U. S. NUCLEAR REGULATORY COMMISSION
REGION 1

Docket No. 50-272
50-311

Report No. 50-272/91-04
50-311/91-04

License No. DPR-70
DPR-75

Licensee: Public Service Electric and Gas Company
P. O. Box 236
Hancocks Bridge, New Jersey 08038

Facility Name: Salem Generation Station

Inspection At: Hancocks Bridge, New Jersey

Inspection Conducted: February 4, 1991 to February 15, 1991

Inspectors: M. C. Modes, Project Manager NDE, NDE Staff, Engineering Branch, DRS — 3/15/91 date

FOR R. H. Harris, NDE Technician, NDE Staff, Engineering Branch, DRS — 3/15/91 date

P. M. Peterson, NDE Technician, NDE Staff, Engineering Branch, DRS — 3/15/91 date

D. C. Wiggins; TET, Inc.; Mobile, Alabama

W. M. Mingus; TET, Inc.; Mobile, Alabama

J. P. Durr, Chief, Engineering Branch, Division of Reactor Safety, Region I — 5/2/91 date

Inspection Summary and Conclusions: A routine announced inspection was conducted at Salem Generating Station Units 1 and 2 during the period February 4, 1991 through February 15, 1991 using the NRC's Mobile Nondestructive Examination (NDE) Laboratory. (Report No. 50-311 & 272/91-04)

Areas Inspected: Selected areas of the service water system piping were independently examined by NDE methods. The licensee's procedures used for nondestructive evaluation and the licensee's evaluation results, including radiographs and ultrasonic test reports, where applicable, were reviewed.

Results: No violations or deviations were identified in the review of the program areas examined.

DETAILS

1.0 Persons Contacted

Public Service Electric and Gas

* M. Bachman	External Affairs
R. Beckwith	Station Licensing Engineer
* R. Brown	Principal Licensing Engineer
* T. Cellmer	RPCM
P. Dues	Delmarva P&L
* W. Denlinger	Salem ISI Supervisor
J. Jackson	Technical Engineer BOP Systems
E. Krufka	Lead Engineer (Atlantic Electric)
* S. LaBruna	VP Nuclear Operations
* S. Maginne	E&PB Special Projects
* M. Metcalf	Manager of Projects
* M. Morroni	Technical Department Manager
J. Musumeci	Ops Engineer Unit 1
A. Orticelle	Maintenance Manager Salem
* V. Polizzi	Operations Manager- Salem
* J. Pollock	Maintenance Engineer
B. Preston	Manager Licensing and Regulatory Compliance
* J. Ronafalvy	E&PB Manager Nuclear Engineer Design
J. Rowry	E&PB Mechanical Engineering
* W. Schultz	Manager Station QA
* W. Staubmuller	E&PB
F. Thomson	Asst-to-Plant Manager
* E. Villar	Station Licensing Engineer Salem

U.S. Nuclear Regulatory Commission

* R. Brown	Senior Resident RI
* S. Pindale	Resident Inspector RI

* Denotes those attending the exit meeting on February 15, 1991

The inspector also contacted other administrative and technical personnel during the inspection.

2.0 Scope

In order to understand the NRC concerns with the continuing problems of service water corrosion/erosion and leakage at Salem, the regulatory framework and history of erosion and corrosion should be considered. This framework gives the officially stated position of the NRC.

Concern for erosion and corrosion in balance of plant piping systems has been heightened as a result of the December 9, 1986 feedwater line rupture that occurred at Surry Unit 2. This event was the subject of NRC Information Notice 86-106 issued December 16, 1986 and its supplement issued on February 13, 1987. The concerns and issues raised by this event were taken up by the NUMARC Technical Subcommittee Working Group on Piping and Erosion /Corrosion in their Summary Report dated June 11,1987. The NRC followed this report with NUREG-1344 "Erosion/Corrosion Induced Pipe Wall Thinning in U.S. Nuclear Power Plants", Dated April 1989 and Generic letter 88-08 issued May 2, 1989. Further regulatory guidance can be found in Generic Letter 89-13 which addresses the degradation of safety related heat exchangers.

