REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR: 8709220002 DOC. DATE: 87/09/14 NOTARIZED: NO DOCKET #
FACIL: 50-397 WPPSS Nuclear Project, Unit 2, Washington Public Powe 05000397
AUTH. NAME AUTHOR AFFILIATION
SORENSEN, G. C. Washington Public Power Supply System
RECIP. NAME RECIPIENT AFFILIATION
Document Control Branch (Document Control Desk)

SUBJECT: Forwards response to 870709 IE Bulletin 87-001, "Thinning of Pipe Walls in Nuclear Power Plants." Util committed to maintaining design margin in all plant piping sys.

DISTRIBUTION CODE: IE11D COPIES RECEIVED: LTR 1 ENCL 1 SIZE: 16
TITLE: Bulletin Response (50 DKT)

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD5 LA	1	0	PD5 PD	1	1
	SAMWORTH, R	1	1			
INTERNAL:	AEOD/DOA	1	1	AEOD/DSP	1	1
	AEOD/DSP/TPAB	1	1	NRR/DEST/ADE	1	1
	NRR/DEST/ADS	1	1	NRR/DEST/MEB	1	1
	NRR/DOEA/EAB	1	1	NRR/DOEA/GCB	1	1
	NRR/DREP/EPB	1	1	NRR/PMAS/ILRB	1	1
	REG FILE 02	1	1	RES/DE/EIB	1	1
	RGN5 FILE 01	1	1			
EXTERNAL:	LPDR	1	1	NRC PDR	1	1
	NSIC	1	1			

TOTAL NUMBER OF COPIES REQUIRED: LTTR 19 ENCL 18

Washington Public Power Supply System
3000 George Washington Way P.O. Box 968 Richland, Washington 99352-0968 (509)372-5000

September 14, 1987
G02-87-245

Docket No. 50-397

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Gentlemen:

Subject: NUCLEAR PLANT NO. 2
OPERATING LICENSE NPF-21
RESPONSE TO NRC BULLETIN NO. 87-01:
THINNING OF PIPE WALLS IN NUCLEAR
POWER PLANTS

Reference: NRC Bulletin No. 87-01: Thinning of Pipe Walls in Nuclear Power Plants, dated 7/9/87

NRC Bulletin No. 87-01 requested that licensees submit information concerning their programs for monitoring the thickness of pipe walls in high-energy single-phase and two-phase carbon steel piping systems. Within 60 days from receipt of the subject bulletin, the licensee was to provide certain information concerning their programs for monitoring the wall thickness of pipes in condensate, feedwater, steam, and connected high-energy piping systems, including all safety-related and non-safety-related piping systems fabricated of carbon steel. The requested information is included as an attachment to this letter.

The Supply System is committed to maintaining the design margin in all plant piping systems. This is being formally implemented via WNP-2 Plant Procedure 8.3.63, "Surveillance Procedure For Monitoring Pipe Wall Thinning", whose stated goal is to identify and take action on degraded high pressure/energy lines caused by erosion/corrosion.

IE11
1/1

As is the case with the rest of the industry, the WNP-2 pipe wall thinning surveillance effort is evolving. The systems baselined to date represent expected worst case conditions; plans to baseline additional piping systems are being formulated. The Supply System will continue to remain current with the industry trends and developments through INPO, EPRI, and participation in workshops, as well as through our own aggressive efforts to maintain a safe and reliable plant.

Should you have any questions, please contact Mr. P. L. Powell, Manager, WNP-2 Licensing.

Very truly yours,

G. C. Sorensen, Manager
Regulatory Programs

HLA/bk
Attachments

cc: C Eschels - EFSEC
JB Martin - NRC RV
NS Reynolds - BCP&R
RB Samworth - NRC
DL Williams - BPA
NRC Site Inspector - 901A

Question 1:

Identify the codes or standards to which the piping was designed and fabricated.

Response:

The codes and standards under which the safety related and nonsafety related plant piping is designed are Section III of the ASME Boiler and Pressure Vessel Code, and the ANSI B31.1 Power Piping Code, respectively. The WNP-2 FSAR (Section 3.9) lists the major safety related systems and piping design criteria for both NSSS and balance of plant systems.

