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Carolina Power & Light Company

July 12, 1979

FILE: NG-3513 (B) SERIAL: GD-79-1739

Mr. James P. O'Reilly, Director
U.S. Nuclear Regulatory Commission
Region II
101 Marietta Street, Suite 3100
Atlanta, GA 30303

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 & 2
LICENSE NOS. DPR-71 AND DPR-62
DOCKET NOS. 50-325 AND 50-324
RESPONSE TO IE BULLETIN 79-02

Dear Mr. O'Reilly:

This letter is in response to your IE Bulletin 79-02, Pipe Support Base Plate Designs Using Concrete Expansion Anchor Bolts, dated March 8, 1979, and Revision 1, dated June 21, 1979. The discussion items below correspond in number to those items in the Bulletin that requested information.

As a result of IE Bulletin 79-07, Seismic Stress Analysis of Safety-Related Piping, dated April 14, 1979, Carolina Power & Light Company committed to a total reanalysis of all safety-related piping and pipe supports to determine the revised seismic loads calculated using an acceptable computer code. As a part of this reanalysis, all pipe supports are being reviewed in detail. During this review in late May, 1979, it was determined that the design of some supports using concrete expansion anchors (Phillips Red Head expansion anchors) did not consider recommended factors of safety in specifying the expansion anchors. The two Brunswick Units were shut down to upgrade these supports, and others which had a tension problem. At that time, all supports using concrete expansion anchors were reviewed and those which might have been a problem were analyzed in detail. All supports determined to be underdesigned in this analysis were corrected prior to restarting. The remaining base plates would be analyzed in detail in accordance with the reanalysis schedule and system priority as indicated in our letter of May 21, 1979, to Mr. T. A. Ippolito.

The status of the analytical review of concrete fastener capacities is as follows:

a. The review of all anchor capacities in the drywell has been completed for the revised seismic loads. Six supports required modifications which were performed during the plant outage in May-June, 1979.

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b. The review of all remaining anchors in the plant for new seismic loads is currently in progress. Approximately 84% have been completed.

Although the capacities for new seismic loads have not yet been determined for all supports outside the drywell, all support details have been reviewed to identify those supports where structural integrity appeared to be in question. Based on that review, three supports were modified during the May-June, 1979, outage.

c. Where expansion bolt allowable design loads are found to be exceeded in the current review, but where structural integrity is maintained, the support is identified and will be modified during a scheduled outage.

d. The current support evaluation program will be completed by July 21, 1979, and will be forwarded as part of our response to IE Bulletin Number 79-07.

Response to Item 1

Initial calculations for base plate design did not account for base plate flexibility. However, a review of the load carrying capability of the base plates has not revealed any generic problems because of not taking into consideration the effect of plate flexibility. Some isolated problems were found and have been repaired.

During the review for IE Bulletin 79-07 as discussed above, calculations are being reviewed to assure that the effects of plate flexibility are accounted for in the determination of anchor bolt loads. When the plates are determined to be rigid (i.e., the distance from the edge of the support member to the edge of the plate is less than two times the thickness of the plate) the compressive force is assumed to act at the centerline of the anchor bolts on the compression side of the plate. Otherwise, the plate is assumed as flexible, and the compressive force is placed closer to the supporting member. The effects of "prying action" in causing additional anchor bolt loading are considered. A straight line shear-tension interaction is assumed in determining anchor bolt capacity reduction when both shear and tension act on the anchor bolts. Minimum edge distance and anchor bolt spacing will be per the manufacturer's recommendations. When anchor bolt spacing and/or edge distance are not within the manufacturer's recommendations, the load capacity of the anchor will be reduced in accordance with the recommendations of the manufacturer. The approach used to calculate anchor bolt load for a typical pipe support base plate configuration is given on Attachment 1.

Response to Item 2

The design load of anchor bolts is being reviewed to assure that the load is less than the maximum allowable design load (MADL).

where

MADL = Fu/SF

and Fu = Ultimate static capacity of anchor bolt based on manufacturer's test

SF = Five for the shell-type anchors

SF = Four for wedge-type anchors

Where required, modifications will be made, and have been made, to be in compliance with this factor of safety.

