UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

CASE'S ANSWER TO APPLICANTS' STATEMENT OF MATERIAL FACTS AS TO WHICH THERE IS NO GENUINE ISSUE REGARDING CONSIDERATION OF CINCHING DOWN OF U-BOLTS

in the form of

AFFIDAVIT OF CASE WITNESS JACK DOYLE

Q: What is the purpose of this Affidavit?

A: This Affidavit is in partial answer to the Applicants' Motion for Summary Disposition Regarding Consideration of Cinching Down of U-Bolts. This answer does not include thorough consideration of a stack of documents about 2-1/2 inches thick received from Applicants on 9/25/84 (some of which applies to cinching of U-bolts) or documents received later, which I have not had an opportunity to thoroughly review yet. I wanted to get this answer to the Board and parties as soon as possible, and it may be necessary to supplement my answer upon thorough review of those documents.

Q: Taking this on a point-by-point basis from Applicants' Statement of Material Facts As To Which There Is No Genuine Issue Regarding Consideration of Cinching U-Bolts, do you agree with Applicants' Statement 1, which states:

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"1. Relaxation is a characteristic of certain materials which when stressed to certain levels will not maintain that level, but will 'relax' to a lower stress level. The total strain remains fixed, but a part of the elastic strain is replaced with inelastic strain. It should be noted that stress relaxation stops after a material reaches a certain level of stress, e.g., for material such as SA-36 this level is approximately 1/2 of the yield stress. Affidavit of Robert C. Iotti and John C. Finneran, Jr. Regarding Cinching Down of U-Bolts at 6."

No, I do not. That is to say, it is not that I don't agree with the statement per se but I believe the statement to be irrelevant since the manufacturer's advertised loads for normal upset conditions does not come close to 1/2 of the yield of the material. For example, in the case of a 3/4" diameter U-bolt for 10" diameter pipes, the manufacturer's allowable load at N/U is 5420 lbs. (see ITT Grinnell Catalog PH76, page PH-46, Figure 137; or see CASE Exhibit 669B, Attachment to Doyle Deposition/Testimony, admitted at Tr. 3630, item 13N, Code 100; see also discussion on survivability in answer 5(d) item (b) herein, in reference to NUREG/CR-2137). The stress the root area of the thread is 1/2 of 5420 divided by the root area equals 8974 psi or 1/4 of the yield for A-36 at advertised yield stress. Therefore, any discussion of stress levels for U-bolts above 1/4 of yield is without merit, much less the almost 3-1/4 times allowable found in Attachment 1 to Applicants' Affidavit, page 43, item 9.0 (8327 lbs. per leg, or 16,654 lbs.). /1/

Q: Do you agree with Applicants' Statement 2:

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/1/ NOTE BY CASE: See also discussion regarding SA-36 at pages 10-12 of CASE's Answer to Applicants' Statement of Material Facts Relating to Richmond Inserts As To Which There Are No Material Issues in the form of Affidavit of CASE Witness Mark Walsh.

"2. The U-bolt/cross piece connection is not a friction type connection, and is not intended to be loaded in shear. While it could be loaded in shear under U-bolt lateral or axial loads, in this instance it is inconsequential whether it acts as a friction or a bearing connection. Accordingly, Note 1 of ASME Table XII-2461.1-1 is not relevant to the U-bolt 'clamp' configuration used at Comanche Peak. Id. at 6-7."

A: No, I do not. On this point Applicants trip over their own semantics, as may be noted at page 3, item (b) of the Statements of Material Facts, under the heading of "Friction Test."

The concept of a friction joint is that there is no shear transfer through the bolt but rather shear is transferred due to the friction plane caused by a tensile preload. This is the same principle whether the friction plane is located on a single plane, as is the case with a joint in a structure, or is located at various planes on a circular clamping mechanism. There is no positive means in either to transfer shear, only friction.

What Applicants would have us believe is that they have produced a major breakthrough in the science of physics -- they have developed the frictionless friction joint.

