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SUBJECT: Forwards response to Generic Ltr 87-12 re loss of RHR while RCS partially filled.

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Arizona Nuclear Power Project
P.O. BOX 52034 • PHOENIX, ARIZONA 85072-2034

September 21, 1987
161-00517-JGH/BJA

U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Document Control Desk

References: (1) Generic Letter 87-12 dated July 9, 1987. Subject: Loss of Residual Heat Removal (RHR) While the Reactor Coolant System (RCS) is Partially Filled.

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos.: STN 50-528 (License No. NPF-41)
STN 50-529 (License No. NPF-51)
STN 50-530 (License No. NPF-65)
Response to Generic Letter 87-12
File: 87-A-056-026

Pursuant to the requirements of 10CFR50.54(f), the NRC has requested additional information on operation of PWRs when the RCS is partially filled. The ANPP responses to the NRC concerns are provided in the attachment to this letter.

If you have any additional questions on this matter, please contact Mr. W. F. Quinn of my staff.

Very truly yours,

VGHaynes

J. G. Haynes
Vice President
Nuclear Production

8709230464 870921
PDR ADOCK 05000528
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JGH/BJA/dlm

Attachment

cc: O. M. De Michele (all w/a)
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A001
1/1

STATE OF ARIZONA)
) ss.
COUNTY OF MARICOPA)

I, Jerry G. Haynes, represent that I am Vice President of Nuclear Production of Arizona Nuclear Power Project, that the foregoing document has been signed by me on behalf of Arizona Public Service Company with full authority to do so, that I have read such document and know its contents, and that to the best of my knowledge and belief, the statements made therein are true and correct.

Jerry G. Haynes
Jerry G. Haynes

Sworn to before me this 21 day of Sept , 1987.

Nora E. Meador
Notary Public

My Commission Expires:

My Commission Expires April 6, 1991

ATTACHMENT

RESPONSE TO NRC REQUEST FOR INFORMATION ON LOSS OF RESIDUAL HEAT REMOVAL

(1) NRC QUESTION

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.

ANPP RESPONSE

There are several recurring maintenance and testing activities that would require a draindown of the RCS to mid-loop conditions. For the purposes of this response, mid-loop operation is defined as anytime RCS level is below the top of the hot legs. The normal maintenance related activities that would require draindown of the RCS to mid-loop include the replacement of Reactor Coolant Pump (RCP) seals and/or journal bearings. This work requires approximately twelve days of mid-loop operation during an outage. However, replacement of RCP seals and journal bearings is not normally required at each refueling outage. Additionally, certain abnormal maintenance activities such as replacement of a RCP shaft would require operation with the RCS partially filled. The testing activities requiring RCS draindown to mid-loop include only the Technical Specification required inservice inspections of the steam generator tubes. Approximately four days of mid-loop operation would be required to remove the steam generator manways, install three nozzle dams in each steam generator to allow eddy current testing in parallel with refueling operations, removal of the nozzle dams after completion of testing, and reinstallation of the steam generator manways. This mid-loop operation would normally occur simultaneously with the RCP maintenance work. In addition to these recurring maintenance and testing activities there are other non-routine activities that would necessitate operation with the RCS partially filled. A recent example of this was a design modification to the pressurizer level instruments in PVNGS Unit 3 that required a partial draindown of the RCS.

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During mid-loop operations, there is one set of interlocks that have the potential for disturbing the shutdown cooling system. These interlocks are the shutdown cooling system suction isolation valve interlocks. The purpose of these interlocks is to close the shutdown cooling suction valves to protect the relatively low pressure shutdown cooling system in the event of an unanticipated RCS pressurization. Past industry experience has shown that inadvertent closure of the suction isolation valves has been a major contributor to disruptions of the shutdown cooling function. In order to reduce the possibility of this type of event occurring at PVNGS, ANPP has initiated an evaluation to determine if it is feasible to disable the shutdown cooling suction isolation valve interlocks during certain plant conditions such as mid-loop operations.

There have been four instances of mid-loop operations at PVNGS Units 1 and 2 since initial criticality of the units. The time required to achieve the mid-loop condition from power operations is different for each case. Based upon actual PVNGS experience, the time varies from a maximum of 22 days after power operations to a minimum of 4 days-3 hours. As an additional note, the current outage schedule for the upcoming Unit 1 refueling outage requires approximately 12.5 days to reach the mid-loop condition from power operations. Mid-loop operations are required during the Unit 1 refueling outage to support steam generator eddy current testing and RCP maintenance.

Mid-loop operations at PVNGS are governed by Technical Specification 3.4.1.4.2. This Specification requires two operable shutdown cooling loops with at least one loop in operation. Currently, there are no Technical Specification or procedural requirements concerning steam generator levels during mid-loop operations. However, during Mode 5 operations, the steam generators are normally kept in wet layup recirculation with a significant inventory of water on the secondary side. This water would normally be capable of supporting RCS heat removal unless the steam generator nozzle dams were installed. The nozzle dams isolate the steam generators which render them useless for decay heat removal.

