

PIPE WALL THICKNESS CALCULATION

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ABSTRACT

This paper presents the pipe wall thickness calculation of piping system. The calculation will include off-plot piping and on-plot piping system which service including produced fluid, kill water, vent, casing gas condensate and chemical feed. The pipe wall thickness will be calculated and verified for each size, service and rating. The calculation is performed generally for all quadrant of piping system. Results of the calculation will be summarized and tabulated on this report.

Key word : wall thickness, piping

ABSTRAK

Makalah ini menampilkan perhitungan ketebalan dinding dari suatu sistem pemipaan. Perhitungan ini meliputi pipa-pipa yang berada diluar plot yang berada didalam plot yang pelayanannya mencakup: penghasil fluida, air pemadam, saluran, wadah kondensat gas dan zat kimia. Perhitungan dan verifikasi dari ketebalan dinding pipa dilakukan untuk tiap ukuran, macam pelayanan dan rating. Perhitungan dilakukan pada seluruh kwadran sistem pemipaan. Hasil perhitungan akan disimpulkan dan ditabelkan pada laporan ini.

Kata kunci: ketebalan dinding, pemipaan.

INTRODUCTION

Wall thickness verification will be performed in accordance with SP-PP-PI-002 Piping Specification and the design codes used for the piping system which consist of ASME B31.4 for off-plot piping system and ASME B31.3 for on-plot piping system.

Piping Design Parameter

Pipe design parameter for this report is classified in accordance with the service fluid and piping system location (off-plot or on-plot). The design parameter is as tabulated below.

Table 1. Produced Fluid Piping System (Off-Plot)

No	Description	Unit	Size / Rating		
			3" / 300#	4" / 300#	6" / 300#
1	Pipe Outside Diameter, D	in. (mm)	3.5 (88.9)	4.5 (114.3)	6.625 (16 8.3)
2	Pipe Material	-	API 5L Gr. B	API 5L Gr. B	API 5L Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)
4	Design Code	-	ASME B31.4	ASME B31.4	ASME B31.4
5	Design Pressure, P	Psig. (MPa)	665 (4.6)	665 (4.6)	665 (4.6)
6	Design Temperature	°F (°C)	250 (121,1)	250 (121,1)	250 (121,1)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)
8	Design Factor, F	-	0.72	0.72	0.72

Table 2. Produced Fluid Piping System (On-Plot)

No	Description	Unit	Size / Rating						
			2" / 150#	2" / 300#	3" / 300#	4" / 300#	8" / 300#	10" / 300#	20" / 300#
1	Pipe Outside Diameter, D	in. (mm)	2.375 (60.3)	2.375 (60.3)	3.5 (88.9)	4.5 (114.3)	8.625 (319.1)	10.75 (273.1)	20.00 (508)
2	Pipe Material	-	A 106 Gr. B	A 106 Gr. B	API 5L Gr. B	API 5L Gr. B	API 5L Gr. B	API 5L Gr. B	API 5L Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)
4	Design Code	-	ASME B31.3	ASME B31.3	ASME B31.3	ASME B31.3	ASME B31.3	ASME B31.3	ASME B31.3
5	Design Pressure, P	Psig. (MPa)	245 (1.7)	665 (4.6)	665 (4.6)	665 (4.6)	665 (4.6)	665 (4.6)	665 (4.6)
6	Design Temperature	°F (°C)	250 (121,1)	250 (121,1)	250 (121,1)	250 (121,1)	250 (121,1)	250 (121,1)	250 (121,1)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)

Table 3. Casing Gas Condensate Piping System (On-Plot)

No	Description	Unit	Size / Rating			
			4" / 150#	6" / 150#	10" / 150#	14" / 600#
1	Pipe Outside Diameter, D	in. (mm)	4.5 (114.3)	6.625 (168.3)	10.75 (273.1)	14 (355.6)
2	Pipe Material	-	API 5L Gr. B	API 5L Gr. B	API 5L Gr. B	API 5L Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)
4	Design Code	-	ASME B31.3	ASME B31.3	ASME B31.3	ASME B31.3
5	Design Pressure, P	Psig. (MPa)	245 (1.7)	245 (1.7)	245 (1.7)	1333 (9.2)
6	Design Temperature	°F (°C)	250 (121,1)	250 (121,1)	250 (121,1)	250 (121,1)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)

