 TORUS	PIPE WALL THICKNESS, HOOP STRESS AND BURIED LATERAL EXTERNAL LOADS					Document No.	MEC-CAL-001
						Revision / Date	A · September 29, 2026
						Issue purpose	Issued for Review
MECHANICAL · PIPE WALL THICKNESS, HOOP STRESS AND BURIED LATERAL EXTERNAL LOADS							
Rev.	Date	Revision description	Prepared	Reviewed	Approved		
A	2026-09-29	Issued for Review					

OBJECTIVE AND METHOD

This calculation confirms the wall thickness of every pipe size in piping classes A6, A1, D1 and S1 against the steel pipe design formula of 49 CFR 192.105 and ASME B31.8 841.1.1, and reports the hoop stress of each size at design pressure and at hydrostatic test pressure. It then checks the buried 12 in outlet lateral 12”-G-1042-A6, where it crosses under internal road R-3, for earth load, H20 wheel load, effective stress and fatigue by the method of API RP 1102, and checks the two buried fuel gas lines under roads.

The design factor is F = 0.50 for all station piping and for the buried lateral. This is the meter and regulator station factor of ASME B31.8 Table 841.1.6-2 and is at least as conservative as 49 CFR 192.111 for the station's class location, so one factor covers every line. Hoop stress is calculated on nominal wall, which is the code basis; neither 49 CFR 192 nor B31.8 deducts mill tolerance. Every number on this sheet was calculated by TORUS from the inputs in Table 1-2 and checked independently.

REFERENCE DOCUMENTS

The codes and project documents in Table 1-1 govern the calculation.

Table 1-1: Reference Documents

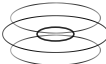
No.	Document
1	49 CFR Part 192, 192.105 design formula for steel pipe, 192.111 design factor, 192.113 longitudinal joint factor, 192.115 temperature derating factor, 192.619 maximum allowable operating pressure
2	ASME B31.8-2022, Gas Transmission and Distribution Piping Systems: 841.1.1 steel pipe design formula, Table 841.1.6-2 design factors for steel pipe construction, 841.3 testing after construction
3	API RP 1102, Steel Pipelines Crossing Railroads and Highways, 7th Edition (2007, reaffirmed): Figures 3, 14 and 17, effective stress and fatigue criteria
4	API Specification 5L, 46th Edition (2018), Line Pipe; ASTM A106, ASTM A312; ASME B36.10M-2018 and B36.19M-2018, pipe dimensions
5	[redacted] GEN-DB-001, Basis of Design; [redacted] GEN-RPT-002, Design Decisions Register
6	[redacted] PIP-SPC-001, Piping Material Specification; [redacted] MEC-LST-001, Line List
7	[redacted] MEC-CAL-003, Hydrostatic Test Calculation; [redacted] SPC-SPC-011, Hydrostatic Testing, Dewatering and Drying
8	[redacted] MEC-CAL-006, Flange, Gasket and Bolting, and Pressure-Temperature Rating Checks
9	[redacted] PIP-DWG-004, [redacted] Tie-in and Outlet Lateral 1042 Plan and Profile; [redacted] PIP-DWG-015, Isometric Line 1042; [redacted] CIV-CAL-003, Access and Internal Roads

INPUTS

Table 1-2 lists the inputs with the symbols used in the equations. Values taken from another project document name that document.

