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## **Piping Calculation per ASME B31.3-2008**

Drawing Description:  
Sample P&ID

Drawing Name:  
KEY-026 P&ID

**These are Sample Calculations,  
For Demonstration Purposes only.**

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Date: July 9, 2010

Project: KEY-026

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## Piping Calculations: Summary

Code of construction:	ASME B31.3-2008
Material:	316 Stainless (see BOM)
Design Pressure Internal:	90 psig
Operating Internal Pressure:	65 psig
Design Temperature:	150°F
Operating Temperature:	150°F
PWHT:	None
NDE:	100% Visual
Corrosion Allowance:	0"
Test Pressure:	135 psig

### Discussion & Conclusion:

#### Tube:

**1/2" Tubing:** The limiting MAWP is 2,576 PSI for the 1/2", given a Corrosion Allowance of 0.00". This is greater than the design pressure of 90 PSI.

**Acceptable**

#### Pipe:

**1/2" to 4" Pipe:** For piping in this size range, the limiting MAWP is 1,531 PSI for the 4.0"-Sch40, given a Corrosion Allowance of 0.00". This is greater than the design pressure of 90 PSI.

**Acceptable**

#### Fittings: Butt weld

All elbows, tees, bushings and similar fittings are ASME B16.9 compliant, and as such are subject to the pressure rating of pipe, which has been calculated and is acceptable. Furthermore, they are all CRN-registered for the province of installation.

**Acceptable**

#### Fittings: Olets

Olets are calculated conservatively per ASME B31.3-2006 on the following sheets as a Branch connection, per Figure 328.5.4D(1). All connections are acceptable for the design condition of 90 psi at 150F and no additional reinforcement is required beyond the external fillet weld that has been specified on the drawing notes.

**Acceptable**

#### Flanges:

All Flanges are B16.5 RFWN & bear a CRN from ABSA for Alberta. The pressure rating for A182 F316 @ 150F is 255 PSI, which is greater than the design pressure of 90 PSI.

**Acceptable**

**Pipe and Shell Calculation, B31.3, Rev.4.3**

Ref: ASME B31.3, 2008 Edition, para. 304.1

Item: **Item 1: 1/2" Sch.80**Design Temperature: 150FMaterial= A312 TP316

Do =	0.84	in, Outside Diameter
t =	0.147	in, Nominal wall thickness
CA =	0	in, Corrosion allowance
P =	90	psi, Design Pressure
S =	20000	psi, Allowable stress at temperature
E =	0.80	Longitudinal Efficiency
UTP =	0.125	Undertolerance Allowance, as a decimal
W =	1.00	Weld joint Reduction Factor (para 302.3.5(e))
Y =	0.4	Coefficient, Table 304.1.1

**Calculation of Variables**

UT=	0.018375	in, for $UT=t*UTP$
nt=	0.128625	in, for $nt=(t-CA-UT)$
Ri=	0.291375	in, for $Ri=Do/2-nt$
d=	0.58275	in, for $d=Ri*2$

**304.1.2: Straight Pipe under Internal Pressure, Minimum Required Thickness**

These values don't include corrosion allowance and any other mechanical allowances

$$t = \frac{PD}{2(SEW + PY)} \quad a \quad t_{3a} = 90 \cdot 0.84 / (2(20000 \cdot 0.8 \cdot 1 + 90 \cdot 0.4))$$

$$t = \frac{P(d + 2c)}{2[SEW - P(1 - Y)]} \quad b \quad t_{3b} = 90 \cdot (0.58275 + 2 \cdot 0) / (2(20000 \cdot 0.8 \cdot 1 - 90 \cdot (1 - 0.4)))$$

$$t_{3a} = 0.002 \text{ in}$$

$$t_{3b} = 0.002 \text{ in}$$

Check: Is  $\text{MAX}(t_{3a}, t_{3b}) \leq nt$ ? Yes  
 $\text{MAX}(0.002, 0.001) \leq 0.128$

**Therefore thickness is Acceptable**

$$\text{MAWP} = 5,584 \text{ psi}$$

**304.1.2 Check for applicability**

Conditions below are checked to ensure that the calculations performed above are applicable to the geometry and the pressure range. Additional verification would otherwise be required.

