REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:9402030224 DOC.DATE: 94/01/26 NOTARIZED: NO DOCKET #
FACIL:STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
STN-50-529 Palo Verde Nuclear Station, Unit 2, Arizona Publi 05000529
STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530
AUTH.NAME AUTHOR AFFILIATION
CONWAY,W.F. Arizona Public Service Co. (formerly Arizona Nuclear Power
RECIP.NAME RECIPIENT AFFILIATION
Document Control Branch (Document Control Desk)

SUBJECT: Responds to questions raised during 931215 telcon re NRC Bulletin 88-008 actions,results of APS thermal stratification monitoring & plans for long term monitoring of thermal stratification of APSS piping.

DISTRIBUTION CODE: IE16D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 9
TITLE: Bulletin Response 88-08 - Thermal Stress in Piping to RCS.

NOTES:STANDARDIZED PLANT 05000528
Standardized plant. 05000529
Standardized plant. 05000530

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PDV PD	1	1	POLICH, T	1	1
	TRAN,L	1	1			
INTERNAL:	AEOD/DOA	1	1	NRR/DE/EMCB	1	1
	NRR/DE/EMEB	1	1	NRR/DORS/OGCB	1	1
	NRR/DSSA	1	1	NRR/PDII-1	1	1
	REG FILE 02	1	1	RES/DSIR/EIB	1	1
	RGN5 FILE 01	1	1			
EXTERNAL:	NRC PDR	1	1	NSIC	1	1

R I D S / A D D S

R I D S / A D D S

NOTE TO ALL "RIDS" RECIPIENTS:

PLEASE HELP US TO REDUCE WASTE! CONTACT THE DOCUMENT CONTROL DESK, ROOM P1-37 (EXT. 20079) TO ELIMINATE YOUR NAME FROM DISTRIBUTION LISTS FOR DOCUMENTS YOU DON'T NEED!

TOTAL NUMBER OF COPIES REQUIRED: LTTR 14 ENCL 14

Arizona Public Service Company
P.O. BOX 53999 • PHOENIX, ARIZONA 85072-3999

WILLIAM F. CONWAY
EXECUTIVE VICE PRESIDENT
NUCLEAR

102-02801-WFC/RAB/ZE
January 26, 1994

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-37
Washington, DC 20555

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Bulletin 88-08 Follow-up on Telephone Discussion with the NRC on 12/15/93.
File: 94-055-026; 94-056-026

On December 15, 1993, a telephone discussion was held between Brian Holian, NRC and Richard Bernier, Arizona Public Service Company (APS). The discussion focused on NRC Bulletin 88-08 actions, results of APS thermal stratification monitoring, and on APS plans for long term monitoring of thermal stratification in the Auxiliary Pressurizer Spray System (APSS) piping.

APS provides the following responses to the questions asked during the telephone discussion.

1. Why did APS use "Plastic Pipe Element STIF20" in the bounding thermal stratifcation analysis?

   APS modeled the APSS stratified section by using the plastic pipe element in ANSYS 4.4A in order to allow for the input of the variable pipe wall temperatures experienced during stratification. The plastic capability of this plastic element was not utilized in the calculation (13-MC-ZZ-643), because the stresses remained within the elastic region of the stress-strain diagram for the APSS piping material. Thus, the accuracy of the calculation has not been degraded by the use of the plastic element.

010088

JE16

b

2. Was the stratified temperature data from the APSS piping cyclic?

The temperature stratification data measured by APS on the APSS piping in Unit 3 during and after the second refueling outage did not show high cycle fluctuations. Once a stratification profile was established, it remained constant in relation with a constant valve in-leakage rate. Therefore, in the absence of cycling, APS concluded that the temperature stratification recorded on the APSS line does not represent the potential for high cycle thermal fatigue as described in NRC Bulletin 88-08, and consequently, is not within the scope of the Bulletin. APS has determined that the observed temperature stratification in the APSS line was the result of valve in-leakage as demonstrated by starting and securing the charging pumps which produced a marked change in the recorded temperature distribution. Since the static temperature stratification was not considered in the original design basis calculation, APS prepared a bounding thermal analysis calculation and is preparing for additional temperature measurements in the APSS line. The required instrumentation will be installed in Unit 3 during the Spring 1994 refueling outage. This APS long term monitoring is designed to establish the limiting conditions to help revise the associated calculations. The enclosure to this letter is a summary of APS actions and plans regarding NRC Bulletin 88-08.

