TAYLOR FORGE Engineered Systems

Traditionally Dependable

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HEAT EXCHANGER SPECIFICATION SHEET

Customer	KP Engineering	P.O. No.	J144-B-007
Address	Tyler, TX	Job No.	1203-04
Plant Location	Holly Frontier- Tulsa, OK	Date	2/24/16
Service of Unit	Debutanizer Steam Reboiler	Item No.	374-E-C221
Size 40-240	Type AEU Horizontal	Connected In	1 Parallel 1 Series
Surf/Unit (Eff), Sq Ft 3189	Shell/Unit 1	Surf/Shell (Eff)	3189 Sq Ft

PERFORMANCE OF ONE UNIT

		Shell Side		Tube Side	
Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Steam		Debutanizer Bottoms	
Fluid Quantity, Total	lb/hr	32,535		615,692	
Vapor (In/Out)					206,934
Liquid				615,692	408,758
Steam		32,535			
Water			32,535		
Noncondensable					
Temperature (In/Out)	F	552.70	420.79	334.40	354.6
Density			52.71	32.27	31.67
Viscosity	cP	0.0196	0.1239	0.1000	0.011 V/L 0.095
Molecular Weight, Vapor		18.02			83.87
Molecular Weight, Noncondensable					
Specific Heat	Btu/lb-F	0.511	1.200	0.733	0.598 V/L 0.758
Thermal Conductivity	Btu/hr-ft-F	0.026	0.377	0.038	0.017 V/L 0.036
Latent Heat	Btu/lb				
Inlet Pressure	psia	314.70		206.70	
Velocity	ft/sec			11.21	
Pressure Drop, Allow/Calc	psi	10.000	0.765	15.000	5.551
Fouling Resistance (min)	ft2-hr-F/Btu	0.00050		0.0040	

Heat Exchanged Btu/hr	28,750,000	MTD (Corrected)	72.7 F
Transfer Rate, Service	124.0 Btu/ft2-hr-F		

CONSTRUCTION OF ONE SHELL

		Shell Side	Tube Side
Design Pressure	PSI	675 / F.V.	525 / F.V.
Test Pressure		CODE	CODE
Design Temperature / MDMT	F	725 / 300 / -20	425 / 300 / -20
No Passes per Shell		1	2
Corrosion Allowance	inch	0.1250	0.1250
Connections In	inch	1 @ 12 600 # RFWN	1 @ 10 300 # RFWN
Connections Out	inch	1 @ 6 600 # RFWN	1 @ 14 300 # RFWN

Tube No 313U	OD 1.0000 Thk(Min) 0.109 inch	Length 20.0 feet	Pitch 1.250 inch Layout 45
Tube Type	BARE	Material	SA-214
Shell	SA-516-70 ID 40.00 inch	Shell Cover	SA-516-70
Channel or Bonnet	SA-516-70	Channel Cover	SA-516-70
Tubesheet-Stationary	SA-350-LF2	Tubesheet-Floating	
Floating Head Cover		Impingement Plate	Circular plate
Baffles-Cross	SA-36 Type Sing Seg - Vert	%Cut (Diam) 30.10	Spacing(c/c) 9
Baffles-Long			
Supports-Tube	SA-36	U-Bend SA-36	Type Full
Bypass Seal Arrangement		Tube-Tubesheet Joint	Rolled & Double Grooved
Gaskets - Shell	GMGC	Tube	GMGC
-Floating Head			
Code Requirements	ASME Section VIII, Div. I	TEMA Class	R, API 660

Remarks: Unit is thermally, vibrationaly and mechanically guaranteed by Taylor Forge Engineered Systems. Two grounding lugs.
Counter current flow. National Board registration included. 1" minimum bolting. Two sets of spare gaskets included.
Lath Stud type fireproofing supports. PMI bolting. Full X-ray.

Revised: Gasket material per customer by K Duke

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Design Verification

Doc. No.:	1203-04-K01	**Doc. Title:**	Mechanical Design Calculations
TFES Job No.:	1203	**Customer:**	KP Engineering
Item No.(s):	04	**P.O. No.:**	J1422-B-007
No. of Pages:	53 Pages plus cover	**Customer Item No.(s):**	374-E-C221
Job Description:	One 40”-240” AEU Debutanizer Steam Reboiler		
CODE:	**ASME - B31.1** ☐ **ASME - B31.3** ☐ **ASME - B31.4** ☐ **ASME - B31.8** ☐ **ASME - B31.11** ☐	**ASME – Section I** ☐ **ASME - Section VIII Div. 1** ☒ **ASME - Section VIII Div. 2** ☐ **NBIC** ☐ **Other**__________	

Customer Comments / Stamp:

7	Matls corrected to as-built (ie. Normalized)	KAD	ADR	07/05/16
6	Added PWHT to Channel (pg 1)	KAD	ADR	04/21/16
5	Added stress ratio to test calc	KAD	ADR	03/14/16
4	Rev gasket material	KAD	ADR	02/24/16
3	Rev Support calculations, Tubesheet calcs with strength weld	KAD	ADR	02/05/16
2	Tubesheet matl. from plate to forging. Shell flange forging matl. from SA-105 to SA-350-LF2. Added Test @ 1.3xMAWP	KAD	ADR	01/22/16
1	Rev per customer comments	KAD	ADR	12/29/15
0	Original Issue	KAD	ADR	12/03/15
Rev.	**Description**	**Prepared**	**Approved**	**Date**

P.O. no: J1422-B-007	Job no : 1203-04
Date: 07/05/16 | By: K Duke	Item no: 374-E-C221
Customer: KP ENGINEERING	HORIZONTAL
Service : DEBUTANIZER STEAM REBOILER	U-TUBE
No. Shells: 1 Par. 1 Ser. 1	Surface: 3189 Each 3189 TotalSq.Ft.
Size: 40 x 240 " Type: A E U	

313 Tubes x 1.000 OD x 0.109 Thk BWG x 240 " Lg 1.2500 ROT.SQ. Pitch

Tubes : SA-214

Shell : SA-516-70N

Channel : SA-516-70

Tubesheets : SA-350-LF2CL1

Cross Baffles : SA-36 No. 23 Pitch 9.000 Cut 0.30 SGL SEG VERT

Code requirements: SHELL SECT VIII STAMP YES CHANNEL SECT VIII STAMP YES

Natl. Board #YES Canadian Reg. # Tema R

Weight Ea Dry: 38550 Lbs Wet 50250 Lbs Bundle 18500 Lbs

	Shell	Tubes
Design Press/Ext	675.0 / 15.0 psig	525.0 / 15.0 psig
Test Press.(1.3x Des x Sr)	1067.0 psig	684.0 psig
Test Press.(1.3x MAWP x Sr)	1067.0 psig	684.0 psig
Sr = Stress ratio	1.216 psig	1.0 psig
Design Temp/MDMT	725 / -20 deg.F	425 / -20 deg.F
Corrosion Allowance	0.1250"	0.1250"
No. of Passes	1	2
Radiograph	FULL	FULL
Stress Relieve	NONE deg.F	1150 / U-Bends 1200 deg.F

Paint: PREP & PAINT PER CUSTOMER SPECIFICATIONS

INSUL BY OTHERS. INSUL SUPPORT BY TFES.

Remarks: TUBE JOINT: EXPANDED & DOUBLE GROOVED.

PMI REQUIRED: FLG STUDS

NOZZLES

Label	Size & Type	Bore	Sch	Proj	Weld Pad
S1 Shl INLET	12.00"- 600#RF WN	11.374	80	40.000	18.500x 1.000"
S2 Shl OUTLET	6.00"- 600#RF WN	5.761	XH	40.000	9.625x 0.875"
T1 Fch INLET	10.00"- 300#RF WN	9.062	120	40.000	0.000x 0.000"
T2 Fch OUTLET	14.00"- 300#RF WN	12.124	100	40.000	0.000x 0.000"

PRESSURE VESSEL CALCULATIONS PER RCS SHELL AND TUBE DESIGN SOFTWARE Version : 01.01.16

SUPPORT / SEISMIC & WIND CALCULATIONS PER PV ELITE SOFTWARE Version : 17.00.00.000

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                           SHELL SIDE
============================================================================
 NOM.
 SIZE         PRESS.       TEMP.         C.A.       RT    H.T.         TEMA
  40.000"     675.0psig      725deg.F  0.1250"     FULL        0deg.F    R
============================================================================
ASME CODE SEC.VIII DIV.I UG-27                                [ CYLINDER ]
====DESIGN CONDITIONS==============CYLINDER CALCULATIONS ON I.D. FORMULA====
SHELL CYL
MATERIAL: SA-516-70N        PRESS =  675.0psig   TEMP =    725deg.F
I.D.          NOM. THK.    RW=0/PIPE=1   CORR.ALLOW   EFFICIENCY
  40.0000"      1.2500"        0          0.1250"       1.00
ATM.STRS      DES.STRS     STRS/STRS     MAWP N-C     MAWP CORR.
  20000.0psi    16450.0psi   1.216      1204.819psig    889.724psig

 P*(R+CA)
---------- =  0.84664"   + CORR. ALLOW. =  0.97164"   + MTOL. =  0.97164"
S*E-(.6*P)
****************************************************************************

ASME CODE SEC.VIII DIV.I UG-32                         [ ELLIPTICAL HEAD ]
====DESIGN CONDITIONS=======ELLIPTICAL HEAD CALCULATIONS ON I.D. FORMULA====
SHELL HEAD
MATERIAL: SA-516-70N     PRESS =  675.0psig   TEMP =    725deg.F
I.D.           (min)THK.    CORR.ALLOW    EFFICIENCY
  40.0000"      1.0000"      0.1250"       1.00
ATM.STRS       DES.STRS     STRS/STRS     MAWP N-C     MAWP CORR.
  20000.0psi     16450.0psi  1.216        995.025psig  712.121psig

 P*(R+CA)                                             0.0000
---------- =  0.82920"   + CORR. ALLOW. =  0.95420"   + MTOL. =  0.95420"
S*E-(.1*P)
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```
Shell
----- External Pressure Calculations -----
Ext Press Chart....=       1  CS-2
Actual Chart Used..=       1  CS-2
Material..........=    SA-516-70N
OD................=       42.50000
T.................=        1.12500
L.................=      236.00000
Temp..............=      725.00000
Stress from MT.....=    16450.00000
Yield  from MT.....=    26750.00000
2 x Stress.........=    32900.00000
B1 from Chart@Right=        0.00000
Yield= 2 x B1 x 0.9=        0.00000
S.................=        0.00000
DO/T..............=       37.77778
L/DO..............=        5.55294
A.................=        0.00095
B.................=     7646.76953
PA1...............=        0.00000
PA2...............=        0.00000
PA................=      269.88599

Errors/Warnings:
- None


Ellip. Head External pressure calculations:

Ext Press Chart....=       1  CS-2
Actual Chart Used..=       1  CS-2
Material..........=    SA-516-70N
OD................=       42.25000
RO................=       38.02500
T.................=        0.87500
Temp..............=      725.00000
Stress from MT.....=    16450.00000
Yield  from MT.....=    26750.00000
A.................=        0.00288
B.................=     9705.76465
PA1...............=      223.34108
PA2...............=      423.79901
PA................=      223.34108

Errors/Warnings:
 None
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                           FRONT CHAN.
============================================================================
 NOM.
 SIZE          PRESS.        TEMP.         C.A.       RT    H.T.         TEMA
  40.000"     525.0psig      425deg.F  0.1250"     FULL        0deg.F    R
============================================================================
ASME CODE SEC.VIII DIV.I UG-27                                  [ CYLINDER ]
====DESIGN CONDITIONS==============CYLINDER CALCULATIONS ON I.D. FORMULA====
CHAN. CYL
MATERIAL: SA-516-70         PRESS =  525.0psig   TEMP =    425deg.F
I.D.          NOM. THK.     RW=0/PIPE=1   CORR.ALLOW   EFFICIENCY
  40.0000"      1.0000"        0          0.1250"       1.00
ATM.STRS      DES.STRS      STRS/STRS     MAWP N-C     MAWP CORR.
  20000.0psi    20000.0psi  1.000        970.874psig    847.458psig

 P*(R+CA)
---------- =  0.53673"   + CORR. ALLOW. =  0.66173"   + MTOL. =  0.66173"
S*E-(.6*P)
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Channel

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----- External Pressure Calculations -----
Ext Press Chart....=       1  CS-2
Actual Chart Used..=       1  CS-2
Material...........=    SA-516-70
OD.................=      42.00000
T..................=       0.87500
L..................=      24.68750
Temp...............=     425.00000
Stress from MT.....=   20000.00000
Yield  from MT.....=   32125.00000
2 x Stress.........=   40000.00000
B1 from Chart@Right=       0.00000
Yield= 2 x B1 x 0.9=       0.00000
S..................=       0.00000
DO/T...............=      48.00000
L/DO...............=       0.58780
A..................=       0.00743
B..................=   15193.60156
PA1................=       0.00000
PA2................=       0.00000
PA.................=     422.04449
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Errors/Warnings:
- None

