BURIED PIPING COMPLIANCE ASSESSMENT TO AS 2566.1-1998

The calculation is applicable for De >= 75 , initial (3-min) ring bending stiffness >=1250 N/m/m and long-term (50 years) ring-bending stiffness >= 625 N/m/m.

Description of pipe under consideration

PIPE DIMENSIONS:

External Diameter	D_e	106.4	mm	
Internal Diameter	D_i	99.3	mm	
Minimum Wall Thickness	t	3.3	mm	
Mean pipe diameter for calculation	$D = D_i + t =$	102.6	mm	

PIPE MATERIAL: PE100

Minimum yield strength of pipe material (for steel only)	f_y	N/A	MPa	
Ring Bending Modulus (3 minutes)	E_b	950	MPa	Table 2.1
Ring Bending Modulus (3 minutes) (for GRP only)	E_b	120	MPa	
Ring Bending Modulus (50 years)	E_{bL}	260	MPa	Table 2.1
Ring Bending Modulus (50 years) (for GRP only)	E_{bL}	140	MPa	
Poisson's Ratio	ν	0.4		Table 2.1
Long-term safety factor for pressure	η_p	1.25		Table 2.1
Long-term safety factor for bending	η_b	2		Table 2.1
Long-term safety factor for combined stress	η	1.25		Table 2.1
Allowable long-term vertical pipe deflection for non-pressure	$\Delta_{yall} / D =$	7.5	%	Table 2.1
Allowable long-term ring-bending strain	ε_{ball}	4	%	Table 2.1
Allow. long-term hoop stress	σ_{hall}	8	MPa	Table 2.1
Allow. long-term hoop stress for GRP only	σ_{hall}	N/A	MPa	for the assigned pressure class
Allow. long-term hoop stress for steel only	$\sigma_{hall} = 0.72 f_y =$	N/A	MPa	
Allow. long-term hoop stress considered for calculation	σ_{hall}	8	MPa	
Ring Bending Modulus (3 minutes) for calculation	E_b	950	MPa	
Ring Bending Modulus (50 years) for calculation	E_{bL}	260	MPa	
Second moment of inertia of pipe wall	$I = t^3 / 12 =$	2.995E-09	m^3	Eq. 2.2.1.2
Ring bending stiffness (3-minutes)	$S_{DI} = E_b I / D^3 * 10^6 =$	2361.9	N/m/m OKAY	Eq 2.2.1.1 (1)
Ring bending stiffness (50 years)	$S_{DL} = E_{bL} I / D^3 * 10^6 =$	720.9	N/m/m OKAY	Eq 2.2.1.1 (2)

EMBEDMENT CHARACTERISTICS:

Selected native soil	CI			Table 3.2
	Fine-grained soil (LL<50%) with medium to no plasticity and containing less than 25% coarse-grained particles			
Selected embedment soil	GM-GL			Table 3.2
	Sand and coarse-graind soil with less than 12% fines			
Density index, Dry density ratio, number of blows	RD = 95%, ID = 70%, 24<NOB<=50			Table 3.2
Native soil modulus	E'_n	3	MPa	Table 3.2
Embedment soil modulus	E'_e	7	MPa	Table 3.2
Pipe external diameter range	75 <= De <= 150			Fig 3.1

Minimum Embedment Geometry :

Pipeline location from table	Subject to vehicular loading in sealed roadways			Table 3.1
Minumum cover height	H	0.6	m	Table 3.1
Depth of Bedding below the bottom of pipe	I_b	75	mm	Fig 3.1
Clearance	I_c	100	mm	Fig 3.1
Depth of Overlay	I_o	100	mm	Fig 3.1

The permanent trench width at springline	$B = D_e + 2\,l_c$ =	306.4	mm		Fig 3.1
Used Embedment Geometry :					
Cover Height	H	1.2	m	OKAY	
Depth of Bedding below the bottom of pipe	l_b	75	mm		
Clearance	l_c	96.8	mm		
Depth of Overlay	l_o	100	mm	OKAY	
The permanent trench width at springline	$B = D_e + 2\,l_c$ =	300	mm		
	B / D_e =	2.820			
Design Factor	$\Delta_f = [B/D_e - 1] / [1.154 + 0.444 (B/D_e - 1)]$ =	0.927			Eq. 3.4.3(3)
Leonhardt CF	$\zeta = 1.44 / [\Delta_f + (1.44 - \Delta_f) * (E'_e / E'_n)]$ =	0.678			Eq. 3.4.3(2)
Effective combined soil modulus	$E' = \zeta E'_e$ =	4.747	MPa		Eq. 3.4.3(1)
	7500 E' =	35603	N/m/m		Clause C1.4.6.2

Long-term ring bending stiffness,SDL is LESS than 7500E. Therefore the pipe is in the FLEXIBLE mode.'

