Transportation Calculation of 18-D-1802，REV.1

ASME VIII Division 2 Horizontal Vessel Analysis, Right Saddle:

Horizontal Vessel Stress Calculations : Ocean Transport

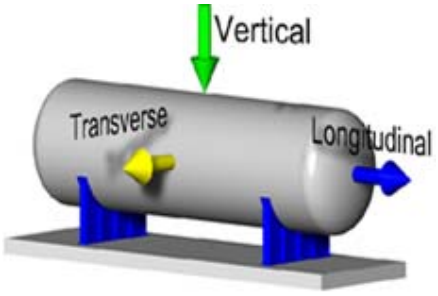
Note:
Wear Pad Width (340.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
= min( b + 1.56*sqrt( Rm * t ), 2a )
= min( 218 + 1.56*sqrt( 1071 * 10 ), 2 * 584 )
= 379.4582 mm
```

Input and Calculated Values:

Vessel Mean Radius	Rm	1071.20	mm
Shell Thickness used in this Case	t	10.000	mm
Stiffened Vessel Length per 4.15.6	L	5105.20	mm
Distance from Saddle to Vessel tangent	a1 or a	584.00	mm
Saddle Width	b1 or b	218.00	mm
Saddle Bearing Angle	delta or theta	120.00	degrees
Shell Allowable Stress used in Calculation		137.90	MPa
Head Allowable Stress used in Calculation		0.00	MPa
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	1677.00	mm
Coefficient of Friction	mu	0.00	
Saddle Force Q for this Transportation Case		15180.91	N
Shipping Longitudinal Acceleration	gx	0.40	g
Shipping Transverse Acceleration	gz	0.75	g
Shipping Vertical Acceleration	gy	2.00	g
Vertical Acceleration Acting with Transverse	gw	1.00	g
Internal Pressure during Transport		0.00	MPa
Transportation Wind Load Scalar Factor	wlsf	1.00	
Transportation Wind Velocity	wv	0.0	km/hr



Horizontal Vessel Analysis Results:	Actual MPa	Allowable MPa
Long. Stress at Top of Midspan	-0.35	-192.37
Long. Stress at Top of Midspan	0.35	137.90
Long. Stress at Bottom of Midspan	0.35	137.90
Long. Stress at Top of Saddles	-0.18	-235.81
Long. Stress at Top of Saddles	0.18	137.90
Long. Stress at Bottom of Saddles	0.10	137.90

Tangential Shear in Shell	1.28	110.32
Circ. Stress at Horn of Saddle	7.42	206.85
Circ. Compressive Stress in Shell	3.04	137.90

Intermediate Results: Saddle Reaction Q due to Ocean Transport Load:

Transverse Force due to Wind during Transport [Ft_w]:
= Transverse Area * 0.00256 * wv^2 * wlsf
= 275 * 0.00256 * 0^2 * 1
= 0.0 lbf
= 0.000 N

Longitudinal Force due to Wind during Transport [Fl_w]:
= pi * D^2/4 * 0.00256 * wv^2 * wlsf * Wind Dia. Mult
= pi * 7.06^2/4 * 0.00256 * 0^2 * 1 * 1.2
= 0.0 lbf
= 0.0 N

Transverse Force due to Lateral Acceleration [Ft]:
= gz * saddle Load * gw + Ft_w
= 0.75 * 5060 * 1 + 0
= 3795.2 N

Longitudinal Force due to Axial Acceleration [Fl]:
= gx * saddle Load * gw + Fl_w
= 0.4 * 5060 * 1 + 0
= 2024.1 N

Saddle Reaction Force due to Lateral Acceleration [Fwt]:
= Ft/Num of Saddles * B / E
= 3795/2 * 1677/1560
= 2039.9 N

Saddle Reaction Force due to Transport Load [Fwl]:
= Fl * B / Ls
= 2024 * 1677/4088
= 830.3 N

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:
= Saddle Load * gy
= 5060 * 2
= 10120.607 N

Load Combination Results due to Transport Loading [Q]:
= Saddle Load + max(Fwl, Fwt, Fsl)
= 5060 + max(830, 2040, 10121)
= 15180.9 N

Summary of Loads at the Base of this Saddle:

Vertical Load (including saddle weight)	18808.15	N
Transverse Shear Load	2039.93	N
Longitudinal Shear Load	2024.12	N

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:
= Specified by Analyst
= 1560.000 mm

The Computed K values from Table 4.15.1:

K1 = 0.1066 K2 = 1.1707 K3 = 0.8799 K4 = 0.4011

