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Mr. J. T. Collins
Director, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76102

Dear Mr. Collins:

South Texas Project
Units 1 & 2
Docket Nos. STN 50-498, STN 50-499
Third Revised Response to NRC IE Bulletin 79-02

Houston Lighting & Power Company is revising the response to IE Bulletin No. 79-02 which was transmitted to the NRC by letter dated December 4, 1981. This submittal completely supercedes previous responses. The revised position, as attached, has been prepared to reflect changes in the design of the South Texas Project that affect expansion anchor bolts. Also provided is further clarification of the adequacy of the design and installation of the anchor bolts for assuring the operability of Seismic Category I systems.

If you have any questions, please contact Mr. Michael E. Powell at (713) 993-1328.

Very truly yours,

G. W. Oprea, Jr.
Executive Vice President

PLW/na

Attachment: Third Revised Response to NRC IE Bulletin 79-02

W2B/L003PW/u

Dmb
IE11
1/1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter	§	
	§	
Houston Lighting & Power	§	Docket Nos. 50-498
Company, et al.,	§	50-499
	§	
South Texas Project	§	
Units 1 and 2	§	

AFFIDAVIT

G. W. Oprea, Jr., being duly sworn, hereby deposes and says that he is an Executive Vice President of Houston Lighting & Power Company; that he is duly authorized to sign and file with the Nuclear Regulatory Commission the attached Third Revised Response to NRC IE Bulletin 79-02; that he is familiar with the content thereof; and that the matters set forth therein are true and correct to the best of his knowledge and belief.

G. W. Oprea, Jr.
Executive Vice President

STATE OF TEXAS	§
	§
COUNTY OF HARRIS	§

Subscribed and sworn to before me, a Notary Public in and for Harris County, Texas this day of , 1984.

NOTARY PUBLIC STATE OF TEXAS

Notary Public in and for the State of Texas

My commission expires:
6-28-86

W2B/L003PW/u

cc:

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South Texas Project
Units 1 & 2
Docket Nos. STN 50-498, STN 50-499
Third Revised Response to NRC IE Bulletin 79-02

Houston Lighting & Power Company (HL&P) has previously responded to IE Bulletin 79-02 for the South Texas Project (STP). The following response supercedes all of these previous submittals. This revised response describes the design of the expansion anchor bolts in Seismic Category I systems used on STP.

The changes made in this response from the earlier submittals reflect the design methods employed by Bechtel, which replaced Brown & Root as architect/engineer for the STP. Bechtel has reviewed the design and installation of expansion anchor bolts as documented by Brown & Root specifications and procedures, and has found them to satisfy Bechtel's requirements.

STP uses two types of expansion anchor bolts for permanent plant installations. Wedge-type (Hilti kwik-bolt) expansion anchor bolts have been discussed in previous responses to the Bulletin; this revised response provides further discussion regarding how these anchor bolts are currently used at STP. Ductile-type (Drillco maxi-bolts) have not been discussed previously; use of these anchor bolts has only recently been initiated at STP. The revised response includes the design and installation criteria to be followed when ductile-type expansion anchor bolts are used.

The anchorage system for ductile-type expansion anchor bolts differs substantially from that of other types of expansion anchor bolts. Ductile-type expansion anchor bolts are secured by expansion into an undercut hole of larger diameter provided at the base of the hole drilled for the shaft of the anchor bolt. Because of this positive mechanical anchorage system, HL&P does not consider the concerns addressed by the Bulletin to be applicable to ductile-type expansion anchor bolts. However, ductile-type expansion anchor bolts are included in the following discussion to clarify how they are used on STP.

1. Baseplate Flexibility

Analyses of baseplates for pipe supports and miscellaneous supports which utilize expansion anchors are performed either by computer or manual calculations.

a) The computer program used is CDC, CE035, BASEPLATE 2. Using finite element analysis, the program considers the flexibility of the plate interacting with the stiffness of the expansion anchors and the bearing concrete under the plate. This method includes the effects of prying action in calculating expansion anchor tensions.

b) The manual method of calculation of expansion anchor tensions due to externally applied moments considers the flexibility of the plate by prescribing that the tension/compression couple resulting from the applied moment be defined as follows:

i. The tension resultant is located at the centroid of the bolt group in tension.

ii. The compression resultant is located under the compressive edge of the member which is attached to and delivers the external moment to the plate.

