Revision C
March 14, 1996

NEI 96-XX [ORIGINAL]

NUCLEAR ENERGY INSTITUTE

GUIDELINE FOR MONITORING THE CONDITION OF STRUCTURES AT NUCLEAR POWER PLANTS

MARCH 1996

ACKNOWLEDGMENTS

This guidance document, Guideline for Monitoring the Condition of Structures at Nuclear Power Plants, NEI 96-XX, was developed by the Nuclear Energy Institute (NEI) Structures Task Force and the NEI Maintenance Rule Working Group. We appreciate the direct participation of the many utilities who contributed to the development of the guideline and the participation of the balance of the industry who reviewed and submitted comments to improve the document clarity and consistency. The dedicated and timely effort of the many Task Force participants, including their management's support of the effort, is greatly appreciated.

NOTICE

TABLE OF CONTENTS

1.0 BACKGROUND

On July 10, 1991, the Nuclear Regulatory Commission (NRC) promulgated the Maintenance Rule, 10 CFR 50.65 (56 Fed. Reg. 31324). The Maintenance Rule is effective July 10, 1996. Prior to regulatory implementation of the maintenance rule, the industry and NRC conducted pilot site visits at nine utilities. The results of these pilot site visits are documented in NUREG-1526.

NUREG-1526 concluded that most of the pilot utilities considered structures to be inherently reliable and a low priority. Based on those conclusions, NRC recommended the industry reevaluate the monitoring of structures.

In 1991, at the same time the Maintenance Rule was issued, the NRC also promulgated the License Renewal Rule 10 CFR 54 (60 Fed. Reg. 22461). This rule delineates the requirements for obtaining a renewed operating license. The scope of the License Renewal and Maintenance Rules are very similar. For example, both rules apply to systems, structures, and components (SSCs) that are safety-related and SSCs that are non-safety related but support a safety related SSC. NEI 95-10 "Industry Guidance for Implementing the Requirements of 10 CFR Part 54 - The License Renewal Rule" provides a methodology for preparing a license renewal application. This methodology recognizes the need to evaluate structures.

In October 1995, the NEI Maintenance Rule Working Group considered the findings outlined in NUREG-1526 and recommended moving forward with industry guidance for monitoring structures. It is also envisioned that monitoring the condition of structures for the Maintenance Rule will be beneficial to licensees electing to pursue license renewal.

2.0 PURPOSE AND SCOPE

The purpose of this document is to provide guidance for monitoring structures at nuclear power plants. The methodology outlined in this guideline, combined with existing programs, should ensure that structures are monitored effectively.

This guideline is applicable in meeting the regulatory requirements of the maintenance rule and the license renewal rule. In addition, the methodology outlined in this guideline may be beneficial in a non-regulatory application for maximizing the useful life of structures.

Typically, such non-regulatory actions are performed because of a favorable cost-benefit analysis or insurance purposes.

2.1 Regulatory Application and Scope

The maintenance rule, 10 CFR 50.65, requires licensees to monitor the performance or condition of structures against licensee-established goals or require that structures be maintained under an effective preventive maintenance program. The maintenance rule also requires utilities take appropriate corrective action when the performance or condition of a structure or component does not conform to established goals.

If a licensee decides to pursue license renewal, the requirements of 10 CFR Part 54 must be satisfied. The license renewal rule requires an evaluation of aging effects on structures. The license renewal rule further requires a demonstration that the effects of aging will be adequately managed so that the structure will be able to perform its function for the extended period of operation.

The scope of structures encompassed by the aforementioned regulations include safety related structures and non-safety related structures that:

(1) are relied upon to mitigate accidents or transients,

(2) that are used in EOPs (this applies to the maintenance rule only),

(3) whose failure could prevent safety related SSCs from fulfilling their intended function,

(4) whose failure could cause a scram or actuation of a safety related system (this applies to the maintenance rule only), and

(5) that are relied on for compliance with the Commission's regulations for fire protection (10 CFR 50.48), environmental qualification (10 CFR 50.49), pressurized thermal shock (10 CFR 50.61), anticipated transients without scram (10 CFR 50.62), and station blackout (10 CFR 50.63) (this applies to license renewal only).

