

APPENDIX E

SIZING OF WATER PIPING SYSTEM

E101 GENERAL

E101.1 Scope.

E101.1.1 This appendix outlines a procedure for sizing a water piping system. This design procedure is based on the minimum static pressure available from the supply source, the head charges in the system due to friction and elevation, and the rates of flow necessary for operation of various fixtures.

E101.1.2 Because of the variable conditions encountered in hydraulic design, it is impractical to specify definite and detailed rules for sizing of the water piping system. Accordingly, other sizing or design methods conforming to good engineering practice standards are acceptable alternates to that presented herein.

E102 INFORMATION REQUIRED

E102.1 Preliminary. Obtain the necessary information regarding the minimum daily static service pressure in the area where the building is to be located. If the building supply is to be metered, obtain information regarding friction loss relative to the rate of flow for meters in the range of sizes likely to be used. Friction loss data can be obtained from most manufacturers of water meters.

E102.2 Demand Load.

E102.2.1 Estimate the supply demand of the building main and the principal branches and risers of the system by totaling the corresponding demand from the applicable part of Table E102.

E102.2.2 Estimate continuous supply demands in gallons per minute for lawn sprinklers, air conditioners, etc., and add the sum to the total demand for fixtures. The result is the estimated supply demand for the building supply.

E103 SELECTION OF PIPE SIZE

E103.1 General. Decide what is the desirable minimum residual pressure that should be maintained at the highest fixture in the supply system. If the highest group of fixtures contains flush valves, the pressure for the group should not be less than 15 psi (103.4 kPa) flowing. For flush tank supplies, the available pressure may not be less than 8 psi (55.2 kPa) flowing, except blowout action fixtures may not be less than 25 psi (172.4 kPa) flowing.

E103.2 Pipe Sizing.

E103.2.1 Pipe sizes may be selected according to the following procedure, except that the sizes selected shall not be less than the minimum required by this code.

E103.2.2 This water pipe sizing procedure is based on a system of pressure requirements and losses, the sum of which must not exceed the minimum pressure available at the supply source. These pressures are as follows:

1. Pressure required at fixture to produce required flow. See Sections 604.3 and 604.5.
2. Static pressure loss or gain (due to head) is computed at 0.433 psi per foot (9.8 kPa/m) of elevation change.

Example: Assume that the highest fixture supply outlet is 20 feet (6.1 m) above or below the supply source. This produces a static pressure differential of 20 feet \times 0.433 psi/foot (6.1 m \times 9.8 kPa/m) and an 8.66 psi (59.8 kPa) loss.

3. Loss through water meter. The friction or pressure loss can be obtained from meter manufacturers.
4. Loss through taps in water main. See Table E103A.
5. Losses through special devices such as filters, softeners, backflow preventers and pressure regulators. These values must be obtained from the manufacturers.
6. Loss through valves and fittings, see Tables E103B and E103C. Losses for these items are calculated by converting to equivalent length of piping and adding to the total pipe length.
7. Loss due to pipe friction can be calculated when the pipe size, the pipe length and the flow through the pipe are known. With these three items, the friction loss can be determined using Figures E103A.1 through E103D. When using charts, use pipe inside diameter. For piping flow charts not included, use manufacturers' tables and velocity recommendations.

E103.3 Example.

Note: For the purposes of this example, the following metric conversions are applicable:

| | | |
|---------------|---|-----------------------|
| 1 cfm | = | 0.4719 L/s |
| 1 square foot | = | 0.0929 m ² |
| 1 degree | = | 0.0175 rad |
| 1 psi | = | 6.895 kPa |
| 1 inch | = | 25.4 mm |
| 1 foot | = | 304.8 mm |
| 1 gpm | = | 3.785 L/m |

APPENDIX E

Problem: What size copper water pipe, service and distribution will be required to serve a two-story factory building having on each floor, back-to-back, two toilet rooms each equipped with hot and cold water? The highest fixture is 21 feet above the street main, which is tapped with a 2-inch corporation cock at which point the minimum pressure is 55 psi. In the building basement, a 2-inch meter and 3-inch reduced pressure principle backflow preventer with a maximum pressure drop of 9 psi are to be installed. The system is shown by the Example Diagram. To be determined are the pipe sizes for the service main and the cold and hot water distribution pipes.

Solution: A Tabular Arrangement such as shown in Table E101A should first be constructed. The steps to be followed in solving the problem are indicated by the Tabular Arrangement itself as they are in sequence, columns 1 through 10 and lines a through l.

Step 1

Column 1: Divide the system into sections breaking at major changes in elevation or where branches lead to fixture groups. After point B (See Figure E103), separate consideration will be given to the hot and cold water piping. Enter the sections to be considered in the service and cold water piping in Column 1 of the Tabular Arrangement.

Column 3: According to the method given in E102.2, determine the gpm of flow to be expected in each section of the system. These flows range from 28.6 to 108 gpm.

Step 2

Line a: Enter the minimum pressure available at the main source of supply in Column 2. This is 55 psi.

Line b: Determine from Section 604.3 the highest pressure required for the fixtures on system, which is 15 psi, to operate a flushometer valve.

Line c: Determine the pressure loss for the meter size given or assumed. The total water flow from the main through the service as determined in Step 1 will serve to aid in the meter selected.

Line d: Select from Table E103A and enter the pressure loss for the tap size given or assumed.

Line e: Determine the difference in elevation between the main or source of supply and the highest fixture on the system and multiply this figure, expressed in feet, by 0.43 psi. Enter the resulting psi product on Line e.

Lines f, g and h: The pressure losses through filters, backflow preventers or other special fixtures must be obtained from the manufacturer or estimated and entered on these lines.

Step 3

Line i: The sum of the pressure requirements and losses that affect the overall system (Lines b through h) is entered on this line.

Step 4

Line j: Subtract Line i from Line a. This gives the pressure that remains available from overcoming friction losses in the system. This figure is a guide to the pipe size that is chosen for each section, as the total friction losses through the longest run of pipe.

Exception: When the main is above the highest fixture, the resulting psi must be considered a pressure gain (static head gain) and omitted from the sums of Lines b through h and added to Line j.

Step 5

Column 4: Enter the length of each section from the main to the end of the longest run (at Point E).

Step 6

Column 5: Select a trial pipe size. A rule of thumb is that size will become progressively smaller as the system extends farther from the main source of supply. Trial pipe size may be arrived at by the following formula:

$$\text{Psi} = j \times 100 / \text{Total pipe length}$$

Example: $\text{psi} = 9.36 \times 100 / 254 = 3.69$

From main to most remote outlet—check applicable graph for size for this psi and gpm.

Step 7

Column 6: Select from Table E103B or Table E103C the equivalent lengths for the trial pipe size of fittings and valves on the section. Enter the sum for each section in Column 6. (The number of fittings to be used in the installation of this piping must be an estimate.)

Step 8

Column 7: Add the figures from Column 4 and Column 6, and enter in Column 7. Express the sum in 100s of feet.