```
K5  = 0.7603     K6  = 0.0529     K7  = 0.0168     K8  = 0.3405
K9  = 0.2711     K10 = 0.0581     K1* = 0.1923
```

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:

```
= -Q*a [1 - (1- a/L + (Rm²-hm²)/(2a*L))/(1+(4hm²)/3L)]
= -15181*584[1-(1-584/5105+(1071²-0²)/
  (2*584*5105))/(1+(4*0)/(3*5105))]
= 692178.2 N-mm
```

Moment per Equation 4.15.2 [M2]:

```
= Q*L/4(1+2(Rm²-hm²)/(L²))/(1+(4hm²)/( 3L))-4a/L
= 15181*5105/4(1+2(1071²-0²)/(5105²))/(1+(4*0)/
  (3*5105))-4*584/5105
= 12220765.0 N-mm
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:

```
= P * Rm/(2t) - M2/(pi*Rm²t)
= 0 * 1071/(2*9.65 ) - 12220765/(pi*1071²*9.65 )
= -0.35 MPa
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:

```
= P * Rm/(2t) + M2/(pi * Rm² * t)
= 0 * 1071/(2 * 9.65 ) + 12220765/(pi * 1071² * 9.65 )
= 0.35 MPa
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma✱3]:

```
= P * Rm/(2t) - M1/(K1*pi*Rm²t)
= 0*1071/(2*10)-692178/(0.11*pi*1071²*10)
= -0.18 MPa
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma✱4]:

```
= P * Rm/(2t) + M1/(K1✱ * pi * Rm² * t)
= 0*1071/(2*10)+692178/(0.19*pi*1071²*10)
= 0.10 MPa
```

Maximum Shear Force in the Saddle (4.15.3) [T]:

```
= Q(L-2a)/(L+(4*hm/3))
= 15181 ( 5105 - 2 * 584 )/(5105 + ( 4 * 0/3))
= 11707.7 N
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:

```
= K2 * T / ( Rm * t )
= 1.17 * 11708/( 1071 * 10 )
= 1.28 MPa
```

Decay Length (4.15.20) [x1,x2]:

```
= 0.78 * sqrt( Rm * t )
= 0.78 * sqrt( 1071 * 10 )
= 80.729 mm
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:

```
= -K5 * Q * k / ( t( b + X1 + X2 ) )
= -0.76 * 15181 * 1.0/( 10 ( 218 + 80.7 + 80.7 ) )
= -3.04 MPa
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7✱]:

```
= -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
= -15181/(4*10 (218 +80.7 +80.7 )) -
    12 * 0.017 * 15181 * 1071/(5105 * 10²)
= -7.42 MPa
```

Effective reinforcing plate width (4.15.24) [B1]:

= min(b + 1.56 * sqrt(Rm * t), 2a)
= min(218 + 1.56 * sqrt(1071 * 10), 2 * 584)
= 379.46 mm

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	1580.0000	mm
Baseplate Thickness	Bpthk	20.0000	mm
Baseplate Width	Bpwid	240.0000	mm
Number of Ribs (inc. outside ribs)	Nribs	6	
Rib Thickness	Ribtk	8.0000	mm
Web Thickness	Webtk	10.0000	mm
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	213.7	MPa
Height of Web at Center	Hw,c	570.0	mm
Friction Coefficient	mu	0.000	