Table 4. Kill Water Piping System (On-Plot)

No	Description	Unit	Size / Rating			
			3/4" / 150#	2" / 300#	3" / 150#	4" / 150#
1	Pipe Outside Diameter, D	in. (mm)	1.05 (26.7)	2.375 (60.3)	3.5 (88.9)	4.5 (114.3)
2	Pipe Material	-	A 106 Gr. B	A 106 Gr. B	API 5L Gr. B	API 5L Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)
4	Design Code	-	ASME B31.3	ASME B31.3	ASME B31.3	ASME B31.3
5	Design Pressure, P	Psig. (MPa)	260 (1.8)	675 (4.7)	260 (1.8)	260 (1.8)
6	Design Temperature	°F (°C)	200 (93,3)	200 (93,3)	200 (93,3)	200 (93,3)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)

Table 5. Vent to Stack Piping System (On-Plot)

No	Description	Unit	Size / Rating		
			2" / 150#	8" / 150#	14" / 600#
1	Pipe Outside Diameter, D	in. (mm)	2.375 (60.3)	8.625 (319.1)	14 (355.6)
2	Pipe Material	-	A 106 Gr. B	API 5L Gr. B	API 5L Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)	35.000 (241.3)	35.000 (241.3)
4	Design Code	-	ASME B31.3	ASME B31.3	ASME B31.3
5	Design Pressure, P	Psig. (MPa)	260 (1.8)	260 (1.8)	1350 (9.3)
6	Design Temperature	°F (°C)	200 (93,3)	200 (93,3)	200 (93,3)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)	0,063 (1.5)	0,063 (1.5)

Table 6. Instrument Air Piping System (On-Plot)

No	Description	Unit	Size / Rating
			1" / 150#
1	Pipe Outside Diameter, D	in. (mm)	1.315 (33.4)
2	Pipe Material	-	A 106 Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)
4	Design Code	-	ASME B31.3
5	Design Pressure, P	Psig. (MPa)	260 (1.8)
6	Design Temperature	°F (°C)	200 (93,3)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)

Table 7. Chemical Feed Piping System (On-Plot)

No	Description	Unit	Size / Rating
			3/4" / 150#
1	Pipe Outside Diameter, D	in. (mm)	1.05 (26.7)
2	Pipe Material	-	A 106 Gr. B
3	Specified Minimum Yield Strength, SMYS	psi. (MPa)	35.000 (241.3)
4	Design Code	-	ASME B31.3
5	Design Pressure, P	Psig. (MPa)	260 (1.8)
6	Design Temperature	°F (°C)	200 (93,3)
7	Corrosion Allowance	in. (mm)	0,063 (1.5)

Design Factor

Design factor used on the design of the off-plot piping system with hydrocarbon liquid service is 0.72 in accordance with ASME B31.4 para. 402.3.1. While factors used on the design of the on-plot piping system shall refer to ASME B31.3 Process Piping.

SMYS = Specified Min. Yield Strength, psi

Design Formula for On-Plot Piping System Minimum required pipe wall thickness for on-plot piping system shall be defined based on the design pressure using formula presented below:

STEEL PIPE DESIGN FORMULA

Design Formula for Off-Plot Piping System Minimum required pipe wall thickness for off-plot piping system shall be defined based on the design pressure using formula presented below:

$$t_n = \frac{P_i D}{2S} + A \dots\dots\dots(1)$$

And $S = 0.72 \cdot E \cdot SMYS$

Where:

- t_n = Nominal wall thickness required, in
- P_i = Internal design pressure, psig
- D = Outside diameter of pipe, in
- S = Applicable allowable stress value, psi
- A = Sum of allowances, in
- E = Weld joint factor

$$t_m = \frac{PD}{2(SE + PY)} + c \dots\dots(2)$$

- t_m = Minimum required wall thickness, in
- P = Internal design pressure, psig
- D = Outside diameter of pipe, in
- S = Stress value for material, psi
- c = Sum of allowances, in
- E = Quality factor
- Y = Coefficient that takematerial properties and design temperature into account.

RESULTS

From the above definition and calculation presented on attachment 1 of this report, the result of pipe wall thickness verification is as tabulated below.