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|ASME SEC.VIII DIV.1 APPENDIX 2               Front Channel to cover flange |
|DESIGN CONDITIONS           GASKET and BOLTING CALCULATIONS   TABLE        |
|Design Pres=  525.0 psig    Eff.Gsk OD=    42.7500"           No.Passes= 2 |
|Neg.   Pres=   None         Eff.Gsk ID=    40.0000"           N=  1.375"   |
|Design Temp=    425 deg.F   THK= 0.1250"            col.=2   b=  0.415    |
|Flg  Matl=SA-105        Gsk Matl=GMGC FLEXPRO STYLE PN        y=   2500psi |
|Bolt Matl=SA-193B7      Gsk Face=                w= 0.0000"   m=  2.000    |
|Corr Allow=    0.1250"         Wm2=    155247 #      Am =  34.2010in^2     |
|Flange  Desn Sfo 19900.0 psi   Hp =    130408 #      Ab =  34.9440in^2     |
|        Atm. Sfa 20000.0 psi   H  =    724617 #      W  =   864312 #       |
|Bolting Desn Sb  25000.0 psi   Wm1=    855025 #      Wm1=   855025 #       |
|        Atm. Sa  25000.0 psi    Gasket Width Check  Nmin =    1.3267"      |
|CONDITION    LOAD         x        LEVER ARM   =    MOMENT                 |
|             HD =   668006 #       hD=  2.15625"    MD=   1440388 in#      |
|Operating    HG =   130408 #       hG=  1.97708"    MG=    257827 in#      |
|             HT =    56611 #       hT=  2.39479"    MT=    135571 in#      |
|                                                   Mo=   1833788 in#      |
|Gasket                                                                     |
|Seating      HG =   864312 #       hG=  1.97708"    mo=   1708813 in#      |
|Allow.Stress-STRESS CALCULATIONS-Operating  |       SHAPE CONSTANTS        |
|1.5 Sfo&2.5 Sno Long Hub,SH   23418.4 psi   |K    = 1.1957 h/ho=  0.2738   |
|    Sfo Radial Flg,SR          3416.5 psi   |T    = 1.8407 F   =  0.8830   |
|    Sfo Tang Flg,ST            9160.5 psi   |Z    = 5.6557 V   =  0.3805   |
|    Sfo .5(SH+SR)or.5(SH+ST)  16289.5 psi   |Y    =10.9627 f   =  1.2328   |
|    J(APP.2-14)=    0.6959                  |U    =12.0469 e = 0.1488in^-1 |
|Allow.Stress-STRESS CALCULATIONS-Gsk.Seating|g1/go= 1.5000 d = 143.838In^3 |
|1.5 Sfa&2.5 Sna Long Hub,SH   21822.4 psi   |ho   =   5.9345"              |
|    Sfa Radial Flg,SR          3183.7 psi   |______________________________|
|    Sfa Tang Flg,ST            8536.2 psi   | OTHER STRESS FORMULA FACTORS |
|    Sfa .5(SH+SR)or.5(SH+ST)  15179.3 psi   |    t         4.1875"         |
|    J(APP.2-14)=    0.6118                  |    Alpha     1.6231          |
|                                            |    Beta      1.8308          |
|                                            |    Gamma     0.8818          |
|                                            |    Delta     0.5105          |
|                                            |    Lambda    1.3923          |
|                                            |    M          45559 #        |
|____________________________________________|____m__________42454 #________|
|O.D.      =   48.1250"           THK.          =    4.3750"                |
|I.D.      =   40.0000"           T-Adder       =    0.0000"                |
|GO        =    1.0000"           G1            =    1.4375"                |
|HUB O.D.  =   42.8750"           HUB LEN       =    1.6250"                |
|HUB ANG   =   15.0685deg         RIB LENGTH    =   40.0000"                |
|G(MEAN)   =   41.3750"           G(CALC)       =   41.9208"                |
|G(MIN.)   =   41.3750"           G(MAX.)       =   42.7500"                |
|B.C.      =   45.8750"           B.S.C.F.      =    1.0000                 |
|No. BOLTS =   48                 BOLT DIAMETER =    1.1250"                |
|R         =    1.5000"           E             =    1.1250"                |
|BOLT SPAC =    3.0004"           TORQUE        =       480ft#              |
|MIN. SPAC =    2.5000"           TEMA MAX. SPAC=   12.3000"                |
|FLG TURN  =    0.1875"           FACING        =    RECESS                 |
|BPRIME    =    0.0000"           BG1           =    0.0000"                |
|FLG RWT   =       956Lbs         FLG FWT       =       737Lbs              |
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|ASME SEC.VIII DIV.1 APPENDIX 2           Front chan to tubesheet flange |
|DESIGN CONDITIONS           GASKET and BOLTING CALCULATIONS   TABLE      |
|Design Pres=  525.0 psig    Eff.Gsk OD=    43.7500"           No.Passes= 2 |
|Neg.   Pres=   15.0 psig    Eff.Gsk ID=    40.0000"           N=  1.875"   |
|Design Temp=    425 deg.F   THK= 0.1250"             col.=2   b=  0.484    |
|Flg  Matl=SA-105        Gsk Matl=GMGC FLEXPRO STYLE PN        y=   2500psi |
|Bolt Matl=SA-193B7      Gsk Face=                w= 0.0000"   m=  2.000    |
|Corr Allow=    0.1250"         Wm2=    181418 #      Am =  47.1602in^2     |
|Flange  Desn Sfo 19900.0 psi   Hp =    152391 #      Ab =  48.3080in^2     |
|        Atm. Sfa 20000.0 psi   H  =    754685 #      W  =  1193352 #       |
|Bolting Desn Sb  24300.0 psi   Wm1=   1145992 #      Wm1=  1145992 #       |
|        Atm. Sa  25000.0 psi    Gasket Width Check  Nmin =    1.7971"      |
|CONDITION    LOAD         x        LEVER ARM   =    MOMENT                 |
|             HD =   668006 #       hD=  2.78125"    MD=   1857892 in#      |
|Operating    HG =   391306 #       hG=  2.17162"    MG=    849770 in#      |
|             HT =    86679 #       hT=  2.80456"    MT=    243096 in#      |
|                                                   Mo=   2950760 in#      |
|Gasket                                                                     |
|Seating      HG =  1193352 #       hG=  2.17162"    mo=   2591511 in#      |
|Allow.Stress-STRESS CALCULATIONS-Operating  |       SHAPE CONSTANTS        |
|1.5 Sfo&2.5 Sno Long Hub,SH   22856.0 psi   |K    = 1.2329 h/ho=  0.2738   |
|    Sfo Radial Flg,SR          2245.5 psi   |T    = 1.8255 F   =  0.8830   |
|    Sfo Tang Flg,ST           12410.5 psi   |Z    = 4.8455 V   =  0.3805   |
|    Sfo .5(SH+SR)or.5(SH+ST)  17633.2 psi   |Y    = 9.3933 f   =  1.2328   |
|    J(APP.2-14)=    0.6792                  |U    =10.3223 e = 0.1488in^-1 |
|Allow.Stress-STRESS CALCULATIONS-Gsk.Seating|g1/go= 1.5000 d = 123.246In^3 |
|1.5 Sfa&2.5 Sna Long Hub,SH   20073.3 psi   |ho   =   5.9345"              |
|    Sfa Radial Flg,SR          1972.1 psi   |                              |
|    Sfa Tang Flg,ST           10899.5 psi   | OTHER STRESS FORMULA FACTORS |
|    Sfa .5(SH+SR)or.5(SH+ST)  15486.4 psi   |    t          5.4375"        |
|    J(APP.2-14)=    0.5628                  |    Alpha      1.8091         |
|                                            |    Beta       2.0788         |
|                                            |    Gamma      0.9910         |
|                                            |    Delta      1.3044         |
|                                            |    Lambda     2.2954         |
|                                            |    M           73310 #       |
|                                            |    m           64385 #       |
|O.D.      =   49.6250"           THK.          =    5.6250"              |
|I.D.      =   40.0000"           T-Adder       =    0.0000"              |
|GO        =    1.0000"           G1            =    1.4375"              |
|HUB O.D.  =   42.8750"           HUB LEN       =    1.6250"              |
|HUB ANG   =   15.0685deg         RIB LENGTH    =   40.0000"              |
|G(MEAN)   =   41.8750"           G(CALC)       =   42.7818"              |
|G(MIN.)   =   41.8750"           G(MAX.)       =   43.3750"              |
|B.C.      =   47.1250"           B.S.C.F.      =    1.0000               |
|No. BOLTS =   52                 BOLT DIAMETER =    1.2500"              |
|R         =    2.1250"           E             =    1.2500"              |
|BOLT SPAC =    2.8453"           TORQUE        =       680ft#            |
|MIN. SPAC =    2.8125"           TEMA MAX. SPAC=   15.5500"              |
|FLG TURN  =    0.1875"           FACING        =    RECESS               |
|BPRIME    =    0.0000"           BG1           =    0.0000"              |
|FLG RWT   =      1393Lbs         FLG FWT       =      1100Lbs            |
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|ASME SEC.VIII DIV.1 APPENDIX 2                   Shell to tubesheet flange |
|DESIGN CONDITIONS          GASKET and BOLTING CALCULATIONS   TABLE         |
|Design Pres=  675.0 psig    Eff.Gsk OD=    43.7500"           No.Passes= 1 |
|Neg.   Pres=   15.0 psig    Eff.Gsk ID=    40.0000"           N=  1.875"   |
|Design Temp=    725 deg.F   THK= 0.1250"              col.=2   b=  0.484    |
|Flg  Matl=SA-105/SA-350-LF2 Gsk Matl= GMGC FLEXPRO STYLE PN   y=   2500psi |
|Bolt Matl=SA-193B7      Gsk Face=                w= 0.0000"   m=  2.000    |
|Corr Allow=    0.1250"         Wm2=    181418 #      Am =  47.1602in^2     |
|Flange  Desn Sfo 16000.0 psi   Hp =    175682 #      Ab =  48.3080in^2     |
|        Atm. Sfa 20000.0 psi   H  =    970309 #      W  =  1193352 #       |
|Bolting Desn Sb  24300.0 psi   Wm1=   1145992 #      Wm1=  1145992 #       |
|        Atm. Sa  25000.0 psi    Gasket Width Check  Nmin =    1.7971"      |
|CONDITION    LOAD         x        LEVER ARM   =    MOMENT                 |
|             HD =   858865 #       hD=  2.59375"    MD=   2227682 in#      |
|Operating    HG =   175682 #       hG=  2.17162"    MG=    381515 in#      |
|             HT =   111444 #       hT=  2.80456"    MT=    312553 in#      |
|                                                   Mo=   2921750 in#      |
|Gasket                                                                     |
|Seating      HG =  1193352 #       hG=  2.17162"    mo=   2591511 in#      |
|Allow.Stress-STRESS CALCULATIONS-Operating  |       SHAPE CONSTANTS        |
|1.5 Sfo&2.5 Sno Long Hub,SH   21901.9 psi   |K    = 1.2329 h/ho=  0.2694   |
|    Sfo Radial Flg,SR          3752.6 psi   |T    = 1.8255 F   =  0.8837   |
|    Sfo Tang Flg,ST            9091.1 psi   |Z    = 4.8455 V   =  0.3824   |
|    Sfo .5(SH+SR)or.5(SH+ST)  15496.5 psi   |Y    = 9.3933 f   =  1.2468   |
|    J(APP.2-14)=    0.6291                  |U    =10.3223 e = 0.1313in^-1 |
|Allow.Stress-STRESS CALCULATIONS-Gsk.Seating|g1/go= 1.5000 d = 229.907In^3 |
|1.5 Sfa&2.5 Sna Long Hub,SH   19426.4 psi   |ho   =   6.7291"              |
|    Sfa Radial Flg,SR          3328.5 psi   |                              |
|    Sfa Tang Flg,ST            8063.6 psi   | OTHER STRESS FORMULA FACTORS |
|    Sfa .5(SH+SR)or.5(SH+ST)  13745.0 psi   |    t         5.0000"         |
|    J(APP.2-14)=    0.4772                  |    Alpha     1.6566          |
|                                            |    Beta      1.8755          |
|                                            |    Gamma     0.9075          |
|                                            |    Delta     0.5437          |
|                                            |    Lambda    1.4512          |
|                                            |    M           72590 #       |
|                                            |    m           64385 #       |
|O.D.      =   49.6250"           THK.          =    5.1875"                |
|I.D.      =   40.0000"           T-Adder       =    0.0000"                |
|GO        =    1.2500"           G1            =    1.8125"                |
|HUB O.D.  =   43.6250"           HUB LEN       =    1.8125"                |
|HUB ANG   =   17.2415deg         RIB LENGTH    =    0.0000"                |
|G(MEAN)   =   41.8750"           G(CALC)       =   42.7818"                |
|G(MIN.)   =   41.8750"           G(MAX.)       =   43.3750"                |
|B.C.      =   47.1250"           B.S.C.F.      =    1.0000                 |
|No. BOLTS =   52                 BOLT DIAMETER =    1.2500"                |
|R         =    1.7500"           E             =    1.2500"                |
|BOLT SPAC =    2.8453"           TORQUE        =       680ft#              |
|MIN. SPAC =    2.8125"           TEMA MAX. SPAC=   14.5000"                |
|FLG TURN  =    0.1875"           FACING        =    RECESS                 |
|BPRIME    =    0.0000"           BG1           =    0.0000"                |
|FLG RWT   =      1345Lbs         FLG FWT       =      1049Lbs              |
```

```
          MAIN FLG IS FLANGE MARK # 2    Front Channel to cover flange
          COMP FLG IS FLANGE MARK # 0

CODE 46 MAIN FLG. SET: GASKET WIDTH WILL NOT CONTROL MAWP.

           /// INDIVIDUAL COMPONENTS ///
 MAWP CORR. MAIN FLG         =   536.0 Limited by: Minimum bolting area Am.
 MAWP CORR. COMP FLG         =     0.0
 MAWP CORR. COVER            =   536.0
 MAWP CORR. T.S.[STD DIA]TEMA=     0.0

 MAWP N-C   MAIN FLG         =   536.0 Limited by: Minimum bolting area Am.
 MAWP N-C   COMP FLG         =     0.0
 MAWP N-C   COVER            =   536.0
 MAWP N-C   T.S.[STD DIA]TEMA=     0.0


     /// AS MATING FLANGES (NO VACCUUM INCLUDED) ///
 MAWP CORR. MAIN FLG     =     0.0
 MAWP CORR. COMP FLG     =     0.0

 MAWP N-C   MAIN FLG     =     0.0
 MAWP N-C   COMP FLG     =     0.0

 NOTE: TEMA TUBESHEETS NOT CONSIDERED.
```

```
          MAIN FLG IS FLANGE MARK # 3    Front chan to tubesheet flange
          COMP FLG IS FLANGE MARK # 7    Shell to tubesheet flange

CODE 46 MAIN FLG. SET: GASKET WIDTH WILL NOT CONTROL MAWP.
CODE 46 COMP FLG. SET: GASKET WIDTH WILL NOT CONTROL MAWP.

           /// INDIVIDUAL COMPONENTS ///
 MAWP CORR. MAIN FLG         =   679.0 Limited by: Minimum bolting area Am.
 MAWP CORR. COMP FLG         =   675.0 Limited by: Minimum bolting area Am.
 MAWP CORR. COVER            =     0.0
 MAWP CORR. T.S.[STD DIA]TEMA=     0.0

 MAWP N-C   MAIN FLG         =   698.0 Limited by: Minimum bolting area Am.
 MAWP N-C   COMP FLG         =   714.0 Limited by: Minimum bolting area Am.
 MAWP N-C   COVER            =     0.0
 MAWP N-C   T.S.[STD DIA]TEMA=     0.0


    /// AS MATING FLANGES (NO VACCUUM INCLUDED) ///
 MAWP CORR. MAIN FLG     =   679.0 Limited by: Minimum bolting area Am.
 MAWP CORR. COMP FLG     =   675.0 Limited by: Minimum bolting area Am.

 MAWP N-C   MAIN FLG     =   698.0 Limited by: Minimum bolting area Am.
 MAWP N-C   COMP FLG     =   714.0 Limited by: Minimum bolting area Am.

