Table of Contents

MICROTEC
Rectangular Duct for Flash Dryer - Section 1

DESIGN CALCULATION

ASME Code Version : 2017

Analysis Performed by : SL Client

Job File : D:\2-PAYAM\1-Projects\Microtec Project\13-Microtec -Flash Dryer-5204\5204-Eng

Date of Analysis : Feb 20,2026

PV Elite 2019 , January 2019

Note:
PV Elite performs all calculations internally in U.S. Customary Units to remain compliant with the ASME Code and any built in assumptions in the ASME Code formulae. Finalized results are converted to the user set of selected units using conversion constants with adequate significant digits.

Input Echo, COMPONENT 1, Description: Rectangular-3

Figure Number Analyzed		A4	
Design Internal Pressure	P	0.5000	bars
Design External Pressure	Pext	0.1000	bars
Design Temperature	Temp	170.0000	C
VESSEL MATERIAL DATA:			
Material Specification		SA-240 316	
Shell Allowable Stress at Design Temp	S	136.0672	N./mm^2
Shell Allowable Stress at Ambient	SA	137.9000	N./mm^2
Shell Yield Stress at Design Temperature	Sy	156.1065	N./mm^2
SHORT-SIDE VESSEL DATA:			
Short-side Length Dimension	H	950.0001	mm.
Minimum Thickness of Short-side Plates	t1	3.0000	mm.
Mid-side Joint Efficiency on Short-side	E	1.0000	
Corner Joint Efficiency on Short-side	EC	1.0000	
LONG-SIDE VESSEL DATA:			
Long-side Length Dimension	h	1370.0000	mm.
Minimum Thickness of Long-side Plates	t2	3.0000	mm.
Mid-side Joint Efficiency on Long-side	E	1.0000	
REINFORCEMENT MATERIAL DATA:			
Reinforcement Material Specification		SA-240	
Reinf Allowable Stress at Design Temp	Sr	120.0000	N./mm^2
Reinf Allowable Stress at Ambient	SA	153.7585	N./mm^2
Reinf Yield Stress at Design Temp	Sy	166.5450	N./mm^2
C-Factor for Reinforcement (from UG-47)		2.1000	
DELTA (Reinforcement Material Parameter)		485.0000	N./mm^2^0.5
SHORT-SIDE RECTANGULAR BEAM DATA:			
Outside Distance from Outside of Vessel		50.0000	mm.
Width of Reinforcing Member		10.0000	mm.
LONG-SIDE RECTANGULAR BEAM DATA:			
Outside Distance from Outside of Vessel		50.0000	mm.
Width of Reinforcing Member		10.0000	mm.

Rectangular Vessel Results, Item number 1, Desc: Rectangular-3
ASME Code, Section VIII, Division 1, 2017 App. 13

Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):

Short-side 1 Calculations

Membrane Ligament Efficiency [Em]:
= 1.000

Bending Ligament Efficiency [Eb]:
= 1.000

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
= t1 - CA / 2
= 3.000 - 0.000 / 2
= 1.500 mm.

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
```
= -( t1 - CA ) / 2
= -( 3.000 - 0.000 ) / 2
= -1.500 mm.
```

Short-side 2 Calculations

Membrane Ligament Efficiency [Em]:
```
= 1.000
```

Bending Ligament Efficiency [Eb]:
```
= 1.000
```

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
```
= t1 - CA / 2
= 3.000 - 0.000 / 2
= 1.500 mm.
```

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
```
= -( t1 - CA ) / 2
= -( 3.000 - 0.000 ) / 2
= -1.500 mm.
```

Long-side 1 Calculations

Membrane Ligament Efficiency [Em]:
```
= 1.000
```

Bending Ligament Efficiency [Eb]:
```
= 1.000
```

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
```
= t1 - CA / 2
= 3.000 - 0.000 / 2
= 1.500 mm.
```

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
```
= -( t1 - CA ) / 2
= -( 3.000 - 0.000 ) / 2
= -1.500 mm.
```

Long-side 2 Calculations

Membrane Ligament Efficiency [Em]:
```
= 1.000
```

Bending Ligament Efficiency [Eb]:
```
= 1.000
```

Dist from Neutral axis of c/s to inside surface of the vesssel [Ci]:
```
= t1 - CA / 2
= 3.000 - 0.000 / 2
= 1.500 mm.
```

