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An American National Standard

Standard Test Method for Determining A-Weighted Sound Power Level of Vacuum Cleaners[1]

This standard is issued under the fixed designation F1334; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method calculates the overall A-weighted sound power level emitted by small portable upright, canister, combination vacuum cleaners, and central vacuum cleaner motorized nozzles intended for operation in domestic and commercial applications.

1.1.1 To determine the Sound Power Level of a central vacuum at the power unit location refer to Test Method F2544.

1.2 A-weighted sound pressure measurements are performed on a stationary vacuum cleaner in a semi-reverberant room. This test method determines sound power by a comparison method for small noise sources, that is, comparison to a broadband reference sound source.

1.3 This test method describes a procedure for determining the approximate A-weighted sound power level of small noise sources. This test method uses a non-special semi-reverberant room.

1.4 Results are expressed as A-weighted sound power level in decibels (referenced to one picowatt).

1.5 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.6 *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:*[2]

C634 Terminology Relating to Building and Environmental Acoustics

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F608 Test Method for Evaluation of Carpet Embedded Dirt Removal Effectiveness of Household/Commercial Vacuum Cleaners

F655 Specification for Test Carpets and Pads for Vacuum Cleaner Testing

F2544 ~~Test Method for Determining A-Weighted Sound Power Level of Central Vacuum Power Units~~ Test Method for Determining A-Weighted Sound Power Level of Central Vacuum Power Units

F2607 Test Method for Measuring the Hard Surface Floor-Cleaning Ability of Household/Commercial Vacuum Cleaners

2.2 *ANSI Standards:*[3]

ANSI S1.10 Method for the Calibration of Microphones

ANSI S1.43 Specifications for Integrating-Averaging Sound Level Meters

ANSI S12.51/ISO 3741 Acoustics - Determination of sound power levels of noise sources using sound pressure - Precision methods for reverberation rooms

ANSI S12.53/ISO 3743 Acoustics - Determination of sound power levels of noise sources - Engineering methods for small, movable sources in reverberant fields

ANSI S12.57/ISO 3747 Standard Acoustics - Determination of sound power levels of noise sources using sound pressure - Comparison method in situ

3. Terminology

3.1 *Definitions:*

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[1] This test method is under the jurisdiction of ASTM Committee F11 on Vacuum Cleaners and is the direct responsibility of Subcommittee F11.25 on Sound Measurement.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

3.1.1 *population*, *n*—the total of all of the units of the particular model or type, or both, of vacuum cleaner being tested.
3.1.2 *population sample or sample*, *n*—three or more test units, randomly taken from the population.
3.1.3 *reference sound source*, *n*—a standard source of broadband sound with a certified set of sound power emissions.
3.1.4 *source*, *n*—a device that emits sound. This may be the vacuum cleaner or a motorized nozzle.
3.1.5 *test unit or unit*, *n*—a single vacuum cleaner or nozzle of the model or type, or both, being tested.
3.1.6 Unless otherwise indicated, definitions are in accordance with Terminology C634.

4. Significance and Use

4.1 The test results enable the comparison of A-weighted sound emission from vacuum cleaners when tested under the condition of this test method.

5. Test Room Requirements

5.1 The test room shall be semi-reverberant. It shall contain sufficiently little sound absorption material so the requirements of 5.2 can be met. It should be large enough to meet the dimension requirements of 5.2.

5.1.1 When a central vacuum cleaner motorized nozzle is to be tested, the test room should be plumbed for a central vacuum system according to the manufacturer's instructions using standard 2.00-in. diameter thin-wall PVC tubing. A single wall inlet shall be located in the test room.

5.2 Identify a location on the test room floor which can accommodate six equally spaced microphone positions 60° apart located at a height of 60 in. (1.5 m) above the floor on a 12 ft (3.6 m) diameter circle the center of which is the center of the sound source. These positions shall result in a standard deviation of the six sound pressure measurements of not more than 2.3 dB when measuring the reference sound source. This location is suitable for the vacuum cleaner and reference sound source for this test method. Refer to Figs. 1-4 for typical layouts.

5.3 *Environmental*—Ambient test conditions within the test room shall be controlled to within 70 ± 5°F (21 ± 3°C) and 30 to 70 % relative humidity.

5.4 Also, any room which has qualified in accordance with ANSI S12.51/ISO 3741, ANSI S12.53/ISO 3743, and ANSI S12.57/ISO 3747 may be used to measure the sound power levels of vacuum cleaners or motorized nozzles.