Question 2:

Describe the scope and extent of your programs for ensuring that pipe wall thicknesses are not reduced below the minimum allowable thickness.

Response:

The WNP-2 pipe wall thinning surveillance effort quantifies degradation of high pressure/energy pipe lines due to the erosion/corrosion phenomena. Identification of those lines to which erosion/corrosion wall thinning is occurring is being made by measurement of the pipe wall thicknesses. Susceptible piping systems are being wall thickness tested at selected known "worst case" locations. The WNP-2 inspection effort includes two-phase and single-phase flow systems. Consideration is given to safety systems with intermittent operation as well as plant process systems. The WNP-2 effort is based on experience and data compiled from other plants which identifies worst case piping systems and locations. Examinations of selected piping systems which are not deemed "worst case" are also completed to ensure a thorough plant surveillance (i.e., feedwater, condensate, service water and corrosion inhibited pipe lines).

Question 2a:

Describe the criteria that you have established for selecting points at which to make thickness measurements.

Response:

The susceptible pipe systems are selected based on the thermodynamic/hydraulic conditions (i.e., temperature, pressure, enthalpy, steam quality, fluid velocity, water chemistry, piping material and pipe nominal wall thickness). For these susceptible pipe systems, calculations are made for bulk fluid velocities and the erosion rates were predicted based on the Keller equation.*

With the understanding that the fluid flow path (pipe geometry) is a major accelerating factor to the erosion/corrosion rates, ultrasonic thickness

measurement locations are selected according to the fluid flow path; i.e., the worst case conditions exist at elbows, tees, fittings, etc. Interactions between different geometry changes are considered in the selection process.

The EPRI developed CHEC program was not available when selection criteria for the last refueling outage was established, but the selection of susceptible piping for wall thinning surveillance used the same basic parameters; i.e., velocity, geometry, temperature, and material; similar to the Keller equation.

*Reference EPRI NP 3944, April 1985

Question 2b:

Describe the criteria that you have established for determining how frequently to make thickness measurements.

Response:

The frequency of inspection is determined by the measured erosion/corrosion rate, and the relative difference between the actual wall thickness and the minimum wall thickness. The WNP-2 pipe wall thinning surveillance optimizes the inspection frequency to the remaining life; i.e., those pipe lines with large design margins are examined less frequently than those which have two to five operating cycles of remaining life. These pipe lines are scheduled for yearly monitoring during the last three years of life. In some cases, selected pipe can be ultrasonically tested during a forced outage to increase confidence in the calculated E/C rate.

Question 2c:

Describe the criteria that you have established for selecting the methods used to make thickness measurements.

Response:

The WNP-2 pipe wall thinning surveillance uses ultrasonic methods to measure pipe wall thickness. Ultrasonic methods are considered the most accurate nondestructive methods available. Radiography may be used on occasion to supplement ultrasonics.

Question 2d:

Describe the criteria that you have established for making replacement/repair decisions.

Response:

The Supply System is committed to maintaining the design margin in all plant piping systems. The WNP-2 pipe wall thinning surveillance effort optimizes the inspection frequencies with the remaining life. The remaining life of thinned pipe is calculated and adjusted to plant maintenance/refueling cycles. As the remaining cycles for unrestricted operation approaches two to five, the inspection frequency increases, thus providing sufficient lead time to schedule repair/replace actions prior to the loss of the design margin.

Question 3:

For liquid-phase systems, state specifically whether the following factors have been considered in establishing your criteria for selecting points at which to monitor piping thickness (Item 2a):

Response:

A. The piping material was considered in the selection process of the single-phase piping systems inspected with ultrasonic thickness measurement techniques.

B. The piping configuration was considered in the selection process.

C. The pH of the water was not considered because, as a BWR, the feedwater and condensate are maintained neutral.

D. The bulk system temperature was considered in the selection process.

E. The bulk fluid velocity was considered in the selection process.

F. The oxygen content of the system was not used to identify a particular location though it was used to qualitatively determine the pipe line susceptibility.

