THREE MILE ISLAND NUCLEAR GENERATING STATION UNIT - 1

DOCKET NO. 50-289

USNRC I.E. BULLETIN NO. 79-02 FINAL REPORT

TOPICAL REPORT # 002

PROJECT NO: 5020-G5300

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TECHNICAL FUNCTIONS
(SIGNIFICANT IMPACT REVIEW)

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I. INTRODUCTION

An inspection and testing program to comply with USNRC I.E. Bulletin 79-02 (entitled "Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts") requirements including engineering evaluations has been completed. Selection of anchors for inspection and testing have utilized both sampling methods that are recommended by the Bulletin.

The Seismic Category I Systems, as well as portions of other systems defined as Category I that were inspected, tested and evaluated are as follows:

System	System
Emergency Feedwater	Condensate
Spent Fuel	Core Flooding
[2]Waste Disposal	Decay Heat Removal
Reactor Coolant	Decay Heat Closed Cycle
[3]Chilled Water	[1]Feedwater
[1]Intermediate Cooling	Instrument Air
Building Spray	[2]Monitoring Post Accident Purge
River Water	[1]Leak Rate
	[1]Main Steam
	Make-Up & Purification
	Nuclear Services Closed Cycle Cooling

[1]FSAR Seismic Category III System. Inspected Portion - Seismic Category I.

[2]FSAR Seismic Category II System. Inspected Portion - Seismic Category I.

[3]FSAR Listing - Vital Ventilation System, Control Building

Per bulletin requirements, the anchor bolts were evaluated such that the necessary factors of safety as defined by the bulletin were satisfied. Anchors that have a factor of safety less than five (5) during the Design Basis Earthquake (DBE) were designated for repair/redesign. Those supports that have a governing factor of safety less than two (2), will be repaired/redesigned before plant start up. Where practical redesign will be based on 2-DBE.

The following is a list of action items that are required by I.E. Bulletin 79-02 with Metropolitan Edison's response signifying compliance for TMI-Unit 1.

Bulletin Action Item 1

Verify that pipe support base plate flexibility was accounted for in the calculation of anchor bolt loads. In lieu of supporting analysis justifying the assumption of rigidity, the base plates should be considered flexible if the unstiffened distance between the member welded to the plate and the edge of the base plate is greater than twice the thickness of the plate. It is recognized that this criterion is conservative. Less conservative acceptance criteria must be justified and the justification submitted as part of the response to the Bulletin. If the base plate is determined to be flexible, then recalculate the bolt loads using an appropriate analysis. If possible, this is to be done prior to testing of anchor bolts. These calculated bolt loads are referred to hereafter as the bolt design loads.

A description of the analytical model used to verify that pipe support base plate flexibility is accounted for in the calculation of anchor bolt loads is to be submitted with the response to the Bulletin.

Response to Action Item I

Base plates were considered rigid in the original design. Analytical techniques were developed for reexamination of base plates and anchorages considering base plate flexibility and expansion bolt stiffness both for moment and axial load applied to the plate surfaces (Appendix I). The equations were derived from statics and deflection compatibility. The prying force on the plate and, subsequently, forces in the anchors and stresses in the plates were calculated.

Response to Action Item 1 (cont'd)

The expansion bolt stiffness (i.e. K_s in Appendix I) was derived from force-displacement curves provided by the manufacturer. For both the moment and the axial load case, a criterion was formulated to determine whether prying exists based upon the geometry of the detail and material properties of the plate and anchor. Analyses of the design review showed that prying effects were small or negligible. Additional analyses on a large variety of base plates substantiated the finding. This result was attributed to low expansion bolt stiffness and the lack of appreciable bolt preload. Although the original design assumption of rigid plate behavior is considered justifiable, considerations for prying were conservatively used for all subsequent bulletin evaluations performed on concrete expansion anchors. A description of the analytical model and more information are included in Appendix I.

Bulletin Action Item 2

Verify that the concrete expansion anchor bolts have the following minimum factor of safety (FS) between the bolt design load and the bolt ultimate capacity determined from static load tests (e. g. anchor bolt manufacturer's) which simulate the actual conditions of installation (i.e., type of concrete and its strength properties):
a. Four - For wedge and sleeve type anchor bolts, or
b. Five - For shell type anchor bolts.
The bolt ultimate capacity should account for the effects of shear-tension interaction, minimum edge distance, and proper bolt spacing. If the minimum factor of safety of four for wedge type anchor bolts and five for shell type anchors cannot be shown, then justification must be provided. The Bulletin Factors of safety were intended for the maximum upport load including the SSE. The NRC has not yet been provided adequate justification that lower factors of safety are acceptable on a long term basis. Lower factors of safety are allowed on an interim basis by the provisions of Supplement No. 1 to I.E. Bulletin No. 79-02. The use of reduced factors of safety in the factored load approach of ACI 349-76 has not yet been accepted by the NRC.

Response to Action Item 2

A. Anchor Type

The anchors originally used at TMI-1 on Seismic Category 1 piping are the Red Head self-drilling "shell" type anchors manufactured by ITT Phillips Drill Division. These are an approved equal to the "RAWL" anchors, which were specified on the design drawings. Some Hilti "TZD" shell anchors were used in the Chilled Water System. "Shell" type anchors require a minimum factor of safety (FS) of five (5).

B. Ultimate Anchor Capacity

1. Shear and Tension Effects

For all base plates, shear and tension effects were combined directly to evaluate the anchors with the resultant shear force being distributed equally to all anchors in the connection. The following paragraphs describe the method for combining these effects.

The factor of safety (FS) is determined using the following shear-tension interaction equation:

$$FS = \frac{1}{\frac{T_a}{T_o} + \frac{V_a}{V_o}}$$

where: FS = Factor of safety

T_a = Tension Force induced into an anchor (considering plate flexibility)

T_o = Ultimate tension capacity of an anchor*,**

V_a = Shear Force induced into an anchor

V_o = Ultimate shear capacity of an anchor*

*Ultimate tensile and shear capacities were based on the manufacturer's anchor capacity data. However, some evaluations had the advantage of larger ultimate tensile pullout capcities, obtained from the on-site testing program once the data became available. See Appendix II, Att. 1, pg. 1 of 9.

**In those cases where a small permanent deformation (anchor extraction) due to test loads (explained in Response to Action Item 4 page 14) were exhibited and the anchor had a deviation from the acceptance criteria, the anchor was either discounted or had its allowable tension capacity reduced to a percentage of the manufacturer's allowable anchor capacity. The effect of this reduction was an increased factor of

safety when compared to the use of manufacturer's ultimate capacity. The anchor was not evaluated using the increased factor of safety, but using the reduced factor of safety resulting from reducing the ultimate tensile allowable. The evaluation was done and if required, the support was designated for repair/redesign per the guidelines established in the introduction on page 1.

2. Minimum Edge Distance Effects

The minimum edge distance between the anchor centerline and the edge of a concrete member is required to be 5 shell diameters or 4 inches, whichever is greater. If this criterion was not met, anchor capacities were linearly reduced.

