Design Requirements for CIPP Liners

Thickness Requirements for CIPP Circular Liners

Table 1a*

Design Parameters					Thickness Requirements by Invert Depth (mm)	
	Nominal Host Pipe Dimensions	Maximum Host Pipe Dimensions			Invert Depth = 7 m (Design thickness shall be the greater of Eq. 1 & Eq. 2)	
Shape	**Diameter (mm)**	**Diameter (mm)**	**Deterioration State**	**Live Load Model**	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)
Circular	1500	1600	Partially Deteriorated	N/A	$t = 141.64S_L^{-0.476}$	$t = 337.73E_L^{-0.327}$

*Table 1a only applicable to circular sewers to be lined with CIPP

t = design thickness (mm) S_L = Long Term Flexural Strength (MPa) E_L = Long Term Flexural Modulus (MPa)

Design Method:	ASTM F1216 -16
Applicable Long Term Flexural Strength:	15.5 MPa - 100 MPa
Applicable Long Term Flexural Modulus:	862 MPa - 4000 MPa
Ovality of Host Pipe:	6.50%
Soil Density:	18.85 kN/m^3
Modulus of Soil Reaction:	6.890 MPa
Water Table Depth:	2.0 m below ground elevation
Factor of Safety on Applied Stresses:	2

Thickness Requirements for CIPP Egg Shaped Liners

Table 1b*

							Thickness Requirements by Invert Depth (mm)							
	Nominal Dimensions		Maximum Dimensions				Invert Depth = 6 m (Design thickness shall be the greater of Eq. 1 & Eq. 2)		Invert Depth = 6.1 m (Design thickness shall be the greater of Eq. 1 & Eq. 2)		Invert Depth = 8.2 m (Design thickness shall be the greater of Eq. 1 & Eq. 2)		Invert Depth = 8.6 m (Design thickness shall be the greater of Eq. 1 & Eq. 2)	
Shape	**Height (mm)**	**Width (mm)**	**Height (mm)**	**Width (mm)**	**Deterioration State**	**Live Load Model**	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)
Egg	1500	1000	1600	1100	Fully Deteriorated	AASHTO HS25	N/A	N/A	$t = 186.49S_L^{-0.479}$	$t = 353.71E_L^{-0.320}$	N/A	N/A	N/A	N/A
Egg	1500	1000	1600	1100	Partially Deteriorated	N/A	$t = 150.47S_L^{-0.483}$	$t = 305.86E_L^{-0.322}$	N/A	N/A	N/A	N/A	N/A	N/A
Egg	1700	1100	1800	1200	Partially Deteriorated	N/A	N/A	N/A	N/A	N/A	$t = 204.17S_L^{-0.480}$	$t = 390.96E_L^{-0.320}$	$t = 209.91S_L^{-0.479}$	$t = 398.07E_L^{-0.320}$

*Table 1b only applicable to egg shaped sewers to be lined with CIPP

t = design thickness (mm) S_L = Long Term Flexural Strength (MPa) E_L = Long Term Flexural Modulus (MPa)

Design Method:	WRc Sewerage Rehabilitation Manual, Type 2 Design
Applicable Long Term Flexural Strength:	15.5 MPa - 100 MPa
Applicable Long Term Flexural Modulus:	862 MPa - 4000 MPa
Lateral Earth Coefficient:	0.4
Soil Density:	18.85 kN/m^3
Modulus of Soil Reaction:	6.890 MPa
Assumed Water Table Depth:	2.0 m below ground elevation
Soil Stress Model:	Effective Stress
Factor of Safety on Applied Stresses:	2

Design Requirements for Unbonded GRP Liners (WRc Type 2)

Thickness Requirements for GRP Circular Liners

Table 2a*

Design Parameters					Thickness Requirements by Invert Depth (mm)	
	Nominal Host Pipe Dimensions	Maximum Host Pipe Dimensions			**Invert Depth = 7 m** (Design thickness shall be the greater of Eq. 1 & Eq. 2)	
Shape	**Diameter (mm)**	**Diameter (mm)**	**Deterioration State**	**Live Load Model**	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)
Circular	1500	1600	Partially Deteriorated	N/A	$t = 16$	$t = 282.46E_L^{-0.329}$

*Table 2a only applicable to circular sewers to be lined with WRc type 2 GRP

t = design thickness (mm) S_L = Long Term Flexural Strength (MPa) E_L = Long Term Flexural Modulus (MPa)

