May 3, 1983

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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

APPLICANTS' REPLY BRIEF REGARDING CONSIDERATION OF LOCA IN DESIGN CRITERIA FOR PIPE SUPPORTS

I. INTRODUCTION

On April 20, 1983, CASE submitted its brief regarding the consideration of the effects of a Loss of Coolant Accident ("LOCA") in the design of pipe supports. Although the Board had directed the parties to submit briefs regarding the legal basis for the conclusion that stresses in pipe supports resulting from the differential thermal expansion in support members under LOCA conditions need not be addressed in the design of individual pipe supports,[1] CASE's brief dealt primarily with CASE's interpretation of the ASME Code. In addition, CASE addressed several matters extraneous to both the application of NRC regulations and the ASME Code to the design of pipe supports. Although Applicants submit that these matters have been adequately examined in this proceeding already, we address below the principal issues raised by CASE in its brief. The initial issue Applicants

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1 Conference call of April 7, 1983, Tr. 30-31, 43.

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address concerns the interpretation of the ASME Code presented by CASE with respect to the distinction between "thermal stresses" and "thermal expansion stresses." The Board had specifically requested that this matter be addressed by Applicants and the NRC Staff in their reply briefs.[2]

II. APPLICANTS' REPLY TO THE ASSERTIONS OF CASE

A. Thermal Stress v. Thermal Expansion Stress

Applicants have presented extensive evidence on the record in this proceeding regarding the appropriate interpretation of the ASME Code regarding the consideration of thermal stresses in the design of pipe supports.[3] Applicants' witnesses are experts in ASME Code interpretation and application, including the application of the Code to the design of pipe supports. Applicants' expert witnesses testified that the ASME Code allows individual linear-type pipe supports to be designed without consideration of thermal stresses. Further, Applicants' witnesses demonstrated that such thermal stresses were self-limiting in that slight deformations of connections or support members would relieve those stresses without loss of function.[4] Now, long after this issue appeared to be resolved,[5] CASE has resurrected its interpretation of the Code and attempts to

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2 Conference call of April 25, 1983, Tr. 5787-88.

3 See e.g., Applicants' Exhibit 142 at 14-20.

4 See Applicants' Exhibits 142 at 21-25; 142D.

5 See Tr. 5253 where Judge Cole, a former member of this panel, noted his agreement with Applicants' interpretation of the Code.

convince this Board, as newly constituted, that its interpretation is accurate. However, as Applicants will once again demonstrate, CASE has erroneously applied provisions of the Code not applicable to the design of linear-type supports and has misinterpreted Code provisions applicable to the design of those supports.

A fundamental error of CASE's interpretation of the Code rests with its interpretation of the term "constraint of free-end displacement" to represent a stress it describes as "thermal expansion stress" and which it contends is different from the stress defined in the Code as "thermal stress." As demonstrated below, the ASME Code does not define a stress labelled "thermal expansion stress" and in fact expressly defines "thermal stress" as including the type of stress CASE labels "thermal expansion stress." Further, the Code also clearly does not require thermal stresses to be considered in the design of individual linear-type pipe supports. Indeed, CASE implicitly recognizes that the Code does not require the consideration of "thermal stress" in the design of linear-type pipe supports when it merely disagrees with Applicants' definition thereof and, based on its interpretation, states that the stress "perhaps will not adversely affect the overall structural capacity of the pipe supports".[6]

The initial error in CASE's interpretation is that it confuses the expansion stresses arising from the restraint (by, _inter alia_, the supports) of the free end displacement of the

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6 CASE Brief at 10.

piping system (as the piping system expands from the contained heated fluid) with stress induced within the pipe support by the restraint of thermal expansion of the support under LOCA (i.e., high temperature) conditions. CASE contends that this expansion stress includes what the Code defines as thermal stress, and designates that expansion stress as "thermal expansion stress." Applicants demonstrate below that not only is CASE's interpretation of "thermal expansion stress" inaccurate, but it also misrepresents the definition of "thermal stress."

