

Section 909. DRAINAGE PRODUCTS

909.01 General Requirements. If only the size and class are specified for a culvert or sewer, the pipe materials to be used are shown in Table 401-1 and 402-1 respectively. Drainage structures and underdrains shall be constructed of the materials specified in the contract documents.

Galvanized corrugated steel structural plates and aluminum structural plates will be used only when specifically called for on the plans or in the proposal. They shall be manufactured and fabricated according to the contract documents.

Sanitary sewer or industrial waste systems shall be constructed according to applicable state and local requirements and shall be installed using a compression gasket as described in subsection 909.03.

909.02 Testing. Testing of materials used to construct drainage systems shall be done according to the applicable AASHTO or ASTM specification, except as otherwise noted.

Each manufacturer of concrete pipe is required to provide a suitable standard testing machine to determine the strength of the product and shall keep this machine in good working condition and accurately calibrated. Labor and materials for performing all strength tests shall be furnished by the manufacturer.

909.03 Watertight Joints for Sewers and Culverts. Watertight joint systems must meet the pressure test requirements of MTM 723 in addition to all applicable specifications for the materials used in assembling the pipe system (pipe, coupling, gaskets, etc.). Watertight joint systems shall be selected from the Qualified Products List.

Compression gaskets shall be flexible rubber gaskets conforming to ASTM C 443 for concrete pipe, ASTM F 477 for plastic pipe, or AASHTO M 36 for metal pipe. Gasket material meeting the low temperature flexibility and elevated temperature flow test of ASTM C 990 and the requirements of AASHTO M 198 (omitting softening point, flashpoint and fire point) is an acceptable alternative to the AASHTO M 36M requirements for metal pipe.

External rubber gaskets, mastic and protective film shall meet ASTM C 877.

909.04 Concrete Pipe Products.

A. **Reinforced Concrete Circular Pipe.** Reinforced concrete circular pipe shall conform to AASHTO M 170 or AASHTO M 242. If AASHTO M 242 pipe is used, the design loads shall conform to AASHTO M 170.

If AASHTO M 170 pipe is used, the following exceptions and additions shall apply.

The circular pipe designs shown in Tables 909-1 through 909-4 may be used in addition to those shown in Tables 2, 3, 4 and 5 of AASHTO M 170.

Lift holes shall be cast or drilled and shall be sealed with concrete plugs after installation of the pipe. Lift holes in circular pipe with elliptical reinforcing shall be cast along the top centerline of the pipe. Circular pipe intended for use in pipe culverts and sewers jacked-in-place shall contain circular reinforcement. The absorption test requirements of the concrete will be waived if the load required to produce the 0.01 inch crack exceeds, by 20 percent or more, the specified minimum load to produce the 0.01 inch crack.

If stirrup supports are used, the top and bottom centerline of the pipe shall be marked, inside and out, on each end of the pipe. These centerline markings shall be indentations on the pipe or painted on with waterproof paint. The stirrup supports shall be placed symmetrically about the centerline in the top and bottom portion of the pipe. Stirrups shall pass around, and be in contact with, each inside circumferential reinforcing member. The required stirrup spacing is given in Tables 909-2 through 909-4. Not more than three sections of stirrup material shall be used in any one support line and the minimum length of section shall be 30 inches.

- B. **Reinforced Concrete Elliptical Pipe.** Reinforced concrete elliptical pipe shall conform to AASHTO M 207, except that the absorption test requirement of the concrete will be waived if the load required to produce the 0.01 inch crack exceeds, by 20 percent or more, the specified minimum load to produce the 0.01 inch crack.

The horizontal elliptical pipe designs shown in Table 909-5 may be used in addition to those shown in Table 1 of AASHTO M 270.

- C. **Non-Reinforced Concrete Pipe.** Non-reinforced concrete pipe shall conform to AASHTO M 86. Required markings shall be made on the barrel of the pipe near the socket and shall be clearly legible at the time the pipe is delivered to the project site.
- D. **Precast Concrete Box Sections.** Precast concrete box sections shall be used only as shown in the contract documents and shall meet AASHTO M 259 or AASHTO M 273, as applicable.
- E. **Concrete End Sections.** Precast concrete end sections shall be constructed of materials which conform to AASHTO M 170, Class II, as modified by details shown on the plans. Concrete for end sections made by the wet-cast method shall have an entrained air content of 6.0 plus or minus 2.0 percent. Concrete for end sections made by the dry-cast process shall contain a minimum of 658 pounds per cubic yard of cement and a liquid air entraining agent used at four times the dosage recommended by the manufacturer for conventional slump concrete.

Connections to pipe culverts shall be by means of tongue and groove joints.

- F. **Pipe Culverts Jacked-in-Place.** Reinforced concrete pipe culverts to be jacked-in-place must meet AASHTO M170, Class IV or V, Wall C requirements and must be at least 36 inches in diameter.

