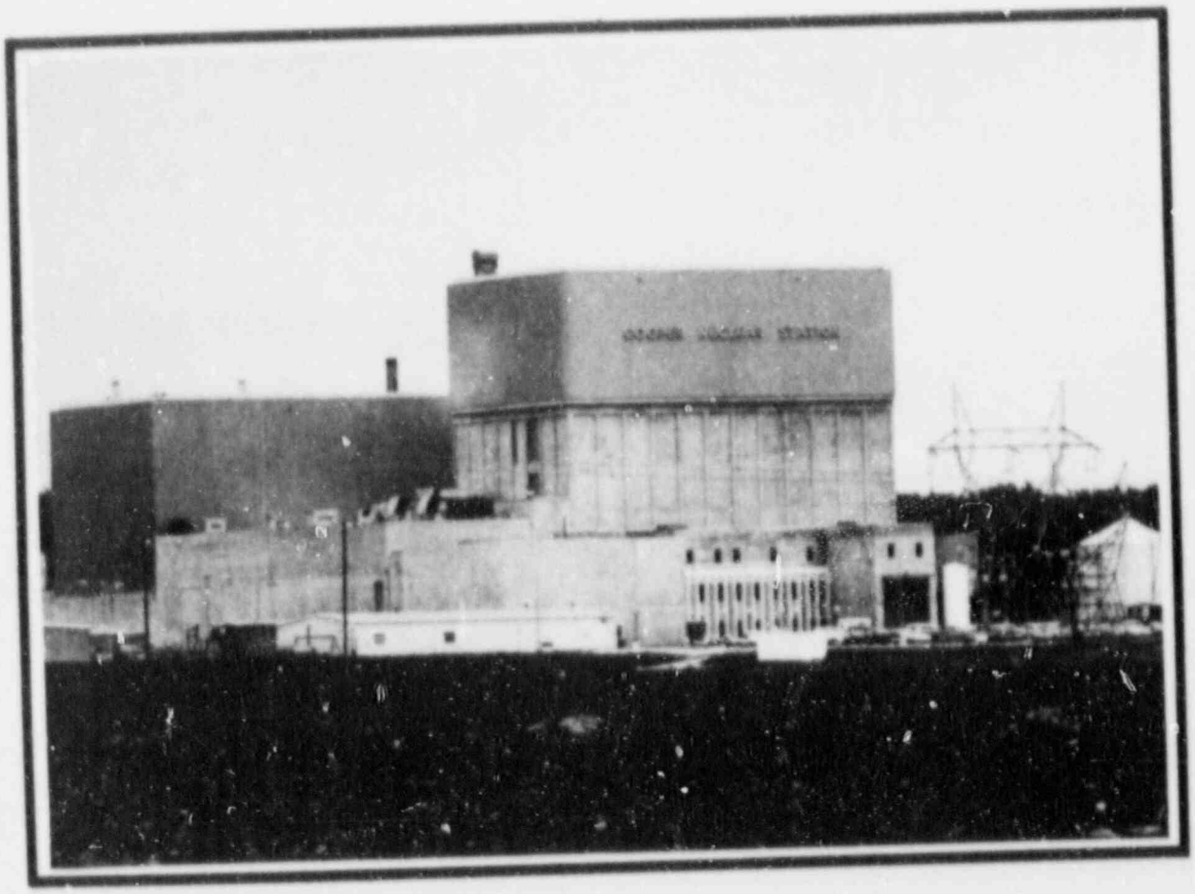
LONG TERM PLAN FOR CODE QUALIFICATION OF SEISMIC CLASS 1S PIPE SUPPORTS COOPER NUCLEAR STATION