WNP-2 is a new boiling water reactor (BWR) plant. As such, less emphasis is placed on single-phase liquid erosion/corrosion (E/C) early in plant life (first four years). This is justified through an understanding of the E/C process, other BWR/industry experience, and plant specific visual inspections. There is evidence that BWR erosion/corrosion in feedwater or condensate piping systems is reduced in comparison to pressurized water reactors (PWR's), partially due to the increased oxide film stability brought about by the relatively high O_2 (20 ppb) and neutral pH.

Question 4:

Chronologically list and summarize the results of all inspections that have been performed, which were specifically conducted for the purpose of identifying pipe wall thinning, whether or not pipe wall thinning was

discovered, and any other inspections where pipe wall thinning was discovered even though that was not the purpose of that inspection.

Response:

The present scope for the pipe wall thinning surveillance is an outgrowth of the results from baseline type inspections made during a maintenance outage in 1985 and the first refueling outage in 1986. The conclusion from these inspections was that E/C is ongoing in some steam piping with conditions of low steam quality and elevated velocities. No evidence was found which indicated a single-phase E/C problem after one operating cycle.

The WNP-2 efforts for the second refueling outage in 1987 changed from simple testing (go/no-go) to an effort which targets worst case areas for actual E/C rate calculations, thus enabling a predictive analysis of component life. Component life is normalized to the plant refueling outage cycle to optimize the inspection results with repair/replacement.

WNP-2 has taken steps to control E/C now that it has been confirmed. Due to the 1986 refueling outage inspection results, a decision was made to install four moisture preseparators beneath the high pressure turbine exhaust. The preseparator specifically addresses the E/C occurring in the bleed steam piping directly between the high pressure turbine and the moisture separator reheater.

Question 4a:

Briefly describe the inspection program and indicate whether it was specifically intended to measure wall thickness or whether wall thickness measurements were an incidental determination.

Response:

The WNP-2 surveillance effort, which quantifies pipe wall thinning due to E/C over the plant life, was formalized prior to the April 1987 refueling outage. The goal of WNP-2 Plant Procedure 8.3.63, "Surveillance Procedure for Monitoring Pipe Wall Thinning," is to identify and take action on degraded high pressure/energy lines caused by erosion/corrosion. The procedure provides assurance that piping systems will be maintained with acceptable design margins. In addition, visual inspections are performed inside piping systems during various maintenance activities. Piping or component degradation due to E/C will be reported and appropriate corrective actions taken. Corrective actions may include replacement/repair of affected piping or increased surveillance. Material substitutions and/or schedule changes will also be considered.

Question 4b:

Describe what piping was examined and how (e.g., describe the inspection instrument(s), test method, reference thickness, locations examined, means for locating measurement point(s) in subsequent inspections).

Response:

The piping examined during the 1987 refueling outage and their corresponding identification numbers are presented in Table I. The table describes the general function of the pipe line.

The UT measurements are made in accordance with plant procedures. The equipment consists of a dual element transducer generating a straight beam and an analyzer/data logger. Specifically, WNP-2 uses two instruments, a Nova 100D and Krautkramer DMX-1, to take the measurements. The DMX unit is supported by a HP-71B/UDL-71 data logger, IBM PC, and Viewsonics software. The test method uses the pulse/echo technique. Reference thickness measurements are made before and after each continuous string of measurements. WNP-2 uses a grid approach for a mapping of the surface contour. The grid varies according to pipe diameter. Table II illustrates the grid schedule. The spacing is roughly the same for all pipe diameters, whereas the number of thickness measurements taken at a location increases with increasing pipe diameter. All thickness measurement locations (intersection of grids) are permanently marked on the pipe with a low stress stamp for repeatability.

Question 4c:

Report thickness measurement results and note those that were identified as unacceptable and why.

