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An American National Standard

Standard Specification for Design and Installation of Plastic Syphonic Roof Drainage Systems[1]

This standard is issued under the fixed designation F 2021; 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[2] covers requirements for plastic syphonic roof drain systems for industrial, commercial, public, and residential buildings. Requirements for materials, pipe, and fittings are included.

1.2 The interchangeability of pipe and fittings made by different manufacturers is not addressed in this specification. Transition fittings for joining pipe and fittings of different manufacturers is provided for in the referenced pipe and fitting specification.

1.3 In referee decisions, the SI units shall be used for metric-sized pipe and inch-pound units for pipe sized in the IPS system (ANSI B36.10). In all cases, the values given in parentheses are for information only.

1.4 The following safety hazards caveat pertains only to the test methods, Section 7, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1600 Terminology for Abbreviated Terms Relating to Plastics[3]

F 412 Terminology Relating to Plastic Piping Systems[4]

F 1901 Specification for Polyethylene (PE) Pipe and Fittings for Drain Systems[4]

2.2 *ANSI/ASME Standards:*

A112.21.2M Roof Drains[5]

B31.9-1996 Building Service Piping[5]

B36.10 Standard Dimensions of Steel Pipe (IPS)[5]

2.3 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[6]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[6]

3. Terminology

3.1 *Definitions*—Terms and abbreviations as described in Terminologies F 412 and D 1600, respectively, shall apply in this specification. General terminology pertaining to roof drains as described in ANSI/ASME A112.21.2M shall also apply in this specification.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *closed flow, n*—a system of piping and piping components that isolate the internal fluid pressure (vacuum) from the surrounding or external atmosphere.

3.2.2 *collection area, n*—the horizontal projected roof area plus allowance for vertical walls.

3.2.3 *down spout*[7], *n*—also referred to as *down pipe(s)*. Those pipes carrying runoff from the leaders or collecting pipes to the combined building drain or storm sewer located at or near the lowest elevation of the building.

3.2.4 *drain*[7], *n*—any pipe which carries waste water or waterborne wastes in a building drainage system.

3.2.4.1 *drainage system*[7], *n*—includes all the piping within public or private premises, which conveys sewage, rain water, or other liquid wastes to a legal point of disposal. It does not include the mains of public sewer treatment or disposal plants.

3.2.4.2 *leader*[7], *n*—also called the *collector* or *collecting pipe(s)*. Any pipe(s) running laterally connecting each roof drain(s) with the down spout(s). These collecting pipes may or may not run horizontally below the plane of the roof being drained.

3.2.4.3 *roof drain*[7], *n*—also referred to as an *outlet*. A conveyance device installed to receive water collected on the surface of a roof and to discharge it to the leader or to the down spout. Normally fitted with a strainer or screened to prevent influx of solids.

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[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.63 on DWV.

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[2] This specification was developed from the American Society of Plumbing Engineers Data Book, Vol I, Chapter 2, "Storm Drainage Systems" and *Engineering Manual* by R.H. Perry.

[3] *Annual Book of ASTM Standards*, Vol 08.01.

[4] *Annual Book of ASTM Standards*, Vol 08.04.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Phila., PA 19111-5094, Attn: NPODS.

[7] Reference American Society of Sanitary Engineers, Plumbing Dictionary, Third Edition.

3.2.4.4 *syphonic (siphonic) roof drain, n*—a roof drain with gravity-induced vacuum based on the vertical differential fluid head principle. (The height of a column of water expressed in pounds per square inch pressure or equivalent metric units.)

3.2.5 *roof cutter*[7], *n*—any valley-shaped device to collect storm water from a roof, directing it to the roof drain.

4. System Components

4.1 *Materials*:

4.1.1 *General*—The pressure (vacuum) ratings established under this specification are based upon materials of high quality. The manufacturer shall be prepared to certify that his product has the mechanical and chemical properties at least equal to the requirements of the specifications governing the material selected.

4.1.2 *Piping*—Polyethylene piping systems shall meet the requirements of Specification F 1901 and shall be tested and rated for the maximum negative pressure.