Nebraska Public Power District

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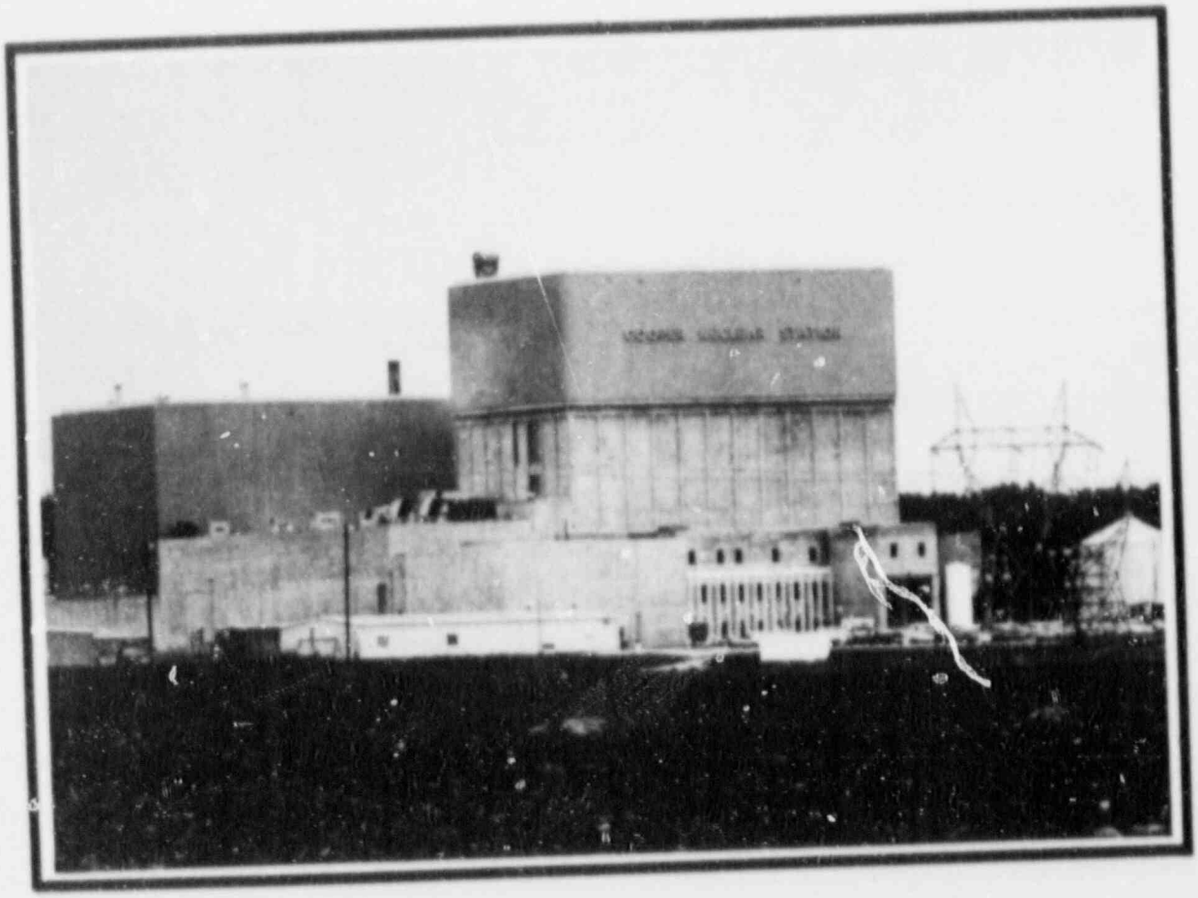

Nebraska Public Power District

NEBRASKA PUBLIC POWER DISTRICT

LONG TERM PLAN
FOR
CODE QUALIFICATION OF SEISMIC CLASS 1S PIPE SUPPORTS

COOPER NUCLEAR STATION

AUGUST 12, 1988

Revision 0

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EXECUTIVE SUMMARY

In preparation for the 1988 refueling outage, detailed design and analysis for a proposed modification to the High Pressure Coolant Injection (HPCI) discharge piping indicated that an affected pipe support was underdesigned, relative to design basis code allowables for operational and seismic loads. As part of the corrective action for this nonconformance, additional pipe supports on the HPCI discharge piping system were reviewed and determined not to meet code. As a result, the District took the following actions:

- Modified the affected HPCI discharge piping system supports to obtain full code qualification,
- Performed an operability evaluation of the as-found HPCI discharge piping system; and
- Reviewed other essential piping systems to ascertain whether the HPCI nonconforming supports were an isolated occurrence.

From a detailed evaluation of the HPCI discharge system, it was concluded that the piping system was operable in accordance with the requirements of CNS Technical Specifications in the as-found condition (Reference 6.1). It was also determined that while the HPCI system nonconforming supports were not an isolated case, they were the bounding case. In addition, all other essential, Seismic Class 1S systems were found to be operable in accordance with an operability criteria similar to that used for the HPCI system (Reference 6.2). Further operational assurance was provided by analyzing all piping Class 1N supports which make up the primary system boundary from the reactor out to the primary containment isolation valves. All piping Class 1N supports met code requirements or were modified to do so before start-up from the 1988 refueling outage.

