HLK® CORRUGATED STEEL PIPE PROPERTIES

HLK® corrugated steel pipe is categorized as flexible due to its response under external loads. In other words, its resistance depends on soil-structure interaction, making proper backfill essential for transferring loads and achieving the structural integrity of the system—exactly as outlined in AASHTO Section 12.

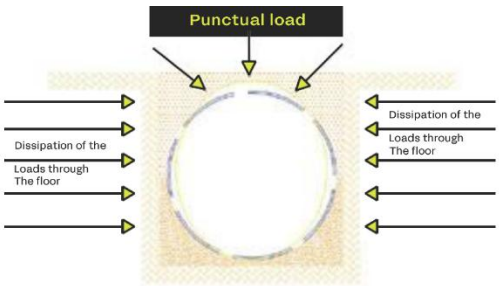
The corrugated steel pipe is available with a wide variety of protective coatings proven to meet the demands of the most challenging environments. With the right coating tailored to the location and application, the pipe can achieve a service life exceeding 100 years. These corrugated pipes are manufactured with either galvanized or aluminized steel, ensuring long-lasting durability.

Specification Table: Compliance with International Standards

Steel Coating	Galvanized > 2 oz/Ft2 Aluminized type 2	ASTM 929 ASTM 929	AASHTO M218 AASHTO M274
Pipe		ASTM 760	AASHTO M36
Installation		ASTM 798	AASHTO Section 26
Desing		ASTM A796	AASHTO Section 12

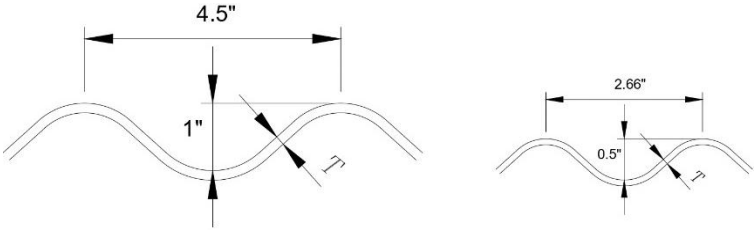
The pipe's structural capacity hinges on a combination of three key factors:

- .**Corrugation**
  Transverse ridges along the pipe's length provide structural form. Pipes with deeper, more closely spaced corrugations offer greater strength compared to those with shallow, widely spaced ones.
- **Gauge**
  Wall Thickness of the tube. A thicker wall lower gauge number increases the pipe's structural strength, given the same corrugation and diameter.
- **Diameter**
  Larger diameters result in lower stiffness, while smaller diameters yield greater rigidity.



The interplay of these factors determines the pipe's ability to resist various cover loads. The details are outlined in the following specification:

TU HLK PIPE – MINIMUM & MAXIMUM COVERS – LIVE LOADS H-20 / H-25 / E-80 – ALUMINIZED / GALVANIZED / POLYMER-COATED STEEL



Diameter (in / m)	Corrugation	Min Cover (ft / m)		Max Cover (ft / m)				
				H-20 / H-25 / E-80				
		Live Load H-20 / H-25	Live Load E-80	Gauges				
				18	16	14	12	10
12"(30 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30	189 / 57	247 / 75	309 / 94		
15"(38 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30	151 / 46	198 / 60	247 / 75		
18"(45 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30	126 / 38	165 / 50	206 / 63		
21"(53 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30	108 / 33	141 / 43	177 / 54	248 / 75	
24"(60 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30	94 / 28	123 / 37	154 / 47	217 / 66	
30"(76 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30		98 / 30	123 / 37	173 / 53	
36"(90 cm)	2-2/3" X 1/2"	1.0 / 0.30	1.0 / 0.30		82 / 25	102 / 31	144 / 44	
42"(107 cm)	2-2/3" X 1/2"	1.0/ 0.30	1.5 / 0.45		70 / 21	87 / 26	123 / 37	159 / 48
48"(122 cm)	2-2/3" X 1/2"	1.5 / 0.45	1.5 / 0.45		61 / 18	76 / 23	108 / 33	139 / 42
54"(137 cm)	4.5" x 1"	1.5 / 0.45	1.5 / 0.45		58 / 17	73 / 22	102 / 31	132 / 40
60"(150 cm)	4.5" x 1"	1.5 / 0.45	2.0 / 0.60		52 / 16	66 / 20	92 / 28	119 / 36
66"(167 cm)	4.5" x 1"	1.5 / 0.45	2.0 / 0.60		48 / 14	59 / 18	83 / 25	108 / 32
72"(182 cm)	4.5" x 1"	1.5 / 0.45	2.0 / 0.60		44 / 13	54 / 16	76 / 23	99 / 30
78"(198 cm)	4.5" x 1"	1.5 / 0.45	2.0 / 0.60		40 / 12	50 / 15	71 / 21	91 / 27
84"(213 cm)	4.5" x 1"	1.5 / 0.45	2.0 / 0.60		37 / 11	47 / 14	66 / 20	85 / 25
90"(228 cm)	4.5" x 1"	2.0 / 0.60	2.5 / 0.76		34 / 10	44 / 13	61 / 18	79 / 24
96"(243 cm)	4.5" x 1"	2.0 / 0.60	2.5 / 0.76		32 / 9	40 / 12	57 / 17	74 / 22
102"(260 cm)	4.5" x 1"	2.0 / 0.60	2.5 / 0.76			38 / 11	54 / 16	70 / 21
108"(275 cm)	4.5" x 1"	2.0 / 0.60	2.5 / 0.76			36 / 11	51 / 15	66 / 20
114"(290 cm)	4.5" x 1"	2.5 / 0.76	3.0 / 0.90			33 / 10	47 / 14	60 / 18
120"(304 cm)	4.5" x 1"	2.5 / 0.76	3.0 / 0.90			31 / 9	43 / 13	56 / 17
126"(320 cm)	4.5" x 1"	2.5 / 0.76	3.0 / 0.90				40 / 12	52 / 16
132"(335 cm)	4.5" x 1"	2.5 / 0.76	3.0 / 0.90				37 / 11	49 / 15
138"(350 cm)	4.5" x 1"	2.5 / 0.76	3.0 / 0.90				34 /10	45 / 13
144"(365 cm)	4.5" x 1"	2.5 / 0.76	3.0 / 0.90					40 / 12

