Deutsche Version

• Decibel Table − Loudness Comparison Chart •

Table of Sound Levels (dB Scale) and the corresponding Units of Sound Pressure and Sound Intensity (Examples)

To get a feeling for decibels, look at the table below which gives values for the sound pressure levels of common sounds in our environment. Also shown are the corresponding sound pressures and sound intensities.
From these you can see that the decibel scale gives numbers in a much more manageable range. Sound pressure levels are measured without weighting filters.
The values are averaged and can differ about ±10 dB. With sound pressure is always meant the effective value (RMS) of the sound pressure, without extra announcement. The amplitude of the sound pressure means the peak value.
The ear is a sound pressure receptor, or a sound pressure sensor, i.e. the ear-drums are moved by the sound pressure, a sound field quantity. It is not an energy receiver. When listening, forget the sound intensity as energy quantity.
The perceived sound consists of periodic pressure fluctuations around a stationary mean (equal atmospheric pressure).

This is the change of sound pressure, which is measured in pascal (Pa) ≡ 1 N/m^2 ≡ 1 J/m^3 ≡ 1 $kg/(m·s^2)$. Usually p is the RMS value.

Table of sound levels L (loudness) and corresponding sound pressure and sound intensity

Sound Sources Examples with distance	Sound Pressure Level L_p dBSPL	Sound Pressure p N/m^2 = Pa	Sound Intensity I W/m^2
Jet aircraft, 50 m away	140	200	100
Threshold of pain	130	63.2	10
Threshold of discomfort	120	20	1
Chainsaw, 1 m distance	110	6.3	0.1
Disco, 1 m from speaker	100	2	0.01
Diesel truck, 10 m away	90	0.63	0.001
Kerbside of busy road, 5 m	80	0.2	0.0001
Vacuum cleaner, distance 1 m	70	0.063	0.00001
Conversational speech, 1 m	60	0.02	0.000001
Average home	50	0.0063	0.0000001
Quiet library	40	0.002	0.00000001
Quiet bedroom at night	30	0.00063	0.000000001
Background in TV studio	20	0.0002	0.0000000001
Rustling leaves in the distance	10	0.000063	0.00000000001
Threshold of hearing	0	0.00002	0.000000000001

The sound level depends on the distance between the sound source and the place of measurement, possibly one ear of a listener.
The sound pressure level L_p in dB without the given distance r to the sound source is really meaningless. Unfortunately this error (unknown distance) is quite often.

Noise is a sound that disturbs or harms.

Assumption: The maximum sound pressure is 194 dBSPL. That cannot be exceeded because the average air pressure of 101325 Pa.
L = 20 · log (101325 / 0,00002) = **194 dB**. This theoretical idea is not correct, because a chaotic noise can also be asymmetrical.
There is no upper noise limit. A typical false statement: "No noise levels can exceed 194 dB ever". Is the end at 194 dB? In addition to this perception threshold is discussed more often a physical limit to 194 dB. Sound is nothing more than a minor disturbance of air pressure and 194 dB is theoretically the same as the disturbance itself. But even louder noise is possible.

Ultrasound between 20 kHz and 1.5 GHz does not belong to our human hearing.
Infrasound below about 16 Hz is insensitive to the human ear.

The total sound power is emitted by the sound source. Sound power levels are connected to the sound source and are independent of distance. Sound pressure levels vary substantially with distance from the source.

Sound pressure p in pascals (newtons per square meter) is not the same physical quantity as intensity J or I in watts per square meter. ... and the sound power (acoustic power) does not decrease with distance r from the sound source - neither with 1 / r nor as 1 / r^2.

Sound Field Quantities	Sound Energy Quantities
Sound pressure, sound or particle velocity, particle displacement or particle amplitude, (voltage, current, electric resistance). **Inverse Distance Law 1/r**	Sound intensity, sound energy density, sound energy, acoustic power. (electrical power). **Inverse Square Law 1/r^2**

The reference sound pressure level for 0 dBSPL is the sound pressure p_0 = 20 µPa = 20 × 10^{-6} Pa = 2 × 10^{-5} Pa = 0.00002 Pa or N/m². That is the threshold of hearing. (The reference sound intensity is $I_0 = 10^{-12}$ W/m^2.)
Pa = Pascal.