2.2 Non-Regulatory Application and Scope

A licensee may elect to apply the methodology presented in this guideline to structures for reasons other than compliance with NRC's

regulations. For example, a licensee may choose to examine the material condition of all structures in the plant even though they are not safety-related or meet any of the regulatory requirements. Performing such a review will most likely be based on a cost-benefit analysis that justifies inspections to ensure continued performance of the structure, to increase availability of the plant, or to minimize repair costs.

This guideline recognizes that licensees may examine structures for reasons not related to regulatory compliance, but that determination is solely up to the utility.

3.0 PROGRAM FOR MONITORING THE CONDITION OF STRUCTURES

A program is needed to effectively monitor the condition of structures. An effective program should include the following elements:

3.1 Identification of Structures

The program should identify the structures within the scope of the monitoring program. If the program is developed for compliance with the Maintenance Rule, the scoping results and function identification from the maintenance rule can be utilized. Similarly, the scoping results and function identification for the license renewal rule should be used if the program is tailored for license renewal. If the program is written more generically, the list of structures should ensure coverage of all relevant structures.

The function of the structure should also be identified to make the determination of functional failures easier.

Other related civil inspection programs may exist and may be identified. The program may also define whether it includes structural items covered by plant technical specifications.

3.2 Responsibilities

The program may describe the organizational structure and responsibilities for program coordination, implementation, examination, and documentation.

3.3 Examination Guidance

The program should describe the methods to be used (primarily visual examination) to assess the condition of structures within the scope of the monitoring program. The degree of examination will depend on many factors including importance to public safety, age of structure, environmental conditions, accessibility, service requirements, and others. Review of the structure design basis and previous examinations reports may be helpful to assess the present conditions.

Monitoring programs are intended to assess the overall condition of structures, and need not require extensive evaluation of all structural component(s), unless evidence of damage or degradation is observed during the initial(i. e., baseline) examination. Further action (as discussed below) may be necessary depending on results of initial structural examination. Evaluation criteria[1] to consider are:

- **Concrete**
  - - spalling, cracking, delaminations, honey combs, water in-leakage, chemical leaching, peeling paint, or discoloration

- **Masonry Walls**
  - - cracks in joints, deteriorated penetrations, missing or broken blocks

- **Structural Steel**
  - - corrosion, peeling paint, beam/column deflection, loose or missing anchors/fasteners, missing or degraded grout under base plates, twisted beams, and cracked welds

- **Roof Systems**
  - - structural integrity of support system, deteriorated penetrations (i.e., drains, vents, etc.), barrier integrity, signs of water infiltration, cracks, flashing degradation, and expansion joint condition

- **Siding**
  - - structural integrity and visible damage

- **Windows/Doors**

[1] The evaluation criteria listed are not intended to be all inclusive or all required. The criteria will vary depending on the structure being evaluated. For example, if the structure is one not required for compliance with an NRC regulation, then the evaluation criteria may be less demanding than described in this guideline.

- - missing panes, cracks, deteriorated glazing, broken or cracked frames, missing or damaged hardware, and seal integrity

- **Earthen Structures/Dams**
  - - erosion, settlement, slope stability, seepage, drainage systems, integrity of rip rap, and environmental conditions (i.e., storms, floods, etc.)

- **Settlement**
  - excessive total or differential settlement

- **Structural/Seismic Gap**
  - insufficient space for structural movement during a seismic event (i.e., exclusion of foreign objects or debris); deteriorated elastomers-type filler

Some structures may be inaccessible due to radiation or obstructions. Site specific characteristics, industry experience data and/or testing history of features under similar conditions may aid in the examination. In addition, accessible areas subject to similar conditions (material, environment, etc.) may be evaluated in lieu of inaccessible areas. Whenever inaccessible areas are excavated, exposed, or modified an examination should be performed.

