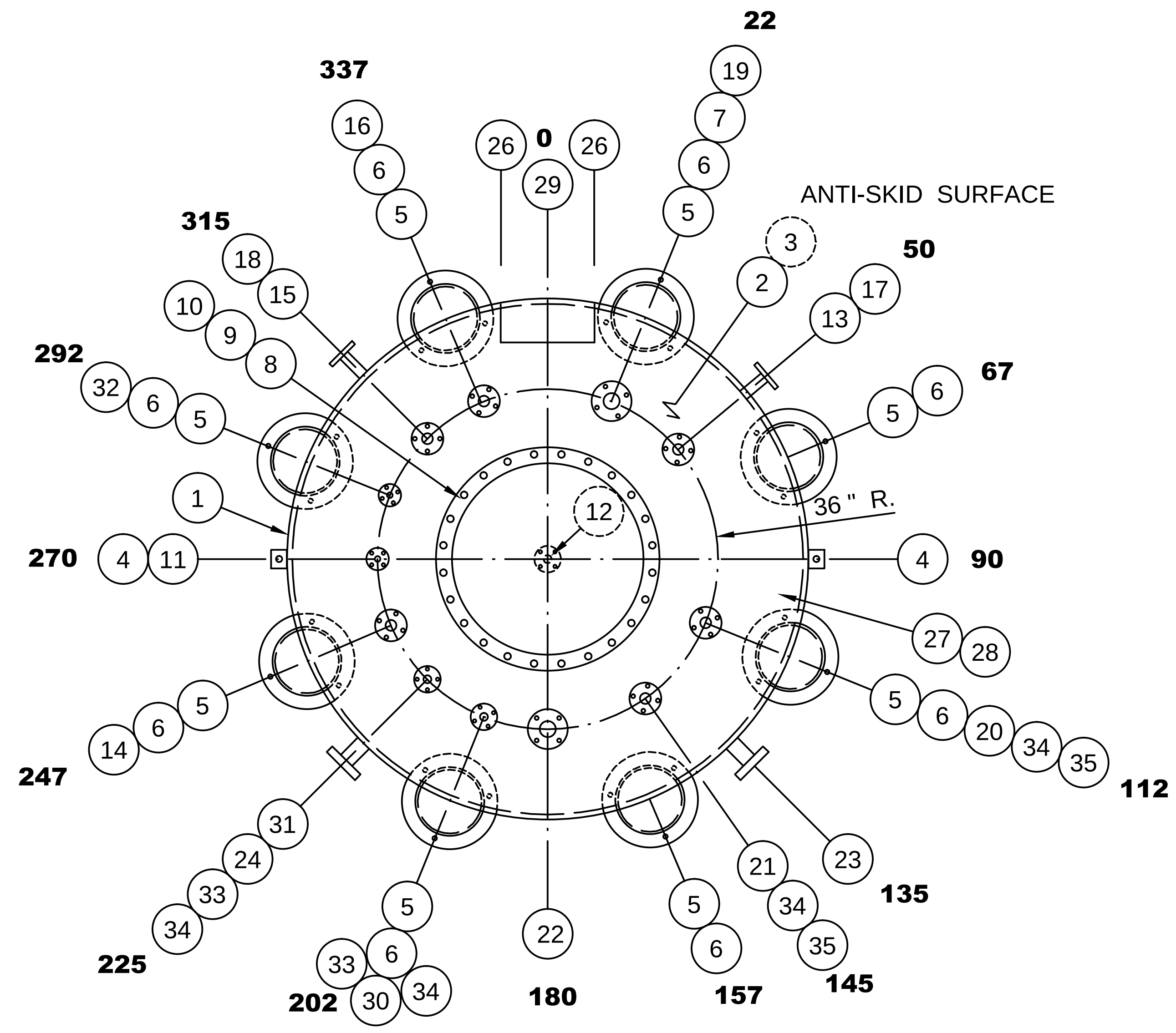
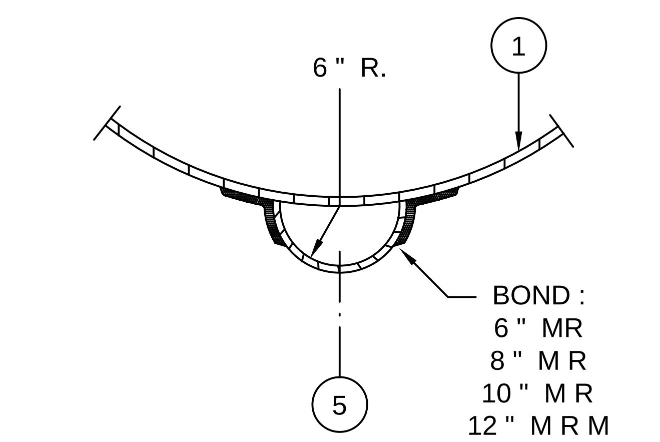
GENERAL NOTES

1. INNER CORROSION BARRIER HETRON 922 OR EQUAL RESIN REINFORCED WITH 20 MIL C - VEIL SURFACE VEIL AND 100 MIL BACKUP.
2. BALANCE OF LAMINATE FABRICATED TO FULL WALL THICKNESS WITH ISOPHTHALIC RESIN.
3. EXTERIOR SURFACE FINISHED WITH WHITE GEL COAT
4. ALL FLANGED NOZZLES TO BE 150 PSI RATED WITH 150 LB. DRILLING.
5. NOZZLE BOLT HOLES TO STRADDLE NATURAL CENTER LINES.
6. USE 2 PLY C - VEIL VEIL ON ALL INSIDE BONDS.
7. RESIN COAT ALL CUT EDGES.
8. SERVICE ______, TEMP. AMBIENT SEISMIC LOAD PER 2006 IBC, SP. GR. 1.1, PRESS. ATMOSPHERIC
9. VESSEL TO BE POSITIVELY VENTED TO ATMOSPHERE.
10. ANCHOR BOLTS PROVIDED & INSTALLED BY OTHERS.
11. VESSEL CAPACITY : 5,700 GALLONS.
12. REF. STRUCTURES LABORATORY DESIGN REPORT NO. 08 - 10 - 9.
13. SHIPPING SADDLES TO BE RETURNED TO XERXES.



PLAN VIEW



VIEW "A" - "A"

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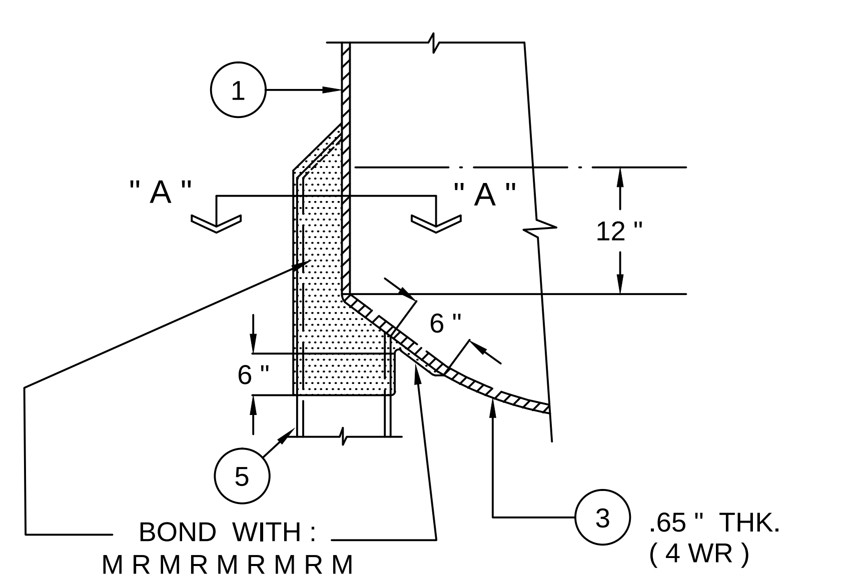