	10 D =	1.026	m	H > 10 D	Clause 4.3

Cover height is greater than 10*D, therefore the design load due to trench may be conservative.

Assessed unit weight of trench fill or embankment fill	γ	19	KN/m^3		
The dead load due to trench fill or embankment fill	$w_g = \gamma H$ =	22.8	KN/m^2		Eq. 4.3
Superimposed uniformly distributed dead load	u	0	KN/m^2		Clause 4.6 (a)
Superimposed concentrated dead load	w_{gu}	0	KN/m^2		Clause 4.6 (b)
The total superimposed dead load	$w_{gs} = u + w_{gu}$ =	0	KN/m^2		
Internal vacuum	q_v	101.3	KN/m^2		Clause 4.5

Superimposed Live Loads (Road Vechiles)

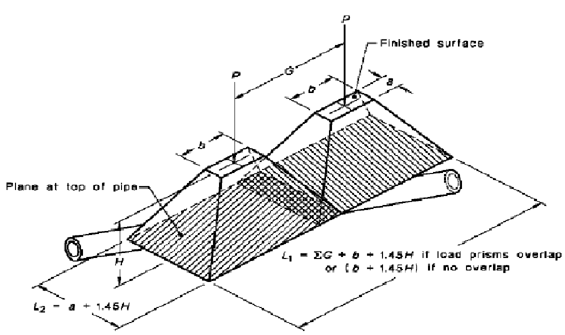

FIGURE 4.2 DISTRIBUTION OF WHEEL OR TRACK LOADS

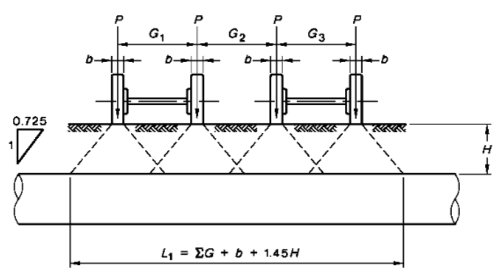

FIGURE C4.7 LOADS FROM VEHICLES IN ADJACENT LANES

Wheel Load (ΣP is the sum of the individual wheel loads)	P	70	KN
Contact area lengths under the wheels	a	0.2	m
	b	0.4	m
Single or dual axles (1 or 2)	sda	2	
Centreline Distance b/w dual axles	dda	1.2	m
Number of axles in adjacent lanes (1 or 2)	noa	1	
The distances b/w wheels from vechiles in adjacent lanes	G_1	0	m
	G_2	0	m
	G_3	1.4	m
	$L_1 = \Sigma G + b + 1.45\,H$ =	3.54	m
	$L_2 = dda + a + 1.45\,H$ =	3.14	m

Live load impact factor	α = 1.4 - 0.15 H =	1.22			Eq. 4.7.2(2)
Total superimposed wheel Live load	ΣP = 2* (noa + sda) * P =	420	KN		
Superimposed vechile live load	$w_q = \Sigma P$ / [L_1 * L_2] * α =	46.10	KN/m^2		Eq. 4.7.2(1)

DEFLECTION:

Bedding constant	K	0.1			Clause 5.2
	$w_g + w_{gs} + w_q$ =	68.90	KN/m^2		
	$\Delta y/D$ = [K /1000 * ($w_g+w_{gs}+w_q$)] / [8/1000000*S_{DL}+0.061 E'] =	2.33	%	PASS	Eq. 5.2(2)

The Defl. ratio is less than the acceptable, therefore the selected pipe and embedment are ADEQUATE in terms of deflection.

STRENGTH:

Shape factor					
	D_f = [3.33*1E-6 * S_{DL}/E'+0.00136]/[1.11*1E-6*S_{DL}/E'+0.000151] =	5.838			Eq. 5.3.1(3)
Outer surface of corrugated wall to the neutral axis	c_1	0.00165	m		Fig 1.2
Inner surface to the neutral axis	c_2	0.00165	m		Fig 1.2
Effective wall thickness of the pipe for the determination of ring bending strain	t_{es} = MAX(2 c_1, 2 c_2) =	0.0033	m		Clause 1.5 & Fig 1.2
	$\varepsilon_b = D_f * \Delta_y/D * t_{es} / D$ =	0.44	%	< ε_{ball}	Eq. 5.3.1(1)&(2)

The predicted long-term ring-bending strain is SATISFACTORY.

