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American Association State Highway
and Transportation Officials Standard
AASHTO No. M 36/M 36M

Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains[1]

This standard is issued under the fixed designation A 760/A 760M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers corrugated steel 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. The steel sheet used in fabrication of the pipe has a protective metallic coating of zinc (galvanizing), aluminum, 55 % aluminum-zinc alloy, or zinc-5 % aluminum-mischmetal alloy.

1.1.1 Steel sheet with zinc and aramid fiber composite coating may be specified for fabrication of pipe. Pipe made from sheet with this composite coating is always furnished with an asphalt coating. Therefore, the requirements in this specification should be considered as applying to a semifinished pipe; the finished pipe must include provisions of Specification A 849.

NOTE 1—Pipe fabricated with zinc and aramid fiber composite coated sheet and asphalt post coating may be used for sanitary sewers and industrial applications. Petroleum products or similar materials in the sewer effluent may affect the performance of the asphalt coating.

1.2 The several different metallic coatings may not provide equal protection of the base metal against corrosion or abrasion in all environments, or both. Some environments may be so severe that none of the metallic coatings included in this specification will provide adequate protection. Additional protection for corrugated steel pipe can be provided by use of coatings applied after fabrication of the pipe as described in Specification A 849, or by use of polymer precoated corrugated steel pipe as described in Specification A 762/A 762M.

1.3 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 installation procedure is described in Practice A 798/A 798M.

1.4 This specification is applicable to orders in either inch-pound units as A 760 or in SI units as A 760M. Inch-pound units and SI units are not necessarily equivalent. SI units are shown in brackets in the text for clarity, but they are the applicable values when the material is ordered to A 760M.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 90/A 90M Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings

A 153/A 153M 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 428/A 428M Test Method for Weight [Mass] of Coating on Aluminum-Coated Iron or Steel Articles

A 449 Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use

A 563 Specification for Carbon and Alloy Steel Nuts

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

A 742/A 742M Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe

A 762/A 762M Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains

A 780 Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

A 796/A 796M Practice for Structural Design of Corrugated Steel Pipe, Pipe-Arches, and Arches for Storm and Sanitary Sewers and Other Buried Applications

A 798/A 798M Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications

[1] This specification is under the jurisdiction of ASTM Committee A05 on Metallic-Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.17 on Corrugated Steel Pipe Specifications.

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[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.

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A 849 Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe
A 885/A 885M Specification for Steel Sheet, Zinc and Aramid Fiber Composite Coated for Corrugated Steel Sewer, Culvert, and Underdrain Pipe[3]
A 929/A 929M Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe
B 633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel
B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
C 443 Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
C 443M Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets [Metric]
D 1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber
F 568M Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners

2.2 *AASHTO Standards:*[4]

T241 Test for Helical Continuous Welded Seam Corrugated Steel Pipe
T249 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 *minimized coating structure*— a coating characterized by a finer metallurgical coating structure obtained by a treatment designed to restrict the formation of the normal coarse-grain structure formed during solidification of the Zn-5 Al-MM alloy coating.

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

3.1.5 *regular coating structure*— the normal coating structure resulting from unrestricted grain growth during normal solidification of the Zn-5 Al-MM alloy coating.

3.2 *Abbreviations:*

3.2.1 *55 Al-Zn*—55 % aluminum-zinc.

3.2.2 *MM*—mischmetal.

3.2.3 *Zn-5 Al-MM*—zinc-5 % aluminum-mischmetal.

4. Classification

4.1 The corrugated steel 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 IS*—This pipe shall have a full circular cross section with a single thickness of smooth sheet, fabricated with helical ribs projecting outwardly, and shall also have metallic-coated steel inserts placed in the ribs so that the inside surface of the pipe is essentially smooth.

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

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

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

4.1.8 *Type IIS*—This pipe shall be a Type IS pipe which has been reformed into a pipe-arch, having an approximately flat bottom.

4.1.9 *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 inflow or outflow of water.

4.1.10 *Type IIIA*—This pipe, intended for use as underdrains, shall consist of a semicircular cross section, having a smooth (uncorrugated) bottom with a corrugated top shield.

4.2 Perforations in Type III pipe are included in three classes as described in 8.3.2.

4.3 Zn-5 Al-MM alloy-coated material is available in two coating classes, or structures, as follows:

4.3.1 *Class A*—Minimized coating structure.

4.3.2 *Class B*—Regular coating structure.

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 steel pipe),

5.1.2 Type of metallic coating (zinc, aluminum, 55 Al-Zn alloy, Zn-5 Al-MM alloy, or zinc and aramid fiber composite coating (see 6.1)).

5.1.2.1 For Zn-5A1-MM coating, the class coating structure (Class A minimized, etc.) (4.3).

5.1.3 ASTM designation and year of issue, as A 760-_____ for inch-pound units or as A 760M-_____ for SI units.

5.1.4 Type of pipe (4.1),

5.1.5 Diameter of circular pipe (Table 1), or span and rise of pipe-arch section (Tables 2-9),

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 For Type I and Type II pipe, the pipe fabrication method, whether with annular corrugations or helical corrugations (see 7.1.1),

NOTE 2—Pipe with annular corrugations with spot welded or riveted seams is designed by different criteria compared to pipe with helical corrugations. Pipe with annular corrugations must consider seam strength. Therefore, consideration of the method of fabrication is important when pipe is installed under certain conditions of loading.

[3] Withdrawn.

[4] Available from American Association of State Highway and Transportation Officials, 444 N. Capitol, Washington DC 20001.

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TABLE 1 Pipe Sizes

Nominal Inside Diameter		Corrugation Sizes[A]				Ribbed Pipe			Minimum Outside Circumference[B]	
in.	mm	1½ by ¼ in. [38 by 6.5 mm]	2⅔ by ½ in. [68 by 13 mm]	3 by 1 in. [75 by 25 mm]	5 by 1 in. [125 by 25 mm]	¾ by ¾ by 7½ in. [19 by 19 by 190 mm]	¾ by 1 by 11½ in. [19 by 25 by 292 mm]	¾ by 1 by 8½ in. [19 by 25 by 216 mm]	in.	mm
4	100	X							11.4	264
6	150	X							17.7	441
8	200	X							24.0	598
10	250	X							30.2	755
12	300	X	X						36.5	912
15	375	X	X			X[C]			46.0	1148
18	450	X	X			X	X	X	55.4	1383
21	500		X			X	X	X	64.8	1620
24	600		X			X	X	X	74.2	1854
27	675		X			X	X	X	83.6	2091
30	750		X			X	X	X	93.1	2483
33	825		X			X	X	X	102.5	2561
36	900		X	X	X	X	X	X	111.9	2797
42	1050		X	X	X	X	X	X	130.8	3269
48	1200		X	X	X	X	X	X	149.6	3739
54	1350		X	X	X	X	X	X	168.4	4209
60	1500		X	X	X	X	X	X	187.0	4675
66	1650		X	X	X	X	X	X	205.7	5142
72	1800		X	X	X	X	X	X	224.3	5609
78	1950		X	X	X	X	X	X	243.0	6075
84	2100		X	X	X	X	X	X	261.7	6542
90	2250			X	X	X	X	X	280.3	7008
96	2400			X	X	X	X	X	299.0	7475
102	2550			X	X	X	X	X	317.6	7941
108	2700			X	X	X	X	X	336.3	8408
114	2850			X	X	X		X	355.0	8874
120	3000			X	X	X		X	373.6	9341
126	3150			X	X			X	392.3	9807
132	3300			X	X			X	410.9	10274
138	3450			X	X			X	429.6	10740
144	3600			X	X			X	448.3	11207

[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] Additional size for Type IS pipe.

