UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of TEXAS UTILITIES GENERATING COMPANY, et al. (Comanche Peak Steam Electric Station Station, Units 1 and 2)		Docket Nos. 50-445-1 and 50-446-1

CASE'S ANSWER TO APPLICANTS' STATEMENT OF MATERIAL FACTS AS TO WHICH THERE IS NO GENUINE ISSUE REGARDING CONSIDERATION OF FRICTION FORCES IN THE DESIGN OF PIPE SUPPORTS WITH SMALL THERMAL MOVEMENTS

in the form of

AFFIDAVIT OF CASE WITNESSES JACK DOYLE AND MARK WALSH

1. Applicants state:

"All pipe support design organizations for Comanche Peak consider friction forces in the design of pipe supports where piping thermal movements are greater than 1/16".

"Two of the pipe support design organizations (PSE and ITT-Grinnell) do not consider friction forces if the piping thermal movements is less than or equal to 1/16". (Finneran Affidavit at 1-2.)"

We challenge Applicants' first sentence. Gibbs & Hill does not consider <u>any</u> friction in the design of their supports, as can be shown from the Applicants' 6/28/84 response to Mr. Walsh's question during the 6/6/84 conference call between Applicants/Staff/CASE. Applicants stated:

> "Gibbs & Hill only designs moment restraints. For these supports the friction forces induced from deadweight plus thermal loads are small compared to the other support loads, and therefore, are neglected."

This statement the Applicants have provided poses a new problem. As the Board is already aware, Gibbs & Hill designed the upper lateral restraint, yet the Applicants have stated here that the only supports they are doing are moment limiting restraints. In addition, the STRUDL group was under Gibbs & Hill supervision, and we were told not to consider friction unless told specifically to do so. The inconsistency of Applicants' statement is obvious and puzzling, to say the least.

With regard to Applicants' second sentence, although we do not agree with their philosophy, we agree that what they are stating here is correct. In addition, as shown above, Gibbs & Hill does not consider friction at all, no matter what the movement is.

2. Applicants state:

"The true friction load for piping movements less than 1/16" is the lesser of:

"1. The normal load on the support times the coefficient of friction, or

"2. The amount of force needed to deflect the support a distance equal to the thermal movement of the pipe."

Item 1 as stated above represents the maximum load that can be transmitted from the pipe to the support through friction. Item 2 represents a more liberal approach to the problem, when the amount of force required to deflect the support a distance equal to the thermal movement of the pipe is less than the normal load on the support times the coefficient of friction.

When one uses item 2 (i.e., the load to deflect the support a distance equal to the movement of the pipe), and this load is greater than the normal load on the support times the coefficient of friction, the results are then unrealistic. Therefore, one must consider item 1 first, and use item 2 of the Applicants' statement to decrease the friction load on the support, as will be shown below in item 4.

3. Applicants state:

"The support configuration which exhibits the most significant effect from friction forces is a relatively short, stiff tube steel cantilever beam."

We agree with this statement for the limited purpose of the Applicants' omission of considering friction forces when piping movements are less than 1/16".

4. Applicants state:

"Application of the second procedure for consideration of friction loads in that support configuration produces unrealistic loads."

We disagree with this statement to a certain extent. (See discussion under answer 2 preceding.)

In addition, consider the following examples of a piping system that moves 1/16" at a support and that support has a stiffness of 16,000 lbs. per inch. That is to say, applying 16,000 lbs., the support will displace (or move) 1", or applying 1,000 lbs., the support will displace 1/16".

Consider in Example 1, a load of 1 lb. normal to the support. Whether this pipe were to move 1/16,000" or 6", the maximum friction force imparted to the support would equal .3 lbs. using a coefficient of friction of .3. (This is item 1 discussed in Applicants' statement number 2.) If one were to consider the stiffness of the support alone (without considering item 1 in Applicants' statement number 2) due to a pipe movement of just 1/16", the friction force would be 1,000 lbs. instead of .3 lbs. and this would be an unrealistic load.

Now consider Example 2, a support where the normal load is 6,000 lbs. and the pipe moves 1/16". Using the coefficient of friction equal to .3, the friction force on the pipe is 2,000 lbs. This 2,000 lbs. would exceed the criteria of 1,000 lbs. per 1/16" (stiffness); therefore, one only needs to consider the maximum load of 1,000 lbs. for a deflection of 1/16" pipe movement, since the pipe is actually only going to move 1/16".

It is highly improbable to have a support where the amount of force needed to deflect the support a distance equal to the thermal movement of the pipe would equal the normal force from the pipe times the coefficient of friction (i.e., it is highly improbable that you would have a condition where item 1 and item 2 of Applicants' statement exist at the same time). But what is more probable is that item 1 controls. But using item 2 will decrease the load from item 1 when properly used and is unconservative. Item 2 would be unrealistic when used by itself when item 1 is not considered.

5. Applicants state:

"Use of the first procedure for calculating friction loads indicates that the maximum friction force which could be transmitted into the beam in reality is much less than that calculated using the second method."

As demonstrated in Answer 4 above, Applicants' item 5 is correct, as far as their statement goes. But the Applicants do not consider friction when the support moves less than 1/16". As Mr. Doyle stated in his testimony (CASE Exhibit 843, admitted at Tr. 6824):

> "In conclusion, I believe that my objection to the friction exclusion for minor pipe movements is not based as much on the fact that is (sic - should be "it") was excluded, as much as it is on the basis for that exclusion--particularly when one considers the principles of static versus dynamic friction."

6. Applicants state:

"Mr. Doyle's recommended guideline for consideration of friction forces (stress ratios greater than .900) is not necessary because the forces from friction are small contributions to total support loads and because the allowables Applicants use for support and Hilti anchor bolt design are much less than could be used if friction forces were considered."

In his affidavit attached to Applicants' 5/16/84 Motion for Summary Disposition on the question of friction, Mr. Finneran quotes Mr. Doyle entirely out of context and twists the statements Mr. Doyle made for his (Mr. Finneran's) own purpose (pages 2 and 3 of Finneran affidavit). Mr. Doyle never inferred that friction of 1/16" should not be considered. What he was stating is that, of the two ways to analyze for friction, the use of the coefficient of friction was the more rational method and had to be addressed if the result would cause the stress ratios to exceed 1. (See Tr. 6826.)

In answer to Chairman Bloch's question, Mr. Doyle stated that it (friction) was not a safety hazard, but we both believed then and believe now that this (nonconservative elimination of friction loads) combined with other nonconservative engineering judgements will present safety hazards. (See also more complete discussions at Tr. 6759-6780 and 6825/5-6829/13.) Our concern is not that the supports are going to fall off the wall as soon as the plant is put into operation, but rather with the survivability over the period of time during which the plant must operate safely.