3. Bolt Spacing Effects

In accordance with the manufacturer's instructions for Phillips ITT Red Head self-drilling shell type anchors, anchor-to-anchor spacings greater than 7 shell diameters develop 100% of the published ultimate strength, and spacings of 3-1/2 shell diameters develop 80%. Therefore, in those cases where the spacing is less than 7 and greater than 3-1/2 shell diamters, the anchor capacity has been linearly reduced. These factors were later checked and found to be conservative by the on-site testing program for close-spaced anchors (Appendix II, Att. 2).

C. Original Design Loads Versus Bulletin Requirements

1. Original Design Load

Pipe support loads were generated as an output of a dynamic piping analysis and were utilized for the design of the individual pipe supports.

Original Design Load (cont'd)

The governing load combination is:

Deadweight + Thermal + OBE* Seismic + Occasional Mechanical Loads = Total design load

*OBE - Operating Basis Earthquake =Design Basis Earthquake (DBE) as defined in FSAR

2. Bulletin Requirements

An anchor bolt inspection and test program, per Bulletin Action Item 4, as well as a support "as-built" program in conjunction with NRC Bulletin 79-14 has been complete. All anchor loads and factor of safety are based on engineering evaluations of the above programs, which may differ from the original design loads, due to "as-built" conditions.

Revision 2 of the Bulletin clarified the intent of Revision 1 and Supplement No. 1 requirements by stating that the FS of 5.0 for shell type anchors was intended for the "worst case" load combination including the SSE. As a result of this clarification which represented more conservative requirements than had been previously applied to the TMI work, an extensive investigation was carried out to determine the consequences of using a "worst case" load combination including SSE. The effect due to two times the DBE was used to conservatively approximate the SSE. The following two (2) sections compare these evaluations.

Results for Design Basis Earthquake (DBE)

An engineering evaluation, based on as-built conditions, was performed on 452 supports which represents those supports with anchor/base plate "deviations". This compares to an inspection total of 828 supports which excludes the Chilled Water System. For a "worst case" load combination including 1 DBE, 148 supports, (17.9 percent of those inspected) have anchors with a FS of less than 5.

Results for Safe Shutdown Earthquake (SSE)

SSE = Maximum Hypothetical Earthquake as defined in FSAR

Based on an engineering evaluation of the as-built condition, 29.5 percent of the supports (244) include anchors with a FS less than 5.0 assuming a "worst case" load combination including 2 DBE.

Any support with an anchor which had a factor of safety less than five (5) for the 1-DBE load case was designated for repair/redesign. All supports with a governing factor of safety less than two (2) for the 1-DBE load case will be reevaluated in conjunction with I.E. Bulletin 79-14 and repaired/redesigned before plant start-up. The redesigns will be done to accommodate the 2-DBE loads, where practical.

Bulletin Action Item 3

Describe the design requirements if applicable for anchor bolts to withstand cyclic loads (e.g. seismic loads and high cylce operating loads).

Response to Action Item 3

Anchor bolt loads are derived from pipe support reactions which are generated as an output of dynamic analyses. These analyses include seismic and mechanical loads as the governing load combination. Occasional operating loads were identified during start-up testing. Pipe support system modifications were made at that time to accommodate these vibrating loads.

Bulletin Action Item 4

Verify from existing Quality Control (QC) documentation that design requirements have been met for each anchor bolt in the following areas:

(a) Cyclic loads have been considered (e.g. anchor bolt preload is equal to or greater than bolt design load). In the case of the shell type, assure that it is not in contact with the back of the support plate prior to preload testing.

(b) Specified design size and type is correctly installed (e.g. proper embedment depth).

If sufficient documentation does not exist, then initiate a testing program that will assure that minimum design requirements have been met with respect to sub-items (a) and (b) above. A sampling technique is acceptable. One acceptable technique is to randomly select and test one anchor bolt in each base plate (i.e. some supports may have more than one base plate). The test should provide verification of sub-items (a) and (b) above. If the test fails, all other bolts on that base plate should be similarly tested. In any event, the test program should assure that such Seismic Category I system will perform its intended function.

The preferred test method to demonstrate the bolt preload has been accomplished is using a direct pull (tensile test) equal to or greater than design load. Recognizing this method may be difficult due to accessibility in some areas; an alternative test method such as torque testing may be used. If torque testing is used, it must be shown and substantiated that a correlation between torque and tension exists. If manufacturer's data for the specific bolt used is not available, or is not used, then site specific data must be developed by qualification tests.

Bulletin Action Item 4 (cont'd)

Bolt test values of one-fourth (wedge type) or one-fifth (shell type) of bolt ultimate capacity may be used in lieu of individually calculated bolt design loads where the test value can be shown to be conservative.

The purpose of Bulletin No. 79-02 and this revision is to assure the operability of each Seismic Category I piping system. In all cases an evaluation to confirm system operability must be performed. If a base plate or anchor bolt failure rate is identified at one unit of a multi-unit site which threatens operability of safety related piping systems of that unit, continued operation of the remaining units at that site must be immediately evaluated and reported to the NRC. The evaluation must consider the generic applicability of the identified failures.

Appendix A describes two sampling methods for testing that can be used. Other sampling methods may be used but must be justified. Those options may be selected on a system by system basis.

Justification for omitting certain bolts from sample testing which are in high radiation areas during an outage must be based on other testing or analysis which substantiates operability of the affected system.

Bolts which are found during the testing program not to be preloaded to a load equal to or greater than bolt design load must be properly preloaded or it must be shown that the lack of preloading is not detrimental to cyclic loading capability. Those licensees that have not verified anchor bolt preload are not required to go back and establish preload. However, additional information should be submitted which demonstrates the effects of preload on the anchor bolt ultimate capacity under dynamic loading. If it can be established that a tension load on any of the bolts does not exist for all loading cases, then no preload or testing of the bolts is required.

If anchor bolt testing is done prior to completion of the analytical work on base plate flexibility, the bolt testing must be performed to at least the original calculated bolt load. For testing purposes, factors may be used to conservatively estimate the potential increase in the calculated bolt load due to base plate flexibility. After completion of the analytical work on the base plates, the conservatism of these factors must be verified.

For base plate supports using expansion anchors, but raised from the supporting surface with grout placed under the base plate, for testing purposes, it must be verified that leveling nuts were not used. If leveling nuts were used, then they must be backed off such that they are not in contact with the base plate before applying tension or torque testing.

Bulletin No. 79-02 requires verification by inspection that bolts are properly installed and are of the specified size and type. Parameters which should be included are embedment depth, thread engagement, plate bolt hole size, bolt spacing, edge distance to the side of a concrete member, and full expansion of the shell for shell type anchor bolts.

If piping systems 2 1/2 inch in diameter or less were computer analyzed, then they must be treated the same as the larger piping. If a chart analysis method was used and this method can be shown to be highly conservative, then the proper installation of the base plate and anchor bolts should be verified by a sampling inspection. The parameters inspected should include those described in the preceding paragraph. If small diameter piping is not inspected, then justification of system operability must be provided.

Response to Action Item 4

QC documentation for the original installation was incomplete. An on-site inspection and testing program was conducted to check if design and installation requirements were met.