All of the above references relate, in some manner, to the problems experienced by Salem Generating Station in their service water systems. This series of documents certainly state the expectations of the NRC in the area of erosion and corrosion. In this context, one should consider the assessments made in NUREG -1050 "Probabilistic Risk Assessment Reference Document", Dated September 1984 and NUREG-1150 "Severe Accident Risk: An Assessment for Five U.S. Nuclear Power Stations", dated December 1990. In these documents the service water system is the sixth most important system, in a list of fifteen, in a pressurized water reactor when considering dominate accident sequences. It should be noted that the service water system was listed ahead of the emergency AC system. In all the documents the underlying concern is the systems ability to mitigate the consequences of a design basis accident. Simply put, the over-riding concern is the system operability.

To assure system operability the minimum expectations are:

- A plan to determine the current status of the systems components and the degree to which the components have degraded due to the erosion /corrosion. This plan should include a sample of the systems components. This sample should be subjected to some form of objective measurement or inspection to evaluate the condition of the component. Since the components' degradation is internal, a visual walk down of the exterior surfaces of the system is insufficient for this purpose.

- An engineering evaluation of the data generated by the inspection of the component samples. This includes some form of method to calculate the erosion/corrosion trends in the components. Sample adjustment and systems operability determinations should be made at each interval. For those systems returned to service a schedule should be established for reexamination of the component or if previous trending history justifies it: removal from the examination plan.

The Salem facilities have experienced substantial degradation over the years in the service water piping system. This inspection was initiated to determine the scope of the licensee's program to assure the structural integrity of the piping.

3.0 Inspection

The NRC Mobile NDE Laboratory examined five areas of the service water system at Salem. They are: (1) Unit 2 service water intakes at Bay 2 and 4, (2) Unit 1 #12 valve room piping, (3) Unit 1 component cooling pump room cooler piping, (4) containment spray pump room cooler piping, and (5) emergency diesel generator water and oil heat exchanger piping. Through the methods of nondestructive evaluation we have revealed areas of concern in three of the five areas.

The main intake bays of the Salem Generating Station were chosen for examination by the NRC since a number of the recent LER's, required by Salem, were in these locations. The main intake pipe in Bay 4 (2-SW-74) was subjected to a gridded ultrasonic thickness examination by the NRC. This pipe is an ASME Class 3 pipe (seismic rating 1). A grid was used of 73 readings around the pipe and 45 readings down the pipe. The readings started at the top of the pipe and went clockwise when facing down flow. There are areas in the Bay 4 intake pipe with wall thicknesses of 0.380" on pipe wall that averages 0.601". The licensees representative explained that a diver had gone down the pipe recently. Where ever he had noted a wearing away of the concrete lining of the pipe, the licensee had taken a thickness reading. A total of 18 readings were taken on this 30" diameter by approximately 10 foot pipe by the licensee. The licensee assured the inspector that based on this examination the pipe was returned to service as satisfactory. The NRC did not correct for the paint thickness which averaged 10 mil in the area of the thinnest readings. If this is subtracted from the thickness reading the thinnest area is 0.370". The thin area was confirmed by the NRC utilizing another ultrasonic method. It appears from this investigation that the licensee's examination method for this system is insufficient. The licensee is investigating the cause for these thinned areas. This piping will be replaced within 2 years.

The NRC attempted to take readings on the exterior of the distribution header of the Bay 2 intake. This was in an area where a known leak had occurred. It appeared the leak was sealed with a short section of approximately 1/2" diameter pipe welded onto the distribution header and a pipe cap put at the end of the section. The licensee attempted to power brush an area of the header around the short pipe section in order to facilitate the NRC ultrasonic thickness testing. The exfoliation of the pipe was too severe for the cleaning method. The licensee workers expressed fear that grinding, instead of brushing, would cause the pipe to loose its integrity. The NRC confirmed the wall thickness of the distribution header in areas surrounding the area of exfoliation. The wall thickness was sufficient in these areas. An analysis of the thickness readings that could be taken did not indicate this area to be subjected to a general wall thinning. The NRC agreed not to pursue the examination of the Bay 2 intake header. The NRC brought the condition of the header to the attention of the licensee. They are planning to replace all 4 distribution headers within 2 years.

