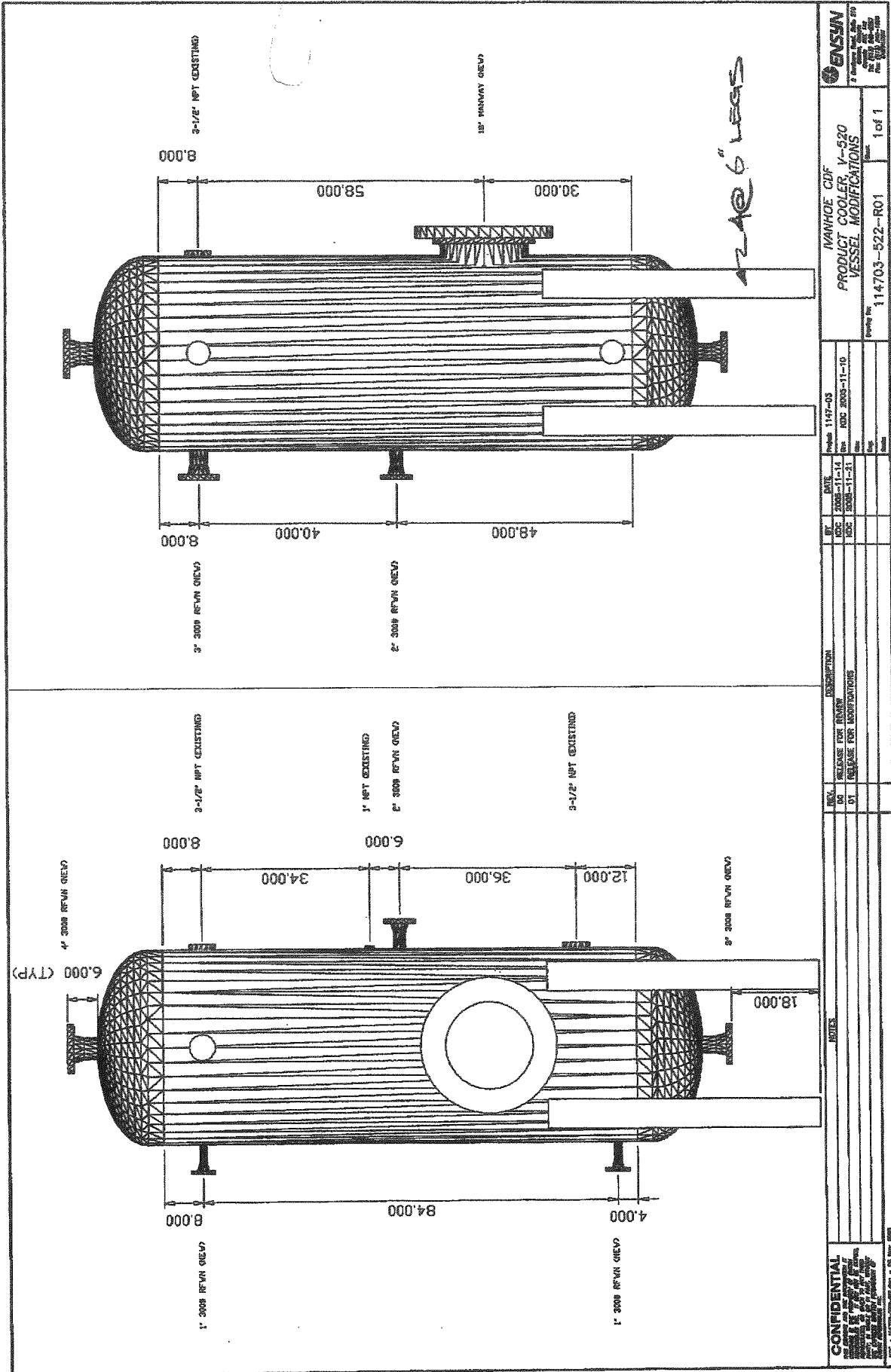


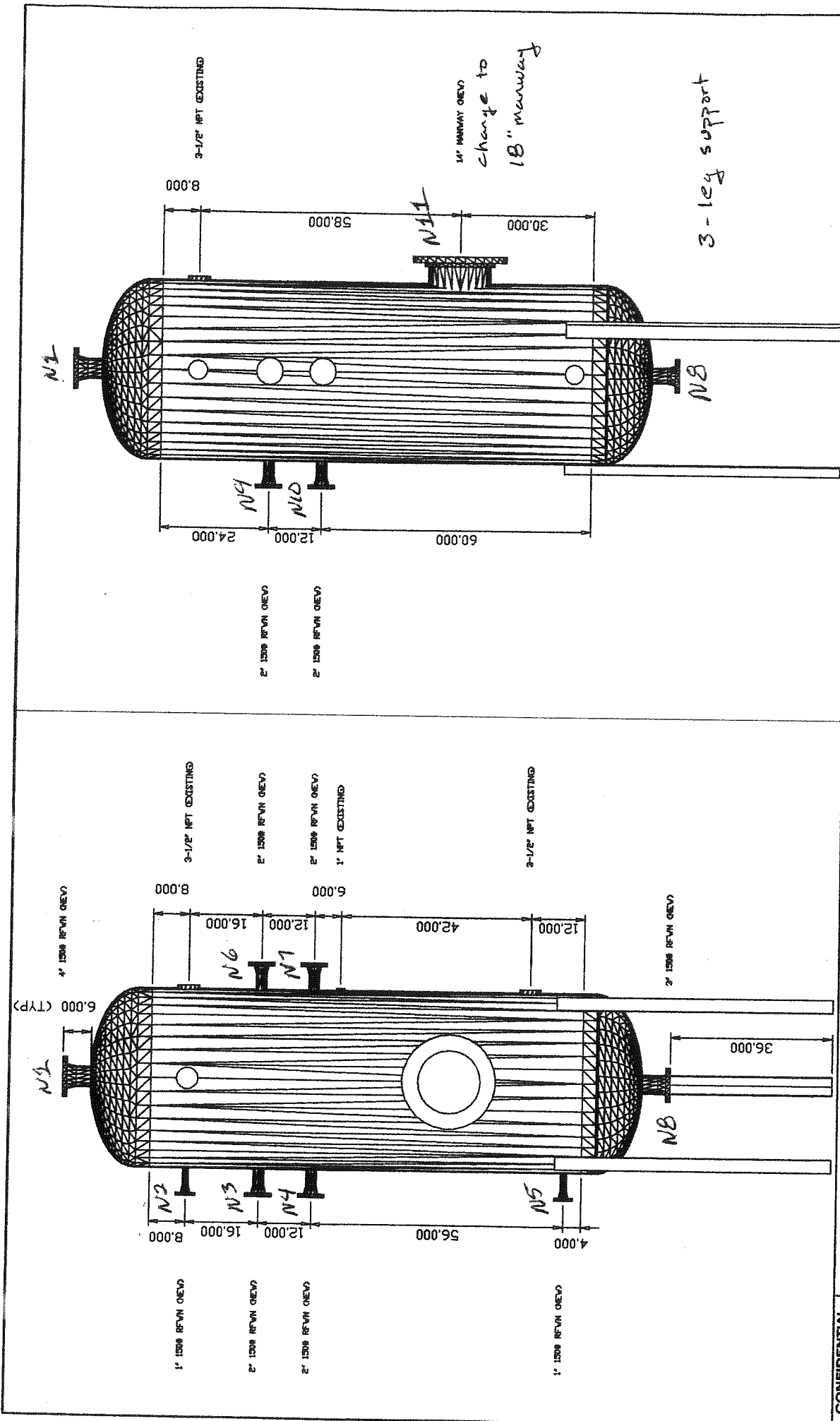
V-520



ENSSIN		MANROE CDF		11/17/03	
PRODUCT COOLER, V-520		DATE		BY	
VESSEL MODIFICATIONS		2008-11-13		2008-11-13	
114703-522-R01		2008-11-21		2008-11-21	
1 of 1					
		DESCRIPTION		REVISION	
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		NOTES			
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AFC Drawing # 73102-39

PWHT = NO



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BY: RDC		DATE: 2006-11-14		PROGRAM: 1147-03	
DESCRIPTION: MANHOE CDF PRODUCT COOLER, V-520 VESSEL MODIFICATIONS		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 00		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 01		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 02		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 03		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 04		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 05		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 06		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 07		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 08		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 09		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 10		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 11		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 12		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 13		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 14		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 15		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 16		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 17		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 18		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 19		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 20		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 21		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 22		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 23		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 24		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 25		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 26		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 27		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 28		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 29		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 30		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 31		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 32		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 33		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 34		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 35		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 36		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 37		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 38		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 39		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 40		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 41		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 42		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 43		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 44		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 45		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 46		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 47		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 48		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 49		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 50		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 51		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 52		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 53		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 54		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 55		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 56		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 57		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 58		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 59		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 60		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 61		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 62		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 63		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 64		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 65		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 66		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 67		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 68		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 69		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 70		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 71		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 72		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 73		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 74		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 75		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 76		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 77		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 78		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 79		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 80		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 81		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 82		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 83		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 84		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 85		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 86		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 87		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 88		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 89		DATE: 2006-11-14		PROGRAM: 1147-03	
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REV. 91		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 92		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 93		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 94		DATE: 2006-11-14		PROGRAM: 1147-03	
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REV. 98		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 99		DATE: 2006-11-14		PROGRAM: 1147-03	
REV. 100		DATE: 2006-11-14		PROGRAM: 1147-03	



