What Is Noise?

Noise is unwanted sound which may be hazardous to health, interfere with speech and verbal communications or is otherwise disturbing, irritating or annoying.

What Is Sound?

Sound is defined as any pressure variation in air, water or other fluid medium which may be detected by the human ear.

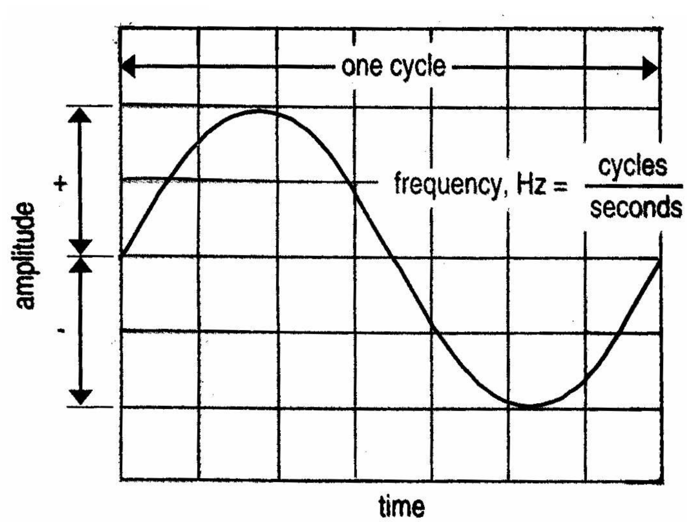
What Are The Characteristics Of Sound?

The two most important characteristics which must be known in order to evaluate the sound or noise are it's amplitude and frequency. The amplitude or height of the sound wave from peak to valley determines the loudness or intensity. The wave length determines the frequency, pitch or tone of the sound.

How Are These Characteristics Expressed?

The frequency of sound is expressed in wavelengths per second or cycles per second CPS). It is more commonly referred to as Hertz. Low frequency noise is 250 Hertz (Hz) and below. High frequency noise is 2000 Hz and above. Mid-frequency noise falls between 250 and 2000 Hz.

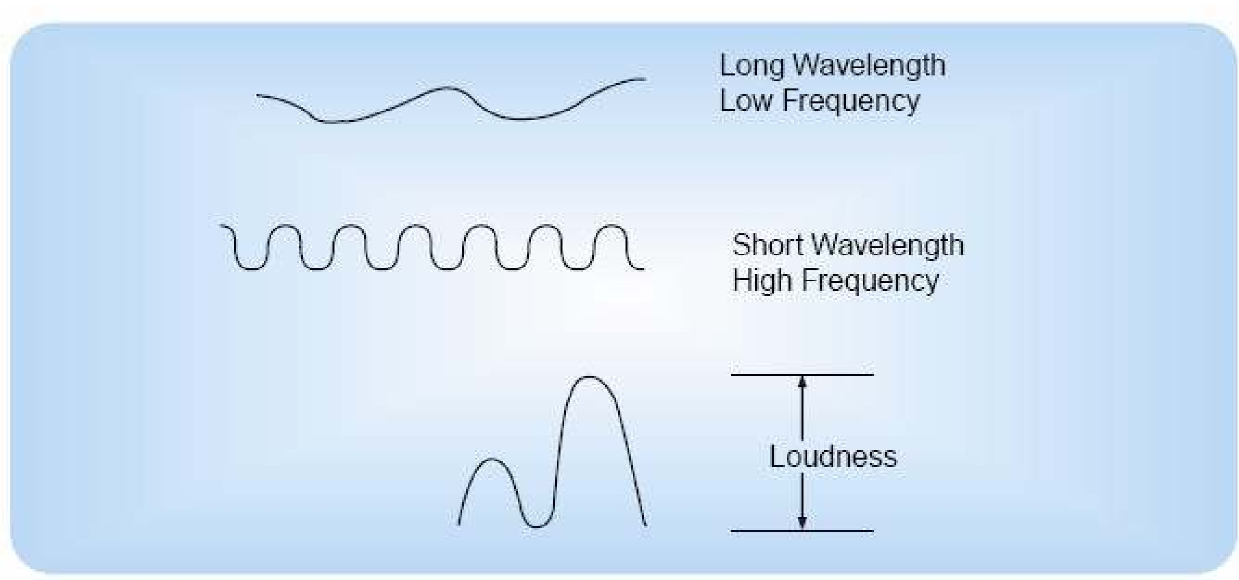
The amplitude of sound is expressed in decibels (dB). This is a logarithmic compressed scale dealing in powers of 10 where small increments in dB correspond to large changes in acoustic energy.



