Procedure for Estimating the Combined Noise Level of Multiple Acoustic Sources

Assumptions:
Noise levels are expressed in $\text{dB}_{\text{SPL}}$.
Noise sources have similar frequency profiles (i.e., same band).
Noise sources are uncorrelated or incoherent (i.e., not phase locked).

$\text{dB}_{\text{SPL}} = 20 \times \log_{10}(\text{sound pressure}/20 \ \mu\text{Pa})$

Note: 20 $\mu\text{Pa}$ 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 $\text{dB}_{\text{SPL}}$ of noise?
(Hint: The correct answer is not 160 dB)

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

$\text{pressure} = 10^{\frac{\text{dB}_{\text{SPL}}}{20}} \times 20 \ \mu\text{Pa}$

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

$\text{pressure} = 10^{\frac{80}{20}} \times 20 = 10^4 \times 20 = 200,000 \ \mu\text{Pa}$

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:

$(200,000^2 + 200,000^2)^{0.5} = (8 \times 10^4)^{0.5} = 282,843 \ \mu\text{Pa}$ RMS pressure

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

$\text{dB}_{\text{SPL}} = 20 \times \log_{10}(\text{summed pressures}/20 \ \mu\text{Pa})$

$\text{dB}_{\text{SPL}} = 20 \times \log_{10}(282,843/20) = 20 \times \log_{10}(14,142)$

$\text{dB}_{\text{SPL}} = 83.0$

or

$\text{dB}_{\text{Total}} = 10 \times \log \left( \sum_{i=1}^{n} 10^{\frac{\text{dB}_i}{10}} \right)$