KOCH
HEAT TRANSFER CANADA LP

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TOTAL NO. OF PAGES 16
(EXCLUDING THIS PAGE)

KHTC REFERENCE : T10176 – SUPT

DOCUMENT TITLE : SUPPORT CALCULATION

EQUIPMENT NAME : SRU FEED STEAM HEATER

CUSTOMER: SHELL ALBIAN SANDS

ITEM NUMBER: 260-SX-101/201 A/B/C/D

P.O. NUMBER: 50274775 002 OP

Rev	Description	By / Date	Chk'd By /Date	App'd By / Date
0	First Issue	HUI R. /2009/5/1	KL 2009/5/4	[illegible] 4 MAY 2009
1	PG 6 CLARIFICATION ADDED, Pg 13-16 added	HUI R. /2009/5/28	KL 2009/5/28	[illegible] 28 May 2009

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T10176 2009-05-01

SADDLE REACTIONS AND CENTRE OF GRAVITY OF EXCHANGER :

DISTANCE OF LEFT SADDLE FROM REF. PT. = 80.375 IN
DISTANCE BETWEEN SADDLES = 182.0 IN

LOAD DISTRIBUTION :-

1. RIGHT OF RIGHT SADDLE :

COMPONENT	WEIGHT LB	DISTANCE IN	MOMENT IN-LB	
SHELL BARREL	2180.	30.2	65945.	
RIGHT BARREL	60.	61.8	3705.	
RIGHT HEAD WATER	1240.	74.5	92380.	
RIGHT 2:1 HEAD	810.	71.7	58085.	
TUBES	9100.	36.5	332031.	B
BAFFLES	350.	33.2	11638.	B
END SUPPORT PLATE	440.	46.1	20268.	B
NOZZ. S2,S3,S4 & S6	120.	51.1	6135.	
WATER	5990.	31.2	187188.	

TOTAL MOMENT = 777374. IN-LB
BUNDLE WT. = 9890. LB
EMPTY WT. = 13060. LB
FLOODED WT. = 20290. LB

2. BETWEEN SADDLES :

COMPONENT	WEIGHT LB	DISTANCE IN	MOMENT IN-LB	
SHELL BARREL	6560.	91.2	598190.	
TUBES	25120.	91.2	2290630.	B
BAFFLES	2440.	119.2	290970.	B
SUPPORT PLATE	350.	17.6	6169.	B
IMPINGEMENT RODSE	200.	17.6	3525.	B
SKID BAR	500.	122.6	61312.	B
NOZZ. S1 & S5	340.	17.6	5992.	
SADDLE	500.	0.0	0.	
SADDLE	1000.	182.0	182000.	
WATER	17540.	91.0	1596140.	

TOTAL MOMENT = 5034929. IN-LB
BUNDLE WT. = 28610. LB
EMPTY WT. = 37010. LB
FLOODED WT. = 54550. LB

3. LEFT OF LEFT SADDLE :

COMPONENT	WEIGHT LB	DISTANCE IN	MOMENT IN-LB	
SHELL BARREL	120.	1.6	195.	
LEFT BARREL	3320.	42.0	139336.	
TUBES	1450.	5.2	7612.	B
CHANN. NOZZLES	1450.	19.4	28094.	
STAT. TUBESHEET	4040.	6.2	25250.	B
SHELL FLG #206	1259.	0.5	630.	
CHANNEL FLG. #505	1210.	11.9	14444.	
CHANNEL FLG. #506	1210.	72.1	87271.	
FLAT COVE	6190.	77.6	480112.	
BOLTING #904	500.	6.2	3125.	
BOLTING #905	370.	74.9	27704.	
P.P.PLATE	830.	42.1	34912.	
WATER-SHELL	380.	1.6	618.	
WATER-CHANNEL	7280.	42.0	305532.	

