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February 22, 1983

Marshall E. Miller, Esq., Chairman
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Kenneth A. McCollom
Administrative Judge
Dean, Division of Engineering,
Architecture and Technology
Oklahoma State University
Stillwater, OK 74078

Dr. Richard Cole
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

In the Matter of
Texas Utilities Generating Company, *et al.*
(Comanche Peak Steam Electric Station, Units 1 and 2)
Docket Nos. 50-445 and 50-446

Dear Administrative Judges:

In the "NRC Staff Response to Memorandum and Order of September 22, 1982," October 11, 1982, ("Response"), the Staff stated that it is "undertaking an inspection to examine the allegations raised by Messrs. Walsh and Doyle (Tr. 5353) and will inform the Board and parties of its findings when they are completed." Response, at 16. Inspection Report 50-445/82-26, 50-446/82-14, dated February 15, 1983, documents that inspection. The Staff has enclosed a copy of the report for the information of the Board. Region IV has transmitted the report to the Applicants and to Intervenor CASE.

The Board has indicated that it anticipates that another hearing will be held "after the Staff has completed its analyses and filed its documents as discussed in previous Board orders." "Memorandum and Order," January 4, 1983, at 7. It appears that such hearing will include, *inter alia*, "the Walsh/Doyle allegations." *Id.*, at 8. The Staff expects that the enclosed inspection report will form the basis for the Staff's testimony on that subject.

Sincerely,

DS07

Marjorie U. Rothschild
Counsel for NRC Staff

Enclosure: As stated
cc w/encl: Service List

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| NAME | :MURothschild | :SATreby | : | : | : | : |
| DATE | :2/22/83 | :2/22/83 | : | : | : | : |

FEB 15 1983

In Reply Refer To:
Dockets: 50-445/82-26
50-446/82-14

Texas Utilities Generating Company
ATTN: R. J. Gary, Executive Vice President
and General Manager
2001 Bryan Tower
Dallas, TX 75201

Gentlemen:

This refers to the special inspection conducted as a result of concerns expressed by Messrs. M. Walsh and J. Doyle during the July and September 1982 evidentiary hearing sessions on Comanche Peak. The special inspection was conducted by Messrs. J. I. Tapia, R. G. Taylor, and Dr. J. R. N. Rajan of our staff, and Dr. W. P. Chen of the Department of Energy's Energy Technology Engineering Center (ETEC) during the period October 13-December 2, 1982 and January 18, 1983, and related to activities authorized by NRC Construction Permits CPPR-126 and CPPR-127 for the Comanche Peak Steam Electric Station, Units 1 and 2. An exit interview was conducted on February 8, 1983.

Areas examined during the inspection and our findings are discussed in the enclosed inspection report. Within these areas, the inspection consisted of selective examination of procedures and representative records, interviews with personnel, and evaluation of design techniques.

Within the scope of the inspection, 4 new unresolved items were identified in Detail Section, paragraphs 3.c and 3.j of the enclosed report.

In accordance with 10 CFR 2.790(a), a copy of this letter and the enclosure will be placed in the NRC Public Document Room unless you notify this office, by telephone, within 10 days of the date of this letter, and submit written application to withhold information contained therein within 30 days of the date of this letter. Such application must be consistent with the requirements of 2.790(b)(1).

Should you have any questions concerning this inspection, we will be pleased to discuss them with you.

Sincerely,

"Original Signed by"
G. L. MADSEN"
G. L. Madsen, Chief
Reactor Project Branch 1

Enclosure:
Appendix - NRC Inspection Report 50-445/82-26
50-446/82-14

cc w/encl:
Texas Utilities Generating Company
ATTN: H. C. Schmidt, Project Manager
2001 Bryan Tower
Dallas, Texas 75201

APPENDIX

U.S. NUCLEAR REGULATORY COMMISSION
REGION IV

Report: 50-445/82-26
50-446/82-14

Dockets: 50-445; 50-446 Category: A2

Licensee: Texas Utilities Generating Company (TUGCO)
2001 Bryan Tower
Dallas, Texas 75201

Facility Name: Comanche Peak Steam Electric Station, Units 1 & 2

Inspection At: Comanche Peak Steam Electric Station; Gibbs & Hill in New York City; and Nuclear Power Services, Inc. (NPSI), in Secaucus, New Jersey

Inspection Conducted: October 13-December 2, 1982 and January 18, 1983

Exit Interview Conducted: February 8, 1983

Inspectors: J. I. Tapia 2/14/83
J. I. Tapia, Reactor Inspector Date
Engineering Section, Reactor Project Branch 2

R G Taylor 2/15/83
R. G. Taylor, Resident Reactor Inspector - Date
Construction

S. B. Burwell FOR 2/9/83
J. R. N. Rajan, Mechanical Engineer, Date
Mechanical Engineering Branch, NRR

S B Burwell FOR 2/9/83
W. P. Chen, Manager, Stress Analysis Unit, Energy Date
Technology Engineering Center (ETEC)

Other NRC and Contractor Technical Personnel:
- O. Rothberg, Structural Engineer, Structural Engineering Branch, NRR
- D. Smith, Senior Materials Engineer, Materials Engineering Branch, NRR
- H. Fleck, Staff Member, Stress Analysis Unit, ETEC
- J. Brammer, Staff Member, Stress Analysis Unit, ETEC
- J. Fair, Senior Mechanical Engineer, Inspection & Enforcement
- R. Bosnak, Branch Chief, Mechanical Engineering Branch, NRR

Approved: T. F. Westerman 2/14/83
T. F. Westerman, Chief Date
Reactor Project Section A

D. M. Hunnicutt 2/14/83
D. M. Hunnicutt, Chief Date
Engineering Section

S. B. Burwell 2/7/83
S. B. Burwell, Licensing Project Manager Date
Division of Licensing, NRR

Inspection Summary

Inspection During Period of October 13-December 2, 1982 and January 18, 1983 (Report 50-445/82-26; 50-446/82-14)

Areas Inspected: Special, announced inspection of the pipe support engineering program in response to concerns expressed at the ASLB hearing by witnesses Messrs. Walsh and Doyle. The inspection identified 19 broad areas of concern expressed by Messrs. Walsh and Doyle, determined the design status of the pipe supports used as examples of these concerns, evaluated the validity and safety significance of each concern, inspected the design procedures and practices of the pipe support design organizations, and inspected a sample of 100 pipe support designs which had passed through the complete design review process. The inspection involved 1,322 inspector-hours by the NRC inspectors and consultant personnel.

Results:

1. The results of the special inspection of the 19 broad areas of concern expressed by Messrs. Walsh and Doyle are summarized in the following list. In its inspection of all of these concerns, the Special Inspection Team did not find any violations of NRC regulations. The Special Inspection Team did find two areas in which there are a total of four matters which

the Special Inspection Team considers to be "unresolved"; that is additional information is needed in order to reach a conclusion as to compliance with the provisions of 10 CFR Part 50 Appendix B or other applicable Commission regulations.

In addition, there were four matters on which additional effort is required to complete resolution of the concerns. In all of these cases the Applicant has identified a similar problem in the course of its design review program and is undertaking corrective action. However, since the work is still in progress, these matters are identified as open items which will be followed in the course of the NRC's construction inspection program. The Applicant's design program and design review procedures are adequate to provide reasonable assurance that appropriate corrective action will be taken.

The Special Inspection Team's conclusions regarding each of the 19 broad areas are given below. The only remaining matter is verification that the corrective action has been completed. The order and identification letters for each concern are the same as utilized in Paragraph 3 of the Details Section of this report.

a. <u>The interfacing between pipe support design groups</u>: No violations of NRC requirements or adopted standards were identified. The concern regarding the interface between the pipe support design groups has not been substantiated.

b. <u>Interfacing between pipe support design groups and pipe stress analysis organizations</u>: The Applicant's iterative design review program provides substantial assurance that pipe support design defects will be identified and corrected prior to or during the As-Built Verification Program. Mr. Doyle's concern was not substantiated.

c. <u>Design analyses for Richmond inserts and Hilti-bolts</u>: Mr. Doyle's concern about large loads on concrete anchors due to LOCA induced thermal expansion of pipe support tube steel is not substantiated. Mr. Doyle's concern about high bending stresses in the concrete anchorage bolts for Richmond inserts is in part confirmed, since such stresses are not calculated by the Applicant and should be calculated in order to assure that these stresses do not exceed the ASME Code allowable stress for bolting. This is an unresolved item. However, the Special Inspection Team considers it unlikely that such stress will lead to failure of the bolt.

In addition, during the course of its review, the Special Inspection Team identified one issue, not raised by Mr. Doyle, relating to the sufficiency of test data used to support the use of 1 1/2 inch Richmond inserts. The Applicant's test program in response to the Special Inspection Team's finding is an unresolved item.

d. Differential thermal expansion effects in pipe supports: The Special Inspection Team agrees that the differential thermal expansion effects resulting from LOCA conditions does not need to be considered in the design of pipe support members. The loads and stresses in the members will be reduced due to the flexibility of the anchor connection. The Special Inspection Team concluded that Messrs. Doyle's and Walsh's concern does not have a valid technical basis.

e. Differential thermal expansion and other effects in wall-to-wall, floor-to-ceiling, and floor-to-wall pipe supports: The effects of differential thermal expansion due to LOCA and concrete creep were found to be acceptable based upon a review of design guidelines, worst-case analyses, and construction practices. With respect to seismic displacement the Applicant identified a similar problem with respect to certain service water system supports during the course of its design review program and is correcting this matter. The redesign resolved the concern. The NRC staff will verify the completion of the modifications in a follow-on inspection as part of its construction inspection program.

f. Stability of pipe support designs: With respect to Messrs. Walsh's and Doyle's concerns about the stability of non-rigid box frames with gaps, the Applicant identified the same problem as a result of its design review program. The Special Inspection Team concluded that Messrs. Walsh's and Doyle's concerns relating to instability of pipe supports is resolved by the Applicant's stability reassessment program. The NRC staff will verify that these modifications are completed in a follow-on inspection as a part of its construction inspection program.

g. Use of U-bolts in pipe support design: Mr. Doyle's concern about the restraint by U-bolts of lateral movement of the pipe due to thermal expansion at one-way restraint points, and his concern about the preloading stresses have also been identified in the course of the Applicant's normal review program and these problems have been rectified. Mr. Doyle's other concerns about the use of U-bolts have been found to be without a valid technical basis.

h. Loading due to seismic acceleration of the pipe support structure: Mr. Walsh's concern regarding a need to include seismic accelerations in the pipe support design analysis and Mr. Walsh's analysis projecting failure of the pipe supports under seismic loads are without a valid technical basis. Mr. Doyle's concern that the pipe stress analysis did not adequately consider the added weight of the support was also without a valid technical basis.

i. Moment restraint and local pipe stress due to welded stanchions on pipes: With respect to Messrs. Walsh's and Doyle's concern that the effect of welded stanchions on piping had not been included in the pipe stress analysis, the Special Inspection Team found that the Applicant has included these effects in the As-Built Verification

Program. With respect to moment restraints, the Applicant had identified a similar problem with respect to a unique design used for some of the main steam supports and was correcting the problem. The Special Inspection Team found the method of analysis for the correction to be acceptable. This concern is resolved.

With respect to local pipe stresses, the Special Inspection Team concluded that the Applicant's method of analysis is acceptable. This concern is resolved. However, during the course of its review of this concern the Special Inspection Team identified a support involving a special condition warranting consideration of differential thermal expansion. The Applicant indicated that it had determined that the stresses were acceptable and agreed to provide the Special Inspection Team with its analysis. The Special Inspection Team will verify the acceptability of this analysis.

j. <u>Deflections and local stresses in pipe support structures</u>: Mr. Doyle's concerns about excessive deflections in certain supports had in two instances also been identified by the Applicant's design review program. In one case the problem has already been rectified and in the other the problem is to be rectified by redesign. The corrective action will be verified by the NRC staff in a follow-on inspection. Mr. Doyle's concerns in two other instances have not been substantiated. Thus, the concerns raised by Mr. Doyle are resolved.

During the course of its review of these concerns, the Special Inspection Team identified another matter, not raised by Mr. Doyle, which required additional information relating to support stiffness. Two studies which the Applicant has agreed to provide remain unresolved items.

k. <u>Consideration of friction loads</u>: Frictional load criteria between pipe and support members used by the pipe support design groups, although different, were found to be acceptable. The concern is resolved.

l. <u>Consideration of kick loads</u>: Mr. Doyle's concern was found to be incorrect.

m. <u>Modeling of wide flange members as infinitely rigid in torsion</u>: Mr. Doyle's concern was found to be incorrect.

n. <u>Effect of cold-forming on the ductility of tube steel</u>: The A500 Grade B cold-formed tube steel is sufficiently ductile to perform its design intent. The concern is resolved.

o. <u>Operating condition loads appear to be in error</u>: The Special Inspection Team concluded that this concern was without a valid technical basis. The concern is resolved.

p. Welded stepped connections, fillet welds and skewed welds: Mr. Doyle's concerns about welded stepped connections in circular tubular joints, undersized fillet welds, and skewed T-joint welds have not been substantiated. This concern is resolved. One unresolved item previously identified by the NRC dealing with QC inspection procedures for skewed welds is still under review by the NRC Region IV staff.

q. Section property values utilized by Pipe Support Engineering: The Special Inspection Team concluded that Mr. Walsh's concern about different tube steel section property values utilized by the PSE pipe support design group is resolved. The Applicant is currently reanalyzing all large bore and Class 1 small bore pipe support designs using consistent member property values. The differences in section property values for small bore Class 2 and 3 supports are less than 8 percent, and will not result in unanticipated support behavior. This concern is resolved.

r. Support pads welded over pipe girth welds: Mr. Doyle's concern that pipe support pads on Class 2 pipe supports were welded over the pipe girth welds is not correct.

s. Damage to pipe support during hydrostatic testing: The Special Inspection Team found that the pipe support tube steel was damaged prior to hydrostatic pressure testing and the damaged tube steel was in place during hydrostatic pressure testing. Mr. Doyle's allegation regarding the cause of the damage to this support was incorrect. The replacement of the damaged tube steel was verified by the NRC staff.

2. The Special Inspection Team conducted a special inspection of 100 pipe support designs which had received their design review by ITT-Grinnell and NPSI, and were "vendor-certified." Each support design was reviewed for fifteen design attributes. The review did not disclose any discrepancies in the random sample which would indicate a failure of the Applicant's design verification program to identify and correct supports to assure compliance with applicable design criteria.

3. Within the areas inspected, 4 unresolved items and 4 open items were identified.

Summary and Conclusions

Mr. Walsh and Mr. Doyle made numerous allegations of widespread design deficiencies in the design of pipe supports at the Comanche Peak plant. They supported their allegations with a number of preliminary designs and sketches for various supports. The Special Inspection Team looked not only at the specific supports alleged to be defective but also into related design practices in some 19 broad areas encompassing the Walsh/Doyle concerns. The various drawings and sketches offered as examples of the design deficiencies alleged by Mr. Walsh and Mr. Doyle reflected initial support designs which had not completed the Applicant's iterative design and review processes.

The Special Inspection Team found in some 12 of these broad areas (Paragraph 3, subsections a, b, d, h, k, l, m, n, o, p, r, and s) that the concerns alleged by Walsh and Doyle were not substantiated. In 6 of these broad areas (Paragraph 3, subsections e, f, g, i, j, and g) some aspects of the concerns expressed by Walsh and Doyle had also been identified by the Applicant during the course of its design review processes and the problems have been or are being rectified; other aspects of the concern were not substantiated. In one broad area (Paragraph 3.c), one aspect to Mr. Doyle's concerns relating to the bending stress in the bolt were in part confirmed. Other aspects of Mr. Doyle's concerns in this area were not substantiated. None of the concerns raised by Walsh and Doyle were substantiated as demonstrating serious deficiencies in the Applicant's pipe support design program. Even in the area of bending stress in the bolt of Richmond inserts, the Special Inspection Team considers the stresses involved are unlikely to lead to bolt failure.