The District has reviewed the existing condition of the Cooper Nuclear Station and, based upon the above, concluded that interim operation of the unit would not jeopardize the health and safety of the public while performing expedited efforts to achieve full code qualification for all essential piping supports. The District has committed to have all nonconforming supports modified to meet the CNS design basis prior to startup from the 1989 refueling outage. This document presents the plan for accomplishing these objectives and determining the root cause analysis of the initiating concern.

1.0 INTRODUCTION

In preparation for the 1988 refueling outage, detailed design and analysis (to the CNS Code of Record, USAS B31.1.0-67) for a proposed modification to the High Pressure Coolant Injection (HPCI) discharge piping indicated that an affected pipe support was underdesigned, relative to design basis code allowables for operational and seismic loads. As part of the corrective action for this nonconformance, additional pipe supports on the HPCI discharge piping system were reviewed and determined not to meet code. As a result, the District took the following actions:

- Modified the affected HPCI discharge piping system supports to obtain full code qualification,
- Performed an operability evaluation of the as-found HPCI discharge piping system; and
- Reviewed other essential piping systems to ascertain whether the HPCI nonconforming supports were an isolated occurrence.

From a detailed evaluation of the HPCI discharge system, it was concluded that the piping system was operable in accordance with the requirements of CNS Technical Specifications in the as-found condition (Reference 6.1).

An initial evaluation of other essential (safety-related), Seismic Class 1S systems revealed that other apparently nonconforming supports existed. Additionally, as the scope of this effort became clear, and reflecting the importance of reactor coolant pressure boundary piping (Class 1N-1S) to safety, the District directed that immediate efforts commence to ensure full code qualification of all supports associated with reactor coolant pressure boundary piping prior to startup from the 1988 refueling outage. This task was completed.

Operability of existing essential, Seismic Class 1S supports was evaluated with regards to system operational characteristics and individual support attributes. As a result of this evaluation, all existing essential supports at CNS were found to be enveloped by the HPCI operability review, except those with unique attributes, specifically deadweight supports and welded attachments used in anchor designs. One hundred percent of deadweight supports and welded pipe support anchors were then reviewed. During this review, it was revealed that certain deadweight supports could experience uplift during design basis seismic events using a conservative interpretation of the loads provided on the support detail drawings. It was also discovered that certain welded attachments were overstressed. Accordingly, the District has reviewed all deadweight supports and modified the seventeen which experience uplift to accommodate the uplift forces. Also, all welded pipe anchors have been evaluated. The four anchors that could not be shown to be in code compliance were modified prior to startup. Additional details supporting the conclusion that all existing essential piping systems are operable is provided in Reference 6.2.

In summary, the existing condition of all essential piping systems at CNS is as follows:

- All large bore pipe supports associated with the isolable reactor coolant pressure boundary are fully code qualified.
- All piping supports associated with the HPCI discharge line are fully code qualified.
- All deadweight supports (17) experiencing uplift during design basis seismic events have been modified to accommodate such loads.
- All welded pipe anchors (4) that were overstressed have been modified.
- All remaining large bore, essential, Seismic Class 1S pipe supports have been shown to remain functional, although they may exceed code limits.

The District has reviewed the existing condition of the Cooper Nuclear Station and, based upon the above, concluded that interim operation of the unit would not jeopardize the health and safety of the public while performing expedited efforts to achieve full code qualification for all large bore, essential Seismic Class 1S piping supports. The District has committed to have all nonconforming supports modified to meet the CNS design basis prior to startup from the 1989 refueling outage. This document presents the plan for accomplishing these objectives and the root cause analysis of the initiating concern.

2.0 ROOT CAUSE ANALYSIS

A root cause evaluation is currently on-going in an attempt to determine the full extent of the problem as it may affect the qualification of essential, Seismic Class 1S piping supports. To date it appears that the nonconforming supports are associated with the standard industry practices utilized during the original design and construction of CNS. Subsequent design and analytical efforts, such as recirculation pipe replacement and torus attached piping modifications, were more rigorously performed and documented thus precluding similar non-conforming supports. In order to ensure that all necessary pipe support populations are included in the long term re-evaluation program, any supports not rigorously reanalyzed as part of the recent programs will be reviewed. Class 1N supports and HPCI pump discharge, however, will be excluded since they were Code qualified as part of the 1988 refueling outage restart effort.

