carrying one-half the total capacity of a 30-in. main with the same friction loss per foot would be 23.4 in. in diameter. By this method of equalizing friction it is unnecessary to consider the resistance of each section of pipe independently, but only to know the distance from the fan outlet to the end of the longest run of pipe, the number and size of elbows, and the diameter and velocity in the largest pipe.

*Example 5.* If the greatest length of piping in a system is 130 ft with a 26-in. diameter main pipe and one 20-in. elbow, the piping having been designed for equal friction per foot of length, the friction would be the same as for 130 linear feet of 26-in. pipe, or 60 diameters. To this should be added the friction loss in elbows, in this case one 20-in. elbow, which has a loss equivalent to 8.5 diameters of 20-in. pipe. This in turn is $\frac{20}{26} \times 8.5 = 6.6$ diameters of 26-in. pipe. The total equivalent length of the system will then be $60 + 6.6$, or 66.6 diameters. Since 50 diameters is equivalent to one velocity head, the loss is $\frac{66.6}{50} = 1.33$ times the velocity head. If the velocity is, for example, 2200 fpm, corresponding to 0.3-in. pressure, the friction loss of the system will be $1.33 \times 0.3 = 0.399$ in.

TABLE 4. SHEET METAL GAGES FOR RECTANGULAR DUCT CONSTRUCTION[a]

| Gage | Width of Duct | Seam | Reinforced Seam |
|---|---|---|---|
| 26 | Up to 12 in. | | |
| 24 | 13 in. to 30 in. | 1 | |
| 22 | 31 in. to 48 in. | 1 | |
| 22 | 49 in. to 60 in. | 1½ | ⅛ in. x 1⅜ in. |
| 20 | 61 in. to 90 in. | 1½ | ⅛ in. x 1⅜ in. |

[a]If panels are not cross-broken two gages heavier material should be used.

Frequently the prevention of sound in a heating or ventilating system imposes more severe restrictions than the prevention of excessive pressure drop. This question is highly involved and requires consideration of many factors. The air velocities to be used will vary with the standard of construction used in the ducts themselves as well as with the nature of the occupancy and the construction of the building. In general, architects and engineers who leave the details of duct construction to the contractor must, of necessity, design for lower velocities than might be required for quiet operation if proper construction details were always followed. The contractor may be expected to build the ducts by the least expensive methods, and the engineer must anticipate this. For further information on noise reduction, see Chapter 30.

## DUCT CONSTRUCTION DETAILS

If panel construction is used with standing seams or similar reinforcement, and the panels are cross-broken to give rigidity, there is less likelihood of vibration due to air flow, or deflection due to air pressure. Elbows made without splitters, and improperly shaped transformation sections produce high local velocities which are the cause of noise in duct work. The use of first-class duct construction with well-designed transformation sections and splitters in elbows tends to maintain relatively uniform velocities with decrease in turbulence and in the noise produced.





Figs. 8 to 12 show acceptable construction details for rectangular ducts, elbows, and transformation pieces or connections. Other methods are also acceptable, such as the use of angle iron stiffeners for large ducts. Good construction is essential to the elimination of duct noises and for the prevention of a flimsy installation.

Fig. 8 is an isometric view of a duct showing the location of the stiffening seams on the top and side panels. The cross seams should not occur at the same place but should be staggered as indicated. Heating units should be installed as shown in Fig. 10 with the duct connections making an angle of not less than 45 deg, but preferably 60 deg. Fan discharge connections should have a maximum slope of 1 in 7, as indicated in Fig. 12. Whenever a pipe or other obstruction passes through a duct an easement should be placed around the pipe as indicated in Fig. 11. The recommended gages for rectangular sheet metal duct construction are given in Table 4.

## REFERENCES

Fan Engineering, Buffalo Forge Co.

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## PROBLEMS IN PRACTICE

**1 ● Determine the equivalent number of diameters of straight pipe equivalent to a 90 deg elbow having center line radii of (a) 100 per cent, (b) 150 per cent, abd (c) 200 per cent of the pipe diameter.**

Assume 1 velocity head lost in 50 diameters.

From Fig. 1 the per cent of velocity head lost:

*a*. For 100 per cent radius is 25.5 per cent $\times$ 50 = 12.8 diameters straight pipe.
*b*. For 150 per cent radius is 17.0 per cent $\times$ 50 = 8.5 diameters straight pipe.
*c*. For 200 per cent radius is 14.5 per cent $\times$ 50 = 7.3 diameters straight pipe.

**2 ● Why is it desirable to make elbows with a radius equal to one and one-half times the pipe diameter?**

Reference to Figs. 1 and 2 will show that while the loss of velocity head, as indicated by the curves, shows considerable variation for elbows between the range of 50 and 150 per cent radius, the line is practically straight after 150 per cent, indicating very little variation in loss of head for elbows of larger radius.

**3 ● What is the best shape to use for ducts?**

The shapes to be used in designing ducts, in the order of their preference, are round, square, and rectangular.

**4 ● What determines which shape to use?**

Structural and space conditions. Because ducts are as a rule part of the building or structure, it is necessary to proportion their sizes to fit the spaces available.