MANHOE CDF
PRODUCT COOLER, V-520
VESSEL MODIFICATIONS

114703-522-R00

1 of 1

IVANHOE

BILL SALZMAN / TOM STEEL
831-8782
201-5922
831-8782 X150

T.J. Cross Engineers, Inc.
Vessel Legs (Replace existing)

Customer: **TIC The Industrial Company**
 Job No: DS-05544-04
 Mark Number: LEG1

Vessel Number: V-520

Date Printed: 11/15/2005

Leg Information

Design Temperature: 100 °F
 Material: SA-36
 Condition:
 B.P. to Vessel Attachment Length (L): 54.0000 in.
 Direction of Applied Force: 0 °
 Length of Supports: 72.0000 in.
 Quantity: 3
 Type: Angle
 Description: 6 x 6 x 3/8
 d₁: 6.0000 in.
 d₂: 6.0000 in.
 Weld Attachment Length Top (W_t): 5.6250 in.
 Weld Leg Dimension (W_l): 0.2500 in.

Factor B Chart: CS-2
 Material Stress (Hot): 14500 PSI
 Material Stress (Cold): 14500 PSI
 Modulus of Elasticity: 28.0 10⁶ PSI
 Yield Strength: 36000 PSI
 Dist. From Reference Line: 18.0000 in.
 Method of Attachment: Leg In
 Molded to Head Curvature: No
 t₁: 0.3750 in.
 t₂: 0.3750 in.
 Side (W_s): 18.0000 in.

Base Plate Information

Design Temperature: 100 °F
 Material: SA-36 Plate
 Condition:
 Length: 8.0000 in.
 Width: 8.0000 in.
 Leg to B.P. Attachment Factor: 0.7500
 Effective Length Factor (K): 1.5000

Material Stress (Hot): 14500 PSI
 Material Stress (Cold): 14500 PSI
 Yield Strength: 36000 PSI
 Thickness: 0.5000 in.
 Bending Coefficient (C_m): 1.0000

Anchor Bolt Information

Material: SA-193 Gr B16 <=2.5"
 Condition:
 Diameter: 0.7500 in.
 Quantity: 3
 Ultimate 28 Day Concrete Strength: 3000 PSI

Material Stress (Hot): 25000 PSI
 Material Stress (Cold): 25000 PSI
 Root Area: 0.3020 sq. in.
 Bolt Circle Diameter: 42.0000 in.

Date Printed: 11/15/2005

Operating Conditions
Support Leg Properties

$$\text{Section Modulus, } S_x = \frac{I_x}{C_x} = \frac{24.5726}{4.2426} = 5.7919 \text{ in.}^3$$

$$\text{Section Modulus, } S_y = \frac{I_y}{C_y} = \frac{6.2006}{2.3181} = 2.6749 \text{ in.}^3$$

$$\text{Radius of gyration, } r_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{24.5726}{4.3594}} = 2.3742 \text{ in.}$$

$$\text{Radius of gyration, } r_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{6.2006}{4.3594}} = 1.1926 \text{ in.}$$

$$\text{Least radius of gyration, } r_{\min} = \sqrt{\frac{I_{\min}}{A}} = \sqrt{\frac{6.2006}{4.3594}} = 1.1926 \text{ in.}$$

$$\text{Slenderness ratio, } SR_x = \frac{K L}{r_x} = \frac{1.5000 * 54.0000}{2.3742} = 34.1168$$

$$\text{Slenderness ratio, } SR_y = \frac{K L}{r_y} = \frac{1.5000 * 54.0000}{1.1926} = 67.9188$$

$$\text{Largest, } SR_{\max} = \frac{K L}{r_{\min}} = \frac{1.5000 * 54.0000}{1.1926} = 67.9188$$

$$\text{Critical slenderness ratio, } C_c = \sqrt{\frac{2 \pi^2 E}{F_y}} = \sqrt{\frac{2 * \pi^2 * (28.0 * 10^6)}{36000}} = 123.91$$

$$F'_{ex} = \frac{4}{3} \frac{12 \pi^2 E}{23 SR_x^2} = \frac{4}{3} * \frac{12 * \pi^2 * (28.0 * 10^6)}{23 * 34.1168^2} = 165163 \text{ PSI}$$

$$F'_{ey} = \frac{4}{3} \frac{12 \pi^2 E}{23 SR_y^2} = \frac{4}{3} * \frac{12 * \pi^2 * (28.0 * 10^6)}{23 * 67.9188^2} = 41675 \text{ PSI}$$