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

Inertia of Shell [ShellInertia]:
= ((1.56 * sqrt(R * t) + WearPlateWidth)t^3)/12
= ((1.56 * sqrt(1066 * 10) + 340)10^3)/12
= 41756.766 mm^4

Resolved Inertia for the Shell [I,shell]:
= ShellInertia + AShell(C1 - Y)^2
= 41757 + 5011 (249 - 5)^2
= 297374752.000 mm^4

	B mm	D mm	Y mm	A mm^2	AY mm^3	I + AD^2 mm^4
Shell	501.1	10.0	5.0	5010.8	25054.1	0.297E+09
Wearplate	340.0	10.0	15.0	3400.0	51000.0	0.186E+09
Web	10.0	570.8	305.4	5708.0	1743221.8	0.173E+09
BasePlate	240.0	20.0	600.8	4800.0	2883838.8	0.596E+09
Totals	...	...	...	18918.8	4703114.5	0.125E+10

Distance to Centroid [C1]:
= AY / A
= 4703114/18919
= 248.595 mm

Angle [beta]:
= 180 - Saddle Angle/2
= 180 - 120/2
= 120.0

Saddle Splitting Coefficient [K1]:
= (1 + cos(beta) - 0.5*$sin(beta)^2$)/(pi - beta + sin(beta)cos(beta))
= (1 + cos(120) - 0.5*$sin(120)^2$)/(pi - 2.09 + sin(120)cos(120))
= 0.2035

Saddle Splitting Force [Fh]:
= K1 * Q
= 0.2 * 15181
= 3089.6445 N

Tension Stress, St = (Fh/As)	=	0.2222 MPa
Allowed Stress, Sa = 0.6 * Yield Str	=	128.2470 MPa

Saddle Splitting Dimension [d]:
= B - R * sin(theta/2)/(theta/2 in radians)
= 1677 - 1066 * sin(120/2)/1.05
= 795.259 mm

```
Bending Moment, M  = Fh * d          =    2458065.2500  N-mm

Bending Stress, Sb = ( M * C1 / I  ) =          0.4879  MPa
Allowed Stress, Sa = 2/3 * Yield Str =        142.4967  MPa
```

Minimum Thickness of Baseplate per Moss:

```
= sqrt( 3( Q + Saddle_Wt )BasePlateWidth / ( 2 * BasePlateLength * AllStress ))
= sqrt( 3(15181 + 3627 )240/( 2 * 1580 * 142 ))
= 5.484 mm
```

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:

```
= 2 * cos( 90 - Saddle Angle/2 )( Inside Radius + Shell Thk + Wear Plate Thk )
= 2 * cos( 90 - 120/2 )( 1066 + 10 + 10 )
= 1881.354 mm
```

Distance between Ribs [e]:

```
= Web Length / ( Nribs - 1 )
= 1881/( 6 - 1 )
= 376.271 mm
```

Baseplate Pressure Area [Ap]:

```
= e * Bpwid / 2
= 376 * 240/2
= 45152.492 mm^2
```

Bearing Pressure [Bp]:

```
= Q / ( BasePlateLength * BasePlateWidth )
= 15181/( 1580 * 240 )
= 0.040 N/mm^2
```

Axial Load [P]:

```
= Ap * Bp
= 45152 * 0.04
= 1807.637 N
```

Area of the Rib and Web [Ar]:

```
= Rib Area + Web Area
= 1664 + 1881
= 3545.353 mm^2
```

Compressive Stress [Sc]:

```
= P/Ar
= 1808/3545
= 0.510 MPa
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	8.0	208.0	114.0	1664.0	189696.0	0.117E+08
Web	188.1	10.0	5.0	1881.4	9406.8	0.494E+07
Totals	...	...	...	3545.4	199102.7	0.167E+08

Rib dimension [D]:

```
= Saddle Width - Web Thickness
= 218 - 10
= 208.000 mm
```

Distance to Centroid from Datum [ytot]:

```
= AY / A
```

= 199103/3545
= 56.159 mm

Distance to Centroid [C1]:
= max(ytot, Saddle Width - ytot)
= max(56.2, 218 - 56.2)
= 161.841 mm

Radius of Gyration [r]:
= sqrt(Total Inertia / Total Area)
= sqrt(16680667/3545)
= 68.593 mm

Length of Outer Rib, step 1, [Lw]:
= 2 * sin(saddle bearing angle / 2)(radius + shlthk + wpdthk)
= 2 * sin(120/2)(1066 + 10 + 10)
= 1881.354 mm

Length of Outer Rib, step 2, [Bd]:
= Baseplate length - clearance
= 1580 - 50.8
= 1529.200 mm

Length of Outer Rib, step 3, [Dd]:
= (Lw - Bd)/2
= (1881 - 1529)/2
= 176.077 mm

Length of Outer Rib [L]:
= sqrt(Rl^2 + Dd^2)
= sqrt(1128^2 + 176^2)
= 1127.730 mm

Intermediate Term [Cc]:
= sqrt(2 * pi^2 * Elastic Modulus / Yield Stress)
= sqrt(2 * pi^2 * 199955/214)
= 135.889

Slenderness ratio [KL/r]:
= KL/r
= 1 * 1128/68.6
= 16.441

Bending Moment [Rm]:
= Fl /(2 * Bplen) * e * L / 2
= 2024/(2 * 1580) * 376 * 1128/2
= 135956.906 N-mm

Compressive Allowable, KL/r < Cc (16.4 < 136) per AISC E2-1 [Sca]:
= (1-$(Klr)^2$/(2*Cc^2))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr^3)/(8*Cc^3)
= (1-(16.4)^2/(2 * 136^2))214/
(5/3+3*(16.4)/(8* 136)-(16.4^3)/(8*136^3)
= 124 MPa

AISC Unity Check of Outside Ribs (must be <= 1)
= Sc/Sca + (Rm * C1 / I)/Sba
= 0.51/124 + (135957 * 162/16680684)/142
= 0.013

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	8.0	208.0	114.0	1664.0	189696.0	0.157E+08

Web	376.3	10.0	5.0	3762.7	18813.5	0.423E+07
Totals	...	...	...	5426.7	208509.5	0.199E+08

Distance to Centroid from Datum [ytot]:
= AY / A
= 208510/5427
= 38.423 mm

Distance to Centroid [C1]:
= max(ytot, abs(Saddle Width - ytot))
= max(38.4, abs(218 - 38.4))
= 179.577 mm

Length of Inner Rib [L]:
= Saddle Height - sqrt((Ro + Wpdthk)^2 - (Pitch/2)^2) - Bpthk
= 1677 - sqrt((1086 + 10)^2 - (376/2)^2) - 20
= 587.217 mm

Radius of Gyration [r]:
= sqrt(Total Inertia / Total Area)
= sqrt(19913214/5427)
= 60.576 mm

Slenderness ratio [KL/r]:
= KL/r
= 1 * 587/60.6
= 9.694

Unit Force [Force,u]:
= Fl / (2 * Baseplate Length)
= 2024/(2 * 1580)
= 0.641 N/mm

Moment at base of inner Rib [Mbase,c]:
= Unit Force * e * L
= 0.64 * 376 * 587
= 141587.359 N-mm

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:
= Bending Moment / Section Modulus
= 141587/110890
= 1.276 MPa

Compressive Allowable, KL/r < Cc (9.69 < 136) per AISC E2-1 [Sca]:
= (1-(Klr)^2/(2*Cc^2))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr^3)/(8*Cc^3)
= (1-(9.69)^2/(2 * 136^2))214/
(5/3+3*(9.69)/(8* 136)-(9.69^3)/(8*136^3)
= 125.9 MPa

AISC Unity Check of Inside Ribs (must be <= 1)
= Sc/Sca + (Mbase,c * C1/I)/Sba
= 0.67/126 + (141587 * 180/19913214)/142
= 0.014

ASME VIII Division 2 Horizontal Vessel Analysis, Left Saddle:

Note:
Wear Pad Width (340.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:
= min(b + 1.56*sqrt(Rm * t), 2a)
= min(218 + 1.56*sqrt(1072 * 9.65), 2 * 584)
= 376.6554 mm

Input and Calculated Values:

Vessel Mean Radius	Rm	1071.63	mm
Shell Thickness used in this Case	t	9.652	mm
Stiffened Vessel Length per 4.15.6	L	5105.20	mm
Distance from Saddle to Vessel tangent	a1 or a	584.00	mm
Saddle Width	b1 or b	218.00	mm
Saddle Bearing Angle	delta or theta	120.00	degrees
Inside or Mean Depth of Head	Hi or hm	540.09	mm
Shell Allowable Stress used in Calculation		137.90	MPa
Head Allowable Stress used in Calculation		137.90	MPa
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	1677.00	mm
Coefficient of Friction	mu	0.00	
Saddle Force Q for this Transportation Case		237985.27	N
Shipping Longitudinal Acceleration	gx	0.40	g
Shipping Transverse Acceleration	gz	0.75	g
Shipping Vertical Acceleration	gy	2.00	g
Vertical Acceleration Acting with Transverse	gw	1.00	g
Internal Pressure during Transport		0.00	MPa
Transportation Wind Load Scalar Factor	wlsf	1.00	
Transportation Wind Velocity	wv	0.0	km/hr

Horizontal Vessel Analysis Results:	Actual | MPa	Allowable | MPa
Long. Stress at Top of Midspan	-4.16	-235.81
Long. Stress at Top of Midspan	4.16	137.90
Long. Stress at Bottom of Midspan	4.16	137.90
Long. Stress at Top of Saddles	3.67	137.90
Long. Stress at Bottom of Saddles	-2.03	-235.81
Long. Stress at Bottom of Saddles	2.03	137.90
Tangential Shear in Shell	18.21	110.32
Circ. Stress at Horn of Saddle	124.34	206.85
Circ. Compressive Stress in Shell	49.77	137.90

Intermediate Results: Saddle Reaction Q due to Ocean Transport Load:

Transverse Force due to Wind during Transport [Ft_w]:

