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ASSESSMENT OF AGING DEGRADATION OF CIVIL/STRUCTURAL FEATURES AT SELECTED OPERATING NUCLEAR POWER PLANTS

by

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May 1993

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EXECUTIVE SUMMARY

In general, Category I structures and other civil engineering features at nuclear power plants are not subjected to formal inspections or surveillances. While nuclear power plant structures have generally performed well, there have been instances of aging-related degradation. These cases include corrosion of steel containments, concrete cracking and spalling, corrosion of rebars, grease leakage from tendon casings in prestressed concrete containments, and concrete cracking at tendon anchorages. These past occurrences indicate that degradation of Category I structures has occurred, and raises a question about the potential existence of undetected structural degradation which may affect their integrity/functionality.

To obtain information about the existing conditions and past performance of structures and civil engineering features, audits were performed at six older-vintage operating plants. Any failures, degradations, maintenance activities, surveillance programs, and modifications/repairs of safety related structures were of interest. This report summarizes the effort to identify aging degradation of structures, documents the observations, presents generic conclusions, and proposes some recommendations for follow-up licensing activities.

The six plants selected for site visits were representative of older-vintage plants, geographically diverse, with different containment designs and unique design features. The structures and civil engineering features included in the review were Seismic Category I buildings, tanks, cable tray, conduit, HVAC, underground structures, water intake structures, service water piping, release stacks, fuel racks, and equipment anchorages.

At each plant visited, the Licensee made a formal presentation to describe the analysis and design basis of the Seismic Category I structures and civil engineering features. The presentation also included a description of various types of degradation that have been identified by the Licensee throughout the plant operating history. Topics covered included containment testing and surveillance results, settlement of structures, ground water and surface water infiltration, cracking of concrete, corrosion of steel, anchorages, masonry walls, equipment foundations, maintenance and operability of seismic instrumentation, Licensing Event Reports, and disposition of previously identified structural issues.

Following the formal presentation and discussions with the Licensee, walkdowns were conducted to examine the existing condition of the structures and civil engineering features. Wherever aging degradation was observed, data were recorded including photographs and/or measurements when appropriate.

Considering that the plants reviewed have been operating for an average of 19 years, most civil/structural plant features have performed very well. Some structures/components, however, do show signs of aging degradation. These include the intake structure, tendon gallery, and service water piping. To a lesser extent, degradation was also associated with the containment liner, water infiltration of buildings, grease leakage from tendon casings, masonry walls, and some degradation of concrete structures and equipment anchorages.

The various types of aging degradations were classified into 11 categories. Table 9-2 presents a rating of each degradation cateogry assigned to each of the six plants. It is recommended that the degradation categories receiving a high rating be considered as candidates for generic letters or information notices to the Licensees. For degradation categories rated medium, it would be prudent to request that each region assess the history and current condition of additional plants before determining any additional action.

It is also recommended that a periodic inspection program for safety related structures and civil engineering features be developed by each Licensee. The purpose of the inspection program is to identify any aging degradation that may be developing and to ensure that the degraded elements are evaluated and corrective actions taken if needed. These periodic inspections would also be very useful for trending of aging mechanisms for continuing operation, and for potential plant life extension. The frequency and level of inspection should be based on the location/environment (temperature, radiation, water, freeze-thaw, chemicals, etc.); susceptibility of the material/structure to degradation; and the current age of the structure.

Other recommendations to address aging degradation for currently operating nuclear power plants, as well as, license renewal applications and new plant design certifications/license applications are described in Chapter 9.

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CHAPTER 1

OBJECTIVE AND SCOPE

Objective

The objective of this evaluation effort was to obtain information about the performance of structures at operating plants and to draw some generic conclusions based on the information obtained from the plant visits. To achieve this objective, an assessment of the existing condition and past performance of structures and civil engineering features at six plants was performed. Any failures, degradations, maintenance activities, surveillance programs, modifications/repairs of safety related structures were of interest.

Scope

To achieve the objective described above, six representative older vintage plants were selected by the NRC. These plants were selected on the basis that they are older-vintage (generally pre-1975) plants, are non SEP plants, are geographically diverse (from different NRC regions), have different containment designs, and have unique design features.

The six plants are listed below along with the date of commercial operation, NRC region, type of containment, and the date at which the audits/walkdowns were conducted.

Plant Name	Commercial Operation	NRC Region	Containment Design	Plant Visit
Trojan	5/76	V	Prestressed Concrete	7/22-25/91
Point Beach 1 & 2	12/70 10/72	III	Prestressed Concrete	10/21-24/91
Turkey Point 3 & 4	12/72 9/73	II	Prestressed Concrete	1/13-17/92
H.B. Robinson 2	3/71	II	Prestressed Concrete	4/13-16/92
Beaver Valley 1	10/76	I	Reinforced Concrete	6/15-19/92
Cooper	7/74	IV	Steel	8/17-21/92

The type of structures and civil engineering features that were included in the scope of review were Seismic Category I buildings; tanks; cable tray, conduit, and HVAC supports; underground structures; water intake structures; and anchorages. The Seismic Category I buildings reviewed include reactor building, containment, radwaste building, control building, fuel handling building, water intake structure, diesel generator building, safety related areas of the turbine building, and release stacks. Both the interior and exterior portions of building structures were examined. Structural components reviewed include the reinforced concrete and structural steel-floors, walls, ceilings, and roofs; masonry walls; and fuel racks.

CHAPTER 2

AUDIT PROCESS

To gain an understanding of the scope of Seismic Category I structures and the type of loads the structures are required to survive at each specific site, the Licensee was requested to make a formal presentation prior to the walkdowns. The presentations provided a brief description of the seismic design criteria, design codes/standards, and what provisions have been made to design or protect safety related plant structures from the effects of various loads such as wind, tornado, floods or dam failure.

The presentation also served to inform the audit team about degradations identified by the Licensee. Thus, the presentations generally covered topics which include containment testing and surveillance results and plant experience with - settlement of structures, ground water or surface water infiltration, cracking of concrete structures, corrosion of steel, problems with anchorages, cracks in masonry walls, problems with equipment foundations (e.g. tanks) and maintenance/operability of seismic instrumentation. Also reviewed were civil/structural Licensing Event Reports (LERs), 10 CFR 50.59 evaluations, and past dispositions of structural issues identified in previous NRC staff inspection reports.

Following the presentation and discussion with the Licensee about their observations and experience with the performance of structures with respect to degradation, walkdowns were conducted. The audit team consisted of two representatives from BNL, and several representatives from the NRC. The Licensee also provided personnel who were assigned to guide us throughout the plant and to answer questions raised by the audit team. If questions could not be immediately answered, they were recorded for follow-up by the plant staff.

During all the walkdowns a log was maintained in which the team recorded for each observation the building/area, elevation, location, component/item, aspect reviewed, photograph number, and any comments. Data were recorded for structural components where aging degradation effects were present as well as where they were not. Photographs were taken for selected items to enhance the documentation; these were noted in the log. In addition, measurements were taken when appropriate (such as crack size), to determine the severity of the degradation.

Throughout the audit, Licensee representatives provided responses and documents in an effort to address and resolve many of the questions and concerns raised by the audit team during the formal presentation session and during the walkdowns. The audit team then reviewed and discussed the observations noted. A list of the more meaningful observations, including those that would be of benefit to the Licensee was compiled. The observations, which are discussed in the following chapters, were conveyed verbally to each Licensee at the exit meetings.

CHAPTER 3

TROJAN NUCLEAR POWER PLANT

Walkdown Description

July 23, 1991:

The walkdown for structures began inside containment. The audit team was separated into two teams (A and B). Team A examined the polar crane, elev. 205′ steel platform, and containment steel liner while Team B examined structures/supports internal to the bioshield. Then the two teams joined together to examine the remaining structures inside containment.

During the afternoon, Team A examined the tendon gallery, outside containment near ground level, and areas of the turbine building. Team B examined areas of the fuel, aux, and control building.

July 24, 1991:

A formal presentation was made by Portland General Electric Company (PGE) personnel. Some of the topics covered include analysis/design criteria (seismic, tornado, codes/standards), performance of containment tendons, support anchorages, spent fuel pool and racks, intake structure, masonry walls, gaps between structures, groundwater problems, seismic instrumentation, tanks, and disposition of structural issues.

July 25, 1991:

During the morning period, Team A examined additional areas of the turbine building (emergency diesel generator room, turbine bay area, switchgear room, etc.) and the intake structure. Team B examined the main steam support structure area and the tendon gallery.

During these activities, a third team was formed which reviewed and evaluated the 10 CFR 50.59 changes at Trojan. This team reviewed the Trojan Nuclear Division Procedure NDP 100-5 and the corresponding training module in detail to evaluate: (1) the effectiveness of the Licensee's training program to provide a thorough understanding of 50.59 requirements and (2) the procedures utilized to implement 50.59 evaluations for civil/structural related changes. The procedure establishes requirements for the preparation of safety evaluations required by NRC Regulations (10 CFR 50.54 and 50.59) and Section 6.5 of the Trojan Technical Specifications for changes to the facility, changes to procedures and licensing documents, and for conducting tests or experiments. It is used to document and ensure the completeness of safety evaluations and to determine whether NRC approval is required prior

to implementing the change or conducting the test or experiment.

The team selected and reviewed eleven 50.59 safety evaluation packages in detail. The team selected packages to review which provided a mix of different subjects, modification size, building location and safety impact.

Results/Observations

Some of the structures at Trojan Nuclear Power Plant were in very good condition after 16 years of operation. However, a number of structural components did exhibit varying degrees of degradation. Some of the significant observations are described below with a more complete list and detailed description presented in Appendix A. Photographs showing some of the observations are also contained in Appendix A.

A significant observation was noted with the containment pre-stress system. Grease was seeping through the concrete containment wall near ground level in a consistent pattern on the outside surface. In addition, grease and water seepage, as well as concrete cracking in the tendon gallery walls, floor, and ceiling were observed. Photographs of these are shown in Appendix A.

Cracking in masonry walls and in reinforced concrete walls and floors was identified. Some cracks in the concrete walls and floors were wider than 0.05 inches. Of the 25 to 30 masonry walls which were evaluated for the IE Bulletin 80-11, numerous cracks were also identified.

Some Category I brackets and steel members were not painted. Apparently this occurred because Trojan has been for some time in the process of developing an approved coating program.

Water seepage through cracks and water ponding were identified. Examples of this occurrence are the turbine building and intake structure.

CHAPTER 4

POINT BEACH NUCLEAR PLANT - UNITS 1 & 2

Walkdown Description

October 22, 1991:

A formal presentation was made by Wisconsin Electric Power Company (WE) personnel. Some of the topics covered include design/codes for category 1 structures, seismic design criteria, containment tendon surveillance, support anchorages, spent fuel pool and racks, intake structure, masonry walls, free spaces/settlement monitoring, and civil/structural LERs. Another important topic for discussion was the use of cathodic protection systems at the site for selected structural components, particularly the piles which support the two containments and fuel pool basemats.

October 23, 1991:

During the initial walkdown inside the Unit 2 containment, the audit personnel were separated into two teams (A and B). Team A began the walkdown inside containment from the top down, while Team B conducted its walkdown from the basemat of the containment working up, until the two teams met.

Team A examined the polar crane and crane girder, containment liner dome region, and containment spray/supports from a distance, by standing on a steel platform beneath the crane girder. Team A also examined the structural steel at the top of the shield wall surrounding the steam generator, the main steam pipe support anchorage to shield wall, supports to the accident fan coolers, conduit/supports, and the shield wall. In addition, the containment liner below the dome was examined up close at various elevations and near the containment personnel hatch and equipment hatch.

Team B examined the accessible areas on Elevations 8′ and 21′. Specifically, the containment liner; the "leak chases" which enclose the liner butt welds; the liner deflection monitoring gages; concrete floors and walls; structural anchorage to walls and floors; the service water piping; containment cavity cooling units; and containment penetrations were reviewed for signs of degradation and conditions which may warrant monitoring or remedial action.

In the latter part of the morning, the two teams joined to perform walkdowns of the Unit 2 tendon gallery, Units 1 & 2 outside containment, and facade structure surrounding the containment. The entire tendon gallery was examined (all 360°) and included the concrete floor, walls, ceiling, tendon bearing plates, and tendon grease caps. The review of the outside containment encompassed the

containment vertical wall, mat, and dome; buttresses; and tendon bearing plates/tendon grease caps. Although the facade structure was examined, it is not a Seismic Category I structure.

In the afternoon, the entire audit team examined areas in the auxiliary building (elevations -19 ft to +26 ft), turbine building (elevations 8 ft to 44 ft), control building (elevations 8 ft to 44 ft) and fuel pool building. These reviews included walkdowns in the diesel rooms, cable spreading room, battery/rack room, vital switchgear room, and control room. Structural components reviewed include concrete floors, walls, and ceiling; conduit; cable tray; piping support anchorages; seismic gaps; equipment supports; tanks; and masonry walls.

October 24, 1991:

In the morning, the entire audit team examined the pumphouse (ground elevation); the fore-bay structure; the exterior walls of the auxiliary building, turbine building, and control building; the tornado missile protection for the diesel generators; and the fuel oil pumphouse (including the fuel oil tank, pumps, and associated supports). In the water intake pumphouse, the primary areas of review included the pumphouse structure, North and South pump rooms, and equipment support/anchorages. The other areas include the fore-bay concrete structure, water baffle concrete structure, and discharge piping. The intake crib could only be visually observed at a distance since it is located 1750 feet offshore. The 14 ft. diameter intake piping between the intake crib and fore bay structure is buried below the lake bed and obviously could not be viewed.

<u>Results/Observations</u>

Most of the civil/structural plant features examined at Point Beach Nuclear Plant were in very good condition after 20 years of operation. However, there were some components which did show varying degrees of aging degradation. Some of the observations are discussed below, with a more complete list and detailed description presented in Appendix B. Although the purpose of our visit was to identify aging-related degradation effects on safety related civil/structural plant features, a few other items were included which would warrant WE attention (e.g., seismic gap observation and pipe support movement in turbine building).

Observations noted inside containment include liner plate separation on the order of 1 inch in several places, two gouges in the liner plate of about 1/8 inch depth, and corrosion of some service water-piping/valves/supports and associated equipment. Outside containment, observations at several locations include corrosion of tendon bearing plates, grease leakage at tendon caps, and cracks at buttresses. In the tendon gallery, there were instances where groundwater seeping in through cracks in the walls

and ceiling is causing (a) corrosion in the vertical tendon bearing plates and (b) concrete degradation. In addition, grease leakage is occurring at some tendon caps. Another concern is verifying the effectiveness of the cathodic protection system for the steel piles supporting the two containments and fuel building.

In several structures (pumphouse, auxiliary building, and diesel generator building), some concrete cracks in the walls, floor, and/or roof have permitted water infiltration to occur. Although these cracks are not severe, if no remedial action is taken, these conditions could lead to further and more rapid degradation.

The seismic gap between the turbine building and the control building at certain locations could not be located. The grout beneath some equipment base plates in the pumphouse was severely degraded, and in the diesel generator rooms a number of anchor bolts did not have full thread engagement. In addition, there is no ongoing surveillance/visual examination program for the identification and subsequent repair of cracks in Seismic Category I masonry walls. Although no cracks were identified by the audit team, a surveillance and repair program is important since the seismic calculations assumed the masonry walls were unreinforced and thus relied on the full bending capability of the masonry walls.

Photographs for some of the key observations noted above are presented in Appendix B.

CHAPTER 5

TURKEY POINT NUCLEAR POWER PLANT - UNITS 3 & 4

Walkdown Description

A formal presentation was made by Florida Power and Light Compnay (FPL) personnel. The major topics covered include design criteria, containment structures, support anchorages, spent fuel pool and racks, intake structure, masonry walls, structural boundaries, geology/foundation conditions, maintenance of structures, seismic instrumentation, civil/structural LERs, past structural issues, civil/structural 10 CFR 50.59 evaluations, and emergency plans for natural emergencies.

January 15, 1992:

The audit team stayed together during the entire walkdown except as noted later on January 16, 1992. Since both nuclear units were operating, no walkdowns could be made inside containment. The audit team began the walkdown in the tendon gallery beneath the Unit 3 containment. The entire tendon gallery was examined (all 360°) and included the concrete walls, floor, ceiling (bottom of mat), tendon bearing plates, and tendon grease caps. The review of the outside containment encompassed the containment dome, ring girder, wall, tendon buttresses, tendon bearing plates and tendon grease caps.

The containment dome was closely examined for any signs of delamination which occurred following original construction of the containment. At that time, the exterior concrete layer of the dome separated from the tendon layer. FPL described the repair made to correct this problem in their formal presentation. It consisted of removing the delaminated layer, placing radial reinforcement, and pouring a new concrete layer to repair the dome.

In the afternoon, the audit team examined areas in the Unit 3 spent fuel pool building, accessible portion of the containment mat, auxiliary building, control building, and Unit 4 switchgear building. These walkdowns included the cable spreading room, battery room, control room, roofs of the spent fuel and auxiliary building, 4160 Volt switchgear room, 480 Volt load center area, air handling equipment room, computer room, seismograph pit, cathodic protection system terminal panel area, CCW heat exchanger room, RHR heat exchanger room, and the RHR pump room. Structural components reviewed in these areas include concrete floors, walls, and ceilings; building structural steel; conduit/supports; cable tray/supports; piping support anchorages; seismic gaps between buildings; equipment supports; tanks; and masonry walls.

January 16, 1992:

In the morning, the audit team examined the Unit 3 and 4 emergency diesel generator buildings, diesel oil tank for Unit 3, condensate storage tank, and Unit 3 and 4 intake structure. In the emergency diesel generator building the structural components reviewed include the concrete floor, walls, and ceiling; diesel support frame/anchorage; day tank anchorage; and electrical equipment support/anchorage. In the intake structure, the structural components reviewed include the concrete floor; partially accessible portions of the CW pump concrete support beams and walls; and concrete walls at the East side of the intake structure and the screen washout area. Since both units were operating, it was not possible to view the concrete walls and slab below grade from inside the intake structure. However, photographs taken by FPL inside the intake structure below grade were made available and were reviewed by the audit team later in the day.

In the afternoon, the audit team split into two groups. The first group consisting of two audit members covered the 10 CFR 50.59 evaluation review. The second group consisting of the remaining members of the audit team examined the cooling canals.

A FPL representative made a short presentation to the first group describing the 10 CFR 50.59 Program and Initiatives. The presentation covered the procedures and guidelines, review and approval process, training, and recent initiatives to improve the program.

The second group was driven by a FPL representative around the perimeter of the cooling canals. Several stops were made to more closely examine the canals. FPL originally released the cooling water discharge directly to the ocean. However, due to environmental concerns, a cooling canal system was constructed to service both nuclear units and the fossil units at Turkey Point. It is an extensive canal system consisting of canals 200 feet wide and spanning 168 miles in total length.

Upon completion of the canal system examination, the audit team reassembled to review representative 10 CFR 50.59 evaluation packages related to the civil discipline. A limited review was made on PCM 79-015, 82-148, 83-050, and 90-472.

Results/Observations

While most of the civil/structural plant features examined at Turkey Point Nuclear Plant were in good condition after 19 years of operation, there were some components which did show varying degrees of aging degradation. The key observations are discussed below, with a more complete list and detailed description presented in Appendix C.

Observations noted in the Unit 3 tendon gallery include some signs of corrosion in the tendon bearing plates, cracks and voids in the concrete adjacent to a few bearing plates, and a gap of about 2" between the tendon gallery wall and the ceiling which permits water infiltration. It appears that the large gap developed due to deterioration of the joint filler material.

In FPL's presentation of the tendon surveillance program at Turkey Point, it was noted that water had accumulated at the bottom of the vertical surveillance tendons in Unit 3. This condition was not observed in Unit 4 during its tendon surveillance. Expanded surveillance of vertical tendons in Unit 3 for the presence of water would identify the extent of this condition as a first step toward resolution.

Examination of the condensate storage tank revealed bent plates on the anchor bolt chairs, deterioration of the water seal at the base of the tank coupled with corrosion of the tank bottom plate, and signs of corrosion/scratches/gouges on the tank wall.

Significant deterioration in the concrete beams supporting the ICW pumps and CW pumps in the intake structure had occurred. This consisted of delamination of concrete cover over the reinforcement and corrosion of the steel reinforcement. FPL was aware of these problems and is in the process of repairing the beams. Repairs began in 1985 and completion is planned by the end of 1996. The audit team reviewed a report on the intake structure prepared by a consultant to FPL. The report indicates that the bay walls are also degrading and experiencing active corrosion of the reinforcing bars. Therefore, the audit team recommended that the Licensee also give close attention to other parts of the intake structure such as the intermediate and exterior walls.

For unreinforced masonry walls, the seismic qualification relies on the assumption that there are no cracks in the wall. However, there appears to be no formal monitoring program to confirm that no cracks develop.

Turkey Point has only one three-component accelograph that records photographically. This provides only limited information which will require time to evaluate. If improved seismic instrumentation were available it may be possible to avoid unnecessarily shutting the plant down in the event of a nondamaging earthquake.

An examination of the Unit 3 containment dome showed no signs of concrete degradation or delamination, which was a problem after original construction. However, the overlay/coating on the dome was peeling. This may also be the cause for some of the clogged drains that have occurred at the base of the dome.

Photographs for some of the key observations noted above are presented in Appendix C.

Although it was not possible to examine the inside of the containments, FPL in its formal presentation on January 14, 1992, did present the results of the Unit 4 containment building Integrated Leak Rate Test (ILRT) structural inspection report. Some of the items identified in the ILRT report are peeled, delaminated, and disbonded topcoat in some areas of the containment liner; surface corrosion of some of the liner seam welds and penetration canisters; leaching of joint filler material between the liner and adjacent concrete structures; radially inward bulging of the liner; and two 1/16 inch cracks in the 4B steam generator cubicle wall.

The 10 CFR 50.59 evaluation procedure seems to have been significantly improved in the past few years. A limited review of the individual engineering packages revealed that up to 1983 there was very little documentation relating to safety evaluations. On a Change Request Notice, the engineer would only be required to identify whether "this change affects nuclear safety or design criteria." A review of a more recent engineering package (PC/M No. 90-472) did, however, reflect a substantial safety evaluation as required by the current FPL procedures regarding 10 CFR 50.59.

CHAPTER 6

H.B ROBINSON NUCLEAR PLANT UNIT 2

Walkdown Description

April 14, 1992:

A formal presentation was made by Carolina Power and Light Company (CP&L) personnel. The major topics covered include design criteria, containment structure, support anchorages, spent fuel pool/racks, intake structure, masonry walls, ground water issues, buried piping, storage tanks, dam design/maintenance, civil/structural LERs and 10 CFR 50.59 evaluations, and plant safety procedures for natural phenomenon.

April 15, 1992:

In the morning the entire audit team conducted a walkdown inside the containment structure. The audit team began its walkdown by entering through the personnel hatch. The containment and internal structures from the operating floor down to the basemat area were examined.

At the operating deck level, a visual examination was made of the dome liner, containment spray ring, polar crane support and refueling pool. At lower levels, the audit team examined the R.C. pump bay, RPV head storage area, shield wall, equipment hatch, piping supports, piping penetrations, cable tray and conduit supports, HVAC, and basemat. These areas were examined for signs of degradation and conditions which may warrant monitoring or remedial action. The vertical portion of the containment liner was not visible because of a layer of rigid insulation attached to the inside face of the liner.

In the afternoon the entire audit team examined the nearby Lake Robinson Dam. This dam, which is located at the southern end of Lake Robinson, maintains the proper water surface elevation normally at elevation 220 feet. The water contained in this lake is used by the Robinson Nuclear Plant Unit 2 and the adjacent coal-fired plant, Unit 1. The earth dam is approximately 4,000 feet long and has a maximum height of 55 feet. The water level is controlled by a gated concrete overflow spillway. Observations were made of the gates, spillway, and the entire length of the earth dam.

During the remainder of the afternoon, the audit team was split into two teams which followed two separate routes to perform additional walkdowns of other structures. The two routes covered the same structures and components but followed different paths.

The structures examined are the reactor auxiliary building, turbine building, exterior of the containment, and water storage tanks. Walkdowns within these areas include waste evaporator area, boric acid batch room, safeguard area, control room, diesel generator rooms, safety injection pump room, emergency bus rooms, battery rooms, spent fuel pool heat exchanger area, RHR pump area, seismic monitor room, refueling water storage tank, and primary water storage tank. Structural components reviewed in these areas include concrete floors, walls, ceilings, and roofs; building structural steel; conduit/supports; cable tray/supports; piping support anchorages; seismic gaps between buildings; equipment supports; tanks; and masonry walls.

April 16, 1992:

In the morning the audit team examined the intake structure along the shore of Lake Robinson. The areas examined were the lower level elevation 218 feet (lower level below grade) and pump area elevation 226 feet (grade level). At the lower elevation, the concrete floor, walls, and ceiling were examined as well as the service water piping and supports. At the grade level, the concrete floor and exterior walls were examined. In addition, the service water - piping, piping supports, and pump anchorage were examined.

Later in the day, the audit team reviewed the 10 CFR 50.59 program at Robinson Unit 2 as it relates to civil/structural modifications/evaluations. The "Plant Operating Manual - Plant Program," PLP-032, Rev. 4 was provided to the audit team for review. Appendix I of this manual contains the CP&L 10 CFR 50.59 Program Manual, Rev. 2. This program manual describes the items requiring 10 CFR 50.59 evaluation, the responsibilities of the personnel performing the safety reviews, procedures for conducting the safety reviews, guidelines for completing the forms, and training/qualification guidelines.

From a list of specific 10 CFR 50.59 packages related to civil/structural items, the audit team selected five packages to review. These covered 50.59 packages for which only evaluations were required and packages which also contained modifications to plant structures/components.

<u>Results/Observations</u>

While most of the civil/structural plant features examined at Robinson Nuclear Plant were in very good condition after 21 years of operation, there were some components which did show varying degrees of aging degradation. Some of the observations are discussed below, with a more complete list and detailed description presented in Appendix D. A few items which were not aging related were also brought to CP&L's attention (e.g., pipe support base plate which straddles what appears to be a seismic gap).

Observations noted inside containment include discoloration on the vertical liner at an insulation joint, liner bulge, corrosion of three component cooling water valves and piping, corrosion of support to main feedwater line A, and peeling/cracking of the coating on the concrete surface of the basemat.

An examination of the exterior condition of the containment structure from the ground and roof of the adjacent reactor auxiliary building showed no significant signs of concrete degradation. CP&L indicated that some cracking in the surface coating on the exterior of the containment dome was identified in 1986. After removal of portions of the surface coat, the Licensee discovered some small voids in the structural concrete. All of these, however, were repaired and a new two inch thick topping coat of concrete was placed on the dome.

Robinson Unit 2 containment is prestressed only in the vertical direction of the cylindrical wall with 1 3/8 inch diameter grouted steel bars. Since the bottom and top anchorages are embedded in the concrete containment structure, no visible examination of the tendon system was possible. Therefore, the audit team relied upon the 1976 Report of Surveillance Tendon Test Results. The most significant finding as a result of the tests performed on one of the surveillance tendons was a 50% reduction from mean ductility for one specimen. Battelle Columbus Laboratories concluded that corrosion was the factor responsible for the low value of ductility. In spite of this all twelve specimens exceeded the minimum breaking load of 238,000 pounds specified in the FSAR. It is believed that the corrosion took place prior to prestressing and grouting of the surveillance tendon. Another tendon surveillance test is planned in 1996.

Examination of the dam identified some water leakage around the side of the gates onto the steel beams that support the gates, spalled concrete underneath two beam seats that support the walkway over the dam gates, and spalled concrete/holes at water line.

The walkdown of the intake structure revealed cracks at the intersection of concrete walls, severe pitting on the service water line, corrosion and questionable design of rod hanger supports, degraded condition of the friction clamp on the south service water header and degraded condition of the strainer foundation bolts.

In the remaining plant structures there were a few locations with signs of water infiltration; several cases of insufficient thread engagements, loose nuts, missing washers, and one case of a missing nut; minor corrosion of structural steel in the Seismic Category I area of the turbine building; and some corrosion of nuts at the base anchorage to storage tanks.

Photographs for some of the key observations noted above are presented in Appendix D.

Although there is no regular schedule for inspection of structures, CP&L has developed a design guide for "Periodic Structural Inspection of Seismic Category I Structures." The purpose is to monitor the structural integrity of safety related structures and provide baseline information for plant restart following an earthquake.

The 10 CFR 50.59 evaluation procedure seems to have been significantly improved in the past few years. A limited review of the individual engineering packages revealed that in 1973 the documentation relating to safety evaluations was limited. A review of more recent packages, such as Document No. EE 91-137, Rev. 0, indicates a detailed safety analysis was prepared along with the appropriate evaluation forms as required by the current CP&L program manual for 10 CFR 50.59.

CHAPTER 7

BEAVER VALLEY POWER STATION UNIT 1

Walkdown Description

June 16, 1992:

A formal presentation was made by Duquesne Light Company (DLCo) personnel. The major topics covered include design criteria, containment structure, support anchorages, spent fuel pool/racks, intake structure, masonry walls, ground water issues, buried piping, storage tanks, civil/structural LERs and 10 CFR 50.59 evaluations, and plant safety procedures for natural phenomena.