4.1.3 *Other Piping Materials*—Materials other than those described in 4.1.2 that meet the requirements of this specification shall be permitted to be used.

4.2 *Syphonic Roof Drains*:

4.2.1 *General*—Any water collection device that provides a sump (trough) and is designed to produce a vacuum or closed flow in the drainage pipe. The closed flow is a necessary feature and differentiates the syphonic roof drain from the general purpose roof drain. Each manufacturer shall rate their siphonic roof drain for maximum flow at specified syphonic (negative) pressures.

4.2.2 *Roof Drain Features*—Features applicable to the syphonic roof drain that are common to most roof drain designs include:

4.2.2.1 Drain body sump (collection trough),

4.2.2.2 Overflow pipe,

4.2.2.3 Gravel barrier (optional), and

4.2.2.4 Leaf or foliage guard (dome).

4.3 *Drain Piping*—The piping of a roof drain system consists of collecting pipes and down pipes leading to the storm sewer. Drain piping for a syphonic roof drain system shall meet the requirements of closed flow from roof drain to storm sewer.

5. Requirements

5.1 At the design rainfall intensity, the system installation shall ensure that the roof drain(s) eliminate the intake of air into the system. This sets up the syphonic action and maximizes the capacity of the drain system.

5.1.1 *System Design and Dimensioning*:

5.1.1.1 The maximum negative pressure must not be less than 20 kPa (2.9 psi) absolute [80 kPa (11.6 psi) below atmospheric] for pipes rated at a pressure of 400 kPa (58 psi) and up to 160 mm (6.3 in.) in diameter. For pipes 200 mm (7.9 in.) or more in diameter, the limiting pressures are dependent on the nominal pressure rating of the pipe. For pipes with a pressure rating of 320 kPa (46.4 psi), the limiting pressure is 40 kPa (5.8 psi) absolute [60 kPa (8.7 psi) below atmospheric]. For pipes with a pressure rating of 400 kPa, the limiting pressure is 20 kPa absolute below atmospheric].

5.1.1.2 Minimum design water velocity under peak load condition shall be 1.0 m/s (3.3 ft/s).

5.1.1.3 Computed flow from an individual roof drain must be within 10 % of the normal required flow and must not exceed the manufacturer's specified maximum for each roof drain size.

NOTE 1—*Computed Flow*—For some manufacturers, this computation is based on two-phase modeling of the flow conditions, incorporating standard hydraulic principles and verified by testing. Consult with the manufacturer's technical data sheet for appropriate piping sizes and maximum permitted flow recommendations for each roof drain size.

NOTE 2—The system shall be designed to meet requirements of local building and plumbing jurisdictions for secondary or emergency roof drainage and for structural loading at maximum ponding of water that can occur with blockage of the primary syphonic drain system

5.1.2 *Roof/Gutter Design*:

5.1.2.1 The roof must be designed to allow rainwater to flow freely to the roof drain(s).

NOTE 3—Roof drains being utilized at their maximum flow capacity should have water retention at each roof drain or in the adjacent gutter no greater than 40 mm (1.57 in.).

5.1.2.2 When used in long valley gutters, only roof drains of 6-L/s (95-gal/min) capacity shall be used.

5.1.2.3 The roof or gutter design, or both, shall incorporate a built-in overflow facility and shall be designed to hold water up to this level should the design rainfall be exceeded or unexpected blockages occur.

5.1.3 *Performance of Joints*:

5.1.3.1 The pipe joints shall be watertight under conditions of pressure and thermal movement expected to occur in the installation.

5.1.3.2 The joint between each roof drain and the roof material shall be made watertight using conventional joining techniques specified for the materials selected.

5.1.4 *Flow Characteristics*:

5.1.4.1 When the system is operating syphonically, the high velocity of the water will ensure the system is self-cleansing. This effect can also occur at rainfall intensity of up to 50 % of the design intensity.

