ATTACHMENT 2

CAROLINA POWER & LIGHT COMPANY
STUDY REPORT
REPORT NO. 7865.007-S-M-020

"CRITERIA FOR EVALUATING AND PERFORMING
COMPUTERIZING PIPING ANALYSES
OF EXISTING SYSTEMS WITH MINOR MODIFICATIONS
(Applicable for NRC Bulletins IE 79-07 and 79-14)

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CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

SOUTHPORT, NC

STUDY REPORT

CRITERIA FOR EVALUATING AND PERFORMING COMPUTERIZED PIPING ANALYSES OF EXISTING SYSTEMS WITH MINOR MODIFICATIONS

(Applicable for NRC Bulletins IE 79-07 and 79-14)

for

CAROLINA POWER AND LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNITS 1 AND 2

SAFETY RELATED

REPORT NO. 7865.007-S-M-020

REVISION NO. 2

PREPARED BY: R.T. Martin DATE: 5/31/89

CHECKED BY: Mark S Underwood DATE: 6-27-89

RECOMMENDED BY: R.T. Martin (PTG LEAD) DATE: 6-27-89

APPROVED BY: Bill Monroe (PRINCIPAL ENGINEER) DATE: 7/28/89

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2							
3							

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1.0 PURPOSE

The purpose of this criteria document is to provide guidance and document original United design criteria for the various tasks encountered in computerized piping analysis on existing systems with minor modifications for the CP&L Brunswick 1, 2 Plants. This criteria document was originally generated by UE&C but has been adopted by CP&L for internal use. Revisions beginning with Rev. 2 are the responsibility of CP&L. This criteria document may be used for minor modifications as defined in Section 2.0, of Definitions. This criteria document includes general guidelines dealing only with linear elastic analysis of piping systems that meet the code of record, USAS B31.1 Power Piping Code 1967 (material properties and allowable stress limits were used from later code editions when not available in the code of record). 2

This document presents methods for determining the adequacy of piping systems subjected to both static and dynamic loadings. The overall coverage includes the following items:

- o Selection of an appropriate computer program to perform the desired analysis
- o Proper construction of a mathematical model which adequately represents the piping system under consideration
- o Application of all loads required to meet the imposed design requirements
- o Actual performance or execution of the analysis to obtain piping responses, such as reaction loads displacements and stresses.
- o Evaluation of analysis results to assess validity and applicability
- o Documentation of analysis results

Although it is discussed briefly in Section 3, this document does not directly provide guidance for determining the type of analysis to be performed. Nor does it deal directly with any specific computer program. The procedures presented herein are general in nature and apply to all types of computer analysis programs. It is the responsibility of the analyst to determine their proper utilization.

Deviations from guidelines contained in this document are permissible providing that the following conditions are satisfied:

1.1 Approvals for the deviation(s) have been obtained from the PTG Principal Engineer. 2

1.2 Adequate justification for the deviation(s) has been demonstrated.

1.3 The deviation has been fully documented as part of the piping analysis calculation package. 2

1.4 All cognizant parties have been informed of the deviation(s).

Further guidance in performance of reanalysis for the piping turnover project should be obtained from PTG-10, Brunswick Piping/Support Analysis Issues.

2.0 DEFINITIONS

The following are additional definitions of terms and acronyms to be used in conjunction with Procedure CPL-GMEDP-0000 (Ref. 12):

2.1 SHALL is used to indicate that a provision is mandatory.

2.2 SHOULD is used to indicate that a provision is not mandatory but recommended as good practice.

2.3 MAY is used to indicate that a provision is optional.

2.4 PIPE SUPPORTS are defined as those hardware components used in a piping system to support the pipe and transmit deadweight, seismic, and transient loads to foundations, floors, walls, and other supporting structures.

2.5 PIPE RUPTURE RESTRAINTS are defined as those hardware devices and components specifically designed and located to prevent uncontrolled motion of pipe segments.

2.6 ANCHORS are devices which provide full restraint (i.e., permitting neither translational nor rotational movement of the pipe on any of the three reference axes). 2

2.7 HANGERS are supports from which piping is suspended from a structure, etc., and which function by carrying the piping load in tension.

2.8 CONSTANT SPRING HANGERS are those hangers which provide a constant supporting force for piping throughout their full range of vertical expansion and contraction.

2.9 VARIABLE SPRING HANGERS are those hangers which provide a varying supporting force proportional to spring deflection.

2.10 PINNED HANGERS or BLOCKED HANGERS are terms describing the hanger condition in which piping deadweight loads are reacted through the bodies of pipe hangers rather than through the hanger springs.

Hangers are placed in this condition with devices such as dowel pins or blocks, and while in this condition provide essentially rigid support.

2.11 SNUBBERS or SUPPRESSORS are devices which are activated only by dynamic loads and support the pipe during earthquakes and other transient loadings. Snubbers offer negligible resistance to static loads such as deadweight loads or thermal loads.

2.12 SUPPORT STIFFNESS refers to the force-deflection relationships of a support. The term is often used synonymously with support spring rate.

2.13 LIMIT STOP is a device which restricts translational movement to a limited amount in one direction along any single axis.

2.14 PIPE STIFFNESS refers to the force-deflection relationships of a segment of pipe. Both the pipes physical and material properties and the method of support are factors in determining pipe stiffness.

2.15 SECTION MODULUS pertains to the cross section of a pipe (or beam). The section modulus with respect to either principal axis is the moment of inertia with respect to that axis divided by the distance from that axis to the extreme fiber of the section. 2

For a pipe section, the section modulus is the same for both axes.

2.16 IN-LINE COMPONENTS are any devices other than pipe segments which may be included in the piping system. Examples of in-line components are flow meters, strainers, valves, and flanges.

2.17 NODE POINT or JOINT is a designated and uniquely numbered location within the piping mathematical model where a model element connect to other elements or to the model boundary. Node points are located within the model by their global X, Y, and Z coordinates which give both distance and direction from the origin.

2.18 LUMPED MASS is a term associated with dynamic analyses. The mass of piping and in-line components may be represented by appropriately concentrating its mass at discrete points (i.e. node points) within the mathematical model; hence, lumped mass.

2.19 PAD is an acronym for Pressure Anchor Displacements and refers to the Drywell and Suppression Chamber displacements resulting from internal pressure during test or LOCA conditions.

2.20 TAD is an acronym for Thermal Anchor Displacements and refers to the thermal growth of the Drywell and Suppression Chamber resulting from LOCA conditions.

2.21 SAD is an acronym for Seismic Anchor Displacements and refers to the seismic movement of structures.

2.22 d T is a symbol representing the difference in temperature between an operating condition temperature and ambient temperature.

2.23 MINOR MODIFICATIONS pertain to minor piping deviations such as adding a valve, changing a valve type or weight, relocating a valve or support, adding a new transient load condition, snubber to strut replacements, As-Built deviations and minor piping reroutes. 2

NOTE: Minor piping reroutes can not be simply defined and require engineering judgement. This judgement should consider practical, technical and Licensing consequences of using the original or state of the art design techniques or a combination of both. Extreme caution should be used when combining design techniques, since the result may not be conservative.

2.24 AS-BUILT DEVIATIONS pertain to piping and support locations/orientation of the as installed piping system which differs from the analysis of record piping system.

NOTE: Prior to November 1, 1986 the As-Built acceptance tolerance for deviations was as documented on page 66 of Attachment A to Study Report 7992.068-S-M-028, Rev. 0. The only exception is the use of 15 degree orientation tolerance utilized during the snubber and strut orientation program in 1981 and 1982. For justification of this 15 degree tolerance refer to APPENDIX C. Subsequent to November 1, 1986 the tolerances provided in APPENDIX B will be utilized for reconciliation of As-Built deviations.

2.25 Primary Stresses are those stresses associated with sustained loads (ex. pressure and weight) and occasional loads (ex. earthquake and wind) and capable of direct overstress failures.

2.26 Secondary Stresses are those stresses associated with secondary loads (ex. thermal expansion and anchor displacements) and capable of causing fatigue failures. 2

3.0 SELECTION OF ANALYSIS TYPE

Different classifications of piping systems may require different types of analy . The analyst shall consult Table 1 and review system piping requirements to determine the type of analysis required. Analyses shall be performed in accordance with USAS B31.1 Power Piping Code, 1967 edition.

4.0 PIPING SYSTEM LOADINGS

The typical piping loads defined below shall be considered when applicable:

- Internal Pipe Pressure
- Dead Weight loads for both the normal and test (hydro) conditions
- Thermal Expansion Loads
- Cold Spring Loads
- Wind Loads (i.e. Diesel Generator Exhaust piping)
- Seismic Loads
- Transient Loads (i.e. Main Steam relief valve discharge piping)
- Anchor Displacements Resulting From - Pressure in the Drywell and Suppression Chamber (PAD) - Thermal expansion of the Drywell and Suppression Chamber (TAD) - Seismic events (SAD)
- Pipe Rupture Loads - The application and combination of the above loads shall be governed by the applicable codes, design specifications and FSAR commitments. (Refer to TABLE A1 in APPENDIX A).

5.0 MODEL CONSTRUCTION AND INPUT DATA PREPARATION

5.1 Analytical Model

The following list identifies minimum computer capabilities required to model piping systems:

- Straight Pipe Elements
- Curved Pipe Elements or Elbows
- Facilities for Specifying Boundary Conditions (i.e. Supports and Anchors) - Displacements and Rotations - Stiffnesses
- Lumped Masses
- Frequency cutoff for modal summation

TABLE 1

PIPING SYSTEM ANALYSIS

TYPE OF LINE	SEISMIC CATEGORY I (5)				NON-SEISMIC CATEGORY I
HOT/COLD (1)	HOT		COLD (2)		HOT (4)/COLD (2)
Sizes	Larger Than 2"	2" and Smaller	Larger Than 2"	2" and Smaller	ALL
Analysis Method	Detailed Computer	Detailed Computer or Other Design (3) Techniques	Detailed Computer	Detailed Computer or Other Design (3) Techniques	Detailed Computer or Other Design (3) Techniques

Notes to Table 1:

(1) HOT LINES are defined as ≥ 170F. for carbon steel (dT=100F.) and 150F. for stainless steel and copper-nickel (dT=80F.). This temperature is a general rule and each line should be reviewed against its system piping design requirements for determination of usage.

(2) COLD LINES do not require Thermal analysis if penetrations, equipment nozzles, anchor displacements or other conditions do not require evaluation. A flexibility check should be performed however, and the minimum distance to the first rigid support at each change of direction should be checked. 2

(3) OTHER Design Techniques include; Static Seismic Analysis, Simplied Computer Analysis, Hand Calculations and Design Tables which are not specified in this Criteria Document.

(4) HOT LINES larger than 2" diameter that directly support plant operation (i.e., Main Steam, Extraction Steam, Feedwater, Condensate, etc., should be analyzed using detailed computer analysis method.

(5) Seismic analysis should be performed on lines whose failure could cause a <u>flooding concern</u> to any safety system. Systems originally analyzed to meet this requirement are addressed in the superseded FSAR, comments 5.33, 5.49, and 10.43. 2

5.1.1 Recommended Coordinate System

A Cartesian, X-Y-Z, global coordinate system is recommended. Unless otherwise specified, the horizontal plane should be defined by the (+) X (North) and (+) Z (East) axes, and the upward vertical direction shall be defined by the (+) Y axis.

In addition to the global system, local coordinate systems are also required in which to define the pipe elements. Local systems are defined in terms of the global system by a rotation or orientation matrix. The analyst shall become familiar with the coordinate system conventions and requirements of his computer program and take the necessary steps to ensure correct input specifications and output interpretations as affected by local and global coordinate systems.

5.1.2 Model Boundaries and Model Substructuring

In general, piping models follow state of the art modeling techniques used prior to the I.E. Bulletins of 1979.

Models should only be terminated at full penetrations, equipment nozzles or other rigid structural anchors. 2

Link-seals were generally modeled in the analyses as terminal points with rigid stiffness. UNITED considered Link-seals as three directional translational restraints under the I.E. Bulletin reanalyses (in the original thermal analyses, link seals were considered as 6-way restraints).

Link-seal axial and radial loads should be evaluated based on the capacities of calculation sets 9527-8-SS-90-F, Rev. 0 and 9527-8-SS-91-F, Revision 0.

For large piping systems whose modeling requirements exceed computer program capacities, the following decoupling techniques shall be utilized:

- Overlapping of main line runs should be avoided. Approval of the PTG Principal Engineer shall be obtained if main run overlap is used on reanalysis. Although some small bore piping lines considered main line overlapping, it should be avoided (see Study Report 7992.001-S-M-037, Rev. 0). 2

- Branch lines may be decoupled from main lines when the ratio of the branch line section modulus to the main line section modulus is less than or equal to 0.05 or when the ratio of moments of inertia is less than or equal to 0.04. 2

5.1.2 Model Boundaries and Model Substructuring (Continued)

This criterion considers the forces and moments which would otherwise be calculated for the branch connection are of such small magnitude that insignificant stresses would be imposed on the main run piping. However, for the subsequent analyses of the branch piping, the displacements experienced by the main run at the branch connection shall be superimposed on the branch piping as anchor displacements. Seismic displacements are considered to be negligible and are not analyzed for the branch piping. For the branch piping, the connection to the main run is analyzed as an anchor. The envelope of the applicable building A.R.S. of the branch piping used and the main run A.R.S. for the branch connection elevation were used for the branch piping.

- In United analyses main lines were decoupled from the branch runs (when not meeting the decoupling criteria) by extending the main line model to include branch piping and supports which provide restraining actions in at least two x-x, two y-y, and one z-z direction (where x-x, y-y and z-z are local piping directions with z-z being parallel to the piping centerline). Likewise, the branch run piping was decoupled from the main line model by extending the branch model into the main line piping 2 (in both directions at Tees) to include the same restraining action presented above for the main line model. Stresses, deflections, and support loads for the main line and branch were determined for the model elements representing them. More specifically, results for the main line piping were obtained from a model of the main line and results for the branch piping were obtained from a model of the branch. Pipe stresses in this region were checked against the appropriate allowables.

Study Report 7992.001-S-M-037, "Evaluation of Overlap Zones", should be used for guidance in evaluating piping not meeting decoupling criteria.

5.2 Computer Program Selection

5.2.1 Program Capabilities

The piping system and its loading conditions shall be properly simulated by the mathematical model and the computer program being used.

When selecting an appropriate program, the program's capabilities must be matched to the problem requirements. Following is a list of items which must be considered:

- Static capabilities
- Dynamic capabilities
- Time History capabilities
- Problem Size capacity
- Use of output
  - Preliminary design
  - Design Verification
- Specific Code Requirements
  - Flexibility Factors
  - Stress Intensification Factors
- Load Accommodation
  - Pressure loads
  - Thermal loads
  - Mechanical loads, concentrated and distributed
- Special Boundary Conditions

5.2.2 <u>Computer Program Verification Requirements</u>

All piping analysis computer programs shall be QA verified. Programs used by UNITED were Q.A. verified in accordance with UE&C Procedure GEDP-0044.

5.2.3 <u>Programs Used For Stress Analysis</u>

<u>ADLPIPE -2</u> - A static and dynamic pipe design and stress analysis program developed by Arthur D. Little, Inc., and modified by UE&C. It was used for Thermal, Deadweight and Seismic reanalysis for the NRC Bulletins 79-07 and 79-14. This program provides elastic analyses of piping systems in accordance with the requirements of ASME III, Class 2 & 3 and ANSI B31.1. Features within the program enable ADL to analyze the effects of the following:

- Pressure
- Deadweight

- Thermal
- Externally applied Forces and Moments
- Statically applied Equivalent Seismic Loads
- Anchor Displacements
- Seismic Response Spectra

ADLPIPE D or ADLPIPE, as opposed to ADLPIPE 2, has the same capabilities as those described above and accommodates ASME III Class 1 pipes in addition to Class 2 and 3. (This version of ADLPIPE may also be utilized through computer service vendors).

ADLPIPE E - Has equivalent features to ADLPIPE D. This version of ADLPIPE may be utilized on the Sun Workstation. 2

MEL -40 - A static piping flexibility analysis program developed by Machinery Laboratory and/or the Mare Island Site of the San Fransicso Bay Naval Shipyard. It was used for the original Thermal and Deadweight analysis prior to the NRC I.E. Bulletins 79-07 and 79-14. This program provides elastic analyses of piping systems in accordance with the requirements of USAS B31.1 Piping Code. Features within the program enable MEL-40 to analyze the effects of the following:

- Pressure
- Deadweight
- Thermal expansion
- Externally applied forces and moments

NUPIPE - A static and dynamic pipe design and stress analysis program developed by Nuclear Services Corporation. It was used for time-history transient analysis of the Mainsteam S.R.V. discharge lines for the Torus Mark 1 modification program. This program provides elastic analysis of piping systems in accordance with the requirements of ASME III, Class 2 & 3 and ANSI B31.1 Piping Code. Features within the program enable NUPIPE to analyze the effects of the following:

- Pressure
- Deadweight
- Thermal
- Externally applied forces and moments
- Seismic response spectra
- Time-history

5.3 Model Input

All piping model input must be compiled from documented sources such as specifications, standards, piping isometrics, and/or other suitable drawings.

5.3.1 Node Point Locations

In order to properly define the piping system and to obtain desired output, node points should be located at the following locations:

- At all anchor points
- At all branch to run intersection points
- At all directional changes
- At all points where concentrated loads are applied
- At all changes in pipe size
- At all temperature changes
- At all discontinuities
- At all restraint points
- At any point where output information is desired 2

5.3.2 Defining In-Line Components

Typical in-line components include the following:

- Valves
- Flanges
- Strainers
- Socket Weld Fittings

The analyst should include the required elements in the mathematical model to represent the stiffness and mass properties of in-line components. Acceptable ADLPIPE modeling techniques for socket weld elbows are given in 2
Appendix F. Vendor valve data should be used when available. The valve operator frequency of motor/air operated valves involved in plant modifications should be requested from the vendors. When vendor frequency data is not available the valve operator drawing should be reviewed to existing plant drawings for similarity (see Study Report 7992.001-S-M-032, Valve Operator Frequency). The original guidelines for modeling of valve operators are as follows:

- o The valve operator and superstructure should be simulated such that the fundamental frequency is greater than or equal to 20 hz to avoid artificial operator excitations from being induced to the piping system.

- o The valve bodies, strainers and flanges may be simulated by a piping element with a diameter of 1.5 times the nominal piping diameter and a thickness equal to 2.0 times the nominal piping wall thickness.

- o Masses of valves, valve operators, and other components should be lumped at their appropriate centroids, either using vendor drawings or catalogue information. (See Study Report 7992.001-S-M-031, "Evaluation of Valve Input Data used for Computerized Piping Analyris of 2
Existing Systems.")

- o Acceleration of Class IA and IB active valves in all 2
analyzed safety related lines shall be calculated and compared with allowable accelerations of 3.0g (Horiz.) and 2.0g (Vert.) unless otherwise specified.

5.3.3 <u>Modeling of Supports and Restraints</u>

Supports and restraints are modeled with zero gaps unless designed to specifically consider a gap other than the nominal (i.e. one-sixteenth of an inch).

Supports and restraints are modeled with representative typical support stiffness. The stiffness value set used under the I.E. Bulletin reanalyses (higher values) changed from the original analyses (Lower values) due to modeling technique changes over the time span. The range of stiffness values are given in the following table:

Pipe Size (Nom. Dia.)	Stiffness (lb/in)
up to 2"	10^4 or 10^5
2-1/2" to 6"	10^5 or 10^6
8" and up	10^6 or 10^7

Note: When reanalyzing existing lines, the stress analyst should use the same stiffness value set as incorporated in the previous analysis (mixing of higher and lower stiffness sets should be avoided). The stress analyst may use actual support stiffness if used consistently throughout the analysis model. Close coordination with the pipe support designer is required. Support stiffness used that are different from generic stiffness should be identified on the support load summary sheet transmittal.

5.3.4 Modeling Large Curved Pipe Sections

Curved pipe elements shall be used to model curved pipes with large bend radii (greater than 1.5 nominal pipe diameters) when the program being used can accommodate them. Large bend radius curved pipes are those which have stress intensification factors no greater than those given for straight pipes in USAS B31.1 Codes (i.e. - not S.I.F. of elbows). Alternately, such large curved pipes shall be modeled, in lieu of curved pipe elements, with straight pipe elements in the following manner:

- Straight pipe segments shall be placed at all node points along the curved piping run, including nodes at concentrated mass and support locations. The straight pipe sections shall be tangent to the curved pipe at these node points.
- Additional node points shall be added at the intersections of the straight pipe segments tangent to the curved piping run.
- The mass lumping distance on straight pipe segments used to simulate large bend radius, curved piping shall be governed by the techniques and procedures given in Subsection 5.3.5.

5.3.5 Modeling for Dynamic Analysis

The piping system shall be represented by an appropriate structural model constructed of lumped masses and sections of straight and/or curved members having the same mass and stiffness properties as the pipe. All in-line components and supporting members shall be represented. As a general rule, masses may be lumped such that the total number of degrees of freedom shall be equal to or greater than twice the number of modes with frequencies less than 20 Hz. (Note: Original analysis cut off at 20 Hz; however, analysis for new designs 2
or modification work would use 33 Hz cutoff and correct for missing mass.)

Lumped masses should be placed along piping runs according to the guidelines used under the I.E. Bulletin reanalyses (Note, the use of computer program automatic lumping option may place lump masses at support locations without proper lump mass distribution) as follows:

a) For 20hz analyses the maximum distance, L, between mass lumps representing the pipe should not exceed the following (Ref. 5):

$$L = 9.2 \left\{\frac{D^3 t}{W}\right\}^{1/4}$$

L = Length between lumped masses in feet

D = Outside diameter of pipe in inches

t = Pipe wall thickness in inches

W = Unit weight of pipe including water, insulation, and any other relevant weight in pounds per foot

b) For 33hz analyses the maximum distance, L, between mass lumps representing the pipe should not exceed the following:

$$L = \left\{\frac{\pi}{2f}\right\}^{1/2} \left\{\frac{EIg}{W}\right\}^{1/4}$$

L = Length between lumped masses in feet. 2

f = frequency, Hz

E = Youngs modulus

g = gravitational acceleration

W = weight of pipe lb/ft

I = Moment of inertia

c) Deviations from the length, L, as determined above are permissible providing that the effects are not significant to the system qualification. Any deviations in the maximum L used should be documented in the calculation. 2

d) Masses should be lumped in the proper locations to represent in-line components.

e) There should be at least one lumped mass between any two restraints.

For those cases for which a single mass is sufficient, that mass shall be lumped in approximately the central third of the span.

For spans requiring more than one mass, judgement shall be exercised in locating masses at adequate distances from the supports.

f) Deviations from the above guideline (d) are permissible for short, stiff spans which have fundamental frequencies lying in the rigid range (greater than 20 Hz.) and are bounded by flexible spans. For these members, mass lumps may be omitted. However, the masses of such elements shall be included in the mass lumps of adjacent spans.

g) Valve motor and/or air operator masses shall be lumped in their proper offset locations.

h) Masses should be lumped at piping direction changes, except in those cases where the elbow and adjacent pipe are supported in such a manner that the pipe is effectively anchored.

i) Masses should not be lumped at rigidly restrained points in the direction of the restraint.

5.3.6 Stress Intensification Factors

The analyst shall verify that the appropriate stress intensification factors are properly utilized in the stress calculations for all piping components including elbows, branches, tees, and in general, all in-line components. Where branch piping has been decoupled at branch connections and tees, the appropriate stress intensification factors shall be used as if these sections were not decoupled.

Stress intensification factors (i) shall be used from the code of record USAS B31.1, 1967. Primary stresses considered a twenty-five percent reduction in stress intensification factor (.75 i), but .75i shall never be taken as less than 1.0 (Reference 7). The permissible piping stress equations for secondary and primary stress calculations with their stress intensification factors are as follows:

$$\text{Secondary or Expansion Stress (SE)} = \frac{\left[(iMx)^2 + (iMy)^2 + Mz^2\right]^{1/2}}{Z}$$

where Mx and My are bending moments and Mz is torsional moment. (67 code) 2

$$\text{Primary or Additive Stress (Sp)} = .75i \; \frac{(Mx^2 + My^2 + Mz^2)^{1/2}}{Z}$$

where .75i shall never be taken as less than 1.0. (73 code) 2

Note, the equation for pressure stress is from the code of record USAS B31.1, 1967. Also, note that the use of alternate equations for Pressure, Secondary and Primary stresses which result in conservative stresses are acceptable.

6.0 INPUT AND OUTPUT DATA CHECKS AND MODEL VERIFICATION

To insure accuracy, the following input items shall be checked when applicable:

o Geometry of the following items

- Structural node points
- Mass points
- Anchor locations
- Restraint locations
- Intersection points
- Origin of global coordinate system
- Coordinates of terminal points (closure)

- Piping Physical Properties
  - Length
  - Bend Radius
  - Inside and outside pipe diameter
  - Pipe Wall thickness
  - Weight per length
- Element Material Properties
  - Modulus of Elasticity, E
  - Shear Modulus, G
  - Poisson's Ratio,
  - Coefficient of Thermal Expansion,
- Boundary Conditions
  - External springs
  - Anchors
  - Specified displacements
  - Boundary stiffness matrices
  - Decoupled and Overlapped Boundaries
- Applied Loads
  - Loaded joints
  - Direction of loads
  - Magnitude of loads
  - Temperature changes
  - Gravitational acceleration
  - Concentrated weights
  - Force time histories
  - External reaction forces

In addition to input data checks, computer results shall be checked as thoroughly as possible.

The output items listed below shall be checked when applicable:

- o Direction and Magnitude of the following:
  - Reaction Forces
  - Resulting Displacements
  - Resulting Stresses
  - Thermal Expansion
- o Dynamic Behavior
  - Frequencies
  - Mode Shapes

6.1 STUDY REPORTS

The Study Reports listed in Reference Section 10 and Appendix D were created to (1) document/justify the inputs utilized in past analyses, (2) provide a documented source of analysis inputs to allow for the future review of completed analyses and (3) document acceptable approaches to evaluating items not previously addressed when reviewing existing analyses or performing future analyses. | 2

7.0 PIPING LOAD ANALYSES

After completion and verification of the mathematical model, the following procedures shall be used to perform the indicated analyses.

7.1 Internal Pressure Analysis

Longitudinal membrane pressure stress shall be calculated according to the equations given in the applicable code. Consideration shall be given to the following pressure levels as applicable:

- o Design Pressure - as specified in system piping requirements
- o Maximum or Peak Pressure - as set by over-pressure safety relief devices
- o Test Pressure - as specified in system piping requirements

Nominal pipe wall thicknesses and diameters shall be used in code calculations.