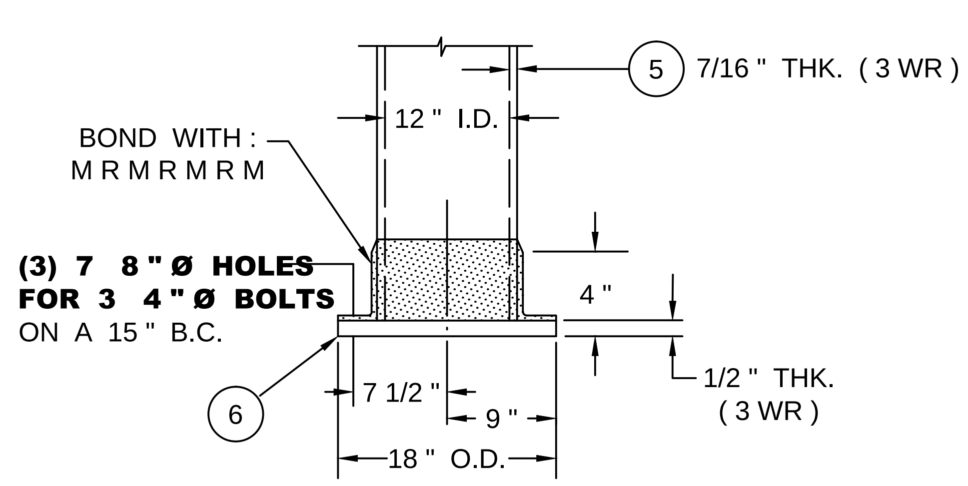

LEG ASSY. DETAILS

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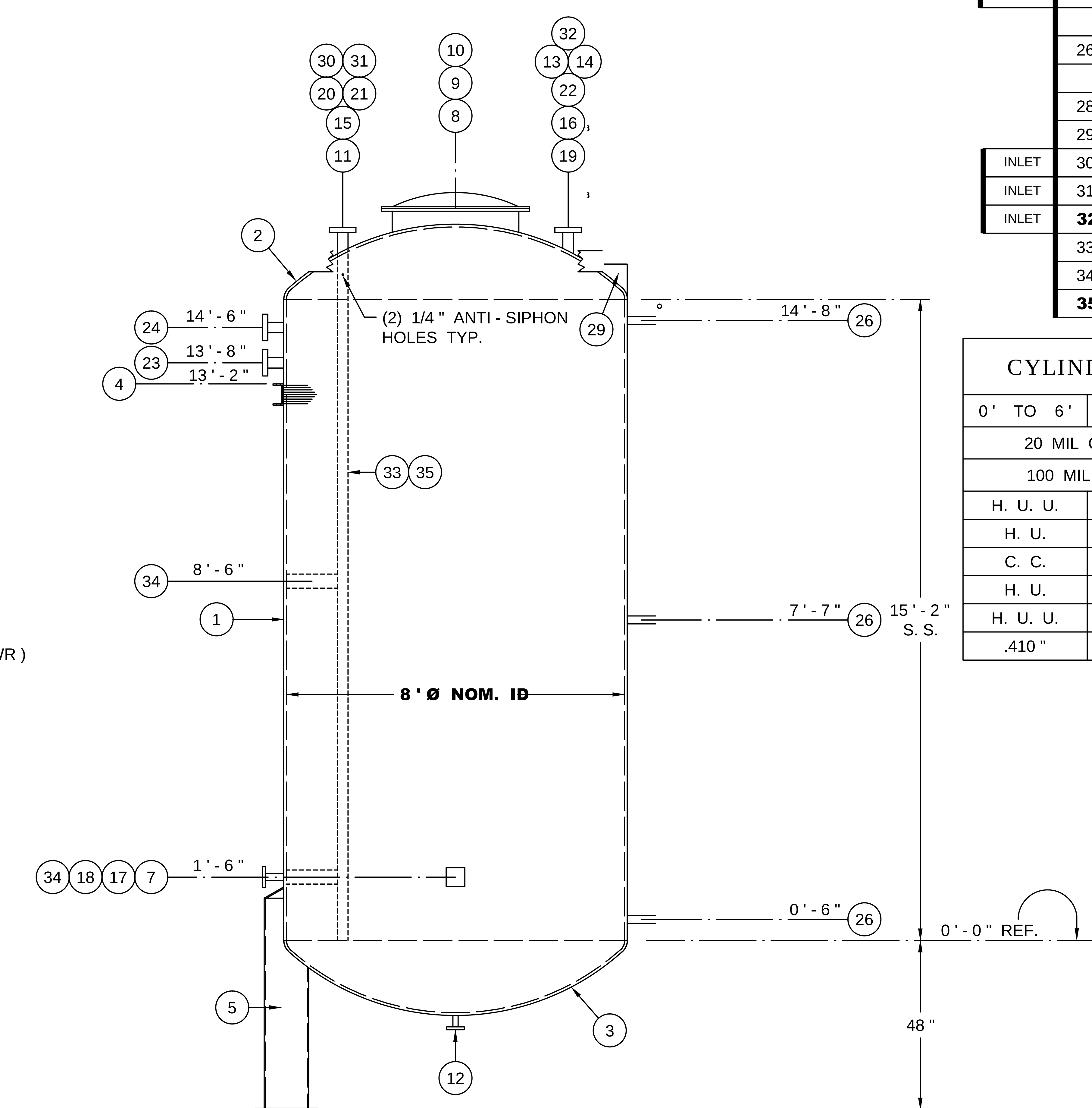


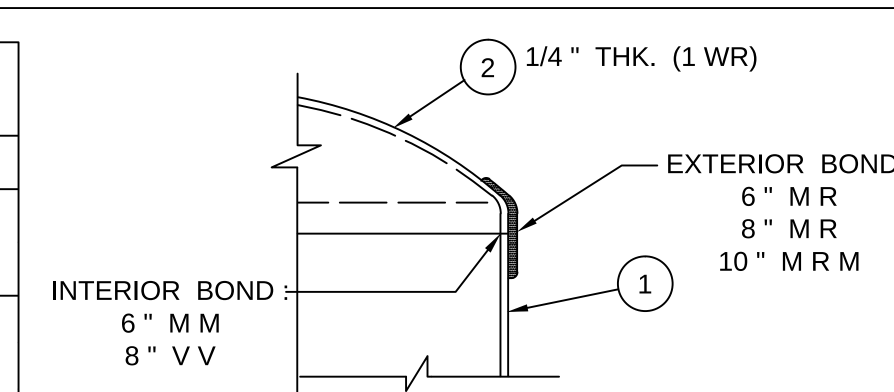
ELEVATION VIEW

(USE PLAN VIEW FOR TRUE ORIENTATION)

CUSTOMER DESIGNATION	ITEM	QTY.	SIZE	DESCRIPTION	NOZZLE PROJ.	ELEV.	ORIENT.
	APPURTENANCE AND MATERIAL SCHEDULE						
	1	**1**	**-**	**8 ' Ø X 15 ' - 2 " LG. FRP FILAMENT WOUND SHELL**			
	2	**1**	**-**	**8 ' Ø FRP TOP DOME HEAD, 1 4 " THK. (1 WR)**			
	3	**1**	**-**	**8 ' Ø FRP DISH BOTTOM, .65 " THK. (4 WR)**			
	4	2	-	GALVANIZED STEEL LIFTING LUG XC - 027 - D1			
	5	8	-	12 " ID X 60 " LONG FRP CONTACT MOLDED PIPE LEGS, 7/16 " THK. (3 WR)			
	6	8	-	18 " OD X 1/2 " THK. (3 WR) FRP BASE PLATES FOR PIPE LEGS			
	7	1	-	XERXES NAMEPLATE		1 ' - 6 "	**22**
MANWAY	8	1	36 " Ø	FRP TOP MANWAY & FLAT COVER SP - 063 - D2	4 "	TOP	CTR.
	9	**1**	**36 "**	**Ø 1 8 " EPDM GASKET FOR ITEM 8**			
	10	24	-	1/2 " X 2 1/2 " STEEL HEX HEAD BOLT SET FOR ITEM 8			
INLET	**11**	**1**	**1 "**	**Ø FRP FLANGED NOZZLE** XC - 047 - D3	4 "	TOP	**270**
OUTLET	12	1	1 1/2 "	FRP FLANGED NOZZLE XC - 047 - D3	4 "	BOTTOM	CTR.
PI	**13**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 048 - D4	6 "	TOP	**50**
SPARE	**14**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 048 - D4	6 "	TOP	**247**
VENT	**15**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 048 - D4	6 "	TOP	**315**
VENT	**16**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 048 - D4	6 "	TOP	**337**
SPARE	**17**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 048 - D4	6 "	1 ' - 6 "	**50**
SPARE	**18**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 048 - D4	6 "	1 ' - 6 "	**315**
LIT	**19**	**1**	**3 "**	**Ø FRP FLANGED NOZZLE** XC - 049 - D5	6 "	TOP	**22**
INLET	**20**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 049 - D5	6 "	TOP	**112**
INLET	**21**	**1**	**2 "**	**Ø FRP FLANGED NOZZLE** XC - 049 - D5	6 "	TOP	**145**
SPARE	**22**	**1**	**3 "**	**Ø FRP FLANGED NOZZLE** XC - 049 - D5	6 "	TOP	**180**
LEVEL	**23**	**1**	**3 "**	**Ø FRP FLANGED NOZZLE** XC - 049 - D5	6 "	13 ' - 8 "	**125**
OVERFLOW	**24**	**1**	**3 "**	**Ø FRP FLANGED NOZZLE** XC - 049 - D5	6 "	14 ' - 6 "	**225**
	26	3 PR.	-	LADDER BRACKETS XC - 040 - D6			
	28	5	-	STEEL HANDRAIL SOCKET XC - 085 - D7			
	29	1	-	TOP STEP - OFF PLATFORM, 1/4 " THK. (1 WR)			
INLET	30	1	1 1/2 "	FRP FLANGED NOZZLE XC - 049 - D5	6 "	TOP	**202**
INLET	31	1	1 1/2 "	FRP FLANGED NOZZLE XC - 049 - D5	6 "	TOP	**225**
INLET	**32**	**1**	**1 "**	**Ø FRP FLANGED NOZZLE** XC - 047 - D3	4 "	TOP	**292**
	33	2	1 1/2 "	FRP INTERNAL DROP PIPE FOR ITEMS 30 & 31			
	34	8	-	INTERNAL PIPE SUPPORTS FOR ITEMS 33 & 35			
	35	**2**	**2 "**	**Ø FRP INTERNAL DROP PIPE FOR ITEMS 20 & 21**			

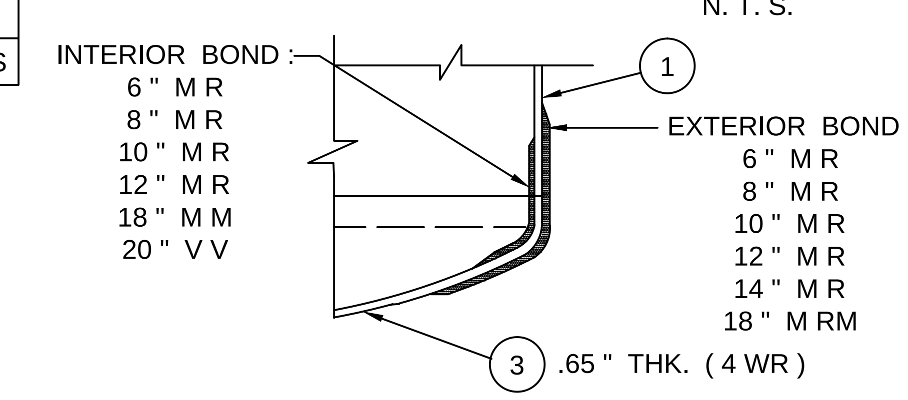
CYLINDER CONSTRUCTION

0' TO 6'	6' TO TOP	HEIGHT
20 MIL C - VEIL		HETRON 922 OR EQUAL
100 MIL CHOP		
H. U. U.	H.	ISOPHTHALIC
H. U.	H.	
C. C.	-------	
H. U.	H.	
H. U. U.	H.	
.410 "	.248 "	NOMINAL THICKNESS



ASSY. DETAIL, ITEMS 1 & 2

N. T. S.



ASSY. DETAIL, ITEMS 1 & 3

N. T. S.

XERXES CORPORATION

1210 N. TUSTIN AVE. ANAHEIM, CA. 92807
PHONE (714)630-0012 FAX (714)632-7133

(1) 8 ' Ø X 15 ' - 2 " SHELL FRP FILAMENT WOUND TANK

JOB NO.	P. O. NO.	SHEET 1 OF 2	
DATE	DRAWN R. F.	DRAWING NO.	REV. 2
SCALE N. T. S.	CHECKED D. H.		