During mid-loop operations, testing and maintenance activities are reviewed to assure minimal impact to shutdown cooling operations. Maintenance and testing activities during mid-loop operations are coordinated through the PVNGS Outage Management Department via a planned computerized schedule. There is typically a licensed operator assigned to the Unit Work Control Department to anticipate any Technical Specification or operational concerns such as activities that could perturb the RCS during mid-loop operations. The Unit Shift Supervisor is advised of upcoming tests and major equipment maintenance activities. Restrictions on testing and maintenance activities while the RCS is partially filled are based on the plant Technical Specifications. The outage schedule is typically derived from Technical Specification requirements, necessary maintenance and testing to be performed, and plant and equipment conditions required for these activities. With the Unit Shift Supervisor having direct responsibility for his unit, he can cancel or suspend any activity which he feels could result in a perturbation of the NSSS or that could result in an unacceptable risk of losing the shutdown cooling system.

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Concerning the capability of the RCS to withstand pressurization when the reactor vessel head and the steam generator manways are in place (i.e., RCS pressure boundary is intact), the only component which would have a limited pressurization capability is the tygon tubing used for the refueling level indication system. However, there are other evolutions which may be required during mid-loop operations, such as RCP maintenance or pressurizer standpipe work, which may render the RCS incapable of repressurization. The tygon tubing used at PVNGS has an allowable pressure rating of between 18 and 21 psig. It should be noted that the new, permanent refueling level system (discussed in the response to question #2) has the same pressurization capability due to the fact that tygon tubing is used as a backup level standpipe in the new system. The Low Temperature Overpressure (LTOP) relief valves on the shutdown cooling suction lines provide overpressure protection of the RCS while the RCS is partially filled.

The PVNGS Technical Specifications do not require containment integrity in Mode 5 with the RCS filled or partially filled. However, due to the recent loss of RHR incident at Diablo Canyon, ANPP has revised the loss of shutdown cooling procedure to include direction to evacuate personnel from the containment building, close the containment equipment hatch, close the containment air lock doors, and isolate penetrations to the outside atmosphere in the event that shutdown cooling flow is lost and cannot be restored. It has been determined, through a review of manpower requirements, tool needs, and required rigging, that in an emergency condition where the containment equipment hatch must be closed, it can be secured and held in place by a minimum of four bolts within one to four hours. The best case estimate of 1 hour is based upon: i) having adequate manpower available inside containment, ii) having the necessary tools immediately available to close the hatch, iii) no equipment is in the process of being moved through the hatch, and iv) the equipment hatch rails are not installed. The worst case estimate of 4 hours is based upon the opposite assumptions from the 1 hour case.

No procedural or Technical Specification requirements exist which would require the re-establishment of the RCS pressure boundary with the RCS at mid-loop levels while a loss of shutdown cooling occurred.

(2) NRC QUESTION

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, and 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.

ANPP RESPONSE

Proper operation of the Shutdown Cooling System (SDCS) is of extreme importance in controlling RCS parameters during mid-loop operations. The operation of the SDCS is controlled and monitored through the use of installed instrumentation. This instrumentation provides the capability to determine heat removal, cooldown rate, SDCS flow rate, and the capability to detect degradation in flow or heat removal capacity. The following table summarizes the instrumentation available during normal SDCS operations:

TABLE 1

INSTRUMENTATION FOR NORMAL SDCS OPERATIONS

MONITORED PARAMETER	INSTRUMENT NUMBERS	INSTRUMENT LOCATION	COMMENTS
Temperature	SIA-TT-303X SIB-TT-303Y	SDCS Heat Exchanger Outlet	SDCS heat exchanger outlet temperature is displayed on the main control board for both SDCS loops.
	SIA-TT-351X SIB-TT-352X	SDCS heat exchanger inlet	SDCS heat exchanger inlet temperature is displayed by a recorder on the main control board for each SDCS loop. This parameter is also displayed on the Remote Shutdown Panel (RSP).
	SIA-TT-351Y SIB-TT-352Y	LPSI header	Low Pressure Safety Injection (LPSI) header temperature is displayed by a recorder on the main control board and has indication at the RSP.

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TABLE 1

INSTRUMENTATION FOR NORMAL SDCS OPERATIONS
(Continued)

MONITORED PARAMETER	INSTRUMENT NUMBERS	INSTRUMENT LOCATION	COMMENTS
	CETs	Top of Fuel Assemblies	Core Exit Thermocouples (CETs) are provided at the top of the fuel assemblies and are displayed in the main control room via the Qualified Safety Parameter Display System (QSPDS). Availability of these instruments is dependent upon whether the fixed incore assemblies have been removed from the core to support refueling activities.
	HJTC Probes	Reactor Vessel	The two Heated Junction Thermocouple (HJTC) probes can be used for reactor vessel water temperature monitoring when the system is available. The system is normally disconnected during reactor head disassembly prior to refueling operations. Other than a refueling outage condition, the HJTC probes would be available for temperature monitoring.
	RCA-TT-112 H1 RCA-TT-122 H1	RCS Hot Leg RTDs	RCS hot leg temperature for loops 1 and 2 is displayed on recorders in the main control room.
Pressure	SIA-PT-303X SIB-PT-303Y	SDCS heat exchanger inlets	Pressure transmitters located on the inlet side of the SDCS heat exchangers and displayed in the main control room.
	SIA-PT-306 SIB-PT-307	LPSI to SDCS heat exchanger cross-tie lines	Pressure transmitters located on the cross-tie lines between the LPSI headers and the SDCS heat exchangers. This parameter is displayed in the main control room.