During the course of its assessment of the Walsh/Doyle concerns, the Special Inspection Team identified two areas related to Richmond inserts and the support stiffness values used in the pipe stress analyses, not raised by Walsh and Doyle, for which further supporting information was needed with respect to certain of the Applicant's design assumptions. But, even with respect to these issues, they do not appear to involve situations in which the plant piping systems would fail to function under any design loading condition. Rather, these questions relate to the need for the Applicant to provide additional data to verify certain assumptions used in the design analyses in order to substantiate that ample margins are available under all design loading conditions.

The examples of design problems offered by Messrs. Walsh and Doyle were interim designs and did not represent designs which had completed the Applicant's design review process. For this reason, the Special Inspection Team conducted a review of a sample of 100 vendor certified supports for 15 design attributes which would be indicative of the problems alleged by Messrs. Walsh and Doyle. The purpose of this review was to determine whether design deficiencies had survived the Applicant's iterative design review process. The review did not disclose any discrepancies which would indicate a failure of the Applicant's design verification program to identify and correct supports to assure compliance with applicable design criteria.

## DETAILS

### 1. Persons Contacted

Licensee Personnel

J. B. George, Vice President and Project General Manager
*H. C. Schmidt, Manager Nuclear Services
*J. C. Finneran, Pipe Support Engineer
*J. S. Marshall, Licensing Manager,
B. Dacko, Senior Licensing Engineer
D. H. Wade, Licensing Engineer
*J. T. Merritt, Startup Manager
R. M. Kissinger, Project Civil Engineer
H. Harrison, Technical Services Supervisor
D. Rencher, Supervisor, Technical Support Design Review[1]
P.S.Y. Chang, Chief Engineer, Small Bore Pipe Design Group[1]
*G. Krishnan, Site Stress Group Supervisor[1]
D. Westbrook, Technical Services As-Built Coordinator
G. Abele, Supervisor, Site Engineering[1]
*M. McBay, Engineering Manager
*R. Jones, Manager Plant Operations

Other Personnel

*M. A. Vivirito, Manager, Analytical Engineering, Gibbs & Hill
P. R. Rajan, Senior Project Engineer, Gibbs & Hill
*R. E. Ballard, Project Manager, Gibbs & Hill
F. A. Colucci, Applied Mechanics, Gibbs & Hill
C. I. Corban, Chief Engineer, Applied Mechanics, Gibbs & Hill
E. L. Bezkor, Supervising Engineer, Structural, Gibbs & Hill
H. W. Mentel, Group Supervisor, Pipe Stress Analysis, Gibbs & Hill
B. Bayles, Metallurgist, Gibbs & Hill
E. Eramiam, Engineering Manager, Site Engineering, ITT-Grinnell
T. Smith, Manager, Applications Engineering, ITT-Grinnell
P. J. Fang, Manager, Piping Structural Analysis, ITT-Grinnell
D. Powers, Engineering Manager, ITT-Grinnell
J. Mangasarian, Supervisor, Applications Engineering, ITT-Grinnell
G. Breidenbach, Engineering Manager, Nuclear Power Services, Inc. (NPSI)
H. D'Errico, Project Manager, NPSI
F. Samaan, Structural Group Supervisor, NPSI
T. Bharati, Assistant Structural Group Supervisor, NPSI
C. Maitey, Supervisor, Applied Mechanics, NPSI
H. Lancelot, Director of Engineering, Richmond Screw Anchor Company
C. W. Gay, Manager, CPSES Structural Services, Westinghouse
R. Henrajani, Lead Engineer in Review Certification, NPSI

*Denotes attendance at the Exit Interview.

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[1] Contract employee, managed and supervised by licensee.

## 2. Introduction

During the Comanche Peak evidentiary hearing sessions on July 29, and September 13 and 14, 1982, before the presiding Atomic Safety Licensing Board (ASLB) regarding Contention 5 (construction QA/QC), Citizens Association for Sound Energy (CASE) witnesses M. Walsh and J. Doyle expressed concerns related to the overall pipe support engineering procedures being utilized for the Comanche Peak facility. In response to the concerns of Messrs. Walsh and Doyle, the NRC formed a Special Inspection Team to address the concerns and evaluate their significiance. Members of the Special Inspection Team and other personnel who assisted them in their tasks are listed above. The inspection was conducted in several steps as follows:

a. The Special Inspection Team reviewed the testimony and depositions with exhibits provided by Messrs. Walsh and Doyle, the testimony and deposition with exhibits provided by the Applicant, and the transcript of the proceeding. The objective of this review was to identify and catalog the concerns expressed by Messrs. Walsh and Doyle. These concerns were identified and are addressed in Paragraph 3 of this inspection report.

b. The Special Inspection Team then conducted a special inspection at the Comanche Peak facility to determine the design status of each of the pipe supports identified by Messrs. Walsh and Doyle. The design review had been completed for only one of these supports (Support No. CC-1-107-008-E23R; Doyle Deposition Attachment 11TT).

c. A series of special inspections were conducted by the Special Inspection Team at the Comanche Peak facility, Gibbs & Hill in New York City, and Nuclear Power Services, Inc. (NPSI) in Secaucus, New Jersey to determine: a) the validity and safety significance of each of the concerns expressed by Messrs. Walsh and Doyle; b) the role and responsibilities of each of the pipe support design groups, both on-site and off-site, and the piping design group, Gibbs & Hill; and c) the design procedures and practices used by each of the pipe support design groups and by Gibbs & Hill.

d. Finally, the Special Inspection Team conducted an inspection of a sample of 100 pipe supports designed by ITT-Grinnell and NPSI which had been "vendor-certified," i.e. they had passed through the required design review procedure and had been found acceptable by the responsible pipe support design group. This inspection consisted of a review of randomly selected pipe supports for the concerns identified by Messrs. Walsh and Doyle. The results of this inspection are described in Paragraph 4 of this report.

e. After considering the information received during the above inspection, the Special Inspection Team scheduled another inspection visit to the station on January 18, 1983. In these subsequent discussions certain additional details were provided or clarified.

f. An exit interview was conducted at the station on February 8, 1983.

3. Concerns Related to Pipe Support Designs

The following expressed concerns relating to the design of pipe supports were reviewed during the inspection:

a. The Interfacing Between Pipe Support Design Groups

Mr. Doyle expressed concern that the interface between the Applicant's various design groups, primarily in the pipe support area but also including other areas, were inadequate and were the cause of design inconsistencies (Tr. 3706, 3852, 3864, 3925 and 3973).

The Special Inspection Team could not determine if the concern was intended to address all of the possible interfaces involved in piping and support design or only the interfaces between the specific group in which Mr. Doyle worked and the other design groups. Regarding the latter and more narrow interpretation of the concern, the Special Inspection Team determined that Mr. Doyle had been assigned to work in the "Site Stress Analysis Group" (SSAG). Mr. Doyle's more specific assignment was to a subgroup within SSAG that analyzed support frames utilizing the Structural Design Language (STRUDL) computer program and hence this subgroup became known as the STRUDL group. The other subgroup in SSAG performs pipe stress analyses using the ADLPIPE computer program. Both programs are in a main-frame computer located in New York City with the site communicating with that computer by telephone lines.

Applicant's engineering instruction No. CP-EI-4.6-9, "Performance Instruction for SSAG," revision 0, dated September 5, 1980, and the current revision 1, dated August 3, 1981 were reviewed during the inspection. The procedure in both revisions describes the SSAG as a group which receives requests from the various design groups for analysis of stresses in either pipe systems or in support frames. The stated purpose of the SSAG is to provide an intermediate check of the stresses before a design is finalized or when a design change is being made to a previously finalized design. The procedure requires that all stress analysis requests must be in writing, and approved by the supervisor of the requesting group. The results of the SSAG analysis are returned to the originating design group. The various design group instructions indicate that design groups are responsible for the analysis rather than SSAG.

Discussions with cognizant Applicant personnel and several tours of the office area housing the SSAG indicate that with one exception, the group is a service organization to the design groups and has no in-line function in the design process. The one exception relates to the pipe analysis group which performs the official pipe stress analysis of pipe runs from 2.5 inches to 4 inches in diameter based on specific instructions from the responsible engineer in the Gibbs & Hill New York office. The STRUDL group is not involved in this particular effort. The Applicant's personnel who were involved in the formation of the STRUDL group have stated that the group was largely staffed with technician level people when originally formed, but was later restaffed with engineering level personnel when it was found that the technicians required too much help in modeling frames for input into the computer program. The Special Inspection Team concluded that the Applicant has defined and documented the responsibilities of each engineering organization, and has also defined and documented the communications paths between the SSAG and the other groups in an effective manner, based upon review of the Applicant's documents, listed below:

a. CP-EI-4.6-9 "Performance Instruction For SSAG."

b. CP-EP-2.1 "General Program For Pipe Support Design, Fabrication and Installation Activities"

c. CP-EI-4.0-4 "Field Structural Engineering Group Design Control Instruction"

d. CP-EI-4.0-1 "Design and Design Verification Control For Pipe Support Engineering"

e. CP-EI-4.0-13 "Control of Stress Analysis For Pipe Support Engineering"

f. CP-EI-4.5-4 "Technical Services Engineering Instruction for Pipe Hanger Design Review"

The narrow interpretation of the concern is resolved.

Considering the concern in its broader sense and including the alleged inconsistent design requirements, the Special Inspection Team found that Messrs. Doyle and Walsh, as members of the STRUDL group, were exposed to the design approaches employed by all of the structural frame engineering organizations and the differing detail design criteria used by these organizations. Further, due to their office location, they had ready access to the design basis documents used by the two offsite pipe support design organizations. Messrs. Doyle and Walsh noted that the three pipe support organizations were each using different design approaches and that another approach was used by the onsite civil/structural design group charged with the design of cable tray and conduit supports. In addition to differing design approaches, they noted that each of the organizations appeared to be using different section property values for the structural shapes involved. Mr. Doyle in particular seemed to feel that, had the design basis inputs and interfaces been adequate, these differences would not have occurred. He further states that since such differences have occurred, the Applicant has violated the requirements of the NRC as expressed in 10 CFR and other documents such as ANSI Standards N45.2, "Quality Assurance Program Requirements for Nuclear Power Plants," and

N45.2.11, "Quality Assurance Requirements for Design of Nuclear Power Plants."

The NRC has endorsed N45.2 via Regulatory Guide 1.28 and has also endorsed N45.2.11 via Regulatory Guide 1.64. N45.2 is a general requirement document essentially equivalent to Appendix B of 10 CFR 50 while N45.2.11 is specific to the design controls requirements contained in Criterion III of Appendix B and N45.2. N45.2 and 45.2.11 were promulgated in their present form after the Applicant was granted a construction permit for Comanche Peak. The Special Inspection Team concluded that there is no evidence that the intended objectives of N45.2.11 have not been achieved nor is there any evidence the Quality Assurance programmatic requirements of 10 CFR 50, Appendix B; N45.2 and/or Section NA of the ASME Code have not been satisfied.

The Special Inspection Team found that the alleged inadequate interfaces are not the cause of the differences in design approaches. The differences appear to be the natural outgrowth of the Applicant's utilization of three separate pipe support design organizations and yet a fourth organization for the design of other structural supports such as those for cable trays and conduits. An early decision was made by the Applicant that the pipe support detail design would be contracted out to one of several companies who are in the business of designing and fabricating pipe support components. In order to satisfy the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) requirements and in order to set a basis for competitive bidding between the companies, it was necessary to provide them with the overall design criteria to be met. The Gibbs & Hill document to accomplish this objective was Specification MS-46A which provides the information required by the ASME Code and also satisfies the requirements for design input information as described by N45.2.11, paragraph 3.2. A contract for the design of pipe supports was awarded to ITT-Grinnell Company in 1975. The means by which ITT-Grinnell would satisfy the detailed requirements of MS-46A and the ASME Code became that company's responsibility.

Later, it became apparent to the Applicant that ITT-Grinnell was not able to maintain an appropriate schedule for either design or fabrication of the supports. In 1977, the Applicant entered into a contract with Nuclear Power Services, Inc. (NPSI) on essentially the same specification basis. As with the ITT-Grinnell contract, the details of functional compliance with specification MS-46A became NPSI's responsibility.

Still later, the Applicant realized that an onsite design/redesign group was necessary if an appropriate schedule was to be maintained. The Applicant therefore created what became the project Pipe Support Engineering (PSE) organization, which also utilized the same specification basis as the other two design groups.

Since neither the specification nor the ASME Code dictate in detail the means by which an engineer is to satisfy the design criteria, differences in engineering approaches occurred between the three parallel pipe support groups. Again, in reference to N45.2.11 and its requirements regarding interfaces, the overall purpose is to assure that each design organization has a clear, documented scope of responsibility and that there are documented paths for communication when the responsibility shifts from one organization to the other or is shared by both. In the case of three pipe support design organizations, each has its own specific scope of responsibility since each has been assigned the responsibility for a specific group of supports. There is no apparent need for cross communication between the three groups since they share no common detailed responsibility. Furthermore, the lines of communication between the Applicant, the A/E and each pipe support design organization are clear and documented.

Based upon the above considerations and upon review of Specification MS-46A, particularly pages 3-7 through 3-12: Applicant's letter dated December 21, 1981 which provides the correspondence matrix regarding orders CP-0046A (ITT-Grinnell) and CP-0046A.1 (NPSI); and Procedure CP-EP.1 "General Program For Pipe Design, Fabrication and Installation"; the Special Inspection Team concluded that the Applicant has adequately defined and documented the responsibilities and paths of communications between the architect/engineer (Gibbs & Hill) and the pipe support design groups, including the responsibilities and communications with the SSAG. No NRC regulation has been violated, and the programmatic objectives of Section NA of the ASME Code, N45.2.11, and N45.2 appear to have been satisfied. This concern is resolved. The concern expressed by Mr. Doyle regarding the interface between the pipe support design groups has not been substantiated.

b. Interfacing Between the Pipe Support Design Groups and the Pipe Stress Analysis Organizations

Mr. Doyle implied a general concern throughout his deposition that the three pipe support design organizations were utilizing designs which induced stresses in the piping that are not considered in the pipe stress analysis (Doyle Deposition). Relative to this concern the Special Inspection Team reviewed: 1) the design process for the piping and the pipe supports in a series of discussions with cognizant members of the Applicant's staff and the three pipe support design groups at the Comanche Peak facility, and 2) the procedures for conducting the pipe stress analysis in discussions with cognizant members of Gibbs & Hill at their offices in New York. The Special Inspection Team also reviewed the Gibbs & Hill instructions, "As Built Verification Instruction," Revision 2 dated June 7, 1982, and the TUSI Engineering Instruction CP-EI-4.5-1, "General Program for As-Built Piping Verification," Revision 6 dated August 30, 1982 which provide the necessary steps and guidelines used by the Applicant to implement its responsibilities in the as-built stress verification of the designated piping.

Gibbs & Hill, as the architect/engineer, is the designer of all ASME Code Class 2 and 3 large bore piping, i.e. greater than 2-1/2 inches in diameter. This is an iterative process involving numerous exchanges of information with various subgroups of the Applicant's organization, including PSE, and with the two contract pipe support design groups (ITT-Grinnell and NPSI). The Special Inspection Team concluded that an understanding of this iterative design process was necessary to establish the significance of the numerous exhibits put forth by Messrs. Walsh and Doyle. These exhibits, without exception were found to be still in the design process. Thus, the Applicant's design and review process had the potential for correcting all alleged design and analysis deficiencies prior to the pipe support becoming operational. This portion of the inspection attempted to address the question whether or not appropriate procedures or guidelines were in place which assure that the corrective actions would be taken.

A description of the Applicant's process of designing and analyzing a length of pipe and its pipe supports, a "stress problem," is provided to place the allegations and this portion of the inspection in perspective. The process is described for a length of pipe rather than an individual pipe support because the design unit is the length of pipe; that is, the pipe support is an accessory in the total design problem and cannot be designed separately from the length of pipe. The following simplified steps give the highlights in the design procedure.

(1) Gibbs & Hill prepares a conceptual design for the length of pipe. The length of pipe is generally chosen to run between two anchor points. The conceptual design consists of a piping layout which defines the proposed routing of the pipe including piping components between the anchor points. The location and lengths of the straight and curved sections of piping are defined by piping plan and elevation drawings and/or isometric drawings.