Another area of the Salem Generating Station that caused a number of LER's was small bore service water used for room, component and instrument cooling. This piping was not planned for change out until the later part of the piping program. The licensee representative claimed that very sophisticated ultrasonic robotics would be required to examine the thickness of the very small piping. The NRC chose to perform tangential radiographic thickness gauging of the small bore piping associated with the component cooling pump room cooler and containment spray pump room cooler. These were chosen as representative of the small bore piping leakage that had occurred at Salem. In doing the radiography, the NRC hoped to demonstrate to the licensee the use of this method of radiography for pipe wall determination. The component cooling room service water pipe revealed aligned indications where thicknesses are estimated to be 0.135" or less. Although the final radiographic interpretation of the indications will have to await destructive confirmation they had the appearance of microbiologically influenced corrosion. The licensee had never done any evaluation, other than exterior walk downs, of any of this piping. The licensee has replaced the small bore piping in this area and is investigating the cause of the indications. The licensee has instituted a program of testing of the small bore piping to compliment the continued visual examinations.

The diesel generator B piping revealed an area on the extrados of an elbow where thicknesses have been measured at 0.130". This is below minimum wall for this elbow. The area of thinning discovered by the NRC in the elbow extrados of the service water vent line is characteristic of erosion. Since the A generator was declared inoperable on 10/5/90 (Event 032571) for a leak in the same area and the C generator has a patch on the same elbow (no event number can be determined at this time) it is apparent that the licensee should have questioned the operability of the B generator for the same reason. The licensee did not perform any evaluations at all of the piping in the B generator. There is the potential for the pipe to rupture at this location and flood the diesel generator room causing the generator to fail under an emergency situation. This would be a combination of the sixth and seventh most important systems in the NUREG 1050 report for PWR's. These findings were brought to the attention of the licensee. All similar piping in the diesel generators of

Unit 2 have already been replaced with plans to replace all the piping in the diesel generators of Unit 1 within 15 months. The licensee has repaired the area discovered by the NRC.

On March 5, 1991, a meeting was held with Public Service Electric and Gas management to discuss the findings of the Mobile NDE Laboratory regarding the erosion/corrosion of the service water and associated piping systems. The licensee stated that they were in the process of replacing the service water piping and had a program for evaluating the overall condition of the piping pending its replacement. The licensee described the service water piping replacement program, the inspection program and the structural integrity program for the system. Sections of the system are selected for replacement based on the material condition of the piping and prioritized based on the high incidence of failure and the potential safety related impacts. The licensee's presentation is summarized in enclosure 1.

4.0 Conclusion

The licensee has developed a program to provide reasonable assurance of the integrity of the service water and cooling system of the plant and that they will function as intended during a design basis event.

5.0 Management Meetings

Licensee management was informed of the scope and purpose of the inspection at the entrance interview on February 4, 1991. The findings of the inspection were discussed with the licensee representatives during the course of the inspection and presented to licensee management at the exit interview (see paragraph 1.0 for those who attended). At no time during the inspection was written material provided to the licensee by the inspector. The licensee did not indicate that proprietary information was involved within the scope of this inspection.

SALEM SERVICE WATER SYSTEM STRUCTURAL INTEGRITY REVIEW

MARCH 5, 1991

ENCLOSURE 1

PRESENTATION AGENDA

- OBJECTIVE
- SWS PIPING REPLACEMENT PROGRAM
  - BACKGROUND
  - WORK PRIORITIZATION
  - MONITORING
  - PROJECT SUMMARY
- SWS INSPECTION PROGRAM
  - BACKGROUND
  - NRC GENERIC LETTER 89 - 13
- SWS STRUCTURAL INTEGRITY PROGRAM
  - PROJECT TEAM
  - APPROACH
  - SITE SELECTION METHODOLOGY
  - EVALUATION METHODOLOGY
  - t NOM / t MIN COMPARISON CHART
  - IMPLEMENTATION SCHEDULE

OBJECTIVE

Develop an Overall Plan to Confirm the Operability Status of the Salem Service Water System.

