

connections and main risers except that the main riser will have its greatest diameter at the top. It will be seen that 35 ft. elevation will give the necessary 15 lb. pressure at the highest fixture and that the pressure drop may be made equal to the static head from the top fixtures down, or 40 lb. per 100.

#### FRICTION IN ELBOWS

Friction caused by elbows should be added to straight pipe friction. Each elbow in a line will add friction equal to a length of straight pipe forty times the diameter of the pipe:

|                                                   |     |     |     |    |     |     |    |      |      |
|---------------------------------------------------|-----|-----|-----|----|-----|-----|----|------|------|
| Pipe Size.....                                    | ¼   | 1   | 1¼  | 1½ | 2   | 2½  | 3  | 3½   | 4    |
| Equivalent length of<br>straight pipe in feet.... | 2.5 | 3.3 | 4.1 | 5  | 6.7 | 8.3 | 10 | 11.7 | 13.3 |

The water supply formula herewith makes it possible to accurately compute the flow of water in gallons through any pipe with any friction head and also gives formula for the additional head due to water entering the main, which, if extremely accurate calculations are necessary, should be added to the head required for friction; generally, however, this can be neglected as it is comparatively small.

#### WATER SUPPLY FORMULA

$CF$  = cubic feet per minute discharged.

$G$  = gallons per minute discharged.

$H$  = friction head of water in feet = pressure  $\times 2.31$ ; if water is raised vertically, deduct number of feet raised, from head due to pressure.

$L$  = length of pipe in feet—including horizontal and vertical runs.

$$CF = 0.16 \sqrt{\frac{(3d)^5 \times 3 H}{L}} \quad (1) \quad G = 1.2 \sqrt{\frac{(3d)^5 \times 3 H}{L}} \quad (2)$$

$$H = \frac{(CF)^2 \times L}{.0768 (3d)^5} \quad (3) \quad H = \frac{(G)^2 \times L}{4.32 (3d)^5} \quad (4)$$

The above formula neglects the head due to entry, which need not be computed except when  $L$  is very short.  $H_1$  = head due to entry in feet.

$$H_1 = \left( \frac{0.83 G}{d^2 \times 13} \right)^2 \text{ or } H_1 = \left( \frac{6.25 CF}{d^2 \times 13} \right)^2$$

**Example.**—Required the discharge of a 2 in. main with pressure 30 lb. 100 ft. horizontal run and 30 ft. vertical run.

$$H = 30 \times 2.31 - 30 = 39.3. \quad \text{Formula (2) } G = 1.2 \sqrt{\frac{(3 \times 2)^5 \times 3 \times 39.3}{100 + 30}} = 100.8$$

In the above case the head due to entry would be  $H_1 = \left( \frac{0.83 \times 100.8}{2 \times 2 \times 13} \right)^2 = 2.56$  ft.

Usually this can be neglected except for very close calculations.

#### HOT WATER SUPPLY

Tables 7, 8, 9, 10 and 11 give the hot-water requirements for several kinds of buildings in terms of gallons per maximum hour and per day.

Pipe sizes for hot-water systems may be calculated from the foregoing data on cold-water systems; using the same quantities for the gallons of hot water required per minute as is given for the cold water. It may be borne in mind that a column of hot water is lighter than one of cold water amounting to about 2½ ft. per 100 ft. in the height of columns of equal weight. In case the cold water must first be fed down from roof tanks to heaters in the basement and then back up to the top floor fixtures, the extra length of run must be taken into consideration. As a check on the total quantity of hot and cold water required per day it is well to know that this generally runs from 2 to 3 times the amount of hot water required and from 80 to 100 gal. per occupant of the building.

TABLE 7. HOT WATER REQUIREMENTS FOR APARTMENT BUILDINGS

| CLASS | HOT-WATER FIXTURES PER APARTMENT |           |                      |                  |                  |                     | GALLONS<br>HOT WATER<br>PER APARTMENT<br>PER MAXIMUM<br>HOUR |
|-------|----------------------------------|-----------|----------------------|------------------|------------------|---------------------|--------------------------------------------------------------|
|       | Lavatories                       | Bath Tubs | Showers<br>Over Tubs | Kitchen<br>Sinks | Laundry<br>Trays | Separate<br>Showers |                                                              |
| A     | 1                                | 1         | 1                    | 1                | 2                | 0                   | 25                                                           |
| A     | 2                                | 2         | 1                    | 1                | 2                | 0                   | 30                                                           |
| A     | 2                                | 2         | 2                    | 1                | 2                | 0                   | 35                                                           |
| A     | 2                                | 1         | 1                    | 1                | 2                | 1                   | 55                                                           |
| B     | 1                                | 1         | 0                    | 1                | 2                | 0                   | 20                                                           |
| C     | 1                                | 1         | 0                    | 1                | 1                | 0                   | 15                                                           |

*Note.*—The quantity of hot water required per day is usually about 10 times the maximum hour requirement.

TABLE 8. HOT WATER REQUIREMENTS FOR HOTELS

| CLASS                       | GALLONS                                      |                                             | ADD FOR KITCHENS<br>PER MEAL CAPACITY |                        | ADD FOR LAUNDRY      |                       |                                      |
|-----------------------------|----------------------------------------------|---------------------------------------------|---------------------------------------|------------------------|----------------------|-----------------------|--------------------------------------|
|                             | Hot Water<br>per H. W.<br>Fixture<br>per Day | Per H. W.<br>Fixture per<br>Maximum<br>Hour | Per Day                               | Per<br>Maximum<br>Hour | Per Piece<br>per Day | Per Washer<br>per Day | Per Washer<br>per<br>Maximum<br>Hour |
| High-class transient.....   | 85                                           | 6.8                                         | 3.0                                   | 1.0                    | 1.0                  | 1200                  | 250                                  |
| Medium-class transient..... | 70                                           | 6.5                                         | 2.5                                   | 0.80                   | 1.0                  | 1000                  | 200                                  |
| Apartment hotels.....       | 50                                           | 5.0                                         | 2.0                                   | 0.60                   | 1.0                  | 1000                  | 200                                  |

*Note.*—Instantaneous demand rate for laundry washers from 25 to 50 gal. per minute.

TABLE 9. HOT WATER REQUIREMENTS FOR OFFICE BUILDINGS

| CLASS                                                                    | HOT WATER PER HOT-WATER FIXTURE |                  |
|--------------------------------------------------------------------------|---------------------------------|------------------|
|                                                                          | Per Day                         | Per Maximum Hour |
| Having hot water in public toilets only.....                             | 50                              | 5.0              |
| Having hot water in private offices as well as in public<br>toilets..... | 30                              | 3.0              |
| For self-closing hot-water fixtures deduct.....                          | 40%                             | 25%              |