Mr. Doyle never stated that you only consider friction when the stress ratio is .900, but used .900 as an example rather than a recommendation, and that was only for one particular type of support. Mr. Doyle also made a recommendation of using a stress ratio of .6 and said that would prove to be academic relative to the allowables for this condition when comparing the allowables for an emergency or faulted condition for some supports. These stress ratios were used as examples for stresses within the main members and not to be construed to include allowable stress ratios for welds, anchor bolts, and all pipe support members.

An additional point that should be remembered is that, in general, the pipe supports at CPSES which are fillet welded do not have weld systems that are effectively 100% efficient (for example, full penetration welds).

At pages 4 and 5 of his Affidavit, Mr. Finneran states that if friction were included in calculations, the ASME Code at NF-3231.1 allows for an increase in allowable loads to 3 times the basic allowable. This defies all logic. If this were a fact, friction could be included in all structural analysis where friction is present to reduce overstress in members, welds, etc. And this is a rather ludicrous stretch of the imagination (but no worse than is offered by Applicants).

For example, if the stress ratio for the normal upset condition were .900 without considering friction (because pipe movement was less than 1/16" and the Applicants' do not consider pipe movement when it is less than 1/16") and the stress ratio for friction alone were .775, the combined effect would be 1.675, and this would exceed the allowable of 1. In response to a discovery request from CASE, Applicants provided the attached document (with Applicants' 6/28/84 letter) regarding the effects of thermal friction force only for the six supports referenced in Applicants' affidavit (see attached 6/26/84 handwritten memorandum from John Finneran, TUGCO, to John Fair, NRC). Referring to the fifth page, Table 1a., for support SI1-029-055-S32R (sic -- should begin SI-1- etc.), for the weld stress calculation, the stress ratio is 2464 divided by 3181 = .775. This stress ratio by itself does not exceed the allowable of 1, but only allows a stress ratio of .225 for the mechanical loads by themselves.

The .225 reserved for the mechanical loads <u>independent</u> of friction is of importance when one considers the Applicants' statement that the code permits the allowables to be increased by a factor of 3 (Finneran affidavit at page 5). Mr. Finneran is in error; Regulatory Guide 1.124 (CASE Exhibit 743, admitted at Tr. 5901) states (B.1.b. "Allowable Increase of Service Limits", page 1.124-2):

> ". . . the increases permitted by NF-3231.1, XVII-2110(a), and F-1370(a) of Section III are not directly applicable to allowable shear stresses and allowable stresses for bolts and bolted connections. The increase permitted by NF-3231.1 and F-1370(a) of Section III for shear stresses or shear stress range should not be more than 1.5 times the level A service limits because of the potential for non-ductile behavior."

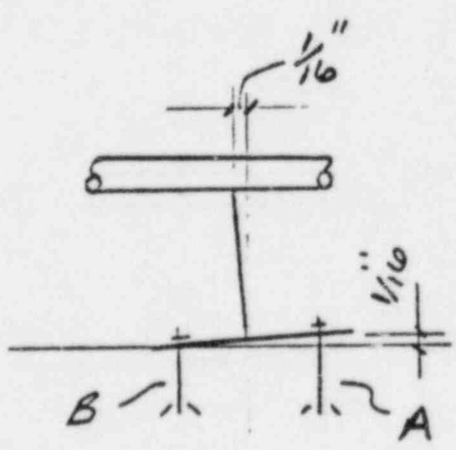
This is also reflected in the Regulatory Guide under C. Regulatory Position, 4., (page 1.124-5) which states, in part:

> "Any increase of limits for shear stresses above 1.5 times the Code level A service limits should be justified."

In addition, the Applicants direct the Board to an allowable factor of safety of 5:1 for Hilti bolts that they claim is being utilized, compared to the 4:1 ratio authorized by IE Bulletin 79-02 (page 5 of Affidavit). Two points can be taken from this position the Applicants have provided. The first is by reviewing the PSE Manual; it is evident in Section XII, pages 12 through 15 (see copy attached), that the allowables for the Hilti bolts are listed utilizing a factor of safety of 4. The second point is that one cannot make a statement that the "movements of the pipe would not cause actual allowables of the Hilti's to be exceeded;" for example:

A pipe support acting as a cantilever is 6" from the floor. The pipe is attempting to move a distance just less than 1/16". This support has a base plate with Hilti bolts, and the anchor bolts are located such that the moment arm due to bending is 6". Because this is a short member, bending deformations are neglected; i.e., it is a short stiff member. The restraining load is in the vertical direction. Dead plus thermal load is vertical down and dead plus thermal plus seismic is vertical up and down. The vertical up load was used to size the anchor bolts since the Applicants' criteria does not require them to consider the effects from friction.

Because this support is short and stiff and bending deformations are neglected, when the pipe moves, it will tend to pull one anchor bolt out an amount equal to the pipe movement, as shown below.



Reviewing the load displacement diagram for a 1/2" diameter Hilti bolt at 1/16" deflection, the load on the bolt (labeled A in the drawing above) would be 4,900 lbs., with the shear load equal to zero and 4,000 psi concrete (see attached 4/15/74 letter from Robert D. Dalton, Jr., President of Abbot A. Hanks Testing Laboratories, to Hilti Fastening Systems, Inc., under Subject of Combined Shear and Tension Testing: KWIK-Bolt). But the allowable is listed as 1,100 lbs. for 2-1/4" embedment, as shown in the PSE Manual (see attached page 8 of 10 of Section V, Hilti Concrete Anchor Bolts, Rev. 0, 1/8/82). Now in the event of a seismic load, this support will only have one anchor bolt (labeled B in the drawing above), since the bolt A exceeded its capacity for predictable behavior.

This example demonstrates two important topics. The first is that when the Applicants neglect friction, they are neglecting an important loading condition. The second and most important is the reason Applicants gave for not considering it. Mr. Finneran stated that the factor of safety for the Hilti bolt was 5 and not 4 (Finneran Affidavit at page 5). As shown in the above example, the Hilti bolt would have been sized for a vertical upward load only, and this would be independent of the effects caused by friction. Mr. Finneran's conclusion does not form a logical basis for not considering friction, in regards to Hilti bolts.

7. Applicants state:

"Inclusion of friction forces in the design of the support referenced by Mr. Doyle results in maximum member stresses, weld stresses, plate stresses, and Hilti interactions that are all within the applicable allowables."

