It is evident that any pipe size adequate to take care of the *probable flow* will also be more than ample to take care of the *average flow*, and hence the latter has no bearing on the pipe size.

## MAXIMUM FLOW

An estimate of maximum flow for various fixtures regardless of type of building with the water at about 35 lb pressure is given in Table 1.

To obtain the probable flow from Table 1, it is necessary to multiply the maximum flow by a factor of usage, and this factor varies with the

TABLE 1. APPROXIMATE MAXIMUM FLOW FROM FIXTURES UNDER NORMAL WATER PRESSURES

| FIXTURES | COLD WATER (GALLONS PER MINUTE) | HOT WATER (GALLONS PER MINUTE) |
|---|---|---|
| Water-closets, flush valve | 45[a] | 0 |
| Water-closets, flush tank | 10 | 0 |
| Urinals, flush valve | 30[a] | 0 |
| Urinals, flush tank | 10 | 0 |
| Urinals, automatic tank | 1 | 0 |
| Urinals, perforated pipe per foot | 10 | 0 |
| Lavatories | 3 | 3 |
| Showers, 4 in. heads, ½ in. inlets | 3 | 3 |
| Showers, 6 in. heads or larger | 6 | 6 |
| Needle bath | 30 | 30 |
| Shampoo spray | 1 | 1 |
| Liver spray | 2 | 2 |
| Manicure table | 1½ | 1½ |
| Baths, tub | 5 | 5 |
| Kitchen sink | 4 | 4 |
| Pantry sink, ordinary | 2 | 2 |
| Pantry sink, large bibb | 6 | 6 |
| Slop sinks | 6 | 6 |
| Wash trays | 3 | 3 |
| Laundry tray | 6 | 6 |
| Garden hose bibb | 10 | 0 |

[a]Actual tests on water-closet flush valves indicate 40 gpm as the maximum rate of flow with 30 lb pressure at the valve; this would increase to 60 gpm (about 50 per cent) at 90 lb pressure. The 45 gpm has been taken as an average flow; possibly, with very low pressures just sufficient to operate the flush valve, 30 gpm could be allowed with safety. Urinal flush valves would vary proportionately in the same manner.

type of occupancy and with the number of fixtures in the installation. With only two fixtures it is possible that both will at some time be in operation simultaneously. With 200 fixtures, however, it is unlikely that the entire 200 would ever operate at the same time. Consequently, the factor of usage becomes smaller as the number of fixtures becomes greater, all other things being equal.

The maximum flow per fixture for cold water should be totaled independently of that for hot water, and the sum of the two may be used in computing the probable flow through the incoming cold water supply main.

## FACTOR OF USAGE

The principal fixture subject to wide variation in water demand is a flush valve closet, though special consideration should also be given to





the demand of shower baths, especially in athletic clubs and in manufacturing plants where the outgoing shifts create a heavy peak.

The curves of Fig. 1 suggest a method of selecting a factor of usage. The curve at the left should be followed for hot water piping and for cold water if the system has gravity tank closets, while the curve to the right allows amply for the influence of flush valve closets.

If the product of the number of fixtures in a building multiplied by the proper values in Table 1 totals 620 gal of water as the maximum flow, using flush tank closets, the factor of usage from Fig. 1 will be about 23 per cent, and the probable flow will be $620 \times 0.23 = 143$ gpm. This is the first item to be determined in the design of a water supply system. In a building using 143 gpm no serious difference in the size of the main supply pipe would be occasioned by use of flush valves, since the factor of usage with the latter would be increased only to about 25 per cent or 155 gpm.

The curves of Fig. 1 are believed conservative for toilet rooms in large office buildings which have early business hour peaks, especially in the men's toilets, but may not be conservative enough for plants such as were mentioned previously where heavy peak demands occur during certain bathing hours. The proper usage percentage for such cases must be a matter of judgment and might properly approach 100 per cent. The average flow will usually be considerably smaller.

*Example 1.* Assume that in a normal building, such as a residential hotel or an apartment house, there are 50 flush valve water-closets, 50 lavatories, 50 sinks and 50 baths, and that it is desired to determine the probable flow in a line supplying all of these fixtures with both hot and cold water.

*Cold Water*

| | |
|---|---|
| 50 W. C. x 45 gpm | 2250 gpm |
| 50 Lavs. x 3 gpm | 150 gpm |
| 50 Sinks x 4 gpm | 200 gpm |
| 50 Baths x 5 gpm | 250 gpm |
| Maximum flow | 2850 gpm |

Fig. 1 shows a factor of usage of 9 per cent.

Probable flow of cold water is $2850 \times 0.09$ = 257 gpm

*Hot Water*

| | |
|---|---|
| 50 Lavs. x 3 gpm | 150 gpm |
| 50 Sinks x 4 gpm | 200 gpm |
| 50 Baths x 5 gpm | 250 gpm |
| Maximum flow | 600 gpm |

Fig. 1 shows a factor of usage of 23 per cent.

Probable flow of hot water is $600 \times 0.23$ = 138 gpm

Total for main supplying cold and hot water $(2850 + 600) \times 0.08$ = 276 gpm

It should be noted that this is a *rate of flow* or an *instantaneous demand*.

## WATER PRESSURE

The usual practice in buildings of moderate height is to place the water supply mains near the basement ceiling, with up-feed risers feeding the various fixtures on the superimposed stories. In tall buildings the pressure due to the weight of the water becomes so great as to limit the service to vertical sections not exceeding about 20 stories in height. Beyond this approximate limit the valves on the lower stories will be noisy and the piping should be extra strong.

For these reasons, the considerations of this chapter are limited to horizontal mains and to risers which serve not more than 20 stories. In taller buildings it is usual to install separate horizontal mains for each superimposed zone, served by extra strong main risers.