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TEXAS UTILITIES GENERATING COMPANY

SKYWAY TOWER · 400 NORTH OLIVE STREET, L.B. 81 · DALLAS, TEXAS 75201

WILLIAM G. COUNSIL
EXECUTIVE VICE PRESIDENT

December 5, 1985

Director of Nuclear Reactor Regulation
Attention: Mr. Vince S. Noonan, Director
Comanche Peak Project
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NOS. 50-445 AND 50-446
REQUEST FOR ADDITIONAL INFORMATION

Dear Mr. Noonan:

As requested by Mr. Larry Shao in the September 19, 1985 meeting between the NRC and TUGCo concerning Active Valves, enclosed is one copy of the pertinent sections of a valve specification and a pump specification.

Very truly yours,

W.G. Counsil

W. G. Counsil

By: D.R. Woodlan
D. R. Woodlan
Licensing Supervisor

BSD/grr
Enclosure

c - A. L. Cook w/o enclosure

Add: Larry Shao

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SECTION 3
TECHNICAL SPECIFICATION

3.0 INTRODUCTION

This section covers the technical and particular requirements for the Nuclear Safety Class 2 and 3 and non-nuclear safety class Power Operated Diaphragm Type Valves and Accessories to be installed at the Comanche Peak Steam Electric Station, a two-unit PWR nuclear power plant. It forms part of the total specification which includes Sections 1, 2, 3 and its Appendices 1 thru 10.

3.1 SCOPE OF WORK

This specification covers the design, manufacture, inspection, testing, certification, cleaning, packaging and delivery of Nuclear Safety Class and Non-Nuclear Safety Class Power Operated Diaphragm Type Valves and Accessories for shutoff and/or modulating service as described herein. The valves are limited to diaphragm designs operated by electric motor or air actuators.

3.1.1 WORK INCLUDED

a. Diaphragm type valves with accessories as delineated by this specification and in accordance with the attached valve data sheets. All accessories shall be piped and/or wired and mounted on the valve operators.

b. Electric motor, air piston or air diaphragm actuator assemblies as specified.

c. Electro-pneumatic and/or pneumatic positioners for modulating service when specified.

d. Pipe reducers or nipples welded to the valve ends where specified on the valve data sheets.

e. Air sets, solenoid operated pilot valves, limit switches, torque switches, and any other accessories indicated on the valve data sheets.

f. Miscellaneous accessory equipment not shown on the valve data sheets, but required for proper operation, or by the intent of the drawings shall be furnished. Each accessory shall be

Identification	System
SF	Spent Fuel Pool Cooling and Cleanup
SI	Safety Injection
SW	Service Water
TR	Boron Thermal Regeneration
WD	Solid Waste Disposal
WP	Waste Processing - Liquid Portion

3.5 PERFORMANCE GUARANTEES

The Seller shall guarantee the performance of each valve as follows:

a. Valve flow coefficient (Cv) for the fluid data shown on the valve data sheets, as proposed by Seller

b. Ability of the valve to open and/or close against the pressure differentials shown on the valve data sheets, within the specified full stroke time

c. The ability of valves and actuators to perform their intended functions without undue vibration, noise or excessive wear when operated under the specified normal and abnormal fluid and ambient conditions

d. The ability of "active" valves to perform their intended functions during and after the prescribed events

e. Leakage values as specified.

3.7.13 STRESS AND SEISMIC REQUIREMENTS

3.7.13.1 GENERAL

a. All Class 2 or Class 3 valves covered by this specification shall be in accordance with Regulatory Guide 1.48 and shall be designed to Category I Seismic Conditions, unless otherwise designated on the Valve Data Sheets.

b. All Class 2 or Class 3 valves shall be designed for plant conditions and load combinations specified in this section.

c. All Class 2 or Class 3 valves shall be considered "active" resulting in the stress limits defined in Table 3.7-13.

3.7.13.2 OPERATING CONDITIONS AND LOAD COMBINATIONS

3.7.13.2.1 OPERATING CONDITIONS

Component operating conditions are defined by the ASME B&PV Code, Subsection NB, Paragraph NB-3113 and NB-3114, in accordance with their anticipated frequency of occurrence and risk to the public.

The component operating conditions are as follows:

a. <u>Normal conditions</u> -- Normal operating conditions are the same as the valve design conditions given on the Valve Data Sheet.

b. <u>Test Conditions</u> -- The test consists of opening and closing the valve fully and pressurizing the valve to 1.5 times the design pressure in both directions and checking for leaks. Rev.1

3.7.13.2.2 LOAD COMBINATIONS

The required load combinations for the component operating conditions specified in section 3.7.13.2.1 of this specification have been categorized under "Plant Condition" in compliance with Regulatory Guide 1.48 and are listed as follows:

For Information Only

a. Component Normal Conditions (same as design)

Plant Condition	Loading Combination
Normal	Internal pressure + dead weight + sustained loads + thermal expansion + occasional load
Upset	Internal pressure + dead weight + sustained loads + 1/2 SSE + thermal expansion + occasional load + transients
Emergency	Internal pressure + weight + sustained loads + SSE + thermal expansion + occasional load
Faulted	Internal pressure + weight + sustained load + SSE + pipe rupture and/or impingement effects where applicable + thermal expansion + occasional loads
Test	Not applicable

Rev.1

b. Component Test Conditions

Plant Condition	Loading Combination
Normal	The valves will be subjected to loads which are as follows: Internal pressure + dead weight + sustained loads + thermal expansion + occasional load
Upset	Not applicable
Emergency	Not applicable
Faulted	Not applicable
Test	Not applicable

For Information Only

Definitions:

1. SSE - safe shutdown earthquake

2. Internal pressure - design pressure as specified on the Valve Data Sheet

3. Deadweight - weight of valve

4. Occasional load - single 500 lb. force vertically downward through the centerline of the valve

5. Transients - 100 F/hour between 40 F and valve design temperature detailed on the Valve Data Sheet

6. Thermal expansion, sustained load, pipe rupture, impingement effects, SSE loads and SSE/2 load as follows:

Valve Size (inch)	Thermal Expansion Thermal Moment (Inch-Kips)	SSE Moment (Inch-Kips)	SSE/2 Moment (Inch-Kips)
3/4	.6	2.0	1.0
1	1.0	3.5	1.8
1-1/2	3.0	10.0	5.0
2	6.0	18.0	9.0
2-1/2	7.0	20.0	10.0
3	11.0	20.0	16.0
3-1/2	15.0	45.0	23.0
4	19.0	60.0	30.0
6	46.0	153.0	77.0
8	230.0	700.0	350.0
10	450.0	1,340.0	670.0
12	740.0	2,200.0	1,110.0
14	960.0	2,870.0	1,435.0
16	1,430.0	4,280.0	2,140.0
18	2,000.0	6,000.0	3,000.0
20	2,740.0	8,200.0	4,100.0
24	4,750.0	14,200.0	7,100.0
30	10,500.0	16,000.0	8,000.0
36	16,200.0	24,400.0	12,200.0

Rev.1

NOTES

1. All moments are resultant moments and must be applied at the valve's weakest axis.

2. Sustained loads are equal to the weight of all valve handwheels, operators and appurtenances + a stress of 1500 psi acting on the valve due to unsupported pipe weight on each valve end. Rev.1

3. Pipe rupture or impingement effects are applied to certain high energy containment isolation valves and are specified on the Valve Data Sheet where applicable.

3.7.13.3 ALLOWABLE STRESS LIMITS

ASME Code Section III, Class 2 and 3 components shall meet the stress limits shown in Table 3.7-13.

TABLE 3.7-13

STRESS LIMITS FOR ASME CLASS 2 AND 3 ACTIVE VALVES

Normal or Upset	per code
Normal + OBE or Upset + OBE	P_r
Emergency	P_r
Faulted	P_r

Notes

1. P_r = Primary pressure rating corresponding to the pressure-temperature classification defined in ANSI B16.5

   OBE = .5 SSE

2. Valves shall be designed using only the standard design rules of NC-3500 and ND-3500 of ASME Section III

3. In addition to compliance with the design limits specified, assurance of operability under all design loading combinations shall be provided per paragraph 3.7.14.

