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LICENSEE: Boston Edison Company
RFD #1 Rocky Hill Road
Plymouth, Massachusetts 02360

FACILITY NAME: Pilgrim Nuclear Power Station

INSPECTION AT: Plymouth, Massachusetts and Braintree, Massachusetts

INSPECTION DATES: June 8-12, 1992

INSPECTORS: P. Patnaik — 7.17.92
P. Patnaik, Reactor Engineer, Date
Materials Section, EB, DRS

for P. Patnaik — 7.17.92
R. A. McBrearty, Reactor Engineer Date
Materials Section, EB, DRS

APPROVED BY: E. H. Gray — 7/17/92
E. Harold Gray, Chief, Materials Section, Date
Engineering Branch, DRS

Areas Inspected: An announced inspection was conducted of the licensee's erosion/corrosion (E/C) inspection program to ascertain that activities relative to the long-term E/C monitoring program are being accomplished in accordance with NRC requirements. Generic Letter 89-08 and licensee commitments and procedures.

Results: The program and its implementation are excellent. The engineering staff responsible for E/C program development and implementation is well qualified and knowledgeable of the activities for which they are responsible. The licensee's E/C consultant is experienced in E/C program development and brings wide experience gained at other nuclear facilities to the licensee's program.

1.0 BACKGROUND

Concerns regarding erosion and corrosion in balance of pla piping systems has been heightened as a result of the December 6, 1986, feedwater line rupture that occurred at Surry Unit 2. This event was the subject of NRC Information Notice 86-17, Bulletin 87-01 and Generic Letter (GL) 89-08. The GL specifies that all licensees provide assurances that a program, consisting of systematic measures to ensure that E/C does not lead to degradation of single and two phase high energy carbon steel systems, has been implemented.

An effective E/C program will detect erosion of high energy carbon steel piping before the pipe wall is significantly reduced below the design or piping code minimum wall thickness. This program should reduce risk to the plant staff and prevent unnecessary system transients thereby contributing to the safety of the public.

2.0 INSPECTION OBJECTIVE

The inspection was conducted to determine whether licensee activities relative to the long-term erosion/corrosion monitoring program are being accomplished in accordance with NRC requirements and licensee commitments and procedures.

3.0 LICENSEE RESPONSE TO GENERIC LETTER (GL) 89-08 AND BULLETIN 87-01

In response to NRC Bulletin 87-01, the licensee committed to develop criteria for determining where and how frequently to make thickness measurements and develop a database for monitoring erosion/corrosion.

The licensee's response to Generic Letter 89-08, dated July 21, 1989, committed the licensee to develop a formal procedure for the implementation of a long-term erosion/corrosion monitoring program based on the guidelines developed by NUMARC, and to conduct initial inspections during the eighth refueling outage (RFO-8). Specification M-577 was prepared by the licensee and provides the guidance and instructions necessary for a comprehensive E/C monitoring program.

4.0 EROSION/CORROSION (E/C) PROGRAM RESPONSIBILITIES

4.1 Corporate Engineering

The Nuclear Engineering Department (NED) responsibilities for the E/C program are delineated by Specification M-577, Revision 2, "Specification For Piping Erosion/Corrosion Monitoring." Those responsibilities include identifying and prioritizing systems which are susceptible to E/C, selecting piping locations for examination, establishing screening and acceptance criteria and establishing sample expansion criteria. Engineering is also responsible

for the evaluation and disposition of inspection results which do not satisfy screening or acceptance criteria and determination of the frequency of subsequent inspections.

The NED responsibility for selecting and prioritizing the E/C program scope is supplemented by a consultant contracted by the licensee. The particular consultant to BECo performs the same function at other nuclear facilities, thereby giving BECo the benefit of experiences at those other plants.

4.2 Site

The licensee's site Quality Assurance Department (QAD) responsibilities for the program, as defined by M-577, include inspection scheduling, the preparation of locations for inspection, performing inspections, requesting engineering disposition of inspection results which fail screening criteria and the generation of nonconformance reports (NCRs) for inspection results which do not satisfy acceptance criteria.

