LILCO
LONG ISLAND LIGHTING

LONG ISLAND LIGHTING COMPANY

SHOREHAM NUCLEAR POWER STATION

P.O. BOX 618, NORTH COUNTRY ROAD • WADING RIVER, N.Y. 11792

Direct Dial Number

June 28, 1983 SNRC-921

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dynamic Qualification
SER Outstanding Issue No. 8
Shoreham Nuclear Power Station - Unit 1
Docket No. 50-322

Reference: Supplement Number 3 of the Safety Evaluation Report Related to the Operation of the Shoreham Nuclear Power Station - Unit 1

Dear Mr. Denton:

The purpose of this letter is to transmit information necessary to complete resolution of three generic items of concern contained in outstanding issue number 8 of Supplement number 3 of the Shoreham Safety Evaluation Report.

First, as stated in item (2) on page 3-5 of SSER 3, LILCO committed to improve the qualification documentation in BOP SQRT packages by including either complete test reports or summaries including anomalies and their resolutions by June 1983. This commitment has been fulfilled. The BOP SQRT packages were reviewed and have been revised as needed to add complete test reports or summaries of anomalies and resolutions.

Second, enclosed are three calculations intended to fulfill the commitments and requirements contained in item (1) of "the applicant's response..." on page 3-8 of SER Supplement number 3. The G.E. calculations are sample calculations of usage factors for both ASME Code and non-ASME Code components. The SWEC calculation evaluates the potential effects of fatigue due to SRV cyclic loading on the dynamic qualification of BOP plant equipment. In the SWEC calculation, four components were chosen based on their location in areas of the plant where SRV loads are known to be most significant. The four components are the head tank, loop level pump, booster heat exchanger and the velan gate valve. For all components analyzed in both the NSSS and BOP calculations, the

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1/1

cumulative fatigue usage factors are less than one. Additionally, we enclose a summary entitled, "Fatigue Evaluation of Components Qualified by Test" in order to clarify how fatigue testing was conducted in assuring that the Test Response Spectra enveloped the Required Response Spectra and that the input loads were sufficient to cover the duration and number of SRV cycles that have been defined. This summary fulfills the requirement stated in item (2) of "the applicant's response..." on page 3-8 of SSER 3. It is a summary of an analysis of a typical shake table acceleration time history and representative SRV floor time histories in which fatigue damage from the test motion is compared to fatigue damage from SRV loads. The calculation demonstrates that the fatigue usage from a typical test sequence far exceeds the fatigue usage from anticipated SRV loads over the 40 year plant life. Thus, the three generic items of concern are addressed.

Finally, we enclose two lists of Shoreham Category I Equipment Change Records, one for BOP and one for NSSS equipment. These are provided to fulfill the commitment beginning in the last paragraph on page 3-8 and continuing on to page 3-9 of SSER 3. The lists contain field modifications made to already qualified and installed safety-related equipment since the September 2, 1982 site SQRT audit date.

In accordance with R. L. Tedesco's letter to LILCO, dated January 21, 1981, four copies of this submittal including enclosures are being forwarded directly to Dr. Morris Reich at Brookhaven National Laboratory.

Should you have any questions regarding the material enclosed, do not hesitate to call this office.

Very truly yours,

J. L. Smith

J. L. Smith
Manager, Special Projects
Shoreham Nuclear Power Station

GJG/law S3
Enclosures

cc: J. Higgins
Dr. Morris Reich, BNL (4)
All Parties Listed in Attachment 1

ATTACHMENT 1

Lawrence Brenner, Esq.
Administrative Judge
Atomic Safety and Licensing
Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Peter A. Morris
Administrative Judge
Atomic Safety and Licensing
Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. James H. Carpenter
Administrative Judge
Atomic Safety and Licensing
Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Daniel F. Brown, Esq.
Attorney
Atomic Safety and Licensing
Board Panel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Bernard M. Bordenick, Esq.
David A. Repka, Esq.
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

James Dougherty
3045 Porter Street
Washington, D.C. 20008

Herbert H. Brown, Esq.
Lawrence Coe Lanpher, Esq.
Karla J. Letsche, Esq.
Kirkpatrick, Lockhart, Hill
Christoper & Phillips
8th Floor
1900 M Street, N.W.
Washington, D.C. 20036

Mr. Marc W. Goldsmith
Energy Research Group
4001 Totten Pond Road
Waltham, Massachusetts 02154

MHB Technical Associates
1723 Hamilton Avenue
Suite K
San Jose, California 95125

Stephen B. Latham, Esq.
Twomey, Latham & Shea
33 West Second Street
P.O. Box 398
Riverhead, New York 11901

Ralph Shapiro, Esq.
Cammer and Shapiro, P.C.
9 East 40th Street
New York, New York 10016

Matthew J. Kelly, Esq.
State of New York
Department of Public Service
Three Empire State Plaza
Albany, New York 12223

GENERAL ELECTRIC CO.
Nuclear Energy Business Operations
ENGINEERING CALCULATION SHEET

NUMBER ______ DATE 12/20/82
SUBJECT SHOREHAM RHR | CORE SPRAY MOTOR BY DRB SHEET 1 OF 4

FATIGUE STRESS EVALUATION:-

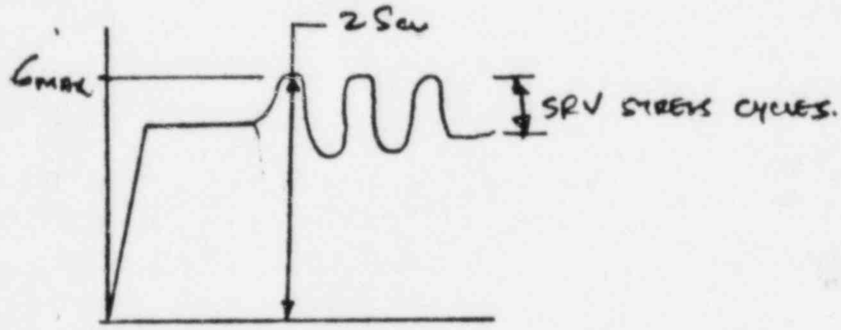
THE FOLLOWING CRITICAL LOCATIONS WERE EVALUATED FOR THE FATIGUE LOADS.

(1) MOTOR HOLD DOWN BOLTS.
(2) LOWER END SHIELD STRESS.

MOTOR HOLD DOWN BOLTS CARRY THE HIGHEST STRESS AND HAVE HIGHEST CALCULATED STRESS TO ALLOWABLE STRESS RATIO. LOWER END SHIELD WAS ALSO SELECTED BECAUSE IT IS MADE OF DIFFERENT MATERIAL (GREY CAST IRON). CALCULATED STRESS VALUES WERE TAKEN FROM THE MOTOR ANALYSIS REPORT CONTAINED IN THE SHOREHAM RHR AND CORE SPRAY PUMP | MOTOR DRF.

CALCULATED STRESS AT THE BASE OF LOWER END-SHIELD IS 3812 psi. APPLYING STRESS INTENSIFICATION FACTOR OF 4, MAX STRESS $\sigma_{max} = 3812 \times 4 = 15248$ psi

$\sigma_{max} = 2S_a = 15248$ psi
$S_a = 7624$ psi.



IT IS EVIDENT FROM THE CURVE OF ATTACHED SHEET 3 THAT VALUE OF S_a IS BELOW THE MATERIAL ENDURANCE LIMIT.

NOTE: THE ABOVE CALCULATION IS VERY CONSERVATIVE BECAUSE CALCULATED STRESS IN THE END SHIELD IS A RESULT OF SSE, SRV AND LOCA LOADINGS. ONLY SRV LOADS NEED BE CONSIDERED. (PLEASE SEE MOTOR HOLD DOWN BOLTS STRESS CALCULATIONS ON THE NEXT SHEET FOR THE SRV g VALUE AND THE g VALUE USED IN THE MOTOR ANALYSIS.)

[signature] 12/20/82
PERFORMED BY

[signature] 12/20/82
REVIEWED BY.

GENERAL ELECTRIC CO.

Nuclear Energy Business Operations

ENGINEERING CALCULATION SHEET

NUMBER ________ DATE ________

SUBJECT SHOREHAM RHR/CS MOTOR BY ________ SHEET 2 OF 4

MOTOR HOLD DOWN BOLT STRESS CALCULATIONS

MAX. ACCELERATION VALUES IN HORIZ. AND VERT. DIRECTIONS:

HORIZ. ACCELERATION = 0.43 g (SRV)
0.62 g (SSE)

VERT. ACCELERATION = 0.34 g (SRV)
0.16 g (SSE)

CONSERVATIVELY, USE

$$a_{HORIZ} = 0.62\ g$$
$$a_{VERT} = 0.34\ g$$

ACCELERATION VALUES USED IN THE MOTOR ANALYSIS:

HORIZ = 3.85 g
VERT = 2.70 g
(REF: MOTOR ANAL. REPORT PAGE. 11)

ACTUAL STRESS FROM THE ANALYSIS = 26195 psi. THIS STRESS WOULD BE CAUSED BY UPLIFT BOLT FORCE AND THE OVER-TURNING MOMENTS. CONSERVATIVELY, ASSUME THAT ABOVE CALCULATED STRESSES WERE SOLELY CAUSED BY THE OVER-TURNING MOMENT (CRUDE CALC;

SO,

$$\text{RATIO} = \frac{\text{NEW ACCL}}{\text{OLD ACCLN}} = \frac{0.62}{3.85} = 0.16$$

ACTUAL STRESS = $0.16 \times 26195 = 4192$ psi

STRESS CONC FACTOR = 4

$$\sigma_{max} = 4 \times 4192 = 16768 \text{ psi}$$

$$S_a = \frac{16768}{2} = 8384 \text{ psi} = 8384 \text{ ksi}.$$

SINCE THIS STRESS IS LESS THAN THE MATERIAL ENDURANCE LIMIT (SEE SHT 4) THE BOLTS WILL WITHSTAND 10^6 STRESS CYCLES WITHOUT FAILURE.

3 of 4

proach is to use the tensile strength (or fatigue limit) and, after determining the section modulus of the actual shape, to apply the proper bending formula. However, because of the difficulty in obtaining a meaningful value for the tensile strength in tests of small specimens, the load computed in this manner will usually be somewhat lower than the actual load required to rupture the part, unless unfavorable residual stresses are present in the finished part.

Elongation of gray iron at fracture is very small (of the order of

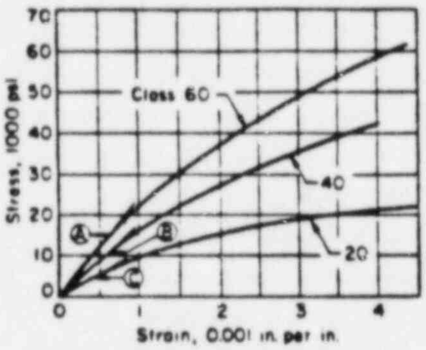


Fig. 10. Typical stress-strain curves for three classes of gray iron in tension. Modulus of elasticity is measured to points A, B and C, representing ¼ of the tensile strength.

0.006 in. per in.) and hence is seldom reported. The designer cannot use the numerical value of permanent elongation in any quantitative manner.

Torsional Shear Strength. As shown in Table 12, most gray irons have high torsional shear strength. Many grades have torsional strength greater than some grades of steel. This characteristic, along with low notch sensitivity, makes gray iron a suitable material for shafting of various types, particularly in the grades of higher tensile strength. Most shafts are subjected to dynamic torsional stresses and the designer should consider carefully the exact nature of the loads. For the higher-strength irons, stress concentration factors associated with changes of shape in the part are important for torque loads as well as for bending and tension loads.

Modulus of Elasticity. Typical stress-strain curves for gray iron are shown in Fig. 10. Gray iron does not obey Hooke's law and the modulus in tension is usually determined arbitrarily as the slope of the line connecting the origin of the stress-strain curve with the point corresponding to ¼ of the tensile strength. Some engineers use the slope of the stress-strain curve near the origin for determining the modulus of elasticity.

As indicated in Table 12, the modulus of gray iron varies considerably more than for most metals. Thus, in using observed strain to calculate stress, it is essential to measure the modulus of the particular gray iron specimen being considered. The numerical value of the modulus in torsion is always less than in tension, just as it is for steel.

Hardness of gray iron, as measured by Brinell or Rockwell testers, is an average result of the soft graphite in the iron and the metallic matrix. Variations in graphite size and distribution will cause wide variations in hardness (particularly Rockwell hardness) even though the hardness of the metallic matrix is constant. To illustrate this effect, the microhardness of the matrix of five types of hardened iron, as compared with Rockwell C measurements on the same iron, is shown in Table 13.

It is apparent that if any hardness correlation is to be attempted, the graphite must be constant as to type and amount in the irons being compared. It is recommended that Brinell hardness be used when possible.

Fatigue Limit in Reversed Bending

Because fatigue limits are expensive to determine, the designer usually has incomplete information on this property. Typical S-N curves for gray iron under completely reversed cycles of bending stress are shown in the graph on left in Fig. 11, in which each point represents the data from one specimen. The effects of temperature on fatigue limit and tensile strength are shown in the right-hand graph in Fig. 11.

Axial loading or torsional loading cycles are frequently encountered in designing parts of cast iron, and in many instances these are not completely reversed loads. Types of regularly repeated stress variation usually can be expressed as a function of a mean stress and a stress range. Wherever possible the designer should use actual data from the limited information available. Without precisely applicable test data, an estimate of the reversed bending fatigue limit of machined parts may be made by using about 35% of the minimum specified tensile strength of the particular grade of gray iron being considered. This is probably a safe value rather than an average of the few data available concerning the fatigue limit for gray iron.

Table 13. Comparison of Rockwell Hardness of Gray Irons, as Influenced by Graphite

Type of graphite	Total carbon, %	Rockwell C hardness (a)	Matrix converted (b)
A	3.06	45.2(c)	61.5
A	3.53	43.1	61.8
A	4.00	32.0	62.0
D	3.30	34.0	63.5
D	3.80	48.7	60.5

(a) Measured by conventional Rockwell C test. (b) Hardness of matrix, measured with superficial hardness tester and converted to Rockwell C. (c) Although this value was obtained in the specific test cited, it is not typical of gray iron of 3.06% C. Ordinarily the hardness of such iron is Rockwell C 48 to 50.

An approximation of the effect of range of stress on the fatigue limit may be obtained from diagrams such as Fig. 12. The tensile strength is plotted on the horizontal axis to represent the fracture strength under static load (which corresponds to zero stress range). The reversed

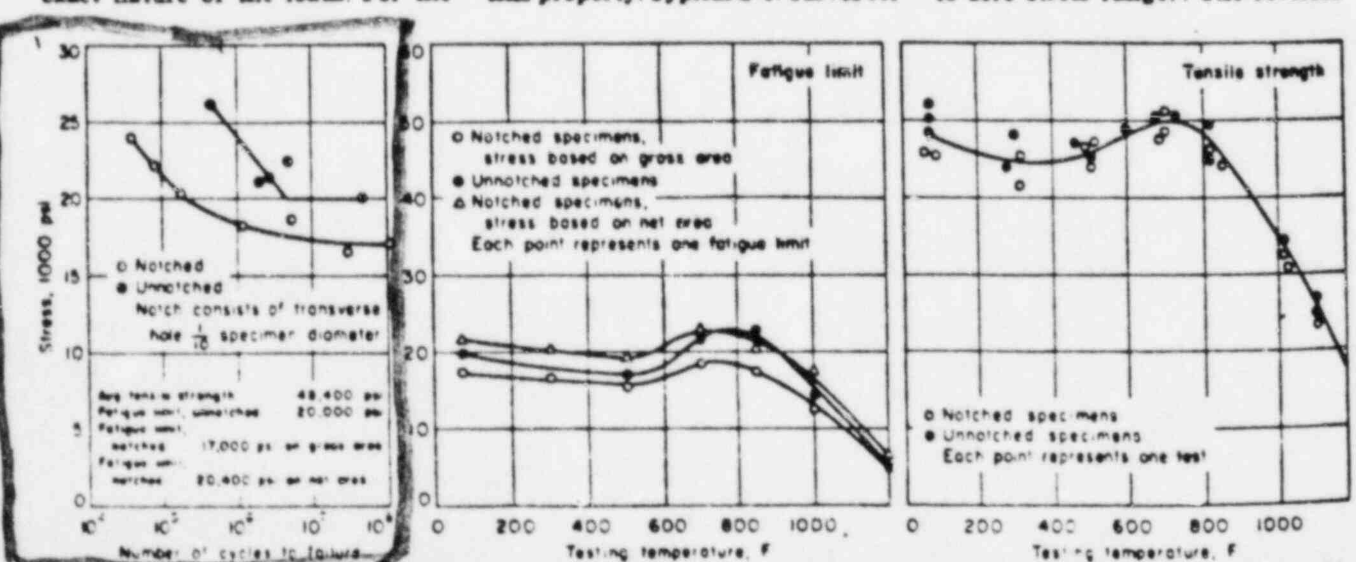


Fig. 11. S-N curves and effects of temperature on fatigue limit of gray iron of the tensile strength shown. Composition: 2.84 C, 1.52 Si, 1.05 Mn, 0.07 P, 0.12 S, 0.31 Cr, 0.20 Ni, 0.37 Cu. (W. Leighton Collins and James O. Smith, Proc. ASTM, 41, 797, 1941)

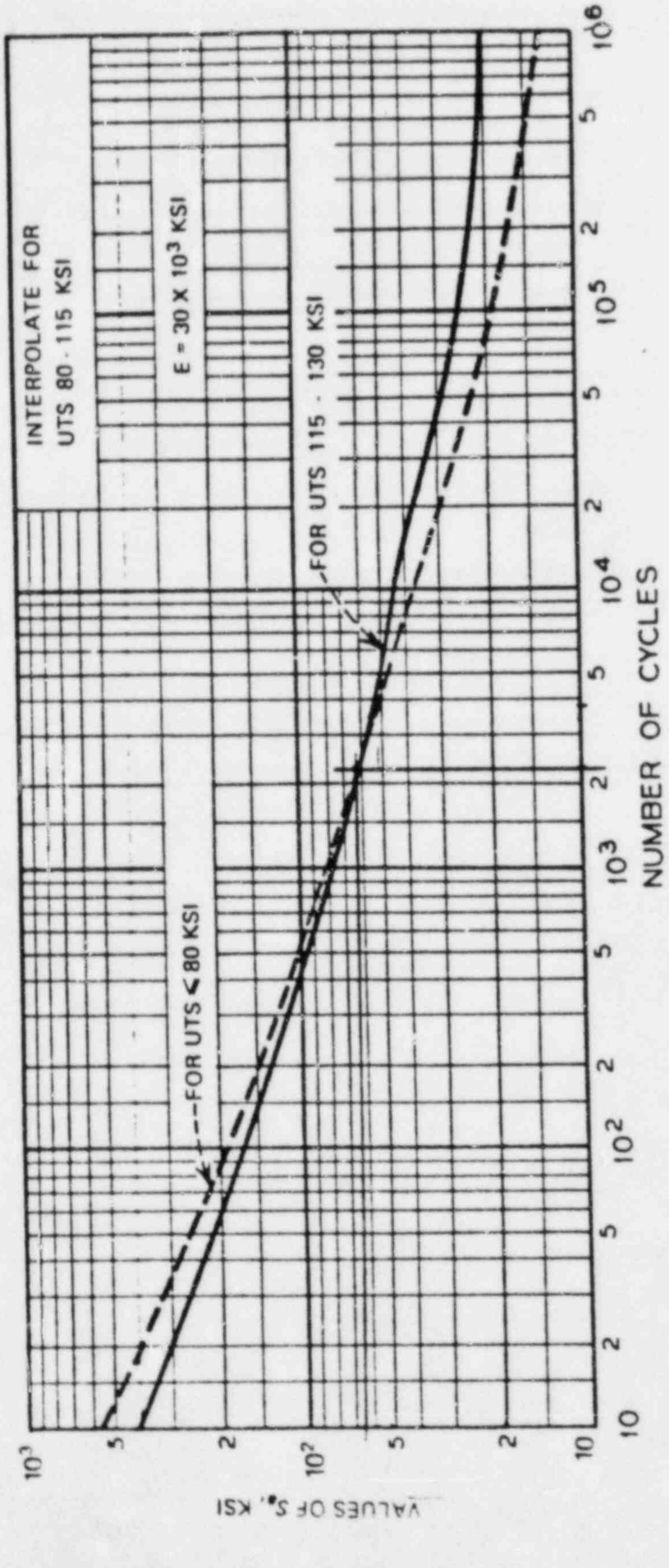


FIG. XIV-1221.3(c)-1 DESIGN FATIGUE CURVES FOR CARBON, NON-ALLOY, SERIES 4XX, HIGH ALLOY STEELS AND HIGH TENSILE STEELS FOR TEMPERATURES NOT EXCEEDING 700 F

Nuclear Energy Business Operations
ENGINEERING CALCULATION SHEET

MADE BY ______
VERIFIED BY [signature] 8-2-83

NUMBER ______ DATE 2-25-82
SUBJECT SHOREHAM RHR P/M FATIGUE LIFE EVALUATION DUE TO SRV ACTUATIONS. BY DRD SHEET 1 OF 5

DUE TO SRV ACTUATIONS

FATIGUE LIFE EVALUATION FOR SHOREHAM RHR P/M HAS BEEN PERFORMED PER PWA # 3816 KS REV. 0. SINCE THE AUTHORIZING PWA DOES NOT SPECIFICALLY SAY WHICH PUMP/MOTOR SYSTEM TO BE WORKED ON FOR FATIGUE LIFE EVALUATION; RHR P/M WAS SELECTED OVER LPCI P/M BECAUSE IT HAS HIGHER STRESSES AT THE COMPONENTS WHICH ARE CRITICAL FOR FATIGUE LIFE EVALUATION. THUS, IF IT CAN BE SHOWN THAT RHR P/M SYSTEM CAN SAFELY WITHSTAND EXPECTED NUMBER OF SRV CYCLES OVER 40 YEARS LIFE; IT CAN BE SAID THAT THE SAME IS TRUE FOR LPCI P/M ALSO.

DRF # E11-11 CONTAINS COMPLETE DETAILED STATIC AND DYNAMIC ANALYSES OF RHR P/M. TO SHOW INTEGRITY AND OPERABILITY OF THE PUMP/MOTOR SYSTEM UNDER ALL PROBABLE STATIC (NOZZLE LOADS, DEAD WT, PRESSURE, HYD. DOWN THRUST, ...) AND DYNAMIC (SSE, SRV, LOCA) LOADINGS. TO EVALUATE FATIGUE LIFE FOR THE SUBJECT EQUIPMENT, STATIC AND SRV LOADS ARE TAKEN FROM THE DRF # E11-11 AND STRESSES ARE CALCULATED. PLEASE NOTE THAT SSE AND LOCA LOADS WERE NOT CONSIDERED TO EVALUATE FATIGUE LIFE DUE TO SRV ACTUATIONS.

NO. OF SRV CYCLES ASSUMED OVER 40 YEARS LIFE IS 1800. THIS IS A CONSERVATIVE NUMBER AND OBTAINED FROM OPERATING PLANT EXPERIENCE.

THE NEXT SHEET IS THE CROSS SECTIONAL VIEW OF THE PUMP/MOTOR (MOTOR NOT SHOWN). WHICH IS BOLTED TO THE BASEMAT. THE MOST CRITICAL LOCATIONS ARE AS FOLLOWS.

- FOUNDATION ANCHOR BOLTS.
- PUMP CASE COVER BOLTS.
- MOTOR STAND AT THE WELD LOCATION.
- MOTOR MOUNTING BOLTS.
- LOWER END SHIELD.

