

TABLE 2. HEAT-CARRYING CAPACITY OF STANDARD BLACK PIPES  
WITH TEMPERATURE DROP OF 20 DEG<sup>a</sup>

Nominal Pipe Sizes  $\frac{3}{8}$  in. to 12 in., and Friction 4 to 800 milinches per foot (A = Capacity, Mbb. B = Velocity, inches per second) (One milinch equals 0.001 in.)

| MILINCH FRICTION LOSS PER FOOT OF PIPE |   | NOMINAL PIPE SIZE, INCHES |               |               |      |                 |                 |      |                 |      |                 |      |      |       |       |       |       |
|----------------------------------------|---|---------------------------|---------------|---------------|------|-----------------|-----------------|------|-----------------|------|-----------------|------|------|-------|-------|-------|-------|
|                                        |   | $\frac{3}{8}$             | $\frac{1}{2}$ | $\frac{3}{4}$ | 1    | 1 $\frac{1}{4}$ | 1 $\frac{1}{2}$ | 2    | 2 $\frac{1}{2}$ | 3    | 3 $\frac{1}{2}$ | 4    | 5    | 6     | 8     | 10    | 12    |
| 4                                      | A | 0.75                      | 1.35          | 2.85          | 5.4  | 11.3            | 17.0            | 33.0 | 53.1            | 95   | 141             | 197  | 363  | 596   | 1250  | 2320  | 3730  |
|                                        | B | 1.5                       | 1.7           | 2.1           | 2.4  | 2.9             | 3.2             | 3.8  | 4.3             | 5.0  | 5.5             | 6.0  | 7.0  | 7.9   | 9.6   | 11    | 12    |
| 6                                      | A | 0.9                       | 1.7           | 3.6           | 6.75 | 14.0            | 21.2            | 41.3 | 66.4            | 119  | 176             | 243  | 456  | 748   | 1570  | 2920  | 4690  |
|                                        | B | 1.8                       | 2.1           | 2.6           | 3.0  | 3.6             | 4.0             | 4.7  | 5.3             | 6.2  | 6.9             | 7.5  | 8.8  | 10    | 12    | 14    | 16    |
| 8                                      | A | 1.05                      | 2.0           | 4.2           | 7.9  | 16.4            | 24.8            | 48.4 | 77.9            | 140  | 207             | 291  | 535  | 879   | 1850  | 3440  | 5520  |
|                                        | B | 2.1                       | 2.5           | 3.0           | 3.5  | 4.2             | 4.7             | 5.6  | 6.3             | 7.3  | 8.0             | 8.8  | 10   | 12    | 14    | 17    | 19    |
| 10                                     | A | 1.2                       | 2.2           | 4.7           | 8.9  | 18.6            | 28.0            | 54.7 | 88.1            | 158  | 234             | 329  | 605  | 997   | 2100  | 3910  | 6270  |
|                                        | B | 2.4                       | 2.8           | 3.4           | 4.0  | 4.8             | 5.3             | 6.3  | 7.1             | 8.2  | 9.1             | 9.9  | 12   | 13    | 16    | 19    | 22    |
| 12                                     | A | 1.35                      | 2.45          | 5.2           | 9.8  | 20.5            | 31.0            | 60.4 | 97.4            | 175  | 259             | 364  | 671  | 1100  | 2320  | 4330  | 6950  |
|                                        | B | 2.7                       | 3.1           | 3.7           | 4.4  | 5.3             | 5.9             | 6.9  | 7.8             | 9.1  | 10              | 11   | 13   | 15    | 18    | 21    | 24    |
| 14                                     | A | 1.45                      | 2.65          | 5.65          | 10.7 | 22.3            | 33.7            | 65.8 | 106             | 190  | 282             | 397  | 731  | 1200  | 2530  | 4730  | 7560  |
|                                        | B | 2.9                       | 3.4           | 4.1           | 4.8  | 5.7             | 6.4             | 7.6  | 8.5             | 9.9  | 11              | 12   | 14   | 16    | 20    | 23    | 26    |
| 16                                     | A | 1.55                      | 2.85          | 6.05          | 11.5 | 24.0            | 36.3            | 70.8 | 114             | 205  | 303             | 428  | 787  | 1300  | 2730  | 5100  | 8190  |
|                                        | B | 3.1                       | 3.6           | 4.4           | 5.1  | 6.2             | 6.9             | 8.1  | 9.7             | 11   | 12              | 13   | 15   | 17    | 21    | 25    | 28    |
| 20                                     | A | 1.75                      | 3.25          | 6.85          | 13.0 | 27.1            | 41.0            | 80.0 | 129             | 232  | 344             | 484  | 892  | 1470  | 3100  | 5790  | 9300  |
|                                        | B | 3.5                       | 4.1           | 4.9           | 5.8  | 7.0             | 7.7             | 9.2  | 10              | 12   | 13              | 14   | 16   | 18    | 22    | 26    | 30    |
| 25                                     | A | 2.0                       | 3.65          | 7.75          | 14.7 | 30.6            | 46.3            | 90.5 | 146             | 263  | 389             | 548  | 1010 | 1670  | 3510  | 6570  | 10560 |
|                                        | B | 4.0                       | 4.6           | 5.6           | 6.5  | 7.9             | 8.8             | 10   | 12              | 14   | 15              | 17   | 19   | 22    | 27    | 32    | 36    |
| 30                                     | A | 2.2                       | 4.0           | 8.55          | 16.2 | 33.8            | 51.2            | 100  | 162             | 290  | 430             | 607  | 1120 | 1850  | 3900  | 7280  | 11710 |
|                                        | B | 4.4                       | 5.1           | 6.1           | 7.2  | 8.7             | 9.7             | 11   | 13              | 15   | 17              | 18   | 22   | 25    | 30    | 35    | 40    |
| 35                                     | A | 2.35                      | 4.4           | 9.3           | 17.6 | 36.8            | 55.7            | 109  | 176             | 316  | 469             | 661  | 1220 | 2010  | 4250  | 7940  | 12780 |
|                                        | B | 4.7                       | 5.6           | 6.7           | 7.9  | 9.5             | 11              | 13   | 14              | 16   | 18              | 20   | 23   | 27    | 33    | 39    | 44    |
