Designation: F2881/F2881M – 21

Standard Specification for 12 to 60 in. [300 to 1500 mm] Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications[1]

This standard is issued under the fixed designation F2881/F2881M; 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 requirements and test methods for dual wall polypropylene pipe and fittings. The nominal inside diameters covered are 12 to 60 in. [300 to 1500 mm].

1.2 The requirements of this specification are intended to provide pipe and fittings suitable for underground use for non-pressure storm sewer systems. Pipe and fittings produced in accordance with this specification shall be installed in compliance with Practice D2321.

1.3 This specification covers pipe and fittings with an interior smooth wall and an annular corrugated profile outer wall (Fig. 1).

1.4 *Units*—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.

1.5 The following precautionary statement caveat pertains only to the test method portion, Section 8, of this specification. *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A666 Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
D618 Practice for Conditioning Plastics for Testing
D638 Test Method for Tensile Properties of Plastics
D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1505 Test Method for Density of Plastics by the Density-Gradient Technique
D1600 Terminology for Abbreviated Terms Relating to Plastics
D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
D2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
D2444 Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
D3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
D4101 Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.62 on Sewer.
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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.

*A Summary of Changes section appears at the end of this standard

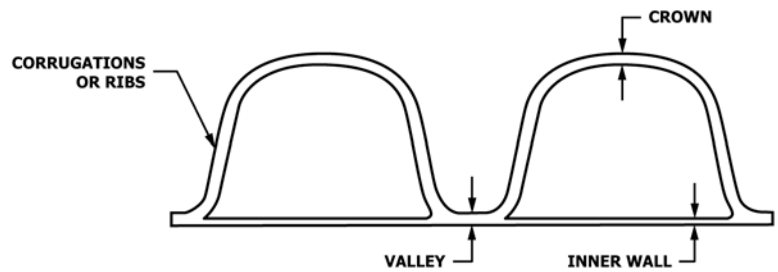

FIG. 1 Interior Smooth Wall and an Annular Corrugated Profile Outer Wall

D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D4389/D4389M Specification for Finished Glass Fabrics Woven From Rovings
D5630 Test Method for Ash Content in Plastics
D6992 Test Method for Accelerated Tensile Creep and Creep-Rupture of Geosynthetic Materials Based on Time-Temperature Superposition Using the Stepped Isothermal Method
F412 Terminology Relating to Plastic Piping Systems
F477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

2.2 *AASHTO Standard:*[3]
LRFD, Section 12 AASHTO LRFD Bridge Design Specifications Section 12 – Buried Structures and Tunnel Liners
M288 Geotextile Specification for Highway Applications

2.3 *Federal/Military Standards:*[4]
Fed. Std. No. 123 Marking for Shipment (Civil Agencies)
MIL-STD-129 Marking for Shipment and Storage

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified. The abbreviation for polypropylene is PP.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dual wall, n*—In this case, the dual pipe wall construction provides an interior wall in the waterway and includes ribs, corrugations, or other shapes, which can be either solid or hollow, that helps brace the pipe against diametrical deformation.

3.2.2 *silt-tight joint, n*—Joint that prevents the passage of silt or soil, does not restrict water passage.

3.2.3 *water-tight joint, n*—Joint that retrains the passage of water to not exceed a specified limit.

4. Classification

4.1 Pipe manufactured in accordance with this specification shall be of two classes identified as Class I or Class II. The corresponding pipe stiffness requirements are prescribed in Table 1.

5. Ordering Information

5.1 Orders for product made to this specification shall include the following information to adequately describe the desired product:

5.1.1 This ASTM designation and year of issue,
5.1.2 Diameters,
5.1.3 Pipe Class,
5.1.4 Total footage of each pipe diameter involved,
5.1.5 Pipe laying length,
5.1.6 Joint requirements
5.1.7 *Fitting type(s):*
5.1.7.1 Size and type of fittings, including mainline and branch diameters, and
5.1.7.2 Number of fittings per diameter.