909.05 Metal Pipe Products. Table 909-6 either specifies the minimum wall thickness for a pipe material and use, or directs the Contractor to Tables 909-7 through 909-17 to determine the required wall thickness.

For gage equivalents to the nominal thicknesses specified, refer to Table 909-19.

- A. **Corrugated Steel Pipe.** Circular and pipe arch corrugated steel pipe shall conform to AASHTO M 36 when metallic coated pipe is specified, or AASHTO M 245 when polymer coated pipe is specified, with the following exceptions and additions.

Type IA, and Type IIA (smooth lined) corrugated steel pipe may be used only when authorized by the Engineer.

1. **Steel Sheet.** Corrugated steel pipe shall be made from zinc coated sheet conforming to AASHTO M 218 or from aluminum coated sheet conforming to AASHTO M 274. The use of the continuous welded seam process in the fabrication of pipe from aluminum coated sheet is not permitted.

For polymer coated corrugated steel pipe, AASHTO M 246 Grade 250/250 polymer on zinc coated steel sheet shall be used.

The weight of metallic coating on any individual sample of fabricated pipe or steel sheet shall meet the single spot and triple spot test requirements. Tables 909-6 through 909-11 specify, the nominal sheet thickness for a given diameter and class of culvert or sewer pipe for the size of corrugation of the pipe furnished.

Steel sheet having a nominal thickness of 0.05 inch or greater shall be used to fabricate 3- to 10-inch diameter pipe.

2. **Corrugations.** Pipe fabricated with 1½ inch by ¼ inch corrugations is not permitted for pipe having a diameter of 12 inches or more.
3. **End Finish for Helical Corrugated Pipe.** Helical corrugated pipe in 12-inch diameter and larger sizes, except perforated pipe, shall have the ends of the pipe rerolled to form at least two circumferential corrugations, or to form an upturned flange, as provided in AASHTO M 36 or AASHTO M 245. Pipe smaller than 12-inch diameter and all perforated pipe may have this end treatment at the option of the fabricator.
4. **Coupling Bands.** For 12-inch diameter and larger pipe (except perforated pipe), the coupling bands for connecting sections of pipe and for attaching end sections to culvert pipe shall be circumferentially corrugated with the same size corrugations as on the ends of the pipe being joined, or shall be preformed channel bands for use on pipe ends with flanges, and shall meet the other requirements of AASHTO M 36 or AASHTO M 245 and the details shown on the plans.

For 10-inch diameter and smaller, the coupling bands shall have corrugations matching the pipe corrugations.

Perforated pipe 12-inch diameter and smaller, may be connected with smooth sleeve-type couplers. For larger sizes of perforated pipe, the coupling bands shall have corrugations matching the pipe corrugations.

Coupling band connections shall be as specified in Subsection 401.03 and AASHTO M 36 or AASHTO M 245 as applicable.

- B. **Corrugated Aluminum Alloy Pipe** shall conform to AASHTO M 196, except that the pipe shall be fabricated from aluminum sheet having the nominal thickness specified in Tables 909-12 through 909-17 for the size and class of culvert furnished.

Type IA and Type IIA (smooth lined) corrugated aluminum alloy pipe may be used only when authorized by the Engineer

- C. **Steel End Sections** shall be fabricated according to the details shown on the plans and shall be furnished complete with coupling bands or hardware as indicated on the plans. The metallic coating on the end sections shall be the same as the metallic coating on the pipe, except zinc coated steel end sections may be used with aluminum coated steel pipe. Metal end sections shall conform to AASHTO M 36, where applicable.
- D. **Steel Pipe for Jacking in Place** shall meet either ASTM A 53, Type E or S, Grade B or ASTM A 139, Grade B. The ends of all steel pipe to be jacked in place shall be prepared for field welding at joints.

909.06 Plastic Pipe Products.

- A. **Smooth-Lined Corrugated Polyethylene Pipe (CPE)** and all required fittings shall meet AASHTO M 294, Type S.
- B. **Corrugated Polyvinyl Chloride Pipe (CPV)** and fittings shall meet AASHTO 304. Corrugated polyvinyl pipe will be tested according to MTM 728.
- C. **Corrugated Plastic Pipe Couplings.** If a separate fitting or coupling is used to ensure a watertight joint in corrugated plastic pipe culverts and sewers it shall be a non-corrugated, solid sleeve fabricated from polyethylene (PE) or polyvinyl chloride (PVC) with a gasket on both sides of the joint. Split collar couplers will not be allowed.

Each sleeve shall have an indentation in the center to ensure proper positioning of the pipe sections in the field. Sleeves shall be factory installed on one end of the pipe sections and a removable protective material shall be placed over the exposed gaskets. Gaskets and sleeves shall be lubricated prior to insertion as required by the manufacturers.