Step 9

Column 8: Select from the applicable figure (E103A.1 through E103D) the friction loss per 100 feet of pipe for the gpm flow in a section (Column 3) and trial pipe size (Column 5).

Step 10

Column 9: Multiply the figures in Columns 7 and 8 for each section and enter in Column 9.

Step 11

Line k: Enter the sum of the values in Column 9.




Step 12

Line l: Subtract Line k from Line j and enter in Column 10.

The result should always be a positive or plus figure. If it is not, it is necessary to repeat the operation using Columns 5, 6, 8 and 9 until a balance or near balance is obtained. If the

difference between Lines j and k is positive and large, it is an indication that the pipe sizes are too large and may, therefore, be reduced, thus saving materials. In such a case, the operations using Columns 5, 6, 8 and 9 should again be repeated.

Answer: The final figures entered in Column 5 become the design pipe size for the respective sections. Repeating this operation a second time using the same sketch but considering the demand for hot water, it is possible to size the hot water distribution piping. This has been worked up as a part of the overall problem in the Tabular Arrangement used for sizing the service and cold water distribution piping. It should be noted that consideration must be given the pressure losses from the street main to the water heater (Section AB) in determining the hot water pipe sizes.

HOT WATER
COLD WATER
M = METER
BFP = BACK FLOW PREVENTER
 = 90° ELBOW
 = "T"
 = VALVE

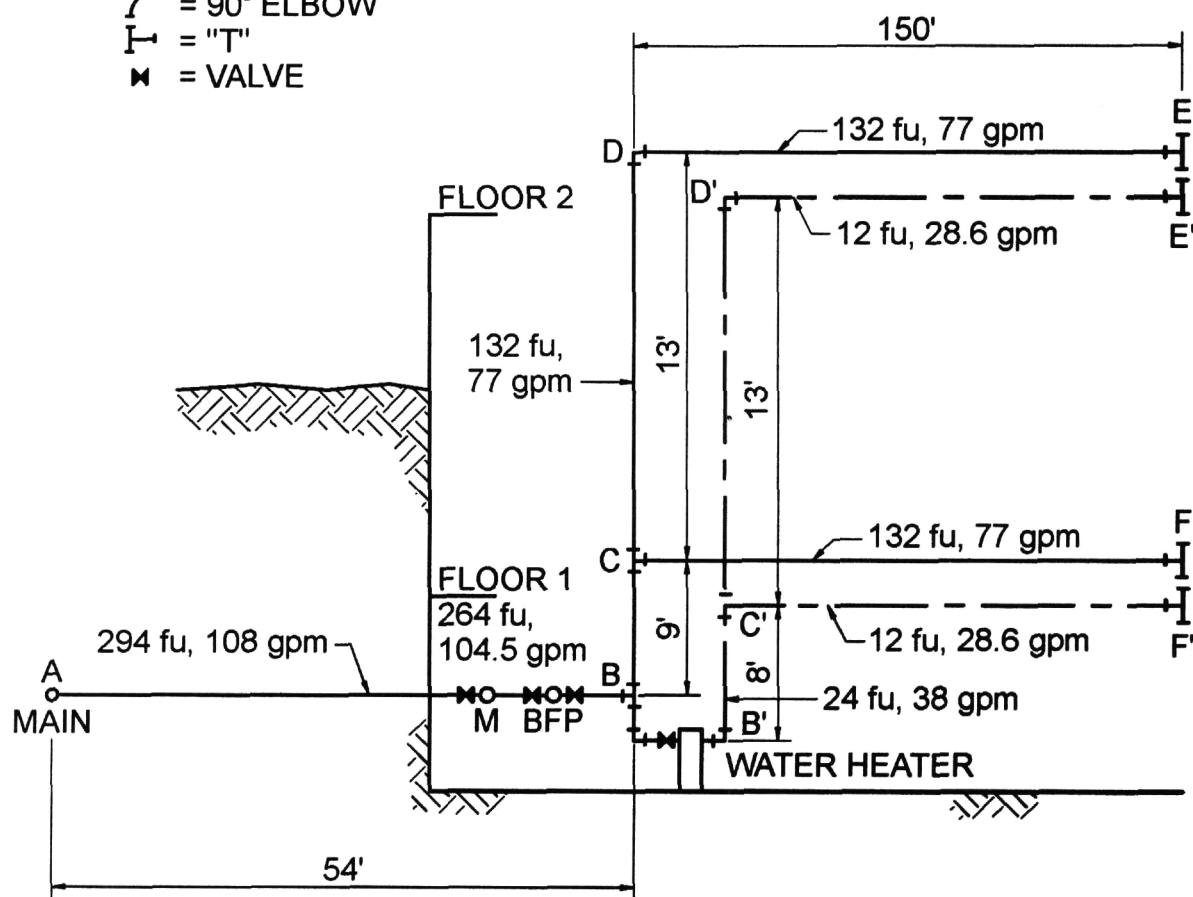


FIGURE E103
EXAMPLE—SIZING

For SI: 1 foot = 304.8 mm, 1 gpm = 3.785 L/m

TABLE E101A
RECOMMENDED TABULAR ARRANGEMENT FOR USE IN SOLVING PIPE SIZING PROBLEMS

| COLUMN | 1 | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--------|---|--|----------------------------|-------------------------------|--------------------------|--------------------------|---|--|---|--|--|
| Line | Description | | Lbs. per square inch (psi) | Gal. per min. through section | Length of section (feet) | Trial pipe size (inches) | Equivalent length of fittings and valves (feet) | Total equivalent length Col. 4 and Col. 6 (100 feet) | Friction loss per 100 feet of trial size pipe (psi) | Friction loss in equivalent length Col. 8 x Col. 7 (psi) | Excess pressure over friction losses (psi) |
| a | Service and cold water distribution piping ^a | Minimum pressure available at main..... | 55 | | | | | | | | |
| b | | Highest pressure required at a fixture (Section 604.3.....) | 15.00 | | | | | | | | |
| c | | Meter loss 2" meter | 11.00 | | | | | | | | |
| d | | Tap in main loss 2" tap (Table E103A).... | 1.61 | | | | | | | | |
| e | | Static head loss 21 x 0.43 psi | 9.03 | | | | | | | | |
| f | | Special fixture loss backflow preventer..... | 9.00 | | | | | | | | |
| g | | Special fixture loss—Filter..... | 0.00 | | | | | | | | |
| h | | Special fixture loss—Other | 0.00 | | | | | | | | |
| i | | Total overall losses and requirements (sum of Lines b through h) | 45.64 | | | | | | | | |
| j | | Pressure available to overcome pipe friction (Line a minus Lines b to h).... | 9.36 | | | | | | | | |
| | | FU | | | | | | | | | |
| | Designation | AB..... | 294 | 108.0 | 54 | 2 1/2 | 12 | 0.66 | 3.3 | 2.38 | |
| | Pipe section (from diagram) | BC..... | 264 | 108.0 | 7" | 2 1/2 | 2.5 | 0.105 | 3.2 | 0.34 | |
| | Cold water distribution | CD..... | 132 | 77.0 | 13 | 2 1/2 | 8 | 0.21 | 1.9 | 0.40 | |
| | piping | CF..... | 132 | 77.0 | 150 | 2 1/2 | 12 | 1.62 | 1.9 | 3.08 | |
| | | DE..... | 132 | 77.0 | 150 | 2 1/2 | 14.5 | 1.645 | 1.9 | 3.12 | |
| k | Total pipe friction losses (cold) | | | | | | | | 6.24 | | |
| l | Difference (Line j minus Line k) | | | | | | 9.36 | 6.24 | | | 3.12 |
| | Pipe section (from diagram) | A'B'..... | 294 | 108.0 | 54 | 2 1/2 | 9.6 | 0.64 | 3.3 | 2.1 | |
| | Hot water distribution | B'C'..... | 24 | 38.0 | 8 | 1 | 9.0 | 0.17 | 1.4 | 0.24 | |
| | piping | C'D'..... | 12 | 28.6 | 13 | 1 1/2 | 5 | 0.18 | 3.2 | 0.58 | |
| | | C'F ^b | 12 | 28.6 | 150 | 1 1/2 | 14 | 1.64 | 3.2 | 5.25 | |
| | | D'E ^b | 12 | 28.6 | 150 | 1 1/2 | 7 | 1.57 | 3.2 | 5.02 | |
| k | Total pipe friction losses (hot) | | | | | | | | 7.94 | | |
| l | Difference (Line j minus Line k) | | | | | | 9.36 | 7.94 | | | 1.42 |