7.2 Deadweight Analysis

Using system piping design requirements and indicated support locations, the analyst shall perform the complete deadweight analysis through a multi-step process. Each successive step in the process is added, as required, to design pipe hangers consistent with the normal operating condition parameters and to provide worst case support loads and pipe stresses resulting from deadweight. The procedure outlined below shall be followed:

Normal Operating Condition

a) Remove spring stiffness at snubbers

b) Represent all hangers and remaining supports by very stiff springs as given in subsection 5.3.3

c) Specify weights of piping, components and their respective contents and insulation to agree with the normal operating condition. (See Study Reports M-031, M-036, and M-041) 2

d) Apply a one (1) "g" downward load to entire piping system model

e) Use resulting hanger reactions (along with thermal displacements) to properly size spring hangers

NOTE: For reanalysis, actual spring stiffness should be used in lieu of steps a & b to minimize field changes.

Hydro Test Condition

a) Include items a, b, and d from above

b) Specify weights of piping, components and their respective contents and insulation to agree with the hydrostatic test (or hydro) condition

Thermal Uplift Condition

a) Identify those conditions in which thermal expansion may relieve piping support reactions produced by deadweight.

b) Analyze pipe for both cold and hot deadweight conditions.

7.3 Thermal Analysis

All operating thermal transients shall be investigated and the worst case transient(s) shall be selected for analysis. The following items apply to thermal analyses:

o Material moduli (i.e., E and G) shall be consistent with pipe temperature for expansion or contraction (EH) for support loads and room temperature (EC) for pipe stress.

- The mean coefficient of thermal expansion shall be specified.
- The nominal pipe wall thickness shall be used.
- Thermal anchor displacement shall be incorporated.
- Snubbers and spring hangers shall be inactive in the model.

All other supports and restraints shall be represented by appropriate springs and boundary conditions.

Note: When performing stress analysis, the analyst should consider replacement of snubbers having less than a sixteenth of an inch axial thermal movement using a rigid restraint (with approval of client). When using as-built spring settings, the force input should be the "HOT load" spring setting unless noted otherwise on the load data sheet. 2

- Ambient temperature of 70°F shall be assumed. When operating temperatures are higher and lower than ambient, the support design shall consider independently the loads from the higher and lower operating temperature ranges of the system, so as to avoid overly conservative support design loads.

Note: In some cases a temperature lower than 70°F was not used in the computation of stresses due to the judgement of conservatism in the thermal analysis (Reference 8). When reanalyzing existing lines this lower temperature case should be included in the stress range computation.

7.4 Cold Spring Analysis

Thermal analysis techniques shall be employed to simulate the cold spring condition. The data contained in the following table are presented to simulate either a "cut short" (shortened pipe section) or "cut long" (lengthened pipe section) segment of pipe with cut of length L:

Type of cold spring	Coefficient of thermal expansion (in/inoF)	T (oF)
cut short	1000. X 10-6	-1000.
cut long	1000. X 10-6	1000.

Piping systems containing a cut short or cut long spring shall be analyzed for both the cold and hot conditions as specified below:

Cold

- Cold material modulii shall be used
- Thermal properties are specified only for the "cut short" or "cut long" elements (See above table).

Hot

- Hot material modulii shall be used
- Actual thermal anchor displacements are specified if applicable
- Actual thermal properties consistent with the condition under study are specified for all pipe segments except for the "cut short" or "cut long" elements which utilize the data from the above table.

The thermal stress range experienced by any particular pipe segment is unaffected by the presence of a "cut short" or "cut long" condition.

The range shall be determined from the cold and hot condition analyses just described or the range shall be determined from a thermal expansion analysis employing the system's original configuration with no regard to the cut.

No credit for cold spring is allowed with regard to pipe stress. A reduced reaction load credit for cold spring is allowed in the calculation of force and moments acting on equipment in accordance with USAS B31.1, 1967 Power Piping Code.

7.5 Seismic Analysis

When performing seismic analyses, the analyst shall select either the Modal Response Spectra method (Detailed Computer) or an appropriate Other Design Technique. (The analyst should consult PTG-10 prior to choosing a reanalysis technique to ensure that project guidelines are met. For example, PTG-10 allows additional techniques such as multilevel response spectra analysis while invoking additional requirements such as minimum mass participation percentages.) The analyst shall consult Table I, Section 3 of this criteria document to determine the method required for any particular piping system. 2

7.5.1 Modal Response Spectra Method

The following procedure shall be employed to perform the modal analysis:

- Ensure that all active supports (snubbers and rigids) are represented
- Include number of modes to a system frequency cutoff of 20 Hz with no "missing mass" correction considered.

Caution: Analyst should not remove seismic supports when reanalyzing existing system using 20 Hz criteria.

- Determine earthquake level to be analyzed, i.e., OBE and DBE loads and stresses. For horizontal DBE either an analysis using the DBE response spectra curves may be used or a factor of 2.0 times OBE may be conservatively used if no DBE curves exist. A factor of less than 2.0 but greater than or equal to 1.2 may be used based on a comparison of DBE to OBE response spectra curves for the specific structure and elevation (Ref. 6 & 11).

- Develop envelope ARS from the individual support's ARS. An envelope shall be generated for each of three mutually perpendicular directions corresponding to the X, Y, Z, coordinate system.

  The envelope must be developed such that the envelope acceleration is equal to or exceeds each individual support's acceleration in any of the three coordinate directions for all frequencies. While identifying the individual support A.R.S., if a specific A.R.S. is not available at the support elevation an envelope of the higher and lower response spectra elevation curves of the piping system should be used. An interpolated response spectra curve is acceptable for reduced conservatism.

- Use Amplified Response Spectra (ARS) piping curves using OBE with 0.5 percent damping and horizontal ground acceleration of 0.08g, also, DBE with 2.0 percent damping and horizontal ground acceleration of 0.16 g for the specific structure and elevation being evaluated (Ref. 11). Vertical acceleration is 2/3 of horizontal ground acceleration for OBE and 4/3 of horizontal ground acceleration for DBE, for all structures at all elevations.

- Specify the acceleration level for each system frequency for each earthquake direction.

- Determine modal inertial forces for each degree of freedom for each mode and for each earthquake direction.

- Apply modal inertial loads to obtain modal responses, i.e., node displacements, support reactions, and member end body forces and moments.

- Combine modal responses for each earthquake direction by summing all modes by the square-root--sum-of-the--squares (SRSS) method, (References 4 and 6).

- Determine final resultant seismic responses by combining each horizontal direction response (X or Z) with the vertical direction (Y) by the square-root-of-the-sum-of-the-squares (SRSS) method, and use the worst result of E1 or E2.

Where, $E1 = (Ex^2 + Ey^2)^{1/2}$

$E2 = (Ez^2 + Ey^2)^{1/2}$

Note: During the initial phases of the I.E. Bulletins 79-07 and 79-14 reanalysis the loads were tabulated with a 1.38 seismic multiplication factor. The 1.38 factor was included to conservatively address some NRC concerns utilizing absolute summation versus square root of the sum of the squares summation of modes for a two directional earthquake analysis. The use of this factor was later found not to be required (Reference 9).

An alternate procedure to perform the modal analysis is as follows:

- Use a response spectra method utilizing the alternate damping criteria of the ASME Code Case N-411. (optional) | 2
- A three-dimensional square root of the sum of the squares (SRSS) earthquake combination will be used in lieu of a two-dimensional SRSS combination.
- Regulatory Guide 1.92 modal combinations accounting for closely-spaced modes will be used in lieu of a straight SRSS of all modes.
- A rigid cutoff frequency of 33 Hz will be used in lieu of 20 Hz.
- Missing mass shall be included | 2

Note: The use of these upgrades for use at the Brunswick Plant, Units 1 and 2 are consistent with design methodology being accepted by the NRC staff for plants currently undergoing licensing review and is acceptable per NRC letter Docket No. 50-325/324 from Mr. Harold R. Denton to Mr. E. E. Utley, dated 8/28/85. The conditions set forth in this letter shall be followed.

7.5.2 Seismic Anchor Displacements (SAD)

Seismic anchor displacements from structures shall be evaluated and used in the analysis unless considered to be insignificant. SAD were analyzed at the drywell and suppression chamber penetrations (see Section 7.7). (Anchor displacements may be obtained from Reference 17.) | 2

7.6 Flow Transient Analysis

Piping response to flow transients shall be analyzed by either static or time history methods. Both methods require the application of piping reaction forces at elbows and at other locations where flow obstructions exist. Piping systems reanalyzed during the Piping Turnover Program will only consider transients previously run by United Engineers. 2

Examples of flow transients include the following:

- Steamhammer
- Waterhammer
- Safety Valve Discharge

If the piping response to a flow transient is to be determined by static methods, a dynamic load factor (DLF) shall be included by applying all transient reaction forces to the system with a DLF of 2.0.

(Although not used on Brunswick, Lower DLF values can be utilized if substantiated by Analyses.)

In lieu of static approaches, time history methods may be used. To perform a time history analysis, the analyst shall apply time history forcing functions to a representative mathematical model utilizing such programs as ADLPIPE, NUPIPE or STARDYNE.

Analyses of relief valve blowdown lines were performed using General Electric Co. supplied blowdown forcing functions. 2

7.7 (PAD & TAD) Displacement Analysis

Static displacement analyses shall be performed for those piping systems connected to the Drywell and Suppression Chamber or to equipment nozzles which experience motion from internal pressure or thermal loads. (Ref. 10, 17, and 21). 2

The analyst shall impose the appropriate displacement on the piping system and combine the resulting stresses with others according to the requirements of Appendix A, Table A1.

7.8 Fatigue Analysis

Fatigue analysis per USAS B31.1, 1967 code is considered in the determination of the stress reduction factor (f) for cyclic conditions in Para. 102.3.2 (c).

7.9 Other Analyses

7.9.1 Pipe Rupture Analysis

Automatic isolation valves in systems connected to the reactor coolant pressure boundary system, and located outside the primary containment, are protected by pipe whip restraints downstream to insure the integrity and operability of the valve. This will prevent an uncontrolled loss of coolant outside the primary containment and subsequent release in excess of the limits of 10 CFR 100. For those portions of piping extending from the penetration to the first outside isolation valve, pipe breaks need not be postulated provided such piping is conservatively stressed and restrained beyond the valve such that, in the event of a postulated pipe break outside containment, the transmitted pipe loads will neither impair the operability of the valve nor the integrity of the piping or the containment penetration. In order to meet this criteria the Loading combinations and the stress limits of Appendix A, Table A1 must be maintained. (A terminal end of such piping is considered to originate at the pipe whip restraint location.)

7.9.2 Wind Load Analysis

Pipe Systems exposed to atmospheric conditions are analyzed for wind effect utilizing an approach that is similar to ASCE Paper No. 3269, 1961.

Shielding effects by other structures are not considered in this analysis.

A uniformly distributed load in the horizontal (North-South and East-West) direction is applied to the piping that is exposed to wind. The magnitude of this uniform load is generated on the basis of a wind pressure acting on the projected area of the pipe, including insulation where applicable.

A gust factor of 1.0 is utilized and the uniform distributed load for a cylindrical structure is given by:

$$F = \frac{q}{A}$$

where: F = uniform distributed load (lb/ft)

q = wind pressure = ($.00256V^2$

A = projected area (ft^2) of a one foot length of pipe

V = wind velocity (mph)

8.0 LOADING COMBINATIONS AND SUMMARY OF RESULTS

The results of the various loading analyses presented in the previous Section require further evaluation. Since some of the loading conditions act simultaneously, they must be superimposed to obtain resultant loads for different operating and design conditions. The subsequent paragraphs address loading combinations and stress evaluations required by power plant piping systems.

8.1 Loading Combinations, Stress Summaries, and Stress Reports

Table A1 of Appendix A presents typical load combinations and corresponding stress limits and recommended stress summary format for USAS B31.1 Class I seismically designed piping. Table A2 presents the nomenclature used in the previous tables. 2

The load combinations and stress limits presented in Appendix A are based on USAS B31.1, 1967 code.

The purpose of a stress summary sheet is to demonstrate code compliance by tabulation of the piping stresses experienced at node points in the piping system under evaluation as compared with allowable stress limits. A tabulation should be made for each different type of piping found in the system. For example, if the piping system undergoes a material change from one segment to another then a summary is required for each different type of piping. Stresses may be tabulated and combined at a coincident point in lieu of maximum stresses.

8.2 Equipment and Component Loads

In addition to piping loads, other required information is generated during the piping loading analysis. Following is a list of items which are required from the various loading analyses:

- Support and restraint loads
- Loads on equipment nozzles
- Loads on In-Line components (when required, such as, flanges)
- Valve operator accelerations
- Displacements at supports and restraint locations
- Integral attachment (welded)

9.0 DOCUMENTATION REQUIREMENTS

Analysis packages shall be prepared for all piping system analyses to maintain proper documentation. Piping stress analysis calculations completed by UE&C as part of the N.R.C. Bulletins I.E. 79-07 and 79-14 shall meet the documentation requirements of CPL-PP-01 (for temporary documentation) and will be upgraded to comply with CPL-PP-02 (for final documentation). Piping stress analysis calculations performed by CP&L's Piping Turnover Group should meet the requirements of PTG-4, Piping Turnover Guide for Pipe Stress Analysis. 2

10.0 REFERENCES

1. USAS/ANSI B31.1 Power Piping Code, 1967 & 1973.
2. NEDO-24583-1, "Mark I Containment Program, Structural Acceptance Criteria, Plant Unique Analysis Application Guide", October 1979, General Electric Company, San Jose, CA
3. NEDO-21888, "Mark I Containment Program Load Definition Report", November 1981, General Electric Company, San Jose, CA
4. CP&L Co., BSEP - Final Safety Analysis Report
5. ASME Publication, "On Mass-Lumping Technique for Seismic Analysis of Piping"; John K. Lin, Adolph T. Molin, and Eric N. Liao; December, 1976.
6. Letter: from E. E. Utley, Executive President of C.P. & L. Co. to T. A. Ippolito, Chief of O.R.B. #3, N.R.C., dated May 29, 1979.
7. Response to RPU-101: from L. R. Scott, Project Manager for U.E. & C. to W. P. Tomlinson, C. P. & L. Co., dated January 18, 1984.
8. Response to Technical Evaluation Item I.A.1: from L. R. Scott, Project Manager for U. E. & C. to P. W. Howe, Vice President of C. P. & L. Co. BESU, dated February 8, 1984.
9. NRC Memorandum: from R. B. Bevan, Project Manager of O.R.B. #3 to T. A. Ippolito, Chief of O.R.B. #3, N.R.C., dated June 12, 1979.
10. CP&L Co. - BSEP, Design Report No. 7, dated 12-31-70
11. CP&L Co. - BSEP, DBD No. DBD-BXX-XXX-DBD-02, Rev. 0
12. CP&L - GMEDP-0000 (List of Definition of Terms and Acronyms.)
13. Study Report - Valve Input Data, 7992.001-S-M-031
14. Study Report - Valve Operator Frequencies, 7992.001-S-M-032
15. Study Report - Documentation of Seismic Class I Boundary Conditions, 7992.001-S-M-034 2

16. Study Report - Piping Insulation Deviation Review, 7992.001-S-M-036

17. Study Report - Reactor Building Piping - Anchor Displacements, 7992.001-S-M-040

18. Study Report - Review of System Pressure and Temperature Conditions, 7992.001-S-M-041

19. Calculation 9527-8-SS-90-F, "Link Seal Breakaway Axial Force"

20. Calculation 9527-8-SS-91-F, "Link Seal Radial Capacity"

21. Calculation 9527-8-SS-92-F, "Equipment Nozzle Displacement"

22. Study Report - Bearing Stress, 7992.001-S-M-039

23. Study Report - Flange Joint Qualifications, 7992.001-S-M-033

24. Brunswick Piping/Support Analysis Issues, PTG-10 2

25. Design and Analysis of Welding Pipe Attachments for the Harris Nuclear Project, NED Design Guide No. DG-II.12.

APPENDIX A

LOAD COMBINATIONS, STRESS LIMITS

and

STRESS SUMMARY TABLES

CONTENTS

TABLE A1

USAS B31.1 - CLASS I SEISMICALLY DESIGNED PIPING SYSTEMS
LOAD COMBINATIONS & STRESS LIMITS

PLANT CONDITION	LOAD COMBINATION	LIMITS (1)
DESIGN	P	Sh
NORMAL	P + D	Sh
	T (2)	Sa
	OR	
	P + D + T	Sh + SA
UPSET	P+D + $(TR^2 + OBE^2)^{1/2}$ (3)	1.2 Sh
	P+D + T +SAD $_{OBE}$	Sh + Sa
EMERGENCY OR FAULTED	P+D + $(TR^2 + DBE^2)^{1/2}$ (3)	1.8 Sh
	P+D+T+PAD+TAD+SAD $_{DBE}$	Sh + Sa
STRUCTURAL INTEGRITY EVALUATION	P+D+$(TR^2 + DBE^2)^{1/2}$	?.4 Sh
PIPE RUPTURE/ SEISMIC BOUNDARY	P+D + OBE+T+SAD $_{OBE}$	.8 (Sh + Sa)
	P + D + DBE + PP	1.8 Sh

Notes: (1) Pipe stress limits are derived from the code of record USAS B31.1, 1967 and F.S.A.R. commitments.
(2) Thermal Stress (T) should consider the maximum temperature range.
(3) Wind load piping stresses should be considered for Upset and Emergency Conditions in lieu of OBE, DBE and transient piping stresses.

TABLE A2

TERMINOLOGY AND NOTATIONS

Symbols for Stress Classification and Stress Limits are in accordance with ASME Section III. Other load symbols and definitions are specified below:

P - Internal Design Pressure

P_{MAX} - Peak Pressure, considered as a set pressure of over-pressure safety devices

P_t - Test Pressure

D - Deadweight, consist of the weight of the pipe and pipe supported elements such as valves and flanges, including weight of insulation and contained fluid

D_t - Same as 'D' where pipe contents are f uid during pressure test

T - Thermal Loads due:

a. Range of piping thermal expansion when subjected to maximum + or - temperature difference between the fluid and the surrounding environment in the specified plant conditions, and

b. anchor displacement due to thermal movements of piping anchors.

TR(P*) - Thrust or Transient due to safety valve discharge, valve trip or fluid flow

SAD - Seismic Anchor Displacement (OBE or DBE), affects piping supported from different structures of relative seismic motions

PAD - Anchor Displacement due to pressure, e.g., containment bldg. penetrations due to internal pressure during test or LOCA

W - Wind Loads

TABLE A2 (Continued)

TAD - Anchor Displacement due to thermal growth of the structure, e.g., radial and vertical growth of containment bldg.

OBE (E)- Loads generated by the Operating Basis Earthquake (OBE), which is the earthquake that could reasonably be expected to affect the plant site during the operating life of the plant and which produced the vibratory ground motion for which those features of the nuclear plant necessary for continued operation without undue risk to the health and safety of the public have been designed to remain functional.

DBE(E')- Loads generated by the Design Basis Earthquake (DBE) which is the earthquake that produces the maximum vibratory ground motion for which certain structures, systems, and components important to safety and required for safe shutdown of the plant have been designed to remain functional.

PR - Pipe Rupture Loads due to a postulated pipe break.

APPENDIX B

UE&C PIPING SYSTEM

TOLERANCES

UE&C PIPING SYSTEM TOLERANCES
APPENDIX B

Acceptable Tolerances

1.0 These tolerances are "total tolerances" and represent any installation tolerances allowed by specifications plus the reconciliation tolerances. Care must be exercised to assure that the installation tolerances are not added to these provided tolerances while reconciling the "As-Constructed" condition with the analysis model of record. When the "As-Constructed" condition is within the following tolerances, as compared to the analysis model of record, the stress analysis shall be considered reconciled. For current installation tolerances, reference CU-12152.

1.1 Piping Configuration

a) Deviation in the locating dimensions (along the pipe centerline) of fittings (except branch connections), flanges, valves, piping specialities and other in-line components, shall be as follows:

Specified Dimension (feet)	Tolerance (inches)
0 to 5	± 3
5 to 10	± 6
10 to 15	± 9
15 to 20	± 12
20 to 25	± 15
25 to 30	± 18
30 to 35	± 21
35 and over	± 24

b) The tolerances in 1.1a) above apply to the locating dimensions of the centerline of branch connections provided that the functional location as specified by the P&ID or any design document are met. With due consideration to the effect of any anchor movement on the branch pipe, the following additional tolerances may be acceptable:

	Tolerance
o For branch/run size combination indicated by "X" in Table B.1 (Note: Tolerances stated in A) above must also be met on the configuration of the branch piping)	No tolerance is required if the Stress Intensification Factor is equal to 1.0. If SIF is greater than 1.0, then tolerance is ± 24 inches.

o For branch/run size combinations <u>not</u> indicated by "X" in Table B.1, See 1.1a) above.

c) Deviation in the angular orientation of pipe legs shall be ± 10 degrees for all pipe sizes. Angular orientation need not be verified if the tolerances in 1.1a) above are augmented with verification of support location.

d) Deviation in the angular orientation of power operated valves or valves with manual gear operators when gear operators are a significant offset mass as compared to the valve weight shall be ± 15 degrees. This is applicable to 2" NPS and smaller valves only when the operator weight is less than or equal to the as-analyzed weight of the valve body.

When the operator weight is greater than the as-analyzed weight of the valve body, the angular orientation shall be ± 5 degrees.

UE&C PIPING SYSTEM TOLERANCES

APPENDIX B

TABLE B.1

Run Size (Inches)	Branch Size (Inches) 3/4	1	1 1/2	2	2 1/2	3
3/4						
1						
1 1/2						
2						
2 1/2						
3	X					
4	X	X				
6	X	X				
8	X	X	X	X		
10	X	X	X	X	X	X
12	X	X	X	X	X	X
14	X	X	X	X	X	X
16	X	X	X	X	X	X
18	X	X	X	X	X	X
20	X	X	X	X	X	X
24	X	X	X	X	X	X

UE&C PIPING SYSTEM TOLERANCES

APPENDIX B

1.2 Component Weights

	Tolerance
A) Uniformly distributed weight	± 20% of analyzed weight
B) Concentrated Weight	± 20% of analyzed weight

1.3 Pipe Supports

	Tolerance
a) Deviation in the location of supports/restraints along horizontal or vertical pipe centerline for supports on straight pipe between bends, ells or terminal ends	Table B.2, Column I
b) Deviation in the location of supports/restraints for the nearest support/restraint adjacent to valves, flanges, risers, ells, bends, or other concentrated loads except for the following:	Table B.2, Column II
1) Support/Restraint is part of a full or partial anchor.	Table B.2, Column V
2) Support/Restraint is adjacent to and acts in direction of long (3 x seismic span) pipe run.	Table B.2, Column IV where "+" direction is toward fitting. (elbow, bend, etc.)

UE&C PIPING SYSTEM TOLERANCES

APPENDIX B

1.3 Pipe Supports (Continued)

	Tolerance
3) Support/restraint on both sides of motor operated valve and locating dimension to valve is less than 10 pipe diameters.	Table B.2, Column III where "+" direction is away from valve.
c) First support/restraint adjacent to active equipment nozzle. or/locating dimension is equal to or less than 10 pipe diameters from any equipment nozzle.	Table B.2, Column III where "+" direction is away from nozzle.
d) First support/restraint adjacent to passive equipment nozzles or whose locating dimension is greater than 10 pipe diameters to the nozzle.	Table B.2, Column III where "+" direction is away from nozzle.
e) Deviation in the location of axial snubber along pipe center line.	Anywhere along pipe leg
f) Deviation in the angular orientation of vertical weight supports, rod, variable and constant spring supports, hangers and struts.	$\pm$ 5 degrees. Except 10 degrees may be used if it can be shown that this does not violate manufacturer's recommendations relative to support function.

UE&C PIPING SYSTEM TOLERANCES

APPENDIX B

1.3 Pipe Supports (Continued)

	Tolerance
g) Deviation in the angular orientation of piping restraints other than vertical.	± 5 degrees. Except 10 may be used if it can be shown that this does not violate manufacturer's recommendations relative to support function.

UE&C PIPING SYSTEM TOLERANCES

APPENDIX B

TABLE B.2

	I	II	III	IV	V
3/4	± 6	± 3	- 1 1/2, + 3	± 3	± 1 1/2
1	± 6	± 3	- 1 1/2, + 3	± 3	± 1 1/2
1 1/2	± 6	± 4 1/2	- 1 1/2, + 3	± 3	± 1 1/2
2	± 6	± 6	- 1 1/2, + 3	± 3	± 1 1/2
2 1/2	± 12	± 7 1/2	- 1 1/2, + 6	- 3, +6	± 1 1/2
3	± 12	± 9	- 1 1/2, + 6	- 3, +6	± 1 1/2
4	± 12	± 12	- 2, + 6	- 4, +6	± 2
6	± 12	± 12	- 3, + 6	± 6	± 3
8	± 12	± 12	- 4, + 6	± 6	± 4
10	± 12	± 12	- 5, + 6	± 10	± 5
12	± 12	± 12	± 6	± 12	± 6
14	± 14	± 14	± 7	± 14	± 7
16	± 16	± 16	± 8	± 16	± 8
18	± 18	± 18	± 9	± 18	± 9
20	± 20	± 20	± 10	± 20	± 10
24	± 24	± 24	± 12	± 24	± 12
30	± 30	± 30	± 15	± 30	± 15

UE&C PIPING SYSTEM TOLERANCES

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The following are the areas of difference between UE&C and PVRC tolerances:

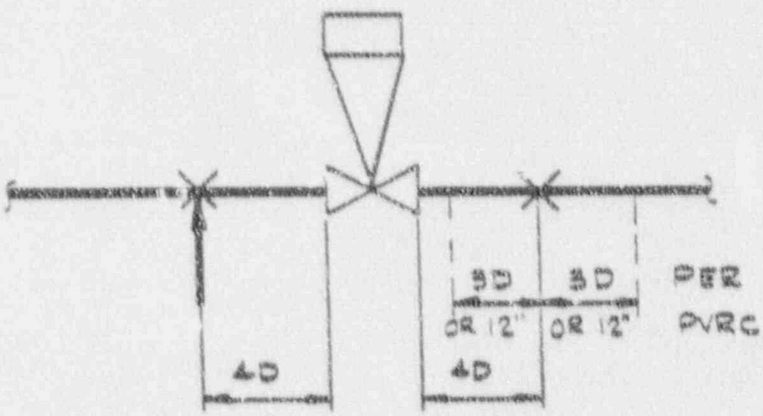
1) Reference:

A. UE&C Tolerances, paragraph 1.3.b), Pipe Supports

B. PVRC Tolerances, Table 1.0, (B), Piping Supports

The above two references are in agreement except for certain specific arrangements as identified by reference A. For these cases, application of the PVRC tolerances has the potential of significantly changing the loading of adjacent pipe supports.