June 17, 1992:

The audit team remained together throughout the plant walkdown activities. The first area visited was the intake structure, which is enclosed by a steel frame superstructure over the traveling screens and pump cubicles. The specific areas examined include interior concrete walls, floors, and ceilings; pump cubicles A, B, C, and D; and the exterior concrete walls. There was no immediate access for examining concrete at the water line. Since this required plant maintenance assistance, it was arranged for the following morning.

Next, the team reviewed the exterior of Category I structures and storage tanks, including the containment; the cable vault and main steam valve house; the coolant recovery structure; the refueling water storage tank; the safeguards area; the diesel generator building; the steam generator drain tank; the primary auxiliary building; the fuel building; the turbine building; and the concrete enclosure for the demineralized water storage tank (no access to confined area).

Following completion of the outside inspections, the team examined the interior of the primary auxiliary building and the fuel building on elevations 722′-6", 735′-6", 752′-6", and 768′. Structural components reviewed included concrete floors, walls, and ceilings; building structural steel; conduit/supports; cable tray/ supports; pipe supports; equipment supports; support anchorages; seismic gaps between buildings; tanks; masonry walls; and the spent fuel pool and fuel transfer canal.

June 18, 1992:

The walkdown began this day with the interior of the diesel generator building. The concrete walls, floors, and ceilings; the diesel generator supports; attachments to concrete; and general features were examined.

Next, the team returned to the intake structure to assess the condition below the operating floor; it is accessible only through normally closed manholes. One team member accompanied the DLCo representative into the C bay pit to check for degradation of concrete and steel.

Following this, the team examined the control room, primarily focusing on masonry walls in the vicinity of safety-related electrical cabinets and control panels.

The remainder of the walkdown encompassed the interior of the service building, the cable vault structure, and the safeguards building. The service building inspection included the switchgear rooms, the process rack area, and the air conditioning room on elevation 713'- 6", the cable mezzanine on elevation 725'- 6"; and elevation 735'.

The cable vault structure review included the west cable vault, the auxiliary feedwater pump room, the main steam room, and motor control center room, and other areas on elevations 722', 735', 751', 756' and 776'. The safeguards building review included the hydrogen recombiner room, the recirculation spray pump room, the charging line, the quench spray line, the river water line, containment piping penetrations, and other areas on elevations 722' and 747'.

Structural components examined in these areas include concrete floors, walls, ceilings, and roofs; building structural steel; conduit/supports; cable tray/supports; piping support anchorages; seismic gaps between buildings; equipment supports; tanks; and masonry walls. This concluded the walkdown activities.

In the late afternoon, the audit team reviewed several LER and 10 CFR 50.59 packages related to civil/structural items. These were either selected from a list provided by DLCo during their presentation or were provided by DLCo in response to specific questions by the audit team.

Results/Observations

While most of the civil/structural plant features examined at Beaver Valley Unit 1 are in very good condition after 16 years of operation, there were some components which did show varying degrees of aging degradation. Some of the observations are discussed below, with a more complete list and detailed description

presented in Appendix E. A few items which were not aging related were also brought to DLCo's attention (e.g., missing or loose concrete anchor bolts; one instance of questionable seismic support for valves in a small bore, safety-related piping run).

An examination of the exterior condition of the containment structure from the ground and from the roof of the adjacent buildings showed no significant signs of concrete degradation. Only minor surface cracking was observed. However, original patches over construction-related holes are deteriorating and falling out, giving the appearance that small chunks of concrete are spalling. Monitoring of this condition and repair of the patches would be beneficial for the long term integrity of the containment.

The Beaver Valley Unit 1 Containment is constructed of reinforced concrete and normally operates at sub-atmospheric pressure (-4 psig). The quench spray and depressurization spray systems are engineered safety features designed to restore sub-atmospheric pressure conditions inside containment following the Design Basis Accident. Because the unit was in operation at the time of the audit, it was not possible to examine inside containment. DLCo presented a summary of results for all integrated and local leak rate tests and for all structural integrity inspections conducted prior to the integrated leak rate tests. A few instances of liner bulging were previously identified; these were subsequently monitored to ensure that the deformation was not growing. Rusted areas and peeled paint in several locations in the interior steel liner were noted in some of the containment inspections performed prior to the ILRTs. Gouges, anchor holes, missing concrete chunks, and some cracks in the exterior concrete surface of the containment were also noted. However, the containment inspection reports concluded that there was no major or gross deterioration of either the outer concrete structure or inside steel liner which would affect its structural integrity.

The last ILRT was conducted in late 1989; these tests are conducted on a 40-month cycle. The current program appears to be sufficient to detect any unusual deterioration which may develop.

For Seismic Category I structures other than containment, cracks were observed in some reinforced concrete floors, walls, and ceilings. The most notable are cracks in the ceiling of the diesel generator building and the ceiling of the pump cubicles in the intake structure. The exterior wall on the South side of the diesel generator building has a region of concrete which has spalled to a depth of 1/2 inch, exposing the steel reinforcement. This reinforcement shows signs of corrosion.

In the intake structure in the bay "C" pit, corrosion of the horizontal structural steel supports for the raw water line was

observed. This may be due to the water that is trapped in the horizontal structural steel shapes used to support the pipes. The concrete walls in this bay above the water surface appear to be in good condition.

While pipe and equipment supports are generally in good condition, there were a few instances of missing nuts, apparently untorqued anchor bolts, degradation of grout beneath base plates, and one case of a missing anchor bolt.

Corrosion was observed in the raw cooling water piping and steel supports for the condensing unit of the control room air conditioning. In several other areas, corrosion was noted on piping and supports. This appears to be primarily related to condensation.

A structural steel angle section, initially installed under DLCo's IE Bulletin 80-11 program to restrain the bottom edge of a masonry wall, was found to be only loosely held in place. It is important to ensure that all structural modifications to masonry walls are maintained in accordance with the qualification basis established in the 80-11 program. Also, any existing cracks in masonry walls which were not considered in the 80-11 program or any cracks which may develop in the future must be evaluated for their impact on the current qualification basis.

Photographs for some of the key observations are presented in Appendix E.

Although there is no formal inspection program for structures, DLCo has developed a Plant Inspection Program (NGAP 8.8). The purpose of this procedure is to ensure that deficiencies relating to materials, fire protection, safety hazards, cleanliness, housekeeping, and radiological protection are identified and that corrective action is taken. Under material condition deficiencies, items such as rust, corrosion, loose/unbraced lines/pipes, and leaks are identified. Expansion of this program to cover other aging degradation effects such as concrete cracks, coating failures, and water infiltration would be very beneficial for maintaining the structural performance of the plant.

Another program developed by DLCo is the Settlement Monitoring Program (NEAP 2.20). This procedure provides the requirements to measure the settlement of Unit 1 and Unit 2 structures at selected locations throughout their operating life. This provides sufficient data for an engineering evaluation of the effect of settlement, as it relates to the integrity of the structures. Settlement markers for Unit 1 are surveyed at least annually. This program was initiated in 1971 during construction of the plant. As a result of this program uneven settlement of the Outfall Structure was observed in 1973/1974. The East side settled down while the West side heaved up. DLCo used piles and steel

beams to underpin the structure to ensure no further settlement.

DLCo currently performs 10 CFR 50.59 evaluations in accordance with their Administrative Procedure 8.18-10 CFR 50.59 Evaluations, Rev. 0. This procedure defines the responsibilities and requirements for preparation, review, and approval of 10 CFR 50.59 evaluations of proposed changes, tests, or experiments. Because this procedure is relatively new, the 10 CFR 50.59 evaluation packages reviewed were in a different format. However, they did include a safety evaluation, an unreviewed safety question determination, and a Q.A. Category Review.

CHAPTER 8

COOPER NUCLEAR STATION

Walkdown Description

August 18, 1992:

A formal presentation was made by Nebraska Public Power District (NPPD) personnel. The major topics covered include design criteria, site geology/foundation conditions, settlement/structural boundaries, structural surveillance programs, Mark I torus, intake structure, spent fuel pool/racks, tanks, containment, and support anchorages.

August 19, 1992:

The audit team remained together during the plant walkdown activities this day. The first area visited was the reactor building outside containment. Access inside containment was not possible since the plant was operating at the time. The walkdown began at the top elevation-refueling floor and proceeded down to the lower elevations ending up at the torus enclosure. The building structural components examined include the concrete walls, floors, and ceilings and structural steel at elevations 1001 ft., 904 ft., 976 ft., 958 ft., 931 ft., 881 ft., and 859 ft. Included in this review was examination of the drywell hatch, tanks, masonry walls, penetrations, conduit/supports, piping supports, equipment supports, anchorages, and the torus/supports.

Next, the team examined the roof and interior portions of the control building at elevations 948 ft., 932 ft., 918 ft., 904 ft., 882 ft., and 877 ft. The structural components reviewed include the concrete walls, floors, and ceilings; building structural steel; conduit/supports; cable tray/supports; equipment supports; pipe supports; support anchorages; and tanks. Specific areas reviewed include the control corridor, roof, cable spreading room, control room, auxiliary relay room, battery room, DC switchgear room, and emergency condensate storage tank. While on the control building roof, the exterior walls of the reactor building were also examined.

August 20, 1992:

To ensure completion of the walkdown in the allotted time, the audit team was split into two groups; A and B.

Team A examined the interior of the radwaste building at elevation 875 ft. and basemat and the interior of the turbine building at elevations 932 ft., 875 ft., and 903 ft. NPPD had informed the audit team that the only safety related area in the radwaste building is at the lowest level (basemat) and the turbine

building has no safety related area/components. Team A also reviewed the interior and exterior portions of the intake structure.

While Team A was performing the walkdown described above, Team B examined the diesel generator rooms, exterior walls of the control building and reactor building, the buried diesel oil tank area, and the elevated release point tower. Team B also examined the exterior and interior portions of the intake structure.

Both teams examined the exterior and interior portions of the intake structure at the grade level (operating floor elevation). Access below the operating floor down to the water level could not be readily obtained. However, visual examination from the operating floor of all the bays in front of the traveling screens down to the water level were made. In addition, walkdowns were performed in the service water pump room.

Structural components reviewed in the areas described above include concrete floors, walls, and ceilings; building structural steel; conduit/supports; cable tray/supports; piping supports; anchorages; seismic gaps between buildings; equipment supports; tanks; and masonry walls. This concluded the walkdown activities.

In the afternoon, the audit team reviewed several LERs and 10 CFR 50.59 evaluation packages related to civil/structural items. These were selected from a list provided by NPPD during their presentation.

Results/Observations

While most of the civil/structural plant features examined at CNS are in very good condition after 18 years of operation, there were some components which did show varying degrees of aging degradation. Some of the observations are discussed below, with a more complete list and detailed description presented in Appendix F. A few items of concern which were not aging related were also brought to NPPD's attention (e.g., insufficient thread engagement or loose concrete anchor bolts, and the adequacy of anchors used with epoxy in high temperature areas).

Signs of corrosion were observed on the external surface of the torus shell. Apparently a water leak from above the torus had run down the torus shell wall removing the reddish coating and initiating some surface corrosion.

As a result of internal inspections of the torus performed in 4 of the 16 bays, NPPD identified numerous corrosion pits. The existing pits were analyzed considering a corrosion growth factor and then 150 pits were patched using underwater cured epoxy. NPPD indicated that the epoxy, when applied properly, will displace water and trapped air in the repair zone. The patches will be

evaluated during the 1993 scheduled refueling outage to confirm their adequacy and the use of the underwater applied epoxy method.

Examination of the exterior concrete walls and basemat floors of most structures showed no signs of water infiltration. However, evidence of water infiltration was observed through the exterior concrete wall of the reactor building when viewed from inside the torus enclosure. Apparently, water leaks in at a piping penetration and runs down the concrete wall onto some conduit. NPPD was aware of this situation, indicating the source of the water is from surface runoff during heavy rainfall. However, it appears that no effort has been made to stop the water infiltration.

At elevation 904 ft. in the control building, the service water booster pump (SWBP) gland water system is in a very bad state of corrosion and degradation. This includes the tanks, piping, supports, and anchorages. NPPD was aware of this situation, indicating that they plan to remove the system completely during the 1993 refueling outage. However, the system has been allowed to continue to operate in this condition for a number of years.

At elevation 882 ft. in the control building, corrosion of piping, valves, and flanges/bolts was observed in components of the service water booster pump system.

Corrosion of the pipe supports and anchorages as well as degradation of the floor coating were observed in the service water pump room of the intake structure. Outside the pump room, water was collecting on the operating floor; some of which was coming from the partially closed traveling screen side door.

Ultrasonic testing (UT) is being utilized to measure pipe wall thickness in the service water piping for the diesel generator lube oil system. This was done due to erosion of the piping at elbows caused by the silty Missouri River water. NPPD indicated that UT of the service water and residual heat removal service water booster system piping, fittings, and valves is routinely performed as part of the Augmented Erosion-Corrosion Program.

The coating at one of the structural steel legs of the elevated release point tower has degraded and corrosion of the base material is evident.

Photographs for some of the key observations discussed above are presented in Appendix F.

Although there is no formal inspection program for all structures, NPPD described their Surveillance Procedures 6.3.10.1 and 6.3.10.12 for inspection of the interior and exterior-drywell and torus. In addition, NPPD developed CNS Procedure 0.11 entitled, "Station Inspections". This procedure defines the

requirements for conducting station inspections by station management. These inspections cover the overall material condition, fire hazards, safety and industrial hazards, design deficiencies, radiological controls, and general housekeeping conditions. This procedure or others should be expanded to more specifically include items such as corrosion, leaks, concrete cracks, coating failures, water infiltration and other aging related effects.

NPPD currently performs 10 CFR 50.59 evaluations in accordance with their CNS Engineering Procedure 3.3, Rev. 11. This procedure provides the method for determining whether a proposed change, test, or experiment constitutes an unreviewed safety question or requires a Technical Specification change as defined in 10 CFR 50.59. The procedure defines the responsibilities and requirements for the preparation of the safety evaluation. Several Station Design Change packages were selected for review. Each of the packages did contain a Safety Evaluation and the 10 CFR 50.59 Reportability Analysis as required by the CNS Procedure 3.3

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Considering that the plants reviewed have been operating for an average of 19 years, most civil/structural plant features have performed very well. Some structures/components, however, do show signs of aging degradation.

The various degradations summarized in the preceding chapters and listed in Appendices A through F are classified under eleven (11) categories. The degradation categories are listed and sequentially numbered in Table 9-1. For each plant a rating is assigned to each category to identify its significance for that specific plant.

The rating system consists of:

H - High (instances of a more significant nature)
M - Medium (several instances of a moderate nature)
L - Low (very few instances of a non-significant nature)
N/A - Category not applicable

Table 9-2 presents this information for the six (6) plants visited. It is important to emphasize that the ratings are <u>not</u> judgements about the current overall safety condition of these specific plants. The ratings indicate the plant-specific historical experience and current remediation programs, as well as physical observations by the audit team. The information provided by the Licensee during the presentation and during the walkdowns was invaluable. Without the assistance of the Licensee's staff at each plant, the value of this effort would have been significantly reduced.

The last row of Table 9-2 is entitled, "Generic Issue Rating". This represents a "qualitative mean" of the six plants for each of the categories. Thus, a Generic Issue Rating of H (or high rating) for Category 5, as an example, indicates that tendon gallery degradation was significant at the plants which have tendon galleries.

Recommendations

Table 9-3 presents significance ratings for each category for the following NRC licensing activities:

- Operating Plant Safety
- License Renewal Application
- New Plant Design Certification/License Application

Note that the ratings for Operating Plant Safety are the same as the "Generic Issue" ratings from Table 9-2 with the exception of category numbers 1, 7, and 11 which are discussed below. Each of these areas is addressed in the following paragraphs.

Operating Plant Safety

The categories rated "H" are candidates for generic letters or information notices to the Licensees, if generic communications related to these categories have not already been issued. The categories rated "M" may be candidates for generic letters or information notices. As a first step, it would be prudent to request that residents and regional inspectors assess the history and current condition of additional plants with respect to these "medium" categories. The ratings would then be adjusted, based on the additional input; the appropriate action would be selected based on the revised ratings.

License Renewal Application

The information collected during the six-plant audit has been evaluated from the perspective of license renewal for an additional twenty years of operation, beyond the original forty year design life.

The ratings in Table 9-3 provide guidance for identifying the types of degradation which may require detailed review during the license renewal process. Several categories which are rated "M" for operating plant safety have been elevated to "H" for license renewal application, because of the increased service life.

For prestressed concrete containments, maintaining the prestressing system components in good working order is essential. Also it will be necessary to ensure that the required level of prestress can be maintained through the life extension period.

For steel containments, such as Mark I, sources of corrosion will have to be identified and eliminated, and an on-going inspection program will be required to ensure that minimum wall thickness requirements are not violated throughout the life extension period.

Problems with corrosion, erosion, and blockage of service water system piping and components are pervasive. Appropriate repairs or retrofits may be required to ensure the safety-related function of the service water system through the life extension period.

The intake structure and associated concrete structures are particularly susceptible to degradation from the elements. This is a major concern at coastal areas where the intake structure is

exposed to a salt water environment. A regular inspection and maintenance program is necessary for license renewal. In the worst situation, rebuilding portions of the structure may be necessary to ensure a ready supply of suitable service water.

Under the Bulletin 80-11 program, all existing masonry walls important to safety had to be qualified for appropriate combinations of operating and severe loadings. Specifically, their capability to survive a design-basis seismic event was questioned and each Licensee had to demonstrate that its masonry walls satisfied criteria acceptable to the NRC. The basis for qualification of masonry walls varied widely - from conservative simplified analysis to installation of major reinforcement schemes. Whatever the basis, it is necessary to ensure that this basis is maintained throughout the plant life including the license renewal period. Regular inspection and maintenance is required to maintain the walls in their originally qualified condition.

The condition of safety-related storage tanks and buried piping must be evaluated before an extension of service life can be approved. These elements are difficult and costly to inspect and are often overlooked by the Licensee. It would be prudent to require detailed, well documented inspections, structural evaluation of the current condition and a conservative estimate of remaining service life as part of the license renewal application.

<u>New Plant Design Certification/Licensing Application</u>

The information collected during the six-plant audit has been evaluated from the perspective of new plant design certification/licensing for a sixty year design life. This is consistent with recent submittals to the NRC for review of evolutionary and advanced reactor designs. The significance ratings in Table 9-3 provide guidance for identifying the types of potential degradation which need to be addressed during the new plant design certification/licensing process. The ratings, by category, are very similar to those specified for license renewal.

Given the operating experience logged to date by the commercial nuclear industry, the next generation nuclear power plant - whether it utilizes an evolutionary reactor design or an advanced reactor design - should improve on the performance of its predecessors. Over the past twenty (20) years, the nuclear industry has had to address many operating problems which were not anticipated at the design stage. The lessons learned must be considered and then extrapolated to a sixty year design life.

Susceptibility to aging degradation is influenced by the following factors:

1) degree of knowledge and understanding of the aging mechanisms

2) design and materials selection
3) fabrication and construction methods
4) level of inspection and maintenance

The current state of knowledge and understanding about aging mechanisms should have a significant impact on the design, materials selection, fabrication, and construction of new nuclear power plant structures and civil engineering features. In addition, accessibility for periodic inspection and ease of maintenance should be important considerations at the detail design stage. This is particularly important for those degradation categories rated "H" in Table 9-3.

Other Recommendations

At two of the plants, Point Beach Units 1 and 2 and Turkey Point Units 3 and 4, cathodic protection systems (CPS) are relied upon to mitigate the degradation of structural steel components. At Point Beach, the CPS is used to prevent corrosion of the steel piles which support the containment and fuel pool basemats (see Appendix B). The Licensee relies on the CPS electrical readings to conclude that the system is functioning and consequently preventing corrosion. No visual or other verification means have been attempted. At Turkey Point, the CPS is used to prevent corrosion of the containment liner plate, reinforcing steel, and tendon assemblies (see Appendix C). In this case, the CPS is presently exhibiting low to very low readings in some of the anodes. The Licensee is presently evaluating this condition.

Although the use of CPS is a unique feature at very few plants, additional information on CPS and data on long term integrity of buried components should be reviewed. In some cases it may be necessary that physical inspection be performed to assess the performance of CPS in preventing corrosion of steel components.

In several plants, cracks were identified in masonry walls. Some of these masonry walls were believed to be unreinforced. In addition, one plant had a large gap between a structural steel support and the masonry wall. The structural steel apparently was intended to provide support to the wall. At another plant, a structural steel angle originally installed to restrain the bottom edge of a masonry wall, was found to be only loosely held in place. Also, a vertical angle did not have an anchor at the top and no washers were present at other anchors where oversized holes were used in the angle.

In the case of unreinforced masonry walls, the original seismic qualification typically relies on the bending capability of the masonry blocks and mortar joints without cracks. For the structural steel members which were installed to provide support to the masonry walls, the installation condition should reflect the seismic qualification basis (i.e. direct support by the structural

members without a gap). Therefore, it is recommended that a periodic inspection program, developed by the Licensee, should be performed to ensure that the condition of each Seismic Category I masonry wall reflects the intended design and assumptions used in the seismic qualification documentation. The inspection should include verification that no additional cracks appear in unreinforced masonry walls which were not considered in the original qualification of the wall.

Although none of the plants had an adequate inspection program that encompassed all civil/structural features, a few plants did develop procedures for a limited review of selected items. At Beaver Valley Power Station, a Plant Inspection Program was developed (see Chapter 7). The purpose of this procedure is to ensure that deficiencies relating to materials, fire protection, safety hazards, cleanliness, housekeeping, and radiological protection are identified and that corrective action is taken. Under material condition deficiencies, items such as rust, corrosion, loose/unbraced lines/pipes, and leaks are identified.

Expansion of this type of program to cover other aging degradation effects such as concrete cracks, coating failures, and water infiltration would be very beneficial for maintaining the structural performance of nuclear power plants. Such inspection programs should be performed on a periodic basis depending on the type of structure and component examined. In addition, threshold values, such as size and length of cracks, should be specified which would trigger an evaluation of the condition and thus will ensure that some sort of action would be taken.

Based on the above, it is recommended that a periodic inspection program for safety related structures and civil engineering features be developed by each Licensee. The purpose of the inspection program is to identify any aging degradation that may be developing and to ensure that the degraded elements are evaluated and corrective actions taken if needed. These periodic inspections would also be very useful for trending of aging mechanisms for continuing operation, and for potential plant life extension. The frequency and level of inspection should be based on the location/environment (temperature, radiation, water, freeze-thaw, chemicals, etc.) susceptibility of the material/structure to degradation, and the current age of the structure. Periodic inspections every 5 to 10 years depending on the structure, environment, and age would seem appropriate.

TABLE 9-1

DEGRADATION CATEGORIES

1	-	Intake Structure/Pumphouse/Dam Degradation
2	-	Service Water Piping System Degradation
3	-	Water Infiltration
4	-	Tendon Grease Leakage
5	-	Tendon Gallery Degradation
6	-	Masonry Wall Condition and Qualification Basis
7	-	Corrosion of Tanks, Buried Piping, Piles; Performance of Cathodic Protection Systems
8	-	General Degradation of Concrete Structures (other than containment)
9	-	General Degradation of Steel Structures (other than containment/liner)
10	-	Corrosion of Anchor Bolts/Grout Degradation/Anchorage Deficiencies
11	-	Containment Structure/Tendon System/Liner Degradation

TABLE 9-2

DEGRADATION RATING

Plant	Reactor Type	Containment Type	Degradation Categories										
			1	2	3	4	5	6	7	8	9	10	11
Trojan	PWR-W (1130 MW)	Prestressed Concrete (Type 3b)	L	L	H	H	H	M	L	M	L	L	M
Pt. Beach 1 & 2	PWR-W (500MW each)	Prestressed Concrete (Type 3b)	M	H	H	M	H	L	L	M	L	M	H
Turkey Point 3 & 4	PWR-W (728MW each)	Prestressed Concrete (Type 3b)	H	L	H	L	H	M	M	M	L	L	H
Robinson 2	PWR-W (665MW)	Prestressed Concrete (Type 3a)	M	H	L	N/A	N/A	L	L	L	L	M	M
Beaver Valley 1	PWR-W (856MW)	Reinforced Concrete (Type 3d)	M	M	L	N/A	N/A	H	L	M	L	M	M
Cooper	BWR-GE (778MW)	Steel (Mark I) (Type 4g)	M	H	L	N/A	N/A	N/A	L	L	L	M	H
Generic Issue Rating			M	H	M	M*	H*	M	L	M	L	M	M

*Where applicable

Key: H - High (instances of a more significant nature)
M - Medium (several instances of a moderate nature)
L - Low (very few instances of a non-significant nature)
N/A - Category not applicable

Note: These ratings are not judgements about the overall safety condition at the plants. They indicate the plant-specific historical experience, current remediation programs, and physical observations by the audit team.

TA[illegible] 9-3

APPLICATION TO FUTURE LICENSING ACTIVITIES

Applicability to	Degradation Categories										
	1	2	3	4*	5*	6	7	8	9	10	11
Operating Plants	M/H**	H	M	M	H	M	M	M	L	M	H
License Renewals	H	H	M	M	H	H	H	M	M	M	H
New Nuclear Power Plants	H	H	M	M	H	***	H	M	M	M	H

Key: H - High importance
M - Medium importance
L - Low importance
N/A - Not applicable

* Where applicable.
** H rating is for coastal plants.
*** New design must meet current NRC restrictions and design criteria for masonry walls.

APPENDIX A

TROJAN NUCLEAR POWER PLANT

DESCRIPTION OF CIVIL/STRUCTURAL OBSERVATIONS

Containment-Interior

1. At Containment El. 61′ near the entrance to the pressurizer, the seal between the floor slab on top of the masonry wall and the liner plate appeared to be in poor condition. At El. 77′ between azimuths 60° and 90°, the seal between the floor slab and the liner is also in poor condition. At El. 77′, there is evidence of deformation of flashing and grout between containment wall and internals. The concern is that water leakage through the seal could cause corrosion in the liner.

2. Ripples in the liner plate were observed at horizontal welds consistently around containmment. In addition, the containment liner plate at azimuth 300°, elevation 130′ had an inward horizontal bulge of approximately 1 1/2" that was tapered over a 10′ vertical span. Bulges in the liner plate were also observed at both sides of the access hatch to containment at El. 45′. When the plate was tapped it sounded hollow behind the liner.

3. The paint on the containment polar crane runway rail girder and its supports was observed to be cracked and was peeling at various locations.

4. It was observed that the containment El. 205′ structural steel under the air coolers had a white buildup on the surface.

5. At El. 45′ azimuth 280° inside the containment on the outside of the bioshield wall, it appears there was a baseplate with anchor bolts removed from the wall. On the face of the wall there are numerous horizontal and vertical cracks in the concrete.

6. On the pipe support that snubber SS-1105 is attached to, at the 45′ elevation inside containment near the recirc. sump, the nuts on the baseplate anchor bolts do not have full thread engagement.

7. Examination of the containment liner indicated that the liner plate had missing/peeling areas of coating at El. 45′, 160° azimuth.

8. Inside containment, rusting and lack of coatings was noted on several recently modified major pipe supports.

Containment - Exterior

1. On the exterior of the containment structure it was observed that near the base, grease has been leaking from vertical cracks in the concrete spaced approximately 3′ on center.

2. On the exterior of the containment structure mid-height it was observed that at the construction opening a gutter has been installed to catch grease leaking from the construction joint.

Containment - Tendon Gallery

1. A grease filler leak was noted at the cap seal on tendon V 104. Grease leakage from the cap of V 116 and V 110 were also noted.

2. A conduit and short pipe section next to the inside wall across from V 201 W has rust deposits.

3. A lot of water was noted in the drainage slot next to the exterior wall and at the entrance sump. This suggests water infiltration has occurred.

4. Spalled concrete was identified on the floor next to the inside wall at the entrance azimuth.

5. What appears to be calcium carbonate deposits next to V 216 and V 108 were observed.

Other Structures

1. Concrete cracking and evidence of relative displacement at joint between Area 12 and auxiliary building was noted.

2. Concrete cracking at the ceiling of the control building El. 105′ was observed.

3. In the auxiliary building at El. 77′ there are cracks in the wall at column line 55. Also some cracking was noted at El. 61′.

4. Rust was observed on support HBD-27-3 SR 813, El. 45′ of the fuel building. Rust exists behind the baseplate with no visible water source. Support is on the Hut enclosure.

5. Rust marks were noted on a steam generator support base plate.

6. On the fuel building El. 77′, Rm. 217 S. Wall, cracks appear on the outside wall of the spent fuel pool cask loading pit.

7. Cracking was observed at the discontinuity between El. 61′ and 65′ in control building "B" switchgear room. A crack in the floor at the East wall shows signs of spalling.

8. In the control room East wall, cracking appears to have reoccurred after grouting was performed.

9. At control building El. 65′, in the East wall of the East battery room, cracking above the door was observed.

10. Cracks above fuel building, El. 45′, were observed on the outside of the spent fuel pool walls near the junction of the basemat and wall.

11. Approximately 4 inches below the El. 93′ slab on the turbine pedestal is a horizontal crack in the concrete.

12. At El. 27′ in the turbine building, seepage from the walls and floors was observed. A 6" x 3" section of concrete has spalled as a result of this condition.