For SI: 1 psi = 6.895 kPa, 1 gpm = 3.785 L/m, 1 foot = 304.8 mm, 1 inch = 25.4 mm.

^a To be considered as pressure gain for fixtures below main (to consider separately, omit from "i" and add to "j").

^b To consider separately, in k use C-F only if greater loss than above.

APPENDIX E

**TABLE E101B
LOAD VALUES ASSIGNED TO FIXTURES^a**

| FIXTURE | OCCUPANCY | TYPE OF SUPPLY CONTROL | LOAD VALUES, IN WATER SUPPLY FIXTURE UNITS (wsfu) | | |
|-------------------------|-------------------|------------------------|---|------|-------|
| | | | Cold | Hot | Total |
| Bathroom group | Private | Flush tank | 2.7 | 1.5 | 3.6 |
| Bathroom group | Private | Flush valve | 6.0 | 3.0 | 8.0 |
| Bathtub | Private | Faucet | 1.0 | 1.0 | 1.4 |
| Bathtub | Public | Faucet | 3.0 | 3.0 | 4.0 |
| Bidet | Private | Faucet | 1.5 | 1.5 | 2.0 |
| Combination fixture | Private | Faucet | 2.25 | 2.25 | 3.0 |
| Dishwashing machine | Private | Automatic | 1.4 | 1.4 | |
| Drinking fountain | Offices, etc. | 3/8" valve | 0.25 | 0.25 | |
| Kitchen sink | Private | Faucet | 1.0 | 1.0 | 1.4 |
| Kitchen sink | Hotel, restaurant | Faucet | 3.0 | 3.0 | 4.0 |
| Laundry trays (1 to 3) | Private | Faucet | 1.0 | 1.0 | 1.4 |
| Lavatory | Private | Faucet | 0.5 | 0.5 | 0.7 |
| Lavatory | Public | Faucet | 1.5 | 1.5 | 2.0 |
| Service sink | Offices, etc. | Faucet | 2.25 | 2.25 | 3.0 |
| Shower head | Public | Mixing valve | 3.0 | 3.0 | 4.0 |
| Shower head | Private | Mixing valve | 1.0 | 1.0 | 1.4 |
| Urinal | Public | 1" flush valve | 10.0 | 10.0 | |
| Urinal | Public | 3/4" flush valve | 5.0 | 5.0 | |
| Urinal | Public | Flush tank | 3.0 | 3.0 | |
| Washing machine (8 lb) | Private | Automatic | 1.0 | 1.0 | 1.4 |
| Washing machine (8 lb) | Public | Automatic | 2.25 | 2.25 | 3.0 |
| Washing machine (15 lb) | Public | Automatic | 3.0 | 3.0 | 4.0 |
| Water closet | Private | Flush valve | 6.0 | 6.0 | |
| Water closet | Private | Flush tank | 2.2 | 2.2 | |
| Water closet | Public | Flush valve | 10.0 | 10.0 | |
| Water closet | Public | Flush tank | 5.0 | 5.0 | |
| Water closet | Public or private | Flushometer tank | 2.0 | 2.0 | |

For SI: 1 inch = 25.4 mm.

^a For fixtures not listed, loads should be assumed by comparing the fixture to one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads and for total load, the separate hot and cold water loads being three-fourths of the total load for the fixture in each case.

TABLE E102
TABLE FOR ESTIMATING DEMAND

| SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS | | | SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH VALVES | | |
|--|----------------------|-------------------------|---|----------------------|-------------------------|
| Load | Demand | | Load | Demand | |
| (Water supply fixture units) | (Gallons per minute) | (Cubic feet per minute) | (Water supply fixture units) | (Gallons per minute) | (Cubic feet per minute) |
| 1 | 3.0 | 0.04104 | | | |
| 2 | 5.0 | 0.0684 | | | |
| 3 | 6.5 | 0.86892 | | | |
| 4 | 8.0 | 1.06944 | | | |
| 5 | 9.4 | 1.256592 | 5 | 15.0 | 2.0052 |
| 6 | 10.7 | 1.430376 | 6 | 17.4 | 2.326032 |
| 7 | 11.8 | 1.577424 | 7 | 19.8 | 2.646364 |
| 8 | 12.8 | 1.711104 | 8 | 22.2 | 2.967696 |
| 9 | 13.7 | 1.831416 | 9 | 24.6 | 3.288528 |
| 10 | 14.6 | 1.951728 | 10 | 27.0 | 3.60936 |
| 11 | 15.4 | 2.058672 | 11 | 27.8 | 3.716304 |
| 12 | 16.0 | 2.13888 | 12 | 28.6 | 3.823248 |
| 13 | 16.5 | 2.20572 | 13 | 29.4 | 3.930192 |
| 14 | 17.0 | 2.27256 | 14 | 30.2 | 4.037136 |
| 15 | 17.5 | 2.3394 | 15 | 31.0 | 4.14408 |
| 16 | 18.0 | 2.90624 | 16 | 31.8 | 4.241024 |
| 17 | 18.4 | 2.459712 | 17 | 32.6 | 4.357968 |
| 18 | 18.8 | 2.513184 | 18 | 33.4 | 4.464912 |
| 19 | 19.2 | 2.566656 | 19 | 34.2 | 4.571856 |
| 20 | 19.6 | 2.620128 | 20 | 35.0 | 4.6788 |
| 25 | 21.5 | 2.87412 | 25 | 38.0 | 5.07984 |
| 30 | 23.3 | 3.114744 | 30 | 42.0 | 5.61356 |
| 35 | 24.9 | 3.328632 | 35 | 44.0 | 5.88192 |
| 40 | 26.3 | 3.515784 | 40 | 46.0 | 6.14928 |
| 45 | 27.7 | 3.702936 | 45 | 48.0 | 6.41664 |
| 50 | 29.1 | 3.890088 | 50 | 50.0 | 6.684 |
| 60 | 32.0 | 4.27776 | 60 | 54.0 | 7.21872 |
| 70 | 35.0 | 4.6788 | 70 | 58.0 | 7.75344 |
| 80 | 38.0 | 5.07984 | 80 | 61.2 | 8.181216 |
| 90 | 41.0 | 5.48088 | 90 | 64.3 | 8.595624 |
| 100 | 43.5 | 5.81508 | 100 | 67.5 | 9.0234 |
| 120 | 48.0 | 6.41664 | 120 | 73.0 | 9.75864 |
| 140 | 52.5 | 7.0182 | 140 | 77.0 | 10.29336 |
| 160 | 57.0 | 7.61976 | 160 | 81.0 | 10.82808 |
| 180 | 61.0 | 8.15448 | 180 | 85.5 | 11.42964 |
| 200 | 65.0 | 8.6892 | 200 | 90.0 | 12.0312 |
| 225 | 70.0 | 9.3576 | 225 | 95.5 | 12.76644 |
| 250 | 75.0 | 10.0260 | 250 | 101.0 | 13.50168 |
| 275 | 80.0 | 10.6944 | 275 | 104.5 | 13.96956 |
| 300 | 85.0 | 11.3628 | 300 | 108.0 | 14.43744 |
| 400 | 105.0 | 14.0364 | 400 | 127.0 | 16.97736 |
| 500 | 124.0 | 16.57632 | 500 | 143.0 | 19.11624 |
| 750 | 170.0 | 22.7256 | 750 | 177.0 | 23.66136 |
| 1,000 | 208.0 | 27.80544 | 1,000 | 208.0 | 27.80544 |
| 1,250 | 239.0 | 31.94952 | 1,250 | 239.0 | 31.94952 |
| 1,500 | 269.0 | 35.95992 | 1,500 | 269.0 | 35.95992 |
| 1,750 | 297.0 | 39.70296 | 1,750 | 297.0 | 39.70296 |

