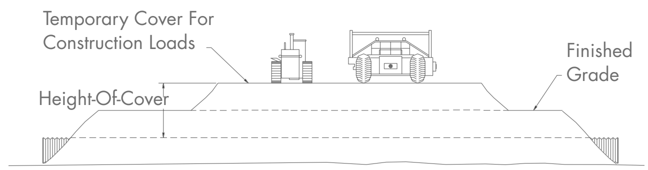
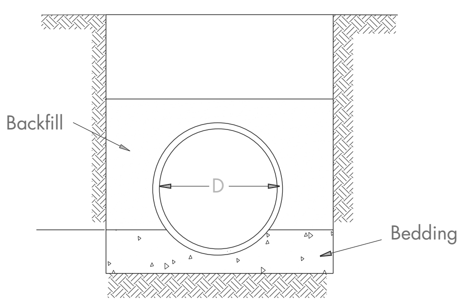
CONTECH CONSTRUCTION PRODUCTS INC.

Corrugated Metal Pipe Design Guide





INNOVATIVE SITE SOLUTIONS & STORMWATER MANAGEMENT

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Durability Design Guide for Drainage Products

Proper design of culverts and storm sewers requires structural, hydraulic, and durability considerations. While most designers are comfortable with structural and hydraulic design, the mechanics of evaluating abrasion, corrosion, and water chemistry to perform a durability design are not commonly found in most civil engineering handbooks.

The durability and service life of a drainage pipe installation is directly related to the environmental conditions encountered at the site and the type of materials and coatings from which the culvert is fabricated. Two principle causes of early failure in drainage pipe materials are corrosion and abrasion.

Service life can be affected by the corrosive action of the backfill in contact with the outside of a drainage pipe or more commonly by the corrosive and abrasive action of the flow in the invert of the drainage pipe. The design life analysis should include a check for both the water side and soil side environments to determine which is more critical—or which governs service life.

The potential for metal loss in the invert of a drainage pipe due to abrasive flows is often overlooked by designers and its effects are often mistaken for corrosion. An estimate for potential abrasion is required at each pipe location in order to determine the appropriate material and gauge.

This manual is intended to guide specifiers through the mechanics of selecting appropriate drainage products to meet service life requirements. The information contained in the following pages is a composite of several national guidelines.

Using the Design Guide

The choice of material, gauge and product type can be extremely important to service life. The following steps describe the procedure for selecting the appropriate drainage product, material, and gauge to meet a specific service life requirement.

Design Sequence

1. Select pipe or structure based on hydraulic and clearance requirements. Use Tables 4 and 5 as reference for size limits and hydraulic properties of all drainage products.
2. Use height-of-cover tables for the chosen pipe or structure to determine the material gauge required for the specific loading condition.
3. Use Table 1 to select the appropriate material for the site-specific environmental conditions. Whenever possible, existing installations of drainage structures along the same water course offer the most reliable estimate of long-term performance for specific environment conditions. In many cases, there will be more than one material that is appropriate for the project environmental conditions. Generally speaking, the metal material types increase in price as you move from top down on Table 1. Please contact your local CONTECH Sales Engineer for pricing.
4. Use Table 2 to determine which abrasion level most accurately describes the typical storm event (2 year storm). The expected stream velocity and associated abrasion conditions should be based on a typical flow and not a 10 or 50-year design flood.
5. Use Table 3 to determine whether the structural gauge for the selected material is sufficient for the design service life. If the structural gauge is greater than or equal to the gauge required for a particular abrasion condition and service life, use the structural gauge. Conversely, if the structural gauge is less than the gauge required for a particular abrasion condition and service life, use the gauge required by Table 3.

Table 1 — Recommended Environments

Material Type	Soil* and Water pH										Resistivity (ohm-cm)	
*	3	4	5	6	7	8	9	10	11	12	Minimum	Maximum
Galvanized Steel*											2000	8000
Aluminized Steel Type 2											1500	N/A
Polymer Coated											250	N/A
Aluminum Alloy											500	N/A
Reinforced Concrete											1000	N/A
Plastic (PVC or HDPE)											N/A	N/A

***Appropriate pH range for Galvanized Steel is 5.8 to 10**

Table 2 — FHWA Abrasion Guidelines

Abrasion Level	Abrasion Condition	Bed Load	Flow Velocity (fps)
1	Non- Abrasive	None	Minimal
2	Low Abrasion	Minor	< 5
3	Moderate Abrasion	Moderate	5 - 15
4	Severe Abrasion	Heavy	> 15

"Interim Direct Guidelines on Drainage Pipe Alternative Selection." FHWA, 1993.

Table 3 — Drainage Product Usage Guide

	Application	Storm Drain, Cross Drain, Median Drain, Side Drain											
	Roadway Classification	Rural	Minor	Major	Urban	Rural	Minor	Major	Urban	Rural	Minor	Major	Urban
	Design Service Life	25	50	75	100	25	50	75	100	25	50	75	100
	Abrasion Level	Abrasion Level 1 & 2				Abrasion Level 3				Abrasion Level 4			
Pipe	**CMP (1/2" or 1" deep corrugations)**	Minimum gauge CMP required to meet design service life.											
	Galvanized (2 oz.)	16	14	10	8	14	12	8	8[1]	12[1]	10[1]	N/A	N/A
	Asphalt Coated	16	14	10	8	14	12	8	8[1]	12[1]	10[1]	N/A	N/A
	Asphalt Coated and Paved Invert	16	16	14	10	16	14	12	8	12	8	N/A	N/A
	Aluminized Type 2	16	16	16	14	16	16	14	12	14	14[1]/12	12[1]/10	10[1]
	Polymer Coated	16	16	16	16	16	16	14	12	14	14[1]/12	12[1]/10	10[1]
	Aluminum Alloy	16	16	16	16	16	16	14	12	14	14[1]/12	12[1]/10	10[1]/8
	Concrete Lined	16	16	16	16	16	16	14	14	16	14	12	12
	ULTRA-FLO[3] (3/4" x 3/4" x 7 1/2" corrugation)	*Minimum gauge ULTRA-FLO required to meet design service life*											
	Galvanized (2 oz.)	16	14	10	N/A	*ULTRA-FLO pipe is used for storm sewer applications. Storm sewers rarely achieve Abrasion Level 3 or 4. Please contact your Sales Engineer for applications above Abrasion Level 2.*							
	Aluminized Type 2	16	16	16	14								
	Polymer Coated	16	16	16	16								
	Aluminum Alloy	16	16	16	16								
	SmoothCor [2,3]	*Minimum gauge SmoothCor required to meet design service life*											
	Polymer Coated	16	16	16	16	*SmoothCor Steel pipe is used for storm sewer applications. Storm sewers rarely achieve Abrasion Level 3 or 4. Please contact your Sales Engineer for applications above Abrasion Level 2.*							
	Plastic Pipe												
	Poly-vinyl Chloride (PVC) High Density Polyethylene (HDPE)	*PVC with smooth interior and corrugated exterior permitted in 25-100 years service life HDPE permitted in applications requiring 25 and 50 year service lives only.*								*Plastic pipe is generally not recommended for use in applications with Level 4 abrasion*			
	Reinforced Concrete Pipe	*RCP acceptable for Levels 1-3*								*A 7 or 8 sack mix is recommended*			