In addition, pipe supports on small bore piping (<2 1/2" diameter) systems will not be reviewed because:

- At the time of original construction, small bore piping at CNS was not computer analyzed for pipe support design load generation. Rather, piping and supports were field routed using span charting procedures and engineering judgement.
- Pipe supports utilized were generally one of a number of typical configurations and not independently designed for each situation or

load case. As a result, these standard supports were typically designed with large margins.

- Different contractors were used during the original construction of Cooper Nuclear Station for the design of small and large bore pipe supports.

- In general, the industry has not reviewed small bore piping installations. I.E. Bulletin 79-14 (Reference 6.4) included only piping of 2 1/2" and larger diameter and any other Seismic Class 1S piping dynamically analyzed by computer.

It should be noted that even with the above on-going efforts, the District feels that the determination of the actual root cause will not be possible without having the original pipe support calculations to review. Present indications are that the original pipe support designers shredded the calculations about five years after CNS construction completion. However, all possible avenues are being investigated to the fullest extent possible.

3.0 SYSTEM PRIORITY AND SCHEDULE

As stated in Section 1.0 above, the District is implementing a program to ensure code qualification of all large bore pipe supports on essential, Seismic Class 1S piping systems. Work will be prioritized to ensure that the supports on the piping systems which are most critical to plant safety are reviewed and, if needed, upgraded first. The system priority schedule and estimated milestone dates are included as Attachment B.

In order to prioritize the pipe support code qualification work, each of the Seismic Class IS systems was reviewed against Chapter XIV, "Station Safety Analysis," and Appendix G, "Nuclear Safety Operational Analysis (NSOA)," of the Updated Safety Analysis Report (USAR) (Reference 6.3). Each system was prioritized in accordance with the importance of the safety function performed in preventing or mitigating the consequences of the transients and accidents analyzed in Chapter XIV and Appendix G. Once the hierarchy of systems was defined, those systems that perform redundant safety functions were identified. The primary and backup were further identified for redundant systems. The schedule was developed to ensure that one train of the most critical systems is reviewed and upgraded first, followed by one train of the redundant system(s). The lowest priority are those Seismic Class 1S systems which have an ancillary role in accident prevention and mitigation, followed by the remaining trains of the system where one train was already completed.

The first group of systems listed on the schedule of Attachment B is: 1) one train of Service Water (SW), 2) one train Residual Heat Removal (RHR), 3) the entire Reactor Building Closed Cooling Water (RBCCW) system, and 4) the remainder of the High Pressure Coolant Injection (HPCI) System. These are the most important systems for ensuring the availability of cooling water to the Emergency Core Cooling Systems and other essential reactor support equipment. These systems, in turn will provide water for the shutdown cooling of the reactor core, and thus, protection of the fuel and process barrier integrity. Also, the Automatic Depressurization System (ADS) will be available. The ADS

system will allow pressure control, while HPCI and RHR (LPCI Mode) can be used to inject water to the core under high and low pressure conditions. Also, torus temperature and decay heat can be controlled by the Suppression Pool Cooling and Decay Heat Removal modes of RHR. The SW and RBCCW systems ensure cooling water to the critical pumps and heat exchangers required for core cooling. With these systems upgraded, the most critical systems will be completed.

The second group of systems to be upgraded includes one train of Core Spray (CS) and the entire Reactor Core Isolation Cooling (RCIC) system. These are redundant to the systems in the first group of Emergency Core Cooling Systems and provide additional trains of low and high pressure injection capability.

The third group of systems include: 1) Diesel Starting Air (STA), 2) Control Rod Drive (CRD), 3) Process Vents (PV), and 4) Standby Liquid Control (SLC). These are systems that are not required for emergency core cooling. The control rod drives will insert the control rods, without the CRD pumps or accumulators, by opening the vent valves and using reactor pressure. SLC is a backup to CRD. These are important systems, but the scram function can be accomplished without taking credit for portions of these systems outside the piping Class 1N boundary. The Diesel Starting Air piping is also important, particularly in the loss of off site power and station blackout events. However, DC power is available as a backup, and the time on the schedule between the most critical systems and diesel starting air is estimated to be one month. Thus, it is believed that this system is properly prioritized. The Process Vents System is also prioritized in this group, since it contains Class 1N piping attached to process piping.