Table 1-2: Design Inputs

Input	Symbol	Value	Unit	Source
Design pressure, class A6 (station MAOP)	P	1,440	psig	[redacted] GEN-DB-001
Design pressure, classes A1 and D1 (Class 150, Group 1.1, to 100 °F)	P	285	psig	[redacted] MEC-CAL-006
Design pressure, class S1 (Class 150, Group 2.1, -150 to 100 °F)	P	275	psig	[redacted] MEC-CAL-006
Design temperature, above grade / buried		-20 to 150 / 32 to 120	°F	[redacted] GEN-DB-001
Design factor	F	0.50		ASME B31.8 Table 841.1.6-2; [redacted] GEN-DB-001
Longitudinal joint factor (SMLS, ERW) and temperature derating factor (below 250 °F)	E , T	1.0, 1.0		49 CFR 192.113, 192.115
Corrosion allowance (dry sweet gas, coated and cathodically protected)		0	in	[redacted] GEN-DB-001
SMYS: API 5L X52 PSL2 / ASTM A106 Gr B / ASTM A312 TP304/304L dual certified	S	52,000 / 35,000 / 30,000	psi	API 5L, ASTM A106, ASTM A312
Hydrostatic test pressure at the high point: A6 / A1 and D1 / S1	P_{high}	2,160 / 430 / 415	psig	[redacted] MEC-CAL-003

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Input		Symbol	Value	Unit	Source	
Test water head			0.436	psi/ft	SPC-SPC-011	
A6 test high point (lines 1002 and 1003 over V-101) / low point (line 1042 at the tap)		z_{high} , z_{low}	1,164.3 / 1,145.1	ft EL	Piping model; MEC-CAL-003	
Class 150 test sections, high point to low point		Δz	10	ft	MEC-CAL-003	
Soil unit weight, lean clay (CL)		γ	120	lb/ft³	GEN-DB-001, HOLD H-07	
Modulus of soil reaction, trench backfill		E'	0.5	ksi	Assumed, Note 6	
Design wheel load, AASHTO H20 rear wheel, and contact area		P_w , A_p	16,000, 144	lb, in²	AASHTO; Note 7	
Pavement type factor, no pavement (road R-3 is aggregate surfaced); axle configuration factor		R , L	1.10, 1.00		API RP 1102; CIV-CAL-003	
Impact factor, highway, cover 5 ft or less		F_i	1.5		API RP 1102	
Burial factor, excavation factor, live load geometry factors		$B_e , E_e , G_{Hh} , G_{Lh}$	1.0		Note 6	
Steel modulus, thermal expansion coefficient, Poisson's ratio		E_s , α , ν	30 x 10 ⁶ , 6.5 x 10 ⁻⁶ , 0.30	psi, 1/°F, none	API RP 1102	
Installation temperature / buried operating range		T_1 / T_2	60 / 32 to 120	°F	Assumed / GEN-DB-001	
Fatigue endurance limits, girth weld and SMLS or ERW seam		S_{FG} , S_{FL}	12,000, 21,000	psi	API RP 1102, Note 8	
Minimum cover under road R-3 (evaluation depth)		H	4.13	ft	Table 1-5	

WALL THICKNESS AND HOOP STRESS

Table 1-3 gives the required wall of every size in each piping class from Eq. 1 and the wall selected. Table 1-4 gives the hoop stress of the selected wall at design pressure and at the hydrostatic test pressure at the high and low points of the test sections. NPS 12 in class A6 governs: it uses 94 % of its nominal wall and runs at 47.1 % SMYS at MAOP.

