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(9-83)

U.S. NUCLEAR REGULATORY COMMISSION
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LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
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TITLE (4)
LICENSEE EVENT REPORT 95-006 - INADEQUATE AUXILIARY FEEDWATER PUMP LOW SUCTION PRESSURE TRIP SETPOINTS

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (6)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	
									N/A	0 5 0 0 0
0 6	2 9	9 5	9 5	- 0 0 6	- 0 0	0 8	2 1	9 5	N/A	0 5 0 0 0

OPERATING MODE (9)	N	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)			
POWER LEVEL (10)	0 0 0	20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
		20.405(a)(1)(i)	50.36(c)(1)	50.73(a)(2)(v)	73.71(c)
		20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vii)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
		20.405(a)(1)(iii)	X 50.73(a)(2)(i)	50.73(a)(2)(viii)(A)	
		20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(viii)(B)	
		20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
	AREA CODE
WILLIAM L ROBERTS, STAFF LICENSING ENGINEER	6 1 6 7 6 4 - 8 9 1 3

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On June 29, 1995 the plant was in cold shutdown for refueling. A self-initiated review by a plant engineer determined that the auxiliary feedwater system had not adequately addressed protection of the auxiliary feedwater pumps from vortexing or air entrapment at low condensate storage tank levels. Analyses determined that the auxiliary feedwater pumps were susceptible to vortexing or air entrapment in the pump suction which could lead to pump damage. Additional reviews completed as a result of this discovery also determined that the low suction pressure trip (LSPT) setpoint for the auxiliary feedwater pumps had been set improperly. From these two discoveries it was determined that the 100,000 gallon technical specification for condensate being available during plant operation had not been met on various occasions. Since the plant was in cold shutdown and the auxiliary feedwater system not required for safety related plant operation, no immediate operational actions were needed.

Calculations were completed to determine what the appropriate LSPT settings should be to protect the pumps from vortexing or air entrapment and ensure the technical specification limits were met. Appropriate plant instrumentation was adjusted to reflect the new settings and plant procedures changed as necessary to reflect the revised plant condition.

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EVENT DESCRIPTION

On June 29, 1995 the plant was in cold shutdown for refueling. A self-initiated review by a plant engineer determined that the auxiliary feedwater system had not adequately addressed protection of the auxiliary feedwater pumps from vortexing or air entrapment at low condensate storage tank levels. Analyses determined that the auxiliary feedwater pumps were susceptible to vortexing or air entrapment in the pump suction which could lead to pump damage. Additional reviews completed as a result of this discovery also determined that the low suction pressure trip (LSPT) setpoint for the auxiliary feedwater pumps had been set improperly. From these two discoveries it was determined that the 100,000 gallon technical specification for condensate being available during plant operation had not been met on various occasions. Since the plant was in cold shutdown and the auxiliary feedwater system not required for safety related plant operation, no immediate operational actions were needed.

Reviews were initiated to determine what effect taking an allowance for pump suction vortexing would have on the three auxiliary feedwater pumps (P-8A, P-8B, and P-8C). Reviews were also initiated to determine if the technical specification required 100,000 gallon inventory would have been assured when a pump suction vortexing allowance was taken. Those analyses that were reviewed included those completed to determine minimum water inventory needed to support a station blackout, how the identified condition may affect an Anticipated Transient Without Scram (ATWS) event, and the effect the condition may have on the auxiliary feedwater inventory warning light on the Appendix R alternate shutdown panel (C-150).

As part of the response to the discovery of this condition, the interior of T-2 was inspected to determine if a vortex breaker was present in the auxiliary feedwater suction pipe opening. While a vortex breaker was not seen, the auxiliary feedwater suction to the tank was found to end in a ten inch standpipe protruding upward into T-2. The standpipe was not documented on any plant drawing and its existence was not considered in any plant analysis. Reviews of the affected analyses were also made to determine the affect the 10 inch standpipe had on the pump vortexing issue and providing the technical specification required water inventory.

During the investigation it was also determined that the low suction pressure trip devices used to protect the auxiliary feedwater pumps are standard pressure transmitters with their sensors located near the suction of the auxiliary feedwater pumps. Since the pump protection transmitter pressure settings did not come directly from a tank level switch, it was determined that the suction pressure in the pump suction pipe would vary with flow. It was further concluded that the pump protection set-point should take into account the flow rate and its affect on the pressure in the pumps suction pipe when determining how the transmitters should be set for pump low suction pressure trip. A review of the plant calculations determined that no allowance had been included in the calculations to account for a pressure change in the pump suction piping due to flow. Analyses were completed and calculation inputs revised to determine what affect the pump flow rate would have on the pump low suction pressure trip settings.

The results of these reviews determined that in many cases the auxiliary feedwater pumps had not been adequately protected from a pump trip due to vortexing or air entrapment, and that the 100,000 gallon technical specification required tank inventory would not have been available during all required post accident scenario's.

This condition is reportable in accordance with 10 CFR 50.73(a)(2)(i) as a condition prohibited by the Palisades Technical Specifications.

CAUSE OF THE EVENT

The root cause of this condition (inadequate AFW pump protection) is that the design of the auxiliary feedwater system suction piping failed to consider suction vortexing and plant analyses to support system operation also failed to address vortexing as a design input. This is a design basis deficiency as it is standard engineering practice to consider, and mitigate, suction vortexing in pump intakes. Design considerations include designing the intake to prevent vortexing and preventing pump operation in regimes were vortexing/air entrapment is possible. No documentation was found to indicate that the AFW pump suction was designed to prevent vortexing.

ANALYSIS OF THE EVENT

I. *SYSTEM DESCRIPTION*

The Palisades auxiliary feedwater (AFW) system consists of two trains taking suction from a common condensate storage tank (T-2), and discharging through redundant piping trains to common steam generator nozzles. Train one consists of a motor-driven pump (P-8A) in parallel with a steam driven pump (P-8B) located in the auxiliary feedwater pump room. The pumps share common suction and discharge lines. Train two consists of a motor-driven pump (P-8C) which is located in the west engineered safeguards room. This pump was converted from a high pressure safety injection pump in the early 1980's. Both trains share a common outlet nozzle on the condensate storage tank. Similarly, the discharge lines for both trains combine at the steam generator auxiliary feedwater nozzle.

The auxiliary feedwater pumps are protected against loss of net positive suction head (NPSH) by low suction pressure trip (LSPT) devices. At the time of original Plant construction, the LSPT function for P-8A and P-8B was provided by a single pressure switch. After the Three Mile Island accident, Palisades changed the single pressure switch to three pressure switches (2/3 logic). These were non-safety grade switches. Later, the pressure switches were replaced with safety related pressure transmitter loops.