The bolt tension for wedge-type expansion anchors (which is conservatively calculated considering the flexibility of the plate as described above) is multiplied by a factor of 1.3 in order to recognize prying action, where applicable. This multiplier is selectively applied for certain combinations of low plate thickness together with larger spacing between the expansion anchors and the edge of the member attached to the plate. The value of the multiplier, as well as the parameters under which it is to be used, were developed from a parametric analytical study utilizing the BASEPLATE 2 program. There is no reliance on the rigidity of the plate that is otherwise implied b methods where the compression resultant is considered to be located at the extreme edge of the plate or at the centroid of bolts in the compression side. This approach for the limited incorporation of prying action in expansion anchors is consistent with the conclusions established in References (1) and (2) and replaces the AISC formulation for A490 bolts submitted under Item 1(b) of Reference (3).

The AISC formulation is applicable to highly pretensioned bolts joining homogeneous steel plies with nearly linear elastic behavior, as opposed to the expansion anchors having low pretension subject to relaxation and which undergo nonlinear behavior related to the varying axial stiffness of the bolt anchorage and the nonuniform compressive contact against the concrete.

The bolt tension for ductile-type expansion anchors is multiplied by a factor of 1.3 regardless of plate thickness except for abnormal or faulted loads.

2. Factor of Safety

The factors of safety for concrete expansion anchor bolts are as follows:

a) For wedge-type anchor bolts, the specified allowable design loads in tension and shear have a minimum factor of safety of 4.0 with respect to the corresponding ultimate load capacities determined from static load tests in concrete. The ultimate loads considered are those determined either by independent testing laboratories (as reported by the supplier) or those determined from site-specific testing, whichever results in lower ultimate loads.

Sleeve-type anchor bolts are not used on STP.

b) Shell-type expansion anchor bolts are not currently used for permanent installations at STP. However, should shell-type expansion anchor bolts be used in such applications, a factor of safety of at least 5.0 will be used.

c) Ductile-type expansion anchor bolts are used in some applications on the South Texas Project. Comprehensive tests have proven that these anchor bolts develop the full ductility and tensile strength of the bolt metal without concrete failure.

In certain ductile-type expansion anchor bolt applications, reduced embedment depth and/or spacing and edge distance allowed by specification results in a calculated concrete ultimate load capacity that is lower than the steel bolt material ultimate load capacity. The value of the ultimate concrete capacity is conservatively based on the ACI 349-80 calculation, rather than on test results, because test results do not indicate concrete and/or anchor bolt failure. The ultimate load capacities determined by tests only indicate the bolt metal strength, and do not enable definition of the higher loads corresponding to concrete and/or anchorage failure. The anchor design will be governed by the limitations of the concrete when the concrete ultimate load capacity is lower than the steel rod ultimate load capacity. Otherwise, the steel rod material governs the design.

The specified allowable loads in tension and in shear have factors of safety as follows:

i) F.S. $\geq$ 4.0 with respect to ultimate load capacity of concrete calculated in accordance with ACI 349-80 (Reference (5)) for f'c = 4000 psi.

ii) F.S. $\geq$ 3.0 with respect to the specified minimum ultimate strength of the bolt material, Fu = 125 ksi. This factor of safety is consistent with the AISC specification (Reference (6)).

The allowable loads for ductile-type anchors are subject to increase for abnormal, faulted, or extreme environmental loading combinations.

The effects of shear/tension interaction, minimum edge distance, and proper bolt spacing are considered in the support design as follows:

Shear/Tension Interaction - For cases where the allowable design loads are based on ultimate loads governed by concrete and/or anchorage capacities, the interaction equation is:

$$\frac{T_{applied}}{T_{allowable}} + \frac{S_{applied}}{S_{allowable}} \leq 1.0$$

$T_{allowable}$ and $S_{allowable}$ are the specified allowable design loads in pure tension and shear, respectively.

The relationship given above is prescribed for all wedge-type expansion anchor bolts and for the cases of ductile-type expansion anchor bolts where the calculated ultimate concrete capacity is lower than the steel bolt ultimate load.

