10 CFR 50.73

A subsidiary of Pinnacle West Capital Corporation

Palo Verde Nuclear Generating Station

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102-05866-DCM/DFH
June 30, 2008

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Unit 1
Docket No. STN 50-528
License No. NPF 41
Licensee Event Report 2006-004-01

Attached please find Licensee Event Report (LER) 50-528/2006-004-01 prepared and submitted pursuant to 10 CFR 50.73 reporting a shutdown required by Technical Specifications (TS) based on the failure of the class pressurizer heaters to meet their designed mission time. This LER supplements the previously submitted LER to report the results of the root cause analysis of the failure.

In accordance with 10 CFR 50.4, copies of this LER are being forwarded to the NRC Regional Office, NRC Region IV and the Senior Resident Inspector. If you have questions regarding this submittal, please contact Ray E. Buzard, Section Leader, Regulatory Affairs, at (623) 393-5317.

Arizona Public Service Company makes no commitments in this letter.

Sincerely,

D. C. Mims

DCM/DFH/gat

Attachment
cc: E. E. Collins Jr. NRC Region IV Regional Administrator
M. T. Markley NRC NRR Project Manager - (send electronic and paper)
R. I. Treadway NRC Senior Resident Inspector for PVNGS

IE22
NRR

NRC FORM 366 (9-2007) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 08/31/2010

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records and FOIA/Privacy Service Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

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4. TITLE

TS Required Reactor Shutdown on failure of the class pressurizer heaters to be able to meet their mission time.

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
09	18	2006	2006	- 004 -	01	06	30	2008		05000
									FACILITY NAME	DOCKET NUMBER
										05000

9. OPERATING MODE

1

10. POWER LEVEL

100

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR§: *(Check all that apply)*

- ☐ 20.2201(b)
- ☐ 20.2201(d)
- ☐ 20.2203(a)(1)
- ☐ 20.2203(a)(2)(i)
- ☐ 20.2203(a)(2)(ii)
- ☐ 20.2203(a)(2)(iii)
- ☐ 20.2203(a)(2)(iv)
- ☐ 20.2203(a)(2)(v)
- ☐ 20.2203(a)(2)(vi)
- ☐ 20.2203(a)(3)(i)
- ☐ 20.2203(a)(3)(ii)
- ☐ 20.2203(a)(4)
- ☐ 50.36(c)(1)(i)(A)
- ☐ 50.36(c)(1)(ii)(A)
- ☐ 50.36(c)(2)
- ☐ 50.46(a)(3)(ii)
- ☒ 50.73(a)(2)(i)(A)
- ☐ 50.73(a)(2)(i)(B)
- ☐ 50.73(a)(2)(i)(C)
- ☐ 50.73(a)(2)(ii)(A)
- ☐ 50.73(a)(2)(ii)(B)
- ☐ 50.73(a)(2)(iii)
- ☐ 50.73(a)(2)(iv)(A)
- ☒ 50.73(a)(2)(v)(A)
- ☒ 50.73(a)(2)(v)(B)
- ☐ 50.73(a)(2)(v)(C)
- ☒ 50.73(a)(2)(v)(D)
- ☐ 50.73(a)(2)(vii)
- ☐ 50.73(a)(2)(viii)(A)
- ☐ 50.73(a)(2)(viii)(B)
- ☐ 50.73(a)(2)(ix)(A)
- ☐ 50.73(a)(2)(x)
- ☐ 73.71(a)(4)
- ☐ 73.71(a)(5)
- ☐ OTHER

Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER (Include Area Code)
Ray E. Buzard, Section Leader, Regulatory Affairs	623-393-5317

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
B	AB	EHTR	W065	Y					

14. SUPPLEMENTAL REPORT EXPECTED

☐ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☒ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

On September 18, 2006 at 10:35 PM, station personnel entered TS Action statements 3.0.3 and 3.4.9, Condition B. Operations personnel declared the Pressurizer (Pzr) Class heaters INOPERABLE when Engineering personnel, with input from the manufacturer (Watlow), informed the control room staff that reasonable assurance of OPERABILITY no longer existed. On September 19, 2006 at 1:05 AM Palo Verde Unit 1 was in Mode 1 (Power Operations), operating at approximately 100 percent power, when Control Room personnel commenced a reactor shutdown required by Technical Specification 3.0.3. At 3:07 AM, Operations personnel manually tripped the reactor. Mode 4 was entered at 5:07PM.

The cause of the Watlow heater failures was high sheath tensile stress introduced during the fabrication process. Palo Verde has replaced or removed from service the affected Watlow heaters, and has installed heaters from a different manufacturer (Doosan). Watlow heaters installed in the other two units at Palo Verde have not experienced the same failure rate, indicating the failure mechanism was unique to those heaters installed in Unit 1.

In the past three years, Palo Verde experienced one similar event where the failure of a Watlow heater resulted in Unit 1 entering a mode of operation without the required number of operable heaters. That event was the first identified failure of this type of heater, which ultimately resulted in this event.

