SUPPLEMENTARY REPORT FOR THE
UNRESOLVED ISSUES OF R. E. GINNA
STORAGE TANKS SEISMIC QUALIFICATION


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# SUPPLEMENTARY REPORT FOR THE UNRESOLVED ISSUES OF R. E. GINNA STORAGE TANKS SEISMIC QUALIFICATION

Prepared for

ROCHESTER GAS & ELECTRIC CORPORATION
89 East Avenue
Rochester, New York

September 1984

Prepared by

STEVENSON & ASSOCIATES
458 Boston Street
Topsfield, Massachusetts

# CERTIFICATION

The undersigned, a registered Professional Engineer, competent in the field of component stress analysis, certifies that to the best of his knowledge and belief the analysis calculations for the subject tanks as presented in this seismic stress report comply with the provisions of the applicable portions of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components and standard acceptable engineering practice.

Components: Refueling Water Storage Tank and Horizontal Waste Hold-up Tank
Plant: R. E. Ginna

COMMONWEALTH OF MASSACHUSETTS
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SUPPLEMENTARY REPORT FOR THE

UNRESOLVED ISSUES OF R. E. GINNA

STORAGE TANKS SEISMIC QUALIFICATION

Revision 0, September 1984

Prepared by ______________________
Tsi-Ming Tseng

Reviewed by ______________________
Walter Djordjevic

Approved by ______________________
Walter Djordjevic

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# 1. INTRODUCTION

The seismic qualification for the storage tanks at the R. E. Ginna nuclear power plant has been performed by Stevenson & Associates in References 1 to 3. The storage tanks analyzed are the Refueling Water Storage Tank (RWST), Vertical Hold-up Tanks, and the Waste Hold-up Tank. A review of the Stevenson & Associates qualification reports has been conducted by Structural Mechanics Associates, Inc. (Ref. 4) in support of EG&G Idaho, Inc. The solutions to some of the issues raised in the review and the analysis of RWST under external nozzle loads are presented in this report.

Section 2 of this report contains the summary of the results. Section 3 presents the analysis procedure and results for the nozzle load analysis. Section 4 shows that the shear cone pull-out capacity is greater than then yielding capacity of the anchor bolts. Section 5 provides an alternative analysis for the Waste Hold-up Tank for which peak of the response spectra is used for the transverse direction seismic response.

## 2. SUMMARY OF RESULTS

The results of the nozzle analysis indicate that the 10-inch nozzle near the base of the RWST resist the combination of the deadweight, injection phase loading, and the SSE loading within the limits of the acceptance criteria. The minimum factor of safety is 1.35.

The analysis of the shear cone pull-out capacity indicates that the previous analysis based on yielding failure of the anchor bolts is satisfactory. The strength of concrete shear cone pull-out is much greater than the yield strength of the anchor bolt.

The re-analysis for the Waste Hold-up Tank based on the peak of the spectra shows that the stresses are still within the acceptance criteria. This is because the transverse direction is less critical for the stresses concerned. The effect of non-full tank conditions are also considered. The results show that full tank is the most critical condition due to the low frequencies associated with the sloshing modes.

## 3. NOZZLE LOAD ANALYSIS FOR RWST

The nozzle considered is the 10-inch butt welding nozzle near the base of the RWST. Both the tank shell and the reinforcing plate have a thickness of 5/16-inch.

### Loads

External piping loads due to deadweight, injection phase, and safe shutdown earthquake (SSE) are considered. The magnitude of the loads is provided by RG&E in Ref. 5 and is tabulated in Table I.

The stresses in the tank wall due to hydrostatic pressure and SSE seismic loads are also considered and combined with the piping loads.

### Acceptance Criteria

The acceptance criteria for the analysis is based on ASME Pressure Vessel & Piping code, Section III, Division I, Subsection NC-3867. The stresses calculated are:

- Primary membrane stresses due to internal pressure
- Primary membrane stresses due to tank seismic response
- Local membrane stresses due to external piping loads

Peak stresses due to stress concentration at the corners and the local bending stresses due to external piping loads are not calculated since fatigue need not be considered in seismic qualification.

The allowable stress is 2.4S according to the code. From the value of S given in Ref. 1, the allowable stress is

Allowable stress = 2.4 x 17.8 = 42.7 ksi

### Analysis Procedure and Results

Stresses in the tank wall due to hydrostatic pressure and tank SSE response are obtained from Ref. 1.

The local membrane stresses due to external piping loads are calculated using the Bijlaard's method (Ref. 6). The stresses at eight response points are calculated (see the figure in Table II). For locations immediately adjacent the nozzle, a tank wall thickness of 5/8-inch is used in the analysis. For locations at the junction of the reinforcing plate and the vessel, the nozzle diameter is taken to equal the dimensions of the reinforcing plate while using 5/16-inch as the tank wall thickness. This procedure is suggested by Bijlaard in Ref. 7 and 8 for cases with reinforcing pads and has been shown to yield conservative results.

The resulting maximum principal stresses and the safety margins are summarized in Table II.

| Types of Loading | Forces (kips) | | | Moments (in-kips) | | |
|---|---|---|---|---|---|---|
| | FX | FY | FZ | MX | MY | MZ |
| Deadweight | 0.01 | 0.15 | 0.02 | -0.2 | 2.0 | -1.7 |
| Injection Phase | -0.32 | 2.54 | -0.11 | -3.1 | -9.6 | -60.7 |
| SSE | 1.54 | 0.44 | 2.24 | 16.2 | 113.0 | 10.5 |

TABLE I External Piping Loads

| Location | Maximum Principal Stress (ksi) | Factors of. Safety |
|---|---|---|
| A | 14.7 | 2.9 |
| B | 14.4 | 3.0 |
| C | 12.6 | 3.4 |
| D | 12.3 | 3.5 |
| A' | 31.6 | 1.35 |
| B' | 30.7 | 1.39 |
| C' | 26.0 | 1.64 |
| D' | 25.5 | 1.67 |

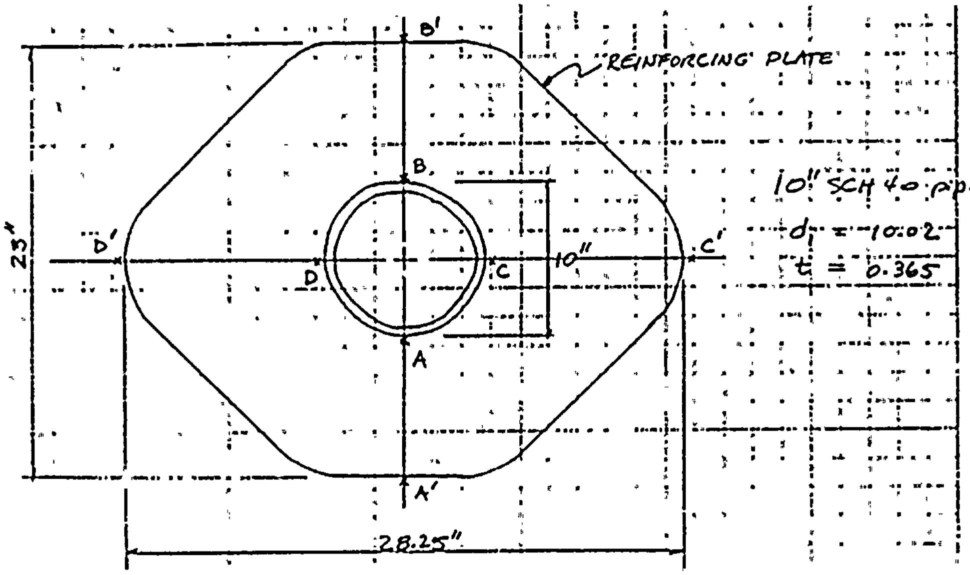


TABLE II Maximum Pricipal Stresses and Safety Margins

4. ANCHOR BOLT SHEAR CONE PULL-OUT CAPACITY

In the previous analysis report for RWST (Ref. 1), The capacity of the base anchor bolts is assumed to be governed by the yielding of the anchor bolts. The allowable load for one bolt is equal to 132 kips. There has been questions as to whether the capacity may be governed by the pull-out of the concrete shear cone.

Based on ACI 349-77, Appendix B, and taking into account the reduction of capacity due to overlapping of adjacent shear cones, the allowable load for one bolt is 312 kips. This verifies the validity of the previous analysis.

[illegible]

## 5. ALTERNATIVE ANALYSIS FOR THE WASTE HOLDUP TANK

In the previous qualification report for the Waste Holdup Tank (Ref. 3), the fundamental frequency for the tank in the transverse direction had been calculated and was shown to be rigid. The review by SMA (Ref. 4) questioned the validity of the calculation and suggested that the fundamental frequency would occur at a lower frequency.

Due to the complex geometry of the structure, the basic assumptions in the approximate analytical analysis cannot be easily justified save for a full scale finite element analysis. An alternative analysis procedure, using 1.5 times the peak of the response spectra at 7% damping as the applied lateral load, is performed for the transverse direction seismic response. The resulting stresses are summarized in Table III, where all the stresses are the same as in Ref. 3 except that the stresses due to transverse earthquake are increased by the new spectral acceleration. The results show that the stresses are still well within the allowable level even with the conservative spectral acceleration assumed. This is because the transverse direction is by far the less critical direction for the stresses concerned.

The effects of sloshing for partially full tanks are also evaluated. The frequencies for the Waste Holdup Tank with water levels of 1/4, 1/2, and 3/4 depth are calculated based on the figures in Ref. 9. The frequencies are 0.40, 0.44, and 0.54 Hz in the transverse direction and 0.12, 0.18, and 0.23 Hz in the longitudinal direction. The corresponding spectral accelerations at 0.5% damping are 0.109, 0.116, and 0.134 g in the transverse direction. Since these spectral accelerations are far less than the accelerations considered for the full tank case, it is concluded that the full tank is the most critical condition for stress evaluation.

| Component | Maximum Stress (ksi) | Allowable Stress (ksi) | Safety Factor |
|---|---|---|---|
| TANK WALL | | | |
| Membrane Stress | 5.9 | 35.6 | 6.0 |
| Local Bending Stress | 65 | 80 | 1.23 |
| Ring Compression | 11.9 | 35.6 | 2.99 |
| SPHERICAL HEAD | | | |
| Membrane Tension | 1.2 | 35.6 | 30 |
| ANCHOR BOLTS | | | |
| Tensile Stress | 23.5 | 40.6 | 1.73 |
| SADDLE SUPPORT | | | |
| Tension in Flange | 1.0 | 24 | 24 |
| Flange Bending | 35.5 | 39.6 | 1.12 |
| Web Compression | 1.6 | 45 | 28 |
| Center Stiffener | 4.0 | 36 | 9.0 |
| End Stiffener | 5.2 | 36 | 6.9 |
| WELDING | | | |
| Tank-Saddle | 10.5 | 36 | 3.4 |

TABLE III Calculated Maximum Stresses and Safe Margins

## 6. REFERENCES

1. Stevenson & Associates, "Seismic Qualification Report for the Refueling Water Storage Tank at the R. E. Ginna Plant," prepared for Rochester Gas & Electric Corporation, August 1983.

