# Basic Acoustic Concepts and Parameters

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April 10, 2019

## About Pressure:

- **Sound Pressure (Pa):** Pressure of sound wave
- **Effective Sound Pressure (Pa):**

$$p_e = \sqrt{\frac{1}{N}\sum_{n=1}^{N} x^2}$$

- **Sound Pressure Level (dB):**

$$L_p = 20 \lg \frac{p_e}{p_{ref}}$$

and

$$p_{ref} = 2 \times 10^{-5} Pa$$

## About Intensity:

- **Sound Intensity ($W/m^2$):** Power of sound wave per unit area
- **Sound Intensity Level (dB):**

$$L_I = 10 \lg \frac{I}{I_0}$$

and

$$I_0 = 1 \times 10^{-12} W/m^2$$

## Relation Between Sound Pressure and Sound Intensity:

$$I = \frac{P^2}{\rho c}$$

- $\rho$ (kg/m$^3$): Density of air
- $c$ (m/s): Speed of sound in air

At standard atmospheric pressure and 20 degrees Celsius:

$$\rho c = 408 Pa \cdot s/m$$

also named "characteristic impedance"

## About Loudness:

- **Loudness (Son):** 1 Son = Loudness of pure sound which sound pressure level is 40dB and frequency is 1kHz.
- **Loudness Level (phon):** 0 phon = Loudness level of pure sound which sound pressure level is 0dB and frequency is 1kHz

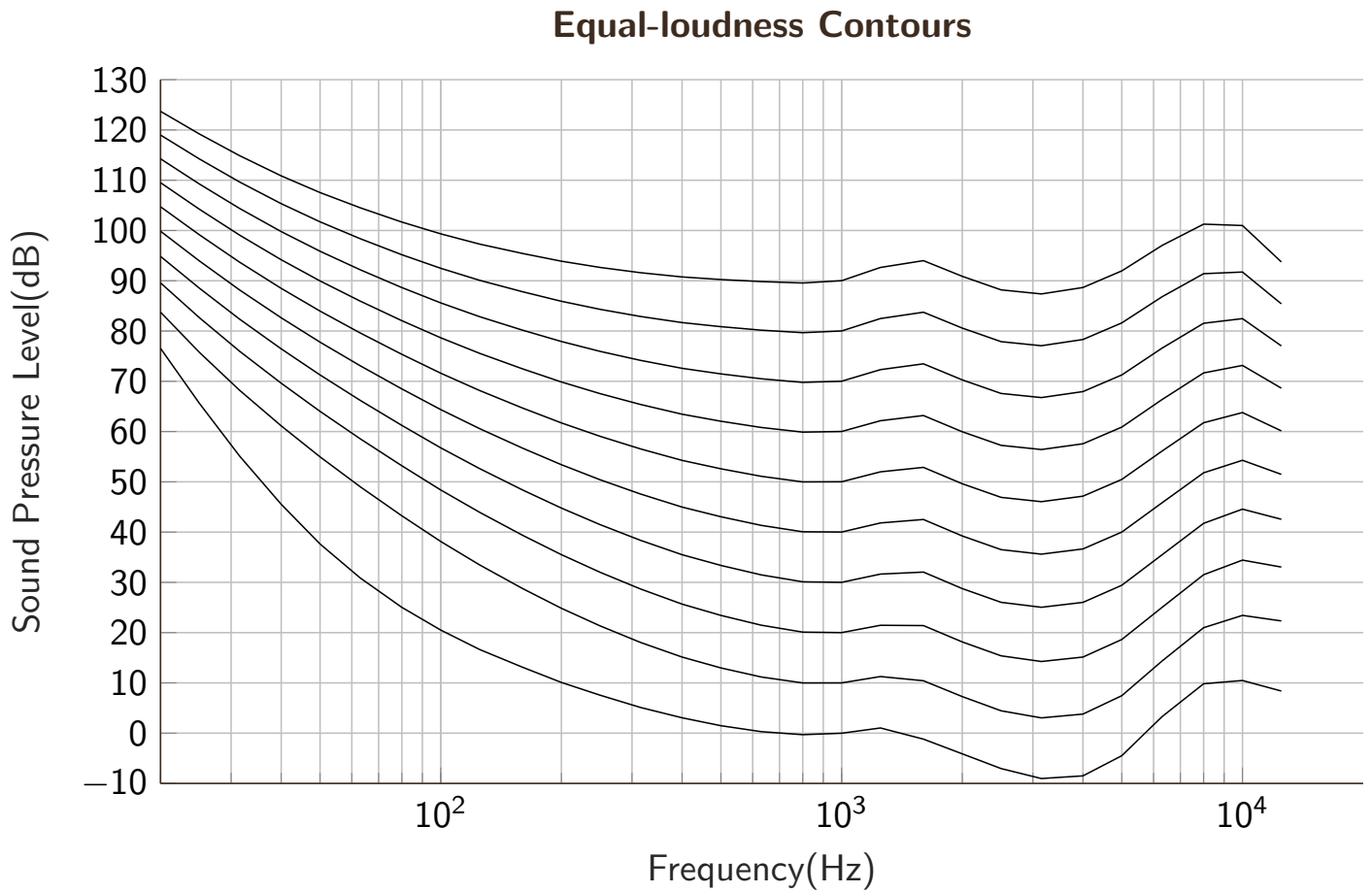
**According to ISO0226-2003:**

$$L_p = (\frac{10}{\alpha_f} \cdot \lg A_f - L_U + 94)$$

and

$$A_f = 4.47 \times 10^{-3} \times (10^{0.0025 L_N} - 1.15) + [0.4 \times 10^{(\frac{T_f + L_U}{10} - 9)}]^{\alpha_f}$$

- $L_p$ (dB): Sound pressure level
- $L_U$ (dB): Amplitude of linear transfer function based on 1000Hz
- $L_N$ (dB): Loudness level of pure sound
- $T_f$ (dB): Hearing threshold
- $\alpha_f$ (1): Loudness perception index


Equal-loudness Contours
Sound Pressure Level(dB)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
$10^2$
$10^3$
$10^4$
Frequency(Hz)