909.07 Pipe for Underdrains.

- A. **Smooth Plastic Pipe** for underdrain shall be polyvinyl chloride (PVC) pipe meeting AASHTO M 278. As an option, acrylonitrile-butadiene-styrene (ABS) pipe meeting ASTM D 2751, SDR 35, with perforations meeting AASHTO M 278, may be furnished for pipes 6 inches in diameter and smaller. The joint tightness requirements shall not apply.

- B. **Corrugated Plastic Tubing** for underdrain shall meet AASHTO M 252 for polyethylene (PE) tubing or ASTM F 949 for polyvinyl chloride (PVC) tubing. The perforations for both PE and PVC tubing shall conform to AASHTO M 252.
- C. **Underdrain Outlets** shall be constructed with polyvinyl chloride pipe meeting ASTM D 1785 Schedule 40, ASTM D 2665 or ASTM D 3034 Type SDR 23.5 or corrugated steel pipe meeting Subsection 909.05.A
- D. **Connections.** All fittings and connections used in the underdrain system shall be approved by the Engineer before underdrain installation begins.

Tape used to seal connections shall be manufactured using adhesives resistant to moisture and organic growth and shall be as recommended by the manufacturer for underground service conditions.

909.08 Pipe for Downspouts.

- A. **Bridge Deck Downspouts.** Pipe shall be polyethylene (PE) pipe meeting PE 3406, Schedule 40, of ASTM D 2447.
- B. **Other Downspouts.** Unless otherwise called for on the plans, the pipe may be corrugated steel pipe meeting subsection 909.05.A, corrugated aluminum alloy pipe meeting subsection 909.05.B, or corrugated polyethylene pipe (CPP) meeting AASHTO M 294, Type C. Any fittings required for CPP shall also meet AASHTO M 294.

The joints between lengths of the pipe shall be sealed as recommended by the pipe manufacturer to form a silt-tight joint. End sections shall meet the requirements as called for on the plans and as specified in subsections 909.04.D or 909.05.C.

- C. **Bridge Deck Drain Extensions.** Bridge deck drain extensions shall be one piece fiberglass reinforced plastic selected from the Qualified Products List.

909.09 Cold-Applied Pipe Joint Sealer. Cold-applied pipe joint sealers will be tested as specified in section 904 with the following exceptions and additions.

The penetration test, cone method, will be as specified by ASTM D 1191, except that the material will be tested as received. The material may be troweled into the ointment can. The flow test will be as specified by ASTM D 1851, except that the material as received may be troweled into the test mold.

The asphaltic material for sealing joints in concrete or clay pipe shall be of such consistency that it may be spread on the joints with a trowel when the temperature of the air is between 14 °F and 100 °F. The material shall adhere to the concrete or clay to make a watertight seal and shall not flow, crack, or become brittle when exposed to the atmosphere.

The asphaltic sealer shall meet the following specific requirements:

Penetration, 77 °F, 150 g, 5 sec., with cone	175-300
Loss on heating, 325 °F, 5 hr., 50 g, percent	1.50 max
Solubility in trichloroethylene, percent	70 min
Ash, percent	15-25
Flow, centimeters, at 60 °C	0 max

The sealer shall be delivered to the project in containers and shall be sealed or otherwise protected from contamination. The container shall be marked as "Cold-Applied Pipe Joint Sealer" and shall show the brand name, net volume or weight, and the requirements for application.

909.10 Drainage Marker Posts. Drainage marker posts shall conform to the requirements for plastic or steel delineator posts in section 919 or the requirements for steel line fence posts in section 907, except that the posts shall be a minimum of 6 feet in length. Alternate post materials may be submitted to the Engineer for approval.

909.11 Rodent Screens. Rodent screens shall be fabricated from hardware cloth (zinc coated steel wire fabric) conforming to ASTM A 740 with 0.30 inch maximum opening size, except that the nominal wire size shall be 0.057 inch and the weight of zinc coating shall be a minimum of 0.59 ounces per square foot of uncoated wire surface. The zinc coating shall be applied after weaving. In lieu of the zinc coated hardware cloth, a fabric made of Type 304 stainless steel wire, 0.30 inch maximum opening, 0.057 inch nominal wire diameter, may be substituted. Other screens with a maximum 0.30 inch opening may be submitted to the Engineer for approval.

The screen shall be formed using a punch and die. After shaping, the fabric shall approximate a cylinder slightly larger than the inside diameter of the outlet pipe.