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TABLE 1

INSTRUMENTATION FOR NORMAL SDCS OPERATIONS
(Continued)

MONITORED PARAMETER	INSTRUMENT NUMBERS	INSTRUMENT LOCATION	COMMENTS
Flow	SIA-FT-306 SIB-FT-307	LPSI headers	Flow instruments are located on the SDCS return lines to the RCS and are displayed in the main control room and at the remote shutdown panel.
	SIA-FT-338 SIB-FT-348	CS Pump Discharge	If a CS pump is being utilized for shutdown cooling, then the pump discharge flow rate is displayed on the main control board.
Pump Status (Motor Amperage)	SIA-HS-5 SIA-HS-3 SIB-HS-6 SIB-HS-4	Motor amps for LPSI and CS pumps	Each pump that can be used for shutdown cooling (LPSI and CS) is provided with motor amperage indication on the main control board.
RCS Level	-	Refueling level indication system	The current tygon tube refueling level indication system consists of a tygon tube with one end installed just downstream of RCN-V214 and the upper end vented to the pressurizer via open vent valve RCN-V058. The system provides a visual display in the main control room by use of a closed circuit television (when installed) and can be monitored locally if the television display is unavailable.

In addition to the instrumentation that would alert the operator to a potential problem involving the residual heat removal function, Table 2 lists some of the alarms that could indicate a problem.

TABLE 2

ALARMS THAT COULD INDICATE SDCS PROBLEMS

WINDOW	DISPLAY	COMMENTS
2A09A	ESS CLG WTR SYS TRBL	This alarm would indicate a problem in the essential cooling water system. This system is an intermediate heat exchange loop that removes heat from the SDCS heat exchangers and transfers the heat to the essential spray pond system (ultimate heat sink).
2A09B 2A10B	ESS CLG WTR PMP A(B) DSCH PRESS HI-LO	These alarms would indicate either a high or low discharge pressure condition from the two essential cooling water pumps.
2A11A	ESP SYS TRBL	This alarm would indicate a problem in either of the two essential spray pond trains.
2A11B 2A12B	ESP PMP A(B) DSCH PRESS HI-LO	These alarms would indicate either a high or low discharge pressure condition from the two essential spray pond pumps.
7B03A	CNTMT SUMPS TRBL	The containment sumps trouble alarm could indicate abnormal amounts of leakage from systems inside containment.
2B01A	ESF EQPT RMS LVL HI	The ESF equipment rooms high level alarm could indicate abnormally high leakage from ESF equipment such as LPSI and CS pumps.
2B01B 2B02B	ESF TR A(B) EQPT RMS LVL HI-HI	The ESF equipment rooms high-high level alarm could also indicate abnormally high leakage from ESF equipment.

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TABLE 2

ALARMS THAT COULD INDICATE SDCS PROBLEMS
(Continued)

WINDOW	DISPLAY	COMMENTS
3A07A	REAC DRN LOOP TRBL	The reactor drain loops trouble alarm could indicate abnormally high amounts of drainage into the reactor drain tank.
2B06A 2B06B	LPSI/CS PMP TR A(B) FLOW LO	During SDCS operations, these alarms will alert the operator of a decrease in LPSI flow below a preselected alarm setpoint. Please note that this alarm is currently being installed in Unit 3. ANPP plans to install this alarm in Units 1 and 2 in the future.

During a total loss of shutdown cooling flow event, much of the instrumentation that was available to monitor the key RCS parameters during normal SDCS operations is lost. Table 3 summarizes the instrumentation that is left to monitor the condition of the RCS.

TABLE 3

INSTRUMENTATION FOR A TOTAL LOSS OF SDCS FLOW

MONITORED PARAMETER	INSTRUMENT NUMBERS	INSTRUMENT LOCATION	COMMENTS
Temperature	CETs	Top of Fuel Assemblies	CETs are provided at the top of the fuel assemblies and are displayed in the main control room via the QSPDS. Availability of these instruments is dependent upon whether the fixed incore assemblies have been removed from the core to support refueling activities.

TABLE 3

INSTRUMENTATION FOR A TOTAL LOSS OF SDCS FLOW
(Continued)

MONITORED PARAMETER	INSTRUMENT NUMBERS	INSTRUMENT LOCATION	COMMENTS
	HJTC Probes	Reactor Vessel	The two HJTC probes can be used for reactor vessel water temperature monitoring when the system is available. The system is normally disconnected during reactor head disassembly prior to refueling operations. Other than a refueling outage condition, the HJTC probes would be available for temperature monitoring.
RCS Level	-	Refueling level indication system	The current tygon tube refueling level indication system consists of a tygon tube with one end installed just downstream of RCN-V214 and the upper end vented to the pressurizer via open vent valve RCN-V058. The system provides a visual display in the main control room by use of a closed circuit television (when installed) and can be monitored locally if the television display is unavailable.

