Decibel ~~Sc~~ Scale for Characterization of Acoustic Pressure.

The basic measurement scale for acoustic pressure is:

$$\text{Sound Pressure Level} = SPL = 20 \log \left[\frac{P_e}{P_{ref}} \right]$$

units ~~are~~ are "dB re P_{ref}".

P_e = Effective pressure amplitude

P_{ref} = Reference Pressure

p_e = root-mean-square amplitude at the measurement location (point).

In general $\quad p_e^2 = \frac{1}{T}\int_0^T p^2(x,t)\,dt \quad T$ = "long averaging period"

Wide-band acoustic pressure $\quad p(x,t)$

$\Rightarrow$ computation of p_e is "difficult".

If however,

$$p(x,t) = A\cos(\omega t + \theta) \qquad \theta = -kx + \phi$$

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In this circumstance

$$P_e = \frac{A}{\sqrt{2}}$$; Restrict ourselves to this case.

In the text, "$\bar{P}$" is used to denote acoustic amplitude A.

Secondly, the most commonly used P_{ref} is

$$P_{ref} = 20 \times 10^{-6}\ Pa = 20\ \mu Pa$$

A human, with "good" hearing, can hear a 1000 Hz pure tone of amplitude $20\ \mu Pa$ effective.

Examples:

$A = 1\ Pa \Rightarrow P_e = \frac{A}{\sqrt{2}} = \frac{1}{\sqrt{2}} = 0.707\ Pa$

$SPL = 20 \log\left[\frac{0.707}{20\times10^{-6}}\right] = 90.87\ dB$ re $20\,\mu Pa$

$P_e = 20\,\mu Pa$

$SPL = 20 \log\left[\frac{20\times10^{-6}}{20\times10^{-6}}\right] = 0\ dB$ re $20\,\mu Pa$

$P_e = 200\,\mu Pa = 0.2\,mPa$

$SPL = 20 \log\left[\frac{200\times10^{-6}}{20\times10^{-6}}\right] = 20\ dB$ re $20\,\mu Pa$

$P_e = 2000\,\mu Pa = 2\,mPa$

$$SPL = 20 \log \left[\frac{2000 \times 10^{-6}}{20 \times 10^{-6}} \right] = 40\,dB \text{ re } 20\,\mu Pa$$

$P_e = 2\,Pa$

$\Rightarrow SPL = 100\,dB \text{ re } 20\,\mu Pa$

$P_e = 20\,Pa \Leftrightarrow SPL = 120\,dB \text{ re } 20\,\mu Pa$

Another "commonly" used $P_{ref} = 1.0\,\mu bar$

Othere topics; Specific acoustic impedance, acoustic intensity, and acoustic power.

Specific acoustic impedance

Specific acoustic impedance is defined as the ratio of complex acoustic pressure amplitude to complex acoustic velocity amplitude at a point in space.

As an example, consider the specific acoustic impedance for a rightward-travelling wave;

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$$\hat{p}(x,t) = \hat{A} e^{j(\omega t - kx)} \quad ; \quad \hat{u}(x,t) = \hat{U} e^{j(\omega t - kx)} = \frac{\hat{A}}{\rho_0 c} e^{j(\omega t - kx)}$$

$\hat{z}$ = Specific acoustic impedance $= \frac{\hat{A}}{\hat{U}} = \frac{\hat{A}}{\frac{\hat{A}}{\rho_0 c}} = \rho_0 c$ = Characteristic acoustic impedance of the medium.

In general

these are amplitudes for a rightward-travelling wave

$\rho_0 c$, $\frac{kg}{m^2 s}$ = Rayls $\Rightarrow$ Turns out that this property is similar to wavelength, in that it determines acoustic behavior.

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for air: $\rho_0 c = 415$ Rayl