In the current system configuration, pumps P-8A and P-8B share three LSPT devices; P-8C has an independent set of three devices. In each case, it takes two out of three devices to trip an auxiliary feedwater pump. The setpoints of the LSPT devices ensure that, under ideal conditions, the pumps will trip before the $NPSH_A$ falls below the $NPSH_R$ for the pumps.

The setpoint calculations for the AFW LSPT devices correctly account for the hydraulic losses in the AFW pump suction piping from the pressure transmitter taps to the pump. The setpoint calculations also calculated a corresponding water level in the suction piping. Until this investigation, the calculated water levels have been assumed to be correct under all conditions. Because the level calculations do not include the effects of hydraulic losses in the AFW pump suction piping from the T-2 tank trip level to the pressure transmitter taps, they are incomplete and misleading. The calculated T-2 tank water levels are valid only for a flow rate of zero gpm.

Because hydraulic losses vary with flow rate, the water level at the time of pump trip will vary with the AFW flow rate existing at the time of the trip. Figures 1,2, and 3 (attached) illustrate the effective water level at trip versus AFW flow for each of the three AFW pumps for the old LSPT setpoints. As can be seen, for P-8A/B, the water level at the time of trip could be either above or below the bottom of the condensate storage tank (at elevation 590'). The water level at trip for P-8C never rises above the bottom of T-2. Several plant conditions and analyses can be affected by the variable water level at trip. Each is addressed in the discussion that follows.

A. *Pump Protection And Condensate Inventory Requirements*

1. Trip Level Below the Bottom of T-2

As shown on Figures 1, 2, and 3, the effective water level at the time of a LSPT would be below the bottom of T-2 for all practical flows with P-8C and for flows less than about 325 gpm for P-8A and P-8B. Pump suction pipe is typically designed such that the suction outlet is always covered with a minimum water level or submergence. The minimum submergence ensures that vortexing and air entrapment are prevented or at least limited to acceptable values during pump operation. Sometimes a vortex breaker of some form is included in the suction line. The vortex breaker will reduce the minimum submergence value but will not eliminate it. A review of available vendor files, purchase specifications, and drawings, showed that no vortex breaker is installed the AFW pump suction line at Palisades. This was confirmed during a special tank inspection completed during this refueling outage.

An alternative to a vortex breaker is to trip the pump before the water level drops below a predetermined value. This would be performed by level-sensing devices in the tank. Palisades does not provide pump protection based on a tank level sensing device.

The lack of protection from vortexing/air entrapment for the AFW pumps is contrary to the following statements from FSAR section 7.1 and 7.4.1.8.5, respectively:

"The Plant systems are instrumented to provide information on Plant conditions at selected locations, *to protect equipment and personnel from undesirable conditions*, and to control the Plant during start-up, operation, and shutdown."

and

"Redundant pressure switches are provided to trip (three switches; two of three required for trip) the auxiliary feedwater pumps on low suction pressure, *thus avoiding pump failure due to low or nonexistent tank level.*"

The existing condition of the AFW pumps being allowed to trip at water levels below the bottom of T-2 is not in accordance with the FSAR nor with good engineering practice. A review of operating procedures did not reveal the existence of a compensating strategy (e.g. having the operators trip the running AFW pump(s) as condensate storage tank level gets low). The operators are directed to line up alternate suction sources as required, but it appears that the AFW pumps would still be allowed to trip automatically if necessary.

This condition appears to have existed at least since the installation of the third AFW pump in the early 1980's. The historical record prior to adding the third auxiliary feedwater pump is unclear.

a. Safety Significance

Since Palisades does not always provide a minimum submergence level in the condensate storage tank and does not have a vortex breaker, the AFW pumps are deemed susceptible to vortexing and air entrapment at the pump suction. A contractors report confirms this and determines that pump operability cannot be assured for water levels in the condensate storage tank below the minimum submergence depth. This means that the possibility of damaging an AFW pump by operating it with low water levels in T-2 exists. The contractors report also provides equations for determining the required submergence

levels to limit vortexing or limit air entrapment to an acceptable level. These curves are plotted on Figures 1, 2, and 3 above.

2. Trip Level Above the Bottom of T-2

At certain AFW flow rates, or when instrument uncertainties are considered, the existing LSPT setpoints could allow AFW pumps P-8A and P-8B to trip at water levels above the bottom of the condensate storage tank. While this may be acceptable with respect to vortex/air entrapment control, it has the undesired effect of leaving a quantity of water unused in T-2. This condition will negatively affect the availability of 100,000 gallons of condensate as required by Technical Specification 3.5.1.e.

After the Spring 1994 forced outage, condensate inventory calculations assumed the AFW pumps would drain the condensate storage tank. This was based on the belief that the water level at LSPT as calculated in the setpoint analysis (i.e. below the bottom of T-2) was correct and acceptable. With the possibility that P-8A and P-8B would have tripped with water remaining in T-2 (depending on the completely variable AFW flow rate), the Plant would have been outside the limits of the inventory calculation during power operation after the Spring of 1994. Availability of the 100,000 gallons would not have been assured for all AFW flow rates during the recent period of power operation.

For plant operation prior to the Spring 1994 forced outage, analysis completed to resolve an earlier concern over assuring the required T-2 plant inventory (E-PAL-94-019), determined that several instances had previously occurred wherein the required 100,000 gallon inventory was not available. These were cases where T-2 level had fallen below 60%. With the possibility that P-8A and P-8B would have tripped with water remaining in the CST, it is likely that more cases exist. Inventory calculations tend to confirm this conclusion. With T-2 at 60% (the old low level alarm setpoint) and a trip level of 2.5 feet in the tank, the available water is approximately 93,000 gallons. With a trip level of 1.488 feet, the available water is approximately 100,000 gallons. This last trip level corresponds to AFW flow rates of approximately 400 to 425 gpm from P-8A and P-8B. Even though these flow rates are higher than the nominal AFW flow rate, it may not be possible to assure 100,000 gallons would have been available under all conditions. The inventory calculation for 1.488 ft also assumed the 3" valves between T-2 and T-81 were opened to help move water into T-2. Prior to the Spring of 1994, the operating procedures instructed the operators to open the 1.5" bypass valves. Additionally, the nitrogen fixture for opening the 3" valves under loss-of-power conditions did not exist prior to the Spring of 1994.