Q. Do you have any comments on Applicants' Statement 3, which states:

"To determine the range of torques which exists in the field, Applicants inspected the torques of a representative sample of cinched down U-bolt supports. This data was used to determine the range of torques to be applied to test specimens. From the data, Applicants established preload test values. Id. at 10."

A. Yes, I do. When absolutely random conditions exist, it is the worst case which controls. Since the worst case cannot be determined through random sampling, the basis of establishing a test parameter is non-existent.

All that Applicants have proved is that within their limited sample (and this in all probability is a very limited sample), the torque range varied as follows: For 4" diameter pipes -- 5 to 60 ft. lbs.; for 10" diameter pipes -- 10 to 100 ft. lbs.; and for the 32" pipes -- 20 to 240 ft. lbs. (See Finneran/Iotti Affidavit at page 10.)

Q: Do you agree with Applicants' Statement 4, which states:

> "The effective torque in the plant for all pipe sizes will be the lesser of the value corresponding to a U-bolt stress of half-yield or the value achieved by a man with a torque wrench or impact wrench. Therefore, it is unlikely that there might be considerably higher torques applied to U-bolts in the plant than those which were measured by random sampling noted above. Id. at 11-12."

A: No, I do not. I find this statement on effective torque to be an assault on intelligence. The Applicants have proved by random sampling that there is no effective torque rate for the plant. They then would have us apply random disorder as a means of establishing the fact that "it is unlikely that there might be considerably higher torques applied to U-bolts in the plant than those which were measured by random sampling noted above."

Additionally, here again Applicants would have us believe that 1/2 the yield stress is acceptable, even though the same U-bolt, if used at a non-nuclear plant, is limited to 1/4 of yield for all normal/upset load conditions. (This is especially pertinent to the West Coast where SEAOC requires dynamic analysis.)

Q: Do you agree with the conclusions drawn by Applicants in Statement 5, which states, in part:

> "Applicants' testing program to respond to concerns regarding cinching down U-bolts consisted of seven distinct tests. The objectives and results of the seven tests are summarized below: . . . " (Applicants then offer their summary of each test.)

A: Definitely not. To start with, this is a unique design and as such was required to be listed and the qualifying procedures delineated in the PSAR (see 10 CFR 34(a)(2) and (a)(8)). Since it was not, the Applicants have displayed a total lack of understanding of the requirements of the law as apply to nuclear power facilities. Having said that, the contents of the entire motion are merely academics orchestrated to convince the Board that a nuclear power plant may be "engineered" and constructed and then justified.

To continue for academic purposes, on Applicants' Statement 5(a), I cannot answer for the state of mind of the Applicants as related to the objectives of tests that is beyond what I have already said above.

In reference to Applicants' Statement 5(b), the item has been discussed above. All I wish to add at this point is that U-bolts on insulated lines are not recommended according to MSS SP-69 (see CASE Exhibit 920, attached hereto, MSS SP-69, Table 1, page 3), to which Applicants are committed under Applicants' Design Specification 2323-MS-46A (page 3-20, Section 3.3, CODES AND STANDARDS, item g.(2); see also discussion at page 10, line 20, through page 13, line 25, of my Affidavit, CASE's First Motion for Summary Disposition Regarding Certain Aspects of the Implementation of Applicants' Design and QA/QC for Design).

Further, the cinched-up U-bolt (clamp assembly analogy) is not recommended for pipes supported from below (nor are standard shell type clamps). This would also apply to any articulating type clamp arrangement (see CASE Exhibit 920 attached, MSS SP-69, page 2, Article

6.2 and 6.3, which recommends "bases, brackets or structural cross members.")

For Applicants' Statement 5(c), the same comments as outlined above also apply. In addition, although the mechanical loads may not be directly additive, a substantial portion of the load is directly additive. This factor and the contents of Applicants' Attachment 1, Item 9.0, page 43, and Table 17 cited by Applicants indicate that preload and thermal loads coupled with mechanical loads are not self-limiting.