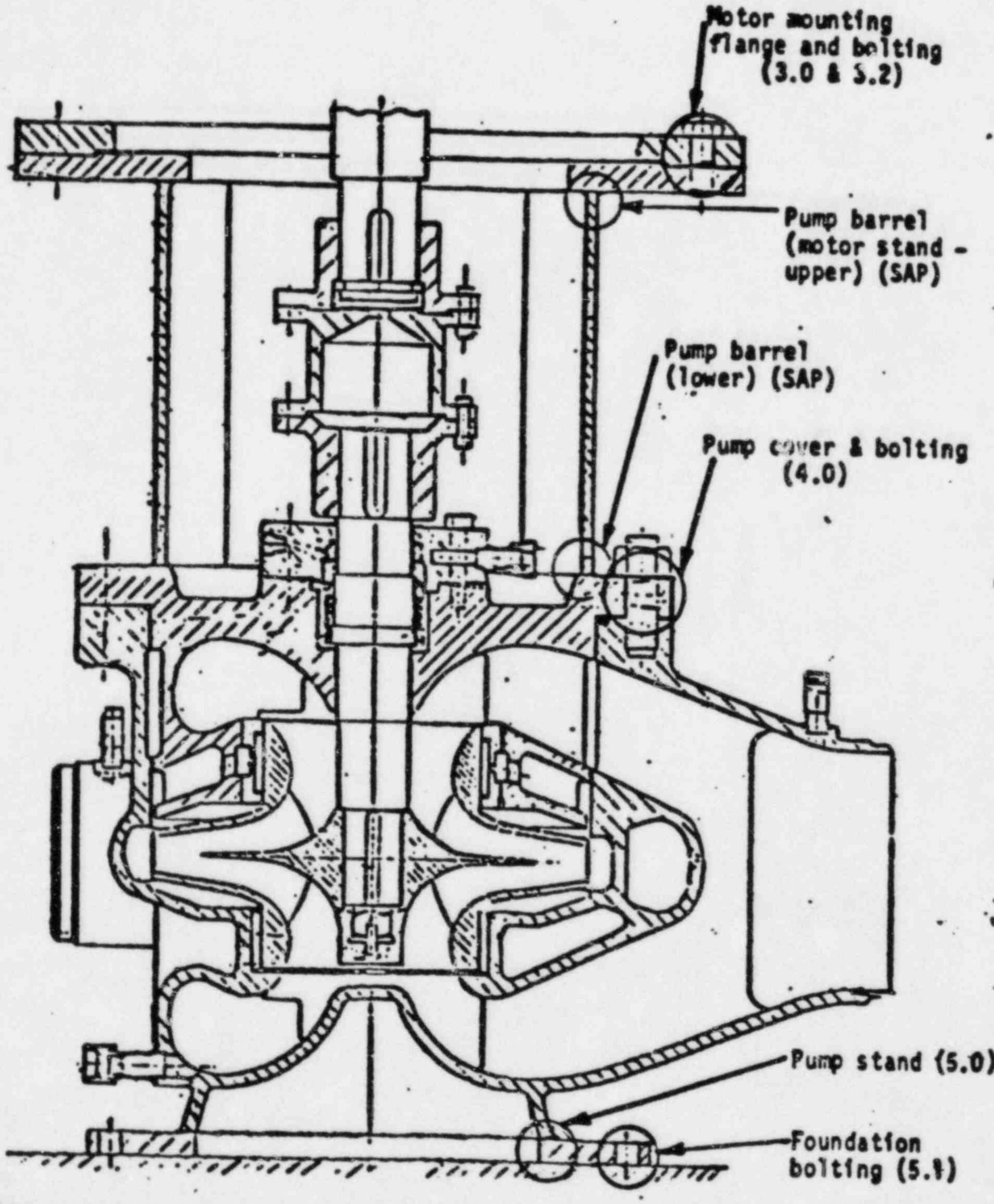
CALCULATED STRESS VALUES FROM THE DRF AND MATERIAL OF EACH OF THE ABOVE COMPONENTS ARE TABULATED BELOW.

COMPONENT	TENSILE STRESS	MATERIAL
FOUNDATION ANCHOR BOLTS	8789 psi	SHOWN LESS THAN 10,000 psi *
PUMP CASE HEAD FLANGE BOLTS.	42507 psi	SA 193 GR B7
MOTOR STAND	14316 psi	ASTM A 516 GR. 55
MOTOR MOUNTING BOLTS	26195 psi	SA 193-GR B7
LOWER END SHIELD	3812 psi	GREY CAST IRON.
PUMP STAND	20256 psi	ASTM A216 GR. WCB

* PER GE SPEC # 22A2652, PARA 4.8.1.

NEO-87 (REV 8/81)

SHOREHAM RHR SPRAY PUMP
PUMP COMPONENTS - STATICALLY ANALYZED
(FIGURE 2)



MADE BY ____________ MADE BY ____________

VERIFIED BY H.T. 9-6-83 ____________

PUMP CASE COVER BOLTING: . STRESS VALUE SHOWN IN THE TABLE WAS DUE TO $P_{EQ} = 615$ psi ; WHERE $P_{DO} = 450$ psi WAS CONSIDERED CONSERVATIVELY. CONSIDERING VALUE OF SUCTION PRESSURE AND STATIC AND SRV LOADS ONLY P_{EQ} CAN BE CALCULATED AS FOLLOWS: .

* $R_1 = R_1$ DUE TO SRV LOADS + R_1 DUE TO STATIC LOADS
$= 2604 + 8807 = 11411$ LBS

$M_2 = M_2$ DUE TO SRV LOADS + M_2 DUE TO STATIC LOADS
$= 39770 + 4583 = 44353$ IN.LBS

$M_3 = M_3$ DUE TO SRV LOADS + M_3 DUE TO STATIC LOADS
$= 37590 + 5120 = 42710$ IN.LBS.

* REF: DRF # E11-11, SEC. 5.3 ELEMENT # 80

$$P_{EQ} = P + \frac{16\left[M_2^2 + M_3^2\right]^{1/2}}{\pi a^3} + \frac{4R_1}{\pi a^2}$$

$$= 220 + \frac{16\left[44353^2 + 42710^2\right]^{1/2}}{\pi \times 25.5^3} + \frac{4 \times 11411}{\pi \times 25.5^2}$$

$$= 261 \text{ psi}$$

FROM DRF CALCULATIONS, FOR $P_{EQ} = 615$ $\sigma = 42507$ psi

THUS FOR $P_{EQ} = 261$, $\sigma = \frac{261}{615} \times 42507 = 18040$ psi.

PEAK STRESS $\sigma_{peak} = 18040 \times$ STRESS CONC. FACTOR
$= 18040 \times 4$
$= 72160$ psi

$S_a = \frac{72160}{2} = 36,080$ psi

BOLT MAT: SA 193 GR B-7.

FROM FATIGUE CURVE (ATTACHMENT-3), FOR $S_a = 36080$ psi $N = 10,000$ cycles

USAGE FACTOR $= \frac{1800}{10,000} = 0.18 < 1.$

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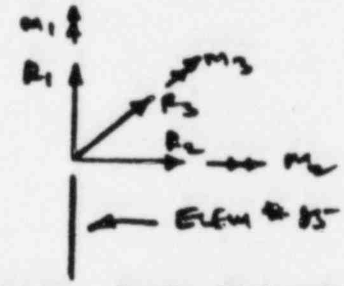
VERIFIED BY R.T. 3-2-83

GENERAL ELECTRIC CO.
Nuclear Energy Business Operations
ENGINEERING CALCULATION SHEET

NUMBER ______ DATE 2/25/83
SUBJECT SHOREHAM RHR P/M FATIGUE LIFE EVALUATION DUE TO SRV ACTUATIONS. BY DRD SHEET 4 OF 8

MOTOR STAND: (REF: DRF # E11-11, SEC 5.9.)
CONSERVATIVELY USE FORCES AND MOMENTS FROM THE DRF, ELEM # 85. WHICH ARE DUE TO STATIC AND SRV, SSE & LOCA LOADS.

$R_1 = 19111$ LBS $\quad M_1 = 5871$ IN.LBS
$R_2 = 2329$ LBS $\quad M_2 = 153{,}000$ IN.LBS
$R_3 = 4051$ LBS $\quad M_3 = 22558$ IN.LBS



LOCAL AXES ORIENTATION.

$$\sigma = \frac{R_1}{A} + \left[\left(\frac{M_2 C_{22}}{I_2}\right)^2 + \left(\frac{M_3 C_{23}}{I_3}\right)^2 \right]^{1/2}$$

(A, C_{22}, C_{23}, I_2 AND I_3 VALUES TAKEN FROM THE DRF)

$$= \frac{19111}{9.126} + \left[\left(\frac{153{,}000 \times 7.87}{223.87}\right)^2 + \left(\frac{22558 \times 2.6}{8.73}\right)^2 \right]^{1/2}$$

$$= 10707 \text{ psi}$$

$$\tau = \frac{\left(R_2^2 + R_3^2\right)^{1/2}}{A/2} + \frac{M_1 C_{22}}{J}$$

$$= \frac{\left(2329^2 + 4051^2\right)^{1/2}}{0.5 \times 9.126} + \frac{5871 \times 7.87}{233}$$

VERIFIED BY H.T. 9.2.83

$$= 716 \text{ psi}$$

$$\sigma_{PRINCIPAL} = \left(\frac{\sigma}{2}\right) + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2}$$

$$= \left(\frac{10707}{2}\right) + \sqrt{\left(\frac{10707}{2}\right)^2 + 716^2} = 10755 \text{ psi}$$

ALLOWABLE VALUE, JOINT EFF. FACTOR
$= 0.55 \times 1.8\, S$
$= 0.55 \times 1.8 \times 15500$
$= 15345$ psi

APPLYING STRESS CONCENTRATION FACTOR OF 4 FOR FILLET WELD,
$\sigma_{peak} = 10755 \times 4 = 43020$ psi, $\quad S_a = \frac{43020}{2} = 21510$ psi
MATERIAL: ASTM A516-GR.55

NEO-87 (REV 8/81)

GENERAL ELECTRIC CO.
Nuclear Energy Business Operations
ENGINEERING CALCULATION SHEET

NUMBER ______ DATE 2-25-83
SUBJECT SHOREHAM RHR P/M FATIGUE LIFE EVALUATION DUE TO SRV ACTUATIONS. BY DRD SHEET 5 OF 8

FROM FATIGUE (ATTACHMENT-1) FOR $S_a = 21510$ psi, N = 55,000 CYCLES.

USAGE FACTOR = $\frac{1800}{55,000} = 0.032 < 1$ VERIFIED BY H.T. 3.2.83

MOTOR MOUNTING BOLTS: THE STRESS VALUE AS CALCULATED IN THE DRF IS AS A RESULT OF SSE, SRV AND LOCA LOADINGS; WHICH IS SHOWN BELOW. (REF: DRF # E11-11, MOTOR STUDY SECTION, PAGE: 66, 67, 68).

$\sigma = 26195$ psi

THE ABOVE STRESS WAS CALCULATED BY USING THE FOLLOWING g VALUES (SEE SHT. 7 OF 8):

VERTICAL (Y) = 2.70 g
HORIZONTAL (X) = 3.44 g
HORIZONTAL (Z) = 1.73 g

$\left.\right\}$ HORIZ. $g = \sqrt{x^2+z^2} = 3.85$ g

SHEET 6 OF 8 SHOWS THAT SRV LOADING IS VERY SMALL. THE g VALUE BREAK DOWN ACCORDING TO DYNAMIC LOADINGS IS SHOWN ON THE SHEET; FROM WHICH,

SRV HORIZ (X) = 0.39 g
SRV HORIZ (Z) = 0.19 g

CONSERVATIVELY SAY HORIZONTAL g VALUE = 0.39 + 0.19 = 0.58 g
NOW, $\sigma = 26195$ psi WAS AS A RESULT OF g = 3.85 IN HORIZONTAL DIRECTION AND g = 2.70 g IN VERT. DIRECTION.

ACTUAL STRESS DUE TO SRV ONLY = $\frac{0.58}{3.85} \times 26195 = 3946$ psi

$\sigma_{peak} = \sigma \times$ STRESS CONC. FACTOR
$= 3946 \times 4 = 15784$ psi

$S_a = \frac{15784}{2} = 7892$ psi MATERIAL = SA 193 - GR B-7

FROM FATIGUE CURVE (ATTACHMENT-3), FOR $S_a = 7892$ psi
N = > 10^6 CYCLES. (VALUE OF S_a IS BELOW ENDURANCE LIMIT.)

NUMBER DRF # E11-11 DATE 2-25-83
SUBJECT SHOREHAM RHR PUMP/MOTOR BY DRD SHEET

ACCELERATION @ MOTOR C.G :

(NODES 231 (STATOR) & 235 (ROTOR). HIGHER VALUES ARE TAKEN OUT OF THESE TWO NODES ACCELERATION VALUES)

	X	Y	Z
SSE	0.304	0.17	0.312
LOCA	0.201	1.92	0.255
SRV	0.09	0.37	0.1
Σ DYN	0.595	2.46	0.667

ACCELERATION IN HORIZ. DIRECTION = $(0.595^2 + 0.667^2) = 0.89 < 1.5\,g^+$
" " VERTICAL " = $2.46\,g > 0.14\,g$
ALLOWABLE ACCELERATION VALUES ARE TAKEN FROM GE PURCHASE SPEC # 21A9222AE REV. 5

ALTHOUGH HORIZONTAL ACCELERATION AT MOTOR C.G IS LESS THAN 1.5 g ACCELERATION AT MOTOR UPPER BEARING (NODE 216 OR 217) IS HIGHER THAN THE ALLOWABLE VALUE OF 1.5 g. A SEPARATE MOTOR ANALYSIS WILL BE PERFORMED TO QUALIFY MOTOR FOR THIS HIGH ACCELERATION VALUES.

ACCELERATION VALUE @ MOTOR UPPER BEARING (NODE 216/217)

	X	Y	Z
SSE	0.46	0.16	0.42
LOCA	1.91	1.78	0.82
SRV	0.39	0.34	0.19
	2.76	2.28	1.43

$a_{horiz} = (2.76^2 + 1.43^2) = 3.1\,g > 1.5\,g$

$a_{vert} = 2.28\,g > 0.14\,g$

NOTE: HIGHER ACCELERATION PROBLEM WAS RESOLVED BY A SEPARATE MOTOR ANALYSIS. SEE SEC. "MOTOR STUDY"

MADE BY

VERIFIED BY H.T. 3.2.83

SHT 7 OF

DRF # E11-11

4. LOADING CRITERIA

4.1 Seismic Loads

The maximum seismic loads to which the RHR and CS Motors are subjected were determined from the results of analyses performed in References 8 and 9, respectively. In these studies, detailed computer models of the entire pump and motor assemblies were developed. Response spectra analysis was then used to determine the induced acceleration at each node location due to a SSE event. The nodal acceleration values output by these computer runs were used to find the maximum seismic loadings by applying the following procedure:

1) In each of the X,Y, and Z directions, the maximum acceleration occurring at any node in each of the two motor models was determined.

2) The highest vertical acceleration occurring in either the RHR or CS motor was then taken as the maximum vertical seismic load.

3) The SRSS was found for the maximum X and Z accelerations occurring in each motor. The X and Z accelerations corresponding to the highest SRSS value were then taken as the horizontal seismic loads.

The above procedure is conservative, in that the maximum seismic loads in the horizontal and vertical directions bound accelerations in both the RHR and CS motors.

The seismic loads applied in this analysis are:

Vertical (Y)	2.70 g
Horizontal (X)	3.44 g
Horizontal (Z)	1.73 g

These loads are input to the computer model of the CS motor as forces applied at the appropriate nodes.

4.2 Magnetic and Centrifugal Loads

If the shaft undergoes a deflection relative to the stator frame, an unbalanced magnetic force will be induced between the rotor and stator cores. From Ref. 2, the radial magnetic force for the core spray motor is 783 lb. for each 10% of the 0.045 in. radial air gap which the rotor is displaced. The magnetic coefficient for the RHR motor is less (770 lb.); therefore, the value corresponding to the core spray motor was used in determining magnetic loads.

MADE BY

VERIFIED BY H.T. 3.2.83

GENERAL ELECTRIC CO.
Nuclear Energy Business Operations
ENGINEERING CALCULATION SHEET

NUMBER ______ DATE 2/25/83

SUBJECT SHOREHAM RHR P/M FATIGUE EVALUATION DUE TO SRV ACTUATION. BY DRD SHEET 8 OF 8

LOWER END SHIELD: STRESSES ARE VERY LOW. O.K. BY JUDGEMENT AND USAGE FACTOR < 1. (SEE TABLE ON PAGE. 1 OF 8)

PUMP STAND BASE: CONSERVATIVELY USE CALCULATED STRESS VALUE FROM THE DRF WHICH IS AS A RESULT OF ALL PRIMARY STATIC FORCES PLUS SSE, SRV AND LOCA DYNAMIC LOADINGS.

$\sigma = 20256$ psi

USING STRESS CONC. FACTOR OF 4,

$\sigma_{peak} = 20256 \times 4$

$= 81024$ psi

$S_a = \frac{81024}{2} = 40512$ psi

FOR MATERIAL: ASTM A 216 GR WCB AND UTS < 80 KSI.

USE FATIGUE CURVE (ATTACHMENT. 1)

FOR $S_a = 40512$ psi $N = 8000$ CYCLES

USAGE FACTOR $= \frac{1800}{8000} = 0.23 < 1.$

MADE BY ______

VERIFIED BY H.T. 3.2.83

NEO-87 (REV 8/81)

ATTACHMENT 1

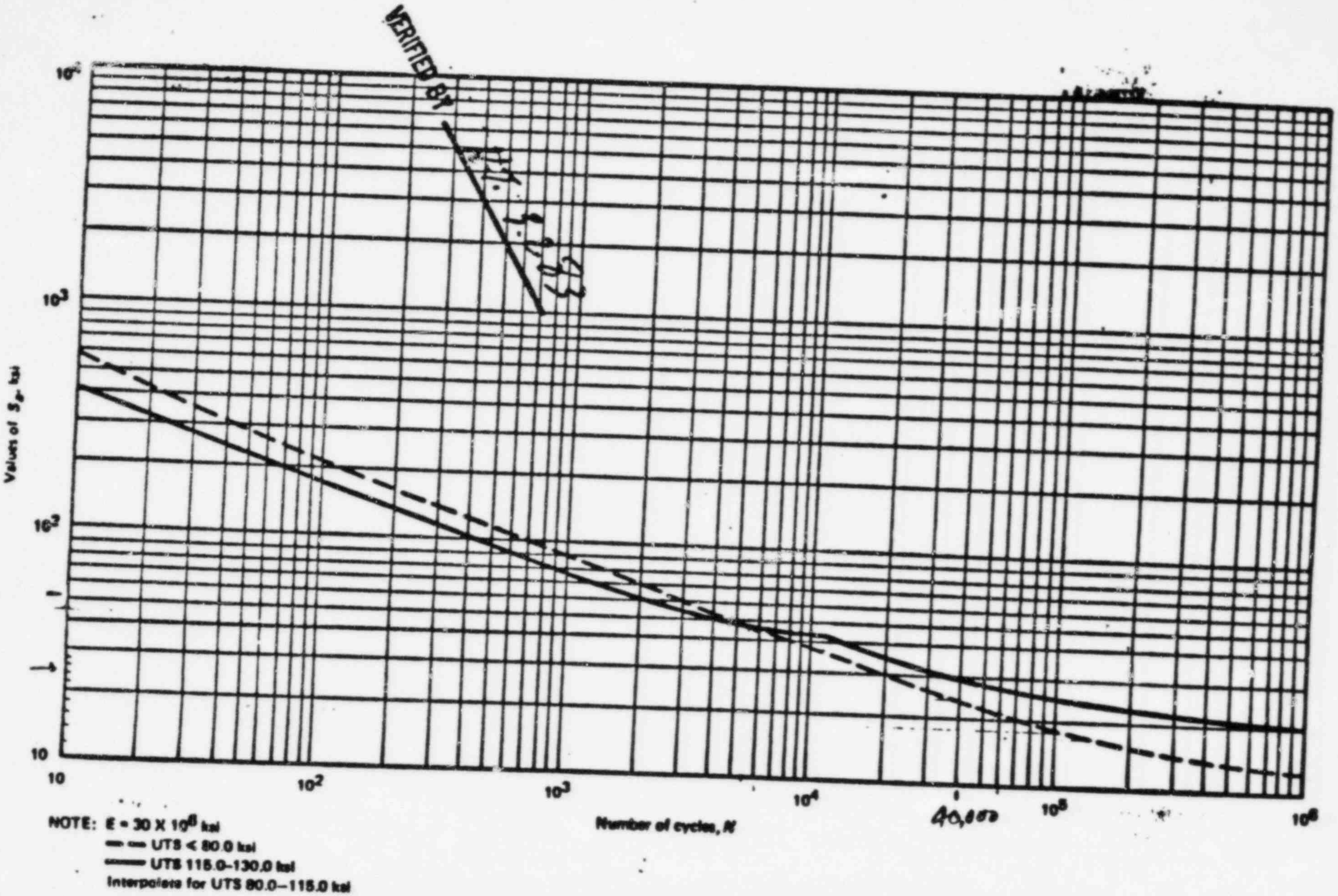


FIG. I-9.1 DESIGN FATIGUE CURVES FOR CARBON, LOW ALLOY, AND HIGH TENSILE STEELS FOR METAL TEMPERATURES NOT EXCEEDING 700°F

Table I-9.1 Contains Tabulated Values and a Formula for Accurate Interpolation of These Curves

ATTACHMENT 2

proach is to use the tensile strength (or fatigue limit) and, after determining the section modulus of the actual shape, to apply the proper bending formula. However, because of the difficulty in obtaining a meaningful value for the tensile strength in tests of small specimens, the load computed in this manner will usually be somewhat lower than the actual load required to rupture the part, unless unfavorable residual stresses are present in the finished part.

Elongation of gray iron at fracture is very small (of the order of

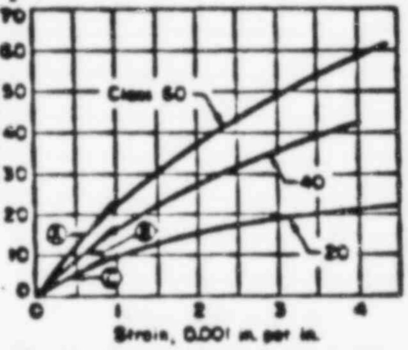


Fig. 10. Typical stress-strain curves for three classes of gray iron in tension. Modulus of elasticity is measured to points A, B and C, representing ¼ of the tensile strength.

0.006 in. per in.) and hence is seldom reported. The designer cannot use the numerical value of permanent elongation in any quantitative manner.

Torsional Shear Strength. As shown in Table 12, most gray irons have high torsional shear strength. Many grades have torsional strength greater than some grades of steel. This characteristic, along with low notch sensitivity, makes gray iron a suitable material for shafting of various types, particularly in the grades of higher tensile strength. Most shafts are subjected to dynamic torsional stresses and the designer should consider carefully the exact nature of the loads. For the higher-strength irons, stress concentration factors associated with changes of shape in the part are important for torque loads as well as for bending and tension loads.

Modulus of Elasticity. Typical stress-strain curves for gray iron are shown in Fig. 10. Gray iron does not obey Hooke's law and the modulus in tension is usually determined arbitrarily as the slope of the line connecting the origin of the stress-strain curve with the point corresponding to ¼ of the tensile strength. Some engineers use the slope of the stress-strain curve near the origin for determining the modulus of elasticity.

As indicated in Table 12, the modulus of gray iron varies considerably more than for most metals. Thus, in using observed strain to calculate stress, it is essential to measure the modulus of the particular gray iron specimen being considered. The numerical value of the modulus in torsion is always less than in tension, just as it is for steel.

Hardness of gray iron, as measured by Brinell or Rockwell testers, is an average result of the soft graphite in the iron and the metallic matrix. Variations in graphite size and distribution will cause wide variations in hardness (particularly Rockwell hardness) even though the hardness of the metallic matrix is constant. To illustrate this effect, the microhardness of the matrix of five types of hardened iron, as compared with Rockwell C measurements on the same iron, is shown in Table 13.

It is apparent that if any hardness correlation is to be attempted, the graphite must be constant as to type and amount in the irons being compared. It is recommended that Brinell hardness be used when possible.

Fatigue Limit in Reversed Bending

Because fatigue limits are expensive to determine, the designer usually has incomplete information on this property. Typical S-N curves for gray iron under completely reversed cycles of bending stress are shown in the graph on left in Fig. 11, in which each point represents the data from one specimen. The effects of temperature on fatigue limit and tensile strength are shown in the right-hand graph in Fig. 11.

Axial loading or torsional loading cycles are frequently encountered in designing parts of cast iron, and in many instances these are not completely reversed loads. Types of regularly repeated stress variation usually can be expressed as a function of a mean stress and a stress range. Wherever possible the designer should use actual data from the limited information available. Without precisely applicable test data, an estimate of the reversed bending fatigue limit of machined parts may be made by using about 35% of the minimum specified tensile strength of the particular grade of gray iron being considered. This is probably a safe value rather than an average of the few data available concerning the fatigue limit for gray iron.

Table 13. Comparison of Rockwell Hardness of Gray Irons, as Influenced by Graphite

Type of graphite	Total carbon, %	Rockwell C hardness (a)	Matrix converted (b)
A	3.06	63.2(c)	61.5
A	3.33	62.1	61.8
A	4.90	33.0	62.0
D	3.30	54.0	62.5
D	3.80	46.7	60.5

(a) Measured by conventional Rockwell C test. (b) Hardness of matrix measured with superficial hardness tester and converted to Rockwell C. (c) Although this value was obtained in the specific test cited, it is not typical of gray iron of 3.06% C. Ordinarily the hardness of such iron is Rockwell C 45 to 50.