Example:



If PVRC is used, the support can be moved as much as 3 diameters toward a concentrated load which would force the support to pick up the greater portion, if not all, of the load. By limiting the tolerance to 1/2 diameter toward the valve the effect on the loads on the adjacent supports is minimized. Each of the three exceptions in UE&C paragraph 1.3,(b) are based on this same concept. In addition, for the anchor case, the effect on the function of the assembly is minimized.

UE&C PIPING SYSTEM TOLERANCES

APPENDIX B

2) References

A. UE&C Tolerances, paragraph 1.3,c) Pipe Supports

B. PVRC Tolerances, Table 1.0, (C), Piping Supports

This difference deals with the location of the first support when it is located at or within 10 pipe diameters of nozzles on active equipment.

The load on nozzles of this type are very critical for Design. Therefore, the PVRC tolerance has been reduced to minimize the effect of the nozzle load variations.

3) References

A. UE&C Tolerances, paragraph 1.1,b), Piping Configuration (also see TABLE B.1)

B. PVRC Tolerances, Table 2.0

The difference between these two sets of piping branch/run ratios is as follows:

a. UE&C Tolerances consider a more restrictive piping branch/run ratio for section modulus (Z) of equal to or less than 1/20 (0.05).

b. PVRC Tolerances consider a piping branch/run ratio for moment of inertia (I) of equal to or less than 1/25 (0.04).

The difference has been implemented for the following reasons:

- The UE&C Tolerances are consistant with the approach used by UE&C in the past.
- Since PVRC allows larger pipes to be decoupled, there is an increased possibility that the NRC would question the method used for the decoupled piping boundary conditions. The NRC has recommended a method that is very conservative (See NUREG CR-1980) and is not 100% consistent with the UE&C method. Note that most A/E's have argued against the NRC method.

APPENDIX C

JUSTIFICATION OF ACCEPTANCE TOLERANCE

for

SNUBBER AND STRUT ORIENTATIONS

APPENDIX C

Justification of the Acceptance Tolerance of a 15 Deviation from the Analyzed Angle for Snubbers and Struts

During the overall review of as-built snubber and strut orientations for BSEP in 1982 (reference the potential 10CFR21 reported to the NRC on August 14, 1982), it was decided to utilize an acceptance tolerance of 15^o from the analyzed angle before reanalysis would be required. It was decided that 15^o was the maximum deviation that would generically result in changes to the pipe stresses or support loads that could be accepted without modifications to the physical plant.

Justification of the use of 15^o for the allowable angle deviation was based on the results of the sizable number of reanalyses involving isometrics with snubber/strut orientation deviations greater than 15.

TABLE C.1

Review of all Isometrics Inside the Drywell

Unit	Number of Supports with Increased Loads	Number of Support Fixes Required
2	103 (UC-33373)	9 (UC-33296) (1)
1	103 (UC-33373)	2 (UC-33302)
	206	11(2)

As Table C.1 demonstrates only 5% of the supports that had load increases required actual modification and none of the supports required a "Short Term" fix.

In addition, it is believed that if conservatisms were removed from the analysis methodology, for example use of low damping or if a test was done, many of the identified fixes would not have been required.

NOTES: (1) Total includes 2 found from review of Pipe Support Group data
(2) No Short Term Fixes required but four were determined to effect operability.

APPENDIX C

Justification of the Acceptance Tolerance of a 15 Deviation from the Analyzed Angle for Snubbers and Struts (Continued)

Note: Any specific analysis review done subsequently to the generic review, (i.e., for plant modifications etc.), should not use this tolerance but should review against the tolerance in Study Reports 7865.007-S-M-020 Appendix B and 7865.007-S-M-021.

APPENDIX D

STRESS ANALYSIS STUDY REPORTS

APPENDIX D - INDEX

APPENDIX E

CLARIFICATION OF VARIOUS CODE REQUIREMENTS AND PROCEDURES

INTRODUCTION

In an effort to establish a consistent and technically accurate piping analysis phase II program, a study of FSAR, USFAR, and code requirements as well as UE&C's past practices and procedures has been made. The following paragraphs describe and document this study.

USAS B31.1 1967 vs. ANSI B31.1 1973 SUMMER ADDENDA.

UE&C chose to use the 1973 edition of the code in their computer runs to automatically accommodate the 25% reduction in the intensification factor for primary stresses. They justified this by pointing out that the '67 edition does not clearly state what if any i or fraction of i was to be used for primary stresses. Also, because other editions of the code use the 25% reduction, it was deemed acceptable. (Ref. UE&C response to letter RPU-0101 1-18-84 dated 6-14-83). To avoid intensification problems with reducers, butt welds on straight pipe, valves, and socket weld elbows, (see Table E1) UE&C substituted these items in the geometry input with items that simulated the properties but reflected the desired SIF from the '67 code of record. Aside from the 25% reduction in the SIF for primary stresses, the values themselves are computed differently in each edition of the code. (See Table E2). The equation for expansion stresses in the '67 code is:

$$S_e = (iS_b^2 + 4S_t^2)^{1/2} \qquad (1)$$

where S_b is the combined bending stresses and S_t is the torsional stress. Note that the torsional stress is not intensified.
In the '73 code:

$$S_e = i\,\frac{Mc}{Z} \qquad (2)$$

where Mc is the combined bending and torsional moments. Note that i intensifies all three moments.
For primary stress computation, the '67 code implies the same equation (1). The full i being applied to the bending stresses of sustained and occasional loads. The '73 edition uses the .75 factor as shown below:

$$S = \frac{.75iMa}{Z} \qquad (3)$$

where Ma is the SRSS combination of bending and torsion moments.

NOTE: .75 i can never be taken as less than 1.0.

2D EARTHQUAKE

Some confusion existed on the proper implementation of a 2D earthquake analysis for stress computation and support load summary generation. A telephone conversation with Bob Harris of UE&C on 6-29-87 clarified their position and procedure. UE&C did not run any seismic load combinations with the computer. Each direction of seismic analysis "xy" and "yz" was considered separately. The highest stress from either direction was used for comparison with code stress allowables. Computer calculated load combinations from outputs of ADL-E and NUPIPE will not yield the same results if the computer programs envelope the moments from each direction first and then compute stresses, thereby yielding a higher value. For support load developement UE&C initially enveloped the loads from both seismic runs. If the enveloped loads created support design problems, they would go back and consider each seismic load set separately.

MODAL SUMMATION METHOD

Initially, the modal summation method was algebraic sum. Presently and during IE Bulletin re-analysis, it is SRSS regardless of modal spacing.

SOURCE OF ALLOWABLE STRESSES

The FSAR and the USFAR both state that the allowable stress values are to be obtained as follows:

(a) For carbon steel, the allowable stress values of USAS B31.1 were used. For materials not covered by USAS B31.1, the stress values of the ASME Boiler and Pressure Vessel Code were used, as applicable.

(b) For Austenitic stainless steel, the allowable stress values of USAS B31.1, the higher stress values of the ASME Boiler and Pressure Vessel Code, Section I, Appendix A-24, or Section VIII, were used. UE&C has interpreted this to mean that when material is not listed in the '67 B31.1 edition of record, later B31.1 editions may be referenced before going to the ASME code. Thus UE&C has used the 1973 B31.1 edition to come up with allowable stress values not found in the '67 edition. (Ref. Tables III thru VIII).

OBE/DBE CONVERSION FACTOR

During the 79-07/14 re-analysis of piping, in an effort to reduce the number of analyses, the OBE stresses were multiplied by a factor of 2.0 to obtain DBE stresses. However, a comparison of OBE vs. DBE ARS curves in the frequency range of interest (4-10Hz) a factor of 1.2 was shown to be more appropriate. This factor was then used throughout the balance of the 79-14 effort to convert OBE to DBE stresses. This approach had added conservatism because the April 1972 interim curves were used. This factor of 1.2 has since been found inappropriate in certain cases.

SOURCE OF ALLOWABLE STRESSES

It is concluded that to avoid confusion with regard to the source of allowable stresses, the method used by UE&C will be continued. If a material is not specified in the '67 code of record, the '73 code summer addenda will be referenced. If the material allowables are still not found then subsequent ANSI editions will be referenced before referencing the ASME code. (Ref Tables E3 through E7 of this appendix for allowables).

OBE/DBE CONVERSION FACTOR

It is the intent of the Phase II program to run both the OBE and DBE seismic cases for all analysis/reanalysis. However, if this is not done, a conversion factor of 1.2 to 2.0 may be used if its use results in a generated DBE curve that envelopes the existing DBE curve in the areas of interest. (Ref: BSEP SPEC. NO. 005-011).

ADL-E/NUPIPE TEST RUN

In an effort to establish confidence in the stress analysis computer programs to be used in Phase II, a Study Run of Problem N22 (Sht 22, G31) was made for the purpose of checking the input requirements, similarities, differences, methods, and output between ADL-E and NUPIPE using the '67 code vs the '73 code. All input was checked and determined to be as close to identical as possible for each case.

SUPPORT ECCENTRICITIES:

UE&C did not consider support eccentricities in their analyses. Per their study report 79[illegible],001-S-M-035, a review of the effects of eccentric loads was performed. The results of this report show that the effect on pipe stress is generally small (up to 12% in one case). This may or may not be a problem depending on the existing stress level. The effect on support integrity is not so easy to define since there are numerous variables that affects the results. UE&C has therefore suggested that supports be reviewed on a case by case basis.

CONCLUSION:

The desired result of this study was to clarify specific items that affect procedures and methods to be used in Phase II of the Piping Design Turnover Program. The following conclusions will be used as a guide to the analysis/re-analyses of piping systems. In no way does it overrule or take precedence over any controlled document.

USAS B31.1 1967 vs. ANSI B31.1 1973 SUMMER ADDENDA.

It is concluded that Phase II computer analyses/reanalyses using the NUPIPE ADLPIPE computer program should utilize the '67 code option. This option will compute stresses as required by the code except where an intensification factor is required. The '67 option uses the full i when computing primary stresses. This is conservative and may be used as is if no overstressing exists. However, if an overstress occurs due to the primary stress level, a 25% reduction of the primary stresses may be calculated by hand and re-checked to the appropriate allowables. $(.75i < 1.0)$

2D EARTHQUAKE

It is concluded that the past method of computing seismic stresses for 2D analyses shall be continued. Separate seismic runs for xy and yz should be made and the max stress obtained by choosing the highest of either direction. The use of stress combinations by computer may be used since the method is not unconservative. For support loads, the minimum requirement for seismic loads is to consider the load set for each direction as part of a separate load case. The use of the computer load combination set is conservative if it envelopes the two direction load sets into one.

MODAL SUMMATION METHOD

In order to simulate a straight SRSS modal summation regardless of mode spacing, the following options should be used:

For ADL-E, a PERMODE value of .01 and a reg. guide specification of 1.70 should be input on the shock card. For NUPIPE, a value of -1 in the NPR field of the second control card should be used.

During a review of the thermal case for ADL-E '73 vs '67 it was noticed that all the stresses for the '67 run were at least 9% lower than for the '73 run. A check of the internal forces revealed no differences in values. Therefore, it must be in the way the stresses were calculated. However, since the expansion stress equations for '73 and '67 differ only when the SIF is not equal to 1, the stresses should be different only at intensified nodes.

$$S_E = \frac{\left[(iM_x)^2 + (iM_y)^2 + M_z^2\right]^{1/2}}{Z} \qquad ('67)$$

$$S_E = \frac{i(M_x^2 + M_y^2 + M_z^2)^{1/2}}{Z} \qquad ('73)$$

The same thing seems to be happening with NUPIPE. The NUPIPE '67 thermal stresses are higher than the '73 stresses at all nodes, not just at intensified nodes as would be expected.

FINDINGS:

NUPIPE II 1967

1. Uses the full i for load cases.
2. Does not intensify torsional moment.
3. Sums the number of modes specified.
4. Totally manual mass lumping is not possible.
5. Uses equation

$$Z = \frac{\pi(D^4 - d^4)}{32\ D}$$

   to compute section modulus.

NUPIPE II 1973

1. Uses the full i for secondary stresses, and .75i for primary stresses. (if $.75i \geq 1.0$)
2. Intensifies the torsional moment.
3. Sums the number of modes specified.
4. Totally manual mass lumping is not possible.
5. Uses equation

$$Z = \pi R_m^2 t_n \qquad (5)$$

   to compute the section modulus, resulting in different stress values than the '67 version.

ADL-E 1967

1. Uses the full i for all stresses.
2. Does not intensify the torsional moment.
3. Frequency cutoff overrides the number of modes in the summation process.
4. Uses equation (4) to compute thermal stresses (adverse to the code) therefore resulting in stresses that must be increased by the ratio E_c/E_h to conform to code requirements.
   (This error has been fixed on the Sun Workstation)

ADL-E 1973

1. Uses the full i for secondary stresses and .75i for primary stresses. (if .75i $\geq$ 1.0)
2. Intensifies the torsional moment.
3. Frequency cutoff overrides the number of modes on the summation process.
4. Uses equation (4) to compute section modulus.
5. Multiplies the thermal stresses by the ratio of E_c/E_h to comply with code requirements.

Item 5. for each category explains the differences found in the stress values of the test run as noted above.

PVRC ANALYSIS CRITERIA:

Brunswick requested the option to use PVRC damping per code case N-411 for their reconciliation work and support optimization in a letter dated 5-22-85 Serial # NLS-85-106. The NRC approved the request per the letter dated 8-28-85 Docket Nos. 50-325/324 with the following conditions:

1. The cut-off frequency changed to 33 Hz.
2. Modal summation changed to provisions of Reg. Guide 1.92.
3. Three directional earthquake method to be used.
4. In the event of support relocations/increased motion on existing clearances and line mounted equipment should be checked.
5. This option is applicable to Response Spectra type analyses only and when used should be used consistently within each stress problem. Also, the code case N-411 must be noted in the documentation of each stress calc that uses it.

In addition to the above requirements, it is suggested that no supports exist that are designed to absorb energy by yielding.

REFERENCES

1. USAS B31.1 1967
2. ANSI B31.1 1973 SUMMER ADDENDA
3. ADL-E USERS MANUAL
4. NUPIPE II USERS MANUAL REV M DATED 6-27-84
5. BSEP SPEC. NO 005-011
6. TELECON BESU. T-515 DATED 6-29-87
7. FSAR
8. UFSAR
9. RESPONSE TO LETTER RPU-0101 DATED 1-18-84
10. STUDY REPORT 7992.001-S-M-035
11. ANSI/ASME B31.1 1980

TABLE E1

S.I.F.

COMPONENT	1967 CODE	1973 CODE
SOCKET WELD ELBOW	1.3	2.1
TRANSITION POINTS (VALVES, FLANGES)	1.0	1.9
STRAIGHT PIPE BUTT WELDS	1.0	1.8
REDUCERS	1.0	2.0

TABLE E2

STRESS EQUATION

CONDITION	1967 CODE	1973 CODE
THERMAL	$S_e=(iS_b + 4S_t^2)^{1/2}$	$Se=\frac{iMc}{Z}$
DEADWEIGHT	$S=\left[\frac{(iM_x)^2+(iM_y)^2+(M_z)^2}{Z}\right]^{1/2}$	$S=\frac{0.75iMa}{Z}$
SEISMIC	$S=\left[\frac{(iM_x)^2+(iM_y)^2+(M_z)^2}{Z}\right]^{1/2}$	$S=\frac{0.75iMb}{Z}$

TABLE E3
(REFS. 1,2,& 11)
MATERIAL PROPERTIES TABLE FOR A106-GR. B

TEMPERATURE DEG. F	MODULUS OF ELASTICITY (X 10E6 PSI)	ALLOWABLE STRESS (X 10E3 PSI)	COEF. OF THERM. EXP. (X 10E-6 IN/IN-DEG)
0	28.352	15.000	5.913
70	27.900	15.000	6.070
100	27.850	15.000	6.142
200	27.700	15.000	6.380
300	27.400	15.000	6.600
400	27.000	15.000	6.820
500	26.400	15.000	7.020
600	25.700	15.000	7.230

TABLE E4

MATERIAL PROPERTIES TABLE FOR A312-TP316L

TEMPERATURE DEG. F	MODULUS OF ELASTICITY (X 10E6 PSI)	ALLOWABLE STRESS (X 10E3 PSI)	COEF. OF THERM. EXP. (X 10E-6 IN/IN-DEG)
0	28.300	15.600	8.988
70	28.300	15.600	9.110
100	28.254	15.600	9.163
200	28.100	15.600	9.340
300	27.500	15.600	9.470
400	26.900	15.500	9.590
500	26.300	14.400	9.700
600	25.600	13.500	9.820

TABLE E5

MATERIAL PROPERTIES TABLE FOR A312-TP304

TEMPERATURE DEG. F	MODULUS OF ELASTICITY (X 10E6 PSI)	ALLOWABLE STRESS (X 10E3 PSI)	COEF. OF THERM. EXP. (X 10E-6 IN/IN-DEG)
0	28.300	18.700	8.988
70	28.300	18.700	9.110
100	28.254	18.700	9.163
200	28.100	17.700	9.340
300	27.500	16.600	9.470
400	26.900	16.100	9.590
500	26.300	15.900	9.700
600	25.600	15.900	9.820

TABLE E6

MATERIAL PROPERTIES TABLE FOR A312-TP304H

TEMPERATURE DEG. F	MODULUS OF ELASTICITY (X 10E6 PSI)	ALLOWABLE STRESS (X 10E3 PSI)	COEF. OF THERM. EXP. (X 10E-6 IN/IN-DEG)
0	28.300	18.750	8.988
70	28.300	18.750	9.110
100	28.254	18.750	9.163
200	28.100	16.550	9.340
300	27.500	15.550	9.470
400	26.900	14.950	9.590
500	26.300	14.550	9.700
600	25.600	14.350	9.820

TABLE E7

MATERIAL PROPERTIES TABLE FOR A312-TP316

TEMPERATURE DEG. F	MODULUS OF ELASTICITY (X 10E6 PSI)	ALLOWABLE STRESS (X 10E3 PSI)	COEF. OF THERM. EXP. (X 10E-6 IN/IN-DEG)
0	28.300	18.700	8.988
70	28.300	18.700	9.110
100	28.254	18.700	9.163
200	28.100	18.700	9.340
300	27.500	18.300	9.470
400	26.900	18.000	9.590
500	26.300	17.900	9.700
600	25.600	17.000	9.820

TABLE E8

MATERIAL PROPERTIES TABLE FOR A335-P22 OR P11

TEMPERATURE DEG. F	MODULUS OF ELASTICITY (X 10E6 PSI)	ALLOWABLE STRESS (X 10E3 PSI)	COEF. OF THERM. EXP. (X 10E-6 IN/IN-DEG)
0	30.106	15.000	5.913
70	29.900	15.000	6.070
100	29.800	15.000	6.142
200	29.500	15.000	6.380
300	29.000	15.000	6.600
400	28.600	15.000	6.820
500	28.000	15.000	7.020
600	27.400	15.000	7.230

APPENDIX F

TABULATED ADLPIPE INPUTS FOR

COMMON INLINE COMPONENTS

TABLE F1

ADLPIPE MODELING OF SOCKET WELD FITTING FOR PHASE II OF THE TURNOVER PROGRAM

NOTE: THE LINEAR WEIGHTS IN THE Z6 FIELD ARE FOR UNINSULATED LINES.

CONTROL	I1	I2	(O.D.) Z1	(t) Z2	Z3	(Rc) Z4	Z5	(w) Z6	NOMINAL SIZE	RATING
4ELBOW	I1	I2	0.405	0.190		0.8750		0.09	1/8	3000#
4ELBOW	I1	I2	0.540	0.238		0.8750		0.09	1/4	3000#
4ELBOW	I1	I2	0.675	0.252		0.9688		0.16	3/8	3000#
4ELBOW	I1	I2	0.840	0.294		1.1250		0.28	1/2	3000#
4ELBOW	I1	I2	1.050	0.308		1.3125		0.33	3/4	3000#
4ELBOW	I1	I2	1.315	0.358		1.5000		0.56	1	3000#
4ELBOW	I1	I2	1.660	0.382		1.7500		0.57	1-1/4	3000#
4ELBOW	I1	I2	1.900	0.400		2.0000		0.60	1-1/2	3000#
4ELBOW	I1	I2	2.375	0.436		2.3750		0.87	2	3000#
4ELBOW	I1	I2	2.875	0.552		3.0000		1.25	2-1/2	3000#
4ELBOW	I1	I2	3.500	0.600		3.3750		1.93	3	3000#
4ELBOW	I1	I2	4.500	0.674		4.1875		3.15	4	3000#
4ELBOW	I1	I2	0.840	0.374		1.3125		0.45	1/2	6000#
4ELBOW	I1	I2	1.050	0.456		1.5000		0.61	3/4	6000#
4ELBOW	I1	I2	1.315	0.500		1.7500		0.82	1	6000#
4ELBOW	I1	I2	1.660	0.500		2.0000		1.01	1-1/4	6000#
4ELBOW	I1	I2	1.900	0.562		2.3750		1.41	1-1/2	6000#
4ELBOW	I1	I2	2.375	0.686		2.5000		1.70	2	6000#
4ELBOW	I1	I2	2.875	0.750		3.2500		2.33	2-1/2	6000#
4ELBOW	I1	I2	3.500	0.874		3.7500		3.27	3	6000#
4ELBOW	I1	I2	4.500	1.062		4.5000		3.73	4	6000#

APPENDIX G

DESIGN GUIDELINE FOR EVALUATING LOCAL STRESS AT WELDED ATTACHMENTS

"DESIGN GUIDELINE FOR EVALUATING LOCAL STRESS AT WELDED ATTACHMENTS"

Guidelines for load combinations and stress allowables addressing lug attachment design verification for Seismic Class I pipe are presented in Table 1. The guidelines are consistent with the criteria of the piping code in effect at the time that the plant was built. A specific code criteria addressing this subject was not available during the plant design phase. To further facilitate the initial evaluation to identify those pipe attachments which may require modification, the above guidelines were simplified as shown in Table 2. Configurations so identified are referred to as potential fixed (potential because of conservatism inherent in the design guidelines of Table 2). These conservatisms are:

(a) The load combinations used for evaluating primary structural integrity include thermal load and

(b) The general pipe stress level is considered to be no larger than $.5S_h$ for straight sections of pipe and no larger than $0.75\ S_h$ for elbow pipe sections.

In item (b) values selected were based upon a random sampling of stress levels at straight and elbow locations in the system.

The potential fixes identified using the guidelines of Table 2 are re-evaluated per the guidelines in Table 3. The guidelines in Table 3 are based upon recent (Winter 1981 addenda) changes in the ASME Code Stress limits. Adoption of these changes do not violate the plant code requirements. Background and motivation for these changes are presented in detail in Reference 1. The changes were considered essential since the intensification factor, i, in the original piping equations is not appropriate for describing limit load behavior. Since the changes are based upon the principles of mechanics and not upon material certification or additional inspection requirements, the changes are judged to be applicable to all plants old and new. Based on the methods presented in Attachment I, it is anticipated that the evaluation, per the guidelines in Table 3, will result in:

(1) Increase the local pipe stress allowable for straight sections of pipe by:
$.6\ S_h$ (Upset Condition)
$.45\ S_h$ (Abnormal Condition)
$.6\ S_h$ (Short Term Condition)

(2) Increase* the local pipe stress allowable for elbow sections of pipe by:
$.6\ S_h - 1.167\sigma_{Bo}$ (Upset Condition)
$.45\ S_h - 1.167\sigma_{Bo}$ (Abnormal Condition)
$.6\ S_h - 1.167\sigma_{Bo}$ (Short Term Condition)

σ_{Bo} = pipe bending stress at the operating condition determined by $\sigma_{Bo} = .75i\ \frac{M}{Z}$ or computer analysis.

* If the numerical value of the increase is negative then the local allowable stress will <u>decrease</u> by that magnitude.

Local pipe stress levels are typically determined by the methods prescribed by Welding Research Council Bulletin No. 107, and 198 and Code Case N392.

Welded attachment evaluation performed by the Piping Turnover Group stress analysts will qualify local pipe stresses and the attachment weld. Support engineers will qualify the remainder of the support, starting with the welded member. Support loads transmitted for evaluation are to be at pipe centerline unless otherwise noted.

TABLE 1

GUIDELINES FOR EVALUATING LOCAL PIPE STRESS AT WELDED ATTACHMENT LOCATIONS

Seismic Class I Piping Systems

OPERATING CONDITION	LOAD COMBINATION	Local Allowable Stress Limits for Operating Condition	
		PRIMARY OR STRUCTURAL INTEGRITY LIMIT	PRIMARY PLUS SECONDARY LIMIT
Original Normal/Upset	P + DW + OBE + TR	1.2 S_h - σ_P	N.A
	P + DW + TH + SAD (OBE)	N.A.	3 S_h - σ_P
Emergency or Faulted	P + DW + DBE + TR	1.8 S_h - σ_P	N.A.
Short Term	P + DW + DBE + TR	2.4 S_h - σ_P	N.A.

Per ASME Code Case N-318-2 for Emergency or Faulted Conditions, Secondary Stresses such as TH, PAD, TAD & SAD need not be considered; therefore they are not included.

P - Pressure Load
DW - Deadweight Load
OBE - Operating Basis Earthquake Load
TH - Thermal Load
S_h - Basic Material Allowable Stress
TR - Thrust or Transient
PAD - Pressure Anchor Displacement
TAD - Thermal Anchor Displacement
SAD (DBE) - Seismic Anchor Displcement

σ_P - Pipe general stress level at attachment location for indicated operating condition as determined by computer analysis of pipe line with appropriate stress intensification factors.

TABLE 2

GUIDELINES FOR EVALUATING LOCAL PIPE STRESS AT WELDED ATTACHMENT LOCATIONS

Seismic Class I Piping Systems

Load Combination	Section	Local Allowable Stress Limits for Establishing Load Capacity		Condition
		Primary	Primary & Secondary	
P + DW + OBE + TH + TR (9)	S	$1.2\ S_h - .5\ S_h$	N.A.	Original Normal/Upset
	E	$1.2\ S_h - X$	N.A.	
P + DW + TH + SAD (OBE) (11)	S	N.A.	$3\ S_h - .5\ S_h$	
	E	N.A.	$3\ S_h - X$	
P + DW + DBE + TH + TR (9)	S	$1.8\ S_h - .5\ S_h$	N.A.	Emergency or Faulted
	E	$1.8\ S_h - Y$	N.A.	
P + DW + DBE + TH + TR (9)	S	$2.4\ S_h - .5\ S_h$	N.A.	Short Term (Structural Integrity)
	E	$2.4\ S_h - Y$	N.A.	

See Note relative to Code Case N-318-2 under Table 1.