1. Thermal Stress

In attempting to explain the definition of thermal stress, CASE quoted only the first sentence of the definition of thermal stress set forth in the ASME Code.[7] An accurate citation to that provision is, as follows:

> NB-3213.13 Thermal Stress is a self-balancing stress produced by a non-uniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape that it normally should under a change in temperature. (Emphasis added.)

CASE's incomplete citation to NB-3213.13 conveniently allows CASE not to address the key provision of that definition which clearly establishes the nature of such stresses. As discussed below, the stress to which Messrs. Walsh and Doyle had addressed themselves is defined in the Code as "thermal stress," and Applicants have repeatedly demonstrated that such stress need not be evaluated in the design of individual linear-type pipe supports.

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7 CASE Brief at 10.

The Code defines "thermal stress" as a secondary stress. As Applicants have time and again noted,"[8] secondary stress:

> is a normal stress or a shear stress developed by the constraint of adjacent material or by self-constraint of the structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions which cause the stress to occur and failure from one application of the stress is not to be expected [ASME Code, Section III, Article NF-3213.8 (emphasis added)].

Further, as Applicants have demonstrated, the self-limiting characteristic of thermal stress arises because of ductile displacement of the support or its attachments upon thermal expansion of the support beam, which displacement relieves the thermal stress.[9]

2. Free-End Displacement/"Thermal Expansion Stress"

CASE would have the Board believe that the stress imposed by the thermal expansion of a pipe support is defined as "expansion stress" in the Code.[10] CASE provides no support for that position with respect to linear support design, but instead relies upon provisions applicable only to the design of plate and shell type supports.[11] Reliance on those provisions is disingenuous at best in that as CASE must be aware significantly

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8 Applicants' Exhibit 142 at 15; Tr. 5215-16, 5236-37.

9 Applicants' Exhibit 142 at 15; Tr. 5236-37.

10 CASE Brief at 11.

11 CASE Brief at 12.

different requirements are imposed by the Code for the design of plate and shell type supports and the design of linear supports.[12]

In any event, the expansion stress considered in the Code is defined in NF-3213.11, as follows:

> NF-3213.11 Expansion Stresses are those stresses resulting from restraint of free-end displacement of the piping system. (Emphasis added.)

The underscored portion of NF-3213.11 limits expansion stresses to only those stresses which arise from the expansion of the piping system as that system expands upon an increase of contained fluid temperature. This expansion does *not* include the thermal stress in the support which results from constraint of thermal expansion *of the support* under LOCA (*i.e.*, high temperature) conditions.

In addition, CASE argues that the consideration of the stresses in pipe supports which arise from the contraint against the thermal expansion of the support under LOCA conditions is required by NF-3231 of the Code. Specifically, CASE relies on the portion of that section which provides for consideration of "constraint of free-end displacement" in the design of supports under design, normal and upset conditions.[13] In so doing, CASE avoids referring to the provisions of Article NF-3231

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12 Indeed, plate and shell type supports are designed to include the stresses induced by thermal expansion of the support (although at a stress equal to twice the yield). Applicants have never contended this to be otherwise. *See* Applicants' Exhibit 142 at 16.

13 CASE Brief at 9.

establishing stress limits for supports analyzed under emergency and faulted component conditions.[14] The Board should note that NF-3231.1(a) provides, as follows:

> 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 the 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. (Emphasis added.)[15]

CASE does not, however, refer to paragraphs (b) and (c) of NF-3231.1 which explicitly state that under emergency and faulted conditions "constrained free-end displacement and differential support motion effects need not be considered." These provisions discredit CASE's position with respect to the consideration of the constraint of free-end displacements under LOCA conditions as thermal stresses. Nonetheless, Applicants discuss below the reasons that CASE's position regarding constraint of free-end displacements is erroneous regardless of the conditions for which stress limits are applied.