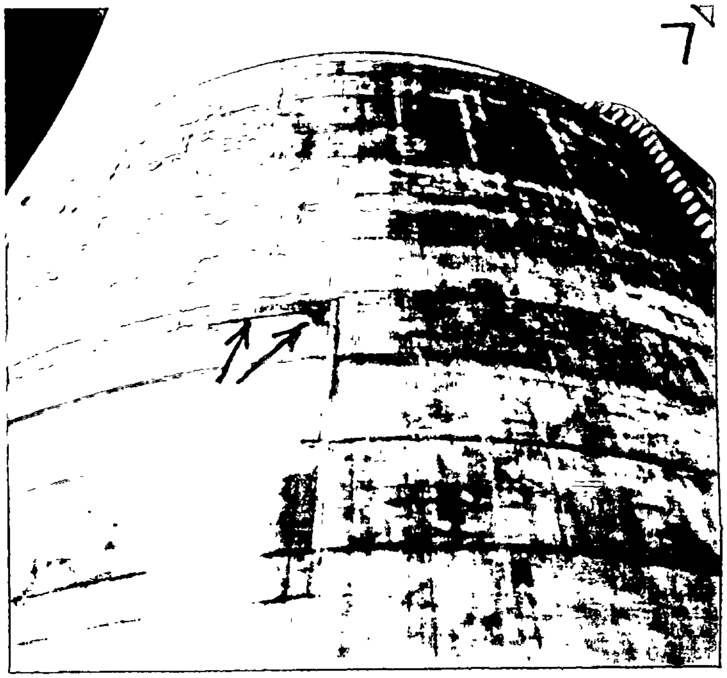
13. Leakage of water from the spent fuel pool walls had occurred previously. PGE personnel were aware of this problem and had performed an evaluation.

14. Emergency diesel room "B", El. 45′, North wall; a large vertical crack in masonry wall was observed. Also, masonry wall spalling in "A" EDG rm. behind electrical cabinet No. C101A was observed.

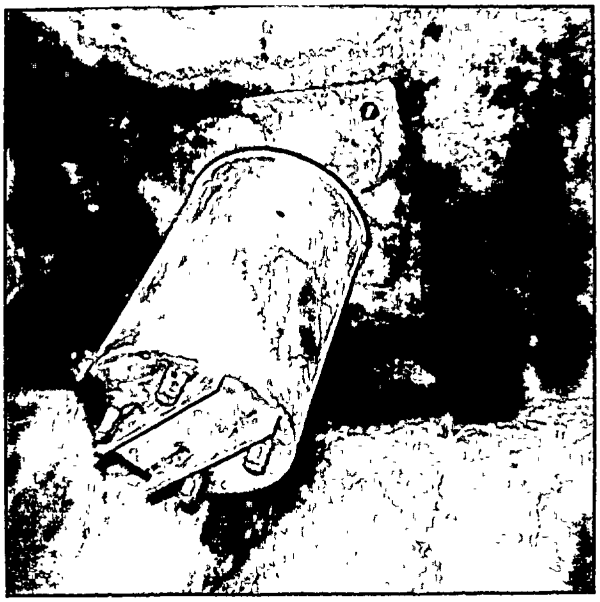
15. Diagonal cracks with paint covering most of them were observed at the West wall A - EDG room.

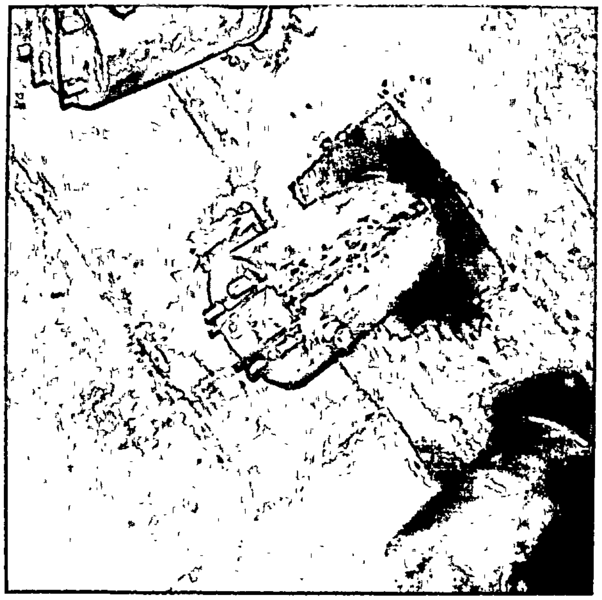
16. Diagonal wall cracks approximately 1/16" were noted at El. 25′, service water pump room. In addition, stains streaking down this wall from the top were observed.

Grease Leakage From Tendon Casings

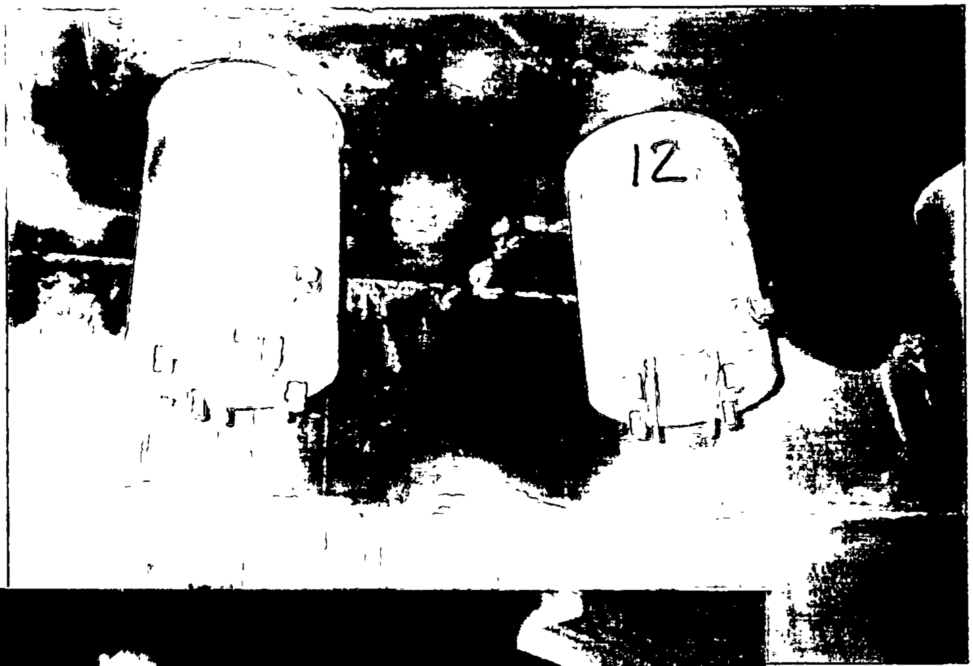


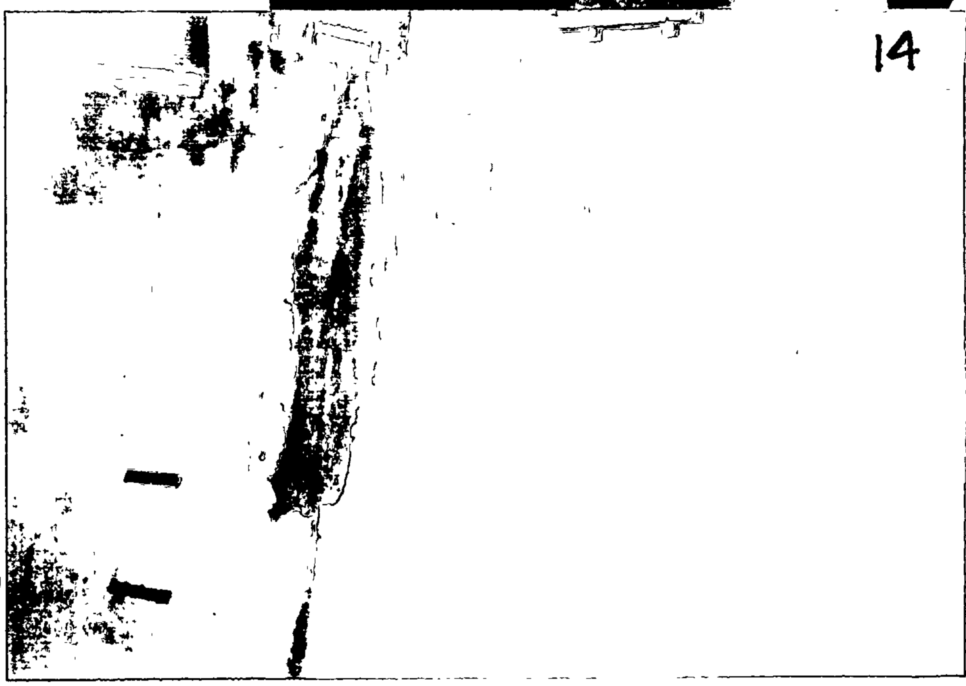
Tendon Gallery - Grease Cap Leakage



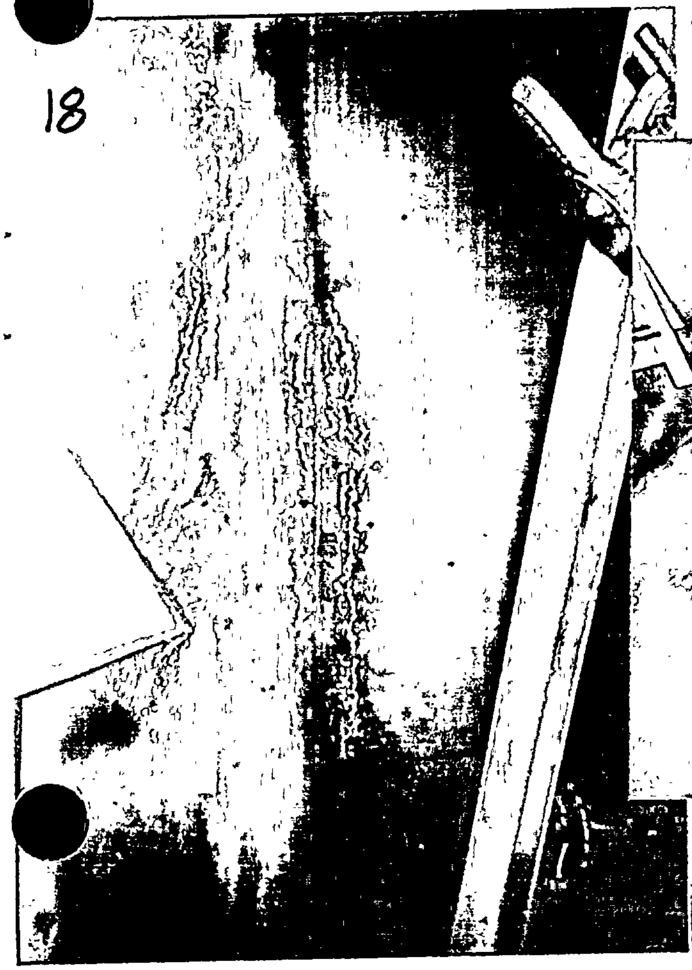


Tendon Gallery
Water Infiltration

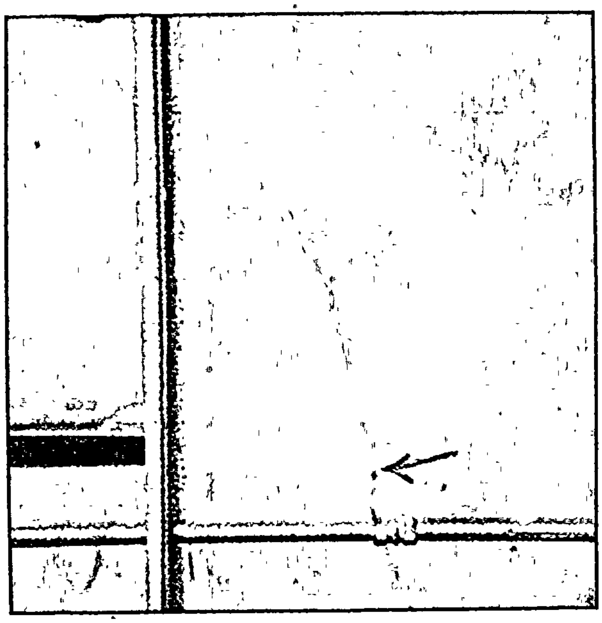




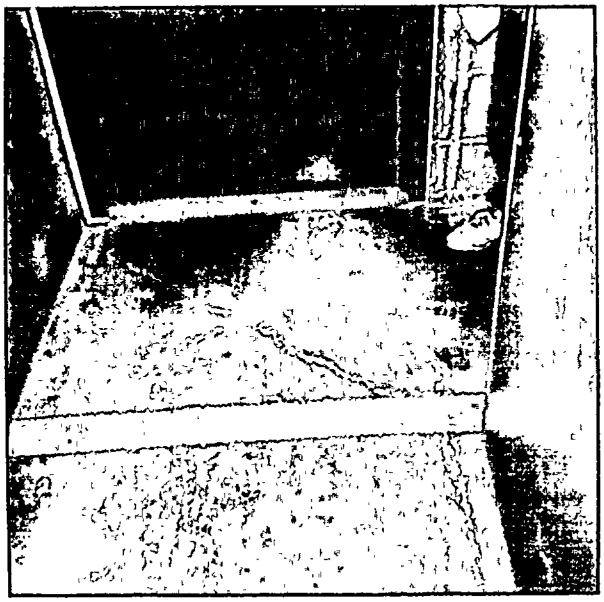
Turbine Bldg. Wall (El. 25')
Concrete Degradation



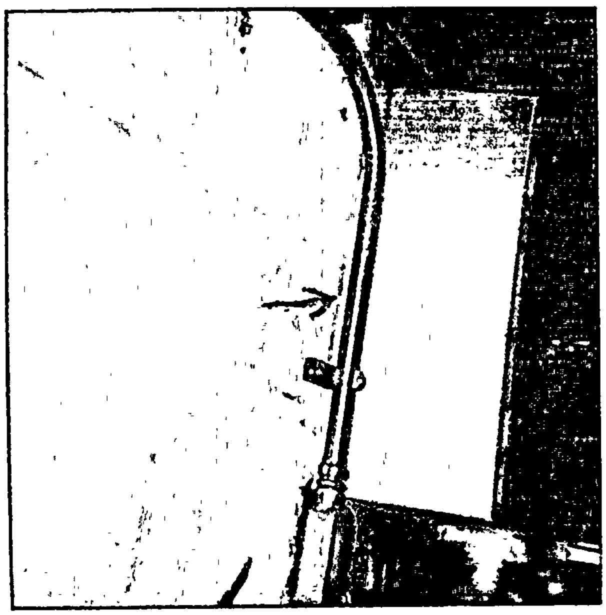
Turbine Bldg. Floor (El. 25')
Water Infiltration



Intake Structure (El. 25')
Diagonal Crack in Concrete Wall



Control Building (El. 61')
Concrete Crack in Floor



Cracks in Masonry Walls

APPENDIX B

POINT BEACH NUCLEAR PLANT

DESCRIPTION OF CIVIL/STRUCTURAL OBSERVATIONS

Inside Containment (Unit 2)

1. At several locations inside containment, the liner plate is separated from the concrete. There is a concern that voids may exist in the concrete. Another potential concern is the one observed by Dr. Newmark in his report to the NRC (page 68, Appendix D) dated 3/11/70. The report described the possibility that a snap through of the liner plate could lead to larger than normal deformations. Although the liner separation is being monitored, no evaluation has been made.

2. Gouges in the liner of approximately 1/8" depth were observed at two locations (elev. 66' and about elev. 46'). The audit team asked if there is any acceptance criteria for such cases. WE indicated that at least in one case the gouge was in existence at the time of construction and evaluated for acceptability. The staff suggested that criteria should be established to evaluate the acceptability of any gouges in the liner that may occur in the future, during refueling outages or repair work.

3. Extensive corrosion and paint blistering was identified in the service water piping and associated valves. Substantial corrosion was also noted on the containment cavity coolers. WE has replaced some of the piping in the service water piping system and is examining the cause of this degradation to prevent its occurrence in the future.

4. In several locations (e.g. elev. 66' East side) the liner paint has either peeled off or was scratched. In addition, some structural supports inside containment (at top of shield wall) were not painted/coated. WE has no acceptance criteria or procedure for the evaluation or repainting of these surfaces.

Outside Containment

1. At the buttresses, substantial corrosion of the tendon plates and grease caps was observed at several locations.

2. Grease leakage was found at several horizontal tendons (e.g., Unit 1, buttress A, azimuth 250°). In addition, grease leakage (possibly from a vertical tendon) to the outside surface of the containment concrete wall was located at Unit 2 Elevation 6'- 6" near azimuth 350°.

3. Horizontal cracks in the buttresses along the centerline of the hoop tendons were found at a number of locations (e.g. Unit 1, buttress D, azimuth 70°). It was suggested that WE may want to determine if the tendons associated with the largest concrete cracks lose prestressing force more than the other tendons.

4. Chunks of concrete were missing at the edge of several buttresses, next to bearing plates for the hoop tendons. An example of this is Unit 1, Elevation 85', Buttress D.

5. Minor radial cracks on the concrete ledge of the containment foundation mat were observed, uniformly spaced around much of the containment. These cracks were more numerous in Unit 1 than Unit 2.

6. In the Unit 2 tendon gallery, groundwater was seeping in through cracks in the walls and ceiling at several locations. Corrosion in the vertical tendon bearing plates and localized degradation of concrete was observed. There would appear to be a potential for corrosion of reinforcing steel.

7. WE relies on cathodic protection systems (CPS) to prevent corrosion of the steel piles which support the containment and fuelpool basemats. Based on CPS operating data, WE has concluded that the system is functioning properly and consequently, preventing corrosion. No visual or other verification means have been attempted. The audit team could not conclude based on WE's input whether or not CPS is effective in eliminating corrosion of the piles. Additional information on CPS and data on long term integrity of steel piles need to be reviewed as part of the assessment of this issue.

   The audit team expressed the opinion that physical inspection of a properly selected sample is required to assess the performance of cathodic protection systems in preventing corrosion of the piles and to assess the current condition of the piles.

Intake Structure (Crib and Forebay)

1. Because the fourteen (14) ft. diameter intake pipes were inaccessible, the audit team could make no observations nor draw any conclusions. WE indicated that periodic inspection is performed using divers and no significant indications of degradation have been reported. It was pointed out by G. Bagchi that if significant leakage develops through the joints of this piping, the surrounding soil can be dissolved/removed leading to the development of large voids in the ground causing foundation failure. This situation occurred at the Bailey fossil fuel power plant.

2. WE's diving inspection procedure used for the crib structure and forebay area of the pumphouse was reviewed. Although the procedure calls for various observations to be made, it does not include inspection of damage to concrete structures. It was suggested that the procedure be revised to include inspection for damage to concrete structures, so that timely repairs can be made if needed. No conclusions for submerged structures could be reached due to lack of accessibility and inspection data.

3. The concrete surrounding the two large discharge pipes has developed cracks and appears to have degraded chemically.

Pumphouse

1. There are a number of cracks in the exterior concrete walls and roof of the pumphouse. The cracks in the roof show some signs of water infiltration and possible concrete degradation.

2. The grout beneath some of the safety related equipment base plates is severely degraded. In some cases a significant portion of the grout is missing. The equipment is located in the North and South service water pump rooms. Examples where this problem exists is beneath the screen wash pump check valve, service water pump P-32E, and the Zurn strain-o-matic base plates.

Auxiliary Building

1. In the central auxiliary building, elevation -19', there are several small cracks in the concrete walls. In addition, groundwater is seeping in through the floor and some of the cracks in the walls. The walls show sign of calcium formation and the floor has a bulge where the ground water has infiltrated. All of these indicate that some concrete degradation has occurred.

2. Also, in the central portion of the auxiliary building, on the West side, there are two large vertical cracks. These may need to be monitored.

Other

1. A seismic gap at the front wall and basemat elevation between the control building and turbine building could not be located. According to WE, a 2" seismic gap should be present between structures to accommodate building seismic movement.

2. Anchor bolts/nuts in several equipment supports did not have full thread engagement. Examples of this include the starting air receiver tanks for the diesel generators.

3. There is no surveillance/visual examination program for the identification and subsequent repair of cracks in seismic category 1 masonry walls. This is important since the seismic calculations assumed the masonry walls were unreinforced and thus relied on the full bending capability of the masonry walls (without cracks).

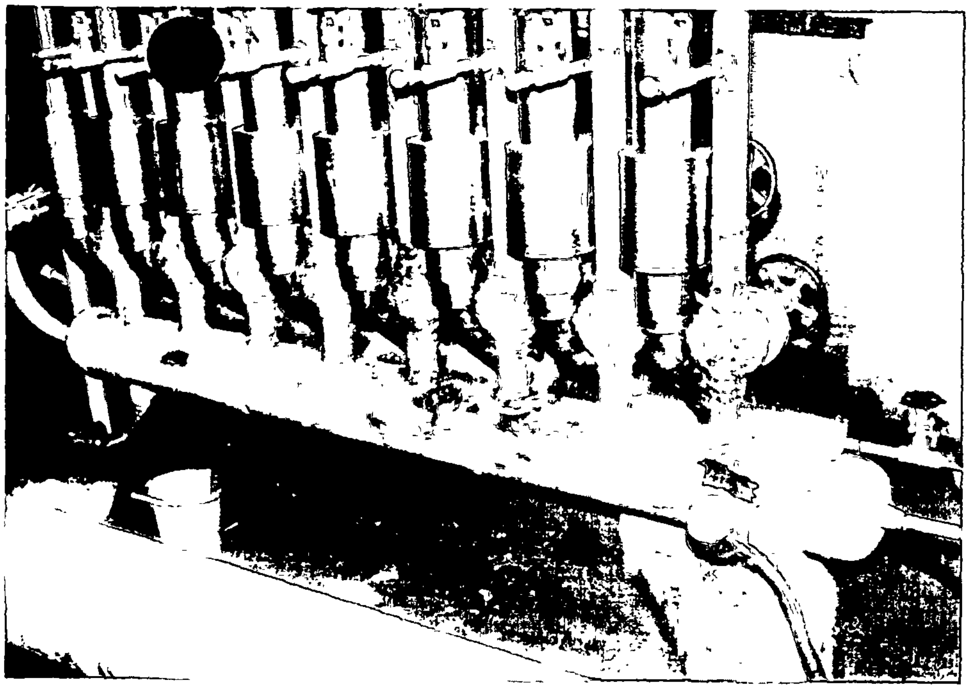
4. Concrete cracks were observed above the two diesel generator exhaust piping penetrations, on the exterior of the emergency diesel generator building East (lakeside) wall.

5. In various areas where groundwater seepage is occurring it may be necessary to test core samples to determine whether or not there is any concrete strength reduction. Reduction in strength may occurr due to loss of alkalinity.

The following items were observed for non-safety related structures/components or are not directly related to aging degradation:

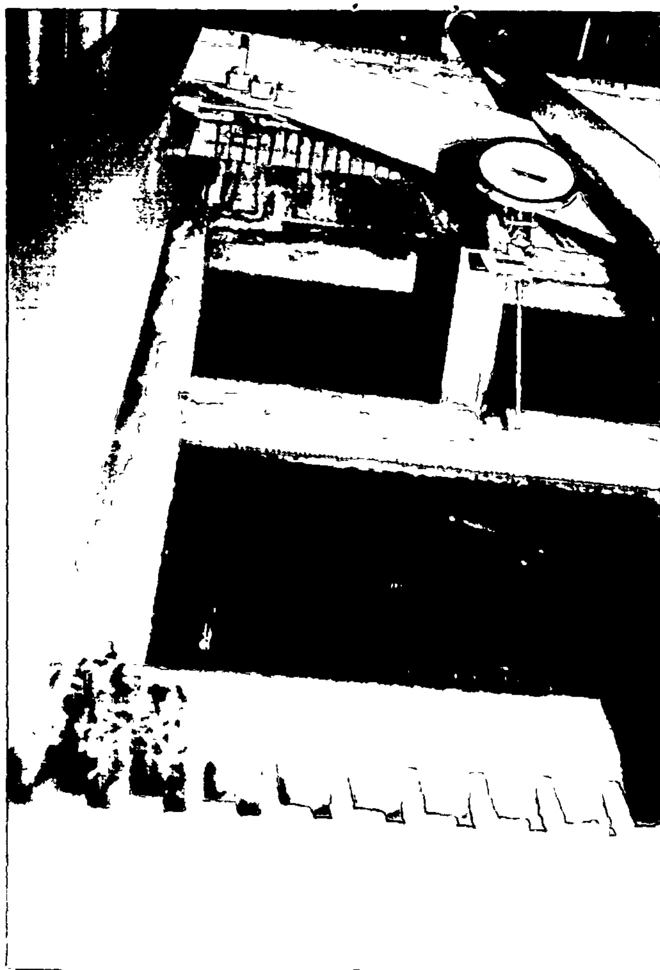
1. In the turbine building, Elevation 26', at Valve No. 1P/P-481, there is visible vibration of the piping and apparent shifting of the deadweight support stanchions.

2. Inservice surveillance reports for containment were requested to gain insights on trends of the loss of prestressing force.