For cases of ductile-type anchor bolts where the allowable design loads are based on ultimate loads governed by the steel bolt ultimate strength, the following relationship is used:

$$\left(\frac{T_{applied}}{T_{allowable}}\right)^{5/3} + \left(\frac{S_{applied}}{S_{allowable}}\right)^{5/3} \leq 1.0$$

This equation is conservative with respect to the tension/shear interaction provisions allowed and recommended for steel bolts by the AISC specification. This relationship is not used when the ultimate capacity is governed by concrete and/or anchorage failure.

Minimum Edge Distance - The minimum concrete edge distance (i.e., the shortest distance to the edge of the concrete from the center-line of the expansion anchor bolt) is 6D or 6 inches, whichever is greater, where D is the bolt diameter in inches.

Bolt Spacing - The minimum spacing between two expansion anchor bolts is normally 12D, or at least twice the embedment length if the embedment is less than 6D in depth. Closer bolt spacing is permitted, but the allowable bolt capacity must be reduced proportionally down to 50% capacity at one-half the minimum spacing.

3. Design Requirements for Cyclic Loading

Safety-related piping systems are analyzed for dynamic loads such as seismic loadings, water hammer, steam hammer, safety relief valve discharge, etc. Equivalent static pipe support design loads are then determined for the above load conditions as applicable.

In accordance with the test program for wedge-type anchor bolts (References (1), (2), and (4)), the dynamic load capacities of such expansion anchor bolts have been determined to be about the same as their corresponding static load capacities. Therefore, the minimum factor of safety given in Section 2 above is considered adequate for the design of wedge-type expansion anchor bolts that may be subjected to dynamic loads. However, as an additional precaution, the allowable loads for wedge-type expansion anchors are reduced by 50% when the anchors are subject to shock or continuous vibration (excluding seismic loads).

The factors of safety given in Section 2 are considered adequate for the design of ductile-type expansion anchor bolts that may be subjected to dynamic loads.

4. Verification of Design Requirements

   a. Cyclic loads have been considered as described in the response in Section 3. However, additional preloading due to the presence of cyclic loads is not required. No additional torque/tension has to be provided other than that which is required for setting the anchor bolt. This statement is substantiated by the conclusions established in References (1) and (2).

   b. Each anchor bolt is provided with a special marking that indicates its length. This special marking is permanently stamped on the top end of the bolt so that it can be read when the bolt is in place.

A static testing program (Reference (7)) of wedge-type expansion anchor bolts was conducted to confirm the manufacturer's published ultimate capacity values or to establish new ultimate capacity values, whichever results in lower ultimate loads.

Ductile-type expansion anchor bolts have been tested by independent laboratories to verify the ultimate load capacities.

The allowable design loads for wedge-type expansion anchor bolts installed in grout have been re-examined relative to the allowable design loads in concrete. Even though the tested ultimate load capacity of these expansion anchor bolts installed in grout is lower than the corresponding ultimate load capacity of expansion anchor bolts installed in concrete, the reduced ultimate capacity in grout remains sufficiently high to maintain the required factor of safety with respect to the allowable design loads as presently specified for wedge-type expansion anchor bolts in concrete. Therefore, the allowable design loads for wedge-type expansion anchor bolts are the same when the anchor bolts are installed in grout or concrete.

Ductile-type expansion anchor bolts may also be used in grout. The factors of safety discussed in Section 2 are maintained for ductile-type expansion anchor bolts in grout. Based upon the anchorage system and review of a limited amount of comparative test data, the capacities are the same for grout and concrete installations.

5. Expansion Anchor Bolts in Concrete Block (Masonry) Walls

Expansion anchor bolts are not used in concrete block (masonry) walls to attach piping supports in Seismic Category I systems.

6. Structural Steel Shapes

Structural steel shapes are not used instead of baseplates when expansion anchor bolts are used with pipe supports in Seismic Category I systems. The only exception to this requirement is one detail used in a limited number of cases to support small bore pipe, as shown in Figure 1.

References:

(1) Summary Report; Static, Dynamic and Relaxation Testing of Expansion Anchors in response to NRC IE Bulletin 79-02, dated July 20, 1981; submitted to the NRC by Commonwealth Edison.

(2) Summary Report; Generic response to NRC IE Bulletin 79-02, Base Plate/Concrete Expansion Anchor Bolts, dated August 30, 1979; submitted to the NRC by Utility Owners Group, response by Teledyne Engineering Services as Technical Report 3501-1.