For $SR_{\max} \leq C_c$, Allowable compressive stress:

$$F_a = \frac{4}{3} \frac{\left(1 - \frac{SR_{\max}^2}{2 C_c^2}\right) F_y}{\frac{5}{3} + \frac{3 SR_{\max}}{8 C_c} - \frac{SR_{\max}^3}{8 C_c^3}} = \frac{4}{3} * \frac{\left(1 - \frac{67.9188^2}{2 * 123.91^2}\right) * 36000}{\frac{5}{3} + \frac{3 * 67.9188}{8 * 123.91} - \frac{67.9188^3}{8 * 123.91^3}} = 22029 \text{ PSI}$$

$$\text{Allowable bending stress : } S_b = \frac{4}{3} 0.6 F_y = \frac{4}{3} 0.6 * 36000 = 28800 \text{ PSI}$$

$$\text{Allowable tension stress : } S_t = \frac{4}{3} 0.6 F_y = \frac{4}{3} * 0.6 * 36000 = 28800 \text{ PSI}$$

Date Printed: 11/15/2005

Leg to Vessel Weld Properties

Distance between welds along side of legs (b) = 7.9550 in.
 $L_w = (2 W_s) + W_t = (2 * 18.0000) + 5.6250 = 41.6250$
 $I_{wy} = \frac{W_s^3 (2 W_t + W_s)}{3 L_w} = \frac{18.0000^3 * (2 * 5.6250 + 18.0000)}{3 * 41.6250} = 1366.0541 \text{ in.}^3$
 $I_{wz} = \frac{6 W_s b^2 + W_t^3}{12} = \frac{6 * 18.0000 * 7.9550^2 + 5.6250^3}{12} = 584.3628 \text{ in.}^3$
 $J_{wx} = I_{wy} + I_{wz} = 1366.0541 + 584.3628 = 1950.4168 \text{ in.}^3$

Distance from weld neutral axis to top of welds:

$EF_{yt} = \frac{W_s^2}{L_w} = \frac{18.0000^2}{41.6250} = 7.7838 \text{ in.}$

Distance from weld neutral axis to bottom of welds:

$EF_{yb} = W_s - EF_{yt} = 18.0000 - 7.7838 = 10.2162 \text{ in.}$

Distance from weld neutral axis to side of welds:

$EF_z = \text{MAX} \left(\frac{b}{2}, \frac{W_t}{2} \right) = \text{MAX} \left(\frac{7.9550}{2}, \frac{5.6250}{2} \right) = 3.9775 \text{ in.}$

UBC 1997 Wind Analysis Information

Basic Wind Speed (V): 80 MPH Wind Exposure type: C
 Importance factor (I_w): 1.0000

Wind Analysis Calculations

Wind Center of Gravity = 101.9133 in.
 $P = C_e C_q q_s I_w = 1.06 * 0.8 * 16.400 * 1.0000 = 13.90 \text{ lb./ft}^2$
 Wind Load, $F_w = P A = 13.90 * 34.0957 = 474 \text{ lb.}$

UBC 1997 Seismic Design Information

Seismic zone factor (Z): 0.4 Soil profile type: SD
 Importance factor (I): 1.0000
 Seismic source type: A Distance to seismic source (km): 15

Seismic Analysis Calculations

Seismic Center of Gravity: = 91.7221 in.
 $V_1 = \frac{2.5 C_a I W}{R} = \frac{2.5 * 0.4400 * 1.0000 * 5356.94}{2.2} = 2678 \text{ lb.}$
 $V_2 = \frac{1.6 Z N_v I W}{R} = \frac{1.6 * 0.4000 * 1.0 * 1.0000 * 5356.94}{2.2} = 1558 \text{ lb.}$
 $V_1 > V_2$, therefore $F_s = \frac{V_1}{1.4} = \frac{2678}{1.4} = 1913 \text{ lb.}$

T.J. Cross Engineers, Inc.
Vessel Legs (Replace existing)

