RAS M-348

VERMONT YANKEE

PIPING FLOW ACCELERATED CORROSION

INSPECTION PROGRAM

(PP 7028)

2001 REFUELING OUTAGE INSPECTION REPORT

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V.Y. PIPING F.A.C. INSPECTION PROGRAM: 2001 REFUELING OUTAGE

INSPECTION REPORT

TABLE OF CONTENTS

V.Y. PIPING F.A.C. INSPECTION PROGRAM: 2001 REFUELING OUTAGE

INSPECTION REPORT

1.0 SUMMARY

This was the first outage in which FAC piping inspection activities were controlled under a new Vermont Yankee Program Procedure, PP-7028 "Piping Flow Assisted Corrosion Inspection Program".

External UT measurements were taken on 25 large bore piping components in the Feedwater and Condensate Systems. Also inspected were 2 sections of small bore piping, on the turbine Steam Seal Regulator drain piping. No internal visual inspections were performed on the Turbine Cross-Around piping.

The large bore results were evaluated using a three level screening process defined in a new plant procedure DP 0072. All components inspected were found to have a wall thickness greater than the code minimum wall thickness. The predicted thickness at the next refueling outage was greater than the code minimum wall thickness for all components. A summary of the large bore piping component screening is contained in Attachment 1. Attachment 2 contains a summary of the small bore piping inspection results.

No piping components required repair or replacement during the refueling outage and there were no immediate operability concerns.

Component selection was based on a combination of; previous inspection experience, industry events, analyses using the EPRI developed CHECWORKS computer code, and the consequences of component failure.

During the 2001 refueling outage, the UT inspections were performed by the same personnel performing the ASME Section XI in-service inspections. Panametrics 26DL+ electronic thickness measurement and data logging equipment was used to collect data. Component preparation, scaffolding, insulation removal, and surface cleaning, were performed by NPS personnel. Due to the small inspection scope, application of grid markings was performed by the UT personnel using guidelines contained in Appendix A of the UT procedure, NE 8053.

This was the first outage that the UT results were directly downloaded from the data loggers into the EPRI CHECWORKS program located on the VY computer network. This reduced both time and effort required to transmit data to engineering personnel and resulted in a faster turn around time for engineering to evaluate the inspection results and release components for restoration.

2.0 2001 REFUELING OUTAGE INSPECTION PLAN

The 2001 refueling outage inspection scope (references 4 & 5) was developed to satisfy the following goals:

- To inspect components requiring follow up inspections, based on UT data from previous refueling outages.
- Inspect components identified by the EPRI CHECWORKS computer code ranked high for susceptibility to wear and/or having the least time remaining to reach code minimum wall thickness.
- Perform repeat inspections on selected components for calibration of the CHECWORKS models.
- To incorporate industry experience into the program through inspection of components at VY that are similar to those that have either failed or showed significant wall thinning at other plants.
- To perform inspections on any large bore and small bore piping components subjected to off normal flow conditions, such as components downstream of normally closed valves with seat leakage. These components are identified by the cognizant Systems Engineer, using the turbine performance monitoring system. Two Heater Drain system bypass valves at the condenser were identified by the thermal performance monitoring system as leaking by the normally closed valves. The plan was for the outage was for maintenance to disassemble the valves, perform an internal visual inspection for erosion of the valve bodies and the downstream piping. External UT measurements would only be performed if indications of internal wear were identified.

3.0 EVALUATION OF INSPECTION RESULTS

3.1 Large Bore Piping

Twenty-four (24) large bore piping components and one (1) equipment nozzle were included in the planned inspection scope for external UT exams. Inspections of the turbine cross around piping were deferred until the 2002 RFO based on an evaluation of the inspection results from the 1996, 1998, and 1999 refueling outages.

The UT results were evaluated using a three level screening process as defined in a new procedure, DP 0072. The UT results were directly downloaded from the data loggers into the EPRI CHECWORKS program located on the VY computer network. This reduced both time and effort required to transmit data to engineering personnel and resulted in a faster turn around time for engineering to evaluate the inspection results and release components for restoration.