Notes:

1. Tables apply to stitched-seam pipes.
2. These values, where applicable, were calculated using K = 0.86 per the AISI Manual.
3. Minimum cover for H-20 and H-25 is measured from the top of the pipe to the surface of flexible pavement or the top of rigid pavement.
4. Minimum cover height for E-80 loads is measured from the base of the rail sleeper (tie) to the outer top of the pipe.

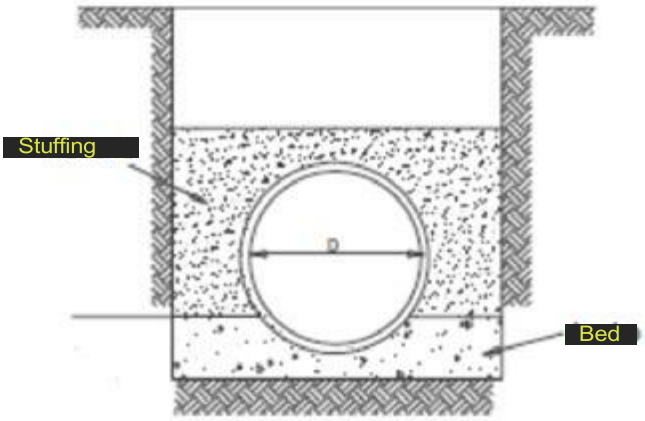
Construction Procedure

Excavation

Once trenching is complete, the recommended width is one pipe exterior diameter plus 50 to 120 cm on each side to allow for adequate haunching, depending on compaction equipment. Reduced space may be acceptable when using non-mechanically compacted backfill materials. In embankment conditions, removing the top layer of soil, mud, organic matter, roots, and protruding stones creates a stable and uniform foundation with adequate compaction.

Foundation

Provide a uniform, stable foundation using fine granular materials (max 3" aggregate), compacted to a minimum of 90% Standard Proctor density. Never install the pipe on organic soil, frozen ground, or rocky surfaces. If needed, remove unstable base materials and replace them with suitable fill. If a concrete cradle is required, do not place the pipe directly on concrete—first lay a layer of compacted granular material as a buffer.



Handling

While steel pipe can endure normal handling, reasonable care is essential, as dragging can damage the protective coatings. HLK® pipe is lightweight and suitable for handling with light equipment; use slings for safe handling.

Pipe Installation

During installation, joint connections must be properly sealed to prevent infiltration/exfiltration, which can lead to soil migration and compromise backfill integrity.

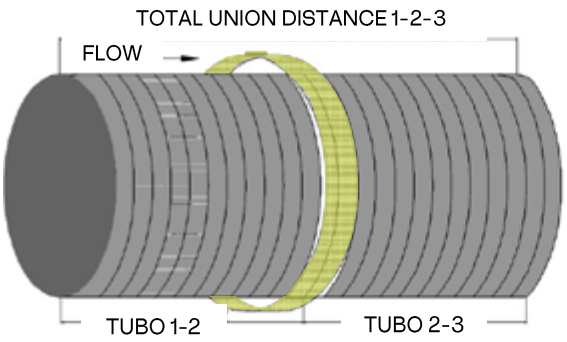
Pipes are joined using steel coupling bands:

- Slide the open band onto the end of the first pipe section.
- Align the second pipe section, leaving about 1 inch (25 mm) between ends.
- Ensure all surfaces are clean and free of dirt, sand, or debris.
- Align the band corrugations with those of the pipe, then tighten the bolts to create a secure, continuous structure.