Without this fixture, the operators would be limited to using the 1.5" bypass valves. It is doubtful if the operators could have transferred enough water from T-81 to assure the availability of the required 100,000 gallons. Further analysis is required to determine exactly the AFW flow rates above which the Plant would not have had 100,000 gallons.

Finally, since the operability of the AFW pumps can not be assured at low tank levels due to excessive air entrapment, it is possible that the pumps would not have been able to drain T-2 as assumed in the calculations completed to resolve the Spring 1994 tank inventory problem. This is essentially the same situation as just described.

The omission of hydraulic losses from the low suction pressure trip (LSPT) setpoint calculation has implications for recent low suction pressure trip setpoint and condensate inventory calculations. These all assumed T-2 was drained to the bottom of the tank. This assumption was based on the LSPT setpoint analysis. Revision 0 of the newly revised LSPT setpoint calculations also assumed the earlier calculation was correct. Revision 1 of the latest inventory calculation, which correctly dispositioned the hydraulic losses in the upper 3 feet of suction piping, assumed the hydraulic losses for the lower suction piping were handled in the early LSPT calculations.

a. Safety Significance

This evaluation concludes that the existing LSPT setpoints for auxiliary feedwater pumps P-8A, P-8B, and P-8C would have allowed AFW system operation outside the limits of the condensate inventory calculation during the recent operating period (from the Spring 1994 forced outage to the 95 Refout), outside the FSAR description (due to inadequate AFW pump protection from air entrapment), and outside the requirements of Technical Specification 3.5.1.e (the 100,000 available gallons could not be assured at all AFW flow rates).

Despite the Plant's inability to meet the 100,000 gallon inventory requirement, the long-term decay heat removal function of the auxiliary feedwater system was not imperiled. The ultimate backup sources for the condensate storage tank, the Fire Protection System and the Service Water System, would have been available to supply water to the AFW pumps.

B. *Auxiliary Shutdown Panel C-150 P-8B Low Suction Pressure Light*

Palisades installed the C-150 panel to comply with the requirements of 10CFR50 Appendix R. This panel contains controls that let the operators use P-8B if a fire in the plant control room would require the control room to be evacuated. When P-8B is operated from this panel, the normal pump low suction pressure trip logic is bypassed and the pump will not automatically trip at any tank level or suction pressure. Instead of an automatic trip, Palisades relies on operator action to switch the suction source from the CST to the Fire Protection System before the CST empties. The initiator for this operator action is an alarm light on the C-150 panel. This light is designed to illuminate when 20 minutes of inventory remains in T-2. Per Technical Specification 3.17.5, the "P-8B Suction Pressure Alarm" shall be operable whenever the PCS is > 300°F. Finally, the C-150 panel light is mentioned in Off Normal Procedure ONP-25.2 as indicating 20 minutes are available to shift the AFW pump suction source.

The setpoint for PS-0741D, the device which activates the light on C-150, was originally calculated in 1985. This switch is also located on the suction piping of the pump. The original PS-0741D setpoint was determined to be 7.75 psig ± 0.5 psi. The calculation for this setpoint assumed that T-2 would be drained to the bottom of the tank. No allowance was made for a minimum submergence level to limit vortexing/air entrapment. For this reason, it seems possible that P-8B could be damaged by air entrapment sometime during the 20 minute interval.

Several anomalies with the 1985 PS-0741D setpoint calculation were evaluated in plant Deviation Report, D-PAL-93-187. This Deviation Report was initiated when PS-0741D was found to be out-of-tolerance in a non-conservative direction. The evaluation noted that the 1985 calculation did not include hydraulic losses between T-2 and the pressure switch. When this was factored in, the actual level in T-2 at the setpoint would have been much higher than necessary for a 20 minute warning. (The level varies with the flow rate, as discussed above.)

The evaluation in D-PAL-93-187 determined that the as-found PS-0741D setpoint was acceptable at an AFW flow rate of 400 gpm. This conclusion is suspect since it determined that the light would have illuminated when T-2 level reached 1 foot above the bottom of the tank. This is less than the 1.5 foot necessary for 20 minutes of P-8B operation. Other flow rates were not evaluated.

As part of D-PAL-93-187, a new analysis reevaluated the setpoint calculation for PS-0741D. This EA also assumed that T-2 was completely drained. It also did not consider hydraulic losses.

The analysis concluded that the 7.75 psig setpoint was acceptable. As shown in the figure 4, the alarm light would have come on at elevations much higher than desired. Note that 20 minutes of AFW pump operation is about 1.5 feet of water in T-2. Also, even if the setpoint had drifted by the maximum allowable amount in the negative direction (1 psig), more than 20 minutes of water would have been available, no matter what AFW flow rate existed.

Finally, with the setpoint found in August 1993, the required inventory for 20 minutes of operation would not have generally been available. Note that no root cause for the low setpoint was ever identified.

1. Safety Significance

With the designed switch setting, more than 20 minutes of water inventory would have been available in the condensate storage tank when the switch actuated. This would be true since the time the switch was installed except for the period when the switch was found not set properly. This condition would have existed for an unknown period of time not longer than the period between the 8/9/93 calibration of PS-0741D and the previous calibration (Figure 5).

C. *Station Blackout Analysis*

Palisades analysis for the Station Blackout event was accepted by the NRC in an SER dated 5/20/91. Palisades determined that 56,000 gallons of water was necessary to remove decay heat for the 4 hour Station Blackout. The NRC revised this value to 57,100 gallons in their SER. Per the station blackout calculation, 57,100 gallons must be available in the condensate storage tank during power operations. This is part of Palisades licensing basis. This volume of water does not include an allowance for a minimum submergence for vortex/air entrapment control.

When the necessary submergence to ensure no more than 5% air entrapment at 346 gpm (0.73 ft) is converted to a volume, an additional 3360 gallons must be maintained in T-2. As a result, the total volume required for the station blackout is ≈ 60500 gallons. This corresponds to a level of about 45% in T-2.

1. Safety Significance

Since this 45% level is lower than both the old and existing T-2 low level alarm setpoints, Palisades has maintained sufficient water in T-2 to cope with a 4 hour station blackout and prevent pump damage due to air entrapment. This has been true since the Station Blackout analysis was accepted.

D. *Anticipated Transient Without SCRAM (ATWS)*

As part of the modifications performed to deal with an ATWS event, Palisades modified the start circuitry for P-8B to allow the pump to automatically start upon a loss of DC Bus D11. This modification was performed during the 1990 Refueling Outage. When P-8B is started in this manner, the low suction pressure trip devices will be unable to stop the pump under any condition. It is possible that P-8B could run until damaged by air entrapment at low tank levels.

