272.

APPLIED ACOUSTICS HANDBOOK

C.E. Ebbing

Carrier Corporation
Carrier Parkway
P.O. Box 4808
Syracuse, New York
13221

The Directivity Factor (Q) is used to account for the presence of nearby reflectors. The sound pressure level (Lp) from an omnidirectional sound source of sound power level (Lw) in a free field can be estimated using the following relationship. The way in which reflecting planes affect the Directivity Factor is illustrated in Figure 2.2.

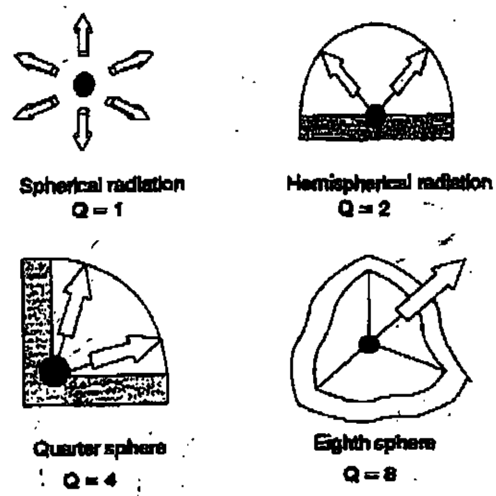


Figure 2.2 - Directivity Factor Depends on Nearby Reflecting Surfaces

CALCULATING SOUND PRESSURE FROM SOUND POWER IN A FREE FIELD

$$Lp = Lw + 10\,\text{Log}_{10}(Q/4\pi r^2) + 10.5 \qquad (2.2)$$

where:

- Q = Directivity factor
  - Q = 0, no reflecting planes present (free field)
  - Q = 2, 1 reflecting plane present (free field above reflecting plane)
  - Q = 4, 2 reflecting planes present (free field with one reflecting wall)
  - Q = 8, 3 reflecting planes present (free field with source in corner of 3 perpendicular planes)
- r = distance from acoustic center of the source to the estimation point (ft)
- π = 3.141593
- Lw = sound power level (dB)
- Lp = sound pressure level (dB)

POINT AND LINE SOURCES

POINT SOURCES

A point source is a sound source whose largest dimension is small in relation to the wavelength it is radiating. An example is a propeller fan of 3 ft. diameter that is radiating noise at 80 Hz (wavelength = 1100/80 = 13.75 ft). Because the fan is small in relation to the radiated wavelength, it can be considered a point source at 80 Hz.

SPREADING LAW

Point sources of sound produce equal sound radiation in all directions. The sound pressure level in a free field (no nearby significant reflecting surfaces) decreases by 6 dB each time the distance from a point source is doubled (Equation 2.3). This effect is sometimes referred to as the inverse square spreading law.

$$dB_1 - dB_2 = 20 \, Log_{10}(r_1/r_2) \quad (2.3)$$

where:

- dB_1 = sound pressure level at distance r_1 (dB)
- dB_2 = sound pressure level at distance r_2 (dB)
- r1 = first distance from point source, ft
- r2 = second distance from point source, ft

As an example, if we are 10 ft away from the geometric center of a point source that measured 80 dB in a free field and we move to 20 ft away, the sound will be 6 dB less or 74 dB. Similarly, if we move double the distance again to 40 ft away, then the level will be 68 dB.

Figure 2.3 shows that the area over which the sound wave is spread varies by the area of the sphere and is proportional to the radius squared.