Table 1-3: Required and Selected Wall Thickness by Piping Class and Size

Class	NPS	Material	Outside diameter	SMYS	Design pressure	Required wall	Selected	Nominal wall	Excess wall
			D , in	S , psi	P , psig	t_{req} , in		t , in	in
		Input	ASME B36.10M	Input	Input	Eq. 1	Note 2	ASME B36.10M	$t - t_{req}$
A6	12	API 5L X52 PSL2	12.750	52,000	1,440	0.3531	STD	0.375	0.022
A6	10	API 5L X52 PSL2	10.750	52,000	1,440	0.2977	Sch 80	0.594	0.296
A6	8	API 5L X52 PSL2	8.625	52,000	1,440	0.2388	Sch 80	0.500	0.261
A6	4	API 5L X52 PSL2	4.500	52,000	1,440	0.1246	Sch 80	0.337	0.212
A6	3	API 5L X52 PSL2	3.500	52,000	1,440	0.0969	Sch 80	0.300	0.203
A6	2	ASTM A106 Gr B SMLS	2.375	35,000	1,440	0.0977	Sch 80	0.218	0.120
A6	1-1/2	ASTM A106 Gr B SMLS	1.900	35,000	1,440	0.0782	Sch 80	0.200	0.122
A6	1	ASTM A106 Gr B SMLS	1.315	35,000	1,440	0.0541	Sch 80	0.179	0.125
A6	3/4	ASTM A106 Gr B SMLS	1.050	35,000	1,440	0.0432	Sch 160	0.219	0.176
A6	1/2	ASTM A106 Gr B SMLS	0.840	35,000	1,440	0.0346	Sch 160	0.188	0.153
A1	8	ASTM A106 Gr B SMLS	8.625	35,000	285	0.0702	Sch 40	0.322	0.252
A1	4	ASTM A106 Gr B SMLS	4.500	35,000	285	0.0366	Sch 40	0.237	0.200
A1	3	ASTM A106 Gr B SMLS	3.500	35,000	285	0.0285	Sch 40	0.216	0.188
A1	2	ASTM A106 Gr B SMLS	2.375	35,000	285	0.0193	Sch 80	0.218	0.199
A1	1-1/2	ASTM A106 Gr B SMLS	1.900	35,000	285	0.0155	Sch 80	0.200	0.185

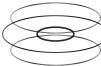
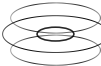
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Class	NPS	Material	Outside diameter	SMYS	Design pressure	Required wall	Selected	Nominal wall	Excess wall
A1	1	ASTM A106 Gr B SMLS	1.315	35,000	285	0.0107	Sch 80	0.179	0.168
A1	3/4	ASTM A106 Gr B SMLS	1.050	35,000	285	0.0086	Sch 160	0.219	0.210
A1	1/2	ASTM A106 Gr B SMLS	0.840	35,000	285	0.0068	Sch 160	0.188	0.181
D1	4	ASTM A106 Gr B SMLS	4.500	35,000	285	0.0366	Sch 80	0.337	0.300
D1	3	ASTM A106 Gr B SMLS	3.500	35,000	285	0.0285	Sch 80	0.300	0.271
D1	2	ASTM A106 Gr B SMLS	2.375	35,000	285	0.0193	Sch 80	0.218	0.199
D1	1	ASTM A106 Gr B SMLS	1.315	35,000	285	0.0107	Sch 80	0.179	0.168
D1	3/4	ASTM A106 Gr B SMLS	1.050	35,000	285	0.0086	Sch 160	0.219	0.210
S1	8	ASTM A312 TP304/304L SMLS	8.625	30,000	275	0.0791	Sch 40S	0.322	0.243
S1	4	ASTM A312 TP304/304L SMLS	4.500	30,000	275	0.0413	Sch 40S	0.237	0.196
S1	3	ASTM A312 TP304/304L SMLS	3.500	30,000	275	0.0321	Sch 40S	0.216	0.184
S1	2	ASTM A312 TP304/304L SMLS	2.375	30,000	275	0.0218	Sch 40S	0.154	0.132
S1	1	ASTM A312 TP304/304L SMLS	1.315	30,000	275	0.0121	Sch 80S	0.179	0.167
S1	3/4	ASTM A312 TP304/304L SMLS	1.050	30,000	275	0.0096	Sch 80S	0.154	0.144