△	DATE	REVISION	BY

TANK DESIGN, INSPECTION & CERTIFICATION SERVICES

CLIENT: Xerxes Corporation
Anaheim, CA

TI&CS Report Number: 08-10-9

Report Title: Design of 8 ft. Diameter by 182 in. High Fiberglass Tank with a Dome Bottom, Dome Top and Eight Legs with Seismic Parameters Based on San Diego, CA and IBC 2006

Author(s): Joseph M. Plecnik, Ph.D., P.E.
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Date of Issue: October 8, 2008

NOTES:

!f

INTRODUCTION AND SUMMARY

This report provides the design of a dome bottom, cylindrical tank supported on eight legs. The seismic parameters are provided on pages A-1 and A-2. The design is based on API 650 and IBC 2006 loads. The allowable stresses and material properties are based on ASTM D 3299 for filament wound construction and ASTM D4097 for contact molded laminates.

The final design is provided in Figs. A-2 through A-5 near the end of Chapter A. Chapter B provides the filament wound laminates.

CHAPTER A: DESIGN OF 96 in. ¢ x 182 in. HIGH TANK USING THE API 650 METHOD, IBC 2006 AND ASTM D3299 DOME BOTTOM, 8 LEGS, FIBERGLASS

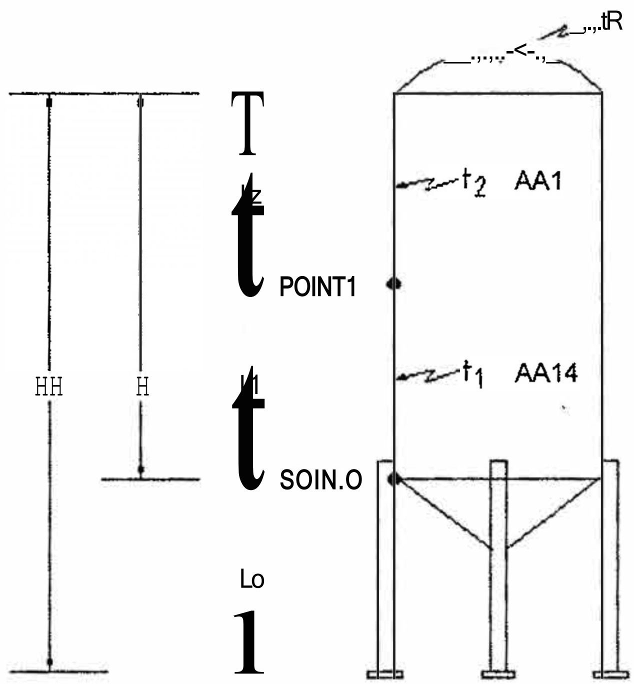

Fig. A-1: Tank Geometry

Min. Dome Thickness ;	tR := 0.25	(in.)
Type of Cover; Flat or Dish Type		
Radius of Cover (∞ for Flat Cover);		
Length 2 ;	Lz:=110	(in.)
Minimum Thickness for L2 ;	t2 := 0.248	(in.)
Eh2 := 3.50591106	Ea2 := 0.93484106	
Length 1 ;	L1 := 72	(in.)
Minimum Thickness for L1 ;	IJ := 0.410	(in.)
E111:= 2.94780106	Ea1:= 2.33518106	

I) Seismic Design Parameters (per IBC 2006 and ASCE 7-05)

A) For plant site, ASCE 7-05 gives the following seismic parameters:

Occupancy Category: J!L

Seismic Design Category: _Q_

Site Class: _Q_

Importance Factor. _I_ I:= 1.50

Response Modification Coefficient; RR:= 3.0

Specific Gravity of Liquid ; SGL:= 1.1

MATERIAL PROPERTIES AND LAMINATE CONSTRUCTIONS FOR SHELL

B)	Total Height (including legs) ;	JIB:= 230	(in.)
	Total Height of Straight Shell	H := 182	(in.)
	Tank Diameter;	D:= 96	(in.)
	Tank Radius;	R:= 48	(in.)
	P.,, = applied pressure (+) or vacuum (·)	Papp:= 0	psi
	Specific Gravity of Shell Material;	SGS:= 1.7	
	Poisson Ratio (for shell);	v := 0.3	
	Number of Legs;	nn:= 8	

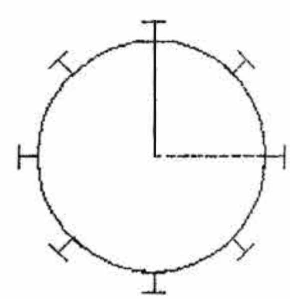

Fig. A-2: Top View of the Tank

A-2a

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Longitude -117.231675 °
W 117 ° 13' 54.0"
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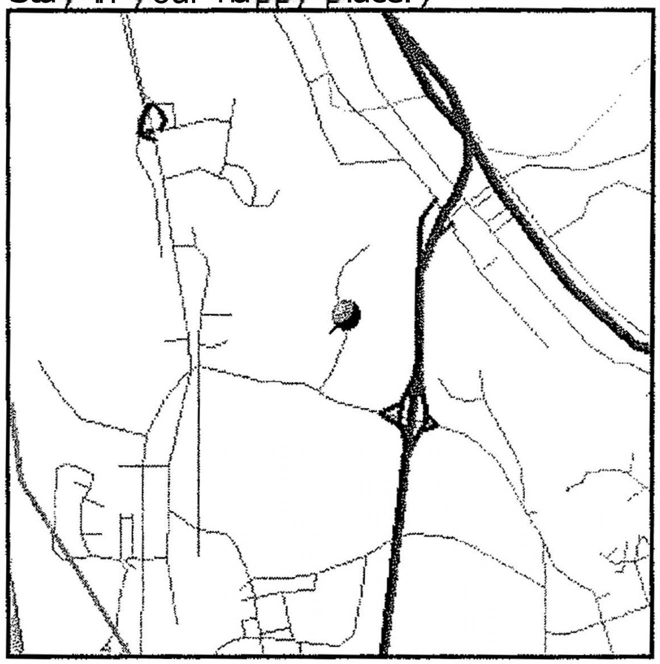

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C) Seismic Response Spectral Acceleration Values:

Ss := 1.497

S1 := 0.566

Fa:= 1.0

Fv := 1.5

SMs := Fa·Ss

SMs = 1.497

SMJ := Fv·S1

SMJ = 0.849

$sos := \frac{2}{3} \cdot SMs$

sos= o.998

$So1 := \frac{2}{3} SMJ$

SDI= 0.566

Since API 650 assumes V; independent of fundamental period of tank structure:

Sai := Sos

Sai = 0.998

W; = impulsive weight component

Wi = W1

ZC = resultant impulsive spectral acceleration

ZC:= Sa;•!+ RR

z c = 0.499

ZC1s := ZC

ZCJR:= ZC

ZCJ I := ZC

D) Convective Component

Tc = natural period for sloshing

g := 32.2 fl./sec. sec. = gravitational acceleration

$Tc := 2\pi \cdot \sqrt{\frac{D + 12}{3.68 \cdot g \cdot tanh(-3 \cdot 6i \cdot H\_)}}$

Tc= 1.633 **sec.**

Since Tc < 4 sec.

$$Sac := \frac{1.5 \cdot Sm}{Tc}$$

Sac= 0.52

C2 = sloshing spectral acceleration

$$C_2 := \frac{S_{ac} \cdot I}{RR}$$

C2 = 0.26

E) Roof Geometry Factors

Dome Roof; RF= 1.25

Flat Roof; RF= 1.00

Conical Roof (15% or less); RF= 1.05

RF:= 1.25

A-4

VII } Calculation of Overturning Moments

A) AT TANK BOTTOM (POINT O, FIG. A-1)

$M_0 = M_{0S} + M_{0R} + M_{01} + M_{02}$

Where,

M0s = (1/1.4) ZC Ws Xs = overturning moment due to shell weight

M0R = (1/1.4) ZC WR H = overturning moment due to roof weight

M_{01} = (1/1.4) ZC W_1 X_1 = overturning moment due to liquid inertial force

M_{02} = (1/1.4) C_2 W_2 =overturning moment due to liquid sloshing

Ws = Total weight of shell

W_5 := 1t·D-(SGS)·(0.036l)·{L1·t1 + Lz·tz)

W_5 = 1051.297 lbs

Xs = Half tank height ; $X_s := \frac{L1 + Lz}{2}$

X_5 = 91 in.

W_R = Weight of tank roof

W_R := n-R^2·IR·(SGS)-0.0361-RF

WR= 138.816 lbs

For $\frac{D}{H}$ = 0.527 , From Fig. A-2:

W_L = Weight of tank contents above Point 0

WL := 1t-R^2-{L 1+ Lz)·0.036l·SGL

WL = 52312.277 lbs

$F_{A1} := \frac{0.866\text{-}D}{H}$ FAI = 0.457

$F_{A2} := \frac{3.67\text{-}H}{D}$ FA2 = 6.958

FA3 := cosh{FAz) - 1 FA3=524.611

$AW_{1a} := \frac{\tanh(F_{A1})\cdot W_L}{F_{A1}}$ AW1a = 48953.845 lb.

$AW1b := \left(1 - \frac{0.218\text{-}D}{H}\right)\cdot WL$ AW 1b = 46296.94 lb.

A-5

$W_1 := \begin{cases} AWJa & \text{ir } \frac{D}{H} 2 1.33 \\ AW lb & \text{otherwise} \end{cases}$ WJ = 46296.94 lb.

Wz := o.230{)-tanh(FA2}•WL Wz = 6346.445 lb.

X1 = moment arm for liquid seismic inertial force

X2 = moment arm for sloshing seismic force

Xia:= 0.375·H Xia = 68.25 in.

$X_{1b} := \left(0.5 - 0.094 \cdot \frac{D}{H}\right) \cdot H$ XJb = 81.976 in.

$X_1 := \begin{cases} X1a & \text{If } \frac{D}{H} 2 1.33 \\ XJb & \text{otherwise} \end{cases}$ XJ = 81.976 in.

$X_2 := \left(1 - \frac{F_{A3}}{F_{A2} \cdot \sinh(F_{A2})}\right) \cdot H$ X2 = 155.892 in.

M0 = overturning moment at Point 'O'

Mos:= (-1-)•ZGW,·Xs (1.4) Mos = 34098.829

MoR:= (-1-)·ZGWR•H (1.4) MoR = 9004.972

Mo1 := (-1-)•ZGW1·X1 (1.4) Mo1 = 1352731.237

Mo2 := (-1-)•C2·W2·X2 (1.4) Mo2 = 183751.005

Mo := Mos + MoR + M01 + Mo2

Mo = 1579586.044 (in - lbs.)