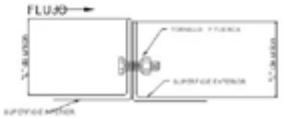
Band types by pipe diameter:

- 12"–48": one-piece band
- 54"–96": two-piece band
- 102" and up: three-piece band

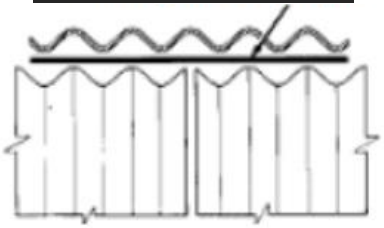
Union of tubes according to helical sequence to the cut



Translap belt detail



Packaging Sleeve



Pipe Bedding

Use loose fine granular materials to fill spaces between corrugations. Minimum bedding thickness before pipe placement:

- 1 inch (25 mm) for ½-inch corrugation depth
- 2 inches (50 mm) for 1-inch corrugation depth

Bedding width should be at least equal to the pipe diameter.

Backfill

The structural performance of any pipe depends heavily on proper backfill. Use well-graded, selected granular material with minimal silt and clay content. Fill should be free of organic matter, frozen soils, roots, or rocks over 3 inches (75 mm).
Backfill must be placed symmetrically. In 15–20 cm (6–8 inch) lifts, compacted to 90% Standard Proctor density (AASHTO T99). Special attention must be given to properly compact the haunch zone to maintain structural integrity.

Multiple Pipe Installations

Backfill must be applied evenly across all pipe structures. The design must consider compactability between pipes. Flowable backfill may be used to eliminate the need for mechanical compaction and reduce spacing requirements.

Recommended minimum spacing:

- For pipes 24"–72": at least ½ the pipe diameter
- For pipes >72": at least 36 inches (915 mm)

Desing criterio for corrugated metal pipes on railway tracks (Cooper-E80

Railway (Cooper E-80)

Design Criteria

Flexible corrugated metal conduits require consideration of four main structural criteria: flexibility factor, wall area, buckling resistance, and seam strength.

Load Calculations

- DL (Dead Load Pressure) = soil density × cover height
- LL (Live Load Pressure) = includes 50% impact allowance for Cooper E-80. It can be interpolated for cover heights not specified. Railway culverts typically have cover heights of 60 cm or more; if less, the designer must determine LL.
- Pv (Total Pressure) = DL + LL

Deck height (feet)	Live load (PSF)
2	3800
5	2400
8	1600
10	1100
12	800
15	600
20	300
30	100

Table 1: Live load pressure values for Cooper E-80, measured from the sleeper base to the top of the pipe.

Formulas

Handling & Install Strength

Flexibility Factor:
$FF = S^2 / (E \times I)$

- FF: flexibility (inches per pound)
- S: span (inches) — typically the pipe diameter
- E: modulus of elasticity of pipe material (psi)
- I: moment of inertia per unit length (in^2/in)

Max FF:

- For ½" corrugation: 0.043
- For 1" corrugation: 0.033

Wall Area Requirement

A = T / fa
T = (Pv × S) / 2
fa = fy / SF

- A: required wall area (in²/ft)
- T: compressive thrust (lb/ft)
- fa: allowable wall stress (yield strength (fy) divided by safety factor)
- SF (safety factor): 2 recommended

Buckling

Corrugations must be checked for buckling. If fcr/SF < fa, recalculate required wall area using fcr/SF instead of fa.

$$\text{if } S < \frac{r}{k}\sqrt{\frac{24E}{f_u}} \text{ then } f_{cr} = f_u - \frac{f_u^2}{48E}\left(\frac{KS}{r}\right)^2$$

$$\text{if } S > \frac{r}{k}\sqrt{\frac{24E}{f_u}} \text{ then } f_{cr} = \frac{12E}{\left(\frac{KS}{r}\right)^2}$$

- fcr: critical buckling stress
- r: radius of gyration
- K: soil stiffness coefficient = **0.22**
- SF: safety factor = **2**

donde:
fcr = tensión crítica de pandeo (psi)
S = luz máxima en pulgadas
r = radio de giro en pulgadas (véanse las Tablas 6 y 7)
E = módulo de elasticidad (psi) Tabla 4
K = factor de rigidez del suelo = 0,22
SF = factor de seguridad (SF recomendado = 2)
fu = minimum tensile strength (psi) (see Table 4)

Seam Strength

The longitudinal seam must withstand the wall compressive thrust:
Required Seam Strength = T × SF
SF: safety factor = 3
Never exceed the longitudinal seam resistance specified in AASHTO Article 4.13.4c, Table 5.