4a. Since "shell" type anchors were used at TMI-1, anchor preload was not a factor in the inspection program (i.e., bolt preload is not needed to set bolt). Testing was accomplished, for the most part, by a direct tension pull of the anchor shell. A section of a site approved inspection and testing procedure provided for shimming base plates which prevented contact between the base plate and shell for testing of shell anchors protruding from the concrete surface. A Torque/Tension correlation test was conducted on-site to substantiate any anchor testing accomplished by torquing.

Anchors installed with plug depth within procedure tolerance and satisfying all the other acceptance criteria were loaded to a value of 20 percent or 1/5 of the manufacturer's ultimate tensile capacity (TEST LOAD). Anchors installed that did not meet the procedure acceptance criteria were loaded to a value of 40 percent or 2/5 of the manufacturer's ultimate tensile capacity (PROOF LOAD). In either case, if the load was achieved with less than 1/16 inch shell movement (extraction) the anchor test was considered acceptable.

Any anchor that exhibited shell movement more than 1/16 of an inch during the application of the TEST or PROOF LOAD was discounted during engineering evaluation.

After an acceptable anchor test (i.e. no movement or less than 1/16 inch movement) the following occurred:

A. If the anchor accepted the TEST LOAD (i.e. no procedure deviations) the manufacturers ultimate tensile capacity was used for engineering evaluation.

B. If the anchor accepted the PROOF LOAD (i.e. one or more deviations) the ultimate tensile capacity was reduced to 40 percent of the manufacturer's ultimate tensile capacity. The reduced ultimate tensile capacity was then used for engineering evaluation. The working load was also devaluated and reestablished at a maximum of 10% of ultimate tensile capacity for engineering evaluation.

The ultimate capacities used as a basis for determining the test and proof loads were obtained from the manufacturer's bolt capacity data. Based on actual site anchor bolt testing, the manufacturer's bolt capacity data is conservative (refer to Appendix II). The 20% of manufacturer's ultimate capacity test load value was also proven conservative by subsequent engineering evaluations which included considerations for plate flexibility. Inspection & testing was done on large bore (2 1/2 inch diameter and larger) Seismic Category I piping systems.

4b. Selection of anchors for inspection and testing utilized both sampling methods recommended by the Bulletin. All supports within scope were inspected for existance, conformity to design, and integrity. Some supports were not tested due to physical limitations; however, a case by case evaluation was conducted to justify system operability. Appendix III contains a list of inspection parameters and sample documentation forms that address Bulletin requirements.

Grouted Base Plates

A total of 75 supports utilized grouted base plates. For anchors with grouted base plates, no testing was performed due to the destructive nature of the testing (i.e., removing grout). In addition, initial attempts at testing such anchors without removing grout resulted

in broken bolts. This was caused by bonding between the stud and shell, resulting from the grouting process. Further attempts at testing with grout removal would have damaged the shell, resulting in an anchor defect and major repair. A high degree of confidence is had in the original installation of such anchors, since accessibility and ease of installation is inherent in a floor level anchor application. The anchor size and location along with base plate parameters were inspected and recorded. Leveling nuts used in conjunction with grouted base plates do not affect the load bearing capacity of shell type anchors. In the case of systems inspected by the random sample method, an additional anchor was selected for inspection and testing to complete the sample population.

A system operability evaluation of supports with grouted base plates was also conducted. This evaluation considered type and magnitude of loading, potential deviations in anchor installation, along with interaction of subject supports. The results were acceptable and system operability was substantiated.

Small Bore Piping

Seismic Category I small bore (two inch nominal diameter and smaller) pipe was designed using a seismic support spacing criteria. The criteria were developed for a multi-span model for each pipe diameter and schedule based on a conservative pipe stress of 25 percent of the code allowable stress (ANSI B31.1, 1967). The spacing criteria provided maximum pipe spans and support loads for that span. The support spacing criteria approach was independently verified by dynamic computer analyses on randomly selected systems.

Typical support configurations were designed and analyzed for structural adequacy of all members, including the anchors. In generating the load rating, the

geometry combination of the maximum distance from the pipe to the structure, in conjunction with the smallest spacing between anchors resulted in the worst load case. Typically, the computer-analyzed pipe systems indicated factors of safety in excess of 15 for 85 percent of the anchors. No anchor had a factor of safety less than five. A sample of small bore Seismic Category I pipe supports, with anchors, was inspected and tested. The sample was selected to represent a variety of installation situations (i.e., floor, wall, difficult access, etc.). A total of 70 anchors in 53 supports from seven (7) systems were included in the sample. The results of the testing indicated two (2) anchors were "defective". Defective is defined as an anchor which was found in a condition such that it could not provide resistance equal to the 20% of rated ultimate capacity or greater test load. The defective anchors had no adverse effect on system operability and were scheduled for repair. No further inspection and testing of small bore piping was performed.

Bulletin Action Item 5

Determine the extent that expansion anchor bolts were used in concrete block (masonry) walls to attach piping supports in Seismic Category 1 systems (or safety related systems as defined by Revision 1 of I.E. Bulletin No. 79-02). If expansion anchor bolts were used in concrete block walls:

a. Provide a list of the systems involved, with the number of supports, type of anchor bolt, line size, and whether these supports are accessible during normal plant operation.
b. Describe in detail any design consideration used to account for this type of installation.
c. Provide a detailed evaluation of the capability of the supports, including the anchor bolts, and block wall to meet the design loads. The evaluation must describe how the allowable loads on anchor bolts in concrete block walls were determined and also what analytical method was used to determine the integrity of the block walls under the imposed loads. Also describe the acceptance criteria, including the numerical values, used to perform this evaluation. Review the deficiencies identified in the Information Notice on the pipe supports and walls at Trojan to determine if a similar situation exists with regard to supports using anchor bolts in concrete block walls.
d. Describe the results of testing of anchor bolts in concrete block walls and any plans and schedule for any further action.

Response to Action Item 5

Response 5a - The solid block wall supports are accessible during plant operation. No supports were found anchored to hollow block walls. The total extent of concrete expansion anchors used in solid block walls is as follows:

Response to Action Item 5 (cont'd)

SYSTEM: Nuclear Services Closed Cycle Cooling.

Support Number	Analysis Number (ME-No.)	Anchor Type W/Size	Nominal Pipe Size Supported
NSH-101	187	Red Head -1/2"Ø	4"Ø
NSH-106	188	Red Head -3/8"Ø	4"Ø
NSH-107	188	Red Head -5/8"Ø	4"Ø
NSH-117	186	Red Head -1/2"Ø	4"Ø
NSH-122	140/142	Red Head -1/2"Ø	6"Ø

Response 5b - The design considerations for supports anchored to solid block walls were the same as those given to supports anchored to poured concrete walls.

Response 5c and 5d - The anchors were inspected and tested per the approved inspection procedure. All anchors accepted a tension test load of forty percent of the rated ultimate capacity for concrete installation and were found to have an acceptable factor of safety against this proof load. The capacity of the block walls is being evaluated under the I.E. Bulletin 80-11 scope of work.

