



Designation: E 1124 – 97

## Standard Test Method for Field Measurement of Sound Power Level by the Two- Surface Method<sup>1</sup>

This standard is issued under the fixed designation E 1124; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the field, or *in situ* measurement of sound power level by the two-surface method. The test method is designed to minimize the effects of reverberant conditions, directivity of the noise source under consideration, and the effects of ambient noise from other nearby equipment operating at the same time.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

2.1 *ASTM Standards:*

C 634 Terminology Relating to Environmental Acoustics<sup>2</sup>

2.2 *ANSI Standard:*

S1.4 Specification for Sound Level Meters<sup>3</sup>

### 3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology C 634.<sup>4</sup>

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *conformal surface*—the locus of points which lie at a fixed distance from the reference surface of a piece of equipment. Two conformal surfaces are used in this test method. These are surfaces over which the measuring microphones are swept. They are located at two different distances from the equipment. Fig. 1 shows a typical arrangement of these surfaces for a generalized piece of equipment.

3.2.2 *constituent surface area*—a portion of the conformal surface.

### 4. Summary of Test Method

4.1 The average one-third or full octave band sound pressure levels are measured over two different conformal surfaces which envelop the equipment. These conformal surfaces should be selected to consist of rectangular, cylindrical, and hemispherical constituent surfaces so that the surface areas may be easily calculated. From the difference between the two average sound pressure levels taken at each surface and from the areas of the surfaces the sound power level may be calculated. The calculation accounts for both the effect of the reverberant field and the noise of other equipment. It is permissible to define conformal surfaces that completely envelope the source, yet only measure over a portion of the conformal surface due to restrictions from process connections or accessibility.

### 5. Significance and Use

5.1 The function and operation of equipment in the field often preclude the measurement of the free-field sound pressure levels of a single piece of equipment in the absence of interfering sound from other equipment operating at the same time. The two-surface method will provide, in most cases, a reliable estimate of the normal sound power levels of a specimen operating in an adverse environment.

5.2 This test method is intended for use in the field in the presence of what is normally regarded as interfering background noise. This test method is based upon the work of Hubner<sup>5</sup> and Diehl,<sup>7</sup> but differs from all other current sound power measurement procedures by requiring simultaneous measurement at both conformal surfaces and by resolving time-averaged sound pressure levels at both surfaces to within 0.1 dB. These two features, simultaneous recording and 0.1-dB

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee E-33 on Environmental Acoustics and is the direct responsibility of Subcommittee E33.08 on Mechanical and Electrical System Noise.

Current edition approved Sept. 10, 1997. Published June 1998. Originally published as E 1124 – 86. Last previous edition E 1124 – 92.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.06.

<sup>3</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

<sup>4</sup> Terminology C 634 – 85 was the edition used during the development of this test method.

<sup>5</sup> Hubner, G., "Analysis of Errors in Measuring Machine Noise Under Free Field Conditions," *Journal of the Acoustical Society of America*, Vol 54, No. 4, 1973, pp. 967–977.

<sup>6</sup> Hubner, G., "Qualification Procedures for Free Field Conditions for Sound Power Determination of Sound Sources and Methods for the Determination of the Appropriate Environmental Correction," *Journal of the Acoustical Society of America*, Vol 61, No. 2, 1977, pp. 456–464.

<sup>7</sup> Diehl, G. M., *Machinery Acoustics*, J. Wiley and Sons, New York, NY, 1973, pp. 97–103.