(2) Gibbs & Hill performs a pipe stress analysis on the conceptual design to produce an acceptable design which will meet the ASME B&PVC (Code) allowable stress requirements. Compliance with appropriate provisions of the ASME Code is required by NRC regulations 10 CFR 50.55a(d). If the conceptual design does not satisfy the Code criteria, design/analysis iterations are performed to produce an acceptable design. Changes to the conceptual pipe routing and the location and number of proposed supports are usually required during this process. The pipe stress problem calculates the forces and type of loads on the proposed pipe supports.

(3) The description of the acceptable piping layout, proposed support locations, pipe movements at the support locations, and the directions of restraint and magnitudes of the forces for each support are sent to one of the three pipe support design groups (ITT-Grinnell Corporation, at Providence, RI, NPSI at Secaucus, NJ, or PSE at the Comanche Peak Offices) depending upon the scope of their contract or assignment. Using that information and other design data (e.g., structural arrangement drawings) the pipe support design groups prepare a design for each of the pipe supports given in the conceptual design for the length of pipe.

(4) If the pipe support installation personnel (craft) determine that a support cannot be installed as designed, PSE field engineers are notified and make changes as necessary to produce a design that can be used. Based on their judgment on the impact of their changes, the PSE field engineers may request an analysis of the change from the site stress analysis group (SSAG).

(5) When the pipe and some of its supports have been installed, the Quality Assurance Group starts its as-built inspection documenting the as-built dimensions of the pipe and installed pipe supports. The drawings for the pipe and pipe supports are revised to reflect the as-built configurations, and are stamped "as-built verified." When a significant portion of the supports on the length of pipe have been as-built verified, a package is assembled and forwarded to Gibbs & Hill for a preliminary stress analysis.

(6) The as-built package for the length of pipe is sent to Gibbs & Hill where it is reviewed and adjusted for any new factors which may impact the pipe stresses e.g., pipe routing changes; support relocations, orientation deviations and restraint characteristics; minimum wall violations; addition/deletion of valves, fittings and other appurtenances; valve weights, orientation of the operators and center of gravity; sleeve clearances/types of seal; and changes in thermal modes of operation. The stress problem is rerun to determine new stresses in the pipe and new loads on the pipe supports.

(7) The stress problem package is returned to the Comanche Peak where the responsible pipe support design group reviews the new pipe loads on the support and the final as-built support configuration to assure that the support will meet the new functional requirements. If the support is found to satisfy the new requirements it is stamped "vendor certified." If the support is found unsatisfactory, it is modified and the new as-built design is sent to Gibbs & Hill to be assessed for its impact on the pipe stress problem.

(8) When all of the pipe supports are installed (and conceivably at intermediate steps), data are added to the stress problem package on the pipe supports installed since the stress problem was last run. The package is returned to Gibbs & Hill to assess whether the new as-built configuration impacts the pipe stresses. If so, the pipe stress problem is rerun, or alternatively the supports are redesigned, until the pipe stresses are found acceptable with the as-built configuration of the pipe and all pipe supports reflected in the stress problem input.

(9) The stress problem package is returned to the Comanche Peak site where any changes to the loads on the pipe support are reviewed by the responsible pipe support design group and if satisfactory, the remaining pipe supports are "vendor certified." If any pipe supports are found unsatisfactory for the new loads, the support must be modified and the stress problem package is recycled through Gibbs & Hill and the pipe support design group until all pipe stresses are acceptable and all pipe supports are vendor certified for the loads developed in the last run of the stress problem.

It should be recognized that the above description is simplified in that it does not include any recognition of the constraints imposed by construction schedules/status. It is further simplified by restricting the description to only the principal or main stream participating organizations. The Special Inspection Team believes the design status of the pipe supports identified by Messrs. Walsh and Doyle fell into steps (4) and (5) of the above procedure. In essence, the supports in question had not entered the as-built verification program.

In its investigation of the specific allegations of Messrs. Walsh and Doyle discussed in Paragraph 3 of this report, the Special Inspection Team found most to be without a valid technical basis. For other concerns the Special Inspection Team found that they had been resolved by the Applicant's normal iterative design review process. On the basis of its review, the Special Inspection Team concluded that the Applicant's iterative design review program provides substantial assurance that pipe support design defects will be identified and corrected prior to or during the Applicant's As-Built Verification Program.

c. Design Analyses of Richmond Inserts and Hilti Bolts

Mr. Doyle's concerns in the area of pipe support concrete anchor design are twofold: (1) very large loads on concrete anchors due to thermal expansion of the pipe support tube steel under LOCA conditions have been excluded in the design of the anchorage; and (2) the method of shear and moment analysis at the point of anchorage is in error and may significantly affect the performance of the anchor.

The Special Inspection Team reviewed the following reference documents to assess the Applicant's overall compliance with Section 3.8 of the CPSES Final Safety Analysis Report (FSAR), and to evaluate the engineering design adequacy of pipe supports utilizing Richmond inserts or Hilti-bolts to anchor the support to the structural concrete:

1. Gibbs & Hill Specification 2323-SS-30, "Structural Embedments," March 19, 1981.
2. Gibbs & Hill Report, "Evaluation of LOCA Temperature Effects on Pipe Supports," August 26, 1982.
3. NPSI Report, "Load Transformation Study on Richmond Insert & Tube Steel Assemblies," September 1982.
4. PSE Guidelines, Section V, "Hilti Concrete Anchor Bolts."
5. PSE Guidelines, Section VI, "Richmond Inserts and Anchor Bolts Stress Allowables."
6. TUGCO Procedure CP-HBM-0.1, "Hilti Bolt Inspection Manual," Revision 31.
7. Polytechnic Institute of Brooklyn Test Reports for Richmond Screw Anchor Company.
8. PSE Report, "Richmond Inserts - Prepared for 1-17-83 meeting with NRC.

## Richmond Inserts

The Special Inspection Team reviewed the Applicant's method of designing pipe supports utilizing Richmond inserts to anchor the pipe support tube steel to the structural concrete. The following describes this review and the Special Inspection Team's conclusions relating to the Richmond insert concrete anchor.

### (1) Thermal Expansion Loads

With respect to the concern about the exclusion of the thermal expansion load, the Special Inspection Team assessed the magnitude of the excluded load, the Applicant's design criteria with factors of safety, and finally the adequacy of the available test data used to generate the design allowables.

The Special Inspection Team determined, from interviews with cognizant design engineers and from calculation reviews, that the Applicant had not considered LOCA thermal expansion effects on concrete inserts and bolts in the design of individual pipe supports and associated concrete anchors. [A concrete anchor is composed on an insert in the concrete and a bolt which is used to attach the support to the insert.] This decision was based primarily on the ASME Code Section III, Appendix F, "Rules for Evaluation of Faulted Conditions," which does not require that differential thermal expansion stresses resulting from faulted conditions be included in the design procedure. This exclusion is based on the ASME Code rationale that these stresses occur once in the lifetime of the plant, are self-limiting in nature and are relieved by small deformations and displacements. Although the ASME Code is not directly applicable to the design of the concrete anchorages, the Applicant adopted the ASME Code philosophy in the design of the concrete inserts. This design approach is documented in Sections 3.8.3.3.3 and 3.8.4.3.3 of the FSAR, where it states, ". . . thermal loads are neglected when they are secondary and self-limiting in nature and when the material is ductile."

With respect to the design of inserts such as Richmond inserts, the Special Inspection Team found that these components are not governed by the ASME Code nor by any other standard which the NRC has adopted as a regulatory requirement. Thus, the only applicable regulatory standards are the requirements of 10 CFR Part 50, Appendix A - General Design Criteria For Nuclear Power Plants, Criteria 1 and 2, which require that such components be capable of performing their intended design function which is to carry the imposed loads without failure.

The Special Inspection Team has evaluated the amount of thermal expansion that would result under worst-case LOCA conditions and the available load-displacement data. For the worst-case analysis of an eleven foot long member, unrestrained thermal growth resulting from LOCA conditions was computed to be 0.086 inches. The worst-case condition was established by identifying the longest tube steel member attached to the concrete. This member was a part of the feedwater system gang hanger located inside containment with an overall span of approximately 30 feet. This gang hanger is anchored to the concrete by the use of 1 1/2-inch diameter Richmond inserts. From the load-displacement curve of the 1 1/4-inch diameter Richmond insert in 3,000 psi concrete, the calculated growth or strain required to relieve the applied thermal load represents 22 percent of the approximate failure strain of 0.4 inches. This simplified calculation does not consider the bending of the bolt due to the 1-inch washer offset. Bending in the bolt would have the effect of lessening the shear force resulting from thermal expansion due to LOCA on the insert. Thus, even for this worse case, the LOCA induced thermal expansion strain contribution in the insert would be reduced. The 1 1/2-inch Richmond inserts used in this design would act in a similar fashion. However, there are no deflection test data for 1 1/2-inch Richmond inserts in shear loading. For the reasons discussed below the Special

Inspection Team concludes that additional test data is required for 1 1/2-inch Richmond inserts.

(2) Allowable Loads and Factors of Safety

The allowable Richmond anchor tension loads were established by the Applicant based on a factor of safety of two of the ultimate load as determined from tests (Reference 7) and/or a shear cone analysis made by the Applicant. The Applicant's analysis consisted of comparing the test ultimate tension (pullout) loads with calculated ultimate shear cone loads determined in accordance with Appendix B of the American Concrete Institute's (ACI) "Code Requirements for Nuclear Safety Related Concrete Structures," ACI 349-76. The ultimate tension load was then defined as the lesser of the two values and the factor of safety of two was then applied on the lesser value. For the 1-inch insert, the factor of safety of two was based on the shear cone analysis load. The resultant allowable load when compared to the test load results in a factor of safety of 2.17. For the 1 1/2-inch insert, the factor of safety of two was based on the actual tension test results. Allowable shear loads were set equal to the allowable tension loads and for the 1 1/2-inch insert, reduced by a factor equal to the ratio of the manufacturer's allowable load values (about 0.83). Shear load allowables for the 1 1/2-inch insert would have a factor of safety of about 2.4 based on the assumption that the shear test ultimate is equal to the tension test ultimate. Although this assumption is basically true for the 1-inch and 1 1/4-inch inserts, no shear tests have been conducted on the 1 1/2-inch size. Published allowable loads in the Richmond Screw Anchor Company Bulletin No. 6 are based on a factor of safety of three. As a result of the Applicant's assumptions as to shear load capability, the specified shear load allowables are 50 percent higher for the 1 1/2-inch insert than the value recommended by the manufacturer.

Richmond inserts have been used at some other nuclear power plants. The Special Inspection Team was able to identify that one of these plants used a factor of safety of three, but did not learn the factor of safety used for Richmond inserts at the other nuclear power plants. The Applicant stated that the manufacturer indicated that a factor of safety of less than three has on occasion been recommended in the concrete precast tilt-up industry.

From a review of the manufacturer's data published in reference 7, the Special Inspection Team determined that the manufacturer's allowable shear values for the 1 1/2-inch diameter Richmond insert were extrapolated from shear tests on 1 1/4-inch diameter insert. Although the published allowable values are theoretically valid, standard industry practice requires that testing be performed to confirm the values. In addition, even for the shear tests conducted (on 3/4, 1, and 1 1/4-inch) the test data does not fully model the configuration of the anchor assembly used with a 1 inch thick washer between the wall and the support frame. This washer introduces a bending moment in the bolt which is not reflected in the shear test results.

No combined shear/tensions tests have been performed on Richmond inserts by the manufacturer or the Applicant. For calculating the effects of combined shear and tension, the Applicant has utilized a curve based on an interaction formula given in the Prestressed Concrete Institute handbook. However, the application of this formula for the 1 1/2-insert is based on the use of shear values extrapolated from the 1 1/4-inch insert.

The Applicant has stated that ACI 349-80, "Code Requirements for Nuclear Safety Related Concrete Structures," an industry standard not adopted by the NRC as a regulatory requirement, allows a factor of safety of two for concrete inserts. The Special Inspection Team found that the ACI standard specifies load factors and capacity reduction factors and requires consideration of the forces caused by thermal effects under accident conditions. In addition, the ACI standard requires a testing program far broader than that which has been carried out for the Richmond inserts. The Special Inspection Team cannot concur that the ACI standard allows a factor of safety of two to be used in the manner in which it has been used by the Applicant.

The Applicant's factor of safety of two for the anchorage would be sufficient if based on test data for the size used inside containment (1 1/2-inch) and if it was based on a test in a loading mechanism that modeled the actual configuration. The actual configuration, which utilizes a 1-inch thick washer, introduces a bending moment in the bolt which may influence the load displacement characteristics. In addition, the inserts should have been tested in combined shear and tension if a factor of safety of two is too be considered sufficient. Conversely, the uncertainties introduced by the use of shear values for 1 1/2-inch inserts extrapolated from tests on 1 1/4-inch inserts, the use of data from a test that did not model the configuration using the 1-inch tick washer, and the use of generic shear/tension corelations in the absence of any shear/tension test for Richmond inserts would not be significant if the design loading for the insert, were based on a higher factor of safety for the anchorage.

The uncertainties introduced by the test modeling, considered together with the limited test data available, result in insufficient evidence to accept that the factor of safety of two for the considered loads (which disregards loads on the inserts and bolts resulting from thermal expansion of the attached support and bending moments introduced by the 1-inch thick washer) is adequate to assure that the Richmond insert assemblies are designed with a ample margin for the intended load carrying functions. Accordingly, the NRC staff will require that additional testing be conducted to verify the adequacy of the design criteria utilized. An applicable standard test method is the American Society for Testing and Materials (ASTM) "Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements," ASTM E488-76. This standard delineates an acceptable testing and reporting procedure which can be applied to the Richmond inserts.

(3) Shear and Moment Design

The Special Inspection Team investigated the concerns related to the adequacy of shear and moment design in the actual Richmond insert configuration by evaluating Reference 3. This study defines the load transformation behavior of a typical insert and tube steel configuration based on a finite element model analysis using the STARDYNE computer code. Tension, shear and moment were calculated for five load cases which represented midspan axial unit loading along the three principal axes and unit torsional loading transverse to and along the axis of the tube steel. This study indicates that in all cases the transfer of shear from the tube steel to the Richmond insert bolt occurs primarily in the flange of the tube steel nearest the concrete wall. The analysis showed that the highest value of shear in the flange away from the concrete wall represented 18 percent of the shear force in the flange near the wall. This behavior, which was verified by the computer analysis, indicates that bolt bending leads to a distribution of shear forces primarily to the tube steel flange near the concrete surface.

Mr. Doyle's concern that high bending moments in the bolt result from the shear force being offset from the concrete surface was evaluated by the Special Inspection Team by calculating the stresses in the bolt due to the offset. The Special Inspection Team found that the Applicant does not calculate the stresses in the bolt in the design of the concrete anchorage. Although the released moment and resulting stresses due to the tube steel being offset from the concrete by a 1-inch thick washer is neglected during the normal course of design, it was quantified by the Applicant in the STARDYNE analysis. Calculation by the Special Inspection Team of the stresses resulting from the shear, tension, and bending moments for the five loading cases analyzed, indicates that bending stresses in the bolt for the worst-case condition are 15 times larger than the stresses resulting from shear. Although bending in the bolt may result in reducing shear on the insert, it imparts an additional bending stress in the bolt which has not been calculated. The Applicant has offered some preliminary calculations indicating that bending moments are insignificant in all but one of 60 cases reviewed. It may be that the effect of such moments are small in the large majority of cases. While there have been questions about whether the bolting is governed by the ASME Code, the NRC staff believes that the total stress (including the bending stress) in the bolts should be evaluated to assure that the value for allowable stress has not been exceeded. The NRC staff requires that this value shall not exceed the ASME Code allowable stress for bolting.

During the inspection, the Special Inspection Team evaluated the ability of the Richmond insert/tube steel assembly to resist axial torsion. The Special Inspection Team found no concern with the Applicant's design guidelines being utilized to design for this form of loading since they are based on valid engineering principles for the design of baseplates. Mr. Doyle's concern about the eccentricity between the tube steel and the Richmond insert was also evaluated by the Special Inspection Team. The Applicant's design criteria limits the eccentricity to two times the thickness of the tube steel wall. This criteria is a result of the necessity to establish a maximum allowable erection tolerance which can be accommodated in the factor of safety without significantly affecting the design calculation. The philosophy behind specifying minimum factors of safety for any design results from the need to establish a reserve capability which will account for the possibilities of overload and understrength. Such possibilities may be due to variations in material dimensions, variations in construction procedure implementation, simplifications in calculation procedures, effects of erection tolerances, and disregard of secondary stresses.