TOTAL MOMENT = 1154835. IN-LB
BUNDLE WT. = 5490. LB
EMPTY WT. = 21949. LB
FLOODED WT. = 29609. LB

DEAD WEIGHT LAOD FOR COMPLETE EXCHANGER :-

TOTAL BUNDLE WT. = 43990. LB
TOTAL EMPTY WT. = 72020. LB
TOTAL FLOODED WT. = 104450. LB

CENTRE OF GRAVITY TO THE RIGHT OF LEFT SADDLE = 79.95 IN

RIGHT SADDLE REACTION RA = 45880. LB
LEFT SADDLE REACTION RB = 58570. LB
TOTAL (FOR CHECKING) RT = 104450. LB

SHELL STRESS AT MID-SPAN

DESIGN PRESSURE, P	=	221. PSI
SHELL CORRODED INSIDE DIAMETER	=	64.2500 IN
CORROSION ALLOWANCE	=	0.1250 IN
SHELL CORRODED THICKNESS, ts	=	0.5000 IN
SHELL CORRODED MEAN RADIUS, Rm	=	32.3750 IN
MOMENT	=	1518109. IN-LB
SECTION MODULUS, Z = pi*Rm*Rm*t	=	1646.419 IN3
BENDING STRESS, Sb = MOMENT/Z	=	922. PSI
PRESSURE STRESS, Sp = (P*Rm)/(2*t)	=	7155. PSI
LONG COMPRES STRESS, Sc = Sb	=	922. PSI
LONG TENSILE STRESS, St = SB + SP	=	8077. PSI
ALLOWABLE TENSILE STRESS = 0.85 x Sa	=	17000. PSI
ALLOWABLE COMPRESSIVE STRESS	=	13260. PSI

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SHELL STRESSES AT RIGHT SADDLE :-


(A) LONGITUDINAL BENDING STRESS S1 :
DESIGN PRESSURE, P                      =      221. PSI
SHELL CORRODED INSIDE DIAMETER          =   64.2500 IN
CORROSION ALLOWANCE                     =    0.1250 IN
SHELL CORRODED THICKNESS, ts            =    0.5000 IN
SHELL CORRODED MEAN RADIUS, Rm          =   32.3750 IN
MOMENT                                  =   777374. IN-LB
CONTACT ANGLE OF SADDLE                 =      120. DEG
COEFFICIENT K1                          =    0.3349
SECTION MODULUS, Z = K1*Rm*Rm*t         =   175.526 IN3
BENDING  STRESS, Sb = MOMENT/Z          =     4429. PSI
PRESSURE STRESS, Sp = (P*Rm)/(2*t)      =     7155. PSI
LONG TENSILE STRESS, St = Sb + Sp       =    11584. PSI
LONG COMPRES STRESS, Sc = Sb            =     4429. PSI
ALLOWABLE TENSILE STRESS = 0.85 x Sa    =    17000. PSI
ALLOWABLE COMPRESSIVE STRESS            =    13260. PSI


(B) TANGENTIAL SHEAR STRESS S2 :
DISTANCE FROM SHELL HEAD TO SADDLE, A =      66.38 IN
PAD THICKNESS, tp                       =    0.6250 IN
LOAD, Q                                 =    45880. LB
COEFFICIENT K2                          =    1.1707
SINCE A ( 66.3750 IN) > Rm/2 ( 16.1875 IN), THEN
 S2 = (K2*Q)/(Rm*(tp+t))
    =   1475. PSI
 ALLOWABLE SHEAR STRESS = 0.8 X Sa      =    16000. PSI


(C) CIRCUMFERENTIAL STRESSES  S4 & S5 :
WIDTH OF SADDLE, b                      =   12.0000 IN
LENGTH OF SHELL BARREL, L               =  245.7500 IN
WIDTH OF WEAR PLATE, W                  =   14.0000 IN
RATIO A/Rm                              =    2.0502
COEFFICIENT K6                          =    0.0529
COEFFICIENT K7                          =    0.7603

(i) AT HORN OF SADDLE :
SINCE A > Rm/2,THEN
 Tc=CORRODED SHELL THICKNESS            =    0.5000 IN
EFFECTIVE LENGTH 1.56*SQRT(Rm*ts)       =    6.2765 IN
SINCE L (245.75 IN) < 8*Rm (259.00 IN) THEN
 S4 =-Q/((4*Tc)*(b+1.56*(Rm*STHK)**.5))-(12*K6*Q*Rm)/(L*Tc**2)
    = -16589. PSI
 ALLOWABLE STRESS = 1.25 x Sa =  25000. PSI
(ii) AT THE BOTTOM OF SHELL :-
SINCE WIDTH OF WEAR PLATE (14.0000 IN) < b+1.56*((Rm*ts)**.5) = 18.2765 IN
THEN ts = CORRODED SHELL THICKNESS     =  0.5000 IN
 S5 = -(K7*Q)/(ts*(b+1.56*(Rm*ts)**.5))
    =  -3817. PSI
 ALLOWABLE STRESS = 0.5 x Sy =    16332. PSI


SHELL STRESSES AT LEFT  SADDLE :-

* NOTE: LEFT SADDLE IS UNDER SHELL GIRTH FLANGE. SHELL STRESS CHECK IS NOT REQUIRED.
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T10176