Response to Item 3

The manufacturer's installation procedure requires no initial tension in Phillips Red Head expansion anchors. Cyclic test results of Phillips Red Head anchors indicate that there is little loss of anchor capacity under repeated load, and thus verify the cyclic load capability of these anchors. However, to satisfy cyclic requirements, all anchors will be pretensioned to a load equal to or greater than the maximum allowable design load. A few anchors used on base plates employ a leveling nut under the plate and therefore cannot be pretensioned. In these cases, cyclic requirements will be satisfied by tightening the top nuts only.

Response to Item 4

Due to insufficient documentation, a testing program has been initiated per Appendix A, Paragraph a, of the subject bulletin. The scope of the testing program is to verify that:

1. The anchor specified for the design is the same as that used in the field.

2. The correct installation procedure was used for the anchor.

At present, testing of all Seismic Category I lines 2 1/2" and larger has been completed. Of the total number of anchors tested for Units 1 and 2, there was less than 5% failure. Base plate failures were just over 4%. A test program for anchor bolts on base plates for lines 2" and

smaller is in progress and should be completed by August 15. All piping related to ECCS systems will be tested first. Therefore, continued operation of both units prior to completion of testing for lines 2" and smaller, should pose no undue hazard to the safety and well-being of the general public.

The test is accomplished by applying a torque to the anchor bolt in accordance with the test procedure of Attachment 2. A torque/tension relationship was developed analytically and verified by testing with a calibrated dynamometer. This correlation data is available for your inspection at the Brunswick site.

During the testing program, some of the supports could not be tested due to inaccessibility and other reasons. These supports represent less than 5% of the total number to be tested. Since the failure rate of supports tested was very low, we do not feel that the inability to test such a small percentage of the supports has any effect on the validity of the entire program.

A summary of the test results is given in Attachment 3.

In accordance with the requirement of IE Bulletin 79-07, the test results will be maintained at the Brunswick Steam Electric Plants for your inspection. At completion of the test program, an update of this response will be submitted to you.

Based on the analyses performed to date, the test results, and the analytical and testing program in progress, it is concluded that continued operation of the Brunswick S.E. Plant is justified without undue risk to public health and safety, and that, with the completion of the analytical and testing program, sufficient factors of safety will be verified for the pipe support base plates using concrete expansion bolts.

Yours very truly,

for E. E. Utley
Executive Vice President
Power Supply & Customer Services

RMC:jmb*

cc: Messrs. Harold Denton
Norman C. Moseley

ATTACHMENT 1
RESPONSE TO IE BULLETIN 79-02
BASE PLATE ANCHOR BOLT LOAD CALCULATION

The approach used to calculate anchor bolt load for a typical pipe support base plate configuration is provided below:

$$T = \alpha_i \left(\frac{M}{N_1 h_i} + \frac{P}{N_2} \right)$$

$$V = \frac{F}{N_2}$$

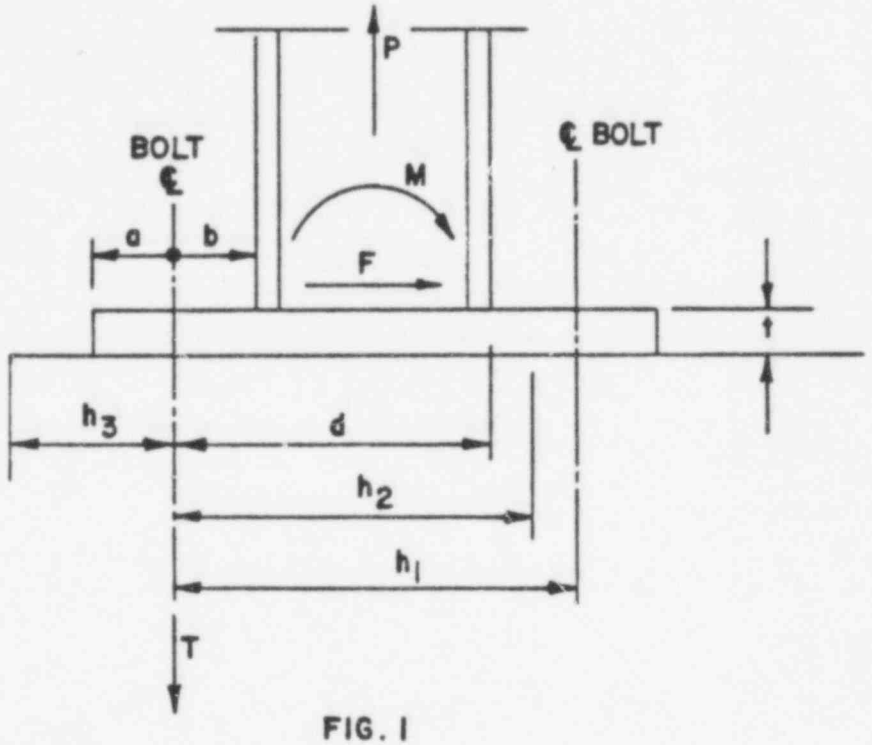


FIG. 1

Where: T, V — Anchor design tension and shear loads.

M, F, P — Moment, shear and axial force acting on the connection.

N_1 — Number of tension anchor bolts.

N_2 — Total number of anchor bolts.

i — Index to identify base plate flexibility

(i = 1 rigid, i = 2 flexible)

α_i — Factor to account for prying action for given plate flexibility

($\alpha_1 = 1.0$, $\alpha_2 = 1.2$)

hi — Moment Arm

h_1 = Center line distance between bolts.

h_2 = d + 2t (not to exceed h_1)

ATTACHMENT 2
RESPONSE TO IE BULLETIN 79-02
TEST PROCEDURE FOR CONCRETE EXPANSION ANCHORS

CAROLINA POWER & LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT

SPECIAL TEST PROCEDURE: SP 79-22

INSPECTION AND TESTING PROCEDURE FOR CONCRETE EXPANSION ANCHORS

Revision

1

Approved By: W. L. Tripplett Date: 4-13-79
Engineering Supervisor

Approved By: C. Dietz Date: 4-14-79
Plant Manager

CAROLINA POWER & LIGHT COMPANY
BRUNSWICK STEAM ELECTRIC PLANT

SPECIAL TEST PROCEDURE: SP 79-22

INSPECTION AND TESTING PROCEDURE FOR CONCRETE EXPANSION ANCHORS

A. PURPOSE

To provide a procedure for testing concrete expansion anchors in place to ensure that the installed anchors employed for selected piping systems meet or exceed the anchor's design strength.

B. SCOPE

1. This procedure outlines acceptable inspection and/or testing methods, acceptance criteria and documentation requirements for concrete expansion anchors.

2. Any installation which does not meet the acceptance criteria of this procedure will be removed and replaced in accordance with Section H of this procedure.

C. INSPECTION

1. Visually inspect the concrete expansion anchors employed in those support installations identified in Table 1 of this procedure. This inspection shall include the following attributes:

   a. Type of anchor employed.

   b. Anchor bolts and/or stud diameter.

   c. Verification of correct anchor length.

   d. Verification of proper seating and/or adequate load capacity for self-drilling type expansion anchors.

   e. Document results per Step E. Note any unusual testing conditions on associated data sheet (include sketches, narrative description) to allow for review by engineering.

C. INSPECTION (Cont'd)

NOTE: Any device which can not be easily removed to facilitate testing for various reasons (e.g., configuration, inaccessibility, partially welded plate, etc.) will be deleted from the list unless a sufficient number of devices is not obtained from the remaining list to satisfy the acceptance criteria. This fact will be noted on data sheet and an exception list will be maintained for test duration.

D. INSPECTION - TEST METHODS

1. Wedge type expansion anchors shall be subjected to the following test:

   a. Verification of bolt torque preload by applying torque to the anchor nut using a calibrated torque wrench. Application of specified torque shall not require more than two (2) complete revolutions of the anchor nut. Torque values are specified in Data Sheet 1 of this procedure.

   NOTE: Prior to applying the specified torque, ensure that the nuts are "snug" to the base plate.

   Upon successful completion of torque verification, remove each nut (one at a time) and verify that there are at least two (2) threads below the plate surface for retorque.