1. Safety Significance

This evaluation considers this possibility to be remote for the following reason: An ATWS occurs, by definition, with the Plant at power. In this condition, Palisades is required to have 100,000 available gallons of condensate. This amount of inventory would provide P-8B with several hours of running time before T-2 is drained. The operators would have sufficient time to take control of AFW in general and P-8B in particular. If the need for AFW continues, the operators would likely shift to P-8C for long term operation. Low suction pressure trip protection will operate for P-8C in an ATWS event (although not without difficulties, as described above).

E. *Auxiliary Feedwater Pump P-8C Suction Line*

The suction line from the condensate storage tank to P-8C, in combination with the existing LSPT setpoint for the pump creates a set of potential problems. The possibility that the pump will be damaged by air entrapment at low tank levels is discussed above. This section will focus on the necessary recovery actions after a low suction pressure trip of P-8C.

After an approximate 355' run of pipe, the suction line for P-8C rises to an elevation of about 592' for a length of 46'. This section of pipe is about 2' higher than the bottom of T-2. If P-8C is operating at low tank levels (as might occur, for example, following a seismic event), air entrained at the tank may accumulate in the elevated portion of the pipe, eventually disrupting flow to the pump.

Also, the current LSPT setpoint for P-8C has an equivalent water level that is about 5' above the pump. Assuming the flow rate is 330 gpm, the flow velocity will be about 3.3 ft/sec. At this flow rate, it would take less than 2 seconds to drain the suction piping down to the pump. Since the LSPT devices have a 5 second delay, it is assured that the piping, and most likely P-8C, will be voided before the trip occurs. Palisades believes that the pump should survive this brief excursion into void operation.

When P-8C is to be placed back in service, it will be important to vent the pump casing and the elevated portion of the suction piping. System Operating Procedure SOP 12 contains an attachment containing instructions for venting various parts of the AFW system. This attachment is intended for use after system maintenance, not during the response to a plant transient. It is concluded that the operating procedures (ARPs, SOPs, etc.) should be reviewed and adjusted as necessary to ensure the operators are aware of the need to vent the elevated portion of P-8C's suction line, as well as P-8C itself, following a low suction pressure trip of the pump. Note that a similar concern may apply to the elevated portion of suction piping between P-8B and P-8A.

1. Safety Significance

Operating procedures exist that contain the information needed to start the pump following a scenario where air is contained in the system. We believe that the pump could be restarted.

II. *EVALUATION OF THE CONSEQUENCES OF THE RECENTLY DISCOVERED TEN-INCH AFW STANDPIPE IN T-2*

As one of the short-term actions performed as the result of the discovery of this condition, the AFW suction nozzle in the condensate storage tank was visually inspected to determine whether or not a vortex breaker was present. While a vortex breaker was not seen, the AFW suction pipe was observed to end in a ten inch standpipe protruding upward into T-2. The standpipe is not documented on any known Plant drawing nor is it considered in any known analysis. Condition Report C-PAL-95-1104 was initiated to evaluate the condition. The evaluation of the impact of the standpipe on the AFW system is incorporated into this condition report evaluation for the sake of completeness.

This evaluation addresses the effect of the standpipe on past operability. Future operability is not a problem because the standpipe has been cut down to an acceptable length.

The impact of the standpipe stems from the direct exclusion of 10" of T-2 inventory from use by the auxiliary feedwater system. This is equivalent to approximately 3840 gallons of water. This is independent of AFW flow rate, any LSPT devices, or which AFW pump is in operation. The standpipe also raises the effective minimum submergence level by ten inches. It does not change the effective water level at the time of a low suction pressure trip; this is still determined by AFW suction flow rate and the hydraulic losses in the piping. Note that the hydraulic losses associated with the standpipe are assumed to be negligible due to the short length of the standpipe.

The presence of the standpipe has the following effect(s) on the issues discussed above:

A. *Pump Protection And Condensate Inventory Requirements*

1. Trip Level Below the Bottom of T-2

The presence of the standpipe effectively "raises" the bottom of T-2 by ten inches. This expands the range of AFW flow rates for which the effective water level at the time of a low suction pressure trip is below the bottom of the tank. To get an idea of the effect of the standpipe, visualize the "5% air limit" and "No Vortex" lines on Figures 1, 2, and 3 raised by 0.83 feet.

a. Safety Significance

The standpipe essentially reduces the already inadequate level of protection afforded the AFW pumps.

2. Trip Level Above the Bottom of T-2

The presence of the standpipe exacerbates the inventory situation by directly excluding approximately 3840 gallons of water from use by the AFW system. This quantity of water is independent of AFW pump, AFW flow rate, or suction pipe hydraulic losses. It also raises the effective water level in T-2 at which the AFW pumps could be damaged due to air entrapment. Essentially, with the standpipe installed, there was a greater probability of AFW pump damage or of not having the required 100,000 gallons of inventory.

For Plant operation after the Spring 1994 forced outage, there was less assurance that the 100,000 gallons would have been available. The degree of assurance is difficult to quantify without extensive analysis.

For Plant operation prior to the Spring 1994 forced outage, the reduction in available T-2 inventory caused by the standpipe would be expected to increase the number of instances in which the Plant would not have had 100,000 gallons of water available. If T-2 level had ever been allowed to drop as far as the low level alarm setpoint, 50%, only about 90,000 gallons would have been available.

In addition to the problems discussed above, the existence of the AFW standpipe renders all known calculations of condensate inventory at Palisades non-conservative. This applies primarily to the equations/methodology used to determine condensate storage tank inventory as listed in the Technical Data Book,

Figure 9.1 and the Emergency Operating Procedures. All such estimates would overestimate the available condensate by approximately 3840 gallons. It is unknown how long this condition has existed at Palisades.

a. Safety Significance

With the standpipe installed, there was a greater probability of AFW pump damage or of not having the required 100,000 gallons of inventory.

B. *Auxiliary Shutdown Panel C-150, P-8B Low Suction Pressure Light*

The presence of the standpipe renders the previous setpoint calculations for PS-0741D incorrect as they were based on ensuring a 1.5' depth of water above the bottom of T-2 at the time of activation. With the standpipe in place, the setpoint would have had to ensure a total of 2.33 feet of water in the tank (not including the minimum submergence depth for air entrapment limitations).

The only positive point is that, because the setpoint calculations do not consider the effect of the suction piping hydraulic losses, the effective water level at low suction pressure trip is higher than the 2.33 foot requirement. This is true even when the maximum allowable negative uncertainty is considered.