The UT inspection results for each component were reviewed for anomalies and consistency with piping geometry. Wear rates (wear/cycle) were calculated for each component using methods specified in DP 0072. For component UT results which indicated no wear or minimal wear has occurred, a minimum wear rate of 0.005 inches/cycle was used. Using the calculated wear rates and the 2001 measured thickness, the predicted thickness at the end of the next cycle (2002 Tpred) was calculated using a safety factor of 1.2 on the calculated wear per cycle. Using both the wear rate and 2001 measurement data, the projected number of cycles beyond the Spring 2001 refueling outage for each component to wear down to the code minimum wall thickness was also calculated.

The methods used to predict wall thickness at the next refueling outage are consistent with NSAC-202L, reference (8). The wear rate calculations and projected times to code minimum wall for single phase flow systems are assumed to be linear. In fact they may not be, but a linear projection is used for the wear rates given that observed wear has occurred at a relatively slow rate (approx. 29 years). These calculated times to code minimum are based on the lowest measured thickness including a safety factor, and generally will be conservative.

Components passing the Level 1 screen have 2002 Tpred greater than .875Tnom (the manufacturing tolerance of new piping) and require no further evaluation. The Level 2 screen is for components with 2002 Tpred less than .875Tnom but greater than Tmin (the code minimum wall thickness). These components are acceptable for continued operation but future monitoring is recommended. The Level 3 screening is for components with 2002 Tpred less than Tmin. The Level 3 screening is a detailed analytical methodology. It also requires that additional piping components be inspected this outage (sample expansion), and considered for inspection during future refueling outages.

Twenty-five (25) large bore piping components were inspected. Only the weld area on the equipment nozzle (P-1-1A) was inspected. Eighteen (72%) passed the Level 1 screen, and the remaining seven (28%) passed the Level 2 screen. All components inspected were

Large Bore Piping – continued

found to have wall thickness greater than code minimum wall thickness. All predicted wall thickness (at the 2002 refueling outage) values were above code minimum wall thickness.

No large bore repairs or replacements were required. Only one component was identified as requiring future monitoring and is discussed in Section 4.0 of this report. A summary of the large bore piping component screening is contained in Attachment 1.

The Systems Engineer for the thermal performance monitoring program identified possible leakage by two normally closed valves, LCV-103-1A-2 and LCV-103-3B-2. These are the high level emergency dump valves for the 1A and 3B feedwater heaters. They are located adjacent to the condenser. No evidence of erosion was found on the valve body or downstream piping for LCV-103-1A-2. Visual inspections identified erosion below the seat on the valve body and in the 6 inch diameter end of the 6 x 16 expander downstream of the valve LCV-103-3B-2. UT measurements were then taken on the valve body and the expander to determine the remaining wall thickness. The evaluation of the UT data is contained in VY Technical Evaluation No. TE-2001-024, reference(10).

The TE concluded that the as-found wall thickness values for the eroded areas on both the valve body and the 6 inch diameter end of the downstream expander are greater than the code minimum required wall thickness. The TE demonstrated the structural integrity of the valve body and the downstream piping as found during RFO 22 with localized eroded areas. It did not address the possibility of continued degradation from leakage past the seat during future operation. The rate of erosion of the valve body wall due to leakage past the seat could not be estimated. However TPM data indicate that this valve may have been leaking since the TPM system was installed in 1995. The valve seat was repaired/replaced during the outage.

3.2 Small Bore Piping

Two sections of small bore piping were scheduled for external UT inspection during the 2001 refueling outage. These were new inspections. They were scheduled due to a leak at the Steam Seal Regulator. No significant wear was found in either section of piping. A summary of the small bore piping inspection results is contained in Attachment 2.

