Exterior Sound Level Measurement Procedure for Earthmoving Machinery—SAE J88b

SAE Standard
Revised April 1979

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LAND SEA AIR SPACE

PREPRINT

EXTERIOR SOUND LEVEL MEASUREMENT ϕPROCEDURE FOR EARTHMOVING MACHINERY—SAE J88b

SAE Standard

Report of Vehicle Sound Level Committee approved November 1972 and completely revised by Construction, Agricultural, and Off-Road Machinery Sound Level Technical Committee April 1979. Rationale statement available.

1. Purpose and Scope

1.1 **Purpose**—This SAE Standard sets forth the instrumentation and procedure to be used in measuring the exterior sound levels for earthmoving machinery as defined under SAE J1057a.

1.2 **Scope**—This SAE Standard is applicable to machinery of 15 kw (20 rated bhp) and over. It is not intended to cover operation of safety devices (such as backup alarms). The sound levels obtained by using the test procedures set forth in this SAE Standard are repeatable and are representative of the higher range of sound levels generated by the machinery under actual field operating conditions, but do not necessarily represent the average sound level over a field use cycle.

2. Instrumentation

2.1 A sound level meter which meets the Type 1 requirements of The American National Standard Specification for Sound Level Meters, S1.4-1971.

2.2 As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with a magnetic tape recorder and/or graphic level recorder or indicating instrument, providing the system meets the requirements of SAE Recommended Practice J184a, Qualifying a Sound Data Acquisition System, for the frequency range that is of primary concern. The deviations in the magnetic tape recorder frequency response from *flat* response especially at lower frequencies must not affect the overall reading by more than ±0.5 dB(A).

2.3 An acoustical calibrator (accuracy within ±0.5 dB(A)—see paragraph 4.2.3).

2.4 The use of a windscreen may be required under some test conditions. (Refer to paragraph 3.1.3), otherwise its use is optional providing that it does not affect the A-weighted sound level of the source being measured by more than ±0.5 dB(A), under zero wind speed conditions. (Also refer to paragraph 4.2.2.)

2.5 An anemometer or other device for measurement of ambient wind speed and direction. The accuracy is ±10% at the highest recommended wind speed. (See paragraph 4.2.2.)

2.6 A power source speed indicator (accuracy within ±2% of the indicated reading).

2.7 A thermometer for measurement of ambient temperature (accuracy within ±1°C (1.8°F)).

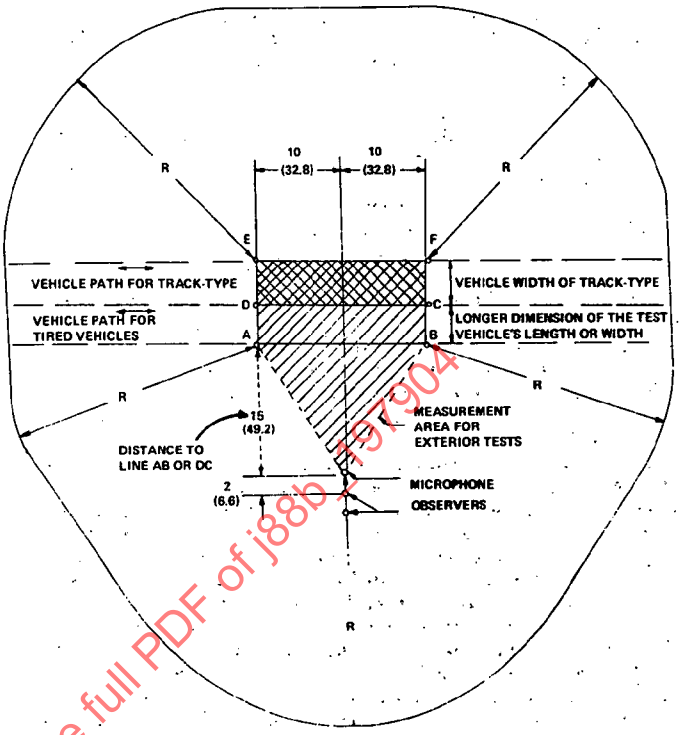
2.8 A barometer for measuring atmospheric pressure (accuracy within ±1.1 kPa (0.3 in Hg) of the indicated reading).