We disagree with this statement. On sheet 1 of 6 (of Attachment A to Finneran Affidavit), the math model is shown. There are a string of dimensions underneath the math model which are 8", 18.0625", and 18.0625". Following page 6 of 6 of the Attachment is the drawing for this support. The centerline of the pipe is 2'3" from the face of the wall, or 2'2" from the face of the base plate. The centerline of the pipe to the edge of the tube steel member is 15.0625" (30"/2 + 1/16"). When the pipe moves, it will be in contact with the face of the tube and therefore the moment arm which the Applicants should have been using would be 2'2" minus 15.0625" = 10.9375". But the analysis which the Applicants used had a moment arm of just 8"; they did not consider the point where the pipe comes in contact with the support. This will result in the loads and stresses for the cantilevered member, as well as the base plates and anchor bolts, increasing by the amount of 10.9375" divided by 8" = 1.37 or a 37% increase of all tabulated values. This error would put the stress ratios above 1 for the welds and anchor bolts.

It should be further noted that on the drawing the centerline of the tube steel member is shown to be 1'6" from the centerline of the pipe. For a 30" diameter pipe and a 6" tube steel member, the distance from the centerline of the tube to the centerline of the pipe can be tabulated as 30" divided by 2 plus 6" divided by 2, and this would be

1'6"; but the drawing indicates there is a 1/16" gap between the pipe and the tube steel member. This gap cannot exist with the dimensions shown on the drawing, or the dimensions on the drawing are in error.

The weld referenced on sheet No. 3 of 6 (of Attachment A to Finneran Affidavit) exceeds the allowable. The resultant weld the Applicants have tabulated is referenced as 3.118 kips/inch. The Applicants claim the allowable is equal to .6 Sy times the weld size of 3/16". This is a gross error. The allowable for the base metal as indicated above in answer 6. is .4 times Sy (the allowable shear strength of the base metal) times 3/16". This value is .4 times 30.5 ksi times .1875 in. = 2.29 kips/inch, which is less than the applied load of 3.118 kips/inch. Also, it is less than the Applicants' arrived-at allowable value of 3.431. The Applicants' method of arriving at the base metal allowable not only is in violation of the ASME, AISC, and AWS codes, it does not make much sense, and appears to be a method arrived at by the Applicants to make a support acceptable (although it violates codes).

The .4 times Sy referenced above can be shown in the AISC Specification in Table 1.5.3 Allowable Stress, under Fillet Welds (see attached page 8 from Supplement No. 3, AISC Manual, Effective 6/12/74, Revised 10/30/75) where it states:

> "Allowable Stress:
>
> "0.30 x nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed <u>0.40 x yield stress of base metal</u> (Emphasis added.)

Applicants are committed to this revision of the AISC Manual, according to Design Specification MS-46A.

It is apparent that the Applicants have not consulted Regulatory Guide 1.124 in Applicants' statement (indicated on sheet 3 of 6 of the attached calculation), which states:

> "Since this support has been shown acceptable for DW + TH loads only, the resultant force can be compared (? -- not certain about spelling) to three times the stress limits of XVII-2000 (per NF-3231.1a)."

Regulatory Guide 1.124 does <u>not</u> allow an increase in allowables in welds due to shear above 1.5 (see discussion in answer 6. preceding) which the Applicants have neglected to consider. Applicants only reference ASME, <u>not</u> the modifications to the NF code which the NRC Regulatory Guide 1.124 recommends; at page 1 of the Reg Guide, it is stated (footnote, bottom of page 1):

"USNRC REGULATORY GUIDES

> "Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable <u>if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission</u>." (Emphasis added.)

Since Applicants have not provided the necessary basis to be able to ignore the recommendations set forth in Regulatory Guide 1.124, they should have to abide by it.

8. Applicants state:

"Five other supports of the kind considered to be most significantly effected (sic) by friction forces were selected at random by Applicants for ranalyses (sic).

"All stresses were shown to be within the regular normal and upset allowables used by Applicants."

We disagree with these statements; see discussion in Item 7. preceding.

With regard to the first sentence, we do not know how random Applicants' sample was or the criteria used for their selection; sufficient information was not supplied with the Motion for Summary Disposition to make this determination.

With regard to Applicants' second sentence, we do not agree with the implications of this sentence, which is obviously designed to complete Applicants' arguments that they have now adequately addressed and resolved all problems associated with the specific supports of concern to us.

In their support analyses, ITT Grinnell and PSE generically omit inclusion of friction when it is less than 1/16", with the blessings of the NRC Staff (see discussions at Tr. 5756, 6759/17-25, 6760/1-25, 6762/18-24, 6764, 6765/16-20, 6771-6772). However, inclusion of friction alone results in increased stresses in the weld, particularly to the limits of the margins allowed, as will be shown below.

A simple dissection of Applicants' calculation No. SI-1-029-055-S32R (which is one of the five supports referenced in Applicants' item

8., and in Table 1 attached to the Finneran Affidavit -- a copy of the drawing and calculations was supplied with Applicants' Motion for Summary Disposition) will illustrate the shortsightedness of neglecting assumed minor effects.

(1) See page 1 of attachment to Motion for Summary Disposition of equation noted above.

(2) It will be noted that Applicants found that the load out-of-plane due to friction was 4,972 lbs. This resulted in an additional stress in the suport of 9,067 psi. The stress ratio without friction was .155; however, the stress ratio with friction became .58, or almost 4 times as high.

(3) For the weld at level A, the load without friction was 797 lbs. per inch of weld. The load considering friction was 3,042 lbs. per inch. Based on the allowable given of 3181 lbs. per inch, the stress ratio without friction was .25; the stress ratio with friction increased to .96. As can be seen, the weld with friction can take very minor increase in loads without exceeding allowables. Some of these increases could come about as a result of including this U-bolt as a two-way constraint, utilizing actual stiffnesses instead of generic stiffnesses, including masses on supports, etc. In addition, when considered as a two-way constraint, this would add an additional friction force at the tangent point of the pipe to the U-bolt.

(4) The calculation for the U-bolt itself at page 3 of 7 indicates an allowable of 23,326 lbs. with a load on the U-bolt of 21,087 lbs.; considering only the one direction of the load, the stress ratio is .904. As can be seen, it would take very little side load to cause this support to fail.

(5) Beyond this, there is a note on page 1 (near top of page on right) of the calculation which indicates that it would only take a 24 lbs. load acting at the top of the U-bolt to move it 1/32". If this were true, the stiffness of the U-bolt for axial load applied at the top of the bolt would be 780 lbs./in. This has not been the prior position of the Applicants insofar as the capability of U-bolts for taking side loads and axial loads. See Applicants' 5/23/84 Motion for Summary Disposition of CASE's Allegations Regarding U-Bolts Acting As Two-Way Restraints; see also Applicants' 5/21/84 Motion for Summary Disposition Regarding Use of Generic Stiffnesses Instead of Actual Stiffnesses in Piping Analysis.

