Application Note

Sound Power Determination according to ISO 374x

by *Erik Cletus Petersen, Brüel & Kjær, Denmark*

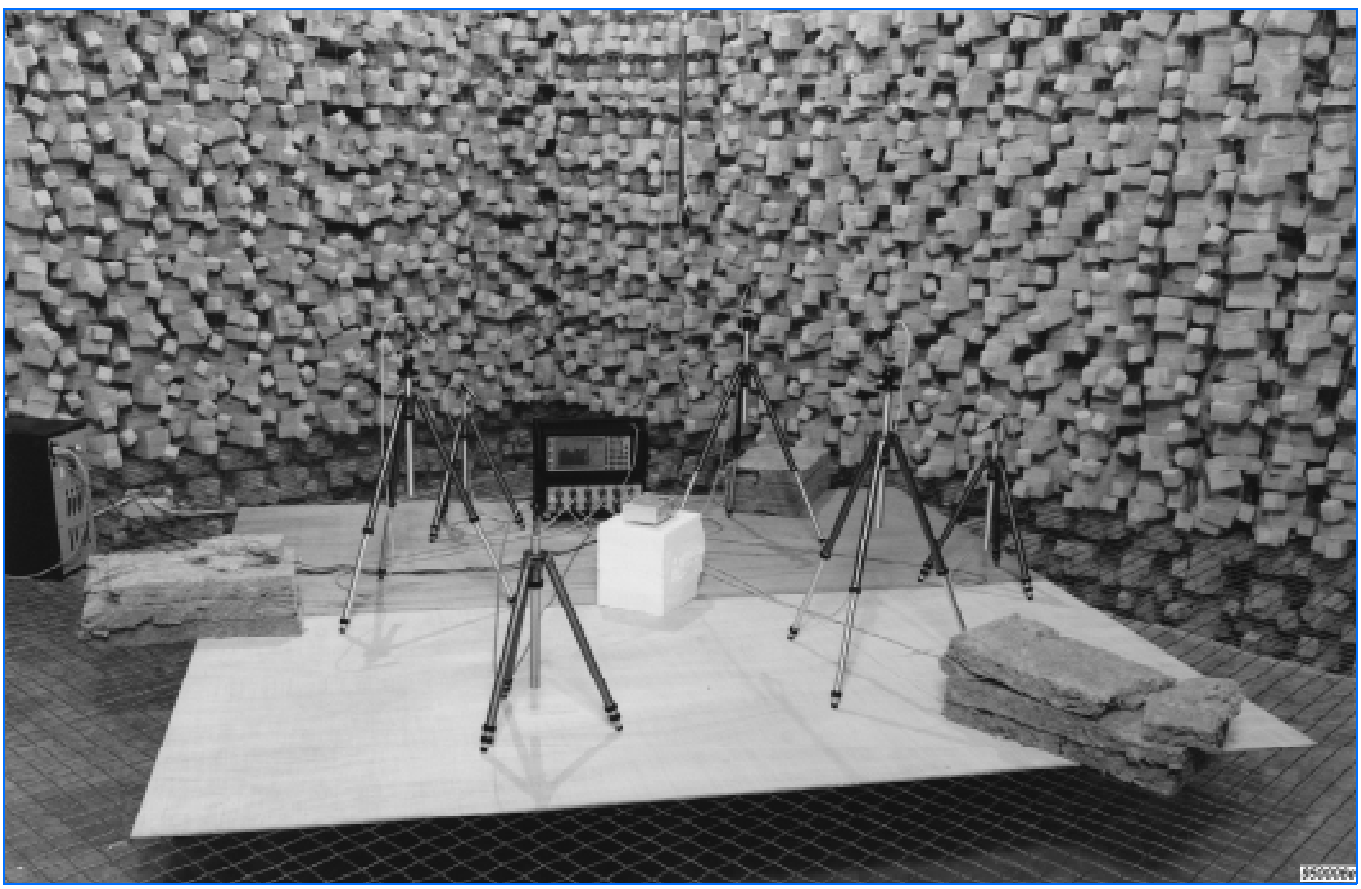

Fig. 1 Measuring a tape streamer according to ISO 3745 in the anechoic room. According to ISO 7779, the tape streamer must be placed 25 cm above the reflecting floor. 10 microphones are placed on a hemisphere. Multiplexer and analyzer can be seen behind the tape streamer, the PC is located outside the room

Labelling a Tape Streamer

More and more manufacturers are beginning to label their office machines regarding noise output. Two standards (noise test codes), describe the operational conditions, making comparison between products possible.