4.0 COMPONENTS REQUIRING FUTURE MONITORING

Components requiring future monitoring are identified using the "2001 Predicted Thickness", the "Screening Level" which the component passed, and the "Approximate Cycles to Tmin" shown in Attachment 1. From the wear rates and cycles to Tmin calculated in Attachment 1, only one component, FD01TE05 was identified as with less than 10 cycles to Tmin. This component has multiple year inspection data and a low calculated wear rate. Previous inspection data indicate that that a local region adjacent to the weld to the downstream valve was fabricated with little margin over code minimum wall thickness. This component will be re-inspected during the 2004 refueling outage.

The 2001 refueling outage inspection results will be incorporated into the existing CHECWORKS models of the Condensate and Feedwater Systems. The 2001 inspection data, and data from previous inspections will be used to refine the wear rate predictions. The results shown in Attachment 1 and the updated CHECWORKS analyses will be used to determine the inspection scope for future refueling outages.

5.0 COMPONENTS REQUIRING POSSIBLE REPAIR OR REPLACEMENT

No specific components were identified as requiring repairs or replacements. However, with future operation under GE hydrogen water chemistry, wear rates in the Feedwater and Heater Drain systems are expected to increase. The Feedwater System piping from the feed pumps past the feed regulator valves has a relatively low margin for wall loss due to flow accelerated corrosion. This is due to the high design pressure and the installed wall thickness. The CHECWORKS models for this piping will be updated with the 2001 RFO inspection data, and inspections of specific components on the Feedwater System piping will continue in the future.

6.0 INSPECTION DATA RETENTION

UT thickness data has been taken using Vermont Yankee owned Panametrics 26DL^{+} digital UT and electronic data logging system. The large bore UT inspection results were downloaded directly into the CHECWORKS data base located on the VY computer network. The measured thickness data for each component is stored in the CHECWORKS data base. A thickness data sheet (form VYNEF8053.01) including the CHECWORKS thickness matrix printout was created for each inspection. The inspection reports are controlled and put into permanent storage by VY ISI personnel per AP 6807 & AP 6809.

7.0 RECOMMENDATIONS FOR FUTURE FAC INSPECTIONS

Recommendations made in past refueling outage inspection reports have been formalized and incorporated into the new Program Procedure PP 7028. These have included the continued use of the Panametrics UT/data logging equipment and conversion from ITHACUS to CHECWORKS for data processing.

7.1 Prepare for Possible Repair or Replacement of Components During the 2001 Refueling Outage.

The potential for finding significant wear in any piping component exists. Contingency planning as required for either weld repair or replacement of large bore components in the piping systems should be considered. ASME code cases for external weld overlay of eroded piping have been approved in recent years. The applicability and possible use of these of these code cases at VY should be evaluated to provide additional methods for timely and effective repairs to be made during short refueling outages.

8.0 REFERENCES

1. V.Y. Program Procedure PP 7028, Piping Flow Accelerated Corrosion (FAC) Inspection Program, Original Issue 5/10/01.

2. V.Y. Department Procedure, DP 0072, "Structural Evaluation of Thinned Wall Piping Components", Original Issue 5/17/01.

3. V.Y. Nondestructive Examination Procedure, NE 8053, "Ultrasonic Thickness Measurement"' Original Issue 11/03/00, LPC 1.

4. Memo J.C.Fitzpatrick to J.H.Callaghan, subject: Piping FAC Inspection Scope for the 2001 Refueling Outage, VYM 2000/051, dated June 15,2000.

5. VY Piping FAC Inspection Program – 2001 Refueling Outage: Inspection Location Worksheets / Methods and Reasons for Component Selection, dated 6/20/00.

6. Memo J.C.Fitzpatrick to S.D.Goodwin, subject: 2001 Refueling Outage Piping Flow Accelerated Corrosion Inspection Summary, VYM 2001/015, dated May 17,2001.

7. Memo J.Fortier/J.C.Fitzpatrick to J.H.Callaghan subject: 1999 Refueling Outage Turbine Cross Around Piping Inspections, VYM 99/129, dated November 28,1999.