During mid-loop operations, PVNGS currently uses a tygon tube refueling level indication system that consists of a tygon tube which is connected to the SDCS loop A suction line via valve RCN-V214 with the upper end vented to the pressurizer via open vent valve RCN-V058. The installation of this tygon tube level indication system will be governed by a maintenance procedure which provides specific directions as to the length of hose, type of hose, hose connections, and the exact method of routing. By use of this system, the RCS level can be determined locally by inspecting the tygon tube or in the main control room by use of a closed circuit television (when available). ANPP has performed a calculation to determine the consequences of a complete failure of the tygon tube. The failure was assumed to occur at the connection of the tygon tube to the shutdown cooling suction line and the RCS was assumed to be drained to mid-loop with a pressure of 10 psig. The results of the calculation indicate a leak rate of less than 63 gpm from a rupture of the tygon tube. This quantity of leakage is within the makeup capability of either two charging pumps, or one HPSI pump, or one Boric Acid Makeup Pump (BAMP).

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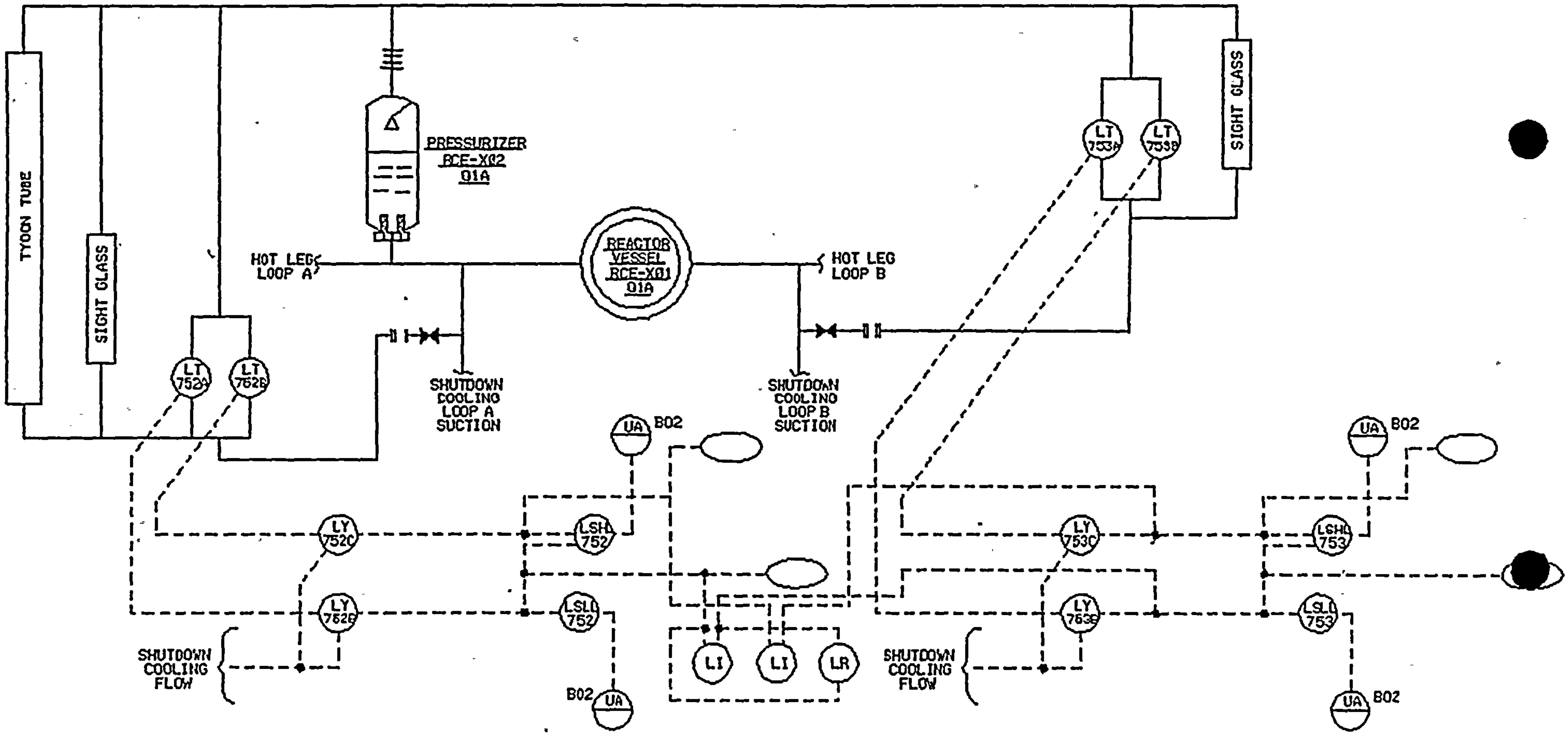
Although this tygon tube level indication system will be used during each units next refueling outage (and until such time as the new system is installed), ANPP is also initiating a modification to install a dedicated refueling level instrumentation system in each unit. The proposed system consists of control room level indicators receiving signals from the level transmitters (one wide range, one narrow range) on each hot leg. The level signals are sent to the main control room for display on two level indicators and one level recorder. The signals are also input to the plant computer for trending and to the plant annunciator system for main control room alarm output. The current plans are to provide the main control room with a high level alarm, a low level alarm and a low-low level alarm. Since the redundant systems tap off of the shutdown cooling suction lines, compensation is provided to correct the level signals during operation of the associated SDCS loop. This compensation is accomplished by characterizing the flow signals from the SIA-FT-306 and SIB-FT-307 transmitter loops and summing to the new level indication loop. Although final design work is still in progress, the new refueling level indication system is expected to resemble Figure 1.