3.4 Evaluation of Results

An effective monitoring program should describe how examination results will be evaluated, and should provide acceptance criteria for use by personnel performing examinations of structures. Acceptance criteria should be based on guidance in Section 3.3 of this guideline, in conjunction with relevant codes and standards, or should be based on the judgment of technically qualified individuals performing the examination.

Monitoring programs could classify the condition of structures as follows:

- Acceptable

Acceptable structures are capable of performing their structural functions, including the protection and support of safety related systems or components. Acceptable structures are free of deficiencies or degradation which could lead to possible failure.

- Acceptable with deficiencies

Structures which are acceptable with deficiencies are those which are capable of performing their structural functions, including the protection or support of safety related systems or components, but are degraded or have deficiencies which could deteriorate to an unacceptable condition, if not analyzed or corrected prior to the next scheduled examination.

- Unacceptable

Unacceptable structures are those which are damaged or degraded such that they are not capable of performing their structural functions, including the protection or support of safety related systems or components. An unacceptable safety related structure should be classified as a functional failure in accordance with the maintenance rule. Because of the robust design and construction methods employed in nuclear power plants it would take extreme environmental conditions or many years of neglect for this state to appear. Early detection, review and repair of deficient conditions can preclude reaching this failure state.

3.5 Corrective Actions

The structural monitoring program should define how corrective actions are to be taken, documented and tracked to ensure the structures can meet their intended function.

Cause determinations should be made for structures which are unacceptable or which could deteriorate to an unacceptable condition prior to the next scheduled examination. The results of the cause determination may result in corrective actions including goal setting, as appropriate.

3.6 Frequency, Trending, and Industry Data

The program should define the frequency at which periodic examinations are conducted for monitoring structures. Frequencies should be based on current structural condition, environment, age of structure and importance to public health and safety. For some structures an examination frequency of five or ten years would be appropriate. The program should also address the need for additional

examinations following unusual events such as flooding or seismic activity.

The program should describe how industry operating experience data will be used to assess potentially applicable conditions at each plant

For the maintenance rule, the effectiveness of the overall structural program should be documented in the periodic assessment and can be integrated with the assessment of systems and components. The program should include provisions for trending examination results and corrective actions.

3.7 Qualification Of Personnel

The quality and value of the examination results are dependent to an extent on the qualifications and capabilities of the examination personnel. Therefore, the program should define minimum qualification requirements for the individual(s) responsible for the monitoring program. The program should also define the minimum requirements for personnel performing monitoring activities and evaluating examination results.

3.8 Documentation

Documentation should be sufficiently comprehensive to allow for an accurate assessment and re-creation of the results for future trending purposes. Accurate documentation of degradation is essential because the indicator is likely to change over time. For the maintenance rule, examination results and corrective actions should be documented as outlined in associated guidance. The documentation report should include:

- Results of the examination, including a summary of the overall condition of the structure(s).
- Description and location of any identified degradation.
- Copies of data sheets, pictures, video tapes or other relevant information. Photographs and videos should be clear and taken from several perspectives and distances from the subject. Pictures and videos should be properly annotated to document the location (e. g., reference to column, floor, etc.) and size (e. g., inclusion of scale or reference).

- Assessment of the degradation.

- Recommendation for additional investigation, corrective actions, or future examination where appropriate.

- Information relative to changes in conditions or continued degradation since the previous examination of areas identified as acceptable with deficiencies or unacceptable.

- Conclusions on the ability of the structure to perform its intended function.

4 LIST OF REFERENCES

10 CFR 50.65, The Maintenance Rule

10 CFR Part 54, The License Renewal Rule

NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants"

NEI 95-10, "Industry Guideline for Implementing the Requirements of the License Renewal Rule - 10 CFR Part 54"

NUREG-1526, "Lessons Learned from Early Implementation of the Maintenance Rule at Nine Nuclear Power Plants"

NUREG-1522, "Assessment of Inservice Conditions of Nuclear Safety-Related Nuclear Plant Structures," USNRC, dated June, 1995.