Dist from Neutral axis of c/s to extreme outside surface of the section [Co]:
```
= -( t1 - CA ) / 2
= -( 3.000 - 0.000 ) / 2
= -1.500 mm.
```

Ligament Efficiency Calculations (Section 13-6, Equations (1)-(6)):

		Em	Eb	Ci	Co
Short-side	1	1.000	1.000	1.500	-1.500
	2	1.000	1.000	1.500	-1.500
Long-side	1	1.000	1.000	1.500	-1.500
	2	1.000	1.000	1.500	-1.500

Effective Width of Shell Plate (Section 13-8, Eq. (2))

In Compression [w]:
```
= Min( Min( t1, t2 ) * Delta / sqrt( Sy ), p )
= Min( Min( 3.00 , 3.00 ) * 5840.83 / sqrt( 156.11 ), 65.00 )
= 65.00 mm.
```

In Tension [w]:
```
= 65.00 mm.
```

Moment of Inertia of a Strip of the Vessel Wall:

```
Thickness  t1, I1  = 0.0000 cm**4
Thickness  t2, I2  = 0.0000 cm**4
```

Effective Area of Reinforcement on Shell (t * w):

```
Short-side Ap = 1.9500 cm^2
Long-side  Ap = 1.9500 cm^2
```

Moment of Inertia of Effective Area of Reinforcement (w * t3 / 12):**

```
Short-side Is = 0.0146 cm**4
Long-side  Il = 0.0146 cm**4
```

Moment of Inertia of Combined Reinforcement and Effective Width:

```
In Compression I11 = 20.2830 cm**4
               I21 = 20.2830 cm**4
In Tension     I11 = 20.2830 cm**4
               I21 = 20.2830 cm**4
```

Distance from Neutral Axis of Cross Section of Composite Section to the Inside Surface of the Vessel (mm.):

		Ci	Co
Short-side,	in Compression	20.5647	-32.4353
	in Tension	20.5647	-32.4353
Long-side,	in Compression	20.5647	-32.4353
	in Tension	20.5647	-32.4353

Rectangular Vessel Reinforcement Parameters:

```
Alpha1 =     H1 / h1      = 0.7055
k(comp)= (I22/I11)*Alpha1 = 0.7055
k(tens)= (I22/I11)*Alpha1 = 0.7055
```

Membrane Stress Calculations per Section 13-8

Membrane Stresses at Short-side 1

Membrane Stress at Short-side 1 [Sms]:
```
= p * h * p / ( 2 * ( A1 + p * t1 ))
= 0.50 * 1370.00 * 65.00 / ( 2 * ( 500.000 + 65.00 * 3.00 ))
= 3.20 N./mm^2
```

Membrane Stresses at Short-side 2

Membrane Stress at Short-side 2 [Sms]:
```
= p * h * p / ( 2 * ( A1 + p * t1 ))
= 0.50 * 1370.00 * 65.00 / ( 2 * ( 500.000 + 65.00 * 3.00 ))
= 3.20 N./mm^2
```

Membrane Stresses at Long-side 1

Membrane Stress at Long-side 1 at A[SmlA]:
```
= p * H * p / ( 2 * ( A2 + p * t2 ))
= 0.50 * 950.00 * 65.00 / ( 2 * ( 5.000 + 65.00 * 3.00 ))
= 2.22 N./mm^2
```

Membrane Stresses at Long-side 2

Membrane Stress at Long-side 2 at A[SmlA]:
```
= p * H * p / ( 2 * ( A2 + p * t2 ))
= 0.50 * 950.00 * 65.00 / ( 2 * ( 5.000 + 65.00 * 3.00 ))
= 2.22 N./mm^2
```

Membrane Stresses at Corner sections

Membrane Stress at Short side [Smsc]:
```
= p * h * p / ( 2 * ( A1 + p * t1 ))
= 0.50 * 1370.00 * 65.00 / ( 2 * ( 5.000 + 65.00 * 3.00 ))
= 3.20 N./mm^2
```

Membrane Stress at Long side [Smlc]:
```
= p * H * p / ( 2 * ( A2 + p * t2 ))
= 0.50 * 950.00 * 65.00 / ( 2 * ( 5.000 + 65.00 * 3.00 ))
= 2.22 N./mm^2
```