F_{HO} = horizontal base shear at Point O

FHo := Mos + Xs + MoR + H + Mo1 + X1 + Mo2 + Xz

FHo = 18104.452

B) OVERTURNING MOMENT AT POINT 1 (SEE FIG. A-1)

$M1 = M_1s + M_1R + M11 + M_12$

Where,

$M18 = (1/1.4)\ ZC\ BW8\ BX8$

$M1R = (1/1.4)\ ZC\ WR\ L2$

$M11 = (1/1.4)\ ZC\ BW1\ BX1$

$M12 = (1/1.4)\ C2\ BW2\ BX2$

BWs = total weight of shell above point 1. (See Fig. A-1)

$BW_5 := 1t \cdot D \cdot (SGS) \cdot (0.036l) \cdot (L2 \cdot t2)$

BWs = 504.919 lbs.

$BX_5 := \frac{L2}{2}$

$BX_5 = 55$ in.

WR= weight of tank roof

WR= 138.816 lbs.

For $\frac{D}{L2} = 0.873$,From Fig. A-2:

BW_L = weight of tank contents above point 1.

$BW_L := \pi \cdot R^2 \cdot (L_2) \cdot (0.0361) \cdot (SGL)$

BWL = 31617.31 lbs.

$Fs1 := \frac{0.866 \cdot 0}{(Lz)}$ FBJ = 0.756

$Fs2 := \frac{3.67 \cdot (L2)}{D}$ Fs2 = 4.205

$F_{B3} := \cosh(F_{B2}) - 1$ FB3 = 32.525

$BW_{1a} := \frac{\tanh(F_{B1}) \cdot BW_L}{F_{B1}}$ BW1a = 26714.536 lb.

BW1b:= [I - $\frac{0.2!8 \cdot D]}{(Lz)}$-BWL BWtb = 25601.973 lb.

BWI:= | BWIa if $\frac{D}{(L2)}$ 2 1.33
| BWIb otherwise

BW2 := 0.230-[(:)}anh(FB2)·BWL BWz = 6343.632 lb.

BX1a== 0.375-(Lz) BX1a = 41.25 in.

BXJb := [0.5 -0.094·(z)}(Lz) BXJb = 45.976 in.

BXJ := | BX1a ir $\frac{D}{(Lz)}$ 2 1.33 BXt = 45.976 in.
| BXIb otherwise

BXz := (I - $\frac{FB3}{FB2 \cdot sinh(FB2)}$) ·(L2) BX2 = 84.61 l in.

Ml = overturning moment at Point "1"

Mts := (-1-)-zc-BWs•BXs M1s = 9898.213
1.4

$M_{1R} := \left(\frac{1}{1.4}\right) \cdot ZC \cdot W_R \cdot (L_2)$ MIR= 5442.566

M[1 := (-1-)-zc-BW1-BX1 M11 = 419543.631
1.4

M12 := (-1-)-C2·BWz-BX2 M 12 = 99687.503
1.4

M1 :=Mis+ MJR + M11 + M12

M1 = 534571.913 (in - lbs.)

VIII) Calculation of Flexural Stresses

A) Flexural Axial Stresses At Point 0

1) S_1 = section modulus for 1_1

   Rn_1 = mean tank radius

   Rm1 := R + .50·(11)

   Rm1 = 48.205

   SJ:= 1t·(Rm1l^2·(11)

   S1 = 2993.077 in.^{3}

   σo := (: 1·θ)

   a_0 = 527.747 psi

   so = strain at tank bottom

   Ea1 = axial modulus of elasticity for L1 length of shell

   $so := \frac{\sigma o}{Ea1}$

   EQ = 0.000226 in.tin.

Ballow = allowable axial strain

= 0.00133 in.fin. (ASTM 03299 with 33% increase for seismic)

Hence,

so = 0.000226 in.tin. ≤ sallow = 0.00133 in.tin. OK

2) Check for buckling at tank bottom

   From Fig. 10-13 of Ref. 1

   $M_e$rlo = critical buckling moment at tank bottom

   $M_{cr/0} = \pi R^2 t_1 \sigma_{cr/0}$

where,

   a_{cr}/O= critical buckling axial stress at tank bottom.

   $$\sigma_{cr/0} = \gamma \cdot C_b \cdot \left(\frac{E_{e1} \cdot t_1}{R} \right)$$

For $R = 48$ in.

$t1 = 0.41$ in.

$\frac{R}{U} = 117.073$,From Fig.10-13 of Ref. 1: $y := 0.64$

$$C_b := \left[\frac{1}{\sqrt{3 \cdot (1 - \nu^2)}} \right]$$ Cb= 0.605

Ee1 = effective modulus for buckling for 11 lamina.

$E_{axial} = E_{a1}$ $E_{hoop} = E_{h1}$

$$E_{e1} := \sqrt{E_{a1} \cdot E_{h1}}$$ Eel= 2.62367 x 10^6 psi

$$\sigma_{cr0} := \gamma \cdot C_b \cdot \left(\frac{E_{e1} \cdot t_1}{R} \right)$$

<>aO = 8680.614 psi

Mera:= $1t \cdot R^2 \cdot t1 \cdot$ <>cra

Mero= 25761233.996 in. - lbs

SF_O= Safely factor against buckling due to M0

SFo:= ($\frac{Mera}{Mo}$) $SF_0 = 16.309$

A minimum safety factor against buckling of 4.0 is recommended

BI Flexural Axial Stresses At Point 1

1} S2 = section modulus for ½

$R_{,2}$ = mean tank radius

Rm2 := R + .so-(12)

Rm2 = 48.124

S2 := 1t·(Rm2f(t2)

S2 = 1804.367 in.^{3}

σ1 := (: :)·

σ_1 = 296.266 psi

s 1 = strain at Point 1

E_{32} = axial modulus of elasticity for L2 length of shell

$s1 := \frac{\sigma 1}{Ea2}$

q = 0.000317 in.fin.

where E_{32} = axial modulus for½ thick lamina

See Chapter B.

Hence,

sj = 0.000317 in.fin. ∴ sallow = 0.00133 in.fin. **OK**

2) Check for buckling at Point 1

From Fig. 10-13 of Ref. 1

Mc,1 = critical buckling moment at Point 1

Mc,1 =" R2 12 σσ1

where,

σc11 = critical buckling axial stress at Point 1

$\sigma_{\sigma 1} = y \cdot Cb \cdot \frac{(Ee2 \cdot t2)}{R}$

For $R = 48$ in.

$t2 = 0.248$ in.

$\frac{R}{t2} = 193.548$,From Fig.10-13 of Ref. 1: $\gamma := 0.58$

$$C_b := \left[\frac{1}{\sqrt{3\cdot\left(1-\nu^2\right)}}\right]$$ Cb= 0.605

$E_{e}2$ = effective modulus for buckling for t2 lamina.

$E_{axial} = E_{a2}$ $E_{hoop} = E_{h2}$

$$E_{e2} := \sqrt{\left(E_{a2}\cdot E_{h2}\right)}$$ $E_{e2} = 1.810377 \times 10^6$ psi

$$\sigma_{cr1} := \gamma\cdot C_b\cdot\left(\frac{E_{e2}\cdot t_2}{R}\right)$$

$\sigma_{cr1} = 3283.418$ psi

$M_{cr1} := \pi\cdot R^2\cdot t_2\cdot\sigma_{cr1}$

$M_{cr1} = 5894000.478$ in. - lbs

SF_1 = Safety factor against buckling due to M1

$SF1 := \left(\frac{M_{cr1}}{M1}\right)$ $SF_1 = 11.026$

A minimum safety factor against buckling of 4.0 is recommended

IX) Calculation of Hoop and Resultant Stresses And Strains

A) Hoop and Resultant Stresses and Strains at Point 0

σ_{h0} = hoop stress = (Po·Rm1 / t1)

Papp= applied pressure(+) or vacuum(-), (psi)

PO = pressure at Point O + Papp

Po:= SGL-0.0361-(L1 + L2) + (Papp)

Po= 7.227 psi

$\sigma_{h0} := \left(\frac{P_0 \cdot R_{m1}}{t_1}\right)$

σ_{h0} = 849.727 psi

ε_{h0} = hoop strain at tank bottom

$\varepsilon_{h0} := \frac{\sigma_{h0}}{E_{h1}}$ ε_{h0} = 0.000288 in./in.

where Eh1 = hoop modulus for t1 thick lamina

Ea1 = axial modulus for t1 thick lamina

ε_{h0} = 0.000288 in./in. ≤ 0.00100 in./in.(ASTM D3299) OK

ε_{QT} = total axial strain due to bending and internal pressure (vacuum)

ε_{aappo} = axial strain due to Papp

$\varepsilon_{aappo} := \left(\frac{P_{app} \cdot R_{m1}}{2 \cdot t_1 \cdot E_{a1}}\right)$

ε_{aappo} = 0

$\varepsilon_{QT} := \varepsilon_Q + \varepsilon_{aappo}$

ε_{QT} = 0.000226

ε_{res0} = resultant strain for t1 thick laminate

$\varepsilon_{res0} := \sqrt{(\varepsilon_{h0})^2 + (\varepsilon_{QT})^2}$

ε_{res0} = 0.000366 in./in. ≤ ε_{allow} = 0.00133 in./in.(ASTM D3299) OK

B) Hoop and Resultant Stresses and Strains at Point 1

$\sigma_{h/1}$ = hoop stress = $\left(\frac{P1 \cdot Rm2}{tz}\right)$

Papp= applied pressure(+) or vacuum(-), (psi)

P_1 = pressure at Point 1 + Papp

P1 := SGL-0.036l·L2 + (Papp)

P1 = 4.368 psi

$$\sigma_{h1} := \left(\frac{P_1 \cdot R_{m2}}{t_2}\right)$$

CTh! = 847.623 psi

Eh! = hoop strain at Point 1

$$\varepsilon_{h1} := \frac{\sigma_{h1}}{E_{h2}}$$ Ehl= 0.000242 in.fin.

where E_{h2} = hoop modulus for t2 thick lamina

Ea_2 = axial modulus for 1_2 thick lamina

Ehl= 0.000242 in.fin. ::: 0.00100 in./in.(ASTM D3299) OK

E IT = total axial strain due to bending and internal pressure (vacuum)

E aapp 1 = axial strain due to Papp

$E_{aap}pl := \frac{(Papp \cdot Rm2)}{2 \cdot t2 \cdot Ea2}$

Eaappl = 0

$$\varepsilon_{1T} := \varepsilon_1 + \varepsilon_{aappl}$$

E IT= 0.0003169

Eresl = resultant strain for 12 thick laminate

$$\varepsilon_{res1} := \sqrt{\left(\varepsilon_{h1}\right)^2 + \left(\varepsilon_{1T}\right)^2}$$

Eresl = 0.000399 in.fin. ::: sallow = 0.00133 in./in.(ASTM D3299) OK

X) Dome Bottom Design

A) Dome Geometry

1) R_{dd} = bottom dome major radius

$R_{dd} := 96$ in.

