Copper Development Association Inc.

A Copper Alliance Member

10. Gutters and Downspouts

Introduction

The design of gutter and downspout assemblies is an area of building design which demands special attention. Leaking gutters and downspouts can cause serious damage to a building's interior as well as exterior, and repairs can be expensive.

Maintenance, durability and longevity are important factors to consider when designing gutters and downspouts. Copper is an intelligent choice of materials because of its low maintenance, high resistance to corrosion and long life. Even in severe climates such as marine atmospheres, a well designed copper gutter and downspout assembly will provide many years of low maintenance service.

Other metals used in gutter and downspout assemblies require frequent repainting or recoating to maintain their durability. Copper is an inherently corrosion resistant material which does not require special coatings to maintain its durability or its appearance.

The ease with which a material can be joined to form a continuous, leak-free water conductor is also important. Copper's inherent properties make it an easy material to form and solder. Thus, strong leakproof joints are readily achievable with copper.

Design Principles for Roof Drainage Systems

The building type, its appearance and location have a direct influence on the design of the roof drainage system. They determine the roof area, slope and rainfall intensity. They also influence the use of gutters and downspouts, roof drains and scuppers.

The process of calculating the required size of gutters and downspouts involves:

1. Obtaining rainfall intensity for the building location.
2. Determining the spacing and locations of downspouts.

3. Calculating design roof areas.
4. Sizing the downspouts.
5. Sizing the gutters.

Rainfall Intensity

Rainfall intensity is measured over a 5-minute period. It is recorded, in inches per hour, as the resulting accumulation as if the intensity remained constant for a full hour. Table 10A shows the rainfall intensity for major U.S. cities. The table is divided into two sections, A and B. These sections represent the intensities which are likely to be exceeded once in 10 years, and once in 100 years, respectively.

The table also shows the calculated roof area which can be drained per square inch of downspout. It is based on the assumption that during a rainfall with an intensity of 1 inch per hour, each square inch of downspout can drain 1200 square feet of roof. If the intensity is doubled the downspout capacity is halved, or 600 sq. ft.; if it is tripled the capacity is one third, and so on.

Table 10A. Rainfall Data and Drainage Factors

		A Storms which should be exceeded only once in 10 years		**B** Storms which should be exceeded only once in 100 years	
AREA		**1** 5 Minute intensity (in/hr)	**2** Area drained per sq. inch of downspout (sq. ft.)	**1** 5 Minute intensity (in/hr)	**2** Area drained per sq. inch of downspout (sq. ft.)
Alabama	Birmingham	7.5	160	10.1	120
	Mobile	8.2	150	10.8	110
Alaska	Fairbanks	2.1	570	3.8	320
	Juneau	1.7	710	2.3	520
Arizona	Phoenix	5.6	210	8.8	140
	Tucson	6.1	200	19.1	130
Arkansas	Bentonville	7.4	160	10.2	120
	Little Rock	7.4	160	10.0	120
California	Los Angeles	4.9	240	6.7	180
	Sacramento	2.5	480	3.9	310
	San Diego	2.2	550	3.1	390
	San Francisco	2.7	440	3.7	320
Colorado	Denver	5.7	210	9.1	130
	Boulder	6.4	190	9.4	130
Connecticut	Hartford	6.2	190	8.7	140
District of Columbia		7.1	170	9.7	120
Florida	Jacksonville	7.9	150	10.1	120
	Miami	7.7	160	9.8	120

