The Loudness of Everyday Life

Examples of everyday noise levels in dB SPL

Weakest sound heard............ *0 dB*
Normal conversation (3 – 5')............ *60 – 70 dB*
Telephone dial tone............ *80 dB*
City traffic (inside car)............ *85 dB*
Train whistle at 500'............ *90 dB*
Subway train at 200'............ *95 dB*

Sustained exposure may result in hearing loss at these levels

Possible hearing loss............ *90 – 95 dB*
Power mower............ *107 dB*
Power saw............ *110 dB*
Pain begins............ *125 dB*
Pneumatic riveter at 4'............ *125 dB*
Jet engine at 100'............ *140 dB*
Death of hearing tissue............ *180 dB*
Loudest sound possible............ *194 dB*

Loudness

Loudness is a sound characteristic that involves the listener—it is a perceived characteristic that can be charted and averaged, but it's not simply a mathematical calculation. The common unit, used to quantify loudness, is the phon. Loudness is a subjective, perceptual aspect of sound.

The human ear is not equally sensitive to all frequencies. In fact, as amplitude varies so does the frequency response characteristic of the ear. The ear is most sensitive between 1 and 4 kHz. This frequency range just happens to contain the frequencies that give speech intelligibility, directional positioning, and understandability. Hmmm … it's almost like it was designed that way. In fact, as the amplitude decreases, our ears become dramatically more sensitive in this frequency range.

So, yes, there is a difference between amplitude and volume. They are very similar at a certain point, though. Two scientists at Bell Laboratories in 1933 charted a survey of perceived volume. They compared actual amplitude to perceived volume throughout the audible frequency range (x-axis) and the accepted range of normal volume (y-axis).

The results of their survey involved generating pure tones through the audible frequency and volume spectrum at a specific amplitude, then asking numerous individuals to subjectively identify if the sound was louder or softer than the reference. Their survey, referred to as the Fletcher-Munson Curve, is a very visual representation of why music sounds fuller at loud volumes and thinner at soft volumes.

Each curve on the graph represents perceived constant volume throughout the audible frequency range. This, for example, shows us that in order to perceive 70 phons of loudness at 1,000 Hz requires 70 dB SPL (amplitude). However, in order to perceive 70 phons at 50 Hertz, 80 dB SPL is required. At 10 kHz, to perceive 70 phons, a similar 10 dB SPL boost is required.

As dB SPL decreases, the contrast becomes even more extreme between loudness and the actual amount of dB SPL required. At 20 phons, 20 dB SPL is equal to 20 phons. In contrast, at 50 Hz almost 65 dB SPL is required to maintain the perceived 20 phons.

Government Regulations on Exposure to Loud Sounds

OSHA Daily Permissible Noise Level Exposure

The Occupational Safety and Health Administration (OSHA) is part of the U.S. Department of Labor. This organization has studied and prescribed maximum sound pressure levels in the workplace, in relation to the number of hours per day the worker is exposed. These guidelines are useful to help audio engineers guard against permanent hearing loss.