What Are Wavelengths?

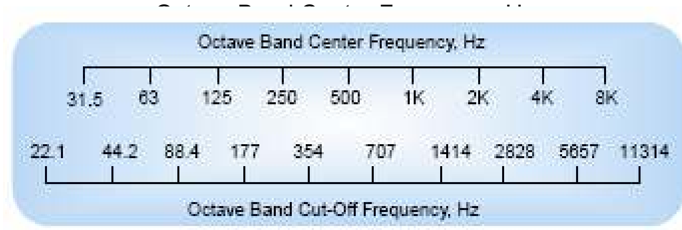
Sound wavelengths are the linear measurement of one full cycle of displacement where the motion of air molecules is first compressed and then rarefield or expanded. The wavelength is determined by the ratio of the speed of sound to the frequency.

$$\text{Wavelength} = \frac{\text{Speed of Sound}}{\text{Frequency}}$$



What Are Octave Bands?

Standardized octave bands are groups of frequencies named by the center frequency where the upper limit is always twice the lower limit of the range. Test data for performance of acoustical materials is standardized for easy comparison at the center frequencies. Equipment noise levels and measurement devices (dB meters) also follow the preferred octave bands



What Are Octave Band Center Frequency Wavelengths At 70°F?

The speed of sound in air at 70°F is 1,130 feet per second. Wavelengths in feet for each center band frequency are listed below:

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Wavelength (Ft.)	17.9	9.03	4.51	2.26	1.13	0.56	0.28	0.14

What Is The Decibel Scale?

The decibel (dB) is a dimensionless unit calculated using the ratio of a measured value (p) to a reference value (pre). The values of sound pressure of most interest range from the threshold of hearing at about 1×10^{-9} psi to the threshold of damage at about 15 psi. This range of energy variation translates to 10 orders of magnitude with the high threshold at a level 1,000,000,000 times that of the lower threshold. The use of a logarithmic scale compresses the unit of measure to a manageable range in order to simplify calculations, computations and quantitative manipulation of data.

What is Sound Pressure?

Decibels of sound pressure (Lp) have a universally accepted reference pressure of 2.0×10^{-5} Pascals (Pa).

$$Lp = 20 \log_{10} \left[\frac{\text{Root Mean Square (RMS) Sound Pressure}}{2.0 \times 10^{-5} \text{ Pa (Reference Pressure)}}\right]$$

What Is Sound Power?

Decibels of sound power (Lw) have a universally accepted reference value of 10^{-12} watts (1 picowatt).

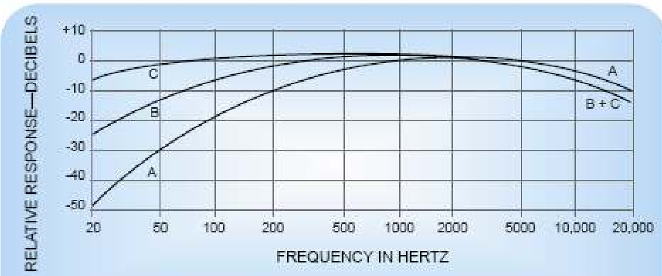
$$Lw = 10 \log_{10} \left[\frac{\text{Watts Sound Power}}{10^{-12} \text{ Watts (Reference Value)}}\right]$$

Are Sound Pressure And Sound Power Equal Values?