5.5 The measured A-weighted sound pressure levels shall be corrected for the influence of background noise according to Table 1. When the steady background-noise sound pressure level is more than 6 dB below the sound pressure level at each measurement point, the measured A-weighted sound pressure levels shall be corrected for the influence of background noise according to Table 1. If this difference is less than 6 dB no correction is allowed and any reported data must include a note indicating that the background noise requirements of this standard were not satisfied.

6. Instrumentation and Equipment

6.1 *Acoustical Instrumentation*—The sound measurement system shall be as specified in ANSI S1.43.

6.2 *Voltage Regulator System*—The regulator shall be capable of maintaining the vacuum cleaner's rated voltage (±1 %) and frequency (±1 Hz) having a waveform that is essentially sinusoidal with 3% maximum harmonic distortion for the duration of the test.

6.3 *Test Carpet and Pad*—The test carpet and pad shall be 54 in. wide (137 cm) and 72 in. (183 cm) long. The carpet shall be multilevel. Carpet and pad shall be as specified in Specification F655.

NOTE 1—For this test method two standard size 27 by 72-in. (69 by 183-cm) long test carpets could be placed side by side to make it 54 by 72 in. (138 by 183 cm) long. It is recommended that the two pieces of test carpet be taped to the floor, side by side with the pile running in the same direction.

6.4 *Hard Surface Floor (VCT)*—Any smooth (minimal texture, no seams) vinyl floor covering as specified in Test Method F2607. Flooring to be glued to a plywood supporting surface over the whole area. Plywood supporting surface to be a flat surface consisting of a piece of ¾-in. (19-mm) thick exterior-grade plywood with the "A" surface upward to support the test surface. Surface shall be 54 in. wide (137 cm) and 72 in. (183 cm) long.

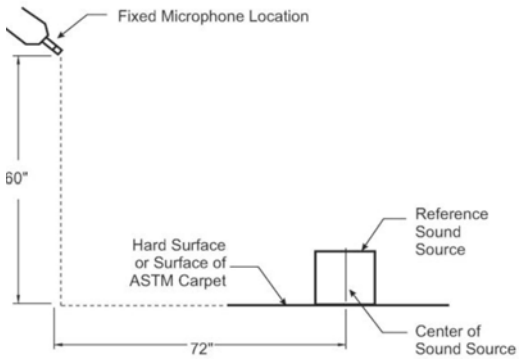

FIG. 1 Sound Set Up

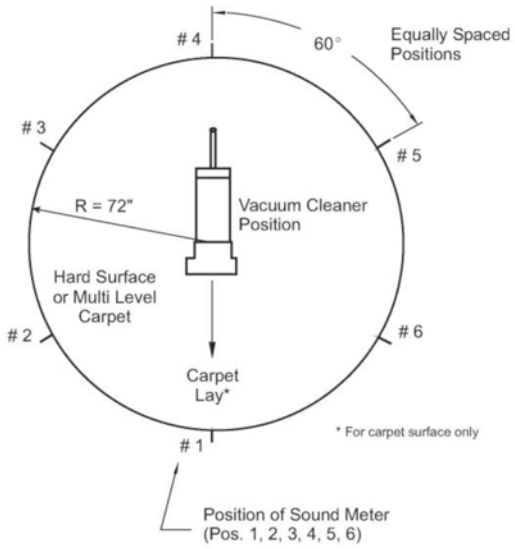

FIG. 2 Sound Test Pattern for Uprights

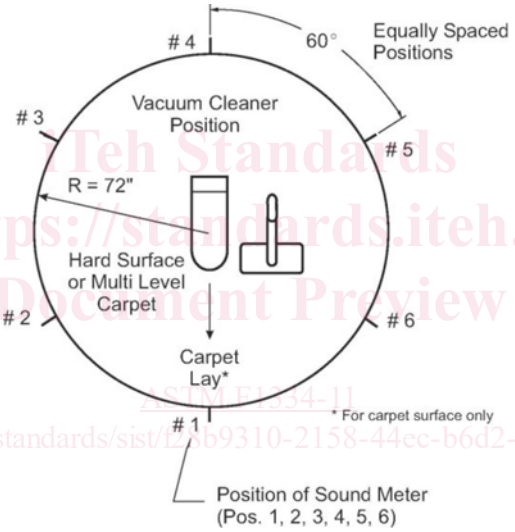

FIG. 3 Sound Test Pattern for Canisters

6.5 *Reference Sound Source*—The reference sound source shall meet the requirements of ANSI S12.57/ISO 3747.
~~6.5~~
6.6 *Instrumentation*:
~~6.5.1~~
6.6.1 *Thermometer*, accurate to within ±3°F (±2°C).
~~6.5.2A~~6.6.2 A means of measuring relative humidity, accurate to within ±2 % over the range used.