SEISMIC LOADS

PER SPEC. No. 001C-2-201 Rev. 1,
SEISMIC Za = 0, Zv = 0, V = 0, SO SEISMIC LOAD CALCULATION NOT REQUIRED

WIND LOADS PER NBC-2205

PER SPEC. No. 001C-2-201 Rev. 1,

BASIC WIND VELOCITY	V = 113 kg/h = 74 mph
USE:	
EXPOSURE CATEGORY:	C
VELOCITY PRESSURE EXPOSURE COEFFICIENT	K_{ZT} = 1.0,
IMPORTANCE FACTOR	I = 1.15,
VELOCITY PRESSURE EXPOSURE COEFFICIENT	K_Z = 0.85,
SHAPE FACTOR	Cf = 0.9
GUST EFFECT FACTOR	G = 0.85

VELOCITY PRESSURE: $q = 0.00256\ Kz\ K_{ZT}\ V^2\ I = 13.7$ PSF

CALCULATION OF THE EXPOSURE FACTOR, Ce, IS AS FOLLOWING:
$Ce = (H/10)^{0.2}$, BUT NOT LESS THAN 0.9 ,
$= (96x0.0254/10)^{0.2} = 0.754$, USE 0.9
EXPOSURE CONDITION FOR OPEN TERRAIN SHALL BE USED FOR CALCULATION Cg = 2, Cp = 0.8
WIND PRESSURE:

$P = I_W\ q\ Cg\ Ce\ C_p = 1.15 \times 13.7 \times 2 \times 0.9 \times 0.8 = 22.7$ PSF

D = O.D. OF INSULATION
= 2 x 2.5 + 64 + 2 x 0.625 = 70.25 INCH
48″ < D < 96″, DIAMETER EFFECTIVE FACTOR = 1.4
SHELL EFFECTIVE DIA. D_e = 1.4 x 70.25/12 = 8.2 FT
SHELL EFFECTIVE LENGTH L_{EFF}= 345/12 = 28.75 FT
PROJECTED WIND LOAD AREA AL (LONGITUDINAL)=(Pi)x $8.2^2/4$ = 52.8 FT^2
PROJECTED WIND LOAD AREA AT (TRANVERSE)= 8.2 x 28.75 = 235.75 FT^2

LONGITUDINAL FORCE F_L = P x AL
= 22.7 x 52.8 = 1199 LB
TRANSVERSE FORCE F_T = 0.5 x P x AT
= 0.5 x 22.7 x 235.75 = 2676 LBS

LONGITUDINAL Q1 = F_L x B/Ls = 1199 x 43.3125/182 = 285 LBS
TRANSVERSE Q2 = 3xF_T x B/E =3x2676x43.3125/59 = 5894 LBS

USE Q = 7000 LB FOR CALCULATION

WHERE : Ls = DISTANCE BETWEEN C.L OF SADDLE = 182 INCH
B = DISTENCE BETWEEN CL. OF SHELL TO BASE PLATE = 43.3125 INCH
E = WIDTH OF SADDLE = 59 INCH

T10176 W/ WIND LOAD 2009-05-01
SADDLE REACTIONS AND CENTRE OF GRAVITY OF EXCHANGER :

DISTANCE OF LEFT SADDLE FROM REF. PT. = 80.4 IN
DISTANCE BETWEEN SADDLES = 182.0 IN

LOAD DISTRIBUTION :-
1. RIGHT OF RIGHT SADDLE :

COMPONENT	WEIGHT LB	DISTANCE IN	MOMENT IN-LB	
SHELL BARREL	2180.	30.2	65945.	
RIGHT BARREL	60.	61.8	3705.	
RIGHT HEAD WATER	1240.	74.5	92380.	
RIGHT 2:1 HEAD	810.	71.7	58085.	
TUBES	9100.	36.5	332031.	B
BAFFLES	350.	33.2	11638.	B
END SUPPORT PLATE	440.	46.1	20268.	B
NOZZ. S2,S3,S4 & S6	120.	51.1	6135.	
WATER	5990.	31.2	187188.	

TOTAL MOMENT = 777374. IN-LB
BUNDLE WT. = 9890. LB
EMPTY WT. = 13060. LB
FLOODED WT. = 20290. LB

2. BETWEEN SADDLES :

COMPONENT	WEIGHT LB	DISTANCE IN	MOMENT IN-LB	
SHELL BARREL	6560.	91.2	598190.	
TUBES	25120.	91.2	2290630.	B
BAFFLES	2440.	119.2	290970.	B
SUPPORT PLATE	350.	17.6	6169.	B
IMPINGEMENT RODSE	200.	17.6	3525.	B
SKID BAR	500.	122.6	61312.	B
NOZZ. S1 & S5	340.	17.6	5992.	
SADDLE	500.	0.0	0.	
SADDLE	1000.	182.0	182000.	
REACTION	7000.	0.0	0.	
REACTION	7000.	182.0	1274000.	
WATER	17540.	91.0	1596140.	