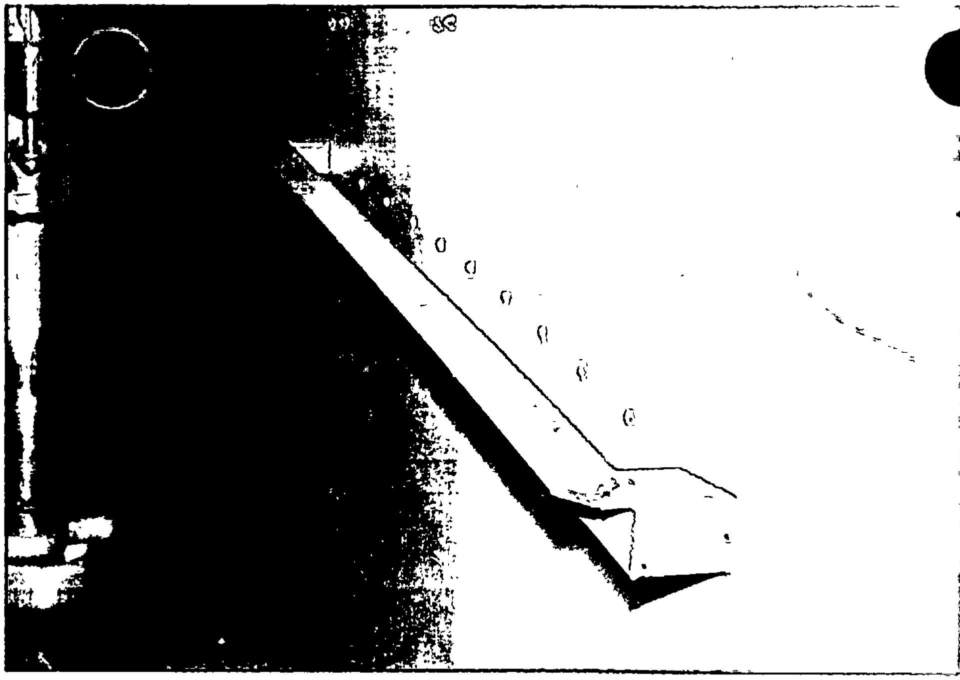
Service Water Return Line (Uninsulated)

Base of Vertical Support for Cooler

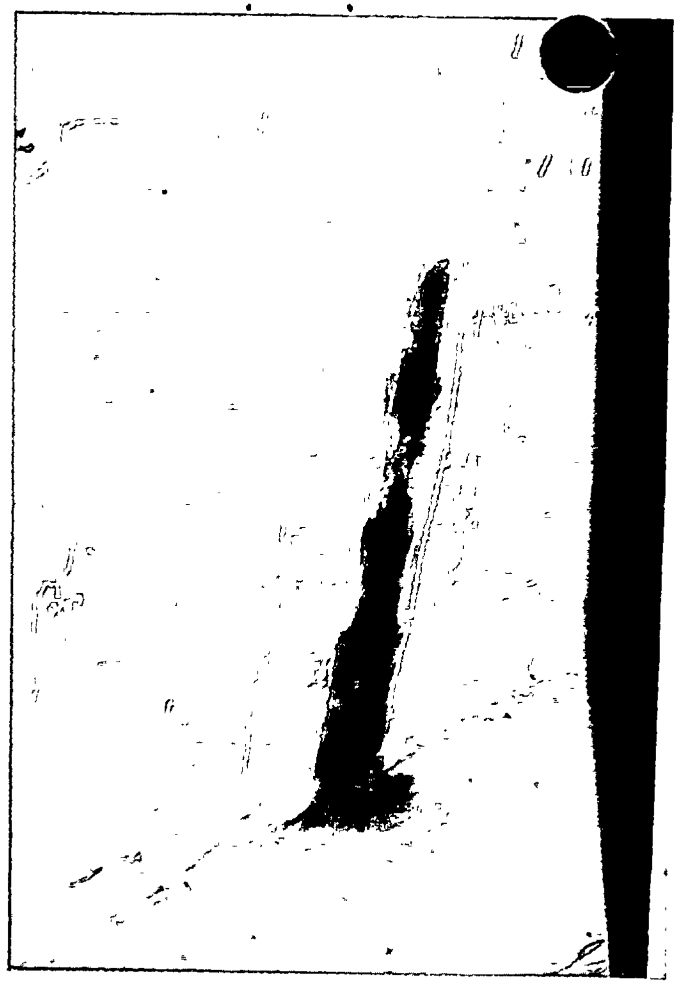


Cavity Cooler/Fan Unit

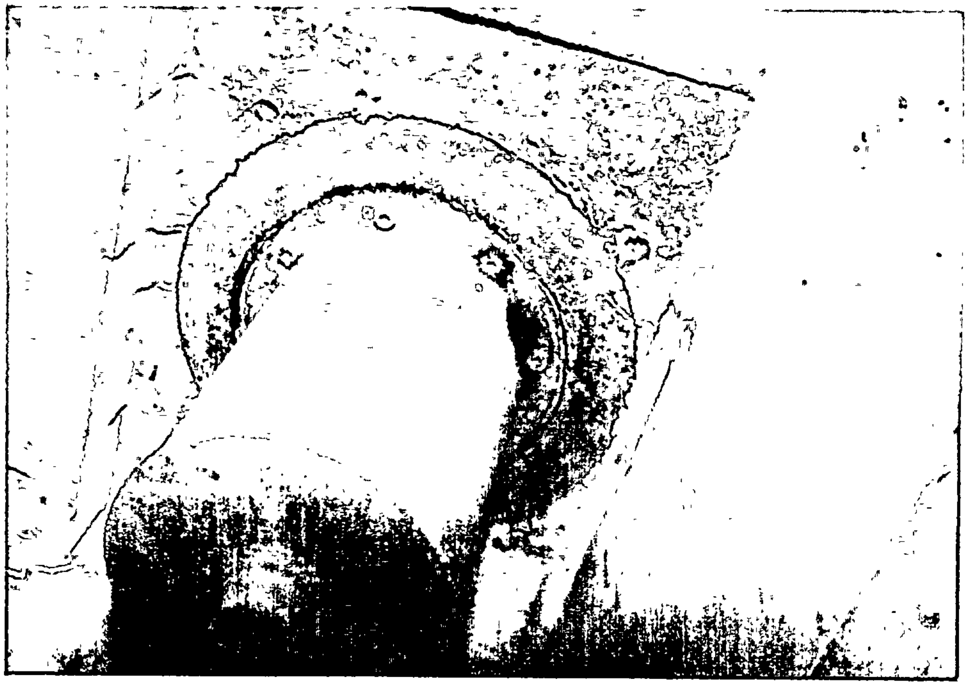
Unit 2 Containment
Elevation 21′
Observed Metal Corrosion



Liner Monitoring Gage,
at Elevation 21′ (Typical)



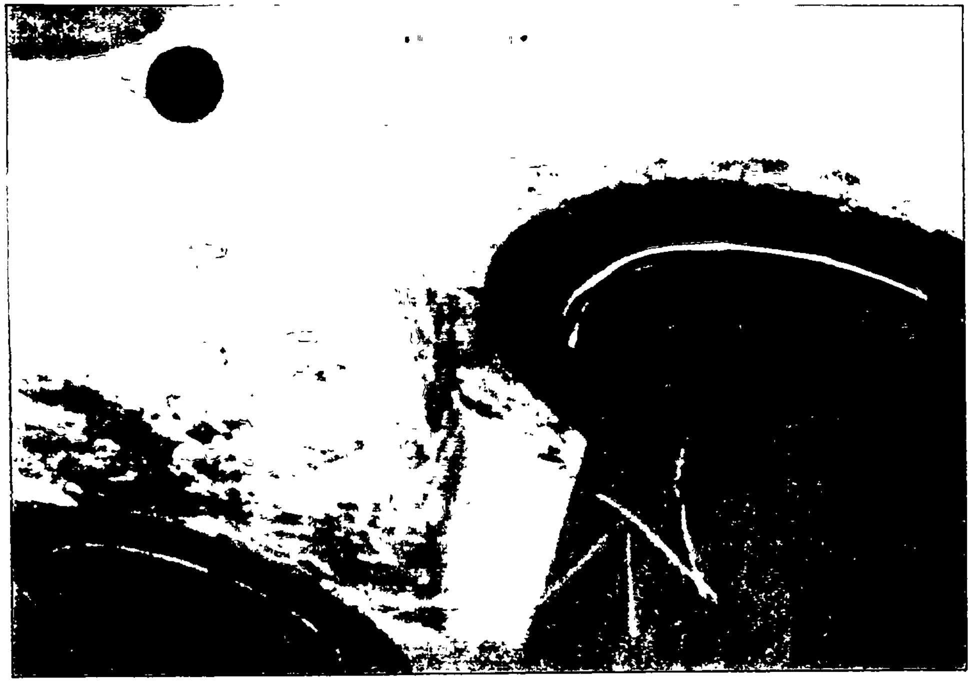
Single Observed Occurrence of Grease Leakage to Outside Surface of Containment, at Elevation 6′6″, near Azimuth 350°



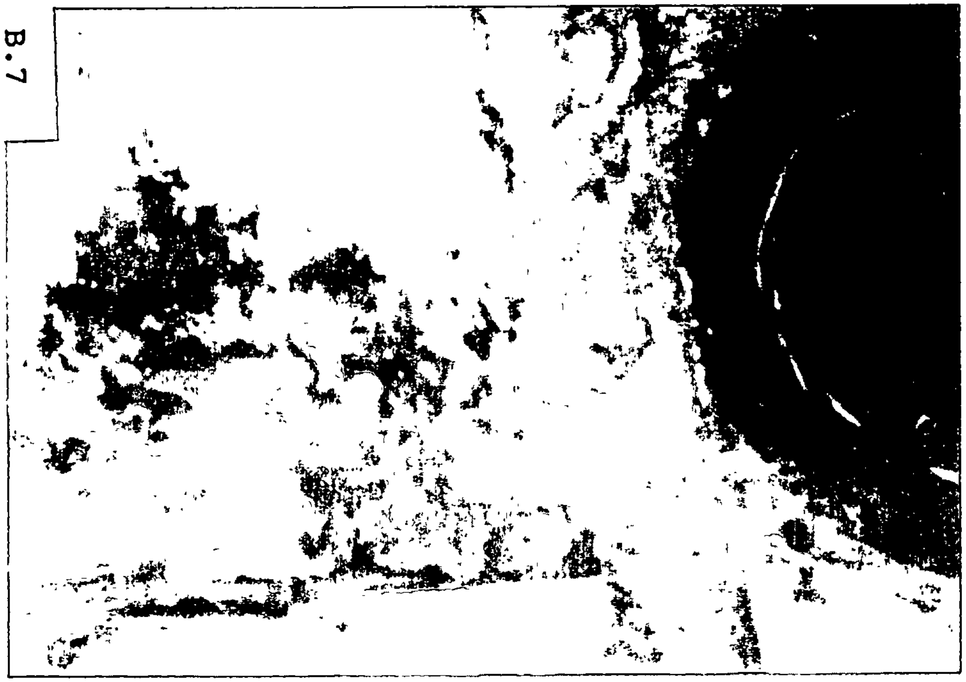
Worst Case of Anchor Corrosion Observed in the Vertical Tendon Gallery

Unit 2 Containment

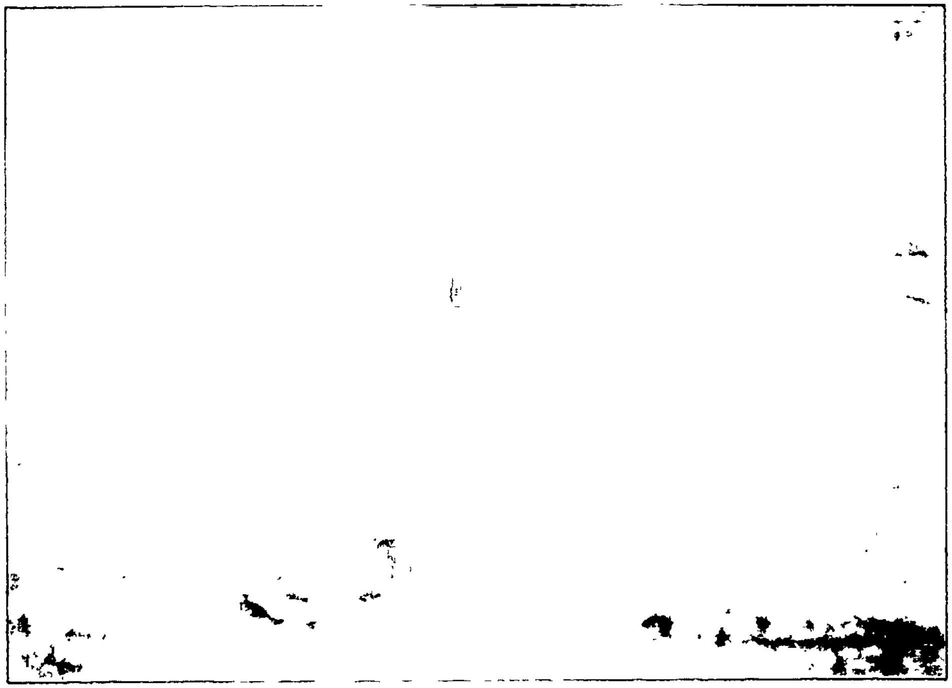
Misc. Observations



Concrete Degradation Caused by Water Seepage
Between Tendons 332 and 334

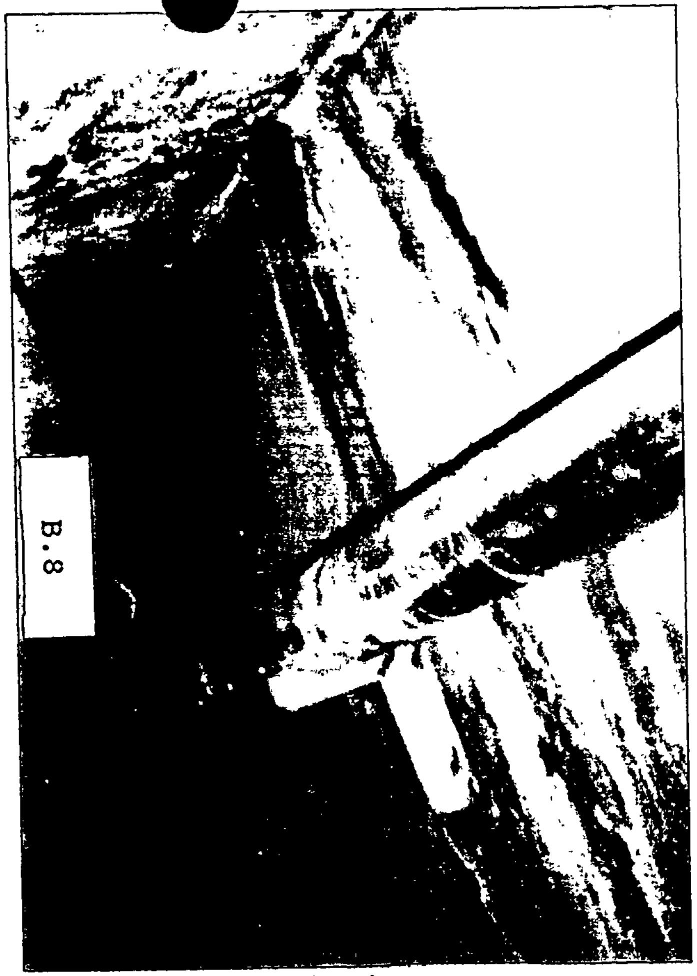


Closeup of Above
Between Tendons 332 and 334



Circumferential Crack in Ceiling
Adjacent to Tendon 256

Unit 2 Tendon Gallery



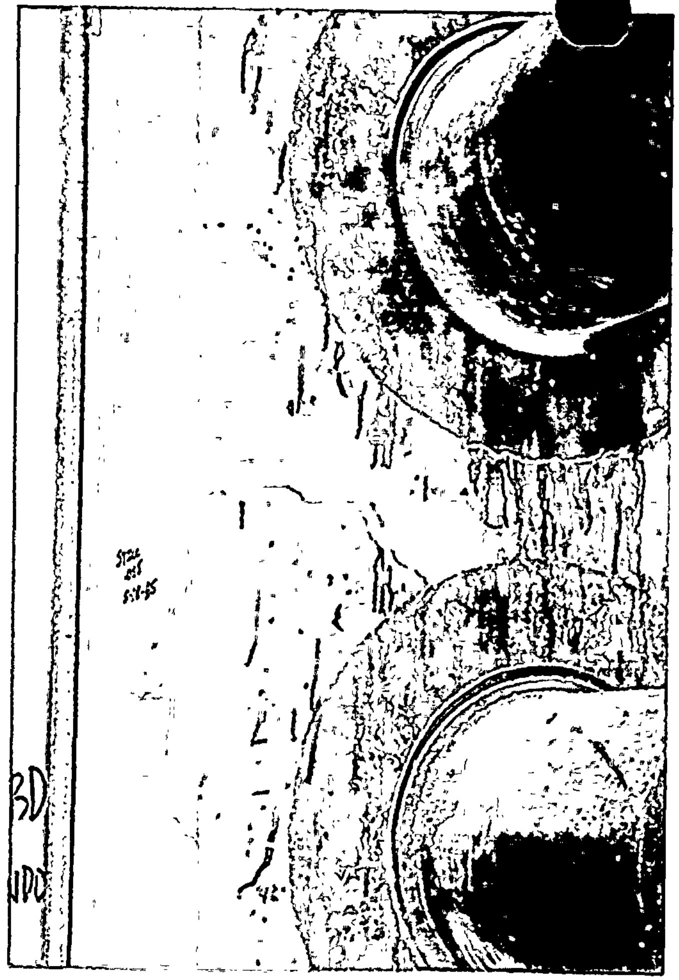
Water Dripping
From Ceiling to Floor
Near Tendon 212

Floor Below the Water Drip
Showing Mineral Deposits
Near Tendon 212

Grease Leakage at
Tendon 291

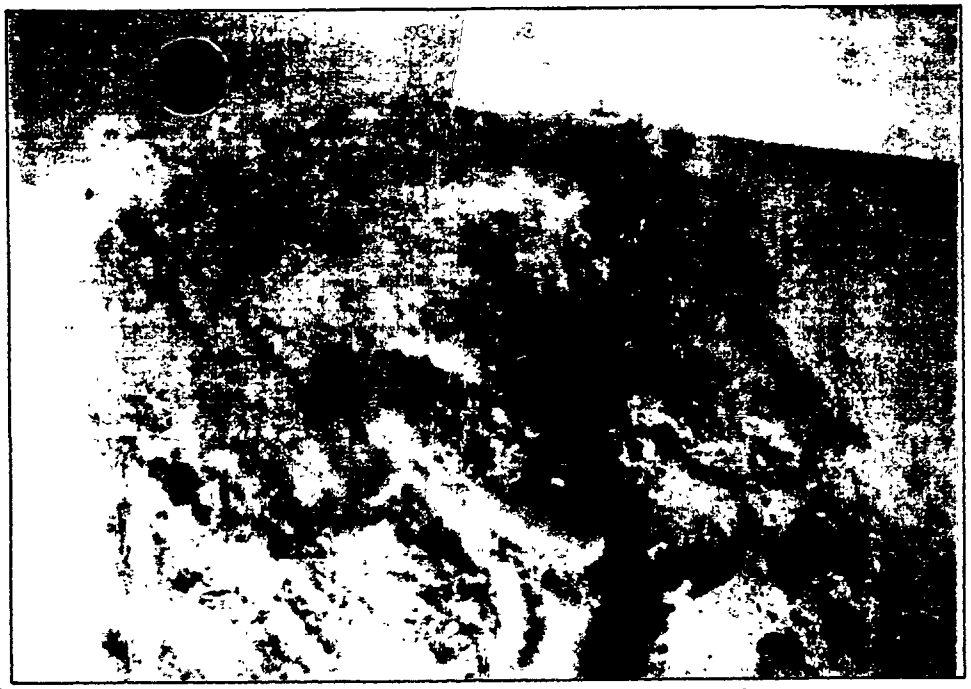
<u>Unit 2 Tendon Gallery</u>
(cont'd)

Closeup of Crack/Missing Concrete

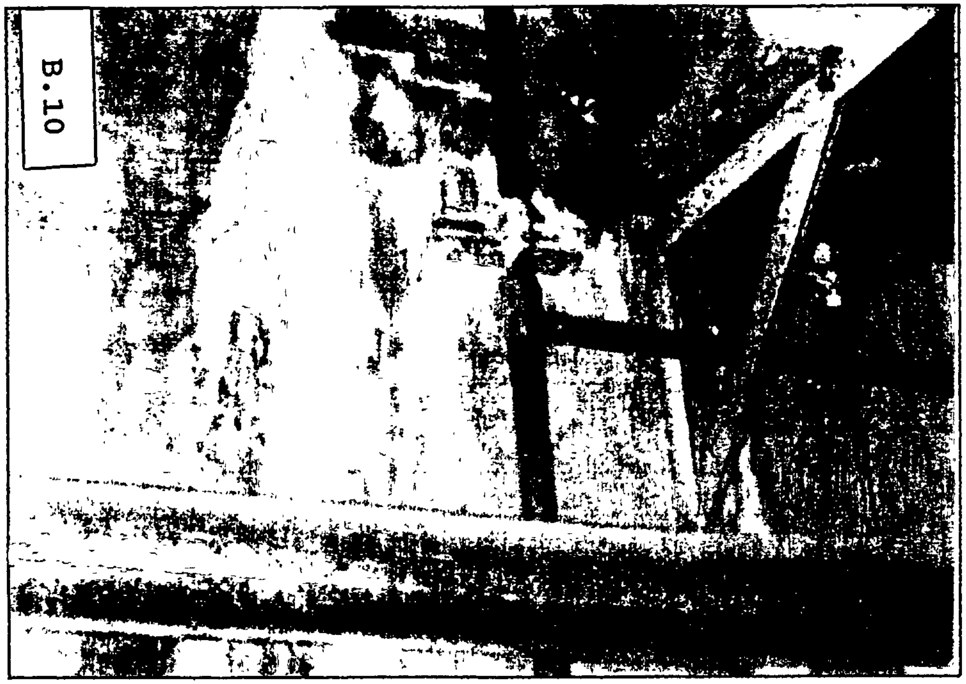


Concrete Damage/Grease Leakage
from Tendon Anchors

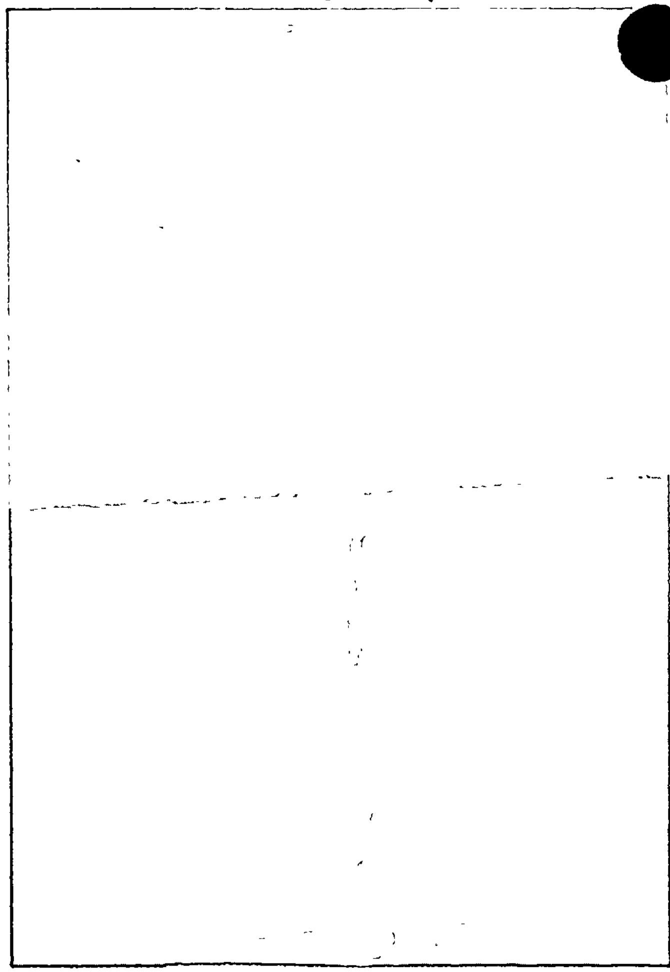
Unit 1 Containment
Elevation 85′
Buttress D (Azimuth 70°)
Horizontal Tendon Anchors



Basemat, Elevation - 19′
Crack in Floor/Bulge in Concrete



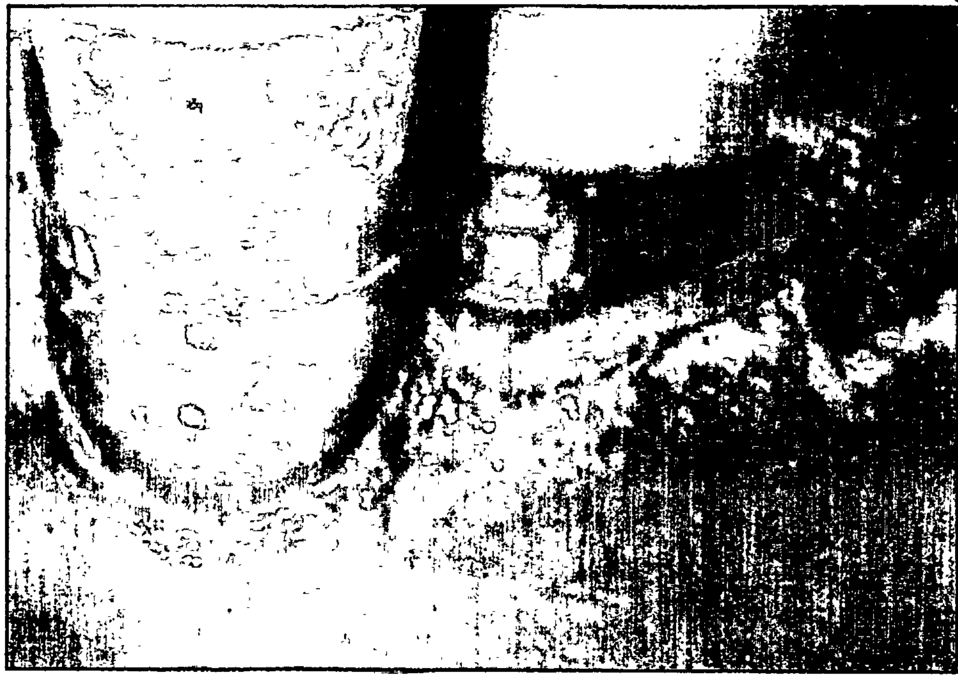
West Wall, Elevation - 5′
Water Source Unknown



RHR Pump Room
Floor-to-Ceiling Crack

Central Auxiliary Building
Evidence of Water Seepage

Support for Strain-O-Matic Filter



Support for Service Water Pump

Pumphouse
North Service Water Pump Room
Observed Grout Degradation

APPENDIX C

TURKEY POINT NUCLEAR PLANT

DESCRIPTION OF CIVIL/STRUCTURAL OBSERVATIONS

Outside Containment

1. Water accumulation in the Unit 3 containment vertical tendons has been observed during tendon surveillance. However, no water accumulation has been observed in Unit 4 containment vertical tendons. Expanded vertical tendon surveillance for the presence of water for Unit 3 would provide additional data to determine the extent of water accumulation.

2. In the Unit 3 tendon gallery, some of the bearing plates show signs of corrosion; there are cracks and voids in the concrete adjacent to the bearing plates; and there is a gap between the tendon gallery wall and the ceiling which allows water infiltration.

3. Near the junction of the Unit 3 containment dome and the ring girder there is a discoloration which appears to be due to poor water drainage.

4. Two spare penetrations in the Unit 3 containment wall at approximately elevation 30 ft. azimuth 226 degrees are not capped at the outside surface of the concrete containment. They go completely through the concrete wall (approximately 4 ft.) and are capped at the liner plate.

Inside Containment (Based on ILRT report for Unit 4)

1. In some areas of the containment liner, the top coat peeled, delaminated, and disbonded.

2. Surface corrosion of some of the liner seam welds and a few penetration canisters was observed.

3. Joint filler material between the liner and adjacent concrete structures was leaching in some areas.

4. Radially inward bulging of the liner was observed at the operating deck level and above the polar crane girder level. The bulging is random but widespread around the perimeter of the containment. The bulges run the entire height of the 10 ft. liner panel, are about 15 inches wide (liner stiffener spacing), and are deflected about 1/2 inch radially inward at the middle of the panel.

5. Two 1/16 inch cracks originating at the lower corners of a duct penetration through the 4B steam generator cubicle wall were found.

Intake Structure

We recognize that FPL is aware of the deteriorating condition of the intake structure and of the corrective actions it has taken for some of these areas. The audit team reviewed a report on the intake structure prepared by a consultant to FPL. The report indicates that the bay walls are also degrading and experiencing active corrosion of the reinforcing bars. Therefore, the audit team recommended that the licensee also give close attention to other parts of the structure such as the intermediate and exterior walls.

Spent Fuel Building

The ceiling of the Unit 3 spent fuel building has a discoloration over an area of about 3 by 6 feet.

Tanks

1. Unit 3 condensate storage tank:

   There are bent plates on the anchor bolt chairs.

   There is deterioration of the water seal at the base of the tank and corrosion of the tank bottom plate is visible.

   In a few places there are signs of corrosion and scratches and gouges on the tank wall.

2. The diesel oil tank does not have washers between the nuts and the anchorage plates.

Masonry Walls

For unreinforced masonry walls the seismic qualification relies on the assumption that there are no cracks in the wall. However, there appears to be no formal monitoring program to confirm that no cracks develop.

In the air handling room in the control building at elevation 30 ft., the angle support at the ceiling is not flush with the masonry wall.

Cathodic Protection System

A Cathodic Protection System (CPS) was installed during original construction to protect the containment-liner plate, reinforcing steel, and tendon assemblies. The system is presently exhibiting low to very low readings in some of the anodes. FPL is presently evaluating the effectiveness of the CPS.

Holes in Concrete Structures

In some concrete walls, abandoned anchor holes, drilled holes, or holes from original construction have not been grouted. One example is the 9 inch deep holes on the exterior concrete wall of the Unit 3 containment.

Seismic Instrumentation

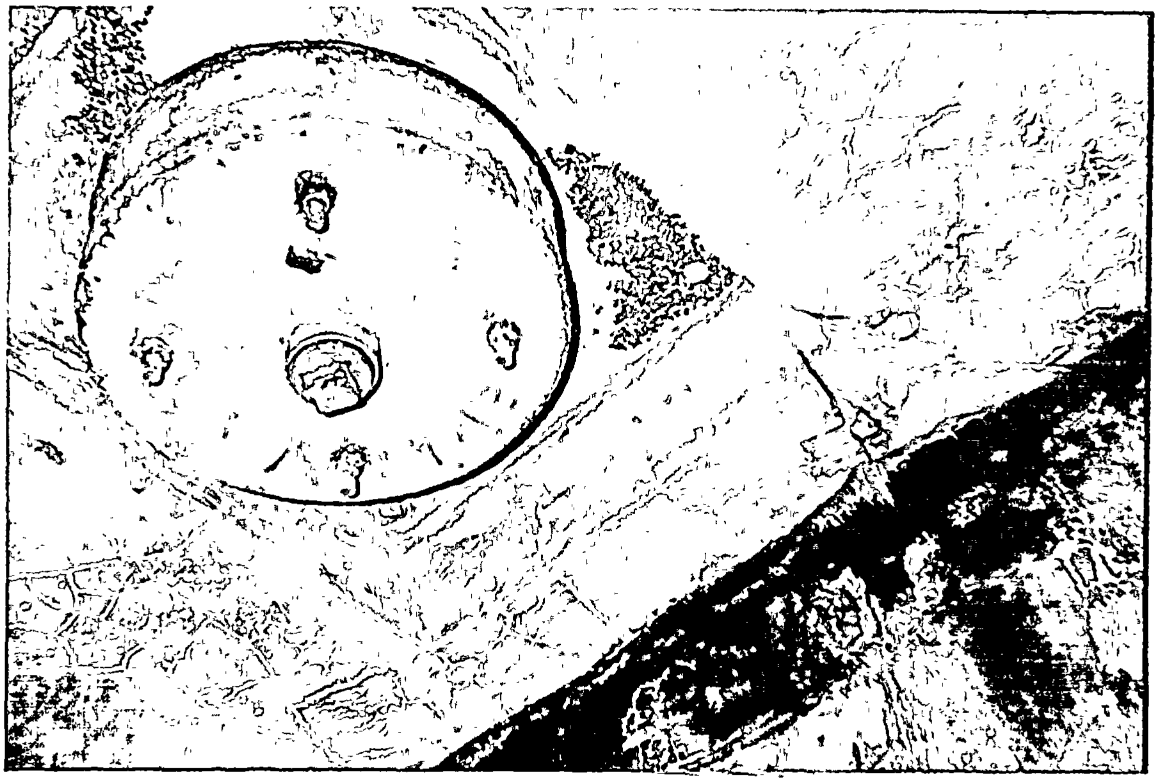
The following item is not related to aging degradation effects but was brought to the attention of FPL for their benefit.