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14 In this regard, CASE apparently relys upon its theories (discussed below) regarding the consideration of stress limits in supports which receive the effects of a LOCA while not supporting the component considered to be in the faulted condition. CASE Brief at 8. A detailed discussion of the appropriate stress limits to be applied under different component and plant conditions is set forth below in Section II.C.

15 Apparently, because of its misinterpretation of the term thermal stress, CASE repeatedly ignores the provisions of the Code, such as NF-3231, which expressly excludes considerations of thermal stresses. See also CASE's reference to NF-1121(a). CASE Brief at 11.

Further, CASE has again provided only a partial definition of a term when it sets forth the definition for free-end displacement. The full provision is, as follows:

> NF-3213.10 Free-End Displacement consists of the relative motions that would occur between an attachment and connected structure or equipment if the two members were separated. Examples of such motions are those that would occur because of relative thermal expansion of piping, equipment, and equipment supports, or because of rotations imposed upon the equipment by sources other than piping.

Two examples of this form of motion are movements imposed by seismic loads or thermal expansion of the piping system. However, CASE continues to confuse the applicability of NF-3231 to the consideration of thermal expansion of the piping system, which is described as free-end displacement in the Code (the constraint of which gives rise to expansion stresses), with thermal expansion of the pipe support (the constraint of which gives rise to thermal stresses). As to these two stresses, NF-3231(a) provides that the expansion stress is considered for the design, normal and upset conditions in the design of pipe supports. However, that provision expressly provides that thermal stresses need not be considered in those conditions. Further, NF-3231.1(b) and (c) clearly provide that neither the constraint of free end displacement (expansion stresses) or thermal stresses need be addressed under emergency or faulted conditions. CASE has not, however, recognized these distinctions in its discussion of NF-3231.

Applicants further note that their interpretation of the ASME Code to not require the consideration of thermal stresses in the design of individual pipe supports, is confirmed by the Winter 1982 Addenda to the Code. This Addenda, which was referred to by Applicants' witness Reedy in testimony presented in the September, 1982 hearing,[16] is an editorial revision to the Code and does not alter the intent of prior Code provisions. The portion of this Addenda applicable to the consideration of thermal stresses in the design of pipe supports provides, as follows:

> NF-3121.11 Thermal Stress - Thermal stress is a self-equilibrating stress produced by a non-uniform distribution of temperature or by differing thermal coefficients of expansion. Thermal stress is developed in a solid body whenever a volume of material is prevented from assuming the size and shape it normally would under a change in temperature. Evaluation of thermal stresses in the support is not required by this Subsection. (emphasis added).

We believe this Addenda should clarify once and for all, hopefully even in the mind of CASE, that thermal stresses need not be evaluated in the design of individual pipe supports.

A final point to be made is that CASE's reference to NF-3111 as supporting its position is inappropriate because that provision merely provide general guidance applicable to both linear and plate and shell type supports.[17] Thus, its terms apply to linear supports only to the extent detailed in the specific provisions of the Code. Again, CASE's reliance on the terms of that provision with respect to the constraint of free-

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16 Tr. 5216.

17 See Applicants' Exhibit 142 at 14-15.

end displacements is inaccurate in that it specifically refers to such displacements as designated in NF-3222.3, which as CASE admits, is applicable only to plate and shell supports.

B. Operability of Components

CASE asserts in its brief that the "operability" of pipe supports "must be assured" in the event of a LOCA.[18] This assertion is made in support of its claim (discussed below) regarding the analysis of supports for components which are not in the faulted condition but which receive the effects of a LOCA, i.e., faulted loads. In making this assertion, CASE has premised its position on several misconceptions which seem to be based on a superficial reading of applicable requirements. As discussed below, pipe supports are designed to the requirements of the ASME Code, to assure their functional capability (i.e., to retain sufficient dimensional stability to assure the integrity of the pressure boundary). The operability of active components is assured by adherence to an operability assurance program, discussed below.