B_d = total depth of dished head dome bottom

$B_d := 20$ in.

r_{dd} = bottom dome minor radius

$r_{dd} := 0.06 \cdot R_{dd}$ $r_{dd} = 5.76$ in.

t_{dd} = bottom dome thickness

$t_{dd} := 0.65$ in.

E_{dd} = modulus of bottom dome

$E_{dd} := 1.4 \cdot 10^6$ psi

P_0 = pressure on bottom of dome

$P_0 := (H + B_d) \cdot (0.0361 \cdot SGL)$ $P_0 = 8.021$ psi

2) Dome stresses away from joint

σ_{rr} = radial stresses

$\sigma_{\theta\theta}$ = hoop stresses

$\sigma_{rr} = \sigma_{\theta\theta}$

$\sigma_{rr} := \frac{P_0 \cdot R_{dd}}{2 \cdot t_{dd}}$ $\sigma_{rr} = 592.351$ psi

$\varepsilon_{rr} := \frac{\sigma_{rr}}{E_{dd}}$ $\varepsilon_{rr} = 0.000423$ in.

ε_{dres} = resultant strain for dome

$\varepsilon_{dres} := \sqrt{\varepsilon_{rr}^2 + \varepsilon_{rr}^2}$ $\varepsilon_{dres} = 0.000598$ in.

3) Stress analysis at joints

RLR = ratio of dome major radius to minor radius

$RLR :; - \frac{Rdd}{'dd}$ RLR ; 16.667 in.

MM = stress multiplier

MM :; I.77 from "Presure Vessel Handbook"

tid = dome joint thickness; total

S. = allowable stress in tension for joint bonds

Sa:; 1200 psi

JE = joint efficiency

JE :; 1.0

$ljd :; \frac{Po \cdot Rdd \cdot MM}{2 \cdot Sa \cdot JE + Po \cdot (MM - 0.2)}$ ljd ; 0.565 in.

4) Volume and weight calculaitons for dome and dome liquid

VdUa = volume of dome liquid

$Y_{d}LIQ :; 0.000049 \cdot D^{3} \cdot 1728$ YdLIQ = 74912.367 in.3

wdliq := Yctuo·SGL-0.0361 $W_{d}liq$ = 2974.770077 lb.

Wdshell = weight of dome shell alone

$W_{dshell} := 1.20 \cdot 3.14 \cdot R^{2} \cdot ldd \cdot SGL \cdot 0.0361$ $W_{d}shell$ = 224.082 lb.

5) Total weight of vessel plus liquid

$W_{TOT} := (W_{dshell} + W_{dliq} + W_{L} + W_{S} + W_{R}) \cdot 1.01$

W-roT = 57268.254 lb. (1 % added for extras)

XI) Calculation of Leg Forces Due to Seismic Loads

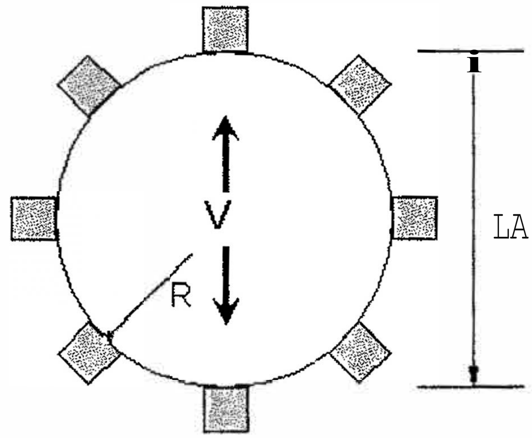


Figure A-3 : Seismic Force Parallel to Legs

Load Case #1 - Full Tank with DL +Seismic:

***A) Calculation of Seismic Load Factors for Overturning at the* Base**

Period of Vibration :

Since the stiffness of the shell is usually large compared with that of the legs, the period of vibration can be found using the general formula for a one mass structure, assuming the deflection, Y, equals the deflection of the legs resulting from a total lateral force equal to the weight of the vessel. For a vessel supported on three or more legs symmetrically spaced about the center, Y may be determined from the formula:

$$Y = \frac{2 W_{TOT} L_O^3}{3 \cdot N \cdot E \cdot (I_x + I_y)}$$

where:

N = number of legs.

$I_x + I_y$ = sum of moments of inertia of one leg about two perpendicular axis.

L_O = length of legs from base to shell attachment.

W_{TOT} = Total weight of Tank+ Content

E = modulus of elasticity of leg material

Leg Sectional Properties (8 in. Diameter Pipe)

A-17

N:= 8

Ix:= 75.3 in.4

Iy := 75.3 in.4

Lo:= IIB-H in. Lo= 48 in.

E:= 1.2-106 psi

$Y_B := 3 \cdot N \cdot E \cdot (I_x + I_y)$

Ya = 4337280000.000

Y:= 2•WToTLo^3 +Y[I

Y = 2.920 in.

g := 386 in./sec.2

Tsys = period of vibration for entire tank system

Tsys := 6.28-H

Tsys = 0.546 sec.

If Tsys < Tc ; use Tc for sloshing for convective loads. Otherwise use Tsys

B) Calculation of Total Lateral Seismic Loads

Vti = total impulsive seismic load at top of legs

vti := (wToT- w2)-zc

Yti = 25409.983

V_{10} = total convective seismic load at top of legs

Y_{tC} '= W2•C2

Ytc = 1650.193

LTH = angle between legs

LTH := 45 deg.

Assume equivalent of LE legs resist in tension and LE legs in compression.
LE= 4 if HID less than or equal to 1.5. LE= 3.5 if HID greater than 1.5 but less than 2.5. LE= 3 otherwise.

LE:= 3

LA = distance between legs (Add 10 in. to center of legs.)

LA := 2(R + R cos(LT ... 14)) 0.5 + 10

LA = 91.955 in.

M_{OTT} = total overturning moment

$$M_{OTT} := V_{ti}\cdot(L_1 + L_2)\cdot\frac{X_1}{H} + V_{tc}\cdot(L_1 + L_2)\cdot\frac{X_2}{H}$$

M_{OTT} = 2340260.155 in.lb.

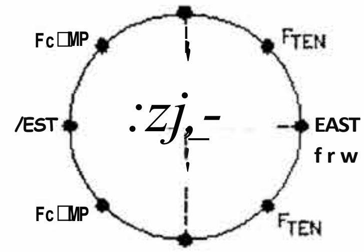


Fig. A-4: East to West Seismic Load

Assume 90% of dead load resistant overturning.

M_{RES} = resisting moment at top of legs (add 5 in. to center of legs)

$M_{RES} := 0.9\cdot W_{TOT}\cdot(R + 5)$

M_{RES} = 2731695.722 in.lb.

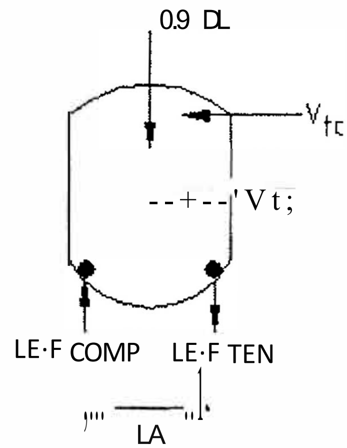


Fig. A-5: Forces for East to West Seismic Load

C) Calculate Leg Forces at Top of Legs (East to West Seismic Direction)

F_{COMP1} = compression force in leg

$$F_{COMP1} := (M_{RES} + M_{OTT})\cdot\frac{1}{LE\cdot LA}$$

F_{COMP1} = 18385.717 lb. + = compression in legs

$F_{TEN1} := (LE\cdot F_{COMP1} - 0.9\cdot W_{TOT})\cdot\left(\frac{1}{LE}\right)$

F_{TEN1} = 1205.241 lb. + = tension in legs

D) Calculate Leg Forces at Top of Legs (West to East Seismic Direction)

$$F_{TEN2} := \frac{M_{OTT} - M_{RES}}{LE\cdot LA}$$

F_{TEN2} = -1418.944 lb. + = tension in legs

$F_{COMP2} := (LE\cdot F_{TEN2} + 0.9\cdot W_{TOT})\cdot\left(\frac{1}{LE}\right)$

F_{COMP2} = 15761.532 lb. + = compression in legs

E) Leg Forces Due to Dead Loads Only

Fn,'N3 := 0

$$FcOMr3 := \frac{WToT}{N}$$

FcoMP3 = 7158.532 lb. + = compression in legs

F) Summary of Maximum Leg Forces

V_{SH} = shear force per leg

$$Vsw = \frac{Yti + Ytc}{N}$$

VsH = 3382.522 lb. + = compression in legs

Maximum Leg Reaction in Tension :

MaxT := | Temp <- FrEN I
| Temp <- FTEN2 if FTEN2 > Temp
| Temp <- 0 if O > Temp

MaxT = 1205.241 lb.

Maximum Leg Reaction in Compression :

MaxC := | Temp<- FcOMPI
| Temp<- FcoMP2 if FcoMP2 > Temp
| Temp<- FcOMP3 if FcoMP3 > Temp

MaxC = 18385.717 lb.

'$lC)5 vƒPot..,T CC'(, l)(FS/G/

..•.~L=/'f' /j,:•.r 4-11

·· 4 = - - 1 ' ___ /_Z rjb <;;c.

""/. = p--(12,/[if-)

= If,$ – '-

σ = 18,400 / 16.5

= 1110 psi ok

Try 3/8" thick leg

A = π(12)(3/8)

= 14.1 in²

rT'''- /f-Co ^10 - . -

{Yi/·_

.:;;,, /3.0tD _...

Safety factor = / (/c?ei. / /i?'dJ

:::: _.· G,k,2 s-- - ok

Use 7/16" legs, 12" ϕ

Buckling ok

ANCHOR BOLTS (3 per leg)

F_h = 27,000 lbs   TEN = 0

.. A>- .. ...."?/ .

