Laboratory exercise on sound power determination using sound intensity

The sound power of three different noise sources should be determined in one-third octave bands in the frequency range from 50 Hz to 10 kHz. Source no 1 is a Brüel & Kjær (B&K) 'Sound Source' of type 4205, a loudspeaker driven with pink noise. Source no 2 is an aerodynamic source, B&K's 'Reference Source' of type 4204. Source 3 is a dipole consisting of two loudspeaker units driven in antiphase. The purpose of the exercise is to determine the sound power of the three sources using the sound intensity method in an ordinary room, and get an idea of the usefulness of in-situ sound intensity measurements, as well as its practical limitations.

Preparation: Read Ch. 6 of reference 1 carefully. Equation (6.12) is the very basis of intensity-based sound power measurements. You should pay particular attention to section 6.4 about the measurement principle and its limitations.

The sound intensity measurement system is a Brüel & Kjær Pulse. This analyser can determine the sound intensity and the mean square pressure in one-third octave bands up to 10 kHz. The sound power of the source under test is determined using the so-called scanning technique, that is, by integrating the normal component of the sound intensity while the intensity probe is slowly moved (manually) along a path that represents the enclosing surface. One scans over one segment (partial surface) at a time, and then repeats the measurement using a different scanning pattern. A typical measurement surface is box-shaped and has five segments, since the source is often placed on the floor, which usually can be assumed to be rigid.

Before you carry out the actual measurements it is a good idea to familiarise yourself with the measurement system. It is important to note that the results of each completed scan measurement should be multiplied with the area of the integration surface as to yield the sound power. The pressure-intensity index of the sound field is automatically determined by the analyser. This will give an indication of how critical the measurement condition is, and it is important to consider this quantity when analysing your results. The measurements should be carried out without and also with a disturbing source of noise (one of the other sources) outside the measurement surface. You may find that you have unacceptably high values of the pressure-intensity index in some frequency bands in the measurements with such background noise – this simply demonstrates that there is a limit to the amount of noise from sources outside the measurement surface that can be tolerated. Also the repeatability of the measurements should be examined, by having two different operators measuring the same source.

Note: When saving your data from the analyser, remember to transfer not only the averaged sound intensity, but also the pressure-intensity index (estimated from the measurement).

A correction for the sensitivity of the microphones (to compensate for the free-field response) should be added. The intensity and sound power data should be corrected as:

Centre frequency (kHz)	1.25	1.6	2	2.5	3.15	4	5	6.3	8	10
Correction (dB)	0.1	0.2	0.4	0.6	1.0	1.7	2.5	3.8	5.8	8.3

Report

The results of all sound power measurements should be presented in dB re 1 pW in one-third octave bands. Present the various sound power estimates, appropriately annotated, so as to demonstrate i) the reproducibility (show that different operators get almost the same results), ii) the influence of *weak* extraneous noise. Discuss your results and relate them to the relevant sources of error (particularly finite difference and phase mismatch errors). It makes sense to present the results from this lab exercise and the exercise *Sound power estimation in a reverberation room* in one single report. iii) Compare your results to

the ones obtained in the reverberation room (naturally, of the source placed in the center of the room, not close to wall or corners). The report should be submitted two weeks after the day of the last of these two exercises.

For guidance: expected length of the report (considering that two lab exercises are presented in one combined report) is approx. ~ 7-10 pages (Intro 0.5 p; Theory 1-3 pp; Setup 1 p. Results & discussion 4-7 pp.; Conclusions 0.5 p.). The report should be complete and concisely written. Please write it in the style of a *scientific article* (not a book or thesis).

References

[1] F. Jacobsen and P. M. Juhl, *Fundamentals of General Linear Acoustics*, John Wiley and Sons, 2013 (Corresponding to note no 31262 “Sound intensity and its measurement and applications”, 2011; particular attention to sections 3.1 and 3.2).