Diameter  $t_{min} < (Do/6)$  **Geometry is Acceptable**  
 Pressure  $P/(S \cdot E) < 0.385$  **Pressure Range is Acceptable**

**Pipe and Shell Calculation, B31.3, Rev.4.3**

Ref: ASME B31.3, 2008 Edition, para. 304.1

Item: **Item 2: 1" Sch.80**Design Temperature: 150FMaterial= A312 TP316

Do =	1.315	in, Outside Diameter
t =	0.179	in, Nominal wall thickness
CA =	0	in, Corrosion allowance
P =	90	psi, Design Pressure
S =	20000	psi, Allowable stress at temperature
E =	0.80	Longitudinal Efficiency
UTP =	0.125	Undertolerance Allowance, as a decimal
W =	1.00	Weld joint Reduction Factor (para 302.3.5(e))
Y =	0.4	Coefficient, Table 304.1.1

**Calculation of Variables**

UT=	0.022375	in, for $UT=t*UTP$
nt=	0.156625	in, for $nt=(t-CA-UT)$
Ri=	0.500875	in, for $Ri=Do/2-nt$
d=	1.00175	in, for $d=Ri*2$

**304.1.2: Straight Pipe under Internal Pressure, Minimum Required Thickness**

These values don't include corrosion allowance and any other mechanical allowances

$$t = \frac{PD}{2(SEW + PY)} \quad a \quad t_{3a} = 90 * 1.315 / (2(20000 * 0.8 * 1 + 90 * 0.4))$$

$$t_{3a} = \mathbf{0.004 \text{ in}}$$

$$t = \frac{P(d + 2c)}{2[SEW - P(1 - Y)]} \quad b \quad t_{3b} = 90 * (1.00175 + 2 * 0) / (2(20000 * 0.8 * 1 - 90 * (1 - 0.4)))$$

$$t_{3b} = \mathbf{0.003 \text{ in}}$$

Check: Is  $MAX(t_{3a}, t_{3b}) \leq nt$ ? Yes  
 $MAX(0.003, 0.002) \leq 0.156$

**Therefore thickness is Acceptable****MAWP= 4,213 psi****304.1.2 Check for applicability**

Conditions below are checked to ensure that the calculations performed above are applicable to the geometry and the pressure range. Additional verification would otherwise be required.

Diameter  $t_{min} < (Do/6)$  **Geometry is Acceptable**  
 Pressure  $P/(S*E) < 0.385$  **Pressure Range is Acceptable**

**Pipe and Shell Calculation, B31.3, Rev.4.3**

Ref: ASME B31.3, 2008 Edition, para. 304.1

Item: **Item 3: 2" Sch.80**Design Temperature: 150FMaterial= A312 TP316

Do =	2.375	in, Outside Diameter
t =	0.218	in, Nominal wall thickness
CA =	0	in, Corrosion allowance
P =	90	psi, Design Pressure
S =	20000	psi, Allowable stress at temperature
E =	0.80	Longitudinal Efficiency
UTP =	0.125	Undertolerance Allowance, as a decimal
W =	1.00	Weld joint Reduction Factor (para 302.3.5(e))
Y =	0.4	Coefficient, Table 304.1.1

**Calculation of Variables**

UT=	0.02725	in, for $UT=t*UTP$
nt=	0.19075	in, for $nt=(t-CA-UT)$
Ri=	0.99675	in, for $Ri=Do/2-nt$
d=	1.9935	in, for $d=Ri*2$