Finally, in accordance with the 12/15/93 telephone discussion, APS will continue its long-term monitoring plan for temperature stratification in the APSS line as described above. Also, APS considers all action items of NRC Bulletin 88-08 closed. If you have additional questions, please contact Richard Bernier at (602) 393-5882.

Sincerely,

James M Levine for WFC

WFC/RAB/ZE/dld

Enclosure

cc: K. E. Perkins
K. E. Johnston
B. E. Holian

ENCLOSURE

DEVELOPMENT AND BASIS FOR THE TECHNICAL POSITION AT PVNGS WITH RESPECT TO NRC BULLETIN 88-08

DEVELOPMENT AND BASIS FOR THE TECHNICAL POSITION AT PVNGS WITH RESPECT TO NRC BULLETIN 88-08

BACKGROUND

NRC Information and Evaluation Bulletin 88-08

The circumstances that resulted in the original IE Bulletin 88-08 involve a small LOCA resulting from a through wall crack on an unisolable section of ECCS piping at the Farley 2 nuclear power reactor. It was postulated in the bulletin that a globe valve located upstream of the crack that isolates the RCS from the charging pumps had been leaking, allowing cold water to flow into the relatively hot ECCS piping connected to the RCS. Consequently, a fluid stratification profile developed in the piping resulting in thermal loadings not accounted for in the original plant design. Interaction of the stratified layers with secondary turbulence within the unisolable section of piping produced cyclic conditions which ultimately resulted in high cycle thermal fatigue.

As a result of the incidence at Farley 2, the NRC requested that all nuclear power plants review their design for any unisolable RCS branch piping that could be subject to temperature differences that produced unacceptable thermal stresses and to take action where such piping was identified. Specifically, in the event that such unisolable sections are found, the licensee was requested to perform nondestructive examination of the welds, heat-affected zones, and high stress locations to ensure that there were no existing flaws. In addition, the licensee was required to implement a program to provide continued assurance that unisolable sections of RCS branch piping would not be subject to combined cyclic and static thermal or other stresses that could cause failure during the remaining life of the unit. Each licensee was required to report their findings and confirmation of completion of those items specified as Actions Requested.

Supplements to IE Bulletin 88-08

Subsequent to the event at Farley 2, Supplement 1 of IE Bulletin 88-08 reported that another incidence of piping failure occurred at the Tihange 1 PWR at Tihange, Belgium. Similar to the failure at Farley 2, the crack developed in an unisolable section of piping as a result of thermal stratification induced high cycle thermal fatigue. Supplement 2 emphasized the need for sufficient examination for the detection of cracks and flaw indications.

Supplement 3 of IE Bulletin 88-08 reported another case of piping failure at a foreign reactor similar in circumstance to those reported previously. However, in contrast to Farley 2, where in-leakage of relatively cooler water past the isolation globe valve is suspected of causing thermal fatigue, the failure at the foreign reactor appeared to be the result of hot RCS water leaking past the packing gland of the isolation valve. The leak at the packing gland allowed the hot RCS water to flow into the unisolable section of branch pipe above the stagnant cooler water. Consequently, a stratified profile developed which presumably resulted in the failure of the pipe.

The significance of Supplement 3, as discussed therein, is that the third incidence of piping failure apparently occurred as a result of out-leakage of relatively hot RCS water into

a cooler stagnant unisolable section of pipe whereas the failure at Farley 2 occurred as a result of in-leakage of relatively cooler water into a warmer stagnant unisolable section of pipe. Consequently, the criteria by which many utilities evaluated their systems, in accordance with the original bulletin, had changed to include branch piping identification based on both in-leakage to and out-leakage from the RCS.