Table 1-4: Hoop Stress at Design and Test Pressure by Piping Class and Size

Class	NPS	Nominal wall	Allowable design pressure	Hoop stress at design	Ratio at design	Ratio at test, high point	Ratio at test, low point	Pressure at 100 % SMYS
		t , in	P_{allow} , psig	S_H , psi	% SMYS	% SMYS	% SMYS	P_{100} , psig
		ASME B36.10M	Eq. 2	Eq. 3	Eq. 4	Eq. 3, 4	Eq. 5, 3, 4	Eq. 6
A6	12	0.375	1,529	24,480	47.1	70.6	70.9	3,059
A6	10	0.594	2,873	13,030	25.1	37.6	37.7	5,747
A6	8	0.500	3,014	12,420	23.9	35.8	36.0	6,029
A6	4	0.337	3,894	9,614	18.5	27.7	27.8	7,788
A6	3	0.300	4,457	8,400	16.2	24.2	24.3	8,914
A6	2	0.218	3,213	7,844	22.4	33.6	33.7	6,425
A6	1-1/2	0.200	3,684	6,840	19.5	29.3	29.4	7,368
A6	1	0.179	4,764	5,289	15.1	22.7	22.8	9,529
A6	3/4	0.219	7,300	3,452	9.9	14.8	14.9	14,600
A6	1/2	0.188	7,833	3,217	9.2	13.8	13.8	15,667
A1	8	0.322	1,307	3,817	10.9	16.5	16.6	2,613
A1	4	0.237	1,843	2,706	7.7	11.7	11.8	3,687
A1	3	0.216	2,160	2,309	6.6	10.0	10.1	4,320
A1	2	0.218	3,213	1,552	4.4	6.7	6.8	6,425
A1	1-1/2	0.200	3,684	1,354	3.9	5.8	5.9	7,368
A1	1	0.179	4,764	1,047	3.0	4.5	4.6	9,529
A1	3/4	0.219	7,300	683	2.0	2.9	3.0	14,600
A1	1/2	0.188	7,833	637	1.8	2.7	2.8	15,667
D1	4	0.337	2,621	1,903	5.4	8.2	8.3	5,242
D1	3	0.300	3,000	1,662	4.8	7.2	7.2	6,000
D1	2	0.218	3,213	1,552	4.4	6.7	6.8	6,425

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Class	NPS	Nominal wall	Allowable design pressure	Hoop stress at design	Ratio at design	Ratio at test, high point	Ratio at test, low point	Pressure at 100 % SMYS	
D1	1	0.179	4,764	1,047	3.0	4.5	4.6	9,529	
D1	3/4	0.219	7,300	683	2.0	2.9	3.0	14,600	
S1	8	0.322	1,120	3,683	12.3	18.5	18.7	2,240	
S1	4	0.237	1,580	2,611	8.7	13.1	13.3	3,160	
S1	3	0.216	1,851	2,228	7.4	11.2	11.3	3,703	
S1	2	0.154	1,945	2,121	7.1	10.7	10.8	3,891	
S1	1	0.179	4,084	1,010	3.4	5.1	5.1	8,167	
S1	3/4	0.154	4,400	938	3.1	4.7	4.8	8,800	

Note 1: A1 and D1 test columns use 430 psig at the high point and 430 + 0.436 x 10 = 434 psig at the low point; S1 uses 415 and 419 psig. The A6 low point is 2,168 psig (Eq. 5).

Note 2: The selected wall is the next standard wall at or above t_{req} , and not less than the mechanical-strength minimum of PIP-SPC-001 for small bore (Sch 160 at NPS 3/4 and under, Sch 80 at NPS 1 to 2 in A6, A1 and D1). NPS 10 Sch 80 is set by the meter bore, not by pressure. NPS 8 in A6 is the PR-101 kicker line 1101. S1 walls are the minimum practical stainless schedules for support spans, wind and blowdown reaction; pressure needs far less.

BURIED OUTLET LATERAL 12”-G-1042-A6

Line 1042 turns down at a 3R bend at the IJ-102 riser, (220, 160), and runs buried due north along X = 220 ft to the outboard flange of the receiving pipeline operator’s tap valve. It passes under internal road R-3 (Y = 170 to 190 ft) and the north fence at Y = 200 ft. The site access road does not cross the lateral, so road R-3, used by trucks and cranes, is the only traffic crossing, and its check also bounds construction traffic along the route. Table 1-5 gives the profile and cover.