[3] Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, http://www.transportation.org.
[4] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

TABLE 1 Pipe Stiffness and Pipe Dimensions

Nominal Size	Minimum Inside Diameter		Minimum Inner Liner Thickness		Minimum Valley Thickness		Minimum Crown Thickness		Class I Minimum Pipe Stiffness at 5 % Deflection		Class II Minimum Pipe Stiffness at 5 % Deflection	
	in.	[mm]	in.	[mm]	in.	[mm]	in.	[mm]	lb/in./in.	[kPa]	lb/in./in.	[kPa]
12	11.82	[300]	0.045	[1.1]	0.103	[2.6]	0.052	[1.3]	70	[482]	...	...
15	14.78	[375]	0.050	[1.3]	0.126	[3.2]	0.068	[1.7]	60	[413]	...	...
18	17.73	[450]	0.055	[1.4]	0.132	[3.4]	0.074	[1.9]	56	[386]	...	...
24	23.64	[600]	0.060	[1.5]	0.144	[3.7]	0.093	[2.4]	50	[344]	...	...
30	29.55	[751]	0.065	[1.7]	0.148	[3.8]	0.108	[2.7]	46	[317]	...	...
36	35.46	[901]	0.070	[1.8]	0.153	[3.9]	0.132	[3.4]	40	[275]	46	[317]
42	41.37	[1051]	0.070	[1.8]	0.158	[4.0]	0.160	[4.1]	35	[241]	46	[317]
48	47.28	[1201]	0.072	[1.8]	0.179	[4.6]	0.165	[4.2]	30	[206]	46	[317]
54	53.19	[1351]	0.078	[2.0]	0.194	[4.9]	0.178	[4.5]	26	[175]	46	[317]
60	59.10	[1501]	0.085	[2.2]	0.215	[5.5]	0.180	[4.6]	25	[170]	46	[317]

6. Materials and Manufacture

6.1 *Pipe and Fabricated Fittings—Polypropylene Compounds*—Polypropylene compounds used in the manufacture of the dual wall pipe and fittings shall have the minimum properties as shown in Table 2. Polypropylene compounds shall be comprised of the base unfilled copolymer polypropylene virgin resin and all additives, colorants, process aids, modifiers, UV inhibitors and stabilizers. Conditioning, sampling, preparation and testing of molded specimens shall be in accordance with the requirements in Specification D4101. Compounds shall be tested and validated on an annual basis or for any new formulations. Compounds that have higher performance properties shall be permitted provided the density of the final formulation shall not exceed 0.0509 lb/in^3 (1.410 g/cm^3) and all other product requirements are met.

NOTE 1—Stress-cracking has not been shown to be a concern with polypropylene resins, so no slow-crack growth test protocol has been developed for assessing it.

6.2 *Color and Ultraviolet Stabilization for Pipe and Fabricated Fittings*—The pipe shall be colored or black. Black polypropylene compounds shall have between 2.0 and 3.0 percent carbon black when tested in accordance with the procedures in Test Method D4218 or in combination with Test Method D5630. Colored polypropylene compounds shall be protected from Ultraviolet (UV) degradation with UV stabilizers.

NOTE 2—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration.

6.3 *Rework Plastic*—Clean polypropylene rework plastic, generated from the manufacturer's own production of the product and having the same minimum physical properties, may be used by the manufacturer, provided that the pipe produced meets all the requirements of this specification.

6.4 *Elastomeric Seal Materials*—Elastomeric compounds and thermoplastic elastomeric compounds used in the manufacture of sealing rings or gaskets shall meet the requirements of Specification F477.

6.5 *Lubricant*—The lubricant used for assembly of gasketed joints shall have no detrimental effect on the gasket or the pipe.

6.6 *Optional Bell Retaining Bands*—Bell retaining bands, if used, shall meet the requirements in 7.11.4 and shall be made of corrosive resistant materials such as fiberglass (Specification D4389/D4389M) or stainless steel (Specification A666).

6.6.1 The Specification D4389/D4389M fiberglass roving shall be an E type glass, free of any alkali, dirt or other impurities. The band shall consist of a continuous, overlapping filament fiber and not a fabric.

NOTE 3—Compound and material properties are typically tested to validate a formulation; they are not routine quality assurance tests. Users requiring such testing for quality assurance purposes should insert these criteria in their project specifications.

7. General Requirements

7.1 *Workmanship*—The pipe and fittings shall be homogeneous throughout and be as uniform as commercially practical in color, opacity, and density. The pipe walls shall be free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye and that may affect the wall integrity. The ends shall be cut cleanly and squarely through valleys.

7.1.1 Visible defects, cracks, creases, splits, in pipe are not permissible.

7.2 *Dimensions and Tolerance:*

7.2.1 *Nominal Size*—The nominal size for the pipe and fittings is shown in Table 1.