...v,;,.,tr=Jk-fJ = /(2a3/ ,0!.,L '

USE 3-3/4" φ BOLTS per leg
CARBON STEEL
HILTI KB-TZ TYPE
$4\frac{3}{4}$" MIN. EMBED NO INSP.
$f'_c \geq 3.0$ ksi

OR EQUAL
See p. A-22 also

CHECK BOLT TENSION   7,)e1€ ,l'::i /┴7" ii-;'€'_

M = V(Lo)   ef 3JR2-
= 3382(48)
= 162,000 in-lb   ?-' vf_{-tt}

$S = \pi r^2 t$
$S = \pi (6.2)^2 (7/16) = 50.7$

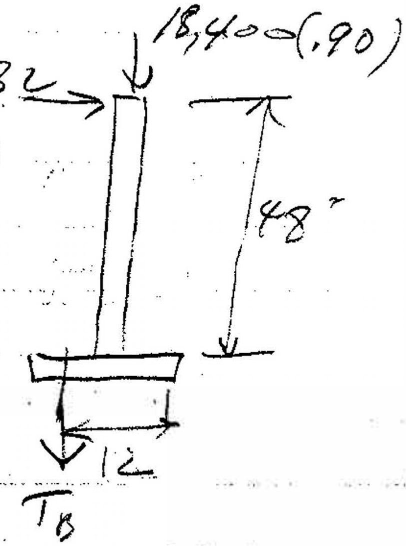
$\sigma = \frac{M}{S} = \frac{162,000}{50.7} = 3,190$ psi ok

σ_{comp} = comp. stress in pipe
= 1110 psi

σ_{net} = 3190 ± 1110
= 2080 psi MIN.
= 4300 psi MAX ok

ANCHOR BOLTS FOR SHEAR + MOMENT

V/bolt = 1120 lb
T_B = bolt tension
$(T_B)(12)$ = 3382(48) − (18,400)(11.)(.9)
T_B = 3870 lb



Check 3/4" ϕ bolts

$\left(\frac{3870}{4272}\right) + \left(\frac{1120}{6313}\right) \leq 1.20$

0.90 + 0.18 = 1.08 ok

A-23

TABLE 9-KS-TZ CARBON AND STAINLESS STEEL ALLOWABLE SEISMIC TENSION (ASD), NORMAL-WEIGHT CRACKED CONCRETE, CONDITION B (pounds)[1,2,3]

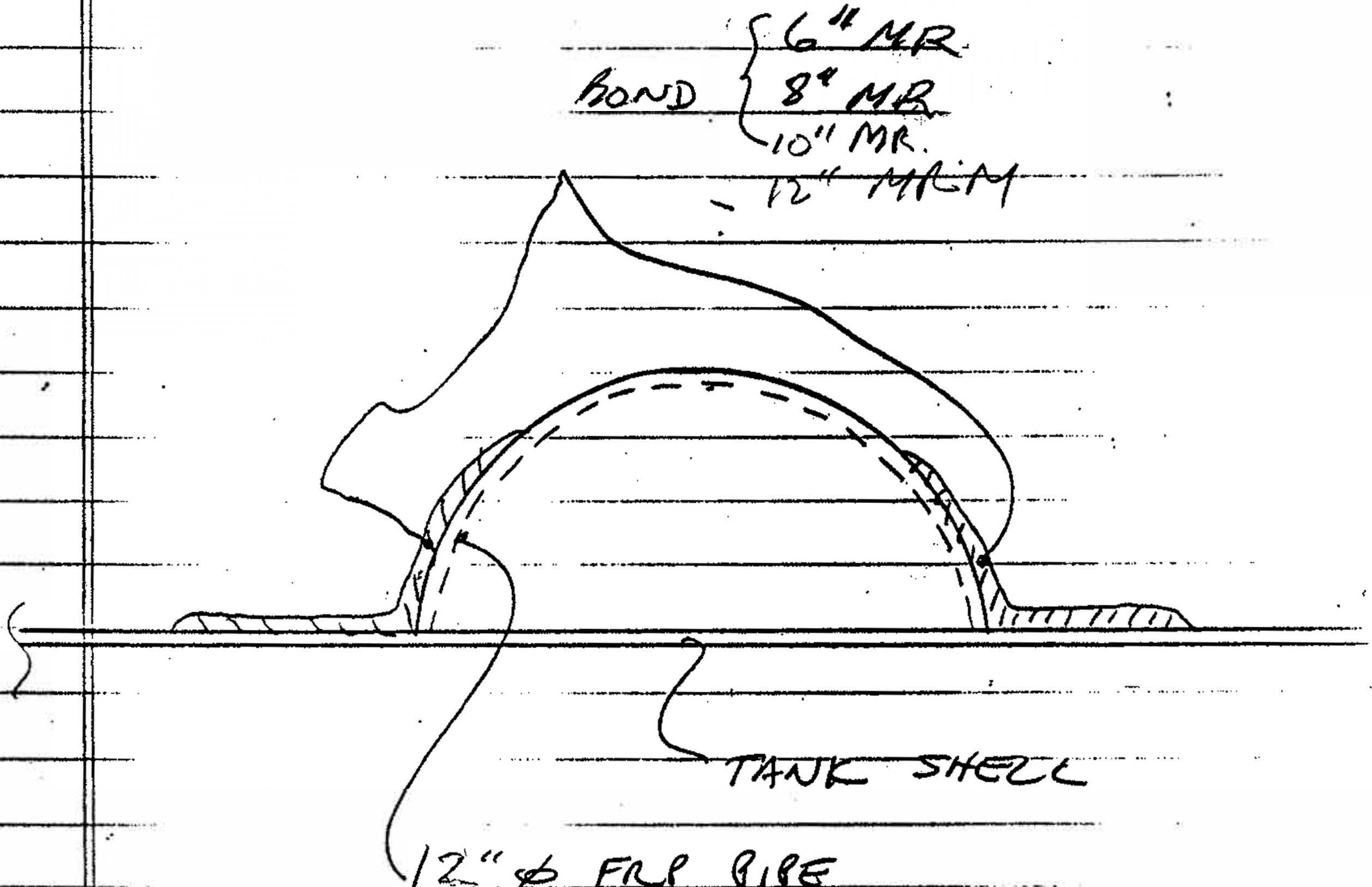
Nominal Anchor Diameter	Embedment Depth h_{ef} (in.)	Concrete Compressive Strength[2]							
		f'c = 2,500 psi		f'c = 3,000 psi		f'c = 4,000 psi		f'c = 6,000 psi	
		Carbon steel	Stainless steel		Stainless steel	Carbon steel	Stainless steel	Carbon steel	Stainless steel
3/8	2	1,006	1,037	1,102	1,136	1,273	1,312	1,559	1,607
1/2	2	1,065	1,212	1,167	1,328	1,348	1,533	1,651	1,878
	3 1/4	2,178	2,207	2,386	2,418	2,755	2,792	3,375	3,419
518	3 118	2,081	2,081	2,280	2,280'	2,632	2,632	3,224	3,224
	4	3,014	2,588	3,301	2,835	3,812	3,274	4,669	4,010
3/4	3 314	2,736	3,594	2,99L	3,937	3,460	4,546	4,238	5,568
	314	3,900	3,900	4,272	4,272	4,933	4,933	6,042	6,042

For SI: 1 psi = 0.00689 MPa For pound-inch units: 1 mm = 0.03937 inches
[1]values are for single anchors with no edge distance or spacing reduction. For other cases, calculation of Re as per AC! 318-05 and conversion to ASD in accordance with Section 4.2 1 Eq. (5) is required.
[2]Values are for nonmal weight concrete. For sand-lightweight concrete, multiply values by 0.60.
[3]condition B applies where supplementary reinforcement in confonnance with ACI 318-05 Section D.4.4 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.

TABLE 1G-KB-'TZ CARBON AND STAINLESS STEEL ALLOWABLE SEISMIC,SHEAR LOAD (ASD), ,Mf!e11nc1s1

Nominal Anchor Diameter	Allowable Stael Capacity,[1] Seisl,,ic Shear	
	Carbon Steel	**Stainless Steel**
318	999	1,252
112	2,83,9.	3,049
518.	AJi78	5,245;
3/4	s,313r	6,477

,or SI: 1 lbf = 4.45 N
[1]Values are for single anchors with no edge distance or spacing reduction due to concrete failure.

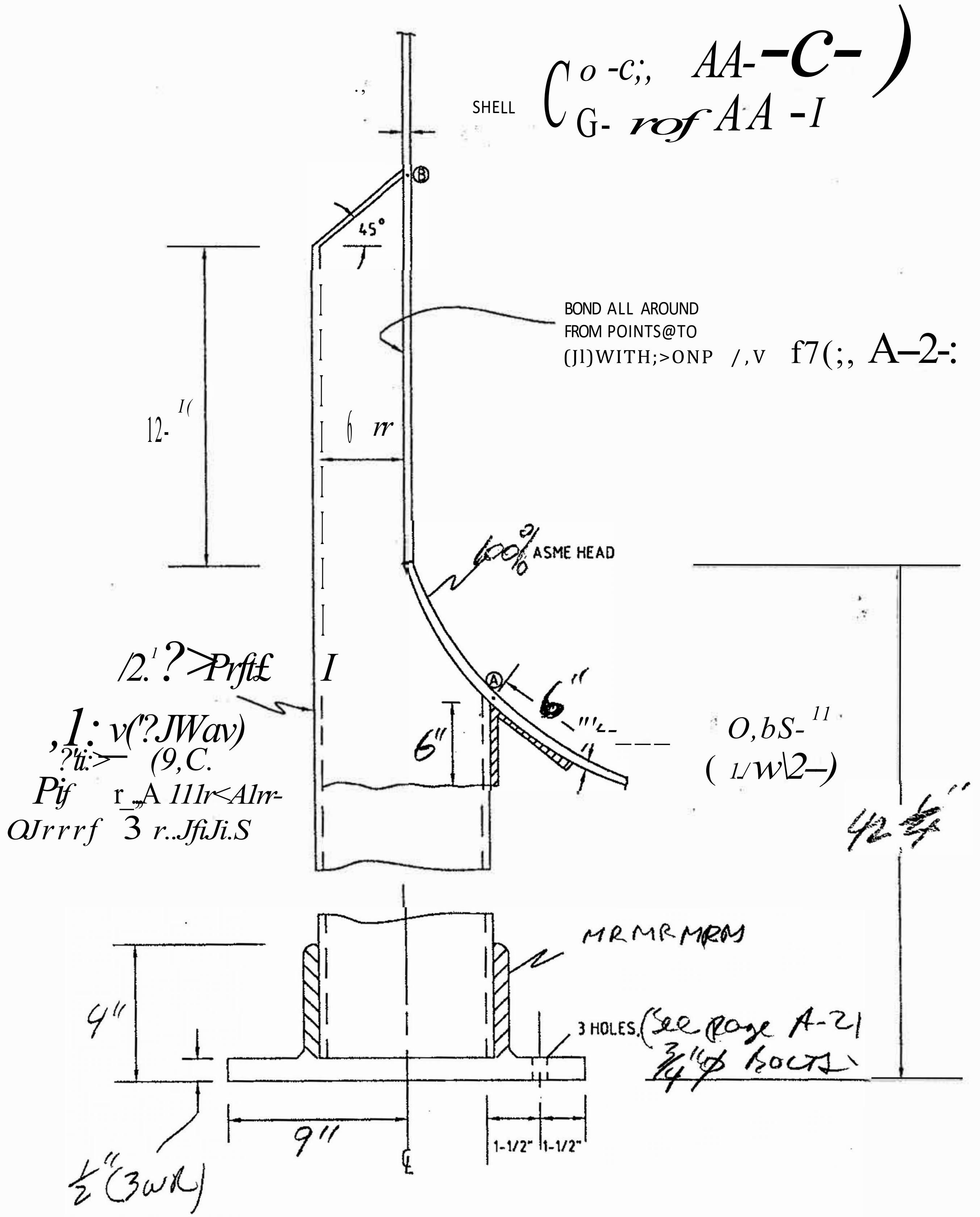


M = 1½ oz Mat
R = 24 oz Woven Roving

FIG A-2: BOND FOR PIPE.