Table 909-1 Additional Designs For Class II Reinforced Concrete Pipe (AASHTO M 170 Table 2 Extended)

D-Load to produce a 0.01 inch crack 1000
 D-Load to produce the ultimate load 1500
 Concrete Strength 5000 psi

Internal Diameter of Pipe, in.	Wall Thickness in., min.	Reinforcement, sq. in. per Linear Foot of Pipe Wall			
		Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe	
		Inner Cage	Outer Cage	Inner Circular Cage	Elliptical Cage
114	9½	0.56	0.34	0.22	0.34
120	10	0.61	0.37	0.24	0.37
126	10½	0.65	0.39	0.26	0.39
132	11	0.70	0.42	0.28	0.42
144	12	0.80	0.48	0.32	0.48

Table 909-2 Additional Designs For Class III Reinforced Concrete Pipe(AASHTO M 170 Table 3 Extended)

D-Load to produce a 0.01 inch crack 1350
 D-Load to produce the ultimate load 2000
 Concrete Strength 5000 psi

Internal Diameter of Pipe, in.	Wall Thickness, in. min.	Reinforcement, sq. in. Per linear foot of Pipe Wall				Stirrup Support System				
		Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe		Minimum Area per Support Element sq. in. (a)	Number of Lines (b)	Longitudinal Spacing in.	Circumferential Spacing on Inner Cage in.	Amplitude of Supports in. (c)
		Inner Cage	Outer Cage	Inner Circular Cage	Elliptical Cage					
114	9½	0.69	0.41	0.28	0.41	0.041	5	2	6 1/8	6.67
120	10	0.74	0.44	0.30	0.44	0.041	5	2	6 ½	7.17
126	10½	0.79	0.47	0.32	0.47	0.041	5	2	6 7/8	7.67
132	11	0.85	0.51	0.34	0.51	0.041	5	2	7 1/4	8.17
144	12	0.97	0.58	0.39	0.58	0.041	5	2	8	9.17

Where a stirrup system is shown for a given size, it must be used with the circumferential reinforcement design selected.

- Two times the cross-sectional area of the wire used in the stirrup support system using 2 inch by 8 inch pattern for inner cage steel.
- Number of longitudinal lines required in the top and in the bottom portions of the pipe.
- Overall width of each line of stirrup support system using 2 in. x 8 in. pattern for inner cage steel. (Use with Shearlock stirrups or S-stirrups or equal)

Table 909-3 Additional Designs For Class IV Reinforced Concrete Pipe(AASHTO M 170 Table 4 Extended)

D-Load to produce a 0.01 inch crack 2000
 D-Load to produce the ultimate load 3000

Internal Diameter of Pipe, in.	Wall Thickness, in., min.	Reinforcement, sq. in. per linear foot of Pipe Wall				Stirrup Support System				
		Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe		Minimum area per Support Element sq. in. (a)	Number of Lines (b)	Longitudinal Spacing in.	Circumferential Spacing on Inner Cage in.	Amplitude of Supports in. (c)
		Inner Cage	Outer Cage	Inner Circular Cage	Elliptical Cage					
78 84	7 ½ 8	Concrete Strength, 5500 psi								
		0.87	0.52	0.35	0.52					
		1.00	0.60	0.40	0.64					
		Concrete Strength, 5000 psi								
78	7½	0.69	0.41	0.28	0.41	0.041	11	2	4 1/8	4.67
84	8	0.74	0.44	0.30	0.44	0.041	11	2	4 5/8	5.17
90	8	0.85	0.51	0.34	0.51	0.041	11	2	4 5/8	5.17
96	8½	0.91	0.55	0.36	0.55	0.041	11	2	5 1/8	5.67
102	8½	1.02	0.61	0.41	0.61	0.041	11	2	5 1/8	5.67
108	9	1.07	0.64	0.43	0.64	0.045	11	2	5 5/8	6.17
114	9½	1.02	0.61	0.41	0.61	0.048	11	2	6 1/8	6.67
120	10	1.10	0.66	0.44	0.66	0.051	11	2	6 ½	7.17
126	10½	1.17	0.70	0.47	0.70	0.055	11	2	6 7/8	7.67
132	11	1.25	0.75	0.50	0.75	0.058	11	2	7 1/4	8.17
144	12	1.42	0.85	0.57	0.85	0.065	11	2	8	9.17

Where a stirrup system is shown for a given size, it must be used with the circumferential reinforcement design selected.