Design Method:	ASTM F1216-16
Applicable Long Term Flexural Strength:	15.5 MPa - 200 MPa
Applicable Long Term Flexural Modulus:	862 MPa - 7000 MPa
Soil Density:	18.85 kN/m^3
Modulus of Soil Reaction:	6.890 MPa
Water Table Depth:	2.0 m below ground elevation
Factor of Safety on Applied Stresses:	2

Thickness Requirements for GRP Egg Shaped Liners

Table 2b*

							Thickness Requirements by Invert Depth (mm)							
	Nominal Dimensions		Maximum Dimensions				**Invert Depth = 6 m** (Design thickness shall be the greater of Eq. 1 & Eq. 2)		**Invert Depth = 6.1 m** (Design thickness shall be the greater of Eq. 1 & Eq. 2)		**Invert Depth = 8.2 m** (Design thickness shall be the greater of Eq. 1 & Eq. 2)		**Invert Depth = 8.6 m** (Design thickness shall be the greater of Eq. 1 & Eq. 2)	
Shape	**Height (mm)**	**Width (mm)**	**Height (mm)**	**Width (mm)**	**Deterioration State**	**Live Load Model**	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)
Egg	1500	1000	1600	1100	Fully Deteriorated	AASHTO HS25	N/A	N/A	$t = 188.30S_L^{-0.482}$	$t = 290.48E_L^{-0.323}$	N/A	N/A	N/A	N/A
Egg	1500	1000	1600	1100	Partially Deteriorated	N/A	$t = 152.54S_L^{-0.487}$	$t = 249.94E_L^{-0.325}$	N/A	N/A	N/A	N/A	N/A	N/A
Egg	1700	1100	1800	1200	Partially Deteriorated	N/A	N/A	N/A	N/A	N/A	$t = 206.10S_L^{-0.483}$	$t = 317.72E_L^{-0.324}$	$t = 211.95S_L^{-0.482}$	$t = 326.91E_L^{-0.323}$

*Table 2b only applicable to egg shaped sewers to be lined with WRc type 2 GRP

t = design thickness (mm) S_L = Long Term Flexural Strength (MPa) E_L = Long Term Flexural Modulus (MPa)

Design Method:	WRc Sewerage Rehabilitation Manual, Type 2 Design
Applicable Long Term Flexural Strength:	15.5 MPa - 200 MPa
Applicable Long Term Flexural Modulus:	862 MPa - 7000 MPa
Lateral Earth Coefficient:	0.4
Soil Density:	18.85 kN/m^3
Modulus of Soil Reaction:	6.890 MPa
Assumed Water Table Depth:	2.0 m below ground elevation
Soil Stress Model:	Effective Stress
Factor of Safety on Applied Stresses:	2

Design Requirements for Bonded, Composite GRP Liners (WRc Type 1)

Thickness Requirements for Type 1 GRP Egg Shaped Liners

Table 3a*

Applicable Sewer: S-MA20018612	Nominal Dimensions		Maximum Dimensions				Invert Depth = 6.1 m (Design thickness shall be the greater of Eq. 1 & Eq. 2)	
Shape	**Height (mm)**	**Width (mm)**	**Height (mm)**	**Width (mm)**	**Deterioration State**	**Live Load Model**	**Eq. 1:** Long Term Flexural Strength in hoop direction (MPa)	**Eq. 2:** Long Term Flexural Modulus in hoop direction (MPa)
Egg	1500	1000	1600	1100	Fully Deteriorated	AASHTO HS25	$t = 154.18S_L^{-0.487}$	$t = 251.80E_L^{-0.325}$

*Table 3a only applicable to sewer S-MA20018612 lined with WRc type 1 GRP

t = design thickness (mm) S_L = Long Term Flexural Strength (MPa) E_L = Long Term Flexural Modulus (MPa)

Design Method:	WRc Sewerage Rehabilitation Manual, Type 1 Design with type 2 design design checks for external hydrostatic stress
Applicable Long Term Flexural Strength:	15.5 MPa - 200 MPa
Applicable Long Term Flexural Modulus:	862 MPa - 7000 MPa
Lateral Earth Coefficient:	0.4
Soil Density:	18.85 kN/m^3
Modulus of Soil Reaction:	6.890 MPa
Assumed Water Table Depth:	2.0 m below ground elevation
Soil Stress Model:	Effective Stress
Minimum long term tensile strength in hoop direction:	10 MPa
Minimum shear bond at grout/liner interface:	0.68 MPa
Factor of Safety on Applied Stresses:	2