ACI 201.1, "Guide for Making a Condition Survey of Concrete in Service"

ACI 349.3, R-95 "Evaluation of Existing Nuclear Safety-Related Concrete Structures"

Regulatory Guide 1.127, "Inspection of Water-Control Structures Associated with Nuclear Power Plants"

APPENDIX A
DEFINITIONS

Function:

As used in this guideline the function is that attribute (e.g., safety related, mitigates accidents, causes a scram, etc.) that included the SSC within the scope of the maintenance or license renewal rule.

Industrywide Operating Experience (including NRC and vendor):

Information included in NRC, industry, and vendor equipment information that are applicable and available to the nuclear industry with the intent of minimizing adverse plant conditions or situations through shared experiences.

Maintenance:

The aggregate of those functions required to preserve or restore safety, reliability, and availability of plant structures, systems, and components. Maintenance includes not only activities traditionally associated with identifying and correcting actual or potential degraded conditions, i.e., repair, surveillance, diagnostic examinations, and preventive measures; but extends to all supporting functions for the conduct of these activities. (Source: *Federal Register* Vol. 53, No. 56, Wednesday, March 23, 1988, Rules and Regulations/ Page 9340).

Performance:

Performance when used ir. the context for criteria and monitoring would include availability and reliability and/or condition as appropriate. To the maximum extent possible both availability and reliability should be used since that provides the maximum assurance that performance is being monitored. There are instances (i.e., reactor coolant system, electrical load centers, certain standby equipment, etc.) where availability does not provide a meaningful measure of performance and should not be captured. The condition of structures is more appropriate to monitor than the reliability or availability. The monitoring of individual components (e.g., unacceptable performance) when setting goals may include the monitoring of condition. Condition typically includes vibration, flow, temperature and other similar parameters.

Good outline ☆

ComEd
Structures Monitoring Program

March 28, 1996
NEI Workshop Presentation
Austin, Texas

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Mechanical & Structural Engineering
Nuclear Engineering Services

ELEMENTS OF PROGRAM

I. Introduction

II. Definitions

III. Structures Identification

IV. Functional Failures

V. Examination Criteria

VI. Evaluation of Results

VII. Examination Frequency

VIII. Qualification of Personnel

IX. Documentation Requirements

IDENTIFICATION OF STRUCTURES

Step 1: Identify Structures

Step 2: Identification of Structural Elements

- concrete
- steel
- masonry
- equipment foundations
- roofing
- component supports
- vertical tanks
- buried piping
- structural isolation gaps
- watertight doors

IDENTIFICATION OF STRUCTURES

Step 3 - Element Selection (continued)

- equipment foundations for MR applicable equipment
- roofing
  - for all structures identified in Step 1
- component supports - sampling
- vertical tanks
  - MR applicable equipment
- buried piping
- structural isolation gaps
  - affecting safety related structures
- watertight doors

EXAMINATION FREQUENCY

Templates

- current industry guidelines
  - ACI 349.3R
- practical considerations using sound engineering judgment

Note: Inspection frequencies may be adjusted based on plant specific environments or observed degradation such as

- Environments which contain aggressive chemicals
- Concrete elements found to have active cracks
- Excessive equipment vibration

PERSONNEL QUALIFICATIONS

- Administrator
  - Registered PE or SE
  - Knowledgeable
    - design
    - evaluation
    - performance requirements of structures
  - 5 years related experience
  - Degreed civil/structural engineer
- Evaluator
  - Knowledgeable
  - 5 years related experience
  - Degreed civil/structural engineer
- Inspector
  - Suitably knowledgeable or trained
  - Approved by Administrator