3.7.13.4 SEISMIC REQUIREMENTS

3.7.13.4.1 SEISMIC CATEGORY I

All equipment, furnished under this specification, shall be designed and analyzed in accordance with the applicable seismic category of Gibbs & Hill Specification 2323-SS-20, Seismic Design Criteria for Equipment Design.

The seismic loadings shown in the table below shall be used. These loadings are to be considered as equivalent static loads at the valve center of gravity acting simultaneously. Rev.1

For Information Only

Equipment	Condition	Horizontal Acceleration	Acceleration
Seismic Category I	SSE	3.0	2.0
	OBE	2.25	1.5

All valves must have a natural frequency of 33 Hertz or more.

3.7.14 VALVE OPERABILITY

All Class 2 or Class 3 equipment furnished under this specification shall be considered "Active" or "Passive" with regard to the operability requirements of the references (particularly Regulatory Guide 1.48) as specified on the Valve Data Sheets.

3.7.14.1 VALVE OPERABILITY - ACTIVE VALVES

An individual prototype valve of each type to be qualified will be tested for verification of operability during a simulated seismic event by demonstrating operational capabilities within the specified limits for the conditions listed on the Valve Data Sheets.

The basis for applying prototype test results to the actual valves supplied shall be demonstrated by the manufacturer and subject to Owner's approval. Justification may include:

a. More severe test conditions for prototypes than for actual valves supplied.

b. Prototype seismic response more severe because of material or other physical considerations.

c. Actual valve size falls between the size of two essentially identical (except for size) prototypes tested.

3.7.14.2 VALVE OPERABILITY - ACCESSORIES

Solenoids, limit switches and other electrical appurtenances for Class 2 of 3 valves shall be qualified under IEEE 323, 344 and 382 as applicable.

3.8 MATERIALS

3.8.1 GENERAL

Materials to be used in valve construction are specified in the Valve Specification Sheets and for Class 2 or Class 3 valves shall meet the requirements of the ASME Code Section III, along with the published Addenda in effect at the time of the contract, and the additional requirements specified herein.

3.8.2 ALTERNATE MATERIALS

a. For consideration of alternate materials, the Bidder shall demonstrate that suggested materials comply with the applicable codes and are compatible for attachment to the Purchaser supplied components. Non-code approved materials for specific purpose or application shall not be used in Class 2 and 3 valves.

b. After award of contract, no substitute or alternate materials will be allowed under any circumstances.

3.8.3 UNACCEPTABLE MATERIALS

a. All materials of construction shall be free of low melting point materials as alloying constituents, that is lead, zinc, cadmium, tin, antimony, mercury, bismuth sulfur and mischmetals and their compounds. Also, processing and cleaning materials, manufacturing processes, shop tools, marking materials, paint coatings, thread lubricants, and so forth, shall be free of low melting point materials. If no practical substitute exists for processing materials, an exception is permitted provided that the low melting point materials are completely removed from all surfaces (with particular emphasis on areas of restricted accessibility, such as holes, corners and crevices) especially prior to any exposure to temperatures above ambient during fabrication,

For Information Only

CONTENTS

For Information Only

1.0 SCOPE

1.1 The purpose of this document is to define the seismic design criteria for equipment to be installed in Comanche Peak Steam Electric Station, Unit Nos. 1 & 2. The equipment supplier shall verify that said equipment can meet its performance requirements during and following a seismic disturbance.

For Information Only

2.0 CLASSIFICATION OF EQUIPMENT

2.1 Equipment is classified into two categories, Seismic Category I and Non-Category I for the purpose of seismic design. These categories are defined as follows:

2.1.1 Seismic Category I - Equipment, components, and parts thereof, failure of which could lead to a release of radioactivity in excess of the guideline values in published regulations pertaining to accident considerations or prevent a safe shutdown of the reactor.

2.1.2 Non-Category I - Equipment, components, and parts thereof, not included in Seismic Category I.

2.1.3 The seismic classifications of particular pieces of equipment are given in the applicable equipment specifications.

2.2 The response of any Non-Category I equipment to the earthquake loadings shall not adversely affect the integrity or operability of any item designated as Seismic Category I.

For Information Only

3.0 EARTHQUAKE INTENSITIES AND RELATED DESIGN OBJECTIVES - SEISMIC CATEGORY I EQUIPMENT

3.1 Earthquake intensities to be considered in the design of Seismic Category I equipment are as follows:

3.1.1 The Safe Shutdown Earthquake (SSE). During and after this event, all Seismic Category I equipment must continue to function in such a manner as to permit a safe and orderly plant shutdown without loss of integrity.

3.1.2 The 1/2 Safe Shutdown Earthquake (1/2 SSE). During and after this event, all Seismic Category I equipment must continue to operate undamaged with no loss of normal function. It shall respond as required for normal operation.

4.0 METHODS OF DETERMINATION OF SEISMIC ADEQUACY - SEISMIC CATEGORY I EQUIPMENT

4.1 The equipment supplier shall demonstrate the capability of his equipment to withstand seismic loads in accordance with Section 3.0, and the seismic classification specified in the applicable equipment specification, by either of the following methods:

4.1.1 Analytical Methods.. (Predict the equipment performance by mathematical analysis).. These methods without testing may be performed if it can be conservatively demonstrated that structural integrity alone can assure operability of seismic Category I equipment..

4.1.2 Testing Methods.. (Test the equipment under simulated seismic conditions)..

4.1.3 Combination of analytical and test methods may be performed when a complete seismic testing is impracticable..

4.2 The equipment supplier shall furnish in his bid a detailed description of the procedure to be used for predicting the equipment performance under seismic disturbances by analysis and/or by testing..

For Information Only

6.0 ALLOWABLE STRESSES AND DEFORMATIONS BASED ON ANALYSIS - SEISMIC CATEGORY I EQUIPMENT

6.1 The maximum stresses in the equipment, including the effects of the normal operating loads plus the 1/2 safe shutdown earthquake, shall be maintained within the normal allowable material working stress limits accepted as good practice and as set forth in the appropriate design standards and codes (as applicable) specified in the equipment specifications.

6.2 [The maximum stresses in the equipment, including the effects of the normal operating loads plus a safe shutdown earthquake, shall be limited to prevent loss of function of the equipment. For the purpose of calculation, the no-loss-of-function stresses shall be limited to 90 percent of the yield strength of the material (including shear yield) or as otherwise set forth in the appropriate design standards and codes specified in the equipment specifications.]

6.3 Deformations resulting from the combined influence of normal operating loads and the loads from the safe shutdown earthquake shall be investigated to verify that they will not impair functional performance.

6.4 For the 1/2 SSE, the equipment function shall be performed without permanent deformation.

6.5 For the SSE, permanent deformation is tolerable if it does not impair the equipment function. Valid plastic analysis shall demonstrate structural integrity. Local, self-limiting, secondary stresses may exceed yield stress levels to the extent as set forth in the appropriate design standards and codes.

6.6 Fatigue analysis, where required by the codes, shall be performed by the equipment supplier, using a minimum of 600 load cycles for 1/2 SSE.

ITT GRINNELL VALVE COMPANY, INC.
DIA-FLO DIVISION
33 CENTERVILLE ROAD
LANCASTER, PENNSYLVANIA 17603

For Information Only

SEISMIC CALCULATIONS
FOR
COMANCHE PEAK STEAM ELECTRIC STATION
UNITS 1 AND 2

REPORT NO. W-129

Gibbs & Hill Specification No. 2323-MS-604
ITT Grinnell Dia-Flo Order No. N76-11863

CALCULATIONS PERFORMED BY [signature] 27 Aug 82
Michael J. Panciera, Sen. Prod. Eng. Date

CALCULATIONS CHECKED BY [signature] 8/27/82
R. D. Randall, Mgr. Prod. Eng. Date

Rev. 5
AUGUST 1982

REVISION 5

Revised to reflect current change in body design	Pages A23-A36-A
Calculation Certification	Page 5
Removed frequency calculations (Refer to test report 3433)	Pages A37-A51

For Information Only

TABLE OF CONTENTS

INTRODUCTION

The purpose of these calculations is to demonstrate that the valves being supplied by ITT Grinnell Dia-Flo Division are designed in accordance with Gibbs & Hill Specification No. 2323-MS-604 and meet the seismic design requirements of the specification covered by this report. These calculations apply to the below-listed valves.