Job No: DS-05544-04
 Mark Number: LEG1

Vessel Number: V-520

Date Printed: 11/15/2005

Loadings and Stresses on Support Legs

Direction of Applied Force =

0 °

Leg Orientation °	Moment of Inertia in. ⁴	Lateral Force lb.	Axial Stress PSI	Bending Stresses (f _{bx}) PSI	Bending Stresses (f _{by}) PSI	Acceptance Ratio (Eqn ₁)	Acceptance Ratio (Eqn ₂)
0	6.2006	257	591	0	5631	0.2229	
120	19.9796	828	-927	5015	8996	0.5286	
240	19.9796	828	-927	5015	8996	0.5286	

Direction of Worst case Force =

4 °

Highest Stress Ratio =

0.5316

Loadings and Stresses on Leg to Vessel attachment welds

Leg Orientation °	Load F _x lb.	Load F _y lb.	Load F _z lb.	Moment M _x in.-lb.	Moment M _y in.-lb.	Moment M _z in.-lb.	Total Stress PSI	Stress Ratio
0	257	0	2576	0	-5755	0	316	0.0334
120	-414	717	-4039	29045	9473	1295	946	0.0999
240	-414	717	-4039	29045	9473	1295	946	0.0999

Direction of Worst case Force =

29 °

Highest Stress Ratio:

0.1339

Loadings and Pressure on Concrete Foundation

Direction of applied force: =

0 °

Leg Orientation °	Bearing Pressure PSI	Moment M _x in.-lb.	Moment M _y in.-lb.	Maximum Pressure P _x PSI	Maximum Pressure P _y PSI	Max. Concrete Pressure PSI	Concrete Pressure Ratio
0	-40	1616	1616	18.94	18.94	0.00	0.0000
120	63	16438	16438	192.63	192.63	448.38	0.4982
240	63	16438	16438	192.63	192.63	448.38	0.4982

Direction of Worst case Force: =

29 °

Highest Stress Ratio =

0.7305

Loadings and Stresses on BasePlate and Anchor bolts

Leg Orientation °	Moment M _x in.-lb.	Moment M _y in.-lb.	Maximum Pressure P _x PSI	Maximum Pressure P _y PSI	Maximum B.P. Stress PSI	BasePlate Stress Ratio	Anchor Bolt Stress PSI	Anchor Bolt Stress Ratio
0	0	0	0	0	0	0.0000	2675	0.0803
120	489	456	11728	10935	16035	0.5568	4757	0.1427
240	489	456	11728	10935	16035	0.5568	4757	0.1427

Direction of Worst case Force: =

29 °

Highest Stress Ratio =

0.7886

T.J. Cross Engineers, Inc.
Vessel Legs (Replace existing)

Job No: DS-05544-04
 Mark Number: LEG1

Vessel Number: V-520

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Maximum General Longitudinal Stresses

$$S_{L1} = \frac{M_a}{Z} - \frac{W}{A} + \left(\frac{P * D}{4 * t} \right) = \frac{72170}{334.2844} - \frac{5356.94}{32.50} + \left(\frac{165.00 * 41.6350}{4 * 0.2500} \right) = 6921 \text{ PSI}$$

$$S_{L2} = -\frac{M_a}{Z} - \frac{W}{A} - \left(\frac{P_e * D}{4 * t} \right) = -\frac{72170}{334.2844} - \frac{5356.94}{32.50} - \left(\frac{15.00 * 41.6350}{4 * 0.2500} \right) = -1005 \text{ PSI}$$

Allowable Tension Stress, $S_{ta} = 1.2 S E = 1.2 * 18800 * 0.85 = 19176 \text{ PSI}$

Allowable Compressive Stress, $S_{ca} = -1.2 B = -1.2 * 9274 = -11129 \text{ PSI}$

$$R_{SL1} = \frac{S_{L1}}{S_{ta}} = \frac{6921}{19176} = 0.3609$$

$$R_{SL2} = \frac{S_{L2}}{S_{ca}} = \frac{-1005}{-11129} = 0.0903$$

Summary

Governing external force	= Seismic load
Total Force	= 1913 lb.
Weight	= 5356.94 lb.
Base Moment	= 175482 in.-lb.
Tangent Moment	= 72170 in.-lb.

Leg Stresses

Maximum combined compressive and bending stress ratio = 0.5316

Leg BasePlate

Concrete Stress Ratio = 0.7305

Base Plate Stress Ratio = 0.7886

Host Stresses

SI1 ratio = 0.3609

SI2 ratio = 0.0903

Weld Stresses

Leg to vessel weld stress ratio = 0.1339