**304.1.2: Straight Pipe under Internal Pressure, Minimum Required Thickness**

These values don't include corrosion allowance and any other mechanical allowances

$$t = \frac{PD}{2(SEW + PY)} \quad a \quad t_{3a} = 90 * 2.375 / (2(20000 * 0.8 * 1 + 90 * 0.4))$$

$$t_{3a} = \mathbf{0.007 \text{ in}}$$

$$t = \frac{P(d + 2c)}{2[SEW - P(1 - Y)]} \quad b \quad t_{3b} = 90 * (1.9935 + 2 * 0) / (2(20000 * 0.8 * 1 - 90 * (1 - 0.4)))$$

$$t_{3b} = \mathbf{0.006 \text{ in}}$$

Check: Is  $MAX(t_{3a}, t_{3b}) \leq nt$ ? Yes  
 $MAX(0.006, 0.005) \leq 0.19$

**Therefore thickness is Acceptable****MAWP= 2,747 psi****304.1.2 Check for applicability**

Conditions below are checked to ensure that the calculations performed above are applicable to the geometry and the pressure range. Additional verification would otherwise be required.

Diameter  $t_{min} < (Do/6)$  **Geometry is Acceptable**  
 Pressure  $P/(S*E) < 0.385$  **Pressure Range is Acceptable**

### Pipe and Shell Calculation, B31.3, Rev.4.3

Ref: ASME B31.3, 2008 Edition, para. 304.1

Item: **Item 4: 3" Sch.40**

Design Temperature: 150F

Material= A312 TP316

Do =	3.5	in, Outside Diameter
t =	0.216	in, Nominal wall thickness
CA =	0	in, Corrosion allowance
P =	90	psi, Design Pressure
S =	20000	psi, Allowable stress at temperature
E =	0.80	Longitudinal Efficiency
UTP =	0.125	Undertolerance Allowance, as a decimal
W =	1.00	Weld joint Reduction Factor (para 302.3.5(e))
Y =	0.4	Coefficient, Table 304.1.1

#### Calculation of Variables

UT=	0.027	in, for $UT=t*UTP$
nt=	0.189	in, for $nt=(t-CA-UT)$
Ri=	1.561	in, for $Ri=Do/2-nt$
d=	3.122	in, for $d=Ri*2$

#### 304.1.2: Straight Pipe under Internal Pressure, Minimum Required Thickness

These values don't include corrosion allowance and any other mechanical allowances

$$t = \frac{PD}{2(SEW + PY)} \quad a \quad t_{3a} = 90 * 3.5 / (2(20000 * 0.8 * 1 + 90 * 0.4))$$

**t<sub>3a</sub> = 0.010 in**

$$t = \frac{P(d + 2c)}{2[SEW - P(1 - Y)]} \quad b \quad t_{3b} = 90 * (3.122 + 2 * 0) / (2(20000 * 0.8 * 1 - 90 * (1 - 0.4)))$$

**t<sub>3b</sub> = 0.009 in**

Check: Is MAX(t<sub>3a</sub>,t<sub>3b</sub>)<=nt? Yes  
 MAX(0.009, 0.008)<= 0.189

**Therefore thickness is Acceptable**

**MAWP= 1,806 psi**

#### 304.1.2 Check for applicability

Conditions below are checked to ensure that the calculations performed above are applicable to the geometry and the pressure range. Additional verification would otherwise be required.

Diameter  $t_{min} < (Do/6)$  **Geometry is Acceptable**  
 Pressure  $P / (S * E) < 0.385$  **Pressure Range is Acceptable**

**Pipe and Shell Calculation, B31.3, Rev.4.3**

Ref: ASME B31.3, 2008 Edition, para. 304.1

Item: **Item 5: 4" Sch.40**Design Temperature: 150FMaterial= A312 TP316

Do =	4.5	in, Outside Diameter
t =	0.237	in, Nominal wall thickness
CA =	0	in, Corrosion allowance
P =	90	psi, Design Pressure
S =	20000	psi, Allowable stress at temperature
E =	0.80	Longitudinal Efficiency
UTP =	0.125	Undertolerance Allowance, as a decimal
W =	1.00	Weld joint Reduction Factor (para 302.3.5(e))
Y =	0.4	Coefficient, Table 304.1.1

**Calculation of Variables**

UT=	0.029625	in, for $UT=t*UTP$
nt=	0.207375	in, for $nt=(t-CA-UT)$
Ri=	2.042625	in, for $Ri=Do/2-nt$
d=	4.08525	in, for $d=Ri*2$