BASIS

The Structural Integrity of the Piping System would be the Basis for this Confirmation.

SERVICE WATER SYSTEM - PIPING REPLACEMENT PROGRAM

BACKGROUND

- 1976 - 1986 - From early in plant life, the SWS experienced erosion / corrosion problems.
- May, 1987 - The need for a comprehensive SWS piping replacement plan was recognized and a Project Team was formed.
- July, 1987 - Development of the SWS Piping Replacement Project Plan was completed.
- November, 1987 - The first 6 % Molybdenum Stainless Steel Piping was installed.

SERVICE WATER SYSTEM - PIPING REPLACEMENT PROGRAM

WORK PRIORITIZATION

The Project Team performed a review of the existing Service Water System piping based on material condition, historical information (Deficiency Reports, Work Orders) and subject matter expertise. Piping replacement was prioritized. The priority rankings were defined as follows:

1. HIGH
   - High Incidence of Failure.
   - High Safety Related Impacts.
2. MEDIUM
   - Potential for Problems Over the Next Five (5) Years Based on Existing Failures.
   - Requires High Surveillance Rates (i.e., Visual Inspection / Repair) to Ensure Unit Reliability.
3. LOW
   - Can be Repaired While Unit is at Power.
   - Short Duration / Quick-Fix Jobs.
   - Observed Good (Relative) Condition.
   - Low Impact on Plant Operation and Safety.

SERVICE WATER SYSTEM - PIPING REPLACEMENT PROGRAM

WORK PRIORITIZATION, (Continued)

The original (1987) project prioritization was as follows:

HIGH	– CFCU (Containment above El. 102 ft.) – CFCU (Penetration Area) – Component Cooling Heat Exchanger Piping – Room Cooler Piping – Chiller Condenser Piping – Turbine Bldg. Miscellaneous
MEDIUM	– Service Water Intake Structure – Nuclear Cross-Ties – Diesel Generator Piping – Turbine Bldg. Miscellaneous
LOW	– CFCU (Containment below El. 102 ft.) – Lube Oil Cooler Piping – Turbine Bldg. Miscellaneous

SERVICE WATER SYSTEM - PIPING REPLACEMENT PROGRAM

MONITORING OF SYSTEM ACTIVITY & UPGRADES

- Inspections of Piping and Equipment in Selected Areas of the System are Performed Every Refueling Outage.
- Equipment Operators Visually Observe Material and Equipment Conditions and Operations Daily.

  NOTE: Project Priorities May Change or Expand Due to the Results of these Inspections and Visual Observations.

- Sample Test Spools Remain in Operation and are Inspected on a 12 to 15 Month Cycle. The Results, to Date, have been very Positive.
- Random NDE (RT) Performed During New Replacement Projects are Used as Baseline Data and Randomly RT'd Every Outage to Monitor Performance.

SERVICE WATER SYSTEM - PIPING REPLACEMENT PROGRAM

PROJECT SUMMARY

- Aggressive Project Plan Includes Over 90 % of Nuclear, Safety Related Linear Footage.
- By the End of 1R9, Approximately 46 % of the Nuclear Project Plan will have been Completed.
- The Completed Piping Includes 70 % of the Total Linear Footage In Containment
- By the End of the Salem Unit 1 - Tenth Refueling Outage, (15 Months from Now) 80 % of the Nuclear Project Plan Will have been Completed Including 100 % of the Containment Piping.