5.1.4.2 At rainfall intensities less than those in 5.1.4.1, the syphonic roof drain system will operate as a conventional system.

6. System Calculations

6.1 *Roof Drainage Area*:

6.1.1 The storm drainage system for a simple building is shown in Fig. 1 and Fig. 2. The collection area is the projected area of a horizontal (flat) roof as shown in Fig. 3.

6.1.2 The collection area, where there is an adjacent wall, is based on a horizontal collection area plus 50 % of the adjacent wall areas (see Fig. 4).

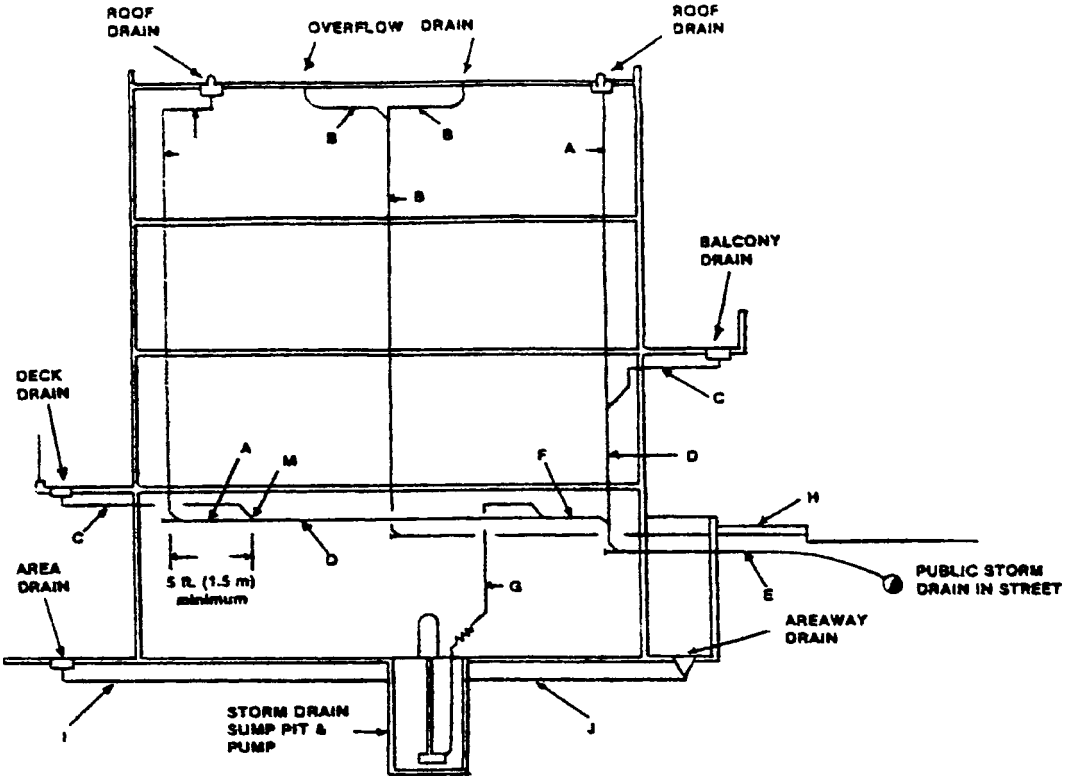

FIG. 1 Elevation Example

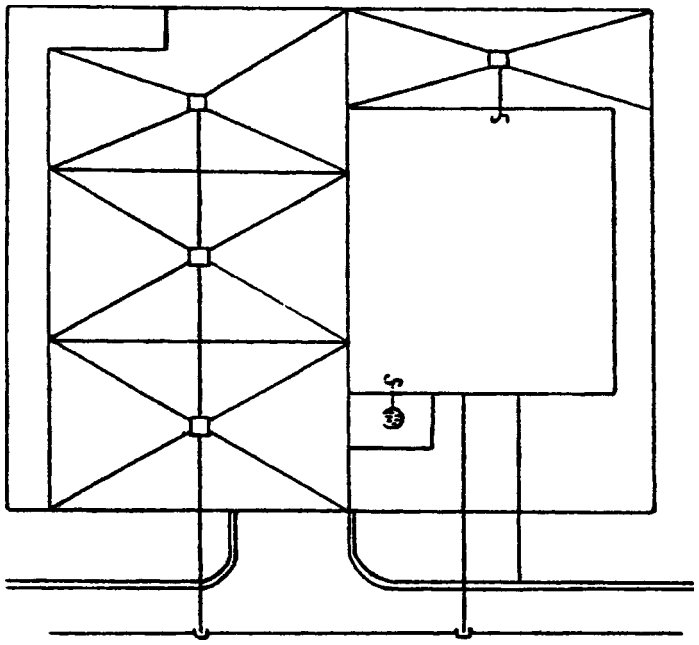

FIG. 2 Plan View Example

6.1.3 *Alternate*—Instead of sizing the storm drainage system on the basis of the actual maximum projected roof area, the roof drainage system (or part of it) shall be sized on the equivalent or adjusted projected roof areas which result from the controlled flow and the storage of storm water on the roof, provided that flow control devices, acceptable to the administrative authority, are used and appropriate roof design details are incorporated into the finished roof. Also, the water of a 25-year frequency storm shall not be stored on the roof for more than 17 h and the water depth on the roof shall not exceed 76.2 mm (3 in.) during the storm. The control device shall be installed so that the rate of discharge of the water shall not exceed the rate allowed, using the values for continued flow of 2.2 mm^2 (23 ft^2) of roof area, based upon a rate of rainfall of 1.7 mm/min (4 in./h), as equivalent of 0.063 L/s (1 gal/min). The roof design for controlled flow roof drainage shall be