7.3 *Inside Diameter*—The manufacturer's stated inside diameter shall not vary by more than ± 1%.

7.4 *Laying Length*—The pipe shall be supplied in any laying length agreeable to both the owner and the manufacturer. Laying length shall not be less than 99 % of stated quantity when measured in accordance with 8.3.2.

7.5 *Minimum Inside Diameter*—The minimum inside diameter shall be as shown in Table 1 when measured in accordance with 7.3. In no case shall the manufacturer's inside diameter, including 1% tolerance, be less than the minimum inside diameter.

NOTE 4—Inside pipe diameters may differ from one manufacturer to another; therefore, each manufacturer establishes inside pipe diameters and applies the manufacturing tolerance. The minimum inside diameter is used for hydraulic calculations.

7.6 *Minimum Wall, Crown, Valley and Liner Thickness*—The minimum thickness of pipe sections shall meet the requirements given in Table 1 when measured in accordance with 8.3.3.

NOTE 5—The outside diameters and the corrugation pitch of products manufactured to this specification are not specified; therefore, compatibility between pipe and fittings made to this specification from different manufacturers should be verified.

7.7 *Pipe Class*—The pipe shall be manufactured to either the Class I or Class II pipe stiffness requirements given in Table 1. Unless otherwise specified by the owner/designer, the pipe shall meet the requirements of Class I given in Table 1.

7.8 *Pipe Stiffness*—Minimum pipe stiffness at 5 % deflection shall meet the requirements given in Table 1 when tested in accordance with 8.4.

TABLE 2 Polypropylene Compound Properties

Property	ASTM Test Method	Units [SI Units]	Minimum Value
Melt Flow Rate	D1238	g/10 min	0.25 at 230 °C
Density	D792, D1505	lb/in.^{3} [g/cm^3]	0.0325 [0.900]
Tensile Strength at Yield	D638	psi [N/mm^2]	3500 [24]
Elongation at Yield	D638	% [%]	5 [5]
Flexural Modulus (1 % secant)	D790 Procedure B	psi [N/mm^2]	175 000 [1200]
IZOD Impact Strength (73 °F [23 °C])	D256	ft-lb/in.^{2} [kJ/m^2]	23.8 [50]
Oxidative-Induction Time (392 °F [200 °C])	D3895	min	25

NOTE 6—The 5 % deflection criterion, which was selected for testing convenience, is not a limitation with respect to in-use deflection. The engineer is responsible for establishing the acceptable deflection limit.

7.9 *Pipe Flattening*—There shall be no evidence of splitting, cracking, breaking, separation of seams, separation of the outer and inner wall, or combinations thereof, when tested in accordance with 8.5. Additionally, at or below the average deflection limit defined in Eq 1 for dual wall profiles the specimen shall be considered as failing this test when the load does not increase continuously with increasing deflection.
Average Buckling Deflection Limit:

$$\Delta = 1.07\ \%\cdot\left(\frac{D}{0.5\ (D_o\ -\ D_i)}\right) \quad (1)$$

where:

Δ = minimum buckling deflection limit (%)
D = mean diameter (centroid) of pipe (in. [mm])
$0.5\ (D_o - D_i\ )$ = height of the corrugation (outside diameter minus inside diameter) (in. [mm])

NOTE 7—Eq 1 is based on the results from NCHRP Report 631[5] and is defined as being derived from the standard parallel plate test equation and modified for polypropylene. The values for the diameter measurements are based on each producer's specific corrugation dimensions.

7.10 *Pipe Impact Strength*—There shall be no evidence of splitting, cracking, breaking, separation of seams, separation of the outer and inner wall, or combinations thereof, when conditioned in accordance with 8.1 and tested in accordance with 8.6 and examined under normal light and the unaided eye. The minimum pipe impact strength at 73 °F [23 °C] shall be 140 ft-lbf [190 J].

NOTE 8—Discoloration or "whitening" of the pipe during pipe flattening and impact tests is normal and does not represent a failure criteria for either test.

7.11 *Fabricated Fittings and Joining Systems:*

7.11.1 Only fabricated fittings and joining systems supplied or recommended by the pipe manufacturer shall be used. Fabricated fittings shall meet the same material requirements as the pipe and be produced from pipe having the same Pipe Class as specified in Table 1 and shall be installed in accordance with the manufacturer's recommendations

NOTE 9—Fittings may be fabricated from the pipe by a variety of processes including hot plate welding, spin welding or other processes.