SUMMARY

The result of calculation and verification, it can be summarized as follows:

- All off-plot piping system wall thickness have been verified in accordance with the required calculated pipe wall thickness.
- Several pipe size & rating for specific service at on-plot piping system are not meet the required calculated thickness. The proposed wall thickness which may be used to substitute the pipe wall thickness is as tabulated on 5.2.
- Technical notes/addendum shall be made on SP-PP-PI-002 Piping Specification, to accommodate the recommended wall thickness, in accordance with this calculation report.

REFERENCES

- [1]. PT. CPI.2002.SP-PP-PI-002 *Piping Specification (Including Piping Material Spec Sheet & Valve Spec Sheet)*.
- [2]. American Soceity Of Mechanical Engineer.2005.ASME B31.4 *Pipeline Transportation Systems for Hydrocarbons and Other Liquids. Liquid.*
3. American Soceity Of Mechanical Engineer.2005. ASME B31.3 *Process Piping.*
- 4.. American Soceity Of Mechanical Engineer.2005. ASME II Part D *Materials.*

Table 8. Off-Plot Piping System

No	Outside Diameter (D), in	Rating	Design Code	Design Pressue (P), psig	Desin Temp., °F	Corrosion Allow., in	SMYS, psi	Thick. Req'd (t _r), in	Thick. Selected (T), in	Wall Thick. Ver.	Remarks
1	3.5	300#	ASME B31.4	665	250	0.063	35000	0.109	0.216	OK	
2	4.5	300#	ASME B31.4	665	250	0.063	35000	0.122	0.237	OK	
3	6.625	300#	ASME B31.4	665	250	0.063	35000	0.150	0.280	OK	

Table 9. On-Plot Piping System

No.	Outside Diameter (D), in	Rating	Design Code	Design Pressure (P), psig	Design Temp., °F	Corrosion Allow., in	Thick. Req'd (t _r), in	Thick. Selected (T), in	Wall Thick. Ver.	Remarks
Produced Fluid										
1	2.375	150#	ASME B31.3	245	250	0.063	0.081	0.154	OK	
2	2.375	300#	ASME B31.3	665	250	0.063	0.112	0.154	OK	
3	3.5	300#	ASME B31.3	665	250	0.063	0.125	0.216	OK	
4	4.5	300#	ASME B31.3	665	250	0.063	0.143	0.237	OK	
5	8.625	300#	ASME B31.3	665	250	0.063	0.217	0.250	OK	
6	10.75	300#	ASME B31.3	665	250	0.063	0.254	0.250	Not OK	Use 0.307" WT
7	20	300#	ASME B31.3	665	250	0.063	0.419	0.375	Not OK	Use 0.5" WT
Casing Gas Condensate										
1	1.05	150#	ASME B31.3	245	250	0.063	0.093	0.237	OK	
2	2.375	150#	ASME B31.3	245	250	0.063	0.107	0.280	OK	
3	3.5	150#	ASME B31.3	245	250	0.063	0.134	0.250	OK	
4	4.5	600#	ASME B31.3	1333	250	0.063	0.556	0.500	Not OK	Use 0.593" WT
Kill Water										
1	1.05	150#	ASME B31.3	260	200	0.063	0.107	0.154	OK	
2	2.375	300#	ASME B31.3	1350	200	0.063	0.162	0.154	Not OK	Use 0.218" WT
3	3.5	150#	ASME B31.3	260	200	0.063	0.188	0.216	OK	
4	4.5	150#	ASME B31.3	260	200	0.063	0.223	0.237	OK	
Vent to Stack										

No.	Outside Diameter (D), in	Rating	Design Code	Design Pressure (P), psig	Design Temp., °F	Corrosion Allow., in	Thick. Req'd (t _n), in	Thick. Selected (T), in	Wall Thick. Ver.	Remarks
1	2.375	150#	ASME B31.3	260	200	0.063	0.082	0.154	OK	
2	8.625	150#	ASME B31.3	260	200	0.063	0.124	0.250	OK	
3	14	600#	ASME B31.3	1350	200	0.063	0.562	0.500	Not OK	Use 0.593" WT
Instrument Air										
1	1.315	150#	ASME B31.3	260	200	0.063	0.074	0.179	OK	
Chemical Feed										
1	1.05	150#	ASME B31.3	260	200	0.063	0.072	0.154	OK	