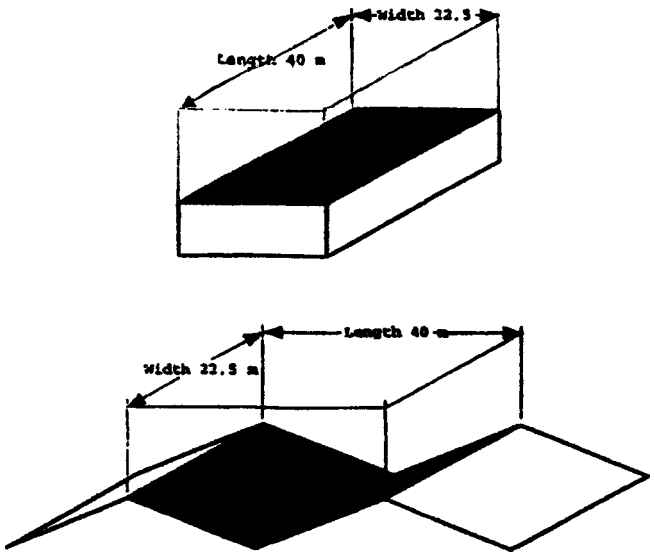

FIG. 3 Projected Roof Area

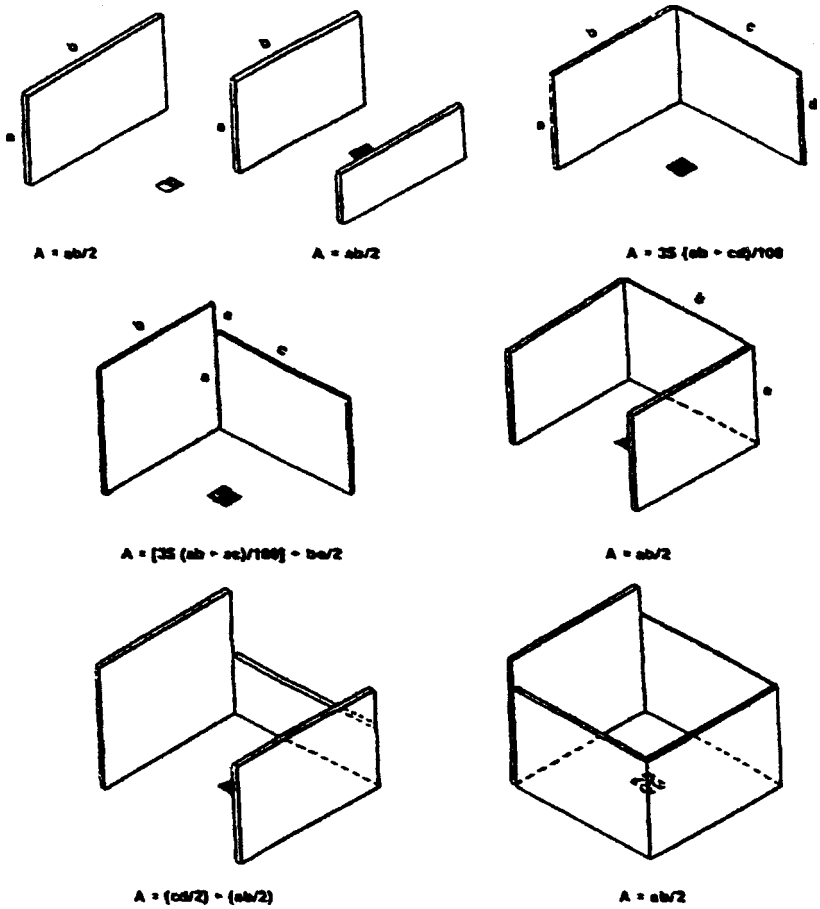

FIG. 4 Adjacent Wall Area Allowance

based on a minimum of 1.44-kPa (30-lb/ft^2) loading to provide a safety factor above 718 Pa (15 lb/ft^2), represented by the 76.2-mm design depth of the water. The roof shall be level and 45° slopes installed at any wall or parapet. The flashing shall extend at least 152.4 mm (6 in.) above the roof level and scuppers placed in the parapet wall 88.9 mm (3.5 in.) above the roof level. Control devices shall be protected by stainers and, in no case, shall the surface in the vicinity of the drain be recessed to create a reservoir. Not less than 2 drains shall be installed in roof areas 929 m^2 (10 000 ft^2).

6.2 *Design Rate of Rainfall*:

6.2.1 The rainfall rates in Table 1 shall be used for design unless higher values are established locally.

TABLE 1 Rainfall Rates

States and Cities	Storm Drainage, 60-Minute Duration, 100-Year Return	
	in./h	gal/min/ft^2
Alabama:		
Birmingham	3.7	0.038
Huntsville	3.3	0.034
Mobile	4.5	0.047
Montgomery	3.8	0.039
Alaska:		
Aleutian Islands	1.0	0.010
Anchorage	0.6	0.006
Bethel	0.8	0.008
Fairbanks	1.0	0.010
Juneau	0.6	0.006
Arizona:		
Flagstaff	2.3	0.024
Phoenix	2.2	0.023
Tucson	3.0	0.031
Arkansas:		
Eudora	3.8	0.039
Ft. Smith	3.9	0.041
Jonesboro	3.5	0.036
Little Rock	3.7	0.038
California:		
Eureka	1.5	0.016
Lake Tahoe	1.3	0.014
Los Angeles	2.0	0.021
Lucerne Valley	2.5	0.026
Needles	1.5	0.016
Palmdale	3.0	0.031
Redding	1.5	0.016
San Diego	1.5	0.016
San Francisco	1.5	0.016
San Luis Obispo	1.5	0.016
Colorado:		
Craig	1.5	0.016
Denver	2.2	0.023
Durango	1.8	0.019
Stratton	3.0	0.031
Connecticut:		
Hartford	2.8	0.029
New Haven	3.0	0.031
Delaware:		
Dover	3.5	0.036
Rehobeth Beach	3.6	0.037
District of Columbia:		
Washington	4.0	0.042
Florida:		
Daytona Beach	4.0	0.042
Ft. Myers	4.0	0.042
Jacksonville	4.3	0.045
Melbourne	4.0	0.042
Miami	4.5	0.047
Palm Beach	5.0	0.052
Tampa	4.2	0.044
Talahassee	4.1	0.043
Georgia:		
Atlanta	3.5	0.036
Brunswick	4.0	0.042
Macon	3.7	0.038
Savannah	4.0	0.042
Thomasville	4.0	0.042
Hawaii:		
Rainfall rates in the Hawaiian Islands vary from 1½ in./h to 8 in./h, depending on location and elevation. Consult local data.		
Idaho:		
Boise	1.0	0.010
Idaho Falls	1.2	0.012
Lewiston	1.0	0.010
Twin Falls	1.0	0.011
Illinois:		
Chicago	2.7	0.028
Harrisburg	3.1	0.032
Peoria	2.9	0.030
Springfield	3.0	0.031
Indiana:		
Evansville	3.0	0.031
Indianapolis	2.8	0.029
Richmond	2.7	0.028
South Bend	2.7	0.028
Iowa:		
Council Bluffs	3.7	0.038
Davenport	3.0	0.031
Des Moines	3.4	0.035
Sioux City	3.6	0.037
Kansas:		
Goodland	3.5	0.036
Salina	3.8	0.039
Topeka	3.8	0.039
Wichita	3.9	0.041
Kentucky:		
Bowling Green	2.9	0.030
Lexington	2.9	0.030
Louisville	2.8	0.029
Paducah	3.0	0.031
Louisiana:		
Monroe	3.8	0.039
New Orleans	4.5	0.047
Shreveport	4.0	0.042
Maine:		
Bangor	2.2	0.023
Kittery	2.4	0.025
Millinocket	2.0	0.021
Maryland:		
Baltimore	3.6	0.037
Frostburg	2.9	0.030
Ocean City	3.7	0.038
Massachusetts:		
Adams	2.6	0.027
Boston	2.7	0.028
Springfield	2.7	0.028
Michigan:		
Cheboygan	2.1	0.022
Detroit	2.5	0.026
Grand Rapids	2.6	0.027
Kalamazoo	2.7	0.028
Traverse City	2.2	0.023
Minnesota:		
Duluth	2.6	0.027
Grand Forks	2.5	0.026
Minneapolis	3.0	0.031
Worthington	3.4	0.035
Mississippi:		
Biloxi	4.5	0.047
Columbus	3.5	0.036
Jackson	3.8	0.039
Missouri:		
Independence	3.7	0.038
Jefferson City	3.4	0.035
St. Louis	3.2	0.033
Springfield	3.7	0.038
Montana:		
Billings	1.8	0.019
Glendive	2.5	0.026
Great Falls	1.8	0.019
Missoula	1.3	0.014
Nebraska:		
Omaha	3.6	0.037
North Platte	3.5	0.036
Scotts Bluff	2.8	0.029