As noted in Section 3.9.3 of the Standard Review Plan ("SRP"),[19] "the design and service stress limits specified by the Code do not assure, in themselves, the operability of components, including their supports, to perform the mechanical motion

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18 CASE Brief at 17.

19 SRP Section 3.9.3, Appendix A. Applicants discuss the provisions of the latest revision to the SRP (July 1981) which as discussed in our April 21, 1983, Brief, provides the most recent and in some instances more extensive Staff guidance on this subject.

required to fulfill the component's safety function." Applicants do not dispute that active components, including their supports, need be addressed from the standpoint of assuring the operability of those components. Indeed, Applicants have established a detailed program to assure operability of active pumps and valves under specified plant conditions, including seismic and faulted conditions. FSAR §§ 3.9N.3.2 and 3.9B.3.2. (Applicants note that the deformations which may arise from thermal stresses are insignificant as compared to such effects as seismic, water hammer and steam hammer considered in the operability program.) With respect to inactive components and their supports, the ASME Code assures the pressure-retaining integrity of such components for each Code class, regardless of the operating condition under which they are analyzed. CASE would impose, however, in addition to the provisions of the Code and the analysis and testing performed to assure operability of active components, a system of analysis not required by the ASME Code or the NRC in establishing guidance for the design of pressure-retaining components.

The NRC position, and that to which Applicants have adhered,[20] is carefully set forth in Regulatory Guide 1.48, "Design Limits and Loading Combinations for Seismic Category I Fluid System Components." Therein, the NRC notes that Section III of the ASME Code establishes design limits utilized to

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20 Applicants commitment to the provisions of Regulatory Guide 1.48 is set forth in FSAR §§ 1A(N) at p. 1A(N)-28 and 1A(B) at p. 1A(B)-20.

provide assurance of the pressure-retaining integrity of vessels, piping, non-active pumps, and non-active valves of each Code class. It further states, as follows:

> For the particular case of active pumps and valves (i.e., pumps and valves that must perform a mechanical motion during the course of accomplishing a system safety function), special design limits and supplemental requirements are specified to provide assurance of operatbility. [Regulatory Guide 1.48 at 1].

Regulatory Guide 1.48 goes on to state that these special design limits and supplemental requirements are established for active pumps and valves because the Code does not apply to assurance of operability but rather to the assurance of pressure-retaining integrity. In short, by adhering to the requirements of the ASME Code and the guidance set forth in Regulatory Guide 1.48, Applicants have assured that fluid system components are designed to perform their necessary functions under all conditions. CASE's assertions to the contrary are founded on a misinterpretation of those provisions.

C. ASME Code Section III, Appendix F

CASE argues that the Applicants and the NRC Staff have "misused" Appendix F of the ASME Code. This argument is related to its position regarding operability, discussed above. Applicants address here, however, the applicability of Appendix F to Applicants' position.

The crux of CASE's argument appears to be that it believes Applicants have utilized Appendix F to justify the exclusion of thermal stresses from the consideration of pipe support designs under all conditions. This misconception appears to arise because of confusion on the part of CASE between the operating condition categories applied to components under various plant operating conditions. CASE seems to argue that Applicants utilized faulted component conditions (and the attendant allowables) for all components under faulted plant conditions.

Contrary to CASE's assertions, Applicants apply loading combinations to components independently of the plant conditions depending upon the need for a particular component to function in order to respond to a plant faulted condition. As described in FSAR § 3.9B.1.1.2, component operating conditions do not necessarily correspond to the plant conditions. Active components, i.e., those which are relied upon to operate normally to accomplish a safety function under all plant conditions, are designed in accordance with normal component operating conditions for all combinations of loads. With respect to inactive components, viz., components which accomplish a safety-related function by virtue of their pressure retaining integrity and are not required to perform a mechanical motion, they are analyzed using loading combinations specified for upset, emergency, or faulted component operating conditions in addition to normal conditions. FSAR §3.9B.1.1.2. Thus, because Appendix F is applicable to analysis only of component faulted conditions, Applicants do not apply the rules under Appendix F to all components in the event of a plant faulted condition. Rather, those conditions instead are established on the basis of the necessary function of the component under plant faulted conditions.