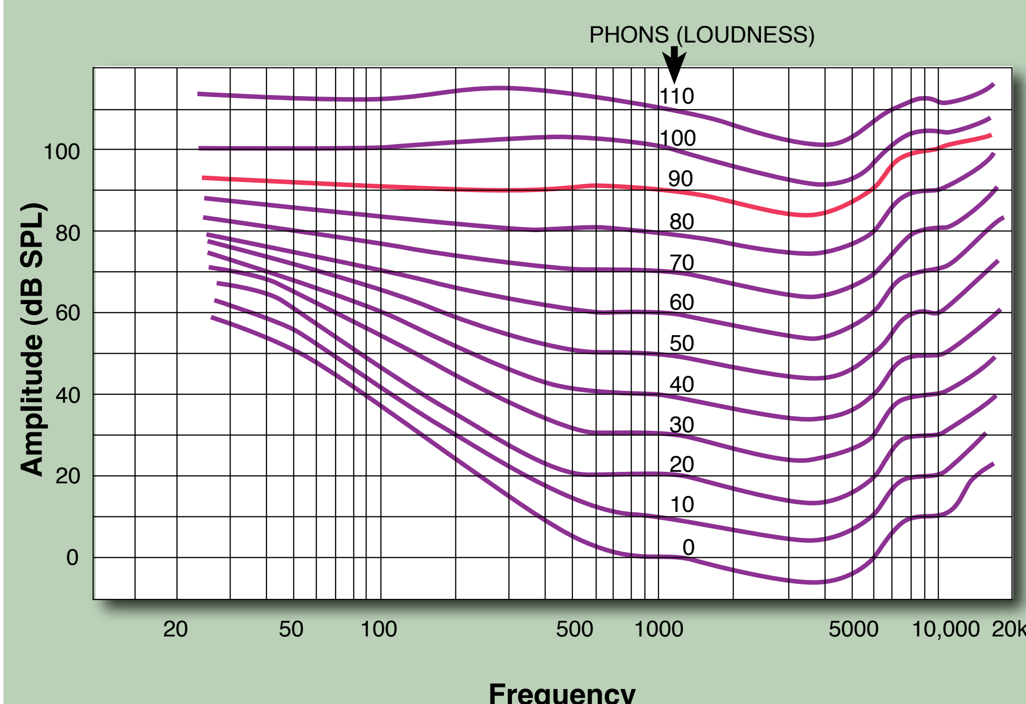
Hours per day	Sound level
8	*90 dB*
6	*92 dB*
4	*95 dB*
3	*97 dB*
2	*100 dB*
1.5	*102 dB*
1	*105 dB*
.5	*110 dB*
.25 or less	*115 dB*

Analysis of the Fletcher-Munson curve points us to the dB SPL range at which the human ear is most accurate throughout the audible frequency spectrum. Notice that between roughly 700 Hz and 1.5 kHz, phons are essentially equal to dB SPL at all volumes. Also, notice that at the center of the graph is where more often than not dB SPL is most similar to phons.

From this graph it is generally held that the most sensitive frequency range is from 1 – 4 kHz, although the graph might indicate an extension of that range from about 700 Hz to 6 kHz or so. Since this is a subjective study, some generalities apply but it is obvious where the consistencies and trends are.

The Fletcher-Munson Curve of Equal Loudness

This graph plots results from a survey that relates amplitude (dB SPL) to perceived volume. This curve is valuable because it highlights the frequency response characteristic of the human ear. Since amplitude is a quantifiable energy level and loudness is a subjective characteristic, based on the listener's opinion, there's no better way to discover perceived volume than to ask human beings and then chart the results.



The SPL Meter

A simple and inexpensive sound pressure level meter is a valuable tool. Weighting can be switched between A and C, and response time is adjustable from slow to fast. The calibrated microphone is built in at the top of the device.

A meter like this is designed to held in space and, as much as possible, kept from the influence of reflections from surrounding surfaces such as surrounding walls or the operator's body.

To use this tool effectively, stand facing 90 degrees away from the source with the SPL meter directly in front of you and at arm's length. The built-in mic is omnidirectional so the meter doesn't need to face the source.

This SPL meter is set to read 90 decibels plus or minus 10 decibels. This 20-dB range is adequate for most situations.

For our recording purposes, it is constructive to find the flattest curves on the graph. A curve with less variation indicates a volume where the human ear's response most often matches loudness to dB SPL—the level where the most accurate assessments can be made regarding mix and tonal decisions.

The LOUDNESS button on your stereo is an example of compensation for the fact that it takes more high and low frequencies at a low volume to perceive equal loudness throughout the audible spectrum.

The most consistent monitor volume for our recording purpose is between 85 and 90 dB SPL, according to the Fletcher-Munson Curve. Notice on the graph that the 80 and 90 phons curves are the flattest, from 20 Hz to 20 kHz.

There are a few different devices available to help you quantify specifically how loud, in dB SPL, you have your system set. The simplest and least expensive way to assess dB SPL is with a handheld decibel meter. They are available at most home electronics stores and, depending on features and manufacturer, typically range in price from about $40 – $300. Most of these instruments offer A- and C-weighting, along with slow (average) and fast (peak) attack times.