TABLE 2 Pipe Arch Requirements—2⅔ by ½-in. Corrugations (A 760)

Pipe Arch Size, in.	Equivalent Diameter, in.	Span,[A] in.	Rise,[A] in.	Minimum Corner Radius, in.	Maximum B,[B] in.
17 by 13	15	17	13	3	5¼
21 by 15	18	21	15	3	6
24 by 18	21	24	18	3	7¼
28 by 20	24	28	20	3	8
35 by 24	30	35	24	3	9½
42 by 29	36	42	29	3½	10½
49 by 33	42	49	33	4	11½
57 by 38	48	57	38	5	13½
64 by 43	54	64	43	6	15
71 by 47	60	71	47	7	16½
77 by 52	66	77	52	8	18
83 by 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 3 Pipe Arch Requirements—68 by 13-mm Corrugations [A 760M]

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

5.1.10 For Types IS and IIS pipe, the type of insert required, whether from metallic coated steel sheet or from polymer-precoated metallic-coated steel sheet (see 6.6 and 8.1.2).

NOTE 3—Aluminized steel Type 2 inserts are not available with a polymer coating

5.1.11 When zinc and aramid fiber composite coated sheet is used for fabrication of pipe, the type of asphalt coating (1.1.1 and 8.5),

NOTE 4—See Specification A 849 for additional ordering information appropriate to post-coatings on pipe.

5.1.12 Joining systems, including the type of joint from 9.1 and gasket, if required (If no joining system is specified, the fabricator shall select the system.),

5.1.13 For Type III pipe, class of perforations, if other than Class 1 (8.3.2),

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TABLE 4 Pipe Arch Requirements—3 by 1-in. or 5 by 1-in. Corrugations (A 760)

Pipe Arch Size, in.	Equivalent Diameter, in.	Span,[A] in.	Rise,[A] in.	Minimum Corner Radius, in.
40 by 31	36	40 – 1.8	31 + 1.8	5
46 by 36	42	46 – 2.1	36 + 2.1	6
53 by 41	48	53 – 2.4	41 + 2.4	7
60 by 46	54	60 – 2.7	46 + 2.7	8
66 by 51	60	66 – 3.0	51 + 3.0	9
73 by 55	66	73 – 3.3	55 + 3.3	12
81 by 59	72	81 – 3.6	59 + 3.6	14
87 by 63	78	87 – 4.4	63 + 4.4	14
95 by 67	84	95 – 4.8	67 + 4.8	16
103 by 71	90	103 – 5.2	71 + 5.2	16
112 by 75	96	112 – 5.6	75 + 5.6	18
117 by 79	102	117 – 5.9	79 + 5.9	18
128 by 83	108	128 – 6.4	83 + 6.4	18
137 by 87	114	137 – 6.9	87 + 6.9	18
142 by 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, no tolerance in opposite direction.

TABLE 5 Pipe Arch Requirements—75 by 25-mm or 125 by 25-mm Corrugations [A 760M]

Pipe Arch Size, mm	Equivalent Diameter, mm	Span,[A] mm	Rise,[A] mm	Minimum Corner Radius, mm
1010 by 790	900	1010 – 45	790 + 45	130
1160 by 920	1050	1160 – 55	920 + 55	155
1340 by 1050	1200	1340 – 60	1050 + 60	180
1520 by 1170	1350	1520 – 70	1170 + 70	205
1670 by 1300	1500	1670 – 75	1300 + 75	230
1850 by 1400	1650	1850 – 85	1400 + 85	305
2050 by 1500	1800	2050 – 95	1500 + 95	355
2200 by 1620	1950	2200 – 110	1620 + 110	355
2400 by 1720	2100	2400 – 120	1720 + 120	410
2600 by 1820	2250	2600 – 130	1820 + 130	410
2840 by 1920	2400	2840 – 145	1920 + 145	460
2970 by 2020	2550	2970 – 150	2020 + 150	460
3240 by 2120	2700	3240 – 165	2120 + 165	460
3470 by 2220	2850	3470 – 175	2220 + 175	460
3600 by 2320	3000	3600 – 180	2320 + 180	460

[A] Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

5.1.14 Certification, if required (14.1), and

5.1.15 Special requirements.

6. Materials and Manufacture

6.1 *Steel Sheet for Pipe*—All pipe fabricated under this specification shall be formed from zinc-coated sheet, aluminum-coated sheet, 55 % aluminum-zinc alloy-coated sheet, zinc-5 % aluminum-mischmetal alloy-coated sheet all conforming to Specification A 929/A 929M, or zinc and aramid fiber composite coated sheet conforming to Specification A 885/A 885M. If the type of metallic coating is not stated in the order, zinc-coated sheet conforming to Specification A 929/A 929M shall be used. All pipe furnished on the order shall have the same metallic coating, unless otherwise specified.

6.2 *Steel Sheet for Coupling Bands*—The sheet used in fabricating coupling bands shall have the same coating and shall conform to the same specification listed in 6.1 as that used for fabrication of the pipe furnished under the order.

6.3 *Rivets*—The rivets used in riveted pipe shall be of the same material as the base metal specified for the corrugated sheets. They shall be thoroughly galvanized or sherardized. If

TABLE 6 Pipe-Arch Requirements—¾ by ¾ by 7½-in. Rib Corrugation[A]

Pipe-Arch Size, in.	Equivalent Diameter, in.	Span,[B] in.	Rise,[B] in.	Minimum Corner Radius, in.
20 by 16	18	20 – 1.0	16 + 1.0	5
23 by 19	21	23 – 1.0	19 + 1.0	5
27 by 21	24	27 – 1.5	21 + 1.5	5
33 by 26	30	33 – 1.5	26 + 1.5	5
40 by 31	36	40 – 1.8	31 + 1.8	5
46 by 36	42	46 – 2.1	36 + 2.1	6
53 by 41	48	53 – 2.4	41 + 2.4	7
60 by 46	54	60 – 2.7	46 + 2.7	8
66 by 51	60	66 – 3.0	51 + 3.0	9
73 by 55	66	73 – 3.3	55 + 3.3	12
81 by 59	72	81 – 3.6	59 + 3.6	14
87 by 63	78	87 – 3.9	63 + 3.9	14
95 by 67	84	95 – 4.2	67 + 4.2	16
103 by 71	90	103 – 4.5	71 + 4.5	16
112 by 75	96	112 – 4.8	75 + 4.8	18
117 by 79	102	117 – 5.1	79 + 5.1	18

[A] For Type IIR and Type IIS pipe.
[B] Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances; no tolerance in opposite direction.

TABLE 7 Pipe-Arch Requirements—19 by 19 by 190-mm Rib Corrugation[A]

Pipe-Arch Size, mm	Equivalent Diameter, mm	Span,[B] mm	Rise,[B] mm	Minimum Corner Radius, mm
500 by 410	450	500 – 25	410 + 25	130
580 by 490	525	580 – 25	490 + 25	130
680 by 540	600	680 – 40	540 + 40	130
750 by 620	675	750 – 40	620 + 40	130
830 by 670	750	830 – 40	670 + 40	130
900 by 750	825	900 – 45	750 + 45	130
1010 by 790	900	1010 – 45	790 + 45	130
1160 by 920	1050	1160 – 55	920 + 55	155
1340 by 1050	1200	1340 – 60	1050 + 60	180
1520 by 1170	1350	1520 – 70	1170 + 70	205
1670 by 1300	1500	1670 – 75	1300 + 75	230
1850 by 1400	1650	1850 – 85	1400 + 85	305
2050 by 1500	1800	2050 – 90	1500 + 90	355
2200 by 1620	1950	2200 – 100	1620 + 100	355
2400 by 1720	2100	2400 – 105	1720 + 105	410
2600 by 1820	2250	2600 – 115	1820 + 115	410
2840 by 1920	2400	2840 – 120	1880 + 120	450
2920 by 1980	2550	2920 – 130	1980 + 130	450