| 40                                     | A | 2.55                      | 4.7           | 10.0          | 18.9 | 39.6            | 59.9            | 117  | 189             | 341  | 505             | 712  | 1320 | 2170  | 4580  | 8570  | 13780 |
|                                        | B | 5.1                       | 5.9           | 7.2           | 8.4  | 10              | 11              | 13   | 15              | 18   | 20              | 22   | 25   | 29    | 35    | 42    | 47    |
| 50                                     | A | 2.85                      | 5.3           | 11.3          | 21.4 | 44.7            | 67.7            | 133  | 214             | 386  | 572             | 807  | 1490 | 2460  | 5190  | 9720  | 15650 |
|                                        | B | 5.7                       | 6.7           | 8.1           | 9.6  | 12              | 13              | 15   | 17              | 20   | 22              | 24   | 29   | 33    | 40    | 47    | 54    |
| 60                                     | A | 3.15                      | 5.85          | 12.4          | 23.6 | 49.4            | 74.9            | 147  | 238             | 427  | 633             | 893  | 1650 | 2730  | 5760  | 10780 | 17360 |
|                                        | B | 6.3                       | 7.4           | 8.9           | 11   | 13              | 14              | 17   | 19              | 22   | 25              | 27   | 32   | 36    | 44    | 52    | 60    |
| 70                                     | A | 3.45                      | 6.35          | 13.5          | 25.7 | 53.8            | 81.4            | 160  | 258             | 465  | 690             | 973  | 1800 | 2970  | 6280  | 11760 | 18950 |
|                                        | B | 6.9                       | 8.0           | 9.7           | 11   | 14              | 15              | 18   | 21              | 24   | 27              | 29   | 35   | 40    | 48    | 57    | 65    |
| 80                                     | A | 3.7                       | 6.8           | 14.5          | 27.6 | 57.9            | 87.6            | 172  | 278             | 500  | 743             | 1050 | 1940 | 3200  | 6770  | 12690 | 20440 |
|                                        | B | 7.4                       | 8.6           | 10            | 12   | 15              | 17              | 20   | 22              | 26   | 29              | 32   | 37   | 43    | 52    | 62    | 70    |
| 100                                    | A | 4.15                      | 7.7           | 16.4          | 31.1 | 65.4            | 99.0            | 194  | 314             | 566  | 840             | 1190 | 2200 | 3630  | 7680  | 14400 | 23200 |
|                                        | B | 8.3                       | 9.7           | 12            | 14   | 17              | 19              | 22   | 25              | 30   | 33              | 36   | 42   | 48    | 59    | 70    | 80    |
| 150                                    | A | 5.2                       | 9.6           | 20.4          | 38.8 | 81.6            | 124             | 243  | 393             | 709  | 1050            | 1490 | 2760 | 4560  | 9650  | 18120 | 29220 |
|                                        | B | 10                        | 12            | 15            | 17   | 21              | 23              | 28   | 32              | 37   | 41              | 45   | 53   | 61    | 74    | 88    | 101   |
| 200                                    | A | 6.05                      | 11.2          | 23.9          | 45.4 | 95.5            | 145             | 285  | 461             | 832  | 1240            | 1750 | 3240 | 5360  | 11350 | 21320 | 34400 |
|                                        | B | 12                        | 14            | 17            | 20   | 25              | 27              | 33   | 37              | 43   | 48              | 53   | 62   | 71    | 87    | 104   | 118   |
| 300                                    | A | 7.5                       | 13.9          | 29.7          | 56.6 | 119             | 181             | 356  | 577             | 1040 | 1550            | 2190 | 4060 | 6730  | 14270 | 26830 | 43300 |
|                                        | B | 15                        | 18            | 21            | 25   | 31              | 34              | 41   | 46              | 54   | 60              | 66   | 78   | 90    | 110   | 131   | 149   |
| 400                                    | A | 8.75                      | 16.2          | 34.7          | 66.2 | 140             | 212             | 417  | 676             | 1220 | 1820            | 2570 | 4780 | 7910  | 16790 | 31580 | 51000 |
|                                        | B | 18                        | 21            | 26            | 30   | 36              | 40              | 48   | 54              | 64   | 71              | 78   | 92   | 105   | 129   | 154   | 175   |
| 500                                    | A | 9.85                      | 18.3          | 39.2          | 74.8 | 158             | 239             | 471  | 765             | 1380 | 2060            | 2910 | 5410 | 8970  | 19040 | 35840 | 57880 |
|                                        | B | 20                        | 23            | 29            | 33   | 41              | 45              | 54   | 62              | 72   | 80              | 88   | 104  | 119   | 147   | 174   | 199   |
| 600                                    | A | 10.9                      | 20.2          | 43.2          | 82.5 | 174             | 264             | 521  | 846             | 1530 | 2280            | 3220 | 5990 | 9930  | 21100 | 39740 | 64210 |
|                                        | B | 22                        | 26            | 32            | 37   | 45              | 50              | 60   | 68              | 80   | 89              | 97   | 115  | 132   | 162   | 193   | 221   |
| 800                                    | A | 12.7                      | 23.6          | 50.5          | 96.5 | 204             | 310             | 610  | 992             | 1790 | 2670            | 3780 | 7030 | 11670 | 24820 | 46780 | 75620 |
|                                        | B | 25                        | 30            | 37            | 43   | 52              | 59              | 70   | 80              | 94   | 104             | 114  | 135  | 155   | 191   | 228   | 260   |