2. Self-drilling, snap-off expansion anchors shall be subjected to the following tests:

   a. Verification of anchor length by specifying vendor and determining anchor bolt size. Anchor bolt or stud size shall be determined by removing the bolt from the anchor and employing a go-no-go gauge, fabricated on site. Vendor identification shall be accomplished through examination of expansion anchor purchase documents. Determine distance between red expansion cone and outward end of anchor by use of scale. Record distance under "REMARKS" on Data Sheet 2.

   b. Verification of thread engagement shall be accomplished by disengaging the bolt from the anchor sleeve and reinserting the bolt (without rotation) until the bolt is seated on the starting thread of the anchor sleeve. Having accomplished the above, measure the distance between the underside (bearing surface) of the bolt head and the surface of the support attachment plate. This dimension is the length of thread engagement.

D. INSPECTION - TEST METHODS (Cont'd)

c. Torque and/or proof-load testing shall be accomplished as follows:

1. Torque method - A manually operated calibrated torque wrench is used to apply the torque given in Data Sheet 2.

(a) If by measuring (thread engagement plus hanger plate thickness minus bolt length) or by visual inspection, the anchor surface can be proven to be not in contact with the inner surface of the hanger plate, the anchor may be tested in place without shimming, as follows:

(1) Replace bolt or stud and nut and torque to the requirements of Data Sheet 2.

(2) Remove bolt and check for anchor movement.

(b) If clearance cannot be confirmed, shim as follows:

(1) Replace all bolts with "all-thread" studs one at a time and tighten nut on each stud before removal of the next bolt.

(2) Let plate pull away from overhead by backing off on all nuts simultaneously until 1/4 shims can be inserted behind the plate.

(3) When placing shims, ensure they will not interfere with the insert, should it pull out during the test.

(4) Tighten all nuts on threaded studs enough to pinch shims.

(5) Test each insert with the torque wrench to the loads indicated on Data Sheet 2.

(6) Replace all bolts in the same fashion as described in Steps D.2.C.1 (b) (1 & 2).

(c) If anchor sleeve embedment cannot be confirmed due to grout under the base plate, expose the "all thread" stud and test as follows:

(1) Chip the grout from under the base plate so as to expose one of the base plate anchors, as indicated on Figure 3.

D. INSPECTION - TEST METHODS (Cont'd)

(2) Where leveling nuts are used, run the leveling nut down a distance of approximately 1/2" below the base plate.

(3) Hold the "all thread" to prevent rotation, and torque as required in Data Sheet 2.

> **CAUTION**
>
> Verify that the base plate does not bend during the approach to the specified torque. If bending occurs, stop and relax bolt torque, and notify engineering.

2. Proof load method - A tensile load of 20% of the ultimate capacity of the anchor, as determined by United Engineers and Constructors, is applied. Refer to Figure 1 for the following steps:

(a) Replace all bolts with "all-thread" studs one at a time and tighten nut on each stud before removal of the next bolt.

(b) Let plate pull away from overhead by backing off on all nuts simultaneously until 1/4" shims can be inserted behind the plate.

(c) When placing shims, ensure they will not interfere with the insert, should it pull out during the test.

(d) Tighten all nuts on threaded studs enough to pinch shims.

(e) Test each insert with the hydraulic jack to the loads indicated by engineering for that particular plate.

(f) Replace all bolts in the same fashion as described in Steps D.2.c.2.(a) and D.2.c.2(b).

NOTE: If a system is temporarily blocked from below during the test, all bolts may be removed at the same time, rather than as described in Steps D.2.c.2(a) and D.2.c.2.(b).

E. TESTING FREQUENCY

1. One randomly selected anchor from each plate will be tested. If the tested anchor fails, all anchors on that plate will be tested.

F. ACCEPTANCE CRITERIA

PROOF LOAD TEST

An anchor shall be considered acceptable if it does not slip more than 1/16 inch during test. This may be verified by using the nut that is against the base plate as a gauge. It will be necessary to cut an inspection port in the jack spacer, Figure 1, to observe the nut.

TORQUE TEST

An Anchor shall be considered acceptable if, following application of the specified torque, no visible anchor movement is observed.

If an insert slips, it may be reseated and retested. If the insert cannot withstand the test loads, it must be removed and replaced by a wedge anchor. Replacement of failed self-drilling shall be as recommended by design engineers, based on in situ evaluation, and review of design documentations.