Figure 1
Permanent Level
Indication System



(3) NRC QUESTION

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 TS requirements.

ANPP RESPONSE

For PVNGS, the pumps that are required to be operable or capable of operation are defined by the Technical Specifications. The applicable Technical Specifications along with the required pumps are listed below:

3.1.2.1 - This specification concerning boration flow paths requires either an operable charging pump, HPSI pump, or a LPSI pump.

3.4.1.4.2 - This specification, concerning shutdown cooling loops, requires two operable shutdown cooling loops with at least one loop in operation. A shutdown cooling loop can utilize either a LPSI pump or a Containment Spray (CS) pump.

3.1.2.3 - This specification currently states that one and only one charging pump shall be operable in Modes 5-6 whenever the RCS level is below the bottom of the pressurizer. Power is removed from the remaining two charging pumps while in this condition. However, ANPP has requested a change to this specification (reference ANPP Letter to NRC 161-00377 dated July 17, 1987). This change will allow for more than one charging pump to be operable when the RCS is drained to below the pressurizer.

Depending upon on-going maintenance activities, Technical Specifications, and system configurations, some of the charging pumps (3), HPSI pumps (2), LPSI pumps (2), and CS pumps (2) that are not specifically credited for meeting a Technical Specification requirement may also be functional and capable of being used to provide makeup to the RCS. Additionally, the following pumps are not Technical Specification related but can be used to control RCS inventory if they are available:

- Boric Acid Makeup Pumps (2)
- Reactor Makeup Water Pumps (2) - Note that these pumps take suction from a non-borated water source.

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(4) NRC QUESTION

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.

ANPP RESPONSE

In accordance with Technical Specification 3.6.1.1, primary containment integrity is maintained in Modes 1, 2, 3 and 4. Additionally, Technical Specification 3.9.4 requires Containment Building penetrations providing direct access from the containment atmosphere to the outside environment to be closed during Mode 6 core alterations or during the movement of irradiated fuel within the containment building. There are no Technical Specification or administrative requirements governing the containment closure condition during Mode 5 operations with the RCS partially filled. However, a normal practice at PVNGS is to maintain a slight negative pressure in the containment building, while in this condition, by using the refueling purge exhaust fans. This ensures that any release of radioactivity is monitored by the plant vent radiation monitors. Another normal practice at PVNGS is to install a sheet plastic cover over the containment equipment hatch opening. This cover allows access to containment but acts as a shield between the outside environment and containment to control contamination and to provide some protection against the release of airborne radioactivity. Additionally, should a total loss of SDCS occur while the RCS is partially filled, the operators are directed by procedure to take actions to close the containment equipment hatch, to implement containment integrity to the maximum extent possible, and to secure the refueling purge exhaust fans.

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(5) NRC QUESTION

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).

ANPP RESPONSE

The procedure for draining down the RCS to mid-loop (4XOP-XZZ06) utilizes the shutdown cooling purification flow being directed to the Holdup Tank as the normal flow path. Reference is made to an additional path utilizing a recirculation line off of the shutdown cooling pump and back to the Refueling Water Tank (RWT). Nitrogen is aligned to maintain a 1 to 2 psig pressure on the pressurizer and the reactor vessel head. Before the draindown starts, a refueling level indication system consisting of a tygon tube is connected to the loop 1 hot leg and to the top of the pressurizer. Prior to draining below 10% level in the pressurizer, an auxiliary operator is required to be in attendance at the refueling level indicator and in communication with the control room. A procedure change is currently in process to establish a procedural prerequisite that the RCS be cooled down to at least 100°F prior to draining the RCS. As an additional note, the summertime temperature conditions in Arizona may not allow for cooldown of the RCS to 100°F. With a maximum average temperature of 89°F in the spray ponds and two heat exchange loops to transfer heat through, there may not be a sufficiently large temperature differential to support a timely RCS cooldown. Thus, the procedural prerequisite is meant to apply only when it is achievable in a timely manner.

Per Technical Specification 3.4.1.4.2, the procedure requires both SDC loops to be operable when in a partially filled condition. When the desired level is achieved, the draindown is stopped and nitrogen is isolated. The procedure specifically directs the operator to not go below elevation 101'-4" which corresponds to the centerline of the hot leg. The pressurizer is then vented to containment through use of the RCS gas vent system. The Heated Junction Thermocouple (HJTC) system is maintained energized until the draindown has been completed at which time it is de-energized. This provides an additional level indication while the draindown operation is in progress. Procedural guidance is also provided for making adjustments to RCS level, as required, using a charging pump to increase level or the draindown path to lower level.