PVNGS Initial Response - Study 13-MS-A12

To address the issues of IE Bulletin 88-08 and Supplements 1 and 2, Engineering Action Request (EAR) 88-1088 was initiated to assess the impact on PVNGS. The disposition of 88-1088 resulted in the study 13-MS-A12 which tabulated all RCS branch piping and applied the criteria as perceived from the original IE Bulletin to evaluate which system interface piping may be susceptible to high cycle thermal fatigue. Consequently, the study determined that only systems that were at higher relative pressure to the RCS were susceptible to thermal fatigue as described in the original bulletin. The review indicated that only the auxiliary pressurizer spray line was susceptible to the thermal loadings suspected of the failures at Farley 2 and Tihange. The safety injection lines, although cross-tied to the charging pumps at higher relative pressure, were not subject to the thermal loadings as these lines are isolated by two normally closed isolation valves. Leakage past both valves was not assumed credible. Thus, the safety injection lines were dismissed from further review.

Study 13-MS-A12 and the actions initiated as a result of EAR 88-1088 formed the basis of the initial response to the NRC. In ANPP correspondence 161-01356-DBK/BJA, dated October 03, 1988, PVNGS had identified all RCS branch piping susceptible to stratification and the associated thermal stresses on the basis described above. In addition, to comply with Requested Action 2 of the original bulletin, non-destructive examinations of the Auxiliary Spray Lines for each unit were planned during the next respective scheduled refueling outages. No cracking was detected in any of the units. Regarding Action 3 of the original bulletin, no long term plan was specified within the PVNGS response to assure that the Auxiliary Spray Line would not be subject to fatigue failure resulting from stratified conditions. However, to fulfill PVNGS's commitment to Requested Action 3, Procedure 73TI-9RC03 was prepared to obtain temperature data for the Auxiliary Spray Line. Subsequent fatigue evaluation based on the temperature data during the full cycle of Unit 3 was prepared to assess integrity of the Auxiliary Spray Line. Therefore, PVNGS was in compliance with the requirements of IE Bulletin 88-08.

Revised Response to IE Bulletin 88-08

Supplement 3 to IE Bulletin 88-08 was issued after the initial PVNGS response to the NRC. As noted, Supplement 3 contained evidence of RCS out-leakage that resulted in stratified conditions and ultimately thermal fatigue in an unisolable section of branch piping. Consequently, all licensees were required to evaluate the potential of similar circumstances at their facilities in addition to those previously reported in the original bulletin.

Concurrent with this revision in evaluation criteria, the NRC had reviewed the original PVNGS response. According to NRC's communication, dated October 18, 1991, the PVNGS response did not adequately address Action 3 of the bulletin. As these details were not included in the original response, the NRC was not informed that PVNGS had

proceeded with installation of temperature monitoring equipment and collection of temperature data with which to assess the Auxiliary Spray Line and its potential for thermal fatigue. Instead, the NRC had concluded that the NDE actions proposed in response to Action 2 were devised to concurrently fulfill the requirements of Action 3. The NRC also re-emphasized the need to address the specific concerns related to Supplement 3 and that, although no specific response was required, audit of the implementation of IE Bulletin 88-08 and all supplements was possible. The NRC did however request additional information concerning planned actions regarding Action 3 assurance plans.

In correspondence 161-04571-WFC/JMQ, dated January 15, 1992, APS supplied the NRC with detailed information regarding existing efforts to collect, reduce, and evaluate temperature data consistent with that required by Action 3 of the bulletin. Further, APS committed to developing a long term monitoring plan to ensure the integrity of the auxiliary spray line for the design life of the plants, and that the monitoring plan would be based upon the results of the U3 data assessment. The revised response also indicated that APS was participating with the Westinghouse / Electric Power Research Institute efforts in the development of screening criteria and evaluation methodology and was participating with related activities of the Combustion Engineering Owners Group. All efforts were concerted to bring about closure of the related issues.

Completion of the Unit 3 cycle 3 auxiliary spray line monitoring concluded that, although stratification in the auxiliary spray line did exist, the temperature profiles were not cyclic and the mechanism associated with the failures described in the bulletin and supplements was absent. Further, since the maximum top to bottom temperature difference was only 115°F, as compared to 600°F from analysis, in-leakage was not suspected. It was postulated that the observed profiles were the result of steam/water stratification, natural convection, external convection effects, or otherwise. Independent of leakage, the stratification was assumed constant and therefore provided a bounding steady state thermal load which could be used for a bounding structural analysis.

The structural analysis for the auxiliary pressurizer spray line was revised accordingly to include the thermal static load. The bounding analysis assumed that the magnitude of the load to be the maximum recorded during the Unit 3 full cycle data collection.