MEMBRANE STRESSES: Membrane Stress Calculations per Section 13-8, Equations (3) and (4). (N./mm^2) :

STRESS LOCATIONS	Actual	Allowable
Short-side 1	3.20	120.00
Short-side 2	3.20	120.00
Short-side Corner	3.20	120.00
Long-side 1 at A	2.22	120.00
Long-side 2 at A	2.22	120.00
Long-side Corner	2.22	120.00

Bending Stress Calculations per Section 13-8

Bending Stresses at Short-side 1

Bending Stress at Short-side 1 at N Inner[SbsNi]:
$$= P * p * c / (24 * I11) * [-3 * H^2 + 2 * h^2 * ((1 + Alpha1^2 * k) / (1 + k))]$$
$$= 0.5 * 65.0 * 20.56 / (24 * 20.3) * [-3 * 950.00^2 + 2 * 1370.00^2 * ((1 + 0.71^2 * 0.71) / (1 + 0.71))]$$
$$= 3.66 N./mm^2$$

Bending Stress at Short-side 1 at N Outer[SbsNo]:
$$= P * p * c / (24 * I11) * [-3 * H^2 + 2 * h^2 * ((1 + Alpha1^2 * k) / (1 + k))]$$
$$= 0.5 * 65.0 * -32.44 / (24 * 20.3) * [-3 * 950.00^2 + 2 * 1370.00^2 * ((1 + 0.71^2 * 0.71) / (1 + 0.71))]$$
$$= -5.77 N./mm^2$$

Bending Stress at Short-side 1 at Q Inner[SbsQi]:

```
  = P * h^2 * p * c / ( 12 * I11 ) *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))
  = 0.50 * 1370.00^2 * 65.00 * 20.56 / ( 12 * 20.28 ) *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))
  = 40.83 N./mm^2
```

Bending Stress at Short-side 1 at Q Outer[SbsQo]:

```
  = P * h^2 * p * c / ( 12 * I11 ) *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))
  = 0.50 * 1370.00^2 * 65.00 * -32.44 / ( 12 * 20.28 ) *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))
  = -64.40 N./mm^2
```

Bending Stresses at Short-side 2

Bending Stress at Short-side 2 at N Inner[SbsNi]:

```
  = P * p * c / ( 24 * I11 ) * [ -3 * H^2 + 2 * h^2
    * (( 1 + Alpha1^2 * k ) / ( 1 + k ))]
  = 0.5 * 65.0 * 20.56 / ( 24 * 20.3 ) * [ -3 * 950.00^2 + 2 * 1370.00^2 *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))]
  = 3.66 N./mm^2
```

Bending Stress at Short-side 2 at N Outer[SbsNo]:

```
  = P * p * c / ( 24 * I11 ) * [ -3 * H^2 + 2 * h^2
    * (( 1 + Alpha1^2 * k ) / ( 1 + k ))]
  = 0.5 * 65.0 * -32.44 / ( 24 * 20.3 ) * [ -3 * 950.00^2 + 2 * 1370.00^2 *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))]
  = -5.77 N./mm^2
```

Bending Stress at Short-side 2 at Q Inner[SbsQi]:

```
  = P * h^2 * p * c / ( 12 * I11 ) *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))
  = 0.50 * 1370.00^2 * 65.00 * 20.56 / ( 12 * 20.28 ) *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))
  = 40.83 N./mm^2
```

Bending Stress at Short-side 2 at Q Outer[SbsQo]:

```
  = P * h^2 * p * c / ( 12 * I11 ) *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))
  = 0.50 * 1370.00^2 * 65.00 * -32.44 / ( 12 * 20.28 ) *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))
  = -64.40 N./mm^2
```

Bending Stresses at Long-side 1

Bending Stress at Long-side 1 at M Inner[SblMi]:

```
  = P * h^2 * p * c / ( 24 * I21 ) * [ -3 + 2 *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))]
  = 0.50 * 1370.00^2 * 65.00 * 20.56 / ( 24 * 20.28 ) * [ -3 + 2 *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))]
  = -36.48 N./mm^2
```