1. Safety Significance

An adequate supply of water has always been assured as long as the setpoint for PS-0741D is within the proper calibration band. See Figure 5.

However, for the setpoint evaluated in D-PAL-93-187, the required 20 minutes of operation would not have been available at any AFW flow rate if the ten inch pipe stub and minimum submergence depth are considered. See Figure 5. This condition would have existed for an unknown period of time not longer than the period between the 8/23/93 calibration of PS-0741D and the previous calibration.

C. *Station Blackout Analysis*

The earlier discussion of the volume of water required for a 4 hour station blackout event concludes that a minimum of approximately 60,500 gallons is required in the condensate storage tank. For the original standpipe, another 3840 gallons must be added. This brings the total quantity of water available in T-2 to 64,340 gallons or approximately 48%. This is still lower than both the old, and existing, low level alarm setpoints for T-2.

For the future, the minimum volume of water in T-2 required to cope with the 4 hour station blackout must account for the final pipe stub height of 1.25". This corresponds to a volume of approximately 480 gallons. Thus, the minimum volume of water that must be maintained in T-2 in order to cope with a station blackout event is 57,100 + 3360 + 480 ≈ 61,000 gallons. This corresponds to a tank level of 45% to 46%.

1. Safety Significance

   Palisades has maintained a sufficient quantity of water in T-2 to cope with the station blackout.

D. *Anticipated Transient Without SCRAM (ATWS)*

The existence of the pipe stub has no impact on the ATWS evaluation presented earlier.

1. Safety Significance

   None.

E. *Auxiliary Feedwater Pump P-8C Suction Line*

The AFW pipe stub does not have any effect on the P-8C suction line characteristics discussed earlier in this evaluation.

1. Safety Significance

   None.

OVERALL SAFETY SIGNIFICANCE SUMMARY

As a summary, listed below is each individual design or safety issue discussed in the analysis and a statement of the effect the condition or potential condition had on the safe operation of the plant.

1. Existing AFW LSPT devices and setpoints for P-8A/8B/8C do not provide adequate protection from pump damage due to air entrapment at low condensate storage tank levels.

   Safety Significance - The unrecognized potential for AFW pump damage is important but is mitigated somewhat by the fact that ,in all likelihood, only one AFW pump would be operating and thus damaged by the time the LSPT occurs. The other two pumps could be used on an alternate suction source.

2. Existing AFW LSPT devices and setpoints for P-8A/8B/8C can allow the pumps to trip at water levels above the bottom of the condensate storage tank. In the past, this would have prevented delivery of the 100,000 gallons of water required by the plant technical specifications.

   Safety Significance - While the situation would prevent the delivery of the required 100,000 gallons of condensate, the long term decay heat removal function of the AFW system would not have been jeopardized. The alternate suction sources for the AFW system, the Fire Protection System and the Service Water System, have always been available.

3. The C-150 panel light, with setpoint within allowed limits, would activate at water levels much higher than desired.

   Safety Significance - This situation would only result in initiating Fire protection system flow or service water flow to the AFW system earlier than desired. While this may have economic implications for the plant, it would not jeopardize the decay heat removal function of the AFW system.

4. The non-conservative low C-150 panel light setpoint, found in August 1993, would have caused the light to illuminate after the condensate storage tank had been drained. This would have resulted in damage to the operating AFW pump.

   Safety Significance - This situation would have caused the operating AFW pump, P-8B, to fail due to air ingestion before the low level light illuminated. The safety significance of this depends on whether or not the other AFW pumps were operable. It also depends on whether or not P-8B could quickly be restored to operability.

5. The station blackout event mitigation requires a certain volume of water in T-2. Palisades has historically been able to ensure the required volume was available.

   Safety Significance - There is no safety significance associated with the station blackout event mitigation.

6. An ATWS event (loss of DC BUS D11) will automatically start P-8B and negate the ability of the LSPT devices to trip the pump. The possibility of pump damage is judged to be remote due to the amount of time available to the operators to take control of P-8B.

   Safety Significance - There is no safety significance associated with the ATWS event.

7. AFW pump P-8C suction line venting instructions were found to be less than desired.

Safety Significance - There is no safety significance associated with P-8C suction line venting. The existing instructions are acceptable but need to be more visible.

8. A 10 inch standpipe was discovered on the AFW suction pipe inside the condensate storage tank. The presence of the standpipe, by excluding nearly 1 foot of water from the available inventory of the tank, exacerbates items 1, 2, 3, and 4 above.

   Safety Significance - The past safety significance of the standpipe with respect to item 1 (increases possibility of pump damage), item 2 (reduces inventory further), item 3 (reduces available margin), item 4 (increases possibility of pump damage), and item 5 (increases tank inventory needed) is not changed by the evaluation of the presence of the standpipe.

9. The standpipe renders existing condensate storage tank inventory methodologies (tech data book and the emergency operating procedures) non-conservative. Both of these have assumed that the tank could be drained dry.

   Safety Significance - The presence of the standpipe could have resulted in the operators running out of water before they expected to. This could have caused damage to the operating AFW pump or a delay in initiating fire water or service water back-up.

CORRECTIVE ACTION

Immediate and Short Term Actions

Several important remedial actions were initiated to ensure they would be complete within the ongoing refueling outage 95. These actions included:

1. A determination of the minimum submergence depth necessary to ensure no more than 5% air entrapment to the AFW pumps as a function of AFW flow rate was completed. This analysis also determined the suction piping head loss terms for various flow rates.

2. Revision of the low suction pressure trip setpoints was made to include both the minimum submergence depths and the hydraulic losses at a flow rate of 330 gpm. This flow rate was chosen because it is the default setting for the auxiliary feedwater flow control valve.

3. Revision of the condensate inventory calculation was made to meet the 100,000 technical specification requirement with the new LSPT setpoints. This analysis determined that it is necessary to raise the condensate storage tank low level alarm setpoint to 73%. The automatic fill setpoint was raised to 76% to avoid overlap with the new alarm setpoint.

4. Revision of the Appendix "R" 20-minute inventory setpoint for PS-0741D was made such that it includes the minimum submergence depth and hydraulic losses at 330 gpm.

5. Inspection of the AFW suction pipe inside the condensate storage tank was completed on July 27, 1995. A vortex breaker was not observed. A pipe stub, or standpipe, approximately 10 inches in length was observed on the AFW suction opening. This pipe stub, along with other pipe stubs found in the tank, are not documented on any known plant drawing. This discrepancy, as well as the root cause determination, is documented in a separate plant Condition Report. The effect of the standpipe on AFW inventory and system operability has been discussed earlier in this evaluation. The standpipe was cut down to a total height of 1.25" above the bottom of T-2.

