UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

July 26, 1996

NRC INFORMATION NOTICE 96-41: EFFECTS OF A DECREASE IN FEEDWATER TEMPERATURE ON NUCLEAR INSTRUMENTATION

Addressees

All holders of operating licenses or construction permits for pressurized water reactors (PWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to the potential for operation above licensed power as a result of a decrease in feedwater temperature event affecting nuclear instrumentation. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On February 14, 1996, the licensee for the Comanche Peak Steam Electric Station was operating Unit 2 at 95 percent rated thermal power near end-of-core life when a significant reduction in feedwater temperature occurred because of the loss of feedwater heaters. This reduction, in turn, caused a reduction in the reactor coolant system cold-leg temperatures. The colder reactor coolant temperature, with a large negative moderator temperature coefficient, caused reactor power to increase to approximately 102 percent according to ex-core nuclear instrumentation. The nitrogen-16 (N-16) detection system reached the overpower turbine runback setpoint (109 percent) and initiated a turbine runback. The N-16 detection system measures N-16 activity in the primary coolant as a measure of the total power generation. This system is a substitute for the resistance temperature detector over-temperature and over-power reactor trip functions used at other Westinghouse PWRs. The plant stabilized at an indicated power of approximately 97 percent according to the ex-core nuclear instrumentation.

After approximately 90 minutes, a second similar turbine runback occurred while restoring balance-of-plant equipment. Following this runback, reactor power was stabilized at approximately 100 percent according to nuclear instrumentation. During the next 30 minutes, the reactor was operated at approximately 100 percent power as indicated by nuclear instrumentation, with reactor coolant temperatures below normal. The licensee noted that the N-16

detection system indicated approximately 106 percent power and the computer-based plant calorimetric system indicated approximately 102 percent power. Subsequently, the reactor power was reduced to less than 100 percent by all indications.

Discussion

There are three aspects of this event which have generic implications. First, with a loss of secondary plant efficiency, programmed T_{Ave} can no longer reliably represent core thermal power. Second, the venturi-based input into the computer-based calorimetric system may not be accurate with cold feedwater. And third, the final safety analysis report had not analyzed this transient accurately.

Following the second runback, operators noted that reactor power indicated ≤100 percent according to nuclear instrumentation. Although the operators knew that cold feedwater could cause an increase in the amount of neutron attenuation, they believed that the nuclear instrumentation indicated conservatively (i.e., higher than actual) because they were maintaining T_{Ave} approximately 1.7 °C [3 °F] above T_{Ref}. The licensee could not use the computer-based calorimetric until some time after the second turbine runback due to maintenance activities. T_{Ref}, based on the main turbine impulse pressure, is programmed as a function of turbine load and, for normal efficiency, is a good representation of thermal power. When the unit lost the feedwater heaters, the plant efficiency decreased. Because the main turbine electro-hydraulic control system maintained generator output, core thermal power increased to account for the loss of efficiency, and thus, T_{Ref} no longer accurately represented the core thermal power.

The cold-leg temperature is a more appropriate indicator of the accuracy of the nuclear instrumentation than programmed T_{Ave}. As the cold-leg temperature decreased, the amount of neutron attenuation in the downcomer area surrounding the core increased and hence affected the amount of neutrons reaching the detectors. The licensee analysis showed that for every 0.6 °C [1 °F] of cold-leg temperature change, the nuclear instrumentation was affected by 0.6 to 0.8 percent power. A review of the second transient showed that the cold-leg temperature was approximately 2.5 °C [4.5 °F] lower than when the detectors were last calibrated. This corresponded to a 3 to 4 percent error, which corresponded to the difference in the actual versus the indicated power (104 percent actual versus 100 percent indicated).

During the review, the licensee noted that the computer-based calorimetric was 4 percent lower than the actual thermal power (N-16 power monitor). The calorimetric was based on feedwater flow measured by venturis. Although the calorimetric calculation used feedwater temperature as an input, temperatures significantly different than the normal 227 °C [440 °F] introduced errors into the calculation.