AREA		A Storms which should be exceeded only once in 10 years		B Storms which should be exceeded only once in 100 years	
		1 **5 Minute intensity (in/hr)**	**2** **Area drained per sq. inch of downspout (sq. ft.)**	**1** **5 Minute intensity (in/hr)**	**2** **Area drained per sq. inch of downspout (sq. ft.)**
	Tampa	8.3	140	10.8	110
Georgia	Atlanta	7.3	160	9.9	120
Hawaii	Honolulu	8.7	140	12.0	100
	Kahului	7.0	170	12.0	100
	Hilo	17.4	70	19.2	60
	Lihue	10.4	120	14.4	80
Idaho	Boise	1.8	670	3.3	360
Illinois	Chicago	6.8	180	9.3	130
Indiana	Indianapolis	6.8	180	9.4	130
Iowa	Des Moines	7.3	160	10.3	120
Kansas	Wichita	7.5	160	10.5	110
Kentucky	Louisville	6.9	170	9.4	130
Louisiana	New Orleans	8.3	140	10.9	110
Maine	Portland	5.4	220	7.6	160
Maryland	Baltimore	7.1	170	9.7	120
Massachusetts	Boston	5.3	230	7.2	170
Michigan	Detroit	6.4	190	8.9	130
Minnesota	Minneapolis	7.0	170	10.0	120
Missouri	Kansas City	7.4	160	14.4	80
	St. Louis	7.1	170	9.9	120
Montana	Helena	1.8	670	3.1	390
	Missoula	1.8	670	2.4	500
Nebraska	Omaha	7.4	160	10.5	110
Nevada	Reno	2.3	520	4.5	270
	Las Vegas	2.1	570	5.2	230
New Jersey	Trenton	6.7	180	9.3	130
New Mexico	Albuquerque	4.0	300	6.7	180
	Santa Fe	4.5	270	6.4	190
New York	Albany	6.5	180	9.1	130
	Buffalo	6.0	200	8.4	140
	New York City	6.7	180	9.2	130
North Carolina	Raleigh	7.3	160	9.8	120
North Dakota	Bismarck	6.6	180	9.8	120

AREA		A Storms which should be exceeded only once in 10 years		B Storms which should be exceeded only once in 100 years	
		1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)	1 5 Minute intensity (in/hr)	2 Area drained per sq. inch of downspout (sq. ft.)
Ohio	Cincinnati	6.8	180	9.3	130
	Cleveland	6.3	190	8.8	140
Oklahoma	Oklahoma City	7.6	160	10.5	110
Oregon	Baker	2.2	550	3.8	320
	Portland	2.1	570	3.0	400
Pennsylvania	Philadelphia	6.8	180	9.4	130
	Pittsburgh	6.4	190	8.8	140
Rhode Island	Providence	5.6	210	7.8	150
South Carolina	Charleston	7.2	170	9.4	130
Tennessee	Memphis	7.4	160	10.0	120
	Knoxville	6.7	180	9.0	130
Texas	Fort Worth	7.6	160	10.5	110
	Dallas	7.6	160	10.5	110
	Houston	8.2	150	10.8	110
	San Antonio	7.6	160	10.5	110
Utah	Provo	3.0	400	5.2	230
	Salt Lake City	2.8	430	4.3	280
Virginia	Norfolk	7.1	170	9.5	130
Washington	Seattle	2.1	570	3.3	360
	Spokane	2.1	570	3.5	340
West Virginia	Parkersburg	6.6	180	9.1	130
Wisconsin	Madison	6.8	180	9.5	130
	Milwaukee	6.6	180	9.1	130
Wyoming	Cheyenne	5.7	210	9.9	120

Downspout Locations

The locations of down-spouts depends on the configuration, architectural features and appearance of the building. The technical considerations include:

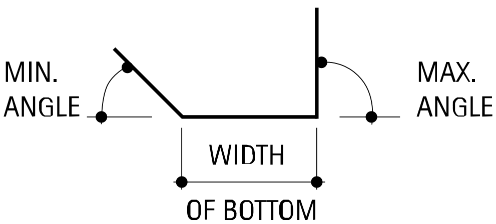
1. Each downspout should drain a maximum of 50 feet of gutter. Gutter expansion characteristics may further limit the distances, since water cannot flow past an expansion joint.
2. Avoid locations where water must flow around a corner to reach a downspout.
3. In locations where icing occurs, downspouts on the north side of the building should be avoided, if possible.

Expansion Joint Spacing

Expansion joints in copper gutters must be provided to allow for the natural expansion and contraction of copper caused by thermal changes. In general, long straight runs should have joints spaced a maximum of 48 feet apart. Expansion joints may also be required at changes in gutter width or depth, at corners and at end conditions. Based upon the desired joint spacing, designers should consult Table 10B to determine the required gauge of copper gutter, width of gutter bottom and angle of gutter sides.

