

**CIPP Corporation**  
 Pipe Wall Thickness Design  
 ASTM F1216-09 - FULLY DETERIORATED GRAVITY PIPE CONDITIONS WITH PARTIALLY DETERIORATED CHECK

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PROJECT: Brodhead Sanitary Sewer Rehabilitation

D =	Mean Inside Diameter of Original Pipe (in) =	<u>8.0</u>	inches
H =	Height of soil above top of pipe	<u>12.0</u>	feet
W =	Soil Density	<u>120</u>	lb/ft <sup>3</sup>
H <sub>w</sub> =	Height of water above top of pipe	<u>12.0</u>	feet
Δ =	Percent ovality of original pipe	<u>2.0%</u>	%
E <sub>s</sub> =	Long term modulus of elasticity for CIPP	<u>200,000</u>	psi
σ <sub>L</sub>	Long Term Flexural Strength =	<u>2,250</u>	psi
E's =	modulus of soil reaction	<u>1000</u>	psi
N =	Safety Factor	<u>2.0</u>	

50% of short term modulus

1000 psi for soil meeting conditions in this table

Soil Class	% Compaction
SC1	Dumped
SC2	85%
SC3	90%
SC4	95%

R<sub>w</sub> Water Bouyancy Factor (0.67 min.)  
 1-0.33 (H<sub>w</sub>/H) = 0.670

Dead Load (W<sub>d</sub>) = WHR<sub>w</sub>/144

Dead Load (W<sub>d</sub>) = 6.70 psi

Groundwater Load (W<sub>w</sub>) = H<sub>w</sub>(62.4/144)

Groundwater Load (W<sub>w</sub>) = 5.20 psi

Live Load (W<sub>l</sub>) Enter From Table

W<sub>l</sub> Live Load (HWY = 2, RR = 3, AIRPT = 4)  
 Live Load (W<sub>l</sub>) = 2  
 Live Load (W<sub>l</sub>) = 0.00 psi

q<sub>s</sub> = Total External Pressure on Pipe =  
 (W<sub>d</sub> + W<sub>w</sub> + W<sub>l</sub>) = 11.90 psi

Height of Cover (ft)	Live Load Transferred to Pipe (lbs/in <sup>2</sup> )		
	Highway H20	Railway E80	Airport
1	12.50		
2	5.56	26.39	13.14
3	4.17	23.61	12.28
4	2.78	18.40	11.27
5	1.74	16.67	10.09
6	1.39	15.63	8.79
7	1.22	12.15	7.85
8	0.69	11.11	6.93
10	0	7.64	6.09
12	0	5.56	4.76
14	0	4.17	3.06
16	0	3.47	2.29
18	0	2.78	1.91
20	0	2.08	1.53
22	0	1.91	1.14
24	0	1.74	1.05
26	0	1.39	0
28	0	1.04	0
30	0	0.69	0
35	0	0	0
40	0	0	0

Thickness Required for Buckling Pressure (ASTM F1216-09 EQ X1.3)

q<sub>s</sub> = (1/N)(32R<sub>w</sub>B'E<sub>s</sub>C(E<sub>s</sub>/D<sup>3</sup>)<sup>1/2</sup>) = 11.90 psi

EQ. X1.3

I = Moment of Inertia of CIPP = t<sup>3</sup>/12

B' = Coefficient of elastic support = 1/[1+(4)(e<sup>-0.065H</sup>)] = 0.353

C = Ovality reduction factor = [(1-Δ/100)/(1+Δ/100)]<sup>2</sup> = 0.836

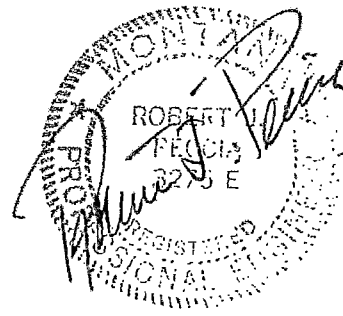
t = Pipe wall thickness = (0.721)(D)[(q<sub>s</sub>N)<sup>2</sup> / (R<sub>w</sub>)(B')(E<sub>s</sub>)(C)]<sup>1/3</sup>

Minimum Wall Thickness (t) = 0.14 inches or 3.6 mm  
 Recommended Wall Thickness (t) = 0.18 inches or 4.5 mm

Check Proposed Thickness for Minimum Thickness Requirement (ASTM 1216-09 EQ X1.4)

E = Initial modulus of elasticity (2X long term E<sub>s</sub>) = 400,000  
 DR = Dimension Ratio = D/t = 45.2

E/12(DR)<sup>3</sup> ≥ .093 in-lbs 0.362 (okay if greater than 0.093) EQ. X1.4



Partially Deteriorated Pipe Condition Check

(ASTM 1216-09 EQ X1.1)

$P_w =$  Groundwater load =  $(2KELC/(1-v^2)(DR-1)3N)$  EQ. X1.5

$DR =$   $\{2(K)(E_p)(C)/((P_w)(N)(1-v^2))\}^{0.5} + 1$

$\sigma_t$  Long Term Flexural Strength = 2,250 psi

$P_w =$   $62.4(H_w+D/12)/144$  5.49 psi

$K =$  Soil and existing pipe enhancement factor 7.00

$v =$  Poisson's Ratio 0.3

$DR =$  62.7

Minimum Wall Thickness 0.13 inches or 3.2 mm

Minimum Pipe Wall Thickness for Ovality

(ASTM 1216-09 EQ X1.2)

$(1.5\Delta/100)(1+\Delta/100)(DR)^2 - 0.5(1+\Delta/100)(DR) - (\sigma_t)/(P_w)(N) = 0$  EQ. X1.2

Solution of the Quadratic Equation for DR

$DR = b \pm \sqrt{b^2 - 4ac} / 2a$

$a =$   $(1.5\Delta/100)(1+\Delta/100) =$  0.0306

$b =$   $0.5(1+\Delta/100) =$  0.5100

$c =$   $(\sigma_t)/(P_w)(N) =$  -205.0

Maximum DR (ovality) = 73.9

Min. Wall Thickness (ovality) = 0.11 inches or 2.8 mm

Minimum Wall Thickness (t) = 0.14 inches 3.6 mm

Recommended Wall Thickness (t) = 0.18 inches 4.5 mm



**Location Info**

Tech info

**Weather**

**Ambient Air Temp**

**Inversion Head Pressure**

**Sample Taken**

Yes  
No

**Times**

**Pressures**

**Begin Install**

**Curing Head PSI**

8.7

**Start Steam**

**Heated Head PSI**

**Exotherm**

14.76

**Start Cooling**

**Installation PSI**

**Stop Cooling**

29.48

**Curing Log**

**Time**

**Temp**

**CK 1**

**Cook Time**

**CK 2**

1 Hr

**CK 3**

**CK 4**