Proof load test equipment:

Test equipment will consist of a hollow hydraulic jack which will be pressurized by a hand actuated pump.

Calibration of test equipment.

The test equipment shall be calibrated. The load cell or Dynometer used for calibration must have calibration records of its own. These records must not be older than 12 months at the time of calibration.

If more than one jack and pump assembly is calibrated, the testing apparatus (pump, jack and pressure gauge) shall not be changed (i.e., a hydraulic jack may only be used with the pressure gauge it was calibrated with, when performing proof tests).

G. DOCUMENTATION

For each hanger, support and/or restraint anchor system inspection and test performed per this procedure, a Wedge Type Concrete Expansion Bolt Inspection Record Data Sheet 1, or Self-Drilling Type Concrete Expansion Bolt Inspection Record Data Sheet 2 shall be completed as applicable.

Completed record sheets shall be returned to staff engineering support personnel (United Engineers and Constructors) for review and acceptance and/or approval.

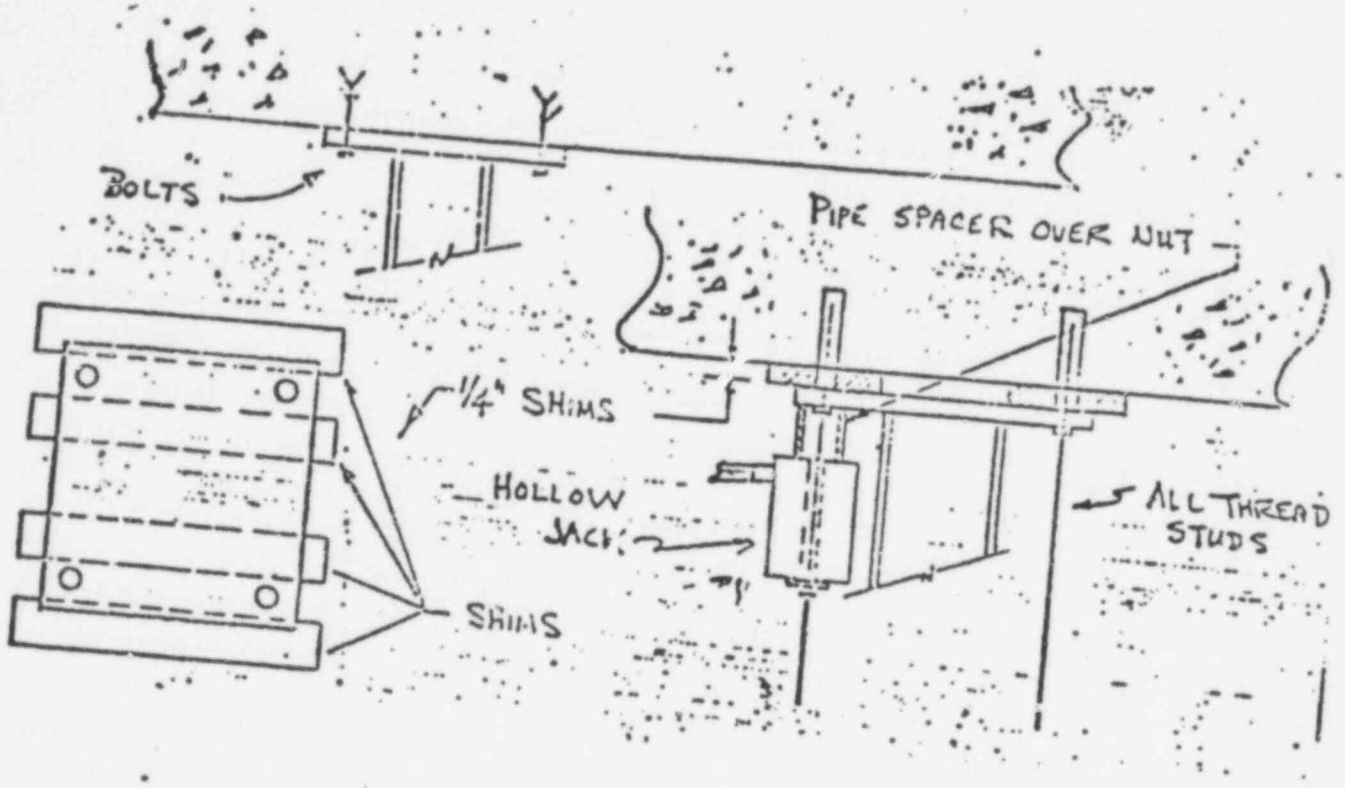
H. SYSTEM RESTORATION

Following completion of inspection of self-drilling and/or wedge type anchors, reinstall support and associated anchors and record all required information on Data Sheet 3. Minimum and maximum torque values for re-installing anchors are specified on Data Sheet 3.