 NOTE: TEMA TUBESHEETS NOT CONSIDERED.
```

```
                ///// FRONT COVER CALCULATIONS /////

EXCHANGER TYPE....= A E U             MATERIAL..........= SA-516-70N
PRESSURE..........=       525.0 psig  CORROSION ALLOWANCE=      0.1250"
TURN LOW..........=      0.1875"      TURN HIGH.........=      0.2500"
S  COVER STRESS...=     20000.0 psi   E.................=         1.0
Sb  STRESS BOLTS..=     25000.0 psi   Ab................=     34.9440 in^2
d.................=     41.9208"      C.................=      0.3000
W.................=      864312 #     Wm1...............=      855025 #
hG (ASME).........=      1.9771"      hG (TEMA).........=      1.9771"
G (TEMA)..........=     41.9208"      E (MOD.) x (10)-6..=        27.6 psi
COVER THK SET HOLD=     [YES]

[ PER ASME SECT.VIII UG-34 USING Wm1 (OPERATING) ]
              ______________________
             /  C P     1.9 Wm1 hG
THK = d  _  /  ----- + -------------  =     4.2036"
          |/    S E     S   E  d^3

[ PER ASME SECT.VIII UG-34 USING W (GASKET SEATING) ]
              ________________
             /    1.9 W hG
THK = d  _  /   -------------  =     1.9679"
          |/     S   E  d^3

[ PER TEMA RCB-9.2 FLAT CHANNEL COVER ]
MAXIMUM DEFLECTION =   40.0000"       x 0.00125 =    0.0500"
DEFLECTION at     4.2632"       THICK =    0.0500"
                     _                           _
           G        |                             |
Y =   ----------    |0.0435 G^3 P + 0.5 Sb Ab hG | =    0.0483"
   E (    4.312 )^3 |_                           _|

[ COV THK Min ] TEMA Deflection     =    4.2632" +    0.1875" =    4.4507"
[ COV THK Min ] CODE Operating      =    4.2036" +    0.1875" =    4.3911"
[ COV THK Min ] CODE Gasket Seating =    1.9679" +    0.1875" =    2.1554"
ACTUAL COVER THICKNESS USED (SET HOLD[YES])=    4.5000"
```

***** TUBE CALCULATIONS *****

```
Tube size........=       1.00000"     Straight or U-Tube.= U-Tube
Internal Press...=     540.00000psig  External press.....=     690.00000psig
Temperature used.=     725.00000deg.  Tube Matl MT# 61...= SA-214
Stress Oper......=    9800.00000psi   Stress Atm.........=   11400.00000psi
Yield............=   18300.00000psi   Inside Radius......=       0.39100"
Joint Eff........=       1.00000      Mill tol...= 0.00% =       0.00000"
Wall Thk. t......=       0.10900"     Tube gauge.........= 12 BWG Gauge
Mean Rad., R.....=       1.50000"     Tube Length........=     240.00000"
Corrosion ID.....=       0.00000"     Corrosion OD.......=       0.00000"
Thinning factor..=       1.16667

tr = PR/SE - .6P =       0.02228"     (tr*TF)+MT+CA......=       0.02600"

MAWP Internal H/C=    2048.06030psig  MAWP Internal N/C..=    2382.43750psig
MAWP External H/C=    1173.06738psig  MAWP External N/C..=    1719.08594psig
```

/// TEMA PASS PLATE CALCULATIONS ///
Per RCB-9.132

$$t = b\sqrt{\frac{q\,B}{1.5\,S}}$$

```
TUBE SIDE PRESSURE DROP   q =  15.00000

FRONT PASS PLATE THK....... =   0.62500
MATERIAL................... = SA-36
STRESS OPER................ =  16600.00
FRONT Chan ID.............. =  40.00000
FRONT Chan OAL............. =  42.12500
a.......................... =  40.00000
b.......................... =  37.93750
TABLE RCB-9.132............ = Short sides fixed
a/b........................ =   1.05437
B.......................... =   0.44609
t.......................... =   0.62191
Min fillet leg [both sides] = 3/4t = .75 x 0.62191 = 0.46643
```

```
         **** PRESSURE/TEMPERATURE RATING **** ASME B16.5 2009


---- SHELL NOZZLES -----------------DESIGN PRESS=  675.0 DESIGN TEMP=  725.0
NOZ#S1     12.0- 600#  MT# FLG=  70 GROUP=1.1  @70deg.=1480.00 @TEMP=1037.50
NOZ#S2      6.0- 600#  MT# FLG=  70 GROUP=1.1  @70deg.=1480.00 @TEMP=1037.50

---- FRONT CHANNEL NOZZLES ---------DESIGN PRESS=  525.0 DESIGN TEMP=  425.0
NOZ#T1     10.0- 300#  MT# FLG=  70 GROUP=1.1  @70deg.= 740.00 @TEMP= 627.50
NOZ#T2     14.0- 300#  MT# FLG=  70 GROUP=1.1  @70deg.= 740.00 @TEMP= 627.50

---- REAR CHANNEL/COVER NOZZLES ----DESIGN PRESS=  525.0 DESIGN TEMP=  425.0
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO=S1     12.00"    600 LB RF  WN
[INLET   ] SHELL SIDE
PRESSURE =  675.0psig   TEMP =  725.0deg.F

-------CYLINDER------------------------NOZZLE-------
SA-516-70N                      SA-106B
OPER STRS=   16450.0 psi        OPER STRS=   14300.0 psi
ATM STRS =   20000.0 psi        ATM STRS =   17100.0 psi
C.A.     =   0.12500"           C.A.     =   0.12500"
I.D.     =  40.00000"           I.D.     =  11.37400"
O.D.     =  42.50000"           O.D.     =  12.75000"
THK.     =   1.25000"           THK. sc80=   0.68800"
T        =   1.12500"           TN       =   0.56300"
TR       =   0.84664"           TRN      =   0.29534"
ET       =   0.27836"           ETN      =   0.26766"

MIN STD. WT. PIPE+C.A.=  0.45312"   TR+C.A.=  0.97164"
LIMITS=  23.24800"
fr1= 0.8693 fr2= 0.8693 fr3= 0.8693 fr4= 1.0000     F=   1.00000
Min weld sizes:NS=  0.0000" NP=  0.3536" PS=  0.5303" IF=  0.0000"

AREA REQD.               A =   9.96597in^2
EXCESS IN CYL.           A1=   3.19467in^2
EXCESS IN NOZ.(OUTSIDE) A2=   1.12033in^2  H =   2.40750"
AREA OF FILLETS            =   0.68475in^2
AREA AVAILABLE             =   4.99974in^2

NOZ. NECK WELD= 0.37500"  AREA=   0.12225in^2

PAD MATL.= SA-516-70N     S=  16450.psi
PAD O.D.=  18.50000"    THK.=   1.00000"    AREA=   5.75000in^2
PAD TO CYL. WELD=   0.75000"    AREA=   0.56250in^2
ARC=  12.949"
PAD RET. DIM.=  18.500"  X   18.750"

< AREA REQD-AREA AVAILABLE >  =   -0.78378in^2

MAWP N-C=   940.0psig  LIMITED BY AR
MAWP COR=   699.0psig  LIMITED BY AR

All Weld Paths are stronger than the required strength /[UG-41 UG-45 UW-15]
```

NOZZLE ATTACHMENT WELD LOADS AND WELD STRENGTH PATHS: UG41 UG45 UW15

```
NOZ NO= S1     12.00"    600 LB RF  WN

FR1   =   0.86930  S_SHL =  16450.00  S_NOZ =  14300.00  A     =   9.96597
A1    =   7.54639  T_NOZ =   0.68800  C_NOZ =   0.12500  OD_NOZ=  12.75000
T_SHL =   1.25000  Tmin  =   0.84664  C_SHL =   0.12500  F     =   1.00000
A2    =   1.12033  A5    =   5.75000  A41   =   0.12225  A42   =   0.56250
A43   =   0.00000  E1    =   1.00000  PAD TK=   1.00000

----------------- Load to be carried by welds per UG41(b)(2) ---------------
W    = [A - A1 + 2 tn fr1 (E1 t - F tr)] Sv                      = 115869.98

----------------- Load to be carried by welds per UG41(b)(1) ---------------
W1-1 = (A2 + A5 + A41 + A42) Sv                                  = 124281.06
W2-2 = (A2 + A3 + A41 + A43 + 2 tn t fr1) Sv                     =  38554.96
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 tn t fr1) Sv          = 142395.58

-------------------------------- Unit stresses -----------------------------
Groove weld pad to nozzle =  10582.00 Fillet at pad OD           =   8060.50
Ext. fillet at nozzle     =   7007.00 Groove weld comp. to nozzle=  10582.00
Nozzle wall shear         =  10010.00 Int. fillet at nozzle      =   7007.00

----------------------- Strength of connection elements --------------------
Groove weld pad to nozzle = 211932.45 Fillet at pad OD           = 175676.83
Ext. fillet at nozzle     =  52625.12 Groove weld comp. to nozzle= 238424.02
Nozzle wall shear         = 107884.45 Int. fillet at nozzle      =      0.00

---------------------------- Check Strength Paths --------------------------
Str. thru path 1-1 must be >= the lesser of W or W1-1 per UG-41(b)
Str. thru path 2-2 must be >= the lesser of W or W2-2 per UG-41(b)
Str. thru path 3-3 must be >= the lesser of W or W3-3 per UG-41(b)
Str. thru path 1-1 ( 107884.4 + 175676.8)                        = 283561.28
Str. thru path 2-2 (  52625.1 + 238424.0 + 211932.5 +      0.0)  = 502981.59
Str. thru path 3-3 ( 175676.8 + 211932.5)                        = 387609.28
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO=S2      6.00"    600 LB RF  WN
[OUTLET  ] SHELL SIDE
PRESSURE =  675.0psig   TEMP =  725.0deg.F

-------CYLINDER------------------------NOZZLE-------
SA-516-70N                    SA-106B
OPER STRS=   16450.0 psi        OPER STRS=   14300.0 psi
ATM STRS =   20000.0 psi        ATM STRS =   17100.0 psi
C.A.     =   0.12500"           C.A.     =   0.12500"
I.D.     =  40.00000"           I.D.     =   5.76100"
O.D.     =  42.50000"           O.D.     =   6.62500"
THK.     =   1.25000"           THK.   XH=   0.43200"
T        =   1.12500"           TN       =   0.30700"
TR       =   0.84664"           TRN      =   0.15346"
ET       =   0.27836"           ETN      =   0.15354"

MIN STD. WT. PIPE+C.A.=  0.37000"   TR+C.A.=  0.97164"
LIMITS=  12.02200"
fr1= 0.8693 fr2= 0.8693 fr3= 0.8693 fr4= 1.0000     F=   1.00000
Min weld sizes:NS=  0.0000" NP=  0.3039" PS=  0.5303" IF=  0.0000"

AREA REQD.               A =   5.15711in^2
EXCESS IN CYL.           A1=   1.65087in^2
EXCESS IN NOZ.(OUTSIDE) A2=   0.43845in^2  H =   1.64250"
AREA OF FILLETS            =   0.59490in^2
AREA AVAILABLE             =   2.68422in^2

NOZ. NECK WELD= 0.37500"  AREA=   0.12225in^2

PAD MATL.= SA-516-70N     S=  16450.psi
PAD O.D.=   9.62500"    THK.=   0.87500"    AREA=   2.62500in^2
PAD TO CYL. WELD=   0.68750"    AREA=   0.47266in^2
ARC=   6.652"
PAD RET. DIM.=   9.625"  X    9.688"

< AREA REQD-AREA AVAILABLE >  =   -0.15211in^2

MAWP N-C=   937.0psig  LIMITED BY AR
MAWP COR=   684.0psig  LIMITED BY AR

All Weld Paths are stronger than the required strength /[UG-41 UG-45 UW-15]
```

NOZZLE ATTACHMENT WELD LOADS AND WELD STRENGTH PATHS: UG41 UG45 UW15

```
NOZ NO= S2      6.00"    600 LB RF  WN

FR1   =   0.86930  S_SHL =  16450.00  S_NOZ =  14300.00  A     =   5.15711
A1    =   3.48986  T_NOZ =   0.43200  C_NOZ =   0.12500  OD_NOZ=   6.62500
T_SHL =   1.25000  Tmin  =   0.84664  C_SHL =   0.12500  F     =   1.00000
A2    =   0.43845  A5    =   2.62500  A41   =   0.12225  A42   =   0.47266
A43   =   0.00000  E1    =   1.00000  PAD TK=   0.87500

----------------- Load to be carried by welds per UG41(b)(2) ---------------
W    = [A - A1 + 2 tn fr1 (E1 t - F tr)] Sv                        =  60121.66

----------------- Load to be carried by welds per UG41(b)(1) ---------------
W1-1 = (A2 + A5 + A41 + A42) Sv                                    =  60179.92
W2-2 = (A2 + A3 + A41 + A43 + 2 tn t fr1) Sv                       =  19101.20
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 tn t fr1) Sv            =  70057.65

--------------------------------- Unit stresses -----------------------------
Groove weld pad to nozzle =  10582.00 Fillet at pad OD             =   8060.50
Ext. fillet at nozzle     =   7007.00 Groove weld comp. to nozzle=  10582.00
Nozzle wall shear         =  10010.00 Int. fillet at nozzle        =   7007.00

----------------------- Strength of connection elements --------------------
Groove weld pad to nozzle =  96356.55 Fillet at pad OD             =  83782.81
Ext. fillet at nozzle     =  27344.43 Groove weld comp. to nozzle= 123886.98
Nozzle wall shear         =  30498.02 Int. fillet at nozzle        =      0.00

---------------------------- Check Strength Paths --------------------------
Str. thru path 1-1 must be >= the lesser of W or W1-1 per UG-41(b)
Str. thru path 2-2 must be >= the lesser of W or W2-2 per UG-41(b)
Str. thru path 3-3 must be >= the lesser of W or W3-3 per UG-41(b)
Str. thru path 1-1 (  30498.0 +  83782.8)                          = 114280.83
Str. thru path 2-2 (  27344.4 + 123887.0 +  96356.5 +      0.0)  = 247587.95
Str. thru path 3-3 (  83782.8 +  96356.5)                          = 180139.36
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO= S3      1.00"    600 LB RF  WN
[VENT    ] SHELL SIDE
PRESSURE =  675.0psig   TEMP =  725.0deg.F

-------CYLINDER------------------------NOZZLE-------
SA-516-70N                      SA-106B
OPER STRS=   16450.0 psi        OPER STRS=   14300.0 psi
ATM STRS =   20000.0 psi        ATM STRS =   17100.0 psi
C.A.     =   0.12500"           C.A.     =   0.12500"
I.D.     =  40.00000"           I.D.     =   0.59900"
O.D.     =  42.50000"           O.D.     =   1.31500"
THK.     =   1.25000"           THK.     =   0.35800"
T        =   1.12500"           TN       =   0.23300"
TR       =   0.84664"           TRN      =   0.03046"
ET       =   0.27836"           ETN      =   0.20254"