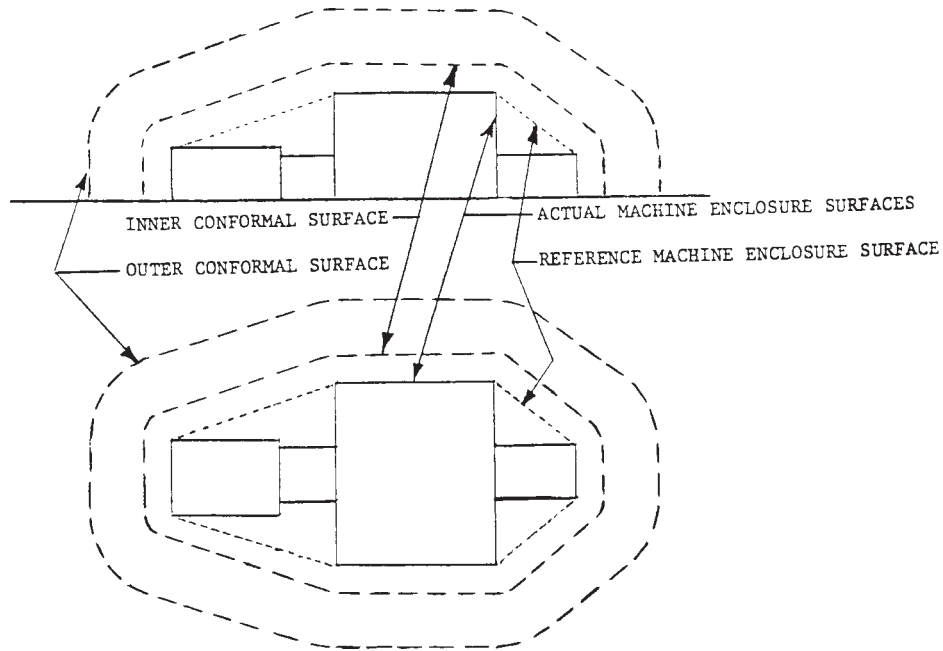


FIG. 1 Configuration of Conformal Surfaces, General Case

resolution, enable source sound power to be calculated when the direct sound field of the source is actually lower in level than the ambient noise.

5.3 The use of this test method is expected to be primarily for the relative assessment of the sound power from similar sources or for the prediction of sound levels in a plant based upon measurements of similar sources in another plant. This test method is believed to be capable of yielding a reasonably good estimate of absolute power level with proper care of application and full conformance to the provisions of this procedure.

5.4 The two-surface method is applicable only when the two measurement surfaces can be physically selected to produce positive values of the difference in average sound pressure level. That is, the inner surface sound pressure level minus the outer surface sound pressure level must be at least + 0.1 dB. This limitation applies to each frequency band and each constituent surface area investigated. Only the frequency band in which a zero or negative difference occurs is considered invalid and usually adjacent bands will be valid. In practice only rarely will all three one-third octave bands of a given octave yield invalid data at all constituent areas. Therefore less than complete results are permissible when one-third octave analysis is used and full octave results are reported.

5.5 The two-surface method may not produce results when testing some very large machines in very reverberant rooms or in rooms having a volume less than about 20 times the space enclosed by an envelope around the larger dimensions of the machine. In such cases, the sound pressure level close to the machine may not decrease in any regular way with increasing distance from a machine surface, making it impossible to select two measurement surfaces producing positive differences of sound pressure level.

## 6. Operating Conditions

6.1 Whenever possible, equipment under test must be operating in a mode acceptable to all parties involved in the test. Otherwise operating conditions must at least be monitored in order that the test results are properly qualified in terms of running speeds, flow rate, production rate, etc.

## 7. Apparatus

7.1 Due to the amount of data which must be gathered and processed, the following are considered to be the minimum equipment necessary to meet the requirements of this test procedure.

7.1.1 *Microphones*, that are matched in terms of frequency and pressure response. Begin by calibrating each data channel, using the same calibrator on each channel. Connect both microphone channels to the cables, connectors, amplifiers, and recorder to be used in data gathering. Then arrange the microphones side by side in the presence of broad band ambient noise and record for 60 s on both channels. The differences in the averaged sound pressure levels in each frequency band are calibration corrections which may be applied to either channel prior to any calculation.

7.1.2 *Magnetic Tape Recorder*, two-channel instrumentation grade having a frequency response of  $\pm 1$  dB over the frequency range of interest.

7.1.2.1 It is recognized that even high-quality Amplitude Modulation (AM) tape recorders cannot maintain channel-to-channel frequency response within 0.1 dB. It is believed, however, that the requirement for determining the corrections in 7.1.1 based on 60-s average readings sufficiently compensates for expected instabilities, channel-to-channel. If digital frequency modulation (FM) or pulse code modulation (PCM) tape recorders are used, the procedure of 7.1.1 should still be used.

NOTE 1—The frequency response and accuracy of the acoustical instruments are different from the interchannel resolution of the tape recorder. Both the frequency response discussed in 7.1.2 and the accuracy of the acoustical calibrators are distinctly different from the 0.1-dB resolution discussed in 5.2.