An approximation of the effect of range of stress on the fatigue limit may be obtained from diagrams such as Fig. 12. The tensile strength is plotted on the horizontal axis to represent the fracture strength under static load (which corresponds to zero stress range). The reversed

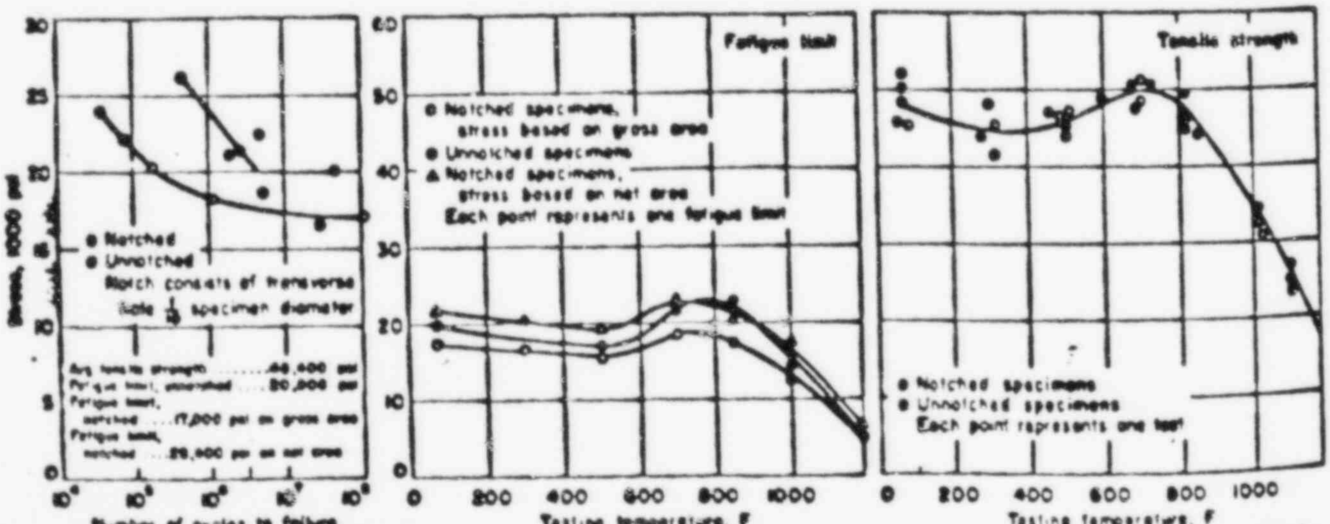
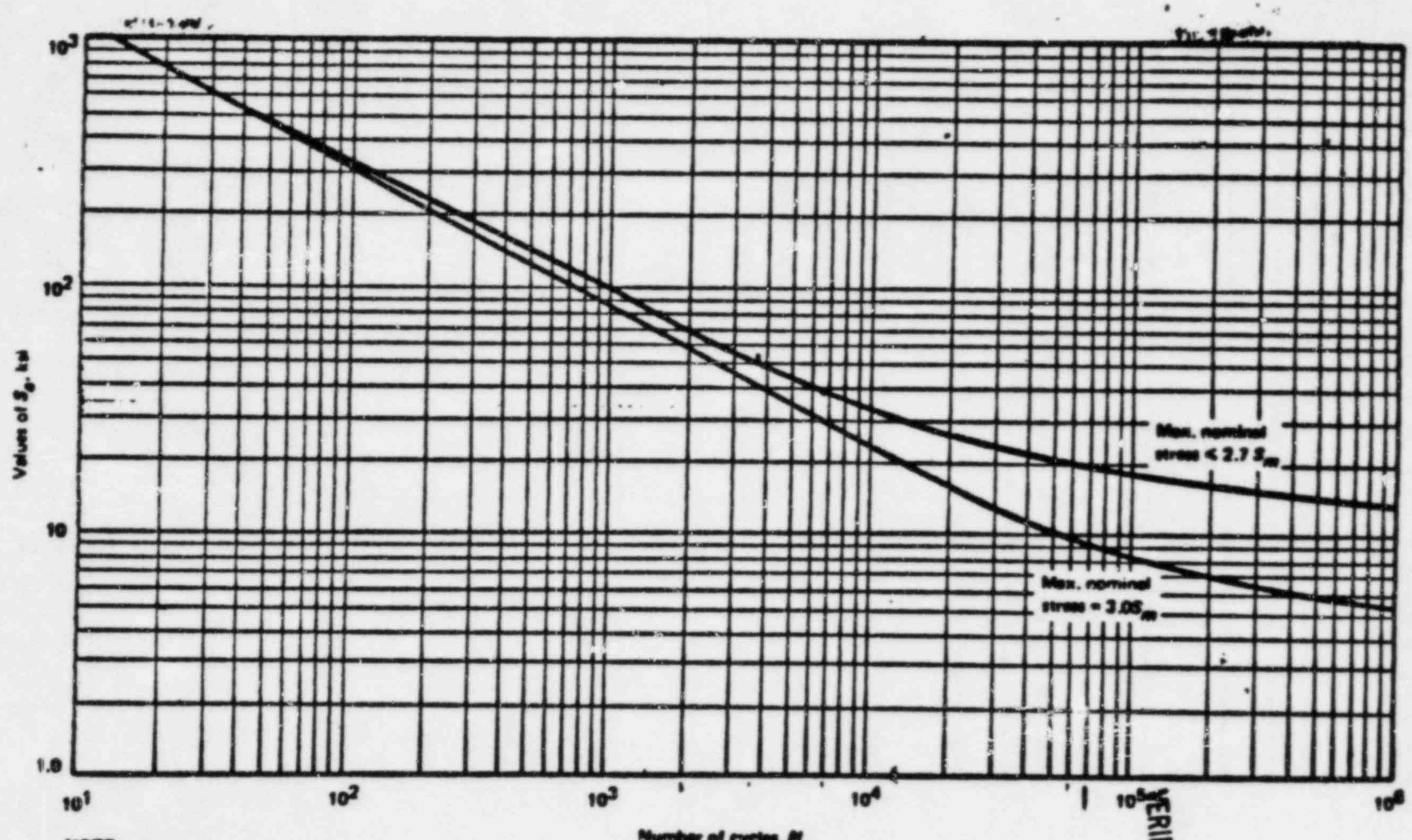


Fig. 11. S-N curves and effects of temperature on fatigue limit of gray iron of the tensile strength shown. Composition: 3.34 C, 1.31 Si, 1.05 Mn, 0.07 P, 0.12 S, 0.31 Cr, 0.20 Ni, 0.37 Cu. (W. Leighton Collins and James O. Smith, Proc. ASTM, 41, 797, 1941)

VERIFIED BY [illegible] 2.23.83

ATTACHMENT . 3



NOTE:
E = 30 X 10^6 psi

VERIFIED BY H.T. 3.2.83

FIG. I-9.4 DESIGN FATIGUE CURVE FOR HIGH STRENGTH STEEL BOLTING FOR TEMPERATURES NOT EXCEEDING 700°F
Table I-9.1 Contains Tabulated Values and a Formula for Accurate Interpolation of These Curves

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION TITLE PAGE

*SEE INSTRUCTIONS ON REVERSE SIDE 11600.02 NM(B) 382 CZC

5010.64 (FRONT)

CLIENT & PROJECT	PAGE 1 OF 86
LILCO SHOREHAM	
CALCULATION TITLE (Indicative of the Objective): SAMPLE COMPONENT FATIGUE ANALYSES	QA CATEGORY (✓) ☒ I - NUCLEAR SAFETY RELATED ☐ II ☐ III ☐ ____ OTHER

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CURRENT CALC. NO.	OPTIONAL TASK CODE	OPTIONAL WORK PACKAGE NO.
11600.02	NM (B)	382	CZC	N/A

* APPROVALS - SIGNATURE & DATE

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	REV. NO. OR NEW CALC NO.	SUPERSEDES * CALC. NO. OR REV. NO.	CONFIRMATION * REQUIRED (✓) YES	NO
P.H. Titus P.H. TITUS 6/9/83 M. YEDVABNY M. Yedvabny 6/9/83 M.A. FALIE M.A. Falie 6-15-83	A.F. Kline A.F. KLINE 6/10/83 L. Ostrovsky 6/15/83 (L OSTROVSKY)	—	0	N/A		✓

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REVIEW STATEMENT

THIS CALCULATION HAS BEEN REVIEWED IN ACCORDANCE WITH EMTP 8.26 AND WAS FOUND TO BE ADEQUATE. THE METHOD OF REVIEW UTILIZED WAS (CIRCLE ONE):

A. COMPARISON WITH A SIMILAR PREVIOUS CALCULATION NO.______

B. REVIEW OF CALCULATION.

C. ALTERNATE CALCULATION NO.______

L. Ostrodbuy 6/15/83 (SECT. E, G, H)
SIGNATURE OF REVIEWER
(SECTIONS F A.F. Kline 6/10/83

(AN INDEPENDENT REVIEW IS NOT REQUIRED FOR THE SHOREHAM PROJECT)

TABLE OF CONTENTS

FATIGUE EVALUATION OF FOUR REPRESENTATIVE COMPONENTS
LILCO SHOREHAM

CALCULATION # 11600.02 NM(B) 382 CZC
FATIGUE EVALUATION OF FOUR REPRESENTATIVE COMPONENTS

REVISION STATUS TABLE

REV NO.	DATE	VOID PAGE	ADDED PAGE	DESCRIPTION OF CHANGE AND/OR ADDITION	ORIGINATOR	REVIEWER
ORIGINAL ISSUE					P.H. Tekien M. Yeslvabniz MAP	A F Kline L. Ostrosky

INTRODUCTION/OBJECTIVE

IT IS NOT GENERAL PRACTICE TO ANALYZE COMPONENTS FOR FATIGUE EFFECTS UNLESS THE COMPONENT IS AN ASME CLASS 1 COMPONENT OR CLEARLY REQUIRES SUCH AN ANALYSIS TO SATISFY NORMAL OPERATING CYCLIC STRESS REQUIREMENTS. THE ADDITION OF MARK II OR HYDRODYNAMIC LOADS, HAS RAISED CONCERN THAT SRV LOADING COULD CONSIDERABLY CHANGE THE ASSUMPTION THAT FATIGUE IS NOT IMPORTANT FOR COMPONENTS OF A NUCLEAR POWER PLANT. SRV (SAFETY RELIEF VALVE) LOADS OCCUR A NUMBER OF TIMES THROUGH-OUT THE LIFE OF THE PLANT AND IMPOSE SIGNIFICANT OSCILLATING ACCELERATIONS ON COMPONENTS. THE NRC HAS REQUESTED AN EVALUATION OF THE POTENTIAL EFFECTS OF FATIGUE DUE TO SRV CYCLIC LOADING ON THE DYNAMIC QUALIFICATION OF PLANT EQUIPMENT. TO SATISFY THIS REQUEST, FOUR COMPONENTS HAVE BEEN CHOSEN FOR EVALUATION. SRV FATIGUE EFFECTS WILL ADD TO THOSE FROM OTHER DYNAMIC LOADS DUE TO NORMAL OPERATION, EARTHQUAKE AND LOCA, THUS ALL DYNAMIC LOADS ARE CONSIDERED IN THIS ANALYSIS

IT IS THE PURPOSE OF THIS REVIEW TO CONSIDER ONLY THOSE COMPONENTS THAT HAVE BEEN QUALIFIED BY ANALYSIS. COMPONENTS QUALIFIED BY TEST WILL BE TREATED IN A SEPARATE REVIEW.

ASSUMPTIONS

1) THE FOUR COMPONENTS HAVE BEEN SELECTED BASED ON THEIR POTENTIAL FOR SRV FATIGUE EFFECTS. AN EFFORT HAS BEEN MADE NOT ONLY TO PICK REPRESENTATIVE COMPONENTS BUT COMPONENTS WHICH REPRESENT "WORST CASES". THE REPRESENTATIVE AND "WORST CASE" NATURE OF THE COMPONENTS CHOSEN IS AN ASSUMPTION BACKED UP BY SELECTION CRITERIA DISCUSSED IN THE "METHOD OF ANALYSIS" SECTION.

3) IT IS ASSUMED THAT "ASSEMBLY" BOLTS HAVE BEEN PRETENSIONED TO AN EXTENT CONSISTENT WITH GOOD MACHINE DESIGN. THESE ASSEMBLY BOLTS ARE THOSE THREADED FASTENERS WHICH CONNECT COMPONENT SUB-ASSEMBLIES. FOR THE PURPOSE OF THIS EVALUATION THE PRETENSION ASSUMED IS 70% OF THE ULTIMATE STRENGTH OF THE BOLTING (REF 40 PAGE 6). PRETENSION IS NOT ASSUMED FOR COMPONENT EMBEDMENT BOLTS. CONSEQUENTLY ASSEMBLY BOLTS DO NOT HAVE STRESS CONCENTRATION FACTORS APPLIED AS LONG AS THE CALCULATED STRESS DOES NOT EXCEED THE PRETENSION STRESS. EMBEDMENT BOLT STRESSES DO HAVE STRESS CONCENTRATION FACTORS APPLIED BECAUSE PRETENSIONING AND MAINTENANCE OF PRETENSION OF THESE BOLTS IS NOT EXPECTED.

METHOD OF ANALYSIS

FOUR COMPONENTS HAVE BEEN CHOSEN FOR FATIGUE EVALUATION. THESE HAVE BEEN CHOSEN BASED ON REVIEW OF STRESS MARGINS AND BASED ON BEING LOCATED IN AREAS OF THE PLANT WHERE SRV LOADS ARE KNOWN TO BE MOST SIGNIFICANT. THE HEAD TANK WAS CHOSEN BECAUSE IT IS THE ONLY SIGNIFICANT TANK INSIDE THE REACTOR BUILDING, THE LOOP LEVEL PUMP AND THE BOOSTER HEAT EXCHANGER BECAUSE THEY ARE MOUNTED AT EL 8 OF THE SECONDARY CONTAINMENT. WHERE SRV LOADS ARE LARGE. THE VELAN GATE VALVE WAS CHOSEN BECAUSE IT HAD BEEN IDENTIFIED AS ONE OF THE MOST SEVERLY LOADED VALVES BASED ON AN EXTENSIVE REVIEW OF VALVE QUALIFICATION LOADS.

FATIGUE EFFECTS HAD NOT BEEN CONSIDERED IN THE STRESS CALCULATIONS FOR THESE COMPONENTS, HOWEVER THE FOUR COMPONENTS HAVE ALSO BEEN CHOSEN BASED ON THEIR POTENTIAL FOR OPERATING LOADS CONTRIBUTING TO FATIGUE. A PUMP HAS BEEN CHOSEN BECAUSE OF THE POTENTIAL FOR ROTATING INERTIA LOADS, A VALVE HAS BEEN CHOSEN BECAUSE OF THE POTENTIAL FOR OPEN/CLOSE LOAD CYCLE FATIGUE. THE HEAT EXCHANGER POTENTIALLY HAS SYSTEM AND FLOW TRANSIENTS THAT MAY CONTRIBUTE TO FATIGUE.

THE FIRST STEP IN THE EVALUATION OF EACH COMPONENT IS TO IDENTIFY MAJOR STRESSED AREAS. THIS INVOLVES SOME JUDGEMENT IN THAT THE ORIGINAL CALCULATIONS MAY NOT HAVE CONSIDERED STRESS CONCENTRATIONS IN THE CHOICE OF AREAS TO BE TREATED IN THE CALCULATION. THUS A PORTION OF THE COMPONENT WITH LOW STRESSES BUT WITH HIGH STRESS CONCENTRATION, MAY HAVE BEEN NEGLECTED. THE COMPONENT DESIGN IS REVIEWED FOR SUCH AREAS AND STRESS CALCULATIONS ADDED AS NEEDED.

THE NEXT STEP IN THE EVALUATION IS TO SORT OUT WHAT PORTION OF EACH STRESS IS CONTRIBUTED BY EACH LOAD CASE. STRESS COMPONENTS DUE TO OSCILATING LOADS ARE SPLIT OUT. NORMAL OPERATING LOADS WOULD TYPICALLY HAVE THE POTENTIAL FOR THE LARGEST NUMBER OF LOAD CYCLES - INERTIA AND PRESSURE LOADS DUE TO ROTATING EQUIPMENT, FLUID TRANSIENTS DUE TO SYSTEM OPERATING CYCLES, VALVE OPEN/CLOSE CYCLES ETC. MARK II SAFETY RELIEF VALVE LOADS ARE CONSIDERED NORMAL OPERATING LOADS IN THAT THE REACTOR BUILDING WILL SEE LOADS DUE TO SRV OPENINGS A NUMBER OF TIMES THROUGHOUT THE LIFE OF THE PLANT. OPERATING BASIS EARTHQUAKE LOADS ALSO FALL INTO THIS CATEGORY. OTHER OSCILLATING LOADS INCLUDE FAULTED LOADS SUCH AS THOSE DUE TO THE DESIGN BASIS EARTHQUAKE.

NEXT, A NUMBER OF CYCLES MUST BE ASSIGNED FOR EACH ALTERNATING LOAD. THE COMPONENT DESIGN REPORT, DESIGN SPEC, PURCHASE SPEC, SYSTEM DESCRIPTION,OR SYSTEM DESIGN SPEC ARE BE CONSULTED TO IDENTIFY NORMAL OPERATING CYCLES. THE EQUIVALENT NUMBER OF PEAK SRV ACTUATIONS HAS BEEN DETERMINED FOR THE SHOREHAM PLANT TO BE 900 EVENTS. THIS NUMBER COMES

Page 7

FROM A CALCULATION OF SRV STRESS CYCLES FOR SHOREHAM PIPING ANALYSIS (REF CALC#11600.02 NP(B) 450 FG). IN THIS CALCULATION THE FULL RANGE OF SRV ACTUATIONS (AND CORRESPONDING SUBSEQUENT ACTUATIONS) ARE CONSIDERED. MANY "LOW LOAD" SRV ACTUATIONS, SUCH AS A SINGLE VALVE ACTUATION, OR FOUR VALVE ACTUATION, OCCUR MANY MORE TIMES THAN THE 900 CALCULATED EQUIVALENT PEAK EVENTS. THE NUMBER OF EQUIVALENT PEAK CYCLES FOR EACH SRV EVENT IS CALCULATED BASED ON A METHOD DERIVED FROM ASME III NB-3653 AND SUMMED TO THE 900 TOTAL. THIS METHOD "DERATES" A TYPICAL LOW-LOAD NUMBER CYCLES TO A LOWER EQUIVALENT NUMBER OF CYCLES AT THE HIGHEST SRV LOAD (SRV 11 VALVE ACTUATION). A SIMILAR TREATMENT OF THE LOCA EVENT YIELDS A REQUIREMENT TO DESIGN THE PLANT FOR A SINGLE PIPE BREAK (REF 11) WHICH PRODUCES UP TO 200 EQUIVALENT PEAK "CHUGS"

THE NUMBER OF DESIGN OBE EVENTS FOR THE SHOREHAM PLANT IS 5. THE NUMBER OF DESIGN DBE EVENTS IS ONE.

EACH APPLICATION OF A DYNAMIC LOAD WILL EXCITE AN OSCILLATING RESPONSE WHICH WILL OCCUR DURING THE EVENT AND DAMP OUT AFTER THE EVENT. AN EQUIVALENT NUMBER OF PEAK STRESS CYCLES MUST BE DETERMINED FOR EACH DYNAMIC EVENT SUMMING OVER ALL THE COMPONENT OSCILLATIONS. THIS ANALYSIS HAS BEEN PERFORMED FOR PIPING (SEE THE ABOVE REFERENCED CALCULATION) AND HAS BEEN FOUND TO BE DEPENDENT UPON COMPONENT FREQUENCY AND STRESS LEVEL. FOR TYPICAL STRESS LEVELS IN PIPES THE UPPER BOUND ON THE NUMBER OF EQUIVALENT MAX STRESS CYCLES HAS BEEN FOUND TO BE .3333*FN PER DYNAMIC EVENT. FOR THE PURPOSE OF COMPONENT EVALUATIONS, THIS RELATION WILL BE ASSUMED TO APPLY FOR ALL DYNAMIC LOADING. THE EQUIVALENT NUMBER OF PEAK STRESS CYCLES FOR EACH LOAD TYPE IS THE PRODUCT OF THE NUMBER OF EVENTS PER LOAD TYPE AND THE NUMBER OF EQUIVALENT PEAK STRESS CYCLES PER EVENT.

AT THIS POINT STRESS LEVELS AND CORRESPONDING NUMBER OF CYCLES AT THESE STRESS LEVELS ARE AVAILABLE. STRESS CONCENTRATION FACTORS ARE APPLIED TO EACH STRESS COMPONENT AND USAGE FACTORS ARE THEN CALCULATED, USING ASME III NB-3653 AS A GUIDE. AT EACH STRESS POINT THE USAGE FACTORS ARE SUMMED OVER ALL LOAD CASES AND THE SUM MUST BE LESS THAN 1.0

DESIGN INPUT

1) THE NUMBER OF DBE EVENTS TO BE CONSIDERED IS ONE, THE NUMBER OF DBE CYCLES IS 10 (REF 10)

2) THE NUMBER OF OBE EVENTS TO BE CONSIDERED IS 5, THE NUMBER OF OBE CYCLES IS 50 (TOTAL) (REF 10)

3) THE NUMBER OF SRV CYCLES TO BE CONSIDERED IS 900 MULTIPLIED BY THE COMPONENT NATURAL FREQUENCY DIVIDED BY THREE (REF 8,9)

4) THE NUMBER OF LOCA CYCLES TO BE CONSIDERED IS 200 MULTIPLIED BY THE COMPONENT NATURAL FREQUENCY DIVIDED BY THREE (REF 11)

5) EARTHQUAKE AND HYDRODYNAMIC ACCELERATIONS ARE TAKEN FROM THE STRUCTURAL DIVISION CALCULATION (REF 13) AND ENGINEERING MECHANICS DIVISION CALCULATION (REF 12)

MATERIALS AND PHYSICAL CONSTANTS

THE MATERIAL PROPERTIES USED IN THIS CALCULATION ARE THE FATIGUE PROPERTIES OF THE COMPONENT MATERIALS. THE FATIGUE CURVES IN ASME III (REF 5,6) ARE USED FOR MATERIAL FATIGUE CHARACTERISTICS.

REFERENCES

(1) CALCULATION # 11600.02 NM(B) 25 IA "DESIGN CALCULATION FOR THE RBCLCW HEAD TANKS 1P42*TK 026 A&B

(2) GOULDS PUMPS,INC DOCUMENT # ME320 "SEISMIC STRESS ANALYSIS OF ASME SECTION III CLASS 2 PUMPS - REACTOR CORE ISOLATION COOLING SYSTEM LOOP LEVEL PUMP", BY MCDONALD ENG ANALYSIS CO. 4-9-76

(3) STRUTHERS WELLS REPORT "SEISMIC ANALYSIS OF BOOSTER HEAT EXCHANGERS" #1-79-06-33475, 1-18-80

(4) VELAN ENGINEERING CALCULATION # SR-6082 "SEISMIC ANALYSIS OF 10" FORGED BOLTED BONNET GATE VALVE, ASME CLASS 300 LB,CARBON STEEL NUCLEAR CLASS 2"

(5) ASME III APPENDIX I FIG-I-9.1 "DESIGN FATIGUE CURVES FOR CARBON, LOW ALLOW AND HIGH TENSILE STEELS"

(6) ASME III APPENDIX I FIG-I-9.2 "DESIGN CURVE FOR AUSTENITIC STEELS, NICKEL-CHROMIUM-IRON ALLOY,NICKEL-IRON-CHROMIUM ALLOY AND NICKEL-COPPER ALLOY"

(7) ASME III SECTION NB PARA. NB-3222.4 " ANALYSIS FOR CYCLIC OPERATION"

(8) CALCULATION # 11600.02 NP(B) 450 FG "EQUIVALENT STRESS CYCLES FOR PIPING COMPONENTS - FATIGUE EVALUATION OF SRV ACTUATIONS"

(9) "STRESS RESPONSE IN HIGH FREQUENCY RANGE - SIMPLIFIED MULTI DEGREE OF FREEDOM SYSTEM UNDER ARBITRARY SUPPORT ACCELERATION TIME HISTORY" (ATTACHMENT 2 TO REF 8)

(10) STANDARD REVIEW PLAN SECTION 3.7.3 "SEISMIC SUBSYSTEM ANALYSIS" SECTION II-2-B "DETERMINATION OF NUMBER OF EARTHQUAKE CYCLES"

(11) "ACRS INFORMATION REQUEST, MARK II POOL DYNAMIC LOADS", LETTER FROM H.CHAU, MARK II OWNERS GROUP CHAIRMAN, TO MR. K.KNEIL, CHIEF - GENERIC ISSUES BRANCH, NRC, JULY 8, 1981

(12) CALCULATION # 11600.02 NM(B) 215 "DESIGN BASIS AMPLIFIED RESPONSE SPECTRA FOR THE SHOREHAM NUCLEAR POWER STATION"

(13) CALCULATION #11600.02 NS(B)-092 - STRUCTURAL DIVISION CALCULATION

WHICH GENERATED CONFIRMATORY (HYDRODYNAMIC) ARS

(14) CALCULATION # 11600.02 NM(B) 254 "PIPE MOUNTED EQUIPMENT LOADS"

(15) "SPECIFICATION FOR LOOP LEVEL PUMPS" NO. SH1-235, STONE&WEBSTER ENGR.CORP. 5-28-80

(16) REV 6 OF THE SEISMIC DATA SHEET DATED MAY 1982, CALCULATION #11600.02 NM(B) 381 CZC

(17) ASME CODE, SEC III, DIV I,SUBSECTION NB 1980

(18) "STANDARD HANDBOOK FOR MECHANICAL ENGINEERS", BAUMEISTER & MARKS, SEVENTH EDITION, MCGRAW HILL

(19) "MANUAL OF STEEL CONSTRUCTION" SEVENTH EDITION, AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.