MIN STD. WT. PIPE+C.A.=  0.24137"   TR+C.A.=  0.97164"
LIMITS=   3.56500"
fr1= 0.8693 fr2= 0.8693 fr3= 0.0000 fr4= 0.0000     F=   1.00000
Min weld sizes:NS=  0.2307" NP=  0.0000" PS=  0.0000" IF=  0.0000"

NOZ. NECK WELD= 0.37500"


MAWP N-C=  1137.0psig  LIMITED BY AR
MAWP COR=   738.0psig  LIMITED BY AR

Note:  Taking a UG-36(c)(3)(a) exemption for nozzle S3.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36.
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO=T1     10.00"    300 LB RF  WN
[INLET   ] FRONT CHANNEL SIDE
PRESSURE =  525.0psig   TEMP =  425.0deg.F

-------CYLINDER------------------------NOZZLE-------
SA-516-70                       SA-106B
OPER STRS=   20000.0 psi        OPER STRS=   17100.0 psi
ATM STRS =   20000.0 psi        ATM STRS =   17100.0 psi
C.A.     =   0.12500"           C.A.     =   0.12500"
I.D.     =  40.00000"           I.D.     =   9.06200"
O.D.     =  42.00000"           O.D.     =  10.75000"
THK.     =   1.00000"           THK.sc120=   0.84400"
T        =   0.87500"           TN       =   0.71900"
TR       =   0.53673"           TRN      =   0.16302"
ET       =   0.33827"           ETN      =   0.55598"

MIN STD. WT. PIPE+C.A.=  0.44438"   TR+C.A.=  0.66173"
LIMITS=  18.62400"
fr1= 0.8550 fr2= 0.8550 fr3= 0.0000 fr4= 0.0000     F=   1.00000
Min weld sizes:NS=  0.3536" NP=  0.0000" PS=  0.0000" IF=  0.0000"

AREA REQD.               A =   5.10999in^2
EXCESS IN CYL.           A1=   3.07939in^2
EXCESS IN NOZ.(OUTSIDE) A2=   1.70893in^2  H =   1.79750"
AREA OF FILLETS            =   0.85500in^2
AREA AVAILABLE             =   5.64332in^2

NOZ. NECK WELD= 1.00000"  AREA=   0.85500in^2

< AREA REQD-AREA AVAILABLE >  =   -0.53333in^2

MAWP N-C=   648.0psig  LIMITED BY AR
MAWP COR=   551.0psig  LIMITED BY AR
```

NOZZLE ATTACHMENT WELD LOADS AND WELD STRENGTH PATHS: UG41 UG45 UW15

```
NOZ NO=T1     10.00"    300 LB RF  WN

FR1   =   0.85500  S_SHL =  20000.00  S_NOZ =  17100.00  A     =   5.33944
A1    =   4.34680  T_NOZ =   0.59400  C_NOZ =   0.12500  OD_NOZ=  10.75000
T_SHL =   0.75000  Tmin  =   0.53673  C_SHL =   0.12500  F     =   1.00000
A2    =   0.81754  A5    =   3.65625  A41   =   0.12023  A42   =   0.31641
A43   =   0.00000  E1    =   1.00000  PAD TK=   0.75000

----------------- Load to be carried by welds per UG41(b)(2) ---------------
W    = [A - A1 + 2 tn fr1 (E1 t - F tr)] Sv                      =  91123.57

----------------- Load to be carried by welds per UG41(b)(1) ---------------
W1-1 = (A2 + A5 + A41 + A42) Sv                                  =  98208.62
W2-2 = (A2 + A3 + A41 + A43 + 2 tn t fr1) Sv                     =  28780.37
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 tn t fr1) Sv          = 108233.50

-------------------------------- Unit stresses -----------------------------
Groove weld pad to nozzle =  12654.00 Fillet at pad OD           =   9800.00
Ext. fillet at nozzle     =   8379.00 Groove weld comp. to nozzle=  12654.00
Nozzle wall shear         =  11970.00 Int. fillet at nozzle      =   8379.00

----------------------- Strength of connection elements --------------------
Groove weld pad to nozzle = 160257.03 Fillet at pad OD           = 135297.00
Ext. fillet at nozzle     =  53058.07 Groove weld comp. to nozzle= 133547.52
Nozzle wall shear         =  90661.28 Int. fillet at nozzle      =      0.00

---------------------------- Check Strength Paths --------------------------
Str. thru path 1-1 must be >= the lesser of W or W1-1 per UG-41(b)
Str. thru path 2-2 must be >= the lesser of W or W2-2 per UG-41(b)
Str. thru path 3-3 must be >= the lesser of W or W3-3 per UG-41(b)
Str. thru path 1-1 (  90661.3 + 135297.0)                        = 225958.28
Str. thru path 2-2 (  53058.1 + 133547.5 + 160257.0 +      0.0)  = 346862.62
Str. thru path 3-3 ( 133547.5 + 135297.0)                        = 268844.50
```

```
NOZZLE REINFORCEMENT CALCULATIONS/ ASME SEC.VIII DIV.I UG-37 & UG-16
NOZ NO=T2     14.00"    300 LB RF  WN
[OUTLET  ] FRONT CHANNEL SIDE
PRESSURE =  525.0psig   TEMP =  425.0deg.F

-------CYLINDER------------------------NOZZLE-------
SA-516-70                      SA-106B
OPER STRS=   20000.0 psi        OPER STRS=   17100.0 psi
ATM STRS =   20000.0 psi        ATM STRS =   17100.0 psi
C.A.     =   0.12500"           C.A.     =   0.12500"
I.D.     =  40.00000"           I.D.     =  12.12400"
O.D.     =  42.00000"           O.D.     =  14.00000"
THK.     =   1.00000"           THK.sc100=   0.93800"
T        =   0.87500"           TN       =   0.81300"
TR       =   0.53673"           TRN      =   0.21231"
ET       =   0.33827"           ETN      =   0.60070"

MIN STD. WT. PIPE+C.A.=  0.45312"   TR+C.A.=  0.66173"
LIMITS=  24.74800"
fr1= 0.8550 fr2= 0.8550 fr3= 0.0000 fr4= 0.0000     F=   1.00000
Min weld sizes:NS=  0.3536" NP=  0.0000" PS=  0.0000" IF=  0.0000"

AREA REQD.               A =   6.76810in^2
EXCESS IN CYL.           A1=   4.10594in^2
EXCESS IN NOZ.(OUTSIDE) A2=   2.08776in^2  H =   2.03250"
AREA OF FILLETS            =   0.85500in^2
AREA AVAILABLE             =   7.04870in^2

NOZ. NECK WELD= 1.00000"  AREA=   0.85500in^2

< AREA REQD-AREA AVAILABLE >  =   -0.28060in^2

MAWP N-C=   625.0psig  LIMITED BY AR
MAWP COR=   535.0psig  LIMITED BY AR
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NOZZLE ATTACHMENT WELD LOADS AND WELD STRENGTH PATHS: UG41 UG45 UW15

```
NOZ NO=T2     14.00"    300 LB RF  WN

FR1   =   0.85500  S_SHL =  20000.00  S_NOZ =  17100.00  A     =   6.94065
A1    =   5.62934  T_NOZ =   0.75000  C_NOZ =   0.12500  OD_NOZ=  14.00000
T_SHL =   0.75000  Tmin  =   0.53673  C_SHL =   0.12500  F     =   1.00000
A2    =   1.10267  A5    =   4.78125  A41   =   0.12023  A42   =   0.31641
A43   =   0.00000  E1    =   1.00000  PAD TK=   0.75000

----------------- Load to be carried by welds per UG41(b)(2) ---------------
W    = [A - A1 + 2 tn fr1 (E1 t - F tr)] Sv                       = 118512.05

----------------- Load to be carried by welds per UG41(b)(1) ---------------
W1-1 = (A2 + A5 + A41 + A42) Sv                                   = 126411.20
W2-2 = (A2 + A3 + A41 + A43 + 2 tn t fr1) Sv                      =  37817.45
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 tn t fr1) Sv           = 139770.58

-------------------------------- Unit stresses -----------------------------
Groove weld pad to nozzle =  12654.00 Fillet at pad OD           =   9800.00
Ext. fillet at nozzle     =   8379.00 Groove weld comp. to nozzle=  12654.00
Nozzle wall shear         =  11970.00 Int. fillet at nozzle      =   8379.00

----------------------- Strength of connection elements --------------------
Groove weld pad to nozzle = 208706.83 Fillet at pad OD           = 176427.28
Ext. fillet at nozzle     =  69098.88 Groove weld comp. to nozzle= 173922.36
Nozzle wall shear         = 157176.45 Int. fillet at nozzle      =      0.00

---------------------------- Check Strength Paths --------------------------
Str. thru path 1-1 must be >= the lesser of W or W1-1 per UG-41(b)
Str. thru path 2-2 must be >= the lesser of W or W2-2 per UG-41(b)
Str. thru path 3-3 must be >= the lesser of W or W3-3 per UG-41(b)
Str. thru path 1-1 ( 157176.5 + 176427.3)                         = 333603.75
Str. thru path 2-2 (  69098.9 + 173922.4 + 208706.8 +      0.0)  = 451728.06
Str. thru path 3-3 ( 173922.4 + 176427.3)                         = 350349.62
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ASME SEC.VIII DIV.1 UHX-12

```
(U-Tube)  Configuration d
No or EPC=Elastic-Plastic Calcs SSC=Simply Supported Calcs       =NO
MT Tubes                  =SA-214       MT Tubesheets            =SA-350LF2CL1
MT Channel                =SA-516-70    MT Shell                 =SA-516-70N
Diameter (Do)             =  39.5000"   Pass Lane Area (AL)      =  139.654in^2
Perimeter of layout (CP)  = 124.0928"   Area enclosed by CP (AP) = 1225.417in^2
Tubesheet thickness (h)   =   6.2500"   Tubesheet thickness HOLD =   YES
Tube Pitch (p)            =   1.2500"   Pitch type =  Rot Square   (45 Deg)
Diameter of tube (dt)     =   1.0000"   Tube thickness (tt)      =   0.1090"
Exp length of tube (ltx)  =   6.0000"   Exp depth ratio (Rho)    =   0.9792
Groove channel side (hg)  =   0.1875"   Groove shell side        =   0.0000"
Channel I.D. (Dc)         =  40.0000"   Channel thickness (Tc)   =   1.0000"
Shell I.D. (Ds)           =  40.0000"   Shell thickness (Ts)     =   1.2500"
Stat TS diameter (A)      =  39.8750"   Bolt circle (C)          =  47.1250"
G Channel side (Gc or G1) =  42.7817"   G Shell side (Gs or G1)  =  42.7817"
Bolt load Chan side (Wc)  =1193352.1#   Bolt load Sh side (Ws)   =1193352.1#
1.8*Sqrt(Dc*Tc)           =   0.0000"   1.8*Sqrt(Ds*(Ts or Ts1)) =   0.0000"
Thickness at Top TS (tr)  =   5.1250"   Outer Tube Circle        =  39.5000"
hr Ch Wm1                 =1145992.#    hr Ch W                  =1193352.1#
hr Sh Wm1                 =1145992.#    hr Sh W                  =1193352.1#
hr Ch Op=  2.6283"  Ch Atm=  2.3989"    Sh Op=  2.6283"   Sh Atm =   2.3989"
DE Stationary Tubesheet   =     0.0"    DE Floating Tubesheet    =      0.0"
Tubes welded Backside TS  =NO           Hole Size in Tubesheet   =   0.0000"
Tube Joint=  Full Strength Welds Per FIG. UW-20.1(c)

Design Press Chan (Pt)    =    525.0psigDesign Press Shell (Ps)  =    675.0psig
Design Temp  Chan         =    425.0deg.Design Temp  Shell       =    725.0deg.
Corr Chan                 =  0.12500"   Corr Shell               =  0.12500"
Corr Chan side TS (ct)    =  0.12500"   Corr Shell side TS (cs)  =  0.12500"
```

```
(U-Tube)  Configuration d
Tubesheet Thickness (h)   =   6.0000"
Exp length of tube (ltx)  =   5.8750"      Exp depth ratio (Rho)    =   0.9792"
Channel I.D. (Dc)         =  40.2500"      Channel thickness (Tc)   =   0.8750"
Shell I.D. (Ds)           =  40.2500"      Shell thickness (Ts)     =   1.1250"
Perimeter of layout (CP)  = 124.0928"      Area enclosed by CP (AP) = 1225.417in^2
Press Chan (Pt)           =    525.0psi    Press Shell (Ps)         =    -15.0psi
Corr Chan                 =  0.12500"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)    =  0.12500"      Corr Shell side TS (cs)  =  0.12500"
_________________________________________________________________________________________________
           Temp          Stress          Yield            Modulus  Coef   Poisson   Prim Plus
                                                          x10^6    x10^-6 Ratio     Stress
_________________________________________________________________________________________________
Temp TS  T = 725deg.F S  = 16450psi   Sy =      0psi   E  =24.9750psi   V =.000 Sps =      0psi
Temp TBS Tt= 725deg.F St = 11529psi   Syt=      0psi   Et =24.9750psi   Vt=.000
Temp TBS T = 725deg.F St = 11529psi                    Et =24.9750psi
Temp CH  Tc= 425deg.F Sc = 20000psi   Syc=  32125psi   Ec =27.5500psi   Vc=.300 Spsc=  64250psi
Temp SH  Ts= 725deg.F Ss = 16450psi   Sys=  26750psi   Es =24.9750psi   Vs=.300 Spss=  53500psi

Mu=0.2000 d*=0.8504"    P*=1.32796"    Mu*=0.3596 hg'=0.0625"    hgs'=   0.0"    hrDE=   0.0"
W*       = 1145992.000#        Rho s   = 1.083082318
Rho c    = 1.083082318         Mts      =-9507.136719In-Lb/In h/p     = 4.800000191
E*       = 10252286.00psi      v*       = 0.320897967         Beta s  =         0.0in^-1
Kappa s  =         0.0#        Lambda s =         0.0psi      Delta s =         0.0In^3/Lb
Delta c  =         0.0In^3/Lb  Beta c   =         0.0in^-1    Kappa c =         0.0#
Lambda c =         0.0psi      Omega s  =         0.0in^2     Omega c =         0.0in^2
K        = 1.009493709         F        = 0.015631560         M*      =-9507.136719In-Lb/In
Mp       =-8955.580078In-Lb/In Mo       =-52673.90625In-Lb/In M       = 52673.90625In-Lb/In
Sigma s,m=         0.0psi      Sigma s,b=         0.0psi      Sigma s =         0.0psi
Sigma c,m=         0.0psi      Sigma c,b=         0.0psi      Sigma c =         0.0psi
Sigma     |  24928 psi  | <= 2S      32900 psi   [OK                 ]
Tau       |   4443 psi  | <= .8S     13160 psi   [OK                 ]
```