(Continued)

APPENDIX E

TABLE E102
TABLE FOR ESTIMATING DEMAND—(Continued)

| SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH TANKS | | | SUPPLY SYSTEMS PREDOMINANTLY FOR FLUSH VALVES | | |
|--|----------------------|-------------------------|---|----------------------|-------------------------|
| Load | Demand | | Load | Demand | |
| (Water supply fixture units) | (Gallons per minute) | (Cubic feet per minute) | (Water supply fixture units) | (Gallons per minute) | (Cubic feet per minute) |
| 2,000 | 325.0 | 43.446 | 2,000 | 325.0 | 43.446 |
| 2,500 | 380.0 | 50.7984 | 2,500 | 380.0 | 50.7984 |
| 3,000 | 433.0 | 57.88344 | 3,000 | 433.0 | 57.88344 |
| 4,000 | 535.0 | 70.182 | 4,000 | 525.0 | 70.182 |
| 5,000 | 593.0 | 79.27224 | 5,000 | 593.0 | 79.27224 |

For SI: 1 gpm = 3.785 L/m, 1 cfm = 0.4719 L/s.

TABLE E103A
LOSS OF PRESSURE THROUGH TAPS AND TEES IN POUNDS PER SQUARE INCH (psi)

| GALLONS PER MINUTE | SIZE OF TAP OR TEE (inches) | | | | | | |
|--------------------|-----------------------------|------|-------|-------|-------|------|------|
| | 5/8 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 3 |
| 10 | 1.35 | 0.64 | 0.18 | 0.08 | | | |
| 20 | 5.38 | 2.54 | 0.77 | 0.31 | 0.14 | | |
| 30 | 12.1 | 5.72 | 1.62 | 0.69 | 0.33 | 0.10 | |
| 40 | | 10.2 | 3.07 | 1.23 | 0.58 | 0.18 | |
| 50 | | 15.9 | 4.49 | 1.92 | 0.91 | 0.28 | |
| 60 | | | 6.46 | 2.76 | 1.31 | 0.40 | |
| 70 | | | 8.79 | 3.76 | 1.78 | 0.55 | 0.10 |
| 80 | | | 11.5 | 4.90 | 2.32 | 0.72 | 0.13 |
| 90 | | | 14.5 | 6.21 | 2.94 | 0.91 | 0.16 |
| 100 | | | 17.94 | 7.67 | 3.63 | 1.12 | 0.21 |
| 120 | | | 25.8 | 11.0 | 5.23 | 1.61 | 0.30 |
| 140 | | | 35.2 | 15.0 | 7.12 | 2.20 | 0.41 |
| 150 | | | | 17.2 | 8.16 | 2.52 | 0.47 |
| 160 | | | | 19.6 | 9.30 | 2.92 | 0.54 |
| 180 | | | | 24.8 | 11.8 | 3.62 | 0.68 |
| 200 | | | | 30.7 | 14.5 | 4.48 | 0.84 |
| 225 | | | | 38.8 | 18.4 | 5.6 | 1.06 |
| 250 | | | | 47.9 | 22.7 | 7.00 | 1.31 |
| 275 | | | | | 27.4 | 7.70 | 1.59 |
| 300 | | | | | 32.6 | 10.1 | 1.88 |

For SI: 1 inch = 25.4 mm, 1 psi = 6.895 kPa, 1 gpm = 3.785 L/m.

TABLE E103B
ALLOWANCE IN EQUIVALENT LENGTH OF PIPE FOR FRICTION LOSS IN VALVES AND THREADED FITTINGS (feet)

| FITTING OR VALVE | PIPE SIZES (inches) | | | | | | | |
|--------------------|---------------------|------|------|-------|-------|------|-------|------|
| | 1/2 | 3/4 | 1 | 1 1/4 | 1 1/2 | 2 | 2 1/2 | 3 |
| 45-degree elbow | 1.2 | 1.5 | 1.8 | 2.4 | 3.0 | 4.0 | 5.0 | 6.0 |
| 90-degree elbow | 2.0 | 2.5 | 3.0 | 4.0 | 5.0 | 7.0 | 8.0 | 10.0 |
| Tee, run | 0.6 | 0.8 | 0.9 | 1.2 | 1.5 | 2.0 | 2.5 | 3.0 |
| Tee, branch | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 10.0 | 12.0 | 15.0 |
| Gate valve | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.3 | 1.6 | 2.0 |
| Balancing valve | 0.8 | 1.1 | 1.5 | 1.9 | 2.2 | 3.0 | 3.7 | 4.5 |
| Plug-type cock | 0.8 | 1.1 | 1.5 | 1.9 | 2.2 | 3.0 | 3.7 | 4.5 |
| Check valve, swing | 5.6 | 8.4 | 11.2 | 14.0 | 16.8 | 22.4 | 28.0 | 33.6 |
| Globe valve | 15.0 | 20.0 | 25.0 | 35.0 | 45.0 | 55.0 | 65.0 | 80.0 |
| Angle valve | 8.0 | 12.0 | 15.0 | 18.0 | 22.0 | 28.0 | 34.0 | 40.0 |