**304.1.2: Straight Pipe under Internal Pressure, Minimum Required Thickness**

These values don't include corrosion allowance and any other mechanical allowances

$$t = \frac{PD}{2(SEW + PY)} \quad a \quad t_{3a} = 90 \cdot 4.5 / (2(20000 \cdot 0.8 \cdot 1 + 90 \cdot 0.4))$$

$$t_{3a} = \mathbf{0.013 \text{ in}}$$

$$t = \frac{P(d + 2c)}{2[SEW - P(1 - Y)]} \quad b \quad t_{3b} = 90 \cdot (4.08525 + 2 \cdot 0) / (2(20000 \cdot 0.8 \cdot 1 - 90 \cdot (1 - 0.4)))$$

$$t_{3b} = \mathbf{0.012 \text{ in}}$$

Check: Is  $MAX(t_{3a}, t_{3b}) \leq nt$ ? Yes  
 $MAX(0.012, 0.011) \leq 0.207$

**Therefore thickness is Acceptable****MAWP= 1,531 psi****304.1.2 Check for applicability**

Conditions below are checked to ensure that the calculations performed above are applicable to the geometry and the pressure range. Additional verification would otherwise be required.

Diameter  $t_{min} < (Do/6)$  **Geometry is Acceptable**  
 Pressure  $P/(S \cdot E) < 0.385$  **Pressure Range is Acceptable**

**Pipe and Shell Calculation, B31.3, Rev.4.3**

Ref: ASME B31.3, 2008 Edition, para. 304.1

Item: **Item 6: 1/2"x0.035" tube**Design Temperature: 150FMaterial= A269 TP316

Do =	0.5	in, Outside Diameter
t =	0.035	in, Nominal wall thickness
CA =	0	in, Corrosion allowance
P =	90	psi, Design Pressure
S =	20000	psi, Allowable stress at temperature
E =	1.00	Longitudinal Efficiency
UTP =	0.125	Undertolerance Allowance, as a decimal
W =	1.00	Weld joint Reduction Factor (para 302.3.5(e))
Y =	0.4	Coefficient, Table 304.1.1

**Calculation of Variables**

UT=	0.004375	in, for $UT=t*UTP$
nt=	0.030625	in, for $nt=(t-CA-UT)$
Ri=	0.219375	in, for $Ri=Do/2-nt$
d=	0.43875	in, for $d=Ri*2$

**304.1.2: Straight Pipe under Internal Pressure, Minimum Required Thickness**

These values don't include corrosion allowance and any other mechanical allowances

$$t = \frac{PD}{2(SEW + PY)} \quad a \quad t_{3a} = 90 \cdot 0.5 / (2(20000 \cdot 1 \cdot 1 + 90 \cdot 0.4))$$

$$t_{3a} = \mathbf{0.001 \text{ in}}$$

$$t = \frac{P(d + 2c)}{2[SEW - P(1 - Y)]} \quad b \quad t_{3b} = 90 \cdot (0.43875 + 2 \cdot 0) / (2(20000 \cdot 1 \cdot 1 - 90 \cdot (1 - 0.4)))$$

$$t_{3b} = \mathbf{0.001 \text{ in}}$$

Check: Is  $MAX(t_{3a}, t_{3b}) \leq nt$ ? Yes  
 $MAX(0.001, 0.001) \leq 0.03$

**Therefore thickness is Acceptable****MAWP= 2,576 psi****304.1.2 Check for applicability**

Conditions below are checked to ensure that the calculations performed above are applicable to the geometry and the pressure range. Additional verification would otherwise be required.