see Flowchart ★
and Inspection Logic
and Inspection checkshe

Con Edison Maintenance Rule

Structural Inspection Program

By: Lou Villani
Con Edison of NY
March 28, 1996

Structural Inspection Program

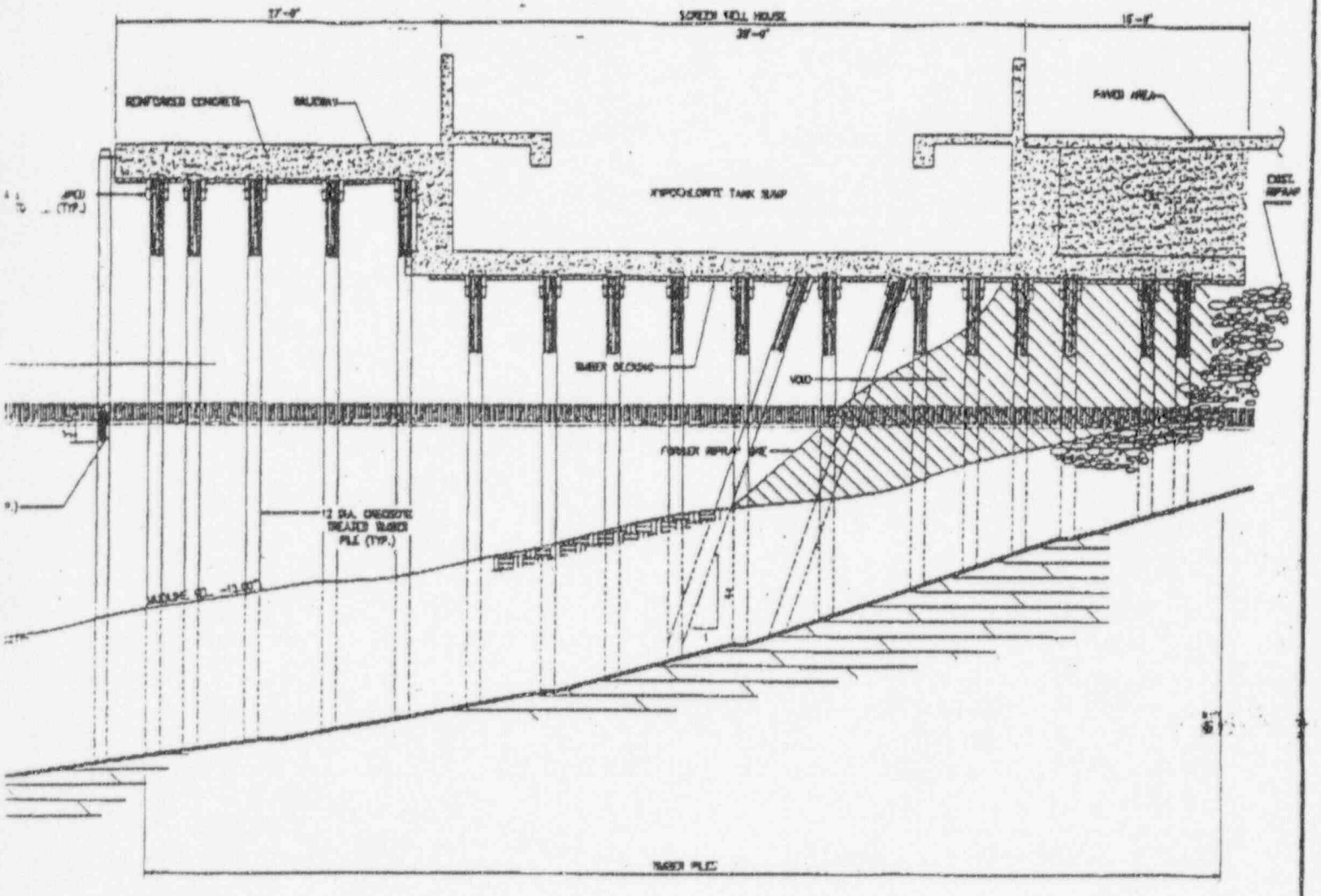
Introduction: Historical Overview

- Structures - - **8 Fossil, 1Nuclear, 10 Gas Turbine**
  - 20 Waterfront Properties
    (Steel, Concrete, Wood)
  - 34 Chimney's
    (Steel,Concrete,Brick)
  - 67 Atmos Fuel Oil Tanks
    (Residual and Distillate Oil)
  - 100's Buildings
    (Industrial and Commercial)
  - 1100 Roofs