Table 1-5: Profile and Cover of Line 1042 along X = 220 ft

Station Y	Pipe centerline	Ground	Cover to top of pipe	Location
ft	EL, ft	EL, ft	ft	
Piping model	Piping model	Grading plan	Eq. 19	
160	1145.92	1150.45	4.00	riser bend
165	1145.88	1150.47	4.06	
170	1145.84	1150.50	4.13	under road R-3
175	1145.80	1150.52	4.20	under road R-3
180	1145.76	1150.55	4.26	under road R-3
185	1145.72	1150.57	4.33	under road R-3
190	1145.67	1150.60	4.39	under road R-3
195	1145.63	1150.62	4.46	
200	1145.59	1150.65	4.53	north fence
205	1145.55	1150.67	4.59	
210	1145.51	1150.70	4.66	edge of graded pad
215	1145.47	1149.78	3.78	existing ground (HOLD H-02)
220	1145.43	1149.82	3.86	
225	1145.39	1149.86	3.94	
230	1145.35	1149.90	4.02	
235	1145.31	1149.94	4.10	receiving operator right-of-way
240	1145.27	1149.98	4.18	receiving operator right-of-way
245	1145.23	1150.02	4.26	receiving operator right-of-way
250	1145.18	1150.06	4.34	receiving operator right-of-way
255	1145.14	1150.10	4.43	tap valve flange

Note 1: Minimum cover is 3.78 ft (45 in) just outside the graded pad, where existing ground is assumed (HOLD H-02); this meets the 36 in basis minimum. Minimum cover under road R-3 is 4.13 ft (50 in), which meets the 48 in basis minimum under roads.

Note 2: The tap-end elevation assumes a side tap at the trunk springline with 4 ft of cover over the trunk (HOLD H-04).

The lateral was first checked with the station wall, 0.375 in STD. Table 1-6 gives the earth and live load stresses under road R-3 for 0.375 in and for 0.500 in XS, and Table 1-7 combines them with internal pressure and the restrained thermal stress. The 0.375 in wall exceeds the effective stress limit of $F \cdot SMYS = 26,000$ psi in both the hot and the cold case. The 0.500 in wall passes with a ratio of 0.964.

Table 1-6: Line 1042 under Road R-3, API RP 1102 Earth and Live Load Stresses (H = 4.13 ft)

Wall	Wall to diameter ratio	Earth load stiffness factor	Earth load stress	Impact factor	Wheel pressure	Live load stiffness factor, hoop	Cyclic hoop stress	Live load stiffness factor, longitudinal	Cyclic longitudinal stress
t , in	t/D	K_{He}	S_{He} , psi	F_i	w , psi	K_{Hh}	ΔS_{Hh} , psi	K_{Lh}	ΔS_{Lh} , psi
Input		RP 1102 Fig. 3	Eq. 7	RP 1102	Eq. 8	RP 1102 Fig. 14	Eq. 9	RP 1102 Fig. 17	Eq. 10
0.375 (STD)	0.0294	3,306	2,927	1.50	111.1	16.7	3,061	12.7	2,319
0.500 (XS)	0.0392	2,498	2,212	1.50	111.1	13.7	2,509	10.6	1,948

Table 1-7: Line 1042 under Road R-3, Principal and Effective Stress

Wall	Case	Operating temperature	Internal pressure stress	Circumferential	Longitudinal	Radial	Effective stress	Allowable	Ratio
t , in		T_2 , °F	S_{Hi} , psi	S_1 , psi	S_2 , psi	S_3 , psi	S_{eff} , psi	$F \cdot SMYS$, psi	$S_{eff}/(F \cdot SMYS)$
Input		Input	Eq. 11	Eq. 12	Eq. 13	Eq. 14	Eq. 15	Eq. 15	
0.375 (STD)	hot	120	23,760	29,748	-1,374	-1,440	31,155	26,000	1.198 (exceeds)
0.375 (STD)	cold	32	23,760	29,748	15,786	-1,440	27,059	26,000	1.041 (exceeds)
0.500 (XS)	hot	120	17,640	22,361	-3,796	-1,440	25,063	26,000	0.964 ()
0.500 (XS)	cold	32	17,640	22,361	13,364	-1,440	20,816	26,000	0.801 ()

Note 1: Hot case: pipe at 120 °F, installed at 60 °F, so the restrained thermal term is compressive. Cold case: pipe at 32 °F, thermal term tensile.