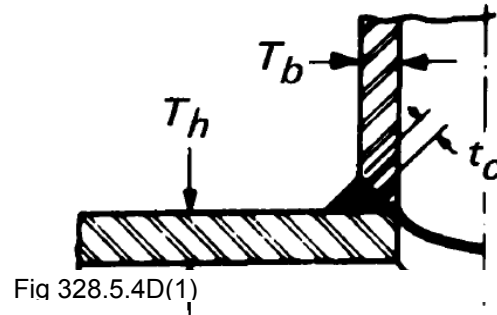
Diameter  $t_{min} < (Do/6)$  **Geometry is Acceptable**  
 Pressure  $P/(S \cdot E) < 0.385$  **Pressure Range is Acceptable**

**Branch Reinforcement, B31.3, ver.3.3**

ASME B31.3, 2008 Edition, para. 304.3

Item: **Item 8: 1" Thredoilet on 2"****For Header/Run:**

Material=	A312 TP316	
P =	90	psi, system design pressure
Do =	2.375	in, outside diameter of header/run
Th =	0.218	in, wall thickness
S =	20,000	psi, allowable stress
E =	1	efficiency of header at branch
UTP =	0.125	undertolerance, as a decimal
Y =	0.4	Y, Table 304.1.1
CA=	0	in, corrosion allowance.
W=	1	Weld joint strength reduction factor

**For Branch:**

Material=	A403 WP316	
Do =	1.315	in, outside diameter of branch
Tb =	0.179	in, wall thickness
S =	20,000	psi, allowable stress
E =	1	efficiency of nozzle shell
UTP =	0.125	undertolerance, as a decimal
Y =	0.4	Y, Table 304.1.1
CA=	0	in, corrosion allowance.
B=	90	degrees, nozzle angle
Weld=	0.1875	in, External Fillet weld leg size

External fillet size is Acceptable

Please note the following limitations on the applicability of these equations;

(b) The rules in paras. 304.3.2 through 304.3.4 are minimum requirements, valid only for branch connections in which (using the nomenclature of Fig. 304.3.3):

- (1) the run pipe diameter-to-thickness ratio ( $D_h/T_h$ ) is less than 100 and the branch-to-run diameter ratio ( $D_b/D_h$ ) is not greater than 1.0
- (2) for run pipe with  $D_h/T_h \geq 100$ , the branch diameter,  $D_b$ , is less than one-half the run diameter,  $D_h$ ;
- (3) angle is at least 45 deg
- (4) the axis of the branch intersects the axis of the run.

**Calculation of Variables**

T, header=	0.191 in, actual thickness with undertolerance removed.
T, branch=	0.157 in, actual thickness with undertolerance removed.
L4=	0.393 in, height of reinforcement zone outside of run pipe
d1=	1.001 in, effective length removed from pipe at branch
d2=	1.001 in, half width of reinforcement zone
tc=	0.125 in, minimum weld throat requirement
Leg41=	0.177 in, Minimum weld leg requirement

**Required Pipe Thicknesses:**

t, header=	$90 \cdot 2.375 / (2 \cdot (20000 \cdot 1 + 90 \cdot 0.4))$	0.005 in, required header thickness, for pressure
t, branch=	$90 \cdot 1.315 / (2 \cdot (20000 \cdot 1 + 90 \cdot 0.4))$	0.003 in, required branch thickness, for pressure

**Area calculations:**

A1=	$0.0053 \cdot 1.001 \cdot (2 \cdot \sin(90/180 \cdot 3.14))$	0.005 sq.in, Reinforcement area required
A2=	$(2 \cdot 1.001 - 1.001) \cdot (0.19075 - 0.0053 - 0)$	0.186 sq.in, Reinf. Area available in run pipe wall
A3=	$2 \cdot 0.3925 \cdot (0.157 - 0.003 - 0) / \sin(90/180 \cdot 3.14)$	0.121 sq.in, Reinf. Area available in branch pipe wall

$$A4 = 2 * 0.5 * 0.1875^2$$

0.035 sq.in, Reinf. Area due to welds and other reinforcement

In order for the joint to be acceptable:

Area Required, A1 <= Area Available, A2+A3+A4

$$0.005 <= (0.186 + 0.121 + 0.035 = 0.3417)$$

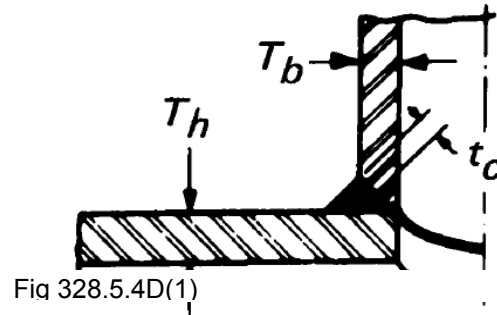
**ACCEPTABLE, NO ADDITIONAL REINFORCEMENT REQUIRED**

**Branch Reinforcement, B31.3, ver.3.3**

ASME B31.3, 2008 Edition, para. 304.3

Item: **Item 9: 1" Thredoilet on 3"****For Header/Run:**

Material=	A312 TP316	
P =	90	psi, system design pressure
Do =	3.5	in, outside diameter of header/run
Th =	0.216	in, wall thickness
S =	20,000	psi, allowable stress
E =	1	efficiency of header at branch
UTP =	0.125	undertolerance, as a decimal
Y =	0.4	Y, Table 304.1.1
CA=	0	in, corrosion allowance.
W=	1	Weld joint strength reduction factor

**For Branch:**

Material=	A403 WP316	
Do =	1.315	in, outside diameter of branch
Tb =	0.179	in, wall thickness
S =	20,000	psi, allowable stress
E =	1	efficiency of nozzle shell
UTP =	0.125	undertolerance, as a decimal
Y =	0.4	Y, Table 304.1.1
CA=	0	in, corrosion allowance.
B=	90	degrees, nozzle angle
Weld=	0.1875	in, External Fillet weld leg size

External fillet size is Acceptable

Please note the following limitations on the applicability of these equations;

(b) The rules in paras. 304.3.2 through 304.3.4 are minimum requirements, valid only for branch connections in which (using the nomenclature of Fig. 304.3.3):

- (1) the run pipe diameter-to-thickness ratio ( $D_h/T_h$ ) is less than 100 and the branch-to-run diameter ratio ( $D_b/D_h$ ) is not greater than 1.0
- (2) for run pipe with  $D_h/T_h \geq 100$ , the branch diameter,  $D_b$ , is less than one-half the run diameter,  $D_h$ ;
- (3) angle is at least 45 deg
- (4) the axis of the branch intersects the axis of the run.

**Calculation of Variables**

T, header=	0.189 in, actual thickness with undertolerance removed.
T, branch=	0.157 in, actual thickness with undertolerance removed.
L4=	0.393 in, height of reinforcement zone outside of run pipe
d1=	1.001 in, effective length removed from pipe at branch
d2=	1.001 in, half width of reinforcement zone
tc=	0.125 in, minimum weld throat requirement
Leg41=	0.177 in, Minimum weld leg requirement

**Required Pipe Thicknesses:**

$$t, \text{ header} = 90 \cdot 3.5 / (2 \cdot (20000 \cdot 1 + 90 \cdot 0.4))$$

0.008 in, required header thickness, for pressure

$$t, \text{ branch} = 90 \cdot 1.315 / (2 \cdot (20000 \cdot 1 + 90 \cdot 0.4))$$

0.003 in, required branch thickness, for pressure

**Area calculations:**

$$A1 = 0.0079 \cdot 1.001 \cdot (2 \cdot \sin(90/180 \cdot 3.14))$$

0.008 sq.in, Reinforcement area required

$$A2 = (2 \cdot 1.001 - 1.001) \cdot (0.189 - 0.0079 - 0)$$

0.181 sq.in, Reinf. Area available in run pipe wall

$$A3 = 2 \cdot 0.3925 \cdot (0.157 - 0.003 - 0) / \sin(90/180 \cdot 3.14)$$

0.121 sq.in, Reinf. Area available in branch pipe wall

$$A4 = 2 * 0.5 * 0.1875^2$$

0.035 sq.in, Reinf. Area due to welds and other reinforcement

In order for the joint to be acceptable:

Area Required, A1 <= Area Available, A2+A3+A4

$$0.008 <= (0.181 + 0.121 + 0.035 = 0.3373)$$

**ACCEPTABLE, NO ADDITIONAL REINFORCEMENT REQUIRED**