7. Operation of Vacuum Cleaner

7.1 *Run-In*—Operate new test cleaners continuously for at least 1 h prior to testing. Canister cleaners shall be run open with no hose attached. Upright and power nozzles shall be run so that the rotating brush does not engage the carpet or the floor.

7.2 *Warm-Up*—Operate the cleaners for 10 min just prior to making sound pressure level measurements in the same configuration as described in 7.1.

7.3 *Test Configuration*:

7.3.1 The vacuum cleaner shall be configured for the carpet cleaning or hard-floor cleaning mode.

7.3.2 The dust bag or primary filter shall be new.

7.3.3 All belts shall be new at the start of the run-in.

7.3.4 Rotating agitator type cleaner including power nozzle shall use the same setting as specified in Test Method F608 for cleaning multilevel carpet or in Test Method F2607 for hard floor cleaning, which is as follows:

7.3.4.1 If various settings are provided, set the motor speed setting, suction regulator, or nozzle height, or combination thereof,

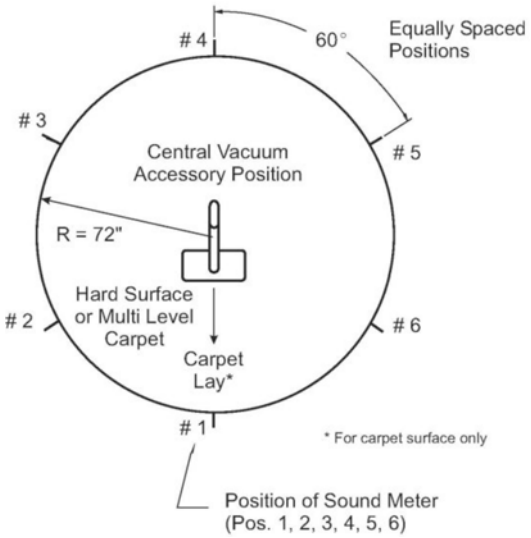

FIG. 4 Sound Test Pattern for CV Accessories

TABLE 1 Corrections for Background Noise Levels

Difference Between Sound Pressure Level Measured with Sound Source Operating and Background Noise Level Alone, dB		Correction to be Subtracted from Sound Pressure Level Measured with Sound Source Operating to Obtain Sound Pressure Level Due to Sound Source Alone, dB
Less than	6	No correction allowed
	6	1
	7	1
	8	1
	9	0.5
	10	0.5
Greater than	10	0

using the manufacturer's specified setting for cleaning multilevel carpet or hard-floor surfaces. Momentary or instantaneous speeds are not to be used.

7.3.5 For straight air canister cleaners use the same setting specified in Test Method F608 for cleaning multilevel carpet or in Test Method F2607 for hard floor cleaning, which is as follows:

7.3.5.1 If various settings are provided, set the motor setting, suction regulator, or nozzle height, or combination thereof, using the manufacturer's specific setting for cleaning multilevel carpet or hard-floor surfaces. If no specific instructions are given, or if judged to be inadequate or unclear, position the nozzle on the carpet so the maximum suction is provided, taking care to maintain the tilt angle throughout the test. Momentary or instantaneous speeds are not to be used.

7.3.6 *Voltage*—Tests are to be conducted at the nameplate voltage (±1 %) and frequency (±1 Hz) throughout the test. For cleaners with dual nameplate voltage ratings, conduct sound tests at the highest voltage.

7.3.7 *Central Vacuum Power Unit*—The central vacuum power unit shall be remotely located (outside the semi-reverberate room) so that the noise levels generated by the power unit do not affect the test results of the central vacuum (motorized or straight air) nozzle being tested.

8. Location of Sound Sources and Equipment

8.1 *Carpet and Pad*—Lay the carpet and pad or the VCT flooring on the floor with the geometric center of the carpet directly over the center of the circle defined in 5.2.

8.2 Locate the vacuum cleaner or the reference sound source at the position determined in 5.2. All modules (generally the motor/blower and its housing in the base of an upright unit, or in the canister of a canister unit) shall be adequately secured in a manner which will not affect the sound pressure readings.