2. Stevenson & Associates, "Seismic Qualification Report for Vertical Hold-up Tanks at the R. E. Ginna Plant," prepared for Rochester Gas & Electric Corporation, September 1983.

3. Stevenson & Associates, "Seismic Qualification Report for the Waste Hold-up Tank at the R. E. Ginna Plant," prepared for Rochester Gas & Electric Corporation, September 1983.

4. D. A. Wesley, "Review of the Seismic Qualification of the R. E. Ginna Storage Tank Seismic Qualification for the Systematic Evaluation Program (SEP)," prepared for EG&G Idaho, Inc., June 1984.

5. Stevenson & Associates document 83C2209-LR-001.

6. K. R. Wichman, A. G. Hopper, and J. L. Mershon, "Local Stresses in Sherical and Cylindrical Shells due to External Loadings," Welding Research Council Bulletin 107, August 1965, (Revised March 1979).

7. P. P. Bijlaard, "Stress from Radial Loads in Cylindrical Pressure Vessels," Welding Research Supplement, Vol. 33, No. 12, 1954, pp. 615s-623s.

8. P. P. Bijlaard, "Additional Data on Stresses in Cylindrical Shells Under Local Loading," Welding Research Council Bulletin 50, May 1959, pp.10-50.

9. H. N. Abramson, "The Dynamic Behavior of Liquids in Moving Containers," NASA SP-106, 1966.

# 7. APPENDIX -- Analytical Calculations

SYSTEM: GINNA Water Tanks

COMPONENT NAME: RWST Waste Holdup Tank COMPONENT №: N/A

LOCATION: Aux. Building ELEVATION: 236 ft

COMPONENT SAFETY FUNCTION: ACTIVE ☐ PASSIVE 1 ☐ 2 ☒

S-LIST PAGE №: N/A

METHOD OF ANALYSIS: Analytical Stress Analysis

SPECTRAL CURVES USED: R.E. Ginna Site Specific Ground Spectra contained in 83C2209-DR-005, File 3

DAMPING VALUE ASSUMED: 7 %

ACCEPTANCE BEHAVIOR CRITERIA USED: ASME B&PV code, Section III, 1980, ACI 349-77, Appendix B,

COMPUTER CODE USED: N/A

REMARKS:

| | | | | |
|---|---|---|---|---|
| S&A | DESIGN REPORT COVER SHEET<br>FIGURE 9.0 | CONTRACT №<br>83C2209 | REV. № | 0 |
| | | | BY | TMT |
| | | | DATE | 9/4/84 |
| | | | CHK'D | WD |
| | | | DATE | 9/?/84 |
| | | | APPR. | WD |
| | | | DATE | 9/?/84 |

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INTRODUCTION

The objective of this calculation is to settle the unresolved issues of S&A project 83C2209 — Qualification of RWST, Vertical holdup tanks, and waste holdup tank at R.E. GINNA power plant. The issues discussed are based on the conference phone conversation on August , 1984.

Three goals are to be achieved in this calc.

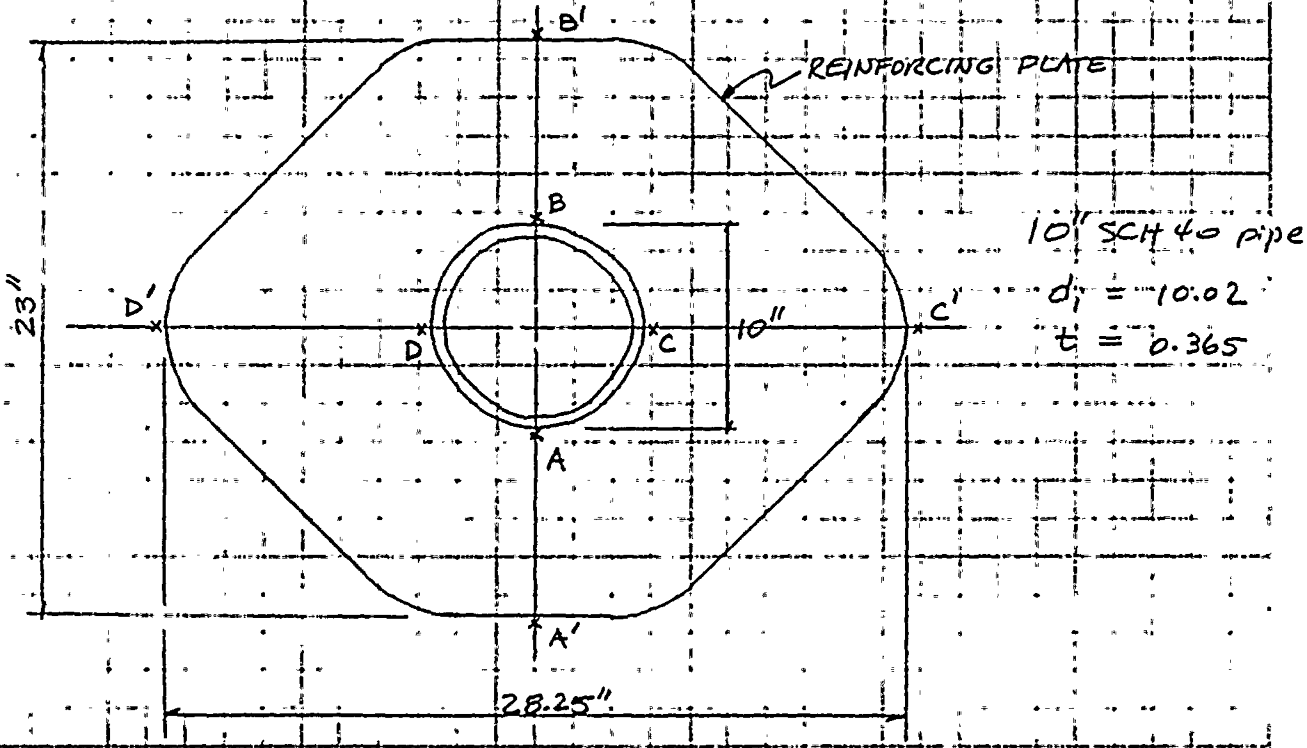
1. Qualify RWST subject to external piping nozzle loads.

2. Verify that the concrete pull-out capacity of the anchor bolts at the base of the RWST is greater than the allowable yield stress. This ensures the factor of safety calculated previously is the minimum.

3. Provide an alternative analysis for the transverse response of the waste holdup tank using peak of the spectra, and thus skirt the calculation of fundamental frequency.

RWST NOZZLE LOAD ANALYSIS

The nozzle considered is the 10" butt welding nozzle near the bottom of the RWST. The details of the pipe-tank connection is shown on the next page. The tank wall thickness is 5/16 inch at the location, where the nozzle opening is reinforced by a 5/16" plate of the shape as shown in the figure below:

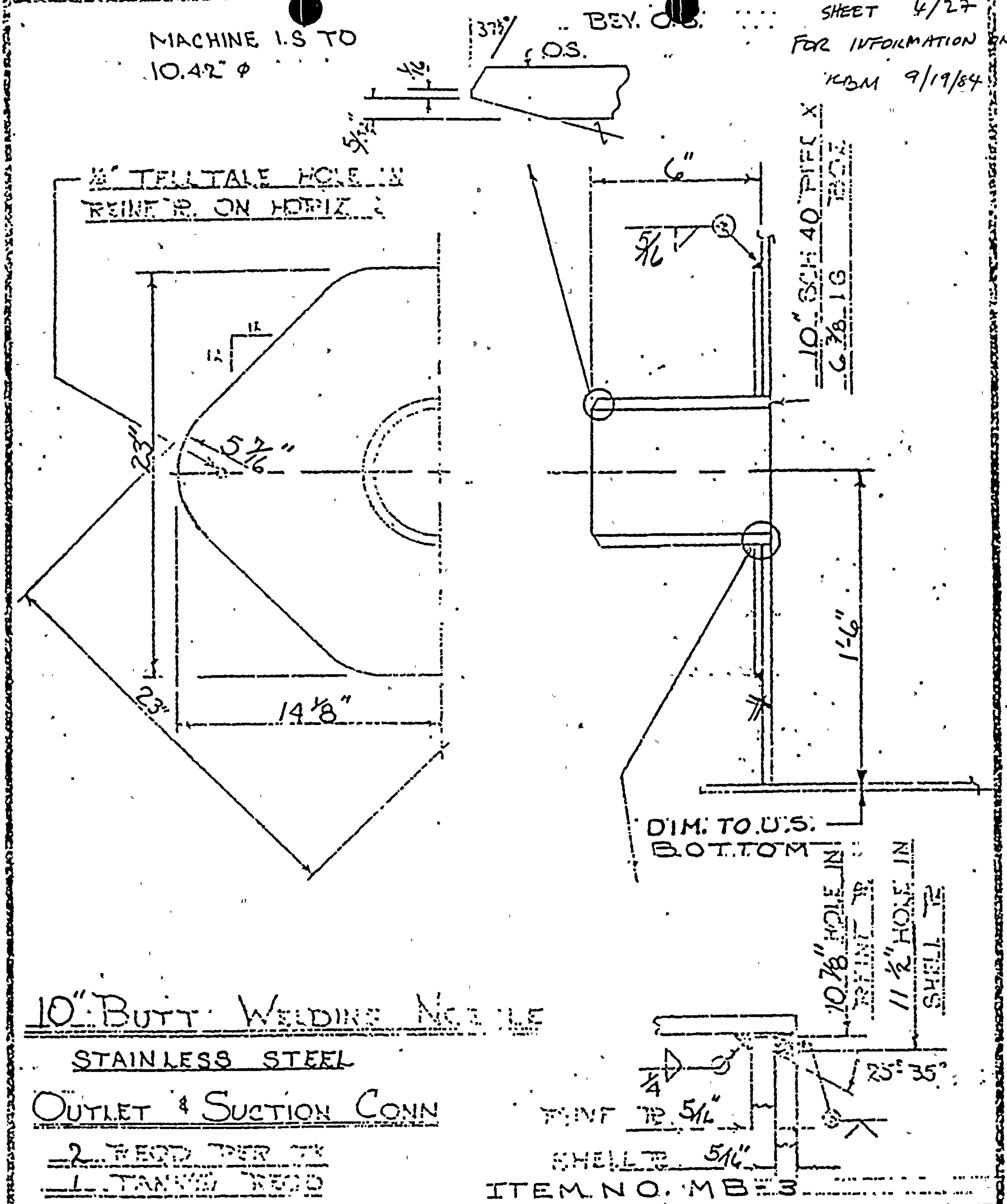



Bijlaard analysis is performed based on the graphs in Ref. 1. Eight stress points are checked:

Points A, B, C, D at junction of nozzle and reinforcing plate

Points A', B', C', D' at junction of reinforcing plate and tank wall.