Structural Inspection Program

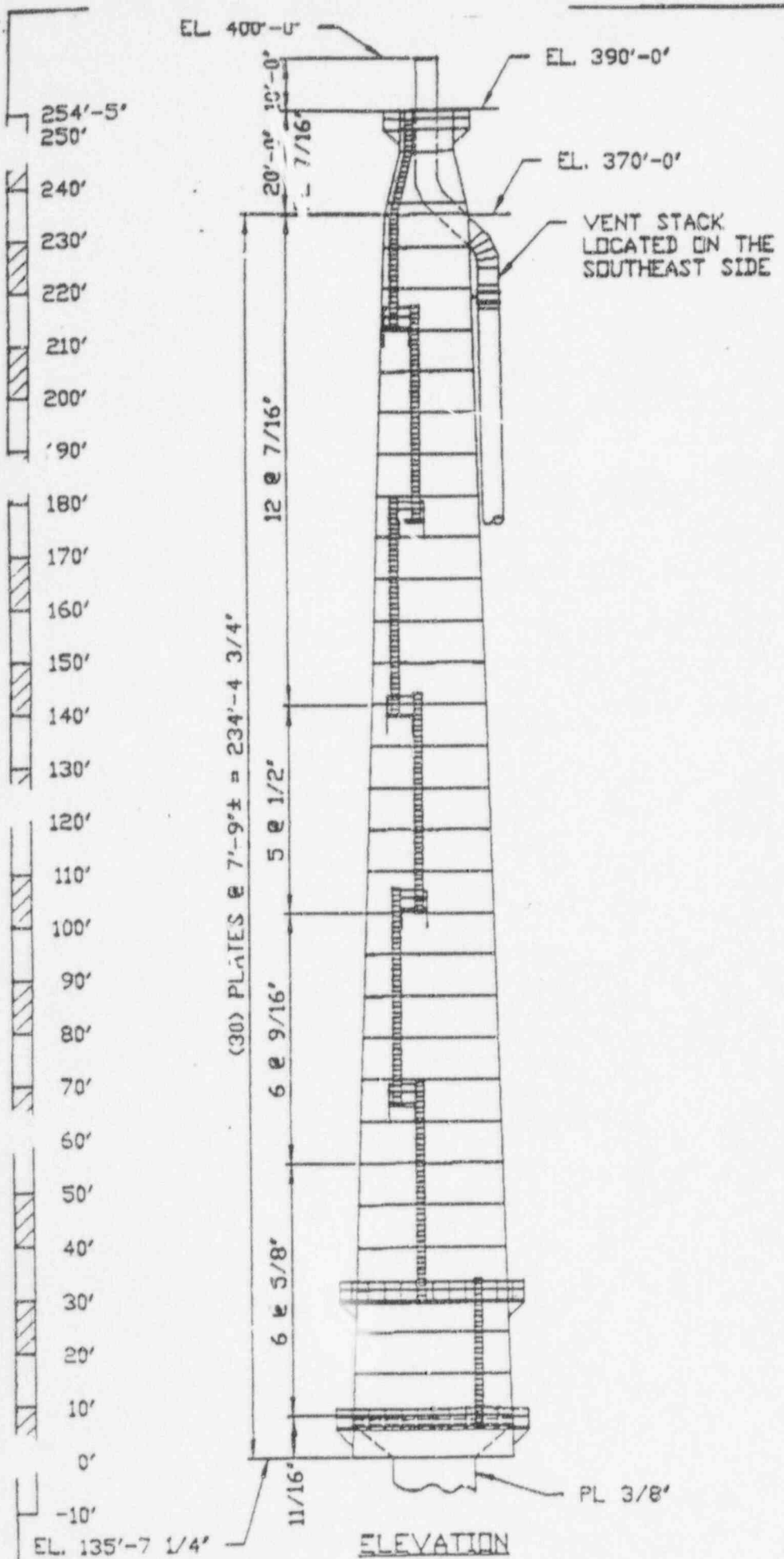
Inspection Criteria

- **Full Tactile Inspection**
- **Categorization of Findings**
  - Cat 1: Cond Req'g Immediate Actions
  - Cat 2: Cond Req'g Repairs in Nr Fut (2-3yrs)
  - Cat 3: Station Maint Items
- **Engineering Evaluation**
- **Short/Long Term Repairs**
- **Cost Estimate**
- **Standard Report, Photo's, VHS Tape**



