Procedure for Estimating the Combined Noise Level of Multiple Acoustic Sources

Assumptions:
Noise levels are expressed in $\mathbf{dB}_{SPL}$
Noise sources have similar frequency profiles (i.e., same band)
Noise sources are uncorrelated or incoherent (i.e., not phase locked)
$\mathbf{dB}_{SPL} = 20 * \log_{10}(\text{sound pressure}/20\ \mu Pa)$

note: 20 μPa is the ISO replacement for the outmoded 0.0003 dynes/cm^2 reference level
1 Pa = 1 N/m^2 (i.e., Pa = Pascal)
1 atmosphere = 101,325 Pa

Sample problem:
What is the combined sound level output of two machines that each generate 80 $\mathbf{dB}_{SPL}$ of noise?
(Hint: The correct answer is not 160 dB)

Step 1.
Convert $\mathbf{dB}_{SPL}$ levels to raw pressure values:

pressure = 10 ^ ($\mathbf{dB}_{SPL}$ /20) * 20 μPa

If $\mathbf{dB}_{SPL}$ = 80 (as in our sample problem), then raw pressure can be computed as follows:

pressure = 10 ^ (80/20) * 20 = 104 * 20 = 200,000 μPa

Step 2.
Convert the raw pressure amplitudes to power values (i.e., square them), sum the resulting power values and then convert this sum back to a pressure amplitude value (via a square-root operation).

i.e., RMS pressure = $(\text{pressure}_1^2 + \text{pressure}_2^2)^{0.5}$
Given the case of the sample problem above:
$(200{,}000^2 + 200{,}000^2)^{0.5} = (8\text{x}1010)^{0.5} = 282{,}843$ μPa RMS pressure

Step 3.
Convert the summed pressure amplitude calculated in Step 2 to $\mathbf{dB}_{SPL}$ as follows:

$\mathbf{dB}_{SPL} = 20 * \log_{10}(\text{summed pressures}/20\ \mu Pa)$
$\mathbf{dB}_{SPL} = 20 * \log_{10}(282{,}843/20) = 20 * \log_{10}(14{,}142)$
$\mathbf{dB}_{SPL} = 83.0$

or

$$dB_{Total} = 10 \times Log\left(\sum_{i=1}^{n} 10^{\left(\frac{dB_i}{10}\right)}\right)$$