8.2.1 *Reference Sound Source Location*—Position the center of the radiating portion (fan blades, for an aerodynamic source) over the location defined above. The reference sound source is placed directly on the carpet or VCT floor.

8.2.2 *Vacuum Cleaner Location*:

8.2.2.1 Center the principal module over the source location as determined in 5.2.

8.2.2.2 Take care to ensure the rotating brush model does not damage the carpet seam (that is, center upright on carpet on center of carpet with the rotating brush perpendicular to seam).

8.2.2.3 *Second Module*—If there is a second module not integral with the basic unit (for example, the power nozzle), it shall be positioned on the side of the principle module away from the center of the room. Position the second module in such a way that, to the maximum extent possible, its sound emissions are not shielded by the principal module, and vice versa. For example, a position shall be such that air exhaust noise will radiate into the room in a direction other than toward the second module.

8.2.3 *Handle*—Any operating handle shall be separately supported in a position such that the handle grip is 31½ in. (80 cm) above the carpet surface or VCT surface. Take care that the support structure does not introduce additional rattles, etc. There shall be a resilient clamping of the handle to the support structure.

8.2.4 *Central Vacuum Cleaner Power (or Straight Air) Nozzles*—For central vacuum power (or straight air) nozzles, the hose is connected to the wall inlet valve. The hose assembly with power (or straight air) nozzle is then positioned in the same manner as the hose assembly and power head for a canister vacuum cleaner. See 8.2.2-8.2.3.

9. Sampling

9.1 Test a sufficient number of samples of each vacuum cleaner model until a 90 % confidence level is established within ±2.0 dBA of the mean value. Test a minimum of three samples.

10. Measurement Procedure

10.1 Check the calibration of each microphone according to the instrument manufacturer's directions (further information provided in ANSI S1.10).

10.2 At each of the six microphone positions determined in 5.2, measure the background A-weighted sound pressure level. This step can be ignored if it is known that the background sound pressure levels are more than 10 dB below the sound pressure levels of all sources being considered at all microphone locations.

10.3 With the reference sound source in the location defined in Section 8 and running in accordance to the manufacturer's recommendations, measure the A-weighted sound pressure level at the six microphone positions. After making the necessary corrections for the influence of the background noise at each microphone location and ensuring that the standard deviation requirement of 5.2 is met, calculate the space-averaged A-weighted sound pressure level of the reference sound source, L_{pr}, using the equation:

$$L_p \text{ or } L_{pr} = 10 \log\left\{\frac{1}{N_m}\sum_{i=1}^{N_m} 10^{L_i/10}\right\} \quad (1)$$

where:

L_p *or* L_{pr} = A-weighted sound pressure level averaged over all microphone positions, for a single source location, dB,
L_i = A-weighted sound pressure level for the i th microphone position, dB, and
N_m = number of microphone positions.

10.4 Replace the reference sound source with the test unit. With the test unit operating in accordance to Section 7, measure the A-weighted sound pressure level at the six microphone locations. After making the necessary corrections for the influence of the background noise at each microphone location, calculate the space-averaged A-weighted sound pressure level, L_p, of the test unit using Eq 1.

10.5 Using the space-averaged A-weighted sound pressure levels, L_{pr} and L_p, and the known A-weighted sound power level of the reference sound source, calculate the A-weighted sound power level of the test unit using the procedure of 11.1.

10.6 Using the same test unit repeat steps 10.2-10.5 two (2) additional times for a total of three (3) test runs.

10.7 The sound power level (score) for each individual test unit is the arithmetic average of the A-weighted sound power levels of three test runs which meet the repeatability requirements of Section 14. See Annex A1 for a procedural example and to determine if additional test runs need to be conducted.

10.8 A minimum of two additional test units of the same model must be selected in accordance with the sampling statement of Section 9. Repeat 10.2-10.7 for each additional test unit. See Annex A1 for a procedural example and whether additional test units need to be tested.

10.8.1 When testing central vacuum cleaner accessories, a minimum of two (2) additional accessories of the same model must be selected in accordance with the sampling statement in Section 9.

10.9 The best estimate of A-weighted sound power level for the population of the vacuum cleaner model being tested is the arithmetic mean of sound power level of the sample population meeting the requirements of the sampling statement in Section 9.

10.9.1 The best estimate of A-weighted sound power level for the population of the central vacuum cleaner accessory model being tested is the arithmetic mean of A-weighted sound power level of the sample population meeting the requirements of the sampling statement in Section 9.