Recommendations for Continued Evaluation of the Auxiliary Pressurizer Spray Line

The Unit 3 cycle 3 data was again reviewed to determine if such monitoring was necessary assuming that the stratification was not due to in-leakage. Re-evaluation and correlation of the data with changes in plant operation demonstrated a relationship between charging pump operation and the stratification profile in the auxiliary spray line. Engineering concluded that the stratified profile was a result of in-leakage, contrary to the first assessment of the data. In evidence of the in-leakage in the auxiliary spray line, Engineering concluded that continuous monitoring was required since the resultant static load was ultimately a function of leak rate. Although no evidence of cycling was found, Engineering proceeded to evaluate the stratification as an IEB 88-08 related issue. In accordance with the requirements transmitted by the NRC in "Evaluation Criteria for Responses to NRC Bulletin 88-08, Action 3 and Supplement 3," a pilot program was proposed for Unit 3 in the fourth refueling outage in the spring of 1994. Based on these efforts and the data collected, permanent monitoring for all three units would be

prescribed. In addition, the limiting temperature distribution may be evaluated analytically provided specific thermal-hydraulic parameters may be accurately determined and verified.

ASSESSMENT OF THE PVNGS SPRAY LINE DATA

The auxiliary spray system provides a flow path from the CVCS charging pumps to the RCS at the main spray line. During warm-up and normal operation the auxiliary spray line is isolated from the RCS by isolation valves HV-203 and HV-205 as shown in Figure 1. Depending upon specific conditions, the valves are cycled during cooldown when inadequate main spray flow exists. It was assumed that leakage past the isolation valves HV-203 and/or HV-205 would result in stratified conditions and consequently thermal loadings not originally accounted for in the design of PVNGS. To establish the existence of such conditions, temperature measurements were made for the auxiliary spray line and the data reduced and assessed for PVNGS by CE-ABB Fatigue Evaluation Services. The data collection occurred in Unit 3 during heat-up after refueling outage 2. Note that the outage was extended and that the plant was placed in cold shut down following start-up. Consequently, auxiliary spray line data obtained from this period represents partial heat-up and cooldown cycles as well as normal operating temperature data.

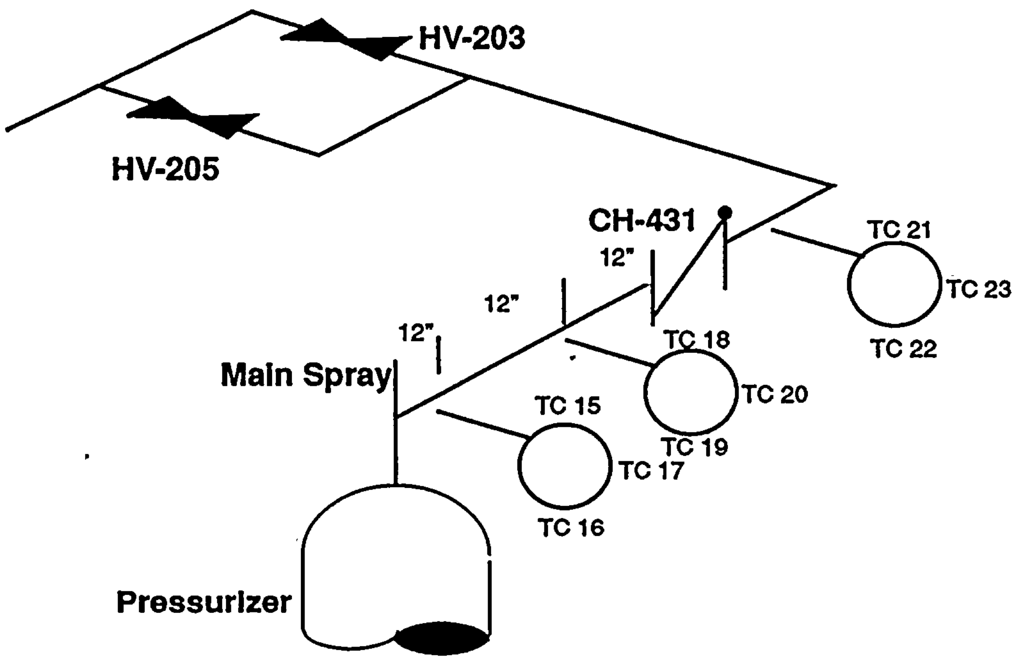

Figure 1. Location of Unit 3 thermocouples on auxiliary pressurizer spray line.