1. Requires a field applied concrete paved invert with minimum thickness 1" above corrugation crests. In some cases, adding one gauge can be substituted for the concrete paved invert
2. SmoothCor Steel Pipe combines a corrugated steel exterior shell with a hydraulically smooth interior liner.
3. Service life estimates for ULTRA-FLO and SmoothCor Pipe assume a storm sewer application. For applications other than storm sewers or abrasion conditions above Abrasion Level 2, please contact your CONTECH Sales Engineer for gauge and coating recommendations.

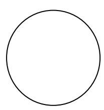
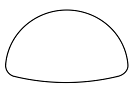
Adjustments for Abrasion

Table 3 makes adjustments to gauge and coating, in accordance with FHWA recommendations, based on abrasion potential and required service life.

Steel: For abrasion levels 1 & 2, no additional invert protection is needed. For abrasion level 3, increase the thickness by one gauge or add invert protection. At abrasion level 4, increase the thickness by one gauge and add invert protection.

Aluminum: For abrasion levels 1 , 2, & 3 no additional invert protection is needed. At abrasion level 4, increase the thickness by one gauge and add invert protection.

Table 4 — Product Dimensions

	Drainage Product	Common Uses	Size Limits Minimum	Size Limits Maximum	Manning's "n" Value
Round Pipe 	Corrugated Steel (1/2" deep corrugation)	Culverts, small bridges, storm water detention/ retention systems, conduits, tunnels, storm sewers.	12"	84"	0.011 - 0.021
	Corrugated Steel with Paved Invert (1/2" deep corrugation)		12"	84"	0.014 - 0.020
	Corrugated Steel (1" deep corrugation)		54"	144"	0.022 - 0.027
	Corrugated Steel with Paved Invert (1" deep corrugation)		54"	144"	0.019 - 0.023
	Corrugated Aluminum (1/2" deep corrugation)		12"	72"	0.011 - 0.021
	Corrugated Aluminum (1" deep corrugation)		30"	120"	0.023 - 0.027
	ULTRA-FLO® Steel	Storm sewers, culverts, storm water detention/ retention systems.	18"	102"	0.012
	ULTRA-FLO Aluminum		18"	84"	0.012
	SmoothCor™ Steel (1/2" deep corrugation)		18"	66"	0.012
	SmoothCor™ Steel (1" deep corrugation)		48"	138"	0.012
	Corrugated Steel Concrete Lined (1/2" deep corrugation)		24"	48"	0.012
	Corrugated Steel Concrete Lined (1" deep corrugation)		54"	120"	0.012
	PVC (Smooth interior, corrugated exterior)		12"	36"	0.009
	HDPE (Smooth interior, corrugated exterior)		12"	60"	0.012 - 0.017
	Reinforced Concrete		15"	120"	0.012
Pipe-Arch 	Corrugated Steel (1/2" deep corrugation)	Culverts, small bridges, storm water detention/ retention systems, conduits, tunnels, storm sewers.	17" x 13"	83" x 57"	0.011 - 0.021
	Corrugated Steel with Paved Invert (1/2" deep corrugation)		17" x 13"	83" x 57"	0.014 - 0.019
	Corrugated Steel (1" deep corrugation)		53" x 41"	142" x 91"	0.023 - 0.027
	Corrugated Steel with Paved Invert (1" deep corrugation)		53" x 41"	142" x 91"	0.019 - 0.022
	Corrugated Aluminum (1/2" deep corrugation)		17" x 13"	71" x 47"	0.011 - 0.021
	Corrugated Aluminum (1" deep corrugation)		60" x 46"	112" x 75"	0.023 - 0.027
	ULTRA-FLO Steel	Storm sewers, culverts, storm water detention/ retention systems.	20" x 16"	66" x 51"*	0.012
	ULTRA-FLO Aluminum		20" x 16"	66" x 51"*	0.012
	SmoothCor Steel (1/2" deep corrugation)		21" x 15"	77" x 52"	0.012
	SmoothCor Steel (1" deep corrugation)		53" x 41"	137" x 87"	0.012
	Elliptical Reinforced Concrete		23" x 14"	106" x 68"	0.012

5" x 1" *For larger sizes please contact your CONTECH Sales Engineer **5" x 1"**

Table 5 — Corrugated Steel Pipe—Values of Coefficient of Roughness (n)

	All Diameters	1-1/2" x 1/4"		Helical* Corrugation: Helical—2-2/3" x 1/2"						
2-2/3" x 1/2"	**Annular**	**8 in.**	**10 in.**	**12 in.**	**15 in.**	**18 in.**	**24 in.**	**36 in.**	**48 in.**	**60 in. and Larger**
Unpaved	0.024	0.012	0.014	0.011	0.012	0.013	0.015	0.018	0.020	0.021
PAVED-INVERT	0.021						0.014	0.017	0.020	0.019
SMOOTH-FLO	0.012						0.012	0.012	0.012	0.012
HEL-COR CL	0.012						0.012	0.012	0.012	0.012
SmoothCor	N/A					0.012	0.012	0.012	0.012	0.012

		Helical*—3" x 1"							
3" x 1"	**Annular**	**36 in.**	**42 in.**	**48 in.**	**54 in.**	**60 in.**	**66 in.**	**72 in.**	**78 in. and Larger**
Unpaved	0.027	0.022	0.022	0.023	0.023	0.024	0.025	0.026	0.027
PAVED-INVERT	0.023	0.019	0.019	0.020	0.020	0.021	0.022	0.022	0.023
SMOOTH-FLO	0.012			0.012	0.012	0.012	0.012	0.012	0.012
HEL-COR CL	0.012				0.012	0.012	0.012	0.012	0.012
SmoothCor	N/A			0.012	0.012	0.012	0.012	0.012	0.012

		Helical*—5" x 1"					
5" x 1"		**48 in.**	**54 in.**	**60 in.**	**66 in.**	**72 in.**	**78 in. and Larger**
Unpaved	0.025	0.022	0.022	0.023	0.024	0.024	0.025
PAVED-INVERT	0.022	0.019	0.019	0.020	0.021	0.021	0.022
SMOOTH-FLO	0.012			0.012	0.012	0.012	0.012
HEL-COR CL	0.012			0.012	0.012	0.012	0.012

ULTRA-FLO		**3/4" x 3/4" x 7-1/2"** All diameters n = 0.012

*Tests on helically corrugated pipe demonstrate a lower coefficient of roughness than for annually corrugated steel pipe. Pipe-arches approximately have the same roughness characteristics as their equivalent round pipes.