Dia-Flo Item No.	Drawing No.	Dia. Valve Description	Nuclear Code Class	Customer Tag No.
1	SD-C-105925	4"-150# S.S.	2	1-HV-5157 1-HV-5158 2-HV-5157 2-HV-5158

For the actual seismic calculations, see Appendix A of this report.

For Information Only

METHODS OF ANALYSIS

The method of analysis is based on applying static forces resulting from the quivalent earthquake accelerations acting at the centers of gravity of the extended masses. Using free body diagrams and strength of materials formulas, stress distributions in equilibrium with the applied loads were determined.

Principal stresses were calculated for valve component parts which are essential to the pressure integrity or functional adequacy of the valve. These stresses were then compared to the applicable allowable stresses in the 1974 ASME Boiler and Pressure Vessel Code including the 1975 Winter Addenda. Where applicable, minimum wall was determined per Table 3.7-13 of Gibbs and Hill Specification No. 2323-MS-604.

Testing was performed to determine the natural frequency of the valve assembly. Refer to test report number 3433 for additional information.

LOADING

[For the analysis of these valves, the load combinations considered were those resulting from the Faulted Plant Condition as defined in the design specification, since this represents the most severe load case.]

The equivalent static forces were calculated by multiplying the applicable valve component part by the appropriate seismic coefficient (i.e., either the vertical or horizontal seismic coefficient).

The vertical seismic coefficient of 3 g's was determined by taking the 2 g coefficient required by the design specification and adding 1 g to it to account for the valve weight. The vertical seismic coefficient is denoted by g_1 in the calculations.

The horizontal seismic coefficient of 4.24 g's was determined by assuming that two horizontal seismic accelerations occur simultaneously. By combining the two 3 g horizontal accelerations required by the design specification by the square root of the sum of the squares method, an equivalent horizontal acceleration of 4.24 g's was calculated. The horizontal seismic coefficient is denoted by g_2 in the calculations.

RESULTS OF SEISMIC ANALYSIS

The stresses in the valve components resulting from the applied loads were found to be below 90% of the minimum yield stresses and as specified in the 1974 ASME Boiler and Pressure Vessel Code including the 1975 Winter Addenda.

Further, the resultant stresses in the valve structural components are such that no yielding takes place and the operability of the valve is maintained.

For results of the natural frequency testing refer to report no. 3433.

For Information Only

CERTIFICATION

This is to certify that this seismic calculation meets the requirements of specification 2323-MS-604, Table 3.7-13 as modified by Appendix C of this report. More specifically, the nozzle end stress is calculated using the minimum wall per the design drawing as opposed to that specified in Table 3.7-13 of the above mentioned specification.

Stephen M Schmidt 1-29-81

S. Schmidt, Sen. Prod. Eng.

R.G. Butler 1-29-81

R. Butler, Sen. Prod. Eng.

Chkd. By RGB Date 1-?9-81 Job No.

For Information Onl

VALVE BODY MATERIAL – SA 351 – CF8

ALLOWABLE STRESS PER THE ASME BOILER + PRESSURE VESSEL CODE SECTION III DIV 1 TABLE I-7.2 IS 14,690 AT 680°F

14,690 psi > 13,928 psi

ITT Grinnell Valve Co., Inc.

DIA-FLO DIVISION

FORM 902

For Information Only

APPENDIX C

Minimum Wall Calculation

By [illegible] Date [illegible] Subject ____ Sheet No. ____ of ____

Chkd. By RGB Date 1-[illegible]-81 ____ Job No. ____

For Information Only

PER TABLE 3.7-B OF SPECIFICATION NO 2323-MS-604

THE MINIMUM VALUE FOR WALL THICKNESS

IS THAT FOUND IN [illegible] FOR 4" DIAMETER

.25 in

THE ABOVE VALUE IS USE AS MIN WALL FOR

PRESSURE RETAINING ITEM WITH THE EXCEPTION

OF THE NOZZLE ENDS. THE MIN WALL USED FOR

THE NOZZLE ENDS IS MIN ALLOWABLE PER THE

design drawing

ITT Grinnell Valve Co., Inc.

DIA-FLO DIVISION

FORM 902

SECTION 3

TECHNICAL SPECIFICATION

3.0 INTRODUCTION

This section covers the technical and particular requirements for the Station Service Water Screen Wash Booster pumps, the Chilled Water Recirculation pumps and their drivers which are nuclear safety related at the Comanche Peak Steam Electric Station (CPSES), a two unit PWR nuclear power plant. It forms part of the total specification, which includes Sections 1, 2, and 3 and its Appendices 1 through 6.

3.1 SCOPE OF WORK

3.1.1 WORK INCLUDED

This specification covers the design, analysis, quality assurance, manufacture, shop testing, inspection, certification, cleaning, finishing, packaging, operating and maintenance instructions performance, and delivery in accordance with ASME B&PV Code, Section III, Class 3 pumping units as listed in Table 3.5-1, each pumping unit shall include, but is not limited to, the following accessories and services:

a. Flexible coupling

b. Electric motor driver

c. All integral fitted piping and trim

d. Coupling guard

e. Common baseplate for pump and motor driver for horizontal pumping units

f. Primer and protective coating

g. One complete set of new special tools and fixtures necessary for proper installation, adjustment and maintenance of each pumping unit

h. Seismic and nozzle load calculations for the pumps, motors and baseplates inclusive as a complete unit

3.1.4 DELIVERY DATES

The delivery of the equipment covered by this specification is critical, and must arrive at jobsite complete with all assemblies, subassemblies, parts, tools and accessories no later than the following:

	Unit No. 1		Unit No. 2	
	Number	Date	Number	Date
Station Service Water Screen Wash Booster Pumps	2	11-16-79		
Chilled Water Recirculation Pumps	2	09-01-78	2	11-16-79

3.2 QUALITY ASSURANCE REQUIREMENTS

a. Quality assurance shall be in accordance with attached, Quality Assurance for Procurement of Materials and Equipment, Specification 2323-GS-903, Appendix 3.

b. The pumps purchased under this specification are nuclear-safety related and require special consideration during design, purchasing, fabrication, handling, shipment, storage, cleaning, erection, installation, inspection and testing. For required tests see Paragraph 3.8; for required inspections see Paragraph 3.9; and for documentation and records see Paragraph 3.10.

3.3. CODES AND STANDARDS

Each pump and its auxiliaries shall be in accordance with the latest edition including all addenda of the following codes, legislation, regulations, and standards in effect on the date of the purchase order:

a. Code of Federal Regulations - 10CFR50

b. American Society of Mechanical Engineers (ASME)

   1. ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components, Class 3 Components

For Information Only

2. ASME Boiler and Pressure Vessel Code, Section II, Material Specifications, as referenced by Section III

3. ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications, as referenced by Section III

4. ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components as specified herein

c. American National Standards Institute (ANSI)

1. ANSI Standard B16.5 Steel Flanges and Flanged Fittings, as specified herein

2. ANSI Standard B16.11 Steel S.W. Fittings, as specified herein

3. ANSI Standard B16.25 Buttwelding Ends, as specified herein

4. ANSI Standard N45.2.9 "Requirements for Collection, Storage and Maintenance of Quality Assurance Records for Nuclear Power Plants"

5. ANSI Standard N45.2.11 "Quality Assurance Requirements for the Design of Nuclear Power Plants"

6. ANSI Standard N45.2.13 "Supplementary Quality Assurance Requirements for Control of Procurement of Equipment, Materials, and Services for Nuclear Power Plants"

7. ANSI Standard B2.1 Pipe Threads

8. ANSI Standard N45.2.2 "Packaging, Shipping, Receiving, Storage and Handling of Items for Nuclear Power Plants."

9. ANSI Standard N.45.2 "Quality Assurance Requirements for Nuclear Power Plants"

d. Nuclear Regulatory Commission Regulatory Guides as specified herein.

e. American Society for Testing and Materials (ASTM), as allowed by the ASME B&PV Code, Section III, Class 3 components

f. Occupational Safety and Health Act (OSHA)

g. Steel Structures Painting Council (SSPC), as specified herein

h. Standards of the Hydraulic Institute (HI)

i. Anti-Friction Bearing Manufacturers Association (AFBMA)

j. American Gear Manufacturers Association (AGMA)

k. Institute of Electrical and Electronics Engineers (IEEE)

l. National Electrical Manufacturers Association (NEMA)

m. National Electrical Code (NEC)

3.4 CONDITIONS OF SERVICE

3.4.1 ATMOSPHERIC CONDITIONS

The equipment installed indoors will be subjected to dust, 50 to 100 percent relative humidity, and temperature fluctuating as indicated in Table 3.5-1 for various pumps.