SERVICE WATER SYSTEM - INSPECTION PROGRAM

BACKGROUND

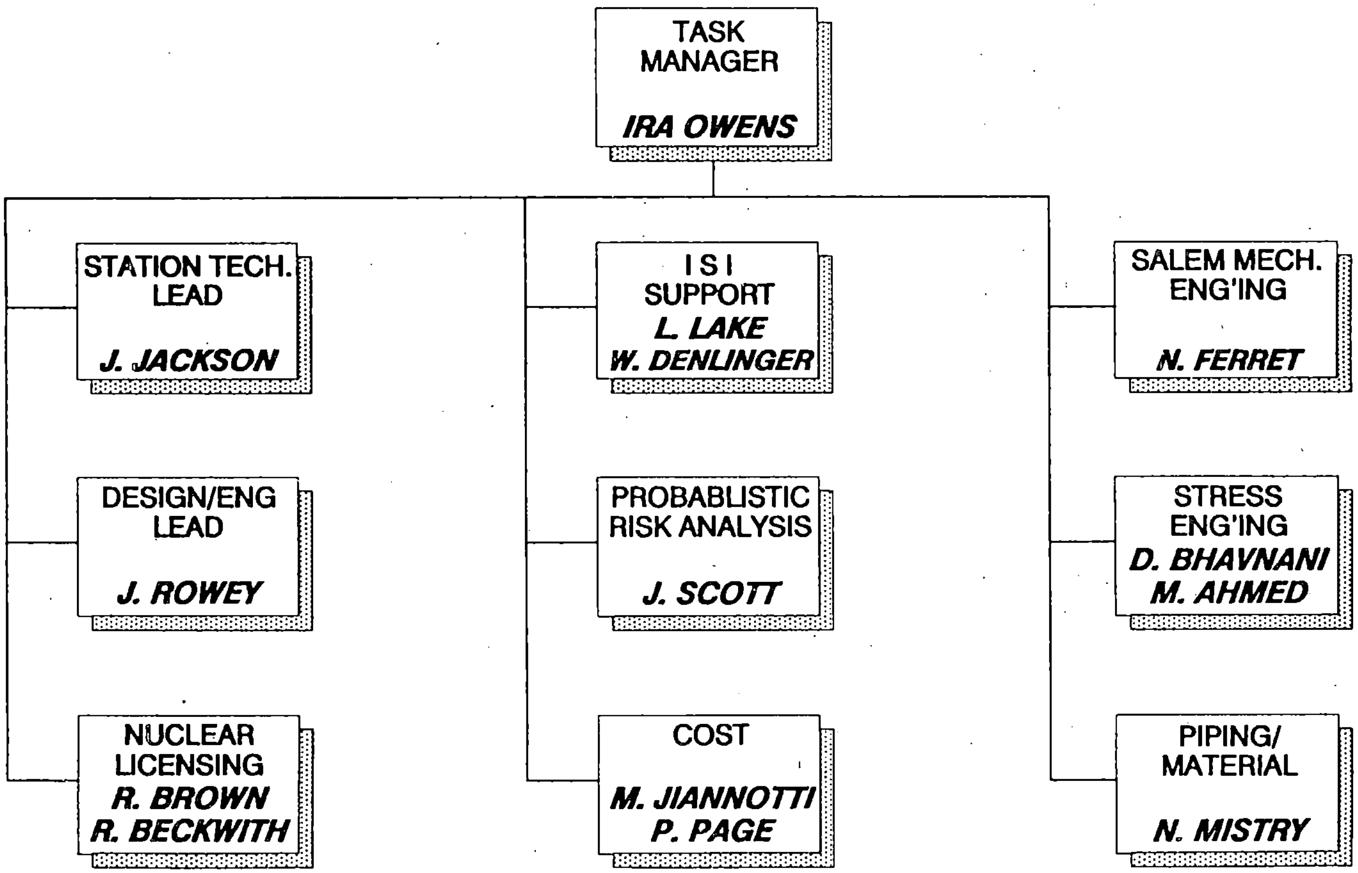
- Since Start-Up, Visual (i.e., Disassemble & Inspect) Inspection has been a Part of the SWS Monitoring.
- Numerous Inspections Were Done on a Routine Basis (i.e., R/T in MMIS)
- Additional Inspections Were Performed Each Refueling Based on Engineering Direction.