## Hilti-Bolts

The Special Inspection Team reviewed the Applicant's method of designing pipe supports utilizing Hilti-bolts to anchor the pipe support to the structural concrete. Due to the high safety margins used for the design of anchors using Hilti-bolts, the resulting small load from LOCA-induced thermal expansion would be unimportant.

The situation for Hilti-bolts is different than for Richmond inserts. Hilti-bolts are commonly used throughout the nuclear industry. As a result of NRC Bulletin 79-02, a great deal of test data has been generated about the performance characteristics of Hilti-bolts in the sizes and configurations used at Comanche Peak. The design of the Hilti-bolts utilizes a factor of safety of five.

With respect to drilled Hilti-bolt anchors, the Special Inspection Team found that the Applicant's design criteria and installation procedures are in accordance with NRC requirements and will provide acceptable conservatism in the design of pipe supports utilizing Hilti-bolts.

This finding is based on the results of the Applicant's testing program conducted on site with the assistance of Hilti Fastening Systems, Inc. This testing program was conducted to establish the necessary torque requirements and to provide response to NRC Bulletin 79-02.

Summary

Mr. Doyle's concern that there are large loads on concrete anchors due to LOCA-induced thermal expansion of pipe support tube steel which are excluded in the design of the anchors is not substantiated. Such loads, although not included in the design process, are not large enough to result in failure of the anchorage as alleged by Mr. Doyle. Mr. Doyle's concern about high bending stresses in the concrete anchorage bolts for Richmond inserts is in part confirmed. Such stresses are not calculated by the Applicant. These stresses should be calculated to assure that they do not exceed the ASME Code allowable stress for bolting. On the other hand, the Special Inspection Team considers it unlikely that such stresses will lead to failure of the bolt. This is an unresolved item (Unresolved Item Nos. 50-445/8226-1 and 50-446/8214-1). In addition, as discussed above, the Special Inspection Team is not satisfied with the sufficiency of the test data supporting the use of the 1 1/2-inch Richmond inserts. The Applicant's test program in response to the Special Inspection Team findings is an unresolved item (Unresolved Item Nos. 50-445/8226-2 and 50-446/8214-2).

### d. Differential Thermal Expansion Effects in Pipe Supports

Mr. Doyle expressed a concern that stresses due to a Loss-of-Coolant Accident (LOCA) were not included in the stress analysis for pipe supports inside containment (Doyle Deposition pp. 14-21 and 36-63, and Attachment E). A similar concern was expressed by Mr. Walsh in Tr. 3109-3145. The concern relates to constraint of differential thermal expansion between the support steel and the concrete to which the support is attached due to temperatures of approximately 280°F in structures inside containment during a LOCA (CASE Exhibit 659C). Both Mr. Doyle and Mr. Walsh alleged that stresses in the support steel and loads on support anchorage resulting from this constraint were not included in the design and analysis of pipe supports at CPSES. The stresses and loads referred to in Messrs. Doyle's and Walsh's testimony were obtained by conservative analyses that assumed rigid connections at the pipe support to concrete structure interface. The assumption of rigid connections is unconservative because it does not consider the ability of the support anchor to deflect when loaded.

The decrease in stresses and loads resulting from the inclusion of the flexibility characteristics of the connections has been demonstrated by the Applicant (Applicant Exhibit 142D). Factors of safety between 3 and 71 of the ultimate deflections are reported by the Applicant. Deflections rather than stresses and loads were considered by the Applicant since they are more appropriate for thermally induced, self relieving secondary stresses. Moreover, the Applicant has stated that the ASME Code does not require that stresses due to constraint of thermal expansion of supports be considered in the design of linear type pipe supports.

The Special Inspection Team agrees with the Applicant that the ASME Code does not require that the differential thermal expansion effects resulting from LOCA conditions in pipe support members be included in the design of linear type pipe supports which are covered by the ASME Code. Further, the Special Inspection Team concluded that the differential thermal expansion effects resulting from LOCA conditions within pipe support members which are bolted to concrete structures will be reduced due to the flexibility of the anchor connection. The Special Inspection Team also concluded that the differential expansion effects in pipe supports resulting from LOCA conditions does not represent a safety concern based primarily upon its analysis of the flexibility characteristics of the worst-case support-to-wall connectors as described in Paragraph 3.c.(1). This conclusion is subject to confirmation of expected deflection/load characteristics in a shear test of the 1 1/2-inch Richmond insert.

With respect to Messrs. Doyle's and Walsh's concerns regarding failure to consider loads and stresses due to differential thermal expansion in pipe support under LOCA conditions, the Special Inspection Team found that the Applicant does not consider these loads and stresses. The Applicant argues that such loads and stresses need not be considered. For the reason discussed above, the Special Inspection Team agrees with the Applicant that such loads and stresses need not be considered in the design of pipe supports. The Special Inspection Team concludes that this concern does not have a valid technical basis and considers it resolved.

e. Differential Thermal Expansion Effects in Wall-to-Wall, Floor-to-Ceiling, and Floor-to-Wall Pipe Supports

Mr. Walsh expressed a concern regarding LOCA differential thermal expansion effects in wall-to-wall, floor-to-ceiling and floor-to-wall pipe supports (Tr. 3120-3122, and 3141-3143; Walsh Testimony, p 3, CASE Exhibit 659; Walsh Supplemental Testimony, CASE Exhibit 668). In particular, concerns about the effects of a 50°F LOCA temperature differential on a group of service water floor-to-ceiling pipe supports were identified (Tr. 3141-3143).

Mr. Doyle expressed concerns regarding (1) LOCA differential thermal expansion, (2) differential seismic displacement, and (3) concrete creep displacement effects in ceiling-to-wall pipe supports and/or anchors and other supports with configurations similar to those mentioned by Mr. Walsh (Doyle Deposition, Volume 1, pp. 62-63, 118-121, 145-151, 214-215, and 307-309; Doyle Deposition, Volume 2, pp. 4-7; Doyle Deposition, Attachments 7C-7D, 14D-14E, 14I-14K, and 18). Specifically, the following supports and/or anchors were identified relative to these concerns: (1) floor-to-wall service water support Nos. SW-1-132-701-Y33R and SW-1-132-703-Y33R (Doyle Deposition, Attachment 7C-7D); (2) floor-to-wall moment restraint No. MR CPI-CSSSMR-02 shown on Drawing No. 2323-SI-0538-07 (Attachment 9Q-9S); (3) wall-to-ceiling anchors No. CC-1 057-021-A33A and CC-1-008-029-S33A (Attachment 14D-14E and 14I-14K,, (4) wall-to-ceiling frame No. RH-1-005-016-C42R (Attachment 18); and (5) wall-to-wall steam generator upper and lower lateral supports.

Regarding differential thermal expansion effects, the Special Inspection Team verified that the PSE guidelines require that differential thermal expansion be considered when pipe supports span between walls or between the floor and ceiling. Based on: 1) the requirements of Items 2 and 8 of Texas Utilities Services, Inc. (TUSI) office memorandum of March 8, 1982, regarding LOCA temperature considerations in pipe support design (CASE Exhibit 659E); and 2) Paragraph 18.0 of ITT-Grinnell Design Guidelines Section IV; the NRC found that the design procedures are sufficient for the consideration of significant differential thermal expansion effects in wall-to-wall, floor-to-ceiling and other mentioned types of pipe support configurations. In order to verify the adequacy of these design procedures, the Special Inspection Team reviewed the Applicant's analyses of LOCA thermal expansion effects in: (1) the floor-to-ceiling support No. SW-1-132-701-Y33R, (2) the floor-to-wall moment restraint shown on Drawing No. 2323-SI-0538-07, and (3) the wall-to-wall steam generator upper lateral restraint. The results of these analyses indicate that LOCA thermal expansion effects satisfy Final Safety Analysis Report (FSAR) commitments. The Special Inspection Team concluded that this concern is resolved.

Regarding the effects of differential seismic displacements, the Special Inspection Team verified that the PSE guidelines require that when large frames are necessary to span across a corridor or from floor-to-ceiling, one end connection must be designed as a slip joint. (Paragraphs 2 and 13, TUSI Engineering Guidelines, Section II). ITT-Grinnell and NPSI guidelines do not have a similar requirement. However, the Special Inspection Team was informed that neither of these pipe support design groups have designed wall-to-wall or floor-to-ceiling support frames. In subsequent discussions the Applicant provided the Special Inspection Team a copy of a memorandum dated January 19, 1983 directing the recipients, specifically ITT-Grinnell and NPSI personnel, to use the same seismic guidelines as those contained in the TUSI Engineering Guidelines in the event they design these types of support frames. The Special Inspection Team concludes that this matter is resolved.

The Applicant stated (Tr. 3142) that the designs of the floor-to-ceiling service water supports identified by Mr. Walsh had been found to be inconsistent with the above mentioned PSE engineering guideline, and the supports were being evaluated by PSE at that time (Applicant Exhibit 142, p. 25). The inconsistency was identified in late 1981 in the normal process of design review. During the course of the inspection, the Applicant informed the Special Inspection Team that these supports would be unable to withstand differential seismic displacements and were being redesigned. In subsequent discussion, the Applicant showed the Special Inspection Team component modification cards (CMC) 46174, Revision 8, and 46730, Revision 4 showing that the bottom portions of Item 25 on support SW-1-132-701-Y33R (Doyle Deposition Attachment 7C) and Item 22 on support SW-1-132-703-Y33R (Doyle Deposition Attachment 7D) respectively, are to be cut off to eliminate the floor-to-ceiling columns on the east end of each support. The Special Inspection Team concluded that the redesign resolves the concern. The NRC staff will verify that these modifications are completed in a follow-on inspection as part of its construction inspection program (Open Item No. 50-445/8226-3).

In addition, the Special Inspection Team reviewed analyses by the Applicant confirming the adequacy of the floor-to-wall moment restraint shown on Drawing No. 2323-SI-0538-07 and the wall-to-wall steam generator upper lateral restraint to withstand differential seismic displacements. Both analyses were found to be acceptable. The Special Inspection Team concluded that PSE guidelines for considering differential seismic displacements are satisfactory.

With regard to the effects of concrete creep displacements expressed in Mr. Doyle's concern, the Special Inspection Team determined that these effects would be most severe in wall-to-wall and floor-to-ceiling supports. Accordingly, the Special Inspection Team performed a review of these effects in the floor-to-ceiling service water supports identified by Messrs. Walsh and Doyle (Doyle Deposition, Attachment 7B). Figure 9.2 of Attachment 7B shows that creep effects are insignificant for sustained loads with durations greater than 12 months. Since the length of time from placement of slab to installation of supports is typically a miminum of 12 months, creep effects are expected to be negligible. [The actual time in this case was 32 months. The concrete placement Number 111-8809-003 for the top slab in the fuel building tunnel was dated April 14, 1978, and the inspection report IRMH 8853 for the Hilti bolts for the support was dated January 7, 1981.] The Special Inspection Team concluded on the basis of the above findings that Mr. Doyle's concerns regarding concrete creep displacements are without merit and considers this matter resolved.

Mr. Walsh's and Mr. Doyle's concerns about LOCA thermal expansion loads and about concrete creep displacement effects on wall-to-wall, floor-to-ceiling and floor-to-wall pipe supports are without technical merit. Mr. Doyle's concern about seismic displacement effects has also been identified in the course of the Applicant's design review program. The identified problem has been rectified by a design modification. And, procedures are in place to assure that seismic displacement effects will be considered in the design of other pipe supports which may be affected. This matter is resolved.

### f. Stability of Pipe Supports Designed for CPSES

Mr. Doyle expressed a concern pertaining to stability of pipe supports (Doyle Deposition, pp. 95-104 and Doyle Deposition, Attachments 4 and 13). Mr. Doyle alleged that:

1. Non-rigid supports, supports which could be characterized as three bar linkages, were unstable if gaps between box frames and U-bolts and the supported piping will permit rotation of the box frames or U-bolts around the supported piping.

2. Supports similar to those described in 1 above but with zero clearance between U-bolts and box frames and the supported piping are potentially unstable because:

    (a) Gaps could be created between the U-bolts and supported piping due to yielding and permanent deformation in the U-bolts.

    (b) Friction between the box frame and the supported piping will not be sufficient to prevent rotation of the box frame around the supported piping.

Mr. Walsh also expressed a concern relating to unstable supports (Tr. 3103-3105, and Walsh Supplemental Testimony, dated July 28, 1982, p.1, CASE Exhibit 649H).

The question of whether a particular support is stable or unstable when standing alone does not have an important bearing on the functional capability of the piping system. Although individual supports, when considered by themselves may appear to be unstable, it is necessary only that the entire piping system and associated supports be stable when considered as a single mechanical system. Mr. Doyle appears to agree with this concept in his discussion of support No. CC-1-043-026-A33R (Doyle Deposition, Attachment 13X). This drawing shows a vertical support utilizing a U-bolt with zero clearance which is the basis for concern number 2 above. This support was judged to be stable by Mr. Doyle when he stated that:

> "even though the structure below is apparently unstable, it takes so little to make it stable that a support horizontally up and downstream is sufficient to keep it stable" (Doyle Deposition, p. 210).

The Applicant also appears to be in agreement with the above concept. The Applicant stated that it is not necessary for each pipe support to be stable by itself but that the piping and supports as a system should be stable (Applicant Exhibit 142, p. 28).

It is not general industry practice to explicitly address the overall stability of piping systems together with their supports in design guidelines. Rather, it is standard industry design practice to address only the structural integrity of supports in design guidelines. The Applicant's practice corresponds to this industry practice. Thus, no explicit design guidelines address overall stability. Functional adequacy, including stability, of the overall piping system is typically a result of the normal iterative design and review process. Furthermore, industrial experience has shown in the case of non-rigid pipe supports that if the support element which attaches to the pipe is prevented from rotating about the axis of the supported pipe at all times, the piping system and its supports will be a stable mechanical system. Frictional forces are sometimes relied upon to prevent rotation of the support element about the axis of the supported pipe; for example, in the case of pipe clamps or U-bolts. The use of U-bolts is discussed further in Paragraph 3.g.

The Applicant has stated that unstable non-rigid supports have been identified in their review process and corrective actions have been or will be taken where necessary before completion of the design process (Applicant Exhibit 142, p. 27). During the course of this inspection, the Special Inspection Team confirmed that the Applicant has begun to assess the stability of non-rigid box frame supports. The Applicant has indicated that all such supports will be reassessed for stability. Design modifications under consideration by the Applicant are intended to prevent rotation of the box frame around the axis of the supported piping. These proposed modifications include: 1) the use of a U-bolt that is fixed to the box frame and cinched down on the pipe, 2) lugs welded to the pipe that will be indexed to the box frame and 3) the addition of stabilizing struts to the box frame. Since it is the Applicant's practice to cinch down U-bolts on non-rigid supports to prevent rotation, and the second and third proposed modifications provide positive means of preventing rotation of the box frames about the axis of the supported pipe at all times, stability and hence the functional adequacy of the piping system plus the supports will be assured. The Special Inspection Team concluded these modifications are acceptable. The NRC Staff will verify that these modifications are completed in a follow-on inspection as part of its construction inspection program (Open Item Nos. 50-445/8226-4 and 50-446/8214-3).

Initially, it was not clear that the Applicant had a similar reassessment program to assure the stability of non-rigid U-bolt supports. In subsequent discussions, the Applicant stated that U-bolts are cinched down to grip the pipe on this type of support. Since the U-bolt will not become loose during service life the concern about the instability of non-rigid U-bolt supports is resolved.

The Special Inspection Team concludes that Messrs. Walsh's and Doyle's concern relating to instability of the pipe supports is resolved by the Applicant's stability reassessment program.

### g. Use of U-Bolts in Pipe Support Design

Mr. Doyle expressed the following concerns regarding the use of U-bolts in pipe support designs:

(1) For rigid supports in which the U-bolts are oriented such that their principal or strong axis is in the direction of the design load, i.e. a one-way support, the use of U-bolts introduces:

  (a) Constraints on the piping system which are not included in the piping stress analysis (Doyle Deposition, pp. 87-88).

  (b) Lateral loads on the U-bolts which are not considered in their design (Doyle Deposition, p. 88).