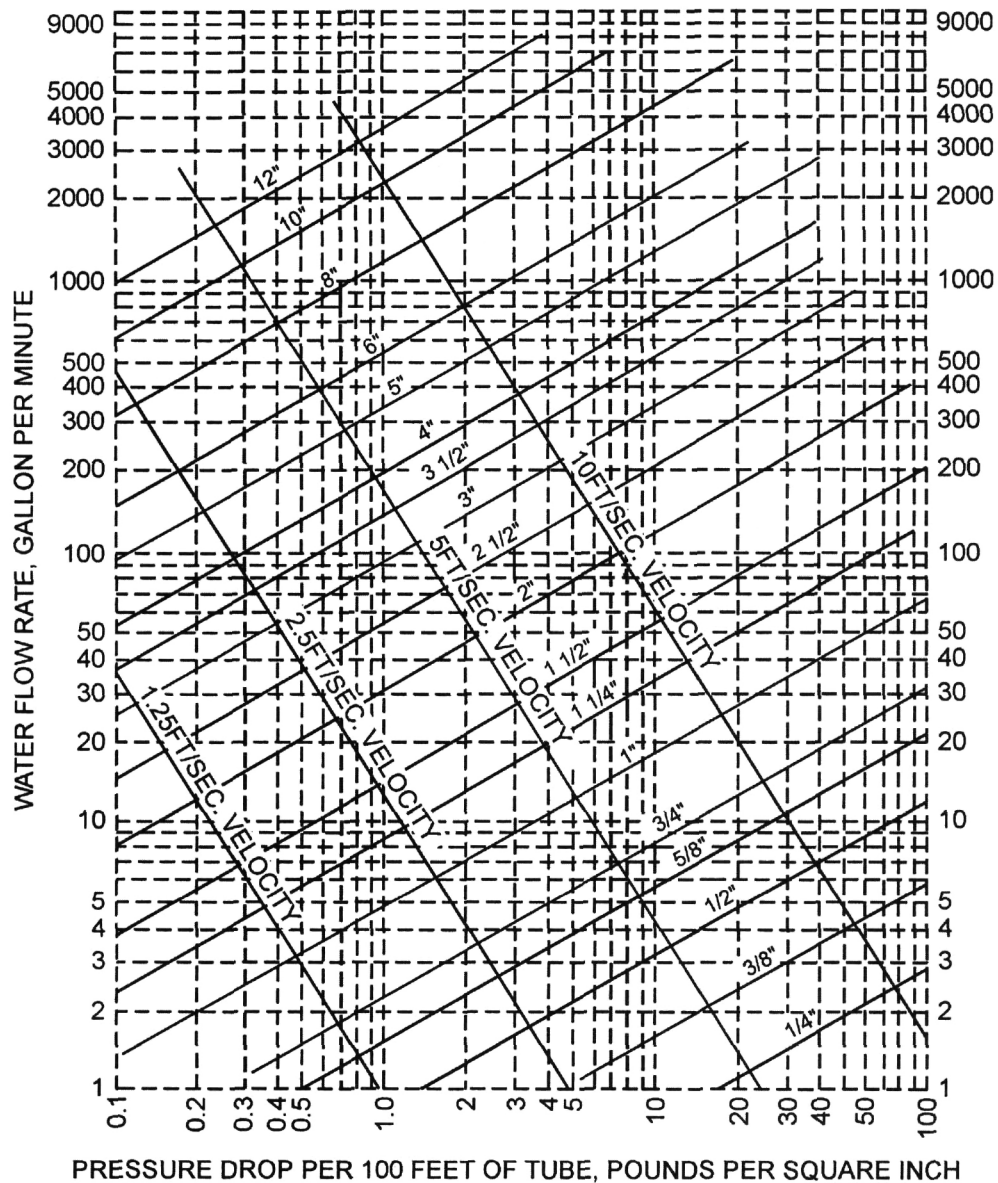
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

TABLE E103C
PRESSURE LOSS IN FITTINGS AND VALVES EXPRESSED AS EQUIVALENT LENGTH OF TUBE^a (feet)

| NOMINAL OR STANDARD SIZE (Inches) | FITTINGS | | | | | VALVE | | | |
|---|--------------|-----------|---------------|--------------|----------|-------|------|-----------|-------|
| | Standard Ell | | 90-Degree Tee | | Coupling | | | | |
| | 90 Degree | 45 Degree | Side Branch | Straight Run | | Ball | Gate | Butterfly | Check |
| 3/8 | 0.5 | — | 1.5 | — | — | — | — | — | 1.5 |
| 1/2 | 1 | 0.5 | 2 | — | — | — | — | — | 2 |
| 5/8 | 1.5 | 0.5 | 2 | — | — | — | — | — | 2.5 |
| 3/4 | 2 | 0.5 | 3 | — | — | — | — | — | 3 |
| 1 | 2.5 | 1 | 4.5 | — | — | 0.5 | — | — | 4.5 |
| 1 1/4 | 3 | 1 | 5.5 | 0.5 | 0.5 | 0.5 | — | — | 5.5 |
| 1 1/2 | 4 | 1.5 | 7 | 0.5 | 0.5 | 0.5 | — | — | 6.5 |
| 2 | 5.5 | 2 | 9 | 0.5 | 0.5 | 0.5 | 0.5 | 7.5 | 9 |
| 2 1/2 | 7 | 2.5 | 12 | 0.5 | 0.5 | — | 1 | 10 | 11.5 |
| 3 | 9 | 3.5 | 15 | 1 | 1 | — | 1.5 | 15.5 | 14.5 |
| 3 1/2 | 9 | 3.5 | 14 | 1 | 1 | — | 2 | — | 12.5 |
| 4 | 12.5 | 5 | 21 | 1 | 1 | — | 2 | 16 | 18.5 |
| 5 | 16 | 6 | 27 | 1.5 | 1.5 | — | 3 | 11.5 | 23.5 |
| 6 | 19 | 7 | 34 | 2 | 2 | — | 3.5 | 13.5 | 26.5 |
| 8 | 29 | 11 | 50 | 3 | 3 | — | 5 | 12.5 | 39 |

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

- a Allowances are for streamlined soldered fittings and recessed threaded fittings. For threaded fittings, double the allowances shown in the table. The equivalent lengths presented above are based on a C factor of 150 in the Hazen-Williams friction loss formula. The lengths shown are rounded to the nearest half foot.