Bulletin Action Item 6

Determine the extent that pipe supports with expansion anchor bolts used structural steel shapes instead of base plates. The systems and lines reviewed must be consistent with the criteria of I.E. Bulletin No. 79-02, Revision 1. If expansion anchor bolts were used as described above, verify that the anchor bolt and structural steel shapes in these supports were included in the actions performed for the Bulletin. If these supports cannot be verified to have been included in the Bulletin actions:

a. Provide a list of the systems involved, with the number of supports, type of anchor bolt, line size, and whether the supports are accessible during normal plant operation.
b. Provide a detailed evaluation of the adequacy of the anchor bolt design and installation. The evaluation should address the assumed distribution of loads on the anchor bolts. The evaluation can be based on the results of previous anchor bolt testing and/or analysis which substantiates operability of the affected system.
c. Describe any plans and schedule for any further action necessary to assure the affected systems meet Technical Specifications operability requirements in the event of an SSE.

Response to Action Item 6

The 79-02 Response Program for TMI-1 has included pipe supports utilizing structural shapes as well as base plates in the scope of work.

Bulletin Action Item 7

For those licensees that have had no extended outages to perform the testing of the inaccessible anchor bolts, the testing of anchor bolts in accessible areas is expected to be completed by November 15, 1979. The testing of the inaccessible anchor bolts should be completed by the next extended outage. For those licenses that have completed the anchor bolt testing in inaccessible areas, the testing in accessible areas should continue as rapidly as possible, but no longer than March 1, 1980. The analysis for the Bulletin items covering base plate flexibility and factors of safety should be completed by November 15, 1979. Provide a schedule that details the completion dates for I.E. Bulletin No. 79-02, Revision 2, items (1), (2), and (4).

Response to Action Item 7

Response to Action Items one (1), two (2), and four (4) is considered complete at this time. No further testing is planned. Supports inaccessible for testing were justified by evaluation or other testing. The reported findings for Action Item two (2) may be impacted by the results of work in progress for the I.E. Bulletin 79-14 program. Any effects on these findings will be reported in a revision to the I.E. Bulletin 79-14 Final Report. These effects will be determined prior to plant startup.

Bulletin Action Item 8

Maintain documentation of any sampling inspection of anchor bolts required by item 4 on site and available for NRC inspection. All holders of operating licenses for power reactor facilities are requested to complete items 5, 6, and 7 within 30 days of the date of issuance of Revision No. 2. Also describe any instances not previously reported, in which the revised (R2) sections of items 2 and 4 were not met and, if necessary, any plans and schedule for resolution. Report in writing within 30 days of the date of this revision issuance, to the Director of the appropriate Regional Office, completion of your review. For action not yet complete, a final report is to be submitted upon completion of action. A copy of the report(s) should be sent to the United States Nuclear Regulatory Commission, Office of Inspection and Enforcement, Division of Reactor Operations Inspection, Washington, D.C. 20555. These reporting requirements do not preclude nor substitute for the applicable requirements to report as set forth in the regulations and license.

Response of Action Item 8

Compliance to the action item is complete in that documentation has been filed at the site and response to Revision 2 of the Bulletin has been sent to the USNRC (REF. GOL 1582 dated 1/10/80). In addition, the intent of this report is to be the final report on all activities completed in response to I.E. Bulletin 79-02 and in compliance with technical specifications.

Bulletin Action Item 9

All holders of construction permits for power reactor facilities are requested to complete items 5 and 6 for installed pipe supports within 60 days of date of issuance of Revision No. 2. For pipe supports which have not yet been installed, document any action to assure that items 1 through 6 will be satisfied. Maintain documentation of these actions on site available for NRC inspection. Report in writing within 60 days of date of issuance of Revision No. 2, to the Director of the appropriate NRC Regional Office, completion of the review and describe any instances not previously reported, in which the revised (R2) sections of items 2 and 4 were not met and, if necessary, any plans and schedule for resolution. A copy of the report should be sent to the United States Nuclear Regulatory Commission, Office of Inspection and Enforcement, Division of Reactor Construction Inspection, Washington, D.C. 20555.

Approved by GAO (R0072); clearance expires 7/31/80. Approval was given under a blanket clearance specifically for identified generic problems.

Response to Action Item 9

Not applicable to TMI-1.

III. REFERENCES

1. Metropolitan Edison I.E. Bulletin 79-02 Rev. 1 Response July 9, 1979

2. Metropolitan Edison I.E. Bulletin 79-02 Rev. 2 Response January 10, 1980

3. TMI Unit 1 FSAR Section 5.0

4. ITT Phillips Drill Division, "Red-Head Concrete Anchoring Handbook and Specifiers Guide", 1973

5. Anchor Plate Analysis Computer Program "Pry"

6. AISC "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings", November 1, 1978

7. Metropolitan Edison I.E. Bulletin 79-14 Response

8. ANSI B31.1, 1967

9. Metropolitan Edison I.E. Bulletin 80-11 Response

10. TDR-TMI-211 Prepared by Gilbert Associates, Inc. for Metropolitan Edison

APPENDIX I
FLEXIBLE PLATE ANALYSES

FLEXIBLE PLATE ANALYSIS NOMENCLATURE

V = Shear force in plate between attachment and tension bolt line

M_{DES} = Applied moment loading

T = Total tension force in bolts on one side of plate (includes any prying force)

C = Compression force on base plate due to moment loading

P_v = Total prying force on one edge of plate

E = Modulus of elasticity of base plate material

G = Shear modulus of base plate material

K_s = Spring constant for all anchors on one side of plate

e = Distance from tension bolt line to face of attachment

I = Effective base plate moment of inertia on plate tension side

I_p = Effective base plate moment of inertia on plate compressive side

L = Location of compressive force for moment loading measured from face of attachment

L_1 = Distance from bolt line to plate edge

Δ = Deflection quantities

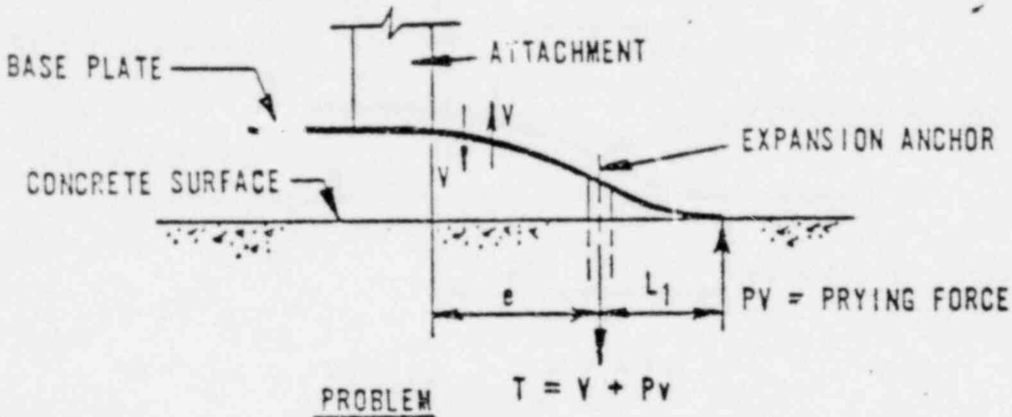
Δ_a = Anchor bolt deflection

A = Plate shear area (equals effective width times plate thickness)