S - Straight Pipe Section
E - Elbow Pipe Section
P - Pressure Load
DW - Deadweight Load
OBE - Operating Basis Earthquake Load
DBE - Design Basis Earthquake Load
S_h - Basic Material Allowable Stress
X - Pipe Elbow General Stress Level $.75\ S_h$ (Normal/Upset)
Y - Pipe Elbow General Stress Level $.75\ S_h$ (Abnormal & Short Term)

TR - Thrust or Transient
PAD - Pressure Anchor Displacement
TAD - Thermal Anchor Displacement
SAD - Seismic Anchor Displacement

TABLE 3

GUIDELINES FOR EVALUATING PIPE LOCAL STRESS AT WELDED ATTACHMENT LOCATIONS IDENTIFIED AS POTENTIAL FIXES BASED ON TABLE 2 GUIDELINES

Seismic Class I Piping Systems

OPERATING CONDITION	LOAD COMBINATIONS	LOCAL ALLOWABLE STRESS LIMITS FOR OPERATING CONDITIONS	
		PRIMARY OR STRUCTURAL INTEGRITY LIMIT	PRIMARY PLUS SECONDARY LIMIT
Original Normal/Upset	P + DW + OBE + TR + SAD (OBE)	$1.8 S_h - \sigma_P'$	N.A.
	P + DW + TH	N.A.	$3 S_h - \sigma_P'$
Emergency or Faulted	P + DW + DBE + TR	$2.25 S_h - \sigma_P'$	N.A.
Short Term	P + DW + DBE + TR	$3.0 S_h - \sigma_P'$	N.A.

See Note relative to Code Case in N-318-2 under Table 1.

P - Pressure Load
DW - Deadweight Load
OBE - Operating Basis Earthquake Load
TH - Thermal Load
S_h - Basic Material Allowable Stress
σ_P' - Pipe general stress level at attachment location for indicated operating condition as determined by computer analysis of pipe line using Stress Indices B_1 & B_2.

TR - Thrust or Transient
PAD - Pressure Anchor Displacement
TAD - Thermal Anchor Displacement
SAD - Seismic Anchor Displacement

GENERAL COMPUTATION SHEET

DISCIPLINE:

united engineers

NAME OF COMPANY: CP&L - Brunswick UNIT/S: ______

SUBJECT: Design Guidelines

[illegible] 7579-CSA-00138-4000

CALC SET NO		REV	COMP BY	CHK'D BY
PRELIM		0	[illegible]	PTC
FINAL			DATE [illegible]	DATE [illegible]
VOID				
SHEET 1 OF 8			DATE	DATE
JO 7579.101				

Attachment I

To

"Design Guideline for Evaluating Local Stress at Welded Attachments"

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[illegible]

GENERAL COMPUTATION SHEET

(DISCIPLINE)

united engineers

NAME OF COMPANY: CP&L - Brunswick UNIT/S: ______

SUBJECT: Design Guidelines

CALC SET NO	REV	COMP BY	CHKD BY
PRELIM	0	[illegible] DATE 2/23/84	[illegible] DATE 3-1-84
FINAL			
VOID			
SHEET 2 OF 8		DATE	DATE
JO 7579.106			

Pipe total stress at welded attachment locations is composed of two parts, pipe general stress and pipe local stress. Pipe general stress results from pipe internal pressure and moment loads in the pipe. Pipe local stress results from loads reacted by the welded attachment.

Allowable pipe local stress at the attachment is defined to be the difference between the allowable pipe total stress and the pipe general stress. Allowable pipe total stress is the allowable stress for the operating condition being evaluated and pipe general stress is the actual stress in the pipe at the operating condition as determined by computerized piping analysis.

In what follows, allowable pipe local stress is determined consistent with that of the piping code in effect at the time the plant was built. This allowable local stress is compared with allowable local stress based on the Winter 1981 Code Addenda. For convenience, allowable local stress based on the Winter 1981 Code Addenda is referred to as new and allowable local stress based on the piping code in effect at the time the plant was built is referred to as old. Background and motivation for the changes are explained in detail in Reference (1). In summary, the changes affect equation (8) of NC-3652 and equation (9) of NC-3653. Equations (10) and (11) of NC-3653 do not change. New equations (8) and (9) have higher allowable (total) stress levels but require that pipe general stress be based upon B indices instead of intensification factors, i. These changes affect local allowable stress for primary or structural integrity evaluations; however, stress limits for primary plus secondary evaluations do not change (equations 10 and 11).

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$\sigma_{local\ allow\ old} = 1.2\ S_h - \sigma_{PO} - \sigma_{BO}$ (UPSET CONDITION)

$\sigma_{PO} = \frac{PD_o}{4t}$, $\sigma_{BO} = .75i \frac{M}{Z}$

$\sigma_{local\ allow\ new} = 1.8\ S_h - \sigma_{PN} - \sigma_{BN}$ (UPSET CONDITION)

$\sigma_{PN} = B_1 \frac{PD_o}{2t}$, $\sigma_{BN} = B_2 \frac{M}{Z}$

THE NEW PRESSURE STRESS, σ_{PN}, AND PIPE BENDING STRESS, σ_{BN}, ARE RELATED TO THE EXISTING OLD PRESSURE STRESS, σ_{PO}, AND EXISTING OLD PIPE BENDING STRESS, σ_{BO}, BY:

$\sigma_{PN} = 2B_1 \sigma_{PO}$, $\sigma_{BN} = \frac{B_2}{.75i} \sigma_{BO}$

FOR STRAIGHT PIPE $B_1 = 0.5$, $B_2 = 1.0$, $.75i = 1.0$

$\therefore \sigma_{PN} = \sigma_{PO}$ AND $\sigma_{BN} = \sigma_{BO}$

$\sigma_{local\ allow\ new} = 1.8\ S_h - \sigma_{PO} - \sigma_{BO}$

$= 0.6\ S_h + 1.2\ S_h - \sigma_{PO} - \sigma_{BO}$

$= 0.6\ S_h + \sigma_{local\ allow\ old}$

$\therefore$ FOR STRAIGHT SECTIONS OF PIPE, LOCAL ALLOWABLE STRESS BASED ON THE WINTER 1981 CODE ADDENDA WILL INCREASE BY 0.6 S_h OVER THE ALLOWABLE LOCAL STRESS DETERMINED FROM THE PIPING CODE IN EFFECT AT THE TIME THE PLANT WAS BUILT FOR THE UPSET CONDITION.

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GENERAL COMPUTATION SHEET

united engineers

(DISCIPLINE)

NAME OF COMPANY: CP&L - Brunswick UNITS

SUBJECT: Design Guidelines

CALC SET NO	REV	COMP BY	CHK'D BY
PRELIM	0		
FINAL		DATE 2/29/80	DATE
VOID			
SHEET 4 OF 8		DATE	DATE
J.O. 7579 106			

Following the above procedure for the Abnormal and Short Term Condition indicates that local allowable stress will increase by 0.45 S_h for the Abnormal condition and by 0.6 S_h for the short term condition.

For Elbow Pipe Sections: $B_1 = 0.5$, $B_2 = \frac{1.4625}{h^{2/3}}$, $.75i = \frac{.675}{h^{2/3}}$

$$\sigma_{PN} = \sigma_{PO} \quad , \quad \sigma_{BN} = \frac{B_2}{.75i}\sigma_{BO}$$

$$\sigma_{\text{local new allowable}} = 1.8\,S_h - \sigma_{PN} - \sigma_{BN}$$

$$= 1.8\,S_h - \sigma_{PO} - \frac{B_2}{.75i}\sigma_{BO}$$

$$= 1.2\,S_h - \sigma_{PO} - \sigma_{BO} + 0.6\,S_h + \left(1 - \frac{B_2}{.75i}\right)\sigma_{BO}$$

$$= \sigma_{\text{local old allow}} + .6\,S_h - \left(\frac{B_2}{.75i} - 1\right)\sigma_{BO}$$

$$\therefore \text{ if } \left(\frac{B_2}{.75i} - 1\right)\sigma_{BO} < 0.6\,S_h$$

Local new allowable stress will increase for the Upset Condition.

The ratio $B_2/.75i$ is a function of the elbow radius and the radius to thickness ratio of the pipe wall. Details are presented on pages 6 to 8. The maximum value this ratio can attain for both long and short radius elbows is 2.167.

Substituting $\frac{B_2}{.75i} = 2.167$ in the above indicates the local new allowable stress for the upset condition will increase if

$$\sigma_{BO} < .514\,S_h$$

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FORM 6007 REV 7/78

GENERAL COMPUTATION SHEET

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NAME OF COMPANY: CP&L-BRUNSWICK UNIT/S ______

SUBJECT: DESIGN GUIDELINES

PIN 7579-CSL-00138-4000

CALC SET NO.		REV	COMP BY	CHK'D BY
PRELIM		0	[illegible]	[illegible]
FINAL			DATE [illegible]	DATE [illegible]
VOID				
SHEET 5 OF 8			DATE	DATE
JO 7579.106				

PROCEEDING IN THE MANNER ABOVE INDICATES NEW LOCAL ALLOWABLE STRESS FOR THE ABNORMAL CONDITION WILL INCREASE IF:

$$\sigma_{B0} < 0.386\ S_h$$

AND FOR THE SHORT TERM CONDITION IF:

$$\sigma_{B0} < .514\ S_h$$

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[illegible]

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DIN 7579 - CSA - 00135 - 4502

CALC SET NO		REV	COMP BY	CHK'D BY
PRELIM		0	DATE 2/19/86	DATE 3-1-86
FINAL				
VOID			DATE	DATE
SHEET 6 OF D				
JO 7579.106				

NAME OF COMPANY: CP&L - BRUNSWICK UNIT/S ______

SUBJECT: DESIGN GUIDELINES

$.75i = \frac{.675}{h^{2/3}} \geq 1.$ $\qquad B_2 = \frac{1.4625}{h^{2/3}} \geq 1.125$

$h = \frac{tR}{r^2}$ $\quad$ t = pipe wall, r = " mean radius, R = elbow bend radius

For long radius elbow, $R = 1.5D \approx 3r$

For short radius elbow, $R = D \approx 2r$

<u>For Long Radius Elbow</u>

$h = \frac{t(3r)}{r^2} = 3\frac{t}{r}$

$.75i = \frac{.675}{(3\frac{t}{r})^{2/3}} \geq 1.$ $\qquad B_2 = \frac{1.4625}{(\frac{3t}{r})^{2/3}} \geq 1.125$

$(.75i)^{3/2} = \frac{(.675)^{3/2}}{3\frac{t}{r}} \geq 1$ $\qquad (B_2)^{3/2} = \frac{(1.4625)^{3/2}}{3\frac{t}{r}} \geq (1.125)^{3/2}$

$(.75i)^{3/2} = .18486\frac{r}{t} \geq 1$ $\qquad (B_2)^{3/2} = .58955\frac{r}{t} \geq 1.19326$

<u>For Short Radius Elbow</u>

$(.75i)^{3/2} = .27729\frac{r}{t} \geq 1$ $\qquad (B_2)^{3/2} = .88433\frac{r}{t} \geq 1.19326$

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GENERAL COMPUTATION SHEET

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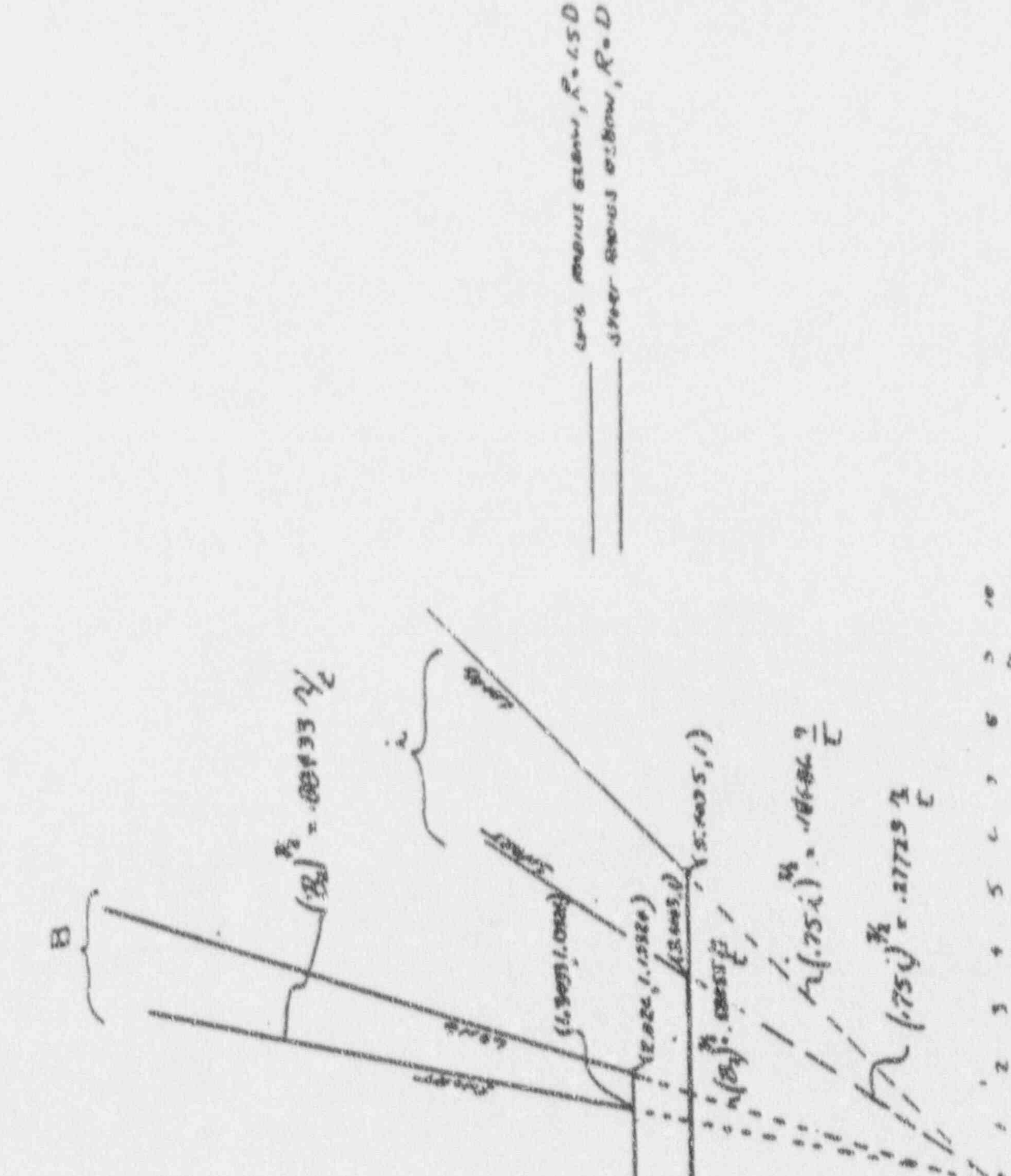
DISCIPLINE

NAME OF COMPANY CP&L - BRUNSWICK UNIT(S)

SUBJECT DESIGN GUIDELINES

7579 - CCA - [illegible]

	CALC SET NO	REV	COMP BY	CHK'D BY
PRELIM		0	[illegible]	DTC
FINAL			DATE [illegible]	DATE [illegible]
VOID				
SHEET 7 OF 8			DATE	DATE
JO 7579.106				



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FORM 1767 REV 1/79 GENERAL COMPUTATION SHEET

DISCIPLINE: united engineers

FIN 7573-CCA-00124-4002

CALC SET NO		REV	COMP BY	CHK'D BY
PRELIM		0	JTV	DT
FINAL			DATE 2/24/86	DATE
VOID				
SHEET 8 OF 8			DATE	DATE
JO 7573.106				

NAME OF COMPANY CP&L-BRUNSWICK UNIT(S) ____

SUBJECT DESIGN GUIDELINES

FOR LONG RADIUS ELBOW

$0 \leq \frac{r}{t} \leq 2.024; \quad \frac{B_2}{.75i} = (1.19326)^{2/3} = 1.125$

$2.024 \leq \frac{r}{t} \leq 5.4095; \quad \frac{B_2}{.75i} = .703\left(\frac{r}{t}\right)^{2/3}$

$5.4095 \leq \frac{r}{t}; \quad \frac{B_2}{.75i} = \left(\frac{.58355}{.18486}\right)^{2/3} = 2.167$

FOR SHORT RADIUS ELBOWS

$0 \leq \frac{r}{t} \leq 1.349; \quad \frac{B_2}{.75i} = (1.19326)^{2/3} = 1.125$

$1.349 \leq \frac{r}{t} \leq 3.606; \quad \frac{B_2}{.75i} = (.88433)^{2/3}\left(\frac{r}{t}\right)^{2/3} = .9213\left(\frac{r}{t}\right)^{2/3}$

$3.606 \leq \frac{r}{t}; \quad \frac{B_2}{.75i} = \left(\frac{.88433}{.27723}\right)^{2/3} = 2.167$

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c) ASME Section VIII, Division 1 (pumps used in Group C piping systems)
3 USAS B31.1.0 Power Piping Code was also used in the design of piping and valves outside the reactor coolant pressure boundary.

The allowable stresses for Group A, B, C and D piping design were as follows:

3 a) For carbon steel, the allowable stress values of USAS B31.1.0 were used. For materials not covered by USAS B31.1.0, the stress values of the ASME Boiler and Pressure Vessel Code were used, as applicable.

3 b) For Austenitic stainless steel, the allowable stress values of USAS B31.1.0 were used. For material not covered by USAS B31.1.0, the higher stress values of the ASME Boiler and Pressure Vessel Code, Section I, Appendix A-24, or Section VIII, were used.

3 Pipe wall thickness, fittings, and flange ratings are in accordance with USAS B31.1.0, including adequate allowances for corrosion, as delineated in the plant piping specification, and for erosion, according to individual system requirements, for a design life of 40 years.

All piping including instrument piping connecting to the reactor pressure vessel nozzles was designed so that the nozzle to pipe interface load would not result in stresses in excess of the allowable material stresses. Thermal sleeves were used where nozzles would be subjected to high thermal stresses.

The general design criteria of Tables 3.9.5-1 through 3.9.5-4 applied to those ductile metallic structures or components which are normally designed using rational stress analysis techniques. These structures include the pressure vessel, core support structures, etc. The criteria were also applied to those components or structures whose ultimate loading capability was determined by tests. These criteria were intended to supplement applicable industry design codes where necessary. Compliance with these criteria was intended to provide design safety margins which were appropriate to extremely reliable structural components, when account was taken of rare event potentialities such as a DBE or primary pressure boundary coolant pipe rupture, or a combination of events.

Many important Class I components or equipment were not designed or sized directly by stress analysis techniques. Simplified stress analyses were sometimes used to augment the design of these components, but the primary design work did not depend upon detailed stress analysis. These components were usually designed by tests and empirical experience. Complete detailed stress analysis was not meaningful nor practical for these components. Examples of such components are valves, pumps, electrical equipment, and mechanisms. Field experience and testing were used to support the design. Where the structural or mechanical integrity of components was essential to safety, the components referred to in these criteria were designed to accommodate the events of the DBE or OBE or a design basis pipe rupture, or a combination where appropriate. The reliability requirements of such components would not be quantitatively described in a general criterion because of the varied nature of each component and its specific function in the system.

The seismic design was based upon appropriate static or dynamic analyses which define the maximum seismic capability of GE supplied equipment. The dynamic

The design requirements for some piping in Group C, such as main steam lines downstream of the outer isolation valve to the main turbine stop valve, but excluding the stop valves, are in accordance with the requirements of ANSI B31.1.0 and supplementary requirements in the project design specifications, namely, full radiography of pressure weld joints.

The above mentioned systems in Groups A, B and C are designated as "critical piping" for design, stress analysis, fabrication, inspection, erection, testing and quality control purposes.

The remaining portion of piping systems, i.e., in Group D, is in accordance with ANSI B31.1.0 and these systems are designated as noncritical systems.

Tables A-1 and A-4 summarize the classification of piping system and lists design guides for plant equipment.

A.3.1.1 Allowable Stresses

The allowable stresses for Group A, B, C and D piping design are as follows:

a) For carbon steel, the allowable stress values of ANSI B31.1.0 are used. For materials not covered by ANSI B31.1.0, the stress values of the ASME Boiler and Pressure Vessel Code are used, as applicable.

b) For Austenitic stainless steel, the allowable stress values of ANSI B31.1.0 are used. For material not covered by ANSI B31.1.0, the higher stress values of the ASME Boiler and Pressure Vessel Code. Section I, Appendix A-24, or Section VIII, are used.

A.3.1.2 Wall Thickness

Pipe wall thickness, fittings, and flange ratings are in accordance with ANSI B31.1.0, including adequate allowances for corrosion, as delineated in the piping specification, and for erosion, according to individual system requirements, for a design life of 40 years.

SUPERSEDED

CAROLINA POWER & LIGHT CO.
TELEPHONE CONVERSATION MEMORANDUM

FILE NO.: 507.2 B001BA

SERIAL: BESU/T-650

Between RICK FROHNAUATH of CP&L and VANN STEPHENSON of CP&L

PROJECT:	UE&C PIPING DESIGN TURNOVER PROGRAM	DATE: 1/22/88
SUBJECT:	SEISMIC BOUNDARY RESTRAINTS	TIME: 11:15A

MESSAGE: I ASKED VANN WHAT CRITERIA WAS USED FOR SEISMIC BOUNDARY RESTRAINTS AT HARRIS, VANN REFERRED ME TO HARRIS DESIGN GUIDELINE 7.2.A, PAGE 59, SECTION C.6.d.ii ALLOWS AN ALTERNATIVE TO DESIGNING THE BOUNDARY ANCHOR TO PLASTIC MOMENT LOADS. TWO 2-WAY RESTRAINTS MAY BE PROVIDED ON THE NON-SEISMIC SIDE OF THE BOUNDARY ANCHOR. THESE RESTRAINTS ARE SIZED FOR COMBINED THERMAL AND SEISMIC DBE LOADS, FOR HARRIS, THEY USE "TAB LOADS" FROM THE ABOVE GUIDELINE PAGE 55 (TABLE III.C.5.C).

Action Required ☐ Yes ☒ No By ______ Tickler Date ______

ROUTE TO: ☐ ___ ☐ ___ ☐ ___ ☐ ___ ☐ ___ File ______

COPY TO: ☐ VANN STEPHENSON ☐ RALPH HILL ☐ BILL MONROE ☐ PAUL WENTEL ☐ FILE 507.2 ☐ FILE B001BA

C. Design Equations (Cont'd)

6. Seismic/Nonseismic Interface Anchors

Design loads for siesmic/nonseismic interface anchors shall be obtained as follows:

a. For Equation 1,

$DW_s + DW_{ns}$

or

$DW_s + DW_{ns} + TH_s + TH_{ns}$

Where the subscript "s" denotes the seismic portion and "ns" the nonseismic portion of the pipe.

DW = Dead Weight

TH = Thermal Forces

b. For Equation 2,

$DW_s + DW_{ns} + TH_s + 3OBE_s + 2OL_s + 2SSD_s$

Where OL = Occasional Loads

SSD = Loads due to Seismic Displacements

c. For equation 6,

$DW_s + DW_{ns} + TH_s + TH_{ns} + 3DBE_s + 2OL_s + 2SSD_s$

Note: The first two supports on the nonseismic side of an anchor must also function as lateral restraints but will be classified as nonseismic.

d. In addition to the design load criteria given in a. through c. above, one of the following criteria must be met for seismic/nonseismic interface anchors:

i - The interface anchor will be designed to a bending moment that causes initial yielding in the pipe.

or,

ii - Two (2) way restraints shall be designed on the nonseismic side of the interface anchor.

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SUBJECT

DESIGN EQUATIONS AND LOADS

TABLE III.C.5.c

COMBINED THERMAL & SEISMIC DBE LOADS FOR 2½" & LARGER NON-STRESS ANALYZED PIPING

PIPE SCH.	PIPE SIZE	COMBINED THERMAL & SEISMIC DBE FORCES (LBS) LATERAL	AXIAL	ANCHOR*	ANCHOR* MOMENTS FT-LBS (DBE)	MAX. SPAN (FT)
40	2½"	600	1,800	1,800	3,100	11
80	"	700	"	"	3,900	
40	3"	840	2,200	2,200	5,800	12
80	"	1,100	"	"	6,800	
40	4"	1,340	3,000	3,000	9,400	14½
80	"	1,970	"	"	12,800	
40	6"	3,000	6,800	6,800	24,800	17
80	"	4,700	"	"	38,600	
40	8"	6,200	12,800	12,800	49,000	19
80	"	7,800	"	"	71,300	
40	10"	8,000	18,000	18,000	87,700	22
80	"	10,900	"	"	118,500	
40	12"	12,000	23,000	23,000	137,400	23
80	"	14,900	"	"	188,400	
40	14"	16,000	33,750	33,000	179,000	25
80	"	23,000	"	"	266,800	
40	16"	28,000	47,000	47,000	287,000	27
80	"	38,800	"	"	422,000	
40	20"	53,000	75,000	75,000	494,000	30
80	"	84,800	"	"	808,000	
40	24"	92,000	128,000	128,000	831,000	32
80	"	137,000	"	"	1,380,000	
.750"	28"	90,000	150,000	150,000	1,432,000	—
.875"	"	106,000	158,000	158,000	1,660,000	
1.00"	"	[illegible]6,000	175,000	175,000	1,866,000	
*FORCES AND MOMENTS ARE COMPONENTS F_x, F_y, F_z & M_x, M_y, & M_z.						

NOTE: For vertical restraints, the calculated pipe deadweight shall be added to the combined load from the chart.

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ATTACHMENT 3

UNITED ENGINEERS & CONSTRUCTORS
REPORT NO. 7865.007-S-M-021

"EVALUATION CRITERIA FOR
EXISTING PIPE SUPPORTS ASSOCIATED WITH
NRC BULLETINS IE 79-02, 79-07 AND 79-14
AND DESIGN CRITERIA FOR
MODIFICATION TO OR DESIGN OF PIPE SUPPORTS"

UNITED ENGINEERS & CONSTRUCTORS
30 SOUTH 17TH STREET
PHILADELPHIA, PENNSYLVANIA 19101

EVALUATION CRITERIA

FOR

EXISTING PIPE SUPPORTS

ASSOCIATED WITH

NRC BULLETINS IE 79-02, 79-07 AND 79-14

AND

DESIGN CRITERIA

FOR

MODIFICATION TO OR DESIGN OF PIPE SUPPORTS

for

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT

UNITS 1 AND 2

QUALITY RELATED x

NON-QUALITY RELATED ____

Report No. 7865.007-S-M-021

REVISIONS							
REV. NO.	DOCUMENT DATE	PREPARER	INDEPENDENT REVIEW	QA REVIEW	SDE REVIEW	PEM/PM APPROVAL	CP&L APPR. LETTER NO.
0	5/17/85	[signature]	[signature]	[signature]	[signature]	[signature]	UC-35226
1	3/21/87	[signature]	[signature]	[signature]	[signature]	[signature]	
2							
3							

TABLE OF CONTENTS

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(Continued)

1.0 PURPOSE

The purpose of this document is to provide Evaluation Acceptance Criteria for existing pipe supports at BSEP Units 1 and 2; and provide design basis for modifications to existing pipe supports and/or designing new pipe supports for existing piping systems.