SERVICE WATER SYSTEM - INSPECTION PROGRAM

NRC GL 89 - 13

- Inspection Activities were Incorporated into MMIS.
- Procedures were Issued / Revised to Perform Inspections.
- Approximately 150 Inspection Activities Per Unit were Generated.
  - Valves (And Associated Piping) - 50 %
  - Piping - 20 %
  - Heat Exchangers (And Associated Piping) - 30 %
- Results of Inspections Will be Factored into Piping Replacement Program.
- Findings During Visual Inspections Could Generate the Need for Additional and / or Follow-Up Inspections.

REVIEW TEAM


TASK MANAGER
IRA OWENS
STATION TECH. LEAD
J. JACKSON
DESIGN/ENG LEAD
J. ROWEY
NUCLEAR LICENSING
R. BROWN
R. BECKWITH
I S I SUPPORT
L. LAKE
W. DENLINGER
PROBABLISTIC RISK ANALYSIS
J. SCOTT
COST
M. JIANNOTTI
P. PAGE
SALEM MECH. ENG'ING
N. FERRET
STRESS ENG'ING
D. BHAVNANI
M. AHMED
PIPING/ MATERIAL
N. MISTRY

APPROACH

- Perform non-destructive examination (NDE) at various sites throughout the Service Water System to Augment the existing Visual Inspection Program.

- Evaluate the as-found results against the design requirements

- Develop acceptance criteria, evaluation methodology, initial sample size, additional sample selection guidelines, etc.

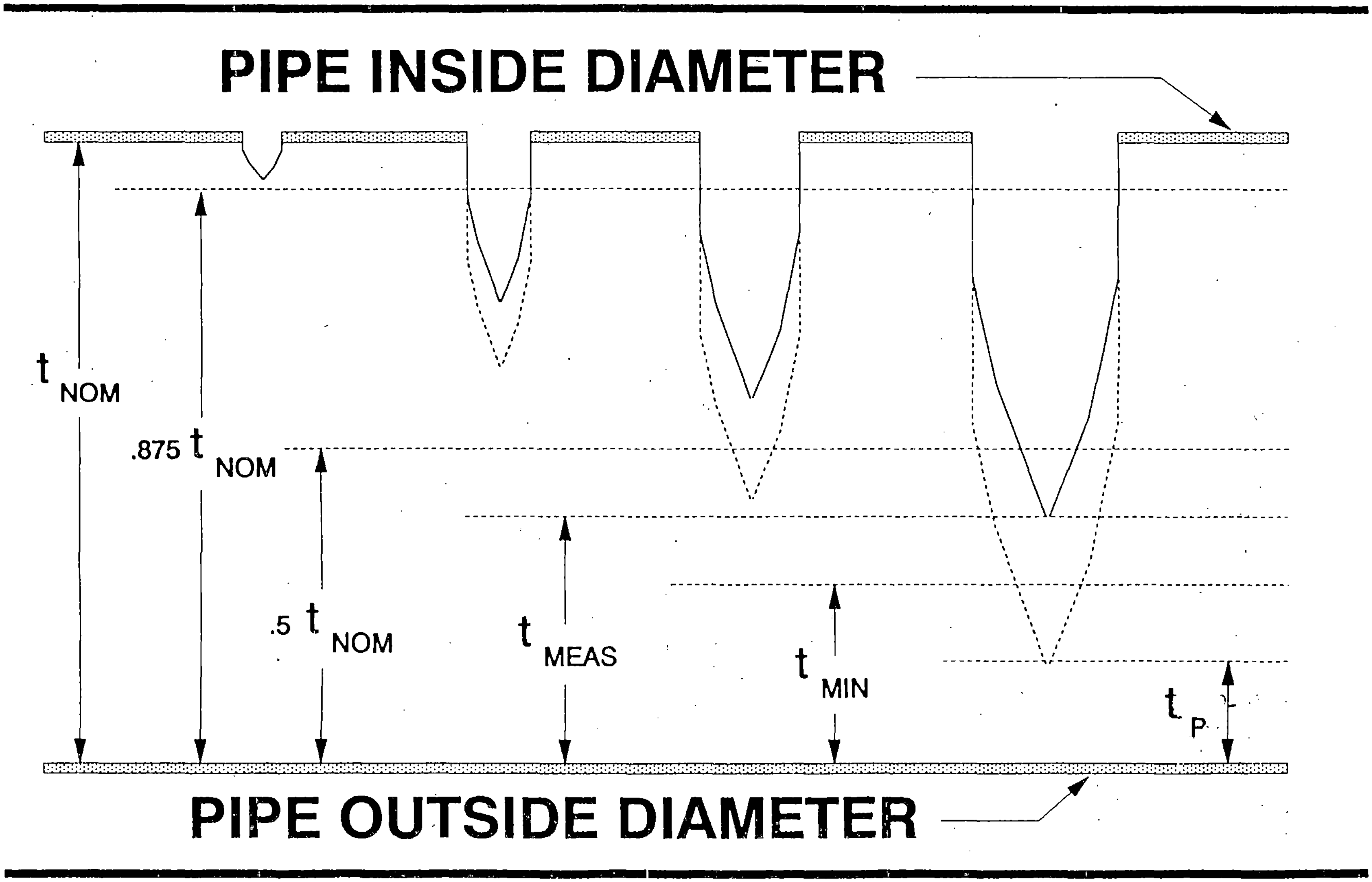
- Assess system status basis on the results of the inspection and evaluation program.