[A] For Type IIR and Type IIS pipe.
[B] Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances; no tolerance in opposite direction.

bolts and nuts are substituted for rivets (see 7.3.1), they shall meet the following requirements:

	Bolts	Nuts
For A 760 pipe	A 449	A 563, Grade C
[For A 760M pipe]	[F 568M, Class 8.8]	[A 563M, Class 12]

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

6.4 *Hardware for Joining Systems*—Bolts and nuts for coupling bands shall conform to the following requirements:

	Bolts	Nuts
For A 760 pipe	A 307	A 563, Grade A
[For A 760M pipe]	[F 568M, Class 4.6]	[A 563M, Class 5]

6.4.1 Bolts, nuts, and other threaded items used with joining systems shall be zinc coated by one of the following processes: hot-dip process as provided in Specification A 153/A 153M;

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TABLE 8 Pipe Arch Requirements—¾ by 1 by 11½-in. Rib Corrugation

Pipe Arch Size, in.	Equivalent Diameter, in.	Span,[A] in.	Rise,[A] in.	Minimum Corner Radius, in.
20 by 16	18	20 – 1.0	16 + 1.0	5
23 by 19	21	23 – 1.0	19 + 1.0	5
27 by 21	24	27 – 1.5	21 + 1.5	5
33 by 26	30	33 – 1.5	26 + 1.5	5
40 by 31	36	40 – 1.8	31 + 1.8	5
46 by 36	42	46 – 2.1	36 + 2.1	6
53 by 41	48	53 – 2.4	41 + 2.4	7
60 by 46	54	60 – 2.7	46 + 2.7	8
66 by 51	60	66 – 3.0	51 + 3.0	9

[A] Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

TABLE 9 Pipe Arch Requirements—19 by 25 by 292-mm Rib Corrugation

Pipe Arch Size, mm	Equivalent Diameter, mm	Span,[A] mm	Rise,[A] mm	Minimum Corner Radius, mm
500 by 410	450	500– 25	410 + 25	130
580 by 490	525	580– 25	490 + 25	130
680 by 540	600	680– 40	540 + 40	130
750 by 620	675	750– 40	620 + 40	130
830 by 670	750	830– 40	670 + 40	130
900 by 750	825	900– 45	750 + 45	130
1010 by 790	900	1010 – 45	790 + 45	130
1160 by 920	1050	1160 – 55	920 + 55	155
1340 by 1050	1200	1340 – 60	1050 + 60	180
1520 by 1170	1350	1520 – 70	1170 + 70	205
1670 by 1300	1500	1670 – 75	1300 + 75	230
1850 by 1400	1650	1850 – 85	1400 + 85	305
2050 by 1500	1800	2050 – 95	1500 + 95	355

[A] Negative and positive numbers listed with span and rise dimensions are negative and positive tolerances, no tolerance in opposite direction.

electroplating process as provided in Specification B 633, Class Fe/Zn 8; or mechanical process as provided in Specification B 695, Class 8. Other 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/A 153M; electroplating process as provided in Specification B 633, Class Fe/Zn 25; or mechanical process as provided in Specification B 695, Class 25.

6.5 *Gaskets*—If gaskets are used in joining systems, 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 [C 443M].

6.6 *Metallic-Coated Steel Inserts*—Metallic-coated steel inserts for Type IS and Type IIS pipe shall be of the same material specified for the pipe in 6.1 and shall have a metallic coating of the same type and coating weight. In addition to these requirements, when specified in the order, the metallic-coated steel insert shall be fabricated from polymer precoated sheet conforming to Specification A 742/A 742M.

7. Fabrication

7.1 *General Requirements*—Pipe shall be fabricated in full circular cross section except for Type IIIA pipe which is described in 8.4.

7.1.1 Type I pipe shall have annular corrugations with lap joints fastened with rivets or resistance spot welds, or shall have helical corrugations with a continuous lock seam or welded seam extending from end to end of each length of pipe. The type of fabrication used shall be the option of the fabricator unless otherwise specified, except that pipe fabricated from zinc and aramid fiber composite-coated sheet shall be fabricated by riveted or lock seam fabrication only.

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 2⅔ or 3-in. [68 or 75-mm] pitch. Zinc and aramid fiber composite-coated sheet shall not be used for fabrication of Type IA pipe.

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.

7.1.4 Type IS pipe shall be fabricated with helical ribs projecting outward with a continuous lock seam extending from end to end of each length of pipe, and shall also have metallic-coated steel inserts placed in the ribs in conformance with 7.8 so that the inside surface of the pipe is essentially smooth.

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 10 for the size indicated in the order, except if the depth measurement of one or more corrugations is less than the minimum depth in Table 10. Then the depth of all corrugations between adjacent seams shall be measured and the values of Table 11 for minimum average depth and minimum corrugation depth shall apply.

NOTE 5—Inspection frequently consists of measurement of the depth of

TABLE 10 Corrugation Requirements for Types I, IA, II, IIA, and III Pipe

Nominal Size	Maximum Pitch[A]	Minimum Depth[B]	Inside Radius[C]	
			Nominal	Minimum
	inches			
1½ by ¼[D]	1⅞	0.24	9/32	0.25
2⅔ by ½	2⅞	0.48	11/16	0.5
3 by 1	3¼	0.95	9/16	0.5
5 by 1	5 5/16	0.95	1.57	1.4
	millimetres			
38 by 6.5[D]	48	6.0	7	6.5
68 by 13	73	12	17	12
75 by 25	83	24	14	12
125 by 25	135	24	40	36

[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. If the depth measurement of one or more corrugations is less than the value indicated herein, the depth of all corrugations between seams shall be measured, and the requirements of Table 11 shall be applied (see 7.2.1).

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

[D] The corrugation size of 1½ by ¼ in. (38 by 6.5 mm) is available only in helically corrugated pipe.

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TABLE 11 Referee Requirements for Corrugation Depth[A]

Nominal Size	Diameter	Minimum Average Depth	Minimum Corrugation Depth
	inches		
1½ by ¼	all	0.24	0.20
2⅔ by ½	12 through 21	0.48	0.40
2⅔ by ½	over 21	0.49	0.44
3 by 1	all	0.98	0.92
5 by 1	all	0.98	0.92
	millimetres		
38 by 6.5	all	6.1	5
68 by 13	300 through 525	12.1	10
68 by 13	over 525	12.4	11
75 by 25	all	24.9	23
125 by 25	all	24.9	23

[A] See 7.2.1 for application of Table 11.

one or a few corrugations. If such measurement indicates insufficient depth, application of the requirements in Table 11 provide for acceptance where greater depth of some corrugations compensates for lack of depth of others. These measurements would normally be made at one location between seams on a length of pipe.

7.2.2 For Type IR pipe, the corrugations shall be essentially rectangular ribs projecting outward from the pipe wall. The dimensions and spacing of the ribs shall be in accordance with Table 12 for the size indicated on the order. For the 11.5-in. [292-mm] rib spacing, if the sheet between the ribs does not include a lock seam, a stiffener shall be included midway between ribs. 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 6—The nominal dimensions and properties for smooth corrugations and for ribs are given in Practice A 796/A 796M.

7.2.3 For Type IS pipe, the corrugations shall be essentially rectangular ribs projecting outward from the pipe wall, but with the width of the rib opening on the inside surface of the pipe wall slightly less than the inside rib width elsewhere on the rib cross section. The dimensions and spacing of the ribs shall be in accordance with Table 13.

