



Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains¹

This standard is issued under the fixed designation B 745/B 745M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers corrugated aluminum pipe intended for use for storm water drainage, underdrains, the construction of culverts, and similar uses. Pipe covered by this specification is not normally used for the conveyance of sanitary or industrial wastes.

1.2 This specification does not include requirements for bedding, backfill, or the relationship between earth-cover load and sheet thickness of the pipe. Experience has shown that the successful performance of this product depends upon the proper selection of sheet thickness, type of bedding and backfill, controlled manufacture in the plant, and care in the installation. The purchaser must correlate the above factors and also the corrosion and abrasion requirements of the field installation with the sheet thickness. The structural design of corrugated aluminum pipe and the proper installation procedures are given in Practices B 790/B 790M and B 788/B 788M, respectively. A procedure for using life-cycle cost analysis techniques to evaluate alternative drainage system designs using corrugated metal pipe is given in Practice A 930.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

¹ This specification is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.08 on Aluminum Culvert.

Current edition approved Sept. 1, 2005. Published September 2005. Originally approved in 1985. Last previous edition approved in 1997 as B 745/B 745M – 97.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A 307 Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

A 563 Specification for Carbon and Alloy Steel Nuts

A 563M Specification for Carbon and Alloy Steel Nuts [Metric]

A 930 Practice for Life-Cycle Cost Analysis of Corrugated Metal Pipe Used for Culverts, Storm Sewers, and Other Buried Conduits

B 209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

B 209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric]

B 221 Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes

B 221M Specification for Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes [Metric]

B 316/B 316M Specification for Aluminum and Aluminum-Alloy Rivet and Cold-Heading Wire and Rods

B 633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel

B 666/B 666M Practice for Identification Marking of Aluminum and Magnesium Products

B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

B 744/B 744M Specification for Aluminum Alloy Sheet for Corrugated Aluminum Pipe

B 788/B 788M Practice for Installing Factory-Made Corrugated Aluminum Culverts and Storm Sewer Pipe

B 790/B 790M Practice for Structural Design of Corrugated Aluminum Pipe, Pipe Arches, and Arches for Culverts, Storm Sewers, and Other Buried Conduits

C 443 Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets

D 1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber

F 467 Specification for Nonferrous Nuts for General Use

F 467M Specification for Nonferrous Nuts for General Use [Metric]

F 468 Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use

F 468M Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use [Metric]

F 568 Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

F 593 Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

F 594 Specification for Stainless Steel Nuts

F 738M Specification for Stainless Steel Metric Bolts, Screws, and Studs

F 836M Specification for Stainless Steel Metric Nuts

2.2 *AASHTO Standard*.³

T 249 Test for Helical Lock Seam Corrugated Pipe

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *fabricator*—the producer of the pipe.

3.1.2 *manufacturer*—the producer of the sheet.

3.1.3 *purchaser*—the purchaser of the finished product.

4. Classification

4.1 The corrugated aluminum pipe covered by this specification is classified as follows:

4.1.1 *Type I*—This pipe shall have a full circular cross-section, with a single thickness of corrugated sheet, fabricated with annular (circumferential) or helical corrugations.

4.1.2 *Type IA*—This pipe shall have a full circular cross-section, with an outer shell of corrugated sheet and an inner liner of smooth (uncorrugated) sheet, fabricated with helical corrugations and lock seams.

4.1.3 *Type IR*—This pipe shall have a full circular cross-section, with a single thickness of smooth sheet, fabricated with helical ribs projecting outwardly.

4.1.4 *Type II*—This pipe shall be a Type I pipe which has been reformed into a pipe-arch, having an approximately flat bottom.

4.1.5 *Type IIA*—This pipe shall be a Type IA pipe which has been reformed into a pipe-arch, having an approximately flat bottom.

4.1.6 *Type IIR*—This pipe shall be a Type IR pipe which has been reformed into a pipe-arch, having an approximately flat bottom.

4.1.7 *Type III*—This pipe, intended for use as underdrains or for underground disposal of water, shall be a Type I pipe which has been perforated to permit the in-flow or out-flow of water.

4.1.8 *Type IIIR*—This pipe, intended for the underground disposal of water or for subsurface drainage, shall be a Type IR pipe which has been perforated to permit the outflow or inflow of water.

4.2 Perforations in Type III pipe are classified as Class 1 or Class 2 and perforations in Type IIIR pipe are classified as Class 4, as described in 8.3.2.

5. Ordering Information

5.1 Orders for material to this specification shall include the following information as necessary, to adequately describe the desired product:

5.1.1 Name of material (corrugated aluminum pipe),

5.1.2 ASTM designation and year of issue, as B 745-__ for inch-pound units or B 745M-__ for SI units,

5.1.3 Type of pipe (4.1),

5.1.4 Method of fabrication for Type I and Type II pipe (7.1),

5.1.5 Diameter of circular pipe (8.1.1), or span and rise of pipe-arch section (8.2.1),

5.1.6 Length, either total length or length of each piece and number of pieces,

5.1.7 Description of corrugations (7.2),

5.1.8 Sheet thickness (8.1.2),

5.1.9 Coupling bands, number, and type (9.1) if special type is required,

5.1.10 Gaskets for coupling bands, if required (9.3),

5.1.11 For perforated pipe, the class of perforations. If no class is specified for Type III pipe, Class 1 perforations will be furnished. Type IIIR pipe is furnished with Class 4 perforations only (8.3.2.1 and 8.3.2.3),

5.1.12 Certification, if required (13.1), and

5.1.13 Special requirements.

6. Materials

6.1 *Aluminum Sheet for Pipe*—All pipe fabricated under this specification shall be formed from aluminum-alloy sheet conforming to Specification B 744/B 744M.

6.2 *Aluminum Sheet for Coupling Bands*—The sheet used in fabricating coupling bands shall conform to Specification B 744/B 744M.