(2) U-bolt deformations are not included in the calculations for support deflections (Doyle Deposition, pp. 195-197).

(3) Where U-bolts are cinched down onto the supported piping:

  (a) Stresses due to preloading and constraint of differential thermal expansion are not considered in the U-bolt analysis (Doyle Deposition, p. 318).

  (b) Local stresses in the supported piping due to constraint of differential thermal expansion are not considered in the piping stress analysis (Doyle Deposition, p. 318).

  (c) Pipe supports may become unstable after yielding and permanent deformation of the U-bolts have occurred.

Approximately 30 supports cited in Doyle Deposition Attachment 13 have U-bolts incorporated in their design and are discussed on pages 195-213 of Mr. Doyle's Deposition.

Relative to the first of Mr. Doyle's concerns, the Special Inspection Team determined that Gibbs & Hill identified the same concern during the Applicant's As-Built Verification Program. This concern was addressed by review procedures established in a Gibbs & Hill interoffice memorandum dated July 16, 1982.

The Gibbs & Hill memorandum requires that if the original thermal expansion pipe stress analysis (which assumes that the piping is unrestrained in the lateral direction) indicated that the piping thermal movement in the unrestrained direction is greater than 1/16 inch, the piping stress analyses be reevaluated as follows:

(1) The thermal expansion Code stress evaluations be based on the results of a supplemental thermal expansion analysis rather than the results of the original thermal expansion analysis. The piping was assumed to be restrained in the U-bolt lateral direction in the supplemental analysis. The support stiffness in this direction was assumed to be equal to the calculated U-bolt lateral stiffness.

(2) The seismic Code stress evaluation be based on the result of the original seismic stress analysis in which the support was assumed to be effective only in the direction of the principal axis of the U-bolt and the support stiffness value in this direction was equal to the generic support stiffness value specified in the Gibbs & Hill Specification MS-200. The restraint offered by the support in the direction of the lateral axis of the U-bolt is ignored for the seismic analysis.

Although the Special Inspection Team initially had some concerns about the adequacy of this procedure, these were negated by other procedures instituted by the Applicant. In particular the Special Inspection Team was informed in subsequent discussions with the Applicant that all one-way U-bolt supports in which the initial thermal expansion analysis indicated a movement in the U-bolt lateral direction greater than 1/16 inch were modified to accommodate the calculated lateral movement or were replaced. Example of these modifications were reviewed by the Special Inspection Team.

Furthermore, in the subsequent discussions with the Applicant, seismic displacement data at selected one-way U-bolt restraints were presented to the Special Inspection Team. These data indicated that these displacements were less than about 1/32 inch. Loads associated with these displacements are also negligible.

Relative to the neglect of constraint effects when the original thermal expansion analyses indicated piping movements less than 1/16 inch in the U-bolt lateral direction, analyses performed by the Special Inspection Team indicate that:

(1) Piping stresses due to restraint of up to 1/16 inch of this type of thermal expansion movement are negligible for all pipe sizes.

(2) Lateral loads on the U-bolts due to thermal expansion movements of this type of up to 1/16 inch are negligible for all pipe sizes when the relative flexibilities of the pipe and U-bolts are considered.

Based on the above, the Special Inspection Team concluded that the Applicant's practice of restricting the use of U-bolts on rigid one-way supports to applications where the lateral movement of the pipe determined by the thermal expansion pipe stress analysis is limited to 1/16 inch is acceptable because the resultant forces from the thermal expansion and seismic loads (and consequent pipe stresses) are negligible. The concern about the use of U-bolts on one-way supports is resolved.

During the course of its review of the use of U-bolts as one-way restraints, the Special Inspection Team reviewed a related Gibbs & Hill concern regarding the use of U-bolts in rigid supports as "two-way" restraints, i.e., restraints where design loads are specified in two directions simultaneously. In these cases: (1) the support designs show that the U-bolts are oriented such that their principal and lateral axis are in the directions of the specified design loads and (2) the pipe stress analysis assumes that the support stiffness values in the direction of the principal and lateral U-bolt axis are both equal to the generic support stiffness values in Specification MS-200.

In subsequent discussions with the Applicant, the Special Inspection Team was informed that U-bolts are not used on two-way rigid supports for pipe sizes larger than 6 inches. This was verified by the Special Inspection Team. The restricted use of U-bolts is a result of the relatively low lateral load capability of U-bolts for piping larger than 6 inches. The Applicant has shown in a Gibbs & Hill study on lateral stiffness in U-bolt attachments that the lateral stiffness values of U-bolts for pipe sizes 6-inch and under are comparable to the generic stiffness values used in the pipe stress analysis. Thus, for small size piping, the Applicant's [illegible] the generic stiffness values in the pipe stress analysis [illegible] realistic support design loads and pipe stress values. [illegible] design groups are instructed to verify that the loads [illegible] are within the U-bolt manufacturer's allowable loads during the as-built verification program. For these reasons the Special Inspection Team found the Applicant's design practices for using U-bolts on two-way rigid supports acceptable. This concern is resolved.

Relative to the second item of Mr. Doyle's concerns, the Special Inspection Team determined by discussion with cognizant engineers that U-bolt deformations have not been included by the Applicant in its support deflection calculations. As noted above, the lateral loads on two-way rigid supports are verified to be within the U-bolt manufacturer's allowable lateral loads. Similarly, the loads in the principal direction are verified to be within the U-bolt manufacturer's allowable loads during the As-Built Verification Program. Therefore, the Special Inspection Team found the failure to include the deflection of U-bolts in the support deflection analysis to be inconsequential since the deflection of the U-bolt is limited to such small (elastic) movement that its contribution to the support deflection analysis is minor. This concern is resolved.

Regarding the preloading stresses in item 3(a) of Mr. Doyle's concern, the Special Inspection Team determined that the Brown & Root Design Change Notice (DCN) Number 1, dated 10/8/82, to Construction Procedure No. 35-1195-CPM 9.10 Rev. 8 provides additional requirements to paragraph 3.3.2, "Threaded Items," for U-bolts. It states:

> "When U-bolts are specified on the design document as not having any clearances, the U-bolt shall be snug tight so that the U-bolt cannot be moved by hand....
>
> Snug tight is defined as the tightness attained by a few impacts on an impact wrench or the full effort of a man using an ordinary spud wrench."

The preloading stresses associated with those procedures are common to industry use of threaded fasteners (a proven method of holding structures together), although difficult to assess. In addition, paragraph 4.2.6 of the Construction Procedure requires the following inspection:

> "The U-bolt shall be visually inspected by QC for cracks, melted spots and excessive deformation. Any one of these conditions shall be cause for rejection. This inspection shall be included in the final inspection of the hanger."

The Special Inspection Team found this inspection procedure to be sufficient to insure that preloading stresses are within acceptable limits. In subsequent discussions, the Applicant informed the Special Inspection Team that the U-bolts will be field verified to confirm that they are properly tightened. Further, that the walkdown inspection conducted prior to preoperational testing routinely checks for the proper installation of U-bolts.

With respect to the constraint of differential thermal expansion aspects of items 3(a) and 3(b) in the third of Mr. Doyle's concerns, the Special Inspection Team would note that differential thermal expansion effects are limited to the case of uninsulated piping. In the case of insulated piping (e.g., main steam, feedwater, and residual heat removal piping), the temperature differences between the U-bolt and the pipe will be negligible because the U-bolt is in thermal contact with the pipe and the insulation is installed over both the U-bolt and the pipe. A review of the design temperatures and pipe sizes of uninsulated piping by the Special Inspection Team indicated that the maximum radial growth of the piping is expected to be less than 1/32 inch. Since the U-bolt is in contact with the pipe and will heat up to some extent, a maximum differential radial growth between the U-bolt and the pipe of about 1/64 inch seems reasonable. Assuming the U-bolt is as stiff as the pipe, the effective maximum radial constraint will be in the order of 1/128 inch (0.008 inch). Since the U-bolt stresses and pipe stresses associated with 1/128 inch radial constraint are negligible, differential thermal expansion effects in uninsulated piping are negligible. Alternately, since the maximum temperature differential between the U-bolt and pipe in uninsulated piping is expected to be less than 50 degrees Fahrenheit, calculations performed by the Special Inspection Team indicated that the associated secondary stresses and loads are negligible relative to ASME Code allowables. Further, the U-bolt is normally provided with a 1/16 inch diametrical gap on the pipe to facilitate its installation. Even after cinching down, there is not full circumferential contact between the U-bolt and the pipe. This will also alleviate differential thermal expansion effects. The Special Inspection Team concluded that the differential thermal expansion aspects of Mr. Doyle's concern are resolved.

The Special Inspection Team would note that Mr. Doyle also expressed a similar concern regarding differential thermal expansion effects in box frame supports with zero clearances. Relative to this concern the Special Inspection Team understood through initial discussions with relevant cognizant engineers that it was an undocumented Gibbs & Hill design recommendation, where U-bolts or box frames are in direct contact with the supported pipe, that clearances be provided between the U-bolts or box frames and the supported pipe only if the diametrical growth of the pipe exceeds 1/32 inch at design temperatures. The Special Inspection Team determined that of the three pipe support design groups (PSE, ITT-Grinnell and NPSI) only ITT-Grinnell has documented guidelines which incorporate the Gibbs & Hill recommendation. The Special Inspection Team was informed that the two remaining groups also follow the ITT-Grinnell guidelines. In subsequent discussions with the Applicant, the Special Inspection Team was informed that the above 1/32-inch design guideline was applicable only to box frames. It was not applied to U-bolts. For the reasons discussed above the Special Inspection Team agrees that such a design guideline is not needed for U-bolts.

With respect to the box frames, the Applicant stated that box frames were used only on low temperature systems (e.g., service water, component cooling water). This was verified by the Special Inspection Team. Because of this, the diametrical expansions of the pipes are generally of the order of 1/64 inch. Assuming zero clearance, since the pipe and the frame are of equal stiffness, the deflection (bow) in the frame would be approximately 1/128 inch (0.008 inch). The pipe wall would also be pushed inward an equal amount. Similar to the case of uninsulated piping discussed above, stresses in the box frame and pipe due to constraints of 1/128 inch of differential thermal expansion are negligible.

The Applicant also stated that although the design may specify a zero clearance (no gap) for a box frame, construction techniques often result in a diametrical gap of up to 1/32 inch. Thus, in practice the frame often provides a gap which further alleviates the constraint. Based on the above, the Special Inspection Team concludes that Mr. Doyle's concerns about the pipe stresses caused by constraint of the thermal expansion of the pipe by box frames is without foundation. This concern is resolved.

With respect to the instability aspects, item 3(c), in the third of Mr. Doyle's concerns, since the stresses due to preloading and differential thermal expansion effects are expected to be negligible, loosening of the U-bolts due to thermal cycling will be precluded. The Special Inspection Team concludes this concern is resolved.

Mr. Doyle's concern about the restraint by U-bolts of lateral movement of the pipe due to thermal expansion at one-way restraint points, and his concern about the preloading stresses have also been identified in the course of the Applicant's normal review program and these problems have been rectified. Mr. Doyle's other concerns about the use of U-bolts have been found to be without a valid technical basis.

### h. Loading Due to the Seismic Acceleration of the Pipe Support Structure

Mr. Walsh expressed a concern regarding the inclusion of seismic acceleration of the pipe supports in the STRUDL analysis. (Walsh Supplemental Testimony, page 1, Case Exhibit 659H). Mr. Doyle expressed a similar concern regarding the effect on pipe stresses of the loads imposed by the pipe supports during a seismic event (Doyle Deposition, Attachment 12A). In addition, Mr. Walsh made assumptions regarding the natural frequency of some supports and concluded that the supports would fail. (Walsh Supplemental Testimony, Tr. 3100) In response to the expressed concerns, the Special Inspection Team reviewed the following items.

#### (1) Review of Analyses to Determine the Effect of Seismic Acceleration Loads

All small bore piping supports were designed by PSE. There are over 8,000 such hangers and supports in Unit 1 and about 7,000 in Unit 2. The large bore piping supports were primarily designed by ITT-Grinnell and NPSI. There are over 16,000 such supports and hangers in Unit 1 and over 11,000 in Unit 2. Seismic accelerations are considered by PSE in the design of the small bore piping. For large bore piping supports the seismic acceleration load of the supports themselves were considered by NPSI and ITT-Grinnell to be relatively low in comparision to the design loads imposed by the piping. Therefore, the seismic acceleration load of the support was not included in the pipe support design process. To confirm and validate that assumption, the Applicant randomly selected approximately 400 supports. From this random sample, which included designs by ITT-Grinnell, NPSI, and PSE, a selection of 23 "worst case" supports was made for detailed analysis by the Applicant. These 23 supports were those in which the seismic acceleration loads were likely to be most significant due to the configuration of these supports. They included unbraced cantilevers, large frames braced in one direction, and large structures with relatively small pipe loads. These 23 supports were reanalyzed in detail by the pipe support design groups to consider the effect of seismic acceleration loads on the support design. It was found that the stresses in the most highly stressed members of the supports were well within allowable limits of the ASME Code Section III and in a majority of cases, the additional loads imposed by the seismic acceleration of the support frames were negligible.

A separate reanalysis was performed by NPSI on 13 supports in which the seismic acceleration loads had been neglected by NPSI in the original design. These supports are considered to be worst cases from the standpoint of seismic acceleration loads. The conclusions from this study are essentially the same as stated above, i.e., the seismic acceleration loads are negligible.

The Special Inspection Team evaluated the calculations performed by both PSE and NPSI in detail. The review included the modeling techniques, design criteria, analytical assumptions, computer programs, and hand calculations. Discussions were held with individuals in the PSE, ITT-Grinnell, and NPSI design groups who routinely performed the calculations and were involved in the design process. On the basis of the Special Inspection Team's review of the Applicant's reanalysis of pipe support designs, the Special Inspection Team concurs with the Applicant's conclusions that: (1) in a majority of cases additional loads resulting from seismic acceleration of support frames are negligible, and (2) in no case will the inclusion of the loads due to seismic acceleration of the support structure result in overstressing the support structure. The Special Inspection Team considers this concern to be resolved.

(2) Review of Design Criteria to Maintain Rigidity of the Supports

Mr. Walsh assumed that the support would be excited at the frequency corresponding to the peak acceleration of the floor response spectra (Walsh cross-examination Tr. 3100). This is an erroneous assumption and results in unrealistic seismic acceleration load predictions. Actually, the natural frequency of the support is much higher than the frequency at which the peak acceleration occurs in the floor response spectrum. When the seismic acceleration of the support is determined at its correct natural frequency, the resulting stresses are found to be within ASME Code allowables.

The NRC Inspector reviewed the design criteria adopted by PSE, ITT-Grinnell and NPSI to ensure rigidity of the supports. All three design groups limit the deflection of the support to 1/16 inch under service level B loading condition. This limitation should ensure a rigid design. The Applicant is providing a study demonstrating the adequacy of its guidelines to assure a rigid support design (see Paragraph 3.j). For rigid frames the seismic acceleration loads would remain low.

In addition to the 1/16-inch deflection criterion, NPSI provides out-of-plane bracing to ensure stability and rigidity. Vertical bracing of the members is provided if the member or frame overhangs more than 5 feet 6 inches in a horizonal direction. Similarly, horizontal bracing is provided if the member or frame extends more than 8 feet in elevation. The PSE and ITT-Grinnell design groups do not have specific guidelines but provide bracing for rigidity based on engineering judgement in their normal design process. The Special Inspection Team's review of 100 randomly selected supports determined that: (1) the NPSI criteria have been adhered to; (2) deflection limits have been maintained in the support design; and (3) the seismic acceleration loads of the supports are likely to remain negligible. The Special Inspection Team concluded that this concern does not present a safety issue and considers the concern resolved.

(3) <u>Effect of the Support Loads On the Pipe Stresses During a Seismic Event</u>

Mr. Doyle expressed a concern that certain types of supports are attached to the wall in such a manner that the weight of the support would transmit some load to the pipe, and that the effects of this additional loading have not been adequately considered in the stress analysis of the piping. (Doyle Deposition Attachment 12A). The weight of these supports acts at some distance from the axis of the pipe. This eccentricity in the support weight may introduce some torsional stresses in the pipe in addition to the stresses due to the support deadweight. Although not explicitly stated by Mr. Doyle in his concerns, this torsional effect was also evaluated by the Special Inspection Team and is discussed in the following paragraphs.