```
= Transverse Area * 0.00256 * wv^2 * wlsf
= 275 * 0.00256 * 0^2 * 1
= 0.0 lbf
= 0.000 N
```

Longitudinal Force due to Wind during Transport [Fl_w]:

```
= pi * D^2/4 * 0.00256 * wv^2 * wlsf * Wind Dia. Mult
= pi * 7.06^2/4 * 0.00256 * 0^2 * 1 * 1.2
= 0.0 lbf
= 0.0 N
```

Transverse Force due to Lateral Acceleration [Ft]:

```
= gz * saddle Load * gw + Ft_w
= 0.75 * 79328 * 1 + 0
= 59496.3 N
```

Longitudinal Force due to Axial Acceleration [Fl]:

= gx * saddle Load * gw + Fl_w
= 0.4 * 79328 * 1 + 0
= 31731.4 N

Saddle Reaction Force due to Lateral Acceleration [Fwt]:
= Ft/Num of Saddles * B / E
= 59496/2 * 1677/1560
= 31979.3 N

Saddle Reaction Force due to Transport Load [Fwl]:
= Fl * B / Ls
= 31731 * 1677/4088
= 13016.7 N

Saddle Reaction Force due to Vertical Transportation Acceleration [Fsl]:
= Saddle Load * gy
= 79328 * 2
= 158656.844 N

Load Combination Results due to Transport Loading [Q]:
= Saddle Load + max(Fwl, Fwt, Fsl)
= 79328 + max(13017, 31979, 158657)
= 237985.3 N

Summary of Loads at the Base of this Saddle:

Vertical Load (including saddle weight)	241612.62	N
Transverse Shear Load	31979.27	N
Longitudinal Shear Load	31731.37	N

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is not Welded to the Shell, k = 1.0

Saddle Dimension [E]:
= Specified by Analyst
= 1560.000 mm

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0168	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:
= $-Q*a\ [1 - (1- a/L + (Rm^2-hm^2)/(2a*L))/(1+(4hm^2)/3L)]$
= $-237985*584[1-(1-584/5105+(1072^2-540^2)/$
$(2*584*5105))/(1+(4*540)/(3*5105))]$
= -13620680.0 N-mm

Moment per Equation 4.15.2 [M2]:
= $Q*L/4(1+2(Rm^2-hm^2)/(L^2))/(1+(4hm^2)/(\ 3L))-4a/L$
= $237985*5105/4(1+2(1072^2-540^2)/(5105^2))/(1+(4*540)/$
$(3*5105))-4*584/5105$
= 144766864.0 N-mm

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:
= $P * Rm/(2t) - M2/(pi*Rm^2t)$
= $0 * 1072/(2*9.65\ ) - 144766864/(pi*1072^2*9.65\ )$
= -4.16 MPa

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:
= $P * Rm/(2t) + M2/(pi * Rm^2 * t)$
= $0 * 1072/(2 * 9.65\ ) + 144766864/(pi * 1072^2 * 9.65\ )$
= 4.16 MPa

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma✱3]:
= P * Rm/(2t) - M1/(K1*pi*Rm²t)
= 0*1072/(2*9.65)--13620680/(0.11*pi*1072²*9.65)
= 3.67 MPa

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma✱4]:
= P * Rm/(2t) + M1/(K1✱ * pi * Rm² * t)
= 0*1072/(2*9.65)+-13620680/(0.19*pi*1072²*9.65)
= -2.03 MPa

Maximum Shear Force in the Saddle (4.15.3) [T]:
= Q(L-2a)/(L+(4*hm/3))
= 237985 (5105 - 2 * 584)/(5105 + (4 * 540/3))
= 160848.7 N

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:
= K2 * T / (Rm * t)
= 1.17 * 160849/(1072 * 9.65)
= 18.21 MPa

Decay Length (4.15.20) [x1,x2]:
= 0.78 * sqrt(Rm * t)
= 0.78 * sqrt(1072 * 9.65)
= 79.328 mm

