Brüel & Kjær application notes

Field Calibration of the Reference Sound Source Type 4204

Introduction

Brüel & Kjær 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.

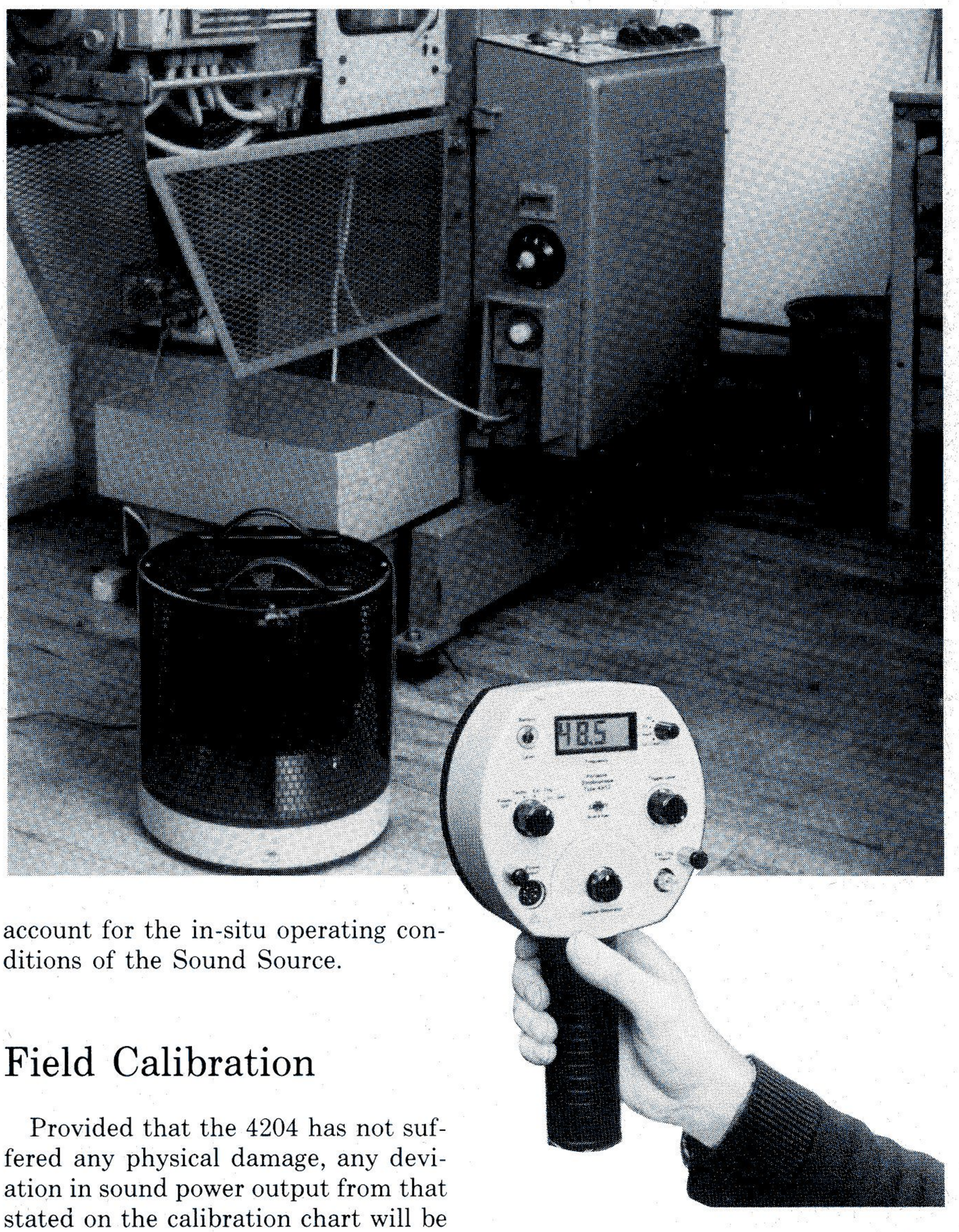
Type 4204 fulfils the requirements of ISO/DIS 6926.2 which deals with the characterization and calibration of reference sound sources for the determination of sound power.

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-

CALIBRATION TABLE FOR REFERENCE SOUND SOURCE 4204

Sound power is measured in 1/3 oct. bands.
1/1 oct. values and A-weighted value are calculated.

The sound source is placed in a free field above a reflecting plane.

Calibration accuracy : 100 - 160 Hz : +/- 1.0 dB
: 200 - 4000 Hz : +/- 0.5 dB
: 5000 - 10000 Hz : +/- 1.0 dB

Serial No.	1114279	Air Temperature	19	C
Date	3 April 1984	Barometric Pressure	1010	mbar
Sign.	Hans Christensen	Rel. Humidity	32	%

Sound Power in dB re. 1 pW

Line frequency	50.0 Hz		60.0 Hz	
Freq. of rotation	48.4 Hz		55.9 Hz	
Center freq. (Hz)	1/3 Oct. (dB)	1/1 Oct. (dB)	1/3 Oct. (dB)	1/1 Oct. (dB)
100	74.5		79.3	
125	74.7	79.8	78.7	83.9
160	75.7		79.4	
200	76.3		79.8	
250	76.1	81.0	80.0	84.8
315	76.4		80.2	
400	76.2		79.8	
500	76.1	80.9	79.7	84.5
630	76.2		79.8	
800	78.4		81.9	
1000	79.7	84.9	83.5	88.5
1250	81.6		85.1	
1600	81.4		85.2	
2000	80.3	85.1	84.5	89.2
2500	78.9		83.3	
3150	78.7		82.6	
4000	77.8	82.7	82.0	86.9
5000	77.4		81.7	
6300	76.1		80.6	
8000	74.1	79.2	78.8	83.8
10000	72.3		77.1	
Curve A :	90.5		94.5	