Expansion Joint Table

Determination of gauge and expansion joint location for various sizes and shapes of copper "U" sections



SECTION

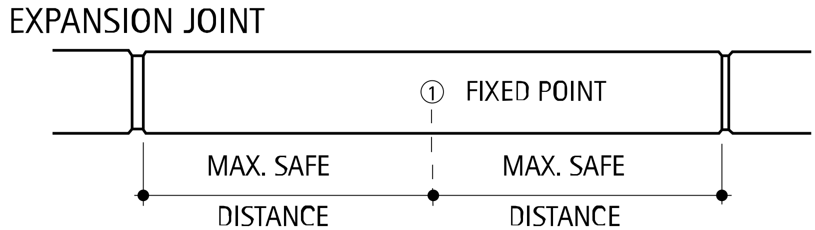


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Table 10B. Critical Load Table - Expansion Joint Table

Maximum Distance Between Fixed Point and Expansion Joint in Feet																
		Angle of Gutter Sides														
Weight of Cold Rolled Copper in Ounces	Width of Gutter Bottom in Inches	90° Max.-25° Min.	90° Max.-35° Min.	90° Max.-45° Min.	90° Max.-60° Min.	90° Max.-90° Min.	60° Max.-25° Min.	60° Max.-35° Min.	60° Max.-45° Min.	60° Max.-60° Min.	45° Max.-25° Min.	45° Max.-35° Min.	45° Max.-45° Min.	35° Max.-25° Min.	35° Max.-35° Min.	25° Max.-25° Min.
	4	19'- 6"	20'- 6"	21'- 6"	23'- 0"	26'- 0"	17'- 0"	18'- 0"	19'- 6"	20'- 6"	16'- 6"	17'- 0"	18'- 0"	13'- 6"	15'- 0"	12'- 0"
	6	16'- 6"	17'- 6"	18'- 6"	19'- 6"	21'- 6"	14'- 0"	15'- 0"	16'- 6"	17'- 6"	13'- 0"	14'- 0"	15'- 0"	11'- 6"	12'- 6"	10'- 6"
	8	14'- 0"	15'- 0"	16'- 0"	17'- 6"	19'- 0"	12'- 0"	13'- 0"	14'- 0"	15'- 0"	10'- 6"	12'- 0"	13'- 0"	9'- 6"	10'- 0"	8'- 6"
16	10	12'- 0"	13'- 0"	14'- 0"	15'- 0"	16'- 6"	10'- 0"	11'- 0"	12'- 0"	13'- 0"	9'- 0"	10'- 0"	11'- 0"	7'- 6"	8'- 0"	6'- 0"
	12	10'- 6"	11'- 6"	12'- 0"	13'- 6"	14'- 6"	9'- 0"	9'- 6"	10'- 6"	11'- 6"	8'- 0"	9'- 0"	10'- 0"	6'- 0"	7'- 0"	5'- 0"
	14	9'- 6"	10'- 0"	11'- 0"	12'- 0"	13'- 0"	7'- 6"	8'- 6"	9'- 6"	10'- 6"	6'- 6"	7'- 6"	8'- 6"			
	16	8'- 6"	9'- 0"	10'- 0"	11'- 0"	12'- 0"	7'- 0"	7'- 6"	8'- 6"	9'- 0"	6'- 0"	7'- 0"	7'- 6"			
	4	25'- 0"	27'- 0"	28'- 0"	30'- 6"	34'- 0"	22'- 0"	24'- 0"	25'- 0"	27'- 0"	20'- 0"	22'- 0"	24'- 0"	17'- 6"	19'- 6"	16'- 0"