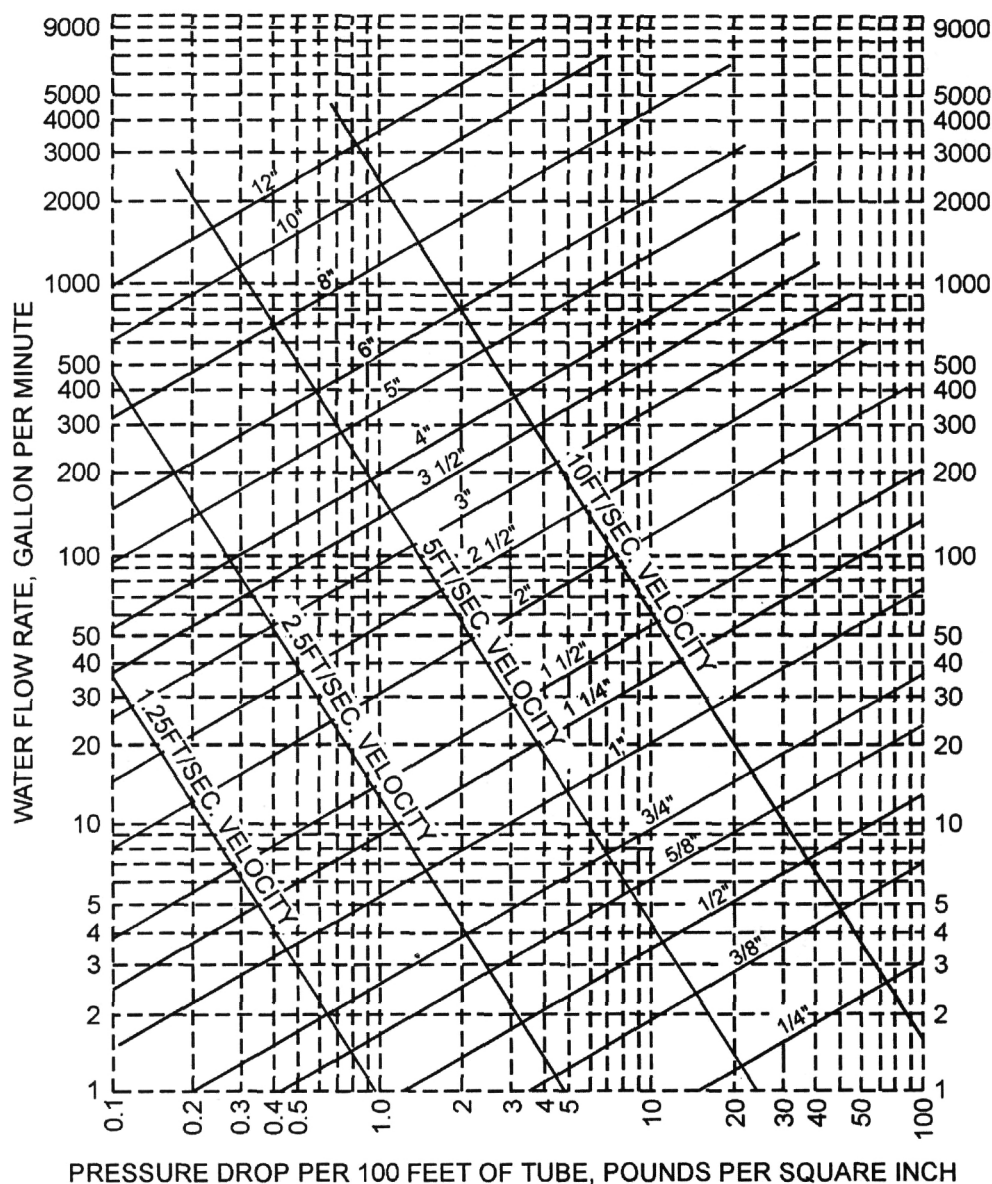


NOTE: FLUID VELOCITIES IN EXCESS OF 5 TO 8 FT/SEC. ARE NOT USUALLY RECOMMENDED

FIGURE E103A.1
FRICTION LOSS IN SMOOTH PIPE^a
(Type K, ASTM B 88 Copper Tubing)

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi = 6.895 kPa,
 1 foot per second = 0.305 m/s.

^a This chart applies to smooth new copper tubing with recessed (Streamline) soldered joints and to the actual sizes of types indicated on the diagram.

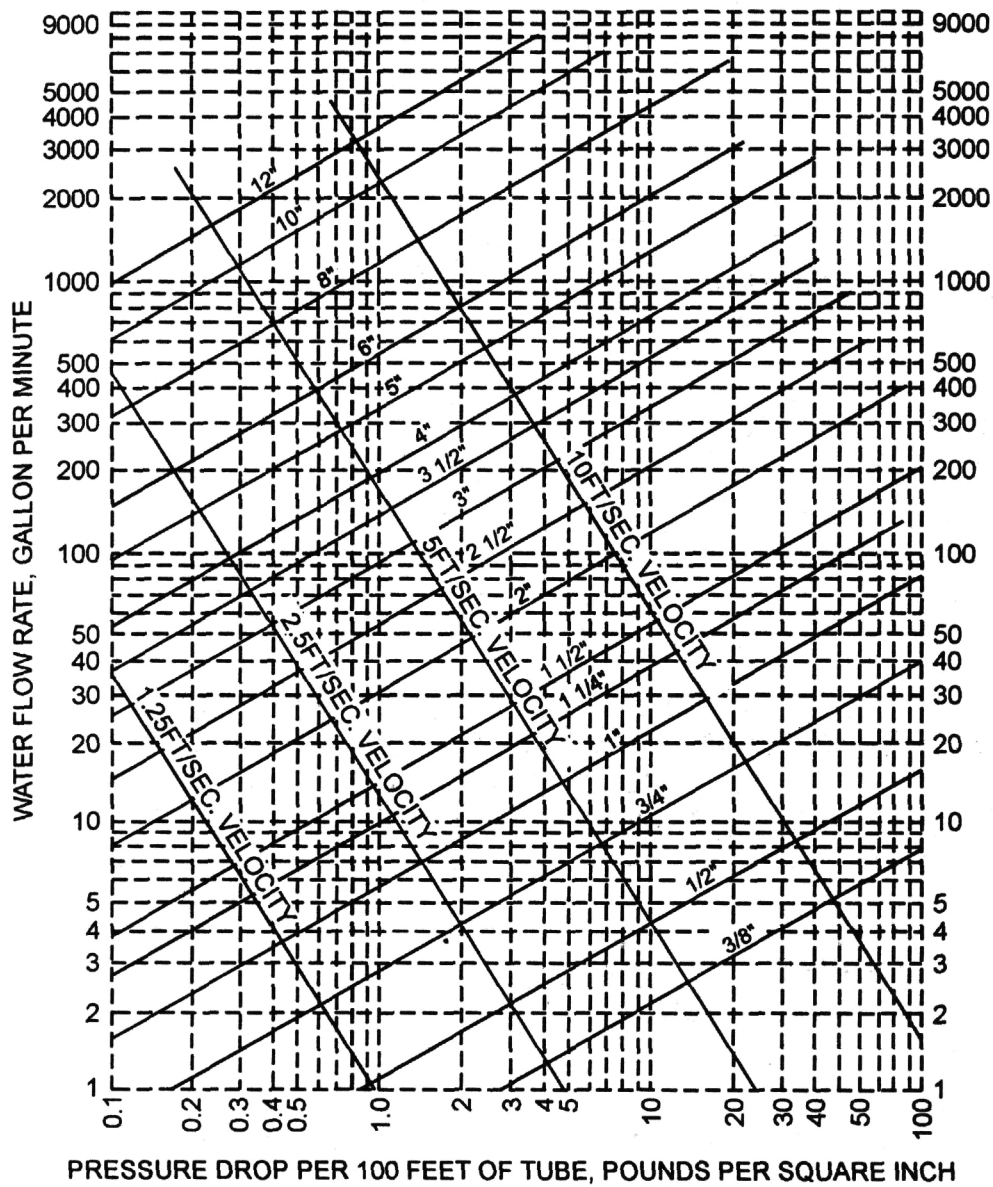


NOTE: FLUID VELOCITIES IN EXCESS OF 5 TO 8 FT/SEC. ARE NOT USUALLY RECOMMENDED

FIGURE E103A.2
FRICTION LOSS IN SMOOTH PIPE^a
(Type L, ASTM B 88 Copper Tubing)

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi = 6.895 kPa,
 1 foot per second = 0.305 m/s.

