Field Calibration of the Reference Sound Source Type 4204

Introduction

Bruel & Kjaer Reference Sound Source Type 4204 is a calibrated source of sound power. It is used mainly for determination of the sound power output of machines and appliances by the comparison, substitution and juxtaposition methods. Procedures for determining the sound power levels of noise sources using a reference sound source are included in ISO standards 3741/42/43/44/46 and ISO/DIS 3747/48. The application of reference sound sources is described in more detail in ISO/DIS 3747.

Type 4204 fulfils the requirements of ISO/DIS 6926.2 which deals with the characterization and calibration of reference sound sources for the determination of sound power.

Factory Calibration

Type 4204 is an extremely stable and rugged aerodynamic sound source. It consists essentially of a centrifugal fan driven by a powerful asynchronous motor. The motor is equipped with an external rotor with a high moment of inertia. This ensures a constant frequency of rotation and a stable noise spectrum.

Before leaving the factory the Type 4204 is individually calibrated in an anechoic chamber. A typical calibration chart is shown in Fig. 1. The calibration is carried out in accordance with ISO/DIS 6926.2 and involves placing the 4204 on a reflecting plane in the anechoic room and recording the sound pressure levels in 1/3-octave bands at a number of positions on a hemisphere that encloses the source.

This is a rather involved procedure and a very simple and precise method of checking the output of the 4204 in the field is now available. Using the supplementary data given on the calibration chart, corrections to the calibrated output levels can be made to account for the in-situ operating conditions of the Sound Source.

Field Calibration

Provided that the 4204 has not suffered any physical damage, any deviation in sound power output from that stated on the calibration chart will be determined by three factors:

Variations in Rotational Speed. These are determined by: a) Mains Supply Line Frequency; b) Mains Supply Voltage; and c) Ambient Pressure and Temperature. The effects of ambient pressure and temperature on rotational speed are due to the pressure and temperature loading of the motor and are quite separate from the acoustical effects described below.

The relationship between sound power output and rotational speed is shown in Fig. 2, indicating an empirical relationship of 0.5 dB/Hz change in output sound power level due to a change in rotational speed.

Ambient Pressure. Ambient pressure determines the specific acoustic impedance of the medium into which the Sound Source radiates and thus the sound power output depends on the barometric pressure at the location of operation.

Ambient Temperature. The specific acoustic impedance of the medi-
um into which the Sound Source radiates is also dependent on the temperature at the location of operation. Thus the sound power output is also temperature dependent.

Field calibration of the 4204 is carried out by determining the rotational speed, ambient pressure and ambient temperature at the location of operation and applying suitable corrections to the calibrated sound power levels. The procedure is as follows:

1. Measure the in-situ frequency of rotation \( f \) of the Sound Source. This can be easily determined using an accurate high-quality stroboscope such as Brüel & Kjær Portable Stroboscope Type 4912.

   Add a correction factor \( \Delta L_f \) to the sound power levels given on the calibration chart. \( \Delta L_f \) is given by:

   \[
   \Delta L_f = 0.5 \times (f - f_{cal}) \quad [\text{dB}]
   \]

   where \( f_{cal} \) is the frequency of rotation given on the calibration chart.

2. Measure the ambient barometric pressure \( B \) (in mbar) and add a correction factor \( \Delta L_B \) to the sound power levels given on the calibration chart. \( \Delta L_B \) is given by:

   \[
   \Delta L_B = 10 \log_{10} \left( \frac{B}{B_{cal}} \right) \quad [\text{dB}]
   \]

   where \( B_{cal} \) is the barometric pressure given on the calibration chart.

3. Measure the ambient temperature \( T \) (in Kelvin) and add a correction factor \( \Delta L_T \) to the sound power levels given on the calibration chart. \( \Delta L_T \) is given by:

   \[
   \Delta L_T = 5 \log_{10} \left( \frac{T_{cal}}{T} \right) \quad [\text{dB}]
   \]

   where \( T_{cal} \) is the temperature given on the calibration chart (expressed in Kelvin).

**Example**
At the location of operation of a Sound Source, the rotational frequency \( f \), ambient pressure \( B \) and temperature \( T \) measured:

\[
f = 47.3 \text{ Hz}; B = 964 \text{ mbar}; T = 20^\circ \text{C}
\]

From calibration data:

\[
f_{cal} = 46.9 \text{ Hz}; B_{cal} = 1023 \text{ mbar}; T_{cal} = 17^\circ \text{C}
\]

Thus,

\[
\Delta L_f = 0.5 \times (47.3 - 46.9) = +0.2 \text{ dB}
\]

\[
\Delta L_B = 10 \log_{10} \left( \frac{964}{1023} \right) = -0.26 \text{ dB}
\]

\[
\Delta L_T = 5 \log_{10} \left( \frac{17}{20 + 273} \right) = -0.02 \text{ dB}
\]

Therefore a total correction \( \Delta L = \Delta L_f + \Delta L_B + \Delta L_T = (0.2 - 0.26 - 0.02) = -0.08 \text{ dB} \) should be added to the sound power output levels given on the calibration chart.

In this example, it is seen that a small temperature change gives a relatively small correction \( \Delta L_T \). The increased rotational speed is compensated for by the lower sound power output due to lower pressure and the overall correction is approximately \(-0.1 \text{ dB} \).