	6	21'- 6"	23'- 0"	24'- 0"	26'- 0"	29'- 0"	18'- 6"	20'- 0"	21'- 6"	23'- 0"	17'- 0"	18'- 6"	20'- 0"	15'- 6"	17'- 6"	14'- 0"
	8	18'- 0"	19'- 6"	20'- 6"	22'- 0"	24'- 6"	15'- 6"	17'- 0"	18'- 0"	19'- 6"	14'- 0"	15'- 6"	17'- 0"	13'- 0"	14'- 6"	11'- 6"
	10	15'- 6"	17'- 0"	18'- 0"	19'- 6"	21'- 6"	13'- 6"	15'- 0"	15'- 6"	17'- 0"	12'- 6"	13'- 6"	15'- 0"	11'- 0"	12'- 6"	10'- 0"
20	12	14'- 0"	15'- 0"	16'- 6"	17'- 6"	19'- 6"	12'- 0"	13'- 6"	14'- 0"	15'- 0"	11'- 0"	12'- 0"	13'- 6"	10'- 0"	11'- 0"	8'- 6"
	14	12'- 6"	13'- 6"	14'- 6"	15'- 6"	17'- 6"	11'- 0"	12'- 0"	12'- 6"	13'- 6"	9'- 6"	11'- 0"	12'- 0"	9'- 0"	10'- 0"	8'- 0"
	16	11'- 6"	12'- 6"	13'- 6"	14'- 6"	16'- 0"	10'- 0"	11'- 0"	11'- 6"	12'- 6"	9'- 0"	10'- 0"	11'- 0"	8'- 0"	9'- 0"	7'- 0"
	18	10'- 6"	11'- 6"	12'- 6"	13'- 6"	14'- 6"	9'- 0"	10'- 0"	10'- 6"	11'- 6"	8'- 0"	9'- 0"	10'- 0"			
	20	10'- 0"	10'- 6"	11'- 6"	12'- 6"	14'- 0"	8'- 6"	9'- 0"	10'- 0"	10'- 6"	7'- 6"	8'- 6"	9'- 0"			
24	4	32'- 0"	34'- 0"	36'- 0"	38'- 6"	41'- 6"	28'- 0"	30'- 0"	32'- 0"	34'- 0"	25'- 6"	28'- 0"	30'- 0"	23'- 6"	26'- 0"	21'- 0"
	6	27'- 0"	29'- 0"	30'- 6"	33'- 0"	36'- 0"	24'- 0"	26'- 0"	27'- 0"	29'- 0"	22'- 0"	24'- 0"	26'- 0"	20'- 0"	22'- 0"	18'- 6"
	8	23'- 6"	25'- 0"	26'- 0"	28'- 0"	31'- 0"	20'- 0"	22'- 0"	23'- 6"	25'- 0"	18'- 6"	20'- 0"	22'- 0"	17'- 0"	19'- 0"	15'- 6"
	10	20'- 6"	22'- 0"	23'- 0"	25'- 0"	27'- 0"	18'- 0"	19'- 6"	20'- 6"	22'- 0"	16'- 6"	18'- 0"	19'- 6"	15'- 0"	16'- 6"	13'- 6"
	12	18'- 6"	20'- 0"	21'- 0"	22'- 6"	24'- 6"	16'- 0"	17'- 6"	18'- 6"	20'- 0"	14'- 6"	16'- 0"	17'- 6"	13'- 6"	15'- 0"	12'- 0"
	14	17'- 0"	18'- 6"	19'- 6"	20'- 6"	22'- 6"	14'- 6"	16'- 0"	17'- 0"	18'- 6"	13'- 6"	14'- 6"	16'- 0"	12'- 0"	13'- 6"	11'- 0"