Table 6 - AASHTO Reference Specifications					
	Material Type	**Material**	**Pipe**	**Design***	**Installation***
Pipe & Pipe Arch	**CMP (1/2″ or 1″ deep corrugations)**				
	Galvanized (2 oz.)	M218	M36	Section 12	Section 26
	Asphalt Coated	M190	M36	Section 12	Section 26
	Asphalt Coated and Paved Invert	M190	M36	Section 12	Section 26
	Aluminized Type 2	M274	M36	Section 12	Section 26
	Polymer Coated	M246	M36 & M245	Section 12	Section 26
	Aluminum Alloy	M197	M196	Section 12	Section 26
	Concrete Lined	M218 & M274	M36	Section 12	Section 26
	ULTRA-FLO (3/4″ x 3/4″ x 7-1/2″ corrugation)				
	Galvanized (2 oz.)	M218	M36	Section 12	Section 26
	Aluminized Type 2	M274	M36	Section 12	Section 26
	Polymer Coated	M246	M36 & M245	Section 12	Section 26
	Aluminum Alloy	M197	M196	Section 16	Section 26
	SmoothCor				
	Polymer Coated	M246	M36 & M245	Section 12	Section 26
	Plastic Pipe				
	Poly-vinyl Chloride (PVC)	Section 18	M304	Section 18	Section 30
	High Density Polyethylene (HDPE)	Section 18	M294	Section 18	Section 30
	Reinforced Concrete Pipe	M170	M170	Section 8	Section 27
	Elliptical Concrete Pipe	M207	M207	Section 8	Section 27

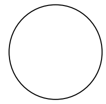
*AASHTO Standard Specification for Highway Bridges.

Corrugated Steel Pipe

Heights-of-Cover

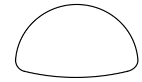
2-2/3" x 1/2" Height-of-Cover Limits for Corrugated Steel Pipe

H 20 and H 25 Live Loads



Diameter or Span, Inches	Minimum Cover, Inches	Maximum Cover, Feet — Specified Thickness, Inches					
		0.052	0.064	0.079	0.109	0.138	0.168
6[10]	12	388	486				
8[10]		291	365				
10[10]		233	392				
12		198	248	310			
15		158	199	248			
18		132	166	207			
21		113	142	178	249		
24		99	124	155	218		
30		79	99	124	174		
36		66	83	103	145	186	
42		56	71	88	124	160	195
48			62	77	109	140	171
54				66	93	122	150
60					79	104	128
66					68	88	109
72						75	93
78							79
84	12						66

H 20 and H 25 Live Loads, Pipe-Arch



Size: Round Equivalent, Inches	Size: Span x Rise, Inches	Minimum Structural Thickness, Inches	Minimum Cover, Inches	Maximum Cover, Feet — 2 Tons/Ft.² Corner Bearing Pressure
15	17 x 13	0.064	12	16
18	21 x 15	0.064		15
21	24 x 18	0.064		
24	28 x 20	0.064		
30	35x 24	0.064		
36	42 x 29	0.064		
42	49 x 33	0.064*		
48	57 x 38	0.064*		
54	64 x 43	0.079*		
60	71 x 47	0.109*		
66	77 x 52	0.109*		
72	83 x 57	0.138*	12	15

E 80 Live Loads

Diameter or Span, Inches	Minimum Cover, Inches	Maximum Cover, Feet — Specified Thickness, Inches					
		0.052	0.064	0.079	0.109	0.138	0.168
12	12	198	248	310			
15		158	199	248			
18		132	166	207			
21		113	142	178	249		
24		99	124	155	218		
30		79	99	124	174		
36		66	83	103	145	186	
42		56	71	88	124	160	195
48	12		62	77	109	140	171
54	18			66	93	122	150
60					79	104	128
66					68	88	109
72	18					75	93
78	24						79
84	24						66

E 80 Live Loads, Pipe-Arch

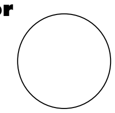
Size: Round Equivalent, Inches	Size: Span x Rise, Inches	Minimum Structural Thickness, Inches	Minimum Cover, Inches	Maximum Cover, Feet — 3 Tons/Ft.² Corner Bearing Pressure
15	17 x 13	0.079	24	22
18	21 x 15	0.079		
21	24 x 18	0.109		
24	28 x 20	0.109		
30	35 x 24	0.138		
36	42 x 29	0.138		
42	49 x 33	0.138*		
48	57 x 38	0.138*		
54	64 x 43	0.138*		
60	71 x 47	0.138*	24	22

* These values are based on the AISI Flexibility Factor limit (0.0433 x 1.5) for pipe-arch. Due to variations in arching equipment, thicker gauges may be required to prevent crimping of the haunches.

Heights-of-cover notes

1. These tables are for lock-seam or welded-seam construction. They are not for riveted construction. Consult your CONTECH Sales Engineer for height-of-cover tables on riveted pipe.
2. These values, where applicable, were calculated using K=0.86 as adopted in the AISI Handbook, Fifth Edition, 1994.
3. The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.
4. E 80 minimum cover is measured from top of pipe to bottom of tie.
5. H 20 and H 25 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.
6. The H 20 and H 25 pipe-arch tables are based on 2 tons per square foot corner bearing pressures.
7. The E 80 pipe-arch tables minimum and maximum covers are based on the corner bearing pressures shown. These values may increase or decrease with changes in allowable corner bearing pressures.
8. 0.052" is 18 gauge.
   0.064" is 16 gauge.
   0.079" is 14 gauge.
   0.109" is 12 gauge.
   0.138" is 10 gauge.
   0.168" is 8 gauge.
9. For construction loads, see Page 12.
10. 1-1/2" x 1/4" corrugation. H20, H25 and E80 loading.
11. SmoothCor and HEL-COR Concrete Lined have same height-of-cover properties as corrugated steel pipe. The exterior shell of SmoothCor is manufactured in either 2-2/3" x 1/2" or 3 x 1 corrugations; maximum exterior shell gauge is 12.