Office machines often consists of parts made by subsuppliers. Sound power labelling of each part is important, because it enables the manufacturer to predict the noise output from a new machine.

As an example, measurements have been made on a tape streamer from Tandberg Data Storage A/S, according to ISO 3744 and ISO 3745. The sound power has been determined using a computer program, Type 7680, running under MS-Windows™. The Windows™ environment makes a very good human interface to the ISO 374x standards. Based on the sound power level, the labelled value is finally determined according to ISO 4871 and ISO 7574.

Introduction

This is a typical case story regarding noise labelling of a tape streamer, made in cooperation with Tandberg Data Storage A/S, Oslo.

People, who are daily surrounded by various types of office machines, know how annoying the noise from them can be. Office machines are normally not very noisy and that makes them automatically in harmony with

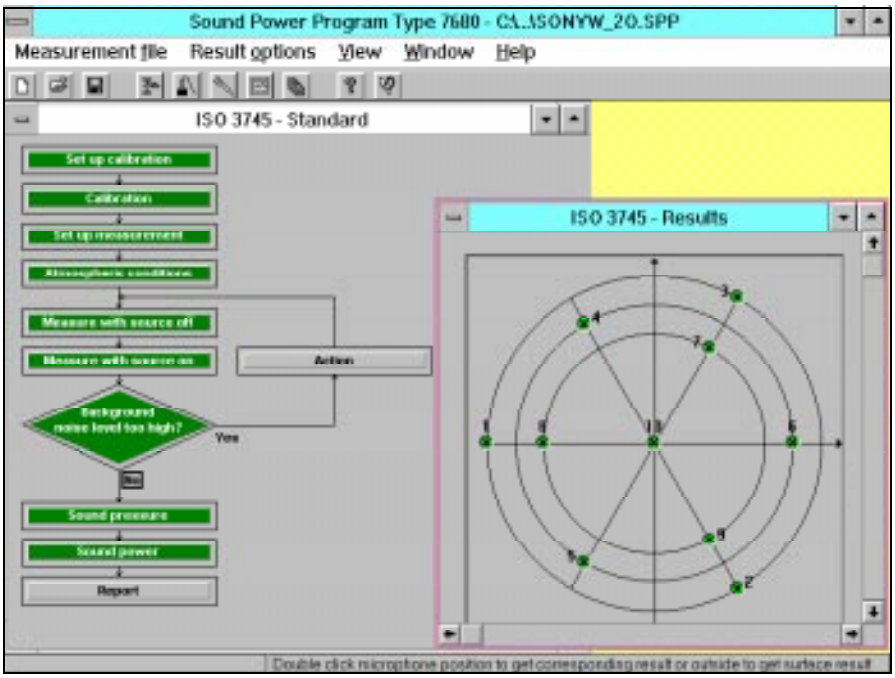

Fig. 2 The Windows™ environment makes a very good human interface to the standard. Just let the flowchart guide you through the measurements and mathematical expressions. No need to spend hours trying to understand difficult standards. The dedication towards sound power determination makes the program very easy to use, even without reading any manuals

the machinery directive 89/392/EEC, 91/368/EEC, 93/44/EEC and 93/68/EEC, the electrical equipment directive 73/23/EEC and 93/68/EEC or any other directive regarding acoustic noise emission.

Also, there is a customer driven request for silent equipment. Since specifications of competitive products are almost identical or the specifications are difficult to understand, the noise has become a new competitive parameter – customers simply choose the most silent equipment.

A computer is an assembly of different parts, e.g. power supply, hard disk, floppy drive, etc. To be able to predict the emitted noise for a particular configuration, the manufacturer needs to know the sound power level from each part of the machine he might even choose the subcontractor supplying the most silent parts.

Selecting the right standard

Tandberg Data Storage A/S, Oslo, Norway, is one of the leading manufacturers of high capacity QIC compatible tape streamers. To fulfil their customer' requests for emitted noise specifications, they need to determine the sound power level. Several standards, dealing with sound power determination, are either based on sound intensity (ISO 9614) or sound pressure measurements (ISO 374x). Common for these standards is that they do not indicate anything about the circumstances under which the equipment should be tested.