3.4.2 PUMPED LIQUIDS

The design construction, and materials of each pump shall be suitable for the type of liquids specified on the individual pump specification sheets and described below:

Corrosion inhibitor: Suitable corrosion inhibitor will be used according to manufacturer's recommendation. One of the following corrosion inhibitors shall be used:

1. Drew Chemical's Drewgard - 100

2. Calgon Corporation's LS-16

3. Betz Laboratories' Orocol-252

3.5 DESIGN, OPERATING AND TEST CONDITIONS

3.5.1 DESIGN CONDITION

The following Table 3.5-1 and Appendix 6 contain the required design conditions for each pump. Table 3.5-2, "Classification Summary," is a synopsis of pertinent design details.

3.5.2 OPERATING CONDITIONS

Component operating conditions are defined by the ASME B&PV Code, Subsection NB, Paragraph NB-3113, in accordance with the anticipated frequency of occurrence and risk to the public.

The specified component operating condition is:

<u>Normal Operating Conditions</u> - Normal operating conditions are given in Table 3.5-1 and in Appendix 6 of this specification.

3.5.3 TEST CONDITIONS

Component test condition is defined by the ASME B&PV Code.

The specified component test condition is:

<u>Testing Condition</u> - Hydrostatic test in accordance with the ASME B&PV Code.

Environmental design conditions shall be per Table 3.5-1. Documentation and Records to be submitted to the Purchaser shall be per paragraph 3.10.2 herein.

3.7.6 STRESS, SEISMIC AND NOZZLE LOAD REQUIREMENTS

3.7.6.1 GENERAL

a. All components covered by this Specification are classified as Seismic Category I.

b. All components covered by this Specification taken separately or as an assembly, shall be designed for plant conditions, load combinations and stress level restrictions as specified herein.

c. Certified, detailed calculations shall be prepared by the Seller to demonstrate that the equipment meets the seismic, stress, and nozzle load requirements of the specification. These calculations shall be prepared in a form which facilitates checking. The form shall substantially conform to Appendix C of the ASME B&PV Code, Section III.

d. The Seller shall as a minimum requirement, consider and design against the following potential failure modes that could occur.

FAILURE MODE	CAUSE
(1) Motor Insulation Failure	Excessive deflection between the rotor and stator allowing them to rub.
(2) Motor Bearing Failure	(a) Excessive load induced by relative movement between the pump and rotor transmitted by the couplings.
	(b) Excessive load induced by rotor deflection.

(3) Pump Bearing Failure	(a)	Excessive load induced by rotor deflection.
	(b)	Excessive load induced by relative movement between the pump and rotor and transmitted by the coupling.
(4) Seal leakage and/or failure		Excessive deflection between the pump shaft and housing.
(5) Support Failure		Excessive deformation due to seismic loads
(6) Coupling Failure		Excessive movement between the pump and motor shafts.
(7) Impeller Failure		Excessive deflection of the shaft or pump housing to cause impeller and pump housing to contact.

e. All required design data is specified in Table 3.5-1.

For Information Only

3.7.6.2 LOAD COMBINATIONS

The mechanical load combinations corresponding to the component design and operating conditions specified in Section 3.5 of this specification have been categorized under the "Plant Condition" under which they occur and are given below:

a. Component Design Condition

(Same as for the component normal operating condition shown in 3.7.6.2.b below).

b. Component Normal Operating Condition

Plant Condition	Loading Combination
Normal	Internal pressure + deadweight + sustained loads + thermal expansion + occasional load
Upset	Internal pressure + deadweight + sustained loads + thermal expansion + occasional load + 0.5 SSE + transients
Emergency	Internal pressure + deadweight + sustained loads + thermal expansion + occasional load + 1.0 SSE + transients
Faulted	Internal pressure + deadweight + sustained loads + thermal expansion + occasional load + 1.0 SSE + transients + pipe whip + jet impingement

c. Component Test Condition

Plant Condition	Loading Combination
Normal	Internal pressure + deadweight + any other sustained loads + nozzle loads + occasional loads

Definitions:

1. Internal Pressure - For the component design and normal operating condition use the design pressure given in Paragraph 3.5 of the specification, Test Condition Pressure per the ASME Code.

2. Deadweight - Weight of the component and all its appurtenances.

3. Sustained Loads and Thermal Expansion - Including Nozzle loads as shown in para. 3.7.7.6 of this specification. Nozzle loadings include, as applicable, pipe weight, sustained loads due to piping, thermal expansion loads due to pipe expansion, seismic loadings, and pipe rupture loadings. The vendor is required to consider any additional loadings that might exist.

4. Occasional Load - Single 500-lb force acting vertically through the center of gravity of each major component.

5. SSE - Safe Shutdown Earthquake

6. Transients - Not applicable to this equipment

7. Pipe Whip Not applicable to this equipment

8. Jet Impingement - Not applicable to this equipment

3.7.6.3 SEISMIC REQUIREMENTS

a. All seismic Category I equipment covered by this specification shall be designed in accordance with the requirements of the attached specification, 2323-SS-20, "Seismic Criteria for Equipment Design," Appendix 4.

b. All final analysis, design and testing for seismic qualification shall be based on the final floor response spectra specified in Specification 2323-SS-20.

c. The function (operability and structural integrity) of the equipment shall not be impaired by the SSE and 0.5 SSE.

d. For the purposes of calculation, the no-loss-of function stresses of the equipment for the SSE condition shall be limited to the applicable values in Table 3.7.6-1.

e. The primary steady state stresses when combined with the stresses caused by 0.5 SSE, shall be maintained within the allowable material working stress limits as established in Section III of the ASME Boiler and Pressure Vessel Code.

f. The two horizontal and one vertical seismic accelerations shall be assumed to act simultaneously, with the resulting stresses, deflections, etc. obtained by taking the square root of the sum of the squares (SRSS) of the components.

g. All Seismic Category I pump-motor assemblies including their supports furnished under this specification shall have an overall natural frequency equal to or greater than 33 hertz. The intent of this requirement is to establish the pump casings as rigid bodies for the purpose of piping analysis. The Seller shall provide certified calculations or test data to substantiate this requirement and in accordance with procedures in Paragraph 3.7.6.1.c.

3.7.6.4 STRESS REQUIREMENTS

The components are classified ASME Code, Section III, Class 3 and shall meet the stress limits shown in Table 3.7.6-1.

TABLE 3.7.6-1

STRESS LIMITS FOR ASME CLASS 3 PUMPS

a. Component Design and Normal Operating Conditions:

Plant Conditions	Stress Limits
Normal	Per ASME B&PV Code, Section III
Upset	$P_m \leq S$
	$P_m + P_b \leq 1.5S$
Emergency	$P_m \leq S$
	$P_m + P_b \leq 1.5S$
Faulted	$P_m \leq S$; $P_m + P_b \leq 1.5 S$

b. Component Test Condition:

Plant Condition	Stress Limits
Normal	Per ASME B&PV Code, Section III

NOTES:

1. General Nomenclature
   (a) P_m = Primary Membrane Stress

   (b) P_b = Primary Bending Stress

   (c) S = Allowable Stress Value as specified in Appendix I of Section III of the ASME B&PV Code.

2. In addition to compliance with the stress limits specified above, assurance of operability under all design loading combinations should be provided by any appropriate combination of the following suggested measures:

   (a) Full-scale prototype testing

   (b) Reduced-scale prototype testing

   (c) Detailed stress and deformation analyses

In the performance of tests or analyses to demonstrate operability, the structural interaction of the entire assembly (e.g., pump-motor assembly) should be considered. If superposition of test results for other than the combined loading is proposed, the applicability of such a procedure should be demonstrated.

CONTENTS

1.0 SCOPE

1.1 The purpose of this document is to define the seismic design criteria for equipment to be installed in Comanche Peak Steam Electric Station, Unit Nos. 1 & 2. The equipment supplier shall verify that said equipment can meet its performance requirements during and following a seismic disturbance.