C/4 SECTION

UCLEAR ACILITY w York	PROJECT: INDIAN POINT WATERFRONT INSPECTION			M.G. McLAREN, P.C. Consulting Engineers 100 Snake Hill Road, West Nyack, NY 10994 Tel. No. (914) 353-4420	DATE
	SHEET TITLE: NORTH TIMBER PILE SUPPORTED PLATFORM				NO. 4
	PROJECT NO. 93319	SCALE 1"=10'	DRAWN BY SMR	CHECKED BY DML	4 OF 11 SHTS



ELEVATION

408	410	391	412
.399 .425	.411 .450	.411 .430	.401 .417
.420	.424	.421	.433
.417	.426	.411	.433
.435	.429	.431	.445
.429	.451	.411	.431
.409	.452	.400	.436
.419	.461	.425	.436
.440	.464	.449	.438
.431	.421	.418	.436
.417	.427	.464	.459
.411	.452	.433	.458
.425	.438	.417	.419
.426	.431	.428	.421
.492	.505	.496	.497
.493	.509	.517	.496
.499	.537	.495	.517
.493	.535	.484	.494
.501	.486	.490	.522
.558	.550	.546	.556
.565	.570	.564	.577
.557	.566	.562	.581
.559	.590	.560	.537
.549	.563	.552	.537
.550	.567	.543	.560
.623	.582	.620	.612
.621	.555	.610	.617
.619	.645	.625	.653
.630	.613	.628	.624
.621	.653	.624	.618
.621	.645	.619	.617
.663	.678	.684	.673
NORTH	WEST	SOUTH	EAST