7.3 *Riveted Seams*—The longitudinal seams shall be staggered to the extent that no more than three thicknesses of sheet are fastened by any rivet. Pipe to be reformed into pipe-arch shape shall have seams meeting the longitudinal seam requirement of 8.2.2.

NOTE 7—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 the 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 14, depending on sheet thickness, corrugation size, and diameter of pipe. For pipe with 1-in. [25-mm] deep corrugations, ½ –in. [metric M12] diameter bolts and nuts may be used instead 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. 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 *Resistance Spot Welded Seams*—The longitudinal seams shall be staggered to the extent that no more than three thicknesses of sheet are fastened by any spot weld. Pipe to be reformed into pipe-arch shape shall also meet the longitudinal seam requirement of 8.2.2 (Note 5).

7.4.1 The size of spot welds, number per corrugation, and width of lap at the longitudinal seam shall be as stated in Table 12, depending on sheet thickness, corrugation size, and diameter of the pipe. Circumferential seams shall be welded using spot welds of the same size as for longitudinal seams and shall have a maximum weld spacing of 6 in. [150 mm], except that six welds will be sufficient in 12-in. [300-mm] diameter pipe.

7.4.2 All spot welds shall be made in such a manner that the sheets will be drawn tightly together throughout the lap. The outside edge of each spot weld shall be at least ¼ in. [6.5 mm] from the edge of the sheet. The welding shall be performed in such a manner that the exterior surfaces of 90 % or more of the spot welds on a length of pipe shall show no evidence of melting or burning of the base metal, and the base metal shall not be exposed when the area adjacent to the electrode contact surface area is wire brushed. Discoloration of the spot weld surfaces will not be cause for rejection.

TABLE 12 Rib Requirements for Types IR and IIR Pipe

Nominal Size	Rib			Bottom Outside Radius, min	Bottom[A] Outside Radius, max, avg	Top Outside Radius, min	Top[A] Outside Radius, max, avg
	Width,[B] min	Depth,[C] min	Spacing,[D] max				
				A 760, 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 8½	0.68	0.95	8¾	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
				A 760M, mm			
19 by 19 by 180	17	19	197	2.5	6.0	2.5 + t	6.0 + t
19 by 25 by 216	17	24	222	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] The average of the two top rib radii and of the two bottom rib radii shall be within the minimum and maximum tolerances. The term "outside" refers to the outside surface of the pipe.

[B] Width is a dimension of the inside of the rib but is measured on the outside of the pipe (outside of the rib) and shall meet or exceed the spaced minimum width plus two times the wall thickness (that is, 2t + 0.68 in. [2t + 17 mm]).

[C] Depth is an average of ribs within one sheet width measured from the inside by placing a straightedge across the open rib and measuring to the bottom of the rib.

[D] Spacing is an average of three adjacent ribs spacings for ¾ by ¾ by 7½ pipe and two adjacent rib spacings for the ¾ by 1 by 11½ pipe and ¾ by 1 by 8½ pipe measured center-to-center of the ribs, at 90° to the direction of the ribs.

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TABLE 13 Rib and Insert Requirements for Types IS and IIS Pipe

Rib Requirements								Insert Requirements[A]	
Narrowest Width, min[B]	Widest Width, min[C]	Depth, min[D]	Spacing, max[E]	Bottom Outside Radius, min[F]	Bottom Outside Radius, max, avg[F]	Top Outside Radius, min[F]	Top Outside Radius, max, avg[F]	Preformed Width, min	Preformed Width, max
A 760, in.									
0.68	0.70	0.73	7¾	0.10	0.25	0.10 + t	0.25 + t	1⅜	1½
A 760M, mm									
17	17.5	19	197	2.5	6.0	2.5 + t	6.0 + t	34.9	38.1

[A]The metallic coated insert shall have a U or channel configuration with legs that make continuous contact along the two inside surfaces of the ribs that project outwardly, exclusive of material on the rib and insert radii. The insert shall be dimensionally compatible with the formed rib such that it essentially fills the rib but does not extend beyond the inside surface of the pipe. The exposed surface of the insert shall be positioned in the rib such that it is no more than 0.20 in. [5.0 mm] from the inside surface of the pipe.

[B]Narrowest width is a dimension of the inside of the rib and is measured on the inside of the pipe.

[C]Widest width is a dimension of the inside of the rib but is measured on the outside of the pipe (outside of the rib) and shall meet or exceed the specified minimum width plus two times the wall thickness (that is, 2t + 0.70 in. [2t + 17 mm]).

[D]Depth is an average of ribs within one sheet width measured from the outside by placing a straightedge across the outside flat surface of two ribs and measuring to the bottom outside radius on the outside surface of the pipe along one edge of the rib.

[E]Spacing is an average of three adjacent rib spacings measured center-to-center of the ribs, at 90° to the direction of the ribs.

[F]The average of the two top rib radii and of the two bottom rib radii shall be within the minimum and maximum tolerances. The term "outside" refers to the outside surface of the pipe.

TABLE 14 Riveted and Spot Welded Longitudinal Seams

Specified Sheet Thickness		Nominal Corrugation Size					
		2⅔ by ½ in. [68 by 13 mm][A,B]		3 by 1 in. [75 by 25mm][C,D]		5 by 1 in. [125 by 25 mm][D,E]	
		Rivet or Spot Weld Diameters, min					
in.	mm	in.	mm	in.	mm	in.	mm
0.052	1.32	5⁄16	8.0	. . .	. . .	. . .	. . .
0.064	1.63	5⁄16	8.0	⅜	9.5	⅜	9.5
0.079	2.01	5⁄16	8.0	⅜	9.5	⅜	9.5
0.109	2.77	⅜	9.5	7⁄16	11.0	7⁄16	11.0
0.138	3.51	⅜	9.5	7⁄16	11.0	7⁄16	11.0
0.168	4.27	⅜	9.5	7⁄16	11.0	7⁄16	11.0

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

[B] Minimum width of the lap is 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 or spot welds each valley for all pipe diameters.

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

[E] Two rivets or spot welds each crest and valley for all pipe diameters.

7.4.3 Welding equipment shall be qualified before use, and the qualification shall be verified before each work shift and when changing sheet thickness, all as described in Annex A1. If use of the equipment at the approved machine settings fail to produce satisfactory welds, fabrication shall be stopped until adjustments are made and the equipment is requalified.

7.5 *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 and Type IS pipe shall be formed in the flat zone of the pipe wall, midway between two ribs.

7.5.1 The edges of the sheets within the cross section of the lock seam shall lap at least 5⁄32 in. [4.0 mm] for pipe 10 in. [250 mm] or less in diameter and at least 5⁄16 in. [7.9 mm] for pipe greater than 10 in. [250 mm] in diameter, with an occasional tolerance of −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 T249) 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 visible 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.

7.5.2 Specimens cut from production pipe normal to and across the lock seam shall develop the tensile strength as provided in Table 15, when tested according to AASHTO T249. For Type IA pipe, the lock seam strength shall be as tabulated based on the thickness of the corrugated shell.

7.5.3 When the ends of helically corrugated lock seam pipe have been rerolled to form annular corrugations, either with or without a flanged end finish, the lock seam in the rerolled 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 7.5.2.

7.6 *Helical Continuous Welded Seams*—The seam shall be parallel to the corrugations and shall have a continuous weld extending from end to end of each length of pipe. Welding shall be done utilizing ultra high-frequency resistance equipment. Seams shall be welded in such a manner that they will develop the full strength of the pipe and not affect shape or nominal

TABLE 15 Lock Seam Tensile Strength

Specified Sheet Thickness[A]		Lock Seam Tensile Strength, per Unit Width, min	
in.	mm	lbf/in.	kN/m
0.040	1.02	175	30
0.052	1.32	240	42
0.064	1.63	340	60
0.079	2.01	520	91
0.109	2.77	700	122
0.138	3.50	880	154
0.168	4.27	1200	210

[A] For Type 1A pipe, the thickness shall be that of the corrugated shell.