W = Width of attachment

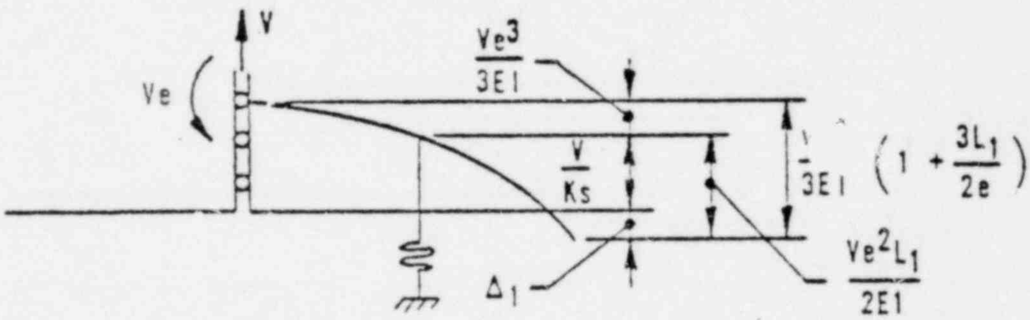
Q = Attachment and base plate rotation under moment loading

FLEXIBLE PLATE ANALYSIS FOR TENSILE LOAD



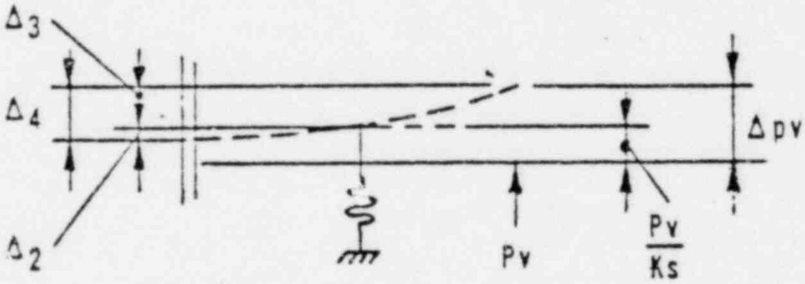
PROBLEM

THE PROBLEM IS SOLVED BY SUPERPOSITION, USING PARTS 1 AND 2 GIVEN BELOW.



PART 1

$$\Delta_1 = \frac{Ve^2L_1}{2EI} - \frac{V}{K_s}$$



PART 2

$$\Delta_3 = (\Delta_4 - \Delta_2) = \frac{P_v L_1 2e}{EI} + \frac{P_v L_1^3}{3EI} + \frac{6}{5}\frac{P_v L_1}{AG}$$

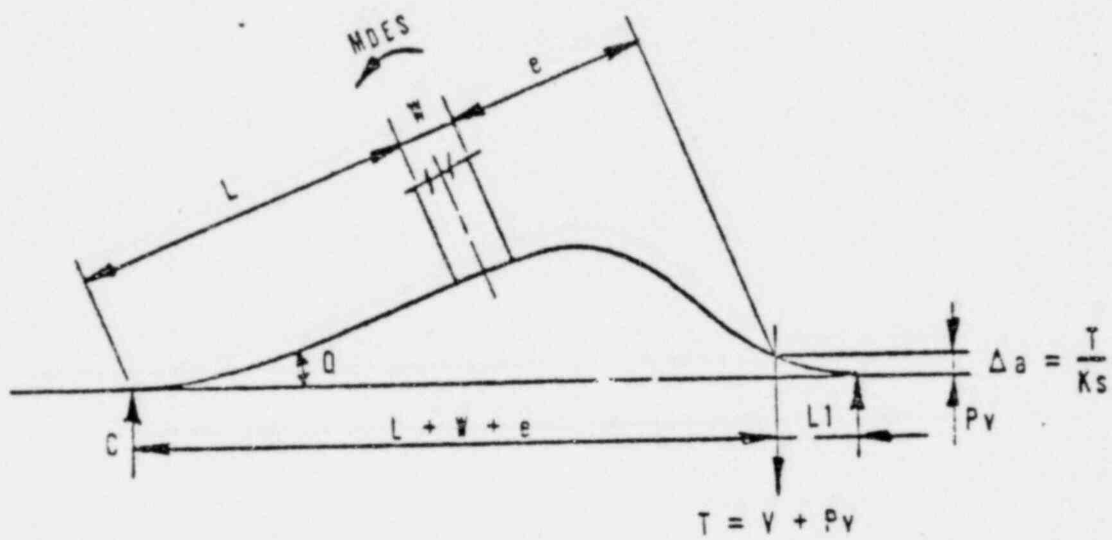
$$\Delta_{pv} = \frac{P_v}{K_s} + \frac{P_v L_1^2 e}{EI} + \frac{P_v L_1^3}{3EI} + \frac{6}{5}\frac{P_v L_1}{AG}$$

EQUATION 1 - EQUATING $\Delta_1 = \Delta_{pv}$: $\frac{P_v}{V} = \left[\frac{e^2L_1}{2EI} - \frac{1}{K_s}\right] \div \left[\frac{1}{K_s} + \frac{L_1^2 e}{EI} + \frac{L_1^3}{3EI} + \frac{6}{5}\frac{L_1}{AG}\right]$

IF $\frac{1}{K_s} \geq \frac{e^2L_1}{2EI}$ NO PRYING EXISTS AND T = V

IF $\frac{1}{K_s} < \frac{e^2L_1}{2EI}$ SOLUTION OF EQUATION 1 WILL YIELD THE PRYING FORCE Pv

FLEXIBLE PLATE ANALYSIS FOR APPLIED MOMENT



$$T = V + Pv$$

$$\Delta a = \frac{T}{Ks}$$

$$Q = \frac{VL^2}{2EIp}$$

$$L = \frac{3}{Q}\left\{\left[\Delta a - \frac{PvL_1e^2}{2EI} + \frac{Ve^3}{3EI}\right] - QW - Qe\right\}$$

$$V = \frac{MDES + PvL_1}{e + W + L}$$

$$Pv = \frac{V\left[\frac{e^2L_1}{2EI} - \frac{1}{Ks}\right] - QL_1}{\frac{1}{Ks} + \frac{L_1{}^2e}{EI} + \frac{L_1{}^3}{3EI} + \frac{6}{5}\frac{L_1}{AG}}$$

IF $\frac{V}{Ks} + QL_1 \geq \frac{Ve^2L_1}{2EI}$ NO PRYING EXISTS AND $T = V$

IF $\frac{V}{Ks} + QL_1 < \frac{Ve^2L_1}{2EI}$. SIMULTANEOUS SOLUTION OF THE SIX EQUATIONS GIVEN ABOVE WILL YIELD THE LOCATION OF THE COMPRESSIVE FORCE "C" AND THE MAGNITUDE OF THE PRYING FORCE "PV".

APPENDIX II

TMI-1 ANCHOR TEST PROGRAM

TMI-1
ANCHOR TEST PROGRAM

A test program using Red Head Self-Drilling anchors was conducted to determine the following:

1. Tension pull-out capacity of anchors installed in concrete representative of concrete throughout the plant.

2. Tension pull-out capacity of double anchor groups with center to center spacings between 2-1/2 and 3-1/2 shell diameters.