This Criteria applies to Piping Systems Analyzed under Piping Design Criteria 7865.007-S-M-020 only.

2.0 SCOPE

2.1 Evaluation Acceptance

Supports, support components, and supporting structures will be evaluated to the extent necessary to determine the limiting part of the support as follows:

2.1.1 All supports with increased analysis loads will be evaluated to determine their capacity by either Pmax. (maximum allowable load) or computed stress methods. Evaluations will include those evaluations required by Para. 2.1.3 and 2.1.4, as applicable.

2.1.2 For supports with new analysis loads equal to or less than previous loadings only those evaluations necessary to satisfy paragraphs 2.1.3 and 2.1.4, below will be made as applicable.

2.1.3 All supports loaded in torsion or inducing torsional loads to supporting members will be evaluated. See Study Report 7992.001-S-M-038 "Effects of Torsional Loads on Angles and Channels for Existing Supports".

2.1.4 All supports containing concrete expansion anchors will be evaluated to confirm anchor and base plate adequacy.

2.1.5 Pipe intersections are evaluated under Pipe Stress Analysis and are therefore not addressed as pipe supports.

2.2 Design

2.2.1 Design all support modifications resulting from evaluations undertaken for Project Procedure CPL-PP-01 and identified as "Short Term Fix" or "Long Term Fix" and any additional supports as required by analysis for all lines evaluated under Section 2.1.

2.2.2 Establish the minimum design requirements for modifications of existing supports and design of new supports in existing system for modifications performed outside the scope of the 79 IE Bulletin work. (Note the overall impact on system design should be carefully considered and the results documented before implementing any design requirements that are considered more conservative by todays standards to new work unless the more conservative design basis is applied to the entire section of the system in which the modification is being made.) The boundaries of such system section to which the new design requirements are applied shall be full 6-way anchors.

2.2.3 "Non-Safety" support systems may be designed using this document as guideline.

3.0 ACRONYMS/DEFINITIONS

NRC - Nuclear Regulatory Commission

SDE - Supervising Discipline Engineerr

AISC - American Institute of Steel Construction

ACI - American Concrete Institute

STSI - Short Term Structural Integrity

Snubber - As used in this Criteria refers to Hydraulic Piston Devices designed to resist seismic and or Shock Loadings only.

Support - As used in this Criteria refers to any device or component designed to support or resist the following loadings:

1. Seismic
2. Dead Weight
3. Thermal
4. Transient

4.0 GENERAL REQUIREMENTS

The following Codes, Procedures and Specifications are to be used as the basis for Evaluation Acceptance and/or Design Criteria except as modified within this document.

4.1 USA Standards Committee
Power Piping Code
USAS B31.1 - 1967

4.2 American Institute of Steel Construction
Manual of Steel Construction
Seventh or Eighth Edition*

4.3 American Welding Society
Structural Welding Code
AWS D1.1-79

4.4 Pipe Stress Reanalysis
Doc. No. CPL-PP-01

4.5 Specification for Pipe Supports
Spec. No. 9527-1-248-15, Rev. 5

4.6 Power Discipline - Technical Bulletin #7
Concrete Expansion Anchor Bolts
Used With Pipe Supports - May 2, 1979

4.7 American Concrete Institute
Building Code Requirements For Reinforced Concrete
ACI 318-71

4.8 "ASME" Boiler and Pressure Vessel Code
Section III Sub-Section NF 1977 with Addenda thru Summer 1977

*Either edition is acceptable. Both editions have been referenced in the calculations.

4.9 General Design Considerations

4.9.1 Major modifications requiring "NRC" approval may require conformance to codes other than the original design codes such as "Mark I" program outlined below.

4.9.1.1 <u>Evaluation of SRV Line Supports</u>

The Safety Relief Valve (SRV) discharge piping analysis is divided into two models. The upper model includes the primary steam line with the attached SRV discharge piping lines in the drywell down to the vent header. The lower model includes the SRV discharge piping from the vent header downstream into the suppression pool and is discussed in detail in the Plant Unique Analysis Report section 2.3.11.

The upper model of SRV discharge piping including primary steam line was analyzed for the usual thermal, dead weight, and seismic loading conditions as well as SRV discharge transients. The Seismic analysis used the dynamic response spectrum approach in accordance with NRC, IE Bulletin 79-07.

The SRV supports in the drywell were evaluated in accordance with the criteria contained within this document.

The Safety relief valve discharge piping supports located in the Torus were evaluated and/or redesigned in accordance with ASME III Sub-section NF requirements under the Mark I program.

4.9.2 Support design should be consistent with the requirements of BSEP Spec. 248-107. This specification covers fabrication and installation/inspection of seismic pipe supports. 1

4.9.3 All support modifications and additional supports shall consider the effect of the support loads on the supplementary and building steel as applicable. Investigate for additional (other) supports, equipment providing load to member, and any dead loadings that may be concurrent with support loadings.

5.0 DETAILED REQUIREMENTS

5.1 Structural Attachments to piping, both integral and non-integral, shall be evaluated per USAS B31.1-1967 Chapter II, Part 5 and Attachment "A" to this document; "Design Guideline for Evaluating Pipe Local Stress at Welded Attachments". Items included shall be defined as follows:

5.1.1 Integral: Lugs, plates and stanchions welded to piping for the purpose of transferring loading from pipes to the support structure, see Attachment "A". Shear lugs utilized with pipe clamps need not be evaluated for local pipe stress since application of this load produces negligible piping bending stresses in the pipe wall. Qualification of these shear lugs shall be based on the capacity of the weld joint.

5.1.2 Non Integral: Straps, clamps, saddles, Guides, and U-bolts in contact with piping and designed to transmit loadings to support structure.

5.2 Support Components

5.2.1 Vendor allowables shall be used whenever available. Exception will be taken in the evaluations of "U-bolt" components due to inconsistent values provided by various vendors for similar components under the same applications. See Section 7.5 for discussion of "U-Bolts".

5.2.2 Standard pipe clamps, Bergen-Paterson Model EA3, utilized in on-axis and off-axis applications may be evaluated on the basis of the Detailed Criteria presented in Figures 6.1 thru 6.7.

5.2.3 Published vendor allowables for non-integral attachments are based on a specific design temperature. Increase of published allowables is permitted for temperature below the specified design temperature,

i.e., $P\ allow = P\ allow\ @\ V.S.T. \times \frac{(Fy\ @\ actual\ temp.)}{(Fy\ @\ V.S.T.)}$

V.S.T. = Vendor Specified Temperature

5.2.3.1 All mate[illegible] listed by the vendor for a specifi[illegible]ard support shall be considered, such that the smallest increase based on yield strengths will be used.

5.2.3.2 This increase may not be used for springs, snubbers, struts or parts in which there is a compressive load because analysis of 2/3 critical buckling would be required.

5.2.4 Hydraulic snubbers shall be evaluated on the basis of Bergen-Patterson confirmed allowables listed in Figure 1. Calculation 9327-9-PSSS-12-F, "Snubber Component Capacity" evaluates individual snubber and strut components and standard EA1 and EA3 attachments. This calculation demonstrates that, with the exception of off-axis clamp applications, capacity i[illegible] controlled by relief valve for snubbers and rated capa[illegible]ty for struts. Individual qualification of thse components may be neglected in support qualifications.

5.2.5 Structural members provided as component supports shall be evaluated in accordance with AISC as modified under Section 6.

Large $K\ell/r$ ratios ($>$ 200 but not more than 300) may be accepted if the stress level is significantly lower than at 200.

5.2.5 (Continued)

Evaluation of angle support members for bending may be based on limiting allowable stress F_b to be equal to F_a at the appropriate Kl/r in lieu of bi-axial bending calculation.

Existing fillet welds shall be evaluated on the basis of stress. Lack of AISC minimum fillet weld size for a given member thickness shall not be cause for rejection. All new welds shall be per AISC.

(Deleted)

Unless otherwise specified, all welds shall be evaluated based on the use of E70XX electrodes.

5.2.6. <u>Supplementary Support Steel</u> shall be evaluated in accordance with AISC Code as modified by Section 6. Supplementary support steel is defined as those structural members w[illegible] have been provided f[illegible]r the primary purpose of [illegible]ting pipe. See Figure 2 for example of jurisdictional boundary.

Take special note that on this project most miscellaneous steel shown on structural drawings is designed for the supporting of piping. Therefore, if structural members under consideration can not be defined by investigation to be integral to the "building structure" they shall be considered as supplementary support steel and evaluated as required.

(Deleted)

5.2.7 Vendor Non-Catalog Components

Non-catalog components supplied by vendors are acceptable for use provided capacity and application conditions are confirmed by vendor or confirmatory calculations provided; and controled procurement, fabrication, installation and inspection can be assured. Examples are: special EA3 clamps, U-bolt pipe clamps, structural attachments, etc.

5.2.8 Special Design Components

Non standard special components may be designed and used for unique applications; or in some cases, typical applications, provided detailed design calculations are provided; and controlled procurement, fabrication, installation and inspection can be assured. Examples: Bergen-Paterson Internal Clamp I.P.S. Dwg. No. B20107, or "United" pipe strap (tight) Dwg. C-21.0.

5.2.9 (Deleted)

5.2.10 Anchorage of Base Plates shall be evaluated based on "UNITED" Power Discipline - Technical Bulletin #7, dated May 2, 1979.

NRC Bulletin IE 79-02 caused re-evaluation of anchorages using ITT Phillips Red Head Snap-Off Self Drilling Anchors. These anchors are commonly identified on detail drawings as Bergen-Paterson catalog (No. 66) part no. 511 or 512.

The following shall be used for evaluations of snap-off anchors only. These values are based on the manufacturer's recommendations and industry practices at the time the anchors were installed and should not be used for future installations. For replacements of existing anchors or new anchor installations see Item 5.3.

Red Heads (Snap Off Type) -

Cat. No.	Bolt Size (in)	Tension (lbs.)	Shear (lbs)
S-14	1/4	734	267
S-16	5/16	812	406
S-38	3/8	1,134	674
S-12	1/2	1,700	1,344
S-58	5/8	2,340	2,380
S-34	3/4	3,240	3,240
S-78	7/8	3,570	3,690

Tension and shear values based on factor of safety of 5, 3500 PSI concrete @ 28 days. No reduction for 3,000 PSI concrete taken since concrete strength with age offsets reduction.

$$\frac{\text{(Actual Tension)}}{\text{(Allow Tension)}} + \frac{\text{(Actual Shear)}}{\text{(Allow Shear)}} \leq K$$

K = 1.0 when (Act. Spacing) $\geq$ 7 x Bolt. Dia.

K = 0.8 when (Act. Spacing) $<$ 7 x Bolt. Dia.

5.2.11 Anchorages utilizing cast-in-place anchor bolts shall be evaluated to the AISC Code for bolts and the ACI Code for concrete.

5.2.12 Anchorages utilizing concrete stud anchors shall be evaluated to ACI limitations; preferably using "TRW" Nelson-Design Data 10 of 1977 as primary evaluation reference.

For convenience, embedments may be evaluated against Figure 3, if applicable. Figure 3 provides details and capacities of typical embedments.

5.3 <u>Concrete Expansion Anchors - Modifications & Additions</u>

5.3.1 All new installations of concrete expansion anchors and replacements of existing "Snap-off" anchors shall be wedge anchors. Adjustment of published allowable loads for concrete strengths other than those provided by Vendor shall be made in accordance with vendor's recommendations.

5.3.2 Factor of safety used to obtain the base allowable load as adjusted per Item 5.3.1 shall be 1/4 of the ultimate values for design levels Normal, Upset and Emergency.

5.3.3 When short term structural integrity criteria is used for design the allowable anchor loads shall be 1/2 ultimate published load, adjusted per Item 5.3.1.

5.3.4 Credit for increase in strength of concrete e to age is permitted provided material so treated is not newly placed.

5.3.5 Straight line interaction shall be used for the combination of pullout and shear loadings.

5.4 Weld Joints for "Bergen-Paterson" EA1 Attachments

Allowable loads for typical weld joints provided for attachment of "EA 1" components are provided in Calculation 9527-9-PSSS-13-F. These values may be used as the basis of joint qualification in lieu of a specific calculation under support evaluations.

5.5 Link Seals

Allowable axial forces for typical link-seal support applications are provided in Calculation 9527-8-SS-90-F. Allowable radial forces for typical link-seal support applications are provided in Calculation 9527-8-SS-91-F. These allowables were developed in January of 1987 and should be used for any subsequent link-seal evaluations as well as qualification of past loadings.

6.0 ACCEPTANCE LIMITS

The final load to capacity ratio (L/C) for any support component should not exceed the following for condition evaluated, i.e. upset, emergency or faulted, or short term structural integrity (STSI). Any support found to be unacceptable for upset or emergency or faulted conditions but is acceptable for short term structural integrity requires a long term fix. Any support that does not meet STSI requirements should be considered to be a "potential" short term fix and immediately presented to the Design Supervisor and/or the SDE for submittal to the Review Committee (Refer to CPL-PP-01 for Review Committee Responsibilities).

6.1 Upset

Item		Limit (L/C = 1.0)
Snap-off Anchors	-	(See Emergency)
Seismic Snubbers	-	Vendor Confirmed Allowable
Structural Steel Members	-	AISC or B31.1 Allowable as Applicable (Ref. Fig. 2 for Boundary)
Factory Supplied Components	-	Catalog Load

6.2 Emergency or Faulted

Item		Limit (L/C = 1.0)
Snap-off Anchors	-	1/5 Ultimate
Seismic Snubbers	-	Vendor Confirmed Allowable
Structural Steel Members	-	1.5 AISC or 1.2 x B31.1 as Applicable (Ref. Figure 2 for Boundary)
Factory Supplied Components	-	1.2 x Catalog Load; or 1.33 x AISC if detailed calculations are performed in accordance with AISC.

6.3 Short Term Structural Integrity

The limits provided below can only be used when the Code Allowable Stresses stated in paragraph 6.2 cannot be met. When these limits given below cannot be met alternatives allowed by the NF faulted rules may be used with supervisory concurrence.

Item		Limit (L/C = 1.0)
Snap-off Anchors	-	1/2 Ultimate
Seismic Snubbers	-	1.5 Nominal Rating (i.e. HSSA-3 = 1.5 x 3000) (See Figure 1)
Structural Steel Members		
Tension	-	Yield
Bearing	-	Yield
Bending	-	Yield x Shape Factor x $\left[\frac{(F_b \text{Allow.})^*}{(21.6)}\right]$
Shear	-	Yield x .625
Compression	-	(Yield x AISC) ÷ 21.6
Factory Supplied Components	-	3 x Catalog Load
Weld Joints	-	Controlled by Base Metal @ Joint (See Str. Stl. above).

*Note: Shape factor used in the above bending equation is the ratio of Plastic Section Modulus to Elastic Section Modulus

(i.e. $\frac{\text{Plastic Section Modulus}}{\text{Elastic Section Modulus}}$ = Shape Factor).

Also $\frac{(F_b \text{ allow.})}{(21.6)} \leq 1$

Typical Shape Factors

Rectangular Shapes (Plates)	1.5
Wide Flange Shapes	1.14
Circular Shapes	1.7

7.0 GENERAL INSTRUCTIONS AND COMMENT

The evaluations within the scope of this document are not intended to impose requirements in excess of Codes or industry practices at the time of installation unless specifically required by related project procedures (Example CPL-PP-01, Rev. 0) or related Criteria document (Report No. 7865.007-S-M-020).

The original BSEP support designs considered certain support capabilities and features in a unique fashion as discussed below in Sections 7.1 thru 7.6.

7.1 Stiffness and Frequency

Original support designs were not based on stiffness and/or frequency criteria, therefore stiffness and frequency limitations will not be applied for evaluations performed under NRC Bulletins 79-02, 79-07, and 79-14. Subsequent and future modifications, resulting in significant changes to the Analysis Model, may require that actual support stiffness and frequency be calculated if required by the associated pipe stress analysis.

7.2 Friction

Under original design frictional effects were considered for supports with large displacements (1" or greater) by utilizing friction reducing materials (lubrite plates, etc.). In general, the effects of friction on support components or structures with less than 1" displacements was not considered in original plant design. Therefore, supports will not be evaluated for frictional effects unless friction has been originally considered. Friction calculations for modified or added supports is required only when new thermal displacements of piping are greater than original. New supports in new systems shall consider frictional effects on support structures.

7.3 Spring Supports

Constant and variable springs are dead weight supports only and are not considered in the seismic analysis. Therefore, they will not be evaluated for NRC Bulletin 79-07 (Seismic Reanalysis) reviews. Evaluation of spring support anchorage, baseplate and snap-off anchors, is required per NRC Bulletin 79-02 if the support is so designed. This does not require evaluation of the support components other than the base plate and anchors. Spring supports will be evaluated if for any reason dead weight and or thermal re-analysis produces load or displacement changes.

7.4 Snubber (HSSA) and Strut (RSSA) Supports

Particular care should be taken to determine the actual installed orientation of snubber and strut type supports since deviations from the design analysis orientation may result in significant changes in pipe stress and/or support loads.

Angular deviations in excess of 5° should be brought to the attention of the Senior Stress Analyst to evaluate the effect on the Pipe Stress Analysis.

Check of Swing Angle (Support Travel Arc) was accounted for in the original design. Standard installation requirements allow for at least 1/2" clearance. Therefore, check of swing angle is required only when the reanalysis yields significant additional thermal displacements (1/2") or the support location changed from the original design.

7.5 "U-Bolts" (Loose and/or Tight Conditions)

At the outset of the support evaluation effort, U-bolt allowable loads as shown on Figure 4.1 were used for acceptance criteria. It was then determined that these values were excessively

7.5 "U-Bolts" (Loose and/or Tight Conditions) (Continued)

conservative in shear (side loads). Therefore, in lieu of values shown on Figure 4.1 the Allowable Loads as shown on Figure 4.2 were adopted.

No re-evaluation of the supports evaluated under the earlier Figure 4.1 criteria was required because the Figure 4.1 criteria was more conservative.
U-bolts have been also used as axial and or rotational restraints. These non-standard applications were accepted provided that the U-bolt is tight and the following conservative limitations are not exceeded.

a. Axial: Limit to 25% of Vert. (tension) allowable. This load to be additive to other tension loads.
b. Rotational: Limit was based on the tension allowable for the U-bolt(s). Tight "U" bolts provide torsional resistance because they act as friction clamp devices. The designer should translate the pipe torsional load to a "U" bolt tension load. The designer should ensure that slippage does not occur based on a friction factor of 35%.

Subsequent project calculations confirm the above limits and approach to be conservative. See Calc. 7579-144-8-SS-71 (Rev. 0) for confirmatory evaluation. Figures 5.1 thru 5.6 are based on this calculation and shall be used to evaluate tight U-bolts conforming to stock sizes and geometry shown.

7.5.1 In the event tight "U-bolts" of other stock sizes are encountered, they shall be evaluated in the same manner as the "U-bolts" evaluated in Calc. 7579-144-8-SS-71.

7.5.2 Loose "U-bolts" shall be evaluated on the basis of vendor published data for the "U-bolt" used if they are other than standard stock sizes as shown in Figure 5.1.

7.6 Pipe Clamps

Use of Bergen-Paterson standard EA3 pipe clamps in off-axis applications was determined to be acceptable as qualified by Calculations 7579-032-8-SS-59-F and 7579-144-8-SS-74-F.

See Figures 6.1 thru 6.7 for Detailed Criteria used in evaluation of these clamps as extracted from Calculation sets 7579-032-8-SS-59-F and 7579-144-8-SS-74-F. | 1

Other clamps are to be evaluated in accordance with vendor information.

8.0 LOAD COMBINATION AND DESIGN LOADS

The following Load Combinations shall be considered on each type of support as indicated below. Not all indicated loadings apply to a particular analysis.

Support \ Load Condition	Non-Seismic Supports	Seismic Supports		
	Normal Operation	Upset (OBE)	Emergency or Faulted (DBE)	Short Term Structural Integrity (DBE)
Springs	D	D	D	D
Hydraulic Snubbers	TR	$\sqrt{E^2 + TR^2}$ + SAD	$\sqrt{(E')^2 + TR^2}$ + SAD'	$\sqrt{(E')^2 + TR^2}$ + SAD'
Anchors Guides Nozzles Link-Seals	D + T + TR	$\sqrt{E^2 + TR^2}$ + D + T + SAD	$\sqrt{(E')^2 + TR^2}$ + D + T + SAD' + PAD + TAD	$\sqrt{(E')^2 + TR^2}$ + D + T + SAD' + PAD + TAD

D = Dead Weight T = Thermal TR = Transient

E = Seismic (OBE) E' = Seismic (DBE)

SAD = Seismic Anch. Displ. (OBE Load) SAD' = Seismic Anch. Displ. (DBE Load)

PAD = Pressure Anch. Displ.

TAD = Thermal Anch. Displ.

8.1 In order to prevent inadvertent damage to supports; supports should be capable of sustaining, as a minimum, a load of 200 lbs. in the vertical (-Y) direction or 150 lbs. in the vertical (-Y) and 150 lbs. in the horizontal direction transverse to the pipe axis. These values, if used, need only satisfy structural integrity criteria. This criteria is considered a good practice wherever practical.

8.2 If design is undertaken based on Section 8.1, care must be taken not to alter or violate the analyzed function of the support. If the design inputs loadings to the piping other than those specifically required by the piping stress analysis, the documented concurrence of the Senior Stress Analyst shall be obtained for the given design.

8.3 Seismically supported small bore piping (2" and under) that does not require computer analysis may be supported utilizing loadings determined from the spacing Tables given in Study Report: Doc. No. 7150-046-S-MS-025. (Reference Section 3.0 of Study Report 7865.007-S-M-020 for determination of when to computer analyze small bore piping.) This document shall be used only when no detailed computer pipe stress analysis is to be performed.

8.4 Design loads may be developed using hand calculations or a combinatic of hand calculations and "TMAP" or "STRUDL" type computer programs; provided any program used has been approved for use in accordance with applicable project procedures.

9.0 TABULATION (SUMMATION) OF SUPPORT LOADS

9.1 For first level evaluations all loads shown on the load on support sheet shall be tabulated to reflect the maximum postulated load for a given sign (+ or −) of load.

9.2 Dead weight, when present, shall always be included in summation with its given sign.

9.3 All seismic and transient loads shall be considered to have both + (positive) and − (negative) signs.

9.4 Thermal loads shall be considered with its given sign except that it shall not be used to reduce the maximum load summation.

9.5 The above (Items 9.1 thru 9.4) provide conservative summation results. If support evaluation based on this summation method is not acceptable, an alternate summation considering the actual loadings for particular analysis conditions (cases) may be utilized.

9.6 Load combinations for structural anchor supports at analysis terminations, within safety systems, shall consider the loads from the analysis on both sides of the anchor using the following method.

a. Seismic or transient loads from both analyses to be combined using square root sum of squares.

b. Deadweight and/or thermal loads from both analyses to be combined algebraically (with signs).

c. Final summation after 9.6.a. and 9.6.b. to be same as 9.1 thru 9.4, above.

9.7 Load combinations for anchors or supports at boundaries between safety and non-safety related portions of systems are addressed by Study Report 7992.001-S-M-034.

9.8 Application of loads on supports in an analysis overlap zone are addressed by Study Report 7992.001-S-M-037. 1

FIGURE 1

HYDRAULIC SNUBBER ALLOWABLE LOAD
(Bergen-Paterson Model "HSSA")
With Standard Relief Valve Spring

Allow. Max. / 251/252 Model	Normal Operation	Upset OBE	Emergency or Faulted DBE	DBE STSI	@ Max. Pin To Pin Dim., (Model 252)
HSSA-3	3,000#	3,920#	3,920#	4,500#	7'-2"
HSSA-10	10,000#	13,800#	13,800#	15,000#	6'-7"
HSSA-20	20,000#	23,600#	23,600#	30,000#	6'-4"
HSSA-30	30,000#	37,600#	37,600#	45,000#	6'-6"

Ref's.

1. Bergen-Paterson Letter, H.R. Erikson to R. Anzalone of 6/1/79, VU-91057
2. Bergen-Paterson Letter, H.R. Erikson to R. Anzalone of 6/20/79, VU-91058

HYDRAULIC SNUBBER ALLOWABLE LOAD
(Bergen-Paterson Model "HSSA")
With Heavy Duty Relief Valve Spring

Allow. Max. / 251/252 Model	Normal Operation	Upset OBE	Emergency or Faulted DBE	DBE STSI	@ Max. Pin To Pin Dim., (Model 252)
HSSA-3	3,000#	4,500#	4,500#	5,010#	7'-2"
HSSA-10	10,000#	15,000#	15,000#	16,700#	6'-7"
HSSA-20	20,000#	30,000#	30,000#	33,400#	6'-4"
HSSA-30	30,000#	45,000#	45.000#	50,100#	6'-6"

FIGURE 1
(Continued)

STRUT ALLOWABLE LOAD
(Bergen-Paterson Model "RSSA")

Model	Normal Operation	Upset OBE	Emergency or Faulted DBE	STSI* DBE
RSSA-3	3,000#	3,000#	4,000#	5,010#
RSSA-10	10,000#	10,000#	13,300#	16,700#
RSSA-20	20,000#	20,000#	26,600#	33,400#
RSSA-30	30,000#	30,000#	39,000#	50,100#

*STSI Allow. per Ref. 1 above @ Max. pin to pin same as listed for HSSA Units.

Strut Units (RSSA) have been qualified under Bulletin calculations based on capacity equivalent to snubber units (HSSA). The above table should be used for any subsequent evaluations or designs.