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diameter of the pipe. Welded seams shall be controlled such that the combined width of weld and adjacent coating burned by welding does not exceed three times the metal thickness. Damage outside this width shall be repaired as required in Section 11. The fabricator shall certify that the welds have been tested and found satisfactory.

7.6.1 Continuous welded seams shall be tested in accordance with Section 3 of AASHTO T241. The welded seam shall be acceptable if the sum of the length of cracks or other defects on either side of the cup does not exceed ¼ in. [6.5 mm], basing the result on the second test if the first shows greater defects. The provisions of the referee test method of Section 4 of AASHTO T241 shall be applicable in the event of disagreement between the purchaser and the fabricator.

7.6.1.1 Tests of continuous welded seams shall be made as follows:

7.6.1.2 Pipe lengths of 24 ft [7.3 m] or less shall be tested on one end of each length, normally the trailing end.

7.6.1.3 If a length of pipe having a diameter greater than 48 in. [1200 mm] and length of 24 ft [7.3 m] or less is rejected, the following length of pipe produced shall be tested on both ends. If the test on either end fails, this entire length shall also be rejected.

7.6.1.4 Pipe lengths greater than 24 ft [7.3 m] shall be tested on each end of each length of pipe. If either end fails, the entire length shall be rejected.

7.6.2 The requirement for conducting quality control tests in accordance with 7.6.1 shall not apply for pipe in which the ends have been rerolled to form annular corrugations. The manufacturer shall maintain visual evaluation of the quality of the weld after rerolling and any indication of weld or base metal failure will be cause for rejection of the pipe.

7.6.3 Any indication of cracks, skips, or deficient welds found through visual inspection will be cause for rejection unless repaired. It is the option of the fabricator to remove the defective portion of the length of pipe or to manually repair defects in the automatically welded seam. Altered or repaired pipe shall meet the applicable requirements of 7.6. Where a manual repair occurs within 16 in. [400 mm] of the end of the length of pipe, a test shall be conducted on both the manually repaired section and on the immediately adjacent automatically welded section. If either test results in failure under the criterion of 7.6.1, the length of pipe shall be rejected.

7.7 *End Finish*:

7.7.1 To facilitate field jointing, the ends of individual pipe sections with helical corrugations or ribs may be rerolled to form annular corrugations extending at least two corrugations from the pipe end, or to form an upturned flange meeting the requirements in 7.7.2, 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 rerolled 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].

7.7.1.1 When pipe with any size helical corrugation or rib is rerolled to form annular corrugations in the ends, the usual size of the annular corrugation is 2⅔ by ½ in. [68 by 13 mm].

7.7.2 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.

7.7.3 The ends of all pipe which will form the inlet and outlet of culverts, fabricated of sheets having nominal thicknesses of 0.079 in. [2.01 mm] and less, shall be reinforced in a manner approved by the purchaser, when specified.

7.8 *Metallic-Coated Steel Inserts*—The metallic-coated steel inserts for Type IS and Type IIS pipe shall be formed prior to insertion into the open rib on the interior surface of the pipe wall, and shall be crimped into place. The inserts must be placed so they do not become dislodged during normal handling, installation, and use of the finished pipe product.

7.8.1 After pipe fabrication, but before annular rerolling of ends, the fabricator shall examine the metallic-coated steel inserts at each end of the pipe and establish that they are secure and not easily dislodged. This examination shall be conducted using a ½ by ½ by 8 in. [13 by 13 by 200 mm] long steel bar and 2 lb [1 kg], 10 in. [250 mm] long, ball peen hammer. Systematically positioning each insert end at the pipe invert, the fabricator shall place one end of the steel bar squarely against the underside of the insert at an approximate 45 degree angle below the pipe invert and then apply three medium hammer blows against the opposite end of the steel bar in an attempt to dislodge the insert. Using the same steel bar and hammer, the fabricator shall vertically place the steel bar inside the pipe atop the insert and apply three medium hammer blows against the opposite end of the steel bar in an attempt to press in the insert. If no significant insert movement or damage is observed, the insert is considered to be secure. Such examination shall be made each time the equipment is set up to manufacture a pipe of different diameter or sheet thickness, or to manufacture a pipe with a different insert thickness.

8. Pipe Requirements

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

8.1.1 *Pipe Dimensions*—The nominal diameter of the pipe shall be as stated in the order, selected from the size listed in Table 1. The size of corrugations which are standard for each size of pipe are also shown in Table 1. 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 for Type I pipe, or the inside liner for Type IA pipe, or the inside surface for Type IR and Type IS pipe. Alternatively, 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 1.

NOTE 8—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 16 (Note 9 and Note 10). For Type IA pipe, the thickness of both the shell and the liner shall be given; the thickness of the corrugated shell shall be not less than 60 % of the thickness of the equivalent Type I pipe; the liner shall have a nominal

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TABLE 16 Thicknesses of Metallic Coated Steel Sheet[A]

Specified Thickness		Coating Type				
in.	mm	Zinc Coated	Aluminum Coated	55 Al-Zn Alloy Coated	Zn-5 Al-MM Alloy Coated	Zinc/ Aramid Composite Coated
0.040	1.02	x		x	x	
0.052	1.32	x	x	x	x	
0.064	1.63	x	x	x	x	x
0.079	2.01	x	x	x	x	x
0.109	2.77	x	x	x	x	x
0.138	3.51	x	x	x	x	x
0.168	4.27	x			x	x

[A] An "X" indicates sheet thicknesses included in Specification A 929/A 929M or Specification A 885/A 885M for the coating types listed.

thickness of at least 0.040 in. [1.02 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 in accordance with the design criteria in Practice A 796/A 796M. For Type IS pipe, the outer thickness of steel sheet shall be specified in accordance with the design criteria in Practice A 796/A 796M; the metallic-coated steel insert shall have a minimum specified thickness of 0.052 in. [1.32 mm]; or alternatively, when inserts fabricated from polymer precoated sheet are specified in the order, the metallic-coated steel insert shall have a minimum specified thickness of 0.040 in. [1.02 mm] and a Grade 10/10 [250/250] polymer coating in accordance with A 742/A 742M.

NOTE 9—The sheet thicknesses listed in Table 16 are the thicknesses indicated as available in Specifications A 929/A 929M, for zinc-coated, aluminum-coated, 55 % aluminum-zinc alloy-coated, and zinc-5 % aluminum-mischmetal alloy-coated sheet, and in Specification A 885/A 885M for zinc and aramid fiber composite coated sheet.

NOTE 10—The purchaser should determine the required thickness for each of the types of pipe described in 4.1.1 through 4.1.8 in accordance with the design criteria in Practice A 796/A 796M, or other appropriate guidelines.

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.

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

8.2.1 *Pipe-Arch Dimensions*—Pipe furnished as Type II, IIA, IIR, or Type IIS shall be made from Type I, IA, IR, or Type IS pipe, respectively, and shall be reformed to provide a pipe-arch shape. All applicable requirements for Types I, IA, IR, and IS pipe shall be met by finished Types II, IIA, IIR, and IIS pipe, respectively. Pipe arches shall conform to the dimensional requirements of Tables 2-9. All dimensions shall be measured from the inside crests of corrugations for Type II pipe or from the inside liner for Type IIA pipe, or the inside surface for Type IIR pipe and Type IIS pipe.

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

8.2.3 Reforming Type IR or Type IS into Type IIR or Type IIS pipe shall be done in such a manner as to avoid damage to the external ribs. Reforming Type IS into Type IIS pipe shall be done in such a manner as to avoid dislodgement of the metallic-coated steel inserts.