ULTRASONIC THICKNESS READING

Indian Point 2

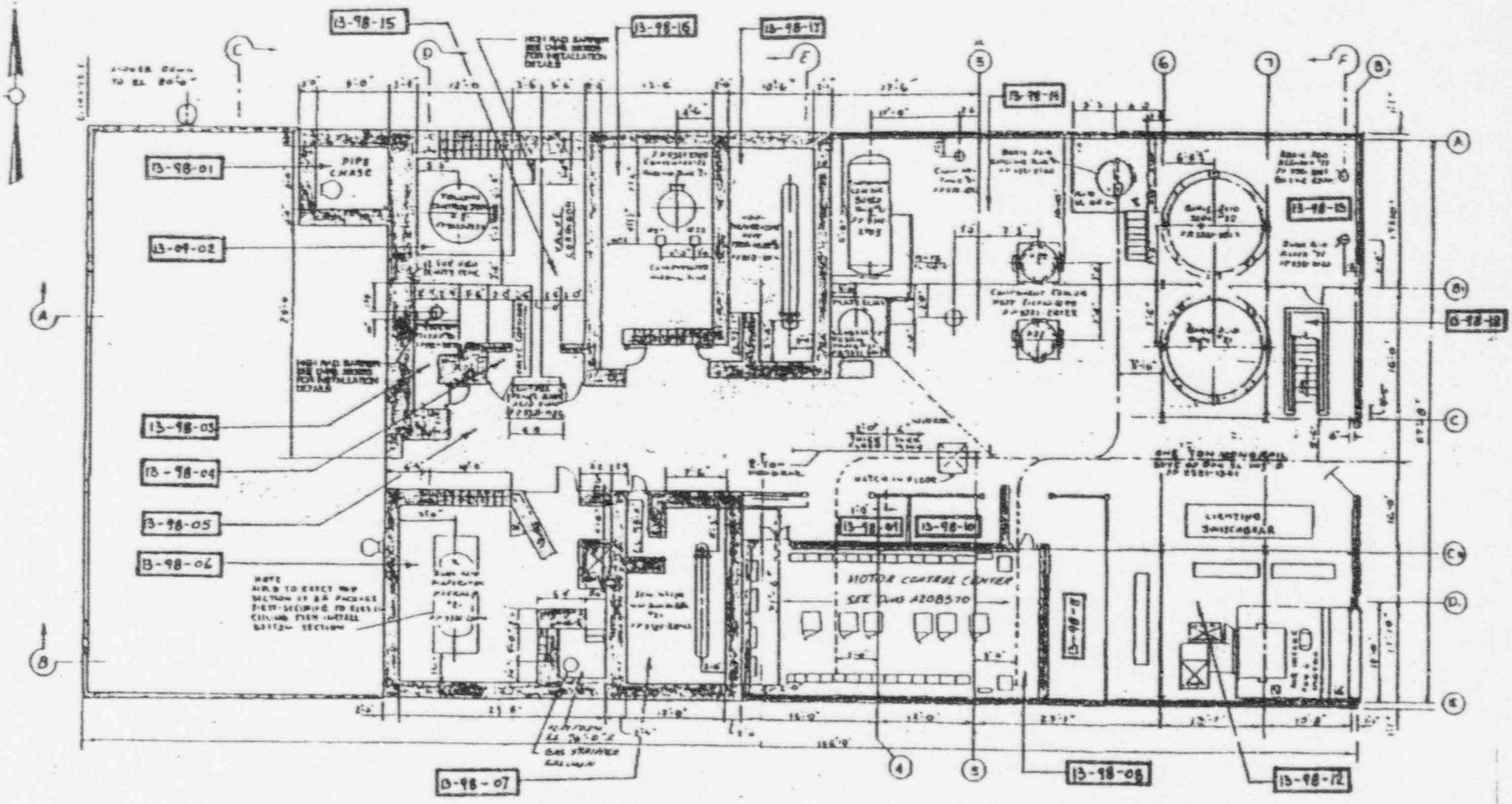
Proposed Structures Program

Items Included:

- Concrete & Steel (45 bldg's, ~750,000 sf)
- Waterfront Structures (600' long)
- Stack (250' high)
- Atmospheric Tanks (20)
- Tunnels (3, longest 1250')
- Roofs/Doors/Windows
- Fire Walls
- Sitework/Drainage

Sample Program Logic

- Structural inspection team - 2 Civil Engineers.
- Utilize inspection checklist for various structural components.
- Download data & evaluation results into database program.
- Schedule corrective action/monitoring program.
- Follow through construction.
- Assimilate final data into database.



PLAN @ EL. 98'-0"
(13-98)

UNIT NO. 2 PRIMARY AUXILIARY BUILDING. (REF. DWG. 9321-F-2510)

REFERENCE DATA

REFERENCE DRAWINGS: _____

_____

_____

_____

DESIGN LOADINGS:

		REF.			REF.
WIND LOAD:			SEISMIC LOAD:		
SNOW LOAD :			INTERNAL PRESSURE:		
D.L.			OTHER :		
L.L.					

SKETCH OF INSPECTED AREA
(FLOOR MAP KEY #)

TOTAL AREA INSPECTED: _____ SQ. FT.

Questions To Be Answered

TECHNICAL:

- How many total deficiencies ?
- How many deficiencies are structural stress related ?
- How many deficiencies are non-structural ?
- How many water infiltration problems ?
- How many coating problems ?
- Is the deficiency a recurring problem ?
-
-

ADMINISTRATIVE:

- What was cost of inspections ?
- How much time was spent on evaluation process ?
- What was average "turn around time" for corrective action to be completed ?
- Which structure had the most deficiencies ?
- How much money will need to be invest for life extension ?
- How many personnel safety deficiencies ?
-
-

PMAI 96-05-023
ATTACHMENT 2
26 PAGES
(INCLUDING THIS SHEET)