3. Procedure

3.1 **Test Site**—The test area shall consist of a flat open space free of any large reflecting surfaces, such as a signboard, building, or hillside, located within 30 m (98.4 ft) of either the microphone or the machinery being measured (see Fig. 1).

3.1.1 The minimum measurement area (see Fig. 1) shall consist of the triangle formed by the microphone location, points A and B, and the rectangle formed by points A, B, C, and D. Both designated areas shall be smooth concrete or smooth and sealed asphalt or a similar hard and smooth surface. The rectangle formed by points C, D, E, and F shall consist of hard-packed earth. The planes between the microphone location and line AB and planes encompassed by points A, B, C, F, E, and D shall form a continuous, uniform plane. If a minimum measurement area test site is used, it will require reorientation of the machine for each major surface measurement during the stationary tests, and the moving tests will have to be run in two opposite directions. The other option is to have a larger measurement area test site and relocate the microphone for the series of prescribed test conditions with the machine in one position for stationary tests and driving by in only one direction for moving tests.

3.1.2 Because bystanders may have an appreciable influence on the meter response when they are in the vicinity of the earthmoving machinery or microphone, not more than one person, other than the observer reading the meter, shall be within 17 m (55.8 ft) of the earthmoving machinery and 2 m (6.6 ft) of the measuring microphone, and that person shall be directly behind the observer who is reading the meter, on a line through the microphone and the observer (see Fig. 1).



NOTE: R=30 (98.4) RADIUS MINIMUM FOR EXTERIOR MEASUREMENTS

DIMENSIONS ARE IN M(FT)

FIG. 1—TEST SITE CONFIGURATION

3.1.3 The ambient sound level due to sources other than the earthmoving machinery being measured (including wind effects) shall be at least 10 dB(A) lower than the sound level of the machinery being measured. (See paragraph 3.3.3.)

3.1.4 The surface between and under the earthmoving machinery and microphone shall be smooth and free of acoustically absorptive material, such as snow or grass.

3.1.5 For all stationary tests the machinery shall be located on the hard surface area formed by points A, B, C, and D in Fig. 1.

3.1.6 Moving Tests

3.1.6.1 For moving tests of all rubber-tired machines, the path of travel shall be across the area defined by points A, B, C, and D in the directions shown in Fig. 1.

3.1.6.2 For moving tests of all steel wheel or track type machines the path of travel shall be across the area defined by C, D, E, and F in the directions shown in Fig. 1.

3.2 **Tests Required**

Self-propelled earthmoving machinery that is used primarily in a mobile mode, shall be tested per paragraphs 3.2.1.1, 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.2.

Combined earthmoving machinery (such as a small loader with a backhoe) shall be tested per paragraphs 3.2.1.1, 3.2.1.2, 3.2.1.3, 3.2.1.4, and 3.2.2.

Rubber-tired and track excavators shall be tested in a stationary test mode only per paragraphs 3.2.1, 3.2.1.2, 3.2.1.3, and 3.2.1.4.

3.2.1 Stationary tests with ground propulsion transmission shift selector in neutral position.

3.2.1.1 Operate all mobile earthmoving machinery engines at no load with all component drive systems in neutral position and maximum governed speed (high idle at no load) at a stabilized condition.

3.2.1.2 Operate all mobile earthmoving machinery engines at no load and rated speed with all component drive systems in neutral position. Rated speed is defined per SAE J245 or J270.

3.2.1.3 It is recommended that care be taken to ensure stabilized com-

The ϕ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

bustion chamber surface temperatures prior to this test sequence. For on some types of engines, such as engines with precombustion chambers, repeatability of sound levels may be affected. A cool down period of 5 min is recommended. Operate mobile earthmoving machinery engines at no load with all major component drive systems in neutral position through the cycle *low idle—maximum governed speed (high idle)—low idle* as rapidly as possible, but allowing the engine to stabilize for at least 10 s at the maximum governed speed (high idle) before it is permitted to return to low idle.