Response:

Two tables are provided to illustrate the extent of the WNP-2 effort and the findings since plant startup. Table III summarizes the results of the ultrasonic thickness measurements. At each location, the thickness measured was greater than the minimum required wall thickness determined by the piping codes. Table III highlights the locations that, based on preliminary conservative E/C rate estimates, may be sites of increased, albeit localized, erosion. Those areas will be included in future inspections to evolve more accurate E/C rate information. All data taken indicates that design criteria are being met. Table IV chronologically lists other erosion/corrosion occurrences discovered during plant operation. Also listed in the table for each item are actions taken for repair.

Question 4d:

Describe actions already taken or planned for piping that has been found to have a nonconforming wall thickness. If you have performed a failure analysis, include the results of that analysis. Indicate whether the actions involve repair or replacement, including any change of materials.

Response:

Pipe wall thickness measurements at selected locations during Spring 1986 and 1987 outages indicate that each wall thickness measured was greater than the

minimum wall thickness. Pipe with subsequent thickness measurements which indicate remaining life less than two operating cycles shall be considered for repair/replacement, including change of material as appropriate.

Question 5:

Describe any plans either for revising the present or for developing new or additional programs for monitoring pipe wall thickness.

Response:

The WNP-2 pipe wall thinning surveillance effort is evolving. The systems baselined so far represent expected worst case conditions; plans to baseline additional piping systems are being formulated. The Supply System will continue to remain current with the industry trends and developments through INPO, EPRI, and participation in workshops.

TABLE I

SUMMARY OF LOCATIONS EXAMINED
DURING REFUELING OUTAGE 1987

Test Location Identification	Description of Piping Selected for Surveillance
314-1 313-1	16-inch diameter bleed steam piping from high pressure turbine to Feedwater Heater #6.
312-1 311-1 311-2	18-inch diameter bleed steam piping from high pressure turbine discharge cross-under pipe to Feedwater Heater #5.
304-1 303-1 302-1 302-2	20-inch diameter bleed steam piping from low pressure turbine to Feedwater Heater #3.
307-1 306-1 305-1	24-inch diameter bleed steam piping from low pressure turbine to Feedwater Heater #2.
356-1 358-1	10-inch diameter heater drain piping from second stage reheater to drain tank.
362-1 363-1	8-inch diameter heater drain piping from second stage reheater drain tank to Feedwater Heater #6.
364-1 365-1 366-1 367-1	6-inch diameter heater drain piping from the moisture separator reheater first stage drain tank to Feedwater Heater #6.
393-1 393-2	6-inch diameter bleed steam piping from 16-inch bleed steam pipe (same as 314-1) to seal steam evaporators.
390-1 388-1	12-inch or 16-inch diameter bleed steam piping from high pressure turbine to moisture separator reheater first stage.

TABLE I

SUMMARY OF LOCATIONS EXAMINED
DURING 1987 REFUELING OUTAGE (CONT'D)

Test Location Identification	Description of Piping Selected for Surveillance
369-1 371-1	16-inch diameter bleed steam piping from second stage moisture separator reheater drain tank to Feedwater Heater #5.
372-1 372-2	3-inch diameter heater drain piping from seal steam evaporator to Feedwater Heater #5.
342-1	8-inch diameter auxiliary steam piping from the auxiliary boiler to the seal steam evaporator.
403-1 403-2	18-inch diameter bleed steam piping from the moisture separator reheater to the feedwater pump turbine.
334-1	24-inch diameter feedwater piping discharge from the feedwater pump.
331-1 331-2	24-inch diameter condensate piping from Feedwater Heater #4 to Feedwater Heater #5.
430-1 430-2 430-3 430-4 431-1 431-2 431-3	6-inch and 3-inch diameter heater vent piping from moisture separator reheater to bleed steam piping to Feedwater Heater #6.
458-1 458-2 459-1	4-inch and 3-inch piping diameter heater vent piping from moisture separator reheater to Feedwater Heater #5.