C-weighting is optimized for full-bandwidth sources at levels exceeding

A-, B-, and C-Weighting

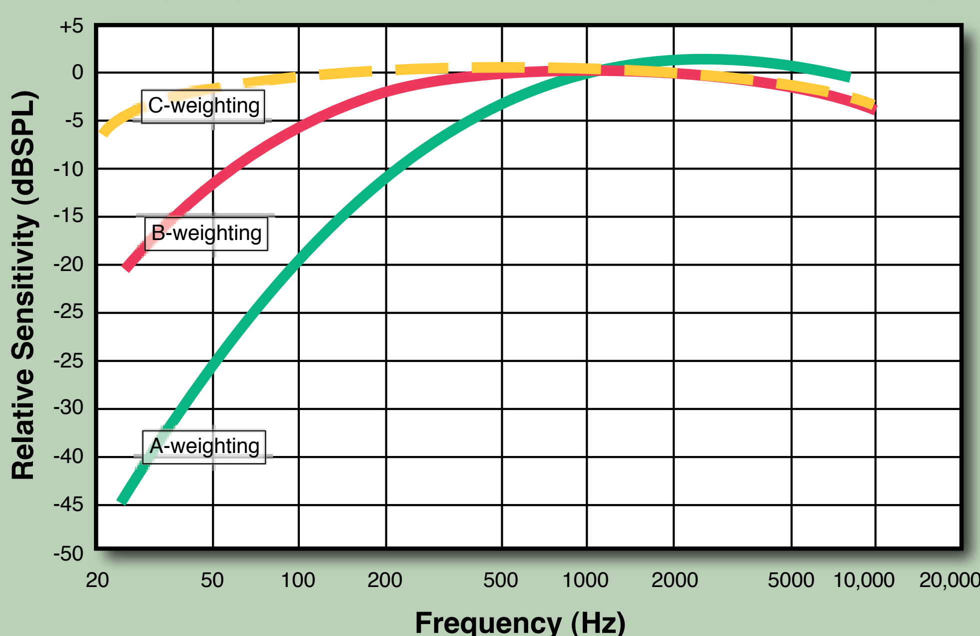
Any piece of gear that quantifies amplitude must specify whether it's sensitive to a full or limited bandwidth. Weighting is the qualifier for sound pressure level measurements.

C-weighting closely approximates full-bandwidth sensitivity. This is the scale that most accurately represents amplitude.

A-weighting closely approximates loudness, attenuating the lower frequencies to resemble the response of the human ear (which is most sensitive to frequencies between 1,000 and 4,000 Hz).

B-weighting includes more of the mid frequencies in its sensitivity than A-weighting. It's usually used in conjunction with A- and C-weighting in analysis of acoustical anomalies.

Weighting Characteristics for Sound Pressure Level Metering



85 dB. A-weighting filters out the high and low frequencies and is optimized for lower volumes. The A-weighted scale more closely reflects perceived volume, whereas the C-weighted scale measures amount of energy (amplitude).

Phase

We discovered previously that a sound wave is represented by one complete cycle—a crest and a trough—which is measured along the timeline in degrees. The beginning of the crest is at zero degrees and the end of the trough is 360 degrees. The way multiple sound waves interact in the same acoustical or electrical space is called phase.

Since a sound wave has a crest, which pushes on your eardrum, and a trough, which pulls on your eardrum, it's fairly simple to visualize that if two identical waveforms happen simultaneously and follow the exact same path, their energy would increase as they worked together—in fact, they double in amplitude, meaning the peak is twice as high and the trough is twice as deep. As seen by your eardrum, the compression and rarefaction are doubled. Two identical waveforms, which start at the exact same point in time and follow the identical path through the crest and trough, are said to be in phase.

If two signals are out of phase, their waveforms are mirror images of each other. The electronic result of this combination is silence. When this happens electronically, the energies oppose each other completely—for each push there is an equal pull throughout all 360 degrees. Since we refer to a complete cycle as 360 degrees, we mark the center point of the cycle at 180 degrees. By delaying one of two identical waveforms so that the beginning of the trough of one coincides with the beginning of the crest on the other (180 degrees into the cycle), we create a scenario of complete phase cancellation. When this happens, we say the two waveforms are 180 degrees out of phase.

It's easy to create a scenario, electronically, where two waveforms combine 180 degrees out of phase. It rarely happens acoustically because of the predominance and complexity of reflections, along with the fact that we hear with two ears, which already receive the same waveform at slightly different points of time. Interactions between acoustic sound waves is, however,