As relates to Applicants' Statement 5(d), Thermal Cycling/Thermal Gradient Test, I have several comments. The main failure in this test, as is true for all of the tests performed for Comanche Peak, involves two factors: (1) The motivation for these tests is not to show that a particular structure or component is adequate for use, but rather is intended to show that the use of the component or structure was justified. This difference in motivation affects the testing procedures, which can ultimately have an adverse effect on the health and safety of the public; and (2) Standard testing procedures for tests used to quality a component require that the ratios of actual physical and mechanical properties versus the advertised minimum values be determined in order to equate the tests to the real world of engineering.

Testing, to have any legitimacy, must also be based on the imposed limits of the law and the codes. For example, if one were to engineer by judgement a parking facility which was constructed and later found

to have stresses in excess of the allowable loads imposed by code for plastic design of structure, one could not take samples of the steel to one's local testing facility to prove that such section will not fail under the design load or in fact greater loads. This is due to the fact that departures from code allowables introduces, at a minimum, a deleterious impact on the structural survivability factor which may be determined by use of Gompertz or other statistical procedures.

Perhaps I should spend a moment on this feature of man-made structures made up of a multiplicity of components:

(a) Applicants and the NRC Staff place an inordinate amount of confidence in safety factors which are derived after the fact and which involve structures which do not include the total contributors to the real stress in the component.

(b) The fact is that safety factors are of less concern during the 30 to 40-year life cycle of a facility once constructed than are survivability factors. For example, NUREG/CR-2137 (see CASE Exhibit 742 attached hereto) states (page 31) that for Hilti bolts which are subjected to design loads of 1/4 of the average test load, the probability of failure is .001. While it would appear that there is a reserve strength of 300% before failure is a consideration based on safety factors, in the real world of statistical distribution, there is a 1 in 1,000 probability that this component will fail.

(c) The survivability of structures is based on the Gompertz formulae for the first asymptote of probability and not the

safety factor. The purpose of utilizing safety factors as a tool for design is to produce structures that result in a reasonable probability of survival. This survivability is based on the events which are selected that will produce stress levels which do not exceed allowables established by code. The survivability vs. allowable selection is determined in two ways: (1) Analysis based on statistical distribution (generally the procedure utilized by the aircraft industry); and (2) the use of codes which are based on a time/history of methodology derived from experience with revisions from time to time based on analysis and accepted new information (the procedure generally utilized for facility design).

(d) The conflict between survivability and safety factors becomes obvious if one equates the two features realistically, and to do this, one does not need an understanding of statistical distribution to appreciate the problem. For example, if one assumes that at design loads (say, 1/4 of the average test load) the survivability of a component is 99.90% (which is true for the Hilti's discussed above), then simple observation reveals the problem: (1) If instead of using 1/4 of the average ultimate load as an allowable, one reduces this by a factor of 4, one would have an allowable equal to 1/16 of the ultimate load. But since the survivability cannot exceed 100%, the benefit of such reduced allowable is of minimum benefit in relation to survivability. (2) On the

other hand, if instead of using the ratio of 1/4 of the average ultimate load, one increases the allowable by a factor of 4, one may have a marginal belief that one or so units out of a large number may survive. But the overall probability of failure will exceed 99%. Obviously, decreased allowable loads offer few advantages while a proportional increase in allowables result in disaster.

The real probability of failure is based on the level of real stresses and unknown factors, and in this, stress ratios may be altered in two ways:

(a) Overtly, by increasing the allowable used in design; or

(b) Covertly, by omitting one or more of the stress-inducing parameters.

For the above reasons, while the Applicants' tests may show on the surface that code allowables may be conservative, they fail to show that the survivability of the same structure is radically reduced from what would be expected using code allowables.

So the statement by Applicants that the U-bolt/cross bar arrangement will retain adequate clamping force (under, by implication, all circumstances throughout the life of the plant) is misleading and without qualification. Beyond this, errors of unknown magnitude were incorporated in the tests (see Note 8, page 21, of Finneran/Iotti Affidavit).