7.1.3 *Microphone Mounting Fixture*—A suggested fixture is shown in Fig. 2.

7.1.4 *Spectrum Analyzer*, real-time one-third or full octave, having a resolution of 0.1 dB with a digital display or printing capabilities.

NOTE 2—Real-time analyzers having a resolution of 0.25 dB may also be used. However, because of the requirement for a positive sound level difference, as discussed in 5.4, these analyzers may yield less complete results compared with what could be obtained with an analyzer with better resolution. In addition, the precision of the results will be reduced if only differences greater than 0.25 dB can be obtained.

7.2 Optional equipment may include:

7.2.1 *Programmable Calculator or Desktop Computer*.

7.2.2 *Data Processing*, direct from output of real-time analyzer.

8. Procedure

8.1 *Selection of Measurement Surfaces:*

8.1.1 Conduct a preliminary survey of the sound field to estimate the two optimum conformal measurement surfaces that will yield a measurable drop in average sound pressure

level between the two surfaces for the frequency range of interest. As stated in Section 5, merely a 0.1 dB difference in average sound pressure levels constitutes a measurable drop. However, the surfaces should be chosen so as to maximize the difference since the overall accuracy of the estimated sound power levels will be thereby improved. Obviously, the closer the inner surface is to the equipment, the easier it will be to obtain a large positive difference, but possible near-field effects dictate an inner surface farther from the equipment. Such near-field effects cannot be quantified by this test method nor can their effect on the calculated power levels be determined, so that this procedure can only suggest that the inner surface microphone be always at least 0.15 m, and for larger machines at least 0.3 m, from the equipment surface thereby avoiding most such effects.

8.1.2 If the locations of the two conformal surfaces are too close together, measurable differences in average sound pressure levels will be difficult to obtain. On the other hand, no advantage is gained by using progressively larger outer surfaces once the outer surface microphone is in the fully reverberant field since the sound level, and therefore the differential, will be constant. No clear optimum ratio between these two surface areas can be prescribed for all equipment. As a guide, however, experience has shown that an area ratio of

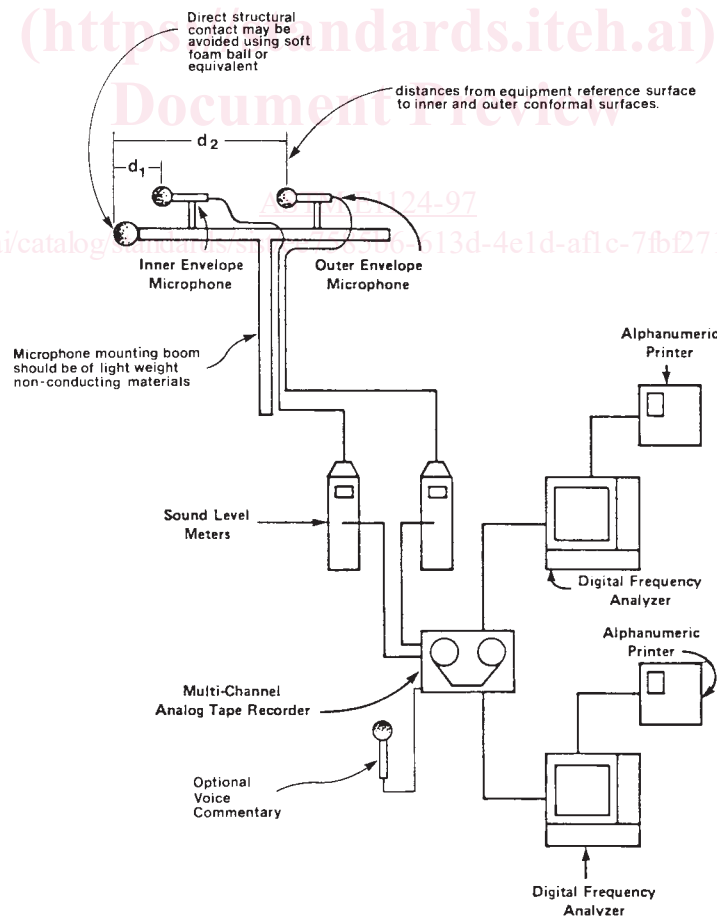


FIG. 2 Example of Suggested Measurement System