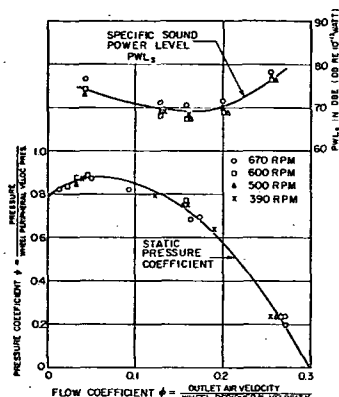




These data are for a particular fan. The quantities ψ_s , ϕ , and PWL_s are discussed in the text. Such curves apply to all fans in a similar series.

Fig. 5. . . . Specific Fan Characteristic Curves, including Specific Sound Power Level

$$\psi_s = \frac{p_s}{\left[\frac{(\pi)(D)(rpm)}{4005} \right]^2} = \frac{\text{static pressure}}{\left(\frac{\text{wheel peripheral velocity pressure}}{\text{velocity pressure}} \right)} \quad (16)$$

$$\phi = \frac{(cfm)/(\text{Outlet Area})}{(\pi)(D)(rpm)} = \frac{\text{outlet velocity}}{\text{wheel peripheral velocity}} \quad (17)$$

where

D = wheel diameter, feet.
 p_s = static pressure.
 p_t = total pressure.

Such curves apply to all fans in a similar series, i.e., a series of fans differing in size only while preserving complete similarity in shape by having all linear dimensions changed in the same proportions.

An overall specific sound power level PWL_s , in db as shown in Fig. 5 can also be defined that will be applicable to all fans in a family.⁷ It is obtained by means of Equation 18 which follows:

$$PWL_s = PWL - 10 \log_{10} [q \cdot p] \text{ db} \quad (18)$$

where

q = quantity of air discharged, cfm.
 p = pressure, inches of water.
 PWL = sound power level actually measured.

Since static pressure p_s is more frequently measured for fans than total pressure p_t , p_s may be used under most normal operating conditions (when the difference between p_s and p_t is less than 20 percent) and the error will then be less than 1 db. Near free discharge, p_s becomes zero and p_t must be used. In other words, PWL_s is the sound power level that a similar (although hypothetical) fan would produce when operating at 1 cfm and a total pressure of 1 in. of water. As an example, the specific power level for one fan tested is shown on Fig. 5.

Although few data are available to confirm the conclusion, it is indicated that such a plot also holds throughout a series of fans for all eight of the frequency bands provided rotor or blade passage frequencies are not predominant.

Approximate Overall Sound Power Level

In practice, data of the type shown in Fig. 5 are usually not available. Hence, in design an estimate has to be made of the overall sound power level and of the shape of the noise spectrum. Tests on centrifugal fans ranging in size from 0.01 hp to 100 hp show that the sound power level in a duct either upstream or downstream from the fan can be found within ± 4 db from the simple relation:^{8, 10}

$$PWL = 100 + 10 \log_{10} W_s + 10 \log_{10} p \text{ db} \quad (19)$$

where

W_s = nameplate electrical horsepower of the motor driving fan (assuming that the motor is operating near rated hp).

p = pressure head, inches of water.

db = number of decibels re 10^{-12} watt.

(See discussion following Equation 18.)

The assumption is made that the fan is being operated near the knee on its operating characteristics, i.e., near maximum efficiency or near the minimum in the curve of specific sound power (upper curve on Fig. 5).

By assuming a fan mechanical efficiency of 50 percent, Equation 19 can be put in the form of Equation 18 with $PWL_s = 65$ db, i.e.,

$$PWL = 65 + 10 \log_{10} q + 20 \log_{10} p \text{ db} \quad (20)$$

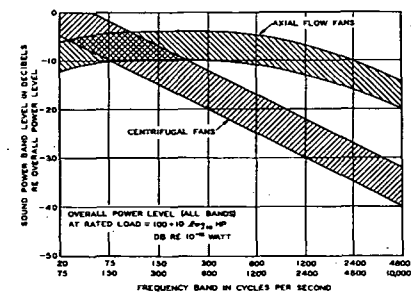
where

q = air quantity, cfm.

p = pressure head, inches of water.

(See discussion after Equation 18.)

It should be emphasized that Equations 19 and 20 are intended to be used only when actual noise data are not available.



The overall power level is first determined from Equation 19 or 20 and is added algebraically to the ordinate in Fig. 6. Acoustics by L. L. Beranek (McGraw-Hill, 1954 Second Printing). Used by permission.