TOTAL MOMENT = 6308929. IN-LB
BUNDLE WT. = 28610. LB
EMPTY WT. = 51010. LB
FLOODED WT. = 68550. LB

3. LEFT OF LEFT SADDLE :

COMPONENT	WEIGHT LB	DISTANCE IN	MOMENT IN-LB	
SHELL BARREL	120.	1.6	195.	
LEFT BARREL	3320.	42.0	139336.	
TUBES	1450.	5.2	7612.	B
CHANN. NOZZLES	1450.	19.4	28094.	
STAT. TUBESHEET	4040.	6.2	25250.	B
SHELL FLG #206	1259.	0.5	630.	
CHANNEL FLG. #505	1210.	11.9	14444.	
CHANNEL FLG. #506	1210.	72.1	87271.	
FLAT COVE	6190.	77.6	480112.	
BOLTING #904	500.	6.2	3125.	
BOLTING #905	370.	74.9	27704.	
P.P.PLATE	830.	42.1	34912.	
WATER-SHELL	380.	1.6	618.	
WATER-CHANNEL	7280.	42.0	305532.	

TOTAL MOMENT = 1154835. IN-LB
BUNDLE WT. = 5490. LB
EMPTY WT. = 21949. LB
FLOODED WT. = 29609. LB

RIGHT SADDLE REACTION RA = 52880. LB
LEFT SADDLE REACTION RB = 65570. LB
TOTAL (FOR CHECKING) RT = 118450. LB *

1 * INCLUDES 14000 LB WIND LOAD REACTION ON SADDLES

SHELL STRESS AT MID-SPAN
DESIGN PRESSURE, P = 221. PSI
SHELL CORRODED INSIDE DIAMETER = 64.2500 IN
CORROSION ALLOWANCE = 0.1250 IN
SHELL CORRODED THICKNESS, ts = 0.5000 IN
SHELL CORRODED MEAN RADIUS, Rm = 32.3750 IN
MOMENT = 2154662. IN-LB
SECTION MODULUS, Z = pi*Rm*Rm*t = 1646.419 IN3
BENDING STRESS, Sb = MOMENT/Z = 1309. PSI
PRESSURE STRESS, Sp = (P*Rm)/(2*t) = 7155. PSI
LONG COMPRES STRESS, Sc = Sb = 1309. PSI
LONG TENSILE STRESS, St = SB + SP = 8464. PSI
ALLOWABLE TENSILE STRESS = 0.85 x Sa = 17000. PSI
ALLOWABLE COMPRESSIVE STRESS = 13260. PSI

SHELL STRESSES AT RIGHT SADDLE :-

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(A) LONGITUDINAL BENDING STRESS S1 :
DESIGN PRESSURE, P                     =      221. PSI
SHELL CORRODED INSIDE DIAMETER         =   64.2500 IN
CORROSION ALLOWANCE                    =    0.1250 IN
SHELL CORRODED THICKNESS, ts           =    0.5000 IN
SHELL CORRODED MEAN RADIUS, Rm         =   32.3750 IN
MOMENT                                 =   777374. IN-LB
CONTACT ANGLE OF SADDLE                =      120. DEG
COEFFICIENT K1                         =    0.3349
SECTION MODULUS, Z = K1*Rm*Rm*t        =   175.526 IN3
BENDING  STRESS, Sb = MOMENT/Z         =     4429. PSI
PRESSURE STRESS, Sp = (P*Rm)/(2*t)     =     7155. PSI
LONG TENSILE STRESS, St = Sb + Sp      =    11584. PSI
LONG COMPRES STRESS, Sc = Sb           =     4429. PSI
ALLOWABLE TENSILE STRESS = 0.85 x Sa   =    17000. PSI
ALLOWABLE COMPRESSIVE STRESS           =    13260. PSI


(B) TANGENTIAL SHEAR STRESS S2 :
DISTANCE FROM SHELL HEAD TO SADDLE, A =      66.38 IN
PAD THICKNESS, tp                      =    0.6250 IN
LOAD, Q                                =    52880. LB
COEFFICIENT K2                         =    1.1707
SINCE A ( 66.3750 IN) > Rm/2 ( 16.1875 IN), THEN
 S2 = (K2*Q)/(Rm*(tp+t))
    =   1700. PSI
 ALLOWABLE SHEAR STRESS = 0.8 X Sa     =    16000. PSI


(C) CIRCUMFERENTIAL STRESSES  S4 & S5 :
WIDTH OF SADDLE, b                     =   12.0000 IN
LENGTH OF SHELL BARREL, L              =  245.7500 IN
WIDTH OF WEAR PLATE, W                 =   14.0000 IN
RATIO A/Rm                             =    2.0502
COEFFICIENT K6                         =    0.0529
COEFFICIENT K7                         =    0.7603