4 2 0 4 5 9 1

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## LOADS

- External loads from piping include:
  - Deadweight
  - Injection phase
  - SSE

The magnitude of the loads is provided in S&A QA file 83C2209-LR-001

| | FX | FY | FZ | MX | MY | MZ |
|---|---|---|---|---|---|---|
| Deadweight | 0.01 k | 0.15 | 0.02 | -0.2 k-in | 2.0 | -1.7 |
| Inj. phase | -0.32 | 2.54 | -0.11 | -3.1 | -9.6 | -60.7 |
| SSE | 1.54 | 0.44 | 2.24 | 16.2 | 113.0 | 10.5 |

Since the directions of the deadweight and the injection phase load are fixed, the two loads are summed algebraically. The induced stresses are calculated on standard Bijlaard analysis forms.

The stresses induced by SSE are also calculated on standard Bijlaard analysis forms, however, the stresses due to different component of loads are combined by the SRSS rule. Since the seismic load can act in both directions, the final stress values are the sum of the absolute values of the deadweight + injection phase loads and the SSE loads.

- Besides the above external loads, stresses in the RWST tank wall due to internal pressure and SSE response will also be considered.

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SUBJECT: RWST NOZZLE LOADS
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## ACCEPTANCE CRITERIA

The acceptance criteria will be based upon ASME Pressure Vessel and Piping code, Section III, Division I, Section NC-3867 (b). The stresses calculated are:

- primary membrane stresses due to internal pressure
- primary membrane stresses due to tank seismic response
- local primary membrane stresses due to external piping loads.

Peak stresses due to stress concentration at the corners and the local bending stresses (secondary stresses) due to external piping loads will not be considered since fatigue is not of concern in seismic analysis.

The allowable stress, according to NC-3867 (b), is 2.4S. S has been calculated in the previous RWST report, S = 17.8 ksi. Thus

Allowable stress = 2.4 × 17.8 = 42.7 ksi

STRESS CALCULATIONS

The maximum membrane stresses in the unreinforced tank wall are, from the previous report,

| | | Dead load | Seismic |
|---|---|---|---|
| Hoop stress | $\sigma_\phi$ | 17.7 ksi | 4.7 |
| Axial stress | $\sigma_x$ | 0.2 | 11.7 |
| Shear stress | $\tau_{\phi x}$ | 0 | 3.2 |

At the reinforcing plate, these stresses are 1/2 of the above.

The local membrane stresses due to piping loads are calculated by Bijlaard's method in pages 8-15. For locations just next to the nozzle, i.e., points A, B, C, D, the analysis is made as if the tank wall having a thickness of 5/8 inch. For locations at the junction of the vessel and the reinforcing plate (points A', B', C', D') the nozzle diameter is taken as equal to the dimension of the reinforcing plate, while original tank thickness 5/16 inch is used. This procedure is recommend by Bijlaard in Ref. 2 and 3 and has been shown to be conservative.

For convenience, the sign of deadweight + injection phase loads have been changed. The parameter $\gamma$ for points A', B', C', and D' is 509 which is outside the charts provided in Reference 1. The data was extrapolated on the log-log scale.

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RWST NOZZLE LOADS

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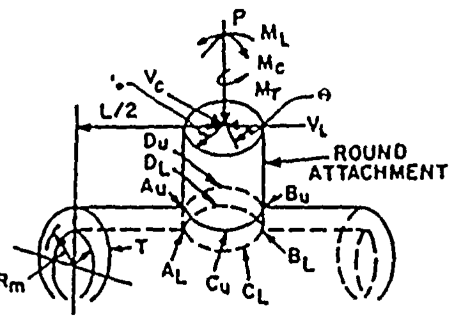
DEAD WEIGHT + INJECTION PHASE

LOCATIONS : A, B, C, D

**Table 5—Computation Sheet for Local Stresses in Cylindrical Shells**

1. Applied Loads*
   - Radial load, $P = 310$ lb.
   - Circ. Moment, $M_c = 7600$ in. lb.
   - Long. Moments, $M_L = 62400$ in. lb.
   - Torsion Moment, $M_T = 3300$ in. lb.
   - Shear Load, $V_c = 90$ lb.
   - Shear Load, $V_L = 2650$ lb.
2. Geometry
   - Vessel thickness, $T = 0.625$ in.
   - Attachment radius, $r_o = 5.38$ in.
   - Vessel radius, $R_m = 159$ in.
3. Geometric Parameters
   - $\gamma = \frac{R_m}{T} = 254$
   - $\beta = (0.875)\frac{r_o}{R_m} = 0.03$
   - Stress Concentration due to:
     - a) membrane load, $K_n$ = 1.0
     - b) bending load, $K_b$ = ___

*NOTE: Enter all force values in accordance with sign convention




CYLINDRICAL SHELL

| From Fig. | Read curves for | Compute absolute values of stress and enter result * | Au | AL | Bu | BL | Cu | CL | Du | DL |
|---|---|---|---|---|---|---|---|---|---|---|
| 3C or 4C | $\frac{N\phi}{P/R_m}$ = 41, 47 | $K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = 130, 150 | -150 | -150 | -150 | -150 | -130 | -130 | -130 | -130 |
| 1C or 2C-1 | $\frac{M\phi}{P}$ = | $K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$ = | – | + | – | + | – | + | – | + |
| 3A | $\frac{N\phi}{M_c/R_m^2\beta}$ = 6 | $K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = 100 | | | | | -100 | -100 | +100 | +100 |
| 1A | $\frac{M\phi}{M_c/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | | | | | – | + | + | – |
| 3B | $\frac{N\phi}{M_L/R_m^2\beta}$ = 21 | $K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = 2760 | -2760 | -2760 | +2760 | +2760 | | | | |
| 1B or 1B-1 | $\frac{M\phi}{M_L/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | – | + | + | – | | | | |
| Add algebraically for summation of φ stresses, $\sigma\phi$ | | | -2910 | -2910 | +2610 | +2610 | -230 | -230 | -30 | -30 |
| 3C or 4C | $\frac{N_x}{P/R_m}$ = 41, 47 | $K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = 130, 150 | -130 | -130 | -130 | -130 | -150 | -150 | -150 | -150 |
| 1C-1 or 2C | $\frac{M_x}{P}$ = | $K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ = | – | + | – | + | – | + | – | + |
| 4A | $\frac{N_x}{M_c/R_m^2\beta}$ = 7.5 | $K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = 120 | | | | | -120 | -120 | +120 | +120 |
| 2A | $\frac{M_x}{M_c/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | | | | | – | + | + | – |
| 4B | $\frac{N_x}{M_L/R_m^2\beta}$ = 5.8 | $K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = 760 | -760 | -760 | +760 | +760 | | | | |
| 2B or 2B-1 | $\frac{M_x}{M_L/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | – | + | + | – | | | | |
| Add algebraically for summation of X stresses, $\sigma_x$ | | | -890 | -890 | 630 | .630 | -270 | -270 | -30 | -30 |
| Shear stress due to Torsion, $M_T$ | | $\tau_{\phi x} = \tau_{x\phi} = \frac{M_T}{2\pi r_o^2 T}$ = 30 | +30 | +30 | +30 | +30 | +30 | +30 | +30 | +30 |
| Shear stress due to load, $V_c$ | | $\tau_{x\phi} = \frac{V_c}{\pi r_o T}$ = 10 | +10 | +10 | -10 | -10 | | | | |
| Shear stress due to load, $V_L$ | | $\tau_{x\phi} = \frac{V_L}{\pi r_o T}$ = -250 | | | | | ±250 | ±250 | ±-250 | ±-250 |
| Add Algebraically for summation of shear stresses, $\tau$ | | | 40 | 40 | 20 | 20 | 280 | 280 | -220 | -220 |

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|---|---|---|---|
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SSE

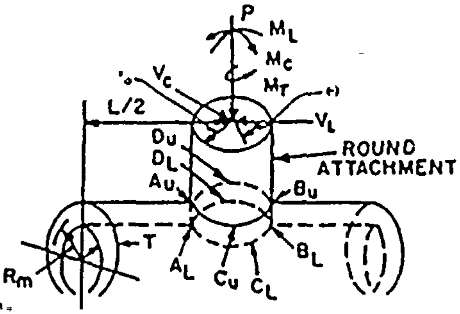
LOCATIONS: A, B, C, D

**Table 5—Computation Sheet for Local Stresses in Cylindrical Shells**

1. Applied Loads*
   - Radial load, P = 1540 lb.
   - Circ. Moment, Mc = 113000 in. lb.
   - Long. Moments, ML = 10500 in. lb.
   - Torsion Moment, $M_T$ = 16200 in. lb.
   - Shear Load, Vc = 2240 lb.
   - Shear Load, VL = 440 lb.
2. Geometry
   - Vessel thickness, T = 0.625 in.
   - Attachment radius, $r_o$ = 5.38 in.
   - Vessel radius, Rm = 159 in.
3. Geometric Parameters
   - $\gamma$ $\frac{Rm}{T}$ = 254
   - $\beta$ $(0.875)\frac{r_o}{Rm}$ = 0.03