Finally, the actual events involved temperature and power levels that exceeded those in the analysis of the "Decrease in Feedwater Temperature" event presented in Chapter 15 of the licensee final safety analysis report. In that

analysis, the inadvertent opening of the low-pressure heater bypass valve, coupled with the trip of the heater drain pumps, resulted in a feedwater temperature drop of less than 19 °C [35 °F], and a corresponding power increase of less than 10 percent. In the actual event, the feedwater temperature dropped by approximately 111 °C [200 °F], and the licensee calculated that reactor power would have increased by approximately 35 percent without operator or protective actions. The licensee determined that although the initiating events were the same, the Chapter 15 analysis did not account for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the Comanche Peak analysis and had similar conclusions concerning the amount of feedwater temperature drop. The licensee has reanalyzed the event to include a 119 °C [246 °F] feedwater temperature drop and concluded that all accident analysis parameters remained within requirements.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
E-mail: haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
E-mail: cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices

ATTAchment filed in JAcket

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
96-40	Deficiencies in Material Dedication and Procurement Practices and in Audits of Vendors	07/25/96	All holders of OLs or CPs for nuclear power reactors
96-09, Supp. 1	Damage in Foreign Steam Generator Internals	07/10/96	All holders of OLs or CPs for pressurized-water reactors
96-39	Estimates of Decay Heat Using ANS 5.1 Decay Heat Standard May Vary Significantly	07/05/96	All holders of OLs or CPs for nuclear power reactors
96-38	Results of Steam Generator Tube Examinations	06/21/96	All holders of OLs or CPs for pressurized water reactors
96-37	Inaccurate Reactor Water Level Indication and Inadvertent Draindown During Shutdown	06/18/96	All pressurized water reactor facilities holding an operating license or a construction permit
96-36	Degradation of Cooling Water Systems Due to Icing	06/12/96	All holders of OLs or CPs for nuclear power reactors
96-35	Failure of Safety Systems on Self-Shielded Irradiators Because of Inadequate Maintenance and Training	06/11/96	All U.S. Nuclear Regulatory Commission irradiator licensees and vendors
96-34	Hydrogen Gas Ignition during Closure Welding of a VSC-24 Multi-Assembly Sealed Basket	05/31/96	All holders of OLs or CPs for nuclear power reactors

OL = Operating License
CP = Construction Permit

analysis, the inadvertent opening of the low-pressure heater bypass valve, coupled with the trip of the heater drain pumps, resulted in a feedwater temperature drop of less than 19 °C [35 °F], and a corresponding power increase of less than 10 percent. In the actual event, the feedwater temperature dropped by approximately 111 °C [200 °F], and the licensee calculated that reactor power would have increased by approximately 35 percent without operator or protective actions. The licensee determined that although the initiating events were the same, the Chapter 15 analysis did not account for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the Comanche Peak analysis and had similar conclusions concerning the amount of feedwater temperature drop. The licensee has reanalyzed the event to include a 119 °C [246 °F] feedwater temperature drop and concluded that all accident analysis parameters remained within requirements.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Original signed by Brian K. Grimes

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
E-mail: haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
E-mail: cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices

DOCUMENT NAME: G:\SSK2\INFONOT.C_P

To receive a copy of this document, indicate in the box C=Copy w/o attachment/enclosure E=Copy with attachment/enclosure N = No copy

OFFICE	CONT:jkd		BC:SRXB		BC:PECB		(A)D:DRPM
NAME	CYLiang* HAFreeman*		RJones*		AChaffee*		BGrimes
DATE	6/ 3/96		6/21/96		7/08/96		7/23/96

OFFICIAL RECORD COPY

* See previous concurrence Tech Editor reviewed & concurred on 05/28/96

for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the Comanche Peak analysis and had similar conclusions concerning the amount of feedwater temperature drop. The licensee has reanalyzed the event to include a 119 °C [246 °F] feedwater temperature drop and concluded that all accident analysis parameters remained within requirements.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
E-mail: haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
E-mail: cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices
DOCUMENT NAME: G:\SSK2\INFONOT.C_P

To receive a copy of this document, indicate in the box C=Copy w/o attachment/enclosure E=Copy with attachment/enclosure N = No copy

OFFICE	CONT:jkd		BC:SRXB		BC:PECB		(A)D:DRPM	
NAME	CYLiang* HAFreeman*		RJones*		AChaffee*		BGrimes	
DATE	6/ 3/96		6/21/96		7/08/96		7/ /96	

OFFICIAL RECORD COPY

* See previous concurrence

for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the licensee analysis and had similar conclusions concerning the amount of feedwater temperature drop. The licensee has reanalyzed the event pursuant to Section 50.59 of Title 10 of the *Code of Federal Regulations* to include a 119 °C [246 °F] feedwater temperature drop and concluded that all accident analysis parameters remained within requirements.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
E-mail: haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
E-mail: cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices
DOCUMENT NAME: G:\SSK2\INFONOT.C P