5.0 INSPECTION ACTIVITIES

5.1 General Requirements

The licensee's primary inspection method incorporates ultrasonic examination techniques for measuring pipe wall thickness. Specification M-577 provides for the use of visual inspection of the internal pipe surface, where practical, as an alternate method for determining locations of E/C susceptibility. The specification notes that visual inspection should be supplemented by ultrasonic thickness measurements when areas of erosion are detected. In practice, the licensee has determined that significantly eroded areas sometimes appear to be insignificant or go undetected by the remote visual inspection technique that is required to perform the majority of the inspections, thus giving a false sense of security regarding the actual pipe condition. Based on the above, the licensee stated that it does not plan to use visual inspection methods unless there is no other available inspection method.

After the initial piping selection is made and prioritized by NED, the inspection sample is transmitted from NED to the inservice inspection (ISI) group which is part of the QA/QC organization. The delegated QC staff member then prepares a Maintenance Request (MR) from which the planning group prepares a Maintenance Work Plan (MWP). The MWP sequentially lists the steps necessary to perform the work, including inspection hold points. There was no provision for an independent review of the work plan against the original NED list to confirm that all of the required points were scheduled for inspection. In response to the inspector's questions in that regard, the licensee revised Quality Control Instruction 10.03 to require that, for QC generated ISI/Erosion-Corrosion Maintenance Requests, the work plan shall be independently verified against source documentation for completeness.

When inspections are in progress during an outage, the QC staff is responsible for providing the ISI vendor with the inspection locations. Vendor personnel, under licensee direction, apply the appropriate grid pattern, as specified by M-577, to each inspection location. Datum points to locate the grid patterns are permanently marked on the pipe using low stress stamps. Grid spacing is identified by M-577 based on nominal pipe size (NPS) as follows:

Pipe Diameter	Grid Size
< 6.625"	1"
> 6.625" to < 12.75"	2"
> 12.75" to < 24.0"	3"
> 24.0"	4"

As an alternate method for determining grid size, the following formula can be used:

$$2\sqrt{Rt}$$

where R = radius
t = nominal thickness

When the formula is used to calculate grid size, the calculated size is rounded down to the nearest 1/2".

5.2 E/C Program Review

The licensee performed computer analysis using the EPRI CHECMATE program of the main steam, feedwater/condensate, moisture separator drains, extraction steam, reactor water clean-up and heater drain systems. During the inspection, the accuracy of licensee's input data to the computer program was verified on a sampling basis for the moisture separator drain tank #102 to the level control valve and the extraction steam to the heater #E105A. The information obtained from the input file was accurate. The chemistry data used was based on the average chemistry over the fuel cycle taken from the daily logs. Since the licensee has applied hydrogen water chemistry to mitigate intergranular stress-corrosion cracking, hydrogen is injected into the feedwater system and oxygen is fed to the condensate system. An average oxygen concentration of 35 ppb with a neutral pH was factored in the analysis. The design parameters for the analysis were taken from the piping specification and the operating parameters such as flow rate and enthalpy were derived from a heat balance. A network flow analysis was performed where change of phase condition took place. A first set of E/C results predicted an average erosion rate and a current erosion rate for each component. Since the as-built thickness of the components is not known, the actual amount of wall loss that has occurred to reduce the component to the present wall thickness was

calculated by using the EPRI band method. A second set of E/C results was obtained by inputting the thickness data taken from RFO 8, into the existing models.

The CHECMATE models were also revised to reflect changes in operating hours as of the next refueling and the use of low alloy steel (P-11) material in place of carbon steel. The models were rerun to determine the components planned for inspection during the next refueling outage.

The input data for analysis were reviewed and verified by the licensee subsequent to data input by the licensee's consultant. The results of the analysis were extensively reviewed by the licensee's consultant and by their own engineering department. The licensee conservatively estimated screening thickness for components for evaluation of measured wall thickness.

Based on the review of the analysis and discussions with personnel, the licensee's program meets the current industry standard and complies with the requirements of the Generic Letter 89-08.

5.3 Inspection Method

The information regarding inspection locations includes sketches and drawings showing where in the plant the piping is located and, additionally, the specific inspection points are identified on the sketches.

After the appropriate gridline pattern is applied to the pipe, thickness readings are sequentially recorded at the intersection of each grid line. The technicians use an ultrasonic data logger to store each reading until the data are loaded into a personal computer. After loading data into the computer, the information is saved on a computer disc for analysis and printed on a hard copy report, each of which is provided to the licensee.