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb —

*NOTE: Enter all force values in accordance with sign convention




CYLINDRICAL SHELL

| From Fig. | Read curves for | Compute absolute values of stress and enter result • | Au | AL | Bu | BL | Cu | CL | Du | DL |
|---|---|---|---|---|---|---|---|---|---|---|
| 3C or 4C | $\frac{N\phi}{P/Rm}$ = 41 / 47 | $Kn\left(\frac{N\phi}{P/Rm}\right)\cdot\frac{P}{RmT}$ = 640 / 730 | −730 | −730 | −730 | −730 | −640 | −640 | −640 | −640 |
| 1C or 2C-1 | $\frac{M\phi}{P}$ = — | $Kb\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$ = — | — | + | — | + | — | + | — | + |
| 3A | $\frac{N\phi}{Mc/Rm^2\beta}$ = 6 | $Kn\left(\frac{N\phi}{Mc/Rm^2\beta}\right)\cdot\frac{Mc}{Rm^2\beta T}$ = 1430 | | | | | −1430 | −1430 | +1430 | +1430 |
| 1A | $\frac{M\phi}{Mc/Rm\beta}$ = | $Kb\left(\frac{M\phi}{Mc/Rm\beta}\right)\cdot\frac{6Mc}{Rm\beta T^2}$ = — | | | | | — | + | + | — |
| 3B | $\frac{N\phi}{ML/Rm^2\beta}$ = 21 | $Kn\left(\frac{N\phi}{ML/Rm^2\beta}\right)\cdot\frac{ML}{Rm^2\beta T}$ = 470 | −470 | −470 | +470 | +470 | | | | |
| 1B or 1B-1 | $\frac{M\phi}{ML/Rm\beta}$ = | $Kb\left(\frac{M\phi}{ML/Rm\beta}\right)\cdot\frac{6ML}{Rm\beta T^2}$ = — | — | + | + | — | | | | |
| ~~Add algebraically for summation of Φ stresses,~~ $\sigma\phi$ . SRSS P, Mc, ML on | | | 870 | 870 | 870 | 870 | 1570 | 1570 | 1570 | 1570 |
| 3C or 4C | $\frac{Nx}{P/Rm}$ = 41 / 47 | $Kn\left(\frac{Nx}{P/Rm}\right)\cdot\frac{P}{RmT}$ = 640 / 730 | −640 | −640 | −640 | −640 | −730 | −730 | −730 | −730 |
| 1C-1 or 2C | $\frac{Mx}{P}$ = | $Kb\left(\frac{Mx}{P}\right)\cdot\frac{6P}{T^2}$ = — | — | + | — | + | — | + | — | + |
| 4A | $\frac{Nx}{Mc/Rm^2\beta}$ = 3.5 | $Kn\left(\frac{Nx}{Mc/Rm^2\beta}\right)\cdot\frac{Mc}{Rm^2\beta T}$ = 1790 | | | | | −1790 | −1790 | +1790 | +1790 |
| 2A | $\frac{Mx}{Mc/Rm\beta}$ = | $Kb\left(\frac{Mx}{Mc/Rm\beta}\right)\cdot\frac{6Mc}{Rm\beta T^2}$ = — | | | | | — | + | + | — |
| 4B | $\frac{Nx}{ML/Rm^2\beta}$ = 5.8 | $Kn\left(\frac{Nx}{ML/Rm^2\beta}\right)\cdot\frac{ML}{Rm^2\beta T}$ = 130 | −130 | −130 | +130 | +130 | | | | |
| 2B or 2B-1 | $\frac{Mx}{ML/Rm\beta}$ = | $Kb\left(\frac{Mx}{ML/Rm\beta}\right)\cdot\frac{6ML}{Rm\beta T^2}$ = — | — | + | + | — | | | | |
| ~~Add algebraically for summation of X stresses,~~ $\sigma_x$ = SRSS P, Mc, ML on | | | 650 | 650 | 650 | 650 | 1930 | 1930 | 1930 | 1930 |
| Shear stress due to Torsion, $M_T$ | | $\tau x\phi = \tau\phi x = \frac{M_T}{2\pi r_o^2 T}$ = 140 | +140 | +140 | +140 | +140 | +140 | +140 | +140 | +140 |
| Shear stress due to load, Vc | | $\tau x\phi = \frac{Vc}{\pi r_o T}$ = 210 | +210 | +210 | −210 | −210 | | | | |
| Shear stress due to load, VL | | $\tau x\phi = \frac{VL}{\pi r_o T}$ = 40 | | | | | −40 | −40 | +40 | +40 |
| ~~Add algebraically for summation of shear stresses,~~ $\tau$ = SRSS $M_T$, Vc, VL on | | | 250 | 250 | 250 | 250 | 150 | 150 | 150 | 150 |

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SUBJECT: RWST NOZZLE LOADS — JOB No. 83C2209 — SHEET 10 OF 27

| REVISIONS | | |
|---|---|---|
| 0 | TMT | 8/31/84 |
| | KBM | 9/19/84 |
| | | |
| | | |
| | | |

DEAD WEIGHT + INJECTION PHASE

LOCATIONS: "A', B'

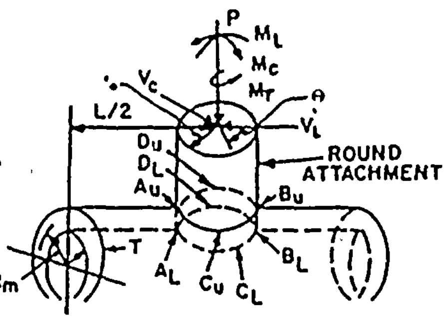
**Table 5—Computation Sheet for Local Stresses in Cylindrical Shells**

1. Applied Loads*
   - Radial load, $P$ = 310 lb.
   - Circ. Moment, $M_c$ = 7600 in. lb.
   - Long. Moments, $M_L$ = 62400 in. lb.
   - Torsion Moment, $M_T$ = 3300 in. lb.
   - Shear Load, $V_c$ = -90 lb.
   - Shear Load, $V_L$ = -2690 lb.

2. Geometry
   - Vessel thickness, $T$ = 0.3125 in.
   - Attachment radius, $r_o$ = 11.5 in.
   - Vessel radius, $R_m$ = 159 in.

3. Geometric Parameters
   - $\gamma$ $\frac{R_m}{T}$ = 509
   - $\beta$ $(0.875)\frac{r_o}{R_m}$ = 0.063
   - Stress Concentration due to:
     - a) membrane load, $K_n$ 1.0
     - b) bending load, $K_b$ —

*NOTE: Enter all force values in accordance with sign convention




CYLINDRICAL SHELL

| From Fig. | Read curves for | Compute absolute values of stress and enter result • | Au | AL | Bu | BL | Cu | CL | Du | DL |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | STRESSES – if load is opposite that shown, reverse signs shown | | | | | | | |
| ~~2C~~ or 4C | $\frac{N\phi}{P/R_m}$ = 71 | $K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = 440 | -440 | -440 | -440 | -440 | – | – | – | – |
| 1C or 2C-1 | $\frac{M\phi}{P}$ = | $K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$ = — | — | + | — | + | – | + | – | + |
| 3A | $\frac{N\phi}{M_c/R_m^2\beta}$ = | $K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = | | | | | – | – | + | + |
| 1A | $\frac{M\phi}{M_c/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | | | | | – | + | + | – |
| 3B | $\frac{N\phi}{M_L/R_m^2\beta}$ = 60 | $K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = 7520 | -7520 | -7520 | +7520 | +7520 | | | | |
| 1B or 1B-1 | $\frac{M\phi}{M_L/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = — | — | + | + | — | | | | |
| Add algebraically for summation of $\phi$ stresses, $\sigma\phi$ | | | -7960 | -7960 | 7080 | 7080 | | | | |
| 3C or ~~4C~~ | $\frac{N_x}{P/R_m}$ = 46 | $K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = 290 | -290 | -290 | -290 | -290 | – | – | – | – |
| 1C-1 or 2C-1 | $\frac{M_x}{P}$ = | $K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ = — | — | + | — | + | – | + | – | + |
| 4A | $\frac{N_x}{M_c/R_m^2\beta}$ = | $K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = | | | | | – | – | + | + |
| 2A | $\frac{M_x}{M_c/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | | | | | – | + | + | – |
| 4B | $\frac{N_x}{M_L/R_m^2\beta}$ = 22 | $K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = 2760 | -2760 | -2760 | +2760 | +2760 | | | | |
| 2B or 2B-1 | $\frac{M_x}{M_L/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | — | + | + | — | | | | |
| Add algebraically for summation of X stresses, $\sigma_x$ | | | -3050 | -3050 | 2470 | 2470 | | | | |
| Shear stress due to Torsion, $M_T$ | | $\tau x\phi = \tau\phi x = \frac{M_T}{2\pi r_o^2 T}$ = 13 | +13 | +13 | +13 | +13 | + | + | + | + |
| Shear stress due to load, $V_c$ | | $\tau x\phi = \frac{V_c}{\pi r_o T}$ = ·8 | +8 | +8 | -8 | -8 | | | | |
| Shear stress due to load, $V_L$ | | $\tau x\phi = \frac{V_L}{\pi r_o T}$ = | | | | | – | – | + | + |
| Add Algebraically for summation of shear stresses, $\tau$ | | | 20 | 20 | 5 | 5 | | | | |

SSE

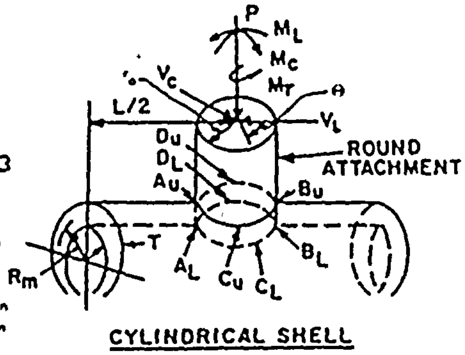
LOCATIONS : A', B'

## Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

1. Applied Loads*
   - Radial load, $P = 1540$ lb.
   - Circ. Moment, $M_c = 113000$ in. lb.
   - Long. Moments, $M_L = 10500$ in. lb.
   - Torsion Moment, $M_T = 16200$ in. lb.
   - Shear Load, $V_c = 2240$ lb.
   - Shear Load, $V_L = 440$ lb.
2. Geometry
   - Vessel thickness, $T = 0.3125$ in.
   - Attachment radius, $r_o = 11.5$ in.
   - Vessel radius, $R_m = 159$ in.
3. Geometric Parameters
   - $\gamma \quad \frac{R_m}{T} = 509$
   - $\beta \quad (0.875)\frac{r_o}{R_m} = 0.063$

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb —

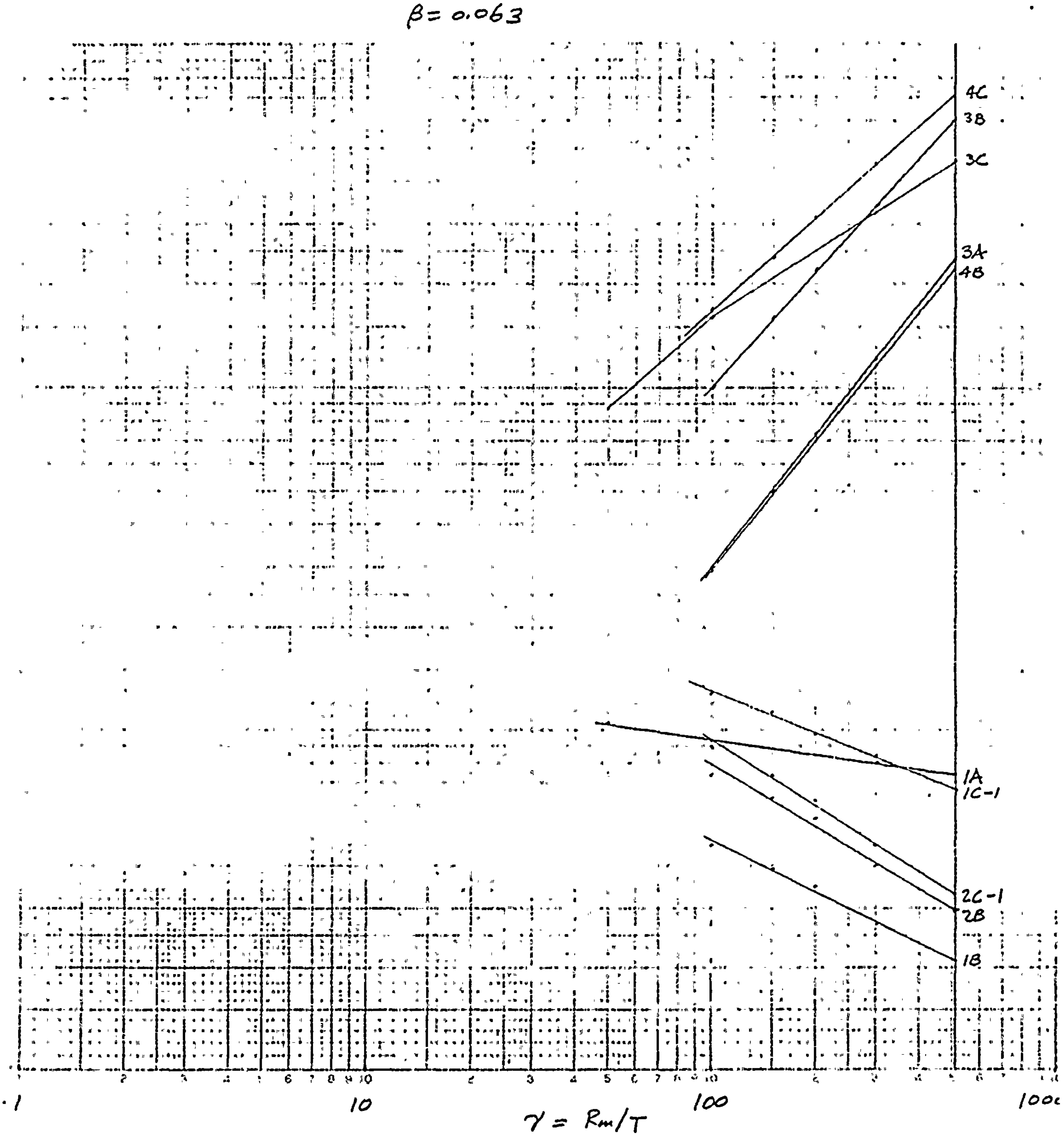
*NOTE: Enter all force values in accordance with sign convention