Maximum Distance Between Fixed Point and Expansion Joint in Feet																
		Angle of Gutter Sides														
Weight of Cold Rolled Copper in Ounces	Width of Gutter Bottom in Inches	90° Max.- 25° Min.	90° Max.- 35° Min.	90° Max.- 45° Min.	90° Max.- 60° Min.	90° Max.- 90° Min.	60° Max.- 25° Min.	60° Max.- 35° Min.	60° Max.- 45° Min.	60° Max.- 60° Min.	45° Max.- 25° Min.	45° Max.- 35° Min.	45° Max.- 45° Min.	35° Max.- 25° Min.	35° Max.- 35° Min.	25° Max.- 25° Min.
	16	15'- 6"	16'- 6"	17'- 6"	19'- 0"	21'- 0"	13'- 6"	14'- 6"	15'- 6"	17'- 0"	12'- 6"	13'- 6"	14'- 6"	11'- 0"	12'- 6"	10'- 0"
	18	14'- 6"	15'- 6"	16'- 6"	18'- 0"	19'- 6"	12'- 6"	13'- 6"	14'- 6"	15'- 6"	11'- 6"	12'- 6"	13'- 6"	10'- 6"	11'- 6"	9'- 6"
	20	13'- 6"	14'- 6"	15'- 6"	16'- 6"	18'- 0"	11'- 6"	12'- 6"	13'- 6"	14'- 6"	10'- 6"	11'- 6"	12'- 6"	10'- 0"	10'- 6"	8'- 6"
	22	12'- 6"	13'- 6"	14'- 6"	15'- 6"	17'- 0"	11'- 0"	12'- 0"	12'- 6"	13'- 6"	10'- 0"	11'- 0"	12'- 0"			
	24	12'- 0"	13'- 0"	14'- 0"	15'- 0"	16'- 6"	10'- 6"	11'- 6"	12'- 0"	13'- 0"	9'- 6"	10'- 6"	11'- 6"			
32	6	46'- 0"	48'- 6"	51'- 0"	54'- 6"	59'- 6"	40'- 6"	43'- 0"	46'- 0"	48'- 6"	37'- 0"	40'- 6"	43'- 0"	36'- 0"	39'- 6"	33'- 6"
	8	41'- 0"	44'- 0"	46'- 0"	49'- 0"	53'- 6"	36'- 6"	39'- 0"	41'- 0"	44'- 0"	33'- 6"	36'- 6"	39'- 0"	31'- 0"	34'- 0"	28'- 6"
	10	36'- 6"	39'- 0"	40'- 6"	43'- 6"	47'- 6"	32'- 6"	34'- 6"	36'- 6"	39'- 0"	30'- 0"	32'- 6"	34'- 6"	27'- 6"	30'- 0"	25'- 0"
	12	33'- 6"	35'- 6"	37'- 6"	39'- 6"	43'- 0"	29'- 6"	31'- 6"	33'- 6"	35'- 6"	27'- 0"	29'- 6"	31'- 6"	25'- 6"	27'- 0"	23'- 0"
	14	30'- 6"	32'- 6"	34'- 6"	36'- 6"	40'- 0"	27'- 0"	29'- 0"	30'- 6"	32'- 6"	25'- 0"	27'- 0"	29'- 0"	23'- 0"	25'- 0"	21'- 0"
	16	28'- 6"	30'- 6"	32'- 0"	34'- 0"	37'- 0"	25'- 0"	27'- 0"	28'- 6"	30'- 6"	23'- 0"	25'- 0"	27'- 0"	21'- 0"	23'- 0"	19'- 6"
	18	27'- 0"	28'- 6"	30'- 0"	32'- 0"	35'- 0"	23'- 6"	25'- 6"	27'- 0"	28'- 6"	21'- 6"	23'- 6"	25'- 6"	20'- 0"	22'- 0"	18'- 0"
	20	25'- 6"	27'- 0"	28'- 0"	30'- 0"	33'- 0"	22'- 0"	24'- 0"	25'- 6"	27'- 0"	20'- 6"	22'- 0"	23'- 6"	19'- 0"	20'- 6"	17'- 6"
	22	24'- 0"	25'- 6"	27'- 0"	28'- 6"	31'- 6"	21'- 0"	22'- 6"	24'- 0"	25'- 6"	19'- 6"	21'- 0"	22'- 6"	18'- 0"	19'- 6"	16'- 6"
	24	23'- 0"	24'- 6"	25'- 6"	27'- 6"	30'- 0"	20'- 0"	21'- 6"	23'- 0"	24'- 6"	18'- 6"	20'- 0"	21'- 6"	17'- 0"	18'- 6"	15'- 6"
	26	22'- 0"	23'- 6"	24'- 6"	26'- 0"	28'- 6"	19'- 0"	20'- 6"	22'- 0"	23'- 6"	17'- 6"	19'- 0"	20'- 6"	16'- 6"	18'- 0"	15'- 0"
	28	21'- 0"	22'- 6"	23'- 6"	25'- 0"	27'- 6"	18'- 6"	20'- 0"	21'- 0"	22'- 6"	17'- 0"	18'- 6"	20'- 0"	16'- 0"	17'- 6"	14'- 6"