No! While both sound power levels (Lw) and sound pressure levels (Lp) are both expressed in decibels, the referenced standards for each are different. More importantly, the sound power level is the total acoustic energy output of a noise source independent of environment. Sound pressure levels are dependent on environmental factors such as the distance from the source, the presence of reflective surfaces and other characteristics of the room/building/area hosting the source. Actual sound pressure levels will always be higher than sound power levels.

What Is The Difference Between dB and dBA?

dB sound pressure levels are un-weighted. dBA levels are "A" weighted according to the weighting curves shown below to approximate the way the human ear hears. For example, a 100 dB level at 100 Hz will be perceived to have a loudness equal to only 80 dB at 1000 Hz. Other weighting scales (C and B) are also shown. The dBA scale is based on a child's hearing and was originally documented based on actual hearing tests to characterize the human ear's relative response to noise.



SLM WEIGHTING CURVES — ANSI S1.4-1971

How Are Decibel Levels Added Together?

For adding several decibel levels of the same value:

No. of Equal Levels	Add the Following Amount to that Level to Get the Sum
2	3.0 dB
3	4.8 dB
4	6.0 dB
5	7.0 dB
6	7.8 dB
7	8.4 dB
8	9.0 dB
9	9.5 dB
10	10.0 dB
N	10 log N dB

At the final total, round off to the nearest whole number.

For adding any two decibel levels to an accuracy of about 1 dB:

When Two Decibel Values Differ By	Add the Following Amount to the Higher Value
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
10 dB or more	0 dB

When adding several levels, start with lowest levels first; continue two at a time until only one final value remains.

The tables at left show the additive effect for adding equal and unequal decibel levels. Unless the two levels differ by 10 or more dB there will always be some increase to the higher level. Frequency levels can also be added together in a similar fashion to get overall dB levels.

Decibel addition is illustrated in the following example: An industrial fan radiates levels of 88 dBA from the fan housing, 86 dBA from the motor and 85 dBA from the belt drive assembly. To figure the overall dBA level we find the difference between the fan housing and motor noise (88 – 86 = 2 dBA difference). The above table shows that 2 dBA is added to the higher value resulting in 90 dBA (88 + 2). Considering the belt drive now, adding 85 dBA to the 90 dBA (5 dBA difference) results in an overall level of 91 dBA (90 + 1 = 91).

How Are Frequencies Added Together?

<table>
<tr><th>octave band</th><th>center frequency (Hz)</th><th>unweighted sound pressure (dB)</th><th>A-weighting factor (dB)</th><th>A-weighted sound pressure (dB)</th><th>decibel addition</th><th></th><th>overall resultant level</th></tr>
<tr><td>1</td><td>63</td><td>94</td><td>-26</td><td>68</td><td rowspan="2">72</td><td rowspan="4">86</td><td rowspan="8">91 dBA</td></tr>
<tr><td>2</td><td>125</td><td>86</td><td>-16</td><td>70</td></tr>
<tr><td>3</td><td>250</td><td>85</td><td>-9</td><td>76</td><td rowspan="2">86</td></tr>
<tr><td>4</td><td>500</td><td>89</td><td>-3</td><td>86</td></tr>
<tr><td>5</td><td>1,000</td><td>89</td><td>+0</td><td>89</td><td rowspan="2">89</td><td rowspan="4">89</td></tr>
<tr><td>6</td><td>2,000</td><td>77</td><td>+1</td><td>78</td></tr>
<tr><td>7</td><td>4,000</td><td>75</td><td>+1</td><td>76</td><td rowspan="2">79</td></tr>
<tr><td>8</td><td>8,000</td><td>76</td><td>+0</td><td>76</td></tr>
</table>

In the example above, successive pairs of frequency dBA levels are added together in accordance with the procedure outlined on the previous page. Unweighted dB levels are “A” scale corrected prior to final addition.