In a related matter, Cygna Energy Services, in its Phase III Report ("Final Report, Independent Assessment Program, of Comanche Peak Steam Electric Station (Phase 3), Prepared by Cygna Energy Services, July 16, 1984"), stated that Applicants did not consider friction. On page 1 of 1 of Attachment A, Observation Record Review PS-08 (Appendix G), Cygna states as part of 2.0 Resolution (see copy attached):

"d) Friction is only considered in the normal load case; for upset (dynamic) conditions, friction need not be considered . . . "

Both Applicants and Cygna are incorrect in their assumption that friction need not be considered. This is not in compliance with ASME NF-3231.1, which states, in applicable part:

> "(a) Design, Normal, and Upset Conditions. The stress limits for Design, Normal, and Upset Conditions are identical and are given in Appendix XVII. The allowable stress for the combined mechanical loads and effects which result from constraint of free-end displacements (NF-3213.10), but not thermal or peak stresses, shall be limited to three times the stress limits of XVII-2000."

As can be seen from the above code citation, the Applicants are required to consider friction with upset (dynamic) conditions. Further, any statements made by the Applicants indicating the inclusion of the upset (dynamic) condition as being conservative are misleading, since this is a code requirement.

Attachments:

6/26/84 handwritten memorandum from John Finneran, TUGCO, to John Fair, NRC, regarding effects of thermal friction force only for six referenced supports (see answer 6, page 7)

PSE Manual, Section XII, pages 12 through 15, regarding factor of safety of 4 for Hilti bolts (see answer 6, page 9)

4/15/74 letter from Robert D. Dalton, Jr., President of Abbot A. Hanks Testing Laboratories, to Hilti Fastening Systems, Inc., Subject: Combined Shear and Tension Testing: KWIK-Bolt) (see answer 6, page 10)

Page 8 of 10, PSE Manual, Section V, Hilti Concrete Anchor Bolts, Rev. 0, 1/8/82 (see answer 6, page 10)

Page 8, Supplement No. 3, AISC Manual, Effective 6/12/74, Revised 10/30/75, regarding Allowable Stress for Fillet Welds (see answer 7, page 12)

Observation Record, Checklist No. General, Observation No. PS-08, Sheet 1 of 1, and Observation Record Review, Attachment A, Checklist No. N/A, Observation No. PS-08, Sheet a of 1, Final Report, Independent Assessment Program, of Comanche Peak Steam Electric Station (Phase 3), Prepared by Cygna Energy Services, July 16, 1984, Volume 1 (see answer 8, pages 16 and 17)

The preceding CASE's Answer to Applicants' Statement of Material Facts As To Which There Is No Genuine Issue was prepared jointly under the personal direction of the undersigned, CASE Witnesses Jack Doyle and Mark Walsh. We can be contacted through CASE President Mrs. Juanita Ellis, 1426 S. Polk, Dallas, Texas 75224, 214/946-9446.

Our qualifications and background are already a part of the record in these proceedings. (See CASE Exhibit 842, Revision to Resume of Jack Doyle, accepted into evidence at Tr. 7042, and CASE Exhibit 841, Revision to Resume of Mark Walsh, accepted into evidence at Tr. 7278; see also Board's 12/28/83 Memorandum and Order (Quality Assurance for Design), pages 14-16.)

We have read the statements therein, and they are true and correct to the best of our knowledge and belief. We do not consider that Applicants have, in their Motion for Summary Disposition, adequately responded to the issues raised by us; however, we have attempted to comply with the Licensing Board's directive to answer only the specific statements made by Applicants.

Jack Doyle
(Signed) Jack Doyle

Date: Aug 4 1984

STATE OF Massachusetts

COUNTY OF Worcester

On this, the 4th day of August, 1984, personally appeared Jack J. Doyle, known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes therein expressed.

Subscribed and sworn before me on the 4th day of August, 1984.

Norma A. Pate
Notary Public in and for the
State of Massachusetts

My Commission Expires: ______________________

MY COMMISSION EXPIRES JANUARY 9, 1987

The preceding CASE's Answer to Applicants' Statement of Material Facts As To Which There Is No Genuine Issue was prepared jointly under the personal direction of the undersigned, CASE Witnesses Jack Doyle and Mark Walsh. We can be contacted through CASE President, Mrs. Juanita Ellis, 1426 S. Polk, Dallas, Texas 75224, 214/946-9446.

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We have read the statements therein, and they are true and correct to the best of our knowledge and belief. We do not consider that Applicants have, in their Motion for Summary Disposition, adequately responded to the issues raised by us; however, we have attempted to comply with the Licensing Board's directive to answer only the specific statements made by Applicants.

Mark Walsh

(Signed) Mark Walsh

STATE OF TEXAS

On this, the 4th day of August, 1984, personally appeared Mark Walsh, known to me to be the person whose name is subscribed to the foregoing instrument, and acknowledged to me that he executed the same for the purposes therein expressed.

Subscribed and sworn before me on the 4th day of August, 1984.

Notary Public in and for the
State of Texas

My Commission Expires: 12/31/84

Item 5

From: John Finneran - TUGCO

6-26-84

To: Mr. John Fair - NRC

Attached hereto are the effects of therma friction force only for the 6 supports referen in Applicants Affidavit regarding Consideration of Friction Forces in the Design of Pipe Suppor with Small Thermal Movements. For the 5 supports listed in Table 1 of the affidavit we have attached a similar Table, Table 1a which shows the effect of friction force only on the supports. For the support covered by Attachme A to the affidavit, we have attached Attachm A.1, which is an assesment of friction force o on the subject support.

One must be careful when reviewing these resu A friction force can never really act alone o a support. It must act together with the normal force from which it came. Thus to asses the friction force alone, all that need be reviewed should be the Level A + F data already furnished in Table 1 of the affidavit Nevertheless we have supplied the information requested. A good example of the above discuss is SI-1-029-055-S32R, which has a bolt intera of .775 from friction alone. In this case the associated dead weight normal forces on the support tended to offset the friction force effect.

BY RTW DATE 6/12/82 SUBJECT .... SHEET NO. 1 OF ...

CHKD. BY [illegible] DATE 6/13/94 CUSTOMER 'TUSI' SUPPORT I.D. ....