5″ x 1″ or 3″ x 1″ Height-of-Cover Limits for Corrugated Steel Pipe



H 20 and H 25 Live Loads

Diameter or Span, Inches	Minimum Cover Inches	Maximum Cover, Feet — Specified Thickness, Inches				
		0.064	0.079	0.109	0.138	0.168
54	12	56	70	98	126	155
60		50	63	88	114	139
66		46	57	80	103	126
72		42	52	73	95	116
78		39	48	68	87	107
84		36	45	63	81	99
90		33	42	59	76	93
96	12	31	39	55	71	87
102	18	29	37	52	67	82
108			35	49	63	77
114			32	45	58	71
120			30	41	54	66
126				39	50	62
132				36	47	57
138				33	43	53
144	18				39	49

Maximum cover heights shown are for 5″ x 1″.

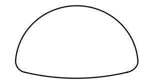
To obtain maximum cover for 3″ x 1″, increase these values by 13%

E 80 Live Loads

Diameter or Span, Inches	Minimum Cover Inches	Maximum Cover, Feet — Specified Thickness, Inches				
		0.064	0.079	0.109	0.138	0.168
54	18	56	70	98	126	155
60		50	63	88	114	139
66		46	57	80	103	126
72	18	42	52	73	95	116
78	24	39	48	68	87	107
84		36	45	63	81	99
90		33[1]	42	59	76	93
96	24	31[1]	39	55	71	87
102	30	29[1]	37	52	67	82
108			35	49	63	77
114			32[1]	45	58	71
120	30		30[1]	41	54	66
126	36			39	50	62
132				36	47	57
138				33[1]	43	53
144	36				39	49

Maximum cover heights shown are for 5″ x 1″.
To obtain maximum cover for 3″ x 1″, increase these values by 13%.
[1] These diameters in these gauges require additional minimum cover.

5″ x 1″ Pipe-Arch Height-of-Cover Limits for Corrugated Steel Pipe



H 20 and H 25 Live Loads

Size — Equivalent Pipe Diameter	Size — Span x Rise Inches	Minimum Specified Thickness, Inches*	Minimum Cover Inches	Maximum Cover, Feet — 2 Tons/Ft.^{2} Cover Bearing Pressure
72	81 x 59	0.109	18	21
78	87 x 63	0.109	18	20
84	95 x 67	0.109	18	20
90	103 x 71	0.109	18	20
96	112 x 75	0.109	21	20
102	117 x 79	0.109	21	19
108	128 x 83	0.109	24	19
114	137 x 87	0.109	24	19
120	142 x 91	0.138	24	19

E 80 Live Loads

Size — Equivalent Pipe Diameter	Size — Span x Rise Inches	Minimum Specified Thickness, Inches*	Minimum Cover Inches	Maximum Cover, Feet — 2 Tons/Ft.^{2} Cover Bearing Pressure
72	81 x 59	0.109	30	21
78	87 x 63	0.109	30	18
84	95 x 67	0.109	30	18
90	103 x 71	0.109	36	18
96	112 x 75	0.109	36	18
102	117 x 79	0.109	36	17
108	128 x 83	0.109	42	17
114	137 x 87	0.109	42	17
120	142 x 91	0.138	42	17

*Some 3″ x 1″ and 5″ x 1″ minimum gauges shown for pipe-arch are due to manufacturing limitations.

Heights-of-cover notes

1. These tables are for lock-seam or welded-seam construction. They are not for riveted construction. Consult your CONTECH Sales Engineer for height-of-cover tables on riveted pipe.
2. These values, where applicable, were calculated using K=0.86 as adopted in the AISI Handbook, Fifth Edition, 1994.
3. The span and rise shown in these tables are nominal. Typically the actual rise that forms is greater than the specified nominal. This actual rise is within the tolerances as allowed by the AASHTO & ASTM specifications. The minimum covers shown above take in to consideration this plus tolerance on rise.
4. The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.
5. E 80 minimum cover is measured from top of pipe to bottom of tie.
6. H 20 and H 25 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.
7. The H 20 and H 25 pipe-arch tables are based on 2 tons per square foot corner bearing pressures.
8. The E 80 pipe-arch tables minimum and maximum covers are based on the corner bearing pressures shown. These values may increase or decrease with changes in allowable corner bearing pressures.
9. 0.052″ is 18 gauge.
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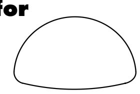
10. For construction loads, see Page 12.
11. SmoothCor and HEL-COR Concrete Lined have same height-of-cover properties as corrugated steel pipe. The exterior shell of SmoothCor is manufactured in either 2-2/3″ x 1/2″ or 3 x 1 corrugations; maximum exterior shell gauge is 12.

Heights-of-Cover

3" x 1" Pipe-Arch Height-of-Cover Limits for Corrugated Steel Pipe Arch



H 20 and H 25 Live Loads

Size		Minimum Specified Thickness, Inches*	Minimum Cover Inches	Maximum Cover, Feet
Equivalent Pipe Diameter	Span x Rise Inches			2 Tons/Ft.^{2} Cover Bearing Pressure
48	53 x 41	0.079	12	25
54	60 x 46	0.079	15	25
60	66 x 51	0.079	15	25
66	73 x 55	0.079	18	24
72	81 x 59	0.079	18	21
78	87 x 63	0.079	18	20
84	95 x 67	0.079	18	20
90	103 x 71	0.079	18	20
96	112 x 75	0.079	21	20
102	117 x 79	0.109	21	19
108	128 x 83	0.109	24	19
114	137 x 87	0.109	24	19
120	142 x 91	0.138	24	19

Larger sizes are available in some areas of the United States.
Check with your local CONTECH Sales Engineer.

Some minimum heights-of-cover for pipe-arches have been increased to take into account allowable "plus" tolerances on the manufactured rise.

E 80 Live Loads

Size		Minimum Specified Thickness, Inches*	Minimum Cover Inches	Maximum Cover, Feet
Equivalent Pipe Diameter	Span x Rise Inches			2 Tons/Ft.^{2} Cover Bearing Pressure
48	53 x 41	0.079	24	25
54	60 x 46	0.079	24	25
60	66 x 51	0.079	24	25
66	73 x 55	0.079	30	24
72	81 x 59	0.079	30	21
78	87 x 63	0.079	30	18
84	95 x 67	0.079	30	18
90	103 x 71	0.079	36	18
96	112 x 75	0.079	36	18
102	117 x 79	0.109	36	17
108	128 x 83	0.109	42	17
114	137 x 87	0.109	42	17
120	142 x 91	0.138	42	17

*Some 3" x 1" and 5" x 1" minimum gauges shown for pipe-arch are due to manufacturing limitations.

Note: Sewer gauge (trench conditions) tables for corrugated steel pipe can be found in the AISI book "Modern Sewer Design," 4th Edition, 1999, pp. 201-204. These tables may reduce the minimum gauge due to a higher flexibility factor allowed for a trench condition.