FIGURE 2

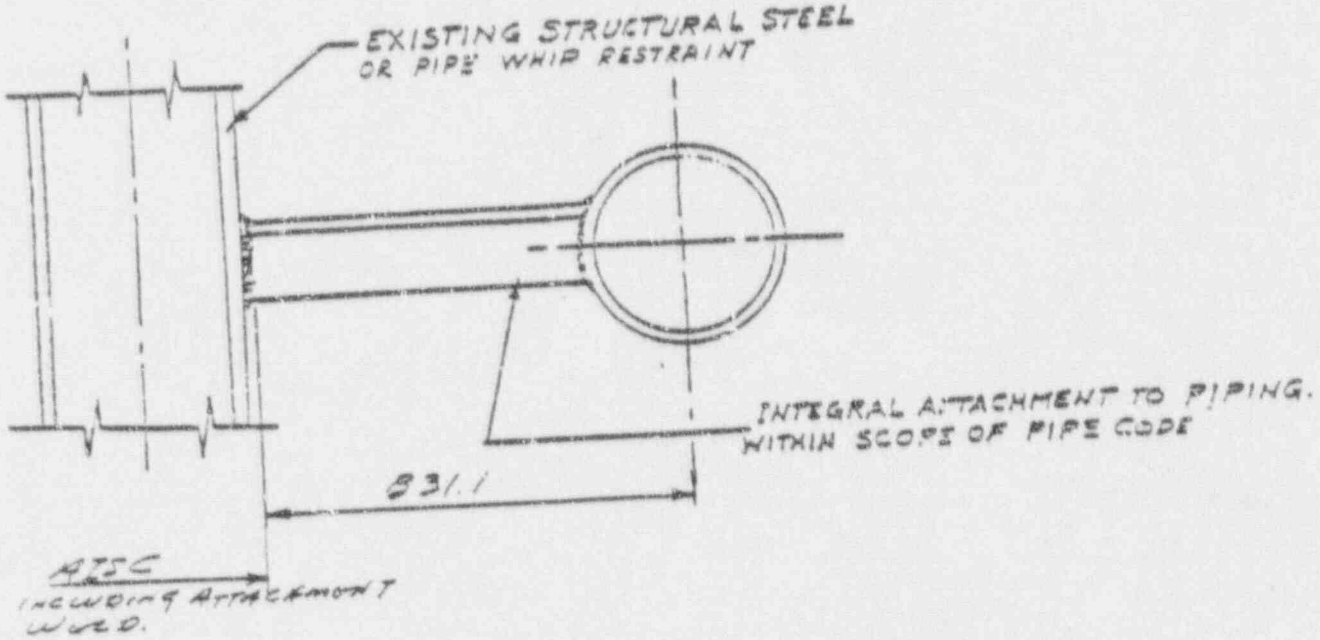


FIGURE 2.1 — JURISDICTIONAL BOUNDARY BETWEEN INTEGRAL ATTACHMENT & Component Support or Supplementary Steel.

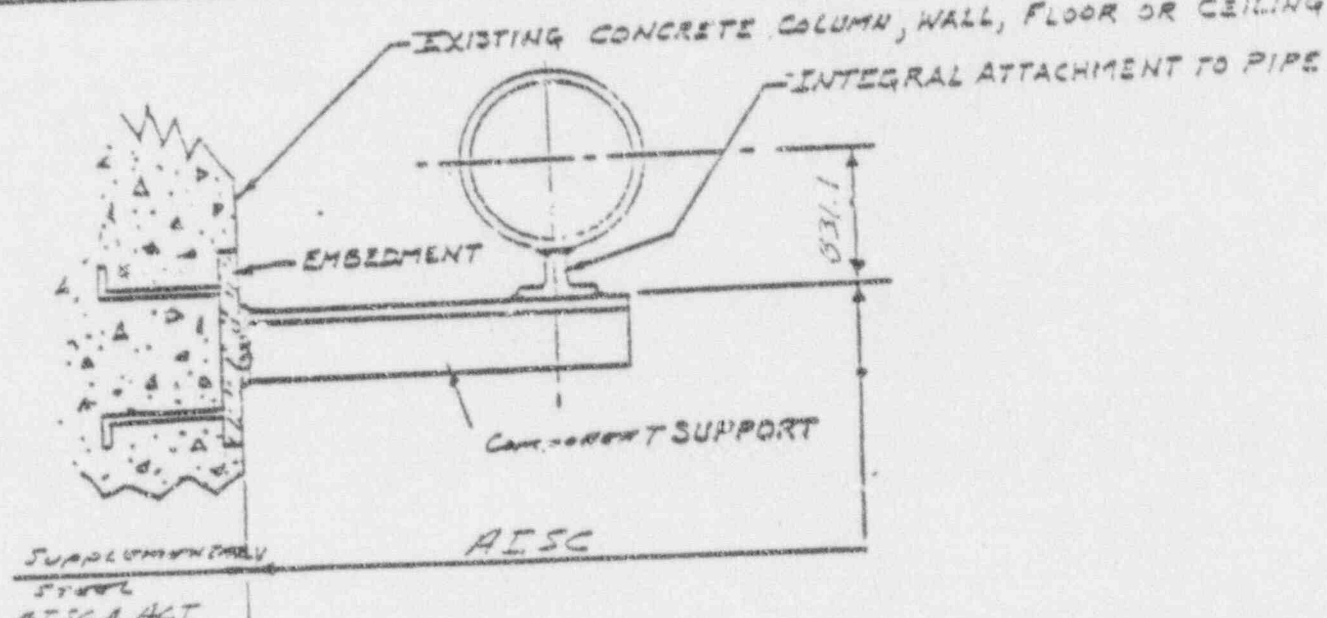
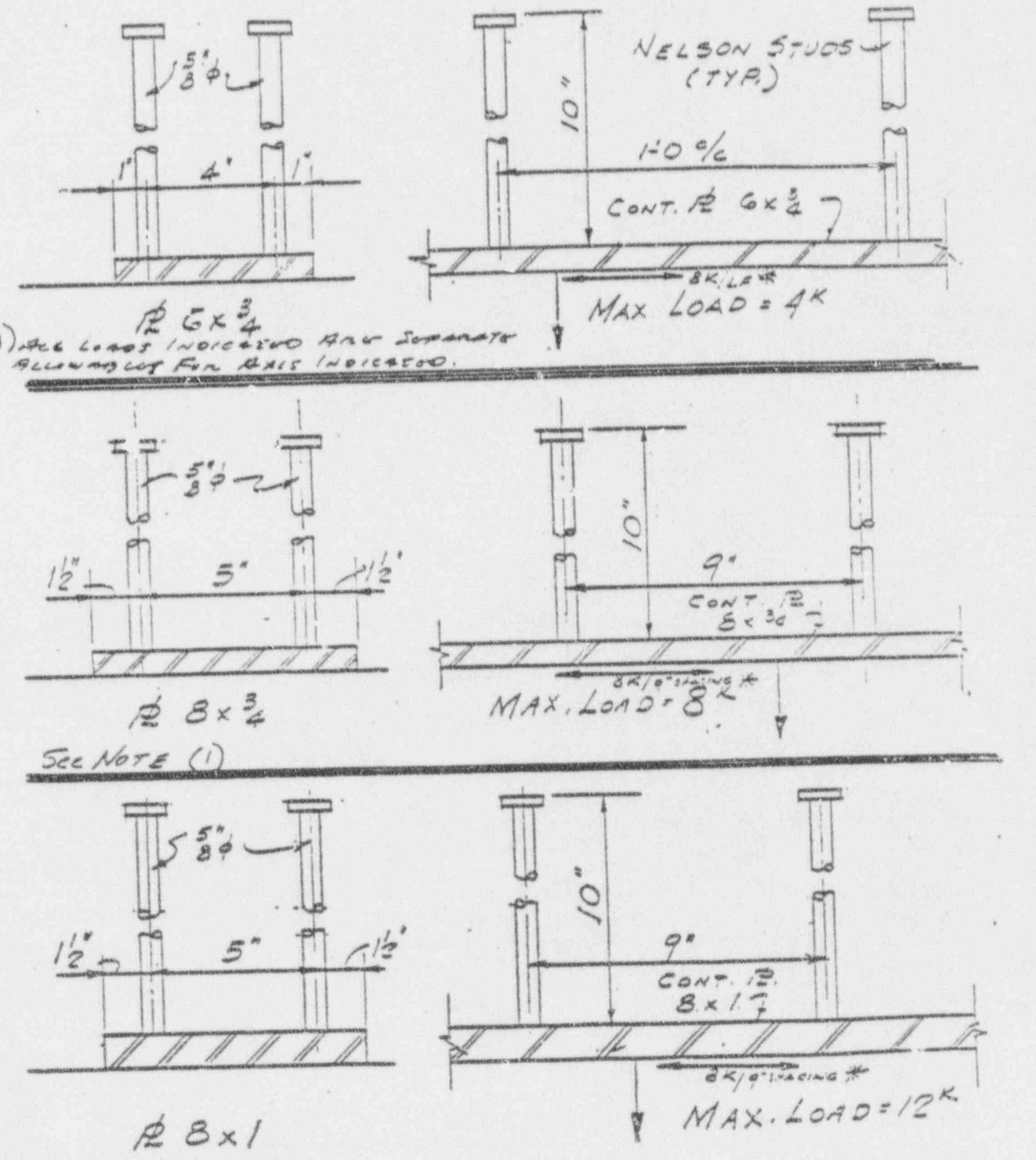


FIGURE 2.2 — JURISDICTIONAL BOUNDARY BETWEEN INTEGRAL ATTACHMENT & Component Support.

FIGURE 3

STANDARD EMBED PLATES



* THE 8K LOAD SHOWN // TO THE INSERT PL'S IS A MAX. AND MUST BE REDUCED FOR SPACING AND OR EDGE REQUIREMENTS AS APPLICABLE.
SEE NOTE (1)

FIGURE 4.1

(Superseded by Figure 4.2)

The following criteria shall be used for evaluation of U-Bolts for the Upset Condition (Carbon Steel)

Nominal Pipe Size	Tension	Shear
1	490	170
1½	1,250	390
2	1,250	290
2½	2,350	610
3	2,400	470
3½	2,450	400
4	2,450	350
5	2,500	280
6	4,000	460
8	4,050	350
10	6,100	480
12	8,500	640
14	8,550	570
16	8,600	500
18	11,300	660
20	11,350	590
24	11,400	490

FIGURE 4.2

Loose U-Bolts - All Sizes
Tight U-Bolts - All Sizes, except after 3/15/85, sizes 6" and under shall conform to the values given in Figs. 5.1 thru 5.6

Design Conditions		Maximum Rated Load Pipe Size (Pounds)						
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
Normal and Upset Conditions	$P_{vert.}$	485	485	485	1220	1220	1220	2260
	$P_{hor.}$	160	160	160	400	400	400	745
Emergency & Faulted	$P_{vert.}$	645	645	645	1620	1620	1620	3000
	$P_{hor.}$	210	210	210	530	530	530	900
STSI	$P_{vert.}$	900	900	900	2280	2280	2280	4225
	$P_{hor.}$	300	300	300	740	740	740	1390
Stock ∅		1/4	1/4	1/4	3/8	3/8	3/8	1/2

Design Conditions		Maximum Rated Load Pipe Size (Pounds)						
		3	3-1/2	4	5	6	8	10
Normal and Upset Conditions	$P_{vert.}$	2260	2260	2260	2260	3620	3620	5420
	$P_{hor.}$	745	745	745	745	1190	1190	1730
Emergency & Faulted	$P_{vert.}$	3000	3000	3000	3000	4815	4815	7220
	$P_{hor.}$	990	990	990	990	1580	1580	2370
STSI	$P_{vert.}$	4225	4225	4225	4225	6770	6770	10135
	$P_{hor.}$	1390	1390	1390	1390	2220	2220	3320
Stock ∅		1/2	1/2	1/2	1/2	5/8	5/8	3/4

"Tight" - See Fig's. 5.1 thru 5.6 ⟵⟶

Design Conditions		Maximum Rated Load Pipe Size (Pounds)						
		12	14	16	18	20	24	30
Normal and Upset Conditions	$P_{vert.}$	7540	7540	7540	9920	9920	9920	9920
	$P_{hor.}$	2480	2480	2480	3270	3270	3270	3270
Emergency & Faulted	$P_{vert.}$	10000	10000	10000	13190	13190	13190	13190
	$P_{hor.}$	3300	3300	3300	4350	4350	4350	4350
STSI	$P_{vert.}$	14100	14100	14100	18550	18550	18550	18550
	$P_{hor.}$	4630	4630	4630	6110	6110	6110	6110
Stock ∅		7/8	7/8	7/8	1"	1"	1"	1"

Design Temperature
650°F

Note: Use straight line interaction for cases with loading in both horiz. and vertical directions.

Materials:
ASME SA-36, SA-307, Gr. B

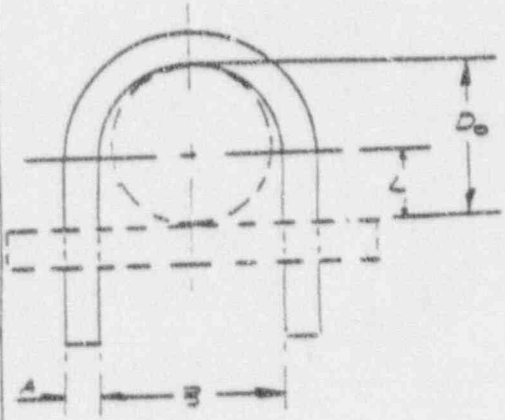
Stock Sizes and Geometry same as Figure 5.1 for 6" ∅ and less.

$P_{vert.}$ is tension allowable load.
$P_{hor.}$ is shear (side load) allowable.

FIGURE 5.1 of 5.6

U-BOLT GEOMETRY

NOMINAL PIPE SIZE IN	PIPE OUTSIDE DIA. D_o IN	U-BOLT ROD DIA. A IN	U-BOLT INSIDE DIA. B IN	L IN
1/2	0.840	1/4	7/8	.403
3/4	1.050	↓	1 1/8	.488
1	1.315	1/4	1 3/8	.628
1 1/4	1.660	3/8	1 3/4	.785
1 1/2	1.900	↓	2	.900
2	2.375	3/8	2 1/2	1.125
2 1/2	2.875	1/2	3	1.375
3	3.500		3 5/8	1.688
3 1/2	4.000		4 1/8	1.938
4	4.500	↓	4 5/8	2.188
5	5.563	1/2	5 5/8	2.751
6	6.625	5/8	6 3/4	3.250



$$L = D_o - \frac{B}{2}$$

FIGURE 5.2 of 5.6

CONDITION: NORMAL OPERATION OR UPSET 1
SINGLE U-BOLT CAPACITY LOADS
SYSTEM PRELOAD = 20% OF YIELD STRESS
MATERIAL ALLOWABLE STRESS, S = 15000 PSI
MATERIAL YIELD STRESS = 36000 PSI

NOMINAL PIPE SIZE IN	P_I TENSION LOAD LB	P_{II} SIDE LOAD LB	P_{III} AXIAL LOAD LB	M_{III} TORSIONAL LOAD IN LB
1/2	1175	403	247	252
3/4	1175	376	247	315
1	1175	347	247	395
1 1/4	2650	826	555	1120
1 1/2	2650	791	555	1285
2	2650	744	555	1605
2 1/2	4710	1354	989	3455
3	4710	1286	989	4207
3 1/2	4710	1248	989	4808
4	4710	1218	989	5403
5	4710	1172	989	6687
6	7360	1847	1546	12440

(1) CAPACITY INDICATED IS FOR THE LOAD ACTING ALONE

(2) PRELOAD MUST PRODUCE AT LEAST 20% YIELD STRESS FOR RESULTS TO BE APPLICABLE

FIGURE 5.3 of 5.6

SINGLE U-BOLT CAPACITY LOADS
SYSTEM PRELOAD = 20% OF YIELD STRESS
MATERIAL ALLOWABLE STRESS, S = 15000 PSI
MATERIAL YIELD STRESS = 36000 PSI

NOMINAL PIPE SIZE IN	EMERGENCY OR FAULTED				STSI			
	P_I TENSION LOAD LB	P_{II} SIDE LOAD LB	P_{III} AXIAL LOAD LB	M_{III} TORSION LOAD IN LB	P_I TENSION LOAD LB	P_{II} SIDE LOAD LB	P_{III} AXIAL LOAD LB	M_{III} TORSION LOAD IN LB
1/2	1754	480	247	252	2192	537	247	252
3/4	1754	439	247	315	2192	487	247	315
1	1754	397	247	395	2192	435	247	395
1 1/4	3960	958	555	1120	4950	1059	555	1120
1 1/2	3960	905	555	1285	4950	995	555	1285
2	3960	837	555	1605	4950	907	555	1605
2 1/2	7050	1535	989	3455	8810	1671	989	3455
3	7050	1435	989	4207	8810	1545	989	4207
3 1/2	7050	1376	989	4808	8810	1472	989	4808
4	7050	1332	989	5409	8810	1418	989	5409
5	7050	1262	989	6687	8810	1330	989	6687
6	11040	1997	1596	12440	13800	2110	1596	12440

(1) CAPACITY INDICATED IS FOR THE LOAD ACTING ALONE.

(2) PRELOAD MUST PRODUCE AT LEAST 20% YIELD STRESS FOR RESULTS TO BE APPLICABLE

FIGURE 5.4 OF 5.6

CONDITION: NORMAL OPERATION OR UPSET
DOUBLE U-BOLT CAPACITY LOADS
SYSTEM PRELOAD = 20% OF YIELD STRESS
MATERIAL ALLOWABLE STRESS, S = 15000 PSI
MATERIAL YIELD STRESS = 36000 PSI

NOMINAL PIPE SIZE IN.	P_I TENSION LOAD LB	P_{II} SIDE LOAD LB	P_{III} AXIAL LOAD LB	SIDE LOAD COUPLE $\frac{M_I}{d_B}$ LB	TORS. LOAD COUPLE $\frac{M_{II}}{d_B}$ LB	M_{III} TORSIONAL LOAD IN LB
½	2350	806	494	403	1175	504
¾	2350	752	494	376	1175	630
1	2350	694	494	347	1175	790
1¼	5300	1652	1110	826	2650	2240
1½	5300	1582	1110	791	2650	2570
2	5300	1488	1110	744	2650	3210
2½	9420	2708	1978	1354	4710	6910
3	9420	2572	1978	1286	4710	8414
3½	9420	2496	1978	1248	4710	9616
4	9420	2436	1978	1218	4710	10818
5	9420	2344	1978	1172	4710	13374
6	14720	3694	3092	1847	7360	24880

(1) d_B = DISTANCE BETWEEN U-BOLTS

(2) CAPACITY INDICATED IS FOR THE LOAD ACTING ALONE

(3) PRELOAD MUST PRODUCE AT LEAST 20% YIELD STRESS FOR RESULTS TO BE APPLICABLE

FIGURE 5.5 of 5.6

CONDITION: EMERGENCY OR FAULTED

DOUBLE U-BOLT CAPACITY LOADS
SYSTEM PRELOAD = 20% OF YIELD STRESS
MATERIAL ALLOWABLE STRESS, S = 15000 PSI
MATERIAL YIELD STRESS = 36000 PSI

NOMINAL PIPE SIZE IN	P_I TENSION LOAD LB	P_{II} SIDE LOAD LB	P_{III} AXIAL LOAD LB	SIDE LOAD COUPLE M_I/d_B LB	TENS. LOAD COUPLE M_{II}/d_B LB	M_{III} TORSIONAL LOAD IN LB
½	3508	960	494	480	1754	504
¾	3508	878	494	439	1754	630
1	3508	794	494	397	1754	790
1¼	7920	1916	1110	958	3960	2240
1½	7920	1814	1110	907	3960	2570
2	7920	1674	1110	837	3960	3210
2½	14100	3070	1978	1535	7050	6910
3	14100	2870	1978	1435	7050	8414
3½	[illegible]100	2752	1978	1376	7050	9616
4	14100	2664	1978	1332	7050	10818
5	14100	2524	1978	1262	7050	13374
6	22080	3994	3092	1997	11040	24880

(1) d_B = DISTANCE BETWEEN U-BOLTS

(2) CAPACITY INDICATED IS FOR THE LOAD ACTING ALONE

(3) PRELOAD MUST PRODUCE AT LEAST 20% YIELD STRESS FOR RESULTS TO BE APPLICABLE

FIGURE 5.6 of 5.6

CONDITION: SHORT TERM STRUCTURAL INTEGRITY
DOUBLE U-BOLT CAPACITY LOADS
SYSTEM PRELOAD = 20% OF YIELD STRESS.
MATERIAL ALLOWABLE STRESS, S = 15000 PSI
MATERIAL YIELD STRESS = 36000 PSI

NOMINAL PIPE SIZE in	P_I TORSION LOAD LB	P_{II} SIDE LOAD LB	P_{III} AXIAL LOAD LB	SIDE LOAD COUPLE M_I / d_B LB	TORS. LOAD COUPLE M_{II} / d_B LB	M_{III} TORSIONAL LOAD IN LB
1/2	4384	1074	494	537	2192	504
3/4	4384	974	494	487	2192	630
1	4384	870	494	435	2192	790
1 1/4	9900	2118	1110	1059	4950	2240
1 1/2	9900	1990	1110	995	4950	2570
2	9900	1814	1110	907	4950	3210
2 1/2	17620	3342	1978	1671	8810	6910
3	17620	3090	1978	1545	8810	8414
3 1/2	17620	2944	1978	1472	8810	9616
4	17620	2836	1978	1418	8810	10818
5	17620	2660	1978	1330	8810	13374
6	27600	4220	3092	2110	13800	24880

(1) d_B = DISTANCE BETWEEN U-BOLTS

(2) CAPACITY INDICATED IS FOR THE LOAD ACTING ALONE

(3) PRELOAD MUST PRODUCE AT LEAST 20% YIELD STRESS FOR RESULTS TO BE APPLICABLE.

FIGURE 6.1 of 6.7

DETAILED EVALUATION CRITERIA

Bergen-Paterson (Standard) EA3 Clamps

a. Evaluation for Axial Loading

Axial Loading is defined as load applied to clamp within a 12° cone of action relative to the major axis of the clamp. That is, ± 6° about Pv as shown on Figure 6.2.

a.1 Evaluation shall be based on Pv allowable, for condition indicated, as shown in the Table presented on Figure 6.2.

b. Evaluation for Off-Axis Loading:

Off-Axis loading is defined as loads applied to clamp at an angle of greater than 6° relative to the major clamp axis. That is, any angle more than 6° from the Pv axis as shown on Figure 6.2.

b.1 Compute Pv and Ph components based on snubber/strut analysis load and angle of application.

b.2 Compute load to capacity ratio (L/c) for Pv and Ph component loads separately using Pv max. from Table on Figure 6.2 and Ph max. from appropriate table on Figure 6.3, 6.4, 6.5, or 6.6

b.3 Plot Pv and Ph L/c on graph provided on Figure 6.7. Determine intersect of Pv and Ph values; if result is within curve shown, clamp is adequate for load. If result is outside curve shown then clamp must be either replaced or evaluated as acceptable by an alternate approach.

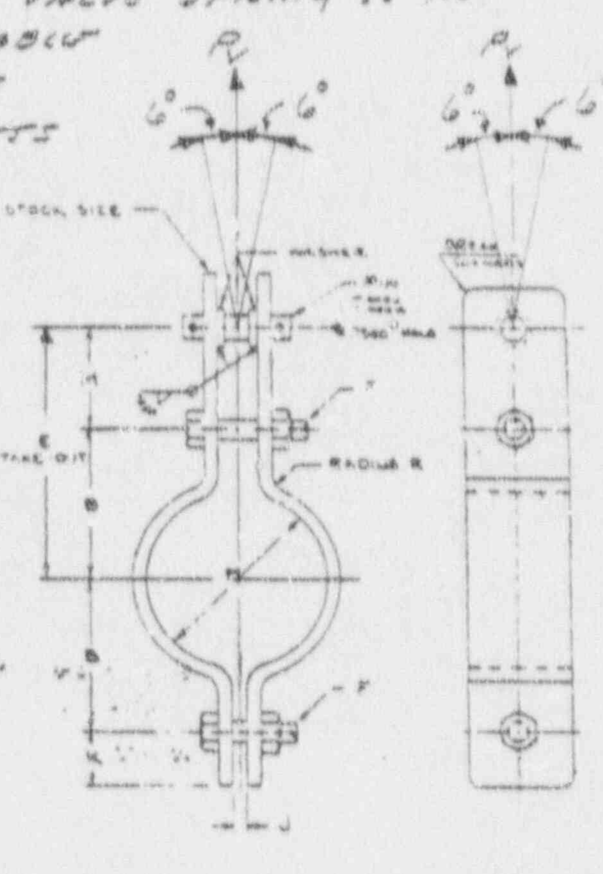
NOTE: Ph max. allowables shown on Figures 6.3, 6.4, 6.5, and 6.6 presume the presence of pipe lugs at clamp. If lugs are not present the condition must be evaluated to ensure slippage does not occur.

FIGURE 6.3 of 6.7

Bergen-Paterson (Standard) EA3 Clamp

	P_Y MAX. ALLOWABLE @ 650°F			
NOMINAL RATING	NORMAL OPERATION	UPSET	EMERGENCY OR FAULTED	STS I*
3k	3000#	4000#	4,500#	5010#
10k	10,000#	13,350#	15,000#	16,700#
20k	20,000#	26,700#	30,000#	33,400#
30k	30,000#	40,000#	45,000#	50,100#

* VALUES BASED ON MAXIMUM CAPACITY OF SNUBBER UNITS (HSSA) FOR LEVEL INDICATED. THESE ALLOWABLES ARE DERIVED FROM MECHANICAL FUNCTION OF THE SNUBBER RELIEF VALVE SPRING ∴ NO INCREASE OF ALLOWABLE FOR TEMPERATURE IS PERMITTED IN EXCESS OF THESE VALUES.



NOTES:

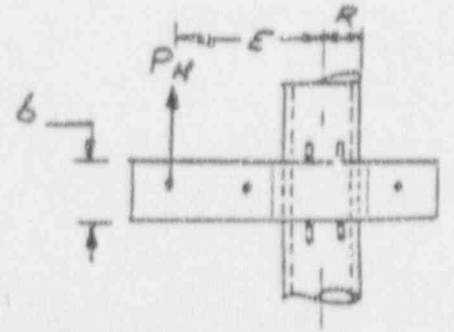
a. UPSET AND EMERGENCY OR FAULTED VALUES ARE BASED ON YIELD AT 1.88 TIMES NOMINAL RATING.
   i.e. 1.88 = YIELD
   1.50 = EMERGENCY OR FAULTED
   1.33 = UPSET
   1.00 = NORMAL OPERATION

b. AISI C-1020 (BAR) IS EQUIVALENT TO SA-36 ∴ NO ADJUSTMENT FOR DIFFERENT PROPERTIES IS REQUIRED.

REFERENCE:
NOTES a & b PER TELECON T-1290 3/10/87 H.R. ERICSON OF BERGEN-PATERSON TO J.T. ALLEN OF UNITED.