I. QUALITY ASSURANCE

Brunswick Steam Electric Plant Quality Assurance personnel will perform random surveillance checks of bolt tests, and review design values and engineering modifications of pipe supports.. The QC inspector will sign off for the bolt inspected, in the Remarks section.

FIGURE 1

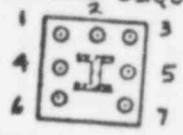


Procedure for testing overhead support carrying dead weight load.

1. Replace all bolts with long studs, one at a time.
2. Back off nuts simultaneously and insert 1/4" shim plates.
3. Pull plate up against shims.
4. Back off one nut at a time (finger tight) and test with hydraulic jack.

FIGURE 2

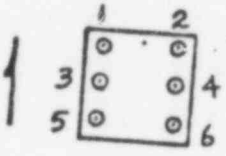
NUMBERING SEQUENCE



VERTICAL PLATE

1. Start at upper left corner (your upper left corner as you face the plate) and number across to the right.
2. Then go to the left most anchor on the next row down. Number across to the right.
3. Continue until all bolts are numbered.

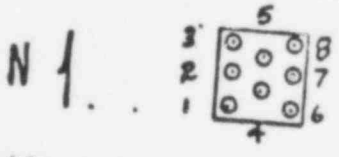
FLOOR MOUNTED PLATE OR CEILING MOUNTED PLATE



1. Stand on South side of plate and face North.
2. Anchor farthest away from you and to the left will be number one (1).
3. Number across to the right.
4. Then number next row in toward you, again from left to right.
5. Continue until all bolts are numbered.

FLOOR MOUNTED OR CEILING MOUNTED PLATE

1. Position yourself Southeast of plate and looking Northwest.
2. Then number the same as Steps 2 through 5 on the preceding example.



WALL MOUNTED PLATE

1. Start on left side and number up and to the right.
2. Then go to the next row down and repeat.
3. Continue until all are numbered.

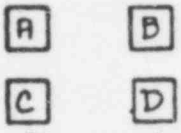
TWO PLATED VERTICAL

1. Upper plate numbered first using numbering sequence given on preceding examples.
2. Then number the next plate (B) starting with the next number not used on the first plate (A).