<sup>a</sup> For other temperature drops the pipe capacities may be changed correspondingly. For example, with a temperature drop of 30 deg. the capacities shown in this table are to be multiplied by 1.5.

alent number of elbows of the same pipe size which would have the same friction loss. An elbow is assumed to have the same friction loss as a straight pipe having a length equal to 25 diameters (nominal) of the elbow.

The resistance of various types of fittings expressed in equivalent elbow resistance is shown in Table 1.

The friction loss in pipes and tubing may be determined from Fig. 2 and Table 2 for black iron pipes, and from Fig. 3 and Table 3 for type L copper tubing. The scale at bottom of Figs. 2 and 3 is the heat carrying capacity in thousands of Btu per hour based on a 20 deg temperature difference between flow and return risers. In order to use the scale for other than 20 deg difference, refer to footnote under Figs. 2 and 3.

If the flow in a given pipe is calculated in pounds per hour, it may be

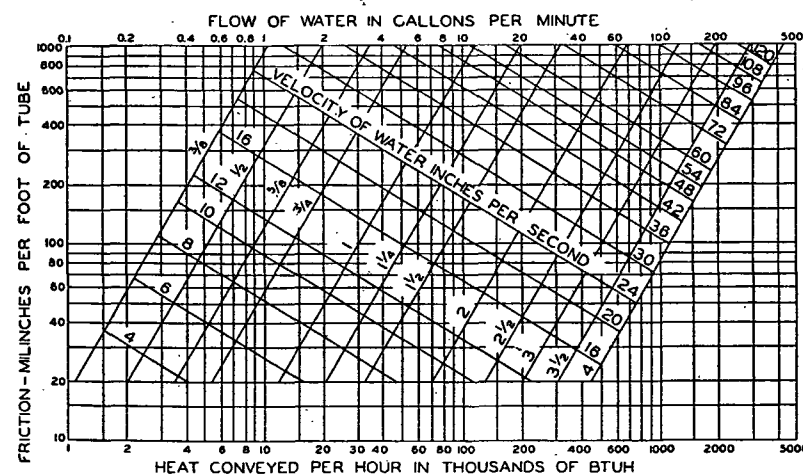


FIG. 3. FRICTION IN TYPE L COPPER TUBING

Lower scale of chart is based on 20 deg temperature difference between flow and return risers. To find friction when temperature drop is other than 20 deg, multiply the actual heat conveyed by  $\left(\frac{20}{\text{actual temp. drop}}\right)$  and read the corresponding friction.

converted to corresponding gallons per minute by dividing the flow in pounds by 500, after which the friction may be found by entering Figs. 2 and 3 at the top scale reading which corresponds to the flow in gallons per minute as determined.

Orifices drilled in plates inserted in pipe unions are convenient means for introducing friction, where required to balance various circuits. The friction losses caused by various sizes of orifices are given in Table 4.

### CLASSIFICATION OF SYSTEMS

Gravity or forced systems of piping may be classified according to piping arrangement and type of circulation as shown in Table 5. Flow and return main piping (gravity systems) for one-pipe, two-pipe direct return, and two-pipe reversed return systems are shown in Figs. 4, 5, and 6, re-