CYLINDRICAL SHELL

| From Fig. | Read curves for | Compute absolute values of stress and enter result • | Au | AL | Bu | BL | Cu | CL | Du | DL |
|---|---|---|---|---|---|---|---|---|---|---|
| ~~2C~~ or 4C | $\frac{N\phi}{P/R_m} = 71$ | $K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT} =$ 2200 | −2200 | −2200 | −2200 | −2200 | − | − | − | − |
| 1C or 2C-1 | $\frac{M\phi}{P} =$ | $K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2} =$ | − | + | − | + | − | + | − | + |
| 3A | $\frac{N\phi}{M_c/R_m^2\beta} =$ | $K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T} =$ | | | | | − | − | + | + |
| 1A | $\frac{M\phi}{M_c/R_m\beta} =$ | $K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2} =$ | | | | | − | + | + | − |
| 3B | $\frac{N\phi}{M_L/R_m^2\beta} = 6$ | $K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T} =$ 1270 | −1270 | −1270 | +1270 | +1270 | | | | |
| 1B or 1B-1 | $\frac{M\phi}{M_L/R_m\beta} =$ | $K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2} =$ | − | + | + | − | | | | |
| ~~Add algebraically for summation of $\sigma\phi$ stresses, $\sigma\phi$~~. SRSS P, Mc, ML on | | | 2540 | 2540 | 2540 | 2540 | | | | |
| 3C or ~~4C~~ | $\frac{N_x}{P/R_m} = 46$ | $K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT} =$ 1430 | −1430 | −1430 | −1430 | −1430 | − | − | − | − |
| 1C-1 or 2C | $\frac{M_x}{P} =$ | $K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2} =$ | − | + | − | + | − | + | − | + |
| 4A | $\frac{N_x}{M_c/R_m^2\beta} =$ | $K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T} =$ | | | | | − | − | + | + |
| 2A | $\frac{M_x}{M_c/R_m\beta} =$ | $K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2} =$ | | | | | − | + | + | − |
| 4B | $\frac{N_x}{M_L/R_m^2\beta} = 22$ | $K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T} =$ 460 | −460 | −460 | +460 | +460 | | | | |
| 2B or 2B-1 | $\frac{M_x}{M_L/R_m\beta} =$ | $K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2} =$ | − | + | + | − | | | | |
| ~~Add algebraically for summation of x stresses, $\sigma_x$~~ SRSS P, Mc, ML on | | | 1500 | 1500 | 1500 | 1500 | | | | |
| Shear stress due to Torsion, $M_T$ | | $\tau_{x\phi} = \tau_{\phi x} = \frac{M_T}{2\pi r_o^2 T} =$ 62 | +62 | +62 | +62 | +62 | + | + | + | + |
| Shear stress due to load, $V_c$ | | $\tau_{x\phi} = \frac{V_c}{\pi r_o T} =$ 200 | +200 | +200 | −200 | −200 | | | | |
| Shear stress due to load, $V_L$ | | $\tau_{x\phi} = \frac{V_L}{\pi r_o T} =$ | | | | | − | − | + | + |
| ~~Add algebraically for summation of shear stresses, $\tau$~~ SRSS MT, Vc, VL on | | | 210 | 210 | 210 | 210 | | | | |

SHEET 12/27
BY TMT 8/31/84
KBM 9/19/84




Full Logarithmic, 3 × 3 Cycles

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SUBJECT: RWST NOZZLE LOADS JOB No. 83C2209 SHEET 13 OF 27

REVISIONS: 0 — TMT 8/31/84 — KBM 9/19/84

## Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

**1. Applied Loads***

- Radial load, P = 310 lb.
- Circ. Moment, $M_c$ = 7600 in. lb.
- Long. Moments, $M_L$ = 6240 in. lb.
- Torsion Moment, $M_T$ = 3300 in. lb.
- Shear Load, $V_c$ = 90 lb.
- Shear Load, $V_L$ = 2690 lb.

**2. Geometry**

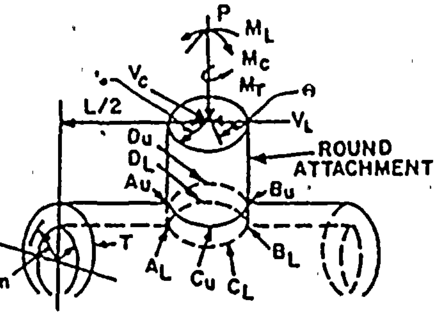
- Vessel thickness, T = 0.3125 in.
- Attachment radius, $r_o$ = 14.13 in.
- Vessel radius, $R_m$ = 159 in.

**3. Geometric Parameters**

- $\gamma$ $\frac{R_m}{T}$ = 509
- $\beta$ $(0.875)\frac{r_o}{R_m}$ = 0.078

Stress Concentration due to:
a) membrane load, Kn 1.0
b) bending load, Kb —

*NOTE: Enter all force values in accordance with sign convention




CYLINDRICAL SHELL

| From Fig. | Read curves for | Compute absolute values of stress and enter result • | | Au | AL | Bu | BL | Cu | CL | Du | DL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | STRESSES – if load is opposite that shown, reverse signs shown | | | | | | | |
| 3C or ~~4C~~ | $\frac{N\phi}{P/R_m}$ = 36 | $K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = | 220 | − | − | − | − | −220 | −220 | −220 | −220 |
| 1C or 2C-1 | $\frac{M\phi}{P}$ = | $K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$ = | — | | + | | + | — | + | — | + |
| 3A | $\frac{N\phi}{M_c/R_m^2\beta}$ = 25 | $K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = | 310 | | | | | −310 | −310 | +310 | +310 |
| 1A | $\frac{M\phi}{M_c/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | — | | | | | — | + | + | — |
| 3B | $\frac{N\phi}{M_L/R_m^2\beta}$ = | $K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = | | − | − | + | + | | | | |
| 1B or 1B-1 | $\frac{M\phi}{M_L/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | | − | + | + | − | | | | |
| Add algebraically for summation of φ stresses, $\sigma_\phi$ = | | | | | | | | −530 | −530 | 90 | 90 |
| ~~3C~~ or 4C | $\frac{N_x}{P/R_m}$ = 65 | $K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = | 410 | − | − | − | − | −410 | −410 | −410 | −410 |
| 1C-1 or 2C | $\frac{M_x}{P}$ = | $K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ = | — | — | + | − | + | − | + | − | + |
| 4A | $\frac{N_x}{M_c/R_m^2\beta}$ = 48 | $K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = | 590 | | | | | −590 | −590 | +590 | +590 |
| 2A | $\frac{M_x}{M_c/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | — | | | | | — | + | + | — |
| 4B | $\frac{N_x}{M_L/R_m^2\beta}$ = | $K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = | | − | − | + | + | | | | |
| 2B or 2B-1 | $\frac{M_x}{M_L/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | | − | + | + | − | | | | |
| Add algebraically for summation of X stresses, $\sigma_x$ = | | | | | | | | −1000 | −1000 | 180 | 180 |
| Shear stress due to Torsion, $M_T$ | | $\tau_{x\phi} = \tau_{\phi x} = \frac{M_T}{2\pi r_o^2 T}$ = | 8 | + | + | + | + | +8 | +8 | +8 | +8 |
| Shear stress due to load, $V_c$ | | $\tau_{x\phi} = \frac{V_c}{\pi r_o T}$ | | + | + | − | − | | | | |
| Shear stress due to load, $V_L$ | | $\tau_{x\phi} = \frac{V_L}{\pi r_o T}$ = | 190 | | | | | −190 | −190 | +190 | +190 |
| Add Algebraically for summation of shear stresses, τ = | | | | | | | | −180 | −180 | 200 | 200 |

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REVISIONS: 0 — TMT 8/31/84; KBM 9/19/84

## Table 5—Computation Sheet for Local Stresses in Cylindrical Shells

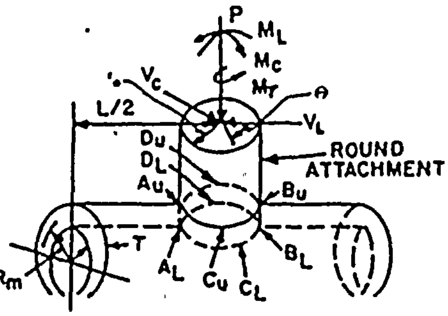
1. Applied Loads*
   - Radial load, P = 1540 lb.
   - Circ. Moment, Mc = 113000 in. lb.
   - Long. Moments, ML = 10500 in. lb.
   - Torsion Moment, $M_T$ = 16200 in. lb.
   - Shear Load, Vc = 2240 lb.
   - Shear Load, VL = 440 lb.

2. Geometry
   - Vessel thickness, T = 0.3125 in.
   - Attachment radius, $r_o$ = 14.13 in.
   - Vessel radius, Rm = 159 in.