6. The new LSPT setpoints for all three AFW pumps, along with the required procedural changes, were implemented by a plant modification package (FC-954). The Plant will still have to deal with assuring the pumps trip using a flow-rate-dependent trip level. This is because the LSPT devices, which were originally designed for NPSH protection, are being used to trip the AFW pumps at a desired tank level instead. Because of hydraulic losses in the suction pipe between the transmitters and the tank, the LSPT devices will activate at the desired tank level only if the flow rate matches that assumed in the setpoint calculation. This means that, as T-2 level approaches the trip level, the AFW flow rate must be restored to the predetermined value to ensure the trip occurs at that level. Alternatively, the operators could closely monitor T-2 level and manually trip the running pump when level approaches the desired limit. These precautions are being implemented via the procedural changes associated with FC-954.

7. The Nuclear Network was queried regarding what type of AFW suction source anti-vortexing precautions were taken at other plants. One reply was received. At the responding plant, the primary supply for AFW is called the bypass tank. This tank supplies makeup to the condenser via one or two 30" pipes. The AFW suction piping begins as an 8" tap off of the 30" piping. Because of the large pipe diameter connecting to the tank (and resulting low flow velocity), vortexing is not a problem.

   The alternate source of AFW at the responding plant is the hotwell. The responding plant has a vortex breaker installed at the AFW suction pipe opening into the hotwell.

   Palisades Industry Experience database was queried for historical information regarding vortexing or air entrapment in auxiliary feedwater systems or condensate storage tanks. No other instances were found in the data base.

8. Other locations at Palisades were evaluated for vortexing include the Volume Control Tank, the SIRWT, the containment sump, and the PCS hot leg (during reduced inventory conditions) (References 15 and 16). No vortexing problems were identified.

The issue of vortexing/air entrapment in the containment sump/SIRW tank was further investigated. The results of this investigation in summary concludes that vortexing/air entrapment in the containment sump has been satisfactorily resolved. Vortexing/air entrapment in the SIRWT may be higher than desired for short periods of time prior to the recirculation actuation signal. Engineering judgement is used to conclude that the existing situation is acceptable. A long-term action to reevaluate installing vortex breakers on the SIRWT outlet lines is recommended as is an action to evaluate other large investment pumps which are susceptible to low suction levels. Both actions have been added to this CR.

Long Term Actions

The following additional actions will be completed:

1. The AFW system procedures will be reviewed and revised, as necessary, to include suction piping venting requirements following a low suction pressure trip.

2. A thorough investigation of the AFW system design requirements and the condensate storage tank inventory requirements will be performed.

3. A thorough evaluation of the potential for unacceptable vortexing or air entrapment in the SIRWT will be performed.

ADDITIONAL INFORMATION

LER 94-009 dated May 9, 1994, reported a condition where it had been identified that on various occasions the requirement to have 100,000 gallons of condensate available was not met.

Figure 1

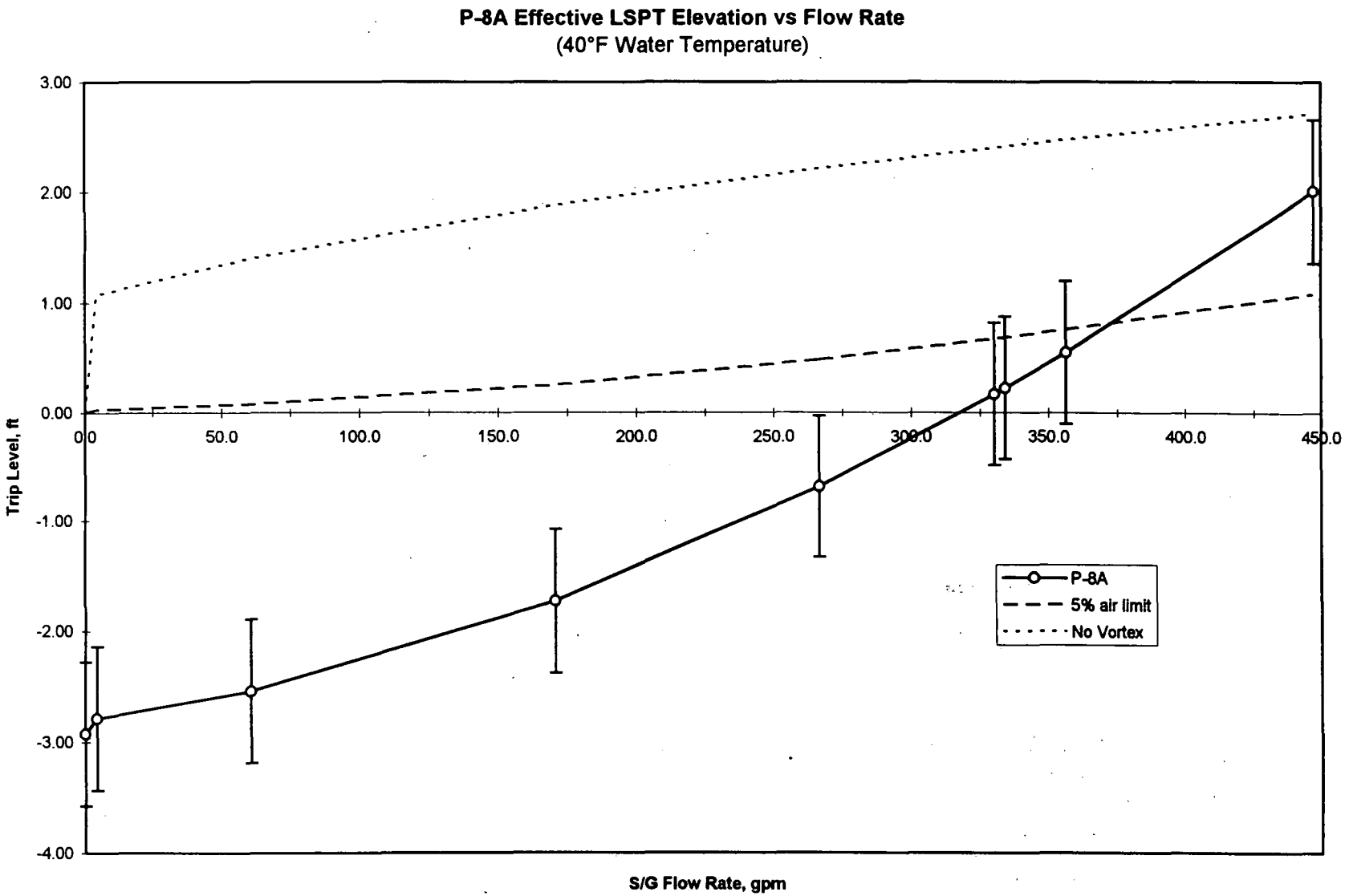
P-8A Effective LSPT Elevation vs Flow Rate
(40°F Water Temperature)
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
Trip Level, ft
S/G Flow Rate, gpm
P-8A
5% air limit
No Vortex