TABLE II

EROSION/CORROSION PIPE GRID EXAMINATION SCHEDULE

Pipe Diameter (inches)	Actual O.D. (inches)	Linear Distance Between Measurements (inches)	Circumferential Spacing from 0^o or 180^o as Measured in Inches			
			90^o	45^o	22^o	11^o
2	2.375	1	1.85	.95		
2.5	2.875	1	2.25	1.10		
3	3.5	1	2.75	1.35		
3.5	4.0	1	3.15	1.55		
4	4.5	1	3.55	1.75		
5	5.563	1	4.35	2.20	1.10	
6	6.625	1	5.2	2.6	1.30	
8	8.625	1	6.75	3.40	1.70	
10	10.75	1	8.45	4.20	2.10	1.0
12	12.75	2	10.0	5.0	2.5	1.25
14	14	2	11.00	5.5	2.75	1.35
16	16	2	12.55	6.30	3.15	1.55
18	18	2	14.15	7.0	3.5	1.75
20	20	2	15.7	7.8	3.90	1.95
22	22	2	17.3	8.65	4.30	2.15
24	24	2	18.8	9.40	4.70	2.35

Table III

WNP-2 EROSION/CORROSION RESULTS FOLLOWING FY 1987 REFUELING OUTAGE

Test Location	Line Number	Material and Fitting Type	Pressure PSIG	Temperature °F	Nominal Thickness IN	Minimum Wall Thickness IN	1986 Outage Data IN	1987 Outage Data IN
314-1	16"BS(3)-2	A106 GRB ELBOW	500	470	0.500	0.263		0.490
313-1	16"BS(3)-2	A106 GRB ELBOW	500	470	0.500	0.263		0.477
312-1	18"BS(4)-2	A106 GRB ELBOW*	265	420	0.375	0.157		0.297
311-1	18"BS(4)-2	A106 GRB ELBOW*	265	420	0.375	0.157		0.242
311-2	18"BS(4)-2	A106 GRB ELBOW*	265	420	0.375	0.157		0.246
304-1	20"BS(7)-1	A106 GRB ELBOW	50	380	0.375	0.033		0.366
303-1	20"BS(7)-1	A106 GRB ELBOW	50	380	0.375	0.033		0.355
302-1	20"BS(7)-1	A106 GRB ELBOW	50	380	0.375	0.033		0.352
302-2	20"BS(7)-1	A106 GRB ELBOW	50	380	0.375	0.033		0.372
307-1	24"BS(8)-1	A106 GRB ELBOW	50	380	0.375	0.039		0.317
306-1	24"BS(8)-1	A106 GRB ELBOW	50	380	0.375	0.039		0.375
305-1	24"BS(8)-1	A106 GRB ELBOW	50	380	0.375	0.039		0.350
356-1	10"HD(8)-2	A106 GRB ELBOW	570	490	0.365	0.201		0.350
358-1	10"HD(8)-2	A106 GRB ELBOW	570	490	0.365	0.201		0.371
362-1	8"HD(7)-4	A106 GRB ELBOW	1250	575	0.500	0.347		0.477
363-1	8"HD(7)-4	A106 GRB ELBOW	1250	575	0.500	0.347		0.486
364-1	6"HD(8)-2	A106 GRB ELBOW	570	490	0.280	0.123		0.315
365-1	6"HD(8)-2	A106 GRB ELBOW*	570	490	0.280	0.123		0.232
366-1	6"HD(8)-2	A106 GRB ELBOW*	570	490	0.280	0.123		0.252
367-1	6"HD(8)-2	A106 GRB ELBOW*	570	490	0.280	0.123		0.230
393-1	6"BS(2)-2	A106 GRB ELBOW	570	490	0.280	0.123		0.313
393-2	6"BS(2)-2	A106 GRB ELBOW	570	490	0.280	0.123		0.270
390-1	12"BS(1)-2	A106 GRB ELBOW	570	490	0.406	0.238		0.402
388-1	16"BS(1)-2	A106 GRB ELBOW	570	490	0.500	0.299		0.485
369-1	16"BS(9)-2	A106 GRB ELBOW	265	420	0.375	0.140		0.334
371-1	16"BS(9)-2	A106 GRB ELBOW	265	420	0.375	0.140		0.357
372-1	3"HD(10)-2	A106 GRB ELBOW	425	450	0.300	0.049		0.293
372-2	3"HD(10)-2	A106 GRB ELBOW	425	450	0.300	0.049		0.304
342-1	8"AS(1)-2	A106 GRB ELBOW	250	410	0.322	0.071		0.312
403-1	18"BS(5)-2	A106 GRB ELBOW	265	575	0.375	0.157	0.378	0.353
403-2	18"BS(5)-2	A106 GRB ELBOW	265	575	0.375	0.157	0.378	0.362
334-1	24"RFW(1)-5	A106 GRB ELBOW	1950	450	1.812	1.482		2.087
331-1	24"COND(4)-3	A106 GRB TEE	775	420	0.969	0.607		0.888
331-2	24"COND(4)-3	A106 GRB TEE	775	420	0.969	0.607		0.915
430-1	6"HV(11)-4	A335 P11 TEE	1250	575	0.432	0.267	0.430	0.426
430-2	6"HV(11)-4	A335 P11 TEE	1250	575	0.432	0.267	0.436	0.421
430-3	3"HV(11)-4	A335 P11 ELBOW	1250	575	0.438	0.141		0.414
430-4	6"HV(11)-2	A335 P11 ELBOW	50	575	0.280	0.011		0.235
458-1	4"HV(12)-2	A335 P11 ELBOW	570	575	0.237	0.084		0.236
458-2	3"HV(12)-2	A335 P11 ELBOW	570	575	0.300	0.065	0.428	0.411
431-1	6"HV(11)-4	A335 P11 TEE*	1250	575	0.432	0.272		0.382
431-2	6"HV(11)-4	A335 P11 TEE*	1250	575	0.432	0.272	0.428	0.378
431-3	6"HV(11)-2	A335 P11 ELBOW	50	575	0.280	0.011		0.223
459-1	4"HV(12)-2	A335 P11 ELBOW	570	575	0.237	0.085		0.222