Heights-of-cover notes

1. These tables are for lock-seam or welded-seam construction. They are not for riveted construction. Consult your CONTECH Sales Engineer for height-of-cover tables on riveted pipe.
2. These values, where applicable, were calculated using K=0.86 as adopted in the AISI Handbook, Fifth Edition, 1994.
3. The span and rise shown in these tables are nominal. Typically the actual rise that forms is greater than the specified nominal. This actual rise is within the tolerances as allowed by the AASHTO & ASTM specifications. The minimum covers shown above take in to consideration this plus tolerance on rise.
4. The haunch areas of a pipe-arch are the most critical zone for backfilling. Extra care should be taken to provide good material and compaction to a point above the spring line.
5. E 80 minimum cover is measured from top of pipe to bottom of tie.
6. H 20 and H 25 minimum cover is measured from top of pipe to bottom of flexible pavement or top of rigid pavement.
7. The H 20 and H 25 pipe-arch tables are based on 2 tons per square foot corner bearing pressures.
8. The E 80 pipe-arch tables minimum and maximum covers are based on the corner bearing pressures shown. These values may increase or decrease with changes in allowable corner bearing pressures.
9. 0.052" is 18 gauge.
   0.064" is 16 gauge.
   0.079" is 14 gauge.
   0.109" is 12 gauge.
   0.138" is 10 gauge.
   0.168" is 8 gauge.
10. For construction loads, see Page 12.
11. SmoothCor and HEL-COR Concrete Lined have same height-of-cover properties as corrugated steel pipe. The exterior shell of SmoothCor is manufactured in either 2-$^2/_3$" x $^1/_2$" or 3 x 1 corrugations; maximum exterior shell gauge is 12.

Approximate Weight/Foot CONTECH Corrugated Steel Pipe

(Estimated Average Weights—Not for Specification Use)

1-1/2" x 1/4" Corrugation

Inside Diameter, in.	Specified Thickness, in.	Galvanized & ALUMINIZED	Full Coated
6	0.052	4	5
	0.064	5	6
8	0.052	5	6
	0.064	6	7
10	0.052	6	7
	0.064	7	8

2-2/3" x 1/2" Corrugation

Inside Diameter, in.	Specified Thickness in.	Galvanized & ALUMI-NIZED[1]	Full Coated	Coated & PAVED-INVERT	SMOOTH-FLO	HEL-COR CL	SmoothCor
12	0.052	8	10	13			
	0.064	10	12	15			
	0.079	12	14	17			
15	0.052	10	13	16	26		
	0.064	12	15	18	28		
	0.079	15	18	21	31		
18	0.052	12	16	19	31		
	0.064	15	19	22	34		17
	0.079	18	22	25	37		20
21	0.052	14	18	23	36		
	0.064	17	21	26	39		21
	0.079	21	25	30	43		24
24	0.052	15	20	26	41		
	0.064	19	24	30	45	65	
	0.079	24	29	35	50	69	23
	0.109	33	38	44	59	77	26
30	0.052	20	26	32	51		
	0.064	24	30	36	55	82	
	0.079	30	36	42	60	87	29
	0.109	41	47	53	72	96	34
36	0.052	24	31	39	50		
	0.064	29	36	44	65	98	35
	0.079	36	43	51	75	104	41
	0.109	49	56	64	90	116	
	0.138	62	69	77	100	127	
42	0.052	28	36	45	71		
	0.064	34	42	51	77	114	42
	0.079	42	50	59	85	121	48
	0.109	57	65	74	100	135	
	0.138	72	80	89	115	149	
48	0.064	38	48	57	85	128	46
	0.079	48	58	67	95	138	53
	0.109	65	75	84	112	154	
	0.138	82	92	101	129	170	
	0.168	100	110	119	147	186	
54	0.079	54	65	76	105	156	52
	0.109	73	84	95	124	173	59
	0.138	92	103	114	143	191	
	0.168	112	123	134	163	209	
60	0.109	81	92	106	140	192	68
	0.138	103	114	128	162	212	
	0.168	124	135	149	183	232	
66	0.109	89	101	117	160	211	96
	0.138	113	125	141	180	233	
	0.168	137	149	165	210	255	
72	0.138	123	137	154	210	254	(2)
	0.168	149	163	180	236	278	
78	0.168	161	177	194	260	302	(2)
84	0.168	173	190	208	270	325	(2)

3" x 1" or 5" x 1" Corrugation

Inside Diameter, in.	Specified Thickness in.	Galvanized & ALUMI-NIZED*	Full Coated	Coated & PAVED-INVERT	SMOOTH-FLO	HEL-COR CL	SmoothCor
54	0.064	50	66	84	138	197	58
	0.079	61	77	95	149	207	67
	0.109	83	100	118	171	226	
	0.138	106	123	140	194	245	
	0.168	129	146	163	217	264	
60	0.064	55	73	93	153	218	64
	0.079	67	86	105	165	229	74
	0.109	92	110	130	190	251	
	0.138	118	136	156	216	272	
	0.168	143	161	181	241	293	
66	0.064	60	80	102	168	240	70
	0.079	74	94	116	181	252	81
	0.109	101	121	143	208	276	
	0.138	129	149	171	236	299	
	0.168	157	177	199	264	322	
72	0.064	66	88	111	183	262	77
	0.079	81	102	126	197	275	89
	0.109	110	132	156	227	301	
	0.138	140	162	186	257	326	
	0.168	171	193	217	288	351	
78	0.064	71	95	121	198		83
	0.079	87	111	137	214	298	96
	0.109	119	143	169	246	326	
	0.138	152	176	202	279	353	
	0.168	185	209	235	312	380	
84	0.064	77	102	130	213		89
	0.079	94	119	147	230	321	104
	0.109	128	154	182	264	351	
	0.138	164	189	217	300	379	
	0.168	199	224	253	335	409	
90	0.064	82	109	140	228		96
	0.079	100	127	158	246		111
	0.109	137	164	195	283	376	144
	0.138	175	202	233	321	406	
	0.168	213	240	271	359	438	
96	0.064	87	116	149	242		102
	0.079	107	136	169	262		118
	0.109	147	176	209	302	401	154
	0.138	188	217	250	343	433	
	0.168	228	257	290	383	467	
102	0.064	93	124	158	258		108
	0.079	114	145	179	279		126
	0.109	155	186	220	320	426	164
	0.138	198	229	263	363	460	
	0.168	241	272	306	406	496	
108	0.079	120	153	188	295		133
	0.109	165	198	233	340		173
	0.138	211	244	279	386	487	
	0.168	256	289	324	431	525	
114	0.079	127	162	199	312		141
	0.109	174	209	246	359		183
	0.138	222	257	294	407	514	
	0.168	271	306	343	456	554	
120	0.109	183	220	259	378		193
	0.138	234	271	310	429	541	
	0.168	284	321	360	479	583	
126	0.138	247	285	326	452	(2)	(2)
132	0.138	259	299	342	474	(2)	(2)
	0.168	314	354	397	529		
138	0.138	270	312	357	495	(2)	(2)
	0.168	328	370	415	553		
144	0.168	344	388	435	579	(2)	(2)

[1]Weights for TRENCHCOAT polymer-coated pipe are 1% to 4% higher, varying by gauge.
[2]Please contact your CONTECH Sales Engineer.