7.11.2 The joining system(s) shall be of a design that preserves alignment at the joints while maintaining the specified level of watertight requirements in accordance with 7.11.3.

7.11.3 Pipe and fittings shall be specified in 5.1.6 and have either silt-tight bell/spigot joints that utilize a gasket that complies with the requirements of Specification F477 or watertight bell/spigot joint that complies with the laboratory tests defined and described in Specification D3212 and utilizes a gasket that complies with the requirements of Specification F477. It is permissible to supply silt-tight bell/spigot joints with geotextile wrapping meeting the requirements of M 288 in lieu of a rubber gasket. Note that special provisions must be taken in order to join field cut pipe that must have watertight joints meeting the requirements of Specification D3212.

NOTE 10—Specification D3212 testing only confirms laboratory short-term watertight integrity of the joint design. If long-term watertight performance is required, field testing of the joint should be conducted a minimum 30-days after installation. This testing assesses the impact of long-term material properties and installation quality.

7.11.4 Optional retaining bands, when used and tested in accordance with 7.11.3, shall show no signs of cracking, separation, splitting or delamination from the pipe during this test.

7.12 *Perforations*—Perforations shall be cleanly cut and shall be placed only in the valley of the corrugation rib, and uniformly spaced along the length and circumference of the pipe. Dimensions of the perforations and the minimum perforation inlet area shall be as listed in Table 3. Other perforation dimensions and configurations shall be permitted, where required to meet the needs of the specifier. All measurements shall be made in accordance with 8.3.4. Pipe connected by bell and spigot joints shall not be perforated in the area of the bells and spigots.

7.13 *Creep Rupture Strength*—Specimens fabricated in the same manner and composed of the same materials as the finished pipe shall have a 50-year creep rupture tensile strength at 73 °F [23 °C] not less than 1000 psi [7 MPa], when determined in accordance with 8.7.

[5] National Cooperative Highway Research Program (NCHRP) Report 631: Updated Test and Design Methods for Thermoplastic Drainage Pipe. DOI: 10.17226/23045

TABLE 3 Perforation and Dimensions

Nominal Size		Type of Perforation			
		Circular			
		Maximum Diameter		Minimum Inlet Area	
in.	[mm]	in.	[mm]	in.	[mm]
12	[300]	⅜	[10]	1,5	[40]
15	[375]	⅜	[10]	1.5	[40]
18	[450]	⅜	[10]	1.5	[40]
21	[525]	⅜	[10]	2.0	[30]
24	[600]	⅜	[10]	2.0	[40]
27	[675]	⅜	[10]	2.0	[40]
30	[750]	⅜	[10]	2.0	[40]
36	[900]	⅜	[10]	2.0	[40]
42	[1050]	⅜	[10]	2.0	[40]
48	[1200]	⅜	[10]	2.0	[40]
54	[1350]	⅜	[10]	2.0	[40]
60	[1500]	⅜	[10]	2.0	[40]

7.14 *Creep Modulus*—Specimens fabricated in the same manner and composed of the same materials as the finished pipe shall have a 50-year tensile creep modulus at 73 °F [23 °C] at the stress level of 500 psi [3.5 MPa] not less than 27 000 psi [186 MPa]. The creep modulus shall be determined in accordance with 8.8.

NOTE 11—The 50-year creep rupture strength and 50-year creep modulus values, determined by the test methods in 8.7 and 8.8, are used to define the slope of the logarithmic regression curves to describe the required material properties sampled from the product. They are not to be interpreted as service life limits.

7.15 *Installation Requirements*—The pipe manufacturer shall provide the purchaser with the requirements for the proper installation of the pipe and the minimum and maximum allowable cover height for specific traffic and non-traffic loading conditions. The installation requirements shall be based on Practice D2321 with a design that satisfies the safety factors specified in the AASHTO LRFD Bridge Design Specifications, LRFD, Section 12 for Thermoplastic Pipe for earth and live loads, with consideration for impact and multiple vehicle presences.

7.16 *Structural Data*—If requested by the purchaser, the pipe manufacturer shall provide data to enable verification of structural design safety factors, including pipe profile geometry, wall centroid, wall area, wall moment of inertia, and material strain limits.