Summarized test results for the two series of tests are presented in Attachment I. Evaluation of the test data indicates that for the small diameters and shallow embedments utilized, the classical 45° failure cone is not representative of the failure mode exhibited by the test samples. Figures 6-1 and 6-2 illustrate that the total included angle of the failure cone of the TMI test specimens is in the neighborhood of 120°. The following is a excerpt from ACI 349-76, Appendix B Commentary on Steel Embedments (1978C) which discusses this phenomenon for shallow embedments:

> The nominal inclination of the failure plane for pullout of the concrete is 45 deg due to principal stress orientation if the concrete is stress free transverse to the pullout force. As the crack propagates toward the surface the uncracked portion flexes as a shallow disc putting the outer surface in compression around the perimeter and causing a change in the failure plane inclination. For shallow embedments, generally less than 5 in., the flexural strength due to the disc action is greater than the cone pullout strength such that an increase in load is required to propagate the crack. For this reason, the normal 90 deg failure cone (total angle) will approach 120 deg with decreasing anchor depth in correlating failure loads[1] to calculated values using $4\sqrt{f'_c}$ as a uniform stress. The actual concrete spall for shallow depth anchors will produce an even wider area of failure. However, caution should be observed in the utilization of inclination

angles greater than 45 deg because of the possibility of surface cracking which might restrict flexural action. For this reason the committee does not recommend the use of inclination angles greater than 45 deg for shallow depth anchors.

Section B.1.3 of ACI 349 Appendix B permits the use of design limits based on experimental investigations. With the code requirements as a basis, the TMI anchor test program results were used in the engineering evaluations reported herein.

With reference to in-place concrete strength in the Seismic Category I structures, the TMI test program was carried out in a non-Seismic Category I 3000 psi design mix concrete. Several cores were taken from the test site and the average in-place concrete strength was found to be approximately 5400 psi. Since the design mix of the Seismic Category I structures was originally 5000 psi, the current in-place strengths would be considerably higher. Therefore, applying the ultimate tensile capacities obtained using a 3000 psi design mix to a 5000 psi design mix concrete is conservative.

Design allowables based on results obtained from the testing program are presented in Attachment 2.

FIGURE 6-1
SINGLE ANCHOR-TYPICAL TENSION
TEST FAILURE CONE

FIGURE 6-2
DOUBLE ANCHOR--TYPICAL TENSION
TEST FAILURE CONE

Tension Pull-Out Capacity for Red Head Self-Drilling Anchors

Anchor Diameter (inches)	Catalog Value (lb)	Average Test Value (lb)
1/2	7480	8480
5/8	10296	10445
3/4	14256	15547
7/8	15708	20468

Tension Pull-Out Capacity for Close Spaced Red Head Self-Drilling Anchors

Anchor Spacing, S, 2-1/2 D < S < 3-1/2 D

Anchor Diameter (inches)	Average Test Value (lb)
1/2	4820
5/8	9940
3/4	10925
7/8	18336

Summary of Single Anchor Test
1/2-inch Diameter Red Heads

Test ID	Failure Load (lbs)	Average Load (lbs)
1	8200	
2	9900	
3	9460	
4	9690	
5	9900	8480
6	9100	
3A	7140	
1A	5740	
2A	7200	

[illegible] of Single Anchor Test
[illegible] Diameter Red Heads

Test ID	Failure Load (lbs)	Average Load (lbs)
11	10200	
12	11380	
13	9350	
63	13800	
69	12540	10445
5A	9920	
3A	9120	
4A	8700	
1A	9700	
2A	9740	

Summary of Single Anchor Test
3/4-inch Diameter Red Heads

Test ID	Failure Load (lbs)	Average Load (lbs)
2	17200	
3	13360	
4	16000	
9	11000	
		15547
5	13380	
6	15800	
7	20140	
8	17500	

Summary of Single Anchor Test
7/8-inch Diameter Rod Heads

Test ID	Failure Load (lbs)	Average Load (lbs)
2	24980	
3	23620	
4	25400	
5	25800	
1A	17280	20463
2A	16200	
3A	12700	
4A	17770	

Summary of Double Anchor Test Groups
1/2-inch Diameter Red Heads
Anchor Spacing S, 2-1/2 D > S < 3-1/2 D

Test ID	Group Failure Load (lb)	Load Per Anchor (lb)	Avg. Load Per Anchor (lb)
1	11000	5500	
2	8300	4150	
4	10500	5250	
5	11020	5510	
6	9700	4350	4820
7	9380	4690	
8	9940	4970	
9	9300	4150	
-	9620	4810	

Summary of Double Anchor Test Groups
5/8-inch Diameter Red Heads
Anchor Spacing S, 2-1/2 D > S < 3-1/2 D

Test ID	Group Failure Load (lb)	Load Per Anchor (lb)	Avg. Load Per Anchor (lb)
32	19390	9695	
34	24180	12090	
35	17550	8775	
36	21020	10510	
37	15900	7950	9940
38	20250	10125	
39	21300	10650	
40	19460	9730	

Summary of Double Anchor Test Groups
3/4-inch Diameter Red Heads
Anchor Spacing S, 2-1/2 D > S < 3-1/2 D

Test ID	Group Failure Load (lb)	Load Per Anchor (lb)	Avg. Load Per Anchor (lb)
44	22350	11175	
46	25320	12660	
47	19850	9925	
1A	21880	10940	
2A	24010	12005	10925
3A	21900	10950	
4A	21500	10750	
5A	18000	9000	

Summary of Double Anchor Test Groups
7/8-inch Diameter Red Heads
Anchor Spacing S, 2-1/2 D > S < 3-1/2 D

Test ID	Group Failure Load (lb)	Load Per Anchor (lb)	Avg. Load Per Anchor (lb)
49	35700	17850	
52	41140	20590	
55	39520	19760	
56	36900	18450	
57	37940	18970	18336
51	37040	18520	
53	39700	19850	
54	39120	19560	
1A	23000	11500	

ATTACHMENT 2

memorandum Gilbert/Commonwealth

January 8, 1980

to: Distribution Listed

from: J. C. Herr

subject: Three Mile Island - Unit No. 1
Red Head Self-Drilling Anchors
In-Place Capacity
W.O. 04-4692-503

Based on site testing, the average ultimate pullout capacity for subject anchors has been determined for TMI-1 concrete. Evaluation of pipe supports requiring this information will use this data. Shear capacities will be based on Red Head published data.