6.3 *Rivets*—The material used for rivets in riveted pipe shall conform to the requirements of Specification B 316/B 316M for alloy 6053-T4, with the following mechanical properties:

Tensile Strength, min, ksi [MPa]	25 [170]
Yield Strength, min, ksi [MPa]	14 [95]
Shear Strength, min, ksi [MPa]	15 [105]
Elongation in 2 in., 50 mm, or 4x dia., min, %	16

If bolts and nuts are substituted for rivets (see 7.3.1), they shall meet the following requirements for either steel bolts and nuts, stainless steel bolts and nuts, or aluminum alloy bolts and nuts:

	Bolts	Nuts
For B745 pipe (Steel)	A 307	A 563 , Gr. A
(Stainless Steel)	F 593 , Alloy Grp 1, 2, or 3	F 594 , Alloy Grp 1, 2, or 3
(Aluminum Alloy)	F 468 , Alloy 6061-T6	F 467 , Alloy 6061-T6
For B745M pipe (Steel)	F 568 , Cl. 4.6	A 563M , Cl. 5
(Stainless Steel)	F 738M , Alloy Grp A1, A2, or A4	F 836M , Alloy Grp A1, A2, or A4
(Aluminum Alloy)	F 468M , Alloy 6061-T6	F 467M , Alloy 6061-T6

The steel bolts and nuts shall be hot-dip galvanized in conformance with Specification A 153, or be mechanically galvanized in conformance with Specification B 695 Class 40.

6.4 *Hardware for Coupling Bands*—Bolts and nuts for coupling bands shall conform to the requirements shown in 6.3 except for the coating on steel bolts and nuts. Steel bolts, nuts, and other threaded steel items used with coupling bands shall be zinc coated by one the following processes: hot-dip process as provided in Specification A 153, electroplating process as

³ Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001.

provided in Specification **B 633** Class FE/ZN 8, or mechanical process as provided in Specification **B 695** Class 8. Other steel hardware items used with coupling bands shall be zinc-coated by one of the following processes: hot-dip process as provided in Specification **A 153**; electroplating process as provided in Specification **B 633** Class FE/ZN 25; or mechanical process as provided in Specification **B 695** Class 25. Aluminum angles and lugs shall conform to the requirements of Specification **B 221** or **B 221M** for alloy 6063-T6.

6.5 Gaskets—If gaskets are used in couplings, they shall be a band of expanded rubber meeting the requirements of Specification **D 1056** for the “RE” closed cell grades, or O-rings meeting the requirements of Specification **C 443**.

7. Fabrication

7.1 General Requirements—Pipe shall be fabricated in full circular cross-section.

7.1.1 Type I pipe shall have annular corrugations with lap joints fastened with rivets or shall have helical corrugations with a continuous lock seam extending from end to end of each length of pipe. As there are important differences in the structural characteristics of annular, riveted pipe versus helical pipe, it is important for the purchaser to stipulate, for Type I and Type II pipe, the method of fabrication desired. If the method of fabrication is not stated in the ordering information, the fabrication method shall be at the option of the fabricator.

7.1.2 Type IA pipe shall be fabricated with a smooth liner and helically corrugated shell integrally attached at helical lock seams extending from end to end of each length of pipe. The shell shall have corrugations of nominal $2\frac{2}{3}$ (or 3 in. [68 or 75 mm] pitch).

7.1.3 Type IR pipe shall be fabricated with helical ribs projecting outward with a continuous lock seam extending from end to end of each length of pipe.

7.2 Corrugations—The corrugations shall be either annular or helical as provided in **7.1**. The direction of the crests and valleys of helical corrugations shall not be less than 60° from the axis of the pipe for pipe diameters larger than 21 in. [525 mm], and not less than 45° from the axis for pipe diameters of 21 in. [525 mm] and smaller.

7.2.1 For Type I and IA pipe, corrugations shall form smooth continuous curves and tangents. The dimensions of the corrugations shall be in accordance with **Table 1** for the size indicated in the order.

7.2.2 For Type IR pipe, the corrugations shall be essentially rectangular ribs projecting outward from the pipe wall. The dimensions and spacings of the ribs shall be in accordance with **Table 2** for the size indicated in the order. See also **Fig. 1**. For the $11\frac{1}{2}$ in. [292 mm] rib spacing, a stiffener shall be included midway between the ribs, if the sheet between the ribs does not include a lock seam. This stiffener shall have a nominal radius of 0.25 in. [6.4 mm] and a minimum height of 0.20 in. [5.1 mm] toward the outside of the pipe.

NOTE 1—The nominal dimensions and properties for smooth corrugations and for ribs are given in Practice **B 790/B 790M**.

7.3 Riveted Seams—The longitudinal seams shall be staggered to the extent that no more than three thicknesses of sheet

TABLE 1 Corrugation Requirements for Type I, IA, II, IIA, and III Pipe

Nominal Size	Maximum Pitch ^A	Minimum Depth ^B	Inside Radius ^C	
			Nominal	Minimum
<i>B 745 (in.)</i>				
1½ by ¼ ^D	1⅞	0.24	⅝ ₃₂	0.25
2½ by ½	2⅞	0.48 ^E	⅞ ₁₆	0.5
3 by 1	3¼	0.95	⅞ ₁₆	0.5
6 by 1	6¼	0.95	2.2	2.0
<i>B 745M (mm)</i>				
38 by 6.5 ^D	48	6.0	7	6.5
68 by 13	73	12 ^E	17	12
75 by 25	83	24	14	12
150 by 25	160	24	56	51

^A Pitch is measured from crest to crest of corrugations, at 90° to the direction of the corrugations.

^B Depth is measured as the vertical distance from a straightedge resting on the corrugation crests parallel to the axis of the pipe, to the bottom of the intervening valley.

^C Minimum inside radius requirement does not apply to a corrugation containing a helical lock seam.

^D The corrugation size of $1\frac{1}{2}$ by $\frac{1}{4}$ in. [38 x 6.5 mm] is available only in helically corrugated pipe.

^E For pipe 12 to 21 in. [300 to 525 mm] dia. inclusive, the minimum corrugation depth shall be 0.42 in. [11 mm].

are fastened by any rivet. Pipe to be reformed into pipe-arch shape shall also meet the longitudinal seam requirement of **8.2.2**.