In the event SDCS is lost, the operator is directed to the Loss of Shutdown Cooling procedure (4XAO-XZZ22). This procedure is formatted to cover a loss of SDCS any time it is in service. The procedure is divided into sections relating to causes of the loss of SDCS (i.e., loss of inventory, loss of flow, loss of support systems).

i) The loss of inventory section addresses stopping cavitating SDCS pump(s), evacuating containment if the RCS is open to the containment atmosphere, and initiating makeup flow. The operators are then directed to have the containment equipment hatch closed and to implement containment integrity to the maximum extent possible. After level has been restored to the centerline of the hot leg or above, the operator is directed to start the SDCS loop which has a separate suction connection from the other hot leg. After ensuring the SDCS pump is running properly, an investigation is made into the loss of inventory.

ii) The loss of flow section attempts to restore flow by starting the standby SDCS loop and verifying the valve lineup. If flow can not be restored, the steam generators (if available), are used to remove decay heat by steaming or by feed and bleed. If the reactor vessel head is removed, makeup is initiated to ensure that the core remains covered until SDCS flow can be restored.

iii) The loss of support systems (Essential Cooling Water, Spray Pond, etc.) section attempts to restore heat removal by starting the standby SDCS loop, if available. If the support systems cannot be recovered, the operator is directed to the Loss of SDCS Flow section of the procedure.

iv) Appendices to the Loss of Shutdown Cooling procedure are provided to: (1) vent the SDCS system including each pump, (2) provide makeup from various sources/components, and (3) for cross-tying SDCS flow from one loop to the SDCS heat exchanger in the other loop.

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A procedure change is in process to direct the operators to utilize the CETs or HJTC probes for RCS temperature measurement following a loss of SDCS flow. The procedure directs the initiation of EPIP-02 (Event Classification) during the initial stages of the event. Cautions are in the procedure to not start a SDCS pump until level is verified to be at or above the center line of the hot leg and to reflect the immediate need to restore level and core cooling to prevent boiling in the core. The operator is directed to have the containment equipment hatch closed, to close at least one air lock door in each air lock, and to initiate a containment purge isolation signal if the RCS is open to containment.

Concerning the effects of air entrainment on the SDCS pumps (LPSI and CS), the most applicable data on this subject is considered to be that presented in NUREG-0897. Based on a series of tests done with various pump models, it is concluded in NUREG-0897 that at air entrainment levels of less than 3%, pump performance is not affected. At entrainment levels greater than 15%, the performance of most centrifugal pumps is fully degraded. Between 3% and 15%, the performance is specific to the pump and its piping configuration but would generally be expected to degrade exponentially with increasing air entrainment. ANPP does not have specific data concerning the air entrainment performance of our LPSI or CS pumps nor is it considered prudent to perform in-plant testing to gather this data. The only location where air can be expected to collect in the SDCS piping is in the cross-tie line to the CS pump suction from the LPSI pump SDCS suction line. This line can be vented via valves V018 (for Train A) and V019 (for Train B) which are the only local high points in the piping.

ANPP considers an analytical treatment of vortexing at the shutdown cooling nozzle to be ineffective. Such a treatment would require a scale model test so that unique geometrical and hydraulic conditions can be accounted for. However, plant operating experience demonstrates that at a RCS level elevation of 101'-4" and a shutdown cooling flow of 4400 gpm, shutdown cooling pump performance is not affected. From this known acceptable operating point, a minimum water level as a function of SDCS flowrate has been determined using established empirical relationships. This information only illustrates the operating margin available at reduced flow since PVNGS administrative controls prohibit operation below the hot leg centerline elevation of 101'-4".

The following procedural guidance has been provided to the operators to give directions on operator actions for normal SDCS operations at mid-loop and for responding to minor variations in SDCS pump performance:

1) During mid-loop operations, only one SDCS loop should be in operation (except during SDCS loop swaps) and the pump flow should be decreased to approximately 4100 gpm to reduce the chances of vortexing. Operation of more than 1 pump in a single SDCS loop during mid-loop conditions are not permitted.

2) If a SDCS pump (LPSI or CS) begins to experience flow or current oscillations at discrete intervals which are one minute or greater apart, RCS refill should be initiated immediately. It is not necessary to stop the pump in this case as no pump damage is expected.

3) If the pump flow/current oscillations remain at discrete intervals but occur with a frequency of less than 1 minute, then refill should be initiated immediately and pump flow should be reduced by throttling the valves (SIA-HV-657 and 306 for Train A; SIB-HV-658 and 307 for Train B).

4) If the fluctuations in pump flow/current are continuous or the periodic fluctuations persist after the flow rate has been reduced, then the pump should be tripped and RCS refill initiated if not already started. The pump should not be restarted until after level has been restored to above loop centerline and the pump casing has been vented.

Operation of SDCS loop A can have a significant effect on the temporary refueling level indication system. During normal operation of SDCS loop A, the pressure seen at the refueling water level connection is lowered due to flow dynamics. Therefore, with SDCS loop A in service, a correction factor (Δ H) must be applied to the indicated level in order to determine the actual RCS level. The correction factor is provided to the operators in the form of a curve in Appendix D of Procedure 4XOP-XZZ06. The introduction of air into the SDCS loop A suction line will have a definite effect on the level indicated by the tygon tube refueling level indication system and on the new refueling level indication system. The refueling water level connection is relatively close to the Loop 1 hot leg. A loss of SDCS and introduction of air into the SDCS loop A suction line will cause rather rapid pressure changes at the refueling water level connection. However, this monitoring of level fluctuations from the SDCS suction lines allows the air entrainment phenomenon to be observed. If for example, the level connection was connected to one of the RCS cold legs and not the hot leg (SDCS suction), the level could appear to be steady when in fact a pump was losing suction. Because the tygon tube refueling water level connection is off the SDCS suction line from the loop 1 hot leg, potential erroneous indication due to level differences between the SDCS suction connection and any other point in the RCS is avoided. This configuration also eliminates the potential erroneous level indication caused by entrained air pressurizing the cold legs of the RCS. Minor variations in level indications from expected behavior caused by air entrainment and de-entrainment are accommodated by operating the SDCS at a target RCS level several inches above the minimum allowable mid-loop elevation. This provides a margin for accommodating minor level perturbations.