```
Tube Joint=     Full Strength Welds Per FIG. UW-20.1(c)

Tube O.D. do .............................................................=1.000000"
Tube Thickness t .........................................................=0.109000"
Stress Tubes Sa ..........................................................=11529.41psi
St = Stress Tubesheet or Base if Clad ....................................=16450.00psi
Sw = Stress Weld = Lesser of Sa or St ....................................=11529.41psi
fw = Weld strength factor = Sa/Sw ........................................=1.000000
af = Fillet Weld leg .....................................................=0.120000"
ag = Groove Weld leg .....................................................=0.120000"
ac = Length of the combined weld legs = af + ag ..........................=0.240000"
Weld throat ..............................................................=0.084853"
Ft = Axial tube strength = Phi*t*(do-t)*Sa ...............................=3517.719#
Fd = Design strength, but not greater than Ft ............................=3517.719#
fd = Ratio of design strength to tube strength
fd = 1.0 for Full strength welds
fd = Fd/Ft for Partial strength welds ....................................=1.000000
Fg = Groove weld strength, but not > Ft, = 0.85*Phi*ag*(do+0.67*ag)Sw .......=3517.719#
Ff = Fillet weld strength, but not > Ft, = 0.55*Phi*af*(do+0.67*af)Sw .......=2582.769#
ff = Ratio of fillet weld strength to design strength = 1.0-Fg/(fd*Ft) ......=     0.0
ar = 2.0*[Sqrt((0.75*do)^2+1.07*t*(do-t)fw*fd) -0.75*do] ...................=0.132688"
Lmax = Ft ................................................................=3517.719#

--- Weld Size Check ---
ac shall not be less than the greater of [ar or t]   0.240"       >= 0.133"
```

```
(U-Tube)  Configuration d
Tubesheet Thickness (h)   =   6.0000"
Exp length of tube (ltx)  =   5.8750"      Exp depth ratio (Rho)    =   0.9792"
Channel I.D. (Dc)         =  40.2500"      Channel thickness (Tc)   =   0.8750"
Shell I.D. (Ds)           =  40.2500"      Shell thickness (Ts)     =   1.1250"
Perimeter of layout (CP)  = 124.0928"      Area enclosed by CP (AP) = 1225.417in^2
Press Chan (Pt)           =    -15.0psi    Press Shell (Ps)         =    675.0psi
Corr Chan                 =  0.12500"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)    =  0.12500"      Corr Shell side TS (cs)  =  0.12500"
```

```
           Temp          Stress          Yield            Modulus  Coef   Poisson   Prim Plus
                                                          x10^6    x10^-6 Ratio     Stress
Temp TS  T = 725deg.F S  = 16450psi   Sy =      0psi   E  =24.9750psi   V =.000 Sps =      0psi
Temp TBS Tt= 725deg.F St = 11529psi   Syt=      0psi   Et =24.9750psi   Vt=.000
Temp TBS T = 725deg.F St = 11529psi                    Et =24.9750psi
Temp CH  Tc= 425deg.F Sc = 20000psi   Syc=  32125psi   Ec =27.5500psi   Vc=.300 Spsc=  64250psi
Temp SH  Ts= 725deg.F Ss = 16450psi   Sys=  26750psi   Es =24.9750psi   Vs=.300 Spss=  53500psi
```

```
Mu=0.2000 d*=0.8504"    P*=1.32796"    Mu*=0.3596 hg'=0.0625"    hgs'=   0.0"    hrDE=   0.0"
W*       = 1145992.000#        Rho s   = 1.083082318
Rho c    = 1.083082318         Mts      = 12148.00879In-Lb/In h/p     = 4.800000191
E*       = 10252286.00psi      v*       = 0.320897967         Beta s  =         0.0in^-1
Kappa s  =         0.0#        Lambda s =         0.0psi      Delta s =         0.0In^3/Lb
Delta c  =         0.0In^3/Lb  Beta c   =         0.0in^-1    Kappa c =         0.0#
Lambda c =         0.0psi      Omega s  =         0.0in^2     Omega c =         0.0in^2
K        = 1.009493709         F        = 0.015631560         M*      = 12148.00879In-Lb/In
Mp       = 11443.24219In-Lb/In Mo       = 67305.54688In-Lb/In M       = 67305.54688In-Lb/In
Sigma s,m=         0.0psi      Sigma s,b=         0.0psi      Sigma s =         0.0psi
Sigma c,m=         0.0psi      Sigma c,b=         0.0psi      Sigma c =         0.0psi
Sigma     |  31852 psi  | <= 2S      32900 psi   [OK                ]
Tau       |   5678 psi  | <= .8S     13160 psi   [OK                ]
```

```
Tube Joint=     Full Strength Welds Per FIG. UW-20.1(c)

Tube O.D. do .................................................................=1.000000"
Tube Thickness t .............................................................=0.109000"
Stress Tubes Sa ..............................................................=11529.41psi
St = Stress Tubesheet or Base if Clad ........................................=16450.00psi
Sw = Stress Weld = Lesser of Sa or St ........................................=11529.41psi
fw = Weld strength factor = Sa/Sw ............................................=1.000000
af = Fillet Weld leg .........................................................=0.120000"
ag = Groove Weld leg .........................................................=0.120000"
ac = Length of the combined weld legs = af + ag ..............................=0.240000"
Weld throat ..................................................................=0.084853"
Ft = Axial tube strength = Phi*t*(do-t)*Sa ...................................=3517.719#
Fd = Design strength, but not greater than Ft ................................=3517.719#
fd = Ratio of design strength to tube strength
fd = 1.0 for Full strength welds
fd = Fd/Ft for Partial strength welds ........................................=1.000000
Fg = Groove weld strength, but not > Ft, = 0.85*Phi*ag*(do+0.67*ag)Sw .......=3517.719#
Ff = Fillet weld strength, but not > Ft, = 0.55*Phi*af*(do+0.67*af)Sw .......=2582.769#
ff = Ratio of fillet weld strength to design strength = 1.0-Fg/(fd*Ft) ......=     0.0
ar = 2.0*[Sqrt((0.75*do)^2+1.07*t*(do-t)fw*fd) -0.75*do] ....................=0.132688"
Lmax = Ft ....................................................................=3517.719#

--- Weld Size Check ---
ac shall not be less than the greater of [ar or t]   0.240"       >= 0.133"
```

```
(U-Tube)  Configuration d
Tubesheet Thickness (h)   =   6.0000"
Exp length of tube (ltx)  =   5.8750"      Exp depth ratio (Rho)    =   0.9792"
Channel I.D. (Dc)         =  40.2500"      Channel thickness (Tc)   =   0.8750"
Shell I.D. (Ds)           =  40.2500"      Shell thickness (Ts)     =   1.1250"
Perimeter of layout (CP)  = 124.0928"      Area enclosed by CP (AP) = 1225.417in^2
Press Chan (Pt)           =    525.0psi    Press Shell (Ps)         =    675.0psi
Corr Chan                 =  0.12500"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)    =  0.12500"      Corr Shell side TS (cs)  =  0.12500"
_______________________________________________________________________________________________
           Temp          Stress          Yield            Modulus  Coef    Poisson   Prim Plus
                                                          x10^6    x10^-6 Ratio     Stress
_______________________________________________________________________________________________
Temp TS  T = 725deg.F S  = 16450psi   Sy =      0psi   E  =24.9750psi   V =.000 Sps =      0psi
Temp TBS Tt= 725deg.F St = 11529psi   Syt=      0psi   Et =24.9750psi   Vt=.000
Temp TBS T = 725deg.F St = 11529psi                    Et =24.9750psi
Temp CH  Tc= 425deg.F Sc = 20000psi   Syc=  32125psi   Ec =27.5500psi   Vc=.300 Spsc=  64250psi
Temp SH  Ts= 725deg.F Ss = 16450psi   Sys=  26750psi   Es =24.9750psi   Vs=.300 Spss=  53500psi

Mu=0.2000 d*=0.8504"    P*=1.32796"    Mu*=0.3596 hg'=0.0625"    hgs'=   0.0"    hrDE=   0.0"
W*       = 1145992.000#        Rho s   = 1.083082318
Rho c    = 1.083082318         Mts      = 2640.871338In-Lb/In h/p     = 4.800000191
E*       = 10252286.00psi      v*       = 0.320897967         Beta s  =         0.0in^-1
Kappa s  =         0.0#        Lambda s =         0.0psi      Delta s =         0.0In^3/Lb
Delta c  =         0.0In^3/Lb  Beta c   =         0.0in^-1    Kappa c =         0.0#
Lambda c =         0.0psi      Omega s  =         0.0in^2     Omega c =         0.0in^2
K        = 1.009493709         F        = 0.015631560         M*      = 2640.871338In-Lb/In
Mp       = 2487.661133In-Lb/In Mo       = 14631.64062In-Lb/In M       = 14631.64062In-Lb/In
Sigma s,m=         0.0psi      Sigma s,b=         0.0psi      Sigma s =         0.0psi
Sigma c,m=         0.0psi      Sigma c,b=         0.0psi      Sigma c =         0.0psi
Sigma     |   6924 psi  | <= 2S      32900 psi   [OK                ]
Tau       |   1234 psi  | <= .8S     13160 psi   [OK                ]
```

Tube Joint= Full Strength Welds Per FIG. UW-20.1(c)

```
Tube O.D. do ...............................................................=1.000000"
Tube Thickness t ...........................................................=0.109000"
Stress Tubes Sa ............................................................=11529.41psi
St = Stress Tubesheet or Base if Clad ......................................=16450.00psi
Sw = Stress Weld = Lesser of Sa or St ......................................=11529.41psi
fw = Weld strength factor = Sa/Sw ..........................................=1.000000
af = Fillet Weld leg .......................................................=0.120000"
ag = Groove Weld leg .......................................................=0.120000"
ac = Length of the combined weld legs = af + ag ............................=0.240000"
Weld throat ................................................................=0.084853"
Ft = Axial tube strength = Phi*t*(do-t)*Sa .................................=3517.719#
Fd = Design strength, but not greater than Ft ..............................=3517.719#
fd = Ratio of design strength to tube strength
fd = 1.0 for Full strength welds
fd = Fd/Ft for Partial strength welds ......................................=1.000000
Fg = Groove weld strength, but not > Ft, = 0.85*Phi*ag*(do+0.67*ag)Sw .......=3517.719#
Ff = Fillet weld strength, but not > Ft, = 0.55*Phi*af*(do+0.67*af)Sw .......=2582.769#
ff = Ratio of fillet weld strength to design strength = 1.0-Fg/(fd*Ft) ......=     0.0
ar = 2.0*[Sqrt((0.75*do)^2+1.07*t*(do-t)fw*fd) -0.75*do] ...................=0.132688"
Lmax = Ft ..................................................................=3517.719#

--- Weld Size Check ---
ac shall not be less than the greater of [ar or t]   0.240"       >= 0.133"
```

ASME SEC.VIII DIV.1 UHX-12   Case 4

```
(U-Tube)  Configuration d
Tubesheet Thickness (h)   =   6.0000"
Exp length of tube (ltx)  =   5.8750"      Exp depth ratio (Rho)    =   0.9792"
Channel I.D. (Dc)         =  40.2500"      Channel thickness (Tc)   =   0.8750"
Shell I.D. (Ds)           =  40.2500"      Shell thickness (Ts)     =   1.1250"
Perimeter of layout (CP)  = 124.0928"      Area enclosed by CP (AP) = 1225.417in^2
Press Chan (Pt)           =    -15.0psi    Press Shell (Ps)         =    -15.0psi
Corr Chan                 =  0.12500"      Corr Shell               =  0.12500"
Corr Chan side TS (ct)    =  0.12500"      Corr Shell side TS (cs)  =  0.12500"
_______________________________________________________________________________________________
           Temp          Stress          Yield            Modulus  Coef   Poisson   Prim Plus
                                                          x10^6    x10^-6 Ratio     Stress
_______________________________________________________________________________________________
Temp TS  T = 725deg.F S  = 16450psi   Sy =      0psi   E  =24.9750psi   V =.000 Sps =      0psi
Temp TBS Tt= 725deg.F St = 11529psi   Syt=      0psi   Et =24.9750psi   Vt=.000
Temp TBS T = 725deg.F St = 11529psi                    Et =24.9750psi
Temp CH  Tc= 425deg.F Sc = 20000psi   Syc=  32125psi   Ec =27.5500psi   Vc=.300 Spsc=  64250psi
Temp SH  Ts= 725deg.F Ss = 16450psi   Sys=  26750psi   Es =24.9750psi   Vs=.300 Spss=  53500psi

Mu=0.2000 d*=0.8504"    P*=1.32796"    Mu*=0.3596 hg'=0.0625"    hgs'=   0.0"    hrDE=   0.0"
W*       = 1145992.000#        Rho s   = 1.083082318
Rho c    = 1.083082318         Mts      =        0.0In-Lb/In h/p     = 4.800000191
E*       = 10252286.00psi      v*       = 0.320897967        Beta s  =        0.0in^-1
Kappa s  =        0.0#         Lambda s =        0.0psi      Delta s =        0.0In^3/Lb
Delta c  =        0.0In^3/Lb  Beta c   =        0.0in^-1    Kappa c =        0.0#
Lambda c =        0.0psi      Omega s  =        0.0in^2     Omega c =        0.0in^2
K        = 1.009493709         F        = 0.015631560        M*      =        0.0In-Lb/In
Mp       =        0.0In-Lb/In Mo       =        0.0In-Lb/In M       =        0.0In-Lb/In
Sigma s,m=        0.0psi      Sigma s,b=        0.0psi      Sigma s =        0.0psi
Sigma c,m=        0.0psi      Sigma c,b=        0.0psi      Sigma c =        0.0psi
Sigma     |      0 psi  | <= 2S      32900 psi   [OK                ]
Tau       |      0 psi  | <= .8S     13160 psi   [OK                ]
```

```
Tube Joint=     Full Strength Welds Per FIG. UW-20.1(c)