8.3 *Type III Pipe*:

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

8.3.2 *Perforations*—The perforations shall conform to the requirements for Class 1, unless otherwise specified in the order. Class 1 perforations are for pipe intended to be used for subsurface drainage. Class 2 and Class 3 perforations are for pipe intended to be used for subsurface disposal of water, but pipe containing Class 2 and Class 3 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 3⁄16 in. [4.8 mm] nor greater than 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. 1 shall be as specified

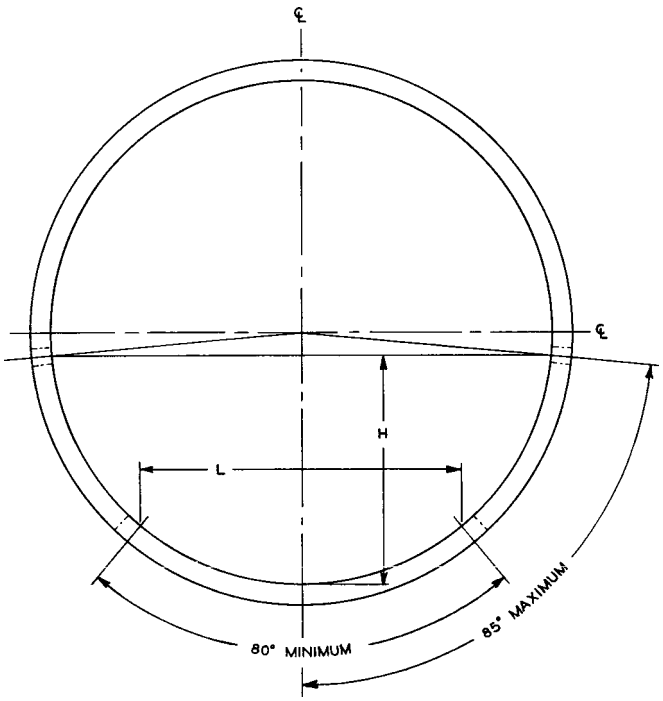

FIG. 1 Requirements for Perforations

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in Table 17.

NOTE 11—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 5⁄16 to 3⁄8 in. [8.0 to 9.5 mm], or slots with nominal width of 3⁄16 to 5⁄16 in. [4.8 to 8.0 mm] and not to exceed ½ in. [13 mm]. The perforations shall be uniformly spaced around the full periphery of the pipe. The perforations shall provide an opening area of not less than 3.3 $in.^2/ft^2$ [230 cm^2/m^2] of pipe surface based on nominal diameter and length of pipe.

NOTE 12—Thirty perforations 3⁄8 in. in diameter, per square foot [323 perforations, 9.5 mm in diameter, per square metre] satisfies this requirement.

8.3.2.3 *Class 3 Perforations*—The perforations shall be slots with a width of 0.10 ± 0.04 in. [2.5 ± 1.0 mm] and length of 1.0 ± 0.25 in. [25 ± 6.5 mm], spaces 1¾ to 2½ in. [45 to 65 mm] on centers around the circumference and staggered on the outside crests of the corrugations of the pipe. No metal shall be removed in making the slot. Slots shall be made from the inside of the pipe.

8.4 *Type IIIA Pipe*:

8.4.1 Type IIIA pipe shall be fabricated of an unperforated semicircular bottom section with a top shield of corrugated steel, both of nominal 0.052-in. [1.32-mm] thickness or greater. The smooth semicircular bottom section shall be approximately 4⅝ in. [120 mm] in diameter and shall have a continuous lip extending outward along each side; the corrugated top shield shall be approximately 6⅜ in. [160 mm] wide including a ¾-in. [19-mm] sloping overhang on each side and shall be secured to the lip of the bottom section by integral tabs spaced at about 3½ in. [90 mm] center to center. The top shield shall have corrugations approximately ⅞-in. [22 mm] center to center and approximately 5⁄16-in. [9.0-mm] depth.

8.5 *Pipe Fabricated from Zinc and Aramid Fiber Composite Coated Sheet*—Pipe which has been fabricated from zinc and aramid fiber composite coated sheet shall be coated with asphalt as described in Specification A 849, Class B, fully coated. If full or partial smooth lining is desired, it shall be specified by the purchaser. (See 1.1.1 and Specification A 849.)

TABLE 17 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 Diameter 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[C]	5.5	138	7.7	192
15	375	6[C]	6.9	172	9.6	240
18	450	6[C]	8.3	207	11.5	288
21	525	6	9.7	241	13.4	336
24 and larger	600 and larger	8	[D]	[D]	[D]	[D]

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

[B] See Fig. 1 for location of dimensions *H* and *L*.

[C] Minimum of 4 rows permitted in pipe with 1½ by ¼-in. [38 by 6.5-mm] corrugations.

[D] *H* (max) = 0.46*D*; *L* (min) = 0.64*D*, where *D* = internal diameter of pipe, inches or millimetres as appropriate.

9. Joining Systems

9.1 *Types of Joining Systems*—Joining systems shall be of the following types, depending upon the configuration of the steel band joining the pipe together. If required, the joining system shall incorporate a flat, o-ring, or profile gasket. The corrugations at the ends of pipe sections being joined shall conform to one of the corrugations detailed in Practice A 796/A 796M.

9.1.1 *Corrugated Bands*—Bands with either annular or helical corrugations. The band corrugation shall match that of the pipe sections being joined or the annular rerolled ends of those pipe sections.

9.1.2 *Partially Corrugated Bands*—Flat bands with a minimum of one corrugation formed along each circumferential edge of the band. These bands are intended for use with helically corrugated pipe with its ends rerolled to a 2⅔-in.-by-½-in. [68-mm-13-mm] corrugation

9.1.3 *Bands with Projections*—Flat bands with projections, such as dimples, are used to join pipe with either helical or annular corrugations. The bands shall be formed with the projections in annular rows with one projection for each corrugation of helical pipe engaged by the band. Bands 10½ in. [265 mm] or 12 in. [300 mm] wide shall have two annular rows of projections, and bands 16¼ in. [415 mm] or wider shall have four annular rows of projections.

9.1.4 *Channel Bands*—Channel bands that incorporate a connector formed into a channel (hat) shape, shall be used only with pipe having upturned flanges on the pipe ends. Channel bands shall conform with the requirements of 9.3.3.

9.1.5 *Flat Bands*—When specified by the purchaser, flat bands shall be used with helical corrugated pipe, annular corrugated pipe, or pipe with helical corrugations on which the ends have been rerolled to form annular corrugations.

9.1.6 *Sleeve Couplers*—When specified by the purchaser, the joining system shall incorporate a push-on type coupler designed to properly interface with the pipes being joined. Sleeve couplers generally do not have any external device for tightening around the pipe. Sleeve couplers shall provide a centering device so the coupler laps equally on both pipe being joined. Sleeve couplers for pipe diameters less than 12 in. [300 mm] shall have a minimum stab depth of 3 in. [75 mm]. The minimum stab depth for 12 in. [300 mm] through 42 in. [1050 mm] diameters, shall be 6 in. [150 mm]. When sleeve couplers are used with pipes other than Type III or Type IIIA, pipe with annular corrugations or re-rolled ends shall be used. Sleeve couplers are not intended for pipe diameters larger than 42 in. [1050 mm].