There is no "dBA" value given as threshold of human hearing.
These values are not given as dBA, but as dBSPL, that means **without any weighting filter.**

$$L_p = 20\ \log_{10}\left(\frac{p}{p_0}\right)\ \text{in dB} = L_I = 10\ \log_{10}\left(\frac{I}{I_0}\right)\ \text{in dB}$$

Differentiate between sound pressure p as a "sound **field** quantity" and sound intensity I as a "sound **energy** quantity". $I \approx p^2$ for progressive plane waves. When it comes to our ears and the hearing, it is recommended that the inappropriate expression of the sound energy parameters, such as sound power (acoustic power) and sound intensity to leave aside. So we are just listening to the sound pressure as sound field quantity, or the sound pressure level SPL.

The sound pressure level decreases in the free field with 6 dB per distance doubling.
That is the 1/*r* law.

Often it is argued the **sound pressure** would decrease after the $1/r^2$ law (inverse square law). **That's wrong.**
The sound pressure in a free field is inversely proportional to the distance from the microphone to the source. ***p* ~ 1/*r*.**

How does the sound decrease with increasing distance?
Damping of sound level with distance

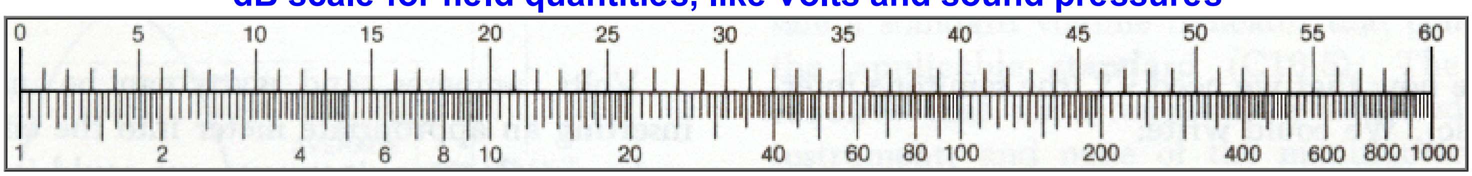
Relation of sound intensity, sound pressure and **distance law**:

$$I \sim p^2 \sim \frac{1}{r^2}$$

From this follows $p \sim \frac{1}{r}$

Note: The often used term "**intensity** of sound pressure" is not correct. Use "magnitude", "strength", "amplitude", or "level" instead.
"Sound intensity" is sound power per unit area, while "pressure" is a measure of force per unit area. Intensity (sound energy quantity) is not equivalent to pressure (sound field quantity).

dB scale for field quantities, like volts and sound pressures



ratio

The sound pressure is the force F in newtons N of a sound on a surface area A in m^2 perpendicular to the direction of the sound.
The SI-unit for the sound pressure p is N/m^2 = Pa. $p \sim 1/r$.

Note - Comparing dBSPL and dBA:
There is no conversion formula for measured dBA values to sound pressure level dBSPL or vice versa.
That is only possible measuring one single frequency.

There is no "dBA" curve given as threshold of human hearing.

The weighted sound level is neither a physiological nor a physical parameter.

Words to bright minds: Always wonder what a manufacturer is hiding when they use A-weighting. *)

***) http://www.google.com/search?q=Always+wonder+what+a+manufacturer+Rane&filter=0**

Readings of a pure 1 kHz tone should be identical, whether weighted or not.