FIGURE 2

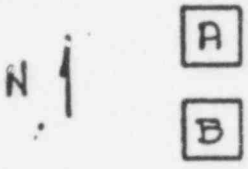
TWO PLATES
VERTICAL

1. Number left plate first, then the right plate.



FOUR PLATES
VERTICAL

1. Number upper left plate first, then upper right, then lower left, then lower right.

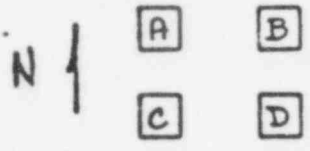


FLOOR OR CEILING MOUNTED

1. Number Northernmost plate first, then the Southernmost plate (B).

FLOOR OR CEILING
MOUNTED

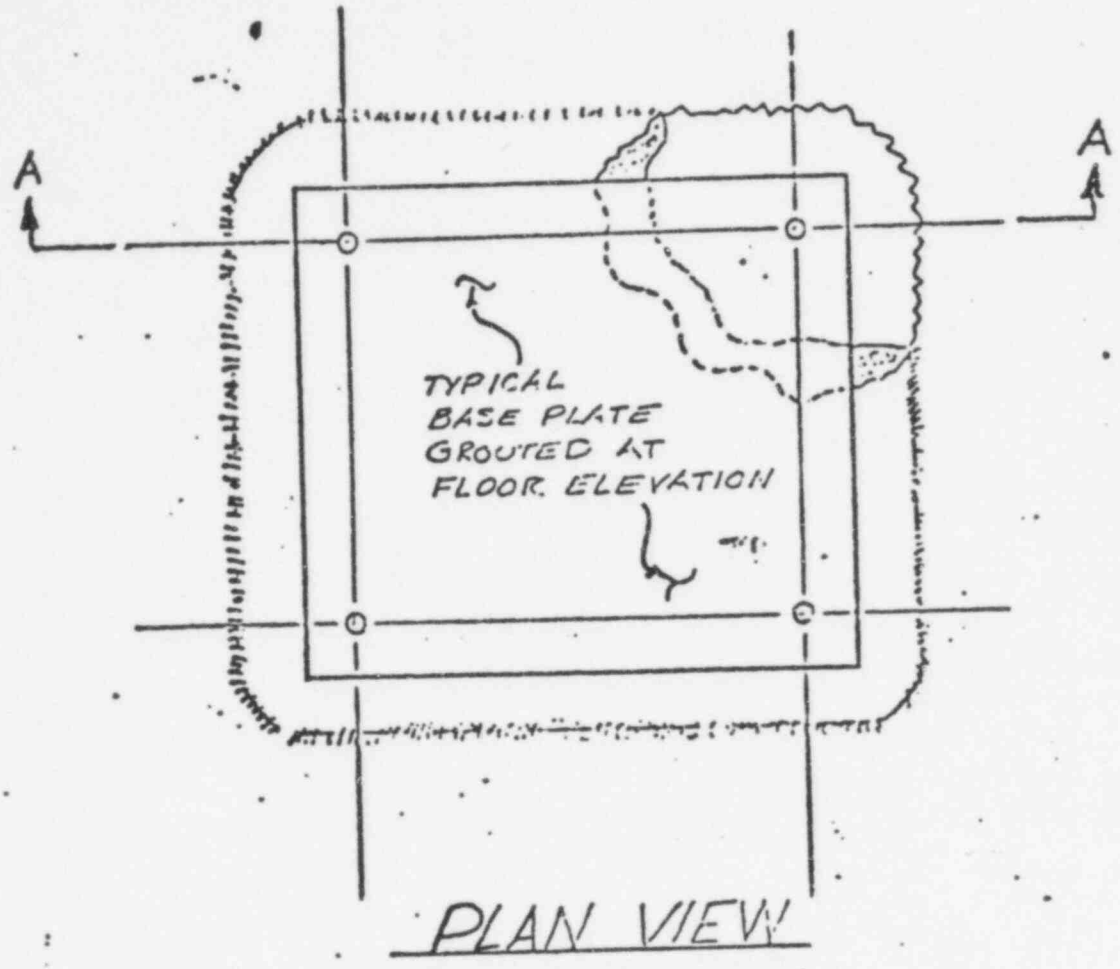
1. Number West plate first (A), then number the East plate (B).