Is A 5 dB Change Significant?

Yes! The pressure associated with the loudest known sound is more than one billion times that associated with the faintest sound. Such a large range is unmanageable for measurement purposes. Using a logarithmic scale compresses the range to between 0 and 200 dB. At right, various sound level changes are referenced to relative loudness and acoustic energy loss. A 5 dB change is more than a 50% change in acoustic energy!!!

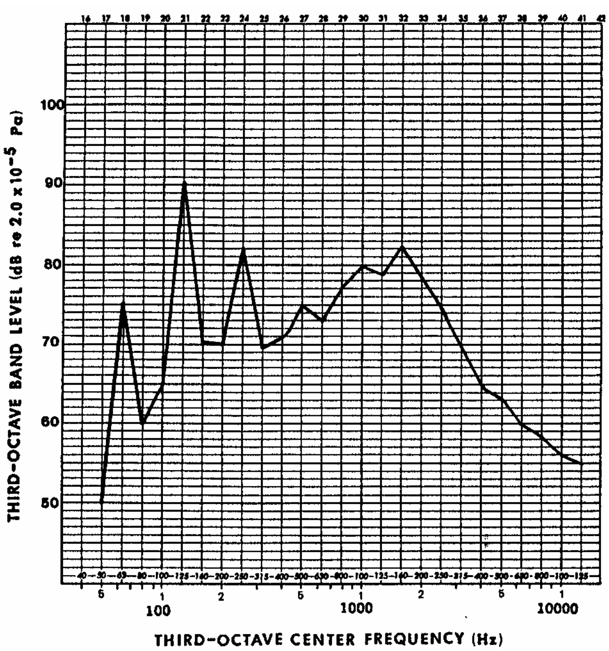
Sound Level	Acoustic Energy Loss	Relative Loudness
0 dB	0	Reference
-3 dB	50%	Perceptible Change
-10 dB	90%	Half as Loud
-20 dB	99%	¼ as Loud
-30 dB	99.9%	1/8 as Loud
-40 dB	99.99%	1/16 as Loud

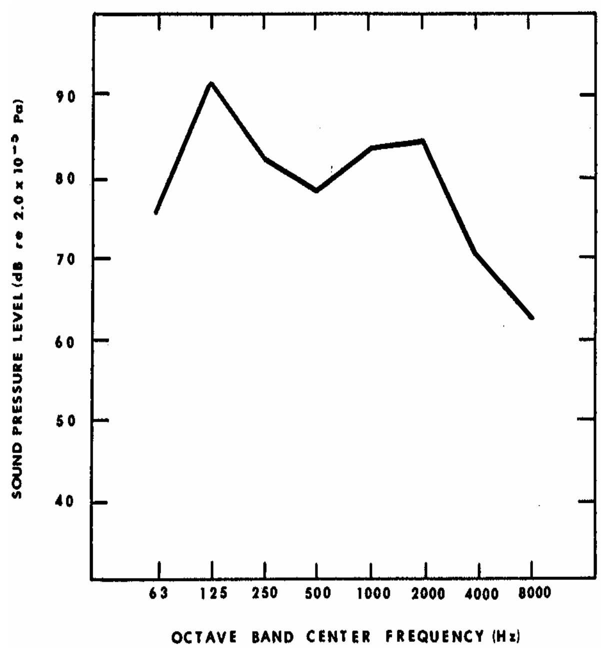
What Is Broadband Noise?

Broadband noise has a frequency spectrum or signature where there are no discreet or dominant tones. Sound pressure fluctuations of broadband noise are non-periodic in nature with relatively random phase and amplitude. Although devoid of discrete frequencies, the acoustical energy of broadband noise may still be largely concentrated in one or more areas of the spectrum. Examples of broadband noise are shop air blow-offs, gas fired burners, jet engines and grinding tools.

What Is Tonal Noise?

