for other mitigating actions in the case that RHR cannot be restored.

As stated in our response to Item 4, there are no restrictions regarding containment closure. Therefore, the time required to provide containment integrity in order to control release of effluents depends on the status of many containment penetrations. No worst-case time for containment closure can be specified at this time. We will add a step to the existing procedures for operating with a partially filled RCS to instruct that actions be taken immediately to isolate containment upon loss of the RHR function. The previous summary of the radiological dose calculations performed for this scenario assumed no containment integrity.

Item 6

A brief description of training provided to operators and other affected personnel that is specific to the issue of operation while the RCS is partially filled. We are particularly interested in such areas as maintenance personnel training regarding avoidance of perturbing the NSSS and response to loss of decay heat removal while the RCS is partially filled.

Response to Item 6

The following outlines the training provided to the licensed operators regarding the loss of decay heat removal and operation of the RCS when in a half-loop configuration. Also identified is the training to be presented to the operators in the near future concerning these topics.

- Training provided to licensed operators in the past year concerning operation of the residual heat removal system, and loss of decay heat removal while the RCS is partially filled.

  1. Review of the operating procedure "Operation of the Residual Heat Removal System."

  2. Review of the abnormal operating procedure "Recovery From Loss of RCS Level When Partially Drained or at Half-Loop". This abnormal procedure is reviewed annually in requalification training.

  3. Review of Information Notice 87-23: Loss of Decay Heat Removal During Low Reactor Coolant Level Operation.

  4. Review of SOER 85-4: Loss or Degradation of Residual Heat Removal Capability in PWRs.

  5. Case Study: Discussion of the events surrounding the March 1986 loss of shutdown cooling flow at San Onofre, SER 17-86.

  6. Case Study: Discussion of the events surrounding the April 10, 1987 loss of RHR while in half-loop at Diablo Canyon.

- Training to be provided to licensed operators during Requalification training in the next year.

  1. Review of SER 15-87: Extended Loss of Residual Heat Removal. This will be covered in lesson plan RQ-R-1291 along with the response to training concerns generated as a result of the initial review of IN 87-23: Loss of Decay Heat Removal During Low Reactor Coolant Level Operation.

2. Annual review of the "Recovery from Loss of RCS Level When Partially Drained or at Half-Loop" abnormal operating procedure.

3. Presentation of the lesson plan being developed addressing operation of the RHR system and loss of RHR cooling while at half-loop (TDR 87-52).

4. Should any material be received by the Plant facility from either the NRC, INPO or other agency concerning these topics, it will be evaluated for incorporation into our training program.

- In addition, simulator training will be provided when the Cook specific simulator becomes available regarding operation of the RHR system and the loss of decay heat removal when in a half-loop configuration.

The following is a brief description of training provided to other affected personnel that is specific to the issue of operation while the RCS is partially filled:

Training provided to Maintenance Department personnel described in lesson plan #MM-C-F204, "Residual Heat Removal System," will cover problems associated with plant safety while the RCS is partially filled. Maintenance training will include situations that can lead to loss of residual heat removal, jobs that could create or worsen the condition, and responsibilities that Maintenance personnel would have if a loss of residual heat removal occurred. Generic Letter 87-12 will be attached to the lesson plan for instructor review and use during the class. This lesson plan is scheduled for the last quarter of this year and is a continuing training topic with a 2 year frequency. Generic Letter 87-12 will also be attached to lesson plan #MM-C-F563, "Piping Specialties," in which the purpose and installation of the temporary reactor vessel level indication system (TRVLIS) is presented.

Item 7

Identification of additional resources provided to the operators while the RCS is partially filled, such as assignment of additional personnel with specialized knowledge involving the phenomena and instrumentation.

Response to Item 7

The following resources assist the operator while the RCS is partially filled:

- A dedicated operator is normally assigned to monitor half-loop level during draindown.
- Various instrumentation and alarms are provided to the operators for controlling the thermal and hydraulic aspects of the NSSS. This equipment was described in our response to Question 2 and Question 5.
- Training is provided to licensed operators specifically regarding the loss of decay heat removal and operation of the RCS while in a half-loop configuration. The training provided to operators while the RCS is partially filled is outlined in the response to Question 6.

Item 8

Comparison of the requirements implemented while the RCS is partially filled and requirements used in other Mode 5 operations. Some requirements and procedures followed while the RCS is partially filled may not appear in the other modes. An example of such differences is operation with a reduced RHR flow rate to minimize the likelihood of vortexing and air ingestion.

Response to Item 8

The following discussion compares the requirements to be implemented while the RCS is partially filled and requirements used in other Mode 5 operations:

- o An administrative level of 8 inches above half-loop is maintained whenever possible to prevent cavitation or air binding of the RHR pumps unless RHR flow is correspondingly reduced.

- o Careful observation of the RHR system parameters is required while draining of the RCS is in progress. Erratic RHR pump amperage readings are the first indication of cavitation or loss of suction.

- o RHR loop and related equipment are not removed from service (i.e., made inoperable) for elective reasons while the RCS is partially filled.

- o RHR flow is reduced to less than 3500 gpm prior to lowering the RCS level to 8 inches above half-loop.

- o Only 1 RHR pump is operated at a time while the RCS is drained to half-loop level. This prevents the possibility of cavitation or air binding with 2 pumps operating and leaves one pump vented and available for use.

- o If the operating RHR pump becomes air bound during half-loop operation, the pump is stopped and the pump casing is vented. The RHR is restarted when adequate loop level for RHR pump operation has been re-established by makeup to RCS. If the operating RHR pump trips during other Mode 5 operations, the standby RHR pump is started and checked for satisfactory operation.

Item 9

As a result of your consideration of these issues, you may have made changes to your current program related to these issues. If such changes have strengthened your ability to operate safely during a partially filled situation, describe those changes and tell when they were made or are scheduled to be made.

Response to Item 9

As a result of our consideration of the issues discussed in Generic Letter 87-12, no specific program or hardware changes are regarded as necessary with respect to half-loop operation. However, operator and affected non-operator training has been enhanced by making these personnel more cognizant of the loss of RHR while the RCS is at a half-loop level scenario.

Also, steps to direct control room personnel to take immediate actions to isolate containment, if possible, upon loss of the RHR function will be added to procedures for operation with the RCS partially filled.

In addition, any new guidance obtained for half-loop operations, as an outcome of the WOG Generic Letter 87-12 program as previously described, will be carefully considered as those results become available.