Bending Stress at Long-side 1 at M Outer[SblMo]:

```
  = P * h^2 * p * c / ( 24 * I21 ) * [ -3 + 2 *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))]
  = 0.50 * 1370.00^2 * 65.00 * -32.44 / ( 24 * 20.28 ) * [ -3 + 2 *
    (( 1 + 0.71^2 * 0.71 ) / ( 1 + 0.71 ))]
  = 57.54 N./mm^2
```

Bending Stress at Long-side 1 at Q Inner[SblQi]:

```
  = P * h^2 * p * c / ( 12 * I21 ) *
    (( 1 + Alpha1^2 * k ) / ( 1 + k ))
  = 0.50 * 1370.00^2 * 65.00 * 20.56 / ( 24 * 20.28 ) *
```

```
    (( 1 + 0.71² * 0.71 ) / ( 1 + 0.71 ))]
  = 40.83 N./mm^2
```

Bending Stress at Long-side 1 at Q Outer[SblQo]:

```
  = P * h² * p * c / ( 12 * I21 ) *
    (( 1 + Alpha1² * k ) / ( 1 + k ))
  = 0.50 * 1370.00² * 65.00 * -32.44 / ( 24 * 20.28 ) *
    (( 1 + 0.71² * 0.71 ) / ( 1 + 0.71 ))]
  = -64.40 N./mm^2
```

Bending Stresses at Long-side 2

Bending Stress at Long-side 2 at M Inner[SblMi]:

```
  = P * h² * p * c / ( 24 * I21 ) * [ -3 + 2 *
    (( 1 + Alpha1² * k ) / ( 1 + k ))]
  = 0.50 * 1370.00² * 65.00 * 20.56 / ( 24 * 20.28 ) * [ -3 + 2 *
    (( 1 + 0.71² * 0.71 ) / ( 1 + 0.71 ))]
  = -36.48 N./mm^2
```

Bending Stress at Long-side 2 at M Outer[SblMo]:

```
  = P * h² * p * c / ( 24 * I21 ) * [ -3 + 2 *
    (( 1 + Alpha1² * k ) / ( 1 + k ))]
  = 0.50 * 1370.00² * 65.00 * -32.44 / ( 24 * 20.28 ) * [ -3 + 2 *
    (( 1 + 0.71² * 0.71 ) / ( 1 + 0.71 ))]
  = 57.54 N./mm^2
```

Bending Stress at Long-side 2 at Q Inner[SblQi]:

```
  = P * h² * p * c / ( 12 * I21 ) *
    (( 1 + Alpha1² * k ) / ( 1 + k ))
  = 0.50 * 1370.00² * 65.00 * 20.56 / ( 24 * 20.28 ) *
    (( 1 + 0.71² * 0.71 ) / ( 1 + 0.71 ))]
  = 40.83 N./mm^2
```

Bending Stress at Long-side 2 at Q Outer[SblQo]:

```
  = P * h² * p * c / ( 12 * I21 ) *
    (( 1 + Alpha1² * k ) / ( 1 + k ))
  = 0.50 * 1370.00² * 65.00 * -32.44 / ( 24 * 20.28 ) *
    (( 1 + 0.71² * 0.71 ) / ( 1 + 0.71 ))]
  = -64.40 N./mm^2
```

BENDING STRESSES: Bending Stress Calculations per Section 13-8, Equations (5-8). (N./mm^2) :

STRESS LOCATIONS		Inner	Outer	Allowable
Short-side 1	at N	3.66	-5.77	104.07
	at Q	40.83	-64.40	104.07
Short-side 2	at N	3.66	-5.77	104.07
	at Q	40.83	-64.40	104.07
Long-side 1	at M	-36.48	57.54	104.07
	at Q	40.83	-64.40	104.07
Long-side 2	at M	-36.48	57.54	104.07
	at Q	40.83	-64.40	104.07

Total Stress Calculations per Section 13-8

Total Stresses at Short-side 1

Total Stress at short side 1 at N inner [STS_Ni]:

```
  = Sms + SbsNi
  = 3.20 + 3.66
  = 6.86 N./mm^2
```

Total Stress at short side 1 at N outer [STS_No]:

```
  = Sms + SbsNo
  = 3.20 + -5.77
  = -2.56 N./mm^2
```

Total Stress at short side 1 at Q inner [STS_Qi]:
```
  = Smsc + SbsQi
  = 3.20 + 40.83
  = 44.04 N./mm^2
```