The Main Steam/Bleed Steam Pipe Supports outside the Class 1N Boundary will be done next to assure that engineering is complete to allow necessary support modifications to be made during the 1989 refueling outage. Other piping supports inaccessible during normal operation will also be done during this time frame.

The last category of pipe supports are those included in the redundant trains of the RHR, Core Spray and Service Water Systems. Engineering will be done in time to assure the support modifications can be made before plant startup from the 1989 outage. However, if some slippage should occur, these systems can be modified while the plant is on line.

The repair/modification of pipe supports will be done with the plant in service to the extent possible. Pipe supports in high radiation (due to ALARA conditions) and/or high temperature areas will be modified during the 1989 refueling outage. Modification work will begin as soon as enough engineering is done to support a full time modification effort. Pipe supports will be modified in place in most cases. If supports need to be removed, appropriate temporary restraints will be provided, unless analysis shows the support is not required to meet the accident condition.

4.0 PROJECT CRITERIA

This section provides a concise description of the basic methodology and analytical modeling techniques for the analysis of piping systems within the scope of the long term plan. It is intended to specifically address questions raised by the NRC staff during recent audits and formal questions. Additional or more specific requirements will be detailed in the project criteria document. All piping and pipe supports shall be reviewed for compliance with References 6.5 through 6.11.

The piping systems shall be modeled as lumped mass systems with sufficient mass points and enough detail to accurately predict piping dynamic response. As a minimum, the mass point spacing shall be based on a minimum fundamental frequency of 33 Hz; furthermore, there should be a minimum of two mass points per span. Piping models shall terminate at structural anchors or equipment nozzles. For extensive piping systems, analysis by overlap models is acceptable provided the results (i.e., pipe stresses and support loads) thus obtained are within acceptable accuracy. The weight of the piping contents plus insulation shall be added to the weight of the pipe in the form of uniformly distributed load (lbs/ft). The weight of valves and other inline components shall be included in the mass model.

For verification/evaluation of existing piping analysis, the weights of pipe supports are not required to be included in the piping analysis. However, for new designs or modifications the weights of the pipe support shall be included if the hardware weight of the supports (clamp, stanchion, etc.) on the pipe is greater than that of the length of pipe equal to two times the pipe diameter (O.D.), the hardware weight shall be lumped on the piping model at the support location.

The effects of bending and torsion due to eccentric masses, such as valve operator acting through the operator center of gravity, shall be properly modelled. However, if the pipe stress due to torsional effect is expected to be less than 500 psi (based upon hand calculation and experience), the offset moment due to the operator may be neglected.

For the evaluation of existing designs, pipe support stiffness may be assumed to be rigid. However, for new design or piping modification, the actual support stiffness, when available, shall be used in the piping analysis.

Seismic analysis shall be performed using the "response spectrum method" of analysis. Spectra with 0.5% damping shall be used for both OBE and SSE. The appropriate amplified response spectra for the applicable floor elevation shall be used. The selection of floor elevation for the spectra shall be based on the location of the attachments between the piping system and the plant structures or equipment. The vertical response spectra shall be equal to 2/3 of the corresponding ground response spectra.

The effects due to earthquakes acting in the X (horizontal) and Y (vertical) directions simultaneously shall be obtained by the absolute sum of the responses from the horizontal direction and the vertical direction. The maximum response of each mode shall be calculated and

combined by the root mean square method (i.e., square-root-or-sum-of-the-squares SRSS). The effects due to earthquakes acting in the Z (horizontal) and the Y (vertical) directions shall be computed similarly. The most critical of the two resulting combinations shall be evaluated. When closely spaced modes exist, the modal responses of the system shall be combined by direct summation (sum of absolute values). The 10 percent grouping method, per the requirements of Regulatory Guide 1.92 (Reference 6.8) is an acceptable method to account for these effects.

The mass associated with the higher frequency modes (i.e., rigid range, zero period accelerations, (ZPA), or missing mass) shall be accounted for in the analysis. The results shall be combined with the results of the lower frequency modes by the SRSS method.
The forces and moments due to the seismic differential anchor movements (SAM) shall be determined by a static analysis with the movement at supports as input.