In reference to Applicants' Statement 5(f), the tests contain several serious flaws: (1) The loads used (4,000 lbs. and 1,000 to

1,500 lbs.) were below what the actual 10" U-bolt may be subjected to, which would be 7,200 lbs. for level D. (2) The frequency range used to 200 Hz is unrealistic; the more degenerate range of 8 to 12 Hz would have been more realistic.

Another failure in this test was the torque used for the U-bolt; 60 ft. lbs. as best that I can determine is far in excess of the 10 ft. lbs. which can exist in the plant for this size line (see above).

This Statement also fails to note items discussed in the Finneran/ Iotti Affidavit at page 27, and that is that the friction plane can part during vibration at certain preload values, allowing the U-bolt to rotate and/or walk.

This parting of the friction plane can alter the response of the node point and thereby affect the loads at this and other node points of the system.

In addition, since at 20 ft. lbs. of torque the rotation and/or walking occurred, and since supports exist at Comanche Peak that have from 5 to 20 ft. lbs., the Applicants have proved that their first engineering judgement or QA/QC program was inadequate (see page 29 of Finneran/Iotti Affidavit). Further, even at 50 ft. lbs. of torque, some movement was noted (see same source).

While Applicants would have the Board believe that these tests represented many magnitudes of energy more than the energy realized by an earthquake (see Finneran/Iotti Affidavit at page 26), they contradict themselves with Note 8 (see same source).

In response to Applicants' Statement 5(g), I find a major error. I cannot respond to an answer which does not exist.

Q: What, if anything, do you have to say on Statement 6, which states:

"Each U-bolt assembly tested was modeled with a finite element analysis utilizing MSC NASTRAN Version 63. Id. at 42. This computer code was chosen because it is universally recognized and accepted by industry as having the capability of providing analytical solutions that accurately characterize the local stress, gap, friction effects, and plastic material behavior (if any) that are important for assessing the pipe and U-bolt assembly stress, and the support stability. Id. at 42-43.

"The objectives of the finite element analysis program were (1) to determine if the pipe would slip, creating an unstable support condition when the hanger support was subjected to the preload, thermal, pressure and mechanical loads that would be expected in the Comanche Peak hanger assemblies; and (2) to calculate pipe and pipe support stresses that could be expected to be experienced by the Comanche Peak U-bolt support assemblies and assess their significance. Id. at 44-45.

"The results of the analyses reflect that (1) the U-bolt assemblies would behave stably at and even below the low preload values evaluated in the analyses (below those values generally expected in the field) (Id. at 45-46); (2) maximum stress in the U-bolt as a result of the worst case load combination evaluated compared favorably with test results and demonstrated that stresses in the U-bolts will not cause any adverse impact (Id. at 46-47); and (3) stresses in piping due to preload values expected in the field in conjunction with other loads imposed will not result in any adverse impact. Id. at 47-49."

A: This element represents a further attempt by Applicants to develop a procedure which may be slipped by the Board. For example, one of the purposes of this finite element procedure was to prove that slip would not occur between the U-bolt and the pipe which the output showed to be the case, and this at preloads less than any actual preload which exists in the field. However, as shown above, Applicants' own tests proved otherwise. And now they must modify at least some of the 380 supports which they mention.

Q: Do you wish to comment on Applicants' Statement 7, which states:

"From the testing and finite element analyses, the U-bolt/cross piece assembly can perform effectively as a clamp provided that sufficient preload is established in the U-bolt. Id. at 34 and 71-73. (It should

be noted that a clamp also requires preloading.) Further, if the preload level was insufficient, but present in some amount, the U-bolt support would vibrate, but still be capable of suporting the necessary loads, thus behaving 'stably.' Id. at 34 and 74-75. The results of the finite element analyses support the conclusions of the test in this regard. Id. at 45-46 and 74-75."

A: I have one remark to make, since the above material also applies to this Statement. The Applicants state that "the U-bolt/cross piece assembly can perform effectively as a clamp provided that sufficient preload is established in the U-bolt." What they fail to note is that this is after modification of those supports which by their own tests may fail in service.