How loud is dangerous?
Typical dbA levels

190 dBA	Heavy weapons, 10 m behind the weapon (maximum level)
180 dBA	Toy pistol fired close to ear (maximum level)
170 dBA	Slap on the ear, fire cracker explodes on shoulder, small arms at a distance of 50 cm (maximum level)
160 dBA	Hammer stroke on brass tubing or steel plate at 1 m distance, airbag deployment very close at a distance of 30 cm (maximum level)
150 dBA	Hammer stroke in a smithy at 5 m distance (maximum level)
130 dBA	Loud hand clapping at 1 m distance (maximum level)
120 dBA	Whistle at 1 m distance, test run of a jet at 15 m distance
	Threshold of pain, above this fast-acting hearing damage in short action is possible
115 dBA	Take-off sound of planes at 10 m distance
110 dBA	Siren at 10 m distance, frequent sound level in discotheques and close to loudspeakers at rock concerts, violin close to the ear of an orchestra musicians (maximum level)
105 dBA	Chain saw at 1 m distance, banging car door at 1 m distance (maximum level), racing car at 40 m distance, possible level with music head phones
100 dBA	Frequent level with music via head phones, jack hammer at 10 m distance
95 dBA	Loud crying, hand circular saw at 1 m distance
90 dBA	Angle grinder outside at 1 m distance
	Over a duration of 40 hours a week hearing damage is possible
85 dBA	2-stroke chain-saw at 10 m distance, loud WC flush at 1 m distance
80 dBA	Very loud traffic noise of passing lorries at 7.5 m distance, high traffic on an expressway at 25 m distance
75 dBA	Passing car at 7.5 m distance, un-silenced wood shredder at 10 m distance
70 dBA	Level close to a main road by day, quiet hair dryer at 1 m distance to ear
65 dBA	**Bad risk of heart circulation disease at constant impact is possible**
60 dBA	Noisy lawn mower at 10 m distance
55 dBA	Low volume of radio or TV at 1 m distance, noisy vacuum cleaner at 10 m distance
50 dBA	Refrigerator at 1 m distance, bird twitter outside at 15 m distance
45 dBA	Noise of normal living; talking, or radio in the background
40 dBA	**Distraction when learning or concentration is possible**
35 dBA	Very quiet room fan at low speed at 1 m distance
25 dBA	Sound of breathing at 1 m distance
0 dBA	Auditory threshold

From a dB-A measurement no accurate description of the expected noise volume is possible.

Table of the Threshold of pain

What is the threshold of pain?

You can find the following rounded values in various audio articles:

Sound pressure level L_p	Sound pressure p
140 dBSPL	200 Pa
137.5 dBSPL	150 Pa
134 dBSPL	**100 Pa**
120 dBSPL	20 Pa

The Psychoacoustic Loudness

Notice: Psycho acousticians tell us, that a 10 dB increase of level give the impression of the doubling the loudness (volume).
Your loudspeakers need 10 times more power.
If you have 6 violins as source, then you have to ten times the violins; you need 60 violins to double the psycho-acoustic loudness (volume).

Half loudness ≡ level: –10 dB	Double loudness ≡ level: +10 dB
Half sound pressure ≡ level: –6 dB	Double sound pressure ≡ level: +6 dB
Half power ≡ level: –3 dB	Double power: ≡ level +3 dB
four times power ≡ level: +6 dB	Ten times power ≡ level: +10 dB
Double distance ≡ level: –6 dB	Double sources (Double power) ≡ +3 dB

Sound Level Comparison Chart and the Ratios

Table of sound level dependence and the change of the respective ratio to subjective volume (loudness), objective sound pressure (voltage), and sound intensity (acoustic power)
How many decibels (dB) change is double, half, or four times as loud?
How many dB to appear twice as loud (two times)? Here are all the different ratios.
Ratio means "how many times" or "how much" ... Doubling of loudness.

Subjectively perceived loudness (volume), *objectively measured* sound pressure (voltage), and *theoretically calculated* sound intensity (acoustic power)

Level Change	Volume Loudness	Voltage Sound pressure	Acoustic Power Sound Intensity
+40 dB	16	100	10000
+30 dB	8	31.6	1000
+20 dB	4	10	100
+10 dB	2.0 = double	3.16 = √10	**10**
+6 dB	1.52 times	2.0 = double	4.0

+3 dB	1.23 times	1.414 times = √2	2.0 = double
- - - - ±0 dB - - - -	- - - - 1.0 - - - - - - -	- - - - 1.0 - - - - - - -	- - - - - 1.0 - - - - -
−3 dB	0.816 times	0.707 times	0.5 = half
−6 dB	0.660 times	0.5 = half	0.25
−10 dB	0.5 = half	0.316	0.1
−20 dB	0.25	0.100	0.01
−30 dB	0.125	0.0316	0.001
−40 dB	0.0625	0.0100	0.0001
Log. quantity	**Psycho quantity**	**Field quantity**	**Energy quantity**
dB change	**Loudness multipl.**	**Amplitude multiplier**	**Power multiplier**

The psycho-acoustic volume or loudness is a subjective sensation size.