*Meets the criteria for increased inspection frequency and/or analysis.

TABLE III

DEFINITIONS

Test Location	Corresponds with descriptions given in Table 2.
Line Number	Pipe line numbers were initially designated by Plant A/E used to define symmetrical piping systems within common anchor groups.
Material and Fitting Type	Material used as specified and the fitting type at the ultrasonic thickness test location.
Pressure	Design pressure, psig.
Temperature	Design temperature, ^{o}F
Nominal Thickness	Nominal thickness of pipe line defined as the textbook thickness* for the specified thickness for the pipe schedule. Units are given in inches. (*Crane Technical Paper #410)
Minimal Wall Thickness	Minimum pipe wall thickness based on design temperature and pressure of the pipe line. The calculation uses the formulation referenced in the ASME Code NC-3641.1 1986 Edition, Equation 3. Units are given in inches. $t_m = \frac{P\ D_o}{2(S+Py)} + A$ A is taken to be 0.
1986 Outage Data	Six locations were baseline tested in 1986. The number represents the lowest wall thickness in the entire data field. Units are given in inches.
1987 Outage Data	The remaining 38 locations were baselined in 1987. The number represents the lowest wall thickness in the entire data field. Units are given in inches.

*Notes: Locations identified as 311-1, 311-2, and 312-1 are common to the bleed steam supply for Feedwater Heaters 5A and 5B. These lines exhibit the greatest E/C rate for the large diameter/high energy pipe. These lines also are expected to be influenced the most by the installation of moisture preseparators. The remaining life is expected to increase by several years.

TABLE IV

SUMMARY OF OTHER INSPECTIONS

The following presents the other plant inspections where pipe wall thinning was discovered. This list includes some examples where the definition of erosion/corrosion is stretched to include cavitation flow or flashing flow or some other unknown condition.