9.1.7 *Bell and Spigot*—Bell and spigot configurations incorporate an integral bell that is permanently installed at the factory to one end of the pipe, while the other end of the pipe serves as a spigot. The bell shall be affixed to the pipe by welding or with mechanical fasteners. The steel in the bell shall meet the thickness requirements of 9.3.1. The bell and spigot configuration shall be classified in accordance with 9.2. The

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spigot end of the pipe shall be re-rolled or provide annular corrugations to allow placement of a gasket if required. The bell shall provide a minimum stab depth of 6 in. [150 mm], or 8% of the pipe diameter, which ever is greater.

9.1.8 *Special Design*—Other joining systems that meet the requirements of 9.3, 9.4 (if required), and 9.5 (if required), and are specified by the purchaser, shall be used on the project for which they are specified.

9.2 *Joining Systems: Significance and Use*—Joining systems are classified as standard or gasketed, based on the ability of the system to control infiltration, or exfiltration, or both. These classifications of standard and gasketed systems are covered in 9.2.1 and 9.2.2. When site conditions near the pipe are such that movement or differential settlement is possible at the joint, the joining system shall have structural requirements that conform with 9.4.

9.2.1 *Standard Systems*

9.2.1.1 Standard joining systems for corrugated steel pipe are intended to control the infiltration of soil into the pipe. Standard joining systems are used in the majority of CSP installations. The gradation and plasticity of the backfill materials around the pipe are important factors in the selection of a joining system. The greater the concentration of very fine particles, such as silts which pass the #200 [75 µm] sieve, the greater the possibility of soil infiltration. Additionally, when the water table is above the pipe or where the backfill is otherwise saturated and the flow level in the pipe varies rapidly, soil infiltration is more likely to occur.

9.2.1.2 External bands conforming with 9.1.1-9.1.3, or 9.1.5, when used with annular pipe or with helical pipe with rerolled ends, generally provide adequate control of infiltration of soil particles. Properly installed, these bands provide continuous metal-to-metal contact with the periphery of the annular portion of the pipe. Where these bands do not provide adequate soil infiltration control, a geotextile wrap around the exterior of the joining system and the adjacent pipe will inhibit the movement of silt and larger soil particles into the pipe.

9.2.2 *Gasketed Systems*

9.2.2.1 Gasketed joining systems are used to limit the flow of water from the pipe interior to the backfill, to limit the flow of ground water into the pipe, and where necessary, to provide further control of soil particle infiltration. Joining systems such as those described in 9.1.4, 9.1.6, and 9.1.7 require gaskets to adequately control soil particle infiltration, except where the pipe is used in underdrain applications. Gaskets used in all joining systems shall conform to the requirements of 6.5 and 9.5.

9.2.2.2 Sites where excessive water infiltration is expected or where the pipe will carry hazardous pollutants require a gasketed joining system. In these cases, the joining system shall be tested to establish a leakage rate not to exceed 200 gal per diameter inch per mile per day [18.5 L per millimeter of diameter per kilometre per day] with no pressure applied to the pipe or joining system. The joining system shall be tested at the pipe fabricator's plant or a laboratory, with the pipe in straight alignment. The test shall be witnessed and certified by an approved laboratory.

9.3 *Requirements*—Joining systems shall be fabricated in a manner that ensures that the band or coupler extends over each pipe section an equal length. The joining system shall be fabricated in such a way that proper installation will result in performance conforming with 9.2.1 or 9.2.2 as required for the project.

9.3.1 *Band, Sleeve, or Bell Thickness and Width*—The band, sleeve coupler, or bell portion of the joining system shall be sufficiently strong to resist the forces to which it is subjected. Table 18 provides minimum steel thickness requirements for bands, sleeves, or bells based on the steel thickness of the pipes being connected. Table 18 does not apply to channel (hat) bands, which are covered under 9.3.3. The width of coupling bands (9.1.1-9.1.3, and 9.1.5) shall be equal to or greater than the minimum widths shown in Tables 19 and 20.

9.3.2 *Band Connectors*—The bands shall be connected in a manner approved by the purchaser with hardware that has been suitably galvanized to provide durability. This hardware includes angles and integrally or separately formed and attached flanges that will be connected together with galvanized or cadmium-plated bolts, bars and straps, wedge locks, and straps or lugs. Bands shall be connected with the bolts in accordance with Table 21.

9.3.3 *Channel Bands*—Pipe sections provided with flanges on the ends will be connected by interlocking the flanges of two pipes with a channel (hat) band or other band incorporating an interlocking channel, not less than ¾ in. [19 mm] in width. The depth of the channel shall be not less than ½ in. [13 mm]. The channel band shall have a minimum thickness of 0.064 in. [1.62 mm].

9.3.4 *Sleeve Couplers*—Sleeve couplers for pipes less than 12 in. [300 mm] in diameter shall be made from steel with a minimum thickness of 0.040 in. [1.02 mm]. The steel thickness for larger sizes shall conform to Table 18. Alternatively the coupler shall be a plastic sleeve with adequate strength to maintain the in-service pipe alignment and meet the requirements of 9.2.1.

9.4 *Structural Properties*—Joining systems that are subject to forces created by differential soil movement or settlement require certain structural properties to withstand the applied forces. Minimum values for these structural properties are shown in Table 22. These values for a joining system are determined by either a rational analysis or a suitable physical test.

9.4.1 *Shear Strength*—The shear strength required of the joining system is expressed as a percentage of the calculated shear strength of the pipe at a typical cross section at a location other than a rerolled end.

TABLE 18 Band, Sleeve, or Bell Thickness[A,B]

Nominal Pipe Thickness		Minimum Band Sleeve or Bell Thickness	
in.	[mm]	in.	[mm]
0.109	[2.77] and thinner	0.052	[1.32]
0.138	[3.51]	0.064	[1.63]
0.168	[4.27]	0.079	[2.01]

[A] For annular corrugated pipe or helically corrugated pipe with 2⅔-by-½-in. [68-by-13-mm] annular rerolled ends.

[B] Applies to joining systems covered by 9.1.1-9.1.3, 9.1.5, 9.1.7, and 9.1.6, when the coupler is 12 in. [300 mm] or larger and made from steel.

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TABLE 19 Band Width Requirements for Pipe with Annular Corrugated Ends[A,B]

Nominal Pipe Diameter		Minimum Band Width	
in.	[mm]	in.	[mm]
12 to 36	[300 to 900]	7	[175]
42 to 144	[1050 to 3600]	10 ½	[265]

[A]For annular pipe or helical pipe with 2⅔-by-½-in. [68-by-13-mm] rerolled ends.
[B]Applies to joining systems covered by 9.1.1-9.1.3, and 9.1.5

9.4.2 *Moment Strength*—The moment strength required of a joining system is expressed as a percent of the calculated moment strength of the pipe at a typical cross section at a location other than a rerolled end.

9.4.3 *Tensile Strength*—Where pull-apart (tensile) strength is required to control disjointing in slope drains and similar applications, corrugated, partially corrugated, or channel bands shall be specified. When special requirements exist, joining systems shall provide tensile strength levels of 5,000 lb [22kN] for 42 in. [1050 mm] and smaller sizes and 10,000 lb [46 kN] for larger sizes.

9.5 *Gaskets*—Where infiltration or exfiltration is a concern, as defined in 9.2.2, the joining system shall incorporate gaskets. Rubber gaskets shall meet the requirements of 6.5 and shall be flat, o-ring, or have a profile shape. Flat gaskets shall be continuous or have a lap joint and be approximately 7 in. [18 mm] wide and approximately ⅜ in. [9.5 mm] thick. O-ring gaskets shall be 13⁄16-in. [20 mm] or ⅞ in. [22 mm] in diameter for pipe diameters of 36 in. [900 mm] and smaller, or ⅞ in. [22 mm] diameter for larger diameters of pipe fabricated with a ½ in. [13 mm] deep corrugation. O-ring gaskets shall be 1⅜ in. [35 mm] in diameter when used on pipes having a 1 in. [25 mm] or deeper corrugation. Other types of gaskets may be used, including profile gaskets, that meet the specific requirements of the joining system.