SITE SELECTION METHODOLOGY

- Limit the assessment to the safety-related portion of the Service Water System.
- Exclude areas already replaced with 6% Moly Stainless Steel.
- Divide the system into discrete areas based on function.
- Prioritize the functional areas based upon PRA input.
- Identify the known corrosion mechanism.
- Select sites for inspection.
  - Known problem areas
  - Suspected problem sites
  - Random sites

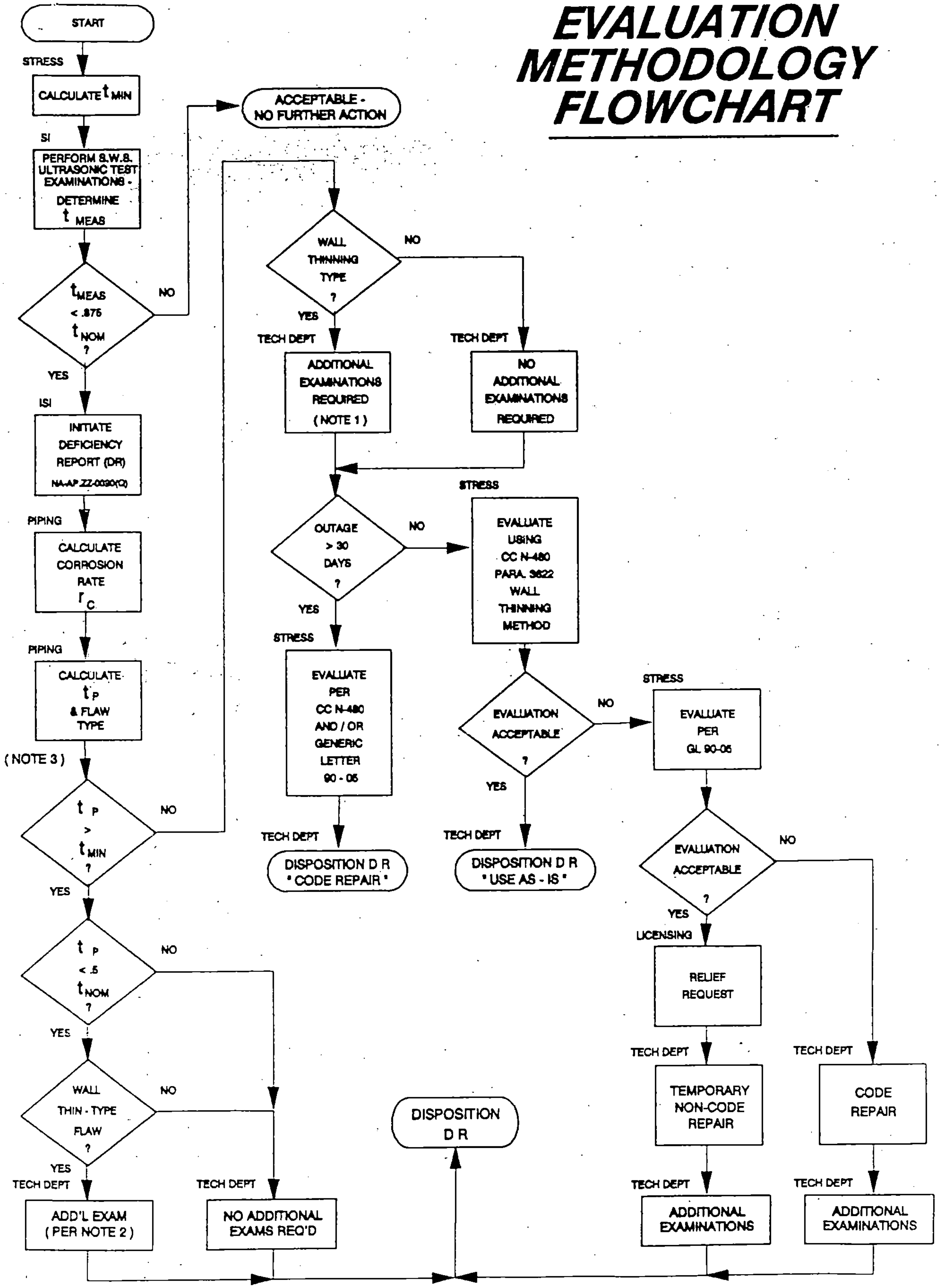
EVALUATION METHODOLOGY

- Review the guidance provided in NRC Generic Letter 90-05:
  - Flaw evaluation
  - Code repair vs. temporary non-code repair
  - Reporting requirements
  - Additional sample requirements
- Review the guidance provided in ASME Code Case N480:
  - Flaw evaluation
  - t MIN, t PROJECTED, t NOMINAL, etc.
  - Additional sampling methodology
- Consider PSE&G's past experience with SWS degradation
- Develop a methodology which would best address PSE&G's situation



NOTE: NOT TO SCALE

EVALUATION METHODOLOGY FLOWCHART



LEGEND/NOTES FOR FLOWCHART