ANPP has performed a calculation to determine heatup rates and the time to boiling in the event of a total loss of shutdown cooling. The calculation was made for the condition where the RCS was at mid-loop. The RCS temperature was assumed to be 100°F prior to the loss of SDCS event. The water in the active core region, the inactive core region above the active core region, and one-half of the upper plenum was considered for cooling the core. The core shroud and the fuel were also considered as part of the mass heating up. Water in the vessel downcomer, the lower plenum, and the heat loss through the pressure vessel wall were not considered in this analysis. The results of this

analysis are provided in Table 4. This table shows the decay heat loading (based on ANSI/ANS 5.1-1979 methodology), the heatup rate, and the time to boiling. Table 5 also provides the results of a calculation performed to determine the time to boil-off the coolant from a level of 7 inches below mid-loop to the top of the active core. For this calculation, the two steam generators were assumed to be unavailable for heat removal. Additionally, the water volumes considered for the boil-off calculation were the same as those assumed for the time to boiling calculation with the addition of the coolant in the RCS hot legs, cold legs, and the vessel downcomer to a level equivalent to the top of the active core. Onset of core damage is conservatively assumed to occur at the time when the coolant has boiled-off to the top of the active core.

TABLE 4

RCS HEATUP RATES AFTER A LOSS OF SHUTDOWN COOLING

Time Following Shutdown (Days)	Decay Heat Load (MWth)	Heat Up Rate (Deg F/Min)	Time From 100 Deg F to Boiling (Min)
0	236.6	120.1	0.9
0.5	25.2	12.8	8.8
1	20.5	10.4	10.8
2	16.8	8.5	13.2
3	15.3	7.8	14.4
4	14.3	7.3	15.3
5	13.0	6.6	17.0
10	10.3	5.2	21.5
15	8.8	4.5	24.9
20	7.8	4.0	28.0
30	6.6	3.3	33.9
40	5.7	2.9	38.6
50	4.9	2.5	44.8
80	4.3	2.2	50.9
100	3.3	1.7	65.9
200	2.1	1.1	101.8
300	1.6	0.8	140.0

[illegible]

TABLE 5

TIME TO BOIL TO TOP OF CORE AFTER A LOSS OF SHUTDOWN COOLING

Time (Days)	Volumetric Loss Rate (Ft^3/Min)	Time to Boil to Top of Core Once Boiling Starts (Min)	Total Time to Boil* to Top of Core After SDCS is Lost (Min)
0	232.2	2.9	3.8
0.5	24.6	27.2	36.0
1	20.1	33.2	44.0
2	16.4	40.8	54.0
3	15.0	44.6	59.0
4	14.0	47.7	63.0
5	12.7	52.6	69.6
10	10.1	66.2	87.7
15	8.6	77.7	102.6
20	7.6	87.9	115.9
30	6.5	102.8	136.7
40	5.6	119.3	157.9
50	4.8	139.2	184.0
80	4.2	159.1	210.0
100	3.2	208.8	274.7
200	2.1	318.2	420.0
300	1.6	417.7	557.7

* Time to Boil to Top of Core Once Boiling Starts + Time to Boiling from Table 4.

(6) NRC QUESTION

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.

ANPP RESPONSE

The licensed control room operators receive the training concerning loss of SDCS as part of their Simulator Courses A and B. Simulator Course A provides classroom and simulator training on abnormal operating procedure 4XAO-XZZ22 concerning loss of shutdown cooling. The training provides instruction on many aspects of the loss of SDCS event including: 1) instrumentation and alarms available for diagnosis of the event, 2) makeup flow paths for providing water to the RCS, 3) operator actions to recover from the loss of SDCS, and 4) operator actions in regards to establishing containment integrity. Simulator Course B provides classroom and simulator training on LOCA and Small Break LOCA events including discussion of NRC I&E Information Notice 86-101 which deals with the loss of decay heat removal capability due to a loss of fluid level in the RCS.

The licensed control room operators also receive training relevant to mid-loop operations as part of their requalification training. The requalification cycle (NLR05) that was presented from 07/06/87 through 08/14/87 included training on NRC Information Notice 86-101 and 87-23, INPO SEN #8, abnormal operating procedure 4XAO-XZZ22, and simulator training on loss of shutdown cooling.

The Auxiliary Operators (AOs) do not currently receive training in regards to loss of shutdown cooling or mid-loop operations. However, the training program will be revised to include training to the AOs for reading the tygon tube level indication system and for the effect of a bubble on the level indication system.

Future changes to the training program for license candidates include training on: 1) the causes and consequences of vortexing, 2) the accuracy of the level detection system, 3) heatup rates for a loss of SDCS event, and 4) the effects of operating history and time since shutdown on heatup rates.

ANPP does not believe that it is necessary for training to be provided to maintenance personnel so that they can fully understand the operation of plant systems. It is the responsibility of the operations personnel and the work control group to arrange and schedule work so as to minimize the potential for a loss of SDCS event.