STRUCTURES LABORATORY
COMPOSITES DIVISION
CALIFORNIA STATE UNIVERSITY, LONG BEACH
CALIFORNIA 90840 (562) 985-4406

· FIG.,4~3,'fANK SUPPORT DESIGN
{%LEGS REQD.)



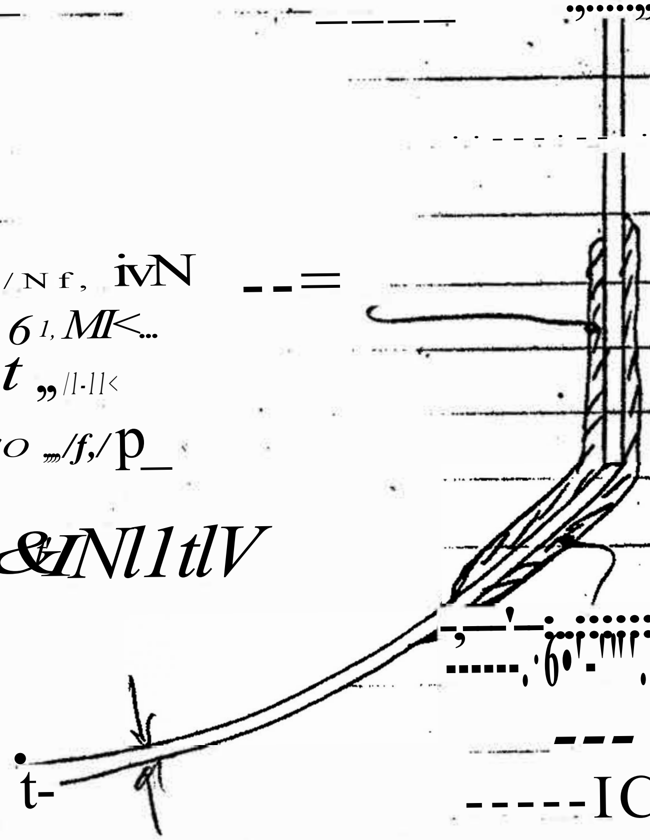


FIG. A-4: DOME BOTTOM/SHELL BOND

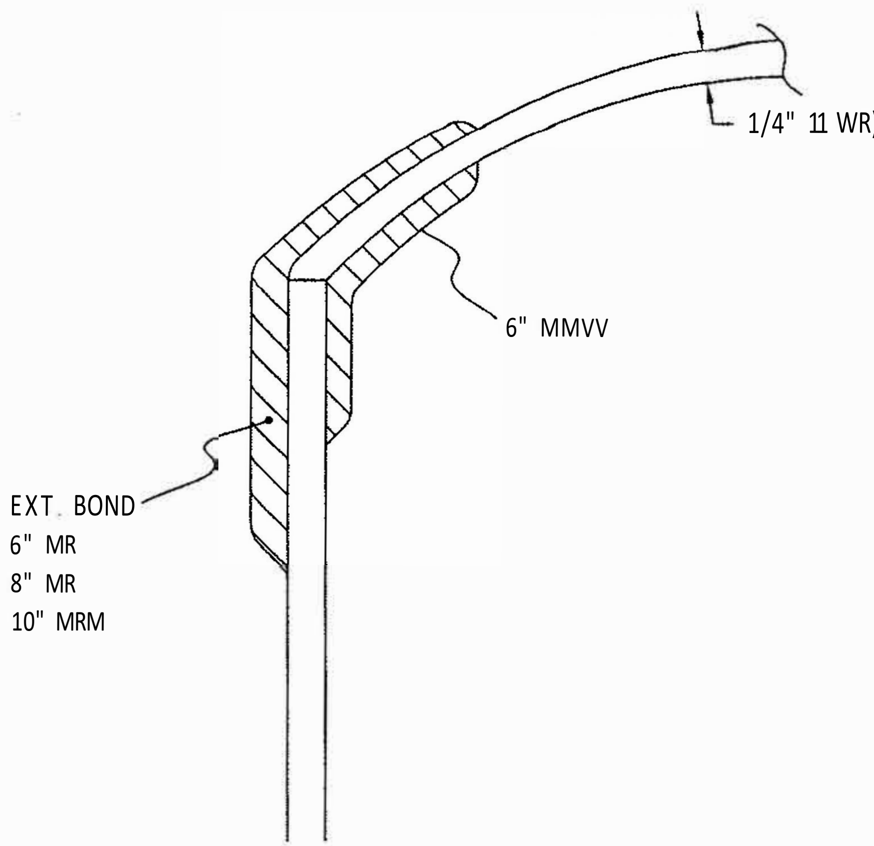


FIG. A-5: DOME TD SHELL BOND

A-28

Description: Solvent Waste Surge Tank Equipment No.: V-590-001
Layout Drawing No.:
P&I Diagram No.: PID590

DESCRIPTION

Quantity: I
Manufacturer: VS * Model No.; VS * **Size:** VS*
Unit Design: [Z] Vertical 0 Control Package D Other

CODES AND STANDARDs

[Z]ASTM [g]API ☐NEC ☐UL

SERVICE CONDITIONS AND PERFORMANCE REQUIREMENTS

Process Fluid	Solvent Waste	Total Volume	5778 Gal
Snccific Gravity	1.1	Working Volume	4600 Gal
Viscosity Range	1.OCn	Tank Fill Rate	S0GPM
Process fluid soecitic heat	1.00 BTU/lb•F	Tank Draw Rate	5GPM
Solids in Liquid;	No	Tank Oneratino Temn. Ran•e ('F)	50-150
Size of Solids:	NA	Tank Oneratinl! Press. Ran(!e (nsi•)	Atmosnheric
Density of Solids	NA	Jacket Supply Temnerature (°F)	NA
Jacket Fluid	NA	Jacket Supply Pressure (psig)	NA
CIP Fluid	NA	Time to heat contents	NA
CIP supply nressure	NA	Time to cool contents	NA

CONSTRUCTION

Inner Diameter	84 Inches	Vessel Desi•n Temn. ('F')	250
Strai•ht Side Lcn•th	182 Inches	Vessel Desi a Pressure (psig)	Atmospheric
Free Board	VS•	Jacket Dcsi•n Temo. (°F/°C)	NA
Overall hei•ht	VS•	Jackel DesianPressure (osi2)	NA
Outer Vessel Diameter	VS• Note3	Jackel Type	NA
Vessel Material of Construction	Steam cured fiberglass reinforced Polyethylene (FRP)	Jacket Coverage	NA
Vessel Internal Finish	Mfo Standard	Jacket Allowable Pressure Dron	NA
Electronolish Required	NA	Jacket Material of Construction	NA
Passivation Required	NA	Insulation Material	NA
Ton Head Type	Domed	Insulation Thickness	NA
Ton Head Connection	NA	Insulation CoveraPe	NA
Bottom Head Type	Domed !Note 9)	Insulation Sheathin• Material	NA
Bottom Head Connection	NA	Insulation Sheathino Thickness	NA
Head Gasket Type	NA	Exterior Finish - sheet	NA (Note 2)
Head Gasket Material	NA	Exterior Finish - nlate and weldments	NA (Note 2)
Manway Gasket Material	EPDM bonded PTFE	Support Structure	Legs. Qty 4
Seismic Zone	4 Jmnortance factor- I 5	Sunnort Material	VS•
Full Wei•ht	VS• Kins	Liftin" Luos	Yes

INTERNALS

Agitator	NA	Dip Tubes	
Vortex Breaker	Yes (Note 5)	Baffles	NYoes

VS• - Vendor/Manufacturer to Supply Information

REV	0 - Issued for Construction 8/28/08	Snec. by	J f Cochran
		Cheeked by	Clay Seese PE
		Approved by	

Description: **Solvent \Vastc Surge Tank** Equipment No.: V-590-001

NOZZLE SCHEDULE

Dwg. Tog No.	Nozzle Size	Pipe Size	Service	Oricntntion / Location	Type
	36"	NA	ManWav	Vertical/ Too	Bolted
	3"	NA	Level Sensor	Vertical/fop	FFFlanee
	3"	1.5"	Inlet Din-Tube (Note 4, 5)	Vertical/ Too	FF Flange/ FF Flanee
	3"	I.5"	Inlet Dio-Tube (Note 4. 5)	Vertical/ Too	FF Flange/ FF Flange
	2"	NA	Pressure Sensor	Vertical/Top	FF Flange
	2"	NA	Tank Vent	Vertical/ Too	FF Flange
	2"	NA	Tank Vent	Vertical/fop	FF Flanrre
	1.1/2"	NA	Outlet Valve	Bottom Head Center	FFF!ange
	2"	NA	Soare	Vertical/foe	FF Flange
	3"	NA	Snare	Vertical /Too	F f Flange
	I"	NA	Process Inlet	Vertical/Too	FFF!anee
	3"	NA	HH Level Switch	Upper Side Wall Note 6)	FF Flange
	3"	NA	Overflow	Horizontal/ Sidewall (Note 7)	FF Flange
	2"	NA	Spare	Horizontal / Sidewall (Note 8)	FF Flange
	2"	NA	Spare	Horizontal/ Sidewall (Note 8)	FF Flange