Figure 2

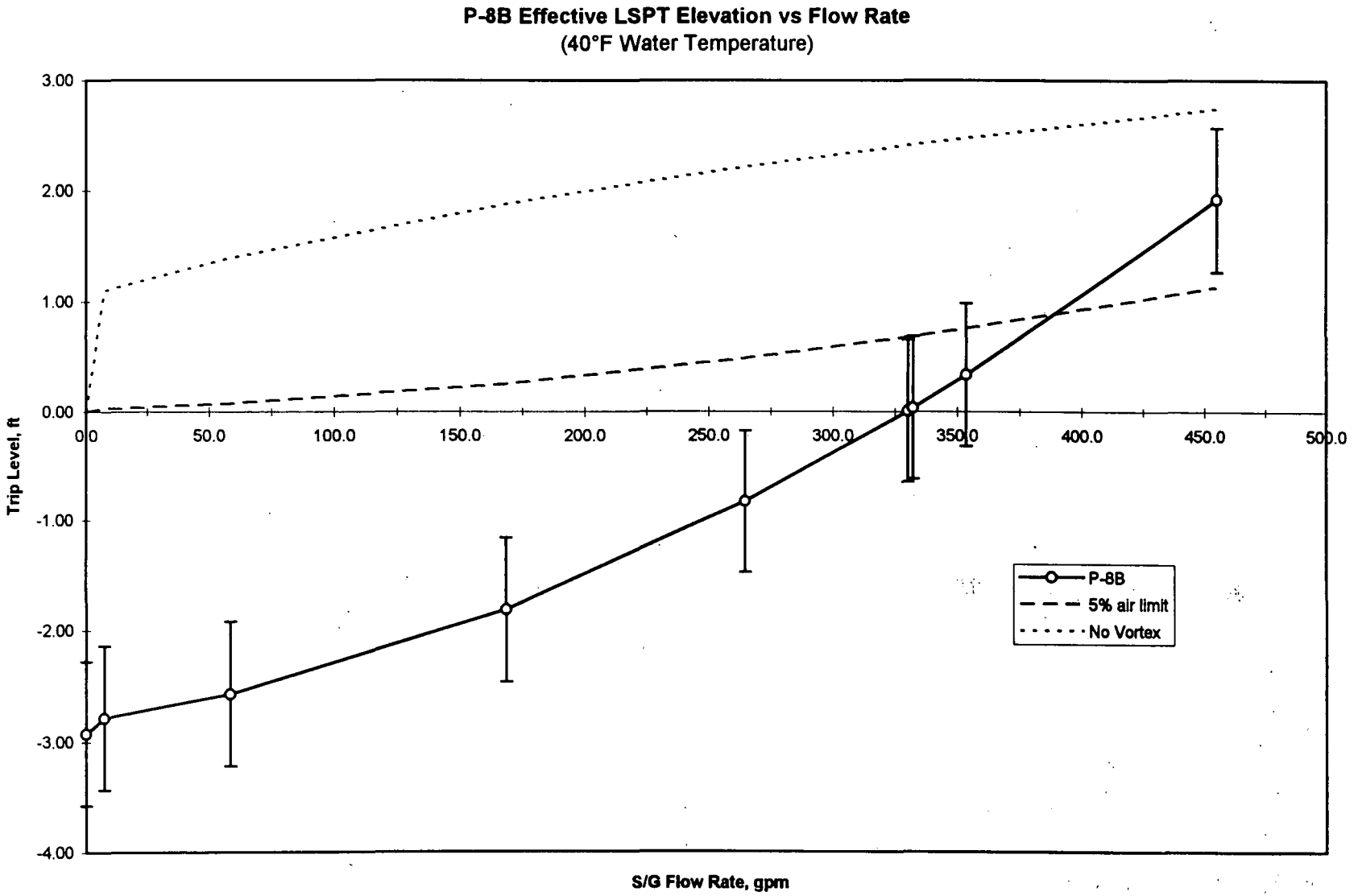
P-8B Effective LSPT Elevation vs Flow Rate
(40°F Water Temperature)
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Trip Level, ft
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
S/G Flow Rate, gpm
P-8B
5% air limit
No Vortex

