Since $\tilde{p}(\vec{r},t) = \tilde{p}(\vec{r},\omega)\cdot e^{i\omega t}$ and $\tilde{\vec{u}}(\vec{r},t) = \tilde{\vec{u}}(\vec{r},\omega)\cdot e^{i\omega t}$, the complex 3-D vector ***specific*** acoustic impedance {here} is:

$$\tilde{\vec{z}}_a(\vec{r},\omega) = \frac{\tilde{p}(\vec{r},\omega)}{\tilde{\vec{u}}(\vec{r},\omega)} = \frac{\cancel{\tilde{p}(\vec{r},t)}}{-\frac{1}{\rho_o\omega}\left[\vec{\nabla}\varphi_p(\vec{r},\omega) - i\frac{\vec{\nabla}\left|\tilde{p}_o(\vec{r},\omega)\right|}{\left|\tilde{p}_o(\vec{r},\omega)\right|}\right]\cancel{\tilde{p}(\vec{r},t)}} = -\frac{\rho_o c(\omega/c)}{\left[\vec{\nabla}\varphi_p(\vec{r},\omega) - i\frac{\vec{\nabla}\left|\tilde{p}_o(\vec{r},\omega)\right|}{\left|\tilde{p}_o(\vec{r},\omega)\right|}\right]}$$

The ***purely <u>real</u>*** quantity $z_o \equiv \rho_o c = 1.204\left(kg/m^3\right)\cdot 343\left(m/s\right) \simeq 413 \ \left(Pascal\text{-}sec/m \equiv Rayls = \Omega_a\right)$ @ NTP is known as the ***<u>characteristic</u> <u>longitudinal</u> <u>specific</u> <u>acoustic</u> <u>impedance</u>*** of ***<u>free</u> <u>air</u>***.

Its inverse is the ***purely real <u>characteristic</u> <u>longitudinal</u> <u>specific</u> <u>acoustic</u> <u>admittance</u>*** of ***<u>free</u> <u>air</u>***: $y_o = 1/z_o = 1/\rho_o c \simeq 1/413 \simeq 2.42\times 10^{-3} \ \left(\Omega_a^{-1}\right)$.

Note that c, ρ_o, z_o and y_o are ***<u>not</u>*** constants, they are dependent *e.g.* on the air temperature, T as shown in the table below, for an ambient pressure of P_{atm} = 1.0 atmosphere:

Temperature (°C)	c (m/s)	ρ_o (kg/m^3)	z_o (Ω_a)	y_o (Ω_a^{-1})
–10	325.2	1.342	436.1	2.293×10^{-3}
–5	328.3	1.317	432.0	2.315×10^{-3}
0	331.3	1.292	428.4	2.334×10^{-3}
+5	334.3	1.269	424.3	2.357×10^{-3}
+10	337.3	1.247	420.6	2.378×10^{-3}
+15	340.3	1.225	416.8	2.399×10^{-3}
+20	343.2	1.204	413.2	2.420×10^{-3}
+25	346.1	1.184	409.8	2.440×10^{-3}
+30	349.0	1.165	406.3	2.461×10^{-3}

For the specific case of a monochromatic 3-D traveling plane wave propagating *e.g.* in "free air", using $k = \omega/c$, where $k = \left|\vec{k}\right| = \sqrt{k_x^2 + k_y^2 + k_z^2} \ \left(m^{-1}\right)$ and using the relation $z_o \equiv \rho_o c$, we can rewrite the above expression for the complex 3-D vector ***<u>specific</u>*** acoustic impedance for the specific case of a monochromatic 3-D traveling plane wave propagating *e.g.* in "free air" as:

$$\tilde{\vec{z}}_a(\vec{r},\omega) = \frac{\tilde{p}(\vec{r},\omega)}{\tilde{\vec{u}}(\vec{r},\omega)} = -\frac{k}{\left[\vec{\nabla}\varphi_p(\vec{r},\omega) - i\frac{\vec{\nabla}\left|\tilde{p}_o(\vec{r},\omega)\right|}{\left|\tilde{p}_o(\vec{r},\omega)\right|}\right]}\cdot z_o$$

We can also write this as a dimensionless relation, and since $\tilde{\vec{z}}_a(\vec{r},t) = \rho_o\tilde{\vec{c}}_a(\vec{r},t)$, we have:

$$\frac{\tilde{\vec{z}}_a(\vec{r},\omega)}{z_o} = \frac{\tilde{\vec{c}}_a(\vec{r},\omega)}{c} = -\frac{k}{\left[\vec{\nabla}\varphi_p(\vec{r},\omega) - i\frac{\vec{\nabla}\left|\tilde{p}_o(\vec{r},\omega)\right|}{\left|\tilde{p}_o(\vec{r},\omega)\right|}\right]}$$