8. EPRI Report, "Recommendations for an Effective Flow-Accelerated Corrosion Program", EPRI NSAC-202L-R2, April 1999.

9. CHECWORKS - Computer Program User Guide, TR 103496, August 1994 by Altos Engineering Applications Inc. for EPRI.

10. VY Technical Evaluation No. 2001-024, " Evaluation Of Wall Loss Found In Valve LCV-103-2B-2 and Downstream Piping."

V.Y. PIPING F.A.C. INSPECTION PROGRAM: 2001 REFUELING OUTAGE INSPECTION REPORT

ATTACHMENT 1: SUMMARY OF LARGE BORE PIPING UT INSPECTION RESULTS

Inspection No.	Comp ID	DIA	Tnom	.875* Tnom	Tmin	2001 Min Tmeas	Wear Rate(in./ cycle)	2002 Tpred.	Passed Screen Level	Approx. Cycles to Tmin	Future Inspections Recommended	Comments
01-01	PUMP1A-NZL	12	1.000	0.875	0.769							Note 5
01-02	FD01RD01	12	1.000	0.875	0.769	0.869	0.005	0.863	2	16.7		
		16	1.219	1.067	0.984	1.035	0.005	1.029	2	11.7		
01-03	FD01EL01	16	1.219	1.067	0.965	1.059	0.005	1.053	2	12.5		
01-04	FD01TE05	16	1.219	1.067	0.965	0.994	0.005	0.988	2	4.8	2004 RFO	
01-05	FD01SP02DS	16	1.219	1.067	0.965	1.120	0.006	1.113	1	21.5		
01-06	FD01EL03	16	1.219	1.067	0.965	1.527	0.009	1.516	1	49.8		
01-07	FD01SP03US	16	1.219	1.067	0.965	1.069	0.005	1.063	2	17.3		
01-08	FD03EL03	16	1.219	1.067	0.965	1.448	0.005	1.395	1	77.		
01-09	FD03SP03	16	1.219	1.067	0.965	1.029	0.005	1.023	2	10.7		
01-10	FD03EL04	16	1.219	1.067	0.965	1.423	0.006	1.416	1	65.4		
01-11	FD03SP04	16	1.219	1.067	0.965	1.068	0.006	1.061	2	14.3		
01-12	FD07RD03	10	0.844	0.738	0.648	0.760	0.005	0.754	1	18.7		
		18	1.375	1.203	1.085	1.223	0.005	1.217	1	23.		
01-13	FD08SP03	18	1.375	1.203	1.085	1.231	0.005	1.225	1	24.3		
01-14	FD18TE01	16	0.844	0.738	0.645	0.906	0.0065	0.899	1	33.5		@ Row 1 transition from Sch. 80 pipe.
		16	1.219	1.067	0.645	1.494	0.0065	1.486	1	108.8		Rows 2-11
		16			1.335	1.560	0.005	1.554	1	37.5		@ branch connection reinforcement zone, Note.6
01-15	FD18SP04	10	0.844	0.738	0.433	0.758	0.005	0.752	1	54.2		Note 7
01-16	FD20RD01	16	1.219	1.067	0.645	1.083	0.013	1.067	1	28.		Note 8
		10	0.844	0.738	0.433	0.962	0.016	0.943	1	27.6		rows 6 & 7 on reducer
		10	0.844	0.738	0.433	0.770	0.016	0.751	1	17.		rows 8-10 on pup piece
01-17	FD20SP01	10	0.844	0.738	0.433	0.727	0.005	0.721	2	49.		