PROJECT COMM. PEAK OTHER I.D. SA-4995

OBJECTIVE: TO RERUN STRUDL MODEL I RUN FOR THE CASE OF FRICTION ONLY BASED ON DW + TH. THREE LOADING CASES WILL BE RUN THEY ARE:

a) FRICTION AT JT. 2
b) FRICTION AT JT. 8
c) FRICTION AT JTS. 2 & 8

} MEMBER WE[IGHT] NOT INCLUDE[D]

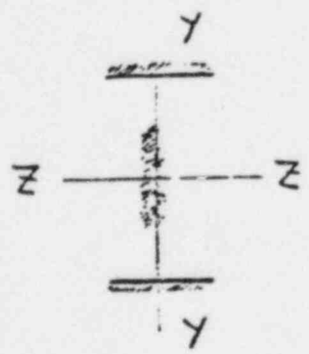
THE CALCULATED STRESSES AT THE WELD AND PLATE WILL BE REPORTED AS WELL AS THE BOLT TENSILE AND SHEAR FORCES.

ANALYSIS LOADING 3 FRICTION AT JTS. 2 & 8

"M4X13"

THE M4X13 PASSED ALL CODE CHECK REQUIREMENTS.

"3/16" WELD AT JOINT 1"



$L_w = 12.63$ in

$S_{wy} = 5.17$ in^2

$J_w = 43.95$ in^3

$c_y = 2.00$ in

$c_z = 1.97$ in

LOADING 3 JOINT 1

F_x -

F_y -

F_z - 1.63 KIPS

M_x - .756 in-KIPS

M_y - 15.438 in-KIPS

M_z - 0

$$F_N = \frac{15.432}{5.17} = 2.986 \ ^{K/IN}$$

$$F_{sy} = \frac{1.631}{12.63} + \frac{.756(2)}{43.95} = .1635 \ ^{K/IN}$$

$$F_R = \left[2.986^2 + .1635^2\right]^{1/2} = 2.9904 \ ^{K/IN}$$

BASEPLATE AND BOLTS (FUB II R3)

F_x - M_x - .756 in-kips
F_y - M_y - 15.428 in-kips
F_z · 1.631 KIPS M_z - 0

TEST STRIP

INPUT

0.	00
0.	01
0.	02
0.	03
400.	04
500.	05
600.	06
4000.	07
5000.	08
6000.	09
3.	10
4.	11
5.	12
6.	13
4.	14
5.	15
6.	16
7.	17
0.	18
0.	19
0.	20
1.33	21
2.	22
3.	23
0.	24
0.75	25

OUTPUT

F MAX
1880.60

P STR
6591.20

SHEAR
418.00
437.75
449.16
465.71

FUB II R3

ITT Grinnell Corporation

BY RTW DATE 6/12/84 SUBJECT .... SHEET NO. 3 OF ...

CHKD. BY [illegible] DATE 6/13/84 CUSTOMER 'TUSI' SUPPORT I.D. ....

PROJECT COMM. PEAK OTHER I.D. SA-4995

FINAL RUN

INPUT

0.	00
0.	01
0.	02
0.	03
0.	04
0.	05
1631.	06
756.	07
15438.	08
0.	09
6.	10
6.	11
6.	12
6.	13
6.	14
6.	15
6.	16
6.	17
0.	18
0.	19
0.	20
1.	21
1.97	22
2.	23
0.	24
1.	25
1.	26
0.	27
0.	28
0.	29

OUTPUT

F MAX
1002.36

P STR
5003.00

SHEAR
430.02
430.02
430.02
430.02

FUB II R3

RESULTS.

PLATE STRESS = 5003.00 PSI

FMAX = 1002.36 LBS

SHEAR = 430.02 LBS

FORM DHE-5

TEXAS UTILITIES SERVICES INC.
COMANCHE PEAK S.E.S.
Agent For
DALLAS POWER & LIGHT COMPANY
TEXAS ELECTRIC SERVICE COMPANY
TEXAS POWER & LIGHT COMPANY

Filing Code ______
Sheet No. ______ of ______
G & H Job No. ______
Ref. Dwg./Spec. No. ______

Date ______
Calc By ______
Chk'd/Apprd. By ______
Subject ______

Table 1a.

SUPPORT	CASE	COMB. BEND. & COMP STRESS	SHEAR STRESS (PSI)	WELD STRESS (#/IN)	PLATE STRESS (PSI)	BOLT INTERACTION	REMARKS
CT1·004·011·S32R	FRICT. ONLY	.08	968	595	1097	0.17	
	ALLOW	1	15300	4772	21700	1	
SW1·129·088·Y33R	FRICT. ONLY	.014	68	250	1066	0.115	
	ALLOW	1	15300	3976	21700	1	
SW1·010·001·A33R	FRICT. ONLY	.032	214	321	1824	0.163	THIS SUPPORT HAD 3 PLATES, VALUES FOR PLATE STRESS & BOLT INT. IS THE WORST CASE
	ALLOW	1	15300	3976	21700	1	
SI1·029·055·S32R	FRICT. ONLY	.47	891	2464	7299	0.775	RESULT FROM FUB II OUTPUT USING PLATE THK. OF 1" ACTUAL PLATE THK. IS 1 1/2"
	ALLOW	1	12700	3181	21700	1	
SW1·129·060·S43R	FRICT. ONLY	.03	432	412	687	0.13	
	ALLOW	1	15300	3712	21700	1	

TEXAS UTILITIES SERVICES INC.		REV.	ISSUE DATE	PAGE
ENGINEERING GUIDELINE TITLE	COVER SHEET FOR GUIDELINE REVISIONS	1	6-2-82	1 OF 7
SECTION XII NPSI and ITT-Grinnell Load Capacity Data Sheets/ Certified Design Report Summaries		APPROVED: John C. Finneran Jr.		
		PSE PROJ. ENGR.		

I. INSTRUCTIONS FOR FILING GUIDELINE PAGES

1. Add the enclosed page 68 A, Rev. 1.

2. Remove the existing cover sheets, page 1 thru 7, Rev. 0 and replace with the enclosed cover sheets, pages 1 thru 7, Rev. 1.

NOTE: This revision added page 68 A. Vendor page numbers have not been changed and consequently two page numbers usually appear on a sheet.

II. STATUS OF GUIDELINE PAGES

PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV
1	2	11	B	21	N/A	31	0	41	0	51	0
2	N/A	12	B	22	0	32	0	42	0	52	0
3	N/A	13	B	23	0	33	0	43	0	53	0
4	0	14	B	24	0	34	0	44	0	54	0
5	0	15	N/A	25	0	35	0	45	0	55	0
6	0	16	N/A	26	0	36	0	46	0	56	0
7	0	17	0	27	0	37	0	47	0	57	0
8	0	18	N/A	28	0	38	0	48	0	58	0
9	N/A	19	N/A	29	0	39	0	49	0	59	0
10	N/A	20	N/A	30	0	40	0	50	0	60	0

Reference No. Page 2
Revision No. 3
Revision Date 1/28/81

HILTI KWIK-BOLT

ALLOWABLE TENSILE & SHEAR WORKING LOADS (LBS.)