(i) AT HORN OF SADDLE :
SINCE A > Rm/2,THEN
 Tc=CORRODED SHELL THICKNESS           =    0.5000 IN
EFFECTIVE LENGTH 1.56*SQRT(Rm*ts)      =    6.2765 IN
SINCE L (245.75 IN) < 8*Rm (259.00 IN) THEN
 S4 =-Q/((4*Tc)*(b+1.56*(Rm*STHK)**.5))-(12*K6*Q*Rm)/(L*Tc**2)
    = -19120. PSI
 ALLOWABLE STRESS = 1.25 x Sa =  25000. PSI
(ii) AT THE BOTTOM OF SHELL :-
SINCE WIDTH OF WEAR PLATE (14.0000 IN) < b+1.56*((Rm*ts)**.5) = 18.2765 IN
THEN ts = CORRODED SHELL THICKNESS    =  0.5000 IN
 S5 = -(K7*Q)/(ts*(b+1.56*(Rm*ts)**.5))
    =  -4399. PSI
 ALLOWABLE STRESS = 0.5 x Sy =    16332. PSI
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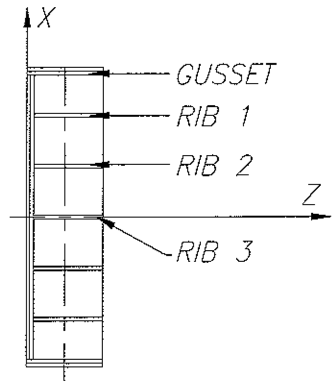
SHELL STRESSES AT LEFT SADDLE :-

* NOTE: LEFT SADDLE IS UNDER SHELL GIRTH FLANGE. SHELL STRESS CHECK IS NOT REQUIRED.

SLIDING SADDLE MOMENT OF INERTIA AND RADIUS OF GYRATION

Job No.	T10176	
Thickness of web	in	0.625
Length of web	in	61.9208
Thickness of gussets (corroded)	in	0.625
Length of gussets	in	5
Number of gussets		2
Projection of Gusset	in	0
Thickness of rib (corroded)	in	0.5
Length of rib	in	4.375
Number of rib 1		2
Number of rib 2		2
Number of rib 3		0



Caluculation for x-x axis:

	Area	d	A*d	A*d*d	I	A*d*d+I
Web	38.7005	0.3125	12.0939	3.7793	1.2598	5.0391
Gussets	6.2500	2.5	15.6250	39.0625	13.0208	52.0833
Rib 1	4.3750	2.8125	12.3047	34.6069	6.9784	41.5853
Rib 2	4.3750	2.8125	12.3047	34.6069	6.9784	41.5853
Rib 3	0.0000	0	0.0000	0.0000	0.0000	0.0000
Summation	53.7005		52.3283			140.2930

Ix-x	in4	89.3019
Neutral Axis	in	0.9744
Section Modulus Sx-x	in3	22.1838
Radius of gyartion	in	1.2896

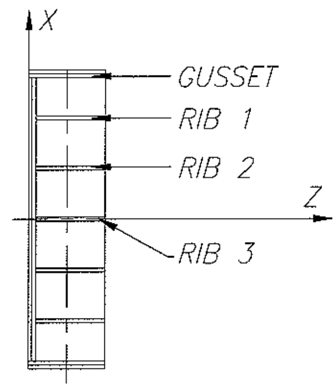
Caluculation for z-z axis:

	Area	d	A*d	A*d*d	I	A*d*d+I
Web	38.7005	0	0.000	0.0000	12365.418	12365.418
Gussets	6.2500	30.960	193.503	5990.9180	0.2035	5991.121
Rib1	4.3750	0.000	0.000	0.0000	0.0911	0.091
Rib 2	4.3750	0.000	0.000	0.0000	0.0911	0.091
Rib 3	0.0000	0.000	0.000	0.0000	0.0000	0.000
Summation	53.7005		193.503			18356.721

Iz-z	in4	18356.7214
Section Modulus Sz-z	in3	592.9095
Radius of gyartion	in	18.4888

FIX SADDLE MOMENT OF INERTIA AND RADIUS OF GYRATION

Job No.	T10176	
Thickness of web	in	0.625
Length of web	in	57.5907
Thickness of gussets	in	0.625
Length of gussets	in	12
Number of gussets		2
Projection of Gusset	in	0
Thickness of rib (corroded)	in	0.5
Length of rib	in	11.375
Number of rib 1		2
Number of rib 2		2
Number of rib 3		0



Caluculation for x-x axis:

	Area	d	A*d	A*d*d	I	A*d*d+I
Web	35.9942	0.3125	11.2482	3.5151	1.1717	4.6867
Gussets	15.0000	6	90.0000	540.0000	180.0000	720.0000
Rib 1	11.3750	6.3125	71.8047	453.2671	122.6515	575.9186
Rib 2	11.3750	6.3125	71.8047	453.2671	122.6515	575.9186
Rib 3	0.0000	0	0.0000	0.0000	0.0000	0.0000
Summation	73.7442		244.8576			1876.5240