Base plate flexibility and prying effect shall be considered in the design of the base plates and anchor bolts for the pipe supports. In general, when hand calculation is used for simple, regular base plate design (e.g., rectangular, 4-bolt base plate with sufficient thickness) a prying factor of 1.5 may be used. However, for flexible base plate with irregular plate and bolt patterns, and for configuration which is judged to have significant prying effect (e.g., 2-bolt phase plate, etc.) a more refined analysis shall be used. A finite element analysis, or any other acceptable method may be used to check the adequacy of the base plate and anchor bolts.

Any snubber optimization will be completed based on existing CNS design basis criteria as set forth in the CNS USAR (Reference 6.3) and Project Design Specification (see Section 5.0).

Allowable stresses for all other pipe support components are provided in Attachment A.

5.0 PROJECT METHODOLOGY

The District has committed to have all nonconforming supports modified to meet the CNS design basis prior to start-up from the 1989 refueling outage. In order to meet this commitment, a dedicated District project team has been assembled and Engineering Analysis Services (EAS), a consultant with extensive experience in pipe support products, analysis techniques, current regulatory technical positions, design and analysis process procedures, and problem resolving capabilities has been retained to perform the necessary calculations.

The District will direct piping stress analysis be performed as required in order to optimize the use of snubbers and reduce or eliminate the impact of modifications. Such piping stress analysis will follow the requirements provided in project criteria (See Section 4.0).

Listed below is a discussion of essential elements which will control the code qualification and associated modification work:

- Design Specification

A design specification will be prepared for all systems and components affected by this Long Term Plan. The Design Specification will include the following:

o Design requirements specified in the CNS Design Basis Document for Piping and Pipe Supports.

o Specific stress problem jurisdictional boundaries for each system.

o Specific Design and Operational Characteristics for each system.

o Listing of all reference documents to be utilized in the implementation of the Long Term Plan.

This Design Specification will be completed and approved by the District by August 26, 1988.

- Project Technical Procedures

In order to obtain a high quality and standardized stress report, the District feels that on a project of this type, the preparation and dissemination of well written project procedures are critical. This will assure that all project team members will perform calculations in a similar manner, as well as standardizing the approach to a particular type of support analysis. The procedures will specify such considerations as calculation format, support load combinations, use of engineering standards, and use of computer software.

- Project Status Reports

Detailed computerized scheduling and tracking techniques will be utilized to maintain an updated status of all work at any time during the project. Biweekly status reports will be submitted to the District's Project Manager by the Consultant with status meetings held as required. By implementing this detailed tracking system, progress can be easily evaluated by District Management.

- Quality Assurance

All work will be done in accordance with EAS and NPPD's Quality Assurance programs. Strict Quality Assurance procedures, which include the use of checklists and report approvals, will be utilized throughout the duration of the Long Term Plan. Through the proper incorporation of a Quality Assurance program, increased engineering productivity and high quality calculations and stress reports will result.

- District Review

All work will be reviewed and approved by the District. Appropriate QA audits of all aspects of the Long Term Plan will be carried out by the District Quality Assurance Department.

Based upon the information outlined above, the District is confident that accurate ca culations will be performed to achieve full code qualification for all affected essential, Seismic Class 1S piping supports through an expedited and controlled process.

6.0 REFERENCES

6.1. CYGNA Report No. TR-88037A-2 for NPPD, Revision 1, June 1988, "Operability Evaluation of the HPCI Pump Discharge System for Cooper Nuclear Station."

6.2. CYGNA Report No. TR-88037A-3 for NPPD, Revision 1, June 1988, "Operability Evaluation of Essential Piping Systems for Cooper Nuclear Station."

6.3. NPPD, "Cooper Nuclear Station, Updated Safety Analysis Report," July 1987.

6.4. Burns & Roe, Inc. Technical Report W.O. No. 3401-26 for NPPD, Revision 0, July 1980, "Seismic Review of Safety-Related Systems in Response to NRC Bulletin 79-14."

6.5. USAS B31.1.0, 1967 - Power Piping.

6.6. American Institute of Steel Construction, "Specification for the Design, Fabrication, and Erection of Structural Steel Buildings," 8th Edition, 1980.

6.7. NPPD Contract Document E-69-4 for Cooper Nuclear Station Section G (Volumes 2 and 3, and Amendment Nos. 35, 44, 46, 47, 48, 49, 54, 55, 56, 57, and 58).