Total Stress at short side 1 at Q outer [STS_Qo]:
```
  = Smsc + SbsQo
  = 3.20 + -64.40
  = -61.20 N./mm^2
```

Total Stresses at Short-side 2

Total Stress at short side 2 at N inner [STS_Ni]:
```
  = Sms + SbsNi
  = 3.20 + 3.66
  = 6.86 N./mm^2
```

Total Stress at short side 2 at N outer [STS_No]:
```
  = Sms + SbsNo
  = 3.20 + -5.77
  = -2.56 N./mm^2
```

Total Stress at short side 2 at Q inner [STS_Qi]:
```
  = Smsc + SbsQi
  = 3.20 + 40.83
  = 44.04 N./mm^2
```

Total Stress at short side 2 at Q outer [STS_Qo]:
```
  = Smsc + SbsQo
  = 3.20 + -64.40
  = -61.20 N./mm^2
```

Total Stresses at Long-side 1

Total Stress at long side 1 at M inner [STL_Mi]:
```
  = SmlA + SblMi
  = 2.22 + -36.48
  = -34.26 N./mm^2
```

Total Stress at long side 1 at M outer [STL_Mo]:
```
  = SmlA + SblMo
  = 2.22 + 57.54
  = 59.76 N./mm^2
```

Total Stress at long side 1 at Q inner [STL_Qi]:
```
  = Smlc + SblQi
  = 2.22 + 40.83
  = 43.05 N./mm^2
```

Total Stress at long side 1 at Q outer [STL_Qo]:
```
  = Smlc + SblQo
  = 2.22 + -64.40
  = -62.18 N./mm^2
```

Total Stresses at Long-side 2

Total Stress at long side 2 at M inner [STL_Mi]:
```
  = SmlA + SblMi
  = 2.22 + -36.48
```

= -34.26 N./mm^2

Total Stress at long side 2 at M outer [STL_Mo]:
= SmlA + SblMo
= 2.22 + 57.54
= 59.76 N./mm^2

Total Stress at long side 2 at Q inner [STL_Qi]:
= Smlc + SblQi
= 2.22 + 40.83
= 43.05 N./mm^2

Total Stress at long side 2 at Q outer [STL_Qo]:
= Smlc + SblQo
= 2.22 + -64.40
= -62.18 N./mm^2

TOTAL STRESSES: Total Stress Calculations per Section 13-8, Equations (9-12). (N./mm^2) :

STRESS LOCATIONS	Inner	Outer	Allowable
Short-side 1 at N	6.86	-2.56	104.07
at Q	44.04	-61.20	104.07
Short-side 2 at N	6.86	-2.56	104.07
at Q	44.04	-61.20	104.07
Long-side 1 at M	-34.26	59.76	104.07
at Q	43.05	-62.18	104.07
Long-side 2 at M	-34.26	59.76	104.07
at Q	43.05	-62.18	104.07

Note: The following can be used for outer stress:

Short-side 1 at N, outer allowable	111.03 N./mm^2
Short-side 2 at N, outer allowable	111.03 N./mm^2
Long-side 1 at M, outer allowable	111.03 N./mm^2
Long-side 2 at M, outer allowable	111.03 N./mm^2
At Corner Q, outer allowable	111.03 N./mm^2

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	3.20	N./mm^2
High Stress Percentage	2.67	%
M.A.W.P. for Membrane Stresses	18.73	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-64.40	N./mm^2
High Stress Percentage	61.88	%
M.A.W.P. for Bending Stresses	0.81	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	-62.18	N./mm^2
High Stress Percentage	59.75	%
M.A.W.P. for Total Stresses	0.84	bars

Rectangular Vessel Results For Item 1 : A4

SUMMARY OF RESULTS:

MEMBRANE STRESS SUMMARY,

High Stress (Highest % of Allowable)	3.20	N./mm^2
High Stress Percentage	2.67	%
M.A.W.P. for Membrane Stresses	18.73	bars

BENDING STRESS SUMMARY,

High Stress (Highest % of Allowable)	-64.40	N./mm^2
High Stress Percentage	61.88	%
M.A.W.P. for Bending Stresses	0.81	bars

TOTAL STRESS SUMMARY,

High Stress (Highest % of Allowable)	-62.18	N./mm^2
High Stress Percentage	59.75	%
M.A.W.P. for Total Stresses	0.84	bars