Ix-x	in4	1063.5077
Neutral Axis	in	3.3204
Section Modulus Sx-x	in3	122.5291
Radius of gyartion	in	3.7976

Caluculation for z-z axis:

	Area	d	A*d	A*d*d	I	A*d*d+I
Web	35.9942	0	0.000	0.0000	9948.454	9948.454
Gussets	15.0000	28.795	431.930	12437.5781	0.4883	12438.066
Rib1	11.3750	0.000	0.000	0.0000	0.2370	0.237
Rib 2	11.3750	0.000	0.000	0.0000	0.2370	0.237
Rib 3	0.0000	0.000	0.000	0.0000	0.0000	0.000
Summation	73.7442		431.930			22386.995

Iz-z	in4	22386.9945
Section Modulus Sz-z	in3	777.4519
Radius of gyartion	in	17.4234

SADDLE ANALYSIS (INCLUDING BUNDLE PULLING):

PER TEAM PRG-G-7.113

Job No. T10176				
Yield Strength	Fy	psi	38000	
Bundle Weight		lb	43990	
Bundle pulling factor			1.5	
Bundle pulling force	Pb	lb	65985	
Distance between saddles	L	in	182	
			LEFT SADDLE	RIGHT SADDLE
Types			SLIDING	FIX
Shell (support pad) od	D	in	71.5	71.5
Saddle Height (from centre line)	H	in	43.3125	43.3125
Saddle Contact angle	theta	deg	120	120
Vertical force (weight)	RVwt	lb	58570	45880
Vertical force (Pb) = Pb*leff/L		lb	4984	4984
Effective Vertical force	RV	lb	63554	50864
Horizontal longitudinal force	RL	lb	0	65985
Horizontal transver force	RH	lb	0	0
Circumfrential moment	MS	in-lb	0	0
Section moudulus	Sx-x	in3	22.18	22.18
Section moudulus	Sz-z	in3	592.91	592.91
Metal cross sectional area	A	in2	53.7005	53.7005
Radius of Gyration	r	in	1.2896	1.2896
Effective saddle height	leff	in	13.7475	13.7475
leff = H - (D/2) * sin (theta)/theta				
slender Ratio	leff/r	psi	10.6606	10.6606
Allowable compressive stress	Fa	psi	16945	16945
Allowable bending stress	Fb=0.9*Sy	psi	34200	34200
Moment Mx-x = RL*leff		in-lb	0	907128
Moment Mz-z = MS		in-lb	0	0
Bending Stress Sbx = Mx-x /Sx-x		psi	0	40892
Bending Stress Sbz = Mz-z /Sz-z		psi	0	0
Total Bending Stress Sb=Sbx + Sbz		psi	0	40892
Compresive Stress Sc = RV/A		psi	1183	947
Sc/Fa + Sb/Fb			0.0698	1.2516
			OK	REDO

SADDLE ANALYSIS (INCLUDING BUNDLE PULLING):

PER TEAM PRG-G-7.113

Job No.	T10176			
Yield Strength	Fy	psi	38000	
Bundle Weight		lb	43990	
Bundle pulling factor			1.5	
Bundle pulling force	Pb	lb	65985	
Distance between saddles	L	in	182	
			LEFT SADDLE	RIGHT SADDLE
Types			SLIDING	FIX
Shell (support pad) od	D	in	66.5	66.5
Saddle Height (from centre line)	H	in	43.3125	43.3125
Saddle Contact angle	theta	deg	120	120
Vertical force (weight)	RVwt	lb	58570	45880
Vertical force (Pb) = Pb*leff/L		lb	5734	5734
Effective Vertical force	RV	lb	64304	51614
Horizontal longitudinal force	RL	lb	0	65985
Horizontal transver force	RH	lb	0	0
Circumfrential moment	MS	in-lb	0	0
Section moudulus	Sx-x	in3	122.53	122.53
Section moudulus	Sz-z	in3	777.45	777.45
Metal cross sectional area	A	in2	73.7442	73.7442
Radius of Gyration	r	in	3.7976	3.7976
Effective saddle height	leff	in	15.8150	15.8150
leff = H - (D/2) * sin (theta)/theta				
slender Ratio	leff/r	psi	4.1645	4.1645
Allowable compressive stress	Fa	psi	16992	16992
Allowable bending stress	Fb=0.9*Sy	psi	34200	34200
Moment Mx-x = RL*leff		in-lb	0	1043551
Moment Mz-z = MS		in-lb	0	0
Bending Stress Sbx = Mx-x /Sx-x		psi	0	8517
Bending Stress Sbz = Mz-z /Sz-z		psi	0	0
Total Bending Stress Sb=Sbx + Sbz		psi	0	8517
Compresive Stress Sc = RV/A		psi	872	700
Sc/Fa + Sb/Fb			0.0513	0.2902
			OK	OK