INTERNAL PRESSURE:

The maximum operating pressure	P_w	0.45	MPa	
The maximum allowable operating pressure	$P_{all} = 2\ \sigma_{hall}\ t / D$ =	0.51	MPa	Clause 1.5

The maximum operating pressure is less than the MAOP, therefore it is SATISFACTORY.

COMBINED LOADING:

Re-rounding coefficient

For P_w < = 3.0 MPa	$r_c = 1 - P_w /3$ =	0.85		Clause 5.3.3
For P_w > 3.0 MPa	r_c =	0		Clause 5.3.3
P_w <= 3.0 MPa thus	r_c =	0.85		
	$1 / \eta$ =	0.8		
	$P_w / (\eta_p P_{all}) + r_c * \varepsilon_b / (\eta_b \varepsilon_{ball})$ =	0.746	< $1 / \eta$	Eq. 5.3.3

The response to the combined external load and internal pressure is SATISFACTORY.

BUCKLING:

Design factor for buckling	F_s	2.50		
	$q_{all\ 1} = 1 / F_s * 24 / (1 - \nu^2) * S_{DL}$ * 1E-3 =	8.24	KPa	Eq. 5.4(4)
	$q_{all\ 2} = (S_{DL} * 1E-6)^{(1/3)} (E')^{(2/3)}$ * 1E3 / F_s =	101.31	KPa	Eq. 5.4(5)
	H	>=	0.5 m	
Allow. buckling pressure	q_{all} = greater of qall 1 and qall 2, =	101.31	KPa	Clause 5.4 (i) & (ii)

When q_v should be considered because it is critical

	$q_{all\ 1} = 1 / F_s * 24 / (1 - \nu^2) * S_{Dl}$ * 1E-3 =	26.99	KPa	Eq. 5.4(4) & NOTE

$q_{all\,2} = (S_{DI} * 1E\text{-}6)^{(1/3)} (E')^{(2/3)} * 1E3 / F_s =$ 150.46 KPa — Eq. 5.4(5) & NOTE

Allow. buckling pressure $q_{all} =$ greater of qall 1 and qall 2 = 150.46 KPa — Clause 5.4 (i) & (ii) & NOTE

Height of the water surface above the top of the pipe H_w 3.00 m

Where $H >= H_w$ $\gamma (H - H_w) + (\gamma_L+\gamma_{sub}) [D_e / 2 + H_w) + w_{gs} + w_q + q_v <= q_{all}$ — Eq. 5.4.1

Specific gravity of soil particles	γ_s	2.65		Clause 5.4 (a) NOTE
Assessed unit weight of liquid external to the pipe	γ_L	10	KN/m^3	for water

Submerged unit weight of trench fill or embankment fill

$\gamma_{sub} = (\gamma_s - 1) / \gamma_s * \gamma =$ 11.830 KN/m^3 — Eq. 5.4(2)

$q_v =$ 0 KPa

$\gamma (H - H_w) + (\gamma_L + \gamma_{sub}) [D_e / 2 + H_w) + w_{gs} + w_q + \cancel{q_v} =$ 78.549 KN/m^3 PASS — Eq. 5.4(1)

$q_v =$ 101.3 KPa

$\gamma (H - H_w) + (\gamma_L + \gamma_{sub}) [D_e / 2 + H_w) + w_{gs} + w_q + q_v =$ 179.849 KN/m^3 FAIL — Eq. 5.4(1)

Where $H < H_w$ $\gamma_L (D_e / 2 - H_w) + \gamma_{sub} (D_e / 2 + H) + w_{gs} + w_q + q_v <= q_{all}$ — Eq. 5.4(3)

$q_v =$ 0 KPa

$\gamma_L (D_e / 2 - H_w) + \gamma_{sub} (D_e / 2 + H) + w_{gs} + w_q + \cancel{q_v} =$ 91.455 KN/m^3 PASS — Eq. 5.4(3)

$q_v =$ 101.3 KPa

$\gamma_L (D_e / 2 - H_w) + \gamma_{sub} (D_e / 2 + H) + w_{gs} + w_q + q_v =$ 192.755 KN/m^3 FAIL — Eq. 5.4(3)