NOTE 2—Fabrication of pipe without longitudinal seams in 120° of arc, so that the pipe may be installed without longitudinal seams in the invert, is subject to negotiation between the purchaser and fabricator.

7.3.1 The size of rivets, number per corrugation, and width of lap at the longitudinal seam shall be as stated in **Table 3**, depending on sheet thickness, corrugation size, and diameter of pipe. For pipe with 1 in. [25 mm] deep corrugations, $\frac{1}{2}$ -in. [Metric M12] diameter bolts and nuts may be used in lieu of rivets on a one-for-one replacement ratio. Circumferential seams shall be riveted using rivets of the same size as for longitudinal seams and shall have a maximum rivet spacing of 6 in. [150 mm], measured on centers, except that six rivets will be sufficient in 12-in. [300-mm] diameter pipe.

7.3.2 All rivets shall be driven cold in such a manner that the sheets shall be drawn tightly together throughout the entire lap. The center of a rivet shall be no closer than twice its diameter from the edge of the sheet. The distance between the centerlines of the two rows of rivets, where two rows are required, shall not be less than $1\frac{1}{2}$ in. [38 mm]. All rivets shall have neat, workmanlike, and full hemispherical heads or heads of a form acceptable to the purchaser, shall be driven without bending, and shall completely fill the hole.

7.4 Helical Lock Seams—The lock seam for Type I pipe shall be formed in the tangent element of the corrugation profile with its center near the neutral axis of the corrugation profile. The lock seam for Type IA pipe shall be in the valley of the corrugation, shall be spaced not more than 30 in. [760 mm] apart, and shall be formed from both the liner and the shell in the same general manner as Type I helical lock seam pipe. The lock seam for Type IR shall be formed in the flat zone of the pipe wall, midway between two ribs.

TABLE 2 Rib Requirements for Type IR Pipe

Nominal Size	Rib			Bottom Outside Radius, Min	Bottom ^D Outside Radius, Max Avg.	Top Outside Radius, Min	Top ^D Outside Radius, Max Avg.
	Width, Min ^A	Depth, Min ^B	Spacing, Max ^C				
			in.				
¾ by ¾ by 7½	0.68	0.73	7¾	0.10	0.25	0.10+t	0.25+t
¾ by 1 by 11½	0.68	0.95	11¾	0.10	0.25	0.10+t	0.25+t
			mm				
19 by 19 by 190	17	19	197	2.5	6.0	2.5+t	6.0+t
19 by 25 by 292	17	24	298	2.5	6.0	2.5+t	6.0+t

^A Width is a dimension of the inside of the rib but is measured on the outside of the pipe (outside of the rib). It shall meet or exceed the stated minimum width plus two wall thicknesses, that is, $2T + 0.68$ in. [$2t + 17$ mm].

^B Depth is an average of the ribs within a sheet width measured from the inside by placing a straight edge across the open rib and measuring to the bottom of the rib.

^C Spacing is an average of three adjacent rib spacings for ¾ by ¾ by 7½ in. [19 by 19 by 190 mm] pipe and two adjacent rib spacings for ¾ by 1 by 11½ in. [19 by 25 by 292 mm] pipe measured center-to-center of the ribs, at 90° to the direction of the ribs.

^D The averages of the two top rib radii and of the two bottom radii shall be within the minimum and maximum tolerances. The term outside radius refers to the surface outside of the pipe. See Fig. 1.

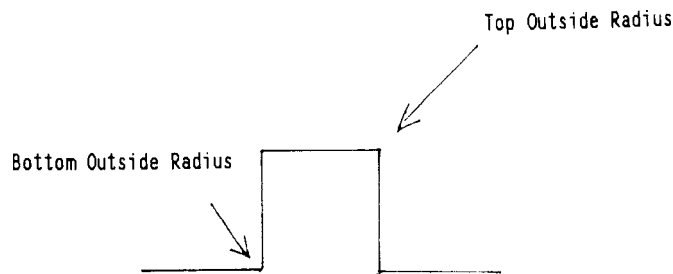


FIG. 1 Outside Radius of the Pipe (see Table 2)

TABLE 3 Riveted Longitudinal Seams

Specified Sheet Thickness		Nominal Corrugation Size					
		2½ × ½ in. 68 × 13 mm ^{A,B}		3 × 1 in. 75 × 25 mm ^{C,D}		6 × 1 in. 150 × 25 mm ^{E,D}	
		Rivet Diameters, min.					
in.	mm	in.	mm	in.	mm	in.	mm
0.060	1.52	⅝ ₁₆	8.0	⅜	9.5	½	12.7
0.075	1.91	⅝ ₁₆	8.0	⅜	9.5	½	12.7
0.105	2.67	⅜	9.5	½	12.7	½	12.7
0.135	3.43	⅜	9.5	½	12.7	½	12.7
0.164	4.17	⅜	9.5	½	12.7	½	12.7

^A One rivet each valley for pipe diameters 36 in. [900 mm] and smaller. Two rivets each valley for pipe diameters 42 in. [1050 mm] and larger.

^B Minimum width of lap: 1½ in. [38 mm] for pipe diameters 36 in. [900 mm] and smaller, and 3 in. [75 mm] for pipe diameters 42 in. [1050 mm] and larger.

^C Two rivets each valley for all pipe diameters.

^D Minimum width of lap: 3 in. [75 mm] for pipe of all diameters.

^E Two rivets each crest and valley for all pipe diameters.

7.4.1 The edges of the sheets within the cross-section of the lock seam shall lap at least ⅝ in. [4.0 mm] for pipe 10 in. [250 mm] or less in diameter and at least ⅝ in. [7.9 mm] for pipe greater than 10 in. [250 mm] in diameter, with an occasional tolerance of minus 10 % of lap width allowable. The lapped surfaces shall be in tight contact. The profile of the sheet shall include a retaining offset adjacent to the 180° fold (as described in AASHTO T 249) of one sheet thickness on one side of the lock seam, or one-half sheet thickness on both sides of the lock seam, at the fabricator's option. There shall be no visual cracks in the metal, loss of metal-to-metal contact, or excessive angularity on the interior of the 180° fold of metal at the completion of forming the lock seam. The lock seam shall be mechanically staked (indented) at periodic intervals, or otherwise specially constructed to prevent slippage.