^a This chart applies to smooth new copper tubing with recessed (Streamline) soldered joints and to the actual sizes of types indicated on the diagram.



NOTE: FLUID VELOCITIES IN EXCESS OF 5 TO 8 FT/SEC. ARE NOT USUALLY RECOMMENDED

FIGURE E103A.3
FRICTION LOSS IN SMOOTH PIPE^a
(Type M, ASTM B 88 Copper Tubing)

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi = 6.895 kPa,
 1 foot per second = 0.305 m/s.

^a This chart applies to smooth new copper tubing with recessed (Streamline) soldered joints and to the actual sizes of types indicated on the diagram.

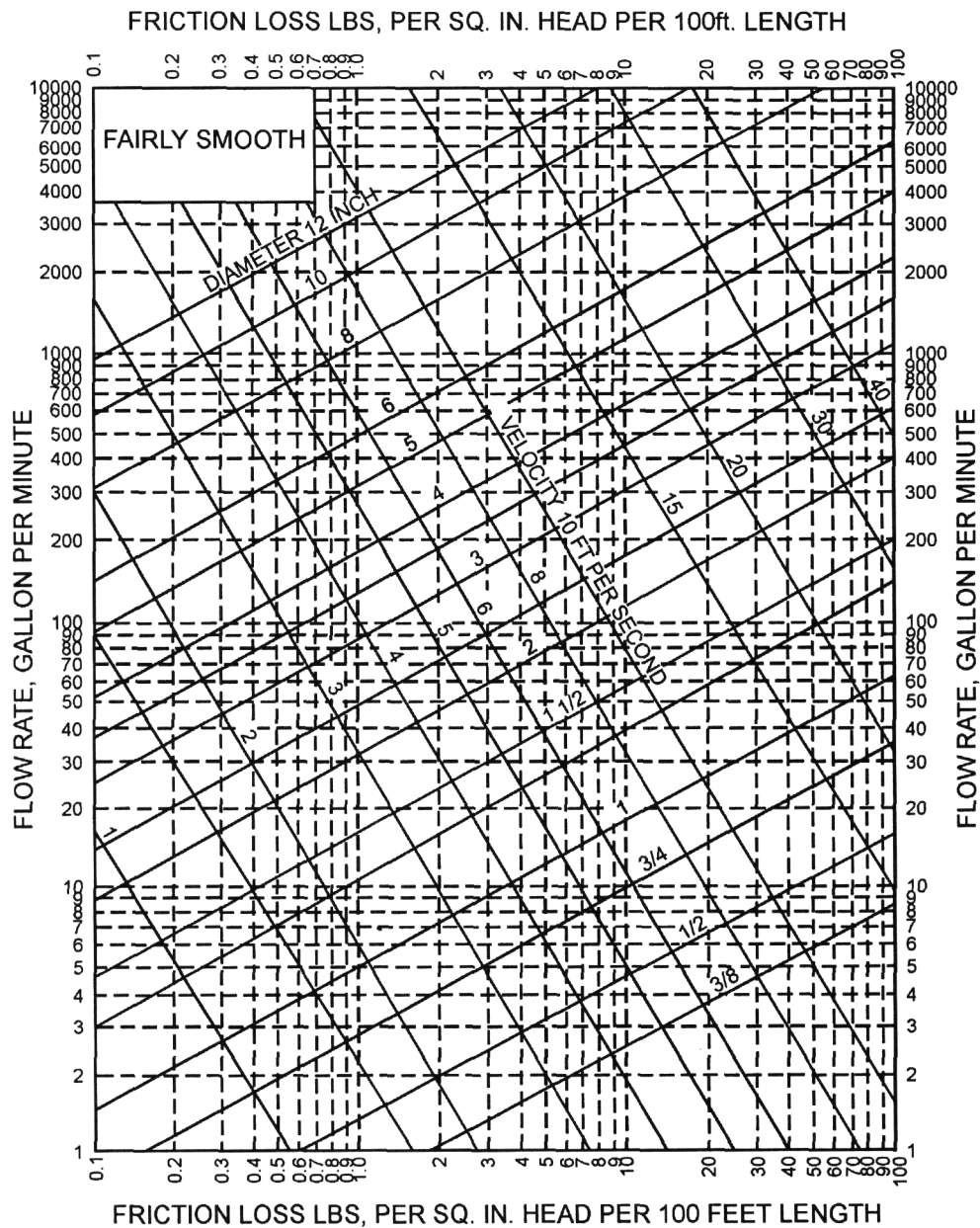


FIGURE E103B
FRICTION LOSS IN FAIRLY SMOOTH PIPE^a

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi head per 100-foot length = 2.26 kPa head per 10 m length, 1 foot per second = 0.305 m/s.

^a This chart applies to smooth new steel (fairly smooth) pipe and to actual diameters of standard-weight pipe.