3. Geometric Parameters
   - $\gamma$ $\frac{R_m}{T}$ = 509
   - $\beta$ $(0.875)\frac{r_o}{R_m}$ = 0.078

Stress Concentration due to: 1.0
   a) membrane load, Kn = 
   b) bending load, Kb = 

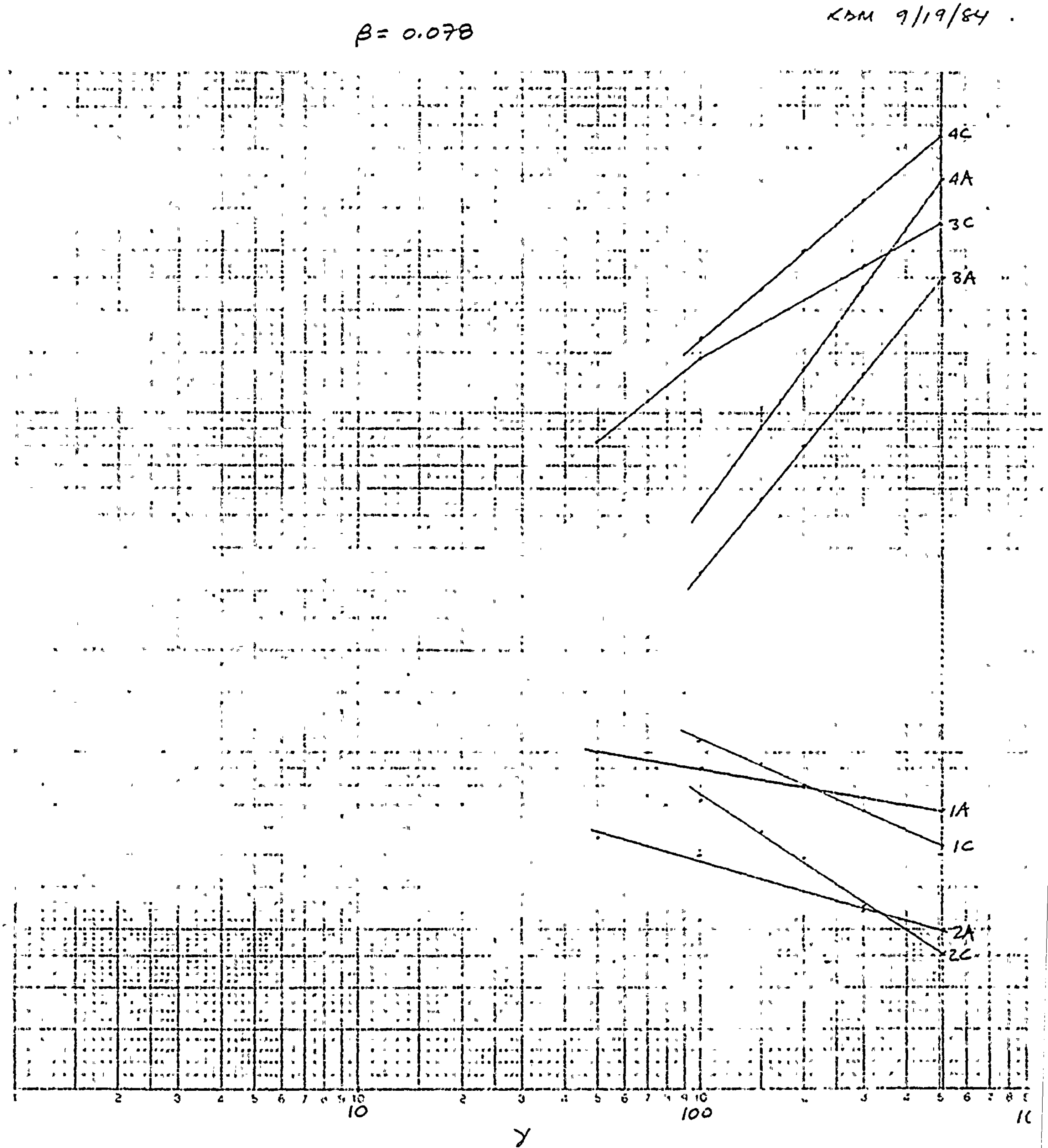
*NOTE: Enter all force values in accordance with sign convention




CYLINDRICAL SHELL

| From Fig. | Read curves for | Compute absolute values of stress and enter result • | Au | AL | Bu | BL | Cu | CL | Du | DL |
|---|---|---|---|---|---|---|---|---|---|---|
| 3C or ~~4C~~ | $\frac{N\phi}{P/R_m}$ = 36 | $K_n\left(\frac{N\phi}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = 1120 | − | − | − | − | −1120 | −1120 | −1120 | −1120 |
| 1C or 2C-1 | $\frac{M\phi}{P}$ = | $K_b\left(\frac{M\phi}{P}\right)\cdot\frac{6P}{T^2}$ = | − | + | − | + | − | + | − | + |
| 3A | $\frac{N\phi}{M_c/R_m^2\beta}$ = 25 | $K_n\left(\frac{N\phi}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = 4580 | | | | | −4580 | −4580 | +4580 | +4580 |
| 1A | $\frac{M\phi}{M_c/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | | | | | − | + | + | − |
| 3B | $\frac{N\phi}{M_L/R_m^2\beta}$ = | $K_n\left(\frac{N\phi}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = | − | − | + | + | | | | |
| 1B or 1B-1 | $\frac{M\phi}{M_L/R_m\beta}$ = | $K_b\left(\frac{M\phi}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | − | + | + | − | | | | |
| ~~Add algebraically for summation of~~ $\phi$ stresses, $\sigma_\phi$ — SRSS effects of P, Mc, ML on | | | | | | | 4700 | 4700 | 4700 | 4700 |
| ~~2C~~ or 4C | $\frac{N_x}{P/R_m}$ = 65 | $K_n\left(\frac{N_x}{P/R_m}\right)\cdot\frac{P}{R_mT}$ = 2010 | − | − | − | − | −2010 | −2010 | −2010 | −2010 |
| 1C-1 or 2C | $\frac{M_x}{P}$ = | $K_b\left(\frac{M_x}{P}\right)\cdot\frac{6P}{T^2}$ = | − | + | − | + | − | + | − | + |
| 4A | $\frac{N_x}{M_c/R_m^2\beta}$ = 48 | $K_n\left(\frac{N_x}{M_c/R_m^2\beta}\right)\cdot\frac{M_c}{R_m^2\beta T}$ = 8800 | | | | | −8800 | −8800 | +8800 | +8800 |
| 2A | $\frac{M_x}{M_c/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_c/R_m\beta}\right)\cdot\frac{6M_c}{R_m\beta T^2}$ = | | | | | − | + | + | − |
| 4B | $\frac{N_x}{M_L/R_m^2\beta}$ = | $K_n\left(\frac{N_x}{M_L/R_m^2\beta}\right)\cdot\frac{M_L}{R_m^2\beta T}$ = | − | − | + | + | | | | |
| 2B or 2B-1 | $\frac{M_x}{M_L/R_m\beta}$ = | $K_b\left(\frac{M_x}{M_L/R_m\beta}\right)\cdot\frac{6M_L}{R_m\beta T^2}$ = | − | + | + | − | | | | |
| ~~Add algebraically for summation of~~ x stresses, $\sigma_x$ — SRSS P, Mc, ML on | | | | | | | 9000 | 9000 | 9000 | 9000 |
| Shear stress due to Torsion, $M_T$ | | $\tau_{x\phi} = \tau_{\phi x} = \frac{M_T}{2\pi r_o^2 T}$ = 40 | + | + | + | + | +40 | +40 | +40 | +40 |
| Shear stress due to load, Vc | | $\tau_{x\phi} = \frac{V_c}{\pi r_o T}$ | + | + | − | − | | | | |
| Shear stress due to load, VL | | $\tau_{x\phi} = \frac{V_L}{\pi r_o T}$ = 30 | | | | | −30 | −30 | +30 | +30 |
| ~~Add Algebraically for summation of shear stresses,~~ $\tau$ — SRSS MT, Vc, VL on | | | | | | | 50 | 50 | 50 | 50 |

SHEET 15/27
BY TMT 8/31/84
KDM 9/19/84




Full Logarithmic, 3 × 3 Cycles

**STEVENSON & ASSOCIATES**
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SUBJECT: RWST NOZZLE LOADS

JOB No. 83C2209 SHEET 16 OF 27

REVISIONS: 0 TMT 8/31/84; KBM 9/19/84

## SUMMARY OF STRESSES

$$DW + DW_{piping} + IP_{piping} + \sqrt{SSE^2_{vessel} + SSE^2_{piping}}$$

| POINT | STRESS | Vessel DW | Vessel SSE | Piping DW+IP | Piping SSE | Combined | Maximum Principal Stress | Factor of Safety |
|---|---|---|---|---|---|---|---|---|
| A | $\sigma_\phi$ | 8.9 | 2.4 | 2.9 | 0.9 | 14.4 | | |
| | $\sigma_x$ | 0.1 | 5.9 | 0.9 | 0.7 | 6.9 | 14.7* | 2.9 |
| | $\tau_{\phi x}$ | 0 | 1.6 | 0 | 0.3 | 1.6 | | |
| B | $\sigma_\phi$ | 8.9 | 2.4 | 2.6 | 0.9 | 14.1 | | |
| | $\sigma_x$ | 0.1 | 5.9 | 0.6 | 0.7 | 6.6 | 14.4 | 3.0 |
| | $\tau_{\phi x}$ | 0 | 1.6 | 0 | 0.3 | 1.6 | | |
| C | $\sigma_\phi$ | 8.9 | 2.4 | 0.2 | 1.6 | 12.0 | | |
| | $\sigma_x$ | 0.1 | 5.9 | 0.3 | 1.9 | 6.6 | 12.6 | 3.4 |
| | $\tau_{\phi x}$ | 0 | 1.6 | 0.3 | 0.2 | 1.9 | | |
| D | $\sigma_\phi$ | 8.9 | 2.4 | 0 | 1.6 | 11.8 | | |
| | $\sigma_x$ | 0.1 | 5.9 | 0 | 1.9 | 6.3 | 12.3 | 3.5 |
| | $\tau_{\phi x}$ | 0 | 1.6 | 0.2 | 0.2 | 1.8 | | |
| A' | $\sigma_\phi$ | 17.7 | 4.7 | 8.0 | 2.5 | 31.0 | | |
| | $\sigma_x$ | 0.2 | 11.7 | 3.1 | 1.5 | 15.1 | 31.6 | 1.35 |
| | $\tau_{\phi x}$ | 0 | 3.2 | 0 | 0.2 | 3.2 | | |
| B' | $\sigma_\phi$ | 17.7 | 4.7 | 7.1 | 2.5 | 30.1 | | |
| | $\sigma_x$ | 0.2 | 11.7 | 2.5 | 1.5 | 14.5 | 30.7 | 1.39 |
| | $\tau_{\phi x}$ | 0 | 3.2 | 0 | 0.2 | 3.2 | | |
| | $\sigma_\phi$ | 17.7 | 4.7 | 0.5 | 4.7 | 24.8 | | |
| C' | $\sigma_x$ | 0.2 | 11.7 | 1.0 | 9.0 | 16.0 | 26.0 | 1.64 |
| | $\tau_{\phi x}$ | 0 | 3.2 | 0.2 | 0.1 | 3.4 | | |
| | $\sigma_\phi$ | 17.7 | 4.7 | 0.1 | 4.7 | 24.4 | | |
| D' | $\sigma_x$ | 0.2 | 11.7 | 0.2 | 9.0 | 15.2 | 25.5 | 1.67 |
| | $\tau_{\phi x}$ | 0 | 3.2 | 0.2 | 0.1 | 3.4 | | |

* Maximum principle stress calculated by $(\sigma_x + \sigma_\phi)/2 + \sqrt{(\sigma_x - \sigma_\phi)^2/4 + \tau_{\phi x}^2}$

Anchor bolt shear cone pull out capacity

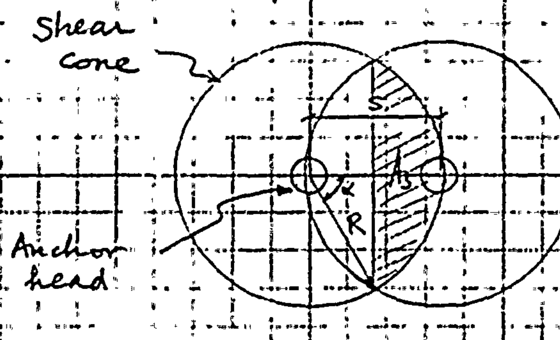
RWST has 30 - $2\frac{1}{4}\phi$ anchor bolts at the base uniformly distributed around a circle of radius 13'-7". The distance between two adjacent anchor bolts is S = 2'-10$\frac{1}{8}$" (see p. 18). The embedment length of the anchors is 30" (see p. 19).