Appendix A to 10 CFR Part 100 states that if the vibratory ground motion from an earthquake exceeds the plants operating basis earthquake, the plant will be required to shutdown. The NRC staff has developed guidelines it will use to make plant shutdown recommendations. The consequences of the guidelines is based on the ability of the plant to provide prompt information about the earthquake.

Turkey Point has only one three-component accelograph that records photographically. It requires three hours to develop the film after the instrument trigger is detected. Prompt analysis of the photographic record could only provide peak ground acceleration. To obtain response spectra, the records would have to be digitized and used to generate response spectra. This could take a considerable time.

EPRI has developed an OBE exceedance criterion based on a damage threshold estimate. To use the EPRI criterion, digital recording and the generation of response spectra and cumulative absolute velocity are required. The ability to do this can provide the information to avoid unnecessarily shutting the plant down in the event of a nondamaging earthquake which has short duration high frequency exceedance of the OBE.

Grease Leakage at Tendon 56-V-5 (typical)

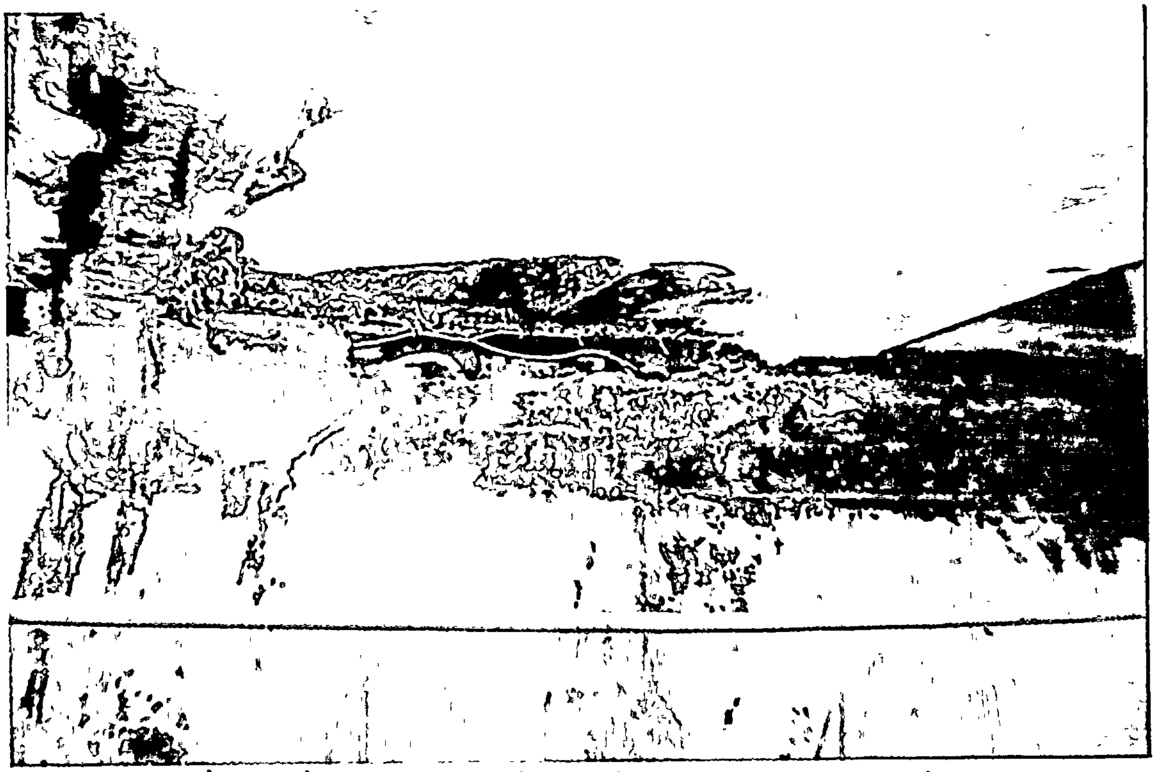


Metal Corrosion and Concrete Cracking at Tendon 12-V-1 (typical)

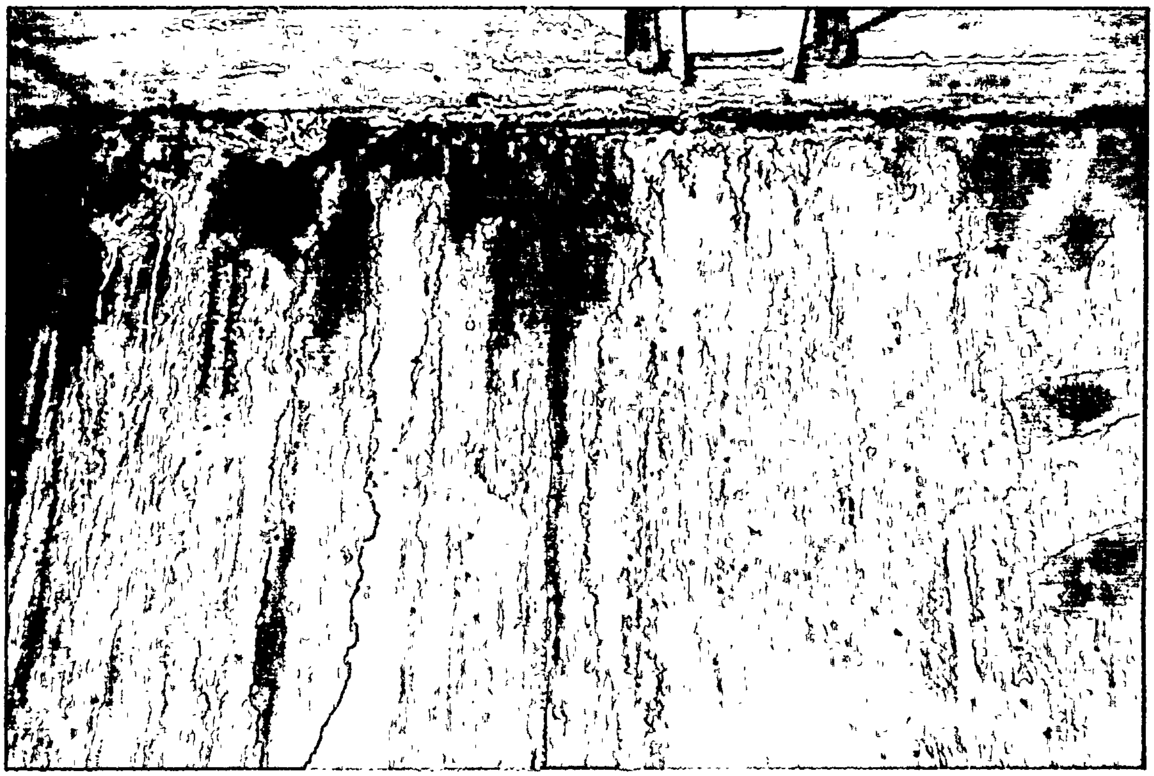
Unit 3 Tendon Gallery

Crack and Void in Concrete
at Edge of Bearing Plate for Tendon 12-V-5

Patch on Concrete Wall in Vicinity of Tendon 34-V-9

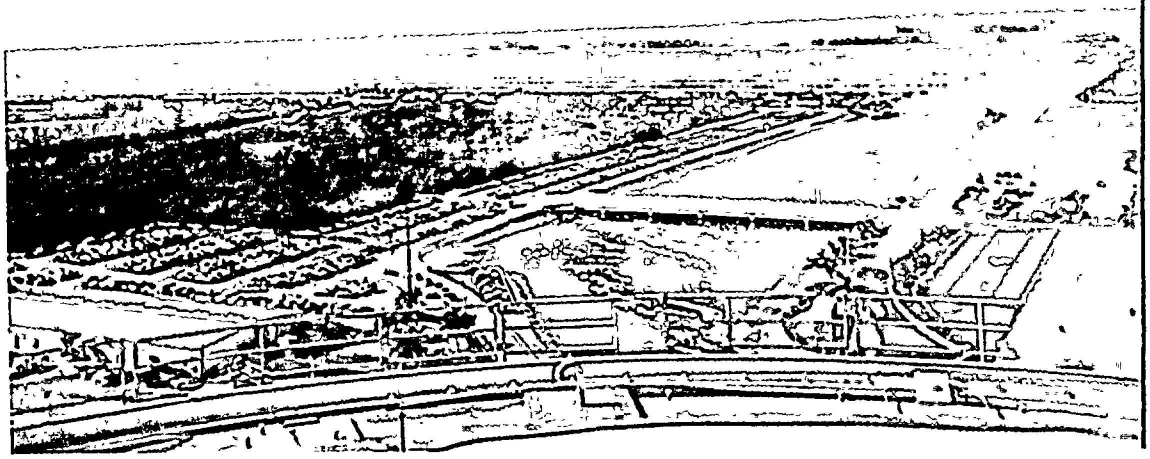


Joint Filler Deterioration Between Outside Wall and Ceiling in Vicinity of Tendon 12-V-8 (typical)



Water Infiltration thru Joint Between Inside Wall and Ceiling in Vicinity of Tendon 45-V-1 (typical)

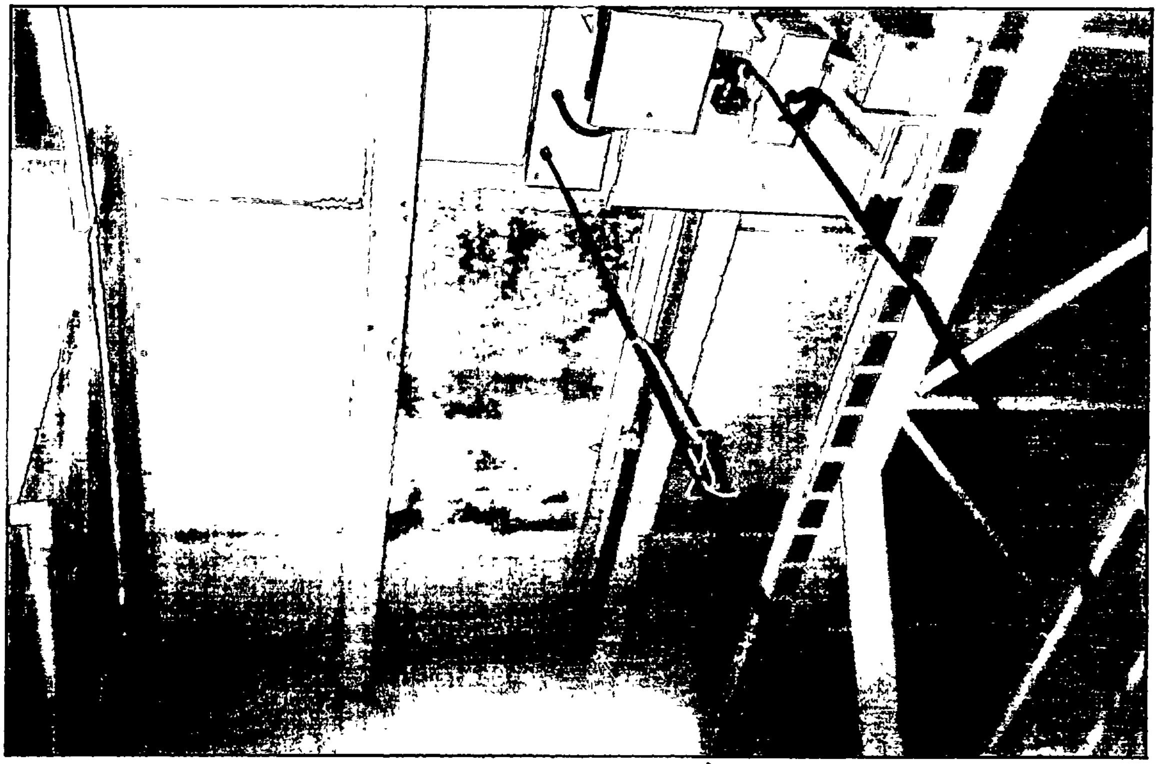
<u>Unit 3 Tendon Gallery</u>



View of Site Cooling Water Discharge and Canal System, Looking SW from atop Unit 3 Containment

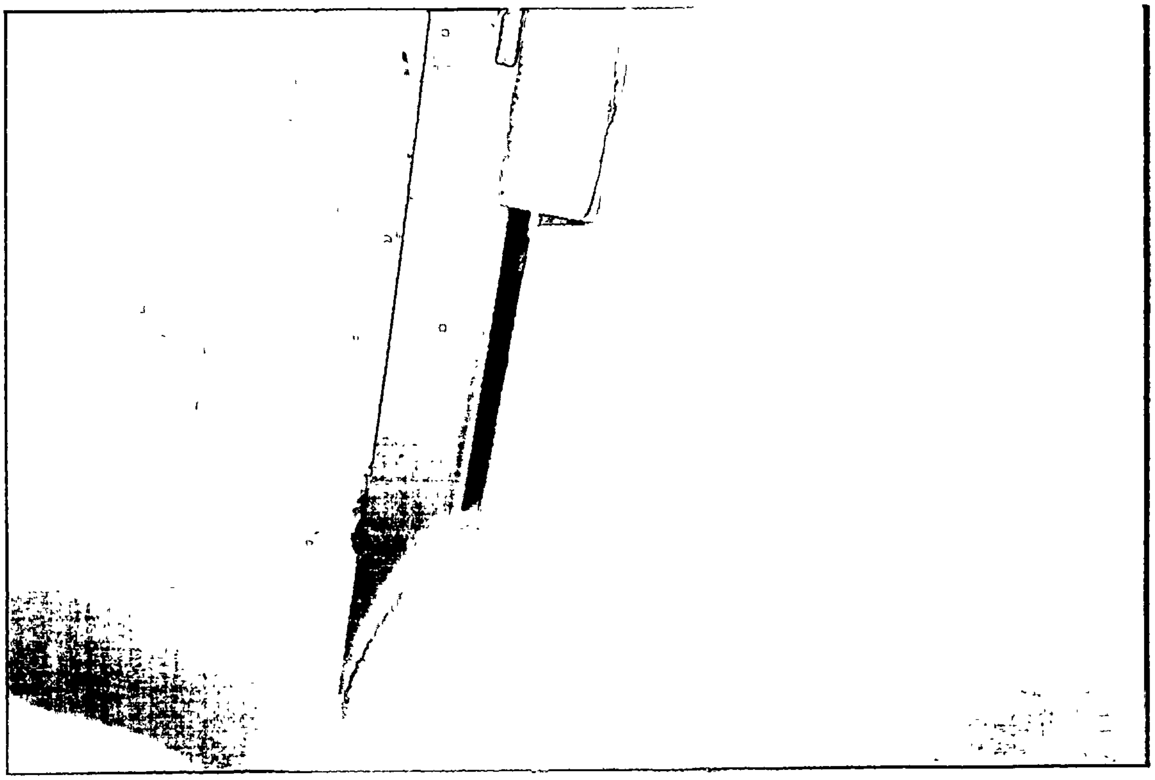
Peeling of Dome Coating Material (White Areas); Possible Cause of Water Drain Blockage

Unit 3 Containment Dome



Unit 3 Spent Fuel Building

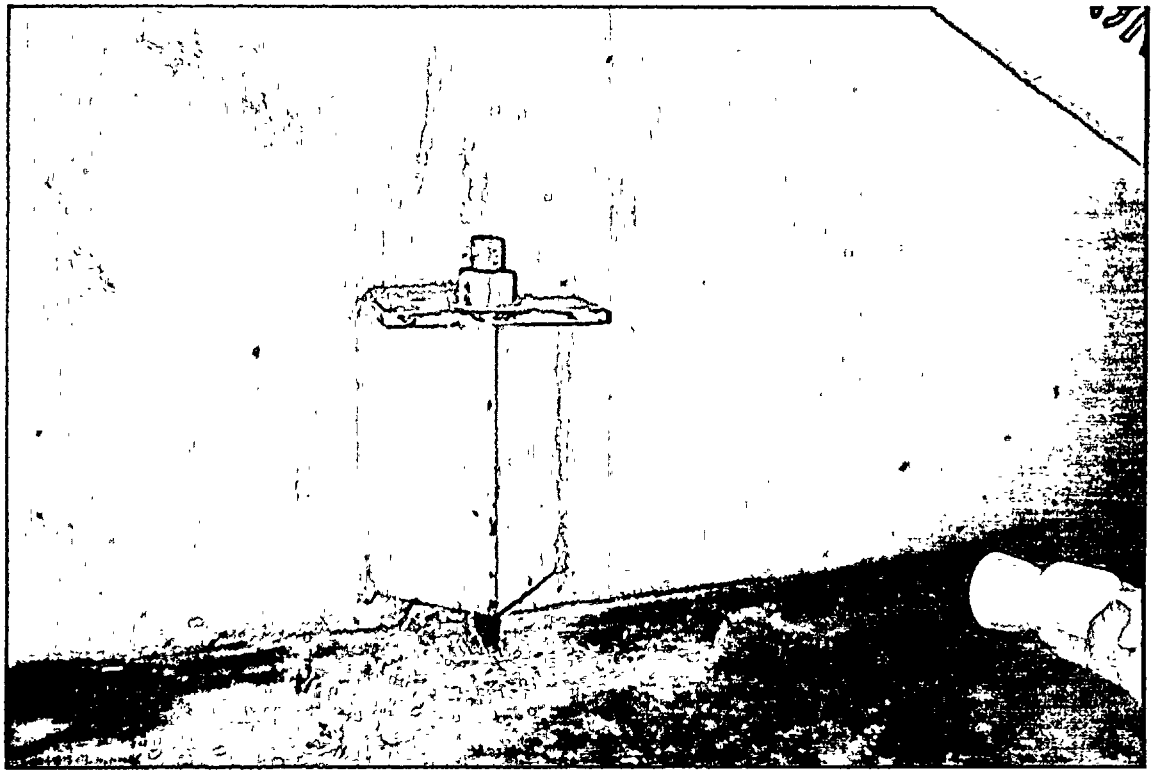
Approx. 3′ x 6′ Area of Discoloration on Ceiling;
Possible Water Leak from Roof



Air Handling Room in Control Building

Gap Between Masonry Wall and Angle Support Installed at Ceiling
as Part of Bulletin 80-11 Program (View Looking Up)

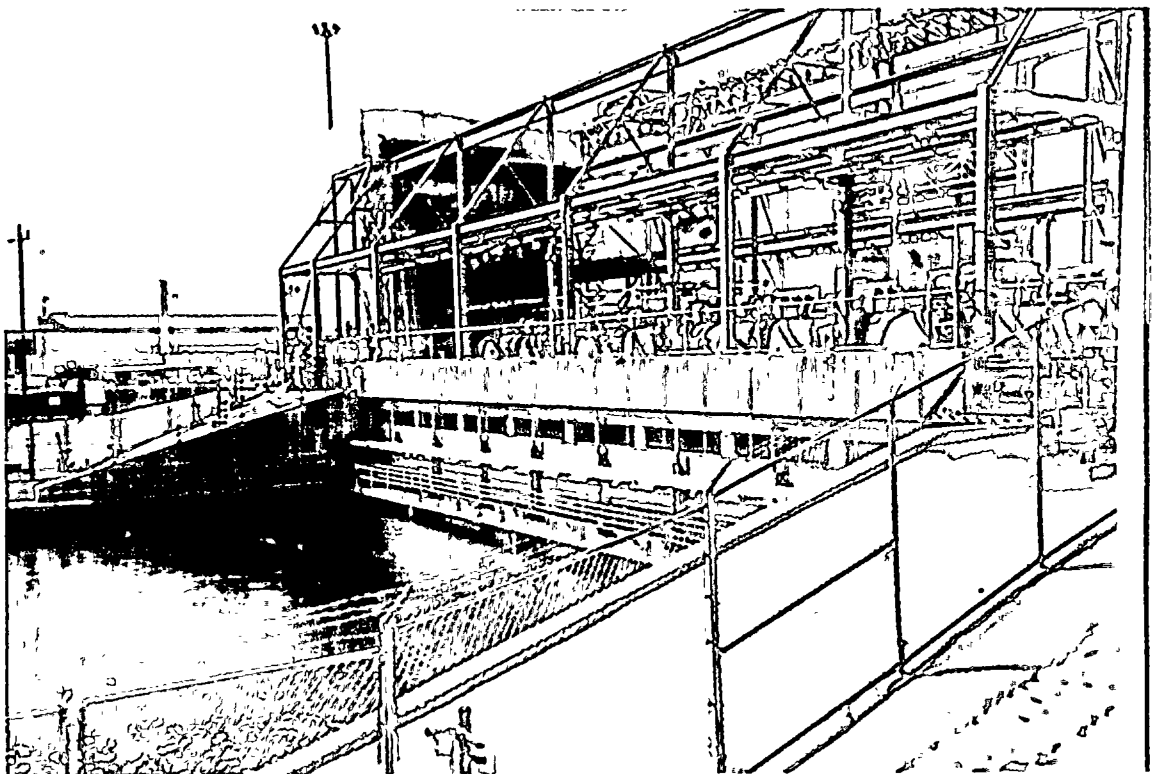
Deterioration of the Water Seal at Base of Tank/
Corrosion of Tank Bottom Plate



Typical Condition of Anchor Bolt Chairs

Unit 3 Condensate Storage Tank

Circulating Water Pumps Mounted On top of Intake Structure; Supporting Concrete Beams Have Deteriorated and Currently Being Strengthened



View of Cooling Water Inlet, from North Side, Looking SW

Intake Structure

APPENDIX D

H.B. ROBINSON NUCLEAR PLANT

DESCRIPTION OF CIVIL/STRUCTURAL OBSERVATIONS

Inside Containment

1. Discoloration of the vertical portion of the containment liner at an insulation joint was observed. The vertical portion of the liner was not generally visible because of a layer of rigid insulation attached to the inside face of the liner. Thus, it was not possible to determine if the discoloration was due to corrosion, degradation of the liner paint/coating or some other cause.

2. There were a number of locations of liner bulging radially inwards. Extent of deformation was difficult to identify due to insulation covering the liner. CP&L discovered this during Post-Structural Integrity Test inspection in May 1974. Condition was visually inspected and mapped. Stress analysis was performed to verify structural integrity of the liner. Surveillance program was established using strain gages to observe long-term changes.

3. Extensive corrosion of three valves and piping associated with the component cooling water system was observed. The tag numbers on these valves are CC-724B, CC-725B, and CC-726B.

4. Corrosion of a support to the main feedwater line A was identified. The corrosion was located at the top of this vertical support which was located at the 2nd level inside containment.

5. In some areas of the basemat, the coating on the concrete surface was peeling and cracking severely. The concern is that any water accumulation could enter into the concrete floor and potentially reach the liner in the basemat which would cause corrosion to occur.

Exterior Containment

1. Some abandoned holes on the outside of the concrete containment were identified. These, as well as any other abandoned holes, should be filled.

2. In the pipe alley, two baseplates were identified which bridge the 2" seismic gap between the reactor auxiliary building (RAB) elev. 226 ft. floor slab and containment base slab. In addition, at the support to the WD line, the basemat has a 6 to 8 foot long crack up to 1/8" wide.

Reactor Auxiliary Building (RAB)

1. Signs of past water infiltration at the intersection of the roof to wall junction were observed from the stairs leading to the waste evaporator area (level 3). A tear in the roofing membrane was noted at the junction of the roof and wall when viewed from outside in the same area.

2. Spalling of concrete in the ceiling was identified when viewed from level 2. The ceiling location corresponds to the floor of the waste evaporator.

3. Various anchorage deficiencies were observed at different locations. Examples are insufficient anchor thread engagement in nuts for the neutralizer filter support, missing nuts and insufficient thread engagement in other nuts for C.V. vent panel, missing washer on anchor for electrical cabinet in charging pump room, and missing washer and anchor out of plumb for conduit support in elev. 226 ft. hallway South of diesel generator room.

4. A number of water stains were identified on the bottom of cable trays in the safeguards room.

5. A number of concrete cracks were identified in various locations including emergency diesel generator room B (size hard to determine due to coating) and concrete wall adjacent to C.V. vent panel on level 2. These type of cracks should be identified, monitored, evaluated if significant, and repaired if necessary.

Intake Structure

1. Cracks at intersection of the concrete walls when viewed at grade level elev. 226 feet.

2. Severe pitting on the service water line was observed on many sections of pipe.

3. Some service water hangers showed signs of corrosion and the rod connection detail to channel section should be checked.

4. The friction clamp on the South service water header was found to be in a degraded condition.

5. The foundation bolts of the strainer were observed to be degraded.

Water Storage Tanks

1. Corrosion of nuts at beam seats were observed at the refueling water storage tank (RWST) and the primary water storage tank (PWST).

Lake Robinson Dam

1. A substantial amount of water was leaking around the side of the gates onto the steel beams that support the gates. This occurred at two of four steel beam support structures to the gate. If this condition is not corrected then the steel will corrode and deteriorate quickly.

2. Spalled concrete was identified beneath two beam seats that support the walkway over the dam gates.

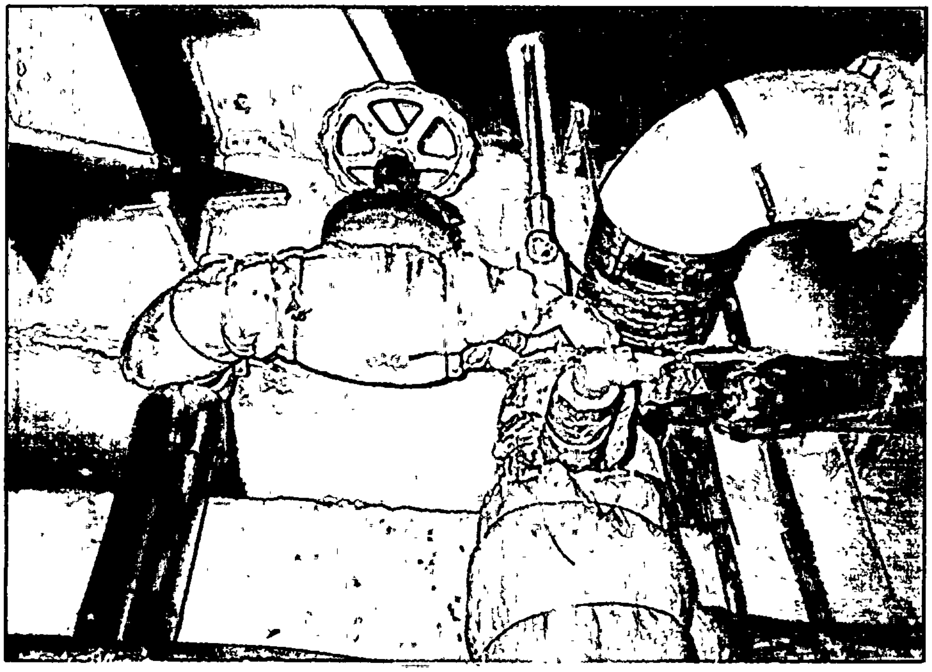
3. Spalled concrete or holes were observed in the dam at the water line.

Other Structures

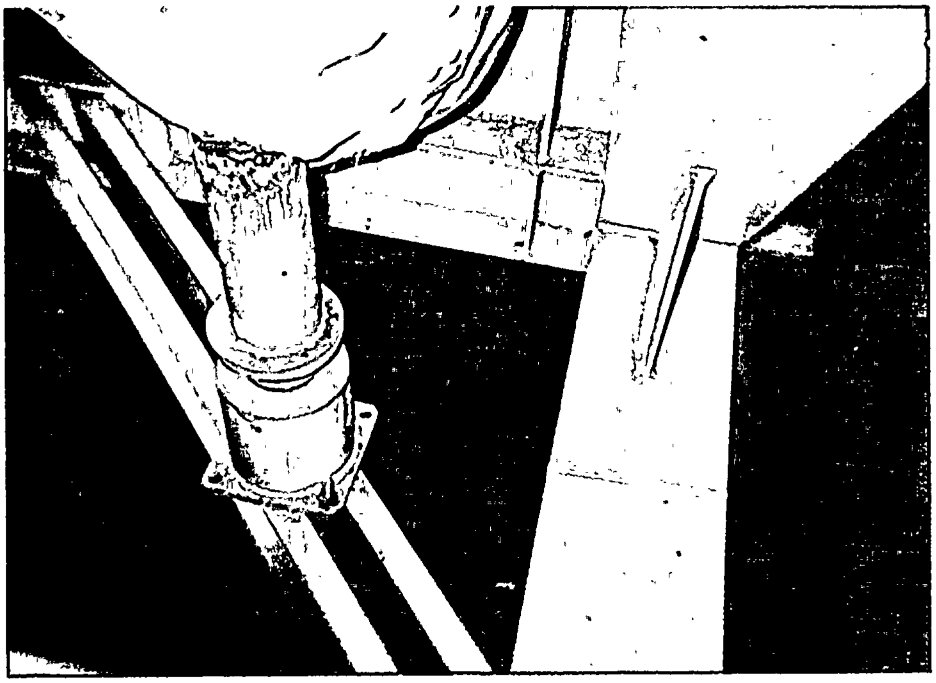
1. Initiation of corrosion was observed underneath structural steel located in the Seismic Category I area of the turbine building near column F12 (looking up from lowest level).