Tube O.D. do ...............................................................=1.000000"
Tube Thickness t ...........................................................=0.109000"
Stress Tubes Sa ............................................................=11529.41psi
St = Stress Tubesheet or Base if Clad ......................................=16450.00psi
Sw = Stress Weld = Lesser of Sa or St ......................................=11529.41psi
fw = Weld strength factor = Sa/Sw ..........................................=1.000000
af = Fillet Weld leg .......................................................=0.120000"
ag = Groove Weld leg .......................................................=0.120000"
ac = Length of the combined weld legs = af + ag ............................=0.240000"
Weld throat ................................................................=0.084853"
Ft = Axial tube strength = Phi*t*(do-t)*Sa .................................=3517.719#
Fd = Design strength, but not greater than Ft ..............................=3517.719#
fd = Ratio of design strength to tube strength
fd = 1.0 for Full strength welds
fd = Fd/Ft for Partial strength welds ......................................=1.000000
Fg = Groove weld strength, but not > Ft, = 0.85*Phi*ag*(do+0.67*ag)Sw .......=3517.719#
Ff = Fillet weld strength, but not > Ft, = 0.55*Phi*af*(do+0.67*af)Sw .......=2582.769#
ff = Ratio of fillet weld strength to design strength = 1.0-Fg/(fd*Ft) ......=     0.0
ar = 2.0*[Sqrt((0.75*do)^2+1.07*t*(do-t)fw*fd) -0.75*do] ...................=0.132688"
Lmax = Ft ..................................................................=3517.719#

--- Weld Size Check ---
ac shall not be less than the greater of [ar or t]   0.240"       >= 0.133"
```

```
------------------------------------------------------------------------
         [   Pressure    ]  [ Temperature ]
[Case]   [ Pt   ] [ Ps   ]  [T_ch ] [T_sh ]  [Corr] [ Thermal Expansion ]
------------------------------------------------------------------------
  1        525.0    -15.0    425.0   725.0    Yes            -
  2        -15.0    675.0    425.0   725.0    Yes            -
  3        525.0    675.0    425.0   725.0    Yes            -
  4        -15.0    -15.0    425.0   725.0    Yes            -

          ////////// Recap of all Cases //////////
(Case Number  1)OK
(Case Number  2)OK
(Case Number  3)OK
(Case Number  4)OK
(hr Calc StatTS)OK


//////////////////////////// Tubesheet Stresses /////////////////////////////
Case#  (Per.Sigma/Allow)    (Sigma)          (Per.Tau/Allow)     (Tau)
[ 1]       [  76 ]     |  24928|<  32900          [  34 ]   |   4443|<  13160
[ 2]       [  97 ]     |  31852|<  32900          [  43 ]   |   5678|<  13160
[ 3]       [  21 ]     |   6924|<  32900          [   9 ]   |   1234|<  13160


>>>>> UHX-10 (b) Data for Stationary Tubesheet <<<<<
Tubesheet Thicknes h =   6.2500
Tubesheet OD         =  49.6250
A =  39.8750,  at Min. Cylinder Inside Diameter turns
Thickness of Tubesheet at A diameter =   6.2500
Thickness at A diameter not less than Smaller of (  0.75h , h-0.375)
                                                 ( 4.6875 ,  5.8750)
Thickness at A diameter  6.2500 not less than  4.6875
Tubesheet complies with UHX-10 (b)   [[ Yes ]]
```

ASME Horizontal Vessel Analysis: Stresses for the Left Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Operating Case

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

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8.000 + 1.56*sqrt( 20.6875 * 1.1250 ), 2 * 27.750 )
  = 15.5258 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	20.69	in.
Stiffened Vessel Length per 4.15.6	L	25.29	ft.
Distance from Saddle to Vessel tangent	a	27.75	in.
Saddle Width	b	8.00	in.
Saddle Bearing Angle	theta	117.63	degrees
Shell Allowable Stress used in Calculation		16450.00	psi
Head Allowable Stress used in Calculation		0.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Operating Case		28822.54	lb.

Horizontal Vessel Analysis Results:	**Actual**	**Allowable**	
Long. Stress at Top of Midspan	5277.87	16450.00	psi
Long. Stress at Bottom of Midspan	7138.80	16450.00	psi
Long. Stress at Top of Saddles	6547.62	16450.00	psi
Long. Stress at Bottom of Saddles	6020.78	16450.00	psi
Tangential Shear in Shell	1225.18	13160.00	psi
Circ. Stress at Horn of Saddle	2286.92	20562.50	psi
Circ. Compressive Stress in Shell	126.97	16450.00	psi

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:

```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3.00 * ( 1646.5/2 + 0 ) * 60.0000/41.0000
  = 3614.3 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
  = max( Fl, Friction Load, Sum of X Forces) * B / Ls
  = max( 355.22 , 0.00 , 27750 ) * 60.0000/141.0004
  = 11808.5 lb.
```

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:

```
  = max( Fl, Friction Force, Sum of X Forces ) * B / Ls
  = max( 2082.35 , 0.00 , 27750 ) * 60.0000/141.0004
  = 11808.5 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:

```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3.00 * ( 2082/2 + 0 ) * 60.0000/41.0000
  = 4571.0 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 17014 + Max( 11808 , 3614 , 11808 , 4571 )
  = 28822.5 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	29766.24	lb.
Transverse Shear Load Saddle	1041.18	lb.
Longitudinal Shear Load Saddle	27750.00	lb.

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

```
K1  = 0.1029     K2  = 1.2107     K3  = 0.9225     K4  = 0.4110
K5  = 0.7694     K6  = 0.0549     K7  = 0.0549     K8  = 0.3427
K9  = 0.2746     K10 = 0.0598     K1* = 0.1862
```

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

Moment per Equation 4.15.3 [M1]:

```
= -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
= -28823*2.31[1-(1-2.31/25.29+(1.724²-0.000²)/
  (2*2.31*25.29))/(1+(4*0.00)/(3*25.29))]
= -4400.7 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
= Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
= 28823*25.3/4(1+2(1.724²-0.000²)/(25.29²))/(1+(4*0.000)/
  (3*25.292))-4*2.31/25.29
= 117283.9 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
= P * Rm/(2t) - M2/(pi*Rm²t)
= 675.227 * 20.688/(2*1.125 ) - 1407407/(pi*20.7²*1.125 )
= 5277.87 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
= P * Rm/(2t) + M2/(pi * Rm² * t)
= 675.227 * 20.688/(2 * 1.125 ) + 1407407/(pi * 20.7² * 1.125 )
= 7138.80 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
= P * Rm/(2t) - M1/(K1*pi*Rm²t)
= 675.227*20.688/(2*1.125)--52809.0/(0.1029*pi*20.7²*1.125)
= 6547.62 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
= P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
= 675.227*20.688/(2*1.125)+-52809.0/(0.1862*pi*20.7²*1.125)
= 6020.78 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
= Q(L-2a)/(L+(4*h2/3))
= 28823 ( 25.29 - 2 * 2.31 )/(25.29 + ( 4 * 0.00/3))
= 23551.9 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
= K2 * T / ( Rm * t )
= 1.2107 * 23551.86/( 20.6875 * 1.1250 )
= 1225.18 psi
```

Decay Length (4.15.22) [x1,x2]:

```
= 0.78 * sqrt( Rm * t )
= 0.78 * sqrt( 20.688 * 1.125 )
= 3.763 in.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

```
= -K5 * Q * k / ( t * ( b + X1 + X2 ) )
= -0.7694 * 28823 * 0.1/( 1.125 * ( 8.00 + 3.76 + 3.76 ) )
= -126.97 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:

```
= -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
= -28823/(4*1.125 *(8.000 +3.763 +3.763 )) -
   3*0.0549 *28823/(2*1.125²)
= -2286.92 psi
```

Effective reinforcing plate width (4.15.1) [B1]:

```
= min( b + 1.56 * sqrt( Rm * t ), 2a  )
= min( 8.00 + 1.56 * sqrt( 20.688 * 1.125 ), 2 * 27.750 )
= 15.53 in.
```

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:

```
= Alpha * Ls * ( Design Temperature - Ambient Temperature )
= 0.765E-05 * 141.000 * ( 725.0 - 70.0 )
= 0.707 in.
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	41.0000	in.
Baseplate Thickness	Bpthk	0.6250	in.
Baseplate Width	Bpwid	9.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	1.2500	in.
Web Thickness	Webtk	1.1250	in.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Io
Shell	0.5625	19.6007	11.0254	8.2690
Wearplate	1.3125	3.7500	4.9219	6.5039
Web	20.4375	42.6094	870.8291	22891.2227
BasePlate	39.6875	5.6250	223.2422	8860.1074
Totals	62.0000	71.5850	1110.0186	31766.1035

```
Value  C1 = Sumof(Ay)/Sumof(A)             =      15.5063  in.
Value   I = Sumof(Io) - C1*Sumof(Ay)       =   14553.8320  in**4
Value  As = Sumof(A) - Ashell              =      51.9844  in²

K1 = (1+Cos(beta)-.5*Sin(beta)² )/(pi-beta+Sin(beta)*Cos(beta)) =   0.1992

Fh = K1 * Q = 0.1992 * 28822.543 = 5742.1738 lb.

Tension Stress, St = ( Fh/As )       =       110.4596  psi
Allowed Stress, Sa = 0.6 * Yield Str =     21600.0000  psi

d  = B - R*Sin(theta) / theta        =        43.3527  in.
Bending Moment, M  = Fh * d          =     20744.8848  ft.lb.

Bending Stress, Sb = ( M * C1 / I  ) =       265.2301  psi
Allowed Stress, Sa = 2/3 * Yield Str =     24000.0000  psi
```

Minimum Thickness of Baseplate per Moss :

```
= ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
  AllStress ))½
= ( 3 * (28823 + 944 ) * 9.00/( 4 * 41.000 * 24000.000 ))½
= 0.452 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:
```
  = ( Bplen - Clearance ) / ( Nribs - 1)
  = ( 41.0000 - 1.0 )/( 2 - 1 ) = 40.0000 in.
```

Baseplate Pressure Area [Ap]:
```
  = e * Bpwid / 2
  = 40.0000 * 9.0000/2 = 180.0000 in²
```

Axial Load [P]:
```
  = Ap * Bp
  = 180.0 * 78.11 = 14059.8 lb.
```

Area of the Rib and Web [Ar]:
```
  = ( Bpwid - Clearance - Webtk ) * Ribtk + e/2 * Webtk
  = ( 9.000 - 1.0 - 1.125 ) * 1.250 + 40.0000/2 * 1.125
  = 31.094 in²
```

Compressive Stress [Sc]:
```
  = P/Ar
  = 14059.8/31.0938 = 452.1737 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay^2	Io
Rib	4.0000	8.5938	34.3750	0.0000	53.3333
Web	4.0000	22.5000	90.0000	0.0000	4.7461
Values	4.0000	31.0938	124.3750	0.0000	58.0794

Bending Moment [Rm]:
```
  = Fl /( 2 * Bplen ) * e * rl / 2
  = 27750.0/( 2 * 41.00 ) * 40.000 * 49.12/2
  = 27705.650 ft.lb.
```

```
 KL/R < Cc ( 35.9415 < 126.0993 ) per AISC E2-1
 Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
 Sca = ( 1-( 35.94 )²/(2 * 126.10² )) * 36000/
       ( 5/3+3*(35.94 )/(8* 126.10 )-( 35.94³)/(8*126.10³)
 Sca = 19505.58 psi
```

AISC Unity Check on Outside Ribs (must be <= 1.0)
```
 Check = Sc/Sca + (Rm/Z)/Sba
 Check = 452.17/19505.58 + (332467.81/14.520 )/24000.00
 Check = 0.98
```

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Minimum Wear Plate Width to be considered in analysis [b1]:
```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8.000 + 1.56*sqrt( 20.6875 * 1.1250 ), 2 * 69.000 )
  = 15.5258 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	20.69	in.
Stiffened Vessel Length per 4.15.6	L	25.29	ft.
Distance from Saddle to Vessel tangent	a	69.00	in.
Saddle Width	b	8.00	in.
Saddle Bearing Angle	theta	117.63	degrees
Shell Allowable Stress used in Calculation		16450.00	psi
Head Allowable Stress used in Calculation		0.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Operating Case		37473.15	lb.

Horizontal Vessel Analysis Results:	Actual	Allowable	
Long. Stress at Top of Midspan	6020.54	16450.00	psi
Long. Stress at Bottom of Midspan	6396.12	16450.00	psi
Long. Stress at Top of Saddles	9815.31	16450.00	psi
Long. Stress at Bottom of Saddles	4214.45	16450.00	psi
Tangential Shear in Shell	1063.00	13160.00	psi
Circ. Stress at Horn of Saddle	2973.30	20562.50	psi
Circ. Compressive Stress in Shell	165.07	16450.00	psi

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:

```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3.00 * ( 1646.5/2 + 0 ) * 60.0000/41.0000
  = 3614.3 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
  = max( Fl, Friction Load, Sum of X Forces) * B / Ls
  = max( 355.22 , 0.00 , 27750 ) * 60.0000/141.0004
  = 11808.5 lb.
```

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:

```
  = max( Fl, Friction Force, Sum of X Forces ) * B / Ls
  = max( 2082.35 , 0.00 , 27750 ) * 60.0000/141.0004
  = 11808.5 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:

```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3.00 * ( 2082/2 + 0 ) * 60.0000/41.0000
  = 4571.0 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 25665 + Max( 11808 , 3614 , 11808 , 4571 )
  = 37473.1 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	38416.84	lb.
Transverse Shear Load Saddle	1041.18	lb.
Longitudinal Shear Load Saddle	27750.00	lb.

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

```
K1  = 0.1029     K2  = 1.2107     K3  = 0.9225     K4  = 0.4110
K5  = 0.7694     K6  = 0.0549     K7  = 0.0549     K8  = 0.3427
K9  = 0.2746     K10 = 0.0598     K1* = 0.1862
```

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

Moment per Equation 4.15.3 [M1]:

```
= -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
= -37473*5.75[1-(1-5.75/25.29+(1.724²-0.000²)/
  (2*5.75*25.29))/(1+(4*0.00)/(3*25.29))]
= -46785.0 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
= Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
= 37473*25.3/4(1+2(1.724²-0.000²)/(25.29²))/(1+(4*0.000)/
  (3*25.292))-4*5.75/25.29
= 23670.7 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
= P * Rm/(2t) - M2/(pi*Rm²t)
= 675.227 * 20.688/(2*1.125 ) - 284048.8/(pi*20.7²*1.125 )
= 6020.54 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
= P * Rm/(2t) + M2/(pi * Rm² * t)
= 675.227 * 20.688/(2 * 1.125 ) + 284048.8/(pi * 20.7² * 1.125 )
= 6396.12 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
= P * Rm/(2t) - M1/(K1*pi*Rm²t)
= 675.227*20.688/(2*1.125)--561419.9/(0.1029*pi*20.7²*1.125)
= 9815.31 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
= P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
= 675.227*20.688/(2*1.125)+-561419.9/(0.1862*pi*20.7²*1.125)
= 4214.45 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
= Q(L-2a)/(L+(4*h2/3))
= 37473 ( 25.29 - 2 * 5.75 )/(25.29 + ( 4 * 0.00/3))
= 20434.3 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
= K2 * T / ( Rm * t )
= 1.2107 * 20434.29/( 20.6875 * 1.1250 )
= 1063.00 psi
```

Decay Length (4.15.22) [x1,x2]:

```
= 0.78 * sqrt( Rm * t )
= 0.78 * sqrt( 20.688 * 1.125 )
= 3.763 in.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

```
= -K5 * Q * k / ( t * ( b + X1 + X2 ) )
= -0.7694 * 37473 * 0.1/( 1.125 * ( 8.00 + 3.76 + 3.76 ) )
= -165.07 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:

```
= -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
= -37473/(4*1.125 *(8.000 +3.763 +3.763 )) -
   3*0.0549 *37473/(2*1.125²)
= -2973.30 psi
```

Effective reinforcing plate width (4.15.1) [B1]:

```
= min( b + 1.56 * sqrt( Rm * t ), 2a  )
= min( 8.00 + 1.56 * sqrt( 20.688 * 1.125 ), 2 * 69.000 )
= 15.53 in.
```

Results for Vessel Ribs, Web and Base

Baseplate Length	Bplen	41.0000	in.
Baseplate Thickness	Bpthk	0.6250	in.
Baseplate Width	Bpwid	9.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	1.2500	in.
Web Thickness	Webtk	1.1250	in.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Io
Shell	0.5625	19.6007	11.0254	8.2690
Wearplate	1.3125	3.7500	4.9219	6.5039
Web	20.4375	42.6094	870.8291	22891.2227
BasePlate	39.6875	5.6250	223.2422	8860.1074
Totals	62.0000	71.5850	1110.0186	31766.1035

```
Value  C1 = Sumof(Ay)/Sumof(A)            =      15.5063  in.
Value   I = Sumof(Io) - C1*Sumof(Ay)      =   14553.8320  in**4
Value  As = Sumof(A) - Ashell             =      51.9844  in²

K1 = (1+Cos(beta)-.5*Sin(beta)² )/(pi-beta+Sin(beta)*Cos(beta)) =   0.1992

Fh = K1 * Q = 0.1992 * 37473.148 = 7465.5918 lb.

Tension Stress, St = ( Fh/As )       =       143.6122  psi
Allowed Stress, Sa = 0.6 * Yield Str =     21600.0000  psi

d  = B - R*Sin(theta) / theta        =        43.3527  in.
Bending Moment, M  = Fh * d          =     26971.1172  ft.lb.

Bending Stress, Sb = ( M * C1 / I  ) =       344.8345  psi
Allowed Stress, Sa = 2/3 * Yield Str =     24000.0000  psi
```

Minimum Thickness of Baseplate per Moss :

```
= ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
  AllStress ))½
= ( 3 * (37473 + 944 ) * 9.00/( 4 * 41.000 * 24000.000 ))½
= 0.513 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

```
= ( Bplen - Clearance ) / ( Nribs - 1)
= ( 41.0000 - 1.0 )/( 2 - 1 ) = 40.0000 in.
```

Baseplate Pressure Area [Ap]:

```
= e * Bpwid / 2
= 40.0000 * 9.0000/2 = 180.0000 in²
```

Axial Load [P]:

```
  = Ap * Bp
  = 180.0 * 101.55 = 18279.6 lb.
```

Area of the Rib and Web [Ar]:

```
  = ( Bpwid - Clearance - Webtk ) * Ribtk + e/2 * Webtk
  = ( 9.000 - 1.0 - 1.125 ) * 1.250 + 40.0000/2 * 1.125
  = 31.094 in²
```

Compressive Stress [Sc]:

```
  = P/Ar
  = 18279.6/31.0938 = 587.8861 psi
```

<u>Check of Outside Ribs:</u>

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay²	Io
Rib	4.0000	8.5938	34.3750	0.0000	53.3333
Web	4.0000	22.5000	90.0000	0.0000	4.7461
Values	4.0000	31.0938	124.3750	0.0000	58.0794

Bending Moment [Rm]:

```
  = Fl /( 2 * Bplen ) * e * rl / 2
  = 27750.0/( 2 * 41.00 ) * 40.000 * 49.12/2
  = 27705.650 ft.lb.
```

```
 KL/R < Cc ( 35.9415 < 126.0993 ) per AISC E2-1
 Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
 Sca = ( 1-( 35.94 )²/(2 * 126.10² )) * 36000/
       ( 5/3+3*(35.94 )/(8* 126.10 )-( 35.94³)/(8*126.10³)
 Sca = 19505.58 psi
```

AISC Unity Check on Outside Ribs (must be <= 1.0)

```
 Check = Sc/Sca + (Rm/Z)/Sba
 Check = 587.89/19505.58 + (332467.81/14.520 )/24000.00
 Check = 0.98
```

ASME Horizontal Vessel Analysis: Stresses for the Left Saddle
(per ASME Sec. VIII Div. 2 based on the Zick method.)

Horizontal Vessel Stress Calculations : Test Case

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

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8.000 + 1.56*sqrt( 20.6250 * 1.2500 ), 2 * 27.750 )
  = 15.9209 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	20.62	in.
Stiffened Vessel Length per 4.15.6	L	25.29	ft.
Distance from Saddle to Vessel tangent	a	27.75	in.
Saddle Width	b	8.00	in.
Saddle Bearing Angle	theta	117.63	degrees
Shell Allowable Stress used in Calculation		36100.00	psi
Head Allowable Stress used in Calculation		36100.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Test Case, no Ext. Forces		26513.40	lb.

Horizontal Vessel Analysis Results:	**Actual**	**Allowable**	
Long. Stress at Top of Midspan	6466.46	36100.00	psi
Long. Stress at Bottom of Midspan	8016.33	36100.00	psi
Long. Stress at Top of Saddles	7524.65	36100.00	psi
Long. Stress at Bottom of Saddles	7084.82	36100.00	psi
Tangential Shear in Shell	1017.39	28880.00	psi
Circ. Stress at Horn of Saddle	1729.68	54150.00	psi
Circ. Compressive Stress in Shell	102.51	36100.00	psi

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:

```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3.00 * ( 543.4/2 + 0 ) * 60.0000/41.0000
  = 1192.7 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
  = max( Fl, Friction Load, Sum of X Forces) * B / Ls
  = max( 117.22 , 0.00 , 0 ) * 60.0000/141.0004
  = 49.9 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 25321 + Max( 50 , 1193 , 0 , 0 )
  = 26513.4 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	27457.10	lb.
Transverse Shear Load Saddle	271.68	lb.
Longitudinal Shear Load Saddle	117.22	lb.

Hydrostatic Test Pressure at center of Vessel: 877.745 psig

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

```
K1  = 0.1029     K2  = 1.2107     K3  = 0.9225     K4  = 0.4110
K5  = 0.7694     K6  = 0.0549     K7  = 0.0549     K8  = 0.3427
K9  = 0.2746     K10 = 0.0598     K1* = 0.1862
```

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

Moment per Equation 4.15.3 [M1]:

```
 = -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
 = -26513*2.31[1-(1-2.31/25.29+(1.719²-0.000²)/
   (2*2.31*25.29))/(1+(4*0.00)/(3*25.29))]
 = -4057.6 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
 = Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
 = 26513*25.3/4(1+2(1.719²-0.000²)/(25.29²))/(1+(4*0.000)/
   (3*25.292))-4*2.31/25.29
 = 107878.2 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
 = P * Rm/(2t) - M2/(pi*Rm²t)
 = 877.745 * 20.625/(2*1.250 ) - 1294539/(pi*20.6²*1.250 )
 = 6466.46 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:

```
 = P * Rm/(2t) + M2/(pi * Rm² * t)
 = 877.745 * 20.625/(2 * 1.250 ) + 1294539/(pi * 20.6² * 1.250 )
 = 8016.33 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:

```
 = P * Rm/(2t) - M1/(K1*pi*Rm²t)
 = 877.745*20.625/(2*1.250)--48690.9/(0.1029*pi*20.6²*1.250)
 = 7524.65 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:

```
 = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
 = 877.745*20.625/(2*1.250)+-48690.9/(0.1862*pi*20.6²*1.250)
 = 7084.82 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:

```
 = Q(L-2a)/(L+(4*h2/3))
 = 26513 ( 25.29 - 2 * 2.31 )/(25.29 + ( 4 * 0.00/3))
 = 21665.0 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:

```
 = K2 * T / ( Rm * t )
 = 1.2107 * 21664.99/( 20.6250 * 1.2500 )
 = 1017.39 psi
```

Decay Length (4.15.22) [x1,x2]:

```
 = 0.78 * sqrt( Rm * t )
 = 0.78 * sqrt( 20.625 * 1.250 )
 = 3.960 in.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:

```
 = -K5 * Q * k / ( t * ( b + X1 + X2 ) )
 = -0.7694 * 26513 * 0.1/( 1.250 * ( 8.00 + 3.96 + 3.96 ) )
 = -102.51 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:

```
  = -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
  = -26513/(4*1.250 *(8.000 +3.960 +3.960 )) -
     3*0.0549 *26513/(2*1.250²)
  = -1729.68 psi
```

Effective reinforcing plate width (4.15.1) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 8.00 + 1.56 * sqrt( 20.625 * 1.250 ), 2 * 27.750 )
  = 15.92 in.
```

Results for Vessel Ribs, Web and Base:

Baseplate Length	Bplen	41.0000	in.
Baseplate Thickness	Bpthk	0.6250	in.
Baseplate Width	Bpwid	9.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	1.2500	in.
Web Thickness	Webtk	1.1250	in.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Io
Shell	0.6250	22.2500	13.9062	11.5885
Wearplate	1.4375	3.7500	5.3906	7.7930
Web	20.5000	42.4688	870.6094	22890.8770
BasePlate	39.6875	5.6250	223.2422	8860.1074
Totals	62.2500	74.0938	1113.1484	31770.3652

```
 Value  C1 = Sumof(Ay)/Sumof(A)              =      15.0235  in.
 Value   I = Sumof(Io) - C1*Sumof(Ay)        =   15046.9668  in**4
 Value  As = Sumof(A) - Ashell               =      51.8438  in²

 K1 = (1+Cos(beta)-.5*Sin(beta)² )/(pi-beta+Sin(beta)*Cos(beta)) =   0.1992

 Fh = K1 * Q = 0.1992 * 26513.402 = 5282.1353 lb.

 Tension Stress, St = ( Fh/As )       =        101.8857  psi
 Allowed Stress, Sa = 0.6 * Yield Str =      21600.0000  psi

 d  = B - R*Sin(theta) / theta        =         43.3319  in.
 Bending Moment, M  = Fh * d          =      19073.7266  ft.lb.

 Bending Stress, Sb = ( M * C1 / I  ) =        228.5280  psi
 Allowed Stress, Sa = 2/3 * Yield Str =      24000.0000  psi
```

Minimum Thickness of Baseplate per Moss :

```
  = ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
    AllStress ))½
  = ( 3 * (26513 + 944 ) * 9.00/( 4 * 41.000 * 24000.000 ))½
  = 0.434 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

```
  = ( Bplen - Clearance ) / ( Nribs - 1)
  = ( 41.0000 - 1.0 )/( 2 - 1 ) = 40.0000 in.
```

Baseplate Pressure Area [Ap]:

```
  = e * Bpwid / 2
  = 40.0000 * 9.0000/2 = 180.0000 in²
```

Axial Load [P]:

```
  = Ap * Bp
  = 180.0 * 71.85 = 12933.4 lb.
```

Area of the Rib and Web [Ar]:

```
  = ( Bpwid - Clearance - Webtk ) * Ribtk + e/2 * Webtk
  = ( 9.000 - 1.0 - 1.125 ) * 1.250 + 40.0000/2 * 1.125
  = 31.094 in²
```

Compressive Stress [Sc]:

```
  = P/Ar
  = 12933.4/31.0938 = 415.9474 psi
```

Check of Outside Ribs:

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay^2	Io
Rib	4.0000	8.5938	34.3750	0.0000	53.3333
Web	4.0000	22.5000	90.0000	0.0000	4.7461
Values	4.0000	31.0938	124.3750	0.0000	58.0794

Bending Moment [Rm]:

```
  = Fl /( 2 * Bplen ) * e * rl / 2
  = 117.2/( 2 * 41.00 ) * 40.000 * 49.00/2
  = 116.738 ft.lb.
```

```
 KL/R < Cc ( 35.8500 < 126.0993 ) per AISC E2-1
 Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
 Sca = ( 1-( 35.85 )²/(2 * 126.10² )) * 36000/
       ( 5/3+3*(35.85 )/(8* 126.10 )-( 35.85³)/(8*126.10³)
 Sca = 19512.54 psi
```

AISC Unity Check on Outside Ribs (must be <= 1.0)

```
 Check = Sc/Sca + (Rm/Z)/Sba
 Check = 415.95/19512.54 + (1400.86/14.520 )/24000.00
 Check = 0.03
```

ASME Horizontal Vessel Analysis: Stresses for the Right Saddle

(per ASME Sec. VIII Div. 2 based on the Zick method.)

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

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8.000 + 1.56*sqrt( 20.6250 * 1.2500 ), 2 * 69.000 )
  = 15.9209 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	20.62	in.
Stiffened Vessel Length per 4.15.6	L	25.29	ft.
Distance from Saddle to Vessel tangent	a	69.00	in.
Saddle Width	b	8.00	in.
Saddle Bearing Angle	theta	117.63	degrees
Shell Allowable Stress used in Calculation		36100.00	psi
Head Allowable Stress used in Calculation		36100.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Saddle Force Q, Test Case, no Ext. Forces		27890.93	lb.

Horizontal Vessel Analysis Results:

Horizontal Vessel Analysis Results:	Actual	Allowable	
Long. Stress at Top of Midspan	7114.91	36100.00	psi
Long. Stress at Bottom of Midspan	7367.88	36100.00	psi
Long. Stress at Top of Saddles	9672.93	36100.00	psi
Long. Stress at Bottom of Saddles	5897.28	36100.00	psi
Tangential Shear in Shell	714.22	28880.00	psi
Circ. Stress at Horn of Saddle	1819.54	54150.00	psi
Circ. Compressive Stress in Shell	107.83	36100.00	psi

Intermediate Results: Saddle Reaction Q due to Wind or Seismic

Saddle Reaction Force due to Wind Ft [Fwt]:

```
  = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3.00 * ( 543.4/2 + 0 ) * 60.0000/41.0000
  = 1192.7 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
  = max( Fl, Friction Load, Sum of X Forces) * B / Ls
  = max( 117.22 , 0.00 , 0 ) * 60.0000/141.0004
  = 49.9 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
  = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
  = 26698 + Max( 50 , 1193 , 0 , 0 )
  = 27890.9 lb.
```

Summary of Loads at the base of this Saddle:

Vertical Load (including saddle weight)	28834.63	lb.
Transverse Shear Load Saddle	271.68	lb.
Longitudinal Shear Load Saddle	117.22	lb.