Review of the control room logs corresponding in time to the temperature variations recorded during warm-up indicated a relationship between the auxiliary spray line temperature distribution and charging pump operation. Starting and securing the charging pumps produced a marked change in the auxiliary spray line temperature distribution as shown in Figure 2. Securing all charging pumps produces an instantaneous temperature rise in the auxiliary spray line up to and consistent with pressurizer temperatures. Conversely, starting a charging pump produced an immediate uniform decrease in exterior pipe wall temperature. Such rate of change in the exterior pipe wall temperature can only be explained by forced convection within the pipe (i.e. full pipe flow).

Although this does not demonstrate stratification, it does demonstrate leakage past the auxiliary spray isolation valves. Thermal stratification is a function of the leakage flow rate which in turn is a function of the relative pressure difference between the RCS and the charging system. Consequently, at normal operating pressure, the relative pressure difference between the RCS and charging system is decreased and the leakage flow rate is correspondingly smaller. Leakage flow rates, insufficient to maintain full pipe flow, result in a stratified fluid profile.

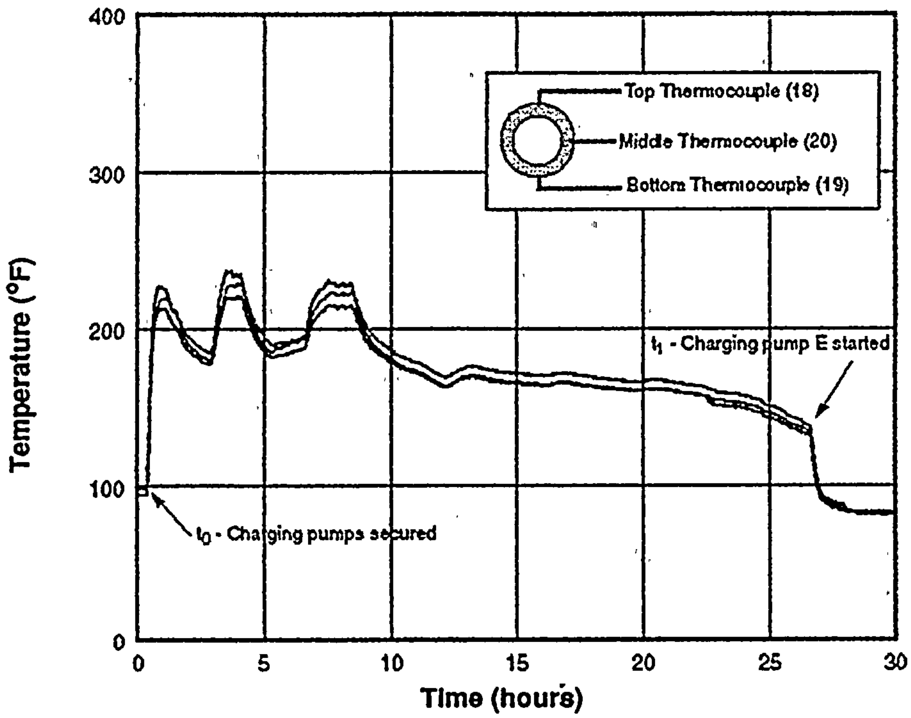

Figure 2. Temperature distribution downstream of the auxiliary spray injection check valve. Refer to Figure 1. Distribution demonstrates the effect of securing all charging pumps at t_0 and the effect of starting one charging pump at t_1. Charging pump flow, leaking past the isolation valves, cools the pipe uniformly prior to and after t_0 and t_1 respectively. Cessation of charging pump flow allows pressurizer steam to enter the pipe resulting in a sharp increase in pipe wall temperature. The relatively uniform temperature between t_0 and t_1 indicates that the water layer height is small and the pipe is full of steam.

Data collected during normal operation substantiates this conclusion. Specifically, the normal operating data shown in Figure 3 demonstrates stratification, the magnitude of which is proportional to system temperature and pressure. The data does not reflect high cycle fluctuations in the spray; once established, the stratification is constant corresponding to a constant leak rate.