(20) "FORMULAS FOR STRESS AND STRAIN", FOURTH EDITION, R.J. ROARK, MCGRAW HILL

(21) "FORMULAS FOR STRESS AND STRAIN", FIFTH EDTION, R.J. ROARK, MCGRAW HILL

(22) "DESIGN OF WELDED STRUCTURES" OMER W. BLODGETT, MAY 1972 PRINTING, THE JAMES F. LINCOLN ARC WELDING FOUNDATION, CLEVELAND OHIO

(23) "STRUDL-SW USERS MANUAL" (ST-346) APRIL 1980, REISSUED AUGUST 1982, P.A,RANCOURT

(25) "MECHANICAL VIBRATIONS", THIRD EDITION, J.P. DEN HARTOG, MCGRAW HILL

(26) MEMO TO RICK GAUTHIER FROM P.TITUS/M.YEDVABNY DATED 4-22-83 AND RESPONSE BY J.POWERS DATED 4-22-83 TRANSMITTING THE LOOP LEVEL PUMP EXPECTED OPERATIONAL SEQUENCE THROUGHOUT THE LIFE OF THE PLANT.

(28) "1977 ANNUAL BOOK OF ASTM STANDARDS", PARTS 1 THROUGH 48, AMERICAN SOCIETY FOR TESTING AND MATERIALS, PHILADELPHIA, PA.

(29) MATERIALS SELECTOR GUIDE FOR 1973", MID SEPTEMBER 1972

(31) SPECIFICATION FOR THE REACTOR BUILDING CLOSED LOOP COOLING WATER AND SPENT FUEL POOL COOLING WATER HEAT EXCHANGERS, NO. SH1-190 SWEC, 7-19-73

(32) CALCULATIONS NO. 11600.02-AX-3AR-1 DATED 2-2-80 AND 11600.02 AX -33N-3

(33) ASME III, DIV I APPENDIX I, 1980

(34) CALCULATION NO. 11600.02-NS(B)-092 "CONFIRMATORY ARS"

(35) CALCULATION NO. 11600.02-NS(B)-20-JA, ARS TAPE NO. 001816

(36) CONFIRMATORY SPECTRA FOR EQUIPMENT, DOCKET NO. 50-322, OCT 1981

(37) PIPE STRESS, PIPE SUPPORT, AND DUCT SUPPORT CRITERIA DOCUMENT FOR THE SHOREHAM NUCLEAR POWER STATION, SWEC 1981

(38) MANUAL OF STEEL CONSTRUCTION, AISC, SEVENTH EDITION, 1973

(39) "MODERN FLANGE DESIGN" BULLETIN 502, TAYLOR FORGE, FIFTH EDITION 1964

(40) SPECIFICATION FOR STRUCTURAL JOINTS USING ASTM A-325 OR A 490 BOLTS AISC,1978

(41) CALCULATION #12846.19 NM(B) 84 IA "REFUELING WATER STORAGE TANK"

DETERMINED THAT THIS PARTICULAR VALVE IS ONE OF THE MOST SEVERLY LOADED IN THE PLANT. ITS RELATIVELY HIGH USAGE FACTOR IS EXPECTED TO BE ONE OF THE LARGEST OF ALL VALVES IN THE PLANT

-- SUMMARY OF USAGE FACTORS --

COMPONENT	MAX USAGE FACTOR
RBLCLCW HEAD TANK	.064
LOOP LEVEL PUMP	0.0 (BELOW ENDURANCE LIMIT)
HEAT EXCHANGER	.063
10" GATE VALVE	.35

IT IS EVIDENT FROM THIS STUDY THAT SRV FATIGUE IS NOT A PROBLEM FOR THE FOUR COMPONENTS EVALUATED, ALSO BASED ON THIS REVIEW IT CAN BE SAID THAT FOR SRV FATIGUE TO BE A PROBLEM FOR OTHER EQUIPMENT IN THE PLANT, THERE WOULD HAVE TO BE AN IMPLAUSIBLE COINCIDENCE OF:

A) LOW STRESS MARGINS FOR SRV TYPE LOADING
B) LOCATION WITHIN THE PLANT WHERE SRV LOADS ARE SIGNIFICANT
C) COMPONENT FREQUENCY RESPONSE THAT WOULD AMPLIFY SRV LOADS
D) LOW COMPONENT DAMPING THAT WOULD SUPPORT THE ASSUMPTION OF FN/3 CYCLES PER EQUIVALENT PEAK SRV EVENT
E) FATIGUE DERIVED FAILURE MECHANISMS THAT WOULD LEAD TO UNACCEPTABLE CONSEQUENCES.
F) IMPROBABLE POOR MATERIAL BEHAVIOR ADHERING TO THE STATISTICALLY CONSERVATIVE DESIGN FATIGUE S-N CURVES (REF 5,6)

SUMMARY OF RESULTS

THE FOUR COMPONENTS CHOSEN FOR REVIEW HAVE BEEN LOOKED AT IN SUFFICIENT DETAIL TO DRAW CONCLUSIONS AS TO THE EFFECTS OF FATIGUE ON THESE PARTICULAR COMPONENTS. NONE OF THE FOUR HAVE BEEN FOUND TO FAIL THE CRITERIA ESTABLISHED FOR THIS REVIEW.

THE TANK THAT WAS EXAMINED IS AT EL 151 IN THE SECONDARY CONTAINMENT WHERE SRV LOADING IS RELATIVELY SMALL. OVERTURNING MOMENTS DUE TO SRV BARELY OVERCOME THE TANK RIGHTING MOMENT.THUS ANCHOR BOLT AND CHAIR STRESSES ARE LOW. EVEN WITH THE FAIRLY HIGH STRESS CONCENTRATIONS THAT WERE APPLIED TO THREADS, WELDS, AND HOLES AT THE HOLD-DOWN DETAILS, NO FATIGUE PROBLEM WAS IDENTIFIED. ACTUAL NOZZLE LOADS ARE SMALL. NOZZLE STRESSES WERE CALCULATED BASED ON MEMBRANE+BENDING+DISCONTINUITY STRESSES AND WERE WELL BELOW FATIGUE ALLOWABLES.

THE LOOP LEVEL PUMPS ARE AT EL 8 IN THE SECONDARY CONTAINMENT WHERE THE SRV ACCELERATIONS ARE SIGNIFICANT. THE GOULDS PUMPS ANALYSIS WAS BASED ON STATIC GS WHICH ENVELOPED THE SRV PEAK (MULTIPLIED BY 1.3) BUT REVIEW OF THE FREQUENCY CALCULATIONS INDICATED ZPA VALUES WERE APPROPRIATE. WITH THE LOWER G VALUES APPLIED ALL THE STRESSES WERE WITHIN FATIGUE ALLOWABLES. SRV LOADS WERE FOUND TO HAVE A NEGLIGIBLE EFFECT ON ROTATING PARTS.

THE BOOSTER HEAT EXCHANGER WAS ALSO FOUND TO SATISFY FATIGUE CRITERIA. THE VENDORS REPORT WAS SUPPLEMENTED SUBSTANTIALLY. ACTUAL PIPE LOADS FROM AX CALCULATIONS WERE USED TO QUALIFY LOWER NOZZLE STRESSES. USAGE FACTORS WERE FOUND TO BE SMALL. ANCHOR BOLT STRESSES WERE SHOWN TO BE BELOW THE ENDURANCE LIMIT OF THE BOLTING MATERIAL.

THE 10" VELAN GATE VALVE WAS FOUND TO HAVE THE HIGHEST TOTAL USAGE FACTOR (TOTAL U =.35) OF THE FOUR COMPONENTS REVIEWED. THE YOKE ASSEMBLY WAS THE LIMITING ELEMENT OF THE VALVE AND MOST OF THE STRESSES IN THE YOKE WERE FROM SRV. (THE SRV USEAGE FACTOR ALONE WAS .33). THE VALVE OPERATOR WAS QUALIFIED BY TEST AND THUS WAS NOT INCLUDED IN THIS REVIEW. THE FREQUENCY USED TO QUANTIFY THE NUMBER OF REQUIRED SRV AND LOCA CYCLES WAS THE COMBINED FUNDAMENTAL NATURAL FREQUENCY OF THE VALVE AND PIPE. THIS WAS FOUND TO BE 36CPS, ONLY SLIGHTLY LOWER THAN THE VALVE ALONE (40CPS) BECAUSE OF RIGID SUPPORT CONDITIONS OF THE PIPE IN QUESTION. NORMAL OPERATING STRESSES DUE TO OPEN/CLOSE CYCLES DID NOT CONTRIBUTE TO FATIGUE. THE VALVE WHICH WAS STUDIED IS IN A SYSTEM WHICH ONLY OPERATES AFTER A LOCA.

BASED ON A REVIEW OF PIPE MOUNTED EQUIPMENT ACCELERATIONS, IT WAS

Page 15

CONCLUSIONS

THE FOUR COMPONENTS CHOSEN WERE JUDGED TO HAVE A HIGH POTENTIAL FOR SRV FATIGUE EFFECTS AND FOR ALL FOUR THAT WERE STUDIED, SRV FATIGUE WAS NOT FOUND TO BE IMPORTANT. ALL FOUR COMPONENTS WERE FOUND TO SATISFY THE SRV FATIGUE STRESS CRITERIA ESTABLISHED FOR THIS STUDY WITH AMPLE MARGINS.

SECTION E

FATIGUE REVIEW OF

THE RBCLCW HEAD TANK
MARK NO. 1P42*TK 026 A&B, SPEC SH1-114

LOCATED AT:
ELEVATION 151 SECONDARY CONTAINMENT

PREPARED BY P. TITUS

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

E-1

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 18
11600.02	NM (B)	382	CZC	

E-1

Head Tank - Summary of Fatigue Usage factors

1¼" ANCHOR BOLTS

	NORMAL	OBE	SSE	SRV	LOCA
STRESS INC STRESS CONC	0.0	(PAGE E-10) 55,720 (ASSUMED = SSE)	(PAGE E-10) 55,720	0.0	0.0
ALLOWABLE CYCLES	∞	3500	3500	∞	∞
REQUIRED CYCLES	0	50	10	2580 (900 x 8.6/3	574 200 x 8.6/3
USAGE FACTORS	0	.014	.0039		0

TOTAL U = .01714 < 1.0

¼" THICK SKIRT JUST ABOVE CHAIR

	NORMAL	OBE	SSE	SRV	LOCA
STRESS INC STRESS CONC	388.4	14562.8 ASSUMED = SSE	14562.8	0.0	0.0
ALLOWABLE CYCLES	∞	$\sim 10^5$	$\sim 10^5$	∞	∞
REQUIRED CYCLES	0	50	10	2580	574
USAGE FACTORS	0.0	.0005	.0001		

Total U << 1.0

Shell around Nozzle N6B near bottom of tank

	NORMAL	OBE	SSE	SRV	LOCA
STRESS INC STRESS CONC	23782 (ASSUMED = SSE)	23782 (ASSUMED = SSE)	23782	23782 (ASSUMED = SSE)	23782 (ASSUMED = SSE)
ALLOWABLE CYCLES	5×10^4	5×10^4	5×10^4	5×10^4	5×10^4
REQUIRED CYCLES	0	50	10	2580	574
Usage Factors	0	.001	.0002	.0516	.0114

Total U = .064 << 1.0

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

E-2

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 19
11600.02	NM(B)	382	CZC	

g loads For SRV SSE & LOCA

The frequency of the head tank is 8.6 cps (Ref 1 pages) or T = .1163 sec. the tank is located at El 151 in Secondary Containment

		Hor g at T=.1163	Vert g at T=.1163
LOCA			
CO Basic Envelope (Ref 13)	N-S	.0015	.07
	E-W	.0018	
Generic Chugging	N-S	.004	.07
	E-W	.009	
SRV			
SRV all (Ref 13)	N-S	.002	.11
	E-W	.02	
SRV 3 Valve (Ref 13)	N-S	.06	.04
	E-W	.07	

These "g" levels are used in calculating overturning moments for SRV on prelim page E-7

E-3

5010.65

CALCULATION IDENTIFICATION NUMBER

J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE
11600.02	NM(B)	582	CZC	20

NOZZLE N2 - TK 026 A
FROM AX 3AL-2 Pg 57, 58

	FX	FY (LB - TYP)	FZ	MX	MY (FT-LB TYP)	MZ
CASE 1 THERMAL NEU PEAK 130 & 95F	2	-21	19	-44	-11	1.0
CASE 13 THERMAL AT 120 & 130	4	-11	22	-23	-11	1
OBE ENU INERT & ANCHOR DISP	-42	-55	105	-65	-72	-95
SSE	-65	-85	-80	-100	-50	-147 (1764 IN-LB)
SRV-ALL (ENVELOPES OTHER SRV	-65	-80	-68	-102 (1224 IN-LB)	-40	-96
LOCA CO BASIC ENU CO-ADS CHUGING	-18	-26	-19	-28	-11	-27

5010.65

CALCULATION IDENTIFICATION NUMBER				PAGE 21
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
11600.02	NM (B)	382	CZC	

Nozzle N6-B TK026A

	Fx	FY	FZ	MX	MY	Mz
CASE 1 THERM N&U PEAK 130 & 95	12	-4	12	7	16	3
Case 13 THERM 120 & 130	12	-3	12	7	16	1
OBE inert + anchor Disp	-85	-8	-35	-16	OBE INERT = -4 110 1320 IN-LB	-3
SSE	-4	-2	-14	-1.	-7	-3
SRV ENVELOPE	-1.0	-1.0	-1.0	-1.0	-1.0	-1.
LOCA CO BASIC	1.0	-2.0	-2.0	-0.	-1.	-2.

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

E5

5010.55

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 22
11600.02	NM(B)	382	C&C	

NOZZLE N3 TK-026 A
FROM AX 3Q-3 Page 22, 23

	FX	FY	FZ	MX	MY	MZ
CASE 1 THERMAL EXP & ANCHOR	58	.8	19	-14	3	11
CASE 2 DEADWEIGHT	5	12	1	6	3	3
CASE 9 OBE INERTIA	-29	-11	-29	-11	-24	-6
CASE 14 OBE ANCHOR MOVEMENTS	-49	-7	-15	-18	-8	-4
CASE 10 SSE INERTIA	-49	-19	-50	-19	.42	-10
CASE 16 SSE ANCHOR MOVEMENTS	-91	-10	-28	-35	-15 (684 in-lb) -57	-4
CASE 11 SRV INERT	-25	-22	-32	-18	-25	-12
CASE 12 LOCA INERT	-8	-10	-11	-8	-8	-6

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 23
11600.02	NM(B)	382	CZC	

E-5a

Estimate of Nozzle Stresses from from ST 147 runs (Ref 1)

Allowable from ST 147 Run #5 (Ref 1) PL + Q, σ = 3SM*	Max actual from AX	Approx actual stress (PSI)	With stress concentration (PSI) (SEE FOLLOWING PAGE)
N3 P = 28290.43 LB ML = 53455.46 P = 28374.39 MC = 53614.11	684 (IN-LB)	525	2549
N2 P = 8110.95 ML = 24063.32 P = 8138.5 MC = 24536.58	1764 (IN-LB)	3012.9	5036.99
N6B N7 (FROM RUN #6) P = 1135.88 ML = 2724.01 P = 1142.4 MC = 2493.35	1320 IN-LB	21,158	23782.09

SM = 13700 psi.

$$* \ \text{APPROX ACT STRESS} = 3SM \times \frac{\text{MAX ACT FROM AX}}{\text{REPRESENTATIVE ALLOWABLE LOAD}}$$

From ASME III NB 3338.2 the peak stress index is 3.3 - based on a specific stress intensity at a particular point in the nozzle - but only due to internal pressure, the head tank is an atmospheric tank - the peak internal pressure at N_3 is

```
P=(13-14/12)*62.2/
144
          5.111342593   (PSI)
R=30
                   30   (IN)
T=.25
                 0.25   (IN)
ST=P*R/T
          613.3611112   (PSI)
```

(Dimension of the Tank are from Ref 1 page 1 n)

Conservatively apply the 3.3 stress index to the membrane stress and add to the nozzle stress calculated on the previous page.

```
ST*3.3
          2024.091667
```

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CALCULATION SHEET

E-7

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 25
11600.02	NM(B)	382	CBC	

SRV anchor bolt loads

Following the analysis on page 6 of Ref I: (Tank calc)

$$M_{SRV} = 16470 lb \times \frac{g_{SRV}}{g_{seis}} \times 93'' = 16470 \times \frac{.07}{.9} \times 93$$

$$= 119133 \text{ in-lb.} = 9.93 \text{ Ft-kips}$$

assume the nozzle loads are all due to SRV the net overturning moment is:

$$119{,}133 + 159{,}194 = 278{,}327 \text{ in lb}$$

$$= 23.19 \text{ Ft-kips}$$

According to the definition of W, 18.3-18.335 is $18.3 - \underset{gV}{.9} \times 18.3 - \Sigma$ Vert Nozzle loads

Then Σ vert nozzle loads =

$$18.335 - .9 \times 18.3 = 1.865$$

Assuming the nozzle loads are all due to SRV the max anchor Bolt load is

```
1/8*(4*23.19/5.354
-(18.3-.11*18.3-1.
865))
   3.629205267E-01
```

← assumes Nozzle loads are all SRV

```
1/8*(4*9.930/5.354
-(18.3-.11*18.3-0.
000))
       -1.108530958
```

← assumes Nozzle loads due to SRV = 0.0

Note Ref 1 calculations were based on Kellog loads. actual values from the AX are much smaller so the anchor bolt load will not go tensile due to SRV

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 26
11600.02	NM (B)	382	22C	

if the anchor bolts never see tension due to SRV then the chair doesn't see loads either, The Skirt does see loads though. Following the analysis on page 7 of Ref 1 and from the previous page

The net Overturning moment is: 278,327 in-lb

The net downward vertical Force due to SRV is . 18.3 x (1+.11) = 20.313 kips, add all 1.865 kips of nozzle loads:

$$\sigma = \frac{20{,}313+1865}{\pi \times 60'' \times .25''} + \frac{278{,}327}{\pi \times 30^2 \times .25} = 864.38 \text{ PSI}$$

For Normal Loads - only dead weight is considered;

$$\sigma = \frac{18300}{\pi \times 60'' \times .25} = 388.4 \text{ PSI}$$

For Earthquake - SSE - see page 7 of Ref 1

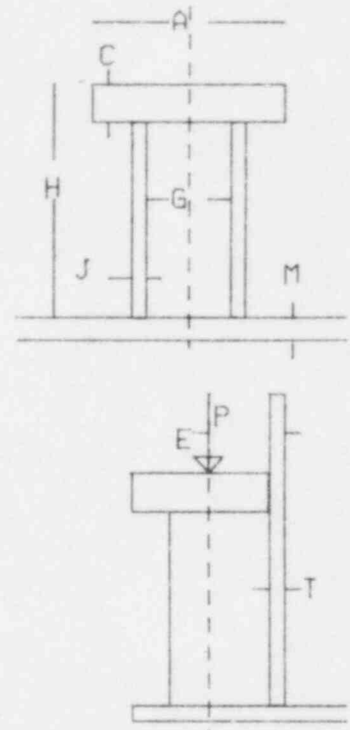
$\sigma = 3169$ PSI — to which the stresses in the skirt due the chair/anchor bolt loads must be added,

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 27
11600.02	NM(B)	382	CZC	

The net skirt stress due to SSE is

$3169 + 5696.908 \times 2^{*} = 14562.8$

*Note that the shell stress above the chair is an average bend stress - actual stresses are somewhat larger near the ends of the top plate - a stress concentration of 2 is assumed



Chair Stress calculations are based on those found in Ref (41) Section Q

```
CHAIR INPUT DATA
R= 30
T= 0.25
H= 6
E= 2.125
M= 0.75
A= 4
P 13500
C= 0.75
D= 1.25
G= 2
F= 1.25 = A-E-D/2
CHAIR TOP PLATE ST
RESS=
                8928
SHELL STRESS=
          5696.90877
```

```
ST=P*(.37*G-.2
2*D)/F/C/C:SS=
.9*P*E*(R*T)^.
25/(H*A*(T*T+
M*M))
```

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CALCULATION SHEET

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 28
11600.02	NM(B)	382	CZC	

E-10

SSE anchor Bolt Stress

The Tensile Stress area for $1\frac{1}{4}$" Bolts From Ref 38 page 4-3 is .9691 in^2

From Ref 1 Page 6 the SSE Bolt load is 13.15 Kips

$$\sigma_{bolt} = \frac{13.5}{.9691} = 13.9304 \text{ KSI}$$

with the ASME III bolt thread stress concentration factor of 4.0

$$\sigma_{bolt} = 55.72 \text{ KSI}$$

SECTION F

FATIGUE REVIEW OF THE

REACTOR CORE ISOLATION COOLING SYSTEM LOOP LEVEL PUMP
MARK NO. IE51*P51, SPEC#SH1-235

LOCATED AT:
ELEVATION 8 SECONDARY CONTAINMENT

PREPARED BY M. YEDVABNY

STONE & WEBSTER ENGINEERING CORPORATION

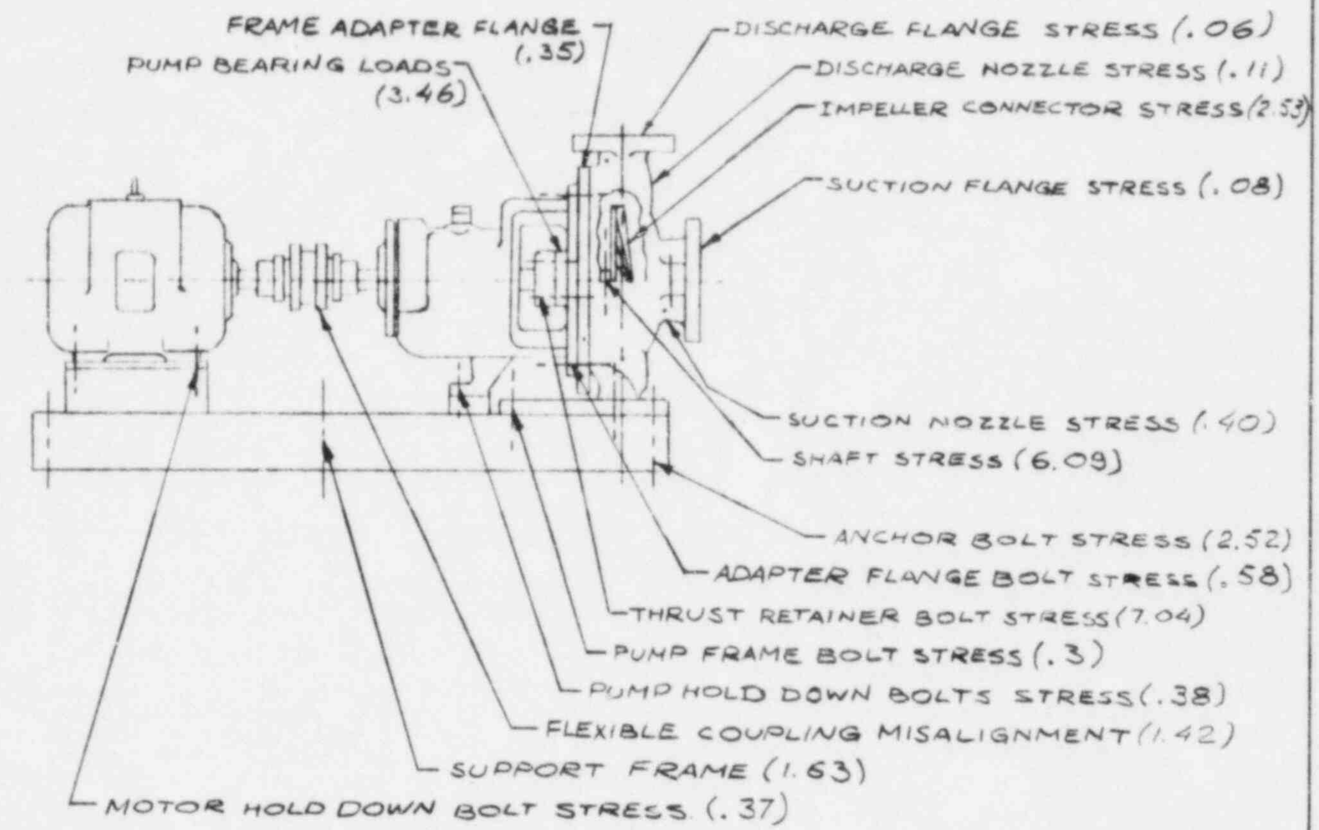
CALCULATION SHEET

F-1

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 30
11600.02	NM(B)	382	C.3C	

THE FOLLOWING SECTIONS OF THE MOTOR/PUMP ASSEMBLY WERE ANALYZED IN REF. 2.