TABLE 1 *Continued*

States and Cities	Storm Drainage, 60-Minute Duration, 100-Year Return	
	in./h	gal/min/ft^2
Nevada:		
Las Vegas	1.5	0.016
Reno	1.2	0.012
Winnemucca	1.0	0.010
New Hampshire:		
Berlin	2.2	0.023
Manchester	2.5	0.026
New Jersey:		
Atlantic City	3.4	0.035
Patterson	3.0	0.031
Trenton	3.2	0.033
New Mexico:		
Albuquerque	2.0	0.021
Carlsbad	2.6	0.027
Gallup	2.1	0.022
New York:		
Binghamtom	2.4	0.025
Buffalo	2.3	0.024
New York	3.1	0.032
Schenectady	2.5	0.026
Syracuse	2.4	0.025
North Carolina:		
Ashville	3.2	0.033
Charlotte	3.4	0.035
Raleigh	4.0	0.042
Wilmington	4.4	0.046
North Dakota:		
Bismarck	2.7	0.028
Fargo	2.9	0.030
Minot	2.6	0.027
Ohio:		
Cincinnati	2.8	0.029
Cleveland	2.4	0.025
Columbus	2.7	0.028
Toledo	2.8	0.027
Youngstown	2.4	0.025
Oklahoma:		
Boise City	3.4	0.035
Muskogee	4.0	0.042
Oklahoma City	4.1	0.043
Oregon:		
Medford	1.3	0.014
Portland	1.3	0.014
Ontario	1.0	0.010
Pennsylvania:		
Erie	2.4	0.025
Harrisburg	2.9	0.030
Philadelphia	3.2	0.033
Pittsburgh	2.5	0.026
Scranton	2.8	0.029
Rhode Island:		
Newport	3.0	0.031
Providence	2.9	0.030
South Carolina:		
Charleston	4.1	0.043
Columbia	3.5	0.036
Greenville	3.3	0.034
South Dakota:		
Lemmon	2.7	0.028
Rapid City	2.7	0.028
Sioux Falls	3.4	0.035
Tennessee:		
Knoxville	3.1	0.032
Memphis	3.5	0.036
Nashville	3.0	0.031
Texas:		
Corpus Christi	4.6	0.048
Dallas	4.2	0.044
El Paso	2.0	0.021
Houston	4.6	0.048
Lubbock	3.3	0.034
San Antonio	4.4	0.046
Utah:		
Bluff	2.0	0.021
Cedar Lake	1.5	0.016
Salt Lake City	1.3	0.014
Vermont:		
Bennington	2.5	0.026
Burlington	2.3	0.024
Rutland	2.4	0.025
Virginia:		
Charlottesville	3.4	0.035
Richmond	4.0	0.042
Roanoke	3.3	0.034
Norfolk	4.0	0.042
Washington:		
Seattle	1.0	0.010
Spokane	1.0	0.010
Walla Walla	1.0	0.010
West Virginia:		
Charleston	2.9	0.030
Martinsburg	3.0	0.031
Morgantown	2.7	0.028
Wisconsin:		
La Cross	2.9	0.030
Green Bay	2.5	0.026
Milwaukee	2.7	0.028
Wausau	2.5	0.026
Wyoming:		
Casper	1.9	0.020
Cheyenne	2.5	0.026
Evaston	1.3	0.014
Rock Springs	1.4	0.015

6.2.2 *Sizing by Flow Rate*—Storm drainage systems can be sized by storm water flow rates, using the approximate rainfall listed in Table 1 for the local area. Multiply the listed rainfall by the roof area being drained by each roof drain to obtain the gallons per minute of required flow for sizing each roof drain. Add the flow rates to determine the flow in each section of the drainage system. Pipe sizes required for various flow rates are listed in Table 2 and Table 3.

6.2.3 *Sizing by Roof Area*—Storm drainage systems can be sized using the roof area served by each section of the drainage system. Maximum allowable roof areas with various rainfall rates are listed in Table 2 and Table 3, along with the required pipe sizes. Using this method, it may be necessary to interpolate between two listed rainfall rate columns. To determine the allowable roof area for a listed size pipe at a listed slope, divide

TABLE 2 Sizing Roof Drains, Leaders, and Vertical Rainwater Piping

Size of Drain, Leader, or Pipe, in.	Flow, gal/min	Maximum Allowable Horizontal Projected Roof Areas, Square Feet at Various Rainfall Rates					
		1 in./h	2 in./h	3 in./h	4 in./h	5 in./h	6 in./h
2	23	2 176	1 088	725	544	435	363
3	67	6 440	3 220	2 147	1 610	1 288	1 073
4	144	13 840	6 920	4 613	3 460	2 768	2 307
5	261	25 120	12 560	8 373	6 280	5 024	4 187
6	424	40 800	20 400	13 600	10 200	8 160	6 800
8	913	88 000	44 000	29 333	22 000	17 600	14 667