Design Area for Pitched Roofs

The roof area to be drained is a key factor in designing gutters and downspouts. The area of roof contributing runoff to each gutter and downspout should be determined. The maximum accumulation of rainfall occurs when it falls perpendicular to the roof plane. With flat roofs, it is a simple matter of calculating area, since the true roof area is equal to plan area.

When a roof is pitched, its plan area is less than its true area. However, using the true area in the calculations has typically resulted in oversized gutters, downspouts and drains. Table 10C shows the factors that should be used to determine the design area for pitched roofs. The plan roof area should be multiplied by this factor. The result is the design roof area that is used to calculate the required sizes of downspouts.

Table 10C. Area Factor for Pitched Roofs

Pitch, in/ft	B Area Factor
Level to 3	1.00
4 to 5	1.05
6 to 8	1.10
9 to 11	1.20
12	1.30

Downspout Sizing

Downspouts should have a cross-sectional area of at least 7 square inches, except for small areas such as porches and canopies. Their size should be constant throughout their length.

The design roof area is divided by the area of roof shown in Table 10A, column A2 or B2 (see discussion above), to give the minimum required area for each downspout. See Table 10.7A for standard downspout sizes.

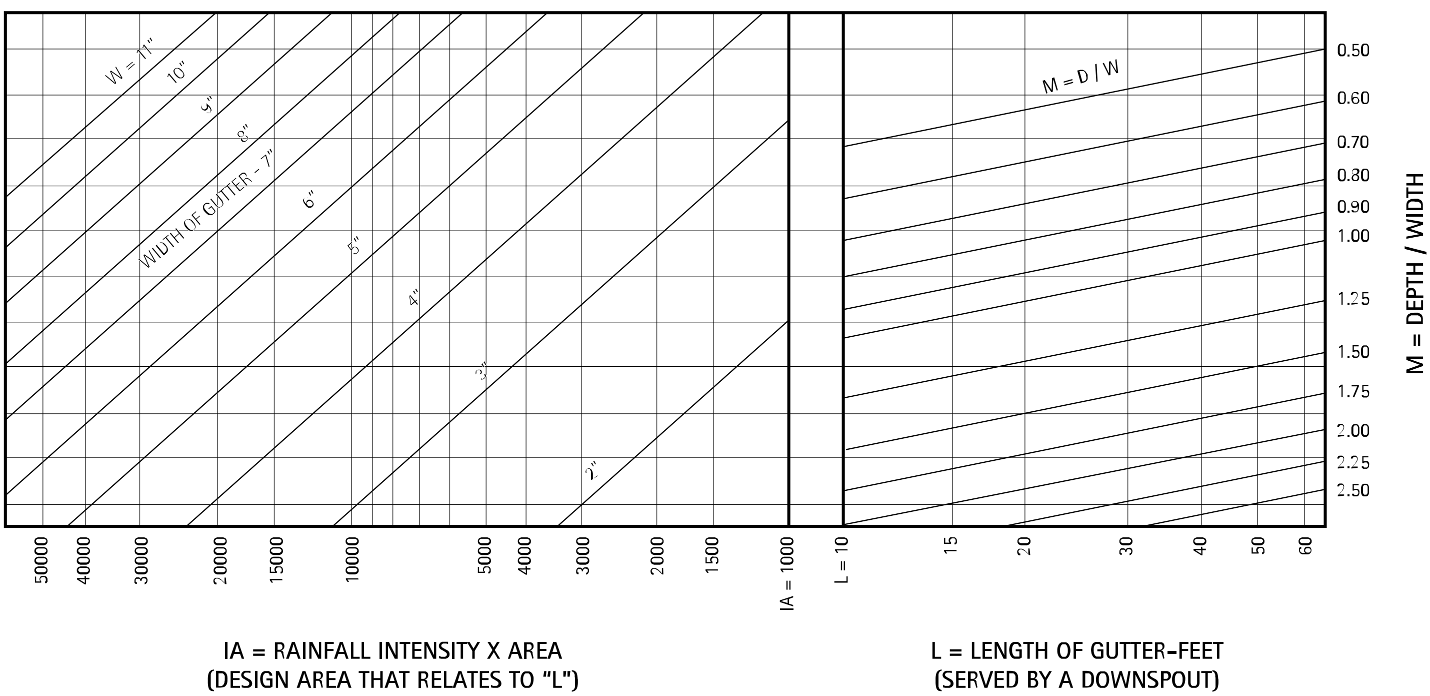
Gutter Sizing

The minimum required size of a gutter is related to the intensity of rainfall and the area of roof that drains into the gutter. The latter depends on the length of the gutter, which is related to locations of downspouts, expansion joints, and gutter ends.

Other factors considered in the design of gutters, include the size and spacing of outlets, the shape of the gutter, and the pitch of the roof. The gutter size must be capable of handling even fast moving water from a steep roof.

Table 10D is used to determine the required width and depth of a gutter. To do this, a ratio, M which equals the depth divided by the width, is initially assumed. Starting with the length of the gutter, L, follow a vertical line until the ratio, M, is reached. At this point follow a horizontal line to the left until the vertical line of rainfall intensity x design area, IA, is crossed. The required gutter width can be read from the diagonal lines. If the intersection lies between two lines, use the higher value. Finally, the width is multiplied by the ratio, M, to determine the depth.