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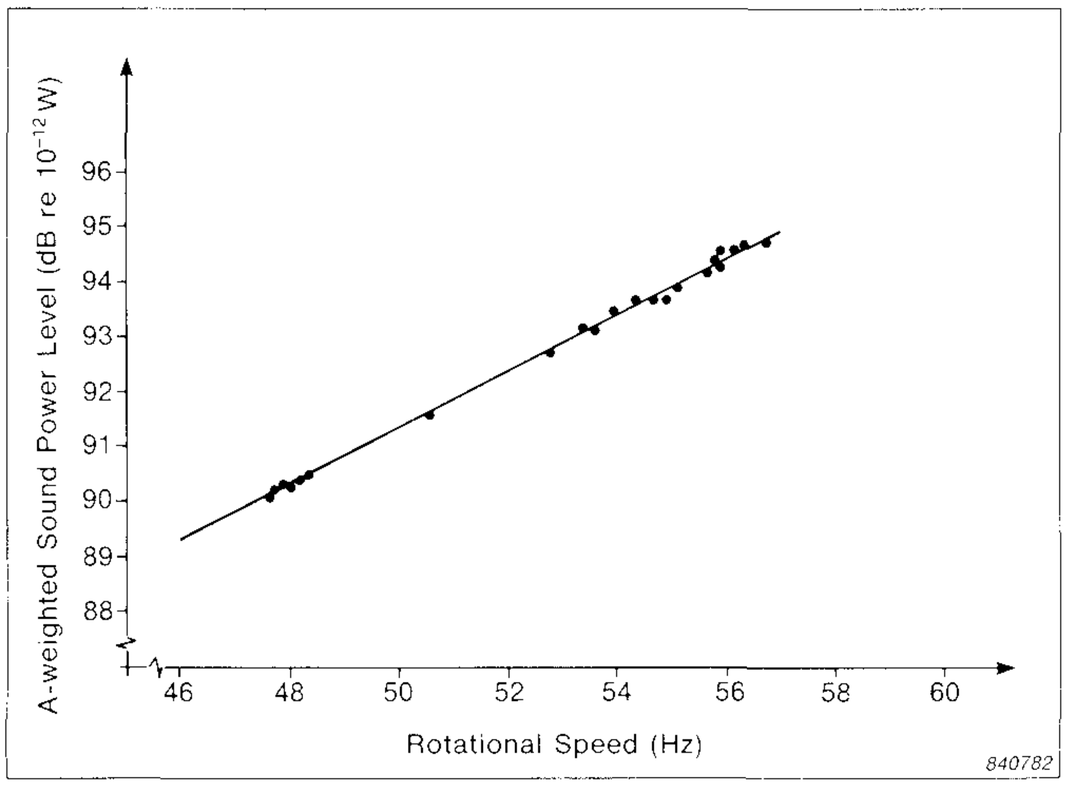
Fig. 1. Typical calibration chart for Type 4204. The Sound Source is individually calibrated in accordance with ISO/DIS 6926.2. It is placed in a free field above a reflecting plane and the sound power output levels are measured in 1/3-octave bands over the frequency range 100 Hz to 10 kHz. 1/1-octave and A-weighted levels are then calculated. The rotational frequency of the Source is determined using a stroboscope and environmental data at the time of calibration is given, allowing in-the-field calibration checks to be carried-out and corrections for variations in rotational speed, ambient temperature and pressure to be made

Fig. 2. Variation of sound power output with rotational speed for Type 4204, showing an empirical relationship of 0,5 dB/Hz



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 ΔL_f to the sound power levels given on the calibration chart. ΔL_f is given by:

   $$\Delta L_f = 0{,}5 \times (f - f_{cal}) \qquad [\text{dB}]$$

   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 ΔL_p to the sound power levels given on the calibration chart. ΔL_p is given by:

   $$\Delta L_p = 10 \log_{10} (B/B_{cal}) \qquad [\text{dB}]$$

   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 ΔL_T to the sound power levels given on the calibration chart. ΔL_T is given by:

   $$\Delta L_T = 5 \log_{10} (T_{cal}/T) \qquad [\text{dB}]$$

   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 are measured:

f = 47,3 Hz; B = 964 mbar; T = 20°C

From calibration data:

f_{cal} = 46,9 Hz; B_{cal} = 1023 mbar; T_{cal} = 17°C

Thus,

$$\Delta L_f = 0{,}5 \times (47{,}3 - 46{,}9) = +0{,}2\,\text{dB}$$

$$\Delta L_p = 10 \log_{10}\left[\frac{964}{1023}\right] = -0{,}26\,\text{dB}$$

$$\Delta L_T = 5 \log_{10}\left[\frac{(17 + 273)}{(20 + 273)}\right] = -0{,}02\,\text{dB}$$

Therefore a total correction $\Delta L = (\Delta L_f + \Delta L_p + \Delta L_T) = (0{,}2 - 0{,}26 - 0{,}02) = -0{,}08$ 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 ΔL_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 dB.

* Factory calibration of instruments from serial no. 1114253 includes determination of the frequency of rotation. For earlier instruments Brüel & Kjær offer a recalibration service which includes frequency of rotation

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