10. Workmanship, Finish, and Appearance

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 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 Metallic coating which has been bruised, broken, or otherwise damaged.

10.1.5 Lack of rigidity.

10.1.6 Illegible markings on the steel sheet.

10.1.7 Ragged or diagonal sheared edges.

10.1.8 Uneven laps in riveted or spot welded pipe.

10.1.9 Loose, unevenly lined, or unevenly spaced rivets.

10.1.10 Defective spot welds or continuous welds.

10.1.11 Loosely formed lockseams.

10.1.12 For Type IS and IIS pipe, metallic-coated steel inserts that are loose, that protrude beyond the inside surface of the pipe, or that have an exposed surface that is positioned in the rib more than 0.20 in. [5.0 mm] from the inside surface of the pipe.

10.1.13 For Type IS and IIS pipe, polymer coating or metallic coating on inserts that has been bruised, broken, disbonded, or otherwise damaged.

11. Repair of Damaged Coatings

11.1 Pipe on which the metallic coating has been burned by welding beyond the limits provided in 7.4.2 and 7.6, or has been otherwise damaged in fabricating or handling, shall be repaired. The repair shall be done so that the completed pipe shall show careful finished workmanship in all particulars. Pipe which, in the opinion of the purchaser, has not been cleaned or coated satisfactorily may be rejected. If the purchaser so elects, the repair shall be done in his presence.

11.2 The damaged area shall be repaired in conformance with Practice A 780 (Note 13), except as described herein. The damaged area shall be cleaned to bright metal by blast cleaning, power disk sanding, or wire brushing. The cleaned area shall extend at least ½ in. [13 mm] into the undamaged section of the coating. The cleaned area shall be coated within 24 h and before any rusting or soiling.

NOTE 13—While Practice A 780 specifically refers to repair of damaged zinc coatings, the same procedures are applicable to repair of other metallic coatings except as described in this section.

NOTE 14—Repair of asphalt coating is described in Specification A 849.

11.3 *Paints Containing Zinc Dust*—Paints containing zinc dust, as described in the Materials section of Practice A 780, shall be applied to a dry film thickness of at least 0.005 in. [0.13 mm] over the damaged section and surrounding cleared area. Paints containing zinc dust shall be used for repair to all types of metallic coatings such as zinc, aluminum, and alloys of zinc and aluminum.

11.4 *Metallizing Coating*—The damaged area shall be cleaned as described in 11.2, except it shall be cleaned to the near-white condition. The repair coating applied to the cleaned section shall have a thickness of not less than 0.005 in. [0.13 mm] over the damaged section and shall taper off to zero thickness at the edges of the cleaned undamaged section.

11.4.1 Where zinc coating is to be metallized, it shall be done with zinc wire containing not less than 99.98 % zinc.

11.4.2 Where aluminum coating is to be metallized, it shall be done with aluminum wire containing not less than 99 % aluminum.

11.4.3 Where 55 % aluminum-zinc alloy coating is to be metallized, it shall be done using the materials described in 11.4.1 or 11.4.2, or by using an alloy wire of 55 % aluminum and 45 % zinc by weight.

11.4.4 Where Zn-5 Al-MM alloy coating is to be metallized, it shall be done using the materials described in 11.4.1, or by using an alloy wire of 85 % zinc and 15 % aluminum by weight.

11.5 Pipe on which zinc and aramid fiber composite coating is damaged by welding during fabrication of fittings or otherwise damaged during handling or shipping shall be repaired in accordance with 11.2 through 11.4.

12. Inspection

12.1 The purchaser or his representative shall have free access to the fabricating plant for inspection, and every facility

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TABLE 20 Band Width Requirements for Helically Corrugated Pipe

Nominal Corrugation		Nominal Pipe Diameter		Minimum Band Width	
in.	[mm]	in.	[mm]	in.	[mm]
1½ by ¼	[38 by 6.5]	4 to 18	[100 to 450]	7	[175]
2⅔ by ½	[68 by 13]	12 to 84	[300 to 2100]	12	[300]
3 by 1	[75 by 25]	36 to 144	[900 to 3600]	14	[350]
5 by 1	[125 by 35]	36 to 144	[900 to 3600]	22	[550]

NOTE 1—Corrugation of band shall match that pipe
NOTE 2—Band shall be centered on pipes being joined
NOTE 3—Applies to joining systems covered by 9.1.1-9.1.3, and 9.1.5.

TABLE 21 Band Connector Bolt Size

Pipe Diameter		Bolt Diameter	
in.	[mm]	in.	[mm]
≤ 8	[450]	⅜	[Metric M10]
≥ 21	[525]	½	[Metric M12]
Type III and IIIA		5⁄16	[Metric M8]

TABLE 22 Structural Properties of Joining System

	Minimum Value
Shear strength (% of barrel strength)	2
Moment strength (% of barrel strength)	5
Tensile (pull-apart) strength	none

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.

12.2 On a random basis, samples may be taken for chemical analysis and metallic coating measurements 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. The weight [mass] of metallic coating shall be determined in accordance with Test Method A 90/A 90M for zinc, 55 % aluminum-zinc alloy, and zinc-5 % aluminum-mischmetal alloy coatings, and in accordance with Test Method A 428/A 428M for aluminum coating.

13. Rejection

13.1 Pipe failing to conform to the specific requirements of this specification, or that shows poor workmanship, 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.

14. Certification

14.1 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 test results shall be furnished.

15. Keywords

15.1 corrugated steel pipe; drainage pipe; metallic coated pipe; sewer pipe

ANNEX

(Mandatory Information)

A1. QUALIFICATION OF RESISTANCE SPOT WELDING EQUIPMENT

A1.1 *General*—Welding equipment shall be of sufficient capacity, of such design, and in such condition as to make possible the production of first-class welds. Before being permitted to perform welding on corrugated steel pipe, resistance spot welding machines and operators shall be qualified by means of the test prescribed in A1.2. Tests shall be performed by the fabricator's shop or by a recognized independent laboratory at no expense to the purchaser. Qualification tests performed by the fabricator's shop shall be made in the presence of the representative of the purchaser.

A1.2 *Qualification*—Perform three tension shear tests representing each thickness of sheet to be used in the fabrication of the pipe. Prepare specimens by lapping two strips of corrugated steel sheet 1½-in. [38-mm] minimum width by 5-in. [125-mm] minimum length and joining them together by a single spot weld duplicating the size to be used in production. The length of lap shall be 1½ in. [38 mm]. The longer axis of the specimen shall be parallel to the direction of rolling. Test the specimens in tension to destruction in a standard calibrated testing machine. The minimum shear strength in pounds-force [kilonewtons] as determined by this test shall be not less than that shown in Table A1.1 for the nominal thickness of sheet used in the test.

A1.3 *Verification*—After a machine and operator have been qualified by the foregoing procedure, to ensure that qualification is maintained, make three tension shear tests at the start of each work shift, and make three tension shear tests for each change in sheet thickness.

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TABLE A1.1 Shear Strength of Spot Welds

Specified Sheet Thickness		Minimum Shear Strength	
in. (A 760)	mm [A 760M]	lbf (A 760)	kN [A 760M]
0.064	1.63	4 100	18.2
0.079	2.01	5 200	23.1
0.109	2.77	7 000	31.1
0.138	3.51	8 500	37.8
0.168	4.27	10 000	44.5

A1.4 *Machine Settings*—One copy of the approved machine setting shall be posted on the machine for use by the machine operator. No settings shall be varied, except weld phase shift and pressure which may be varied by ±10 %.

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