NOTE: THE MARGIN OF SAFETY WITH RESPECT TO THE ALLOWABLE STRESSES, LOADS, OR DEFLECTIONS IS STATED IN PARENTHESES. IT IS CALCULATED AS

$$MS = \frac{\text{ALLOWABLE VALUE}}{\text{ACTUAL VALUE}} - 1.$$

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CALCULATION SHEET

F-2

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 31
11600.02	NM (B)	382	CZC	

STRESS RECONCILIATION

THE SEISMIC LOADING OF THE VENDOR'S DESIGN ANALYSIS DIFFERS FROM THE REQUIREMENTS OF REF. 15, p. 1-19 AS FOLLOWS:

	VENDOR'S REPORT	SPEC. No. SHI-235
UPSET LOADING		
HORIZONTAL	1.0 G	1.2 G
VERTICAL	1.0 G	0.8 G
FAULTED LOADING		
HORIZONTAL	2.0 G	1.3 G
VERTICAL	2.0 G	1.0 G

THE NATURAL FREQUENCY OF THE PUMP WAS CONSERVATIVELY ESTIMATED IN THE VENDOR'S ANALYSIS AND TURNED OUT TO BE 82 Hz WHICH EXCEEDS THE CUT OFF FREQUENCY OF 60 Hz FROM REF 16. THIS ALLOWS US TO DOWNGRADE THE SEISMIC COEFFICIENTS TO THE ZPA LEVEL FOR THE ELEVATION OF 8 FT. OF THE RBS.

	UPSET LOADING	FAULTED LOADING
HORIZONTAL	0.26 G	0.24 G
VERTICAL	0.38 G	0.40 G

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

▲ 5010.65

F-3

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 32
11600.02	NM (B)	382	CZC	

SINCE THE SEISMIC COEFFICIENTS ARE OF ABOUT THE SAME MAGNITUDE FOR THE UPSET AND FAULTED LOADINGS THE CALCULATION WILL BE CARRIED OUT FOR A SEISMIC LOADING DESCRIBED BY THE FOLLOWING:

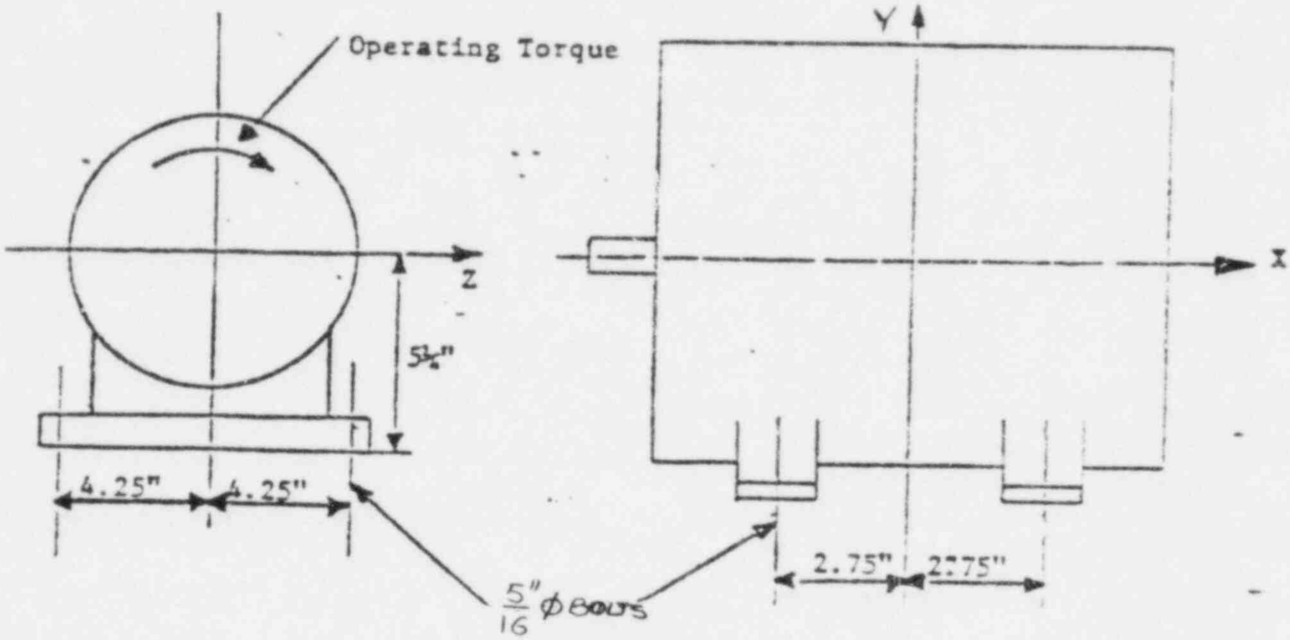
HORIZONTAL 0.26 G

VERTICAL 0.40 G

THE ABOVE VALUES ENVELOPE 2% UPSET AND 4% FAULTED SEISMIC, SRV AND LOCA SPECTRA.

THE FOLLOWING WILL BE A SUBSTITUTION OF THE VENDOR'S STRESS COMPUTATIONS FOR THE APPROPRIATE SEISMIC LOADS FROM REF. 16

I. MOTOR HOLD DOWN BOLTS



SEISMIC LOADING.

0.26(HOR. Z LOAD) - (1-0.40)(VERT. LOAD) + (NOZ/IMPEL Z LOAD) + + OPER. LOAD = 0.26(LOADING #2) - 0.60(LOADING #3) + + (LOADING #5) + OPER. LOAD.

NOTE: THE LOAD VALUES ARE LISTED IN REF. 2, P. 18 & A-1, A-2

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

F-5

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 34
11600.02	NM(B)	382	CZC	

TENSILE STRESS

DUE TO OPERAT. LOAD 152 PSI

DUE TO NOZ/IMP LOAD $\frac{469}{0.052} = 9019$ PSI

DUE TO SEISMIC $\frac{0.26 \cdot 148 - 0.6 \cdot 25}{0.052}$ 452 PSI

TOTAL 9623 PSI

SHEAR STRESS

DUE TO NOZ/IMP LOAD $\frac{(153^2+242^2)^{1/2}}{0.045} = 6362$ PSI

DUE TO SEISMIC $\frac{0.26(37^2+85^2)^{1/2}}{0.045} = 536$ PSI
(VERT. LOAD IS NEGLIGIBLE)

TOTAL 6898 PSI
(USE DIRECT SUMMATION AS ADEQUATELY ACCURATE)

IN REF. 2 THE CALCULATED STRESSES WERE COMPARED AGAINST THE ALLOWABLES FOR A-307 STEEL.

STONE & WEBSTER ENGINEERING CORPORATION

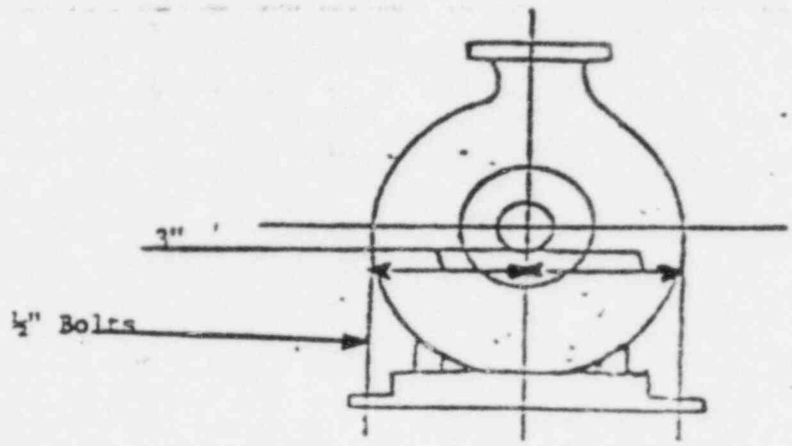
CALCULATION SHEET

F-6

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 35
11600.02	NM(B)	382	C2C	

PUMP HOLD DOWN BOLTS



TENSION

DUE TO OPER. TORQUE	160 PSI
DUE TO NOZ/IMP. LOAD	13359 PSI
DUE TO SEISMIC $0.26 \cdot 939 - 0.6 \cdot 101$	184 PSI
TOTAL	13703 PSI

SHEAR

DUE TO NOZ/IMP. LOAD $(1548^2 + 2047^2)^{1/2} =$	2566 PSI
DUE TO SEISMIC $0.26(465^2 + 288^2)^{1/2} =$ (VERT. LOAD IS NEGLIGIBLE)	142 PSI
TOTAL	2708 PSI

THE ALLOWABLES FOR A-307 STEEL WERE USED FOR COMPARISON.

CALCULATION IDENTIFICATION NUMBER				PAGE 36
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	
11600.02	NM(B)	382	CZC	

ANCHOR BOLTS

THE FOUR ANCHOR BOLTS OF 5/8" DIA ARE USED IN THE PUMP ATTACHMENT TO THE FLOOR. (REF. 2, P. 19)

THE SUPPORT REACTIONS ARE LISTED IN THE COMPUTER ANALYSIS OUTPUT (REF. 2, P. A-4)

TENSION

DUE TO NOZ/IMP LOAD $\frac{1156}{0.226} = 5115$ PSI

DUE TO SEISMIC $\frac{0.26 \cdot 127 - 0.6 \cdot 77}{0.226} = -58$ PSI

TOTAL 5057 PSI

SHEAR

DUE TO NOZ/IMP LOAD $\frac{(226^2+221^2)^{1/2}}{0.202} = 1565$ PSI

DUE TO SEISMIC $\frac{[(0.26 \cdot 61+0.6 \cdot 11)^2+(0.26 \cdot 75+0.6 \cdot 5)^2]^{1/2}}{0.202} = 157$ PSI

TOTAL 1722 PSI

THE ALLOWABLES FOR A-307 STEEL WERE USED FOR COMPARISON.

SHAFT STRESSES

THE COMPUTER OUTPUT FOR STRESSES IS GIVEN IN REF. 2 ON PAGE A-5.

SHEAR STRESS DUE TO TORSION (REF. 2, P. 20) 264 PSI

BENDING STRESS DUE TO SEISMIC

0.26·230 + 1.4·230 382 PSI

BENDING STRESS DUE TO NOZ/IMP. 2079 PSI

TOTAL BENDING 2461 PSI

THE SHOCK FACTORS OF 1.1 TORSIONAL AND 1.5 BENDING ARE APPLIED TO THE STRESSES. (REF. 2, P. 20)

FINALLY

BENDING 1.5·2461 = 3692 PSI

SHEAR 1.1·264 = 290 PSI.

THE ALLOWABLES FOR THE A-276 TYPE 316 STEEL WERE USED FOR COMPARISON.

NOTE: NORMAL OPERATIONAL STRESSES DUE TO ROTATIONAL LOADS DURING THE PUMP'S OPERATING ARE NOT DISCUSSED IN THE VENDOR'S ANALYSIS. USING THE DATA FROM THE VENDOR COMPUTER INPUT IT CAN BE DEMONSTRATED THAT EVEN CONSERVATIVELY ESTIMATED THESE LOADS

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 38
11600.02	NM(B)	382	CZC	

ARE NEGLIGIBLE.

IN THE COMPUTER MODEL THE SHAFT IS REPRESENTED BY MEMBERS 52 THROUGH 58

MEMBER No	MEMBER INCEDENCES START	MEMBER INCEDENCES END	JOINT COORDINATES START	JOINT COORDINATES END	MEMBER LENGTH (END)-(START)	CROSS SECTION AREA
52	16	17	3.25	9.12	5.87	1.5
53	17	18	9.12	13.22	4.1	1.8
54	18	19	13.22	16.75	3.53	1.1
55	19	20	16.75	20.50	3.75	2.0
56 TO 58	20	41	20.50	36.26	15.76	1.5

TOTAL LENGTH $L_{TOT} = 33$

TREAT THE SHAFT AS A SIMPLY SUPPORTED BEAM OF THE LENGTH $L_{TOT} = 33$ IN

THE SHAFT DEAD WEIGHT

$$W = 0.283\,(1.5\cdot 5.87 + 1.8\cdot 4.1 + 1.1\cdot 3.53 + 2\cdot 3.75 + 1.5\cdot 15.76) =$$
$$= 14.5 \text{ LB.}$$

ASSUME THE SHAFT HAS A UNIFORM CROSS SECTION THROUGHOUT THE LENGTH WITH THE MIN. AREA $A = 1.1\ IN^2$

STATIC DEFLECTION

$$\Delta = \frac{5}{384}\,\frac{W\cdot L^3}{E\,I} = \frac{5}{384}\,\frac{14.5\cdot 33^3}{29\cdot 10^6\cdot 0.095} = 0.002 \text{ IN.}$$

CENTRIFUGAL FORCE

$$F = \frac{W}{g}\,\Delta\cdot\omega^2 = \frac{W}{g}\,\Delta\left(\frac{n\cdot 2\pi}{60}\right)^2 = \frac{14.5}{386}\,0.002\left(\frac{3500\cdot 2\pi}{60}\right)^2 = 10 \text{ LB}$$

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CALCULATION SHEET

▲ 5010.65

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IN FACT, EACH HALF OF THE SHAFT (MOTOR & PUMP) HAS TWO SUPPORTS AND THEY ARE CONNECTED BY A FLEXIBLE COUPLING. THIS REDUCES THE SHAFT SPAN AND PRACTICALLY ELIMINATES THE STRAIN DUE TO BENDING. THE ABOVE CALCULATED LOADS ARE COVERED BY THE "OTHER PUMP NORMAL" LOADS OF 75 LB RADIAL AND 525 LB AXIAL ON IMPELLER. (REF. 2, P. 16)

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STRESSES IN SUPPORT FRAME

MATERIAL: A-36 STEEL. REF. 2, P. 21 & A-8.

BENDING DUE TO SEISMIC

$0.26 \cdot 450 + 1.4 \cdot 728 = 1136$ PSI

BENDING DUE TO NOZ/IMP LOAD 6371 PSI

TOTAL 7507 PSI

THRUST BEARING RETAINER BOLTS

(REF. 2, P. 21)

THE THREE 3/8" DIA BOLTS ARE SUBJECTED TO THE THRUST LOADS IMPOSED BY THE SHAFT AND IMPELLER. THE LOADS CAUSED BY THE COMBINED WEIGHT OF THE SHAFT, IMPELLER, AND COUPLING: 50 LB, AND NORMAL THRUST IS 525 LB.

THE TENSILE STRESS PER BOLT IS:

$$\frac{0.26 \cdot 50 + 525}{3 \cdot (.077)} \cong 329 \text{ PSI}$$

A-307 STEEL IS REFERENCED AS A MATERIAL FOR THE BOLTS.

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STRESS IN PUMP FRAME FOOT BOLTING

MATERIAL: A-307 STEEL (REF. 2 P. 21 & A-9)

TENSION DUE TO SEISMIC:

$0.26 \cdot 820 - 0.6 \cdot 932 = -346$ COMPRESSION

TENSION DUE TO NOZ/IMP. LOAD 12363 PSI

TOTAL 12017 PSI

SHEAR

DUE TO SEISMIC $0.26 \cdot 594 + 0.6 \cdot 131 = 233$ PSI

DUE TO NOZ/IMP. LOAD 6465 PSI

TOTAL 6698

FRAME ADAPTER FLANGE

MATERIAL: SA 216 GR. WCB (REF 2, P. 22 & A-10, A-11)

AXIAL FORCE ON FLANGE DUE TO SEISMIC

$P' = 0.26 \cdot 11 + 1.4 \cdot 19 =$ 29 LB

AXIAL FORCE DUE TO NOZ/IMP. LOAD 387 "

TOTAL 416 LB

BENDING MOMENT DUE TO SEISMIC

$0.26 \cdot 400 + 1.4 \cdot 97 =$ 240 IN-LB

BENDING MOMENT DUE TO NOZ/IMP LOAD 7856 "

TOTAL 8096 IN-LB

CALCULATION IDENTIFICATION NUMBER				
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EQUIVALENT PRESSURE PER NC-3647.1

$$P_{EQ} = \frac{16(8096)}{\pi(6.34)^3} + \frac{4(416)}{\pi(6.34)^2} = 175 \text{ PSIG}$$

$$P_{FD} = 100 + 175 = 257 \text{ PSIG}$$

THE ORIGINAL MAGNITUDE OF P_{FD} WAS 293 PSIG (SEE REF. 1, p. 22). THUS WE GET A REDUCTION IN P_{FD} OF ABOUT 12%. IN ORDER NOT TO REPEAT THE ENTIRE ANALYSIS USING THE SPECIAL CHARTS ON PAGES 24 & 25 OF REF 2, WHICH ARE FAR FROM BEING SELFEXPLANATORY, ASSUME THE SAME AMOUNT OF REDUCTION IN THE STRESSES.

THE ORIGINAL STRESSES IN THE FRAME ADAPTER FLANGE WERE CALCULATED AS FOLLOWING:

OBE LOADING 19463 PSI

DBE LOADING 20224 PSI

THE 12% REDUCTION WILL RESULT IN THE STRESS WHICH IS BELOW THE "OBE LOADING" STRESS, SAY 17500 PSI

ADAPTER FLANGE BOLT STRESS

THE STRESSES IN THE ADAPTER FLANGE BOLTS ARE TO BE REDUCED BY THE SAME AMOUNT AS THE REDUCTION IN THE APPLIED LOAD.

$$0.88 \cdot 15813 = 13915 \text{ PSI.}$$

MATERIAL: SA-193 GR. B7.

FATIGUE ALLOWABLES

COMPONENT	MATERIAL	TENSILE STRENGTH △A (UTS) PSI	CALCULATED STRESS Sc PSI	ALLOWABLE STRESS Sa PSI	STRESS CONCENTR. FACTOR K_f
MOTOR BOLTS	A-307	60000	9623	42000 △1	△3
PUMP BOLTS	A-307	60000	13703	42000 △1	△3
ANCHORS	A-307	60000	5057	30000 △2	4.0 △4
BEARING BOLTS	A-307	60000	2329	42000 △1	△3
FRAME BOLTS	A-307	6000	12017	42000 △1	△3
ADAPTER BOLTS	SA-193 B7	125000	13915	87500 △1	△3
SHAFT	A-276 T316	75000	3692	37500 △2	4.0 △5
SUPPORT FRAME	A 36	58000	7507	29000 △2	2.0 △5
ADAPTER FLANGE	SA 216 WCB	70000	17500	35000 △2	△6
DISCH. NOZZLE	SA 351 CF8M	70000	15420 REF. 2	35000 △2	△6
SUCT. NOZZLE	SA 351 CF8M	70000	12171 REF. 2	35000 △2	△6
NOZZLE FLANGES	SA 351 CF8M	70000	24114 REF. 2	35000 △2	△6
IMPEL. CONNECT.	A 276 T316	75000	1570 REF. 2	37500 △2	△6

NOTES: △1 THE BOLTS WHICH ARE THE COMPONENTS IN THE PUMP ASSEMBLY, HAVE THEIR PRETENSION STRESSES SPECIFIED PER REF. 40, PAGE 6 AND EQUAL TO 70% OF MINIMUM TENSILE STRENGTH OF THE MATERIAL (SEE ITEM 2 IN THE ASSUMPTIONS)

△2 FOR THE COMPONENTS EXPOSED TO THE CYCLIC LOADS, THE ENDURANCE LIMIT FOR THE MATERIAL IS SPECIFIED AS 50% OF MINIMUM TENSILE STRENGTH (REF. 21 P. 607)

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3 NOT APPLICABLE SINCE STRESS DOES NOT ALTERNATE IF PRETIGHTENED PROPERLY

4 PER NB-3232.3(c) OF REF. 17

5 ESTIMATED VALUES PER REF. 38

6 THE STRESSES IN THE PUMP NOZZLES AND FLANGES WERE CALCULATED PER REF. 39 WHICH INTRODUCES CERTAIN FACTORS DUE TO STRESS CONCENTRATIONS IN THE DESIGN FORMULAS.

7 PER TABLE I-7.3 OF REF. 33

WITH THE STRESS CONCENTRATION FACTOR APPLIED TO THE CALCULATED STRESS IN THE CASE OF ANCHOR BOLTS

$$S_c' = S_c K_f = 5057 \cdot 4.0 = 20228 < S_a$$

∴ STRESSES IN ALL SECTIONS SUBJECTED TO THE CYCLIC LOADINGS ARE WITHIN THE ALLOWABLES.

F-22

11600.02 NM(B) 382 OZO

INTEROFFICE CORRESPONDENCE

PAGE 45

TO:	LOCATION	SUBJECT / REFERENCE / J.O. NO.
R. GAUTHIER	245/4.	PUMPS 1E21-P49A & B, 1E41-P50, 1E51-P51
FROM: P. TITUS/M. YEDVABNY	LOCATION 245/8	

MESSAGE: —

WE ARE MAKING AN ATEMPT TO IMPOSE FATIGUE CONSIDERATIONS ON THE DYNAMIC QUALIFICATION OF THE ABOVE NOTED PUMPS.

PLEASE PROVIDE YOUR ESTIMATIONS ON THE NORMAL OPERATING CONDITIONS OF THOSE PUMPS, NAMELY:

1) HOW MANY TIMES PER LIFE OF THE POWER PLANT THEY WILL BE ENGAGED,
2) HOW FREQUENTLY THEY WILL BE TURNED ON,
3) WHAT IS THE DURATION OF EACH ENGAGEMENT,
4) ARE THERE ANY PROVISIONS FOR SERVICING OF THE PUMPS.

4/22/83 — DATE | M. Yedvabny — SIGNATURE | 7044 — TELEPHONE

REPLY:

The loop level pumps operate continuously to maintain the ECCS systems full and ready for injection. You could conservatively assume the pumps are shutoff quarterly for maintenance resulting in 4 x 40 => 160 cycles plus 40 planned and spurious trips for a total of 200 cycles

4/22/83 — DATE | J. Powers — SIGNATURE | 2786 — TELEPHONE

040.13B

SECTION G

FATIGUE REVIEW OF THE

BOOSTER HEAT EXCHANGERS
MARK# 1P42*E-117 A,B, SPEC # SH1-190

LOCATED AT:
ELEVATION 8 SECONDARY CONTAINMENT

PREPARED BY M. YEDVABNY

1. NOZZLE FATIGUE ALLOWABLES

G-2

1.1. LOAD COMPARISON

THE ALLOWABLE NOZZLE LOADS FROM REF. 31 (P. 1-11) WERE USED IN THE VENDOR'S ANALYSIS AS THE LOADS APPLIED TO THE HEAT EXCHANGER TOGETHER WITH THE INTERNAL PRESSURE. IN ORDER TO EVALUATE A DEGREE OF CONSERVATISM THESE LOADS WILL BE COMPARED WITH THE ACTUAL LOADS FROM THE PIPING ANALYSIS (REF. 32)

THE TWO LOADING CASES WERE CONSIDERED IN THE VENDOR'S REPORT (REF. 3, P. 23):

CASE 1. AXIAL THRUST + LATERAL FORCE IN LONGITUDINAL DIRECT. + BENDING MOMENT IN CIRCUMFERENTIAL DIRECT.

CASE 2. AXIAL THRUST + LATERAL FORCE IN CIRCUMFERENTIAL DIRECT. + BENDING MOMENT IN LONGITUDINAL DIRECT.