Table 10D. Gutter Sizes for Given Roof Area and Rainfall Intensity



The size of gutters with an irregular shape can be determined by calculating the required size of a rectangular gutter which closely matches in profile and cross-sectional area, the irregularly shaped gutter.

Table 10E shows an example of the complete process.

Table 10E. Example Calculation

Select round downspouts and size rectangular gutters for a building in Chicago, Illinois. The building is 120' x 80' with a gable roof having a pitch of 5 in. per foot. The slope is toward the long side. Maximum rainfall conditions will be used to determine downspout size.

Downspout spacing is restricted by two factors: each downspout should drain no more than 50 feet of gutter; and gutter expansion joints should be spaced no more than 48 feet (see Hung Gutters). Three downspouts will be used on each side, with expansion joints in the gutters 40 feet from the ends. Each downspout therefore, will drain 40 feet of gutter.

Downspout Selection:

The roof plan area that is drained by each downspout is, PLAN AREA = 40' x 40' = 1600 SF

Given the Area Factor, B, in Table 10C, the design area is, DESIGN AREA = PLAN AREA x B = 1600 x 1.05 = 1680 SF

From Table 10A, column B2, the area drained per square inch of downspout is 130 SF. The minimum downspout size is, MIN. DOWNSPOUT AREA = 1680 / 130 = 12.9 SQ. IN.

From Table 10.7A, plain round 5" downspouts, with an area of 19.63 square inches, will be used.

Gutter Sizing:

The roof area that is drained by each gutter is, AREA = 40' x 40' = 1600 SF

From Table 10A, column B1, the rainfall intensity is, I = 9.3 in/hr.

Therefore, IA = 9.3 X 1600 = 14880

On Table 10D, draw a vertical line representing IA = 14880. Initially assume the gutter width ratio, M, is 0.75. On Table 10D, find the vertical line representing L = 40'. Follow the vertical line to its intersection with the oblique line representing M = 0.75. Follow a horizontal line to the left to the intersection with the vertical line drawn previously representing IA = 14880. This intersection occurs on the oblique line representing a gutter width of 7".

The gutter depth should be at least, MIN. GUTTER DEPTH = WIDTH x M = 7 x .75 = 5.25"