TABLE 3 Sizing Roof Drains, Leaders, and Vertical Rainwater Piping

Size of Drain, Leader, or Pipe, mm	Flow, L/s	Maximum Allowable Horizontal Projected Roof Areas, Square Metres at Various Rainfall Rates					
		25 mm/h	50 mm/h	75 mm/h	100 mm/h	125 mm/h	150 mm/h
50	1.5	202	101	67	51	40	34
75	4.2	600	300	200	150	120	100
100	9.1	1 286	643	429	321	257	214
125	16.5	2 334	1 117	778	583	467	389
150	26.8	3 790	1 895	1 263	948	758	632
200	57.6	8 175	4 088	2 725	2 044	1 635	1 363

the allowable square feet of roof for a one inch per hour rainfall rate by the listed rainfall rate for the local area:

Example: The allowable roof area for a 6-in. drain at ⅛-in. slope with a rainfall rate of 3.2 in./h is 21 400/3.2 = 6 688 ft^2.

6.3 *Total Runoff*—The total runoff of a roof area in gallons per minute (litres per second) can be determined by multiplying the design rate of rainfall, gallons per minute per foot square (litres per second per metre square) from Table 1 by the calculated roof area to be drained, square feet (square metres).

6.4 *Number of Roof Drains and Location*—The number of roof drains can be determined by dividing the total runoff of the roof area, gallons per minute (litres per second), calculated in 6.3, by the discharge capacity per roof drain, gallons per minute (litres per second), recommended by the roof drain manufacturer. Locate the roof drains in the area to be drained as evenly distributed as possible so as to maximize discharge at each drain for the design rate of rainfall.

6.5 *Pipe Layout*—An isometric view of the complete pipe drainage system from roof drain to storm sewer shall be prepared to indicate the piping arrangement and determine the existence of any obstructions. The length of piping segments and associated fittings connecting each drainage outlet to the collecting pipe(s) and each collecting pipe to the down pipe(s) shall be provided.

6.5.1 *Collecting Pipes*—The number and location of the collecting pipes shall be determined by the number and location of the roof drains, and their accumulative drainage capacity.

6.5.2 *Down Pipes*—The number and location of the down pipes shall be determined by the location of the collecting pipe(s) in relation to the storm sewer.

6.6 *Length and Volume Flow*—Add the design drainage capacity of each roof drain, gallons per minute (litres per second), to the isometric. Calculate the volume flow for the pipe segments.

6.7 *Pipe Diameters*—The pipe shall be sized to meet the requirements of Section 5.

7. Inspection

7.1 *General*—Prior to initial operation, it is the owner's responsibility to verify that all required examination and testing have been completed and to inspect the piping, or have it inspected, to the extent necessary to satisfy himself that it meets the requirements of the local jurisdiction. Inspection does not relieve the manufacturer, fabricator, or erector or responsibility for performing all required examination and preparing suitable records for the owner's use.

7.2 *Acceptance*—The specified limitations in quality or performance described in this specification shall be met.

8. Testing

8.1 *General*—Prior to initial operation, each piping system shall be testing for leakage. Hydrostatic testing in accordance with 8.2 shall be employed.

8.2 *Hydrostatic System Testing*—Water at ambient temperature shall be used to pressurize the piping system and examine for leaks. The hydrostatic test pressure shall be 3.0 m (10 ft) of the water head.

9. Product Marking

9.1 Marking of all components of the system shall be consistent with that for the pipe and fittings. For example, Specification F 1901, Section 9, shall be used for systems consisting of polyethylene (PE) pipe and fittings.

10. Quality Assurance

10.1 When the product is marked with this ASTM designation (F 2021), the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

11. Keywords

11.1 DWV; pipe fittings; plastic pipe; polyethylene ; siphonic roof drain (building)

SUPPLEMENTARY REQUIREMENTS

S1. Packaging and Marking

S1.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packaging shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S1.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

ANNEX

(Mandatory Information)

A1. INSTRUCTIONS

A1.1 The manufacturer shall ensure that equipment and instructions needed for joining the pipe and fittings are readily obtainable by the installer.

A1.2 Polyethylene drain, waste, and vent systems, as well as other material systems that meet the requirements of this specification, shall be assembled, installed, and supported in accordance with the manufacturer's recommendations.