- a. Two times the cross-sectional area of the wire used in the S-stirrups.
- b. Number of longitudinal lines required in the top and in the bottom portions of the pipe.
- c. Overall width of each line of stirrup support system using 2 in. x 8 in. pattern for inner cage steel. (Use with Shearlock stirrups or S-stirrups or equal)

Table 909-4 Additional Designs for Class V Reinforced Concrete Pipe (AASHTO M 170 Table 5 Extended)

D-Load to produce a 0.01 inch crack 3000
 D-Load to produce the ultimate load 3750
 Concrete Strength 6000 psi

Internal Diameter of Pipe, in.	Wall Thickness, in., min.	Reinforcement, sq. in. linear foot of Pipe Wall				Stirrup Support System				
		Circular Reinforcement in Circular Pipe		Elliptical Reinforcement in Circular Pipe		Minimum Area per Support Element sq in (a)	Number of Lines(b)	Longitudinal Spacing in	Circumferential Spacing on Inner Cage in	Amplitude of Supports in (c)
		Inner Cage	Outer Cage	Inner Circular Cage	Elliptical Cage					
54	5½	0.64	0.38	0.26	0.38	0.041	15	2	2 1/8	2.67
60	6	0.70	0.42	0.28	0.42	0.041	14	2	2 5/8	3.17
66	6½	0.79	0.47	0.32	0.47	0.041	13	2	3 1/8	3.67
72	7	0.87	0.52	0.35	0.52	0.041	12	2	3 5/8	4.17
78	7½	0.92	0.55	0.37	0.55	0.041	11	2	4 1/8	4.67
84	8	0.99	0.59	0.40	0.59	0.041	11	2	4 5/8	5.17
90	8	1.13	0.68	0.45	0.68	0.041	11	2	4 5/8	5.17
96	8½	1.20	0.72	0.48	0.72	0.045	11	2	5 1/8	5.67
102	8½	1.34	0.80	0.54	0.80	0.053	11	2	5 1/8	5.67
108	9	1.51	0.91	0.60	0.91	0.063	11	2	5 5/8	6.17
114	9½	1.51	0.91	0.60	0.91	0.064	11	2	6 1/8	6.67
120	10	1.62	0.97	0.65	0.97	0.068	11	2	6 ½	7.17
126	10½	1.73	1.04	0.69	1.04	0.072	11	2	6 7/8	7.67
132	11	1.84	1.10	0.74	1.10	0.076	11	2	7 1/4	8.17
144	12	2.09	1.25	0.84	1.25	0.085	11	2	8	9.17

Where a stirrup system is shown for a given size, it must be used with the circumferential reinforcement design selected.

- a. Two times the cross-sectional area of the wire used in the Stirrups Support System using 2 in. x 8 in. pattern for inner cage steel. (Use with Shearlock stirrups or S-stirrups or equal)
- b. Number of longitudinal lines required in the top and in the bottom portions of the pipe.
- c. Overall width of each line of stirrups.

Table 909-5 Additional Designs Horizontal Elliptical Pipe

Designated Diameter, Equivalent Round Size, in.	Designated Rise, in. x Span, in.	Minimum Wall Thickness, in.	Reinforcement, sq in per linear foot														
			Class HE-A		Class HE-I		Class HE-II		Class HE-III		Class HE-IV						
			D-Loads											Stirrup Support System			
			0.01 = 600 Ult = 900		0.01 = 800 Ult = 1200		0.01 = 1000 Ult = 1500		0.01 = 1350 Ult = 2000		0.01 = 2000 Ult = 3000		Min. Area per Support Element, sq. in.	Number of Lines (a)	Longitudinal Spacing, in.	Circumferential Spacing on Inner Cage, in. (b)	
In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage								
48	38 x 60	51/12	---	---	---	---	---	---	---	---	0.70	0.70	0.13	15	2	3.000	
54	43 x 68	6	---	---	---	---	---	---	---	---	0.82	0.82	0.15	15	2	3.375	
60	48 x 76	6½	---	---	---	---	---	---	---	---	0.94	0.94	0.17	15	2	3.750	
66	53 x 83	7	---	---	---	---	---	---	---	---	0.99	0.99	0.17	15	2	4.125	
72	58 x 91	7½	---	---	---	---	---	---	---	---	1.11	1.11	0.19	15	2	4.500	
78	63 x 98	8	---	---	---	---	---	---	---	---	1.21	1.21	0.21	15	2	4.875	
84	68 x 106	8½	---	---	---	---	---	---	---	---	1.33	1.33	0.22	15	2	5.250	
90	72 x 113	9	0.28	0.28	0.40	0.40	0.58	0.58	0.84	0.84	1.43	1.43	0.24	15	2	5.625	
96	77 x 121	9½	0.30	0.30	0.45	0.45	0.65	0.65	0.92	0.92	1.56	1.56	0.26	15	2	6.000	
102	82 x 128	9¾	0.33	0.33	0.52	0.52	0.73	0.73	1.03	1.03	1.72	1.72	0.28	15	2	6.188	
108	87 x 136	10	0.36	0.36	0.60	0.60	0.83	0.83	1.16	1.16	1.92	1.92	0.30	15	2	6.375	
114	92 x 143	10½	0.40	0.40	0.64	0.64	0.88	0.88	1.23	1.23	2.02	2.02	0.32	15	2	6.750	
120	97 x 151	11	0.44	0.44	0.70	0.70	0.96	0.96	1.32	1.32	2.16	2.16	0.34	15	2	7.125	
132	106 x 166	12	0.53	0.53	0.81	0.81	1.09	1.09	1.49	1.49	2.40	2.40	0.38	15	2	7.875	
144	116 x 180	13	0.61	0.61	0.91	0.91	1.21	1.21	1.64	1.64	2.62	2.62	0.42	15	2	8.625	
Concrete Strength, psi			4000		4000		4000		5000		48, 54, 60 in. 4000 66-144 in. 5000						

Where a stirrup system is shown for a given size, it must be used with the circumferential reinforcement design selected.