1983 Startup Testing	Auxiliary boiler deaerator return piping was discovered leaking. The investigation concluded that both pitting corrosion and erosion/corrosion were responsible. The pipe section was replaced with the same material and the same design.
1984 Startup	MSR drain line (6" HV(11)-4) discovered leaking at the center of the tee fitting. Steam impingement on the back of the fitting was caused by an orifice upstream of the fitting. The fitting was changed with a more erosion/corrosion resistant alloy, Type 304 stainless steel.
1984 - 1985 Operating Cycle	Heater drain valve, HD-FCV-7B2, was discovered leaking from the bottom of the body. The erosion/corrosion was caused by the valve disk leakage. The eroded area was drilled and a Type 410 stainless steel plug was welded to the body for the repair.
1984 - 1985 Operating Cycle	Heater drain valve, HD-FCV-11A2, was discovered leaking from the bottom of the body. The erosion/corrosion was caused by the valve disk leakage. Three other valves with the same operating conditions were ultrasonically tested and found with little or no erosion/corrosion wall thinning. It was concluded that the singular valve was the problem. A plug of Type 410 stainless steel was welded in place and the valve was returned to operation.
1985 Maintenance Outage	Walkdown of a ~48" mitered elbow revealed a total coatings loss on the outside and inside radius of a 180° bend. The pipe was part of the circulating water system used to divert flow back to the circulation water pond. Further analysis concluded that cavitation erosion/corrosion was caused by operation outside of the recommended design. The design was changed, the surface was recoated and operation of the loop was changed to avoid cavitation flow.

1985 - 1986 Operating Cycle	Heater drain valve, HD-FCV-11A2, was again found leaking. The valve disk was inspected and found to be the cause of the leakage. The hole was again repaired in the same manner and the valve disk was repaired. No further problems have been encountered.
1985 - 1986 Operating Cycle	A leak was discovered on a heater drain line (4" HV(11)-4). Three pinhole leaks were discovered on the outside bend radius of a 4" diameter pipe located just downstream of a flow control valve. The elbow was replaced with similar material. However, the design was changed to allow greater than 10 pipe diameters between the valve and elbow.
1985 - 1986 Operating Cycle	Reactor feedwater return to service, flow control valve, RFW-FCV-2B, was determined to be responsible for impingement attack on a 45° elbow just downstream. The elbow was repaired by patching with stainless steel pipe sections. Further analysis concluded that the valve was not adjusted to completely close during operation. The valve elbow was replaced during the 1987 refueling outage.
1986 Refueling Outage	Standby service water pipe line just downstream of Pump 1A and 1B discharge exhibited localized metal loss from a cavitation mechanism. Both lines exhibited wall thinning--one on the valve body and the other on the pipe line. The localized areas were weld repaired and mapped for reference.
1986 - 1987 Operating Cycle	Auxiliary boiler pump 2A recirculation line to deaerator tank failed due to combined pitting corrosion and erosion/corrosion. Lack of chemical treatment for pitting corrosion inhibition has been pointed out as a contributing factor. The failure area was replaced and the unit was returned to service.
1986 - 1987 Operating Cycle	A leak was found on the low pressure side of a reducing orifice in the CRD pump minimum flow line. The leak was caused by an erosion mechanism likely to be a combined flashing flow and cavitation flow problem. Evaluation is ongoing. The failure was repaired by replacement with a similar design and material.
1986 - 1987 Operating Cycle	Reactor feedwater valve, RFW-FCV-15, was found with a hole in the bottom. The hole was caused by cavitation flow. The hole was weld repaired with a patch. The valve was replaced during the 1987 refueling outage with a design modification to address the cavitation problem.

1987 Refueling Outage

The standby service water pipe line mapped the previous outage was reinspected and valves were replaced. Additional wall thinning had occurred. The weld repair areas were found intact; however some E/C attack was evident. The attack areas on the pipe were mapped again. The wall thinning is believed to have been caused by cavitation from valve flow distortion. With the new valves; the erosion/corrosion is expected to subside.

1987 Refueling Outage

Reactor feedwater piping removed for a design change in the vicinity of RFW-FCV-10 was inspected for surface oxide conditions. During the inspection, a small area of erosion at an elbow was observed. The erosion was documented on film. The remainder of the RFW pipe (~40 feet) exposed for the design change was visually inspected. No other indications were found.