The diameter of the anchor head at the bottom of the embedment is 9" according to Gilbert Associates Drawing S-423-005 (p. 20 value P). Thus, the radius of the shear cone is

$$R = 30 + \frac{9}{2} = 34.5''$$

Since $R > S/2$, reduction of capacity due to overlapping needs to be made. The reduction should equal twice the shaded area ($A_s$) below

$$\alpha = \cos^{-1}(S/2R) = 60.4^\circ$$




$$A_s = \pi R^2 \times \frac{2\alpha}{360} - \sqrt{R^2 - (\frac{S}{2})^2}\ \frac{S}{2}$$

$$= \pi(34.5)^2 \times \frac{120.8}{360}$$

$$- 17.06 \times \sqrt{34.5^2 - 17.06^2}$$

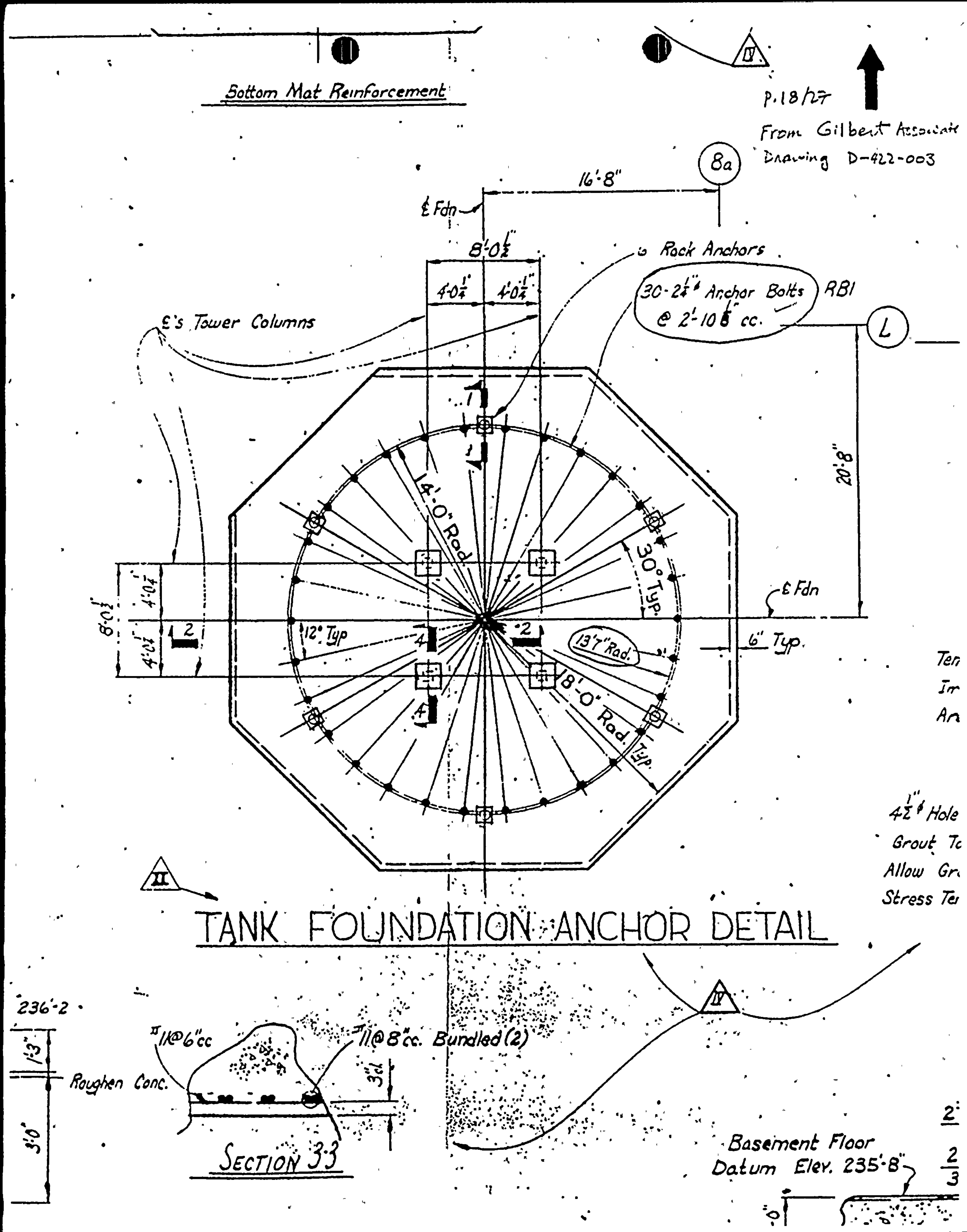
$$= 743.1\ in^2$$

Reduction of anchor head $= \pi(4.5)^2 = 63.6\ in^2$

Effective stress area for one bolt $A_e = \pi(34.5)^2 - 2 \times 743.1 - 63.6$

$$= 2189\ in^2$$

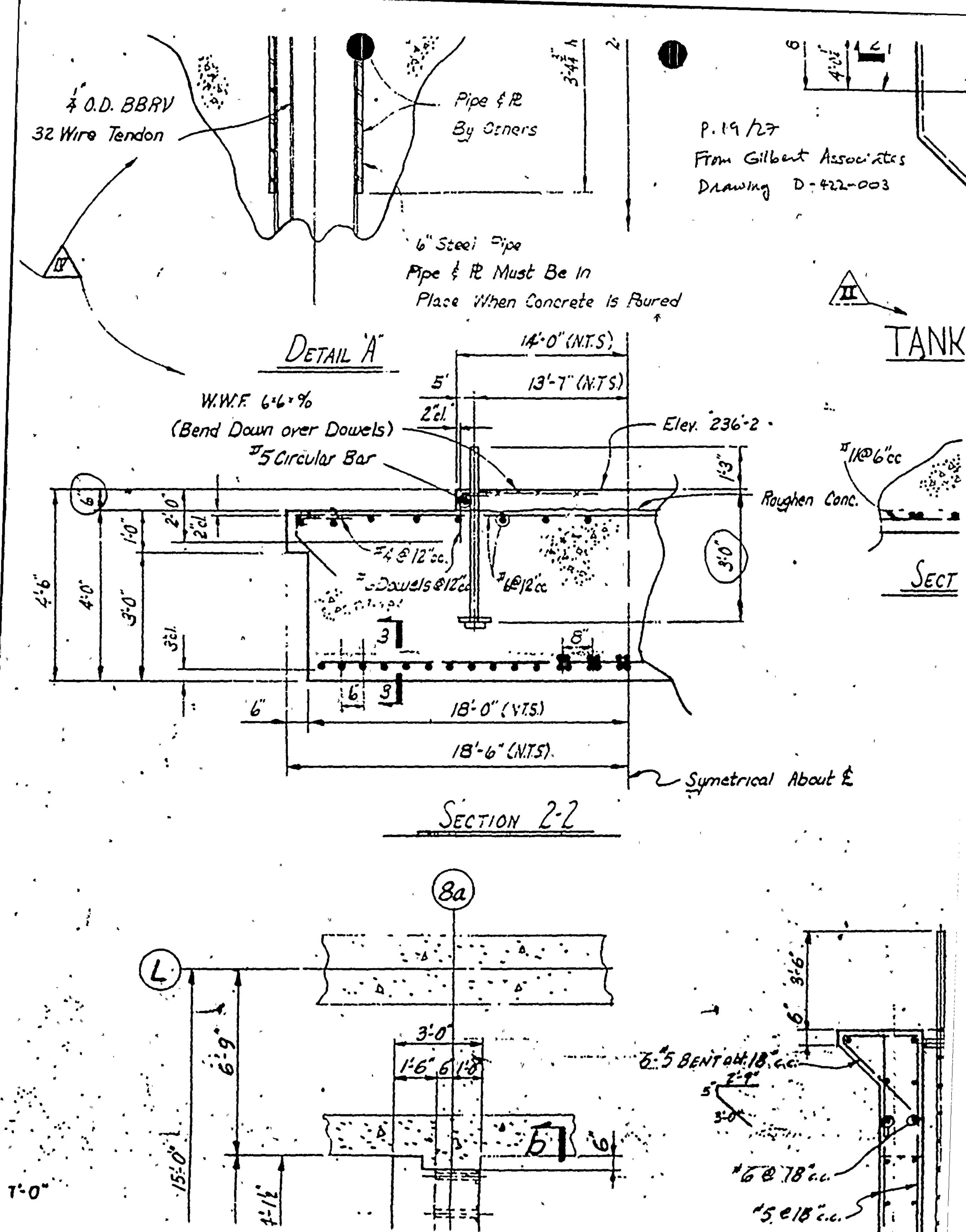
[illegible]




TANK FOUNDATION ANCHOR DETAIL

SECTION 3-3

[illegible]



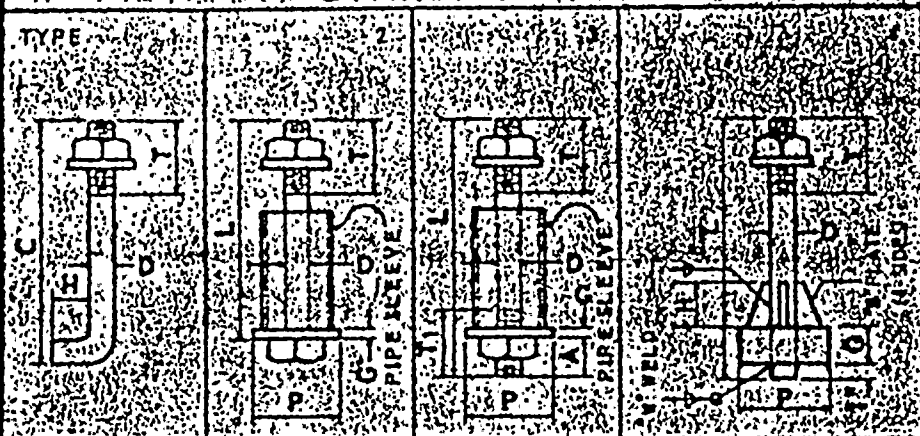
1/4" O.D. BBRV
32 Wire Tendon
Pipe & PL
By Owners
6" Steel Pipe
Pipe & PL Must Be In
Place When Concrete Is Poured
P. 19/27
From Gilbert Associates
Drawing D-422-003
DETAIL "A"
TANK
14'-0" (N.T.S.)
13'-7" (N.T.S.)
W.W.F. 6x6x%
(Bend Down over Dowels)
#5 Circular Bar
Elev. 236'-2
#11@6"cc
Roughen Conc.
#4 @ 12"cc.
Dowels @12"cc
#6@12"cc
SECT
18'-0" (N.T.S.)
18'-6" (N.T.S.)
Symetrical About ℄
SECTION 2-2
8a
L
6:#5 BENT @ 18" c.c.
#6 @ 18" c.c.
#5 @ 18" c.c.