3.2.1.4 With the engine at the maximum governed speed (high idle) or manufacturer's recommended engine operating speed at no load in a stabilized condition, activate the appropriate hydraulic circuits, mechanical, electrical, hydrostatic, or torque converter drive systems to cycle the major components or component from the most retracted and/or lowered position to fully extend and/or maximum height position, and then back to original position. This cycling should be done as fast as practical, taking into consideration all the pertinent safety factors, and be accomplished without blowing relief valves. For short cycle hydraulic operation, the system may be *feathered*. For safety reasons and undesirability of change of location of major noise source in relation to other major components of the machine, a major portion of the mobile machine, such as the tractor of a scraper unit, or the upper rotational structure of an excavator shall not be moved, or scraper elevator placed in operation during this stationary machine test.

3.2.2 Constant Speed Moving Test—Earthmoving machinery shall be operated in a forward intermediate gear ratio at no load at a location as specified in paragraphs 3.1.6.1 or 3.1.6.2. The power source shall be operated at maximum governed speed (high idle). Intermediate is intended to mean second gear ratio for machinery with three or four gear ratios, third gear ratio for machinery with five or six gear ratios, fourth gear ratio for machinery with seven or eight gear ratios, etc.

If there is a problem with the transmission shifting up or down in this phase of the test, one gear lower or higher may be used to eliminate the problem. Machines with hydrostatic, electric drive, or other type drives shall be operated at approximately one-half its maximum ground speed with the governor control set in maximum (high idle) position at no load. If this operating condition cannot be attained because of the interaction of the engine and drive controls, then the ground speed may be increased or decreased so as to still permit the engine governor control to be set in maximum (high idle) position. Machinery that has major noise-generating components which are normally used at the above ground speed shall have these major components in operation during this moving test.

3.2.3 Earthmoving machinery that has a major attachment that is normally used for the main operating function shall be equipped with this attachment. Examples of this are buckets on loaders and dozers on either wheel or track-type tractors. For all tests these attachments shall be in a minimum transport position of 150 mm (6 in) for dozers, scrapers, etc., and for loaders use carry position as specified by SAE Standard J732c, Specification Definitions—Front End Loader. For machinery equipped with a ripper, such as on a wheel or track type tractor, or a backhoe, such as on a front end loader, these attachments shall be in the transport position.

3.3 Measurements

3.3.1 The microphone shall be located at a height of 1.2 m (3.9 ft) above the ground plane.

3.3.2 The sound level meter shall be set for slow response and the A-weighting network.

3.3.3 The ambient wind speed and direction, ambient temperature, atmospheric pressure, and ambient A-weighted sound level shall be measured and recorded at the height of 1.2 m (3.9 ft) and within at least 3 m (9.8 ft) of the one specified location of the microphone as shown in Fig. 1.

3.3.4 The stabilized maximum governed engine speed shall be measured and recorded.

3.3.5 The rated engine speed shall be monitored during the rated speed test per paragraph 3.2.1.2.

3.3.6 The sound level meter needle movement, digital readout, or graphic level recorder trace shall be observed during each test sequence at the specified microphone location. The highest value observed for all tests disregarding sounds of short duration that are out of character with the test on the machine (Example: impact sound such as bucket rack against stops) shall be recorded for each test sequence. For a digital type readout the meter must be frequently reset so that the out-of-character sound levels for the test sequence are not included if the maximum hold mode is being used. For the stabilized test condition, of maximum governed speed (high idle) or rated engine speed, a single reading shall be recorded at each measuring point. For engine cycling, component cycling, and the constant speed moving test conditions (paragraphs 3.2.1.3, 3.2.1.4, and 3.2.2) a minimum of three valid readings shall be taken for each measuring point. If for each specific test mode none of the readings are within 2 dB of each other, then additional readings shall be taken until there are two that are within 2 dB of each other. The recorded sound level for each measuring point shall be the average of those two values that are within 2 dB of each other. If there are two pairs of readings that are within 2 dB of each other, record the average of the higher pair. The final recorded sound level for each test mode shall be the highest reading for the stabilized test condition at each measuring point and the highest average for the cyclic or moving tests at each measuring point.

3.3.7 For stationary tests, record the sound level obtained at a distance of 15 m (49.2 ft) normal to the centers of the four major surfaces of the equipment at the microphone height. Generally, four major surfaces refer to front, rear, and sides of an imaginary box that would just fit over the machine but does not include attachment items such as buckets, dozers, backhoes, rippers, and booms (see Fig. 2). In the case of an excavator, the upper (revolving superstructure) fore-and-aft centerline should be in line with the lower fore-and-aft centerline. Operate the machine in a manner as specified in paragraphs 3.2.1.1, 3.2.1.2, 3.2.1.3, and 3.2.1.4.