THE MAGNITUDES OF THE LOADS ARE:

AXIAL THRUST	10 000 LB
LATERAL FORCE IN ANY DIRECTION	8 000 LB
BENDING OR TORQUE	16 500 FT·LBS (N1 & N2)
	13 000 FT LBS (N3 & N4)

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CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 48
11600.02	NM(B)	382	CZC	

G-3

APPLIED PIPING LOADS

(REF. 32)

TUBE SIDE NOZZLES N1 & N2

MARK NO	NOZ NO.	LOADING CASE	FORCE LB			MOMENT (FT-LB)		
			F_x	F_Y	F_Z	M_x	M_Y	M_Z
1P42 * E-117A	N1	DEAD WEIGHT	-343	-313	-19	-46	253	-437
	N2		311	-259	82	-90	485	571
	N1	THERMAL	81	38	-186	-191	88	196
	N2		40	-29	360	-421	1929	494
	N1	OBE	69	89	186	282	303	191
	N2		148	296	165	217	879	1822
	N1	SSE	92	116	243	258	367	191
	N2		224	437	145	195	768	2719
	N1	SRV	136	176	402	234	505	241
	N2		676	444	410	540	1591	2412
	N1	LOCA	78	114	209	144	300	139
	N2		355	529	255	368	1150	3203
	N1	UPSET	496	510	648	603	930	745
	N2		1043	822	887	1095	4252	3645
	N1	FAULTED	525	553	719	614	1034	774
	N2		1147	1105	947	1193	4526	5466

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CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 49
11600.02	NM(B)	382	CZC	

6-4

APPLIED PIPING LOADS

(REF. 32)

TUBE SIDE NOZZLES N1 & N2

MARK NO	NOZ NO.	LOADING CASE	FORCE LB			MOMENT (FT·LB)		
			F_X	F_Y	F_Z	M_X	M_Y	M_Z
1P42*E-117B	N1	DEAD WEIGHT	-256	-254	1	-77	84	-285
	N2		593	-627	-65	557	216	316
	N1	THERMAL	333	-655	80	-2357	-1083	-257
	N2		129	-65	-235	133	182	245
	N1	OBE	85	131	159	372	337	156
	N2		156	119	936	243	1210	564
	N1	SSE	56	62	184	45	241	120
	N2		235	194	1376	379	1778	876
	N1	SRV	98	137	506	98	729	257
	N2		627	741	1736	867	1946	962
	N1	LOCA	59	85	323	60	466	154
	N2		416	457	1860	627	2309	1032
	N1	UPSET	386	1099	611	2819	1802	843
	N2		1369	1443	2347	1591	2789	1676
	N1	FAULTED	383	1082	709	2557	1897	865
	N2		1510	1584	3202	1825	3915	2222

LOAD COMPARISON

VENDOR'S REPORT — AX-CALC.

MAX AXIAL THRUST

10000 LB > 1510

MAX LATERAL FORCE

8000 LB > $(1584^2+3202^2)^{1/2} = 3572$ LB

MAX MOMENT

16500 FT-LB > $(4526^2+5466^2)^{1/2} = 7097$ FT-LB

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CALCULATION SHEET

G-3

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 51
11600.02	NM(B)	38Z	CZC	

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SHELL SIDE NOZZLES N3 & N4
(REF. 32)
(LOCAL COORD.)

MK No	Noz No	LOADING CASE	FORCE (LB) Fx	Fy	Fz	MOMENT (FT-LB) Mx	My	Mz
1	2	3	4	5	6	7	8	9
1P42*E-117A	N3	DEAD WEIGHT	219.	-63	-343	-186	532	98
	N4		-51	-229	-28	10	-96	-291
	N3	THERM. EXPANSION	24.	41	-56	-12	73	101
	N4		35	11	2	59	90	-108
	N3	OBE	-376.	-288	-263	-603	-542	-774
	N4		-242	-274	-220	-534	-249	-593
	N3	SSE	-617	-472	-439	-989	-890	-1267
	N4		-397	-448	-373	-875	-431	-970
	N3	SRV	-694.	-609	-1037	-497	-1690	-1115
	N4		-400	-299	-55.9	-370	-892	-516
	N3	LOCA	-602	-414	-820	-890	-1440	-1074
	N4		-380	-268	-364	-684	-468	-764
1P42*E-117B	N3	DEAD WEIGHT	-74	-1982	127	1432	220	-2109
	N4		·4	-1134	-110	671	-30	-1530
	N3	THERM EXPANS.	-91	137	432	-194	-512	-99
	N4		-118	-7	-1	67	-58	-267
	N3	OBE	-307	-251	-883	-1065	-671	-780
	N4		-274	-192	-473	-1192	-540	-789

1	2	3	4	5	6	7	8	9
1P42*E-117B	N3	SRV	-727	-731	-1404	-1376	-1221	-1324
	N4		-451	-548	-682	-1565	-546	-1482
	N3	SSE	-509	-416	-1445	-1738	-1095	-1284
	N4		-444	-315	-759	-1912	-878	-1280
	N3	LOCA	-520	-468	-1352	-1402	-1240	-1264
	N4		-462	-334	-743	-1766	-835	-1329

LOAD COMBINATIONS

$$UPSET = DW + THERM. \pm \left(OBE^2 + SRV^2\right)^{1/2}$$

$$FAULTED = DW \pm \left(SSE^2 + SRV^2 + LOCA^2\right)^{1/2}$$

REF. 37 TABLE 4.5.3(b)

(NOTE: ONLY ABSOLUTE VALUES OF THE LOADS ARE CONSIDERED)

MARK No.	NOZ. No.	LOADING COMBINATION	FORCE (LB)			MOMENT (FT.-LB)		
			F_X	F_Y	F_Z	M_X	M_Y	M_Z
1P42*E-117A	N3	UPSET	1032	778	1469	979	2380	1556
	N4		554	646	631	719	1112	1185
	N3	FAULTED	1326	938	1736	1606	2924	2098
	N4		731	831	792	1181	1192	1629
1P42*E-117B	N3	UPSET	95[illegible]	[illegible]92	2218	3366	2125	3745
	N4		[illegible]	[illegible]22	941	2705	856	3476
	N3	FAULTED	11[illegible]	[illegible]4	2553	4055	2276	4345
	N4		860	1849	1372	3708	1359	3897

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LOAD COMPARISON

VENDOR'S REPORT — AX-CALC.

MAX AXIAL THRUST

10000 LB > 1326 LB

MAX LATERAL LOAD

8000 LB > $(2944^2 + 2553^2)^{1/2} = 3897$ LB

MAX MOMENT

13000 FT·LB > $(2276^2 + 4345^2)^{1/2} = 4905$ FT-LB

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CALCULATION SHEET

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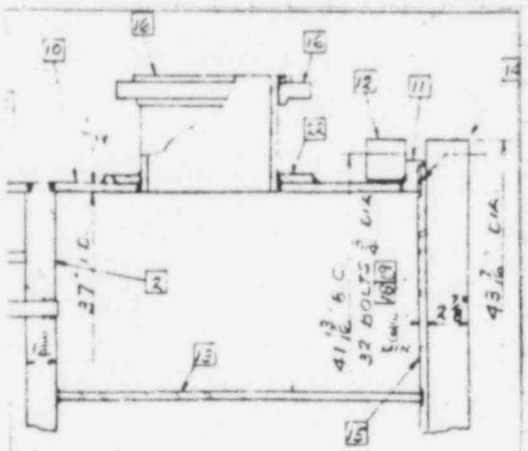
CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 54
11600.02	NM(B)	382	CZC	

1.2 10" CHANNEL NOZZLES N1 AND N2

(REF. 3, P 6)



MATERIAL: SB-402 COPPER ALLOY

UTS = 40000 PSI

(REF. 33, TABLE I-8.4)

MAXIMUM STRESSES

CASE 1:

$\sigma_M = 10185$ PSI

$\sigma_{M+B} = 28013$ PSI

CASE 2

$\sigma_M = 8182$ PSI

$\sigma_{M+B} = 20768$ PSI

STRESS CONCENTRATION FACTOR APPLIED TO THE MEMBRANE STRESS COMPONENT ONLY

$K_f = 1.2$ (REF. 17, TABLE NB-3338.2(c)-1)

MODIFIED MEMBRANE STRESS COMPONENT

$\sigma_M' = \sigma_M \cdot K_f = 10185 \cdot 1.2 = 12222$ PSI

BENDING STRESS COMPONENT

$\sigma_B = \sigma_{M+B} - \sigma_M = 28013 - 10185 = 17828$ PSI

MODIFIED BENDING STRESS COMPONENT AND TOTAL STRESS FOR EACH LOADING CASE RESPECTIVELY.

NOTE: IN EVALUATION A REDUCTION FACTOR FOR THE BENDING STRESS COMPONENT THE RATIO' BETWEEN THE BENDING MOMENTS IS TAKEN INTO CONSIDERATION AS SATISFYING A CONSERVATIVE APPROACH.

	LOADING CASE				
	NORM.	OBE	SSE	SRV	LOCA
LOAD RATIO $R = \frac{M_Z}{M_{INPUT}}$	$\frac{494}{16500} = 0.03$	$\frac{1822}{16500} = 0.11$	$\frac{2719}{16500} = 0.165$	$\frac{2412}{16500} = 0.146$	$\frac{3203}{16500} = 0.194$
MODIFIED BENDING STRESS $\sigma_B' = R \cdot \sigma_B$	535	1961	2942	2603	3459
MODIFIED TOTAL STRESS $\sigma_{M+B}' = \sigma_M' + \sigma_B'$	12757	14183	15164	14825	15681

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CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 56
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FATIGUE ANALYSIS FOR EACH LOADING CASE IS PRESENTED IN THE TABLE BELOW:

	LOADING CASE				
	NORM	OBE	SSE	SRV	LOCA
STRESS LEVEL	12757	14183	15164	14825	15681
EXPECTED No OF CYCLES n	480***	50	10	2271*	505**
ALLOWABLE No OF CYCLES N_a (REF. 5, FIG I-9.3)	$5 \cdot 10^5$	$3 \cdot 10^5$	$2 \cdot 10^5$	$2 \cdot 10^5$	$1.8 \cdot 10^5$
USAGE FACTOR $U = \frac{n}{N_a}$	$9.6 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$	$5 \cdot 10^{-5}$	$1.14 \cdot 10^{-2}$	$2.8 \cdot 10^{-3}$

$$* \quad n_{SRV} = 900 \frac{f_N}{3} = 900 \frac{7.57}{3} = 2271$$

$$** \quad n_{LOCA} = 200 \frac{f_N}{3} = 200 \frac{7.57}{3} = 505$$

TOTAL USAGE FACTOR

$$U_{TOT} = \sum U_i = 0.015 \ll 1.0 \qquad \text{OK.}$$

*** ONE OPERATING CYCLE PER MONTH FOR THE 40 YEA PLANT LIFE IS ASSUMED

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CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 57
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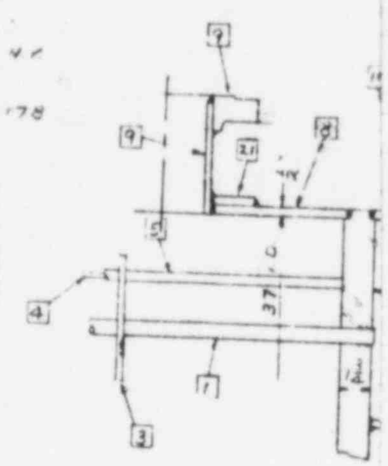
1.3. 10" SHELL NOZZLES N3 & N4 (REF. 3, P. 7)



MAT: SA 516 GR 70 STEEL

MIN TENSILE STRENGTH

UTS = 70000 PSI

(REF. 38 TABLE I-3.1)

MAX. STRESSES

CASE 1 $\sigma_M = 13966$ PSI

$\sigma_{M+B} = 48316$ PSI

CASE 2 $\sigma_M = 15760$ PSI

$\sigma_{M+B} = 51482$ PSI

STRESS CONCENTRATION FACTOR

$K_f = 1.2$ (REF. 17, TABLE NB-3338.2(c)-1)

MODIFIED MEMBRANE STRESS COMPONENT

$\sigma_M' = K_f \cdot \sigma_M = 1.2 \cdot 15760 = 18912$ PSI

BENDING STRESS COMPONENT

$\sigma_B = \sigma_{M+B} - \sigma_M = 51482 - 15760 = 35722$ PSI

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 58
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FATIGUE ANALYSIS

	LOADING CASE				
	NORM	OBE	SSE	SRV	LOCA
LOAD RATIO $R = \frac{M_Y}{M_{INFUT}}$	$\frac{512}{13000}$ = 0.039	$\frac{671}{13000}$ = 0.052	$\frac{1095}{13000}$ = 0.084	$\frac{1221}{13000}$ = 0.094	$\frac{1240}{13000}$ = 0.095
MODIFIED BENDING STRESS $\sigma_B' = R \cdot \sigma_B$	1393	1858	3000	3358	3394
MODIFIED TOTAL STRESS $\sigma_{M+B}' = \sigma_M' + \sigma_B'$	20305	20770	21912	22270	22306
EXPECTED NO OF CYCLES n	480*	50	10	2271	505
ALLOWABLE NO OF CYCLES Na (REF. 5)	$7 \cdot 10^4$	$7 \cdot 10^4$	$6 \cdot 10^4$	$5 \cdot 10^4$	$5 \cdot 10^4$
USAGE FACTOR $U = \frac{n}{Na}$	$6.8 \cdot 10^{-3}$	$7.1 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$	$4.5 \cdot 10^{-2}$	$1.0 \cdot 10^{-2}$

TOTAL USAGE FACTOR

$U_{TOT} = \sum U_i = 0.063 \ll 1.0$ OK.

* ONE OPERATING CYCLE PER MONTH OF THE 40 YEAR PLANT LIFE ASSUMED.

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G-9

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 59
11600.02	NM(B)	382	CZC	

2. CHANNEL SECTION OF SHELL. (REF. 3, P. 7)

HOLLOW CYLINDER WITH THE METAL AREA

$$A = \frac{\pi}{4}(38^2 - 37^2) = 58.9 \text{ in}^2$$

(REF. 3, P. 73)

MAT: SB-402 COPPER ALLOY

STRESS DUE TO FAULTED LOADING

$$\sigma_{max_3} = 6362 \text{ psi}$$

STRESS CONCENTRATION FACTOR

$$K_t = 1.0$$ (NO DISCONTINUITIES)

THE CALCULATED STRESS SHALL BE COMPARED AGAINST THE ALLOWABLES FROM THE DESIGN FATIGUE CURVE FOR COPER ALLOY (REF. 5, FIG. I-9.3). THE CALCULATED STRESS IS WELL WITHIN THE STRESS LEVEL CORRESPONDING TO ONE MILLION CYCLES OF LOAD APPLICATIONS

$$6362 < 12000 \text{ psi}$$

ACCORDING TO REF. 17, NB-3222.4(d.6) SUCH A LOADING IS CONSIDERED AS INSIGNIFICANT.

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CALCULATION SHEET

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11600.02	NM(B)	382	CZC.	

3. SHELL AWAY FROM SUPPORTS (REF. 3, P. 9)

HOLLOW CYLINDER WITH THE METAL AREA

$$A = \frac{\pi}{4}(38^2 - 37.25^2) = 44.3\ IN^2$$

MAT: SA-516 GR 70. STEEL

MIN. ULTIMATE TENSILE STRENGTH = 70 KSI

STRESS DUE TO FAULTED LOADING

$$\sigma_{MAX_3} = 18395\ PSI$$

STRESS CONCENTRATION FACTOR

$K_f = 1.0$ (NO DISCONTINUITIES)

THE CALCULATED STRESS SHALL BE COMPARED AGAINST THE ENDURANCE LIMIT FOR THE MATERIAL WHICH IS ESTIMATED AS 50% OF ULTIMATE STRENGTH (REF. 21, P. 607)

$$S_e = 0.5 \cdot \sigma_u = 0.5 \cdot 70000 = 35000\ PSI$$

NOTE: REF. 28, E468 GIVES STATISTICAL ESTIMATION OF THE ENDURANCE LIMIT EQUAL TO 39000 PSI (STANDARD ERROR OF ESTIMATE = 0.09925, 24 SPECIMENS, A36 STEEL). THEREFORE THE VALUE OF 35000 PSI APPEARS TO BE ACCEPTABLE

$$\sigma_{MAX} < S_e \quad (18395 < 35000)$$

$\therefore$ THE APPLIED LOADS ARE SAFE.

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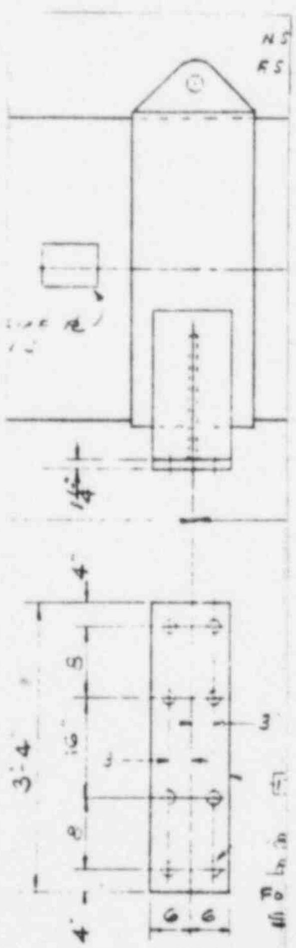
4. SHELL OVER SUPPORTS (REF. 3, P. 9, 85)

CIRCULAR RING SECTOR WITH THE CENTER-ANGLE OF 150° AND THICKNESS OF 1.375 IN.

SECTION MODULUS OF THE SECTION HAS BEEN REDUCED DUE TO SHELL DEFORMATION AND CIRCUMFERENTIAL STRESS AT HORN OF SADDLE.



MAT: SA-516 GR.70 STEEL

STRESS DUE TO FAULTED LOADS

$\sigma_{MAX_3} = 25062$ PSI

STRESS CONCENTRATION IS ACCOUNTED FOR BY REDUCTION IN SECTION MODULUS. THEREFORE

$K_t = 1.0$

THE MAX STRESS IS WITHIN THE ENDURANCE LIMIT FOR THE MATERIAL

$\sigma_{MAX} < S_e$ $(25062 < 35000)$

∴ FATIGUE APPROACH IS NOT RELEVANT.

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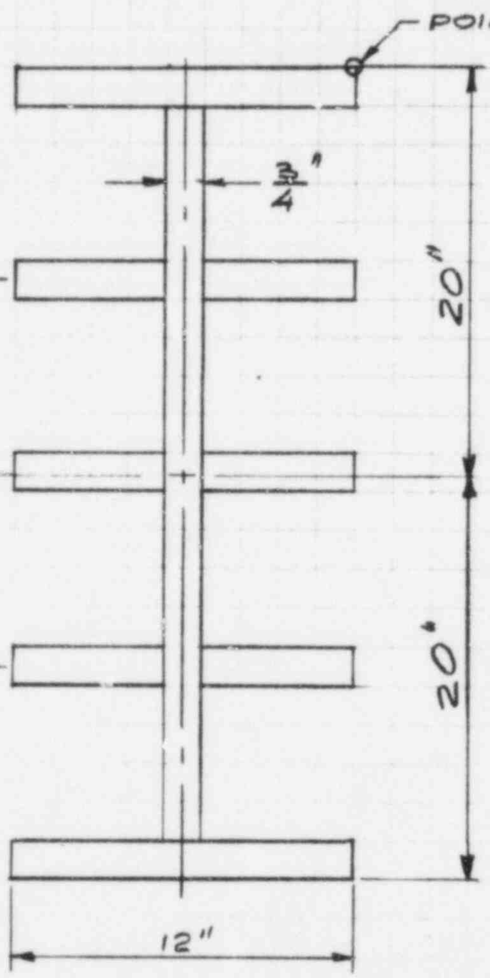
5. SUPPORTS (REF. 3, P. 11)

ARRANGEMENT OF GUSSETS IN THE SUPPORT IS SHOWN IN THE SKETCH BELOW.



MAT. SA 285 GR. C STEEL

UTS = 55000 PSI

MAX COMBINED STRESS

$\sigma_{MAX} = 21002$ PSI

THE ENDURANCE LIMIT FOR THE MATERIAL IS:

$S_e = 0.5 \cdot 55000 = 27500$ PSI,

$\sigma_{MAX} < S_E$ (21002 < 27500 PSI)

∴ THE FATIGUE APPROACH IS NOT RELEVANT

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6. BASE PLATE (REF. 3, P. 11)

STRESSES IN THE BASE PLATE WERE CALCULATED AS FOLLOWING:

BEARING STRESS IN THE WALL OF A CLEARANCE HOLE. 7102 PSI

TEAR-OUT (SHEAR) STRESS TOWARDS THE PLATE EDGE 2071 PSI

MAT: SA 285 GR. C

BOTH STRESS VALUES ARE WELL WITHIN THE ALLOWABLE FOR 10^6 CYCLES OF LOAD APPLICATION FROM REF. 5: $S_{O(10^6)} = 12500$ PSI.

∴ FATIGUE APPROACH IS NOT RELEVANT.

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7. HOLD DOWN BOLTS. (REF. 3 p. 11, 100-102)

EIGHT $1\frac{3}{4}$" DIA BOLTS ARE USED ON EACH SUPPORT. MAT: SA-449 STEEL

UTS = 90 000 (REF. 33 TABLE I-7.3)

THE MAX TENSILE STRESS PER BOLT WAS CONSERVATIVELY ESTIMATED TO BE 37656 PSI BY REVERSING THE VERTICAL LOAD UPWARD. THIS STRESS IS ASSOCIATED WITH THE FOLLOWING SEISMIC COEFFICIENTS:

HORIZONTAL	1.2 G	REF. 3, p. 64.
VERTICAL	0.7 G.	

KNOWING THE ACTUAL NATURAL FREQUENCY OF THE HEAT EXCHANGER INSTALLATION A PARTICULAR ACCELERATION LEVEL CORRESPONDING TO THIS NATURAL FREQUENCY CAN BE DETERMINED.

FROM REF'S. 34 & 35 THE COMPONENTS CONTRIBUTING TO THE TOTAL ACCELERATION LEVEL FOR THE EQUIPMENT POSSESSING THE FUNDAMENTAL FREQUENCY $f_N = 7.562$ Hz (OR PERIOD 0.132 SEC) AT THE ELEVATION 8 FT OF THE SECONDARY CONTAINMENT ARE DEFINED AS FOLLOWING

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DYNAMIC LOADING

SECONDARY CONTAIN.
EL. 8 FT

REF. CALC & SECTION		DYNAMIC EVENT	DIRECTION	ACCELERATION G's DAMPING 2%	4%
REF. 34	3a	FINAL CONDENSATION OSCILLATION LOAD (CO)	HOR. N-S	.06	.05
	3b		HOR E-W	.06	.05
	4		VERTICAL	.05	.04
	7a	CHUGGING	HOR. N-S	.045	.04
	7b		HOR. E-W	.035	.03
	8		VERTICAL	.04	.04
	9a	SRV - ALL VALVES SIMULTAN.	HOR. N-S	.075	.07
	9b		HOR. E-W	.065	.06
	10		VERTICAL	.06	.06
	11a	SRV - ADS	HOR. N-S	.07	.06
	11b		HOR. E-W	.07	.06
	12		VERTICAL	.055	.05
	13a	SRV - THREE VALVES	HOR. N-S	.06	.04
	13b		HOR. E-W	.03	.03
	14		VERTICAL	.04	.03
	15a	SRV - ONE VALVE	HOR. N-S	.03	.03
	15b		HOR. E-W	.03	.03
	16		VERTICAL	.025	.02
REF. 35		OBE	HORIZONT.	.16	
			VERTICAL	.15	
		SSE	HORIZONT.		.25
			VERTICAL		.26

ACCORDING TO REF. 36 THE ACCELERATION COMPONENTS ARE DEFINED AS FOLLOWS:

SRV = ENVELOPE [(SRV-ALL) + (SRV-ONE) + (SRV-THREE)]

LOCA = ENVEL (CO + CHUG)

$$UPSET = \left[OBE^2 + SRV^2 \right]^{1/2}$$

$$FAULTED = \left[SSE^2 + LOCA^2 + (SRV\text{-}ADS)^2 \right]^{1/2}$$

SRV

HOR. $g^{v}_{SRV.h} = 0.075 + 0.06 + 0.03 = 0.165$

VER $g^{v}_{SRV.V} = 0.06 + 0.04 + 0.025 = 0.125$

LOCA

HOR. $g_{LOCA.h} = 0.05 + 0.04 = 0.09$

VER. $g_{LOCA\,V} = 0.04 + 0.04 = 0.08$

UPSET CONDITIONS

HOR. $g^{h}_{U} = (0.16^2 + 0.165^2)^{1/2} = 0.23$

VER. $g^{v}_{U} = (0.15^2 + 0.125^2)^{1/2} = 0.20$

FAULTED CONDITIONS

HOR $g^{h}_{F} = (0.25^2 + 0.09^2 + 0.06^2)^{1/2} = 0.27$

VER $g^{v}_{F} = (0.26^2 + 0.08^2 + 0.05^2)^{1/2} = 0.28$

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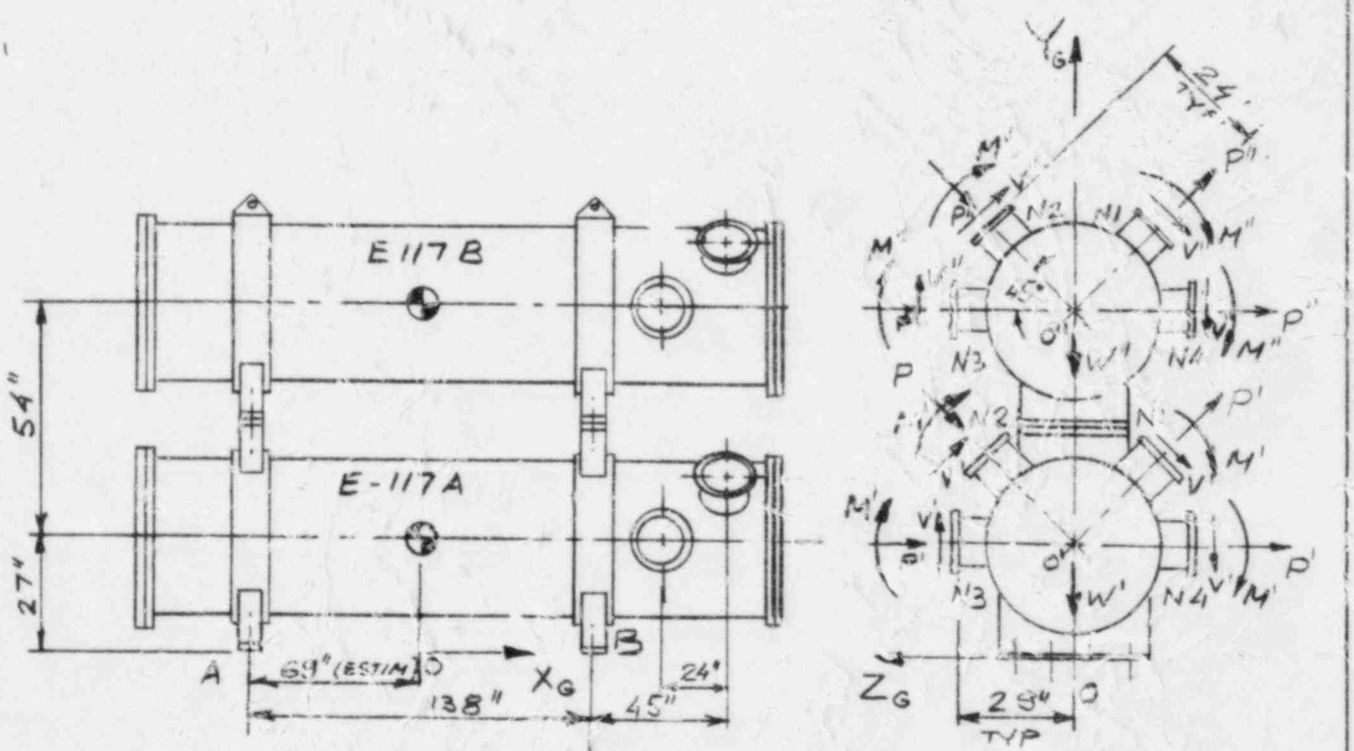
11600.02	NM(B)	382	CZC	6a1

ESTIMATION OF EMBEDMENT LOADS

DUE TO REDUCTION IN THE NOZZLE LOADS AND IN THE STATIC COEFFICIENTS WITH RESPECT TO THOSE FROM REF. 3 THE NEW SUPPORT LOADS WILL BE ESTIMATED BY HAND CALCULATIONS



WEIGHT OF EACH UNIT (FLOODED) W = 25117 LB

$$\left.\begin{aligned} P &= F_{X_L} \\ V_Y &= F_{Y_L} \\ V_X &= F_{Z_L} \\ M_X &= M_{Z_L} \\ M_Y &= M_{Y_L} \\ M_Z &= M_{X_L} \end{aligned}\right\} \text{NOZZLE LOADS (LOCAL COORD)}$$

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A 5010.65

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NOZZLE LOADS
(SEE P. AND REF. 32) FAULTED COND.