Installation
Corrugated Steel Pipe

Economies in installation

Corrugated steel drainage structures from CONTECH can be installed quickly and easily. The following recommendations are based on actual experiences covering thousands of installations. While incomplete in detail, they serve to illustrate the relative simplicity with which corrugated steel structures can be installed.

Preparing the bedding

Corrugated steel structures can be installed successfully only on a properly prepared bedding. The bedding should offer uniform support to the pipe and help seat the corrugations in the underlying soil. Frozen soil, sod, large rocks or other similar objects must be removed from the bed.

Placing the pipe

Corrugated metal pipe weighs much less than other commonly used drainage structures. This is due to the efficient strength of the metal, further improved with carefully designed and formed corrugations. Even the heaviest sections of CONTECH Pipe can be handled with relatively light equipment compared with equipment required for much heavier reinforced concrete pipe.

Backfilling

All suitable structural backfill materials will perform well with CONTECH Corrugated Steel Pipe and Pipe-Arches. However, backfill should be free of large stones, frozen lumps and other debris.

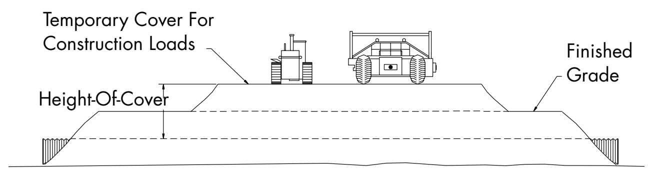
Backfill materials should be placed in layers about six inches deep, deposited alternately on opposite sides of the pipe. Each layer should be compacted carefully. Select backfill is placed and compacted until minimum cover height is reached, at which point, standard road embankment backfill procedures are used.

Complete information

For more information, see ASTM A798, AASHTO Section 26 and the Installation Manual of the National Corrugated Steel Pipe Association.

Construction Loads

For temporary construction vehicle loads, an extra amount of compacted cover may be required over the top of the pipe. The height-of-cover shall meet minimum requirements shown in the table below. The use of heavy construction equipment necessitates greater protection for the pipe than finished grade cover minimums for normal highway traffic.



General Guidelines for Minimum Cover

Pipe Span, Inches	Minimum Cover (feet) for Indicated Axle Loads (kips)			
	18-50	50-75	75-110	110-150
12-42	2.0	2.5	3.0	3.0
48-72	3.0	3.0	3.5	4.0
78-120	3.0	3.5	4.0	4.0
126-144	3.5	4.0	4.5	4.5

Minimum cover may vary depending on local conditions. The contractor must provide the additional cover required to avoid damage to the pipe. Minimum cover is measured from the top of the pipe to the top of the maintained construction roadway surface.

Corrugated Aluminum Pipe

Heights-of-Cover

2-2/3" X 1/2" Height-of-Cover Limits for Corrugated Aluminum Pipe

HS 20 Live Load

Diameter or Span (In.)	Minimum Cover (In.)	Maximum Cover, (Ft.)[4] Equiv. Standard Gauge 16	14	12	10	8
6	12	237				
8		178				
10		142	178			
12		118	148			
15		94	118			
18		78	98			
21		67	84			
24			73	103		
27			65	92		
30			58	82		
36			48	68	88	
42				58	76	
48	12			51	60	81
54	15			45	58	72
60	15				48	60
66	18					50
72	18					40

2 2/3" x 1/2" Height-of-Cover Limits for Corrugated Aluminum Pipe-Arch

HS 20 Live Load

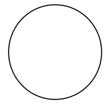
Size, (In.) Span x Rise in. x in.	Minimum Gauge	Minimum[5] Cover (In.)	Max.[4][5] Cover (ft.)
17x13	16	12	11
21x15	16	12	9
24x18	16	12	8
28x20	14	12	7
35x24	14	12	5
42x29	12	12	5
49x33	12	15	5
57x38	10	15	5
64x43	10	18	6
71x47	8	18	6

Notes
1. Cover limits indicated with * are for trench installation only. For embankment condition, use next heavier gage.
2. Based on load modification factors of1.0 and a soil density of 120 PCF.
3. Based on 3004-H32 materials.
4. Maximum cover based on AASHTO LRFD.
5. For 4,000 psf corner bearing.

Corrugated Aluminum Pipe

Heights-of-Cover

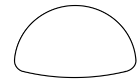
3" x 1" Height-of-Cover Limits for Corrugated Aluminum Pipe



HS 20 Live Load

Diameter or Span (In.)	Minimum Cover (In.)	Maximum Cover, (Ft.) (3) Equiv. Standard Gauge 16	14	12	10	8
30	12	54	68	95	127	150
36		44	56	79	106	125
42		38	47	67	91	107
48	12	33	42	59	79	93
54	15	29	37	52	70	83
60	15	26	33	47	63	74
66	18	23	30	42	57	68
72	18	21	27	39	52	62
78	21		25	36	48	57
84	21			33	45	53
90	24			31	42	49
96				29	39	46
102					36	43
108					34	41
114						37
120	24					33

3" x 1" Height-of-Cover Limits for Corrugated Aluminum Pipe



HS 20 Live Load

Size, (In.) Span x Rise in. x in.	Minimum Gauge	Minimum(4) Cover (In.)	Max.(3)(4) Cover (ft.)
53x41	14	15	8
60x46	14	15	8
66x51	14	18	9
73x55	14	21	10
81x59	14	21	11
87x63	14	24	10
95x67	14		11
103x71	14		10
112x75	14	24	10

Notes
1. Based on lopad modificationfactors of 1.0 and a soil density of 120 PCF.
2. Based on 3004-H32 material.
3. Maximum cover based on AASHTO LRFD.
4. For 4,000 psf corner bearing.