Q: And do you have a comment on Statement 8, which states:

"To provide further assurance of acceptable preload values, Applicants have committed to an inspection program to assure that every cinched down U-bolt on a single strut or snubber (a total of 380) is torqued to a level at which the assembly will be stable in the absolute truest sense, i.e., no rotation, and axial movement, if any, is toward the strut. Id. at 34 and 75."

A: Yes. This statement confirms my previous answer, since they state that they are committed to bring the torque level up to their standards which, I might add, are not based on determining the proper safety factor for use in this endeavor.

Q: What do you have to say in reference to Statement 9, which states:

"The results of the tests conducted for vibration, seismic response, creep and thermal cycling confirm the capability to maintain over time and varying conditions the stability of the assembly when preloaded to observed values. Id. at 21-34."

A: The Applicants are wrong, again on the basis of the material presented above, but additionally the tests did not prove that there were no problems. To the contrary, the tests proved that a corrective action program was required to prevent slip and rotation.

Q: Do you wish to comment on Statement 10, which states:

"From the results of tests, stresses produced in the U-bolts at CPSES would not adversely impact the U-bolts' capability to function. Id. at 36-42. High stresses in the U-bolts occur only if large preload values are applied (i.e., near the maximum used in the tests) to small diameter U-bolts. Id. Large preload values are generally not present in the plant supports, nor are they needed to assure stability of the supports under seismic excitation. Id. In those instances where high preload toques may be initially present, the characteristic relaxation behavior of the material employed (A-36) will reduce the preload value, and hence, the stresses in the U-bolt, to acceptable levels. Id. Moreover, tests have demonstratd that there is adequate margin between yield and failure of the U-bolts. Id. The finite element analyses in essence confirmed the results of testing. Id. at 46-47."

A: Yes. In reference to the stresses in the U-bolt, the Applicants are wrong, since the torque values used in the tests are present in the field. In addition, when correction/reduction factors are applied to the test results and proper safety factors are applied to insure slip requirements, Applicants' torque values may indeed approach or exceed the test values.

Second, Applicants' own tests prove that the high stress levels (some of which present yield problems; see pages 48, 49, and 68 of Finneran/Iotti Affidavit) are far beyond the allowables put forward by the manufacturer and beyond the allowables by code for bar stock. And one must keep in mind that these stresses could be much higher if all of the contributors to stress were included (mass on pipe, stiffness, etc.) /2/ /3/.

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/2/ Regarding "the characteristic relaxation behavior of the material employed (A-36)," see attached "Response to NRC Questions of Meeting of August 8-9 and August 23, 1984, A. U-Bolt Cinching."

/3/ NOTE BY CASE: Further regarding "the characteristic relaxation behavior of the material employed (A-36)," see also discussion regarding SA-36 at pages 10-12 of CASE's Answer to Applicants' Statement of Material Facts Relating to Richmond Inserts As To Which There Are No Material Issues in the form of Affidavit of CASE Witness Mark Walsh.

Q: Do you have any comment on Applicants' Statement 11, which states:

"Testing reflects that the maximum torques to the U-bolt pipe assemblies can potentially result in high but acceptable local pipe stresses. Id. at 37-40. The finite element analyses confirm that piping stresses resulting from U-bolt assemblies and associated loading will not adversely impact plant safety. Id. at 47-49."

A: Yes, and they are similar to those listed above. The pipe stresses found by Applicants were very high, approaching the allowable limits of the piping and in several cases exceeding the limits. The latter required massaging to bring them into compliance (see pages 60 and 68 of Finneran/Iotti Affidavit; see also attached copy of Applicants' "Response to NRC Questions of Meeting of August 8-9 and August 23, 1984, A. U-bolt Cinching," page 18, Table C, sent under cover letter, but without attachments except to the Staff and CASE, of 9/24/84 from Applicants to Geary Mizuno).

In short (codes notwithstanding), the tests prove Applicants' U-bolt/cross bar assembly are marginal at best as far as stress in the U-bolt, pipe, and cross bar are concerned, and somewhat less than marginal as far as U-bolt slip. And beyond that, not all of the real loads are included, since Applicants have dismissed them as negligible.