7.4.2 Specimens cut from production pipe normal to and across the lock seam shall develop the tensile strength as

provided in Table 4, when tested according to AASHTO T 249. For Type IA pipe, the lock seam strength shall be as tabulated based on the thickness of the corrugated shell.

7.4.3 When the ends of helically-corrugated lock seam pipe have been re-rolled to form annular corrugations, either with or without a flanged end finish, the lock seam in the re-rolled end shall not contain any visible cracks in the base metal and the tensile strength of the lock seam shall be not less than 60 % of that required in 7.4.2.

7.5 End Finish:

7.5.1 To facilitate field jointing, the ends of individual pipe sections with helical corrugations or ribs may be re-rolled to form annular corrugations extending at least two corrugations from the pipe end, or to form an upturned flange meeting the requirements in 7.5.3, or both. The diameter of ends shall not exceed that of the pipe barrel by more than the depth of the corrugation. All types of pipe ends, whether re-rolled or not, shall be matched in a joint such that the maximum difference in the diameter of abutting pipe ends is ½ in. [13 mm].

7.5.2 When pipe with helical corrugations or ribs is re-rolled to form annular corrugations in the ends, the usual size of annular corrugations is 2⅔ by ½ in. [68 by 13 mm].

7.5.3 If a flanged finish is used on the ends of individual pipe sections to facilitate field jointing, the flange shall be uniform in width, be not less than ½ in. [13 mm] wide, and shall be square to the longitudinal axis of the pipe.

7.5.4 The ends of all pipe which will form the inlet and outlet of culverts, fabricated of sheets having normal thicknesses of 0.075 in. [1.91 mm] and less, shall be reinforced in a manner approved by the purchaser, when specified.

TABLE 4 Specified Aluminum Alloy Sheet Thicknesses and Lock Seam Tensile Strength

Specified Sheet Thickness ^{A,B}		Lock Seam Tensile Strength, min.	
in.	mm	lbf/in.	kN/m
0.036	0.91	100	17
0.048	1.22	145	25
0.060	1.52	170	30
0.075	1.91	245	43
0.105	2.67	425	74
0.135	3.43	550	96
0.164	4.17	700	122

^A Thicknesses listed are those included in Specification B 744/B 744M.

^B For Type IA pipe, the lock seam tensile strength requirement shall be based on the thickness of the corrugated shell.

8. Pipe Requirements Pipe Requirements

8.1 Type I, Type IA, and Type IR Pipe:

8.1.1 *Pipe Dimensions*—The nominal diameter of the pipe shall be as stated in the order, selected from the sizes listed in **Table 5**. The size of corrugations, which are standard for each size of pipe, are also shown in **Table 5**. The average inside diameter of circular pipe and pipe to be reformed into pipe-arches shall not vary more than 1 % or ½ in. [13 mm], whichever is greater, from the nominal diameter when measured on the inside crest of the corrugations. Alternately, for pipe having annular corrugations, conformance with the inside diameter requirement may be determined by measuring the outside circumference, for which minimum values are given in **Table 5**.

NOTE 3—The outside circumference of helically corrugated pipe is influenced by the corrugation size and the angle of the corrugations, affecting the number of corrugations crossed, therefore no minimum circumferential measurement can be specified.

8.1.2 *Sheet Thickness*—Sheet thickness shall be as specified by the purchaser from the specified sheet thicknesses listed in **Table 4** (**Note 4** and **Note 5**). For Type IA pipe, the thickness of both the shell and the liner shall be given; the thickness of the corrugated shell shall be at least 60 % of the thickness of the equivalent Type I pipe; the liner shall have a nominal thickness of at least 0.036 in. [0.91 mm]; and the sum of the specified thicknesses of shell and liner shall equal or exceed the specified thickness of an equivalent pipe of identical corrugations as the shell according to the design criteria in the Practice **B 790/B 790M**.

NOTE 4—The sheet thicknesses indicated in **Table 4** are the thicknesses listed as available in Specification **B 744/B 744M**.

NOTE 5—The purchaser should determine the required thickness for Type I, IA, or IR pipe, or Type I, IA or IR pipe to be reformed into Type II, IIA or IIR pipe according to the design criteria in Practice **B 790/B 790M**, or other appropriate guidelines. Specified thickness of 0.036 in. [0.91 mm] is generally used only for Type IA pipe.

8.1.3 When specified by the purchaser, the finished pipe shall be factory elongated to the extent specified. The elongation shall be accomplished by the use of a mechanical apparatus which will produce a uniform deformation throughout the length of the section.

NOTE 6—When corrugated aluminum pipe is designed according to Practice **B 790/B 790M** and installed according to Practice **B 788/B 788M**, vertical elongation (factory or field) is not required for structural purposes.

8.2 Type II, Type IIA, and Type IIR Pipe:

8.2.1 *Pipe-Arch Dimensions*—Pipe furnished as Type II, IIA, or IIR shall be made from Type I, IA, or IR pipe respectively, and shall be reformed to provide a pipe-arch shape. All applicable requirements for Types I, IA, or IR pipe shall be met by finished Types II, IIA, and IIR respectively. Pipe-arches shall conform to the dimensional requirements of **Table 6**, **Table 7**, or **Table 8** [**Table 9**, **Table 10**, or **Table 11**]. All dimensions shall be measured from the inside crest of corrugations for Type II pipe or from the inside liner or surface for Types IIA or IIR pipe, respectively.

8.2.2 *Longitudinal Seams*—Longitudinal seams of riveted pipe-arches shall not be placed in the corner radius.