Figure 3

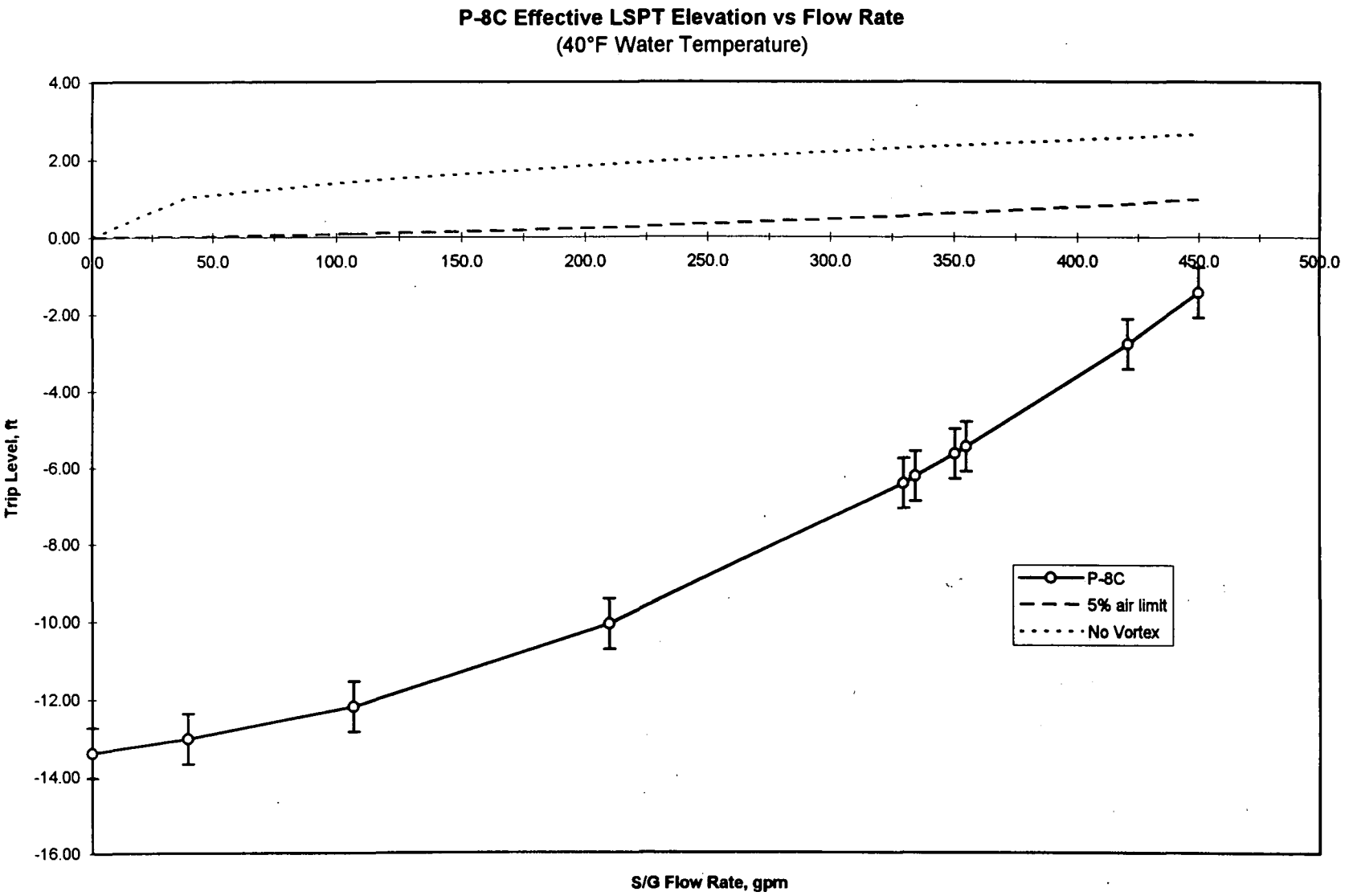
P-8C Effective LSPT Elevation vs Flow Rate
(40°F Water Temperature)
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-16.00
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
Trip Level, ft
S/G Flow Rate, gpm
P-8C
5% air limit
No Vortex

Figure 4

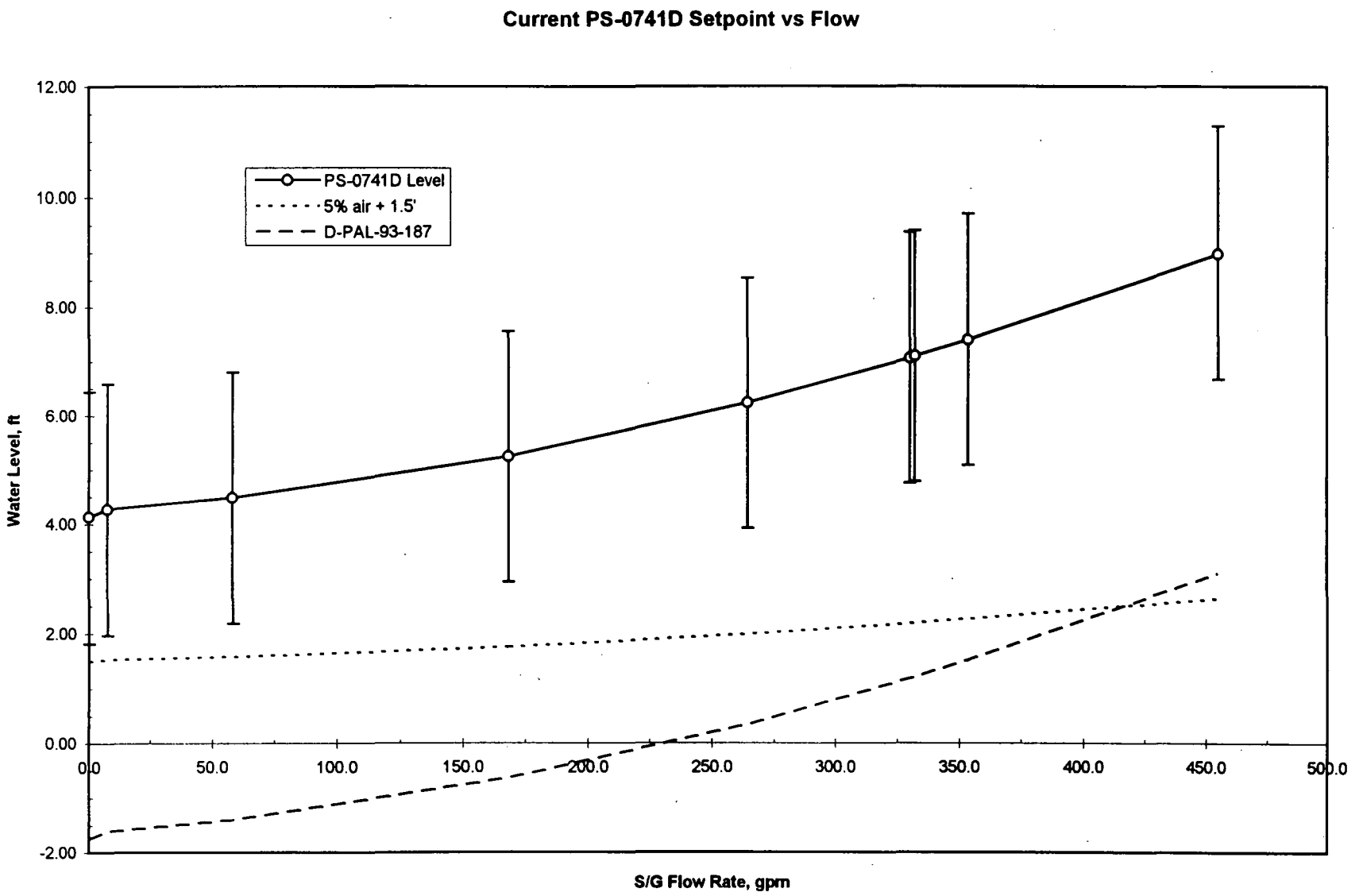
Current PS-0741D Setpoint vs Flow
PS-0741D Level
5% air + 1.5'
D-PAL-93-187
Water Level, ft
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
S/G Flow Rate, gpm

Figure 5

Current PS-0741D Setpoint vs Flow

includes original pipe stub length