2. A significant bulge in concrete wall of the CVCs hold up tank structure was observed.

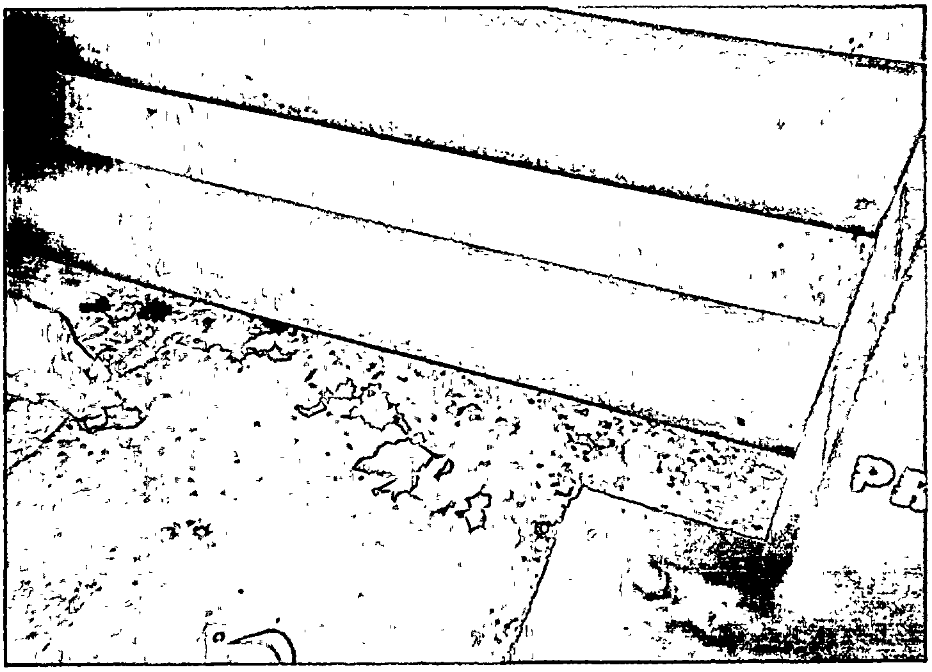
3. There is no ongoing program for the identification and subsequent repair of cracks in Seismic Category I masonry walls. This is important since the seismic calculations assumed that the masonry walls were unreinforced and thus relied on the full bending capability of the masonry walls (without cracks).

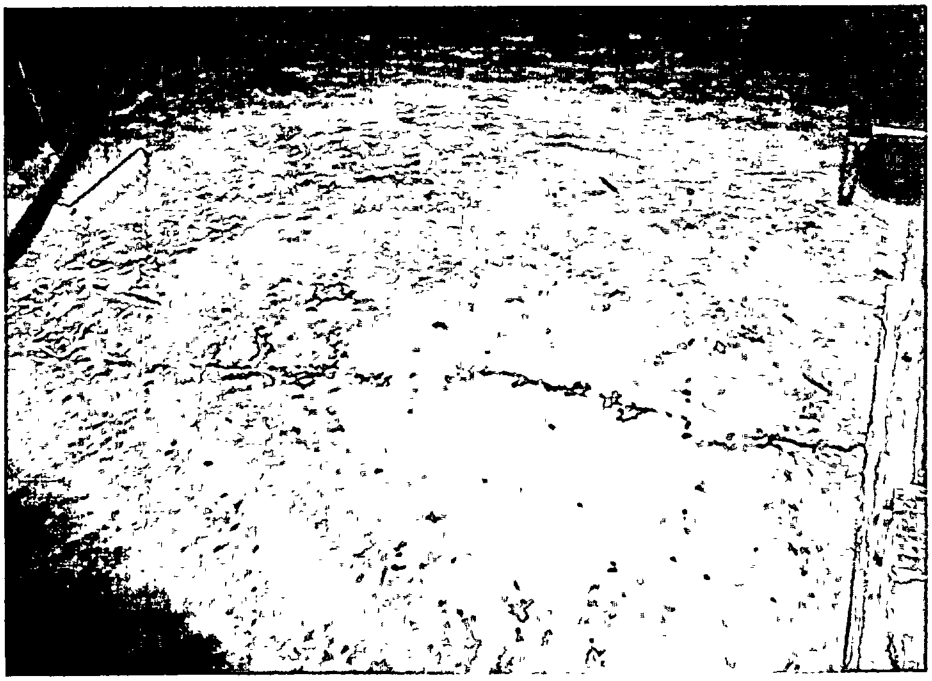


Corrosion of Component Cooling Water Valve and Piping



Corrosion at Top of Support to the Main Feed Line A



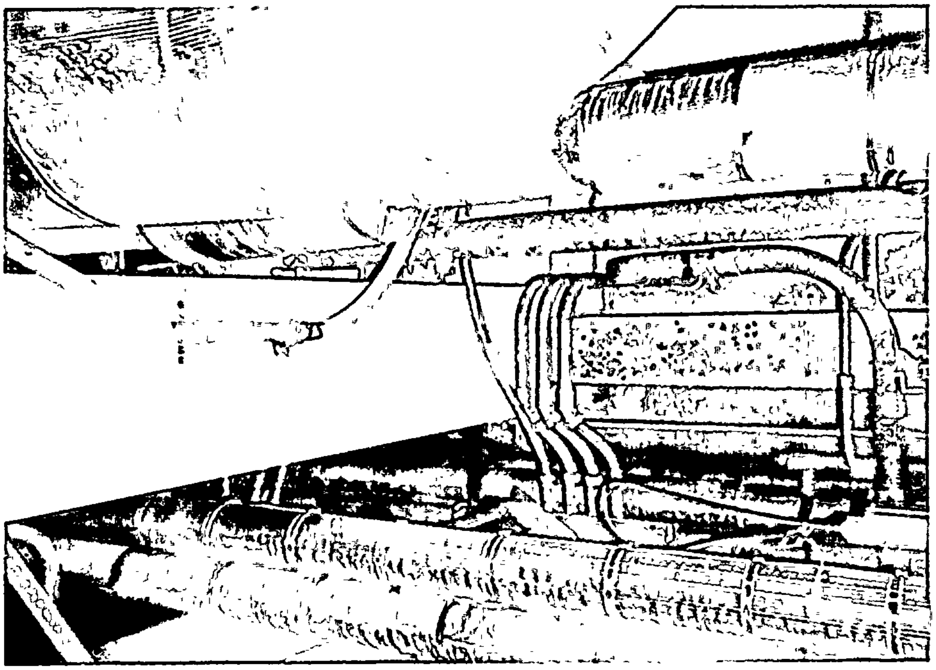


Peeling and Cracking of Coating on Basemat

Inside Containment

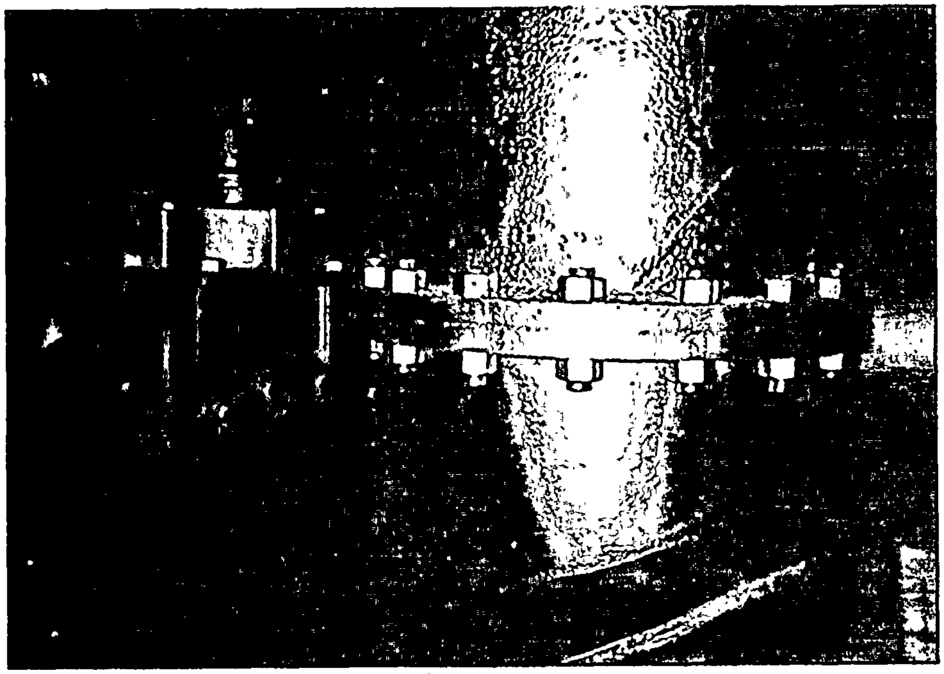
A Tear in Roofing Membrane

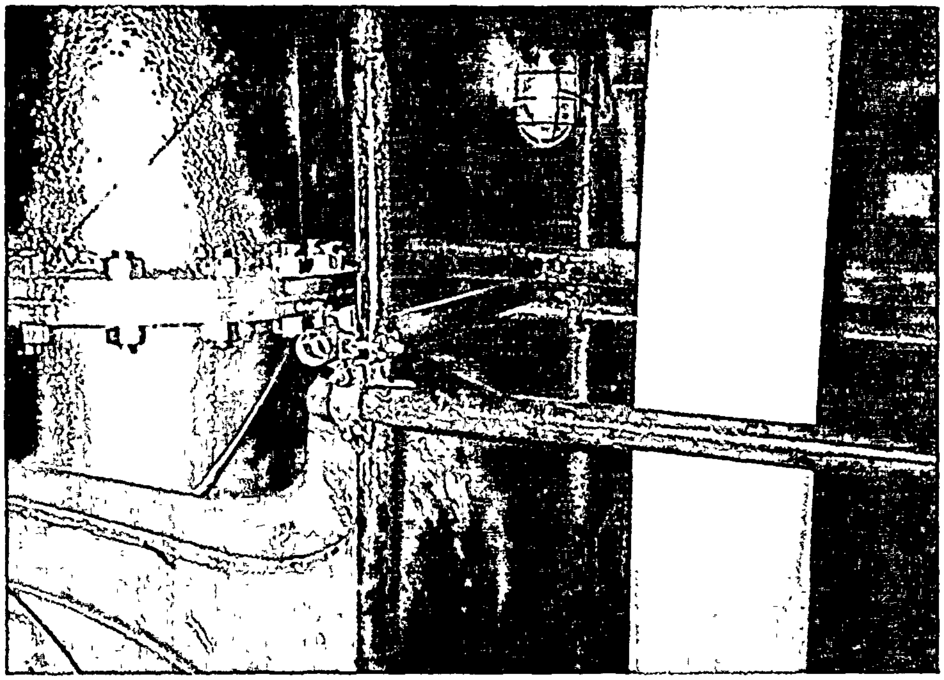
Indication of Water Infiltration at Intersection of Wall and Roof



Corrosion of Structural Steel in Seismic Class 1 Area of Turbine Building

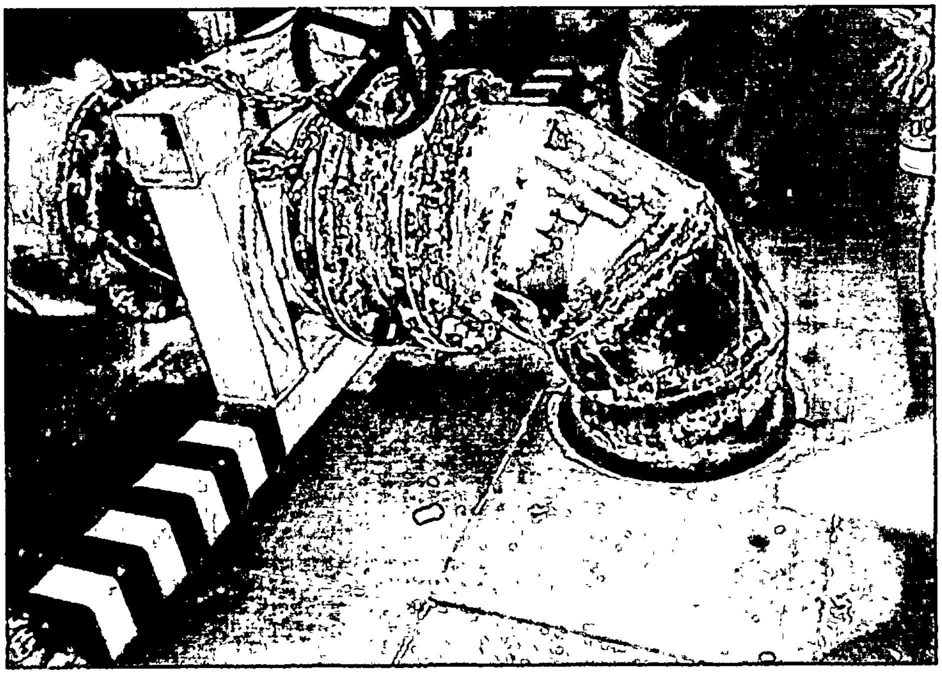
Corrosion of Nut at Beam Seat of Primary Water Storage Tank



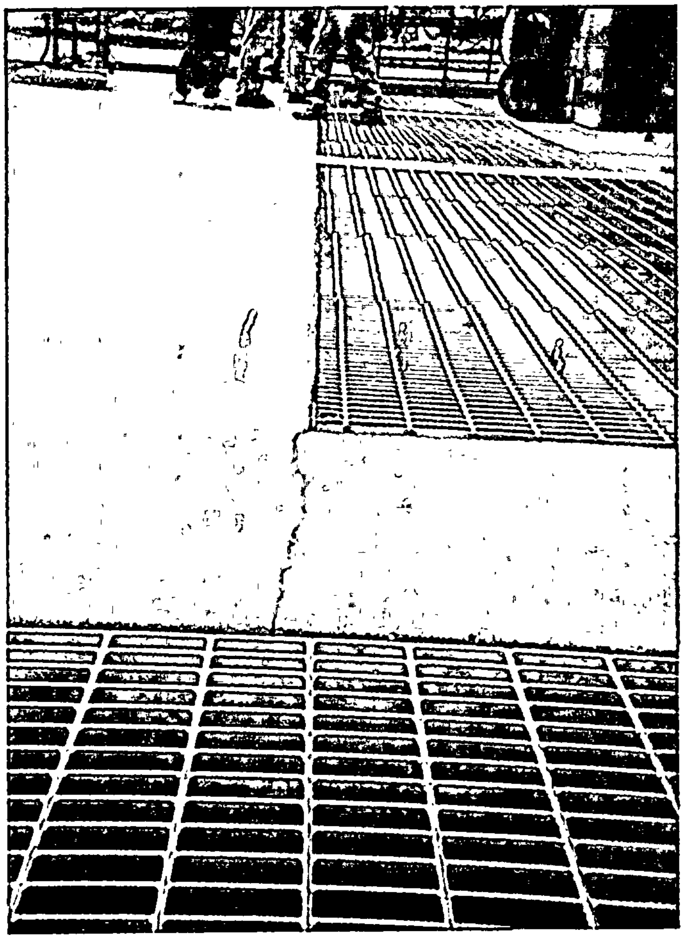


Severe Pitting of Service Water Line - Below Grade Elev.

<u>Intake Structure</u>



Corrosion and Degradation of Service Water Line - Above Grade Elev.



Cracks at Intersection of Concrete Walls

APPENDIX E

BEAVER VALLEY POWER STATION UNIT 1

DESCRIPTION OF CIVIL/STRUCTURAL OBSERVATIONS

Containment

1. Concrete patches over construction related holes are deteriorating and falling out. This gives the appearance that small chunks of concrete are spalling.

2. Based on the Containment Inspection Reports conducted prior to the ILRTs, gouges, anchor holes, missing concrete chunks, and some cracks in the exterior concrete surface were also noted. In addition, rusted areas and peeled paint in several locations in the interior steel liner were identified.

3. A few instances of liner bulging were previously identified. DLCo stated that these were subsequently monitored to ensure that the deformations were not growing.

4. Corrosion of the containment penetration for the component cooling line was observed from the safeguards structure at elevation 722 ft.

Intake Structure

1. Concrete cracks in the ceilings of the pump cubicles were identified. Many of the cracks were located near the access panels used for pump maintenance. Crack sizes up to approximately .075 inches were observed.

2. Corrosion of the horizontal structural steel supports for the raw water piping was observed in bay "C" pit (below grade). This may be due to the water that is trapped in the horizontal structural shapes used to support the pipes.

3. In some of the pump cubicles, grout degradation and baseplate corrosion were identified in small diameter piping supports. In addition, conduit supports on the concrete wall had missing washers, untorqued anchors, one missing anchor, gaps with the wall and bent members.

4. Three vertical cracks were observed on the exterior concrete wall on the South side. The cracks were approximately .02 inches wide and 10 feet long.

Diesel Generator Building

1. Long cracks running in the ceiling of both diesel generator rooms were observed. The cracks run the entire width of the room from the East wall to the West wall.

2. The exterior South wall has a region of concrete which has spalled off to a depth of 1/2 inch, exposing the steel reinforcement. The reinforcement shows signs of corrosion.

Primary Auxiliary Building

1. A structural steel angle, initially installed under DLCo's IE Bulletin 80-11 program to restrain the bottom edge of a masonry wall, was found to be only loosely held in place. The masonry wall where this was located is at elevation 722 ft.- 6 in. in the cable vault structure. In addition, a vertical angle did not have an anchor at the top and no washers were present at other anchors where oversized holes were used in the angle.

2. At elevation 722 ft.-6 in. a long, large crack in the concrete ceiling was observed. Signs of rust discoloration were also present.

3. Corrosion was observed in the raw cooling water piping and steel supports for the condensing unit of the control room air conditioning. This was identified at elevation 722 ft.-6 in.

4. At elevation 735 ft.-6 in. grout degradation was observed below the baseplate support to the CCR heat exchanger 1A pressure gauge.

Service Building

1. At elevations 713 ft.-6 in. and 725 ft.-6 in., the concrete ceilings exhibited signs of water infiltration and calcium formation.

2. Degradation of the foundation and corrosion of steel supports were observed in the switchgear room, elevation 713 ft.-6 in.

3. Cracks in the masonry wall next to the computer room at elevation 735 ft. of the control room were identified.

Cable Vault Structure

1. Cracks were identified in the masonry wall on elevation 735 ft. of the West cable vault.

2. Water from the fan coil unit drain line at elevation 735 ft. was corroding the base/steel supports.

3. Corrosion of the structural steel frame supporting the main steam and feedwater piping was observed at elevation 762 ft.-roof level.

Safeguards Structure

1. Corrosion of the sliding support plates for the river water piping was observed at elevation 722 ft.

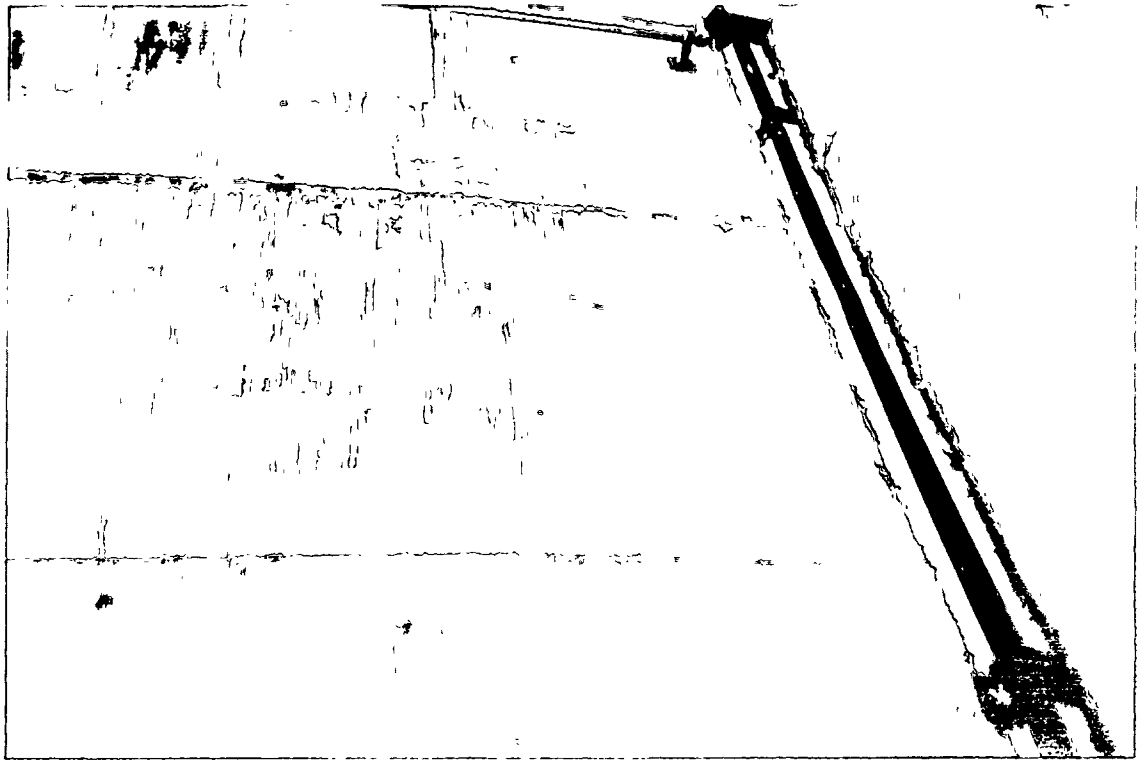
2. Corrosion of two pipe support base plates was identified on the ceiling above elevation 722 ft.

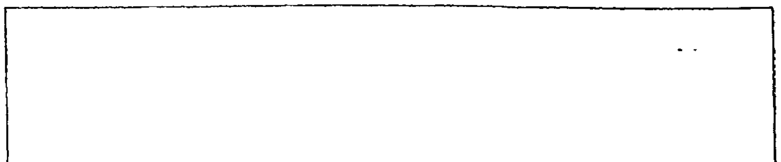
3. Water infiltration and corrosion of steel angles at the ceiling, adjacent to the exterior containment wall, was observed at elevation 747 ft.

Other Structures

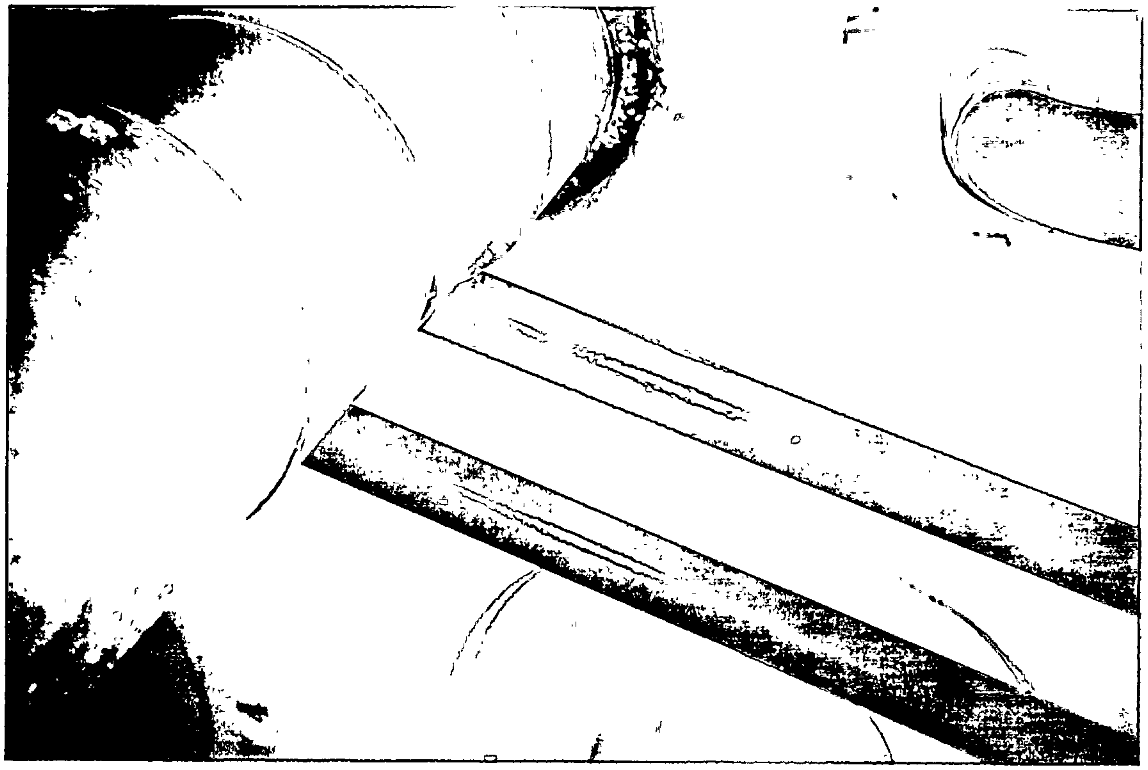
1. Steam Generator Drain Tank - cracks, water infiltration and calcium formation was observed at the West wall.

Outside Containment Wall - Concrete Crack Pattern

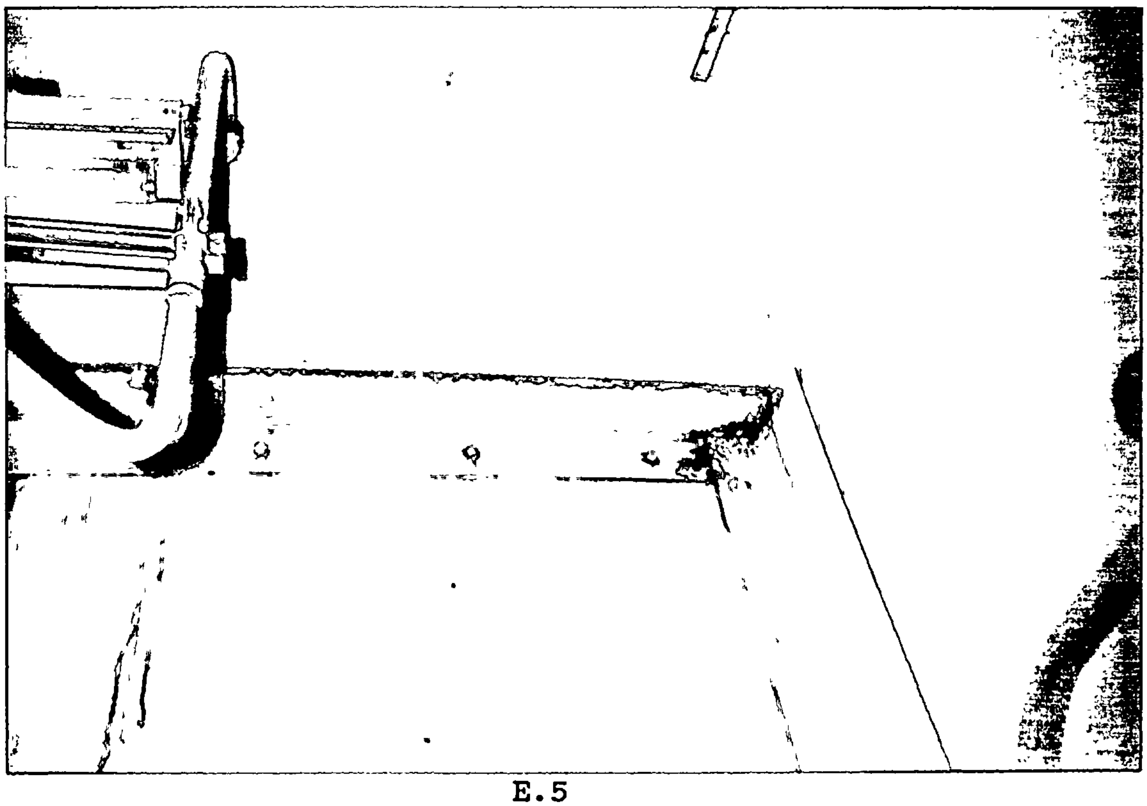




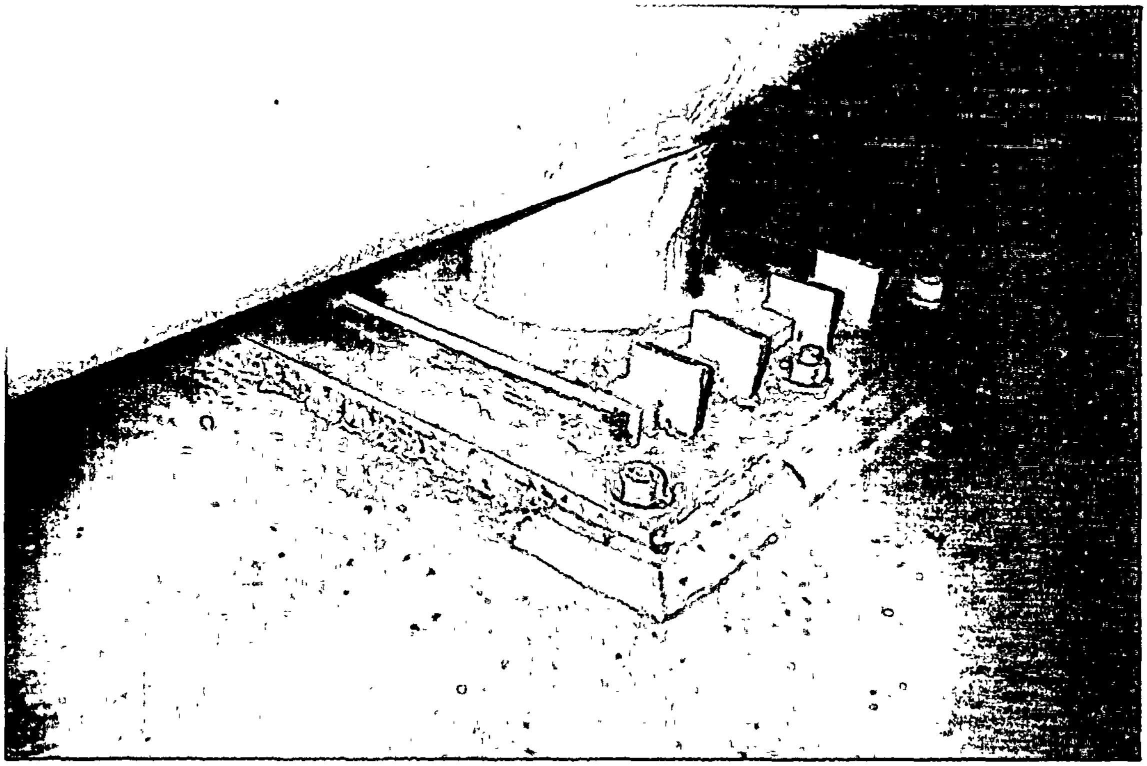
Containment-Corrosion of Containment Penetration for Component Cooling Line