MARK NO	NOZZLE NO	P LB	V_X LB	V_Y LB	M_X FT·LB	M_Y FT·LB	M_Z FT·LB
1P42*E-117A	N1	525	719	553	774	1034	614
	N2	1147	947	1105	5466	4526	1193
	N3	1326	1736	938	2098	2924	1606
	N4	731	792	831	1629	1192	1181
1P42*E-117B	N1	383	709	1082	865	1897	2557
	N2	1510	3202	1584	2222	3915	1825
	N3	1103	2553	2944	4345	2276	4055
	N4	860	1372	1849	3897	1359	3708

RESULTING LOADINGS TAKEN AT CG'S

$$F'_{Z_G} = 0.707 \sum_1^2 P'_{N_i} + \sum_3^4 P'_{N_i} + 0.707 \sum_1^2 V'_{YN_i}$$

$$F'_{Y_G} = 0.707 \sum_1^2 P'_{N_i} + \sum_3^4 V'_{YN_i} + 0.707 \sum_1^2 V'_{YN_i} + W'$$

$$M'_X = \sum_1^4 M'_{N_i} + \frac{24}{12} \sum_1^2 V'_{YN_i} + \frac{29}{12} \sum_3^4 V'_{YN_i}$$

$$M'_Z = \frac{45+69}{12}\left[0.707\left(\sum_1^2 P'_{N_i} + \sum_1^2 V'_{YN_i}\right)\right] + \frac{45-24+69}{12} \sum_3^4 V'_{YN_i} +$$
$$+ 0.707\left(\sum_1^2 M'_{Y_{N_i}} + \frac{24}{12} \sum_1^2 V'_{X_{N_i}} + \sum_1^2 M'_{X_{N_i}}\right) + \sum_3^4 M'_{XN_i}$$

$$F'_X = \sum_1^4 V'_{XN_i}$$

$$M'_Y = 0.707\left(\sum_1^2 M'_{YN_i} + \frac{24}{12} \sum_1^2 V'_{XN_i} + \sum_1^2 M'_{XN_i}\right) + \sum_3^4 M'_{YN_i} +$$
$$+ \frac{29}{12} \sum_3^4 V'_{XN_i}$$

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11600.02	NM(B)	382	CZC	

$$F''_{Z_G} = 0.707\sum_1^2 P''_{Ni} + \sum_3^4 P''_{Ni} + 0.707\sum_1^2 V''_{Ni}$$

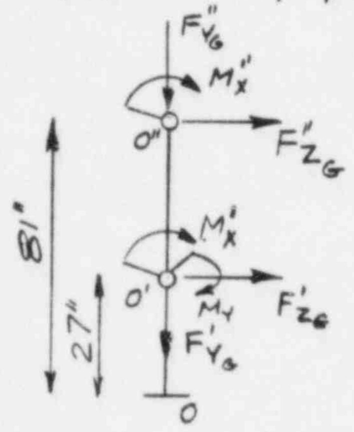
$$F''_Y = 0.707\sum_1^2 P''_{Ni} + \sum_3^4 V''_{Ni} + 0.707\sum_1^2 V''_{Ni} + W''$$

$$M''_x = \sum_1^4 M''_{Ni} + \frac{24}{12}\sum_1^2 V''_{Ni} + \frac{29}{12}\sum_3^4 V''_{Ni}$$

$$M''_Z = \frac{45+69}{12}\left[0.707\left(\sum_1^2 P''_{Ni} + \sum_1^2 V''_{Ni}\right)\right] + \frac{45-24+69}{12}\sum_3^4 V''_{Ni} +$$
$$+0.707\left(\sum_1^2 M''_{Y_{Ni}} + 24\sum_1^2 V''_{xNi} + \sum_1^2 M''_{xNi}\right) + \sum_3^4 M''_{xNi}$$

$$F''_x = \sum_1^4 V''_{xNi}$$

$$M''_Y = 0.707\left(\sum_1^2 M''_{YNi} + \frac{24}{12}\sum_1^2 V''_{xNi} + \sum_1^2 M''_{xNi}\right) + \sum_3^4 M''_{YNi} + \frac{29}{12}\sum_3^4 V''_{xNi}$$



$$F'_{Z_G} = 0.707(525+1147) + 1326 + 731 +$$
$$+0.707(553+1105) = 4411 \text{ LB} (\rightarrow)$$

$$F'_{Y_G} = 0.707(525-1147) + 938 - 831 +$$
$$+0.707(-553+1105) - 25117 = -25059 (\downarrow)$$

$$M'_x = -774 - 5466 - 2098 - 1629 -$$
$$-\frac{24}{12}(553+1105) - \frac{29}{12}(938+831) =$$
$$= -17558 \text{ FT-LB}$$

$$M'_Z = \frac{45+69}{12}\left[0.707(525-1147-553+1105)\right] +$$
$$+\frac{45-24+69}{12}(938-831) + 0.707\left[1034+4526+\right.$$
$$\left.+\frac{24}{12}(719-947) + 774 + 5466\right] + 2098 + 1629 = 12079 \text{ FT-LB}$$

$$F'_x = 719 - 947 + 1736 - 792 = 716 \text{ LB}$$

$$M'_Y = 0.707\left[1034 + 4526 + \frac{24}{12}(719-947) + 774 + 5466\right] + 2924 + 1192 +$$
$$+ 29/12\,(1736-792) = 14418 \text{ FT-LB}$$

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11600.02	NM(B)	382	CZC	

$$F''_{Z_G} = 0.707(383+1510)+1103+860+0.707(1082+1584)=$$
$$=5186 \text{ LB.}$$

$$F''_{Y_G} = 0.707(383-1510)+2944-1849+0.707(-1082+1584)-$$
$$-25117=-24464 \text{ LB}$$

$$M''_X = -865-2222-4345-3897-\frac{24}{12}(1082+1584)-$$
$$-\frac{29}{12}(2944+1849)=-28244 \text{ FT-LB} \downarrow$$

$$M''_Z = \frac{45+69}{12}\left[0.707(383-1510-1082+1584)\right]+$$
$$+\frac{45-24+69}{12}(-2944-1849)+$$
$$+0.707\left[1897+3915+\frac{24}{12}(709-3202)+865+2222\right]+4345+3897=$$
$$=15023 \text{ FT. LB.}$$

$$F''_x = 709-3202+2553-1372=-1312 \text{ LB}$$

$$M''_Y = 0.707(1897+3915+\frac{24}{12}(709-3202)+865+2222]+2276+1359+$$
$$+\frac{29}{12}(2553-1372)=9256 \text{ FT-LB.}$$

COMBINED LOADS

$$F_X = 716-1312=-596 \text{ LB}$$

$$F_Y = -25059-24464=-49523 \text{ LB}$$

$$F_Z = 4411+5186=9597 \text{ LB}$$

$$M_X = -17558-28244-\frac{27}{12}4411-\frac{81}{12}5186=-90732 \text{ FT-LB.}$$

$$M_Y = 14418+9256=26674 \text{ FT. LB}$$

$$M_Z = 12079+15023-\frac{27}{12}716+\frac{81}{12}1312=34347 \text{ FT-LB}$$

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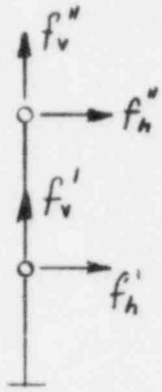
INERTIA LOADS ON HEAT EXCHANGERS DUE TO FAULTED CONDITIONS.



$f_h' = f_h'' = W \cdot g_F^h = 25117 \cdot 0.27 = 6782$ LB

$f_v' = f_v'' = W \cdot g_F^v = 25117 \cdot 0.28 = 7033$ LB

TOTAL LOADS

$F_Z^T = F_Z + f_h' + f_h'' = 9597 + 2 \cdot 6782 = 23161$ LB

$F_Y^T = F_Y + f_v' + f_v'' = -49523 + 2 \cdot 7033 = -35457$

$F_X^T = -596$ LB

$M_X^T = -90732 - \left(\frac{27+81}{12}\right) 6782 = -151770$ FT·LB

$M_Y^T = 26674$ FT·LB

$M_Z^T = 34\,347$ FT-LB

LOADS PER SUPPORT

$X = 0.5 \cdot F_X^T = 0.5(-596) = -298$ FT·LB

$Y = 0.5 F_Y^T + \frac{M_Z^T}{138} 12 = 0.5(-35457) + \frac{34347}{138} 12 = -14741$ LB

$Z = 0.5 \cdot F_Z^T + \frac{M_Y^T}{138} 12 = 0.5 \cdot 23161 + \frac{26674}{138} 12 = 13900$ LB

$M_X = 0.5 \cdot M_X^T = 0.5 \cdot (-151770) = -75885$ FT·LB.

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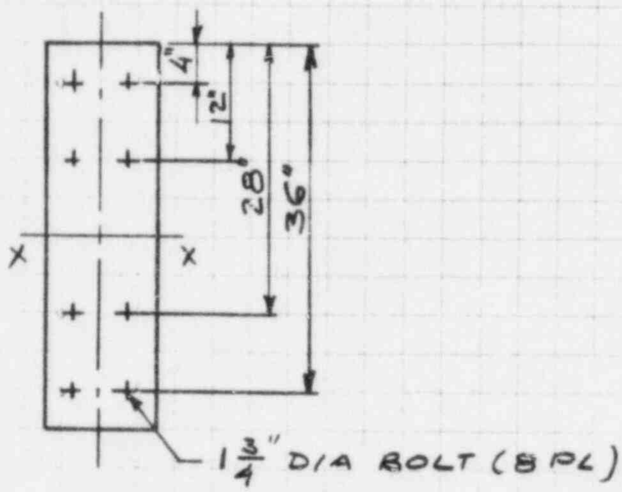
LOADS ON MOUNTING BOLTS



VERTICAL FORCE

$$T_{MAX} = \frac{M_x \cdot 36 \cdot 12}{2(36^2+28^2+12^2+4^2)} - \frac{1}{8} Y =$$

$$= \frac{75885 \cdot 36 \cdot 12}{2(36^2+28^2+12^2+4^2)} - \frac{14741}{8} =$$

$$= 5475_{LB} \text{ (TENSION)}$$

TENSILE STRESS

$$\sigma = \frac{T_{MAX}}{A_T} = \frac{5475}{1.90} = 2882 \text{ PSI}$$

WHERE $A_T = 1.90 \text{ IN}^2$, TENSILE STRESS AREA.
(REF. 38, P. 4-125)

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SHEAR FORCE

ONLY ONE SUPPORT TAKES SHEAR SINCE THE OTHER HAS THE SLOTTED CLEARANCE HOLES FOR THE BOLTS.

SHEAR LOAD PER BOLT

$$S = \frac{\left[(F_x^I)^2 + (F_z^I)^2\right]^{1/2}}{8} = \frac{(596^2 + 23161^2)^{1/2}}{8} = 2896$$

SHEAR STRESS IN BOLT

$$\tau = \frac{S}{A_S} = \frac{2896}{1.74} = 1664 \text{ PSI.}$$

WHERE $A_S = 1.74 \text{ IN}^2$, SHEAR STRESS AREA (REF. 38 P. 4-125)

MAX TENSILE STRESS

$$\sigma_{MAX} = \frac{\sigma}{2} + \sqrt{\left(\frac{\sigma}{2}\right)^2 + \tau^2} = \frac{2882}{2} + \sqrt{\left(\frac{2882}{2}\right)^2 + 1664^2} =$$

$$= 3642 \text{ PSI}$$

APPLYING THE STRESS CONCENTRATION FACTOR $K_f = 4$ AS RECOMMENDED IN REF. 17, NB-3232.3 (b), THE FINAL STRESS IS:

$$\sigma_f = 4 \cdot 3642 = 14568 \text{ PSI}$$

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ACCORDING TO REF. 21, P. 607, THE ENDURANCE LIMIT FOR STEEL WITH THE ULTIMATE STRENGTH 90 KSI (SAME AS FOR SA-449 STEEL USED FOR THE BOLTS) IS

$$S_e = 0.4\,\sigma_u = 0.4 \cdot 90000 = 36\,000 \text{ psi}$$

$$\sigma_f < S_e \quad (14568 < 36000) \quad \text{OK.}$$

SECTION H

FATIGUE REVIEW OF:

10" FORGED BOLTED BONNET GATE VALVE
MARK NOS. 1E11*MOV 039 A,B, 1G41*MOV 034 A,B SPEC # SH1-88V

PREPARED BY J. HOWE
&
M. PALIE

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

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▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
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VELAN SR-6082
10" FORGED BOLTED BONNET GATE VALVE
ASME CLASS 300#
CARBON STEEL
NUCLEAR CLASS 2

MARK No.'s 1E11*MOV039A, B
1G41*MOV034A, B

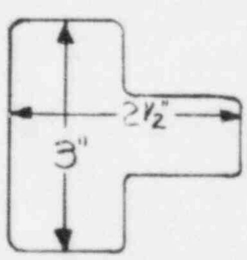
S&W SPECIFICATION: SH1-88V

1. SECTION 2-2 IS THE MOST CRITICAL SECTION IN THE YOKE ARM (REF: VELAN REPORT SR-6082 PAGE 1.4)

2. VALVE 1E11*MOV039A IS THE WORST CASE BY INSPECTION OF THE 'G' LOADS FROM THE AX'S.

3 THE VENDORS REPORT CALCULATES STRESS BASED ON A 5"g" DESIGN LOAD PLUS THRUST LOAD. THE STRESS FOR EACH INERTIA LOADING CONDITION IS CALCULATED BY SUBTRACTING THE THRUST LOAD STRESS FROM THE TOTAL STRESS AND MULTIPLYING THIS VALUE BY THE APPROPRIATE RATIO OF ACCELERATIONS. MARKED UP PAGES OF THE VENDOR REPORT ARE FOUND ON PAGES 83 THROUGH 86

4. A STRESS CONCENTRATION FACTOR OF 2 IS CONSERVATIVE BECAUSE THE CAST STEEL YOKE HAS NO SHARP EDGES, NOTCHES, OR DISCONTINUITIES



CROSS-SECTION OF YOKE

ALL CORNERS ROUNDED

5. THE NATURAL FREQUENCY IS 36 Hz AS REPORTED IN AX-8F, 8H

6 THE STRESS DUE TO THRUST LOAD IN THE YOKE IS SMALL, AND BELOW THE ENDURANCE LIMIT AND THEREFORE HAS BEEN NEGLECTED IN THE FATIGUE EVALUATION

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11600.02	NM(B)	382	CZC	

FROM VELAN SR-6082 PAGE 3
FOR SECTION 2-2
THE STRESS INTENSITY $S12 = 13208$ PSI
OLD 'G' VALUE = 5g's
REMOVING STRESS DUE TO THRUST LOAD (PAGES 83-86) $S12 = 10625$
NEW 'G' VALUES

$$\sqrt{(\text{WORST CASE HORIZ})^2 + (1g + \text{VERT})^2} = \text{NEW 'G' VALUE}$$

$$\text{OBE} \quad \sqrt{(.332)^2 + (1+.103)^2} = 1.15$$

$$\text{SSE} \quad \sqrt{(.530)^2 + (1+.164)^2} = 1.28$$

$$\text{SRV} \quad \sqrt{(5.655)^2 + (1+1.666)^2} = 6.25$$

$$\text{LOCA} \quad \sqrt{(2.619)^2 + (1+1.321)^2} = 3.50$$

	NORMAL	OBE	SSE	SRV	LOCA
σ_{2-2}	10625	10625	10625	10625	10625
'G' RATIO	1.0/5.0	1.15/5.0	1.28/5.0	6.25/5.0	3.5/5.0
$\sigma = \text{'G'}\, \sigma_{2-2}$	2125	2443	2720	13281	7437
K_f	2	2	2	2	2
$K_f \sigma$	4250	4886	5440	26562	14875
N		50	10	$900 \frac{f_N}{3}$	$200 \frac{f_N}{3}$
N_A	∞	∞	∞	33000	132433

K_f = STRESS CONCENTRATION FACTOR

N = NUMBER OF CYCLES – 40 YR LIFE

N_A = NUMBER OF CYCLES ALLOWED FROM ASME SECTION III, DIV I APPENDICES, TABLE I-9.1

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USEAGE FACTORS

$\Sigma \frac{N}{N_A} < 1$ FOR ACCEPTABILITY

NORMAL + OBE + SSE + SRV + LOCA

$$0 + 0 + 0 + \frac{900\left(\frac{36}{3}\right)}{33,000} + \frac{200\left(\frac{36}{3}\right)}{132433} = .35$$

$0.35 < 1$ ok

CONCLUSION

THE VALVES 1E11*MOV039A, B AND 1G41*MOV034A, B WILL NOT FAIL DUE TO FATIGUE UNDER THE LOADING CONDITIONS SPECIFIED.

LILCO - SHOREHAM - #11600.02 Prelim [illegible] H-4

G's - DYNAMIC ACCELERATION AT VALVE OPERATOR C.G.

PROBLEM #: 805 NODE #: 778 BY: [illegible] DATE: ______

AX/MSK #: 8F-2 RUN #: R1649258 DATE: 2/28/83

SYSTEM #: 1E11 MARK #: 1E11*MOV039A

G's FOR LOAD CASE					
	OBE	SSE	SRV	LOCA	AP
X	.332	.530	4.712	2.459	.219
Y	.103	.164	1.666	1.321	.063
Z	.280	.440	5.655	2.619	.310

$G_H = G_X$ OR G_Z (GREATER)

$G_V = G_Y$

UPSET: $G = \text{NORMAL} \pm \sqrt{OBE^2 + SRV^2}$ (LC #2)

$$G_H = \pm\sqrt{.280^2 + 5.655^2} = 5.7$$

$$G_V = \pm\sqrt{.103^2 + 1.666^2} = 1.7$$

FAULTED: $G = \text{NORMAL} \pm \sqrt{SSE^2 + SRV^2 + LOCA^2}$ (LC #6)

$$G_H = \pm\sqrt{.440^2 + 5.655^2 + 2.619^2} = 6.3$$

$$G_V = \pm\sqrt{.164^2 + 1.666^2 + 1.321^2} = 2.1$$

$G = \text{NORMAL} \pm \sqrt{SSE^2 + AP^2}$ (LC #7)

$$G_H = \pm\sqrt{.440^2 + .310^2} = .54$$

$$G_V = \pm\sqrt{.164^2 + .063^2} = .18$$

NOTE: $G_{FAULTED}$ = LC #6 OR LC #7 (GREATER)

REMARKS:

H-5

11600.02 NM(B) 382 OZO

Client LILCO Location SHOREHAM PAGE 80

Subject G's ON MOV.

11600.02-NM(B)-254-CEC

Based on

MANUFACTURE'S PRINT: POINT #: 87

PROBLEM #: 0074 RUN #: R0674690

MSK #: AX-7E-3 DATE: 5/27/82

SYSTEM #: 1G41 MOV #: 034B

LINE DESIGNATION #: VALVE #:

ELEVATION: MOV (STEM LENGTH) ' – "

EXPERIENCED ACCELERATED G's FOR LOAD CASE:

	OBE-INERTIA	SSE-INERTIA	SRV-INERTIA *	LOCA-INERTIA
x	.296	.504	1.377	.825
y	.147	.241	.337	.212
z	.264	.457	1.471	.982

COMMENTS:

HORIZONTAL G's

$$G_{FAULTED} = \sqrt{.457^2 + 1.471^2 + .982^2} = 1.8$$

$$G_{UPSET} = \sqrt{.264^2 + 1.471^2} = 1.5$$

VERTICAL G's

$$G_{FAULTED} = \sqrt{.241^2 + .337^2 + .\text{– –}}$$

$$G_{UPSET} = \sqrt{.147^2 + .337^2} = .4$$

Client LILCO Location SHOREHAM PAGE 81

Subject G's ON M.O.V.

11600.02-NM(B)-254-CZC

Based on

MANUFACTURE'S PRINT: POINT #: 142

PROBLEM #: 0074 RUN #: R0674690

MSK #: AX-7E-3 DATE: 5/27/82

SYSTEM #: 1G41 MOV #: 034A

LINE DESIGNATION #: VALVE #:

ELEVATION: MOV (STEM LENGTH) ' - "

EXPERIENCED ACCELERATED G's FOR LOAD CASE:

	OBE-INERTIA	SSE-INERTIA	SRV-INERTIA *	LOCA-INERTIA
x	.252	.420	4.67	1.393
y	.132	.214	.992	.412
z	.251	.390	2.009	.745

COMMENTS:

HORIZONTAL G's

$G_{FAULTED} = \sqrt{.42^2 + 4.67^2 + 1.393^2} = 4.9$

$G_{UPSET} = \sqrt{.252^2 + 4.67^2} = 4.7$

VERTICAL G's

$G_{FAULTED} = \sqrt{.214^2 + .992^2 + .412^2}$

$G_{UPSET} = \sqrt{.132^2 + .992^2} = 1.0$

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

11600.02 NM(B) 382 CZC PAGE 82

5010.65

LILCO - SHOREHAM - #11600.02-NM(B)-254-CZC

G'S - DYNAMIC ACCELERATION AT VALVE OPERATOR C.G.