Note 2: With the API RP 1102 default single-axle wheel of 12,000 lb on a paved surface, the 0.375 in wall still reaches 30,556 psi in the hot case. Away from the road, with no live load at the minimum cover of 3.78 ft, it reaches 29,319 psi hot and 24,373 psi cold. Internal pressure at 47 % SMYS, earth load and the restrained thermal stress together exceed the limit over the whole buried length, so the heavier wall is needed for the full lateral and not only at the road.

Table 1-8 checks both walls for fatigue under the cyclic wheel load and gives the hoop stress of the lateral at MAOP and at the low-point hydrostatic test pressure. Both walls pass the fatigue limits with wide margin, so the effective stress alone sets the wall.

Table 1-8: Line 1042, Fatigue under Cyclic Wheel Load and Hoop Stress at MAOP and Hydrotest

Wall	Cyclic longitudinal stress	Girth weld limit	Cyclic hoop stress	Seam limit	Hoop stress at MAOP	Hoop stress at test, low point	Result
t , in	ΔS_{Lh} , psi	$S_{FG}F$, psi	ΔS_{Hh} , psi	$S_{FL}F$, psi	% SMYS	% SMYS	
Input	Eq. 10	Eq. 16	Eq. 9	Eq. 16	Eq. 3, 4	Eq. 5, 3, 4	
0.375 (STD)	2,319	6,000	3,061	10,500	47.1	70.9	Not adequate (effective stress)
0.500 (XS)	1,948	6,000	2,509	10,500	35.3	53.2	Adequate

As an independent check of the RP 1102 figure factors, Table 1-9 calculates the ring bending stress from a Boussinesq wheel pressure and a prism earth load with the Spangler (Iowa) formula, including pressure stiffening. The pressurized bending stress is of the same order as the RP 1102 sum of earth and cyclic hoop stress and below it, which confirms that the RP 1102 values are reasonable and conservative.

Table 1-9: Line 1042, Independent Ring-Bending Check (H = 4.13 ft)

Wall	Wheel pressure at crown	Earth pressure	Line load	Ring bending, pressurized	Ring bending, unpressurized	RP 1102 earth plus live hoop stress
t , in	p_{live} , psi	p_{earth} , psi	W , lb/in	S_b , psi	psi	$S_{He} + \Delta S_{Hh}$, psi
Input	Eq. 17	Eq. 17	Eq. 17	Eq. 18	Eq. 18, $P = 0$	Eq. 7, 9
0.375 (STD)	4.66	3.44	103.4	4,088	6,412	5,988
0.500 (XS)	4.66	3.44	103.4	2,897	3,570	4,721

Note 1: Bending constant $K_b = 0.235$ and deflection constant $K_z = 0.108$ (bedding angle 30°). The unpressurized value applies only to the empty pipe and does not govern.

Table 1-10 checks the two buried fuel gas lines at 48 in cover under the same H20 wheel. 2”-F-1051-A1 crosses under the B-101 spur road R-6; 1”-F-1052-A1 runs clear of roads along Y = 46 ft and is checked to cover construction traffic. Their wall-to-diameter ratios, 0.092 and 0.136, are beyond the range of the RP 1102 figures, so they are checked by ring bending (Note 9). Both are adequate at Sch 80, and their effective stress is governed by the restrained thermal term, not by traffic.

Table 1-10: Buried Fuel Gas Lines at 48 in Cover, H20 Wheel

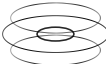
Line	Pipe	Wheel pressure at crown	Earth pressure	Ring bending, pressurized	Hoop stress	Effective stress, restrained 60 to 120 °F	Allowable
	$D \times t$, in	p_{live} , psi	p_{earth} , psi	S_b , psi	S_{Hi} , psi	S_{eff} , psi	$F \cdot SMYS$, psi
	ASME B36.10M	Eq. 17	Eq. 17	Eq. 18	Eq. 11	Eq. 15	Eq. 15
2”-F-1051-A1, under road R-6	2.375 x 0.218	5.0	3.3	629	1,410	12,320	17,500
1”-F-1052-A1, clear of roads	1.315 x 0.179	5.0	3.3	273	904	11,942	17,500

EQUATIONS

Table 1-11 lists the equations referenced in the Eq. rows of the calculated tables, with the code clause for each.