Ultimate Capacity For Single Anchors

Bolt Diameter (Inches)	Pullout (P_u - kips)	Shear (kips)	Min Spacing (d_m Inches)
1/2	8.5	7.3	5
5/8	10.4	13.1	6
3/4	15.5	17.8	7
7/8	20.5	20.3	8

Ultimate pullout capacities for close spaced anchors are calculated by:

$$P_R = P_u \times \left[1 - 0.6 \left(\frac{d_m - d_a}{d_m} \right) \right]$$

P_R = Reduced ultimate capacity for close spacing
P_u and d_m defined in above table
d_a = Actual spacing with a minimum of 0.35 d_m

J. C. Herr

JCH:rll

cc: F. L. Moreadith, R. M. Rogers, J. B. Groncki, G. A. Delp, R. T. Boyd, T. D. Biss, Support Evaluation Group

GAI 35 12/75

APPENDIX III

ANCHOR BOLT INSPECTION AND TEST DOCUMENTATION

ANCHOR EVALUATION

SHELL TYPE

1. Anchor Identification
2. As-Found-Torque
3. Bolt Diameter
4. Bolt Length
5. Washer Thickness
6. Plate Thickness
7. Manufacturer
8. Top-of-Plate to Top-of-Shell
9. Thread Engagement
10. Shell Placement (Rec, Flu, Pro)
11. Top-of-Plate to Top-of-Plug
12. Plug Depth (Top-of-Shell to Top-of-Plug)
13. Bolt Replaced (Length if Replaced)
14. Shims Required for Inspection (If Yes, Go to Step 19)
15. TEST LOAD/TORQUE (circle)
16. Shell Movement
17. PROOF LOAD/TORQUE (circle)
18. Shell Movement
19. Test With Shims
    a. Top-of-Plate to Top-of-Plug
    b. Top-of-Plate to Top-of-Shell
    c. Plug Depth

SUPPORT NO.
PLATE
SUPPORT DWG. NO.
DATE
INSPECTOR

TORQUE WRENCH
LOAD CELL

REVIEWER

DATA SHEET #1

SUPPORT PLATE EVALUATION

PROCEDURE NO. 7902-2
REV. 1 9-7/79

SUPPORT NO. ____________
PLATE ____________
SUPPORT DWG NO ____________

1. Measure width, length, and thickness of plate. Record.
2. Note location and size of holes (Note extra or enlarged holes).
3. Note orientation of plate, visually compare to support drawing. Note differences.
4. Visually compare gussets and attachments to support drawing. Note differences.
5. Measure bolt hole to plate edge distances (two plate edges). Record.
6. Number anchors for identification.
7. Note if grouted, indicate thickness.
8. Note gaps under plate, measure and record.
9. Leveling nuts present - indicate. (Forward Action Item Report.)

COMMENTS:

____
INSPECTION DATE

____
INSPECTOR

____
ENGINEER/DESIGNER

OFFICIAL FIELD COPY

ACTION ITEM REPORT

SUPPORT NO. ______ PLATE NO. ______ SUPPORT DRAWING NO. ______________

DESCRIPTION OF INFORMATION/ACTION NEEDED:

______________________ ______
INITIATOR DATE

RESPONSE:

______________________ ______
DATE

DISPOSITION COMPLETED:

______________________ ______
TASK MANAGER DATE

 OFFICIAL FIELD COPY

DAILY HANGER AUTHORIZATION LIST

(TO BE COMPLETED EACH DAY PRIOR TO WORK)

DATE

HANGER NOS.	TEMP. SUPPORT REQUIRED (YES/NO)	TEMP. SUPPORT DETAILS ATTACHED (YES/NO)	COMMENTS

TASK MANAGER — DATE

SHIFT FOREMAN COMMENTS:

SHIFT FOREMAN — DATE

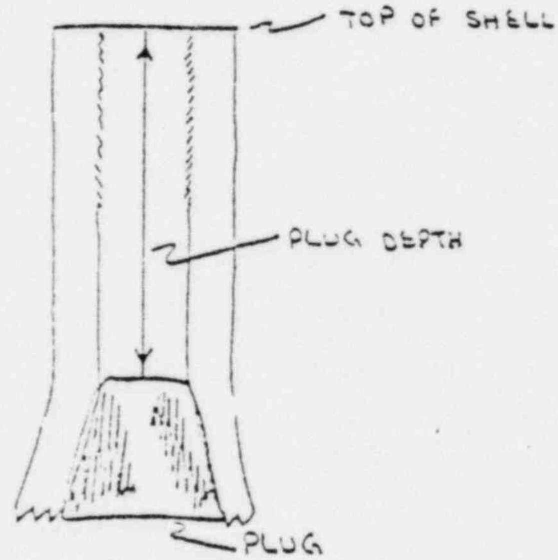
COPY TO: UNIT 1 SUPERINTENDENT, TECH SUPPORT, LEAD MECHANICAL ENGINEER

PROCEDURE TSO2-2

OFFICIAL FIELD COPY

APPENDIX I
TABLE 3

EXPANSION PLUG DEPTH
FOR
PHILLIPS RED-HEAD, TYPE 2



BOLT DIAM. (IN.)	PLUG DEPTH, IN. MINIMUM	MAXIMUM
3/8	0.65	0.91
1/2	1.03	1.28
5/8	1.28	1.53
3/4	1.84	2.10
7/8	2.14	2.40

OFFICIAL FIELD COPY

PROCEDURE 79-02-2
REV. 1 8-17-79

TEST AND PROOF LOAD REQUIREMENTS
ANCHOR: PHILLIPS RED-HEAD, TYPE 2

Bolt Diam. in.	Test Load lbs	Test Torque in-lbs (ft-lbs)	Proof Load lbs	Proof Torque in-lbs (ft-lbs)
3/8	610	140	2000	390 (32)
1/2	1130	175	3000	420 (35)
5/8	1810	300	4120	630 (53)
3/4	2710	450	5700	930 (78)
7/8	3770	1065 (89)	6285	1710 (143)