Approximate Weight/Foot CONTECH Corrugated Aluminum Pipe

(Estimated Average Weights—Not for Specification Use)

2 2/3" x 1/2" Corrugation Aluminum Pipe						
Diameter or Span (In.)	Weight (Lb./Lineal Ft.) Equiv. Standard Gauge					
	(.048") 18	(.060") 16	(.075") 14	(.105") 12	(.135") 10	(.164") 8 (3)
6 (2)	1.3	1.6				
8 (2)	1.7	2.1				
10 (2)	2.1	2.6				
12		3.2	4.0			
15		4.0	4.9			
18		4.8	5.9			
21		5.6	6.9			
24		6.3	7.9	10.8		
27			8.8	12.2		
30			9.8	13.5		
36			11.8	16.3	20.7	
42				19.0	24.2	
48				21.7	27.6	33.5
54				24.4	31.1	37.7
60					34.6	41.9
66						46.0
72						50.1

3" x 1" Corrugation Aluminum Pipe					
Diameter or Span (In.)	Weight (Lb./Lineal Ft.) Equiv. Standard Gauge				
	(.060") 16	(.075") 14	(.105") 12	(.135") 10	(.164") 8 (3)
30	9.3	11.5			
36	11.1	13.7			
42	12.9	16.0	22.0		
48	14.7	18.2	25.1	32.0	
54	16.5	20.5	28.2	35.9	
60	18.3	22.7	31.3	40.0	48.3
66	20.2	24.9	34.3	43.7	53.0
72	22.0	27.1	37.4	47.6	57.8
78		29.3	40.4	51.5	62.5
84			43.5	55.4	67.2
90			46.6	59.3	71.9
96			49.6	63.2	76.7
102				66.6	80.8
108				71.0	86.1
114					90.9
120					95.6

Notes

1. Helical lockseam pipe only. Annular riveted pipe weights will be higher.
2. 1 1/2" x 1/4" Corrugation.
3. 8-gauge pipe has limited availability.

Installation
Corrugated Aluminum Pipe

Required elements

Satisfactory site preparation, trench excavation, bedding, and backfill operations are essential to develop the strength of any flexible conduit. In order to obtain proper strength while preventing settlement, it is necessary that the soil envelope around the pipe be of good granular material, properly placed, and carefully compacted.

A qualified engineer should be engaged to design a proper foundation, adequate bedding, and backfill. (Reference: ASTM B788).

Trench excavation

If the adjacent embankment material is structurally adequate, the trench requires only a bottom clear width of the pipe's span, plus sufficient room for compaction equipment.

Bedding

Bedding preparation is critical to both pipe performance and service life. The bed should be constructed to uniform line and grade to avoid distortions that may create undesirable stresses in the pipe and/or rapid deterioration of the roadway. The bed should be free of rock formations, protruding stones, frozen lumps, roots and other foreign matter that may cause unequal settlement.

It is recommended that the bedding be a stable, well graded, granular material. Placing the pipe on the bedding surface is generally accomplished by one of two methods to ensure satisfactory compaction in the haunch area. One method is shaping the bedding surface to conform to the lower section of the pipe.
The other is carefully tamping a granular or select material in the haunch area to achieve a well-compacted condition.

Backfill

Satisfactory backfill material, proper placement and compaction are key factors in obtaining maximum strength and stability.

The backfill material should be free of rocks, frozen lumps and foreign matter that could cause hard spots or decompose to create voids. Backfill material should be a well graded, granular material that meets the requirements of AASHTO M145. Backfill should be placed symmetrically on each side of the pipe in six-inch to eight-inch loose lifts. Each lift is to be compacted to a minimum of 90 percent density per AASHTO T180.

A high percent of silt or fine sand in the native soils suggests the need for a well graded, granular backfill material to prevent soil migration, or a geotextile separator can be used.

During backfill, only small tracked vehicles (D-4 or smaller) should be near the pipe as fill progresses above the top and to finished grade. The engineer and contractor are cautioned that the minimum cover may need to be increased to handle temporary construction vehicle loads (larger than a D-4). Refer to **Heavy construction loads** below.

Salt water installation

In salt water installations, the bedding and backfill around the pipe must be clean granular material. If the backfill is subject to possible infiltration by the adjacent native soil, the clean granular backfill should be wrapped in a geotextile.

Pavement

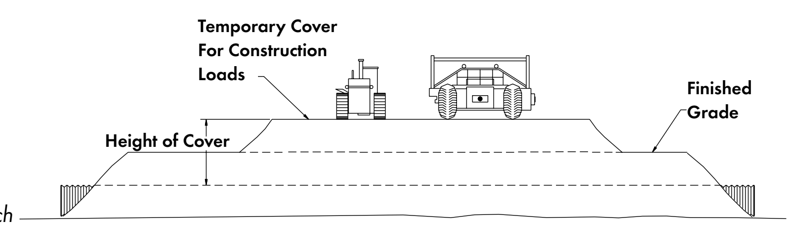
For minimum cover applications, CONTECH recommends that a properly designed flexible or rigid pavement be provided to distribute level loads and maintain cover heights.

Heavy construction loads

For temporary construction vehicle loads, an extra amount of **compacted cover** may be required over the top of the pipe. The height-of-cover shall meet the minimum requirements shown in the Table below. The use of heavy construction equipment necessitates greater protection for the pipe than finished grade cover minimums for normal highway traffic.

Min. Height-of-Cover Requirements for Construction Loads On Corrugated Aluminum Pipe

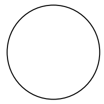
Diameter/ Span (Inches) Aluminum	Axle Load (Kips) 18-50	50-75	75-110	110-150
12-42	3.0′	3.5′	4.0′	4.0′
48-72	4.0′	4.0′	5.0′	5.5′
78-120	4.0′	5.0′	5.5′	5.5′



ULTRA-FLO®

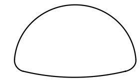
Heights of Cover

Table 1
ALUMINIZED STEEL Type 2 or **Galvanized Steel** ULTRA FLO
HS 20 Live Load



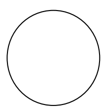
Diameter (Inches)	Minimum/Maximum Cover (Feet) Specified Thickness and Gauge (0.064″) 16	(0.079″) 14	(0.109″) 12
18	1.0/68		
21	1.0/58		
24	1.0/51		
30	1.0/41		
36	1.0/34	1.0/48	
42	1.0/29	1.0/41	1.0/69
48	1.0/25	1.0/36	1.0/60
54	1.25/22	1.25/32	1.0/53
60	1.25/20*	1.25/28	1.0/48
66		1.5/26	1.25/44
72		1.5/24*	1.25/40
78		1.75/22*	1.5/37
84			1.75/34
90			2.0/32*
96			2.0/30*
102			2.5/28*

Table 2
ALUMINIZED STEEL Type 2 or **Galvanized Steel** ULTRA FLO
Pipe-Arch HS 20 Live Load



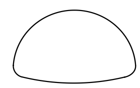
Equiv. Pipe Dia. (In.)	Span (In.)	Rise (In.)	Minimum/Maximum Cover (Feet) Specified Thickness and Gauge (0.064″) 16	(0.079″) 14	(0.109″) 12
18	20	16	1.0/15		
21	23	19	1.0/15		
24	27	21	1.0/15		
30	33	26	1.0/15	1.0/15	
36	40	31	1.0/15	1.0/15	
42	46	36	M.L.[8]	M.L.[8]	1.0/15
48	53	41	M.L.[8]	M.L.[8]	1.0/15
54	60	46	M.L.[8]	M.L.[8]	1.0/15
60	66	51	M.L.[8]	M.L.[8]	1.25/15