TABLE 5 Pipe Sizes

Nominal Inside Diameter		Corrugation Sizes ^A					Minimum Outside Circumference ^B	
in.	mm	1½ by ¼ in. 38 by 6.5 mm	2⅝ (by ½ in. 68 by 13 mm	3 by 1 in. 75 by 25 mm	6 by 1 in. 150 by 25 mm	Ribbed Pipe ^C	in.	mm
4	100	X					11.4	284
6	150	X					17.7	441
8	200	X					24.0	598
10	250	X					30.2	755
12	300		X				36.5	912
15	375		X			X	46.0	1148
18	450		X			X	55.4	1383
21	525		X			X	64.8	1620
24	600		X			X	74.2	1854
27	675		X			X	83.6	2091
30	750		X	X		X	93.1	2325
33	825		X	X		X	102.5	2561
36	900		X	X		X	111.9	2797
42	1050		X	X		X	130.8	3269
48	1200		X	X	X	X	149.6	3739
54	1350		X	X	X	X	168.4	4209
60	1500		X	X	X	X	187.0	4675
66	1650		X	X	X	X	205.7	5142
72	1800		X	X	X	X	224.3	5609
78	1950			X	X	X	243.0	6075
84	2100			X	X	X	261.7	6542
90	2250			X	X		280.3	7008
96	2400			X	X		299.0	7475
102	2550			X	X		317.6	7941
108	2700			X	X		336.3	8408
114	2850			X	X		355.0	8874
120	3000			X			373.6	9341

^A An "X" indicates standard corrugation sizes for each nominal diameter of pipe.

^B Measured in valley of annular corrugations. Not applicable to helically corrugated pipe.

^C Rib sizes ¾ by ¾ by 7½ in. [19 by 19 by 190 mm] and ¾ by 1 by 11½ in. [19 by 25 by 292 mm].

**TABLE 6 Pipe-Arch Requirements—
2½ by ½ in. Corrugations**

Pipe Arch Size, in.	Equiv. Dia., in.	Span ^A , in.	Rise ^A , in.	Min. Corner Radius, in.	Max B ^B , in.
17 × 13	15	17	13	3	5¼
21 × 15	18	21	15	3	6
24 × 18	21	24	18	3	7¼
28 × 20	24	28	20	3	8
35 × 24	30	35	24	3	9½
42 × 29	36	42	29	3½	10½
49 × 33	42	49	33	4	11½
57 × 38	48	57	38	5	13½
64 × 43	54	64	43	6	15
71 × 47	60	71	47	7	16½
77 × 52	66	77	52	8	18
83 × 57	72	83	57	9	20

^A A tolerance of ±1 in. or 2 % of equivalent diameter, whichever is greater, is permissible in span and rise.

^B B is defined as the vertical dimension from a horizontal line across the widest portion of the arch to the lowest portion of the base.

**TABLE 7 Pipe-Arch Requirements—
3 by 1 in. Corrugations**

Pipe Arch Size, in.	Equiv. Dia., in.	Span ^A , in.	Rise ^A , in.	Min. Corner Radius, in.
53 × 41	48	53–2.4	41 + 2.4	7
60 × 46	54	60–2.7	46 + 2.7	8
66 × 51	60	66–3.0	51 + 3.0	9
73 × 55	66	73–3.3	55 + 3.3	12
81 × 59	72	81–3.6	59 + 3.6	14
87 × 63	78	87–4.4	63 + 4.4	14
95 × 67	84	95–4.8	67 + 4.8	16
103 × 71	90	103–5.2	71 + 5.2	16
112 × 75	96	112–5.6	75 + 5.6	18
117 × 79	102	117–5.9	79 + 5.9	18
128 × 83	108	128–6.4	83 + 6.4	18
137 × 87	114	137–6.9	87 + 6.9	18
142 × 91	120	142–7.1	91 + 7.1	18

^A Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, zero tolerance in opposite direction.

**TABLE 8 Pipe-Arch Requirements—
¾ by ¾ by 7½ in. and ¾ by 1 by 11½ in. Rib Corrugations**

Pipe Arch Size, in.	Equiv. Dia., in.	Span ^A , in.	Rise ^A , in.	Min Corner Radius, in.
20 × 16	18	20–1.0	16 + 1.0	5
23 × 19	21	23–1.0	19 + 1.0	5
27 × 21	24	27–1.5	21 + 1.5	5
33 × 26	30	33–1.5	26 + 1.5	5
40 × 31	36	40–1.8	31 + 1.8	5
46 × 36	42	46–2.1	36 + 2.1	6
53 × 41	48	53–2.4	41 + 2.4	7
60 × 46	54	60–2.7	46 + 2.7	8
66 × 51	60	66–3.0	51 + 3.0	9
73 × 55	66	73–3.3	55 + 3.3	12
81 × 59	72	81–3.6	59 + 3.6	14

^A Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, zero tolerance in opposite direction.

8.2.3 Reforming Type IR pipe into Type IIR pipe-arch shall be done in such a manner as to avoid damage to the external ribs.

8.3 Type III and IIR Pipe:

8.3.1 Type III and IIR pipe shall have a full circular cross-section and shall conform to the requirements for Type I or Type IR pipe, and in addition shall contain perforations conforming to one of the classes described in 8.3.2.

**TABLE 9 Pipe-Arch Requirements—
[68 by 13 mm Corrugations]**

Pipe Arch Size, mm	Equiv. Dia., mm	Span ^A , mm	Rise ^A , mm	Min. Corner Radius, mm	Max B ^B , mm
430 × 330	375	430	330	75	135
530 × 380	450	530	380	75	155
610 × 460	525	610	460	75	185
710 × 510	600	710	510	75	205
780 × 560	675	780	560	75	225
885 × 610	750	870	630	75	240
970 × 690	825	970	690	75	255
1060 × 740	900	1060	740	90	265
1240 × 840	1050	1240	840	100	290
1440 × 970	1200	1440	970	130	345
1620 × 1100	1350	1620	1100	155	380
1800 × 1200	1500	1800	1200	180	420
1950 × 1320	1650	1950	1320	205	460
2100 × 1450	1800	2100	1450	230	510

^A A tolerance of ±25 mm or 2 % of equivalent diameter, whichever is greater, is permissible in span and rise.