Options and Accessories

O Agitator Inlet

18:1 Epoxy Coated Carbon Steel Ladder w/ cage

JgJ Top railing w/work platfonn

O High Water Alann

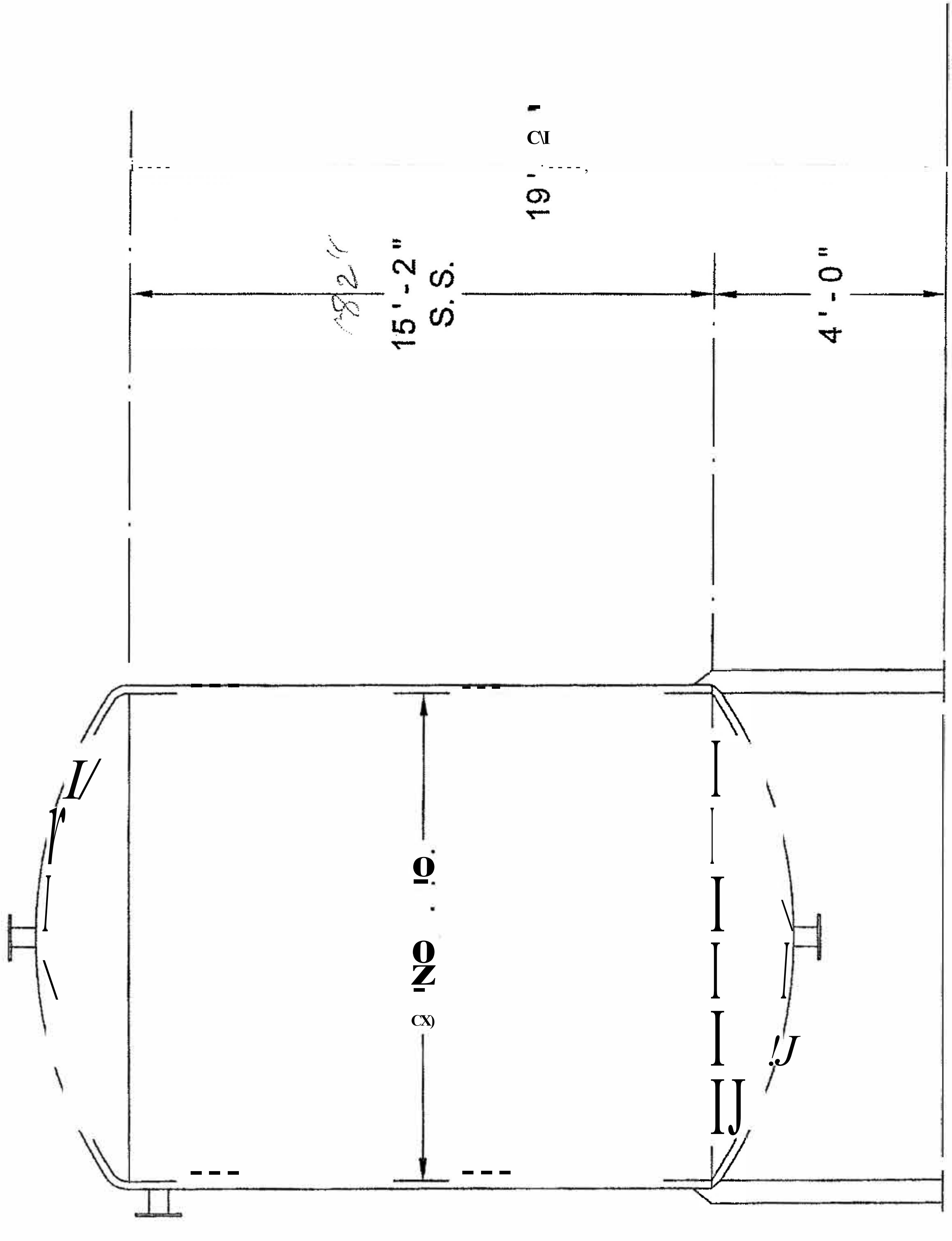
O Low Water Alarm

O Vessel Light w/Sight Glass

REMARKS:

1. **The vessel is sized with a 75% working volume.**
2. **Vessel color shall be painted white.**
3. Vessel maximum width (including fittings) shall be 11.5 feel.
4. Provided by tank vendor.
5. Fabricate dip tubes ofFRP with tapered end.
6. Locate H H Level Switch connection at 90% level in the tank.
7. Locate overlow connection direclly above the IHI Level Switch, but off set the nozzles.
8. Located nozzles so that an operator can access them from the ground level.
9. **Vendor to bid ns m nltcrnntc n flat bottom vessel with sloped bottom nod side outlet vnlvc connection.**

VS* Vcndor/Manufncturcr to Supply Information


19'
15'-2"
S.S.
4'-0"

IA

CHAPTER !;;;' SHELL CONST.

B-4

ULTRA FIBER
c.s.u.L.B. s.c.L.
Laminate Model

DATE: 07-30-1993 TIME: 09:31:09
PAGE: 1

File Name :AA14 LAMINATE AA14

Material Properties for Laminate Model in L-T Coordinates (psi)

El(Times E6)	Et(Times E6)	G(Times E6)	Poisson Ratio
5.7000	0.8000	0.2800	0.2800
1.0000	1.0000	0.4000	0.2500

Data for each Lamina (Theta(8) measured clockwise from·+y axis)

Lamina#	Material #	Theta(81 (deffl	Thickness (in.)	Graphical Lawp
1	2	LINER	0.0800	▬
2	1	70	0.0210	<><><>
3	1	0	0.0200	|||||||||||
4	1	0	0.0200	|||||||||||
5	1	-70	0.0210	<><><>
6	1	70	0.0210	<><><>
7	1	0	0.0200	||||||||||
8	1	-70	0.0210	<><><>
9	1	90	0.0210	======
10	1	90	0.0210	======
11	1	-70	0.0210	<><><>
12	1	0	0.0200	||||||||||
13	1	70	0.0210	<><><>
14	1	-70	0.0210	<><><>
15	1	0	0.0200	|||||||||||
16	1	0	0.0200	|||||||||||
17	1	70	0.0210	<><><>

▬	CORROSSION LINER HAS	1 LAYERS WITH	•).080	in.	THICKNESS
<><><>	HELIX WINDING CONSISTS OF	8 LAYERS WITH	c,.i.68	in.	THICKNESS
░░░	CHOPPED wAMINA CONSISTS OF	0 LAYERS WITH	(1. ,)OO	in.	THICKNESS
====	GERT WINDING CONSISTS OF	2 LAYERS WITH	0.042	"	THICKNESS
||||||||||	UNI WINDING CONSISTS OF	6 LAYERS WITH	:,.120	in.	THICKNESS

The Total Thickness of the Composite Construction= 0.410 inches

B-2

ULTRA FIBER
c.s.u.L.B. s.c.L.
LAMINATE MATRIX DATA
Units are in in. lbs.

DATE: 07-30-1993 TIME: 09:31:13
PAGE: 2

File Name :AA14 LAMINATE AA14

Force-Moment Total Matrix (Times E6)

1.208596	0.182831	0.000000	0.030851	0.002940	0.000000
0.182831	0.957425	0.000000	0.002940	o. C,,:0804	0.000000
0.000000	0.000000	0.211155	0.000000	0.000000	0.001886
0.030851	0.002940	0.000000	0.012941	o.•.io2375	0.001150
0.002940	0.020804	0.000000	0.002375	0.0:,2980	0.000147
0.000000	0.000000	0.001886	0.001150	o. 0,)0147	0.002859

Inverse Force-Moment Total Matrix (Times E-6)

0.911900	-0.177700	-0.008100	-2.304000	0.489600	0.906500
-0.177700	1.116900	0.001000	o.518400	-1. 843400	-0.114200
-0.008100	0.001000	4.765000	0.313100	-0.020000	-3.268000
-2.304000	0.518400	0.313100	88.728500	-16.146000	-35.049800
0.489600	-1.843400	-0.020000	-16.146000	82.815300	2.241300
0.906500	-0.114200	-3.268000	-35.049800	2.241.300	365.846100

A Elasticity Matix (Times E6)

2.94780	0.44593	0.00000
0.44593	2.33518	0.00000
0.00000	0.00000	0.51501

Ainv Elasticity M trix (Times E-6)

0.34933	-0.06671	0.00000
-0.06671	0.4.,1097	0.00000
0.00000	0. (;0000	1.94170

B Elasticity Matix (Times E6)

0.07525	0.00717	0.00000
0.00717	0.05074	0.00000
0.00000	0.00000	0.00460

Binv Elasticity Matrix (Times E-6)

13.47131	-1. 90373	0.00000
-1.90373	19.97710	0.00000
0.00000	0.00000	217.36647

D Elasticity Matix (Times E6)

0.03156	0.00579	0.00280
0.00579	0.03166	0.00036
0.00280	0.00036	0.00697

Dinv Elasticity Matrix (Times E-6)

33.98277	-6.06637	-13.35094
-6.06637	32.63895	0.75613
-13.35094	0.75613	148.71153

B-3

ULTRA FIBER
c.s.U.L.B. Laminate Model S.C.L.

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Material Properties for Laminate Model in L-T Coordinates (psi)

El(Times E6)	Et(Times E6)	G(Times E6)	Poisson Ratio
5.7000	0.8000	0.2800	0.2800
1.0000	1.0000	0.4000	0.2500

Data for each Lamina (Theta(EI) measured clockwise from +Y axis)

Lamina#	Material #	Theta(EI) /deg)	Thickness (in.)	Graphical Layup
1	2	LINER	0.0800	█████
2	1	70	0.0210	<><><>
3	1	-70	0.0210	<><><>
4	1	70	0.0210	<><><>
5	1	-70	0.0210	<><><>
6	1	-70	0.0210	<><><>
7	1	70	0.0210	<><><>
8	1	-70	0.0210	<><><>
9	1	70	0.0210	<><><>

█	CORROSSION LINER HAS	1	LAYERS WITH	0.080	in.	THICKNESS
<><><>	HELIX WINDING CONSISTS OF	8	LAYERS WITH	0.168	in.	THICKNESS
tt1\\@i\\\:	CHOPPED LAMINA CONSISTS OF	0	LAYERS WITH	O.JOO	in.	THICKNESS
	CERT WINDING CONSISTS OF	0	LAYERS WITH	).JOO	in.	THICKNESS
||||||||||||	UNI WINDING CONSISTS OF	0	LAYERS WITH	,).000	in.	THICKNESS

The Total Thickness of the Composite Construction = 0.248 inches