Table 1-11: Equations

Eq.	Equation	Reference
Eq. 1	$t_{req} = \frac{P D}{2 S F E T}$	49 CFR 192.105; ASME B31.8 841.1.1
Eq. 2	$P_{allow} = \frac{2 S t}{D} F E T$	49 CFR 192.105; ASME B31.8 841.1.1
Eq. 3	$S_H = \frac{P D}{2 t}$	Barlow, nominal wall
Eq. 4	$\% SMYS = 100 \frac{S_H}{S}$	Percent of SMYS
Eq. 5	$P_{low} = P_{high} + 0.436 (z_{high} - z_{low})$	ASME B31.8 841.3; SPC-SPC-011
Eq. 6	$P_{100} = \frac{2 S t}{D}$	Barlow at 100 % SMYS
Eq. 7	$S_{He} = K_{He} B_e E_e \gamma D$	API RP 1102, earth load
Eq. 8	$w = \frac{P_w}{A_p}$	API RP 1102, wheel pressure
Eq. 9	$\Delta S_{Hh} = K_{Hh} G_{Hh} R L F_i w$	API RP 1102, cyclic hoop stress
Eq. 10	$\Delta S_{Lh} = K_{Lh} G_{Lh} R L F_i w$	API RP 1102, cyclic longitudinal stress
Eq. 11	$S_{Hi} = \frac{P (D - t)}{2 t}$	API RP 1102, internal pressure
Eq. 12	$S_1 = S_{He} + \Delta S_{Hh} + S_{Hi}$	API RP 1102, circumferential principal stress
Eq. 13	$S_2 = \Delta S_{Lh} - E_s \alpha (T_2 - T_1) + \nu (S_{He} + S_{Hi})$	API RP 1102, longitudinal principal stress
Eq. 14	$S_3 = -P$	API RP 1102, radial principal stress
Eq. 15	$S_{eff} = \sqrt{\frac{1}{2} [(S_1 - S_2)^2 + (S_2 - S_3)^2 + (S_3 - S_1)^2]} \leq F \cdot SMYS$	API RP 1102, effective stress criterion
Eq. 16	$\Delta S_{Lh} \leq S_{FG} F, \quad \Delta S_{Hh} \leq S_{FL} F$	API RP 1102, fatigue criteria

 TORUS	[redacted] [redacted] · Owner PIPE WALL THICKNESS, HOOP STRESS AND BURIED LATERAL EXTERNAL LOADS		Document No.	MEC-CAL-001
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			Issue purpose	Issued for Review
MECHANICAL · PIPE WALL THICKNESS, HOOP STRESS AND BURIED LATERAL EXTERNAL LOADS				
Eq.	Equation		Reference	
Eq. 17	$p_{live} = \frac{3 P_w F_i}{2 \pi H^2}, \quad p_{earth} = \gamma H, \quad W = (p_{live} + p_{earth}) D$		Boussinesq point load; prism earth load	
Eq. 18	$S_b = \frac{6 K_b W E_s t r}{E_s t^3 + 24 K_z P r^3}, \quad r = \frac{D - t}{2}$		Spangler (Iowa) ring bending with pressure stiffening	
Eq. 19	$\text{cover} = EL_{ground} - \left(EL_{CL} + \frac{D}{24} \right)$		Top of pipe from the centerline, D in inches, elevations in ft	