It is therefore necessary to chose a "noise test code" like ECMA 74 or ISO 7779. In this case, it would be the ISO 7779 standard (Measurement of airborne noise emitted by computer and business equipment), which is in harmony with the ISO 374x family. Regarding labelling, ISO 4871 (Noise labelling of machinery and equipment) and ISO 7574 (Statistical methods for determining and verifying stated noise emission values of machinery and equipment) will be used. Note that because the emitted noise from a tape streamer is very low, intensity based methods are not convenient (less sensitivity of intensity probes and additional human noise using scanning).

Preparations

According to ISO 7779 paragraph C.8, the tape drive must be tested in 3 different modes:

1. Idling unload mode. Power must be switched on; the tape must not be loaded in the column.
2. Idling loaded mode. Power must be switched on; the tape must be loaded and the equipment must be ready to receive and respond to control line commands.
3. Operation mode. The streamer must either "start, read or write, stop" – with command timing for capstan operation as given by the standard, or be in "streaming" mode – forward run while writing.

The standard prescribes 10 measurement positions on a hemisphere with a radius of 1 m. The "sub-assembly" must be supported 0.25 m above the reflecting plane by vibration-isolating elements. The acoustic field should be free according to ISO 3745 (anechoic room) or preferably be free- or nearly free-field according to ISO 3744 (office). Since the tape streamer has almost spherical directivity, additional points are not needed. Calculations and corrections for the acoustical environment (ISO 3744 only) and for the background noise are done automatically by the Brüel & Kjær Sound Power Program Type 7680.

According to Tandberg Data Storage A/S, one of the noisiest sources is the tape cassette. Measurements should therefore be carried out using a wide range of tapes from a couple of manufacturers. For this measurement, Tandberg Data has chosen seven tapes from two different manufacturers. The sound power level is based on an average of the tapes used.

Measurements

The ISO 7779 standard recommends that the sound power determination is performed according to ISO 3745. A large reflecting plane is installed in the anechoic room. The 10 free-field microphones are placed on a hemisphere, pointing towards the centre (see Fig. 1). The MS-Windows™ based Sound Power Program Type 7680 facilitates that the measurements are performed quickly and easily (see Fig. 2).

The measurement is carried out in 1/3-octaves from 100 Hz to 10 kHz. First the background noise is measured, and then the noise from the tape streamer under operation is measured.

To fulfil ISO 3745, the source noise must be at least 6 dB above the background noise, which in this case was not fulfilled in the 500 Hz 1/3-octave band. One way to cope with this type of problem is to use 1/1-octave filters instead.

The measurement was repeated giving the same A-weighted value, but this time, the background noise field check, given by ISO 3745, was fulfilled.

$$L_{WA} = 52.6\,\text{dB re } 1\,\text{pW}$$

The result of the measurement is illustrated in Fig. 3.

The measurement of seven tapes took approximately two hours, calibration and reporting included.

A new test was performed, but now using the ISO 3744 standard. The instrumentation set-up was moved into an office (see Fig. 4). The standard prescribes a limit in acoustical hardness of the room (the amount of reflections from the walls).

To fulfil this requirement, it was necessary to insert some absorption material in the room. The A-weighted sound power level, determined in the office, was 0.7 dB larger than the value obtained in the anechoic room.