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17. NARRATIVE *(If more space is required, use additional copies of NRC Form 366A)*

NOTE: All times listed in this event report are approximate and Mountain Standard Time (MST) unless otherwise indicated.

1. REPORTING REQUIREMENT(S):

LER (50-528/2006-004-00) was submitted pursuant to 10 CFR 50.73(a)(2)(i)(A), to report the completion of a reactor shutdown required by Technical Specifications. Specifically, on September 19, 2006 at 1:05 AM, Palo Verde Nuclear Generating Station (PVNGS) Unit 1 commenced a reactor shutdown required by Technical Specification 3.0.3.

LCO 3.4.9 Condition B requires the pressurizer shall be OPERABLE with two groups of pressurizer heaters OPERABLE with the capacity of each group to be 125 KW and capable of being powered from an emergency power supply. Having no OPERABLE heater groups the more limiting LCO 3.0.3 was entered.

Limiting Condition for Operations (LCO) 3.0.3 states that when an LCO is not met and the associated ACTIONS are not met, an associated ACTION is not provided, or if directed by the associated ACTIONS, the unit shall be placed in a MODE or other specified condition in which the LCO is not applicable. Action shall be initiated within 1 hour to place the unit, as applicable, in:
a. MODE 3 within 7 hours;
b. MODE 5 within 37 hours.

LER 50-528/2006-004-00 was also submitted pursuant to 10 CFR 50.73 (a)(2)(v), to report an event or condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to: (A) Shut down the reactor and maintain it in a safe shutdown condition; (B) remove residual heat or (D) Mitigate the consequences of an accident. (Reference: ENS call # 42847)

This supplement is being submitted to report the results of the root cause analysis of the failure, and corrective actions associated with the causal factors.

2. DESCRIPTION OF STRUCTURE(S), SYSTEM(S) AND COMPONENT(S):

The pressurizer (Pzr) (EIIS: AB) provides a point in the Reactor Coolant System (RCS) (EIIS: AB) where liquid and vapor are maintained in equilibrium under saturated conditions for pressure control purposes to prevent bulk boiling in the remainder of the RCS. Key functions include maintaining required primary system pressure during steady state operation and limiting the pressure changes caused by reactor coolant thermal expansion and contraction during normal load transients.

The Pzr pressure control elements addressed by Technical Specification (TS) 3.4.9 include the Pzr water level, the required heaters (EIIS: EHTR) and their backup heater controls, and emergency power supplies. Per TS LCO 3.4.9 Bases, the "class" heaters are required to be operable in modes 1-3 in order to ensure sub-cooled conditions in the reactor coolant that are needed for proper core heat removal. Brief heater operation is credited in some UFSAR Chapter 15 accident and reloads analyses. In addition, heater operation is required in safety related analysis in support of 10 CFR 50 Appendix A general design criteria (natural circulation cooldown) and in 10 CFR 50 Appendix R (Fire Protection). The limiting case is the Control Room fire, which requires heater operation for up to 68 hours after the event.

The Pzr heaters are single unit, direct immersion heaters that protrude vertically into the Pzr through sleeves welded in the lower head of the pressurizer. There are 36 Pzr heaters in Unit 1.

A number of the heaters are connected to proportional controllers, which adjust the heat input to account for steady-state losses and to maintain the desired steam pressure in the Pzr. The remaining heaters are connected to on-off controllers and are designated as “back-up” heaters. Two groups of back-up heaters are designated as the “class” heaters associated with TS 3.4.9. These back-up heaters are normally de-energized but are automatically turned on by a low Pzr pressure signal or a high level error signal. This latter feature is provided since load increases result in an in-surge of relatively cold coolant into the Pzr, thereby decreasing the bulk water temperature. The Chemical and Volume Control System (EIIS: CA) acts to restore level, resulting in a transient pressure below normal operating pressure. To minimize the extent of this transient, the backup heaters are energized, contributing more heat to the water. Backup heaters are de-energized in the event

of concurrent high-level error and high-Pzr pressure signals. A low-low Pzr water level signal de-energizes all heaters before they are uncovered to prevent heater damage.

3. INITIAL PLANT CONDITIONS:

On September 19, 2006 Palo Verde Unit 1 was in Mode 1 (Power Operations), operating at approximately 100 percent power. No other major structures, systems, or components were inoperable at the start of the event that contributed to the event.

4. EVENT DESCRIPTION:

During the last unit refueling outage (U1R12), all 36 pressurizer heaters were replaced with new heaters manufactured in 2005 by Watlow. Following restart in December 2005, the unit had an irregular power history due to complications associated with the Reactor Coolant System (RCS) Loop 1 shutdown cooling line vibration. Although heaters typically operate for many years of continuous service, several heaters meggered low or failed in less than 6 months. These heaters were electrically isolated due to either actual ground-fault (electrical protection trip) or detection of significantly degraded insulation conditions. An enhanced monitoring program was established to periodically megger the pressurizer heaters.