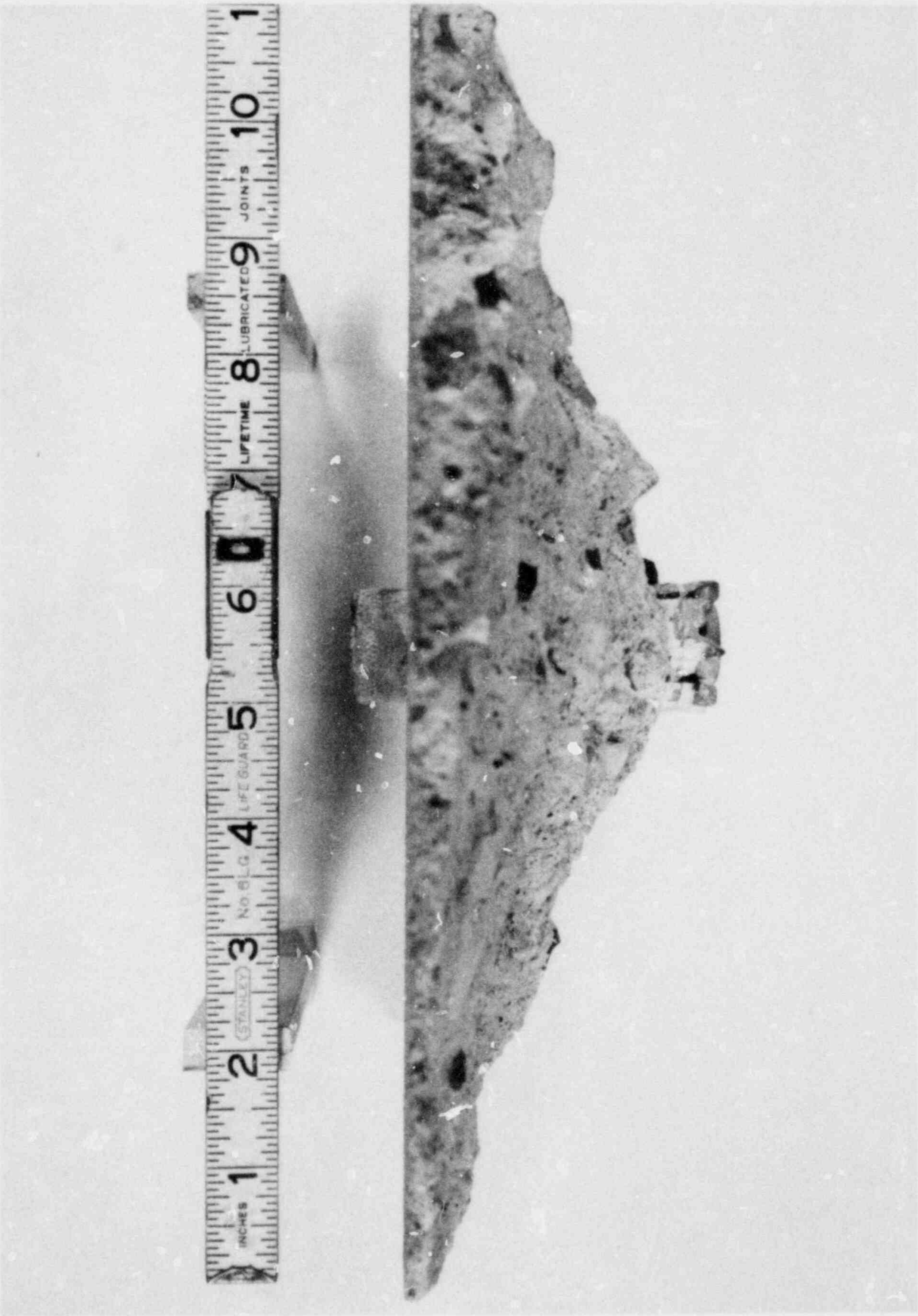


FIGURE 6-1
SINGLE ANCHOR-TYPICAL TENSION
TEST FAILURE CONE

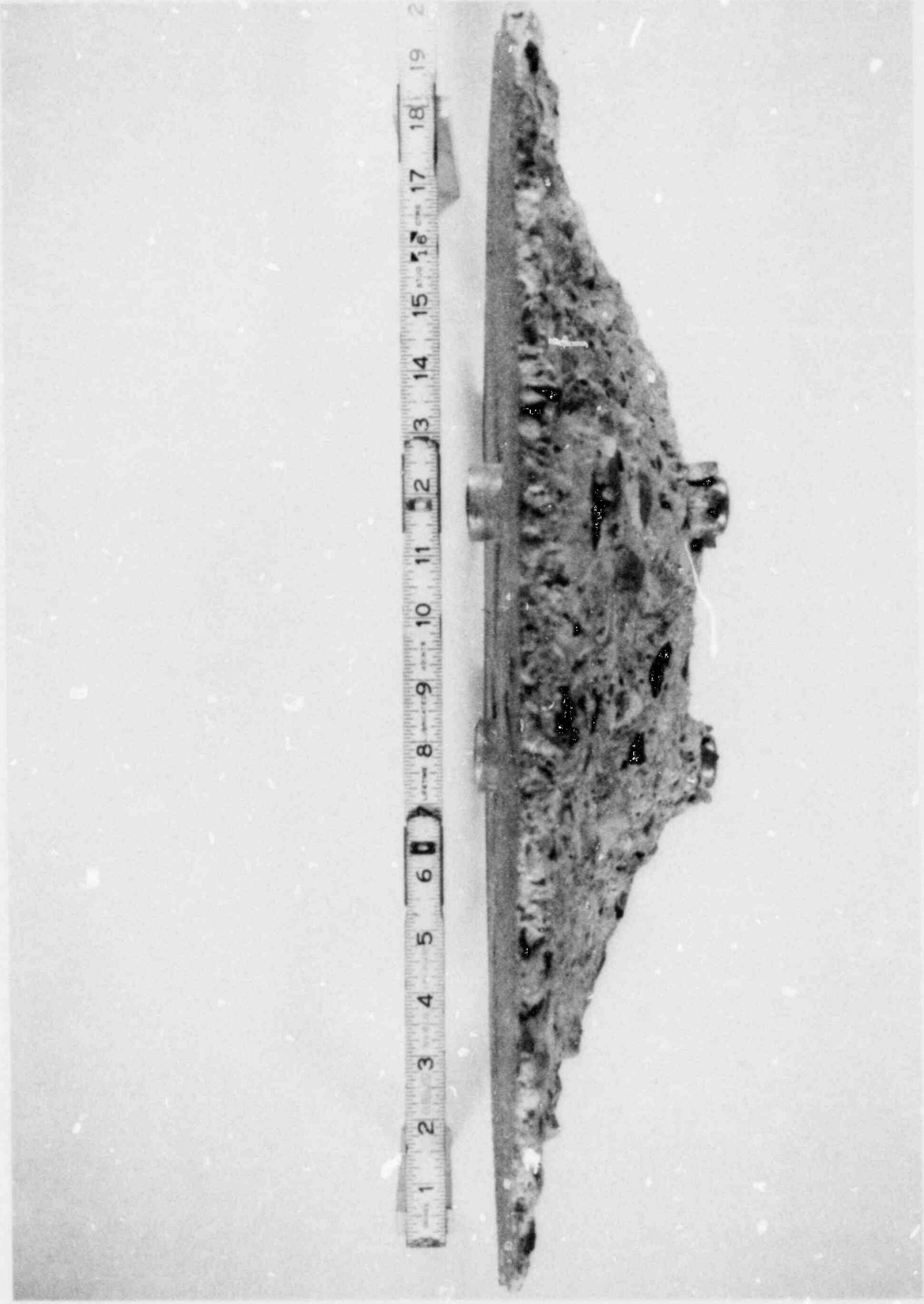


FIGURE 6-2
DOUBLE ANCHOR-TYPICAL TENSION
TEST FAILURE CONE

PHILADELPHIA ELECTRIC COMPANY

2301 MARKET STREET

P.O. BOX 8699

PHILADELPHIA, PA. 19101

(215) 841-4000

RECEIVED
SEP 10 1981
U.S. NUCLEAR REGULATORY COMMISSION

August 25, 1981

Mr. Boyce H. Grier
Director, Region I
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, PA 19406

SUBJECT: Annual Plant Modification Re_ rt
January 1, 1980, through December 31, 1980
Peach Bottom Atomic Power Station Unit Nos. 2 and 3
Docket Nos. 50-277 and 50-278

Dear Mr. Grier:

Enclosed are two copies of the Annual Plant Modification Report for Peach Bottom Atomic Power Station Unit Nos. 2 and 3 for the year 1980.

This report is being submitted pursuant to Operating Licenses DPR-44 and DPR-56, and in compliance with 10 CFR 50.59.

Very truly yours,

W. M. Alden
Engineer-In-Charge
Nuclear Section
Generation Division

IE-24
5/1