PROBLEM #: 807 NODE #: 775 BY: E. Rowcot DATE: 12/1/82

AX/MSK #: AX-8H-2 RUN #: R1649367 DATE: 9/24/82

SYSTEM #: 1E11 MARK #: MOV 039B

	G'S FOR LOAD CASE				
	OBE	SSE	SRV	LOCA	AP
X	0.260	0.411	3.997	1.932	0.198
Y	0.278	0.456	3.303	1.717	0.165
Z	0.127	0.199	1.181	0.835	0.066

$G_H = G_X$ OR G_Z (GREATER)

$G_V = G_Y$

UPSET: $G = \text{NORMAL} \pm \sqrt{OBE^2 + SRV^2}$ (LC #2)

$G_H = \pm\sqrt{0.260^2 + 3.997^2} = 4.01$

$G_V = \pm\sqrt{0.278^2 + 3.303^2} = 3.31$

FAULTED: $G = \text{NORMAL} \pm \sqrt{SSE^2 + SRV^2 + LOCA^2}$ (LC #6)

$G_H = \pm\sqrt{0.411^2 + 3.997^2 + 1.932^2} = \boxed{4.46}$

$G_V = \pm\sqrt{0.456^2 + 3.303^2 + 1.717^2} = \boxed{3.75}$

$G = \text{NORMAL} \pm \sqrt{SSE^2 + AP^2}$ (LC #7)

$G_H = \pm\sqrt{0.411^2 + 0.198^2} = 0.46$

$G_V = \pm\sqrt{0.456^2 + 0.165^2} = 0.48$

NOTE: $G_{FAULTED}$ = LC #6 OR LC #7 (GREATER)

REMARKS:

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

H-8

▲ 5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO. 11600.02	DIVISION & GROUP NM(B)	CALCULATION NO. 382	OPTIONAL TASK CODE CZC	PAGE 83

RECALCULATION OF VALVE STRESS WITH THRUST FORCE REMOVED H-8

10" FORGEL BOLTED BONNET NUCLEAR VALVE

****

THRUST

TR = 0.7854 * DIAGL^2 * DELTAP * SEATF + GF

= 0.7854 * 9.689^2 * 575.00 * 0.30 + 3181.00

= ~~15900. LBS~~ = 0 Lbs. NOTE: VALVES 1E11*MOV039A,B AND 1G41*MOV034A,B ARE NORMALLY CLOSE DURING DYNAMIC EVENTS. (ie; SRV, LOCA, SSE)

TORQUE

TQ = 12 * STEM THREAD FACTOR * ~~TR~~

= 12. * 0.0181 * 15900. (**)

= 3457. IN-LBS

MT = ~~TQ~~(**) + P1 * B

= ~~3457.~~ + 2000. * 3.000

= ~~9457.~~ 6000 IN-LBS

(**) THE ABOVE COMPUTED MOV INDUCED THRUST LOAD ON THE VALVE GATE IS REQUIRED TO OVERCOME SEAT FRICTION, PACKING FRICTION, AND LINE PRESSURE WHEN SYSTEM OPERATION REQUIRES OPENING OR CLOSING THE VALVE. SINCE THE VALVES ARE NORMALLY CLOSED DURING DYNAMIC EVENTS, AS STATED ABOVE, THE STEM THRUST FORCE WAS NOT CONSIDERED TO BE SIGNIFICANT TO THE FATIGUE LIFE OF THE VALVE. THEREFORE THIS LOAD COMPONENT IS NEGLECTED.

INTERNAL COUPLE LOADS

P2 = P1 * (L + L1/2) / EAVE

$$= \frac{2000. * (7.375 + 10.750 / 2.)}{7.583}$$

= 3363. LBS

P3 = ~~MT~~ / EAVE

= ~~9457.~~ 6000 / 7.583

= ~~1247.~~ 791 LBS

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 84
11600.02	NM(B)	382	CZC	

10" FORGED BOLTED BONNET NUCLEAR VALVE

****

BENDING MOMENTS

MZP = P1 * L1 / 4
= 2000. * 10.750 / 4.
= 5375. IN-LBS

MZD = (0.50 * (~~TR~~ (**) +PVERT) + P2) * DELTA
= (0.50 *(~~15900.~~ + 0.) + 3363.) * 0.0417
= ~~471.~~ 140 IN-LBS

MZ1 = MZ2 = MZP + ~~MZD~~ 140 (**)
= 5375. + ~~471.~~
= ~~5846.~~ 5515 IN-LBS

MXT = P3 * L1 / 2 (**)
= ~~1247.~~ * 10.750 / 2. = 791 * 10.75/2
= ~~6703.~~ 4251 IN-LBS

MX1P= P1 * L / 2
= 2000. * 7.375 / 2.
= 7375. IN-LBS

MX1 = MXT + MX1P (**)
= ~~6703.~~ + ~~7375.~~ = 4251 + 7375
= ~~14078.~~ 11626 IN-LBS (**)

MX2P= P1 * (L + L1) / 2
= 2000. * (7.375 + 10.750) / 2.
=18125. IN-LBS

MX2 = MXT + MX2P
= ~~6703.~~ +18125. = 4251 + 18125
= ~~24828.~~ 22376 IN-LBS (**)

MX3 = P1 * (L + L1 + L2)
= 2000. * (7.375 + 10.750 + 2.750)
= 41750. IN-LBS

MX4 = P1 * (L + L1 + L2 + L3)
= 2000. * (7.375 + 10.750 + 2.750 + 1.900)
= 45550. IN-LBS

MX5 = P1 * (L + L1 + L2 + L3 + L4)
= 2000. * (7.375 + 10.750 + 2.750 + 1.900 + 5.352)
= 56254. IN-LBS

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11600.02	NM(B)	382	CZC	

10" FORGED BOLTED BONNET NUCLEAR VALVE

****

YOKE PN 89182

SECTION 2 - 2 STRESSES

CASE 1 - LOAD P1 IN X-DIRECTION

- AXIAL STRESS AT POINT 'U' -

SY2 = (0.50 * (~~IR~~+PVERT) + P2) / AREA
= (0.50 *(~~15900~~. + 0.) + 3363.) / 5.625
= ~~2011~~. PSI

SY2Z = MZ2 * C2 / IZZ
= ~~5846~~. * 1.458 /2.6855 = 5515 * 1.458/2.6855
= ~~3175~~. PSI
2994

SYXT = MXT * 0.50 * H2 / IXX
= ~~6703~~. * 0.50 * 1.500 /3.1641 = 4251 * 0.5 * 1.5 /3.1641
= ~~1589~~. PSI
1007

SY = SY2 + SY2Z + SYXT
= ~~2011~~. + ~~3175~~. + ~~1589~~. = 598 + 2994 + 1007
= ~~6775~~. PSI
4600 (**)

- AXIAL STRESS AT POINT 'V' -

SY2 = (0.50 * (~~IR~~+PVERT) + P2) / AREA
= (0.50 *(15900. + 0.) + 3363.) / 5.625
= ~~2011~~. PSI
598 (**)

SY2Z = MZ2 * C1 / IZZ
= ~~5846~~. * 1.042 /2.6855 = 5515 * 1.042/2.6855
= ~~2268~~. PSI
2140 (**)

SYXT = MXT * 0.50 * H1 / IXX
= ~~6703~~. * 0.50 * 3.000 /3.1641 = 4251 * .5 * 3.0/3.1641
= ~~3178~~. PSI
2015 (**)

SY = SY2 + SY2Z + SYXT
= ~~2011~~. + ~~2268~~. + ~~3178~~. = 598 + 2140 + 2015
= ~~7456~~. PSI
4753 (**)

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 86
11600.02	NM(B)	382	CZC	

10" FORGED BOLTED BONNET NUCLEAR VALVE

**** ***** ******** ******* ****** ********************* ******* ******* ********** ***********

SECTION 2 - 2 (CONT'D)

CASE 2 - LOAD P1 IN Z-DIRECTION

- AXIAL STRESS AT POINT 'V' -

SY2 = 0.50 * (~~TR~~+PVERT) / AREA
= 0.50 *(~~15900~~. + 0.)/ 5.625
= ~~1413~~. PSI
0 (**)

SY2X = MX2 * 0.50 * H1 / IXX
= ~~24028~~. * 0.50 * 3.000 /3.1641 = 22376*.5*3.0/3.1641
= ~~11770~~. PSI
10607 (**)

SY = SY2 + SY2X
= ~~1413~~. + ~~11770~~. = 0 + 10607
= ~~13184~~. PSI
10607 (**)

MAXIMUM SY @ SECTION 2-2 = ~~13184~~. PSI
10607

SHEAR STRESSES

ST2 = (0.50 * P1 + P3) / AREA
= (0.50 * 2000. + ~~1247~~.) / 5.625
791
= ~~399~~. PSI
318

PRINCIPLE STRESS & STRESS INTENSITY

$$SIGMA1,SIGMA2 = (SY/2) \pm SQRT [(SY/2)^2 + ST2^2]$$

$$= (\cancel{13184}./2.) \pm SQRT [(\cancel{13184}./2.)^2 + \cancel{399}.^2]$$

10607 10607 318

SIGMA1 = ~~13196~~. PSI = 10616
SIGMA2 = ~~-12~~. PSI
-9.5

S12 = SIGMA1 - SIGMA2
= ~~13196~~. - (~~-12~~.) = 10616 - (-9.5)
= ~~13208~~. PSI
10625 (**)

ALLOWABLE STRESS INTENSITY = 26250. PSI (REF:PAGE 6)

~~13208~~. < 26250.
10625

CONDITION SATISFIED

STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

H12

5010.65

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 86 A
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STRESS INTENSITY DUE TO STEM THRUST ONLY

THE FOLLOWING CALCULATIONS ESTABLISH THE CONTRIBUTION OF THE STRESS ASSOCIATED WITH STEM THRUST LOAD TO THE TOTAL YOKE STRESS.

THRUST

$TR = 15900$ #

TORQUE

$TQ = 12 * \text{STEM THREAD FACTOR} * TR$

$TQ = 12 \times 0.0181 \times 15900 =$

$= 3457$ IN-LBS

$MT = TQ + \cancel{PT} \cancel{*8} = 3457$ IN-LB.

INTERNAL COUPLE LOADS

$P_3 = MT / EAVE = 3457 / 7.583 = 456$ LBS

BENDING MOMENTS

$MZD = 0.5 \times TR \times 0.0417 = 0.5 \times 15900 \times 0.0417 = 331$ IN-LB

$MZ2 = MZ1 = MZD = 331$

$MXT = P3 \times L1/2 = 456 \times 10.75/2 = 2451$ IN-LB.

$MX1 = MXT = 2451$ IN-LB

$MX2 = MXT = 2451$ IN-LB.

CALCULATION IDENTIFICATION NUMBER				
J.O. OR W.O. NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 86B

SECTION 2-2 STRESSES

CASE I - LOAD P1 IN X-DIRECTION

-AXIAL STRESS AT POINT "U"

SYZ = .5 × TR/5.625 = 1413 PSI

SYZZ = MZZ × C2/IZZ = 331 × 1.458/2.6855 = 179 PSI

SYXT = MXT × 0.5 × H2/IXX = 2451 × 0.5 × 1.5/3.1641 = 581 PSI

SY = 1413 + 179 + 581 = 2173 PSI.

-AXIAL STRESS AT POINT "V"

SY2 = 0.5TR/5.625 = 1413 PSI

SYZZ = MZZ × C1/IZZ = 331 × 1.043/2.6855 = 128 PSI

SYXT = MXT × 0.5 × H1/IXX = 2451 × 0.5 × 3/3.1641 = 1162 PSI

SV = SYZ + SYZZ + SYXT = 1413 + 128 + 1162 = 2703 PSI MAX

CASE 2 - LOAD P1 IN Z-DIRECTION

-AXIAL STRESS AT POINT "V"

SY2 = 0.5 × TR / AREA = 0.5 × 15900/5.625 = 1413 PSI

SY2X = MX2 × 0.5 × H1 / IXX = 2451 × 0.5 × 3/3.16 = 1162 PSI

SY = SY2 + SY2X = 1413 + 1162 = 2575 PSI

SHEAR STRESSES

ST2 = P3 / AREA = 456 / 5.625 = 81 PSI

PRINCIPLE STRESS & STRESS INTENSITY

SIGMA1, SIGMA2 =

$$\left(\frac{S_y}{2}\right) \pm SQRT\left[\left(\frac{S_y}{2}\right)^2 + \cancel{S_T 2^2}\right]$$ NEGLECTED

$$SIGMA1 = \frac{2703}{2} + \frac{2703}{2} = 2703 \text{ PSI}$$

$$SIGMA2 = \frac{2703}{2} - \frac{2703}{2} = 0$$

$$S_{12} = SIGMA1 - SIGMA2$$

$$= \underline{\underline{2703 \text{ PSI}}}$$

S12 IS WELL BELOW THE ENDURANCE LIMIT.

SHOREHAM NUCLEAR POWER STATION - UNIT #1
FATIGUE EVALUATION OF COMPONENTS QUALIFIED BY TEST

Supplement No. 3 to the Shoreham Safety Evaluation Report (Ref. 1) addresses the subject of seismic and dynamic qualification of safety-related equipment. It was requested therein (Item 8.b) that clarification be provided "of how the fatigue testing was actually conducted in assuring that TRS's envelop RRS's and that the input loads cover sufficient duration and number of SRV cycles which have been defined." That clarification is provided herein.

It is first noted that, with few exceptions, "fatigue testing" has not been performed for Shoreham equipment. It is a requirement that the amplitude and frequency content of test acceleration inputs bound Shoreham requirements for combined seismic and hydrodynamic loads. Also, for tests performed since SRV loads have been defined, the required test duration has generally been increased from a minimum of 15 sec/axis/test to typically 30 sec/axis/test to account for additional SRV cycles. Here "test" refers to each of the five OBE (or upset events) and the one SSE (or faulted event) to give a total of 180 sec/axis.

In order to further quantify the number of equivalent SRV cycles achieved, a detailed analysis of an actual Shoreham test acceleration time history has been performed. The objective of the analysis was to calculate the fatigue damage to a family of idealized components due to the test time history and compare to the calculated fatigue damage to the same components due to the expected number of SRV actuation events in Shoreham. The equivalent number of SRV cycles inherent in the test can be inferred from this comparison.

The primary assumption made in the analysis is that for a comparison of test and SRV event fatigue effects, equipment components can be idealized as linear single degree of freedom oscillators. With this assumption, fatigue damage is calculated as described below.

First a family of oscillators was selected. The oscillators were chosen to have frequencies in the ranges of Shoreham SRV response spectra peaks, i.e., 8 Hz, 18H, and 30 Hz; and also at 50 Hz which is generally above the range of SRV resonances.

Each of these oscillators was then subject to one or more calculated reactor building SRV acceleration time histories. The input building time histories used were three representative time histories factored up such that their resultant response spectra would bound all reactor building spectra within the frequency range of the oscillator being analyzed. Output displacement time histories were then calculated for the oscillators with 2% damping and the peak output displacements were then assumed to correspond to a component stress of 30 ksi as a reference point.

The same oscillators were then subject to six typical one second segments of an actual Shoreham test acceleration time history (Ref. 2). The peak output displacements were then multiplied by the ratio of assumed SRV peak stress to calculated SRV peak displacement to arrive at a relative peak stress due to the test time history.

The test displacement (or stress) time histories were then searched for peaks (first derivative zero, second derivative non-zero) and each pair of peaks was taken as one half of a fatigue cycle. From the mean stress and alternating stress range for each half cycle, an allowable number of cycles is found using a set of fatigue damage curves based on figure I-9.1 of ASME III. A discussion of the approach used to generate the fatigue damage curves may be found in reference 3, page 270, in which the concept of constant fatigue damage curves is discussed.

The net usage factor is then calculated to be:

$$U_{net} = \sum_{\text{all pairs}} 0.5/N_{allowable}$$

The equivalent number of cycles at the peak SRV stress level is then calculated to be:

$$N_{SRV\ cycles} = U_{net} \times N_{allowable\ at\ SRV\ stress}$$

This number, associated with 6 seconds of test input, is then multiplied by 30 to account for a total of 180 seconds of testing (for each axis). This number ranged from 1.2×10^6 to 11.4×10^6 for the idealized components analyzed.

The equivalent number of SRV cycles in the test must then be compared to the required number for Shoreham. The Shoreham plant is expected to experience 253 SRV all valve actuation events and a large number of single valve subsequent actuation events. Analysis of these smaller amplitude events has concluded that they are equivalent to approximately 650 all valve events leading to a total number of 900 used for design. The number of stress cycles per event has been found to be generally proportional to the frequency of component response, i.e., f/3. The total number of stress cycles, therefore is 900 (f/3). For the idealized components analyzed this number ranged from 2,400 to 15,000.

For all cases analyzed, the ratio of test cycles to required cycles ranged from 150 to over 2000 or a minimum factor of safety of 150.

On this basis it is concluded that typical Shoreham test time histories have a more than sufficient number of equivalent SRV cycles to cover Shoreham requirements.

References

1. "Supplement No. 3, Safety Evaluation Input for Shoreham Unit 1, Docket No. 50-322, Equipment Qualification Branch", December 27, 1982.

2. Shake Table Qualification Acceleration Time History for the Kaman KDA-HR Detector. Transmitted to Stone & Webster Engineering Corp. from Acton Environmental Testing Corporation via letter dated April 22, 1983.

3. "Engineering Considerations of Stress, Strain and Strength", R.C. Juvinall, McGraw Hill Book Co. 1967.

SHOREHAM NUCLEAR POWER STATION

SHOREHAM CATEGORY I EQUIPMENT CHANGE RECORD
STONE AND WEBSTER ENGINEERING CORPORATION

CURRENT DATE 06-21-83

DOCUMENT #	DATE OF ISSUE	EQUIP. AFFECTED	NATURE OF CHANGE	EFFECT ON SEISMIC QUAL.
F-42213	09-08-82	1H21*PNL-060	ADDITIONAL RELAYS TO BE ADDED TO CAT.I PANEL	MASS OF ADDED RELAYS NEGLIGIBLE-NONE
F-40426J	09-09-82	1D11*PNL-021	ATTACHMENTS TO SKID /RAD. MONITOR. SYS.	MASS OF ATTACHMENTS NEGLIGIBLE-NONE
P-3930M	09-27-82	1H21*RK-40,41	CLEARANCE PROB. FOR O2 BOTTLE RACKS	MODIFICATION INCORPORATED INTO CALC 341-CZC-NONE
F-42825	09-30-82	1Z97*PNLER1-6	ADDITIONAL SUPPORT FOR MODULE CASES TO CONFORM WITH TEST MOUNTING CONDITIONS-CAT. 1 PANEL	APPROVED BY CALC. 292-CZC-009 - NONE
P-3930L	10-05-82	1H21*RK-40,41	SUPPORT OF 'MARANITE I' FIRE BARRIER	SMALL PLATES ADDED TO FRAME -NO IMPACT TO QUALIFICATION (CALC 341-CZC)
F-18681B	10-07-82	1R24*MCC-1119	ATTACHMENT OF 1" DIAMETER CONDUIT	MASS OF ADDED CONDUIT NEGLIGIBLE- NONE(CALC 311-CZC)
F-43143	10-28-82	1T47*UC-17A,B	NOZZLE SUPPORT FOR UNIT COOLER	APPROVED BY CALC. # 356-HZ -NONE
F-39452E	11-04-82	1D11*PNL-21,22	1" DIAMETER CONDUIT ATTACHMENT TO CAT. I PANELS	FLEX CONDUIT USED ON ALL CONNECTIONS-NONE(CALC 311-CZC)
F-43727	11-09-82	1T48*RC-002A&B	ATTACH SM BORE SUPPT TO RECOMBINER FRAME	MASS OF SUPPORT NEGLIGIBLE-(CALC. #292-CZC-008)-NONE
F-42897	11-12-82	1H11*MCB-01	BATTERY CHARGE/DISCHARGE AMMETERS ADDED TO MAIN CONTROL BOARD	MASS OF AMMETER NEGLIGIBLE-NONE
F-29608A	12-15-82	1P50*PS-113A *PS-113B *PS-105A *PS-105B 1P50*PT-116A *PT-116B *PT-111A *PT-111B 1C61*PT-106	INSTR. STD ATTACHED TO STRUCTURAL PLATFORM	APPROVED BY CALC 363-CZC

DOCUMENT #	DATE OF ISSUE	EQUIP. AFFECTED	NATURE OF CHANGE	EFFECT ON SEISMIC QUAL.
F-40156C	12-09-82	1Z97*PNL-ER1 -ER2 -ER3	ADD TERMINAL STRIPS TO FRAME OF PANEL	MASS OF TERMINAL STRIPS NEGLIGIBLE(CALC.# 292-CZC-009) -NONE
P-39300	12-09-82	1H21*RK-40 -41 -42 -43	APPROVE GRINDING OF FRAME FOR INSTALL. OF HYDRO. BOTTLES	APPROVED BY CALC 341-CZC -NONE
F-44635	01-07-83	1G33*FT-012	INSTRUMENT STD.-BASE PLATE MODIFICATION	LARGER PL & BOLT PATTERN USED/APPROVED BY CALC. 292-CZC -NONE
N&D 5520	02-08-83	1B21*HSR-21	GAP REQUIREMENTS	APPROVED BY CALC.# 332-JE 052 -NONE
N&D 5554	02-08-83	1G33*PRR-07	BRACING MODIFICATION, WELD CLARIFICATION	LARGER SECTION INSTALLED THAN REQ'D -NONE
F-43822A	03-04-83	1T48*PNL-068A 069A	TUBE SUPPORT ATTACHMENT TO CAT 1 PANEL	APPROVED BY CALC. 292-CZC-001 -NONE
F-45139	04-07-83	1T48*PNL-068A -068B -069A -069B	TUBE SUPPORT ATTACHMENT TO CAT 1 PANEL	APPROVED BY CALC. 292-CZC 001 -NONE
F-43143D	05-09-83	1T47*UC-17A&B	UNIT COOLER NOZZLE SUPPTS	APPROVED BY CALC. #356-HZ -NONE
F-22727C	05-19-83	1H43*PNL-C01A -C08/11	C02 STAND SUPPORT INTERFERENCE	APPROVED BY CALC. 289-CZC -NONE

SHOREHAM NUCLEAR POWER STATION

SHOREHAM CATEGORY I EQUIPMENT CHANGE RECORD
STONE AND WEBSTER ENGINEERING CORPORATION

CURRENT DATE 06-21-83

DOCUMENT #	DATE OF ISSUE	EQUIP. AFFECTED	NATURE OF CHANGE	EFFECT ON SEISMIC QUAL.
F-44182	11/29/82	(NSSS)STEAM DRYER/ SEPARATOR - SLING/ HEAD STRONGBACK	ADDS REDUNDANCY AT THE POLAR CRANE INTERFACE	NONE-APPROVED BY CALC 309-HF
F-44890	01/26/83	(NSSS) MSIV VALVES	CHANGE ON NAMCO LIMIT SWITCHES	NONE-ITEMS REPLACED WITH QUALIFIED ITEMS
F-44170A	12/28/82	(NSSS)PANELS 1H21*PNL-04,05,09,10	REPLACE EXISTING LEVEL & PRESS. TRANSMITTER MODELS WITH ROSEMOUNT 1153 SERIES	NONE-ITEMS REPLACED WITH QUALIFIED ITEMS
F-32306	12/30/80	(NSSS)PANELS 1H21*PNL-635,636	ADD PWR SUPPLY FOR ROSE-MOUNT TRIP UNITS MODEL # 510DU	NONE-ADDED ITEMS ARE QUALIFIED
F-32232	12/02/80	(NSSS)PANELS 1H11*PNL-601	ADD ROSEMOUNT TRIP UNIT MODEL #510DU	NONE-ADDED ITEMS ARE QUALIFIED
P-4429	05/18/83	1D11*RE-062	REPLACE #440 ST. STEEL NUT WITH A NYLON LINED LOCKING NUT	NONE-REPLACEMENT IMPROVES THE MOUNTING CONDITION.

SHOREHAM CATEGORY I EQUIPMENT CHANGE RECORD
GENERAL ELECTRIC COMPANY

Document # (FDI/FDDR)	DATE OF ISSUE	EQUIP. AFFECTED	NATURE OF CHANGE	EFFECT ON SEISMIC QUAL.
KS-01-1127	11/3/82	1B21*AOV81/82	Replace limit switches	New limit switches qualified by test
121-88524 Rev. 1	9/23/82	IE51*TU005	Modify hardware	Modifications made to conform Shoreham RCIC turbine to tested turbine
KS-01-2144	11/11/82	1H11*PNL602	Add relays	Relays identical to other qualified relays
KS-01-2148	1/12/83	1H21*PNL009/010/ 004/005	Change pressure transmitters	New transmitters do not affect the qualification of the panel
TFHN	9/20/82	IE32*PDT038	Relocate device from rack to ship loose mounting	Device qualified at new location
KS-01-2160 Rev. 1	4/22/83	1H21*PNL004	Change pressure transmitter	New transmitter does not affect the qualification of the panel.
KS-01-2196	4/20/83	1H11*PNL654	Change relay	New relay qualified by test
KS-01-782	11/14/80	1H11*PNL601	Add Rosemount trip unit model #510DU	New unit does not affect the qualification of the panel
KS-01-792	11/14/80	1H11*PNL635,636	Add power supply for Rosemount trip unit model #510DU	New power supply does not affect qualification of the panel

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