FIGURE 6.2 OF 6.7

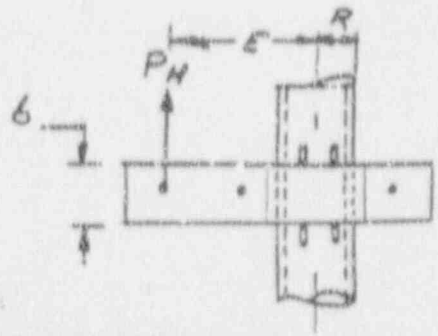
"EA3" CLAMP FOR HSSA-3, RSSA-3



					P_H ALLOWABLE @ 650°F (LBS.)			
PIPE SIZE	R IN.	E IN.	STOCK tc	STOCK b	NORMAL OPERATION	UPSET	EMERGENCY OR FAULTED	STS I
1½	0.95	4¾	5/16	2	350	465	525	590
2	1.19	5	5/16	2	350	465	525	590
2½	1.44	5¾	3/8	2	435	580	655	735
3	1.75	6	3/8	2	440	590	665	745
4	2.25	7	3/8	2½	505	675	760	850
5	2.78	7½	3/8	2½	510	680	765	855
6	3.31	8	3/8	2½	515	685	770	860
8	4.31	9½	1/2	2	620	830	935	1045
10	5.38	11	1/2	2	575	770	865	970
12	6.38	12	1/2	2½	740	985	1110	1240
14	7.00	13	1/2	3	845	1130	1270	1425
16	8.0	14	1/2	3	845	1130	1270	1425
18	9.0	15	1/2	3	850	1130	1270	1425
20	10.0	16	1/2	4	1155	1540	1735	1940
24	12.0	18	5/8	3	1285	1710	1925	2155
30	15.0	21	5/8	3	1285	1710	1925	2155
36	18.0	24	5/8	4	1760	2345	2640	2955

FIGURE 6.4 OF 6.7

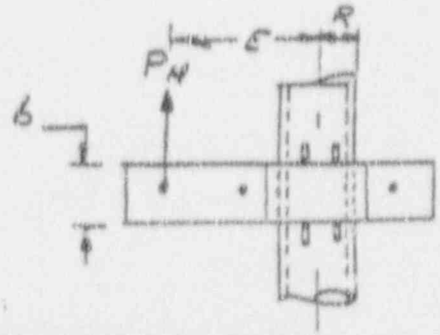
"EA3" CLAMP FOR HSSA-10, KSSA-10



					PH ALLOWABLE @ 650 °F (LBS.)			
PIPE SIZE	R IN.	E IN.	STOCK tc	STOCK b	NORMAL OPERATION	UPSET	EMERGENCY OR FAULTED	STS I
3	1.75	7 3/4	1/2	4	1155	1540	1735	1940
3 1/2	2.0	7 3/4	1/2	4	1205	1605	1805	2020
4	2.25	8 1/4	1/2	4	1155	1540	1730	1940
5	2.78	8 3/4	1/2	4	1160	1545	1740	1950
6	3.31	9 1/2	5/8	4	1705	2275	2560	2865
8	4.31	10 1/2	5/8	4	1705	2275	2560	2865
10	5.38	12	3/4	4	2250	3000	3375	3780
12	6.38	13	3/4	4	2250	3000	3375	3780
14	7.0	14	7/8	4 1/2	3225	4305	4845	5425
16	8.0	15	7/8	4 1/2	3225	4305	4845	5425
18	9.0	16	7/8	4 1/2	3225	4305	4845	5425
20	10.0	17	1	5	4635	6180	6950	7790
24	12.0	19	1	5	4635	6180	6950	7790
28	14.0	21	1 1/8	6	7035	9355	10550	11815
30	15.0	22	1 1/8	6	7030	9350	10545	11810

FIGURE 6.5 OF 6.7

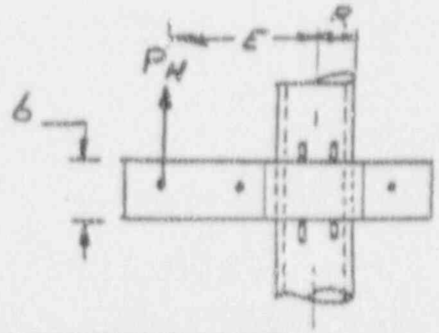
"EA3" CLAMP FOR HSSA-20, RSSA-20



PIPE SIZE	R IN.	E IN.	STOCK t	STOCK b	P_N ALLOWABLE @ 650°F (LBS.) NORMAL OPERATION	UPSET	EMERGENCY OR FAULTED	STSI
4	2.25	8¼	5/8	4½	1995	2660	2990	3350
5	2.78	8¾	¾	4	2480	3305	3720	4165
6	3.31	9½	¾	4½	2725	3635	4090	4575
8	4.31	10½	7/8	4½	3625	4835	5440	6090
10	5.38	12	7/8	4½	3405	4535	5110	5715
12	6.38	13	1	5	4885	6515	7330	8210
14	7.0	14	1	5	4635	6180	6950	7790
16	8.0	15	1	5	4635	6180	6950	7790
18	9.0	16	1 1/8	6	7035	9375	10545	11815
20	10.0	17	1 1/8	6	7035	9375	10545	11815
22	11.0	18	1 1/8	6	7035	9355	10550	11815
24	12.0	19	1 1/8	6	7035	9375	10545	11815
26	13.0	20	1 1/8	6	7035	9355	10550	11815
28	14.0	21	1¼	6	8530	11345	12795	14330
30	15.0	22½	1¼	6	8000	10665	12000	13440
33	16.5	24	1¼	6	8000	10640	12000	13440
36	18.0	26	1½	6	10495	13960	15740	17630
36	18.0	26½	1¾	7	15565	20755	23350	26155

Figure 6.6 of 6.7

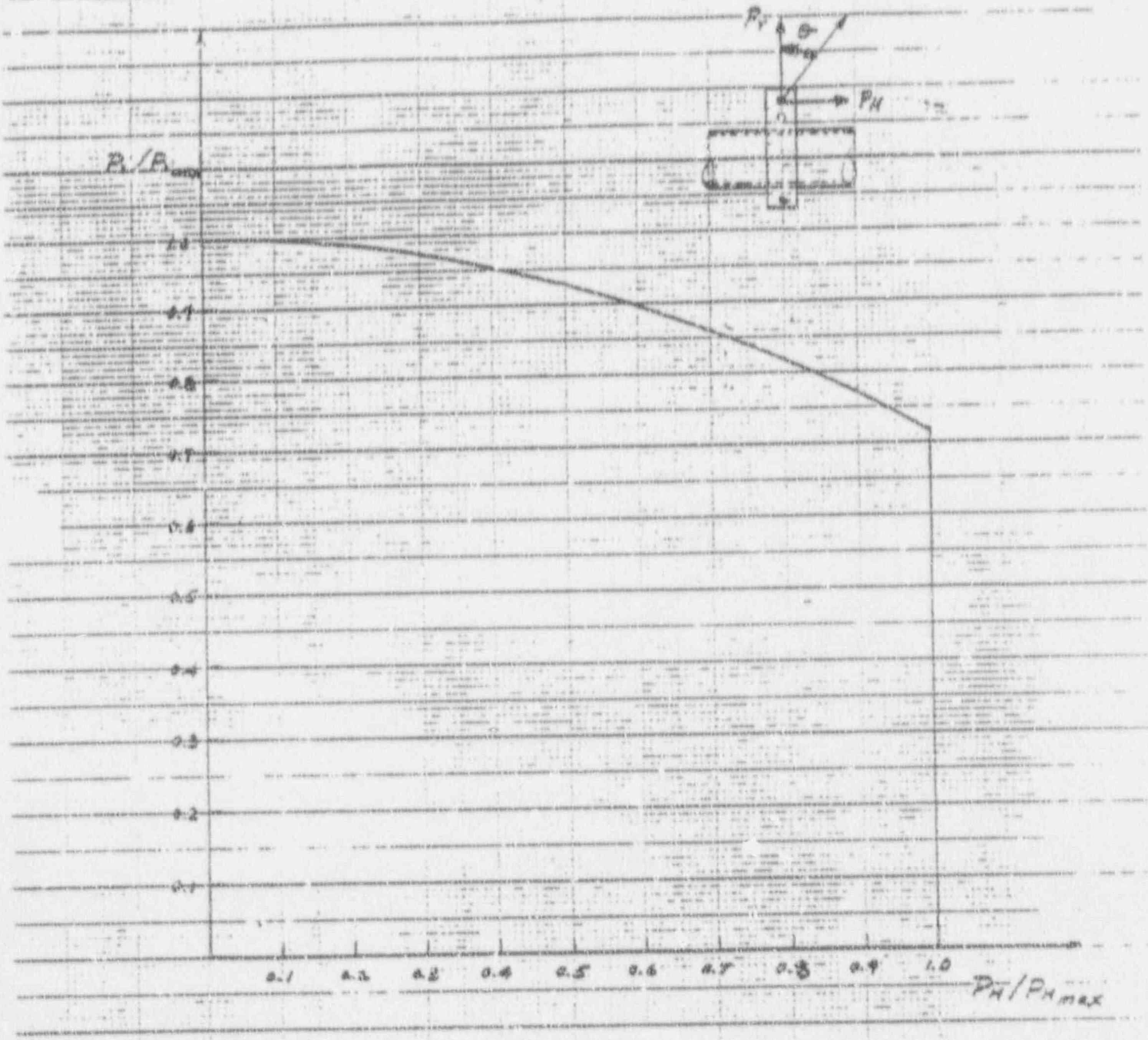
"EA3" Clamp For HSSA-30, RSSA-30



					P_H Allowable @ 650°F (Lbs.)			
Pipe Size	R In.	E In.	Stock Ec	Stock W	Normal Operation	Upset	Emergency or Faulted	STS I
4	2.25	9¼	¾	5	2720	3620	4075	4565
5	2.78	10	⅞	4	2755	3665	4130	4625
6	3.31	11	⅞	5	3315	4410	4970	5570
8	4.31	12	1	5	4245	5645	6365	7130
10	5.38	13½	1	6	4920	6545	7380	8265
12	6.38	14½	1⅛	6	6120	8140	9180	10280
14	7.0	16	1¼	5	5505	7320	8260	9250
16	8.0	17	1¼	5	5505	7320	8260	9250
18	9.0	18	1¼	6	6745	8970	10115	11330
20	10.0	19	1¼	6	6745	8970	10115	11330
22	11.0	21	1½	6	8525	11340	12785	14320
24	12.0	22	1½	6	8525	11340	12785	14320
26	13.0	23	1½	6	8525	11340	12785	14320
28	14.0	24	1½	6	8525	11340	12785	14320
30	15.0	25	1½	6	8525	11340	12785	14320
34	17.0	27	1½	7	10120	13460	15180	17000
36	18.0	28	1½	8	11725	15595	17585	19695
38	19.0	29	1½	8	11725	15595	17585	19695

FIGURE 6.7 of 6.7

Interaction Curve For Bergen-Paterson (Standard) BA-3 Pipe Clamps



Note: $P_{H max}$ & $P_{V max}$ are the max. capacities of the clamp for the service condition investigated.

"DESIGN GUIDELINE FOR EVALUATING LOCAL STRESS AT WELDED ATTACHMENTS"

Guidelines for load combinations and stress allowables addressing lug attachment design verification for Seismic Class I pipe are presented in Table 1. The guidelines are consistent with the criteria of the piping code in effect at the time that the plant was built. A specific code criteria addressing this subject was not available during the plant design phase. To further facilitate the initial evaluation to identify those pipe attachments which may require modification, the above guidelines were simplified as shown in Table 2. Configurations so identified are referred to as potential fixes (potential because of conservatism inherent in the design guidelines of Table 2). These conservatisms are:

(a) The load combinations used for evaluating primary structural integrity include thermal load and

(b) The general pipe stress level is considered to be no larger than .5 [illegible] straight sections of pipe and no larger than 0.75 S_h for elbow pipe sections.

In Item (b) values selected were based upon a random sampling of stress levels at straight and elbow locations in the system.

The potential fixes identified using the guidelines of Table 2 are re-evaluated per the guidelines in Table 3. The guidelines in Table 3 are based upon recent (Winter 1981 addenda) changes in the ASME Code Stress limits. Adoption of these changes do not violate the plant code requirements. Background and motivation for these changes are presented in detail in Reference 1. The changes were considered essential since the intensification factor, i, in the original piping equations is not appropriate for describing limit load behavior. Since the changes are based upon the principles of mechanics and not upon material certification or additional inspection requirements, the changes are judged to be applicable to all plants old and new. Based on the methods presented in Attachment I, it is anicipated that the evaluation, per the guidelines in Table 3, will result in:

(1) Increase the local pipe stress allowable for straight sections of pipe by:
$.6\ S_h$ (Upset Condition)
$.45\ S_h$ (Abnormal Condition)
$.6\ S_h$ (Short Term Condition)

(2) Increase* the local pipe stress allowable for elbow sections of pipe by:
$.6\ S_h - 1.167\ \sigma_{Bo}$ (Upset Condition)
$.45\ S_h - 1.167\ \sigma_{Bo}$ (Abnormal Condition)
$.6\ S_h - 1.167\ \sigma_{Bo}$ (Short Term Condition)

σ_{Bo} = pipe bending stress at the operating condition determined by $\sigma_{Bo} = .75i \frac{M}{Z}$ or computer analysis.

* If the numerical value of the increase is negative then the local allowable stress will <u>decrease</u> by that magnitude.

Local pipe stres levels are typically determined by the methods prescribed by Welding Research Council Bulletin No. 107, March 1979 Revision.

TABLE 1

GUIDELINES FOR EVALUATING LOCAL PIPE STRESS AT WELDED ATTACHMENT LOCATIONS

Seismic Class I Piping Systems

		Local Allowable Stress Limits for Operating Condition	
OPERATING CONDITION	LOAD COMBINATION	PRIMARY OR STRUCTURAL INTEGRITY LIMIT	PRIMARY PLUS SECONDARY LIMIT
Original	P + DW + OBE + TR	$1.2\ S_h - \sigma_p$	N.A
Normal/Upset	P + DW + TH + SAD (OBE)	N.A.	$3\ S_h - \sigma_p$
Emergency or Faulted	P + DW + DBE + TR	$1.8\ S_h - \sigma_p$	N.A.
Short Term	P + DW + DBE + TR	$2.4\ S_h - \sigma_p$	N.A.

Per ASME Code Case N-318-2 for Emergency or Faulted Conditions, Secondary Stresses such as TH, PAD, TAD & SAD need not be considered; therefore they are not included.

P - Pressure Load
DW - Deadweight Load
OBE - Operating Basis Earthquake Load
TH - Thermal Load
S_h - Basic Material Allowable Stress
TR - Thrust or Transient
PAD - Pressure Anchor Displacement
TAD - Thermal Anchor Displacement
SAD (DBE) - Seismic Anchor Displcement

σ_p - Pipe general stress level at attachment location for indicated operating condition as determined by computer analysis of pipe line with appropriate stress intensification factors.

TABLE 2

GUIDELINES FOR EVALUATING LOCAL PIPE STRESS AT WELDED ATTACHMENT LOCATIONS

Seismic Class I Piping Systems

Load Combination	Section	Local Allowable Stress Limits for Establishing Load Capacity: Primary	Local Allowable Stress Limits for Establishing Load Capacity: Primary & Secondary	Condition
P + DW + OBE + TH + TR (9)	S	$1.2\ S_h - .5\ S_h$	N.A.	Original
	E	$1.2\ S_h - X$	N.A.	
P + DW + TH + SAD (OBE) (11)	S	N.A.	$3\ S_h - .5\ S_h$	Normal/Upset
	E	N.A.	$3\ S_h - X$	
P + DW + DBE + TH + TR (9)	S	$1.8\ S_h - .5\ S_h$	N.A.	Emergency or Faulted
	E	$1.8\ S_h - Y$	N.A.	
P + DW + DBE + TH + TR (9)	S	$2.4\ S_h - .5\ S_h$	N.A.	Short Term (Structural Integrity)
	E	$2.4\ S_h - Y$	N.A.	

See Note relative to Code Case N-318-2 under Table 1.

S - Straight Pipe Section
E - Elbow Pipe Section
P - Pressure Load
DW - Deadweight Load
OBE - Operating Basis Earthquake Load
DBE - Design Basis Earthquake Load
S_h - Basic Material Allowable Stress
X - Pipe Elbow General Stress Level .75 S_h (Normal/Upset)
Y - Pipe Elbow General Stress Level .75 S_h (Abnormal & Short Term)

TR - Thrust or Transient
PAD - Pressure Anchor Displacement
TAD - Thermal Anchor Displacement
SAD - Seismic Anchor Displacement

TABLE 3

GUIDELINES FOR EVALUATING PIPE LOCAL STRESS AT WELDED ATTACHMENT LOCATIONS IDENTIFIED AS POTENTIAL FIXES BASED ON TABLE 2 GUIDELINES

Seismic Class I Piping Systems

OPERATING CONDITION	LOAD COMBINATIONS	LOCAL ALLOWABLE STRESS LIMITS FOR OPERATING CONDITIONS: PRIMARY OR STRUCTURAL INTEGRITY LIMIT	LOCAL ALLOWABLE STRESS LIMITS FOR OPERATING CONDITIONS: PRIMARY PLUS SECONDARY LIMIT
Original Normal/Upset	P + DW + OBE + TR + SAD (OBE)	$1.8 S_h - \sigma_p'$	N.A.
	P + DW + TH	N.A.	$3 S_h - \sigma_p'$
Emergency or Faulted	P + DW + DBE + TR	$2.25 S_h - \sigma_p'$	N.A.
Short Term	P + DW + DBE + TR	$3.0 S_h - \sigma_p'$	N.A.

See Note relative to Code Case in N-318-2 under Table 1.

P - Pressure Load
DW - Deadweight Load
OBE - Operating Basis Earthquake Load
TH - Thermal Load
S_h - Basic Material Allowable Stress
σ_p' - Pipe general stress level at attachment location for indicated operating condition as determined by computer analysis of pipe line using Stress Indices B_1 & B_2.

TR - Thrust or Transient
PAD - Pressure Anchor Displacement
TAD - Thermal Anchor Displacement
SAD - Seismic Anchor Displacement

GENERAL COMPUTATION SHEET

united engineers

DISCIPLINE

NAME OF COMPANY CP&L - BRUNSWICK UNITS

SUBJECT DESIGN GUIDELINES

CALC SET NO		REV	COMP BY	CHKD BY
PRELIM		0	[illegible] DATE 8/29/86	[illegible] DATE [illegible]
FINAL				
VOID				
SHEET 1 OF 9			DATE	DATE
JO 7579.109				

Attachment I

To

"Design Guidelines For Evaluating Local Stress At Welded Attachments"

FORM 9001 REV. 1-79

(DISCIPLINE)

GENERAL COMPUTATION SHEET

united engineers

CALC SET NO		REV	COMP BY	CHKD BY
PRELIM		0	[illegible]	[illegible]
FINAL			DATE 2/23/84	DATE 3-[illegible]-84
VOID				
SHEET 2 OF 8			DATE	DATE
JO 7579 106				

NAME OF COMPANY CP&L - Brunswick UNIT/S

SUBJECT Design Guidelines

Pipe total stress at welded attachment locations is composed of two parts, pipe general stress and pipe local stress. Pipe general stress results from pipe internal pressure and moment loads in the pipe. Pipe local stress results from loads reacted by the welded attachment.

Allowable pipe local stress at the attachment is defined to be the difference between the allowable pipe total stress and the pipe general stress. Allowable pipe total stress is the allowable stress for the operating condition being evaluated and pipe general stress is the actual stress in the pipe at the operating condition as determined by computerized piping analysis.

In what follows, allowable pipe local stress is determined consistent with that of the piping code in effect at the time the plant was built. This allowable local stress is compared with allowable local stress based on the Winter 1981 Code Addenda. For convenience, allowable local stress based on the Winter 1981 Code Addenda is referred to as new and allowable local stress based on the piping code in effect at the time the plant was built is referred to as old. Background and motivation for the changes are explained in detail in Reference (1). In summary, the changes effect equation (8) of NC-3652 and equation (9) of NC-3653. Equations (10) and (11) of NC-3653 do not change. New equations (8) and (9) have higher allowable (total) stress levels but require that pipe general stress be based upon B indices instead of intensification factors, i. These changes affect local allowable stress for primary or structural integrity evaluations; however, stress limits for primary plus secondary evaluations do not change (equations 10 and 11).

FORM 5007 REL 779 GENERAL COMPUTATION SHEET

DISCIPLINE

United Engineers

NAME OF COMPANY CP&L - BRUNSWICK UNIT/S

SUBJECT DESIGN GUIDELINES

9.13 7579 - CSA - OD 35 - 4000

CALC SET NO		REV	COMP BY	CHKD BY
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FINAL			DATE 2/29/84	DATE
VOID				
SHEET 3 OF 8			DATE	DATE
10 7579.106				

$$\sigma_{LOCAL\ ALLOW\ OLD} = 1.2\,S_h - \sigma_{PO} - \sigma_{BO} \quad \text{(UPSET CONDITION)}$$

$$\sigma_{PO} = \frac{PD_o}{4t}, \quad \sigma_{BO} = .75i\,\frac{M}{Z}$$

$$\sigma_{LOCAL\ ALLOW\ NEW} = 1.8\,S_h - \sigma_{PN} - \sigma_{BN} \quad \text{(UPSET CONDITION)}$$

$$\sigma_{PN} = B_1\,\frac{PD_o}{2t}, \quad \sigma_{BN} = B_2\,\frac{M}{Z}$$

THE NEW PRESSURE STRESS, σ_{PN}, AND PIPE BENDING STRESS, σ_{BN}, ARE RELATED TO THE EXISTING OLD PRESSURE STRESS, σ_{PO}, AND EXISTING OLD PIPE BENDING STRESS, σ_{BO}, BY:

$$\sigma_{PN} = 2B_1\,\sigma_{PO}, \quad \sigma_{BN} = \frac{B_2}{.75i}\,\sigma_{BO}$$

<u>FOR STRAIGHT PIPE</u> $B_1 = 0.5$, $B_2 = 1.0$, $.75i = 1.0$

$\therefore$ $\sigma_{PN} = \sigma_{PO}$ AND $\sigma_{BN} = \sigma_{BO}$

$$\sigma_{LOCAL\ ALLOW\ NEW} = 1.8\,S_h - \sigma_{PO} - \sigma_{BO}$$
$$= 0.6\,S_h + 1.2\,S_h - \sigma_{PO} - \sigma_{BO}$$
$$= 0.6\,S_h + \sigma_{LOCAL\ ALLOW\ OLD}$$

$\therefore$ FOR STRAIGHT SECTIONS OF PIPE, LOCAL ALLOWABLE STRESS BASED ON THE WINTER 1981 CODE ADDENDA WILL INCREASE BY 0.6 S_h OVER THE ALLOWABLE LOCAL STRESS DETERMINED FROM THE PIPING CODE IN EFFECT AT THE TIME THE PLANT WAS BUILT FOR THE UPSET CONDITION.

FORM 5007 REV 7/78

GENERAL COMPUTATION SHEET

(DISCIPLINE) united engineers

NAME OF COMPANY: CP&L-BRUNSWICK UNIT/S ______

SUBJECT: DESIGN GUIDELINES

CALC SET NO		REV	COMP BY	CHK'D BY
PRELIM		0		
FINAL			DATE 2/21/84	DATE
VOID				
SHEET 4 OF 8			DATE	DATE
10 7579.106				

FOLLOWING THE ABOVE PROCEDURE FOR THE ABNORMAL AND SHORT TERM CONDITIONS INDICATE THAT LOCAL ALLOWABLE STRESS WILL INCREASE BY 0.45 S_H FOR THE ABNORMAL CONDITION AND BY 0.6 S_H FOR THE SHORT TERM CONDITION.

FOR ELBOW PIPE SECTIONS $\quad B_1 = 0.5,\ B_2 = \frac{1.4625}{h^{2/3}},\ .75i = \frac{.675}{h^{2/3}}$

$$\sigma_{PN} = \sigma_{PO}\ , \quad \sigma_{BN} = \frac{B_2}{.75i}\sigma_{BO}$$

$$\sigma_{LOCAL\ NEW\ ALLOWABLE} = 1.8\,S_H - \sigma_{PN} - \sigma_{BN}$$

$$= 1.8\,S_H - \sigma_{PO} - \frac{B_2}{.75i}\sigma_{BO}$$

$$= 1.2\,S_H - \sigma_{PO} - \sigma_{BO} + 0.6\,S_H + \left(1 - \frac{B_2}{.75i}\right)\sigma_{BO}$$

$$= \sigma_{LOCAL\ NO\ ALLOW} + .6\,S_H - \left(\frac{B_2}{.75i} - 1\right)\sigma_{BO}$$

$$\therefore \text{ IF } \left(\frac{B_2}{.75i} - 1\right)\sigma_{BO} < 0.6\,S_H$$

LOCAL NEW ALLOWABLE STRESS WILL INCREASE FOR THE UPSET CONDITION.

THE RATIO $B_2/.75i$ IS A FUNCTION OF THE ELBOW RADIUS AND THE RADIUS TO THICKNESS RATIO OF THE PIPE WALL. DETAILS ARE PRESENTED ON PAGES 6 TO 8. THE MAXIMUM VALUE THIS RATIO CAN ATTAIN FOR BOTH LONG AND SHORT RADIUS ELBOWS IS 2.167.