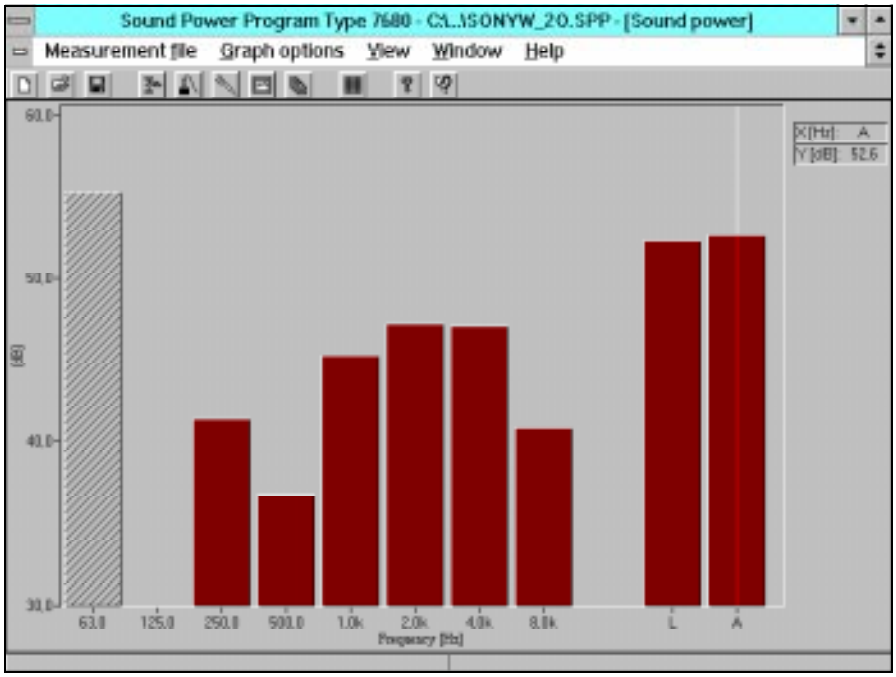

Fig. 3 The sound power spectrum of one of the tapes, as presented in the program. Note that the 63 Hz octave band is "excluded" from the valid sound power determination according to ISO 3745

Labelling

The sound power has now been determined, using two different standards. In the following, the result of the measurement in the anechoic room, according to ISO 3745, will be used, but which number should be stated as the official value? 52.6 dB? The labelling of the tape streamer could be done according to ISO 4871, which refers to ISO 7574 parts 1 to 4 giving information about stating and verification of labelled values. The standard deviation of the sound power level of a batch of machines can be found as:

$$\sigma_t = \sqrt{\sigma_R^2 + \sigma_P^2}$$

where

σ_R is the reproducibility

σ_P is the due to production

The reproducibility is in this case determined by the precision of the method.

The ISO 3745 standard does not prescribe any standard deviation for A-weighted values because they are optional. The A-weighted σ_R can be determined from the standard deviation of the individual filter bands, to approx. σ_R = 0.6 dB. (Using ISO 3744, the A-weighted σ_R = 1.5 dB). Since there was only one tape streamer available, and since the primary noise is caused by the tape casette, σ_P is based on measurements made on the seven tapes:

$$\sigma_P = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(L_i - \mu)^2} = 1.42\,\text{dB}$$

where

Fig. 4 Sound power determination in an office according to ISO 3744. With the reference sound source Type 4204, which can be seen behind the tape streamer, the acoustic properties of the room can be determined. To obtain sufficient absorption, absorption material had to be installed

L_i are the individual sound power levels in dB

μ is the mean sound power level in dB

σ_t can then be calculated as 1.54 dB.

In order to obtain the labelled value, the manufacturer must take into account the risk of rejection. According to a note in ISO 4871, a "recommended" risk of 5% determines the labelled value as:

$$L_{WA} = L_{WA\ meas} + 1.5 * \sigma_t = 55\ dB$$

If the sound pressure level in free-field conditions is of interest at a certain distance, r, it can be calculated from the following equation:

$$L_p = L_W - 10\log(2\pi r)$$

The sound pressure level, 1 m from the tape streamer, can be calculated as:

Area corr. $10 \log (2\pi r) = 8.0$ dB

$L_{pA} = 55$ dB $-$ 8 dB $= 47$ dB

According to ISO 7779 the tape streamer should be labelled for three different operation conditions (see "Preparations").

Noise output:

Idling unload ... L_{WA} < 25 dB re 1 pW
Idling loaded .... L_{WA} < 25 dB re 1 pW
Streaming ..... L_{WA} 55 dB re 1 pW

Note that in idling mode there are no mechanical movements, and the electronics do not make any audible or measurable noise. The sound power level is, therefore, just stated to be less than 25 dB(A), which corresponds to the measured background noise.

Conclusion

The sound power level from a tape streamer has been determined according to ISO 3744 and 3745. By using the Brüel & Kjær Sound Power Program Type 7680, long tedious calculations and verifications are done quickly and easily in accordance with the chosen ISO standard. The report generator included provides the user with a comprehensive report in seconds (see Fig. 5).

Runar Angelsen, Tandberg Data Storage A/S, said, after the measurement of seven tapes with two different streaming speeds, which was done in two hours, that a similar measurement, using the equipment available to them, would have taken three days!

From the results, the labelling values have been established. For the manufacturer, it is of course necessary to determine the sound power level of several tape streamers, in order to establish a certain accuracy on the labelled value.