Pipe restraints of the type cited by Mr. Doyle function by restraining pipe motion along the axis of the snubbers (Doyle Depostion Attachments 12E through 12N). The weight of the support structure may provide some additional loading on the pipe at the location of the restraint. The Special Inspection Team reviewed the analysis of these supports and the procedures used by the Applicant to include the effect of the support load on the pipe. The Special Inspection Team found that an assessment of this contribution to the piping load is made on a case-by-case basis by both the Gibbs & Hill and Westinghouse pipe stress analysis groups, and it is added to the piping loads during the stress analysis of the piping run, if the contribution is considered significant. The following table summarizes the treatment of the weight of the support in the piping stress analysis for the specific examples cited by Mr. Doyle.

| Support No. | Pipe Dia. | Organization Responsible for Analysis | Support Load on Pipe | Support Load in Piping Analysis |
|---|---|---|---|---|
| SI-1-120-004-C52K | 10" | Westinghouse | 130 | Neglected |
| SI-1-104-008-C52K | 10" | Westinghouse | 100 | Neglected |
| SI-1-031-704-A32R | 12" | Gibbs & Hill | 30 | Neglected |
| MS-1-003-013-C72K | 32" | Gibbs & Hill | 974 | Considered |
| MS-1-003-009-C72K | 32" | Gibbs & Hill | 2015 | Considered |

The Special Inspection Team also investigated torsional effect of the eccentric support load on the pipe stresses. Support Nos. MS-1-003-013-C72K, MS-1-003-009-C72K, CC-1-043-015-A43K (Doyle exhibit 13LL) were selected for this purpose. These are considered to be worst case configurations from the standpoint of torsional effects. Calculations performed by the Special Inspection Team indicate that the increase in pipe stresses due to the torsional loading was less than one percent. Based on this investigation, the Special Inspection Team found the increase in the pipe stresses due to torsional effects of eccentric support loads to be negligible.

The Special Inspection Team found that in practice the Applicant includes the weight of the support in the pipe stress analysis if the support weight exceeds a small percentage of the support pipe weight. On that basis, the Special Inspection Team found that the Applicant's procedure of adding the weight of the support to the piping weight, on a case-by-case basis, to account for the effect of the support load on the pipe stresses is acceptable and does not represent any safety concern. In addition, based upon the negligible increase in pipe stresses due to torsional effects, the Special Inspection Team concluded that torsional effects do not represent any safety concern. Mr. Doyle's concern is considered to be resolved.

Mr. Walsh's concern regarding a need to include seismic accelerations in the pipe support design analysis and Mr. Walsh's analysis projecting failure of the supports under seismic loads are without valid technical bases. Mr. Doyle's concern that the pipe stress analysis did not adequately consider the added weight of the support was also without a valid technical basis.

### i. Moment Restraints and Local Pipe Stress Due to Welded Stanchions on Pipes

Mr. Walsh and Mr. Doyle expressed a concern that the effects due to welded stanchions on main steam, containment spray and feedwater piping have not been included in the as-built piping stress analysis. These effects are: (1) moment restraints introduced in the piping system and (2) local stresses in the pipe wall. Examples identified by Mr. Walsh are supports CT-1-024-004-S22K and FW-1-096-704-C62K (Walsh Supplemental Testimony, CASE Exhibit 668, p. 1; Item 2, CASE Exhibit 668A). Examples identified by Mr. Doyle are supports CT-1-008-006-S22K and MS-1-003-009-C72K (Doyle Deposition, Attachments 11LL-11NN and 12N-12P, respectively).

The Applicant has stated that, regarding welding of stanchions to pipes by NPSI, ITT-Grinnell and PSE, the final as-built piping and support verification program will assure that the actual support configurations will be taken into account (Applicant's Exhibit 142, Pages 25-26). The Applicant has further stated that

> "stresses at pipe/welded attachment interfaces will be qualified by Gibbs & Hill to the as-built loads during the as-built stress analysis." (D.M. Rencher to ITT, NPSI TSDRE's, Stress Analysis of Welded Attachments, TSBR #V92, April 7, 1982).

The Special Inspection Team conducted a review of the Applicant's As-Built Verification Program at Gibbs & Hill in New York on October 27, 1982 to verify the adequacy of the program in addressing the concern expressed by Mr. Walsh and Mr. Doyle. The review showed that the verification program requires consideration of: (1) restraint characteristics of "as-installed" (as-built) supports; and (2) stresses due to welded attachments in combination with appropriate ADLPIPE computer program piping stresses.

To confirm that the Applicant's As-Built Verification program is being adequately implemented in this regard, the Special Inspection Team selected for detailed review Gibbs & Hill Stress Problem AB-1-03 dated August 23, 1982, for the main steamline No. 3 inside containment. The Special Inspection Team selected this problem because the main steamline is the most critical of the three lines identified by Messrs. Walsh and Doyle. The review showed that stanchions are welded to the 32-inch diameter main steam line pipe at the following snubber supports and that the pipe stress problem included the analysis of local pipe stresses due to these stanchions:

MS-1-03-005-C72K
MS-1-03-007-C72K
MS-1-03-009-C72K (Doyle Exhibit 12N-12P)
MS-1-03-010-C72K
MS-1-03-014-C72K

All but the first of these supports utilize dual snubber designs with distances of approximately 5 feet between snubbers. With respect to moment restraints on the main steam piping, the Special Inspection Team found that no moment restraints were considered at these supports in the Applicant's piping stress analysis. The Special Inspection Team performed calculations based on the snubber or translational stiffness of Table 3.4-1 of the Gibbs & Hill Specification 2323-MS-200 and the 5-feet distance mentioned above. These calculations gave stiffnesses of rotational restraint of the same order of magnitude (2 to 7 times) as the generic rotational stiffnesses used by Gibbs & Hill in the pipe stress analyses. The Special Inspection Team concluded that the rotational stiffness associated with these designs should have been included in the piping stress analysis. Subsequent discussions with the Applicant indicated that this rotational restraint had also been identified during the Applicant's normal design review and that the pipe stress analysis was being modified to consider this rotational restraint. The Special Inspection Team reviewed the proposed method of analysis ("Minutes of discussion at the Meeting between G&H and NPSI on March 17, 1982") and concluded that the method of modeling the rotational restraint and the attendant loads on the snubbers was acceptable. Since the Applicant is including this rotational restraint in the pipe stress analysis, the Special Inspection Team found the concern on moment restraints introduced in the piping system to be resolved.

With respect to local stresses, the Special Inspection Team found that the Applicant evaluated local pipe stress effects in their As-Built Verification Program where applicable, due to radial and shear loads and moments. The Applicant utilized for its local stress evaluations the CYLNOZ 2 computer program. The CYLNOZ 2 computer program was developed by Franklin Institute on the basis of Welding Research Council (WRC) Bulletin No. 107, "Local Stresses in Spherical and Cylindrical Shells due to External Loadings," August 1975. The Special Inspection Team concluded that the use of the CYLNOZ 2 computer program is an acceptable method of analyzing local stresses.

The Special Inspection Team also determined that the Applicant's calculated local pipe stresses were combined with internal pressure and ADLPIPE bending stresses at these support locations in accordance with the criteria in Equations 8, 9, and 11 of NC-3650 of the ASME Code Section III, Subsection NC. The criteria were satisfied at all five support locations on the main steam pipe.

The Special Inspection Team noted however that differential thermal expansion effects between the insulated main steam pipe and the uninsulated structural steel support structure were not included in the local stress evaluations for support No. MS-1-003-009-C72K. These differential thermal expansion effects should be considered. In subsequent discussions, the Applicant stated that it had in fact considered this effect and determined that the resultant stresses were acceptable. The Applicant has agreed to provide the Special Inspection Team with its analysis. The Special Inspection Team will verify the acceptability of this analysis (Open Item No. 50-445/8226-5).

On this basis, the Special Inspection Team concludes that the concern expressed by Mr. Walsh and Mr. Doyle is being adequately addressed by the Applicant's As-Built Verification Program.

### j. Deflections and Local Stresses in Pipe Support Structures

Mr. Doyle has expressed concerns about excessive deflections and uncalculated local stresses at locations where brackets are attached to plates and other members of the pipe support structure. Mr. Doyle alleges that bracket loads cause local deflections which are not included in the total displacement calculations for the support hanger. He also alleges that localized stresses resulting from the bracket are not considered in the stress analysis of the support hanger. (Doyle Deposition, pp. 169-172; Doyle Deposition, Attachment 11A). Specifically, the following supports were identified as being examples of these concerns:

(1) Support CC-2-008-709-A43K (Doyle Deposition, Attachments 11FF thru 11II).

(2) Support CC-1-028-034-S33R (Doyle Deposition, Attachment 4G-4H).

(3) Support CC-1-107-008-E23R (Doyle Deposition, Attachment 11TT).

(4) Support CS-1-239-007-A42R (Doyle Deposition, Attachment 13DD thru 13GG).

In computing the response of a piping system to complex loading combinations such as those which include a seismic event, it is important to assure that piping supports are sufficiently stiff so that they do not adversely affect the response of the piping system. The Applicant uses generic stiffness values in its calculations of piping system response. The use of generic stiffness values is common practice and is acceptable provided that the generic stiffnesses adequately represent the stiffness of the installed supports. The Applicant and its piping analyst, Gibbs & Hill, indicated that they believe that the use of their overall deflection guideline of 1/16 inch maximum deflection under service B condition loads will result in supports whose stiffness is adequately conformed to the generic values used in the piping stress analysis. In discussions with the

Applicant, the Special Inspection Team noted that in the absence of review of the particular supports, it was unclear that the 1/16 inch deflection guideline in fact results in support stiffness comparable to the generic stiffness used in the piping stress analysis. The Applicant agreed to provide a study demonstrating that supports designed in accordance with Applicant's criteria and guidelines have sufficient stiffness to assure that they do not adversely affect the response of the piping system. This matter remains unresolved.

For the Component Cooling Water support No. CC-1-107-008-E23R (Doyle Deposition, Attachment 11TT), Mr. Doyle alleged that the displacement of the support will exceed the design guideline of 1/16 inch because a 1-inch plate will allow rotation which has not been computed. This support has been "vendor certified" by ITT-Grinnell to satisfy the deflection guideline of 1/16-inch maximum deflection. A review by the Special Inspection Team of the original design calculations showed that the deflection calculation did not include the potential rotation of the pl[illegible] alleged by Mr. Doyle. Subsequently, the Applicant tested t[illegible]rt to determine the actual deflection under service level B lo[illegible]he actual deflection was found to be less than 1/16 inch. The test has shown that the potential rotational effect alleged by Mr. Doyle does not result in excessive deflection.

However, since the actual stiffness of this support was found to be about 1/8 of the generic value used in the piping analysis, the Applicant has been requested to rerun the piping stress problem with the actual stiffness value and to provide a report of its results. This matter remains unresolved.

In component cooling water support No. CC-2-008-709-A43K a 16-inch diameter stub pipe is welded at the elbow of a 24-inch diameter component cooling water piping. (Doyle Deposition, Attachments 11F thru 11II). A 1/2-inch thick circular cap is welded at the end of the 16-inch diameter stub pipe which in turn has a bracket welded to it. Mr. Doyle alleges that the displacement and local stresses in the 1/2-inch thick plate exceed allowables under application of the 11.9-kilopounds service level C load. He further alleges that the 3/16-inch weld attaching the bracket to the center of the plate is overstressed. Although this support had not been vendor certified at the time of the inspection, the Special Inspection Team made calculations which indicated that the maximum deflection may exceed the Applicant's 1/16-inch maximum deflection guideline, but the 3/16-inch weld was not found to be overstressed. The Special Inspection Team reviewed some preliminary calculations provided by the Applicant covering the displacements and local stresses for this support. A numerical error was uncovered by the Special Inspection Team in the Applicant's preliminary calculations, which resulted in the underestimation of bending stress in one member of this support and could result in an overstress condition. In discussions the Applicant indicated that its subsequent review has also identified an overstress condition in this support which would be rectified as part of its normal design iteration process. The Applicant will provide a status report on the status of this support design. The corrective action will be verified by the NRC staff in a follow-on inspection as part of its construction inspection program (Open Item No. 50-446/8214-4).

For the Component Cooling Water Support No. CC-1-028-034-S33R, Mr. Doyle alleged that the stress in the web of the W6 x 12 beam exceeds the ultimate stress for the material of the beam (Doyle Deposition, Attachment 4G-4H and 11B). The Special Inspection Team found that the calculations performed by Mr. Doyle are in error. In determining the stress in the web of the W6 x 12 beam of this support, Mr. Doyle has erroneously used the cube of the web thickness instead of the square of the thickness, resulting in unrealistic stress values. Mr. Doyle's concern about this support is considered resolved.

In chemical volume and control system support No. CS-1-239-007-A42R, Mr. Doyle alleges that the deflection guideline of 1/16 inch is exceeded. The Special Inspection Team determined that the plate thickness in this support was initially specified to be 1 inch. A Component Modification Card (CMC No. 58004) dated June 11, 1982 was issued to revise the plate thickness to 1.5 inches. With the revised thickness, the 1/16-inch maximum deflection guideline and the ASME Section III Subsection NF Code requirements are satisfied. The concerns relative to this support are considered resolved.

During its inspection, the Special Inspection Team noted that there did not appear to be clear guidelines for specifically considering local stresses resulting from bracket loads, nor do they appear to have clear guidelines for considering deflection contributions from localized effects. In discussions with the Special Inspection Team, the Applicant stated that even though there are no explicit guidelines, it is routine practice for the support reviewers of all three pipe support design groups to consider these local effects in the design of pipe supports and in the review of such designs. The Special Inspection Team has examined examples of cases in which local effects have been considered in its inspection of vendor certified supports described in Paragraph 4.

In summary, Mr. Doyle's concerns about excessive deflections in certain supports had in two instances also been identified by the Applicant's design review program. In one case the problem has already been rectified and in the other the problem is to be rectified by redesign. Mr. Doyle's concerns in two other instances have not been substantiated. Thus, the concerns raised by Mr. Doyle are resolved.

The following two additional studies discussed above relating to support stiffness which the Applicant has agreed to provide remain unresolved.

a) A study providing assurance that the Applicant's design criteria and guidelines provide sufficient stiffness to the supports (Unresolved Item Nos. 50-445/8226-6 and 50-446/8214-5).

b) A pipe stress analysis providing assurance that support No. CC-1-107-008-E23R has sufficient stiffness to perform satisfactorily (Unresolved Item No. 50-445/8226-7).

### k. Consideration of Friction Loads

Mr. Walsh expressed a concern regarding the consideration of frictional loads between the pipe steel and supports during thermal expansion. He stated that when considering the coefficient of friction in thermal expansion ITT-Grinnell uses 30% coefficient of friction of the deadload plus thermal load of the pipe, while NPSI uses 45 percent of the deadload plus thermal plus OBE load, and PSE "only considers it (frictional loads) when they want to." (Walsh Supplemental Testimony, p.3, CASE Exhibit 659E).

The Special Inspection Team has reviewed the guidelines used by the three design groups (PSE, ITT-Grinnell and NPSI). The NPSI guidelines specify the following values of the coefficient of friction.

| Coefficient of Friction | Condition |
|---|---|
| 0.33 | For steel contact in each of two directions. |
| 0.45 | For steel contact in any one direction to simplify calculations. |

The frictional force is defined by NPSI as the frictional coefficient multiplied by the deadweight plus thermal plus OBE loads. If the pipe movement, Δp, is larger than the deflection of the structure, Δs, due to the full friction force (P), the full value of the friction force on the support structure is utilized in designing the support. If Δp is less than Δs [due to the full friction force, (P)] a reduced value of the friction force is used on the support structure. This reduced value of the friction force is (Δp/Δs) x P.

ITT-Grinnell guidelines specify the following coefficient of friction:

| Coefficient of Friction | Condition |
|---|---|
| 0.33 | Steel to steel |

ITT-Grinnell defines the frictional force as the frictional coefficient multiplied by the deadload plus thermal expansion loads and this is to be considered only for pipe movements in excess of 1/16 inch. If displacement of the structure under full frictional loads exceeds thermal displacement, the friction force may be derated by the structure's spring rate multiplied by the thermal displacement.