@ 100°F, 200°F, 300°F & 400°F

CONCRETE STRENGTH		2000 PSI		4000 PSI		6000 PSI	
Diameter	Embedment	Tension	Shear	Tension	Shear	Tension	Shear
5/8"	2-3/4"	1352	2799	1650	2890	1925	3375
	3-1/2"	1562	2799	2275	2890	2390	3375
	4-1/2"	1750	2799	3000	2890	3625	3375
	5-1/2"	1887	3344	3575	3859	5075	3859
	6-1/2"	2006	3344	4000	3859	5250	3859
	7-1/2"	2250	3344	4250	3859	5250	3859
3/4"	3-1/4"	2038	3314	2537	4283	2715	4525
	4"	2425	3314	3350	4283	3425	4525
	5"	2925	3314	4125	4283	4400	4525
	6"	3450	3798	4500	4616	5625	5252
	7"	3950	3798	5250	4616	5900	5252
	8"	4000	3798	5750	4616	5900	5252
	9"	4000	3798	5875	4616	5900	5252
1"	4-1/2"	3500	6838	4000	6719	5125	8029
	5"	3875	6838	4725	6719	5860	8029
	6"	4400	6838	5860	6719	5860	8029
	7"	4550	6838	5860	6719	5860	8029
	8"	4550	6838	5860	8622	5860	9098
	9"	4550	6838	5860	8622	5860	9098
	10"	4550	6838	5860	8622	5860	9098

* Indicates Section XVII - 2460 allowable stresses govern working load. All other values governed by a 4 to 1 Factor of Safety applied to the average ultimate tensile and shear loads.

HILTI KWIK-BOLT

ALLOWABLE TENSILE & SHEAR WORKING LOADS (LBS.)

@ 100°F, 200°F, 300°F & 400°F

CONCRETE STRENGTH		2000 PSI		4000 PSI		6000 PSI	
Diameter	Embedment	Tension	Shear	Tension	Shear	Tension	Shear
1-1/4"	5-1/2"	4750	9187	5750	8920	7800	11298
	6-1/2"	5400	9187	6775	8920	9125	11298
	7-1/2"	5900	9187	7775	8920	10500	11298
	8-1/2"	6275	9960	8650	8920	11100	11774
	9-1/2"	6550	9960	9450	8920	11100	11774
	10-1/2"	6700	9960	10225	8920	11100	12399

Reference No. Page 4
Revision No. B
Revision Date 1/28/81

HILTI SUPER KWIK-BOLT

ALLOWABLE TENSILE & SHEAR WORKING LOADS (LBS.)

@ 100°F, 200°F, 300°F & 400°F

CONCRETE STRENGTH		2000 PSI		4000 PSI		6000 PSI	
Diameter	Embedment	Tension	Shear	Tension	Shear	Tension	Shear
1/2"	3-1/4"	1754	2466	2496	2728*	3496	2728*
	4-1/4"	2211	2466	3695	2728*	3750	2728*
	5-1/4"	2462	2466	3695	2728*	3750	2728*
	6-1/4"	2709	2466	3695	2728*	3750	2728*
1"	6-1/2"	5737	4853	8741	6884	9383	8191
	8-1/2"	7207	4853	12439	6884	13328	8191
	10-1/2"	8706	4853	12439	6884	14400	8191
1-1/4"	8-1/8"	7243	9389	10675	10369	11067	9934
	10-5/8"	7742	9389	13420	10369	14988	9934
	13-1/8"	9312	9389	16230	10369	17276	9934

* Indicates Section XVII - 2460 allowable stresses govern working load. All other values governed by a 4 to 1 Factor of Safety applied to the average ultimate tensile and shear loads.

NPS INDUSTRIES' LCDS/CDRS INDEX

Section G
Page 1 of 1
Date 09/08/81

CURRENT		OBSOLETE	
LCDS/CDRS	REV.	LCDS/CDRS	REV.
-		LCDS G-2	0,1

ABBOT A. HANKS

ESTABLISHED 1866

1115 INDIANA STREET, P. O. BOX 77265
SAN FRANCISCO, CA 94107
(415) 282-8600

FILE NO. H2139-S1

REPORT NO. 9059

April 15, 1974

HILTI FASTENING SYSTEMS, INC.
360 Fairfield Avenue
Stamford, Connecticut 06904

SUBJECT: COMBINED SHEAR AND TENSION TESTING: KWIK-BOLT

At your request, we have conducted a test program to determine the effect of combined shear and tensile loads on the Kwik-Bolt anchor embeded in concrete. The following anchor diameters and embedments were selected for testing:

1/2"	Diameter	@ 2 1/4"	Embedment
1/2"	"	@ 5 1/4"	"
3/4"	"	@ 3 1/4"	"
3/4"	"	@ 6 1/4"	"

Anchors, drills and drill bits were furnished by Hilti from regular production runs and are considered to be indicative of that material normally used for installations of this type.

Concrete was supplied by a local batch plant and placed by Abbot A. Hanks personnel. Two, non reinforced, 7'-0" x 9'-6" x 10" slabs were used for testing. The concrete mix for the test slabs used limestone aggregate in accordance with ASTM C-33 (3/4" maximum) and Type II cement. The concrete was placed in a typical construction manner and finished with a bull-float. Compressive strengths were verified from standard 6 x 12 cylinders from each slab, prepared in accordance with ASTM C-31 and tested in accordance with ASTM C-39. Actual compressive strength at the time of testing was 5570 psi.

Under observation by Abbot A. Hanks, Hilti personnel drilled holes and installed the anchors in accordance with manufacturer's instructions. Prior to installing the anchors the hole diameters (top and bottom of hole) and hole depths were measured. Anchors were spaced at 18" o.c. each way.

Tensile and shear loads were applied using hollow-core hydraulic jacks equipped with calibrated pressure gauges. Tensile loads were supported by a three-legged reaction tripod which distributed the reaction outside a 30" diameter circle. Shear loads were supported by a fixture attached to the edge of the slab, at least 30" away from the anchors tested. Loads were transferred from the jacks to the anchor using high strength steel rods equipped with various couplers. Loads were applied at a rate of 20% of the expected failure load per minute.

Each diameter-embedment combination was tested by applying a constant shear load while applying an increasing tensile load until failure occurred. A dial indicator was used to record the vertical displacement of the anchor. Horizontal displacements were not recorded. Initial horizontal displacements were noted to be the same as previously determined (our report #8784, Hilti #TR-111A). It was also noted that additional horizontal displacements while the tensile load was applied were minor, the tensile load tended to prevent horizontal displacement.

The shear loads applied corresponded approximately to 1/4, 1/2 and 3/4 of the average ultimate shear capacity of the diameter-embedment combination. A series of three tests at each level were run to establish an average value.