(7) NRC QUESTION

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.

ANPP RESPONSE

ANPP provides at least one Shift Technical Advisor (STA) on site for each shift. The STA provides onsite technical support to the Unit Shift Supervisors in the areas of thermal hydraulics, reactor engineering, and plant analysis with regards to operational safety. The STA is available to provide support to the Operations staff during normal mid-loop operations and in the unlikely event of a total loss of shutdown cooling.

(8) NRC QUESTION

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.

ANPP RESPONSE

ANPP has compared the requirements and equipment configurations for normal (RCS filled) Mode 5 operations with those for the condition where the RCS is partially filled. In both cases, the required equipment conditions are bounded by the Technical Specification requirements. The major differences are listed below:

1) During operations with the RCS partially filled, a tygon tube level indication system is utilized for RCS level indication. This compares to the normal pressurizer level instrument which is used when the RCS is filled.

2) As described in the response to question #5, a procedural prerequisite is being established to cooldown the RCS to at least 100°F (when possible) prior to RCS draindown. This compares to a maximum temperature of 210°F for Mode 5 operations with the RCS filled. Additionally, the pressurizer heaters are de-energized during operations with the RCS partially filled.

3) During operations with the RCS partially filled the SDC flow rates differ depending upon the number of loops/pumps in service and the level in the RCS. The flow rates are specified to prevent vortexing.

4) The HJTC system is normally operational when the RCS is filled and is de-energized once the RCS drain down process has been completed. The heaters in the HJTC system can be de-energized when the RCS is at mid-loop. While this action renders the system incapable of measuring level, the system can still be used to determine RCS temperature. The HJTC probes can be used for temperature measurement until such time as they are disconnected during reactor head disassembly prior to refueling operations.

(9) NRC QUESTION

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.

ANPP RESPONSE

ANPP has developed several procedural and design related improvements to further ensure that mid-loop operations can be safely conducted at PVNGS. These improvements are listed below. It should be noted that these upgrades have been developed in response to the many industry advisories that have been published on this subject over the past several years in addition to the NRC 50.54(f) letter.

(1) Implementation of the design change to install a permanent refueling level indication system in each of the PVNGS units. As discussed in the response to question 2, it is expected that this system will consist of separate level indication from each of the RCS hot legs with compensation for SDCS flow and indications and alarms in the main control room. Final engineering work on the design is still in process with a projected completion date for the design of June 30, 1988. Based upon completion of the design work by this time, it is expected that the permanent refueling level indication system will be installed during the second refueling outages for Units 1 and 2. Additionally, installation of the modification in Unit 3 is expected to be completed during the first refueling outage.

(2) When possible, maintain at least two operational Core Exit Thermocouples (CETs) or an operational Heated Junction Thermocouple (HJTC) probe capable of displaying RCS temperature in the main control room. The availability of the HJTCs during operation with the RCS at mid-loop is limited by the fact that the instruments must be disconnected and removed during reactor closure head disassembly in preparation for refueling activities. The CETs availability is dependent upon whether the fixed incore assemblies have been removed from the core to support refueling activities.

(3) In order to provide the capability to makeup to the RCS, a procedural prerequisite will state that at least one HPSI pump will be maintained operational during mid-loop operations. The HPSI pump will be capable of taking suction from the Refueling Water Tank (RWT) and providing makeup to either a RCS hot leg or cold leg.

(4) During mid-loop operations, the time that the containment equipment hatch is opened will be minimized by use of administrative controls through procedure 4XOP-XZZ06 and through the use of an outage schedule. The opening of the hatch during mid-loop operations will be governed by the need to move equipment through the hatch.

(5) Due to the fact that the shutdown cooling suction isolation valves have been shown to be a large contributor to loss of RHR events, ANPP is investigating the possibility of disabling the SDCS suction valve interlocks during plant conditions where SDCS operation is vital to plant safety.

(6) A low flow alarm for the SDCS system will be totally implemented during future planned system outages in the PVNGS units. The alarm will alert the operators when LPSI flow decreases below a fixed setpoint during SDCS operations or when the combined LPSI and CS flow decrease below a fixed setpoint during SDCS operations.

(7) The Auxiliary Operators will be trained on the use of the tygon tube level indicating system. Also, ANPP is planning to upgrade the simulator so that it can more accurately simulate mid-loop operations.

(8) The loss of shutdown cooling procedure has been revised to provide additional directions for coping with this event. Some of the procedure changes that have been made since the Diablo Canyon event include: i) added a requirement for establishing containment penetration control to prevent direct access from containment to the outside atmosphere if the RCS is open to the containment atmosphere, ii) re-formatted the procedure to separate the different causes for the degraded SDCS condition (i.e., loss of inventory, loss of support systems, and loss of flow), iii) added cautions to the procedure to warn the operator of the urgency of restoring core cooling to prevent boiling from occurring in the reactor vessel, and iv) added directions to the procedure for venting the SDCS trains. Additional information on heatup rates, time to boil, and time to core damage will be incorporated in the procedure. The operators will also be directed to use the heatup rate tables if no RCS temperature instrumentation is available.

(9) A procedure is being developed to provide specific instructions on the proper installation of the temporary refueling level indication system. This procedure will be in place prior to the installation of the tygon tube level system during the first refueling outage of Unit 1.