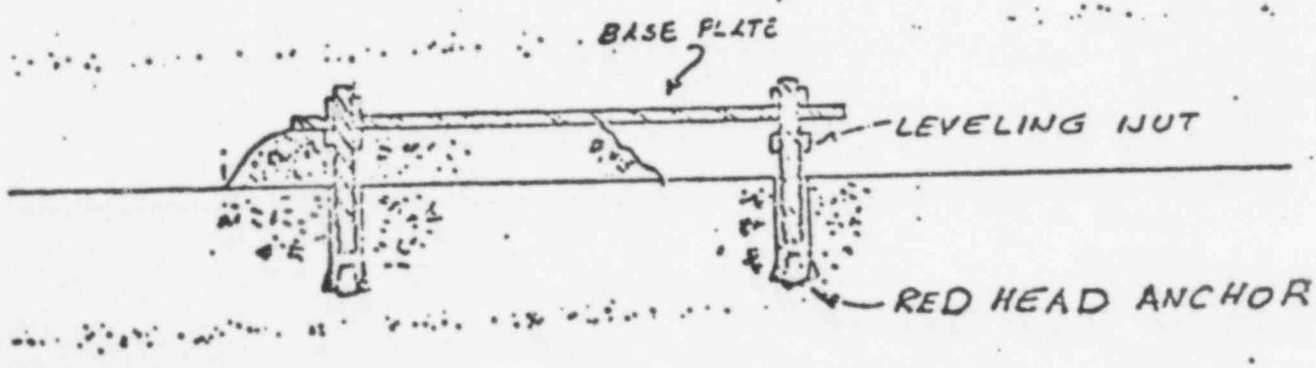
FLOOR OR CEILING
MOUNTED PLATES

1. Number Northwest plate first, then Northeast plate, then Southwest plate, then Southeast plate.

FIGURE 3



PLAN VIEW



SECTION A-A

DATA SHEET 1

WEDGE TYPE CONCRETE FASTENER

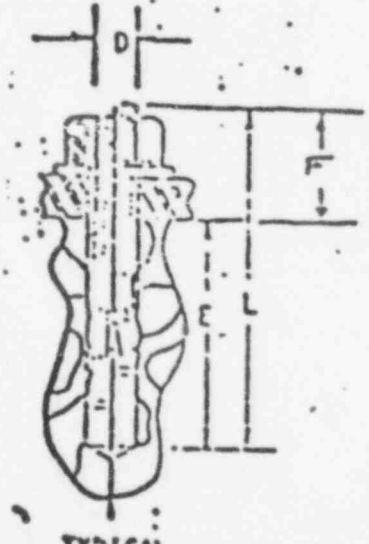
HANGER I.D. NO. _____

TORQUE WRENCH NO. _____

BOLT "D" "L"	THREADS ENGAGED (in.)	EMBED "E" (L-E)	TORQUE (Ft-lb.)	REMARKS

NOTE

Sketch support identifying all concrete fasteners and bearing plate(s) on back of this sheet.



TYPICAL

Verified By/date

_____
INSPECTOR

Engineering has reviewed this record and the results are acceptable

_____
(Reviewing Engineer)

POOR ORIGINAL

DATA SHEET 2

SELF DRILLING TYPE CONCRETE FASTENER

HANGER I.D. NO. _____

TORQUE WRENCH NO. _____

HYDRAULIC JACK NO. _____

BOLT #	TEST LOAD CYCLE: BOLT TORQUE	TEST LOAD CYCLE: HYDRAULIC PRESSURE	THREAD ENGAGE (in.)	BOLT DIAM. (in.)	ANCHOR TYPE	ANCHOR LENGTH: FROM CHART	ANCHOR LENGTH: ACTUAL	PASS = P FAIL = F	REMARKS

NOTE

Sketch support identifying all concrete fasteners and bearing plate(s) on back of this sheet.

_____/_____
Inspector/Date

CONCRETE EXPANSION ANCHOR TORQUE VALUES	
Size (in.)	Self Drilling Torque (Ft-lb)
3/8	15÷20
1/2	25÷30
5/8	45÷50
3/4	70÷75
7/8	90÷95

The fasteners used are
all thread rod ____
Hex Head Bolt ____

BOLT	PLATE	TO SHOULDER	TO CONE

Engineering has reviewed this record and the results are acceptable.

_____/_____
REVIEWING ENGINEERING

DATA SHEET 3

HANGER REINSTALLATION

Hanger I.D. No. _____

Torque Wrench No. _____

Hanger Reinstallation Verified Correct Per Torque Values in Table Below - - -

Verified By/Date

Grout Replacement Required Yes ☐ No ☐

_____ /
Inspector

CONCRETE EXPANSION ANCHOR TORQUE VALUES		
Size (in.)	Self Drilling Torque (Ft-lb)	Wedge Torque (Ft-lb)
3/8	15-20	
1/2	25-30	40-55
5/8	45-50	70-90
3/4	70-75	125-175
7/8	90-95	200-250
1		250-300

Engineering has reviewed this record and the results are acceptable.

_____ /
(Reviewing Engineer)

ATTACHMENT 3
RESPONSE TO IE BULLETIN 79-02
SUMMARY OF TEST RESULTS ON
CONCRETE EXPANSION ANCHORS

Safety-Related Piping - 2 1/2" and Larger

Number of Base Plates Tested	186
Number not Tested due to Inaccessibility	4
Number Failed	8
Percent Failure	4.3%

Safety-Related Piping - 2" and Smaller

Number of Base Plates to be Tested	402
Test Completion Date	August 15, 1979