- a. Number of longitudinal lines required in the top and in the bottom portions of the pipe.
- b. Overall width of each line of stirrups.

Table 909-6 References for Spiral Ribbed and Corrugated Metal Pipes

(Minimum wall thickness in inches to meet structural and durability requirements for various metal pipes to meet the design life.)

Pipe Material Type	Driveway Culverts and Downspouts	Culverts	Sewers	
		Minimum Design Life		
		25 years	50 years	70 years
Galvanized Spiral Ribbed Metal Pipe	Table 909-8	0.109	0.168	
Aluminized Type 2 Spiral Ribbed Metal Pipe	Table 909-8	Table 909-11	0.138	
Polymeric Coated Spiral Ribbed Metal Pipe	Table 909-8	Table 909-8	0.109	
Galvanized Corrugated Metal Pipe	Table 909-7	Table 909-9	0.168 (a)	
Aluminized Type 2 Corrugated Metal Pipe	Table 909-7	Table 909-10	0.138 (a)	
Polymeric Coated Corrugated Galvanized Pipe	Table 909-7	Table 909-7	0.109 (a)	
Aluminum pipe	Table 909-12	Table 909-13	Table 909-14	
Aluminum Spiral Ribbed Pipe	Table 909-15	Table 909-16	Table 909-17	

Numbers represent the minimum durability gage requirements for the specific pipe material.
 Table 909-7 represents the minimum structural gage thickness requirements for corrugated steel pipe.
 Table 909-8 represents the minimum structural gage thickness requirements for spiral ribbed steel pipe.
 a. Permitted for 12 inch.

**Table 909-7 Wall Thickness Requirements in Inches,
Based on Diameter Class of Pipe, and Size of Corrugation.***

Diameter of Pipe, in.	0 to 16 ft.		Over 16 ft. to 24 ft.			Over 24 ft. to 32 ft.		
	Corrugation Size, in.		Corrugation Size, in.			Corrugation Size, in.		
	2 2/3 x 1/2	3 x 1, 5 x 1	2 2/3 x 1/2	3 x 1	5 x 1	2 2/3 x 1/2	3 x 1	5 x 1
12-30	0.064	-	0.064	-	-	0.064	-	-
36-48	0.064	0.064	0.064	0.064	0.064	0.064(a)	0.064	0.064
54	0.079	0.064	0.079	0.064	0.064	0.079	0.064	0.064
60	0.109	0.064	0.109	0.064	0.064	0.109	0.064(a)	0.064
66	0.138	0.064	0.138	0.064	0.064	0.138	0.064(a)	0.064
72	0.138	0.064	0.138	0.064(a)	0.064	0.138	0.064(a)	0.064
78	0.168	0.064	0.168	0.064(a)	0.064	0.168	0.064(b)	0.064
84	0.168	0.064	0.168	0.064(a)	0.064	0.168	0.064(b)	0.079
90	-	0.064	-	0.064(b)	0.064	-	0.079(a)	0.079
96	-	0.079	-	0.079(a)	0.079	-	0.079(a)	0.079
102	-	0.079	-	0.079(a)	0.079	-	0.079(a)	0.109
108-120	-	0.109	-	0.109	0.109	-	0.109(a)	0.109
126	-	0.138	-	0.138	0.138	-	0.138	0.138
130-136	-	0.138	-	0.138	0.138	-	0.138(a)	0.138
144	-	0.168	-	0.168	0.168	-	0.168(c)	0.168

- a. Increase the wall thickness by one gage for riveted or spot welded longitudinal seams.
- b. Increase the wall thickness by two gages for riveted or spot welded longitudinal seams.
- c. Not allowed for riveted or spot welded longitudinal seams. Riveted or spot welded seams will not be permitted for 5 in. x 1 in. corrugations.
- * For pipe-arch shape corrugated steel pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-8 Wall Thickness Requirements in Inches,
Based on Diameter, Class of Pipe, and Size of Ribs***