With respect to the specific question of thermal stresses in linear-type pipe supports, Applicants have clearly demonstrated that the remainder of the ASME Code does not require the consideration of such stresses regardless of the component condition analyzed. Thus, CASE's claim that Appendix F should not apply in all situations where faulted conditions exist, while true, has no implication for the consideration of thermal stresses in linear-type pipe supports under other plant or component conditions.

D. Applicants' Analysis of Support Anchors and Inserts

CASE makes several allegations regarding the analysis Applicants performed to demonstrate that concrete anchors and inserts used to attach pipe supports to the containment structures can withstand the deformations which may occur upon thermal expansion of the supports.[21] CASE's arguments can be summarized as involving three principal issues. Applicants address each of the issues seriatim, below.

1. Evaluation of Bending Stress

CASE cites portions of the NRC Special Inspection Team Report[22] wherein the NRC Staff concludes that additional analysis for tests need be performed to confirm the capability of inserts

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21 CASE Brief at 23-32.

22 I&E Report 82-26/82-14.

to withstand the bending and shear stresses to which they might be subjected in the event of a LOCA.[23] While Applicants believe that their analysis of the stresses in the concrete anchors and inserts adequately demonstrated their ability to withstand those bending and shear stress,[24] we committed to perform additional testing on specific Richmond Inserts for which specific test data had not been developed. As discussed below, that test data demonstrates that Applicants had correctly assessed the ability of those inserts to withstand bending and shear stresses to which they might be subjected.

The tests Applicants performed to demonstrate the adequacy of the 1 1/2 inch Richmond Inserts and bolts involved nine bolt specimens. The various test configurations were designed to assure that the effect of the bending moment due to the presence of a one-inch washer plate could be compared to the application of a pure shear load at the concrete surface. The test specimens were loaded to a point that would demonstrate a minimum factor of safety of three on the design allowable load.[25] The test results for the specimens with the one inch washers are comparable to the test results for the specimens without the washers. This indicates that the presence of the washer had little effect on the performance of the bolt or the Richmond Insert. In fact, the additional bending stresses due to the washer plate were not

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23 See CASE Brief at 24, 29-31.

24 See Applicants' Exhibit 142D.

25 A minimum factor of safety of three was demonstrated for the bolts, whether utilizing the ASME or AISC allowables.

distinguishable in the test results. In addition, following the tests, the bolts were examined for evidence of imminent failure. No such evidence was detected.

In sum, the test results for these inserts and bolts demonstrate that further examination of the bending stresses in these bolts is unwarranted. Applicants' previous assessment of the ability of the inserts and bolts to withstand bending and shear stresses has been demonstrated to be accurate.[26]

2. Applicability of ASME Code to Bolts and Inserts

CASE argues that the bolt which is inserted into the Richmond Insert falls within the jurisdictional boundary of the ASME Code and thus need be evaluated using different allowable shear strengths than utilized by Applicants.[27] In support of its position CASE cites Article NF-1132.5 of the ASME Code and portions of Appendix XVII of the Code. As demonstrated below, these provisions need not be applied to the design of anchors and inserts used to attach pipe supports to concrete structures.

On March 9, 1980, the ASME issued Interpretation No. III-80-107 to establish guidance to owners of ASME systems, components and structures regarding the establishment of

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26 These test results are being provided to the NRC Staff for review in connection with the Special Inspection Team Report. Applicants anticipate these results will be addressed by the Staff in connection with their testimony on that Report.