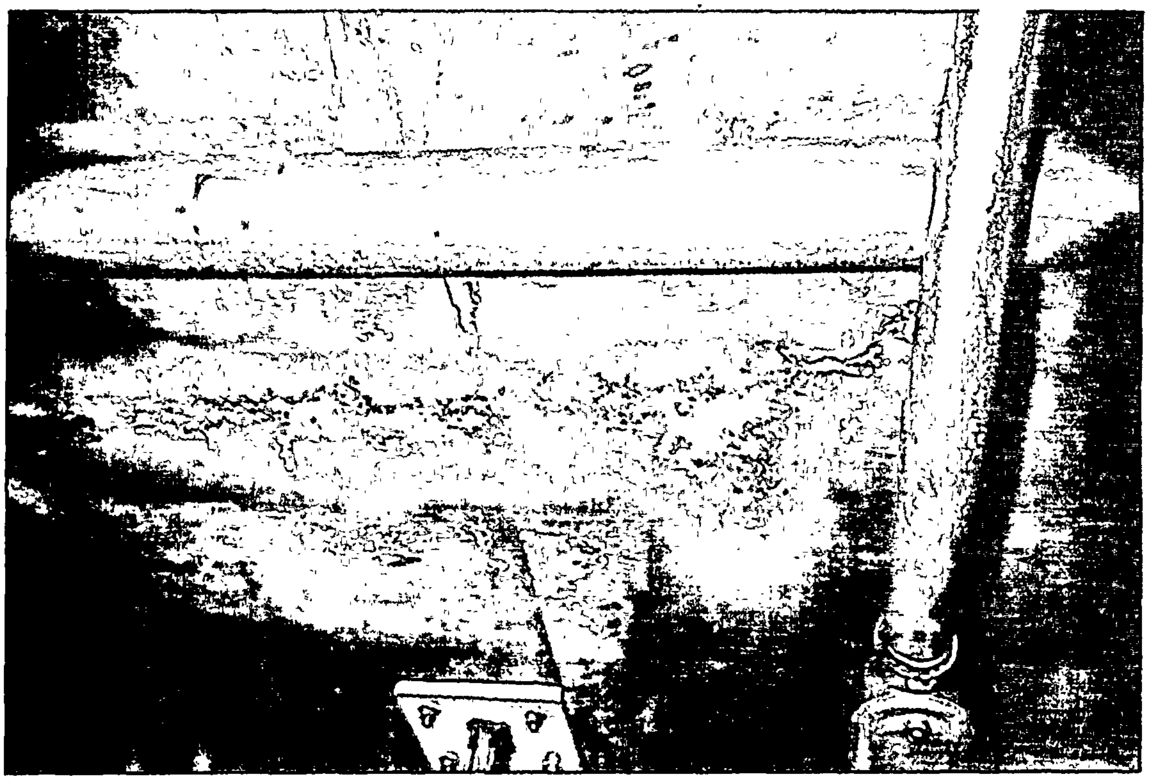
Safeguards Structure - Water Infiltration and Corrosion of Steel Angles



Safeguards Structure-Corrosion of Sliding Support Plates for River Water Piping



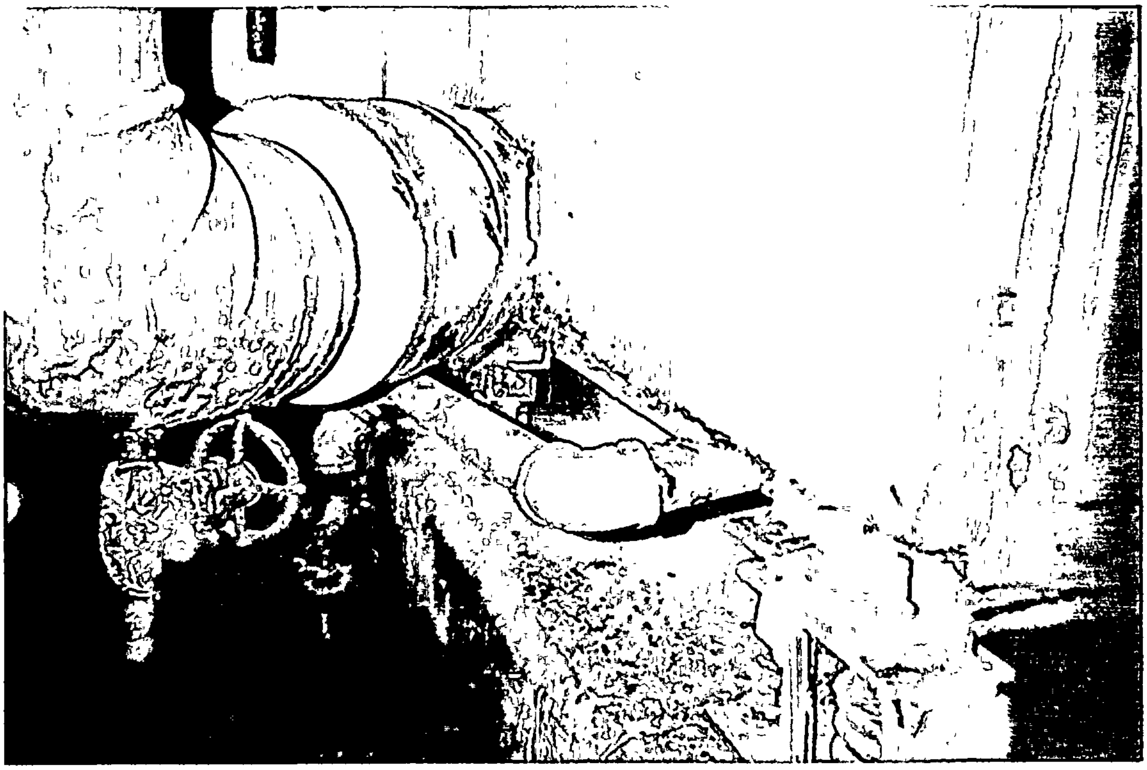
Service Building - Water Infiltration and Calcium Formation



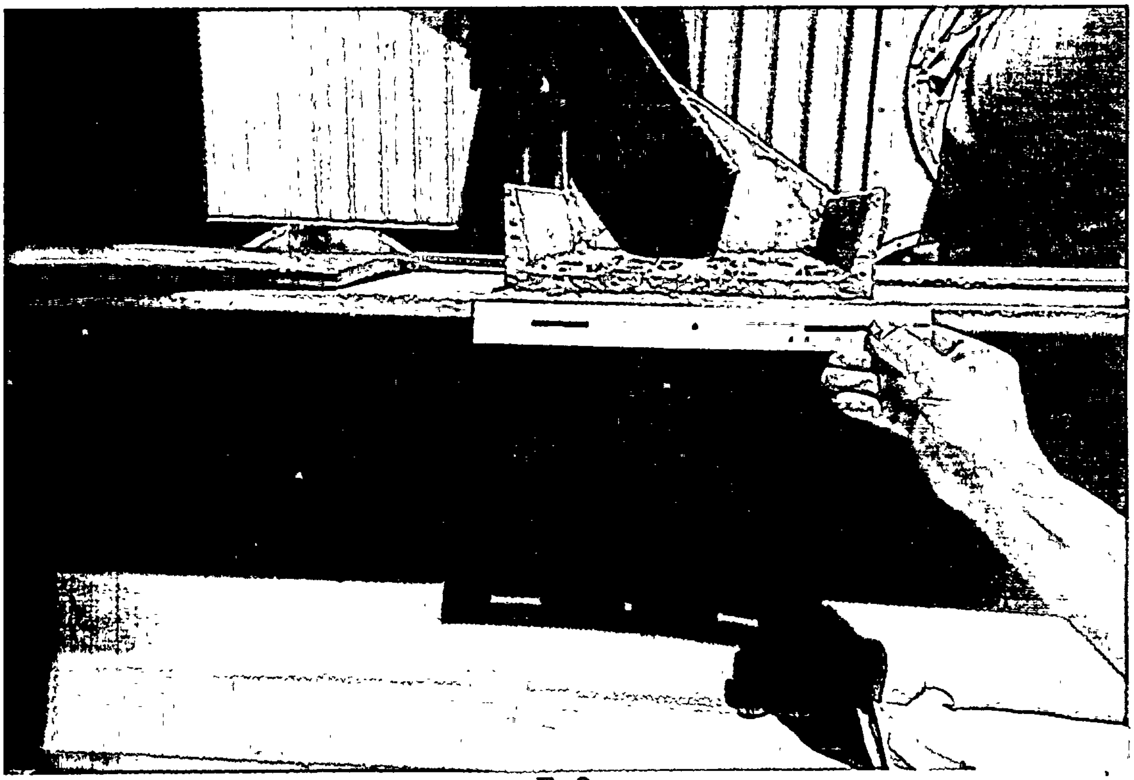
Degradation of Base/Foundation and Corrosion of Steel Supports

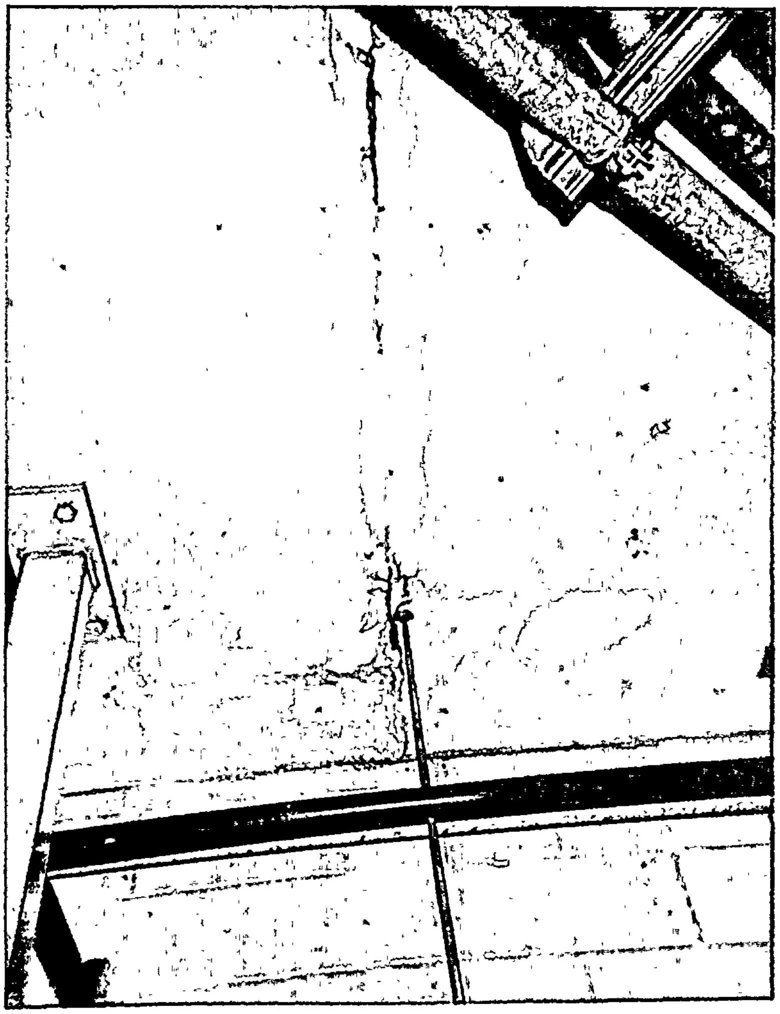
Metal Corrosion of Frame Support

Corrosion of Base/Steel Supports of the Fan Coil Unit



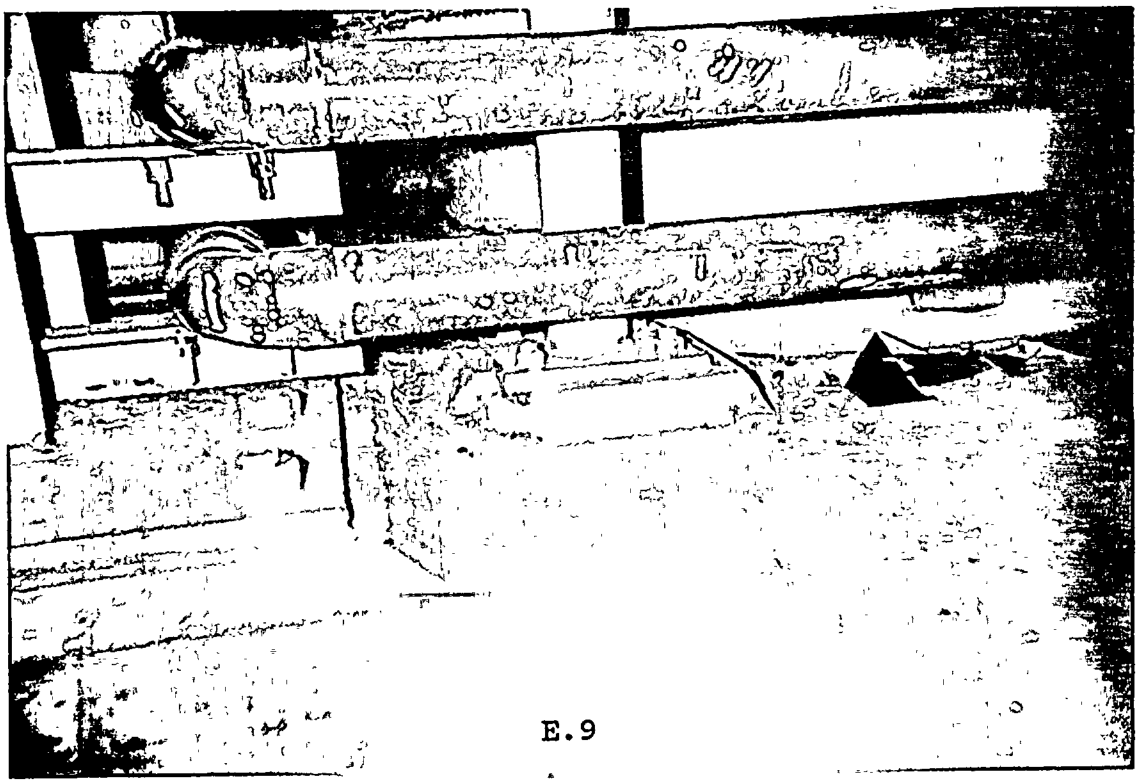
Corrosion of Structural Steel for Main Steam/Feedwater Piping



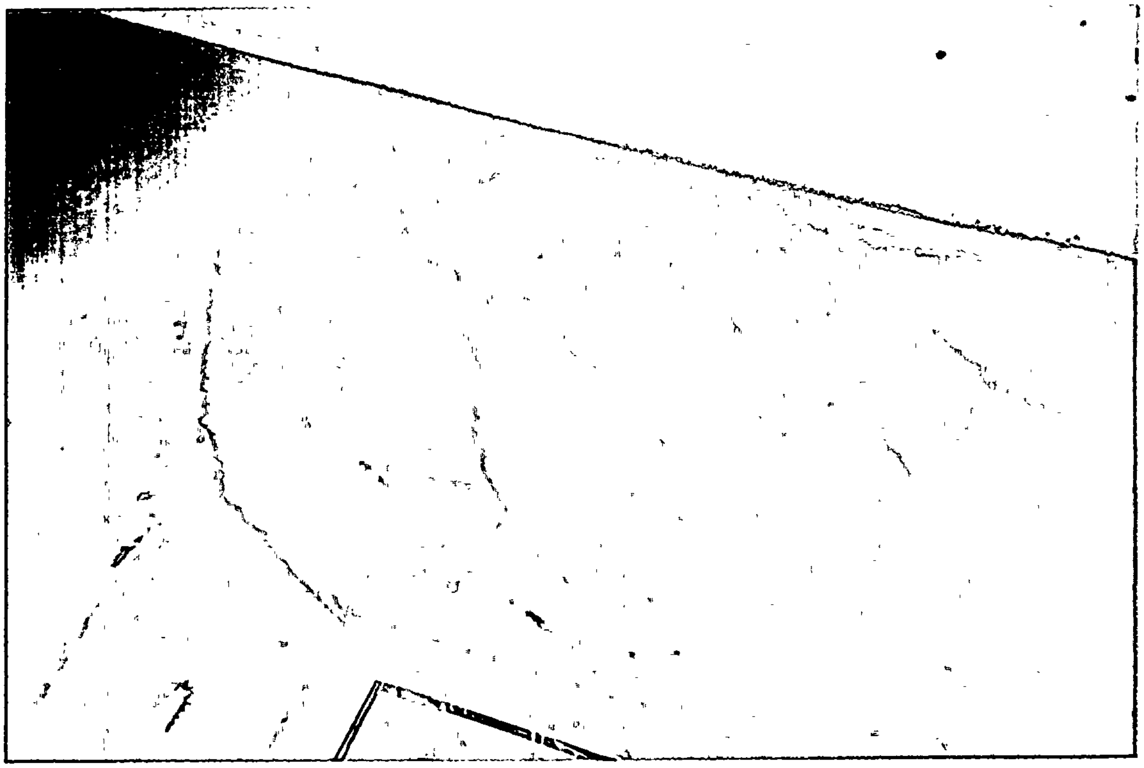


Concrete Crack and
Rust Discoloration
at Ceiling

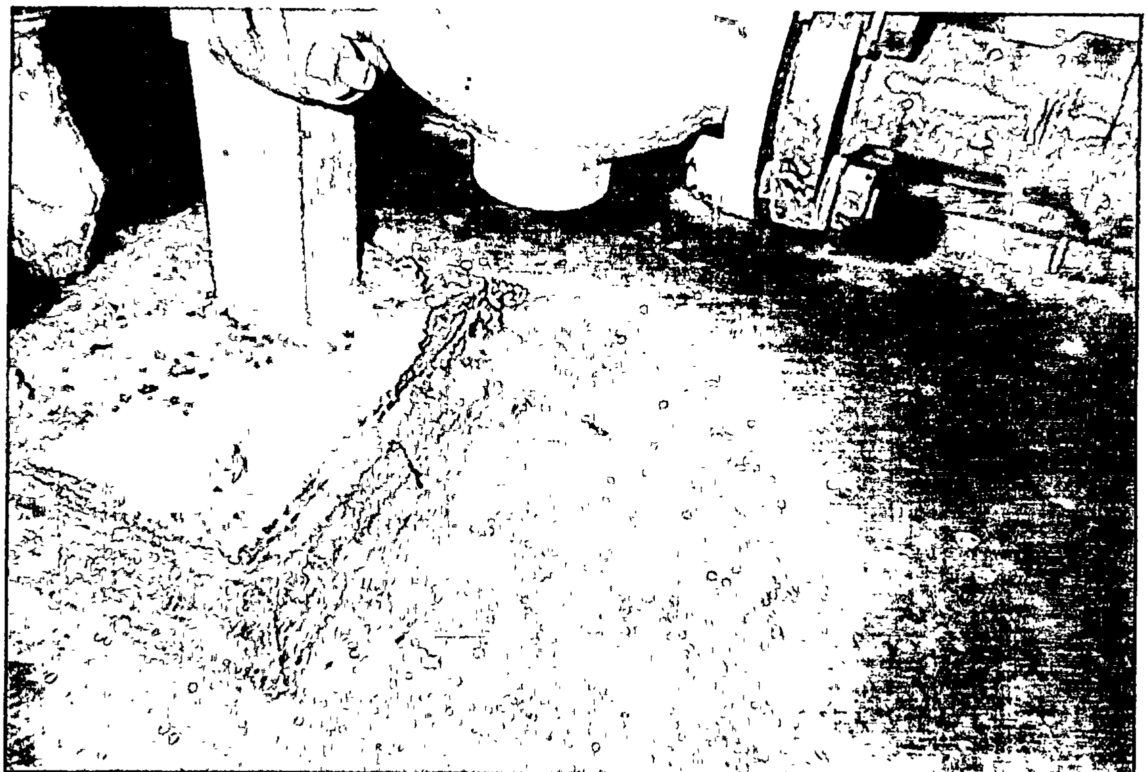
Missing/Degradation of Grout Below Baseplate

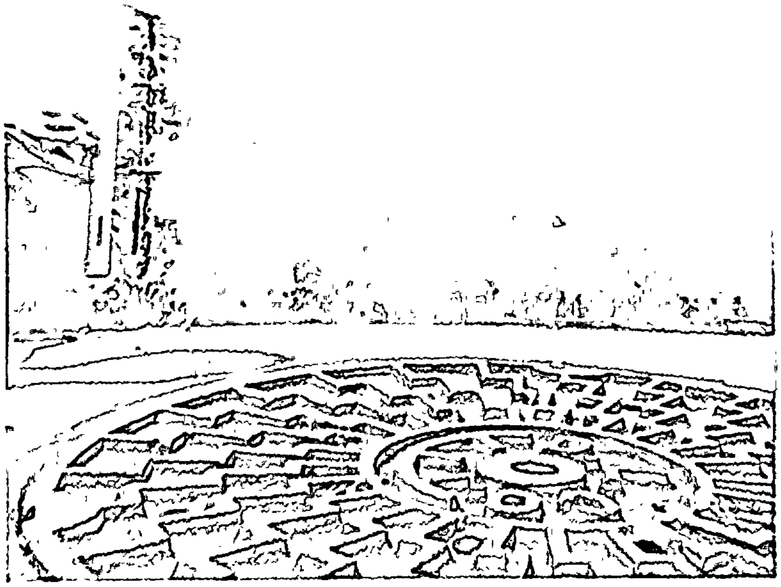


Diagonal Cracks Near Access Panels to Pump Cubicle

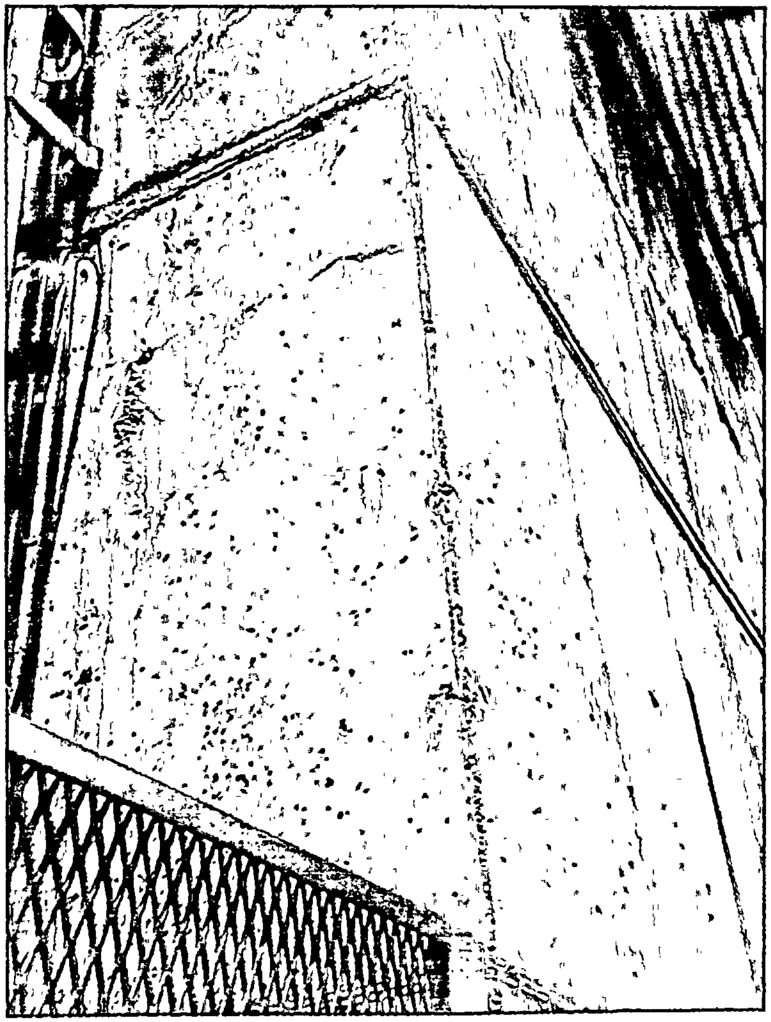


Grout Degradation and Baseplate Corrosion





South Wall of Diesel Generator Building - Concrete Spall and Corrosion of Reinforcement



Steam Generator Drain Tank - Cracks, Water Infiltration and Calcium Formation

APPENDIX F

COOPER NUCLEAR STATION

DESCRIPTION OF CIVIL/STRUCTURAL OBSERVATIONS

1. Signs of corrosion were observed on the external surface of the torus shell, near torus support #7. The normally reddish color of the torus shell now had dark streaks on it. Apparently, a leak from above the torus has been running down the torus shell wall, on both the inner and outer side. This has removed the reddish coating and has initiated surface corrosion of the shell.

2. Evidence of water leakage through a piping penetration in the exterior concrete wall of the Reactor Building was observed from inside the torus enclosure. The water apparently ran down along the wall onto some conduit adjacent to the wall. NPPD was aware of this situation, indicating the source of the water is from surface runoff during heavy rainfall. However, it appears that no effort has been made to stop the water infiltration.

3. In the service water pump room of the intake structure, corrosion of piping and pipe supports as well as degradation of anchorages and floor coating were observed. Better housekeeping and maintenance of the equipment, piping, supports, anchorages, and floor is recommended. In addition, in view of the condition in the service water pump room and excessive water on the operating floor outside the pump room, inspections of the concrete and steel structure should be periodically performed; particularly in areas that are not visible or readily accessible.

4. At elevation 904 ft. in the control building, the RHR service water booster pump (SWBP) gland water system is in a very bad state of corrosion and degradation. This includes the tanks, piping, supports, and anchorages. NPPD was aware of this condition, indicating that they plan to remove the system completely since it is not required. NPPD stated that they plan to remove it during the 1993 refueling outage. However, the system has been allowed to continue to operate in this condition for a number of years.

5. At elevation 882 ft. in the control building, the service water booster pump system was observed to be in a degraded condition. Corrosion was identified on the piping, pump B, valve SW-85, and on several flange connections.

6. At elevation 877 ft. in the control building, several horizontal pipes near the ceiling over the emergency storage tank appear to show signs of corrosion.

7. Several instances of cracks in concrete floors and walls were observed. These include the floor at elevation 882 ft. in the service water booster pump room and West wall (floor to ceiling); exterior wall of the diesel generator structure on the North end and East end; floor at elevation 958 ft. of the reactor building (MG pump area); and the crack/spalled concrete of the reactor building exterior wall at the junction of upper and lower levels (North East corner). Although these cracks are not severe, it would be prudent to monitor them to ensure they do not worsen and lead to degradation of the structure.

8. A number of instances of potential connection/anchorage problems were observed. These include: missing bolt/nut at cable tray splice plate in the cable expansion room, (cable tray # C227 near hanger #65), conduit support anchor angularity about 10°-15° (excessive) and a gap exists between the anchor head and plate in the cable expansion room, insufficient thread engagement of anchor nuts in a base plate for the service water line near valve SW-125 at elevation 931 ft. of the reactor building, and missing anchors at base angle attached to corrugated steel supports to a masonry wall at elevation 931 ft. of the reactor building.

9. At the base of the structural steel leg of the elevated release point tower (North West corner) the coating has peeled off and corrosion of the base material is evident.