6.8. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.92, Revision 1, "Combining Modal Response and Spatial Components in Seismic Response Analysis."

6.9. ASME Boiler and Pressure Vessel Code, Code Case N-318-2, July 12, 1984.

6.10. Local Stresses in Spherical and Cylindrical Shells due to External Loadings," WRC Bulletin 107, March 1979.

6.11. Local Stresses in Cylindrical Shells due to External Loadings on Nozzles," WRC Bulletin 297, August 1984.

7.0 ATTACHMENTS

ATTACHMENT A
ALLOWABLE STRESSES FOR PIPE SUPPORTS

Stress Type		Service Level: Normal/Upset	Service Level: Faulted
		Value	Value
Tension		$0.6\ F_y$	$0.9\ F_y$
Shear		$0.4\ F_y$	$0.52\ F_y$
Web Crippling		$0.75\ F_y$	$0.9\ F_y$
Compression		F_a	Smaller of $1.5\ F_a$ or $2.3\ F_{cr}$
Bending		$0.6\ F_y$ *	$0.9\ F_y$ *
Base Plate Bending		$0.75\ F_y$	$0.9\ F_y$
Bearing		$0.9\ F_y$	N/A
Bolts	Tension	Allowable Tension per AISC	1.5 x (Allowable Tension per AISC)
	Shear	Allowable Shear per AISC	1.5 x (Allowable Shear per AISC)
Welds (Fillet)	Shear	$0.3\ F_{uw}$ (Weld Metal) $0.4\ F_{uw}$ (Base Metal)	$0.42\ F_{uw}$ (Weld Metal) $0.52\ F_y$ (Base Metal)
(Full or Partial Penetration)	Tension	$0.6\ F_y$ (Base Metal)	$0.9\ F_y$ (Base Metal)
Combined Stress		Per AISC	Per AISC
Catalog Items		Catalog Values**	Catalog Values**

* Values are for basic bending allowables. Reduction of allowable stress shall be per AISC specification as appropriate.

** Or as qualified by test or analysis.

Note: F_y is the minimum yield strength of the material at temperature.

F_{uw} is the minimum ultimate tensile strength of the weld electrode material.

ATTACHMENT B

PROJECT WORK SCHEDULE AND MILESTONE DATES

PROJECT WORK SCHEDULE

Estimated Milestone Dates

ITEM	ESTIMATED COMPLETION DATE
1. Award of Service Agreement	August 5, 1988
2. Complete Design Specification	August 19, 1988
3. Begin Implementation of Pipe Support Modifications	October 1, 1988
4. Complete calculations and provide necessary documentation to install any necessary field modifications for the following systems (except those which are inaccessible): a. Service Water - one loop b. Reactor Building Closed Cooling Water - both loops c. Residual Heat Removal - one loop d. HPCI Suction and Test Return Line	November 18, 1988
5. Complete calculations and provide necessary documentation to install any necessary field modifications for the following systems (except those which are inaccessible): a. Core Spray - One Loop b. Reactor Core Isolation Cooling	December 16, 1988
6. Complete calculations and provide necessary documentation to install any necessary field modifications for the following systems (except those which are inaccessible): a. Diesel Starting Air b. Control Rod Drive c. Process Vents d. Stand-by Liquid Control	December 23, 1988
7. Complete calculations and provide necessary documentations required for modifications to the following systems: a. Main Steam/Bleed Steam b. Any other system support that will be done during the 1989 Outage	January 20, 1989

8.	Complete calculations and provide necessary documentation to install any necessary field modifications one train for the following systems (except those which are inaccessible): a. Service Water - second loop b. Residual Heat Removal - second loop	March 31, 1989
9.	Complete calculations and provide necessary documentation to install any necessary field modifications for one train of the following systems (except those which are inaccessible): a. Core Spray - second loop	April 8, 1989
10.	Start of 1989 Refueling Outage	April 26, 1989
11.	Install necessary modifications for the following systems: a. Main Steam/Bleed Steam b. Any inaccessible supports which could not be modified during plant operation.	May 12, 1989
12.	Complete As-building of any modified or new supports and reconcile all calculations.	May 19, 1989
13.	Start-up from 1989 Refueling Outage	June 2, 1989
14.	Close-out and transmittal of all documents from EAS to the District.	June 15, 1989