BASE PLATE CHECK			LEFT SADDLE	RIGHT SADDLE
			SLIDING	FIX
base plate thk.	t_b	in	0.750	0.750
base plate width	B	in	6	12
base plate length	F	in	59.0	60.0
Eeffective vertical force	R_V	lb	64304	51614
Allowable bending stress	$F_b = 0.66\ F_y$	psi	25080	25080
Max. bending stress	$F_a = 3\ R_v B / (4\ t_b^2 * F)$	psi	8719	13764
			$< F_b$	$< F_b$

ANCHOR BOLTS CHECK:			
Anchor bolts No. on each saddle	n	2	4
Anchor bolt diameter	d	1.250	1.500
Anchor bolt root area	A	0.929	1.405
Allowable bolt stress	S_b	20000	20000
Horizontal longitudinal force	R_L	0	65985
Anchor bolt shear stress	$S_h = R_L / (n*A)$	0	11741
Allowable bolt shear stress	$F_s = 0.8\ S_b$	16000	16000
		OK	OK

SADDLE ANALYSIS (INCLUDING WIND LOAD):

PER TEAM PRG-G-7.113

Job No. T10176				
Yield Strength	Fy	psi	32665	
Bundle Weight		lb	43990	
Bundle pulling factor			0	
Bundle pulling force	Pb	lb	0	
Distance between saddles	L	in	182	
			LEFT SADDLE	RIGHT SADDLE
Types			SLIDING	FIX
Shell (support pad) od	D	in	71.5	71.5
Saddle Height (from centre line)	H	in	43.3125	43.3125
Saddle Contact angle	theta	deg	120	120
Vertical force (weight)	RVwt	lb	65570	45880
Vertical force (Pb) = Pb*leff/L		lb	0	0
Effective Vertical force	RV	lb	65570	45880
Horizontal longitudinal force	RL	lb	0	0
Horizontal transver force	RH	lb	0	0
Circumfrential moment	MS	in-lb	0	0
Section moudulus	Sx-x	in3	22.18	22.18
Section moudulus	Sz-z	in3	592.91	592.91
Metal cross sectional area	A	in2	53.7005	53.7005
Radius of Gyration	r	in	1.2896	1.2896
Effective saddle height	leff	in	13.7475	13.7475
leff = H - (D/2) * sin (theta)/theta				
slender Ratio	leff/r	psi	10.6606	10.6606
Allowable compressive stress	Fa	psi	16945	16945
Allowable bending stress	Fb=0.9*Sy	psi	29398.5	29398.5
Moment Mx-x = RL*leff		in-lb	0	0
Moment Mz-z = MS		in-lb	0	0
Bending Stress Sbx = Mx-x /Sx-x		psi	0	0
Bending Stress Sbz = Mz-z /Sz-z		psi	0	0
Total Bending Stress Sb=Sbx + Sbz		psi	0	0
Compresive Stress Sc = RV/A		psi	1221	854
Sc/Fa + Sb/Fb			0.0721	0.0504
			OK	OK

SADDLE ANALYSIS (INCLUDING WIND LOAD):

PER TEAM PRG-G-7.113

Job No.	T10176			
Yield Strength	Fy	psi	32665	
Bundle Weight		lb	43990	
Bundle pulling factor			0	
Bundle pulling force	Pb	lb	0	
Distance between saddles	L	in	182	
			LEFT SADDLE	RIGHT SADDLE
Types			SLIDING	FIX
Shell (support pad) od	D	in	66.5	66.5
Saddle Height (from centre line)	H	in	43.3125	43.3125
Saddle Contact angle	theta	deg	120	120
Vertical force (weight)	RVwt	lb	65570	52880
Vertical force (Pb) = Pb*leff/L		lb	0	0
Effective Vertical force	RV	lb	65570	52880
Horizontal longitudinal force	RL	lb	0	0
Horizontal transver force	RH	lb	0	0
Circumfrential moment	MS	in-lb	0	0
Section moudulus	Sx-x	in3	122.53	122.53
Section moudulus	Sz-z	in3	777.45	777.45
Metal cross sectional area	A	in2	73.7442	73.7442
Radius of Gyration	r	in	3.7976	3.7976
Effective saddle height	leff	in	15.8150	15.8150
leff = H - (D/2) * sin (theta)/theta				
slender Ratio	leff/r	psi	4.1645	4.1645
Allowable compressive stress	Fa	psi	16992	16992
Allowable bending stress	Fb=0.9*Sy	psi	29398.5	29398.5
Moment Mx-x = RL*leff		in-lb	0	0
Moment Mz-z = MS		in-lb	0	0
Bending Stress Sbx = Mx-x /Sx-x		psi	0	0
Bending Stress Sbz = Mz-z /Sz-z		psi	0	0
Total Bending Stress Sb=Sbx + Sbz		psi	0	0
Compresive Stress Sc = RV/A		psi	889	717
Sc/Fa + Sb/Fb			0.0523	0.0422
			OK	OK