V.Y. PIPING F.A.C. INSPECTION PROGRAM: 2001 REFUELING OUTAGE INSPECTION REPORT

ATTACHMENT 1: SUMMARY OF LARGE BORE PIPING UT INSPECTION RESULTS

Inspection No.	Comp ID	DIA	Tnom	.875* Tnom	Tmin	2001 Min Tmeas	Wear Rate(in./ cycle)	2002 Tpred.	Passed Screen Level	Approx. Cycles to Tmin	Future Inspections Recommended	Comments
01-18A	CD32FE01	20	0.594	0.520	0.393	0.793	0.005	0.787	1	66.7		Note 9.
01-18	CD32EL04	20	0.594	0.520	0.393	0.591	0.005	0.585	1	32.		
01-19	CD32SP02	20	0.594	0.520	0.393	0.547	0.005	0.541	1	25.7		
01-20	CD32EL05	20	0.594	0.520	0.393	0.626	0.012	0.612	1	16.2		
01-21	CD30EL02	20	0.594	0.520	0.393	0.559	0.005	0.553	1	27.7		
01-22	CD30EL03	20	0.594	0.520	0.393	0.536	0.005	0.530	1	23.8		
01-23	CD30SP01	20	0.594	0.520	0.393	0.561	0.005	0.555	1	28		
01-24	CD27EL12	20	0.594	0.520	0.393	0.649	0.010	0.637	1	21.3		
01-25	CD27EL13	20	0.594	0.520	0.393	0.745	0.005	0.739	1	58.7		

NOTES:

1. All thickness values are inches.
2. Wear/Cycle is approximately inches/18 months. The wear per cycle was calculated per DP0072 using 15.9 equivalent 18 month cycles based on approx. 157,000 operating hours up to 1996 outage, and 12000 ± hrs./cycle. Minimum Wear/Cycle used to calculate Tpred and Cycles to Tmin is 0.005 inches per cycle.
3. 2002 **T** predicted = 2001 **T** measured - F.S. * (Wear/Cycle), F.S. = Factor of Safety = 1.20.
4. Cycles to Tmin is calculated from: $\frac{(\text{2001 T measured} - \text{Tmin})}{\text{F.S. x Wear/Cycle.}}$ (i.e. Cycles from 2001 RFO)
5. Only area adjacent to weld on Feedwater Pump 1 A discharge nozzle was inspected. Asbestos insulation on pump casing at discharge nozzle was not abated, only attached reducer was exposed.
6. FD18TE01, additional thickness required in branch reinforcement zone for 10" diameter pipe.
7. FR18SP04, conservative measured thickness (single low reading) Tmeas = 0.770in. would be more representative.
8. FD20RD01 conservative measured thickness (single low reading) Tmeas = 1.133 in. would be more representative.
9. Section of pipe supplied with condensate flow element FE-2 appears to be Sch. 60 vs. Sch 40 for Condensate piping.

V.Y. PIPING F.A.C. INSPECTION PROGRAM: 2001 REFUELING OUTAGE INSPECTION REPORT

ATTACHMENT 2: SUMMARY OF SMALL BORE PIPING UT INSPECTION RESULTS

SMALL BORE PIPING

S.B. Inspection. Number (Data Base No.)	Description / Location	Section	Size	Sch.	Tnom. (inch)	.875 * Tnom. (inch)	T min. (inch) (Note 1)	2001 Min. Measured Thickness (inch)	Apparent Wear Rate (inch/cycle)	Cycles to Tmin. (Note2)	Comments
01-SB01 (117)	1SLSSR -1" drain off SSR US & DS branches at Tee fitting. TB Heater Bay (Approx. El. 262 under SSR).	Rows: 1-3, & 38-40	½"	40	.109	.095	.039*	.102	<0.005	10.5	Conservative wear rate used.
		Rows: 4-24,& 41-50	¾"	80	.154	.135	0.040	.135	<0.005	15.8	
		Rows: 25-37,& 51	1"	80	.179	.157	.042	.160	<0.005	21.3	
01-SB02 (117)	1SLSSR -1" drain off SSR piping at connection to 8"- SPE pipe. (Approx. El. 262)	N/A	1"	80	.179	.157	.042	.161	<0.005	19.8	

NOTES:

1. Tmin includes a 0.035 inch corrosion allowance per ANSI B31.1 –1967.
2. Cycles to Tmin from 2001 refueling outage. SF (safety factor) = 1.2 was used on the apparent wear rate. Small bore wear is not trended for the purposes of repeat inspections. Small bore components will generally be replaced if significant thinning is observed.