Pipe Diameter, in	0 to 16 ft.		Over 16 to 24 ft.		Over 24 to 32 ft.	
	Corrugation Size, in.		Corrugation Size, in.		Corrugation Size, in.	
	$\frac{3}{4} \times \frac{3}{4} \times 7 \frac{1}{2}$	$\frac{3}{4} \times 1 \times 11 \frac{1}{2}$	$\frac{3}{4} \times \frac{3}{4} \times 7 \frac{1}{2}$	$\frac{3}{4} \times 1 \times 11 \frac{1}{2}$	$\frac{3}{4} \times \frac{3}{4} \times 7 \frac{1}{2}$	$\frac{3}{4} \times 1 \times 11 \frac{1}{2}$
18-36	0.064	0.064	0.064	0.064	0.064	0.064
42	0.064	0.064	0.064	0.064	0.064	0.079
48	0.064	0.064	0.064	0.079	0.064	0.079
54	0.079	0.064	0.079	0.079	0.079	0.109
60	0.079	0.079	0.079	0.079	0.079	0.109
66	0.109	0.079	0.109	0.109	0.109	0.109
72-78	0.109	0.109	0.109	0.109	0.109	0.109
84	-	0.109	-	0.109	-	0.109

*For pipe-arch shape corrugated steel pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch

**Table 909-9 Wall Thickness Requirements in Inches,
Based on Class of Pipe and Size of Corrugation***

Pipe Diameter, in.	Class 1 and 2		Class 3		Class 4		
	Corrugation Size, in.		Corrugation Size, in.		Corrugation Size, in.		
	$2 \frac{2}{3} \times \frac{1}{2}$	3 x 1, 5 x 1	$2 \frac{2}{3} \times \frac{1}{2}$	3 x 1, 5 x 1	$2 \frac{2}{3} \times \frac{1}{2}$	3 x 1	5 x 1
12-30	0.109	-	0.109	-	0.109	-	-
36-60	0.109	0.109	0.109	0.109	0.107	0.109	0.109
66-72	0.138	0.109	0.138	0.109	0.138	0.109	0.109
78-84	0.168	0.109	0.168	0.109	0.168	0.109	0.109
90-102	-	0.109	-	0.109	-	0.109	0.109
108-120	-	0.109	-	0.109	-	0.109	0.109
						(a)	
126	-	0.138	-	0.138	-	0.138	0.138
130-136	-	0.138	-	0.138	-	0.138	0.138
						(a)	
144	-	0.168	-	0.168	-	0.168	0.168
						(c)	

- a. Increase the wall thickness by one gage for riveted or spot welded longitudinal seams.
- b. Increase the wall thickness by two gages for riveted or spot welded longitudinal seams.
- c. Not allowed for riveted or spot welded longitudinal seams. Riveted or spot welded seams will not be permitted for 5 in. x 1 in. corrugations.

* For pipe-arch shape corrugated steel pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-10 Wall Thickness Requirements in Inches,
Based on Diameter, Class of Pipe and Size of Corrugation***

Pipe Diameter, in.	Class 1 and 2		Class 3			Class 4		
	Corrugation Size, in.		Corrugation Size, in.			Corrugation Size, in.		
	2 2/3 x 1/2	3 x 1, 5 x 1	2 2/3 x 1/2	3 x 1	5 x 1	2 2/3 x 1/2	3 x 1	5 x 1
12-30	0.079	----	0.079	----	----	0.079	----	----
36-54	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
60	0.109	0.079	0.109	0.079	0.079	0.109	0.079	0.079
66-72	0.138	0.079	0.138	0.079	0.079	0.138	0.079	0.079
78-84	0.168	0.079	0.168	0.079	0.079	0.168	0.079(a)	0.079
90-96	-	0.079	-	0.079(a)	0.079	-	0.079(a)	0.079
102	-	0.079	-	0.079(a)	0.079	-	0.079(a)	0.109
108-120	-	0.109	-	0.109	0.109	-	0.109(a)	0.109
126	-	0.138	-	0.138	0.138	-	0.138	0.138
130-136	-	0.138	-	0.138	0.138	-	0.138(a)	0.138
144	-	0.168	-	0.168	0.168	-	0.168(c)	0.168

- a. Increase the wall thickness by one gage for riveted or spot welded longitudinal seams.
b. Increase the wall thickness by two gages for riveted or spot welded longitudinal seams.
c. Not allowed for riveted or spot welded longitudinal seams. Riveted or spot welded seams will not be permitted for 5 in. x 1in. corrugations.
* For pipe-arch shape corrugated steel pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-11 Wall Thickness Requirements in Inches,
Based on Diameter, Class of Pipe, and Size of Ribs***