t_{NOM} = Wall thickness identified in ANSI B36.10

t_{MEAS} = Thickness measured during examination

t_P = $(t_{MEAS}) - [r_C (P)]$, Where

P = Time period (IN MONTHS) until the next refueling outage

t_{MIN} = Calculated minimum wall thickness based on primary stress. (See Code Case N-480, Para. 3610).

r_C = Corrosion rate $\dfrac{(t_{NOM}) - (t_{MEAS})}{60}$

NOTE 1. Examine similar item(s) in the sister train(s) if applicable.

NOTE 2. Examine one (1) similar item.

NOTE 3. If flaw size is $\leq$ 3 inches or 15% of pipe circumference, (whichever is less) it may be considered a "localized" flaw.

t NOM / t MIN COMPARISON CHART

	PIPE DIMENSIONS		
SITE NUMBER	PIPE SIZE, inches	t_{NOM}	t_{MIN}
6	8	0.322	0.063
10	24	0.500	0.180
15	20	0.500	0.150
18	4	0.237	0.060
19	3	0.216	0.050
31	6	0.280	0.100

IMPLEMENTATION SCHEDULE

- Pursue an aggressive schedule on Unit 1 to take advantage of the outage.

- Utilize the recently removed Unit 1 Containment Fan Coil Unit piping to obtain additional data.

- Perform selected inspections on Unit 2 based upon the Unit 1 results.