2.0 CLASSIFICATION OF EQUIPMENT

2.1 Equipment is classified into two categories, Seismic Category I and Non-Category I for the purpose of seismic design. These categories are defined as follows:

2.1.1 Seismic Category I - Equipment, components, and parts thereof, failure of which could lead to a release of radioactivity in excess of the guideline values in published regulations pertaining to accident considerations or prevent a safe shutdown of the reactor.

2.1.2 Non-Category I - Equipment, components, and parts thereof, not included in Seismic Category I.

2.1.3 The seismic classifications of particular pieces of equipment are given in the applicable equipment specifications.

2.2 The response of any Non-Category I equipment to the earthquake loadings shall not adversely affect the integrity or operability of any item designated as Seismic Category I.

EARTHQUAKE INTENSITIES AND RELATED DESIGN OBJECTIVES - SEISMIC CATEGORY I EQUIPMENT

3.1 Earthquake intensities to be considered in the design of Seismic Category I equipment are as follows:

3.1.1 The Safe Shutdown Earthquake (SSE). During and after this event, all Seismic Category I equipment must continue to function in such a manner as to permit a safe and orderly plant shutdown without loss of integrity.

3.1.2 The 1/2 Safe Shutdown Earthquake (1/2 SSE). During and after this event, all Seismic Category I equipment must continue to operate undamaged with no loss of normal function. It shall respond as required for normal operation.

4.0 METHODS OF DETERMINATION OF SEISMIC ADEQUACY - SEISMIC CATEGORY I EQUIPMENT

4.1 The equipment supplier shall demonstrate the capability of his equipment to withstand seismic loads in accordance with Section 3.0, and the seismic classification specified in the applicable equipment specification, by either of the following methods:

4.1.1 Analytical Methods. (Predict the equipment performance by mathematical analysis). These methods without testing may be performed if it can be conservatively demonstrated that structural integrity alone can assure operability of seismic Category I equipment.

4.1.2 Testing Methods. (Test the equipment under simulated seismic conditions).

4.1.3 Combination of analytical and test methods may be performed when a complete seismic testing is impracticable.

4.2 The equipment supplier shall furnish in his bid a detailed description of the procedure to be used for predicting the equipment performance under seismic disturbances by analysis and/or by testing.

5.0 ANALYTICAL METHODS - SEISMIC CATEGORY I EQUIPMENT

5.1 Response of Equipment to Seismic Ground Motion

5.1.1 The response of the equipment to seismic ground motion (SSE and 1/2 SSE) shall be determined by using the appropriate floor response spectra referred to in Appendix A.

5.1.2 If the equipment is structurally simple so that it can be defined as a single-degree-of-freedom system, the dynamic model may consist of one mass and one equivalent spring. Using the values of mass and spring constant, the natural frequency of the equipment shall be determined. The response of the equipment is determined directly from the appropriate response spectra, when used in conjunction with the natural frequency and equipment damping.

5.1.3 If the equipment is structurally complex such that it cannot be modeled as a single-degree-of-freedom system, the following method of analysis shall be used:

5.1.3.1 Model the equipment using a multidegree of freedom representation.

5.1.3.2 Determine the dominant natural frequencies and mode shapes of the model.

5.1.3.3 Calculate the modal participation factors for each direction of support excitation to be considered.

5.1.3.4 For each significant mode determine spectral response value from the floor response spectra in Appendix A. Damping values given in Paragraph 5.2 shall be used.

5.1.3.5 Determine modal response such as modal absolute accelerations, modal relative displacements, modal inertia loads, etc. by the use of spectrum modal analysis.

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5.1.3.6 The maximum responses of the equipment shall be determined by combining the responses in each mode, (as determined in paragraph 5.1.3.5), using a recognized method such as square-root-of-the sum of the squares or absolute sum of modal responses and combinations thereof, depending on relevant factors such as spacing relationship between the frequency of each mode, etc. The method of combining modal responses shall be selected to yield realistically conservative results.

5.1.3.7 For relatively heavy equipment on relatively flexible supporting structures listed in Appendix A, the properties of the support structure including effective masses, damping factors and flexibility characteristics as given in Appendix A, shall be utilized. The analysis shall include the mathematical model of the supporting structure as an integral part of the equipment and its supports. The combined effects of the damping factors associated with the equipment and the supporting structures must be taken into account in the analysis.

5.1.3.8 In addition to inertia force considerations, relative displacements between equipment support points shall be considered. If a piece of equipment is supported at more than one floor elevation the equipment supplier shall provide to G&H drawings showing the details and locations of supports. G&H will then provide to the equipment supplier the relative displacements of these points, in each significant mode of the supporting structure and/or combined effects.

5.1.4 Equipment whose lowest dominant natural frequency is 33 Hz, or higher, can be considered rigid. In this case the acceleration of the equipment can be assumed the same as the zero period acceleration of the appropriate floor response spectrum.

5.1.5 For equipment which responds essentially as a single-degree-of-freedom system, the equipment supplier may elect not to calculate the natural frequency of his equipment. In such a case, the maximum peak value of the floor response spectra,

at the appropriate damping value, shall be used to determine the equipment response.

5.2 Damping factors to be used in the analysis shall, in general, be as follows:

Equipment Component	Percent of Critical Damping	
	1/2 SSE	SSE
Equipment and large-diameter piping system, (pipe diameter greater than 4")	2	3
Small-diameter piping system, (diameter equal to or less than 4")	1	2
Welded steel assemblies	2	4
Bolted steel assemblies	4	7

5.3 Any intermediate supports, consoles, racks, panels, etc. between the structure and the equipment being analyzed shall be considered as an integral part of the equipment in the dynamic analysis.

5.4 The effects of seismic motion of the equipment support structure induced by ground excitations in the three orthogonal directions (two horizontal at right angle to each other and vertical) shall be assumed to occur simultaneously. The responses of the equipment shall be determined by taking the square root of the sum of the squares of the responses at a particular point caused by each of the three components of earthquake motion.

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6.0 ALLOWABLE STRESSES AND DEFORMATIONS BASED ON ANALYSIS - SEISMIC CATEGORY I EQUIPMENT

6.1 The maximum stresses in the equipment, including the effects of the normal operating loads plus the 1/2 safe shutdown earthquake, shall be maintained within the normal allowable material working stress limits accepted as good practice and as set forth in the appropriate design standards and codes (as applicable) specified in the equipment specifications.

6.2 The maximum stresses in the equipment, including the effects of the normal operating loads plus a safe shutdown earthquake, shall be limited to prevent loss of function of the equipment. For the purpose of calculation, the no-loss-of-function stresses shall be limited to 90 percent of the yield strength of the material (including shear yield) or as otherwise set forth in the appropriate design standards and codes specified in the equipment specifications.

6.3 Deformations resulting from the combined influence of normal operating loads and the loads from the safe shutdown earthquake shall be investigated to verify that they will not impair functional performance.

6.4 For the 1/2 SSE, the equipment function shall be performed without permanent deformation.

6.5 For the SSE, permanent deformation is tolerable if it does not impair the equipment function. Valid plastic analysis shall demonstrate structural integrity. Local, self-limiting, secondary stresses may exceed yield stress levels to the extent as set forth in the appropriate design standards and codes.

6.6 Fatigue analysis, where required by the codes, shall be performed by the equipment supplier, using a minimum of 600 load cycles for 1/2 SSE.

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(R)

BASIC TECHNOLOGY REF. NO. BJ-80019

CUSTOMER REF. NO. S.O. No.: 1A658/61

SEISMIC ANALYSIS FOR CHILLED WATER RECIRCULATION PUMP 3x4x7-1/2-CAP

RECEIVED
JUN 3 1981
GIBBS & HILL, Inc.

PREPARED FOR

BINGHAM-WILLAMETTE COMPANY
A DIVISION OF GUY F. ATKINSON COMPANY
2800 NORTHWEST FRONT AVENUE
PORTLAND, OREGON 97210

APPROVED
FOR ARRANGEMENT ONLY
PROCEED WITH FABRICATION
SUBJECT TO COMPLIANCE WITH
ALL CONTRACT REQUIREMENTS.
DRAWINGS, AND SPECIFICATIONS.