SHEET 20

| | | |
|---|---|---|
| WESTINGHOUSE ELECTRIC CORPORATION | MADE CEWhary | GILBERT ASSOCIATES, INC. |
| ATOMIC POWER DIVISION | CHKD Voelker | ENGINEERS AND CONSULTANTS |
| ROBERT EMMETT GINNA NUCLEAR POWER STATION-UNIT NO. 1 | SQ CF R.N.L. | READING, PENNA. AND NEW YORK, N.Y. |
| R.G.& E. CORP. ROCHESTER, N.Y. | CF DSN RW/RL/WHK | 4155-00 (WORK ORDER) · S (SIZE) · 423-005 (DRAWING) · REV. |
| ANCHOR BOLT LIST - Fuel Storage Tank D-422-003 | ENGR [illegible] · REV. CK. APP. DATE | |

## STANDARD TYPES

## SPECIAL TYPES




RECEIVED
OCT 20 1966
R.G.&E. - ENG. DEPT.

| TYPE | MARK | NO. REQD | DIAM D | LENGTH L | A | B | C | H | THREADS T | THREADS T1 | NO. OF NUTS SQ | NO. OF NUTS HEX | SQ PLATE P | SQ PLATE G | WELD | WASHERS | PIPE SLEEVE DIA | PIPE SLEEVE LENGTH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | RB1 | 30 | 2 1/4" | 4'-3" | | | | | 8" | | | | 9 | 1/8" | | | | |

DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED

NOTES:-

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SUBJECT: RWST JOB No.: SHEET 21 OF 27

Anchor Bolt

REVISIONS: 0 TMJ 8-14-84; WD 9/18/84

The pull out strength, according to ACI 349-77, is

$$P_d = 4 \phi \sqrt{f_c'} A_e$$

Conservatively use $\phi = 0.65$ and $f_c' = 3000$ psi.

$$P_d = 4 \times 0.65 \times \sqrt{3000} \times 2189$$

$$= 312{,}000 \text{ lb} = 312 \text{ kips}$$

The ultimate capacity for yielding of the anchor bolt is

$$P_u = (3.25)(40.6) = 132 \text{ kips} < P_d$$

Refer to RWST calc. 83C2209 p. 45 and 57.

∴ Anchor bolt yielding governs the design

$$P_d / P_u = 2.36 = \text{Factor of Safety}$$

ALTERNATIVE ANALYSIS FOR THE WASTE HOLDUP TANK.

In the previous qualification report for the waste holdup tank (Ref. 4), the fundamental frequency in the transverse direction was calculated to be rigid. The review by SMA (Ref. 2) questioned the validity of the calculation and suggested that the fundamental frequency would occur at around half a hertz. Due to the complex geometry of the structure, the basic assumptions in the approximate analysis cannot be justified save for a full scale finite element analysis.

An alternative analysis procedure, similar to the equivalent static analysis, will be used in this section, where 1.5 times the peak of the spectra at 7% damping will be applied as the lateral load. Since the transverse direction is by far the less critical direction in the final stress evaluation, the waste holdup tank still satisfies the acceptance criteria under the conservative spectral assumption assumed.

Before pursuing the response calculation, the effect of sloshing is evaluated. The evaluation concludes that full tank is the most critical condition under the seismic input.

SLOSHING EFFECTS

The sloshing frequencies in the transverse direction of the tank are calculated for three water levels, 1/4, 1/2, and 3/4 water depths.

$f_n = \lambda_n \sqrt{\frac{g}{a}} / 2\pi$ (Hz)

| h/2a | $\lambda_n$ (Frequency parameter from Ref. 3, p. 48) | $f_n$ |
|---|---|---|
| 0.75 | 1.4 | 0.54 |
| 0.50 | 1.15 | 0.44 |
| 0.25 | 1.05 | 0.40 |

where a = radius of tank = 66 inches

The corresponding spectral accelerations for the site specific response spectra are extrapolated as in the RWST calc. p. 34.

| h/2a | Sa (5% damping) | |
|---|---|---|
| 0.75 | $\exp(\ln 0.336 + (\ln 0.54 - \ln 2.5)(\ln 0.168 - \ln 0.336)/(-\ln 2.5))$ | = 0.105 g |
| 0.50 | " 0.44 " | 0.090 |
| 0.25 | " 0.40 " | 0.084 |

The factor $C_T$ is also extrapolated

| h/2a | $C_T$ | |
|---|---|---|
| 0.75 | $-\exp(\ln 1.81 + (\ln 0.54 - \ln 1.33)(\ln 1.96 - \ln 1.81)/(-\ln 1.33))$ | = −2.33 |
| 0.50 | " 0.44 " | −2.46 |
| 0.25 | " 0.40 " | −2.53 |

The spectral acceleration for 0.5% damping are

| h/2a | Sa (0.5%) | |
|---|---|---|
| 0.75 | $0.105 \times 10^{-2.33(0.005-0.05)}$ | = 0.134 g |
| 0.50 | $0.090 \times 10^{-2.46(0.005-0.05)}$ | = 0.116 g |
| 0.25 | $0.084 \times 10^{-2.53(0.005-0.05)}$ | = 0.109 g |

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SUBJECT: GINNA WASTE HOLDUP TANK    JOB No. 83C2209    SHEET 24 OF 27

REVISIONS: 0 TMT 8-31-84; (1) 9/18/84

It can be seen that the spectral accelerations at 0.5% damping corresponding to the sloshing modes are much less than either the peak of the spectra or ZPA at 7% damping. This concludes* that full tank is the critical condition in the seismic analysis for the horizontal waste hold-up tank under consideration.

Peak of the spectra at 7% damping $= 0.397 \times 10^{-1.7(0.02)}$

$= 0.37\,g$

The same can be concluded for the longitudinal direction sloshing modes, the frequency of which are

| $h/2a$ | $\gamma_n$ (from Ref. 3 - p. 48) | $f_n = \gamma_n \sqrt{\frac{g}{\ell} \tanh \frac{\pi h}{\ell}} / 2\pi$ |
|---|---|---|
| 3/4 | 1.75 | 0.23 |
| 1/2 | 1.6 | 0.18 |
| 1/4 | 1.5 | 0.12 |

* As for overturning moment, the sloshing mass acting at the free surface tends to have larger moment arm. However, this effect does not invalidate the conclusion.

STRESSES DUE TO TRANSVERSE SEISMIC LOAD

- Maximum bending stress at horn of saddle (Ref. 4, calc. p. 23)

$$\sigma_b = 0.007 \times \frac{1.5 \times 0.37}{0.17} = \underline{0.023} \text{ ksi}$$

- Maximum membrane stress (p. 23)

$$\sigma_m = 0.23 \times \frac{1.5 \times 0.37}{0.17} = \underline{0.75} \text{ ksi}$$

- Anchor bolt stress (p. 26).

$$\sigma_t = 6.97 \times \frac{1.5 \times 0.37}{0.17} = 22.8 \text{ ksi}$$

combine with longitudinal response $\sigma_T = (35.6^2 + 22.8^2)^{1/2}$
$= \underline{42.3}$ ksi

- End stiffner axial compression (p. 30)

$$\sigma_c = 1.1 \times \frac{1.5 \times 0.37}{0.17} = 3.6 \text{ ksi}$$

Combined
$\sigma_c = (3.6^2 + .8^2)^{1/2}$
$= \underline{3.7}$ ksi

- Welding between saddle plate and vessel (p. 31)

$$v_T = 1.4 \times \frac{1.5 \times 0.37}{0.17} = 4.6 \text{ ksi}$$

combined stress $= (1.6^2 + 9.3^2 + 4.6^2)^{1/2} = \underline{10.5}$ ksi

SUMMARY TABLE OF SAFETY MARGINS ( Ref. 4, Calc. p.36)

| LOCATION | Dead Load stress (ksi) | Vertical Seismic (ksi) | Horizontal Seismic (ksi) | Total | Allowable stress (ksi) |
|---|---|---|---|---|---|
| VESSEL SHELL | | | | | |
| • Mid-span | | | | | |
| $\sigma_{xm}$ | 0.04 | ~0 | 0.02 | 0.06 | 35.6 |
| • Plane of saddle | | | | | |
| $\sigma_{xm}$ | 1.9 | 0.2 | 0.75 | 2.7 } 5.9 | |
| $\sigma_{x\phi}$ | 1.7 | 0.2 | 0 | 1.9 | 35.6 |
| $\sigma_{\phi m}$ | 2.8 | 0.3 | 0.75 | 3.6 | |
| $\sigma_{\phi b} + \sigma_{\phi m}$ | 56+2.8 | 6.2+0.3 | 0+0.75 | 65 | 80 |
| Ring compression $\sigma_{\phi m}$ | 10.7 | 1.2 | 0 | 11.9 | 35.6 |
| • Head | | | | | |
| Tension $\sigma_{hm}$ | 1.1 | 0.1 | 0 | 1.2 | 35.6 |
| • Anchor | | | | | |
| Tension $\sigma_t$ | 18.9 | 2.1 | 42.3 | 23.5 | 40.6 |
| • Saddle Support | | | | | |
| Tension in Flange | 0.87 | 0.1 | 0 | 0.97 | 24.0 |
| Flange bending | 32 | 3.5 | 0 | 35.5 | 39.6 |
| Web compression | 1.4 | 0.2 | 0 | 1.6 | 45 |
| Center stiffener | 1.1 | 0.1 | 2.9 | ✓~4.0 | 36 |
| End stiffener | 1.5 | 0.2 | 3.7 | ✓~5.2 | 36 |
| • Welding between Saddle and Vessel | 0 | 0 | 10.5 | 10.5 | 36 |

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SUBJECT: RWST NOZZLE LOADS

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REVISIONS: 0 TMT 8/31/84; WD 9/18/84

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