Pipe Diameter, in.	Class 1 and 2		Class 3		Class 4	
	Corrugation Size, in.		Corrugation Size, in.		Corrugation Size, in.	
	3/4 x 3/4 x 7 1/2	3/4 x 1 x 11 1/2	3/4 x 3/4 x 7 1/2	3/4 x 1 x 11 1/2	3/4 x 3/4 x 7 1/2	3/4 x 1 x 11 1/2
18-72	0.079	0.079	0.079	0.079	0.079	0.079
54-60	0.079	0.079	0.079	0.079	0.079	0.109
66-78	0.109	0.109	0.109	0.109	0.109	0.109
84	-	0.109	-	0.109	-	0.109

*For pipe-arch shape corrugated steel pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-12 Wall Thickness Requirements in Inches,
Based on Class of Pipe and Size of Corrugation,
Lock Seam Pipe Only.***

Pipe Diameter, in.	0 to 16 ft.		Over 16 to 24 ft.		Over 24 to 32 ft.	
	Corrugation Size, in.		Corrugation Size, in.		Corrugation Size in.	
	2 2/3 x 1/2	3 x 1	2 2/3 x 1/2	3 x 1	2 2/3 x 1/2	3 x 1
12-26	0.060	0.060	0.060	0.060	0.060	0.060
30-36	0.075	0.060	0.075	0.060	0.075	0.060
42-54	0.105	0.060	0.105	0.060	0.105	0.060
60	0.135	0.075	0.135	0.075	0.135	0.075
66-72	0.164	0.075	0.164	0.075	0.164	0.075
78	-	0.075	-	0.075	-	0.075
84-96	-	0.105	-	0.105	-	0.105
102-108	-	0.135	-	0.135	-	0.135
112-120	-	0.164	-	0.164	-	0.164

* For pipe-arch shape corrugated aluminum pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-13 Wall Thickness Requirements in Inches,
Based on Class of Pipe and Size of Corrugation,
Lock Seam Pipe Only.***

Pipe Diameter, in.	Class 1, 2,3,4	
	Corrugation Size, in.	
	2 2/3 x 1/2	3 x 1
12-36	0.075	0.075
42-54	0.105	0.075
60	0.135	0.075
66-72	0.164	0.075
78	-	0.075
84-96	-	0.105
102-108	-	0.135
112-120	-	0.164

* For pipe-arch shape corrugated aluminum pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-14 Wall Thickness Requirements in Inches,
Based on Class of Pipe and Size of Corrugation,
Lock Seam Pipe Only.***

Pipe Diameter, in.	Class 1, 2, 3, 4	
	Corrugation Size, in.	
	2 2/3 x 1/2	3 x 1
12-54	0.105	0.105
60	0.135	0.105
66-72	0.164	0.105
78-96	-	0.105
102-108	-	0.135
112-120	-	0.164

* For pipe-arch shape corrugated aluminum pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-15 Wall Thickness Requirements in Inches,
Based on Diameter, Class of Pipe, and Size of Rib,
Lock Seam Pipe Only.***

Pipe Diameter, in.	Class 6
	3/4x3/4x7 1/2
18-24	0.060
30-36	0.075
42-54	0.105
60-66	0.135

* For pipe-arch shape corrugated aluminum pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-16 Wall Thickness Requirements in inches,
Based on Diameter, Class of Pipe, and
Size of Rib, Lock Seam Pipe Only***

Pipe Diameter, in.	Class 1, 2, 3, 4
	3/4x3/4x7 1/2
18-36	0.075
42-54	0.105
60-66	0.135

*For pipe-arch shape corrugated aluminum pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-17 Wall Thickness Requirements in Inches,
Based on Diameter, Class of Pipe, and Size of Rib,
Lock Seam Pipe Only.***

Pipe Diameter, in.	Class 1, 2, 3, 4
	3/4x3/4x7 1/2
18-54	0.105
60-66	0.135

* For pipe-arch shape corrugated aluminum pipe, use the gage requirement for the circular pipe equal to or next larger than the span of the pipe-arch.

**Table 909-18 Nominal O.D. and Wall Thickness in Inches
Jacked In Place Steel Pipe.**

Nominal Size	Nominal Outside Diameter	Wall Thickness
2	2.375	0.154
4	4.500	0.188
6	6.625	0.188
8	8.625	0.188
10	10.750	0.188
12	12.750	0.188
14	14.000	0.250
16	16.000	0.250
18	18.000	0.250
20	20.000	0.250
24	24.000	0.250
30	30.000	0.312
36	36.000	0.312
42	42.000	0.438
48	48.000	0.500
54	54.000	0.563

Table 909-19 Gage Equivalents to Nominal Thickness

Sheet Gage Number		18	16	14	12	10
Nominal Thickness in.	Galvanized	0.052	0.064	0.079	0.109	0.138
	Aluminum Alloy	0.048	0.060	0.075	0.105	0.135
Sheet Gage Number		8	7	5	3	1
Nominal Thickness in.	Galvanized	0.168	0.188	0.218	0.249	0.280
	Aluminum Alloy	0.164	--	--	--	--