Tonal noise is commonly referred to as discrete frequency noise and is characterized by spectral tones that are pure tone in nature. Pure tones are wave forms that occur at a single frequency. Tonal noise is generated by rotating equipment at a predictable frequency relating to the rotational speed of the shaft and the number of compressor vanes, fan blades, engine pistons, gear teeth, etc. The fundamental tone (F) may also manifest itself at progressively lower intensity levels at integer harmonic multiples (2F, 3F, etc.). Tolerance levels for tonal noise are generally at a lower threshold.





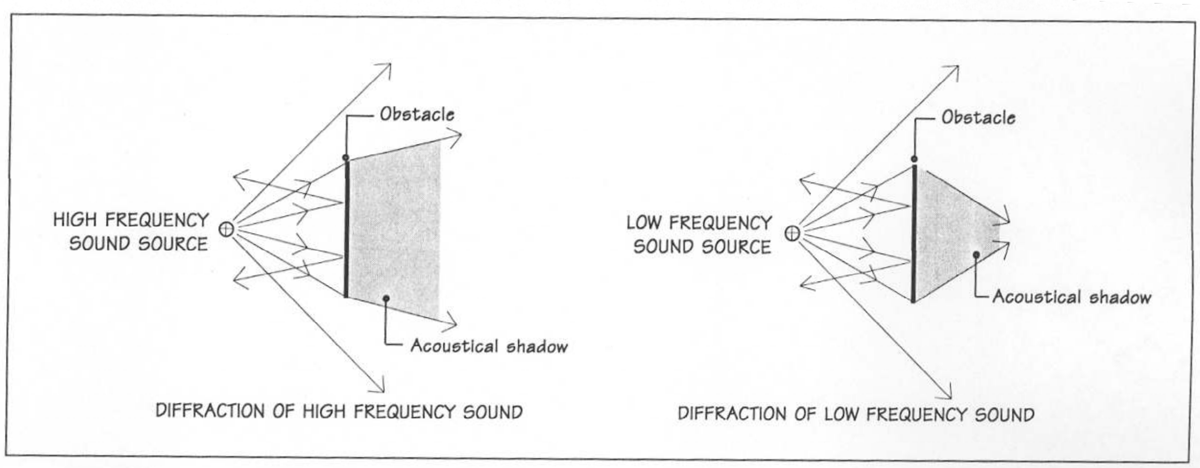
Spectral data measured using frequency filter sets is necessary to asses tonal content. Characterizing the source noise frequencies in full octave bands (see example above right for a transformer) does not provide the degree of spectral definition of fractional 1/3 octave bandwidths (see above left for same transformer example). Discernable tones shown in 1/3 octave format can disappear in a full octave analysis. Narrow band frequency analysis is used to precisely identify tones. Examples of tonal noise include fans, rotary lobe blowers, compressors, gears, transformers, saws, and piston driven engines. Noise control treatment strategies for tonal noise sources must target the discrete frequencies.

What Is Impulse Noise?

Impulse noise is a short duration transient acoustic event characterized by a sudden rise or spike in sound pressure followed by a uniform or oscillatory decay (depends on type of source equipment) lasting less than ½ second. Impulse noise usually exhibits a distinct spectral signature across the frequency range without the presence of discrete tones. Examples of impulse noise include gunshots, pulse cleaning systems, punch presses, etc.

What Is The Audible Range?

At birth, the audible frequency range is 20 Hz to 20,000 Hz. Generally speaking the average audible range in humans is from 30 Hz to 17,000 Hz. Sound pressure wave forms below and above this range are described as infrasonic and ultrasonic. Infrasonic sound is experienced as a flutter while ultrasonic sound produces no sensation of hearing.



What Is Diffraction?

Diffraction of sound is "bending" of the pressure wave around objects, obstacles and walls. Diffraction is greatest with low frequency sound or where the wavelength is large compared to the object it strikes. As illustrated above, diffraction of sound results in a less pronounced acoustic shadow zone.