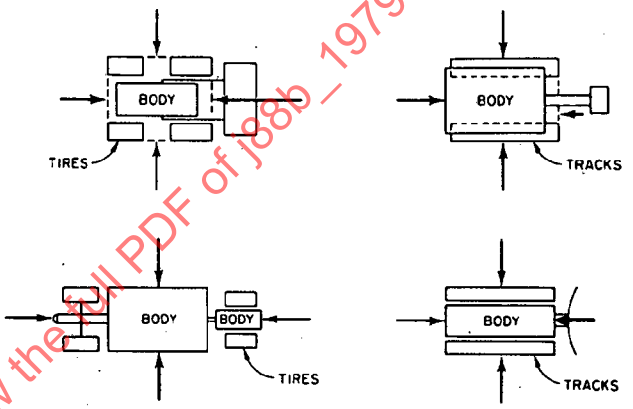


FIG. 2—MAJOR SURFACE OUTLINES

3.3.8 For moving tests, take measurements at a distance of 15 m (49.2 ft) measured in a direction normal to both major side surfaces which are parallel to the machine path, as shown in Fig. 1. Operate the machine in a manner specified in paragraph 3.2.2.

3.3.9 The reported sound level for each of the stationary test modes (per paragraphs 3.2.1.1, 3.2.1.2, 3.2.1.3, and 3.2.1.4) shall be the arithmetical average of the recorded sound levels at each of the four measuring points. The reported sound level for the moving test (per paragraph 3.2.2) shall be the arithmetical average of the recorded sound levels at each of the two measuring points. The reported sound levels for a given piece of earthmoving machinery shall be included in the report format as shown in Appendix A.

4. General Comments

4.1 It is recommended that persons technically trained and experienced in the current techniques of sound measurements select the instrumentation and conduct the tests. Dedicated attention to detail and a thorough understanding of the machine and test instrumentation operational requirements shall be prerequisite of all personnel attached to the evaluation program.

4.2 Proper use of all test instrumentation is essential to obtain valid measurements. Operating manuals or other literature furnished by the instrument manufacturer should be referred to for both recommended operation of the instrument and precautions to be observed.

4.2.1 The effects of ambient weather conditions on the performance of all instruments (for example: temperature, humidity, barometric pressure, and stray magnetic fields), should be known. Instrumentation can be influenced by low temperature or significant changes in temperature, and caution should be exercised.

4.2.2 It is recommended that the wind speed of the air over the microphone not exceed 20 km/h (12.4 mph). Caution should be used in making measurements with higher relative velocities.

4.2.3 Proper signal levels, terminating impedances, and cable lengths on multi-instrument measurement systems should be known.

4.2.4 Proper acoustical calibration procedure, to include the influence

of extension cables, etc., should be performed. Field acoustical calibration shall be made immediately before and after the testing of each piece of earthmoving machinery or at least every 4 h. The calibration before and after shall not vary by more than ±0.5 dB for the tests to be valid.

4.3 It should be recognized that variations in measured sound levels may occur due to variations in test site, ambient weather differences (temperature, wind, and their gradients), test equipment differences, and inherent differences between nominally identical machines.

5. References

ANSI S1.1-1960 (R1971), Acoustical Terminology.

ANSI S1.2-1962 (R1971), Physical Measurement of Sound.

ANSI S1.4-1971 (R1976), Specification for Sound Level Meters.

ANSI S1.13-1971, Methods for the Measurement of Sound Pressure Levels.

SAE Recommended Practice J1262, Sound Level Measurement Procedure for Trenching Equipment.

SAE Recommended Practice J184a, Qualifying a Sound Data Acquisition System.

SAE Standard J732c, Specification Definitions—Front End Loader.

ANSI 5.5.1, Test Code for Measurement of Sound from Pneumatic Equipment.

SAE Standard J245, Engine Rating Code—Spark Ignition.

SAE Standard J270, Engine Rating Code—Diesel.

SAE Recommended Practice J1057a, Identification Terminology of Earthmoving Machines.

ISO R362, Measurement of Noise Emitted by Vehicles.

Rationale statement is on file at SAE Headquarters and is available upon request.

ANSI and ISO documents are available from: American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.