BASE PLATE CHECK

			LEFT SADDLE	RIGHT SADDLE
			SLIDING	FIX
base plate thk.	t_b	in	0.750	0.750
base plate width	B	in	6	12
base plate length	F	in	59.0	60.0
Eeffective vertical force	R_V	lb	65570	52880
Allowable bending stress	$F_b = 0.66\ F_y$	psi	21559	21559
Max. bending stress	$F_a = 3\ R_v B /(4\ t_b^2 *F)$	psi	8891	14101
			$< F_b$	$< F_b$

ANCHOR BOLTS CHECK:

Anchor bolts No. on each saddle	n	2	4
Anchor bolt diameter	d	1.250	1.500
Anchor bolt root area	A	0.929	1.405
Allowable bolt stress	S_b	20000	20000
Horizontal longitudinal force	R_L	0	0
Anchor bolt shear stress	$S_h = R_L / (n*A)$	0	0
Allowable bolt shear stress	$F_s = 0.8\ S_b$	16000	16000
		OK	OK

UNIT LIFTING LUG CALCULATION (PER ASME BTH -1-2005)

JOB NO. T10176
LIFTING LUG MATERIAL SA516-70N

72020LBS(ACTUAL UNIT SHEPPING WEIGHT)
X 180% (SAFETY FACTOR)/4(NO. OF LUG)=32409LBS<35000 LBS

P=	DESIGN LOAD	35000 LBS
Fu=	ALLOW. TENSILE STR.	70000 PSI
Fy=	MIN.YIELD STRESS	38000 PSI
Nd=	DESIGN FACTOR	3
Dh=	HOLE DIA.	2.375 IN
r =	RADIUS OF LUG	4.250 IN
R =	DISTANCE FROM THE CENTER OF THE HOLE TO THE EDGE OF THE PLATE	4.250 IN
be =	ACTUAL WIDTH BETWEEN THE EDGE OF THE HOLE & EDGE OF THE PLATE	
	be=r-(Dh/2)	3.0625 IN
L =	WIDTH OF LUG	14.000 IN
h =	DISTANCE FROM THE CENTER OF THE HOLE TO THE PLATE	5.875 IN
t	THICKNESS OF THE PLATE	1.250 IN

beff EFFECTIVE WIDTH TO EACH SIDE OF THE PIN (PER 3-47)

be 0.6 (Fu/Fy) * SQRT (Dh/be) = 2.9808 IN

beff = be 0.6 (Fu/Fy) * SQRT (Dh/be) ≤ be

beff = 2.9808 < 3.0625

USE beff 1.875 IN

1) Pt ALLOWABLE TENSILE STRENGTH THROUGH THE PIN HOLE (PER 3-45)

Pt= Fu*2t*beff/(1.20*Nd) = 91146 LBS

P < Pt OK

2) Pb ALLOWABLE SINGLE PLANE FRACTURE STRENGTH BEYOND THE PIN HOI (PER 3-48)

Pb= Fu/(1.20*Nd)*[1.13(R-(Dh/2)+0.92be/(1+be/Dh))]t 114024 LBS

P < Pb OK

3) Pv ALLOWABLE DOUBLE PLANE SHEAR STRENGTH BEYOND THE PIN HOLE (PER 3-49)

Z' = THE LOSS OF LENGTH OF ONE SHEAR PLANE

Z' = r- SQRT(r^2 - ((Dh/2) sin 45°)^2) 0.084

Av = TOTAL AREA OF THE TWO SHEAR PLANES BEYONES BEYOND THE PIN HOLE

Av1 = (R-(Dh/2)*cos45°)t = 4.263 $INCH^2$

Av2 = (R-(Dh/2)*cos45°-Z')t = 4.158 $INCH^2$

Av = Av1+ Av2 = 8.421 $INCH^2$

Pv = 0.70 Fu*Av/(1.20 Nd) = 114620 LBS

P < Pv OK

4) BEARING STRESS

fp =	BEARING STRESS			
d =	Shackle Pin. Diamter	=	1.875 INCH	
fp =	P/(d*t)	=	14933 PSI	
Fp =	1.25Fy/Nd	=	15833 PSI	(PER 3-51)
	fp < Fp		OK	