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:
= -K5 * Q * k / (t(b + X1 + X2))
= -0.76 * 237985 * 1.0/(9.65 (218 + 79.3 + 79.3))
= -49.77 MPa

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7✱]:
= -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
= -237985/(4*9.65 (218 +79.3 +79.3)) -
12 * 0.017 * 237985 * 1072/(5105 * 9.65²)
= -124.34 MPa

Effective reinforcing plate width (4.15.24) [B1]:
= min(b + 1.56 * sqrt(Rm * t), 2a)
= min(218 + 1.56 * sqrt(1072 * 9.65), 2 * 584)
= 376.66 mm

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	1580.0000	mm
Baseplate Thickness	Bpthk	20.0000	mm
Baseplate Width	Bpwid	240.0000	mm
Number of Ribs (inc. outside ribs)	Nribs	6	
Rib Thickness	Ribtk	8.0000	mm
Web Thickness	Webtk	10.0000	mm
Web Location	Webloc	Side	
Saddle Yield Stress	Sy	213.7	MPa
Height of Web at Center	Hw,c	570.0	mm
Friction Coefficient	mu	0.000	

Moment of Inertia of Saddle - Transverse Direction (90 degrees to long axis)

Inertia of Shell [ShellInertia]:
= ((1.56 * sqrt(R * t) + WearPlateWidth)t³)/12
= ((1.56 * sqrt(1067 * 9.65) + 340)9.65³)/12
= 37338.695 mm^4

Resolved Inertia for the Shell [I,shell]:
= ShellInertia + AShell(C1 - Y)²

= 37339 + 4810 (251 - 4.83)^2
= 291031936.000 mm^4

	B mm	D mm	Y mm	A mm^2	AY mm^3	I + AD^2 mm^4
Shell	498.3	9.7	4.8	4809.6	23211.0	0.291E+09
Wearplate	340.0	10.0	14.7	3400.0	49816.8	0.190E+09
Web	10.0	570.5	304.9	5705.5	1739750.0	0.171E+09
BasePlate	240.0	20.0	600.2	4800.0	2880960.8	0.586E+09
Totals	...	...	...	18715.1	4693738.0	0.124E+10

Distance to Centroid [C1]:
= AY / A
= 4693738/18715
= 250.800 mm

Angle [beta]:
= 180 - Saddle Angle/2
= 180 - 120/2
= 120.0

Saddle Splitting Coefficient [K1]:
= (1 + cos(beta) - 0.5*sin(beta)^2)/(pi - beta + sin(beta)cos(beta))
= (1 + cos(120) - 0.5*sin(120)^2)/(pi - 2.09 + sin(120)cos(120))
= 0.2035

Saddle Splitting Force [Fh]:
= K1 * Q
= 0.2 * 237985
= 48435.1602 N

Tension Stress, St = (Fh/As) = 3.4835 MPa
Allowed Stress, Sa = 0.6 * Yield Str = 128.2470 MPa

Saddle Splitting Dimension [d]:
= B - R * sin(theta/2)/(theta/2 in radians)
= 1677 - 1067 * sin(120/2)/1.05
= 794.763 mm

Bending Moment, M = Fh * d = 38510104.0000 N-mm

Bending Stress, Sb = (M * C1 / I) = 7.7972 MPa
Allowed Stress, Sa = 2/3 * Yield Str = 142.4967 MPa

Minimum Thickness of Baseplate per Moss:
= sqrt(3(Q + Saddle_Wt)BasePlateWidth / (2 * BasePlateLength * AllStress))
= sqrt(3(237985 + 3627)240/(2 * 1580 * 142))
= 19.656 mm

Calculation of Axial Load, Intermediate Values and Compressive Stress:

Web Length Dimension [Web Length]:
= 2 * cos(90 - Saddle Angle/2)(Inside Radius + Shell Thk + Wear Plate Thk)
= 2 * cos(90 - 120/2)(1067 + 9.65 + 10)
= 1881.790 mm

Distance between Ribs [e]:
= Web Length / (Nribs - 1)
= 1882/(6 - 1)
= 376.358 mm

Baseplate Pressure Area [Ap]:
= e * Bpwid / 2
= 376 * 240/2