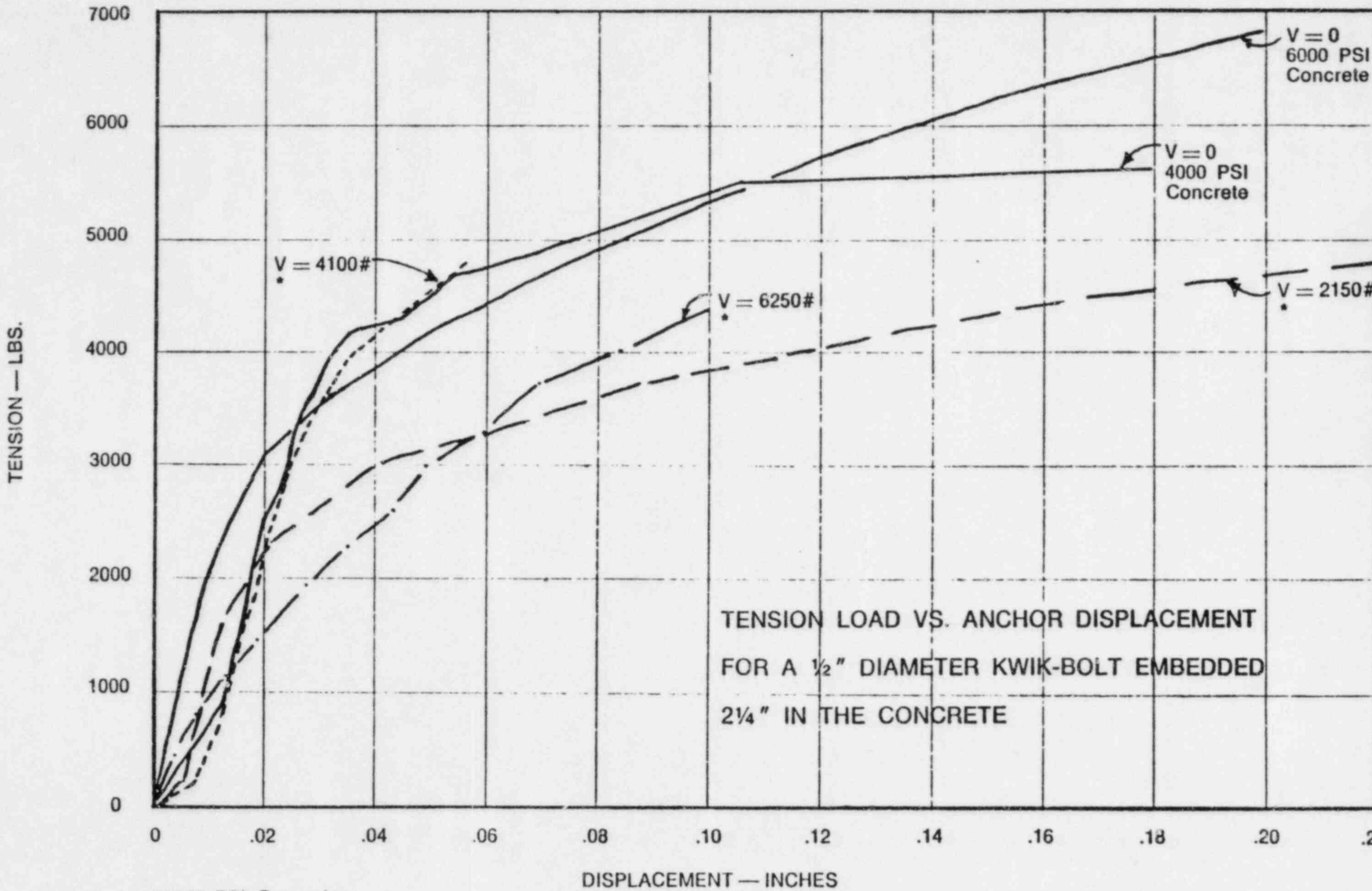
The results of the testing are recorded on the attached data sheets. Figures 1 and 2 are a plot of average ultimate shear vs. average ultimate tension for each diameter-embedment combination. Figures 3 and 4 are a plot of tensile load vs. vertical displacement for two of the anchors tested. Each figure has three curves corresponding to the three levels of shear and two additional curves corresponding to zero shear levels previously tested in 4000 psi and 6000 psi concrete (refer to our report #8785, Hilti #TR-111B).

ABBOT A. HANKS
TESTING LABORATORIES

Robert D. Dalton Jr.
ROBERT D. DALTON, JR., PRESIDENT

File No. 2189-S1

Report No. 9059



*5570 PSI Concrete

V = Shear Load

NOTE: All anchors were installed according to the normal procedures except the nut was not torqued (tightened 3 to 4 turns)

TEXAS UTILITIES SERVICES INC.	COVER SHEET FOR GUIDELINE REVISIONS	REV.	ISSUE DATE	PAGE
ENGINEERING GUIDELINE TITLE		0	1-8-82	1 OF 1
SECTION V HILTI CONCRETE ANCHOR BOLTS		APPROVED: John C. Finneran		
		PSE PROJ. ENGR.		

I. INSTRUCTIONS FOR FILING GUIDELINE PAGES

1. Remove Section V in it's entirety from the engineering manual and replace with the enclosed pages 1 thru 10.

2. Place this cover sheet directly in front of page 1, Rev. 4.

II. STATUS OF GUIDELINE PAGES

PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV	PAGE	REV
1	4	8	3								
2	5	9	3								
3	3	10	2								
4	3										
5	3										
6	4										
7	3										

SECTION V

FIGURE 6

TEXAS UTILITIES SERVICES INC.
Agent For
DALLAS POWER & LIGHT COMPANY
TEXAS ELECTRIC SERVICE COMPANY
COMANCHE PEAK S.E.S.