Table 3
Aluminum ULTRA FLO HS 20 Live Load



Diameter (Inches)	Minimum/Maximum Cover (Feet)[11] Specified Thickness and Gauge (0.060″) 16	(0.075″) 14	(0.105″) 12	(0.135″) 10
18	1.0/41	1.0/57		
21	1.0/35	1.0/49	1.0/79	
24	1.0/30	1.0/42	1.0/69	
30	1.25/24	1.0/33	1.0/55	
36	1.50/19*	1.25/27	1.0/45	1.0/65
42		1.50/23*	1.25/39	1.0/55
48			1.50/34	1.25/48
54			1.75/30	1.25/43
60			2.0/46*	1.50/38
66				1.75/35
72				2.0/31*

Table 4
Aluminum ULTRA FLO Pipe-Arch HS 20 Live Load



Size, (In.) Span x Rise in. x in.	Minimum/Maximum Cover (Feet)[11] Specified Thickness and Gauge (0.060″) 16	(0.075″) 14	(0.105″) 12	(0.135″) 10
20 x 16	1.0/17			
23 x 19	1.0/14			
27 x 21	1.25/12			
33 x 26	1.50/11*			
40 x 31		1.75/10*		
46 x 36			1.50/9	
53 x 41			1.75/8	
60 x 46			2.0/8*	
66 x 51				1.75/9

NOTES (Tables 1, 2, 3, and 4)

1. Allowable minimum cover is measured from top of pipe to bottom of flexible pavement or top of pipe to top of rigid pavement. Minimum cover in unpaved areas must be maintained.
2. All heights of cover are based on trench conditions. If embankment conditions exist, there may be restrictions on gages for the large diameters. Your CONTECH Sales Engineer can provide further guidance for a project in embankment conditions.
3. Tables 1, 2, 3 and 4 are for HS-20 loading only. For heavy construction loads, higher minimum compacted cover may be needed. See Page 19.
4. All steel ULTRA FLO is installed in accordance with ASTM A798 "Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications."
5. Heights of cover are for 3/4″ x 3/4″ x 7-1/2″ external rib corrugation.

NOTES (Tables 2 only)

6. The foundation in the corners should allow for 4,000 psf corner bearing pressure.
7. Larger size pipe-arches may be available on special order.
8. M.L. (Heavier gage is required to prevent crimping at the haunches.)

NOTES (Tables 3 and 4 only)

9. Cover indicated with * are for trench installation only. For embankment conditions, use the next heavier gage.
10. Based on load motification factors of 1.0.
11. Maximum cover based on AASHTO LRFD.
12. For 4,000 psf corner bearing

Approximate Weight/Foot CONTECH ULTRA-FLO Pipe

Table 1
Handling Weight for **ALUMINIZED STEEL Type 2** or **Galvanized Steel** ULTRA FLO

Diameter (Inches)	Weight (Pounds/Lineal Foot) Specified Thickness and Gage (0.064″) 16	(0.079″) 14	(0.109″) 12
18	15		
21	18		
24	20		
30	25		
36	30	37	
42	35	43	59
48	40	49	67
54	45	55	75
60	50	61	83
66		67	92
72		73	100
78		80	108
84			116
90			125
96			133
102			140

Table 2
Handling Weight for **ALUMINUM** ULTRA FLO

Diameter (Inches)	Weight (Pounds/Lineal Foot) Specified Thickness and Gage (0.060″) 16	(0.075″) 14	(0.105″) 12	(0.135″) 10
18	5			
21	6			
24	7	9		
30	9	11	15	
36	11	13	18	23
42	12	15	21	26
48		17	24	30
54		19	27	34
60			30	37
66			33	41
72			36	45
78				49
84				52

Reduced excavation because of ULTRA FLO's smaller outside diameter.

ULTRA FLO is available in long lengths. And, its light weight allows it to be unloaded and handled with small equipment.

Installation ULTRA-FLO

Overview

Millions of feet of ULTRA-FLO have been installed in a variety of storm sewer projects across the U. S. Like all pipe products, proper installation is important for long-term performance. The installation of ULTRA-FLO is similar to standard corrugated steel pipe in a trench condition. Your CONTECH Sales Engineer will be glad to assist you if you have any questions.

Bedding and Backfill

Typical ULTRA-FLO installation requirements are the same as for any other corrugated metal pipe installed in a trench. Bedding and backfill materials for steel Ultra Flo follow the requirements of the CSP installation specification ASTM A798; and must be free from stones, frozen lumps or other debris. For Aluminum Ultra Flow see ASTM A790. When ASTM A796 or A788 designs are to be followed for condition III requirements, indicated by asterisk (*) in the tables on page 17, use clean, easily compacted granular backfill materials

Embankment Conditions

ULTRA-FLO is a superior CMP storm sewer product that is normally installed in a trench condition. In those unusual embankment installation conditions, pipe sizes and gages may be restricted. Your CONTECH Sales Engineer can provide you with further guidance.

Construction Loads

For temporary construction vehicle loads, an extra amount of **compacted cover** may be required over the top of the pipe. The use of heavy construction equipment necessitates greater protection for the pipe than finished grade cover minimums for normal highway traffic. The contractor must provide the additional cover required to avoid damaging the pipe. Minimum cover is measured from the top of the pipe to the top of the maintained roadway surface.

Heavy Construction Loads Minimum Height of Cover Requirements for Construction Loads on ULTRA FLO Pipe

Diameter/Span (Inches)	Axle Load (Kips)			
	>32≤50	50≤75	75≤110	110≤150
	Steel 3/4″ x 3/4″ x 7-1/2″			
15-42	2.0 ft.	2.5 ft.	3.0 ft.	3.0 ft.
48-72	3.0 ft.	3.0 ft.	3.5 ft.	4.0 ft.
78-108	3.0 ft.	3.5 ft.	4.0 ft.	4.5 ft.
	Aluminum 3/4″ x 3/4″ x 7-1/2″			
15-42	2.5 ft.	3.0 ft.	3.5 ft.	3.5 ft.

Relining and Rehabilitation

Restoration of failed or deteriorating pipe can be accomplished by relining with ULTRA-FLO. Its low-wall profile may yield an inside diameter that approaches the original pipe, while the hydraulic capacity is improved.

ULTRA-FLO's light weight makes the lining process easier and can be provided in various lengths to meet individual site conditions.

For more information, call 1-800-338-1122, one of CONTECH's Regional Offices located in the following cities:

Ohio (Corporate Office)	**513-645-7000**
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