at other values of tip speed, total pressure, and size may be approximated by the following relationships.

1. With total pressure and size constant.

$$db \text{ (change)} = 10 \operatorname{Log}_{10} \left[ \frac{(\text{Tip Speed})_{new}}{(\text{Tip Speed})_{old}} \right]^6 \quad (1)$$

2. With total pressure and tip speed constant.

$$db \text{ (change)} = 10 \operatorname{Log}_{10} \left( \frac{\text{Size}_{new}}{\text{Size}_{old}} \right)^2 \quad (2)$$

3. With size and tip speed constant.

$$db \text{ (change)} = f \text{ (Total Pressure}_{old} - \text{Total Pressure}_{new}) \quad (3)$$

The factor $f$ is a function of the fan type. For a centrifugal fan with backward curved blades $f = 9.6$. For a single inlet single width type of ventilating fan with backward curved blades, the noise level at the fan discharge or intake operating at 4000 fmp tip speed and total pressure of 1 in. may be approximately 65 db. The noise level of a double inlet width fan may be 3 db higher than a single width fan at similar conditions

Table 2. Attenuation in Straight Sheet Metal Duct Runs

| Duct | Size, In. | Attenuation per Ft, db |
|---|---|---|
| Small | 6 x 6 | 0.10 |
| Medium | 24 x 24 | 0.05 |
| Large | 72 x 72 | 0.01 |

Table 3. Attenuation of Elbows[a]

| Elbow | Size, In. | Attenuation per Elbow, db |
|---|---|---|
| Very small | 2 wide | 3 |
| Small | 3 to 15 | 2 |
| Medium | 15 to 36 | 1.5 |
| Large | 36 + | 1 |

[a]The attenuation in vaned elbows should be considered the same as in elbows having the same dimensions as the radius of curvature of the vanes. If the vanes are lined for the purpose of damping any vibrations in them, one third may be added to the above attenuation values.

Table 4. Attenuation at Duct Branches or Outlets

| Ratio: (Branch Duct + Outlet Area) / Supply Duct Area or Sum of Branch Areas / Supply Duct Area | Attenuation per Transformation, db |
|---|---|
| 1.00 | 0.0 |
| 1.20 | 0.8 |
| 1.35 | 1.3 |
| 1.50 | 1.8 |
| 1.75 | 2.5 |
| 2.00 | 3.0 |





Table 5. Approximate Attenuation Between Grilles and Room

| Outlet Velocity fpm | Air Change Min. | Live Room[b] $\alpha^a = 0.05$ db | Medium Room[c] $\alpha = 0.15$ db | Dead Room[d] $\alpha = 0.25$ db |
|---|---|---|---|---|
| 500 | 5 | 11 | 16 | 18 |
| | 10 | 14 | 19 | 21 |
| | 15 | 16 | 21 | 23 |
| | 20 | 17 | 22 | 24 |
| 750 | 5 | 13 | 18 | 20 |
| | 10 | 16 | 21 | 23 |
| | 15 | 18 | 23 | 25 |
| | 20 | 19 | 24 | 26 |
| 1000 | 5 | 14 | 19 | 21 |
| | 10 | 17 | 22 | 24 |
| | 15 | 19 | 24 | 26 |
| | 20 | 20 | 25 | 28 |
| 1250 | 5 | 15 | 20 | 22 |
| | 10 | 18 | 23 | 25 |
| | 15 | 20 | 25 | 27 |
| | 20 | 21 | 26 | 28 |

[a]Alpha ($\alpha$) is the average absorption coefficient for the room.
[b]Live room average absorption coefficient 0.05. Bare wood or concrete floor—hard plaster walls and ceiling—minimum of furniture.
[c]Medium room average absorption coefficient 0.15. Carpeted floor, upholstered furniture, hard plaster walls and ceiling or bare room with acoustically treated ceiling.
[d]Dead room average absorption coefficient 0.25. Heavy carpeted floor. Walls and ceiling acoustically treated. Upholstered furniture.

of tip speed, total pressure, and size. For the same tip speed and size the noise level of a fan with forward curved blades is higher than for one with backward curved blades, however, the capacity of the fan with the forward curved blades will be greater.

## NATURAL ATTENUATION IN THE DUCT SYSTEM

The natural attenuation existing in a duct system consists of three component parts which are described herewith.

### Straight Sheet Metal Ducts

The attenuation of sound in straight sheet metal ducts is a function of the length, shape, and size of the duct. Attenuation values are given in Table 2. In general, this attenuation is so negligible except for long runs that it may be neglected for all practical purposes.

### Elbows and Transformations

Due to reflective interference, attenuation will take place at elbows and transformations. The magnitude of the attenuation will depend on the size and abruptness of the elbow or transformation as shown in Table 3.

When the area of a duct increases, an attenuation of noise level takes place in the duct. In duct design practice the total area of the branch ducts is greater than the supply duct. Similarly with outlets, the area of the outlet plus the area of the duct after the outlet is greater than the