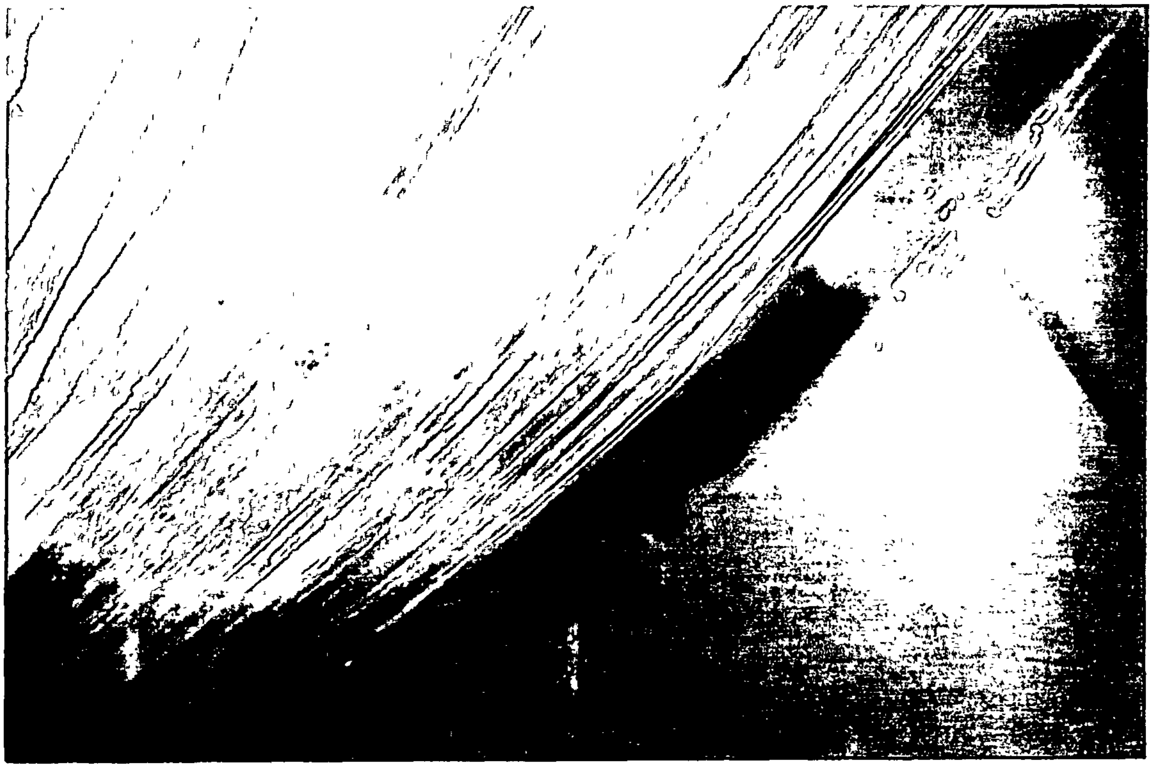
10. If epoxy dipped anchors are used in high temperature areas, then evaluation for possible hardening and brittleness of the epoxy and the capacity of the anchors should be evaluated. In addition, the letter to the NRC regarding IE Bulletin 79-02 Resolution describes criteria and plans to resolve the IE Bulletin but does not give any schedule for its completion.

11. As a result of past internal inspections of the torus, NPPD identified numerous cases of corrosion pits in 4 of the 16 bays examined. The existing pits were analyzed with a corrosion growth factor which would conservatively allow for all pits to remain uncoated until the 1993 scheduled refueling outage. However, NPPD decided to patch the 150 pits identified in the 4 bays using underwater cured epoxy.

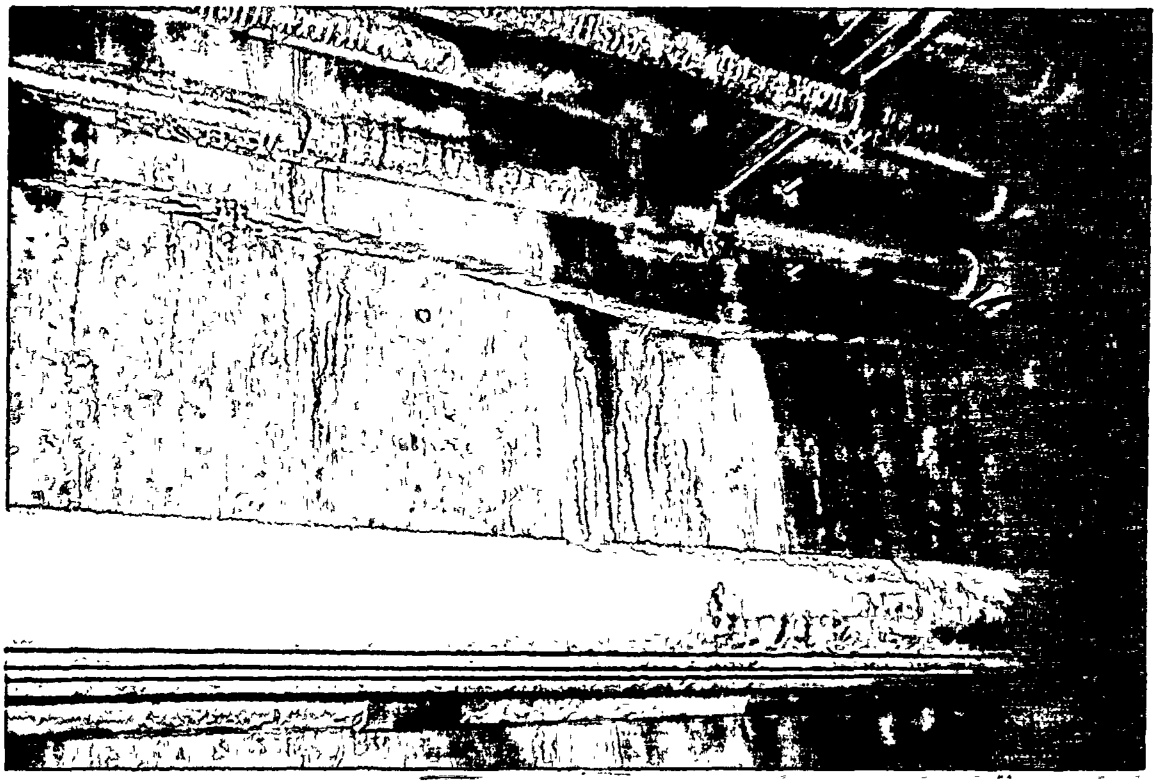
    The audit team expressed a concern about pits in other bays that were not inspected and about the ability of the underwater cured epoxy to arrest the problem. NPPD indicated that the epoxy used was Brutem 15 and, when applied properly, will displace water and trapped air in the repair zone.

    The patches will be evaluated during the 1993 scheduled refueling outage and this evaluation should provide justification for the use of underwater applied epoxy.

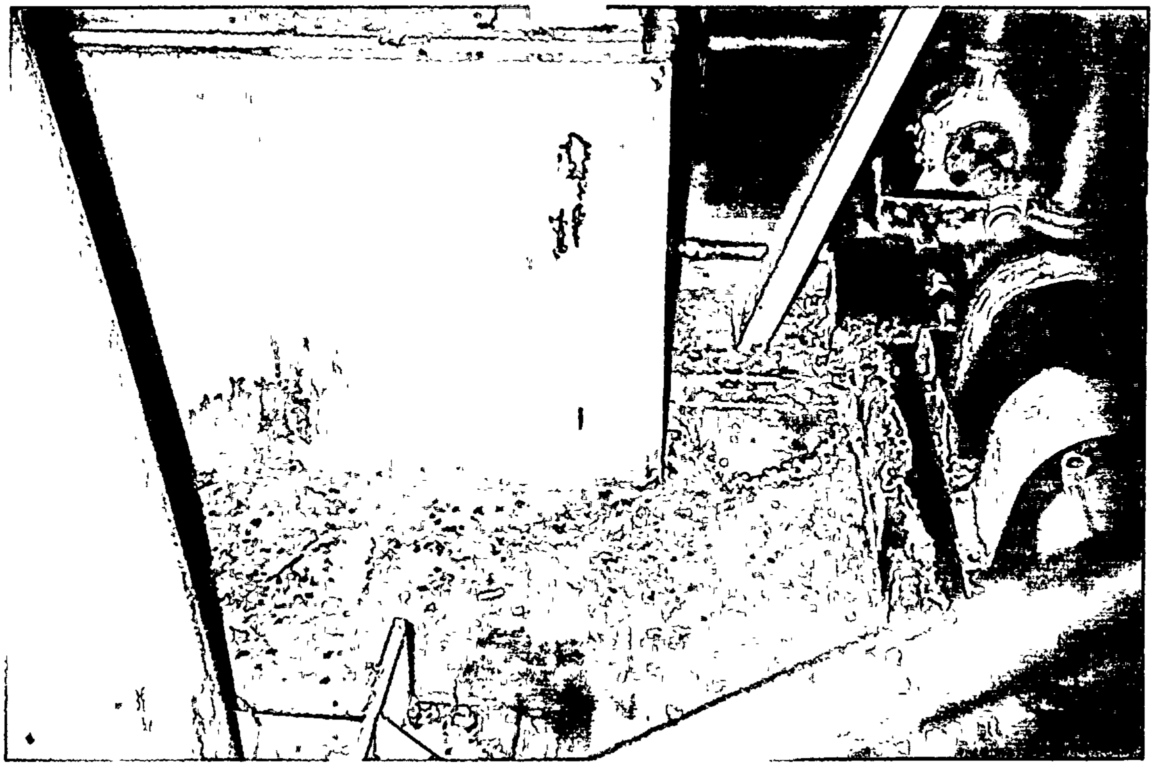
12. NPPD indicated that ultrasonic testing (UT) of the service water and residual heat removal service water booster system piping, fittings, and valves is routinely performed as part of the Augmented Erosion-Corrosion Program. This program is concerned with lower pressure systems that could be subjected to erosion caused by the silty Missouri River water. The Augmented Erosion-Corrosion Program contains those items which are potentially subject to wall loss, but are not flagged by the criteria of the Erosion-Corrosion Program.



Reactor Building, Torus - Surface Corrosion

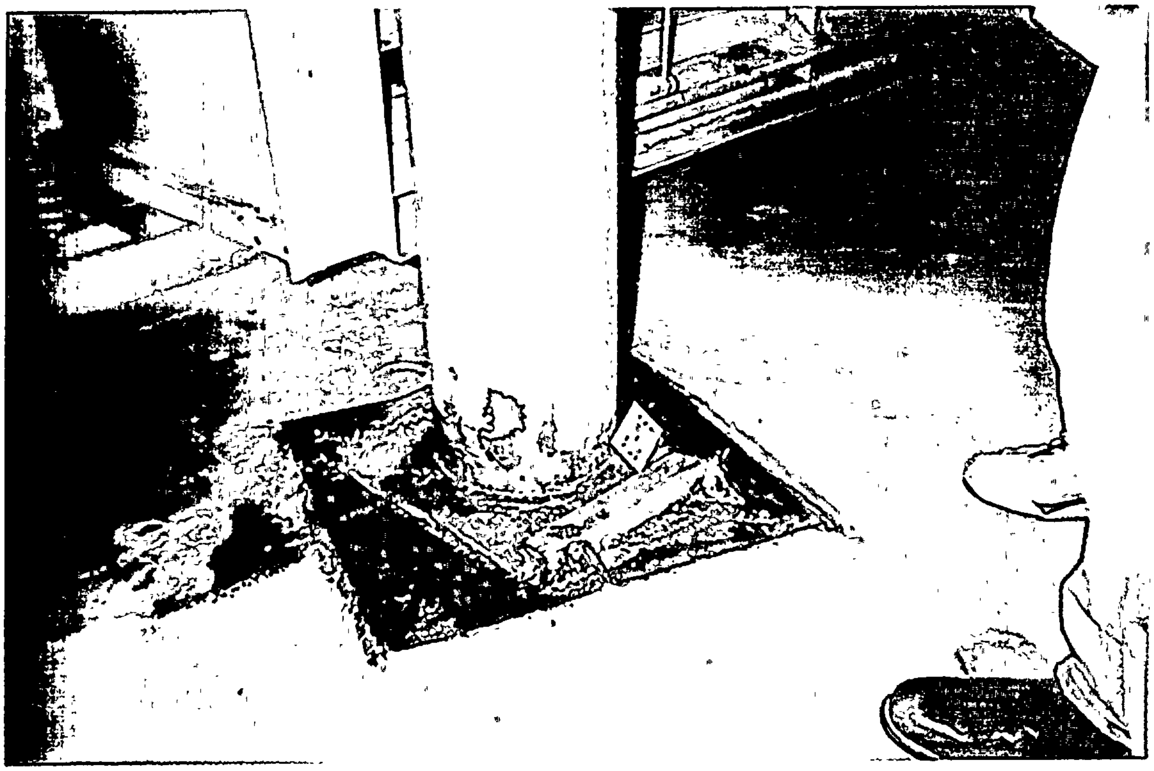


Reactor Building, Exterior Concrete Wall - Water Infiltration



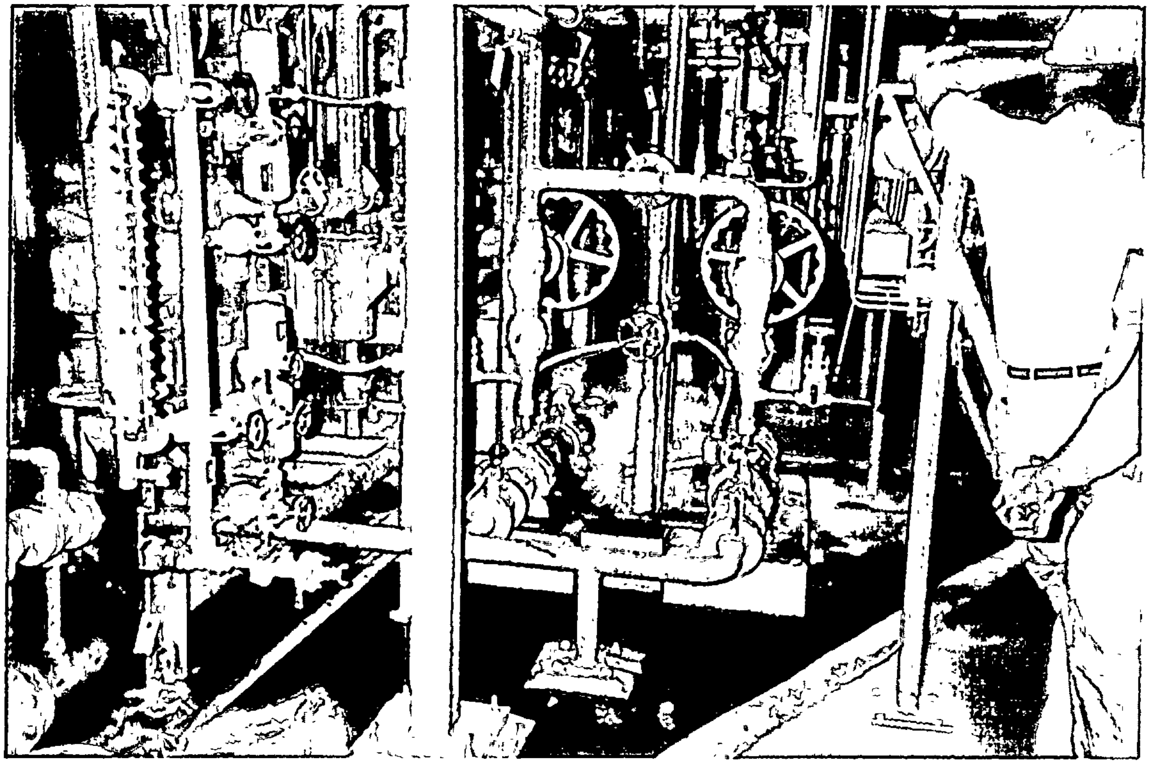
Intake Structure, Service Water Pump Room - Degradation

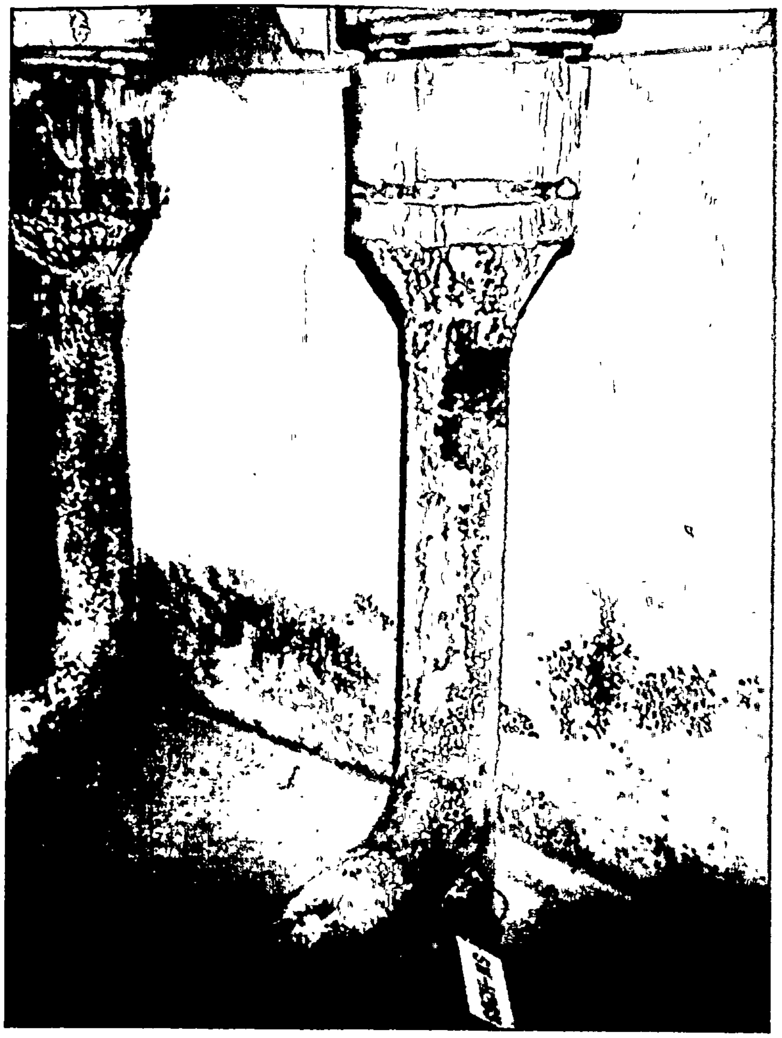
Intake Structure, Service Water Pump Room - Corrosion of S.W. Piping



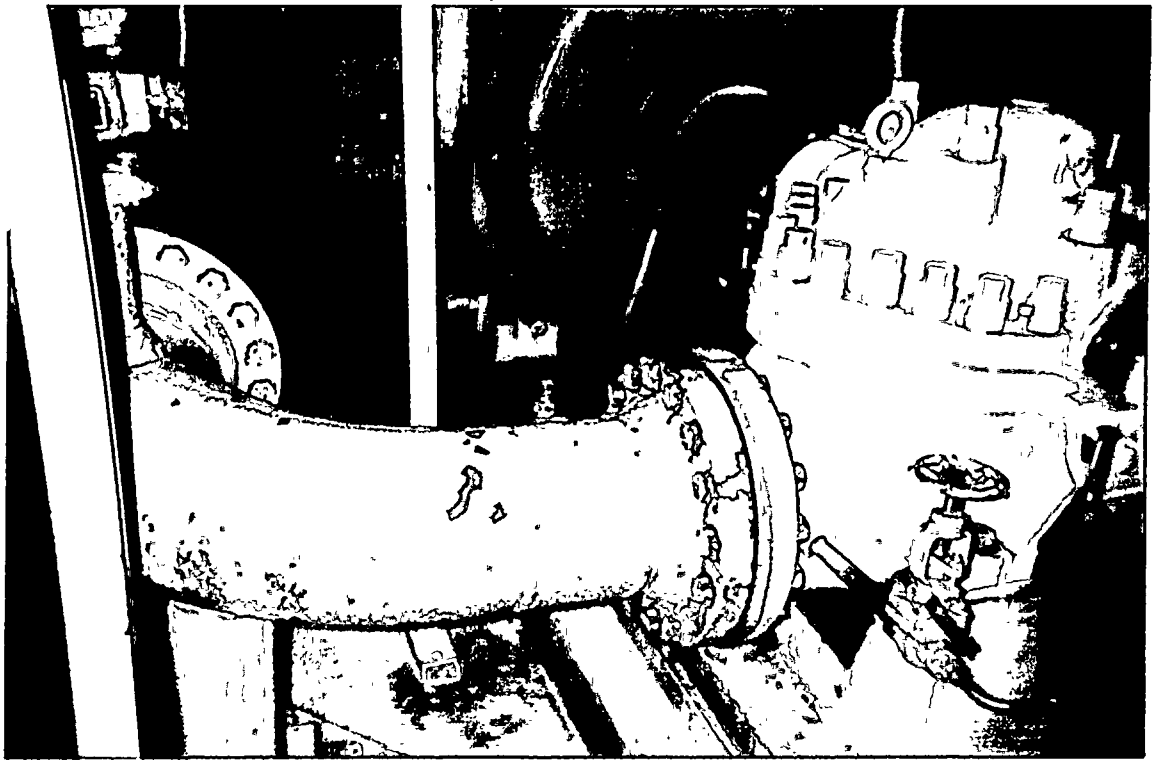
Intake Structure, Service Water Pump Room - Corrosion of Pipe Support

Intake Structure, Service Water Pump Room - Degradation of Floor Coating

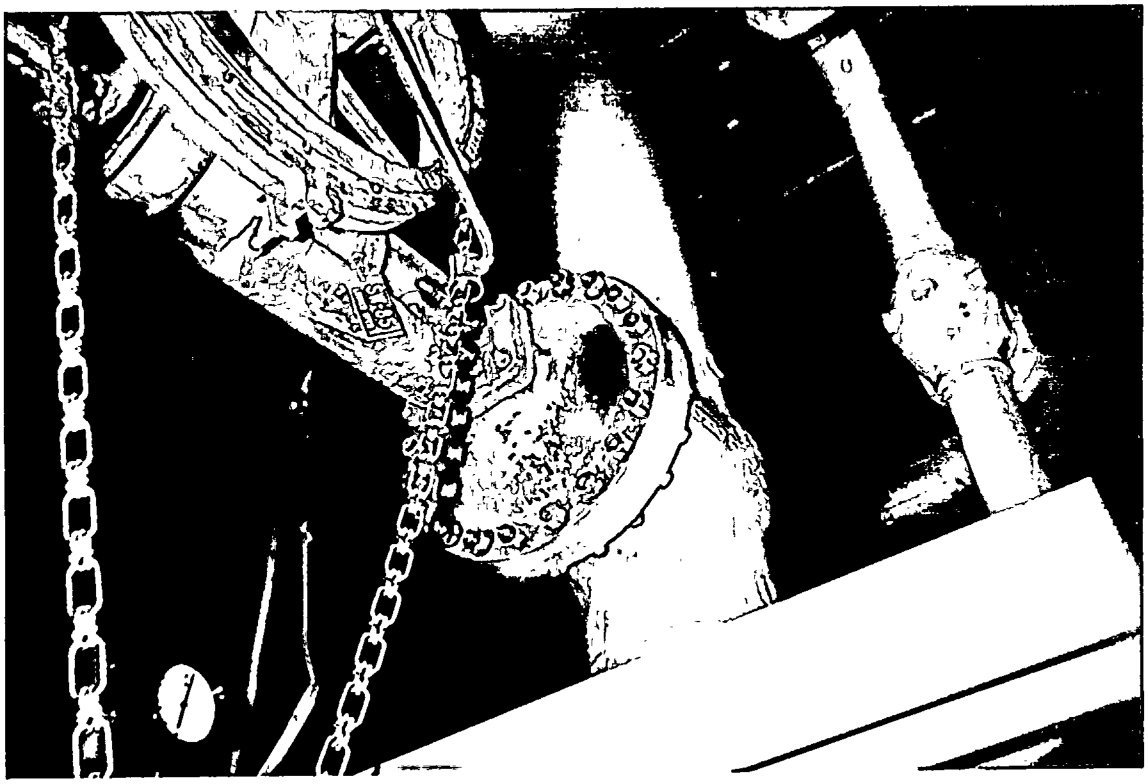




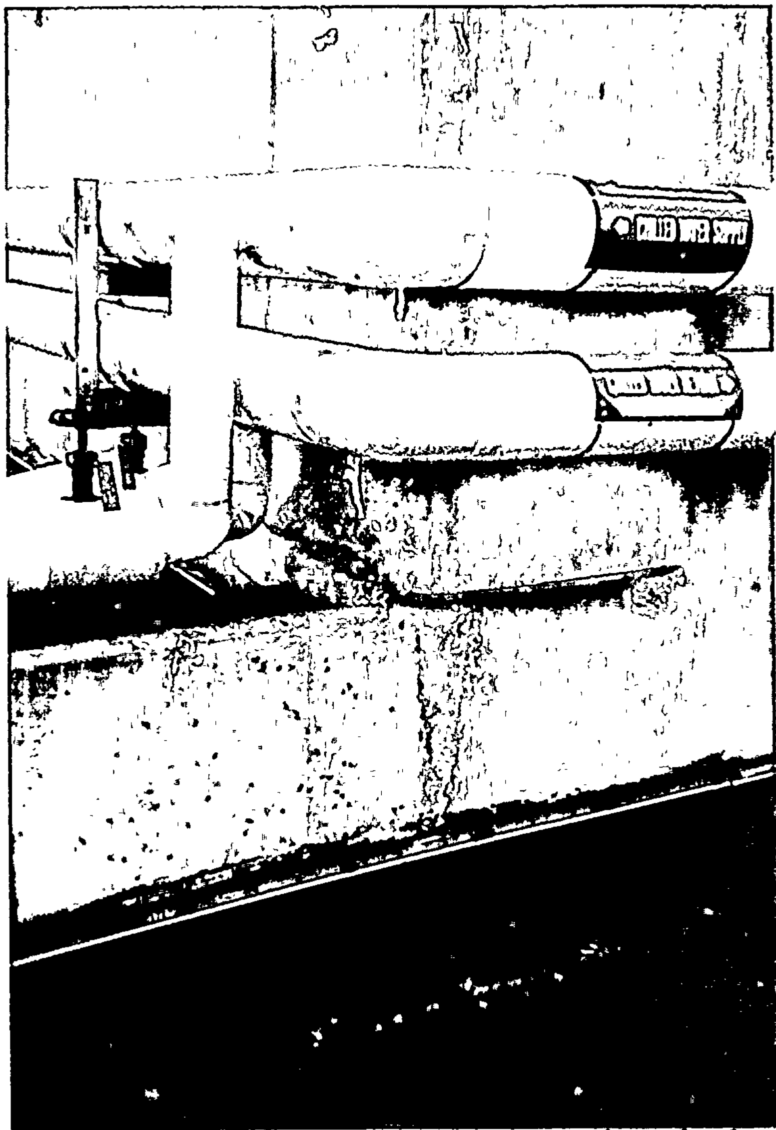
Control Building, Service Water Gland Water System Corrosion/Degradation



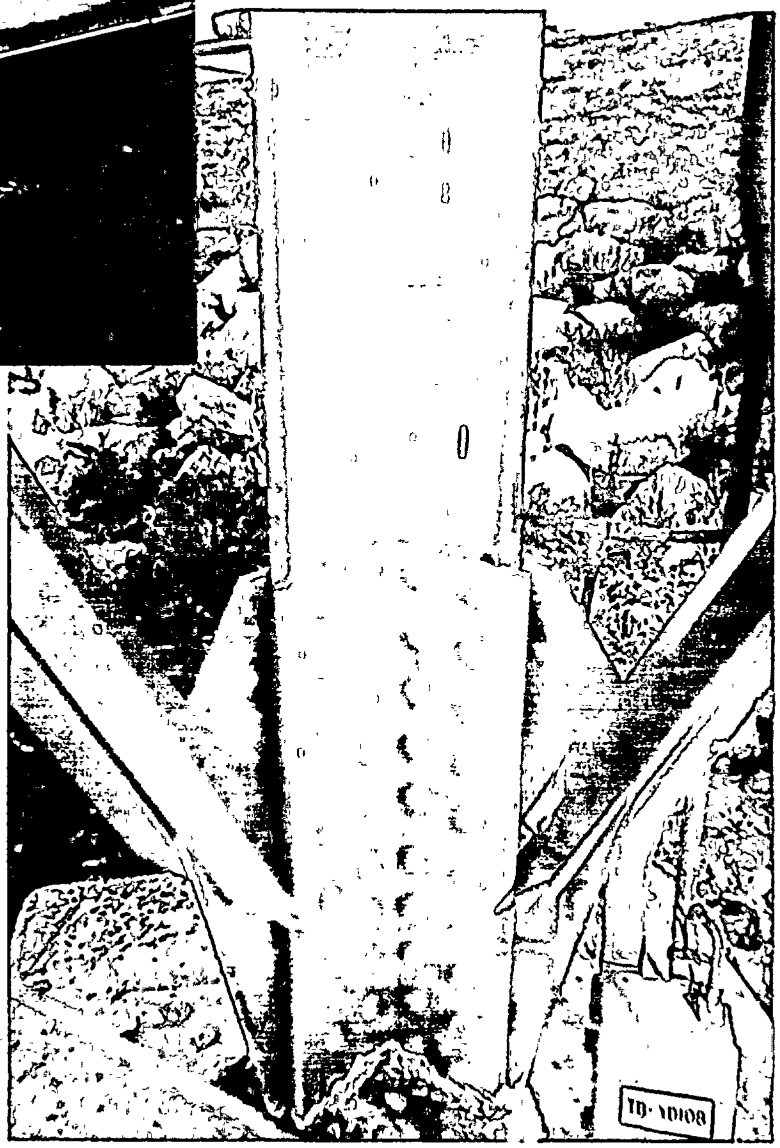
Control Building, RHR Service Water Booster Pump - Piping Corrosion



Control Building, RHR Service Water Booster Pump System - Valve Corrosion



Reactor Building,
Exterior Concrete Wall
Cracks and Spalling



Elevated Release Point Tower,
Structural Steel Leg
Corrosion

Reactor Building, Pipe Suppor
At Elev. 904′-Corrosion

Diesel Generator Room,
Grids on S.W. Piping
For U.T. to Monitor
Internal Erosion