Consequently, the assumptions regarding the bounding thermal stratification loads used in the class 1 structural evaluation are not correct. The magnitude of the thermal load is directly proportional to the leak rate which may vary from cycle to cycle and with valve maintenance. Therefore, the leak rate or the actual temperature distribution must be monitored to ensure that the maximum top to bottom temperature difference does not exceed that assumed in APS calculation 13-MC-ZZ-643. Alternatively, if a correlation can be made relating the leak rate and the resultant temperature distribution, the

maximum stress can be determined and factored into the fatigue evaluation thereby eliminating the need for continuous monitoring.

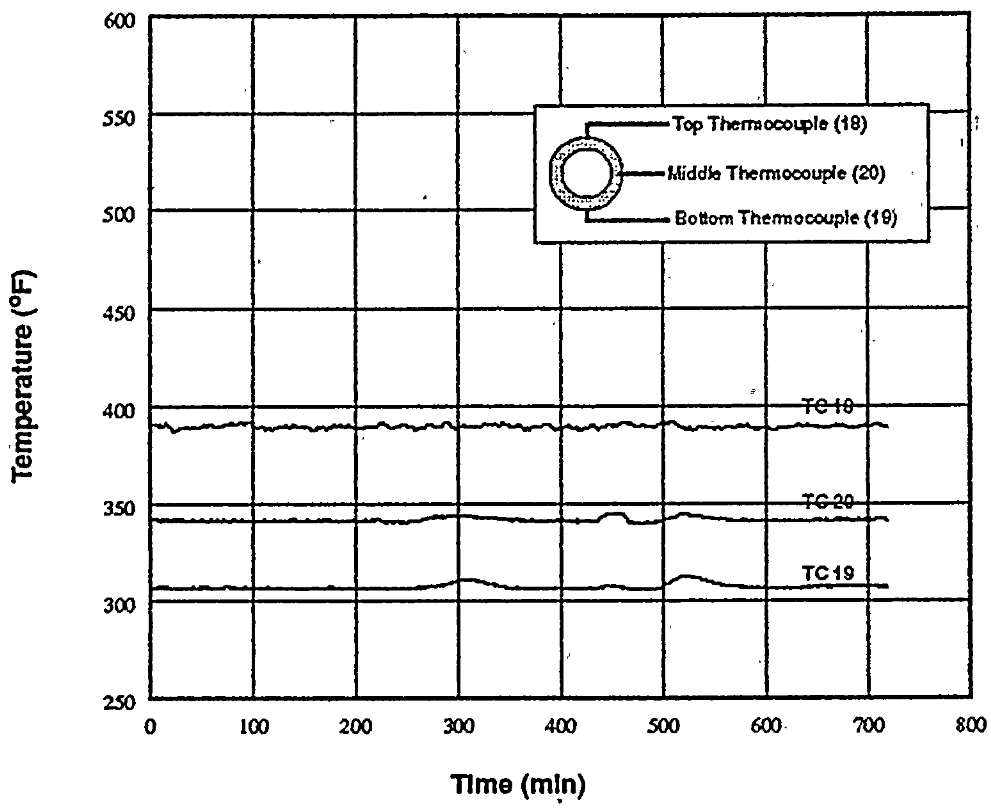

FIGURE 3. Normal operating temperature distribution on the auxiliary pressurizer spray line. The recorded data does not demonstrate cycling during normal operation. Data is representative of maximum normal operating top to bottom temperature difference.

MONITORING PROGRAM AND CLOSURE ACTIONS

In the absence of cycling, Engineering has concluded that the stratification recorded on the auxiliary spray line does not represent the potential for high cycle thermal fatigue and therefore is beyond the scope of NRC Bulletin 88-08. The static load itself, however, was not considered in the original design basis and must be properly incorporated. The existing calculation accounts for the recorded temperature load but there is no assurance that these are the limiting conditions. Engineering, therefore, has prepared an installation plan for the Unit 3 fourth refueling outage to re-instrument the auxiliary spray line.

The auxiliary spray line will be re-instrumented with thermocouples at the approximate locations used in the previous data collection effort. Additional thermocouples will be used to further define the temperature distribution upstream of the auxiliary spray isolation valves. The equipment will be installed during Unit 3 refueling outage 4 for data collection during cycle 5 and will provide one complete cycle of data. The effort will conclude at the end of the cycle and data analysis will be completed thereafter.