The data logger identifies the grid location that should be measured allowing the technician to confirm that the ultrasonic transducer is at the correct location. Additionally, the logger permits inspection personnel to review its data bank prior to leaving the inspection site, thereby assuring that all required inspection points were measured. The use of the data logger helps to assure that data are accurately recorded and, by speeding up the data acquisition process, helps reduce personnel exposure to radiation.

During the performance of E/C inspections during RFO-8, no licensee QC surveillance of vendor E/C inspection activities was performed. The licensee pointed out that the same vendor personnel performed ISI examinations during the outage and QC surveillance were performed of those activities. The licensee stated that the surveillances of the ISI activities provided adequate assurance that the vendor examiners followed procedures and competently performed the examinations.

Inspection results are evaluated and dispositioned by the licensee, and are used to update the CHECMATE computer program. The updated program produces more accurate wear rate values from which subsequent inspections are planned. Piping which is shown to be the most susceptible to E/C and which exhibits the greatest wear rate is replaced by the licensee with piping fabricated from material containing 1.25% chromium and 0.5% molybdenum, which is more resistant to E/C than is carbon steel.

The piping locations selected for initial inspections during RFO-8 included approximately 10% of the most susceptible areas of the following four plant systems:

1. Extraction Steam Piping - 8 components
2. Moisture Separator Piping - 8 components
3. Feedwater Piping - 2 components
4. Heater Drain & Vents - 11 components

Prior to RFO-8, two leaks were identified and temporarily repaired on the extraction steam and moisture separator systems.

The results of the licensee's inspection revealed unacceptable wear in extraction steam piping and moisture separator piping. However, there was negligible wear in feedwater piping and heater drain and vents. Based on evaluation of the RFO-8 inspection results that did not meet the acceptance criteria, and because two through wall leaks existed prior to the outage, the licensee determined that piping replacement was the most effective option for portions of the extraction steam piping as compared to augmented inspections and local repairs. The decision to replace piping resulted in the replacement of 900 feet of piping, 200 feet of 12" diameter pipe on the 8th stage extraction steam system in the condenser bay and 700 feet of 6" diameter pipe on the moisture separator drain system in the condenser bay.

The RFO 8 experience demonstrated that pipe replacement may be a more efficient long term option as compared to augmented inspections and local repairs. At present the licensee plans to continue its use. The replacement option will be evaluated periodically by the licensee. The benefits derived from the replacement program include minimizing the need for followup inspections, significantly reducing the risk of unexpected failures in future plant operating cycles, less outage time to replace large sections of pipe than to perform local repairs and exposure to radiation by construction personnel is minimized.

Planning for RFO 9, which is scheduled for April 1993, is in progress. The engineering activities are scheduled to be completed by July 1, 1992. The engineering E/C activities for RFO 10 are intended to be completed 1 year prior to the outage. At present, tracking and trending of E/C inspection results is performed by NED at Braintree, Massachusetts. The licensee intends that those functions be performed in the future by systems engineering at the plant.

6.0 CONCLUSIONS

The licensee was found to have a well-planned and documented erosion/corrosion program in place. The program and measurements to detect erosion/corrosion at Filgrim are effective in that they have been demonstrated to be capable of detecting pipe wall thinning early enough to permit repair or replacement prior to failure.

The ultrasonic data logger enhances the licensee's capability to accurately record inspection data and helps reduce personnel exposure to radiation by speeding up the data acquisition process.

The licensee policy of replacing highly susceptible piping with E/C resistant material in lieu of performing inspections and local repairs also helps in minimizing personnel exposure to radiation and additionally, reduces the risk of unexpected failure in future plant operating cycles.

The use of an experienced consultant provides the licensee with the benefit of that experience in the development of its own E/C program.

7.0 ENTRANCE AND EXIT MEETINGS

Members of the licensee's management, engineering and technical staff were informed of the scope and the purpose of the inspection at the entrance meeting which took place on June 8, 1992. The findings of the inspection were presented to and discussed with members of the licensee's management at the conclusion of the inspection on June 12, 1992. A list of attendees at the exit meeting is appended to this report as Attachment I.