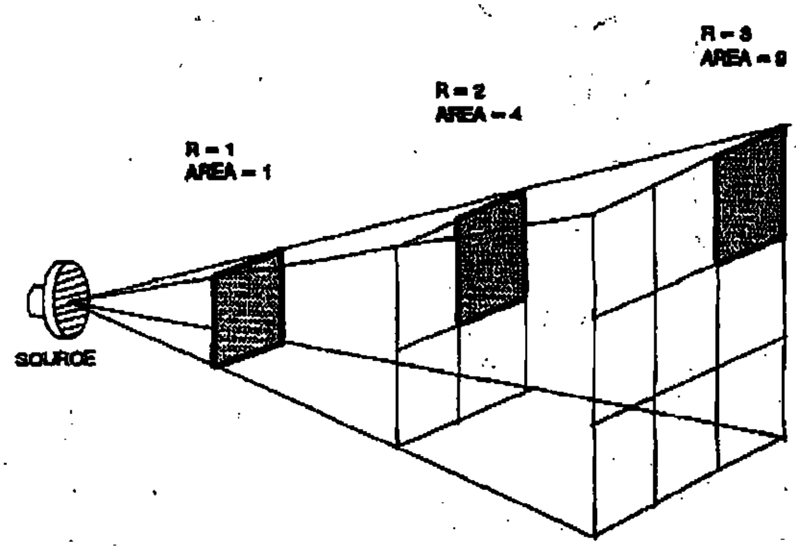


Figure 2.3 - The Spreading of Sound Energy With Distance

LINE SOURCES

A line source is a sound source composed of many point sources arranged next to each other in a line.

Line sources of sound produce equal sound pressures at equal distances perpendicular to the axis of the line source, out to a distance of approximately L/π, where L is the length of the line source. This happens because, initially, the wave fronts are cylindrical and the energy spreads in only one direction rather than in two directions, as with a point source. At distances greater than L/π, a line source starts to behave like a point source. At this distance the resulting wave fronts are more like spheres than cylinders.

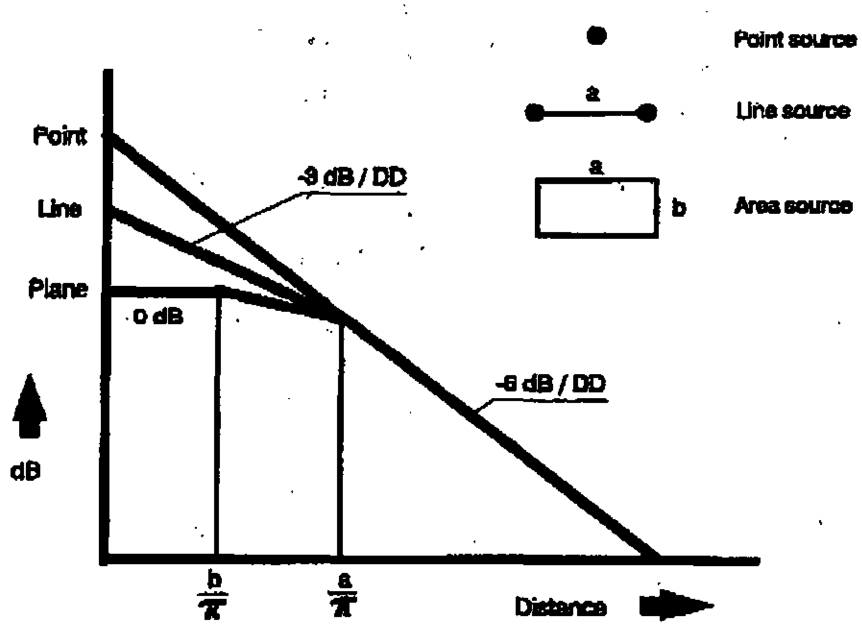
In the region where cylindrical spreading takes place, sound pressure drops off 3 dB each time the distance is doubled from a line source (Equation 2.4).

$$dB_1 - dB_2 = 10 \text{ Log}10(r_1/r_2) \qquad (2.4)$$

where:

dB_1 = sound pressure level at distance r_1 (dB)
dB_2 = sound pressure level at distance r_2 (dB)
r1 = first distance from point source
r2 = second distance from point source

Figure 2.4 illustrates the falloff of sound pressure level from point, area and line sources.



Falloff from point and area noise sources

Figure 2.4 - Point, Area, and Line Sources