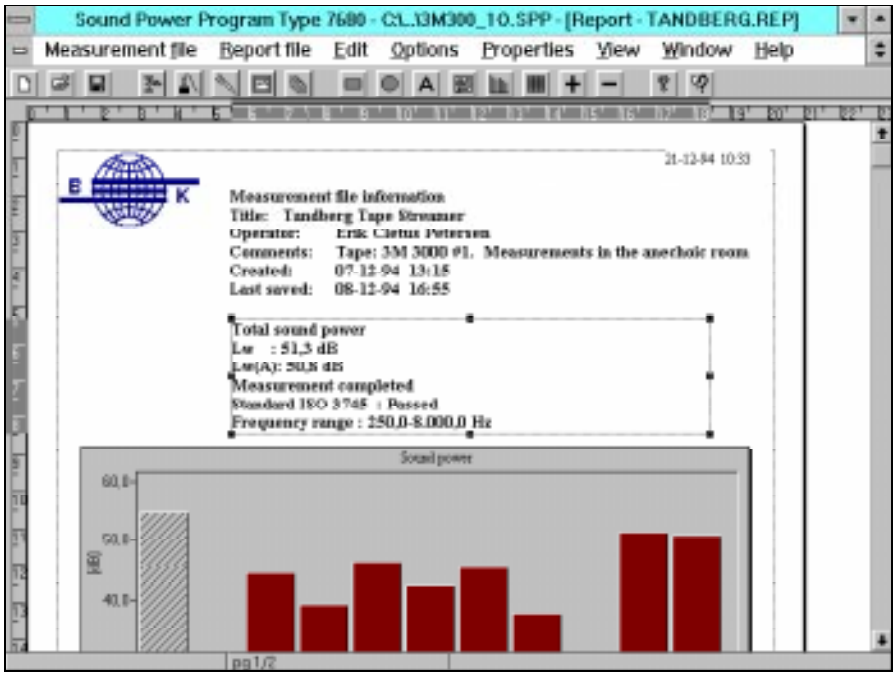

Fig. 5 For more permanent documentation, the report generator included can generate comprehensive user-defined reports in seconds. The bitmapped Brüel & Kjær globe can easily be exchanged for any private company logo. The use of report templates enables the creation of various standardized company reports

Instrumentation

To perform the sound power determination, the following Brüel & Kjær equipment has been used:

- Type 2144 Portable Real-time Frequency Analyzer.
  Note that Type 2140, 2141 or 2143 could have been used instead.
- Type 2822 Microphone Multiplexer
- 10×Type 2669 Falcon™ Microphone Preamplifier
- 10×Type 4190 Falcon™ Condenser Microphone Cartridge
- Type 4231 Sound Level Calibrator
- Type 4204 Reference Sound Source
- Type 7680 Sound Power Program
- AO 0087 BNC Coaxial Cable
- 2×AO 0265 IEEE–488 Standard Digital Interface Cable
- 10×UA 0587 Portable Tripod
- PC with IEEE–488.2 interface running MS-Windows™

Reference

Brüel & Kjær Application Note: "An Overview of Standards for Sound Power Determination", BO 0416.

All measurement results are reproduced with the permission of Tandberg Data Storage A/S, Oslo, Norway.

Brüel & Kjær

WORLD HEADQUARTERS:
DK-2850 Naerum · Denmark · Telephone: +45 45 80 05 00 · Fax: +45 45 80 14 05 · Internet: http://www.bk.dk · e-mail: info@bk.dk
Australia (02) 9450-2066 · Austria 00 43-1-865 74 00 · Belgium 016/44 92 25 · Brazil (011) 246-8166 · Canada: (514) 695-8225 · China 10 6841 9625 / 10 6843 7426
Czech Republic 02-67 021100 · Finland 90-229 3021 · France (01) 69 90 69 00 · Germany 0610 3/908-5 · Holland (0)30 6039994 · Hong Kong 254 8 7486
Hungary (1) 215 83 05 · Italy (02) 57 60 4141 · Japan 03-3779-8671 · Republic of Korea (02) 3473-0605 · Norway 66 90 4410 · Poland (0-22) 40 93 92 · Portugal (1) 47114 53
Singapore (65) 275-8816 · Slovak Republic 07-37 6181 · Spain (91) 36810 00 · Sweden (08) 71127 30 · Switzerland 01/94 0 09 09 · Taiwan (02) 713 9303
United Kingdom and Ireland (0181) 954-236 6 · USA 1 - 800 - 332 - 2040
Local representatives and service organisations worldwide