```
  = 45162.957 mm^2
```

Bearing Pressure [Bp]:
```
  = Q / ( BasePlateLength * BasePlateWidth )
  = 237985/( 1580 * 240 )
  = 0.628 N/mm^2
```

Axial Load [P]:
```
  = Ap * Bp
  = 45163 * 0.63
  = 28344.191 N
```

Area of the Rib and Web [Ar]:
```
  = Rib Area + Web Area
  = 1664 + 1882
  = 3545.790 mm^2
```

Compressive Stress [Sc]:
```
  = P/Ar
  = 28344/3546
  = 7.994 MPa
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	B	D	Y	A	AY	Io
Rib	8.0	208.0	114.0	1664.0	189696.0	0.117E+08
Web	188.2	10.0	5.0	1881.8	9408.9	0.494E+07
Totals	...	...	...	3545.8	199104.9	0.167E+08

Rib dimension [D]:
```
  = Saddle Width - Web Thickness
  = 218 - 10
  = 208.000 mm
```

Distance to Centroid from Datum [ytot]:
```
  = AY / A
  = 199105/3546
  = 56.152 mm
```

Distance to Centroid [C1]:
```
  = max( ytot, Saddle Width - ytot )
  = max( 56.2, 218 - 56.2 )
  = 161.847 mm
```

Radius of Gyration [r]:
```
  = sqrt( Total Inertia / Total Area )
  = sqrt( 16681812/3546 )
  = 68.591 mm
```