SUBSTITUTING $\frac{B_2}{.75i} = 2.167$ IN THE ABOVE INDICATES THE LOCAL NEW ALLOWABLE STRESS FOR THE UPSET CONDITION WILL INCREASE IF

$$\sigma_{BO} < .514\,S_H\,.$$

GENERAL COMPUTATION SHEET

united engineers

DISCIPLINE:

NAME OF COMPANY: CP&L-Brunswick UNIT/S:

SUBJECT: Design Guidelines

D-1) 7575 - C24 - 00188 - 4000

CALC SET NO.		REV	COMP BY	CHK'D BY
PRELIM		0	[illegible] DATE [illegible]	[illegible] DATE [illegible]
FINAL				
VOID			DATE	DATE
SHEET 5 OF 8				
I.O. 7579.106				

Proceeding in the manner above indicates new local allowable stress for the abnormal condition will increase if:

$$F_{30} < 0.336\ S_h$$

and for the short term condition if:

$$F_{30} < .514\ S_h$$

GENERAL COMPUTATION SHEET

united engineers & constructors inc

DISCIPLINE:

NAME OF COMPANY: CP&L - Brunswick UNIT/S

SUBJECT: Design Guidelines

BN 7579 - 224 - 00135 - 4000

CALC SET NO	REV	COMP BY	CHK'D BY
PRELIM	0	DATE 2/28/86	DATE 3/1/86
FINAL			
VOID		DATE	DATE
SHEET 6 OF 8			
JO 7579.106			

$$.75i = \frac{.675}{h^{2/3}} \geq 1 \qquad B_2 = \frac{1.4625}{h^{2/3}} \geq 1.125$$

$$h = \frac{tR}{r^2}$$

t = pipe wall
r = " mean radius
R = elbow bend radius

For long radius elbow, $R = 1.5D \approx 3r$

For short radius elbow, $R = D \approx 2r$

For Long Radius Elbow

$$h = \frac{t(3r)}{r^2} = 3\frac{t}{r}$$

$$.75i = \frac{.675}{\left(3\frac{t}{r}\right)^{2/3}} \geq 1 \qquad B_2 = \frac{1.4625}{\left(3\frac{t}{r}\right)^{2/3}} \geq 1.125$$

$$(.75i)^{3/2} = \frac{(.675)^{3/2}}{3\frac{t}{r}} \geq 1 \qquad (B_2)^{3/2} = \frac{(1.4625)^{3/2}}{3\frac{t}{r}} \geq (1.125)^{3/2}$$

$$(.75i)^{3/2} = .18486\frac{r}{t} \geq 1$$

$$(B_2)^{3/2} = .58955\frac{r}{t} \geq 1.19326$$

For Short Radius Elbow

$$(.75i)^{3/2} = .27729\frac{r}{t} \geq 1$$

$$(B_2)^{3/2} = .88433\frac{r}{t} \geq 1.19326$$

2.1.1 7579-CCA-90132-4 [illegible]

GENERAL COMPUTATION SHEET

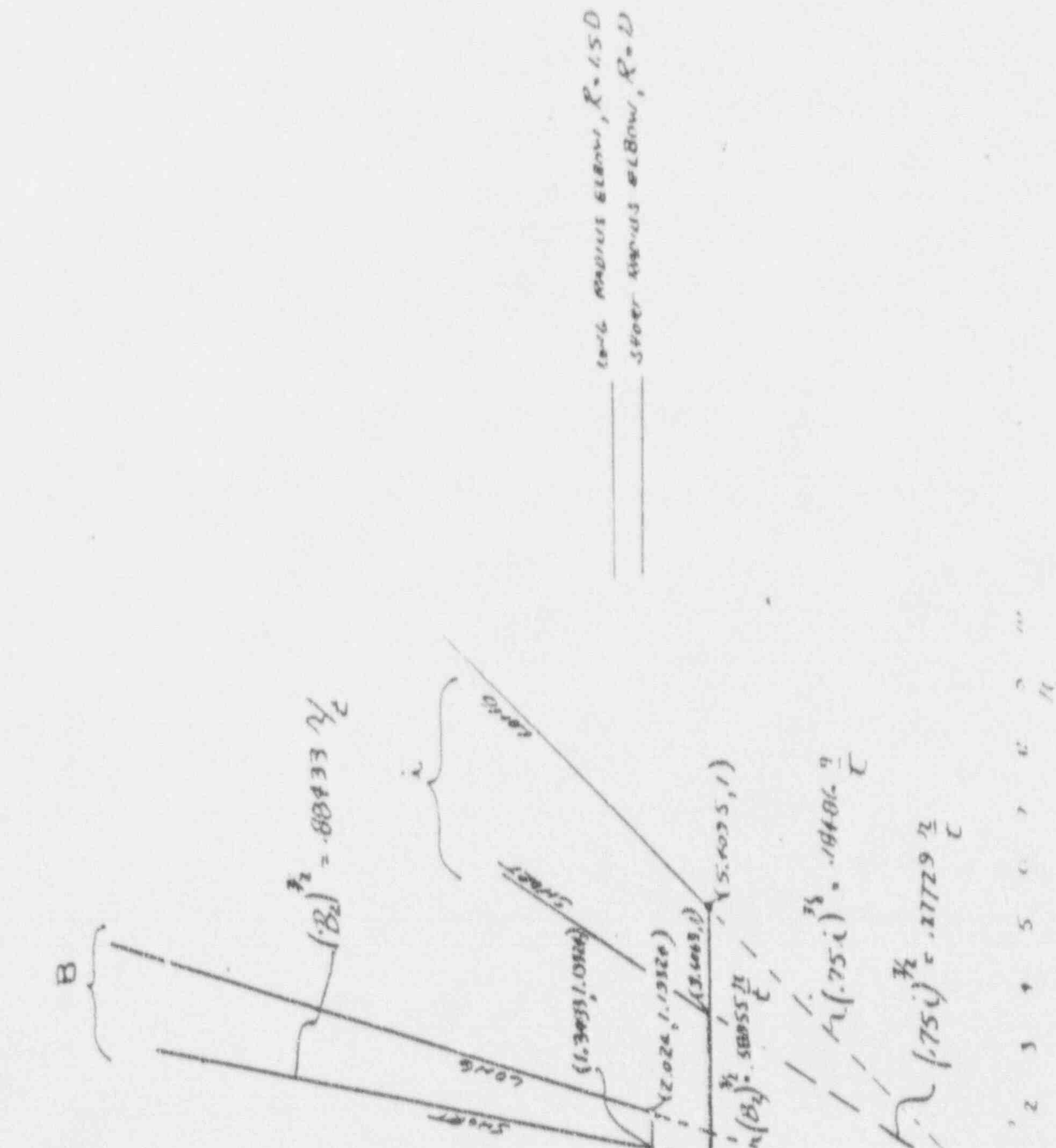
DISCIPLINE

united engineers

CALC SET NO		REV	COMP BY	CHK'D BY
PRELIM		0	[illegible]	[illegible]
FINAL			DATE 2/29/84	DATE [illegible] 84
VOID				
SHEET 7 OF 8			DATE	DATE
JO 7579.106				

NAME OF COMPANY CP&L - BRUNSWICK UNIT/S

SUBJECT DESIGN GUIDELINES



GENERAL COMPUTATION SHEET

united engineers

DISCIPLINE

S.N 7579 - ... - 4000

CALC SET NO		REV	COMP BY	CHK'D BY
PRELIM		0	[illegible]	[illegible]
FINAL			DATE 2/24/82	DATE [illegible]
VOID				
SHEET 8 OF 8			DATE	DATE
JO 7579.106				

NAME OF COMPANY CP&L - BRUNSWICK UNIT/S

SUBJECT DESIGN GUIDELINES

For Long Radius Elbow

$0 \leq \frac{r}{t} \leq 2.024; \quad \frac{B_2}{.75i} = (1.19324)^{2/3} = 1.125$

$2.024 \leq \frac{r}{t} \leq 5.4095; \quad \frac{B_2}{.75i} = .703\left(\frac{r}{t}\right)^{2/3}$

$5.4095 \leq \frac{r}{t}; \quad \frac{B_2}{.75i} = \left(\frac{.58955}{.18486}\right)^{2/3} = 2.167$

For Short Radius Elbows

$0 \leq \frac{r}{t} \leq 1.349, \quad \frac{B_2}{.75i} = (1.19324)^{2/3} = 1.125$

$1.349 \leq \frac{r}{t} \leq 3.606; \quad \frac{B_2}{.75i} = (.88433)^{2/3}\left(\frac{r}{t}\right)^{2/3} = .9213\left(\frac{r}{t}\right)^{2/3}$

$3.606 \leq \frac{r}{t}; \quad \frac{B_2}{.75i} = \left(\frac{.88433}{.27723}\right)^{2/3} = 2.167$

Report No. 7865.007-S-M-021
Rev. 1
Attachment "B" (8 pages total)

FORM 1500

MEMORANDUM

united engineers & constructors inc.

JOB NO. 6702.001

DEPT. Power Engineering

TO: Distribution

FROM: C. E. Hanton

OFFICE: Philadelphia

DATE: May 2, 1979

COPIES: G. E. Sarstan
A. M. Ebner
G. Rigamonti

SUBJECT: Power Discipline - Technical Bulletin #7
Concrete Expansion Anchor Bolts
Used with Pipe Supports

Recently a number of structural failures of pipe supports which use concrete expansion anchor bolts have been reported. Investigations indicate that design of base plates using rigid plate assumptions have resulted in underestimating loads on some anchor bolts. In addition, a large number of anchor bolts at some plants have proven to be deficient (i.e., the concrete anchor bolts were not installed properly).

A wide range of design practices and installation procedures have contributed to the present situation. This technical bulletin provides an approach to assure more rigorous controls and verification of the installation of the bolts.

Attachment #7A gives the company position regarding the selection of concrete expansion anchor bolts used with pipe supports and Attachment #7B provides the design criteria for the selection and use of these bolts.

C. E. Hanton
Chief Power Engineer

CEH:wva
Attach.

POWER DISCIPLINE

TECHNICAL BULLETIN #7A

CONCRETE EXPANSION ANCHOR BOLTS
USED WITH PIPE SUPPORTS

To the maximum extent possible, pipe support connections to supporting concrete structures should not use concrete expansion anchor bolts. Where concrete expansion anchor bolts are required, they should be of the wedge or sleeve type design. Shell type anchors are not recommended for the following reasons:

(a) They have experienced a high failure rate in the field.

(b) They are more susceptible to failure due to improper installation.

(c) They are more prone to brittle type failure (i.e., they exhibit a load/deflection curve with only a small amount of deflection before failure as compared to the wedge type anchors).

The calculation of anchor bolt design loads shall consider the effects of base plate flexibility.

Installation of concrete expansion anchor bolts shall include bolt pretensioning to meet cycling load requirements. Constant spring washers are recommended in order to control the amount of pretensioning.

Leveling nuts should be avoided as they do not allow for proper pretensioning.

POWER DISCIPLINE

TECHNICAL BULLETIN #71

DESIGN CRITERIA FOR CONCRETE EXPANSION ANCHOR BOLTS USED WITH PIPE SUPPORT BASE PLATES

I. INTRODUCTION

Selection of the type and size of concrete expansion anchor bolts depends upon many design factors such as support base plate design, method of calculating the anchor bolt loads, anchor bolt load-carrying capability, anchor bolt and support installation requirements, etc.

A design approach which addresses the above considerations is provided herein.

II. DESIGN APPROACH

A. Base Plate Flexibility

Computation of anchor bolt loads is affected by the base plate flexibility. The base plates may be considered to be either rigid or flexible according to the following definition:

> A base plate shall be assumed rigid if the unstiffened distance between the member welded to the plate and the edge of the base plate is less than or equal to twice the thickness of the plate (Reference USA NRC IE Bulletin 79-02 - March 8, 1979).

A. Base Plate Flexibility (Cont'd)

$a + b \leq 2t$ (a,b,t shown in Figure 1)

A base plate is assumed flexible if

$a + b \geq 2t$

B. Anchor Bolt/Concrete Edge Distance (h_3 in Figure 1)

Base plates and supporting concrete structure designs must be reviewed to verify allowable minimum edge distance.

The ultimate pull-out loads are based on cone pull-out type of failure and therefore, minimum edge distance must be maintained. Allowable loads must be reduced according to manufacturers' specifications when minimum edge distances are not met.

C. Anchor Bolt Spacing

Due to cone pull-out type of failure, minimum distance between bolt must be maintained.

Allowable anchor spacing is specified by the anchor manufacturer and maximum allowable forces must be reduced if the minimum spacing cannot be met.

D. Anchor Bolt Load Calculation

Figure 1 shows a typical pipe support base plate/anchor bolt configuration. A recommended approach which gives consideration

D. Anchor Bolt Load Calculation (Cont'd)

to the base plate flexibility and the tension-shear nature of the bolt loading is provided below:

$$T = \alpha_i \left(\frac{M}{N_1 h_i} + \frac{P}{N_2} \right)$$

$$V = \frac{F}{N_2}$$

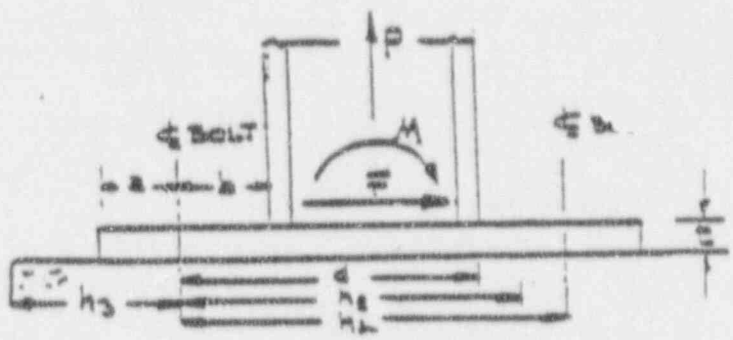


Fig. 1

Where: T,V. Anchor design tension and shear loads.

M,F,P Moment, shear and axial force acting on the connection.

N_1 Number of tension anchor bolts.

N_2 Total number of anchor bolts.

i Index to identify base plate flexibility

(i = 1 rigid, i = 2 flexible)

α_i Factor to accou[illegible] for prying action for given plate fle[illegible]ity.

(α_1 = 1.0, α_2 = 1.2)

hi Moment Arm

h_1 = Center line distance between bolts.

h_2 = d + 2t (not to exceed h_2)

D. Anchor Bolt Load Calculation (Cont'd)

Where the connection is subject to biaxial loading, the aforementioned approach must be repeated for the other principal plane and the absolute sum of the bolt reactions combined.

E. Anchor Bolt Allowables

For each expansion anchor used, the design tension load shall be less than or equal to the Maximum Allowable Design Load (MADL). The MADL is defined by:

$$MADL = \frac{Fu}{SF}$$

where Fu is the ultimate static capacity of the anchor based on manufacturers' static test for the applicable strength of concrete and SF is the appropriate safety factor based on the type of anchor:

$SF \geq 4$ for wedge and sleeve type anchors

$SF \geq 5$ for shell type anchors

When both shear and tension act on the anchor, a straight line shear-tension interaction must be assumed as follows:

$$\frac{T}{Ta} + \frac{V}{Va} < 1.0$$

Where: T = Design tension force

Ta = MADL in tension

V = Design shear force

Va = MADL in shear

F. Pretensioning

All expansion anchors must be pretensioned to a load, To, not greater than two but not less than one-and-a-half the maximum allowable design load, i.e. (1.5 MADL ≤ To ≤ 2.0 MADL) to meet cycling load requirements. This pretension force To, may be applied by a torque device, tension device or a constant load washer. It is recommended that the constant load washer be used for the following reasons:

1. Ease of installation.
2. Initial preload tension is assured by proper washer selection.
3. Preload tension is maintained after installation.
4. Ease of inspection to verify preload tension.

In cases where shell type anchors have been used, assurance should be obtained that the shell is not in contact with the back of the support plate prior to applying the preload tension (i.e., 1/16" below the surface of the concrete).

In cases where a leveling nut has been used against the back side of the support plate, the preload tension should still be applied to ensure that the anchor hold-down nut remains tight during cyclic loadings.

Limited dynamic tests are available which indicate that the static capacity of the shell type anchor is essentially unaffected by dynamic loading. These tests were performed without any initial

F. Pretensioning (Cont'd)

preload tension. These tests may be used as justification that the shell type anchors have the capability to withstand cyclic loadings.

CAROLINA POWER & LIGHT CO.

TELEPHONE CONVERSATION MEMORANDUM

FILE NO.: 212

SERIAL: BESU/T-499

Between T.[redacted]TIN of CP&L and C. KINSEL of UEC

PROJECT:	PID 1534	DATE: 4-29-87
SUBJECT:	WELDED ATTACHMENT FILLET WEL[illegible] REINFORCE	TIME: 9:30 AM

MESSAGE: TUCKER MARTIN OF CP&L DISCUSSED FILLET WELD REINFORCEMENT OF WELDED ATTACHMENTS WITH C. KINSEL, JOHN ALLEN AND T.C. OF UEC. FILLET WELD REINFORCEMENT HAS NOT BEEN TAKEN CREDIT FOR IN EVALUATING LOCAL PIPE STRESSES FOR BRUNSWICK AT UEC. FILLET WELD REINFORCEMENT IS GENERALLY NOT REQUIRED FOR THE ATTACHMENT LUGS PERFORMANCE AS A SUPPORT AS LONG AS THERE IS NO REASON TO SUSPECT THAT THE CORRESPONDING GROOVE WELDS ARE SUBSTANDARD. UNDERSIZED FILLET WELD REINFORCEMENT SHOULD, HOWEVER, BE ADDRESSED ON A CASE BY CASE BASIS FOR THE PIPE SUPPORT FUNCTION OF WELDED ATTACHMENTS.

Clarify & add to Attach A of M-21

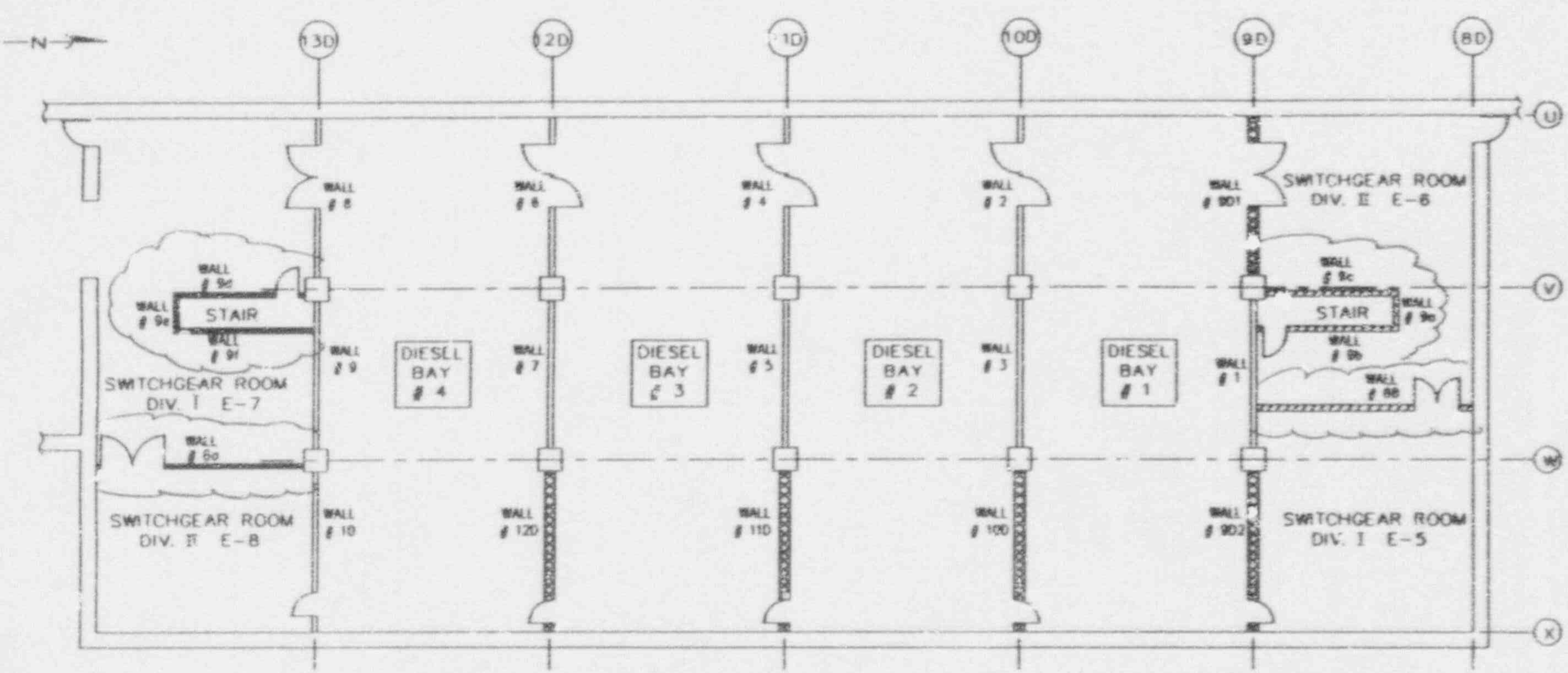
Action Required ☐ Yes ☒ No By ________ Tickler Date ________

ROUTE TO: ☒ ATM ☐ ___ ☐ ___ ☐ ___ ☐ ___ File ________

COPY TO: ☒ RLW ☒ RSH ☒ [illegible] ☐ ___ ☐ ___ ☐ ___

ATTACHMENT 4

DIESEL GENERATOR BUILDING
FLOOR PLAN FOR ELEVATION 23 FOOT



KEY PLAN

DIESEL GENERATOR BLDG.
(PARTIAL PLAN @ ELEV. 23'-0")
NOTE: SECTION 0-0, Q-Q, U-U & k-k
NOT SHOWN FOR CLARITY.

WALL LEGEND

- REINFORCED CONCRETE
- MASONRY W/STEEL PLATE
- MASONRY
- MODIFIED UNDER 80-11

ATTACHMENT 5

CONCRETE MASONRY UNIT TEST RESULTS
BRUNSWICK STEAM ELECTRIC PLANT

*** RETYPED - ORIGINAL ATTACHED ***

PITTSBURGH TESTING LABORATORY

Laboratory No. 3357
Order No. DH 809
Report No. 2
May 5, 1972

CONCRETE MASONRY UNITS

Type Unit: Expanded Slate 2 Core Hollow Load Bearing Block (Snowden)

Mfg'd By: Adams Concrete Products Company, Fayetteville, NC

Sampled By: P. T. L. on April 27, 1972

Reported To: Adams Concrete Products Company, Fayetteville, NC

Nominal Size: 8x8x16 Inches
Date Made: Unknown
Date Tested: 5/2/72

Minimum Face Shell Thickness: 1 1/4 Inches
Date Received: 4/27/72
Age of Test: Over 28 Days

Sample "P" Blocks Sampled from Plant
Sample "F" Blocks Sampled from Field

COMPRESSIVE STRENGTH

Spec. No.	(4/28/72) Wt., Lbs.	SIZE * * * INCHES Height	Width	Length	Gross Area Sq. Ins.	Total Load Lbs.	Unit Load Lbs./Sq. In.
P-1	26.19	7-5/8	7-5/8	15-5/8	119.1	195,000	1640
P-2	25.42	7-5/8	7-5/8	15-5/8	119.1	190,000	1600
P-3	26.01	7-5/8	7-5/8	15-5/8	119.1	160,000	1340
P-4	25.89	7-5/8	7-5/8	15-5/8	119.1	185,000	1550
P-5	25.67	7-5/8	7-5/8	15-5/8	119.1	173,500	1460

Physical Requirements
Compressive Strength
Lbs. Per Sq. In.

	AVERAGE	MINIMUM
ASTM C90-70, Grade N, NC Fire Insurance Rating Bureau, and Underwriter's Lab Std.	1000	800
Sample	1520	1340

Remarks: Sample complies with specification requirements.

(9913MAT/ccc)

AUG 26 '80 Armus E. Fiorello

FORM 407 REV.

PITTSBURGH TESTING LABORATORY

ESTABLISHED 1881

3619 HILLSBORO ROAD, DURHAM, N. C. 27705

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Laboratory No. 3537

REPORT

Client's No.

Order No. PH 009
Report No. 2
May 5, 1972

CONCRETE MASONRY UNITS

Type Unit: Expanded Slate 2 Core Hollow Load Bearing Block (Shardon)

Mfg'd. by: Adams Concrete Products Company, Fayetteville, N. C.

Sampled by: P. T. L. on 4-27-72

Reported to: Adams Concrete Products Company, Fayetteville, N. C.

Nominal Size: 8x8x16 Inches
Date [illegible]: unknown
Date Tested: 5-2-72

Minimum Face Shell Thickness: 1 1/4 Inc
Date Received: 4-27-72
Age of Test: over 28 days

Sample "P" Blocks Sampled from Plant
[illegible] "F" Blocks Sampled from Field

COMPRESSIVE STRENGTH

Spec. No.	(4-29-72) Wt., lbs.	Size - - - Inches Height	Width	Length	Gross Area Sq. Ins.	Total Load Lbs.	Unit Load Lbs./Sq.In.
P-1	26.19	7-5/8	7-5/8	15-5/8	119.1	195,000	1640
P-2	25.42	7-5/8	7-5/8	15-5/8	119.1	190,000	1600
P-3	25.01	7-5/8	7-5/8	15-5/8	119.1	160,000	1340
P-4	25.09	7-5/8	7-5/8	15-5/8	119.1	185,000	1550
P-5	25.67	7-5/8	7-5/8	15-5/8	119.1	173,500	1460

Physical Requirements
Compressive Strength
Lbs. Per Sq. In.

	AVERAGE	MINIMUM
ASTM C90-70, Grade N, N. C. Fire Insurance Rating Bureau, and Underwriter's Lab Std.	1000	800
Sample	1520	1340

Remarks: Sample complies with specification requirements.

2

ATTACHMENT RAI-C-1a

*** RETYPED - ORIGINAL ATTACHED ***

PITTSBURGH TESTING LABORATORY

Laboratory No. 3911
Order No. DH 877
Report No. 2
May 24, 1972

CONCRETE MASONRY UNITS

Type Unit: 8x8x16 Inch 100% Solid Load Bearing Block

Mfg'd By: Adams Concrete Products Company, Fayetteville, NC

Project: Carolina Power & Light Company, Southport, NC

Sampled By: Client on May 15, 1972 and May 16, 1972

Reported To: Adams Concrete Products Company, Fayetteville, NC

Actual Size: 7 5/8 x 7 5/8 x 15 5/8 Inches
Date Made: Unknown

Date of Test: 3A: 5/19/72
3B & 3C: 5/22/72
Age of Test: Unknown

ADSORPTION TESTS

Specimen No.	Wt. Recv'd Lbs.	Oven Dry Wt., Lbs.	Absorption Lbs./Cu. Ft.	Absorption, Percent
3A	77.35	75.00	6.4	4.5
3B	74.60	72.38	7.4	5.4
3C	76.63	74.22	6.9	5.0

Specimen No.	Unit Wt. Lbs./Cu. Ft. at 30% Moisture Content
3A	144.0
3B	140.7
3C	142.5

Remarks: Sample complies with ASTM C145-70 specifications.

Respectfully submitted,

PITTSBURGH TESTING LABORATORY

Original Signed By

Walter C. Wingate, Manager
Durham Branch

(9913MAT/ccc)

FORM 401 R4-7-60 3

PITTSBURGH TESTING LABORATORY

ESTABLISHED 1881

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Laboratory No. 3911

REPORT

Client's No.

Order No. DI 077
Report No. 2
May 24, 1972

CONCRETE MASONRY UNITS

Type Unit: 8x8x16 Inch 100% Solid Load Bearing Block

Mfg'd. by: Adams Concrete Products Company, Fayetteville, N. C.

Project: Carolina Power and Light Company, Southport, N. C.

Sampled by: Client on 5-15-72 and 5-16-72

Reported to: Adams Concrete Products Company, Fayetteville, N. C.

Actual Size: 7 5/8 x 7 5/8 x 15 5/8 Inches Date of Test: 3A: 5-19-72
3B & 3C: 5-22-72
Date Made: unknown
Age of Test: unknown

ABSORPTION TESTS

Specimen No.	Wt. Rec'd., Lbs.	Oven Dry Wt., Lbs.	Absorption Lbs./Cu. Ft.	Absorption, Percent
3A	77.35	75.00	6.8	4.5
3B	74.60	72.38	7.4	5.4
3C	76.62	74.22	6.9	5.0

Specimen No.	Unit Wt. Lbs./Cu. Ft. at 30% Moisture Content
3A	144.5
3B	140.7
3C	142.5

Remarks: Sample complies with ASTM C145-70 Specifications

Respectfully submitted,

PITTSBURGH TESTING LABORATORY

Walter C. Wingate

Walter C. Wingate, Manager
Durham Branch

cc: 5-Client

ATTACHMENT BAIC-2