Q: Do you have any comment on Applicants' Statement 12, which states:

"While the ASME Code does not provide any direct quantitative guidance regarding local stresses induced by external attachments such as U-bolt clamp assemblies, the acceptance criteria established and met by Applicants in this regard conform with the intent of the ASME Code. Id. at 50-73."

A: Due to redundancy of any answer, no. (See preceding answers.)

Q: Do you wish to comment on Applicants' Statement 13, which states:

"A significant number of U-bolt supports at CPSES were always intended to be cinched down. On only a relatively small number (less than 15)

was the initial design changed such that U-bolts were cinched down because of potential pipe support instability. There are other U-bolt supports at CPSES which are not cinched down, e.g., U-bolts on rigid frames used as one- or two-way supports. Id. at 5."

A: No, again due to redundancy of any answer. (See preceding answers herein; see also CASE's Answer to Applicants' Motion for Summary Disposition of CASE's Allegations Regarding U-Bolts Acting As Two-Way Restraints.)

Q: Do you have any general comments in regards to Applicants' Motion?

A: Yes. There is an interesting comparison of the logic used by Appicants for two different purposes.

(1) In Applicants' answer to Cygna Question 43, June 8, 1984 (copy attached), Applicants are qualifying the reason for writing off a support (U-bolt) problem which calculations indicated had stresses in excess of 106 ksi. The principle used by Applicants was to use Roark equations to prove that local yielding would reduce the load to acceptable levels. By this means, Applicants calculated the width of the flattened area and found it to be .135 inches, which would reduce the stress. The decrease in U-bolt radius would be .012 for a 2-1/2" diameter rod size. This flat and radial reduction would be a highly visible phenomenon.

(2) In their Affidavit, Messrs. Finneran and Iotti state (at page 18):

> "With the exception of the 10-inch stainless steel specimen, no polishing of the contact surface between the pipe and the assembly was observed after all the testing. This is strongly indicative of little if any surface yielding at the contact points."

The two statements are tailored to two requirements of Applicants to answer questions.

Q: Do you wish to make any further comments?

A: Yes. Since the principal participants in past tests for Applicants (ITT Grinnell for other tests and Westinghouse for these tests) are both engaged by Applicants at Comanche Peak, putting them in charge of tests will hardly result in independent procedures and conclusions.

This is tantamount to allowing the accused to sit as the presiding judge at his own trial.

At best, I can only state that these tests were somewhat less than independent.

/4/ (See next page.)

The government of the United States sold the American public on the safety of nuclear power by use of the same pipe dreams that were used to convince the public that nuclear plants would produce "power without cost."

The government promised that nuclear power plants would be designed to standards far more stringent that those currently applicable to non-nuclear facilities. That is to say, the public bought and accepted the "built better than Jane Fonda" syndrome.

However, now we know that this was merely the bait to obtain acceptance of this technology which is critical to the survival of the national economy in the coming century (due to the finite nature and potentially more serious problems associated with fossil fuels, especially coal, geopressurized methane, oil shale, and geothermal, for examples).

But on the other side of the coin, we have a technology which has the potential for disaster when treated in a cavalier manner. What Applicants' Motion lays before this Board is a request to join the industry in the national plot to sacrifice a significant technology to save the insignificant posteriors of "somewhat knowledgeable" individuals. /4/

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/4/ It should be noted that the last four paragraphs of Mr. Doyle's Affidavit, from the middle of page 16 through the end of the Affidavit, are the views of Mr. Doyle and do not reflect CASE's position. See discussion in cover letter attached.

I have read the foregoing affidavit, which was prepared under my personal direction, and it is true and correct to the best of my knowledge and belief.

Jack J. Doyle
(Signed)

Date: Oct 1 1984

STATE OF Massachusetts

COUNTY OF Worcester

On this, the 1st day of October, 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 1st day of October, 1984.

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

My Commission Expires: MY COMMISSION EXPIRES JANUARY 9, 1987