^B B is defined as the vertical dimension from a horizontal line across the widest portion of the arch to the lowest portion of the base.

**TABLE 10 Pipe Arch Requirements—
[75 by 25 mm Corrugations]**

Pipe Arch Size, mm	Equiv. Dia., mm	Span ^A , mm	Rise ^A , mm	Min. Corner Radius, mm
1340 × 1050	1200	1340–60	1050 + 60	180
1520 × 1170	1350	1520–70	1170 + 70	205
1670 × 1300	1500	1670–75	1300 + 75	230
1850 × 1400	1650	1850–85	1400 + 85	305
2050 × 1500	1800	2050–95	1500 + 95	355
2200 × 1620	1950	2200–110	1620 + 110	355
2400 × 1720	2100	2400–120	1720 + 120	410
2600 × 1820	2250	2800–130	1820 + 130	410
2840 × 1920	2400	2840–145	1920 + 145	460
2970 × 2020	2550	2970–150	2020 + 150	460
3240 × 2120	2700	3240–165	2120 + 165	460
3470 × 2220	2850	3470–175	2220 + 175	460
3800 × 2320	3000	3600–180	2320 + 180	460

^A Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, zero tolerance in opposite direction.

**TABLE 11 Pipe Arch Requirements—
[19 by 19 by 190 mm and 19 by 25 by 292 mm Rib Corrugations]**

Pipe Arch Size, mm	Equiv. Dia., mm	Span ^A , mm	Rise ^A , mm	Min Corner Radius, mm
500 × 410	450	500–25	410 + 25	130
580 × 490	525	580–25	490 + 25	130
680 × 540	600	680–40	540 + 40	130
830 × 670	750	830–40	670 + 40	130
1010 × 790	900	1010–45	790 + 45	130
1160 × 920	1050	1160–55	920 + 55	155
1340 × 1050	1200	1340–60	1050 + 60	180
1520 × 1170	1350	1520–70	1170 + 70	205
1670 × 1300	1500	1670–75	1300 + 75	230
1850 × 1400	1650	1850–85	1400 + 85	305
2050 × 1500	1800	2050–95	1500 + 95	355

^A Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, zero tolerance in opposite direction.

8.3.2 Perforations—The perforations in Type III pipe shall conform to the requirements for Class 1 or Class 2 as specified in the order and described in 8.3.2.1 and 8.3.2.2 respectively. The perforations in Type IIR pipe shall conform to the requirements for Class 4 as described in 8.3.2.3. Class 1

perforations are for pipe intended to be used for subsurface drainage. Class 2 and Class 4 perforations are for pipe intended to be used for subsurface disposal of water, but pipe containing these classes of perforations may also be used for subsurface drainage.

8.3.2.1 Class 1 Perforations—The perforations shall be approximately circular and cleanly cut; shall have nominal diameters of not less than $\frac{3}{16}$ in. [4.8 mm] nor greater than $\frac{3}{8}$ in. [9.5 mm]; and shall be arranged in rows parallel to the axis of the pipe. The perforations shall be located on the inside crests or along the neutral axis of the corrugations, with one perforation in each row for each corrugation. Pipe connected by couplings or bands may be unperforated within 4 in. [100 mm] of each end of each length of pipe. The rows of perforations shall be arranged in two equal groups placed symmetrically on either side of a lower unperforated segment corresponding to the flow line of the pipe. The spacing of the rows shall be uniform. The distance between the center lines of rows shall be not less than 1 in. [25 mm]. The minimum number of longitudinal rows of perforations, the maximum heights of the centerlines of the uppermost rows above the bottom of the invert, and the inside chord lengths of the unperforated segments illustrated in Fig. 2 shall be as specified in Table 12.

NOTE 7—Pipe with Class 1 perforations is generally available in diameters from 4 to 21 in. [100 to 525 mm] inclusive, although perforated pipe in larger sizes may be obtained.

8.3.2.2 Class 2 Perforations—The perforations shall be circular holes with nominal diameters of $\frac{5}{16}$ to $\frac{3}{8}$ in. [8.0 to 9.5 mm], or slots with nominal width of $\frac{3}{16}$ to $\frac{5}{16}$ in. [4.8 to 8.0 mm] and maximum length of $\frac{1}{2}$ in. [12.7 mm]. The perforations shall be uniformly spaced around the full periphery of the pipe. The perforations shall provide an opening area of not less

TABLE 12 Rows of Perforations, Height H of the Centerline of the Uppermost Rows Above the Invert, and Chord Length L of Unperforated Segment, for Class 1 Perforations

Internal Dia of Pipe		Rows of Perforations ^A	H , max ^B		L , min ^B	
in.	mm		in.	mm	in.	mm
4	100	2	1.8	46	2.6	64
6	150	4	2.8	69	3.8	96
8	200	4	3.7	92	5.1	128
10	250	4	4.6	115	6.4	160
12	300	6	5.5	138	7.7	192
15	400	6	6.9	172	9.6	240
18	450	6	8.3	207	11.5	286
21	500	6	9.7	241	13.4	336
24 and larger	600 and larger	8	C	C	C	C

^A Minimum number of rows. A greater number of rows for increased inlet area shall be subject to agreement between purchaser and fabricator. Note that the number of perforations per foot [metre] in each row (and inlet area) is dependent on the corrugation pitch.

^B See Fig. 2 for location of dimensions H and L .

^C H (max) = $0.46D$; L (min) = $0.64D$, where D = internal diameter of pipe, inches or millimetres as appropriate.

than 3.3 sq in./sq ft [230 sq cm/sq m] of pipe surface based on nominal diameter and length of pipe.

NOTE 8—Thirty perforations, $\frac{3}{8}$ in. diameter, per square foot [323 perforations, 9.5-mm diameter, per square metre] satisfies the inlet area requirement for Class 2 perforations.