Length of Outer Rib, step 1, [Lw]:
```
  = 2 * sin( saddle bearing angle / 2 )( radius + shlthk + wpdthk )
  = 2 * sin( 120/2 )( 1067 + 9.65 + 10 )
  = 1881.790 mm
```

Length of Outer Rib, step 2, [Bd]:
```
  = Baseplate length - clearance
  = 1580 - 50.8
  = 1529.200 mm
```

Length of Outer Rib, step 3, [Dd]:
```
  = ( Lw - Bd )/2
  = ( 1882 - 1529 )/2
```

= 176.295 mm

Length of Outer Rib [L]:
= sqrt(Rl^2 + Dd^2)
= sqrt(1128^2 + 176^2)
= 1127.640 mm

Intermediate Term [Cc]:
= sqrt(2 * pi^2 * Elastic Modulus / Yield Stress)
= sqrt(2 * pi^2 * 199955/214)
= 135.889

Slenderness ratio [KL/r]:
= KL/r
= 1 * 1128/68.6
= 16.440

Bending Moment [Rm]:
= Fl /(2 * Bplen) * e * L / 2
= 31731/(2 * 1580) * 376 * 1128/2
= 2131667.250 N-mm

Compressive Allowable, KL/r < Cc (16.4 < 136) per AISC E2-1 [Sca]:
= (1-$(Klr)^2$/(2*Cc^2))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr^3)/(8*Cc^3)
= (1-(16.4)^2/(2 * 136^2))214/
(5/3+3*(16.4)/(8* 136)-(16.4^3)/(8*136^3)
= 124 MPa

AISC Unity Check of Outside Ribs (must be <= 1)
= Sc/Sca + (Rm * C1 / I)/Sba
= 7.99/124 + (2131667 * 162/16681828)/142
= 0.210

Check of Inside Ribs:

Inertia of Saddle, Inner Ribs - Axial Direction

	B	D	Y	A	AY	Io
Rib	8.0	208.0	114.0	1664.0	189696.0	0.157E+08
Web	376.4	10.0	5.0	3763.6	18817.9	0.423E+07
Totals	...	...	...	5427.6	208513.9	0.199E+08

Distance to Centroid from Datum [ytot]:
= AY / A
= 208514/5428
= 38.417 mm

Distance to Centroid [C1]:
= max(ytot, abs(Saddle Width - ytot))
= max(38.4, abs(218 - 38.4))
= 179.583 mm

Length of Inner Rib [L]:
= Saddle Height - sqrt((Ro + Wpdthk)^2 - (Pitch/2)^2) - Bpthk
= 1677 - sqrt((1086 + 10)^2 - (376/2)^2) - 20
= 586.969 mm

Radius of Gyration [r]:
= sqrt(Total Inertia / Total Area)
= sqrt(19914196/5428)
= 60.573 mm

Slenderness ratio [KL/r]:
= KL/r
= 1 * 587/60.6

= 9.690

Unit Force [Force,u]:
= Fl / (2 * Baseplate Length)
= 31731/(2 * 1580)
= 10.042 N/mm

Moment at base of inner Rib [Mbase,c]:
= Unit Force * e * L
= 10 * 376 * 587
= 2219187.500 N-mm

Bending Stress due to Transverse Force and Weight Load [SigmaB,base,c]:
= Bending Moment / Section Modulus
= 2219187/110892
= 20.006 MPa

Compressive Allowable, KL/r < Cc (9.69 < 136) per AISC E2-1 [Sca]:
$= (1-(Klr)^2/(2*Cc^2))Fy/(5/3+3*(Klr)/(8*Cc)-(Klr^3)/(8*Cc^3)$
$= (1-(9.69)^2/(2 * 136^2))214/$
$(5/3+3*(9.69)/(8* 136)-(9.69^3)/(8*136^3)$
= 125.9 MPa

AISC Unity Check of Inside Ribs (must be <= 1)
= Sc/Sca + (Mbase,c * C1/I)/Sba
= 10.5/126 + (2219187 * 180/19914196)/142
= 0.224