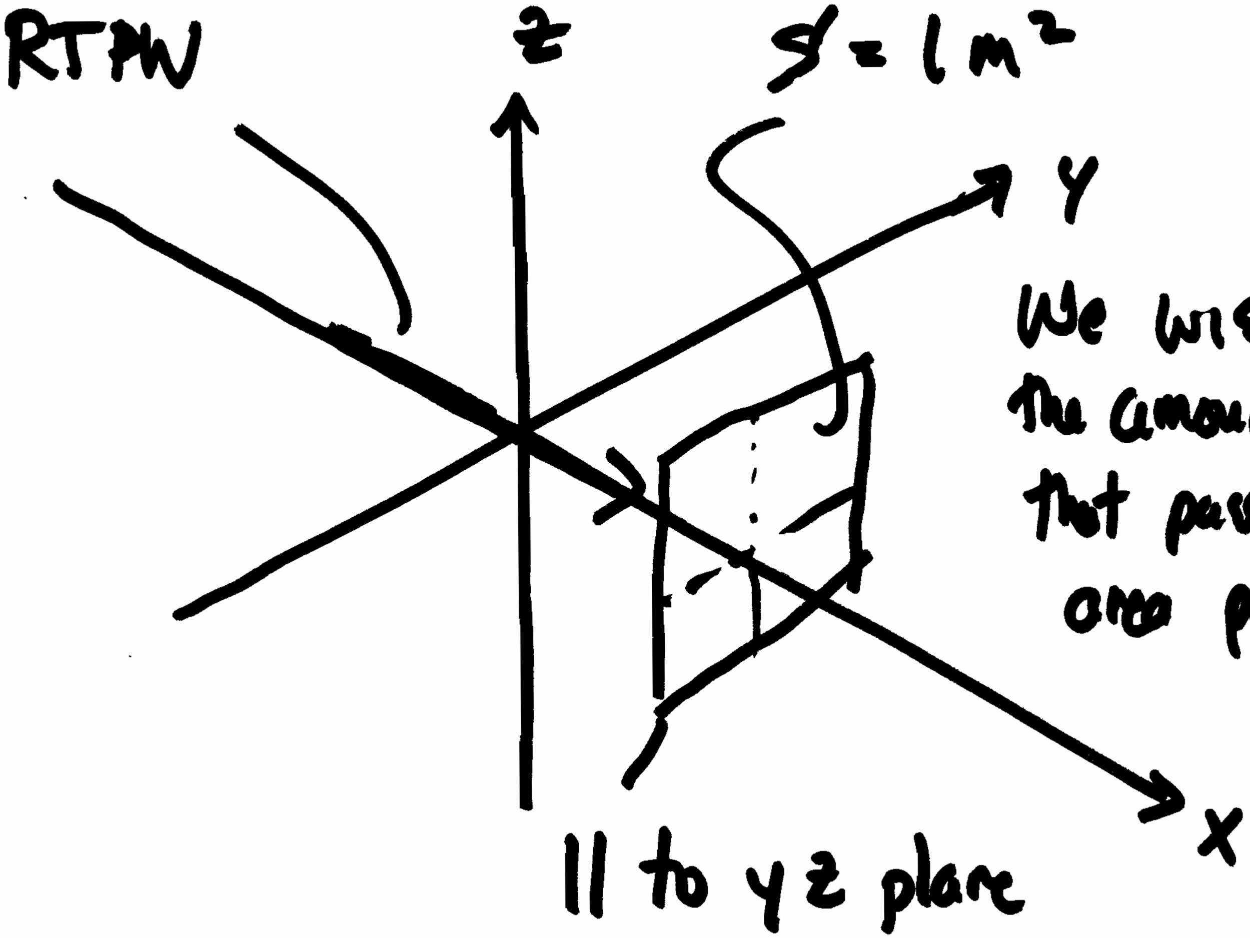
for water; $\rho_0 c = 1.5 \times 10^6$ Rayl $= 1.56$ M Rayl

Lets do another example; leftward-travelling plane wave;

$$\hat{p}(x,t) = \hat{A} e^{j(\omega t + kx)} \quad ; \quad \hat{u}(x,t) = \hat{U} e^{j(\omega t + kx)} = -\frac{\hat{A}}{\rho_0 c} e^{j(\omega t + kx)}$$

$\Rightarrow \hat{z} = \dfrac{\hat{A}}{\hat{U}} = -\rho_0 c \neq$ Characteristic ~~impedance~~ acoustic impedance of the medium.

Acoustic Intensity



We wish to know the amount of energy that passes thru this area per second.

In general, the ~~the~~ instantaneous acoustic ~~therm~~ intensity is:

$$\frac{\text{Force}}{\text{Area}}\ \text{velocity} = \frac{\text{Force} \cdot \text{velocity}}{\text{Area}}$$

$$\vec{I}_i(x,t) = p(x,t)\,\vec{u}(x,t) \quad ; \quad W/m^2$$

indicates instantaneous