ALLOWABLE LOADS FOR HILTI-KWIK AND SUPER HILTI KWIK BOLTS USING 4000 PSI CONCRETE, 5:1 SAFETY FACTOR, A.A. HANKS TESTING LAB REPORT NO. 873R AND HILTI LETTER DATED OCT. 27, 1980 W/ CPPA-7419 COVER LETTER

HILTIS

BOLT DIA	EMB LENGTH	TENSION	SHEAR
1/2"	2 1/4"	1102	1663
	2 3/4"	1440	↓
	3 1/2"	1890	↓
	4 1/2"	2245	2046
	5 1/2"	2410	↓
	6"	2460	↓
5/8"	2 3/4"	1320	2312
	3 1/2"	1820	↓
	4 1/2"	2400	↓
	5 1/2"	2860	3087
	6 1/2"	3200	↓
	7 1/2"	3400	↓
3/4"	3 1/4"	2030	3427
	4"	2680	↓
	5"	3300	↓
	6"	3600	3693
	7"	4200	↓
	8"	4600	↓
	9"	4700	↓
1"	4 1/2"	3200	5375
	5"	3780	↓
	6"	4688	↓
	7"	↓	↓
	8"	↓	6898
	9"	↓	↓
	10"	↓	↓
1 1/4"	5 1/2"	4600	7136
	6 1/2"	5420	↓
	7 1/2"	6220	↓
	8 1/2"	6920	↓
	9 1/2"	7560	↓
	10 1/2"	8180	↓

SUPER HILTIS

BOLT DIA.	EMB. LENGTH	TENSION	SHEAR
1/2"	3 1/4"	1997	2288
	4 1/4"	2956	↓
	5 1/4"	2956	↓
	6 1/4"	3029	↓
1"	6 1/2"	6993	5507
	8 1/2"	9951	↓
	10 1/2"	9951	↓
1 1/4"	8 1/8"	8540	8296
	10 5/8"	10736	↓
	13 1/8"	12984	↓

SUPPLEMENT NO. 3

TO THE SPECIFICATION FOR THE DESIGN, FABRICATION & ERECTION OF STRUCTURAL STEEL FOR BUILDINGS

(ADOPTED FEBRUARY 12, 1969)

Effective June 12, 1974
Revised Effective October 30, 1975

(INCLUDING ADDENDA TO THE **COMMENTARY** ON THE SPECIFICATION)

AMERICAN INSTITUTE
OF STEEL CONSTRUCTION
1221 AVENUE OF THE AMERICAS, NEW YORK, N.Y. 10020

Price: $1.00

1.5.2 Rivets, Bolts, and Threaded Parts

1.5.2.1 In Table 1.5.2.1, under the column headed "Description of Fastener", immediately after "A325" in the fifth and sixth items, delete "and A449".

Delete Table 1.5.3 in its entirety and substitute new Table 1.5.3.

TABLE 1.5.3 ALLOWABLE STRESS

Type of Weld and Stress[1]	Allowable Stress	Required Weld Strength Level[2,3]
Complete Penetration Groove Welds		
Tension normal to the effective area	Same as base metal	"Matching" weld metal must be used; see Table 1.17.2.
Compression normal to the effective area	Same as base metal	Weld metal with a strength level equal to or less than "matching" weld metal may be used.
Tension or compression parallel to the axis of the weld	Same as base metal	
Shear on the effective area	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	
Partial Penetration Groove Welds[4]		
Compression normal to effective area	Same as base metal	Weld metal with a strength level equal to or less than "matching" weld metal may be used.
Tension or compression parallel to axis of the weld[5]	Same as base metal	
Shear parallel to axis of weld	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	
Tension normal to effective area	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.60 × yield stress of base metal	
Fillet Welds		
Stress on effective area	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	Weld metal with a strength level equal to or less than "matching" metal may be used.
Tension or compression parallel to axis of weld[5]	Same as base metal	
Plug and Slot Welds		
Shear parallel to faying surfaces (on effective area)	0.30 × nominal tensile strength of weld metal (ksi), except stress on base metal shall not exceed 0.40 × yield stress of base metal	Weld metal with a strength level equal to or less than "matching" weld metal may be used.

[1] For definition of effective area see Sect. 1.14.7.
[2] For "matching" weld metal, see Table 1.17.2.
[3] Weld metal one strength level stronger than "matching" weld metal will be permitted.
[4] See Sect. 1.10.8 for a limitation on use of partial penetration groove welded joints.
[5] Fillet welds and partial penetration groove welds joining the component elements of built-up members, such as flange-to-web connections, may be designed without regard to the tensile or compressive stress in these elements parallel to the axis of the welds.

Observation Record

Checklist No.	General	Revision No.	0
Observation No.	PS-08	Sheet	1 of 1
Originated By	C.K. Wong C.K. Wong	Date	7/1/84
Reviewed By	G. Bjorkman G. Bjorkman	Date	7/10/84

1.0 Description

In supports designed by the CPSES Pipe Support Engineering (PSE) organization, loads due to friction are neglected if the piping thermal movement is less than 1/16".

2.0 Requirement

2.1 Paragraph NF-3124 of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NF, "Provisions for Movement of Supported Component".

3.0 Document Reference

TUGCO Pipe Support Calculation CC-1-028-044-S33R, Rev. 2.

4.0 Potential Design Impact

Failure to consider all applied loads may result in the inability of the support to perform its intended function.

Attachment

A. Observation Record Review

Extent		
Isolated	Extensive X	Other (Specify)

CYGNA

Observation Record Review
Attachment A

Checklist No.	N/A	**Revision No.**	0
Observation No.	PS-08	**Sheet** 1 **of**	1

	Yes	No
Valid Observation		X
Closed	X	

Comments

1.0 Probable Cause

Assumption that the failure potential is negligible for small deformations/loads.

2.0 Resolution

As noted by TUGCO in their response to Cygna (6/8/84 letter), neither ITT nor PSE include frictional effects if the pipe movement is less than 1/16".

Based on a review of pipe support design guide documents of other A/E's, Cygna has concluded that not considering frictional effects for pipe movements of less than 1/16" is consistent with industry practice. Further, Cygna finds that this practice is substantiated by the technical points presented in the "Affidavit of John C. Finneran, Jr., Regarding Consideration of Friction Forces in the Design of Pipe Supports with Small Thermal Movmements."

These points may be summarized as follows:

a) The load is due to thermal expansion of the piping and, therefore, is self-limiting, i.e., if the pipe does not try to move, friction loads do not exist;

b) The ASME Code does allow the use of 3 times the normal allowable for loads resulting from constrained displacement;

c) TUGCO has used a safety factor on Hilti bolts of 5:1, where the NRC accepted factor is 4:1;

d) Friction is only considered in the normal load case; for upset (dynamic) conditions, friction need not be considered;

e) TUGCO has used the normal allowable for upset condition loads, which are higher (by the addition of 1/2 SSE) than the normal condition loads;

f) TUGCO has reanalyzed 6 of the support geometries for large piping, which would tend to have higher normal condition loads due to higher weights. TUGCO's reanalysis shows no overstress conditions exist.

Based on industry practice, the TUGCO sample reanalysis and the factors of safety available for normal conditions, Cygna considers this observation invalid.

III Approvals

Originator	C. K. Wong	**Date**	7/6/84
Project Engineer	John C. Minichiello	**Date**	7/13/84
Project Manager	N. H. Williams	**Date**	7/16/84
Senior Review Team	[illegible]	**Date**	7/16/84

Texas Utilities Electric Company; 84042
Independent Assessment Program, Phase 3