27 CASE Brief at 25, 28-29.

jurisdictional boundaries of the Code with respect to anchor bolts which extend beyond the plane of the building structure. Therein, the ASME stated, as follows:

> ...the Owner may establish the boundary such that the anchor bolt with welded attachments is part of the building structure or else the completed anchor bolt may meet the rules of Subsection NF. Either case is acceptable.

In that the ASME is recognized by the NRC as the only official interpreter of the ASME Code, that interpretation conclusively demonstrates that the jurisdictional boundary of ASME Code with respect to the subject bolts may be established by the Owner. To this end, Applicants have designated such bolts to be outside the scope of the ASME Code (i.e., as part of the building structure) and have applied appropriate design criteria and allowable stresses for all bolts used for pipe supports at Comanche Peak in accordance with the AISC Code.[28]

The criteria and allowables established in that Code have been reviewed by the NRC Staff and have been considered satisfactory. Further, the analysis performed by Applicants' and submitted in the September, 1982 hearings,[29] as well as the additional testing performed on Richmond Inserts (described above), has conclusively established that the allowables used at Comanche Peak are conservative.

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28 The American Institute of Steel Construction ("AISC") Code applies to building structures. In accordance with the ASME Code interpretation described above, Applicants have designated these bolts as building structures.

29 Applicants' Exhibit 142D.

Finally, with respect to CASE's reference to provisions of Appendix XVII of the ASME Code, Applicants' note that the Appendix is applicable only to Article NF of the Code and in view of the interpretation provided by the ASME discussed above, is inapplicable to the design of concrete inserts and bolts.

3. Consideration of Non-Ductile Nature of Concrete

CASE argues that the analysis of concrete inserts must be based on the conclusion that because the concrete is a non-ductile material, the insert itself must be evaluated as a non-ductile material.[30] Specifically, CASE contends that the statement in the FSAR that "...thermal loads are neglected when they are secondary and self-limiting in nature and when the material is ductile", FSAR §§ 3.8.3.3.3 and 3.8.4.3.3. is not applicable to the Richmond Inserts imbedded in the concrete.

CASE has failed to recognize that the Applicants have considered the actual ductility of the anchor system based on actual load vs. displacement test results.[31] Therefore, in demonstrating the self-relieving properties of the anchor, Applicants have considered the known demonstrated ductility. Thus, Applicants have shown that appropriate displacement capacity exists in these attachment assemblies to relieve the loads that may be imposed by the thermal expansion of supports.

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30 CASE Brief at 26-27.

31 CASE also argues that Applicants relied upon tests which were inadequate in that they utilized reinforced concrete. To the contrary, it is appropriate for Applicants to have utilized test data derived from tests which employ reinforcing because all concrete at Comanche Peak is reinforced.

E. Remaining Issues

CASE has made other allegations in its Brief which concern particular support designs. In addition, CASE subsequently submitted "supplemental testimony" of Jack Doyle to address these and other matters in more detail.[32] Applicants intend to address these issues shortly in a separate affidavit.

III. CONCLUSION

As demonstrated above, CASE has misinterpreted the ASME Code with respect to the consideration of thermal stresses in the design of linear-type supports. Applicants have shown that the Code provides that such stresses are self-limiting and therefore need not be addressed in the design of individual pipe supports.

Respectfully submitted,

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May 3, 1983

32 See CASE letter of April 26, 1983.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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TEXAS UTILITIES GENERATING COMPANY, et al.	)	Docket Nos. 50-445 50-446
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(Comanche Peak Steam Electric Station, Units 1 and 2)	)	(Application for Operating Licenses)

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing "Applicants' Reply Brief Regarding Consideration Of LOCA In Design Criteria For Pipe Supports," in the above-captioned matter were served upon the following persons by express delivery (**) or by deposit in the United States mail, first class postage prepaid, this 3rd day of May 1983, or will be served by hand delivery (*), the 4th day of May 1983:

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