Fig. 6. . . . Chart for Determining the Sound Power Band Levels for Ventilating Fans of Two Types

ble. All fans of the same power input are not equally noisy. The example illustrated in Fig. 5 demonstrates this fact since the minimum value of PWL_s for this particular fan is 69 db, 4 db higher than the value used in Equation 20. It is on the edge of the stated limit of approximation ± 4 db.

Approximate Octave Band Spectrum

Within about ± 4 db approximation, and assuming no turbulence in the duct or the coupling between it and the fan, the octave band spectrum for a centrifugal fan, relative to the overall sound power level, is given in Fig. 6.

Limited data on vane-axial fans,¹¹ where sound pressure level measurements were made in the discharge duct, indicate that the overall sound power level is about the same as that for centrifugal fans. However, the spectrum shape of the vane-axial fan noise has a shape something like that shown in Fig. 6.

More recent free field measurements on axial fans indicate that perhaps the drop in level at the high and low ends of the spectrum are more pronounced.⁸ The solid line in Fig. 7 is typical of the sound power spectrum for the axial fans reported, as taken directly from the free field measurements. Application of a correction for the end reflection losses from the discharge opening (see Fig. 11) gives the dashed curve in Fig. 7, which corresponds to the relative sound power level in the duct. This spectrum shape for the axial fan appears to be based on more extensive data than those of Fig. 6.

NOISE GENERATED BY GRILLES AND DIFFUSERS

Grille Noise

The subject of grille noise has not been covered thoroughly in the literature. The information given in this chapter has been taken from the advertising literature of several grille manufacturers and from recent experiments at the Massachusetts Institute of Technology.

In general, grille noise at the lower frequencies is dependent primarily on the size and shape of the grille opening, on the mass flow per minute, and on the temperature of the air. At the higher frequencies, the noise is determined primarily by the area of the grille, the velocity of air through the free (open) areas (not the core or nominal area), and the pressure drop across the grille.

For two simple types of grille, stamped and deflector vane, power levels are given in Fig. 8. These power levels are given

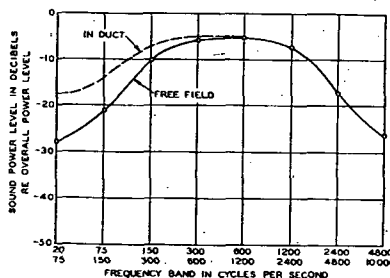
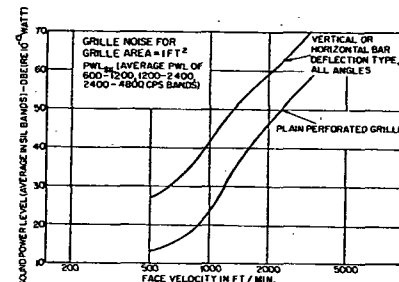


Fig. 7. . . . Sound Power Spectrum for Single-stage Axial Fan⁸



The noise is expressed as the sound power level in db in each of the three speech interference bands (PWL_{s11}).

Fig. 8. . . . Grille Noise for a Grille Area of One Square Foot

in terms of the speech interference level, PWL_{s11} . Conversion to the speech interference level in db in the room at a listener's position is described in the section on Determination of Room Levels. In the absence of more complete information, it may be assumed that the power levels of the noise produced by the grilles themselves at low frequencies are inconsequential.

Fig. 8 is for a grille core area of 1 sq ft. Correction to other areas of grille is made by the relation:

$$\text{Decibel addition} = 10 \log_{10} A \text{ db}$$

where

A = core area, square feet.

Values of the decibel addition for various values of A are given in Table 3.

Table 3. . . . Decibel Correction for Area

A sq ft	Decibel Addition	A sq ft	Decibel Addition	A sq ft	Decibel Addition
0.5	-3	8	9	70	18
1	0	16	12	100	20
2	3	20	13	200	23
4	6	40	16	400	26

Example 3: Assume a deflector vane type of grille with a core area of 2 sq ft. Determine the sound power level in the speech interference bands for an air velocity of 2000 fpm.

Solution: From Fig. 8, the PWL_{s11} for a 1 sq ft deflection grille is 59 db. From Table 2, an addition of 3 more db is required, so that $PWL_{s11} = 62$ db.

Diffuser Noise

Aside from the information furnished by diffuser manufacturers, to their users, on sound levels generated by air diffusers, few other data are available. Recently, however, some test results on several types of ceiling air diffusers have yielded a satisfactory correlation of the sound generating characteristics of these devices.¹² The data, covering ceiling diffusers ranging in size from 4- to 18-in. neck diameter, show that the