Hydrostatic Test Pressure at center of Vessel: 877.745 psig

Formulas and Substitutions for Horizontal Vessel Analysis:

Note: Wear Plate is Welded to the Shell, k = 0.1

The Computed K values from Table 4.15.1:

K1 = 0.1029	K2 = 1.2107	K3 = 0.9225	K4 = 0.4110
K5 = 0.7694	K6 = 0.0549	K7 = 0.0549	K8 = 0.3427
K9 = 0.2746	K10 = 0.0598	K1* = 0.1862	

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

Moment per Equation 4.15.3 [M1]:

```
  = -Q*a [1 - (1- a/L + (R²-h2²)/(2a*L))/(1+(4h2)/3L)]
  = -27891*5.75[1-(1-5.75/25.29+(1.719²-0.000²)/
    (2*5.75*25.29))/(1+(4*0.00)/(3*25.29))]
  = -34831.5 ft.lb.
```

Moment per Equation 4.15.4 [M2]:

```
  = Q*L/4(1+2(R²-h2²)/(L²))/(1+(4h2)/( 3L))-4a/L
  = 27891*25.3/4(1+2(1.719²-0.000²)/(25.29²))/(1+(4*0.000)/
    (3*25.292))-4*5.75/25.29
  = 17608.0 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.6) [Sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 877.745 * 20.625/(2*1.250 ) - 211296.5/(pi*20.6²*1.250 )
  = 7114.91 psi
```

Longitudinal Stress at Bottom of Shell (4.15.7) [Sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 877.745 * 20.625/(2 * 1.250 ) + 211296.5/(pi * 20.6² * 1.250 )
  = 7367.88 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.10) [Sigma*3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 877.745*20.625/(2*1.250)--417978.5/(0.1029*pi*20.6²*1.250)
  = 9672.93 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.11) [Sigma*4]:
```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 877.745*20.625/(2*1.250)+-417978.5/(0.1862*pi*20.6²*1.250)
  = 5897.28 psi
```

Maximum Shear Force in the Saddle (4.15.5) [T]:
```
  = Q(L-2a)/(L+(4*h2/3))
  = 27891 ( 25.29 - 2 * 5.75 )/(25.29 + ( 4 * 0.00/3))
  = 15209.1 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.14) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 1.2107 * 15209.06/( 20.6250 * 1.2500 )
  = 714.22 psi
```

Decay Length (4.15.22) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 20.625 * 1.250 )
  = 3.960 in.
```

Circumferential Stress in shell, no rings (4.15.23) [sigma6]:
```
  = -K5 * Q * k / ( t * ( b + X1 + X2 ) )
  = -0.7694 * 27891 * 0.1/( 1.250 * ( 8.00 + 3.96 + 3.96 ) )
  = -107.83 psi
```

Circ. Comp. Stress at Horn of Saddle, L>=8Rm (4.15.24) [sigma7]:
```
  = -Q/(4*t*(b+X1+X2)) - 3*K7*Q/(2*t²)
  = -27891/(4*1.250 *(8.000 +3.960 +3.960 )) -
     3*0.0549 *27891/(2*1.250²)
  = -1819.54 psi
```

Effective reinforcing plate width (4.15.1) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 8.00 + 1.56 * sqrt( 20.625 * 1.250 ), 2 * 69.000 )
  = 15.92 in.
```

Results for Vessel Ribs, Web and Base

Baseplate Length	Bplen	41.0000	in.
Baseplate Thickness	Bpthk	0.6250	in.
Baseplate Width	Bpwid	9.0000	in.
Number of Ribs (inc. outside ribs)	Nribs	2	
Rib Thickness	Ribtk	1.2500	in.
Web Thickness	Webtk	1.1250	in.
Web Location	Webloc	Center	

Moment of Inertia of Saddle - Lateral Direction

	Y	A	AY	Io
Shell	0.6250	22.2500	13.9062	11.5885
Wearplate	1.4375	3.7500	5.3906	7.7930
Web	20.5000	42.4688	870.6094	22890.8770
BasePlate	39.6875	5.6250	223.2422	8860.1074
Totals	62.2500	74.0938	1113.1484	31770.3652

```
Value  C1 = Sumof(Ay)/Sumof(A)              =      15.0235  in.
Value   I = Sumof(Io) - C1*Sumof(Ay)        =   15046.9668  in**4
Value  As = Sumof(A) - Ashell               =      51.8438  in²

K1 = (1+Cos(beta)-.5*Sin(beta)² )/(pi-beta+Sin(beta)*Cos(beta)) =   0.1992

Fh = K1 * Q = 0.1992 * 27890.934 = 5556.5742 lb.

Tension Stress, St = ( Fh/As )       =        107.1793  psi
Allowed Stress, Sa = 0.6 * Yield Str =      21600.0000  psi

d  = B - R*Sin(theta) / theta        =         43.3319  in.
Bending Moment, M  = Fh * d          =      20064.7227  ft.lb.

Bending Stress, Sb = ( M * C1 / I  ) =        240.4014  psi
Allowed Stress, Sa = 2/3 * Yield Str =      24000.0000  psi
```

Minimum Thickness of Baseplate per Moss :

```
  = ( 3 * ( Q + Saddle_Wt ) * BasePlateWidth / ( 4 * BasePlateLength *
    AllStress ))½
  = ( 3 * (27891 + 944 ) * 9.00/( 4 * 41.000 * 24000.000 ))½
  = 0.445 in.
```

Calculation of Axial Load, Intermediate Values and Compressive Stress

Effective Baseplate Length [e]:

```
  = ( Bplen - Clearance ) / ( Nribs - 1)
  = ( 41.0000 - 1.0 )/( 2 - 1 ) = 40.0000 in.
```

Baseplate Pressure Area [Ap]:

```
  = e * Bpwid / 2
  = 40.0000 * 9.0000/2 = 180.0000 in²
```

Axial Load [P]:

```
  = Ap * Bp
  = 180.0 * 75.59 = 13605.3 lb.
```

Area of the Rib and Web [Ar]:

```
  = ( Bpwid - Clearance - Webtk ) * Ribtk + e/2 * Webtk
  = ( 9.000 - 1.0 - 1.125 ) * 1.250 + 40.0000/2 * 1.125
  = 31.094 in²
```

Compressive Stress [Sc]:

```
  = P/Ar
  = 13605.3/31.0938 = 437.5584 psi
```

<u>Check of Outside Ribs:</u>

Inertia of Saddle, Outer Ribs - Longitudinal Direction

	Y	A	AY	Ay²	Io
Rib	4.0000	8.5938	34.3750	0.0000	53.3333
Web	4.0000	22.5000	90.0000	0.0000	4.7461
Values	4.0000	31.0938	124.3750	0.0000	58.0794

Bending Moment [Rm]:

```
  = Fl /( 2 * Bplen ) * e * rl / 2
  = 117.2/( 2 * 41.00 ) * 40.000 * 49.00/2
  = 116.738 ft.lb.

 KL/R < Cc ( 35.8500 < 126.0993 ) per AISC E2-1
 Sca = (1-(Klr)²/(2*Cc²))*Fy/(5/3+3*(Klr)/(8*Cc)-(Klr³)/(8*Cc³)
 Sca = ( 1-( 35.85 )²/(2 * 126.10² )) * 36000/
       ( 5/3+3*(35.85 )/(8* 126.10 )-( 35.85³)/(8*126.10³)
 Sca = 19512.54 psi
```

AISC Unity Check on Outside Ribs (must be <= 1.0)

```
 Check = Sc/Sca + (Rm/Z)/Sba
 Check = 437.56/19512.54 + (1400.86/14.520 )/24000.00
 Check = 0.03
```

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Input Values:

```
Wind Design Code                                             IBC-2009
Wind Load Reduction Scale Factor                                  1.0
Basic Wind Speed                          [V]                  90.000  mile/hr
Surface Roughness Category                            C: Open Terrain
Importance Factor                                                1.15
Type of Surface                                     Moderately Smooth
Base Elevation                                                 2.0000  ft.
Percent Wind for Hydrotest                                       33.0
Using User defined Wind Press. Vs Elev.                             N
Height of Hill or Escarpment      H or Hh                      0.0000  ft.
Distance Upwind of Crest               Lh                      0.0000  ft.
Distance from Crest to the Vessel       x                      0.0000  ft.
Type of Terrain ( Hill, Escarpment )                             Flat
Damping Factor (Beta) for Wind (Ope)                           0.0100
Damping Factor (Beta) for Wind (Empty)                         0.0000
Damping Factor (Beta) for Wind (Filled)                        0.0000
```

Wind Analysis Results

Static Gust-Effect Factor, Operating Case [G]:

```
= min(0.85, 0.925((1 + 1.7 * gQ * Izbar * Q )/( 1 + 1.7 * gV * Izbar)))
= min(0.85,0.925((1+1.7*3.400*0.228*0.980)/(1+1.7*3.400*0.228)))
= min(0.85, 0.915 )
= 0.850
```

```
Natural Frequency of Vessel (Operating)                 33.000 Hz
Natural Frequency of Vessel (Empty)                     33.000 Hz
Natural Frequency of Vessel (Test)                      33.000 Hz
```

Note: Per Section 1609 of IBC 2003/06/09 these results are also applicable
for the determination of Wind Loads on structures (1609.1.1).

```
User Entered Importance Factor is                       1.150
Force Coefficient                                  [Cf] 0.601
Structure Height to Diameter ratio                      7.154
```

This is classified as a rigid structure. Static analysis performed.

Sample Calculation for the First Element

The ASCE code performs all calculations in Imperial Units
only. The wind pressure is therefore computed in these units.

Value of [Alpha] and [Zg]:

```
Exposure Category: C from Table C6-2
Alpha = 9.500 : Zg = 900.000 ft.
```

Effective Height [z]:

```
= Centroid Height + Vessel Base Elevation
= 5.000 + 2.000 = 7.000 ft.
```

Velocity Pressure coefficient evaluated at height z [Kz]:

Because z (7.000 ft.) < 15 ft.

$= 2.01 * (15 / Zg)^{2 / Alpha}$

$= 2.01 * (15/900.000)^{2/9.500}$

$= 0.849$

Type of Hill: No Hill

Wind Directionality Factor [Kd]:
= 0.95 per [6-6 ASCE-7 98][6-4 ASCE-7 02/05]

As there is No Hill Present: [Kzt]:
K1 = 0, K2 = 0, K3 = 0

Topographical Factor [Kzt]:
$= (1 + K1 * K2 * K3)^2$
$= (1 + 0.000 * 0.000 * 0.000)^2$
= 1.0000

Velocity Pressure evaluated at height z, Imperial Units [qz]:
$= 0.00256 * Kz * Kzt * Kd * I * Vr(mph)^2$
$= 0.00256 * 0.849 * 1.000 * 0.950 * 1.150 * 90.000^2$
= 19.2 psf

Force on the first element [F]:
= qz * G * Cf * WindArea
= 19.231 * 0.850 * 0.601 * 25.977
= 255.1 lb.

Element	Hgt (z) ft.	K1	K2	K3	Kz	Kzt	qz psf
1203-04 Channel	7.0	0.000	0.000	0.000	0.849	1.000	19.231
1203-04 Shell	7.0	0.000	0.000	0.000	0.849	1.000	19.231

Wind Load Calculation

From	To	Wind Height ft.	Wind Diameter ft.	Wind Area in²	Wind Pressure psf	Element Wind Load lb.
20	50	7.00000	6.56250	3740.62	19.2307	255.133
50	60	7.00000	6.64062	20400.0	19.2307	1391.40

Input Values:

Earthquake Analysis per IBC 2009

```
Short-period site coefficient 1613.5.3(1)                   Fa: 1.600
Long -period site coefficient 1613.5.3(2)                   Fv: 2.400
Maximum Mapped Acceleration Value for Short Periods         Ss: 0.167
Maximum Mapped Acceleration Value for 1 Sec. Period         S1: 0.067
Response Modification Factor                                 R: 3.000
Importance Factor                                           Ie: 1.250
Site Class                                                       D
```

Seismic Analysis Results:

```
Sms = Fa * Ss = 1.600 * 0.167 = 0.267
Sm1 = Fv * S1 = 2.400 * 0.067 = 0.161
Sds = 2/3 * Sms = 2/3 * 0.267 = 0.178

Sds = Max( 0.8*Sds, SdsUser )
    = Max( 0.143 , 0.178 )
    = 0.178

Sd1 = 2/3 * Sm1 = 2/3 * 0.161 = 0.107

Sd1 = Max( 0.8*Sd1, Sd1User )
    = Max( 0.086 , 0.108 )
    = 0.108
```

Check Approximate Fundamental Period from 12.8-7 [Ta]:

= Ct * hn^x where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)
= 0.020 * ($6.6667^{0.75}$)
= 0.083 seconds

The Coefficient Cu from Table 12.8-1 is : 1.700

Fundamental Period (1/Frequency) [T]:

```
= ( 1/Natural Frequency ) = ( 1/33.000 )
= 0.030
```

Check the Value of T which is the smaller of Cu*Ta and T:

```
= Minimum Value of (1.700 * 0.083 , 0.030 ) per 12.8.2
= 0.030
```

As the time period is < 0.06 second, use section 15.4.2.

Compute the Base Shear per equation 15.4-5, [V]:

```
= 0.3 * Sds * W * I
= 0.3 * 0.178 * 44566 * 1.25
= 2974.789 lb.
```

Vertical load per 9.5.2.7-1, [YEq]:

```
= 0.2 * Sds * W
= 0.2 * 0.178 * 44566 = 1586.55 lb.
```

```
Final Base Shear,      V = 2082.35 lb.
Final Vertical Load, YEq = 1110.59 lb.
```

Earthquake Load Calculation

From	To	Earthquake Height ft.	Earthquake Weight lb.	Element Ope Load lb.
20	50	1.66667	11141.5	520.588
50	Sadl	1.66667	11141.5	520.588
Sadl	60	1.66667	11141.5	520.588
50	60	1.66667	11141.5	520.588

Note: The Earthquake Loads calculated and printed in the Earthquake
Load calculation report have been factored by the input
scalar/load reduction factor of: 0.700.