8.3.2.3 Class 4 Perforations—The perforations shall be circular holes with nominal diameters of $\frac{5}{16}$ to $\frac{3}{8}$ in. [8.0 to 9.5 mm], or slots with a nominal width of $\frac{3}{16}$ to $\frac{5}{16}$ in. [4.8 to 8.0 mm] and a maximum length of $\frac{1}{2}$ in. [12.7 mm]. All perforations shall occur in the flat sheet between spiral ribs or lockseam with the center of any hole no closer than $\frac{3}{4}$ in. [19.0 mm] from the outside edge of a rib. The perforations shall be uniformly spaced around the full periphery of the pipe. The perforations shall provide an opening area of not less than 2.0 sq in./sq ft [140 sq cm/sq m] of pipe surface based on the nominal diameter and length of pipe.

NOTE 9—There is no provision for Class 3 perforations in this specification.

9. Coupling Bands

9.1 Types of Coupling Bands—Field joints for each type of corrugated aluminum pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installation.

9.1.1 Coupling bands may be of the following types:

9.1.1.1 Bands with annular corrugations,

9.1.1.2 Bands with helical corrugations,

9.1.1.3 Bands with projections (dimples),

9.1.1.4 Channel bands for upturned flanges, with or without annular corrugations,

9.1.1.5 Flat bands, and

9.1.1.6 Smooth sleeve-type couplers.

9.1.2 Except as provided in 9.1.3-9.1.6, the type of coupling furnished shall be at the option of the fabricator unless the type is specified in the order.

NOTE 10—Bands are classified according to their ability to resist shear, moment, and tensile forces as described in Practice B 788/B 788M, and identified as standard joints and special joints. The four types of bands listed in 9.1.1.1-9.1.1.4, and meeting the requirements of 9.2, are expected

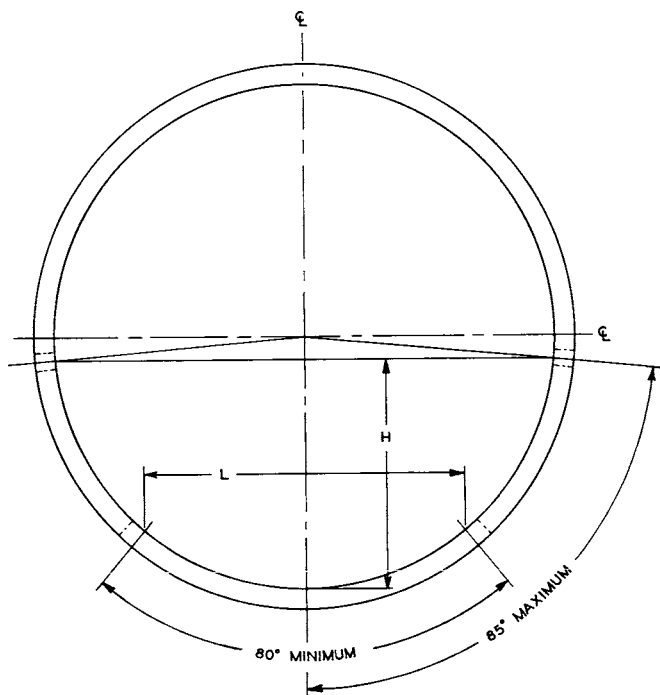


FIG. 2 Circumferential Location of Class 1 Perforations

to meet the requirements for standard joints. Some may also be able to meet the requirements for special joints, but such capability should be determined by analysis or test.

9.1.3 Coupling bands with annular corrugations shall be used only with pipe with annular corrugations, or helical pipe in which the ends have been re-rolled to form annular corrugations. The corrugations in the band shall have the same dimensions as the corrugations in the pipe end, or may be of a special design to engage either the first or the second corrugation from the end of each pipe. The band may also include a U-shaped channel to accommodate upturned flanges on the pipe.

9.1.4 Coupling bands with helical corrugations shall be used only with pipe with helically corrugated ends. The corrugations in the bands shall be designed to properly mesh with the corrugations in the pipe.

9.1.5 Coupling bands with projections (dimples) may be used with pipe with either annular or helical corrugations. The bands shall be formed with the projections in annular rows with one projection for each corrugation of helical pipe. Bands 10½ in. [265 mm] wide shall have two annular rows of projections, and bands 16¼ and 26 in. [415 and 660 mm] wide shall have four annular rows of projections.

9.1.6 Channel bands may be used only with pipe having upturned flanges on the pipe ends.

9.1.7 When specified by the purchaser, flat bands may be used on pipe with helically corrugated ends, annular corrugated pipe, or helical pipe on which the ends have been re-rolled to form annular corrugations.

9.1.8 Smooth sleeve-type couplers may be used with Type III pipe of 12-in. [300-mm] diameter or smaller.

9.2 *Requirements*—Coupling bands shall be fabricated to lap on an equal portion of each of the pipe sections to be connected. The ends of the bands shall lap or be fabricated to form a tightly closed joint upon installation. Coupling bands shall conform to the requirements in Table 13 based on the sheet thickness of the pipe to be connected, except as provided in 9.2.1 and 9.2.2. The band width shall be not less than as shown in Table 14. The bands shall be connected in a manner approved by the purchaser with suitable aluminum or galvanized steel devices such as: angles, or integrally or separately formed and attached flanges, bolted with bolts as described in 6.4; bars and straps; wedge lock and straps; or lugs. Coupling bands shall be fastened with the following size of bolts: pipe diameters 18 in. [450 mm] and less—¾-in. [Metric M10] dia.; pipe diameters 21 in. [525 mm] and greater—½-in. [Metric M12] dia.