11. Calculation of A-Weighted Sound Power Levels for the Comparison Method

11.1 The A-weighted sound power level produced by the test unit shall be calculated as follows. Subtract the A-weighted sound pressure level produced by the reference sound source (corrected for background noise according to 5.5) from the A-weighted sound pressure level of the test unit under test (corrected for the background noise according to 5.5). Add the difference to the known A-weighted sound power level produced by the reference sound source:

$$L_W = L_{wr} + L_p - L_{pr} \quad (2)$$

where:

L_W = the A-weighted sound power level, in decibels, produced by the test unit under test.
L_p = the average A-weighted sound pressure level, in decibels, produced by the test unit under test, as determined in accordance with 10.3,
L_{wr} = the known A-weighted sound power levels, in decibels, produced by the reference sound source, and
L_{pr} = the average A-weighted sound pressure level, in decibels, produced by the reference sound source, as determined in accordance with 10.2.

NOTE 2—The calculated sound power value is that which will occur at the environmental conditions specified with the reference sound source calibration information (typically at sea level, and at a specified reference temperature). Typically, the uncorrected result will be acceptable for site elevations below 3000 ft (1000 m) and for air temperatures from 50 to 80°F (10 to 27°C). Corrections are required for determining the sound power value at other site elevations, or for significantly different air temperatures. The required corrections for other environments should be provided by the supplier of the reference sound source and the supplier of its applicable calibration.

12. Information

12.1 *General*—Record the name and location of the test laboratory, including the date and time of the measurements.

12.2 *Test Room*—Record the description of the room construction, dimensions, configurations, and deployment of absorptive materials, etc.

12.3 *Equipment*—Maintain recorded diagram of the acoustical data acquisition system. This shall include the model number and serial number of all microphones, preamplifiers, filters, meters, etc. Describe microphone cables specifically. Record the calibrator model number and serial number, output frequency and calibrated level. Record any other pertinent equipment information.

12.4 *Geometry*—Record the source location point and the microphone positions.

12.5 *Vacuum Cleaner*—Record the manufacturer, model name and number, and unit serial number.

12.6 *Environment*—Record the temperature and relative humidity.

12.7 *Calibration Check*—Record the actual readout level with the calibrator on the microphone, both at the beginning and end of the measurement period, to the nearest 0.1 dB, or as closely as the instrumentation permits.

12.8 *Ambient Sound Pressure Level*—Record the ambient overall (A-weighted) sound pressure levels at each of the microphone locations to the nearest 0.1 dB.

12.9 *Reference Sound Source*—Record the overall A-weighted sound pressure levels at each of the microphone positions to the nearest 0.1 dB. Include a copy of the sound power data calibration sheet as supplied from the source manufacturer.

12.10 *Vacuum Cleaner*—Record the overall A-weighted sound pressure levels at each of the microphone locations to the nearest 0.1 dB.

12.11 Record any other pertinent data or comments.

13. Test Report

13.1 Report the following information:

13.1.1 A description of the test samples used and the means used to distinguish them from other similar specimens (make, model, serial number, manufacturing date),

13.1.2 Approximate size and weight of the models tested and whether an operator was present during the sound level measurements, and

13.1.3 Average A-weighted sound power level (calculated) shall be reported to the nearest decibel.

14. Precision and Bias [4]

14.1 *Precision*—The following precision statements are based on interlaboratory tests involving ten laboratories and three test units:

14.1.1 The statistics have been calculated as recommended in Practice E691.

14.1.2 The following statements regarding repeatability limit and reproducibility limit are used as directed in Practice E177.

14.1.3 The standard deviations of repeatability and reproducibility of the calculated A-weighted sound power level results have been derived from ten sets of data, where each set of three test runs has been performed by a single analyst within each of the ten laboratories on multidays using the test unit which produced the largest value of average A-weighted sound power level of 89.4 dBA.

14.1.4 *Repeatability (Single Operator and Laboratory; Multiday Testing)*—The ability of a single analyst to repeat the test within a single laboratory.

14.1.4.1 The expected standard deviation of repeatability of the calculated A-weighted sound power level results within a laboratory, S_r, has been found to be 0.7 dBA.

14.1.4.2 The 95 % repeatability limit within a laboratory, r, has been found to be 1.94 dBA, where $r = 1.96\sqrt{2}\,(S_r)$.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F11-1011.