PSE guidelines specify the following coefficient of friction:

| Coefficient of Friction | Condition |
|---|---|
| 0.33 | Steel to steel |

The PSE guidelines state that friction loads shall be calculated for thermal and deadweight loads, and applied in the direction in which the thermal movement of the pipe is unrestrained on rigid frames. For thermal movements of 1/16 inch or less, frictional loading is to be ignored.

All three support design groups provide adequate bracing to maintain rigidity and structural integrity of the supports during a seismic event. Therefore, it is not necessary to consider seismic loads in the determination of frictional loads. On this basis, the Special Inspection Team found the load combinations (deadweight plus thermal) used by ITT-Grinnell and PSE for computing frictional loads to be acceptable. The inclusion of the OBE in these load combinations by NPSI results in a more conservative estimate of the frictional loads and is acceptable.

In addition to a difference in the load combinations used by the three support design groups, there is a difference in the coefficient of friction used by the three support design groups. The Special Inspection Team found the use of a coefficient of friction value of 0.33 for steel to steel contact a commonly used value and its use by PSE and ITT-Grinnell is acceptable for steel to steel contact. As to the difference in friction coefficient, the higher friction value used by NPSI is more conservative and is also acceptable.

The seismic response of the piping system is highly insensitive to variations in frictional loads. Therefore, any differences in the calculated frictional loads arising out of the use of differing friction parameters by the three support design groups will not have a significant effect on the pipe stress analysis.

The Special Inspection Team concludes that the frictional load design parameters utilized by the Applicant are acceptable. Mr. Walsh's concern is resolved.

### l. Consideration of Kick-Loads

Mr. Doyle expressed a concern that the Applicant was not considering "kick-loads" in the design of the plant piping (Doyle Deposition Attachment 11RR).

The Special Inspection Team found that Gibbs & Hill included the directions of supports and hence the "kick-load" force component in the pipe stress problem for the main steam and feedwater lines if the support as-built misalignment was 5 degrees or more. The Special Inspection Team found that acceptable for the main steam and feedwater lines. In subsequent discussions with the Applicant, the Special Inspection Team was informed that a similar procedure was employed for all other Class 2 and 3 piping. This procedure was verified by the Special Inspection Team's review of a stress problem for the boron recycle system. This concern is resolved. Mr. Doyle's concern was found to be incorrect.

### m. Modeling of Wide Flange Members As Infinitely Rigid In Torsion

Mr. Doyle expressed a concern with respect to the ITT-Grinnell modeling of wide flange members using large torsional rigidity values in ITT-Grinnell Procedure No. RP-2, "STRUDL Modeling for Structures Subjected to Web Bending (Doyle Deposition, pp. 180-81, CASE Exhibit 669B). Although Mr. Doyle's concern was with the use of a torsional constant of 10,000 inches$^4$ for wide flange members, he states, "I don't recall what that was used for." The Applicant responded to Mr. Doyle's concern by stating that large torsional rigidity values are intended to maximize the torsional moment which in turn is utilized to perform a conservative evaluation of torsional stresses. (Applicant's Exhibit 142F, "Supplemental Testimony of Kenneth L. Scheppele, Roger F. Reedy, Peter S.Y. Chang, John C. Finneran, Jr., and Gary Krishnan Regarding Doyle Allegations").

The NRC Special Inspection Team reviewed ITT-Grinnell Procedure RP-2. The review determined that the procedure provides guidelines for STRUDL modeling when investigating web bending in wide flange structural members subject to certain well-defined support configurations. The guidelines require that the torsional constant (polar moment of inertia) of the wide flange members in which web bending is to be evaluated be assumed to be 10,000 inches$^4$. Torsional stresses in the members are subsequently calculated from the results of the moment analyses based upon the above assumption. On page 11 of the procedure it states, "In evaluating stresses one must be careful to realize which output values are real and which are fictitious because of the way that properties were assigned."

The basic torsional analysis of a wide flange member initially involves calculation of the torsional moment to be resisted. This moment calculation is determined by multiplying the rigidity of the member with the maximum angle of rotation to be resisted. Torsional shear stresses are subsequently computed by dividing the product of the torsional moment and the member thickness by the polar moment of inertia. Since both calculations are independent of each other, the initial calculation of torsional moment may assume a large value of torsional rigidity and thus result in a corresponding large moment. The subsequent calculation of torsional shear stresses will therefore result in a more conservative result. The Special Inspection Team found that the torsional moments evaluated on the bases of the torsional constant of 10,000 $\text{inches}^4$ are conservative. Subsequent calculations of shearing stresses utilize the correct torsional constant values published by the American Institute of Steel Construction (AISC). The Special Inspection Team considers this design approach to be valid and conservative.

Mr. Doyle's concern that ITT-Grinnell erroneously utilized large torsional rigidity values in the modeling of wide flange members has no technical merit. Large torsional rigidity values were employed by ITT-Grinnell to maximize torsional moments of wide flange members. Use of large torsional moment values in calculating the torsional shear results in conservative stresses. ITT-Grinnell used correct AISC torsional rigidity values in the torsional shear calculations. Mr. Doyle's concern is incorrect. This concern is resolved.

### n. Effect of Cold-Forming On The Ductility of Tube Steel

During Mr. Walsh's cross-examination of the Applicant's rebuttal witnesses, he presented a concern with respect to the effect of cold-forming on the ductility of tube steel (Tr. 5078). The Special Inspection Team has addressed this general concern by performing a literature review and identifying the results of tests conducted to quantify the effects of cold-forming.

Although the cold-forming of structural steels will increase the yield and ultimate strengths of the material, the relative magnitude of the increases are not the same and therefore result in reduction in the spread between the yield and ultimate strengths. This reduction results in a decrease in the elongation capability or ductility. Ductility in a material is a desirable quality which represents its ability to undergo plastic deformation prior to rupture. This ductility reduces the effects of stress concentrations and helps to achieve uniform load distribution by guaranteeing plastic stress redistribution. This plastic deformation mechanism is relied upon in the design process to take into account any detrimental effects resulting from secondary stresses. Ductility therefore provides relief of secondary stresses prior to the material reaching failure strain. The tube steel utilized in the design of pipe supports is designated as American Society for Testing and Materials (ASTM) A500-Grade B steel having a minimum ductility requirement expressed as minimum elongation in a 2-inch length of 23 percent.

The following papers, published in the American Society of Civil Engineer's Journal of the Structural Division, dealing with the effects of cold-forming on steel were reviewed as part of this inspection:

1. "Structural Behavior of Thick Cold-Formed Steel Members," by W. W. Yu, V. A. S. Liu and W. M. McKinney, November, 1974.

2. "Suggested Steel Ductility Requirements," by A. K. Dhalla and G. Winter, February, 1974.
3. "Steel Ductility Measurements," by A. K. Dhalla, and G. Winter, February, 1974.
4. "Corner Properties of Cold-Formed Steel Shapes," by K. W. Karren, February, 1967.
5. "Effects of Cold-Straining On Structural Sheet Steels," by A. Chajes, S. J. Britvec, and G. Winter, April 1963.
6. "Effects of Cold-Forming On Light-Gage Steel Members," by K. W. Karren, and G. Winter, February 1967.

Dhalla and Winter have demonstrated that even if the ductility in a material is reduced to 3 percent, this value still would result in an acceptable level of ductility for structural performance. In their paper (Reference 2), Dhalla and Winter stated, "An analytical study of perforated and notched plates in tension indicated that a uniform elongation greater than or equal to 3 percent appears necessary to plastify the critical cross section of members with such stress concentrations and to achieve full net section strength."

Karren (Reference 4) has determined that the percentage elongation in 2 inches for corner specimens representative of cold-formed A 500 Grade B steel varies from 6 to 19 percent, depending on the ratio of the corner radius to thickness. Karren concludes that even though the corners of cold-formed structural shapes will see a loss of ductility, the structural shape will remain functional. He states, "The reduction in percentage elongation as compared to that of the virgin material varies from 20 percent to as much as 90 percent, but permanent elongation even for the sharpest corners tested was in the range of 5 to 10 percent, indicating considerable remaining ductility."

Other ASME approved materials such as A513-77 - Grade 1015CW, have minimum elongations of less than 12 percent and are acceptable NF materials for pipe supports. This fact also indicates that the reduction of ductility in the corners of A500 - Grade B material, although less than the specified 23 percent, does not necessarily render the tube steel shape nonductile.

Mr. Walsh's concern that cold forming of A500-Grade B tube steel adversely affects its ductility has not been substantiated. A500-Grade B cold-formed tube steel is sufficiently ductile to perform its design intent. The concern is resolved.

o. Operating Condition Loads Appear To Be In Error

Mr. Doyle stated a concern that emergency operating condition loads were smaller than normal and upset operating condition loads on pipe supports. Support No. CS-1-235-067-C41K (Doyle Attachment 8T-8U) was identified on p. 130 of the Doyle Deposition in this regard. The drawing for that support indicates that the emergency operating condition load is 1030 lbs. and the normal and upset operating condition load is 1070 lbs. In general, normal and upset operating condition loads are usually smaller than emergency operating condition loads, which in turn are usually smaller than faulted operating condition loads. Thus, the Special Inspection Team interpreted Mr. Doyle's concern to relate to suspected computational errors in the Applicant's analysis.

Examination of the drawings for support No. CS-1-235-067-C41K show that: (1) the support is a seismic east-west restraint utilizing a mechanical snubber, and (2) the faulted operating condition load of 1040 lbs. is smaller than the normal and upset operating condition load of 1070 lbs. The Special Inspection Team reviewed the Westinghouse seismic piping analyses using codes ADAYAPQ and ADAYAPS for Stress Problem 1-41, which includes support No. CS-1-235-067-C41K. This review verified these support load values were correctly calculated and that both the emergency and faulted operating conditions loads were smaller than the normal and upset operating condition load.

The Special Inspection Team also found that the seismic analysis inputs for the upset operating condition were the Operating Basis Earthquake (OBE) response spectra, and the corresponding inputs for both the emergency and faulted operating condition were the Safe Shutdown Earthquake (SSE) response spectra. Comparison of both of these spectra show that: (1) for some periods, accelerations for the OBE horizontal spectra are greater than the corresponding SSE accelerations; and (2) for all periods, the SSE accelerations are less than twice the corresponding OBE accelerations. The Special Inspection Team concluded that these response spectra characteristics, together with the fact that the SSE damping value of 4 percent is twice the OBE damping value of 2 percent, lead to the condition expressed in Mr. Doyle's concern. This condition is not unexpected when seismic analyses are performed where actual response spectra and differing damping values for the OBE and SSE are used as analyses inputs.

Mr. Doyle's concern that the emergency condition loads are smaller than normal and upset loads, in particular on support No. CS-1-235-067-C41K, is without a valid technical basis. The Applicant correctly used the OBE and SSE response spectra and damping values in the seismic analysis, and the loadings for support No. CS-1-235-067-C41K are correct as shown on the drawings. The fact that the emergency and/or faulted operating condition loads are smaller than the normal and upset operating condition load is not indicative of an error in the analysis. This concern is resolved.

p. Welded Stepped Connections, Fillet Welds and Skewed Welds

Mr. Doyle raised concerns about welded stepped connections, undersized fillet welds and the use of skewed T-joint welds (Doyle Deposition, Tr. 3742-3749). Mr. Doyle referenced the requirements of the American Institute of Steel Construction (AISC) and the American Welding Society (AWS). Doyle Deposition Attachments 6B through 6F provided specific references to requirements for circular tubular joints, minimum fillet weld sizes, and multiplying factors for skewed T-joint fillet welds. Deposition Attachment 6A identified supports Nos. CC-1-045-026-A33R, SI-1-031-704-A32R and MS-1-029-039-S63R as examples where welds are undersized by 1/16 inch. The Attachment also identified support No. AF-1-008-003-S33R as being in violation of AWS Code requirements for the diameter ratio of circular branch and main members.

Welded Stepped Connections

Welded stepped connections are perpendicular joints between pipes or tubes of different sizes. With respect to support No. AF-1-008-003-S33R, the referenced AWS requirements for stepped pipe-to-pipe geometric parameters do not apply since there are no pipe-to-pipe welds at this support. Nevertheless, the Special Inspection Team reviewed the PSE design guidelines being utilized for the design of integral stanchions on pipes. Mr. Doyle's AWS reference applies to the design of architectural tubular structures which are not intended to serve as pressure piping. The design of integral attachments on pressure piping is governed by the ASME Code, not the AWS or AISC code. Design guidelines being implemented for pipe to pipe attachments allow fillet welds to be used when the ratio of the diameter of the stanchion over the diameter of the pressure boundary pipe is less than or equal to 1/3. A combination bevel and fillet partial penetration weld is specified when the ratio is greater than 1/3 but less than or equal to 2/3. Ratios greater than 2/3 are treated as special cases requiring analysis of actual effective weld throats. Additionally, local effects due to integral attachments are analyzed during Gibbs & Hill's pipe stress analysis to verify that localized pipe wall stresses do not exceed ASME Code allowables. This analysis is performed utilizing the CYLNOZ 2 computer code. Representative examples were reviewed by the Special Inspection Team during the inspection at Gibbs & Hill. The Special Inspection Team found that the Gibbs & Hill stress analysis techniques are acceptable (See Paragraph 3.i).

Although Mr. Doyle's exhibit (Doyle Deposition Attachment 6B) only related to circular tubular joints, the Special Inspection Team considered the adequacy of the design of perpendicular tube-to-tube welded connections by reviewing the results of analytical evaluations of such connections. The following paper, published in the American Society of Civil Engineer's Journal of the Structural Division, was reviewed as part of this inspection:

> "Finite Element Analysis of RHS [Rectangular Hollow Section] T-Joints," by R. A. Korol and F. A. Mirza, September 1982.

This paper presents the results of RHS T-Joint modeling performed to determine ultimate and working strengths and to determine the sensitivity of joints to different geometric parameters. Punching shear and rotational stiffness results were also analyzed in this reference. The model utilized in this reference takes into account strain hardening and the rounded corners inherent in tube steels. Korol and Mirza found with respect to ultimate strength, that joints having member width ratios of about 0.4 and less are weak in resisting branch moments and punching shear without reinforcing. Supports at Comanche Peak do not fall into this category since the lowest width ratio utilized is 0.67. For joints with member width ratios greater than 0.6, Korol and Mirza found that RHS T-joint connections are much stronger. The authors also found that ultimate axial loads and moments were typically five times higher than the corresponding yield load and moment. Since the designs for RHS T-Joint designs reviewed at CPSES are similar to designs shown by Korol and Mirza to be in conformance with sound engineering practice, the Special Inspection Team found that the tube-to-tube joint designs utilized by the Applicant represent connections which will perform the design intent, and their use is acceptable.

## Fillet Welds

The drawings of the three supports with alleged undersized welds were evaluated by the Special Inspection Team to determine if an undersized weld condition was specified. The Special Inspection Team determined that support No. CC-1-045-026-A33R is a support number which has never been issued and there is no other indication that such a support ever existed. Design drawings of the two other supports (support Nos. SI-1-031-704-A32R and MS-1-029-039-S63R) were evaluated with respect to minimum fillet weld requirements of Appendix XVII of the ASME Code. All the reviewed welds were found to be in accordance with Code requirements.

Prior to the concerns of Messrs. Walsh and Doyle, representatives of the NRC Region IV Engineering Section and the Vendor Programs Branch conducted an inspection at Nuclear Power Services, Inc., (NPSI) on November 17-20, 1981, (Inspection No. 99900531/81-01). During that inspection, 15 support drawings for the CPSES which specified fillet welds that were not in accordance with ASME Appendix XVII requirements were identified by the NRC. As a result of this findings, NPSI performed an internal design audit to define the extent of nonconforming fillet welds. The internal review identified 382 supports which did not meet the requirements of the ASME Code for minimum fillet weld size. Component Modification Cards (CMC's) were subsequently issued to modify all welds not meeting code requirements. As part of the current inspection, an independent review was performed by the Special Inspection Team of a representative sample of the documentation which defines and resolves the undersized welds identified during the inspection at NPSI. This review indicates that the affected supports are nc in compliance with the ASME Code. In addition, during the Special Inspection Team's independent design review of the one-hundred supports referenced in Paragraph 4 of this report, all specified welds were evaluated for adequate size and no discrepancies were identified.