AUG 10 1981

GIBBS & HILL, INC.
ENGINEERS, DESIGNERS, CONSTRUCTORS
NEW YORK

REPORT: BTI-80019
MARCH 4, 1980

REV.	DATE	PREP. BY	DATE	CHECKED BY	DATE	APPR. BY
2	4/15/81	T. A. Damico	4/15/81	T. J. Walcott	4/15/81	I. S. Tuba
1	8/28/80	T.A. Damico	8/28/80	T.J. Walcott	8/28/80	I.S. Tuba
0	2/29/80	T.A. Damico	3/4/80	T.J. Walcott	3/4/80	I.S. Tuba

Form No. 12.0

1.0 INTRODUCTION

Basic Technology Incorporated was engaged by Bingham-Willamette Company as their agent to perform an ASME Section III Cl. 3 analysis for a Chilled Water Recirculation Pump 3x4x7 - 1/2 - CAP per Gibbs and Hill, Incorporated specification Number 2323-MS-15C pertaining to Texas Utilities Comanche Peak Power Station.

1.1 OBJECTIVE

The objective of this report is to show that the pump and motor assembly remains operable during and after a seismic disturbance, and that all stresses and deflections are within the limit of the governing Codes and Standards.

2.0 SUMMARY OF RESULTS

For Information Only

The results of the seismic analysis presented in this report show that the pump and motor assembly remains operable during and after a seismic disturbance, and that all stresses and deflections are within the limit of the governing Codes and Standards. The results of the stress analysis are summarized in Table 2-1, Page 2.2.

The pump bearings and suction and discharge nozzle flanges were shown to be acceptable based on their specified ratings.

The deflection of the impeller relative to the pump casing (0.00235 in.) was shown to be less than the radial clearance (0.0095 in.). The angular misalignment (0.070°) and offset misalignment (0.020 in.) of the pump shaft was shown to be less than the capabilities of the coupling (1/2° and 0.029 in., respectively).

TABLE 2-1

ALLOWABLE AND CALCULATED STRESSES (KSI)

	STRUCTURE	STEEL	MIN. YIELD STRENGTH	MIN. ULT. TENSILE STRENGTH	FORMULA FOR		ALLOWABLES		CALCULATED	
					TENSILE	SHEAR	TENSILE	SHEAR	TENSILE	SHEAR
1	DRIVER HOLD DOWN BOLT[1]	SA-325	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	2.00	0.76
2	PUMP HOLD DOWN BOLT[1]	SA-325	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	7.14	——
3	BASE HOLD DOWN BOLT[1]	SA-325	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	27.95	8.78
4	SHAFT[2]	AISI416	40.0	75.0	$0.6S_y$	$0.4S_y$	24.0	16.0	1.88	0.05
5	BASE PLATE[1]	SA-36	36.0	58.0	$0.6S_y$	τ	21.6	18.0	5.50	833 lb/in
6	PEDESTAL[1]	SA-36	36.0	58.0	$0.6S_y$	$0.4S_y$	21.6	14.4	20.11	1.29
7	PEDESTAL WELDS[1]	SA-36	36.0	58.0	——	τ	——	18.0	——	700 lb/in
8	TAIL BRACKET BOLT[1]	SA-449	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	36.45	——
9	THRUST BEARING COVER BOLT[3]	SA-193B7	105.0	125.0	S	0.6S	25.0	15.0	7.18	0.48
10	VOLUTE CASE BOLTS[3]	SA-193B7	105.0	125.0	S	0.6S	25.0	15.0	9.42	7.14
11	STUFFING BOX BOLTS	SA-193B7	105.0	125.0	$0.5S_u$	$0.207S_u$	62.5	25.875	32.80	23.80
12	SUCTION/DISCHARGE INTERSEC.[3]	SA-216 WCB	36.0	70.0	S	0.6S	17.5	10.5	7.79/ 8.01	——
13	IMPELLER BOLT[3]	SA-193B7	105.0	125.0	S	0.6S	25.0	15.0	7.52	0.38
14	IMPELLER KEY[2]	AISI 416	40.0	75.0	$0.5S_u$	$0.207S_u$	37.5	15.525	——	1.31
15	TAPER PIN[1]	SA-193B7	105.0	125.0	$0.5S_u$	$0.207S_u$	62.5	25.875	——	10.47
16	PACKING GLAND[3]	SA-216WCB	36.0	70.0	S	0.6S	17.5	10.5	3.14	0.36

*Notes:

1. See Reference 3.06
2. See Reference 3.09
3. See Reference 3.0.10

2.1 CERTIFICATION

Basic Technology Incorporated, acting as agent for the manufacturer Bingham-Willamette Company, has prepared this seismic analysis report. In preparation of this report, procedures from pertinent sections in the References shown in Section 3.0 have been followed.

It is hereby certified, to the best knowledge of the undersigned, that the Chilled Water Circulation Pump (S.O. 1A658/61) manufactured to the drawings, tabulated in Section 4.0, will not exceed the stress limits of the ASME Code, Section III, Class 3, 1977 Edition, when subjected to the Seismic Loading Conditions set forth in the Specifications (References 3.0.2, 3.0.4, and 3.0.5). The certification is based on the assumptions and boundary conditions set forth herein.

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CHECKED BY: Thomas J. Walcott
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April 15, 1981

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
DR. I. S. TUBA
ENGINEER

3.0 REFERENCES

For Information O...

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3.0.4 "BWC Letter - Additional Information Required for Seismic Analysis," Susan Washburn, Seismic Engineer, Bingham - Willamette, 2800 N.W. Front Avenue, P.O. Box 10247, Portland, Oregon 97210, February 2, 1980.

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APPENDIX I

For Information Only

SUMMARY OF RESULTS AND ANALYSIS

A.1 INTRODUCTION

This section provides the actual analysis for Bingham Willamette pump 3x4x7 - 1/2 - CAP. The maximum stresses, support loads and foundation loads are in tabular form.

From the mode frequency analysis, it is observed that the natural frequency (fundamental) at the pump and motor assembly is above 33 hertz. To obtain the reactions at the support locations, on the thrust bearing and supports, and the shaft deflection, a static analysis was applied. In all cases, the pump met the governing criteria.

A.2 ANALYSIS SPECIFICATION

The list of items to be considered in the seismic analysis of BWC CAP pump S.O. 1A658/61 is shown on the following page.

A.2.1 PRESSURE CONTAINING PARTS

From Reference 3.0.4, the maximum pressure is 153 psi.

A.2.2 PLANT CONDITIONS

From Reference 3.0.2, the following plant conditions and allowables were specified:

Normal - ASME Section III, Subsection NC-3400:
Upset, Emergency, Faulted - $P_m \leq 1.0S$; $P_m + P_L \leq 1.5$ S.

A. 2.3. SEISMIC LOADS-SAFE SHUTDOWN EARTHQUAKE (SSE)

According to Reference 3.0.5, for natural frequencies above 33 hertz, elevation 778.0 feet, equipment damping coefficient 0.03, acceleration has to be taken as:

(0.2) g for horizontal direction

(0.5) g for vertical direction

SSE Seismic loads were conservatively applied for all plant conditions.

A. 2.4. TEMPERATURE CONTAINING PARTS

The design temperature specified in the operating conditions, Reference 3.0.2, equals 100°F. The properties of steel, shown in Table A.3.1., conform to this temperature requirement.

A. 2.5. SUPPORTS AND MOUNTING BOLTS

For the design of bolts, Paragraph NF-3280 of Reference 3.0.6, states that the procedures of Appendix XVII are to be used. The allowable design stress values shall be the yield strength values of Table I-13.3 of Appendix I multiplied by the applicable design factors of Table XVII-2461, 1-1.

For the present analysis, the mounting bolt loads are obtained for the faulted condition.

The shear stress, τ_s, in the tail bracket mounting bolt is given by,

$$\tau_s = \frac{R_v}{A_s} = \frac{511.4 \text{ lbs.}}{0.0678 \text{ in.}^2} = 7,543 \text{ psi}$$

which is less than the allowable,

$$\tau_s = 7,543 \text{ psi} < 21,735 \text{ psi} = 0.207\ S_u$$

For combined shear and tension stress in the bolt (See Page A-4),

$$\frac{S_t^2}{(0.5\ S_u)^2} + \frac{\tau_s^2}{(0.207\ S_u)^2} \leq 1$$

or,

$$\left(\frac{36,540\text{psi}}{52,500\text{psi}}\right)^2 + \left(\frac{7,543\text{psi}}{21,735\text{psi}}\right)^2 \leq 1$$

$$0.602 < 1$$

Therefore, the tail bracket mounting bolt design is acceptable.