HULKO® Steel Pipe Technology

Design Properties for Culverts

- Table 3: Gauge vs. metal thickness used in culvert design
- Table 4: Mechanical properties of metals used in culverts
- Table 5: Longitudinal seam strength for riveted culverts
- Tables 6 & 7: Section properties for corrugated steel and aluminum pipes
  Note: spiral ribbed pipe section properties are reduced effective values due to geometry and differ between steel and aluminum.

Table 3: Gauge versus metal thickness

Indicator	Steel	Aluminium
	Thickness specified (in)	Thickness specified
16	0.064	0.06
14	0.079	0.075
12	0.109	0.105
10	0.138	0.135
8	0.168	0.164

Table 4: Mechanical properties of metal

Metal	Have silence mínimum strength (psi)	Minimum performance (psi)	Modulus of elasticity (psi)
Steel	45000	33000	29,000,000
Aluminium H34	31000	24000	10,000,000

Table 5: Minimum longitudinal grap strenght in Kips per foot

Indicator	Corrugation				
	2-2/3" x 1/2" y 2" x 1/2			4.5" x 1"	
	Simple grab K/ft	Double grab K/ft	Grab size (in)	Double grab K/ft	Grab size (in)
Stapled steel tube					
16	16.7	21.6	5/16	28.7	3/8
14	18.2	29.8	5/16	35.7	3/8
12	23.4	46.8	3/8	53	7/16
10	24.5	49	3/8	63.7	7/16
8	25.6	51.3	3/8	70.7	7/16
Sticed aluminum tube					
16	9	14	5/16	16.5	3/8
14	9	18	5/16	20.5	3/8
12	15.6	31.5	3/8	28	1/2
10	16.2	33	3/8	42	1/2
8	16.8	34	3/8	54.5	1/2

Table 6: Section properties for corrugated steel and aluminum pipes

Indicator	Corrugation											
	1-1/4" x 1/2"			2-2/3" x 1/2"			3" x 1			5" x 1" (NOTE)		
	A	r	I x10^-3	A	r	I x10^-3	A	r	I x10^-3	A	r	I x10^-3
	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$
16	0.76	0.0832	0.439	0.755	0.1712	1.89	0.89	0.3417	8.66	0.794	0.3657	8.85
14				0.968	0.1721	2.39	1.113	0.3427	10.89	0.992	0.3663	11.09
12				1.356	0.1741	3.43	1.56	0.3448	15.46	1.39	0.3677	15.65
10				1.744	0.1777	4.53	2.008	0.3472	20.18	1.788	0.3693	20.32
8				2.133	0.1795	5.73	2.458	0.3499	25.09	2.186	0.3711	25.09

Table 7: Section properties for corrugated steel and aluminum pipes

Indicator	Corrugation											
	Steel						Aluminium					
	3/4"x3/4"x7-1/2"			3/4"x1"x11-1/2"			3/4"x3/4"x7-1/2"			3/4"x1"x11-1/2"		
	A	r	Ix10^-3	A	r	Ix10^-3	A	r	Ix10^-3	A	r	Ix10^-3
	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$	$\frac{in^2}{ft}$	in	$\frac{in^4}{in}$
16	0.509	0.258	2.82	0.374	0.383	4.58	1.415	0.272	2.558	0.312	0.396	4.08
14	0.712	0.25	3.7	0.524	0.3773	6.08	0.569	0.267	3.372	0.427	0.391	5.45
12	1.184	0.237	5.54	0.883	0.355	9.26	0.914	0.258	5.073	0.697	0.38	8.39
10	1.717	0.228	7.43	N/A	N/A	N/A	1.29	0.252	6.826	1.009	0.369	11.48

Note: spiral ribbed pipe section properties are reduced effective values due to geometry and differ between steel and aluminum.

Safety Factors

- FS = 3.0 for longitudinal joints (bolt/riveted)
- FS = 2.0 for wall buckling and required wall area
- FF as defined above

Design Criteria Recap

- Dead load pressure: 120 psf per foot of cover
- Live load pressure: Cooper E-80 with 50% impact allowance
- Design tables include modulus of elasticity, tensile and yield strengths, seam strength, pipe section properties
- Soil stiffness coefficient (K): 0.22
- Results are based on structural design; applications with abrasive or corrosive environments may require thicker materials, protective coatings, or inverted pavement.