NOTE 12—For perforated pipe applications, the size of the embedment zone and permeability of the embedment material provide the desired level of infiltration or exfiltration. The pipe or embedment zone shall be wrapped with a geotextile designed to prevent migration of fine soils into the pipe or embedment zone. Where a geotextile is not used, the gradation of the embedment material shall be compatible with the perforation size to avoid backfill migration into the pipe.

8. Test Methods

8.1 *Conditioning:*

8.1.1 *Referee Testing*—When conditioning is required for referee tests, condition the specimens in accordance with Procedure A of Practice D618 at 73.4 ± 3.6 °F [23 ± 2 °C] for not less than 40 h prior to test. Conduct tests under the same conditions of temperature. The selection of the sample or samples of the pipe and fittings shall be as agreed upon between the owner and the seller. In case of no prior agreement, any sample selected by the testing laboratory shall be deemed permitted.

8.1.2 *Quality Control Testing*—Condition specimens for a minimum of 4 h prior to test in air or 1 h in water at 73.4 ± 3.6 °F [23 ± 2 °C] without regard to relative humidity.

8.2 *Test Conditions*—Conduct tests other than those for routine quality control purposes in the standard laboratory atmosphere of 73.4 ± 3.6 °F [23 ± 2 °C], in the referenced test method or in this specification.

8.3 *Dimensions:*

8.3.1 *Inside Diameter*—Measure the inside diameter in accordance with Test Method D2122.

8.3.2 *Laying Length*—Measure pipe laying length in accordance with Test Method D2122. These measurements may be taken at ambient temperature.

8.3.3 *Minimum Inside Diameter, and Wall, Crown, Valley and Liner Thickness*—Measure the thickness of each wall component in accordance with Test Method D2122. Each specimen shall be cut perpendicular to the longitudinal axis of the pipe. This circumferential cut shall be made directly through a corrugation allowing a plain view of the inner wall 360° around the circumference in order to obtain a minimum of eight measurements in accordance with Test Method D2122. Each specimen shall also be cut along the longitudinal axis of the pipe to measure the longitudinal profiles for two full corrugation periods to obtain a minimum of eight measurements for each section thickness.

8.3.4 *Perforations*—Measure dimensions of perforations on a straight specimen without external forces applied. Linear measurements shall be made with an instrument with calibration increments of 0.01 in [0.25 mm].

8.4 *Pipe Stiffness*—Select a minimum of three pipe specimens and test for pipe stiffness F/Δy, as described in Test Method D2412, except for the following conditions:

8.4.1 The test specimens shall be at least one diameter or 24 in. [609 mm] in length, whichever is less, but shall not be less than three full corrugations. The exact length shall be an integer multiple of the corrugation pitch.

8.4.2 Locate the first specimen in the loading machine between two corrugations parallel to the loading plates. The specimen must lay flat on the plate within ⅛ in. [3 mm]. Use the first location as a reference point for rotation of 90°. Rotate the second specimen 450 and 900. Test each specimen in one position only.

8.4.3 The deflection indicator shall be readable and accurate to +0.001 in. [+0.02 mm].

8.4.4 The parallel plates must exceed the samples in length.

8.5 *Flattening*—Flatten the three test specimens from 8.4 between parallel plates until the pipe inside diameter is reduced by 40 %. It is permissible to increase the rate of loading for this test from 0.5 + 0.02 in./min [12.5 + 0.5 mm/min] to a maximum rate of 2 + 0.02 in./min [50 + 0.02 mm/min] to reduce the test times for large diameter pipe. The test specimens, when examined under normal light and the unaided eye, shall show no splitting, cracking, breaking, or separation of the pipe walls.

8.6 *Impact Resistance*—Test pipe specimens in accordance with Test Method D2444, except six specimens shall be tested or six impacts shall be made on one specimen. Tests shall be conducted using either a 20 lb [9 kg] Tup B or 30 lb [15 kg] Tup B and a flat-plate specimen Holder B. The center of the falling tup shall strike on a corrugation crown. All pipes must pass.

8.6.1 Test specimens shall be cut valley-to-valley and equal in length to one-half of the nominal diameter but not less than 18 in. [457 mm].

8.7 *Creep Rupture Strength*—Determine creep rupture strength at 73 °F [23 °C] in accordance with the tensile creep test methods in D2990, except as follows. Test shall include an additional stress level selected so as to produce rupture at approximately 10 000 h. Alternately, use time-temperature superposition methods.