A. 4.19 SUCTION AND DISCHARGE NOZZLE/CASING INTERSECTIONS

Stresses in the suction and discharge nozzle/casing intersections are analyzed by treating the discharge to suction nozzle junction as a reducing outlet branch connection (or tee) under the rules of ND-3650 (See Reference 3.0.17, Page 127).

The design of the suction to discharge nozzel junction using the piping tee model shall be analyzed for the effects of pressure, deadweight, and sustained loads.

The circumferential stress, $(S_{LP})_s$, in the suction nozzle due to internal design pressure P = 153 psi is given by,

$$(S_{LP})_s = \frac{P\, d_s^{\,2}}{(D_o)_s^{\,2} - d_s^{\,2}}$$

where,

d_s = 4.00 in. = nominal inside diameter of suction nozzle

t_n = 15/32 in. = design metal thickness (See BWC Drawing H-5289)

$(D_o)_s = d_s + 2\, t_n$ = 4.00 in. + 2 (15/32 in.) = 4.938 in.

= nominal outside diameter of suction nozzle

Then,

$$(S_{LP})_s = \frac{(153 \text{ psi})(4.00 \text{ in.})^2}{(4.938 \text{ in.})^2 - (4.00 \text{ in.})^2} = 292 \text{ psi}$$

Similarly, for the discharge nozzle,

$$(S_{LP})_D = \frac{P\, d_D^{\,2}}{(D_o)_D^{\,2} - d_D^{\,2}}$$

where,

d_D = 3.00 in. = nominal inside diameter of discharge nozzle

t_s = 15/32 in. = design metal thickness (See BWC Drawing H-5289)

$(D_o)_D = d_D + 2t_s$ = 3.00 in. + 2 (15/32 in.) = 3.938 in.

= nominal outside diameter of discharge nozzle

Then,

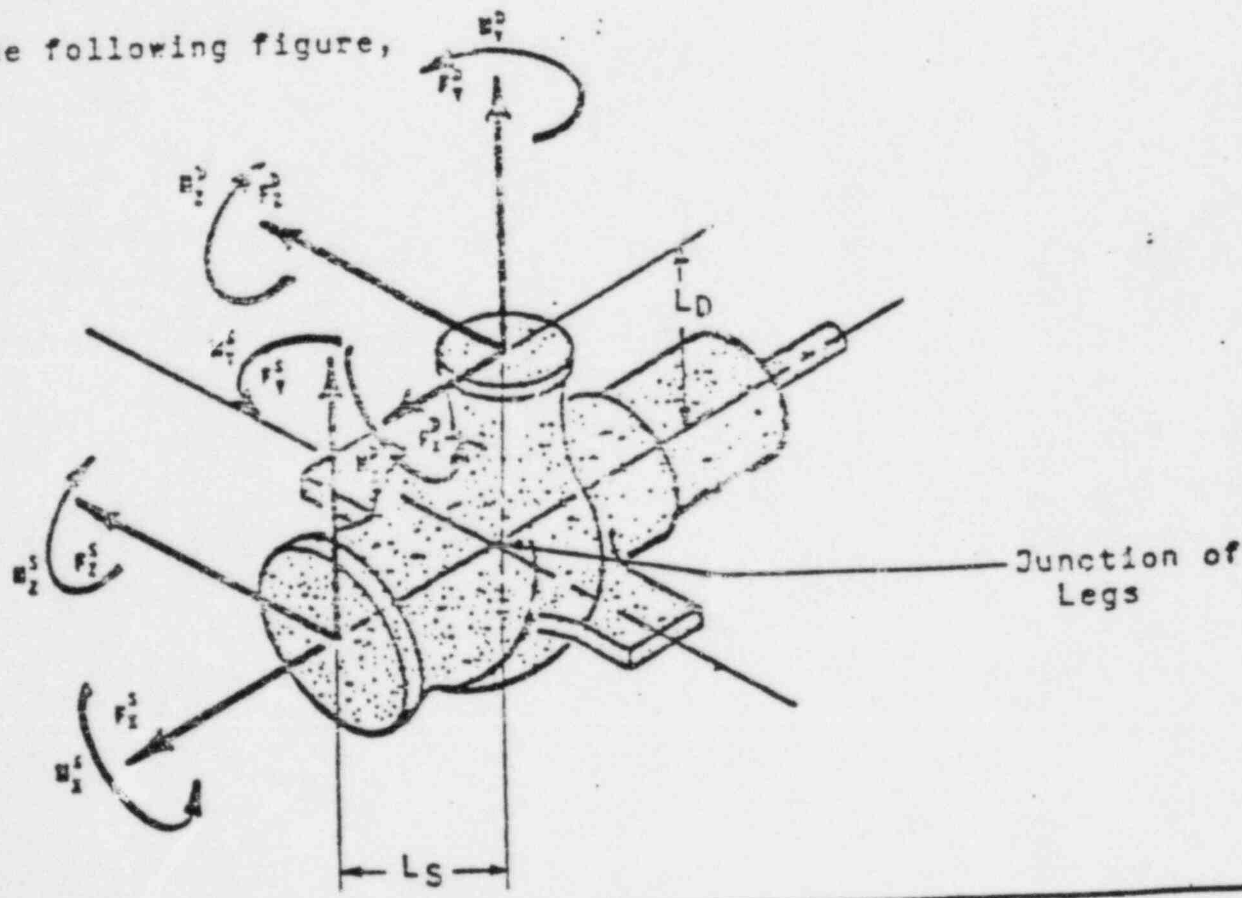
$$(S_{LP})_D = \frac{(153psi)(3.00in.)^2}{(3.938in.)^2 - (3.00in.)^2} = 212 \text{ psi}$$

Next, the resultant moments, $(M_A)_s$ and $(M_A)_D$, acting acting on the suction and discharge nozzles (legs), respectively, due to deadweight, sustained loads, and seismic loads are calculated in accordance with,

$$(M_R)_s = \left[(M_x)_s^2 + (M_y)_s^2 + (M_z)_s^2\right]^{1/2}$$

$$(M_R)_D = \left[(M_x)_D^2 + (M_y)_D^2 + (M_z)_D^2\right]^{1/2}$$

where the component moments are taken at the junction of the legs as shown in the following figure,



The weight of the entire volute case is given as 122 lbs. (See the Table on Page 4.2). It is conservatively assumed that each leg weighs 61 lbs. one-half of the entire volute case weight, and that the centers of gravity are at the ends of each leg. Then, the suction nozzle load components due to deadweight, sustained loads, and seismic loads are given by

$$(F_x)_s = (F_x)_N + (F_x)_{SSE} = (F_x)_N + 0.2g \frac{W_s}{g}$$

$$(F_y)_s = (F_y)_N + (F_y)_{SSE} + (F_y)_{DW} = (F_y)_N + 0.5g \frac{W_s}{g} + 1.0g \frac{W_s}{g}$$

$$(F_z)_s = (F_z)_N + (F_z)_{SSE} = (F_z)_N + 0.2g \frac{W_s}{g}$$

$$(M_x)_s = (M_x)_N$$

$$(M_y)_s = (M_y)_N + (F_z)_s L_s$$

$$(M_z)_s = (M_z)_N + (F_y)_s L_s$$

where, the subscripts indicate,

S = suction nozzle

N = sustained loads (See BWC Item Number HS-15-C)

SSE = seismic inertial loads (accelerations, 0.2g in horizontal directions, 0.5g in vertical direction)

DW = deadweight (acceleration, 1g in vertical direction)

and,

W_s = 61 lbs. = weight of suction nozzle

L_s = 5.125 in. = distance from end of suction nozzle to junction of legs.