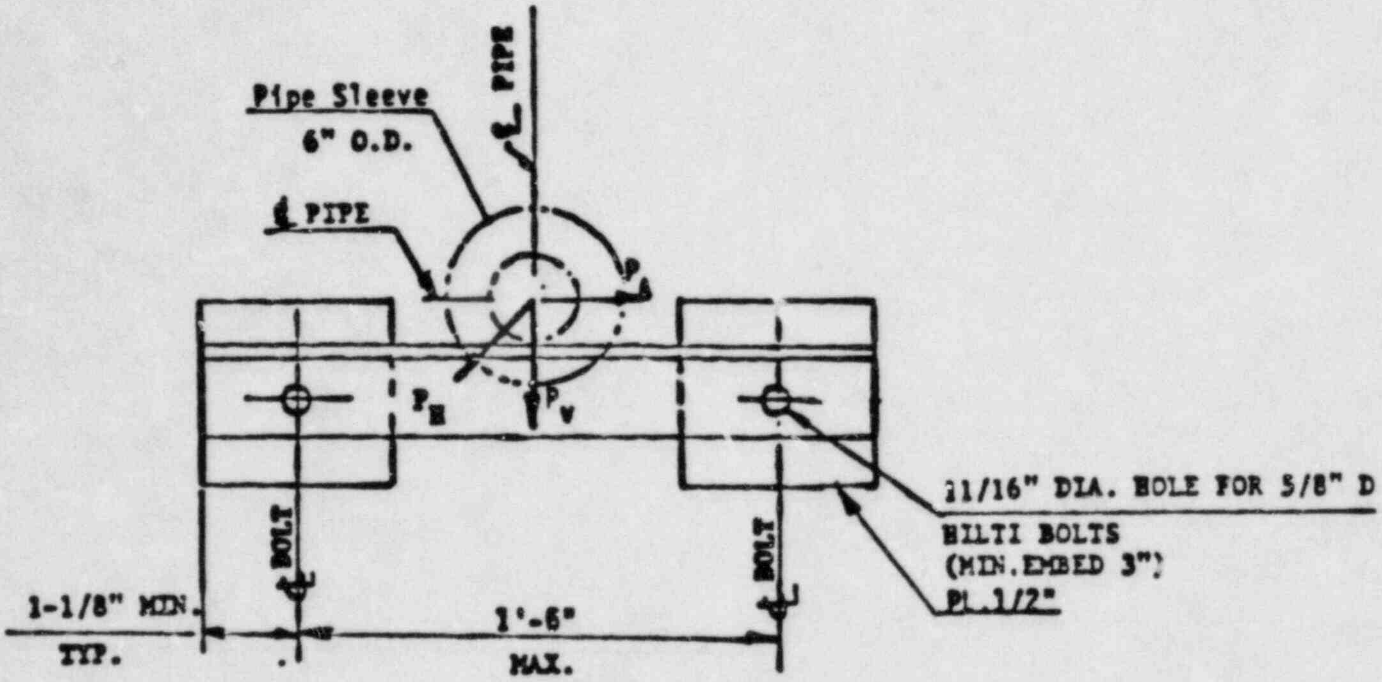
(3) HL&P to NRC letter ST-HL-AE-747, dated December 4, 1981, Subject: Docket Nos. STN 50-498, STN 50-499, NRC IE Bulletin 79-02; Second Response Revision.

(4) Drilled-In Expansion Bolts Under Static and Alternating Load, A Report prepared for Hanford Engineering Development Laboratory, Richland, Washington, by Bechtel Power Corporation, San Francisco, California, Report No. BR-5853-C-4, January 1975.

(5) Code Requirements for Nuclear Safety-Related Concrete Structures (ACI 349-80), Reported by ACI Committee 349; Appendix B.

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

(7) Test Report; Tension, Shear and Relaxation Testing of Expansion Anchors at the South Texas Project, Bay City, Texas for Brown & Root, Inc., WJE No. 81052Q Second Issue May 19, 1981; TPNS No. A700XR1376 BWJ.



P_A MAX. (LBS)	P_V MAX. (LBS)	P_H MAX. (LBS)
950	1070	-

NOTES: 1) Loads P_H, P_V and P_A may act simultaneously.

2) Use this detail only when end of pipe sleeve is flush with concrete.

FIGURE 1