9.2.1 If flanges are provided on the pipe ends, the coupling may also be made by interlocking the flanges with a preformed channel band or other band incorporating a locking channel not less than ¾ in. [19 mm] in width. The depth of the channel

TABLE 14 Coupling Band Width Requirements

Nominal Corrugation Size ^A	Nominal Pipe Inside Dia ^B	Coupling Band Width, min		
		Annular Corrugated Bands	Helically Corrugated Bands	Bands With Projections
<i>B 745 (in.)</i>				
1½ by ¼	4 to 10	10½	7	10½
2¾ by ½	12 to 36	7	12	10½
	42 to 72	10½	12	10½
	78 to 120 ^C	10½	12	16¼
3 by 1	30 to 72	12	14	10½
	78 to 120	12	14	16¼
6 by 1	48 to 114	24	24	26
<i>B 745M (mm)</i>				
38 by 6.5	100 to 250	265	180	265
68 by 13	300 to 900	180	300	265
	1050 to 1800	265	300	265
	1950 to 3000 ^C	265	300	415
75 by 25	750 to 1800	300	350	265
	1950 to 3000	300	350	415
150 by 25	1200 to 2650	600	600	660

^A For helically corrugated pipe with re-rolled ends, the nominal corrugation size refers to the dimensions of the end corrugations in the pipe.

^B Equivalent diameter of Type II, Type IIA, and Type IIR pipe.

^C Diameters through 120 in. [3000 mm] for annular corrugated bands used on re-rolled ends of helically corrugated pipe.

shall be not less than ½ in. [13 mm]. The channel band shall have a minimum nominal thickness of 0.075 in. [1.91 mm].

9.2.2 Smooth sleeve type couplings shall be aluminum sheet having a nominal thickness of not less than 0.036 in. [0.91 mm], or as an option, may be a plastic sleeve to provide equivalent strength. The coupling shall be close-fitting, to hold the pipe firmly in alignment without the use of sealing compounds or gaskets. The coupling shall contain a device so that the coupling will lap equally on the two pipes being joined. The overall length of the coupling shall be equal to or greater than the nominal diameter of the pipe.

9.3 *Gaskets*—Where infiltration or exfiltration is a concern, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band, approximately 7 in. [180 mm] wide and approximately ⅜ in. [9.5 mm] thick. Rubber O-ring gaskets shall be 1⅜-in. [20-mm] diameter for pipe diameters of 36 in. [900 mm] or smaller, and ⅞-in. [22-mm] diameter for larger pipe diameters, having ½ in. [13 mm] deep end corrugations. Rubber O-ring gaskets shall be 1⅜-in. [35-mm] diameter for pipe having 1 in. [25 mm] deep end corrugations.

NOTE 11—Riveted pipe is not water tight, having small openings at the intersection of longitudinal and circumferential seams. Therefore this type of fabrication should not be used where water tightness is a concern unless the pipe is bituminous coated or lined prior to installation.

9.4 Other types of coupling bands or fastening devices which are equally effective as those described, and which comply with the joint performance criteria of Practice B 788/B 788M, may be used when approved by the purchaser.

10. Workmanship

10.1 The completed pipe shall show careful, finished workmanship in all particulars. Pipe which has been damaged, either during fabrication or in shipping, may be rejected unless

TABLE 13 Coupling Band Thickness

Nominal Pipe Thickness		Nominal Coupling Band Thickness, min	
in.	mm	in.	mm
0.105 and thinner	2.67 and thinner	0.048	1.22
0.135	3.43	0.060	1.52
0.164	4.17	0.075	1.91

repairs are made which are satisfactory to the purchaser. Among others, the following defects shall be considered as constituting poor workmanship:

- 10.1.1 Variation from a straight centerline,
- 10.1.2 Elliptical shape in pipe intended to be round,
- 10.1.3 Dents or bends in the metal,
- 10.1.4 Lack of rigidity,
- 10.1.5 Illegible markings on the aluminum sheet,
- 10.1.6 Ragged or diagonal sheared edges,
- 10.1.7 Uneven laps in riveted pipe,
- 10.1.8 Loose, unevenly lined, or unevenly spaced rivets, and
- 10.1.9 Loosely formed lockseams.

11. Inspection

11.1 When agreement is made as part of the purchase contract, the purchaser or his representative shall have free access to the fabricating plant for inspection, and every facility shall be extended to him for this purpose. This inspection shall include an examination of the pipe for the items in 10.1 and the specific requirements of this specification applicable to the type of pipe and method of fabrication.

11.2 On a random basis, samples may be taken for chemical analysis and mechanical property determination for check purposes. These samples will be secured from fabricated pipe or from sheets or coils of the material used in fabrication of the pipe. Testing shall be as described in Specification B 209 or B 209M.

12. Rejection

12.1 Pipe failing to conform to the requirements of this specification may be rejected. This requirement applies not only to the individual pipe, but to any shipment as a whole where a substantial number of pipe are defective. If the average deficiency in length of any shipment of pipe is greater than 1 %, the shipment may be rejected.

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13. Certification

13.1 When specified in the purchase order or contract, a manufacturer's or fabricator's certification, or both, shall be furnished to the purchaser stating that samples representing each lot have been tested and inspected in accordance with this specification and have been found to meet the requirements for the material described in the order. When specified in the order, a report of the mechanical test results and chemical composition limits shall be furnished.

NOTE 12—As the identity of the sheet is not maintained from the original ingot production, if numerical results are required by the purchaser, tests should be performed on the finished sheet.

14. Product Marking

14.1 If the aluminum alloy sheet was not marked by the manufacturer as indicated in Specification B 744/B 744M, it shall be marked by the fabricator as described in 14.2, during the course of corrugating the sheet and fabricating the pipe.

14.2 Each corrugated sheet used in annular corrugated pipe, and each 2 to 5 ft [0.6 to 1.5 m] of coiled sheet used in helically corrugated pipe, shall be identified by the fabricator showing the following:

- 14.2.1 Name of sheet manufacturer,
- 14.2.2 Identification of the pipe fabricator, if different than the sheet manufacturer,
- 14.2.3 Alloy and temper,
- 14.2.4 Specified thickness,
- 14.2.5 Fabricator's date of corrugating or forming into pipe by a six digit number indicating in order the year, month, and day of the month, and
- 14.2.6 ASTM designation number.

14.3 The marking shall be applied to the sheet by a permanent method such as coining in accordance with Practice B 666/B 666M. This identification shall appear on the outside of the pipe.

15. Keywords

15.1 aluminum culvert; aluminum storm drains; culvert pipe; storm drain pipe