Then,

$$(F_x)_s = 1000 \text{ lbs.} + 0.2g \frac{61 \text{ lbs.}}{g} = 1012.2 \text{ lbs.}$$

$$(F_y)_s = 800 \text{ lbs.} + 0.5g \frac{61 \text{ lbs.}}{g} + 1.0g \frac{61 \text{ lbs.}}{g} = 891.5 \text{ lbs.}$$

$$(F_z)_s = 900 \text{ lbs.} + 0.2g \frac{61 \text{ lbs.}}{g} = 912.2 \text{ lbs.}$$

$$(M_x)_s = 23760 \text{ in.-lb.}$$

$$(M_y)_s = 19920 \text{ in.-lb.} + 912.2 \text{ lbs.} (5.125 \text{ lb.}) = 24595 \text{ in.-lb.}$$

$$(M_z)_s = 19920 \text{ in.-lb.} + 891.5 \text{ lbs.} (5.125 \text{ lb.}) = 24489 \text{ in.-lb.}$$

and the resultant moment is given by,

$$(M_R)_s = \left[(23760 \text{ in.-lb.})^2 + (24595 \text{ in.-lb.})^2 + (24489 \text{ in.-lb.})^2\right]^{1/2}$$

$$= 42061 \text{ in.-lb.}$$

Similarly, for the discharge nozzle,

$$(F_x)_D = 670 \text{ lb.} + 0.2g \frac{61 \text{ lbs.}}{g} = 682.2 \text{ lbs.}$$

$$(F_y)_D = 750 \text{ lb.} + 0.5g \frac{61 \text{ lbs.}}{g} + 1.0g \frac{61 \text{ lbs.}}{g} = 841.5 \text{ lbs.}$$

$$(F_z)_D = 600 \text{ lb.} + 0.2g \frac{61 \text{ lbs.}}{g} = 612.2 \text{ lbs.}$$

$(M_x)_D = (M_x{}^1)_N + (F_z)_D L_D$ = 11760 in.-lb.+612.2lb.(9.125in.)=17346in.-lb.

$(M_y)_D = (M_y{}^1)_N$ = 10920 in.-lb.

$(M_z)_D = (M_z{}^1)_N + (F_x)_D L_D$ = 10320 in.-lb.+682.2lb.(9.125in.)=16545in.-lb.

where,

L_D = 9.125 in. = distance from end of discharge nozzle to junction of legs

and the resultant moment is given by,

$$(M_R)_D = \left[(17346\ \text{in.-lb.})^2+(10920\text{in.-lb.})^2+(16545\text{in.-lb.})^2\right]^{1/2}$$

$$= 26341\ \text{in.-lb.}$$

The section moduli, Z_s and Z_D, for the suction and discharge nozzles, respectively, are given by,

$$Z_s = \pi r^2 t_n$$

$$Z_D = \pi (r_m)^2 t_s$$

where,

r = 2.234 in. = mean cross-sectional radius of suction nozzle

t_n = 0.469 in. = nominal wall thickness of suction nozzle

r_m = 1.734 in. = mean cross-sectional radius of discharge nozzle

t_s = 0.469 in. = effective branch wall thickness which in this case is the nominal discharge nozzle wall thickness

Then,

$$Z_s = \pi\,(2.234\text{ in.})^2\,(0.469\text{in.}) = 7.353\text{ in.}^3$$

$$Z_D = \pi\,(1.734\text{ in.})^2\,(0.469\text{in.}) = 4.430\text{ in.}^3$$

Next the stress intensification factor is calculated. The flexibility characteristic, h, flexibility factor, K, and stress intensification factor, i, of the suction to discharge nozzle "tee" may best be represented by assuming the average of the values for a welding tee (per ANSI B 16.9) and an unreinforced fabricated tee (See Figure ND-3673.2 (b)-1, Reference 3.0.1.7, Page 133), For welding tee,

$$h = \frac{4.4}{r}\,t_n$$

$$K = 1$$

$$i = 0.9/h^{2/3}$$

while, for an unreinforced fabricated tee,

$$h = \frac{t_n}{r}$$

$$K = 1$$

$$i = 0.9/h^{2/3}$$

where, t_n and r were defined on Page A-80. Then, the average stress intensification factor is given by,

$$\bar{i} = \frac{\dfrac{0.9}{\left[\dfrac{4.4\ t_n}{r}\right]^{2/3}} + \dfrac{0.9}{\left[\dfrac{t_n}{r}\right]^{2/3}}}{2}$$

or,

$$\bar{i} = \frac{\dfrac{0.9}{\left[\dfrac{4.4(0.469\text{in.})}{2.234\text{ in.}}\right]^{2/3}} + \dfrac{0.9}{\left[\dfrac{0.469\text{ in.}}{2.234\text{ in.}}\right]^{2/3}}}{2} = 1.748$$

The maximum stress, $(S_{OL})_s$, in the suction nozzle/ volute case intersection due to deadweight, pressure, sustained loads, and seismic loads is given by,

$$(S_{OL})_s = (S_{LP})_s + 0.75\ \bar{i}\ \frac{(M_R)_s}{Z_s}$$

or,

$$(S_{OL})_s = 292\text{ psi} + 0.75(1.748)\ \frac{42061\text{ in.-lb.}}{7.353\text{in.}^3} = 7791\text{ psi}$$

Similarly, for the discharge nozzle/volute case intersection,

$$(S_{OL})_D + (S_{LP})_D + 0.75\ \bar{i}\ \frac{(M_R)_D}{Z_D}$$

or,

$$(S_{OL})_D = 212\text{ psi} + 0.75\ (1.748)\frac{26341\text{ in.-lb.}}{4.430\text{ in.}^3} = 8007\text{ psi}$$

Conservatively comparing $(S_{OL})_s$ and $(S_{OL})_D$ to the allowable stress limit

S (for seismic loads excluded) (See Table A-3.1, Page A-5),

$$(S_{OL})_s = 7791 \text{ psi} < 17500 \text{ psi} = S$$

$$(S_{OL})_D = 8007 \text{ psi} < 17500 \text{ psi} = S$$

e find that the suction and discharge nozzle/volute case intersection esign is acceptable.

TABLE A-3.1

ALLOWABLE AND CALCULATED STRESSES (KSI)

	STRUCTURE	STEEL	MIN. YIELD STRENGTH	MIN. ULT. TENSILE STRENGTH	FORMULA FOR		ALLOWABLES		CALCULATED	
					TENSILE	SHEAR	TENSILE	SHEAR	TENSILE	SHEAR
1	DRIVER HOLD DOWN BOLT[1]	SA-325	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	2.00	0.76
2	PUMP HOLD DOWN BOLT[1]	SA-325	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	7.14	—
3	BASE HOLD DOWN BOLT[1]	SA-325	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	27.95	8.78
4	SHAFT[2]	AISI416	40.0	75.0	$0.6S_y$	$0.4S_y$	24.0	16.0	1.88	0.05
5	BASE PLATE[1]	SA-36	36.0	58.0	$0.6S_y$	τ	21.6	18.0	5.50	833 lb/in
6	PEDESTAL[1]	SA-36	36.0	58.0	$0.6S_y$	$0.4S_y$	21.6	14.4	20.11	1.29
7	PEDESTAL WELDS[1]	SA-36	36.0	58.0	—	τ	—	18.0	—	706 lb/in
8	TAIL BRACKET BOLT[1]	SA-449	81.0	105.0	$0.5S_u$	$0.207S_u$	52.5	21.735	36.45	—
9	THRUST BEARING COVER BOLT[3]	SA-193B7	105.0	125.0	S	0.6S	25.0	15.0	7.18	0.48
10	VOLUTE CASE BOLTS[3]	SA-193B7	105.0	125.0	S	0.6S	25.0	15.0	9.42	7.14
11	STUFFING BOX BOLTS	SA-193B7	105.0	125.0	$0.5S_u$	$0.207S_u$	62.5	25.875	32.80	23.80
12	SUCTION/DISCHARGE INTERSEC.[3]	SA-216 WCB	36.0	70.0	S	0.6S	17.5	10.5	7.79/ 8.01	—
13	IMPELLER BOLT[3]	SA-193B7	105.0	125.0	S	0.6S	25.0	15.0	7.52	0.38
14	IMPELLER KEY[2]	AISI 416	40.0	75.0	$0.5S_u$	$0.207S_u$	37.5	15.525	—	1.31
15	TAPER PIN[1]	SA-193B7	105.0	125.0	$0.5S_u$	$0.207S_u$	62.5	25.875	—	10.47
16	PACKING GLAND[3]	SA-216WCB	36.0	70.0	S	0.6S	17.5	10.5	3.14	0.36

*Notes:

1. See Reference 3.0.6
2. See Reference 3.0.9
3. See Reference 3.0.10