NOTES

- The 0.500 in wall of line 1042 also serves the two 3R riser bends and the pup at the IJ-102 downstream weld. The joint between the 0.500 in lateral and the 0.375 in IJ-102 end is made with a 1:3 internal taper per ASME B31.8 Appendix I and ASME B16.25, or IJ-102 is supplied with a 0.500 in pup ([redacted] MEC-DS-008).
- The crossing of road R-3 is uncased. API RP 1102 permits an uncased crossing where the effective stress and fatigue checks pass, and a casing would complicate cathodic protection and add a shorted-casing risk. Abrasion-resistant overlay coating is applied across the road footprint, with warning tape and marker posts.
- Civil maintains 48 in minimum cover under road R-3 and 36 in elsewhere in the final grading and ditch design, including under the north interceptor ditch where it crosses the lateral near Y = 218 ft. If surveyed existing ground outside the pad gives less than 36 in, the lateral is lowered (HOLD H-02).
- Minimum cover under road R-3 from this profile is 4.13 ft; [redacted] CIV-CAL-003 reports 4.03 ft at the crossing. Both exceed 48 in; the survey will confirm the final value.
- The A6 test window is set by the Class 600 flange limit of 2,220 psig ([redacted] MEC-CAL-006), not by pipe yield. Every size stays below 71 % SMYS at test, and the NPS 12 STD wall would reach 100 % SMYS only at 3,059 psig. At a wall 12.5 % below nominal, NPS 12 would run at 53.8 % SMYS at MAOP; this is reported for information only.
- The API RP 1102 stiffness factors K_{He} , K_{Hh} and K_{Lh} were read from Figures 3, 14 and 17 for $E' = 0.5$ ksi by log interpolation. B_e , E_e , G_{Hh} and G_{Lh} are taken as 1.0 as an upper bound. The soil values depend on the geotechnical investigation (HOLD H-07). *Verification required before issue for construction: figure values and soil data.*
- The AASHTO H20 wheel of 16,000 lb exceeds the API RP 1102 default design wheels (12,000 lb single, 10,000 lb tandem) and covers the vacuum truck and crane traffic on road R-3. The axle configuration factor is taken as 1.0 for this single wheel.
- The endurance limits are the API RP 1102 values for girth welds and for SMLS or ERW longitudinal seams in X52. *Verification required against the pipe supplier's seam type.*
- The ring-bending check of the fuel gas lines uses Eq. 17 and Eq. 18 at 48 in cover; the effective stress uses Eq. 15 with $S_1 = S_{Hi} + S_b$, $S_2 = \nu S_{Hi} - E_s \alpha (120 - 60)$ and $S_3 = -P$.

RESULTS AND CONCLUSIONS

- Every wall in classes A6, A1, D1 and S1 meets 49 CFR 192.105 and ASME B31.8 841.1.1 at F = 0.50. NPS 12 STD (0.375 in) governs, at 47.1 % SMYS at MAOP, 70.6 % at the 2,160 psig high-point test and 70.9 % at the low point. With this wall the station piping could operate at 1,529 psig, 6.2 % above MAOP.
- Because the NPS 12 station headers run below 50 % SMYS, the branch reinforcement of [redacted] MEC-CAL-002 follows the ordinary rules of ASME B31.8 831.4.
- The buried lateral 12"-G-1042-A6 is 12.750 x 0.500 in API 5L X52 PSL2 for its full buried length, including the riser bends. The 0.375 in wall exceeds the API RP 1102 effective stress limit (ratio 1.198 hot, 1.041 cold). The 0.500 in wall gives 0.964 hot and 0.801 cold, passes the fatigue checks, and runs at 35.3 % SMYS at MAOP and 53.2 % at the low-point test pressure. The piping model, the isometric [redacted] PIP-DWG-015 and the material take-off carry 0.500 in.
- The road R-3 crossing is uncased (Note 2), and the buried fuel gas lines 1051 and 1052 are adequate at Sch 80.
- The open items are the geotechnical data (HOLD H-07), existing ground outside the pad (HOLD H-02), the trunk depth and tap geometry (HOLD H-04), and verification of the RP 1102 figure values before issue for construction.