Skewed Welds

Procedures utilized by the three pipe support design groups for the design of fillet welds at skewed joints (skewed welds) were reviewed by the Special Inspection Team during this inspection. Skewed welds are those welds joining two structural members that are other than in the same plane and are not perpendicular to each other. A typical example is two members joined at an angle of 45 degrees with a weld at the joint toe of 135 degrees and another at the heel of 45 degrees. Weld angles between 60 and 135 degrees are being analyzed by the Applicant by determining the effective throat of the weld. (The effective throat of a weld is the minimum distance from the root of a weld to its face). Weld angles of less than 60 degrees but greater than 45 degrees are considered to be groove welds, not fillet welds, and are thus considered to be a form of penetration weld. Groove welds are allowed by the ASME Code. This weld type is also allowed by the AWS Code, which Mr. Doyle erroneously identified as the controlling code (Doyle Desposition Attachment 6). The Special Inspection Team concluded that the design procedures being utilized by the three pipe support design groups for skewed joints are based on sound engineering practice.

An additional related matter not raised by Mr. Doyle was earlier identified with respect to the adequacy of the Applicant's quality control inspection criteria for skewed welds (NRC Inspection Report No. 50-445/82-14, Unresolved Item No. 8214-02). In response to this item, the Applicant has begun a reinspection program of skewed welds in supports utilizing newly developed inspection criteria. This program, when completed, will provide information on whether skewed welds have been constructed to the required sizes. This item is still under review by the NRC Region IV staff.

Summary

Mr. Doyle's concerns about welded stepped connections in circular tubular joints, undersized fillet welds, and skewed T-joint welds have not been substantiated. The concern is resolved.

## q. Section Property Values Utilized by PSE

Mr. Walsh raised a concern about the use of two different member properties for tube steel sections (Walsh Testimony, p. 5, CASE Exhibit 659). Mr. Walsh stated that because of the variation in the properties, "reactions and deflections could be off by a much as 25 percent" (Walsh Testimony, p. 5).

Prior to January 1982, Pipe Support Engineering (PSE) used the member property values of the 7th Edition of the American Institute of Steel Construction (AISC). From January 1981 to January 1982, PSE also used the values listed in the Welded Steel Tube Institute's Manual of Cold Form Welded Structural Steel Tubing (1974). Subsequent to January 1982, PSE used the values listed in the 8th Edition of the AISC Manual. Calculations of stiffness and stress were performed by the Special Inspection Team on a cantilever beam to assess the true generic impact of the section variations. The maximum relative difference in stiffness in a 6 X 6 section of tube steel due to the use of differing tube steel member properties was found to be 4.6 percent. For a 4 X 4 section the relative difference was 7.5 percent. The relative differences in stress were found to be 4.2 percent for the 6 X 6 tube steel section, and 7.1 percent for the 4 X 4 size. These values are based on the maximum difference between the 8th Edition of the AISC Manual, and the two previously used member property tables.

Since all large bore and Class 1 small bore pipe support designs are being re-examined by the Applicant using the member property values in the 8th Edition of the AISC manual, only small bore Class 2 and 3 supports are affected by the variations. As discussed above, the actual variations in stiffness and stresses are all less than 8 percent. Accordingly, the Special Inspection Team found that any impact on the affected supports resulting from the section property variations are minor and will not result in unanticipated behavior of the support due to gross errors in stiffness. Since the actual variations in the stress levels will not exceed 8 percent, it is not expected that unforeseen detrimental stresses will occur.

The Special Inspection Team concluded that Mr. Walsh's concern about different tube steel section property values utilized by the PSE pipe support design group is resolved. The Applicant is currently reanalyzing all large bore and Class 1 small bore pipe support designs using consistent member property values. The differences in section property values for small bore Class 2 and 3 supports are less than 8 percent, and will not result in unanticipated support behavior. This concern is resolved.

r. Support Pads Welded Over Pipe Girth Welds

Mr. Doyle expressed a concern about the welding of support pads over pipe girth welds (Doyle Deposition, p. 82). Two pipe supports are specifically identified, Nos. CT-1-137-701 and CT-1-137-702. Mr. Doyle stated that both supports are ASME Code Class 2 supports for the Component Cooling System. He further stated that ASME Code Section XI will be violated in that inservice inspection will become impossible to perform on the covered girth welds. Page 5 of Deposition Attachment No. 2 is sketch of a detail on the supports which are identified as support Nos. CT-1-137-701-S22R and CT-1-137-702-S22R. The support numbers designate these two supports as Class 2 supports. The sketch appears to be a rough representation of a proposed support orientation and does not contain a drawing number.

Upon review of the controlled Brown & Root support drawings and associated Component Modification Cards, the Special Inspection Team determined that the supports identified by Mr. Doyle are actually Class 5 supports for the Containment Spray System. The correct support numbers are CT-1-137-701-S25R and CT-1-137-702-S25R. The Special Inspection Team concluded that these supports are correctly designated Class 5, because they support that portion of the Containment Spray System which forms the by-pass test loop and are not related to the functional safety-related portion, which is Class 2. The Special Inspection Team notes that Class 5 pipe welds are not included in the ASME Section XI inspection program.

Additionally, the Special Inspection Team determined that both supports employ removable clamps and do not have any parts permanently covering a pipe girth weld. The existing designs for these two supports do not preclude the inspection of the girth welds.

Mr. Doyle's concern that pipe support pads on Class 2 pipe supports were welded over pipe girth welds is not correct. The supports identified by Mr. Doyle are Class 5, not Class 2 supports and therefore are not included in the ASME Section XI Inspection program. Second, the supports employ removable clamps which do not preclude inspection of the girth welds. This concern is resolved.

s. Damage to Pipe Support During Hydrostatic Testing

Mr. Doyle alleged that pipe support No. CC-1-116-038-F43R (Doyle Deposition Exhibit 11WW-11XX) failed during hydrostatic pressure testing of the component cooling water system by excessive local yielding of the support tube steel wall (Doyle Deposition, pp. 72-73, 181-182).

The Applicant stated that the deformation due to local yielding in this support: (1) had occurred during installation and adjustment of the piping system, and (2) had been identified by a design review engineer during a field walk-down prior to the hydrostatic pressure testing; i.e., long before Mr. Doyle made his allegation. The Applicant further stated that the support is being modified to accommodate increased piping loads resulting from an as-built piping analysis (Applicant's Supplemental Testimony, p. 6, Applicant Exhibit 142F).

The Special Inspection Team reviewed the Applicant's QA Nonconformance Report (NCR) No. M-2531 against support No. CC-1-116-038-F43R, dated October 9, 1980, which indicated that the adjustable eye rod of the support sway strut was bent approximately 15 degree in the threaded portion. Bending was attributed to "movement of the pipe without disconnecting the sway strut" (NCR No. M-2531). Although NCR M-2531 makes no mention of damage to the 1/4 inch x8 inch x8 inch structural tubing to which the 1 inch x 2 inch clevis of the support sway strut is welded, it is reasonable to expect that the structural tubing was damaged at the time of issuance of the NCR in view of the severity of damage to the eye rod. The NCR disposition required only that the bent eye rod be scrapped. Replacement of the bent eye rod was documented in the NCR follow-up inspection report dated November 26, 1980. The Applicant's hydrostatic pressure test Data Sheet No. 1CC-014-1101 and Flow Diagram No. MI-0230, R-6 show that the hydrostatic pressure test was started on May 13, 1982, and completed on May 14, 1982. Since no other NCR's were issued on this support between November 26, 1980, and May 13, 1982, it can be assumed that the damaged tube steel was still in place during hydrostatic pressure testing. Additionally, the results of the Gibbs & Hill analysis for stress problem 1-64F show that the 158 lb. load incurred during hydrostatic testing was much smaller than the 4897 lb. design load for normal and upset operating conditions. Since the hydrostatic load is only a small percentage of the design load, the Special Inspection Team concluded that the support could not have been damaged during hydrostatic testing. In subsequent discussions, the Applicant showed the Special Inspection Team a copy of Component Modification Card (CMC) 81948, Revision 3, dated October 28, 1982. This CMC showed that the original tube steel alleged to be damaged was to be replaced with a new piece of 3/8 inch x 6 inch x 8 inch structural tubing. The NRC Staff verified that the damaged tube steel was replaced.

Mr. Doyle's allegation regarding the cause of the damage to support No. CC-1-116-038-F43R was incorrect. The support was damaged before the hydrostatic test. The damaged tube steel was replaced. The concern is resolved.

## 4. Inspection of Vendor Certified Supports

In its testimony regarding the concerns raised by Messrs. Walsh and Doyle, the Applicant stated that Messrs. Walsh and Doyle did not see final approved designs because of their position within the organization, and that the examples provided by Mr. Doyle were not final approved (vendor-certified) designs, but were interim designs in the pipe support design evolution process. The Special Inspection Team reviewed the design status of each of the pipe supports identified by Messrs. Walsh and Doyle and found that only one had been vendor-certified (Support No. CC-1-107-008-E23R).

The Applicant also presented testimony that the final design review procedures and practices would have detected and eliminated any of the significant shortcomings identified by Messrs. Walsh and Doyle, had all steps in the design evaluation of the pipe supports taken place. In order to determine the validity of the Applicant's statements, the Special Inspection Team evaluated the implementation of the design review process by reviewing a sample of the pipe support designs which had completed the design evaluation process; i.e., the pipe support design drawing had been marked "vendor-certified."

Therefore, in order to assess the overall design process, the Special Inspection Team performed an inspection of 100 pipe supports which have been vendor certified. (Such certification indicates that the pipe support design organization has reviewed the support and certified that it is capable of resisting the design loads as determined from the Gibbs & Hill pipe stress analysis.) As of the date (December 1 and 2, 1982) of this inspection, 1,264 supports have been vendor-certified. Of this total number, 1,161 (92 percent) were ITT-Grinnell designs and 103 (8 percent) were NPSI designs. No PSE designs had been vendor certified as of the date of this inspection. Utilizing Military Standard 105D-63, "Sampling Procedures and Tables for Inspection By Attributes," as a basis for determining an appropriate sample size, 80 ITT-Grinnell supports and 20 NPSI supports were randomly selected from the 1,264 vendor-certified supports for independent design verification. Each support was reviewed for adequacy of design with respect to the following attributes: stability; compliance with the Gibbs & Hill 1/32-inch temperature/clearance recommendation for box frames; fillet and angular weld sizes; floor-to-ceiling and wall-to-wall constraints; Richmond anchor offset from centerline; inversion of design load condition magnitudes, potential for unaccounted torsional loads; local stress effects; cinching of U-bolts on non-rigid supports; use of U-bolts as two-way restraints; out-of-plane bracing for seismic loads; static and dynamic effect of support mass on pipe; kick load potential; out-of-plane friction loads; and satisfaction of the Applicant's 1/16 inch deflection guideline. The vendor certified supports which were selected by the Special Inspection Team for independent design verification are listed below:

ITT-Grinnell Supports

| Support No. | Revision | Support No. | Revision |
|---|---|---|---|
| AF-1-001-032-Y33R | 3 | AF-1-003-004-S33R | 5 |
| AF-1-009-019-S33K | 3 | AF-1-027-005-S33K | 4 |

| | | | |
|---|---|---|---|
| AF-1-035-007-Y33R | 3 | AF-1-036-010-S33R | 4 |
| AF-1-062-002-S33R | 2 | AF-1-097-027-S33R | 3 |
| AF-1-100-019-S33R | 5 | BR-1-016-003-S53R | 2 |
| BR-X-106-056-S43R | 2 | CC-1-007-021-A43R | 3 |
| CC-1-009-003-A33R | 6 | CC-1-011-018-A43K | 4 |
| CC-1-030-007-S33K | 3 | CC-1-033-003-S33R | 6 |
| CC-1-110-004-A43R | 4 | CC-1-126-012-F33R | 4 |
| CC-1-132-005-S43R | 2 | CC-1-148-003-S43R | 3 |
| CC-1-155-004-S43R | 2 | CC-1-156-015-A73R | 3 |
| CC-1-167-004-S43R | 2 | CC-1-196-002-S52R | 2 |
| CC-1-203-003-S52R | 2 | CC-1-250-002-S52R | 4 |
| CC-1-250-005-S52R | 1 | CC-2-011-004-A73R | 4 |
| CC-X-006-003-A43R | 3 | CC-X-021-002-A43R | 3 |
| CC-X-031-002-A43R | 4 | CC-X-038-006-F43R | 2 |
| CC-X-041-006-F43R | 5 | CS-1-014-016-S52R | 5 |
| CS-1-063-013-S22R | 4 | CS-1-074-042-S42R | 2 |
| CS-1-155-026-S42R | 4 | CS-1-158-008-S42R | 4 |
| CS-1-158-040-S42R | 3 | CS-1-217-002-A42K | 2 |
| CS-1-454-010-S52R | 3 | CS-1-911-007-S52K | 4 |
| DD-1-012-018-Y33R | 5 | DD-1-012-043-Y33R | 2 |
| FW-1-103-002-S62R | 2 | FW-1-103-005-S62R | 2 |
| FW-1-104-011-S62R | 3 | FW-1-114-004-S62R | 2 |
| MS-1-025-007-S72K | 2 | MS-1-027-019-S43R | 5 |
| MS-1-027-039-S33R | 5 | MS-1-028-006-S63R | 5 |
| MS-1-028-046-S53R | 2 | MS-1-073-002-S52R | 4 |

| | | | |
|---|---|---|---|
| MS-1-075-003-S52K | 5 | MS-1-416-004-S33R | 2 |
| RH-1-013-008-S32K | 3 | RH-1-014-010-S32K | 5 |
| RH-1-025-004-S22R | 2 | RH-1-064-008-S22K | 3 |
| SI-1-031-020-Y32R | 4 | SI-1-031-038-Y32R | 3 |
| SI-1-031-064-S32R | 3 | SI-1-038-009-S22K | 4 |
| SI-1-039-027-S32R | 4 | SI-1-039-036-S42R | 3 |
| SI-1-052-003-S42R | 2 | SI-1-093-006-S32R | 4 |
| SW-1-007-010-J03R | 3 | SW-1-027-003-J03R | 4 |
| SW-1-102-080-S43R | 2 | SW-1-129-067-S43R | 2 |
| SW-1-132-042-A43R | 2 | SW-1-132-068-S43R | 4 |
| SW-1-173-049-S43K | 3 | SW-2-004-008-A33R | 2 |
| SW-2-102-006-A33R | 5 | SW-2-132-013-A43R | 3 |
| SW-X-007-001-J03R | 3 | SW-X-007-002-J03R | 4 |

## NPSI Supports

| Support No. | Revision | Support No. | Revision |
|---|---|---|---|
| CC-1-197-013-C42R | 3 | CC-1-197-038-C42R | 2 |
| CC-1-199-002-S52R | 4 | CC-1-208-002-C53R | 3 |
| CC-1-208-006-C53R | 3 | CC-1-208-008-C53R | 2 |
| CC-1-212-007-C53S | 2 | CC-1-215-032-C53R | 2 |
| CC-1-256-006-S53S | 3 | CC-1-264-003-C53R | 2 |
| CC-1-272-006-C53R | 1 | CS-1-012-003-C42R | 2 |
| CS-1-012-005-C42K | 3 | CS-1-077-013-C42R | 4 |

| | | | |
|---|---|---|---|
| CT-1-039-431-C42R | 2 | CT-1-051-416-C72R | 2 |
| FW-1-098-008-C62S | 2 | FW-1-099-006-C62K | 3 |
| MS-1-151-005-C52R | 2 | MS-1-151-012-C52R | 3 |

As a result of this independent design review, the Special Inspection Team has determined that all supports reviewed in the random sample satisfy the Applicant's applicable design criteria for the attributes reviewed. The review did not disclose any discrepancies in the random sample which would indicate a failure of the Applicant's design verification program to identify and correct supports to assure compliance with applicable design criteria.

5. Exit Interview

An exit interview was conducted on February 8, 1983, with the Applicant onsite. Each of the unresolved and open items were discussed.

The following NRC personnel were present:

J. T. Collins
G. L. Madsen
S. B. Burwell
T. F. Westerman
D. L. Kelley
S. McCrory