Is a 10 dB or 6 dB sound level change for a doubling or halving of the loudness (volume) correct?
About the connection between sound level and loudness, there are various theories. Far spread is still the theory of psycho-acoustic pioneer Stanley Smith Stevens, indicating that the doubling or halving the sensation of loudness corresponds to a level difference of 10 dB. Recent research by Richard M. Warren, on the other hand leads to a level difference of only 6 dB. ***)** This means that a double sound pressure corresponds to a double loudness. The psychologist John G. Neuhoff found out that for the rising level our hearing is more sensitive than for the declining level. For the same sound level difference the change of loudness from quiet to loud is stronger than from loud to quiet.
It is suggested that the sone scale of loudness reflects the influence of known experimental biases and hence does not represent a fundamental relation between stimulus and sensation.
***) Richard M. Warren, "Elimination of Biases in Loudness Judgments for Tones"**

It follows that the determination of the volume (loudness) which is double as loud should not be dogmatically defined. More realistic is the claim:

A doubling of the sensed volume (loudness) is equivalent to a level change approximately between 6 dB and 10 dB.

Subjectively perceived loudness (volume), objectively measured sound pressure (voltage), and theoretically calculated sound intensity (acoustic power)

Psychoacoustic: Relationship between phon and sone

Conversion of sound units (levels)
Calculations of Sound Values and their Levels
Conversion of voltage V to dBm, dBu, and dBV

The total sound power is emitted from the sound source. The sound power level and the sound power is connected firmly with the sound source and is really independent of the distance. On the other hand, the SPL varies significantly with the distance from the sound source.

Question: What is the standard distance to measure sound pressure level away from equipment?
There is no standard distance. It depends on the size of the sound source and the sound pressure level.

Sound pressure p in pascals is not the same physical quantity as intensity I in watts per square meter.
... and the sound power (acoustic power) does not decrease with distance r from the sound source - neither with 1 / r nor as 1 / r^2.

Often the **sound pressure** as a **sound field quantity** is mixed incorrectly with the **sound intensity** as a **sound energy quantity**. But $I \approx p^2$.

Note: The radiated sound power (sound intensity) is the cause - and **the sound pressure is the effect**.
The effect is of particular interest to the sound engineer.
The effect of temperature and sound pressure.

Acousticians and sound protectors (noise fighters) need the sound intensity (acoustic intensity). As a sound designer you don't need that. Look out more for the sound pressure that makes an effect to your ears and to the microphones.

Sound pressure and Sound power – Effect and Cause

Ratio magnitudes and levels

The decibel is defined as a 20 times logarithm of a ratio of linear quantities to each other and as a 10 times logarithm of a ratio of quadratic quantities to each other.
Ratios of electric or acoustic quantities, such as electric voltage and the sound pressure is referred to as ratios (factors), such as reflection factor.
Ratios of square quantities to one another, such as power and energy are called grades, such as efficiency.
Logarithmically ratios of electric or acoustic quantities of the same unit, we express as measures such as transfer factor, or level, such as sound pressure level.
Levels are measured in decibels - dB in short.

If the output voltage level is 0 dB, that is 100%, the level of −3 dB is equivalent to 70.7% and the level of −6 dB is equivalent to 50% of the initial output voltage.
This applies to all field quantities; e.g. sound pressure.

If the output power level is 0 dB, that is 100%, the level of −3 dB is equivalent to 50% and −6 dB is equivalent to 25% of the initial output power.

This applies to all energy quantities; e.g. sound intensity.

Try to understand this.

Conversion of sound pressure to sound power and vice versa

The sound pressure changes depending on the environment and the distance from the sound source. In contrast, the sound power of a sound source is location-independent.

Formulas for conversion:

Acoustical power (sound power) $P_{ac} = I \cdot A$ in watts

Sound intensity $I = p_{eff}^2 / Z_0$ in W/m^2 = P_{ak} / A in W/m^2

Perfused area $A = 4 \cdot \pi \cdot r^2$ in m^2

Distance measurement point from the sound source r in meters (has only meaning with sound pressure, not with sound power)

Acoustic impedance of air Z_0 = 413 N·s/m^3 at 20 °C

Sound pressure p_{eff} in Pa = N/m^2

In point-like sound sources spherical areas A shall be inserted.

Depending on the arrangement following sections are taken into account:

Solid sphere - sound source anywhere in the room, Q = 1

Hemisphere - sound source on the ground, Q = 2

Quarter Sphere - sound source on the wall, Q = 4

Eighth sphere - sound source in the corner, Q = 8

Q = direction factor and area $A = (4 \cdot \pi \cdot r^2) / Q$

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