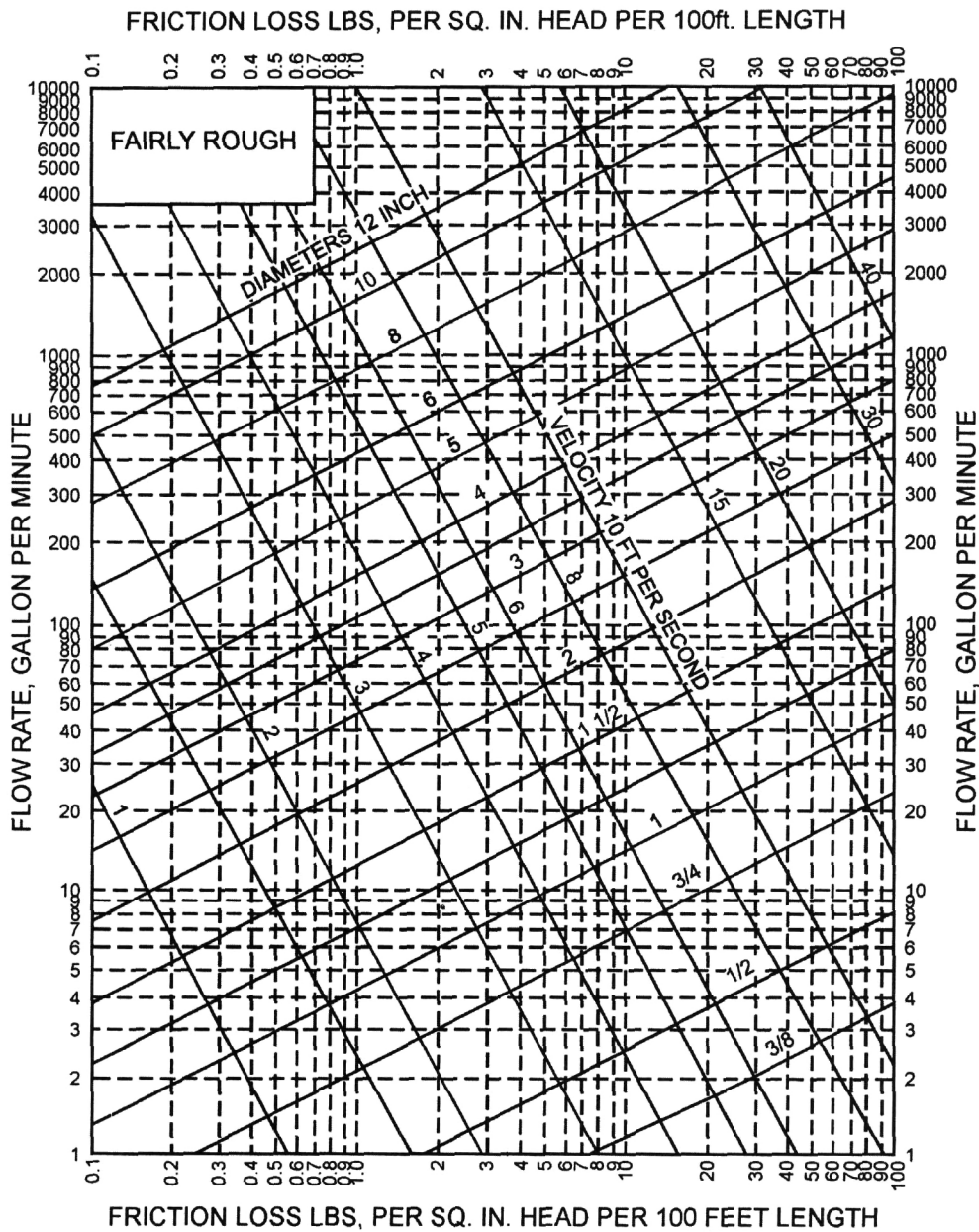


FIGURE E103C
FRICTION LOSS IN FAIRLY ROUGH PIPE^a

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi head per 100-foot length = 2.26 kPa head per 10 m length, 1 foot per second = 0.305 m/s.

^a This chart applies to fairly rough pipe and to actual diameters which in general will be less than the actual diameters of the new pipe of the same kind.

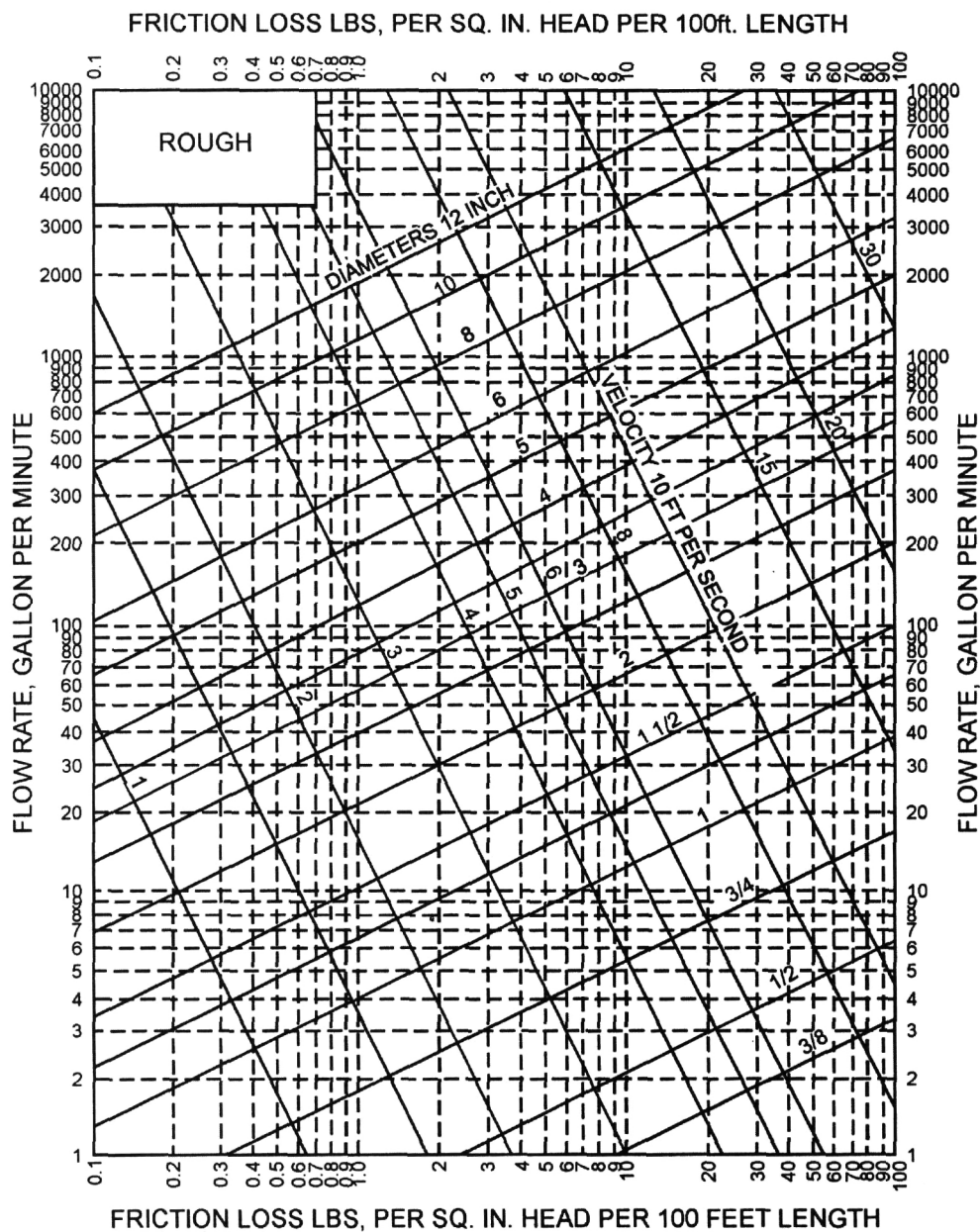


FIGURE E103D
FRICTION LOSS IN ROUGH PIPE^a

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 gpm = 3.785 L/m, 1 psi head per 100-foot length = 2.26 kPa head per 10 m length, 1 foot per second = 0.305 m/s.

^a This chart applies to very rough pipe and existing pipe and to their actual diameters.