On September 18, 2006, during the increased monitoring of the Unit 1 pressurizer heaters, the meggering results were low on the class pressurizer heaters. Engineering contacted the vendor (Watlow) and determined that based upon the current indications the class pressurizer heaters may not be able to meet their mission time. LCO 3.0.3 was entered at 10:35 AM on September 18, 2006. A unit shutdown was commenced at 01:05 AM on 9/19/06. At 3:07 AM, Operations personnel manually tripped the reactor in accordance with normal shut down procedures. Mode 4 was entered at 5:07 PM.

5. ASSESSMENT OF SAFETY CONSEQUENCES:

A degraded condition involving the PVNGS Unit 1 pressurizer heaters resulted in a plant shutdown when adequate assurance of equipment operability could not be established. There was adequate functioning pressurizer heater capacity to satisfy design and licensing requirements at the time the unit was shut down. The shutdown was

necessitated when the degraded reliability of the pressurizer heaters challenged the presumption that the heaters could be relied upon for their required mission time.

The degraded condition involved stress corrosion cracking of some pressurizer heater sheaths. Although the heater sheath constitutes part of the reactor coolant pressure boundary (RCPB), there was no RCPB leakage since the design includes a backup seal within the ASME III stamped heater assembly. Consequently, the event did not result in any challenges to fission product barriers or result in the release of radioactive materials. Therefore, there were no adverse safety consequences or implications as a result of this event and the event did not adversely affect the safe operation of the plant or health and safety of the public.

The event did not result in a transient more severe than those analyzed in the updated Final Safety Evaluation Report Chapters 6 and 15. The event did not have any nuclear safety consequences or personnel safety impact.

6. CAUSE OF THE EVENT:

The direct cause of the heater failure was water intrusion past the heater sheath, caused by intergranular stress corrosion cracking (IGSCC) initiated from the external surface. Metallurgical examination of the cracked material revealed the IGSCC initiated from the outside surface, and that there were no indications of manufacturing or incident defects such as laps and dents, and no evidence of fatigue cracking or ductile failure.

Investigation by Westinghouse engineering identified that the root cause of the heater failure was high tensile stresses in the heater sheath's outer surface. Upon identifying this as the failure mechanism, Westinghouse analyzed four potential sources for the high tensile stresses: heater operation, heater operating environment, heater installation, and heater fabrication. Further analysis concluded that the high tensile stresses occurred during fabrication, after ruling out the other three possibilities. Contributing to this condition was that the pressurizer heater specification did not provide guidance to control the residual stresses in the as-fabricated heater sheaths.

There are nine Watlow heaters currently installed in Unit 2 and twelve Watlow heaters currently installed in Unit 3. However, these heaters were installed as original plant equipment or as spares over the life of the plant, and have a significantly greater mean

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time between failures (MTBF) than those installed in Unit 1 in 2005. The calculated MTBF for the Unit 1 Watlow heaters (installed in 2005, and now removed) is 2.25 years versus a calculated MTBF of 27 and 135 years for those installed in Unit 2 and Unit 3 respectively. Therefore, PVNGS personnel have concluded that this condition is limited to the new Prz heaters manufactured by Watlow that were delivered and installed in Unit 1 in 2005.

7. CORRECTIVE ACTIONS:

Thirty five of the thirty six Prz heaters were replaced, with one (heater B18) abandoned in place as described below. The heaters were replaced with new heaters manufactured by Doosan Heavy Industries and Construction from Korea. APS operating experience with the Doosan heaters shows a good service record. In Unit 3, 14 Doosan heaters have operated in non-class heater banks without failure since fall of 2005. The Doosan heaters are designed as an assembly in accordance with ASME Section III and have essentially the same pressure seal design as the other manufacturer heaters. The Doosan heaters were welded in place in accordance with the existing design.

Heater B18 was not removed due to interference between its damaged sheath and the pressurizer nozzle. As a result, the B18 heater was abandoned in place and its nozzle was plugged using a plug that meets all ASME Code requirements. An evaluation of the overall acceptability of abandonment of heater B18 was performed, including the potential for ingress of magnesium oxide (heater insulation) and nickel chromium (sheath material) as contaminants into the reactor coolant system. All ASME Code required in-service inspections have been performed. An in-service leak test was performed when the unit returned to normal operating pressure and temperature.

The remaining Watlow heaters in the warehouse have been quarantined. The pressurizer heater specification will be revised to provide direction to heat treat the fabricated heaters to remove/reduce residual stresses.

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8. PREVIOUS SIMILAR EVENTS:

In the past three years, Palo Verde reported reactor shutdowns required by Technical Specifications but none associated with the pressurizer heaters.

However, in LER 50-528/2006-002-00 APS reported a condition prohibited by Technical Specifications where Unit 1 entered Mode 3 (Hot Standby) without the required number of pressurizer heaters operable. One of the required pressurizer heaters had experienced a failure due to grounding which is the first failure of the Watlow heaters being reported in this LER (2006-004-00).