Next, we explain why $\vec{\tilde{z}}_a(\vec{r},\omega)$ and $\vec{\tilde{y}}_a(\vec{r},\omega)=1/\vec{\tilde{z}}_a(\vec{r},\omega)$ are called complex ⇒ ***specific*** ⇐ acoustic impedance and admittance, respectively. As mentioned above, $\vec{\tilde{z}}_a(\vec{r},\omega)$ and $\vec{\tilde{y}}_a(\vec{r},\omega)=1/\vec{\tilde{z}}_a(\vec{r},\omega)$ are immittances ***specifically*** associated with the propagation medium. And, in order to avoid confusion, there {already} exists two ***other*** acoustic immittance quantities, known as the complex 3-D vector acoustic impedance $\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)$ and the complex 3-D vector acoustic admittance $\vec{\tilde{Y}}_a(\vec{r},\omega)=1/\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)$, which are associated with the acoustics of sound waves propagating inside ***ducts*** (*i.e.* pipes) with cross-sectional area $S_\perp$ as defined below:

Complex 3-D Acoustic Immittances (for Harmonic Sound Fields):

Complex 3-D Acoustic Impedance:

$$\boxed{\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)\equiv\frac{\tilde{p}(\vec{r},\omega)}{\vec{\tilde{u}}(\vec{r},\omega)S_\perp}=\frac{1}{\vec{\tilde{Y}}_a(\vec{r},\omega)}\quad\left(\begin{matrix}Pa\text{-}s/m^3\\=N\text{-}s/m^5\end{matrix}=Rayl/m^2\right)}$$

Complex 3-D Acoustic Admittance:

$$\boxed{\vec{\tilde{Y}}_a(\vec{r},\omega)\equiv\frac{\vec{\tilde{u}}(\vec{r},\omega)S_\perp}{\tilde{p}(\vec{r},\omega)}=\frac{1}{\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)}\quad\left(\begin{matrix}m/Pa\text{-}s\\=m^3/N\text{-}s\end{matrix}=Rayl^{-1}\text{-}m^2\right)}$$

Note that the quantity $\vec{\tilde{U}}(\vec{r},\omega)\equiv\vec{\tilde{u}}(\vec{r},\omega)S_\perp$ $\left(m/s\cdot m^2=m^3/s\right)$ is known as the ***volume*** ***velocity***, because of its dimensions $\left(m^3/s\right)$.

Inside a duct of cross sectional area $S_\perp$, the complex 3-D vector ***specific*** acoustic immittances $\vec{\tilde{z}}_a(\vec{r},\omega)$ and $\vec{\tilde{y}}_a(\vec{r},\omega)=1/\vec{\tilde{z}}_a(\vec{r},\omega)$ are thus related to the complex 3-D vector immittances $\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)$ and $\vec{\tilde{Y}}_a(\vec{r},\omega)=1/\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)$ by the relations:

$$\boxed{\vec{\tilde{z}}_a(\vec{r},\omega)=\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)S_\perp}\quad\text{and}\quad\boxed{\vec{\tilde{y}}_a(\vec{r},\omega)=\vec{\tilde{Y}}_a(\vec{r},\omega)/S_\perp}$$

or:

$$\boxed{\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)=\vec{\tilde{z}}_a(\vec{r},\omega)/S_\perp}\quad\text{and}\quad\boxed{\vec{\tilde{Y}}_a(\vec{r},\omega)=\vec{\tilde{y}}_a(\vec{r},\omega)S_\perp}$$

From the above relations, since the complex 3-D vector ***specific*** acoustic immittances $\vec{\tilde{z}}_a(\vec{r},\omega)$ and $\vec{\tilde{y}}_a(\vec{r},\omega)=1/\vec{\tilde{z}}_a(\vec{r},\omega)$ are manifestly ***frequency*** ***domain*** quantities, we see that the complex 3-D vector acoustic immittances $\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)$ and $\vec{\tilde{Y}}_a(\vec{r},\omega)=1/\vec{\tilde{\mathbb{Z}}}_a(\vec{r},\omega)$ are also manifestly ***frequency*** ***domain*** quantities.