Conversion: Sound pressure to Sound intensity and vice versa (Formulas)

Deutsch: Umrechnung und Formeln: Schalldruck in Schallintensität und zurück
http://www.sengpielaudio.com/SchalldruckInSchallintensitaetFormel.pdf

Here are the equations (formulas) for the often desired direct conversion of sound pressure to sound intensity and vice versa.

UdK Berlin
Sengpiel
05.2013
Tutorium

Sound pressure p 1 Pa ≡ 0.0025 W/m² (equivalent to sound level 94 dB)
The threshold of hearing is the fixed reference sound pressure p_0 = 20 µPa = 2 · 10⁻⁵ Pa.
This corresponds to f = 1 kHz at the sound pressure level L_p = 0 dB.

$$p = 2 \cdot 10^{-5} \cdot 10^{\frac{10 \cdot \log\left(\frac{I}{10^{-12}}\right)}{20}}$$

Sound intensity I 1 W/m² ≡ 20 Pa (equivalent to sound level 120 dB)
The threshold of hearing is the fixed reference sound intensity I_0 = 1 · 10⁻¹² W/m².
This corresponds to f = 1 kHz at the sound intensity level L_W = 0 dB

$$I = 10^{-12} \cdot 10^{\frac{20 \cdot \log\left(\frac{p}{10^{-5}}\right)}{10}}$$

There is another easier way, assuming of the rounded constant:
Specific acoustic impedance of air Z_0 = 400 N·s/m³

(Specific acoustic impedance of air: Z_0 = 413 N·s/m³ or Pa·s/m at 20°C)

Sound pressure p 1 Pa ≡ 0.0025 W/m² (equivalent to sound level 94 dB)

$$p = \sqrt{I \cdot Z} = \sqrt{I \cdot 400}$$

Sound intensity I 1 W/m² ≡ 20 Pa (equivalent to sound level 120 dB)

$$I = \frac{p^2}{Z} = \frac{p^2}{400}$$

"Temperature Dependence of Physical Quantities":
http://www.sengpielaudio.com/TemperatureSound.htm
Speed of sound c, density ρ, Specific acoustic impedance of air $Z = \rho \cdot c$

"Direct Conversion: Sound pressure to Sound intensity and vice versa":
http://www.sengpielaudio.com/calculator-soundvalues.htm
http://www.sengpielaudio.com/calculator-soundlevel.htm