To receive a copy of this document, indicate in the box C=Copy w/o attachment/enclosure E=Copy with attachment/enclosure N = No copy

OFFICE	CONT:jkd		BC:SRXB		BC:PECB		(A)D:DRPM	
NAME	CYLiang* HAFreeman*		RJones*		AChaffee*		BGrimes	
DATE	6/ 3/96		6/21/96		7/08/96		7/ /96	

OFFICIAL RECORD COPY

* See previous concurrence

for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the licensee analysis and had similar conclusions concerning the amount of feedwater temperature drop. The licensee has reanalyzed the event pursuant to Section 50.59 of Title 10 of the *Code of Federal Regulations* to include a 119 °C [246 °F] feedwater temperature drop and concluded that all accident analysis parameters remained within requirements.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
Internet:haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
Internet:cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices
DOCUMENT NAME: G:\SSK2\INFONOT.C P

To receive a copy of this document, indicate in the box C=Copy w/o attachment/enclosure E=Copy with attachment/enclosure N = No copy

OFFICE	CONT:jkd		BC:SRXB		BC:PECB		(A)D:DRPM	
NAME	CYLiang* HAFreeman*		RJones*		AChaffee		BGrimes	
DATE	6/ 3/96		6/21/96		7/ 8/96		7/ /96	

OFFICIAL RECORD COPY

* See previous concurrence

for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff's review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the licensee's analysis and had similar conclusions concerning the amount of feedwater temperature drop. The licensee has reanalyzed the event pursuant to Section 50.59 of Title 10 of the *Code of Federal Regulations* to include a 119 °C [246 °F] feedwater temperature drop and concluded that all accident analysis parameters remained within requirements.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
Internet:haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
Internet:cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices
DOCUMENT NAME: G:\SSK2\INFONOT.C_P 6/25

To receive a copy of this document, indicate in the box C=Copy w/o attachment/enclosure E=Copy with attachment/enclosure N = No copy

OFFICE	CONT:jkd		BC:SRXB		BC:PECB		(A)D:DRPM	
NAME	CYLiang* HAFreeman*		RJones		AChaffee		BGrimes	
DATE	6/ 3/96		6/21/96		6/ /96		6/ /96	

OFFICIAL RECORD COPY

* See previous concurrence

detection system. The licensee believed that this system would probably not be significantly affected by feedwater temperatures because of a different mass flow rate determination method.

Finally, the licensee's final safety analysis report did not accurately analyze this transient. The actual events were similar to the analysis of the "Decrease in Feedwater Temperature" event presented in Chapter 15. In that analysis, the inadvertent opening of the low-pressure heater bypass valve, coupled with the trip of the heater drain pumps, resulted in a feedwater temperature drop of less than 35 °F, and a corresponding power increase of less than 10 percent. In the actual event, the feedwater temperature dropped by approximately 200 °F, and the licensee calculated that reactor power would have increased by approximately 35 percent without operator or protective actions. The licensee determined that although the initiating events were the same, the Chapter 15 analysis did not account for the loss of extraction steam to the high-pressure heaters, which was the cause of the temperature difference. During the event, a level imbalance occurred between the two heater drain tanks, which resulted in the isolation of extraction steam.

The NRC staff's review of analyses of feedwater temperature events at similar facilities revealed that most of these analyses assumed similar initiating events as the licensee's analysis and had similar conclusions concerning the amount of feedwater temperature drop.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation project manager.

Brian K. Grimes, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Technical contacts: Harry A. Freeman, RIV
(817) 897-1500
Internet:haf@nrc.gov

Chu-Yu Liang, NRR
(301) 415-2878
Internet:cyl@nrc.gov

Attachment: List of Recently Issued NRC Information Notices
DOCUMENT NAME: G:\SSK2\INFONOT.C P

To receive a copy of this document, indicate in the box C=Copy w/o attachment/enclosure E=Copy with attachment/enclosure N = No copy

OFFICE	CONT:jkd		BC:SRXB		BC:PECB		(A)D:DRPM	
NAME	CYLiang CYL HAFreeman SSK for		RJones		AChaffee		BGrimes	
DATE	6/3/96		6/ /96		6/ /96		6/ /96	

OFFICIAL RECORD COPY